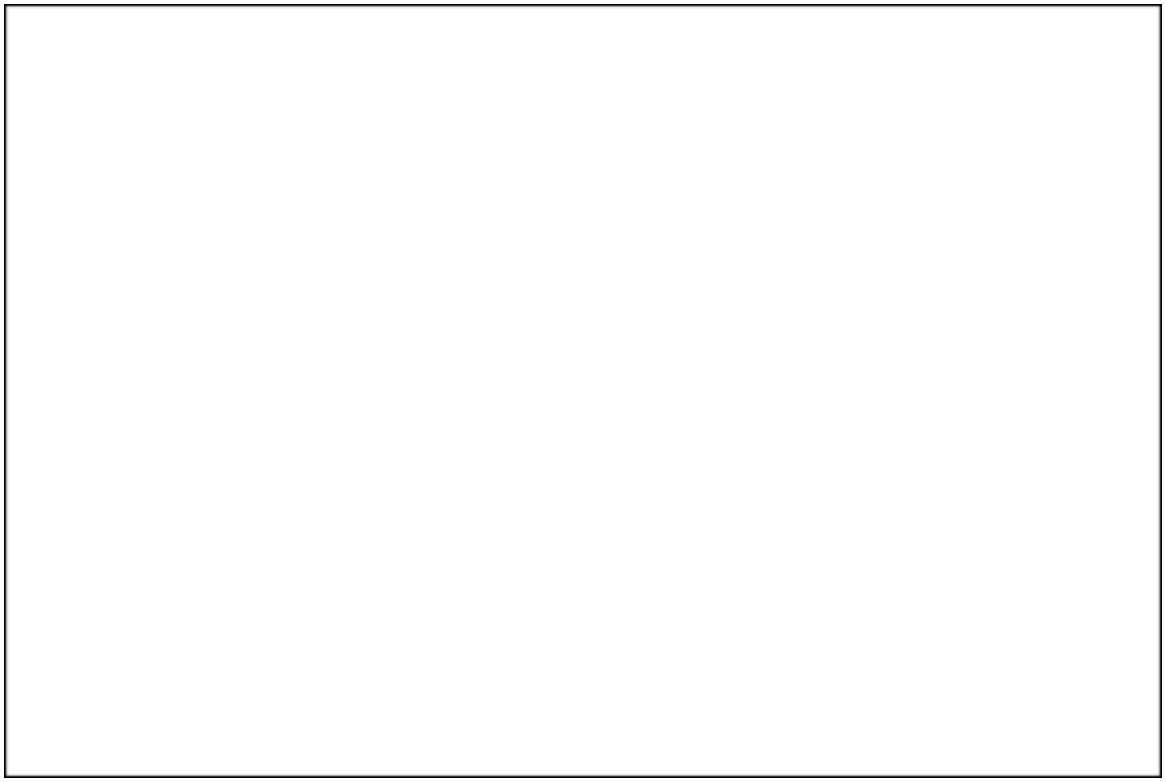
Quarch Technology Ltd

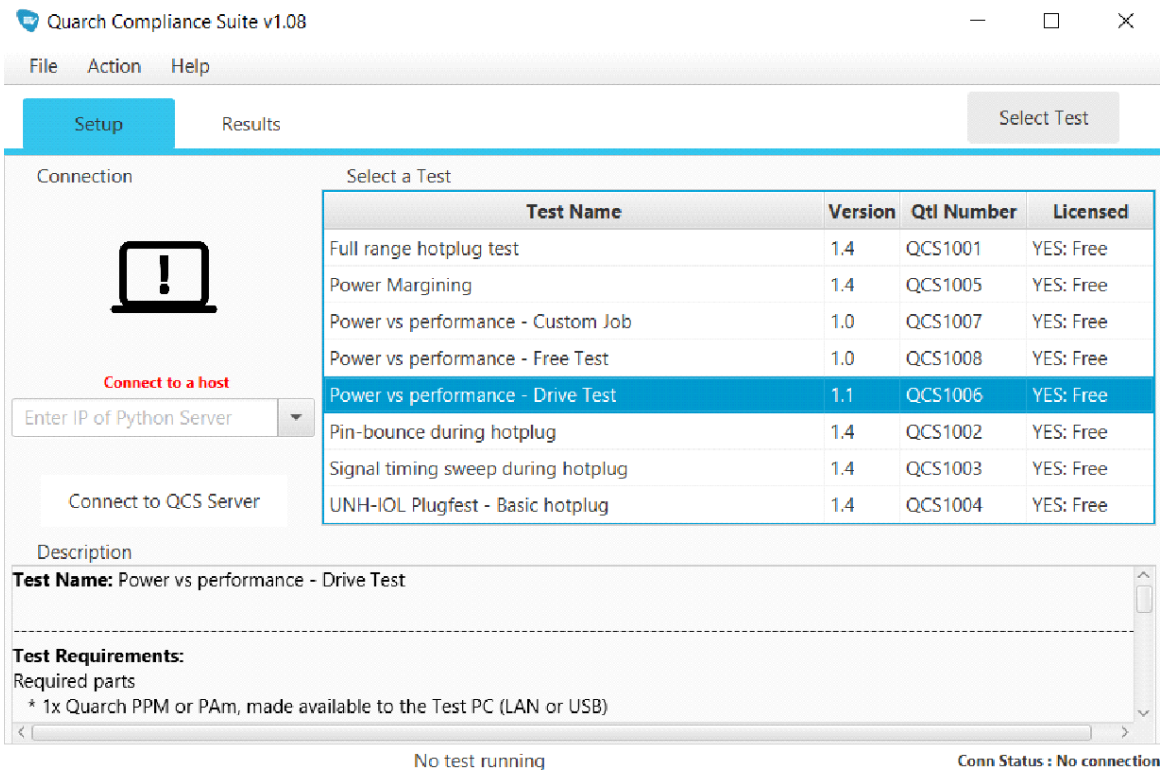
Quarch Compliance Suite

Setup & Test Specification

QCS1006 – Power Vs Performance

V1.0





Change History

1.0		Initial Release

Contents

Introduction

To provide a high-quality comparison for the performance and power consumption of a storage device, Quarch has created this suite of automated tests.

These are designed to exercise read and write performance across a range of standard workloads, while monitoring the device power consumption.

Requirements

- Host PC
- This is the PC which will mount the storage device under test (DUT). This system required admin privileges to install and execute the QCS server. Windows and Linux are supported.

- Client PC

- This is the PC which will run the QCS client and record the results. This can be the same as the Host PC but it NOT recommended for this test. The Java applications running here may significantly impact the performance test. Windows and Linux are supported.

- Quarch PPM or PAM and appropriate fixture

- The Quarch power analyzer that will capture the power consumption. The correct fixture will also be required for the storage device that you are using.

  Supported Quarch Power Modules: XLC, HD, and PAM

  - https://quarch.com/products/xlc-programmable-power-module/
  - https://quarch.com/products/hd-programmable-power-module/
  - https://quarch.com/products/power-analysis-module/

- Device Under Test (DUT)

- Your storage device. SAS, SATA and PCIe NVMe devices are supported.

Installation

Initial installation and setup is described in the QCS ‘Quickstart’ guide. Please see this document if you are setting up for the first time. It will walk you through the QCS install process.

Setup

Host and Client PC setup is common across all QCS tests, so some of the steps below are only required the first time you prepare for testing

- **Setup the Host PC**
  - As described in the QCS Quickstart document

- Ensure the Host PC is connected to the LAN (assuming a separate Client PC is in use
- Use of WIFI is highly discouraged for this testing.

- **Setup the Client PC**
  - As described in the QCS Quickstart document
  - Ensure the Client PC is connected to the LAN (assuming a separate Host PC is in use
  - Use of WIFI is highly discouraged for this testing.
  - Launch QPS and QIS on this machine. If Quarchpy is already installed on this machine, this can be launched via the command
    python -m quarchpy.run qps
    Alternatively, this can be install from the quarch website:
    https://quarch.com/file/power-studio/

- **Setup the Quarch PPM / PAM**
  - Place the power fixture between the DUT and host slot. Connect the fixture cable to the Quarch Power Module. If you are using an SFF drive fixture, ensure the voltage selection jumper is correct for your drive.
  - Power on the Quarch Module
  - Chose either USB or LAN for connection of the Quarch Power Module. The Power Module must be accessible to the **Client** PC, so be sure you cable to the right one if using USB.
    - If you need to configure the Power Module LAN settings, you can do so via TorridonTerminal: https://quarch.com/file/torridon-terminal/
    - This is also helpful to ensure you have connected the module correctly and can see it. If you are using a PPM, the DUT will NOT be powered on yet. This will happen at the start of the test, if you want to turn it on now, use TorridonTerminal to issue the command:

      ```
      > run:power up
      ```

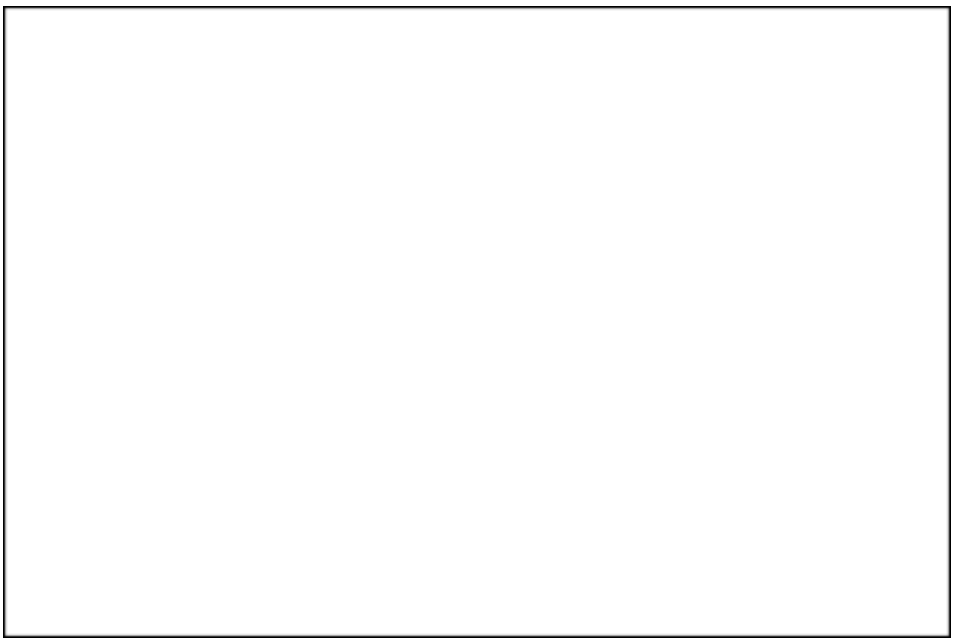
Typical equipment layout

A typical equipment layout is shown below. The Quarch Power Module can be optionally connected via USB to the **Client** PC instead of using the LAN.

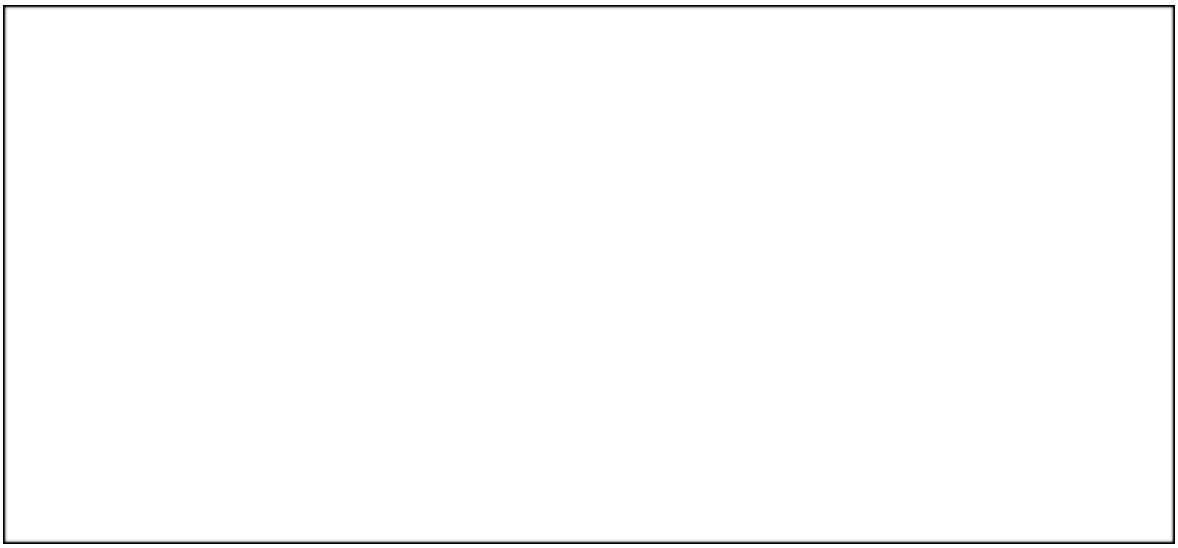
The Quarch Power Fixture must be fitted to correctly:

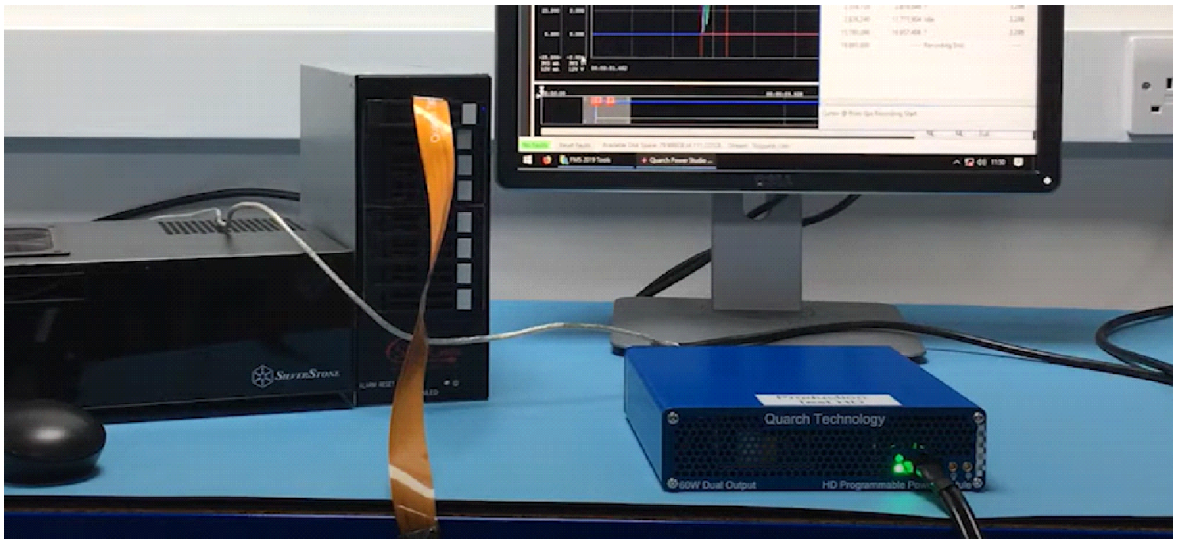
- For a PPM, the fixture (or output cable) must be able to supply power to the drive
- For a PAM, the fixture must be in the path of the power supplied by the host.

Example using a simple injection cabling with a PPM



Example using SerialCables JBOD and SFF injection fixture



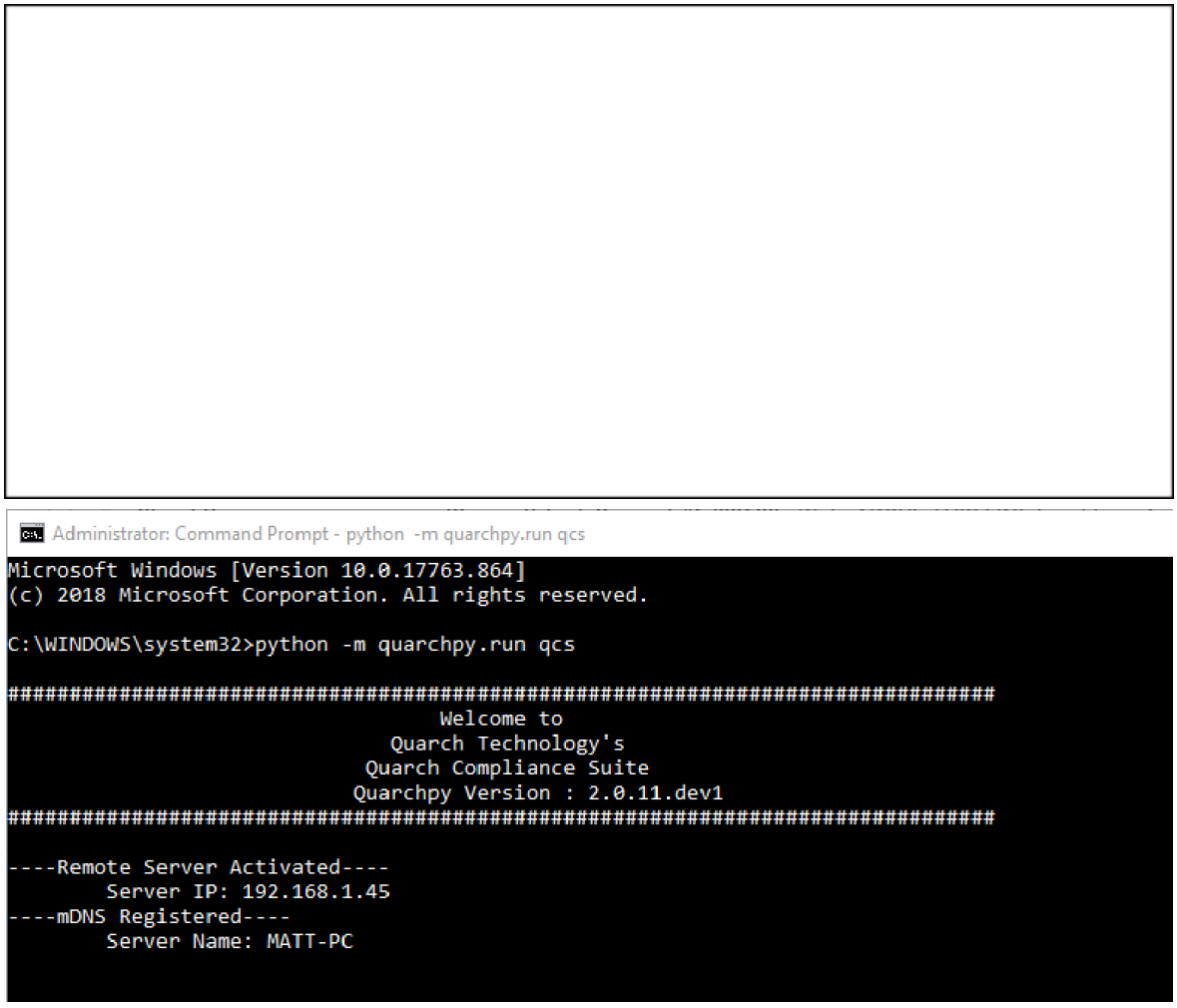


Begin the test

- Start QCS server of the Host PC

- > python -m quarchpy.run qcs

The server should start up almost immediately. Note the IP address and mDNS name which you will use to connect to the server later.

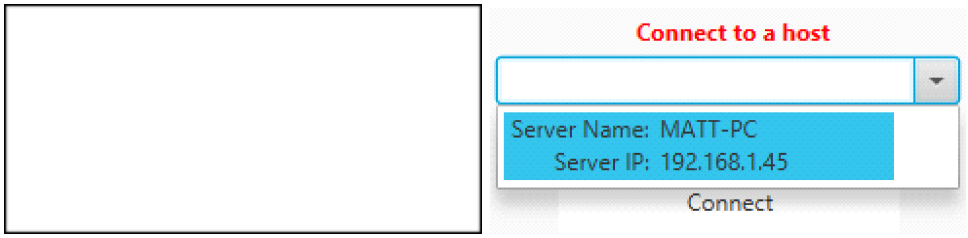


- Start QCS application on the Client PC

- > Double click on the QCS icon to start

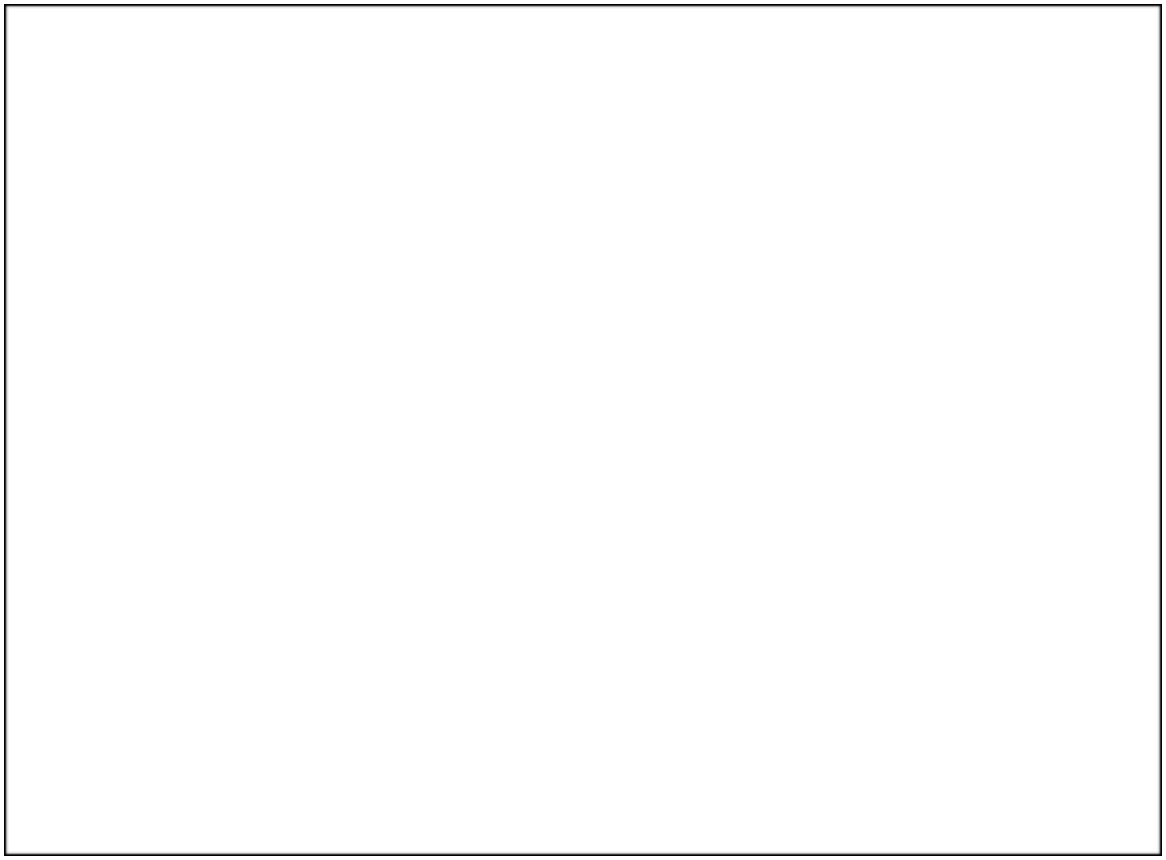
- Connect the Client to the Server

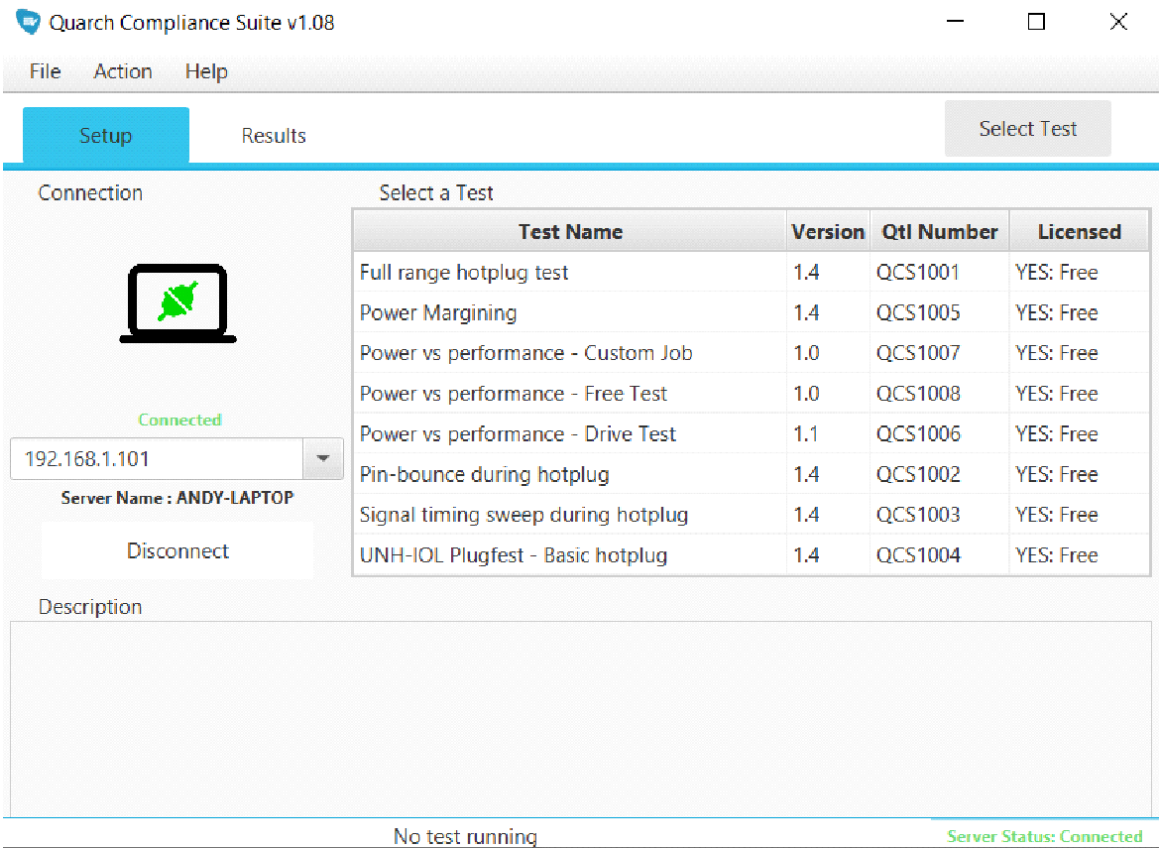
- Enter the IP address of the Server into the Client connection box. If ‘zeroconf’ is installed on the server then it should autodetect and be visible in the connection drop-down menu for fast connection.



- Select the test to run

- In this case, select the QCS1006, ‘Power Vs Performance’ and either double-click or select ‘Select Test’



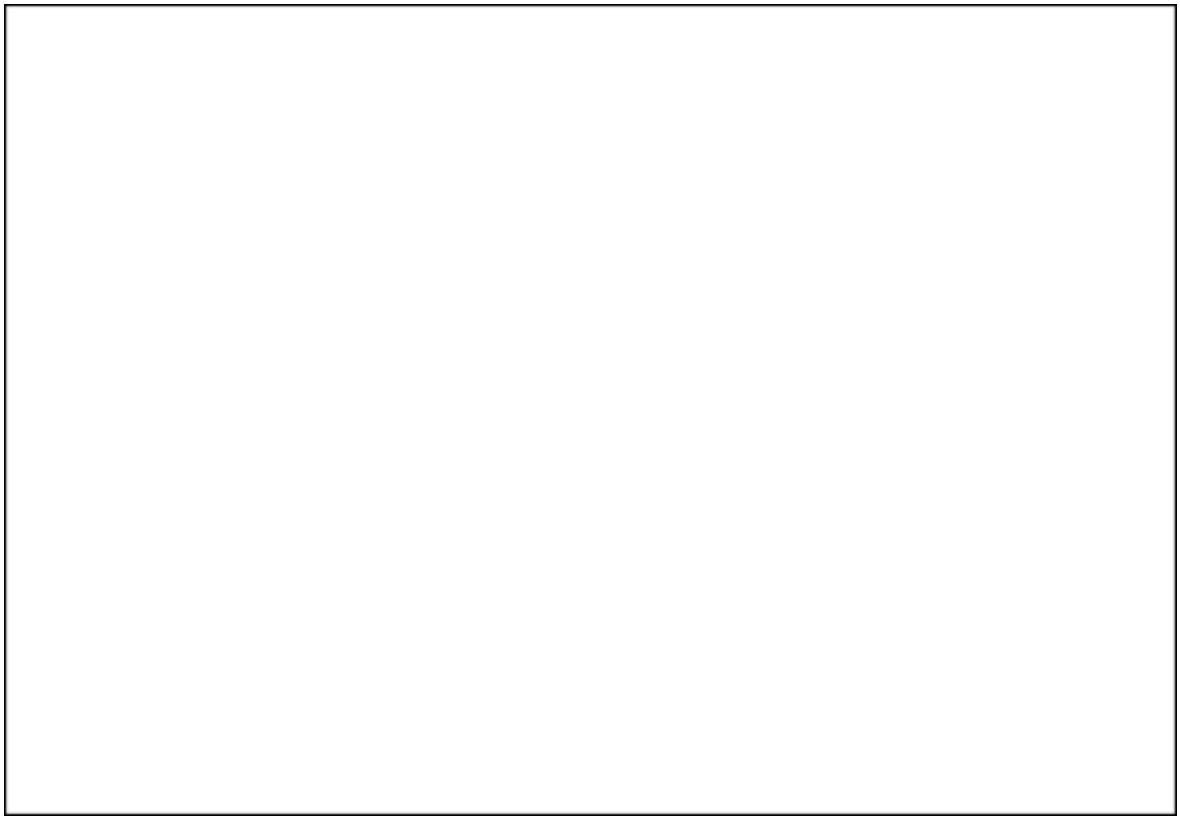


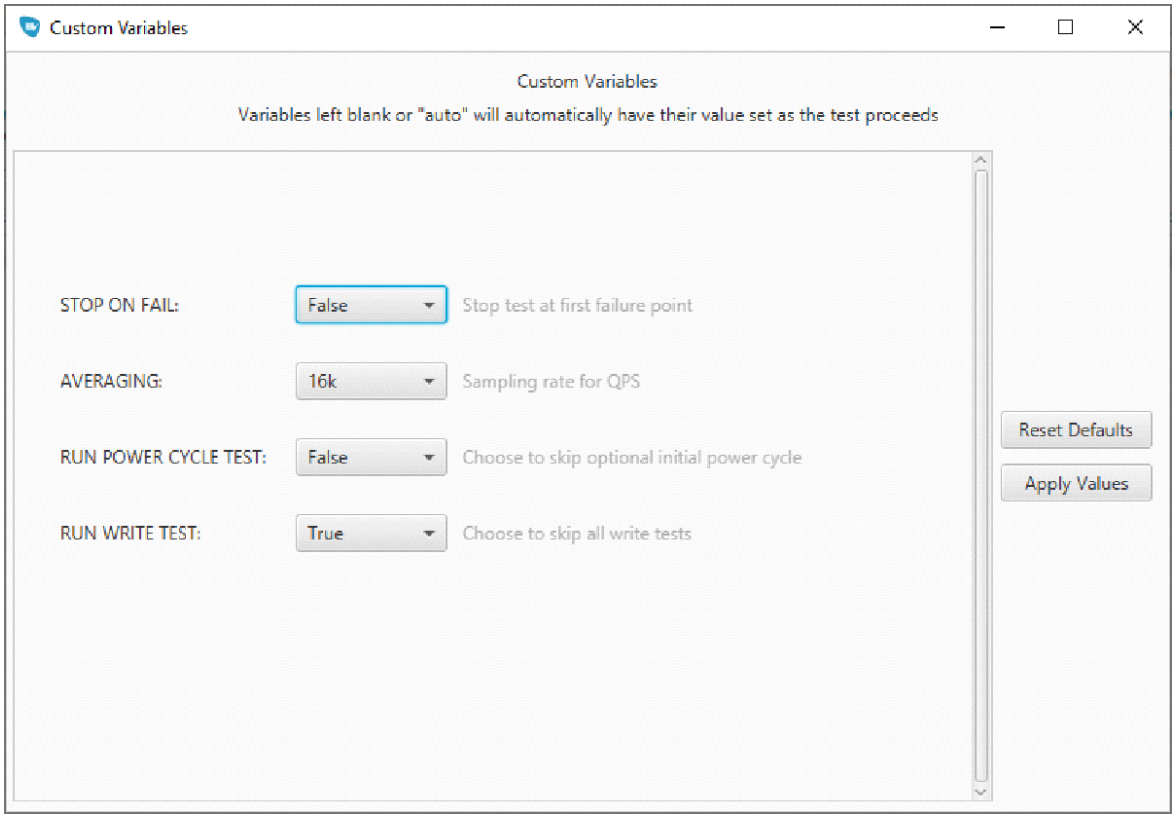
- This process can take 30 seconds or so, as the test is sent to the Server and the required applications are started on the Client.
- When the test is ready, the ‘Start/Play’ button will become available to begin running. If you want to change any setting for the test, you can do so now in the ‘Custom Variables’ window.
- When you have made any changes you require, press the run button to begin.

Custom variables

Most tests have several variables that can be set. These allow for things such as setting the number of times that a test loops or setting the time to wait for a drive to enumerate. These will be different in each test suite.

QCS1006 has several useful settings to consider:




Custom Variables
Custom Variables
Variables left blank or "auto" will automatically have their value set as the test proceeds
STOP ON FAIL:
False
Stop test at first failure point
AVERAGING:
16k
Sampling rate for QPS
RUN POWER CYCLE TEST:
False
Choose to skip optional initial power cycle
RUN WRITE TEST:
True
Choose to skip all write tests
Reset Defaults
Apply Values

Stop on fail

- When set to true, the test will halt if there are any errors or test failures

Averaging

- Changing the averaging rate will affect the resolution of the power data captured.
- The rate combines a set number of 4uS samples, so an averaging value of 4 is 4 x 4uS = 16uS sampling rate. This is the fastest setting that is likely to work for a long test like this (due to bandwidth limits).
- A low averaging rate will produce a very large capture file though so take care!

  16k sampling equates to roughly 15 samples per second. Every 4uS sample is combined into the final sample, so the average power result should be very accurate regardless of the rate chosen.

Run power cycle test

- This is an optional test at the start which allows inrush current to be measured. If your drive does not support hot-plug, this can be disabled

Run write test

- The test suite has both read and write tests. Write tests can be skipped if you do not want to write to the drive.

Idle time

- Time to wait before performing each test

While the test aims to make no modification to a drive when the write tests are disabled, mistakes can happen so we STRONGLY recommend you do not run this test on a drive which contains important data.

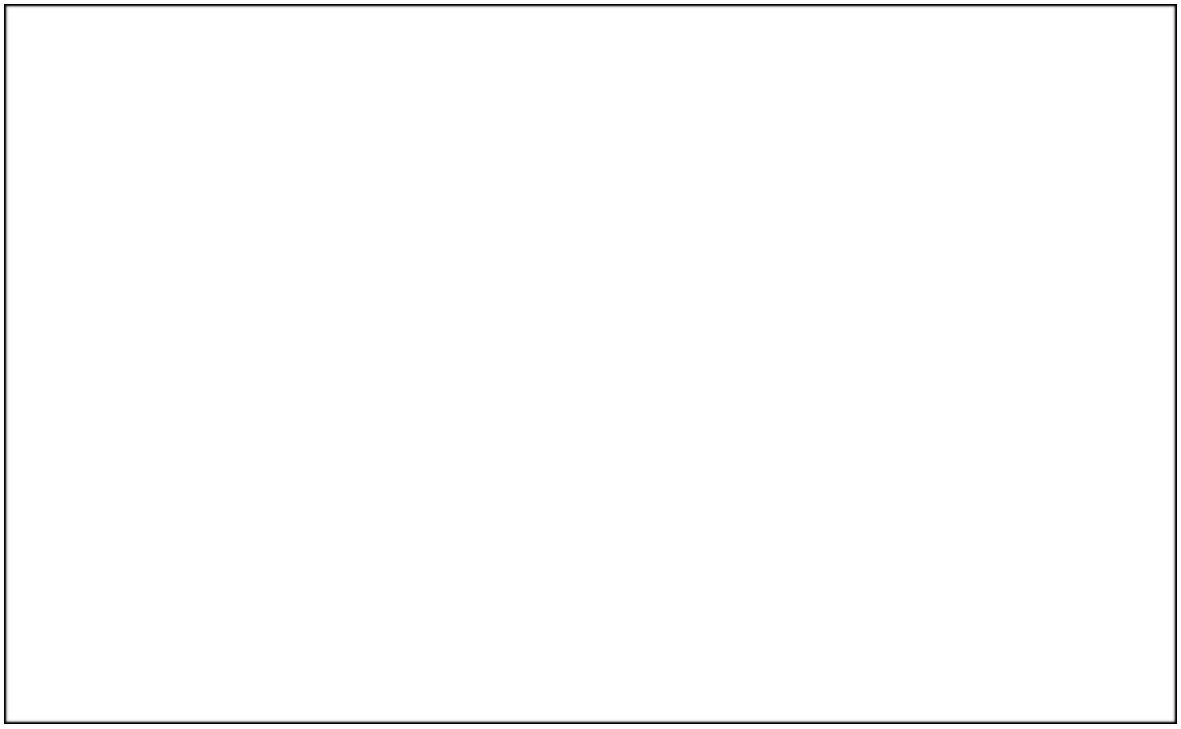
Select the devices

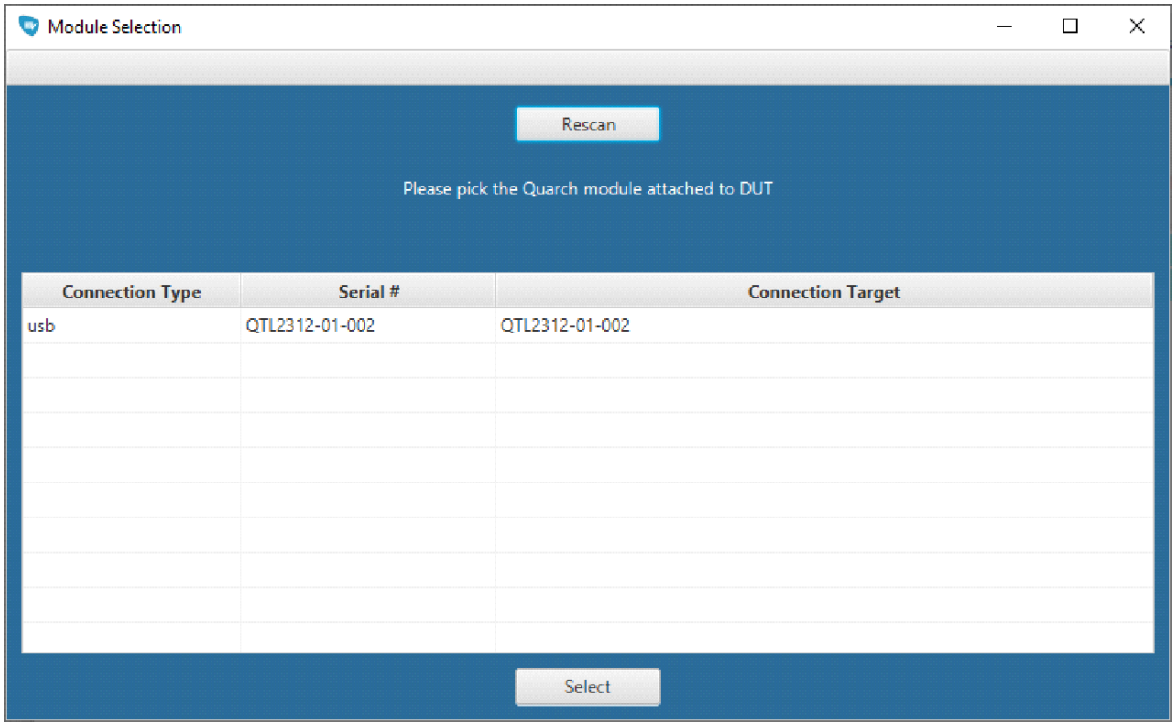
As the test starts running, you will be prompted to select the Quarch Power Module and storage device to use. The dialogs have a rescan button: just in case you have forgotten to plug something in!

Select the power module

First you will be prompted to select the Power Module. Here we have a QTL2312 (PAM) module connected to the Client PC via USB.

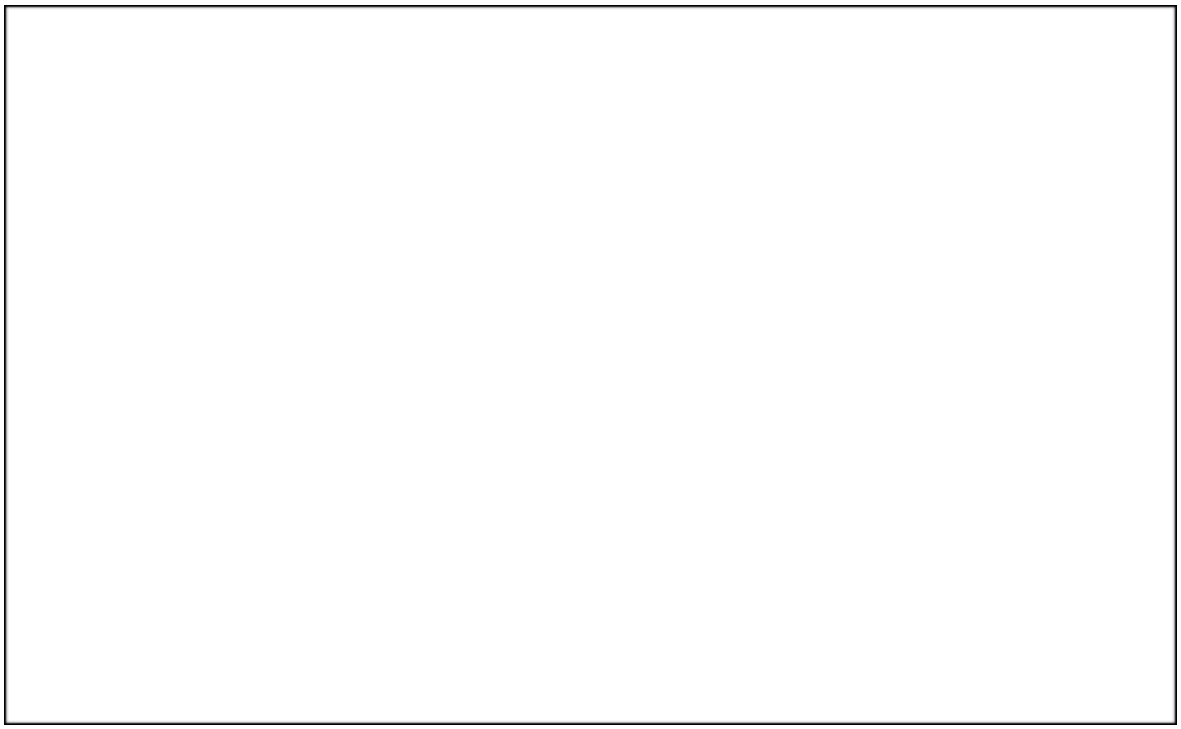
The power module must be available to the **Client** PC. If this is not the case, you will not see it shown here.

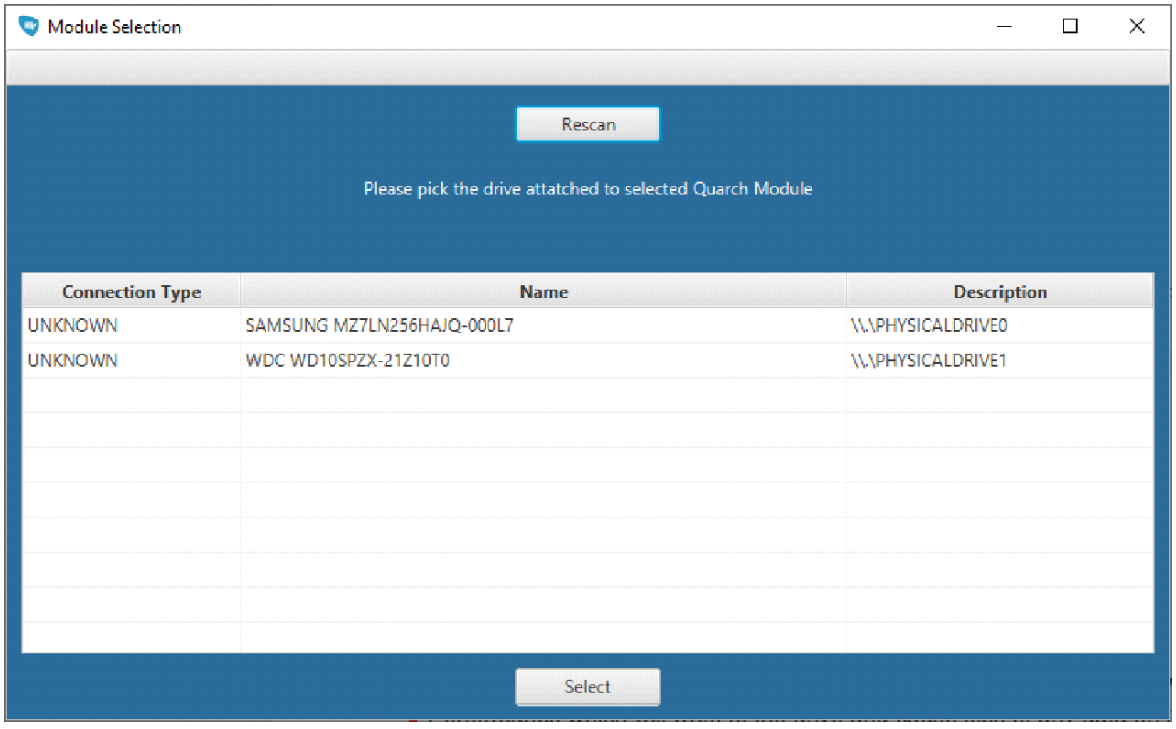



Module Selection
Rescan
Please pick the Quarch module attached to DUT
Connection Type
Serial #
Connection Target
usb
QTL2312-01-002
QTL2312-01-002
Select

Select the storage device (DUT)

Next you will be prompted to select the storage device to test.





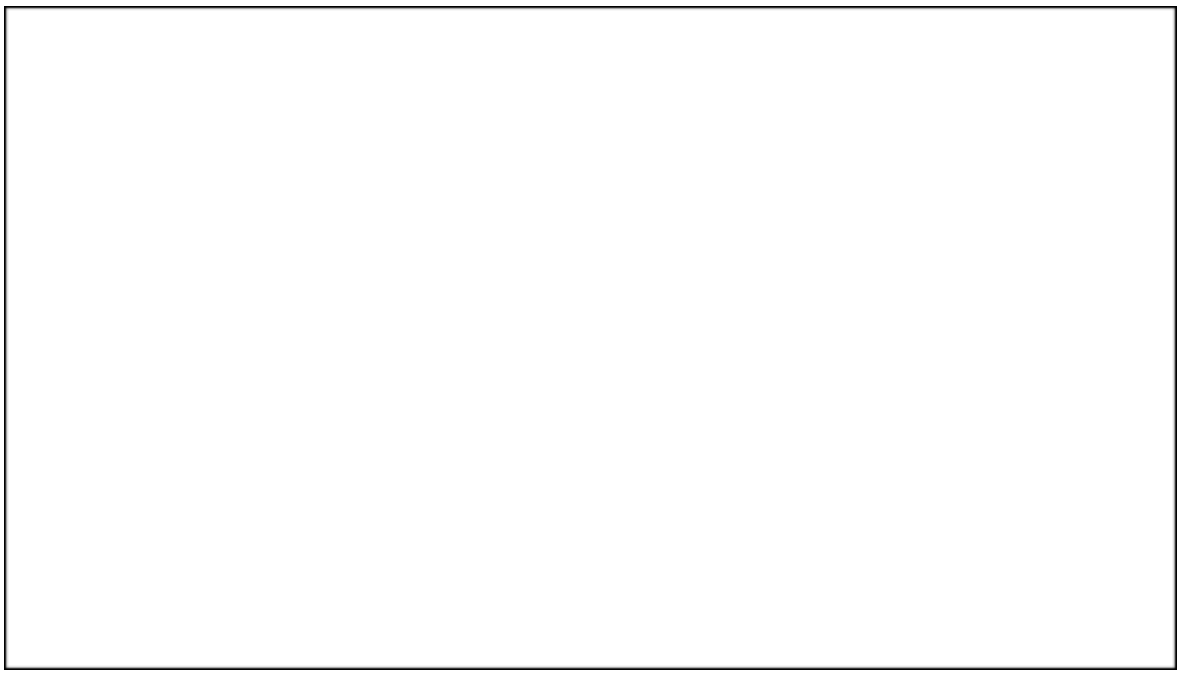
Be sure that you select the correct DUT, *especially* for tests such as Power Vs Performance which will write to the drive and cause loss of any data on it.

View test progress

This test suite can take significant time to complete. Currently around 17 hours, though this will depend on the size of the drive. A progress indicator shows the level of completion.

Real time results are displayed in the log. Any failures will be clearly marked in red, and noted on the error counters.

If many failures occur early on, it is likely that you have a problem with the setup of the equipment. Expanding the failed rows gives more information on the failure.



Quarch Compliance Suite v1.05

File Help

Setup | Results

Custom Variables | Start Tests

Passed: 160 Errors: 0
Failed: 0 Warnings: 0
Elapsed Time: 01:40

Total Progress
Current Test

Test status
PASSED

Expand/Collapse

Id	Type	Time	Description	Details
0	testDescription	2020-11-27..	Setting up required test resources	n/a
0.1	testDescription	2020-11-27..	User module selection	n/a
0.2	testDescription	2020-11-27..	User drive selection	n/a
1	testDescription	2020-11-27..	Beginning tests core	n/a
1.1	testDescription	2020-11-27..	10mS Staged hot-plug test, with enumeration and link verification	n/a
1.1.1	testDescription	2020-11-27..	Repeat cycle 1 of 10	n/a
1.1.1.1	testDescription	2020-11-27..	Setting up hotplug test	n/a
	quarchCommand	2020-11-27..	Quarch Command: source:1:delay 0 - Response: OK	{textDetails=Executing command on module, debugLevel=1}
	quarchCommand	2020-11-27..	Quarch Command: source:2:delay 10 - Response: OK	{textDetails=Executing command on module, debugLevel=1}
	quarchCommand	2020-11-27..	Quarch Command: source:3:delay 20 - Response: OK	{textDetails=Executing command on module, debugLevel=1}
	quarchCommand	2020-11-27..	Quarch Command: source:4:delay 30 - Response: OK	{textDetails=Executing command on module, debugLevel=1}
	quarchCommand	2020-11-27..	Quarch Command: source:5:delay 40 - Response: OK	{textDetails=Executing command on module, debugLevel=1}
	quarchCommand	2020-11-27..	Quarch Command: run:power down - Response: OK	{textDetails=Executing command on module, debugLevel=1}
1.1.1.3	testDescription	2020-11-27..	Polling system for indication of drive removal	n/a
1.1.1.5	testDescription	2020-11-27..	Polling system for indication of drive insertion	n/a
1.1.1.6	testResult	2020-11-27..	Checking device enumerated after power up	{Test Result =True}
	Debug	2020-11-27..	Was: 0GT/s Now: 0GT/s	n/a
1.1.1.7	testResult	2020-11-27..	Checking device's reported link speed	{Test Result =True}
	Debug	2020-11-27..	Was: x2 Now: x2	n/a
1.1.1.8	testResult	2020-11-27..	Checking device's reported lane width	{Test Result =True}
1.1.2	testDescription	2020-11-27..	Repeat cycle 2 of 10	n/a

Test Running : UNH-IOL Plugfest - Basic hotplug

Server Status: Connected

Inbox (5) -... | Executable | pciutils | eclipse-w... | Untitled - ... | Untitled - ... | quarchpy ... | *new 1 - ... | Administr... | Quarch C... | Quarch C... | Settings | 12:11

Common test failures

- **Command to a Quarch module fails to get a response**.
- Module has become disconnected or powered down. Check your cabling.
- **Command to a Quarch module returns a bad command or invalid parameter error.**
- The Module connected is not the correct one for the test, or it required an upgrade.
- **The DUT is not removed from the system correctly during the power cycle test.**
- The wrong DUT may be selected. Make sure you have chosen the right device. If uncertain, you can use TestMonkey or TorridonTerminal to manually hot swap the DUT and verify that it is powering the correct drive.
- **The DUT is not enumerated on the system after the power cycle test.**
- Does the DUT and Host system support hot plug? If you cannot manually hot plug a device in the Host and have it enumerated correctly, then the test will not work.
- This test can be disabled in the custom variable settings.

- **“Fail – Module already streaming”**
- The module chosen is already streaming. If you have an instance of QPS open connected to the same module that has a stream ongoing, click the “stop stream” button on the QPS interface.
  If there is no QPS instance running that is streaming this module, a simple power cycle of the module will release the connection and reset the stream state to stop.

Test specification

Basis for testing

These tests are based on existing industry standards and common practices, while making sensible decisions over what is practical to test by fully automated means.

A detailed description of each test is included in this document. Your comments, requests and suggestions are very welcome and can be directed to support@quarch.com.

Future versions of the test suite will aim to include these improvements where practical.

Assumptions

We assume that the drive connected is in ‘optimal’ condition, to begin testing (ie: that it is empty and in ‘out the box’ condition).

Test 0 – Setup

This test block is purely for setup and preparation of the required resources. No actual performance tests are done here.

Test 1 – Power cycle test

Aims

Turn on the drive and let it power up, verifying that it enumerates correctly and measuring inrush current.

Steps

- Power down the drive.
- Wait for it to fully shut down.
- Power up the drive.
- Measure the power consumption during power up.
- Monitor the host for drive enumeration.

Reporting

- Max inrush current.
- Time to enumerate.

Test 2 – Idle power test

Aims

Perform a basic mixed workload for a short time then capture the power performance of the device as it returns to idle.

The combination of the captured stats and the power trace will show how quickly the drive goes to idle after the workload stops, and how low that idle it.

Steps

- Run a 60 second mixed workload.
    - Writes: 50%, Random: 100%, QD: 1, BlockSize: 4k
- Stop the workload.
- For the next 2 minutes, monitor the power consumption in 15 second intervals.

Reporting

- Max, Min, Average power consumption in each 15 second interval

Test 3 – Latency test, sequential write

Aims

Test the latency response of the drive to sequential writes in a best-case scenario, where the drive was idle before the test workload.

Steps

- Wait 5 minutes for drive to idle and perform housekeeping.
- Run a 5-minute workload.
    - Writes: 100%, Random: 0%, QD: 1, BlockSize: 4k

Reporting

- Average IOPS
- Average MB/s per watt
- Max, Average power consumption
- Latency figures: 2-5 9's

Test 4 – Latency test, random write

Aims

Test the latency response of the drive to random writes in a best-case scenario, where the drive was idle before the test workload.

Steps

- Wait 5 minutes for drive to idle and perform housekeeping.
- Run a 5-minute workload.
    - Writes: 100%, Random: 100%, QD: 1, BlockSize: 4k

Reporting

- Average IOPS
- Average MB/s per watt
- Max, Average power consumption
- Latency figures: 2-5 9’s

Test 5 – Block size sweep, sequential write

Aims

Test the performance of the drive when handling different block sizes during sequential writes. This is in a best-case scenario, where the drive was idle before the test workload.

Steps

- Wait 5 minutes for drive to idle and perform housekeeping.
- Run a 5-minute workload.
    - Writes: 100%, Random: 0%, QD: 1, BlockSize: [Variable]
- Repeat multiple times, changing the BlockSize value for each run.

Reporting

For each BlockSize setting:

- Average Write IOPS
- Average Write MB/s
- Average power consumption
- Max power consumption

- Average MB/s per watt

Test 6 – Block size sweep, random write

Aims

Test the performance of the drive when handling different block sizes during random writes. This is in a best-case scenario, where the drive was idle before the test workload.

Steps

- Wait 5 minutes for drive to idle and perform housekeeping.
- Run a 5-minute workload.
    - Writes: 100%, Random: 100%, QD: 1, BlockSize: [Variable]
- Repeat multiple times, changing the BlockSize value for each run.

Reporting

For each BlockSize setting:

- Average Write IOPS
- Average Write MB/s
- Average power consumption
- Max power consumption
- Average MB/s per watt

Test 7 – QueueDepth sweep, sequential write, best case

Aims

Test the performance of the drive when handling different QueueDepths during sequential writes. This is in a best-case scenario, where the drive was idle before the test workload.

Steps

- Wait 5 minutes for drive to idle and perform housekeeping.
- Run a 5-minute workload.
    - Writes: 100%, Random: 0%, QD: [Variable], BlockSize: 4k
- Repeat multiple times, changing the QD value for each run.

Reporting

For each QD setting:

- Average MB/s
- Average power consumption
- Max power consumption
- Average MB/s per watt

Test 8 – QueueDepth sweep, random write, best case

Aims

Test the performance of the drive when handling different QueueDepths during random writes. This is in a best-case scenario, where the drive was idle before the test workload.
This Queue depth sweep will record queue depth value that resulted in the highest MB/s throughput.

Steps

- Wait 5 minutes for drive to idle and perform housekeeping.
- Run a 5-minute workload.
    - Writes: 100%, Random: 100%, QD: [Variable], BlockSize: 4k
- Repeat multiple times, changing the QD value for each run.

Reporting

For each QD setting:

- Average MB/s
- Average power consumption
- Max power consumption
- Average MB/s per watt

Test 9 – Drive preparation – Steady State

Aims

Force the drive to reach a steady state of performance, such that it is fully saturated with writes and given no time to perform housekeeping at idle. We expect the performance to be poorer for following tests.

Steps

- Run a workload based on drive capacity.
    - Writes: 100%, Random: 100%, QD: [FromTest], BlockSize: 4k
    - Write 200% of the full drive capacity.
    - QD set to the highest performing QD value as per “Queue depth sweep, random write test”.

Reporting

- Time taken to prepare drive.
- Average power consumed.
- Maximum power consumed.
- MB/s achieved (average).
- MB/s achieved (min).
- MB/s achieved (max).

Test 10 – Random Write Performance – Steady State

Aims

Tests random write performance when the drive is in a steady and fully loaded state. We use the QD value identified as the best for write performance

Steps

- Run a 5-minute workload.

    - Writes: 100%, Random: 100%, QD: [FromTest], BlockSize: 4k
    - QD set to the highest performing QD value as per “Queue depth sweep, random write test”.

Reporting

- Max, Average power consumed.
- Average MB/s.
- Average MB/s per Watt.

Test 11 – Sequential Write Performance – Steady State

Aims

Tests sequential write performance when the drive is in a steady and fully loaded state. We use the QD value identified as the best for write performance.

Steps

- Run a 5-minute workload.
    - Writes: 100%, Random: 0%, QD: [FromTest], BlockSize: 4k
    - QD set to the highest performing QD value as per “Queue depth sweep, random write test”.

Reporting

- Max, Average power consumed.
- Average MB/s.
- Average MB/s per Watt.

Test 12 – Mixed IO Performance – Steady State

Aims

Tests mixed IO workloads to see how drive performance varies in more varied general use cases.

Steps

- Run a 5-minute workload.
    - Writes: [Variable]%, Random: 50%, QD: [FromTest], BlockSize: 4k
    - QD set to the best write queue depth, found earlier.
- Repeat the workload from 10% to 90% writes

Reporting

- Max, Average power consumed.
- Average MB/s.
- Average MB/s per Watt.

Test 13 – Latency test, sequential read

Aims

Test the latency response of the drive to sequential reads. Drive is filled with random data and idled before the test.

Steps

- Wait 5 minutes for drive to idle and perform housekeeping.
- Run a 5-minute workload.
    - Writes: 0%, Random: 0%, QD: 1, BlockSize: 4k

Reporting

- Average IOPS
- Average MB/s per Watt
- Latency figures: 2-5 9’s
- Average, Max power

Test 14 – Latency test, random read

Aims

Test the latency response of the drive to random reads. Drive is filled with random data and idled before the test.

Steps

- Wait 5 minutes for drive to idle and perform housekeeping.
- Run a 5-minute workload.
    - Writes: 0%, Random: 100%, QD: 1, BlockSize: 4k

Reporting

- Average IOPS
- Average MB/s per Watt
- Latency figures: 2-5 9’s
- Average, Max power

Test 15 – Block size sweep, sequential read

Aims

Test the performance of the drive when handling different block sizes during sequential reads. This is in a best-case scenario, where the drive was idle before the test workload.

Steps

- Wait 5 minutes for drive to idle and perform housekeeping.
- Run a 5-minute workload.
    - Writes: 0%, Random: 0%, QD: 1, BlockSize: [Variable]
- Repeat multiple times, changing the BlockSize value for each run.

Reporting

For each BlockSize setting:

- Average Read IOPS
- Average MB/s
- Average power consumption
- Max power consumption
- Average MB/s per watt

Test 16 – Block size sweep, random read

Aims

Test the performance of the drive when handling different block sizes during random reads. This is in a best-case scenario, where the drive was idle before the test workload.

Steps

- Wait 5 minutes for drive to idle and perform housekeeping.
- Run a 5-minute workload.
    - Writes: 0%, Random: 100%, QD: 1, BlockSize: [Variable]
- Repeat multiple times, changing the BlockSize value for each run.

Reporting

For each BlockSize setting:

- Average Read IOPS
- Average MB/s
- Average power consumption
- Max power consumption
- Average MB/s per watt

Test 17 – QueueDepth sweep, sequential read

Aims

Test the performance of the drive when handling different QueueDepths during sequential reads. This is in a best-case scenario, where the drive was idle before the test workload.

Steps

- Wait 5 minutes for drive to idle and perform housekeeping.

- Run a 5-minute workload.
    - Writes: 0%, Random: 0%, QD: [Variable], BlockSize: 4k
- Repeat multiple times, changing the QD value for each run.

Reporting

For each QD setting:

- Average MB/s
- Average power consumption
- Max power consumption
- Average MB/s per watt

Test 18 – QueueDepth sweep, random read

Aims

Test the performance of the drive when handling different QueueDepths during random reads. This is in a best-case scenario, where the drive was idle before the test workload.

Steps

- Wait 5 minutes for drive to idle and perform housekeeping.
- Run a 5-minute workload.
    - Writes: 0%, Random: 100%, QD: [Variable], BlockSize: 4k

- Repeat multiple times, changing the QD value for each run.

Reporting

For each QD setting:

- Average MB/s
- Average power consumption
- Max power consumption
- Average MB/s per watt