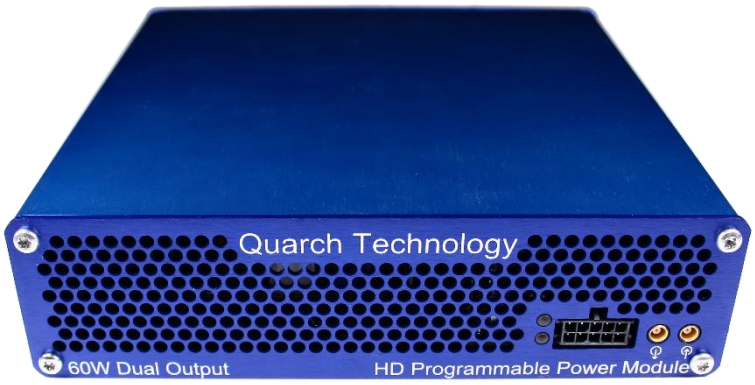
Quarch Technology Ltd
HD Programmable Power Module
Technical Manual

For use with:

QTL1999 – Single Programmable Power Module
QTL1995 – x6 Programmable Power Module

Firmware v6.000 and above

June 2023



Change History

1.0	January 2017	Initial release
1.1	May 2019	Updated for double-pole fuse warning
1.2	August 2019	Added clearer requirement for rack rails
1.3	October 2019	Updated Maximum Current Information
1.4	March 2021	Factory reset and SFF fixture setting info added
1.5	July 2021	Updates on power sync fixtures
1.6	October 2021	Added ‘stream monitor’ feature
1.7	June 2023	Updated for v6.x firmware and PPM Plus

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About this Manual

Thank you for your purchase of this Quarch Module. This manual is intended as a technical reference, describing the features, operations and control API of the unit.

Additional documents available include Quick start guides, Datasheets and Application notes. These can be located on our website: www.quarch.com

This manual provides the following:

- Safety information
- An overview of the product and its features
- Details of the control interfaces
- Command specification
- Locations of additional help and examples.

Product Safety

This product is intended for experienced technical users in a test lab environment. It is able to stress/damage devices under test, so it is essential that you are familiar with this manual before using the device.

Safety warnings

This product must be connected to an appropriately earthed mains supply. There are no user serviceable parts inside; do **NOT** open the enclosure.

The product contains a high-speed fan for cooling. Ensure the fan is not obstructed before powering up the unit. Do **NOT** remove the protection grills from the fans.

QTL1995 units are heavy (8.5kg) and may require two people to relocate them.

Additional safety notes

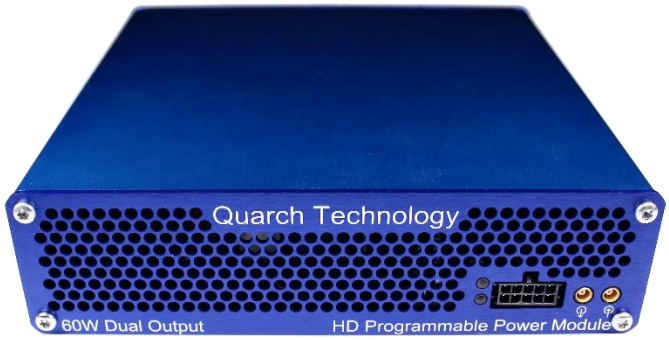
- HD modules have a standard IEC C-13 connector and should be used with the supplied cable or an appropriate 10A rated replacement cable.
- QTL1995 units have brackets, allowing them to be bolted in to standard 19” test racks. It is strongly recommended that these be secured before use. The product must be mounted onto full length rack rails for support.
- CAUTION: Double pole / neutral fusing is used on these products

In the Box

Each power module comes with the same basic kit of parts.

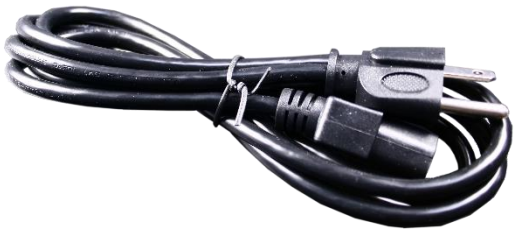
QTL1999 – single module

1x power module unit



1x USB cable

1x power cable (region specific)

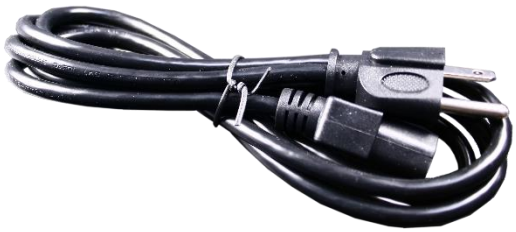


1x 10 pin power output cable (connects to injection fixtures)

QTL1995 – 6-module rack mount

1x power module unit

1x power cable (region specific)



6x 10 pin power output cable (connects to injection fixtures)

Technical Specifications

HD power products from Quarch are all based on the same design and can be used within the same testing system.

The QTL1999 is a single-output unit, designed for testing one device.

The QTL1995 rack-mounted version simply mounts 6 power outputs in a 19” rack enclosure, ideal for testing multiple devices at the same time.

USB connections are not available on QTL1995, but all other features are identical.

A test written to work on one product can be very easily moved to the other, allowing for simple debug or scaling up of an existing test.

QTL1999 – single module layout

Front panel of QTL1999

Rear panel of QTL1999

QTL1999 – connections and indicators

Item	Location	Purpose
Trigger In	Front panel	MCX 3.3v trigger in
Trigger Out	Front panel	MCX 3.3v Trigger Out
10 pin Output *1	Front panel	Power output connection to device under test
Upper LED	Front panel	Record Indicator; Red=Recording/Streaming
Lower LED	Front panel	Status Indicator; Green=OK, Red=Fault
IEC	Rear panel	115-240V 40/50Hz Mains supply
USB	Rear panel	USB port for direct control from a local PC
LAN	Rear panel	100Base-T network port for remote control

*1 – *See next section for pinout details*

QTL1995 – 6-module rack mount layout

Front panel of QTL1995

Rear Panel of QTL1995

QTL1995 – connections and indicators

Item	Location	Purpose
Trigger In	Front panel	MCX 3.3v trigger in
Trigger Out	Front panel	MCX 3.3v Trigger Out
10 pin Output *1	Front panel	Power output connection to device under test
Upper LED	Front panel	Record Indicator; Red=Recording/Streaming
Lower LED	Front panel	Status Indicator; Green=OK, Red=Fault
IEC	Rear panel	115-240V 40/50Hz Mains supply
LAN (x6) *2	Rear panel	100Base-T network port for remote control

*1 – *See next section for pinout details*
*2 – *See next section for connection layout*

Connection details and pinout

Power output connectors

The 10 pin output connector is used to supply power to the device under test (DUT), and to communicate with intelligent fixtures.

Power output pinout

GPIO 2	15v Aux	5V Output	12V Sense	12V Output
GPIO 1	GPIO 0	5V Sense	Common GND	Common GND

- “GPIO X” pins are reserved for communicating with the fixture.
- 15v Aux allows fixtures to draw power without skewing the power measurements.
- GND connections are common across voltage rails.
- “Output” pins supply power to the DUT.
- “Sense” pins are for remote voltage sense, allowing us to measure the voltage as close to the DUT as possible.

QTL1995 LAN connections

This product has 6 RJ-45 network ports. Each port links directly to a single power module, so they are controlled entirely separately.

Looking at the unit from the front, modules are numbered 1 to 6, from left to right.

The LAN connections on the rear of the unit each connect directly to a single power module as follows:

Module 1	Module 2	Module 3
Module 4	Module 5	Module 6

Power output characteristics

HD Power Modules have a dual channel power output, with a 12V channel and a channel that can be switched between 5V and 3V3 modes, depending on the device under test.

When an intelligent fixture is attached, the correct voltage range will be automatically selected.

Output characteristics

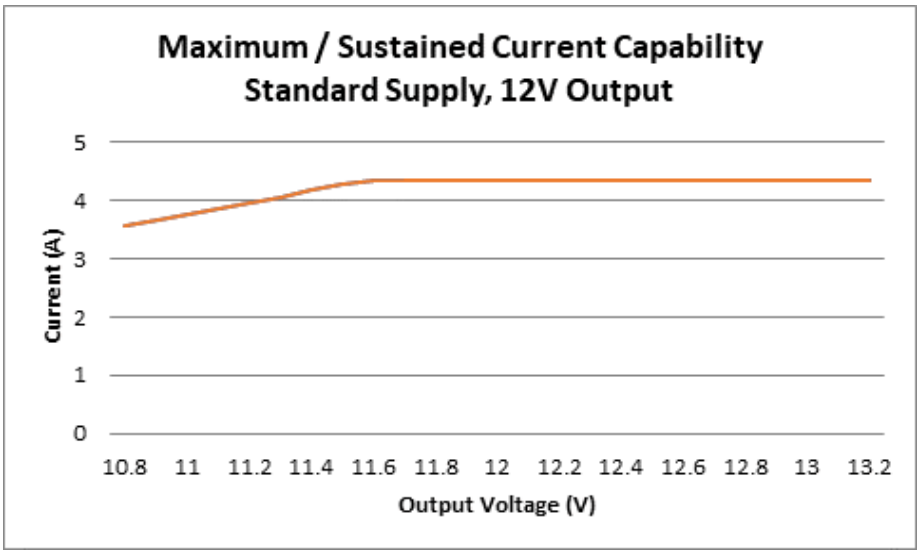
Parameter	Min	Max	Step
3V3 Output Voltage	0mV	3960mV	~3.54mV
5V Output Voltage	0mV	6000mV	~3.54mV
12V Output Voltage	0mV	14400mV	~5.54mV
Continuous Output Current 3V3	5000mA Max		
Maximum Output Current at 3V3	Up to 9200mA for 10 seconds		
Continuous Output Current 5V	5000mA Max		
Maximum Output Current at 5V	Up to 9200mA for 10 seconds		
Continuous Output Current 12V	4300mA Max		
Voltage Slew Rate (No Load)	1V/uS (rising)		

Output protection

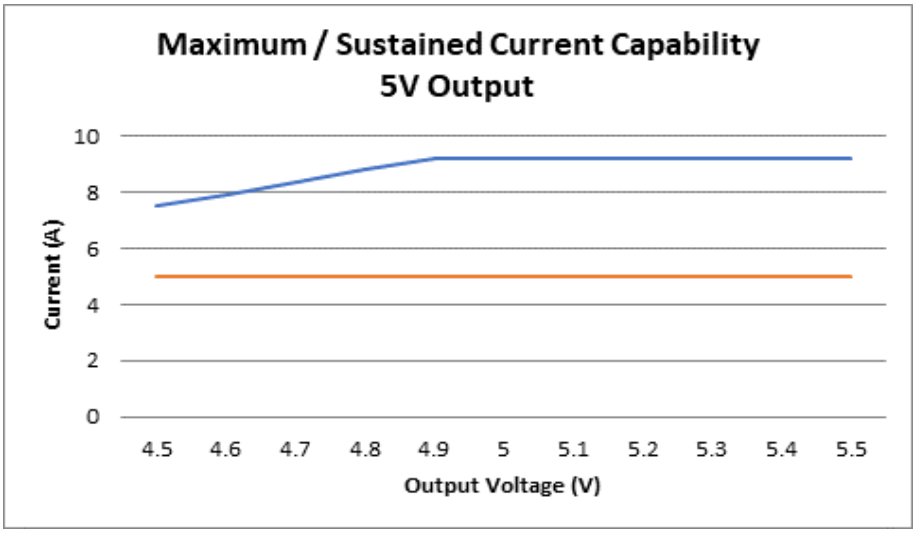
A module will automatically turn off its outputs if the current exceeds the limits (see the graphs below) for more than 1mS. An unlimited current is allowed for less than 1mS.

A similar shutdown will occur if the unit is over temperature. The status of the module can be seen in the TestMonkey GUI or via a command line query.

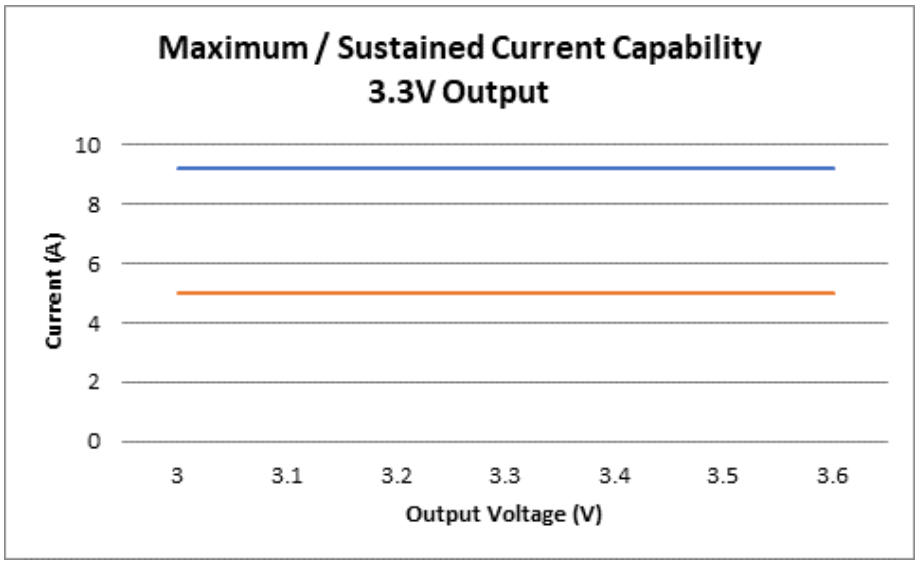
12V Channel: Max continuous current Vs Vout



5V Channel: Max continuous current Vs Vout



3V3 Channel: Max continuous current Vs Vout



Introduction

The Programmable Power Module (PPM) is a combined (dual channel) power supply and recording scope. PPMs are designed to test and characterize storage devices, such as HDDs and SSDs, but there are many other applications as well.

The module can output a voltage from 0 to nominal +20%, independently on each channel. This allows full power margining of the attached device. Instantaneous voltage, current and power measurements allow the user to monitor the performance of the attached device.

The output voltage on each channel can be controlled independently, with microsecond resolution and up to 1V/uS slew rate. This allows complex power patterns such as ramps, steps, glitches and even sine waves on a DC level.

Each channel can output up to 4 Amps continuous current. An unrestricted current can be supplied for up to 1mS, allowing for large inrush current during startup of a device.

Main features

- Dual output programmable power supply
- Fully programmable output waveforms
- High speed measurement and recording
- Simultaneous measurement of voltage and current
- Accurate measurement, down to 100uA for low power states
- External triggering, for connection to analyzers and similar
- Simple control via GUI or Python (and similar) scripts.

PPM Plus changes (v6.x Firmware)

The HD Programmable Power module was first released in 2016. We aim to support our products for many years, and HD is no exception.

The more advanced Power Analysis Module (PAM) range launched in 2021 and made many architectural improvements to our original power designs.

V6.x firmware for the PPM can be loaded prior to a calibration cycle and provides major benefits

- Faster streaming (Recording at 4uS is now possible for several minutes)
- Better accuracy at low power levels
- Additional triggers now exist, including more trigger-out options

A small number of commands have changed to align with the PAM design and may have an effect on existing tests:

- TestMonkey is no longer supported, all features have been migrated to QPS which is also cross platform and can capture vastly more data
- The response of measure commands now match the PAM format. They have a space between the number and the unit PPM = “692mV“ PPM Plus = “692 mV“
- The response of measure command can now have a wider range of units. A command that always responded in ‘mA’ before may now be in ‘uA’

Measurement and Recording

The Power Module samples constantly at 250K samples/second. Each measurement channel (current and voltage on each of the two rails) is captured in parallel by separate ADCs. This allows very accurate power values to be calculated.

Parameter	Options
Recording sample rate	4uS/sample (250k samples/second)
Recording sample averaging	0 to 32k samples, in powers of 2 (1, 2, 4, 8…)
Voltage accuracy	± 1% Typical
Current accuracy (1mA and up)	± (2mA + 1%)
Current accuracy (100uA - 1mA)	± (2uA + 2%)

The user can disable recording of any of the four measurements with the command:

`RECord:[channel]:[VOLTage|CURrent]:ENAble [ON|OFF]`

Disabling measurement channels increases the recording time available.

Measurement averaging

Each module has internal RAM for capture. At the full 4uS resolution, this corresponds to around 2.7 seconds of record time. This can be increased by turning off record channels that are not required or by increasing the ‘Averaging’ setting.

‘Averaging’ allows multiple samples to be combined to give a single result. This reduces noise in a reading, allows a larger recording time and reduces the amount of storage space required when streaming the recording to disk.

The averaging setting is set in powers of 2 (1, 2, 4, 8….16k, 32k). A setting of ‘4’ will average 4 consecutive samples, reducing the resolution and storage requirements by 4 times.

Even at the highest 32k averaging rate, every 4uS sample is calculated fully in the average, ensuring a very accurate total power consumption number. Each sample within the averaging window is summed together then divided by the number of samples. The calculated value is stored as a single measurement.

Lower averaging rates are used to capture detailed events, such as power up spikes, while larger values make it easier to see longer term power trends.

Streaming mode

‘Streaming’ mode allows the module to record data over an unlimited period of time (depending on the storage space you have available on disk).

In this mode, the module sends data to the controlling PC in real time, where it can be stored for later analysis. The speed of the connection (USB or LAN) and the power of the PC storing the data will limit the resolution that can be recorded.

A reasonable logging PC using USB or LAN control is generally able to record indefinitely at an averaging setting of 4 (~62k samples per second/64uS resolution). Running additional software on the PC may reduce this. At faster rates, less data will be recorded before streaming automatically terminates.

This mode is the default for Quarch software and automation examples and is the primary method of recording data.

Stream monitor mode

Streaming can require large amounts of disk space to store the data for post processing or display. It also requires CPU cycles to capture and store.

In some cases, you may want simple statistics of the power measured, but without adding any additional load to the test system. This may be due to high-speed workload tests being run on the host system.

Stream ‘monitor’ mode allows the HD PPM to monitor the stream data instead of sending it to disk. Power statistics for each channel (max, min and average) are calculated, giving precise values over the time of the stream, but with only two commands needed, one to start the process and one to gather the results.

The monitor system us controlled via the “**MONitor**” commands, see the command spec for full details.

> NOTE: Monitor mode can NOT be run at the same time as streaming or recording!

Monitor process example

- Start your workload
- Start monitoring "**MONitor:RUN**"
- Wait for as long as you want
- Monitor stats can be read back with "**MONitor:STAts?**" or "**MONitor:STAts:XML?**"
- If very precise stats regions are required run "**MONitor:STOP**" then poll "**MONitor?**" until it returns "STOPPED". Now run "**MONitor:STATS?**". This will ensure that all data is processed when the results are returned. If this is not done, some samples may still be in the process buffer.
  - XML form stats can re returned for easier parsing with "**MONitor:STATS:XML?**"

Voltage Output

Each of the two voltage rails can be set independently, from 0mV up to the nominal value of the rail +20%. This allows full range voltage margining and over voltage.

Voltage output defaults to OFF and must be manually enabled with the command

```
> RUN:POWER UP
```

At this point, the currently selected DC levels will be output to your device under test.

Host power sync

Systems that do not support ‘Hot Add’ (The ability to plug a drive in at any time) may not like it when the drive is not powered at exactly the expected time. This failure can cause the drive to fail to enumerate, or to enumerate at to lower speed.

In order to prevent this, some Quarch fixtures support ‘Host Power Sync’. This feature monitors the host rails and only switches power through from the PPM, when host power is also on. This ensures the drive powers up at exactly the same time as it would when Quarch equipment was not present.

This feature is present on all M.2 and AIC fixtures (where Hot Add is rarely supported). It is a purchase option on other interfaces, such as SFF-8639 and EDSFF.

Output mode selection

The second rail on the unit can be used for 5V (SAS/SATA) or 3V3 (PCIe) devices. When an HD compatible fixture is attached, its required voltage will be automatically selected. This reduces the risk of supplying the wrong voltage to a device.

If a legacy fixture or unmarked cable is connected, the user must specify the voltage range to use before the module will allow the outputs to be activated.

If an HD compatible fixture is attached, mode selection is automatic and the ‘conf:output:mode’ command will no longer allow you to change the mode.

Voltage margining

In the simplest mode of operation, the user selects the voltage level to be applied to each rail. To ‘margin’ a rail, a single command is used to change to a new level.

Pattern Generation

Power modules have a pattern generator for each voltage rail. This allows complex voltage patterns to be separately applied to each rail.

A pattern is made up of one or more points; each point has a time value (relative to the start of the pattern), a voltage (relative to the starting DC level, at the point the pattern is run), and an interpolate flag that specifies if the voltage should ramp or step between values.

> IMPORTANT: As the voltage of each point is relative, you MUST ensure the DC output level is correct before you run the pattern. This will normally involve setting both rails to nominal, or both to 0mV. If the last point in your pattern is not 0mV, then the DC levels after the pattern has run will be different than it was at the start.

Pattern generator characteristics

Characteristic	Settings
Pattern resolution	1uS
Number of pattern points	1 to 1024
Time value for a point	0 to ~71 minutes
Run modes	Single, Repeat n times, Cycle
Action between points	Step, Interpolate

Each point in a pattern is set with:

1. Time: The time for the point to occur (from pattern start).
2. Voltage: The voltage difference from the starting voltage level. A -ve value will equate to a drop in the requested voltage.
3. Interpolate flag: When set, the voltage will move smoothly between points, rather than stepping.

As the pattern runs relative to the voltage levels in use when the pattern is started, it is important to set the output levels before running a pattern.

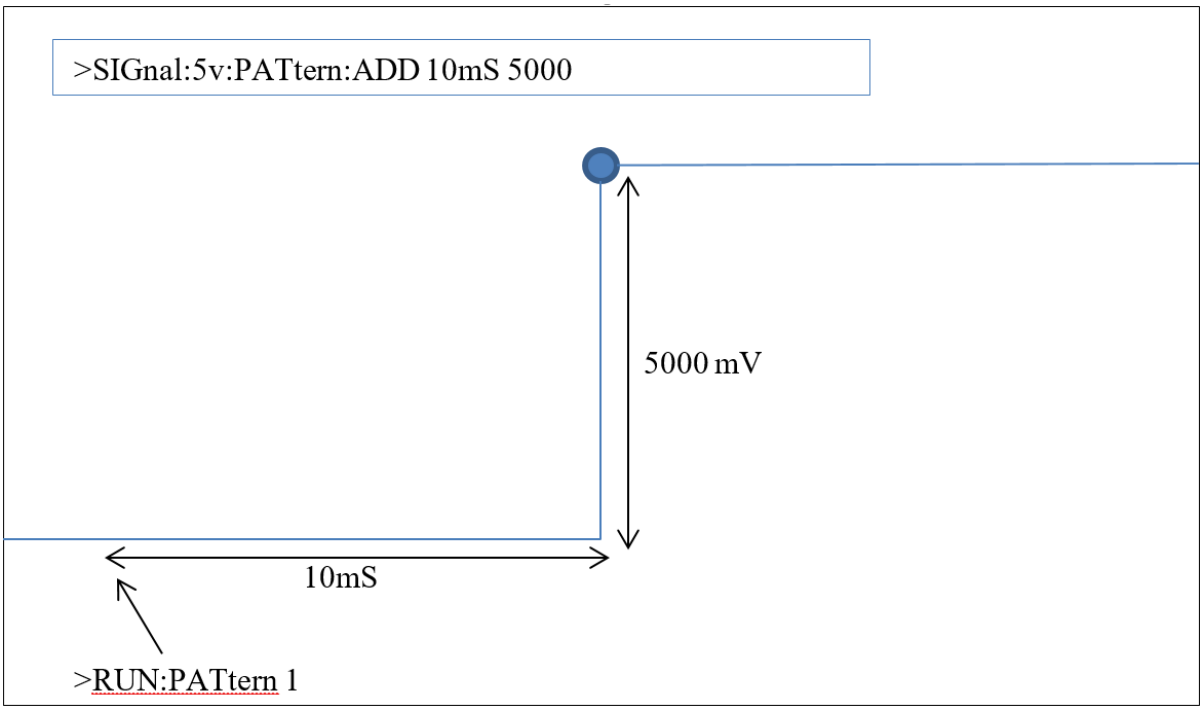
Patterns can be run in a number of ways:

- Manually triggered by command
- Started via the external triggering port.

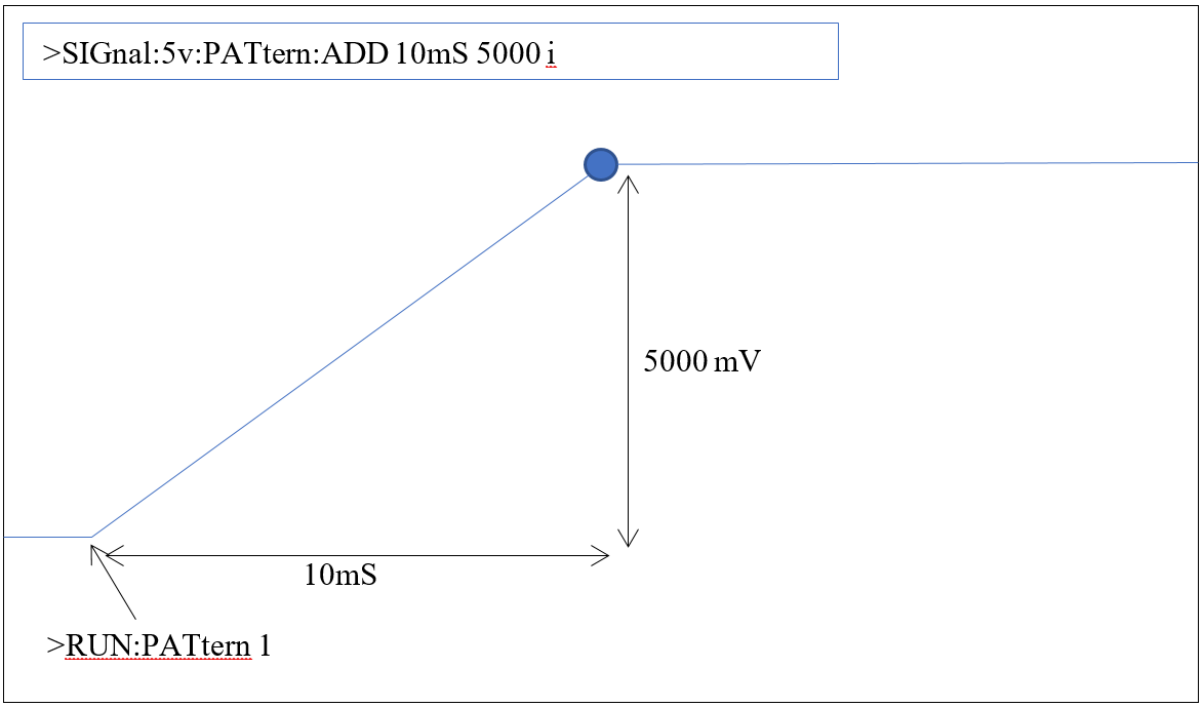
Pattern examples

Below are some example patterns and the points needed to generate them.

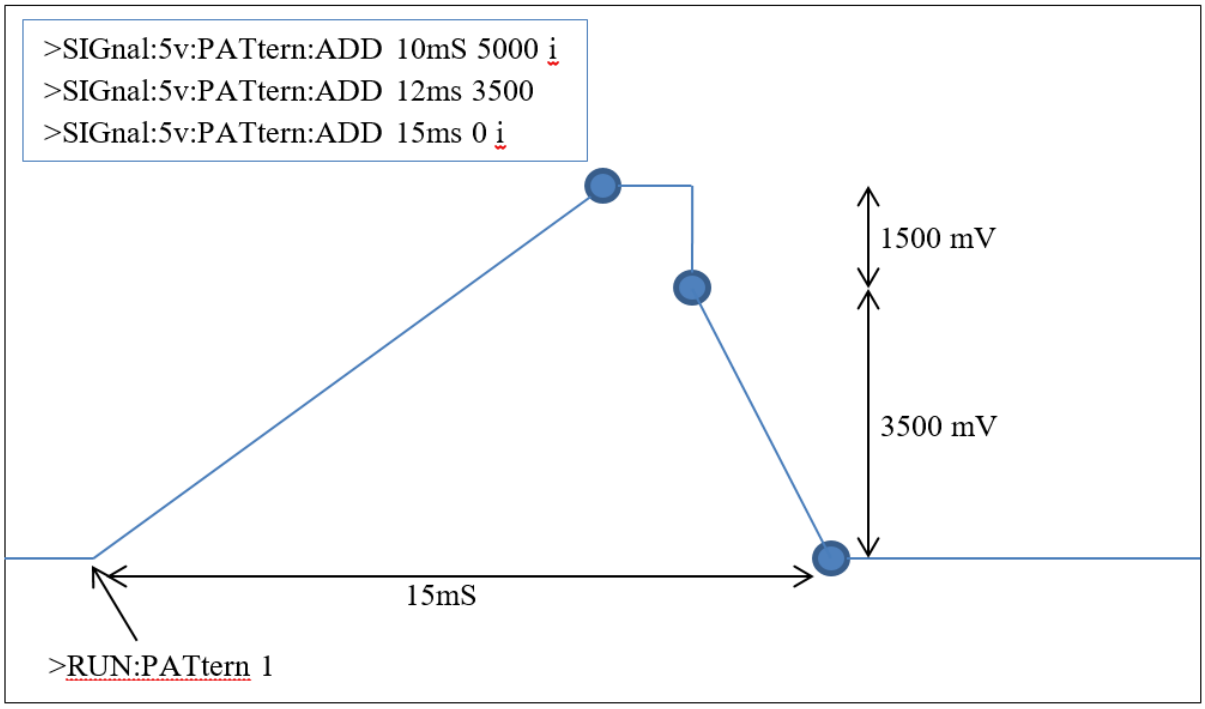
Pattern example: pattern with a single point



Pattern example with interpolated single point



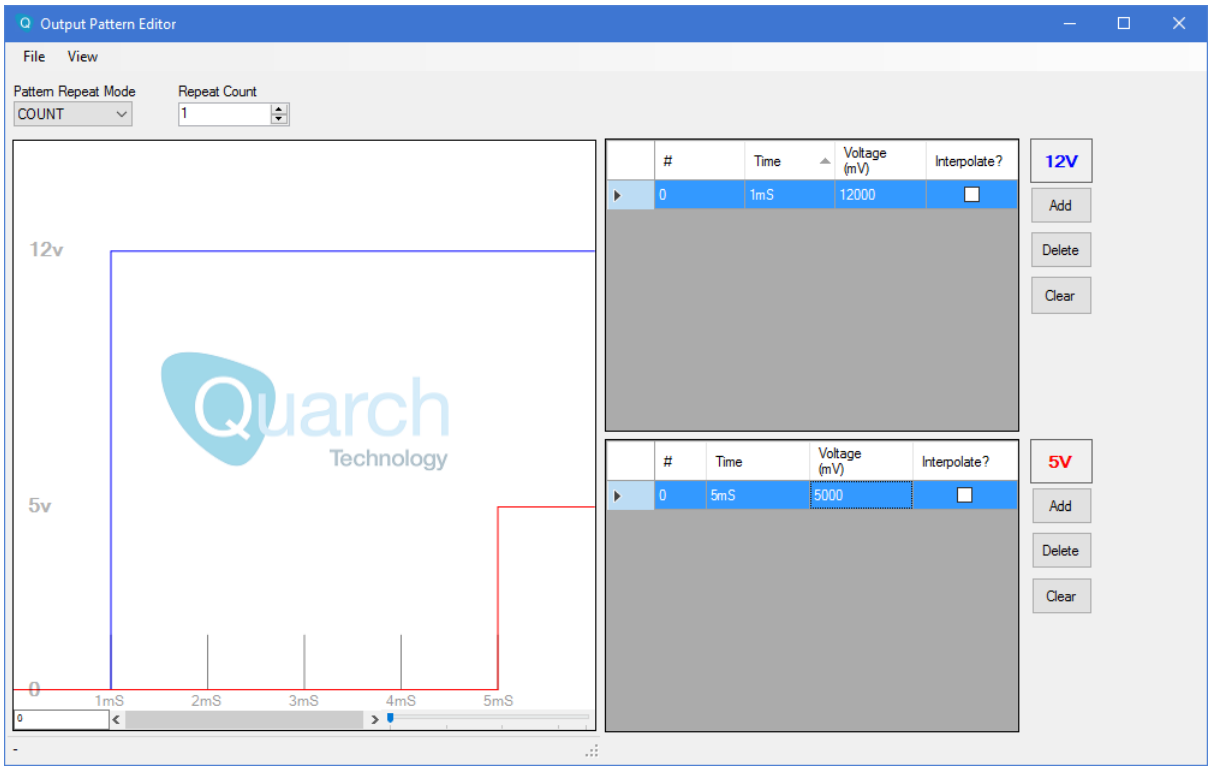
Pattern example with multiple points



Simple power up

Here we use a single pattern point on each rail to raise the voltages to nominal. The 12v rail powers up 4mS before the 5v rail.

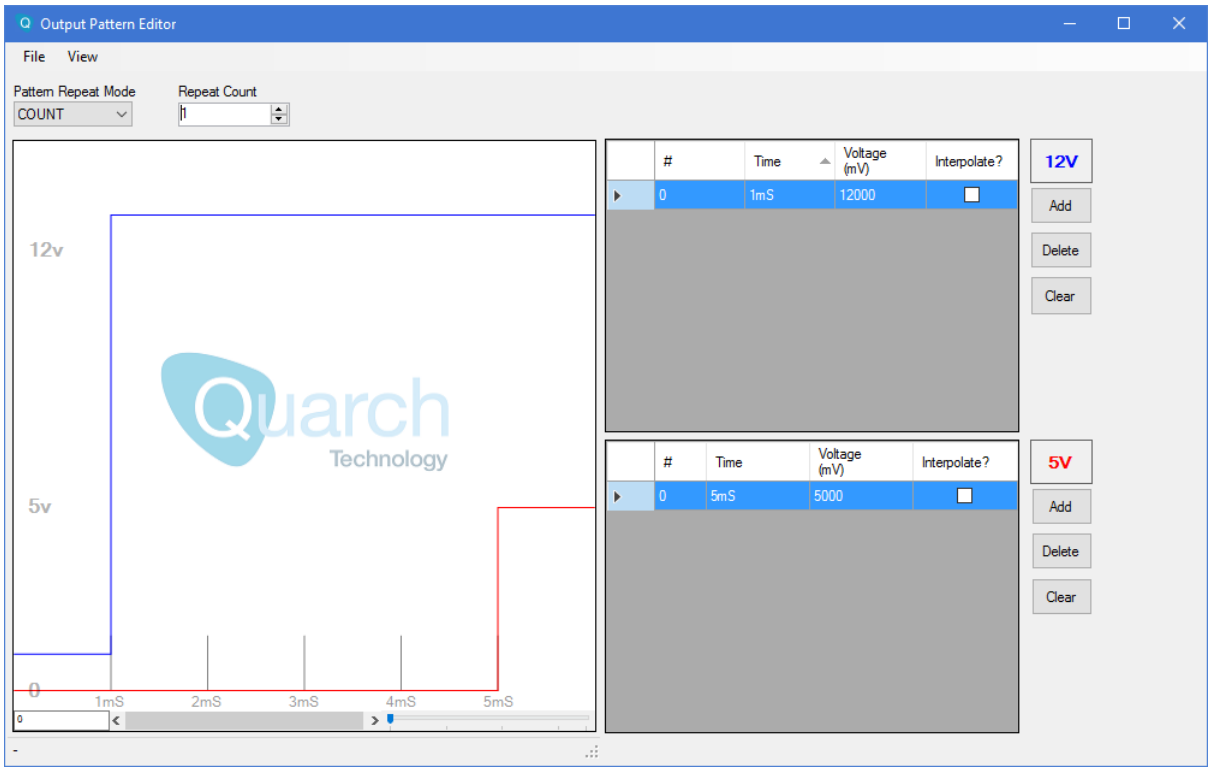
In order to make this work, the output voltages MUST be set to 0 on both rails before starting the pattern.



Simple power up (non-zero starting voltage)

In this example, we use the same pattern, but leave the 12V rail at 1000mV output.

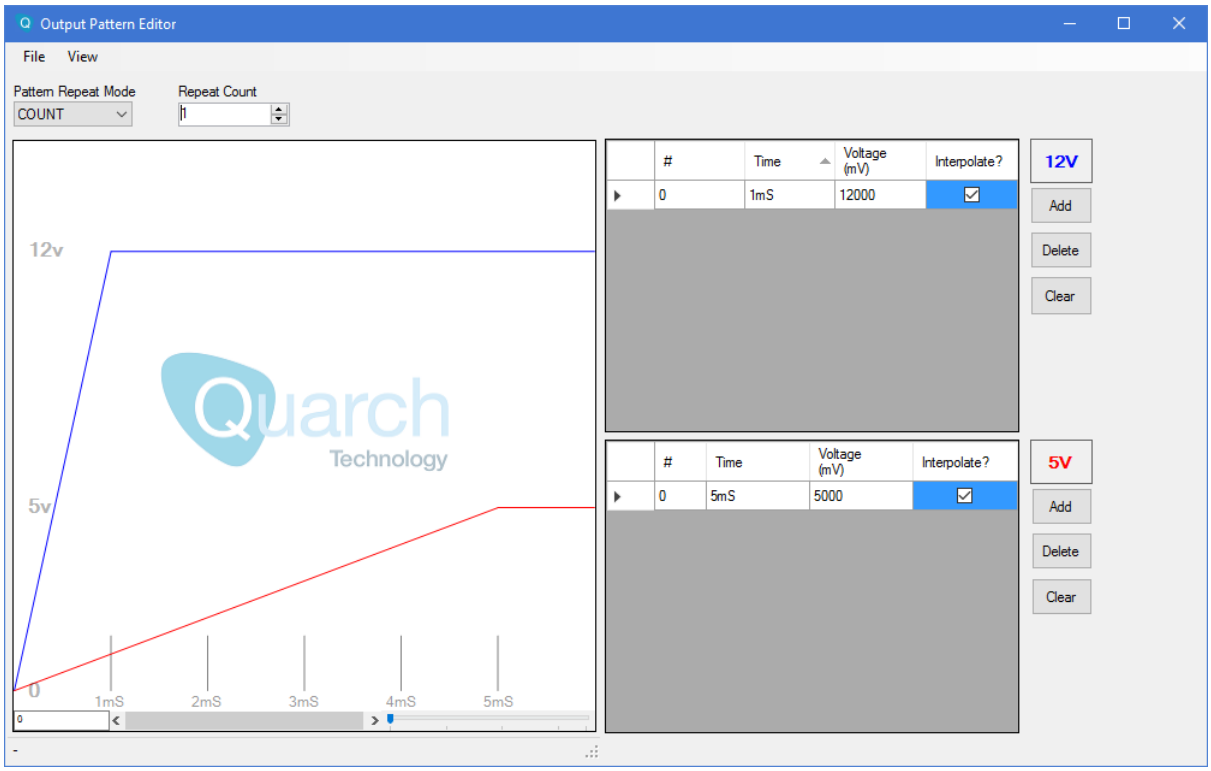
This time we see the 12V rail starts at 1000mV, and raises by an **additional** 12V, to a total of 13V.



Ramping up

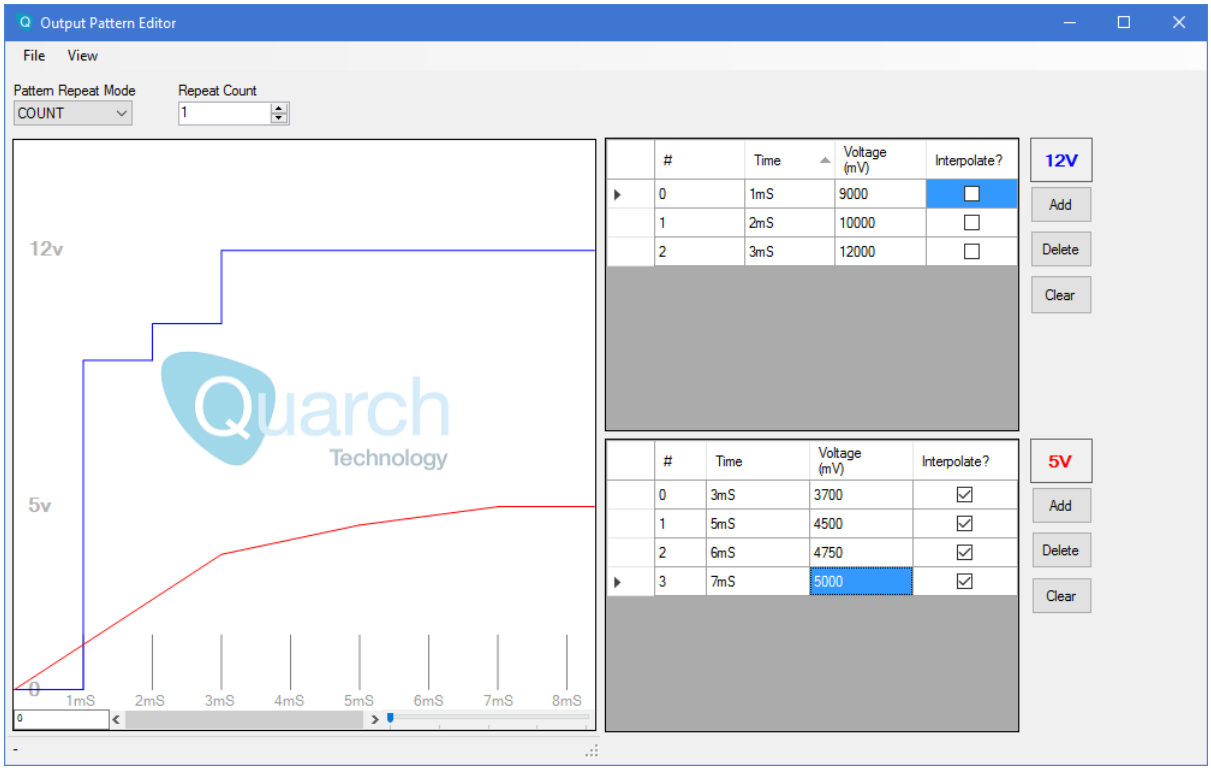
Instead of jumping to a new voltage level, we can ramp up, at any required rate. This is done by setting the ‘Interpolate’ flag on the point.

Now we see that the 12V rail is ramping over 1mS, while 5V is ramping over 5mS.



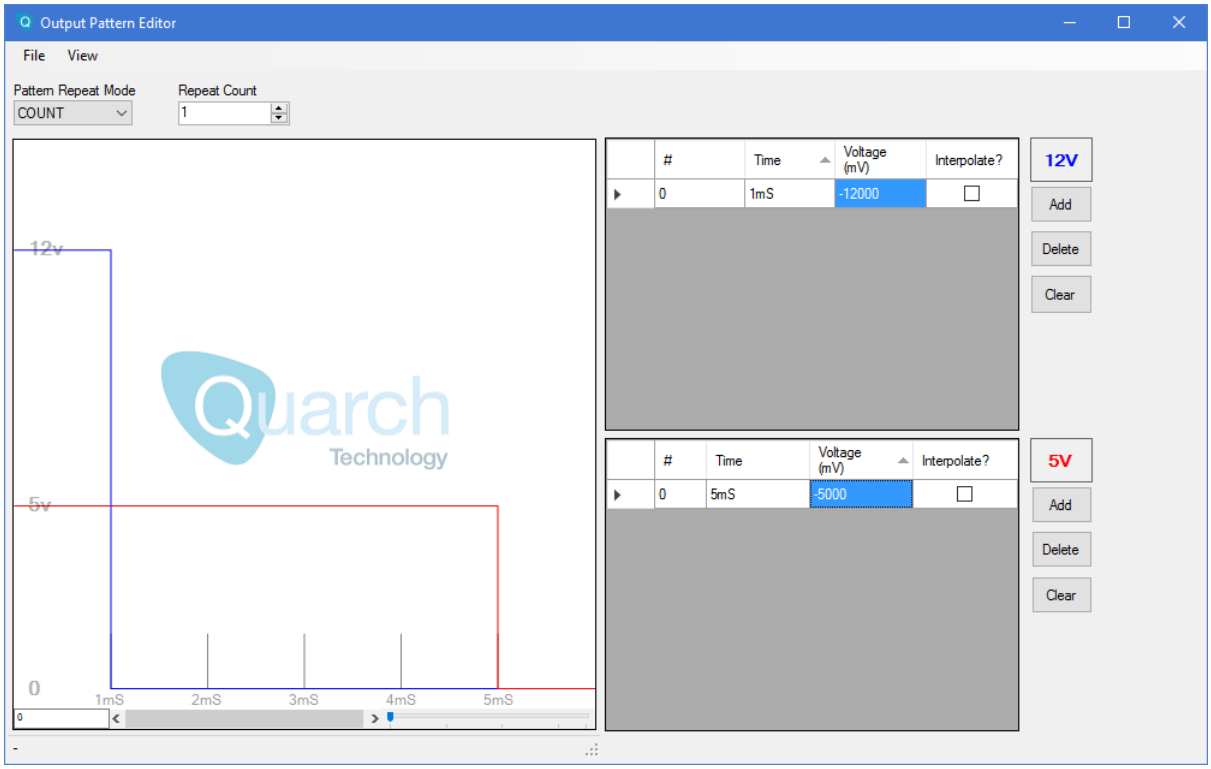
Multiple steps

Multiple points can be used to ramp/step in a more detailed fashion. Below we see the 12V rising in three discrete steps, while 5V uses 4 points to simulate a rough curve.



Power down example

This time we are starting with a DUT that is powered up. The initial voltage levels are 12V and 5V. This is identical to the “Simple power up” example, except that we are now dropping the rails, instead of raising them. On the 12V rail, we enter -12000 to bring the rail down to zero from its current value.

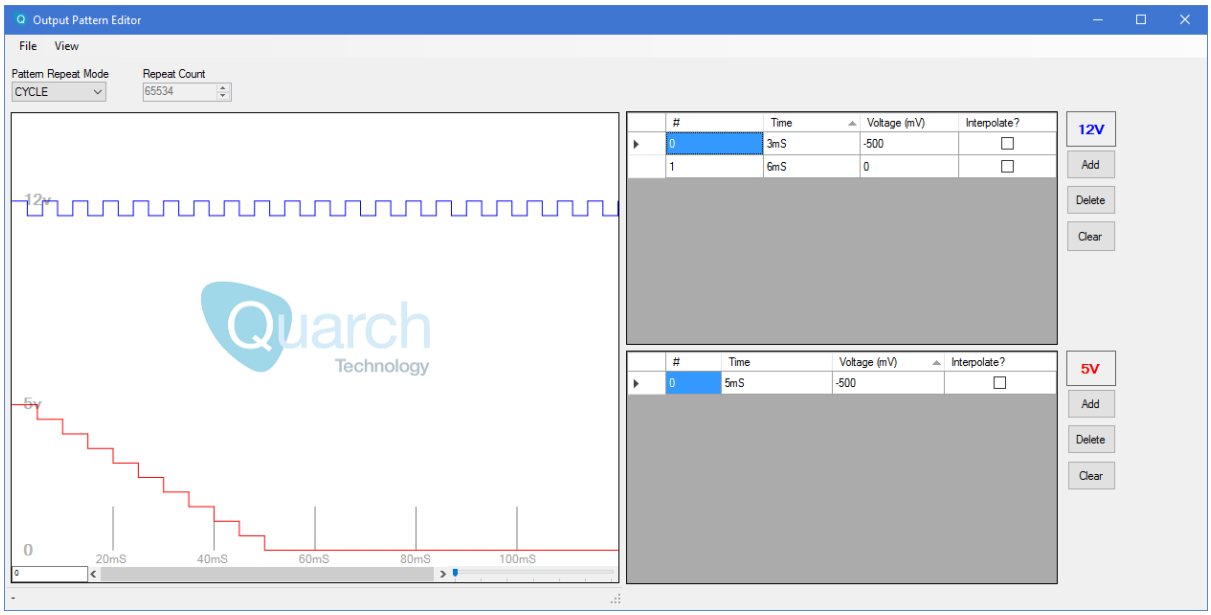


Repeating patterns

Patterns can be set to repeat a fixed number of times or to cycle until stopped.

> Warning: Each run of the pattern will be with reference to the voltages at the end of the previous cycle. Thus, if you end with a point on 0mV, the pattern will end at the same voltage as it starts and can cycle as required. If you end with a different value, the voltage will be higher/lower after each cycle. This could result in a higher voltage that you wanted to apply. If in doubt, set the maximum voltage limits to a safe level before running patterns.

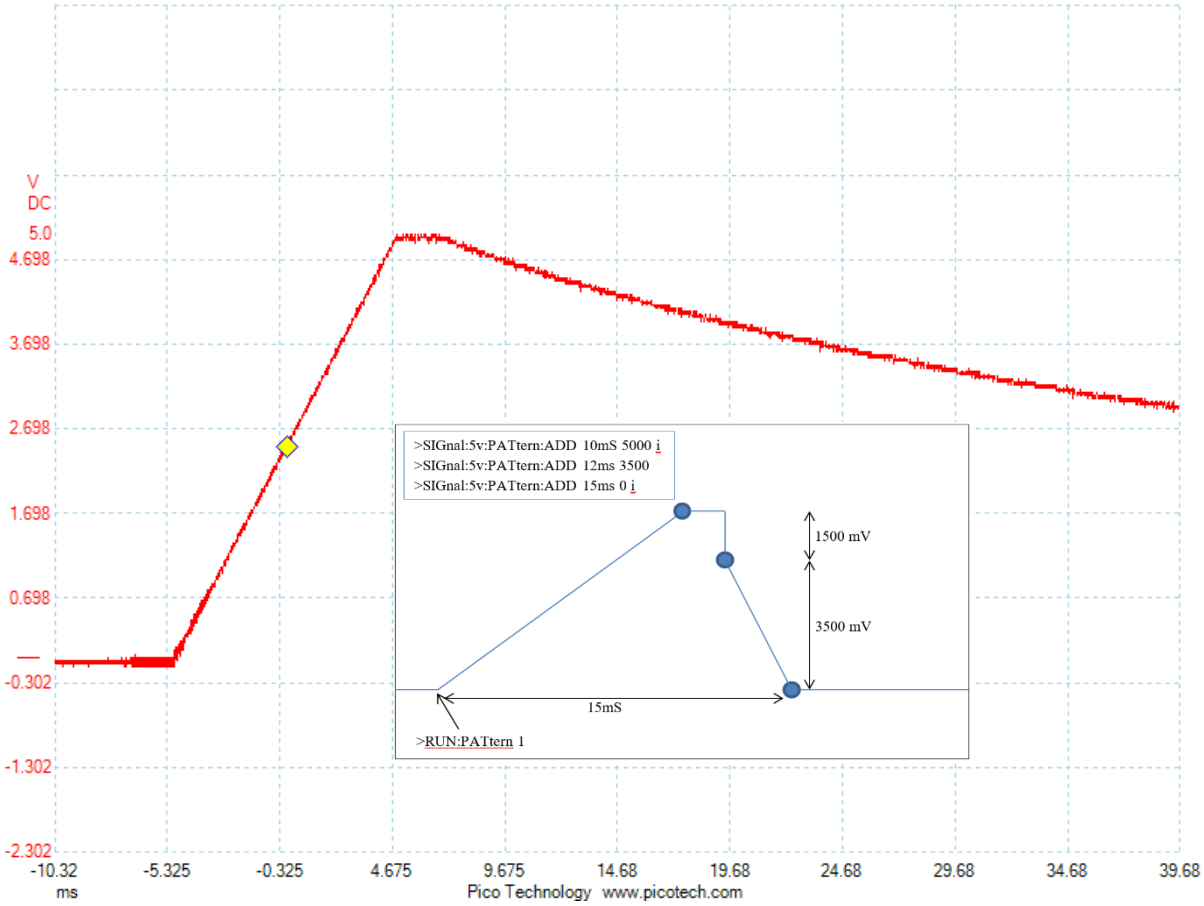
Below we have a cycling pattern. The 12V rail is a square wave with a period of 6mS and a height of 500mV. The 5V rail is missing the second point (which takes the relative voltage back to 0) and so steps down until it hits 0mV, where it stops.



Effects of patterns on real devices

The patterns shown above in this section demonstrate the voltage the module is trying to achieve but, in real world, the unit is able to source current not sink it (which is just like a typical power supply). This means that the capacitance of the output and the load may prevent the voltage from dropping even when the module's output is OFF. The graph below shows the pattern run on a hard drive; the capacitance of the drive continues to keep the rail charged long after the module's power has been turned OFF.

Enabling the 'Pull Down' option on the module will cause the ramp down to occur much faster, as the module can sink current as well as source it.



External Triggering Modes

Trigger In

- Run Pattern on Trigger In

  In this mode, you can set the module to run a pattern to completion when the Trigger In is received (Edge trigger) or to begin running a pattern and continue while the Trigger is set (Level trigger).

  This allows you to insert a power spike/level change/noise at a given point in the operation of the drive (perhaps using a data analyzer as the source of the trigger).

- Begin Recording on Trigger In

  In this mode, recording can be started when the trigger is received. In Edge triggered mode, recording will end when the memory is full. In Level triggered mode, recording will end when the trigger is cleared. This allows specific points or regions of operation to be captured.

- Enable Outputs on Trigger in

  When enabled, the primary output enable control will follow the external Trigger In signal.

Trigger Out

Trigger Out can be used to sync external equipment with the PPM.

- Trigger Out on pattern state:

  The PPM will assert Trigger Out when a pattern is running.

- Trigger Out on recording state:

  The PPM will assert Trigger Out when recording is running.

- Trigger Out on current/power threshold:

  The PPM will assert the Trigger Out while either power or current output has exceeded a user-set threshold. This might be used to identify points in operation where the drive exceeds expected power consumption.

Power Injection Fixtures

The SFF fixture for SFF-8639 drives (SAS, SATA, U.2, U.3) have a setting for SAS or PCIe mode. This ensures the correct voltages are presented to the required drive pins. Ensure the selection is correct for the drive you are using.

The 10 pin output port on the power modules can be connected to a range of standard fixtures and cables. There are several types of device that can be connected:

- HD ‘Basic’ fixtures

  These are fixtures using the HD 10 pin connector, which are marked as to the voltage range they require. When connected to an HD module, the output voltages will automatically change if needed.

- HD ‘Intelligent’ fixtures

  These fixtures are currently being planned; they will support processing on the fixture and communication with the HD module. This should allow advanced triggering and additional measurements.

- XLC fixtures/customer-built custom cables

  Fixtures from the old (6 pin output) power modules can be used with the appropriate adaptor cable. These are not marked for the required voltage range, so this must be selected manually.

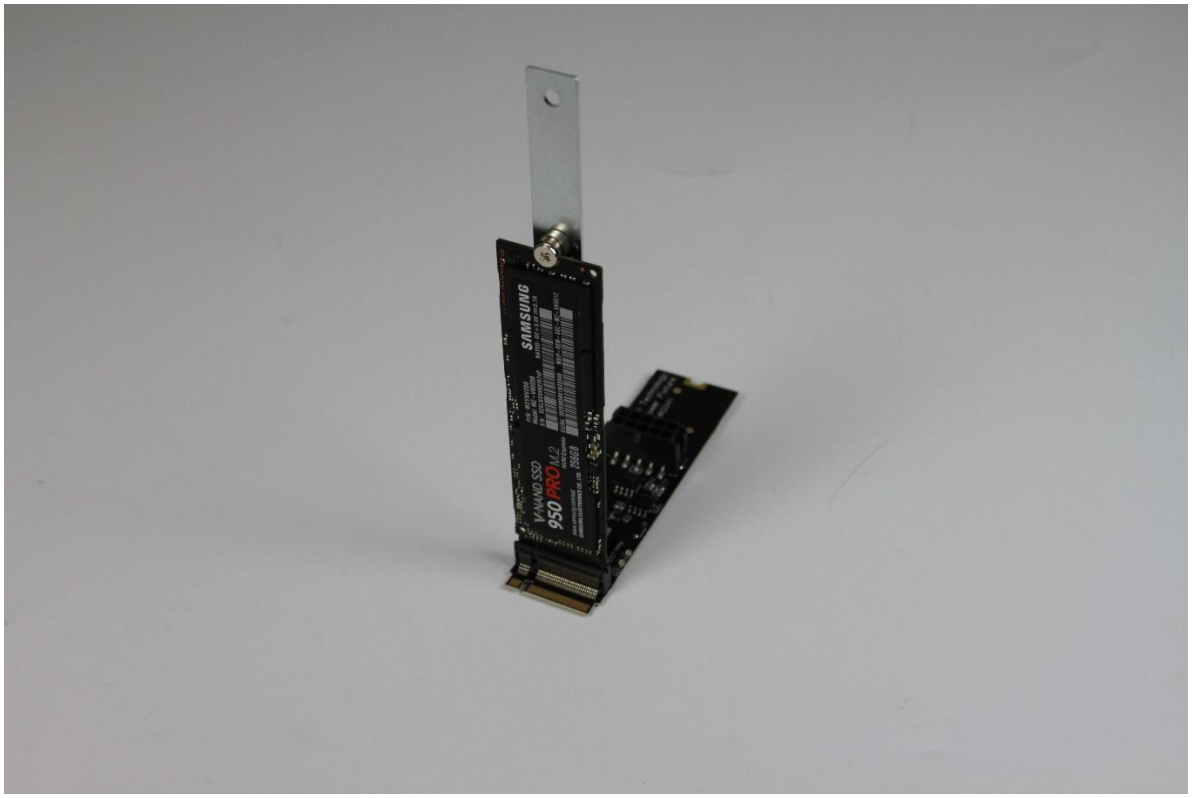
Example fixtures

Here are a number of the fixtures currently available. Please see www.quarch.com for an up-to-date list of available options.

QTL1960 PCIe x4 to M.2 HD Injection Fixture

QTL2015 Gen4 M.2 Vertical HD Injection Fixture

QTL3004 Gen5 M.2 M-Key Vertical Power Injection Fixture



QTL3004 features:

- Support for M-Keyed SSDs including SATA 3.5 and NVMe PCIe Gen 5.0
- Fully backwards compatible with previous SATA (SATA 3.4, 3.3, 3.2, 3.1, 3.0) and NVMe generation M.2 SSDs (PCIe 4.0 and 3.0)
- Suitable for use with Quarch PPM devices (HD and XLC are supported)
- 3.3V is isolated from the device and provided by the HD or XLC module
- PPM sense 3V3 is connected near the device power pins to improve accuracy
- Host Sync - 15V from HD PPM / 12V from XLC is used to power components on the module. These voltages are used to allow the device to be powered at the same time as the host starts up.

Controlling the Module

The primary control interface for HD Power Modules is via a LAN connection. QTL1999 (single power modules) also support a USB connection, to keep them compatible with tests designed for use with the older XLC module.

All major features are available over both interfaces. However, the maximum data transfer rate may be different (and dependent on your network).

Communication protocol

Commands sent to the module are simple, text based commands, roughly based on the SCPI specification. For instance, the following command sets the voltage on the 5V rail to margin down to 4800mV:

```
SIGNAL:5V:VOLTAGE 4800
```

Download of recorded and streamed data uses a compressed binary format for speed.

Quarch applications and examples handle the sending of commands and processing of recorded data, allowing very simple automation from Python scripts and similar.

LAN

The main mode of communication on a network is a TCP based custom protocol. This mode is required for downloading and streaming data.

ReST control is also possible, allowing basic automation without any Quarch code on the control PC. In this mode, you can control the module and take basic measurements, but you cannot download or stream data.

USB

USB control supports the full range of control, download and streaming. The Quarch USB driver is required on Windows PCs. LibUSB can be used for Linux.

Control options

There are a number of applications and scripted control options for HD Power Modules:

- Torridon Terminal

  This is a simple terminal application that can connect to a module and send manual commands. It is useful for testing, debugging and small amounts of manual control.

  This is a Windows-only application and can be run directly (no installer needed). It can connect to the module over USB or LAN.

- TestMonkey GUI

  TestMonkey is a simple GUI that allows control of all existing Quarch modules. It is great for evaluating and learning to use power modules. It can also be used for easy manual testing.

  TestMonkey is Windows-only and requires to be installed.

- QIS (Quarch Instrumentation Server)

  QIS is a small Java server that runs on a Windows or Linux PC. It can connect to any Quarch module and allows very simple automation from Python scripts and similar.

  Scripts connect to QIS via a network socket. Application Note AN-012 on the Quarch website (http://quarch.com/content/downloads) demonstrates this.

  QIS can connect to modules over USB or LAN. The controlling Python scripts can be on the same PC or elsewhere on the user's network.

- Legacy Python scripts

  Is it is possible to control modules directly via Python scripts (and similar). This avoids the need for QIS and Java. These scripts are no longer actively maintained though, so QIS is strongly recommended for automation. The examples for this can be found in Application Note AN-004

Serial and Enclosure Numbering

Serial numbers

Most Quarch modules have a simple “Serial Number”, displayed on the product label and stored in the device firmware. The format is:

QTLXXXX-YY-ZZZ

XXXX Part number of the product

YY Hardware version of the product

ZZZ Incrementing serial number section

Each Quarch product type always has a unique XXXX number

HD Power Modules are slightly different. HD modules come in x1 and x6 enclosures (other port counts may come in the future). To make the single and multi-port units totally compatible, we use the SAME part number for the power module, regardless of how many modules are in the enclosure.

As such, a test can swap a single module QTL1999 with one of the six modules on a QTL1995.

ALL HD Power Modules will have a serial number in the form:

QTL1944-XX-YYY

This number is NOT normally needed by the user. It is displayed on the “*IDN?” screen response for debug purposes, but you will not identify the module with it and it is not printed on the product stickers. Instead, HD modules are identified and controlled via their ‘Enclosure Number.’ (see below)

Enclosure numbers

An enclosure number is the top-level, unique number of the product. An enclosure contains one or more individual modules which can be separately controlled.

This number is printed on the product label, is displayed on the “*IDN?” screen and forms the basis of the LAN identification system.

For single HD modules, the enclosure number is in the form:

QTL1999-XX-YYY

This number is also the default NetBIOS name and will be the number used to identify the product in all Quarch software.

For x6 HD Modules, the enclosure number is in the form:

QTL1995-XX-YYY

This number is appended with a three-digit ‘position’ number, to indicate the location within the enclosure. Thus a x6 HD module will have an enclosure number on the product label such as:

QTL1995-02-004

The full identifier (and default NetBIOS name) for each unit in the enclosure will be:

QTL1995-02-004-001 (Left-most unit when looking at the front)
QTL1995-02-004-002
QTL1995-02-004-003
QTL1995-02-004-004
QTL1995-02-004-005
QTL1995-02-004-006 (Right-most unit when looking at the front)

Default Startup State

On power up or reset, the module enters a default state. In this state, the outputs will be turned OFF and the DC level setting will be set to the nominal value of the voltage rails.

Running a “RUN:POWer UP” command will therefore enable the outputs immediately at their nominal value (assuming an HD power fixture is attached).

Basic setting	Default value
Output enable	OFF
12v Level	12000 mV
5v Level	3300mV / 5000 mV *1
3v3 Level	3300mV
Patterns	NONE
Measurement averaging	No averaging

*1 – *Depends on the detected injection fixture*

LAN setting	Default value
DHCP	ON
IP address	192.168.1.99
IP mask	255.255.255.0
DNS1,2	0.0.0.0
GATEWAY	192.168.1.1
NetBIOS name (QTL1999)	1999-nn-nnn
NetBIOS name (QTL1995)	1995-nn-nnn-ppp

nn-nnn = Serial number section, as stated on the product label

ppp = Position of module within the enclosure in the form ‘001’ to ‘006’

Factory Reset

HD units can be returned to their factory default states with the command:

> CONFIG:DEFAULT FACTORY

This will reset all user settings, including LAN / IP addresses and similar.

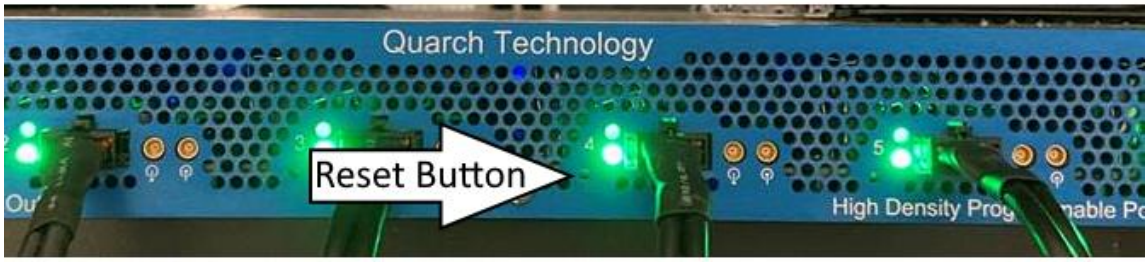
On more recend builds (QTL1999-06 and QTL1995-05 and later) If the terminal is not available (perhaps you forgot your IP and cannot talk to the unit), there is a recessed reset button hidden behind the front panel.

Carefully press the button with a non-conductive blunt probe. This is a microswitch so you do NOT need much force for this, if it does not press easily, you are not pressing the button.

Hold the button down. The LEDs will change color in sequence. After 10 seconds, until both lights have turned blue, now then release it.

The port will now be in factory reset condition. On QTL1995, there is a separate reset button for each port.

Note: Any press of this button, however short will cause a reset of the module, similar to what would occur with a power cycle.



Command Set

These commands are based on the SCPI style control system that is used by many manufacturers of test instruments. The entire SCPI specification has NOT been implemented but the command structure will be very familiar to anyone who has used it before.

- Commands are NOT case sensitive.
- Commands are in a hierarchy separated by ':' (LEVel1:LEVel2:LEVel3).
- Most words have a short form (e.g. 'register' shortens to 'reg'). This will be documented as REGister, where the short form is shown in capitals.
- Many commands take parameters. These are separated by spaces after the main part of the command (e.g. "meas:volt:self 3v3?" obtains the 3v3 self test measurement).
- Query commands that return a value have a '?' on the end.
- Commands with a preceding '*' are special control/query commands, found on all devices.
- Commands that do not return a particular value will return "OK" or "FAIL". Unless disabled, the fail response will also append a text description for the failure if it can be determined.

Identify commands

These commands allow you to identify the device you are working with.

***ENCLOSURE?**

Returns the enclosure number of the overall product.

***POSITION?**

Returns the numeric position of the current power module within its enclosure.

HELLO?

Returns the descriptive name of the module

HELP

Returns basic help to the terminal, including a list of more detailed help commands.

CONFig:ALIAS [Name]
CONFig:ALIAS?

Sets or returns the module Alias. This is a custom text descriptor which can be used to identify between modules where multiple units are used.

Basic Setup commands

These are standard commands to setup the module

 # [comments]

Any command beginning with a # character is ignored as a comment.

***RST**

Triggers a reset; the module will behave as if it had just been powered on. A reset will cause USB/LAN connections to be lost and the module must be reconnected again.

CONFig:DEFault STATE

Sets the unit to its power on default state. This will leave the unit in the same state as if it was power cycled.

CONFig:DEFault FACTory

Sets the unit to the state it left the factory in. This will set any EEPROM stored parameters to factory defaults. It will not affect the calibration settings for the unit.

If this command changes the NetBIOS name, a power cycle or ***RST** command will be required for the change to take effect.

CONFig:FAULT:RESet

Resets fault flags and activates the unit if outputs have tripped due to over current/over power.

CONFig:FAULT?

Returns the state of the output fault flags. This will return OK unless an over current/over power fault has occurred.

CONFig:MESSages [SHORt|USER]
CONFig:MESSages?

Sets or returns the message returns mode. When ‘SHORT’, detailed error messages will be suppressed.

Output Control Commands

These commands allow you to set the output voltage levels.

RUN:POWer [UP|DOWN]

Activates/deactivates the outputs. The output voltage will be the current DC voltage setting for the channel when in power up mode.

When used with an XLC injection fixture, or a custom fixture without electronic marking, this command will FAIL. You must run the **CONFIG:OUTPUT MODE** command first, to manually select the output voltage range.

RUN:POWer?

Returns the current power output activation state.

CONFig:OUTput:MODE [5V|3V3]
CONFig:OUTput:MODE?

Sets or returns the output mode of the device. When not using an intelligent fixture that can indicate the range it works over, then this mode MUST be set with the command before the outputs can be enabled.

The return from this command can also be DISABLED, which indicates that the output mode has not been set and an intelligent fixture is not in use.

If you are using an HD compatible fixture, You cannot use this command, the output voltage mode will be set automatically.

SIGnal:[name]:VOLTage [#mV]
SIGnal:[name]:VOLTage?

Sets/returns the DC output voltage level for the given channel where [name] is one of 12V or 5V. If the outputs are enabled, the voltage will change to the new level immediately.

> This command is the primary method of setting out output voltage level for standard operation and voltage margining tests.

Feature setup commands

These commands allow you to set up the various features of the module.

CONFig:OUTput:LIMit:[5v:12v]:VOLTage [#mV]
CONFig:OUTput:LIMit:[5v:12v]:VOLTage?

Sets or returns the voltage output limit on a channel. This limit can be chosen to ensure the output voltage never goes above the set level.

The setting is persistent over reset/power cycle.

CONFig:OUTput:[5v:12v]:PULLdown [ON|OFF]
CONFig:OUTput:[5v:12v]:PULLdown?

Sets or returns the output pulldown enable state. When enabled, the module will actively pull down the rail when the requested voltage is below the current rail level. This is ONLY available on XLC modules.

CONFig:STREAM:ENABLE [ON|OFF]
CONFig:STREAM:ENABLE?

Sets or returns the enable state for streaming mode. Streaming clients must use this command to enable streaming before the feature can be used. This ensures that clients that cannot handle the data return will not accidentally request it.

Status Commands

These commands allow you to query the operation of the module

CONFig:FIXTURE?

Returns the fixture type attached to the module. This can be:

NONE = No fixture (or fixture does not support identify). Outputs are disabled.

OVERRIDE = As with **NONE**, but output mode has been overridden (to either 5v or 3v3 mode, in order to enable the outputs.

LEGACY = An intelligent fixture with basic voltage detection is attached. Outputs will have been set to the correct levels for the fixture (3v3 or 5v).

CONFig:TERMINAL:MODES?

Returns a list of terminal modes that can be supported by this module.

RUN:INTerrupts?

Returns a list of interrupt flags, showing the actions that have occurred. Querying the interrupts will clear the flags (assuming the interrupt item is no longer in effect'

Interrupts are:

TRIGGERED	A trigger in occurred
COMPLETE	An action completed
M_BUFF	Memory is pre-buffering
M_DONE	Memory pre-buffering is done
M_TRIG	Memory recording triggered
R_PART	Recording is available to download (memory not full)
R_FULL	Recording is available to download (memory is full)

Measurement commands

These commands return a simple, instantaneous measurement. They are useful in scripts when you do not want to deal with downloading a larger block of measurement data.

> Voltage/current/power measurements are always affected by the current 'averaging' setting. A higher averaging setting will produce a more stable and more consistent result when using these commands.

MEASure:VOLTage [name]?
MEASure:CURrent [name]?
MEASure:POWer [name]?

Returns the voltage/current/power of the given output where [name] is 5V or 12V.

MEASure:OUTputs?

Returns the voltage and current measurements for both channels at the same time.

MEASure:TEMPerature [name]?

Returns the output temperature in Deg C where [name] is 5V or 12V.

MEASure:TEMPerature UNIT?

Returns the temperature in Deg C of the enclosure.

Pattern commands

These commands allow you to setup and run complex output patterns

Pattern Control

RUN:PATtern [n]

Starts the currently stored output patterns and runs them in a loop [n] times. As patterns are relative.

If you run a pattern more than once, it is normally important that the pattern finishes at the same voltage that it started at. This will avoid the output tending towards it maximum as the pattern repeats.

RUN:PATtern CYCLE

Starts the currently stored output patterns and runs them in a constant loop.

As patterns are relative, if you run a pattern more than once, it is normally important that the pattern finishes at the same voltage that it started at. This will avoid the output tending towards it maximum as the pattern repeats.

RUN:PATtern STOP

Immediately stops a pattern that is currently running. The outputs will remain at the state they were in when the pattern stopped.

RUN:PATtern END

Stops a pattern that is currently running, at the end of its current cycle. This is used to stop a cycling/repeating pattern such that the outputs will always end up in a known state (the last point in the pattern).

RUN:PATtern?

Returns the running state of a pattern.

Setup commands

SIGnal:[name]:PATtern ADD [#Time] [#Voltage] [i]

Adds a point to the output pattern for the output named [name].

[name] is the output channel 5V or 12V for this point.

[#Time] is in the form XuS, XmS or XS, where X is an integer value. This is the time that the point takes effect at.

[#Voltage] and is an integer value in mV. The value is relative to the DC output voltage before the first point in the pattern and so this parameter may be negative to allow a point to be specified that is lower that the initial voltage.

[i] is an optional parameter. Placing an “i” at the end of the command will tell the unit to interpolate (ramp) to the new voltage rather than making an immediate step. In this case, the voltage will begin to change at the previous time point.

If you specify a time point that has already been used, the original value will be overwritten.

SIGnal:[name]:PATtern DELete [index]

Deletes the point in the output pattern at position: [index]. The index of a given point can be found by displaying the current pattern with the **DUMP** command.

SIGnal:[name]:PATtern CLEAR

Deletes all points in the output pattern.

SIGnal:[name]:PATtern DUMP?

Displays all points currently in the pattern.

Recording and streaming commands

These commands allow you to bring back blocks of measurement data for display or further processing.

RECord [RUN|STOP]
RECord?

In the STOP state, recording will not run. In the RUN state, recording will either start immediately (MANUAL trigger mode) or at the point that the currently set trigger occurs.

> This command MUST be run before any recording can be taken. It will clear the current recording and setup for pre-trigger (if a pre-trigger option is set).

RECord:[channel]:[channel_type]:ENAble [ON|OFF]
RECord:[channel]:[channel_type]:ENAble?

Enables/disables the record of each of the 4 available channels,

where [channel] is: 5V or 12V

and [channel_type] is: VOLTage or CURrent

The module can store 65k measurement samples so each channel enabled will reduce the total length of time that can be recorded.

RECord:TRIGger:MODE [mode]
RECord:TRIGger:MODE?

The trigger mode can be set to one of the following:

PATTERN	Trigger occurs when an output pattern is started.
POWER	Trigger occurs when the power state is changed to ‘ON’.
MANUAL	No Trigger; recording starts on issuing **RECord:RUN** command.
EXTernal	Trigger is taken from the external Trigger In connector (supporting modules only).
THRESHold	Trigger is taken from the set current/power threshold levels. Recording will start if any of the limits is exceeded.

RECord:LIMit:PERcentage [#percent]
RECord:LIMit:PERcentage?

The memory to use for recording can be limited to a percentage of the total capacity. This can be specified as a fraction (e.g., “30.33”) for greater resolution.

RECord:TRIGger:PRE [#percent]
RECord:TRIGger:PRE?

The record function can pre-trigger, to capture data before the trigger occurs. This sets the percentage of available memory to be used for the pre-trigger region.

RECord:AVEraging [rate]
RECord:AVEraging?

By default, the module collects samples at a rate of 250,000 samples per second. This can be reduced by averaging across multiple measurements to give a longer recorded period.

The averaging option allows 2^n samples to be averaged together for a single recorded reading.

We recommend you instead use the QIS ‘stream mode resample’ command or the quarchpy resample API. This is clearer to understand and consistent with newer devices.

Valid rate enumerations are:

[rate]	Samples averaged	Averaging window
0	No Averaging	N/A
2	2	8 uS
4	4	16 uS
8	8	32 uS
16	16	64 uS
32	32	0.13 mS
64	64	0.25 mS
128	128	0.5 mS
256	256	1 mS
512	512	2 mS
1K	1024	4.1 mS
2K	2048	8.2 mS
4K	4096	16.4 mS

8K	8192	32.8 mS
16K	16384	65.5 mS
32K	32768	131 mS

RECord:DUMP [#Time] [#Time]
RECord:DUMP ALL

This command displays recorded measurements on the terminal. The time values specify the start and end times in memory to be displayed. Due to communications limitations, it is not recommended to dump a large number of samples at the same time as it will be a slow process.

[#Time] is in the form XuS, XmS or XS, where X is an integer value.

RECord:STREAM
RECord:STREAM?

Begins (or checks the state of) streaming of measurement data. This is only available after enabling streaming, and requires a stream compatible client to handle the high volume of data.

Monitor commands

These commands allow the module to consume stream data internally, rather than return it to an external application. This allow you to gather basic statistics with no additional processing

MONitor:RUN

Begins a monitor stream, cannot be done at the same time as a recording stream

MONitor:STOP

Ends the monitor stream

MONitor?

Returns the state of the monitor process, poll until this is STOPPED to ensure all data has been fully processed

MONitor:STATS?
MONitor:STATS:XML?

Returns the monitor statistics in simple user or XML format

External triggering commands

TRIGger:OUT:MODE [PATtern|RECord|THReshold]
TRIGger:OUT:MODE?

Sets the action that will cause a Trigger Out to occur. In Pattern mode, the trigger will assert while a pattern is running. In Record mode, the trigger will assert while the recording is running. In Threshold mode, the pattern will assert while any power/current value is above the user-set threshold for that value.

TRIGger:OUT:THReshold:[channel]:CURrent [#mA]
TRIGger:OUT:THReshold:[channel]:CURrent?

Where [channel] is: 5V or 12V and

[mA] is a current level in milli Amps.

Sets the current threshold for the channel. If the measured current exceeds this level, Trigger Out will be asserted (if the Trigger Out mode is set to threshold).

TRIGger:OUT:THReshold:[channel]:POWer [#mW]
TRIGger:OUT:THReshold:[channel]:POWer?

Where [channel] is: 5V or 12V and

[mW] is a power level in milli Watts.

Sets the power threshold for the channel. If the measured power exceeds this level, Trigger Out will be asserted (if the Trigger Out mode is set to threshold).

> Power threshold is NOT available on PPM Plus, use the current threshold instead.
>
> Due to the nature of the calibration, power threshold values will not be quite as accurate as current threshold values. If you require a very accurate threshold value, it may be better to use a current threshold instead.

PATtern:TRIGger:EXTernal [ON|OFF]
PATtern:TRIGger:EXTernal?

Sets the enable state of the external pattern trigger. When enabled, an external trigger will cause the current pattern to start running.

PATtern:TRIGger:EXTernal:TYPE [EDGE|LEVEL]

PATtern:TRIGger:EXTernal:TYPE?

Sets the type of external trigger expected that will control the pattern start. An Edge trigger will start the pattern when the trigger is asserted. The pattern will stop when completed or when stopped manually. If a cycled pattern is currently set, it will only end when stopped manually.

A Level trigger will start the pattern when asserted and will end the pattern immediately when de-asserted.

RECord:TRIGger:EXTernal:TYPE [EDGE|LEVEL]
RECord:TRIGger:EXTernal:TYPE?

Sets the type of external trigger expected that will control the recording start. An Edge trigger will start the recording when the trigger is asserted. The recording will stop when memory is full or when stopped manually.

A Level trigger will start the recording when asserted and will end immediately when de-asserted.

CONFig:RUN:TRIGger:MODE [EXT|MANUAL]
CONFig:RUN:TRIGger:MODE?

Sets or returns the mode used to power up the outputs.

MANUAL = Outputs enabled with **RUN:POWER UP** command

EXTernal = Outputs enabled with external trigger port

Ethernet commands

Ethernet commands are generally persistent through reset. Some network settings may not take effect until a power cycle.

CONFig:ETHernet:NAME[xxxx]
CONFig:ETHernet:NAME?

Sets the NetBIOS name of the unit. This is persistent through reset. You will have to reset/power cycle the unit for the changes to take effect.

CONFig:ETHernet:IP [x.x.x.x]
CONFig:ETHernet:IP?

Sets the static IP address of the unit. Setting a static IP address will disable DHCP if it is currently enabled. You will have to reset/power cycle the unit for the change to take effect.

CONFig:ETHernet:MASK [xxx.xxx.xxx.xxx]
CONFig:ETHernet:MASK?

Sets the IP mask of the unit.

CONFig:ETHernet:DNS[1|2] [x.x.x.x]
CONFig:ETHernet DNS[1|2]?

Sets the primary and secondary DNS addresses for the unit.

CONFig:ETHernet:GATE[x.x.x.x]
CONFig:ETHernet GATE?

Sets the Gateway of the unit. You will have to reset/power cycle the unit for the change to take effect.

CONFig:ETHernet:DHCP [ON|OFF]
CONFig:ETHernet:DHCP?

Enables/disables the DHCP client. When enabled, the controller will try to obtain an IP address from the local DHCP server.

CONFig:ETHernet:HTTP:PORT [#Number]
CONFig:ETHernet:HTTP:PORT?

Gets/sets the port number to use for HTTP control

CONFig:ETHernet:TCP:PORT [#Number]
CONFig:ETHernet:TCP:PORT?

Gets/sets the port number to use for TCP control

CONFig:ETHernet:REST [ON|OFF]
CONFig:ETHernet:REST?

Gets/sets the enable state for REST control of the device

CONFig:ETHernet:TCP [ON|OFF]
CONFig:ETHernet:TCP?

Gets/sets the enable state for TCP control of the device

CONFig:ETHernet:LOCATE [ON|OFF]
CONFig:ETHernet:LOCATE?

Gets/sets the enable state for the LAN location system. This allows devices to be located on the network via a broadcast packet. Disabling this will prevent applications such as TestMonkey and QIS from locating the module automatically (though manual connection can still be used).

Stream monitor commands

MONitor [RUN|STOP]

Start or stop the stream monitor process

MONitor?

Return the status of the monitor process
RUNNING = Monitor operating
STOPPED = Monitor idle, all data is processed
OVERRUN = Monitor process has overrun and data is not valid

OVERRUN can happen if too high a stream rate is used, so the processor cannot keep up.

MONitor:RESet

Resets the statistics in the middle of a monitor process, allowing new min/max/average data to be calculated

MONitor:STAts?

Returns the current statistics from the monitor process

MONitor:STAts:XML?

Returns the current statistics from the monitor process in XML form

Debug Commands

These commands are used to look at the details of the module and its operation. You may be requested to use these if reporting a fault to Quarch.

***IDN?**

Displays a standard set of information, identifying the device. An example return is shown below:

```
Family: Torridon System          [The parent family of the device]
Name: Programmable Power Module  [The name of the device]
Part#: QTL1999-02                [The part number of the hardware]
Serial#: QTL1944-02-012          [Serial number of the module]
Enclosure#: QTL1999-02-003       [Enclosure number of the module]
Processor: QTL1159-01,3.50       [Part# and version of firmware]
Bootloader: QTL1170-01,1.00      [Part# and version of bootloader]
FPGA 1: 1.3                      [Version of FPGA core]
```

***TST?**

Runs a set of standard tests to confirm the device is operating correctly; these tests are also performed at start up. Returns ‘OK’ or ‘FAIL’ followed by a list of errors that occurred, each on a new line.

***SERIAL?**

Returns the serial number of the internal power module.

***MAC?**

Returns the MAC address of the module

MEASure:VOLT:SELF [channel]?

Returns a self test voltage measurement on the modules internal rails.

channel can be: 15V, 6V5, 5V, 3V3,1V2

Customer support from Quarch

There are multiple ways to access the support you need. You can contact us directly or access an extensive range of valuable support materials from http://quarch.com/support.

Contact us direct

Get going quickly and easily, with help direct from the engineers:

- Call **+44 1343 508 140** or email support@quarch.com during UK office hours.
- Our international partners are well trained in the use of our products and can deal with many basic technical queries from within your time zone, if you prefer. Check http://quarch.com/resellers for the contact details of your regional supplier.

Access support from the Quarch website

You can download up-to-date software and drivers, technical manuals, datasheets and more from our website. To help you get started quickly we provide additional documents, such as examples in Perl, Python and C# and Telnet and Serial instructions.

Key places to visit on the Quarch website

- Register your Quarch product to confirm your international warranty: http://quarch.com/product-registration
- Download a wide range of documentation, free applications and drivers to help you make the best possible use of your Quarch tools: http://quarch.com/content/downloads
- Access the Quarch support forum (http://quarch.com/forum):
  - Find discussion topics, support information and testing ideas.
  - Browse existing topics or login to your user account to ask for information and advice.
- Sign up for Quarch Technical Updates to get the most out of your Quarch products. Updates are published approximately once a quarter and include news about the latest features, tools, application notes and software updates. See http://quarch.com/content/sign-quarch-technical-updates.