Operation Manual

Option QCT – Rev 1.0 P/N 160939-10

QUICK CHARGER TESTER OPTION

ADAPTIVE POWER SYSTEMS™

ADAPTIVE Power Systems

Worldwide Supplier of Power Equipment

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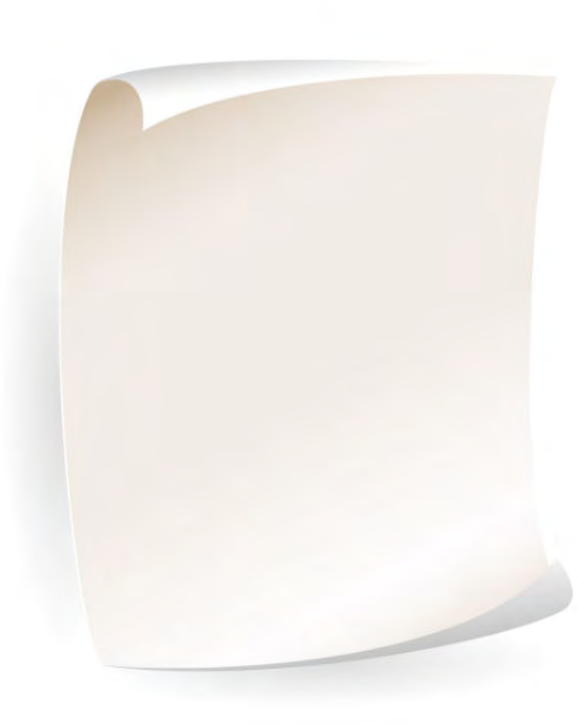

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1 Contact Information

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2 Front Matter

2.1 Limited Warranty

Adaptive Power Systems, Inc. (APS) warrants each unit to be free from defects in material and workmanship. For the period of one (1) year from the date of shipment to the purchaser, APS will either repair or replace, at its sole discretion, any unit returned to the APS factory in Irvine, California or one of its designated service facilities. It does not cover damage arising from misuse of the unit or attempted field modifications or repairs. This warranty specifically excludes damage to other equipment connected to this unit.

Upon notice from the purchaser within (30) days of shipment of units found to be defective in material or workmanship, APS will pay all shipping charges for the repair or replacement. If notice is received more than thirty (30) days from shipment, all shipping charges shall be paid by the purchaser. Units returned on debit memos will not be accepted and will be returned without repair.

This warranty is exclusive of all other warranties, expressed or implied.

2.2 Service and Spare Parts Limited Warranty

APS warrants repair work to be free from defects in material and workmanship for the period of ninety (90) days from the invoice date. This Service and Spare Parts Limited Warranty applies to replacement parts or to subassemblies only. All shipping and packaging charges are the sole responsibility of the buyer. APS will not accept debit memos for returned power sources or for subassemblies. Debit memos will cause return of power sources or assemblies without repair.

This warranty is exclusive of all other warranties, expressed or implied.

2.3 Safety Information

This chapter contains important information you should read BEFORE attempting to install and power-up APS Equipment. The information in this chapter is provided for use by experienced operators. Experienced operators understand the necessity of becoming familiar with, and then observing, life-critical safety and installation issues. Topics in this chapter include:

- Safety Notices
- Warnings
- Cautions
- Preparation for Installation
- Installation Instructions

Make sure to familiarize yourself with the **SAFETY SYMBOLS** shown on the next page. These symbols are used throughout this manual and relate to important safety information and issues affecting the end user or operator.

SAFETY SYMBOLS

Direct current (DC)

Alternating current (AC)

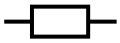
Both direct and alternating current

Three-phase alternating current

Protective Earth (ground) terminal

On (Supply)

Off (Supply)



Fuse

Caution: Refer to this manual before this Product.

Caution, risk of electric shock

2.4 Safety Notices

SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Adaptive Power Systems assumes no liability for the customer's failure to comply with these requirements.

GENERAL

This product is a Safety Class 1 instrument (provided with a protective earth terminal). The protective features of this product may be impaired if it is used in a manner not specified in the operation instructions.

ENVIRONMENTAL CONDITIONS

This instrument is intended for indoor use in an installation category I, pollution degree 2 environments. It is designed to operate at a maximum relative humidity of 80% and at altitudes of up to 2000 meters. Refer to the specifications tables for the ac mains voltage requirements and ambient operating temperature range.

BEFORE APPLYING POWER

Verify that the product is set to match the available line voltage and the correct fuse is installed.

GROUND THE INSTRUMENT

This product is a Safety Class 1 instrument (provided with a protective earth terminal). To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The instrument must be connected to the AC power supply mains through a properly rated three-conductor power cable, with the third wire firmly connected to an electrical ground (safety ground) at the power outlet. Any interruption of the protective (grounding) conductor or disconnection of the protective earth terminal will cause a potential shock hazard that could result in personal injury.

FUSES

Only fuses with the required rated current, voltage, and specified type (normal blow, time delay, etc.) should be used. Do not use repaired Fuses or short circuit the fuse holder. To do so could cause a shock or fire hazard.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE.

Do not operate the instrument in the presence of flammable gases or fumes.

KEEP AWAY FROM LIVE CIRCUITS.

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified service personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power, discharge circuits and remove external voltage sources before touching components.

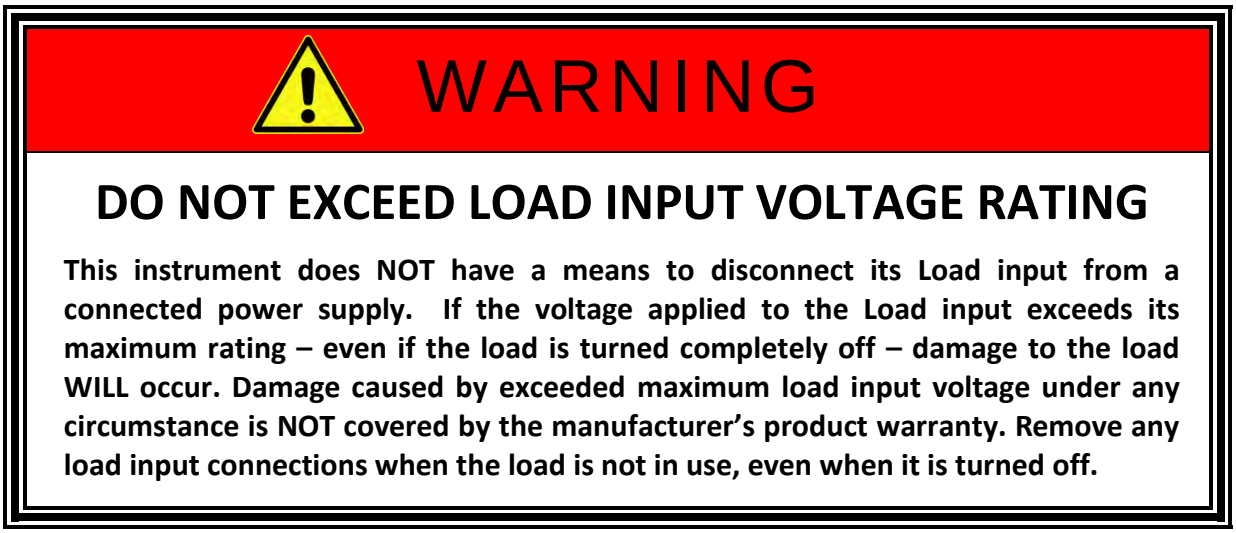
DO NOT SERVICE OR ADJUST ALONE.

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT EXCEED INPUT RATINGS.

This instrument may be equipped with a line filter to reduce electromagnetic interference and must be connected to a properly grounded receptacle to minimize electric shock hazard. Operation at line voltages or frequencies in excess of those stated on the data plate may cause leakage currents in excess of 5.0 mA peak.

DO NOT EXCEED LOAD INPUT VOLTAGE RATING.



DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT.

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to an Adaptive Power Systems Sales and Service Office for service and repair to ensure that safety features are maintained.

Instruments that appear damaged or defective should be made inoperative and secured against unintended operation until they can be repaired by qualified service personnel.

3 Product Overview

3.1 General Description

The Quick Charger Tester (QCT) option is designed to test modern USB chargers for portable devices. New chargers deploy several charging protocols to reduce charging times and to support ever growing battery sizes needed to support high end smart phones and tablets.

The QCT Option supports a range of charging protocols such as Quick Charger, Pump Express and USB PD Quick Charging. The QCT can simulate the fast charge control signals of mobile phones, tablets and notebook devices for a variety of fast charging technologies to allow for rapid testing and verification of the charger in both product development and manufacturing test applications.

The integrated QCT banana plugs can be directly connected with the binding post of single channel electronic loads, using the electronic load to simulate the load the quick charger would normally see from these devices.

For the connection with the charging device (U.U.T), the QCT provides a Micro USB and a USB Type C hardware interface. The QCT front/rear panel and Micro USB / Type C pin definitions are shown in the figures below.

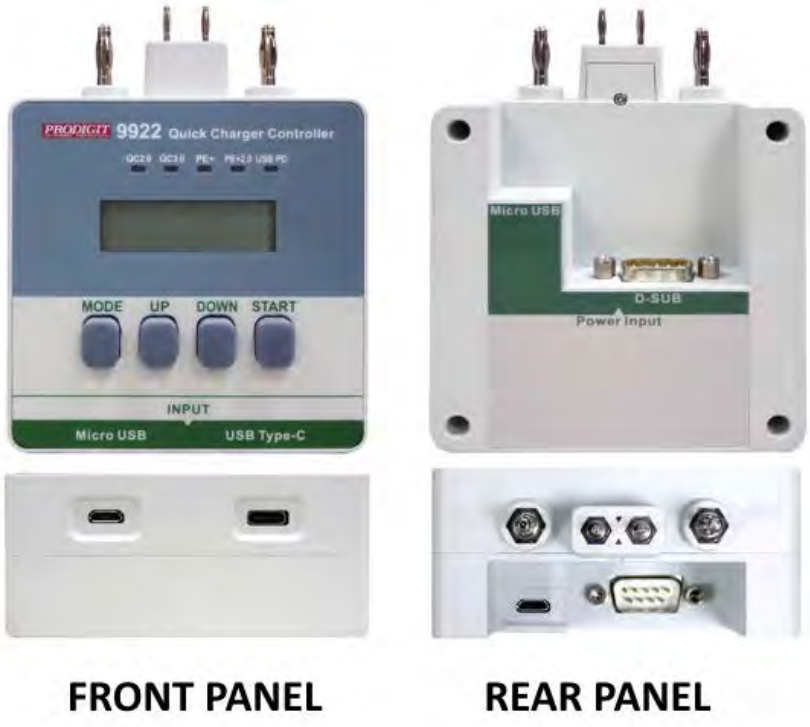


Figure 3-1: QCT Option Front and Rear Panels with Connectors shown

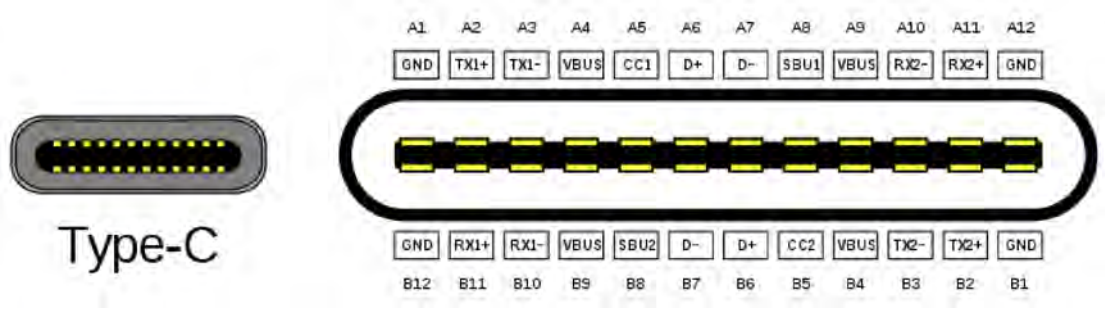
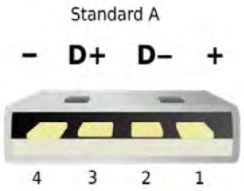
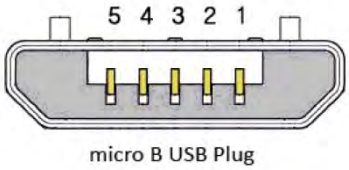


Figure 3-2: USB Type C Pin Definitions

The output of the quick charger is equipped with the connector USB Type A or Type C. Chargers with other USB Type plugs can be accommodated using the appropriate adaptor cables which allow connection to the Quick Charger Tester's Micro USB or USB Type C input. For example, a USB Type A - Micro USB or USB Type A - USB Type C adaptor cable.

USB Type A and Micro-USB pin definitions are shown in the figure below.





Pin	Name	Description
1	Vcc	+5 Vdc
2	D-	Data -
3	D+	Data +
4	NC	
5	Gnd	Ground

3.2 Product Features

The following key characteristics apply to the QCT Option:

- Direct Support for Mobile Devices Fast Chargers
- Support for Charger Output Voltages from 5.0Vdc to 20.0 Vdc
- Support for Multiple Fast Charging Protocols:
  - MediaTek PumpExpress
  - MediaTek PumpExpress+
  - MediaTek PumpExpress+ 2.0
  - Qualcomm Quick Charge 2.0
  - Qualcomm Quick Charge 3.0
  - USB PD2.0
- Sockets for direct connection to Micro-USB and USB-C chargers provided
- Supports USB Power Delivery (PD)
- Compatible with Single channel 4-Series modular DC loads

3.3 Compatible APS DC Load Models

The QCT option is compatible with the APS DC Load model series shown in the table below.

Model Series	Description
4 Series	Compatible with 4 Series Modular DC loads. Option plug into DC load input terminals. Use of included adapter harness is required for 42L, 41D and 42D load models.
5 Series	May be used with 5 Series Loads with use of included adapter harness.

Table 3-1: Compatible DC Load Models

3.4 Accessories Included

The following accessories are included with this option. The QCT Option shipkit contains an adapter harness for connection to modular 4 Series DC Loads that have a different input and voltage sense terminal configuration from the 41L modules.

Item	Description	Quantity
1	Adapter Harness (See image below).	1

Table 3-2: Accessory Ship Kit content

Figure 3-3: Cable Adapter for use with 42L and 41D Loads

4 Technical Specifications

Technical specifications shown here apply at an ambient temperature of 25° C ± 5°. For all other specifications, refer to the relevant DC Load Operation Manual with which the QCT Option is used.

Parameter	Specification
Electrical	
No. of Channels:	One
Charging Voltage Range:	3.3 Vdc ~ 20.0 Vdc
Protocol Support:	QC2.0, QC3.0, PE+, PE+2.0, USB PD2.0
EUT Connectors:	Micro USB, USB Type C Additional connector types supported using USB adaptor cables
Input Power	
Micro USB Charger:	Not included. Charger output 5.0 Vdc, 150 mA
AC Power Supply Option:	D-Sub 9 pin power output connector option for 44M0x Load Mainframe. Not included.
Dimensions & Weight	
W x H X D:	87 x 113 x 44.8 mm / 3.43” x 4.45” x 1.76”
Weight:	200 grams / 0.44 lbs.

Table 4-1: Technical Specifications

5 Unpacking and Installation

5.1 Inspection

The QCT option modules are carefully inspected before shipment. If damage has occurred during transport, please inform Adaptive Power Systems' nearest sales and service office or representative.

5.2 Option Installation and Removal in Mainframe

The QCT Option plug into the load input of APS DC loads, either directly for 41L Load models or using the included cable adapter. 5Vdc bias voltage must be supplied through the USB connector on the back of the QCT module or from a 44M0x Chasses equipment with the optional DC bias output connector.

5.2.1 Option Removal

1. Turn off the DC Load.
2. Pull out the QCT module.
3. Disconnect the USB charger that provides the 5V dc bias for the QCT module.

5.3 Equipment Connection and Setup

To connect the QCT option to the DC load, proceed as follows:

1. Turn on the power switch of the electronic load.
2. Insert the QCT module's banana plugs into the binding posts of electronic load. This includes the Load +/- and the Vsense +/- connector pairs. The QCT plug terminal group is designed to be fully compatible with the Load and Vsense terminal connectors of the 41L series electronic loads. The included adaptor cable may be used when the QCT module cannot be directly inserted into the electronic load input terminals.
3. Provide +5Vdc power input via either the Micro USB connector using an AC to USB device charger or the D-SUB connector from the optional DC output connector on the 44M0x mainframe if present.
4. The connectors for power input connector are located on the rear panel of the QCT module. When using the Micro USB power input, you can use any +5V, I ≧ 0.15A power supply or adapter Micro-USB connector.
5. When using the D-SUB for bias supply, the 44M0x mainframe needs to be equipped with the optional "QCT Power Supply". Connect the 44M0x rear panel's D-SUB connector to the rear panel's D-SUB input of the QCT module and the QCT will be powered by the DC load mainframe.

6. The output of the device charger being tested must be connected to the Micro USB or USB Type C connector on the front of the of the QCT module.
7. After the connection is complete, start the test. Refer to Chapter 6, “Front Panel Operation” for operating instructions.

5.4 In Case of Malfunction

In the unlikely event of an instrument malfunction or if the instrument does not turn on despite the presence of the correct 5V DC Bias voltage, please attach a warning tag to the module to identify the owner and indicate that service or repair is required. Contact Adaptive Power Systems or its authorized representative to arrange for service.

6 Front Panel Operation

The Quick Charger Tester option communicates with the charger under test using the relevant protocol. This allows it to control the charger voltage. It uses the DC load to sink the amount of current needed to load the charger appropriately.

The load can be operated from its own front panel or over the remote control interface once the charger is setup for the device charger being tested.

6.1 Front Panel Keys

Figure 6-1: QCT Option Front Panel Display and Controls

The following keys are located on the front panel of the QCT Option:

MODE Key

Using the MODE key, you can select one of the available fast charge control technology protocols. The QCT will cycle through these in this order:

QC 2.0 -> QC 3.0 -> PE + -> PE + 2.0 -> PD

It is required to select the same quick charge control technology as used by the device charger being tested to all the QCT to control the charger device.

UP Key

Increase the programmed voltage value. For the QC3.0 and PE + 2.0 mode, the function of UP key is different between a short press and a press and hold excitation; pressing and holding the UP key for 2 secs quickly increases the voltage value. See the key operation table below.

DOWN Key

Decrease the programmed voltage value. For the QC3.0 and PE + 2.0 mode, the function of DOWN key is different between a short press and a press and hold excitation; pressing and holding the UP key for 2 secs quickly decreases the voltage value. See the key operation table below.

START Key

Short press: Execute the output voltage programming setting according to the UP/DOWN key.

Press and hold for 2 seconds: Execute programming, store the selected fast charge mode and the programming hold time of the PE mode into EEPROM of the QCT. One of the LEDs flashes three times as acknowledgement of the store operation. These settings are automatically restored at the next power ON of the QCT module so that the user does not need to set the mode and programming hold time of the QCT module every time.

6.2 Key Operation by Charging Protocol

The table below provides an overview of the key functions as a function of the selected charging protocol.

Key / QC Protocol		QC 2.0	QC 3.0	PE+	PE+ 2.0	USB PD 2.0
UP	Press	5V -> 9V -> 12V -> 20V	0.2V step increment	5V -> 7V -> 9V -> 12V	0.5V step increment	1 ~ 7
	Press+Hold		5V -> 9V -> 12V -> 20V		5V -> 7V -> 9V -> 12V	
DOWN	Press	5V <- 9V <- 12V<- 20V	0.2V step decrement	5V <- 7V <- 9V<- 12V	0.5V step decrement	1 ~ 7
	Press+Hold		5V <- 9V <- 12V<- 20V		5V <- 7V <- 9V<- 12V	
UP+DOWN	Press	N/A	N/A	Enter the programmable Hold time mode (for PE+ / PE+ 2.0 only)		N/A
	Press+Hold					
START	Press	Execute the UP/DOWN setting operation				
	Press+Hold	Store the fast charge mode and programmable Hold time (PE+ / PE+ 2.0 only) into the EEROM of the QCT.				

6.3 LCD Display

The QCT's display shows the DC voltage output mode of the charger under test as programmed by the QCT module.

6.4 Programmable DC Load Setup

Figure 6-2: QCT Option and DC Load Test Setup

The QCT option requires the use of a programmable DC load to sink current from the quick charger being tested. For most chargers, 150W or 300W modular DC load will be more than adequate to handle the power delivered by fast chargers.

Use the following steps to set up the DC Load and QCT option to test a smart charger:

1. Turn ON the DC load unit.
2. Plug in the QCT into the DC load and Vsense input terminals. The QCT mates with the 41L DC loads models directly. Other 4 Series load may require the use of the provided adapter harness to connect the DC load input and Vsense terminals.
3. Power ON the QC adapter by connecting a USB Charger that provides +5Vdc @ 150mA.
4. Plug in the Quick Charging power adapter output cable to the QCT micro-USB or Type C connector.
   Note: DO NOT plug in TWO power adapters to the same QCT. Only one quick charger output may be connected and tested at a time.
5. The DC load should now display the measured power adapter output voltage on the load voltage meter display. It should read +5V, because the QC power adapter default output voltage is +5V.
6. To operating the QCT module, press MODE key to select the correct QC protocol type (PE1.1, PE2.0+, QC 2.0, QC3.0 or PD).
7. You can see the output voltage read back on the DC load change when setting different output voltage modes are selected using the UP/DOWN keys.

8. All quick chargers are voltage sources so the DC load must be operated in either CC mode and setting the CC current level or in CP mode and setting the CP power levels. Press the load ON key to start sinking current from the Quick charger under test.

7 Applications

7.1 Overview

This section includes examples of the QCT tester operation for various charger types and explains how to set up the tester and DC load.

7.2 QC 2.0 and QC 3.0 Testing

In response to the increasing power demands of handheld devices like mobile phones and tablets, battery capacity for mobile devices continues to increase. The use of standard 5V / 1A, 5W USB chargers results in charging times that are too long for most users.

A QC 1.0 5V / 2A, 10W charger doubles available power form the 5W standard charger and can reduce charging times by up to 50%.

7.2.1 Quick Charge 2.0 Testing

Quick Charge 2.0 is a solution developed by Qualcomm supports even faster charging for high end mobile devices. Devices that support the Quick Charge 2.0 protocol, can instruct the device charger to increase the charger voltage and power to achieve very fast charging of the device's battery.

Quick Charge 2.0 type device charges support output voltage levels of 5V, 9V, 12V and 20V with a maximum output power rating of 18W.The QC 2.0 symbol is a lightning plus in a circle with either Class A or Class B indication. See sample image below

- Class A supports three charge voltage levels: 5V, 9V and 12V
- Class B supports four charge voltages levels: 5V, 9V, 12V and 20V

7.2.2 QC 2.0 Operation

A QC 2.0 charger detects the voltage request from the device being charged by sensing the D + and D – data line voltage. This data is used by the charger to set its output voltage. The coding is shown in the table below.

D+	D-	Charging Voltage
0.6 V	0.6 V	12 Vdc
3.3 V	0.6 V	9 Vdc
3.3 V	3.3 V	20 Vdc
0.6 V	GND	5 V (default)

Table 7-1: QC 2.0 Control Table

The QCT Quick Charger Controller can simulate the various voltage combinations of D +, D- for QC 2.0 testing to verify the output voltage of the test charger, and to simulate the connection and remove the connection to the charger to verify that the charger can be immediately

stopped and the voltage reduced to 5V, to ensure that the charger functionality is normal and meets the Quick Charge 2.0 specification.

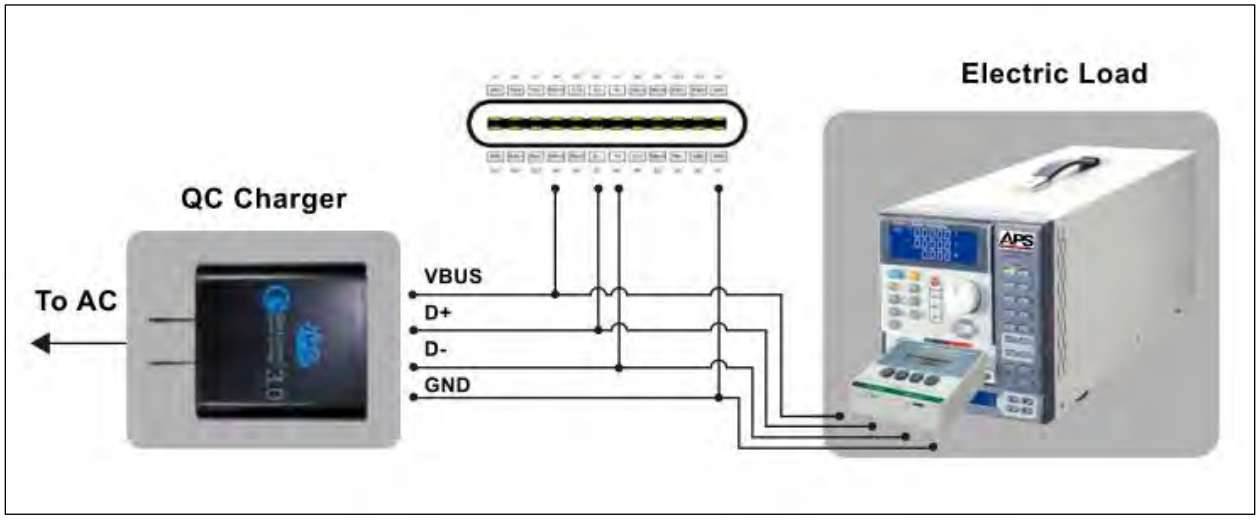


Figure 7-1: Quick Charger Application Connections

The scope images below show the device request for high voltage being executed by the charger supply.

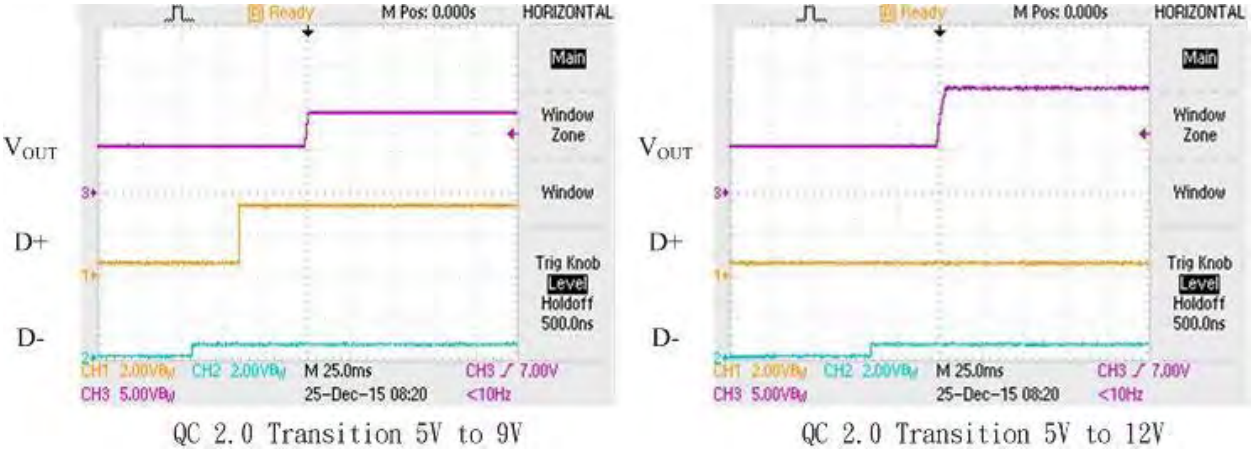


Figure 7-2: Quick Charge 2.0 Tests

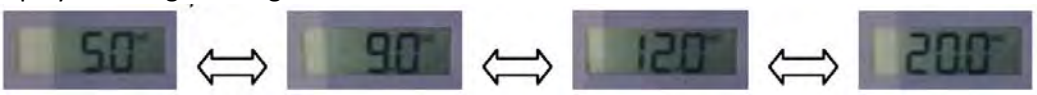
At this time, many device manufacturers' products support Quick Chargers. Because Quick Charge 2.0 results in a significant reduction in charging time, it is very convenient for consumers and its popularity will continue to grow. Non QC capable chargers will most likely be upgraded from the current standard 5V / 1A 5W to 15W or 18W in order to support QC 2.0.

7.2.3 QC 2.0 Operating Instructions.

The following steps walk the user through configuring the QCT option for QC 2.0 testing.

1 Select MODE: Press the MODE button to switch to QC 2.0. The QC 2.0 LED should be lit.

2 Set the output voltage: Press the UP or DOWN keys to increase or decrease the displayed voltage setting between 5.0 and 20.0 Vdc.



3 Start Test: Press the START button to start charging. The load will be applied to the charger under test.

7.2.4 Quick Charge 3.0 Testing

In addition Quick Charge 2.0, Qualcomm also introduced the next generation of Quick Charge 3.0 fast charging technology. Using a best voltage precision algorithm known as Intelligent Negotiation for Optimum Voltage or INOV, further reductions in power losses up to 45% can be achieved. Quick Charge 3.0 supports 0.2V voltage changes from 3.6V to 20V voltage to get the optimal charging voltage for mobile phone under all battery state of charge conditions so as to achieve improved efficiency and improved heat management.

QC 3.0 Operation

A QC 3.0 charger detects the voltage request from the device being charged by sensing and detecting pulsing of the D + and D – data line voltages. This data is used by the charger to set its output voltage. The coding is shown in the table below.

D+	D-	Charging Voltage	Note
0.6 V	0.6 V	12 Vdc	Class A
3.3 V	0.6 V	9 Vdc	Class B
0.6 V	3.3 V	Continuous Mode	Class A/B with ±0.2V step size
3.3 V	3.3 V	20 Vdc	Class B
0.6 V	GND	5 Vdc	Default mode

Table 7-2: QC 3.0 Control Table

The key difference between QC 3.0 and QC 2.0 is the ability of the mobile device to increase or decrease the charging voltage gradually as needed. D + PULSE causes the Vout voltage to increase by 0.2V. A D - PULSE causes the Vout voltage to decrease by 0.2V.

The test results are shown below. A total of 16 D + PULSEs results in the charge voltage to rise by 3.2V. 16 D-PULSEs reduces the charge voltage by the same amount.

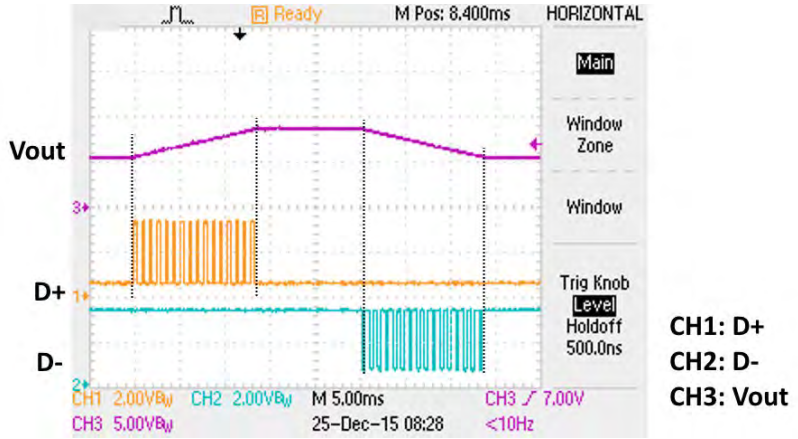


Figure 7-3: Quick Charge 3.0 Ramp Voltage in 16 steps

The Quick Charger Tester is capable of simulating D +, D- pulse control to control these 0.2V increments and decrements and to verify and test the output voltage of the charger to ensure

compliance with the Quick Charge 3.0 specification. This is illustrated with the scope images shown below.

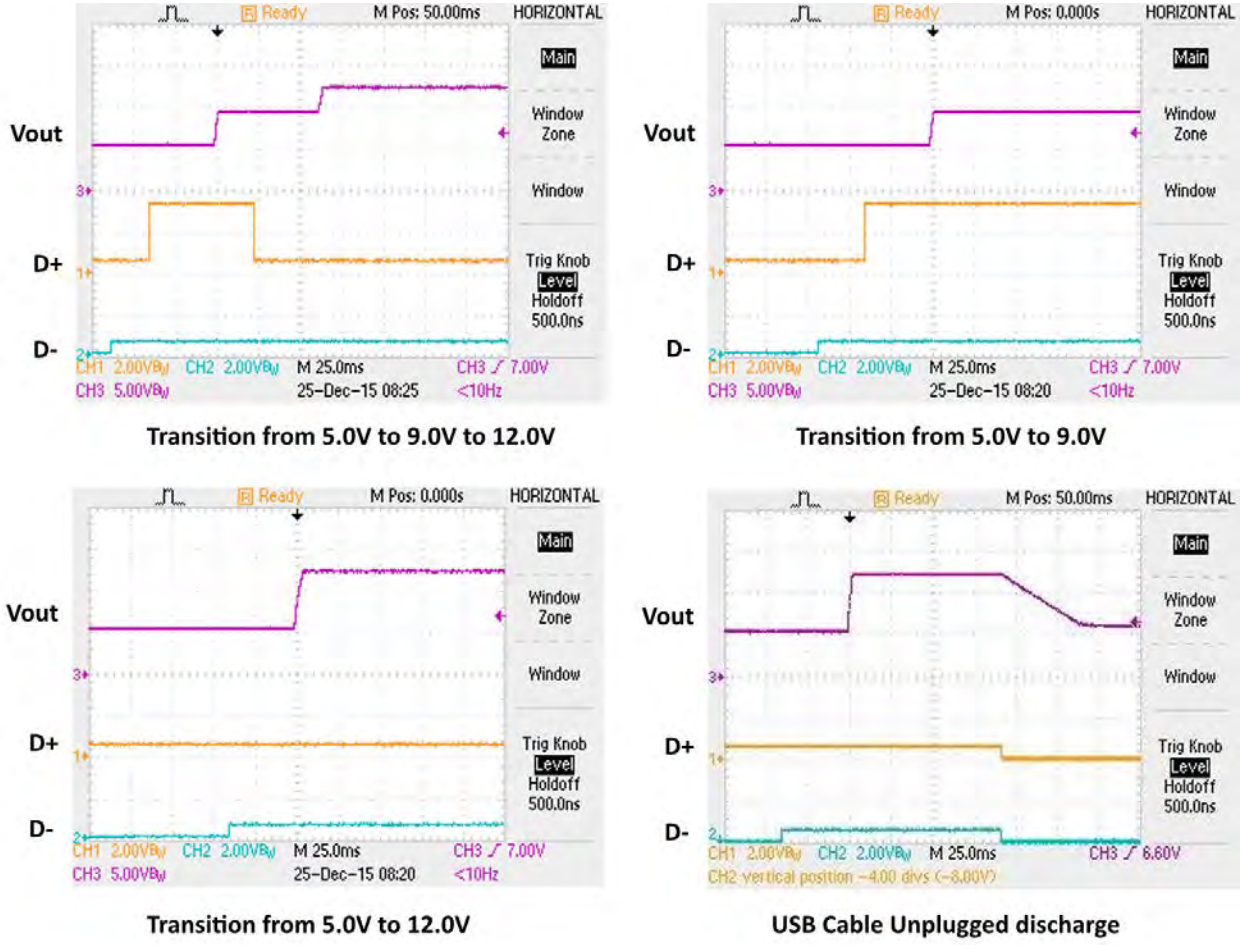


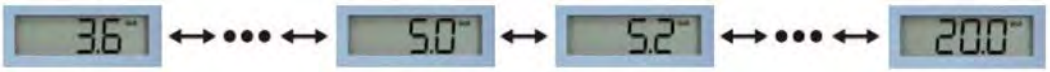
Figure 7-4: Quick Charge 3.0 Tests

7.2.5 QC 3.0 Operating Instructions.

The following steps walk the user through configuring the QCT option for QC 2.0 testing.

1 Select MODE: Press the MODE button to switch to QC 3.0. The QC 3.0 LED should be lit.

2 Set the output voltage:
Short Press. Press the UP or DOWN keys to increase or decrease the displayed voltage in 0.2V steps.



OR
Press and Hold for 2 seconds: Press the UP or DOWN keys to increase or decrease the displayed voltage from 3.6V to 20.0V in QC 2.0 level steps.

3 Start Test: Press the START button to start charging. The load will be applied to the charger under test.

7.3 Pump Express Plus Testing

Pump Express is a quick charge product from MediaTek. This protocol has been extended to version 3.0. Basically it uses high voltage and high current to provide faster charge times.

It has been used by SONY, Lenovo and other brands. The features of Pump Express are allowing the charger to adjust the current to determine the initial voltage required for charging. A pulse current command from the PMIC in the mobile device is sent to the charger via the USB Vbus. The charger adjusts the output voltage according to this instruction.

MediaTek currently has two fast charge specifications:

- Pump Express Plus.
- Pump Express Plus 2.0.

7.3.1 Pump Express Plus

Pump Express Plus provides output power for fast DC chargers less than 15W (5V) similar to QC2.0. It controls Fixed output voltages of 5V, 7V, 9V and 12V and a mainstream Output power: 5V / 1A & 5V / 1.5A.

7.3.2 Pump Express Plus 2.0

Pump Express Plus 2.0 allows the charger to provide output power greater than 15W. The difference is that the output voltage can be more precisely controlled - similar to QC3.0 - but based on a 0.5V increase or decrease. With a voltage output range from 5V to 20V, the most appropriate voltage for the mobile device can be selected by the device to achieve improved efficiency and improved heat management.

7.3.3 Pump Express Plus 2.0 Operation

This protocol uses commands by sinking different current levels to control charger output voltage, as shown in the figure below. A current of I-low <0.13A and I-high> 0.3A, PE shall sink current of at least 0.3A immediately. If not, the voltage will automatically jump back to 5V. This is illustrated below.

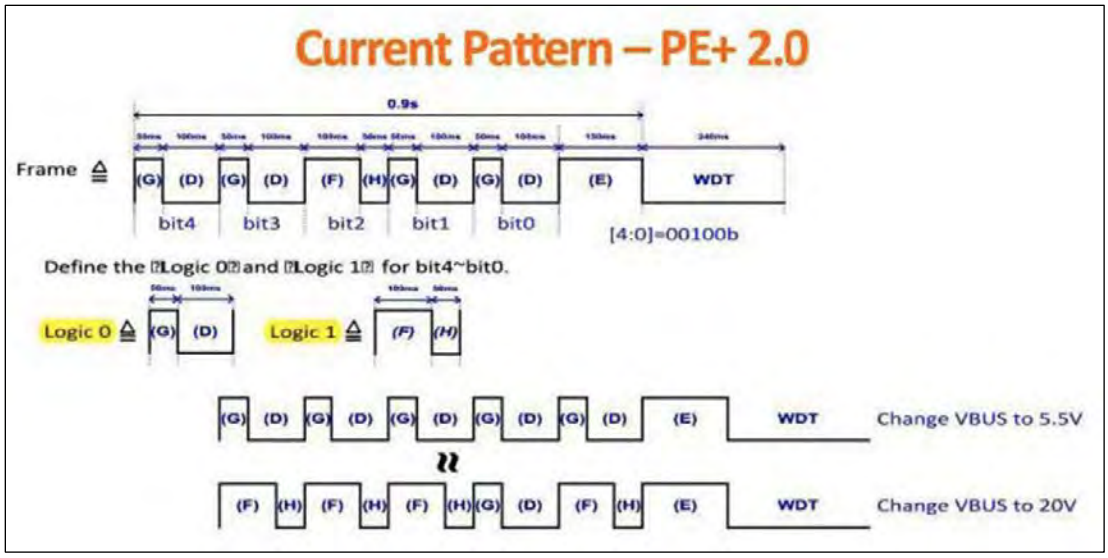


Figure 7-5: Pump Express Plus 2.0 Timing Diagram

The Quick Charger Tester is capable of simulating commands and loads at different current levels, current I-low <0.13A and I-high> 0.3A to verify and test the output voltage of the charger and to ensure compliance with PE specifications. The test setup is shown below.

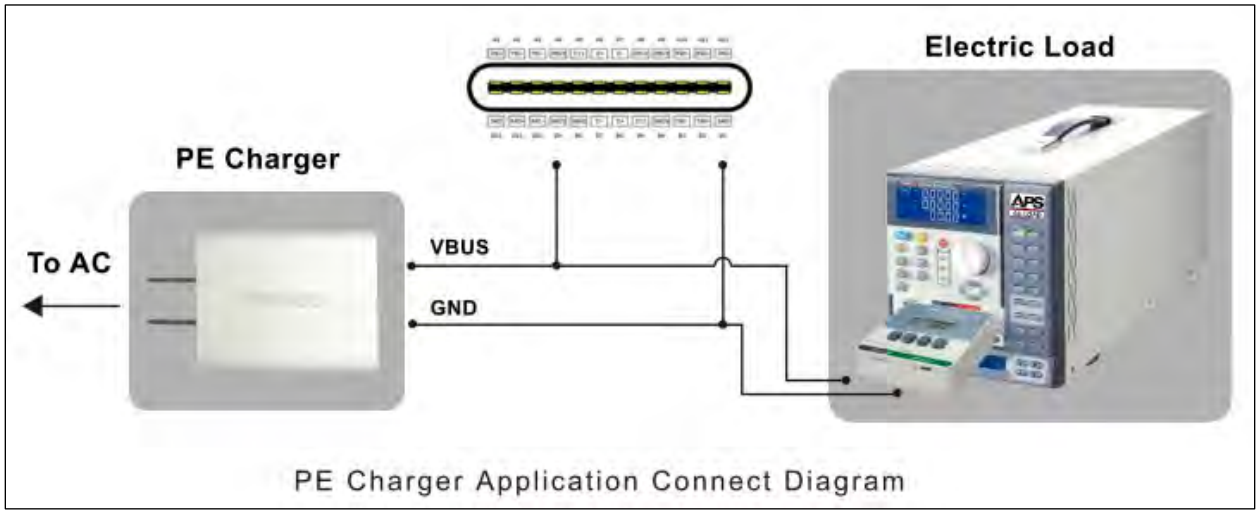


Figure 7-6: Pump Express Charger Application Connections

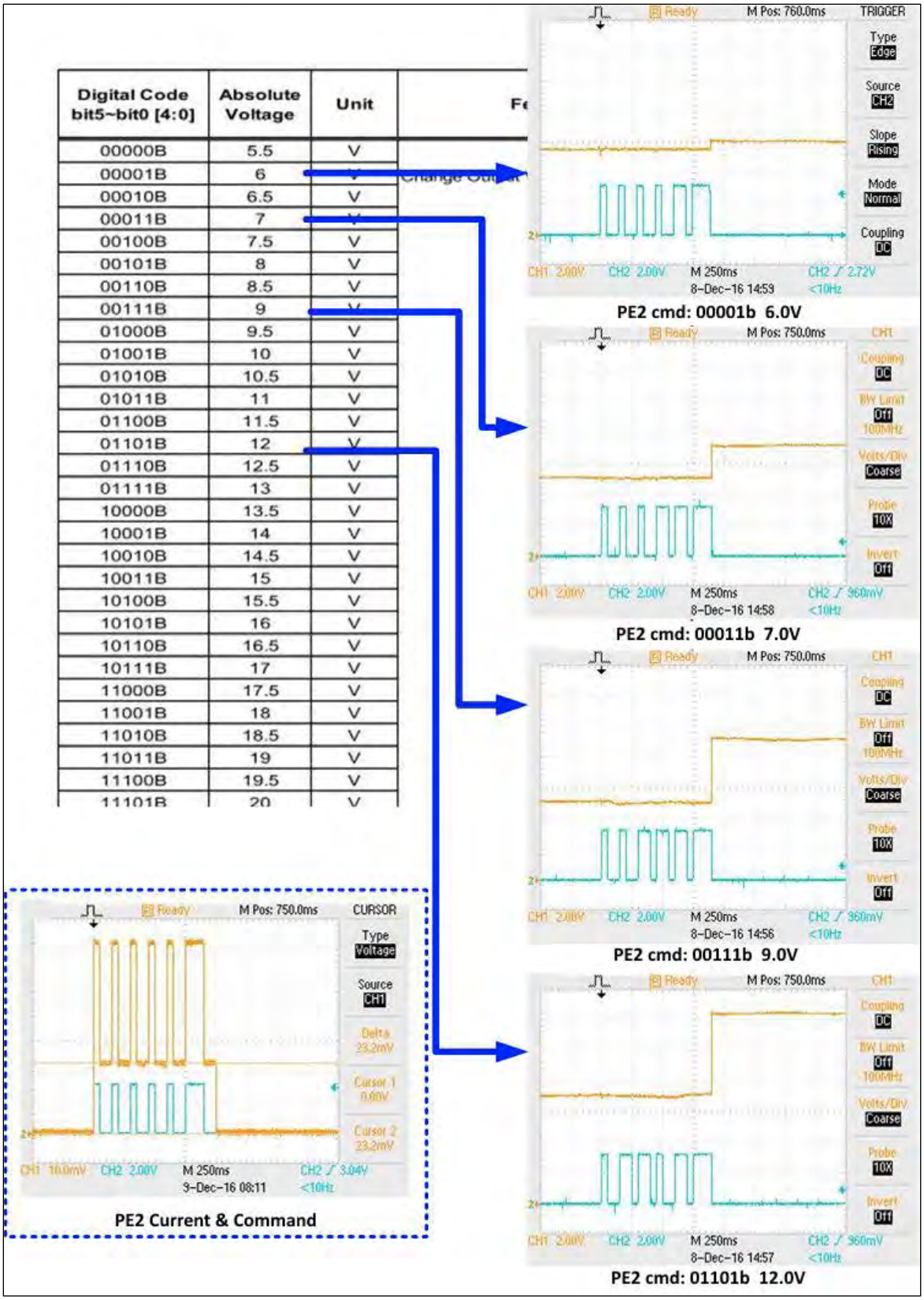


Figure 7-7: Pump Express 2.0 Test Scope Captures

7.3.4 PE+ Operating Instructions.

The following steps walk the user through configuring the QCT option for QC 2.0 testing.

1 Select MODE: Press the MODE button to switch to PE+. The PE+ LED should be lit.

2 Set the output voltage: Press the UP or DOWN keys to increase or decrease the displayed voltage setting between 5.0 and 12.0 Vdc.

3 Start Test: Press the START button to start charging. The load will be applied to the charger under test.

7.3.5 PE+ 2.0 Operating Instructions.

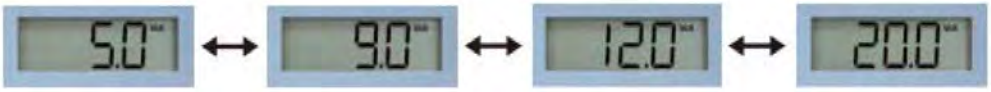
The following steps walk the user through configuring the QCT option for PE+ 2.0 testing.

1 Select MODE: Press the MODE button to switch to PE+ 2.0 The PE+ 2.0 LED should be lit.

2 Set the output voltage:
Short Press. Press the UP or DOWN keys to increase or decrease the displayed voltage in 0.5V steps.

OR

Press and Hold for 2 seconds: Press the UP or DOWN keys to increase or decrease the displayed voltage at 5.0V, 9.0V, 12.0V or 20.0V in PE+ 2.0 steps.



3 Start Test: Press the START button to start charging. The load will be applied to the charger under test.

7.4 USB PD Power Delivery Testing

With the introduction of USB 2.0, a new power transfer specification called USB Power Delivery (PD) was introduced. This standard aims to deliver power using up to 20V, 5A or 100 watts using up to seven voltage output combinations.

A variety of devices can now use a single USB cable to meet the power supply needs. The USB PD standard also provides the advantage of shortening charging times and more user convenience. The USB PD standard is available for both USB 2.0 and USB 3.0, identified by the symbols shown below.

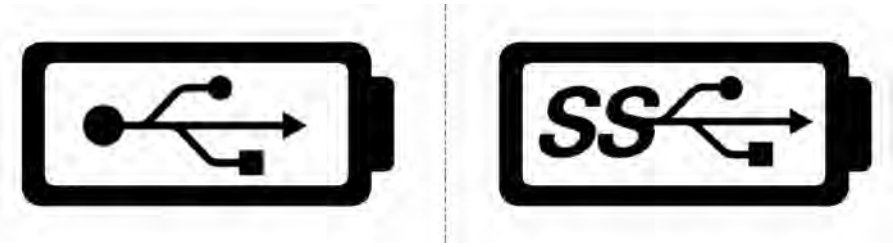


Figure 7-8: USB 2.0 PD and USB 3.0 PD Symbols

7.4.1 USB PD Charge Principle

USB PD communication is a protocol layer where messages are modulated using a FSK signal of 24MHz that is coupled to the VBUS to achieve mobile phone and charger communication.

The following explains this USB PD protocol:

- Detection: The physical layer (PHY) of a USB-On-The-G0 (USB OTG) monitors the VBUS voltage. If 5V voltage exists on the is VBUS and the OTG ID pin 1K pull-down resistor is detected, the charger supports USB PD. (Indicates non-OTG Host mode if the ID resistance of OTG Host mode is less than 1K)
- The USB OTG performs the normal BCS V1.2 standard charger detection and starts the USB PD device policy manager. The policy manager monitors the VBUS DC level if it is coupled with the FSK signal, and the decoding message gets a Capabilities Source message. According to the USB PD Specification Resolution, this message communicates all voltage and current list combinations supported by the USB PD Charger.
- The phone selects a voltage and current pair from the Capabilities Source message according to the user's configuration and adds the voltage and current pairs to the payload of the Request message. Then the policy manager couples the FSK signal to the VBUS DC level.
- The charger decodes the FSK signal and issues an Accept message to the mobile device while adjusting the Power supply's DC voltage and current output.
- The device receives an Accept message to adjust the charging voltage and current of the Charger IC.
- The phone can send a Request message dynamically during charging to request the charger to change the output voltage and current to achieve a faster charging process.

7.4.2 USB PD Quick Charge Testing

The QCT Quick Charger Controller contains a PD-controller chip which can simulate the mobile device to verify and test the USB PD communication process. The user can use all the required operations needed to perform tests to ensure compliance of the USB charger with the PD specification.

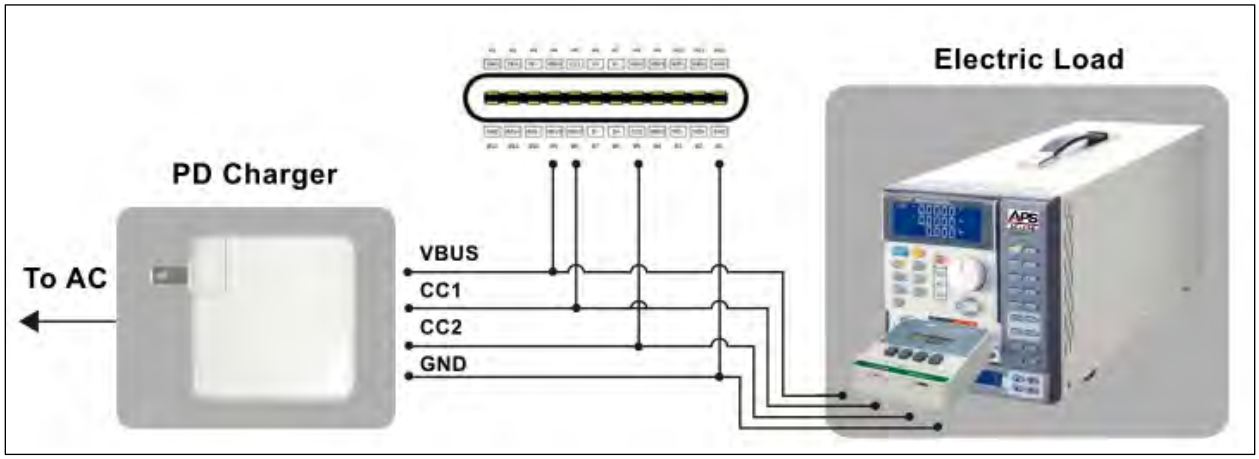
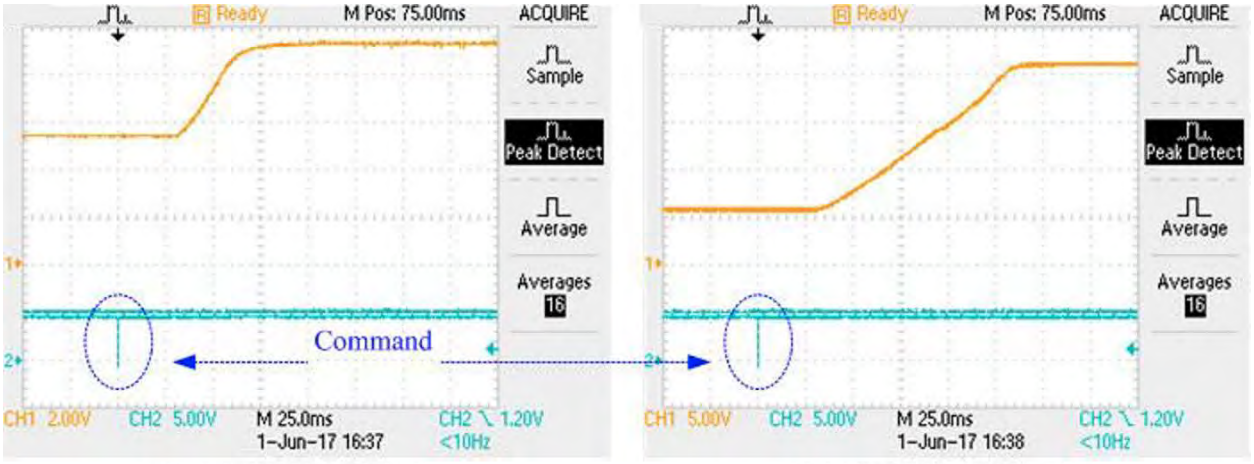


Figure 7-9: USB PD 2.0 Test Setup

Sample tests steps are shown using the scope images below.



PD 5V to 9V Transition

PD 5V to 20V Transition

Figure 7-10: USB PD 2.0 Tests

7.4.3 USB PD Operating Instructions.

The following steps walk the user through configuring the PD option for PD 2.0 testing.

1 Select MODE: Press the MODE button to switch to USB PD. The USB PD LED should be lit.

2 Set the output voltage: Press the UP or DOWN keys to increase or decrease the displayed voltage setting between groups 1 through 7.

3 Start Test: Press the START button to start charging. The load will be applied to the charger under test.

8 Calibration

8.1 Overview

All APS products ship with factory calibration. No additional calibration is required when first received.

8.2 Calibration Interval

There are no calibration coefficients associated with the QCT option.

9 RoHS Material Content Declaration

The table below shows where these substances may be found in the supply chain of APS's products, as of the date of sale of the relevant product. Note that some of the component types listed above may or may not be a part of the enclosed product.

Part Name	Hazardous Substance					
	Pb	*Hg*	*Cd*	*Cr6+*	*PBB*	*PBDE*
PCB Assy's	**x**	**0**	**x**	**0**	**0**	**0**
Electrical Parts not on PCB Assy's	**x**	**0**	**x**	**0**	**0**	**0**
Metal Parts	**0**	**0**	**0**	**x**	**0**	**0**
Plastic Parts	**0**	**0**	**0**	**0**	**x**	**x**
Wiring	**x**	**0**	**0**	**0**	**0**	**0**
Packaging	**x**	**0**	**0**	**0**	**0**	**0**

Legend:

0: Indicates that the concentration of the hazardous substance in all homogeneous materials in the parts is below the relevant RoHS threshold.

x: Indicates that the concentration of the hazardous substance of at least one of all homogeneous materials in the parts is above the relevant RoHS threshold.

Notes:

1. APS has not fully transitioned to lead-free solder assembly at this point in time. However, the vast majority of components used in production are RoHS compliant.
2. These APS products are labeled with an environmental-friendly usage period in years. The marked period is assumed under the operating environment specified in the product specifications.

Example of marking for a 10 year period.

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