User Guide for

FEBFAN6100QMPX_CH07U15A Evaluation Board

Fairchild W2B Adaptive Charger

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This user guide supports the evaluation kit for the FAN6100Q. It should be used in conjunction with the FAN6100Q datasheets as well as Fairchild's application notes and technical support team. Please visit Fairchild's website at https://www.fairchildsemi.com/

1. Introduction

This document is an engineering report describing a 15 W charger design using FAN501A and FAN6100Q which is for adaptive charger to comply with Qualcomm Quick Charger 2.0 specifications. The output voltages/current adaptively varies between 5 V/2 A, 9 V/1.67 A and 12 V/1.25 A according to protocol command.

The FAN6100Q is a highly integrated secondary side power adaptor controller that is compatible with Qualcomm Quick Charger 2.0. It is designed for use in application that requires constant voltage (CV) and constant current (CC) regulation.

The controller consists of two operational amplifiers for voltage and current loop regulation with adjustable voltage references. The CC control loop also incorporates a current sense amplifier with gain of 10. Outputs of the CV and CC amplifiers are tied together in open drain configuration.

When used in conjunction with primary side PWM controller FAN501A, battery chargers can be implemented to support adaptive output current and output voltage in the range of 5 V/9 V/12 V.

The FAN6100Q enables power adaptor's output voltage adjustment if it detects an adaptive capable powered device. If a non compliant powered device is detected, the controller disables adaptive output voltage to ensure safe operation with smart phone and tablets that support only 5 V.

FAN6100Q also incorporates an internal charge pump circuit to maintain CC regulation down to power supply's output voltage of 2 V without external voltage supply to the IC. Programmable cable drop compensation allows precise CV regulation at end of the cable.

This design shows excellent efficiency satisfying Code of Conduct (CoC) Tier 2 specification while providing ultra low standby power consumption.

This document contains the design specifications, schematics, bill of materials, transformer specifications, PCB layout and performance data.

2. Evaluation Board Specifications

All data for this table was measured with 90 V_{AC}~264 V_{AC} line input at an ambient temperature of 25°C.

Table 1. Summary of Features and Performance

Specification	Min.	Max.	Unit
Input Voltage	90	264	V_{AC}
Input Frequency	47	63	Hz

Description	Mode	Design Spec.	Test Result	Comments
Output Voltage (CV)	5 V	4.75~5.25 V	±0.3%	CV<± 5% Regulation CC<±5% Regulation
	9 V	8.55~9.45 V	±0.1%	
	12 V	11.40~12.60 V	±0.1%	
Output Current (CC)	5 V	0 ~2.0 A	±0.5%	
	9 V	0 ~1.67 A	±0.3%	
	12 V	0 ~1.25 A	±0.2%	
Input Power	5 V	< 30 mW	15.2 mW	264 V_{AC}
Ripple	All	< 150 mVp-p	136 mVp-p (Max.)	Measured at PCB End
Start up time	5 V	<1 S	0.2 S	5 V at Full Load
Dynamic	5 V	>4.5 V at 5 V Mode	4.67 V	Measure at PCB End
	9 V	>8.1 V at 9 V Mode	8.73 V	Measure at PCB End
	12 V	>10.8 V at 12 V Mode	11.79 V	Measure at PCB End
Input Power at Output Short Circuit Protection (SCP)	All	1 W	0.37W (Max.)	264 V_{AC}
Voltage Stress	12 V	640 V	581V	264 V_{AC}
	12 V	60 V	54.3V	264 V_{AC}
Temperature	All	-	101°C at Diode	115 V_{AC} & 230 V_{AC} Full Load Burn in 60 Min.
Efficiency	10% Load	69.73% at 5 V, 74.14% at 9 V,12 V	79.65% at 5 V 79.77% at 9 V 75.99% at 12 V	Meets CoC Tier 2.
	Avg.	79.00% at 5 V, 84.5% at 9 V,12 V	82.05% at 5 V 84.74% at 9 V 84.73% at 12 V	
Conducted EMI	All	Under 6 dB	3 dB Margin	Meets CISPER22B/EN55022B/IEC950/UL1950 Class II

3. Photographs

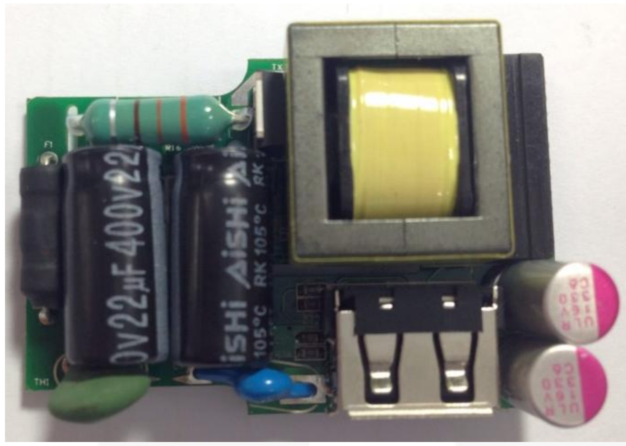


Figure 1. Photograph (W x L :45 x 31 mm2) Top View

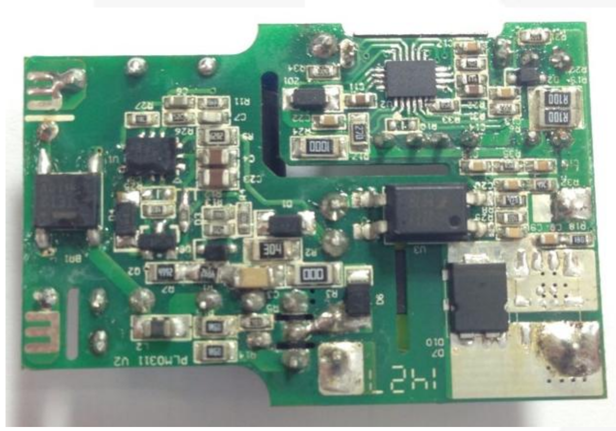


Figure 2. Photograph (W x L :45 x 31 mm2) Bottom View

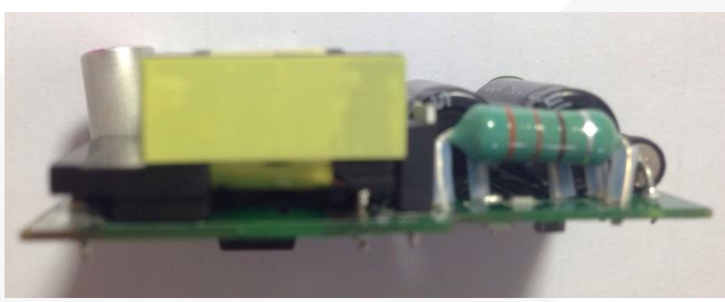


Figure 3. Photograph (H:15 mm) Side View

4. Printed Circuit Board

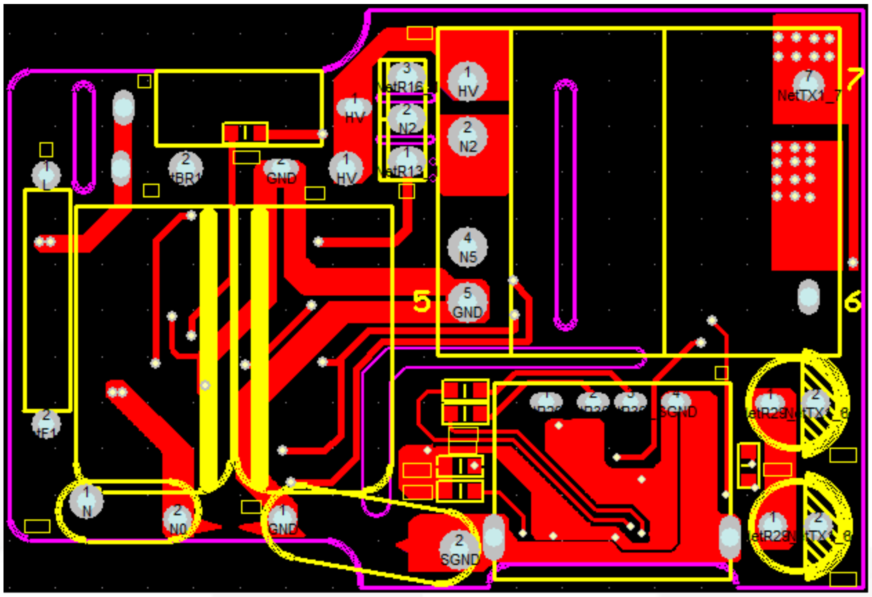


Figure 4. Top View

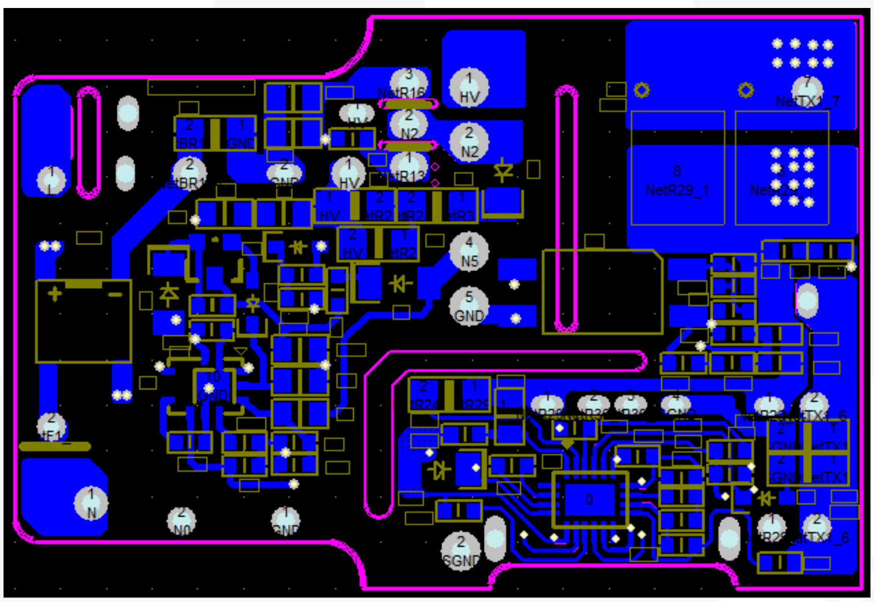


Figure 5. Bottom View

5. Schematic

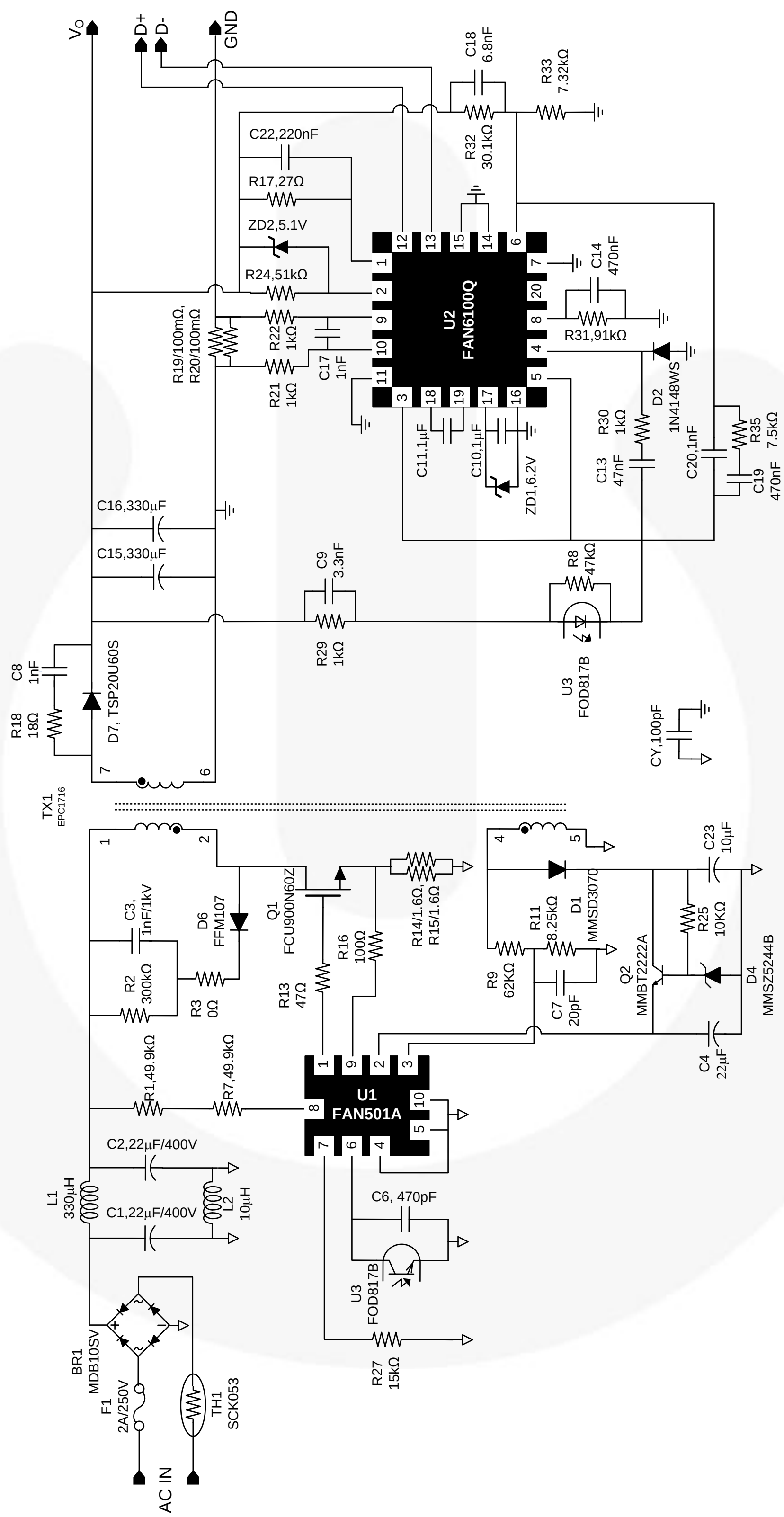


Figure 6. Evaluation Board Schematic

6. Bill of Materials

Part Specification	Package	Qty.	No.
SMD Res. 0603 0 Ω ±5%	REEL	2	R34,R36
SMD Res. 0603 18 Ω ±5%	REEL	1	R18
SMD Res. 0603 100 Ω ±5%	REEL	1	R16
SMD Res. 0603 1 KΩ ±5%	REEL	4	R21, R22, R29, R30
SMD Res. 0603 10 KΩ ±5%	REEL	2	R5, R25
SMD Res. 0603 8.25 KΩ ±1%	REEL	1	R11
SMD Res. 0603 91 KΩ ±1%	REEL	1	R31
SMD Res. 0603 47 KΩ ±1%	REEL	1	R8
SMD Res. 0603 7.5 KΩ ±5%	REEL	1	R35
SMD Res. 0603 7.32 KΩ ±5%	REEL	1	R33
SMD Res. 0603 30.1 KΩ ±-1%	REEL	1	R32
SMD Res. 0603 15 KΩ ±1%	REEL	1	R27
SMD Res. 0603 47 Ω ±-5%	REEL	1	R13
SMD Res. 0805 1.6 Ω ±5%	REEL	2	R14, R15
SMD Res. 0805 27 Ω ±1%	REEL	1	R17
SMD Res. 0805 49.9 KΩ ±1%	REEL	2	R1, R7
SMD Res. 0805 62 KΩ ±1%	REEL	1	R9
SMD Res. 1206 0 Ω ±5%	REEL	1	R3
SMD Res. 1206 0.1 Ω ±1%	REEL	2	R19, R20
SMD Res. 1206 300 KΩ ±5%	REEL	1	R2
SMD Res. 1206 51 Kω ±5%	REEL	1	R24
SMD inductance 0805 10 µ	REEL	1	L2
Thermistor 8ψ 5 Ω SCK053	--	1	TH1
0603 NPO ±5% 22P 50 V	REEL	1	C7
0603 X7R ±10% 102P 50 V	REEL	3	C8, C17, C20
0603 ±20% 105P 25 V	REEL	2	C10, C11
0603 X7R ±10% 224P 25 V	REEL	1	C22
0603 X7R ±10% 332P 50 V	REEL	1	C9
0603 X7R ±10% 471P 50 V	REEL	1	C6
0603 X7R ±10% 473P 50 V	REEL	1	C13
0603 X7R ±10% 474P 16 V	REEL	2	C14, C19
0603 X7R ±-10% 682P 50 V	REEL	1	C18
0805 X5R ±20% 22 µF 25 V	REEL	1	C4
1206 X7R ±10% 102P 1K V	REEL	1	C3
Elec. Cap. 22µF (0~-40%) 400 V 105°C	8*16.5 mm, G-Luxon,GSM126M400T2H5G160	2	C1, C2
0805 X5R ±20% 10 µF 35 V	REEL	1	C23

Continued on the following page…

Part Specification	Package	Qty.	No.
Y1 Cap 100P 250 V ±20%	D7xF7xT9.5 mm	1	CY
Inductor 330 µH ±10%	EC0410-330K	1	L1
OSCON Cap 330 µF 16 V 105°C	6.3*12 mm, ULR337M1CE12R	2	C15,C16
Transformer	EPC1716 SUMIDA	1	TX1
FUSE GLASS 250 V/2 A Fast Blow	3.6*10 mm 36FG(L)R	1	F1
SMD Diode FFM107-M	1 A/1000 V SOD-123	1	D6
SMD TSP20U60S	20 A/60 V	1	D7
Transistor MMBT2222A	NPN General Purpose Amplifier	1	Q2
USB JC0010 4411-02004L	Short Type 10*13 mm	1	J1
SMD Zener 1/2 W 6.2 V	MMSZ5234B Fairchild	1	ZD1
SMD Zener 1/2 W 5.1 V	MMSZ5231B Fairchild	1	ZD2 Parallel on R24
SMD Zener 1/2 W 14V	MMSZ5244B Fairchild	1	D4
SMD Diode 1N4148WS	1 A/100 V SOD-323 Fairchild	1	D2
SMD Diode MMSD3070	1 A/200 V SOD123 Fairchild	1	D1
Bridge diode MDB10SV	1.2 A/1000 V SOIC-4 Fairchild	1	BR1
MOSFET FCU900N60Z	4.5 A/640 V TO-251 Fairchild	1	Q1
FOD817B	SMD-B 4Pin Fairchild	1	U3
IC FAN501AMPX	MLP Fairchild	1	U1
IC FAN6100QMPX	MLP Fairchild	1	U2
PCB PLM0311 REV2	For FAN501A+FAN6100Q 15 W	1	

7. Transformer and Winding Specifications

- Core: EPC1716
- Bobbin: EPC1716 (7 pins)

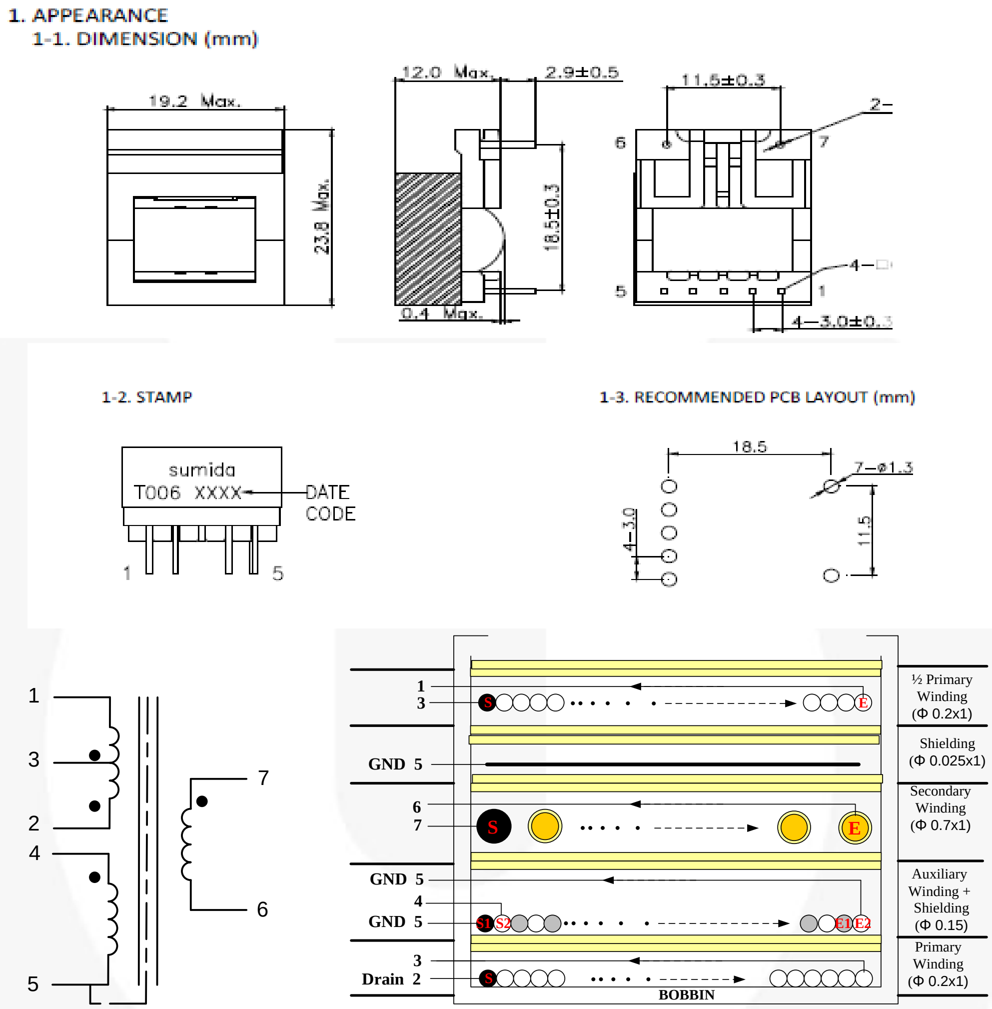


Figure 7. Transformer Specifications & Construction

Table 2. Winding Specifications

Winding	Terminal		Winding	Turns	Isolation Layer
	Start Pin	End Pin			Turns
Np-2	3	1	0.2 mm*1	26	2
Copper Shielding	5	Open	Copper Foil 0.025 mm	1	2
Ns	7	6	0.7 mm*1	6	2
Naux	4	5	0.15 mm*1	11	2
Na-shield	5	Open	0.15 mm*1	11	2
Np-1	2	3	0.2 mm*1	34	2
Bobbin-EPC1716					

Table 3. Electrical Characteristics

	Pin	Specification	Remark
Inductance	2 - 1	600 µH ±5%	100 kHz
Effective Leakage	2 - 1	30 µH Max.	Short Other Pin

8. Test Conditions & Test Equipment

Table 4. Test Conditions & Test Equipment

Evaluation Board #	FEBFAN6100Q_CH07U15A
Test Date	2014-07-04
Test Temperature	25℃
Test Equipments	AC Power Source: 6800 AC POWER SOURCE Electronic Load: Chroma 63030 and 63102 Power Meter : WT210 Oscilloscope : LeCory 24Xs-A

9. Performance of Evaluation Board

9.1. Input Power at No Load Condition

Test Condition:

Measure the input power at three output voltage level at no load condition.

Table 5. Test Result

Input Voltage	V_O = 5 V	V_O = 9 V	V_O = 12 V
90 V_{AC} / 60 Hz	11.5 mW	25.1 mW	41 mW
115 V_{AC} / 60 Hz	11.3 mW	24.9 mW	40 mW
230 V_{AC} / 50 Hz	13 mW	26 mW	42.6 mW
264 V_{AC} / 50 Hz	15.2 mW	27.7 mW	46.4 mW

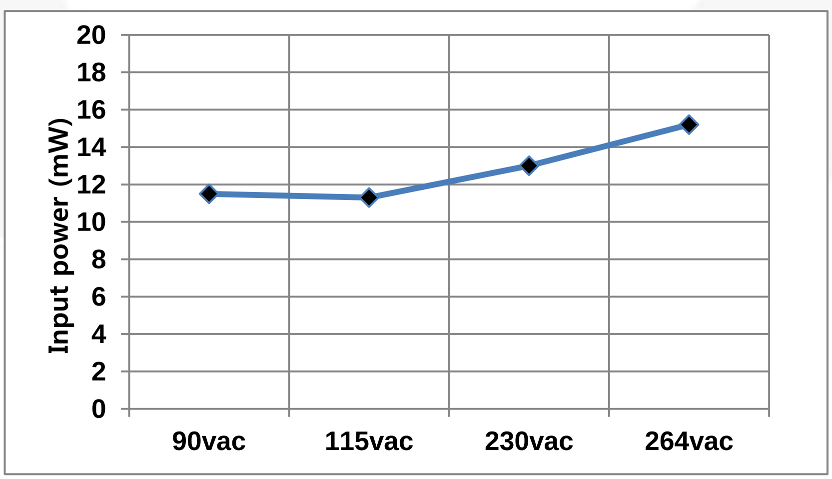


Figure 8. 5 V Input Power Curve

9.2. Startup Time

Test Condition:

Measure the time from AC plug-in to nominal output voltage build-up at full load condition.

Table 6. Test Result

Input Voltage	Startup Time	Specification
90 V_{AC} / 60 Hz	201 ms	<1 sec

Waveform:

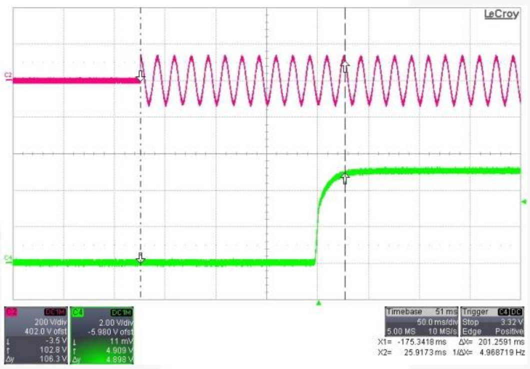


Figure 9. C2[V_{IN}], C4[Vo], 90 V_{AC} / 60 Hz

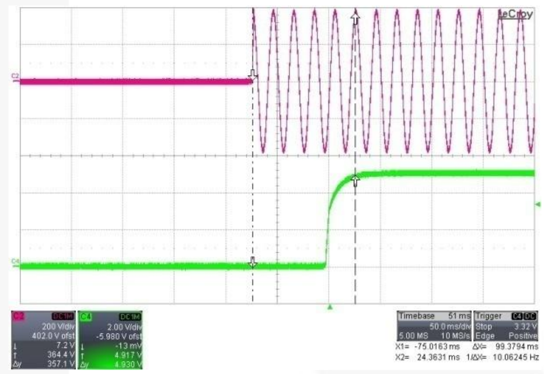


Figure 10. C2[V_{IN}], C4[Vo]. 264 V_{AC} / 50 Hz

9.3. Input Current

Test Condition:

Measure the AC input current at 9 V/1.67 A output, where the maximum input power occurs.

Table 7. Test Result

Input Voltage	Input Current	Specification
90 V_{AC} / 60 Hz	349 mA	
264 V_{AC} / 50 Hz	165 mA	

Waveforms:

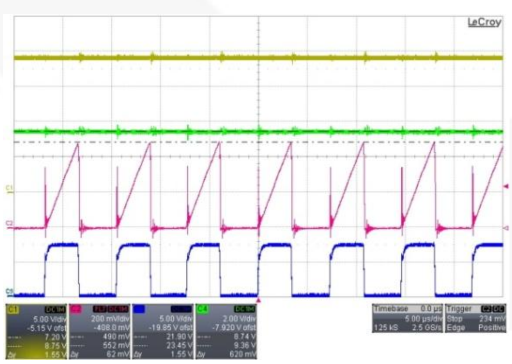


Figure 11. C1[V_{DD}], C2[V_{CS}], C3[GATE] C4[V_O], 90 V_{AC} / 60 Hz

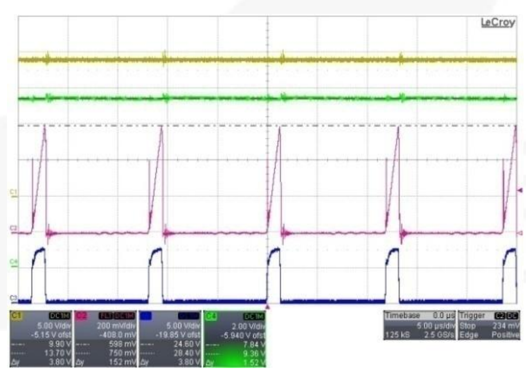


Figure 12. C1[V_{DD}], C2[V_{CS}], C3[GATE], C4[V_O], 264 V_{AC} / 50 Hz

9.4. DC Output Rising Time

Test Condition:

Measure the time interval between 10% to 90% of output voltage during startup (CR mode electric load at 5 V output mode).

Table 8. Test Result

Input Voltage	Minimum Load	Full Load	Specification
90 V_{AC}/60 Hz	26.03 ms	24.12 ms	<30 ms
264 V_{AC}/50 Hz	25.47 ms	23.78 ms	

Waveforms:

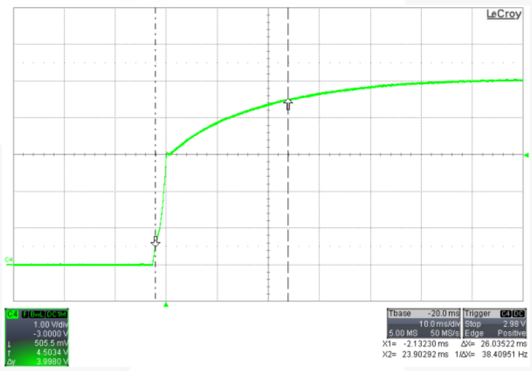


Figure 13. C4[V_O], 90 V_{AC}/60 Hz, Minimum Load

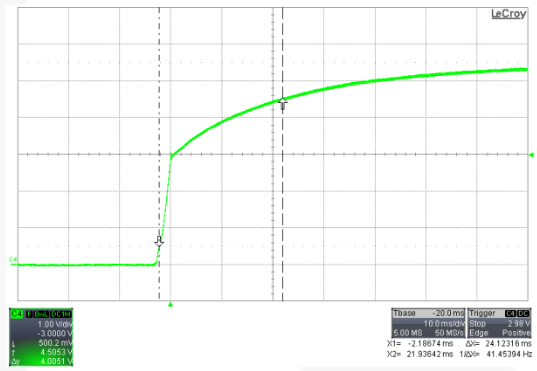


Figure 14. C4[V_O], 90 V_{AC}/60 Hz, Full Load

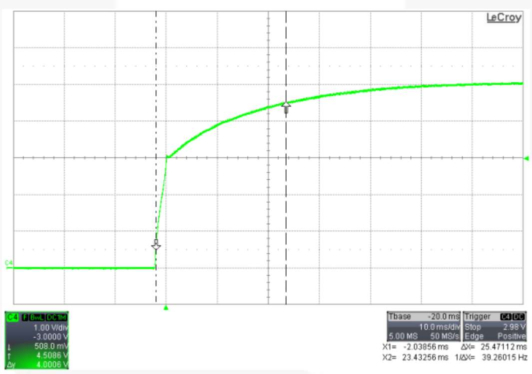


Figure 15. C4[V_O], 264 V_{AC}/50 Hz, Minimum Load

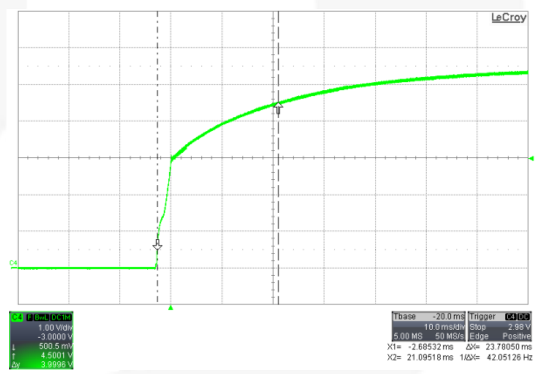


Figure 16. C4[V_O] 264 V_{AC}/50 Hz, Full Load

9.5. Dynamic Response

Test Condition

Dynamic loading (0%~100%), 50% duty cycle (5 ms), 2.5 A/µsec rise/fall time. Measured at PCB end.

Table 9. Test Result

V_O = 5 V			
Input Voltage	**Overshoot**	**Undershoot**	**Specification**
90 V_{AC}/60 Hz	5.576 V	4.750 V	> 4.5 V
264 V_{AC}/50 Hz	5.466 V	4.794 V	
V_O = 9 V			
Input Voltage	**Overshoot**	**Undershoot**	**Specification**
90 V_{AC}/60 Hz	9.560 V	8.828 V	>8.1 V
264 V_{AC}/50 Hz	9.512 V	8.912 V	
V_O = 12 V			
Input Voltage	**Overshoot**	**Undershoot**	**Specification**
90 V_{AC}/60 Hz	12.532 V	11.886 V	>10.8 V
264 V_{AC}/50 Hz	12.524 V	11.998 V	

Waveforms:

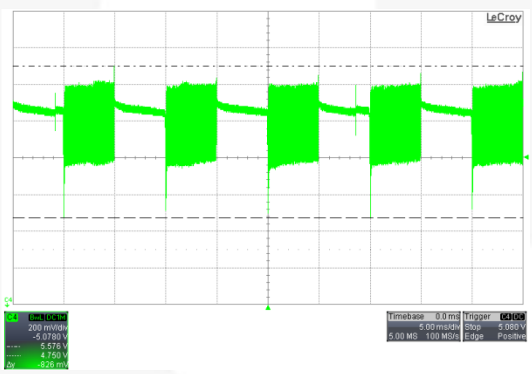


Figure 17. C4[V_O], 90 V_{AC} / 60 Hz, V_O=5 V

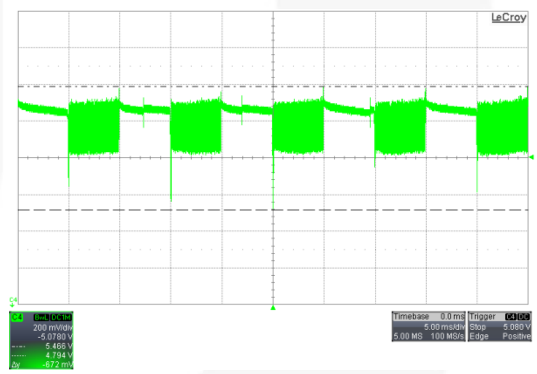


Figure 18. C4[V_O], 264 V_{AC} / 50 Hz, V_O=5 V

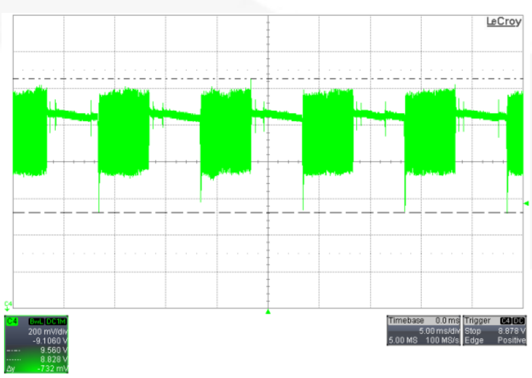


Figure 19. C4[V_O], 90 V_{AC} / 60 Hz, V_O=9 V

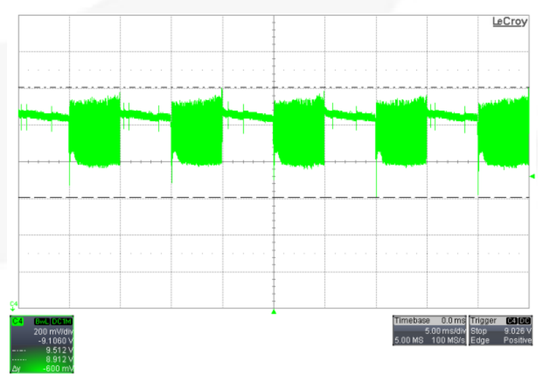


Figure 20. C4[V_O], 264 V_{AC} / 50 Hz, V_O=9 V

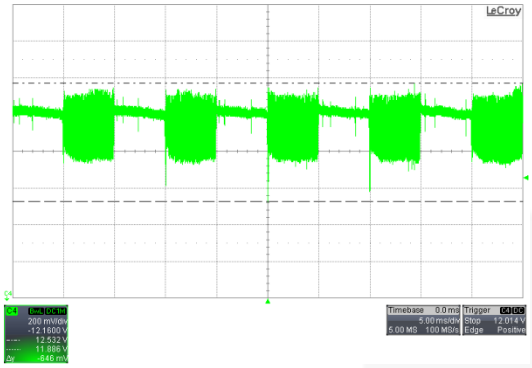


Figure 21. C4[V_O] 90 V_{AC} / 60 Hz, V_O=12 V

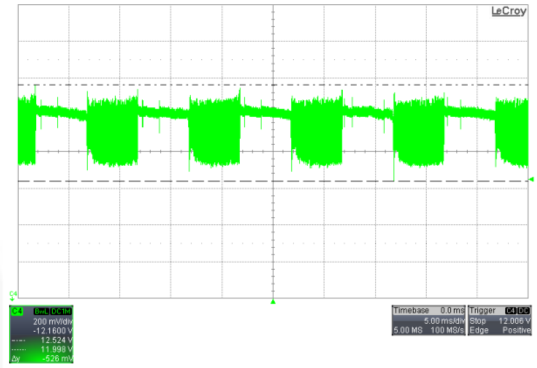


Figure 22. C4[V_O], 264 V_{AC} / 50 Hz, V_O=12 V

9.6. Output Ripple & Noise

Test Condition

Measure the output voltage ripple at full load condition at EVB end with 10 µF electrolytic capacitor in parallel with 0.1 µF MLCC.

Table 10. Test Result

Input Voltage	V_O = 5 V	V_O = 9 V	V_O = 12 V	Specification
90 V_{AC} / 60 Hz	103 mV_{P-P}	121 mV_{P-P}	116 mV_{P-P}	<150 mV_{P-P}
115 V_{AC} / 60 Hz	96 mV_{P-P}	115 mV_{P-P}	110 mV_{P-P}	
230 V_{AC} / 50 Hz	106 mV_{P-P}	136 mV_{P-P}	125 mV_{P-P}	
264 V_{AC} / 50 Hz	108 mV_{P-P}	130 mV_{P-P}	125 mV_{P-P}	

Waveforms:

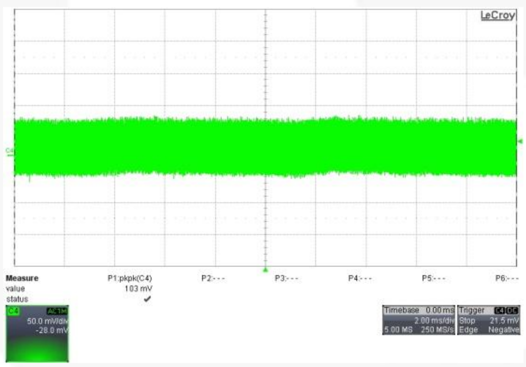


Figure 23. C4[V_O], 90 V_{AC} / 60 Hz, I_O=2 A, V_O=5 V

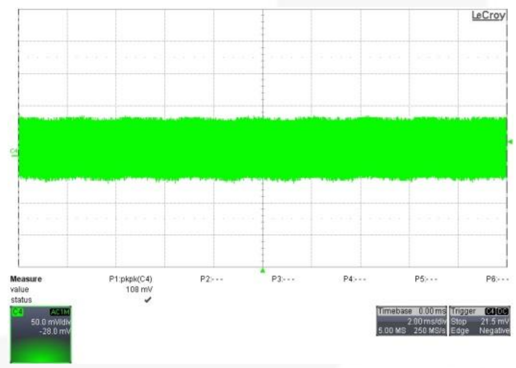


Figure 24. C4[V_O], 264 V_{AC} / 50 Hz, I_O=2 A, V_O=5 V

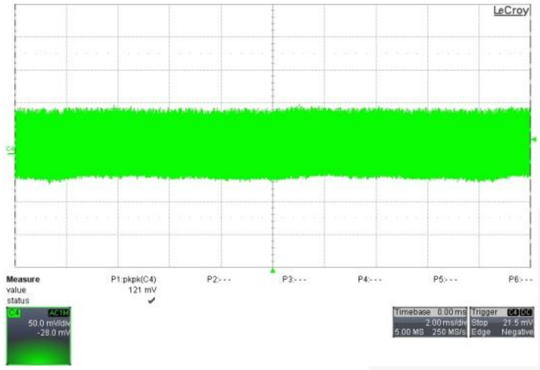


Figure 25. C4[V_O], 90 V_{AC} / 60 Hz, I_O=1.8 A, V_O=9 V

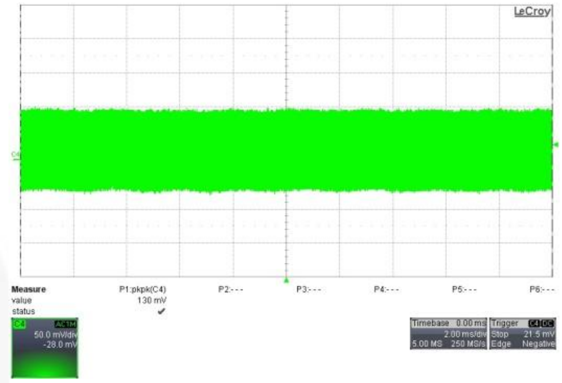


Figure 26. C4[V_O], 264 V_{AC} / 50 Hz, I_O=1.8 A, V_O=9 V

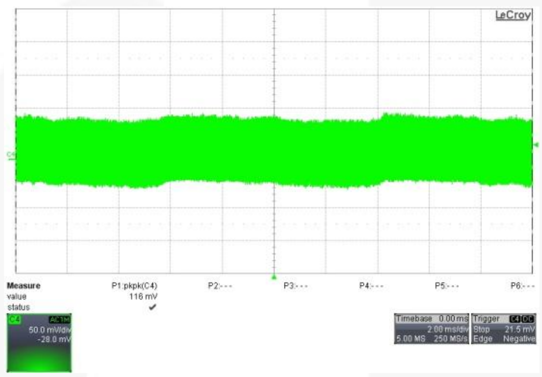


Figure 27. C4[V_O], 90 V_{AC} / 60 Hz, I_O=1.67 A, V_O=12 V

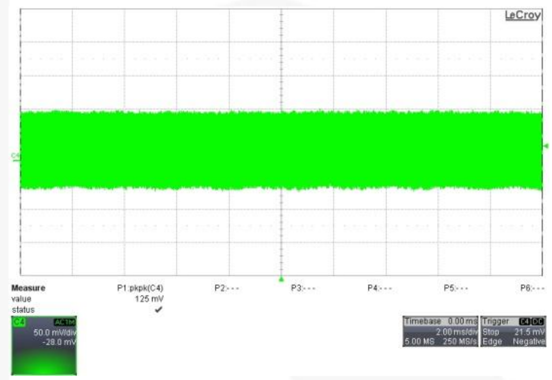


Figure 28. C4[V_O], 264 V_{AC} / 50 Hz, I_O=1.67 A, V_O=12 V

9.7. Short-Circuit Protection (SCP)

Test Condition

Short output voltage, then the power supply should enter hiccup mode protection with less than 1 W input power. 5 V, 9 V and 12 V mode has the same power loss at this condition.

Table 11. Test Result with Input Power

	Maximum Output Load	Minimum Output Load	Specification
90 V_{AC} / 60 Hz	0.18 W	0.18 W	<1 W
264 V_{AC} / 50 Hz	0.37 W	0.35 W	

Waveforms:

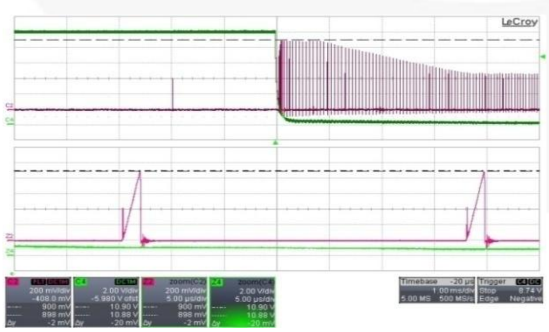


Figure 29. C2[V_{CS}], C4[V_O], 264 V_{AC}/50 Hz, I_O=0 A, V_O=12 V

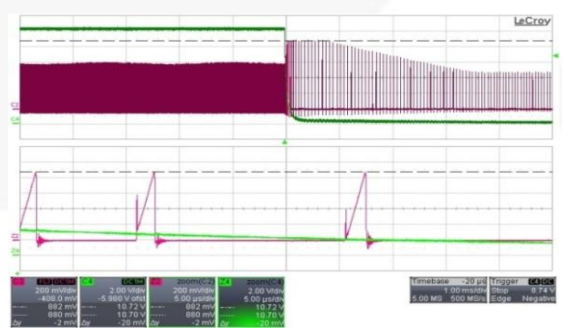


Figure 30. C2[V_{CS}], C4[V_O],264 V_{AC}/50 Hz, I_O=1.25 A, V_O=12 V

9.8. V_{DD} Voltage Level

Test Condition:

Measure VDD level at 5 V and 12 V system in minimum load and CC point.

Table 12. Test Result

V_O = 5 V			
Input Voltage	**Minimum Load**	**CC Point**	**Specification**
90 V_{AC} / 60 Hz	7.14 V	13.1 V	<26.5 V
264 V_{AC} / 50 Hz	7.10 V	13.1 V	
V_A = 12 V			
Input Voltage	**Minimum Load**	**CC Point**	**Specification**
90 V_{AC} / 60 Hz	12.8 V	13.1 V	<26.5 V
264 V_{AC} / 50 Hz	12.8 V	13.1 V	

Waveforms:

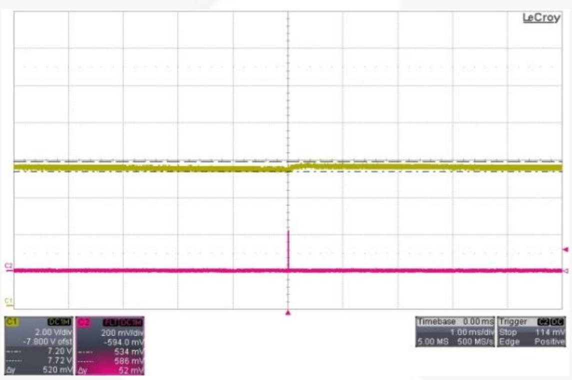


Figure 31. C1[V_{DD}], C2[V_{CS}], 90 V_{AC}/60 Hz. 0 A, V_O=5 V

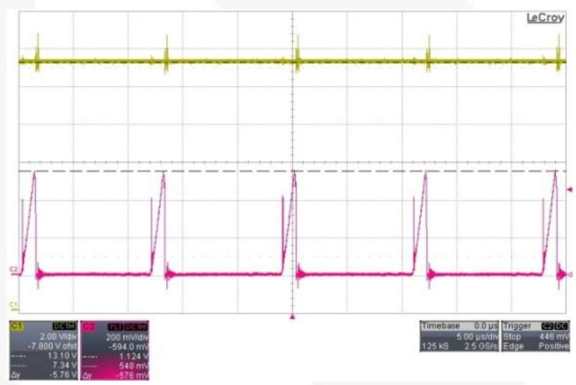


Figure 32. C1[V_{DD}], C2[V_{CS}] 264 V_{AC}/50 Hz, 2.3 A, V_O=5 V

9.9. Voltage Stress on MOSFET & Rectifiers

Test Condition

Measure the voltage and current stress on MOSFET and secondary rectifier under below the conditions in 12 V mode where the maximum voltage stress occurs.

Table 13. Test Result

		90 V_{AC}/ 60 Hz		264 V_{AC}/ 50 Hz		Specification
		Min. Load	**Full Load**	**Min. Load**	**Full Load**	
Normal	**MOSFET**	267 V	318 V	530 V	576 V	V_{DS}<640 V V_D<60 V
	Rectifier	27.3 V	35.2 V	53.6 V	54.3 V	
Short Circuit	**MOSFET**	272 V	320 V	534 V	581 V	
	Rectifier	27.3 V	35.3 V	53.9 V	54.3 V	

Waveforms:

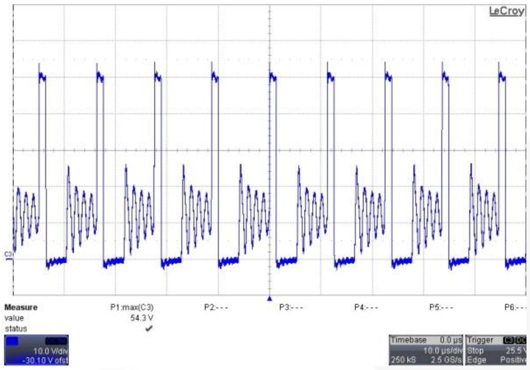


Figure 33. C3[V_{DS}], 264 V_{AC}/50 Hz, 12 V, Full Load

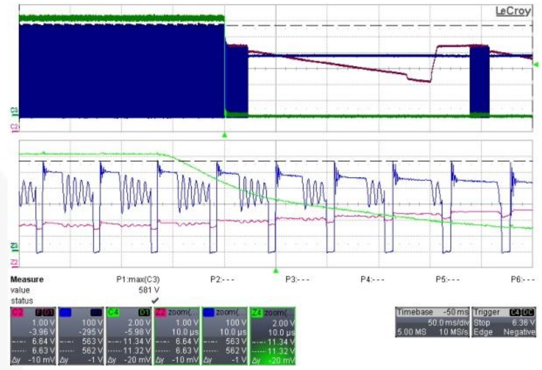


Figure 34. C2[FB], C3[V_{DS}]. C4[V_O] 264 V_{AC}/50 Hz,12 V, Full Load Output Short

9.10. Constant Current Regulation

Test Condition

Aging five seconds at minimum load and measure the output current and output voltage each load / one second interval. Electric load is in CV mode.

Table 14. Test Result with CC

V_O = 5 V (Until 3 V)				
Input Voltage	**Maximum Current**	**Minimum Current**	**Tolerance**	**Specification**
90 V_{AC} / 60 Hz	2372.81 mA	2357.81 mA	±0.4%	< ±5%
115 V_{AC} / 60 Hz	2367.18 mA	2352.18 mA	±0.4%	
230 V_{AC} / 50 Hz	2366.25 mA	2351.25 mA	±0.4%	
264 V_{AC} / 50 Hz	2369.06 mA	2355.00 mA	±0.4%	
Total	2372.81 mA	2351.25 mA	±0.5%	
V_O = 9 V (Until Enter UVP Point)				
Input Voltage	**Maximum Current**	**Minimum Current**	**Tolerance**	**Specification**
90 V_{AC} / 60 Hz	1875.00 mA	1869.37 mA	±0.2%	< ±5%
115 V_{AC} / 60 Hz	1873.12 mA	1868.43 mA	±0.1%	
230 V_{AC} / 50 Hz	1871.25 mA	1877.81 mA	±0.1%	
264 V_{AC} / 50 Hz	1877.81 mA	1873.12 mA	±0.1%	
Total	1877.81 mA	1866.56 mA	±0.3%	
V_O = 12 V (Until Enter UVP Point)				
Input Voltage	**Maximum Current**	**Minimum Current**	**Tolerance**	**Specification**
90 V_{AC} / 60 Hz	1379.06 mA	1378.12 mA	±0.1%	< ±5%
115 V_{AC} / 60 Hz	1379.06 mA	1377.18 mA	±0.1%	
230 V_{AC} / 50 Hz	1378.12 mA	1376.25 mA	±0.1%	
264 V_{AC} / 50 Hz	1377.18 mA	1375.31 mA	±0.1%	
Total	1379.06 mA	1375.31 mA	±0.2%	

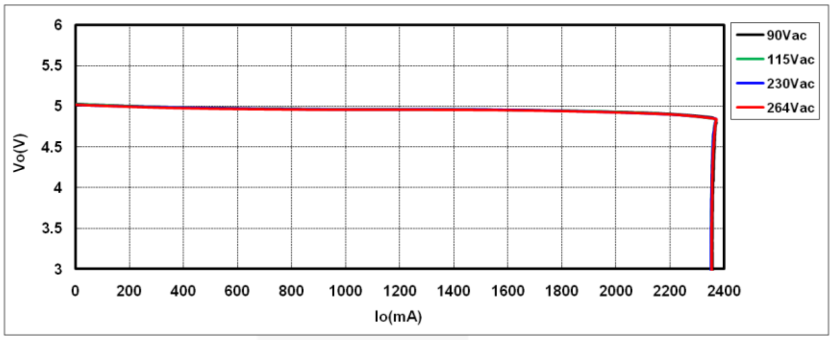


Figure 35. 5 V CC Deviation Curve

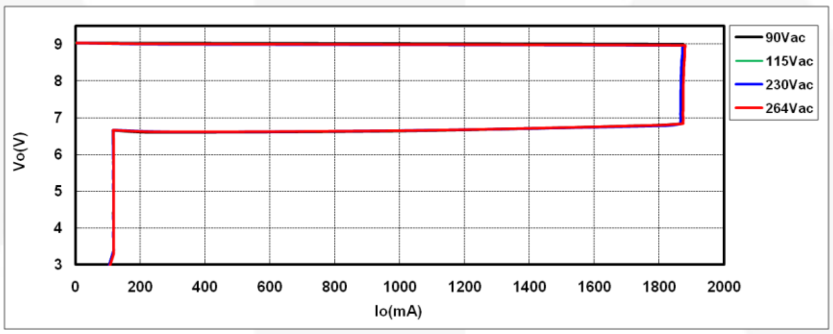


Figure 36. 9 V CC Deviation Curve

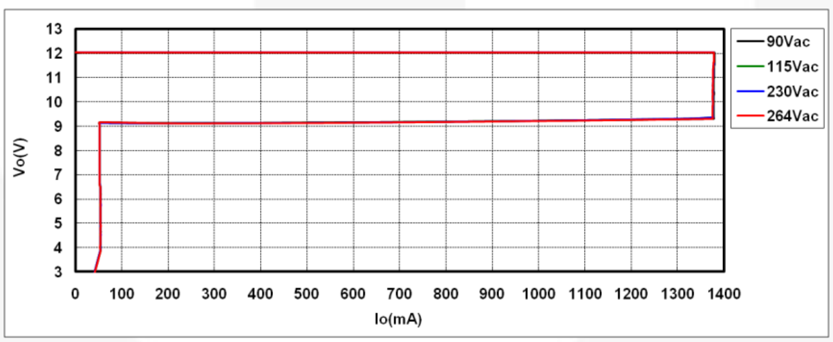


Figure 37. 12 V CC Deviation Curve

9.11. Constant Voltage Regulation

Test Condition

Aging five seconds at minimum load and measure the output current and output voltage each load / one second interval. Electric load is in CR mode.

Table 15. Test Result with CV

V_O = 5 V				
Input Voltage	**Maximum Voltage**	**Minimum Voltage**	**Tolerance**	**Specification**
90 V_{AC} / 60 Hz	5.026 V	5.015 V	±0.1%	< ±5%
115 V_{AC} / 60 Hz	5.033 V	5.021 V	±0.1%	
230 V_{AC} / 50 Hz	5.037 V	5.021 V	±0.2%	
264 V_{AC} / 50 Hz	5.041 V	5.021 V	±0.2%	
Total	5.041 V	5.021 V	±0.3%	
V_O = 9 V				
Input Voltage	**Maximum Voltage**	**Minimum Voltage**	**Tolerance**	**Specification**
90 V_{AC} / 60 Hz	9.06 V	9.037 V	±0.1%	< ±5%
115 V_{AC} / 60 Hz	9.06 V	9.036 V	±0.1%	
230 V_{AC} / 50 Hz	9.061 V	9.038 V	±0.1%	
264 V_{AC} / 50 Hz	9.061 V	9.038 V	±0.1%	
Total	9.061 V	9.036 V	±0.1%	
V_O = 12 V				
Input Voltage	**Maximum Voltage**	**Minimum Voltage**	**Tolerance**	**Specification**
90 V_{AC} / 60 Hz	12.051 V	12.034 V	±0.1%	< ±5%
115 V_{AC} / 60 Hz	12.051 V	12.033 V	±0.1%	
230 V_{AC} / 50 Hz	12.052 V	12.035 V	±0.1%	
264 V_{AC} / 50 Hz	12.052 V	12.035 V	±0.1%	
Total	12.052 V	12.033 V	±0.1%	

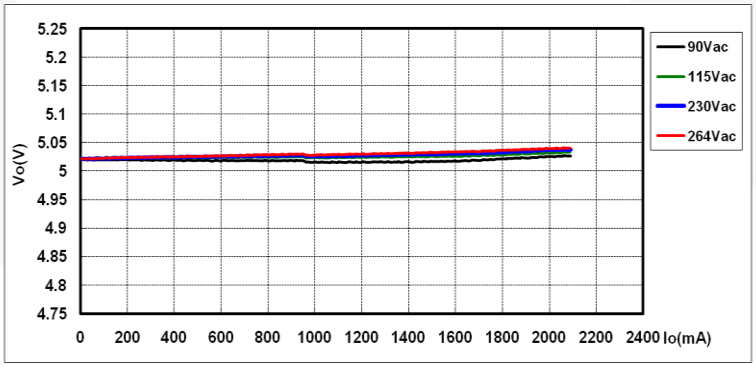


Figure 38. 5 V CV Deviation Curve

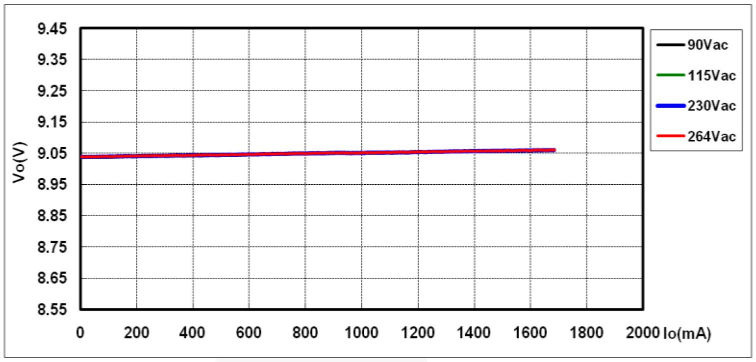


Figure 39. 9 V CV Deviation Curve

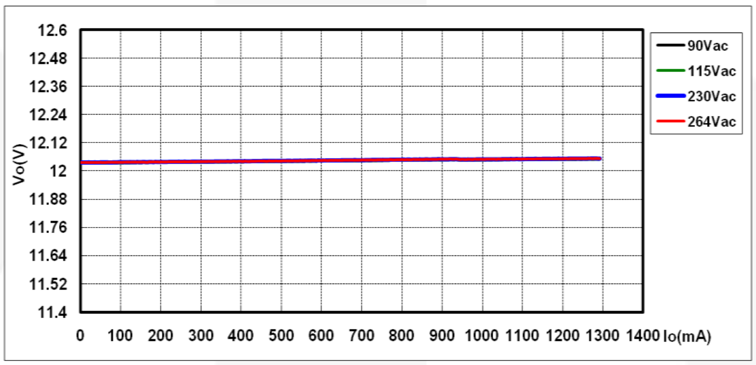


Figure 40. 12 V CV Deviation Curve

9.12. Efficiency

Test Condition

Measure input wattage and output wattage at PCB end. Average efficiency is obtained from 25%, 50%, 75% and 100% load condition.

Table 16. Test Result

V_O = 5 V							
Input Voltage	**10%**	**25%**	**50%**	**75%**	**100%**	**Avg.**	**Specification**
90 V_{AC} / 60 Hz	83.19%	83.47%	83.35%	83.56%	83.23%	83.40%	CoC Tier 2: 115 V_{AC}/230 V_{AC} Average >79% 10% >69.73%
115V_{AC} / 60 Hz	83.40%	83.83%	83.71%	84.71%	83.28%	83.88%	
230 V_{AC} / 50 Hz	80.62%	81.68%	82.69%	83.76%	83.79%	82.98%	
264 V_{AC} / 50 Hz	79.65%	80.85%	81.25%	83.02%	83.08%	82.05%	
V_O = 9 V							
Input Voltage	**10%**	**25%**	**50%**	**75%**	**100%**	**Avg.**	**Specification**
90 V_{AC} / 60 Hz	80.97%	83.84%	86.26%	86.29%	84.94%	85.33%	CoC Tier2: 115 V_{AC}/230 V_{AC} Average >84.51% 10% >74.14%
115 V_{AC} / 60 Hz	82.51%	84.21%	85.21%	86.34%	86.67.%	85.61%	
230 V_{AC} / 50 Hz	80.62%	82.94%	85.33%	86.34%	86.82%	85.36%	
264 V_{AC} / 50 Hz	79.77%	81.95%	84.50%	85.91%	86.58%	84.74%	
V_O = 12 V							
Input Voltage	**10%**	**25%**	**50%**	**75%**	**100%**	**Avg.**	**Specification**
90 V_{AC} / 60 Hz	77.21%	81.45%	84.67%	86.34%	86.45%	84.73%	CoC Tier2: 115 V_{AC}/230 V_{AC} Average >84.50% 10% >74.13%
115 V_{AC} / 60 Hz	79.03%	83.48%	86.13%	85.88%	86.88%	85.59%	
230 V_{AC} / 50 Hz	76.76%	81.94%	85.79%	86.74%	87.63%	85.52%	
264 V_{AC} / 50 Hz	75.99%	81.14%	84.65%	86.07%	87.13%	84.75%	

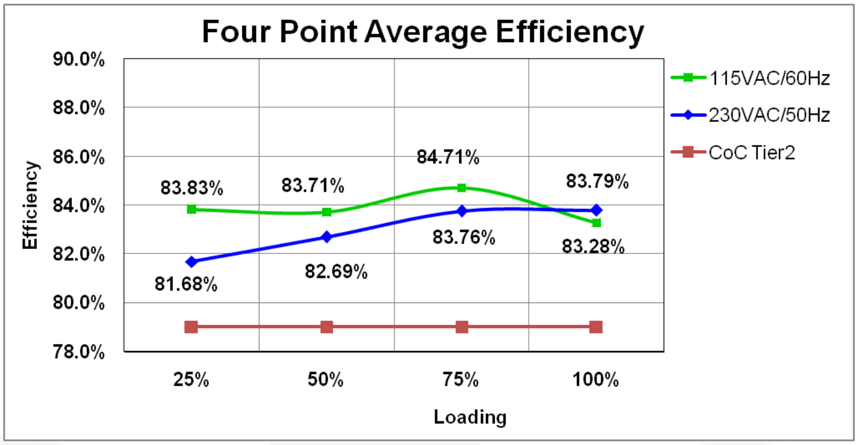


Figure 41. 5 V Efficiency Curve (4 Point Average: 100%, 75%, 50%, 25%)

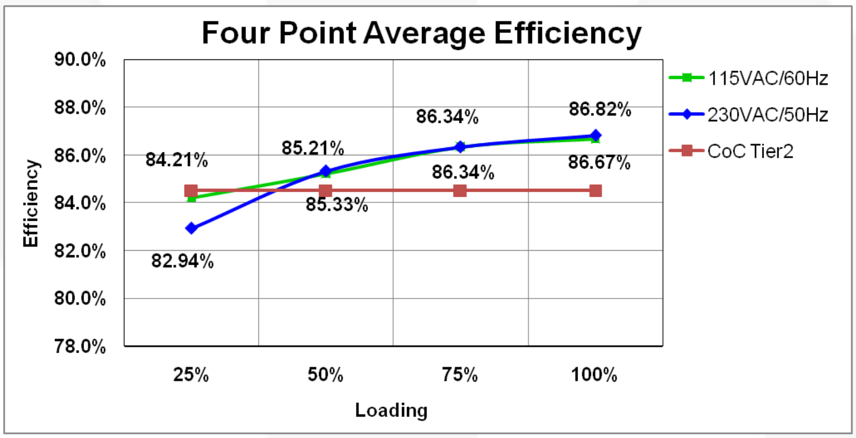


Figure 42. 9 V Efficiency Curve (4 Point Average: 100%, 75%, 50%, 25%)

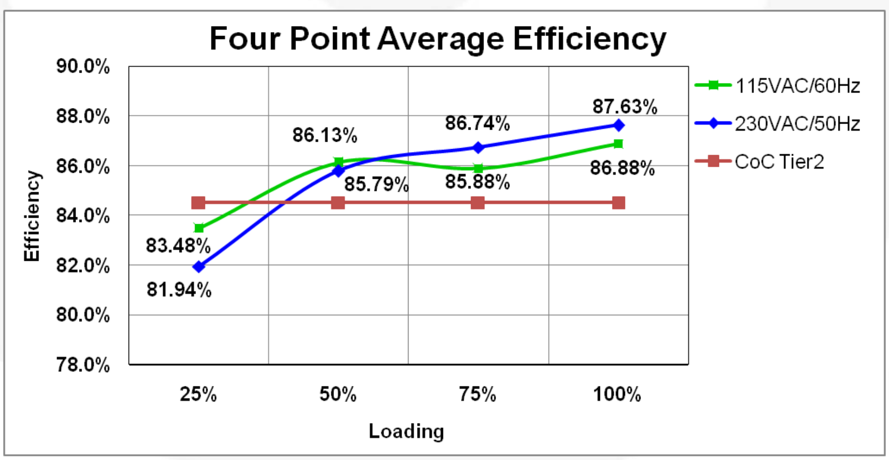


Figure 43. 12 V Efficiency Curve (4 Point Average: 100%, 75%, 50%, 25%)

9.13. Output Over-Voltage Protection(V_O OVP)

Test Condition

Measure the maximum output voltage when second side VREF resistor is open. When V_O OVP is triggered, OVP signal is pulled low, pulling down FB signal. V_O = 5 V.

Table 17. Test Results

Input Voltage	Minimum Load	Maximum Load	Specification
90 V_{AC} / 60 Hz	6.27 V	7.38 V	
264 V_{AC} / 50 Hz	6.27 V	7.38 V	
V_O = 9 V			
Input Voltage	**Minimum Load**	**Maximum Load**	**Specification**
90 V_{AC} / 60 Hz	11.5 V	12 V	
264 V_{AC} / 50 Hz	11.5 V	12 V	
V_O = 12 V			
Input Voltage	**Minimum Load**	**Maximum Load**	**Specification**
90 V_{AC} / 60 Hz	14.8 V	15.3 V	<16 V
264 V_{AC} / 50 Hz	14.6 V	15.3 V	

Waveforms:

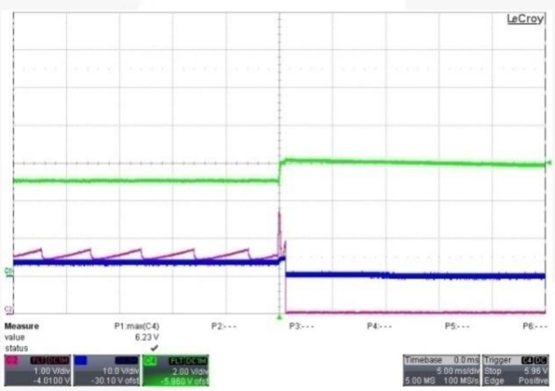


Figure 44. C2[V_{FB}] C3[V_{OVP}] C4[V_O]
V_O OVP Test, 5 V

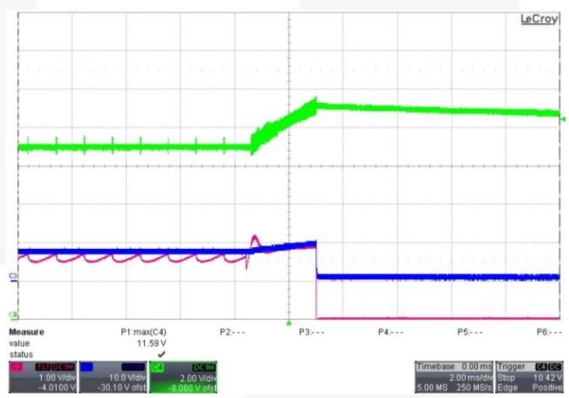


Figure 45. C2[V_{FB}] C3[V_{OVP}] C4[V_O]
V_O OVP Test, 9 V

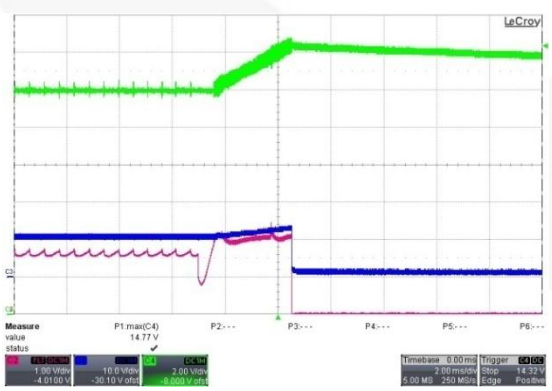


Figure 46. C2[V_{FB}] C3[V_{OVP}] C4[V_O]
V_O OVP Test, 12 V

9.14. Bleeder (BLD) Function Test

Test Condition

Measure time when mode changes from high voltage to low voltage. Function turns on for 320 ms to discharge output voltage.

Table 18. Test Result

Mode Change	Change Time
9 V➔5 V	67.88 ms
12 V➔5 V	75.52 ms
12 V ➔9 V	59.74 ms

Waveforms:

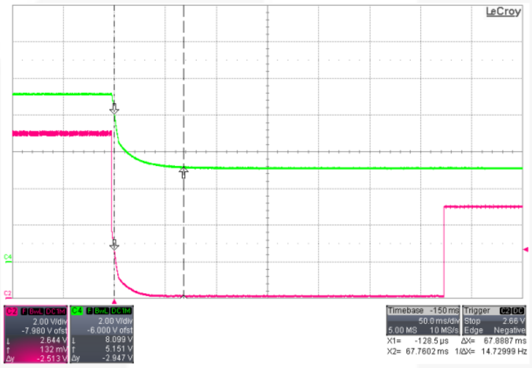


Figure 47. C2[V_{BLD}], C4[V_O] 90 V_{AC} / 60 Hz & I_O=0 A, 9 V to 5 V

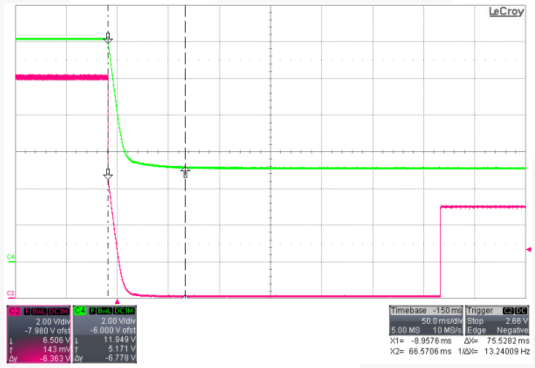


Figure 48. C2[V_{BLD}], C4[V_O] 90 V_{AC} / 60 Hz & I_O=0 A, 12 V to 5 V

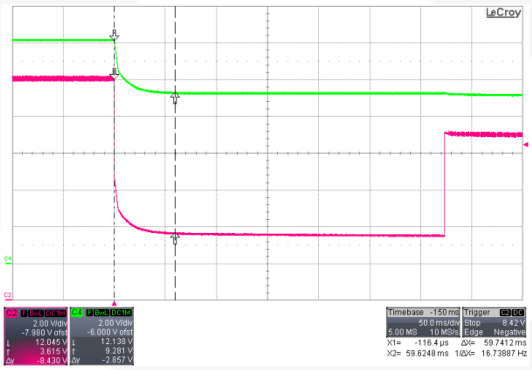


Figure 49. 90 V_{AC} / 60 Hz & I_O=0 A, 12 V to 9 V

9.15. Conducted EMI

Test Condition

- Frequency Range: 150 kHz – 30 MHz, Probe: 2-Line-LISN ENV216
- Signal Path: Receiver-2-Line-LISN ENV216, Detectors: Average
- IF Bandwidth: 9 kHz, Step Size: 0.4%, Meas. Time: 0.1 s, Preamp: 0 dB
- Output Load: 5 V=> 2.5 Ω, 9 V=> 5.39 Ω, 12 V=> 9.6 Ω.

Test Result

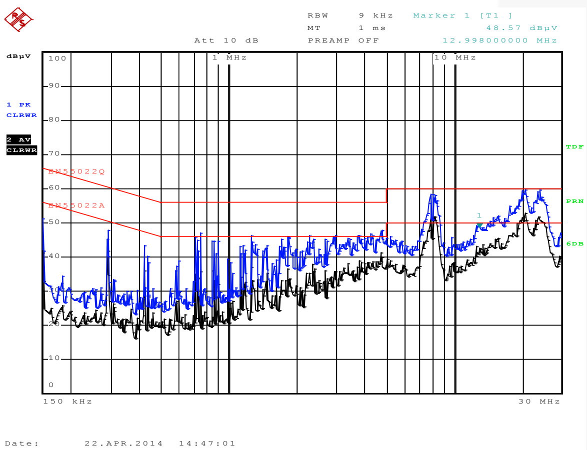


Figure 50. Line: 115 V_{AC} / 60 Hz & 5 V_O

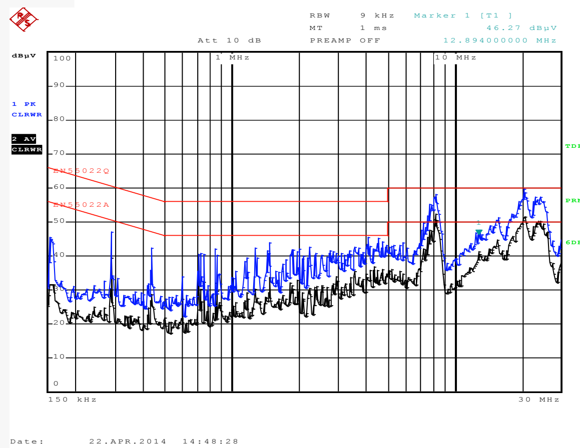


Figure 51. Neutral: 115 V_{AC} / 60 Hz & 5 V_O

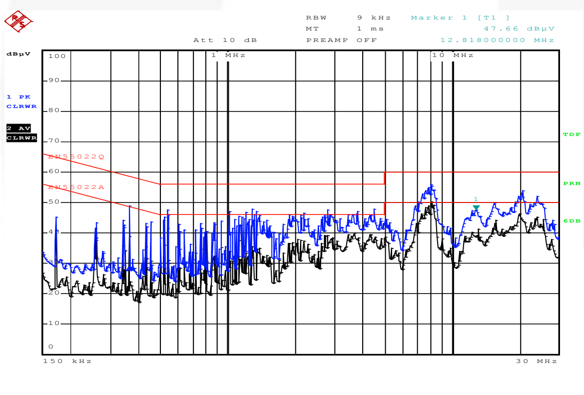


Figure 52. Line: 230 V_{AC} / 50 Hz & 5 V_O

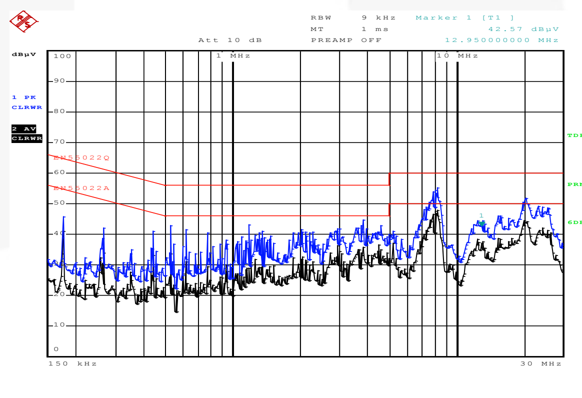


Figure 53. Neutral: 230 V_{AC} / 50 Hz &5 V_O

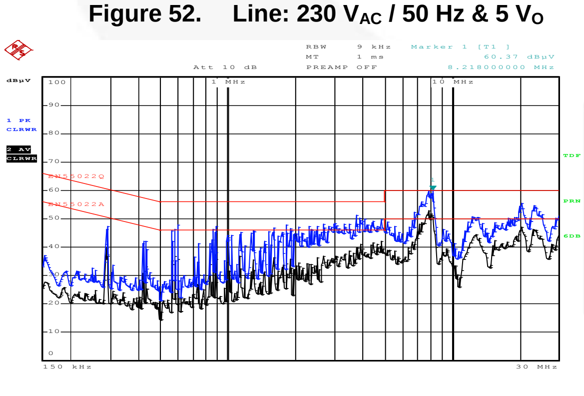


Figure 54. Line: 115 V_{AC} / 60 Hz & 9 V_O

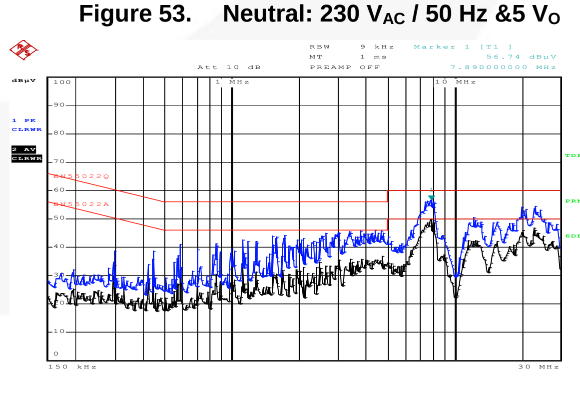


Figure 55. Neutral: 115 V_{AC} / 60 Hz & 9 V_O

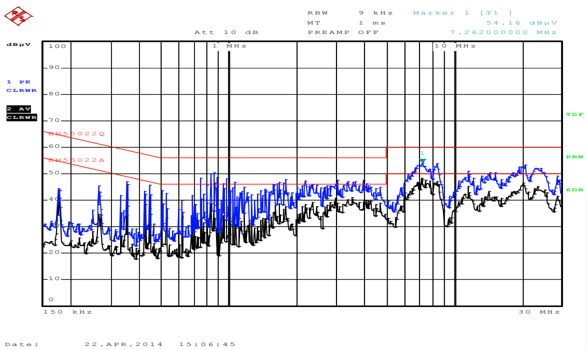


Figure 56. Line: 230 V_{AC} / 50 Hz & 9 V_O

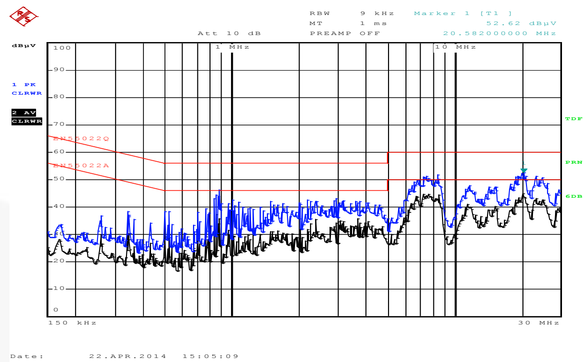


Figure 57. Neutral: 230 V_{AC} / 50 Hz & 9 V_O

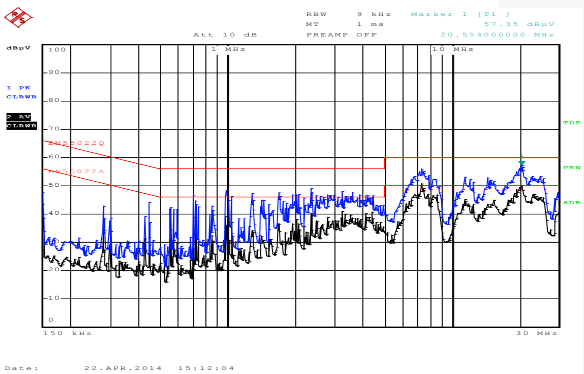


Figure 58. Line: 115 V_{AC} / 60 Hz & 12 V_O

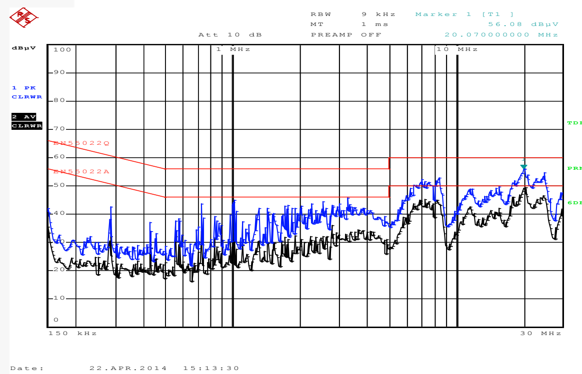


Figure 59. Neutral: 115 V_{AC} / 60 Hz & 12 V_O

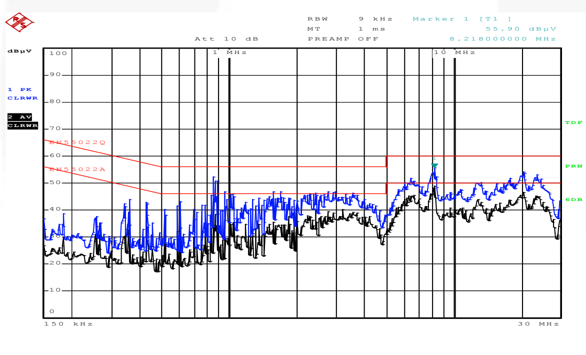


Figure 60. Line: 230 V_{AC} / 50 Hz & 12 V_O

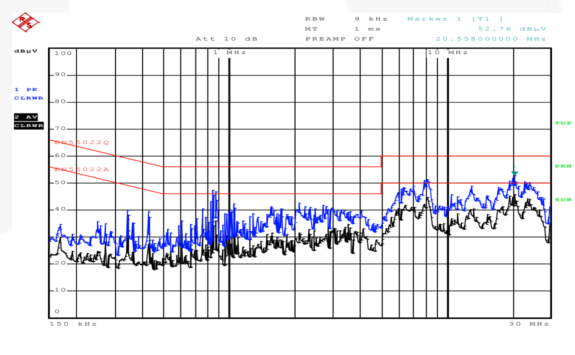


Figure 61. Neutral: 230 V_{AC} / 50 Hz &12 V_O

9.16. Qualcomm QC2.0 Compatible Test Result

Test Condition

- Mode change function test with Qualcomm protocol.
- 90V_{AC}, minimum load.

Table 19. QC2.0 DP/DN Section Table

	DP	DN	Output Voltage
BC1.2	0.6 V	0.6 V	5 V
Mode 1	0.6 V	0 V	5 V
Mode 2	3.3 V	0.6 V	9 V
Mode 3	0.6V	0.6V	12V

Waveforms:

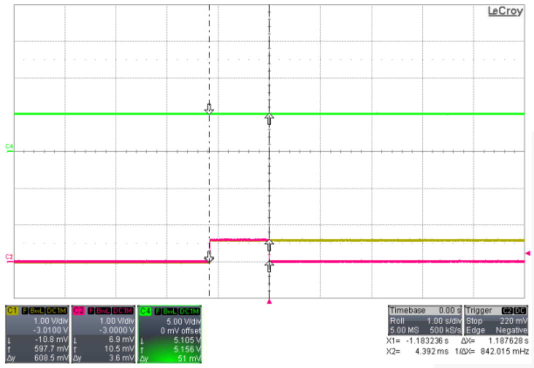


Figure 62. CH1[DP], CH2[DN], CH4[V_O]
BC1.2 Process

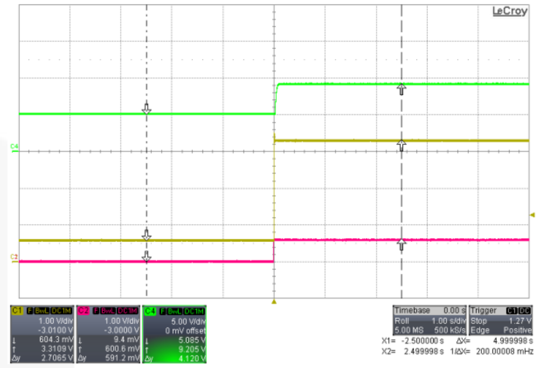


Figure 63. CH1[DP], CH2[DN], CH4[V_O]
Mode Change from 5 V to 9 V

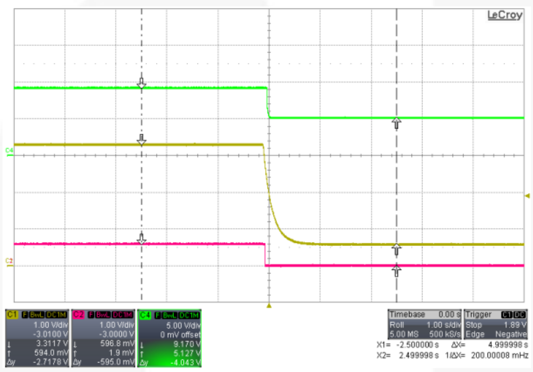


Figure 64. CH1[DP], CH2[DN], CH4[V_O]
Mode Change from 9 V to 5 V

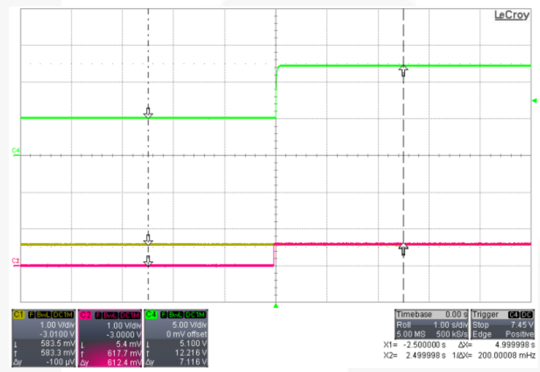


Figure 65. CH1[DP], CH2[DN], CH4[V_O]
Mode Change from 5 V to 12 V

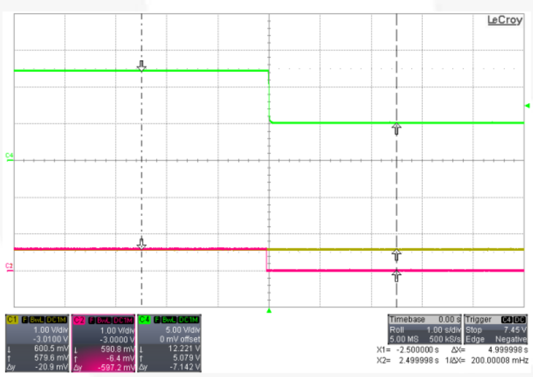


Figure 66. CH1[DP], CH2[DN], CH4[V_O]
Mode Change from 12 V to 5 V

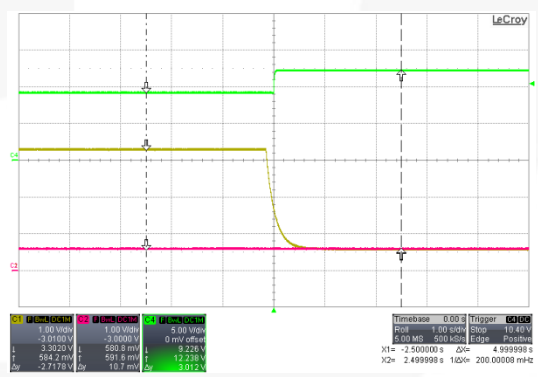


Figure 67. CH1[DP], CH2[DN], CH4[V_O]
Mode Change from 9 V to 12 V

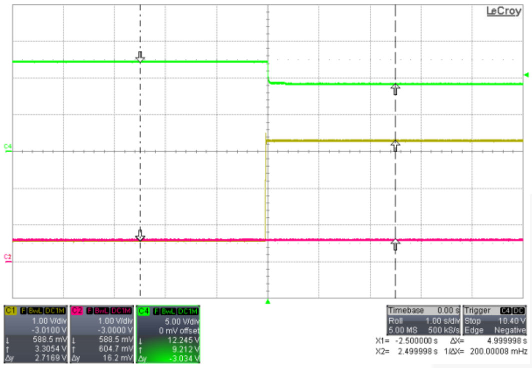
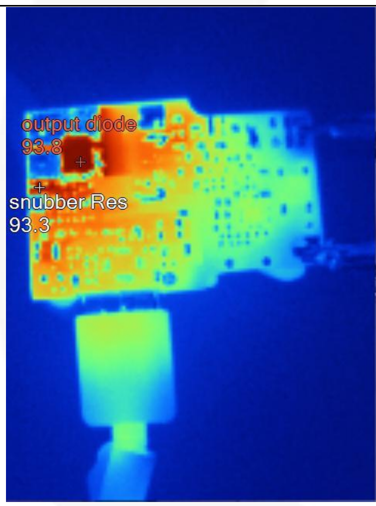


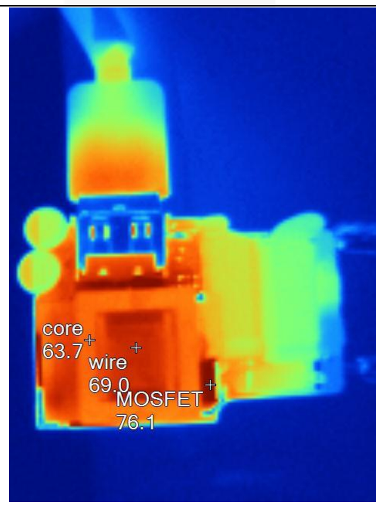
Figure 68. CH1[DP], CH2[DN], CH4[V_O]
Mode Change from 12 V to 9 V

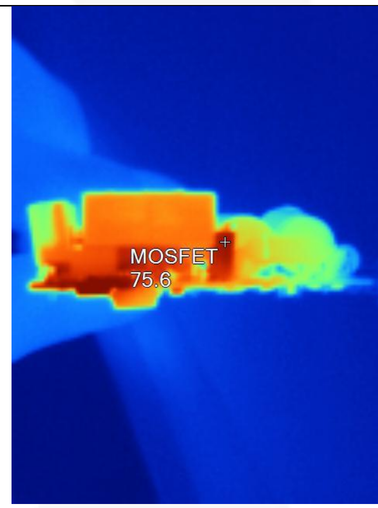
9.17. Component Temperature

Test Condition:

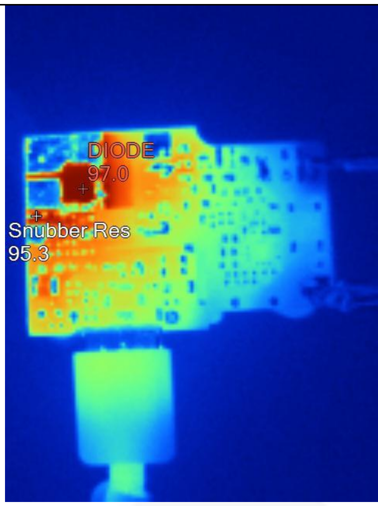
Burn in 60 min. and measure component temperature. 5 V/2 A, 9 V/1.67 A and 12 V/1.25 A at 115 V_{AC}/230 V_{AC}, Ambient: 24°C.

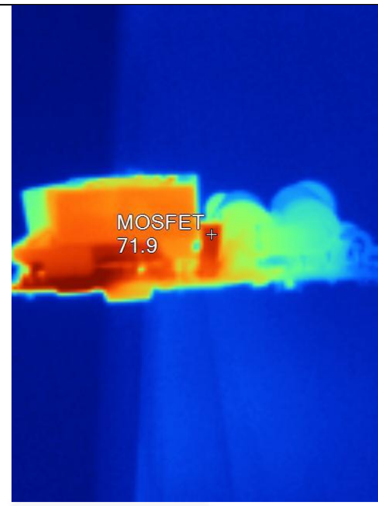




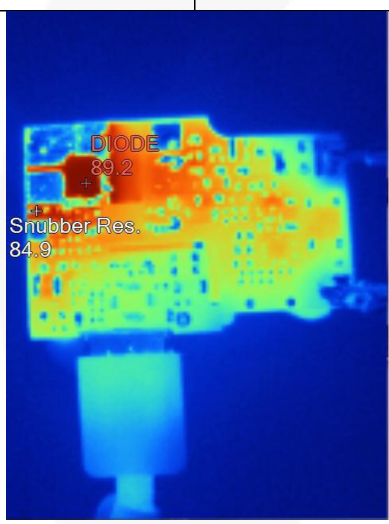


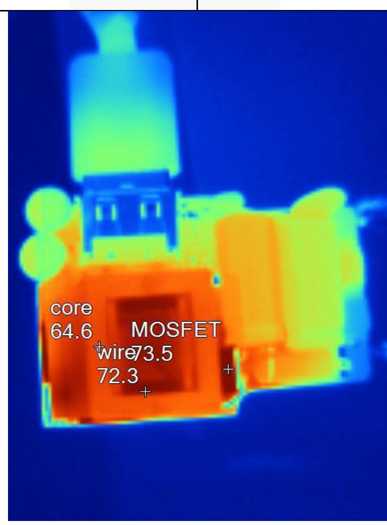
5 V/2 A	MOSFET	Output Diode	Secondary Side Snubber	Transformer Wire	Transformer Core
115 V_{AC}	76.1°C	93.8°C	93.3°C	69°C	63.7°C

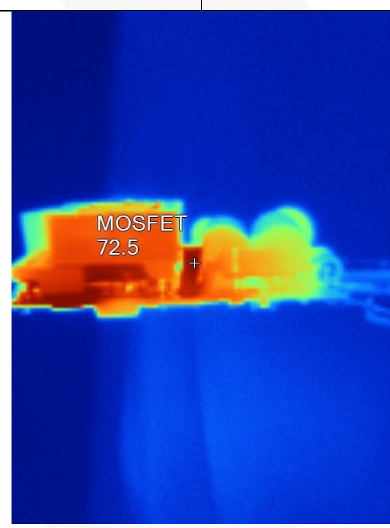




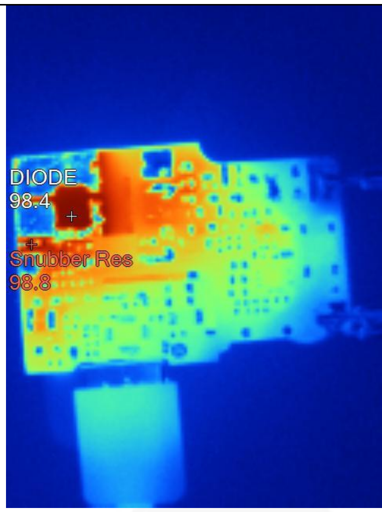
5 V/2 A	MOSFET	Output Diode	Secondary Side Snubber	Transformer Wire	Transformer Core
230V$_{AC}$	73.1°C	97°C	95.3°C	73.5°C	65.8°C

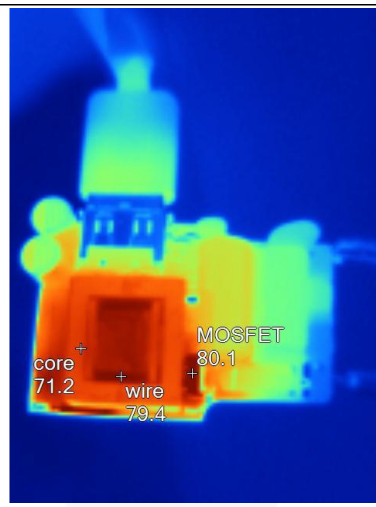


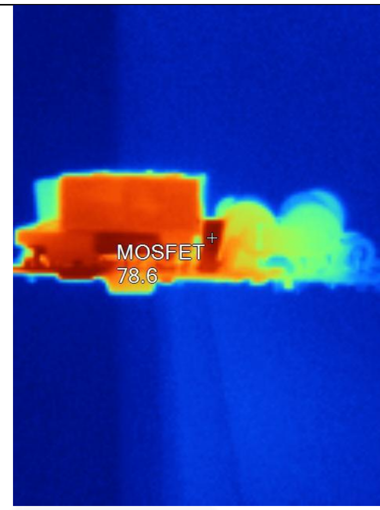




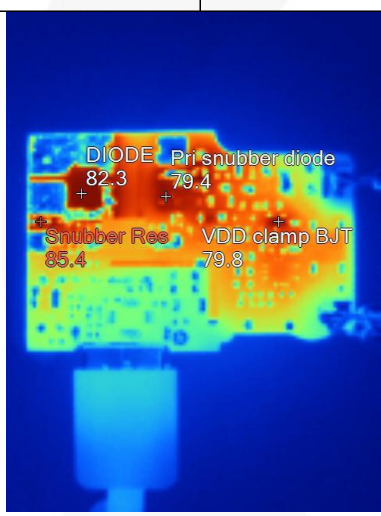
9 V/1.67 A	MOSFET	Output Diode	Secondary Side Snubber	Transformer Wire	Transformer Core
115V$_{AC}$	73.5°C	89.2°C	84.9°C	72.3°C	64.6°C

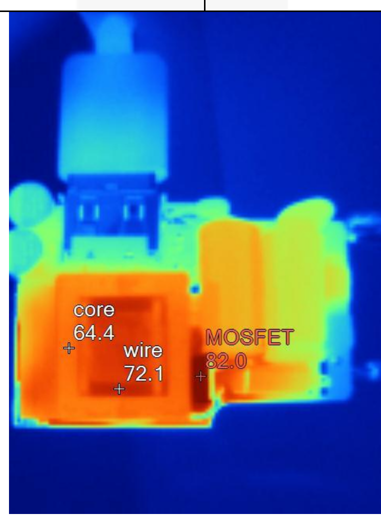


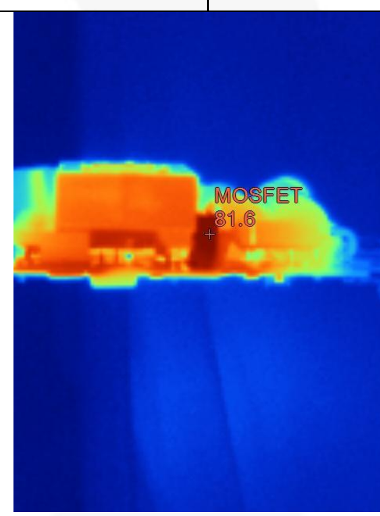




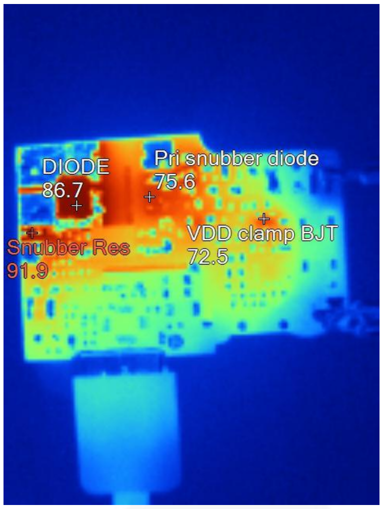
9 V/1.67 A	MOSFET	Output Diode	Secondary Side Snubber	Transformer Wire	Transformer Core
230V_{AC}	80.1°C	98.4°C	98.8°C	79.4°C	71.2°C

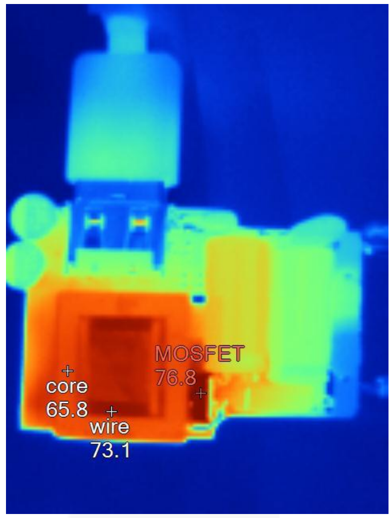


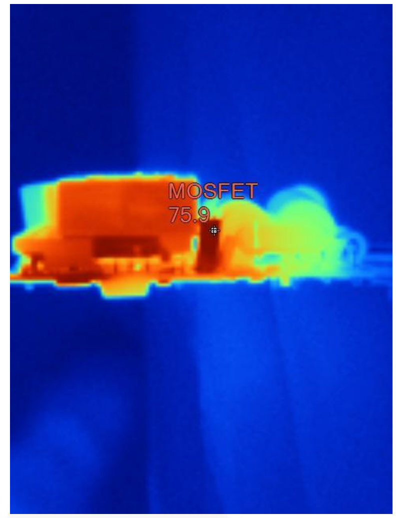




12 V/1.25 A	MOSFET	Output Diode	Secondary Side Snubber	Transformer Wire	Transformer Core	Primary Snubber Diode	VDD BJT
115 V_{AC}	82°C	82.3°C	85.4°C	72.1°C	64.4°C	79.4°C	79.8°C







12 V/1.25 A	MOSFET	Output Diode	Secondary Side Snubber	Transformer Wire	Transformer Core	Primary Snubber Diode	VDD BJT
230 V_{AC}	76.8°C	86.7°C	91.9°C	73.1°C	65.8°C	75.6°C	72.5°C

10. Appendix

10.1. Test for 1.5 A Output Current (Fixed Output Current)

Test Condition:

QP resistance (R36) is shorted and QN resistance (R34) is left open to program for 1.5 A constant output current condition in 5 V and 9 V mode. Only in 12 V mode, the maximum current is 1.1 A.

Table 20. Different Current Mode with QP QN Section

	QP	QN	Max. Current Level
Variable CC	0	0	5 V / 2 A, 9 V / 1.67 A, 12 V / 1.25 A
Fixed CC at 1.5 A	0	1	5 V / 1.5 A, 9 V / 1.5 A, 12 V / 1.1 A

Table 21. Efficiency Measurement at Fixed Output Current Setting

V_O = 5 V							
Input Voltage	**10%**	**25%**	**50%**	**75%**	**100%**	**Avg.**	**Specification**
90 V_{AC} / 60 Hz	82.40%	84.32%	84.35%	84.97%	83.66%	84.33%	CoC Tier2: 115 V_{AC}/230 V_{AC} Average >76.88% 10% >67.65%
115 V_{AC} / 60 Hz	82.43%	84.43%	84.19%	83.56%	84.46%	84.16%	
230 V_{AC} / 50 Hz	80.00%	82.22%	82.46%	83.45%	84.19%	83.08%	
264 V_{AC} / 50 Hz	79.17%	81.28%	81.73%	82.65%	83.39%	82.26%	
V_O = 9 V							
Input Voltage	**10%**	**25%**	**50%**	**75%**	**100%**	**Avg.**	**Specification**
90 V_{AC} / 60 Hz	80.73%	82.57%	85.82%	86.07%	85.70%	85.04%	CoC Tier2: 115 V_{AC}/230 V_{AC} Average >83.93% 10% >73.59%
115 V_{AC} / 60 Hz	81.79%	83.97%	86.36%	87.37%	86.37%	86.02%	
230 V_{AC} / 50 Hz	80.43%	83.19%	85.80%	87.00%	87.13%	85.78%	
264 V_{AC} / 50 Hz	79.65%	82.53%	85.06%	86.42%	86.54%	85.14%	
V_O = 12 V							
Input Voltage	**10%**	**25%**	**50%**	**75%**	**100%**	**Avg.**	**Specification**
90 V_{AC} / 60 Hz	77.67%	81.35%	85.73%	87.01%	86.80%	85.22%	CoC Tier2: 115 V_{AC}/230 V_{AC} Average >83.8% 10% >73.47%
115 V_{AC} / 60 Hz	79.77%	83.98%	85.74%	86.40%	87.96%	86.02%	
230 V_{AC} / 50 Hz	77.99%	82.61%	85.71%	87.64%	87.98%	85.99%	
264 V_{AC} / 50 Hz	77.40%	81.97%	85.04%	87.20%	87.43%	85.41%	

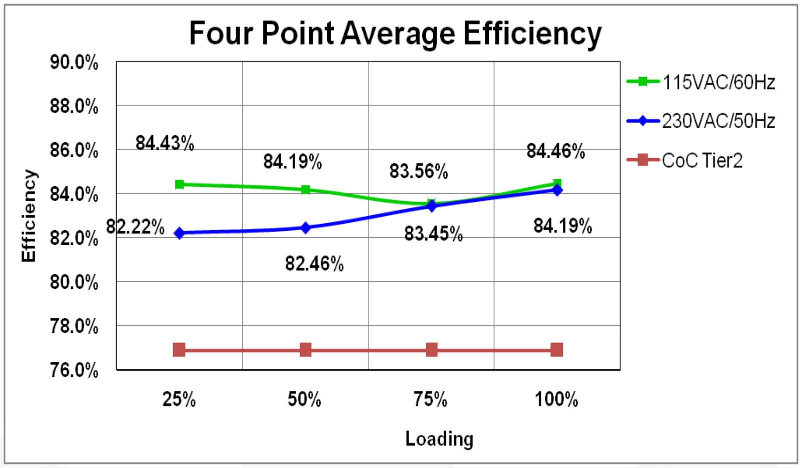


Figure 69. Efficiency at 5 V/1.5 A (Fixed Output Current Setting)

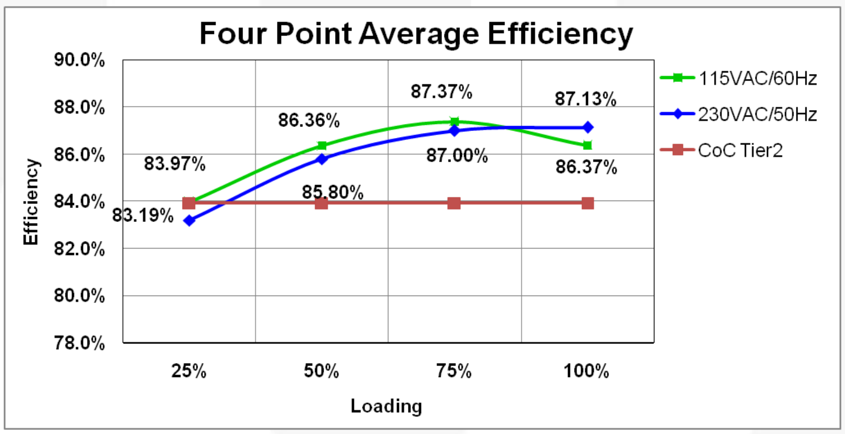


Figure 70. Efficiency at 9 V/1.5 A (Fixed Output Current Setting)

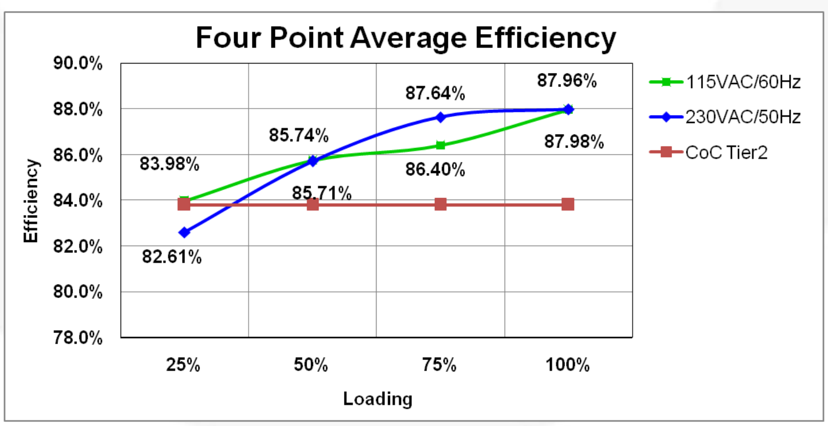


Figure 71. Efficiency at 12 V/1.1 A (Fixed Output Current Setting)

11. Revision History

Rev.	Date	Description
1.0	July 2014	Initial Release