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Chapter 1. Summary

1.1 General Description

The 27W QC4/4+ Class A charger Evaluation Board EV1 is composed of three main parts, AP3302A offers the QR PWM switching control & working under the DCM mode with peak current controlling, APR345 is a Synchronous Rectification Controller, and the WT6615F is USB PD and Qualcomm® Quick Charge™ 4/4+ Controller for implementing quick charger decoder functions. Based on monitoring D+ & D- and CC1 & CC2 signals, WT6615F will interprets desired voltage and current setting, and then feedback information to primary side AP3302A controller for providing well regulated voltage and current as well as related power protections.

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
- Supports the USB PD3.0 Function and PPS (3V-11V@20mV)
- Meet DOE6 and CoC Tier 2 Efficiency Requirements
- <75mW No-Load Standby Power

1.2.2 AP3302A Key Features

- Quasi-Resonant Operation with Valley Lock under all Lines and Load Conditions
- Switching Frequency: 22kHz-120kHz
- Non-audible-noise QR Controlling
- Soft Start Process during the Start-up Turn-on Moment
- During the burst mode operation and Low start-up operating quiescent currents, 75mW standby power can be achieved
- Built-in Jittering Frequency Function which is the EMI emission can be improved
- Internal Auto Recovery OCP, OVP, OLP, OTP Power Protection, cycle by cycle current limit, also with DC polarity & transformer short and Brown out Protection

1.2.3 APR345 Key Features

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

1.2.4 WT6615F Key Feature

- Type-C Source
- USB PD 3.0 v1.1 (PPS)
- BC1.2 DCP
- Qualcomm Quick Charge 4/4+
- Built in Shunt Regulator for Constant Voltage and Constant Current
- Programmable OVP/UVP/OCP/OTP
- Internal Discharge MOS
- Internal Vbus Load Switch Driver
- 3V- 30V Operation Voltage without External Regulator

1.3 Applications

- QC4/4+ Wall Chargers

1.4 Main Power Specifications (CV & CC Mode)

Parameter	Value
Input Voltage	90Vac to 264Vac
Input standby power	< 75mW
Main Output Vo / Io	3V/3A, 5V/3A, 9V/3A, 12V/2.25A
	PPS Mode 3V-11V, 20mV/step, 50mA/step
Per Step Voltage	Continuous Mode 200mV, 3.6V-12V
	PPS 20mV, 3V-11V
Efficiency	89%
Total Output Power	27W
Protections	OCP, OVP, UVP, OLP, OTP
XYZ Dimension	40 x 40 x 25mm
ROHS Compliance	Yes

1.5 Evaluation Board Picture

Figure 1: Top View

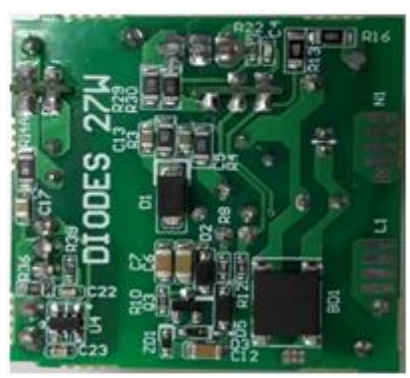


Figure 2: Bottom View

Chapter 2. Power Supply Specification

2.1 Specification and Test Results

Parameter	Test conditions	Min	Nom	Max	Eff / DoE VI	Eff / Tier2	Test Summary
V_{ACIN} Input Voltage	-	90 V_{RMS}	115/230	264 V_{RMS}	-	-	-
F_{LINE} Frequency	-	47Hz	50/60	64Hz	-	-	-
I_{IN} Input Current	-	-	-	1.5 A_{RMS}	-	-	Pass
No load Pin	At 230Vac /50Hz, @ 5V, Pin < 75mW	-	-	75mW	-	-	Pass, the test result is 58mW
3V/ 3A @115Vac/230Vac Average efficiency	Board end	-	3V / 3A	-	77.87%	81.34%	Pass, average efficiency is 83.6%
5V/ 3A @115Vac/230Vac Average efficiency	Board end	-	5V/3A	-	81.39%	81.84%	Pass, average efficiency is 87%
5V/ 3A @115Vac/230Vac 10% efficiency	Board end	-	5V/0.3A	-	-	72.48%	Pass, efficiency is 78.5%
9V/ 3A @115Vac/230Vac Average efficiency	Board end	-	9V/3A	-	86.60%	87.30%	Pass, average efficiency is 89.32%
9V/ 3A @115Vac/230Vac 10% efficiency	Board end	-	9V/0.3A	-	-	76.62%	Pass, efficiency is 80.6%
12V/ 2.25A @115Vac/230Vac Average efficiency	Board end	-	12V/2.25A	-	86.20%	87.30%	Pass, average efficiency is 88.89%

2.2 Compliance

Parameter	Test conditions	Min	Nom	Max	Test Summary
Standby Power (mW)	5V Output	-	-	75mW	Pass
Output Voltage Tolerance	3V/0-3A		3V		Pass
Output Voltage Tolerance	5V/0-3A	4.75V	5V	5.25V	Pass
Output Voltage Tolerance	9V/0-3A	8.55V	9V	9.45V	Pass
Output Voltage Tolerance	12V/0-2.25A	11.4V	12V	12.6V	Pass
Output Connector	USB Type C	-	-	-	
Temperature	90Vac , 9V / 3A	-	-	-	Pass
Dimensions (W /D/ H)	40mm x 40mm x 25mm	-	-	-	-
Safety	IEC/EN/UL 60950 Standard	-	-	-	-
EMI/EMC	FCC/EN55022 Class B	-	-	-	

Chapter 3. Schematic

3.1 EV1 Board Schematic

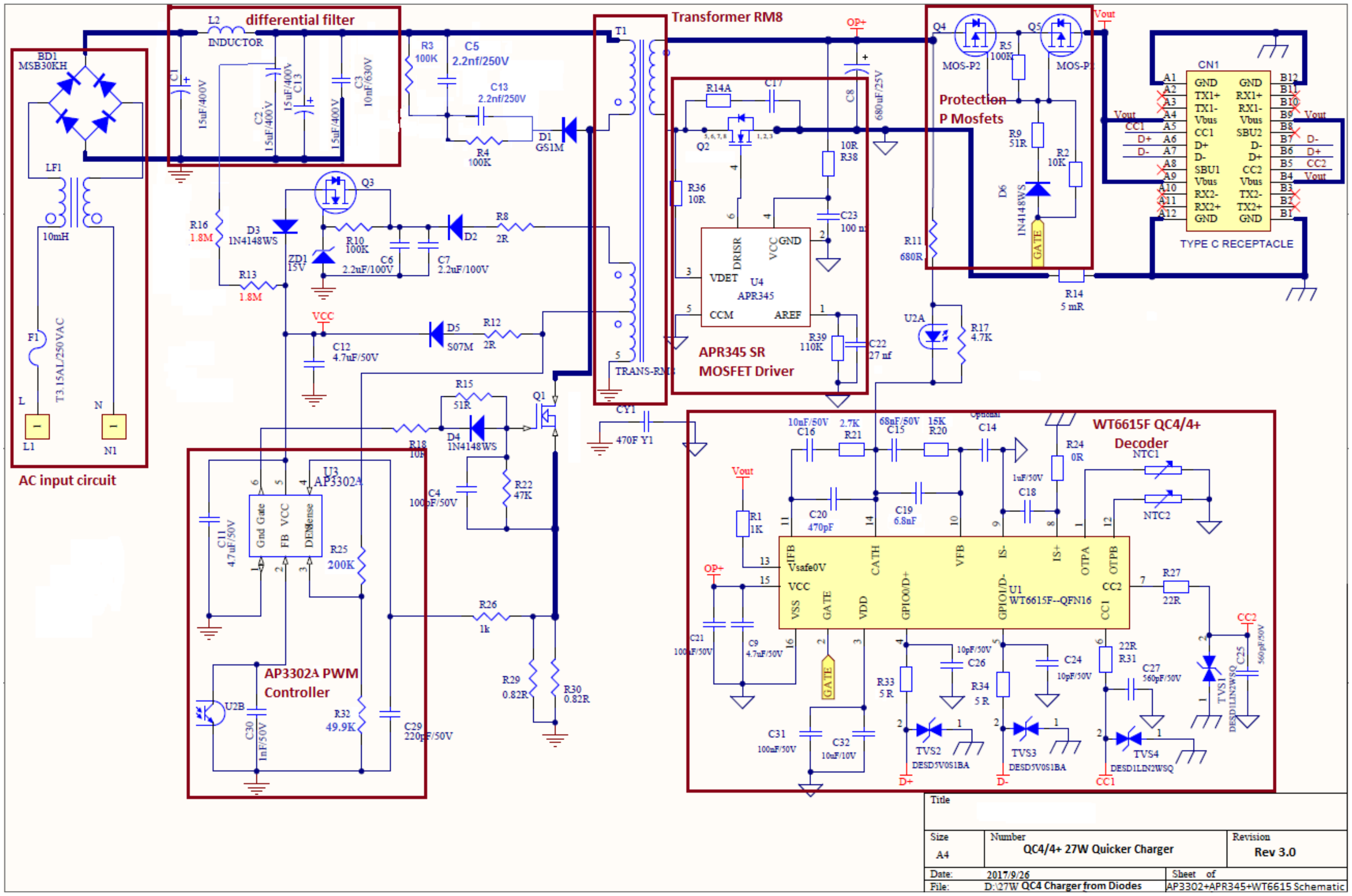


Figure 3: Evaluation Board Schematic

3.2 Bill of Material (BOM)

Designator	Comment	Designator	Comment	Designator	Comment
BD1	MSB30KH	C33	1µF/50V	R14	5 mΩ 1206
C1, C2	15µF/400V	CN1	TYPE C RECEPTACLE	R14A	51Ω 1206
C3	10nF/630V	CY1	470pF Y1	R17	4.7kΩ
C4	100pF/50V	D1	GS1M	R18, R36	10Ω
C5, C13	2.2nF/250V	D2, D5	S07M	“R20”	15kΩ
C6, C7	2.2µF/100V	D3, D4, D6	1N4148WS	R21	2.7kΩ
C8	680µF/16V	F1	T2AL/250VAC	R22	47kΩ
C9, C11, C12	4.7µF/50V	L2	220µH	R24	0kΩ
C10	22µF/400V	LF1	10mH	R25	200kΩ
“C15”	68nF/50V	NTC1, NTC2	10kΩ NTC		
C16	10nF/50V	Q1	DMJ65H650SCT, TO220	R27, R31	22Ω
C17	1nF/200v	Q2	DMTH10H010SCT	R29, R30	0.82Ω 1206
C18	1µF/25V	Q3	DMN24H3D	R32	49.9kΩ
C19,	6.8nf/50V	Q4, Q5	DMP2007UFG	R33, R34	5Ω
C21, C23	100nF/50v	R1	1kΩ	R38	10Ω
C20	470pF/50V	R2	20kΩ	R39	110KΩ
C22	22nF/50v	R3, R4	100kΩ	T1	TRANS-RM8
C24, C26	10pF/50V	R5	100kΩ	TVS1, TVS2，TVS3, TVS4	DESD5V0S1BA
C25, C27	560pF/50V	R8, R12	2Ω	U1	WT6615F--QFN16
C28	47nF/50v	R9, R15	51Ω 0603	U2	EL1019
C29	220pF/50V	R10	100kΩ	U3	AP3302A
C30	1nF/50V	R11	680Ω	U4	APR345
C31	100nF/16V	R26	1kΩ	ZD1 BZT52C20T	20V Zener
C32	10µF/10V	R13, R16	1.8MΩ	-	-

NOTE:
For optimization of WT6615F QC4/4+ decoder performance, please adjust component values as below (different from component values used in the Section 3.2 System BOM above):

1) Minimize total resistance from D+/D- path to WT6615F: Change R33 and R34 from 51Ω to 5Ω
2) Improve discharge time of WT6615F: Change R1 from 10kΩ to 1kΩ

3.3 Schematics Description

3.3.1 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 is a common mode chock for the common mode noise suppression filleting because of the each coil with large impedance. The BD1 is rectifier, and basically converts alternating current & voltage into direct current & voltage. The C1, L2, C2, C3 & C10 are composted of the Pi filter for filtering the differential switching noise back to AC source.

3.3.2 AP3302A PWM Controller

The AP3302A PWM controller U1 and Opto-Coupler U2 and Q1 are the power converting core components. Connected to filtered output after bridge circuit, R13 & R16 resistor path will provide start-up voltage and current during starting up through Vcc (Pin 5). Subsequent VCC power will be provided by voltage feedback from middle-tapped auxiliary winding through two options, R12-D5 and R8-D2-Q3-D3, depending on desired output voltage. This design is to accommodate with the required wide voltage range to support various protocols (including QC 4/USB PD Programmable Power Supply PPS), from 3V to 12V.

Based on feedback of secondary side (Pin CATH of WT6615 Decoder) to primary side (FB pin of AP3302A) through Opto-coupler U2, AP3302A will switch ON and Off Q1 to regulate desired voltage and current on the secondary side.

3.3.3 APR345 Synchronous Rectification (SR) MOSFET Driver

APR345 operates in DCM mode in this design and drives the Q2 MOSFET based on the secondary side transformer on/off ‘s duty cycle. As the power loss with the APR345-controlled MOSFET Q2 is less than that with Schottky Diodes, the total efficiency can be improved.

3.3.4 WT6615F QC4/4+ Decoder & Protection on /off P MOSFET and Interface to Power Devices

The few sets of important pins provide critical protocol decoding and regulation functions in WT6615F:

1) **CC1 & CC2 (Pin 6, 7)**: 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 4, 5):** 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 15) via resistor divider and comparing with internal reference voltage to generate a CV compensation signal on the CATH pin (pin 14). The output voltages can be adjusted by firmware programming.
4) **Constant Current (CC)**: The CC is implemented by sensing current sense resistor (R14, 5mΩ) and current sense amplifier, then comparing with internal programmable reference voltage to generate a compensation signal on CATH pin (pin 14)
5) **Loop Compensation:** C16, R21 & C20 form the voltage loop compensation circuit, and C15, R20 & C19 form the current loop compensation circuit.
6) **CATH (Pin 14)**: It is a key interface link from the secondary decoder (WT6615F) to the main regulator circuit (AP3302A). This pin is connected to the Opto-Coupler U2A cathode to feedback all sensed voltage and current for getting desired voltage and current set by CC1, CC2, D+, and D- signals.
7) **GATE Driver (Pin 2) to PMOSFET Gate: The pin is us**ed to turn on/off Vbus load switch (Q4 & Q5) to enable/disable voltage output to the Vbus. Two back to back PMOSFETs (Q4 & Q5) are required to prevent reverse current from the attached battery source.

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.

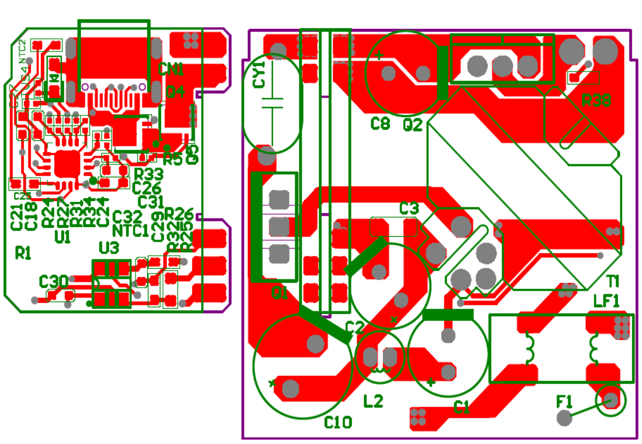


Figure 4: PCB Board Layout components Top View

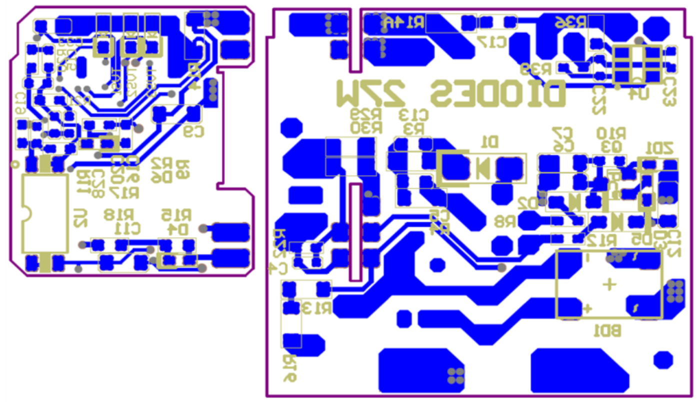


Figure 5: PCB Board Layout Bottom SMD View

4.2 Quick Start Guide Before Connection

1) Before starting the QC4/4+ 27W EVB test, the end user needs to prepare the following tool, software and manuals. For details, please contact Weltrend Semiconductor local agent for further information.

- Test Kit: WPD016 (Weltrend's Qualcomm Quick Charge 4/4+ Test Kit)
- Software: GUI v1.09 (file name: QC4_v1.09)
- Software: Driver (folder name: libusb-driver)
- Manual: USBPW_DOC26_WPD016_User_Guide_V1.0
- Manual: USBPW_DOC28_WPD016_Driver Installation Guide_V1.0

WPD016 Test Kit	GUI v1.09	Standard-A to Micro-B Cable	Type-C Cable

Figure 6: Weltrend Items: Test Kit / PC Test GUI Software /Test Cables

2) Prepare a certified three-foot 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.

Figure 7: The Sample Board Input & Output Location

5) A type-C cable for the connection between EVB’s and WPD016’s Type-C receptacles.

6) Use 2 banana jack cables, one port of the cables are connected to E-load + & - terminals while the other port of the cables are connected to WPD016’s VBUS & GND holes.

7) A Standard-A to Micro-B cable to be connected to the WPD016’s Micro-B receptacle & PC Standard-A receptacle respectively.

4.3 System Setup

4.3.1 Connection with E-Load

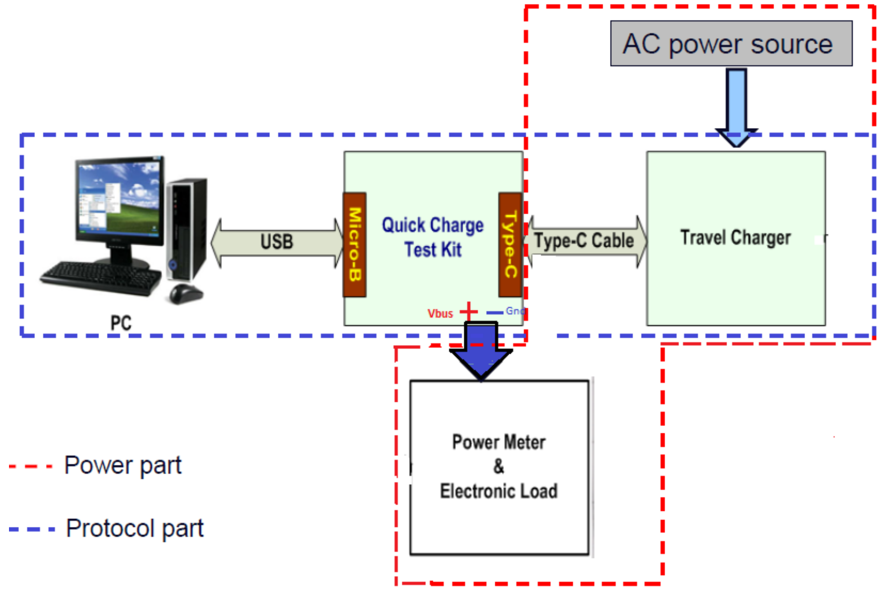


Figure 8: Diagram of Connections in the Sample Board

4.3.2 WPD016 – Weltrend's Qualcomm Quick Charge 4/4+ Test Kit

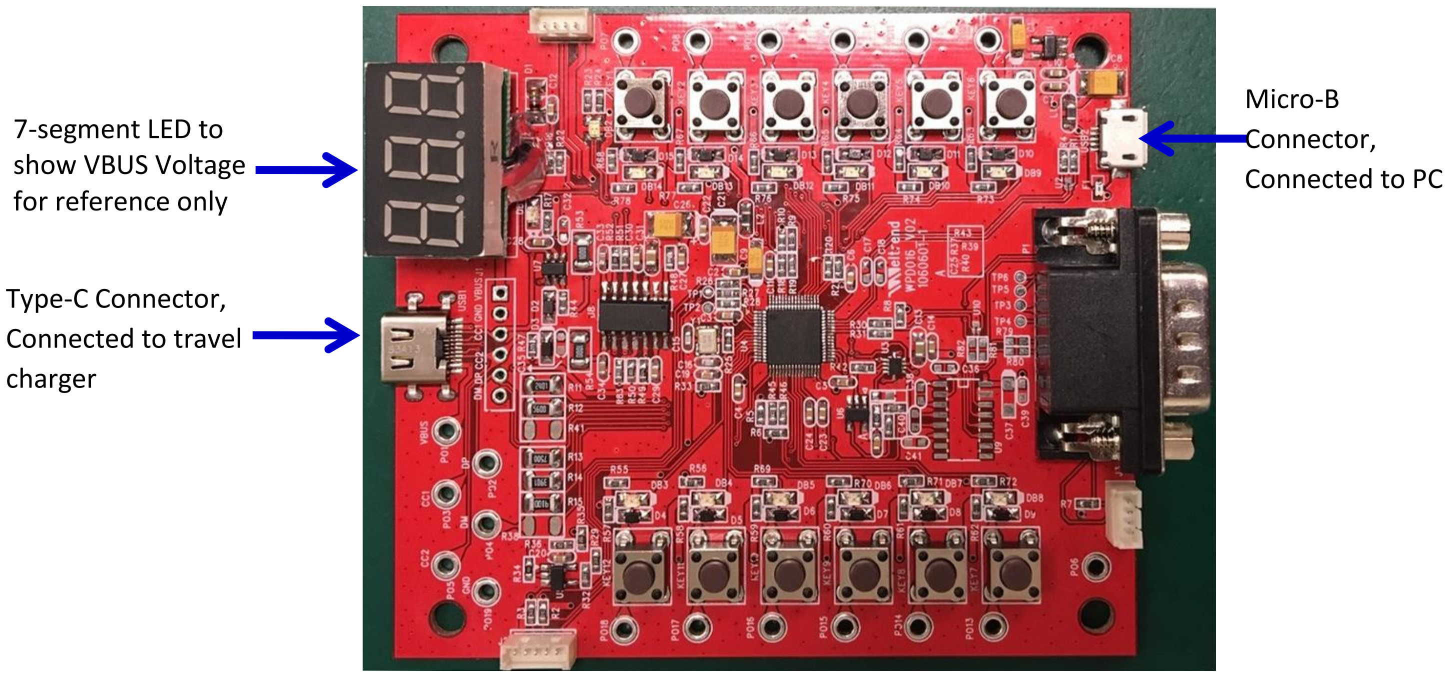


Figure 9: The Test Kit Input & Output and E-load Connections

For details, please contact Weltrend Semiconductor local agent for WPD016 User Guide.

4.3.3 Input & Output Wires Connection

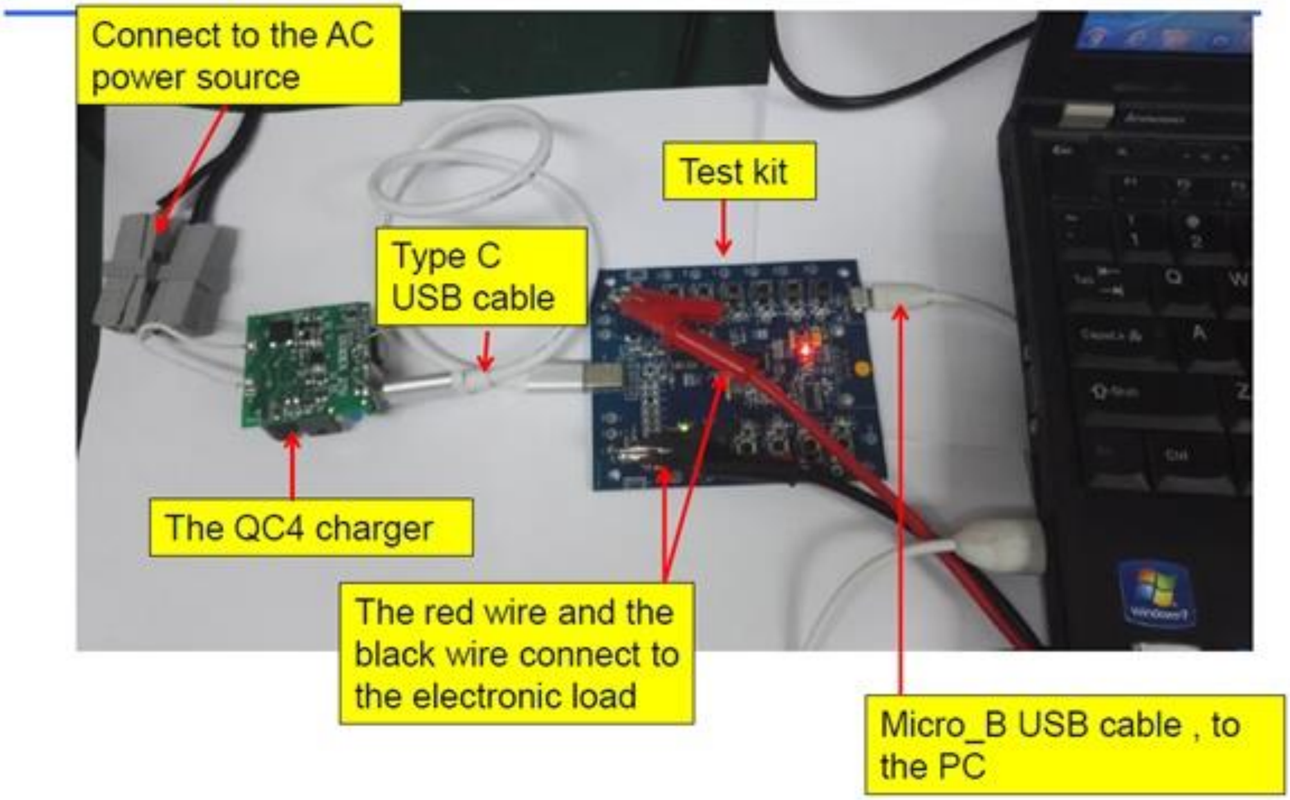


Figure 10: Wire Connection of 27W QC4/4+ EVB to Test Kit and PC Computer

Chapter 5. Testing the Evaluation Board

5.1 Input & Output Characteristics

5.1.1 Input Standby Power

@No Load +5VDC

Vin(Vac)	Fin (Hz)	Vin(V)	Iin (mA)	PF	**Pin(mW)**	Vout(V)	Iout(A)	Pout(W)	Pd(W)
90	47	89.97	3.4069	0.0963	**29.52**	*	*	*	*
115	60	115.03	3.2842	0.0791	**29.88**	*	*	*	*
230	50	230.15	2.9293	0.0634	**42.6**	*	*	*	*
264	63	264.26	2.842	0.0632	**47.4**	*	*	*	*

5.1.2 Input Power Efficiency at Different AC Line Input Voltage

EFFICIENCY (+12VDC)

Vin(Vac)	Freq(Hz)	Vin(V)	Iin(A)	PF	Pin(W)	Vout(V)	Iout(A)	Pout(W)	Pd(W)	Eff(%)
90	47	90.00	0.5515	0.6040	29.98	**11.788**	2.2512	26.5376	3.44240416	88.52%
115	60	114.98	0.4777	0.5391	29.611	**11.788**	2.2512	26.53805	3.07295392	89.62%
230	50	230.08	0.3126	0.4096	29.46	**11.7882**	2.2512	26.5376	2.92240416	90.08%
264	63	264.00	0.2944	0.3805	29.58	**11.7862**	2.2512	26.53309	3.04690656	89.70%

EFFICIENCY (+9VDC)

Vin(Vac)	Freq(Hz)	Vin(V)	Iin(A)	PF	Pin(W)	Vout(V)	Iout(A)	Pout(W)	Pd(W)	Eff(%)
90	47	90.02	0.5684	0.6033	30.867	**9.041**	3.0006	27.12872	3.73827534	87.89%
115	60	114.99	0.4916	0.5393	30.483	**9.042**	3.0006	27.13263	3.35037456	89.01%
230	50	230.16	0.3305	0.3977	30.26	**9.0411**	3.0006	27.12872	3.13127534	89.65%
264	63	264.37	0.3284	0.3504	30.42	**9.0405**	3.0006	27.12692	3.2930757	89.17%

EFFICIENCY (+5VDC)

Vin(Vac)	Freq(Hz)	Vin(V)	Iin(A)	PF	Pin(W)	Vout(V)	Iout(A)	Pout(W)	Pd(W)	Eff(%)
90	47	90.04	0.3493	0.5371	16.888	**4.905**	3.0006	14.71914	2.16885676	87.16%
115	60	115.00	0.3206	0.4563	16.82	**4.906**	3.0006	14.72064	2.09935646	87.52%
230	50	230.12	0.2154	0.3435	17.03	**4.9058**	3.0006	14.72034	2.30965652	86.44%
264	63	264.24	0.2004	0.3236	17.13	**4.9058**	3.0006	14.72034	2.40965652	85.93%

EFFICIENCY (+3.3VDC)

Vin(Vac)	Freq(Hz)	Vin(V)	Iin(A)	PF	Pin(W)	Vout(V)	Iout(A)	Pout(W)	Pd(W)	Eff(%)
90	47	90.05	0.2584	0.4992	10.783	**3.028**	3.0006	9.085817	1.6971832	84.26%
115	60	115.01	0.2403	0.4200	10.75	**3.028**	3.0006	9.085817	1.6641832	84.52%
230	50	230.09	0.1614	0.3194	10.872	**3.03**	3.0006	9.091818	1.780182	83.63%
264	63	264.24	0.1431	0.3167	10.963	**3.03**	3.0006	9.091818	1.871182	82.93%

5.1.3 Average Efficiency at Different Loading

Aerage efficiency(+12VDC)

Vin (Vac)	Fin (Hz)	Vin(V)	Iin (A)	PF	Pin (W)	Vout(V)	Iout (A)	Pout (W)	Pd(W)	Eff(%)	Average EFF(%)
115	60	114.98	0.47774	0.5391	29.611	**11.7884**	2.2512	26.538	3.0729539	89.62%	89.06%
115	60	114.99	0.37842	0.5123	22.293	**11.802**	1.6878	19.9194	2.3735844	89.35%	
115	60	115.00	0.2710	0.4779	14.891	**11.8073**	1.1252	13.2856	1.605426	89.22%	
115	60	115.02	0.15207	0.4315	7.548	**11.8163**	0.5623	6.64431	0.9036945	88.03%	
230	50	230.08	0.31255	0.4096	29.46	**11.7882**	2.2512	26.5376	2.9224042	90.08%	88.89%
230	50	230.13	0.24711	0.3912	22.24	**11.801**	1.6878	19.9177	2.3222722	89.56%	
230	50	230.14	0.18125	0.3583	14.94	**11.8084**	1.1252	13.2868	1.6531883	88.93%	
230	50	230.15	0.09334	0.3559	7.64	**11.8186**	0.5623	6.6456	0.9944012	86.98%	

Aerage efficiency(+9VDC)

Vin (Vac)	Fin (Hz)	Vin(V)	Iin (A)	PF	Pin (W)	Vout(V)	Iout (A)	Pout (W)	Pd(W)	Eff(%)	Average EFF(%)
115	60	114.99	0.49156	0.5393	30.483	**9.0424**	3.0006	27.1326	3.3503746	89.01%	89.32%
115	60	114.98	0.39013	0.5078	22.811	**9.0628**	2.2512	20.4022	2.4088246	89.44%	
115	60	115.00	0.2920	0.4520	15.175	**9.0732**	1.5001	13.6107	1.5642927	89.69%	
115	60	115.01	0.17458	0.3807	7.645	**9.0855**	0.75	6.81413	0.830875	89.13%	
230	50	230.16	0.33052	0.3977	30.26	**9.0411**	3.0006	27.1287	3.1312753	89.65%	88.99%
230	50	230.12	0.2628	0.3766	22.77	**9.0621**	2.2512	20.4006	2.3694005	89.59%	
230	50	230.14	0.19534	0.3402	15.29	**9.0732**	1.5001	13.6107	1.6792927	89.02%	
230	50	230.07	0.10983	0.3077	7.77	**9.0842**	0.75	6.81315	0.95685	87.69%	

Aerage efficiency(+5VDC)

Vin (Vac)	Fin (Hz)	Vin(V)	Iin (A)	PF	Pin (W)	**Vout(V)**	Iout (A)	Pout (W)	Pd(W)	Eff(%)	Average EFF(%)
115	60	115.00	0.32056	0.4563	16.82	**4.9059**	3.0006	14.7206	2.0993565	87.52%	87.53%
115	60	115.00	0.23996	0.461	12.719	**4.9257**	2.2512	11.0887	1.6302642	87.18%	
115	60	115.01	0.1888	0.3886	8.438	**4.9398**	1.5001	7.41019	1.027806	87.82%	
115	60	115.01	0.10662	0.3458	4.24	**4.9532**	0.75	3.7149	0.5251	87.62%	
230	50	230.12	0.21543	0.3435	17.03	**4.9058**	3.0006	14.7203	2.3096565	86.44%	86.24%
230	50	230.14	0.17082	0.3247	12.763	**4.9253**	2.2512	11.0878	1.6751646	86.87%	
230	50	230.11	0.12056	0.3091	8.585	**4.9393**	1.5001	7.40944	1.1755561	86.31%	
230	50	230.04	0.06462	0.2929	4.353	**4.9526**	0.75	3.71445	0.63855	85.33%	

Aerage efficiency(+3.0VDC)

Vin (Vac)	Fin (Hz)	Vin(V)	Iin (A)	PF	Pin (W)	Vout(V)	Iout (A)	Pout (W)	Pd(W)	Eff(%)	Average EFF(%)
115	60	115.01	0.24034	0.42	10.75	**3.028**	3.0006	9.08582	1.6641832	84.52%	**84.28%**
115	60	115.01	0.19542	0.3872	8.067	**3.026**	2.2512	6.81213	1.2548688	84.44%	
115	60	115.02	0.1422	0.3559	5.386	**3.02**	1.5001	4.5303	0.855698	84.11%	
115	60	115.02	0.07583	0.3339	2.695	**3.02**	0.75	2.265	0.43	84.04%	
230	50	230.09	0.16144	0.3194	10.872	**3.03**	3.0006	9.09182	1.780182	83.63%	**82.77%**
230	50	230.14	0.1251	0.309	8.223	**3.027**	2.2512	6.81438	1.4086176	82.87%	
230	50	230.14	0.08654	0.3007	5.48	**3.02**	1.5001	4.5303	0.949698	82.67%	
230	50	230.05	0.04682	0.2823	2.756	**3.01**	0.75	2.2575	0.4985	81.91%	

5.2 Output CV & CC Mode Testing

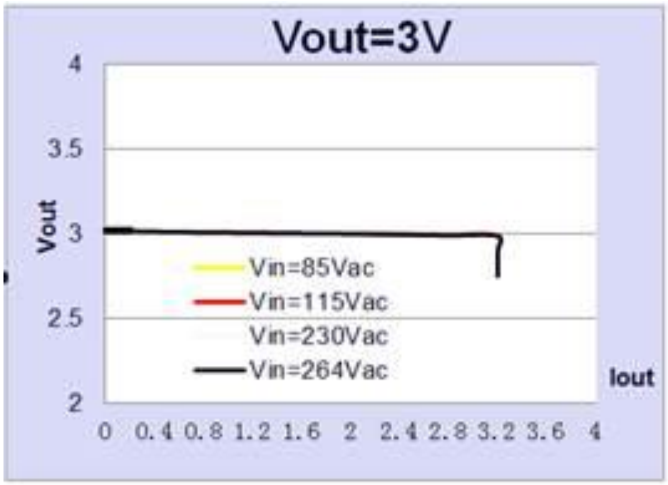


Figure 12: I-V Curve – 3.0V Output

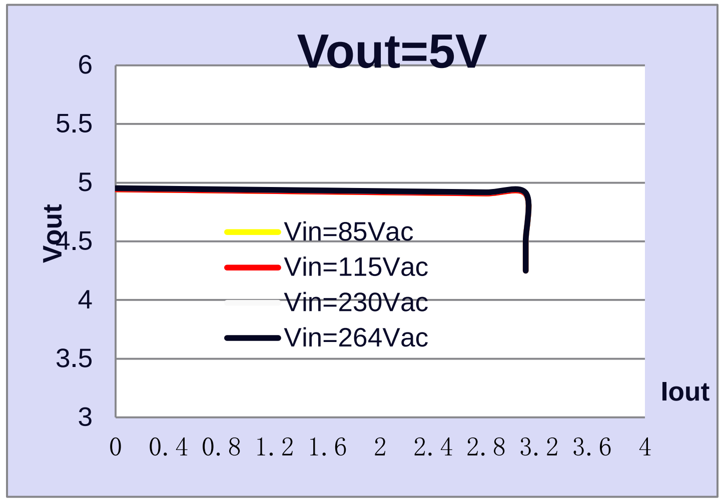


Figure 13: I-V Curve – 5V Output

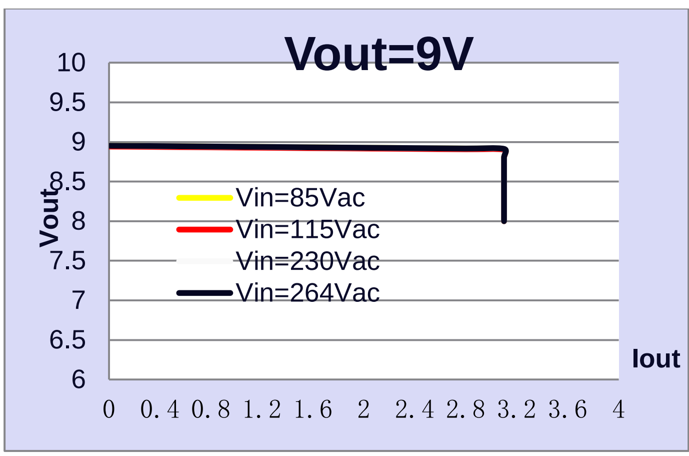


Figure 14: I-V Curve – 9V Output

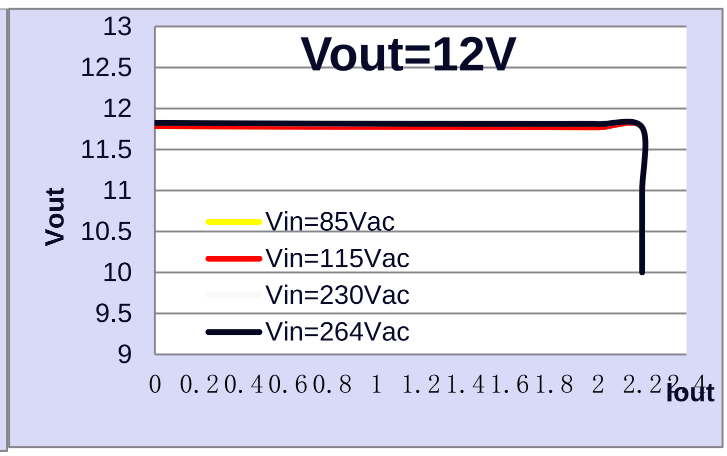


Figure 15: I-V Curve - 12V Output

5.3 QC Series Compatible Mode Testing

5.3.1 QC 2.0 Mode Testing

.

4.963V

9.038V

11.725V

5.3.2 QC 3.0 Continuous Mode 200mV/Step Testing

5.024V

9.042V

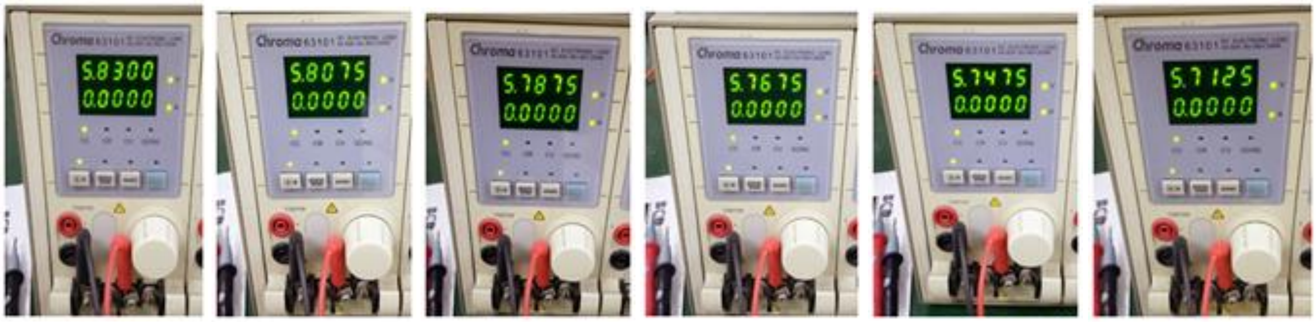
11.711V

5.221V

9.251V

11.916V

5.3.3 QC4/4+ CV Accuracy 20mV/Step Testing (PPS Support)



5,830mV	5,808mV	5,788mV	5,768mV	5,748mV	5,713mV

4,628mV	4,608mV	4,585mV	4,568mV	4,545mV	4,528mV

3,143mV	3,125mV	3,103mV	3,078mV	3,060mV	3,040mV

5.4.4 QC4/4+ CC Accuracy 50mA/Step Testing (PPS Support)

3,004mA	2,954mA	2,905mA	2,860mA	2,811mA	2,763mA

1,759mA	1,709mA	1,659mA	1,611mA	1,565mA	1,519mA

2.905A

2.954A

3.004A

5.4 Key Performance Waveforms

5.4.1 AC Input Requirements

AC Brownout on/off

		Input AC Reading
Turn_Off	Max Load	73.54Vac
	Min Load	72.38Vac
Turn_On	Max Load	80.43Vac
	Min Load	81.48Vac

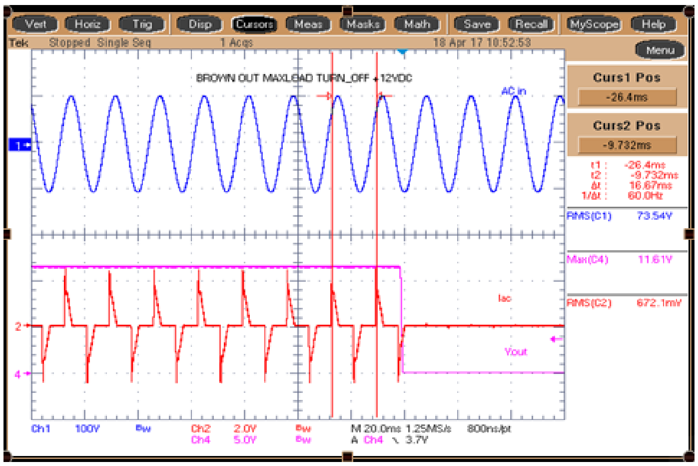


Figure 16

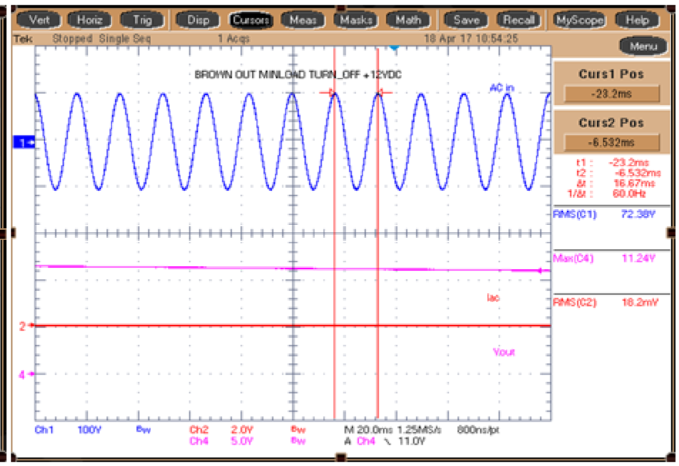


Figure 17

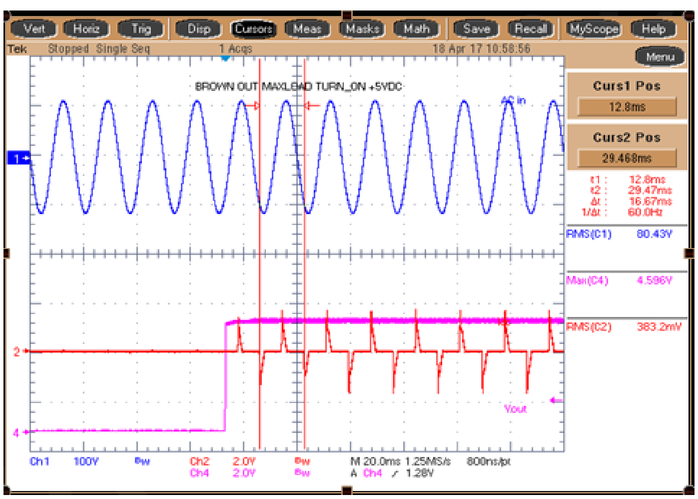


Figure 18

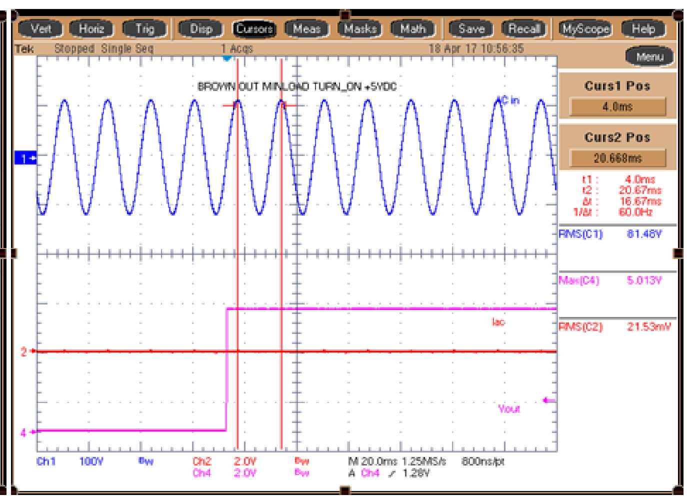


Figure 19

5.4.2 AC Line Slow Transients (Sag/Surge)

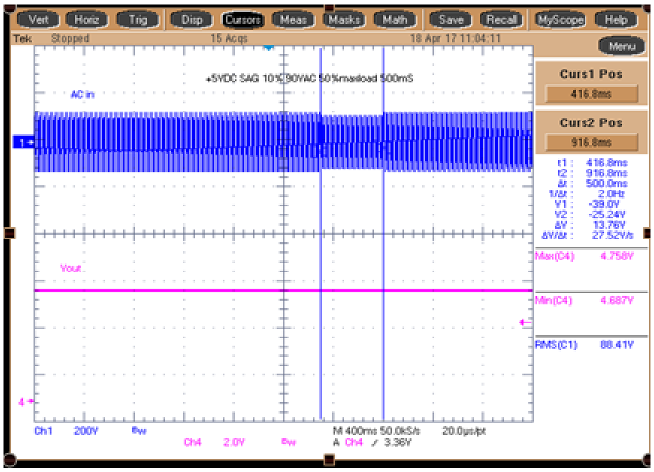


Figure 20: 500ms Sag at 10% of 90Vac with 5Vo at 1.5A

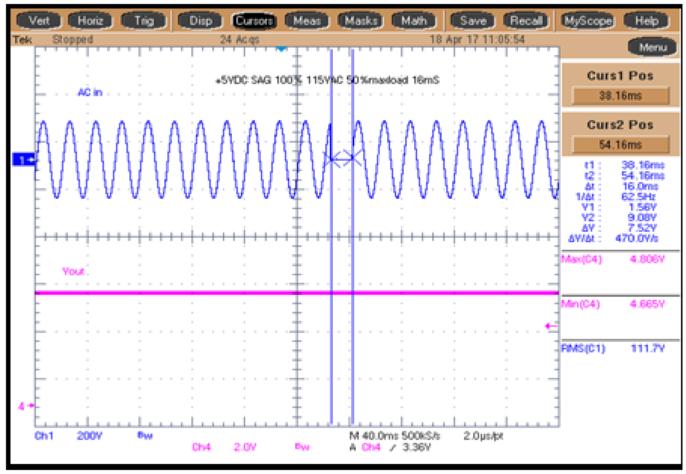


Figure 21: 16ms 100% Sag of 90Vac with 5Vo at 1.5A

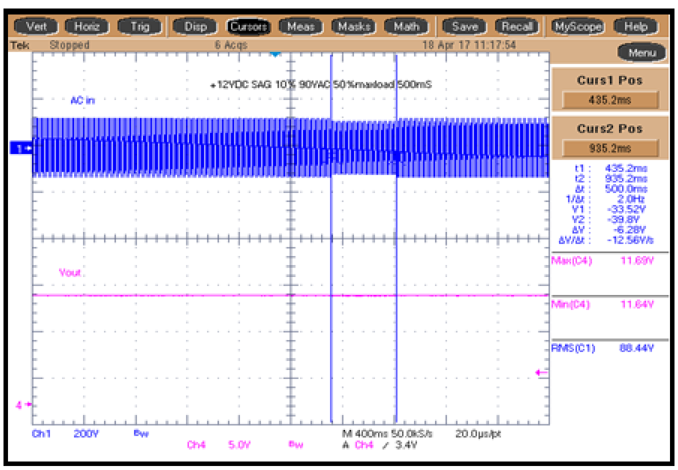


Figure 22: 500ms Sag 10% of 90Vac with 12Vo at 1.15A

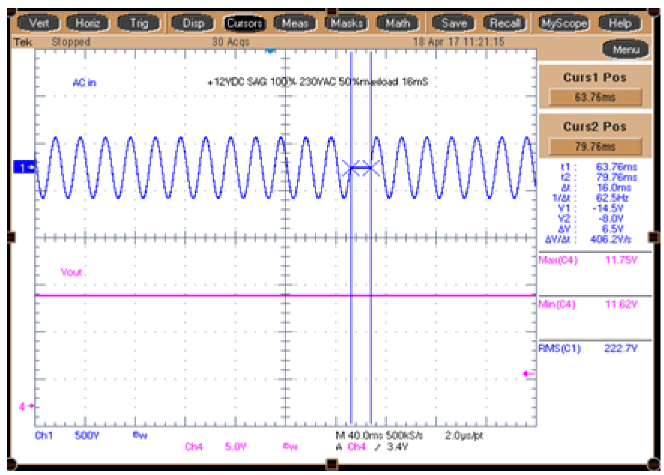


Figure 23: 16ms 100% Sag of 90Vac with12V at 1.15A

5.4.3 27W QC4/4+ System Start-up Time & Hold-up Time

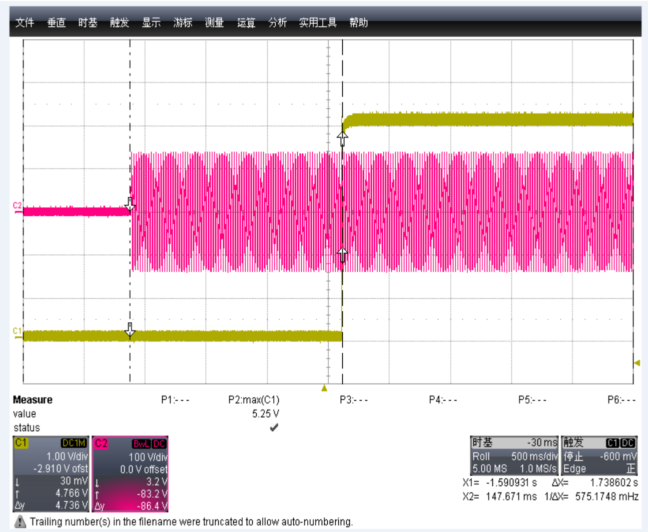


Figure 24: 27w QC4/4+ turn on time 1.74s FL at 90Vac

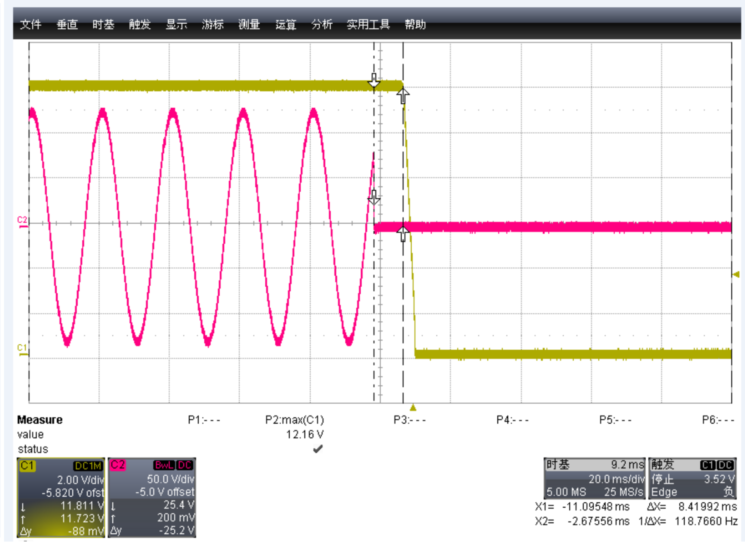


Figure 25: 27w QC4/4+ hold time 8.42s at 12V- 2.25A, at 90Vac

5.4.4 Q1 /Q2 Main Switching Voltage MOSFET Stress on at 12V/ 2.25A Loading

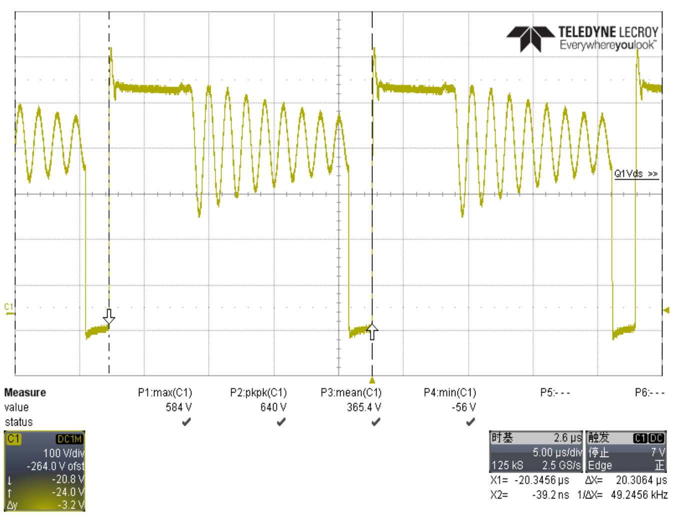


Figure 26: 264Vac/50Hz Primary Q1 Vds(max)= 584Vp-p

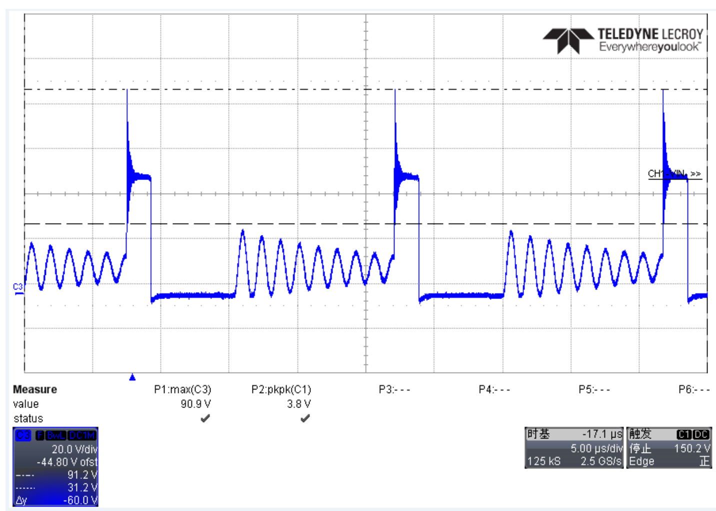


Figure 27: 264Vac/50Hz Secondary Q2 Vds(max) = 90.9Vp-p

5.4.5 System Output Ripple & Noise with @ 1.2m Cable End

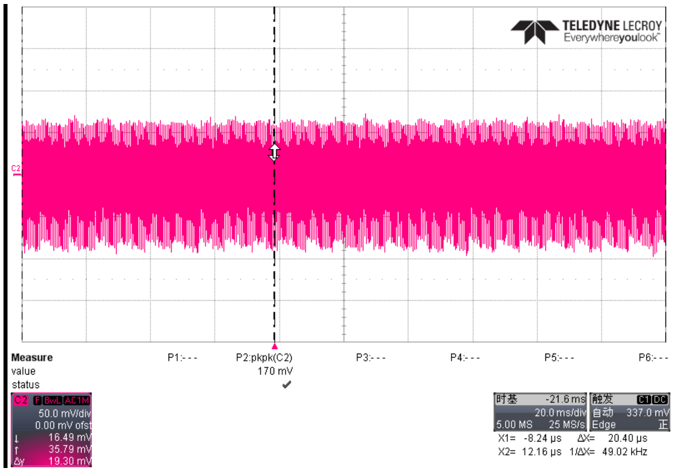


Figure 28: The Ripple at 90Vac/60Hz ΔV=170mV 5V/3A

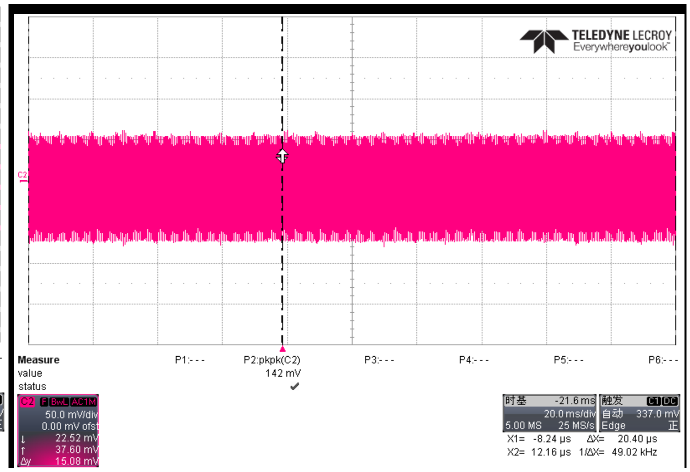


Figure 29: The Ripple at 264Vac/50Hz ΔV=142mv 5V/3A

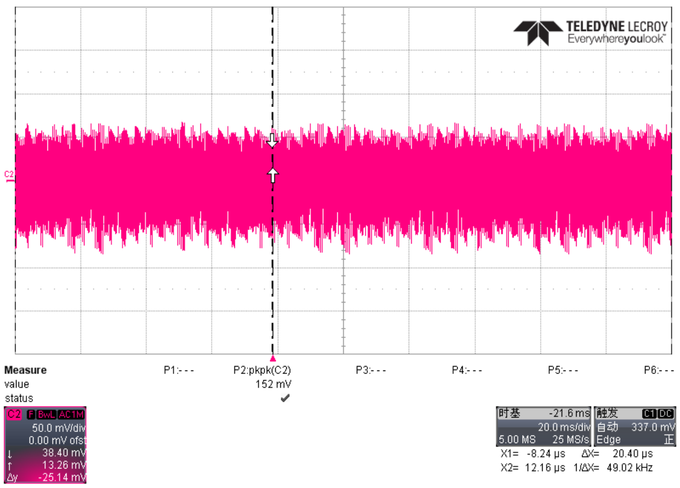


Figure 30: 90Vac/60Hz 9V/3A ΔV=152mV

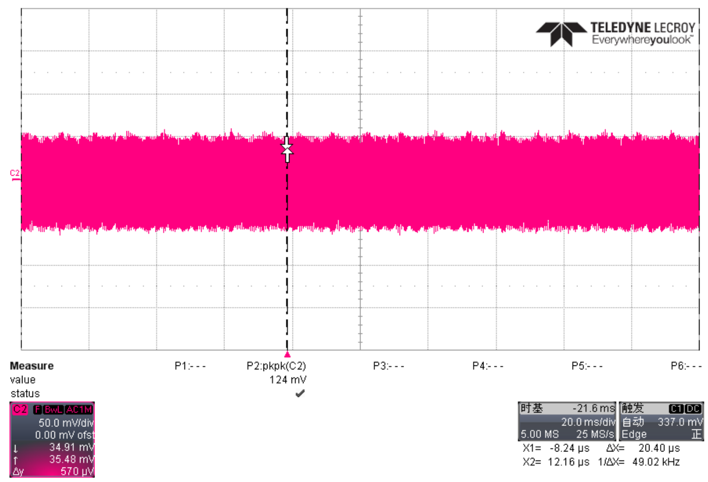


Figure 31: 264Vac/50Hz 9V/3A ΔV=124mv

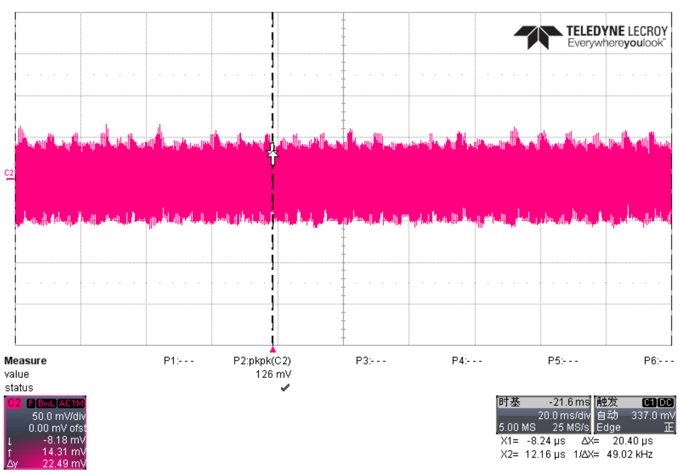


Figure 32: 90Vac/60Hz 12V/2.25A ΔV=126mV

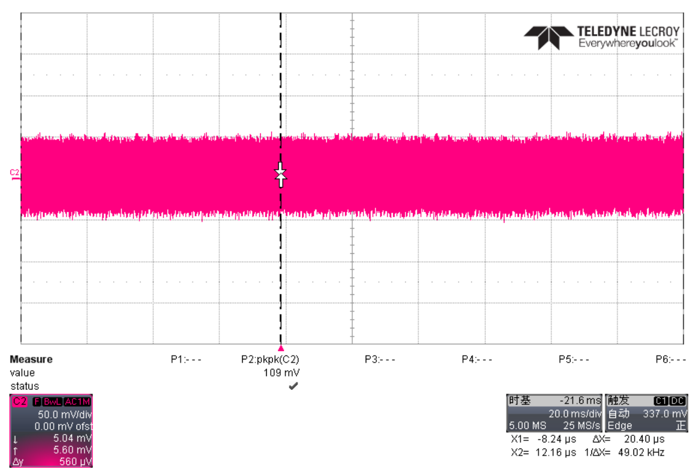


Figure 33: 264Vac/50Hz 12V/2.25A ΔV=109mv

5.4.6 Output Voltage Transition Time

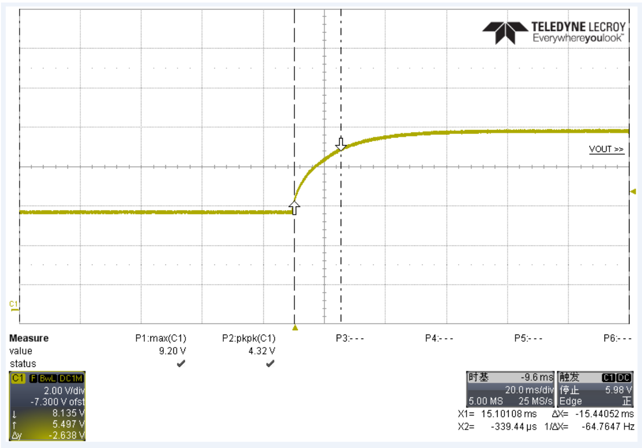


Figure 34: 5V→9V Rise Time: 15.44ms

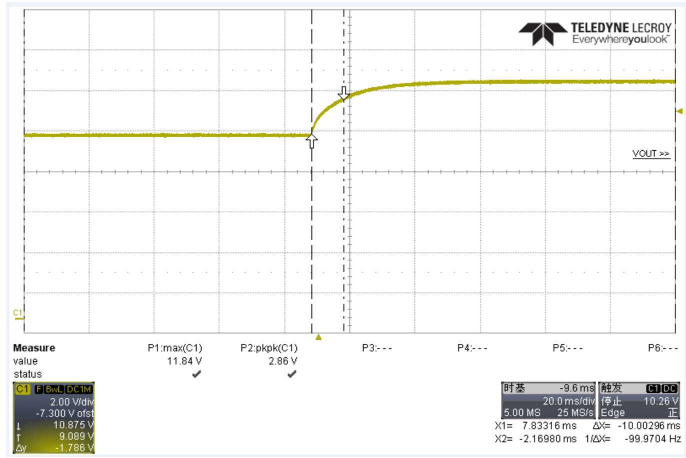


Figure 35: 9V→12V Rise Time: 10.02ms

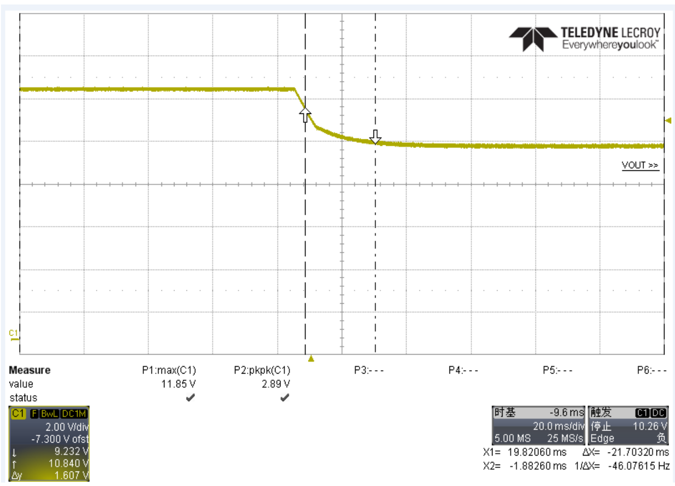


Figure 36: 12V→9V Fall Time: 21.7ms

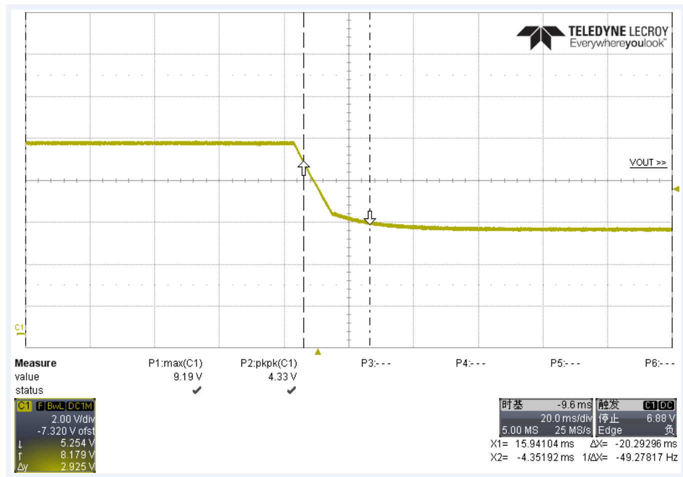


Figure 37: 9V→5V Fall Time: 20.3ms

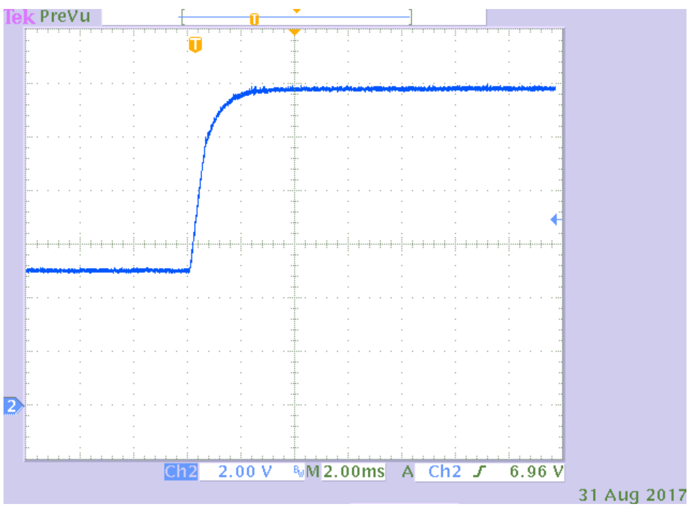


Figure 38: 5V→12V Fall Time: 2ms

Figure 39: 12V→5V Fall Time: 18.8ms

5.4.7 Thermal Testing

Test Condition: Vin=90V   Vo=9V Io=3A Open Frame

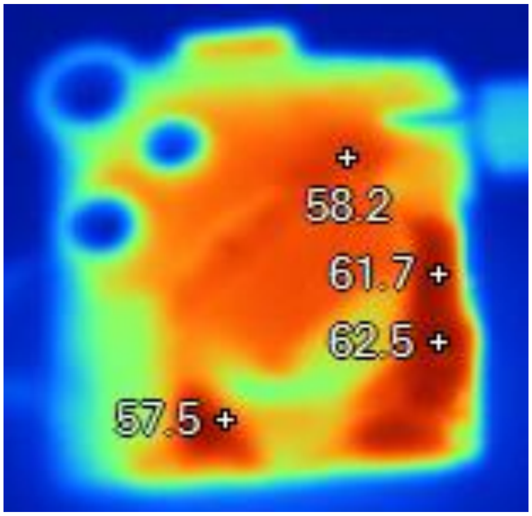


Figure 40:   components side

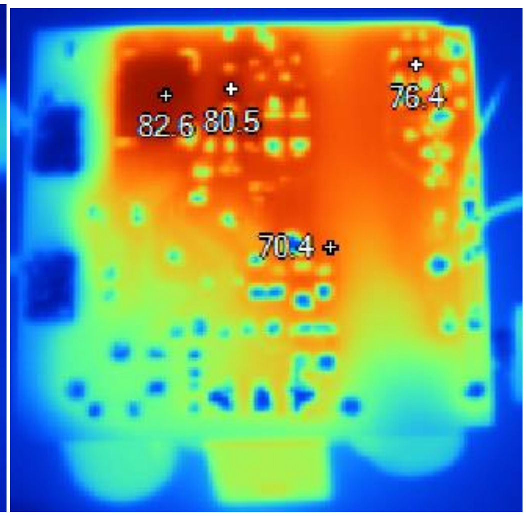


Figure 41: surface mount side

	Temperature
Ambient Temp.	24.7℃
Bridge	82.6℃
Q3	80.5℃

5.4.8 EMI (CE) Testing

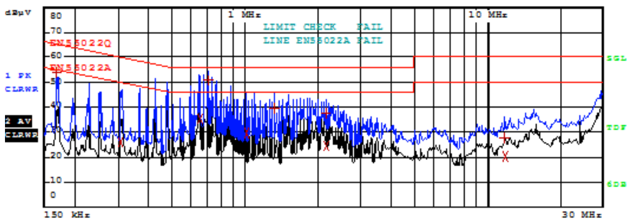


Figure 42: 115Vac/60Hz 12V/2A (L)

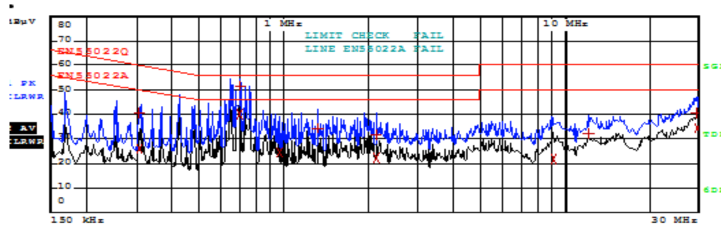


Figure 43: 115Vac/60Hz 12V/2A (N)

EDIT PEAK LIST (Final Measurement Results)

Trace1:	EN55022Q
Trace2:	EN55022A
Trace3:	---

TRACE		FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
1	Quasi Peak	170 kHz	54.16	-10.79
2	Average	310 kHz	26.14	-23.82
2	Average	650 kHz	35.40	-10.59
1	Quasi Peak	706 kHz	50.73	-5.26
2	Average	1.018 MHz	29.78	-16.21
1	Quasi Peak	1.326 MHz	39.63	-16.36
1	Quasi Peak	2.154 MHz	37.57	-18.42
2	Average	2.154 MHz	24.64	-21.35
1	Quasi Peak	11.746 MHz	27.63	-32.36
2	Average	11.966 MHz	20.39	-29.61
2	Average	29.318 MHz	35.29	-14.71
1	Quasi Peak	29.45 MHz	41.08	-18.91

EDIT PEAK LIST (Final Measurement Results)

Trace1:	EN55022Q
Trace2:	EN55022A
Trace3:	---

TRACE		FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
1	Quasi Peak	310 kHz	40.29	-19.67
2	Average	310 kHz	25.85	-24.11
1	Quasi Peak	702 kHz	51.71	-4.28
2	Average	702 kHz	40.04	-5.95
2	Average	962 kHz	24.34	-21.65
1	Quasi Peak	1.322 MHz	34.50	-21.49
1	Quasi Peak	2.13 MHz	31.52	-24.47
2	Average	2.13 MHz	22.00	-23.99
2	Average	9.162 MHz	21.93	-28.06
1	Quasi Peak	12.218 MHz	31.98	-28.01
1	Quasi Peak	29.466 MHz	40.57	-19.42
2	Average	29.63 MHz	34.48	-15.51

L		N	
QP	AV	QP	AV
-10.79dB	-5.26dB	-5.95dB	-4.28dB

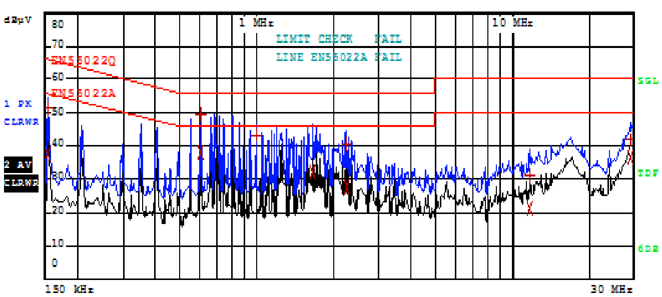


Figure 44: 230Vac/50Hz 12V/2A (L)

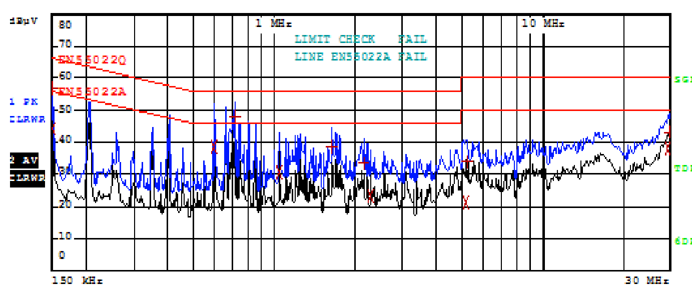


Figure 45: 230Vac/50Hz 12V/2A (N)

EDIT PEAK LIST (Final Measurement Results)

Trace1:	EN55022Q
Trace2:	EN55022A
Trace3:	---

TRACE		FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
1	Quasi Peak	154 kHz	51.43	-14.34
2	Average	154 kHz	37.83	-17.94
1	Quasi Peak	602 kHz	49.41	-6.58
2	Average	602 kHz	37.97	-8.02
1	Quasi Peak	998 kHz	43.08	-12.91
2	Average	1.65 MHz	31.96	-14.03
1	Quasi Peak	2.254 MHz	40.37	-15.63
2	Average	2.254 MHz	27.74	-18.25
1	Quasi Peak	11.75 MHz	31.18	-28.81
2	Average	11.75 MHz	21.19	-28.80
2	Average	29.014 MHz	36.52	-13.47
1	Quasi Peak	29.15 MHz	41.84	-18.15

EDIT PEAK LIST (Final Measurement Results)

Trace1:	EN55022Q
Trace2:	EN55022A
Trace3:	---

TRACE		FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
1	Quasi Peak	150 kHz	56.70	-9.29
2	Average	150 kHz	44.21	-11.78
2	Average	598 kHz	38.38	-7.61
1	Quasi Peak	714 kHz	48.08	-7.91
2	Average	1.05 MHz	30.61	-15.38
1	Quasi Peak	1.646 MHz	38.82	-17.17
1	Quasi Peak	2.166 MHz	33.64	-22.35
2	Average	2.298 MHz	22.94	-23.05
2	Average	5.23 MHz	21.36	-28.63
1	Quasi Peak	5.278 MHz	34.10	-25.89
2	Average	29.446 MHz	38.17	-11.82
1	Quasi Peak	29.61 MHz	43.47	-16.52

Revision History

Revisions	Change Item #	Reason for Changes	Items Changed
Rev 1.0 (June 30, 2017) to Rev1.1 (Oct 1, 2017)	#1	Extended low operating voltage range down to 3V (PPS 3V-5.99V & 3V~11V requirement)	AP3302A (instead of AP3302) R32=49.9K (instead 56K)
Rev 1.0 (June 30, 2017) to Rev1.1 (Oct 1, 2017)	#2	Improved the voltage transition time to meet QC4 requirements (< 25mS)	Tune component values associated with CV and CC loop compensation filters (C15=68nf, C16=10nf, C19=6.8nf, C20=470pf R11=680Ω, R20=15K, R21=2.7K, R24=0Ω, ZD1=20Vz)
Rev 1.0 (June 30, 2017) to Rev1.1 (Oct 1, 2017)	#3	Improved Total resistance from D+/D- path to WT6615F To Imrpve discharge time of WT6615F	Change R33 and R34 from 51Ω to 5Ω Change R1 from 10kΩ to 1kΩ Change R39 from 51Ω to 110K
Rev 1.1 (Oct 1, 2017) to Rev1.2 (Dec 20, 2017)	#4	Corrected typing mistake	DML60H650SCT to DMJ65H650SCT
Rev 1.1 (Oct 1, 2017) to Rev1.2 (Dec 20, 2017)	#5	Corrected Pin 7 PCB layout mistake	Updated the main PCB layout with the two slits & the daughter cut board with two insert stands