

USB Power Delivery Tester

Users Guide

Model PM110 (Rev 1)

Model PM125 (Rev 2)



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Introduction

The USB Power Delivery Tester can be used to diagnose and troubleshoot your USB ports and USB chargers. With the USB Power Delivery Tester, you can:

- Test the power delivery capability of USB ports and USB chargers.
- Check if a USB host is capable of delivering its maximum specified wattage without failing.
- Detect the wattage a USB charger (wall-wart / transformer) claims to support, which in turn controls the charging speed of mobile phones and other USB connected battery devices.
- Check that voltage levels remain within specification under high load.
- Measure the exact power usage of USB devices.
- Measure the capacity of power banks
- Use it with the USB loopback tester, to test communication speed, data integrity, and power delivery of USB ports simultaneously. For example, does data corruption occur under high electrical load.
- Test USB Type-C cables for voltage drop
- Test the capacity of battery powered power banks which have USB connectors.
- Test for ripple on the power supply (sampling rate of 1Khz)

Warnings – Important – Please read.



- Do not touch or cover heatsink during operation as it can reach high temperatures, which could result in **burns** or failure of the USB PD Tester.
- Do not block the operation of the fans & allow good airflow. Allow at least 10cm of air gap around the back of the fans. Also ensure there is airflow under the device.
- Some USB power supplies are known to not fully comply with the USB standards. Some also do not comply with relevant electrical standards in the countries where they are sold. Faulty or poorly designed devices can be dangerous! The USB PD Tester may expose design and manufacturing flaws in the device when putting the device under high load. The result can be catastrophic failure of the device under test. Which in turn can lead to **fire**, **melting** of the device under test, **smoke**, **electrical shorts** and even destruction of the USB PD tester itself.
- Only use the USB PD tester with devices that claim compliance with the USB standards. A catastrophic failure of the device under test can result in the shorting of mains power to the USB cable. Which can both destroy the USB PD Tester and present a serious **electrocution hazard**.
- Always have someone monitor the testing in case the device under test suddenly fails. Do not start a test and walk away.
- Do not draw more current from the device than it claims to support. The port might be damaged as a result, or over current protection might lead to the port shutting down.

- The USB PD Tester is not a consumer device. It was designed for use by qualified electrical engineers.

Background

USB History

Universal Serial Bus (USB) is a standard interface for connecting peripheral devices to a host computer. The USB system was originally devised by a group of companies including Compaq, Digital Equipment, IBM, Intel, Microsoft, and Northern Telecom to replace the existing mixed connector system with a simpler architecture. The main goal of USB was to make the addition of peripheral devices quick and easy (although it could be argued that USB is in fact vastly more complex than the interfaces it replaced).

To ensure maximum interoperability the USB standard defines all aspects of the USB system from the physical layer (mechanical and electrical) all the way up to the software layer. The USB standard is maintained and enforced by the USB Implementers Forum (USB-IF).

USB 1.0 was first introduced in 1996 but was not adopted widely until 1998 with USB 1.1. In 2000, USB 2.0 was released and has since become the de facto standard for connecting devices to computers and beyond. In 2008, the USB specification was expanded with USB 3.0, also known as SuperSpeed USB. USB 3.0 represents a significant change in the underlying operation of USB. USB 3.0 adds SuperSpeed, which is a new transfer mode with transfer speeds of up to 5 Gbps. This is more than 10x faster than the top speed of USB 2.0, which is only 480 Mbps.

Another area of evolution for USB was sidelined earlier in its development—power delivery. With the focus on speed, power delivery was never the priority for USB. In fact, the first time a specification was made specifically for power delivery occurred only in 2010: The Battery Charging Specification – BC 1.2 increased USB power delivery from 4.5 W to 7.5 W. This specification introduced a mode called CDP (charging downstream port) and DCP (dedicated charging port) that allowed for higher charging current (up to 1.5 A) compared to traditional SDP ports (standard downstream port).

However, this specification was only a precursor for what was to come. Almost at the same time as the USB 3.1 release, the USB Implementers Forum (USB-IF) released the USB Power Delivery Specification. This new USB power delivery specification allows power transfers of up to 100 W, along with other features and benefits. Using the new protocol, devices negotiate what power they need, thus ensuring that a device doesn't draw too much current, which would cause things to fail, catch on fire, melt or explode.

Power capability in different USB standards

In the USB 1.0 specification, a standard downstream port can deliver up to 100mA at 5Volts, over 4 wires. (Two data wires, +5V and ground).

In the USB 2.0 specification, a standard downstream port can deliver up to 500mA at 5Volts, again over 4 wires. (2.5 Watts) once a device is enumerated. The limit is just 100mA prior to enumeration.

USB 3.0 ports add an additional row of five pins to make a total of nine wires. They can supply more current (900mA).

There are three types of USB ports specified by the Battery Charging Specification, BC1.1 and then BC1.2):

1. A standard downstream port (SDP): Found on most computers, with a current limit of 500mA before enumeration and 900mA after enumeration.
2. A charging downstream port (CDP): Found on some computers, 1500mA (1.5A, 7.5W)
3. A dedicated charging port (DCP): for "dumb" wall chargers, also allowing 1500mA (1.5A, 7.5W)

In the Power Delivery specification, power transfers of up to a massive 100W at varying voltages is possible. A device can have up to 7 power profiles.

Device Operation

The PassMark USB Power Delivery Tester is an active load designed to test the power capability of USB devices/ports. It simulates a multitude of devices by negotiating different voltage and power levels and allows users to sweep the full range of electrical loads to test the voltage stability over the entire output range.

Front Panel

The front panel of the USB Power Delivery Tester offers a 1.8" LCD screen, a rotary dial and three USB ports.



Figure 1

LCD Display

The PassMark USB Power Delivery Tester features a built-in 1.8" LCD display to display port type, voltage, current and power. The default screen when a device is connected is shown below.

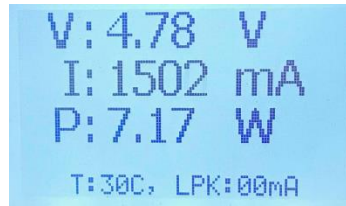


Figure 2

V: Voltage supplied by device under test in volts.

I: Current drawn by the tester in milliamps. This can be changed by turning the rotary dial.

P: Power dissipated by the tester in watts.

T: Heatsink temperature in Celsius.

LPK: Current drawn from the Loopback Port in milliamps.

By pushing the rotary dial, more options appear on the display. The below screenshot is taken when an Apple 87W charger is connected to the tester. Here a voltage profile can be selected from the three available profiles listed.

To select a profile or item, simply turn the dial until that profile/item is highlighted, then push the dial.



Figure 3

Supported Voltages: List of the available profiles advertised by the device under test.

VBUS: Using this option, users can enable/disable the estimation of voltage at the host/charger side (upstream side). Note that the tester measures the voltage at the device end (downstream side), therefore for the estimation of voltage at the host side the total resistance of the path should be known.

Cable Resistance: For calculating the estimated voltage at the upstream side, the total resistance of the path in milliohms should be specified by the user. The resistance can only be set using the monitoring software. The total resistance can be calculated using the following formula.

$$R_{\text{Total}} = (R_T + R_C * 2 + R_W) * 2$$

R_T = Host Trace Resistance

R_C = Mated Connector Resistance

R_W = Cable Resistance

Loopback Port: This allows to enable or disable the loopback port. When this is enabled, the power and data lines of the device under test is routed to the Loopback Port and thus communication speed, data integrity, and power delivery of USB ports can be tested simultaneously.

SDP Cur. Limit: This option allows to specify the maximum current limit for SDP ports. The 900mA is allowed when a USB3 device connected to the loopback port (e.g. a USB3 loopback plug)

Dial Velocity: Using this option, users can enable/disable the dial velocity measurement. Enabling the Dial Velocity option will help to increase/decrease the load faster.

Ports

The three USB ports, are,

Analysis (Left): This both powers the device and allows data logging back to a PC. The analysis port **must** be connected to a USB port which can provide 500mA of current. This could be a port on a PC, or a USB charger port (if there is no requirements to use the Windows management software)

Loopback (Middle): Connection of an **optional** downstream device (e.g. a USB3.0 loopback plug). This port would be used when you wanted to test data transmission at the same time as maximum power draw. Other USB devices can also be connected to this port to measure their current consumption.

Device Under Test (Right): Connection to the USB power source to be tested. This can be a wall charger or a computer with a USB port.

Rotary Dial (Load Adj)

The rotary dial on the right is for adjusting the variable load/voltage and selecting the power profile. The dial has velocity measurement which allows the user to quickly and precisely adjust the load (i.e. slow turning speed will result in 5mA steps while fast turning speed will result in 100mA steps).

More options will be displayed by pushing the rotary dial.

To change the dial function between current and voltage adjustment, push the dial to access the menu and then change the “Dial Mode”.

Cables

Each tester comes with 3 cables:

- A 1-meter (39inch) USB B (male) to USB A (male) cable. This cable is used to connect the tester to a PC.
- A 40cm (15inch) E-Marked USB Type-C TO Type-C cable. This cable is used to connect the tester to a Type-C USB power source (USB port or wall charger).
- A 40cm (15inch) USB TYPE-C TO USB A (male) cable. This cable is used to connect the tester to a Type A USB power source (USB port or wall charger).

It is recommended to only use the original cables supplied with the tester. Avoid using longer cables as they introduce error in voltage measurement. Moreover, the original E-Marked Type-C cable is qualified for 5A, but not all Type-C cables have this capability.

Setting up the tester

To power up the tester, the “Analysis Port” should be connected to a power source (e.g. a computer running the monitoring software or any power source like a wall charger). Then the device under test should be connected to the “Device Under Test” port. The device under test could be one of the following devices:

- Desktop or laptop USB port
- Wall charger

- Portable power bank
- Hub

Depending on the device under test, you may need to use one of the following cables:

- E-Marked USB Type-C TO Type-C cable for testing USB Type-C ports
- USB TYPE-C TO USB A (male) cable for testing Type A ports

Once connected, the LCD displays the type of USB port as well as the maximum current. Then it displays the voltage, current, power and heatsink temperature in real time. To increase the load, the rotary dial must be turned clockwise. For USB ports that support multiple voltage levels, the profile can be selected by pushing the rotary dial.

The below diagram illustrates how different devices can be connected to the tester.

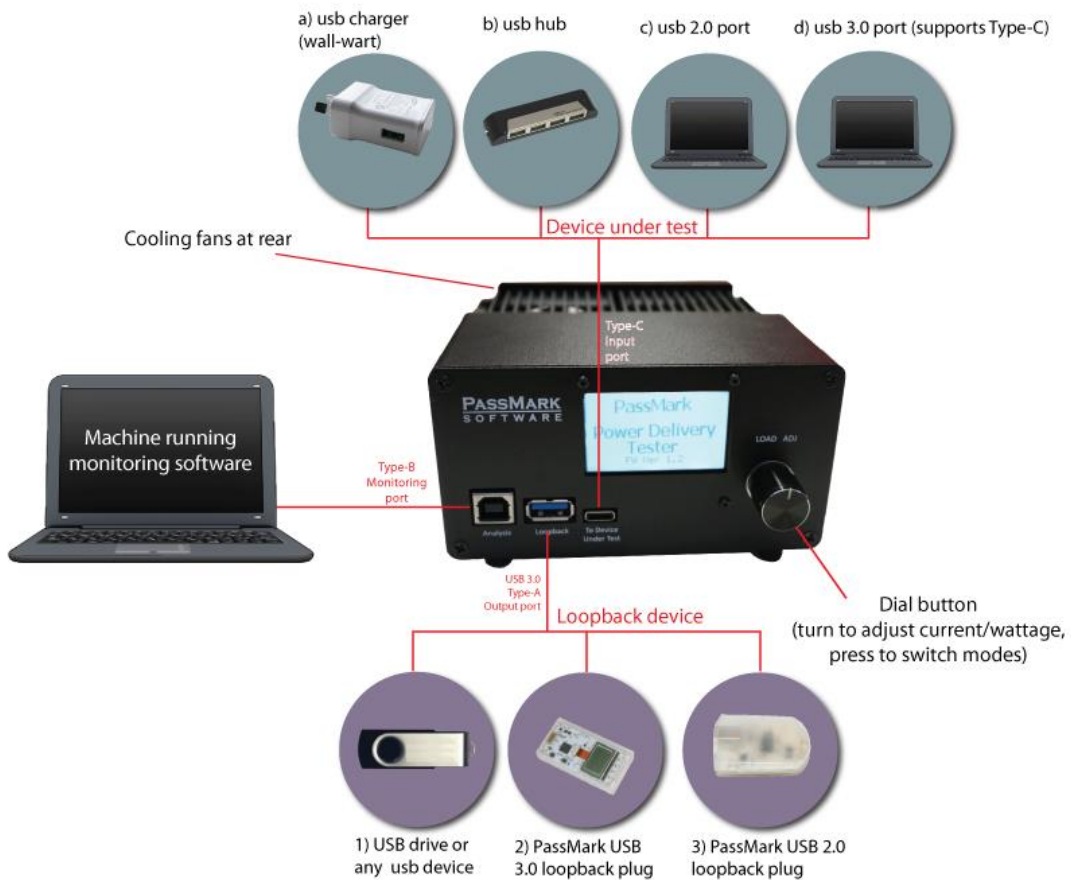


Figure 4

Monitoring Software

The main USBPDTest application window is divided into 5 sections: Select USB Power Delivery Tester, Log Window, Port Statistics, Set Load, Graph buttons and other control buttons.

Main Window

The main screen contains the following features and options:

Device

This drop-down list shows each connected PassMark USB Power Delivery device. If PassMark USB Power Delivery devices are added or removed while the application is running, the drop-down selection list will be automatically updated.

Voltage

Allow users to select the voltage when a USB Type-C port with multiple profiles is being tested.

Disconnect USB-C (PM125 only)

Clicking this button will simulate a physical disconnection of the device under test from the unit. This button will then change to *Connect USB-C* which can be used to simulate the reconnection.

Set Voltage

This allows the user to adjust the voltage when a PPS or QS profile is selected. This option only works on PM125 (Rev 2).

Set Load

Allow adjusting the variable load. The load can be adjusted by entering the current in mA or by moving the slider. The speed at which the load changes can also be adjusted using the *Load Change Speed* drop-down menu on the right of the slide bar.

Port Statistics: This section displays some characteristics of the connected device/port such as port type and maximum current that device/port can deliver. The application also tracks and displays the bus voltage, current and heatsink temperature.

Log Window

The log window displays test results and events logged during operation. It starts with a list of the PassMark USB Power Delivery devices connected. Specifically, this includes the:

- The version of USBPDTTest application.
- A list of PassMark USB Power Delivery devices connected.
- The type of USB Port connected to the “Device Under Test” port.
- The power capabilities (voltage profiles) that device under test supports.
- Warnings such as under voltage or over voltage.
- Voltage Sweep results.

Reset Capacity

The tester can be used as a capacity meter to test power banks. The monitoring software accumulates the capacity over the time until the voltage drops below the required voltage limit. The “Reset Capacity” button allows users to reset the accumulated capacity.

Graphs and Tests Window

The controls for running a test are found along the right side of the graph. Within the *Test Graph Configuration* box, the list of tests can be viewed by clicking the drop-

down box under *Graph Type* and the test selected by clicking on it. Beneath this, the configuration parameters for that test will be displayed and can be adjusted. Hitting the *Run Test* button begins the set test, during the test the Tester will become busy until it is either complete or the *Stop* button is pressed. When a test is complete, the graph can be saved as an image with the *Save Graph* button or exported in the form of a CSV file with the *Export CSV* button.

Real-time Voltage Graph

The Real-time voltage graph (figure 5) is used to monitor the voltage of the port in real-time. A green band is imposed over the output graph to indicate whether the measured voltage falls within the acceptable range. The maximum and minimum voltage measured during the test is also displayed, which is used to determine the ripple voltage.

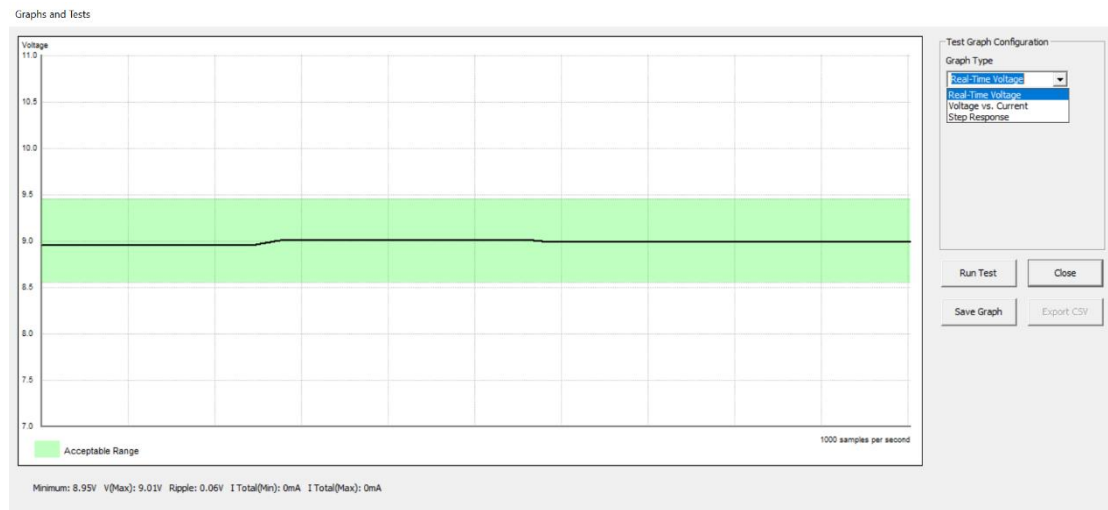


Figure 5

Voltage vs. Current Graph

The Voltage vs. Current test will sweep the full range of electrical loads to test the voltage stability over the entire output range. A graph of “Voltage vs. Current” will be displayed as a result (figure 6), which provides an easy way to check if voltages remain in spec even under maximum load.

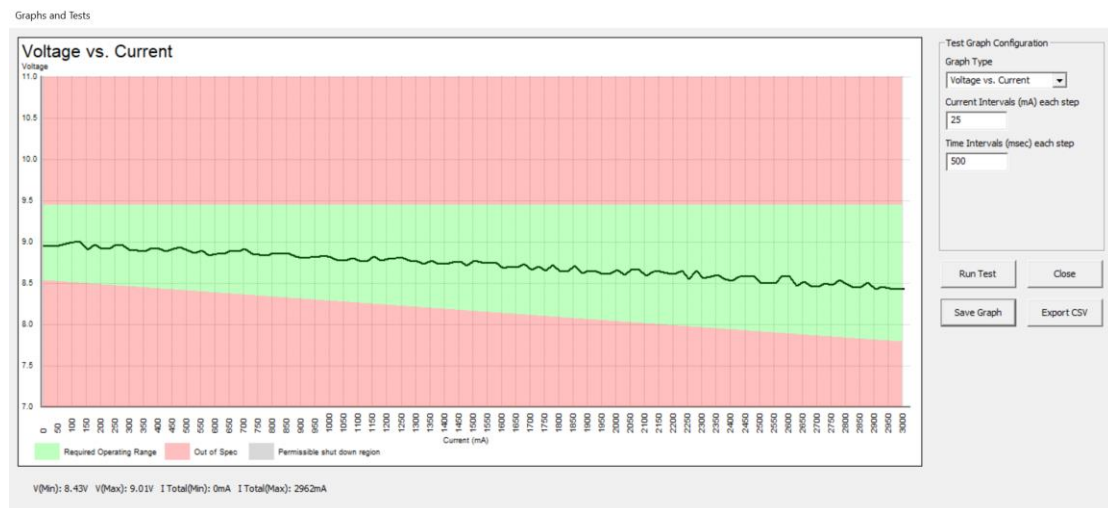


Figure 6

The graph is divided into three regions:

Required Operating Range (Green area): The voltage vs. current graph for a normal device/port should stay within this area for all currents less than the advertised current by the manufacturer.

Out of Spec (Red area): This means either over voltage or under voltage detected.

Permissible Shutdown Region (Grey area): The device/port under test can shut down when voltage is in this area.

While the graph is being plotted, the voltage measured at each current step will be stored in the Log Window.

Step Response Graph

The step response test will quickly change the load from the set initial current to the final current. As this change happens, the voltage is measured every 100 microseconds to create an accurate graph of the device under test's output voltage (Figure 7). The minimum and maximum voltage during the test is also recorded and displayed in the bottom left corner.

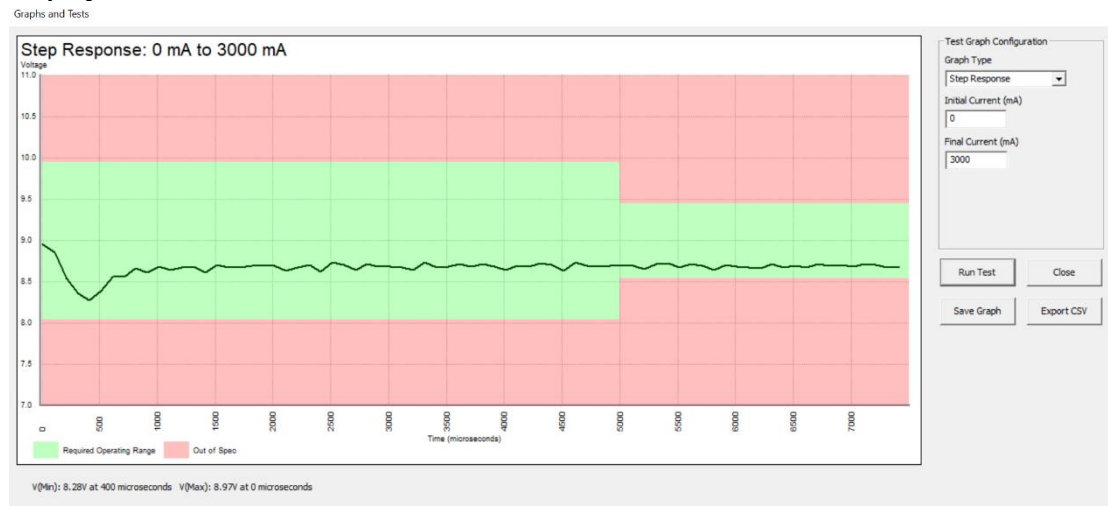


Figure 7

The graph is divided into two regions:

Required Operating Range (Green area): The step response graph for a normal device/port should always stay within this area.

Out of Spec (Red area): This means either over voltage or under voltage detected.

Message Tracer and Generator Window (PM125 Only)

The table in the top half of the window displays a log of all the power delivery messages sent and read by the Power Delivery Tester. Below the table, the *Log View Mode* dropdown box can be used to adjust what information is displayed, with the following three options: Default, for a simplified overview; Extended data, for viewing data related to extended type messages; Raw messages, for viewing the raw data sent over the USB cable. Below this, clicking the *Export to CSV* button will save

all the log entries to a file, and to the right, clicking the *Clear Log* will reset the log to be empty.

In the bottom left corner of the window is the message generator. Detailed information of each message type and its corresponding data can be found by referring to the Protocol Layer section USB Power Delivery specification. Clicking the send message button will form the power delivery message and send it to the device under test. For generating invalid messages, the Custom type can be used.

Configuration Window

The following options appear in the configuration window:

Enable Loopback Port: This option allows the loopback port to be enabled. By enabling the loopback port, USB power and data lines from the “Device Under Test” port will be routed to the “Loopback Port”. This would be useful when data transmission and maximum power draw need to be tested at the same time.

Standard Port Current Limit: The maximum current for standard downstream ports can be defined by this option.

Voltage vs. Current Graph settings: This allows to specify the current/time intervals for each step in the Voltage vs. Current graph.

Disable Current Limit: This option allows the user to disable the detected current limit and extends the range up to 5A. It is possible to extend the range by 20% or manually force a new limit. Precautions should be taken when disabling the current limit as drawing excessive current could damage the device/port under test.

Default Configuration: Sets the initial profile index, voltage and load when connecting a device. PM125 models have the option to set the profile index and PM110 models are in *auto* mode. *Auto* mode will find the best matching profile based on the settings provided and select it on connecting the device.

Manually Set Operating Current (PM125 only): The Power Delivery specification allows for a device to advertise the maximum current it can accept, through a field within the message that requests a new profile. The value advertised by the tester can either be manually set or be in automatic mode where it is set to the maximum current.

Profile Detection Settings (PM125 only): Sets which profiles will be detected, as well as the maximum current that can be drawn for each type (up to the maximum limit defined in the specifications). Some settings are disabled unless the “Unlock all settings (dangerous)” box is ticked, as some chargers may falsely advertise they support these profiles.

Sink Capabilities (PM125 only): This contains the capabilities advertised by the PM125 when requested by a source. Capability 1 is required by the PD specifications and Capability 2 can be modified if enabled by ticking the box next to it.

Calibration Window

The unit should provide accurate measurements out of the box, with its default calibration. Typical default accuracy is around 1% for voltage readings and $\pm 10\text{mA}$ for current measurements. So, for most uses, further calibration is not required.

However, using an adjustable power supply and a quality multimeter, experienced users can calibrate the tester to improve the voltage & current measurement accuracy. Please note that onsite calibration by user is only possible for model PM125.

To calibrate, two known voltages/loads should be applied for voltage/current calibration. For voltage and current readings, you should split open a USB cable to be able to measure the Volts and Amps with multimeter. This cable should have a 5Kohms pull up resistor between CC line and VBUS to be detected by the tester. The voltage measurement should be done as close as possible to the tester’s DUT connector. For current measurement, a multimeter must be inserted in series with VBUS wire. The applied voltage/load should be measured by a multimeter and is called “Applied Value”. The PD Tester also software records its own measurement, known as the “Measured Value” and finds the gain and offset required to map this value to the expected value.

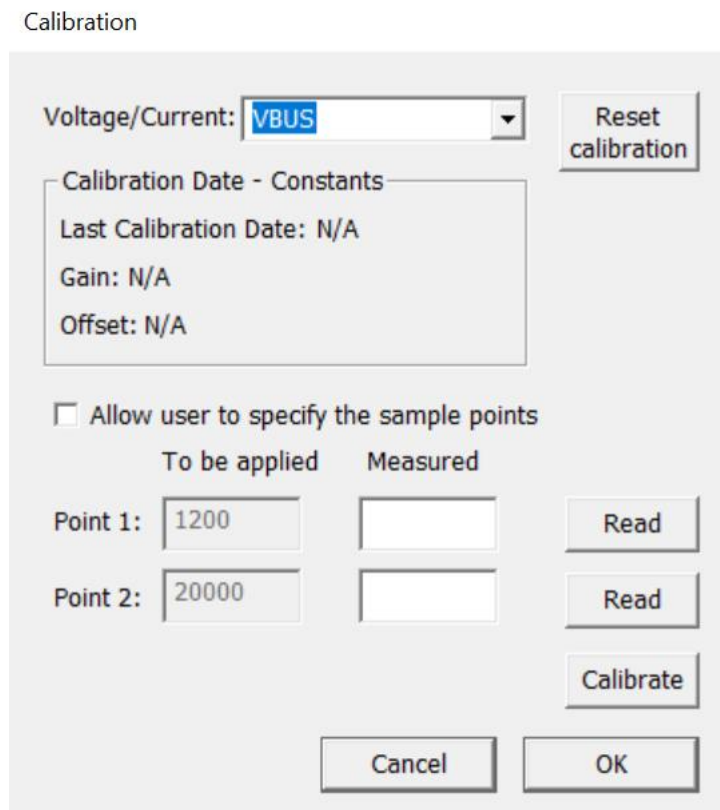


Figure 8

Voltage measurement calibration:

- Open the calibration window.
- From the dropdown list, select VBUS.
- Click “Reset calibration data” to erase all previous calibration data.
- Apply an external voltage equal or close to Point 1 to VBUS. If you cannot apply the exact voltage, activate the “Allow user to specify the sample points” option, which allows you to specify the exact applied voltage.
- Click “Read” button for the Point 1.
- Apply an external voltage equal or close to Point 2 to VBUS. Again, if you cannot apply the exact voltage, activate the “Allow user to specify the sample points” option, which allows you to specify the exact applied voltage.
- Click “Read” button for the Point 2.
- Click “Calibrate”.

Current measurement calibration:

- Open the calibration window.
- From the dropdown list, select Current.
- Connect the VBUS to a low noise external power source and insert a multimeter in series with VBUS for current measurement.
- Click “Reset calibration data” to erase all previous calibration data.
- Turn the knob until load measured by multimeter is equal or close to Point 1. If you cannot apply the exact load, activate the “Allow user to specify the sample points” option, which allows you to specify the exact applied load.
- Click “Read” button for the Point 1.
- Turn the knob until load measured by multimeter is equal or close to Point 2. If you cannot apply the exact load, activate the “Allow user to specify the sample points” option, which allows you to specify the exact applied load.
- Click “Read” button for the Point 2.
- Click Calibrate.

Driver Installation

In most cases, if there is an available Internet connection, Windows will silently connect to the Windows Update website and install the driver automatically. If the automatic installation takes place there is no need to continue with the procedure outlined below.

Windows 7, 8 & 10 Installation

Un-install any previous version of the USBPD Loopback plug device driver before installing a new version.

Step1 – connect the device

With the computer turned on and running, connect the USB Power Delivery Tester to the USB port on the computer to be tested. The device LCD should turn on and display “Waiting for Device Under Test”.

For Win7 users, the “Installing device driver software” bubble should be displayed.



Figure 9

For Win10 users, the Device Setup windows will be displayed.

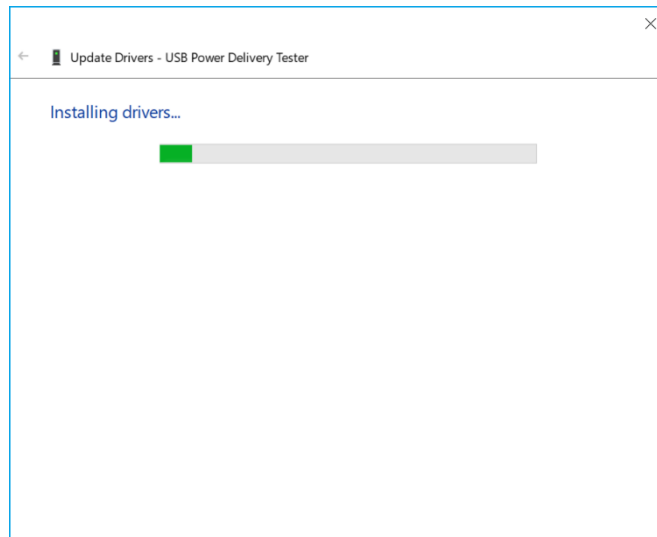


Figure 10

If a USB Power Delivery device has been installed on the system previously the device drivers will be automatically installed, and the installation is complete.

Step 2 – Install the device driver

Download the latest driver from the following address and extract the package.
http://www.passmark.com/download/usbpctest_download.htm

Start Device Manager by selecting Windows Start and typing “Device Manager”.

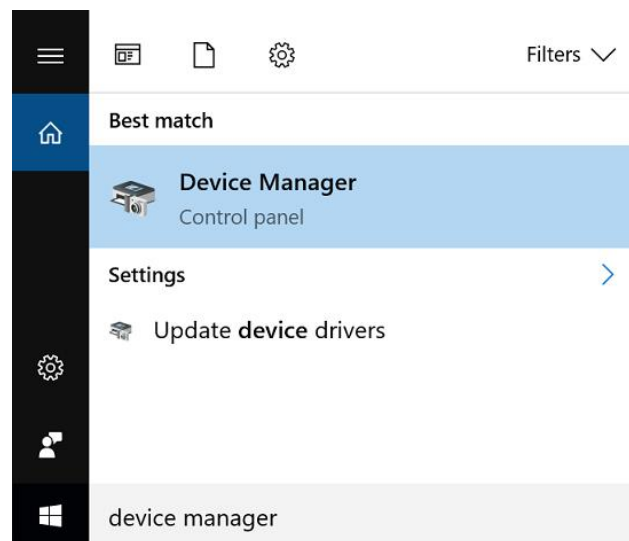


Figure 11

From within Device Manager, select the “PassMark USBPDTTester” device and select “Update Driver Software...”

Select “Browse my computer for driver software” and enter the location of the device drivers. Select Next.

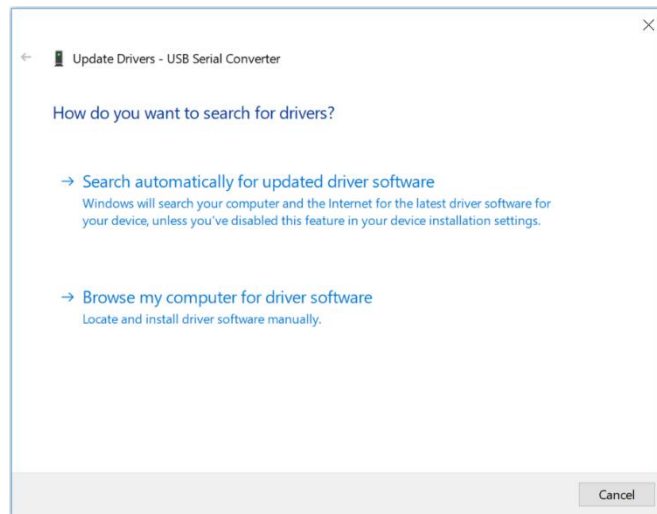


Figure 12

After successful installation, a Window will be displayed indicating that “Windows has successfully updated your driver software”.

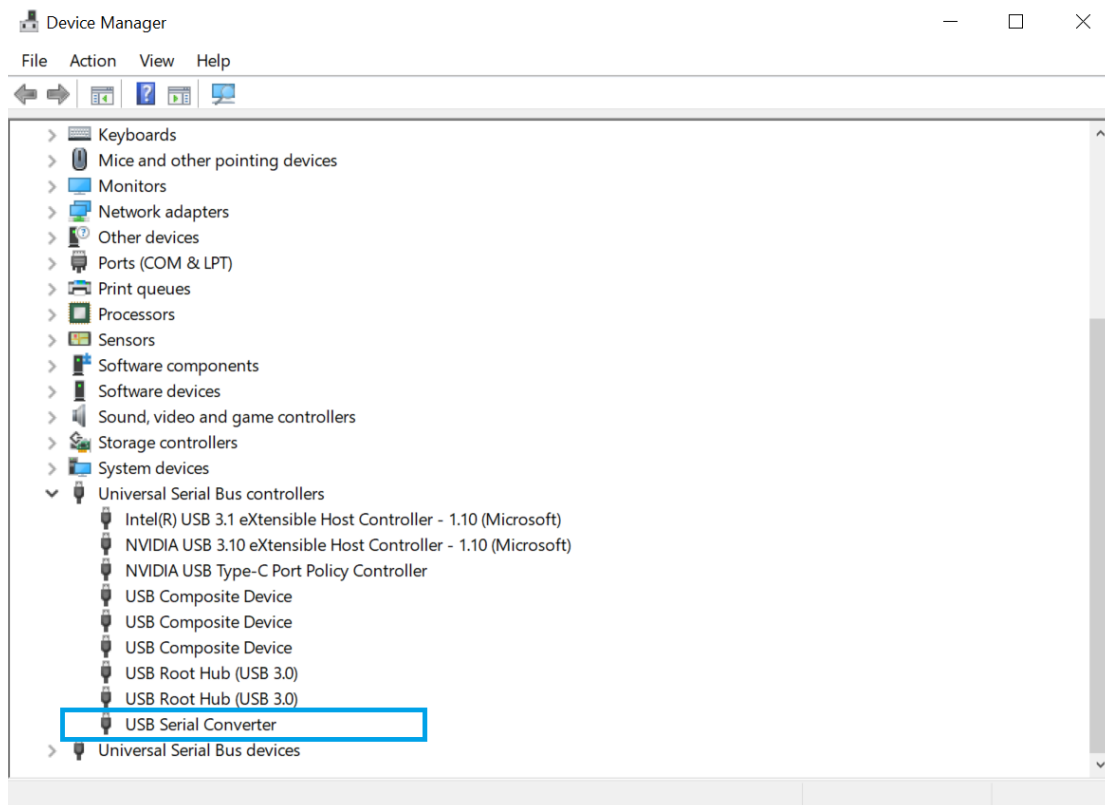


Figure 13

The tester should appear as “USB Serial Converter” under “Universal Serial Bus Controllers” in Device Manager.

Uninstalling in Windows 7, 8 and 10

From the Windows "Start" option, select
Control Panel → System → Hardware → Device Manager

from the "Universal Serial Bus controllers" branch of the device tree, select the "PassMark USBPDTTester" device and from the menu select Action→Uninstall.

Technical Specification PM110 (Rev 1)

CPU	ARM Cortex M0
Memory	16KB RAM, 128K Flash
User Interface	1.8" LCD 128X64 Pixels + Rotary dial
USB standards	USB Power Delivery Specification Revision 3.0 and Battery Charging Specification Revision 1.2
Port Detection	DCP, SDP, CDP, Type-C, Proprietary Chargers
Physical connectors	USB A, USB B, USB Type-C
Maximum Load	60W Continuous, 100W for 5 Minutes
Current Adjustment	Yes
Voltage Adjustment for PPS/QC profiles	No
Cooling	Heatsink with two fans
Operational Voltage	4.5V – 5.6V
Operational Current	350mA
Type-C Voltage	0V – 28V (for comparison, Type-C specs are 5 to 20V)
Type-C Current	0 - 5A
Type-A Current (Source)	0 - 1.5A when Type-C Voltage = 5V 0 - 0.3A when Type-C Voltage > 5V
Measurement Error (A)	±10mA for the entire range (0-5A), calibration improves the accuracy to 1% (Note 1)
Measurement Error (V)	1% before calibration, 0.25% after calibration
Case	Aluminium - Black Anodized
Size	140mm x 120mm x 75mm (5.5 x 4.7 x 3 inches)
Weight	570g (20.1oz)
EMC standards	AS/NZS 3548:1995, EC
Safety Protections	Over current protection Over voltage protection (up to 30V on VBUS line; up to 4V on data and CC lines) ESD Protection on USB2 data lines (IEC 61000-4-2 level 4, ±15kV contact discharge, ±20kV air discharge) Short circuit protection between VBUS line and Ground Isolated USB Monitoring port (1kv) Heatsink temperature monitor
Storage Temperature	-30 °C to + 80 °C

Usage Temperature	0 °C to + 35 °C (lower temperature allows longer period of higher loads)
Part number	PM110
RoHS (Lead free)	Yes

The USB Power Delivery Tester is software upgradeable.

Technical Specification PM125 (Rev 2)

CPU	ARM Cortex M0
Memory	16KB RAM, 128K Flash
User Interface	1.8" LCD 128X64 Pixels + Rotary dial
USB standards	USB Power Delivery Specification Revision 3.0, Battery Charging Specification Revision 1.2 and Quick Charge 4 (including QC1, QC2, QC3, QC4 and QC4+)
Port Detection	DCP, SDP, CDP, Type-C (non-PD, fixed profile and PPS), QC and Proprietary Chargers
Physical connectors	USB A, USB B, USB Type-C
Maximum Load	60W Continuous, 100W for 5 Minutes
Current Adjustment	Yes
Voltage Adjustment for PPS/QC profiles	Yes
Cooling	Heatsink with two fans
Operational Voltage	4.5V – 5.6V
Operational Current	350mA
Type-C Voltage	0V - 28V (for comparison, Type-C specs are 5 to 20V)
Type-C Current	0 - 5A
Type-A Current (Source)	0 - 1.5A when Type-C Voltage = 5V 0 - 0.3A when Type-C Voltage > 5V
Measurement Error (A)	±10mA for the entire range (0-5A), calibration improves the accuracy to 1% (Note 1)
Measurement Error (V)	1% before calibration, 0.25% after calibration
Case	Aluminium - Black Anodized
Size	140mm x 120mm x 75mm (5.5 x 4.7 x 3 inches)
Weight	570g (20.1oz)
EMC standards	AS/NZS 3548:1995, EC
Safety Protections	Over current protection Over voltage protection (up to 28V on VBUS line; up to 4V on data and CC lines)

	ESD Protection on VBUS (IEC 61000-4-2 level 4, ±8 kV contact discharge, ±15 kV air discharge) ESD Protection on USB2 data lines (IEC 61000-4-2 level 4, ±15kV contact discharge, ±20kV air discharge) Short circuit protection between VBUS line and Ground Isolated USB Monitoring port (1kv) Heatsink temperature monitor
Storage Temperature	-30 °C to + 80 °C
Usage Temperature	0 °C to + 35 °C (lower temperature allows longer period of higher loads)
Part number	PM125
RoHS (Lead free)	Yes

The USB Power Delivery Tester is software upgradeable.

Software Compatibility

Window 7, 8, 10 are supported.

Windows: USBPDTest software is required for Windows. Both 32bit and 64bit Windows drivers are available.

Troubleshooting

Symptom: No display after connecting the USB cable

The tester takes its power from the Analysis port. There is most likely a fault with the cable or computer.

Symptom: Power, but no Found New Hardware window

The basic USB device enumeration process could not be completed. This could be a fault in the Windows O/S installation or with the USB hardware in the computer.

Disclaimer

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