9922 quick charger technology〈QC2.0、QC3.0、PE+、PE+2.0、USB PD〉test solution

Chapter 1 Introduction

The Prodigit newly developed Model 9922 Quick Charger controller provides support for quick charging, Pump Express and UBS PD-3 charging protocol simulation for test purposes.

The 9922 controller can simulate fast charge protocol signals for mobile phones, tables and notebook computers for a wide variety of fast charging devices to support rapid testing and verification of the device charger.
A standard banana plug can be connected directly to the binding post of an electronic DC load allowing the DC load to simulate load for the fast charging power supply under test.

For connection to the unit under test (UUT), the 9922 provides a Micro USB and a USB Type C socket interface. Images of the front panel and rear of the controller are shown in Figure 1. Pin out definitions for both USB sockets are detailed in Table 1 and Table 2.

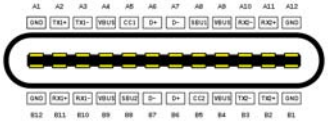
Other USB charger connector types can be accommodated by using specific adaptor cables such as USB Type A to Micro USB, USB Type A to USB Type C or USB Type C to USB Type C. These cables can be plugged in to the 9922 Quick Charger Controller's Micro USB or USB Type C ports.

Front panel Rear panel

Figure 1: Front panel and rear of controller module

USB Type-C pin definition

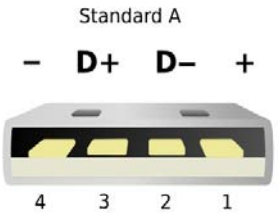
Type C Connector

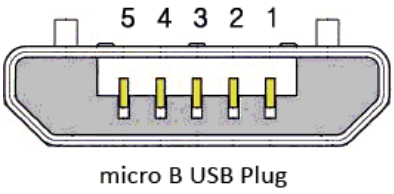


Type C pin definition

Table 1: Type C USB Connector Pins

USB Type A and Micro USB pin definition





micro B USB Plug

Table 2: USB Type A Micro Connector Pins

Pin	Name	Description
1	VCC	+5V
2	D-	Data-
3	D+	Data+
4	NC	
5	GND	Ground

Micro USB pin definition

1-1 Equipment connection and operation

① Please turn on the power of the electronic load, then insert the 9922 banana plugs into the binding posts of electronic load. This includes the Load +/- and Vsense +/- connectors. The 9922 plug terminal group is designed to mate with the Load and Vsense terminal connectors of the 3310F series of electronic load. In cases where the 9922 controller cannot be directly mated with the connectors of DC load used, an adaptor cable kit is provided as well.

② + 5V Power input must be supplied through either the Micro USB or D-SUB connector for 9922 circuit operation. Both power input connectors are located on the rear panel of the 9922. (See Figure 1, right hand image). When using a Micro USB cable to supply power to the 9922, any power supply capable of providing VOUT = 5V and IOUT ≧ 0.15A may be used and connected to the Micro USB power input connector of the 9922.

③ When opting to use the 9922's D-SUB power input connection, the 3302F mainframe needs to be purchased with the "9922 Power Supply" option. Connect the 3302F rear panel's D-SUB connector to the rear panel's D-SUB input of 9922, and the 9922 will be powered by 3302F.

④ After these connections are made, testing can be started.

1-2 Panel operation

① **MODE Key**

Press the MODE key. You can select one of the available fast charge control technology by cycling through the available options: QC 2.0 -> QC 3.0 -> PE + -> PE + 2.0 -> PD. The selected quick charge control technology is embedded in the 9922 to comply with the fast charging charger's (UUT) supported control protocol.

② **UP Key**

Increase the programmed voltage value. For the QC3.0 and PE + 2.0 modes, the function of UP key can be either a short press for a small change; Or press and hold the UP key for 2 seconds to quickly increase the voltage value. Please refer to the key operation list below.

③ **DOWN Key**

Decrease the programmed voltage value. For the QC3.0 and PE + 2.0 modes, the function of DOWN key can be either a short press for a small change; Or press and hold the DOWN key for 2 seconds to quickly decrease the voltage value. Please refer to the key operation list below.

④ UP+DOWN Key

Due to the PE + and PE + 2.0 control technology, the voltage will automatically return to the default +5 V output if there is no load detected. Thus, to avoid user programming of the output voltage, do not immediately press the Load ON button of the electronic load to start load testing. This causes the test PE + or PE + 2.0 fast charger to automatically return to + 5V. The 9922 controller supports a parameter for the user to set the programming hold time of 0 ~ 5.0 seconds (PE + and PE + 2.0 use only). During this time, the 9022 will continue to sink 0.3A current to prevent the PE+ or PE+2.0 charger from going to the default +5 V state. As long as the user presses the Load ON button of the load within the programmed hold time, the charger can adjust its output voltage according to the UP/DOWN key setting.

Press the UP and DOWN keys simultaneously for two seconds to enter the 9922 enters the setting mode of programmable Hold Time setting mode.

Press the UP or DOWN button to increase or decrease the programming hold time setting in the range of 0 ~ 5 seconds with a resolution 0.1 second.

Press and hold: UP or DOWN button for two seconds to increase or decrease the programming hold time in the range of 0 ~ 5 seconds with a resolution 1.0 second.

Press the START Key to store the programmable hold time setting into the RAM of 9922. This will exit the hold time setting mode.

⑤ START Key

Press the START key briefly: This executes 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 EEROM of 9922. The LED flashes three times to acknowledge the store operation. These settings are automatically restored at the next power ON of the 9922 so the user does not need to set the mode and programming hold time of 9922 each time it is turned on.

Key operation list

<table>
<tr><th colspan="2">Key / QC technology</th><th>QC 2.0</th><th>QC 3.0</th><th>PE+</th><th>PE+ 2.0</th><th>USB PD 2.0</th></tr>
<tr><td colspan="2">MODE</td><td colspan="4">Select fast charge mode</td><td></td></tr>
<tr><td rowspan="2">UP</td><td>Press</td><td rowspan="2">5V→9V→12V→20V</td><td>0.2V step increment</td><td rowspan="2">5V→7V→9V→12V</td><td>0.5V step increment</td><td rowspan="2">1~7</td></tr>
<tr><td>Press and hold</td><td>5V→9V→12V→20V</td><td>5V→9V→12V→20V</td></tr>
<tr><td rowspan="2">DOWN</td><td>Press</td><td rowspan="2">5V←9V←12V←20V</td><td>0.2V step decrement</td><td rowspan="2">5V←7V←9V←12V</td><td>0.5V step decrement</td><td rowspan="2">7~1</td></tr>
<tr><td>Press and hold</td><td>5V←9V←12V←20V</td><td>5V←9V←129V←20V</td></tr>
<tr><td rowspan="2">UP+DOWN</td><td>Press</td><td rowspan="2">NA</td><td rowspan="2">NA</td><td colspan="2">間格時間設定加減 0.1S</td><td rowspan="2">NA</td></tr>
<tr><td>Press and hold</td><td colspan="2">間格時間設定加減 1S</td></tr>
<tr><td rowspan="2">START</td><td>Press</td><td colspan="5">Execute the UP/DOWN setting operation</td></tr>
<tr><td>Press and hold</td><td colspan="5">Store the fast charge mode and programmable Hold time (PE+ / PE+ 2.0 only) into the EEROM of 9922</td></tr>
</table>

Chapter 2 Quick Charger 2.0 and 3.0 Protocol Testing

In response to rapid advancements in handheld devices, mobile phones and tablets, their battery capacity has increased as well. The use of 5V / 1A, 5W standard chargers now results in charging times that are too long. New charging standards have been developed to reduce charging times. The QC 1.0 standard, 5V / 2A, 10W chargers reduce the charging times by 50% compared to basic 5W chargers. The Quick Charge 2.0 standard from Qualcomm can provide for even faster charging of mobile devices. Mobile devices and chargers that meet the Quick Charge 2.0 protocol use instructions from the mobile device to increase the charger power output as needed to achieve fastest charging of the mobile device battery. Specifically, Quick Charge 2.0 protocol provides output voltages of 5V, 9V, 12V and 20V and a maximum of 18W four voltage level charging. The QC 2.0 symbol is a lightning bolt plus a circle with a Class A or Class B indication as shown below. Class A supports three voltage levels (5 / 9 / 12V) while Class B supports four voltage levels (5 / 9 / 12 / 20V).

The principle of QC 2.0 charging

The charger detects the voltage of D + and D - on USB to control the output voltage of the charger, as shown in Table 3:

D+	D-	Output
0.6V	0.6V	12V
3.3V	0.6V	9V
3.3V	3.3V	20V
0.6V	GND	5V(default)

QC 2.0 Class A Adapter

Table 3 : QC 2.0 control table

The 9922 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 being tested. It also simulates the connection and removes the connection to the charger to verify that the charger can be automatically change the high voltage output down to 5V. This verifies that the charger meets the Quick Charge 2.0 specification.

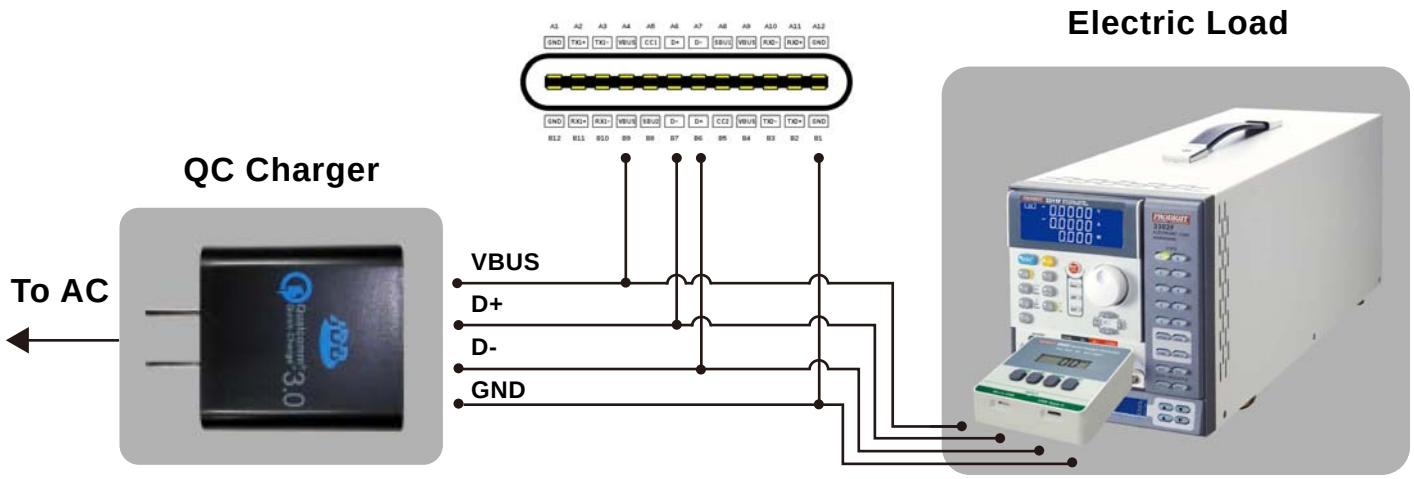


Figure 2: QC Charger Connection Diagram

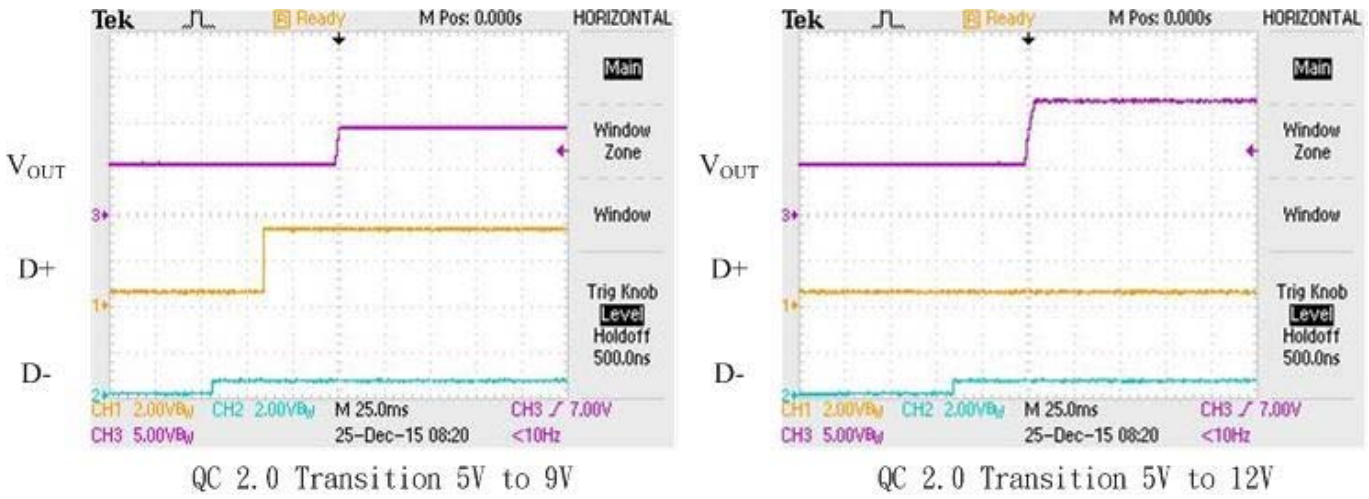


Figure 3 : QC 2.0 Voltage Transition Test

Because Quick Charge 2.0 has a significant performance advantage in reducing the charging time, it is very convenient for users. It is expected that this will become more common. This requires that charger must be redesigned from the current standard 5V / 1A @ 5W to the 15W or 18W QC standard in order to be able to support quick charging.

In addition to Quick Charge 2.0, Qualcomm also introduced the next generation of Quick Charge 3.0 fast charging technology. QC 3.0 uses an even better voltage precision algorithm called Intelligent Negotiation for Optimum Voltage or INOV. It can further reduce power losses up to 45%. Quick Charge 3.0 chargers can adjust output volt with 0.2V resolution, from 3.6V to 20V, to get the most appropriate voltage for a mobile phone and as to achieve improved efficiency while reducing heat problems.

Operating instructions of 9922 in QC 2.0 mode

① **Select mode**

Press the MODE button to switch to QC2.0, then QC2.0 LED lights.

② **Set the output voltage**

Press the MODE button to switch to QC2.0, then QC2.0 LED lights.

③ **Start**

Press the START button to start changing the output voltage value.

The principle of QC 3.0 charging

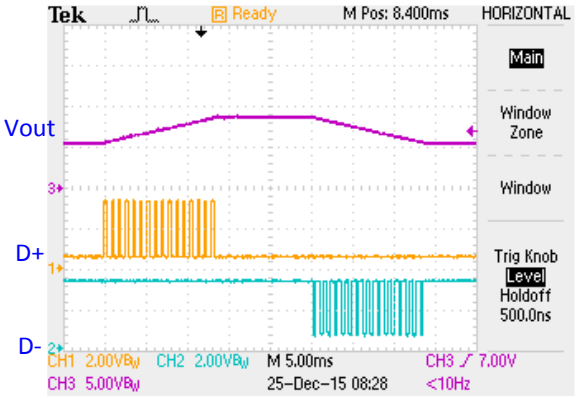
The Charger detects the D + and D on the USB voltage and pulse to control the charger output voltage, as shown in the table below

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

QC 3.0 Class A Adapter

Table 3 : QC 3.0 control table

The difference between QC 3.0 and QC 2.0 is in increasing the voltage fine-tuning resolution. D + PULSE allows Vout voltage increases of 0.2V, D-PULSE allows Vout voltage reduction of 0.2V. Test results are shown below. 16 steps of D + PULSE increases Vout voltage by 3.2V while 16 steps of D-PULSE decreases Vout voltage by 3.2V.

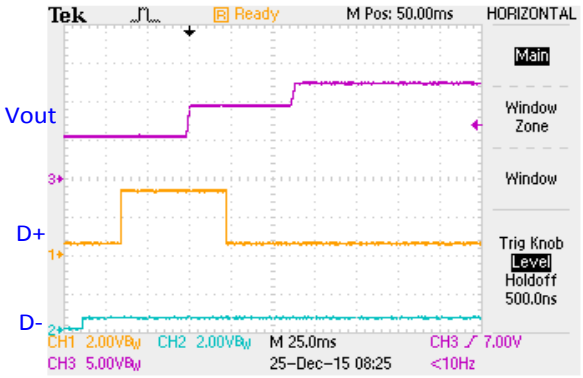


CH1: D+
CH2: D-
CH3: Vout(adapter voltage output)

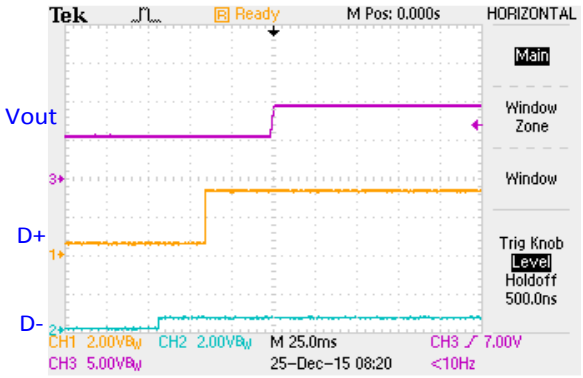
Continuous Mode Ramp Up and Down

Figure 4 : Quick Charge 3.0 Ramp Up 3.2V and Ramp Down 3.2V

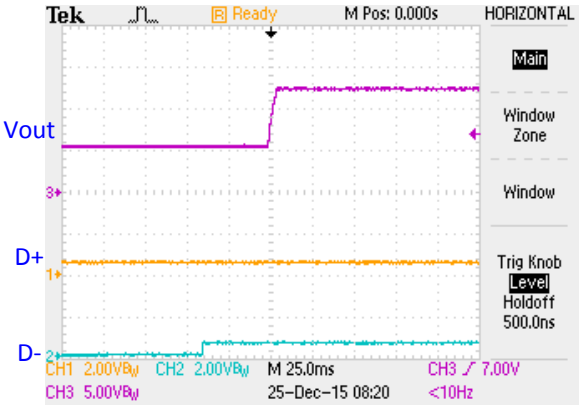
The 9922 Quick Charger Controller is capable of simulating D +, D- pulse control in 0.2V increments and decrements to verify and test the output voltage of the charger to ensure compliance with the Quick Charge 3.0 specification. Refer to the samples shown in Figure 5.



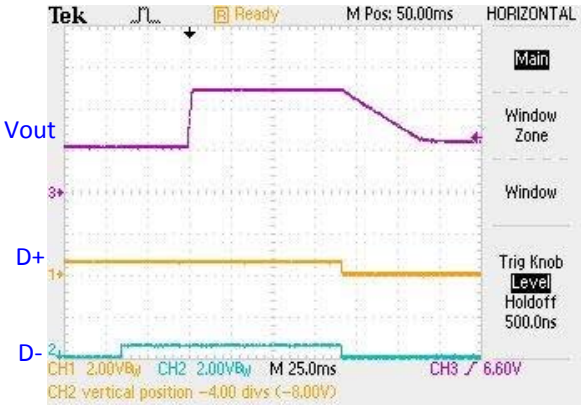
Transition from 5.0 V to 9.0 V to 12V



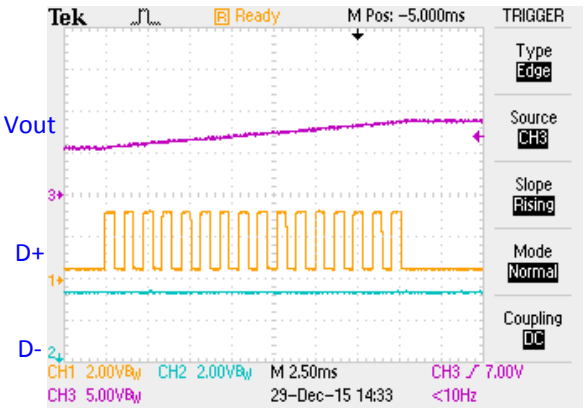
Transition from 5.0 V to 9.0 V



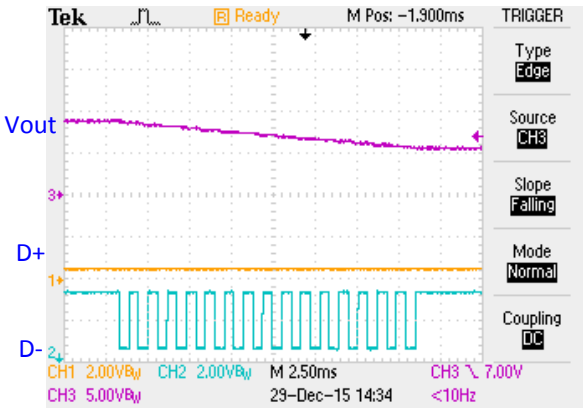
Transition from 5.0 V to 12 V



USB Cable Unplug Discharge



Continuous Mode Ramp Up



Continuous Mode Ramp Down

Figure 5 : QC 3.0 Test Voltage Output Examples

Operating instructions of 9922 in QC 3.0 mode

① Select mode

Press the MODE button to switch to QC3.0, then QC3.0 LED lights

② Set the output voltage

Short press : press UP, DOWN button to increase or decrease the voltage setting, resolution 0.2V

Press 2 seconds : Press UP, DOWN button to increase or decrease the voltage setting 3.6 ~ 20.0V

③ Start

Press the START button to start changing the output voltage values.

Chapter 3 Pump Express Plus & Pump Express Plus 2.0 Testing

Pump Express is the quick charge product of MediaTek. It has been extended to version 3.0 and uses a high voltage and high current to provide a fast charge.

This protocol has been used by SONY, Lenovo, Gionee, Meizu and other PC brands. The features of Pump Express allow the charger to determine the initial voltage required for charging based on the current drawn. The pulse current command from the PMIC in the phone or device is sent to the charger via USB Vbus. The charger adjusts the output voltage according to this instruction.

MediaTek currently has two fast charge specifications：

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

(2) Pump Express Plus 2.0 for the charger to provide the output power is greater than 15W, the difference is the output voltage can be controlled, similar to QC3.0 but based on 0.5V be increase or decrease, from 5V to 20V voltage to get the most appropriate voltage for mobile phone so as to achieve improved efficiency while reducing heat problems.

PumpExpress+ by MediaTek

PumpExpress 2.0 by MediaTek

The principle of Pump Express

Use the command (sink different current) control Adapter output different voltage, as shown in Figure 2 & 3, current Ilow <0.13A, Ihigh> 0.3A, PE shall sink current of at least 0.3A immediately in the conversion voltage, otherwise the voltage will automatically jump back 5V. As shown below...

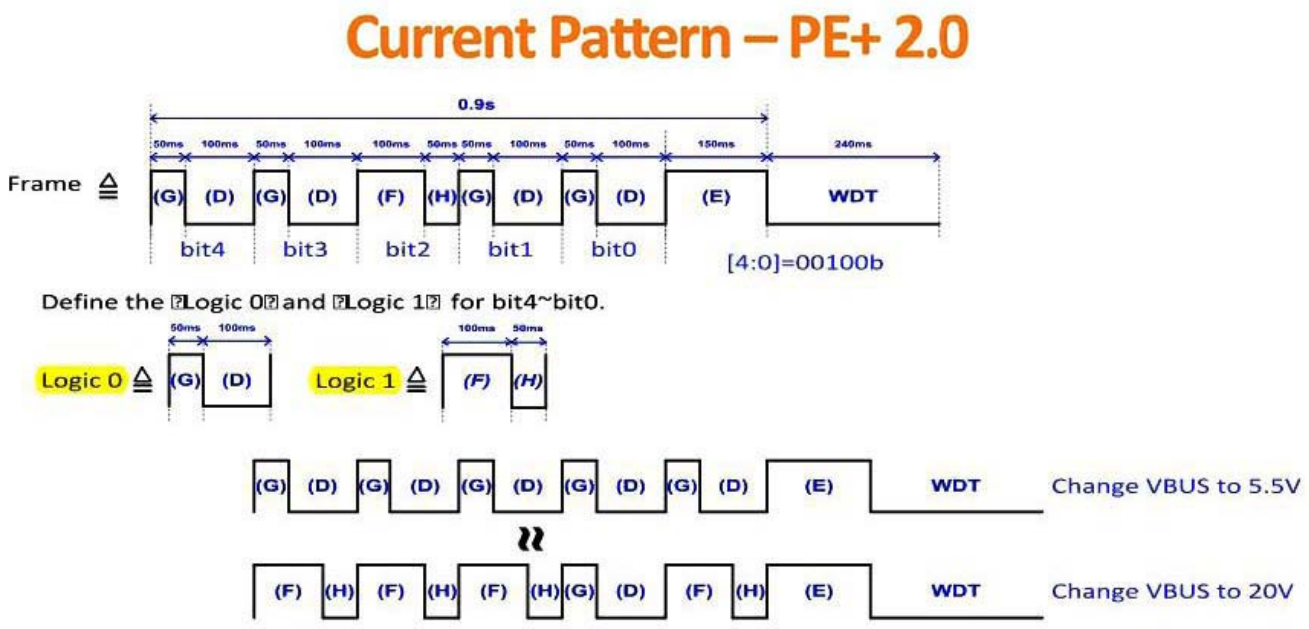


Figure 6: PE+ 2.0 Timing Diagram

PE 1.0 Adapter **PE+ 2.0 Adapter**

Figure 7: PE 1.0 and PE+ 2.0 Chargers

The 9922 Quick Charger Controller, which is capable of simulating commands and loads a different current, current Ilow <0.13A and Ihigh> 0.3A to verify and test the output voltage of the charger to ensure compliance with PE specifications. Refer to Figure 8.

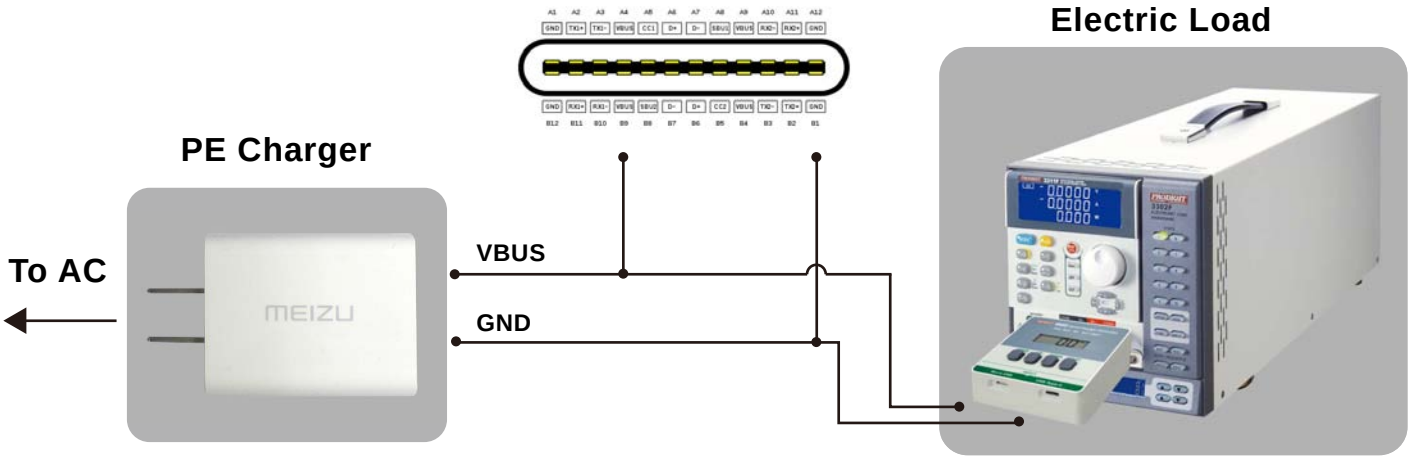
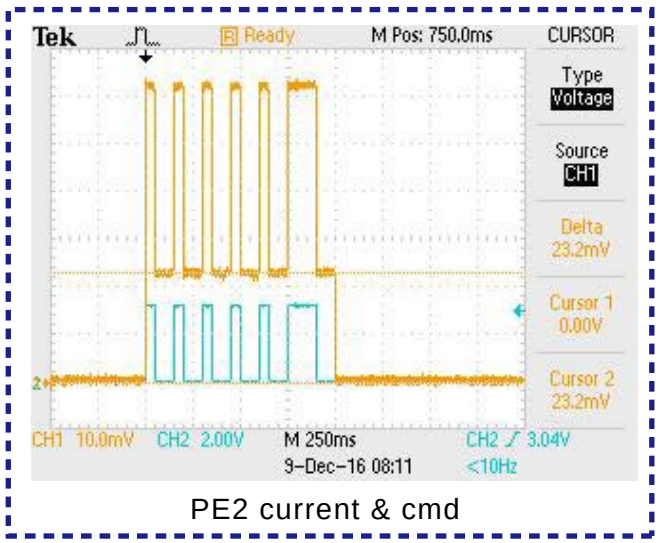


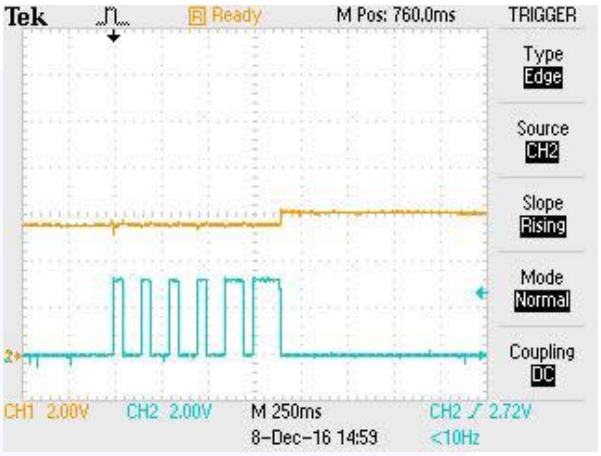
Figure 8: PE Charger Connection Diagram

Digital Code bit5~bit0 [4:0]	Absolute Voltage	Unit
00000B	5.5	V
00001B	6	V
00010B	6.5	V
00011B	7	V
00100B	7.5	V
00101B	8	V
00110B	8.5	V
00111B	9	V
01000B	9.5	V
01001B	10	V
01010B	10.5	V
01011B	11	V
01100B	11.5	V
01101B	12	V
01110B	12.5	V
01111B	13	V
10000B	13.5	V
10001B	14	V
10010B	14.5	V
10011B	15	V
10100B	15.5	V
10101B	16	V
10110B	16.5	V
10111B	17	V
11000B	17.5	V
11001B	18	V
11010B	18.5	V
11011B	19	V
11100B	19.5	V
11101B	20	V

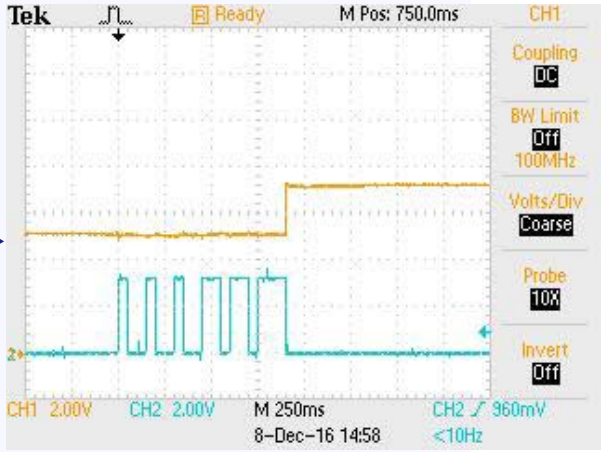
PE+ 2.0 COMMANHD



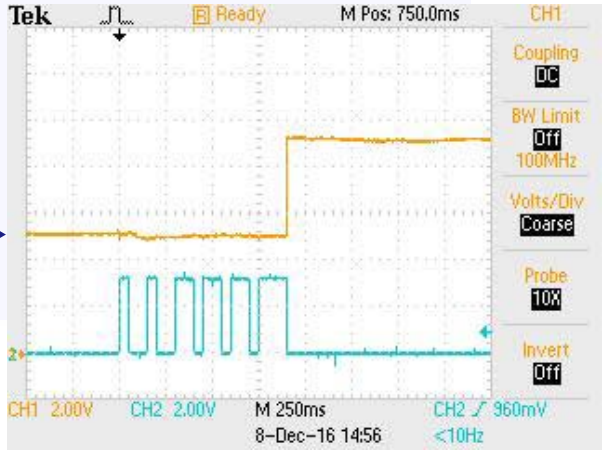
PE2 current & cmd



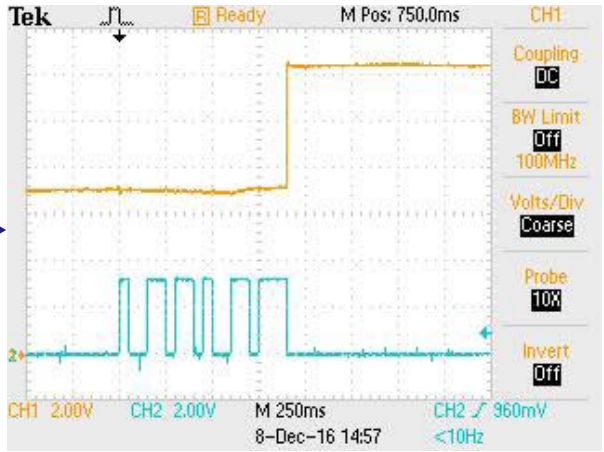
PE2 cmd: 00001b 6.0V



PE2 cmd: 00011b 7.0V



PE2 cmd: 01111b 9.0V



PE2 cmd: 01101b 12.0V

The operating instructions of 9922 in PE+

① **Select mode**

Press the MODE button to switch to PE +, then the LED of PE + lights up

② **Set the output voltage**

Press UP, DOWN button to increase or decrease the voltage setting 5.0V / 7.0V / 9.0V / 12.0V

③ **Start.**

Press the START button to start changing the output voltage values

The operating instructions of 9922 in PE+ 2.0

① **Select mode**

Press the MODE button to switch to PE + 2.0, then the LED of PE + 2.0 lights up

② **Set the output voltage**

Short Press: Press UP, DOWN button to increase or decrease the voltage setting 0.5V

Press 2 seconds: press UP, DOWN button to increase or decrease the voltage setting 5.0V / 9.0V / 12.0V / 20.0V

③ **Start**

Press the START button to start changing the output voltage values.

Chapter 4 USB Type-C support USB Power Delivery

The use of the USB interface to charge portable devices was an effort to reduce the number of different power connectors and power chargers. It also provides greater convenience for the user as the same charger could be used to charge multiple different devices. The USB IF standards group has recently announced the USB Power Delivery (USB-PD) power transfer specification. This new specification aims to aims to deliver up to 100 Watts using up to 20V @ 5A. Seven different voltage output configurations are supported so the same charger can be used to charge a wide variety of devices using a single USB cable using the shortest possible charging time supported by the device.

USB Power Delivery icon

USB 2.0 PD icon

USB 3.0 PD icon

APPLE USB Type-C Charger

Figure 9: USB PD and Type Power Chargers

The principle of Power Delivery

USB-PD uses a 24Mhz modulated FSK signal coupled to the VBUS as a protocol layer for communication between the charger and the device.
The following is an example based on mobile phones and chargers, supported by USB PD :

- The PHY of the USB OTG monitors the VBUS voltage. If the VBUS 5V voltage I and detects the OTG ID pin pull-down resistor is determined to be at least 1K Ohm indicating non OTG Host mode - the ID resistance of OTG Host mode is less than 1K - , this indicates the USB connection supports USB PD.
- The USB OTG will use the normal BCS V1.2 standard charger protocol 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 CapabilitiesSource message. Conform the USB PD Specification, the Resolution message includes a list of all voltage and current combinations supported by the USB PD Charger.
- The phone selects a voltage and current pair from the CapabilitiesSource 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 handset while adjusting the Power supply's DC voltage and current output.
- The phone 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.

Prodigit's 9922 Quick Charger Controller includes a PD-controller chip which can simulate the device to verify and test the USB PD testing process. The operator can use all the simple operations to complete all the tedious tests to ensure compliance with the PD specification. This is illustrated in Figure 9 below.

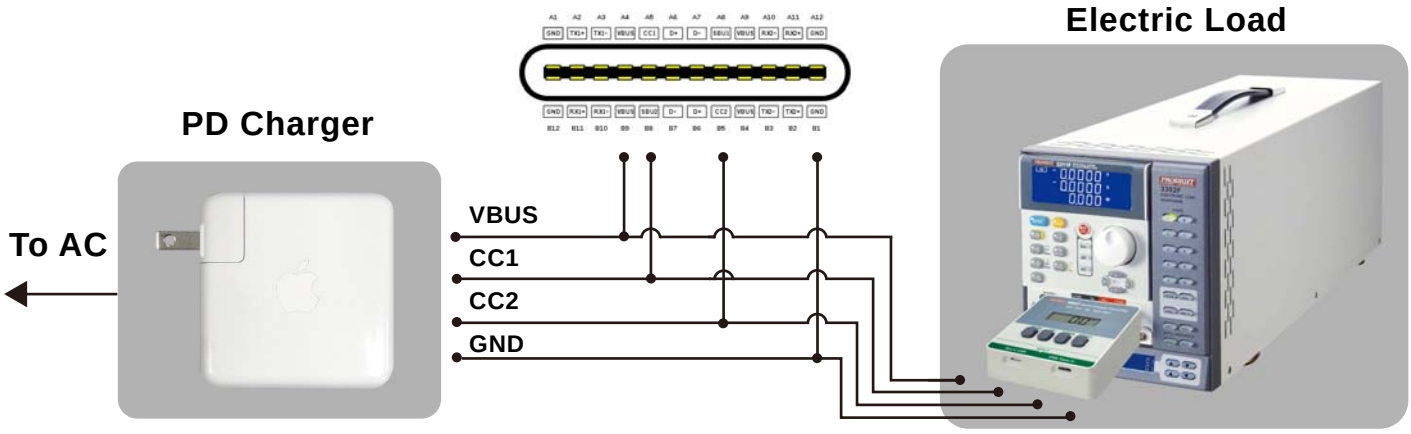


Figure 10: USB PD Charger Protocol Support

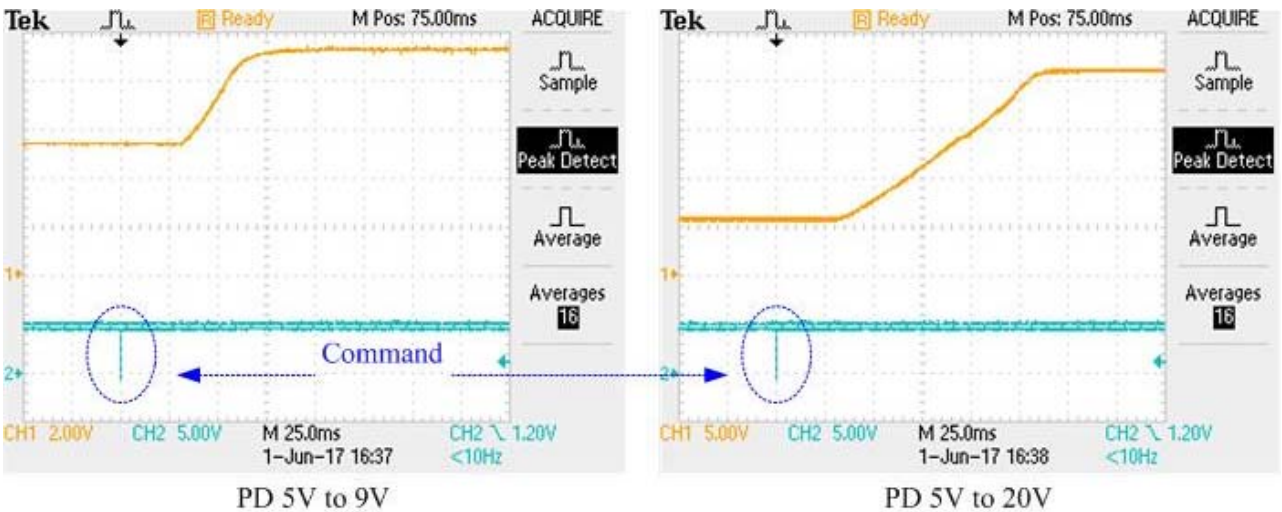


Figure 11: USB-PD FSK Signals on VBU

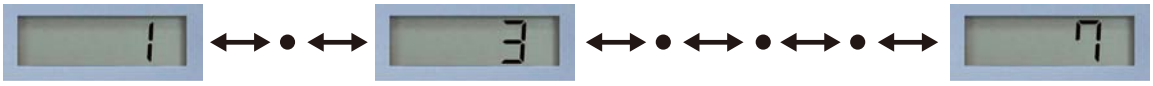
The operating instructions of 9922 in USB PD

① Select mode

Press the MODE button to switch to the PD, then PD LED lights up

② Set the output voltage

Press the UP and DOWN buttons to select the voltage output from 1 to 7 groups

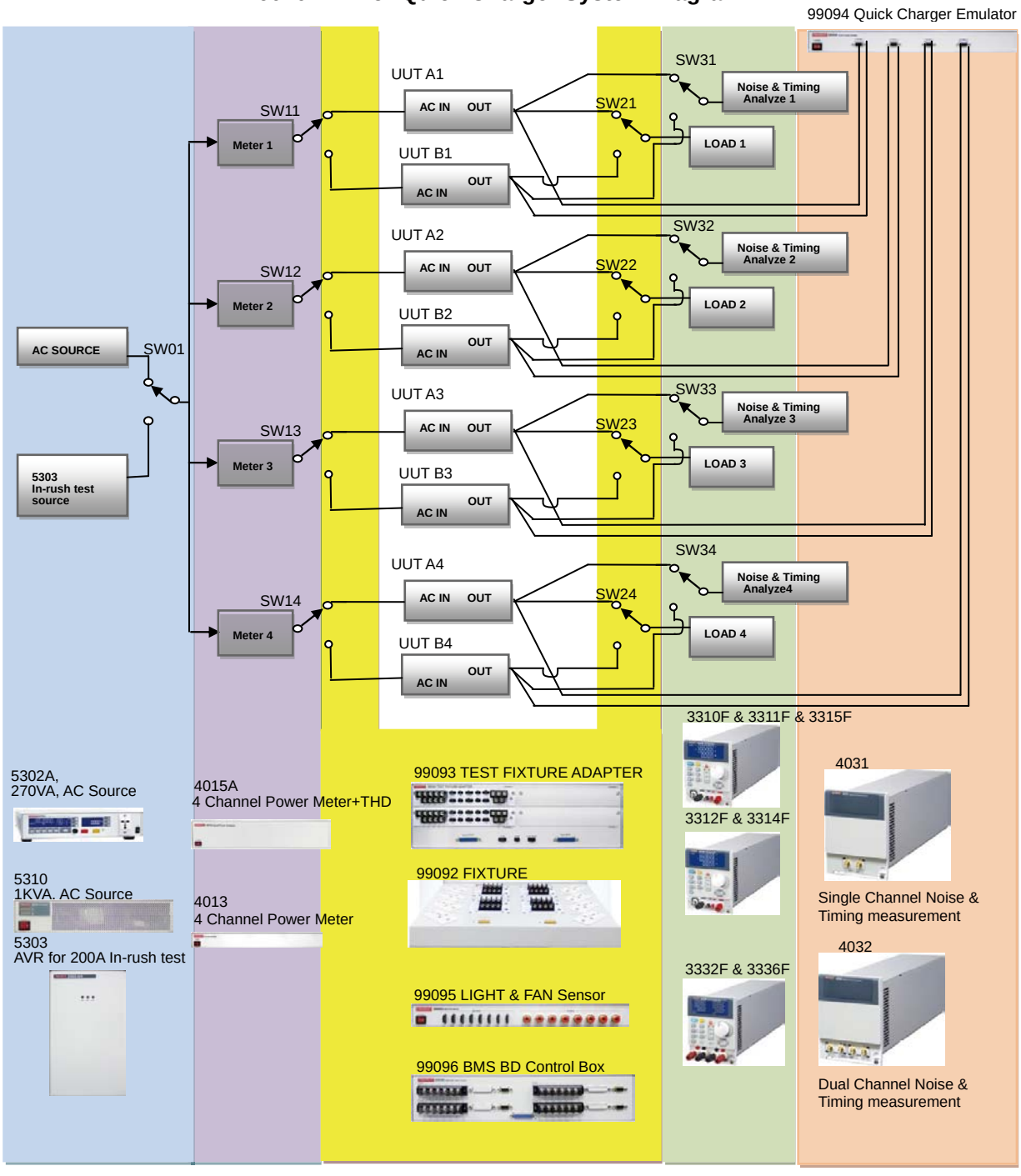


③ Start.

Press the START button to start changing the output voltage

※ Note : Take USB PD as an example, the output voltage is only three groups, one group is 5V, the second group is 9V, the third group is 20V.

6010 ATE for Quick Charger System Diagram



SW01 : General test or In-rush Current test

SW11 ~SW14 : AC Voltage select Switch for UUT A/B AC Input
SW21 ~SW24 : DC Load select Switch for UUT A/B Output.
SW31~ SW34 : Noise & Timing Meter select Switch for UUT A/B Output.

60104+3311F+4031

60104 is the mainframe for modules

Conclusion

The newer generations of quick charging technology mobile devices chargers is not the same as previous charger types and can no longer use conventional methods to test and verify these new quick chargers. The quick charge technology chargers is basically a higher power programmable power supply that, based on the requirements of mobile phones, tablets or laptops, can provide a higher voltage, more current and more power to the phone, tablet or laptop battery to achieve faster charging target as described in this article.

Prodigit's 9922 is a single channel, quick charge controller to meet the needs of R & D testing and verification. For testing a large number of test requirements, the multi-channel 99094 quick charge simulator offers four channels of quick-charge control testing. The 99094 Quick Charge Simulator in combination with the 6010 ATE can test and verify four chargers simultaneously for production line applications.

For more information, please contact Prodigit sales office or distributor in your area.