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Chapter 1. Summary

1.1 General Description

The 18W/22W PD3.0 PPS/QC4/4+ Evaluation Board EV1 is composed of three main parts. AP39303 offers the QR PWM controller which combines a 700V high performance Power MOSFET. APR34709 is secondary side combo IC, which combines an N-MOSFET and a driver circuit designed for synchronous rectification. AP43771 is USB PD3.0 PPS and Qualcomm® Quick Charge™ 4/4+ Decoder for implementing quick charger decoder in charge of communicating with devices and controls feedback network to fulfill voltage and current requirements from devices.

1.2 Key Features

1.2.1 System Key Features

- SSR topology implementation with an Opto-coupler for accurate step voltage controlling
- QC4+ offers QC3.0/QC2.0 backward compliance
- QC4 supports the USB PD3.0 function and PPS (3V-11V@20mV/step)
- Meet DOE6 and CoC Tier 2 efficiency requirements
- <30mW No-Load Standby Power
- USB PD 3.0 PPS Compliance:
  (**Power Brick TID: 1100026 for 18W / TID: 152 for 22W**)

1.2.2 AP39303 Key Features

- Quasi-Resonant operation
- Peak current mode control
- High-Voltage startup
- Soft Start
- Built-in 120V high voltage VCC LDO to guarantee wide range output voltage application (3.3V~20V, PPS)
- Built-in 700V high performance Power MOSFET
- Low VCC operating current reduces stand-by power
- Adaptive burst mode operation with output voltage
- Adaptive output power limit with output voltage
- Non-Audible-Noise Quasi-Resonant control
- Frequency fold back for high average efficiency
- Secondary winding short protection with FOCP
- Frequency dithering for reducing EMI
- VCC maintain mode
- Useful Pin fault protection:
  SENSE Pin floating and FB/Opto-Coupler Open/Short
- Comprehensive system protection feature:
  Programmable External OTP / OLP / BNO / SOVP / SUVP

1.2.3 APR34709 Key Features

- Synchronous Rectification for DCM QR operation Flyback
- Built-In a 60V N-MOSFET with low gate charge, low $R_{DS(ON)}$, fast switching speed and body diode reverse recovery performance
- Eliminate resonant ring interference
- Fewest external components used

1.2.4 AP43771 Key Features

- Supports one USB PD3.0 PPS Type-C and QC4/QC4+
- Drives N-MOSFET for Load Switch
- Built-in VBUS discharger Pin
- 3V – 21V operation voltage without external regulator
- On-chip OVP, OCP, UVP, and SCP
- Supports OTP through integrated ADC circuit
- USB PD 3.0 PPS Compliance (**Silicon TID: 1090028**)

1.3 Applications

- Offer both PD3.0+PPS +QC4/4+ Wall Chargers

1.4 Main Power Specifications (CV & CC Mode)

Parameter	Value
Input Voltage	$90V_{AC}$ to $264V_{AC}$
Input standby power	< 30mW
Main Output (Vo / Io)	PDO: 5V/3A, 9V/2A, 22W only: 3.3V/3A, 3.8V/3A, 8V/2.25A, 11V/1.64A
	APDO: 3.3V to 5.9V/3A, 3.3V to 11V/2A
Per Step Voltage	Continuous mode 200mV, 3.6V-12V
	PPS 20mV step voltage, 3.3V-11V
Efficiency	Comply with CoC version 5 tier-2
Total Output Power	18W / 22W at PPS
Protections	OCP, OVP, UVP, OLP, OTP
Dimension	34mm x 48mm x 16mm

1.5 Evaluation Board Picture

EVB Top View

EVB Bottom View

Chapter 2. Power Supply Specification

2.1 Specification and Test Results

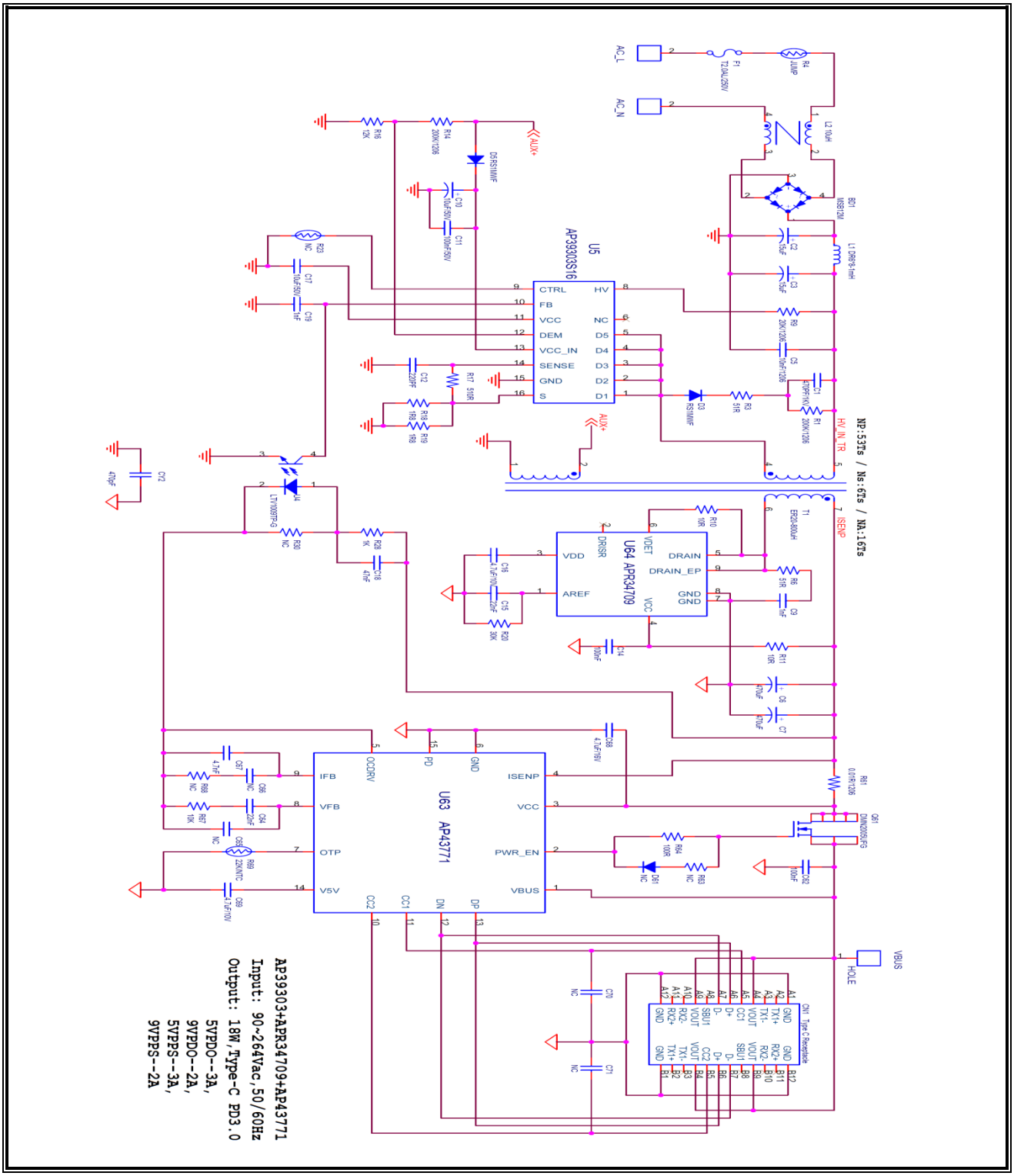
Parameter	Value	Test Summary
Input Voltage / Frequency	$90V_{AC}$ to $264V_{AC}$ / 47Hz to 63Hz	Test Condition
Input Current	<$0.5A_{RMS}$ at $100V_{AC}$	**PASS,**
Standby Power	<30mW; load disconnected	**PASS,** 24.5mW@$230V_{AC}$/50Hz
3.3V/3A Average Efficiency (For 22W only)	DoE VI Efficiency >78.63%	**PASS,** 88.51% @$115V_{AC}$/60Hz, 87.46% @$230V_{AC}$/50Hz
	CoC Version 5, Tier2 Efficiency >78.93%	
3.3V/0.3A Efficiency (10% Load) (For 22W only)	CoC Version 5, Tier2 Efficiency >69.66%	**PASS,** 86.60% @$115V_{AC}$/60Hz, 79.20% @$230V_{AC}$/50Hz
3.8V/3A Average Efficiency (For 22W only)	DoE VI Efficiency >79.6%	**PASS,** 88.58% @$115V_{AC}$/60Hz, 87.88% @$230V_{AC}$/50Hz
	CoC Version 5, Tier2 Efficiency >79.94%	
3.8V/0.3A Efficiency (10% Load) (For 22W only)	CoC Version 5, Tier2 Efficiency >70.65%	**PASS,** 85.80% @$115V_{AC}$/60Hz, 80.60% @$230V_{AC}$/50Hz
5V/3A Average Efficiency	DoE VI Efficiency >81.39%	**PASS,** 88.21% @$115V_{AC}$/60Hz, 88.20% @$230V_{AC}$/50Hz
	CoC Version 5, Tier2 Efficiency >81.84%	
5V/0.3A Efficiency (10% Load)	CoC Version 5, Tier2 Efficiency >72.48%	**PASS,** 86.30% @$115V_{AC}$/60Hz, 82.70% @$230V_{AC}$/50Hz
8V/2.25A Average Efficiency (For 22W only)	DoE VI Efficiency >85.00%	**PASS,** 89.97% @$115V_{AC}$/60Hz, 89.78% @$230V_{AC}$/50Hz
	CoC Version 5, Tier2 Efficiency >85.45%	
8V/0.225A Efficiency (10% Load) (For 22W only)	CoC Version 5, Tier2 Efficiency >75.45%	**PASS,** 87.02% @$115V_{AC}$/60Hz, 83.04% @$230V_{AC}$/50Hz
9V/2A Average Efficiency	DoE VI Efficiency >85.00%	**PASS,** 90.23% @$115V_{AC}$/60Hz 89.68% @$230V_{AC}$/50Hz
	CoC Version 5, Tier2 Efficiency >85.45%	
9V/0.2A Efficiency (10% Load)	CoC Version 5, Tier2 Efficiency >75.45%	**PASS,** 86.20% @$115V_{AC}$/60Hz 83.80% @$230V_{AC}$/50Hz
11V/1.64A Average Efficiency (For 22W only)	DoE VI Efficiency >85.01%	**PASS,** 89.45% @$115V_{AC}$/60Hz 89.24% @$230V_{AC}$/50Hz
	CoC Version 5, Tier2 Efficiency >85.46%	
11V/0.164A Efficiency (10% Load) (For 22W only)	CoC Version 5, Tier2 Efficiency >75.46%	**PASS,** 82.46% @$115V_{AC}$/60Hz 79.67% @$230V_{AC}$/50Hz
Output Voltage Regulation Tolerance	+/- 5%	**PASS,**
5V PPS	3.3V – 5.9V +/- 5%, 0~3A +/-150mA	**PASS,**
9V PPS	3.3V – 11V +/- 5%, 0~2A +/-150mA	**PASS,**
Conducted EMI	>6dB Margin; according to EN55032 Class B	**PASS,**
Radiated EMI	>6dB Margin; according to EN55032 Class B	**PASS,**

2.2 Compliance

Parameter	Value	Summary
Output Connector	USB Type C	
Stress	<95%	
Dimensions W/D/H	34 x 48 x 16 (mm)	

Chapter 3. Schematic

3.1 Schematic



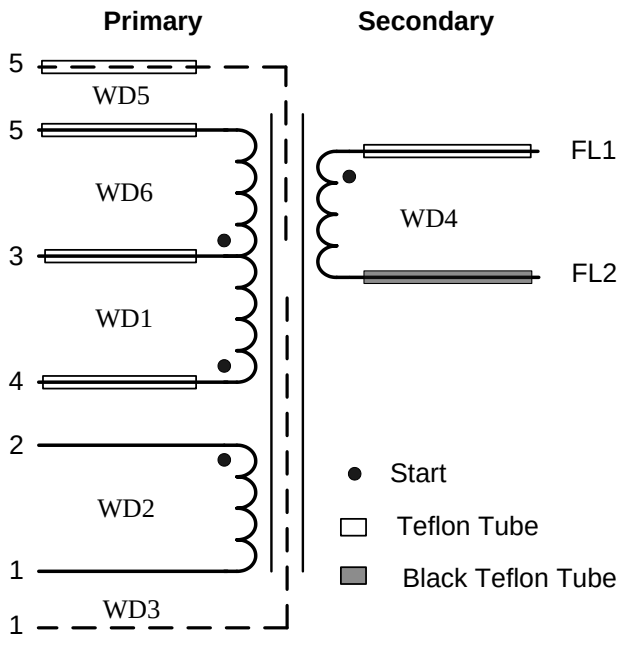
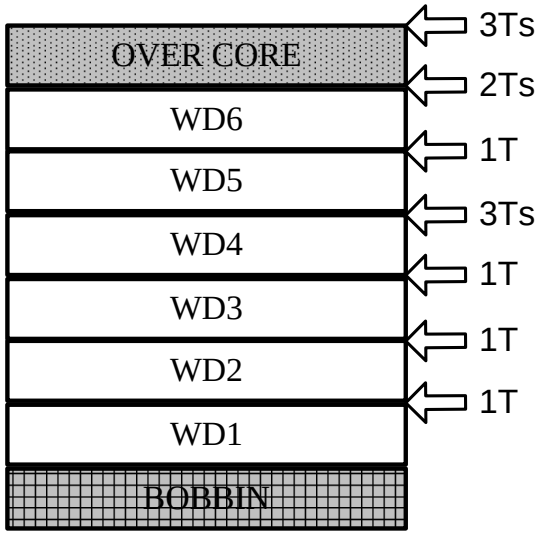
3.2 Bill of Material

Item	Quantity	Designator	Description	Manufacturer Part Number	Manufacturer
1	**1**	**U5**	**AP39303, QR PWM Switcher**	**AP39303S16-13**	**Diodes**
2	**1**	**U63**	**AP43771, USB PD Controller**	**AP43771FB-7**	**Diodes**
3	**1**	**U64**	**APR34709, SR Switcher**	**APR34709SP-13**	**Diodes**
4	**1**	**BD1**	**MSB12M, Bridge Rectifier Diode**	**MSB12M-13**	**Diodes**
5	**2**	**D3,D5**	**RS1MWF, Fast Recovery Diode**	**RS1MWF-7**	**Diodes**
6	**1**	**Q61**	**DMN2005UFG, 20V N-MOSFET**	**DMN2005UFG-13**	**Diodes**
7	**1**	**U4**	**LTV1009TP-G (CTR-200/400)**	**LTV-1009TP1-G**	**Lite-On**
8	1	C1	470PF/1KV/X5R/1206		
9	1	C5	10nF/1KV/X5R/1206		
10	1	C9	1nF/1KV/X5R/1206		
11	1	C17	10uF/50V/X5R/1206		
12	3	C11,C14,C62	100nF/50V/X7R/0603		
13	1	C12	220PF/50V/X7R/0603		
14	2	C15,C64	22nF/50V/X7R/0603		
15	2	C16,C69	4.7uF/16V/X5R/0603		
16	1	C68	4.7uF/16V/X5R/0805		
17	1	C19	1nF/50V/X7R/0603		
18	1	C67	4.7nF/50V/X7R/0603		
19	1	C18	47nF/50V/X7R/0603		
20	1	R61	0.01R//1%/1206 (Low TCR)	SMF12M1FR010T	SART
21	2	R18,R19	1R6/1%/1206		
22	1	R6	51R/1%/1206		
23	1	R9	20K/1%/1206		
24	2	R1,R14	200K/1%/1206		
25	1	R3	51R/1%/0805		
26	2	R10,R11	10R/1%/0603		
27	1	R16	12K/1%/0603		
28	1	R64	100R/1%/0603		
29	1	R17	510R/1%/0603		
30	2	R28,R67	1K/1%/0603		
31	1	R20	30K/1%/0603		
32	1	R69	22K/1%/0603 (NTC)		
33	2	C2,C3	15uF/400V/10*12.5 (E-CAP)		
34	2	C6,C7	470uF/16V/6.3*11 (Polymer CAP)	RS471M016E110	POLYCAP
35	1	C10	10uF/50V/5*11 (E-CAP)		
36	1	CY2	470pF/Y1-CAP		
37	1	CN1	Type C Receptacle	UT13513-1180A-7H	FOXCONN
38	1	F1	T2.0AL/250V		
39	1	T1	ER20-800uH		
40	1	L1	DR6*8-1mH		
41	1	L2	CM Choke, T6*3*3 6Ts		
42	1	R4	JUMP (0.6Φ)		

Note:

- Not connected location (NC): R30,R63,C65,C66,R68,C70,C71 / 0603; D61 / SOD323; R23 / 0805
- Current sense resistor (R61) should use the Low TCR type resistor.

3.3 Transformer SPEC

Circuit：	Cross sectional view：
	

Definition	Pin define (Start >> End)	Wire (*Diameter*)	Turn (*Ts*)	Layers	Layers of Tape
WD1	*4→3*	*2UEW-B 0.2mm x 1P*	*36*	*2*	*1Ts*
WD2	*2→1*	*2UEW-B 0.18mm x 1P*	*16*	*1*	*1Ts*
WD3	*1→Null*	*2UEW-B 0.18mm x 1P*	*16*	*1*	*1Ts*
WD4	*FL1→FL2*	*Triple wire-B 0.7mm x 1P*	*6*	*2*	*3Ts*
WD5	*5→Null*	*2UEW-B 0.18mm x 1P*	*12*	*1*	*1Ts*
WD6	*3→5*	*2UEW-B 0.2mm x 1P*	*17*	*1*	*2Ts*
	OVER CORE (14mm)				*3Ts*

Item	*Test Condition*	*Rating*
Primary Inductance	Pin 3-1,all other windings open, measured at 20kHz / 1V	800uH+/- 5%

3.4 Schematics Description

3.4.1 Fuse, EMI Filter and Rectifier

The Fuse F1 protects against over-current conditions which occur when some main components failed. The L2 is a common mode choke for the common mode noise suppression. The BD1 is a rectifier witch converts alternating current and voltage into direct current and voltage. The C2, L1, C3 are composed of the Pi filter for filtering the differential switching noise back to AC source.

3.4.2 AP39303 Quasi-Resonant PWM Switcher

AP39303 is a highly integrated power switcher with a built-in Quasi-Resonant (QR) PWM controller and a 700V high performance Power MOSFET. AP39303 has built-in high-voltage start-up function and provides an excellent green power solution. The AP39303 integrates a 120V VCC LDO circuitry and allows a wide voltage range of VCC_IN. This makes to be a good choice in wide output voltage range application such as PD and QC.

3.4.3 APR34709 Synchronous Rectification Switcher

APR34709 is a secondary side Combo IC, which combines an N-Channel MOSFET and a driver circuit designed for synchronous rectification (SR). The internal N-MOSFET is optimized for low gate change, low $R_{DS(ON)}$, fast switching speed and body diode reverse recovery performance. The synchronous rectification can effectively reduce the secondary side rectifier power dissipation and provide high performance solution. By sensing primary MOSFET drain-to-source voltage, APR34709 can output ideal drive signal with less external components.

3.4.4 AP43771 PD3.0 and QC4/4+ Decoder

The following pins provide critical protocol decoding and regulation functions in AP43771:

1) **CC1 & CC2 (Pin 11, 10)**: CC1 & CC2 (Configuration Channel 1 & 2) are defined by USB PD spec to provide the channel communication link between power source and sink devices.
2) **D+ & D- (Pin 13, 12):** While defined under USB PD for data transfer only, D+ and D- are used in QC4+ to provide voltage information and backward compatibility with QC2.0 and QC3.0 devices.
3) **Constant Voltage (CV)**: The CV is implemented by sensing VCC (pin 3) via built-in resistor divider and compared with internal reference voltage. The output voltages can be adjusted by firmware programming.
4) **Constant Current (CC)**: The CC is implemented by sensing the current sense resistor (R61, 10mΩ) and compared with internal programmable reference voltage. The output current can be adjusted by firmware programming.
5) **Loop Compensation:** C64, R67 & C65 form the voltage loop compensation circuit, and C66, R68 & C67 form the current loop compensation circuit.
6) **OCDRV (Pin 5):** It is the key interface link from secondary decoder (AP43771) to primary regulation circuit (AP39303). It is connected to Opto-coupler U4 Pin 2 (Cathode) for feedback information based on all sensed CC1 & CC2, D+ & D- voltage status for getting desired V_{BUS} voltage & current.
7) **PWR_EN (Pin 2) to N-MOSFET Gate**: The pin is used to turn on and off V_{BUS} load switch (Q61) to enable and disable voltage output to the V_{BUS} respectively.

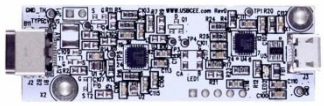
Chapter 4. Evaluation Board Connections

4.1 Quick Start Guide Before Connection

1) Before starting the 18W/22W EVB test, the end user needs to prepare the following tool, software and manuals.

   For details, please contact Canyon Semiconductor local sales 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
			

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

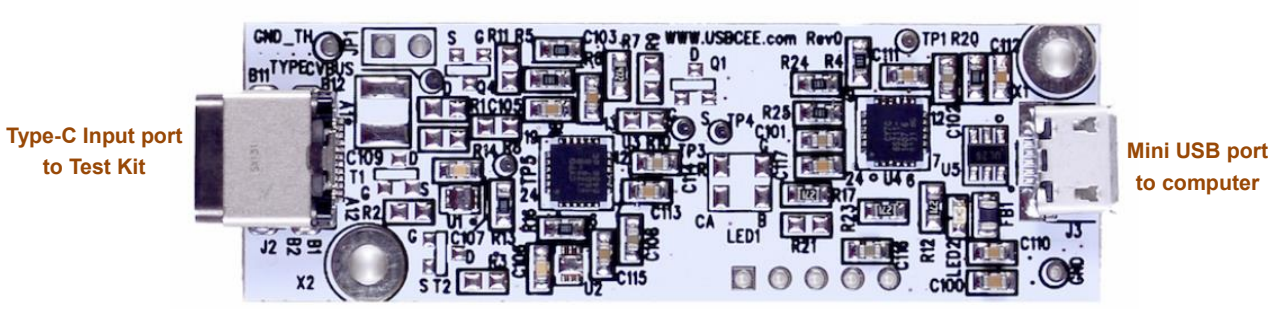
3) Connect the input AC L & N wires to AC power supply output “L and N “wires.

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

5) Use a type-C cable for the connection between EVB to Tester.

6) Apply E-load at the terminal “JP1” on tester which indicated in figure below.

7) A Standard-A to Micro-B cable to be connected to the Cypress test kit’s Micro-B receptacle & PC Standard-A receptacle respectively.



The Test Kit Input & Output and E-load Connections

4.2 Connection with E-Load

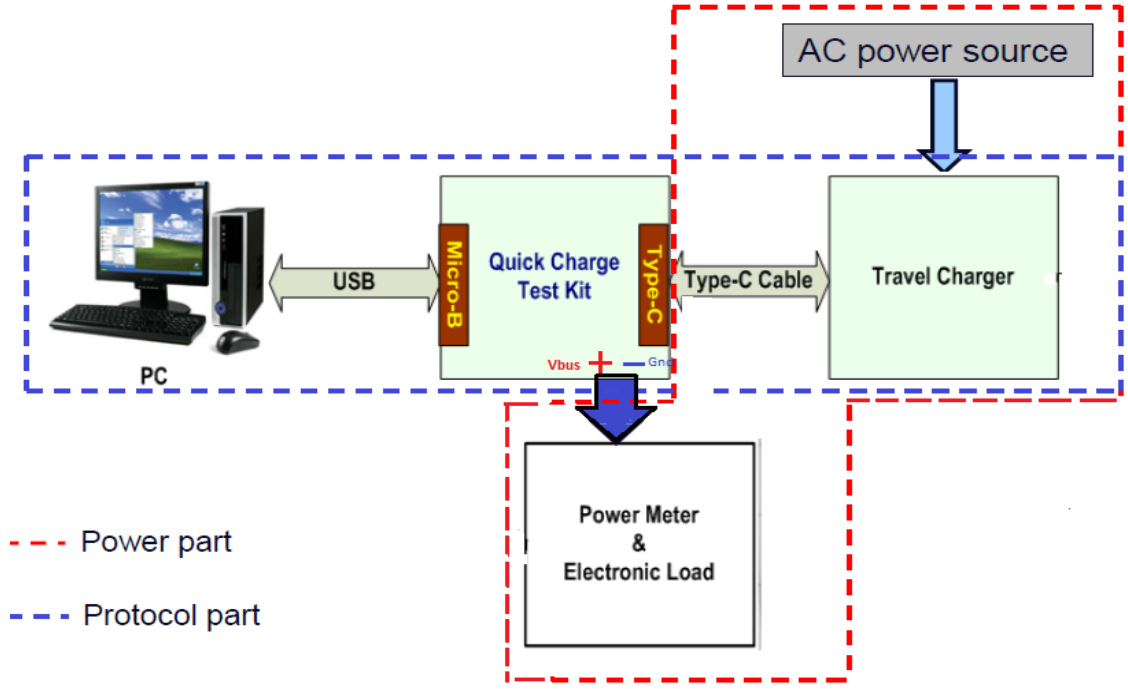
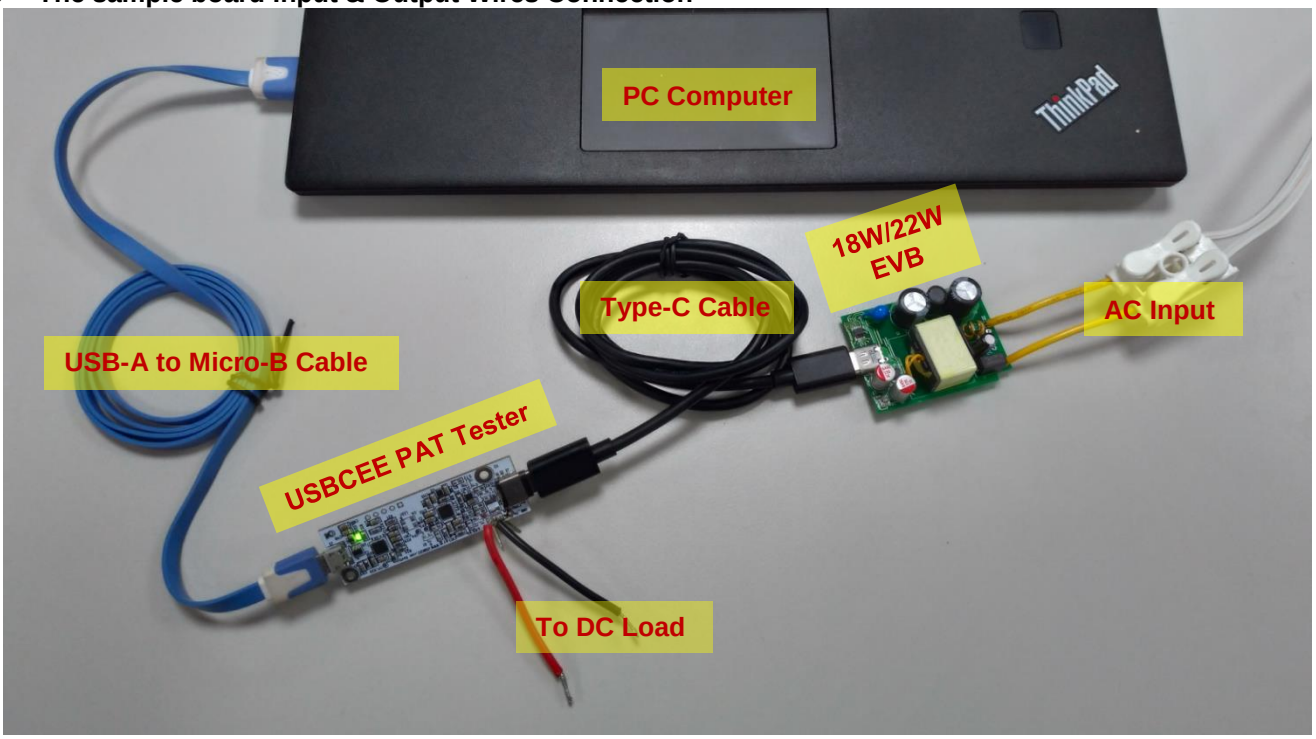


Diagram of Connections in the Sample Board

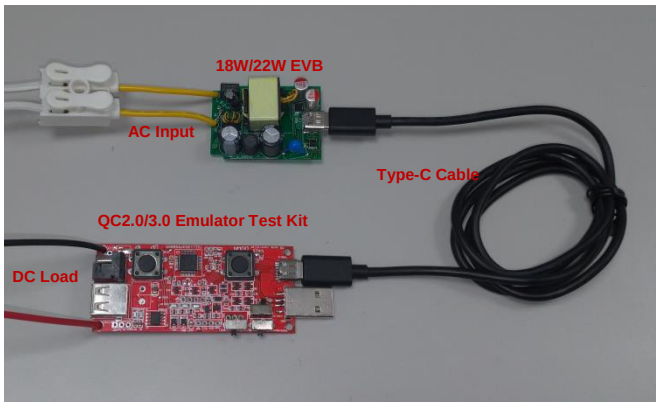
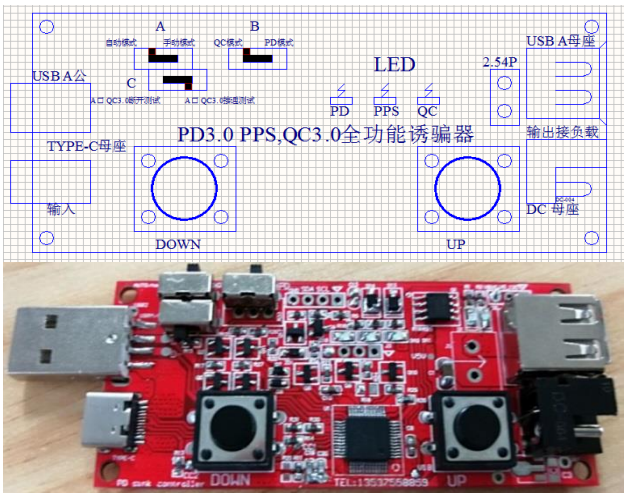
4.3 The sample board Input & Output Wires Connection



Wire Connection of 18W/22W PD3.0 EVB to Test Kit and PC Computer

4.4 QC2.0/3.0 Emulator connection

Or using the QC2.0/QC3.0 emulator test Kit to testing the QC2.0 & QC3.0 functions, see the connection the between testing sample board to DC load by mean of a USB-C to USB A converting cable.

	
Wire Connection of EVB to QC2.0/3.0 Test Kit	**QC2.0/3.0 Emulator Test Kit**

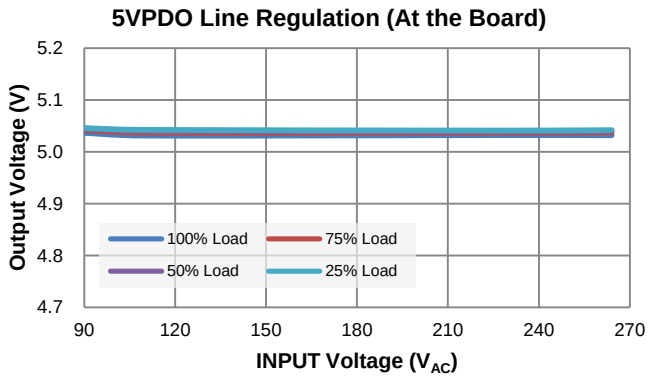
Chapter 5. Input & Output Characteristics

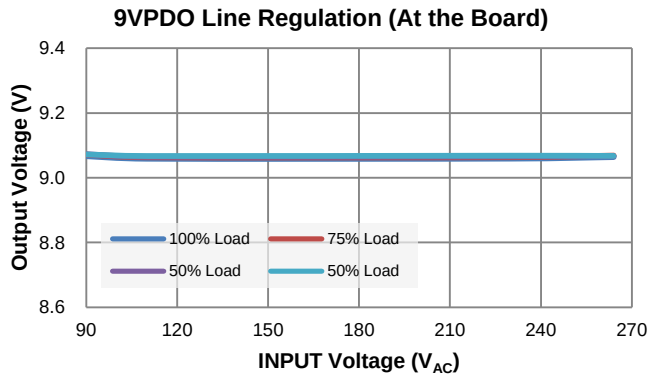
5.1 Input Standby Power

V_{IN}	V_{OUT}	P_{IN}
90V_{AC}/47Hz	5.03V	22.67mW
115V_{AC}/60Hz	5.03V	25.15mW
230V_{AC}/50Hz	5.03V	24.72mW
264V_{AC}/63Hz	5.03V	26.81mW

5.2 Output Voltage Regulation Performance Curve

PDO 5V/3A Line Regulation (At the Board)					PDO 9V/2A Line Regulation (At the Board)				
VIN	**$V_{OUT\_100\%}$**	**$V_{OUT\_75\%}$**	**$V_{OUT\_50\%}$**	**$V_{OUT\_25\%}$**	**VIN**	**$V_{OUT\_100\%}$**	**$V_{OUT\_75\%}$**	**$V_{OUT\_50\%}$**	**$V_{OUT\_25\%}$**
90V_{AC}/47Hz	5.04V	5.04V	5.05V	5.05V	**90V_{AC}/47Hz**	9.07V	9.07V	9.07V	9.07V
115V_{AC}/60Hz	5.03V	5.04V	5.04V	5.04V	**115V_{AC}/60Hz**	9.06V	9.06V	9.06V	9.07V
230V_{AC}/50Hz	5.03V	5.04V	5.04V	5.04V	**230V_{AC}/50Hz**	9.06V	9.06V	9.07V	9.07V
264V_{AC}/63Hz	5.03V	5.04V	5.04V	5.04V	**264V_{AC}/63Hz**	9.06V	9.07V	9.07V	9.07V

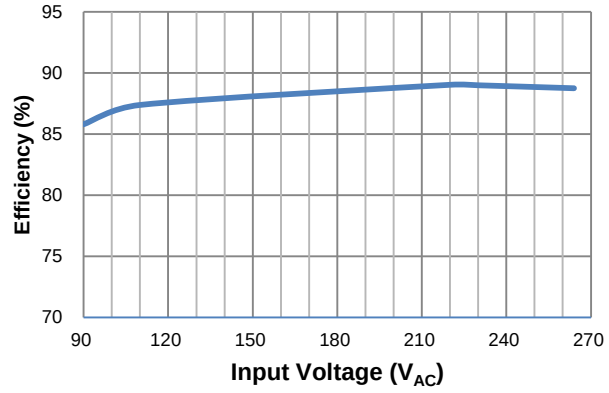




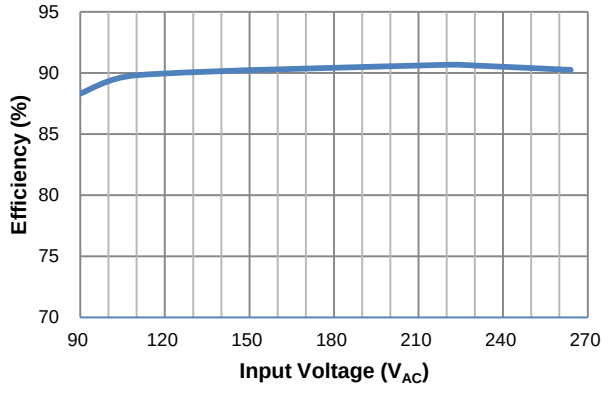
5.3 Efficiency vs. AC Line Input Voltage

PDO 5V/3A Efficiency (At the Board)						PDO 9V/2A Efficiency (At the Board)					
V_{IN}	V_{OUT}	I_{OUT}	P_{IN}	Efficiency	10% Load Efficiency	V_{IN}	V_{OUT}	I_{OUT}	P_{IN}	Efficiency	10% Load Efficiency
90V_{AC}/60Hz	4.99V	3.01A	17.5W	85.8%	87.27%	**90V_{AC}/60Hz**	9.00V	2.00A	20.4W	88.3%	86.63%
110V_{AC}/60Hz	4.99V	3.01A	17.2W	87.4%	87.78%	**110V_{AC}/60Hz**	9.00V	2.00A	20.0W	89.8%	87.28%
230V_{AC}/50Hz	4.99V	3.01A	16.9W	89.0%	87.04%	**230V_{AC}/50Hz**	9.01V	2.00A	19.9W	90.6%	86.69%
264V_{AC}/50Hz	4.99V	3.01A	16.9W	88.8%	86.00%	**264V_{AC}/50Hz**	9.01V	2.00A	20.0W	90.3%	86.08%

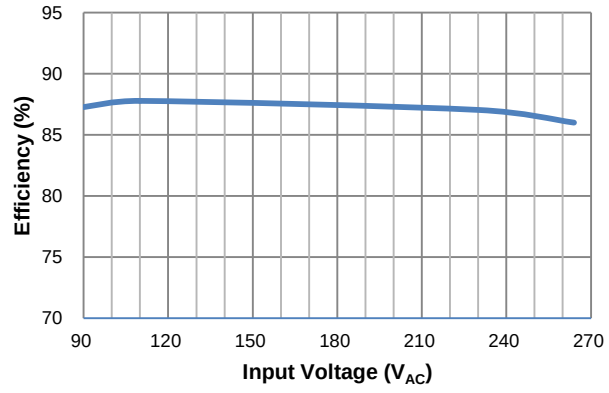
5V/3A Efficiency (At the Board)



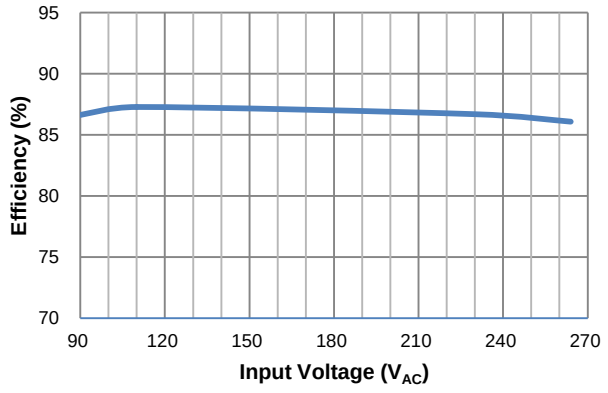
9V/2A Efficiency (At the Board)



5V/0.3A Efficiency (10% At the Board)

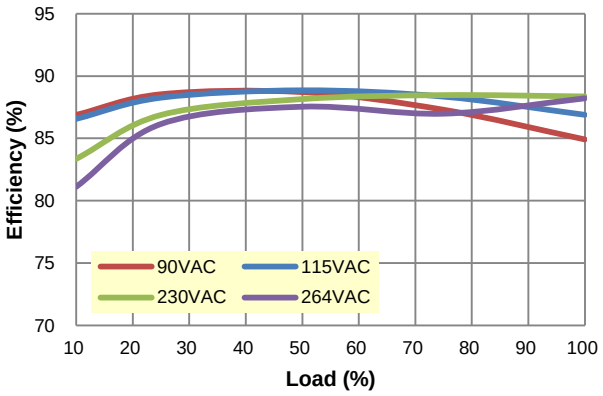


9V/0.2A Efficiency (10% At the Board)

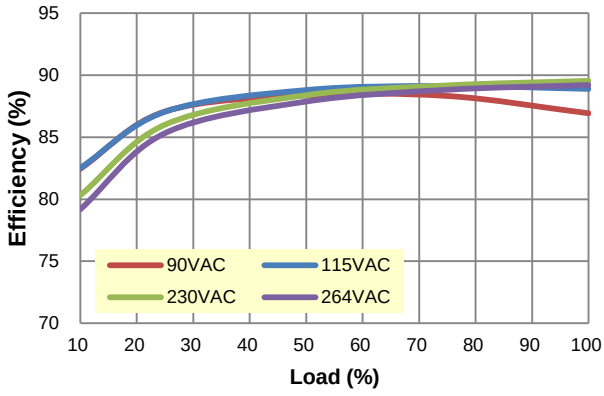


5.4 Efficiency vs. Output Load

PDO 5V/3A Efficiency (At the Board)

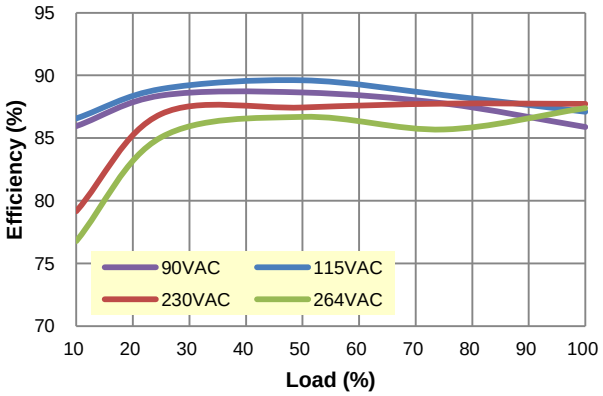


PDO 9V/2A Efficiency (At the Board)



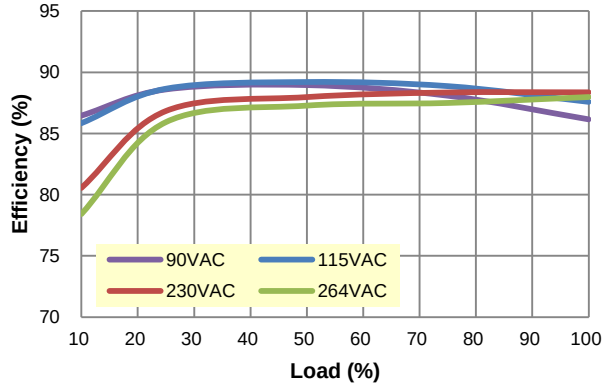
For 22W Only

PDO 3.3V/3A Efficiency (At the Board)



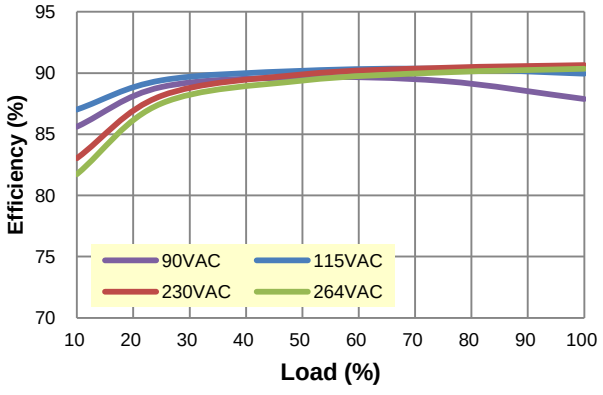
For 22W Only

PDO 3.8V/3A Efficiency (At the Board)



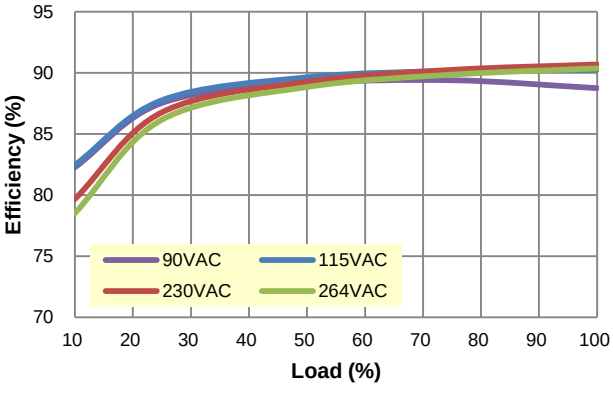
For 22W Only

PDO 8V/2.25A Efficiency (At the Board)



For 22W Only

PDO 11V 1.64A Efficiency (At the Board)



5.5 Average Efficiency at Different Loading

5.5.1 Average Efficiency (5V / 3A)

V_{IN}	I_{OUT}		V_{OUT}	P_{IN}	P_{OUT}	Efficiency	Average Efficiency	CoC Tier 2 required
115V_{AC}/60Hz	100%	3.00A	5.01V	17.17W	15.03W	87.5%	88.82%	81.84%
	75%	2.25A	5.02V	12.69W	11.29W	89.0%		
	50%	1.50A	5.02V	8.41W	7.53W	89.6%		
	25%	0.75A	5.03V	4.23W	3.77W	89.1%		
	10%	0.3A	5.03V	1.74 W	1.51 W	87.0%		72.48%
230V_{AC}/50Hz	100%	3.00A	5.01V	16.99W	15.04W	88.5%	88.24%	81.84%
	75%	2.25A	5.02V	12.81W	11.30W	88.2%		
	50%	1.50A	5.02V	8.49W	7.53W	88.7%		
	25%	0.75A	5.03V	1.80 W	1.51 W	84.2%		
	10%	0.3A	5.03V	1.82W	1.52W	83.4%		72.48%

5.5.2 Average Efficiency (9.0V / 2A)

V_{IN}	I_{OUT}		V_{OUT}	P_{IN}	P_{OUT}	Efficiency	Average Efficiency	CoC Tier 2 required
115V_{AC}/60Hz	100%	2.00A	9.08V	20.10W	18.17W	90.4%	90.23%	85.45%
	75%	1.50A	9.09V	15.04W	13.63W	90.6%		
	50%	1.00A	9.09V	10.06W	9.10W	90.4%		
	25%	0.50A	9.09V	5.09W	4.55W	89.4%		
	10%	0.2A	9.09V	2.12 W	1.82 W	86.2%		72.48%
230V_{AC}/50Hz	100%	2.00A	9.08V	20.06W	18.17W	90.6%	89.68%	85.45%
	75%	1.50A	9.09V	15.09W	13.63W	90.3%		
	50%	1.00A	9.09V	10.14W	9.10W	89.8%		
	25%	0.50A	9.09V	5.17W	4.55W	88.0%		
	10%	0.2A	9.09V	2.17 W	1.82 W	83.8%		72.48%

5.5.3 Average Efficiency (3.3V / 3A for 22W only)

V_{IN}	I_{OUT}		V_{OUT}	P_{IN}	P_{OUT}	Efficiency	Average Efficiency	CoC Tier 2 required
115V_{AC}/60Hz	100%	3.00A	3.32V	11.43W	9.96W	87.10%	88.51%	78.93%
	75%	2.25A	3.33V	8.47W	7.49W	88.42%		
	50%	1.50A	3.33V	5.58W	5.00W	89.61%		
	25%	0.75A	3.34V	2.81W	2.50W	88.92%		
	10%	0.3A	3.34V	1.16 W	1.00 W	86.57%		69.66%
230V_{AC}/50Hz	100%	3.00A	3.32V	11.36W	9.96W	87.73%	87.46%	78.93%
	75%	2.25A	3.33V	8.53W	7.49W	87.75%		
	50%	1.50A	3.33V	5.72W	5.00W	87.44%		
	25%	0.75A	3.34V	2.88W	2.50W	86.92%		
	10%	0.3A	3.34V	1.27 W	1.00 W	79.17%		69.66%

5.5.4 Average Efficiency (3.8V / 3A for 22W only)

V_{IN}	I_{OUT}		V_{OUT}	P_{IN}	P_{OUT}	Efficiency	Average Efficiency	CoC Tier 2 required
115V_{AC}/60Hz	100%	3.00A	3.80V	13.00W	11.39W	87.58%	88.58%	79.94%
	75%	2.25A	3.81V	9.63W	8.56W	88.87%		
	50%	1.50A	3.81V	6.41W	5.71W	89.20%		
	25%	0.75A	3.82V	3.23W	2.86W	88.66%		
	10%	0.3A	3.82V	1.32 W	1.15 W	86.46%		70.65%
230V_{AC}/50Hz	100%	3.00A	3.80V	12.90W	11.40W	88.36%	87.88%	79.94%
	75%	2.25A	3.80V	9.69W	8.56W	88.35%		
	50%	1.50A	3.81V	6.50W	5.72W	87.97%		
	25%	0.75A	3.82V	3.29W	2.86W	86.84%		
	10%	0.3A	3.82V	1.33 W	1.14 W	85.84%		70.65%

5.5.5 Average Efficiency (8.0V / 2.25A for 22W only)

V_{IN}	I_{OUT}		V_{OUT}	P_{IN}	P_{OUT}	Efficiency	Average Efficiency	CoC Tier 2 required
115V_{AC}/60Hz	100%	2.25A	8.04V	20.10W	18.08W	89.95%	89.97%	85.45%
	75%	1.69A	8.05V	15.01W	13.56W	90.35%		
	50%	1.13A	8.05V	10.04W	9.06W	90.18%		
	25%	0.56A	8.05V	5.07W	4.53W	89.40%		
	10%	0.225A	8.05V	2.08 W	1.81 W	87.02%		75.45%
230V_{AC}/50Hz	100%	2.25A	8.04V	19.95W	18.09W	90.65%	89.78%	85.45%
	75%	1.69A	8.04V	14.99W	13.55W	90.43%		
	50%	1.13A	8.05V	10.08W	9.06W	89.89%		
	25%	0.56A	8.05V	5.12W	4.51W	88.14%		
	10%	0.225A	8.05V	2.18 W	1.81 W	83.04%		75.45%

5.5.6 Average Efficiency (11.0V / 1.64A for 22W only)

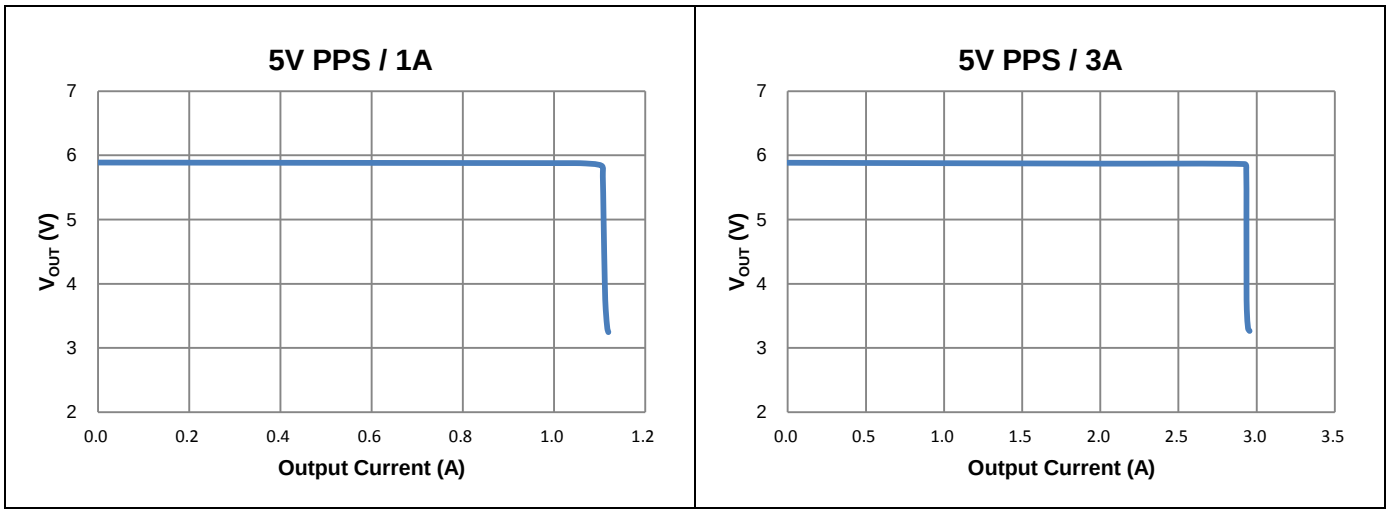
V_{IN}	I_{OUT}		V_{OUT}	P_{IN}	P_{OUT}	Efficiency	Average Efficiency	CoC Tier 2 required
115V_{AC}/60Hz	100%	1.64A	11.08V	20.13W	18.17W	90.26%	89.97%	85.46%
	75%	1.23A	11.08V	15.12W	13.63W	90.15%		
	50%	0.82A	11.09V	10.15W	9.10W	89.64%		
	25%	0.41A	11.09V	5.19W	4.55W	87.76%		
	10%	0.164A	11.09V	2.15 W	1.78 W	82.46%		75.46%
230V_{AC}/50Hz	100%	1.64A	11.08V	20.04W	18.18W	90.69%	89.78%	85.46%
	75%	1.23A	11.09V	15.12W	13.64W	90.24%		
	50%	0.83A	11.09V	10.32W	9.21W	89.27%		
	25%	0.41A	11.10V	5.25W	4.55W	86.77%		
	10%	0.164A	11.10V	2.23 W	1.78 W	79.67%		75.46%

5.6 QC4/4+ & PPS Compatible Mode Testing

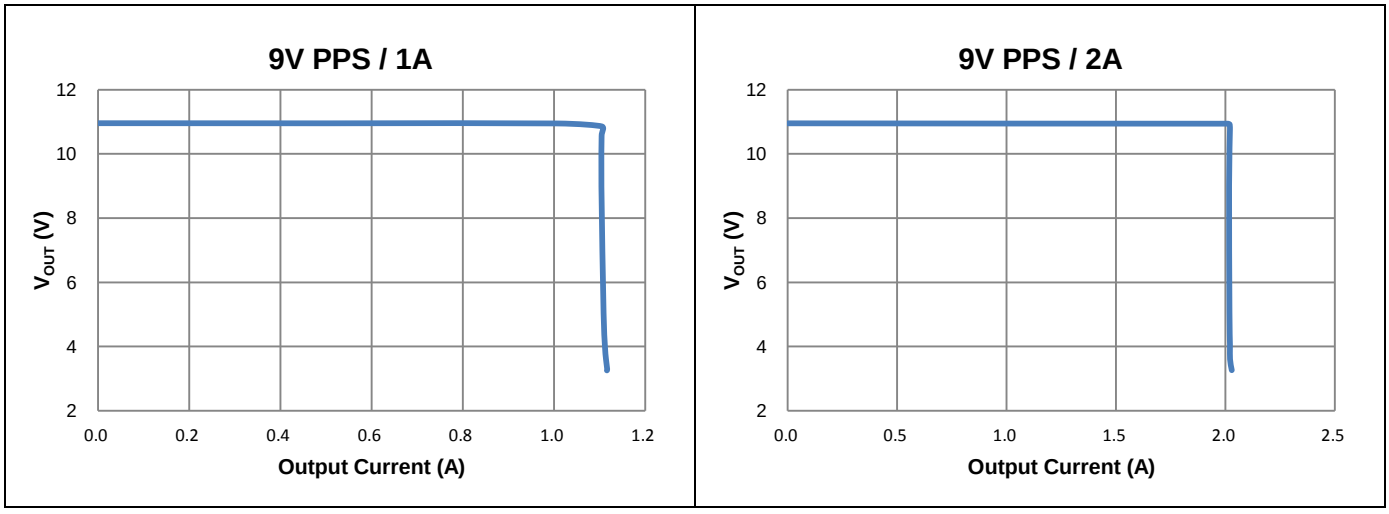
5.6.1 CC Mode current limitation function testing

The test is by with E-Load set at CR mode.

To PPS Mode set 5V-1A & 5V-3A and then increase the current (by reducing R) to see the CC-CV curve

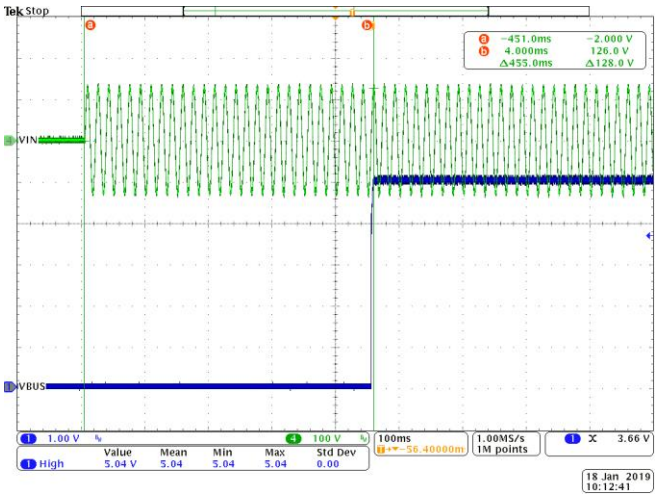


To PPS Mode set 9V-1A & 9V-2A and then increase the current (by reducing R) to see the CC-CV curve

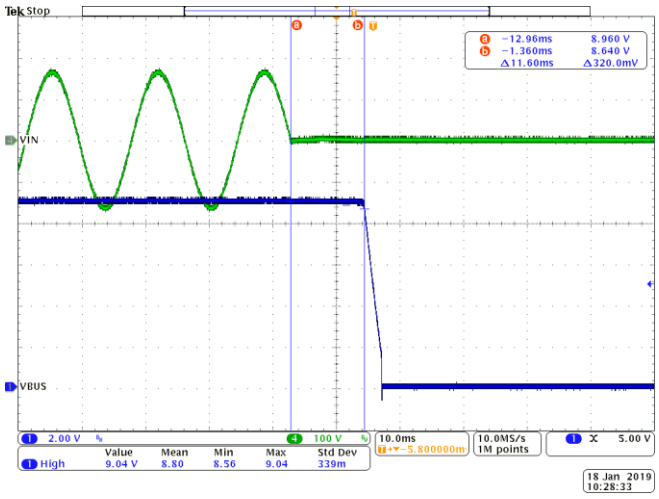


5.7 Key Performance Waveforms

5.7.1 EVB System Start-up Time & Hold-up Time

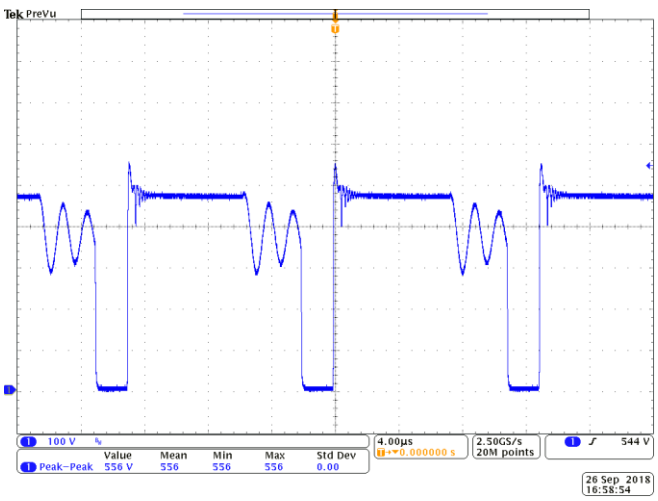


Input: 90V_{AC} / 60Hz
Output: 5V/3A
Start-up Time= 455ms

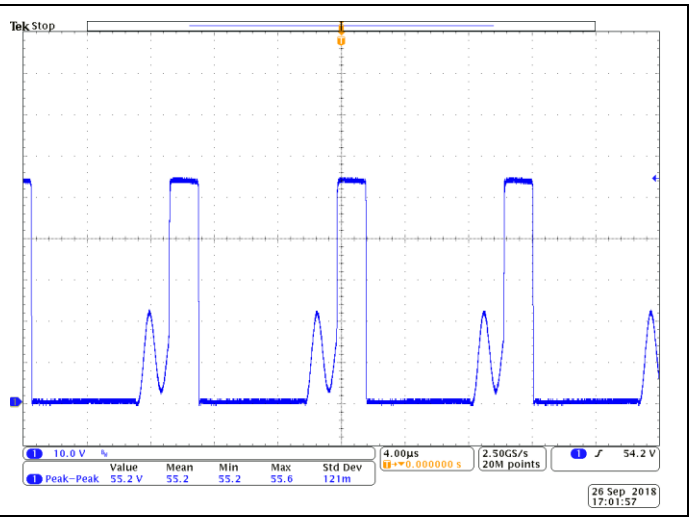


Input: 115 V_{AC} / 60Hz
Output: 9V/2A
Hold-up Time= 11.6ms

5.7.2 Q1 & U64 Main Switching MOSFET V_{DS} Stress

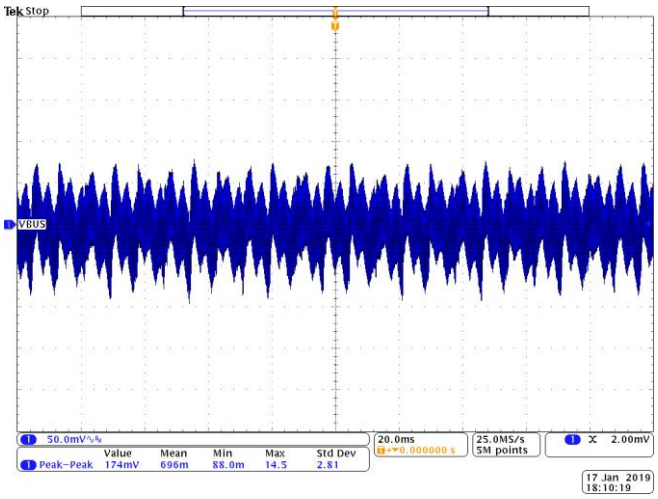


Input: 264V_{AC} / 60Hz
Output: 9V / 2A
Primary Side Switcher (Q1) V_{DS}: 556V_{MAX}

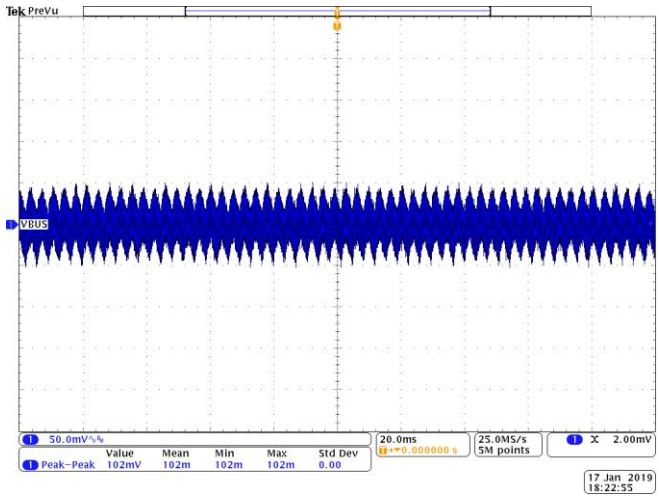


Input: 264V_{AC} / 60Hz
Output: 9V / 2A
Secondary Side SR Switcher (U64) V_{DS}: 55.2V_{MAX}

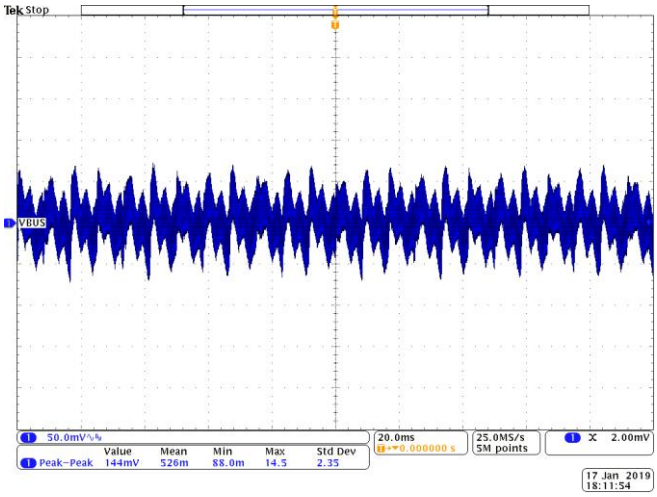
5.7.3 System Output Ripple & Noise @1.2m Cable End



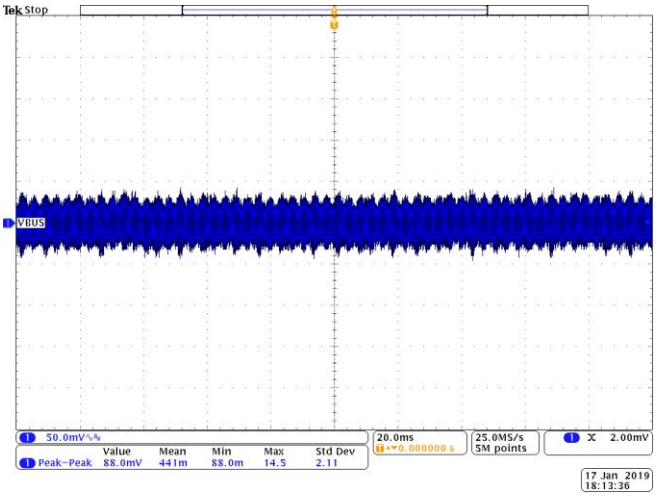
Input: 90V_{AC} / 60Hz
Output: 5V / 3A
Output Voltage Ripple Noise V_{P-P}: 174mV



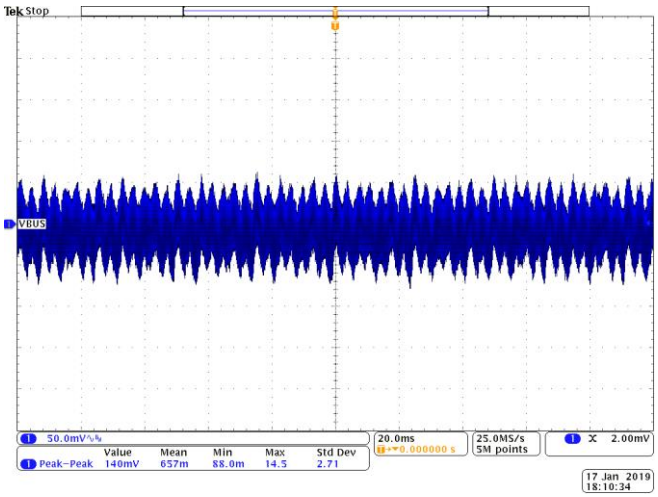
Input: 264V_{AC} / 60Hz
Output: 5V / 3A
Output Voltage Ripple Noise V_{P-P}: 102mV



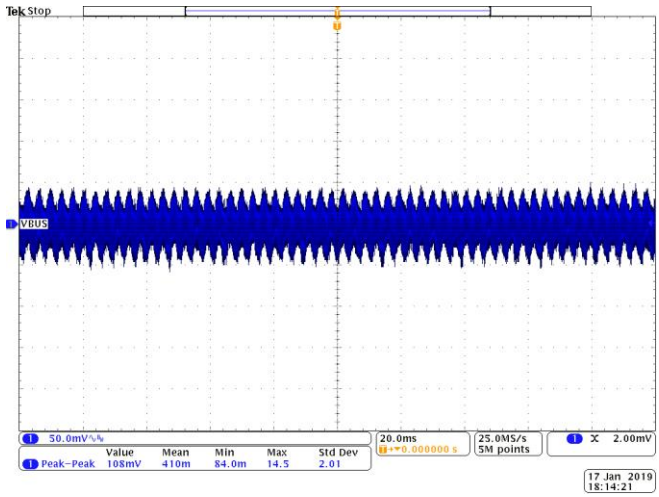
Input: 90V_{AC} / 60Hz
Output: 9V / 2A
Output Voltage Ripple Noise V_{P-P}: 144mV



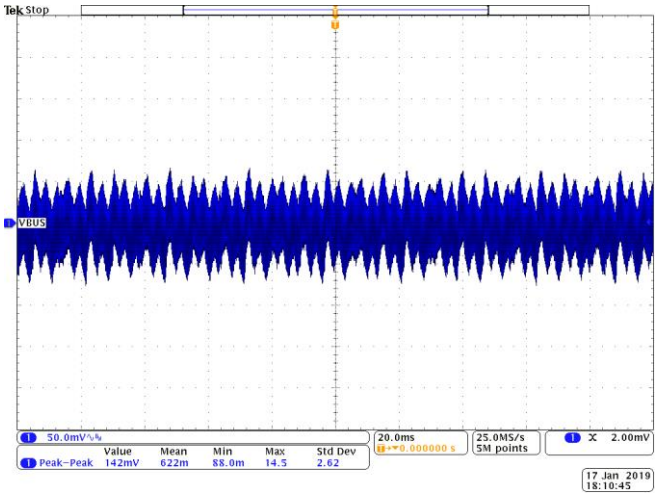
Input: 264V_{AC} / 60Hz
Output: 9V / 2A
Output Voltage Ripple Noise V_{P-P}: 88mV



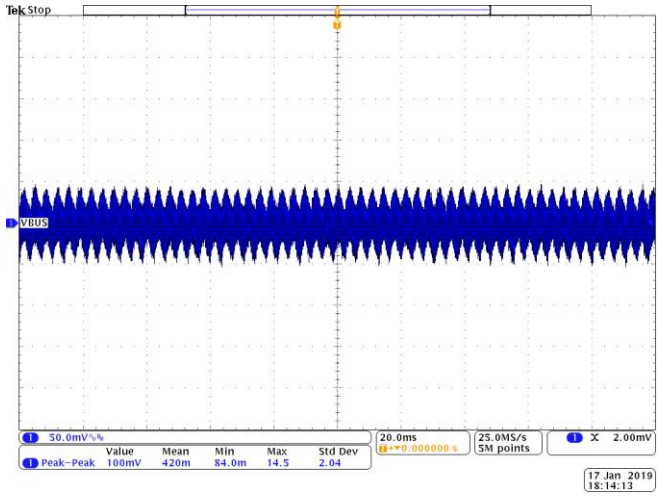
Input: 90V_{AC} / 60Hz
Output: 3.3V / 3A (for 22W only)
Output Voltage Ripple Noise V_{P-P}: 140mV



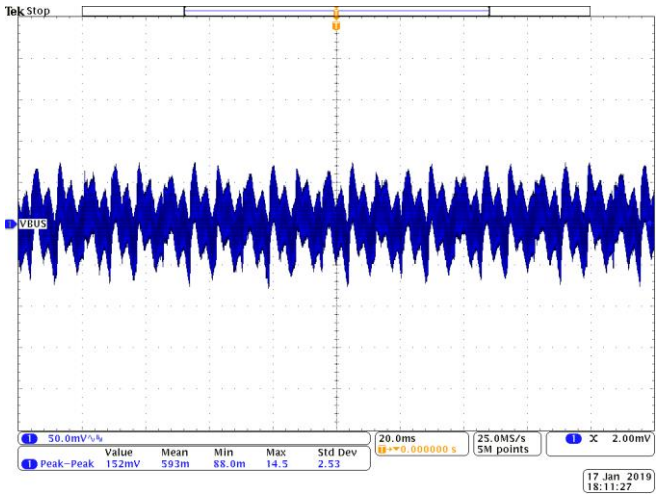
Input: 264V_{AC} / 60Hz
Output: 3.3V / 3A (for 22W only)
Output Voltage Ripple Noise V_{P-P}: 108mV



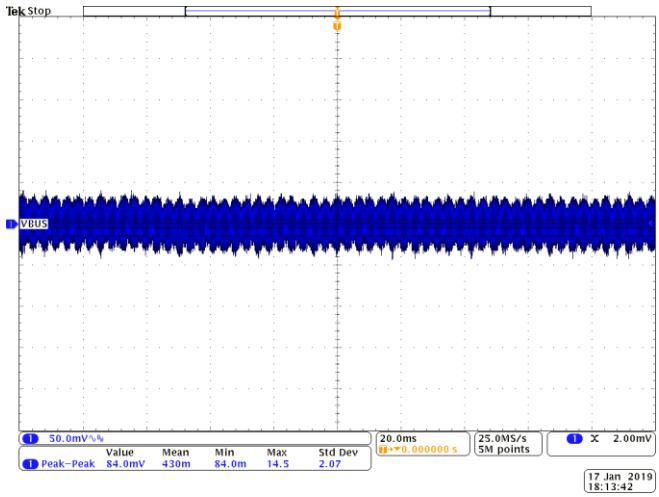
Input: 90V_{AC} / 60Hz
Output: 3.8V / 3A (for 22W only)
Output Voltage Ripple Noise V_{P-P}: 142mV



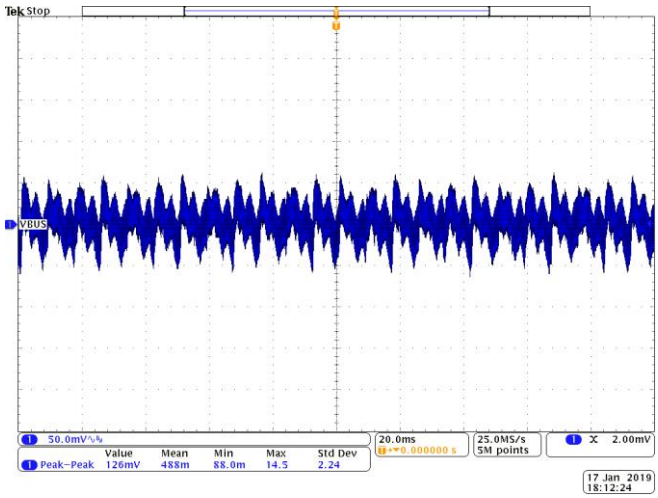
Input: 264V_{AC} / 60Hz
Output: 3.8V / 3A (for 22W only)
Output Voltage Ripple Noise V_{P-P}: 100mV



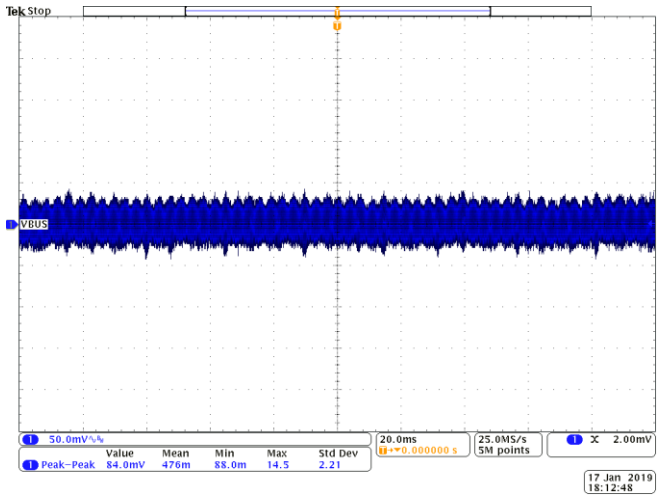
Input: 90V_{AC} / 60Hz
Output: 8V / 2.25A (for 22W only)
Output Voltage Ripple Noise V_{P-P}: 152mV



Input: 264V_{AC} / 60Hz
Output: 8V / 2.25A (for 22W only)
Output Voltage Ripple Noise V_{P-P}: 84mV

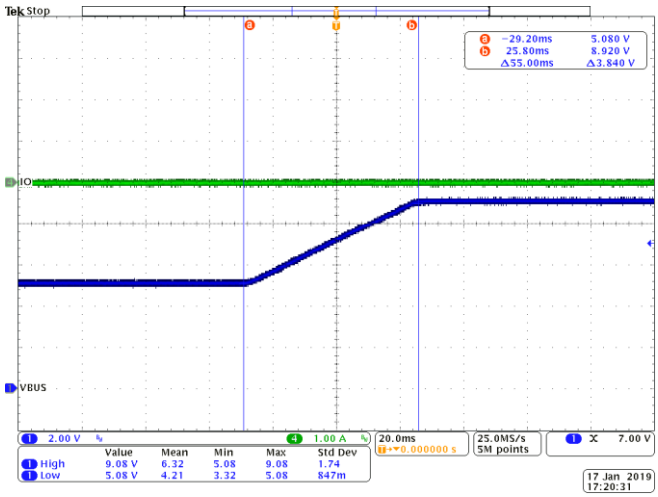
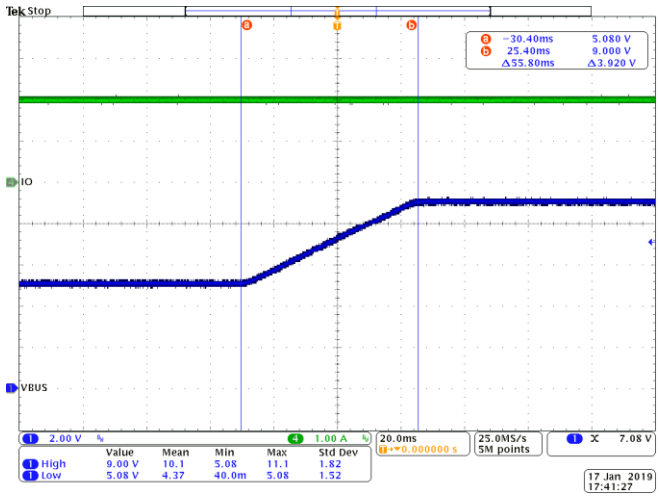
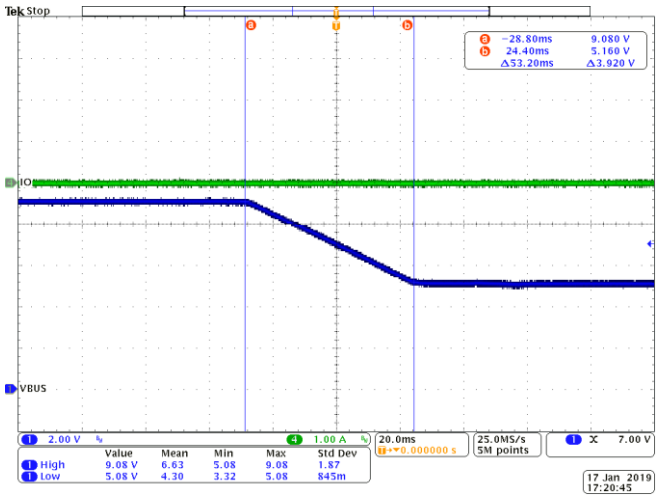
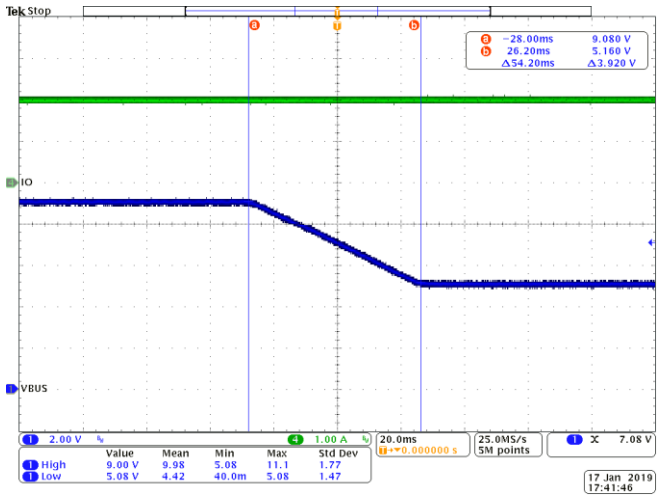


Input: 90V_{AC} / 60Hz
Output: 11V / 1.64A (for 22W only)
Output Voltage Ripple Noise V_{P-P}: 126mV

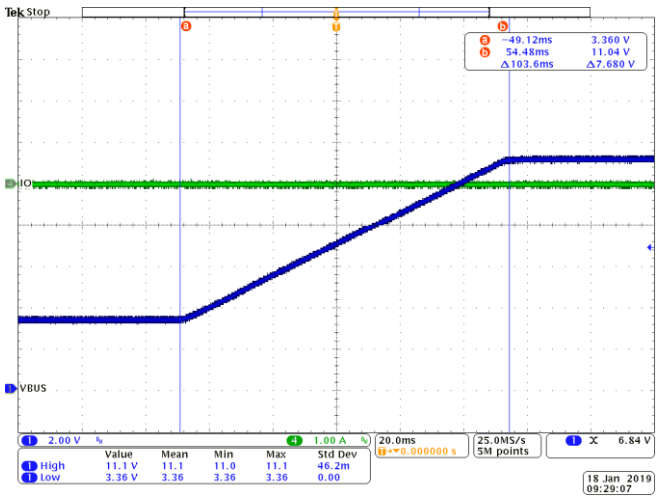


Input: 264V_{AC} / 60Hz
Output: 11V / 1.64A (for 22W only)
Output Voltage Ripple Noise V_{P-P}: 84mV

5.7.4 Output Voltage Transition Time

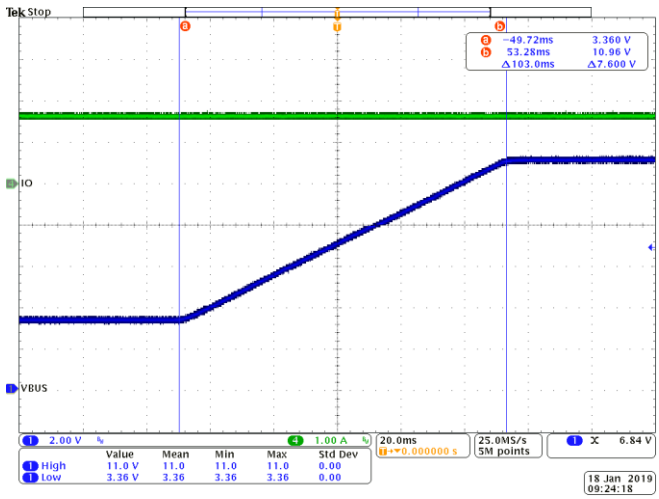
CH1: Output Voltage, CH4: Output Current  	**CH1: Output Voltage, CH4: Output Current** 
Input: 115V$_{AC}$ / 60Hz **Output: 5V to 9V / 0A** **Transition Time: 55.0ms**	**Input: 115V$_{AC}$ / 60Hz** **Output: 5V to 9V / 2A** **Transition Time: 55.8ms**
CH1: Output Voltage, CH4: Output Current  	**CH1: Output Voltage, CH4: Output Current** 
Input: 115V$_{AC}$ / 60Hz **Output: 9V to 5V / 0A** **Transition Time: 53.2ms**	**Input: 115V$_{AC}$ / 60Hz** **Output: 9V to 5V / 2A** **Transition Time: 54.2ms**

CH1: Output Voltage, CH4: Output Current



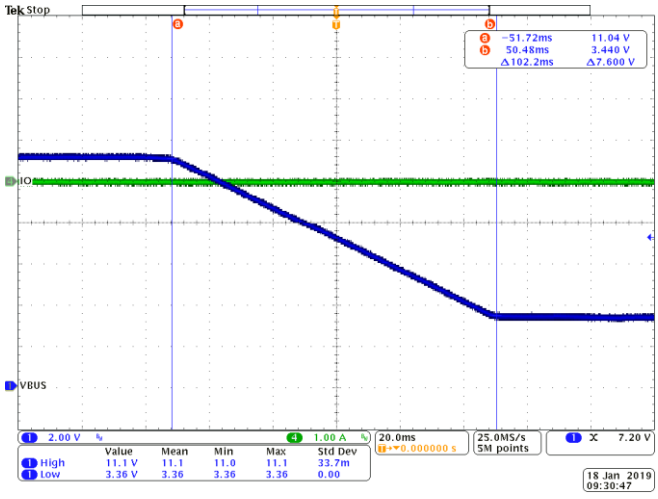
Input: 115V_{AC} / 60Hz
Output: 3.3V to 11V / 0A (for 22W only)
Transition Time: 103.6ms

CH1: Output Voltage, CH4: Output Current



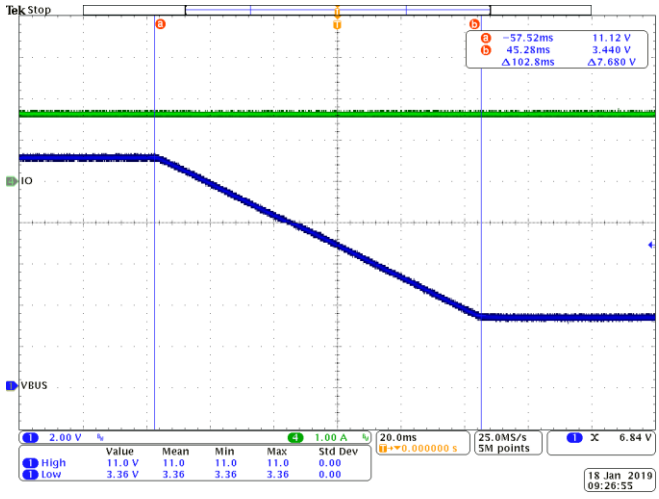
Input: 115V_{AC} / 60Hz
Output: 3.3V to 11V / 1.64A (for 22W only)
Transition Time: 103.0ms

CH1: Output Voltage, CH4: Output Current



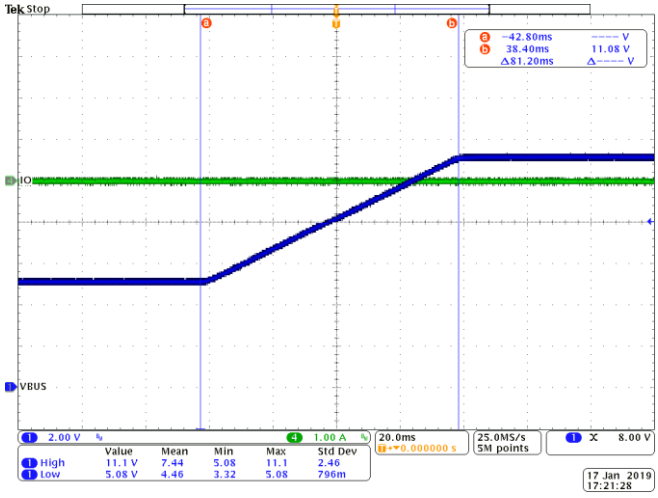
Input: 115V_{AC} / 60Hz
Output: 11V to 3.3V / 0A (for 22W only)
Transition Time: 102.2ms

CH1: Output Voltage, CH4: Output Current



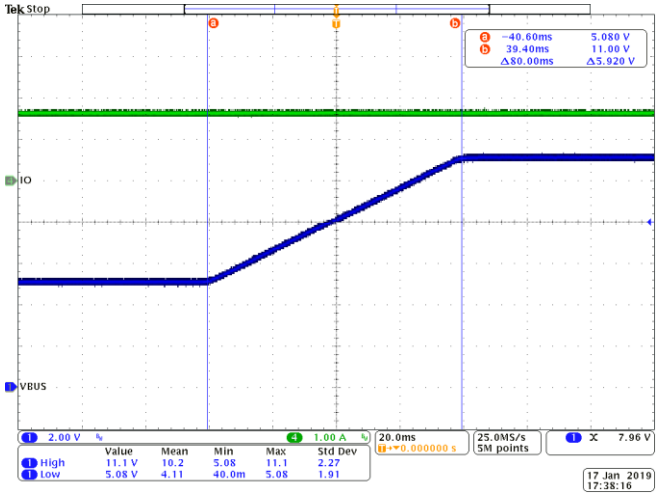
Input: 115V_{AC} / 60Hz
Output: 11V to 3.3V / 1.64A (for 22W only)
Transition Time: 102.8ms

CH1: Output Voltage, CH4: Output Current



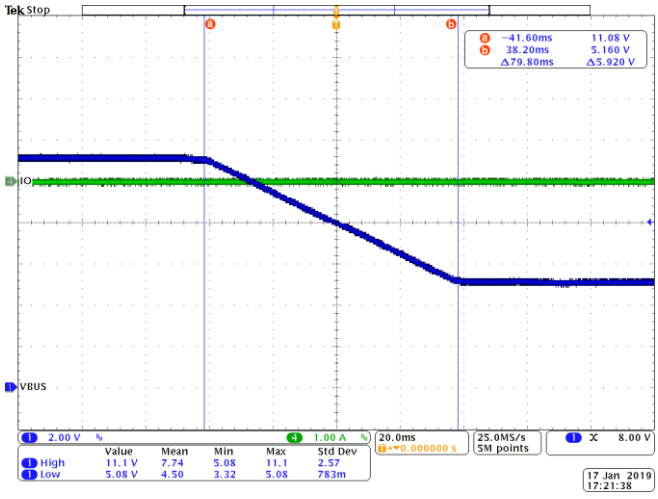
Input: 115V_{AC} / 60Hz
Output: 5V to 11V / 0A (for 22W only)
Transition Time: 81.2ms

CH1: Output Voltage, CH4: Output Current



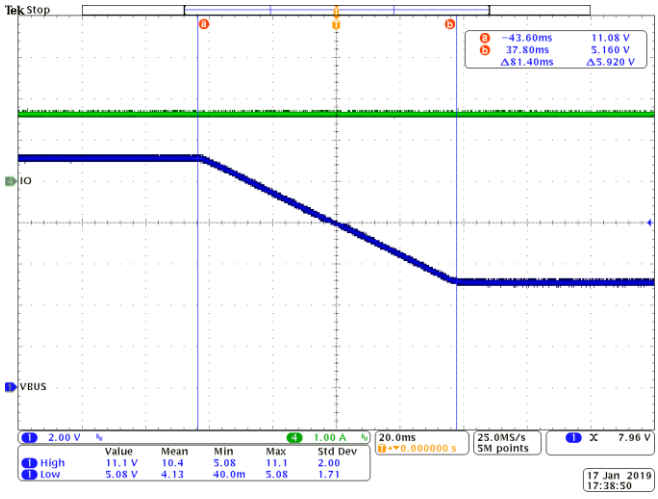
Input: 115V_{AC} / 60Hz
Output: 5V to 11V / 1.64A (for 22W only)
Transition Time: 80.0ms

CH1: Output Voltage, CH4: Output Current



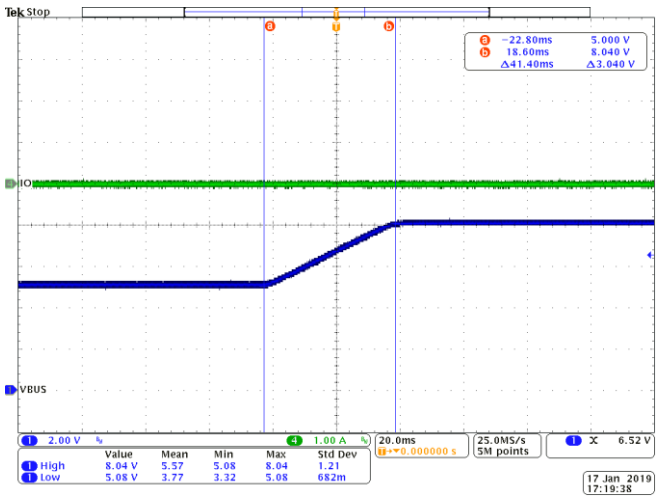
Input: 115V_{AC} / 60Hz
Output: 11V to 5V / 0A (for 22W only)
Transition Time: 79.8ms

CH1: Output Voltage, CH4: Output Current



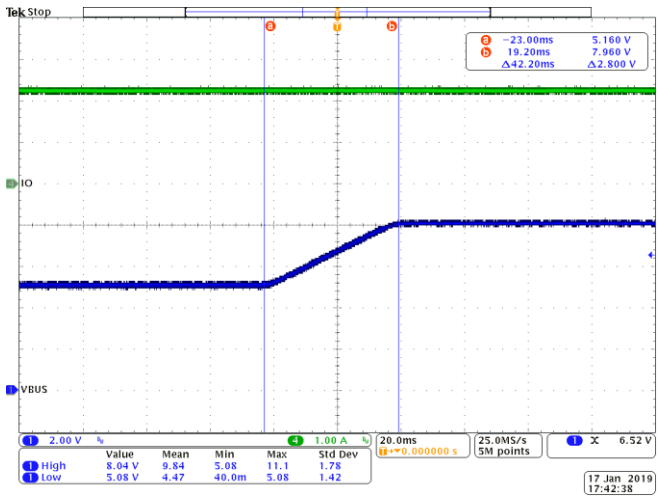
Input: 115V_{AC} / 60Hz
Output: 11V to 5V / 1.64A (for 22W only)
Transition Time: 81.4ms

CH1: Output Voltage, CH4: Output Current



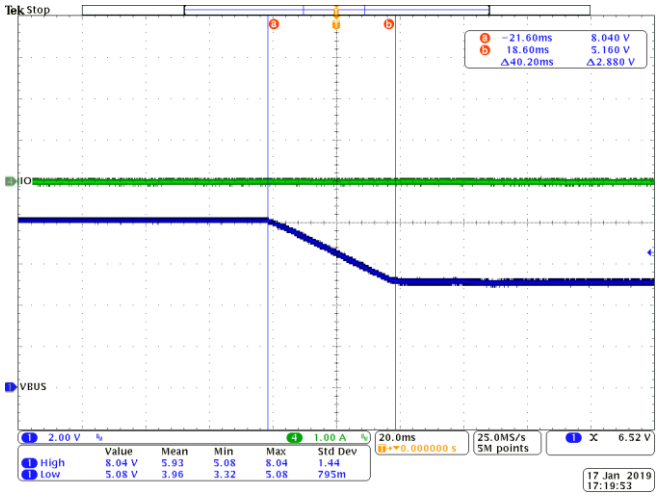
Input: 115V_{AC} / 60Hz
Output: 5V to 8V / 0A (for 22W only)
Transition Time: 41.4ms

CH1: Output Voltage, CH4: Output Current



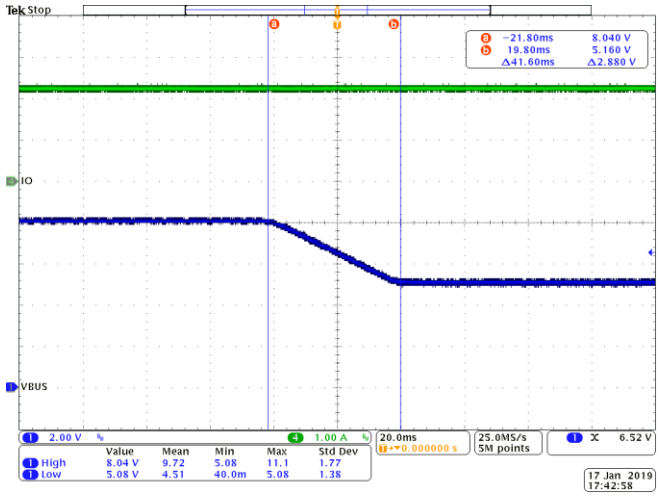
Input: 115V_{AC} / 60Hz
Output: 5V to 8V / 2.25A (for 22W only)
Transition Time: 42.2ms

CH1: Output Voltage, CH4: Output Current



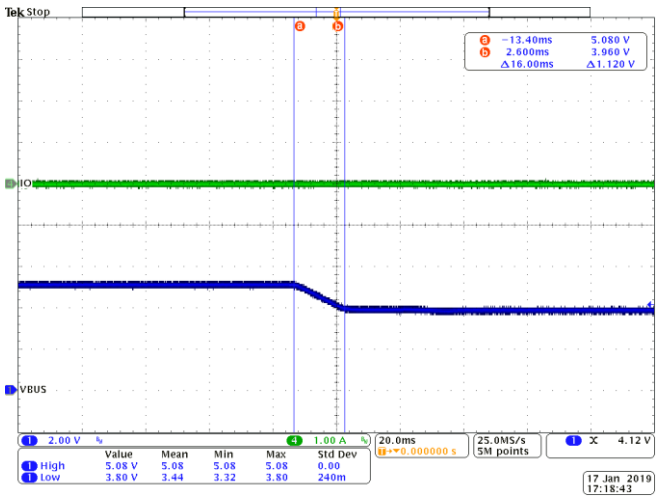
Input: 115V_{AC} / 60Hz
Output: 8V to 5V / 0A (for 22W only)
Transition Time: 40.2ms

CH1: Output Voltage, CH4: Output Current



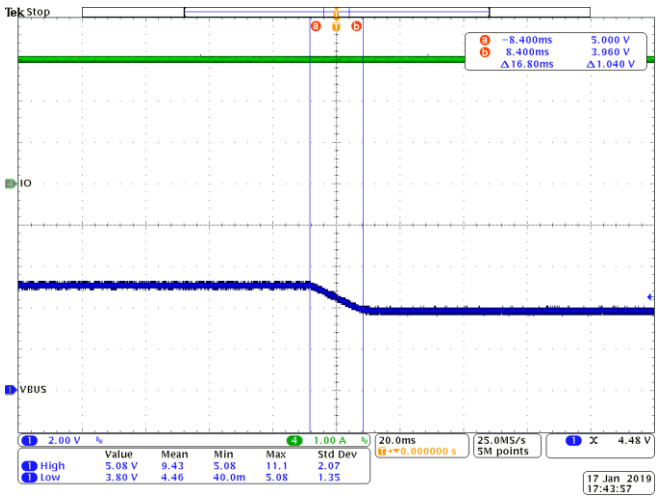
Input: 115V_{AC} / 60Hz
Output: 8V to 5V / 2.25A (for 22W only)
Transition Time: 41.6ms

CH1: Output Voltage, CH4: Output Current



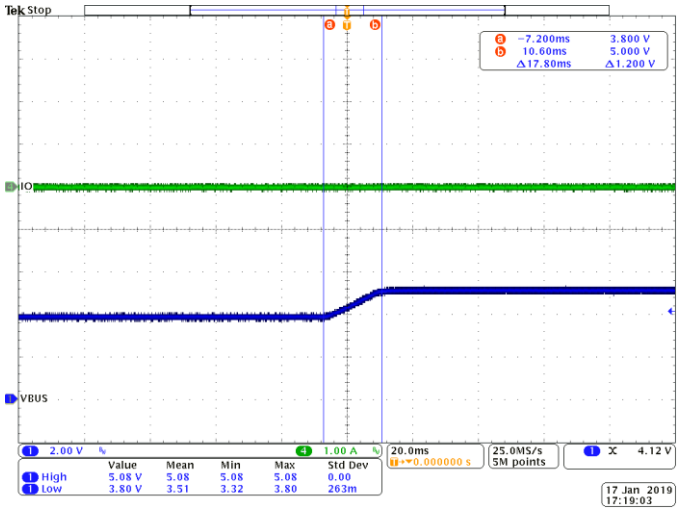
Input: 115V_{AC} / 60Hz
Output: 5V to 3.8V / 0A (for 22W only)
Transition Time: 16ms

CH1: Output Voltage, CH4: Output Current



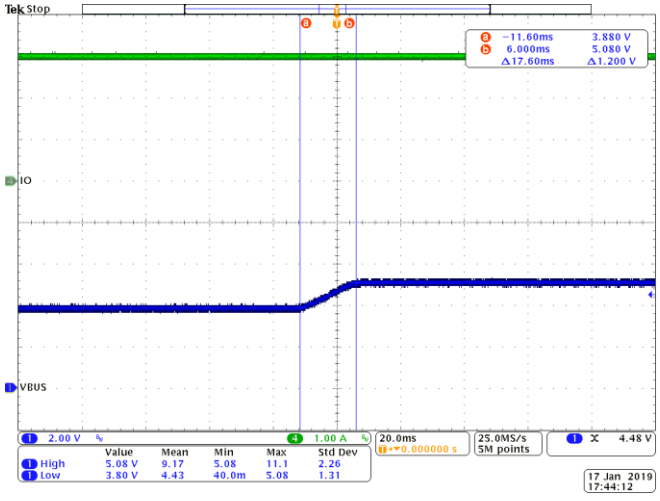
Input: 115V_{AC} / 60Hz
Output: 5V to 3.8V / 3A (for 22W only)
Transition Time: 16.8ms

CH1: Output Voltage, CH4: Output Current



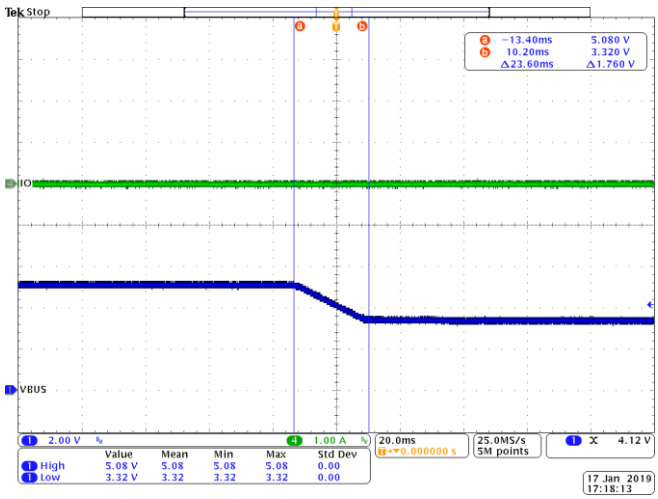
Input: 115V_{AC} / 60Hz
Output: 3.8V to 5V / 0A (for 22W only)
Transition Time: 17.8ms

CH1: Output Voltage, CH4: Output Current



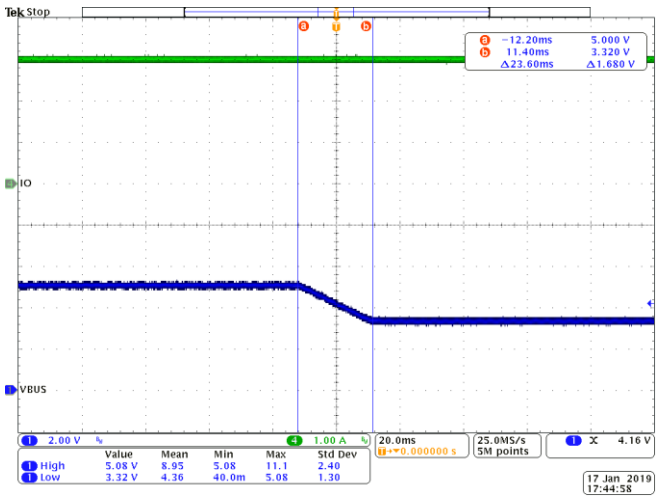
Input: 115V_{AC} / 60Hz
Output: 3.8V to 5V / 3A (for 22W only)
Transition Time: 17.6ms

CH1: Output Voltage, CH4: Output Current



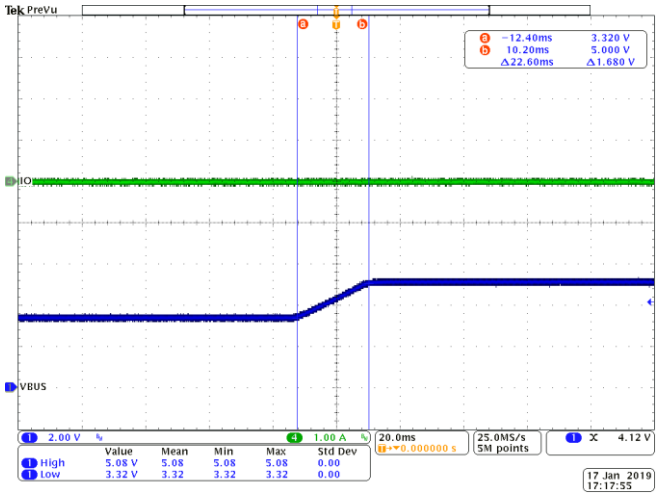
Input: 115V_{AC} / 60Hz
Output: 5V to 3.3V / 0A (for 22W only)
Transition Time: 23.6ms

CH1: Output Voltage, CH4: Output Current



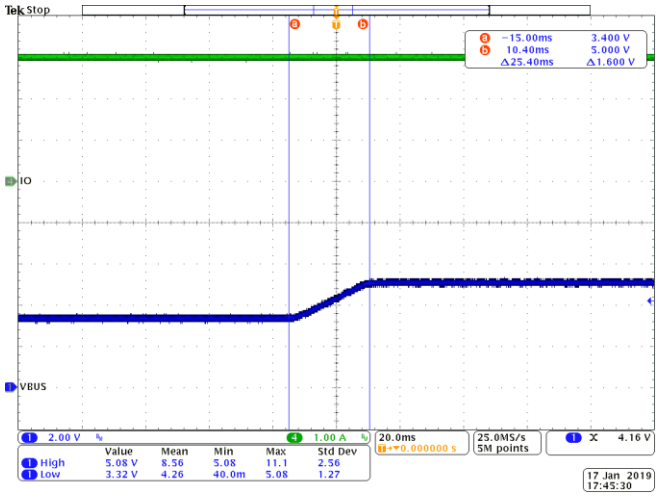
Input: 115V_{AC} / 60Hz
Output: 5V to 3.3V / 3A (for 22W only)
Transition Time: 23.6ms

CH1: Output Voltage, CH4: Output Current



Input: 115V_{AC} / 60Hz
Output: 3.3V to 5V / 0A (for 22W only)
Transition Time: 22.6ms

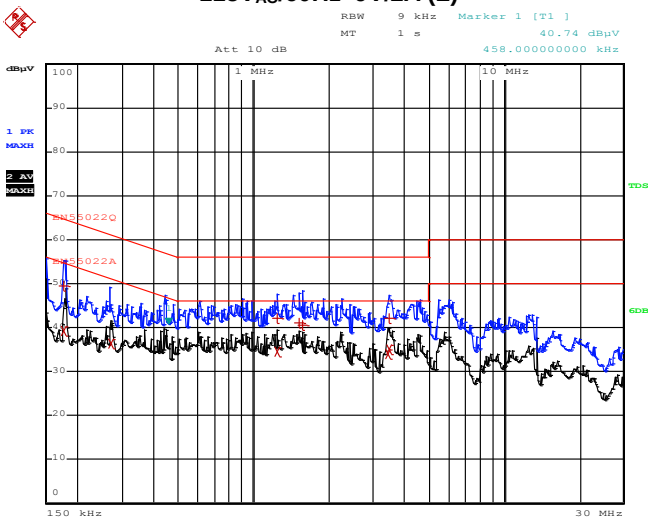
CH1: Output Voltage, CH4: Output Current



Input: 115V_{AC} / 60Hz
Output: 3.3V to 5V / 3A (for 22W only)
Transition Time: 25.4ms

5.7.6 EMI (Conduction) Testing

115V_{AC}/60Hz 9V/2A (L)

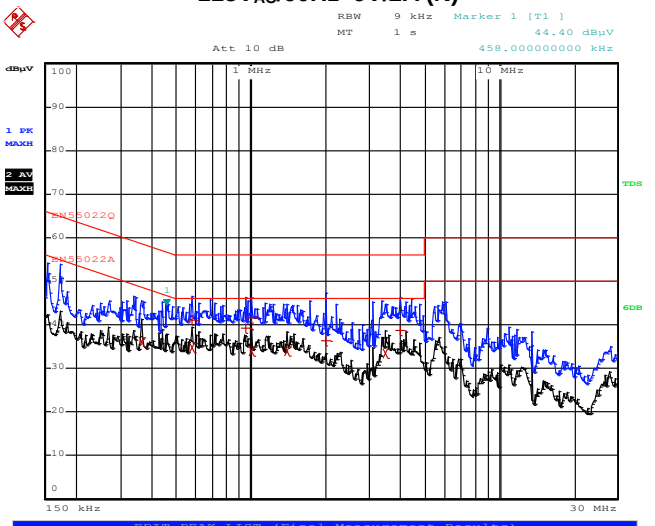


EDIT PEAK LIST (Final Measurement Results)

Trace1: EN55022Q
Trace2: EN55022A
Trace3: ---

TRACE		FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
1	Quasi Peak	178 kHz	49.42	-15.15
2	Average	178 kHz	39.36	-15.21
2	Average	270 kHz	36.36	-14.75
1	Quasi Peak	1.242 MHz	42.24	-13.75
2	Average	1.242 MHz	34.42	-11.57
1	Quasi Peak	1.526 MHz	41.19	-14.80
1	Quasi Peak	1.574 MHz	40.52	-15.47
2	Average	3.438 MHz	34.07	-11.92
1	Quasi Peak	3.482 MHz	42.05	-13.95
2	Average	3.482 MHz	35.02	-10.97

115V_{AC}/60Hz 9V/2A (N)

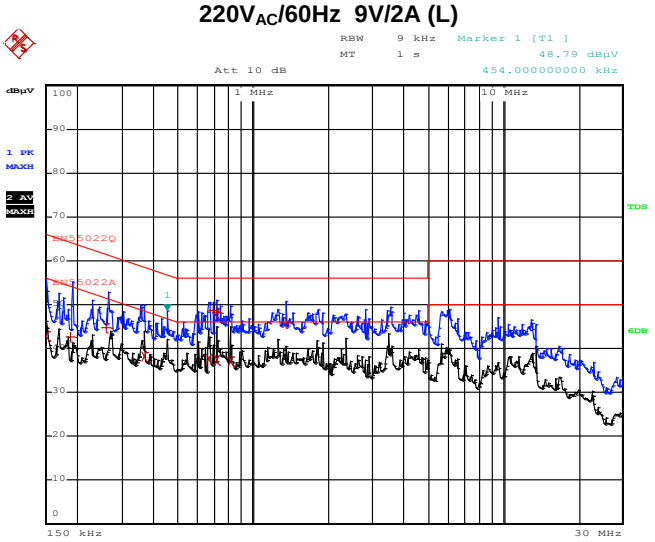


EDIT PEAK LIST (Final Measurement Results)

Trace1: EN55022Q
Trace2: EN55022A
Trace3: ---

TRACE		FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
2	Average	362 kHz	35.99	-12.69
1	Quasi Peak	578 kHz	41.00	-14.99
2	Average	578 kHz	34.73	-11.26
1	Quasi Peak	950 kHz	39.18	-16.81
1	Quasi Peak	1.002 MHz	41.55	-14.44
2	Average	1.002 MHz	34.08	-11.91
2	Average	1.406 MHz	33.92	-12.08
1	Quasi Peak	2.002 MHz	36.40	-19.59
2	Average	3.498 MHz	33.41	-12.58
1	Quasi Peak	4.022 MHz	38.65	-17.34

220V_{AC}/60Hz 9V/2A (L)

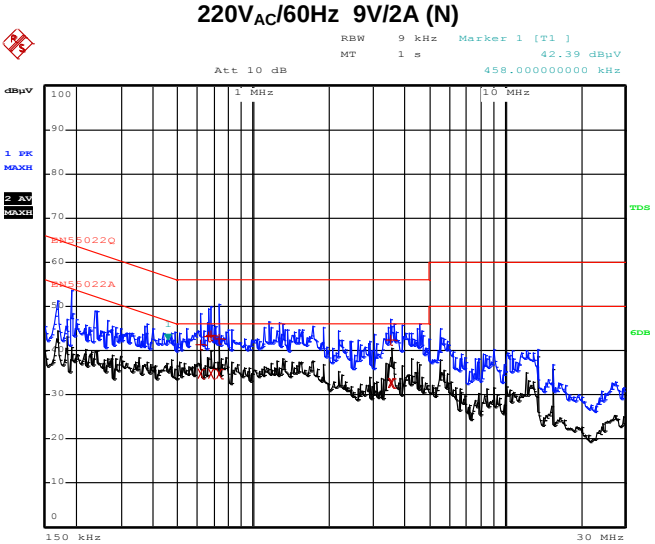


EDIT PEAK LIST (Final Measurement Results)

Trace1: EN55022Q
Trace2: EN55022A
Trace3: ---

TRACE		FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
2	Average	150 kHz	42.95	-13.04
1	Quasi Peak	190 kHz	42.74	-21.29
1	Quasi Peak	262 kHz	44.83	-16.53
2	Average	366 kHz	38.15	-10.43
2	Average	666 kHz	37.57	-8.42
1	Quasi Peak	690 kHz	48.81	-7.18
1	Quasi Peak	718 kHz	48.16	-7.83
2	Average	718 kHz	37.40	-8.59
2	Average	814 kHz	37.22	-8.77
1	Quasi Peak	1.35 MHz	45.68	-10.31

220V_{AC}/60Hz 9V/2A (N)



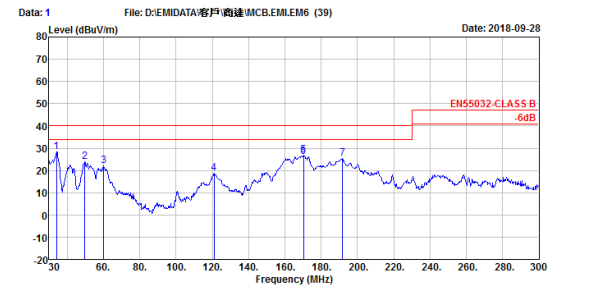
EDIT PEAK LIST (Final Measurement Results)

Trace1: EN55022Q
Trace2: EN55022A
Trace3: ---

TRACE		FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
1	Quasi Peak	614 kHz	41.24	-14.75
2	Average	614 kHz	34.83	-11.16
1	Quasi Peak	662 kHz	43.18	-12.81
1	Quasi Peak	682 kHz	43.36	-12.63
2	Average	682 kHz	34.87	-11.12
1	Quasi Peak	730 kHz	42.74	-13.25
2	Average	730 kHz	34.90	-11.09
1	Quasi Peak	3.51 MHz	42.49	-13.50
2	Average	3.53 MHz	32.58	-13.41
2	Average	3.554 MHz	32.66	-13.33

5.7.1 EMI (Radiation) Testing

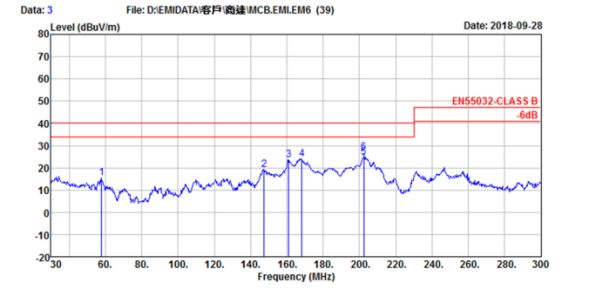
110V$_{AC}$/60Hz 9V/2A (Vertical)



Site : 03CH04-HY
Condition: EN55032-CLASS B 3m ANT2724+ATTENUATOR VERTICAL
EUT : 18W PD3.0
MODEL :
POWER : 110V / 60Hz
MEMO : Sample 1
: 9V 2A

	Freq	Limit Line	Level	Over Limit	Read Level	Cable Loss	PreampFactor	Antenna Factor	A/Pos	T/Pos	Remark
	MHz	dBuV/m	dBuV/m	dB	dBuV	dB	dB	dB/m	cm	deg	
1 pp	34.05	40.00	28.45	-11.55	45.87	0.72	30.32	22.93	---	---	Peak
2	49.71	40.00	23.94	-16.06	45.61	0.70	30.33	15.16	---	---	Peak
3	60.24	40.00	22.01	-17.99	41.95	1.04	30.31	11.99	---	---	Peak
4	120.99	40.00	18.76	-21.24	39.11	1.22	30.13	17.68	---	---	Peak
5	170.40	40.00	26.83	-13.17	46.63	1.41	29.91	15.59	---	---	Peak
6 qp	170.40	40.00	26.01	-13.99	45.81	1.41	29.91	15.59	---	---	QP
7	191.73	40.00	25.29	-14.71	45.72	1.39	29.82	14.89	---	---	Peak

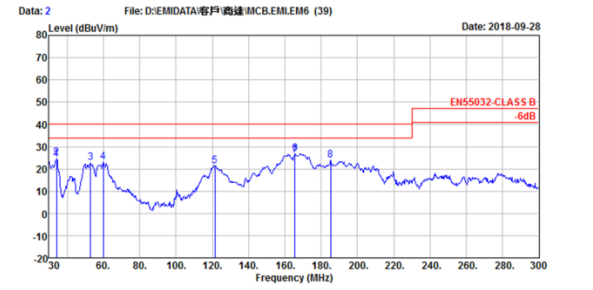
110V$_{AC}$/60Hz 9V/2A (Horizontal)



Site : 03CH04-HY
Condition: EN55032-CLASS B 3m ANT2724+ATTENUATOR HORIZONTAL
EUT : 18W PD3.0
MODEL :
POWER : 110V / 60Hz
MEMO : Sample 1
: 9V 2A

	Freq	Limit Line	Level	Over Limit	Read Level	Cable Loss	PreampFactor	Antenna Factor	A/Pos	T/Pos	Remark
	MHz	dBuV/m	dBuV/m	dB	dBuV	dB	dB	dB/m	cm	deg	
1	57.81	40.00	15.39	-24.61	32.10	0.97	30.31	12.13	---	---	Peak
2	147.45	40.00	19.16	-20.84	34.12	1.35	30.01	17.20	---	---	Peak
3	160.95	40.00	23.54	-16.46	40.17	1.46	29.95	16.46	---	---	Peak
4	168.24	40.00	24.01	-15.99	42.53	1.42	29.92	15.72	---	---	Peak
5 pk	202.53	40.00	24.83	-15.17	39.45	1.42	29.77	15.10	---	---	Peak
6 pp	202.53	40.00	26.69	-13.31	41.31	1.42	29.77	15.10	---	---	QP

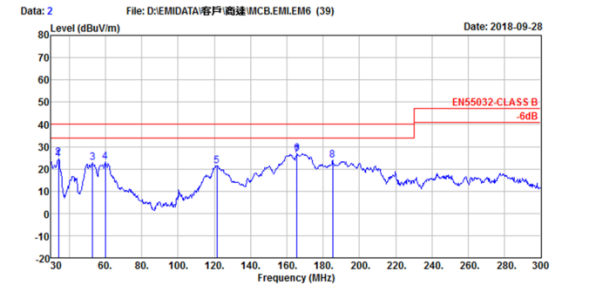
230V$_{AC}$/50Hz 9V/2A (Vertical)



Site : 03CH04-HY
Condition: EN55032-CLASS B 3m ANT2724+ATTENUATOR VERTICAL
EUT : 18W PD3.0
MODEL :
POWER : 230V / 50Hz
MEMO : Sample 1
: 9V 2A

	Freq	Limit Line	Level	Over Limit	Read Level	Cable Loss	PreampFactor	Antenna Factor	A/Pos	T/Pos	Remark
	MHz	dBuV/m	dBuV/m	dB	dBuV	dB	dB	dB/m	cm	deg	
1	34.05	40.00	24.19	-15.81	41.61	0.72	30.32	22.93	---	---	Peak
2	34.05	40.00	25.00	-15.00	42.42	0.72	30.32	22.93	---	---	QP
3	52.95	40.00	22.75	-17.25	46.60	0.80	30.32	13.32	---	---	Peak
4	59.97	40.00	23.21	-16.79	43.15	1.04	30.31	11.99	---	---	Peak
5	121.53	40.00	21.51	-18.49	41.86	1.22	30.13	17.68	---	---	Peak
6 pp	165.54	40.00	26.96	-13.04	47.65	1.43	29.93	15.89	---	---	Peak
7 qp	165.54	40.00	26.27	-13.73	46.96	1.43	29.93	15.89	---	---	QP
8	185.25	40.00	23.85	-16.15	46.20	1.37	29.85	14.81	---	---	Peak

230V$_{AC}$/50Hz 9V/2A (Horizontal)



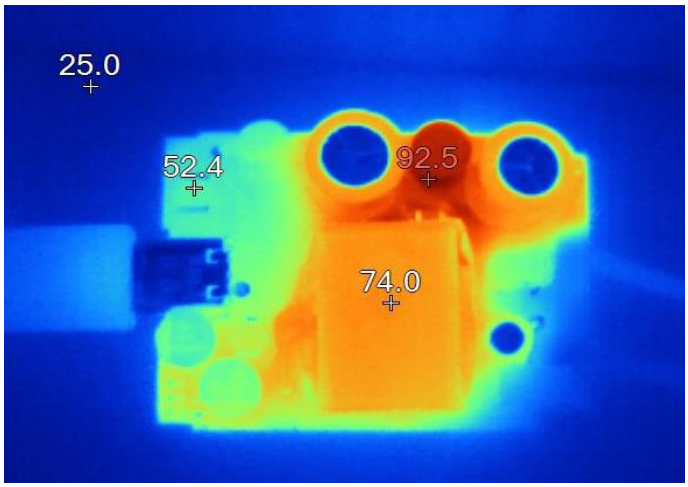
Site : 03CH04-HY
Condition: EN55032-CLASS B 3m ANT2724+ATTENUATOR VERTICAL
EUT : 18W PD3.0
MODEL :
POWER : 230V / 50Hz
MEMO : Sample 1
: 9V 2A

	Freq	Limit Line	Level	Over Limit	Read Level	Cable Loss	PreampFactor	Antenna Factor	A/Pos	T/Pos	Remark
	MHz	dBuV/m	dBuV/m	dB	dBuV	dB	dB	dB/m	cm	deg	
1	34.05	40.00	24.19	-15.81	41.61	0.72	30.32	22.93	---	---	Peak
2	34.05	40.00	25.00	-15.00	42.42	0.72	30.32	22.93	---	---	QP
3	52.95	40.00	22.75	-17.25	46.60	0.80	30.32	13.32	---	---	Peak
4	59.97	40.00	23.21	-16.79	43.15	1.04	30.31	11.99	---	---	Peak
5	121.53	40.00	21.51	-18.49	41.86	1.22	30.13	17.68	---	---	Peak
6 pp	165.54	40.00	26.96	-13.04	47.65	1.43	29.93	15.89	---	---	Peak
7 qp	165.54	40.00	26.27	-13.73	46.96	1.43	29.93	15.89	---	---	QP
8	185.25	40.00	23.85	-16.15	46.20	1.37	29.85	14.81	---	---	Peak

5.7.8 Thermal Testing

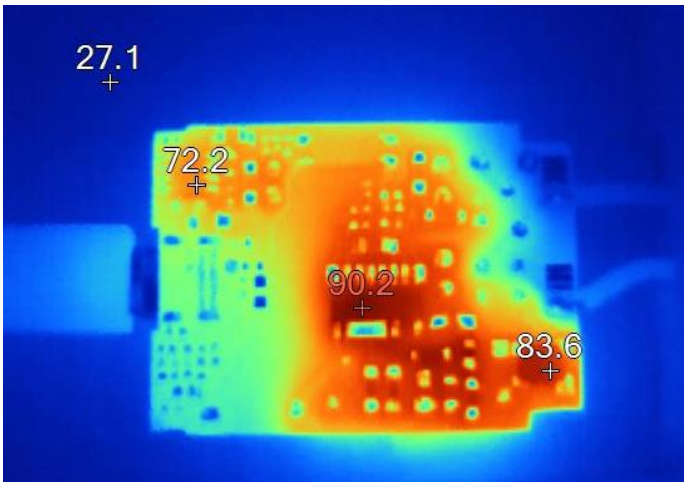
Test Condition: V_{IN}=90V_{AC}, V_O=9V, I_O=2A, Set up the EVB into the closed box at room temperature +25 °C

90V_{AC} 18W TOP Side



Ambient Temperature ---------- 25.0 °C
L1 (DR6*8) ---------- 92.5 °C
T1 (Transformer) ---------- 83.6 °C
U61 (AP43771) ---------- 52.4 °C

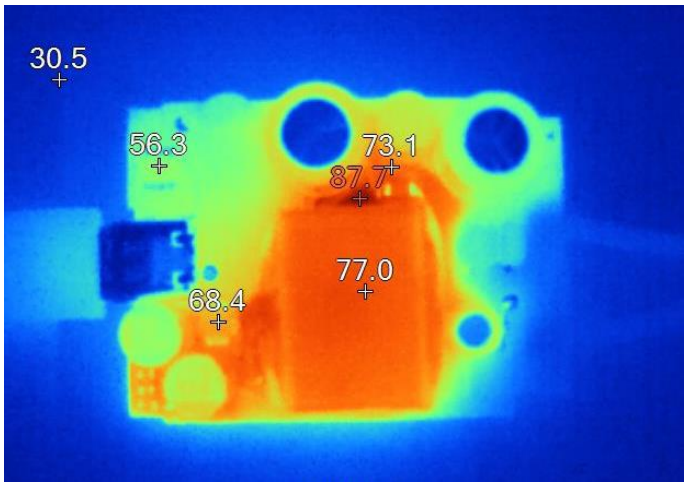
90V_{AC} 18W Bottom Side



Ambient Temperature --------- 27.1 °C
U5 (AP39303) ---------- 90.2 °C
BD1 (MSB12M) ---------- 83.6 °C
U64 (APR34709) ---------- 72.2 °C

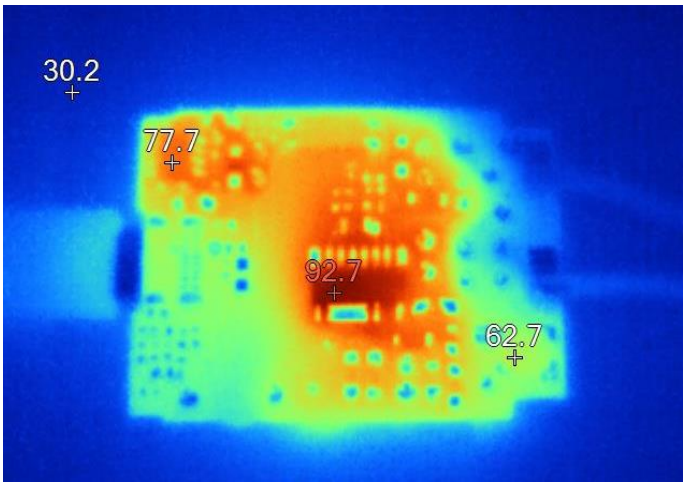
Test Condition: V_{IN}=264V_{AC}, V_O=9V, I_O=2A, Set up the EVB into the closed box at room temperature +25 °C

264V_{AC} 18W TOP Side



Ambient Temperature ---------- 30.5 °C
L1 (DR6*8) ---------- 73.1 °C
T1 (Transformer) ---------- 77.0 °C
U61 (AP43771) ---------- 56.3 °C

264V_{AC} 18W Bottom Side



Ambient Temperature --------- 30.2 °C
U5 (AP39303) ---------- 92.7 °C
BD1 (MSB12M) ---------- 62.7 °C
U64 (APR34709) ---------- 77.7 °C

Chapter 6. USB IF Power Brick Certification Test Detail

6.1 18W power brick certification test detail

1). USB IF Power Brick Certification name: PD3.0 with PPS
2). Diodes Product Marketing name: PD3.0 18W Charger (with AP43771 decoder)
3). Product Model / Part Number: USB‑PD3‑PPS‑18W‑EV1 (REV:1)
4). Power Brick Test TID: 1100026
5). Certification Testing & Passing date: 8-31-2018
6). USB IF Certified list link: https://www.usb.org/products

6.2 22W power brick certification test detail

1). USB IF Power Brick Certification name: PD3.0 with PPS
2). Diodes Product Marketing name: PD3.0 22W Quick Charger (with AP43771 decoder)
3). Product Model / Part Number: USB‑PD3‑PPS‑22W‑EV1 (REV:1)
4). Power Brick Test TID: 152
5). Certification Testing & Passing date: 12-07-2018
6). USB IF Certified list link: https://www.usb.org/products

Chapter 7. Revision Control

7.1 Revision table

Revision	Items Changed & added	The changing reason
1.0	Release	

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1. are intended to implant into the body, or
2. support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labeling can be reasonably expected to result in significant injury to the user.

B. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or to affect its safety or effectiveness.

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