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Chapter 1. Summary

1.1 General Description

Co-existence of PD Type C and QC3.0 Micro Type B equipped smartphones gives rise to popular needs for multiple-port Type "Cs'+As'" chargers and adaptors. The 60W adaptor EV1 board exemplifies a dual-port "C+A" smart power-sharing feature to optimize system BOM cost and maximize usage of total power and protocol decoder usage.

When only one port is connected, PD3.0 or QC3.0 could be supported through the protocol decoder AP43771T16 for Type C or A port, respectively. When both Type C and A ports are connected, total power will be shared between Port A (maximum 15W) and Port C (balance of the total maximum power design).

Typical applications are more suitable for relatively larger power adaptor with power over 30W.

1.2 Key Features

1.2.1 System Key Features

- SSR Topology Implementation with an Opto-coupler for Accurate Step Voltage Controlling
- USB PD 3.0 Compliance Type-C Port, QC3. Compliance Type-A Port,
- Meets DOE VI and COC Tier 2 Efficiency Requirements
- <100mW No-Load Standby Power for overall system
- Low overall system BOM cost

1.2.2 AP3108L Key Features

- Current Mode PWM Controller (CCM)
- Frequency Shift function changes frequency per line loading
- Frequency fold back for high average efficiency
- Integration of High-Voltage Start-Up Circuit to enable low standby power (<30mW)
- Integration of 120V LDO, X-Cap discharge for minimal system BOM components
- Constant load output current during output short circuit
- Rich Protection Functions: , Precise Secondary Side OVP, UVP, OLP, BNO, FOCP, SSCP, External Programmable OTP

1.2.3 APR348 Key Features

- Synchronous Rectification Working at DCM, CCM and QR Flyback
- Eliminate Resonant Ringing Interference
- Fewest External Components used

1.2.4 AP43771 Key Feature

- Supports USB PD3.0 PPS Type-C and QC4/QC4+
- Drives N-Channel MOSFET for Load Switch
- Built-in VBUS Discharger Pin
- 3V-20V operation voltage without external regulator
- On-chip OVP,UVP,OCP and SCP
- Supports OTP through integrated ADC circuit
- USB PD3.0 PPS Compliance (TID : 1100023)

1.2.5 EUP3271 Key Feature

- CC/CV Mode Synchronous Step-Down Converter (up to 4A)
- Duty ratio from 0 to 100% PWM, co-package MOSFET
- Switching frequency 300KHz typical, SOP-8L package
- With current limit, Enable & Thermal shutdown functions
- http://www.eutechmicro.com/index.php?a=products_data&id=353

1.3 Applications

Dual-Port C+A Quick Charger with PD3.0 or QC3.0 + 5V-2.4A

1.4 Main Power Specifications

Parameter		Value
Input Voltage		90Vac to 264Vac
Input standby power		< 100mW
Main Output Vo / Io	Only - C IN	60W PD3.0 (5V,9V,12V,15V,20V-3A)
	Only - A IN	A port: 5V/2.4A
	C & A - IN	C - 45W PD3.0 (5V,9V,12V,15V-3A, 20V2.25A)
		A - 12W (5V/2.4A)
Type C only Efficiency		>90%
Combine Efficiency		>89%
Total Output Power		60W
Protections		OVP, UVP, OLP, BNO, FOCP, SSCP, OTP
XYZ Dimension		L55 x 55 x 25mm
ROHS Compliance		Yes

1.5 Evaluation Board Picture

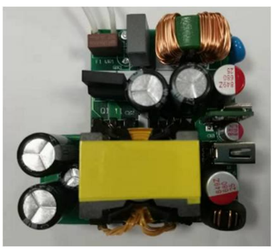


Figure 1: Top View

Figure 2: Bottom View

Chapter 2. Power Supply Specification

2.1 Specification and Test Results

Parameter	Test conditions	Min	Nom	Max	Eff/ DoE VI	Test Summary
V_{acin} Input Voltage		90 V_{rms}	115/230	264 V_{rms}		
F_{line} Frequency		47 Hz	50/60	64 Hz		
I_{in} Input Current				1.5 A_{rms}		Pass
Standby Power (mW) @ No load conditions	At 230Vac_in/50Hz @ No Load			100mW		Pass , the test result is 70mW
5V/3A+5V/2.4A @115Vac/230Vac, Average efficiency	Board end				>80.82%	Pass, average efficiency is 88.16%
9V/ 3A+5V/2.4A @115Vac/230Vac, Average efficiency	Board end				>83.58%	Pass, average efficiency is 89.29%
12V/3A+5V/2.4A @115Vac/230Vac, 100% efficiency	Board end				>85.13%	Pass, average efficiency is 88.94%
15V/3A+5V/2.4A @115Vac/230Vac, 100% efficiency	Board end				>86.00%	Pass, average efficiency is 88.83%
20V/2.25A+5V/2.4A @115Vac/230Vac,100% efficiency	Board end				>86.00%	Pass, average efficiency is 89.12%
USB-A 5V-2.4A	Board end		5V-2.4A			

2.2 Compliance

Parameter	Test conditions	Low to High	High to Low	standard	Test Summary
Output Voltage Transition time	5V/3A to 9V/3A	58ms	58ms	275ms <	Pass
Output Voltage Transition time	9V/3A to 12V/3A	47ms	46ms	275ms <	Pass
Output Voltage Transition time	12V/3A to 15V/3A	46ms	43ms	275ms <	Pass
Output Voltage Transition time	15V/3A to 20V/3A	71ms	74ms	275ms <	Pass
Output Voltage Transition time	5V/3A to 20V/3A	202ms	204ms	275ms <	Pass
Output Connector	USB Type-C & USB-A	-	-	-	
Temperature	90Vac , Full Load	-	-	-	Pass
Dimensions (W /D/ H)	L55mm x55mm x 25mm	-	-	-	
Safety	IEC/EN/UL 60950 Standard	-	-	-	
EMI Conduction	FCC/EN55022 Class B	-	-	-	6db Margin, Pass

Chapter 3. Schematic

3.1 EV1 Board Schematic

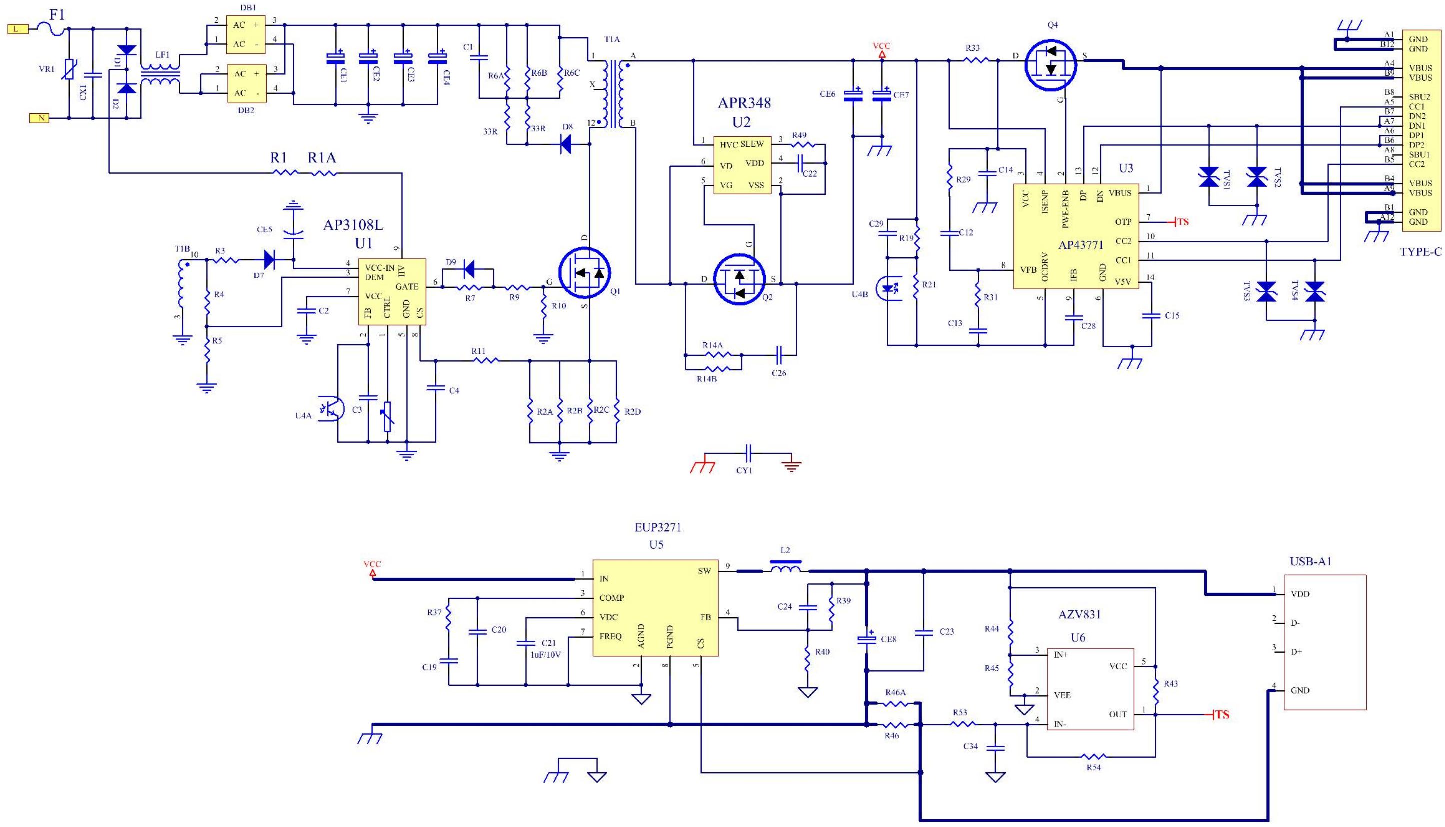


Figure 3: 60W A+C Share Power EV1 Board Schematic

For multiple outputs

DoE VI Eff ≥ 0.0750xLn(Po)+0.561	1 --- 49W	27W (5Vx3A+5Vx2.4A) Eff=80.8% 39W (9Vx3A+5Vx2.4A) Eff =83.57%
DoE VI Eff ≥ Pout > 49W >= 86.0%	57W (60W A+C+12W) >49W Eff >= 86	

3.2 Bill of Material (BOM)

BOM1

Designator	Description	Part Number	Manufacturer	Footprint	Quantity
D1, D2, D7	1.0A/1000V RECTIFIER	S1MWF	DIODES	SOD123	3
D8	1.5.0A/1000V RECTIFIER	RS2MA	DIODES	SMA	1
D9	FAST SWITCHING DIODE	1N4148WS	DIODES	SOD-323	1
DB1, DB2	3.0A/1000V BRIDGE RECTIFIER	MSB30M	DIODES	MSBL	2
Q2	100V N-CHANNEL, RDS(ON)=8.3mΩ @VGS = 10V	DMT10H010LPS -13	DIODES	PowerDI506 0-8	1
Q4	30V N-CHANNEL ENHANCEMENT MODE MOSFET	DMN3008SFGQ	DIODES	DFN3*3	1
TVS1, TVS2, TVS3, TVS4	VBR(min)=5.5V,BIDIRECTI ONAL TVS DIODE	DESD5V0S1BA	DIODES	SOD-323	4
U1	CCM PWM CONTROLLER-	AP3108L	DIODES	SSOP-9	1
U2	SECONDARY SIDE SR CONTROLLER	APR348	DIODES	SOT23-6	1
U3	USB PD CONTROLLER	AP43771	DIODES	DFN14	1
U6	single channel rail-to-rail input and output amplifier	AZV831	DIODES	SOT-23-5	1
U4	TCLT1006		VISHAY	PC-SMD	1
U5	PWM CONTROL 3A STEP-DOWN CONVERTER	EUP3271	EUTECH	SOP-8	1
Q1	650V N-Channel MOSFET, 12A, Rds(ON)=250mΩ	FCPF250N65S3	Fairchild	TO-220F	1
C1	1nF/1KV			C1206	1
C4	220pF/50V			C0603	1
C2	6.8uF/50V			C1206	1
C14	100nF/50V			C0603	1
CE5	6.8uF/100V, E-CAP			EC5	1

BOM2

Designator	Description	Part Number	Manufacturer	Footprint	Quantity
C12,C3,C29	1.2nF/50V			C0603	1
C26	2.2nF/200V			C0805	1
C22	3.3uF/10V			C0603	1
C28	Not Used				
C15	10uF/ 7.5V			C0805	1
C19	10nf/16V			C0603	1
C13	68nF/50V			C0603	1
C20	22PF/16V			C0603	1
C21	1uF/10V			C0603	1
C24,C34	100pF/16V			C0603	2
CE1A	NC			C1206	
CX1	330nF/275VAC, X-CAP				1
CY1	1.5nF/300VAC, Y-CAP			CY-10.0	1
EC1, EC2, EC3,EC4	27UF/400V,E-CAP			EC10.0	4
EC6,EC7	680UF/25V, Solid Cap			EC5.0	2
EC8	470UF/6.3V, Solid Cap			EC3.5	1
F1	T3.15A/250V, Fuse			FUSE1	1
J1	TYPE-C, Connector			C-TYPE-C	1
J2	USB-A, Connector			USB-A	1
L1	22uH Ring Core inductor			L1	1
LF1	Common Chock, LP >20mH				1
VR1	10D561			VR-7D561	1
T1	Transformer, Lp=600uH	PQ2620		PQ2620	1

BOM3

Designator	Description	Part Number	Manufacturer	Footprint	Quantity
R1, R1A	10K			R1206	2
R6A,R6B,R6C	820K			R1206	3
R8A, R8B	33R			R1206	2
R14A, R14B	43R			R1206	2
R49	24K			R0603	1
R7	47R			R0603	1
R2A,R2B,R2C,R2D	1.2R			R1206	4
R9	10R			R0603	1
R10	33K			R0603	1
R3	2.2R			R0805	
R4	270K±1%			R0603	1
NTC1	100K NTC Resistor			R0603	1
R5	20K±1%			R0805	1
R29,R45	1K			R0603	2
R43	10K±1%			R0603	1
R21,R31	4.7K			R0603	2
R39	100K±1%			R0603	1
R37	200K			R0603	1
R40	13.7K±1%			R0603	1
R44,R54	1M			R0603	2
R46,R46A	39mR±1%, 1/4W			R1206	2
R33	Current Sensing Resistor, Metal Strip Type, 10mR±1%, 1W		SART TECHNOLOGY	R1206	1
R19	3K			R1206	1
R53	150R			R0603	1

3.3 Transformer Design

T1=PQ2620(AE=120mm²)				Rev2.0		
NO.	Name	TERMINAL NO.		Winding		
		Start	Finish	Wire	Turns	Layers
1	Np1	5	4	Φ 0.15mm*9P **2UEW**	27	2
2	Na	1	6（GND）	Φ 0.15*1P **2UEW**	15	1
	Shiled1	6（GND）	NC	Φ 0.15*2P **2UEW**	15	
3	Ns	A	B	Φ 0.23mm *15P **TIW-B**	6	1
4	Shield2	6（GND）	NC	Φ 0.15mm*1P **2UEW**	28	1
5	Np2	4	3	Φ 0.15mm*9P **2UEW**	13	1

Primary Inductance	Pin 5-3,all other windings open, measured at 20kHz, 0.4VRMS	600uH, ±5%
Primary Leakage Inductance	Pin 5-3, all other windings shorted, measured at 20kHz, 0.4VRMS	20 uH (Max.)

3.4 Schematics Description

3.4.1 AC Input Circuit & Differential Filter

There are three components in the section. The Fuse F1 protects against over-current conditions which occur when some main components failed. The LF1 & CX1 are common mode chock filter for the common mode noise suppression because of the large impedance of each coil. The DB1 & DB2 are rectifier, and basically converts alternating current & voltage into direct current & voltage.

3.4.2 AP3108L PWM Controller

The AP3108L PWM controller U1 and Opto-Coupler U4 and Q1 are the power converting core components, connected to filter AC input & after bridge circuit, R1 & R1A resistor path provides start-up voltage and current during starting up phase through HV (Pin 9). Subsequent VCC power will be provided by voltage feedback from the auxiliary winding through R3-D7. This design is to accommodate required wide arrange voltage range to support various protocols from 5V to 20V.

Based on feedback of secondary side current of information (Pin VFB_Out of AP43771 Decoder) through Opto-coupler U4 to primary side (FB pin of AP3108L), AP3108L PWM controller will switch ON and Off Q1 to regulate desired voltage and current on the secondary side.

3.4.3 APR348 Synchronous Rectification (SR) MOSFET Driver

The IC APR348 is SR Mosfet driver would operate at DCM/CCM mode in this design that based on input voltage & current loading. As the power loss with the APR346-controlled MOSFET Q2 that is less than Schottky Diodes, the total efficiency can be improved.

3.4.4 AP43771 PD 3.0 Decoder & Protection on/off P MOSFET and Interface to Power Devices

Few important pins provide critical protocol decoding and regulation functions in AP43771:

1) **CC1 & CC2 (Pin 7, 8)**: CC1 & CC2 (Configuration Channel 1 & 2) are defined by USB Type-C spec to provide the channel communication link between power source and sink device.
2) **Constant Voltage (CV)**: The CV is implemented by sensing VFB (pin 8) and comparing with internal reference voltage to generate a CV compensation signal on the OCDRV pin (pin 5). There is a loop compensation circuit C13 & R31 between Pin8 & Pin5, and the voltage response speed can be controlled by adjusting their value. The output voltage is controlled by firmware through CC1/CC2 channel communication with the sink device.
3) **Over Current Protection (OCP)**: The OCP is implemented by using R33 between Pin3 & Pin4.

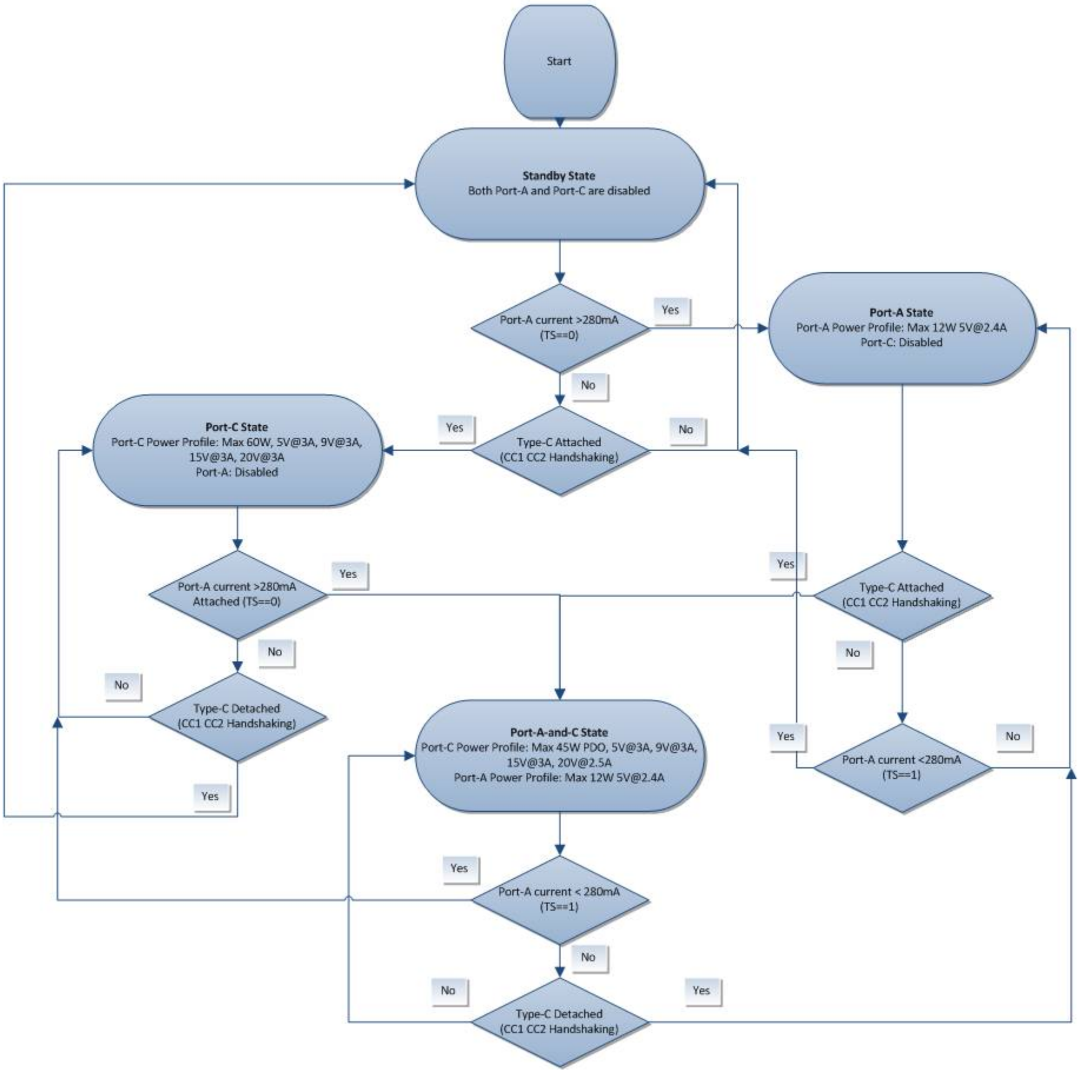
4) **OCDRV (Pin5)**: It is the key interface link from secondary decoder (AP43771) to primary regulation circuit (AP3108L). It is connected to Opto-coupler U4B Cath for feedback information based on all sensed CC1/ CC2 signals for getting desired Vbus voltage & current.
5) **PWR_ENB (Pin2) to N-MOSFET Gate**: The pin is used to turn on/off N-MOSFET (Q4) to enable/disable voltage output to the Vbus.

3.4.5 Detection of A-Port Connection and Power Sharing Scheme

Detection of A-Port connection is simply done by using current sense resister (R46 & R46A) and a single amplifier (U6). A-Port is connected by Type A to Micro B cable (to Phone). A-Port charge start to charging phone, and charging current flow through R46 & R46A, when the voltage of R46 & R46A is bigger than threshold voltage set by R44 & R45, the output of amplifier U6-V_{TS} would turn into low voltage(close to 0V).

In separate path, OTP Pin (Pin 7) of AP43771, served as a GPIO pin, is used to notify embedded MCU of AP43771 to trigger proper power sharing algorithm – 15W reserved for Port A and balance of maximum power design less 15W will be allocated to Port C to perform PD3.0 power profile functions.

Power Sharing Control Sequence



Chapter 4. The Evaluation Board (EVB) Connections

4.1 EVB PCB Layout

The thickness for both sides of PCB board trace cooper is 2 Oz.

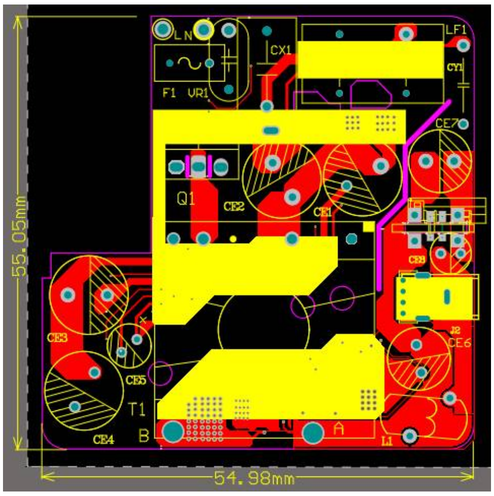


Figure 4: PCB Board Layout Top View

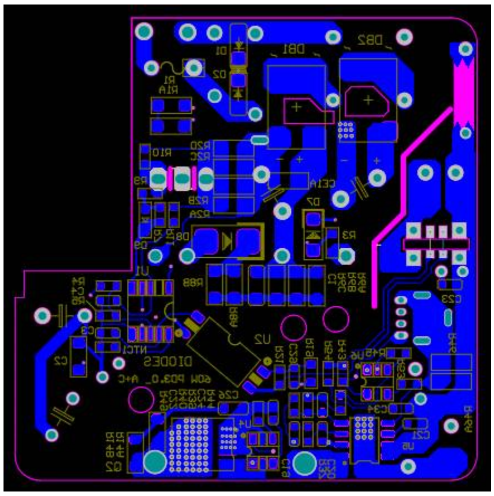


Figure 5: PCB Board Layout Bottom View

4.2 Quick Start Guide Before Connection

1) Before starting the 60W_A+C EVB test, the end user needs to prepare the following tool, software and manuals.

For details, please consult USBCEE sales through below link for further information.

USBCEE PD3.0 Test Kit: USBCEE Power Adapter Tester. https://www.usbcee.com/product-details/4

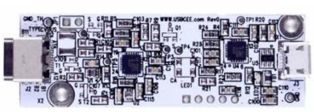
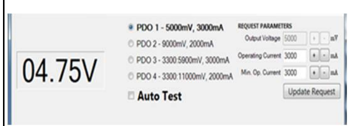
USBCEE PAT Tester	GUI Display	USB-A to Micro-B Cable	Type-C Cable
			

Figure 6: Test Kit / Test Cables

2) Prepare a certified three-foot Type-C cable and a Standard-A to Micro-B Cable.

3) Connect the AC inputs: L & N wires of EVB to AC power supply output “L and N “wires.

4) Ensure that the AC source is switched OFF or disconnected before the connection steps.

5) A type-C cable for the connection between EVB’s and Type-C receptacles of test kit.

6) Output of Type-C port & USB A-port are connected to E-load + & - terminals by cables.

4.3 System Setup

4.3.1 Connection with E-Load

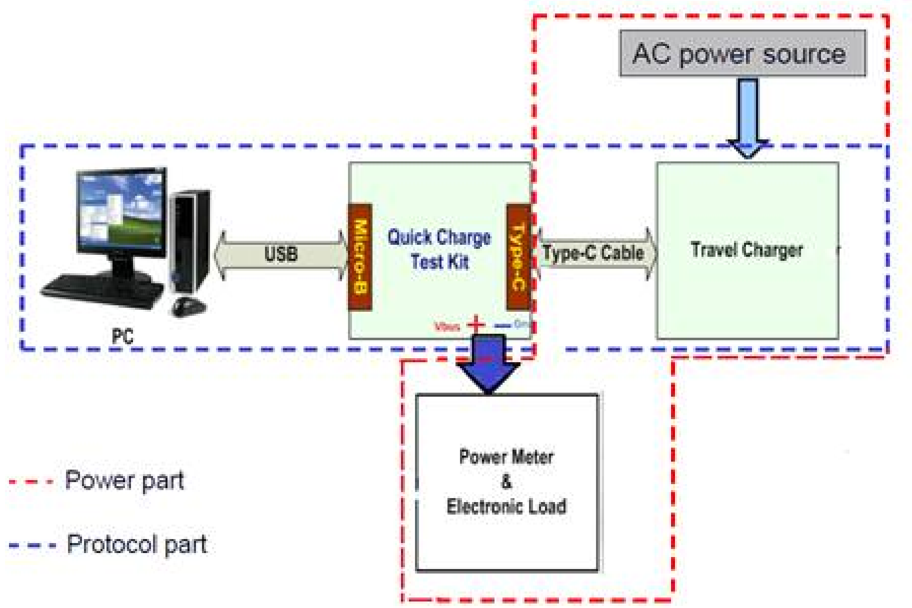


Figure 7: Diagram of Connections in the Sample Board

4.3.2 USBCEE PAT Tester

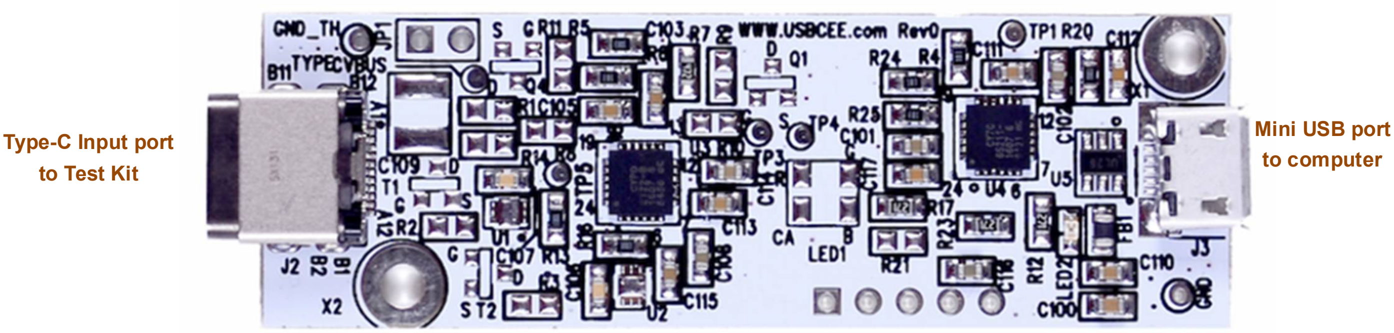


Figure 8: The Test Kit Input & Output and E-load Connections

4.3.3 Input & Output Wires Connection

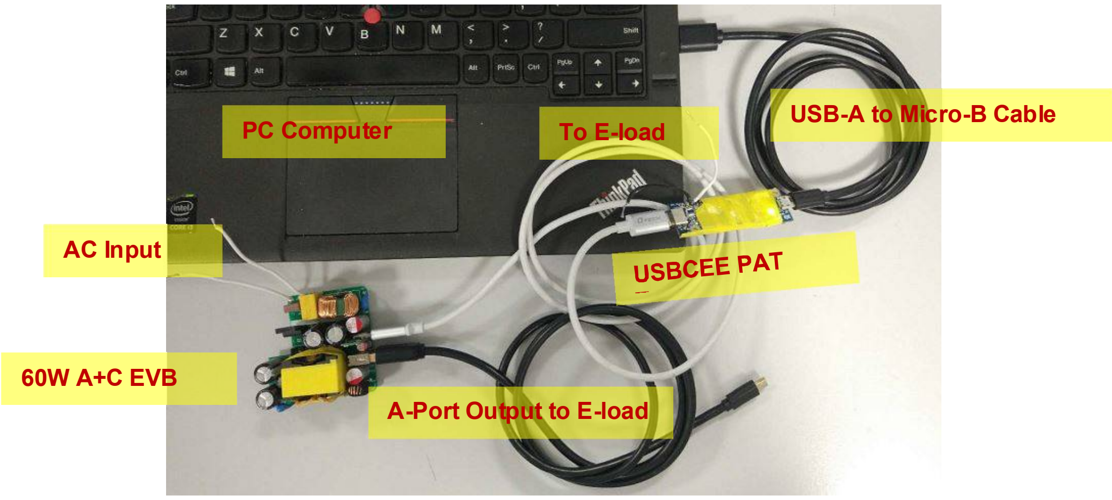


Figure 9: Wire Connection of 60W A+C PD3.0 EVB to Test Kit and PC Computer

Chapter 5. Testing the Evaluation Board

5.1 Input & Output Characteristics

5.1.1 Input Standby Power

	Input Voltage (Vac)	Standby Power (mW)
60W A+C PD3.0 Charger (USB-A Port =5V/0A & USB-Type C Port=5V/0A)	115	66
	230	70
60W A+C PD3.0 Charger USB-A board is disconnected (USB-Type C Port = 5V/0A)	115	28
	230	36

5.1.2 Input Power Efficiency at Different AC Line Input Voltage

<table>
<tr><th>Vin(VAC)</th><th>Freq(HZ)</th><th>Vin(V)</th><th>Iin(A)</th><th>PF</th><th>Pin(W)</th><th>Vout(V)</th><th>Iout(A)</th><th>Pout(W)</th><th>Eff（%)</th></tr>
<tr><td rowspan="2">90</td><td rowspan="2">47</td><td rowspan="2">90.01</td><td rowspan="2">0.72</td><td rowspan="2">0.474</td><td rowspan="2">30.79</td><td>5.035</td><td>3</td><td>15.105</td><td rowspan="2">87.10</td></tr>
<tr><td>4.88</td><td>2.4</td><td>11.712</td></tr>
<tr><td rowspan="2">115</td><td rowspan="2">60</td><td rowspan="2">115.14</td><td rowspan="2">0.604</td><td rowspan="2">0.437</td><td rowspan="2">30.47</td><td>5.035</td><td>3</td><td>15.105</td><td rowspan="2">88.01</td></tr>
<tr><td>4.88</td><td>2.4</td><td>11.712</td></tr>
<tr><td rowspan="2">230</td><td rowspan="2">50</td><td rowspan="2">230.37</td><td rowspan="2">0.34</td><td rowspan="2">0.387</td><td rowspan="2">30.38</td><td>5.035</td><td>3</td><td>15.105</td><td rowspan="2">88.27</td></tr>
<tr><td>4.88</td><td>2.4</td><td>11.712</td></tr>
<tr><td rowspan="2">264</td><td rowspan="2">63</td><td rowspan="2">264.35</td><td rowspan="2">0.308</td><td rowspan="2">0.374</td><td rowspan="2">30.5</td><td>5.035</td><td>3</td><td>15.105</td><td rowspan="2">87.92</td></tr>
<tr><td>4.88</td><td>2.4</td><td>11.712</td></tr>
<tr><td rowspan="2">90</td><td rowspan="2">47</td><td rowspan="2">90.01</td><td rowspan="2">0.961</td><td rowspan="2">0.513</td><td rowspan="2">44.4</td><td>9.065</td><td>3</td><td>27.195</td><td rowspan="2">88.68</td></tr>
<tr><td>5.075</td><td>2.4</td><td>12.180</td></tr>
<tr><td rowspan="2">115</td><td rowspan="2">60</td><td rowspan="2">115.12</td><td rowspan="2">0.854</td><td rowspan="2">0.447</td><td rowspan="2">44.01</td><td>9.065</td><td>3</td><td>27.195</td><td rowspan="2">89.47</td></tr>
<tr><td>5.075</td><td>2.4</td><td>12.180</td></tr>
<tr><td rowspan="2">230</td><td rowspan="2">50</td><td rowspan="2">230.35</td><td rowspan="2">0.485</td><td rowspan="2">0.393</td><td rowspan="2">44.00</td><td>9.065</td><td>3</td><td>27.195</td><td rowspan="2">89.49</td></tr>
<tr><td>5.075</td><td>2.4</td><td>12.180</td></tr>
<tr><td rowspan="2">264</td><td rowspan="2">63</td><td rowspan="2">264.34</td><td rowspan="2">0.433</td><td rowspan="2">0.383</td><td rowspan="2">43.94</td><td>9.065</td><td>3</td><td>27.195</td><td rowspan="2">89.61</td></tr>
<tr><td>5.075</td><td>2.4</td><td>12.180</td></tr>
<tr><td rowspan="2">90</td><td rowspan="2">47</td><td rowspan="2">89.96</td><td rowspan="2">1.137</td><td rowspan="2">0.532</td><td rowspan="2">54.55</td><td>12.095</td><td>3</td><td>36.285</td><td rowspan="2">88.61</td></tr>
<tr><td>5.022</td><td>2.4</td><td>12.053</td></tr>
<tr><td rowspan="2">115</td><td rowspan="2">60</td><td rowspan="2">115.07</td><td rowspan="2">0.99</td><td rowspan="2">0.473</td><td rowspan="2">54.01</td><td>12.095</td><td>3</td><td>36.285</td><td rowspan="2">89.50</td></tr>
<tr><td>5.022</td><td>2.4</td><td>12.053</td></tr>
<tr><td rowspan="2">230</td><td rowspan="2">50</td><td rowspan="2">230.32</td><td rowspan="2">0.585</td><td rowspan="2">0.397</td><td rowspan="2">53.62</td><td>12.095</td><td>3</td><td>36.285</td><td rowspan="2">90.15</td></tr>
<tr><td>5.022</td><td>2.4</td><td>12.053</td></tr>
<tr><td rowspan="2">264</td><td rowspan="2">63</td><td rowspan="2">263.31</td><td rowspan="2">0.521</td><td rowspan="2">0.387</td><td rowspan="2">53.43</td><td>12.095</td><td>3</td><td>36.285</td><td rowspan="2">90.47</td></tr>
<tr><td>5.022</td><td>2.4</td><td>12.053</td></tr>
<tr><td rowspan="2">90</td><td rowspan="2">47</td><td rowspan="2">90.01</td><td rowspan="2">1.32</td><td rowspan="2">0.548</td><td rowspan="2">65.03</td><td>15.124</td><td>3</td><td>45.372</td><td rowspan="2">88.31</td></tr>
<tr><td>5.022</td><td>2.4</td><td>12.053</td></tr>
<tr><td rowspan="2">115</td><td rowspan="2">60</td><td rowspan="2">115.12</td><td rowspan="2">1.123</td><td rowspan="2">0.496</td><td rowspan="2">64.11</td><td>15.124</td><td>3</td><td>45.372</td><td rowspan="2">89.57</td></tr>
<tr><td>5.022</td><td>2.4</td><td>12.053</td></tr>
<tr><td rowspan="2">230</td><td rowspan="2">50</td><td rowspan="2">230.35</td><td rowspan="2">0.682</td><td rowspan="2">0.4</td><td rowspan="2">63.03</td><td>15.124</td><td>3</td><td>45.372</td><td rowspan="2">91.11</td></tr>
<tr><td>5.022</td><td>2.4</td><td>12.053</td></tr>
<tr><td rowspan="2">264</td><td rowspan="2">63</td><td rowspan="2">264.34</td><td rowspan="2">0.613</td><td rowspan="2">0.391</td><td rowspan="2">63.59</td><td>15.124</td><td>3</td><td>45.372</td><td rowspan="2">90.30</td></tr>
<tr><td>5.022</td><td>2.4</td><td>12.053</td></tr>
<tr><td rowspan="2">90</td><td rowspan="2">47</td><td rowspan="2">89.96</td><td rowspan="2">1.327</td><td rowspan="2">0.548</td><td rowspan="2">65.46</td><td>20.183</td><td>2.25</td><td>45.412</td><td rowspan="2">87.86</td></tr>
<tr><td>5.042</td><td>2.4</td><td>12.101</td></tr>
<tr><td rowspan="2">115</td><td rowspan="2">60</td><td rowspan="2">115.07</td><td rowspan="2">1.127</td><td rowspan="2">0.5</td><td rowspan="2">64.86</td><td>20.183</td><td>2.25</td><td>45.412</td><td rowspan="2">88.67</td></tr>
<tr><td>5.042</td><td>2.4</td><td>12.101</td></tr>
<tr><td rowspan="2">230</td><td rowspan="2">50</td><td rowspan="2">230.32</td><td rowspan="2">0.686</td><td rowspan="2">0.4</td><td rowspan="2">63.28</td><td>20.183</td><td>2.25</td><td>45.412</td><td rowspan="2">90.89</td></tr>
<tr><td>5.042</td><td>2.4</td><td>12.101</td></tr>
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<tr><td>5.042</td><td>2.4</td><td>12.101</td></tr>
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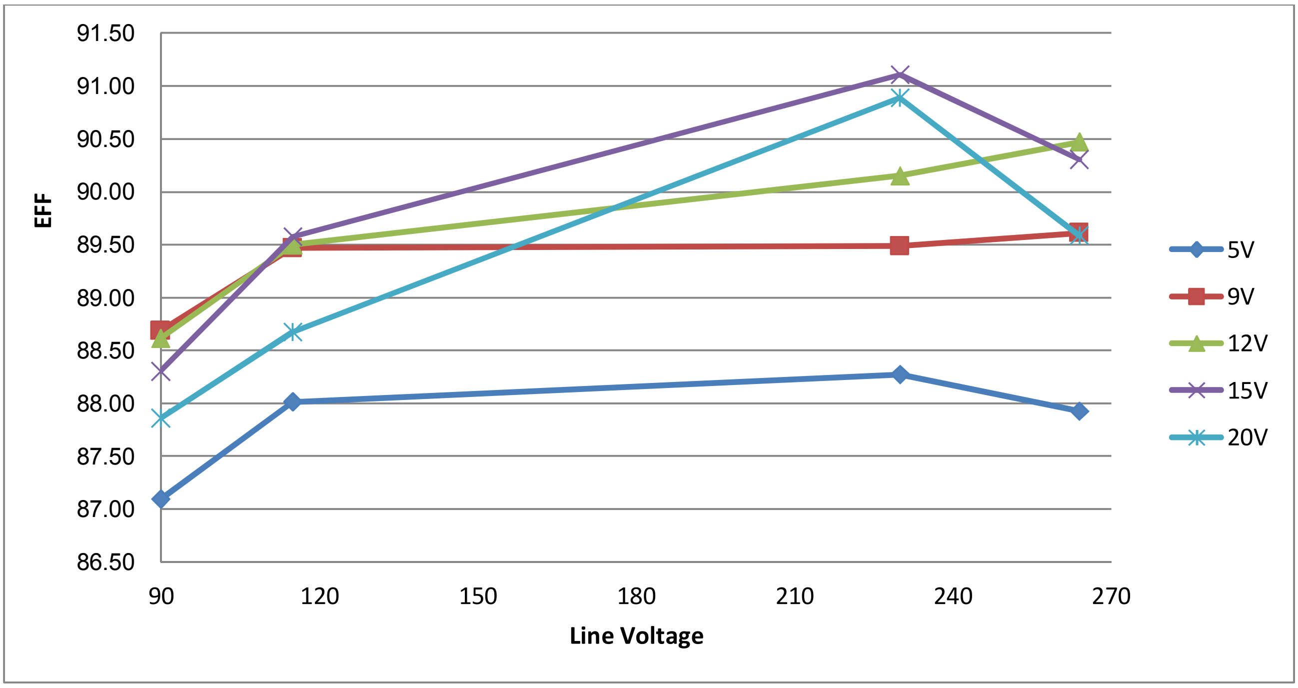
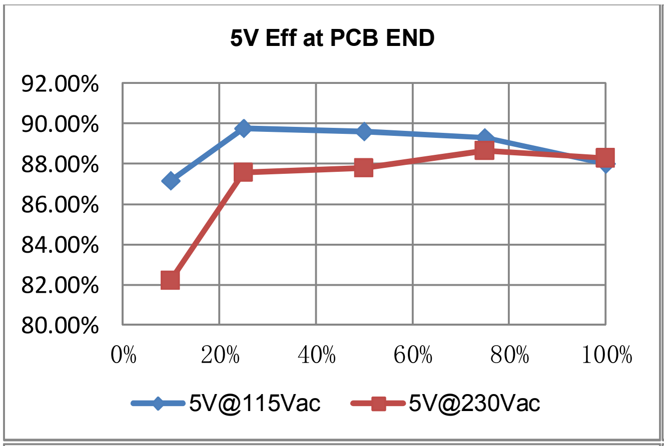
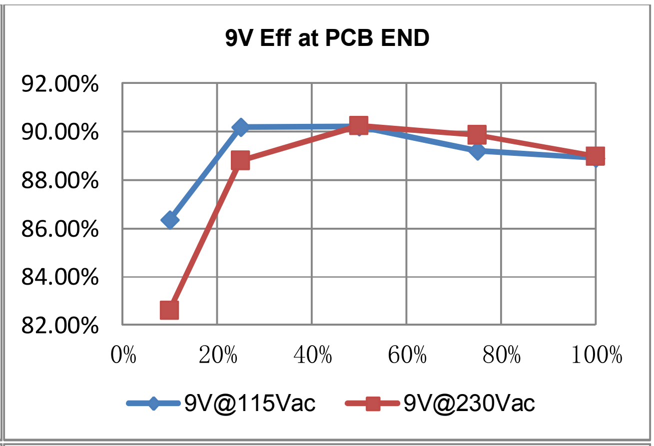
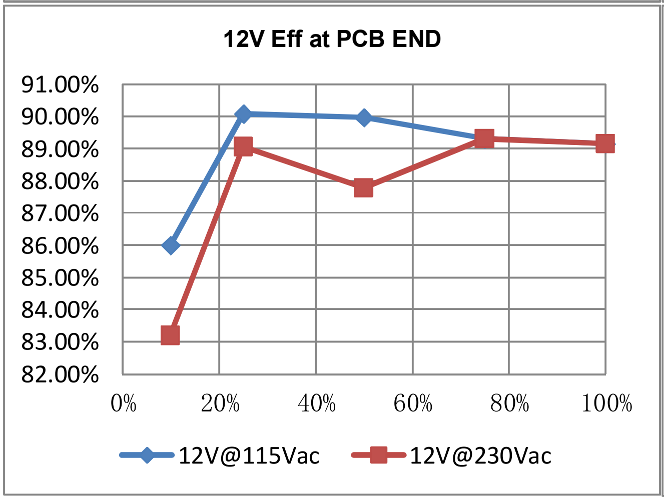


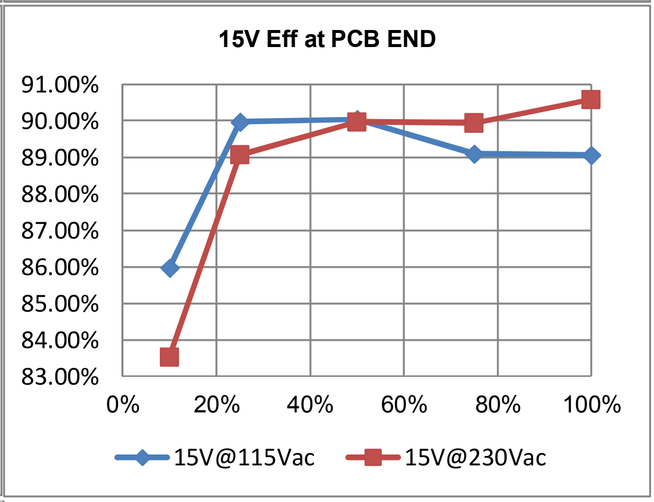
5.1.3 Average Efficiency at Different Loading

Vin	Vo	25% Load	50% Load	75% Load	100% Load	Average Efficiency	Energy Star Level VI	10% Load Efficiency
115V/60Hz	PDO=5V/3A & 5V-2.4A	89.76%	89.62%	89.29%	87.99%	88.16%	>80.82%	87.17%
	PDO=9V/3A & 5V-2.4A	90.18%	90.20%	89.21%	88.90%	89.29 %	>83.58%	86.35%
	PDO=12V/3A & 5V-2.4A	90.08%	89.97%	89.31%	89.15%	88.94%	>85.13%	86.01%
	PDO=15V/3A & 5V-2.4A	89.97%	90.04%	89.10%	89.06%	88.83%	>86.00%	85.98%
	PDO=20V/2.25A & 5V-2.4A	88.64%	90.45%	89.54%	88.27%	89.12%	>86.00%	80.12%
230V/50Hz	PDO=5V/3A & 5V-2.4A	87.58%	87.79%	88.64%	88.29%	88.08%	>80.82%	82.21%
	PDO=9V/3A & 5V-2.4A	88.80%	90.23%	89.85%	88.97%	89.46%	>83.58%	82.59%
	PDO=12V/3A & 5V-2.4A	89.06%	87.79%	89.31%	89.15%	89.19%	>85.13%	83.20%
	PDO=15V/3A & 5V-2.4A	89.06%	89.97%	89.93%	90.59%	89.53%	>86.00%	83.54%
	PDO=20V/2.25A & 5V-2.4A	88.75%	89.92%	89.44%	90.47%	89.65%	>86.00%	78.98%


5V Eff at PCB END
92.00%
90.00%
88.00%
86.00%
84.00%
82.00%
80.00%
0%
20%
40%
60%
80%
100%
5V@115Vac
5V@230Vac


9V Eff at PCB END
92.00%
90.00%
88.00%
86.00%
84.00%
82.00%
0%
20%
40%
60%
80%
100%
9V@115Vac
9V@230Vac


12V Eff at PCB END
91.00%
90.00%
89.00%
88.00%
87.00%
86.00%
85.00%
84.00%
83.00%
82.00%
0%
20%
40%
60%
80%
100%
12V@115Vac
12V@230Vac


15V Eff at PCB END
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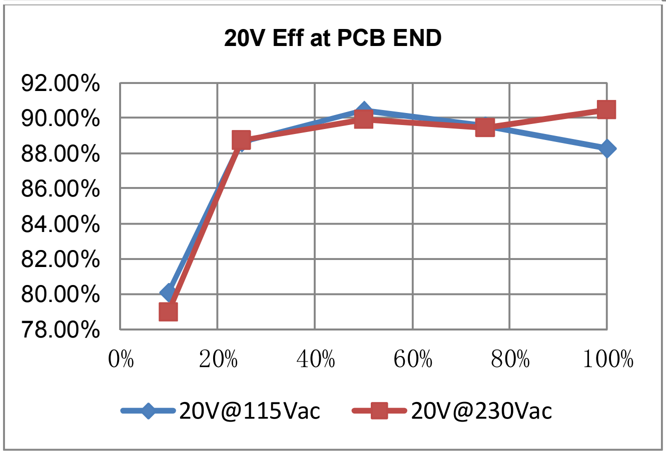
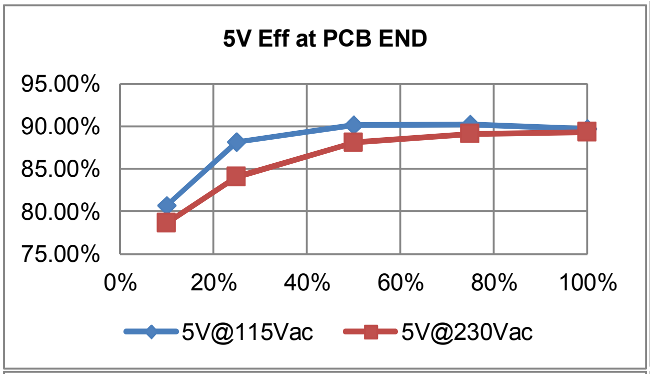
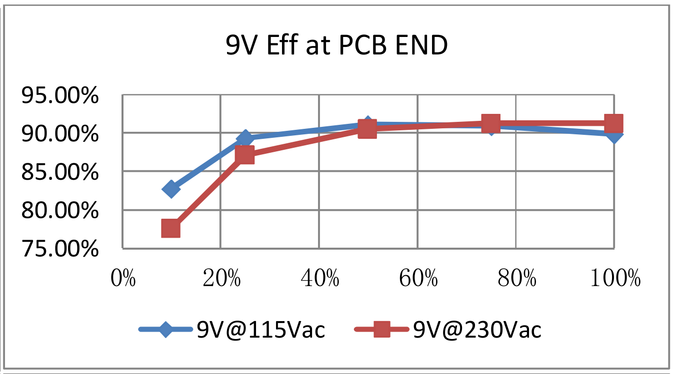
90.00%
89.00%
88.00%
87.00%
86.00%
85.00%
84.00%
83.00%
0%
20%
40%
60%
80%
100%
15V@115Vac
15V@230Vac

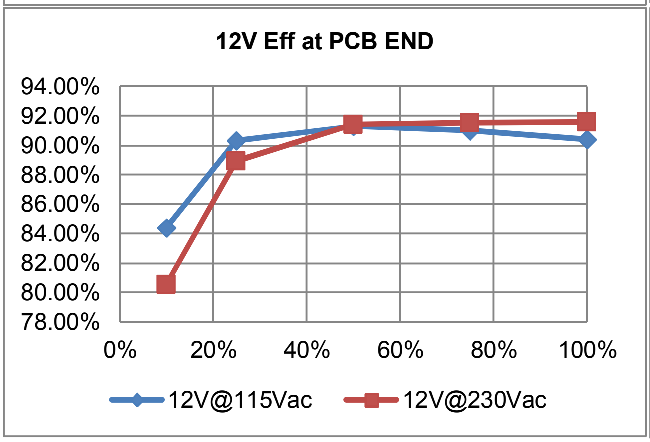

20V Eff at PCB END
92.00%
90.00%
88.00%
86.00%
84.00%
82.00%
80.00%
78.00%
0%
20%
40%
60%
80%
100%
20V@115Vac
20V@230Vac

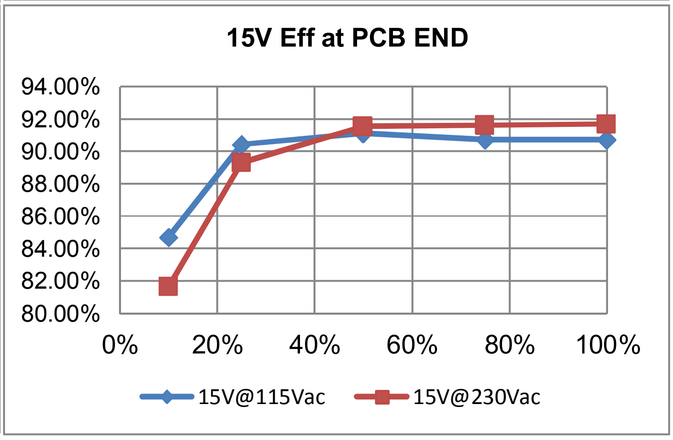
5.1.4 60W A+C PD3.0 Type-C Port Average Efficiency at Different Loading (USB-A Port Off)

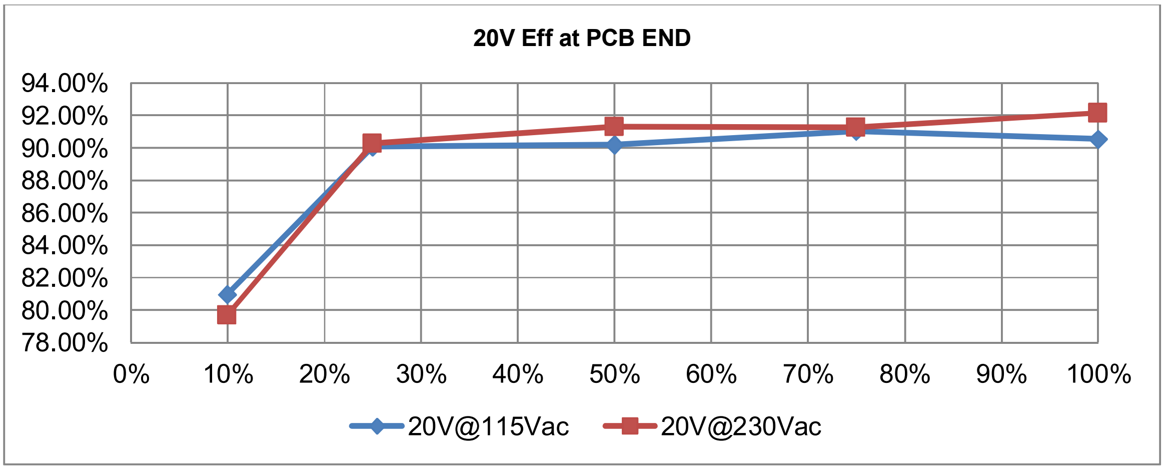
Vin	Vo	25% Load	50% Load	75% Load	100% Load	Average Efficiency	Energy Star Level VI	10% Load Efficiency
115V/60Hz	PDO=5V/3A	88.16%	90.17%	90.18%	89.71%	89.56%	>81.39%	80.71%
	PDO=9V/3A	89.30%	91.06%	90.95%	89.88%	90.30%	>86.62%	82.77%
	PDO=12V/3A	90.32%	91.30%	90.98%	90.40%	90.75%	>87.74%	84.41%
	PDO=15V/3A	90.44%	91.12%	90.72%	90.73%	90.75%	>87.73%	84.69%
	PDO=20V/3A	90.06%	90.20%	91.05%	90.52%	90.46%	>88.00%	80.97%
230V/50Hz	PDO=5V/3A	84.06%	88.10%	89.12%	89.34%	87.65%	>81.39%	78.63%
	PDO=9V/3A	87.14%	90.53%	91.23%	91.22%	90.03%	>86.62%	77.62%
	PDO=12V/3A	88.91%	91.43%	91.56%	91.59%	90.87%	>87.74%	80.55%
	PDO=15V/3A	89.33%	91.55%	91.60%	91.68%	91.04%	>87.73%	81.69%
	PDO=20V/3A	90.28%	91.31%	91.25%	92.15%	91.25%	>88.00%	79.70%





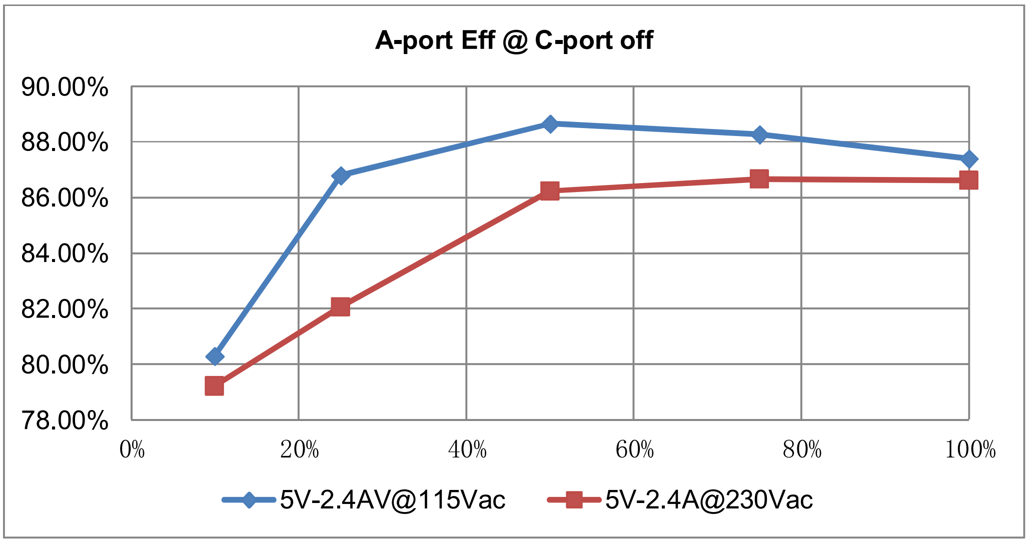






5.1.5 USB-A Port Average Efficiency at Different Loading (Type-C Port Off)

Vin	Vo	25% Load	50% Load	75% Load	100% Load	Average Efficiency	Energy Star Level VI	10% Load Efficiency
115V/60Hz	5V-2.4A	86.80%	88.67%	88.27%	87.41%	87.79%	>79.94%	80.30%
230V/50Hz	5V-2.4A	82.07%	86.25%	86.67%	86.63%	85.40%	>79.94%	79.23%



5.2 Key Performance Waveforms

5.2.1 60W A+C PD3.0 System Start-up Time

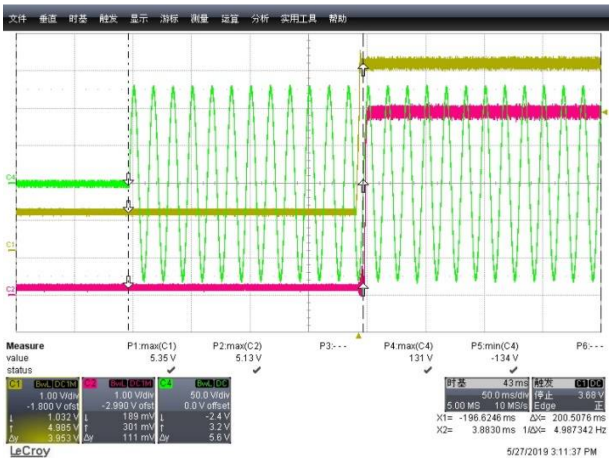


Figure 10: 60W A+C turn on time is 0.2s at Full Load @ 90Vac

5.2.2 Q1 /Q2 Main Switching Voltage MOSFET Stress on at Full Load @264Vac

Primary side MOSFET - Q1

Figure 11: Q1 Vds Voltage stress

Secondary side SR MOSFET- Q2

Figure 12: Q2 Vds Voltage stress

Vout	Vds(V)	Vds_Max_Spec	Ratio of voltage stress	Vout	Vds(v)	Vds_Max_Spec	Ratio of voltage stress
20V	587V	650V	90.30%	20V	83.5V	100V	83.5%*

5.2.3 System Output Ripple & Noise with @ PCB End

5.2.3.1 Type-C Output Ripple & Noise with @ PCB End

Figure 13: 90Vac/60Hz ΔV=68.5mV @5V/0A

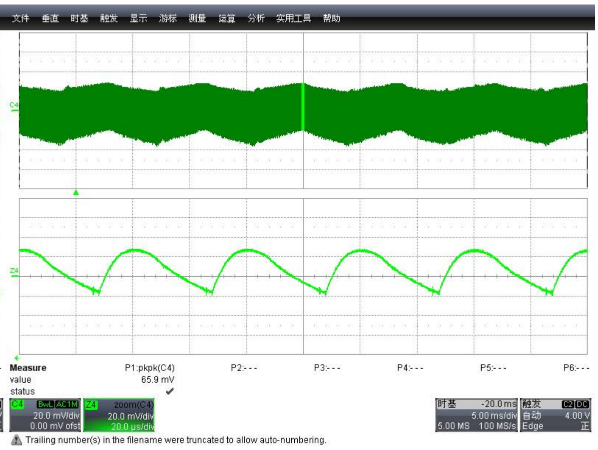


Figure 14: 264Vac/50Hz ΔV=65.9mv@ 5V/0A

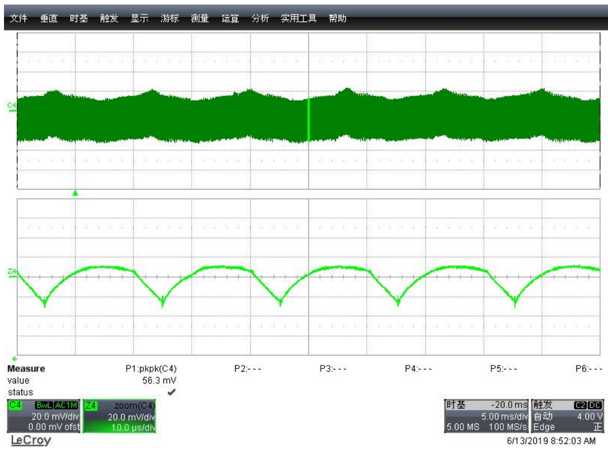


Figure 15: 90Vac/60Hz@ 5V/3A ΔV=56.3mV

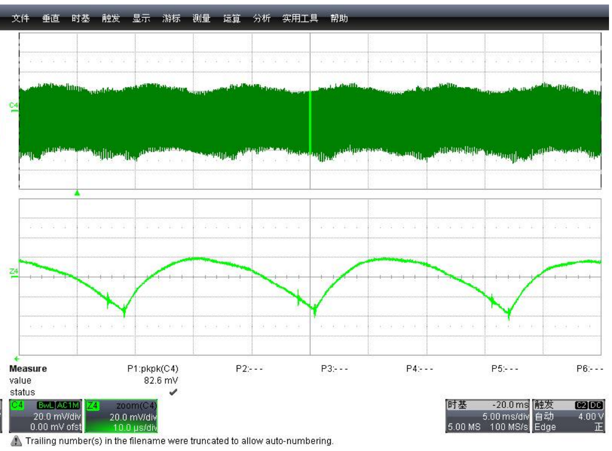


Figure 16: 264Vac/50Hz@5V/3A ΔV=82.6mv

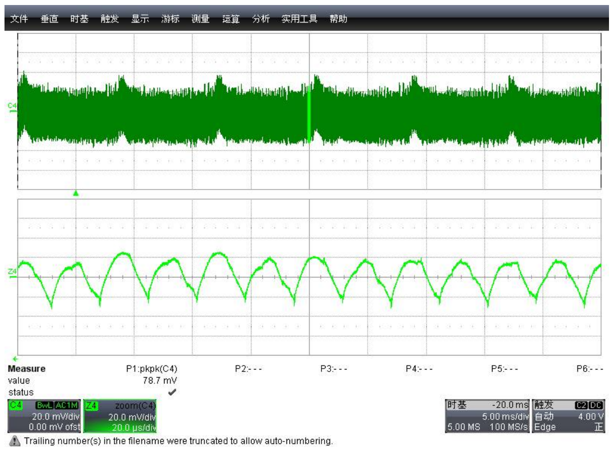


Figure 17: 90Vac/60Hz@9V/0A ΔV=78.7mV

Figure 18: 264Vac/50Hz @9V/0A ΔV=62.7mV

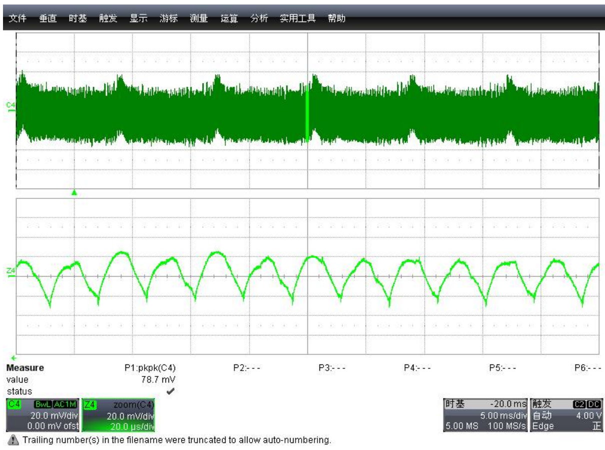


Figure 19: 90Vac/60Hz@9V/3A ΔV=78.7mV

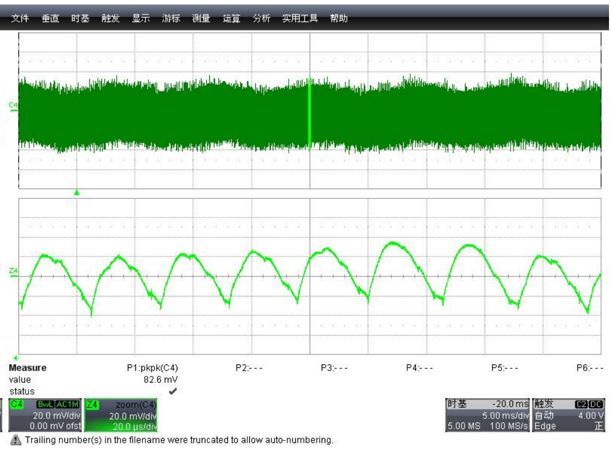


Figure 20: 264Vac / 60Hz@9V/3A ΔV=82.6mV

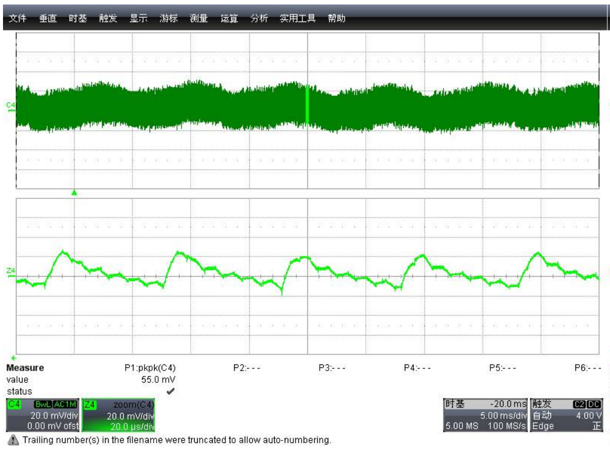


Figure 21: 90Vac/60Hz@12V/0A ΔV=55mV

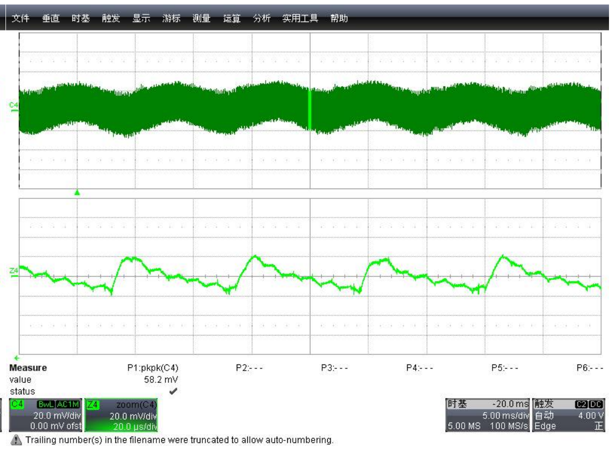


Figure 22: 264Vac / 60Hz@12V/0A ΔV=58.2mV

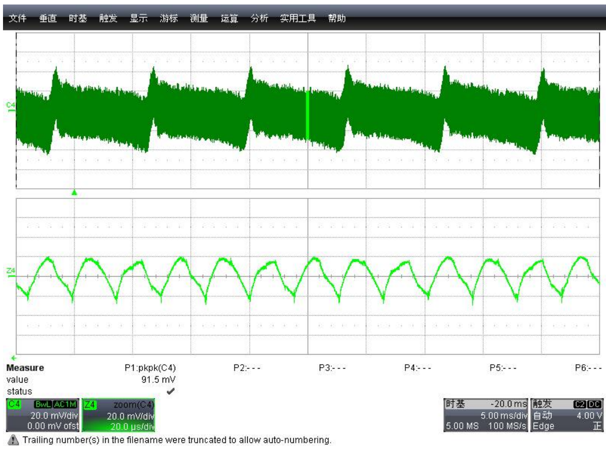


Figure 23: 90Vac/60Hz@12V/3A ΔV=91.5mV

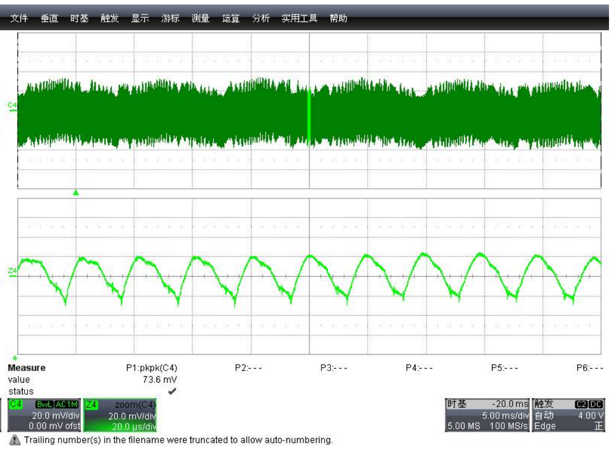


Figure 24: 264Vac / 60Hz@12V/3A ΔV=73.6mV

Figure 25: 90Vac/60Hz@15V/0A ΔV=51.8mV

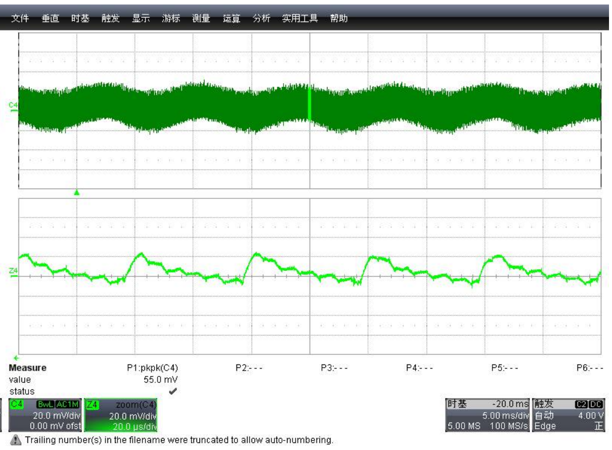


Figure 26: 264Vac / 60Hz@15V/0A ΔV=55mV

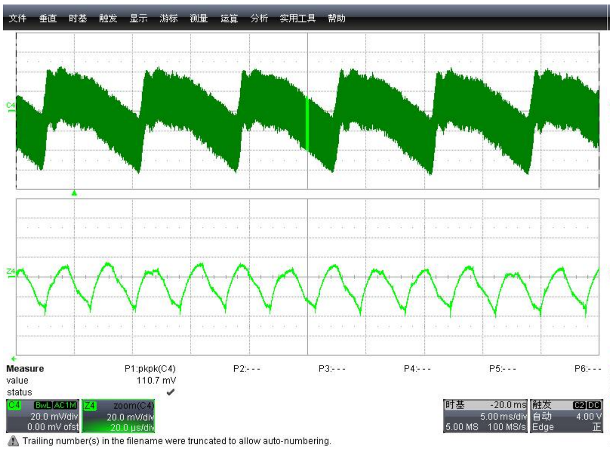


Figure 27: 90Vac/60Hz@15V/3A ΔV=110.7mV

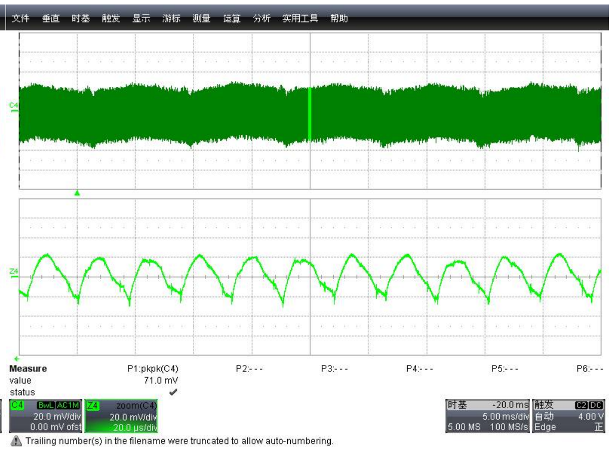


Figure 28: 264Vac / 60Hz@15V/3A ΔV=71mV

Figure 29: 90Vac/60Hz@20V/0A ΔV=46.7mV

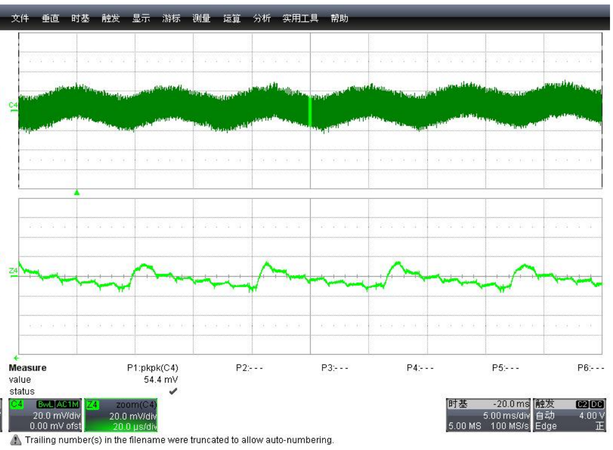
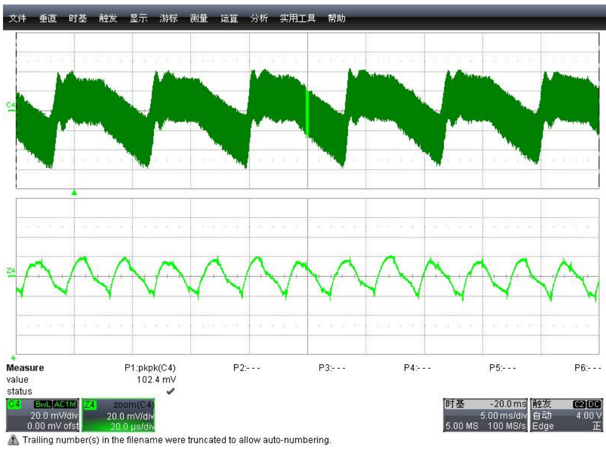


Figure 30: 264Vac / 60Hz@20V/0A ΔV=54.4mV



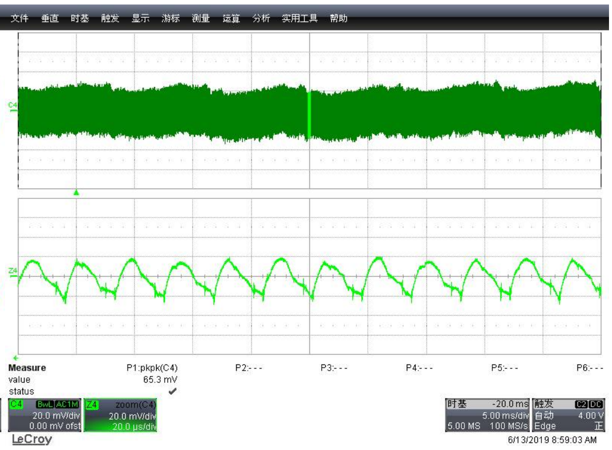
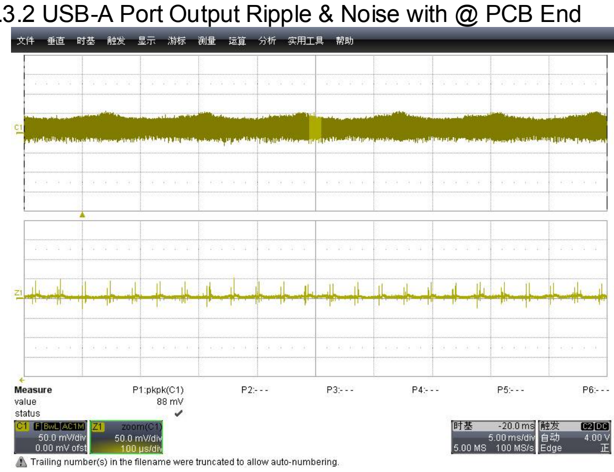


Figure 31: 90Vac/60Hz@20V/2.25A ΔV=102.4mV **Figure 32: 264Vac / 60Hz@20V/2.25A ΔV=65.3mV**

5.2.3.2 USB-A Port Output Ripple & Noise with @ PCB End



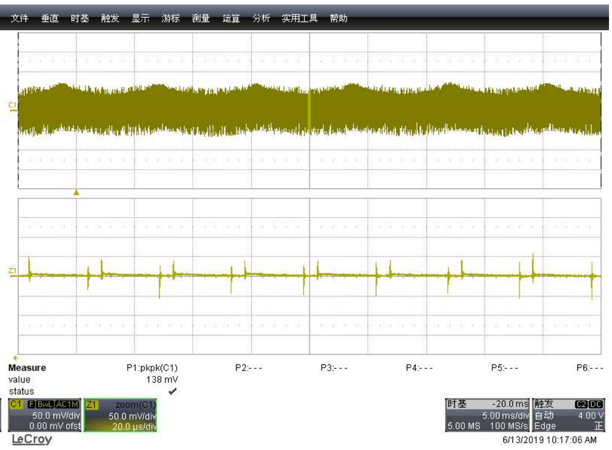
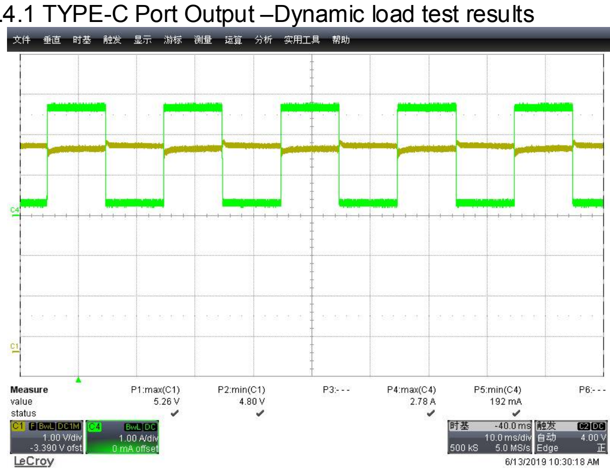


Figure 33: 5V/0A ΔV=88mV **Figure 34: 5V/2.4A ΔV=138mV**

5.2.4 Dynamic load ----10% Load~90% Load, T=10mS, Rate=100mA/uS (PCB End)

5.2.4.1 TYPE-C Port Output –Dynamic load test results



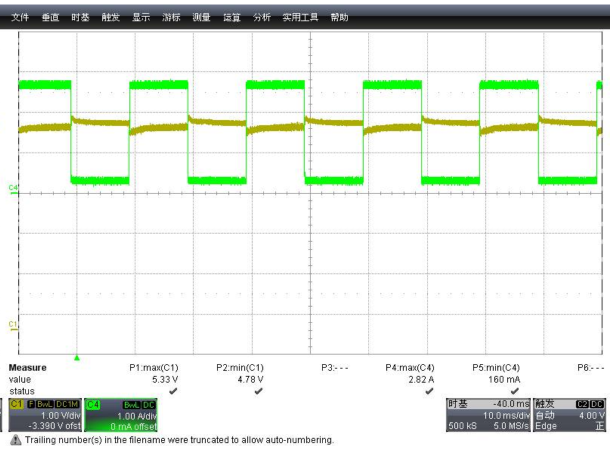


Figure 28: 90Vac / 60Hz Port-C@ Vout=5V **Figure 29: 264Vac / 60Hz Port-C@ Vout=5V**

Figure 30: 90Vac / 60Hz Port-C@ Vout=9V

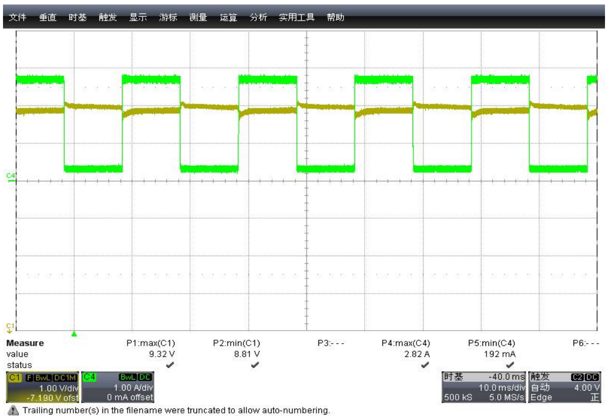


Figure 31: 264Vac / 60Hz Port-C@ Vout=9V

	Vo_ Undershoot(V)	Vo_ Overshoot(V)		Vo_Undershoot(V)	Vo_Overshoot(V)
Vin =90Vac@5V	4.80	5.26	Vin =90Vac@9V	8.84	9.27
Vin=264Vac@5V	4.78	5.23	Vin=264Vac@9V	8.81	9.32

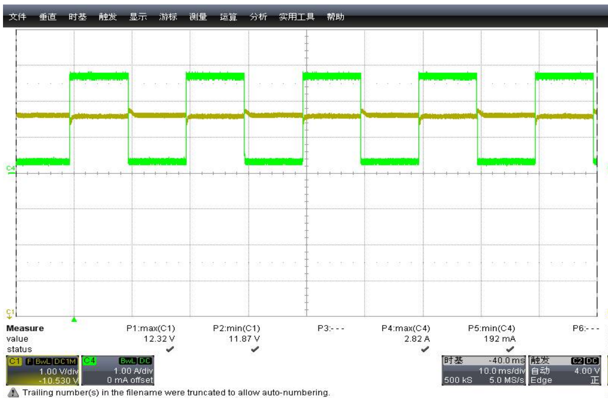


Figure 32: 90Vac / 60Hz Port-C@ Vout=12V

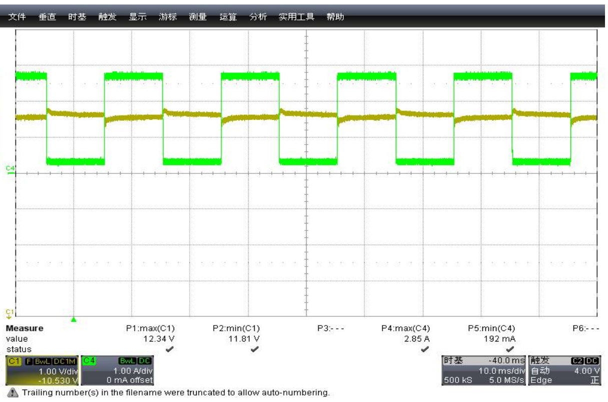


Figure 33: 264Vac / 60Hz Port-C@ Vout=12V

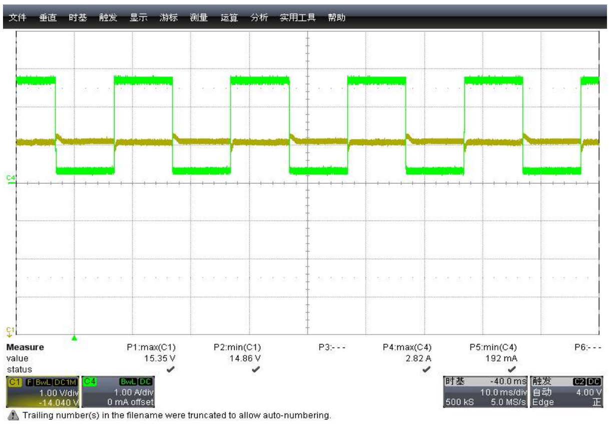


Figure 34: 90Vac / 60Hz Port-C@ Vout=15V

Figure 35: 264Vac / 60Hz Port-C@ Vout=15V

	Vo_ Undershoot(V)	Vo_ Overshoot(V)		Vo_Undershoot(V)	Vo_Overshoot(V)
Vin =90Vac@12V	11.87	12.32	Vin =90Vac@15V	14.86	15.35

Vin=264Vac@12V	11.81	12.34	Vin=264Vac@15V	14.79	15.34

Figure 36: 90Vac / 60Hz Port-C@ Vout=20V

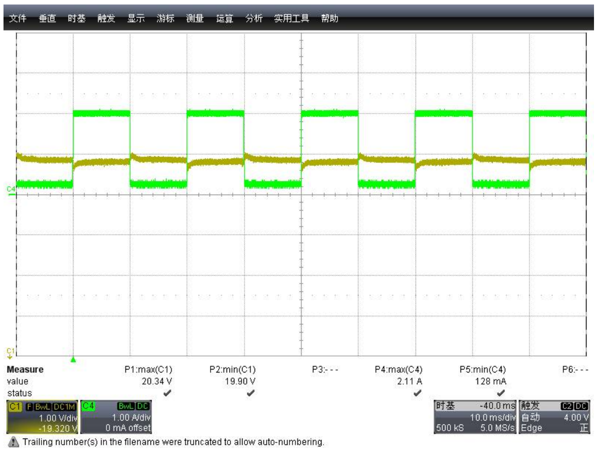


Figure 37: 264Vac / 60Hz Port-C@ Vout=20V

	Vo_ Undershoot(V)	Vo_ Overshoot(V)		Vo_Undershoot(V)	Vo_Overshoot(V)
Vin =90Vac@20V	19.94	20.36	Vin =264Vac@20V	19.90	20.34

5.2.4.2 USB A-Port Output –Dynamic load test results

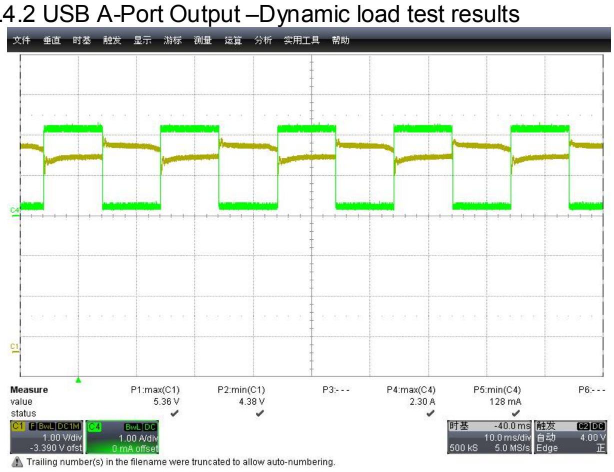


Figure 38: Port-C_VOUT =5V

Figure 39: Port-C_VOUT =9V

	Vo_ Undershoot(V)	Vo_ Overshoot(V)		Vo_Undershoot(V)	Vo_Overshoot(V)
Port-C_V_{OUT}=5V	4.38	5.36	Port-C_V_{OUT}=9V	4.78	5.28

Figure 40: Port-C_VOUT =9V

Figure 41: Port-C_VOUT =12V

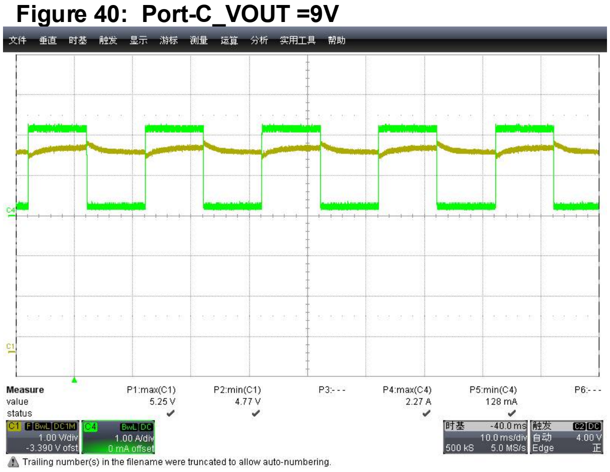


Figure 42: Port-C_VOUT =20V

	Vo_ Undershoot(V)	Vo_ Overshoot(V)		Vo_Undershoot(V)	Vo_Overshoot(V)
Port-C_V_{OUT}=12V	4.77	5.25	Port-C_V_{OUT}=15V	4.78	5.26
Port-C_V_{OUT}=20V	4.77	5.25			

5.2.5 Output Voltage Transition Time from Low to High

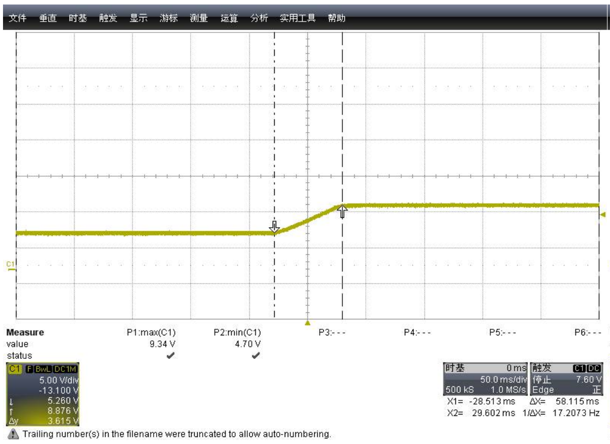


Figure 43: 5V→9V Rise Time: = 58ms

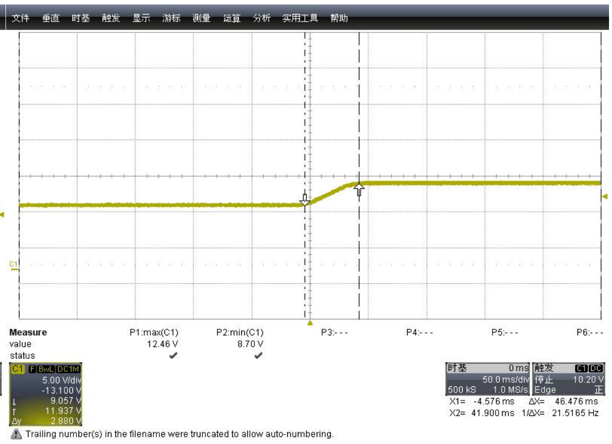


Figure 44: 9V→12V Rise Time: = 47ms

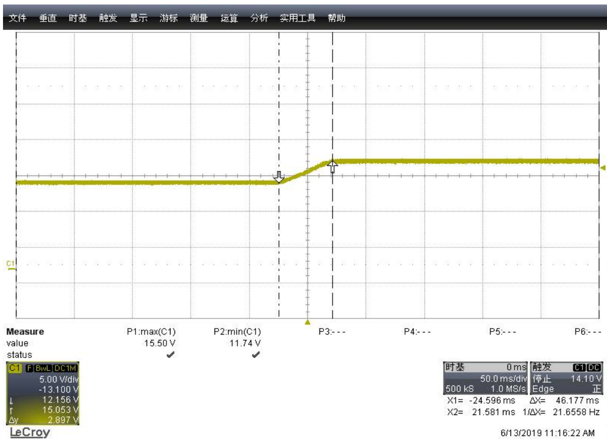


Figure 45: 12V→15V Rise Time: = 46ms

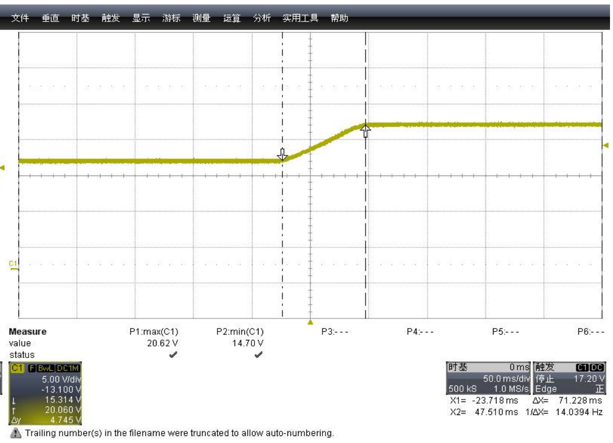


Figure 46: 15V→20V Rise Time: = 71ms

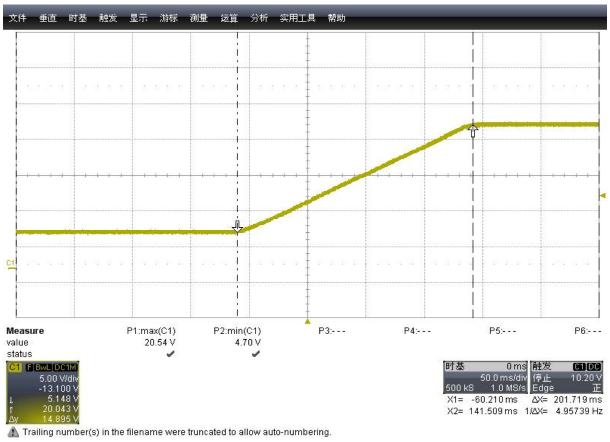


Figure 47: 5V→20V Rise Time: = 202ms

5.2.6 Output Voltage Transition Time from High to Low

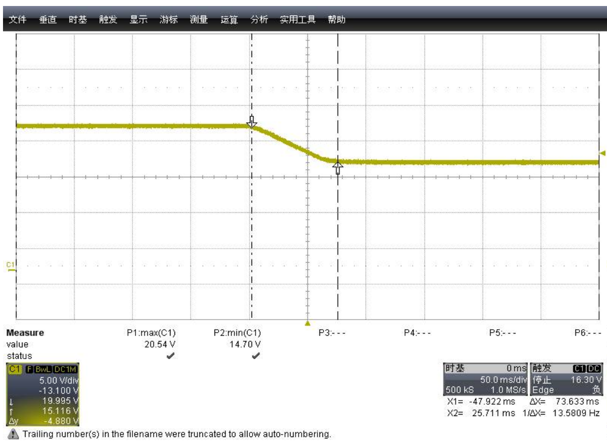


Figure 48: 20V→15V Fall Time = 74ms

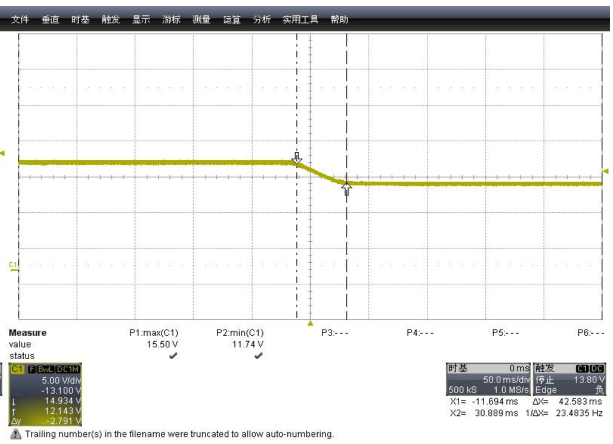


Figure 49: 15V→12V Fall Time = 43ms

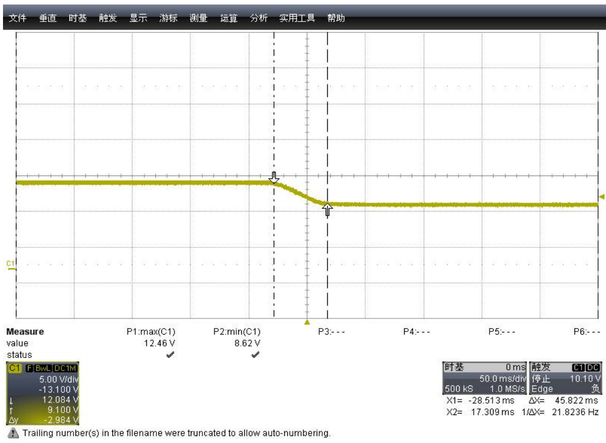


Figure 50: 12V→9V Fall Time = 46ms

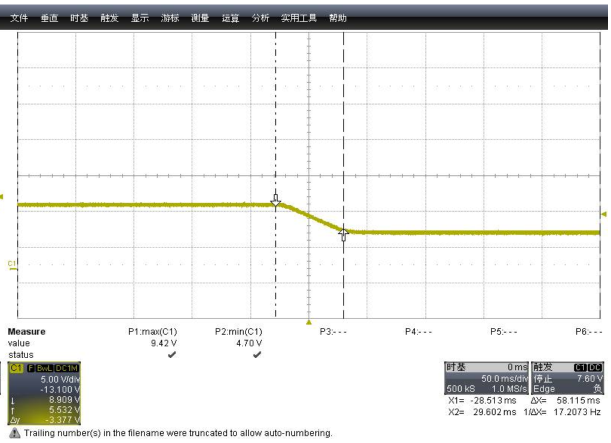


Figure 51: 9V→5V Fall Time = 58ms

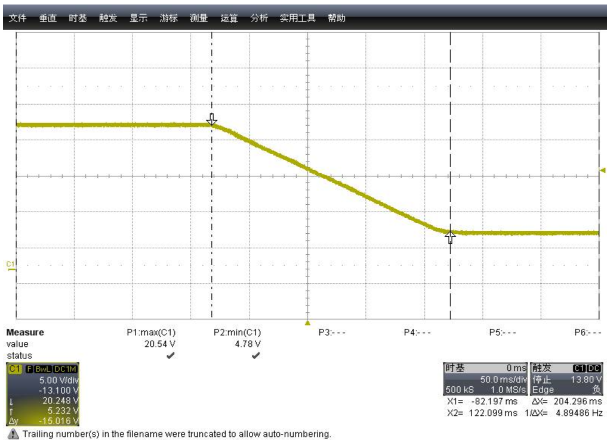


Figure 52: 20V→5V Fall Time = 204ms

5.2.7 Thermal Testing

Test Condition: Vin=90V @ 20V- Full load ,Open Frame

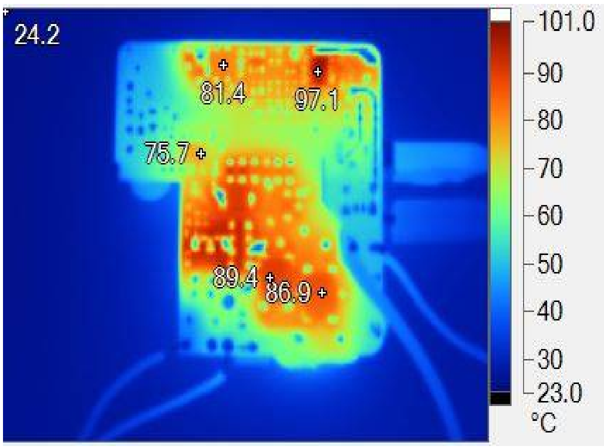


Figure 53: Bottom Suface Mount side

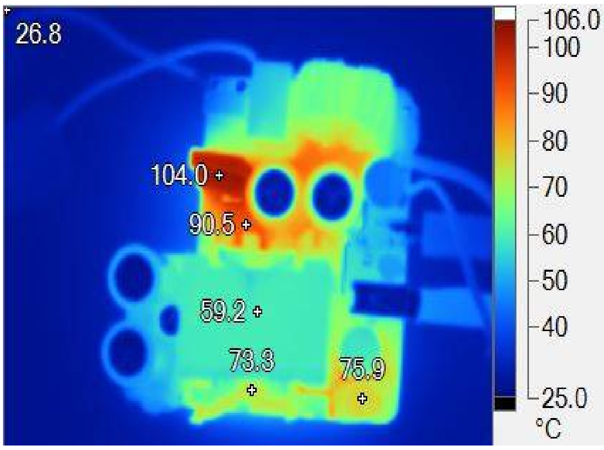


Figure 54: Top Components side

Test Condition: Vin=264Vac @ 20V- Full Load, Open Frame.

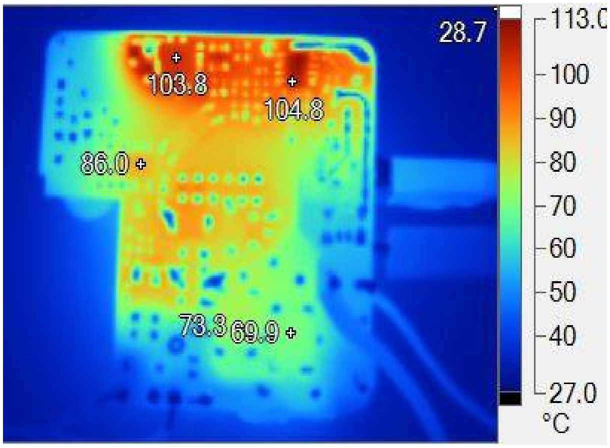


Figure 55: Bottom surface mount side

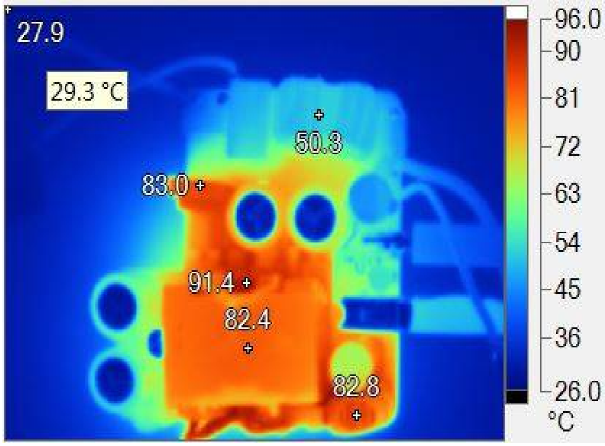


Figure 56: Top components side

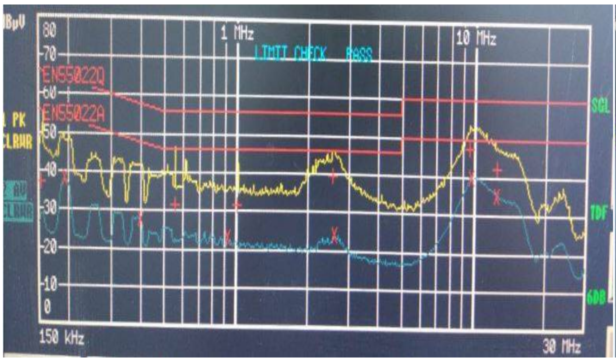
	Temperature		
Test Items	Vin=90V @ Full load	Vin=264V @ Full load	Unit
Ambient Temp	**24.2**	**27.9**	℃
AP3108L	**75.7**	**86**	℃
Q1 (No heatsink) *1	**104**	**83**	℃
EUP3270	**97.1**	**104.8**	℃
T1	**73**	**73**	℃
Q2	**81.4**	**103.8**	℃
DB1	**89.4**	**73.3**	℃
DB2	**86.9**	**69.9**	℃

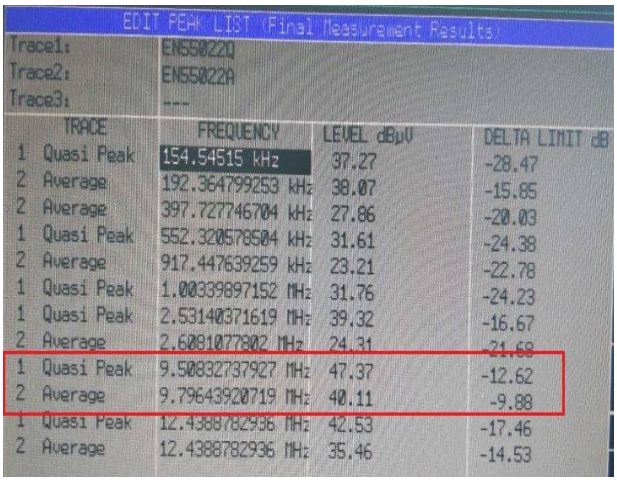
Notes:

1. **Q1 need to use a Heatsink for reducing heat.**
2. **EUP3270 use a thermal rubber pad for spreading heat.**

5.3. EMI (CE) Testing

5.3.1 115Vac @ Full Load testing results



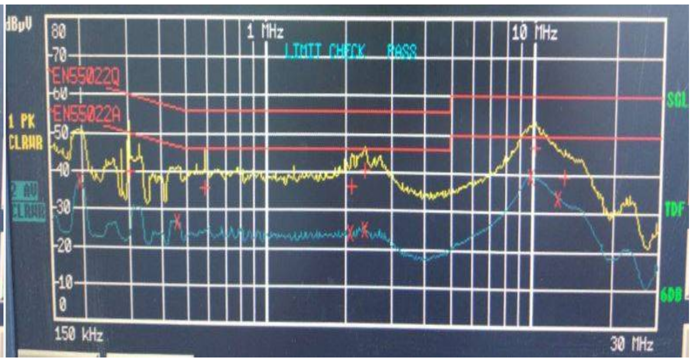


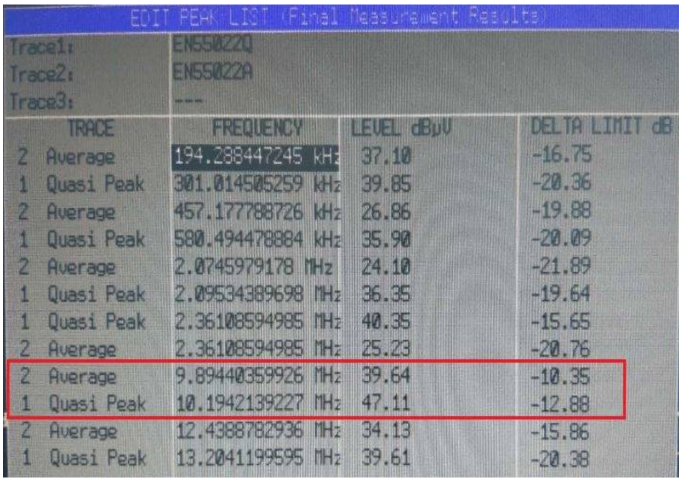
EDIT PEAK LIST (Final Measurement Results)

Trace1: EN55022Q
Trace2: EN55022A
Trace3: ---

TRACE		FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
1	Quasi Peak	154.54515 kHz	37.27	-28.47
2	Average	192.364799253 kHz	38.07	-15.85
2	Average	397.727746704 kHz	27.86	-20.03
1	Quasi Peak	552.320578504 kHz	31.61	-24.38
2	Average	917.447639259 kHz	23.21	-22.78
1	Quasi Peak	1.00339897152 MHz	31.76	-24.23
1	Quasi Peak	2.53140371619 MHz	39.32	-16.67
2	Average	2.6081077802 MHz	24.31	-21.68
1	Quasi Peak	9.50832737927 MHz	47.37	-12.62
2	Average	9.79643920719 MHz	40.11	-9.88
1	Quasi Peak	12.4388782936 MHz	42.53	-17.46
2	Average	12.4388782936 MHz	35.46	-14.53

Figure 57: 115Vac/60Hz L line at Full load





EDIT PEAK LIST (Final Measurement Results)

Trace1: EN55022Q
Trace2: EN55022A
Trace3: ---

TRACE		FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
2	Average	194.288447245 kHz	37.10	-16.75
1	Quasi Peak	301.014505259 kHz	39.85	-20.36
2	Average	457.177788726 kHz	26.86	-19.88
1	Quasi Peak	580.494478884 kHz	35.90	-20.09
2	Average	2.0745979178 MHz	24.10	-21.89
1	Quasi Peak	2.09534389698 MHz	36.35	-19.64
1	Quasi Peak	2.36108594985 MHz	40.35	-15.65
2	Average	2.36108594985 MHz	25.23	-20.76
2	Average	9.89440359926 MHz	39.64	-10.35
1	Quasi Peak	10.1942139227 MHz	47.11	-12.88
2	Average	12.4388782936 MHz	34.13	-15.86
1	Quasi Peak	13.2041199595 MHz	39.61	-20.38

Figure 58: 115Vac/60Hz N line at Full load

L Line		N Line	
Frequency(MHz)	QP Margin	Frequency(MHz)	QP Margin
9.508	12.62	10.194	12.88
Frequency(MHz)	AV Margin	Frequency(MHz)	AV Margin
9.796	9.88	9.894	10.35

5.3.2 230Vac @ Full Load testing results

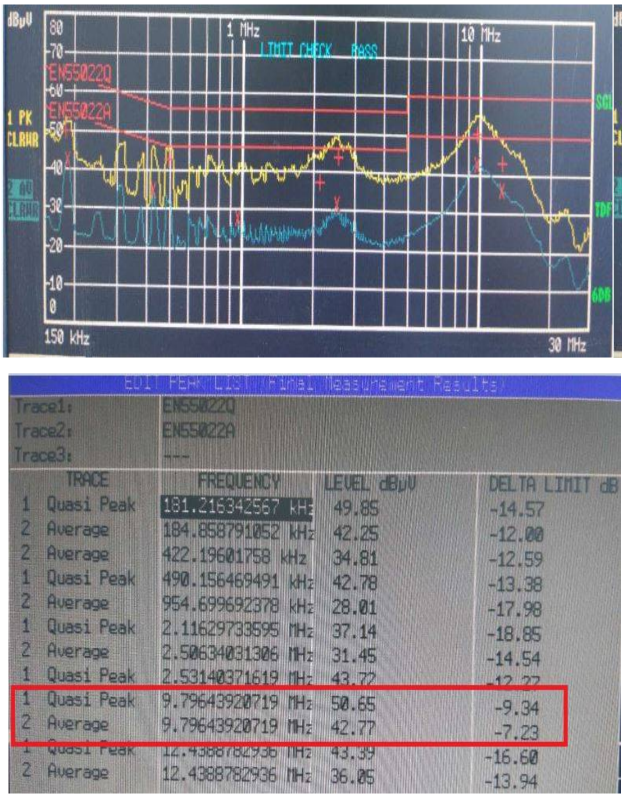


Figure 59: **230Vac/60Hz L line at Full load**

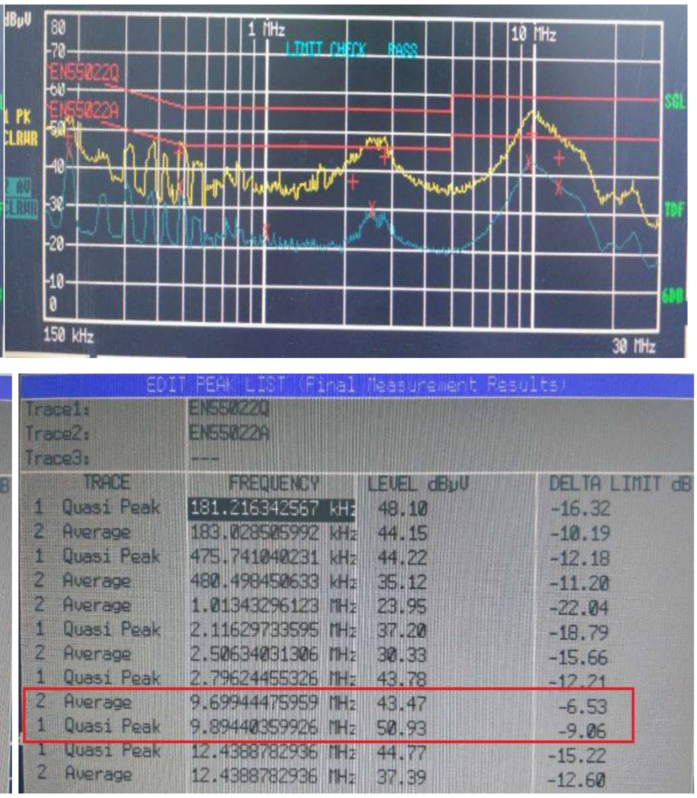


Figure 60: **230Vac/60Hz N line at Full load**

L Line		N Line	
Frequency(MHz)	QP Margin	Frequency(MHz)	QP Margin
9.796	9.34	9.699	6.53
Frequency(MHz)	AV Margin	Frequency(MHz)	AV Margin
9.796	7.23	9.894	9.06