Manual for RFCcontrol - DTU Energy RFCcontrol control software version 8.0.3

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Chapter 1

Introduction

RFCcontrol is a generalized control system for fuel cell, electrolyser cells, battery and other types of materials test stations / test setups. It features data logging as well as device control and can handle gas flow control, gas pressure control, temperature control, relay control, control of DC power supplies as well as handle data acquisition through a number of data logging devices.

The main features of RFCcontrol are listed below:

- Individual device configuration through user friendly graphical user interface.
- Detailed device control.
- Wide range of control and data logging devices supported, including but not limited to:
  - Brooks® and MKS® digital mass flow controllers.
  - Tescom ER3000 digital pressure controllers.
  - Analog pressure controllers as well as analog flow controllers
  - Eurotherm® and Omron® temperature controllers as well as some controllers from some other vendors (Honeywell®, Linkam®, West Instruments®).
  - Delta Elektronika® DC power supplies.
  - BK Precision® DC power supplies.
  - EA Elektro Automatik® electronic loads.
  - Rhode&Schwarz HMP4040 DC power supplies.
  - ICP-Con® DO-, DA-, DI- and AD-modules.
  - Manual control devices (virtual) of flow controllers, pressure controllers as well (for logging flow or pressure from ball flow meters or manual pressure regulators).
  - Composite gas control devices (using multiple MFC's with different flow ranges to increase range while maintain accuracy at low flows).

  - Composite PSU/Eloads making it possible to use two PSU's or a PSU-Eload combo to emulate a full bipolar PSU.
  - Gas group device (a composite device) making it possible to use cross-over valves/relays to facilitate fast gas composition switching by having two gas lines with a cross over valve.
  - Keithley® 2700 and 2750 scanning multimeters as well as 2400 source meters (Support for these devices is through the gpib_socket_server supplied separately).
  - Possibility to control magnetic valves in front of the MFC's in order to force complete cutoff of gasses as most MFC's do not completely close even if valve override is used.
  - Possibility to control a magnetic bypass valve to vent any initial gas overshoot from MFC's (may be required in some cases).

- Possibility for using filter devices to do spline interpolations on return values of physical devices. This can be used to correct measured values if a custom calibration of a device has been made.
- Possibility to use slaved gas controllers (a slaved device always have x% of the master controler flow).
- Possibility to use multiplexed gasses (one MFC controlling one of multiple gasses depending on relay settings).
- Software PID devices which can be used for pressure regulation and / or other situations where stability can be improved by a PID feedback loop.
- Automatic data acquisition/logging which is independent of the user interface.
- Email notifications in case of user defined trigger levels has been exceeded.
- Possibility for automatic software updates.
- Possibility to use custom calibrated thermocouples for temperature measurements in additional to the use of the standard thermocouple calibration tables obtained from NIST (http://www.nist.gov). How to use custom calibration tables is described in detail in chapter 6).
- Graphical display of all logged data.
- Centrally managed user authentication / user permission control.
- Trace-logging of all user activities involving changes in the status of a device.
- Easy integration to Elchemea© (http://www.elchemea.com/elchemea/) and ElchemeaAnalytic© (http://www.elchemea.com) impedance acquisition and impedance analysis software packages.

- Automated i-V curve acquisition (Only in case a DC-power supply is attached and configured)
- Possibility for using custom designed software control systems including PID control loops.
- Possibility for using custom designed graphical user interfaces for individual test stations (See section 2.1).
- Uses only open source software (OSS).
- Possibility to use single sign on if multiple test stations running RFCcontrol are used.
- Possibility for using single sign on in collaboration with non-RFCcontrol systems (refer section 4.3.6).

Each hardware device controlled from RFCcontrol is handled through a software device (object) which internally handles device communication and control. The RFCcontrol system uses an object orientated approach enabling almost infinite configuration combinations. The use of an object oriented approach also makes it more safe and easy to add new device types, thus making maintenance easier to handle.

The first part of this documentation is an overview of the user interface (Chapter 2) mainly intended for new users of the system. The second part (chapters 3 to 7) is mainly intended for more advanced users and system administrators as it contains information regarding configuration and hardware set-up of the system. It is assumed that any administrators has a fairly advanced knowledge of Unix system administration and possibly Perl programming as well.

Chapters 4 and 6 describes configuration of a RFCcontrol system (global and rig specific) and chapter 7 describes the two currently defined watchdog programs as well as custom created alarms.

Chapter 11 contains the documentation for the different Perl module supplied by RFCcontrol and chapter 12 contains the device instance documentation, including device setup tags and potential default values.

1.1 Safety

Do not use the RFCcontrol - DTU Energy RFCcontrol control software for any situation that could result in injury or death! This software is NOT certified to be used for safety related control and should not be used for such.

In cases where dangerous gasses or other equipment / materials are used which could pose a threat to human safety, the safety should be monitored by a self contained and autonomous safety monitoring system (for instance by a safety PLC or similar system).

1.2 License

Copyright (C) 2015 Søren Koch, Karin V. Hansen, Martin Nielsen, Jens V. T. Høgh and DTU Energy at Technical University of Denmark.

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Chapter 2

User interface

RFCcontrol is based on the Apache web server software (Open Source Software, OSS). The measured data are displayed in a number of web pages with one page for each rig and for each day to avoid too much clutter (In the case of fuel cell tests, more than 20 individual channels may be monitored and displayed). The control part of the software is in the form of a number of interactive web pages where one must first log in to use some of them, whereas others are free to use without log in. In figure 2.1 the log-in page is shown as an example of the control web pages. The sidebar on the left is where the site navigation occour.

It is possible to view data without logging in to the RFCcontrol system unless access restrictions are put in place as described in section 3.4.

If some data are confidential or access to them are to be restricted for other reasons, access can be restricted by setting up user access restriction by using .htaccess files in the test directories (refer the Apache manual as how to configure this).

For instance if access to test 10 on rig 3 is to be disabled, place a .htaccess file in */home/http/html/rig3/3test10/* (the content of the .htaccess file must be appropriate or user access will not be restricted).

For more advanced user access control please see section 3.4 where it is dewcribed how to restict access to specific tests based on user authorisation.

Figure 2.2 shows an example of the main page after the user has logged in. The exact number of options in the sidebar may change according to user privileges (typically more options will be available for users with elevated privileges).

After login, the page shows a list of test rigs which can be controlled as well as a list of rigs for whom data are available for inspection similar to the list shown in figure 2.1. Pressing one of these buttons takes the user from the interactive part of the system to the normal static web pages containing historic and current data for the test rig in question.

If the user presses one of the control buttons mentioned above, the user is directed to a page resembling figure 2.3. The four or five rows on the page displays the current conditions for the rig in question; Temperature, Gas flows, cell voltage (or any other property that can be measured as a voltage) as well as current through the device/sample. The last (fifth) row is for alerts / triggers (refer section 7).

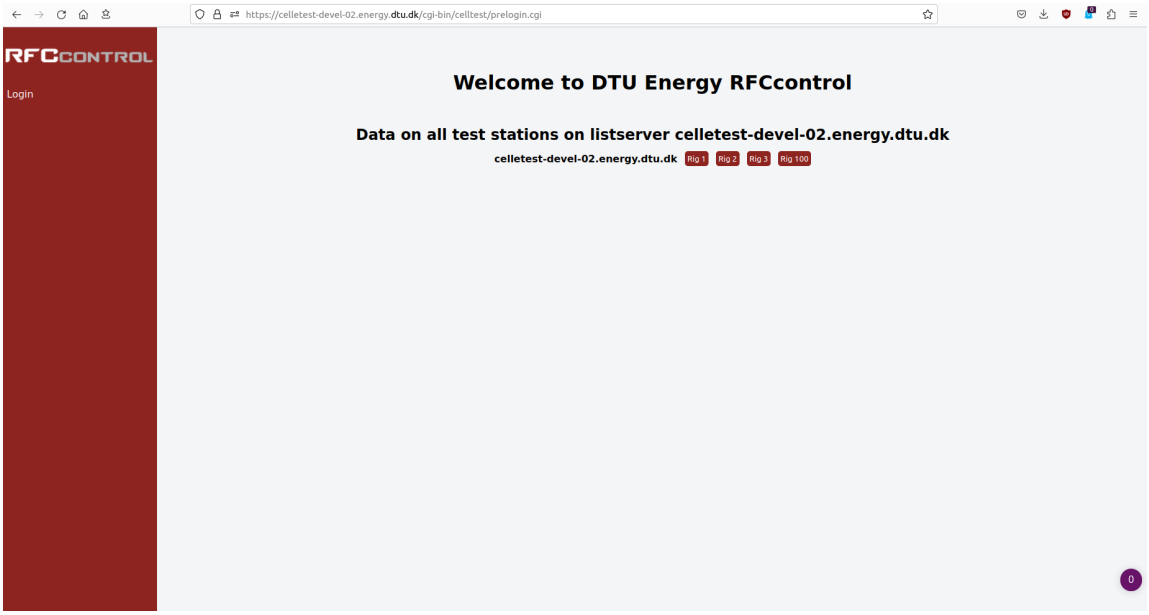


Figure 2.1: Example of what a prelogin page may look like. The actual number of rigs may vary greatly.

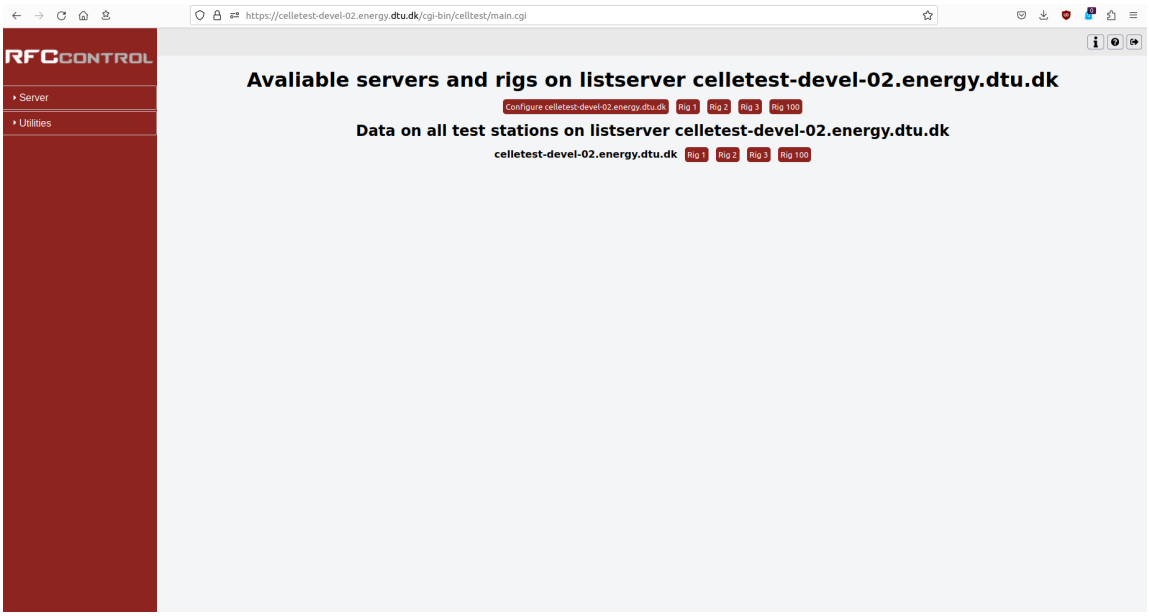


Figure 2.2: Example of what a the main page may look like after the user has logged in. The actual number of rigs may vary greatly. Notice the additional navigation buttons visible on the top navigation bar.

Between the data information pane and the sidebar the toolbox for the rig can be found. This toolbox allows for changes in process parameters (such as gas flow, temperature etc.) The bottom part is the logbook area, where information of the history of the current test is shown (the program log on the right) as well as the latest entry in the errorlog and logbook respectively. It is also possible to add further information the the logbook here. The program log is immutable by the user and all information in this file is computer generated and shows what has happened and at what time. If older log entries are needed

the full errorlog, logbook and program log can be accessed from the sidebar to the left under 'Current test'.

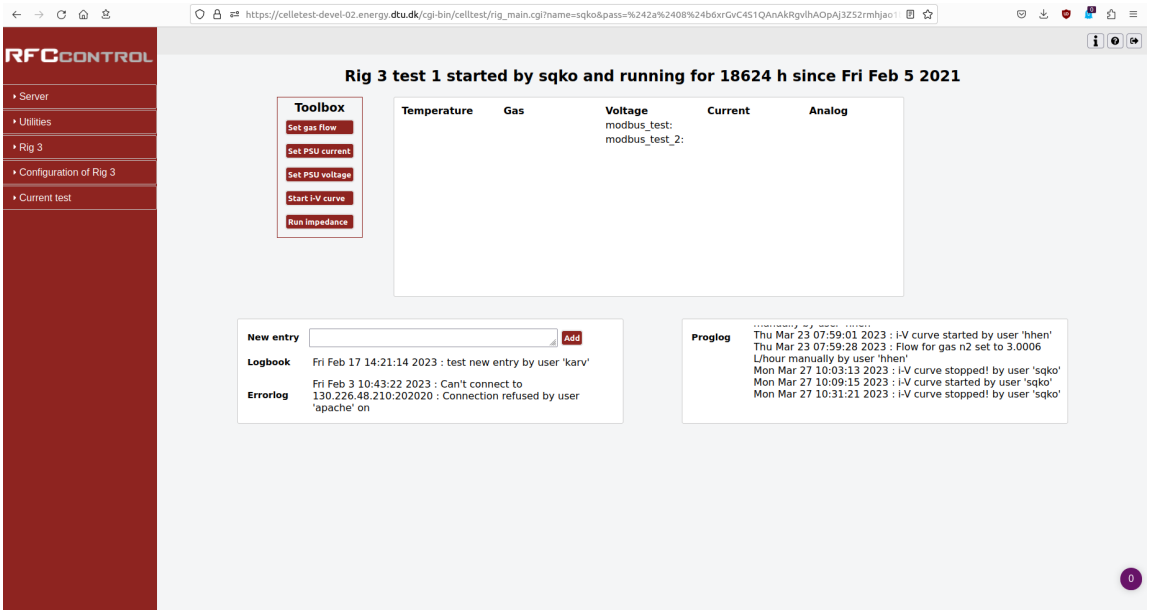


Figure 2.3: Example of what a rig control page may look like.

2.1 Custom rig main page

If a more customized user interface for a rig is wanted, it is possible to use custom designed main pages for a rig.

Setting up a custom rig main page is done using the 'Gui setup' option in the sidebar under 'Configuration of rig xx' (example shown in figure 2.4).

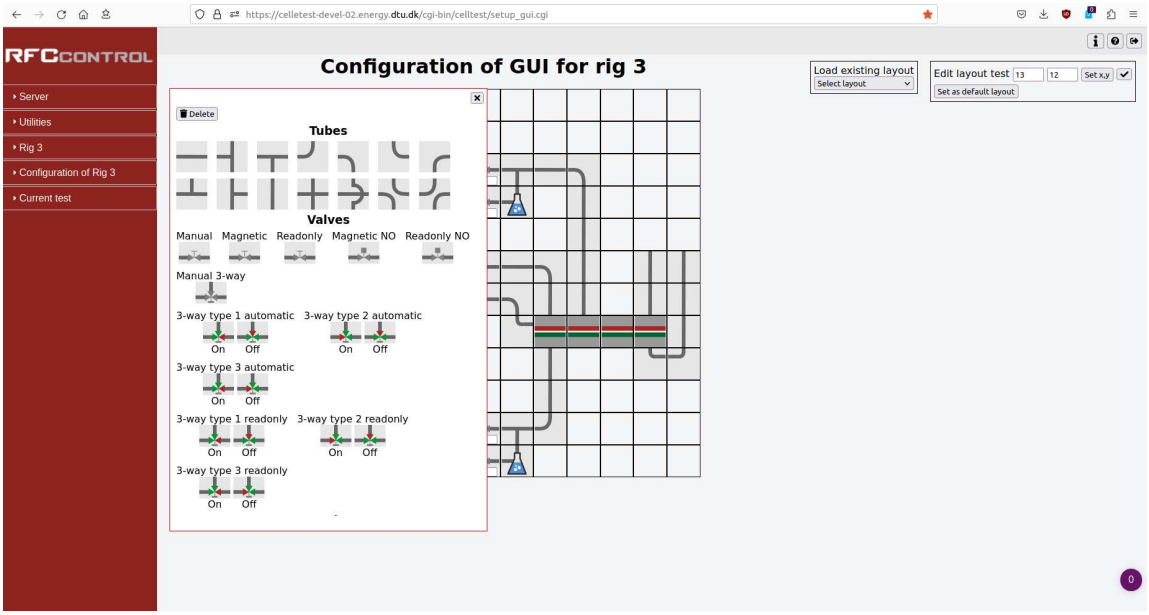


Figure 2.4: Example of how a the setup of a custom main page may look like.

The setup system consist of a tile area where the number of avaliable tiles can be controlled in the upper right corner (and where the template is also given a name). Note that all custom rig man pages must have a unique name.

Once the number of tiles are chosen, the individual tiles can be changed by clicking on a particular tile. This will bring up the toolbox shown in figure 2.4 where the desired tile can be chosen. Some tiles require individual configuration (typecally to bind them to individual devices - refer sections 5 and 12).

Once a design has been configured and given a name, it can be saved (press the check-mark in upper right corner) and if the save is successfull, the template can be activated by pressing the 'set as default lauout' button. This will set the default_layout key in the userinterface seciton in the rigs configuratio file to the slected layout and pressing the main page option in the sidebar will now point to the custom layout like the one shown in figure 2.5.

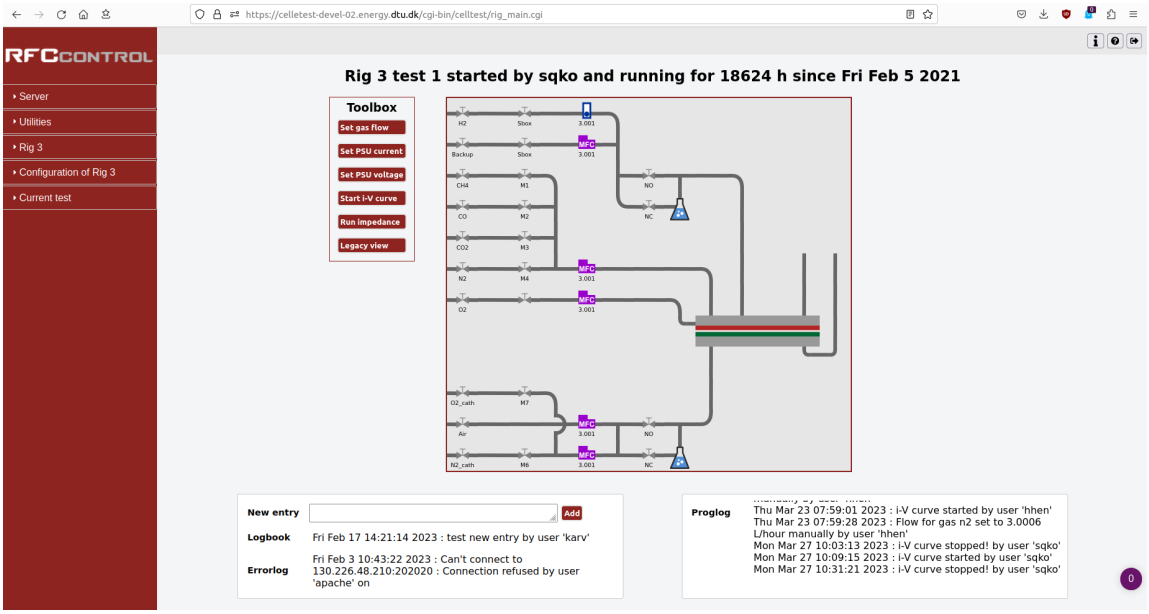


Figure 2.5: Example of what a custom rig control page may look like.

Notice that any custom created rig main pages will likely need to be manually updated if changes in the rig's hardware configuration occurs as opposed to the default main page which should work with most configurations. Thus it is only advisable to create custom layouts for fixed systems where changes in the system hardware is unlikely or prohibited.

2.2 Running i-V curves

As RFCcontrol is designed to be used for testing of fuel cell and electrolyser cells, it has a built-in functionality for acquiring i-V curves. An i-V curve is defined as a sequence of measurements at different DC currents through the device under test. Usually an i-V curve starts at zero current (OCV) and then gradually increase the DC current until a certain limit in either current density or voltage has been reached.

In order for the build-in i-V curve acquisition system to work, the following prerequisites

must be met.

- A simplechannel device measuring the device voltage (returning the voltage in mV).
- A simplechannel device measuring the DC current through the device (in A).
- A unipolar DC power supply controlling the DC current through the device. Notice that in case a bipolar PSU is used, it needs to be encapsulated in a PSU_B2N device which emulates a unipolar PSU in conjunction with a switching relay.
- A Templog device measuring the device temperature.

As RFCcontrol expects a normal fuel cell or electrolyser with a mixture of hydrogen and water vapor on one side and air on the other, thus the cell voltage is expected to be around 1000 mV at zero current (OCV). If this is not the case, the i-V curve program may abort prematurely as it would suspect something wrong if the cell voltage is not in this approximate range (700 to 1300 mV).

This abort mode is primarily intended to protect the device under test if something unexpected occurs during an i-V curve resulting in loss of cell voltage. If the device voltage is not in this range at OCV, it may be necessary to create a filter device which either adds/subtracts and/or multiplies some fixed value to the true device voltage to emulate a OCV of approx 1000 mV and then use this device as the voltage measure device in the i-V control setup (refer section 6.2).

The way the i-V curve program operates is that it first measures the cell voltage a few times and then slowly increase the DC current and measures the voltage and current along the way. As it assumes a normal unipolar PSU, it can not in advance know if the device is tested as a fuel cell or as an electrolyser, it only detects this once it measures the DC-current (and thus the sign). RFCcontrol assumes that the current through the device is positive if the device is run as a fuel cell and negative if the device is run as an electrolyser. Thus once the current is 5 times the minimum defined (the epsilon value, refer section 6.2) it checks the sign, and if the current is negative the program proceeds assuming that the device is run as an electrolyser (and thus that the device voltage increases for increasing (numerical) current. If the current is positive the i-V curve program assumes the device is tested as a fuel cell and that increasing the current will result in a decreasing device voltage.

Once the i-V curve program determines that the current limit has been reached or that the device voltage exceeds one of the defined limits (either electrolysis_limit_voltage or voltagelimit_iv, refer 6.2), the current is gradually decreased again towards no current condition (OCV) and once the OCV condition has been reached the i-V curve program exits.

An i-V curve can be started either from the rig main page or from a sequential program.

2.3 Setting up a sequential program

By pressing the 'Program sequences' button, the user may set up a custom program of sequentially executed commands. These commands may be changes in gas flows and/or composition, temperature, DC current through the device or AC impedance measurements (using the Elchemea© software package running on a separate server). In figure 2.6 the program set-up page is shown.

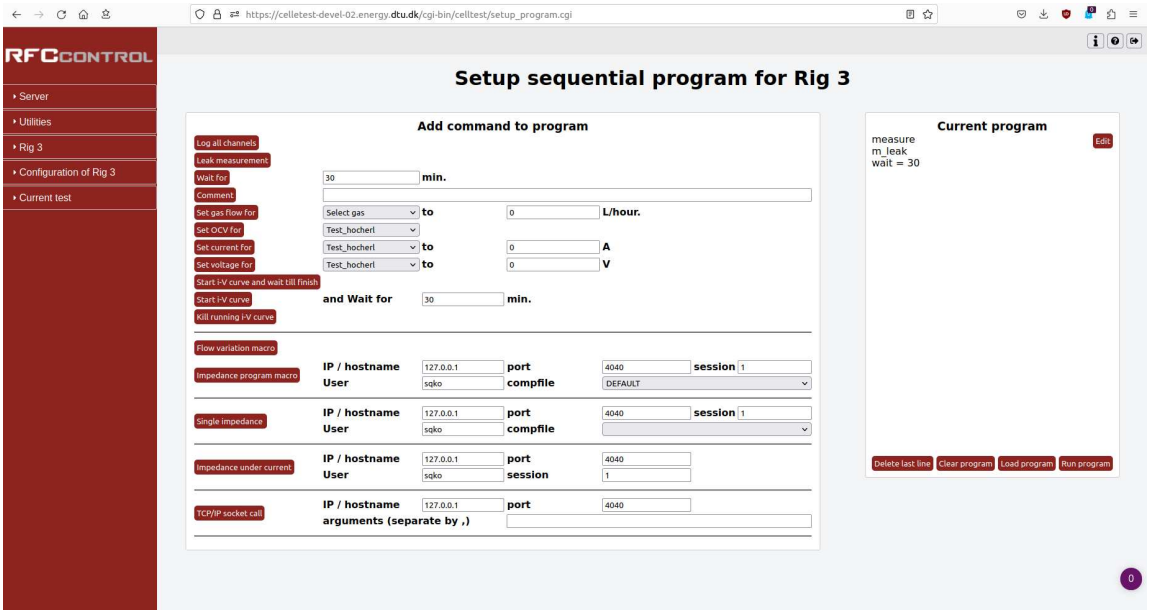


Figure 2.6: Example of a sequential program setup page.

Apart from setting up new programs, it is possible to load old programs for new execution. It should be noted, that a loaded program can be edited before execution and that all executed programs are saved for later analysis/documentation. The text box on the left shows the currently selected program and the buttons on the center of the page is for adding the indicated actions with the parameters as defined by the right text fields.

If a program is already running, pressing the 'setup program' button on the main page (refer figure 2.3) a page resembling figure 2.7 will be shown. This page will show the current program being run, and makes it possible to terminate the running program.

Only the impedance and TCP/IP socket call set-up will be addressed further as the rest of the actions are self explanatory. In order to start an impedance, one must do the following: First connect the Elchemea systems frequency response analyzer correctly to the device under test. The exact set-up may wary, and it is always a good idea to run a manual impedance sweep to ensure that all cables are connected properly before attempting to run automated sequences including impedance sweeps. Once the connections are approved (that is a continuous spectrum can be obtained), the Elchemea© system must be connected to the network (press the 'connect to net' button on the Elchemea© user interface) and note the IP-address and the server port (default is 4040). Similarly, note the session number and the Elchemea© user name of the rig in question. These four values: IP-address, Server port, user name and session number, must then be input in the appropriate fields on the set-up page.

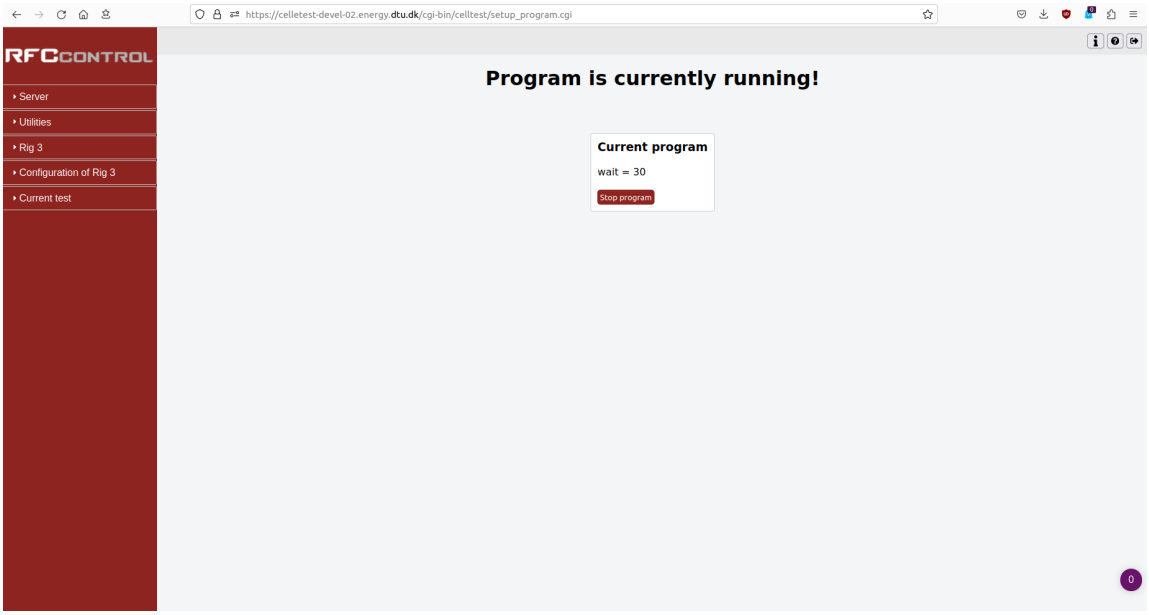


Figure 2.7: What the setup program page will look like if a program is already running.

2.3.1 Execution of external programs

If execution of external programs has been enabled by the system administrator it is possible to execute programs not affiliated with RFCcontrol. These programs must recide in /usr/local/bin/celltest/user_exec/ (see section 4). In a fresh RFCcontrol installation, execution of external programs are not allowed as execution of untrusted code poses a security risk (for instance, consider the implications if the following shell command is executed by a script: 'cat /etc/passwd — mail hacker@crack.com'). 2 default external programs are included by RFCcontrol however (and alredy recide in the correct directory). Those programs are:

- sleep.pl: This program does what is says on the label, It merely sleeps for specified number of minutes.
- fastlog.pl: This program behaves like the fastlog.pl and fastlog_rig.pl programs described in section 10. However the syntax is slightly different as described below: fastlog.pl $rig –time=$minutes –sleep=$seconds [device_type device_name] (where $rig is the rig number and $minutes is the total time the fastlog program is to run and $seconds is the interval between measurements). The data are automatically stored in the test directory (as fastlog_rig.pl) however the device tyoe must be specified for each device that is to be measured individually.

2.3.2 Custom TCP/IP socket calls

A special command is the TCP/IP socket call. This command enables the RFCcontrol system to access other servers/systems through a TCP/IP socket. Apart from specifying the IP / host-name and port of the external system, a command and potential arguments

must be specified. The actual transmission of the socket call is in the form of a command string terminated with two newline characters. The command string consists of the actual command and any arguments joined together with the tab character (thus making it possible to send commands / arguments containing spaces). The external system then has to parse the supplied command string and any response from the external system is simply treated as text and is appended to the rig's program log.

This functionality enables the RFCcontrol system to communicate with other systems if they accepts command through a TCP/IP socket interface.

2.4 Setting up a test

In order to set up a test the configuration of the rig must first be completed (refer chapter 5 and 6). After the configuration is checked for errors (that is the automated system is up and running and the servers are all running, refer chapter 8) the new test can be started from the user interface with one important exception.

In order to make sure that the data logging system is always running, the GUI is not responsible for running the data logging. Instead the data logging is run by cron. Thus the crontab file for the rig in question must contain the following lines (the arguments to the individual programs may be different as may be the time intervals):

```
#### Must always run ###
0 * * * * /usr/local/bin/CGI-server 12 > /dev/null 2>/dev/null &
# PID control programs and custom alert triggers
* * * * * /usr/local/bin/celltest/PID_fast_control.pl 12 &
* * * * * /usr/local/bin/celltest/PID_slow_control.pl 12 &
* * * * * /usr/local/bin/celltest/Check_alert.pl 12 &
* * * * * /usr/local/bin/celltest/Adapter_update.pl 12 &
#### END ###############

########## Data logging commands #####
*/15 * * * * /usr/local/bin/logfile.pl 12
*/15 * * * * /usr/local/bin/cnv.pl 12 60 > /dev/null 2> /dev/null &
##### END ##########################

#### Daily updates of web pages and graphs ####
31 1 * * * /usr/local/bin/cnv.pl 12 0 midnight > /dev/null &
32 1 * * * /usr/local/bin/jdata.pl 12 > /dev/null 2> /dev/null &
33 1 * * * /usr/local/bin/history-plot 12 > /dev/null 2> /dev/null &
34 2 * * * /usr/local/bin/get_all_impedance 12 > /dev/null 2> /dev/null &
#### END ######################################
```

To change the crontab file for a rig, go to the miscellaneous setup page (example shown in figure 2.8) and then press the 'scheduler' tab (upper right). This will bring the user to an editor allowing the user to edit the crontab file (for further info on the crontab system, run 'man cron').

An example crontab file is located in */home/celltest/conf/crontab_example.txt*, however remember to change all instances of the string 'XX' with the correct rig number (for instance 5 in case or rig5).

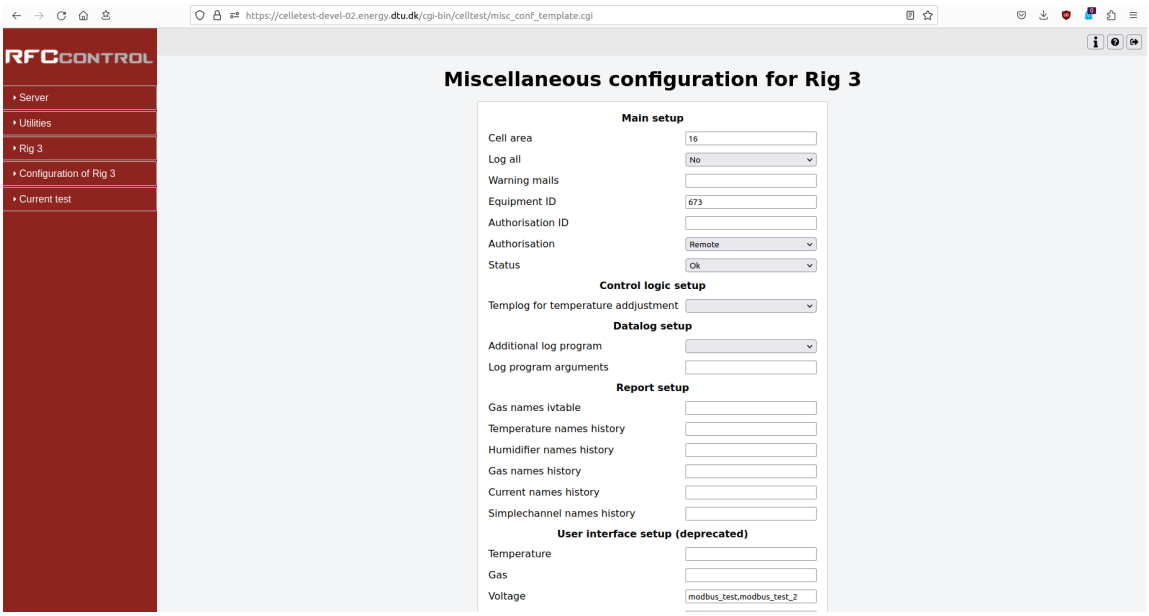


Figure 2.8: The rig miscellaneous setup page. Notice that this page does not concern device configuration.

The crontab system can also be used to run I-V curves at specific times (for instance once a day) or similar time dependent tasks, however to use this functionality, it is advisable to know UNIX® more than in a casual way.

2.5 Creating standard test reports

The cell test software comes bundled with a powerful report generating functionality. Unfortunately this report functionality only works for fuel cell / electrolyser tests and not for normal electrode tests. In order to create a standard test report some knowledge of UNIX® commands are necessary!

A prerequisite for using the report generating scripts described below is that the device naming convention described in section 5.15 have been used.

1. Log in as the rig in question. E.g. Log in as rig2 for running reports on rig2.
2. If necessary perform preformatting of the jdata file using *format_jdata.pl $rig $test*.
3. Perform any necessary calculations using *jdata_conv.pl* (For instance if the T_center temperature sensor has malformed data, it may be necessary to rename an other of the temperature sensors to T_center, in effect setting T_center to the value of the other sensor).
4. Run *history-plot $rig $test* to see if the jdata file contains excessive data after the test has been finished. If so, delete the extra lines in the jdata file and rerun (Hint:

use /usr/bin/head and /usr/bin/tail to find and extract the usable part of the jdata file). Rerun *history-plot $rig $test* and check that the plots now look as expected.

5. Create a preliminary list of I-V curves by running *make_iv_curves.pl $rig $test* where $rig and $test are the rig number and test number in question Note that the program checks that you are logged in as the correct user!

6. Once make_iv_curves.pl has finished, point your web browser of choice to the data presentation part of the cell test user interface and check that all I-V curves has been processed and that all the I-V curves has meaningful data in them. Some of the processed I-V curves may have been aborted ones (e.g. if the power supply was not connected due to a relay under voltage situation etc.) and in this case the 'max current' will be reported as 0. Note all the I-V curves which must be removed from the final report (that is, note each I-V curve number that must be removed).

7. Make a backup of the ivcurvetimes file located in the tests directory (found in the rig's home directory. E.g. */home/rig2/2test45/* in the case of test 45 on rig2).

8. Edit the ivcurvetimes file and remove the lines that represent the I-V curves which must be removed. It is a good idea to start at the bottom and work towards the start, as the line numbers changes when deleting a line!

9. Rerun *'make_iv_curves.pl'* and check that the resulting I-V curve data all have meaningful data in them, if not repeat step 8.

10. If the i-V curves still do not run properly, check the 'epsilon' key in the 'IV_control' section in the configuration file (note the backed up version in the test directory, not the main configuration file). This key specifies which current threshold is used (the current threshold is the value below which the current is assumed to be 0, that is the PSU is disconnected and the cell is in OCV). If this key have a too low a value compared the the measured values of the current at open circuit conditions (as you can never measure 0 A with a current shunt), the *make_iv_curves.pl* program can not determine OCV and the calculations fail. To fix this edit the configuration file and specify a more sensible value for 'epsilon'.

11. Run the *make_report* program which generates the actual report. In the case of test 45 on rig 2 the command would be *make_report 2 45*.

12. The make_report program is interactive and at times asks for further information. Most of this is self explanatory except the part where I-V curves must be selected for the flow variation figures. In this case an Emacs session is started for both the air variation and for the hydrogen variation and in each case up to three I-V curves must be selected (by removing all the other) to be included. Note that in order to make the figure keys consistent, the lines must be rearranged so that the flow values is listed in increasing order. Note that the whole lines must be moved and not only the flow values (thus maintaining the internal integrity of the lines)!

13. Finally the actual LaTeX report is written (this is initialized when make_report asks about the author of the report). Supply the requested information. In some cases

Macro information may be supplied, and in this case writing the specified letter followed by a colon will include the whole string represented by that letter (saves typing). The manually input information is saved in the *report_information.txt* file in the tests public directory (*/home/http/html/rig2/2test45/report_information.txt* in the case of test 45 on rig 2). The information in this file may later be changed and the report can later be updated with this new information by running the *remake_latex_report* program with the –recompile option. Note that when changing this file it is advisable to use the nano editor, as Emacs tends to handle the different carriage returns wrongly (that is not displaying everything correctly).

14. Review the finished report from the user interface by pressing the 'search reports' button and search for the specified test number.

15. If errors are found, manual edit can be necessary. The LaTeX file is located in the web directory of the test in question, and edit the file in order to fix any errors. Note that at any time *make_report* or *remake_latex_report* is run, the LaTeX file is overwritten, so it may be a good idea to save a edited LaTeX file under a different name! Also note that in order to be able to access any postscript file created by a manually edited LaTeX file, the resulting PS file must be moved to (and overwrite) the PS file in the test directory in the rig's home directory.

16. If only changes in the figures are necessary, the figures may be changed and a new report created by running the *remake_latex_report* with the --recompile option (e.g. *remake_latex_report 2 45 --recompile* in case of test 45 on rig 2, note two '-' in front of 'recompile'!).

17. Finalize the report by execute the *set_finish* program so that other users knows that the report is ready for wider circulation (e.g. *set_finish 2 45* in case of test 45 on rig 2).

Chapter 3

Installation and system maintenance

This chapter describes how to install or upgrade a RFCcontrol system.

3.1 Requirements

In order to install the RFCcontrol system, the following must be available:

- Ubuntu version 22.04 or later. It is possible that RFCcontrol - DTU Energy RFC-control control software will install on other Linux operating systems, but it has not been tested.
- Perl version 5.38 or later.
- An Apache web server running with document root in */home/http/html*. The reason for the non-standard location is that all measured data has to be stored and accessible by the web-server and storing all that data in /var is likely not advisable (as most backup utilities usually defaults to only backing up /home on daily basis).
- Gnuplot version 6.0 or later.
- Gnu make or similar functionality
- an update locate database (to update the locate database manually run */usr/bin/updatedb* as root
- A functioning connection to the Internet. The reason for this is that the RFCcontrol installer downloads and installs additional Perl modules from CPAN.org.

3.2 Installation

3.2.1 preinstallation

As RFCcontrol uses a few non-standard settings as compared to a vanilla Ubuntu the following steps must be performed before installation of the actual RFCcontrol software.

- Create the root RFCcontrol user (usually called sofc or rfc). Notice that as RFCcontrol rig users user id's are calculated as follows, no normal users may have user id's between 1100 and 1500 as described below: The user id for a rig user is the rig number + 1100, thus rig25 wold get user id 1125. If the 'base_userid' key in the 'main' section in the RFCcontrol configruation file is set, this value is used instead of the default (1100)
- Move the document root for the Apache web-server to /home/http (cgi-scripts will thus reside in /usr/lib/cgi-bin/ and HTML documents in /home/http/html).
- Make Apache part of the group for the RFCcontrol user (edit /etc/group and add apache to the correct group id).
- Edit /etc/apache2/apache2.conf and make sure that the Apache server is set to start as the RFCcontrol group (refer previous step). Also update the document root specified in the file to point to /home/http.
- make sure that TCP:IP port 2020 and 4040 is open to connection (refer your operating system manual). Port 2020 is used by the password server / ssl server and port 4040 is used by the report server which also handles server intercommunication regarding which rigs are on which servers. As of version 6.0 this may no longer be nescesarry as a number of webservices replacing the password and report servers are avaliable through https (refer section 9.1).
- Reboot.
- Make sure that the server can send emails to users and administrators and that the mail transfer agent and mail server allows this. It is possible to install RFCcontrol on a server which is not allowed to send mail (or which may even operate without a network connection). In this case, refer section 15.1.
- Make sure that the system which is to run RFCcotrol is not directly accessible from the Internet but is protected by an external firewall (in addition to the one bundled with Ubuntu itself). The reason for this is that RFCcontrol is not sufficiently hardened to be exposed to the Internet (and the data acquired by RFCcontrol is potentially confidential themselves which in itself would exclude direct Internet access). The system should however be able to contact the Internet to download and install additional software during installation.

Notice that you need to log out of root before you proceed with the instalation as otherwise the .bashrc file for root does not get rerun!

3.2.2 Steps nescesarry for installation on a Ubuntu system

It may be nescesarry to run the following line on system restart in order for root to be able to access files in /tmp (WTF??!!??):

/usr/sbin/sysctl fs.protected_regular=0

3.2.3 GPIB-server

If a Kepco power supply, Keithley scanning multimeter or a Keithley source meter is to be used, install a GPIB communications card. After the GPIB driver to the card has been installed (and verified that it work), download and install the gpib-server software from https://www.elchemea.com/gpib/

3.2.4 Install RFCcontrol

In order to install the RFCcontrol - DTU Energy RFCcontrol control software system do the following:

1. Unpack the tar-ball in a suitable location, cd into the resulting RFCcontrol directory.
2. Run *make*.
3. Inspect the output of the make program and resolve any errors.
4. On some systems it may be nescesarry to force install the perl Pod::WSDL module nescessarry to generate the wsdl files used by the webservice interface.
   If so, in a terminal type 'cpan' and then:
   force install Pod::WSDL
5. Also make sure that the web server (usually Apache) is running with document root in */home/http/html*.
6. Once all errors have been resolved, run *make test* followed by *make install*.
7. In order to ensure that all servers start upon system reboot, add the following line to roots crontab file:
   @reboot /usr/local/bin/celltest/start_servers &

On a newly installed RFCcontrol - DTU Energy RFCcontrol control software system, no rigs will be available, and each rig on the system has to be installed manually. To install a rig, simply run the *./create_rig.pl $rig* script in the installation directory followed by the script *./INSTALL_RIG* (the $rig argument must be an integer, for instance to install rig15, run *./create_rig.pl 15*).

Note that on Ubuntu systems you have to run *./ubuntu_create_rig.pl $rig* instead!

If the current system is to act as a list server (for a group of RFCcontrol servers), edit the global configuration file (refer chapter 4) and make sure that the listserver key in the servers section is the host name of the current system and add the host name as well as any other host names of other RFCcontrol - DTU Energy RFCcontrol control software systems in the cluster to the server_names key (separated by comma). If the current system is not intended to run as a list server, simply set the listserver key to the host name of the listserver and leave the server_names key blank.

3.2.5 Installing the password server

If the RFCcontrol system is used alone or the system is to act as a password server as well, follow the steps given below in order to install and configure the password server:

1. edit the configuration file (/home/celltest/conf/celltest_global.conf) and change the 'passwd_server' key in the 'paswds' section to the hostname of this server
2. In the 'servers' section, change the 'listserver' key to the hostname of this server (This is not absolutely necessary, as the listserver does not need to be the same server as the password server, however it is usually convenient to have both on the same server.
3. In the 'servers' section, change the 'server_names' key to the hostnames on this cluster (for a single server system, it will just be the hostname of this server).
4. Remove the line '@reboot /bin/su -c "/usr/local/bin/celltest/RFCcontrol-ssl-server –ssl &" - sofc' from roots crontab file to make sure that it does not start upon reboot as it is not needed on the server acting as password server (it will automatically anyways though).
5. Add the line '@reboot /bin/su -c "/usr/local/bin/celltest/celltest-passwd-server –ssl &" - sofc' to roots crontab file to make sure that the password server starts upon reboot.
6. make sure that your MTA allows the server to send mail (can be tested by running 'echo "Test mail" | mail -s "Test" user@foo.com' , remember to substitute for a proper email address).
7. Run the 'initialise_passwdfile.pl' script in the installation directory and note the initial root password thus created.
8. Reboot the computer and it should be possible to log in using the password created in step 7.
9. If it will not be possible to send emails from the server proceed to step 13.
10. Connect the computer to the Internet so that mails with new users passwords can be sent.
11. Create at least a single non-superuser user for normal operation of the RFCcontrol - DTU Energy RFCcontrol control software system and assign correct permissions.
12. Installation should be complete.
13. Use the script create_user.pl found in the installation directory to create non-superuser accounts (note the passwords assigned to each user).
14. Check that the created users thus created can log into the RFCcontrol system.

3.3 maintenance

Generally RFCcontrol requires little maintenance, however make sure that a proper backup / restore procedure is in place, as any data logged by the RFCcontrol system is likely costly in time and / or money and thus should not be lost by hardware or software failures.

The RFCcontrol system includes a facility for automatic software updates. To enable this, simply add the following line to root's crontab file:

*0 8 * * 1 /usr/local/bin/celltest/celltest_updateer.pl ≫ /root/update_log.txt &*

This will update the system once every Monday (thus leaving several working days to fix things if anything went wrong). The automatic update system then fetches any new version which may have been deployed within the last week and installs this if it passes the software test (*make test*). Thus it will not install any new software if mangled configuration files exists, or if the new software version is incompatible with the existing configuration files.

Additionally it may be advisable to add the following line to sofc's crontab:

*0 1 * * * /usr/local/bin/mail_errors.pl*

This will ensure that all users listed in the errormails key in the global section in the global configuration file (refer chapter 4) will receive a mail each day if errors were logged during the previous day. The mail will contain an extract from the error file (*/home/celltest/error.txt*).

3.4 Restricting access to raw data

RFCcontrol can operate in several different modes depending on what restrictions to the raw data is required:

- No restrictions: Al users that can access the webserver can view all data (this is the default for a freshly installed RFCcontrol system).
  Requires that the data_access_authorisationid key in the global section is not set and that any .htaccess files in the webserver directories does not restrict users (see section 3.4.1).
  In addition, the only_allow_explicit_data_access in the global section must be set to no or not be set. This allow users to dorectly access the data on the webserver bypassing all RFCcontrol software and access the raw data files directly. This also makes it easier to configure and debug data logging etc. as all data will be visible at all times.

- Restriction is on the server level: That is a user can either view all data or not view any data on the server. In this case the data_access_authorisationid key in the global section must be set to the specific authorisation(s) id that is to manage if users have access or not. In addition, htaccess files must be setup accroding to the formati described in section 3.4.1 and the only_allow_explicit_data_access key in the

global section must be set to no or not set. If the user is authorised for one or more of the authorisation is's listed he/she will be granted access.

- Restriction on individual rig level: In orfer to enforce this level of restriction, the password server must honor the following function can_read_data which the password server supplied with RFCControl does not honor. Thus this functionality requires an external password server for login and user authorisation control (see section 4.3.2 for a complete list of passwrod server commands). In addittion, the only_allow_explicit_data_access key in the global section must be set to yes.
- Restriction of users to individual rig and test level: As with restrictions on individual rig level the password server is requires to honor the can_read_data function, but also the can_read_test function and the only_allow_explicit_data_access key in the global section must be set to yes. The way the access restriction works in this case is that first it is checked if the user can view all tests on the given rig, and if not the the individual test permission is checked. This allows for speeding up operation as users who has access to all test data will only have to be checked once and the result cached. If all users currently authorised to operate the rig should be allowed to read all data for the current (active) test set the allow_access_current_test_to_auth_users key in the global section to yes.

In all cases where data restrictions is set up, it should be noted that the user who started a particular test can always view data for that particular test regardless of other restrictions (as he/she is defined as the owner of that test).

3.4.1 Resttricting direct access from webbrowser

A default installation of RFCcontrol allows all users which can access the server through http/https to view all stored data. If this is not desired (due to potential confidential data or similar), it is possible to restrict which users can view the data. This restriction is based on external validation of user access and is handles smilar to external rig validation.

In order tu utilise this system, direct access to the data through the public static web pages has to be disabled.

This is configured by using .htaccess files in all rig web directories (such as /home/http/html/rig1 for instance).

The content of the .htaccess file must be as below:

```
order deny,allow
deny from all
allow from 127.0.0.1
allow from ip.of.server.itself
ErrorDocument 403 /cgi-bin/show_data.cgi?rig=rignr
```

Where ip.of.server.itself is the server public facing IP address and 'rignr' is the rig number (e.g 15 for rig 15). The last line is for facilitate a user friendly redirect to login if users are not trying to access data without beeing logged in.

An exapmle of an .htaccess file can be found in the installation directory

This will allow the server itself to access the data but noone else (and if a user has ssh access to the server he/she will already have read access to the data directly, so this is not a security hole in itself).

This allows the show_data.cgi script to access the data and display them if the user is validated.

In order to configure user access validation see section 3.4

Once this is set up, direct access to the data directories by a web-browser will result in a 403 Forbidden error but users will still be able to access the data but will now have to log in first to do so (and be validated).

3.4.2 Restricting access to data in specific tests

If data for a particular test is confidential or otherwise so sensitive so only a limited number of people should have access and it can not be acomondated by the above described system (for instance if the password server does not honor the can_read_data and can_read_test functions), the restrictions described above can be expanded to only allow particular users to access the specific test data. This is controlled by placing a specific .restrict file in the relevant test directory.

If a .restrict file is placed in the test dir (e.g /home/http/html/rig3/3test5/ for test 5 on rig3) with content as described below, the system will check if the user requesting access is authorised for at least one of the authorisations listed in tha 'allow' key:

```
# To restrict set allow to authiorisation to allow
# uses OR so if user is authorised for one of the
# authorisations in the list he/she is allowed
allow = 132,86
```

(132 and 86 here is just examples of authorisation ID's which could be used)

An .restrict template is located in the installation directory and can be copied to the relevant directories.

3.4.3 Restricting users to view active status of a rig

If users should also not be able to view current data unless they are authorised for the specific rig, then the configuration key restrict_access_auth_only should be set to 'yes'. This wil ensure that users will only be able to see active data if they are authorised.

Note that a user may be authorised to view active status of a rig without beeing authorised to view the historic data!

Chapter 4

Global configuration

The global configuration of the RFCcontrol - DTU Energy RFCcontrol control software contains site wide configuration values which are not rig specific. Below is a section by section description of the configuration file which should only be changeable by the site administrators.

4.1 Global

```
SECTION global
logoutdelay = +10min
splineinterpol = /usr/local/bin/splinterpol
splineinterpoldata = /home/celltest/convert-tables
CGI_baseaddress = 2000
CGI_host = localhost
GPIB_host = localhost
logfile = /usr/local/bin/celltest/logfile.pl
errormails = foo@foo.bar
access_mode = celltest
account_number_regexp =
### Only set allow_exec to yes if you really want users to be ###
### able to execute arbitrary system commands!                ###
allow_exec = no
proxy=http://proxy.foo.bar:proxy_port
account_number_regexp = ^\d{5,}\s+\w\-\w+
remote_equipment_database = https://foo.bar.baz/cgi-bin/database.cgi
logbook_url = https://foo.bar.baz/cgi-bin/logbook.cgi
server_name =
project_number_validate_url = https://url.to.call/path/to/
script/script?action=what_to_test&value=
##
## Data access control
##
## data_access_authorisationid can be used if an external
## validation server is used to restrict
```

```
## which users can view the raw data (if a .htaccess file
##  with the following content is placed
## in each rig's web-dir):
##
## order deny,allow
## deny from all
## allow from ip.of.server.itself
##
## If no value is specified all usrs can view raw data
data_access_authorisationid =
## report_authorisationid can be used to determine which
## users can view post test reports.
report_authorisationid =
## restrict_access_auth_only is used if only authorised
## users for a rig can view the control page
## default is no so all users can view status and add to
## logbook but not change anything.
restrict_access_auth_only = no
## only_allow_explicit_data_access should only be set to
## yes if the external password server
## honors the 'can_read_data' and 'can_read_test' commands as following:
## can_read_data username equipmentid
## can_read_test username equipmentid testnr
## The stand alonw password server supplied with RFCControl
## does NOT support this option!
## It also only works if authorisation is set to 'remote' for
## the rig in question and if
## an equpment ID (integer) is specified in the rig configuration
only_allow_exlicit_data_access = no
## to allow all authorised users to access data for current (active) test set this to yes
allow_access_current_test_to_auth_users = no
#####################################################################
#### GUI_reload_time = 10                                        ###
#### Used if the GUI reload time shoudl be less than the default ###
#### 30 seconds. Note that setting a value too low may cause     ###
#### congestion on the hardware communication busses!            ###
#### Minimum value is 5 seconds                                  ###
#####################################################################
GUI_reload_time = 30
ENDSECTION
```

This section defines global variables and file locations. The individual keys are used internally and should normally not be changed unless you are VERY sure about what you do! The access_mode key specifies two things and can have one of two values: 'celltest' and 'electrodetest'. It defines what information is necessary to start a new test (less in case of an electrode test) as well as which user access parameter is used for user authentication for the rigs. The account_number_regexp key specifies which regular expression (if any) is to be used for verification when a user is starting a new test. If no value is specified, the default regular expression '\w+' is used The allow_exec key specifies if it is possible to run

custom designed programs from the 'set-up program' page (section 2). Only programs placed in the directory */usr/local/bin/celltest/user_exec* are allowed to be executed due to security considerations. A default installation only supplies one program 'test.bash' which can be used to test the option, but it does nothing. All other programs must be custom designed.

CAUTION: Any program placed in this directory can be executed by one of the rig users if allow_exec is set to true, so any program must be designed with security in mind so it can only do what is intended and not be 'hijacked' to do something else.

The default setting of this key is 'no' as allowing the execution of arbitrary programs is a potential security risk (consider what would happen if the program executed was just a wrapper for 'rm -rf .*').
Also notice, that any programs placed in */usr/local/bin/celltest/user_exec* must only contain alphanumeric characters and the '.' and '-' character in the filename (this is necessary for security purposes as the remote program parser rejects any commands that contains anything other than those characters). The CGI_host and GPIB_host keys may be absent and in this case the default is localhost. In most cases the localhost setting is correct, but in some network configurations it may be necessary to set the fully qualified host name instead (e.g. foo.bar.com) The proxy key specifies the hostname and port of a web proxy (if such a system is used) and the account_number_regexp key specifies if users should be forced to use a particular format for project/account numbers when starting a new test. If so, use an appropriate regular expression and define it here.

The remote_equipment_database key is used if a remote equipment database can be used for storing user log entries. The value must be the website address which can handle input of user log entries. The script is called with the following variable parameters: name - username, pass - session token, rig - rignumber, test - testnumber, equipid - ID on the remote system (refer section 6.1), description - string supplied by user. In addition the following fixed paramteter values are also supplied: action=new_maint_log, type=Testlog

The key logbook_url is used in conjunction with the RFC::Main::remote_system_log() function and if it is defined any argument (a text string) passed to the remote_system_log function will be appended to the value of this string and a web request with the resulting text string (which should resove to a url) will be initiated. This can be used for appending text messages to any remote logbook system as long as it allows web access. See the documentation for the RFC::Main module for more info.

The tag 'server_name' can be used to supply a more human readable name for the server when displaying it on overview pages and butttons etc.

The tag 'project_number_validate_url' can be used if validation of project numbers can be done on remote site. The content of the project number field on the start new test page is appended to the url string as is the login information (name and pwd hash) and an ajax request is sent to the specified URL. If the response is 'OK' nothing more happens but any other response triggers an alert box with the content. Please note that this validation is merely advisory, as a failure does NOT prevent starting a new test.

The 'GUI_reload_time' key can be used to set the interval for refreshing data on the

GUI. Please note that setting a too low value may cause congestion on the hardware communication. This is especially the case if a single server is servicing multiple rigs!

4.2 Admin

```
SECTION admin
system_mail_users = foo@foo.bar
ENDSECTION
```

The admin section contains a key with a comma separated list of email addresses of the site administrators who is to receive system error mails.

4.3 Passwords

```
SECTION passwds
passwd_server_port = 2020
passwd_server = host.domain
force_encryption = no
#ignore_soap = no
#wsdl = wsdl_file_location
### NB only used in standalone mode ####
passwdfile = /home/celltest/passwd
passwdlock = /home/celltest/pwd.lock
sso_url =
sso_logout_url =
ENDSECTION
```

The passwd section contains the information necessary for user authentication. Two modes of user authentication exists. Either a local password server must be running (using a very primitive flat file database using the Perl Tie module, described below) or a full fledged RDBMS database must be running which handles user authentication. In the first case the software is included (must be configured to run at system boot up) and in that case the passwdfile and passwdlock entries must contain valid file locations. The passwd_server key contains the DNS name of the server running the password server. The passwd_server_port key contains the port number of the server program (must correspond to the port the password server program binds to especially in the case of an external authentication server). The force_encryption key (if set to yes) specifies if RSA encryption is to be used at all times (both by any server running, but also by any client calls to a potentially remote password server (refer section 4.3.4). The wsdl key specifies where the wsdl file for password server access is to be retrieved. Default is in /wsdl/session.wsdl on the web server hosting the password server

Irrespective of authentication method (either local flat file database or full RDBMS) the authentication of user login proceeds as following:

1. User initializes a new session and supplies user-name and password.
2. If user-name and a hash of the supplied password matches the hash stored in the database (not no plain-text passwords are stored) log-in proceeds otherwise the user is not authenticated. Note that it is only for new sessions that the actual user password is needed as explained in the following steps.
3. A hash is calculated based on the stored password hash and a randomly generated string (session key). This hash is returned to the application and is used as a session key unique to this session and the user in question. The random session string is stored in the password server.
4. All further session traffic is validated against this session hash as the password server can calculate what the hash should be and compare with the user supplied session hash.
5. If the user logs out, or too long time passes before a new command is passed, the session key is deleted and a new session has to be initialized as all further authentication with the old session hash will not validate.

Earlier versions of RFCcontrol used the crypt() function, but from 4.6.1 onwards, the local password server uses the bcrypt() function which uses the EKS-Blowfish algorithm as the crypt function is no longer secure.

Irrespective of user authentication method, the active password server must honor all the commands in list 4.3.2 through TCP-IP socket calls: arguments must be separated by a tab character and requests terminated by two newlines as shown in the example below where the actual string transmitted is shown (in the case of a server which does not use encrypted communication, see 4.3.4):

Client sends:

```
isuser\ttest\n\n
```

And the server would send back something like

```
34\n\n
```

assuming user test had user id 34.

4.3.1 Single sign on from multiple test stations

If single sign on is to be used, all the servers which uses this must be configured to use the same password server. Since the communication between the client and server can be encrypted, it is possible without exposing user-names and/or passwords assuming that the web-server only uses ssl (that is that users can only access the test station using https).

In order to configure multiple test stations for this, make sure that all the test stations are configured to use the same server for password authentication. Additionally they should properly also use the same list-server for convenience.

One thing to remember is that for single sign-on to work reliably, the network configuration for the individual test stations should be set up to use proper individual DNS host names (so not all systems identify themselves as 'localhost').

The keys sso_url and sso_logout_url can be used if the password server is itself part of a SSO solution (for instance by using mod_auth_cas). In this case the sso_url key should point to the url used for logging in on the password server and the sso_logout_url should point to the url used for logging out of the SSO solution (this url may or may not be the same host as the passowrd server!

The sso_url should expect the return address to be found in the added 'dest' parameter in the form of a BASE64 encoded string. It should also return with the following parameters set: name (the username) pass (the sesion hash).

4.3.2 List of password server commands

- new_session: Initializes a new user session, arguments: username password. Returns a session token if successful, 0 otherwise
- checkuser: Checks that the user is properly logged in, arguments: username token. Returns the user-id if OK, 0 otherwise. Updates the 'last_login' field so that the users session is extended.
- checkuser_sso: Arguments: username token. This command works like the checkuser command except it allows the option of using single-signon in collaboration with Non-RFCcontrol systems (refer section 4.3.6). Thus if the user is not logged in to RFCcontrol, but is logged in to some remote system which can be used for single-signon, and the password server can verify that the supplied user credentials are valid (username and token is valid), a new local RFCcontrol session is created. If the user is authenticated by at least one of the remote resources the userid as well as a new session-token is returned (userid and token is separated by a newline). The session token is used in the same way as the ones returned by new_session. If single-signon is not enabled, this command always returns 0 followed by a newline (user denied access) - the newline is added to comply with the API for valid login.
- pwdstatus: Checks if a session is valid and returns 'RESET' or 'EXPIRED' instead of the user-id if the session is valid but the user password has been reset or too long time has passed since last password change, arguments: username, token.
- is_logged_in: Checks if a user is already logged in, arguments: username. Returns 1 if user is logged in, 0 otherwise. A user is logged in if the users record in the password database has a session key set and that it is not too long since the user performed an action which required validation through the checkuser command.
- logout_user: Logs out a specific user, arguments user-name. This command removes the users session token, thus making all further uses of that token invalid

- get_users: Returns a list of users on the system, arguments: username token.
- is_user: Checks if a specific user exists, arguments: username. Returns user-id if the user-name exists, 0 otherwise.
- is_admin: Check is the user is an administrator, arguments username token. Returns 1 if user is administrator and session is valid, 0 otherwise.
- adduser: Adds a new user to the system, arguments: username, real_name, [opt email]. If no email address is specified, the default address will be username@dtu.dk. After user creation a new password will be sent to the users email.
- adduser_nomail: Adds a new user to the system, but instead of sending a email with the new password it is returned to the caller. Arguments: user-name, real_name.
- deleteuser: Deletes a user from the system, arguments: administrator_username token, username. Notice that the user record is not deleted, the user is merely set inactive (and is thus unable to log in).
- root_access: Sets or removes superuser status for a user, arguments: administrator_username, token, user-name, status. Status is 1 for root access and 0 for normal user.
- user_auth: Sets use permission for a specific key for a specific user, arguments: administrator_username, token, username, key, permission.
- changepwd: Changes the users password to a new value, arguments: username, token, new_password.
- resetpwd: Resets a users password, arguments: administrator_username, token, username.
- checkauth: Checks if a user has permission for (one or more) specific key(s), arguments: username, token, [key, min_permission]... Returns the user-id if the user has at least the requested permission for the specified keys.
- multiauth: Checks for a uses permissions for multiple keys, arguments: username, token, [key, min_permission]... As opposed to checkauth, multiauth returns a list with success status for each individual check (each check separated by newline).
- email: returns the mail address for a specified user, arguments: username.
- exit: Shuts down the password server.
- get_per: Checks if a user has permission for a specified key, arguments: username, token, key, min_permission. Returns the user-id if the user has at least the requested permission for the specified key.
- get_admin: returns the administrator status for a specified user, arguments: administrator_username, token, username.

- debug: turns debug on or off.
- ping: Returns a string containing the server name as well as other information.
- check_task_status: Checks the status for a user in respect to a particular safety regulation (refer section 4.4), arguments: user-name, task-id.
- check_task_cert: Checks if a user is certified in respect to a particular safety regulation (refer section 4.4), arguments: user-name, task-id. A certified user is allowed to authorize other users to the same regulation and is automatically also authorized.
- is_ssl: Returns 1 if RSA cryptography is to be used for password server communication. Note can be used unencrypted (does not expose secret information).
- public_key: Returns the RSA public key for the server. Note that this command can only be used unencrypted (as it is necessary to know the public key before encryption can proceed).
- logout_delay: Returns the maximum number of seconds between actions before uses are automatically logged out. Note can be used unencrypted (does not expose secret information).
- equip_cert: Checks if the specified user is certified for the specified rig. A user is certified if he/she is certified for all safety id's attatched to the rig and which are defined to require certification. Arguments: username equipmentid **Note that this funciton is NOT supported by the password server supplied with RFCcontrol, the only reason for it beeing mentioned here is for the API syntax to be defined!**
- equip_auth: Checks if the specified user is authorized for the specified equipment. A user is authorised if he/she is authorised for all safety id's attatched to the rig. Arguments: username equipmentid **Note that this funciton is NOT supported by the password server supplied with RFCcontrol, the only reason for it beeing mentioned here is for the API syntax to be defined!**
- list_equip_auth: returns a list of id's nescesarry for a user to be authorised to use the rig. Is intended to be used to find out which safety authorisation(s) a user needs before he/she can use the rig. Arguments: Equipmentid **Note that this funciton is NOT supported by the password server supplied with RFCcontrol, the only reason for it beeing mentioned here is for the API syntax to be defined!**
- can_read_data: Returns true if the specified user can read all data for all tests for the specified equipment ID. It is intended to be used if detailed control over which users can read which test data. The equipmentID in question has to be defined in the rig configuration. Arguments: username, equipmentid **Note that this funciton is NOT supported by the password server supplied with RFCcontrol, the only reason for it beeing mentioned here is for the API syntax to be defined!**

- can_read_test: Returns true if the specified user can read data for the specified test and equipment ID. It is intended to be used if detailed control over which users can read which test data. The equipmentID in question has to be defined in the rig configuration. Arguments: username, equipmentid, testnumber **Note that this funciton is NOT supported by the password server supplied with RFCcontrol, the only reason for it beeing mentioned here is for the API syntax to be defined!**

4.3.3 Additional local password server commands

In addition to the above commands, the local password server (/usr/local/bin/celltest/ celltest-passwd-server) also accepts the following commands for manipulating safety regulations:

- new_task: Creates a new safety regulation. Arguments Name_of_regulation.
- task_name: Gets or changes the name of a safety regulation: Arguments: user-name, token, id, [opt new_name].
- task_valid: Gets or changes the valid status of a safety regulation: Arguments: user-name, token, id, [opt new_status]. Users can only be validated against valid regulations (validation against an invalid regulation always fails).
- get_tasks: Returns a list of safety regulations (id numbers) separated by newlines. Arguments: user-name, token.
- get_task_names: returns a list of safety regulations separated by newlines, each item contains the id number and a tab-character followed by the nam e of the regulation. Arguments: user-name, token.
- set_task_cert: Sets a particular user to be certified for a specific safety regulation. Arguments: user-name, token, user-name_of_user_to_certif y, regulation_id. returns 1 on success, 0 or -1 on failure.
- set_task_auth: Sets a particular user to be authorized for a specific safety regulation. Arguments: user-name, token, user-name_of_user_to_autho rize, regulation_id. returns 1 on success, 0 or -1 on failure.
- rev_task_cert: Removes the certification for a user for a specific safety regulation. Arguments: user-name, token, user-name_of_user_to_remove, regulation_id. returns 1 on success, 0 or -1 on failure.
- rev_task_auth: Removes the authorization for a user for a specific safety regulation. Arguments: user-name, token, user-name_of_user_to_remove, regulation_id. returns 1 on success, 0 or -1 on failure.
- list_cert: Returns a list of user-names which is certified for a specified safety regulation. Arguments: user-name, token, regulation_id.

- list_auth: Returns a list of user-names which is authored for a specified safety regulation. Arguments: user-name, token, regulation_id.

4.3.4 Encrypted communication

It is possible to use encrypted communication between the password server and the clients. To enable this, start the password server with the –ssl argument. The reason for this is that the password server handles information which must remain secret (namely the users passwords) and thus greater protection is warranted.

If encryption is enabled, some additional steps are added to all all communication between the password server and any clients (irrespective of origin, even local requests will be encrypted):

1. If the 'force_encryption' key (refer section 4.3) is set to yes, proceed to step 3.
2. check if server is using encryption: This is performed by doing an unencrypted 'is_ssl' request. If The 'is_ssl' call returns anything but 1, encryption is disabled for this transaction and communication proceeds according to section 4.3.2 with plain-text strings.
3. The client checks if it knows the public key of the server. This is done by look-up in the known_hosts file. If the key is known, proceed to step 5
4. Get the servers public key and store it in known_hosts. The key is retrieved by issuing an unencrypted 'public_key' request (no need for encryption to get the public key as it is intended to be known to the public).
5. If the server request string is shorter than 32 characters in length, proceed to step 11
6. Create a random string containing 32 chars and use this as a key for the AES symmetric cipher.
7. Encrypt the server request using Crypt::CBC (using AES) and this key and base64 encode the resulting ciphertext.
8. Encrypt the AES key using Crypt::OpenSSL::RSA and the servers public key and base64 encode the resulting encrypted key.
9. Create the transmit string the following way: first the encoded key, then an underscore and then the encoded command followed by two newline characters (an underscore is used as separator as the RFC 2045 used by MIME ensures that this character can not by accident be included in a base64 string).
10. Transmit this string to the server and proceed to step 13.
11. Encrypt the real server request string using Crypt::OpenSSL::RSA and the servers public key.

12. Base64 encode the resulting string and send it to the server (to make sure that transfer over the network does not mangle the binary string resulting from the encryption).

13. The server checks if it knows the public key of the client, if so proceed to step 16

14. The server does a reverse public_key request. This must be serviced by either the password server if a local request is serviced or the RFCcontrol-ssl-server if a remote request is serviced (one of the two servers must run on a RFCcontrol server if encryption of password server intercommunication is used).

15. The server stores the client's public key in the servers known_hosts file.

16. the server examines the string and determines if an underscore is present, if not proceed to step 20

17. The string is split up in two parts by the underscore, the first part is the key, the second part is the command.

18. The server reverses the base64 encoding on the key and decrypt it using it's private key.

19. The server reverses the base64 encoding on the command and decrypts it using the decrypted key and the Crypt::CBC module (using AES), then proceed to step 21

20. The server reverses the base64 encoding and decrypts the message using it's private key.

21. The server processes the resulting request according to section 4.3.2.

22. If the result is less than 32 chars in length, proceed to step 28

23. Create a random string containing 32 chars and use this as a key for the AES symmetric cipher.

24. Encrypt the result using Crypt::CBC (using AES) and this key and base64 encode the resulting ciphertext.

25. Encrypt the AES key using Crypt::OpenSSL::RSA and the clients public key and base64 encode the resulting encrypted key.

26. Create the transmit string as in step 9.

27. Transmit this string to the client and proceed to step 30.

28. The server encrypts the response using the clients public key.

29. The result is base64 encoded and transmitted back to the client.

30. the client examines the string and determines if an underscore is present, if not proceed to step 34

31. The string is split up in two parts by the underscore, the first part is the key, the second part is the result.
32. The client reverses the base64 encoding on the key and decrypts it using it's private key.
33. The client reverses the base64 encoding on the result and decrypts it using the decrypted key and the Crypt::CBC module (using AES),then proceed to step 35
34. The client reverses the base64 encoding and decrypts the message using the clients private key.
35. The client returns the decrypted response to the user or program requesting the information.

Notice that the key exchange only happens once for each client. Once the public key has been retrieved, it is used for all future requests. Thus if for some reason a server has to be reinstalled or otherwise changed, remember to delete the corresponding entries in known_hosts or communication will fail! (This is similar to how the ssh program behaves). The is_ssl request is also cached and is reused if the client program needs to do more than just a single request to the server. However each new invocation of a program or script which uses the password_client function in RFC::Main will call 'is_ssl' at least once, except if the 'force_encryption' key is set to yes, in which case the 'is_ssl' request is unnecessary and is skipped.

Also notice that if encryption is enabled on the password server, only the three last commands in list 4.3.2 can be used without encryption!

As encrypting an empty string results in gibberis upon decrypting, the server responds with a single space if the true request result in no response or the empty string (the space character will be encrypted following the above description however) and the client will detect this single space and return an empty string instead.

4.3.5 How to run a local password flat-file database server

In order to run the local flat-file password server distributed with RFCcontrol - DTU Energy RFCcontrol control software, the following steps must be followed:

1. If no previous password server has run, execute the *initialise_passwordfile.pl* script found in the installation directory. Caution: Executing this script will erase any prior password file! Note the initial password assignet to the root user!
2. Start the *celltest-passwd-server* script found in */usr/local/bin/celltest/*.
3. log in using the password generated in step 1
4. change the root password to something suitable.

5. Create the normal users and assign them correct permissions (usually celltest - modify). Creation of users can be done from the GUI only if the server is connected to the network **and is allowed to send mail!** If this is not the case, use the terminal program *create_user.pl* found in the installation directory *RFCcontrol.* The password for the new user will then be printed out in the terminal instead of sent by mail (which would never arrive).

6. add the line */usr/local/bin/celltest/celltest-passwd-server &* to */etc/rc.local*

4.3.6 Single sign-on in collaboration with non-RFCcontrol systems

It is possible to use RFCcontrol in a single-sign-on mode in collaboration with Non-RFCcontrol systems. In order to do this the following prerequisites must be met.

- All remote systems types in the collaboration must supply some form of remotely accessible user verification in order to verify if a specific user has a valid log-in session active.
- A special program must be made for each type of system which accepts a user-name and a password-token as arguments and which returns either 0 (user not authenticated) or a true value (usually a user-id) in case the user has a valid session based on the supplied credentials. These programs must be placed in the directory /usr/local/bin/celltest/sso/.
- The RFCcontrol password server must be started with the special switch –sso, which enables the single sign-on option (note 2 dashes).
- All links to RFCcontrol from the external sources must supply a 'name' parameter (the user-name) as well as a 'pass' parameter (which contains the session token from the external system) and these two parameters must be sufficient to verify that the user in question is authenticated.

If these prerequisites are met, it will be possible to make direct links from external web-pages to RFCcontrol without the user having to log in to RFCcontrol (assuming the user has a valid active session on the external system).

Upon receiving a request originating on one of the external systems, RFCcontrol will first try and validate using the local password server system (which will fail) and then a checkuser_sso request will be issued to the password server.

This request will try all the programs in /usr/local/bin/celltest/sso/ to check if one of them returns a true value. If so, the user is assumed to be authenticated by the system related to that program and a new local session is created and the user can proceed as if he / she had just logged in normally on RFCcontrol.

Notice that this feature can be used to completely bypass all security if by some means a program or script is placed in /usr/local/bin/celltest/sso/

which returns a true value (for instance a simple echo command will do this!). Thus the single-sign-on option has to be explicitly enabled by the –sso switch when starting the password server and the /usr/local/bin/celltest/sso directory must only be writable by root to prevent such attacks.

Troubleshooting

If encrypted communication is used for the password server, and one or more of the remote systems uses a similar communication scheme as the RFCcontrol password server (Other RFCcontrol clusters for instance) situations could arrive in cases where a 'checkuser_sso command' is recieved and one of the programs used to check remote systems forces a reverse public key request. In this case a deadlock occour as the reverse public key request can not be processed as long as the current request is running (and that can not finish before the reverse public key has been recieved).

To prevent this, issue a 'isuser' command using the password_client_raw() function in the RFC::Main.pm library to each of the systems from each of the other systems in order to load all public keys to and from the relevant systems.

4.4 User authentication control based on rig permissions

```
SECTION safety_task_access
rig6 = 18
rig35 = 8,1
rig36 = NONE
ENDSECTION
```

The safety_task_access section is only to be used if individual access rights for particular rigs are to be used. A further condition is that the password server honors the 'check_task_status user-id task-id' request as well as the 'check_task_cert' request. In the case this is not met, remove all entries in this section!

If an entry is found for a rig, the number(s) for that rig is the task-id(s) in the remote database for which the user must be authorized before he/she can change any parameters for the rig in question (current, gas flows etc.). In the example above, in order for a user to change process parameters for rig 6, he/she should be authorized to use safety task number 18. If the user is authorized for the rig in question, the access rights are set as if the user had 'create' rights in the global access system if the user had less than create rights in the global system (note the global access rights are NOT changed permanently, only for the current session). If the special key 'NONE' is found for a specific rig (in the example above for rig 36) the system assigns implicit access rights to all users for that rig as if they had use rights assigned by the remote database (without checking the database). This can be used for overriding the access rights if problems is encountered and it for some reason is not possible to change user permissions in the external database.

if more than one number is found (in the example above for rig 35, then all skids must return a valid authorization for changes to be allowed. Additional, only the first task id is checked for certification status (certified users are allowed more freedom in configuration than merely authorized users).

Thus in order to be certified the user must be authorized for all task id numbers listed as well as be certified for the first task id listed. If no entry is found for the rig in question, the global access mode is used instead. The permission which the system checks for is the one defined by the 'access_mode' key in the 'global' section.

If no such key is defined, the default is to check for 'celltest' and 'celltest_admin' (the administrator part is always generated by appending '_admin' to the access_mode key, so if the access_mode key is electrodetest, then the admin-key will be electrodetest_admin. Thus make sure that the password server has the specified access keys defined.

4.5 Server section

```
SECTION servers
listserver = foo.bar
list_server_names =
server_names = host.domain.tld,host2.domain2.com
ENDSECTION
```

The servers section defines how many servers share the system software so that internal navigation between different servers is possible and as painless as possible. It also includes the listserver key, which specifies which server is to be used as a list server. This makes server farm maintenance easier, as each server only needs to know the name of the list server as well as which rigs are valid on the local system. Only the list server needs to know the names of all servers. It is also possible to use more than one list server (with each list server maintaining it's own list of known serves). In this case use the list_server_names key and supply a comma separated list of list server names. Notice that each list server need not know all servers.

4.6 Test rig control on server

```
SECTION celltest
rigs = 6,35,36,37
rigs_host.domain.tld = 6,35,36,37,40
start_test_mail_users = foo@foo.bar,foo2@foo.baz.bar
ENDSECTION
```

The celltest section defines the number and names of rigs on the server as well as a list of users who get a system mail each time a new test is started on one of the rigs. Notice, that if a rig is physically unavailable / removed, but the data is still intended to be on line and available, make sure that the rig number is removed from the rigs key, but not

from the rigs_... key. In the above example rig 40 will not be available to control, but the data will still be on line and available.

4.7 Gas factors

```
SECTION gas
### This section is for gas factors for Brooks mass flow controllers ####
n2 = 1
o2 = 0.988
h2 = 1.008
co2 = 0.773
co = 0.995
ch4 = 0.763
air = 0.998
d2 = 0.995
he = 1.386
ar = 1.395
ne = 1.398
kr = 1.382
xe = 1.383
no = 0.995
no2 = 0.758
n2o3 = 0.443
n20 = 0.752
ext_anode = 1
ext_cathode = 1
chx = 1
backup = 1
ENDSECTION
```

The gas section contains the gas factors for all the gasses which the system knows about. If a new gas type is added to one of the rigs, make sure that the corresponding gas factor is defined in this section! (refer section 6 and 12.5).

4.8 Impedance acquisition control

```
SECTION impedance
standard_compensation_files = /home/http/html/*.i2b
current_plot_frequencies = 10000:100:1
remote_client = /usr/local/bin/remote-client
comp_program = /usr/local/bin/hio_korr
ENDSECTION
```

The impedance section contains various information necessary for running automated impedance using the Elchemea© software package in conjunction with a Solartron®

1260 or 1255B. The standard_compensation_files key contains the location of the compensation files. If the standard_compensation_files key is empty or not defined, then the impedance compensation files for all impedance compensation is assumed to be in the directory imp_comp in the main web directory for the individual rigs: In case of rig 5 the directory would be */home/http/html/rig5/imp_comp/* assuming standard file locations. If the key is specified, it is possible to include limited pattern match like shown above. In the example displayed above, only files ending with .i2b is included. The current_plot_frequencies key contains the frequencies to be displayed in the overview figures showing impedance data versus time for impedance spectra obtained during constant current. The comp_program key contains the location and name of the impedance compensation program.

4.9 Report generation

The following configuration sections are all concerned with report generation as well as graphics generation.

```
SECTION resistance_calc
minimum_relative_current_Rmin = 0.2
ENDSECTION
```

The resistance_calc section contains only one key that define the relative current above which the software algorithm tries to determine the minimum cell resistance found during an I-V curve (only used when making reports).

```
SECTION GNUPLOT
output_type = ps
postportterm = post port enh color
postportsize = 1,0.5
multmargin = set lmargin 10;set rmargin 10;set bmargin 2
size = 1,1
halfsize = 1,0.5
quartersize = 1,0.25
location = /usr/bin/gnuplot
impedance_time_plot_type = points
ps-size = 0.5,0.5
png-size = 0.5,0.5
ENDSECTION
```

The GNUPLOT section contains location and default margins and terminal types for automatically generated report figures using Gnuplot.

```
SECTION MDRIVE
location = M:/Path/To/Data/
mountloc = M:/Path/To/Mounting/Photos/
```

```
unm_loc = M:/Path/To/De-Mounting/Photos/
stringsize = 39
ENDSECTION
```

The MDRIVE section contains default path descriptions for cell data (only used when making reports and specific for the network environment and Windows/Samba shares in which the server and clients are located)

4.10 Global IV curve control

```
SECTION iVcurves
minimum_cell_voltage_for_iv = 400
maximum_cell_voltage_for_iv = 1600
minimum_current_step = 0.05
current_limit = 50
ENDSECTION
```

The iVcurves section contains absolute maximum and minimum cell voltages for i-V curves. If an i-V curve exceeds one of these values, an emergency shut-down of the i-V curve occurs. Note that the values are in mV! The minimum_current_step key specifies the minimum stepsise (in A) for current changes during i-V curves. before changing this, please refer to the specifications of the attached DC power supplies as the value in this key should not be lower than the resolution of the PSU's! If the key does not exist, the default value of 0.05A is used instead. The current_limit key defines the maximum allowable DC current. Default is 40 A, set this value to something appropriate to the devices under test.

Chapter 5

Device description and philosophy of device design

The RFCcontrol - DTU Energy RFCcontrol control software system uses a number of logical and physical devices. Common to all of them is that they can be queried for their status (by using the read function, refer section 12.1). Some devices are read only whereas others are controllable. Below is a general description of the main types of devices.

For all RFCcontrol device types it should be noted that device names may never contain spaces as spaces in device names may result in internal errors which may be difficould to determine! In case a device name ought to contain a space, use an underscore instead.

5.1 Simple channel

The most basic device type in the RFCcontrol - DTU Energy RFCcontrol control software system is the simplechannel. This device type is typically connected to a AD converter (digital voltmeter typically) and is a read-only device type. Whenever the device is queried (read) the voltage or current is measured and returned. The simplechannel device type is used by a lot of the more complex device types in the RFCcontrol - DTU Energy RFCcontrol control software system.

5.2 Control relay device

This device type is basically a Boolean device which usually is controlling a physical relay which in turn can be used to control magnetic valves, switching relays or digital input to other physical devices (PLC's etc.). If the status of the relay device is on, then a read will result in a '1' whereas a off state will result in a value of '0'. Note, that if the relay is controlling a normally open magnetic valve, then a status of 'on' will actually be a closed valve! As with

simplechannel (refer section 5.1) the relay device is used internally by a lot of the more complex device types.

5.3 Analog output device

This type of device is used to control DA converters (notice, do not confuse this with a power supply). The actual physical device may be either a voltage source or a current source (but not both at the same time!). In RFCcontrol - DTU Energy RFCcontrol control software an analog output device is usually used to control analog mass flow controllers or similar devices with only analog input.

5.4 Gas device

The gas device is logically a gas tube with a flow measuring and/or flow control device attached. This control device may range from a fully automatic and electronically controllable device to a fully manual needle-valve (in which case the logical gas device only remembers the value that the user specified he/she had set the flow to). The name of the gas device may either be the gas name or a logical name (in this case it must be configured which gas is actually being controlled/measured).



Figure 5.1: Logical overview of a gas device. The control device may be a simple valve, a pressure controller, a electronic mass flow controller or even a more complex flow control device (possibly composite including parts of a multiplexer device (refer section 5.7).

A gas device may be configured as manual or automatic, if it is automatic, then a MFC (or derived) device is attached to control the flow or the pressure. Notice that a single gas device can have the flow rate or the gas pressure controlled, but not both at the same time! This is the reason for pressure control devices to emulate the MFC interface. If both flow rate and pressure for a gas is to be controlled (physically in different controllers), one gas device controls the flow and an other the pressure.

For example, the gas device 'h2' would be set up to control the hydrogen flow rate and the gas device 'h2_pressure' would be used to control the pressure. The two devices would then report data in L/hour and barA respectively.

5.4.1 Multiline devices

A special type of gas device is the multiline device. This device is a parallel connection of two other gas devices (usually with different flow ranges) making it possible to accurately control the gas flow over wider ranges than is possible with a single gas device as usually the accuracy of a gas control device can only be trusted over a single order of magnitude. Warning: never mix gas devices configured to control flow rate with gas devices configured to control pressure in a multiline device as the result would be unpredictable! Also be careful not to create circular links as such a link will render the system unresponsive due to deep recursion.

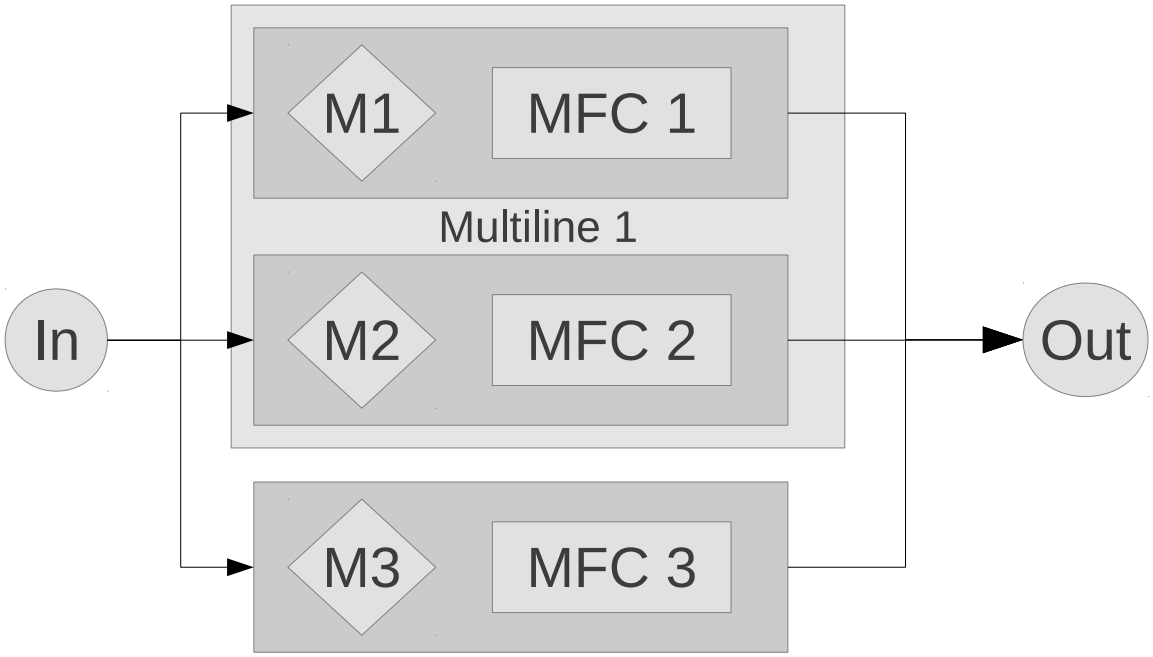


Figure 5.2: Logical diagram of a multiline gas device. M1 to M3 are magnetic valves and MFC 1 to 3 are mass flow controllers with different flow ranges (in this example it is assumed that MFC 1 has the lowest flow range and MFC 3 the highest). The grey boxes containing a valve and a MFC indicate a primitive gas device (normal gas device as according to section 5.4). The box labeled Multiline 1 is a multiline gas device consisting of MFC 1 and 2 (in addition to the associated valves). This device itself behaves 'from the outside' as a primitive gas device, and can be used as such in other multiline gas devices as it is in this example where the complete figure indicate a multiline gas device consisting of a primitive (MFC 3 + M3) and a multiline device (multiline 1).

5.5 Gas group device

A RFCcontrol - DTU Energy RFCcontrol control software gas group device is a purely logical device, and is used to group several gas lines into a single logged value depending on the status of some control relay. The principle is described in figure 5.3 where the status of a electronically controlled cross-over valve is used to control if gas line 1 or 2 is shunted to the sample under test (this is usually only used in cases where gas concentrations has to be changed fast as a step function).

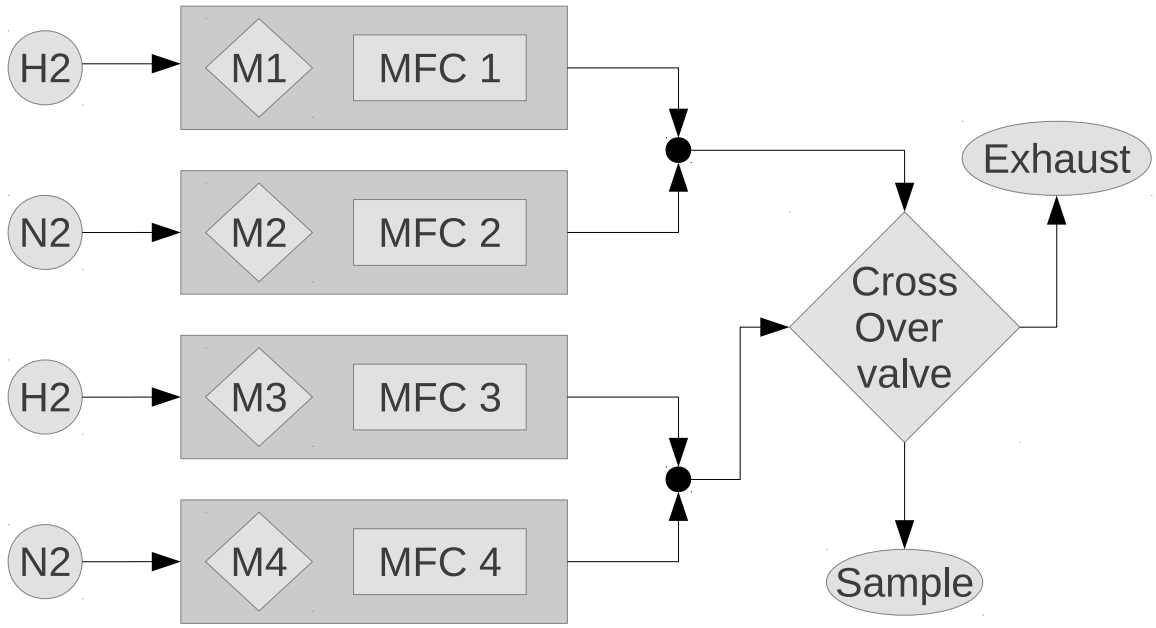


Figure 5.3: Logical overview of a 2 gas group devices. Device 1 is MFC 1 and 3 (both hydrogen) and device 2 consists of MFC 2 and 4 (both nitrogen). However depending on the status of the cross-over valve only MFC 1 and 2 or MFC 3 and 3 can supply gas to the sample. Thus for each gas group, only the flow of one of the MFC's should be counted as supplied to the sample. To solve this, each gas device (MFC + magnetic valve) must be assigned a control relay (the relay device controlling the cross over valve) and a control value so that the gas group device knows which gas line to include upon a read request depending on the setting of the cross over valve.

All RFCcontrol - DTU Energy RFCcontrol control software gas group devices are read-only devices as the flow of the individual gasses are controlled by themselves as is the status of the cross-over valve.

5.6 Mass flow controller

The mass flow controller device is a composite device. Logically it consist of a cutoff valve, a flow control device and a bypass valve (refer figure 5.4). Only the control device is mandatory however. The reason for this is that most automatic flow control devices (mass flow controllers) usually can not close

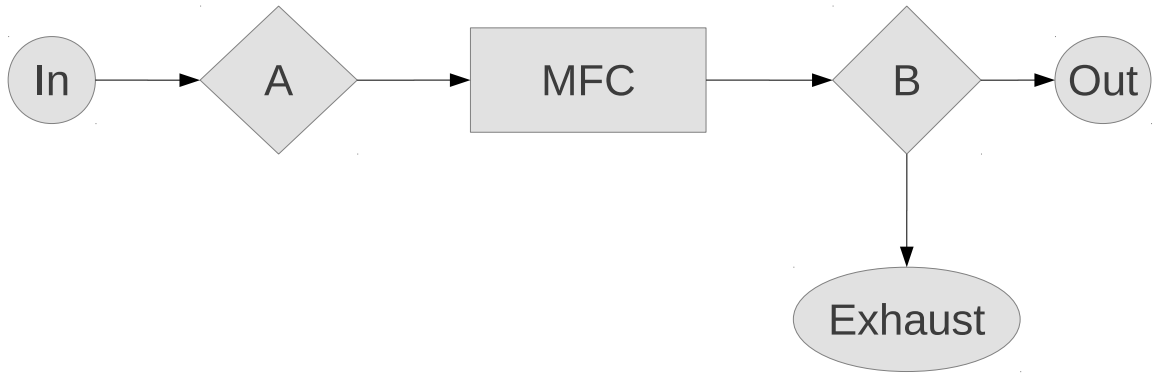


Figure 5.4: Logical overview of a MFC device. The only mandatory device is the MFC (flow control device). The optional valve (A) is a cutoff valve to ensure that no gas can flow and the valve (B) is a three-way valve (may be implemented as a normally open and normally closed valve pair). The port of the three-way valve which is open upon activation is connected to the system exhaust and the port open upon no valve activation is connected to the test setup. Note that the complete MFC-device (one MFC and up to 2 magnetic valves) constitute the flow control device shown in figure 5.1.

completely, and thus the MFC device can include a cutoff valve which can close the gas flow completely. The bypass valve is used in case no overshoot of the gas flow is acceptable. In this case a three-way magnetic valve should be mounted as shown in figure 5.4 and this valve will open for a short while if the gas flow is to be turned on (from an off state). After the gas flow has stabilized (and any overshoot has been vented through the aux output) the valve returns to normal and the gas flow continues as normal. A RFCcontrol - DTU Energy RFCcontrol control software MFC device must be connected to a corresponding gas device and therefore it is usually advantageous to initially configure all gasses before starting to configure MFC devices.

5.7 Multiplexer device

The RFCcontrol - DTU Energy RFCcontrol control software multiplexer device is a logical device consisting of a number of relay devices (refer section 5.2) used to control which gas line is selected as shown in figure 5.5. Only one gas line is allowed to be selected at any time, however the gas control valves used by the multiplexer device must NOT be confused with the control valves used by the MFC devices as described in section 5.6 (physically it is possible that the same magnetic valve may be used as both a multiplexer valve and a cutoff valve though, but logically inside the RFCcontrol - DTU Energy RFCcontrol control software system they must be different devices!).

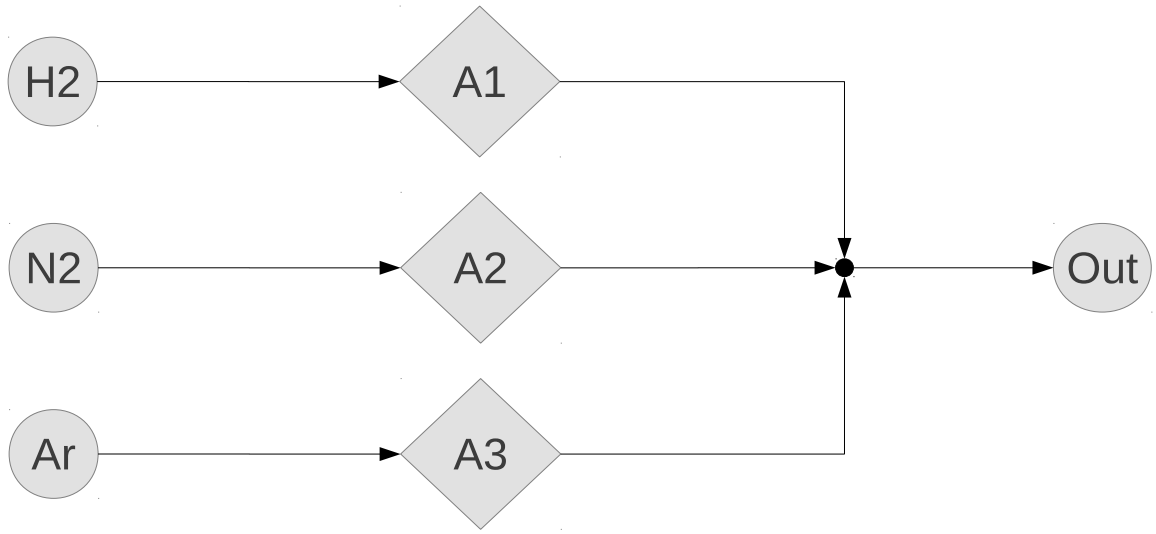


Figure 5.5: Schematic overview of a gas multiplexer device. The three different magnetic valves control which gas (H_2, N_2 or Ar in this case) is allowed to be passed on. The output in this case would be the input of a MFC device. This enables a single MFC device to control multiple gasses (although only one at a time)!. Note that only mass flow control er devices and not pressure controller devices can be connected to a gas multiplexer.

5.8 Power supply device

The power supply device is used to control power supplies (usually DC). This must not be confused with the analog output device described in section 5.3. As opposed the the analog output device it is possible to specify both the current output as well as the voltage output and depending on the physical device these values will usually be maximum values meaning that the PSU may operate as both a constant voltage source or a constant current source.

For instance if the current is set to 10 A and the voltage is set to 5 V, then depending on resistance of the sample being tested the output will be either 5 V (in case of a sample resistance above 0.5 Ohm) or 10 A (in the case the sample resistance is below 0.5 Ohm). In either case the voltage or current may be below the specified values, but never above.

A PSU device may also include a relay device to completely disconnect the power supply from the sample under test (full open circuit conditions). In this case the relay device must be connected to a large power relay capable of handling the voltages and currents possible by the Power supply in question (and this may be several hundreds of amperes in some cases!).

Notice that RFCcontrol defines the positive current direction as seen from the device under test. Thus if a battery is discharged or a fuel cell is supplying current as through a resistive load, then the current is positive. Similarly if a battery is charged or an electrolyser is supplied power to generate gas, then the current is negative.

5.9 Temperature logging device

The temperature logging device is a composite device usually consisting of one or more simpeldevices as shown in figure 5.6. The primary input device usually measures a thermovoltage from a thermocouple and then converts it (using the appropriate conversion tables) to a temperature by using the cold junction temperature determined by the values of the secondary channels (refer figure 5.6). If accurate temperature measurements are to be made up to 3 measurements may be needed (one voltage measurement and 2 resistance measurements). However, if more than one thermovoltage are to be measured, the cold junction measurements can be shared as long as the screw terminals in question are in thermal contact (and can be assumed to be at the same temperature).

All RFCcontrol - DTU Energy RFCcontrol control software temperature logging devices are read-only devices.

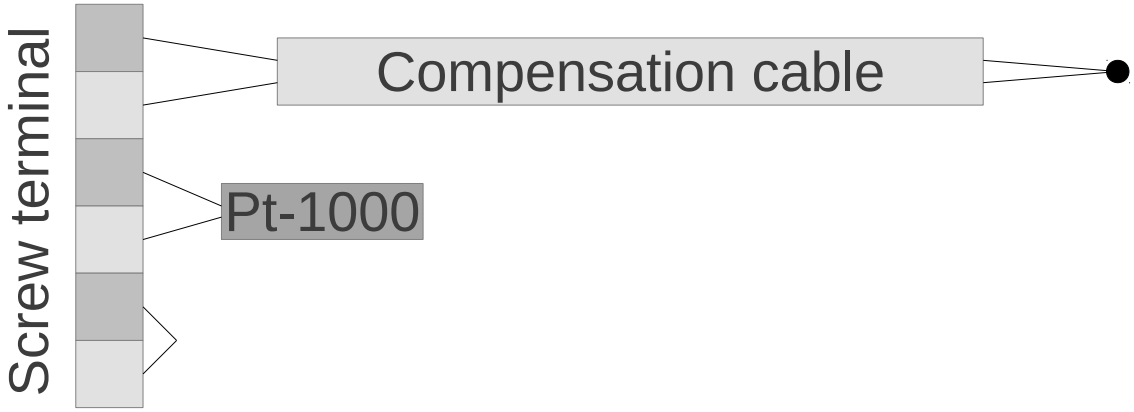


Figure 5.6: Logical overview of a temperature logging device. The actual temperature measured is the temperature at the thermocouple junction at the right. The screw terminals on the left is assumed to be at normal temperatures and be connected to a AD converter by normal Cu-wires. As the measured thermovoltage depends not only on the temperature of the thermocouple junction but also of the 'cold junction' (where the compensation cable is connected to normal uncompensated cables) this temperature must be known as well. This is best achieved by measuring the resistance of a Pt-1000 resistor in thermal contact with the screw terminals. However in order to accurately measure this resistance it is necessary to compensate for the resistance in the wires from the AD converter and to the screw terminals, and this can be done by measuring the resistance of a simple short circuit (below the Pt-1000 shown in the figure).

5.10 Temperature control device

A RFCcontrol - DTU Energy RFCcontrol control software temperature control device is connected to a temperature controller and is used to set the temperature set point and ramp rate. The physical temperature control de-

vice must be configured to only work by accepting a ramp rate and a set point, and any changes in set point must result in the controller ramping from the current set point to the new one by the current ramp-rate. Notice that a lot of commercially available controllers can be configured to run autonomous programs, however this option should NOT be used in conjunction with the RFCcontrol - DTU Energy RFCcontrol control software system.

5.11 Filter devices

A special virtual device class called filter is also available. The device is purely virtual and works by converting the read value of a normal device to a calculated value based on the filter device type and settings. A filter device passes all commands sent to it to the underlying device. The only influence is on the return value of a read request (and hence readstring requests). If a read request is passed to the filter device, the underlying device processes the read request and returns the value to the filter device. Depending on the type and internal settings of the filter device, the returned value is then mathematically transformed and the transformed value is then returned to the caller instead of the raw read value from the underlying device.

The most common filter is a spline interpolation which allows conversion according to a (potentially non-algebraic) monotonic function specified by a spline table.

One specific feature of a filter device is that it will masquerade as the same device type as the underlying device. Thus if a simplechannel device is filtered, the resulting filter device will itself be available as a simplechannel device and if a gas device is filtered, the resulting device will be available as a gas device! Any filter device will also be available as a filter device however (for configuration and explicit invocation). The reason for letting filter devices masquerade as the underlying device type is to allow the filter devices to work between simple and complex devices. For instance if an analog MFC device measures a specific flow, a filter device can be configured to correct the measured flow (from the simplechannel device) according to a calibration table before the flow is calculated based on gas factors, thus resulting in a higher accuracy than without filtering.

Warning: One side effect of the ability of filters to masquerade is that it is possible to accidentally create circular links in the configuration for a rig. Therefore whenever filters are used, be extremely careful that no circular links are crated, as just one such link will render the whole system unresponsive (due to deep recursion)!

5.11.1 Summing devices

A special filter device is the Summing device. This device operates on more than one input (all of which must be of the same type). Whenever the read operation is performed on an instance of this device type, the result is the arithmetic sum of the read function call on the input devices. This device can thus be used to get the sum of gas flows for specific control situations where for instance feed-forward is needed for a PID control device to operate properly. Additionally any setflow command performed on one of the inputs is forwarded to the output device (if it is defined) but with the sum of the inputs as argument instead of the original command input. As with the logic devices described in the next section, whenever summing devices are used, a detailed schematic should be maintained for better operator overview of the control system as a whole.

5.11.2 Typecast devices

A final special filter device type is the Typecast device. This device type can convert an underlying device to an other type (as viewed from observers on the typecast device). The benefit of this is that it makes it possible to use for instance the DC current as a gas flow (with the proper conversion according to Faraday's law of electrolysis).

However typecast devices are NOT necessary for simply logging gas flows and/or DC-current load for later processing, only in special cases such as active control of gas flow as a function of DC current load might a typecast device be necessary (chapter 14 has an example of a situation where typecast devices are necessary).

5.12 PID devices

An other special device type is the PID device. This virtual device operates on two other devices, an input device and an output device, and the PID device tries to correct the output device so that the input device measures a specific value (normal PID regulator).

A PID device can operate in two modes, fast and normal. In fast mode, the control loop is as tight as possible (1 second delay between each iteration, may take longer if the devices themselves are slow or queuing prevent fast measurements) whereas the normal mode an iteration is only performed once a minute.

Due to the nature of a PID regulator, be careful that the settings are appropriate, as otherwise unstable operation may result.

Normally it is good practice to wait with PID devices until such time as it has been proved that they are necessary.

5.13 Virtual (pure software) devices

RFCcontrol supports a number of purely virtual device classes. These devices exists only as logical connection between other devices which is connected to the actual physical devices.

Common to all the pure virtual devices is that they do not do any data logging by themselves (specifically the readstring function returns undefined). The reason for this is that the underlying devices (which actually controls or reads from physical devices) should handle this.

Pure virtual devices can operate on input and / or output devices depending on type and configuration.

Although pure virtual devices does not contribute to the data logging, they only work correctly if they are enabled ad opposed to most other types of devices which would get auto-vivified if they are needed by other devices.

5.13.1 Logic devices

These virtual devices operates on one or more input devices, each of which must be of either relay type, logic type or the special filter device type 'Schmidt trigger'.

The logical devices can have a optional output device (which must be of a relay type) which is intended to convey the result of the logical operation to the rest of the rig control system (usually physical relays). If a output device is configured, it is automatically set to be read-only, as control of the output relay state should be exclusively through the logic device and not directly through the user interface.

The different types of logical devices implements the normal Boolean operators (AND, OR, XOR etc.) and allows for cross linking control signals between devices (for instance, closing a specific gas may force the opening of a valve on an other gas line entirely etc).

Whenever it is intended to include logical devices in a rig's control system, it is an extremely good idea to have detailed schematics of the intended control system prepared with unique names for all logical operations as well as all other devices. If no such detailed schematics are available, it is far too easy to create an other logical control system than intended, and it may even be possible to create circular references which would render the complete rig control system inoperable!

5.13.2 Arithmetic devices

An other special device class is the arithmetic devices. These virtual devices operates on one or more input devices.

The different types of arithmetic devices implements the normal arithmetic operators (plus, minus, multiply etc) and allows for cross linking signals between devices.

As with logic devices, whenever it is intended to include arithmetic devices in a rig's control system, it is an extremely good idea to have detailed schematics of the intended control system prepared with unique names for all logical and arithmetic operations as well as all other devices. If no such detailed schematics are available, it is far too easy to create an other control system than intended, and it may even be possible to create circular references which would render the complete rig control system inoperable due to deep recursion!

Arithmetic devices implements the observer pattern on their inputs and thus forwards any commands to any devices which listens on the arithmetic device.

5.13.3 Adapter devices

Adapter devices encapsulate other devices in a manner similar to filter devices. As opposed to filter devices, adapter devices supply functionality which the encapsulated device itself does not supply. For instance, a normal gas device does not support slowly ramping the gas flow to the new set point, but by applying a ramp rate adapter to a gas device this can be accomplished.

5.13.4 Alert devices

Alert devices are intended to be used to create custom watchdog programs. Each alert device monitors a single device (which can be of any type except an other alert device) and if the value (the result of a read operation) exceeds a specific threshold an alarm event is raised (which as a minimum sends an email to the rig operator / owner but potentially also takes corrective action).

5.14 Order of device configuration when setting up a new test rig

In order to avoid errors when setting up a completely new rig, one should configure the devices in the following order:

1. **Simplechannels (all basic measurements including devices which will be used internally by other more complex devices).**
2. **Simple gas devices (Initially all simple gasses should just be configured as manual).**

3. **Multiline gas devices (should just refer to simple gas devices configured above).**
4. **Analog output devices (usually used internally in more complex devices).**
5. **Relay devices (usually but not always used by more complex devices).**
6. **Power supply devices.**
7. **Temperature control devices**
8. **Any potentially necessary filter devices (Note some filter devices may be necessary to configure later if the underlying device has not yet been configured)!**
9. **Temperature logging devices (will be simple if all the input devices was configured in step 1).**
10. **MFC devices**
11. **Reconfigure gas devices to account for MFC's if necessary.**
12. **Gas multiplexer devices. Notice that only gasses that are enabled can be configured as part of a multiplexer!**
13. **Reconfigure MFC devices to account for multiplexers (select relevant multiplexer and set gas_change to automatic) Remember to set the correct possible gas names in the gasses list as only those in that list is avaliable when configuring the gas multiplexer in the next step.**
14. **Reconfigure gas multiplexers to set correct relay devices / port numbers to the corresponding gasses.**
15. **Gas group devices.**
16. **Logic devices if necessary (caution, do not create more complex control systems than necessary!).**
17. **PID devices if necessary.**

In all cases, remember to setup any filter devices at at the same time as the normal devices (e.g a filter device operating on a simplechannel device should be configured at the same time as the normal simplechannel devices).

Remember to enable the devices from which the values should be logged as part of automatic data logging or if the device should be avaliable for user control.

5.15 Note on gas and simplechannel names for ease of reporting

In order to facilitate easy reporting of fuel cell or electrolyser tests using the reporting system distributed with RFCcontrol, a number of device names has special meaning.

Notice that it is only for reporting purposes that the following device names are special and for normal operation and control they are irrelevant and can even be non-existent.

For historical reasons (The first fuel cell test using the predecessor to RFC-control was ran in 2001 and more than 1000 test has been run since then), some of the device names described in the following sections contain capital letters In order for reporting to proceed properly, this capitalization must be preserved.

5.15.1 Simplechannel device names for current, voltage and pressure

The following simplechannel names are used for special calculations during reporting.

- **cell_voltage: A simplechannel with this name is assumed to report the fuel cell / electrolyser cell voltage in mV and must be positive when anode is in contact with reducing gas and cathode is i contact with air or other oxidizing gas!**
- **O2_in: A simplechannel with this name is assumed to represent the voltage measured across a zirconia based pO2 sensor measuring on the anode gas (reducing gas) stream before the fuel cell. The reported value is assumed to be in mV and value must be negative when reducing gas is used.**
- **O2_out: A simplechannel with this name is assumed to represent the voltage measured across a zirconia based pO2 sensor measuring on the exhaust of the anode gas. The reported value is assumed to be in mV and value must be negative when reducing gas is used.**
- **current: A simplechannel directly measuring the DC current through the device in A. Notice that positive current direction is when the device is run as a fuel cell (meaning that a negative current is observed when a device is run as an electrolyser).**
- **pressure: A simplechannel directly measuring the gas pressure in atmospheres. Note that if no pressure logging device is defined (no device called pressure) the reporting scripts assumes a pressure of 1 atmosphere,**

so a pressure measuring device is only needed for situation where experiments are performed in anything else than atmospheric pressure.

5.15.2 Gas device names

- **backup: gas stream measuring the flow of diluted hydrogen (9% hydrogen in nitrogen) to the anode.**
- **h2: gas stream measuring the flow of pure hydrogen to the anode.**
- **o2: gas stream measuring the flow of pure oxygen to the anode (to combine with H2 before the cell to make water vapor).**
- **co: gas stream measuring the flow of pure carbon monoxide to the anode.**
- **co2: gas stream measuring the flow of pure carbon dioxide to the anode.**
- **ch4: gas stream measuring the flow of pure methane to the anode.**
- **h2: gas stream measuring the flow of pure nitrogen to the anode.**
- **ar: gas stream measuring the flow of pure argon to the anode.**
- **he: gas stream measuring the flow of pure helium to the anode.**
- **h2o: gas stream measuring the flow of water to the anode. Note that the flow is to be reported in L/hour gas at 0 C, NOT liquid flow!**
- **air: gas stream measuring the flow of air to the cathode (assuming 21 % oxygen in nitrogen).**
- **o2_cathode: gas stream measuring the flow of pure oxygen to the cathode.**
- **n2_cathode: gas stream measuring the flow of pure nitrogen to the cathode.**

Notice that if other gas device names for the above gas streams are used reporting will likely involve quite some manual data processing!. However additional gas device names can be used without problems (as only the ones described above are used for reporting purposes). If other gasses than the above mentioned is used, make sure that they do not contain reactive species which can influence the fuel or oxygen utilization as this will render the calculations performed by the reporting scripts invalid! For instance if an other gas string containing hydrogen is used (let's call it 'external_h2'), the fuel utilization calculation will only be based on the value found in the 'h2' column and the hydrogen from the external source will be disregarded and not included resulting in completely wrong calculation.

5.15.3 Temperature logging device names

- **T_center: A device measuring the temperature of the fuel cell/electrolyser cell at the center of the cell (in Celsius).**
- **T_corner: A device measuring the temperature of the fuel cell/electrolyser cell at the corner of the cell (in Celsius).**
- **T_in: A device measuring the temperature of the anode gas stream where the O2_in sensor is placed (in Celsius).**
- **T_out: A device measuring the temperature of the anode gas stream where the O2_out sensor is placed (in Celsius).**
- **T_air_flow: A device measuring the temperature of the cathode gas stream (in Celsius).**

5.15.4 water bottle device names

- **bottle_temp: For historical reasons the water bottle connected to the H_2 / backup gas stream has been named this. Notice that only the pure hydrogen and diluted hydrogen (h2 and backup) is assumed to pass this water bubler, NOT the rest of the anode gasses (n2, o2, ar, co, co2 or ch4).**

Chapter 6

Rig configuration

Each rig has it's own configuration file. The file is divided into sections which allows individual configuration values to have identical identifiers as long as they are in different sections.

In order to configure a rig, go the rig device configuration page. This can be accessed from the main page (shown on figure 2.3) and then pressing the 'setup iv curve parameters' tab and then pressing the 'rig configuration' tab. This will bring yo to a page resembling figure 6.1 or 6.2.

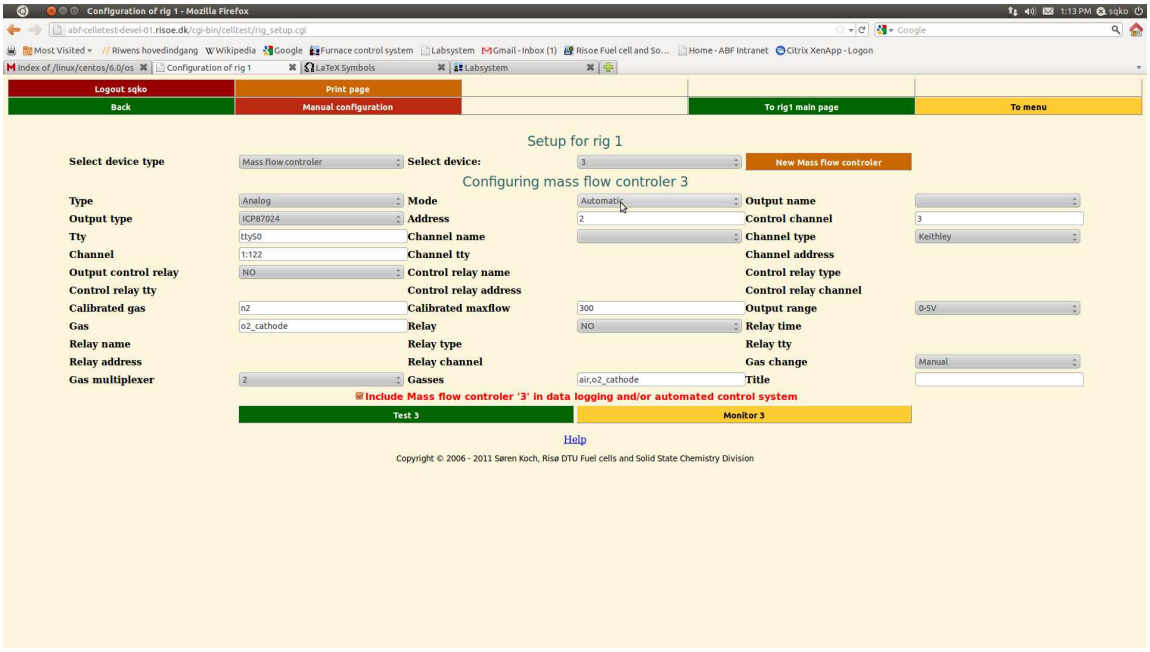


Figure 6.1: Example of what a device configuration page may look like. If no device is selected, only the top line is shown (device type and name as well as the new device button). In this example, a mass flow controller device is selected.

Each device will have it's own configuration page like the ones shown in figure 6.1 or 6.2.

Only fields which is active (that is used) in the current device configuration

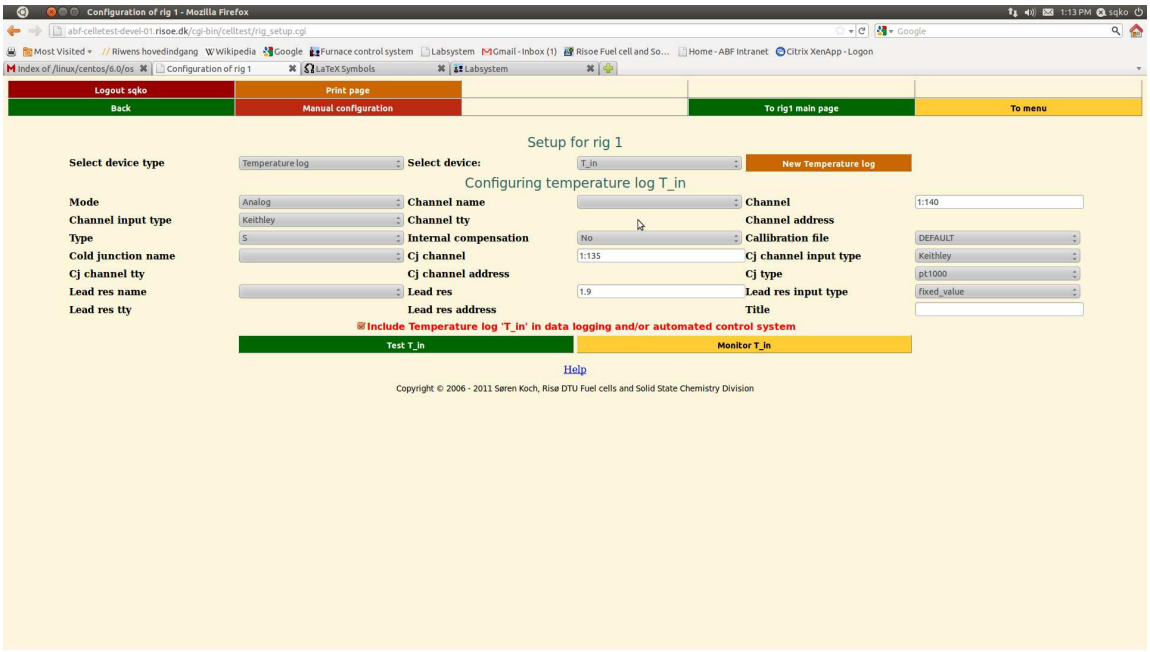


Figure 6.2: An other example of the device configuration page. In this example, a mass temperature log device is selected.

is shown on the page, thus changing one value may add or remove displayed fields if the change activates or disables other fields.

The different data fields will either have a fixed set of possible values (all of which will be selectable from a drop down menu), or will be a floating point, integer or free text field (indicated by having no drop down box).

At the bottom of each device configuration page, a check box is displayed which can be checked to include the device explicitly in the data logging (that is, the device will get an explicit column in the raw data file with the name of the device and the value (determined by the read function (refer chapter 11). It is good practice only to add a device to the explicit data logging once it is fully configured to avoid communication errors or other inconsistencies to interfere with the automatic data logging. At the bottom is also two buttons, one for testing the device (useful for debugging as well as configuration) and an other for device monitoring. Pressing the monitor button will bring up a small page displaying continuous measurements using the selected device.

6.1 Main section

The top section is the 'main' section of which an example is shown here:

```
SECTION main
gas_names = h2,o2,air,o2_cathode,n2_cathode,ch4,co2,ch4,co,ar,n2,backup
temp_names = T_center,T_in,T_out,T_corner,T_air_flow
simple_channel_names = cell_voltage,current,O2_in,O2_out,inplane_V_hydrogen
```

```
relay_names = relay1,relay2
water_names = bottle_temp
gas_group_names = H2,N2
automatic_flowcontrolers = 1,2,3,4
cell_area = 16
vogt_gasses = h2,co,ch4
additional_vogt_gasses_cutoff = co2
additional_gas_trip_program =
warning_message = Warning to be displayed on the main control page
warning_mails = foo@foo.bar,foo2@foo.bar
number_of_plot_cols = 4
main_page =
legacy_mode = no
set_zero_output_start_test = yes
equipmentid = 0
authorisation = local
command_to_execute_at_test_start =
remote_log_url =
fixed_impedance_url =
#fixed_impedance_url = https://foo.bar.baz/cgi-bin/elchemea/main.cgi
ENDSECTION
```

This section defined the number and names of gasses, flow controllers, water bublers, voltage channels etc. Each of the gasses, voltage channels etc. will have it's own configuration section defining the specific set-up of that node as specified in chapter 12.

Only thew keys which should be manually manipulated (either through manual edit or through the 'miscellaneous setup' page in the user interface) is discussed here.

The cell_area key specifies the cell area for the particular fuel cell / device under test and is only used for reporting purposes (to calculate area specific resistances for instance). The vogt_gasses key specifies which gasses is monitored for gas trips (refer chapter 7.1). At least one of the gasses in the list must be above the cut-off value specified in that gas' configuration section (refer section 12.7) unless a gas trip is initiated (refer chapter 7.1). The 'aditional_vogt_gasses_cutoff' key which is optional specifies which gasses in excess of those specified for monitoring should be set to 0 in the case of a gas trip.

It should be noted, that there may be spelling errors in the configuration key or section names and that one should be VERY careful about correcting them, as they are hard coded into the application (OK so sue me, English is not my native language and spelling is not important for variable names inside an application).

Any line starting with a hash (#) is considered a comment and is ignored by the application. Additionally, the order of the sections and individual keys within the sections is arbitrary and does not influence the application as long

as no duplicate key names exists in the same section!

The warning_mails key specifies which email addresses are to receive mail notifications in case of other a voltage trip or a gas trip (refer chapters 7.1 and 7.2). Note that this key can be absent, in which case the corresponding addresses found in the global configuration are used instead (in effect, this key overrides the global value if it exists, refer chapter 4).

The number_of_plot_cols key specifies the number of columns in the daily plots (default is 3 if no value is specified).

The warning_message key may be missing but if it exists, the value will be displayed on the main control page for the rig in question.

The main_page key specifies if a custom designed rig main page is to be used instead of the default (refer section 2.1). The default is for this key to be empty or not exist. If it exist and contains the name of a file located in *//home/http/cgi-bin/celltest/*, this file will be used instead of *rig_main.cgi*.

The legacy_mode key is used to enable all configuration tags for some devices which in previous versions of RFCcontrol included implicit creation simple devices. This mode of configuration is deprecated and is strongly discouraged as it is much harder to debug and configure than the normal configuration order as described in chapter 5 and specifically in section 5.14. However for backwards compatibility setting this key to 'yes' will enable the full configuration options.

The set_zero_output_start_test key determines if gas flows as well as DC output for all controllable devices is to be set to zero upon starting a new test. If the key is not present, the default value of 'yes' is used. In most cases it is desired to set all gas flows and DC output to zero upon starting a new test so as to have a known start state, however in some cases (such as controlling pressures as shown in section 14.3) it may be better to leave settings as they are.

The equipmentid key is used only if a remote database is used for storing user log entries (refer section 4) and should be set to th ID number for this rig in that database.

The authorisation key is only used in case the equipmentid key is set. In this case the RFCcontrol system tries to completely offload all authorisation and certification checks to the remote password server. Please note that this feature is not supported by the password server supplied with RFCcontrol.

The key 'command_to_execute_at_test_start' is used if a program needs to be run wheneever a new test is started. This program must be executable by apache for it to work, and the path and filename may only conatin letters, digits and underscores in addition to (, . - + - /). The restriction in file name is to awoid code injection. If this key is set, the program is run whenever a new test is started, but only at that time. When the program is executed it is called with a single argument, the rig number (15 in the case of rig15).

The key remote_log_url is used in conjunction with the RFC::Main::remote_log() function and if it is defined any argument (a text string) passed to the remote_log function will be appended to the value of this string and a web request with the resulting text string (which should resove to a url) will be initiated. This can be used for appending text messages to any remote logbook system as long as it allows web access. See the documentation for the RFC::Rig module for more info.

The fixed_impedance_url key can be used in the case an Elchemea system is pemanently affixed to the test station in question. In this case the IP address or hostname of the Elchemea system in question can be added to this key making it possible to directly be redirected to the correct system as well as handling single signon (in case the Elchemea sysem uses the same authentification system). Note that this functionality can only be used with Elchemea version 6.1.1 or later!

6.2 IV curve control

In order to correctly control how an I-V curve is run, the system needs to know which channels to use for voltage and current measurements respectively.

```
SECTION IV_control
current_label = current
voltage_label = cell_voltage
pressure_label =
temp_label = T_center
voltagelimit_iv = 600
ivpause = 5
currentstep1 = 0.25
currentstep2 = 1
currentstep3 = 0.1
epsilon = 0.01
currentlimit = 40
diff_current_limit = 0.5
OCV_measure_number = 5
electrolysis_limit_voltage = 1400
allow_caching = No
iv_control_names =
ENDSECTION
```

Most of the keys can be manipulated from the 'miscellaneous setup' interface or the 'setup iV curves' interface (refer figure 2.8 and 6.3).

The current_label key specifies which channel label is to be used for measuring the current through the device (usually one of the voltage channels configured to measure the voltage across a shunt resistor and thus report the current). Similarly the voltage_label key specifies which device label is used

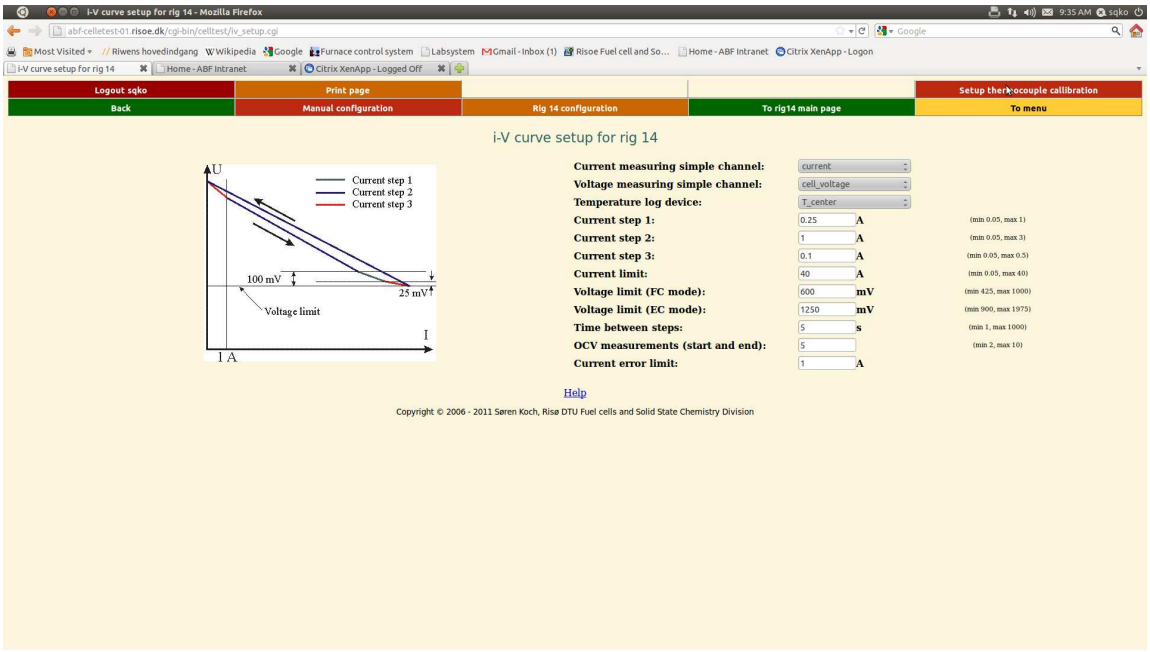


Figure 6.3: The setup iv curve page.

for voltage measurements. In both cases, note that it is only the label name (usually one of the simple channels, refer section 12.1) that is to be specified, NOT the internal channel numbers or similar. The 'temp_label' specifies which device is used for the cell temperature which is printed in the i-V table and is not used in any calculations so this label is only for information. The 'pressure_label' specifies which device data is used for the gas pressure used in any calculations so this label is only for reporting purposes. If experiments are only ever performed at atmospheric pressure, this label can be left blank. The voltagelimit_iv is the minimum cell voltage for an i-V curve (normally run that is). The ivpause is how many seconds to wait between each current step. The currentstep1 to 3 is the size of the current steps (for explanation as to when each step size is used refer figure 6.3). The currentlimit is the maximum current allowed for the i-V curve and the diff_current_limit key specifies how large the deviation between the set current and the measured current is allowed to be before the i-V curve is aborted (useful for detecting under voltage trips). The ocv_measure_number is the number of OCV measurements to be made before and after the actual i-V curve. The electrolysis_limit_voltage is similar to the voltagelimit_iv key except in the case of a fuel cell mode i-V curve the result of a cell voltage above this limit results in a emergency shutdown of the i-V curve (the reverse is the case in a i-V curve run in electrolysis mode, there a cell voltage below the voltagelimit_iv will force an emergency shutdown). If the I-V curve is run in electrolyser mode, this value works as a normal I-V curve voltage limit. It should be noted that all the voltage limits is in mVolt and not in Volt! The 'epsilon' key is discussed in section 2.5. The 'allow_caching' key specifies if caching is allowed during i-V curves (refer section 6.2.1). If no key or value is found the default behavior is 'No'.

The 'iv_control_names' key specifies which PSU's are to be used for controlling the current through the device under test during I-V curves. If only one PSU exists (as it will do in most cases), this key can be omitted. Usually only one PSU should be listed in this key, but in some cases multiple PSU names can be configured (separated by comma). The most common case for multiple PSU names to be configured in this key is if several devices are tested in parallel within the same rig (each with it's own PSU).

6.2.1 Caching of values during i-V curves

From version 4.8.1 and onwards, it is possible to allow caching during i-V curves. This enables some speedup as cached values can be used instead of measured ones. For instance the temperature of a screw terminal block can likely be assumed to change only little during an i-V curve making it feasible to measure it only at start and then reuse that value for the rest of the i-V curve.

The way caching works is that During normal (non-caching) operation, a file is kept up to date with the latest measured values for the devices which honors caching (not all RFC devices do, for instance all filter devices as well as PID regulator devices can never use caching). Once a caching situation occurs (during i-V curve acquisition) the values for the devices configured to use caching is loaded from that file instead of being physically measured.

Caching is dangerous though. First of all, if caching is allowed for a physical value which actually do change during the i-V curve, none of the changes will be logged or even observed (meaning potential loss of relevant data)! Secondly, If the last (non-caching) measurement resulted in an error (for instance a loose connection or communication error), an incorrect value will be stored and all subsequent caching reads will use this wrong value. This is normally not a problem, as in normal operation only one data line containing the erroneous value will occur (and this can then later be discarded), however if caching is used all lines for that i-V curve will contain the erroneous value.

For this reason the default behavior is for caching to be disallowed, in other words it has to be explicitly enabled. Both under i-V setup and in the individual device configurations where the user has to decide which devices can safely be cached during i-V curve acquisition.

6.3 Datalog section

The datalog section controls if additional commands must be run at each normal data acquisition (that is for each execution of *`/usr/local/bin/celltest/logfile.pl`*).

The 'additional_log_program' key specifies which program (if any) is to be run and the 'log_program_arguments' specify which (if any) arguments must be

passed to the program. The system expects the output from any programs thus called to conform with the normal format of the logfile program. Thus for each item to be logged, the result must be a string containing 4 items separated by spaces, the first item being the name of the item, the second the time the logging was performed (formatted as yyyy:mm:dd:hh:mi:ss), the third the time as an integer (utime) and lastly the value.

An example of a single item is shown below:

```
bottle_temp_1 2015:07:15:18:02:46 1436976166 28.556
```

The datalog section may be completely absent in which case it is ignored and the configuration of this section can be accessed from the miscellaneous setup interface (refer figure 2.8).

It should be noted that only programs located in the directory *<u>/usr/local/bin/celltest/logprograms/</u>* can be accessed in this way and they must be executable by the rig user(s)!

6.4 Control logic section

The 'control_logic' section contains setup information for the vogt programs (refer section 7.1 and 7.2). The 'voltage_limit_vogt' key specifies the minimum cell voltage (in mV) below which a voltage trip occurs. Similarly the 'electrolysis_limit_vogt' key determines the maximum voltage (in electrolysis mode). This section also contains the setup information for any additional gas and/or voltage trip programs as well as the channel name for temperature adjustment.

All these keys are defined and modified through the miscellaneous setup interface (refer figure 2.8).

6.5 Thermocouple calibration

The RFCcontrol - DTU Energy RFCcontrol control software system also allows for the use of custom calibration tables for thermocouple operation for data acquisition purposes where accurate temperature measurements are necessary.

Figure 6.3 show the tab used to access the page shown in figure 6.4 where it is possible for rig administrators to add calibration data.. Only system rig administrators can access this page, but once a data file has been loaded, it will be available to all rigs on the system for temperature logging purposes (refer figure 6.2).

In order to load a calibration file for a specific thermocouple, a list of calibration values must be prepared with one data point on each line containing

the voltage (in mV) followed by the corresponding temperature separated by space (an example can be seen for the selected file in figure 6.4). This list must then be added in the text area on the right and a proper file name must be added in the text field above. Once both file name and data has been entered, a 'load' button will appear and the data can be loaded. To view the uploaded data, select the file in the drop down menu on the left and a graph should show up displaying the loaded data as shown in figure 6.4.

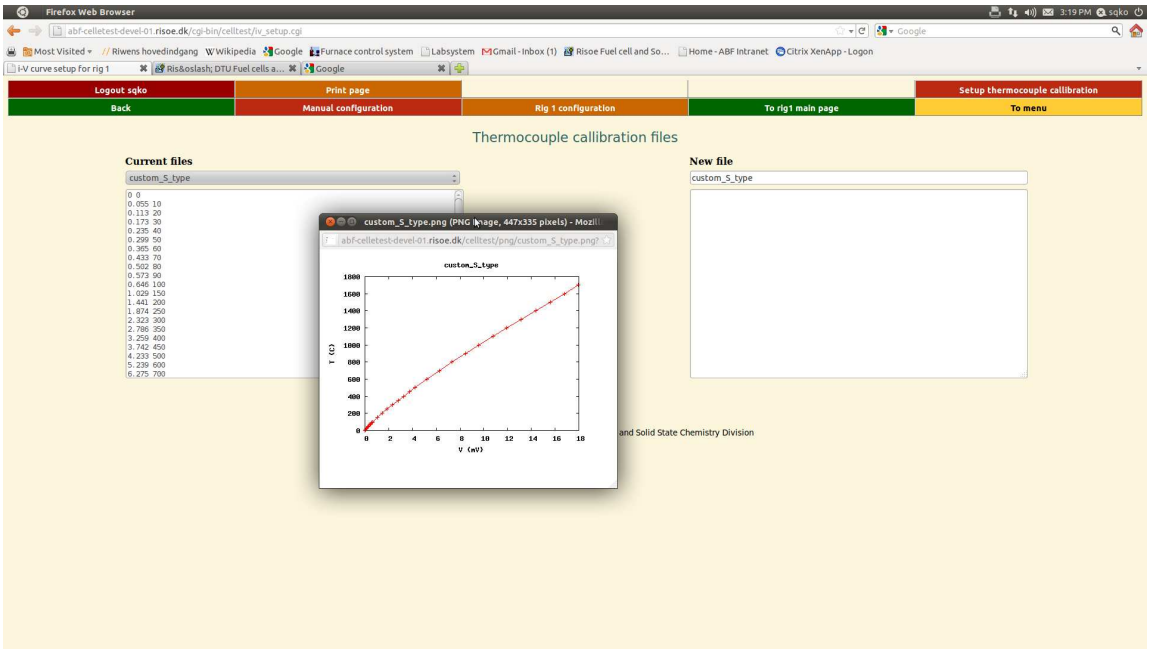


Figure 6.4: Thermocouple calibration input page. The page shows what it looks like once a calibration file has been input and selected. The graph in the center shows a plot of the data uploaded and can be used for sanity checks of the data (the data should show a continuous line with no sharp bends and/or singularities).

6.6 User interface

This section defines which data to present on the main rig screen (that is which data channels to measure and show as 'on-line data'. The four keys are shown below, and each key contains a comma separated list of the names to display. The temp manes will be devices instances of one of the 'Temperature log' classes, the gas names must be devices instances of the 'Gas' class and the voltage and current names must be devices instances of one of the 'Simplechannel' classes (for class definitions, refer chapter 12).

```
SECTION user interface
temp = T_center,T_corner
gas = h2,o2,air,co2,co,ch4
voltage = cell_voltage,O2_in,O2_out
current = current
```

```
alert =
pO2_voltagerange = 300,1400
ENDSECTION
```

The current key also specifies if the rig in question is a normal cell test rig or a single electrode test rig. If an identifier is mentioned in the 'current' key, the rig in question is a cell test rig, whereas if the current key is empty the rig is an single electrode rig. The distinction is only important in the start of a new test and in case of controlling DC current through the device under test, which is only possible in the cell test mode. The 'pO2_voltagerange' key is only used for the history plots and has no influence on tests being run. It is only used to specify the voltage range displayed on the cell voltage and pO2 plots of the reports and overview figures. The key can be missing in the configuration file and in this case the default values are used. The default value used in cell test mode is 300 – 1400 mV and -100 – 1400 mV in electrode test mode.

All the keys can be manipulated from the 'miscelaneous setup' interface (refer figure 2.8).

Chapter 7

Alarms

It is possible to setup email notifications if certain process parameters passes defined thresholds.

Each rig can be configreud with a number of alarm devices each with it's own alarm level. The configuration of these alarm devices is done in the same way as normal data logging or control devices. The only difference is that any enabled alarm device is not logged durring nromal data logging, but is checked each minute if the trigger threshold has been passed. It should be noted, that the status of the alarm devices is only checked once a minute, thus it is possible for the system to be in a state which should trigger an alarm (and potentially correcting commands) for up to one minute before the alarm actually occours.

If an alarm occours, an email notification is sent by the rig to the recipients defined in the warning_mails key (refer section 6.1).

Notice however that it is only possible to recieve email notifications if the server on which RFCcontrol is installed is allowed to send mail (some MTA's does not allow emails to be forwarded from unknown users, so check your local system administrators as to how this is configured for your organisation). Additionally, the alarm device system can potentially be misused to email-spam unsuspecting users, so take care in how the system is configured (normally a system running RFCcontrol should never be directly accessible from the internet).

7.1 Gas trip

The definition of a gas trip is when the security box determines an unsafe condition and shuts down the H_2, CO, O_2 etc. and switches the anode gas stream to 9%H_2 in N_2 (backup gas).

From version 6.0 it is only possible to use alert devices in combination with logic devices to achieve better control of a gas trip situation.

Figure 7.1 shows a diagram of how this can be set up. The basic principle is that an Or-gate is connected to the gasses which must be monitored and if one of the gasses has a true value (that is the gas flow is above the cutoff_report value as specified in the configuration for that gas), then the alert device will recieve a true value (1).

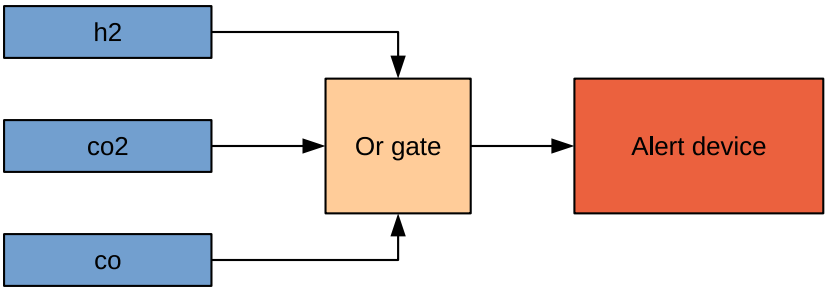


Figure 7.1: Gas trip survaliance control system using a generic alert device. The alert device must be configured with a threshold value of 0.4 and a reset value of 0.6.

If more complex situations are to be monitored, it is possible by inserting other logic and/or gas devices in the control system. Once the alert device recieves a false value (0) it will then execute the configured commands deemed nescesarry to correct the gas trip or prevent damange to the device under test (for instance by switching off any DC power supplies).

7.2 Voltage trip

The definition of a voltage trip is that either an external level relay has determined an under voltage / over voltage situation and shut down the power supply, or that the application has determined that an under voltage / over voltage situation occurs (outside an I-V curve).

In order to protect the device under test, one or more alert devices needs to be configured to correctly handle this situation in such a way that the over or under-voltage situation is corrected. This is most often achieved by setting the output current of any DC power supply connected to the device to the ocv condition,

Chapter 8

Server structure

The programs mentioned in *italics* below all reside in the */usr/local/bin/celltest* directory but some of them have symbolic links to */usr/local/bin*. Most of the programs are written in Perl, but the GPIB-server is written in C.

8.1 Authentication cache server

From version 6.2.0 an autheitication cache server (*/usr/local/bin/celltest/auth_cache.pl*) is included as this version also relies more heavily on user authentication and if its relies on network access to external systems, this may rsult in delays.

The authentication cache server binds to port 4042 on localhost (in order to not be avaliable from the outside).

Thus an authentication cache server cna be started which will locally cache results of user authentication for a short time in order to be able to reuse the results withhout having to contact n external server.

The commands this server understands are the follwing:

- ping: Simply returns a text string indicating that the server process is running.
- login_ok: Checks the supplied login credentials and returns the userid if the credentials are valid. Arguments: username, session_hash. If the value is too old, it will recheck remotely and return the result of this new check 8as well as update the cached value)
- is_admin: Checks the supplied login credentials are valid and returns true if the user is an administrator. Arguments: username, session_hash. If the value is too old, it will recheck remotely and return the result of this new check 8as well as update the cached value)
- get_auth: Returns the cached authenticsation value for the specified user and key. Arguments: username, key. Will return undefined if the value

is older than the timeout.

- **set_auth: Sets the authenticsation value for the specified user and key. Arguments: username, key, value.**
- **reset: Resets all cached access values.**
-

8.2 CGI-server

The CGI server (CGI-server) is responsible for parsing all user commands to the cell test system proper. Each rig runs it's own CGI server as user 'rig#' where the # is the rig number (e.g. 1 or 13 etc..). The CGI server accepts the following commands only (in order to avoid direct execution of possibly damaging commands like 'rm -rf' or similar, refer Leslie Stein's excellent book CGI.pm for further reading on the subject of web security).

- **IV : This command starts an I-V curve using the program *iV_curve.pl*.**
- **stop_iv : This command removes the semaphore file telling the *IV_curve.pl* program to stop the current iV curve and return to OCV.**
- **measure : Performs a complete measurement using *logfile.pl*.**
- **custom : Starts the currently selected program using *custom_prog.pl* (refer section 2.1). Arguments are the program name to execute (only one program can be running at a time for a given rig!).**
- **stop_custom : Stops the currently running program by sending an SIGINT to the process in question. The *custom_prog.pl* program then shuts down cleanly and stops any running I-V curve.**
- **cmdlog : Dumps the rest of the input as a comment in the command log.**
- **logbook : Dumps the rest of the input as a comment in the command log as well as in the rig loogbook.**
- **impedance_ok : This command is used for for notifying the rig that delayed**
  impedance has finished (use in conjunction with multiplexed impedance analyzer where the individual impedance requests are put in queue).
- **debug : Turns debug on and off**
- **version : Returns the RFCcontrol version**

- **ping : Returns a string indicating that the server is alive and which port it is listning on**
- **touch_file : Touches a file, arguments: file name to touch. Note that only files in the user directory for the rig can be touched!**
- **crontab_read : Gets the content of the rigs crontab.**
- **crontab_file : Sets the rigs crontab to the content of the specified file, arguments: file_name**
- **quit : Shuts down the CGI-server, do not use unless necessary as it could ruin other peoples work!**
- **timeslot_begin : Marks that a requested time slot is starting. Removes the semaphore used for waiting for time slot allocation and sets the semaphore indicating a running time slot.**
- **timeslot_end : Removes the semaphore used to indicate a running timeslot. Used by the shared resource to indicate that a reserved time slot has expired and thus ensures that no new commands indicated to be run during a reserved time slot is executed.**
- **set_mailfile : This command sets the mail file which blocks further error mails form being sent (to avoid mail bombs inn case the error condition persists). This command is deprecated and will be discontinued in the future!**
- **unlink_mailfile : This commands removes the file telling the system that an error mail has already been sent (in the case of a voltage trip, refer section 6). This command is deprecated and will be discontinued in the future!**
- **set_H2mailfile : Similar to 'set_mailfile' but for another file. This command is deprecated and will be discontinued in the future!**
- **unlink_H2mailfile : Similar to unlink_mailfile, but for the H2mailfile instead. This command is deprecated and will be discontinued in the future!**
- **current : This command sets the DC current through the device. Arguments are 'ocv' for open circuit condition or the current to be set (ex. 10.5 for 10.5 A). If more than one DC current device is found in the current configuration, a second argument is necessary, this being the name of the device to control. This command is deprecated and will be discontinued in the future!**

- **voltage : This command sets the DC voltage to the device. Arguments are 'ocv' for open circuit condition or the voltage to be set (ex. 2.5 for 2.5 V). If more than one DC current device is found in the current configuration, a second argument is necessary, this being the name of the device to control. This command is deprecated and will be discontinued in the future!**
- **set_temp : This command sets the temperature set point for the furnace controller, arguments are temperature (C) and device name to control. I only one furnace controller is part of the configuration, the device name can be omitted. This command is deprecated and will be discontinued in the future!**
- **set_ramp : This command sets the temperature ramp rate for the furnace controller, arguments are ramp rate (C/hour) and device name to control. I only one furnace controller is part of the configuration, the device name can be omitted. This command is deprecated and will be discontinued in the future!**
- **relay : Sets the status of a relay device, arguments are name of device and status to be set (0 for off and 1 for on). This command is deprecated and will be discontinued in the future!**
- **gas : Sets the gas flow for a single gas. Arguments are: gas_name, flow. This command is deprecated and will be discontinued in the future!**
- **water : Sets the status of a water bubler using water.pl. Arguments are: bubler_name, status. This command is deprecated and will be discontinued in the future!**

The CGI-server is usually accessed directly from the control system (via the web-pages) but in order to facilitate direct access the *CGI_client.pl* program is available.

Notice, that if timeslot_begin, timeslot_end, cmdlog, logbook or impedance_ok commands are to be recieved from external systems, the corresponding port for the CGI server in question must be open and not blocked by the local firewall! (refer the operating system manuals for firewall setup).

Notice that from version 7.1.6 and onwards, the deprecated commands for the CGI-server is only avaliable if the server is started with the –compatibility flag!

The *CGI_client.pl* program has the following usages (based on the above list):

```
CGI_client.pl $rignr IV
CGI_client.pl $rignr stop_iv
CGI_client.pl $rignr measure
CGI_client.pl $rignr custom $programname
CGI_client.pl $rignr stop_custom
```

```
CGI_client.pl $rignr cmdlog $text_to_be_logged
CGI_client.pl $rignr logbook $text_to_be_logged
CGI_client.pl $rignr impedance_ok $ip:$port $user $mode $session $fileid
CGI_client.pl $rignr debug
CGI_client.pl $rignr ping
CGI_client.pl $rignr version
CGI_client.pl $rignr quit
CGI_client.pl $rignr timeslot_begin
CGI_client.pl $rignr timeslot_end
CGI_client.pl $rignr crontab_read
CGI_client.pl $rignr crontab_file $filename
CGI_client.pl $rignr touch $filename
CGI_client.pl $rignr set_mailfile
CGI_client.pl $rignr unlink_mailfile
CGI_client.pl $rignr set_H2mailfile
CGI_client.pl $rignr unlink_H2mailfile
CGI_client.pl $rignr current $current
CGI_client.pl $rignr voltage $voltage
CGI_client.pl $rignr relay $name $status
CGI_client.pl $rignr gas $gasname $gasflow
CGI_client.pl $rignr water $bublername $status
```

In the list above all words beginning with a '$' is a variable (and the exact value must be determined and substituted).

8.3 Report server

The *report-server* program is used when accessing test reports as well as synchronizing access to test rigs on different servers. It accepts the following commands:

- **'quit': Shuts down the *report-server*.**
- **'version': Reports the version of RFCcontrol running on this server.**
- **'search': Search for test reports on a target system, search, value to match.**
- **'is_ssl': Returns 1 in encryption is to be used. Similar to the correspoknding command for the password server (refer section 4.3.4).**
- **'public_key': Returns the servers public key. Similar to the correspoknding command for the password server (refer section 4.3.4).**
- **'servers': Returns a list of valid server names (if the server is specified as being a list server, that is the server-names key is in the servers section of the global configuration file is specified (refer section 4).**

- **'list_servers': Returns a list of valid list server names (if the server is specified as being a list server, refer section 4).**
- **'rigs': Returns a list of valid rigs on the system. It first searches for an entry in the global configuration file section 'servers' named 'rigs_$hostname = ...' and if it exists, returns the rigs mentioned here. If no such line is found, it returns the rigs listed in the 'rigs' key in stead (simmilar to the call to 'active_rigs' listed below). The reason for this difference is that a specific rig may be decommissioned (thus no longer possible to control), but the data should still be accessible. Thus by using the 'rigs' request one could get a list of all possible rigs that have recorded data at some point, even ones which may no longer be operational.**
- **'active_rigs': returns a list of active rigs on the system (that is rigs where commands are possible).**
- **'last_user': Returns the username of the last (real) user which executed a command on the specified rig number. This command does not report the system users ('warning_system', 'custom_prog.pl' etc.) but only real user commands.**
- **'rig_auth': Terurns a true value if the specified user is authorised for the rig in question. Arguments: rignumber username.**
- **'is_report': Returns a string if the rig and test corresponding to the specified arguments has had a report generated and if it has been finalized. The returned string contains the cell name followed by either 'REPORT' or 'PDF' if a report has been prepared (depending on format being postscript or pdf respectively) followed by 'FINISHED' if the report has been finalized. Arguments: Rignumber, testnumber. The reason for returning the cell number as part of this call is that it is the only part of the report file name which can not be determined by the rig and test number directly.**

If the report server is started with the –ssl option or the 'force_encryption' key is set to 'yes' in the passwds section of the server configuration file (refer section 4.3), only the 'is_ssl' and 'public_key' commands can be used without encryption. If encryption is used, the communication between the clients and the servers are similar to the one for the password server communication described in section 4.3.4.

The report server can be accessed through the *report-client* as follows:

```
report-client $IP_or_hostname search $value_to_match
report-client $IP_or_hostname quit
report-client $IP_or_hostname is_ssl
report-client $IP_or_hostname public_key
report-client $IP_or_hostname servers
report-client $IP_or_hostname rigs
```

```
report-client $IP_or_hostname active_rigs
report-client $IP_or_hostname rig_auth $rignr $user
report-client $IP_or_hostname is_report $rig $test
```

The report server then returns a list with the tests that matched the given search term. It only searches the data found in the file *~/celltest/info_table.txt* on the target system!

8.4 Serial server

The serial server handles all communication to the serial devices (one server must be running for each serial device used). The server must be run as root, as only root has access to the hardware devices (/dev/ttyS0 etc.). The server assumes that all modules communicate with baud rate 9600 except in the case of the power supplies which operates at 4800 baud. The serial server accepts the following commands only:

- **'quit': Shuts down the serial server, do not use unless you intend to shut down the serial devices. Note that this command is only avaliable from local connections (from same IP as server).**
- **'debug': Toggles the debug information on/off: If any arguments are passed, the argument specifies if debugging is to be on or off (accepts enable/disable). Note that this command is only avaliable from local connections (from same IP as server).**
- **'temp': This command communicates with an Eurotherm® controller using the bisynch protocol: Arguments: mode, address, tag, [opt. new_value]. Where mode is either 'R' or 'W' for read or write respectively.**
- **'modbus': This command communicates with an Eurotherm® controller using the modbus protocol. Arguments: mode, address, tag_number, [opt. new_value] where mode is one of the following: 'R' for raw read, 'RI' for integer read, 'G' for floating-point read, 'W' for integer write, 'P' for floating-point write and 'H' and 'HC' for communicating with a Honeywell temperature controler (refer the Honeywell.pm module for further information).**
- **'omron': This command communicates with an Omron® controller using the modbus protocol. Arguments: mode, address, tag_number, [opt. new_value] where mode is one of the following: 'R' for integer read and 'W' for integer write.**
- **'brooks': This command is used for communication with a Brooks® S-type mass flow controller. The command assumes that the controller is working with a baud rate of 19200 and a parity of 'odd'. Arguments:**

tag_number, action, [opt value] where action is one of the following: INIT, READFLOW, SETFLOW, OVERRIDE.

- **'mks': This command sends the specified command string to a MKS® mass flow controler and returns the response string. The command assumes that the controler is working with a baud rate of 9600, 8 data bits, 1 stop bit and no parity. Arguments: address, command_string. The server automatically calculates the checksum bytes, so they should not be included in the command string.**
- **'bronkhorst': This command is for communication with a Bronkhorst® mass flow controller. Arguments: command, [opt value] where command is one of the following: string, readflow, setflow, readset. Note that no address argument is necessary as the server assumes only one device on the serial port (Direct RS232 communication)!**
- **'init': This command initializes a DC power supply (of type Delta Elektronika® daisy chained through RS232). Arguments: 31 RS232_box_address, max_voltage. Note that it is necessary to remember the initial argument '31' (for historical reasons this argument is maintained although it is not used)!. Note that this comand is only avaliable from local connections (from same IP as server). This command is deprecated and should not be used.**
- **'current': This command sets the DC current for the power supply. Arguments: 31 RS323_box_address, current where current is either 'OCV' for open circuit operation or the current to be set. Note that it is necessary to remember the initial argument '31' (for historical reasons this argument is maintained although it is not used)!. This command is deprecated and should not be used.**
- **'delta': This command supersedes the current command described above. It is used for Delta Elektronida PSU's. Arguments: mode, address, [optional arguments depending on mode], where mode is one of the list: (raw, idn, init, current, volt, measure_volt, measure_current, ocv, on).**
- **'hmp': This command is used for Rhode&Schwarz HMP4040 power supplies and only works with RS232 (as no addressing is possible). Arguments: mode [Optional additional arguments], where mode is one of the following list: (init, enable, disable, idn, volt, current, measure_volt, measure_current, current_setpoint, volt_setpoint)**
- **'elektro': This command is used for controlling Electronic loads (EL_9160_300_HP and similar). Arguments: mode, address, [optional arguments], where mode is one of the following list: (idn, ocv, on, remote, read, write, read_values, raw, hex, raw_byte_read, raw_byte_write).**
- **'relay': Sets the status of an ICP-con® relay box (model 7064 or 87064 or compatible). Arguments are: address, relay_number, status where status is 1 for closed and 0 for open.**

- **'icptest': Performs a test of the ICP-module (all models that accepts the '$AA2' command) on the address specified, the return value is the string returned by the module.**
- **'icp_raw': passes the argument directly to the RS232/RS485 bus, used for setting the configuration if ICP modules. Please read the documentation for the ICP-con® modules for further info.**
- **'icpmultiread' Reads the status of a ICP-con® analogue to digital data acquisition module returning a string containing all the measured values separated by newlines.**
- **'multiplex': This command has a umber of sub commands as following. All commands regards ICP-con® relay modules model 7064 or 87064 or compatible.**
  - **'SET_SINGLE': This command sets all the relays except one in the off position (Note relay numbers starts with 0). Arguments: module_address, relay_number.**
  - **'SET_MULTI': This command sets all relays to the specified state. Arguments: module_address, relay-status. The relay_status string is in binary representation (ex. '10010110').**
  - **'READ': This command returns the status of the relay module in the form of a binary representation string (ex '10010110'). Arguments are module_address.**
  - **'READ_RAW': Returns the raw status string from a relay module. Arguments: module_address.**
- **'volt_set' or 'flow': These commands sets the output voltage of a ICP-con® multichannel analogue output module (model 7024 or 87924 or compatible). Arguments: module_address, channel_number, output_voltage. Range of output voltage depends on module configuration, refer ICP-con® module manual.**
- **'strgr': This command read the voltage of the input of a ICP-con® strain gauge module (model 7016 or compatible). Arguments: module_address.**
- **'strgs': This command sets the output voltage of a ICP-con® strain gauge module (model 7016 or compatible). Arguments are: module_address, output voltage (Note only positive voltages can be set!, range depends on module configuration).**
- **'da': Sets the output voltage of a ICP-con® module. Arguments: module_address, output voltage, This command may be incomplete, use at own risk!.**

- **'icp7017read': This command reads the analog values of a ICP-con®-7017 module and returns the values as a carriage return delimited list. Arguments: module_address**
- **'relay_crc': Identical to 'relay' except it uses CRC checksum for serial communication.**
- **'icptest_cŕc': Identical to 'icptest' except it uses CRC checksum for serial communication.**
- **'icp_raw_crc': Identical to 'icp_raw' except it uses CRC checksum for serial communication.**
- **'icpmultiread_crc' Identical to 'icpmultiread' except it uses CRC checksum for serial communication.**
- **'multiplex_crc': Identical to 'multiplex' except it uses CRC checksum for serial communication.**
- **'volt_set_crc' or 'flow_crc': Identical to 'volt_set' and 'flow' except it uses CRC checksum for serial communication.**
- **'strgr_crc': Identical to 'strgr' except it uses CRC checksum for serial communication.**
- **'strgs_crc': Identical to 'strgs' except it uses CRC checksum for serial communication.**
- **'da_crc': Identical to 'da' except it uses CRC checksum for serial communication.**
- **'icp7017read_crc': Identical to 'icp7017read' except it uses CRC checksum for serial communication.**
- **Keithley: This command can be used for communication with keithley 2700 ad 2750 scanning multimeters as well as directly to other types of de3vices (through the w, r and c commands). The command type must be spe3cified as a single letter as shown below:**
  - **w: Writes the second argument verbatim to the device. Does NOT wait for a response!**
  - **r: Reads from the device.**
  - **c: Sends the second argument command to the device and reads the sesponse.**
  - **k: Only valid for Keithley 2700 or 2750 scanning multimeters! Closes the specified channel, sets the specified measure type and does a single measurements. Returns the result. The measure type is set as a string. Common types are: 'volt:dc', 'volt:ac', 'res' and 'fres' (fres being 4-point resistance measruements, only avaliable for some**

types of scanner cards). If no measure type is specified, 'volt:dc' is assumed. Arguments: channel_nr [opt setup], where channel_nr is in the form 'BCC' (3 digits), where B is the board nr (1 or 2 for Keithley 2700 and 1 to 5 for Keithley 2750) and CC is the channel nr on the board (from 01 to 40 depending on board type).

- **b: Same as k, except that a burst measurement of n points is performed instead.**

- **'julabo_default': use to communicate over RS232 with Julabo circulator using the default instrument communication settings. $command = the command code $arg = argument if needed for the command please see instrument manual.**

- **'julabo_raw': like 'julabo_default' but with specifying the used $baudrate, $parity and $handshake valid baudrate: 1200 , 2400, 4800, 9600, valid parity: 'none', 'odd', 'even' valid handskake: 'rts','xoff','none' $command = the command code $arg = argument The server is started with the two arguments: the serial device to bind to (ex. ttyS0) and the baud rate. If an optional third argument is used, then the server emulates the tty given as this argument. Thus *serial-socket-server-9.0.pl ttyM0 9600 ttyS20* will bind to /dev/ttyM0 but pretend to be /dev/ttyS20. The serial server is usually accessed only by the command system through the web pages (refer section 9), but the *serial-socket-client-1.2.pl* program can access the serial server directly. The serial client has the following usages (based on the list above):**

See the examples below for the individual commands.

```
serial-socket-client-1.2.pl $tty quit
serial-socket-client-1.2.pl $tty debug [opt. $mode]
serial-socket-client-1.2.pl $tty relay $address $relay $status
serial-socket-client-1.2.pl $tty icptest $address
serial-socket-client-1.2.pl $tty icp_raw @args
serial-socket-client-1.2.pl $tty icpmultiread $address
serial-socket-client-1.2.pl $tty multiplex SET_SINGLE $address $relay
serial-socket-client-1.2.pl $tty multiplex SET_MULTI $address $statusstring
serial-socket-client-1.2.pl $tty multiplex READ $address
serial-socket-client-1.2.pl $tty multiplex READ_RAW $address
serial-socket-client-1.2.pl $tty flow $address $channel $value
serial-socket-client-1.2.pl $tty volt_set $address $channel $value
serial-socket-client-1.2.pl $tty strgr $address
serial-socket-client-1.2.pl $tty strgs $address $value
serial-socekt-client-1.2.pl $tty icp7017read $address
serial-socket-client-1.2.pl $tty da $address $value
serial-socket-client-1.2.pl $tty relay_crc $address $relay $status
serial-socket-client-1.2.pl $tty icptest_crc $address
serial-socket-client-1.2.pl $tty icp_raw_crc @args
serial-socket-client-1.2.pl $tty icpmultiread_crc $address
```

```
serial-socket-client-1.2.pl $tty multiplex_crc SET_SINGLE $address $relay
serial-socket-client-1.2.pl $tty multiplex_crc SET_MULTI $address $statusstring
serial-socket-client-1.2.pl $tty multiplex_crc READ $address
serial-socket-client-1.2.pl $tty multiplex_crc READ_RAW $address
serial-socket-client-1.2.pl $tty flow_crc $address $channel $value
serial-socket-client-1.2.pl $tty volt_set_crc $address $channel $value
serial-socket-client-1.2.pl $tty strgr_crc $address
serial-socket-client-1.2.pl $tty strgs_crc $address $value
serial-socekt-client-1.2.pl $tty icp7017read_crc $address
serial-socket-client-1.2.pl $tty da_crc $address $value
serial-socket-client-1.2.pl $tty temp r $address $tag
serial-socket-client-1.2.pl $tty temp w $address $tag $value
serial-socket-client-1.2.pl $tty modbus r $address $tagnr
serial-socket-client-1.2.pl $tty modbus ri $address $tagnr
serial-socket-client-1.2.pl $tty modbus g $address $tagnr
serial-socket-client-1.2.pl $tty modbus w $address $tagnr $value
serial-socket-client-1.2.pl $tty modbus p $address $tagnr $value
serial-socket-client-1.2.pl $tty modbus h $address $cmd_type $byte_count @args
serial-socket-client-1.2.pl $tty modbus hc $address $cmd_type @args
serial-socket-client-1.2.pl $tty omron r $address $tagnr
serial-socket-client-1.2.pl $tty omron w $address $tagnr $value
serial-socket-client-1.2.pl $tty brooks $tagnr init
serial-socket-client-1.2.pl $tty brooks $tagnr readflow
serial-socket-client-1.2.pl $tty brooks $tagnr setflow $value
serial-socket-client-1.2.pl $tty brooks $tagnr override $value
serial-socket-client-1.2.pl $tty mks $adr $cmdstr
serial-socket-client-1.2.pl $tty bronkhorst string $cmdstr
serial-socket-client-1.2.pl $tty bronkhorst readflow
serial-socket-client-1.2.pl $tty bronkhorst setflow $value
serial-socket-client-1.2.pl $tty bronkhorst readset
serial-socket-client-1.2.pl $tty init 31 $address $max_volt
serial-socket-client-1.2.pl $tty current 31 $address $value
serial-socket-client-1.2.pl $tty delta idn $address
serial-socket-client-1.2.pl $tty delta raw $address [@args]
serial-socket-client-1.2.pl $tty delta ocv $address
serial-socket-client-1.2.pl $tty delta on $address
serial-socket-client-1.2.pl $tty delta volt $address $voltage
serial-socket-client-1.2.pl $tty delta current $address $current
serial-socket-client-1.2.pl $tty delta measure_volt $address
serial-socket-client-1.2.pl $tty delta measure_current $address
serial-socket-client-1.2.pl $tty delta init $address
serial-socket-client-1.2.pl $tty hmp init
serial-socket-client-1.2.pl $tty hmp enable
serial-socket-client-1.2.pl $tty hmp disable
serial-socket-client-1.2.pl $tty hmp idn
serial-socket-client-1.2.pl $tty hmp volt
serial-socket-client-1.2.pl $tty hmp vurrent
serial-socket-client-1.2.pl $tty hmp measure_volt
serial-socket-client-1.2.pl $tty hmp measure_current
```

```
serial-socket-client-1.2.pl $tty hmp current_stpoint
serial-socket-client-1.2.pl $tty hmp voltage_setpoint
serial-socket-client-1.2.pl $tty elektro idn $address
serial-socket-client-1.2.pl $tty elektro remote $address [on/off]
serial-socket-client-1.2.pl $tty elektro ocv $address
serial-socket-client-1.2.pl $tty elektro on $address
serial-socket-client-1.2.pl $tty elektro read_values $address
serial-socket-client-1.2.pl $tty elektro read $address $tag
serial-socket-client-1.2.pl $tty elektro write $address $tag $value
serial-socket-client-1.2.pl $tty elektro raw_byte_read $address $tag
serial-socket-client-1.2.pl $tty elektro raw_byte_write $address $tag [@args]
serial-socket-client-1.2.pl $tty elektro raw $address $mode $length [@args]
serial-socket-client-1.2.pl $tty elektro hex $address [@args]
serial-socket-client-1.2.pl $tty keithley w $command
serial-socket-client-1.2.pl $tty keithley r
serial-socket-client-1.2.pl $tty keithley k $channel_nr [$setup]
serial-socket-client-1.2.pl $tty keithley k $channel_nr $number_of_points [$setup]
serial-socket-client-1.2.pl $tty julabo_raw $baudrate $parity $handshake $command $arg
serial-socket-client-1.2.pl $tty julabo_raw $baudrate $parity $handshake $command
```

As for the *CGI_client.pl* program in the above list all stings beginning with a '$' is variables and any string beginning with a '@' is an array of variables (described in more details previously).

8.5 GPIB-server

Although the GPIB server is not distributed with NAME it is described briefly here, as any keithley device (simple channels for instance) assumes a functioning GPIB-server to work up against. The GPIB-server handles all communication with devices attached to the GPIB controller (Keithley multichannel multi meters mainly). The server version 2.9+ accepts the following commands:

- **'I': This command initializes the channel definitions (is automatically run at server start-up and is only intended if changes have been made to the channel definitions).**
- **'D': Turns debug information on and off (printed on standard out, so redirect this somewhere sensible).**
- **'R': This command reads from the specified device address. Arguments: device_address.**
- **'W': This command writes a command string to the specified device. Arguments: device_address, command_string (remember quotes!).**
- **'T': This command sets the GPIB communication delay to the specified number of milliseconds (default is 1 ms).**

- **'C': Combined write and read command.**
- **'K': This command reads a channel on the Keithley 2700 multimeter. Arguments: address:board_number__channel_number (the set-up is found in the channel definitions). Note that no space between the gpib address, the colon ':', the board number or channel number. Example: measure channel 4 on board 1 on gpib 16: *gpibclient K 16:104***
- **'B': Same as K, but in a burst mode instead with an additional argument specifying how many consecutive measurements to perform. Note that this blocks the keithley and gpib bus until the measurements has been performed and the result returned!**
- **'V': Same as 'K' except that the channel set-up must be specified as an additional argument.**
- **'Q': This command forces the server to quit gracefully (no core dump).**

The channel definitions are located in the directory */etc/gpib/* The *gpibclient* program can be used to directly access the gpib-server: usage:

```
gpibclient I
gpibclient D
gpibclient C $address $command_str
gpibclient R $address
gpibclient W $address $command_str
gpibclient K $address:$channel
gpibclient T $delay
gpibclient B $address:$channel number_of_measurements_in_a_row
gpibclient V $address:$channel $set-up
gpibclient Q
```

Although the true GPIB_server is not distributed with NAME, an small dummy server is, it can be found in the dummy_gpib_server directory in the distribution directory, and can be compiled and installed by running the make and make install commands in that directory. This small dummy server emulates a true GPIB server, and has some of the functionality described above. Specifically it honors the D,T,I and K commands (although the K command only returns a fixed value, -32768). This dummy server is included in order to test the system and to provide a harness for developers in case the normal GPIB_server is not available.

8.6 Custom program parser

The *custom_prog.pl* program is used to parse the program sequence generated by the set-up user interface described in section XX. The parser recognises the following commands (the colon before the descriptive text is NOT part of the command!):

- **exit: This command exits the program thus ignoring all following lines.**
- **wait = XX: This command lets the program wait for XX minutes before executing the next item.**
- **gas:YY = XX: This command sets the gas flow for gas 'YY' to XX L/hour.**
- **gas:ramp:XX YY ZZ QQ: This command ramps the flow for gas XX from the curent level to the specified setpoint (YY) with a stepsize of ZZ and with QQ seconds in between. The stepsize can not be less than half the accuracy of the gas flow controler in question (which is usually 1 % of full scale) and the time between steps can not be less than 1 second.**
- **current = XX [YY]: This command sets the DC current to XX. In order to set open circuit conditions uses the value 'OCV' instead of a number. If the YY argument is added it must be the name of the controler to be used. If an analog controler is to be used, the second argument must be specified.**
- **current:ramp:XX YY ZZ QQ: This command ramps the DC current for PSU or analog output XX from the curent level to the specified setpoint (YY) with a stepsize of ZZ and with QQ seconds in between. The time between steps can not be less than 1 second.**
- **voltage = XX YY: This command sets the DC voltage to XX on device with name YY. In order to set open circuit conditions uses the value 'OCV' instead of a number.**
- **water = X: This command sets the status of the water bubler, use 1 for enabled and 0 for disable (e.g. bypass).**
- **m_leak: This command runs three normal measurements (using *logfile.pl*) and sets a mark in the program logfile (proglog) that a 'leak measurement' has been performed. Note that a leak measurement is nothing more than a normal measurement except for the mark in the proglog file.**
- **iv: This command starts an iV curve by forking and thus imediately executes the next line in the program. Usually this command is not used.**
- **ivwait: This command runs an I-V curve and waits until the I-V curve is finished before the next line is executed.**
- **killiv: This command kills any running I-V curve (started by the command 'iv' in the case the I-V curve is still running by the time this command is reached, usually after an appropriate wait command).**
- **temp = XXX: This command sets the furnace setpoint to XXX °C**

- **ramp = XX: This command sets the ramp rate of the furnace to XX °C/hour.**
- **addjust_temp XXX YY: This command tries to adjust the temperature setpoint so that the measured temperature is close to the target. The algorithm uses the temperature for the first temperature channel defined in the main section! XXX is the target temperature and YY is the maximum temperature offset allowed before the algorithm aborts trying to adjust. Note that this function waits 3 hours before the adjustment in order to allow the temperature to stabilise and to avoid oscillations if more than one adjustment are called. Also note, that this function uses a feedback loop, thus if it measures/reads garbled values, it may set the temperature completely erroneous!**
- **text = xxxxxx... : This command simply appends the string after the equals sign to the program logfile (proglog) of the current test.**
- **measure: This command runs two measurements using logfile.pl with a 10 second wait in between.**
- **c_stepY = XX: This command updates the configuration file (specifically the 'currentstepY' value in the corrent section (refer section 4.7)). The current step value is set to XX A. This command is valid for current_step 1 through 3.**
- **c_limit = XX: This command updates the configuration file similar as c_step and sets the current_limit value to XX A.**
- **v_limit = XX: This command updates the configuration file similar as c_limit and sets the voltage_limit value for i-V curves to XX mV (Used in i-V curves run in fuel cell mode!).**
- **e_limit = XX: This command updates the configuration file similar as c_limit and sets the electrolysis_voltage_limit value for i-V curves to XX mV (Used in I-V curves run in electrolyser more!.**
- **ivpause = XX: This command updates the configuration file similar as c_step and sets the wait tome between current steps in I-V curves to XX seconds.**
- **gas_multiplexer XX YY: This command changes the setting of gas multiplexer XX to use gas YY. The program waits 10 seconds before executing the next command.**
- **relay:X = Y: This command sets the status of a relay output with name X to status Y. Note that the relay name X must be defined in the rig configuration file. The status value is either 'Yes' for on or 'No' for off.**
- **PID:YY = XX: This command sets the setpoint for PID device 'YY' to XX.**

- **impedance XXX.XXX.XXX.XXX:YYYY ZZ AAAA BBBBBBB...: This command runs an impedance on an external Elchemea© system found at IP address X and port Y run by user A and using configuration for session Z. Finally the resulting file is compensated (by complex subtraction) using the file found at location B (*). If the compensation string (B) is as follows, short circuit compenstaion of the data is performed:**
  comp: filename
  Using the data in the file specified by filename. If the compensation string (B) is as follows, open circuit compensation of the data is performed instead:
  comp_ocv: filename
  In this case open circuit compensation is perfomed using data in the file specified by filename.

- **potsweep XXX.XXX.XXX.XXX:YYYY ZZ AAAA: This command runs an potential sweep on an external Elchemea© system found at IP address X and port Y run by user A and using configuration for session Z (*).**

- **chrono XXX.XXX.XXX.XXX:YYYY ZZ AAAA: This command runs an chronoamperometry/potentiometry on an external Elchemea© system found at IP address X and port Y run by user A and using configuration for session Z (*).**

- **current_impedance XXX.XXX.XXX.XXX:YYYY ZZ AA: This command runs an impedance in constant current mode (utilising the external shunt). Options are similar to impedance command above except that the compensation is done automatically with out specifying which file) (*). Note that this compensation can only be short cirduit compensation as well as shunt resistor compensation. Also note that the compensation files must be named short.i2b and shunt.i2b and must be placed in the imp_comp directory of the rig in question for this to work.**

- **change_channel XXX.XXX.XXX.XXX:YYYY A: This command changes the measure channel on the remote Elchemea© system at IP-address X and port Y to channel A (valid values are 0, 1, 2 and 3). Note that this command can only be accessed through the manual edit functionality (*). If a relay device is found with the name 'multiplex_channel', the status of this relay (which should be a manual (e.g. virtual) relay) is set to the channel value. This is usefull for data procesing purposes as the selected channel number will be logged by the dala logging subsystem for later referencing. For instance it can be included in the 'relay_names_ivtable' key in the report section (refer section 6) in which case it will bee displayed in the impedance tables.**

- **socket X:YYYY [args]: This comand sends a TCP/IP socket call to the specified host (X) and port (YYYY). Any additional arguments (seperated by the tab character) is passed on to the remote server. As opposed**

to the impedance, chrono and potsweep family of commands, the host value for this command can either be a TCP/IP address or a normal hostname. The returned text string form the remote system is appended to the proglog file directly.

- **mail: user.name@domain.address message_to_user: This command attempts to send the message to the specified email address. A message is logged that the mail was sent or in the case of error, that no mail could be sent. Note that only alphanumeric characters are supported in the address (that is a-z, A-Z, underscores, punctuations and 0-9 is allowed) both as user name and as domain name and that this command can only be accessed through the manual edit functionality (note remember the colon after the mail command!).**

- **function device_type device_name function_name [arguments]: This command calls the specified member function on the RFC::BaseDevice derived instance with the specified type and name. If no device instance is returned by $rig→get_device() an error is raised and the same happens if no function matches the specified function name for the device instance in question. Notice that this command could potentially leave the RFCcontrol rig instance in an undefined state as blindly calling member functions on a device could result in unwanted (or indeed undefined) behaviour! Thus this function should only be used if no other option is found for achieving the desired result. Also note that only already initialised devices are avaliable as this command does NOT attempt to initialise new devices not already loaded as part of the rig instance initialisation.**

  Remember that some member functions require objects and / or references as arguments, and as the function command can only supply strings and / or numbers as arguments, any call to a member function expecting a reference or object will fail (Refer capter 11 for descriptions of the avaliable member functions).

- **timeslot_start XXX.XXX.XXX.XXX YYYY ZZZ: This command is used to initiate and wait for a time slot of duration Z minutes on a shared resource on IP X and port Y (could be an impedance multiplexer for instance). The command sends a timeslot request to the shared resource and waits untill the timeslot_wait semafore is removed (by a reverse callback to the CGI-server, refer section 8.2). Once the semafore is removed the program continues. However any commands executed before the corresponding 'timeslot_end' command will only execute if the 'timeslot_start' seafore exists! The format of the timeslot request string which is send to the shared resource is: *add_item timeslot $time $rigname $ip_address* where $time is the time in seconds!, $rigname is the rig name ('rig1' for rig 1) and $ip_address is the ip-address of the current system so that the remote server knows where to send the reverse callback once the timeslot is due. Note that this command is only accesible**

through the manual edit functionality.

- **timeslot_end: This command marks the end of a time synchronised sequence (a time slot on a shared resource as described above). Note that this command is only accesible through the manual edit functionality.**
- **wait_for_input: devicename [optional maximum wait time]: This comand delays further program execution untill the specified device (which must be a relay or a device which masquerade for a relay such as logic devices) returns a true value. If the optional maximum time (minutes) is specified, once this time is exceeded the program will continue even if the device has not returned a true value yet. Note that if the specified device name does not exist as one of the avaliable relay names, an error is raised and the program continues.**

Note that some of the commands in the above list is only accessible through the manual edit functionality whereas others are directly accessible through the GUI shown in figure 2.6. All commands marked with an asterisks (*) are ONLY available in conjunction with an external Elchemea© impedance control system. An example of a custom program file is shown below:

```
wait = 1
temp = 650
wait_for_input: impedance_ready 120
gas:o2 = 0.5
wait = 15
current = 0
measure
current_impedance 10.0.17.119:4040 2 rig1 comp:
current = OCV
ivwait
wait = 1
gas:o2 = 2.5
wait = 15
current = 0
measure
current_impedance 10.0.17.119:4040 2 rig1 comp:
current = OCV
ivwait
wait = 1
gas:o2 = 4
wait = 1
gas:o2 = 6.1
wait = 15
current = 0
measure
current_impedance 10.0.17.119:4040 2 rig1 comp:
current = OCV
ivwait
```

```
wait = 1
gas:o2 = 3
wait = 1
gas:o2 = 0.5
text = End of non synchronised program
timeslot_start 10.0.10.120 4041 60
current_impedance 10.0.10.120:4040 2 rig1 comp:
timeslot_end
mail: foo@foo.bar Program is finished
```

Chapter 9

Web services

RFCcontrol includes a number of ways for other systems to interface with it as well as a number of rig and device functions through the web interface implemented by the *rig_ajax_run.cgi* and *ajax_interface.cgi* scripts as well as true webservices accessed through SOAP.

9.1 SOAP interfaces

Prior to version 6.0 of RFCcontrol, most interserver communication was performed by direct TCP/IP RPC calls (to the password server as well as the report server). This requires the TCP ports 2020 and 4040 to be open through firewalls, which sometimes is not possible. As of version 6.0 all these calls can be performed through the web services defined by the wsdl files in the /wsdl directory (https://host.domain/wsdl/, subsittute your own hostname for yor RFCcontrol server(s)).

The *r*eport.wsdl file defines the webservice frontend for the report server, and all commands (except quit, is_ssl and public_key) described in section 8.3 can be accessed through this webservice.

Similarly the *s*ession.wsdl file defines the web service which replaces the direct call to the passsword server (refer sections 4.3.2 and 4.3.3).

The *c*gi_service.wsdl file defines all the functions which will be needed for remotely controlling a RFCcontrol rig. However it does not contain any functionality for configuring a rig, it only exposes the normal control functions, such as set current, change temperature and start a new test as well as login and logout etc.

Although the SOAP interface method is slower than the direct TCP:IP calls (due to the nescesarry overhead caused by the webserver and XML transformations), it is to be prefered as it is less prone to errors, notably it will awoid the need to cach the public keys from the remote servers.

One thing to note however is that if self signed certificates are used, the

following command needs to be executed in the RFCcontrol install directory

make allow_selfsign

Although normal TCP::IP is deprecated it can be enabled by setting the 'ignore_soap' configuration value in the 'passwds' section to 'yes' in the global configuration file (refer

9.2 globalconf

), in which case no SOAP calls are attempted.

9.3 Remote interface

The *ajax_interface.cgi* script exposes a number of information which can be accessed from external systems which needs to interface with RFCcontrol.

Section 8.3 describes the TCP:IP socket interface which can be used for some of the interaction (mainly between individual RFCcontrol servers who is part of a cluster and where confidential information could be transmitted).

The web service interface described in this section can only expose public information, and is primarily designed for interfacing with ElchemeaAnalytic.

Detailed information regarding the usage of the web interface can be obtained by pointing your browser at host.domain/cgi-bin/celltest/ajax_interface.cgi where the web service script in lack of any parameters will print a page describing the expected input parameters and different available functions.

The way to limit information to only be available to authorized users is to add a .htaccess file in the root directory (test directory) of the data which is to be kept confidential (Refer the Apache documentation as to how to properly configure Apache to restrict access by using .htaccess files).

If such a file is located in the test directory, all web service calls which could transmit any information from within such a directory merely return an empty string.

9.4 Ajax callback interface

In addition to the remote web service interface, RFCcontrol also has a number of functions which is intended to be called by Ajax callback through the *rig_ajax_run.cgi* script.

The function exposed by the *rig_ajax_run.cgi* script can be used by third party programs to remotely control a RFCcontrol rig instance making interfacing with other systems possible.

The following sections describe each of the individual functions exposed by this interface as well as the parameters which must be specified for the specified function to run.

A common parameter for all the functions described is this section is the 'rig' parameter which must contain an integer corresponding to the rig number that is to be accessed / controlled. An exception to this is the checkuser and new_session commands which do not require this.

A third parameter is the 'action' parameter which controls which action is to be taken.

9.5 Functions which can be called without log-in information

The first list of functions can be called without log-in information.

9.5.1 checkuser

Returns 'OK' if the user session is valid and an error otherwise The parameters are:

- **'name' - Username**
- **'pass' - session token**

9.5.2 new_session

Initiates a new login session. If the supplied username and password combination is correct it returns 'OK', the userid and a new valid session token. It retuns an error message if credentials was not valid. The parameters are:

- **'name' - Username**
- **'pass' - Password**

9.5.3 get_imp_data

This function returns the impedance data from an impedance file where the file name matches the specified name. The parameters are:

- **'rig'**
- **'action' - action parameter, must be: 'get_imp_data'**

- **'testno' - The test number of the test to access.**
- **'file' - The filename to access.**

If a .htaccess file exists in the test directory no information is exposed unless the 'name' and 'pass' parameters are also supplied (and the user in question has a valid log in session and is authorised to access data for the rig in question, refer section 9.6).

9.5.4 show_log

This function returns the content of the current program log for the specified rig. Parameters are:

- **'rig'**
- **'action' - action parameter, must be: 'show_log'**

If a .htaccess file exists in the test directory no information is exposed unless the 'name' and 'pass' parameters are also supplied (and the user in question has a valid log in session and is authorised to access data for the rig in question, refer section 9.6).

9.5.5 show_info

This function returns the content of the current test log for the specified rig. Parameters are:

- **'rig'**
- **'action' - action parameter, must be: 'show_info'**

If a .htaccess file exists in the test directory no information is exposed unless the 'name' and 'pass' parameters are also supplied (and the user in question has a valid log in session and is authorised to access data for the rig in question, refer section 9.6).

9.5.6 show_error

This function returns the content of the current error log for the specified rig. Parameters are:

- **'rig'**

- **'action' - action parameter, must be: 'show_error'**

If a .htaccess file exists in the test directory no information is exposed unless the 'name' and 'pass' parameters are also supplied (and the user in question has a valid log in session and is authorised to access data for the rig in question, refer section 9.6).

9.5.7 is_iv

This function returns 1 if an i-V curve is running, 0 otherwise. Parameters are:

- **'rig'**
- **'action' - action parameter, must be: 'is_iv'**

9.5.8 get_callibration_file

This function returns the content of a custom thermocouple calibration file for the specified rig and file name. Parameters are:

- **'rig'**
- **'action' - action parameter, must be: 'get_callibration_file'**
- **'filename' - The name of the file containing the calibration data, located in *'/home/celltest/convert-tables/userfiles/***

9.5.9 plot_callibration_file

This function returns a link to an image file (a png file) which shows a plot of the contents of a thermocouple calibration file. The returned link is a relative link beginning with *celltest/png* Parameters are:

- **'rig'**
- **'action' - action parameter, must be: 'plot_callibration_file'**
- **'filename' - The name of the file containing the callibration data, located in *'/home/celltest/convert-tables/userfiles/***

9.6 Functions requiring a valid log in session

The following functions require a valid log-in before they can be accessed, and in addition the the 'rig' and 'ajax' parameters must also be called with the 'name' parameter (the user-name) as well as the 'pass' parameter (which does NOT contain the password but a session token).

In addition to a valid log-in session, the user must also be authorized to change parameters on the rig in question (refer section 4.4).

9.6.1 list_caching

This function returns a list of devices for which caching is enabled (refer section 6.2.1).

The parameters are:

- **'rig'**
- **'name' - User name**
- **'pass' - Session token**
- **'action' - action parameter, must be: 'list_caching'**

9.6.2 start_iv

This function starts an i-V curve for the specified rig. Notice that only one i-V curve can be running at the same time for a particular rig.

The parameters are:

- **'rig'**
- **'name' - User name**
- **'pass' - Session token**
- **'action' - action parameter, must be: 'start_iv'**

9.6.3 stop_iv

This function stops an i-V curve for the specified rig.

The parameters are:

- **'rig'**

- **'name' - User name**
- **'pass' - Session token**
- **'action' - action parameter, must be: 'stop_iv'**

9.6.4 get_programs_test

This function returns a list of previously run programs for the specified rig and test number.

The parameters are:

- **'rig'**
- **'name' - User name**
- **'pass' - Session token**
- **'action' - action parameter, must be: 'get_programs_test'**
- **'session' - The test number to access. If the current test is to be accessed, this parameter can be omitted.**

9.6.5 set_imp

This function attempts to start an impedance scan on an external Elchemea (or compatible) system. Notice that an impedance scan can only be started using this function if no user programs are running.

The parameters are:

- **'rig'**
- **'name' - User name**
- **'pass' - Session token**
- **'action' - action parameter, must be: 'set_imp'.**
- **'server' - IP address of the Elchemea system to access.**
- **'port' - TCP port to contact (default is port 4040 for a normal Elchemea system).**
- **'impuser' - User-name on the Elchemea system.**
- **'session' - Elchemea Session number from which to use the configuration.**

- **'comp' - File name of compensation file. If standard compensation is used the value must be 'DEFAULT' and the compensation files 'short.i2b' and 'shunt.i2b' located in the web directory 'imp_comp' for the rig in question is used. First by subtracting the the measured file with 'short.i2b' file and the by multiplying the 'shunt.i2b' file (the data that is, not the files themselves).**

9.6.6 set_multiplex

This function sets a particular gas multiplexer to the specified gas.

The parameters are:

- **'rig'**
- **'name' - User name**
- **'pass' - Session token**
- **'action' - action parameter, must be: 'set_multiplex'**
- **'dev' - Device name of the multiplexer.**
- **'gas' - Name of the gas to enable.**

9.6.7 set_relay

This function sets a particular relay to the specified value.

The parameters are:

- **'rig'**
- **'name' - User name**
- **'pass' - Session token**
- **'action' - action parameter, must be: 'set_relay'**
- **'dev' - Device name of the relay.**
- **'status' - Device value to set.**

9.6.8 set_gas

This function sets a particular gas to the specified flow rate.

The parameters are:

- **'rig'**
- **'name' - User name**
- **'pass' - Session token**
- **'action' - action parameter, must be: 'set_gas'**
- **'dev' - Device name of the gas device.**
- **'flow' - Flow rate to set.**

9.6.9 set_pid

This function sets a particular PID device to the specified set-point.

The parameters are:

- **'rig'**
- **'name' - User name**
- **'pass' - Session token**
- **'action' - action parameter, must be: 'set_pid'**
- **'dev' - Device name of the PID.**
- **'setpoint' - New Set-point.**

9.6.10 set_current

This function sets a particular DC power supply or analog output device to the specified current output.

The parameters are:

- **'rig'**
- **'name' - User name**
- **'pass' - Session token**
- **'action' - action parameter, must be: 'set_current'**
- **'dev' - Device name of the multiplexer.**
- **'current' - New value.**

9.6.11 set_voltage

This function sets a particular DC power supply or analog output device to the specified voltage output.

The parameters are:

- **'rig'**
- **'name' - User name**
- **'pass' - Session token**
- **'action' - action parameter, must be: 'set_voltage'**
- **'dev' - Device name of the multiplexer.**
- **'voltage' - New value.**

9.6.12 add_info

This function add the specified test string to the info file for the current test of the specified rig.

The parameters are:

- **'rig'**
- **'name' - User name**
- **'pass' - Session token**
- **'action' - action parameter, must be: 'add_info'**
- **'comments' - The text string to append.**

9.6.13 run_device_function

This function runs a specified member function on a RFC::BaseDevice derived class instance. Although this function is merely intended for getting data, it can be misused. To minimize damage, it can only be called by logged in users.

The parameters are:

- **'rig'**
- **'name' - User name**
- **'pass' - Session token**

- **'action' - action parameter, must be: 'run_device_function'**
- **'type' - Device type**
- **'dname' - Device name**
- **'function' - Name of the device instance member function to call (refer chapters 11 to 12 for full documentation on device member functions).**
- **'arguments' - List of arguments to the specified member function. If the member function can be called without arguments, this parameter can be omitted. The actual number of arguments vary depending on which member function is used (refer chapters 11 to 12 for full documentation on device member functions).**

Chapter 10

System command interface (command line)

Although RFCcontrol is designed to be used primarily through the web interface, a lot of command line tools are included in order to facilitate greater freedom in running complex test sequences as well as system debugging in the case of malfunctioning hardware etc. Below is a list of the most used command line tools for the cell test control system:

Most of the programs and scripts are located in /usr/local/bin/. However some are located in /usr/local/bin/celltest/ and thus require full path for execution.

- ***rfcctl*: This program is used to interface with the global configuration of RFCccontrol. It supports a number of maintenance functions such as adding or removing users to the errormail list etc. For a full list of avaliable commands, run it without arguments. Usually it can only be used by root (as other users may not have sufficient permissions to modify the configuration of RFCcontrol).**
- ***CGI_client.pl* (discussed in section 8.2)**
- ***celltest-passwd-client*: Command line interface to the password server, refer section 4.3 for details.**
- ***gpibclient* (discussed in section 8.5)**
- ***serial-socekt-client-1.2.pl* (discussed in section 8.4)**
- ***make_iv_curves.pl* (discussed in section 2)**
- ***make_report* (discussed in section 2)**
- ***set_finish* $rig $test (discussed in section 2)**
- ***remake_latex_report* (discussed in section 2)**

- ***test_rig_conf.pl $rig*: This program runs the test script for a particular rig. This script runs through all devices initialized based on the current configuration file. If the configuration file is somehow been corrupted, this script can sometimes help find the inconsistency / error (depending on how mangled the configuration is).**
- ***list_uninitialised_devices.pl $rig*: This program list any devices which is defined in a rig's configuration but which with the current configuration is uninitialised. Note that uninitialized devices is not necessary unused at all times!**
- ***OCV_corr*: This program has a lot of command line options and is used primarily for correcting fuel cell resistances for conversion impedance. For a complete list of options, run the command: OCV_corr –help.**
- ***Reforming_delG_Min* This program is used to calculate equilibrium gas compositons for carbon containing atmosperes. For a full description run Reforming_delG_Min –help The program has been developed by Yashwanth Kutti Pochareddy and is used by OCV_corr but can also be used directly.**
- ***iV_curve.pl $rig [opt –debug]*: Runs an i-V curve for the rig in question. If the –debug option is specified, information is printed to stdout during operation. Usually this program is called from the GUI or as part of a programmed sequence. If called from the command line it tries to show the resulting i-V curve graph in a separate window (requires X11-forwarding), if no X11 forward is possible a harmless 'Graphics::GnuplotIF : cannot find environment variable DISPLAY' will be shown).**
- ***gas.pl $rig $gas $flow*: This program sets the gas flow for a particular rig and gas to the specified value. This program is deprecated and will likely be excluded from future releases.**
- ***set_current $rig $value*: Sets the DC-current for a rig. This program is deprecated and will likely be excluded from future releases.**
- ***set_voltage $rig $value*: Sets the DC-voltage for a rig. This program is deprecated and will likely be excluded from future releases.**
- ***potentiostat.pl $rig $voltage [opt $range opt $istep opt $psuname]*: Emulates potentiostatic control for a constant current controlled power supply. The program is intended to be run from the scheduler (crontab). If no power supply name is specified, the first item in the list of PSU's is used (only advisable if only one power supply is attached to the rig!). This program is deprecated and is no longer supported. Use the functionality described in chapter 14 instead.**

- ***water.pl $rig $name $status*: Sets the status for the water bubler for a particular rig. This program is deprecated and will likely be excluded from future releases.**

- ***cnv.pl $rig [opt delay]* : This program updates the web-pages displaying the current data for the rig in question. Note that only the figures for the data for the current day are updated! If a delay is specified, the program waits the specified number of seconds before creating the graphs (intended to be used when called from crontab to allow the logfile.pl program to finish before plotting commences). Should normally only be called from the crontab interface.**

- ***relay-socket-server-1.0.pl $virtual_tty $remote_host $remote_port*: This program is used if the hardware set-up requires more serial ports than can physically be fitted to the control computer. In this case a slave server is set up with the real serial server and the relay server is started with the correct parameters and RFCcontrol can use the remote serial port as if it was on the local computer. Notice that using this makes the RFCcontrol system vulnerable to network failures which it it otherwise would not be!**

- ***jdata.pl $rig $test*: This program creates the jdata file from the raw measured data. If passed the optional 'raadata' argument the raadata file is not recreated (if it has been edited to remove excessive data lines which could for instance be at the start before heating).**

- ***create_data_export.pl $rig [opt $test]*: This program is used to create tar files of the core data files for each test. The files included in the tar-file (which will be located in the test web directory) is: jdata, info.txt, proglog, impedance files as well as iv-curve files (including metadata for iv-curves and impedance files). Note that only the raw data files is included in the tar file, not any graphs etc. If the second (optional) argument is supplied a fresh file is made for this test (useful if post test processing has resulted in changes in iv-curve and/or impedance data).**

- ***format_jdata.pl $rig [opt $test]*: This program is used to reformat an existing jdata file if changes in the number of columns and / or order of alignment has occurred during the test. If no test argument is specified, the current test is assumed. Notice that for tests with large data files this program may take a while to run!**

- ***jdata_conv.pl $rig $test "$func" $output_col $input_col_1 .. $input_col_n*: This program can be used to do columnar calculations on a jdata file. It can be compared to awk. Unlike awk it does not work on column numbers, but on column names (jdata file format), thus if the jdata file changes the order of alignment during a test, *jdata_conv.pl* will handle this correctly. *jdata_conv.pl* only has limited calculation capability and**

no loops etc. To get a more detailed description run *jdata_conv.pl* without arguments. Notice that for tests with large data files this program may take a while to run!

- ***get_jdata_value.pl*** **This program can be used to extract a specific data value from a jdata line. The program expects the keyname as argument and the jdata line supplied to stdin:**
  tail -1 jdata | /usr/local/bin/celltest/get_jdata_value.pl coulomb

- ***get_all_impedance.pl $rig [opt $test]*****: This program tries to create impedance and bode plots of all impedance files located in the impedance directory (/home/http/html/rig1/1test34/impedance) in the case of test 57 on rig1. If the test argument is omitted the latest test is used as default**

- ***impedance_multiplot.pl $rig $test $options $file1 $title1 ..... $fileN $titleN*****: This program creates an impedance plot with multiple scans on the same graph. For a complete list, run impedance_multiplot.pl without any options.**

- ***hio_korr $mode correction_file [files_to_be_corrected]*****: This program is used to do impedance correction (for for instance inductance). The modes are one of -A, -S, -M or -D for addition, subtraction, multiplication or division respectively. The program does the full complex operation on all frequencies in all the files. It is useful for correcting large amounts of impedance files. Note that it can only handle files in the .i2b format.**

- ***open_circ_comp correction_file [files_to_be_corrected]*****: This program works like hio_corr described above except it can only do open cirrcuit compensation: Z = Zmeasure * Zocv / (Zocv - Zmeasure)**

- ***program_iv.pl $rig $current*****: This program can be used to make programmed i-v curves in the case a long term experiments is to be run where I-V curves are to be acquired each day and the test is to be run in constant current otherwise. The current argument is the steady state current to be applied between the I-V curves. This program is intended to be run from crontab.**

- ***leak [options]*****: This program can be used to calculate the leak current through the cell if the gases is only hydrogen/water and air use the –help option for a full list of options. Note that this program is superseded by the OCV_corr program which can handle a much wider range of gas compositions.**

- ***logfile.pl $rig [opt test | conf | ignore | caching | debug]*****: This program handles the actual data logging for the entire system. The program is intended to be run by crontab (without the optional test argument) but if run with this argument is also prints the result to standard out in additional to appending the result to the normal data logging file. The**

logfile.pl program also contains the possibility to test a configuration file. To do this, use the 'conf' argument. The program will then output additional information regarding the current configuration. Note that with the 'conf' argument no data logging is performed! the 'ignore' argument changes the behaviour of the file locking system for data logging. If this option is specified, the logfile program does not exit if the i-V curve semafore is detected. Additionally the program waits for the internal file lock insread of exiting if no lock could be aquired. Notice that if custom designed data logging programs are to be used they must implement a similar behaviour to avoid race conditions or out of processes id errors (in case too many logging programs are started simultaneously). The caching argument (introduced in version 4.8.1) specifies that the logfile program atempts to use cached values for the devices which is set up to do so (refer section 6.2.1). A last option is calling the logfile program with the 'debug' option which enables debugging information. Additional debug information can be aquirired by specifying a higher debug level (fo instance to use debug level 4 use 'debug=4' instead of just 'debug'). If debug level 4 is used if so, all calls to external TCP:IP socket servers are displayed (that is all calls to the serial servers, gpib-server etc. are displayed). This is useful for debugging a malfunctioning configuration or if some data suddenly looks strange, then it is possible to manually repeat all external calls and directly inspect the results. To do so use the programs *gpibclient* and *serial-socket-client-1.2.pl* in */usr/local/bin* (the mentioned programs are simple wrappers around the library socket communication functions).

- ***mail_errors.pl*: This program is intended to be run by crontab once a day. It scans the error file (*/home/celltest/error.txt*) and emails any entries for the last day to the recipients defined in the errormails key in the global section of the global configuration file (refer section 6)**

- ***load_test_data_db.pl $rig $test*: This program processes a specific test, and if the *make_iv_curves.pl* program has been run, it uploads key informations regarding the test, any i-V curves as well as any impedance spectra which has been aquired to an external database. The database loacation and name is specified in the database section in the global configuration file (refer section 4). This program is only configured to access a database running on a Risoe Fuel cells and solid state chemistry division Labsystem database version 2.1.10 or above with installed celltest datamining database!**

- ***test_cluster.pl*: This program can be used to test if all servers in a cluster is responding.**

- ***get_max_gas.pl $rig $test*: This script gets the maximum gas flows logged for a specified rig and test. Normally used only for reporting purposes.**

- ***format_jdata.pl $rig $test*: This script reformats the jdata file for a specified rig and test making sure that the number and order of allignment of the diferent columns are constant throughout the file. This may sometimes be nescesarry to do before post test reporting is performed (for instance if additional channels have been configured durring a test, then the number of collumns will not be constant throughout the jdata file as most of the reporting scripts depend on).**
- ***history-plot $rig $test*: This program creates all the plots for the whole test history for a given rig and test.**
- ***PID_fast_control.pl $rig*: This program handels PID control loop execution for PID devices configured as 'fast'. The meaning of fast is that the system will run the PID cotnrol once / second. Notice however that if multiple PID devices are configred as fast, the response time for each loop may be significantly longer than 1 second as hardware communication overhead may delay execution as only one PID device can be serviced at a time. Should normally only be called from the crontab interface.**
- ***PID_slow_control.pl $rig*: This program handles PID control loop execution for PID devices configured as 'slow'. The meaning of slow in this case is one iteration each minute. Should normally only be called from the crontab interface.**
- ***Check_alert.pl $rig*: This program handels watchdog survaliance and checks all defined alert devices for the rig in question. Should normally only be called from the crontab interface.**
- ***custom_prog.pl $rig $filename [opt $username]*: This program executes the sequential programs set up as shown in section 2.3. Usually it is called from the GUI by the CGI-server, but it is possible to exwecute it directly from the command line. The filename is the name of the file containing the commands to be executed, and the optional username is used to get the email address for sending an email in case program execution stops unexpcted (if the process gets a SIG-INT or kill -2).**
- ***fastlog_type.pl $rig [–option...] [device names]*: This program can be run from the command line to do fast data logging of devices of the same type. The default device type is simplechannels. The recognised options for this program are:**
  - **–type=type : sets the device type.**
  - **–intervel=interval : Sets the interval between measuremnts in seconds.**
- ***create_all_data.bash $rig $test [opt email_address]* This command recalculates the jdata file, the iv-curves and the impedance tables unless the**

standard report has been run It also recreates the zip-archive with the test data for download (it always does this even if the report has been crated). It can be called from the GUI from the list of active tests.

- ***fastlog_type_rig.pl $rig [–option...] [device names]*: This program can be run from the command line to do fast data logging of devices of the same type. The default device type is simplechannels. The recognised options for this program are:**
  - **–type=type : sets the device type.**
  - **–duration=duration : sets the total time the program should run (default is 120 minutes).**
  - **–intervel=interval : Sets the interval in seconds between measuremnts (default is 1 second).**

  It works similarly to *fastlog_type.pl* except it does not output to standard out, but instead outputs to a file in the current test. The filename will be in the format fastlog.¡timestamp¿.txt. As opposed to *fastlog_type.pl* this program does NOT run untill explicitly killed, but stops after the specified duration has expired.

- ***sync_ssl_server.pl $host*: This program will test the ssl communication (used by the password client and report client and server) with the specified host (or IP address). If no public key exists for the host specified, the program will try to get the public key. If the public key is not found, or the poblic key of the host is different from the local cached copy (as would be the case in a man in the middle attack or server reinstallation), a warning is issued. This program is usefull for debugging password and report client communication.**

- ***cleanup_old_data.pl $rig [opt –interval=XX –debug]*: This program wil reduce the amount of data needed to be stored / backed up by removing some of the data for each test older than 5 default years. The data removed is ONLY data used for conviniently accessing data. The data removed are: All data in the daily data plot directories (such as /home/http/html/rig14/14test13/2021:05:13/) the daily raadata files (if a total raadata file exists!). It is important that the raadata file (f.eks /home/http/html/rig14/14test13/raadata) as well as the jdata file remains untouched! If automatic cleanup is desired, the program could be set to run by crontab once pr year for each rig on the system. if the debug flag is specified, the processed files and directories will be printed to standard out. If the interval flag is used the default 5 years can be overrdden, however the minimum age for cleanup is 2 years.**

- ***recover_daily_plots.pl $rig $test* This program will recreate the daily plots for a given test if the daily plots have been deleted by *cleanup_old_data.pl*. Note that this program should ONLY be run in the stated condition as it overwrites any existing daily data plots!**

- ***refresh_info_file.pl*** **This program will recreate / update the info_file.txt storing basic metadata about all tests on this server. The file is mostly used for searching post test reports. It can be used to recreate the file if data has been copied from one server to an other or if the info file for a test has been manually edited.**

- ***load_cluster_cache.pl*** **This program can be used to preload the listserver cache file. This can be useful if a lot of servers are used in the same cluster and it causes too long delays for users when refreshing the cache. To use it run it as user www-data from root's crontab once every 30 minutes:**
  sudo -u www-data /usr/local/bin/celltest/load_cluster_cache.pl

Chapter 11

Module specifications

This chapter contains the module specification for the perl modules supplied as part of the RFCcontrol software suite. It includes function descriptions including number and type of any function arguments. Some of the modules are object oriented (with only a publicly accessable constructor) and in other cases the modues are function orientated.

In the case of function orientated modules, any functions exported by the module are described, both for what it does, as well as number and types of arguments.

In the case of the object oriented modules, any inheritance is also described (usually in the beginning of the module description). For the object instances, usually only the member functions intended to be public is described (as perl does not have a true private function decleration). Note that some of the opject orientated modules define more than one class type, but as all the class types in this case behave similarly (polymorphic), only the main class is described as the subsequent clas definitions imlements the main class type behaviour.

Each module is described in it's own section.

11.1 Debug

Use: my $id = Debug→new();

This class is intended to be a base class for other classes to derive from so that easy debug functionality can be included.

Utility class for debugging. It contains the following member functions:

$id→debug()	Sets or gets the debug level: level 0 is no debug, level 5 is complete debug including stack backtrace. This class only uses level 0 (no debug), level 1-4 (debug iformation displayed) and 5 , debug info displayed with complete stack backtrace. The levels 1-4 lets other modules define debug levels inbetween the ones used here.
$id→writedebug($,[$])	Writes the string to standard error if debuglevel is 1 or higher. If overide is specified (second argument which is optional), debug level 5 is assumed for this debug.
$id→die($)	Appends stack backtrace to argument string and calls CORE::die
$id→print_setup()	Prints out the complete current setup including all member functions and data fields (uses Class::Inspector).

11.2 SemaforeFile

Inherits from Debug (refer section 11.1).

This package makes file inout/output on multiprocess systems more easy by encapsulating file locking. To define a new semaforefile use the new method:

my $id = SemaforeFile→new($filename,$lockfile);

my $id = SemaforeFile→new($filename);

If the lockfile is not specified, the default (/var/lock/SemaforeFile/SemaforeFile.lock or /tmp/SemaforeFile.lock) is used instead. This form should generally notbe used however, as in some cases /var/lock/SemaforeFile/SemaforeFile.lock can not be used and files in /tmp/ will from time to time be deleted...

The package includes the following simple public methods on semafore files:

$id→readonly()	Returns true if the file is readonly for the current user
$id→exist()	Returns false if the file does not exists;
$id→chmod($)	Sets the file permissions according to CORE::chmod
$id→filename()	Returns the filename of the semafore file
$id→readlines()	Returns the content of the file as an array with one line in each element Note thet it removes any trailing newline from the read lines!
$id→writeline(@)	Writes the arguments to the file (NB: Overwrites file and add a newline to each argument if they do not already have it).

$id→append(@)	**Appends the arguments to the file (Also adds newlines if nescesarry).**

It is not nescesarry to check for file esistence in readlines as an empty array is returned if the file does note exist Note that the readlines function should only be used on small files as it globs the entire content to memory! For large files, use the more advanced member functions (see below). Also note that trailing newlines are removed from the individual lines. If this are not desired, use the readline() method described below.

The module also includes the following methods for advanced use: Note none of these functions check if the file exist before trying to open! The unsafe versions of open and close does not lock or unlock (assumes the user does this explicitly!)

$id→lock_ex()	**Locks file for exclusive use (Read, Write or Anppend)**
$id→lock_sh()	**Locks file for shared access (Read only)**
$id→lock_ex_nb()	**Locks file for exclusive use non blocking (Check return status!)**
$id→lock_sh_nb()	**Locks file for shared access non blocking (Check return status!)**
$id→unlock()	**Unlocks file**
$id→open_read()	**Opens the file for reading (locks file shared if not already locked)**
$id→open_readback()	**Opens the file for reading backwards (locks file shared if not already locked)**
$id→open_write()	**Opens the file for writing (locks file exclusive if not already locked exclusive)**
$id→open_append()	**Opens the file for appending (locks file exclusive if not already locked exclusive)**
$id→close()	**Closes the file and unlocks it**
$id→open_read_unsafe()	
$id→open_readback_unsafe()	
$id→open_write_unsafe()	
$id→open_append_unsafe()	
$id→close_unsafe()	
$id→mtime()	**Returns the time of modification of the file as reported by File::stat→mtime, returns 0 if the file does not exist.**
$id→readline()	**Reads and returns the next line from the file, assumes an open file Raises an excpeption (die) if not.**
$id→fh()	**Returns the underlying file handle for direct IO (Use with care!)**

Additionally the $id→debug($) member function (inherited from Debug.pm)

can turn debug information on and off $id→debug($level) turns debug on and $id→debug(0) turns debug off ($level is the debug level, 1 - 5) This may be usefull if deadlock is encountered (so that the individual file locking operations can be monitored! If $id→debug() is called without arguments it returns the status (i-e if debug in on 1 is returned else 0.

11.3 ElchemeaConfig

Inherits from Debug (refer section 11.1).

Use:

my $id = ElchemeaConfig→new($filename);

my $id = ElchemeaConfig→new(SemaforeFile_instance);

Or

my $id = ElchemeaConfig→new($filename,$lockfilename);

This class is intended to be used for accessing a file where the data is stored in the way of key = value pairs inside sections delimited by SECTION $name - ENDSECTION pairs (example below)

SECTION testsection
key1 = value1
key2 = value2
ENDSECTION

In the example above any leading '#' should be removed as they indicate comments and the ElchemeaConfig package honors this convention making it possible to include comments in the data file (configuration file).

The ElchemeaConfig module incorporates the possibility to use transactions.

All ElchemeaConfig instances honors the following member functions:

$id→debug()	**Sets or gets the debug level (inherited from Debug.pm).**
$id→die($)	**Terminates current process with supplied string (with stacktrace) as errorcode (Inherited from debug.pm).**
$id→filename()	**Returns the filename of the configuration file.**
$id→readlines()	**Returns the content of the file, only allowed outside a transaction**
$id→writeline(@)	**Write the supplied strings to the file (note owerwrites file!), Only works outside a transaction.**

$id→modtime()	**Returns the last time of modification for the file. Note that when a transaction is initiated the time reported will be the last time before transaction initiation!**
$id→get_config_value($$)	**Returns the value associated with the specified key in the specified section (arguments: $section, $key). If called in a list context, returns a list of values based on the value of the specified key (value split along commas, ignores spaces around commas)**
$id→get_sections()	**Returns a list of the section names in the file.**
$id→get_keys($)	**Returns a list of key names for the specified section name.**
$id→is_readonly()	**Returns true if the file is read only, false if the file is writable.**
$id→section_exists($)	**Returns true if the specified section exists in the file.**
$id→exists($$)	**Returns true if the specified key exists in the specified section. Arguments: section, key**
$id→change_config_value($$$[opt	**@values]) Changes the value associated with the specified section - key pair to the specified value. If inside a transaction, the change is stored in an internal data structure and the file itself is not changed. subsequent calls to get_config_value() with this pair as argument will return the new (not yet commited) value instead of the value stored in the file. Required arguments: $section,$key,$newvalue. If additional arguments all the additional values as well as the first are stored as a comma separated list (thus conforming with get_config_value called in a list context)**
$id→error()	**Returns the errorstring (returns an empty string if no error).**
$id→begin()	**Initiates a transaction.**
$id→commit()	**Commits any changes (through calls to change_config_value()) to the file. If the file itself has changed between the initiation of the transaction and the commit, a warning is issued and no changes is written, thus always check the return status of commit (1 for succes, 0 otherwise). If an error or warning orccours the error string is set.**
$id→rollback()	**Discards any changes not yet committed.**

Note that if a transaction is initiated and no commit is issued, aotumatic

rollback occours uppon instance destruction and/or program termination.

11.4 SocketClient

This module defines a number of communication functions used for accessing tcp:IP sockets on local and/or remote systems. The functions defined are listed below:

socket_client_raw($$@)	**Base function used by all subsequent functions, handles the raw tcp:IP cummunication. Arguemnts: server, port, [additional args to server]. The server can either be a ip-address or a hostname. Any additional arguments gets serialised with tab characters and 2 newlines are appended to the resulting string before transmission.**
socket_client($$@)	**Same as above, but catches any communication errors in an eval guard.**
socket_client_nocr($$@)	**Same as above, but do not append any newlines to the transmitted string.**
socket_client_raw_nocr($$@)	**same as socket_client_raw() but do not append newlines.**
serial_client($@)	**communicates with a local serial server (which handles hardware communication on the serial port. Arguments: tty, args_to_server. The server is assumed to be the local server (either localhost or the public IP address of the server) and the port number is the tty number added to 202020 (Note wraparound!).**
GPIB_client()	**Communicates with the GPIB-server. Arguments are passed to the GPIB-server serialised with tab characters using socket_client_nocr(). The server is assumed to be the local server (either localhost or the public IP address of the server) and the port number is 12345.**
serial_client_raw($@)	**Same as serial_client() but without eval guard.**
GPIB_client_raw()	**Same as GPIB_client() but without eval guard.**
timeout([$])	**Sets or gets the timeout value (default is 2 seconds).**

11.5 RFC::Header

This module contains site wide file locations and similar global variables used by the other modules supplied as part of RFCcontrol.

11.6 RFC::Main

This module exports a number of utility functions used by both the user interface, but also by some of the other modules supplied by RFCcontrol.

The functions exported by default are

CGI_client($@)	**Client program for communication with the different CGI-servers for the rigs attatched to the system. The first argument must be a rig name, and any additional arguments are passed to the CGI-server.**
errorlog()	**Writes any arguments to the errorlog (usually /home/celltest/errorlog.txt)**
get_cv($$)	**returns a configuration value obtained from the global configuration file (usually /home/celltest/conf/celltest_global.conf). Arguments: section and key. If called in a list context it returns the value as an array split along any commas (ignres spaces before and after the commas). If no matching key or no value is returned default values may be returned instead.**
print_error()	**Prints any error information incapsulated in appropriate html tags. If an argument is specified, that is displayed, if not, the last string appended to the error file is displayed instead.**
get_error()	**Returns the last string appended to the error file.**

Additionally, the following functions are also avaliable through explicit function call.

get_cv_default($$)	**Returns the default value for the specified kay - value pair. Returnes undef if no default value is defined.**
config()	**Returns a ElchemeaConfig instance of the global configuration file**
get_uicfg($$)	**returns a configuration value obtained from the user interface configuration file (usually /home/celltest/conf/UI.cfg). Arguments: section and key. Note this function is deprecated and should not be used from 7.3.0 onwards as it will be removed at a future date.**
get_rigs()	**Returns a list of valid rigs on the server**
get_servers()	**Returns a list of known servers (obtained form global configuration file).**
get_user_name($)	**Returns the user name from a given userid (note only usable from local password server).**
check_rig_nr($)	**Returns 1 if the rig specified is a valid rig 0 otherwise.**

spline($$)	Returns the splineinterpolated value based on filename specifying a file containing the interpoation table and the value to interpolate. Arguments: filename and value.
spline_user_files()	Returns a list of valie filenames for spline interpolation. The list is defined as the files found in the splineinterpolation directory (usually /home/celltest/convert-table/userfiles/)
passwd_client(@)	Returns the response from the password server when queried with the specified arguments.
passwd_client_raw($$@)	Same as password_client, but the hostname and port number must be specified as the first 2 arguments (before the real arguments passed on to the password server).
mail($$[$])	Sends an email to the specified email address with the specified message. An optional third argument will be used as subject. Arguments: address, message, [subject].
mail_att($$$[$])	Sends an email to the specified email address with the specified message. The third argument will be used as subject. Any further arguemnts are assumed to bi filenames to be attatched to the email. Arguments: address, message, subject [files].
get_gasses()	Returns a list of gasses for for which the gas factor is known.
get_soap()	Returns the soap interface object (if a SOAP interface is used for the password subsystem)
remote_system_log($)	Appends the supplied string to the remote logbook. The call is made by calling the url specified in the 'logbook_url' key in the global section of the main configuration file appended with the supplied string (which will be url-encoded). Thus if the logbook_url contains 'https://foo.bar/cgi-bin/log.cgi?id=342&msg=' and the function is called woth the string 'test_msg' the resulting url called will be: https://foo.bar/cgi-bin/log.cgi?id=342&msg=Test_msg

11.7 RFC::RFCCGI

This module contains a number of utility functions for outputting properly formatted html code for user interface generation. Thus it mainly extends the CGI.pm module by Lincoln D. Stein. The module exports these functions in two groups.

The :html group exports these functions:

print_header($[	
print_end()	**Prints the help button and ends the html output with the proper tag.**
not_auth()	**Prints the information supplied to the user if the user is nor authorised. Also prints a link to the log in page.**
xss($)	**Wrapper for CGI::excapeHTML.**
print_hidden()	**Prints a number of hidden fields used to maintain state. This includes user name and a cryptographic hash of the users password.**
print_hidden_rig()	**Same as print_hidden(), but with the additional information abut the active rig.**
logout()	**Printys a logout button.**
action($)	**Prints a hidden field with an action parameter with the specified value which can be used for program control flow.**
RFC_start_html()	**A wrapper for CGI::start_html. Any arguments (in the form of a hash) are passed to CGI::start_html. Automatically appends a reference to the javascript source file on the server.**
js_back()	**Prints the javascript for gping backwards (uses the browser.back() fjavascrpt call).**
get_CGI_value($)	**Retrieves the value of the specified CGI parameter (supplied by the web browser.**
get_CGI_value_clean($)	**Same as get_CGI_value, but does pattern match on the retrieved value and only returns the part that matches. The pattern match is [\w\s\.\,\-]*. This has the benefit of untainting the returned parameter value (For taint checks in perl and web access, refer Lincoln D. Steins book *Official Guide to Programming with CGI.pm*)**

rig_auth()	**This function returns 1 if the user is certified for the rig in question. It only checks if the rig in question is mentioned in the 'safety_task_access' section in the global configuration Where each rig is supposed to define which taskid(s) are connected with which rig. If more than one taskid is connected with the rig (specified by a list of id numbers), the user has to be authentificated for all taskids in the list for authentification to occour. The definition is in the form: rig1 = 45,1 where 45 and 1 are the taskids to check against. Usage is either with named rig argument or without any argument, if used without argument, the current rig number is used as default. Usage: rig_auth(), rig_auth($rig) or rig_auth($rig,$taskidstring). If the last call method is used the taskidstring must be a string of integers seperated by comma.**
rig_cert()	**This function returns 1 if the user is certified for the rig in question. It only checks if the rig in question is mentioned in the 'safety_task_access' section in the global configuration Where each rig is supposed to define which taskid(s) are connected with which rig. If more than one taskid is connected with the rig (specified by a list of id numbers), the user has to be certified for the first in the list for certification to occour. The definition is in the form: rig1 = 45,1 where 45 is the taskid to check against. Usage is either with named rig argument or without any argument, if used without argument, the current rig number is used as default. Usage: rig_cert() or rig_cert($rig).**
rig_auth_nocgi($$)	**Similar to rig_auth(), but the rig number and username must be specified.**
rig_cert_nocgi($$)	**Similar to rig_cert(), but the rig number and username must be specified.**
rig_data_access_allow([$])	**Returns 1 if the user is allowed to access historical data for the rig in question. If an optional argument is specified, this is the username to check for.**
rig_data_test_access_allow($$[$])	**Returns true if the user is allowed to access the specified rig and test data. If an optional third argument is specified, this is the username to check for.**

The :cgi group of functions include the following:

get_CGI_value($)	**See above.**
get_CGI_value_clean($)	**See above.**
rig_cert()	**See above**
rig_auth()	**See above**
action($)	**See above**
not_auth()	**See above**
xss($)	**See above**
login_ok()	**Checks if the user supplied login credentials are ok. This can be either against a small local database, or against a full RDBMS.**
menu_button(@)	**Prints a menu button. Arguments: name, value, style. The name will be the CGI parameter name, the value vill be the text on the button and the style is a style class name to use for displaying.**
top_nav_bar_start()	**Prints the html tags to start the top navigation bar (table specifications etc.)**
top_no_button()	**Prints a no action button (goes nowhere) in the top navigation bar.**
top_nav_bar_button()	**prints a top navigation button. Arguments: File, name, value, style, [optional additional name, value and force triplets]. The file is the cgi-script to be called upon button press, the name,value and style arguments are passed to menu_button() and the additional optional arguments are used to initialise and print hidden html fields in the form of name-value pairs and a force argument (1 for force value, 0 for allow reuse of value).**
tab_newrow()	**Prints a new row in the top navigation bar.**
top_js_return()	**Prints a top navigation return button (uses the javascript printed by js_back(), see above)**
end_top_bar()	**Prints the end of the top navigation bar.**
is_logout_time()	**Returns 1 or 0 depending on time since last action by the current user (used for authentification purposes). Deprecated from version 4.6.2 onwrads!**
is_admin()	**Return 1 if the current user is an administrator (gets explicit access)**
user_auth()	**Returns 1 if the user is authorised for the rig in question. Some of the authentification is forwarded to rig_auth()**
get_user()	**Returns the username of current user.**
get_pass()	**Returns the cryptographic hash of the current users password.**

logout_delay()	**returns the number of minutes a user can remain inactive before automatic logout occours.**
process($$)	**processes the specified template with the specified data structure (a reference). If no data reference is specified, the default from get_template_data_ref() is used instead.**
get_template_data_ref($)	**Returns a data structure suitable for processing by process(). If an argument is specified it as to be either a hash reference or an array reference (and will be avaliable as the list or data field from within the template).**
get_template_data_ref_nocheck($)	**Returns a data structure suitable for processing by process(). If an argument is specified it as to be either a hash reference or an array reference (and will be avaliable as the list or data field from within the template). Doed NOT check for valid rig!**

An additional function which is often used (but which is not exported by default) is the print_js_validate() function. This function prints a javascript function for client side input validation. The function can check any number of fields (names specified in the arguments list) and can either check if a field is filled out, OR check that if a field value is 'NEW' then an other field must not be empty The syntax for this case is: 'name_1#name_2' where name_1 is the name of the field which can be 'NEW' and name_2 is the name of field 2 which must not be empty. Another form of check is where a number of fields exists and where not all fields can be empty to use this option use the ':' separator in the string: '$field_group_name:$field1:$field2:...'.

Usage: print_js_validate($form_name,[$field_names...]) It is also possible to include regular expression tests in the validation. To do this use the format: 'name;"regexp";[opt $]Error message'. If the $ is the value of the input field is placed in front of the errormessage!

11.8 RFC::Device

This module contains two types of functions: one set (prefixed list_) returns a list of possible device types of the specified master type. For instance, list_GAS retrns a list of possible gasses whereas list_PSU returns a list of possible PSU classes. The list functions never require any arguments except the list_device_types function which takes a type argument and returns a list of possible sub types for the device type in question.

The other group of functions are factory functions createing and returning instances of the specified type. For instance new_GAS($name,$rig) returns a new RFC::Gas object.

The individual factory functions require a varying number of arguments, however common is the first two (rig and name) which are compulsory. Most of the factory functions only require the first 2 arguemnts.

The rig argument must be an instance of the RFC::Rig class or an object of a similar type that at least honors the get_cv() member function. (Some devices requires additional memberfunctions to be honored by the rig instance, however all these memeber functions are included in a RFC::Rig instance).

The name arguments is the name of the object to be created. Note that the name must correspond to the name in the section in the configuration file where the device instance data is defined!

Below is a complete list of the functions defined in RFC::Device.pm:

list_device_types($)	**returns a list of the possible subtypes of the specified master type.**
new($@)	**Returns a class instance of the specified type. Arguments: type, rig, name, [optional subtype], where rig is an instance of the RFC::Rig class.**
new_GasGroup($$)	**Returns a gas group instance, arguments: rig, name.**
list_GasGroup()	**Returns a list of possible gas group subtypes.**
new_GAS($$)	**Returns a gas instance, arguments: rig, name.**
list_GAS()	**Returns a list of possible gas names (that is, the names of gasses where the gas factor is defined in the global configuration file).**
new_TEMP($$)	**Returns a temperature controler instance, arguments: rig, name, [opt. subtype]**
list_TEMP()	**Returns a list of possible temperature controler subtypes.**
new_Multiplexer($$)	**Returns a gas multiplexer instance, arguments: rig, name, subtype**
list_Multiplexer()	**Returns a list of possible gas multiplexer subtypes.**
new_MFC($$)	**Returns a gas flow controler instance, arguments: rig, name, [opt subtype]**
list_MFC()	**Returns a list of possible gas flow controler subtypes.**
new_RELAY($$)	**Returns a relay instance, arguments: rig, name, [opt. subtype]**
list_RELAY()	**Returns a list of possible relay subtypes.**
new_SimpleChannel($$)	**Returns a simple data aquisition instance, arguments: rig, name, [opt. subtype]**
list_SimpleChannel()	**Returns a list of possible simple data aquisition subtypes.**
new_Water($$)	**Returns a gas humidifier instance, arguments: rig, name, [opt subtype]**

list_Water()	**Returns a list of possible gas humidifier device subtypes.**
new_Templog($$)	**Returns a temperature aquisition instance, arguments: rig, name, [opt. subtype]**
list_Templog()	**Returns a list of possible temperature aquisition subtypes.**
new_PSU($$)	**Returns a DC power supply device instance, arguments: rig, name, subtype**
list_PSU()	**Returns a list of possible DC power supply subtypes.**
new_AnalogOut($$)	**Returns an analog DC output device instance, arguments: rig, name, subtype**
list_AnalogOut()	**Returns a list of possible analog DC output device subtypes.**
new_filter($$)	**Returns an filter device instance, arguments: rig, name, subtype**
list_filter()	**Returns a list of possible filter device subtypes.**
new_PID($$)	**Returns an PID device instance, arguments: rig, name**
list_PID()	**Returns a list of possible PID device subtypes.**
new_logic($$)	**Returns an logic device instance, arguments: rig, name, [opt subtype]**
list_logic()	**Returns a list of possible logic device subtypes.**
new_Math($$)	**Returns an arithmetic device instance, arguments: rig, name, [opt subtype]**
list_Math()	**Returns a list of possible arithmetic device subtypes.**
new_Alert($$)	**Returns an Alert device instance, arguments: rig, name, [opt subtype]**
list_Alert()	**Returns a list of possible Alert device subtypes.**

11.9 RFC::Observer

Inherits from Debug (refer section 11.1).

This module implements the observer pattern and defines the member functions nescesarry for this.

To obtain a device instancee call the constructor: my $id = RFC::Observer→new();

$id→attatch_observer($[$])	**Attatches a new object to the list of observers. The first argument must be a reference to an object. The second (optional) argument can be a reference to a function to be called. In absence of this second argument, the default function to call is the observe() member function of the observer. If a custom function is specified it must accept at least 1 argument which is a string describing which action triggered the notify. Please note that only one reference to each object is allowed (the same device can not attatch itself to an other device more than once, any new invocations of attatch_observer to the same device will merely overide the notify function name). This makes sure that any notify of an object will only trigger once for each action trigger (for instance a call to setflow on a master device will only trigger one setflow command on each slave). Usually a slave can only be slaved to one device when the GUI is used, however it is possible to slave to more than one master device using attatch_obsever directly.**
$id→list_observers()	**Returns a list of observer devices (object references!)**
$id→detatch_observer($)	**Removes an object from the list of observers. The argument must be an object reference.**
$id→notify($[@])	**This function notifies all observers of the action in question (the first argument is a string describing the action triggering the notify), any additional arguments can be passed, however only the first is guarenteed to be passed to the observe functions. The function returns a list of response values / messages (if any) from the called functions.**
$id→observe($[@])	**Default function for callback in case of notification. This function is intended to be overridden in those cases where devices by design depends on the observer pattern. Corresponds the the Update() function according to GoF.**

11.10 RFC::Rig

Inherits from RFC::Observer (refer section 11.9).

This class manages the complete setup ofr a RFCcontroll rig To obtain an instance call the constructor:

$id = RFC::Rig→new($rignr) $id = RFC::Rig→new($rignr,$debug_level) $id = RFC::Rig→new($rignr,$debug_level,'nocheck')

Where $rignr is an integer.

If the 'nocheck' parameter is specified, previously valid rigs can be instantiated. Note that this is only ever intended to be used for accessing historical data for decommisiioned rigs as trying to instantiate rigs which has never been created or get devices / access and/or change parameters in this case is undefined behaviour!

RFC::Rig implements a type of singleton pattern in the way that only a single instance of each rig number can exist at any given time. Thus two successive calls of new() with the same argument will return the same object. However two calls to new() with different arguments will return two different individual objects.

11.10.1 Public member functions

Each Rig instance has the following public member functions:

$id→lock_control()	**Locks the semafore file asociated with the rig instance control.**
$id→unlock_control()	**Unlocks the semafore for rig control.**
$id→die($)	**Wraper for CORE::die, but dumps instance setup.**
$id→config()	**Returns the configuration object of the current test (An ElchemeaConfig instance).**
$id→begin()	**Initiates a transaction.**
$id→commit()	**Commits a transaction.**
$id→rollback()	**Roll back a transaction.**
$id→error()	**Returns the errorstring (if any).**
$id→riglock()	**Returns the SemaforeFile object for the rig instance**
$id→mail_from()	**Returns the address where return mails are to be sent (in most cases this will be user@host But some mail systems require the from field to point to a verified mail domain which may be different than the RFCcontrol server.**
$id→set_warning($)	**Sets the specified string in the mailwarinig file used to make sure that only one errormail is sent for each warning condition.**
$id→check_warning($)	**Checks if the specified type is already in the warning mail file.**

$id→unset_warning([$])	**Removes the specified type from the warningmail file. If called without argument, all warnigns are removed.**
$id→disable_warning_mails([$])	**Sets or gets the setting which allows for supressing sending warning emails to users**
$id→is_iv()	**Returns true if the iv_in_progress file exists**
$id→iv_start()	**Retruns 1 (true) if the iv_in_progress file does not exist, and creates it in the process.**
$id→iv_stop()	**Removes the iv_in_progress file (effectively stopping any programs / iv's locked to the existence of this file).**
$id→iv_in_progress()	**Returns the SemaforeFile object representing the iv_in_progress file. Can be used for using the file for storing and retrieving process parameters.**
$id→warning_mail($type,$s,[$subj],[opt	**emaillist]) Sends a mail with content $s of type $type to the recipients defined in the 'warning_mail' key in the 'main' section of the rig configuration. If no recipients are found the list defined in the 'errormails' key in the 'global' section of the global configuration is used instead. Note that the mail is only sent if the $type is nor already defined in the warningmail file. If a third argument is supplied, this becomes the subject of the mail, otherwise a default subject is used. If a fourth argument is given it is assumed to be a comma separated list of email addresses which are to be used instead of the global list.**
$id→kanaldata()	**Sets and gets the logged data (in conjnction with data logging. If arguments are passed, they are assumed to be in the form returned by the readstring member function of a BaseDevice class instance.**

$id→readstring([$])	**Does a complete data logging by callng the readstring member function on all asociated BaseDevice instances (This includes derived classes). This function handles gracefully if a device instance dies while measuring, in which case an error is logged and a dummy value is returned for that device instead of the real value. This is to ensure that datalogging will proceed as much as possible. If an argument is passed to readstring, it must be an instance of RFC::Cache. Notice, that readstring does NOT write any data to file, it only returns a text string containing all the data. (Saving data to file can be handled by the normal Perl file handling functions).**
$id→readstring_furnace()	**Same as readstring, except it only logs temperature controlers, temperature loging devices and simplechannels. Used by RFCfurnace.**
$id→list_sections()	**Returns a list of configuration sections (names). If a argument is specified, only section names matching the specified string are returned.**
$id→config_section_exists($)	**Returns true if the specified section exists in the current confiuration.**
$id→config_key_exists($$)	**Returns true if the specified section and key exists.**
$id→get_cv($$)	**Returns the value asociated with the specified section and key (returns undef if no no matching section is found or if no matching key is found in the specified section (Arguments: section,key). If called in a list context, it returns an array which is the result of splitting the configuration value along any commas (Notice that the split ignores any spaces before and after commas).**
$id→get_cv_test($$$)	**Same as above, but for specified test number (defaults to current test if no is specified). If called in a list context, it returns an array which is the result of splitting the configuration value along any commas (Notice that the split ignores any spaces before and after commas).**

$id→get_cv_list($$)	**Same as get_cv($$) except it returns a list of elements, the list is the return value of get_cv($$) split up along any commas. If the configuration value does not exist or is empty get_cv_list($$) returns an empty list. Note that this function is deprecated from version 5.3.5 and onwards, Users should switch to using get_cv in a list context as this will now behave as get_cv_list**
$id→change_config_value($$$)	**Sets the value asociated with the specified section and key to the specified value (arguments: section,key,newvalue)**
$id→modtime()	**Returns the modification time for the configuration file fore the test specified (default is curent test).**
$id→set_debug($)	**Sets the debug level for the Rig instance as well as all. device instances attatched to the rig instance. Implemented using the Visitor pattern.**
$id→debug()	**Sets or gets the debug level for the rig instance itself (that is without setting it for all the device instances). If called without arguments returns the current debug level.**
$id→init()	**Initialises (or reinitialises) the rig instance. This member function loads all device instances which according to the configuration file needs to be attatched. On succes any call to error() returns an empty string, otherwise the string returned contains the name of the offending device which could not be initialised and caused init to fail / die. If the init() function is not called within an eval guard, it simply dies with an error indicating what went wrong. The init() function is automatically called by the constructor (within an eval gurad).**
$id→test()	**Returns 1 (true) if init returned no errors, 0 otherwise.**
$id→webdir([$testnr])	**Returns the current web directory path if called without argument. If an argument is specified (and it is a valid test number) the directory path for that directory is returned instead.**
$id→homedir()	**Returns the home directory path for the rig.**
$id→hometest()	**Returns the home test directory path for the rig.**

$id→get_sessionlog($)	**Returns the testlog for the specified test (default is the current test if no test is specified).**
$id→get_userlog($)	**Returns the userlog for the specified test (default is the current test if no test is specified).**
$id→get_errorlog($)	**Returns the errorlog for the specified test (default is the current test if no test is specified).**
$id→name()	**Returns the Rig name (the integer passed to the RFC::Rig constructor).**
$id→type()	**Returns the string 'Rig';**
$id→session()	**Returns the current test number.**
$id→proglog($[$])	**Appends the specified string to the rig proglog for the currnet test. If an atdditional argument is specified it is assumed to be the username of the originating user and the string is appended with this information, if not a generic user identification is appended including terminal of origin (usually 'rigX' on /dev/pts/N). In addition an entry is logged in the tracelog in this case.**
$id→userlog($[$])	**Appends the specified string to the rig userlog for the currnet test. If an atdditional argument is specified it is assumed to be the username of the originating user and the string is appended with this information, if not a generic user identification is appended including terminal of origin (usually 'rigX' on /dev/pts/N). In addition an entry is logged in the tracelog in this case.**
$id→disable_proglog([$])	**Sets or gets the proglog_disabled attribute. if proglog_disabled is set to true, all calls to proglog simply return s withoug appending to the proglog. Default is 0 (flase, logging enabled), and this setting should only be carefully used.**
$id→errorlog($[$])	**Appends the specified string to the rig errorlog for the currnet test similar to proglog. Note that all logged errors are automatically appended to the proglog.**
$id→tracelog($)	**Appends the specified string to the rig tracelog for the currnet test. The logged string includes complete stack backtrace**
$id→print_setup()	**Prints out the complete current setup including all member functions and data fields (uses Class::Inspector). Overloads the print_setup() function in Debug.pm.**

$id→test_list()	**Returns a list of all devices. The returnes list is a array of hashes (with each hash containing id and name of a specific device).**
$id→print_config()	**Prints out the rig configuration**
$id→check_run()	**Forces an error if the current user number does not match the rig number (as determined by RFC::Main::get_user_number)**
$id→check_group()	**Forces an error if the current user is not part of the RFCcontrol base group (the group the apache web server is also part of).**
$id→inc_test($$)	**Increases the test number and reinitialises the rig instance. The aruments are the additional test information and the name of the user initialising a net test.**
$id→remote_log($)	**Appends the supplied string to the remote logbook. The call is made by calling the url specified in the 'logbook_url' key in the main section of the main configuration file appended with the supplied string (which will be url-encoded). Thus if the logbook_url contains 'https://foo.bar/cgi-bin/log.cgi?msg=' and the function is called with the string 'test_msg' the resulting url called will be: 'https://foo.bar/cgi-bin/log.cgi?msg=Test_msg' Please note that additional (fixed) parameters may be specified in the url string, they just have to be before the appended string using normal URL encoding (ampersands etc).**
$id→DESTROY()	**Object destructor.**

A special function is the DESTROY() member function. In most object oriented programming languages, the implementatiion ensures that the destructor is called in reverse order on an object and it's internal objects. Unfortunately the Perl GC does not guarantee this, as a result (and the often deeply nested object tree for a RFC:Rig instance), if the rig's destructor is not called explicitly before program termination, the default object cleanup may result in attempts to de-refer already destroyed objects durring global cleanup. In most cases this is a harmless error, but for some objects (PID's in particular), this will result in internal state not beeing saved (as the file object for saving the state is already gone)

RFC::Rig also implements the Visitor pattern by suppliying the Accept() method.

$id→Accept($)	**Runs the Accept() function for all devices with the supplied visitor as argument (behaves as a CompositeElement (GoF)). Also calls the VisitComplex() function on the visitor.**
$id→ClearVisitor()	**Special function which clears the list of already seen visitors**

Rhe RFC::Rig class also implements the Gof Composite pattern (together with the RFC::BaseDevice derived classes) with RFC::Rig acting as a Gof Component class as will as the Gof Composite class.

Device management. Any RFC::Rig instance has a number of device instances asociated. Some of these devices are read only devices (datalogging) while others may be control devices.

The types avaliable are:

simplechannel
relay
gas (the plural of this is gasses)
gasgroup
MFC (Mass flow controler)
multiplex (plural multiplexers), used for gas multiplexing.
water (water bublers)
PSU (Power supplies, including electronic loads)
templog (Temperature logging only, not control)
tempcontrol (Temperature controller)
analog (Analog output devices)
filter (virtual device)
logic (virtual device)
math (virtual device)
Alert (virtual device)
Adapter (virtual device)
PID (Virtual control device for PID control systems)

and a list of device types can be obtained by calling:

$id→list_types();

Each of these device types has different member functions, but common for all of them is that they must be derived from BaseDevice.pm (which defines the base. member functions on which RFC::Rig relies on). To get a device instance of a particular type, call

$id→get_device($type,$name);

The type must match one of the above defined types (otherwise the function merely return undef). If no device exist of the type and name specified,

undefined is returned instead of a device instance, note that this function does NOT initialise or load new device instances, it merely returns references to already initialised / loaded devices (This is usually handles by the class constructor/init function).

It is also possible to use the init_device function:

```
$id→init_device($type,$name);
```

This function tries to initialise/load the device if it does not already exist.

It is possible to get lists of devices and avaliable devices (that is all possible devices of a type, irrespectively of it is loaded or not) as well as supported device types by using the following functions:

$id→list_types()	Returns a list of supported device types.
$id→list_types_nofilter()	Returns a list of supported device types but excludes filter types.
$id→get_uiname($)	Returns a human readable string describing the specified device type (intended for use on the UI).
$id→list_devices($)	Lists the devices of the specified type.
$id→list_devices_subtype($$)	Lists the devices of the specified type and subtype.
$id→list_devices_control($)	Lists the enabled devices of the specified type which is not readonly.
$id→list_devices_control_subtype($$)	Lists the enabled devices of the specified type and subtype which is not readonly.
$id→list_names($)	Lists the devices of the specified type which will be explicitly initialised during rig initialisation. Note that this list does not include implicit devices or devices initialised as part of other devices!
$id→list_names_tag($)	Returns the tag name used for controling the enabled status for the devices of the specified type (an enabled device gets explicitly initialised).
$id→avaliable_devices($)	Lists the possible devices of the specified type.
$id→avaliable_devices_nofilter($)	Lists the possible devices of the specified type but excludes filter devices which may masquerade.
$id→device_sectionname($)	Returns the cofiguration section base name (identifier) for the device type in question. returns 'channel_' if called with the 'simplechannnel' argument for instance as the simple channel 'cell_voltage' is configured in the 'channel_cell_voltage' section.

$id→get_devce($$)	Returns a device instance of the specified type and name.
$id→delete_device($$)	Removes a device instance of the specified type and name. Use with extreme caution as used wrongly may cause perl's version of a NULL-pointer exception lateron!
$id→register_device($$)	Attatches the specified device instance to the rig instance. Note duplicate names not allowed. (results in an error). Argu,ents are: type,name.
$id→set_cache($$$[$])	Saves a value for the specified device type and name. Arguments: Device type, Device name, Value [opt timestamp]. If no timestamp is supplied the current time is used instead.
$id→get_cache($$)	Gets the cached value for the specified device type and name. Returns undef if caching is not allowed or if no value was found for the type and name specified.
$id→get_cache_time($$)	Gets the cache time for the specified device type and name. Returns undef if caching is not allowed or if no value was found for the type and name specified.
$id→store_cache()	Stores the cached values in a file. Is called automatically by the RFC::Rig destructor.
$id→load_cache()	Loads the stored cache values.
$id→clear_cache([$$])	Clears the persistent cache. If optional parameters are passed, only the cache for that composite key (type and name) is cleared.
$id→allow_cache([$])	Sets or gets if persistent caching is to be allowed. Default is to not allow caching. If caching is disallowed All calls to get_cache() will return undef; Notice that only if the 'allow_caching' key in the 'IV_control' is set to 'Yes' is caching allowed to be turned on (That is, bu setting 'allow_caching' to no disables all persistent caching durring iV curves irrespective of device configuration).
$id→list_caching()	Returns a list of devices for which caching is enabled. Notice that filter devicec can never be caching.

For all of the above functions the specified type must match one of the types returned by $id→list_types() or the functions returns undef.

A number of control functions are also defined. They each operate on one of the device instances (depending on type).

$id→set_temp($)	**Sets the specified temperature setpoint for the specified device name (if no device name is specified and only one. temperatue control device is initialised, that device is used).**
$id→set_ramp($)	**Same as above, but for temperature ramprate (C/hour).**
$id→current($)	**Sets the specified DC curent for the specified PSU (If no PSU name is specified and only one PSU devce is initialised, that one is used).**
$id→voltage($)	**Same as above, but for the DC voltage.**

11.10.2 Private member functions

Each RFC::Rig instance also has the following private member functions.

Perl does not enforce public / private declerations however, so the functions are avaliable. The private member functions is not intended for normal use, only for advanced use by system maintainers!

$id→load_session_nr()	**Loads the session number from the session number file.**
$id→create_dirs()	**Checks the current session and creates the directories asociated with the test if nescesarry.**
$id→last_read()	**Dummy function returning current time**

Each device type has four handling functins described for the simplechannel class below. The four types of handling functions for device type TYPE are:

$id→TYPEs();
$id→TYPE();
$id→init_TYPE();
$id→avaliable_TYPEs();
$id→register_TYPE($);

$id→simplechannels()	**Returns a list of the current simplechannels.**
$id→simplechannel($)	**Returns the Simplechannel class instance with the specified name (if it exists, undef otherwise).**
$id→init_simplechannel($)	**Attempts to initialise a new simplechannel device with the specified name, returns the device instance created. Forces an error if the nescesarry configuration section is not found in the configuration file.**
$id→avaliable_simplechannels()	**Returns a list of possible simplechannels (including disabled simplechannels).**

$id→register_simplechannel($)	**Attatches the specified Simplechanel device instance to the rig instance. Note duplicate names not allowed. (results in an error).**

Eeach type also has a constructor wraper function asociated with it which is a member function of the rig instance:

$id→new_AnalogOut($)
$id→new_RELAY($)
$id→new_SimpleChannel($)
$id→new_PSU($)
$id→new_Multiplexer($)
$id→new_MFC($)
$id→new_TEMP($)
$id→new_GAS($)
$id→new_Water($)
$id→new_Templog($)
$id→new_GasGroup($)
$id→new_filter($)
$id→new_Logic($)
$id→new_Math($)
$id→new_PID($)
$id→new_Alert($)
$id→new_Adapter($)

The new_device functions are wrapper functions for the various Device.pm factory functions. They are used by $rig→init() as well as to obtain an device node for a not enabled device (For testing purposes when installing a ned hwardware/logical device)

11.11 RFC::Visitor

Inherits from Debug (refer section 11.1).

The RFC::Visitor module defines the base behaviour for visitors used together with RFC::Rig and RFC::BaseDevice instances. The RFC::Visitor class is the base class, and the RFC::VisitorClear class isused to clear the internal references to already seen visitors

The DummyVisitor class can be used to test the Visitor pattern on a RFC::Rig instance (it merely count the number of devices).

To obtain an instance call the constructors:

my $v = RFC::VisitorClear→new(); - Clears the list of seen visitors

my $v = RFC::TestVisitor→new(); - Tests the devices it is called on

my $v = RFC::ConfigVisitor→new(); - Prints the device configuration.

my $v = RFC::DebugVisitor→new($debuglevel); - sets the debug level

my $v = RFC::MeasuretimeVisitor→new(); - Gets the last time measurements were done for each device

my $v = RFC::DummyVisitor→new(); - Runs through the devices and counts instances

my $v = RFC::DisableProglogVisitor→new(); - Disables appending to proglog.

my $v = RFC::EnableProglogVisitor→new(); - Enables appending to proglog if this is disabled.

All RFC::Visitor derived classes must implement the follwoing member functions:

$id→VisitSimple($)	**Must handle access to simple devices (such as simplechannels)**
$id→VisitComplex($)	**Must handle access to complex devices (such as Temolog devices).**
$id→result()	**Return the calcualted value or string for the visitor in question**

When designing new visitors it is advisable to make the visitor class name descriptive of what the visitor in question actually does.

11.12 RFC::Cache

Inherits from Debug (refer section 11.1).

this module defines the RFC::Cache class. the RFC::Cache class is intended to be used for caching device data in conjunction with objects derived from RFC::BaseDevice.

A RFC::Cache object can be obtained by calling the constructor:

my $id = RFC::Cache→new();

All RFC::Cache objects has the following public member functions:

$id→clear()	**Clears all data content in the data cache.**
$id→dump()	**Returns a data dump of the cached data (using Data::Dumper).**
$id→stat()	**Returns some statistics for the cache (number of hits as well and tries as well as a dump of the cache).**

$id→set(@)	**Sets a data value to be cached. The first n arguments must be key names and the last argument must be the value to be set. Example: set('ttyS0','icp','1',453.56) Note that all keys are converted to lower case to minimise typing errors!**
$id→get(@)	**Returns the value asociated with the specified keys (using the example above, get('ttyS0','icp','1') would return 453.56 If a value is not found or the keys are not encountered in the correct order, it returns undef. Thus remember to check if the return value of get(@) is defined before it is used!**
$id→get_time(@)	**Returns the time the data was set asociated with the specified keys (using the example above, get('ttyS0','icp','1') would return something like 1444130488.2388 If a value is not found or the keys are not encountered in the correct order, it returns undef. Thus remember to check if the return value of get_time(@) is defined before it is used!**

11.13 RFC::Spline

Inherits from Debug (refer section 11.1).

This module defined the behaviour of a spline interpolation.

The intended use of RFC::Spline instances is to correct measured values according to a callibration table and/or to convert a measured value to an other format (for instance given a conversion table linking measured voltages to pressures a splineinterpolation can be used to obtain the pressure given a measured voltage).

To obtain a RFC::Spline instance call the constructor:

$id = RFC::Spline→new($data);

where $data is a string containing a list of spline data. the list must be formatted in the form of a number of lines with a single x and y cordinate on each line. The data must represent a continious, single valued function (that is for each x there is one and only one y and the function is without 'jumps' like seen in the function 1/x). The x and y values must be separated by space and/or tabs and lines must be separated by newlines. Note that if more than 2 values are found on a line only the two first are used and only valid lines are used (lines with less than 2 detected numbers are discarded!).

An RFC::Spline instance allows numbers to be converted according to the

spline table. Thus to convert a given value simply call the 'value' public member function.

$newval = $id→value($oldval);

The following public member functions exists:

$id→value($)	**Returns the interpolated value based on supplied argument which must be a number!**
$id→data()	**Returns the spline table used in the calculations.**

If only 2 sets of numbers are given in the spline table, the relation is assumed to be a linear one and no spline interpolation is performed. Instead a spmple linear interpolation is used.

The same is the case for input values outside the defined data range. In those cases the first or last 2 data points are used in a linear interpolation. Notice that in general it is poor form to interpolate values outside the defined range!

Below is an exaple of how a spline table may look:

-0.5 -0.1

0 0.1

1 3

1.5 5.7

11.14 RFC::BaseDevice

Inherits from RFC::Observer (refer section 11.9).

This module defines a number of common functions for all RFC devices. Most of these functions are virtual in that respect that they are overwritten by the individual class definitions.

To obtain a device instancee call the constructor (in this case BaseDevice): my $id = BaseDevice→new($name,$rig); Where $name is an identifier string (preferably unique) and $rig is an instance of the RFC::Rig class. This second argument is required for callback functionality used in a number of the device operations (mainly $id→read, but in some cases also by the derived device constructors and/or init functions). Some device constructors may require additional arguments (refer the individual class files for details). The rig object must at least honor the following member functions (refer RFC::Rig for details about the individual member functions):

get_cv(section,key)

change_config_value(section,key,newval)

list_types()

list_types_nofilter()

list_devices(type)

list_devices_control(type)

avaliable_devices(type)

avaliable_devices_nofilter(type)

get_device(type,name)

init_device(type,name)

register_device(object)

disable_warning_mails([opt set]);

warning_mail(type,msg,[opt subj])

unset_warning(type)

proglog(string)

errorlog(string)

get_cache_time(type,name)

get_cache(type,name)

set_cache(type,name,value)

clear_cache(type,name)

All devices inheriting from RFC::Basedevice honors the folliwing member functions:

$id→type()	**Returns the type of the instance (usually the class name)**
$id→name()	**Rreturns the name of the instance.**
$id→UIname()	**Rreturns the name of the instance to be used for user interface purposes. Note that unlike names returned by the name() function, names returned by UIname() are NOT guaranteed to be unique even within device types! The default is that name() and UIname() return the same string.**
$id→mode()	**Returns the mode of the device (usually one of the follwing Readonly, Automatic or Manual).**
$id→sectionname()	**Returns the section name from which the device was initialised.**
$id→init()	**Initialises the device (not all devices require this).**
$id→print_config()	**Returns a string containing the setup information.**

$id→print_setup()	**Prints the contents of the current device data (software only).**
$id→title()	**Returns the title string for the device (if defined) or an empty string.**
$id→rig()	**Returns a reference to the attatched rig instance.#**
$id→proglog($[$$])	**Appends the supplied string to the attatched rig's program log If a second argument is specified that is asumed to be the user name of the user originating the action/logentry. If a third argument is specified or disable_proglog is set, no logging is performed (usefull for i-V curves where lots of commands are given during the i-V curve and logging all of them would polute the program log.**
$id→disable_proglog([$])	**Returns 1 if appending to the attatched rig's proglog is disabled. If an argument is supplied, sets the status instead. Default is 0 (proglog enabled).**
$id→errorlog($)	**Appends the suplied string to the attatched rig's errorlog.**
$id→get_conf($)	**Returns the configuration value for the specifiec key Uses the rig instance for the actual configuration manipulation If called in a list context,returns a list of values based on the raw configruation value split along commas (ignores spaces arrounds commas).**
$id→load_conf()	**Loads all confifguration values from the rig instance. Uses the list supplied by setup_tags_legacy() to get the keys for which values to inport.**
$id→change_cv($$)	**Changes the configuration value for the specifiec key to the new value (second argument) Uses the rig instance for the actual configuration manipulation**
$id→get_default($)	**Returns the default setting for the specified configuration tag.**
$id→change_reload($)	**Returns 1 if changing the specified configuration tag should result in a page leload (due to changes in the number and/or operation mode of other tags as a result of a change of the current tag value). Default return value is 0; Only intended to be used for user interface programming.**

$id→hide_tag($)	**Returns 1 if the specified tag is disabled by the current configuration of the device and thus should not be visible to the user. Default return value is 0;**
$id→setup_tags()	**Returns a list of setup tags which the divice understands. setup_tags() adds the common element 'comments' to the list defined by the individual device classes, and this element is intended to be used for a string containing commetns for the device.**
$id→setup_tags_legacy()	**Same as setup_tags() except it includes potential deprecated setup tags for the device.**
$id→tag_description($)	**Returns the description string asociated with the specified tag. Hardcoded to return the string "Description for this device, not used for other purpose. Do not use ',' in text as that character is used as newline substitute." if the supplied tag is equal to 'comments'.**
$id→tag_type($)	**Returns the type of the specified tag (Read-only or read-write) Default is read-write.**
$id→radonly_value($)	**Returns the value of a specified (readonly) tag. Returns undef if the tag is not readonly. Note to developers: This function needs to be defined for all readonly tags for a given device type!**
$id→get_tag_values($)	**Returns a list of possible values for a specific setup key.**
$id→ui_fn_names()	**Returns a list of function names which can be called from the device configuration page in the user interface Default is to return the empty list as most device types vould usually not have nay functions which it would make sense to call from the device setup user interface as the interface only allows maximum one argument to any function called from there (by using the prompt() javascript function). If the last line of the returned string from this function is the string 'RELOAD', then the setup page will be refreshed (as it is assumed that running this particular function will change the internal variables of the device in question).**

$id→ui_fn_args($)	**Returns the number of arguments which must be supplied fo the function with the specified name. Is intended to be sued in conjunction with ui_fn_names() and only function names mentioned in that list will be valid arguments (returns undef if no match). Default value is 0, so if the function does not have any arguments it is not nescesary to specify a value in the '_ui_fn_args' hash**
$id→ui_fn_description($)	**Returns the description string asociated with the specified function name. All functions listed by ui_fn_names() must have a corresponding description in the '_ui_fn_desc' hash**
$id→list_set_functions()	**Returns a list of possible function names which could trigger a notify event (such as setflow for a gas or set_voltage for a PSU) Returns an empty list for pure input devices (default)**
$id→readonly()	**Returns true (1) if the device is a readonly device false (0) othervise. The default is for a device to be controlable, thus false (0) is the default response.**
$id→set_readonly()	**Sets a device readonly (only use with caution as can not be reversed).**
$id→info_string()	**Returns a string (potentially empty) containing information which the user may need for device configuration.**
$id→persistent()	**Returns 1 if the persistent_settings key is defined and is set to 'Yes'. Returns 0 otherwise. Some device types allow querying the physiccal device for some settings. This can be done each time at device initialisation (default) or stored on file. The advantage of storing those settings in the configuration file is that device communication overhead is minimised. The disadvantage is that if those settings change, the RFCcontrol system will not know this and use the old (and now wrong) settings. If the persistent_settings key is set to yes, the settings are read from the configruation file (and have to be specified there).**

$id→query_settings()	**This function queries the device for the settings which can be aquired directly from the physical device and stores them in the configuration file. For most device types this is a NOP. If defined for a device type, it should be executable from the device configuration user interface.**

All devices also has the following special functions for data access:

$id→read([$])	**Returns the value of the instance, this is dependent on the type of device. If an argument is specified it must be an object of type RFC::Cache. If the device allows using cached values, the cache is first checked and if a value is found this is returned instead of the raw value. Notice that if improperly used, values too far in the past can be returned! The caching is done through the attatched RFC::Rig instance For some device types caching is not possible and a raw read is always returned.**
$id→bool([$])	**Returns the boolean value of the device. For devices which already returns a boolean value from read(), the the bool() function is merely an alias for read() whereas for devices returning non-bool values the default is to return 0 (false) if the value of read() is 0 or undefined and 1 (true) otherwise.**
$id→value()	**Returns the value of the device. This is obtained from the read() function if the value() function is called for the first time. Any subsequent calls to value() will return the internally stored value. unless clear_cache() has been called in which case the read() function is called again. This function is intended to be used when arithmetic opeartor overloading is used in orer to speed up calculations.**
$id→setpoint()	**Alias for read(). Can be overloaded for controlable devices to return the last given setpoint.**
$id→has_ramp()	**Returns 1 (true) if the deivce has a 'set_ramp' function (and thus is capable of ramping to a new setpoint). Default is to return 0 (false).**

$id→read_nocache([$])	**Returns the value of the instance, this is dependent on the type of device. If an argument is specified it must be an object of type RFC::Cache. Unlike read() this function does not check persistent cache even if caching is allowed.**
$id→last_read()	**Returns the last time read_nocache was called.**
$id→read_cache([$])	**Returns the last read value. If an argument (time in seconds) is specified, this forces a new call to read() if the time since last call of read_nocache is larger than the specified difference. Any additional arguments is passed on to read().**
$id→is_caching()	**Returns true if caching is configured to be enabled for this device. Returns false otherwise.**
$id→set_cache($)	**Sets the specified value in the persistent cache (this is done through the attatched RFC::Rig instance, see specification there).**
$id→clear_cache()	**Resest the persistent cache (this is done through the attatched RFC::Rig instance. It also clears the local cache used by the value() function**
$id→read_names()	**Returns a list of valid read functions (most devices only returns a list with the 'read' function).**
$id→set_names()	**Returns a list of valid functions which can be called on the deivce and which changes the internal state of the device. For instance a relay device only has the 'set' function and a gas device has the setflow function as well as the set command (which is an alias for setflow in that case). Some devices (such as simplechannel devices) do not have any and will return the empty list.**
$id→read_named([$])	**Returns the value of the specified function. If no function name is specifiecd, the read function is returned(). Only function names listed in the response from read_names() are valid**
$id→readstring([$])	**Returns the value of the device, but with additional time information. If an argument is specified it must be an object of type RFC::Cache.**

$id→readstring_ignore()	**Sets or gets the variable determining if the readstring function simply returns undef or the real return string. This is useful if calculations require a lot of simple data values to calculate the desired variable and one whishes to awoid 'poluting' the data logging with the raw data values of the intermediate variables. If called without arguments, returns the value of the ignore variable. 1 disables readstring returning a string, 0 enables it again. Default is 0 (readstring enabled).**
$id→readstring_furnace()	**Special version of readstring used by the RFC-furnace adon. If the readstring_furnace key is set, it returns the readstring value.**
$id→get_time()	**Returns the current time in format YYYY MM DD HH MM SS Output is in the form of an array.**
$id→test()	**Returns 1 or 0 depending on device status. BaseDevice always returns 0 as it is meant to be overridden by the derived classes.**
$id→test_full()	**Returns 1 or 0 depending on device status. Usually an alias for**
$id→test()	**but may contain additional validation such as checking that the temperature is above absolute zero for temperature logging devices.**
$id→test_string([$])	**Returns the device status as a string (in some cases the status of devices used by the device is included). Intended to be overridden by derived classes. If the optional argument is specified it should be an instance of RFC::Cache (in some cases this will speed up execution as cached data can be used instead of having to read new values from hardware).**
$id→monitor()	**Returns the value(s) of the device. In most cases this function is just a wrapper for the read() member function, however in the case of devices with more than one interesting value to read (for instance for temperature controlers where one wants both the setpoint and the active setpoint) a string containing the values as well as descriptions are returned instead.**

$id→monitor_rows()	**Returns a string identifying how many data rows moitor() returns and which row numbers contain data (as opposed to identifier strings) Default is the string '2' for a normal device which only returns a single value and a time. For devices returning multiple values the string returned could be '3,5' for instance (as rows 2 and 4 contain the strings describing the values in row 3 and 5 respectively).**
$id→setup_template()	**Returns the html template name uset to setup/configure the device.**

Both read and readstring accepts and additional argument. This argument must be an object of type RFC::Cache (or any other object which has the the get() and set() interface specified the way RFC::Cache does) and if this is specified, the read and readstring functions first looks in this cache to see if they can find the requested data there. If so, the already existing data is returned and if not the data is measured and stored in the cache as well as returned. The advantage of this is that multiple relay instances can share a read operation if they are on the same relay board (and the device has a bulk read option as the ICP-Das modules all does).

To use this option the template below can be used:

my $data = RFC::Cache→new(); my $string = $id→readstring($data);

In this case a new empty cache is defined and it will then be populated by the readstring function. any later calls to id→readstring($data) will thus reuse the stored data (only for the same device or other devices using the same setup keys, refer the documentation for RFC::Cache).

In order to test if the reference passed to readstring is of the correct type the following function can be used:

$id→check_cache($)	**Checks that the supplied argument is of type RFC::Cache and if not, logs a warning and replaces it with an object of the correct type.**

It is also possible to use the observer pattern whith objects which derives from this base class. To facilitate this, BaseDevice inherits from RFC::Observer.

RFC::BaseDevice also inplements the following member function which can be used when overloading the observe() member function in derived classes:

$id→master()	**Returns the master device for a slave device. This can be used to ensure that a master can not at the samae time be a slave (which to some degree protects against infinite recursions).**

All device classes inheriting from BaseDevice also implements the Visitor pattern. Thus all devices implements the Accept(RFC::Visitor) function.

$id→Accept($)	**Runs the VisitSimple or VisitComplex member function of the supplied visitor instance.**
$id→Clear_visitors()	**Special function which clears the list of already seen visitors**

the default Accept method derived from BaseDevise is to call the VisitSimple function. All complex devices (containing internal devices) should implement their own Accept method. As a RFC::Basedevice derived device may be used in more than one other device, the Accept method keeps track of which visitors has already visited it and only calls the VisitSimple/ VisitComplex function once for each visitor. For long runing programs which may continue to create visitors, it may be nescesarry to call Clear_visitor() on all devices to clear the list (The special RFC::VisitorClear visitor will do this if passed to the Accept function of a RFC::Rig instance)

As it is possible (and indeed recommended) that device classes inheriting from
RFC::BaseDevice conains other RFC::BaseDevice derived class instances, the BaseDevice and inherited classes implements the Composite pattern as this works well with the Visitor patern for traversing parts or the whole device structure.

11.14.1 Operator overloading

RFC::BaseDevice overloads the following arithmetic operators: + - * / and ** (exponentiation) as well as unary minus and the string operator "" and the concatanation (dot) operator. Thus it is possible to do:

$dev = RFC::BaseDevice→new(@ARGS);

$val = $dev + 6.5;

and get the expected result.

Similarly it is possible to do:

print "Device: $dev is active"

Note however, that simple assignment is NOT overloaded, thus using $val = $dev will NOT set $val to have the value of $dev→read(). To get the value of a device use the read function directly or the slightly cumbersome $val = $dev + 0 (not to mention the truly ugly $val = -(-$dev) which uses unary minus, which IS overloaded). The advantage of the read function (apart from beeing easier to understand) is that it can be passed a cache argument which the overloaded arithmetic functions can not and which in many cases can speed up runtime as the device can re-use already measured values (refer the definition of the read function).

11.15 RFC::Simple

Inherits from RFC::BaseDevice (refer section 11.14).

This class defines simple dataloging (readonly) channel setup To obtain an instance of this class call one of the constructors like:

$id = RFC::Simple→new($name,$rig)

In case of an RFC::keithley or RFC::SimpleICP instance, it can also be obtained by

$id = RFC::Keithley→new($name,$rig,$channel)

or similarly for a RFC::SimpleICP instance.

The reason for the last option is to allow the instantiation of a device without a separate setup section.

The RFC::Simple module defines no new member functions. However all simplechannel devices have the configuration option of using a scaling factor (effectively a number which is multiplied with the raw physical value). For instance this enables a value to be reported in mV even though it is measured in Volt by setting the scaling factor to 1000.

The avaliable devices are:

$id = RFC::SimpleExternal→new($name,$rig)

$id = RFC::SimpleSocket→new($name,$rig)

$id = RFC::SimpleSOAP→new($name,$rig)

$id = RFC::Keithley→new($name,$rig)

$id = RFC::KeithleyMOM→new($name,$rig)

$id = RFC::SimpleICP→new($name,$rig)

$id = RFC::SimpleICP7017→new($name,$rig)

$id = RFC::SimpleICP7019→new($name,$rig)

$id = RFC::SimpleModbus→new($name,$rig)

$id = RFC::ModbusTCP→new($name,$rig)

The SimpleExternal deivce is a vrapper device for a call to an external program. This allows access to read and log non-RFCcontrol programs providing a wrapper program or link to the program is placed in /usr/local/bin/celltest/external Any call to programs in this directory must print a number when executed. Additionally, programs in this directory may only contain letters and '.' in the filename (this is to prevent the possibility for code injection).

Note however that any program placed in this directory can be called from any user who can log in to any of the rigs on the server, so take care that programs placed in this directory can not do anything that could damage anything (imagine what a wrapper for 'rm -rf .*' could do.....)

The SimpleExternal and SimpleSocket classes has a special option for reading the timestamp form the external program or system. If the returned value has a hash-mark in it, then the string after the hash mark is evaluated to see if it can be parsed to a timestamp. If so, the timestamp fo the measurement is set to this value instead of the local time the call was made (as is normal for most other devices).

11.16 RFC::BaseRelay

Inherits from RFC::BaseDevice (refer section 11.14).

This class defines the behaviour of simple relays To obtain a relay instance use one of the constructors like shown below:

my $id = BaseRelay→new($name,$rig);

The rig argument must be a RFC::Rig instance or a similar object honoring the get_conf() member function. The constructior can also be called with additional arguments:

my $id = BaseRelay→new($name,$rig,$tty,$address,$channel);

where the last 3 argmeutns specify the serial device, the module address and the channel number of the relay (as most relay modules contains more than one relay.

All relay objects have the following member functions (excluding those derived from RFC::BaseDevce and Debug.pm):

$id→set($[$][$]) Sets the status of the relay to the specified arguemnt one indicates closed relay, 0 open. If an additional argument is specified, it is assumed to be the username of the controlling user and that name is appended to the string appended to the rigs proglog. an exception to this is if a further argument is specified in which case no proglog entry is appended!

$id→set_noinfo($) Similar to set() except no proglog info is appended. $id→master() Returns a reference to the master device (if such exists).

It is possible to have a relay device beeing controlled by an other relay device through the observer pattern. To use this feature, set the 'master device' value to the relay acting as the controlling device. Note that a slave relay can not act as a master for an other slave relay (use the original master relay instead)! This feature is in place in order to prevent circular references.

If no data can be read from the device attatched to the object, the read() function returns -1 to indicate the error.

Notice that the bool() function returns 0 (false) in case the status of the relay can not be determined!

11.17 RFC::Monostable

Inherits from RFC::BaseRelay (refer section 11.16).

This class defines the behaviour of monostable relays To obtain a relay instance use one of the constructors like shown below:

my $id = Monostable→new($name,$rig);

my $id = PWM_Mono→new($name,$rig);

The rig argument must be a RFC::Rig instance or a similar object honoring the get_conf() member function. The constructior can also be called with additional arguments:

my $id = Monostable→new($name,$rig,$device);

where the 3'rd argmument is the relay device instance to be used for the control. This device must be an instance of RFC::BaseRelay or a derived class.

The difference between the two types of monostable relays is that the PWM version has varialbe on time which is determined at runtime by using the read value from an other device whereas the normal one has a fixed on time (determined by the configuration).

Notice that it is possible to create a circular list of Monostable relays as RFC::Monostable is polymorphic with RFC::BaseRelay! Do not attempt this as the whole system will be inoperable due to infinite recursion!

The RFC::Monostable class derives from and emulates RFC::BaseRelay but overloads the $id→set function.

$id→set($[$][$]) Triggers the the relay to shortly send a close command followed by a wait duration and then a open command irrespective of the first argument If an additional argument is specified, it is assumed to be the username of the controlling user and that name is appended to the string appended to the rigs proglog. an exception to this is if a further argument is specified in which case no proglog entry is appended!

If no data can be read from the device attatched to the object, the read() function returns -1 to indicate the error.

11.18 RFC::AnalogOut

Inherits from RFC::BaseDevice (refer section 11.14).

This class defines simple analog output devices (D-A converters, not power supplies) To obtain a analog output instance call onw of the constructors:

$id = RFC::AnalogOut→new($name,$rig);

$id = RFC::AnalogICP87024→new($name,$rig);

$id = RFC::AnalogICP87028→new($name,$rig);

$id = RFC::ManualAnalogOut→new($name,$rig); (A virtual, software only, device)

The rig argument must be a RFC::Rig instance or a similar object honoring the get_conf() member function. The constructiors can also be called with additional arguments like shown below:

$id = RFC::AnalogICP87024→new($name,$rig,$tty,$address,$channel);

where the last 3 argmeutns specify the serial device, the module address and the channel number of the output module (as most modules contains more than one output channel).

All analog output objects have the following member functions (excluding those derived from RFC::BaseDevce and Debug.pm):

$id→set($)	**Sets the output voltage/current of the device to the specified argument. the format for sending numbers to the devices supported (i87022/24/26) is the engineering unit DD.DDD according to the manual. The driver uses sprintf to make sure that the supplied number is in this format.**
$id→current($)	**Sets the output (for current control modules) in A. this functio is usually just a wrapper for set().**
$id→mode()	**Returns the control mode of the deivce (mA,A,mV or Volt). This overloads the normal mode() function.**
$id→min()	**Returns the minimum possible value.**
$id→max()	**Returns the maximum possible value.**

11.19 RFC::PSU

Inherits from RFC::BaseDevice (refer section 11.14).

The PSU class (and the derived classes) defines the behaviour of DC power supplies for the RFC control system. To obtain a PSU instance, call one of

the constructors like shown below:

$id = RFC::PSU→new($name,$rig);

$id = RFC::DefaultDelta→new($name,$rig);

$id = RFC::SM_15_100→new($name,$rig);

$id = RFC::SM_18_50→new($name,$rig);

$id = RFC::SM_60_100→new($name,$rig);

$id = RFC::SM_35_45→new($name,$rig);

$id = RFC::SM_52_30→new($name,$rig);

$id = RFC::SM_70_22→new($name,$rig);

$id = RFC::SM_120_13→new($name,$rig);

$id = RFC::SM_300_5→new($name,$rig);

$id = RFC::SM_30_200→new($name,$rig);

$id = RFC::ES015_10→new($name,$rig);

$id = RFC::ES030_5→new($name,$rig);

$id = RFC::ES075_2→new($name,$rig);

$id = RFC::ES0300_045→new($name,$rig);

$id = RFC::ManualPSU→new($name,$rig);

$id = RFC::BKPrecision→new($name,$rig);

$id = RFC::HMP→new($name,$rig);

The PSU class defines the follwing new functions.

$id→voltage($)	**Sets or returns the applied DC voltage If no argument is supplied, it simply returns the last set value.**
$id→current($)	**Sets or returns the applied DC current If no argument is supplied, it simply returns the last set value.**
$id→RSD($)	**Enables or disables DC output if such a device (relay) is attatched to the system.**
$id→minvoltage()	**Returns the minimum voltage.**
$id→maxvoltage()	**Returns the maximum voltage.**
$id→mincurrent()	**Returns the minimum current.**
$id→maxcurrent()	**Returns the maximum current.**
$id→idn()	**Returns a hardware specific identifier string**
$id→measure_U()	**Returns the measured voltage output (if the device implements this).**
$id→measure_I()	**Returns the measured current output (if the device implements this).**
$id→get_I()	**Returns the current setpoint (some devices returns the result of measure_I() instead).**

$id→get_U()	**Returns the voltage setpoint (some devices returns the result of measure_U() instead).**
$id→set($)	**Alias for set_voltage($) or set_current($) depending on the setting of the 'control_mode' variable.**
$id→read	**Alias for measure_I. Any arguments to read is passed to measure_I.**

Note that the HMP PSU does not have the option of running RS232 Daisychain so only one HMP device can be connected to a given serial line (running RS232).

11.20 RFC::Elektro

Inherits from RFC::PSU (refer section 11.19).

This module implements RFC::PSU for electronic loads.

To obtain an instance call one of the constructors as shown below:

$id = RFC::EL_9080_200_HP→new($name,$rig);

$id = RFC::EL_9160_100_HP→new($name,$rig);

$id = RFC::EL_9400_50_HP→new($name,$rig);

$id = RFC::EL_9750_50_HP→new($name,$rig);

$id = RFC::EL_9080_200_HP→new($name,$rig);

$id = RFC::EL_9160_100_HP→new($name,$rig);

$id = RFC::EL_9400_50→new($name,$rig);

$id = RFC::EL_9750_50→new($name,$rig);

$id = RFC::EL_9080_600_HP→new($name,$rig);

$id = RFC::EL_9160_300_HP→new($name,$rig);

$id = RFC::EL_9400_150_HP→new($name,$rig);

$id = RFC::EL_9080_600_HP→new($name,$rig);

$id = RFC::EL_9160_300_HP→new($name,$rig);

$id = RFC::EL_9400_150_HP→new($name,$rig);

$id = RFC::EL_9750_75→new($name,$rig);

$id = RFC::EL_9750_75_HP→new($name,$rig);

$id = RFC::EL_3160_60A→new($name,$rig);

$id = RFC::EL_3400_25A→new($name,$rig);

$id = RFC::EL_9080_200→new($name,$rig);

$id = RFC::EL_9160_100→new($name,$rig);

$id = RFC::EL_9400_50_S01→new($name,$rig);

$id = RFC::EL_9750_25→new($name,$rig);

$id = RFC::EL_9080_400→new($name,$rig);

$id = RFC::EL_9400_100→new($name,$rig);

$id = RFC::EL_9160_200→new($name,$rig);

$id = RFC::EL_9400_100_S01→new($name,$rig);

$id = RFC::EL_9750_50→new($name,$rig);

$id = RFC::Hocherl_ZS→new($name,$rig);

11.21 RFC::Kepco

Inherits from RFC::PSU (refer section 11.19).

This module implements RFC::PSU for Kepco biploar power supplies.

To obtain an instance call one of the constructors as shown below:

$id = RFC::Kepco_BOP_50_200MG→new($name,$rig);

Where $name is the name of the device and $rig is a RFC::Rig instance.

The Kepco class defines the following extra member functions besides those derived from the RFC::PSU class:

$id→send_raw($)	**Sends a raw command string to the device and returns any output returned by the device.**
$id→writecmd($)	**Sends a raw command string to the device, does not expect any return value from the device.**
$id→idn()	**Returns the identifier strign from teh device.**
$id→get_error()	**Returns any error. An empty return value indicates no error. Note that the error register in the device is automatically cleared after this command.**
$id→device_mode([$])	**Gets or sets the device mode (0 is constant voltage, 1 is constant current).**
$id→sine($$$[$])	**Setup a sine wave output. argumentws are: device_mode, frequency (Hz), amplitude (V/A) and optional offset (V/A), where device mode is 0 for voltage control and 1 for current control.**
$id→square($$$[$])	**Setup a square wave output. argumentws are: device_mode, frequency (Hz), amplitude (V/A) and optional offset (V/A), where device mode is 0 for voltage control and 1 for current control.**

$id→reset()	**Resets the device. Remember to use this after a sine or square command has been processed before any normal current and/or voltage commands**

11.22 RFC::Keithley2400

Inherits from RFC::PSU (refer section 11.19).

RFC::Keithley2400 mpelments the RFC::PSU class for Keithley400 source meters.

To obtain an instance of RFC::Keithley2400 use the constructor:

$id = RFC::Keithley2400→new($name,$rig);

The class defines the following new member functions:

$id→PSU_mode([$])	**Sets or gets wether the PSU is a constant current source (default) or a constant voltage source. Argument: 'CC' for constant current and 'CV' vor constant voltage. Note that it may be nescesarry to run reset() on the device after changing the PSU_mode**
$id→reset()	**Resets the keithley2400 to a known state.**

As a Keithley2400 source meter is a true bipolar power supply, it is usually convenient to use a RFC::PSU_B2N device on top of the RFC::Keintley2400 device

Additionally in order to confirm with the basic operation of RFCcontrol, the positive current direction is when the device under test is acting as a fuel cell (that is a positive current acts as a current sink), therefore the current direction is reversed so specifying a positive current actually sets a negative output!

11.23 RFC::PSU_Bipolar

Inherits from RFC::BaseDevice (refer section 11.14).

This class defines the behaviour of container PSU modules. A PSU_Bipolar instance emulates a true bipolar power supply/eload by combining two power supplies or a power supply and an electronic load. A power supply can be used as an electronic load if it is fitted with DC offset diodes which offset the inherent DC bias of the device under test. In the case of a single fuel cell, this is usually below 2 volt, and a series of 2 to 3 silicon diodes can handle the DC bias. However beware that the diodes must be able to handle the full DC

current load (which potentially could be several hundred amps in case of big PSU units) and thus the diodes likely have to be extensively cooled to awoid thermal damage!

A PSU_Bipolar instance behaves exactly as a normal PSU instance, however the minvoltage and mincurrent values are defined by the device acting as the PSU and the maxcurrent and maxcurrent values are defined by the eload device.

The voltage() function is also overloaded so that if an additional argument is specified besides the voltage to set, only the psu device is set if the second (optional) argument matches the string 'psu' and the eload device if it does not match. The rationale for this is that both devices may need different voltage settings for true bipolar constant current operation to work.

The benefit of using the container class is that it makes it possible to use two normal power supplies as a single true bipolar power supply.

Beware, however, that you do not inadvertedly create an infinite recursion if more than one container device is used!

The RFC::PSU_Bipolar class defines whe following extra member functions:

$id→read_volt_psu()	**Returns the result of measure_U() for the psu device**
$id→read_volt_eload()	**Returns the result of measure_U() for the eload device**
$id→read_curr_psu()	**Returns the result of measure_I() for the psu device**
$id→read_curr_eload()	**Returns the result of measure_I() for the eload device**
$id→get_volt_psu()	**Returns the result of get_U() for the psu device**
$id→get_volt_eload()	**Returns the result of get_U() for the eload device**
$id→get_curr_psu()	**Returns the result of get_I() for the psu device**
$id→get_curr_eload()	**Returns the result of get_I() for the eload device**

These four functions are neeeded for accesing the voltage and current of the individual devices.

11.24 RFC::PSU_B2N

Inherits from RFC::BaseDevice (refer section 11.14).

The RFC::PSU_B2N module defines a wrapper class which makes it possible to use bipolar power supplies with the RFC control system. It works by

vivifying a virtual relay which from the system and UI is indistinguishable from the normal physical relays.

The only difference is that when switching polarity by using the virtual relay, the current is switched by using callback through the the observer pattern. By using this, the device behaves as a normal relay system. Thus this module overrides the observe() function and attaches this device to the virtual relay instance created during device initialization (bootstrapping).

A PSU_B2N instance behaves exactly as a normal PSU instance in combination with a normal electrolysis relay device. However, the minvoltage and mincurrent values are defined by the device acting as the PSU, thus the mincurrent would likely be negative as opposed to a normal unipolar PSU which would be unable to give negative current.

The benefit of using the container class is that it makes it possible to use a bipolar power supply instead of a normal power supply fitted with electrolysis switching relays.

The RFC::PSU_B2N module also defines the reverse wrapper (called RFC::PSU_N2B) which can be used to convert a normal unipolar PSU with a switching relay for polarization control into a pseudo bipolar PSU (it will behave as a bipolar PSU as far as RFCcontrol is concerned).

Although RFCcontrol assumes a normal PSU and a switching relay for control, in some cases this is a disadvantage. Especially in the case where PID devices are used to control the current of a PSU, then the inability of the normal PSU device to natively set a negative current is a problem. This will be alleviated by using a RFC::PSU_N2B wrapper between the PID controller and the normal PSU.

The RFC::PSU_B2N module also defines the RFC::PSU_N2B device which works like the inverse of the RFC::PSU_B2N device. The RFC::PSU_N2B device allows a normal PSU to emulate a bipolar power supply by incorporating the electrolyser module and allowing setting and reading the current also for electrolysis if the current is negative.

In order to aquire one of the devices call the constructor:

$id = RFC::PSU_B2N→new($name,$rig)

$id = RFC::PSU_N2B→new($name,$rig)

11.25 RFC::PSUMulti

Inherits from RFC::PSU (refer section 11.19).

This class defines the behaviour of parallel connected PSU devices with diferent ranges. This is intended to be used in the case where both high currents and high presision at low currents are needed (and which rarely is possible with a single PSU). A RFC::PSUMulti class instance behaves as a normal

PSU device with the only exception that it is not possible to use parallel or serial connections of RFC::PSUMulti devices (this has to be done to the individual RFC::PSU devices).

As the API of RFC::PSUMulti is identical to RFC::PSU, it is possible to have more than 2 PSU devices controlled in this way (as a RFC::PSUMulti. device can contain RFC::PSUMulti as well as RFC::PSU device instances).

Beware that you do not inadvertedly create an infinite recursion if more than one container device is used!

It is assumed that the individual PSU devices used handle 'OCV' commands correctly (that is that the PSU is placed in a high impedance output state either by PSU design or by an external relay device, refer RFC::PSU for details).

11.26 RFC::MFC

Inherits from RFC::BaseDevice (refer section 11.14).

This class defines the behaviour of mass flow controlers for gas control. To obtain a MFC instance call one of the constructors as shown below:

$id = RFC::MFC→new($name,$rig);

$id = RFC::Analog→new($name,$rig);

$id = RFC::AnalogReadonly→new($name,$rig);

$id = RFC::Brooks→new($name,$rig);

$id = RFC::BrooksReadonly→new($name,$rig);

All MFC objects have the following member functions in addition to those derived from RFC::BaseDevce and Debug.pm:

$id→gasses()	Returns a list of possible gasses used if more than one gas can be selected, usually in conjunction with a RFC::Multiplexer device.
$id→selected_gas()	Returns the name of the selected gas.
$id→maxflow()	Returns the maximum possible flow for the selected gas.
$id→setflow($[$][$])	Sets the gas flow for the mass flow controler to the specified value. If an additional argument is specified, it is assumed to be the username of the controlling user and that name is appended to the string appended to the rigs proglog. an exception to this is if a further argument is specified in which case no proglog entry is appended!

$id→gas_change()	**Returns the gas change mode (either manual or automatic).**
$id→controler_mode()	**Returns the controler mode (either 'Flowrate' or 'Pressure Dependiong on if the MFC is a flow controler or a pressure controler)**
$id→change_gas($)	**Changes the gas of the controler to the specified type.**
$id→gasses()	**Returns a list of possible gasses for the device This is to be used in conjunction with a RFC::Multiplex device.**
$id→multiplexer()	**Returns the multiplexer deivce if it exists.**
$id→accuracy()	**Returns the expected accuracy of the device (For Brooks MFC's this is usually 1 percent of fullscale).**
$id→read_raw()	**Returns the flow rate reported by the controler. As opposed to the normal read() function the read_raw() does not check for multiplexer operation. Thus use of this function directly can result in inconsistently reported flow rates if the caller does not explicitly check for multiplexer status.**

11.27 RFC::MKS

Inherits from RFC::MFC (refer section 11.26).

This class implements RFC::MFC for MKS mass flow controlers. To obtain a MKS instance call one of the constructors as shown below:

$id = RFC::MKS→new($name,$rig);

$id = RFC::MKSReadonly→new($name,$rig);

The RFC::MKS class does not define any new public member functions

11.28 RFC::Pcontrol

Inherits from RFC::BaseDevice (refer section 11.14).

This class defines the behaviour of pressure controlers for gas control. To obtain a Pcontrol instance call one of the constructors as shown below:

$id = RFC::Pcontrol→new($name,$rig);

$id = RFC::Pcontrol_Analog→new($name,$rig);

$id = RFC::Pcontrol_AnalogReadonly→new($name,$rig);

$id = RFC::Pcontrol_ER3000→new($name,$rig);

The RFC::Pcontrol device is the default manual device.

All RFC::Pcontrol devices emulates the RFC::MFC interface (refer the RFC::MFC.pm module for further documentation of the special member functions for RFC::MFC devices). This makes it possible to use a pressure control device as was it a MFC device and thus a gas device can be used to control gas flow or gas pressure. In order to distinguish, Pcontrol devices allow only the selection of gas device names where the name contains the string 'pres'. This forces a more intuitive user interface where a clear distinction between normal gas devices and gas pressure devices.

RFC::Pcontrol devices does not support the addition of gas multiplexers, however to conform with the RFC::MFC interface, the functions to manipulate gas multiplexers are defined (but usually simply return undef).

All calculations for pressures using Pcontrol devices are performed in bar absolut (barA, 1 barA coresponds roughly to atmospheric pressure and 0 barA is a perfect vaccum).

The RFC::Pcontrol class defines the following membeer functions:

$id→minP	**Returns the minimum pressure for the controler in barA**
$id→maxP	**Returns the maximum pressure for the controler in barA**
$id→setP($[$][$])	**Sets the gas pressure to the specified value If an additional argument is specified, it is assumed to be the username of the controlling user and that name is appended to the string appended to the rigs proglog. an exception to this is if a further argument is specified in which case no proglog entry is appended!**
$id→set	**Alias for $id→setP.**

The following RFC::MFC member function has been remapped:

$id→setflow	**Alias for $id→setP.**
$id→maxflow	**Alias for $id→maxP.**
$id→gasses	**Returns a single element ($id→selected_gas).**

11.29 RFC::Templog

Inherits from RFC::BaseDevice (refer section 11.14).

This class manages temperature logging as usually more than one measuremnt is needed to correctly measure temperatures using thermocouples and/or PT-type resistance measurements

To obtain a Templog instance call the constructor as shown below:

$id = RFC::Templog→new($name,$rig)

The Templog class defines no new functions.

11.30 RFC::Gas

Inherits from RFC::BaseDevice (refer section 11.14).

This calss defines the behaviour of gas flow logging. To obtain a gas instance call the constructor as described below: my $id = RFC::Gas→new($name,$rig) The rig argument must be a RFC::Rig instance or a similar object honoring the get_cv() member function.

All Gas objects have the following member functions (excluding those derived from RFC::BaseDevce and Debug.pm):

$id→setflow($[$][$])	**Sets the gas flow for the gas to the specified value (note all gas flows for RFC devices must be specified in nL/hour). If an additional argument is specified, it is assumed to be the username of the controlling user and that name is appended to the string appended to the rigs proglog. an exception to this is if a further argument is specified in which case no proglog entry is appended!**
$id→cutoff_set()	**Returns the minimum flow for the gas below which the gas flow is defined to be 0. Somne controlers require special commands for completely closing which is the reason for this to be implemented.**
$id→cutoff_report()	**Returns the minimum flow for the gas below which the gas flow is defined to be 0 even if the controler may report a positive value. In case of a manual gas, this value can be set freely, however in case of a gas controlled by a MFC or similar, the default mimimum value is 0.75 times the accuracy of of the control device (it can be manually overridden to a higher value).**
$id→maxflow()	**Returns the maximum flow rate possible.**
$id→maxflow_set()	**Returns the maximum allowable flow rate.**
$id→accuracy()	**Returns the device accuracy (usually forwarded from the controling device e.g MFC).**
$id→control_device()	**Returns the device instance of the control relay (if any).**

$id→control_value()	Returns the control value. this is to be compared to the read response from the control device to determine if the gas is engaged or not (used in fast switching applications where a cross-over valve determines if gas is supplied to the device under test or not).
$id→controler()	Returns the device instance used for controling the gas flow rate. Usually an instance of the RFC::MFC class.
$id→attatch_multiplex($)	Attatches a multiplexer device (of type RFC::Multiplex) to the gas device. The multiplex device is used for determining if the gas flow reported by teh controler is for this gas.
$id→gas()	Returns the name of the gas controlled by this device.
$id→read_cutoff([]$)	Returns the gas flow similar to read(), but if the flow is below the cutoff_report value, it returns 0.
$id→set($[$][$])	Alias for the setflow function.
$id→setpoint()	Returns the last set setpoint for the gas (in case of manual gasses this will be the same as a normal read).
$id→is_pressure()	Returns 1 if the gas device is configured to be automatically controlled by a pressure controler. Returns 0 otherwise.
$id→include_tally()	Returns true if the gas line can be used to totalise gas usage

The RFC::Gas module overloads the bool() function to return 1 (ture) only if the actual flow is above the cutoff_report() value (the bool() returns 0 (false) otherwise.

The RFC::Gas module also allows slaving of one gas to an other. A slaved gas is in the setup specicfied to have a flow which is proportional to the flow rate of the master gas with the proportionality facter defined in the setup. To facility this, the RFC::Gas slave device attatches itself to the master device durring initialisation and uses the observer interface derived from BaseDevice to set the flow to the correct value whenever the flow of the master device is changed. This is achieved by overloading the observe() function.

As a safety precaution, a gas can not be a slave of an other slaveed gas. This is to ensure that no infinite loops are created. To facilitate this, the following member function is alos defined:

$id→master()	Returns the device instance of the master gas device. returns undef if the gas device is a master, thus is only true for slave devices.

11.31 RFC::CGas

Inherits from RFC::BaseDevice (refer section 11.14).

This class defines the behaviour of container gas modules. A container gas instance is a virtual device containing two RFC::Gas or compatible devices. The API for RFC::CGas instances is identical to RFC::Gas instances with the sole exception of the controler() member function which returns a list of devices instead of a single device. The benefit of having an almost identical API to RFC::Gas devices is tha an CGas instance can contain RFC::CGas instances as well as normal RFC::Gas instances.

The reason for RFC::CGas devices is that they are intended for cases where a single gas line contains more than one gas controler for handling vastly differing flow ranges as most MFC's can only give an accuracy of 1 percent of fullscale value. By using a RFC::Cgas container, the possiblele range of flow values can be extended beyond this.

Beware that you do not inadvertedly create an infinite recursion if more than one container device is used!

Note that in order for the container module to work properly, remember to set correct values for 'cutoff_report' for the individual gas names in the container as this setting isused to determine if the gas is shut off! Incorrect setting of this may cause wrong flow values to be logged!

11.32 RFC::Multiplex

Inherits from RFC::BaseDevice (refer section 11.14).

This class defines the control of multiple gasses to the same MFC. To obtain a Multiplexer instance call the constructor:

$id = RFC::Multiplex→new($name,$rig)

$id = RFC::Multiplex_slave→new($name,$rig)

$id = RFC::VICI→new($name,$rig)

$id = RFC::Selector→new($name,$rig)

The slave version is intended to be used in case a single multiplexer feeds more than one control device (MFC) and as a multiplexer device can only handle a single control device, a slave multiplexer can be used on all but the first. the slave multiplexers should then reference the sigle normal multiplexer and will mirror the settings of the master device.

The constructor can also be called with an additional argument which must then be a RFC::MFC (or derived) device instance:

$mfc = RFC::MFC→new($name,$rig);

$id = RFC::Multiplex→new($name,$rig,$mfc);

All Multiplex objects have the following member functions (excluding those derived from RFC::BaseDevce and Debug.pm):

$id→attatch_controler($)	**Attatches an RFC::MFC instance to the multiplexer (if not included in the call of the constructor).**
$id→controler()	**Returns the attatched MFC device.**
$id→relays()	**Returns the list of relay devices used for controling the gasses.**
$id→set($)	**Sets the multiplexer to select the specified gas name.**
$id→gasses()	**Returns a list of possible gasses.**
$id→label()	**Returns the label string (if any) Labels can be used as identifiers instead of device name as multiplexers for historic reasons can only have integers as name. Returns the device name if no label is set.**
$id→gas()	**Returns the name of the selected gas (NB NOT device name). If supplied with an optional argument this is used as a data structure to access if the device had already been read (similar to the read() and readstring()) member functions inherited rom BaseDevice.**
$id→gas_name()	**Returns the device name of the selected gas. If supplied with an optional argument this is used as a data structure to access if the device had already been read (similar to the read() and readstring()) member functions inherited rom BaseDevice.**

Prior to version 4.2.5, the implementation of the RFC::Multiplex class assumed that all gasses were controled from the same relay board (usually a ICP-con relay module) Thus all gas relays shared the same device tty and address, but differed only in the channel number. As of version 5.0 this is deprecated and will only be avaliable for configuration if legacy mode is enabled (it will still work for already configured systems).

As of version 4.2.5 and onwards, it is possible to use arbitrary relay devices to control a gas multiplexer. To do so, simply configure the relays as normal RFC::Relay instances and select the proper names (defined in the '$gasname'_device_name key in the configuration section ($gasname being the name of the gas line in question).

The Selector multiplex class is a virtual device and does not control any gas but can be used to select integer values (for use in other devices such as the input multiplex filter device.

11.33 RFC::GasGroup

Inherits from RFC::BaseDevice (refer section 11.14).

This module defines the virtual concept of a gas group and is only used for data logging for lumping gas flows for differenc controlers into a single data value based on flow values and on a control flag (usually a relay). It is mainly used for cross-over systems where fast gas changes is desired and multiple gas lines with identical control systems are switched after gas flows has stabilised.

To obtain a gas group instance use the constructor:

$id = RFC::GasGroup→new($name,$rig)

The class does not define any new functions

Note that the read and readstring functions only add the gas flows for the gasses where the flow is above the cutoff_report value defined in the configuration for that gas (Thus remember to set a sensible value for this setting)!

Similarly for the setpoint() function which only add the setpoints for the gasses which are selected.

11.34 RFC::TempControl

Inherits from RFC::BaseDevice (refer section 11.14).

This class defines the behaviour of temperature controlers for furnace control. To obtain aTempControl instance call one o fthe constructors like shown below:

$id = RFC::TempControl→new($name,$rig)

All TempControl objects have the following member functions in addition to those derived from RFC::BaseDevce and Debug.pm:

$id→get_atemp()	**returns the active (measured) temperature.**
$id→get_output()	**returns the output power.**
$id→get_temp()	**Returns the temperature setpoint.**
$id→get_ramp()	**Returns the temperature ramp rate (C/hour).**
$id→get_offset()	**Returns the offset between the temperature setpoint and the actual measured temperature. For a functiioning controler this should be close to 0 but if the furnace can not heat suficiently (due to broken heating coils or similar) it will be positive.**

$id→set_temp($[$][$])	Sets the temperature setpoint. If an additional argument is specified, it is assumed to be the username of the controlling user and that name is appended to the string appended to the rigs proglog. an exception to this is if a further argument is specified in which case no proglog entry is appended!
$id→set_ramp($[$][$])	Sets the temperature ramp rate (C/hour). If an additional argument is specified, it is assumed to be the username of the controlling user and that name is appended to the string appended to the rigs proglog. an exception to this is if a further argument is specified in which case no proglog entry is appended!
$id→set($[$][$])	Alias for set_temp.
$id→minramp()	Returns the minimum possible ramprate.
$id→maxramp()	Returns the maximum allowed ramprate.
$id→mintemp()	Returns the minimum allowed temperature.
$id→maxtemp()	Returns the maximum allowed temperature.
$id→check_ramp($[$][$])	Checks if the specified ramprate is within the allowed. range. If not it returns the minimum or maximum value allowed based on what is closest to the specified value. If a second (optional) argument is specified, it is assumed to be the username of the user wanting to set the ramprate and a warning is issued to the log except if a third (optional) argument is specified (similar to set_ramp())

11.35 RFC::Honeywell

Inherits from RFC::BaseDevice (refer section 11.14).

This class implements the RFC::TempControl class for Honeywell temperature controlers.

The RFC::Honeywell module defines the following extra public member functions

$id→P([$])	Sets or gets the proportional gain (Gain)
$id→I([$])	Sets or gets the integration gain (Reset)
$id→D([$])	Sets or gets the diffential gain (Rate)
$id→I_min([$])	Sets or gets the minimum integration limit
$id→I_max([$])	Sets or gets the maximum integration limit
$id→stop()	Forces the controler to 'Hold' (if in a program)

$id→start()	**Starts the default program. Used toghethre with stop() when setting new temperature setpoint in order to properly use the 'hot start' option thus awoiding local setpoint 'stickiness' (basically to make the Honeywell behave as a Eurotherm)**

11.36 RFC::Julabo

Inherits from RFC::BaseDevice (refer section 11.14).

This class defines the behaviour of Julabo thermal heat bath control. To obtain aTempControl instance call one of the constructors like shown below:

$id = RFC::TempControl→new($name,$rig)

Julabo objects have the following member functions in addition to those derived from RFC::BaseDevce and Debug.pm:

$id→readstring()	**returns string with SetP Temp, active Temp, Output Power**
$id→get_atemp()	**returns the active (measured) temperature.**
$id→get_output()	**returns the output power.**

$id→get_offset() Returns the offset between the temperature setpoint and the actual measured temperature. For a functiioning controler this should be close to 0 but if the furnace can not heat suficiently (due to broken heating coils or similar) it will be positive. $id→set_temp($[$][$]) Sets the temperature setpoint. If an additional argument is specified, it is assumed to be the username of the controlling user and that name is appended to the string appended to the rigs proglog. an exception to this is if a further argument is specified in which case no proglog entry is appended! $id→set($[$][$]) Alias for set_temp.

""private member functions"" $id→get_transaction($cmd) send read's commands to the Julabo controller and return the answer $id→get_transaction($cmd, $arg) send set's commands to the julabo controller and return the answer

11.37 RFC::Filter

Inherits from RFC::BaseDevice (refer section 11.14).

This class defines a special virtual device which can be used as a sort of filter on top of a normal device. An input Filter device type operates on an other device and converts all read operations on the underlying device

An output filter device operates on all set() function calls and filters the supplied argument before passing it on to the underlying device.

An input-output filter device does conversion on both read and set operations.

All control commands are passed on to the underlying device and the resulting filter device can be operated on as if it were the underlying device.

The Filter device class defines no new member functions and classes derived from Filter should not normally define any new functions either.

The filter class is not intended to be instantiated directly, only the derived classes.

Notice that the class instance created by the constructors of deviced derived by Filter must NOT call init() as part of the constructor. This must first be done as part of any of the handling functions. This is to allow the underlying device to be autovivified before it is used.

A special type of Filter is the Schmidt Trigger device. This device class contains a nomral device (simple input device usually) which is masqueraded as a read only relay device (that is, read returns either 0 or 1). The exact output value depends on the value of the contained device as well as the settings of the trigger device.

To obtain an instance of the schmid trigger device call the constructer:

my $id = RFC::Strigger→new($name,$rig);

A number of other filter classes are also directly avaliable from RFC:Filter. These are the Lowpass, Integer, MovingAverage, Integrator and Derivative as well as the Truncate classes. They can be obtained by calling the constructors:

my $id = RFC::Integer→new($name,$rig);

my $id = RFC::Lowpass→new($name,$rig);

my $id = RFC::MovingAverage→new($name,$rig);

my $id = RFC::CircularAverage→new($name,$rig);

my $id = RFC::Integrator→new($name,$rig);

my $id = RFC::Derivative→new($name,$rig);

The Derivative filter class contains an extra public member funciton which is the get_confidence()

This function will return difference between the returned derivative value and the positive 95% confidence interval limit. Thus the full interval is: read() - get_confidence() to read() + get_confidence(). Note that each call to read_nocache will make a nex measurement and thus calculate a new confidence value!

The Integrator class also defines a special member function, which is the set_int() function which allows programs to specifically set the integrated value to a specific value. If no argument is supplied to set_int() the value is assuemd to be 0.

The CircularAverage filter works on circular data (such as directions) and will do a moving average using vector calculations on the data represented as complex numbers: avg = sum(cpl(xi(1→n)))/n

The Truncate device is a special device which returns the measured value some time in the past truncated to last whole hour or day etc. Default is to truncate to last whole hour. The truncate device can also be used to retain values in the past by specifying an offset. Note however that only integer values can be used for the offset and that the offset is in units of the interval. Thus if the interval is in 2 hours and the offset is 3, the device will return a value logged between 6 and 8 hours hours ago (as data will be truncated to the specified interval)

11.38 RFC::Redundancy

Inherits from RFC::BaseDevice (refer section 11.14).

This class defines a special filter deivce which can be used to evaluate a number of inputs and if they agree in value the average of the input values are returned. If one or more inputs have values which lie outside the defined range, the average is only calculated based on the 'good' values

If the number of inputs whihc is considered 'bad' is larger than the maximum allowed, the status of the filter will be set to false and the value will again be based on the average of all inputs.

The maximum allowed number of bad inputs has to be less than half the number of inputs (rounded down).

The bool() function returns true if the number of inputs with 'bad' values is not larger than the maximum allowed bad inputs

To determine if an input is 'bad', the value is compared to the average of the other inputs, and if the value is further away from that average than the 'limit' value, the input is considered 'bad'.

Note that input values can have such a distribution that none of the individual inputs can be considered 'good' although all are within the limit from the average of all the inputs, but none of the inoputs are within the limit of the average defined by the remaining inputs!

be avare that setting the limit to 0 effectively disabeles the test for 'badness' of an input (and in which case the bool() funciton will always return true and the read value will be the average of all inputs.

This class also extends the test() member function so that in order for an instance of this class to test true, the bool() function must return true as well as the test() function on each input.

To obtain an instance of this class call the costructor:

my $id = RFC::Redundancy→new($name,$rig);

The RFC::Reduncancy class defines an additional member function which is the $id→badness() function which returns the number of inputs considred to be 'bad'

11.39 RFC::SPDEV

Inherits from RFC::Filter (refer section 11.37).

This module defines a number of filter device classes. All the device classes operates with spline filters on either input and/or output. Notice that for all splines, if only two lines are detected, the relation is a linear relation and are handled accordingly (that is without calls to the external splineinterpol program).

11.39.1 SPDEV: Input spline filter

This SPDEV class defines a filter device which can be used on top of a normal device. The SPDEV device type operates on an other device and converts all read operations on the underlying device according to the specified spline interpolation table.

The SPDEV device class defines no new member functions.

To obtain an instance of this class call the constructor:

$id = RFC::SPDEV→new($name,$rig)

11.39.2 SPOutDEV: Output spline filter

The SPOutDEV device type operates on an other device and converts all set/setflow operations on the underlying device according to the specified spline interpolation table.

To obtain an instance of this class call the constructor:

$id = RFC::SPOutDEV→new($name,$rig)

11.39.3 SPIODEV: Input-output spline filter

The SPOutDEV device type operates on an other device and converts all set/setflow and read operations on the underlying device according to the specified spline interpolation tables.

To obtain an instance of this class call the constructor:

$id = RFC::SPIODEV→new($name,$rig)

11.40 RFC::Ysplit

Inherits from RFC::BaseDevice (refer section 11.14).

This module defins the behaviour of a special filter device An instance of RFC::Ysplit behaves as a selector switch and sends commands to one of two underlying devices based on the status of the control device (which must be of type RFC::BaseRelay or a class derived from RFC::BaseRelay).

The underlying devices to be controlled can be of any type derived from RFC::BaseDevice.

To obtain a RFC::Ysplit instance call the constructor:

$id = RFC::Ysplit→new($name,$rig)

RFC::Ysplit does not export any new member functions besides those derived from BaseDevice. However if a member function is called which is not derived directly from baseDevice the the RFC::Ysplit instance refers the function call to the underlying selected device thourgh autoloading.

If more than 2 options for selecting devices is desired, use the OutputMultiplex filter class instead.

11.41 RFC::Sum

Inherits from RFC::BaseDevice (refer section 11.14).

This class defines several special virtual devices which can be used as a sort of filter on top of a normal devices.

The following description is for a RFC::Sum device, but the other device types (RFC::Min and RFC::Max) behaves similarly when considering the input and output devices

A RFC::Sum device operates on other devices and when the Sum device is read (that is it's read function is called), the device retruns the arithmetic sum of the input devices read functions.

Additionally the RFC::Sum device registers itself on all the input devices resulting in that if a set or setflow or similar control comand is called on one of the inputs, then the same control function on the output device (if any) is called (This is achieved using the observer pattern).

In the case of gas devices, if the setflow command is callen on any of the inputs, the setflow command is called with the sum of the inputs as argument.

When a read command is called on a RFC::Sum device, the device first reads the values of all the inputs, and if the input devices supports the cutoff_set command, it checks if the values are below the value of the cutoff. If so, the value for that device is then set to 0. After this check all the input values are summed together (with the respecive input factors multiplied on the values

before summing).

To obtain an instance of the RFC::Sum device call the constructor:

my $id = RFC::Sum→new($name,$rig);

Instances of the other device classes (RFC::Min and RFC::Max which uppon a read request returns either the minimum or maximum value of the inputs) can be obtained as:

my $id = RFC::Min→new($name,$rig);

my $id = RFC::Max→new($name,$rig);

For RFC::Min and RFC::Max devices any commands passed from any of the inputs is forwarded to the output device (if any) with the minimum or maximum value (instead of the sum) as for a RFC::Sum device.

The Sum device can be used as a simple offsetting filter by only specifying a single input. If this is configured for tempcntrol devices both the setpoint and the ramprate is transferred. Please note, however, that this functionality has been superceeded by the Output spline filters and is thus deprecated in version 5.6.4 and onwards.

11.42 RFC::FilterMultiplex

Inherits from RFC::BaseDevice (refer section 11.14).

This device class defines a composite input filter where a control device determines which of a number of input devices are used for input (read) operations.

This allows for selecting one of several measured values for data logging and/or calculations based on the value of the control device.

All device types can be used a control device, however the actual value of the control device is coerced to an integer (by rounding to nearest integer) which is then used as index to determine which of the inputs are to be used. Thus a value of 0.45 will be evaluated to 0 and 1.5 will be evaluated to 2.

If the control value is outside the range of possible input devices the first or last device is used as appropriate.

To obtain an instance of the RFC::FilterMultiplex device call one of the constructor:

my $id = RFC::FilterMultiplex→new($name,$rig);

my $id = RFC::OutputMultiplex→new($name,$rig);

The FilterMultiplex device class is for multiplexing inputs and the OutputMultiplex class is for multiplexing outputs as well as input.

11.43 RFC::PLC

This class is a modbus communication interface class thats read and write from a modbus device the class do not implement any of the RFC classes and can therefore be used as a stand alone interface for TCP modbus communication. the class is constructed as a singleton class with the IP as the key to the singleton meaning when instantiate an instance of this class the IP will be checked for already exist and if not a new object will be obtained.

this means that all interfacing to a specific modbus device with that IP_address will go through the same object

the PLC class is constructed as a interface/data object containing a data structure of of Modbus addresses and the data associated with this address is saved if a read() cmd as been executed the data structure is dynamic and new addresses to read can be added by running the member function addDataAdr() with augments, if successful the address will now be read with the read() CMD to get data from the structure just run getSingleReading() with the adrName key as argument

Design criterium for the modbus stack: in order for this class to work properly with the modbus stack server the stack should be build in sets of 16 bit words, for example a byte should always come in pairs of 2 bytes after each other so the offset address grow with 2, datatype BOOL is also considered as a byte/single element always avoid to place a 16bit datatype or longer at an odd offset address

To obtain an instance of this class call the constructors like:

$id = RFC::PLC→new(%)

where the argument hash must have at least the 'IP_address' key defined (with the PLC's IP address) Additional possible hash keys are: port (TCP-IP port), readStartAddress, dataQuantity and subNAME

Example of use:

```
$id = RFC::PLC→new(IP_address =¿ '10.0.1.216');
$id→addDataAdr("PLC_Date_and_time", 28, 72,'UDINT');
$id→read();
print scalar(localtime($id→getSingleReading("PLC_Date_and_time")));
```

The RFC::PLC module member functions is definedd below:

$id→addDataAdr($$$$)	**Adds a data item to the data list. Arguments (in roder of alignment): $adrName = hash key name of the modbus adrress ! should be an unique name as it is used as the key in the datastructure. $adr = the modbus stack address number of the variable to read starting from 1 = first data element of the stack $Offset = the modbus stack offset number $dataType which must be one of the following types: 'BOOL', 'BYTE', 'DINT', 'DWORD', 'INT', 'LREAL', 'REAL', 'SINT', 'TIME', 'UDINT', 'UINT', 'USINT', 'WORD'**
Example	**call. $testPLC→addDataAdr("DI24_Analog", 125, 384,'INT');**
$id→print()	**use for debugging, print out obejct configuration (datastruct, name, modbus adr, etc.) to stdout**
$id→getName()	**get the subName of the obejct**
$id→getIP()	**get the Ip address of the modbus server**
$id→checkAdrNameExists()	**return 1 if name exists in the data structure**
$id→read()	**execute a modbus stack read of the full data structure, return 1 if succesfully with out any errors**
$id→getSingleReading($)	**returns the last read value of the address key name specified if exist remember to run read() before to get a new data set**
$id→getReadings()	**get the whole data structure remember to run read() before**
$id→getRawBytes()	**return the last read byte string**
$id→getLastModbusMsg()	**return last status msg of the modbus**
$id→getlastModbusException()	**return last Modbus exception**

————-WRITE section————————————- modbus writing supports up to 16 bit(2byte) register and coil(BOOL) writing, in the case of 1 byte writing this can only be done by writing to the whole 16 bit word and therefore the value of the second byte in the word will be overwritten with zero value if not known else the last know set value will be set but only if added to the @adrstructOut where the last written value is stored, its planed to update the modbus driver to support writing to multiple registers at once by adding the write_registers function code, but for now we see if this will be of any needs in the future. plese note that reading and writing at the same modbus adr. may not give the same value as this is controlled by the modbus slave ex. the PLC and if the same variable point at the same IN and Out register address in the modbus device. writing member functions

$id→addDataAdrWrite($$$$)	add a modbus stack writing address, after adding a an adr. the modbus adr can be write to by calling the write() with the address name and a set value. arg: $adrName, $adr ,$Offset,$dataTybe valid data types: BOOL,BYTE,UDINT,SINT,INT,UINT WORD,
$id→setNewValue($$)	arg: "adr_name" "new value" followed by a writeAllAdr() cmd or Write()
$id→write_raw($$$)	write to a none specified modbus stack address by raw address arg: $address = stackAdr, $type = BOOL or 16 bit INT data type, $value = num
$id→write($$)	arg: $dataAdrName , $value
$id→convToOutputFormat($$)	Privat member function that converts input numbers of different type to the modbus data format ex. a signed INT will be converted to its corresponding unsigned decimal value arg: $dataType, $value
$id→getOutStructData($$)	get adrstruct data by address name and hash key name Arg: $dataAdrName = name of an existing data adr in the @adrstructOut $hashName = key name in the @adrstructOut
$id→getOutStructDataKeyElement($$$)	function that search in the @adrstructOut by a $keyValue in any of the hash struct column selected by the $HashKeyName, and if found returns the value of the $hashName, else returns undef arg: $HashKeyName , $keyValue, $hashName

11.44 RFC::PLCRead

Inherits from RFC::BaseDevice (refer section 11.14).

This class implements (readonly) dataloging through the TCP modbus RFC::PLC.pm device class note PLC.pm is a singleton class that takes care of all communication to and from a modbus server given by the IP adrress meaning all instance of PLCRead.pm with the same IP goes through the same PLC.pm object

To obtain an instance of this class call the constructors like:

$id = RFC::PLCRead→new($name,$rig)

The RFC::PLCRead module defines no new member functions.

11.45 RFC::PID

Inherits from Debug (refer section 11.1).

This module defines a PID controller and can be used together with the other RFCcontroll modules for process control systems.

To obtain an instance of this class call one of the constructors like:

$pid = RFC::PID→new($name,$filename,[opt lock_filename]);

Notice that unlike most other RFC devices the PID device class does not require a RFC::Rig instance as an argument to the constructor. The name argument is the instance name (useful if operating with more than one instance of the PID class).

The filename is the name of the file in which to store process error and integration error information. This is used so that the PID device can maintain state across processes (for instance if the control program is started once a minute from crontab).

The RFC::PID class implements a standard IPD controller (refer wikipedia for a more detailed description of a PID controller)

All RFC::PID objects has the following public member functions besides those derived from the Debug class.

$pid→reset()	Resets the internal data including integrated error.
$pid→name()	Returns the name given as first argument to the constructor.
$pid→intwindup([$])	Sets or gets the maximum integration error possible (default is 0.2) To disable integrtion windup protection set the value to 0.
$pid→data($[$])	Adds a new error value to the device. Arguments must be current error and optionally time. If no time argument is specified, the local system time is used instead (utime).
$pid→P([$])	Sets or gets the proportional gain (default is 0.9)
$pid→I([$])	Sets or gets the integration gain (default is 0.2)
$pid→D([$])	Sets or gets the differential gain (default is 0.1)
$pid→get_P()	Returns the proportional error multiplied with proportional gain
$pid→get_I()	Returns the integrated error multiplied with integration gain
$pid→get_D()	Returns the differential error multiplied with differential gain
$pid→get_int()	Returns the integrated error.
$pid→reset_int()	Resets the integrated error.
$pid→set_int($)	Sets the integrated error to the specified value.

$pid→deadband([$])	Sets ot gets the deadband (if the error is below this calls to Out() returns undef); Remember to check for defined status of out if deadband is used (default is no deadband).
$pid→cutoff([$])	Sets or gets the cutoff vqlue. The cutoff behaves similar to deadband, but only for large error values making the PID more robust with respect to erroneous values of the measured process variable.
$pid→min([$])	Sets or gets the minimum output value (default is -1)
$pid→max([$])	Sets or gets the maximum output value (efault is 1)
$pid→Out([$])	Returns the output to be set to the system. The output value will be between min and max If an argument is specified to Out() it is assumed to be a gain which is then multiplied to the raw output value and the result returned instead. Notice that if the error is within the deadband, Out() returns undef, so remember to check the return value of Out() before using it to set a device!
$pid→remove()	This function works like DESTROY() except it does NOT run a store() command before removing the file object.

Additionally the RFC::PID instances has the following private functions (although Perl does not protect private member functions from being called from outside an instance...)

$pid→load()	Loads the data stored in the data file. Called automatically by the constructor.
$pid→store()	Saves the internal data to file. Called automatically by the destructor. Returns 1 on succes, 0 if the modification time of the file has changed since last read/write Note that store will only save state if it has
changed,	that is that $pid→out() has been run resulting in an output change. This means that if the nescesarry change is below the deadband or above the cutoff, changes will NOT be saved!

The RFC::PID object also implements integration windup protection by the following method (in addition to the posibility to set a maximum value for the integrated error): If the sum of the proportional gain and the previous integrated error is enough for the output to reach the maximum or minimum

value, the integrated error is NOT updated but is maintained at the previous value.

11.46 RFC::RFCPID

Inherits from RFC::BaseDevice (refer section 11.14).

This class defines a virtual PID control device as well as a more simplified control loop. for controling complex systems.

To obtain an indtance of this class, use one of the constructors:

$id = RFC::RFCPID→new($name,$rig)

$id = RFC::LApproach→new($name,$rig)

All RFCPID and derived objects have the following member functions (in addition to those derived from RFC::BaseDevce and Debug.pm):

$id→fast()	**Returns yes if the device is to run continiously and as fast as possible. If no is returned it is only run once a minute (by crontab).**
$id→store()	**Stores the current values and integrated error for Returns 1 (true) for succes, 0 in case of errors.**
$id→remove()	**This function removes the underlying PID device from the current device. Is only to be used when it is certian that the current device is not to be used and no changes in the accumulated error for the device is wanted before device goes out of scope (nescesarry for the PID_fast_control.pl script for excluding slow PID's)**
$id→reset_int()	**Resets the integrated error.**
$id→set_int($)	**Sets the integrated error to the specified value.**
$id→find_int($)	**Calculates and sets the required integrated error nescesarry to get the specified output value.**
$id→set([$])	**Sets or gets the target setpoint.**
$id→data([$])	**Reads the current value and computes the error which is stored internally as well as returned. If an argument is specified, this is assumed to be the current value and is used instead.**
$id→out()	**Sets the output device to the calculated setpoint based on the PID settings.**
$id→control()	**Reads the current value and sets the output (combination of data and out.**

$id→output_enabled()	**Returns 1 if commands will be passed to the output device 0 otherwise.**
$id→show_gain()	**Returns an array with information about the P, I, D and combined output for the device**

Note however, that some of the functions are only dummy functions for the linear approach device (reset_int, set_int, find_int, show_gain).

The difference between LinearApproach (RFC::LApproach) and a true PID is that the linear approach device has a simpler configuration allowing for easier setup as tuning a true PID is notoriously tricky. The linear approach device also offers more stable operation in some cases. The disadvantages of the linear approach device is that it has a fixed regulation rate, and if the process value changes faster than the stepsize can account for, no stable tracking will be observed. An other disadvantage is that the linear approach device is prone to 'hunting' if the stepsize is set too high (this is similar to the PID device's tendency to oscilate if the P or I gains are set too high).

11.47 RFC::Logic

Inherits from RFC::BaseDevice (refer section 11.14).

The RFC::Logic module defines a list of virtual logical devices Each of the devices implements one of the logical operators AND, OR, XOR etc.

A logic device operates on logical inputs from RFC::BaseDevice derived devices where the boolean value can be sensibly derived (by using the bool() member function). The device classes where this is the case are: logical devices, relay devices, gas devices and the special filter device 'Schmidt trigger' which converts a floating point value to a logical value based on specific threshold values.

A RFC::Logic derived device can have from 1 to 9 inputs and an optional single output device. The output device must be a relay device type and is intended to convey the result of one or more logical operations to the actual control system.

As RFC::Logic devices are virtual, they are not included in the normal datalogging (and accordingly readstring_ignore(1) is set uppon device instantiation). However they must be enabled in the rig configuration to work properly.

Interdevice control flow is implemented by the obsever pattern. This ensures that input devices does not need to know that they are used as inputs to logic devices ad any set() or set_noinfo() command exeuted on a relay device automatically forces ay logic device using this as an input to get updated (and potentially forcing updates on logic devices further 'down the chain' to be updated).

Notice however that great care must be taken when including logic devices as it is easy to configure a situation where circular references will occour (essentially causing Perl's version of a stack overflow).

Thus it is recommended that if logic devices is to be included in a rig's control system, make a detailed schematic of the control flow diagram with unique names of each individual logic gate thus ensuring that the correct inputs and gate names are chosen when configuring the rig.

A special Logic device is the RFC::Modulus device which returns the result of the modulus operation:

0 mod 2 = 0

1 mod 2 = 1

2 mod 2 = 0

This device can be used to turn a single integer value into logical values for controling several relays (each with a different modulus device in the command chain) Thus a single manual gas or manual relay (which also can be set to values other than 0 and 1) can be used to set logical internal or external states.

11.48 RFC::Math

Inherits from RFC::BaseDevice (refer section 11.14).

The RFC::Math module defines a number of arithmetic devices which all accepts one or more RFC devices as inputs and performs the arithmetic function on the values obtained from the input devices read funstions.

The RFC::Math devices are purely intended to be used in rare cases where control logic / feedback loops require calculations of measured device values, and NOT intended to be used for data logging purposes.

As RFC::Math devices are virtual, they are not included in the normal datalogging (and accordingly readstring_ignore(1) is set uppon device instantiation). However they must be enabled in the rig configuration to work properly.

Interdevice control flow is implemented by the obsever pattern. This ensures that input devices does not need to know that they are used as inputs to math devices and any command executed on a RFC::Math input device automatically forces the RFC::Math to get updated although this has no direct effect (other than potentially forcing devices further 'down the chain' to be updated).

Notice however that great care must be taken when including math devices as it is easy to configure a situation where circular references will occour (essentially causing Perl's version of a stack overflow).

Thus it is recommended that if math devices is to be included in a rig's control system, make a detailed schematic of the control flow diagram with unique names of each individual math device as well as all other normal devices thus ensuring that the correct inputs and device names are chosen when configuring the rig.

To obtain an instance of a RFC::Math object call one of the constructors:

my $id = RFC::Math_add→new($name,$rig);

my $id = RFC::Math_sub→new($name,$rig);

my $id = RFC::Math_multily→new($name,$rig);

my $id = RFC::Math_divide→new($name,$rig);

my $id = RFC::Math_log→new($name,$rig);

my $id = RFC::Math_exp→new($name,$rig);

my $id = RFC::Math_root→new($name,$rig);

my $id = RFC::Math_abs→new($name,$rig);

my $id = RFC::Math_inv→new($name,$rig);

RFC::Math devices does not allow caching, however the underlying (input) devices may do so by themselves.

Notice that some of the RFC::Math devices behaves slightly different than the normal arithmetic functions they implement. This difference is due to the potential consequences of division by zero or similar errors.

Thus RFC::Math::divide returns 0 if the divisor is 0, RFC::Math::log and RFC::Math::root returns 0 for all non-positive inputs (including 0) and RFC::Math::inv returns 0 if the input is 0.

11.49 RFC::Typecast

Inherits from RFC::Filter (refer section 11.37).

The RFC::Typecast is a special filter device. It can convert one underlying device to an other type.

Typcast devices should not normally be nescesarry, but in specific cases it may be nescesarry to do a typecast.

Typecast devices have a simplified interface as they only implement the BaseDevice classes.

An exception to this is the notify function which allows the conversion of the originating command to the one specified by the 'notify_function' value. Default is the 'set' command.

The possible values for this variable is determined by inspecting any devices attatched to the Typecast device. If (one or more) attatched devices are

found, the first device is asked for potential notify functions by calling the list_set_functions() on it.

As opposed to most other devices, the readstring function simply returns the empty string as the value of the typecast device will be equal to the unederlying device.

A special Typecast device is the RFC::TypecastFaraday (accessed as Typecast_PSU_to_gas), which only accepts RFC::PSU devices as inputs and always masquerade as a RFC::gas device. This device class only forwards 'current' commands but not 'voltage' commands as it only makes sense to convert a current to a gas flow according to Faraday's law of elecrolysis.

To obtain a RFC::Typecast instance, call one of the constructiors as shown below:

$id = RFC::TypeCastDefault→new($name,$rig);

$id = RFC::TypeCastDefault→new($name,$rig,$input_device,$output_type,[opt $read_function]);

$id = RFC::TypecastFaraday→new($name,$rig);

$id = RFC::Constant→new($name,$rig);

In case the input device and output type is specified, a RFC::Typecast device can be instantiated without it having a soresponding section in a RFC::Rig instances configuration. This enables other RFC::BaseDevice derived classes to instantiate RFC::Typecast devices explicitly as part of their own instantiation.

The Constant device is a special typecast device which does not ahve an input or ouptut device, but will register as a device of the output type. This device can then be used as an input to an other device (such as a filter, logic or math device) Where a constant value is needed (for instance, if a Math::Divide device is used and one needs to make sure that the divisor is alway positvie, the input could be passed through a Max device where one input is a constant value device with the value 0.1 and the other is the real input. In this case, the value supplied to divicion will never be below 0.1.

11.50 RFC::Alert

Inherits from RFC::BaseDevice (refer section 11.14).

The RFC::Alert is a device intended to be used for automatic monitoring of process parameters.

Each instance of RFC::Alert can monitor a single parameter (other RFC device) and if a given setpoint is passed, a single alert mail is sent to recipients defined by either the alert_mail key for the RFC::Rig instance or the global system administrators if the alert_mail key is not defined.

If an alert has occoured, the Alert device can be set up to stop any running sequential programs for the rig and / or execute a sequence of commands which potentially could rectify the situation leading up to the alert.

The alert vill be canceled whenever the parameter beeing monitored passes the reset threshold.

The alarm level and the reset level determines if the process parameter have to be either above or below the alarm threshold for an alarm to trigger. If the reset level is below the alarm threshold, an alarm is triggered whenever the process paramater gets above the alarm threshold. If the alarm trheshold is below the reset level, the reverse is the case.

RFC::Alert instances are not included in normal data logging, as the values of the monitored device will be logged by that device iteself.

Complex trigger alarms are possible by combining several individual devices through Math devices, schmidt trigger devices and / or logic devices. However care should be observed as the more complex the system becomes the bigger the risk of misconfiguration resulting in loss of experimental results (by premature shutdown of key devices for instance).

To obtaina RFC::Alert instance, call the constructor as shown below:

$id = RFC::Alert→new($name,$rig);

The RFC::Alert class defines the following extra public member function:

$id→check([opt cache]) This function tests if the value of the underlying device is within the range defined as OK or not. If the value is outside the accepted range, it measures a few times more (up to the retries value) And if the returned value is consistently outside the accepted range, an alert is raised (potentially stopping runing programs and/or executing additional comands which could correct the situation). If an instance of type RFC::Cache is supplied, this is passed on to the underlying device potentially speeding up operation. Note that the retry measurements do NOT pass on the cache (which woulod be pointless)! The function returns 0 if the value is within the accepted range and 1 if the alert has been raised already. If this call of ckeck() results in the alert beeing raised, the return value is a text string describing the alert and any potential actions taken.

the RFC::Trigger class is derived from RFC::Alert. The only difference is that instances of RFC::Trigger do NOT have the option to terminate running

programs or to send mail as they are instended for normal process control and should thus not influence normal program execution. They are thus only usefull if they do in fact include trigger commands.

Notice however that if RFC::Trigger devices are used the content of the actual trigger commands may render running programs invalid or wrong, so care must be observed when using RFC::Trigger devices in control systems!

Be aware that alert devices needs to be enabled / included before they can oparate (Similar to most other RFCcontrol evices).

11.51 RFC::Adapter

Inherits from RFC::BaseDevice (refer section 11.14).

The RFC::Adapter class defines the behaviour of a group of special virtual devices. These devices all operator on top of normal RFC::BaseDevice derived devices and operate according to the Adapter pattern (as defined by GoF).

The adapter devices are intended to supply functionality which the native RFC devies do not themselves suppport. For instance most power supplies do not support slowly ramping voltage or current up to a fixed setpoint.

By using a RamprateAdapter this can be facilitated by letting the adapter device supply a steadialy changing setpoint to the power supply device.

The rationale for using the Adapter pattern is the it makes it possible to use multiple different adapters on any single object (if the application of those adapters make any sense that is).

All RFC::Adapter derived classes has two distinct constructors. One with the normal 2 arguments as for normal RFC::BaseDevice instances:

my $id = RFC::Adapter→new($name,$rig);

And one with an additional argument which must be the RFC::BaseDevice derived instance to wrap:

my $id = RFC::Adapter→new($name,$rig,$dev);

If the second constructor is used, the adapter device does not need to have it's own configurationsection in the rig's configuration file as it already knows the device it is to wrap (for some adapter instances the configuration may still be nescesarry for full functionality).

All RFC::Adapter objects has the following member functions (in addition to those inherited from RFC::BaseDevice).

$id→update()	Performs the internal state change nescesarry for the added functionality.
$id→load_state()	Loads any state information which must be persistent between device invocations
$id→store()	Saves persistent information.

Common to the functions described above is that the default adapter does not define any functionality for the functions (in effct they are pure virtual), and any nescesarry actions must be defined in the classes derived from RFC::Adapter

To obtain one of the operational adapters call one of the constructors as shown below:

my $id = RFC::RamprateAdapter→new($name,$rig);

my $id = RFC::RamprateAdapter→new($name,$rig,$dev);

my $id = RFC::ExponentialDecayAdapter→new($name,$rig);

my $id = RFC::ExponentialDecayAdapter→new($name,$rig,$dev);

Notice that due to the way the RamprateAdapter is implemented, only slow ramprates will be possible (changes taking minutes or hours to complete).

A special ramprate adapeter is the TempControlAdapter This adapter fully emulates a RFC::TempControl device completely with the special TempControl functions like get_atemp() etc (see TempControl.pm for details). This enables virtual temperature controlers and also the possibility to use RFCPID devices as normal (physical) temperature controlers.

11.52 RFC::VacuumControl

Inherits from RFC::BaseDevice (refer section 11.14).

This class implements RFC::VacuumControl for pfeiffer-vacuum PID controller RVC 300 To obtain a VacuumControl instance call one of the constructors as shown below:

$id = RFC::VacuumControl→new($name,$rig);

The RFC::VacuumControl class

The following RFC::MFC member function has been remapped:

$id→setflow	**Alias for $id→setP.**
$id→maxflow	**Alias for $id→maxP.**
$id→gasses	**Returns a single element ($id→selected_gas).**

Class definitions for use with Cal temperature controlers #### The interface is always degrees celsius for setpoints and #### degrees celsius/hour for ramprates! #### The internal conversions within the classes manage the differences #### between the different types of controlers #### Note that the base class Eurotherm does not do any conversion what #### so ever, it merely reports the direct responses from the #### controler. Thus the base class should normally nt be used directly! ####

Chapter 12

Device configuration

This section describes how the different devices are configured and which configuration parameters are used for each device class and type. Each device class contains a number of device types which behaves similarly. For instance, all Simplechannel devices can be used to measure a physical parameter (this beeing a voltage, resistance, current or similar).

All devices contains a number of common functions, these include read and readstring, which allows the application to read the value of the device (readstring is used for data logging, as it includes the device name and a timestamp). The individual devices themselves decides what the 'value' of the device means.

All devices also contains two common tags, a title tag (used for an optional title on the data plots) and a show_plot tag used for determining if the data from the device is to be shown in the data plots. Notice however that the value of this tag only determines if a graph is shown! If the device is enabled (that is included in the data logging), the data will be written in the data file irrespectively of the value of the show_plot tag.

Notice however that the show_plot tag should noly ever be used for enabled devices as otherwise a name overlap may result in plots not beeing shown correctly. Specifically if two devices of different types but identical names exists and one is enabled and the other not, then setting the show_plot tag to no for the not enabled device would result in the plot generating program reading this value instead as device type information is not stored in the stored data byt only the name and thus the plotting program has to check all device types for a device with the specific data collumn name before it can query the value of the show_plot tag.

Note that or all devices described in this chapter, the legacy tags (if any) is included in the list of configurable tags for the device type in quiestion. Thus for some devices the actual number of tags displayed on the setup page may be les than the list described here.

12.1 Simplechannel

Simplechannels are used for measuring a single parameter, this could be for instance a voltage. Often simplechannels are used internally by some of the more complex devices (refer sectios 12.3, 12.6 or 12.5). The use by other devices of simplechannels are either explicitly (by referencing an already defined simplehcannel by name) or implicitly by creating one based on configuration parameters from the domplex device itself.

12.1.1 Keithley

Tag	Description	Values	Default
mode	Device control mode	Readonly	Readonly
communication	Connunication mode	GPIB Serial	GPIB
channel	Channel number of input device, format: X:YZZ, X gpib address, Y board number, ZZ channel number on board		1:101
measure_type	Measure configuration string send to the keithley to set up measurement, fres being 4-point resistance measruements. NB: Values other than Default is only valid for gpibserver version 2.13 or later or Linux_gpib_server version 1.2.1 or later!	Default - gpibserver volt:dc volt:ac res fres	Default - gpibserver
use_gpib_spline	Convert data using gpibserver spline table.	Yes No	Yes
factor	Scaling factor		1
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No

Continued on next page

Table 12.1 – continued from previous page

Tag	Description	Values	Default
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No** **Yes**	**No**

Table 12.1: Configuration tags for simplechannel device type 'Keithley'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.1.2 Keithley580

Tag	Description	Values	Default
mode	**Device control mode**	**Readonly**	**Readonly**
communication	**Connunication mode**		**GPIB**
address	**GPIB address**		**1**
range	**Measurement range**	**Auto** **200m** **2** **20** **200** **2k** **20k** **200k**	**0**
dry_circuit	**Use dry circuit measurement mode**	**None** **Enabled**	**0**
relative	**Use relative measruement mode**	**Off** **On**	**0**
polarity		**Pol+** **Pol-**	**0**
drive	**Measurement drive mode**	**Pulsed** **DC**	**1**
factor	**Scaling factor**		**1**
title	**Optional title**		

Continued on next page

Table 12.2 – continued from previous page

Tag	Description	Values	Default
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.2: Configuration tags for simplechannel device type 'KeithleyMicroohmmeter'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.1.3 ICP

Tag	Description	Values	Default
mode	Device control mode	Readonly	Readonly
tty	Serial device for controling device (eg ttyS0)		ttyS0
address	Device address		1
channel	Channel number on device (Note 0-based)		0
range	Input type and range		
factor	Scaling factor		1
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes

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Table 12.3 – continued from previous page

Tag	Description	Values	Default
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
CRC	Determines if checksum is to be used for serial communication	No Yes	No
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.3: Configuration tags for simplechannel device type 'SimpleICP'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.1.4 ICP7017/18

Tag	Description	Values	Default
mode	Device control mode	Readonly	Readonly
tty	Serial device for controling device (eg ttyS0)		ttyS0
address	Device address		1
channel	Channel number on device (Note 0-based)		0
range	Input type and range		
factor	Scaling factor		1
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No

Continued on next page

Table 12.4 – continued from previous page

Tag	Description	Values	Default
CRC	**Determines if checksum is to be used for serial communication**	**No Yes**	**No**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No Yes**	**No**

Table 12.4: Configuration tags for simplechannel device type 'SimpleICP7017/18'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.1.5 ICP7017ZW

Tag	Description	Values	Default
mode	**Device control mode**	**Readonly**	**Readonly**
tty	**Serial device for controling device (eg ttyS0)**		**ttyS0**
address	**Device address**		**1**
channel	**Channel number on device (Note 0-based)**		**0**
range	**Input type and range**		
factor	**Scaling factor**		**1**
title	**Optional title**		
show_plot	**Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices**	**Yes No**	**Yes**
use_cache	**Determines if persisten caching of read values is allowed**	**Yes No**	**No**
CRC	**Determines if checksum is to be used for serial communication**	**No Yes**	**No**

Continued on next page

Table 12.5 – continued from previous page

Tag	Description	Values	Default
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.5: Configuration tags for simplechannel device type 'SimpleICP7017ZW'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.1.6 ICP7019

Tag	Description	Values	Default
mode	Device control mode	Readonly	Readonly
tty	Serial device for controling device (eg ttyS0)		ttyS0
address	Device address		1
channel	Channel number on device (Note 0-based)		0
range	Input type and range		
factor	Scaling factor		1
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
CRC	Determines if checksum is to be used for serial communication	No Yes	No
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		

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Table 12.6 – continued from previous page

Tag	Description	Values	Default
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No Yes**	**No**

Table 12.6: Configuration tags for simplechannel device type 'SimpleICP7019/87019'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.1.7 ModbusTCP

Tag	Description	Values	Default
mode	**Device control mode**	**Readonly**	**Readonly**
IP	**IP address of module**		**127.0.0.1**
register	**Modbus holding register for reading value**		**0**
factor	**Scaling factor**		**1**
title	**Optional title**		
show_plot	**Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices**	**Yes No**	**Yes**
use_cache	**Determines if persisten caching of read values is allowed**	**Yes No**	**No**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No Yes**	**No**

Table 12.7: Configuration tags for simplechannel device type 'ModbusTCP'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.1.8 Modbus

Tag	Description	Values	Default
mode	Device control mode	Readonly	Readonly
tty	Serial device for controling device (eg ttyS0)		ttyS0
address	Device address		1
channel	Modbus tag number for reading value		0
range	Input type and range		
factor	Scaling factor		1
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
CRC	Determines if checksum is to be used for serial communication	No Yes	No
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.8: Configuration tags for simplechannel device type 'SimpleModbus'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.1.9 PLCRead

Tag	Description	Values	Default
mode	Device read mode	Readonly	Readonly
IP	PLC IP address		10.0.03.216
port	modbus port number		502

Continued on next page

Table 12.9 – continued from previous page

Tag	Description	Values	Default
stackAddress	**modbus stack address index num of the variable to read**		**1**
offset	**modbus stack offset value of the variable to read**		**0**
dataType	**data type of the variable to read**	**BOOL** **BYTE** **DINT** **DWORD** **INT** **LREAL** **REAL** **SINT** **TIME** **UDINT** **UINT** **USINT** **WORD**	**WORD**
title	**Optional title**		
show_plot	**Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices**	**Yes** **No**	**Yes**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No** **Yes**	**No**

Table 12.9: Configuration tags for simplechannel device type 'PLCRead'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.1.10 External

Tag	Description	Values	Default
mode	Device control mode	Readonly	Readonly
program	External program to call when a read request on this device is called. The program must recide in /usr/local/bin/celltest/external/ and must return a number when executed. The filename must also contain only digits, letters and '.' (this restriction is in order to prevent code injection). The program is called with a single argument: the rig number ('15' in case of rig15) which can either be ignored or used by the program to distinguish between different rigs when called.	time.pl	time.pl
factor	Scaling factor		1
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.10: Configuration tags for simplechannel device type 'External'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.1.11 Socket

Tag	Description	Values	Default
mode	Device control mode	Readonly	Readonly
host	IP or hostname of server to contact		localhost
port	Port number		2020
command	Command to execute by host		read
arguments	Optional arguments passed to server, separate by comma		
factor	Scaling factor		1
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.11: Configuration tags for simplechannel device type 'Socket'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.1.12 SOAP

Tag	Description	Values	Default
mode	Device control mode	Readonly	Readonly
wsdl	URL of the WSDL file describing the service		
command	Command to execute by host		read

Continued on next page

Table 12.12 – continued from previous page

Tag	Description	Values	Default
arguments	**Optional arguments passed to server, separate by comma**		
factor	**Scaling factor**		**1**
title	**Optional title**		
show_plot	**Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices**	**Yes** **No**	**Yes**
use_cache	**Determines if persisten caching of read values is allowed**	**Yes** **No**	**No**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No** **Yes**	**No**

Table 12.12: Configuration tags for simplechannel device type 'SOAP'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.2 Relay

Relay devices are used for control of relay modules for controling other external functions. This could for instance be magnetic valves for gasses or similar device control. As with simplechannels, relay devices are often used internally in more complex devices (refer sections 12.5, 12.6 or 12.7). These devices are used either explisitly (by referentinc the realy device by name) ro implictly by creating a relay device from internal parameters in the complex device).

Relay devices supports the set command to set the status of the relay (1 for closed relay, 0 for open)

12.2.1 ICP

Tag	Description	Values	Default
mode	Device control mode	Automatic	Automatic
tty	Serial device for communication		ttyS0
address	Device address		0
channel	Channel number on device (Note is 0 based)		0
title	Optional title		
show_plot	Determines if the current device data is to be shown in the daily data plots	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
CRC	Determines if checksum is to be used for serial communication	No Yes	No
master_device	Master control relay. Relay status will be controlled by master relay status (through the observer pattern)		
invert_master	Inverts status of master relay (if master relay is set)	No Yes	No
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

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Table 12.13 – continued from previous page

Tag	Description	Values	Default

Table 12.13: Configuration tags for relay device type 'ICPRelay'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.2.2 ICPDI

Tag	Description	Values	Default
mode	Device control mode	Readonly	Readonly
tty	Serial device for communication		ttyS0
address	Device address		0
channel	Channel number on device (Note is 0 based)		0
title	Optional title		
show_plot	Determines if the current device data is to be shown in the daily data plots	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
CRC	Determines if checksum is to be used for serial communication	No Yes	No
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.14: Configuration tags for relay device type 'ICPDI'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.2.3 ManualRelay

Tag	Description	Values	Default
output_device	Relay device for output (optional, can be used to control a physical realy or logic device)		
title	Optional title		
show_plot	Determines if the current device data is to be shown in the daily data plots	Yes No	Yes
master_device			
invert_master		No Yes	
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.15: Configuration tags for relay device type 'ManualRelay'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.2.4 Monostable

Tag	Description	Values	Default
mode	Device control mode	Automatic	Automatic
device	Relay device name used for actual control (a BaseRelay device instance)		
duration	Duration of the on pulse in seconds		1
title	Optional title		
show_plot	Determines if the current device data is to be shown in the daily data plots	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		

Continued on next page

Table 12.16 – continued from previous page

Tag	Description	Values	Default
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No** **Yes**	**No**

Table 12.16: Configuration tags for relay device type 'Monostable'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.2.5 Monostable-PWM

Tag	Description	Values	Default
mode	**Device control mode**	**Automatic**	**Automatic**
device	**Relay device name used for actual control (a BaseRelay device instance)**		
timing_device_type	**Device type of the timing device**	**simplechannel** **relay** **templog** **tempcontrol** **MFC** **water** **gas** **gasgroup** **PSU** **analog** **multiplex** **PID** **logic** **math** **Alert**	**simplechannel**

Continued on next page

Table 12.17 – continued from previous page

Tag	Description	Values	Default
timing_device	**Device determining length of on state. The read value of this device uppon a recieved set command is used for the duration of the pulse. If no timing device can be loaded, the duration is fixed to 1 second. If the read value is negative, the duration is set to 0.**		
title	**Optional title**		
show_plot	**Determines if the current device data is to be shown in the daily data plots**	**Yes** **No**	**Yes**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No** **Yes**	**No**

Table 12.17: Configuration tags for relay device type 'Monostable-PWM'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.3 Templog

Temperature log devices are used for measuring temperatures by thermocouples or similar sensor types. Usually the temperature devices uses simplechannel devices internally to do the actual measurements, thus the temperature device can be visualised as simply a computational device.

12.3.1 Analog

Tag	Description	Values	Default
mode	Device control mode	Readonly	Readonly
channel_name	Input device name		
channel	Input device channel, only used if no channel name. Note that the measure channel must report the value in either mV (for thermocouples) or Ohm (for resistive elements such as pt1000 or similar		0
channel_input_type	Input device type , only used if no channel name	Keithley Keithley580 ICP ICP7017/18 ICP7017ZW ICP7019 ModbusTCP Modbus PLCRead External Socket SOAP	Keithley
channel_tty	Input device communication device, only used if no device name and device input type is not Keithley		ttyS0
channel_address	Input device address, only used if no device name and device input type is not Keithley		0

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Table 12.18 – continued from previous page

Tag	Description	Values	Default
type	Sensor type	K N S R B pt100 pt1000 MCP9700 MCP9701 Thermistor_- NTCLE100E31- 03_B0	S
internal_compensation	Switch for controling if the input device reports raw voltage or does internal compensation, thus reporting temperatures directly	Yes No	No
callibration_file	File name of callibration file if custom callibration file is to be used for calculations (Default is NIST tables)	DEFAULT	DEFAULT
cold_junction_name	Name of cold junction input device if using raw input (in conjuction with resistance input device)		
cold_junction_device	Name of temperature log device for determining cold junction temperature		
cj_channel	Cold junction device channel, only used if no cold junction name		0

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Table 12.18 – continued from previous page

Tag	Description	Values	Default
cj_channel_input_type	Cold junction input type, only used if no cold junction name	Keithley Keithley580 ICP ICP7017/18 ICP7017ZW ICP7019 ModbusTCP Modbus PLCRead External Socket SOAP	Keithley
cj_channel_tty	Cold junction communication device, only used if no cold junction name and cond junction input type is not Keithley)		ttyS0
cj_channel_address	Cold junction device address, only used if no cold junction name and cond junction input type is not Keithley)		0
cj_type	Cold junction sensor type	fixed pt100 pt1000 templog_device	pt1000
cj_temp	Cold junction temperature (if fixed)		25
lead_res_name	Lead resistance input device		
lead_res	Lead ressistance if fixed value or lead resistance channel if not fixed value		0

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Table 12.18 – continued from previous page

Tag	Description	Values	Default
lead_res_input_type	Lead resistance input device type	fixed_value Keithley Keithley580 ICP ICP7017/18 ICP7017ZW ICP7019 ModbusTCP Modbus PLCRead External Socket SOAP	fixed_value
lead_res_tty	Lead resistance input device communication device, only used if no lead ressistance name and lead resistance input type is not Keithley		ttyS0
lead_res_address	Lead resistance input device device address, only used if no lead ressistance name and lead resistance input type is not Keithley		0
title	Optional device title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
unit	Temperuature scale (Celcius of Kelvin)	C K	C
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		

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Table 12.18 – continued from previous page

Tag	Description	Values	Default
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.18: Configuration tags for templog device type 'S'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.3.2 E3216

Tag	Description	Values	Default
channel	Controler address		0
tty	Communication device (ex. ttyS0)		ttyS0
controller_mode	Number format	integer decimal	integer
factor	Multiplication factor		1
communication	Communication type	modbus bisynch	modbus
title	Optional device title		
show_plot	Determines if the current device data is to be shown in the daily data plots	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
unit	Temperuature scale (Celcius of Kelvin)	C K	
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		

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Table 12.19 – continued from previous page

Tag	Description	Values	Default
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.19: Configuration tags for templog device type '3216e'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.3.3 E2216

Tag	Description	Values	Default
channel	Controler address		0
tty	Communication device (ex. ttyS0)		ttyS0
controller_mode	Number format	integer decimal	integer
factor	Multiplication factor		1
communication	Communication type	modbus bisynch	modbus
title	Optional device title		
show_plot	Determines if the current device data is to be shown in the daily data plots	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
unit	Temperuature scale (Celcius of Kelvin)	C K	
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		

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Table 12.20 – continued from previous page

Tag	Description	Values	Default
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.20: Configuration tags for templog device type '2216e'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.3.4 E2208

Tag	Description	Values	Default
channel	Controler address		0
tty	Communication device (ex. ttyS0)		ttyS0
controller_mode	Number format	integer decimal	integer
factor	Multiplication factor		1
communication	Communication type	modbus bisynch	modbus
title	Optional device title		
show_plot	Determines if the current device data is to be shown in the daily data plots	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
unit	Temperuature scale (Celcius of Kelvin)	C K	
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		

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Table 12.21 – continued from previous page

Tag	Description	Values	Default
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.21: Configuration tags for templog device type '2208e'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.3.5 E2404

Tag	Description	Values	Default
channel	Controler address		0
tty	Communication device (ex. ttyS0)		ttyS0
controller_mode	Number format	integer decimal	integer
factor	Multiplication factor		1
communication	Communication type	modbus bisynch	modbus
title	Optional device title		
show_plot	Determines if the current device data is to be shown in the daily data plots	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
unit	Temperuature scale (Celcius of Kelvin)	C K	
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		

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Table 12.22 – continued from previous page

Tag	Description	Values	Default
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.22: Configuration tags for templog device type '2404e'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.3.6 E2408

Tag	Description	Values	Default
channel	Controler address		0
tty	Communication device (ex. ttyS0)		ttyS0
controller_mode	Number format	integer decimal	integer
factor	Multiplication factor		1
communication	Communication type	modbus bisynch	modbus
title	Optional device title		
show_plot	Determines if the current device data is to be shown in the daily data plots	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
unit	Temperuature scale (Celcius of Kelvin)	C K	
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		

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Table 12.23 – continued from previous page

Tag	Description	Values	Default
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.23: Configuration tags for templog device type '2408e'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.3.7 E2416

Tag	Description	Values	Default
channel	Controler address		0
tty	Communication device (ex. ttyS0)		ttyS0
controller_mode	Number format	integer decimal	integer
factor	Multiplication factor		1
communication	Communication type	modbus bisynch	modbus
title	Optional device title		
show_plot	Determines if the current device data is to be shown in the daily data plots	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
unit	Temperuature scale (Celcius of Kelvin)	C K	
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		

Continued on next page

Table 12.24 – continued from previous page

Tag	Description	Values	Default
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No Yes**	**No**

Table 12.24: Configuration tags for templog device type '2416e'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.3.8 W6100

Tag	Description	Values	Default
channel	**Controler address**		**0**
tty	**Communication device (ex. ttyS0)**		**ttyS0**
factor	**Multiplication factor**		**1**
title	**Optional device title**		
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No Yes**	**No**

Table 12.25: Configuration tags for templog device type 'West6100'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.3.9 Linkam

Tag	Description	Values	Default
channel	**Controler address**		**0**
tty	**Communication device (ex. ttyS0)**		**ttyS0**
factor	**Multiplication factor**		**1**
title	**Optional device title**		
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No Yes**	**No**

Table 12.26: Configuration tags for templog device type 'Linkam'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.4 Tempcontrol

Temperature control devices are used to control and monitor furnaces controlers (including cryogenic controlers as they work similarly)

Temperature control devices supports the set_temp and set_ramp commands to set the temperature setpoint and temperature ramprate.

A special tag is the 'controler_type'. This tag is not used for internal configuration of the device, but is instead used for device selection. The reason for this is historic as version 4.x had to be backwards compatible on a configuration file level with version 3.x. Thus for instance for a Honeywell device, it is possible to select a value corresponding to a Eurotherm® controler, this will however convert the device to the appropriate Eurotherm® device!.

12.4.1 Honeywell

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
tty	Communication device		ttyS0
address	Device address		1
minramp	Minimum allowable ramprate in C/hour		0
maxramp	Maximum allowable ramprate in C/hour (no value means no limit)		
maxtemp	maximum allowed setpoint, not enforced if not set		
mintemp	Minimum allowed setpoint, not enforced if not set		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Continued on next page

Table 12.27 – continued from previous page

Tag	Description	Values	Default

Table 12.27: Configuration tags for tempcontrol device type 'Honeywell'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.4.2 Julabo

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic Readonly	Automatic
tty	Communication device		ttyS0
baudrate	baudrate	1200 2400 4800 9600	4800
parity	parity	even none odd	even
handshake	handshake type	rts xoff none	rts
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Continued on next page

Table 12.28 – continued from previous page

Tag	Description	Values	Default

Table 12.28: Configuration tags for tempcontrol device type 'Julabo'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.4.3 E3216

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic Readonly	Automatic
tty	Communication device		ttyS0
address	Device address		1
controler_mode	Number format	integer decimal	integer
type	Communication mode	modbus bisynch	modbus
maxramp	Maximum allowable ramprate in C/hour (no value means no limit)		
minramp	Minimum allowable ramprate in C/hour (Default 6 C/hour for Eurotherm)		6
maxtemp	maximum allowed setpoint, not enforced if not set		
mintemp	Minimum allowed setpoint, not enforced if not set		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		

Continued on next page

Table 12.29 – continued from previous page

Tag	Description	Values	Default
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.29: Configuration tags for tempcontrol device type 'E3216'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.4.4 E2216

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic Readonly	Automatic
tty	Communication device		ttyS0
address	Device address		1
controler_mode	Number format	integer decimal	integer
type	Communication mode	modbus bisynch	modbus
maxramp	Maximum allowable ramprate in C/hour (no value means no limit)		
minramp	Minimum allowable ramprate in C/hour (Default 6 C/hour for Eurotherm)		6
maxtemp	maximum allowed setpoint, not enforced if not set		
mintemp	Minimum allowed setpoint, not enforced if not set		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No

Continued on next page

Table 12.30 – continued from previous page

Tag	Description	Values	Default
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No Yes**	**No**

Table 12.30: Configuration tags for tempcontrol device type 'E2216'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.4.5 E2208

Tag	Description	Values	Default
mode	**Device control mode**	**Manual Automatic Readonly**	**Automatic**
tty	**Communication device**		**ttyS0**
address	**Device address**		**1**
controler_mode	**Number format**	**integer decimal**	**integer**
type	**Communication mode**	**modbus bisynch**	**modbus**
maxramp	**Maximum allowable ramprate in C/hour (no value means no limit)**		
minramp	**Minimum allowable ramprate in C/hour (Default 6 C/hour for Eurotherm)**		**6**
maxtemp	**maximum allowed setpoint, not enforced if not set**		
mintemp	**Minimum allowed setpoint, not enforced if not set**		
show_plot	**Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices**	**Yes No**	**Yes**

Continued on next page

Table 12.31 – continued from previous page

Tag	Description	Values	Default
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.31: Configuration tags for tempcontrol device type 'E2208'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.4.6 E2404

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic Readonly	Automatic
tty	Communication device		ttyS0
address	Device address		1
controler_mode	Number format	integer decimal	integer
type	Communication mode	modbus bisynch	modbus
maxramp	Maximum allowable ramprate in C/hour (no value means no limit)		
minramp	Minimum allowable ramprate in C/hour (Default 6 C/hour for Eurotherm)		6
maxtemp	maximum allowed setpoint, not enforced if not set		
mintemp	Minimum allowed setpoint, not enforced if not set		

Continued on next page

Table 12.32 – continued from previous page

Tag	Description	Values	Default
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.32: Configuration tags for tempcontrol device type 'E2404'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.4.7 E2408

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic Readonly	Automatic
tty	Communication device		ttyS0
address	Device address		1
controler_mode	Number format	integer decimal	integer
type	Communication mode	modbus bisynch	modbus
maxramp	Maximum allowable ramprate in C/hour (no value means no limit)		
minramp	Minimum allowable ramprate in C/hour (Default 6 C/hour for Eurotherm)		6

Continued on next page

Table 12.33 – continued from previous page

Tag	Description	Values	Default
maxtemp	**maximum allowed setpoint, not enforced if not set**		
mintemp	**Minimum allowed setpoint, not enforced if not set**		
show_plot	**Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices**	**Yes** **No**	**Yes**
use_cache	**Determines if persisten caching of read values is allowed**	**Yes** **No**	**No**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No** **Yes**	**No**

Table 12.33: Configuration tags for tempcontrol device type 'E2408'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.4.8 E2416

Tag	Description	Values	Default
mode	**Device control mode**	**Manual** **Automatic** **Readonly**	**Automatic**
tty	**Communication device**		**ttyS0**
address	**Device address**		**1**
controler_mode	**Number format**	**integer** **decimal**	**integer**
type	**Communication mode**	**modbus** **bisynch**	**modbus**
maxramp	**Maximum allowable ramprate in C/hour (no value means no limit)**		

Continued on next page

Table 12.34 – continued from previous page

Tag	Description	Values	Default
minramp	**Minimum allowable ramprate in C/hour (Default 6 C/hour for Eurotherm)**		**6**
maxtemp	**maximum allowed setpoint, not enforced if not set**		
mintemp	**Minimum allowed setpoint, not enforced if not set**		
show_plot	**Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices**	**Yes** **No**	**Yes**
use_cache	**Determines if persisten caching of read values is allowed**	**Yes** **No**	**No**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No** **Yes**	**No**

Table 12.34: Configuration tags for tempcontrol device type 'E2416'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.4.9 W6100

Tag	Description	Values	Default
mode	**Device control mode**	**Manual** **Automatic** **Readonly**	**Automatic**
tty	**Communication device**		**ttyS0**
address	**Device address**		**1**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		

Continued on next page

Table 12.35 – continued from previous page

Tag	Description	Values	Default
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.35: Configuration tags for tempcontrol device type 'W6100'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.4.10 Linkam

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic Readonly	Automatic
tty	Communication device		ttyS0
address	Device address		1
controler_mode	Number format	integer decimal	integer
type	Communication mode	modbus bisynch	modbus
maxramp	Maximum allowable ramprate in C/hour (no value means no limit)		
minramp	Minimum allowable ramprate in C/hour (Default 6 C/hour for Eurotherm)		6
maxtemp	maximum allowed setpoint, not enforced if not set		
mintemp	Minimum allowed setpoint, not enforced if not set		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No

Continued on next page

Table 12.36 – continued from previous page

Tag	Description	Values	Default
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No** **Yes**	**No**

Table 12.36: Configuration tags for tempcontrol device type 'Linkam'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.4.11 Omron-E5CC

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic Readonly	Automatic
type	Communication mode	modbus	modbus
tty	Communication device		ttyS0
address	Device address		1
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.37: Configuration tags for tempcontrol device type 'Omron-E5CC'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.4.12 CAL3300

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic Readonly	Automatic
tty	Communication device		ttyS0
address	Device address		1
controler_mode	Number format	integer decimal	integer
type	Communication mode	modbus bisynch	modbus
maxramp	Maximum allowable ramprate in C/hour (no value means no limit)		
minramp	Minimum allowable ramprate in C/hour (Default 6 C/hour for Eurotherm)		6
maxtemp	maximum allowed setpoint, not enforced if not set		

Continued on next page

Table 12.38 – continued from previous page

Tag	Description	Values	Default
mintemp	**Minimum allowed setpoint, not enforced if not set**		
show_plot	**Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices**	**Yes** **No**	**Yes**
use_cache	**Determines if persisten caching of read values is allowed**	**Yes** **No**	**No**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No** **Yes**	**No**

Table 12.38: Configuration tags for tempcontrol device type 'CAL3300'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.4.13 CAL9300

Tag	Description	Values	Default
mode	**Device control mode**	**Manual** **Automatic** **Readonly**	**Automatic**
tty	**Communication device**		**ttyS0**
address	**Device address**		**1**
controler_mode	**Number format**	**integer** **decimal**	**integer**
type	**Communication mode**	**modbus** **bisynch**	**modbus**
maxramp	**Maximum allowable ramprate in C/hour (no value means no limit)**		

Continued on next page

Table 12.39 – continued from previous page

Tag	Description	Values	Default
minramp	**Minimum allowable ramprate in C/hour (Default 6 C/hour for Eurotherm)**		**6**
maxtemp	**maximum allowed setpoint, not enforced if not set**		
mintemp	**Minimum allowed setpoint, not enforced if not set**		
show_plot	**Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices**	**Yes** **No**	**Yes**
use_cache	**Determines if persisten caching of read values is allowed**	**Yes** **No**	**No**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No** **Yes**	**No**

Table 12.39: Configuration tags for tempcontrol device type 'CAL9300'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.4.14 CAL9400

Tag	Description	Values	Default
mode	**Device control mode**	**Manual** **Automatic** **Readonly**	**Automatic**
tty	**Communication device**		**ttyS0**
address	**Device address**		**1**
controler_mode	**Number format**	**integer** **decimal**	**integer**

Continued on next page

Table 12.40 – continued from previous page

Tag	Description	Values	Default
type	Communication mode	modbus bisynch	modbus
maxramp	Maximum allowable ramprate in C/hour (no value means no limit)		
minramp	Minimum allowable ramprate in C/hour (Default 6 C/hour for Eurotherm)		6
maxtemp	maximum allowed setpoint, not enforced if not set		
mintemp	Minimum allowed setpoint, not enforced if not set		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.40: Configuration tags for tempcontrol device type 'CAL9400'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.4.15 CAL9500

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic Readonly	Automatic
tty	Communication device		ttyS0
Continued on next page			

Table 12.41 – continued from previous page

Tag	Description	Values	Default
address	Device address		1
controler_mode	Number format	integer decimal	integer
type	Communication mode	modbus bisynch	modbus
maxramp	Maximum allowable ramprate in C/hour (no value means no limit)		
minramp	Minimum allowable ramprate in C/hour (Default 6 C/hour for Eurotherm)		6
maxtemp	maximum allowed setpoint, not enforced if not set		
mintemp	Minimum allowed setpoint, not enforced if not set		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.41: Configuration tags for tempcontrol device type 'CAL9500'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.5 MFC

A mass flow controler device is used for the actual control of the gas flow controler. This makes it possible for multiple gasses to use the same physical flow controler device by multiplexing (refer sections 12.7 and 12.11).

All MFC devices supports the setflow command to set the actual gas flow.

Notice, that MFC-devices only rarely is used explicitly to measure gas flows. Usually this is done implicitly through a gas device (refer section 12.7) which refers the measurement to the MFC device. Thus to create a new gas flow line, first create a gas device (a manual one), then create the MFC-device (that uses the gas device i question), and at last change the mode of the gas device from manual to automatic (once the gas device has registered the correct MFC device, which happens automatically as long as only one MFC device references the gas device). It is not allowed to have more than one MFC device reference each gas device!

Some MFC devices contains a special setting variable called 'spline'. This is intended to be used in the case a callibration curve/list has been supplied with the controler and can be used to correct the MFC output according to the callibration sheet. The format of the setting is a list of values which can be used in by a spline interpoaltion routine as shown below:

```
0 0
1 1.2
2 2.1
3 3
4 3.9
```

The first column is the flow reported by the controler, and the second is the actual flow (note that flows are in L/hour irrespective of which unit the controler reports the flow in!). If the field is left blank, no correction is atempted and the reported flow is used as is.

A related control device is the pressure controler. Unlike mass flow controler devices it does not support multiplexers but it is used just like a MFC device. The reason for this is that it is possible to control the flow of a gas or the pressure, but not both at the same time.

The data unit for pressure controlers is bar absolute (barA). 0 barA corresponds to a vaccum and 1 barA corresponds roughly to atmospheric pressure.

12.5.1 Manual

Tag	Description	Values	Default
mode	Device control mode	Manual	Manual
calibrated_gas	The gas for which the maxflow is specified on the controler (usually nitrogen)	co2 ext_cathode d2 kr h2 n2o3 n20 ch4 backup ne no xe ar n2 co o2 chx n2_cathode no2 ext_anode he air o2_cathode	n2
calibrated_maxflow	Maximum flowrate for the callibrated gas (Note in L/hour!)		100
gas	selected gas		n2
gas_change	Gas change mode	Manual Automatic	Manual
gas_multiplexer	Name of gas multiplexer device if any		
gasses	Avaliable gasses, Must contain a comma separated list of gas names (device name!) that the MFC can be used to control (in case of no multiplexer, just the single gas connected).		n2

Continued on next page

Table 12.42 – continued from previous page

Tag	Description	Values	Default
spline	Spline interpolation table for correction according to callibration sheet if any (leave blank if no callibration)		
setflow_factor	Callibration factor for settig flow		1
read_factor	Callibration factor for reading flow		1
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.42: Configuration tags for MFC device type 'Manual'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.5.2 Brooks

Tag	Description	Values	Default
mode	Device control mode	Automatic	Automatic

Continued on next page

Table 12.43 – continued from previous page

Tag	Description	Values	Default
tty	Communication device (ex. ttyS0)		ttyS0
channel	Tag number (ex 05691001), NB must be 8 digits!		00000000
calibrated_gas	The gas for which the maxflow is specified on the controler (usually nitrogen)	co2 ext_cathode d2 kr h2 n2o3 n20 ch4 backup ne no xe ar n2 co o2 chx n2_cathode no2 ext_anode he air o2_cathode	n2
calibrated_maxflow	Maximum flowrate for the callibrated gas (Note in L/hour!)		100
unit	Flow unit in which the controler reports the gas flow. MB This may be different than the unit the maxflow is given in!	L/s L/min L/hour mL/s mL/min mL/hour m3/s m3/min m3/hour	L/hour
gas	selected gas		n2

Continued on next page

Table 12.43 – continued from previous page

Tag	Description	Values	Default
relay	Bypass relay avaliable	YES NO	NO
relay_time	bypass relay engage time (seconds)		0
relay_name	Bypass relay name		
relay_type	bypass relay device type (used only if no relay name is specified)	ICP ICPDI ManualRelay Monostable Monostable–PWM	ICP
relay_tty	Bypass relay communication device (used only if no relay name is specified)		ttyS0
relay_address	Bypass relay address (used only if no relay name is specified)		1
relay_channel	bypass relay channel (used only if no relay name is specified)		0
output_control_relay	Switch controling if an external output control device is fitted (for instance a magnetic valve for forcing complete cutoff of gas)	YES NO	NO
control_relay_name	Cutoff relay name		
control_relay_type	Control relay device type (used only if no control relay name is specified)	ICP ICPDI ManualRelay Monostable Monostable–PWM	ICP
control_relay_tty	Control relay tty (used only if no control relay name is specified)		ttyS0
control_relay_address	Control relay address (used only if no control relay name is specified)		1
control_relay_channel	Control relay channel (used only if no control relay name is specified)		0

Continued on next page

Table 12.43 – continued from previous page

Tag	Description	Values	Default
gas_change	Gas change mode	Manual Automatic	Manual
gas_multiplexer	Name of gas multiplexer device if any		
gasses	Avaliable gasses, Must contain a comma separated list of gas names (device name!) that the MFC can be used to control (in case of no multiplexer, just the single gas connected).		n2
setflow_factor	Callibration factor for settig flow		1
read_factor	Callibration factor for reading flow		1
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
persistent_settings	Determines if the device should be queried each time for flow trange settings or if settings should be cached on disk. Default for Brooks MFCs are Yes as communication overhead usually becomes a problem (a single MFC require 1 second for initialisation otherwise)	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		

Continued on next page

Table 12.43 – continued from previous page

Tag	Description	Values	Default
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No** **Yes**	**No**

Table 12.43: Configuration tags for MFC device type 'Brooks'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.5.3 BrooksReadonly

Tag	Description	Values	Default
mode	**Device control mode**	**Automatic**	**Automatic**
tty	**Communication device (ex. ttyS0)**		**ttyS0**
channel	**Tag number (ex 05691001), NB must be 8 digits!**		**00000000**

Continued on next page

Table 12.44 – continued from previous page

Tag	Description	Values	Default
calibrated_gas	The gas for which the maxflow is specified on the controler (usually nitrogen)	co2 ext_cathode d2 kr h2 n2o3 n20 ch4 backup ne no xe ar n2 co o2 chx n2_cathode no2 ext_anode he air o2_cathode	n2
calibrated_maxflow	Maximum flowrate for the callibrated gas (Note in L/hour!)		100
unit	Flow unit in which the controler reports the gas flow. MB This may be different than the unit the maxflow is given in!	L/s L/min L/hour mL/s mL/min mL/hour m3/s m3/min m3/hour	L/hour
controler_mode	Controler mode of operation	Flowrate	Flowrate
gas	selected gas		n2
gas_change	Gas change mode	Manual Automatic	Manual

Continued on next page

Table 12.44 – continued from previous page

Tag	Description	Values	Default
gas_multiplexer	Name of gas multiplexer device if any		
gasses	Avaliable gasses, Must contain a comma separated list of gas names (device name!) that the MFC can be used to control (in case of no multiplexer, just the single gas connected).		n2
setflow_factor	Callibration factor for settig flow		1
read_factor	Callibration factor for reading flow		1
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
persistent_settings	Determines if the device should be queried each time for flow trange settings or if settings should be cached on disk. Default for Brooks MFCs are Yes as communication overhead usually becomes a problem (a single MFC require 1 second for initialisation otherwise)	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		

Continued on next page

Table 12.44 – continued from previous page

Tag	Description	Values	Default
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.44: Configuration tags for MFC device type 'BrooksReadonly'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.5.4 Analog

Tag	Description	Values	Default
mode	Device control mode	Automatic	Automatic
output_name	Name of analog output device (the RFCcontrol device controling the analog output to the physical MFC)		
output_type	Output device type (Only used if no output name)	ICP7024 ICP87024 ICP87028 ManualAnalogOut	ICP87024
address	Output device address (Only used if no output name)		1
control_channel	Output device channel (Only used if no output name)		0
tty	Output device communication device (Only used if no output name)		ttyS0
channel_name	Name of the analog input device (The RFCcontrol input device measuring the analog signal from the physical MFC)		

Continued on next page

Table 12.45 – continued from previous page

Tag	Description	Values	Default
channel_type	Input device type (used only if no channel name is specified)	Keithley Keithley580 ICP ICP7017/18 ICP7017ZW ICP7019 ModbusTCP Modbus PLCRead External Socket SOAP	Keithley
channel	Input device channel (used only if no channel name is specified)		1:101
channel_tty	Input device communication device (used only if no channel name is specified)		ttyS0
channel_address	Input device address (used only if no channel name is specified)		1
output_control_relay	Switch controling if an external output control device is fitted (for instance a magnetic valve for forcing complete cutoff of gas)	YES NO	NO
control_relay_name	Cutoff relay name		
control_relay_type	Control relay device type (used only if no control relay name is specified)	ICP ICPDI ManualRelay Monostable Monostable– PWM	ICP
control_relay_tty	Control relay tty (used only if no control relay name is specified)		ttyS0
control_relay_address	Control relay address (used only if no control relay name is specified)		1
control_relay_channel	Control relay channel (used only if no control relay name is specified)		0

Continued on next page

Table 12.45 – continued from previous page

Tag	Description	Values	Default
calibrated_gas	The gas for which the maxflow is specified on the controler (usually nitrogen)	co2 ext_cathode d2 kr h2 n2o3 n20 ch4 backup ne no xe ar n2 co o2 chx n2_cathode no2 ext_anode he air o2_cathode	n2
calibrated_maxflow	Maximum flowrate for the callibrated gas (Note in L/hour!)		100
accuracy	Accuracy of the flow rate in percent		1
output_range	Output range, note that this may be different than the range of the output device!	0-5V 1-5V 0-10V 2-10V 0-20mA 4-20mA	0-5V
use_underrange_cutoff	Allow the analog output to be set below the operational range in order to force the MFC to close completely	Yes No	Yes
gas	selected gas		n2

Continued on next page

Table 12.45 – continued from previous page

Tag	Description	Values	Default
relay	Bypass relay avaliable	YES NO	NO
relay_time	bypass relay engage time (seconds)		0
relay_name	Bypass relay name		
relay_type	bypass relay device type (used only if no relay name is specified)	ICP ICPDI ManualRelay Monostable Monostable– PWM	ICP
relay_tty	Bypass relay tty (used only if no relay name is specified)		ttyS0
relay_address	Bypass relay address (used only if no relay name is specified)		1
relay_channel	bypass relay channel (used only if no relay name is specified)		0
gas_change	Gas change mode	Manual Automatic	Manual
gas_multiplexer	Name of gas multiplexer device if any		
gasses	Avaliable gasses, Must contain a comma separated list of gas names (device name!) that the MFC can be used to control (in case of no multiplexer, just the single gas connected).		n2
setflow_factor	Callibration factor for settig flow		1
read_factor	Callibration factor for reading flow		1
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes

Continued on next page

Table 12.45 – continued from previous page

Tag	Description	Values	Default
use_cache	**Determines if persisten caching of read values is allowed**	**Yes** **No**	**No**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No** **Yes**	**No**

Table 12.45: Configuration tags for MFC device type 'Analog'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.5.5 AnalogReadonly

Tag	Description	Values	Default
mode	**Device control mode**	**Readonly**	**Readonly**
channel_name	**Name of the analog input device (The RFCcontrol input device measuring the analog signal from the physical MFC)**		
Continued on next page			

Table 12.46 – continued from previous page

Tag	Description	Values	Default
calibrated_gas	The gas for which the maxflow is specified on the controler (usually nitrogen)	co2 ext_cathode d2 kr h2 n2o3 n20 ch4 backup ne no xe ar n2 co o2 chx n2_cathode no2 ext_anode he air o2_cathode	n2
calibrated_maxflow	Maximum flowrate for the callibrated gas (Note in L/hour!)		100
accuracy	Accuracy of the flow rate in percent		
output_range	Output range, note that this may be different than the range of the output device!	0-5V 1-5V	0-5V
gas	selected gas		n2
gas_change	Gas change mode	Manual Automatic	Manual
gas_multiplexer	Name of gas multiplexer device if any		

Continued on next page

Table 12.46 – continued from previous page

Tag	Description	Values	Default
gasses	Avaliable gasses, Must contain a comma separated list of gas names (device name!) that the MFC can be used to control (in case of no multiplexer, just the single gas connected).		n2
read_factor	Callibration factor for reading flow		1
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.46: Configuration tags for MFC device type 'AnalogReadonly'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.5.6 MKS

Tag	Description	Values	Default
mode	Device control mode	Automatic	Automatic

Continued on next page

Table 12.47 – continued from previous page

Tag	Description	Values	Default
tty	Communication device (ex. ttyS0)		ttyS0
channel	Device address (ex 021), NB must be 3 digits! Note that address 254 and 255 are broadcast addresses (all MKS units will listen on those, but will only respond on 254)!		001
calibrated_gas	The gas for which the maxflow is specified on the controler (usually nitrogen)	co2 ext_cathode d2 kr h2 n2o3 n20 ch4 backup ne no xe ar n2 co o2 chx n2_cathode no2 ext_anode he air o2_cathode	n2
maxflow	Maximum flowrate for the selected gas (Note in L/hour!)		
unit	Flow unit in which the controler reports the gas flow. MB This may be different than the unit the maxflow is given in!		
gas	selected gas		n2

Continued on next page

Table 12.47 – continued from previous page

Tag	Description	Values	Default
relay	Bypass relay avaliable	YES NO	NO
relay_time	bypass relay engage time (seconds)		0
relay_name	Bypass relay name		
output_control_relay	Switch controling if an external output control device is fitted (for instance a magnetic valve for forcing complete cutoff of gas)	YES NO	NO
control_relay_name	Cutoff relay name		
gas_change	Gas change mode	Manual Automatic	Manual
gas_multiplexer	Name of gas multiplexer device if any		
gasses	Avaliable gasses, Must contain a comma separated list of gas names (device name!) that the MFC can be used to control (in case of no multiplexer, just the single gas connected).		n2
setflow_factor	Callibration factor for settig flow		1
read_factor	Callibration factor for reading flow		1
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No

Continued on next page

Table 12.47 – continued from previous page

Tag	Description	Values	Default
persistent_settings	**Determines wether or not settings such as callibrated gas should be cached (speeding up normal use) or queried each time**	**Yes** **No**	**No**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No** **Yes**	**No**

Table 12.47: Configuration tags for MFC device type 'MKS'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.5.7 MKSReadonly

Tag	Description	Values	Default
mode	**Device control mode**	**Automatic**	**Automatic**
tty	**Communication device (ex. ttyS0)**		**ttyS0**
channel	**Device address (ex 021), NB must be 3 digits! Note that address 254 and 255 are broadcast addresses (all MKS units will listen on those, but will only respond on 254)!**		**001**
Continued on next page			

Table 12.48 – continued from previous page

Tag	Description	Values	Default
calibrated_gas	The gas for which the maxflow is specified on the controler (usually nitrogen)	co2 ext_cathode d2 kr h2 n2o3 n20 ch4 backup ne no xe ar n2 co o2 chx n2_cathode no2 ext_anode he air o2_cathode	n2
maxflow	Maximum flowrate for the selected gas (Note in L/hour!)		
unit	Flow unit in which the controler reports the gas flow. MB This may be different than the unit the maxflow is given in!		
gas	selected gas		n2
gas_change	Gas change mode	Manual Automatic	Manual
gas_multiplexer	Name of gas multiplexer device if any		

Continued on next page

Table 12.48 – continued from previous page

Tag	Description	Values	Default
gasses	Avaliable gasses, Must contain a comma separated list of gas names (device name!) that the MFC can be used to control (in case of no multiplexer, just the single gas connected).		n2
setflow_factor	Callibration factor for settig flow		1
read_factor	Callibration factor for reading flow		1
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
persistent_settings	Determines wether or not settings such as callibrated gas should be cached (speeding up normal use) or queried each time	Yes No	No
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.48: Configuration tags for MFC device type 'MKSReadonly'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.5.8 Pc_ER3000

Tag	Description	Values	Default
mode	Device control mode	Automatic	Automatic
tty	Communication device (ex. ttyS0)		ttyS0
address	Device address (Default factory address on a ER3000 is 250)		1
minpressure	Minimum pressure (Note in barA, 1 BarA is atmospheric pressure!)		1
maxpressure	Maximum pressure (Note in barA, 1 barA is atmospheric pressure!)		101
gas	selected gas		n2
title	Optional title		
show_plot	Determines if the current device data is to be shown in the daily data plots	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.49: Configuration tags for MFC device type 'Pc_ER3000'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.5.9 Pc_Analog

Tag	Description	Values	Default
mode	**Device control mode**	**Automatic**	**Automatic**
range	**Input analog range**	**0-5V** **1-5V** **0-10V** **2-10V** **0-20mA** **4-20mA**	**0-5V**
input_name	**Input device name**		
output_name	**Output device name**		
output_range	**Output analog range**	**0-5V** **1-5V** **0-10V** **2-10V** **0-20mA** **4-20mA**	**0-5V**
minpressure	**Minimum pressure (Note in barA, 1 BarA is atmospheric pressure!)**		**1**
maxpressure	**Maximum pressure (Note in barA, 1 barA is atmospheric pressure!)**		**101**
gas	**selected gas**		**n2**
title	**Optional title**		
show_plot	**Determines if the current device data is to be shown in the daily data plots**	**Yes** **No**	**Yes**
use_cache	**Determines if persisten caching of read values is allowed**	**Yes** **No**	**No**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No** **Yes**	**No**

Table 12.50: Configuration tags for MFC device type 'Pc_Analog'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.5.10 Pc_AnalogReadonly

Tag	Description	Values	Default
mode	Device control mode	Automatic	Automatic
input_name	Input device name		
output_range	Output analog range	0-5V 1-5V 0-10V 2-10V 0-20mA 4-20mA	0-5V
minpressure	Minimum pressure (Note in barA, 1 BarA is atmospheric pressure!)		1
maxpressure	Maximum pressure (Note in barA, 1 barA is atmospheric pressure!)		101
gas	selected gas		n2
title	Optional title		
show_plot	Determines if the current device data is to be shown in the daily data plots	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.51: Configuration tags for MFC device type 'Pc_AnalogReadonly'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.5.11 Pc_Manual

Tag	Description	Values	Default
mode	Device control mode	Manual	Manual
minpressure	Minimum pressure (Note in barA, 1 BarA is atmospheric pressure!)		1
maxpressure	Maximum pressure (Note in barA, 1 barA is atmospheric pressure!)		101
gas	selected gas		n2
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.52: Configuration tags for MFC device type 'Pc_Manual'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.5.12 VacuumControl_RVC300

Tag	Description	Values	Default
mode	Device control mode	Automatic	Automatic
Continued on next page			

Table 12.53 – continued from previous page

Tag	Description	Values	Default
tty	**Communication device (ex. ttyS0)**		**ttyS0**
minpressure	**Minimum pressure (Note in barA = mbar /1000!)**		**0.001**
maxpressure	**Maximum pressure (Note in barA = mbar /1000!)**		**1.1**
gas	**selected gas**		**n2**
title	**Optional title**		
show_plot	**Determines if the current device data is to be shown in the daily data plots**	**Yes** **No**	**Yes**
use_cache	**Determines if persisten caching of read values is allowed**	**Yes** **No**	**No**
Controllertype	**Controller type setup: a number between: (1-99) = PI and a 0 = PID**		
Kp	**Gain Kp , Kontroller gain setting between 0.1 and 100.0**		
Tn	**Reset time between 0.0 and 3600.0 s.**		
Tv	**Derivative time between 0.0 and 3600.0 s.**		
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No** **Yes**	**No**

Table 12.53: Configuration tags for MFC device type 'VacuumControl_RVC300'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.6 Water

Water bubler devices are compound devices serving two distinct functions. The first is to measure the temperature of the water bubler (for dewpoint determinations) and the second function is to control/determine if the water bubler is enabled or bypassed. The first functions is performed using simpledevices similarly to the temperature log devices in section eftemplogdev and the second function is performed by using a relay device (refer section 12.2). Notice that if the channel device is already a temperature logging device, a lot of the additional tags is not used and can be left blank (In effect only the control device tags are used in this case).

All water devices supports the setstatus command which controls if the water bubler is enabled or not.

12.6.1 Water

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Manual
channel_name	Input device name, may be either a simple channel name or a temperature log device name (temperature log device recomended, will be prefixed with "Tlog_" in list)		
channel	Input channel (if no channel name)		1:101
channel_input_type	Input channel type (if no channel name)	Keithley Keithley580 ICP ICP7017/18 ICP7017ZW ICP7019 ModbusTCP Modbus PLCRead External Socket SOAP	Keithley
channel_tty	Input communication device (ex. ttyS0), used only if channel type is not Keithley		ttyS0

Continued on next page

Table 12.54 – continued from previous page

Tag	Description	Values	Default
channel_address	Input device address (if input type is not Keithley)		1
gas_stream	Name (label) of gas stream the device is attatched to, Used only for display / UI purposes		
type	Device type	pt100 pt1000	pt100
lead_res_name	Name of lead resistance input device		
lead_res	Lead resistance		1:101
lead_res_type	Lead resistance input type (if no lead resistance name)	fixed_value Keithley Keithley580 ICP ICP7017/18 ICP7017ZW ICP7019 ModbusTCP Modbus PLCRead External Socket SOAP	Fixed_value
lead_res_tty	Lead resistance communication device (If no lead resistance name and lead resistance type is not Keithley)		ttyS0
lead_res_address	Lead resistance device address (If no lead resistance name and lead resistance type is not Keithley)		1
lead_res_value	Value (if fixed) for lead resistance		0
control_relay_name	Device name for control relay (Used for controling if Water bubler device is enabled or bypassed)		
control_type	Device type for control relay (if no control relay name)	ICP ICPDI ManualRelay Monostable Monostable–PWM	ICP

Continued on next page

Table 12.54 – continued from previous page

Tag	Description	Values	Default
tty	**Serial device for contro relay communication (ex. ttyS0)**		
control_address	**Control relay device address, only used if no control relay name**		**1**
control_channel	**Control relay device channel, only used if no control relay name**		**0**
show_plot	**Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices**	**Yes** **No**	**Yes**
use_cache	**Determines if persisten caching of read values is allowed**	**Yes** **No**	**No**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No** **Yes**	**No**

Table 12.54: Configuration tags for water device type 'Humidifier'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.7 Gas

Gas devices are used for controling gas flows. Each gas supplied to the device and/or test setup in question must have its own gas device. Each gas device can be either manually controled or automatically controled. In the manual case (for instance safety rules may specify that purge gas flows be controled by manual ball flowmeters to be sure that the purge gas continues in case of poweroutages), the gas devicesimply stores the last entreed flow rate and returns that upon read. In the automatic case, the actual control device (a MFC device, refer section 12.5), is used and a read on the gas device forwards the read command to the control device.

All gas devices supports the setflow command to set the gas flow.

12.7.1 Normal gasses

Tag	Description	Values	Default
class	Device type	Normal Multiline	Normal
gas	Name of gas controlled by this device. Only rarely should this be set to anything other than the device name! If set to something else, problems may arise with gas multiplexer control if the control name (name of gas to be controled) is not the same as the eventuel gas name (intermediate device names may dffer however!)	co2 ext_cathode d2 kr h2 n2o3 n20 ch4 backup ne no xe ar n2 co o2 chx n2_cathode no2 ext_anode he air o2_cathode	n2
mode	Device control mode	Manual Automatic	Manual

Continued on next page

Table 12.55 – continued from previous page

Tag	Description	Values	Default
controler	Name of controler device (if any)	0	0
maxflow	Maximum flow rate (Note L/hour), only used for manual gasses		1
maxflow_set	Maximum allowable flow rate (l/hour)		0
cutoff_set	Cutoff flow rate (force close if set below this value)		0
cutoff_report	Cutoff flow rate for report generation, flows below this level is treated as 0		0
link	Optional gas device name for linking purposes, If a gas (parent) links to one or more other gas devices (childs) and the flow for one of the child devices is above the cutoff value, the flow rate reported by the parent device is set to 0 irrespectively of actual / assumed flow rate. Notice that by using links it is possible to configure circular references which must be awoided!		
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
control_name	Name of control valve device (relay) if any, used mainly if gas is part of a gas group		
control_value	Control valve relay status for allowing flow, used mainly if gas is part of a gas group		0
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device flow rate)		
slave_flow	Percentage of master device flow rate that current device is supposed to have		100

Continued on next page

Table 12.55 – continued from previous page

Tag	Description	Values	Default
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
include_tally	Indicates if the flow of this gas is to be included in any taly of gas use	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.55: Configuration tags for gas device type 'Gas'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.7.2 Multiline

Tag	Description	Values	Default
class	Device type	Normal Multiline	Multiline
mode	Device control mode	Manual Automatic	Automatic
device_1	Device name for first gas device		
device_2	Device name for first gas device		
maxflow	Maximum flow rate (l/hour), readonly		
maxflow_set	Maximum allowable flow rate (l/hour)		0
cutoff_set	Cutoff flow rate (force close if set below this value), readonly		0
cutoff_report	Cutoff flow rate for report generation, flows below this level is treated as 0		0

Continued on next page

Table 12.56 – continued from previous page

Tag	Description	Values	Default
shift_up	Flow level where control shifts from small to large device, default is maxflow of low flow device		1
shift_down	Flow level where control shifts from large to small device, default is 80 percent of maxflow of low flow device		0.8
steps	Number of steps in flow shift between devices		5
sleep	Wait time in seconds on each step in a shift between devices		1
link	Optional gas device name for linking purposes, If a gas (parent) links to an other gas device (child) and the flow for the child device is above the cutoff value, the flow rate reported by the parent device is set to 0 irrespectively of actual/assumed flow rate		
title	Optional title		
show_plot	Determines if the current device data is to be shown in the daily data plots	Yes No	Yes
control_name	Name of control valve device (relay) if any, used mainly if gas is part of a gas group		
control_value	control valve relay status for allowing flow, used mainly if gas is part of a gas group		0
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device flow rate)		
slave_flow	Percentage of master device flow rate that current device is supposed to have		100
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
include_tally	Indicates if the flow of this gas is to be included in any taly of gas use	Yes No	Yes

Continued on next page

Table 12.56 – continued from previous page

Tag	Description	Values	Default
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No** **Yes**	**No**

Table 12.56: Configuration tags for gas device type 'Multiline'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.8 Gasgroup

Gas groups are used for special confugrations of gas systems. If for istance two separate gas lines with the same gas supply are used but with a automatic cross-over walve for fast switching of gas flows, then the gas group can be used to log what the acutal gas flow through the device under test actually was.

For instance assuming that the gas devices o2_1 and o2_2 are each automatically controled and noe are set to 10 L/h and the other to 20 L/h and one wants to do a fast increase in O_2 flow rate, a cross ower valve (actually usually in the form of 4 valves, 2x NO and 2x NC in bridge configuration), then the gas group o2_group can be set to include o2_1 and o2_2 but each of them with different control values, so in one position, only the flow from o2_1 is included in the group value and o2_2 is used in the other.

12.8.1 ICP

Tag	Description	Values	Default
gasses	Names of gas devices included in gas group		
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.57: Configuration tags for gasgroup device type 'Gasgroup'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9 PSU

DC power supply devices are used for cotroling DC power supplies (including electronic loads). This may seem to overlab the analog output devices described in section efanalogdev. However, this overlap is intentional, as in theory a controlable DC powersuppy coudl be used as an analog output device, however in reality this us usually cost ineffective.

PSU devices supports the voltage and current commands, these commands control the DC voltage and current respectively. A special argument 'ocv' can be given to the voltage or current commands, specifying that the device should go to open circuit conditions (some devices supports this natively, others throgh an external relay).

12.9.1 ManualPSU

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Manual
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable–PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		

Continued on next page

Table 12.58 – continued from previous page

Tag	Description	Values	Default
slave_current	Percentage of master device current that this device is supposed to have		100
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.58: Configuration tags for PSU device type 'Manual PSU'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.2 SM_15_100

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1

Continued on next page

Table 12.59 – continued from previous page

Tag	Description	Values	Default
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable–PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		

Continued on next page

Table 12.59 – continued from previous page

Tag	Description	Values	Default
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.59: Configuration tags for PSU device type 'SM-15-100'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.3 SM_18_50

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable–PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0

Continued on next page

Table 12.60 – continued from previous page

Tag	Description	Values	Default
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.60: Configuration tags for PSU device type 'SM-18-50'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.4 SM_60_100

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial

Continued on next page

Table 12.61 – continued from previous page

Tag	Description	Values	Default
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable–PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes

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Table 12.61 – continued from previous page

Tag	Description	Values	Default
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No** **Yes**	**No**

Table 12.61: Configuration tags for PSU device type 'SM-60-100'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.5 SM_35_45

Tag	Description	Values	Default
mode	**Device control mode**	**Manual** **Automatic**	**Automatic**
communication	**Device communication**		**Serial**
tty	**Communication device**		**ttyS0**
address	**Device address**		**0**
serial	**Number of devices in serial (master + slaves)**		**1**
parallel	**Number of devices in parallel (master + slaves)**		**1**
external_RSD	**Existence of external remote shut down device (usually an external relay)**	**Yes** **No**	**No**
RSD_name	**Device name for remote shut down relay**		
RSD_type	**Device type for remote shutdown relay, only used if no RSD name**	**ICP** **ICPDI** **ManualRelay** **Monostable** **Monostable–PWM**	**ICP**
RSD_tty	**Communication device for remote shutdown relay, only used if no RSD name**		**ttyS0**

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Table 12.62 – continued from previous page

Tag	Description	Values	Default
RSD_address	**Remote shutdown relay address, only used if no RSD name**		**0**
RSD_channel	**Remote shutdown relay channel, only used if no RSD name**		**0**
control_mode	**determines if the set() function should control voltage or current**	**Voltage Current**	**Current**
master_device	**Device name for the master device in case current device is a slave device (locked to have X percent of master device current)**		
slave_current	**Percentage of master device current that this device is supposed to have**		**100**
slave_voltage	**Percentage of master device voltage that this device is supposed to have**		**100**
show_plot	**Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices**	**Yes No**	**Yes**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No Yes**	**No**

Table 12.62: Configuration tags for PSU device type 'SM-35-45'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.6 SM_52_30

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable–PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100
slave_voltage	Percentage of master device voltage that this device is supposed to have		100

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Table 12.63 – continued from previous page

Tag	Description	Values	Default
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.63: Configuration tags for PSU device type 'SM-52-30'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.7 SM_70_22

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		

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Table 12.64 – continued from previous page

Tag	Description	Values	Default
RSD_type	**Device type for remote shutdown relay, only used if no RSD name**	**ICP ICPDI ManualRelay Monostable Monostable– PWM**	**ICP**
RSD_tty	**Communication device for remote shutdown relay, only used if no RSD name**		**ttyS0**
RSD_address	**Remote shutdown relay address, only used if no RSD name**		**0**
RSD_channel	**Remote shutdown relay channel, only used if no RSD name**		**0**
control_mode	**determines if the set() function should control voltage or current**	**Voltage Current**	**Current**
master_device	**Device name for the master device in case current device is a slave device (locked to have X percent of master device current)**		
slave_current	**Percentage of master device current that this device is supposed to have**		**100**
slave_voltage	**Percentage of master device voltage that this device is supposed to have**		**100**
show_plot	**Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices**	**Yes No**	**Yes**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No Yes**	**No**

Table 12.64: Configuration tags for PSU device type 'SM-70-22'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.8 SM_120_13

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable–PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100

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Table 12.65 – continued from previous page

Tag	Description	Values	Default
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.65: Configuration tags for PSU device type 'SM-120-13'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.9 SM_300_5

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		

Continued on next page

Table 12.66 – continued from previous page

Tag	Description	Values	Default
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable– PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.66: Configuration tags for PSU device type 'SM-300-5'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.10 SM_30_200

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable–PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100

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Table 12.67 – continued from previous page

Tag	Description	Values	Default
slave_voltage	**Percentage of master device voltage that this device is supposed to have**		**100**
show_plot	**Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices**	**Yes** **No**	**Yes**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No** **Yes**	**No**

Table 12.67: Configuration tags for PSU device type 'SM-30-200'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.11 ES015_10

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable–PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100
slave_voltage	Percentage of master device voltage that this device is supposed to have		100

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Table 12.68 – continued from previous page

Tag	Description	Values	Default
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.68: Configuration tags for PSU device type 'ES015-10'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.12 ES030_5

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		

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Table 12.69 – continued from previous page

Tag	Description	Values	Default
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable– PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.69: Configuration tags for PSU device type 'ES030-5'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.13 ES075_2

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable–PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100

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Table 12.70 – continued from previous page

Tag	Description	Values	Default
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.70: Configuration tags for PSU device type 'ES075-2'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.14 ES0300_045

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		

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Table 12.71 – continued from previous page

Tag	Description	Values	Default
RSD_type	**Device type for remote shutdown relay, only used if no RSD name**	**ICP ICPDI ManualRelay Monostable Monostable– PWM**	**ICP**
RSD_tty	**Communication device for remote shutdown relay, only used if no RSD name**		**ttyS0**
RSD_address	**Remote shutdown relay address, only used if no RSD name**		**0**
RSD_channel	**Remote shutdown relay channel, only used if no RSD name**		**0**
control_mode	**determines if the set() function should control voltage or current**	**Voltage Current**	**Current**
master_device	**Device name for the master device in case current device is a slave device (locked to have X percent of master device current)**		
slave_current	**Percentage of master device current that this device is supposed to have**		**100**
slave_voltage	**Percentage of master device voltage that this device is supposed to have**		**100**
show_plot	**Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices**	**Yes No**	**Yes**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No Yes**	**No**

Table 12.71: Configuration tags for PSU device type 'ES0300-045'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.15 EL_9080_200

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable–PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100

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Table 12.72 – continued from previous page

Tag	Description	Values	Default
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.72: Configuration tags for PSU device type 'EL_9080-200_HP'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.16 EL_9160_100

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		

Continued on next page

Table 12.73 – continued from previous page

Tag	Description	Values	Default
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable– PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.73: Configuration tags for PSU device type 'EL_9160-100_HP'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.17 EL_9400_50

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable–PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100

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Table 12.74 – continued from previous page

Tag	Description	Values	Default
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.74: Configuration tags for PSU device type 'EL_9400-50'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.18 EL_9750_50

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		

Continued on next page

Table 12.75 – continued from previous page

Tag	Description	Values	Default
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable– PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.75: Configuration tags for PSU device type 'EL_9750-50'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.19 EL_9080_200_HP

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable–PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100

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Table 12.76 – continued from previous page

Tag	Description	Values	Default
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.76: Configuration tags for PSU device type 'EL_9080-200_HP'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.20 EL_9160_100_HP

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		

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Table 12.77 – continued from previous page

Tag	Description	Values	Default
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable– PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.77: Configuration tags for PSU device type 'EL_9160-100_HP'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.21 EL_9400_50_HP

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable–PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100
slave_voltage	Percentage of master device voltage that this device is supposed to have		100

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Table 12.78 – continued from previous page

Tag	Description	Values	Default
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.78: Configuration tags for PSU device type 'EL_9400-50_HP'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.22 EL_9750_50_HP

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		

Continued on next page

Table 12.79 – continued from previous page

Tag	Description	Values	Default
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable–PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.79: Configuration tags for PSU device type 'EL_9750-50-HP'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.23 EL_9080_600

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable–PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100

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Table 12.80 – continued from previous page

Tag	Description	Values	Default
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.80: Configuration tags for PSU device type 'EL_9080-600_HP'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.24 EL_9160_300

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		

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Table 12.81 – continued from previous page

Tag	Description	Values	Default
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable– PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.81: Configuration tags for PSU device type 'EL_9160-300_HP'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.25 EL_9400_150

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable–PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100

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Table 12.82 – continued from previous page

Tag	Description	Values	Default
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.82: Configuration tags for PSU device type 'EL_9400-150_HP'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.26 EL_9750_75

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		

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Table 12.83 – continued from previous page

Tag	Description	Values	Default
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable– PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.83: Configuration tags for PSU device type 'EL_9750-75'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.27 EL_9080_600_HP

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable–PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100

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Table 12.84 – continued from previous page

Tag	Description	Values	Default
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.84: Configuration tags for PSU device type 'EL_9080-600_HP'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.28 EL_9160_300_HP

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		

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Table 12.85 – continued from previous page

Tag	Description	Values	Default
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable–PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.85: Configuration tags for PSU device type 'EL_9160-300_HP'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.29 EL_9400_150_HP

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable–PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100

Continued on next page

Table 12.86 – continued from previous page

Tag	Description	Values	Default
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.86: Configuration tags for PSU device type 'EL_9400-150_HP'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.30 EL_9750_75_HP

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		

Continued on next page

Table 12.87 – continued from previous page

Tag	Description	Values	Default
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable– PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.87: Configuration tags for PSU device type 'EL_9750-75_HP'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.31 EL_3160_60A

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable–PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100
slave_voltage	Percentage of master device voltage that this device is supposed to have		100

Continued on next page

Table 12.88 – continued from previous page

Tag	Description	Values	Default
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.88: Configuration tags for PSU device type 'EL_3160-60A'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.32 EL_3400_25A

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		

Continued on next page

Table 12.89 – continued from previous page

Tag	Description	Values	Default
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable– PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.89: Configuration tags for PSU device type 'EL_3400-25A'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.33 EL_9080_200

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable–PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100

Continued on next page

Table 12.90 – continued from previous page

Tag	Description	Values	Default
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.90: Configuration tags for PSU device type 'EL_9080-200_HP'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.34 EL_9160_100

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		

Continued on next page

Table 12.91 – continued from previous page

Tag	Description	Values	Default
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable– PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.91: Configuration tags for PSU device type 'EL_9160-100_HP'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.35 EL_9400_50

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable–PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100

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Table 12.92 – continued from previous page

Tag	Description	Values	Default
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.92: Configuration tags for PSU device type 'EL_9400-50'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.36 EL_9400_50_S01

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		

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Table 12.93 – continued from previous page

Tag	Description	Values	Default
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable–PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.93: Configuration tags for PSU device type 'EL_9400-50 S01'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.37 EL_9750_25

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable–PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100

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Table 12.94 – continued from previous page

Tag	Description	Values	Default
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.94: Configuration tags for PSU device type 'EL_9750_25'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.38 EL_9080_400

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		

Continued on next page

Table 12.95 – continued from previous page

Tag	Description	Values	Default
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable– PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.95: Configuration tags for PSU device type 'EL_9080-400'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.39 EL_9160_200

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable–PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100

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Table 12.96 – continued from previous page

Tag	Description	Values	Default
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.96: Configuration tags for PSU device type 'EL_9160-100'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.40 EL_9400_100

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		

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Table 12.97 – continued from previous page

Tag	Description	Values	Default
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable– PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.97: Configuration tags for PSU device type 'EL_9400-100'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.41 EL_9400_100_S01

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable–PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100
slave_voltage	Percentage of master device voltage that this device is supposed to have		100

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Table 12.98 – continued from previous page

Tag	Description	Values	Default
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.98: Configuration tags for PSU device type 'EL_9400-100 S01'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.42 EL_9750_50

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
address	Device address		0
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		

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Table 12.99 – continued from previous page

Tag	Description	Values	Default
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable– PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.99: Configuration tags for PSU device type 'EL_9750-50'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.43 PSU_Bipolar

Tag	Description	Values	Default
mode	**Device control mode**	**Automatic**	**Automatic**
PSU_device	**Device for controling current in electrolyser mode (negative current)**		
Eload_device	**Device for controling current in fuel cell mode (positive current)**		
control_mode	**determines if the set() function should control voltage or current**	**Voltage Current**	**Current**
show_plot	**Determines if the current device data is to be shown in the daily data plots**	**Yes No**	**Yes**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No Yes**	**No**

Table 12.100: Configuration tags for PSU device type 'PSU_Bipolar'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.44 PSU_B2N

Tag	Description	Values	Default
mode	**Device control mode**	**Automatic**	**Automatic**
PSU_device	**Bipolar power supply device**		
control_mode	**determines if the set() function should control voltage or current**	**Voltage Current**	**Current**

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Table 12.101 – continued from previous page

Tag	Description	Values	Default
show_plot	Determines if the current device data is to be shown in the daily data plots	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.101: Configuration tags for PSU device type 'PSU_B2N'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.45 PSU_N2B

Tag	Description	Values	Default
mode	Device control mode	Automatic	Automatic
PSU_device	Power supply device		
relay_device	Relay device controling the direction of curent for the underlying PSU device		
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
show_plot	Determines if the current device data is to be shown in the daily data plots	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

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Table 12.102 – continued from previous page

Tag	Description	Values	Default

Table 12.102: Configuration tags for PSU device type 'PSU_N2B'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.46 Kepco_BOP_50_20MG

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication	GPIB	
address	Device address		6
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		
RSD_type	Device type for remote shutdown relay, only used if no RSD name	ICP ICPDI ManualRelay Monostable Monostable–PWM	ICP
RSD_tty	Communication device for remote shutdown relay, only used if no RSD name		ttyS0
RSD_address	Remote shutdown relay address, only used if no RSD name		0
RSD_channel	Remote shutdown relay channel, only used if no RSD name		0
control_mode	determines if the set() function should control voltage or current	Voltage Current	Voltage

Continued on next page

Table 12.103 – continued from previous page

Tag	Description	Values	Default
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
title	Optional device title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.103: Configuration tags for PSU device type 'BOP-50-200MG'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.47 Keithley2400

Tag	Description	Values	Default
mode	Device control mode. If set to 'hidden' it will not show up as a controlable device in the GUI. However it will still be available through other devices such as PSU_B2N	Normal hidden	Normal

Continued on next page

Table 12.104 – continued from previous page

Tag	Description	Values	Default
communication	Device connunication	GPIB 488.1	GPIB 488.1
address	Device address		1
PSU_mode	Mode of operation (determines if the device should act as a constant current source or a constant voltage source)	CC CV	CC
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.104: Configuration tags for PSU device type 'keithley2400'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.48 PSUMulti

Tag	Description	Values	Default
class	Device type	Normal PSUMulti	PSUMulti
mode	Device control mode	Automatic	Automatic
device_1	Name of low range PSU device		
device_2	Name of high range PSU device		
cutoff_device_1	curent for device 1 below which the current is defined to be 0 (OCV)		0
cutoff_device_2	curent for device 2 below which the current is defined to be 0 (OCV)		0
minvoltage			
maxvoltage			
mincurrent			
maxcurrent			
shift_up	Flow level where control shifts from small to large device, default is maxcurrent of low range device		1
shift_down	Flow level where control shifts from large to small device, default is 80 percent of maxcurrent of low range device		0.8
steps	Number of steps in current shift between devices		1
sleep	Wait time in seconds on each step in a shift between devices		1
control_mode	determines if the set() function should control voltage or current	Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100
slave_voltage	Percentage of master device voltage that this device is supposed to have		100

Continued on next page

Table 12.105 – continued from previous page

Tag	Description	Values	Default
show_plot	Determines if the current device data is to be shown in the daily data plots	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.105: Configuration tags for PSU device type 'PSUMulti'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.49 BKPrecision

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication	USB RS232	USB
tty	Communication device		ttyS0
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		
control_mode	determines if the set() function should control voltage or current	Voltage Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100

Continued on next page

Table 12.106 – continued from previous page

Tag	Description	Values	Default
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.106: Configuration tags for PSU device type 'BK Precision'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.50 Hocherl_ZS

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Automatic
communication	Device communication		Serial
tty	Communication device		ttyS0
baudrate	Baud rate	4800 9600 14400 19200 28800 38400 57600	9600
parity	Parity check scheme	even odd	even
databits	Data bits	7 8	8

Continued on next page

Table 12.107 – continued from previous page

Tag	Description	Values	Default
stopbits	Stop bits	1 2	2
serial	Number of devices in serial (master + slaves)		1
parallel	Number of devices in parallel (master + slaves)		1
external_RSD	Existence of external remote shut down device (usually an external relay)	Yes No	No
RSD_name	Device name for remote shut down relay		
control_mode	determines if the set() function should control voltage or current	Current	Current
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
slave_current	Percentage of master device current that this device is supposed to have		100
slave_voltage	Percentage of master device voltage that this device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.107: Configuration tags for PSU device type 'Hocherl and hackl ZS Eloads'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.9.51 HMP

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Manual
communication	Device communication		Serial
tty	Communication device		ttyS0
channel	Physical channel of the device	1 2 3 4	1
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device current)		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.108: Configuration tags for PSU device type 'HMP'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.10 Analog

Analog output devices are used for instances where a specific control device needs an analog voltage for actual control. This is usually mass flow controlers, but other devices could also utilise this.

Analog output devices supports the set() command to set the output voltage or current.

12.10.1 ICP7024

Tag	Description	Values	Default
mode	Device control mode	Automatic	Volt
tty	Serial device for communication (ex ttyS0)		ttyS0
address	Device address		0
channel	Device channel		0
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
persistent_settings	Determines wether or not settings should be cached on file (speeding up normal use) or queried each time	Yes No	No
CRC	Determines if checksum is to be used for serial communication	No Yes	No
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.109: Configuration tags for analog device type 'AnalogICP87024'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.10.2 ICP87024

Tag	Description	Values	Default
mode	Device control mode	Automatic	Volt
tty	Serial device for communication (ex ttyS0)		ttyS0
address	Device address		0
channel	Device channel		0
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
persistent_settings	Determines wether or not settings should be cached on file (speeding up normal use) or queried each time	Yes No	No
CRC	Determines if checksum is to be used for serial communication	No Yes	No
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.110: Configuration tags for analog device type 'AnalogICP87024'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.10.3 ICP87028

Tag	Description	Values	Default
mode	Device control mode	Automatic	Volt
tty	Serial device for communication (ex ttyS0)		ttyS0
address	Device address		0
channel	Device channel		0
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
persistent_settings	Determines wether or not settings should be cached on file (speeding up normal use) or queried each time	Yes No	No
CRC	Determines if checksum is to be used for serial communication	No Yes	No
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.111: Configuration tags for analog device type 'AnalogICP87028'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.10.4 ManualAnalogOut

Tag	Description	Values	Default
mode	Device control mode	Volt/mA	Volt/mA
title	Optional title		

Continued on next page

Table 12.112 – continued from previous page

Tag	Description	Values	Default
show_plot	**Determines if the current device data is to be shown in the daily data plots**	**Yes** **No**	**Yes**
use_cache	**Determines if persisten caching of read values is allowed**	**Yes** **No**	**No**
min			**-1e+100**
max			**1e+100**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No** **Yes**	**No**

Table 12.112: Configuration tags for analog device type 'ManualAnalogOut'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.11 Multiplex

Gas multiplexer devices are used in the case that multiple gas strings are used sequentially by the same mass flow controler (this is usually done to save cost) A multiplexer device thus connects several gas devices to a MFC device.

Multiplexer devices supports the set command to set the currently selected gas. If the multiplexer is manually controler, then the user must make sure that whenever he/she changes either the valve status or the multiplexer status, that the other is kept in sync!. In case of automatically controled multiplexers, relay devices (refer section 12.2) handles the gas selection.

12.11.1 Relay

Tag	Description	Values	Default
type		Relay VICI Slave Selector	
mode	Device control mode	Manual Automatic	Automatic
tty	Device communication device (ex. ttyS0)		ttyS0
address	Device address		0
control_type	Device control type	ICP ICPDI ManualRelay Monostable Monostable– PWM	ICP
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
label	As multiplexers can only have integers as name this tag can be used to give the device a meaningfull name		

Continued on next page

Table 12.113 – continued from previous page

Tag	Description	Values	Default
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.113: Configuration tags for multiplex device type 'Gas multiplexer'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.11.2 VICI

Tag	Description	Values	Default
type		Relay VICI Slave Selector	
tty	Device communication device (ex. ttyS0)		ttyS0
communication	Device communication protocol	RS232 RS485	RS485
baudrate	Communication speed	4800 9600 19200 38400 57600 115200	4800
address	Device address		Z
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No

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Table 12.114 – continued from previous page

Tag	Description	Values	Default
label	As multiplexers can only have integers as name this tag can be used to give the device a meaningfull name		
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.114: Configuration tags for multiplex device type 'VICI'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.11.3 Slave

Tag	Description	Values	Default
type		Relay VICI Slave Selector	
mode	Device control mode	Manual Automatic	Automatic
title	Optional title		
master_device			
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
use_cache	Determines if persisten caching of read values is allowed	Yes No	No
label	As multiplexers can only have integers as name this tag can be used to give the device a meaningfull name		

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Table 12.115 – continued from previous page

Tag	Description	Values	Default
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.115: Configuration tags for multiplex device type 'Slave multiplexer'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.11.4 Selector

Tag	Description	Values	Default
type		Relay VICI Slave Selector	
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
positions	Number of positions	2 3 4 5 6 7 8 9	2
label	As multiplexers can only have integers as name this tag can be used to give the device a meaningfull name		

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Table 12.116 – continued from previous page

Tag	Description	Values	Default
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No** **Yes**	**No**

Table 12.116: Configuration tags for multiplex device type ". An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.12 Filter

Filter devices are a special group of devices. The individual filter devices are used as a filter between other devices. The filter devices work by passing all commands to the filtered device but running the result of a read operation on a filtered device through the filter specified by the filter device (usually a spline interpolation).

The Filter device type 'spline' contains a special setting variable called 'spline'. It is intended to be used in case the base device output (read) is to be corrected according to a spline interpolation table. The format of the setting is a list of values as shown below:

```
0 0
1 1.2
2 2.1
3 3
4 3.9
```

If the field is left blank, no correction is atempted and the reported value is used as is, but in which case the use of the filter device is somewhat pointless.

A final special filter device is teh Typecast device. This device can be used to convert commands from one device type to another. Notice however that the typecast device class is limited in scope and not all callable functions on the soruce type may be possible to convert to the target type. As a general rule, only one callable function (usually the 'set' command) can be called on the target type.

12.12.1 Input_spline

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	
spline	Spline table		

Continued on next page

Table 12.117 – continued from previous page

Tag	Description	Values	Default
device_type	Type of raw device	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert	simplechannel
device	Raw device		
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
read_function	Device function to use for read operations	read	read
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.117: Configuration tags for filter device type 'Input_spline_device'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.12.2 Output_spline

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	
spline	Spline table		
device_type	Type of raw device	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert	analog
device	Raw device		
device_set_function	Function to call on the encapsulated device. If no functin name is specified all calls will be forwarded to the set or setflow command.		
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes

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Table 12.118 – continued from previous page

Tag	Description	Values	Default
master_device_type	Device type for the master device in case current device is a slave device (locked to have X percent of master device setpoint)	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert	
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device setpoint)		
master_set_function	Function which triggers a forward response. If no functin name is specified all calls will be forwarded.		
slave_flow	Percentage of master device setpoint that current device is supposed to have		100
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.118: Configuration tags for filter device type 'Output_spline_device'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.12.3 IO_spline

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	
input_spline	Spline table used for read operation		
output_spline	Spline table used for set operation		
device_type	Type of raw device	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert	analog
device	Raw device		
device_set_function	Function to call on the encapsulated device. If no functin name is specified all calls will be forwarded to the set or setflow command.		
title	Optional title		
read_function	Device function to use for read operations	read	read

Continued on next page

Table 12.119 – continued from previous page

Tag	Description	Values	Default
master_device_type	Device type for the master device in case current device is a slave device (locked to have X percent of master device setpoint)	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert	
master_device	Device name for the master device in case current device is a slave device (locked to have X percent of master device setpoint)		
master_set_function	Function which triggers a forward response. If no functin name is specified all calls will be forwarded.		
slave_flow	Percentage of master device setpoint that current device is supposed to have		100
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		

Continued on next page

Table 12.119 – continued from previous page

Tag	Description	Values	Default
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No** **Yes**	**No**

Table 12.119: Configuration tags for filter device type 'IO_spline_device'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.12.4 Y-split

Tag	Description	Values	Default
mode	**Device control mode**	**Automatic**	
control_device	**Relay device for controlling which device is used**		
device_type	**Type of raw device to control**	**simplechannel** **relay** **templog** **tempcontrol** **MFC** **water** **gas** **gasgroup** **PSU** **analog** **multiplex** **PID** **logic** **math** **Alert**	**simplechannel**
input_device	**Optional input device. If it exists, commands from the input device is passed on to one of the output devices**		
device_1	**Device selected if control device is off (0)**		

Continued on next page

Table 12.120 – continued from previous page

Tag	Description	Values	Default
device_2	**Device selected if control device is on (1)**		
title			
show_plot	**Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices**	**Yes** **No**	**Yes**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No** **Yes**	**No**

Table 12.120: Configuration tags for filter device type 'Y-split_filter_device'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.12.5 Schmidttrigger

Tag	Description	Values	Default
mode	**Device control mode**	**Manual** **Automatic**	**Readonly**

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Table 12.121 – continued from previous page

Tag	Description	Values	Default
device_type	Type of raw device	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert	simplechannel
device	Raw device		
shift_up	Threshold above wich the trigger is on		0.6
shift_down	Threshold below which the trigger is off		0.4
reverse_output	Indicates if the locgical output state should be reversed	Yes No	No
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

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Table 12.121 – continued from previous page

Tag	Description	Values	Default

Table 12.121: Configuration tags for filter device type 'Schmidt trigger latch'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.12.6 Sum

Tag	Description	Values	Default
mode	**Device control mode**	**Manual** **Automatic**	
device_type	**Device type**	**simplechannel** **relay** **templog** **tempcontrol** **MFC** **water** **gas** **gasgroup** **PSU** **analog** **multiplex** **PID** **logic** **math** **Alert**	**simplechannel**
offset	**Numeric offset of the output (added to the sum of the inputs)**		**0**
inputs	**number of inputs**	**2** **3** **4** **5** **6** **7** **8** **9**	**2**

Continued on next page

Table 12.122 – continued from previous page

Tag	Description	Values	Default
output_device	Output device (optional if current device is used in a control chain)		
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
read_function	Device function to use for read operations	read	read
input_device_0	Input device 0		
input_device_factor_0	Input device 0 factor (multiplied on input device read value before summing)		1
input_device_1	Input device 1		
input_device_factor_1	Input device 1 factor (multiplied on input device read value before summing)		1
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.122: Configuration tags for filter device type 'Summing device'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.12.7 Min

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	
device_type	Device type	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert	simplechannel
inputs	number of inputs	2 3 4 5 6 7 8 9	2
output_device	Output device (optional if current device is used in a control chain)		
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
read_function	Device function to use for read operations	read	read
input_device_0	Input device 0 factor (multiplied on input device read value before determining minimum)		

Continued on next page

Table 12.123 – continued from previous page

Tag	Description	Values	Default
input_device_factor_0	**Input device 0 factor (multiplied on input device read value before summing)**		**1**
input_device_1	**Input device 1 factor (multiplied on input device read value before determining minimum)**		
input_device_factor_1	**Input device 1 factor (multiplied on input device read value before summing)**		**1**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No** **Yes**	**No**

Table 12.123: Configuration tags for filter device type 'Minimum device'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.12.8 Redundancy

Tag	Description	Values	Default
mode	**Device control mode**	**Manual** **Automatic**	**Redundancy**

Continued on next page

Table 12.124 – continued from previous page

Tag	Description	Values	Default
inputs	number of inputs	2 3 4 5 6 7 8 9 10 11	3
device_type	Type of raw device	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert	simplechannel
maximum_bad	Number of inputs which can have values outside range before bool() returns false	0 1	0
limit	Maximum deviation from the mean of the rest of the inputs an input may have		0
input_device_0	Input device 0		
input_device_1	Input device 1		
input_device_2	Input device 2		
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		

Continued on next page

Table 12.124 – continued from previous page

Tag	Description	Values	Default
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No** **Yes**	**No**

Table 12.124: Configuration tags for filter device type 'Redundancy filter'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.12.9 Max

Tag	Description	Values	Default
mode	**Device control mode**	**Manual** **Automatic**	
device_type	**Device type**	**simplechannel** **relay** **templog** **tempcontrol** **MFC** **water** **gas** **gasgroup** **PSU** **analog** **multiplex** **PID** **logic** **math** **Alert**	**simplechannel**
inputs	**number of inputs**	**2** **3** **4** **5** **6** **7** **8** **9**	**2**

Continued on next page

Table 12.125 – continued from previous page

Tag	Description	Values	Default
output_device	Output device (optional if current device is used in a control chain)		
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
read_function	Device function to use for read operations	read	read
input_device_0	Input device 0 factor (multiplied on input device read value before determining maximum)		
input_device_factor_0	Input device 0 factor (multiplied on input device read value before summing)		1
input_device_1	Input device 1 factor (multiplied on input device read value before determining maximum)		
input_device_factor_1	Input device 1 factor (multiplied on input device read value before summing)		1
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.125: Configuration tags for filter device type 'Maximum device'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.12.10 Lowpass

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Readonly
device_type	Type of raw device	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert	simplechannel
device	Raw device		
time_constant	Time constant in seconds		10
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.126: Configuration tags for filter device type 'Low pass filter'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.12.11 Moving_average

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Readonly
device_type	Type of raw device	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert	simplechannel
device	Raw device		
interval_type	Determines if interval is in number of measruements or a time interval	Measurements Time interval	Measurements
interval	Number of readings to aveage over	3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20	5

Continued on next page

Table 12.127 – continued from previous page

Tag	Description	Values	Default
method	**Averaging method, The median method often gives better noise rejection than simple arithmetic mean**	**Mean Median**	**Mean**
min	**Only values above the min value will be considered for average calculation, if no min value is set, no minimum limit is enforced**		
max	**Only values below the max value will be considered for average calculation, if no max value is set, no maximum limit is enforced**		
read_function	**Device function to use for read operations**	**read**	**read**
title	**Optional title**		
show_plot	**Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices**	**Yes No**	**Yes**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No Yes**	**No**

Table 12.127: Configuration tags for filter device type 'Moving_average'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.12.12 Circular_average

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	Readonly
device_type	Type of raw device	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert	simplechannel
device	Raw device		
interval_type	Determines if interval is in number of measruements or a time interval	Measurements Time interval	Measurements
interval	Number of readings to aveage over	3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20	5
data_type	Specify if data is in radians or degrees	Radian Degree	Radian

Continued on next page

Table 12.128 – continued from previous page

Tag	Description	Values	Default
read_function	**Device function to use for read operations**	**read**	**read**
title	**Optional title**		
show_plot	**Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices**	**Yes** **No**	**Yes**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No** **Yes**	**No**

Table 12.128: Configuration tags for filter device type 'Circular_average'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.12.13 Derivative

Tag	Description	Values	Default
mode	**Device control mode**	**Manual** **Automatic**	**Readonly**

Continued on next page

Table 12.129 – continued from previous page

Tag	Description	Values	Default
device_type	Type of raw device	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert	simplechannel
device	Raw device		
interval_type	Determines if interval is in number of measruements or a time interval	Measurements Time interval	Measurements
interval	Number of readings to iterate over	3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20	5
unit	Scaling factor	/s /min /hour	/s

Continued on next page

Table 12.129 – continued from previous page

Tag	Description	Values	Default
read_function	**Device function to use for read operations**	**read**	**read**
title	**Optional title**		
show_plot	**Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices**	**Yes** **No**	**Yes**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No** **Yes**	**No**

Table 12.129: Configuration tags for filter device type 'Derivative'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.12.14 Integrator

Tag	Description	Values	Default
mode	**Device control mode**	**Manual** **Automatic**	**Readonly**

Continued on next page

Table 12.130 – continued from previous page

Tag	Description	Values	Default
device_type	Type of raw device	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert	simplechannel
device	Raw device		
read_function	Device function to use for read operations	read	read
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.130: Configuration tags for filter device type 'Integrator'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.12.15 Typecast

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	
device_type	Type of raw device	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert	simplechannel
device	Raw device		
output_type	Type of device to convert to	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert	gas
output_device	Optional output device		
notify_function	Function to call on the output device and any listening devices if a notify event is called on current device		set

Continued on next page

Table 12.131 – continued from previous page

Tag	Description	Values	Default
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	Yes

Table 12.131: Configuration tags for filter device type 'Typecast_device'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.12.16 Typecast_PSU_to_gas

Tag	Description	Values	Default
mode	Device control mode	Manual Automatic	
device	Raw device		
output_device	Optional output device		
title			
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	Yes

Continued on next page

Table 12.132 – continued from previous page

Tag	Description	Values	Default

Table 12.132: Configuration tags for filter device type 'Typecast_device_Faraday'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.12.17 Truncate

Tag	Description	Values	Default
mode	**Device control mode**	**Manual Automatic**	**Readonly**
device_type	**Type of raw device**	**simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert**	**simplechannel**
device	**Raw device**		
interval_type	**Timestamp to truncate data to**	**Minute Hour Day Week Month**	**Hour**
interval	**Number of hours or days etc, Note only integers allowed!**		**1**
offset	**Time offset (in units of the interval)**		**0**

Continued on next page

Table 12.133 – continued from previous page

Tag	Description	Values	Default
read_function	**Device function to use for read operations**	**read**	**read**
title	**Optional title**		
show_plot	**Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices**	**Yes** **No**	**Yes**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No** **Yes**	**No**

Table 12.133: Configuration tags for filter device type 'Data truncate'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.12.18 Integer

Tag	Description	Values	Default
mode	**Device control mode**	**Manual** **Automatic**	**Readonly**

Continued on next page

Table 12.134 – continued from previous page

Tag	Description	Values	Default
device_type	Type of raw device	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert	simplechannel
device	Raw device		
read_function	Device function to use for read operations	read	read
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	Yes

Table 12.134: Configuration tags for filter device type 'Integer'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.12.19 Constant

Tag	Description	Values	Default
output_type	**Type of device to convert to**	**simplechannel** **relay** **templog** **tempcontrol** **MFC** **water** **gas** **gasgroup** **PSU** **analog** **multiplex** **PID** **logic** **math** **Alert**	**gas**
value			
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		

Table 12.135: Configuration tags for filter device type 'Constant value'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.12.20 Input_multiplex

Tag	Description	Values	Default
mode	**Device control mode**	**Manual** **Automatic**	
Continued on next page			

Table 12.136 – continued from previous page

Tag	Description	Values	Default
device_type	Device type	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert	simplechannel
inputs	number of inputs	2 3 4 5 6 7 8 9	2
control_device_type	Device type for control device	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert	simplechannel
control_device	Device used for selecting input		

Continued on next page

Table 12.136 – continued from previous page

Tag	Description	Values	Default
title	**Optional title**		
show_plot	**Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices**	**Yes** **No**	**Yes**
read_function	**Device function to use for read operations**	**read**	**read**
input_device_0	**Input device 0**		
input_device_1	**Input device 1**		
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No** **Yes**	**No**

Table 12.136: Configuration tags for filter device type 'Input multiplex filter'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.12.21 Output_multiplex

Tag	Description	Values	Default
mode	**Device control mode**	**Manual** **Automatic**	
device_type	**Device type**	**simplechannel** **relay** **templog** **tempcontrol** **MFC** **water** **gas** **gasgroup** **PSU** **analog** **multiplex** **PID** **logic** **math** **Alert**	**simplechannel**
outputs	**number of outputs**	**2** **3** **4** **5** **6** **7** **8** **9**	**2**

Continued on next page

Table 12.137 – continued from previous page

Tag	Description	Values	Default
control_device_type	Device type for control device	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert	simplechannel
control_device	Device used for selecting input		
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
read_function	Device function to use for read operations	read	read
allow_override	Allow direct commands to multiplexed devices	No Yes	No
output_device_0	Output device 0		
output_device_1	Output device 1		
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Continued on next page

Table 12.137 – continued from previous page

Tag	Description	Values	Default

Table 12.137: Configuration tags for filter device type 'Output multiplex filter'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.13 PID

PID devices are virtual devices used for more complex process control than normally avaliable with fixed setpoints. The devices implement the normal behaviour of a PID controler but uses other RFCcontrol devices for input and output.

12.13.1 PID

Tag	Description	Values	Default
P	Proportional gain		0.8
I	Integrator gain		0.3
D	Differential gain		0.1
intwindup	Maximum integrated error		10
deadband	Deadband, whenever the absolute error is less than this no change in ouptut is made (determined before error gain is applied!). Note that the deadband should not be set to a value less than the accuracy of the sensor measuring the actual value (and hence the error)!		0
cutoff	Maximum error that will result in an iteration. If the error is greater than this value, no iteration will occour (similar to the deadband, except for large errors). If no value is specified, this feature is disabled (Default)		0
min	minimum allowed output (check that it is greater than output device minimum output!)		0
max	maximum allowed output (check that it is less than output device maximum output!)		1

Continued on next page

Table 12.138 – continued from previous page

Tag	Description	Values	Default
sensor_type	Device type of the sensing device	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex filter PID logic math Alert Adapter	simplechannel
sensor_device	Device name of sensing device		
control_type	Device type of the controlled device	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex filter PID logic math Alert Adapter	gas
control_device	Device name of controlled device. Dhe device instance must support the set() member function!		

Continued on next page

Table 12.138 – continued from previous page

Tag	Description	Values	Default
allow_override	Allow controlled device to be controlled directly from the GUI	Yes No	No
error_gain	Factor multiplied on the error. Used to keep the error values within the most optimum range. For RFC devices with long time constants usually a value of 0.01 should be chosen. Note that error_gain can be used to invert the output by changing the sign.		0.1
fast	Determines if the PID control loop is running as fast as possible (Yes) or only with one iteratoion / minute (No)	Yes No	No
output_enabled	Determines if each call to out() or control() should result in commands passed to the output device (closed loop) or merely result in an iteration and resulting update of the integrated error (open loop). Setting this to No is usefull for calibration / configuration / testing purposes	Yes No Relay	Yes
output_enable_input	relay device determining if output is enabled or not		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes

Continued on next page

Table 12.138 – continued from previous page

Tag	Description	Values	Default
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No** **Yes**	**No**

Table 12.138: Configuration tags for PID device type 'RFCPID'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.13.2 LinearApproach

Tag	Description	Values	Default
P	**Proportional gain**		**0.8**
I	**Integrator gain**		**0.3**
D	**Differential gain**		**0.1**
intwindup	**Maximum integrated error**		**10**
deadband	**Deadband, whenever the absolute error is less than this no change in ouptut is made (determined before error gain is applied!). Note that the deadband should not be set to a value less than the accuracy of the sensor measuring the actual value (and hence the error)!**		**0**

Continued on next page

Table 12.139 – continued from previous page

Tag	Description	Values	Default
cutoff	Maximum error that will result in an iteration. If the error is greater than this value, no iteration will occour (similar to the deadband, except for large errors). If no value is specified, this feature is disabled (Default)		0
min	minimum allowed output (check that it is greater than output device minimum output!)		0
max	maximum allowed output (check that it is less than output device maximum output!)		1
sensor_type	Device type of the sensing device	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex filter PID logic math Alert Adapter	simplechannel
sensor_device	Device name of sensing device		

Continued on next page

Table 12.139 – continued from previous page

Tag	Description	Values	Default
control_type	Device type of the controlled device	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex filter PID logic math Alert Adapter	gas
control_device	Device name of controlled device. Dhe device instance must support the set() member function!		
allow_override	Allow controlled device to be controlled directly from the GUI	Yes No	No
error_gain	Factor multiplied on the error. Used to keep the error values within the most optimum range. For RFC devices with long time constants usually a value of 0.01 should be chosen. Note that error_gain can be used to invert the output by changing the sign.		0.1
fast	Determines if the PID control loop is running as fast as possible (Yes) or only with one iteratoion / minute (No)	Yes No	No

Continued on next page

Table 12.139 – continued from previous page

Tag	Description	Values	Default
output_enabled	Determines if each call to out() or control() should result in commands passed to the output device (closed loop) or merely result in an iteration and resulting update of the integrated error (open loop). Setting this to No is usefull for calibration / configuration / testing purposes	Yes No Relay	Yes
output_enable_input	relay device determining if output is enabled or not		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		
disable_readstring	Determines if readstring should always return the empty string (only relevant for enabled devices)	No Yes	No

Table 12.139: Configuration tags for PID device type 'RFCPID'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.14 Logic

Logic devices are virtual logical devices used for more complex process control. The devices implement the normal behaviour of the usual logical operators AND, OR, XOR etc. A logic device can operate with relay, logic or schmidt trigger devices as inputs. The individual logic devices uses short circuit evaluation where appropriate.

Notice that all logic devices return undefined if the readstring function is called as they are virtual devices not intended for data logging but only for process control.

12.14.1 AND

Tag	Description	Values	Default
mode	Device control mode	Logic	Logic
inputs	number of inputs	2 3 4 5 6 7 8 9	2
output_device	Relay device for output (optional if current device is used in a logic chain)		
input_device_0	Input device 0		
reverse_input_0	Indicates if value of input 0 should be inverted before logic operation	No Yes	No
input_device_1	Input device 1		
reverse_input_1	Indicates if value of input 1 should be inverted before logic operation	No Yes	No
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		

Table 12.140: Configuration tags for logic device type 'AND logic device'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.14.2 OR

Tag	Description	Values	Default
mode	Device control mode	Logic	Logic
inputs	number of inputs	2 3 4 5 6 7 8 9	2
output_device	Relay device for output (optional if current device is used in a logic chain)		
input_device_0	Input device 0		
reverse_input_0	Indicates if value of input 0 should be inverted before logic operation	No Yes	No
input_device_1	Input device 1		
reverse_input_1	Indicates if value of input 1 should be inverted before logic operation	No Yes	No
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		

Table 12.141: Configuration tags for logic device type 'OR logic device'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.14.3 NOT

Tag	Description	Values	Default
mode	Device control mode	Logic	Logic
input_device_0	Input device		
output_device	Relay device for output (optional if current device is used in a logic chain)		

Continued on next page

Table 12.142 – continued from previous page

Tag	Description	Values	Default
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		

Table 12.142: Configuration tags for logic device type 'NOT logic device'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.14.4 Buffer

Tag	Description	Values	Default
mode	**Device control mode**	**Logic**	**Logic**
input_device_0	**Input device**		
output_device	**Relay device for output (optional if current device is used in a logic chain)**		
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		

Table 12.143: Configuration tags for logic device type 'Buffer logic device'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.14.5 XOR

Tag	Description	Values	Default
mode	**Device control mode**	**Logic**	**Logic**
inputs	**number of inputs**	**2**	**2**
output_device	**Relay device for output (optional if current device is used in a logic chain)**		
input_device_0	**Input device 0**		

Continued on next page

Table 12.144 – continued from previous page

Tag	Description	Values	Default
reverse_input_0	**Indicates if value of input 0 should be inverted before logic operation**	**No Yes**	**No**
input_device_1	**Input device 1**		
reverse_input_1	**Indicates if value of input 1 should be inverted before logic operation**	**No Yes**	**No**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		

Table 12.144: Configuration tags for logic device type 'XOR logic device'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.14.6 NAND

Tag	Description	Values	Default
mode	**Device control mode**	**Logic**	**Logic**
inputs	**number of inputs**	**2 3 4 5 6 7 8 9**	**2**
output_device	**Relay device for output (optional if current device is used in a logic chain)**		
input_device_0	**Input device 0**		
reverse_input_0	**Indicates if value of input 0 should be inverted before logic operation**	**No Yes**	**No**
input_device_1	**Input device 1**		
reverse_input_1	**Indicates if value of input 1 should be inverted before logic operation**	**No Yes**	**No**

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Table 12.145 – continued from previous page

Tag	Description	Values	Default
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		

Table 12.145: Configuration tags for logic device type 'NAND logic device'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.14.7 NOR

Tag	Description	Values	Default
mode	**Device control mode**	**Logic**	**Logic**
inputs	**number of inputs**	**2** **3** **4** **5** **6** **7** **8** **9**	**2**
output_device	**Relay device for output (optional if current device is used in a logic chain)**		
input_device_0	**Input device 0**		
reverse_input_0	**Indicates if value of input 0 should be inverted before logic operation**	**No** **Yes**	**No**
input_device_1	**Input device 1**		
reverse_input_1	**Indicates if value of input 1 should be inverted before logic operation**	**No** **Yes**	**No**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		

Table 12.146: Configuration tags for logic device type 'NOR logic device'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.14.8 NXOR

Tag	Description	Values	Default
mode	**Device control mode**	**Logic**	**Logic**
inputs	**number of inputs**	**2**	**2**
output_device	**Relay device for output (optional if current device is used in a logic chain)**		
input_device_0	**Input device 0**		
reverse_input_0	**Indicates if value of input 0 should be inverted before logic operation**	**No** **Yes**	**No**
input_device_1	**Input device 1**		
reverse_input_1	**Indicates if value of input 1 should be inverted before logic operation**	**No** **Yes**	**No**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		

Table 12.147: Configuration tags for logic device type 'NXOR logic device'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.14.9 Modulus

Tag	Description	Values	Default
mode	**Device control mode**	**Logic**	**Readonly**
			Continued on next page

Table 12.148 – continued from previous page

Tag	Description	Values	Default
device_type	Input device type	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert	relay
input_device_0	Input device		
divisor	Divisor for modulus operation, must be an integer!		2
offset	Integer offset added to input before modulus operation		0
boolean_output	Force output to be either 0 or 1. For normal modular arithmetic, the result of the reminder (0 to n-1), but if this key is set to yes, any non-zero value will be set to 1 (thus output can be directly used for relay operations)	Yes No	yes
reverse_output	Indicates if the locgical output state should be reversed. Only avaliable if boolean_output is set to yes	Yes No	No
output_device	Relay device for output (optional)		
title	Optional title		
show_plot	Determines if the current device data is to be shown in the normal daily data plots (graph will be shown in the 'all data' page). Only relevant for enabled devices	Yes No	Yes

Continued on next page

Table 12.148 – continued from previous page

Tag	Description	Values	Default
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		

Table 12.148: Configuration tags for logic device type 'Arithmetic Modulus device'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.15 Math

Math devices are virtual arithmetic devices used for more complex process control. The devices implement the normal behaviour of the usual arithmetic operators such as + - * / exp log and sqrt A math device can operate with any kind of device as input(s) For the math devices where specific input values would normally cause a divide by zero error or similar, the devices simply return 0 to awoid causing a premature termination of the program.

Notice that all math devices return undefined if the readstring function is called as they are virtual devices not intended for data logging.

12.15.1 Add

Tag	Description	Values	Default
mode	Device control mode	Math	Automatic
inputs	number of inputs	2 3 4 5 6 7 8 9	2
offset	Nummeric offset added to result of inputs		0
device_type_0	Device type for input 0	simplechann-el relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert	simplechannel
device_0	Input device 0		

Continued on next page

Table 12.149 – continued from previous page

Tag	Description	Values	Default
input_factor_0	**Factor multiplied on value from input 0 before math operation**		**1**
read_function_0	**Device function to use for read operations for device 0**	**read**	**read**
device_type_1	**Device type for input 1**	**simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert**	**simplechannel**
device_1	**Input device 1**		
input_factor_1	**Factor multiplied on value from input 1 before math operation**		**1**
read_function_1	**Device function to use for read operations for device 1**	**read**	**read**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		

Table 12.149: Configuration tags for math device type 'Arithmnitic sum device'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.15.2 Multiply

Tag	Description	Values	Default
mode	**Device control mode**	**Math**	**Automatic**

Continued on next page

Table 12.150 – continued from previous page

Tag	Description	Values	Default
inputs	number of inputs	2 3 4 5 6 7 8 9	2
device_type_0	Device type for input 0	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert	simplechannel
device_0	Input device 0		
input_factor_0	Factor multiplied on value from input 0 before math operation		1
read_function_0	Device function to use for read operations for device 0	read	read

Continued on next page

Table 12.150 – continued from previous page

Tag	Description	Values	Default
device_type_1	Device type for input 1	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert	simplechannel
device_1	Input device 1		
input_factor_1	Factor multiplied on value from input 1 before math operation		1
read_function_1	Device function to use for read operations for device 1	read	read
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		

Table 12.150: Configuration tags for math device type 'Arithmnitic multiplication'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.15.3 Subtract

Tag	Description	Values	Default
mode	Device control mode	Math	Automatic
offset	Nummeric offset added to result of inputs		0

Continued on next page

Table 12.151 – continued from previous page

Tag	Description	Values	Default
device_type_0	Device type for input 0	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert	simplechannel
device_0	Input device 0		
input_factor_0	Factor multiplied on value from input 0 before math operation		1
read_function_0	Device function to use for read operations for device 0	read	read
device_type_1	Device type for input 1	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert	simplechannel
device_1	Input device 1		
input_factor_1	Factor multiplied on value from input 1 before math operation		1
read_function_1	Device function to use for read operations for device 1	read	read

Continued on next page

Table 12.151 – continued from previous page

Tag	Description	Values	Default
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		

Table 12.151: Configuration tags for math device type 'Arithmnitic subtraction'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.15.4 Divide

Tag	Description	Values	Default
mode	**Device control mode**	**Math**	**Automatic**
device_type_0	**Device type for input 0**	**simplechannel** **relay** **templog** **tempcontrol** **MFC** **water** **gas** **gasgroup** **PSU** **analog** **multiplex** **PID** **logic** **math** **Alert**	**simplechannel**
device_0	**Input device 0**		
input_factor_0	**Factor multiplied on value from input 0 before math operation**		**1**
read_function_0	**Device function to use for read operations for device 0**	**read**	**read**

Continued on next page

Table 12.152 – continued from previous page

Tag	Description	Values	Default
device_type_1	Device type for input 1	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert	simplechannel
device_1	Input device 1		
input_factor_1	Factor multiplied on value from input 1 before math operation		1
read_function_1	Device function to use for read operations for device 1	read	read
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		

Table 12.152: Configuration tags for math device type 'Arithmnitic division'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.15.5 Log

Tag	Description	Values	Default
mode	Device control mode	Math	Automatic

Continued on next page

Table 12.153 – continued from previous page

Tag	Description	Values	Default
device_type_0	Device type for input 0	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert	simplechannel
device_0	Input device 0		
input_factor_0	Factor multiplied on value from input 0 before math operation		1
read_function_0	Device function to use for read operations for device 0	read	read
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		

Table 12.153: Configuration tags for math device type 'Arithmnitic logarithm'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.15.6 Exp

Tag	Description	Values	Default
mode	Device control mode	Math	Automatic

Continued on next page

Table 12.154 – continued from previous page

Tag	Description	Values	Default
device_type_0	Device type for input 0	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert	simplechannel
device_0	Input device 0		
input_factor_0	Factor multiplied on value from input 0 before math operation		1
read_function_0	Device function to use for read operations for device 0	read	read
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		

Table 12.154: Configuration tags for math device type 'Arithmnitic exponential'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.15.7 Root

Tag	Description	Values	Default
mode	Device control mode	Math	Automatic

Continued on next page

Table 12.155 – continued from previous page

Tag	Description	Values	Default
device_type_0	**Device type for input 0**	**simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert**	**simplechannel**
device_0	**Input device 0**		
input_factor_0	**Factor multiplied on value from input 0 before math operation**		**1**
read_function_0	**Device function to use for read operations for device 0**	**read**	**read**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		

Table 12.155: Configuration tags for math device type 'Arithmnitic square root'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.15.8 Abs

Tag	Description	Values	Default
mode	**Device control mode**	**Math**	**Automatic**

Continued on next page

Table 12.156 – continued from previous page

Tag	Description	Values	Default
device_type_0	**Device type for input 0**	**simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert**	**simplechannel**
device_0	**Input device 0**		
input_factor_0	**Factor multiplied on value from input 0 before math operation**		**1**
read_function_0	**Device function to use for read operations for device 0**	**read**	**read**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		

Table 12.156: Configuration tags for math device type 'Arithmnitic absolute value'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.15.9 Inv

Tag	Description	Values	Default
mode	**Device control mode**	**Math**	**Automatic**

Continued on next page

Table 12.157 – continued from previous page

Tag	Description	Values	Default
device_type_0	**Device type for input 0**	**simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert**	**simplechannel**
device_0	**Input device 0**		
input_factor_0	**Factor multiplied on value from input 0 before math operation**		**1**
read_function_0	**Device function to use for read operations for device 0**	**read**	**read**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		

Table 12.157: Configuration tags for math device type 'Arithmnitic inverse'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.16 Alert

Alert devices are virtual logical devices used for more monitoring the sytem and alerting the operators if process parameters exceeds specific limits.

Notice that all Alert devices return undefined if the readstring function is called as they are virtual devices not intended for data logging.

12.16.1 Normal

Tag	Description	Values	Default
class	Device class	Normal Trigger	Normal
device_type	Type of raw device	simplechann- el relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex filter logic math Adapter	simplechannel
device	Raw device		
read_function	Device function to use for read operations		read
title	Optional title		

Continued on next page

Table 12.158 – continued from previous page

Tag	Description	Values	Default
threshold	Threshold over (or under) which the devices triggeres an alert mail. If the threshold value is higher than the reset value the device value must be higher than the trigger level to trigger an alert, if threshold is lowet than reset value, a value below the threshold value triggers an alert.		1
reset	Value under (or over) the device resets the alert. If the threshold value is higher than the reset value the device value must be higher than the trigger level to trigger an alert, if threshold is lowet than reset value, a value below the threshold value triggers an alert.		0.5
retries	The number of retries performed before an alert is triggered (to awoid single read errors to triger alerts)		3
kill_program	Terminate any running sequential program if alert is triggered (only terminated once / alert)	Yes No	No
execute_commands	Execute additional commands if alert is triggered (only executed once / alert)	Yes No	No

Continued on next page

Table 12.158 – continued from previous page

Tag	Description	Values	Default
command_list	List of commands to be executed upon alert trigger. Uses exactly same structure as normal sequential programs. Do NOT include comands which require a komma "," in the argument list or any commands depending on external resources (timeslot and/or impedance commands etc)		
output_enable	Relay name used to control if this device should act on a trigger event or not. If defined and the specified relay device returns 0, any call to check() will return without any actions! (effectively disabling this device)		
warning_mails	Comma separated list of email addresses which will recieve warnings if the threshold is exceeded. If no value is given, the global list is used as default instead		
mail_subject	Subject of alert mail, if no is supplied the default is used "Value for device is above/below threshold". Note that the device nami is always appended in paranthesis to be able to identify the device.		
mail_text	Additional text to be included in warning mail. Do NOT use comma "," in text as it is used as a newline placeholder!		
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		

Continued on next page

Table 12.158 – continued from previous page

Tag	Description	Values	Default

Table 12.158: Configuration tags for Alert device type 'Alert'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.16.2 Trigger

Tag	Description	Values	Default
class	Device class	Normal Trigger	Trigger
device_type	Type of raw device	simplechann- el relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex filter logic math Adapter	simplechannel
device	Raw device		
read_function	Device function to use for read operations		read
title	Optional title		

Continued on next page

Table 12.159 – continued from previous page

Tag	Description	Values	Default
threshold	Threshold over (or under) which the devices triggeres an alert mail. If the threshold value is higher than the reset value the device value must be higher than the trigger level to trigger an alert, if threshold is lowet than reset value, a value below the threshold value triggers an alert.		1
reset	Value under (or over) the device resets the alert. If the threshold value is higher than the reset value the device value must be higher than the trigger level to trigger an alert, if threshold is lowet than reset value, a value below the threshold value triggers an alert.		0.5
retries	The number of retries performed before an alert is triggered (to awoid single read errors to triger alerts)		3
command_list	List of commands to be executed upon alert trigger. Uses exactly same structure as normal sequential programs. Do NOT include comands which require a komma "," in the argument list or any commands depending on external resources (timeslot and/or impedance commands etc)		

Continued on next page

Table 12.159 – continued from previous page

Tag	Description	Values	Default
output_enable	**Relay name used to control if this device should act on a trigger event or not. If defined and the specified relay device returns 0, any call to check() will return without any actions! (effectively disabling this device)**		
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		
disable_readstring	**Determines if readstring should always return the empty string (only relevant for enabled devices)**	**No** **Yes**	**No**

Table 12.159: Configuration tags for Alert device type 'Trigger'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.17 Adapter

Adapter devices are virtual logical devices used to supply functionality to normal devices which does not themselves supply the needed functionality natively. For instance a device may only have an option for specifying a set-point but not a ramprate. By suing a ramprate adapter the missing ramprate can be emulated.

The adpapter devices uses the GoF Adapter pattern allowing fo multiple adapters to be applied to individual devices. A device wrapped in an adapter is automatically set to be readonly, as the adapter device takes over the responsibility for controlling the wrapped device.

Notice that all Adapter devices return undefined if the readstring function is called as they are virtual devices not intended for data logging but only for process control.

12.17.1 Ramprate

Tag	Description	Values	Default
class		Ramprate Exponential-Decay TempControl	Ramprate
mode	Device control mode	Manual Automatic	
device_type	Type of raw device	simplechann-el relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert	simplechannel
device	Raw device		

Continued on next page

Table 12.160 – continued from previous page

Tag	Description	Values	Default
read_function	**Device function to use for read operations. This value will be used as the start value for the ramp operation**	**read**	**read**
control_function	**Device function to use for setpoint operations**	**set**	**set**
minramp	**Minimum alllowed ramprate for device**		**0**
maxramp	**Maximum alllowed ramprate for device**		
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		

Table 12.160: Configuration tags for Adapter device type 'Ramprate adapter'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.17.2 ExponentialDecay

Tag	Description	Values	Default
class		**Ramprate ExponentialDecay TempControl**	**ExponentialDecay**
mode	**Device control mode**	**Manual Automatic**	

Continued on next page

Table 12.161 – continued from previous page

Tag	Description	Values	Default
device_type	Type of raw device	simplechannel relay templog tempcontrol MFC water gas gasgroup PSU analog multiplex PID logic math Alert	simplechannel
device	Raw device		
read_function	Device function to use for read operations. This value will be used as the start value for the ramp operation	read	read
control_function	Device function to use for setpoint operations	set	set
time_constant	Time constant for decay in seconds		10
cutoff	If the difference between the local setpoint and target setpoint is below this the decay is stopped and target setpoint is set		0.01
comments	Description for this device. Do not use ',' in text as that character is used as newline substitute.		

Table 12.161: Configuration tags for Adapter device type 'Exponential decay adapter'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

12.17.3 TempControl

Tag	Description	Values	Default
class		**Ramprate Exponential-Decay TempControl**	**TempControl**
mode	**Device control mode**	**Manual Automatic**	
device	**Raw device**		
minramp	**Minimum alllowed ramprate for device**		**0**
maxramp	**Maximum alllowed ramprate for device**		
mintemp	**Minimum alllowed temperature for device**		**-273**
maxtemp	**Maximum alllowed temperature for device**		**6000**
comments	**Description for this device. Do not use ',' in text as that character is used as newline substitute.**		

Table 12.162: Configuration tags for Adapter device type 'Temperature controler adapter'. An empty value field generally indicates that the tag value can be either a free text string or a number (integer or floating point).

Chapter 13

Troubleshooting

13.1 The web server only returns 'Internal server error' when trying to display the prelogin.cgi page

- Is the Apache web server running as group sofc?. If not, edit /etc/groups and add Apache to the sofc group. Remember to check in httpd.conf if the Apache web server is set to start as group sofc as well. Restart the web server after this.
- Check the errorlog of the web server (Often located in */var/log/httpd/error_log*) to identify if file permission errors or other misconfiguration are the cause.

13.2 Data logging suddenly stops or user interface appears unresponsive for a single rig

13.2.1 Does the rig use PID devices?

If so, a potential cause could be too many open files for that rig.

- In order to check this, in a terminal type (as root):
  lsof | grep rigXX | wc
  Where XX is the rig number. The response will look something like this:
  400 3663 37848.
  Where the first number is the number of open files for that rig user.
- This number has to be compared to any limits set by the operating system on open files (refer the operating system manual as how to do this).
- If the cause is too may open files, kill all instances of PID_fast_control.pl for the rig in question and restart one instance again.

- **If necessary a cron job may be needed to restart the PID fast control program periodically.**

The cause for the above problem can be that PID-devices are used with too complex control structures causing the Perl garbage collector to not work properly. For instance it is known that using feed-forward of gas flows in combination with sum devices and a PID control can cause this.

13.2.2 Test the rig configuration

Test that the rig configuration is sane and that no devices takes too long time to respond and/or reports errors. In order to do this, run the diagnostics program:

/usr/local/bin/celltest/test_rig_conf.pl $rig.

Where $rig is the rig number in question.

This program will run througn all devices configured for that rig and query each one according the the test() function on each.

If one or more devices does not pass the test this will be reported as well as it will be visible how long communication with each device takes. This makes it possible to identivy a particular device which has long response times, which may adversely affect system performance.

Particular Brooks MFC's sometimes fails gradually where the communication takes longer and longer before finally failing completely.

13.3 Sequential programs can not be started

The likely cause for this error is that the CGI-server for the rig in question is not running.

Check that the CGI-server is running for the rig in question. To do this, in a terminal write: *ps -ef | grep CGI*. The response should look something like like:
0 S rig10 1358 1 0 85 0 - 3481 ? Sep14 ? 00:00:00 /usr/bin/perl /usr/local/bin/celltest/CGI-server 10
0 R sofc 5000 3387 0 78 0 - 999 - 12:52 pts/8 00:00:00 grep CGI
0 S rig1 14674 1 0 77 0 - 3351 ? Apr04 ? 00:00:00 /usr/bin/perl /usr/local/bin/celltest/CGI-server 1
0 S rig2 25611 1 0 83 0 - 3447 ? Aug31 ? 00:00:00 /usr/bin/perl /usr/local/bin/celltest/CGI-server 2
Check that each rig on the system has a CGI server running (in the above example, rig 1,2 and 10 has servers running).

The CGI-server should be restarted once every hour if it is not running, but can be started explixcitly by running (as root) the following command:

/usr/local/bin/celltest/start_servers

13.4 Daily graphs looks strange (sudden jumps in values, missing graphs etc)

It is normal that the daily graphs of logged values may behave strangely if the number (or order) of enabled devices has changed, as the graph subsystem only looks at the first line of the daily data file to determine which data columns to plot as well as their names.

If a device has been added, the data of subsequent lines for that day may be misaligned and thus the graphics will be displayed wrong. However all the data are still logged correctly and can be viewed in the raadata file.

Also test the rig configuration to see if any device behaves wrong and / or strangely (see section 13.2.2).

13.5 History plots shows strange sudden jumps in data values

It is not uncommon for the history plots to show strange jumps if one or more devices has been enabled or disabled durring the course of a test as this causes the order of alignment of the data collumns to differ between different parts of the jdata file (refer section 13.4).

This file can be post-test corrected manually by running the program:

/usr/local/bin/celltest/format_jdata.pl $rig $test

Followed by

/usr/local/bin/history_plot $rig $test

(where $rig and $test are the rig and test numbers respectively).

Also test the rig configuration to see if any device behaves wrong and / or strangely (see section 13.2.2).

13.6 Specific device data are not shown in the daily graphs

1. **Is the device in question enabled in the configuration? If not, the data is not logged and graphs can not be created for that device.**
2. **If the device is enabled, is the show_plot key set to 'No'? If so, plotting this device data is disabled.**

3. **Is there an other device (potentially with an other type) with the same name configrued, and does this device have the show_plot key set to 'No'. This will in some cases override the true device configuration for plotting data, as due to historical reasons, the device type is not stored as part of the device name when storeing logged data. Thus the plotting system has to run through all device types untill it finds one with the same name as the data it is to plot and then query the value of the show_plot key. There is thus a risk that the wrong value vill be used. The best way to awoid this is to make sure that all devices (irrespectively of enabled status) have unique names.**

13.7 Viewing old data only shows error or blank page

Does the hostname command return the fully qualified hostname (inlcuding domain name)?

In order to check run:

hostname

If the result is only 'foo' and not 'foo.domain.tld', this is the likely cause.

In order to fix it, please refer to the OS documentation.

13.8 No data can be wiewed for a specific test (shows blank page)

Is access restriction set up as described in section 3.4?

If so, is the correct server IP-address listed in the .htaccess file in the test directory?

13.9 User restrictions does not work (all users can still access data)

Has Apache been cofigured to use .htaccess files (refer the Apache manual for how to configure and test this).

Is the RFCcotnrol configuration file configured correctly (specifically is the data_access_authorisationid key set correctly), refer section 3.4.

13.10 Font size on daily graphs too small

If the font on the daily graphs appears to be too small, lower the values in the GNUPLOT section of the main configuration file for the keys ps-size and png-size:

```
ps-size = 1,1
png-size = 1,1
```

and replace with for instance:

```
ps-size = 0.6,0.6
png-size = 0.6,0.6
```

13.11 Program execution stops and / or command interface behaves strangely (some commands work but others does not)

Check that the default lock file (called SemaforeFile.lock) for the SemaforeFile.pm module has the right permissions. It is located in /var/lock/Semaforefile and should have permissions 666 (Yes, I know the number of all evil...). During normal operation, it will be created with this permission, but sometimes the system may clean up the temp directory, and in this case sometimes it may be created with the wrong permissions. To resolve this, simply remove the file or manually set the right permissions (both operations may be necessary to do as root).

13.12 RFCcontrol-ssl-server can not start and exits with 'Could not create socket Invalid Argument'

This error can arise if the hostname reported by the local system does not match the hostname assigned by the DNS/DHCP server. If this is the case, the hostname or IP address must be specified by starting the RFCcontrol-ssl-server with the –host argument as shown below:

RFCcontrol-ssl-server –host IP_ADDRESS

Where the IP-address is the address of the external IP, not 127.0.0.1, as the server must be accessible from other systems.

13.13 report-server can not start and exits with 'Could not create socket Invalid Argument'

This error can arise if the hostname reported by the local system does not match the hostname assigned by the DNS/DHCP server. If this is the case, the hostname or IP address must be specified by starting the report-server with the –host argument as shown below:

report-server –host IP_ADDRESS

Where the IP-address is the address of the external IP, not 127.0.0.1, as the server must be accessible from other systems.

13.14 report webservice can not be accessed

This is likely caused by ssl certificate verification failure if self signed certificates are used.

execute the following command in the RFCcontrol install directory:

make allow_selfsign

13.15 Users can not log in

If users can not log into the RFCcontrol system, check the following:

- **Is the password system using webservice, if so communication with the service can be tested by running:**
  /usr/local/bin/celltest/test_pwdservice.pl
- **is a self signed ssl certificate used on the password server system, if so refer section 13.14.**
- **If the web-service programs does not recognise the certificate chain of the certificate on the password server, you may need to install the correct chain certificate on the RFCcontrol server and tell the system where this file is: To do this, add the following section to the global configuration file:**

```
SECTION SSL
chainfile = /path/to/ssl/chainfile
ENDSECTION
```

- **Is the password server running (may be on the local server or on a remote server).**

- **is the password server using RSA encryption (started with the –ssl argument)?.**
  - **Is the correct public keys found in the respective known_hosts files (on both password and RFC server)?.**
  - **If remote password server is used, Is the local RFCcontrol-ssl-server running?**
  - **Can it be accessed from the password server system?**
  - **Check the communication by running *\/usr\/local\/bin\/celltest\/sync_ssl_server.pl $host* where $host is the hostname of the password server and listserver respectively.**
- **Is the password server accessible from the current system? To check this, in a terminal write the following: *\/usr\/local\/bin\/celltest\/passwd-client ping*. The response should be something like *ABF-passwd-server on ABF-labsystem-devel-01.RISOE.DK listening on port 2020*. If no response is received or a connection error is encountered, perhaps a firewall is blocking access.**

13.16 Rig list can not be shown

- **is a self signed ssl certificate used on the password server system, if so refer section 13.14.**
- **Is the report-server running on the specified host (log in with ssh on the specified host and check with 'ps').**
- **Is the *RFCcontrol-ssl-server* or *celltest-passwd-server* running on the local system: To check this, run the command 'ps -efl | grep server' and inspect the output. Remember that only one of the above programs will be running (and both should never run at the same time)!**
- **Is it possible to contact the listserver host. In order to check this try to ping the server.**
- **Is report and password communication set up to use encryption, if so try the following:**
  - **Check the communication by running *\/usr\/local\/bin\/celltest\/sync_ssl_server.pl $host* where $host is the hostname of the password server and listserver respectively.**
  - **If errors occour, perhaps firewall settings prevent communication (remember to check both the local system and the remote systems). TCP-IP Ports 2020 and 4040 should be open.**

13.17 Users can log in but not change anything or view new data

Check the following:

- **Check that the users has the right access privileges.**
- **Does the 'safety_task_access' section exists in the global configuration file and is the rig(s) listed in this? If so, does the users have authorization/certification for this safety task (refer section 4.4).**
- **Check that the CGI-server is running for the rig in question. To do this, in a terminal write: *ps -ef | grep CGI*. The response should look something like like:**
  0 S rig10 1358 1 0 85 0 - 3481 ? Sep14 ? 00:00:00 /usr/bin/perl /usr/local/bin/celltest/CGI-server 10
  0 R sofc 5000 3387 0 78 0 - 999 - 12:52 pts/8 00:00:00 grep CGI
  0 S rig1 14674 1 0 77 0 - 3351 ? Apr04 ? 00:00:00 /usr/bin/perl /usr/local/bin/celltest/CGI-server 1
  0 S rig2 25611 1 0 83 0 - 3447 ? Aug31 ? 00:00:00 /usr/bin/perl /usr/local/bin/celltest/CGI-server 2
  Check that each rig on the system has a CGI server running (in the above example, rig 1,2 and 10 has servers running).

13.18 Log-in page does not complete loading or the list of servers is incomplete

Run the *//usr/local/bin/celltest/test_cluster.pl* script to check if one or more of the servers in the cluster is not responding on the server intercommunication.

If the script hangs on one or more of the servers it tries to test, likely the report-server on that server in hanging for some unknown reason. In that case, log in to the affected server using ssh and issue the command *killall report-server* followed by */usr/local/bin/celltest/start_servers*.

13.19 Data logging on a rig is not running

- **Check that data logging it is enabled in the crontab scheduler. From the rigs main page, go to miscellaneous setup, and then to Rig scheduler and check that the line with logfile.pl is not disabled.**
- **Test that the rig configuration is sane. In a terminal type the following as the correct user (user 'rig5' for rig 5 and so on):**

/usr/local/bin/celltest/test_rig_conf.pl $rig. **This will test the rig configuration including test each individual device. If errors are reported, find and fix any critical errors (It is possible to have non critical errors which the data logging system will handle and just report an invalid data for that device, usually in the form of the magic number -32768).**

- **Check that the *logfile.pl* program does not return errors for that rig. In a terminal type the following as the correct user (user 'rig5' for rig 5 and so on):**
  /usr/local/bin/celltest/logfile.pl $rig conf. **This command will write the complete rig configuration for data logging. If errors are reported, find and fix any critical errors (It is possible to have non critical errors which the data logging system will handle and just report an invalid data for that device, usually in the form of the magic number -32768).**
- **Check that the *cnv.pl* program is also enabled in crontab as it is this program which generates the web pages displaying the data.**

13.20 Errors are reported when users are trying to change process parameters

- **In a terminal type the following as the correct user (user 'rig5' for rig 5 and so on):**
  /usr/local/bin/celltest/test_rig_conf.pl $rig. **This will test the rig configuration including test each individual device. If errors are reported, find and fix any critical errors (It is possible to have non critical errors which the data logging system will handle and just report an invalid data for that device, usually in the form of the magic number -32768).**
- **Check that all serial servers are running as appropriate. To do this, in a terminal write: *ps -ef | grep serial.* The response should look like:**
  4 S root 3682 1 0 75 0 - 2387 ? 09:26 ? 00:00:00 /usr/bin/perl /usr/local/bin/celltest/serial-socket-server-9.0.pl ttyS0 9600
  4 S root 3683 1 0 76 0 - 2387 ? 09:26 ? 00:00:00 /usr/bin/perl /usr/local/bin/celltest/serial-socket-server-9.0.pl ttyS2 9600
  4 S root 3684 1 0 76 0 - 2387 ? 09:26 ? 00:00:00 /usr/bin/perl /usr/local/bin/celltest/serial-socket-server-9.0.pl ttyS3 9600
  0 S sofc 9245 9214 0 78 0 - 1005 pipe_w 12:58 pts/0 00:00:00 grep serial
- **Check the individual device configuration under the device configuration page (go to 'setup iv-curve parameters' and then to 'rig configuration' and select the devices on at a time and run the test for each, refer section 6).**

- **If some of the tests described above fails, try communicating directly with the serial servers and devices using the serial_client interface described in section 8.4.**

13.21 The logged data values from a Keithley 2700 / 2750 are not correct, i.e. value -32768

.

- **Check that the GPIB-server is running as appropriate. To do this, in a terminal write *ps -ef | grep gpib*. The response should look like:**
  0 S root 3043 1 0 75 0 - 20725 415457 09:54 ? 00:00:01
  /usr/local/bin/gpib_socket_server
  If the gpib server is not running, it can usually be started in a terminal by writing (as root):
  ***/usr/local/bin/start_servers*.**
  Alternative it can be started by writing */usr/local/bin/gpib_socket_server*.
  This will give you a message if the GPIB-driver need an update as is sometimes necessary for the drivers supplied by National Instruments®.
  If so this can be done by writing (as root) */usr/local/bin/updateNIDrivers* after which the computer needs to be rebooted.
- **Is the correct GPIB-address and board number selected. To check this use the test facility in the setup page: If the response is something like:**
  2011:10:25:15:10:39 1319548239 3:303 CHANNEL_ERROR -32768.000000 -32768.000000
  Then either the GPIB-address or the board / channel number is incorrect.

13.22 The temperature logging does not report the right values

- **If a temperature logging device reports only values close to room temperature irrespectively of the actual temperature, check the following:**
  - **Is the channel measuring the thermovoltage configured to measure mV? To check this, use the test facility, and in case of a Keithley channel, the last two values in the reported raw measurement must be a factor of 1000 different, if the numbers are equal, then the channel is configured for voltage and must be reconfigured (refer the manual for the gpib-server as how to do this). A correctly setup Keithley channel should report something like this:**
    2011:11:22:08:37:07 1321947427 1:102 volt:dc 0.000010 0.009622

  - **Is the thermocouple short circuited at a lower temperature (terminal block or similar).**

- **The temperature device is reporting wrong values (either too large, or too small).**
  - **Check the polarity of the thermocouple. If the temperature is above room temperature, the raw voltage measured by a thermocouple must be positive.**
  - **Check the thermocouple type (K, N, S etc).**
  - **Check that the cold junction measurement is correct. If the temperature of the terminal block is measured by a pT100/1000 and there is a loose connection, then the temperature will be measured incorrectly.**

13.23 Temperature control does not work correctly or errors are reported when trying to change temperature control setup

Check that only one version of the Eurotherm.pm module are installed. Older versions of RFCcontrol installed modules in an other location, and depending on search path, this may not have been detected by the NAME installer.

To resolve this, in a terminal type:

locate Eurotherm.pm

If more than one line is found beginning with /usr/lib, find which one is the newest, and delete the rest.

13.24 Remote impedance does not work

If impedance spectroscopy measurements using the Elchemea system is not working, do the following in order:

1. **Check that a normal impedance spectrum can be acquired manually on the Elchemea system. If errors are encountered, follow the Elchemea manual to correct this.**
2. **Check that communication between the RFCcontrol system and the Elchemea system is working:**
   (a) **Check that the Elchemea system is on-line by typing the following in a terminal:**
   remote-client IP:port ping **(IP and port should be substituted for**

the IP address of the Elchemea system and the correct port number, usually 4040). The response should be something like this:
CGI-remote-server on abf-impmultiplex-01 on addr: 10.0.3.203
Listening on port 4040
If not, check firewall settings or other network issues on the RFC-control or Elchemea system.

(b) **Get the measurement mode form the Elchemea system by by using the following command:**
remote-client IP:port mode

(c) **Check that an impedance can be started remotely by executing the following command:**
remote-client IP:port impedance user mode session_nr **where the user is the user-name (on the Elchemea system!) and the mode is the measurement mode acquired in step 2b and session_nr is the Elchemea system session number which configuration is to be used (usually it is best to select the current Elchemea session). The response in case an impedance measurement was started should be something like:**
Impedance, Mode 1255, Session 10, File 1004, Totaltime 3756.74

3. **Check that the correct frequency settings are used (including start frequency and number of points / decade).**

4. **If automatic impedance compensation is to be used, check that the compensation file to be used has the exact same frequencies at all data points and in the same order. If 'impedance under current' is used, the compensation files which will be used are the 'short.i2b' and 'shunt.i2b' found in the *imp_comp* directory in the rigs main data directory. If the imp_comp directory does not exist, it needs to be created and the short and shunt file needs to be placed there for impedance compensation to work correctly, check the Linux/Unix manual as how to do this.**

5. **Run an impedance from the program interface (select either 'single impedance' or 'impedance under current', but if 'single impedance is selected, the only compensation which will be performed is the subtraction of the selected file!). Remember to use correct user-name and session number as well as IP address and port number (Note that the user-name entered must be the one on the Elchemea system as described above).**

6. **Check that the impedance measurement start on the Elchemea system.**

7. **Once the measurement is finished, check that it is transferred to the 'raw' directory in the 'impedance' directory of the current test.**

8. **Check that it is compensated correctly, If the file only contains a few liens, likely the wrong compensation files were chosen. To check/correct htis, do the following:**

(a) **In a terminal first change directory to the raw directory (refer any Unix/Linux help page/manual how to do this) and type:**
x *hio_korr -X filename_of_compensation_file file_to_be_compensated*
where X is the compensation mode (S for subtract, M for multiply, A for add and D for divide).

(b) **Check the resulting compensated file and see that it has the same number of lines as the original. The compensated file will be named as the original except it will have '_cor' appended just before the extension. If not, check the original file and the compensation file and carefully check that each data line begins with the same frequency (to within 0.1%).**

(c) **If the compensation file is not correct, Either make a new compensation file with correct frequency ranges or redo the measurement with frequency settings which match the compensation file (which is often by far the easiest as usually the compensation file is a short circuit measurement which can only be performed without a sample in the test setup).**

13.25 i-V curves behave strangely

If multiple PSU devices are configrued, the default behaviour (that is to use the ifrst PSU device listed for controlling the DC current durring an i-V curve) risks controlling an other device than intended.

The fix for this is to explicitly specify which PSU device to use durring i-V curves. This is done by setting the correct PSU name in the 'iv_control_names' key in the 'IV_control' section of the rig's configuration (refer section 6.2).

13.26 PID regulators does not work although they are enabled and set-points can be set

Make sure that the following lines are included in the rig's crontab file:

```
* * * * * /usr/local/bin/celltest/PID_fast_control.pl $rig &
* * * * * /usr/local/bin/celltest/PID_slow_control.pl $rig &
```

(substitute $rig for the appropriate rig number).

13.27 Automatic software updates are blocked by a web proxy

In order for the automatic software updater (celltest_updater.pl) to work through a web proxy, add the following line to the configuration file:

In the 'main' section add

proxy=http://proxy.foo.bar:1234

Remember to change the server name and port number to the settings for your proxy server.

13.28 Alerts does not work or are not sent although they are enabled

Make sure that the following line is included in the rig's crontab file:

```
* * * * * /usr/local/bin/celltest/Check_alert.pl $rig &
```

(substitute $rig for the appropriate rig number).

13.29 Adapters does not work although they are enabled

Make sure that the following line is included in the rig's crontab file:

```
* * * * * /usr/local/bin/celltest/Adapter_update.pl $rig &
```

(substitute $rig for the appropriate rig number).

13.30 Programs stops prematurely without any apparent cause

Thes may result from the operating system preventing opening more file handles for the rig user in question.

On most sytsems there is a limit on how many files can be open simultaneously for each individual user.

To check this, run the following command:

lsof | grep $rig | wc -l

(where $rig is the username for the rig user, f.eks 'rig45')

If the rig in question has a configuration with many individual devices, this number can approach the limit as each program (logfile.pl, CGI-server or similar) will open lockfiles for a number of the devices in order to prevent race conditions.

Refer your operating system manual as to how to increase this limit and restart the CGI-server for the rigs in question.

Chapter 14

Examples

This chapter discusses a number of complex control situations which can be performed by combining RFCcontrol devices.

14.1 Using a PID and a galvanostatic power supply to emulate potentiostatic control

Usually when testing electrolysers of fuel cells, the DC current through the device is controlled galvanostatically (that is a fixed current is specified) as this makes it easier to avoid too high current which could result in damage to the tested device (for instance by trying to convert more gas than is being fed to the device).

However in some cases it is desirable to run a test potentiostatically (could be at the thermoneutral potential in case of a solid oxide electrolyser cell). In order to do this, a software PID can be used to adjust the DC current so that the resulting cell voltage matches the desired target value.

Figure 14.1 shows such an example.

The control loop consists of an input device (the cell voltage) a PID device and an output device (the DC power supply in galvanostatic mode). However in order to be able to switch to and from potentiostatic control, a output enable input is used. This virtual relay can be set to off when the PID device is configured and tuned and then first set to on when the user wants to 'close the loop' (go to automatic potentiostatic control).

I order to make the switch to potentiostatic control as smooth as possible, the DC current can be manually set (before enabling the PID output) so that the cell voltage is close to the desired target.

However one must remember to set the integrated error to an appropriate value before closing the loop as otherwise a large accumulated error could result in large deviations before the PID loop stabilizes. Fortunately RFC-control PID devices is equipped with a function to automatically set the

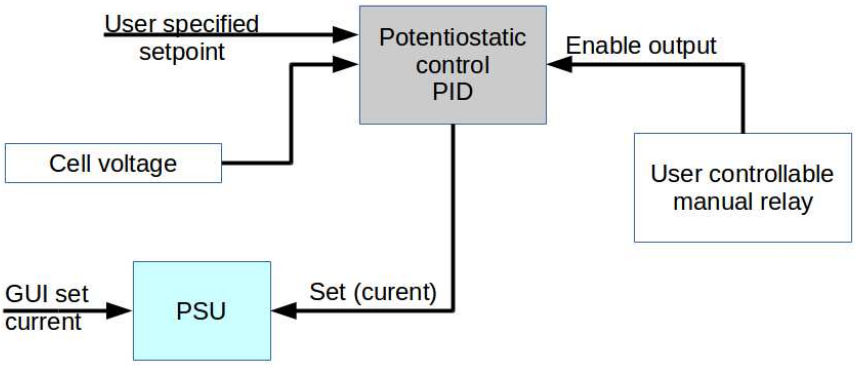


Figure 14.1: Schematic of a PID device used to control a galvanostatic DC power supply to emulate potentiostatic control. The user controllable manual (virtual) relay is used to switch to and from potentiostatic control.

integrated error to a value which would result in a specified output based on the measured process variable. This function however is only available to the certified users of a particular rig, as using this function can bring a PID controlled system out of equilibrium.

So in order to go to potentiostatic control do the following:

- **Configure the PID device to use the cell voltage as input, disable output and set the DC power supply as output.**
- **Configure the PID to allow override of the output device (otherwise no GUI control of the DC current will be possible).**
- **Preferable configure a manual (virtual) relay to control the output enable of the PID device. If so set it to off and the 'output enable' key in the PID setup to to 'relay'.**
- **manually set the DC current to a value close to where it is desired for the cell voltage to be as wanted.**
- **In the PID setup, use the just set current value as input for the find_int function to set the integrated error for the PID to a value which does not result in large over/under shoots.**
- **Toggle the virtual relay to on in order to close the PID loop.**

When you then want to leave potentiostatic control, it is simply enough to disable the PID output.

If no output enable relay is used, the output enabled can be controlled from the PID setup page.

14.2 Potentiostatic control with fixed fuel utilization

It is possible to extend the potentiostatic control described in section 14.1 to also control the gas flows so that a fuel cell or electrolyser cell can be run at constant voltage at a fixed fuel utilization. Figure 14.2 shows a device schematic of how this can be done. In the example described in the figure, an electrolyser cell is to be run at a constant fuel utilization of 56% with an input gas composition of 10% hydrogen and 90% water. It is assumed that the water is created by auto-thermal conversion of oxygen and hydrogen, thus in order for the water-hydrogen ratio to be fixed at 90% water, the flow of oxygen must in this case be 45% of the hydrogen flow. This is achieved by setting the oxygen gas to have 45% flow of the master gas (hydrogen) as shown in the figure.

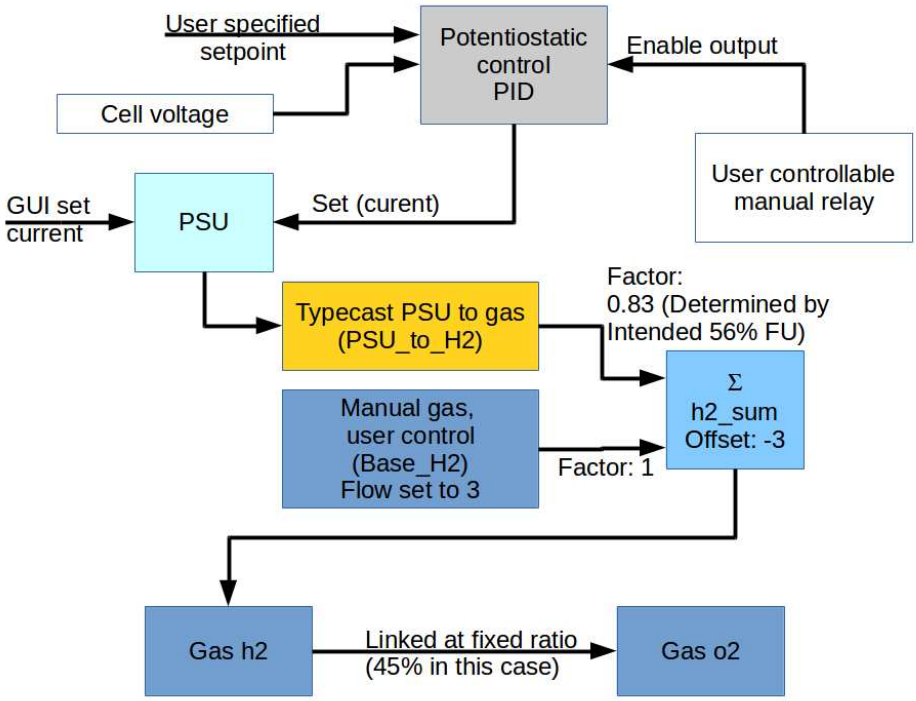


Figure 14.2: Schematic of a PID device used to control a galvanostatic DC power supply to emulate potentiostatic control and at the same time having a fixed ratio between gas flows and DC current (constant fuel utilization). The user controllable manual (virtual) relay is used to switch to and from potentiostatic control. In this example the electrolyser cell is run with a fixed fuel utilization of 56% and an inlet gas composition of 90% water (the oxygen is used to burn hydrogen to make water).

The upper part of the figure 14.2 is like figure 14.1 and work as described above. However the addition of the typecast device as well as the summing device necessitates a more elaborate control sequence. First of all, if the summing device and the manual offset gas was omitted, the gas flows would

be set to 0 if the DC power supply was ever set to 0 Amp or OCV. To protect against this, the manual gas must be set to a sufficiently high value before the current is shut off (so that the summing device output is higher than 0)

Notice that the summing device in the example has a negative offset. The reason for the negative offset for the summing device is that it enables the possibility for reducing gas flows below the theoretical if inaccuracies in the physical devices results i higher flows than intended.

The procedure for setting up a control system like the one shown in figure 14.2 is as follows:

1. **Configure the potentiostatic PID control loop as described in section 14.1**
2. **Configure the typecast device to accept input from the PSU and output as gas.**
3. **Configure the manual offset gas and give it an appropriate initial flow (more than the negative offset for the summing device).**
4. **Configure the summing device to accept inputs from the typecast device and manual gas respectively. When configuring the summing device, use Faraday's law of electrolysis to calculate the input factor from the typecast device according to the intended fuel utilization.**
5. **Test the summing device and check that the output would be above 0.**
6. **Configure any slave gas devices to have the correct flow according to the 'master gas' (the gas which is intended to be controlled, in the example, it is the hydrogen flow)**
7. **Set the desired start gas flow of the master gas (from the GUI).**
8. **Check that all slave gas flows works as intended.**
9. **Set the DC current as close to the intended value (without potentiostatic control)**
10. **Check the summing device output.**
11. **If the summing device output is at least the value of the gas flow just set, configure the output device for the summing device to be the master gas.**
12. **Set the current again to update all gas flows (and check that forwarding of commands works).**
13. **Reduce the flow of the manual gas to an appropriate value. Ideally to the same (positive) value as the summing device negative offset, in the example this would be 3 L/h, but i some cases it may be necessary to set it at an other value.**

14. **Start the potentiostatic control as described in section 14.1.**

If a true bipolar power supply is used, it will be necessary to configure a RFC::Math::abs device between the PSU and the typecast device as in that case running in electrolysis mode will result in negative currents being forwarded.

An additional complexity when running potentiostatic control with fixed fuel utilization is that setting a DC current of 0 A (or OCV) will most likely result in shutting down the gas flows completely. In order to prevent this, follow the following procedure when the DC current is to be shut off.

- **Stop the potentiostatic control PID by setting the control relay to off.**
- **Increase the gas flow of the manual offset gas to a value big enough to supply enough gas even when the typecast device reports no (zero) flow.**
- **Shutdown the DC current (setting the current to 0 A or OCV). This will reduce the gas flows to the minimum set by the manual offset gas above (corrected for potential negative offset on the summing device).**

Now the DC power has been shut off, however the gas flow is still linked to the power supply and any future changes in DC current will result in changes in the gas flows (although with an offset). In order to remove this linking do the following:

- **Remove the output device for the summing device (Select the empty option).**
- **If the coupling between the individual linked gasses are to be discontinued, for each of those gasses remove the 'master gas' name (select the empty option).**

Now the gasses can be controlled individually as can the DC power supply.

14.3 Pressure regulation using mass flow controllers

It is possible to control pressure in a pressure vessel by using pressure controllers. However in some cases more precise control of the pressure is needed. Figure 14.3 shows a schematic overview of a system where a device is tested at elevated pressures abut at the same time one or more gasses is flowed through the device.

In figure 14.3 the yellow boxes are gas devices (refer section 5.4) and are assumed to be connected to mass flow controllers and the lines connecting devices are the (simplified) gas tubing. In order to control the pressure in

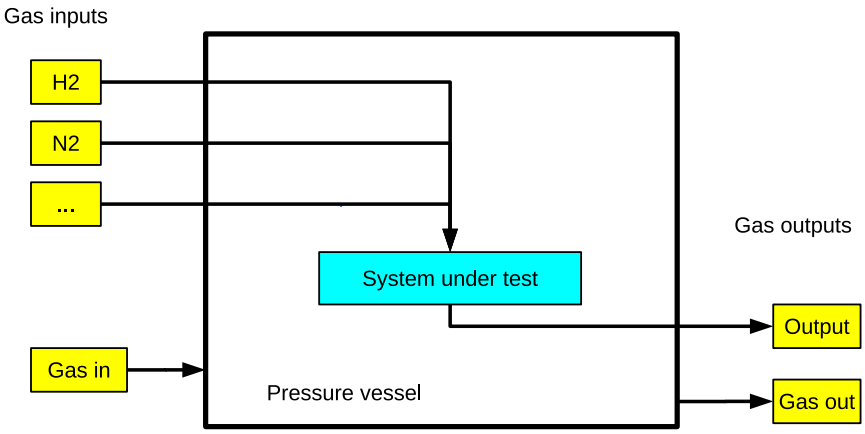


Figure 14.3: Schematic overview of a device tested under pressure and which requires gas flowing trough it.

the pressure vessel, the flow of gas in and out must be balanced. This can be achieved by using a PID regulation loop as described in figure 14.4.

For simple pressure regulation of the pressure vessel there may only be one input gas (and in which case the first summing device will not be needed).

The pressure in the vessel can then be controlled by setting the input flow to some fixed value and regulating the output flow by the PID. The pressure in the vessel will then be increased or decreased until it matches the PID setpoint. Notice however that if the input flow is the fixed one, then the error gain in the PID device must be negative for the regulation loop to work (if not exponential deviation from the desired setpoint will be observed).

The same regulation loop described in figure 14.4 can also be used to balance the pressure in a device relative to the device surroundings. In this case the pressure sensor should then be replaced with a differential pressure sensor and the setpoint should be set to 0 (in case of complete balance) or some other desired value.

14.4 Pressure regulation accounting for production / removal of gas in the device under test

In some cases the flow of gas to a device may not be the same as the flow out of a device. For instance in the case of a fuel cell, if DC current are passed through the fuel cell, hydrogen is either converted to water or produced from water depending on current direction. If a water trap is installed between the device and the output mass flow controller (not shown in the diagrams), the gas flow in to and out from the device will not be identical, and will vary with the DC current through the device. Water traps are often necessary in this situation as most MFC's designed for use with gasses do not handle water

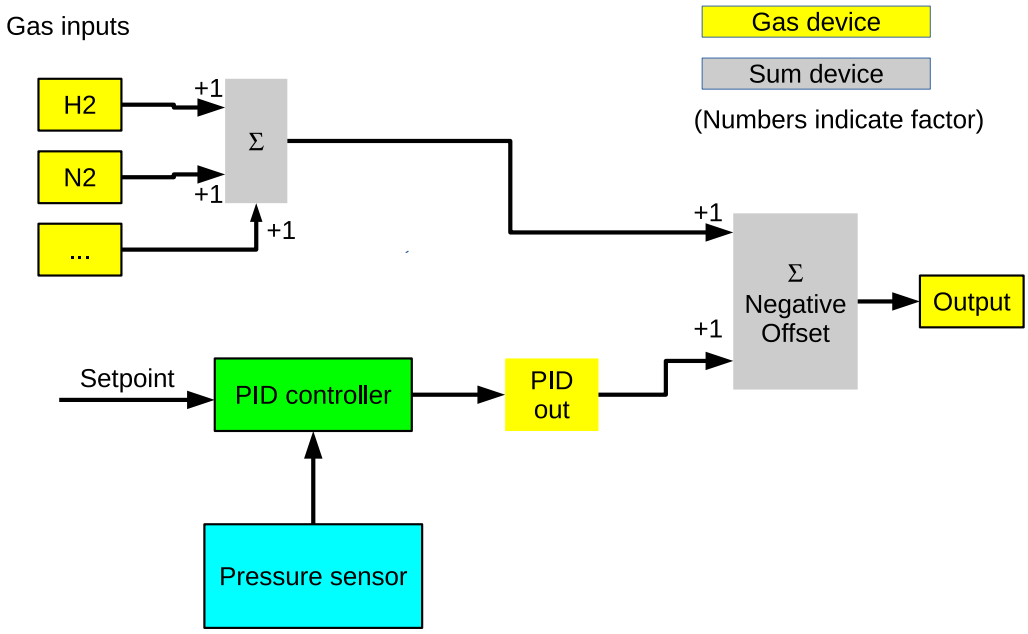


Figure 14.4: Logical diagram of simple pressure regulation using mass flow controllers, pressure sensor and a PID regulator device using feed forward. Note that in this configuration the error gain in the PID must be negative. In this diagram all devices without solid borders can be configured with the 'disable readstring' option as in most cases their value do not need to be stored as they are only necessary for control input forwarding (only the input and output device values are necessary to log). As opposed to figure 14.3, lines in this diagram does NOT represent physical wires or tubing, but instead the logical connection between devices (both real and virtual / software devices).

well as condensation within the controller will result in wrong measurements and / or unstable operation.

Figure 14.5 shows an example of how pressure balancing of the gas flow can still be achieved by RFCcontrol by utilizing typecast devices. By using the logical layout described in figure 14.5 any changes in the DC current load and/or current direction (which is assumed to be controlled by the relay device) is fed forward to the output controller. The blue dotted lines in figure 14.5 indicate that the gas devices should be configured with the same 'control_name' (the device name for the switching relay) but with different value of the 'control_value' (zero for the 'Pos' gas device and one for the 'Neg' gas device). This is necessary as only one of the gas group devices at a time may supply a non-zero value. This ensures that the 'gas' from the PSU is either added to or subtracted from the result of the other gasses depending on the setting of the switching relay (and thus the direction of the current).

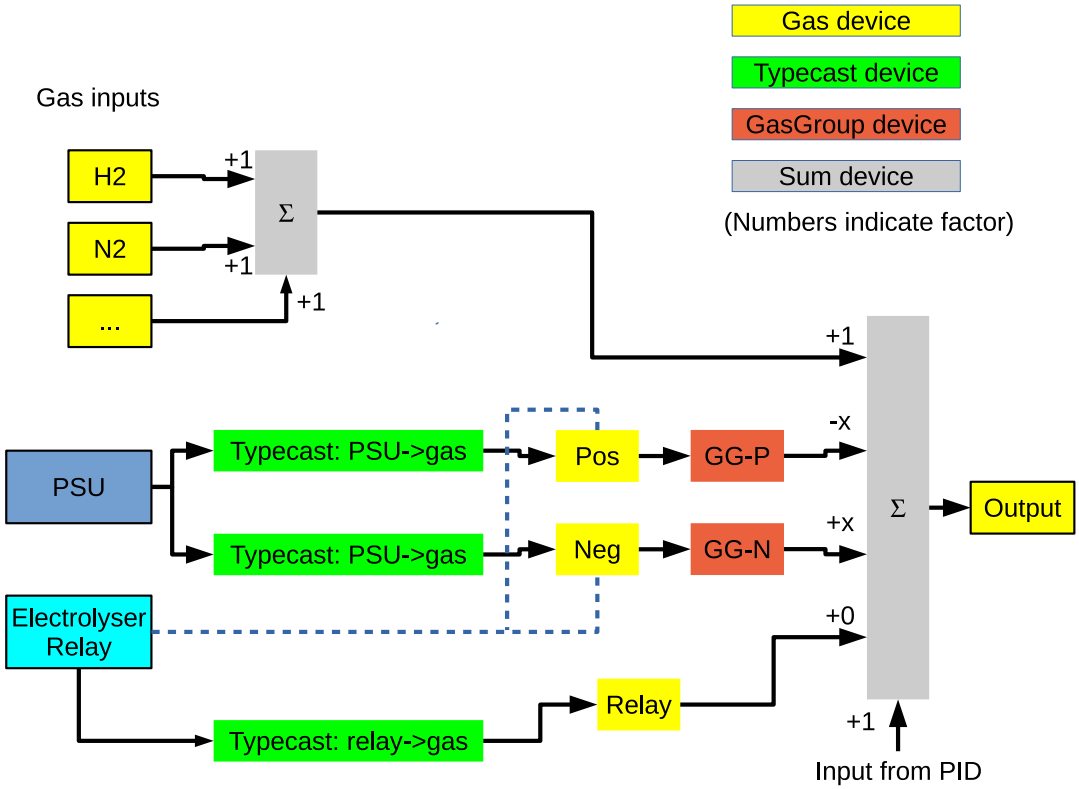


Figure 14.5: Logical diagram of a pressure regulation system where gas can be created or removed from the system by a DC current (for instance by a fuel cell). For simplicity, the input from the PID has been omitted. The value of x needs to be determined by Faraday's law of electrolysis converting current in amps to gas flow in L/hour.

Chapter 15

FAQ / How-to

15.1 How to set up a stand-alone RFCcontrol password server on a system with no DNS name

1. edit the configuration file (/home/celltest/conf/celltest_global.conf) and change the 'passwd_server' key in the 'paswds' section to 'localhost'
2. In the 'servers' section, change the 'listserver' key to 'localhost'.
3. In the 'servers' section, change the 'server_names' key to 'localhost'.
4. Remove the line '@reboot /bin/su -c "/usr/local/bin/celltest/RFCcontrol-ssl-server –ssl &" - sofc' from roots crontab file to make sure that it does not starts upon reboot (it will automatically exit but it is not needeed in a stand alone system).
5. Add the line '@reboot /bin/su -c "/usr/local/bin/celltest/celltest-passwd-server –ssl &" - sofc' to roots crontab file to make sure that the password server starts upon reboot.
6. As the RFCcontrol system user (usually sofc), run the 'initialise_passwdfile.pl' script in the installation directory and note the initial root password thus created.
7. make sure that the firewall does not block port 2020 (refer your operation system manual, this should have been handled durring RFCcontrol installation, but do make sure....).
8. Reboot the computer and it should be possible to log in using the password created in step 6.
9. If it will not be possible to send emails from the server proceed to step 13.

10. **Connect the computer to the Internet so that mails with new users passwords can be sent.**
11. **Create at least a single non-superuser user for normal operation of the RFCcontrol system and assign correct permissions.**
12. **Installation should be complete.**
13. **Use the script create_user.pl found in the installation directory to create non-superuser accounts (note the passwords assigned to each user).**
14. **Check that the created users thus created can log into the RFCcontrol system.**
15. **If a user needs to have his/her password reset without sending emails (either because no network connection is possible or if the MTA does not allow the host computer to send mail), then use the command: /usr/local/bin/celltest/celltest-passwd-client resetpwd_cmd $user.**

15.2 How to prevent setting gas flows / DC current to zero upon starting a new test

Set the set_zero_output_start_test key in the main section of the rigs configuration to 'no' (refer section 6.1). This will prevent setting gas flows to zero (and DC putputs to zero) upon starting a new test. The setting has to be changed by manually editing the configuration file (No special GUI function for this).