6010 ATE provides USB PD solutions for Quick Charger technology (QC2.0, QC3.0, PE, PE+ 2.0, USB PD) testing

To support high speed testing of multiple intelligent quick charging products for mobile devices, Prodigit has developed the 99094 Quick Charger Emulator. This fully automated test system provides simulation of Quick Charger protocols for Pump Express and USB PD and other kinds of quick charging devices.

The 99094 contains a four channels quick charger emulator. The 6010 ATE system can simultaneously simulate four quick charge control signals for chargers aimed at mobile phones, tablets and notebook devices. A variety of quick charging technologies and protocols is supported to provide rapid testing and verification of this new generation of device chargers.

Each of the four 99094 emulator channels contains a 15 Pin interface connector, as shown in Figure 1. These connectors each include two sets of control signals (CHA and CHB) to support high throughput production line testing using dual A / B test fixture switching. Each connector pin assignments are shown in Table 1.

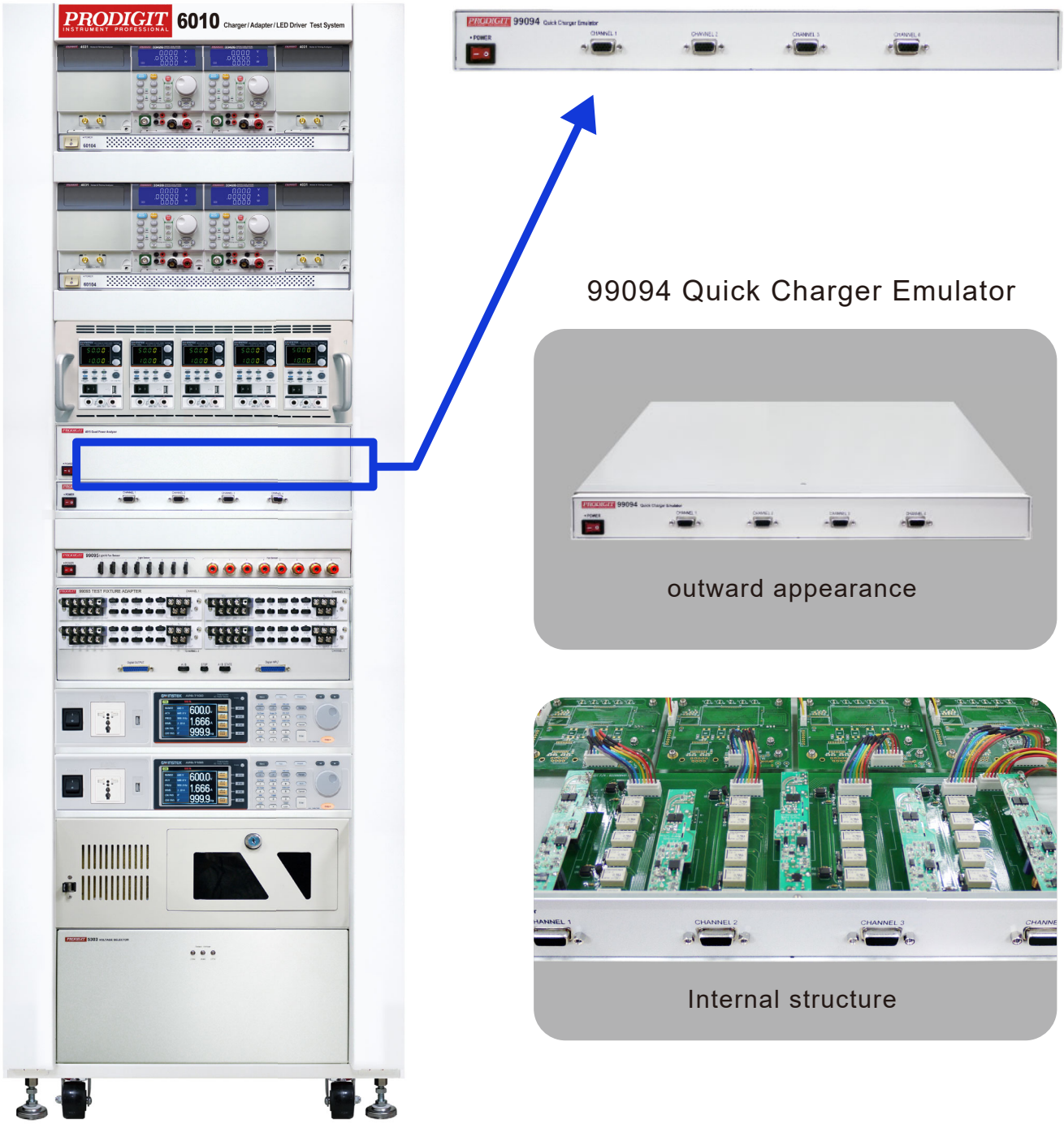
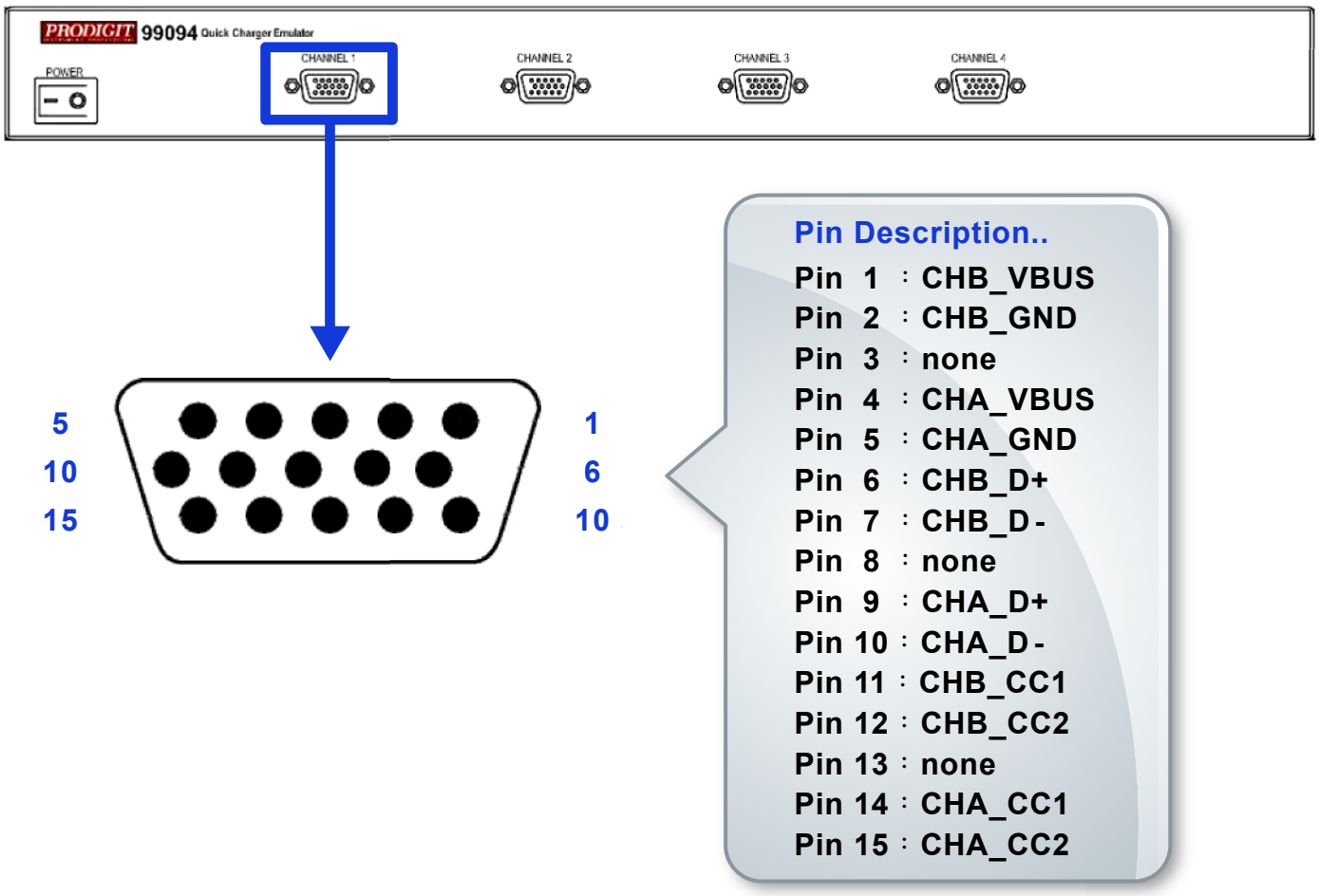


Figure 1: 99094 ATE Test System Components



99094 pin define

Table 1: 99094 Interface Connector Pin Definitions

1. Quick Charger 2.0 and 3.0

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 2:

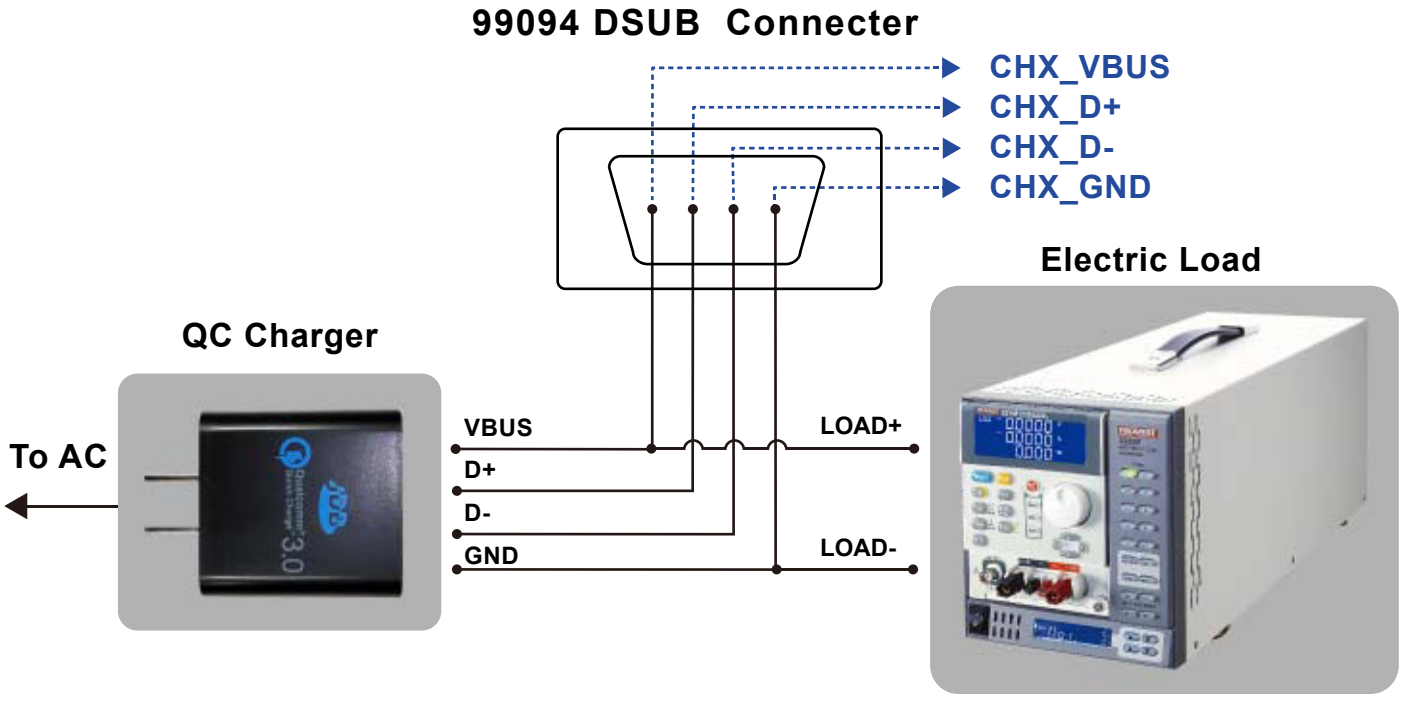
D+	D-	Output
0.6V	0.6V	12V
3.3V	0.6V	9V
3.3V	3.3V	20V
0.6V	GND	5V(default)

QC 2.0 Class A Adapter

Table 2 : QC 2.0 Control Table

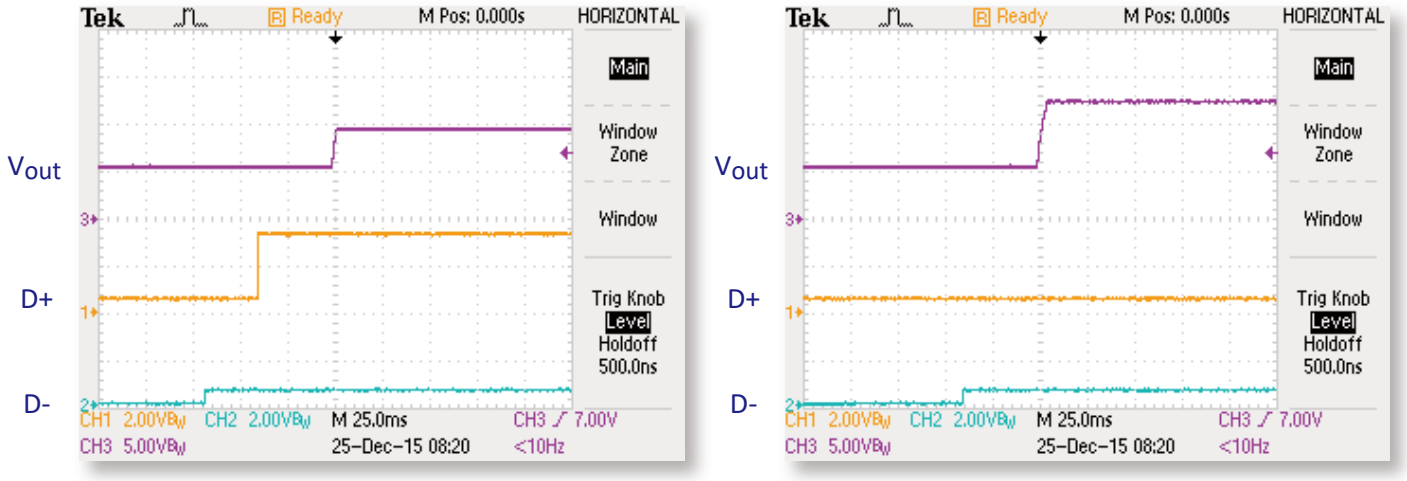
QC 2.0 control method

Prodigit 99094 Quick Charger Emulator used in the of 6010 ATE station 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



QC Charger Application Connect diagram

Figure 3 : Charger Connection Diagram



QC 2.0 Transiton 5V to 9V

QC 2.0 Transition 5V to 12V

Figure 4 : QC 2.0 Voltage Transition Test

At present there are many manufacturers' products to support Quick Charge devices, such as HTC, SONY, MOTOROLA, Google, Samsung, Asus and so on.

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 achieve improved efficiency while reducing heat problems.

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

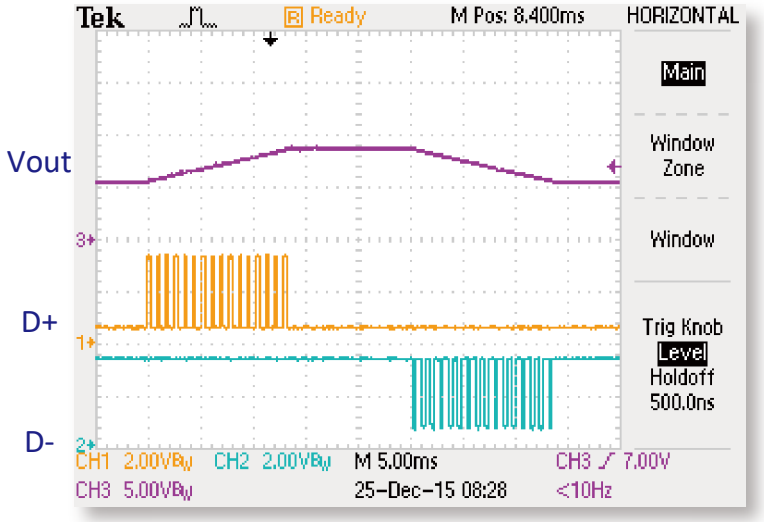
D+	D-	Output	Note
0.6V	0.6V	12V	Class A
3.3V	0.6V	9V	Class B
0.6V	3.3V	Continuous Mode	Class A/B with ±0.2V step size
3.3V	3.3V	20V	Class B
0.6V	GND	5V	Default mode

QC 3.0 Class A Adapter

Table 3 : QC 3.0 Control Table

QC 3.0 control method

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.

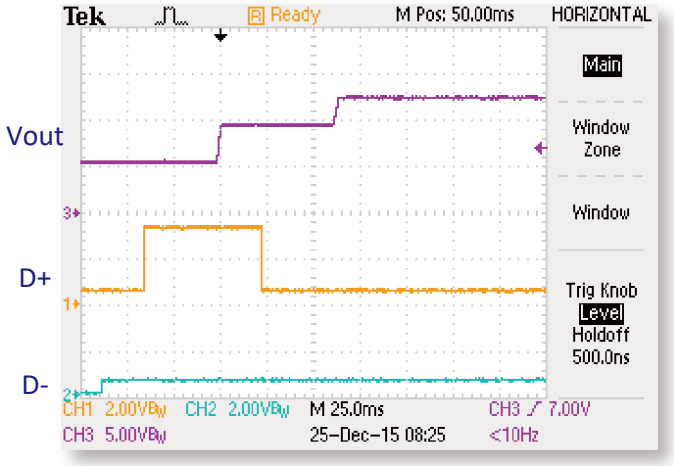


CH1: D+
CH2: D-
CH3: Vout(adapter voltage output)

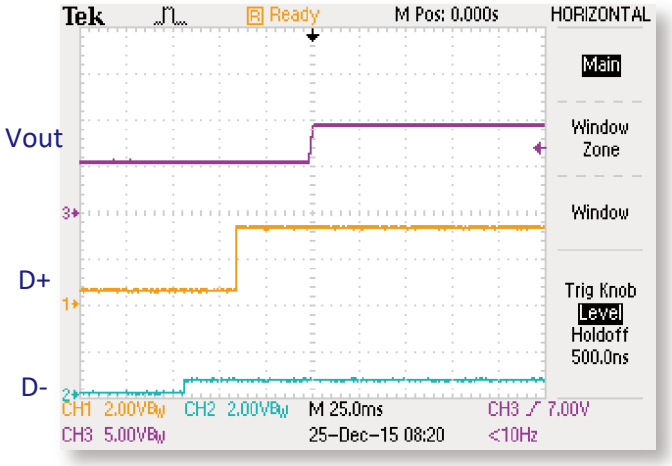
Continuous Mode Ramp Up and Down

Quick Charge 3.0 Ramp Up 3.2V and Ramp Down 3.2V

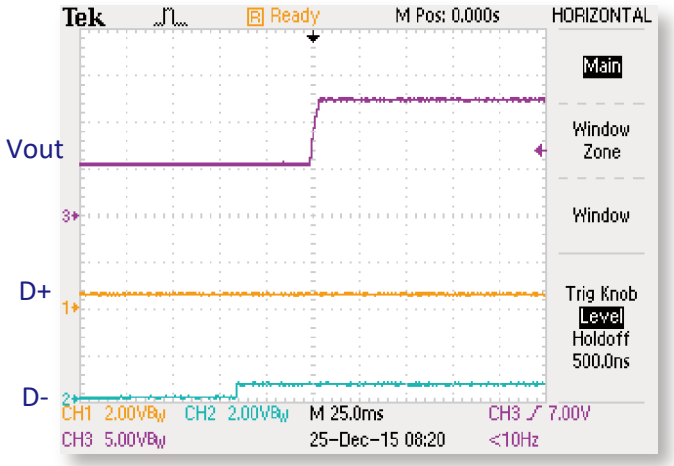
Prodigit 99094 is a 4 channels Quick Charger Emulator of 6010 ATE which is capable of simulating D +, D- pulse control to control 0.2V increments and decrements to verify and test the output voltage of the charger to ensure compliance with the Quick Charge 3.0 specification. Refer to the samples shown in Figure 5.



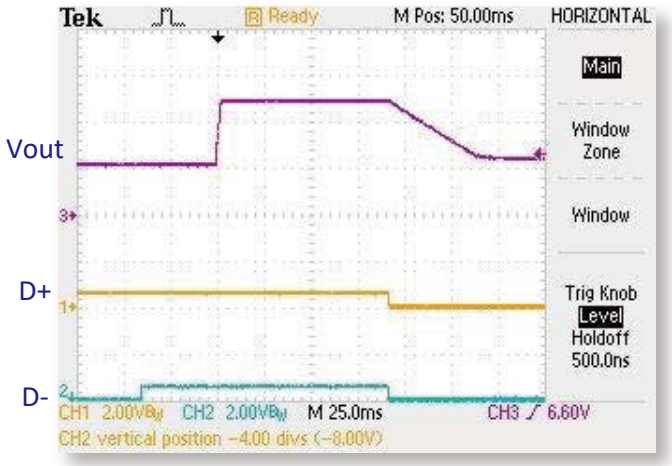
Transition from 5.0 V to 9.0 V to 12V



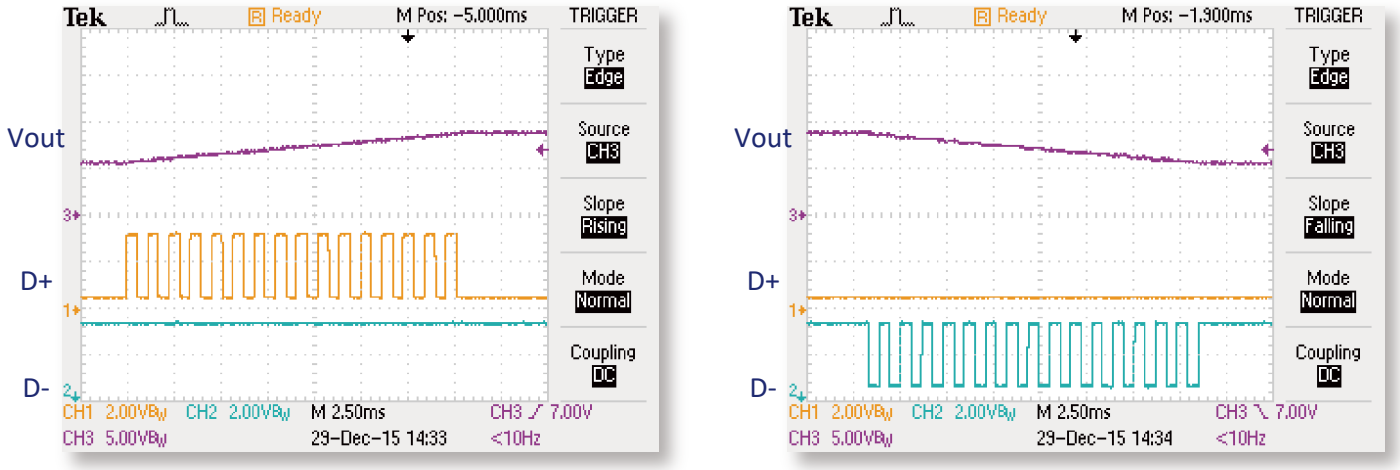
Transition from 5.0 V to 9.0 V



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

2. Pump Express Plus & Pump Express Plus 2.0

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：

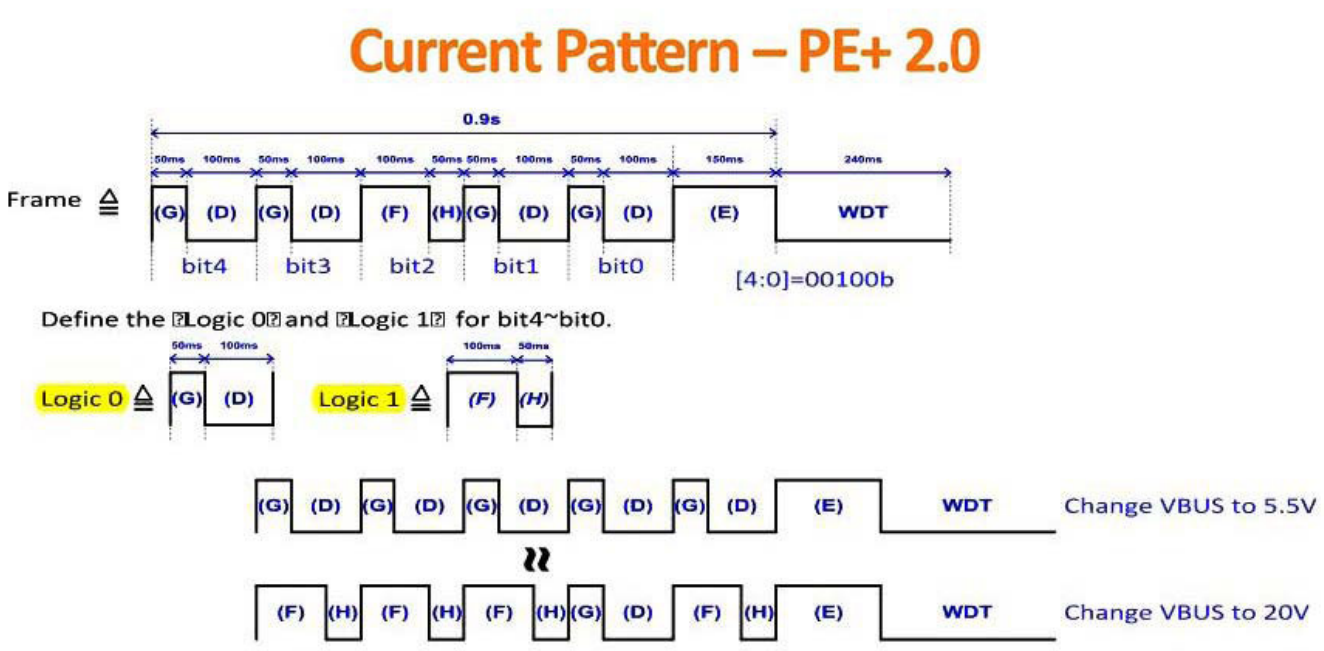
（1）Pump Express Plus provides output power for fast DC chargers less than 15W (5V) similar to QC2.0, controlled output Fixed voltage: 5V, 7V, 9V, 12V.

（2）Pump Express Plus 2.0 charger, its output power can be higher than 15W, the difference compare to Pump Express Plus is the output voltage can be controlled, similar to QC3.0 but based on 0.5V increment or decrement, from 5V to 20V voltage to get the most appropriate voltage for mobile phone so as to achieve improved efficiency and improve the heat problem.

PumpExpress+ by MediaTek PumpExpress 2.0 by MediaTek

The principle of Pump Express

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



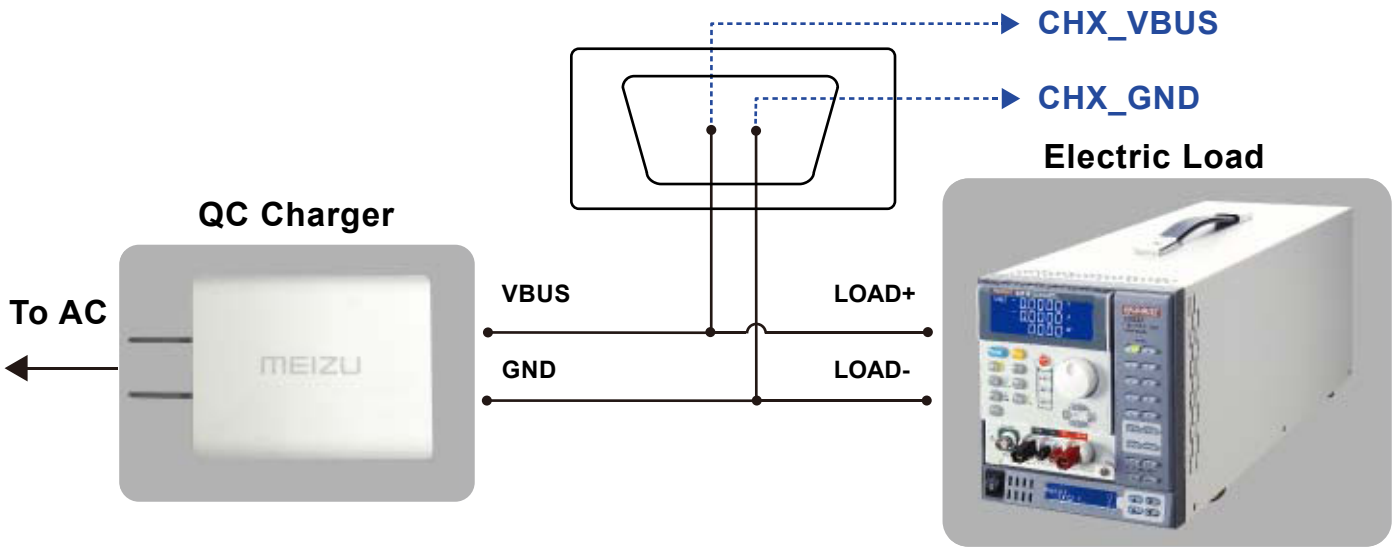
PE + 2.0 action timing diagram

PE 1.0 Adapter

PE+ 2.0 Adapter

Prodigit 99094 is a 4 channels Quick Charger Emulator for the 6010 ATE system which is capable of simulating commands and loads at different current levels - Ilow <0.13A, Ihigh> 0.3A - to verify and test the output voltage of the charger and ensure compliance with PE specifications. Refer to Figure 6.

99094 DSUB Connecter

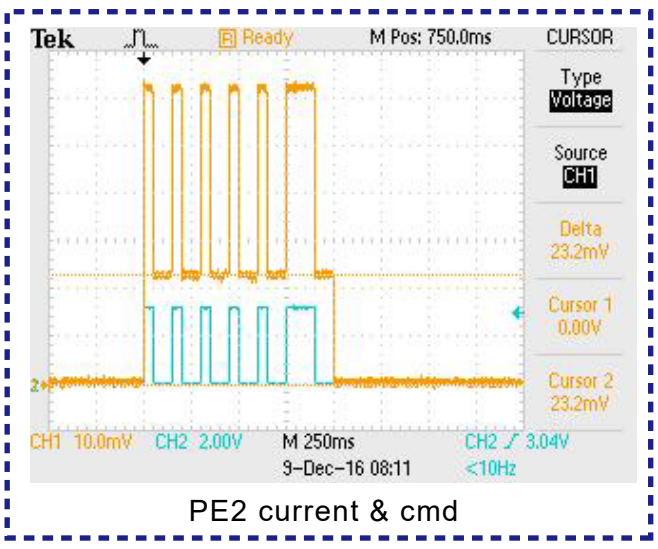


PE Charger Application Connect diagram

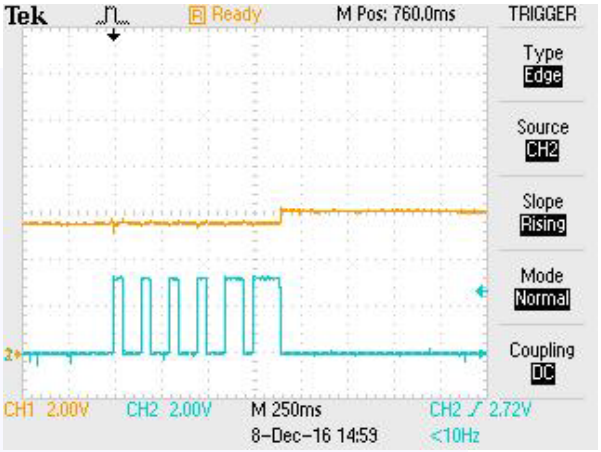
Figure 6 : PE Charger Connection Diagram

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

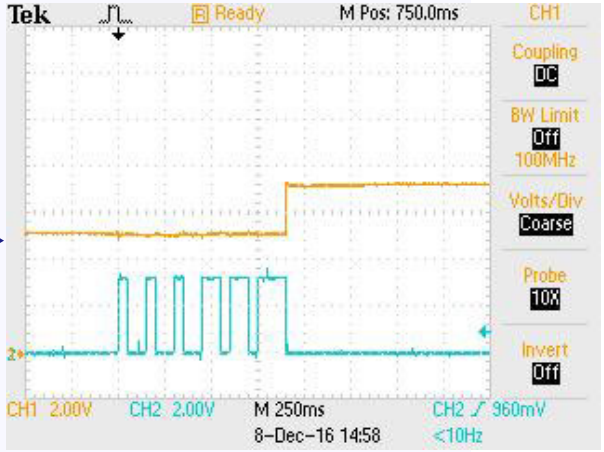
PE+ 2.0 COMMANHD



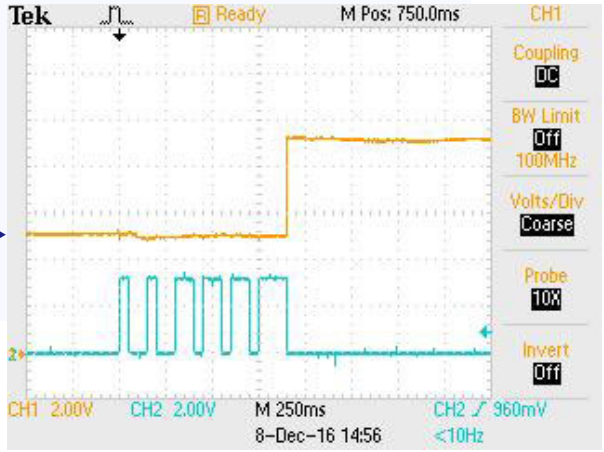
PE2 current & cmd



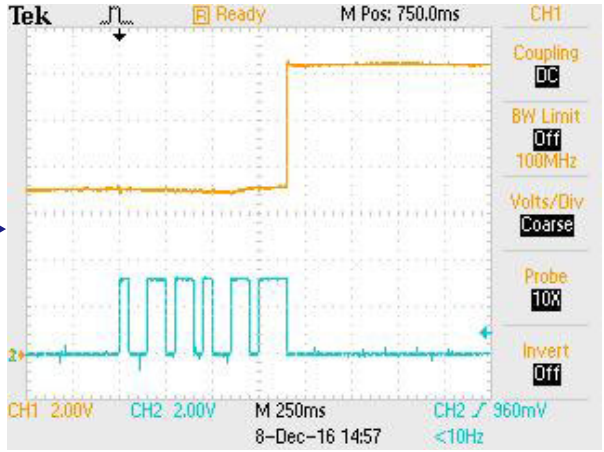
PE2 cmd: 00001b 6.0V



PE2 cmd: 00011b 7.0V



PE2 cmd: 01111b 9.0V



PE2 cmd: 01101b 12.0V

3. USB Type-C support 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 20 V @ 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 logo

USB 2.0 PD icon USB 3.0 PD icon

APPLE USB Type-C Charger

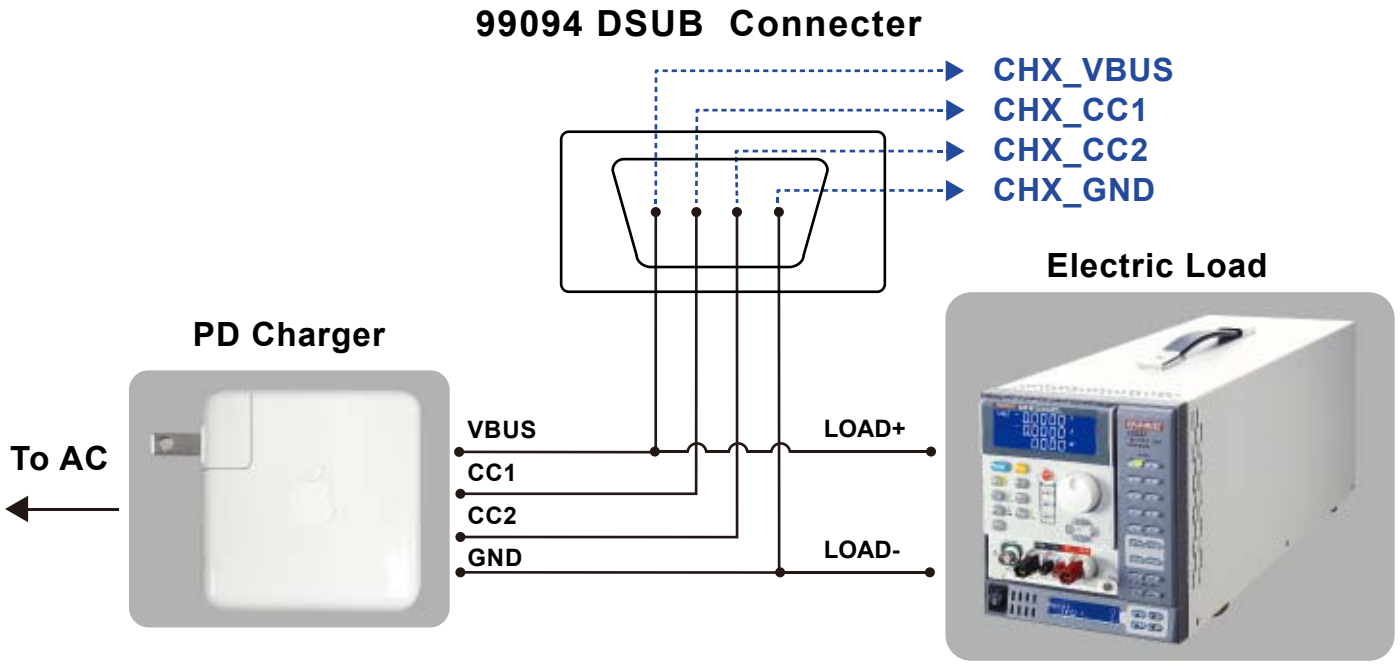
Figure 7: USB PD and Type Power Chargers

The principle of Pump Express

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 :

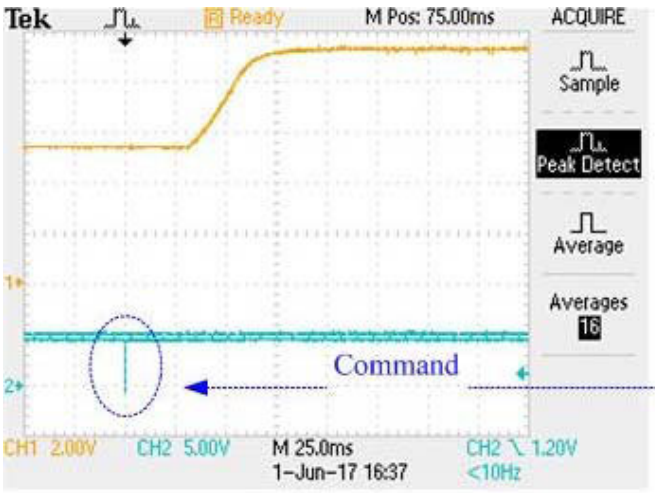
- The PHY of the USB OTG monitors the VBUS voltage. If the VBUS 5V voltage I and detects the OTG ID pin pull-down resistor is determined to be at least 1K Ohm indicating non OTG Host mode - the ID resistance of OTG Host mode is less than 1K - , this indicates the USB connection supports USB PD.
- The 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 Capabilities Source 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 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 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 99094 4 channel Quick Charger Emulator in the 6010 ATE system includes four USB PD control chips that can simulate the device to verify and test the USB PD test procedures. All specifications of the power supply products can be tested easily by 6010 ATE, after programming all necessary test procedures in 6010 ATE. The operator can get test reports, effectively shortening the test verification time, to ensure compliance with the PD specification. See Figure 8.

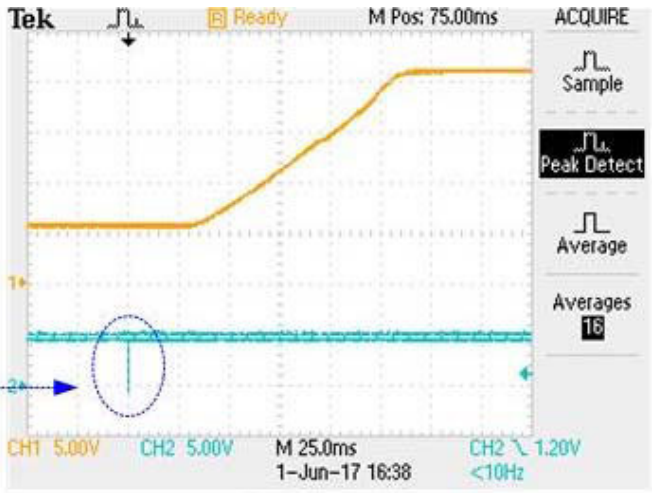


PD Charger Application Connect diagram

Figure 8 : USB PD Charger Protocol Support

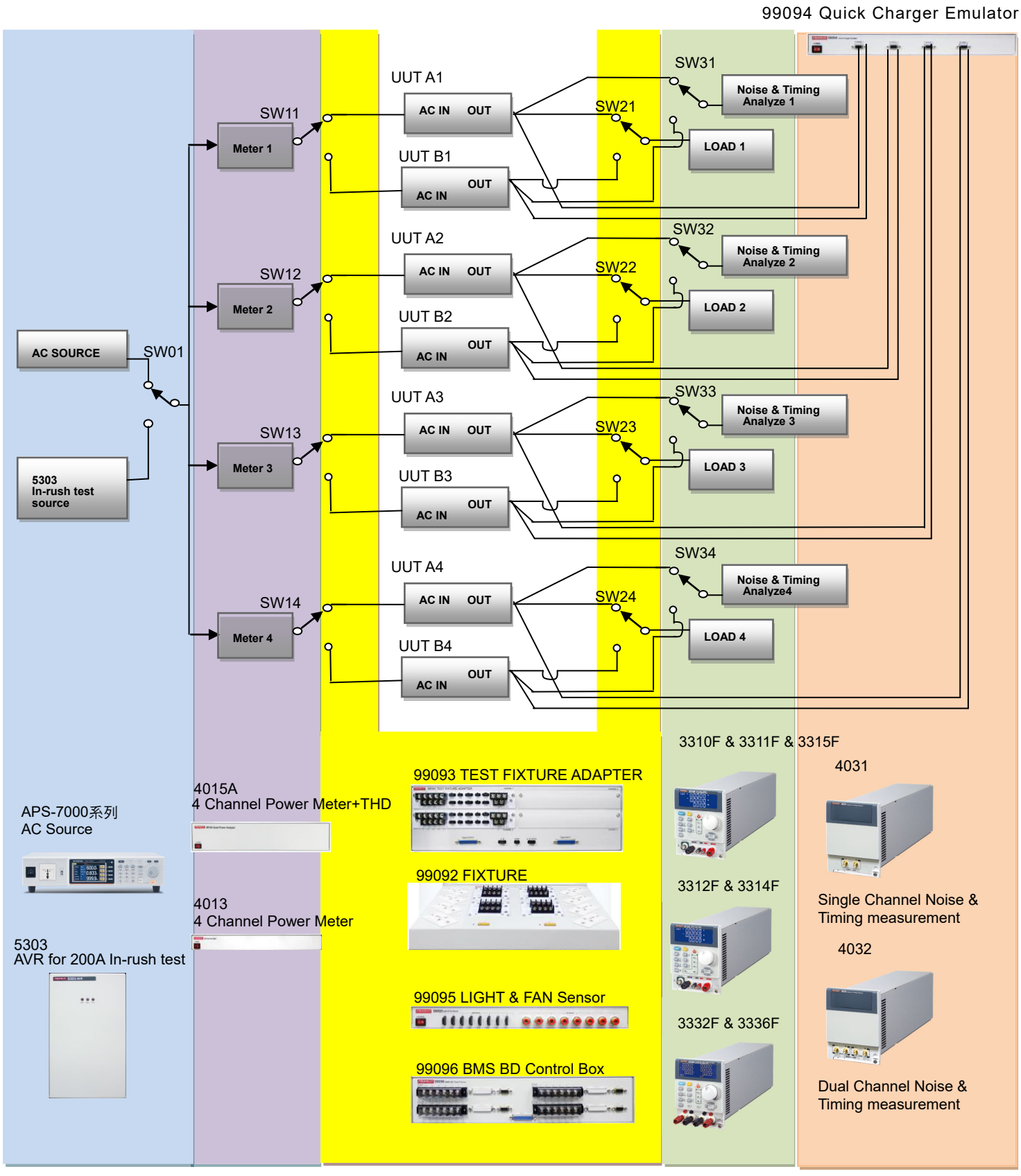


PD 5V to 9V



PD 5V to 20V

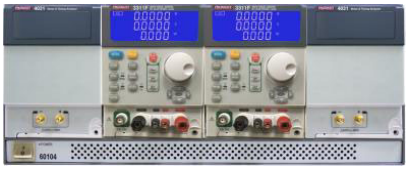
6010 ATE for Quick Charger System Diagram



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.

The 99094 is a 4 channel Quick Charger Emulator for the 6010 ATE test system. It can test and verify four quick chargers on a production line at the same time. A stand-alone manually operated quick charger controller, model 9922, is available as well to simulate the quick charger technologies described in this article. This manual model is very suitable for R & D test & validation needs.

The 6010 ATE test system can be purchased as a complete system (Hardware + Software) or individual hardware components. Prodigit provides the operation and programming instruction for each hardware module. This means the individual hardware components such as the 99094 Quick Charger Emulator can be added to your existing ATE system as needed, or used to build your own ATE system.