

Quarch Technology Ltd

Power Analysis Module

Technical Manual

For use with:

QTL2312 – Power Analysis Module (PAM)
PAM Fixtures (multiple parts)



Change History

1.0	August 2020	Initial customer release
1.1	February 2021	Updated threshold triggering
1.2	September 2021	Added Annex A for Fixture Spec
1.3	November 2021	Updated M.2 PAM Fixture
1.4	March 2022	Added QTL2788 Gen5 SFF Drive PAM Fixture
1.5	July 2023 (unreleased)	Added: QTL2910 Gen5 PCIe x16 AIC PAM Fixture QTL2980 Gen5 Vertical M.2 PAM Fixture
1.6	September 2023	Added calibration notes
1.7	September 2023	Added QTL2983 AIC PAM for GPU/AI
1.8	September 2023	Completed annexes for: QTL2910 Gen5 PCIe x16 AIC PAM Fixture QTL2980 Gen5 Vertical M.2 PAM Fixture
1.9	January 2024	Added QTL2887/QTL2888 PAM information
1.10	March 2024	Added multi-rate commands and descriptions

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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. It primarily details the operation of the QTL2312 Power Analysis Module. Information on PAM Fixtures can be found in the appendix.

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 essential that you are familiar with this manual before using the device.

Safety warnings

This product must be connected to the supplied 12V 15W DC PSU. Do not use any other power supply. Stontronics Part Number: T5880ST

There are no user serviceable parts inside; do **NOT** open the enclosure.

Risk Assessment

While these products have no significant hazard cases, they must be used carefully by competent personnel.

In new use cases, a risk assessment should be completed, to ensure the entire test setup is safe to operate and will not cause an unacceptable risk to the operators or other lab users.

This should include careful routing of power and control cables to avoid trip hazards.

Cleaning and Maintenance

The products may be dusted with a dry cloth. Water and alcohol based (or any other liquid) cleaners should not be used.

All parts of the system should be inspected before and after use.

Damaged components should not be used and cannot be repaired by the user. Please contact Quarch to arrange for repair.

Manufacturer Details

The Torridon System is designed and manufactured by:

Quarch Technology Ltd (registered in Scotland no: SC307569)

Unit 7, Dalfaber Industrial Estate

Aviemore

UK

PH22 1ST

Web: www.quarch.com

Email: enquiries@quarch.com

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Environmental Conditions

The products are designed for use in dry, dust free, indoor lab conditions, at altitudes below 2000m and ambient temperatures between 10C-40C and 0-80% non-condensing humidity.

Installation

The product is designed for use on a desk/bench location. The provided 12V DC, 15W PSU must be used.

Product Misuse

The product is designed lab testing industry standard interfaces, complying with the relevant industry specifications. Other uses may cause incorrect operation, protection impairment or damage to the product and should be avoided.

In the Box

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

QTL2312 – Single Power Analysis Module

1x Main unit



1x USB cable for control



1x 12V DC 15W PSU with multi region adaptor

1x USB-C cable to connect to a measurement fixture

Technical Specifications

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

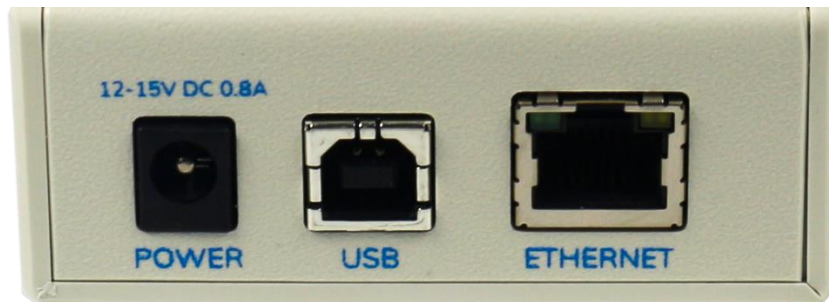
The QTL2312 allows you to capture analogue and digital measurements from a wide range of devices, using one of our custom measurement fixtures. This is a modular system and any one of a number of fixtures can be attached to the unit, allowing to be adapted for a wide range of devices.

QTL2312 – single module layout

Front panel of QTL2312



Rear panel of QTL2312



QTL2312 – connections and indicators

Item	Location	Purpose
Status LED	Front panel	Indicates the recording /action status
Power/Action LED	Front panel	Unit power on and fault state
Trigger IN	Front panel	MCX Triggering power, 3v3
Trigger OUT	Front panel	MCX Triggering power, 3v3
USB-C	Front panel	Connects to the measurement fixture
Reset	Front panel	Recessed hard reset button
Power	Rear panel	12V DC 15W power supply input
USB-A	Rear panel	Connects to controlling PC
LAN	Rear panel	100Base-T network port for remote control

Introduction

The Power Analysis Module (PAM) allows you to capture both analogue measurements (mainly voltage, power and current) and access to digital sidebands and other useful information.

The PAM requires a 'Fixture' to be attached in order to access the measurement data. A variety of fixtures are available.

The data can be captured in high resolution and viewed in real time, or stored for later processing and analysis.

Main features

- View and capture power performance of a device
- Capture digital sideband transitions
- Monitor a wide range of different devices

Calibration

PAM fixtures are calibrated measurement devices. Regular recalibration will ensure they are within spec over the life of the product. Calibration interval should be considered based on your requirements for accuracy, but Quarch generally recommends yearly.

Calibration accuracy is specified from 20-30C ambient temperature and with the fixture being turned on for 10 minutes prior to measurement to allow its internal temperature to stabilize. If the device has been stored at a significantly different temperature prior to use, it may take longer to reach stable operation.

Getting started

There are multiple ways to use PAMs, the simple way to begin is with our Quarch Power Studio application. This is cross-platform and provides a simple way to record, view, export and analyze power and sideband data:

QPS Product page:

<https://quarch.com/products/quarch-power-studio/>

QPS Download link:

<https://quarch.com/file/power-studio/>

QPS can be fully automated, an application note demonstrating this in Python is here:

<https://quarch.com/file/an-015-automating-qps/>

If the graphical interface is not desired, you can instead automate via QIS, our lower-level server application. In this case you can access data stripes directly, normally into a CSV file for your own post-processing. An example of this is here:

<https://quarch.com/file/an-012-qis-python-control-of-power-modules/>

For more reading, our automation overview manual is here:

<https://quarch.com/file/quarch-automation-manual/>

You can automate the hardware directly, with the commands given later in this manual. Processing power data and getting averaging rates correct between different fixtures has to be done in your own code though. We recommend QIS/QPS and our quarchpy python library as the best way to start.

LEDs

The PAM provides 2 LEDs on the front panel. These provide basic information on the function of the product

Power/Action LED

Color	Meaning
Off	No Power
Green	Power on standard state
Red	Unit fault

Status LED

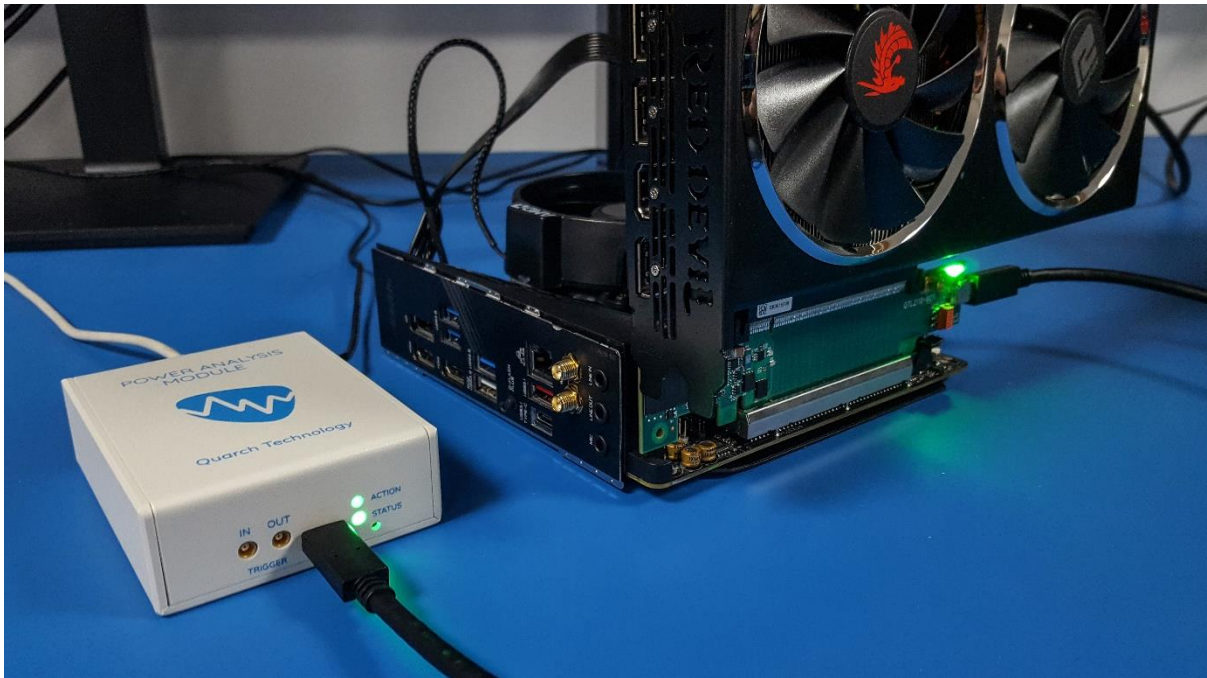
Color	Meaning
Off	Idle
Red (Flashing)	Recording

Connection and accessories

The product is designed to connect to a PC via USB-B, or directly to a standard LAN, via the RJ-45 port.

You can have a range of ‘fixtures’ attached, via the supplied USB-C cable. Only official PAM fixtures may be connected here. Do not use this port for any other purpose. Only one fixture can be attached at a time and no additional USB-C switches, extenders or similar components may be used.

Here we show a “PCIe x16 PAM Fixture” along with the main unit, fitted into a Gen4 test system. This is for illustrative purposes only.



The triggering ports may be connected to any standard 3.3v compatible device, such as a scope or analyzer

Fixture types

Older fixtures are ‘single-rate’ meaning that all channels sample at the same speed

Newer fixtures support ‘multi-rate’ mode. This allows us to clock the digital signals at a different sampling rate from the analog ones, providing more flexibility.

The multi-rate update also speeds up the base rate of digital signals from 4uS to 1uS for faster capture.

At the same time, stream compression was introduced, which helps us to reduce the amount of data in the buffers and allows us to stream for longer when running at high rates.

Multi-rate fixtures have additional commands:

```
# This allow configuring of compression (on by default)
```

```
STReam:MODE:COMPRESS [ON|OFF]
```

```
STReam:MODE:COMPRESS?
```

```
# This allow configuring of hardware averaging for individual groups
```

```
# On all current fixtures, group 0 is analog and group 1 is digital
```

```
RECORD:AVERAGING:GROUP [#group_number] [#averaging]
```

Using the “record:averaging 0” command with no group, will apply the same averaging factor to all groups.

Capturing Data

'Streaming' mode allows the module to record data over a nearly 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.

With high resolution recording (configured with the “record:averaging” setting), the amount of data may saturate the USB/LAN connection and cause recording streaming to halt when the inboard RAM is full. Increase the averaging setting to allow streaming to run for longer periods. The minimum averaging setting needed for indefinite streaming will depend on the number of channels being recorded and the speed of the host PC.

“record:averaging” refers to the output from the hardware, note that Quarch software (QIS and QPS) shows sample averaging as a time value, which is easier to work with. The software also allows resampling to any time desired. For example, 32k averaging is 131mS, but QIS/QPS can be requested to resample to exactly 100mS. The recommended way to work is to automate via QIS or QPS, using our application notes as a base. This allows you to ignore the complexity of hardware averaging

This mode is useful when a very high resolution is not essential, but large recording times are important.

You can record to internal memory at any time, to capture a trace which can be viewed and downloaded later.

Capture can be started from a number 'Trigger' of events:

- Manual trigger from the GUI or scripted command
- External “Trigger In” event from other test equipment (such as an analyzer)
- Trigger on the power outputs being activated
- Trigger on a voltage pattern being activated
- Trigger on a defined current or power threshold being exceeded.

When triggered, the recording will continue until memory is full or a command is sent to stop.

Memory depth to record

The user can limit the percentage of RAM to be used for recording. This will limit the record time.

Pre-trigger buffer

The user can select the percentage of RAM to be used as a pre-trigger buffer. This allows capture of a region before the capture trigger occurs.

Controlling the Module

The control interface for PAMs is via either LAN or USB.

All major features are available over both interfaces. Control is either via the QPS, QIS, QCS or our simple Python API.

Communication protocol

Commands sent to the module are simple, text based commands, roughly based on the SCPI specification. For instance:

MEASure:VOLTage:SELF 12v?

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

LAN

A simple TCP based custom protocol is the default. Simplified HTTP/REST is also available.

USB

USB control is supported. The Quarch USB driver is required on Windows PCs. LibUSB can be used for Linux.

Control options

There are several applications and scripted control options:

- **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.

- **QPS GUI**

This application is designed for fast control of the power analysis modules, allowing real time viewing and long-term recording of large data traces.

- **Python scripts**

The quarchpy python package provides simple control of the module. Python scripting can also be used to automate QPS

- **QCS GUI**

This application is used to run a series of pre-defined tests utilizing breakers and power measurement modules.

Default Startup State

On power up or reset, the module enters a default state.

Basic setting	Default value
Recording	Idle
Power State (Hot-Plug)	PLUGGED
Record Averaging	Fixture dependant
Memory Depth	100%
Pre Trigger	0%
Triggering	Disabled

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	QTL2312-nn-nnn

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

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

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.

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).

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: 12V (EXTernal) 3V3,1V2

Record Commands

These commands control the recording and downloading of data.

RECORD [RUN|STOP|TERMINATE]

RECORD?

In the RUN state, recording will either start immediately (MANUAL trigger mode) or at the point that the currently set trigger occurs.

STOP will end the recording. If streaming is running, stream will continue until all data is downloaded

TERMINATE will end the recording and also immediately end a stream if active.

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:TRIGGER:MODE [mode]

RECORD:TRIGGER:MODE?

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

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?

RECORD:AVERAGING:GROUP [#number] [rate]

RECORD:AVERAGING:[#number]?

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.

For multi-rate fixtures, we recommend you use the group averaging command to explicitly set the required rate for each group.

When automating via QIS/QPS (this is the common use case), use the “stream mode resample” command which automatically sets the record averaging for you, allowing user selection of a sample ‘time’ which is easier to understand.

Multi-rate fixtures have a different base sample rate for each group, so setting the hardware averaging rate with this command requires you to check the base rates and do the calculations yourself!

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

This command also affects the instantaneous measurements that can be requested.

Note that Quarch software (QIS and QPS) shows averaging in a time value (ie: 100mS) which is easier to understand. The software also allows resampling to any arbitrary time for increased flexibility.

Valid rate enumerations are here and are just an example. Digital signals on multi-rate modules have a 1uS base clock, so the averaging window is 4x smaller for example.

[rate]	Samples averaged	Averaging window
0	No Averaging	N/A
2	2	8 uS

4	4	16 μ S
8	8	32 μ S
16	16	64 μ S
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:TRIGGER:TYPE [EDGE|LEVEL]

RECORD:TRIGGER:TYPE?

Sets the record trigger to EDGE (start on trigger edge) or LEVEL (record while trigger is high)

Trigger Commands

These commands control the various trigger options. Most of these are implemented on the PAM fixture and so the channel type and name must be taken from the fixture manual, or use the FIXTURE:CHANNELS? Command to list those currently available.

TRIGger:[Chan_Type][Chan_Name]:ENAbLe [ON|OFF]

TRIGger:[Chan_Type][Chan_Name]:ENAbLe?

Enable triggering for a given channel type and name, channels are defined by the attached fixture.

Example: rec:trig:voltage:3.3v:ena on

TRIGger:[Chan_Type][Chan_Name]:THReshold [#level]

TRIGger:[Chan_Type][Chan_Name]:THReshold?

Set the level threshold for triggering on a channel. These values are will not be exact when set to an arbitrary value. The fixture has 127 trigger points, spread across the maximum range of the channel (and the same for negative values). The closest value will be used when the trigger is set. Reading the value back will always show the exact value. Digital channels do not have a trigger threshold setting.

#level = Integer value in the base units of the channel

TRIGger:[Chan_Type][Chan_Name]:POLArity [RISING|FALLING]

TRIGger:[Chan_Type][Chan_Name]:POLArity?

Set the trigger polarity, deciding if the trigger should be issued when the level rises above or falls below the trigger level

TRIGger:[Chan_Type][Chan_Name]:POLArity [RISING|FALLING]

TRIGger:[Chan_Type][Chan_Name]:POLArity?

Set the trigger polarity, deciding if the trigger should be issued when the level rises above or falls below the trigger level

TRIGger?

Returns a list of active threshold triggers on the fixture

RECOrd:TRIGger CLEAR

Clears all active threshold triggers

Fixture Commands

These commands report on the attached fixture

FIXture:CHANnels?

Lists the available channels on a fixture

Channel_Type, Channe_Name, Unit
[V|Voltage],3.3v,mV

FIXture:SERial?

Returns the serial number of the attached fixture

FIXture:IDENTity?

Returns a detailed identity list for the attached fixture

FIXture:hello?

Returns the name of the fixture as a simple test response

FIXture:VERsion?

Returns the version number of the fixture FPGA

FIXture:RESet?

Resets the attached fixture

FIXture:CHANnels:XML?

Outputs the XML descriptors of the fixture capabilities in a form that is easy to parse in automation code. This is normally used by QIS, QPS and Quarchpy to configure.

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>.

Annex A – PAM Fixtures

General Fixture Information

Safety warnings

This product must be used with the Quarch Power Analysis Module (PAM) only. It must be directly connected to the PAM via the provided USB-C cable only.

Risk Assessment

While these products have no significant hazard cases, they must be used carefully by competent personnel.

In new use cases, a risk assessment should be completed, to ensure the entire test setup is safe to operate and will not cause an unacceptable risk to the operators or other lab users.

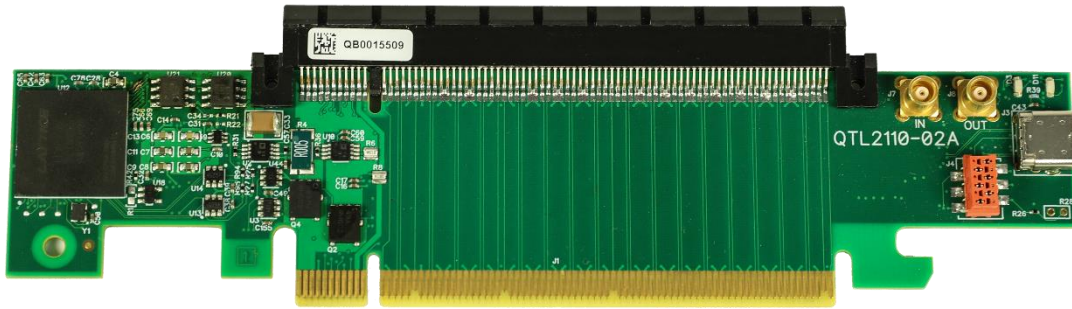
This should include careful routing of power and control cables to avoid trip hazards.

Each fixture type has the potential should be considered based on its particular use case.

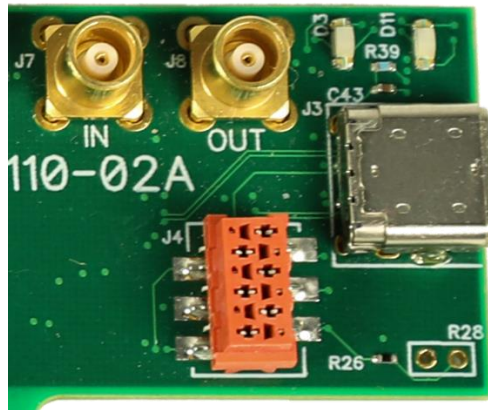
Annex A.1 - QTL2347 Gen4 PCIe x16 PAM Fixture

In the Box

1x Fixture



Fixture connections



Item	Location	Purpose
USB-C	Main PCB	Connects to PAM controller ONLY

Introduction

The fixture allows you to capture both power rail measurements and access to digital sidebands for Gen4 PCIe AIC devices.

The data can be captured in high resolution and viewed in real time or stored for later processing and analysis.

This fixture requires a PAM controller to function.

LED

There is an LED present on the PAM Fixture. It will be illuminated green when power is provided by the PAM and a link is present. If the LED is red, then power is present, but there is no working link between the PAM fixture and PAM.

Controlling the Module

All control of the fixture is via the PAM controller. The PAM technical manual should be referenced to see the available commands.

Some PAM commands work with a specific measurement rail on the fixture. These details can be found in the Appendices below, which describe every measurement channel on this fixture.

Measurement Channels

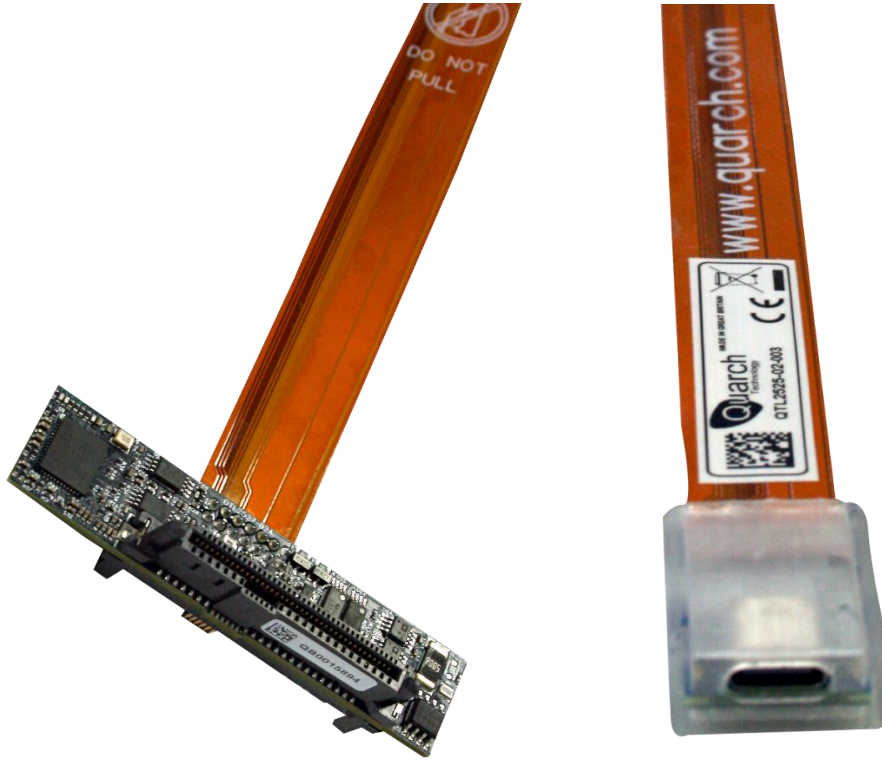
The fixture supports multiple analog and digital measurement channels as listed below:

Channel_Type	Channel_Name	Unit
V VOLTage	+3.3V	mV
V VOLTage	+12V	mV
V VOLTage	+3.3VAUX	mV
C CURrent	+3.3V	uA
C CURrent	+12V	uA
C CURrent	+3.3VAUX	uA
D DIGital	PERST#	Boolean
D DIGital	CLKREQ#	Boolean
D DIGital	WAKE#	Boolean
D DIGital	SMBDAT	Boolean
D DIGital	SMBCLK	Boolean

Annex A.2 - QTL2525 SFF Drive PAM Fixture

In the Box

1x Fixture



Fixture connections

Connection Board of QTL2525



Item	Location	Purpose
USB-C	Connection Board	Connects to PAM controller ONLY

Introduction

The fixture allows you to capture both power rail measurements and access to digital sidebands for SFF drives.

The data can be captured in high resolution and viewed in real time or stored for later processing and analysis.

This fixture requires a PAM controller to function.

LED

There is an LED present on the PAM Fixture. It will be illuminated green when power is provided by the PAM and a link is present. If the LED is red, then power is present, but there is no working link between the PAM fixture and PAM.

Controlling the Module

All control of the fixture is via the PAM controller. The PAM technical manual should be referenced to see the available commands.

Some PAM commands require to identify a specific measurement rail on the fixture. These details can be found in the Appendices below, which describe every measurement channel on this fixture.

Measurement Channels

The fixture supports multiple analog and digital measurement channels as listed below:

Channel_Type	Channel_Name	Unit
V VOLTage	5V	mV
V VOLTage	12V	mV
V VOLTage	3.3V AUX	mV
C CURrent	5V	uA
C CURrent	12V	uA
C CURrent	3.3V AUX	uA
D DIGital	PRSNT#	Boolean
D DIGital	CLKREQ#_PERSTB#	Boolean
D DIGital	WAKE#	Boolean
D DIGital	SMBCLK	Boolean
D DIGital	SMBDAT	Boolean
D DIGital	ACTIVITY#	Boolean
D DIGital	PWRDIS	Boolean
D DIGital	PRSNT#	Boolean
D DIGital	IFDET	Boolean
D DIGital	IFDET2	Boolean
D DIGital	HPT0	Boolean
D DIGital	HPT1	Boolean
D DIGital	DUALPORTEN#	Boolean
D DIGital	P2	Boolean

Annex A.3 - QTL2573 Gen4 M.2 PAM Fixture

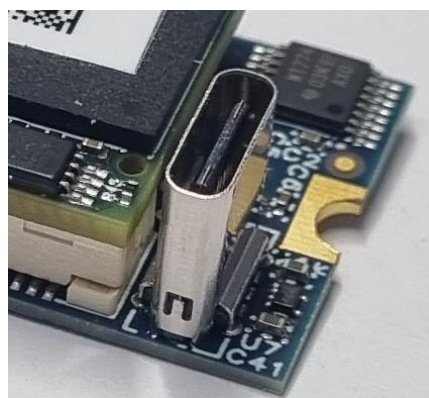
In the Box

1x Fixture



Fixture connections

Connection Board of QTL2525



Item	Location	Purpose
USB-C	Main PCB	Connects to PAM controller ONLY

Introduction

The fixture allows you to capture both power rail measurements and access to digital sidebands for M.2 drives.

The data can be captured in high resolution and viewed in real time or stored for later processing and analysis.

This fixture requires a PAM controller to function.

LED

There is an LED present on the PAM Fixture. It will be illuminated green when power is provided by the PAM and a link is present. If the LED is red, then power is present, but there is no working link between the PAM fixture and PAM.

Controlling the Module

All control of the fixture is via the PAM controller. The PAM technical manual should be referenced to see the available commands.

Some PAM commands require to identify a specific measurement rail on the fixture. These details can be found in the Appendices below, which describe every measurement channel on this fixture.

Measurement Channels

The fixture supports multiple analog and digital measurement channels as listed below:

**1 – Signals supported on -04 and up hardware only*

Channel_Type	Channel_Name	Unit
V VOLTage	3.3V	mV
V VOLTage	VIO_1V8*1	mV
C CURrent	3.3V	uA
C CURrent	VIO_1V8*1	uA
D DIGital	CLKREQ#	Boolean
D DIGital	PERST#	Boolean
D DIGital	PEWAKE#	Boolean
D DIGital	SUSCLK	Boolean
D DIGital	PEDET	Boolean
D DIGital	ALERT#	Boolean
D DIGital	SMB_DATA	Boolean
D DIGital	SMB_CLK	Boolean
D DIGital	LED_1#	Boolean
D DIGital	DEVSLP*1	Boolean
D DIGital	MFG_DATA	Boolean
D DIGital	MFG_CLK	Boolean
D DIGital	VIO_CFG*1	Boolean
D DIGital	PWRDIS*1	Boolean
D DIGital	PLA_S3#*1	Boolean
D DIGital	PLN#*1	Boolean

Annex A.4 - QTL2608 2-Channel PAM Fixture

In the Box

1x Fixture



4x Digital signal removable screw terminal connectors



2x Power signal removable screw terminal connectors



Fixture connections



Item	Location	Purpose
USB-C	Front edge of box	Connects to PAM controller ONLY

Introduction

The fixture allows you to capture both power rail measurements and access to digital sidebands for M.2 drives.

The data can be captured in high resolution and viewed in real time or stored for later processing and analysis.

This fixture requires a PAM controller to function.

LED

There is an LED present on the PAM Fixture. It will be illuminated green when power is provided by the PAM and a link is present. If the LED is red, then power is present, but there is no working link between the PAM fixture and PAM.

Controlling the Module

All control of the fixture is via the PAM controller. The PAM technical manual should be referenced to see the available commands.

Some PAM commands require to identify a specific measurement rail on the fixture. These details can be found in the Appendices below, which describe every measurement channel on this fixture.

Measurement Channels

The fixture supports multiple analog and digital measurement channels as listed below:

Channel_Type	Channel_Name	Unit
V VOLTage	POWER_1	mV
V VOLTage	POWER_2	mV
C CURrent	POWER_1	uA
C CURrent	POWER_2	uA
D DIGital	CHANNEL_1	Boolean
D DIGital	CHANNEL_2	Boolean
D DIGital	CHANNEL_3	Boolean
D DIGital	CHANNEL_4	Boolean
D DIGital	CHANNEL_5	Boolean
D DIGital	CHANNEL_6	Boolean
D DIGital	CHANNEL_7	Boolean
D DIGital	CHANNEL_8	Boolean
D DIGital	CHANNEL_9	Boolean
D DIGital	CHANNEL_10	Boolean
D DIGital	CHANNEL_11	Boolean
D DIGital	CHANNEL_12	Boolean
D DIGital	CHANNEL_13	Boolean
D DIGital	CHANNEL_14	Boolean
D DIGital	CHANNEL_15	Boolean
D DIGital	CHANNEL_16	Boolean

Annex A.5 - QTL2673 / QTL2887 / QTL2888 EDSFF PAM Fixtures

In the Box

1x Fixture



Fixture connections

Connection Board of QTL2673



Item	Location	Purpose
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USB-C	Connection Board	Connects to PAM controller ONLY
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Introduction

The fixture allows you to capture both power rail measurements and access to digital sidebands for EDSFF SSDs.

The data can be captured in high resolution and viewed in real time or stored for later processing and analysis.

This fixture requires a PAM controller to function.

LED

The Fixture provides power LED on the board. This LED in the connector board will illuminate green if power for the PAM controller is being received.

Controlling the Module

All control of the fixture is via the PAM controller. The PAM technical manual should be referenced to see the available commands.

Some PAM commands require to identify a specific measurement rail on the fixture. These details can be found in the Appendices below, which describe every measurement channel on this fixture.

Measurement Channels

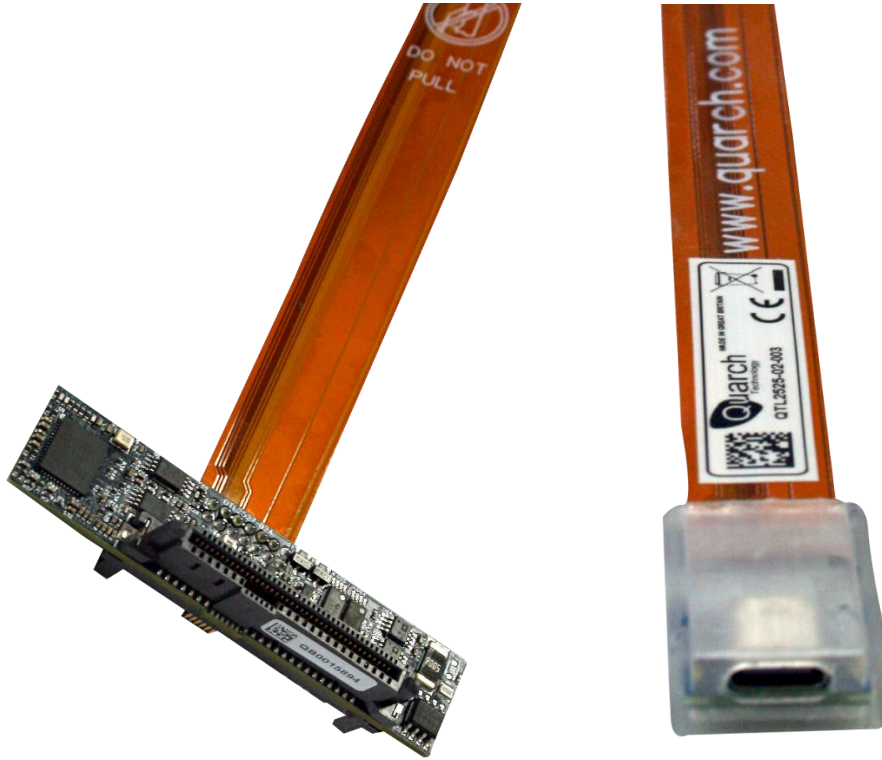
The fixture supports multiple analog and digital measurement channels as listed below:

Channel_Type	Channel_Name	Unit
V VOLTage	3.3V AUX	mV
V VOLTage	12V	mV
C CURrent	3.3V AUX	uA
C CURrent	12V	uA
D DIGital	PRSENT#	Boolean
D DIGital	PERST1#_ CLKREQ#	Boolean
D DIGital	LED	Boolean
D DIGital	SMBRST#	Boolean
D DIGital	SMBDAT	Boolean
D DIGital	SMBCLK	Boolean
D DIGital	PWRDIS	Boolean
D DIGital	PERST0#	Boolean
D DIGital	DUALPORTEN#	Boolean
D DIGital	RFU	Boolean
D DIGital	MFG	Boolean

Annex A.6 - QTL2788 Gen5 SFF Drive PAM Fixture

In the Box

1x Fixture



Fixture connections

Connection Board of QTL2788



Item	Location	Purpose
USB-C	Connection Board	Connects to PAM controller ONLY

Introduction

The fixture allows you to capture both power rail measurements and access to digital sidebands for SFF drives.

The data can be captured in high resolution and viewed in real time or stored for later processing and analysis.

This fixture requires a PAM controller to function.

LED

There is an LED present on the PAM Fixture. It will be illuminated green when power is provided by the PAM and a link is present. If the LED is red, then power is present, but there is no working link between the PAM fixture and PAM.

Controlling the Module

All control of the fixture is via the PAM controller. The PAM technical manual should be referenced to see the available commands.

Some PAM commands require to identify a specific measurement rail on the fixture. These details can be found in the Appendices below, which describe every measurement channel on this fixture.

Measurement Channels

The fixture supports multiple analog and digital measurement channels as listed below:

Channel_Type	Channel_Name	Unit
V VOLTage	5V	mV
V VOLTage	12V	mV
V VOLTage	3.3V AUX	mV
C CURrent	5V	uA
C CURrent	12V	uA
C CURrent	3.3V AUX	uA
D DIGital	PRSNT#	Boolean
D DIGital	CLKREQ#_PERSTB#	Boolean
D DIGital	WAKE#	Boolean
D DIGital	SMBCLK	Boolean
D DIGital	SMBDAT	Boolean
D DIGital	ACTIVITY#	Boolean
D DIGital	PWRDIS	Boolean
D DIGital	PRSNT#	Boolean
D DIGital	IFDET	Boolean
D DIGital	IFDET2	Boolean
D DIGital	HPT0	Boolean
D DIGital	HPT1	Boolean
D DIGital	DUALPORTEN#	Boolean
D DIGital	P2	Boolean

Annex A.7 - QTL2910 Gen5 PCIe x16 PAM Fixture

In the Box

1x Fixture



Fixture connections



Item	Location	Purpose
USB-C	Main PCB	Connects to PAM controller ONLY

Introduction

The fixture allows you to capture both power rail measurements and access to digital sidebands for Gen5 PCIe AIC devices.

The data can be captured in high resolution and viewed in real time or stored for later processing and analysis.

This fixture requires a PAM controller to function.

LED

There is an LED present on the PAM Fixture. It will be illuminated green when power is provided by the PAM and a link is present. If the LED is red, then power is present, but there is no working link between the PAM fixture and PAM.

Controlling the Module

All control of the fixture is via the PAM controller. The PAM technical manual should be referenced to see the available commands.

Some PAM commands work with a specific measurement rail on the fixture. These details can be found in the Appendices below, which describe every measurement channel on this fixture.

Measurement Channels

The fixture supports multiple analog and digital measurement channels as listed below:

Channel_Type	Channel_Name	Unit
V VOLTage	+3.3V	mV
V VOLTage	+12V	mV
V VOLTage	+3.3VAUX	mV
C CURrent	+3.3V	uA
C CURrent	+12V	uA
C CURrent	+3.3VAUX	uA
D DIGital	PERST#	Boolean
D DIGital	CLKREQ#	Boolean
D DIGital	WAKE#	Boolean
D DIGital	SMBDAT	Boolean
D DIGital	SMBCLK	Boolean

Annex A.8 - QTL2980 Gen5 Vertical M.2 PAM Fixture

In the Box

1x Fixture



Fixture connections

Connection Board of QTL2980



Item	Location	Purpose
USB-C	Connection Board	Connects to PAM controller ONLY

Introduction

The fixture allows you to capture both power rail measurements and access to digital sidebands for Gen5 M.2 drives.

The data can be captured in high resolution and viewed in real time or stored for later processing and analysis.

This fixture requires a PAM controller to function.

LED

There is an LED present on the PAM Fixture. It will be illuminated green when power is provided by the PAM and a link is present. If the LED is red, then power is present, but there is no working link between the PAM fixture and PAM.

Controlling the Module

All control of the fixture is via the PAM controller. The PAM technical manual should be referenced to see the available commands.

Some PAM commands require to identify a specific measurement rail on the fixture. These details can be found in the Appendices below, which describe every measurement channel on this fixture.

Measurement Channels

The fixture supports multiple analog and digital measurement channels as listed below:

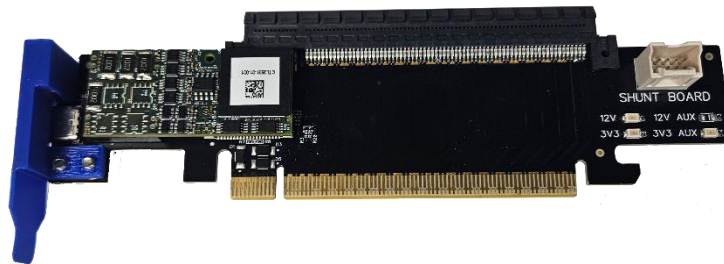
**1 – Signals supported on -04 and up hardware only*

Channel_Type	Channel_Name	Unit
V VOLTage	3.3V	mV
V VOLTage	VIO_1V8*1	mV
C CURrent	3.3V	uA
C CURrent	VIO_1V8*1	uA
D DIGital	CLKREQ#	Boolean
D DIGital	PERST#	Boolean
D DIGital	PEWAKE#	Boolean
D DIGital	SUSCLK	Boolean
D DIGital	PEDET	Boolean
D DIGital	ALERT#	Boolean
D DIGital	SMB_DATA	Boolean
D DIGital	SMB_CLK	Boolean
D DIGital	LED_1#	Boolean
D DIGital	DEVSLP*1	Boolean
D DIGital	MFG_DATA	Boolean
D DIGital	MFG_CLK	Boolean
D DIGital	VIO_CFG*1	Boolean
D DIGital	PWRDIS*1	Boolean
D DIGital	PLA_S3#*1	Boolean
D DIGital	PLN#*1	Boolean

Annex A.9 - QTL2983 Gen5 AIC x16 fixture with AUX power

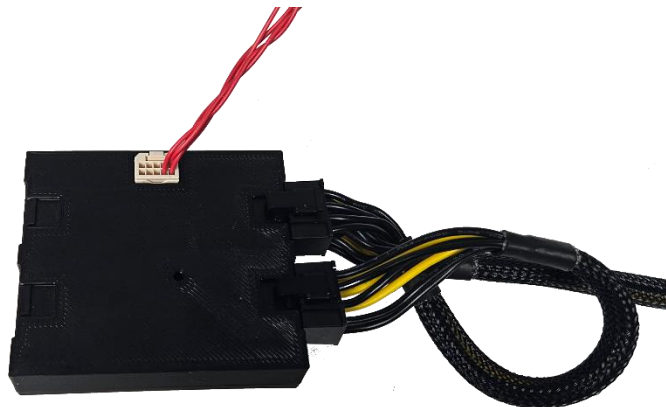
In the Box

1x Main Fixture



Main fixture board

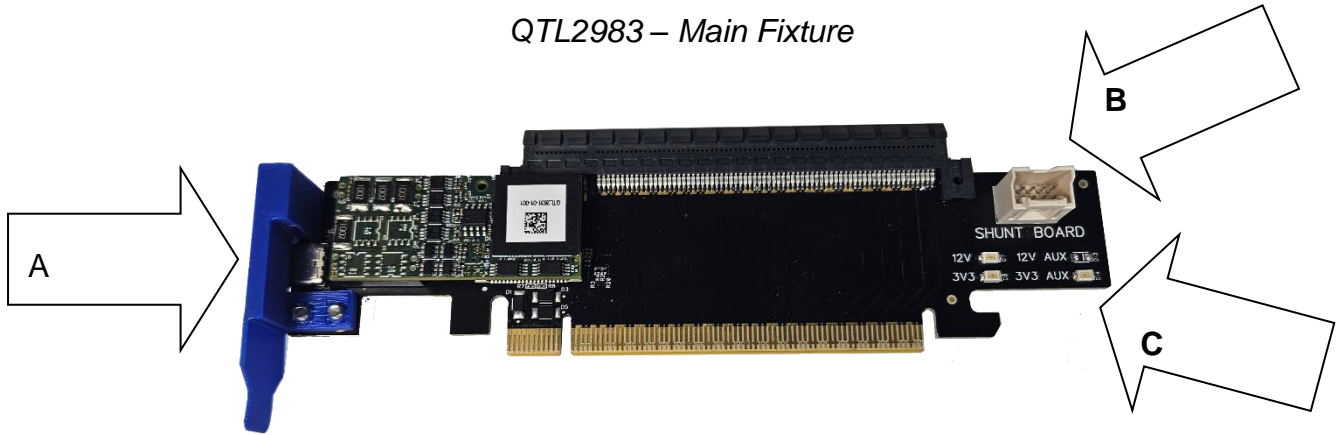
1x AUX Fixture (fixture layout depends on the version ordered)



Dual ATX AUX Fixture

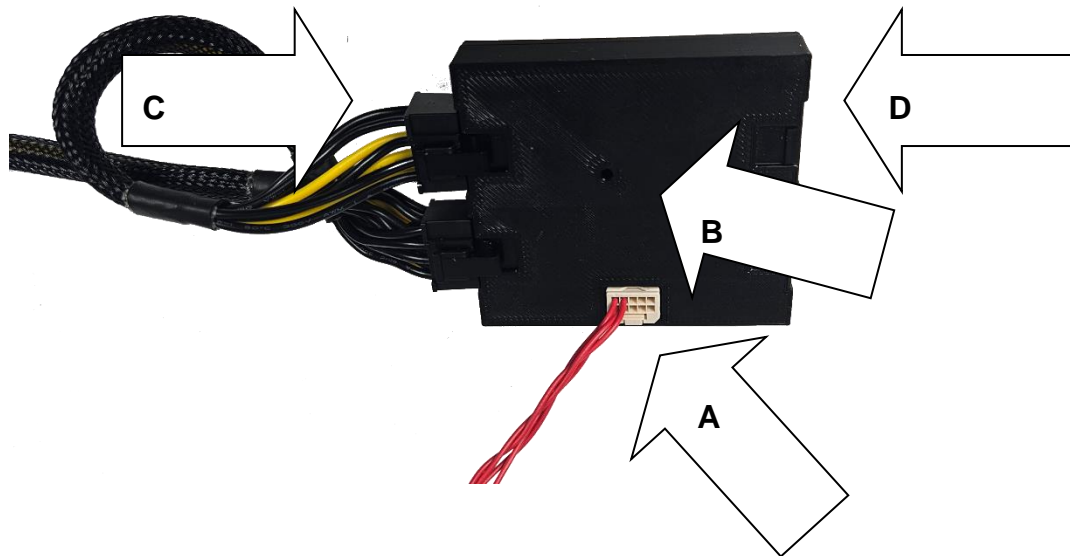
Fixture connections and features

QTL2983 – Main Fixture



Item	Location	Purpose
(A) USB-C	Main Fixture IO panel	Connects to PAM controller ONLY
(B) AUX board connection	Main Fixture inner edge	Connects the main board to the AUX board
(C) Power LEDs	Main Fixture inner edge	Shows power status

Dual ATX AUX Fixture



Item	Location	Purpose
(A) AUX board connection	AUX Fixture front	Connects the main board to the AUX board
(B) Power LED	AUX Fixture front	Shows 12v power status
(C) PCIe power IN	AUX Fixture left side	Input from supply
(D) PCIe power OUT	AUX Fixture right side	Output to device

Introduction

The fixture allows you to capture the power supply and sidebands for a Gen5 PCIe x16 device and its AUX power input.

The data can be captured in high resolution and viewed in real time or stored for later processing and analysis.

This fixture requires a PAM controller to function.

LED

There is an LED present on the PAM Fixture. It will be illuminated green when power is provided by the PAM and a link is present. If the LED is red, then power is present, but there is no working link between the PAM fixture and PAM.

Controlling the Module

All control of the fixture is via the PAM controller. The PAM technical manual should be referenced to see the available commands.

Some PAM commands require to identify a specific measurement rail on the fixture. These details can be found in the Appendices below, which describe every measurement channel on this fixture.

Measurement Channels

The fixture supports multiple analog and digital measurement channels as listed below:

Channel_Type	Channel_Name	Unit
V VOLTage	+12V	mV
dV *1	+12V	udV
V VOLTage	+3.3V	mV
dV *1	+3.3V	udV
V VOLTage	+3.3Vaux	mV
dV *1	+3.3Vaux	udV
V VOLTage	+12Vaux	mV
dV *1	+12Vaux	udV
D DIGital	PERST#	Boolean
D DIGital	CLKREQ#	Boolean
D DIGital	WAKE#	Boolean
D DIGital	PWRBRK#	Boolean
D DIGital	SMBCLK#	Boolean
D DIGital	SMBDAT#	Boolean
D DIGital	REFCLK_OK	Boolean

*1 – dV = deltaVolts, the voltage drop across the sense resistor. In Quarch Power Studio this is automatically turned into a current channel. For manual reads, this has to be calculated given the shunt resistance for the channel which is found with the command:

FIXture:[channel_name]:SHUNT?

Annex A.10 - Gen5 OCP NIC 3.0 PAM Fixture

In the Box

1x Fixture



Fixture connections

Connection Board of QTL3024



Item	Location	Purpose
USB-C	Connection Board	Connects to PAM controller ONLY

Introduction

The fixture allows you to capture high resolution power rail and digital sideband measurements for OCP NIC 3.0 SFF (x16 PCIe), TSFF (x16 PCIe), and LFF (x16 PCIe) cards.

The measurement data can be viewed in real time or stored for post processing and analysis.

Controlling the Module

All control of the fixture is via the PAM controller. Section on [Command Set](#) should be referenced to see the available commands.

Some PAM commands require the measured signals or rails on the fixture to be specified. These details can be found in the Appendices below, which describe every measurement channel on this fixture.

Measurement Channels

The fixture supports multiple analog and digital measurement channels as listed below:

Channel_Type	Channel_Name	Unit
V VOLTage	12v	mV
C CURrent	12v	uA
V VOLTage	3v3	mV
C CURrent	3v3	uA
D DIGital	REFCLK_0_LOS	Boolean
D DIGital	REFCLK_1_LOS	Boolean
D DIGital	REFCLK_2_LOS	Boolean
D DIGital	REFCLK_3_LOS	Boolean
D DIGital	BIF0#	Boolean
D DIGital	BIF1#	Boolean
D DIGital	BIF2#	Boolean
D DIGital	PWRBRK#	Boolean
D DIGital	WAKE#	Boolean
D DIGital	NIC_PWR_GOOD	Boolean
D DIGital	MAIN_PWR_EN	Boolean
D DIGital	AUX_PWR_EN	Boolean
D DIGital	PERST0#	Boolean
D DIGital	PERST1#	Boolean
D DIGital	PERST2#	Boolean
D DIGital	PERST3#	Boolean