Design Example Report

Title	*27 W USB PD 3.0 with 3.3 V - 11 V PPS Power Supply Using InnoSwitch™ 3-Pro INN3366C and Weltrend WT6635P*
Specification	85 VAC – 265 VAC Input; 5 V, 3 A; 9 V, 3 A; and 3.3 V – 11 V PPS Outputs
Application	Mobile Phone Charger
Author	Applications Engineering Department
Document Number	DER-703
Date	June 28, 2019
Revision	1.1

Summary and Features

- InnoSwitch3-Pro - digitally controllable CV/CC QR flyback switcher IC with integrated high-voltage MOSFET, synchronous rectification and FluxLink feedback
  - I^2C Interface enables low pin count USB PD Controller (10 pin)
  - Sophisticated telemetry and comprehensive protection features
- USB PD 3.0 with using PPS. Highly optimized low pin count USB PD Controller WT6635P
- All the benefits of secondary-side control with the simplicity of primary-side regulation
  - Insensitive to transformer variation
- Meets DOE6 and CoC V5 2016 efficiency requirement (>1% efficiency margin)
- Micro stepping of voltages (20 mV) and CC thresholds (50 mA) in compliance with PPS protocol
- Output overvoltage and overcurrent protection
- Integrated thermal protection
- <25 mW no-load input power

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Important Note:
Although this board is designed to satisfy safety isolation requirements, the engineering prototype has not been agency approved. Therefore, all testing should be performed using an isolation transformer to provide the AC input to the prototype board.

1 Introduction

This document is an engineering report describing a 5 V / 3 A, 9 V / 3 A USB PD PPS power supply. This power supply uses InnoSwitch3-Pro INN3366C IC and Weltrend WT6635P USB PD controller. This design shows the high power density and efficiency that is possible due to the high level of integration of the InnoSwitch3-Pro controller providing exceptional performance.

This document contains the power supply specification, schematic, bill of materials, transformer documentation, printed circuit layout, and performance data

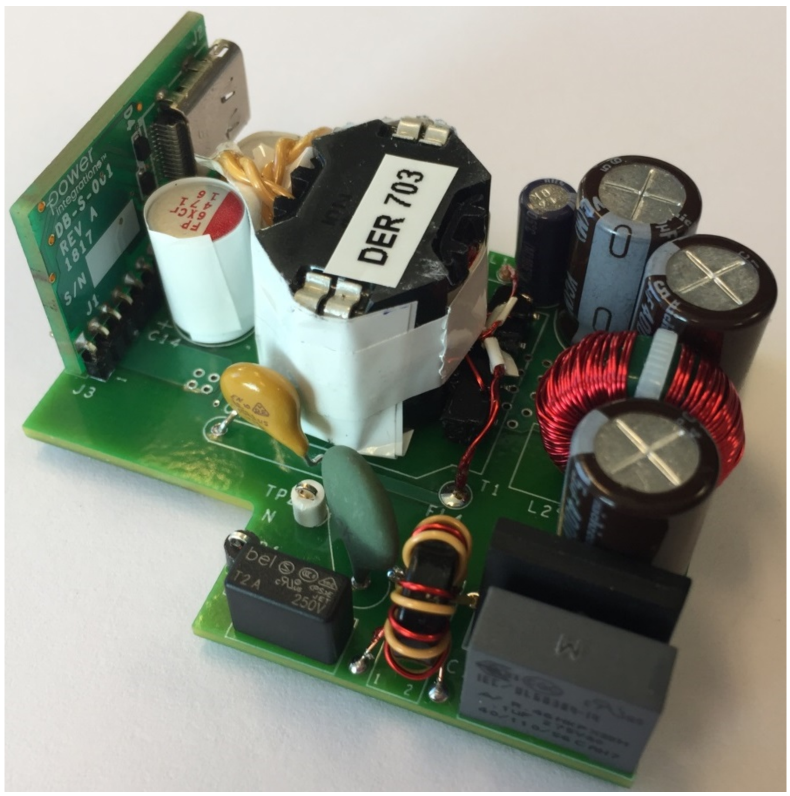

Figure 1 – Populated Circuit Board Photograph, Entire Assembly.

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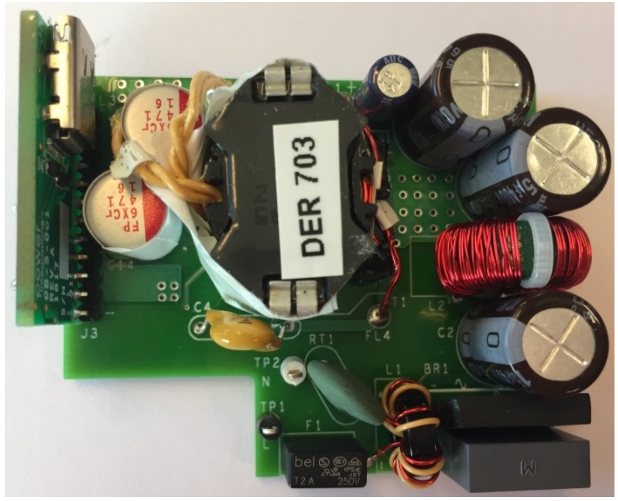

Figure 2 – Populated Circuit Board Photograph - Top.

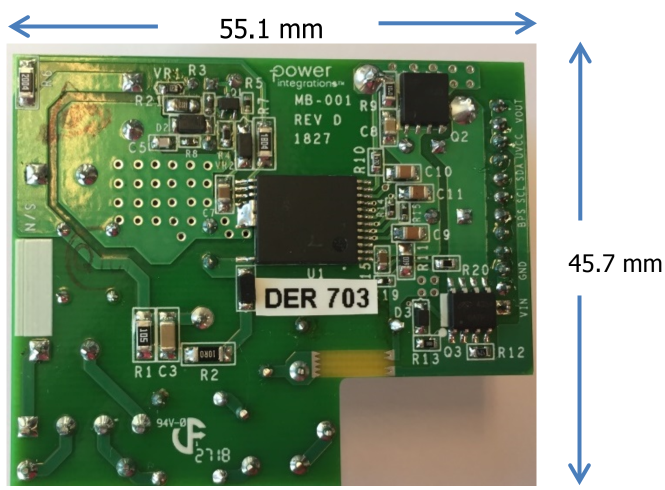

Figure 3 – Populated Circuit Board Photograph - Bottom.

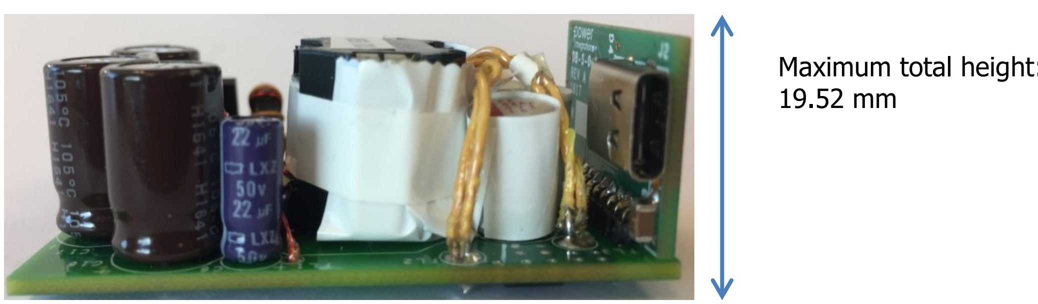

Figure 4 – Populated Circuit Board Photograph (Side View).

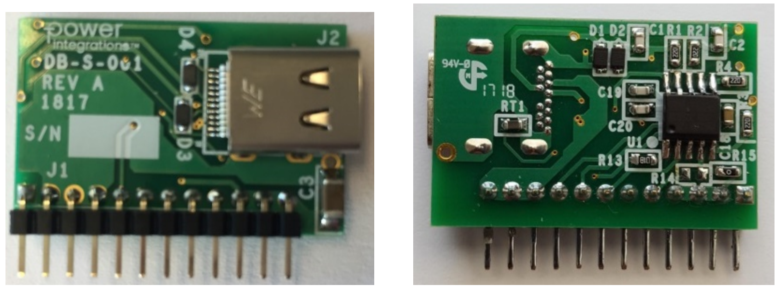

Figure 5 – Populated Circuit Board Photograph, Daughter Board. [Front and Rear].

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2 Power Supply Specification

The table below represents the minimum acceptable performance of the design. Actual performance is listed in the results section.

Description	Symbol	Min	Typ	Max	Units	Comment
Input						
Voltage	V_{IN}	85		265	VAC	2 Wire – no P.E.
Frequency	f_{LINE}	47	50/60	64	Hz	
No-load Input Power (85 VAC)			20	25	mW	Measured at 85 VAC.
Output						
Output Voltage	V_{OUT}		5.0		V	±3%
Output Ripple Voltage	V_{RIPPLE}			150	mV	At End of Cable. Cable Needs a Resistance of 100 mΩ.
Output Current	I_{OUT}	3.0			A	20 MHz Bandwidth.
Efficiency	η	87			%	
Continuous Output Power	P_{OUT}			15	W	
Output						
Output Voltage	V_{OUT}		9.0		V	±3%
Output Ripple Voltage	V_{RIPPLE}			150	mV	At End of Cable. Cable Needs a Resistance of 100 mΩ.
Output Current	I_{OUT}	3.0			A	20 MHz Bandwidth.
Efficiency	η	88.3			%	
Continuous Output Power	P_{OUT}			27	W	
Maximum Programmable Output Voltage	V_{OUT}	11			V	APDO Maximum Voltage .
Minimum Programmable Output Voltage	V_{OUT}	3.3			V	APDO Minimum Voltage.
PPS Voltage Step	V_{OUT}		20		mV	PPS Voltage Step (USB PD 3.0).
PPS Current Step	I_{OUT}		50		mA	PPS current Step (USB PD 3.0).
Conducted EMI		Meets CISPR22B / EN55022B				
Ambient Temperature	T_{AMB}	0		40	ºC	Free Convection, Sea Level.

Note: To use this design for a charger/adapter, circuit board would need to be modified depending on shape and form factor of the housing. ESD and Line surge performance should be evaluated and layout adjusted to meet the target specification.

3 Schematic [Part A - Mother Board]

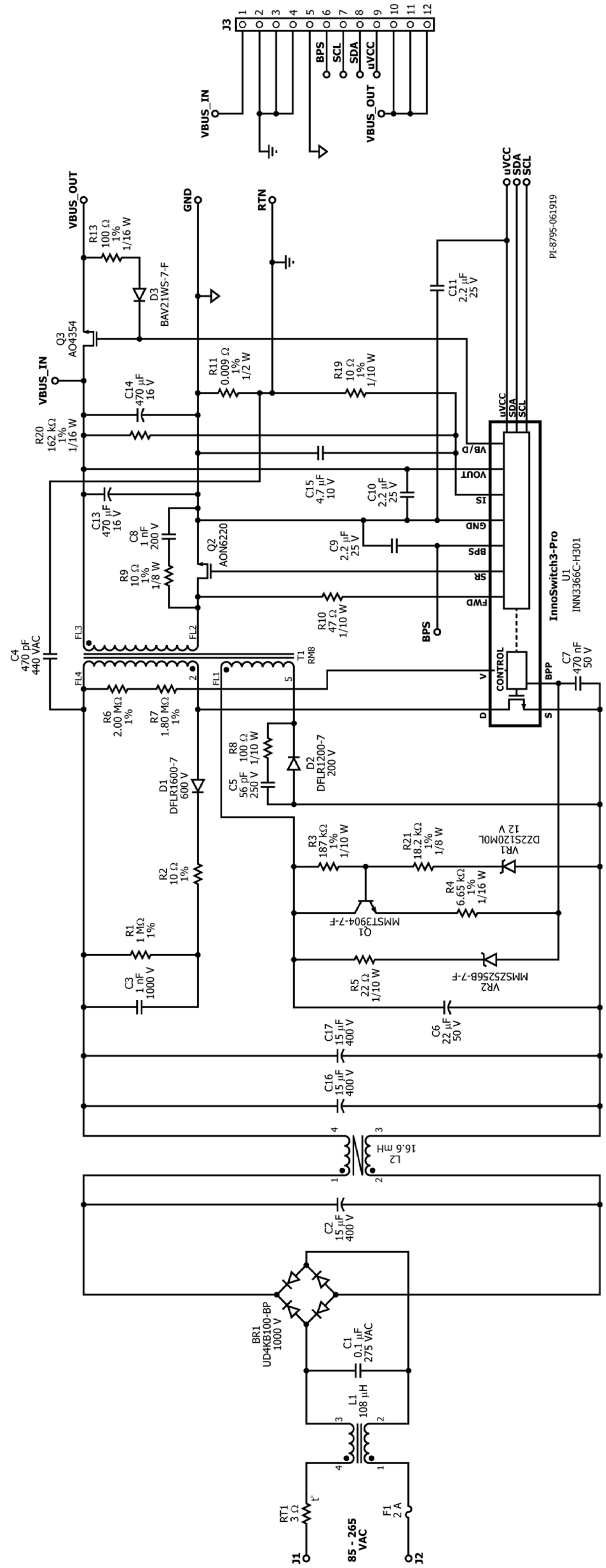

Figure 6 – Schematic of Mother Board.

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4 Schematic [Part B - Daughter Board]

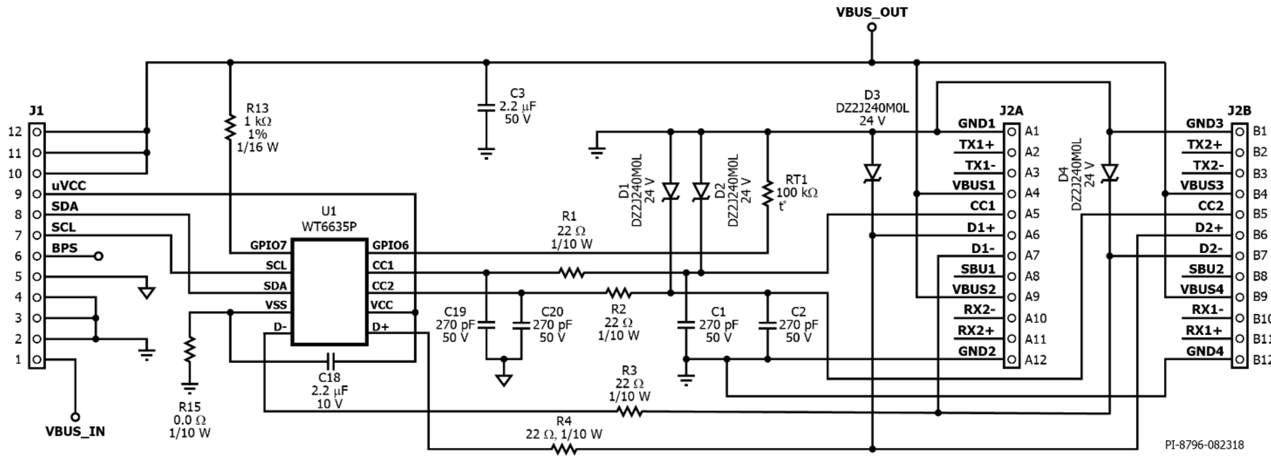

Figure 7 – Schematic of Daughter Board.

5 Circuit Description

5.1 *Mother Board Circuit Description*

5.1.1 Input Rectifier and Filter

Fuse F1 isolates the circuit and provides protection from component failure, and the common mode choke L1 with capacitor C1 provides attenuation for EMI. Bridge rectifier BR1 rectifies the AC line voltage and provides a full wave rectified DC across the filter consisting of C2, L2, and C16. The inductor L2 and capacitors C2, C16 and C17 form a pi-filter. This filter provides differential and common mode noise filtering. Thermistor RT1 limits the inrush current when the power supply is connected to the input AC supply. X-capacitor C1 provides differential mode noise filtering.

5.1.2 InnoSwitch3-Pro IC Primary

One end of the transformer primary is connected to the rectified DC bus; the other is connected to the drain terminal of the MOSFET inside the InnoSwitch3-Pro IC (U1). Resistors R6 and R7 provide input voltage sense protection for under-voltage and over-voltage conditions.

A low cost RCD clamp formed by diode D1, resistors R2, R1 and capacitor C3 limits the peak Drain voltage of U1 at the instant of turn off of the MOSFET. The clamp helps to dissipate the energy stored in the leakage reactance of transformer T1.

The IC is self-starting, using an internal high-voltage current source to charge the BPP pin capacitor (C7) when AC is first applied. During normal operation the primary side block is powered from an auxiliary winding on the transformer T1. Output of the auxiliary (or bias) winding is rectified using diode D2 and filtered using capacitor C6. Resistor R4 limits the current being supplied to the BPP pin of the InnoSwitch3-Pro IC (U1). A linear regulator comprising resistor R3, R21, BJT Q1 and Zener diode VR1 ensures sufficient current flows through R4 such that the internal current source of U1 is not required to charge C7 during normal operation. The RC network comprising of resistor R8 and capacitor C5 offers damping of the high frequency ringing in the voltage across diode D2 which reduces radiated EMI.

Zener diode VR2 offers primary sensed output overvoltage protection. In a flyback converter, output of the auxiliary winding tracks the output voltage of the converter. In case of over voltage at output of the converter, the auxiliary winding voltage increases and causes breakdown of VR2 which then causes excess current to flow into the BPP pin of InnoSwitch3-Pro IC U1. If the current flowing into the BPP pin increases above the I_{SD} threshold, the InnoSwitch3-Pro controller will latch off and prevent any further increase in output voltage. Resistor R5 limits the current injected to BPP pin.

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5.1.3 InnoSwitch3-Pro IC Secondary

The secondary-side of the InnoSwitch3-Pro IC provides output voltage, output current sensing and drive to a MOSFET providing synchronous rectification. The secondary of the transformer is rectified by MOSFET Q2 and filtered by capacitors C13 and C14. High frequency ringing during switching transients that would otherwise create radiated EMI is reduced via a RC snubber, R9 and C8.

The gate of Q2 is turned on by secondary-side controller inside IC U1, based on the secondary winding voltage sensed via resistor R10 and fed into the FWD pin of the IC.

In continuous conduction mode of operation, the MOSFET is turned off just prior to the secondary-side commanding a new switching cycle from the primary. In discontinuous mode of operation, the power MOSFET is turned off when the voltage drop across the MOSFET falls below a threshold of approximately $V_{SR(TH)}$. Secondary-side control of the primary-side power MOSFET avoids any possibility of cross conduction of the two MOSFETs and provides extremely reliable synchronous rectifier operation.

The secondary-side of the IC is self-powered from either the secondary winding forward voltage or the output voltage. Capacitor C9 connected to the BPS pin of InnoSwitch3-Pro IC U1 provides decoupling for the internal circuitry.

During CC operation, when the output voltage falls, the device will power itself from the secondary winding directly. During the on-time of the primary-side power MOSFET, the forward voltage that appears across the secondary winding is used to charge the SECONDARY BYPASS pin decoupling capacitor C9 via resistor R10 and an internal regulator. This allows output current regulation to be maintained down to the minimum UV threshold. Below this level the unit enters auto-restart until the output load is reduced. Capacitor C10 is needed between the VOUT pin and the SECONDARY GROUND pin for ESD protection of the VOUT pin.

Output current is sensed by monitoring the voltage drop across resistor R11 between the IS and SECONDARY GROUND pins. A threshold of approximately 32 mV reduces losses. A decoupling capacitor C14 is needed between the IS and SECONDARY GROUND pin to improve CC accuracy. Resistors R19 and R20 provide a positive slope to the CC characteristic. Once the internal current sense threshold is exceeded, the device regulates the number of switch pulses to maintain a fixed output current. When the output current is below the CC threshold, the device operates in constant voltage mode. The output voltage is set by the I^2C interface.

N-MOSFET Q3 forms the bus switch and is controlled by the VB/D pin on the InnoSwitch3-Pro IC. When the bus switch is opened, resistor R13 and diode D3 are needed from the source of the MOSFET to its gate for providing a voltage discharge path for capacitor C3 on the daughter board.

5.2 Daughter Board Circuit Description

5.2.1 USB Type-C and PD Interface

In this design, WT6635P (U1) is the USB Type-C and PD controller. Output of the InnoSwitch3-Pro IC powers the WT6635P device through the µVCC pin. USB PD protocol is communicated over either CC1 or CC2 line depending on the orientation in which Type-C plug is connected.

WT6635P IC communicates with InnoSwitch3-Pro IC through the I2C interface using the SCL and SDA pins through which it sets the CV, CC, V_{KP}, OVA and UVA parameters. The status of the InnoSwitch3-Pro IC is read by the WT6635P IC from the telemetry registers also using the I2C interface.

Capacitor C18 provides decoupling to VCC of the WT6635P IC. Capacitors C19, C20, C1, C2; resistors R1, R2, R3 and R4; TVS D1, D2, D3 and D4 provide protection from ESD to pins CC1, CC2, D1 and D2.

Thermistor (RT1) connected to pin GPIO6 of the WT6635P IC provides temperature detection functionality of the Type-C connector. Capacitor C3 is needed for radiated EMI. Resistor R13 is needed for discharging the capacitor C3 through GPIO7 after the Bus switch Q3 is opened. WT6635P uses the same GPIO7to sense the output voltage at the Type-C receptacle i.e. after the PassFET.

Resistor R15 connects the USB PD controller VSS to Type-C connector J2 GND in order to ensure CC-pin signal fidelity required for satisfactory eye diagram compliance.

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6 PCB Layout

PCB copper thickness is 0.062 inches.

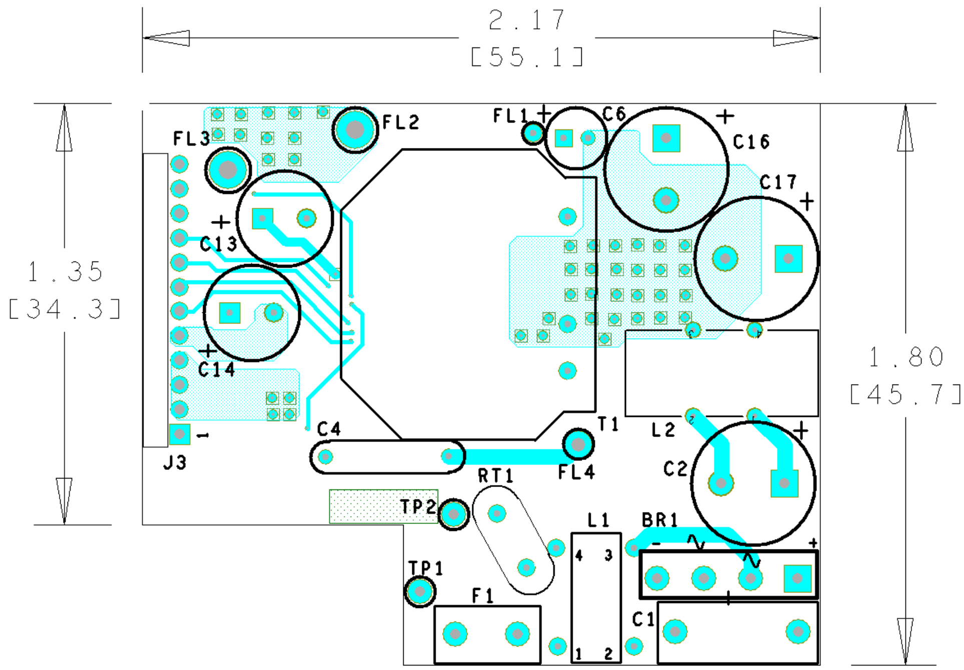

Figure 8 – Printed Circuit Layout, Mother Board, Top.

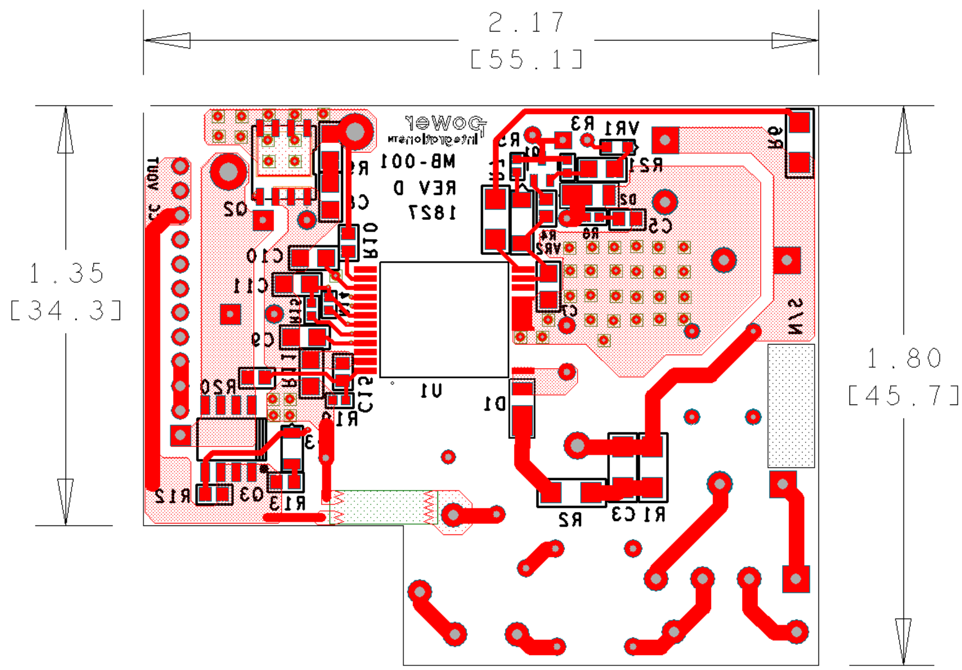

Figure 9 – Printed Circuit Layout, Mother Board, Bottom.

Note:
Component references R12, R14, R15, J3 although present in the layout; they are not to be populated when used with a daughter board.

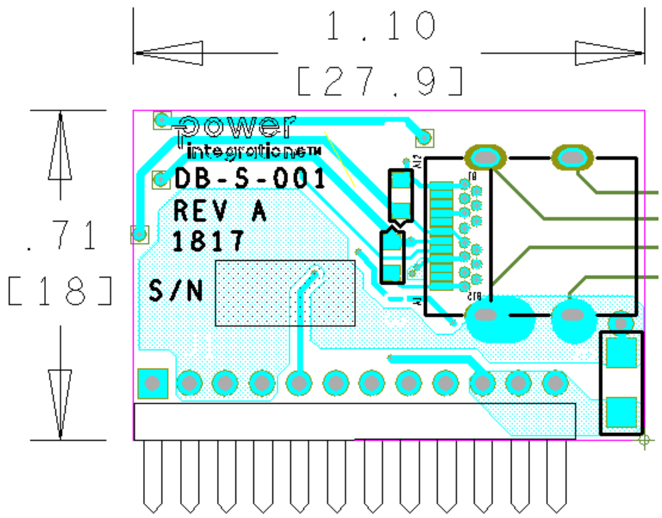

Figure 10 – Printed Circuit Layout, Daughter board, Top.

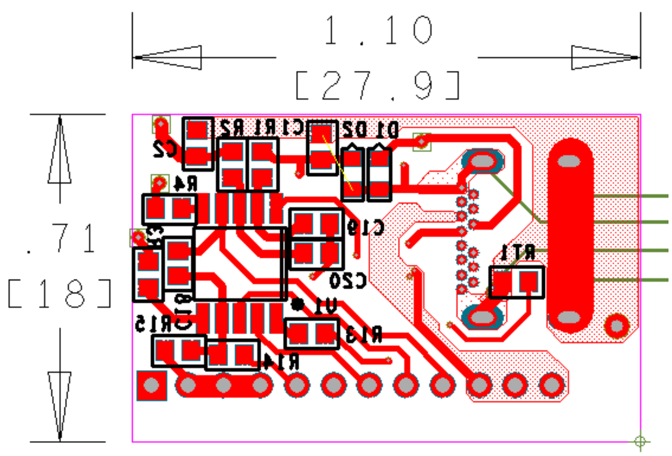

Figure 11 – Printed Circuit Layout, Daughter Board, Bottom.

Note:

Component reference R14 although present in the layout, is not to be populated.

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7 Bill of Materials

7.1 Mother Board

Item	Qty	Ref Des	Description	Mfg Part Number	Mfg
1	1	BR1	Bridge Rectifier, 1000 V, 4 A, 4-ESIP, D3K, -55°C ~ 150°C (TJ), Vf = 1 V @ 7.5 A	UD4KB100-BP	Micro Commercial
2	1	C1	0.1 μF, 20% , 275 VAC, 560 VDC, X2, -40°C ~ 110°C, 5 mm W x 13 mm L x 11.1 mm H	R46KF310000P1M	KEMET
3	3	C2 C16 C17	15 μF, 400 V, Electrolytic, (10 x 16)	UVC2G150MPD	Nichicon
4	1	C3	1 nF, 1000 V, Ceramic, X7R, 1206	CC1206KKX7RCBB102	Yageo
5	1	C4	470 pF, ±10%, 440VAC, (X1, Y2) rated, Ceramic Capacitor, Y5S, Radial, Disc, -40°C ~ 125°C	VY2471K29Y5SS63V7	Vishay
6	1	C5	56 pF, 250 V, Ceramic, NP0, 0603	GQM1875C2E560JB12D	Murata
7	1	C6	22 μF, 50 V, Electrolytic, (5 x 11)	UPW1H220MDD	Nichicon
8	1	C7	470 nF, 50 V, Ceramic, X7R, 0805	GRM21BR71H474KA88L	Murata
9	1	C8	1 nF, 200 V, Ceramic, X7R, 0805	08052C102KAT2A	AVX
10	3	C9 C10 C11	2.2 μF, 25 V, Ceramic, X7R, 0805	C2012X7R1E225M	TDK
11	2	C13 C14	470 μF, 16 V,Al Organic Polymer, 12 mOhm, (8 x 11.5)	RNE1C471MDN1	Nichicon
12	1	C15	4.7 μF, 10 V, Ceramic, X5R, 0603	C1608X5R1A475M/0.50	TDK
13	1	D1	600 V, 1 A, Rectifier, Glass Passivated, POWERDI123	DFLR1600-7	Diodes, Inc.
14	1	D2	200 V, 1 A, Rectifier, Glass Passivated, POWERDI123	DFLR1200-7	Diodes, Inc.
15	1	D3	250 V, 0.2 A, Fast Switching, 50 ns, SOD-323	BAV21WS-7-F	Diodes, Inc.
16	1	F1	2 A, 250 V, Slow, Long Time Lag, RST	RST 2	Belfuse
17	1	L1	Toroidal Common Mode Choke, 108 μH, ±20%, primary leakage inductance = 0.5 μH, constructed on Core 35T0375-10H from PI# 30-00275-00	32-00369-00	Power Integrations
18	1	L2	Toroidal Common Mode Choke, 16.6 mH, ±25%, Core Effective Inductance = 5500 nH//N2, leakage inductance =80 μH +/-10%, custom, DER-xxx, wound on 32-00286-00 core (14.90 mm O.D. 6.5 mm Th 7.0 mm ID)	32-00368-00	Power Integrations
19	1	Q1	NPN, Small Signal BJT, 40 V, 0.2 A, SOT-323	MMST3904-7-F	Diodes, Inc.
20	1	Q2	MOSFET, N-CH, 100V, 48A (Tc), 113.5 W (Tc), DFN5X6, 8-DFN (5x6)	AON6220	Alpha & Omega Semi.
21	1	Q3	MOSFET, N-CH, 30 V, 23 A (Ta), 3.1 W (Ta), 3.7 mΩ (@ 20 A, 10 V), 8SOIC	AO4354	Alpha & Omega Semi.
22	1	R1	RES, 1 MΩ, 5%, 1/4 W, Thick Film, 1206	ERJ-8GEYJ105V	Panasonic
23	1	R2	RES, 10 Ω, 1%, 1/4 W, Thick Film, 1206	ERJ-8ENF10R0V	Panasonic
24	1	R3	RES, 187.0 kΩ, 1%, 1/10 W, Thick Film, 0402	ERJ-2RKF1873X	Panasonic
25	1	R4	RES, 6.65 kΩ, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF6651V	Panasonic
26	1	R5	RES, 22 Ω, 5%, 1/10 W, Thick Film, 0402	ERJ-2GEJ220X	Panasonic
27	1	R6	RES, 2.00 MΩ, 1%, 1/4 W, Thick Film, 1206	ERJ-8ENF2004V	Panasonic
28	1	R7	RES, 1.80 MΩ, 1%, 1/4 W, Thick Film, 1206	ERJ-8ENF1804V	Panasonic
29	1	R8	RES, 100 Ω, 5%, 1/10 W, Thick Film, 0402	ERJ-2GEJ101X	Panasonic
30	1	R9	RES, 10 Ω, 1%, 1/8 W, Thick Film, 0805	ERJ-6ENF10R0V	Panasonic
31	1	R10	RES, 47 Ω, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ470V	Panasonic
32	1	R11	RES, 0.009 Ω, 0.5 W, 1%, 0805	CRF0805-FZ-R009ELF	Bourns
33	1	R13	RES, 100 Ω, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF1000V	Panasonic

34	1	R19	RES, 10 Ω, 1%, 1/10 W, Thick Film, 0402	ERJ-2RKF10R0X	Panasonic
35	1	R20	RES, 162 kΩ, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF1623V	Panasonic
36	1	R21	RES, 18.2 kΩ, 1%, 1/8 W, Thick Film, 0805	ERJ-6ENF1822V	Panasonic
37	1	RT1	NTC Thermistor, 3 Ω, 5 A	SCK10035LSY	Thinking Electronics
38	1	T1	Bobbin, RM8, Vertical, 12 pins	P-803	Pin Shine
39	1	TP1	Test Point, BLK, Mini THRU-HOLE MOUNT	5001	Keystone
40	1	TP2	Test Point, WHT, Mini THRU-HOLE MOUNT	5002	Keystone
41	1	U1	InnoSwitch3-Pro, InSOP24D	INN3366C-H301	Power Integrations
42	1	VR1	12 V, 5%, 150 mW, SSMINI-2	DZ2S120M0L	Panasonic
43	1	VR2	DIODE ZENER 30 V 500 mW SOD123	MMSZ5256B-7-F	Diodes, Inc.

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7.2 Daughter Board

Item	Qty	Ref Des	Description	Mfg Part Number	Mfg
1	4	C1 C2 C19 C20	CAP, CER, 270 pF, ±5%, 50 V, Low ESL,C0G/NP0, 0603	C0603C271J5GACTU	Kemet
2	1	C3	2.2 μF, 50 V, Ceramic, Y5V, 1206	UMK316F225ZG-T	Taiyo Yuden
3	1	C18	2.2 μF, 10 V, Ceramic, X5R, 0603	GRM188R61A225KE34D	Murata
4	4	D1 D2 D3 D4	DIODE, ZENER, 24 V, 200 mW, SMINI2	DZ2J240M0L	Panasonic
5	1	J1	15 Position (1 x 15) header, 2 mm pitch, Right Angle	NRPN151PARN-RC	Sullins Connector
6	1	J2	Connector, "Certified", USB - C, USB 3.1, For 0.062" PCB Material!,Superspeed+, Receptacle Connector, 24 Position, Surface Mount, Right Angle, Through Hole	632723300011	Wurth
7	4	R1 R2 R3 R4	RES, 22 Ω, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ220V	Panasonic
8	1	R13	RES, 1 kΩ, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF1001V	Panasonic
9	1	R15	RES, 0 Ω, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEY0R00V	Panasonic
10	1	RT1	NTC Thermistor, 100 kΩ, 3%, 0603	NCP18WF104E03RB	Murata
11	1	U1	USB Power Delivery Controller. 10-pin SOP	WT6635P-SG10A	Weltrend Semiconductor

8 Transformer Specification

8.1 *Electrical Diagram*

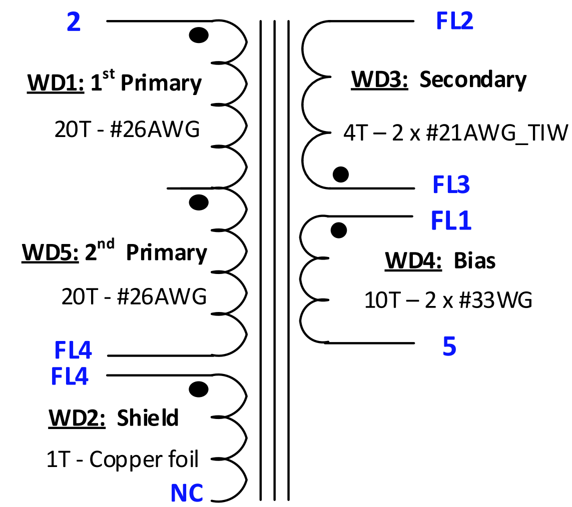

Figure 12 – Transformer Electrical Diagram.

8.2 *Electrical Specifications*

Electrical Strength	60 seconds, 60 Hz, from pins 2, 5, FL1, FL4 to FL2 - FL3.	3000 VAC
Primary Inductance	Pins 2 - FL4 , all other windings open, measured at 100 kHz, 0.4 V_{RMS}.	570 μH, ±7%
Resonant Frequency	Pins 2 - FL4, all other windings open	2000 kHz (Min.)
Primary Leakage Inductance	Pins 2 - FL4, with FL2 - FL3 shorted, measured at 100 kHz, 0.4 V_{RMS}.	5.5 μH (Max.)

8.3 *Material List*

Item	Description
[1]	Core: TDK PC95- RM8.
[2]	Bobbin: RM8-V-12(6/6), in-line, PI#: 25-00041-00; or Equivalent. See Figure 14 to Modify the Bobbin.
[3]	Clip: RM8, Allstar Magnetic, CLI/P-RM8/I.
[4]	Magnet Wire: #26 AWG, Solderable Double Coated.
[5]	Magnet Wire: #33 AWG, Solderable Double Coated.
[6]	Magnet Wire: #21 AWG, Triple Insulated Wire.
[7]	Tape: Polyester Film, 3M, 1 mil Thick, 9.0 mm Wide.
[8]	Tape: Polyester Film, 3M, 1 mil Thick, 27.5 mm x 54.0 mm
[9]	Copper Foil: Copper Tape; 8.6 mm width x 38.0 mm Length x 1 mil Thick, Soldered with Magnetic Wire #32 AWG at 1 End.
[10]	Varnish: Dolph BC 359

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8.4 Transformer Build Diagram

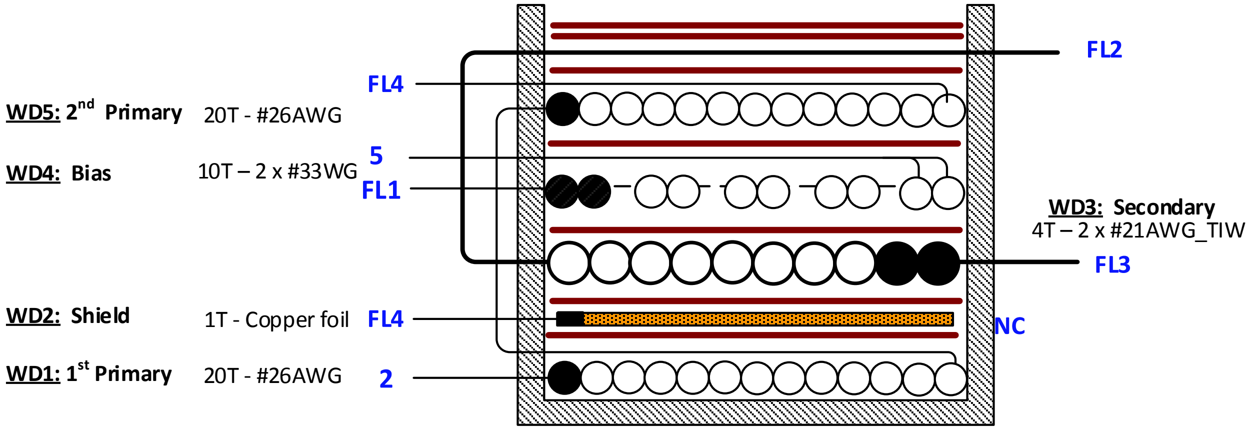

Figure 13 – Transformer Build Diagram.

8.5 Transformer Construction

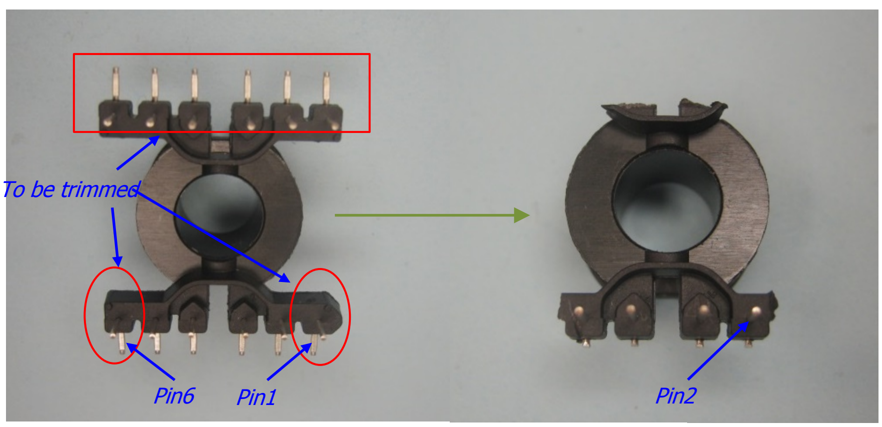

Figure 14 – Modify the Bobbin.

Winding Preparation	Trim secondary flange of bobbin Item [2] to match top flange. Trim off the portions at pin 1 and pin 6 of primary flange. Cut off all side pins on primary flange, (see figure 14). Position this bobbin on the mandrel such that the primary side of the bobbin is on the left side. Winding direction is clock-wise direction for forward direction.
WD1 1st Primary	Start at pin 2, wind 20 turns of wire Item [4] in 1 layer, with tight tension, from left to right. At the last turn bring the wire back to the left and leave 3ft of wire for 2nd primary winding – WD5.
Insulation	1 layer of tape Item [7].
WD2 Shield	Use copper Item [9], start as FL4 with the wire which is soldered to the copper foil, wind 1 turn overlapped but not shorted.
Insulation	1 layer of tape Item [7].

WD3 Secondary	Use 2 wires Item [6], leave ~30mm floating, and mark as FL3. Start at the slot on the right of the bobbin, wind 4 turns with tight tension in 1 layer. At the last turn, exit the wires at the slot on the left of bobbin and leave ~ 40mm as FL2.
Insulation	1 layer of tape Item [7].
WD4 Bias	Use 2 wires Item [5], leave ~ 20mm marked as FL1, wind 10 turns in 1 layer, from right to left, spread the wires evenly across the bobbin. At the last turn bring the wires back to the right and finish at pin 5.
Insulation	1 layer of tape Item [7].
WD5 2nd Primary	Use wire floating from WD1-1st Primary; continue winding 20 turns from left to right. At the last turn, bring the wire back to left, leave ~20mm floating, and mark as FL4.
Finish	Apply 1 layer of tape Item [7], bring wires floating FL2 from WD3-Secondary to the right and continue to apply 2 layers tape to secure all windings. Gap core halves to get 570 uH, secure with clips Item [3] with GND pins on top and cut short. Varnish with Item [10]. Place 2 layers of tape Item [8] at the bottom of transformer then wrap up to body of transformer, and wrap around transformer with 1 turn of tape Item [7], (see illustration below)

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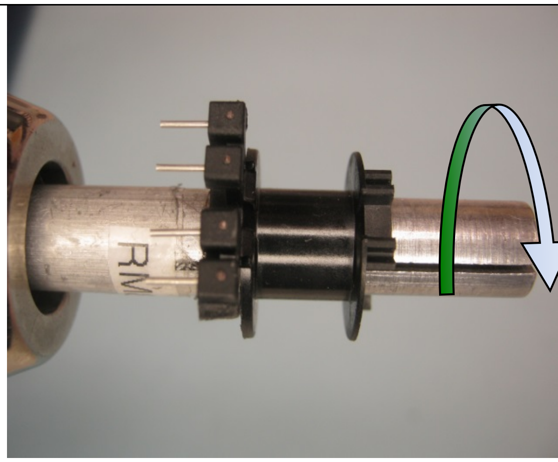
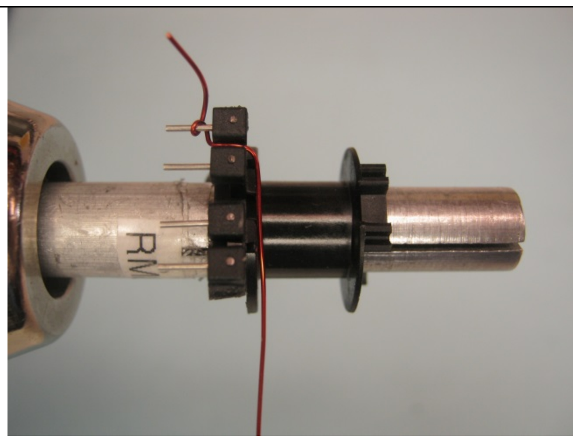
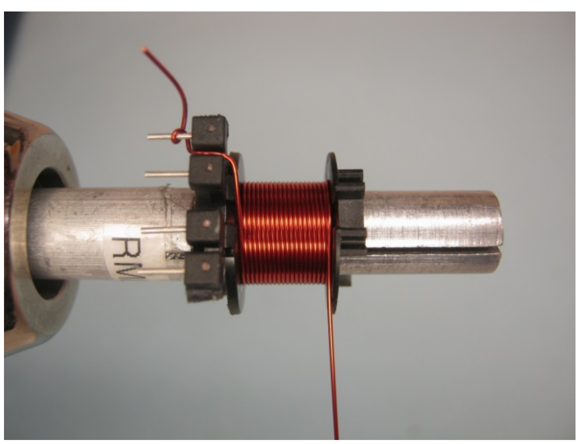
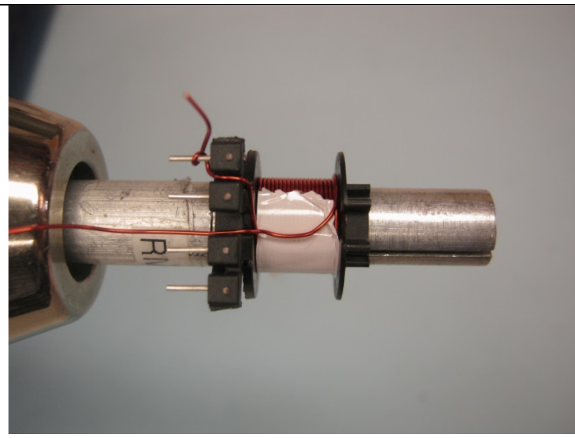
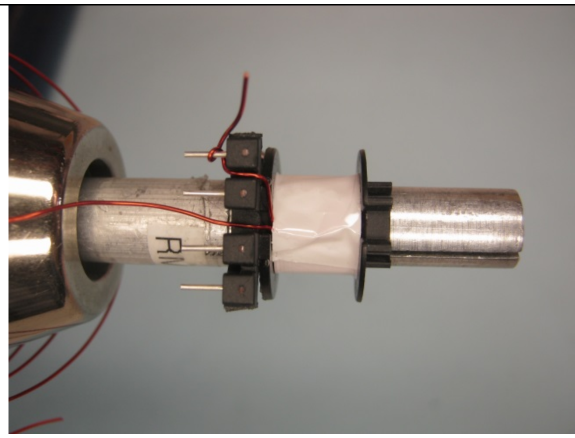
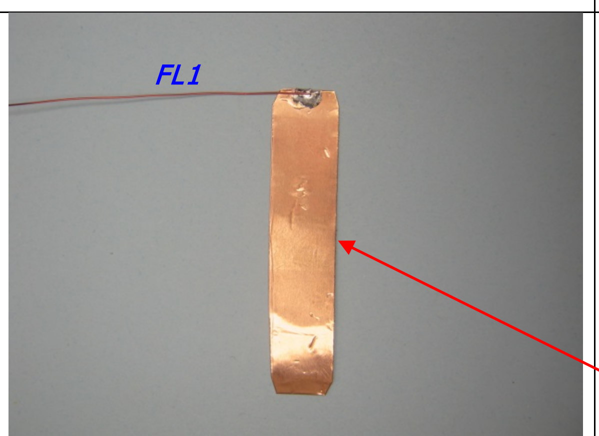
8.6 Winding Illustrations

Winding Preparation		Trim round secondary flange of bobbin Item [2] to match top flange. Trim off the portions at pin 1 and pin 6 of primary flange. Cut off all side pins on primary flange, (see figure 14). Position this bobbin on the mandrel such that the primary side of the bobbin is on the left side. Winding direction is clock-wise direction for forward direction.
WD1 **1st Primary**	 	Start at pin 2, wind 20 turns of wire Item [4] in 1 layer, with tight tension, from left to right. At the last turn bring the wire back to the left and leave 3ft of wire for 2nd primary winding – WD5.

		
Insulation		1 layer of tape Item [7].
WD2 **Shield**		Prepare copper foil Item [9], start as FL4 with the wire which is soldered to the copper foil, wind 1 turn overlapped but not shorted.

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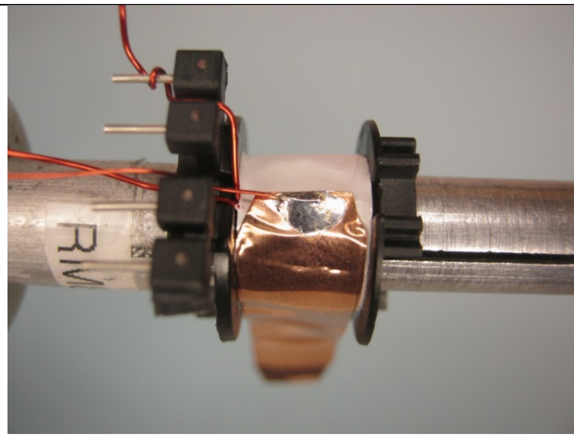
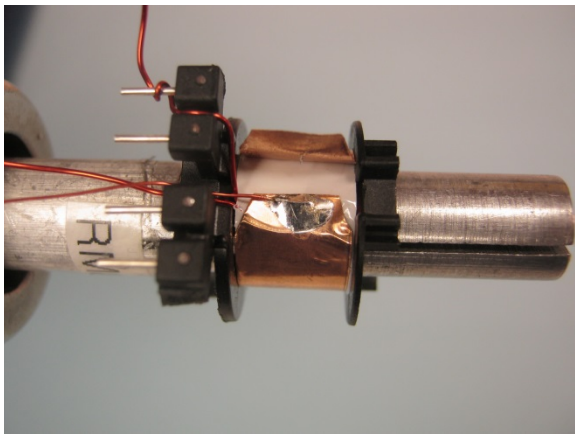
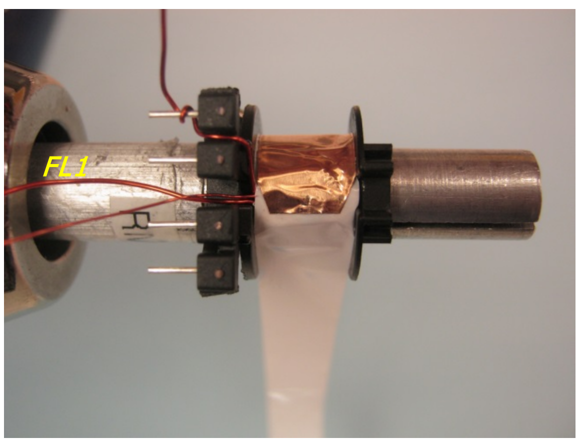
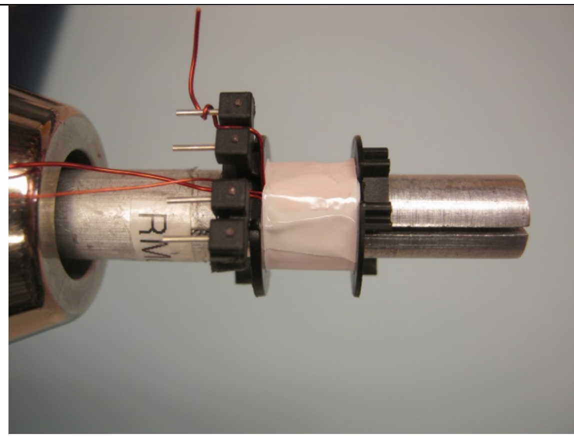
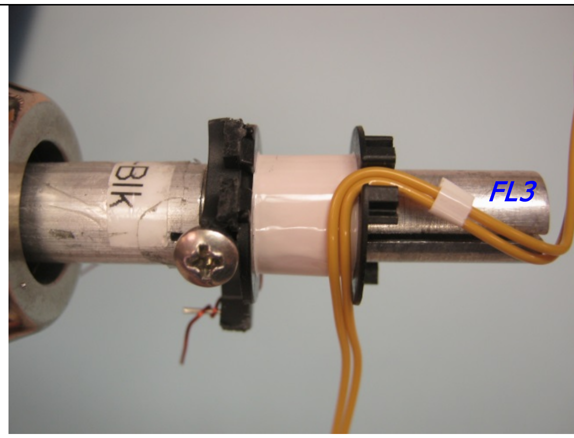
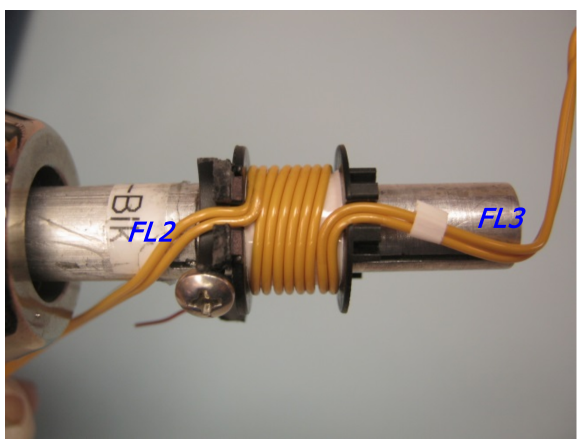





FL1

Insulation		1 layer of tape Item [7].
WD3 **Secondary**	 	Use 2 wires Item [6], leave ~30 mm floating, and marked as FL3. Start at the slot on the right of the bobbin, wind 4 turns with tight tension in 1 layer. At the last turn, exit the wires at the slot on the left of bobbin and leave ~ 40 mm as FL2.

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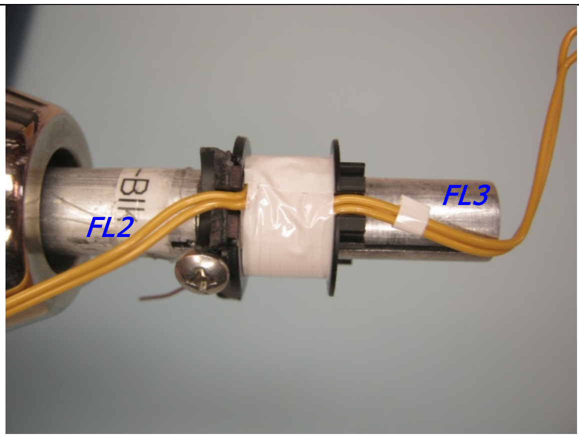
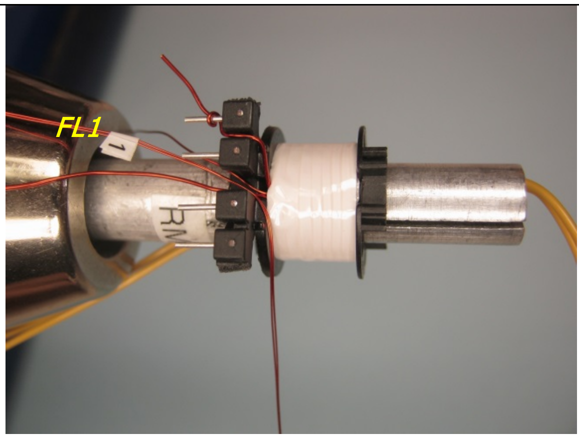
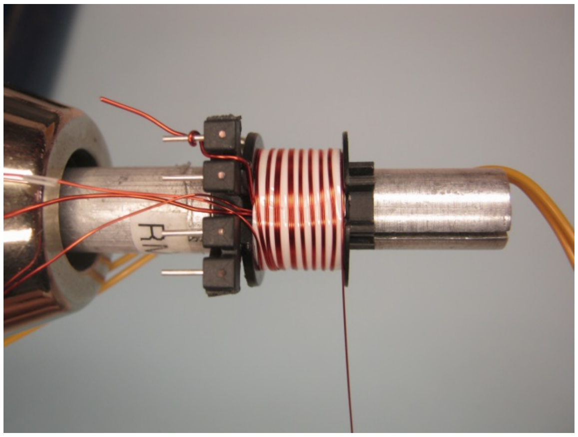
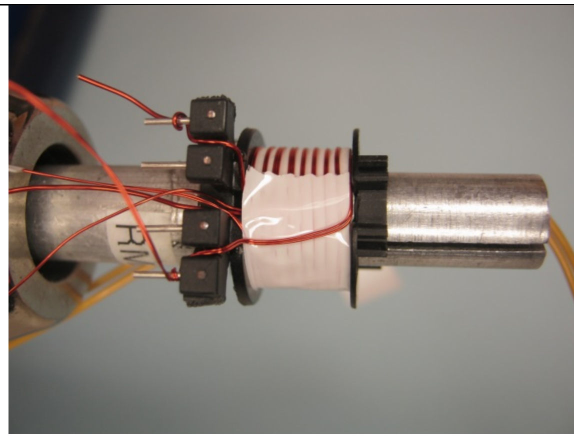
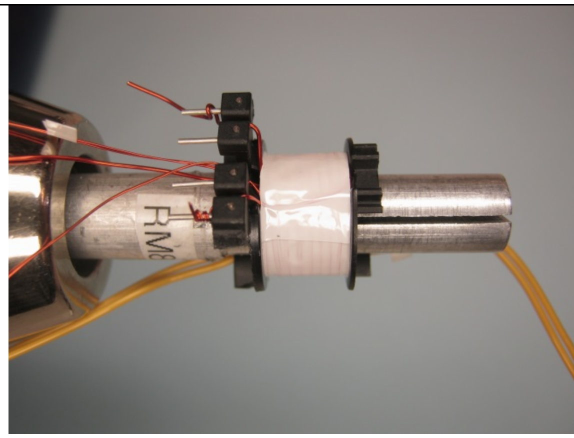
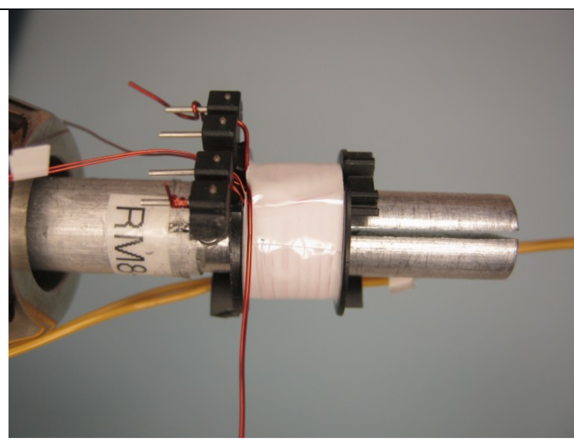
Insulation		1 layer of tape Item [7].
WD4 **Bias**	 	Use 2 wires Item [5], leave ~ 20 mm marked as FL1, wind 10 turns in 1 layer, from right to left, spread the wires evenly across the bobbin. At the last turn bring the wires back to the right and finish at pin 5.

		
Insulation		1 layer of tape Item [7].
WD5 **2nd Primary**		Use wire floating from WD1- 1st Primary; continue winding 20 turns from left to right. At the last turn, bring the wire back to left, leave ~20 mm floating, and mark as FL4.

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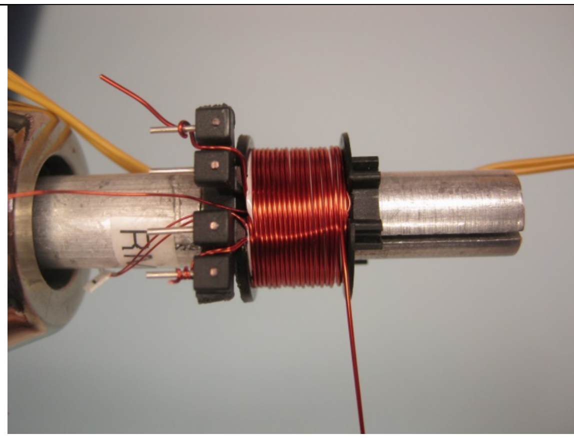
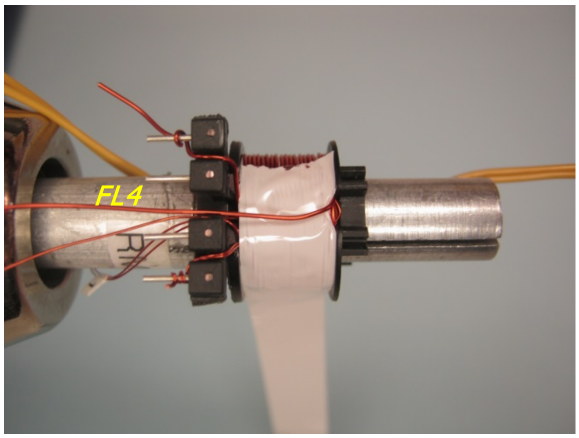
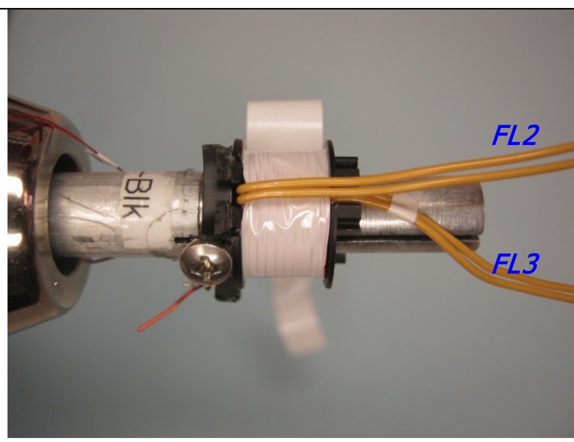
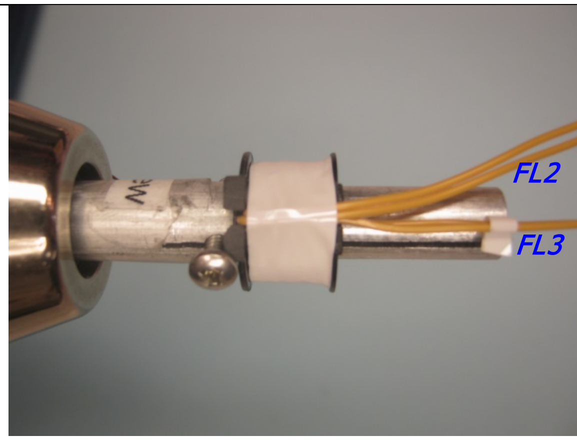
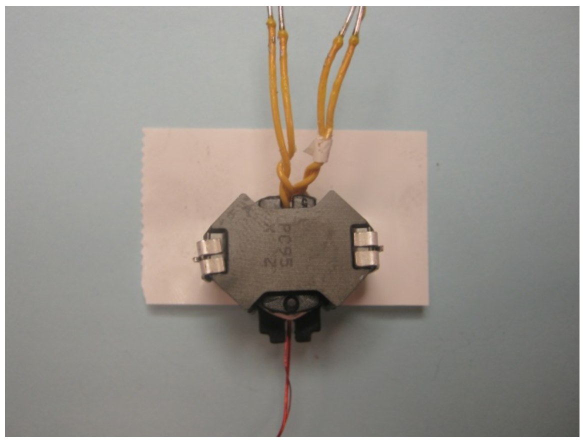
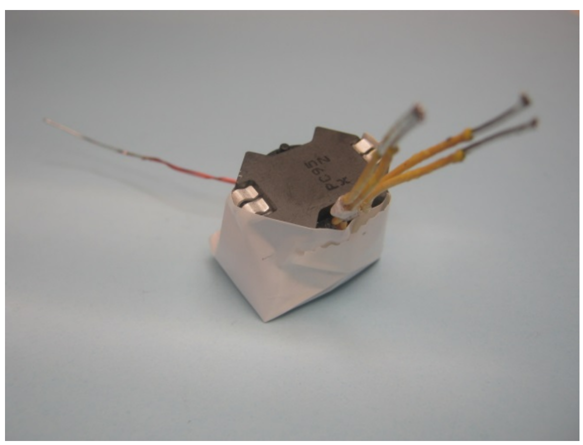
<table>
<tr><td></td><td>

</td><td></td></tr>
<tr><td>Finish</td><td>
</td><td>Apply 1 layer of tape Item [7], bring wires floating FL2 from WD3-Secondary to the right and continue to apply 2 layers tape to secure all windings.

Gap core halves to 570 μH, secure with clips Item [3] with GND pins on top and cut short.

Varnish with Item [10].

Place 2 layers of tape Item [8] at the bottom of transformer then wrap up to body of transformer, and wrap around transformer with 1 turn of tape Item [7], (see illustration below)</td></tr>
</table>

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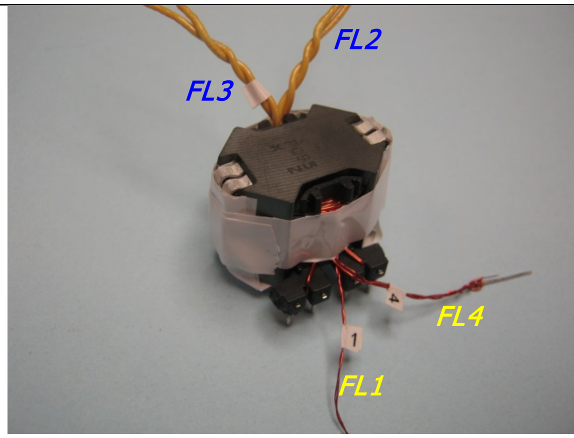
FL2
FL3
FL4
FL1

9 Common Mode Choke Specifications

9.1 16.6 mH Common Mode Choke (L2)

9.1.1 Electrical Diagram

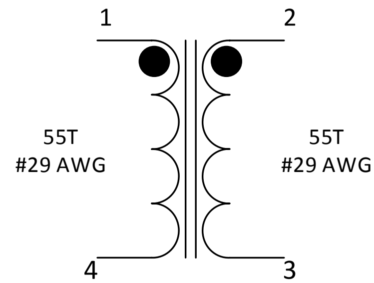

Figure 15 – Inductor Electrical Diagram.

9.1.2 Electrical Specifications

Inductance	Pins 1 - 4 and pins 2 - 3 measured at 100 kHz, 0.4 RMS.	16.6 mH ±25%
Core effective Inductance		5500 nH//N2
Leakage Inductance	Pins 1 - 4, with 2 - 3 shorted.	80 μH ±10%

9.1.3 Material List

Item	Description
[1]	Toroid: FERRITE INDUCTR TOROID T14 x 8 x 5.5, PI#: 32-00286-00.
[2]	Divider: Cable Tie, Panduit - Fish Paper, Insulating Cotton Rag, 0.010” Thick, PI#: 66-00042-00.
[3]	Magnet Wire: #29 AWG Heavy Nyleze.
[4]	Epoxy: Devon, 5mins Epoxy; or Equivalent.

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9.1.4 Illustrations

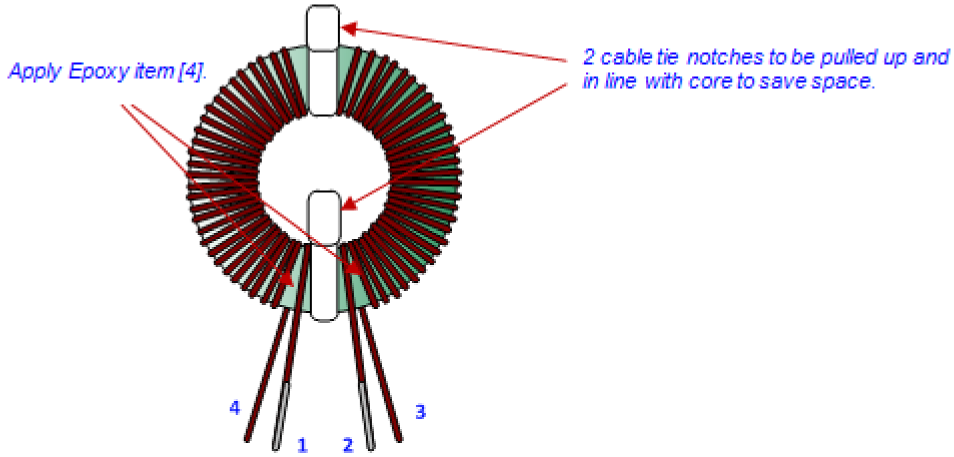

Figure 16 – 16.6 mH CMC Illustration Image.

9.1.5 Winding Instructions

- Place 2 pieces of cable tie Item [2] on to toroid Item [1] to divide 2 equal sections.
- Use 4 ft of wire Item [3], start as 1, wind 55 turns in 2 layers in 1 section of toroid, and end as 4.
- Do the same for another half of Toroid, start as 2 and end as 3.
- Pull up 2 notches of cable ties to be in line with toroid body (to save space), and apply Epoxy Item [4] where leads floating.

9.2 108 µH Common Mode Choke (L1)

9.2.1 Electrical Diagram

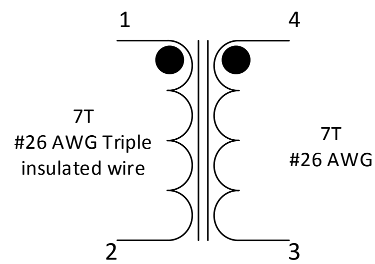

Figure 17 – Inductor Electrical Diagram.

9.2.2 Electrical Specifications:

Inductance	Pins 1-2 measured at 100kHz, 0.4 RMS.	108 µH ±20%
Primary Leakage Inductance	Pins 1-2, with 3-4 shorted.	0.5 µH

9.2.3 Materials:

Item	Description
[1]	Toroid: FERRITE INDUCTR TOROID 0.415" OD; Mfg Part number: 35T0375-10H Dim; 9.53 mm; O.D. x 4.75 mm I.D. x 3.18 mm L.
[2]	Magnet Wire: #26 AWG.
[3]	Triple Insulated Wire #26 AWG.

9.2.4 Illustrations

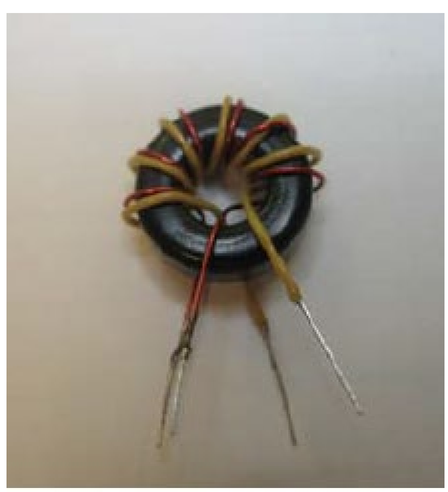

Figure 18 – 108 µH CMC Illustration Image.

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10 Transformer Design Spreadsheet

1	ACDC_InnoSwitch3-Pro_Flyback_042018; Rev.1.0; Copyright Power Integrations 2018	INPUT	INFO	OUTPUT	UNITS	InnoSwitch3-Pro Flyback Design Spreadsheet
2	**APPLICATION VARIABLES**					
3	VAC_MIN	85		85	V	Minimum AC line voltage
4	VAC_MAX			265	V	Maximum AC input voltage
5	VAC_RANGE			UNIVERSAL		AC line voltage range
6	FLINE			60	Hz	AC line voltage frequency
7	CAP_INPUT	45.0		45.0	uF	Input capacitance
9	**SETPOINT 1**					
10	VOUT1	11.00		11.00	V	Output voltage 1, should be the highest output voltage required
11	IOUT1	2.450		2.450	A	Output current 1
12	POUT1			26.95	W	Output power 1
13	EFFICIENCY1	0.89		0.89		Converter efficiency for output 1
14	Z_FACTOR1	0.50		0.50		Z-factor for output 1
16	**SETPOINT 2**					
17	VOUT2	9.00		9.00	V	Output voltage 2
18	IOUT2	3.000		3.000	A	Output current 2
19	POUT2			27.00	W	Output power 2
20	EFFICIENCY2	0.89		0.89		Converter efficiency for output 2
21	Z_FACTOR2	0.50		0.50		Z-factor for output 2
23	**SETPOINT 3**					
24	VOUT3	5.00		5.00	V	Output voltage 3
25	IOUT3	3.000		3.000	A	Output current 3
26	POUT3			15.00	W	Output power 3
27	EFFICIENCY3	0.89		0.89		Converter efficiency for output 3
28	Z_FACTOR3	0.50		0.50		Z-factor for output 3
30	**SETPOINT 4**					
31	VOUT4	3.00		3.00	V	Output voltage 4
32	IOUT4	3.000		3.000	A	Output current 4
33	POUT4			9.00	W	Output power 4
34	EFFICIENCY4	0.85		0.85		Converter efficiency for output 4
35	Z_FACTOR4	0.50		0.50		Z-factor for output 4
37	**SETPOINT 5**					
38	VOUT5			0.00	V	Output voltage 5
39	IOUT5			0.000	A	Output current 5
40	POUT5			0.00	W	Output power 5
41	EFFICIENCY5			0.00		Converter efficiency for output 5
42	Z_FACTOR5			0.00		Z-factor for output 5
44	**SETPOINT 6**					
45	VOUT6			0.00	V	Output voltage 6
46	IOUT6			0.000	A	Output current 6
47	POUT6			0.00	W	Output power 6
48	EFFICIENCY6			0.00		Converter efficiency for output 6
49	Z_FACTOR6			0.00		Z-factor for output 6
51	**SETPOINT 7**					
52	VOUT7			0.00	V	Output voltage 7
53	IOUT7			0.000	A	Output current 7
54	POUT7			0.00	W	Output power 7
55	EFFICIENCY7			0.00		Converter efficiency for output 7
56	Z_FACTOR7			0.00		Z-factor for output 7

58	**SETPOINT 8**					
59	VOUT8			0.00	V	Output voltage 8
60	IOUT8			0.000	A	Output current 8
61	POUT8			0.00	W	Output power 8
62	EFFICIENCY8			0.00		Converter efficiency for output 8
63	Z_FACTOR8			0.00		Z-factor for output 8
65	**SETPOINT 9**					
66	VOUT9			0.00	V	Output voltage 9
67	IOUT9			0.000	A	Output current 9
68	POUT9			0.00	W	Output power 9
69	EFFICIENCY9			0.00		Converter efficiency for output 9
70	Z_FACTOR9			0.00		Z-factor for output 9
72	VOLTAGE_CDC	0.000		0.000	V	Cable drop compensation desired at full current
76	**PRIMARY CONTROLLER SELECTION**					
77	ENCLOSURE	ADAPTER		ADAPTER		Power supply enclosure
78	ILIMIT_MODE	STANDARD		STANDAR D		Device current limit mode
79	VDRAIN_BREAKDOWN	650		650	V	Device breakdown voltage
80	DEVICE_GENERIC	INN33X6		INN33X6		Device selection
81	DEVICE_CODE			INN3366C		Device code
82	PDEVICE_MAX			27	W	Device maximum power capability
83	RDSON_25DEG			1.50	Ω	Primary MOSFET on-time resistance at 25°C
84	RDSON_100DEG			2.32	Ω	Primary MOSFET on-time resistance at 100°C
85	ILIMIT_MIN			1.162	A	Primary MOSFET minimum current limit
86	ILIMIT_TYP			1.250	A	Primary MOSFET typical current limit
87	ILIMIT_MAX			1.338	A	Primary MOSFET maximum current limit
88	VDRAIN_ON_MOSFET			0.85	V	Primary MOSFET on-time voltage drop
89	VDRAIN_OFF_MOSFET			553.31	V	Peak drain voltage on the primary MOSFET during turn-off
93	**WORST CASE ELECTRICAL PARAMETERS**					
94	FSWITCHING_MAX	85736		85736	Hz	Maximum switching frequency at full load and the valley of the minimum input AC voltage
95	VOR	110.0		110.0	V	Voltage reflected to the primary winding (corresponding to setpoint 1) when the primary MOSFET turns off
96	VMIN			79.20	V	Valley of the rectified minimum input AC voltage at full load
97	KP			0.789		Measure of continuous/discontinuous mode of operation
98	MODE_OPERATION			CCM		Mode of operation
99	DUTYCYCLE			0.584		Primary MOSFET duty cycle
100	TIME_ON			9.76	us	Primary MOSFET on-time
101	TIME_OFF			4.98	us	Primary MOSFET off-time
102	LPRIMARY_MIN			531.4	uH	Minimum primary magnetizing inductance
103	LPRIMARY_TYP			571.4	uH	Typical primary magnetizing inductance
104	LPRIMARY_TOL	7.0		7.0		Primary magnetizing inductance tolerance

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105	LPRIMARY_MAX			611.4	uH	Maximum primary magnetizing inductance
107	**PRIMARY CURRENT**					
108	IAVG_PRIMARY			0.366	A	Primary MOSFET average current
109	IPEAK_PRIMARY			1.275	A	Primary MOSFET peak current
110	IPEDESTAL_PRIMARY			0.238	A	Primary MOSFET current pedestal
111	IRIPPLE_PRIMARY			1.274	A	Primary MOSFET ripple current
112	IRMS_PRIMARY			0.559	A	Primary MOSFET RMS current
114	**SECONDARY CURRENT**					
115	IPEAK_SECONDARY			12.747	A	Secondary MOSFET peak current
116	IPEDESTAL_SECONDARY			2.384	A	Secondary MOSFET pedestal current
117	IRMS_SECONDARY			5.210	A	Secondary MOSFET RMS current
118	IRIPPLE_CAP_OUT			4.260	A	Output capacitor ripple current
122	**TRANSFORMER CONSTRUCTION PARAMETERS**					
123	**CORE SELECTION**					
124	CORE	RM8	Info	RM8		The transformer windings may not fit: pick a bigger core or bobbin and refer to the Transformer Parameters tab for fit calculations
125	CORE NAME			PC95RM08Z		Core code
126	AE			64.0	mm^2	Core cross sectional area
127	LE			38.0	mm	Core magnetic path length
128	AL			5290	nH	Ungapped core effective inductance per turns squared
129	VE			2430	mm^3	Core volume
130	BOBBIN NAME			B-RM08-V		Bobbin name
131	AW			30.0	mm^2	Bobbin window area
132	BW			8.80	mm	Bobbin width
133	MARGIN			0.0	mm	Bobbin safety margin
135	**PRIMARY WINDING**					
136	NPRIMARY			40		Primary winding number of turns
137	BPEAK			3271	Gauss	Peak flux density
138	BMAX			2994	Gauss	Maximum flux density
139	BAC			1495	Gauss	AC flux density (0.5 x Peak to Peak)
140	ALG			357	nH	Typical gapped core effective inductance per turns squared
141	LG			0.210	mm	Core gap length
142	LAYERS_PRIMARY	2		2		Primary winding number of layers
143	AWG_PRIMARY			27		Primary wire gauge
144	OD_PRIMARY_INSULATED			0.418	mm	Primary wire insulated outer diameter
145	OD_PRIMARY_BARE			0.361	mm	Primary wire bare outer diameter
146	CMA_PRIMARY			360.5	Cmils/A	Primary winding wire CMA
148	**SECONDARY WINDING**					
149	NSECONDARY	4		4		Secondary winding number of turns
150	AWG_SECONDARY			19		Secondary wire gauge
151	OD_SECONDARY_INSULATED			1.217	mm	Secondary wire insulated outer diameter
152	OD_SECONDARY_BARE			0.912	mm	Secondary wire bare outer diameter
153	CMA_SECONDARY			247.2	Cmils/A	Secondary winding wire CMA
155	**BIAS WINDING**					
156	NBIAS			10		Bias winding number of turns
160	**PRIMARY COMPONENTS SELECTION**					

161	**LINE UNDERVOLTAGE**					
162	BROWN-IN REQURED	76.00		76.00	V	Required line brown-in threshold
163	RLS			3.82	MΩ	Connect two 1.91 MOhm resistors to the V-pin for the required UV/OV threshold
164	BROWN-IN ACTUAL			76.58	V	Actual brown-in threshold using standard resistors
165	BROWN-OUT ACTUAL			69.26	V	Actual brown-out threshold using standard resistors
167	**LINE OVERVOLTAGE**					
168	OVERVOLTAGE_LINE		Warning	319.20	V	The device voltage stress will be higher than 90% of the breakdown voltage when overvoltage is trigerred
170	**BIAS WINDING**					
171	VBIAS	7.00	Info	7.00	V	The rectified bias voltage maybe too low to supply the BP pin: Increase the rectified bias voltage to a value higher than 9V
172	VF_BIAS			0.70	V	Bias winding diode forward drop
173	VREVERSE_BIASDIODE			100.33	V	Bias diode reverse voltage (not accounting parasitic voltage ring)
174	CBIAS			22	uF	Bias winding rectification capacitor
175	CBPP			0.47	uF	BPP pin capacitor
179	**SECONDARY COMPONENTS SELECTION**					
180	**RECTIFIER**					
181	VDRAIN_OFF_SRFET			48.33	V	Secondary rectifier reverse voltage (not accounting parasitic voltage ring)
182	SRFET	Auto		AOD2816		Secondary rectifier (Logic MOSFET)
183	VBREAKDOWN_SRFET			80	V	Secondary rectifier breakdown voltage
184	RDSON_SRFET			29.0	mΩ	SRFET on time drain resistance at 25degC for VGS=4.4V
188	**VARIABLE OUTPUTS ANALYSIS**					
189	**TOLERANCE CORNER**					
190	CORNER_VAC			85	V	Input AC RMS voltage corner to be evaluated
191	CORNER_ILIMIT	TYP		1.250	A	Current limit corner to be evaluated
192	CORNER_LPRIMARY	TYP		571.4	uH	Primary inductance corner to be evaluated
194	**SETPOINT SELECTION**					
195	SETPOINT	1		1		Select the setpoint which needs to be evaluated
196	FSWITCHING			69826.7	Hz	Maximum switching frequency at full load and the valley of the minimum input AC voltage
197	VOR			110.0	V	Voltage reflected to the primary winding when the primary MOSFET turns off
198	VMIN			79.28	V	Valley of the minimum input AC voltage
199	KP			0.957		Measure of continuous/discontinuous mode of operation
200	MODE_OPERATION			CCM		Mode of operation
201	DUTYCYCLE			0.584		Primary MOSFET duty cycle
202	TIME_ON			8.36	us	Primary controller's maximum on-time

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203	TIME_OFF			5.96	us	Primary controller's minimum off-time
205	**PRIMARY CURRENT**					
206	IAVG_PRIMARY			0.365	A	Primary MOSFET average current
207	IPEAK_PRIMARY			1.199	A	Primary MOSFET peak current
208	IPEDESTAL_PRIMARY			0.051	A	Primary MOSFET current pedestal
209	IRIPPLE_PRIMARY			1.148	A	Primary MOSFET ripple current
210	IRMS_PRIMARY			0.540	A	Primary MOSFET RMS current
212	**SECONDARY CURRENT**					
213	IPEAK_SECONDARY			11.987	A	Secondary MOSFET peak current
214	IPEDESTAL_SECONDARY			0.512	A	Secondary MOSFET pedestal current
215	IRMS_SECONDARY			4.564	A	Secondary MOSFET RMS current
216	IRIPPLE_CAP_OUT			3.850	A	Output capacitor ripple current
218	**MAGNETIC FLUX DENSITY**					
219	BPEAK			2856	Gauss	Peak flux density
220	BMAX			2676	Gauss	Maximum flux density
221	BAC			1281	Gauss	AC flux density (0.5 x Peak to Peak)

Notes:

1. (Overvoltage Line) Warning: We find that there is sufficient margin above the datasheet specified breakdown voltage at normal operating voltage of 265 VAC. This warning is for abnormal operating conditions and can be ignored.

11 Performance Data

11.1 No-Load Input Power at 5 V_{OUT}

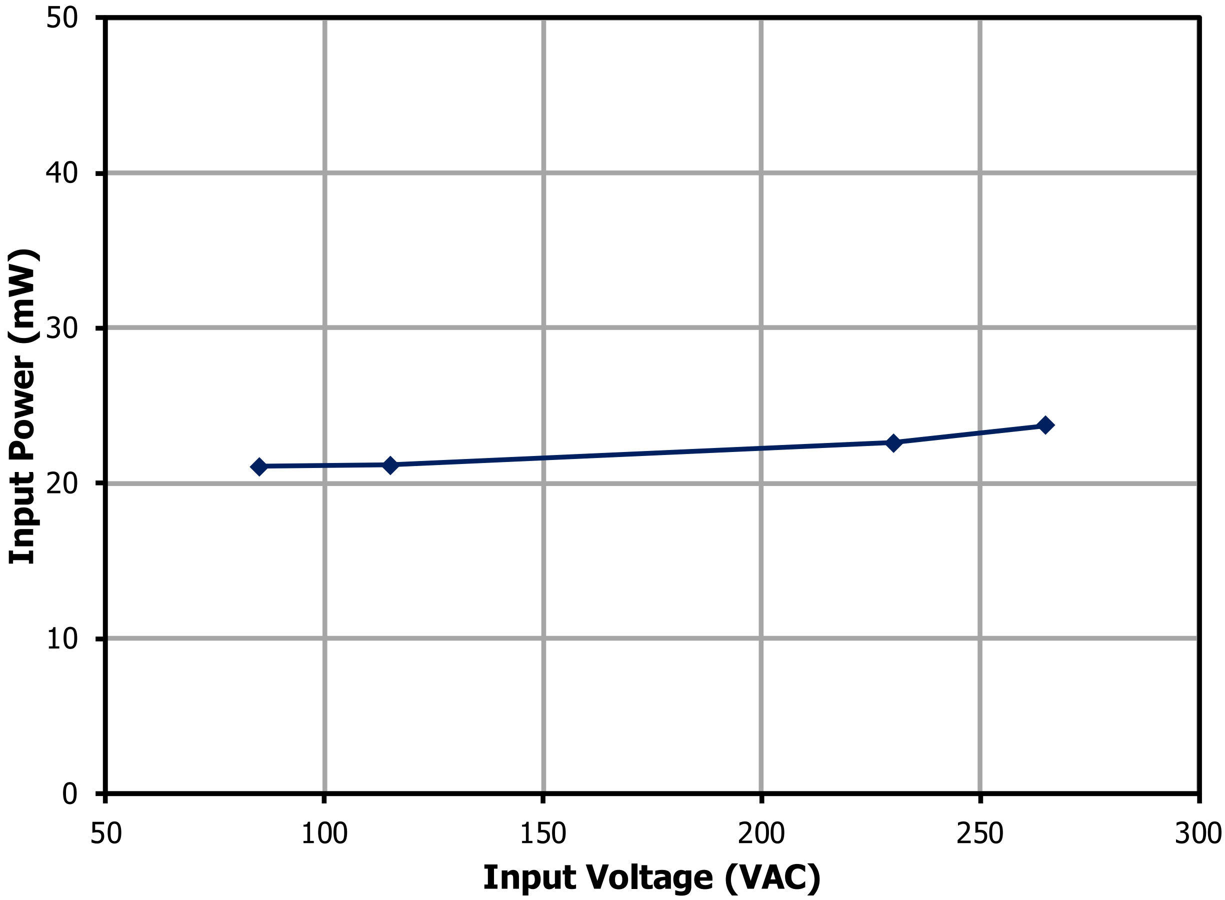

Figure 19 – No-Load Input Power vs. Input Line Voltage, Room Temperature.

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11.1.1 Average Efficiency Requirements

Test	Power (W)	Average	Average	10% Load	Average	Average	10% Load
Model		<6 V Voltage	<6 V Voltage	<6 V Voltage	>6 V Voltage	>6 V Voltage	>6 V Voltage
Regulation		**New IESA2007**	**CoC v5 Tier 2**	**CoC v5 Tier 2**	**New IESA2007**	**CoC v5 Tier 2**	**CoC v5 Tier 2**
	9.9	**78.6%**	**78.9%**	**69.7%**			
	15	**81.4 %**	**81.8%**	**72.5%**			
	27				**86.6%**	**87.3%**	**77.3%**

11.1.2 Average Efficiency Summary

Power (W)	V_{OUT} (V)	Average		10%Load	
		115 VAC	**230 VAC**	**115 VAC**	**230 VAC**
9.9	**3.3**	88.16	85.18	85.63	77.61
15	**5**	89.30	88.55	88.34	80.94
27	**9**	89.33	89.22	82.02	79.94

11.2 Average Efficiency (On Board) and 10% Load at 115 VAC Input

11.2.1 3.3 V, 3 A Output

% Load	P_{OUT} (W)	Efficiency (%)	Average Efficiency (%) [100%-25%]
100	9.95	87.16	
75	7.53	87.77	
50	5.05	88.49	88.16
25	2.54	89.20	
10	1.02	85.63	

11.2.2 5.0 V, 3 A Output

% Load	P_{OUT} (W)	Efficiency (%)	Average Efficiency (%) [100%-25%]
100	15.06	88.38	
75	11.37	89.18	
50	7.67	89.71	89.30
25	3.82	89.93	
10	1.53	88.34	

11.2.3 9.0 V, 3 A Output

% Load	P_{OUT} (W)	Efficiency (%)	Average Efficiency (%) [100%-25%]
100	27.06	89.97	
75	20.37	89.92	
50	13.63	89.31	89.33
25	6.84	88.11	
10	2.73	82.02	

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11.3 Average Efficiency (On Board) at 230 VAC Input and 10% Load

11.3.1 3.3 V Output

% Load	P_{OUT} (W)	Efficiency (%)	Average Efficiency (%) [100%-25%]
100	9.98	86.45	
75	7.53	86.44	
50	5.06	85.78	85.18
25	2.54	82.04	
10	1.02	77.61	

11.3.2 5.0 V Output

% Load	P_{OUT} (W)	Efficiency (%)	Average Efficiency (%) [100%-25%]
100	15.10	89.01	
75	11.39	89.15	
50	7.63	88.82	88.55
25	3.83	87.23	
10	1.53	80.94	

11.3.3 9.0 V Output

% Load	P_{OUT} (W)	Efficiency (%)	Average Efficiency (%) [100%-25%]
100	27.09	90.18	
75	20.41	90.00	
50	13.64	89.44	89.22
25	6.84	87.25	
10	2.73	79.94	

11.4 Efficiency Across Load (On Board)

11.4.1 5 V Output

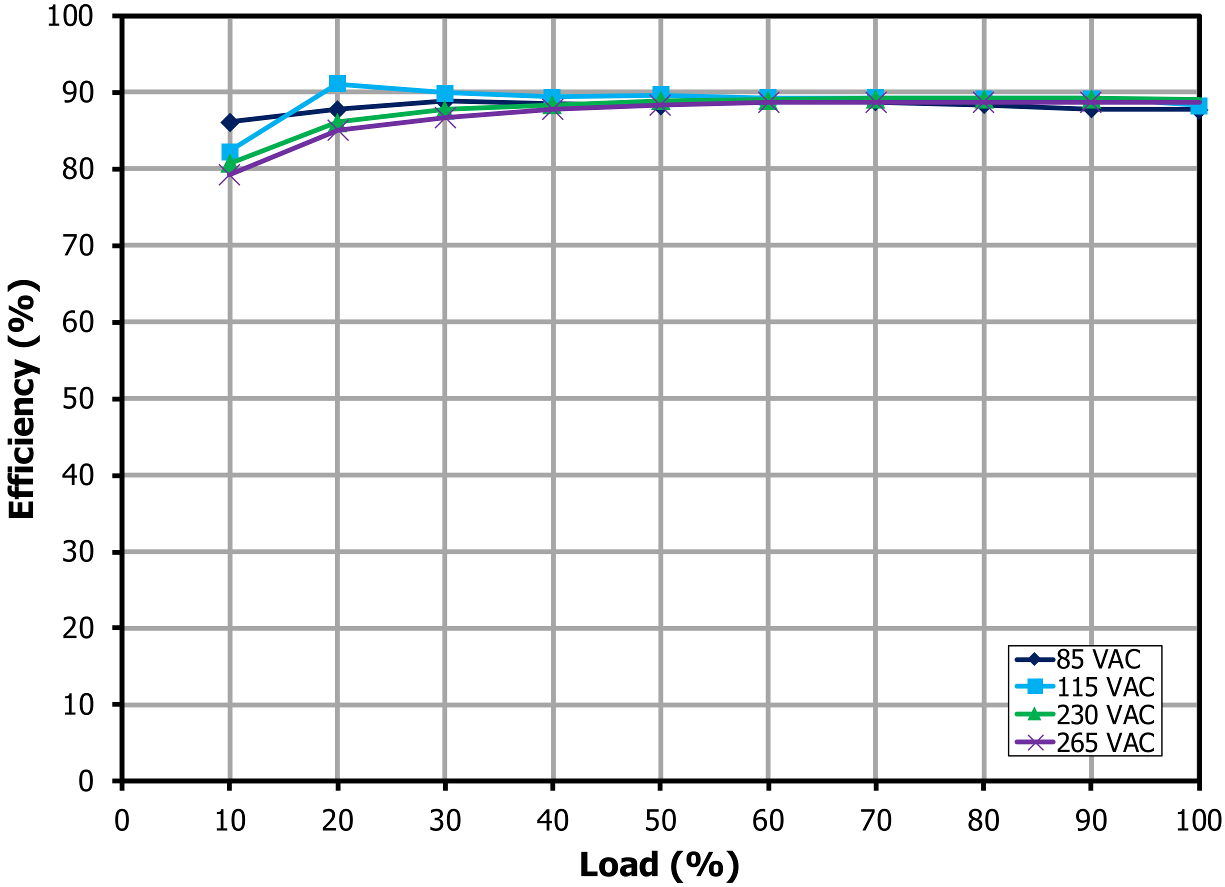

Figure 20 – Efficiency vs. Load for 5 V Output, Room Temperature.

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11.4.2 9 V Output

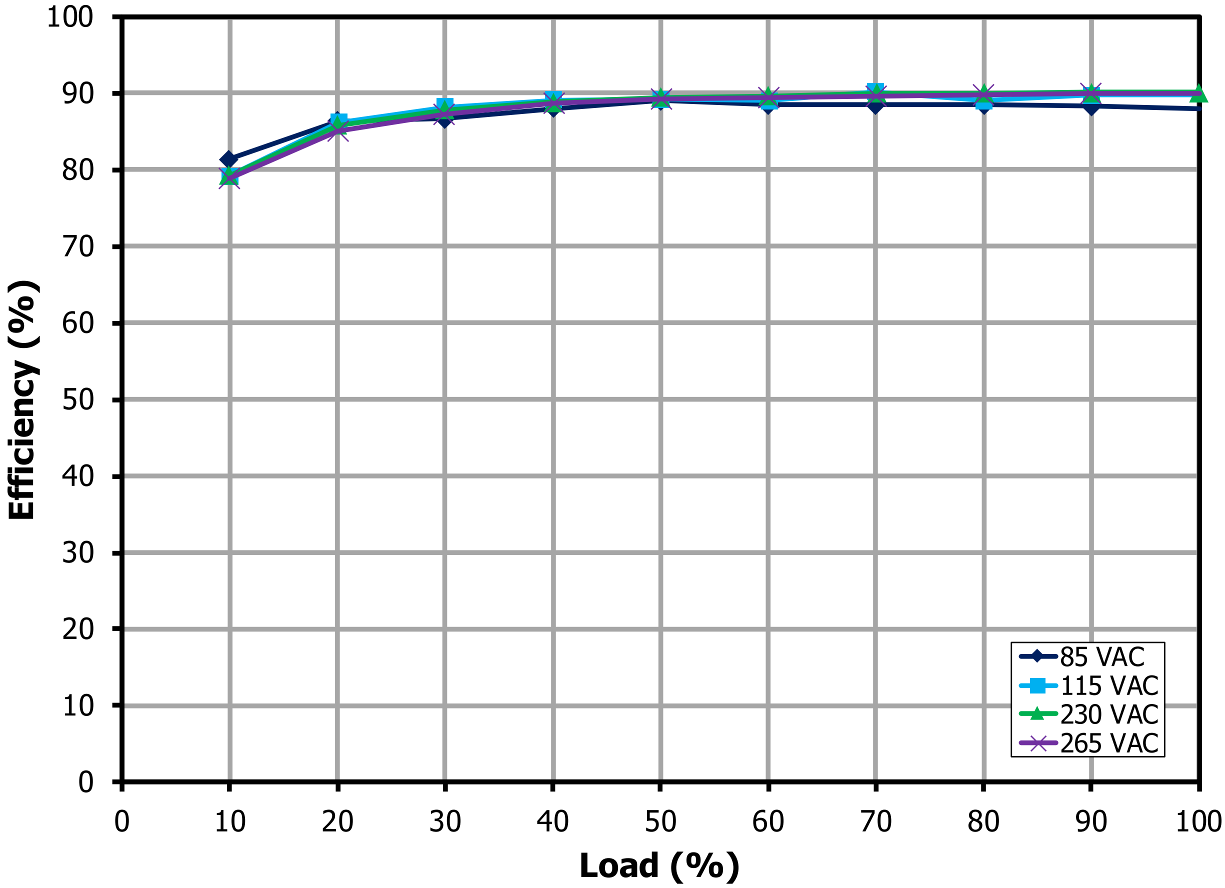

Figure 21 – Efficiency vs. Load for 9 V Output, Room Temperature.

11.4.3 11 V Output

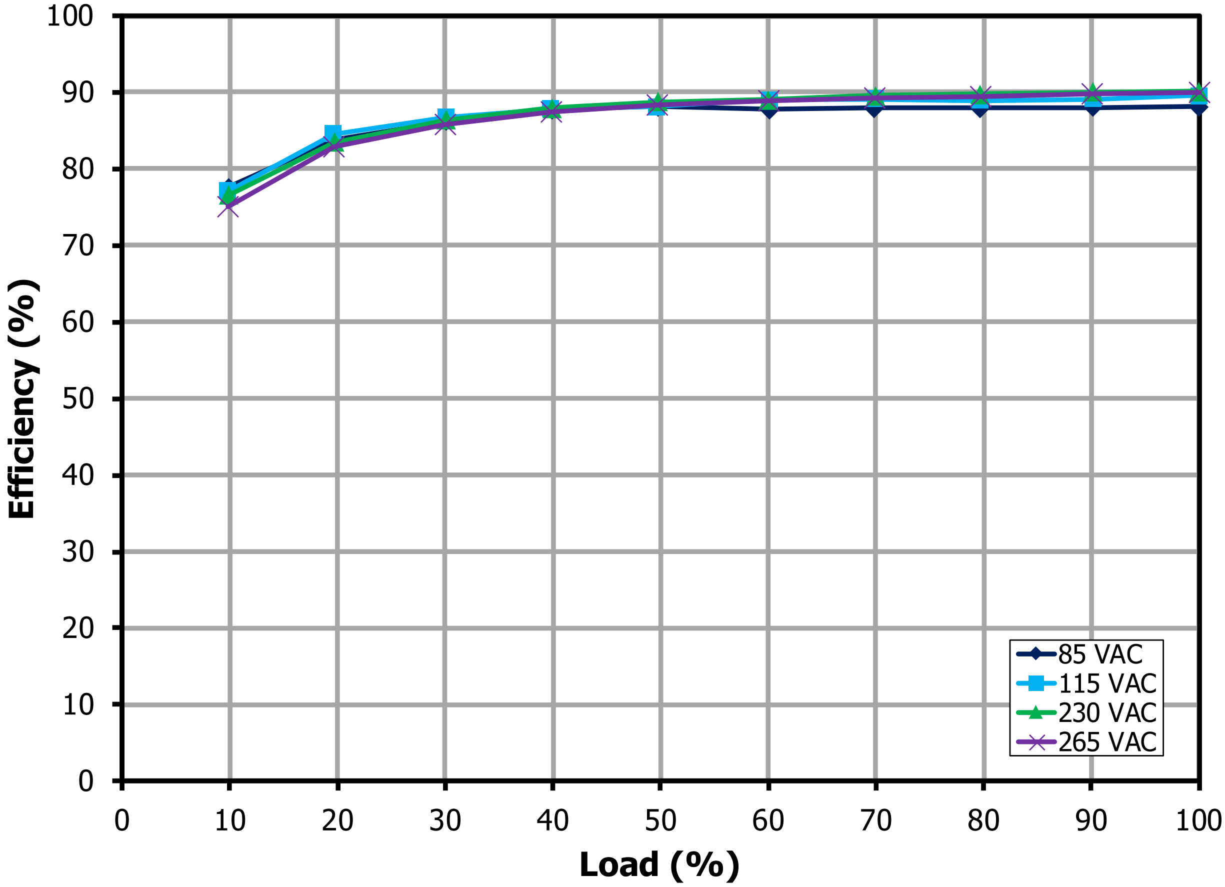

Figure 22 – Efficiency vs. Load for 11 V Output, Room Temperature.

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11.4.4 3.3 V Output

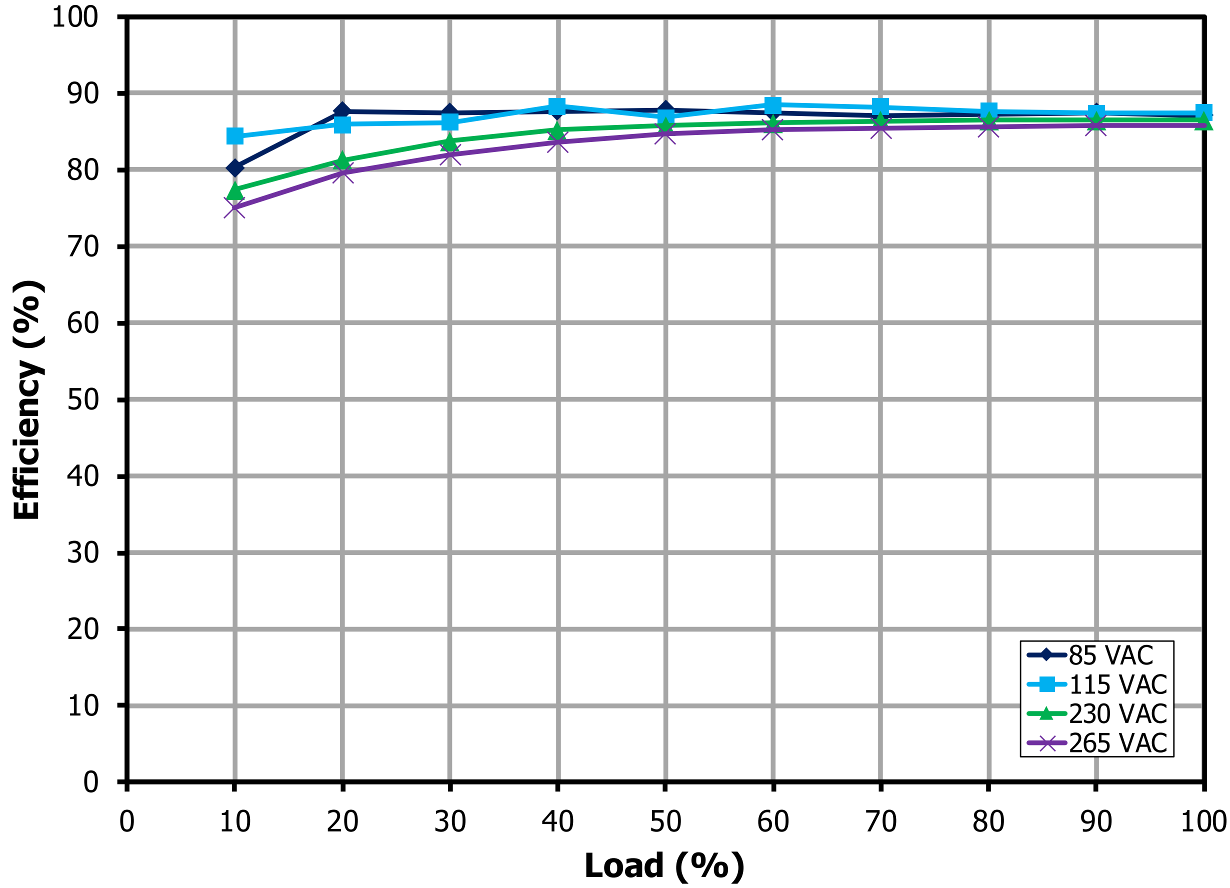

Figure 23 – Efficiency vs. Load for 3.3 V Output, Room Temperature.

11.5 Efficiency Across Line (On Board)

11.5.1 5 V Output

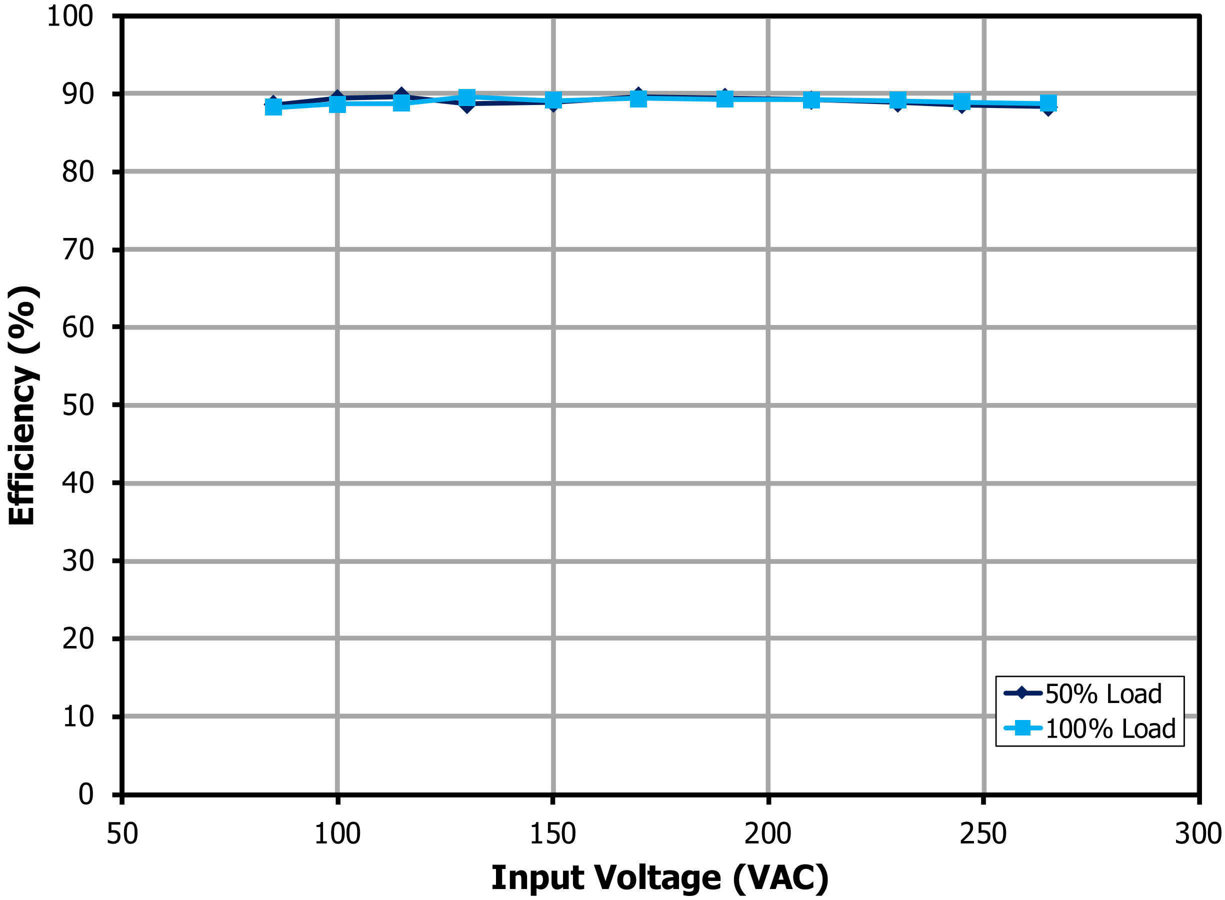

Figure 24 – Efficiency vs. Input Line for 5 V Output, Room Temperature.

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11.5.2 9 V Output

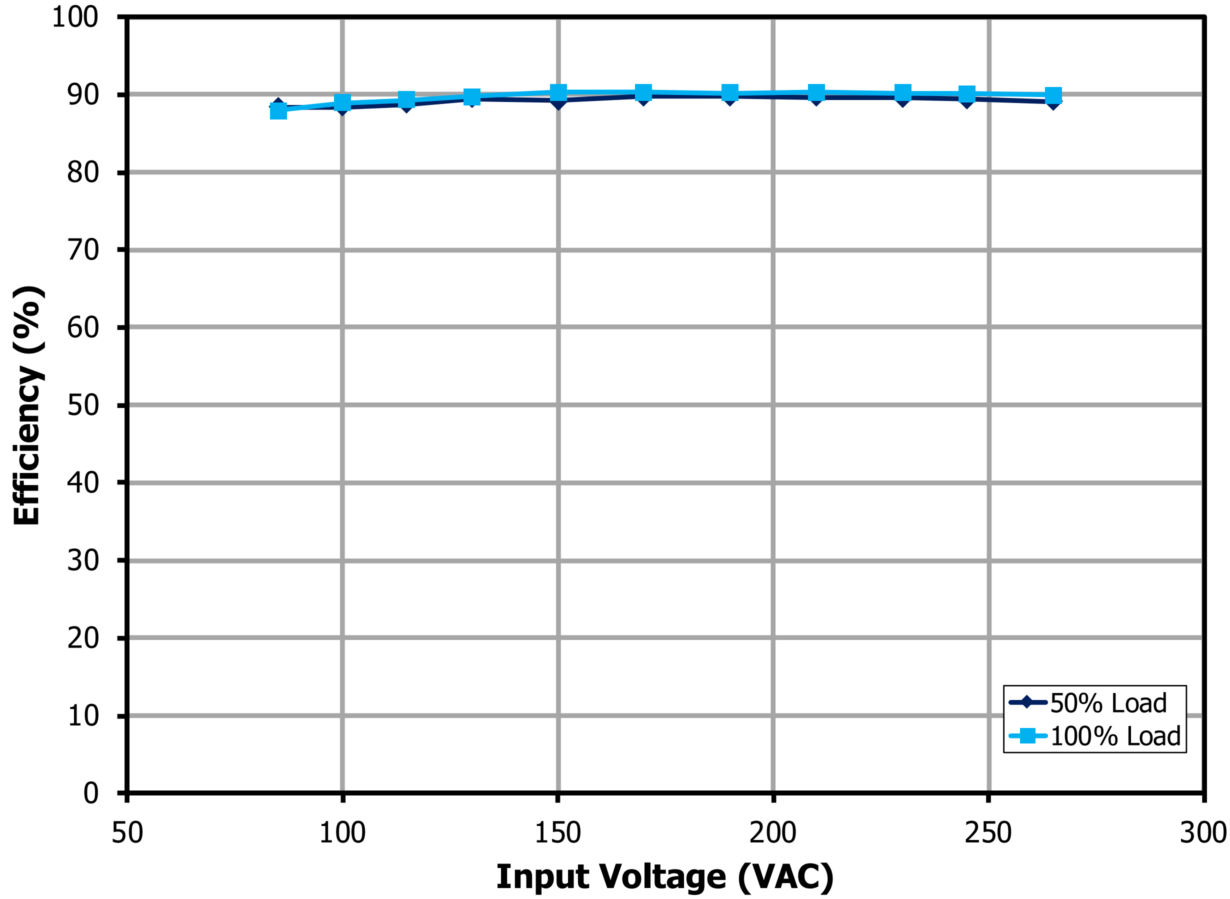

Figure 25 – Efficiency vs. Input Line for 9 V Output, Room Temperature.

11.5.3 11 V Output

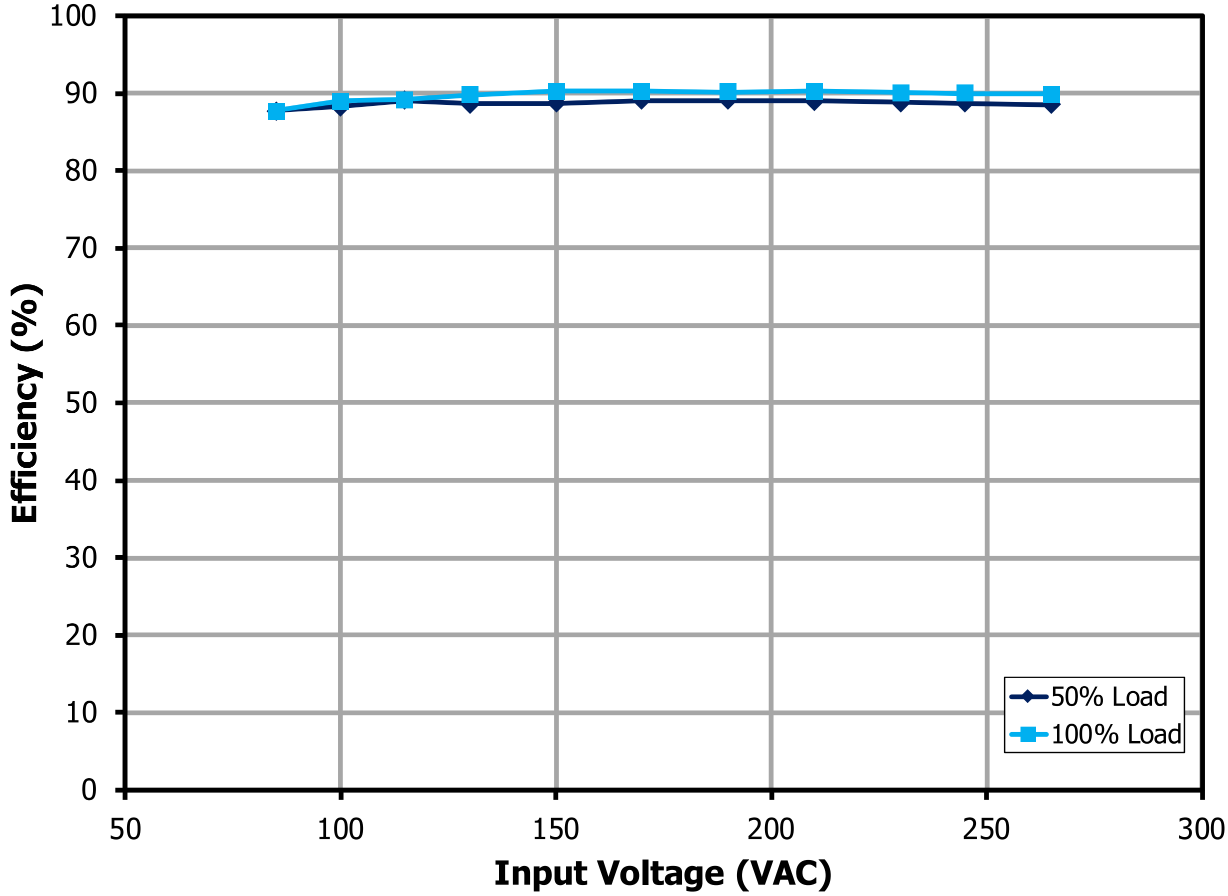

Figure 26 – Efficiency vs. Input Line for 11 V Output, Room Temperature.

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11.5.4 3.3 V Ouput

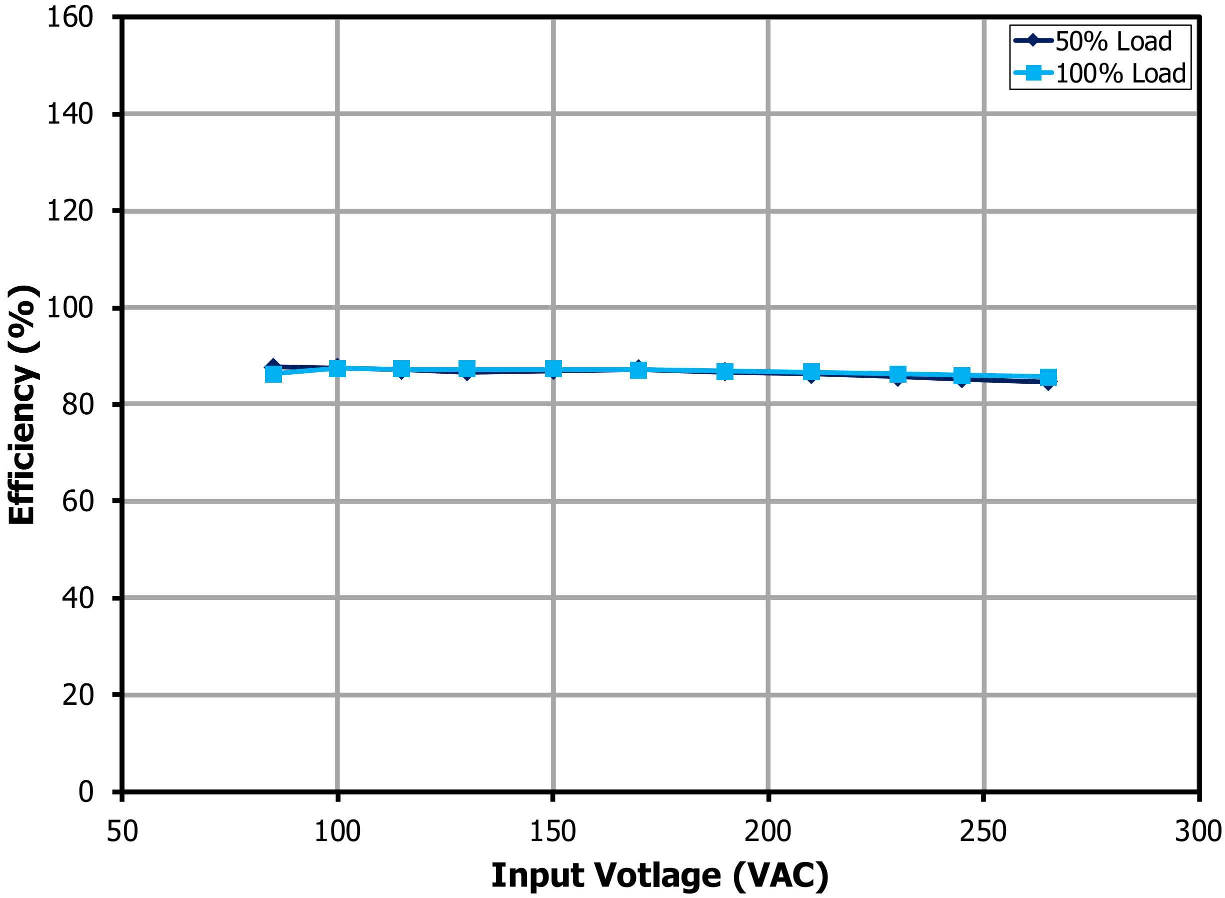

Figure 27 – Efficiency vs. Input Line for 3.3 V Output, Room Temperature.

11.6 Line Regulation (On Board)

11.6.1 5.0 V Output

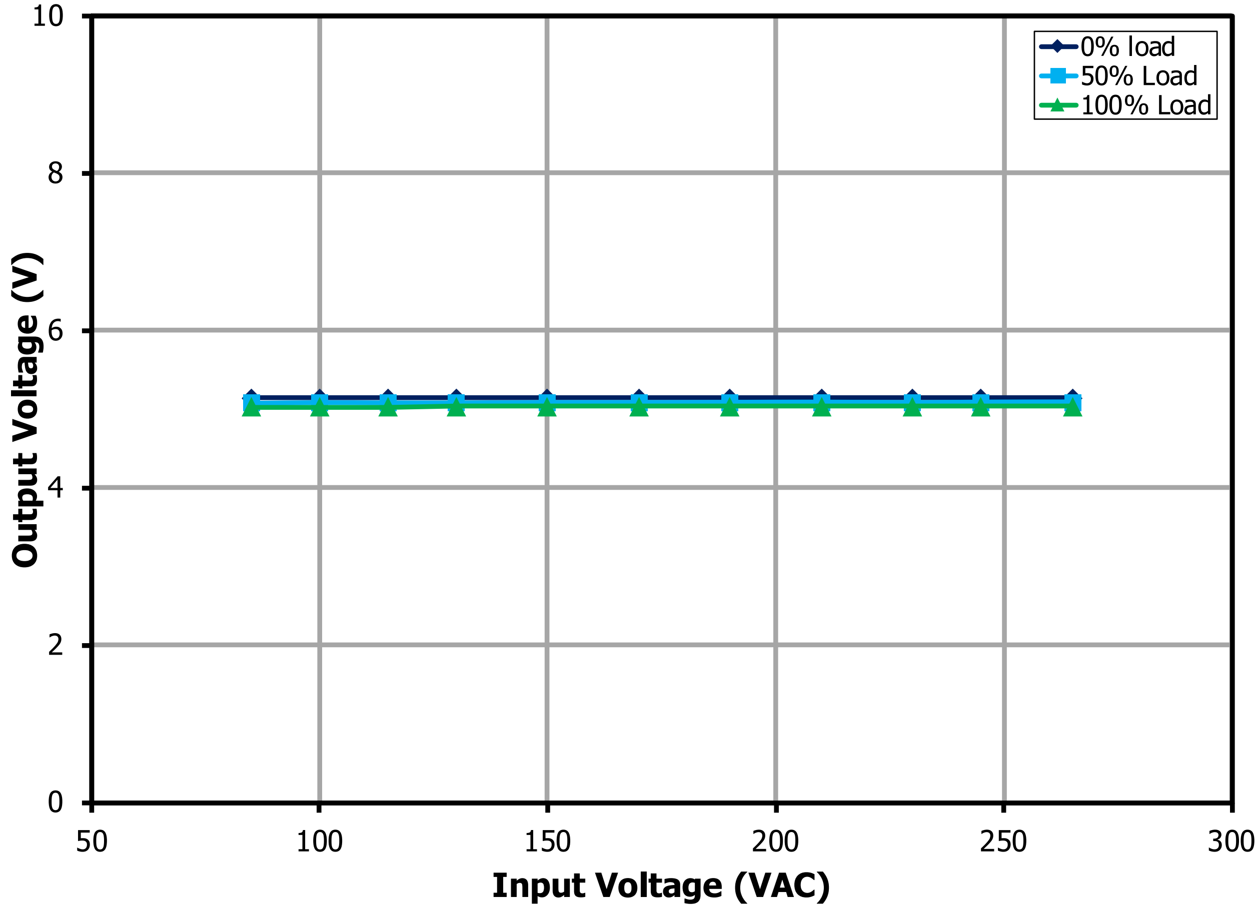

Figure 28 – Output Voltage vs. Input Line Voltage for 5 V Output, Room Temperature.

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11.6.2 9.0 V Output

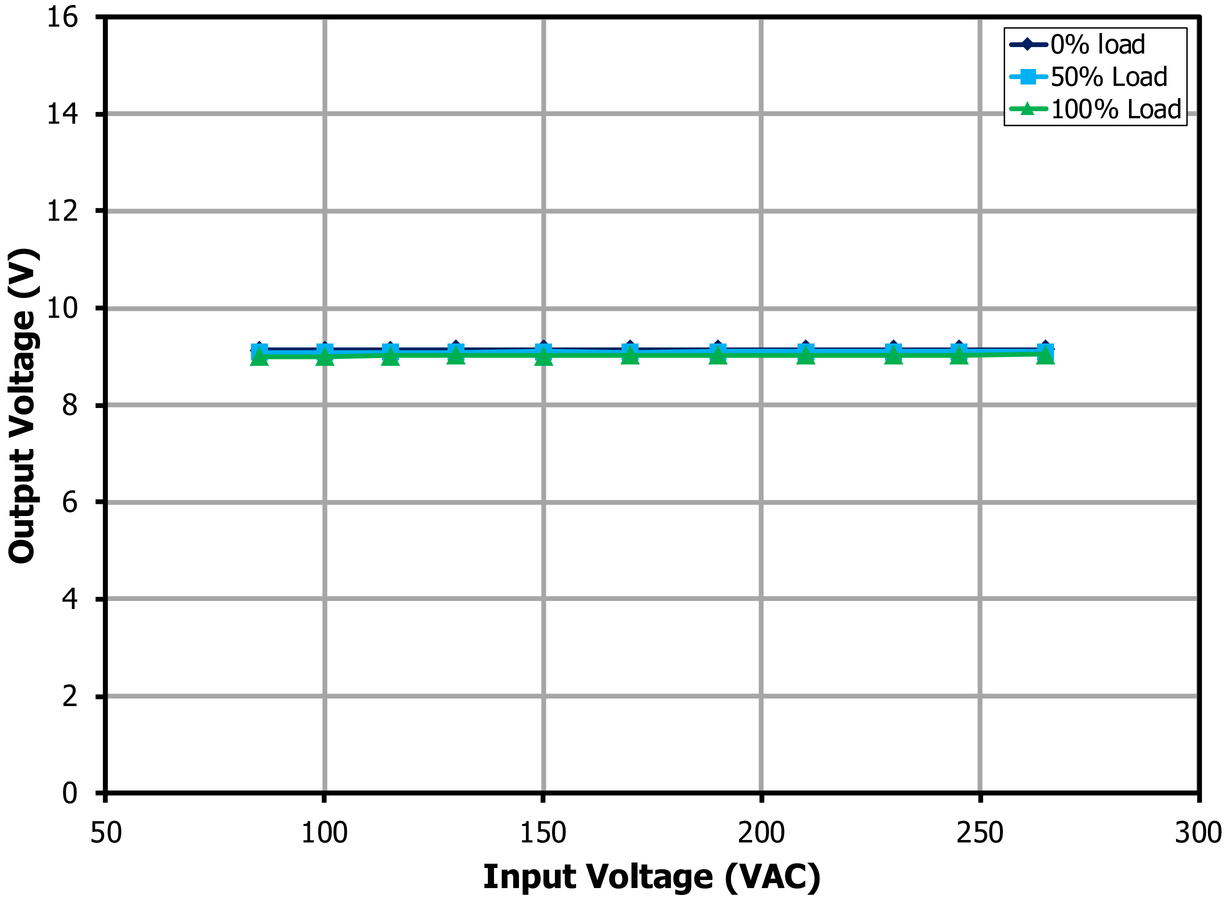

Figure 29 – Output Voltage vs. Input Line Voltage for 9 V Output, Room Temperature.

11.6.3 11.0 V Output

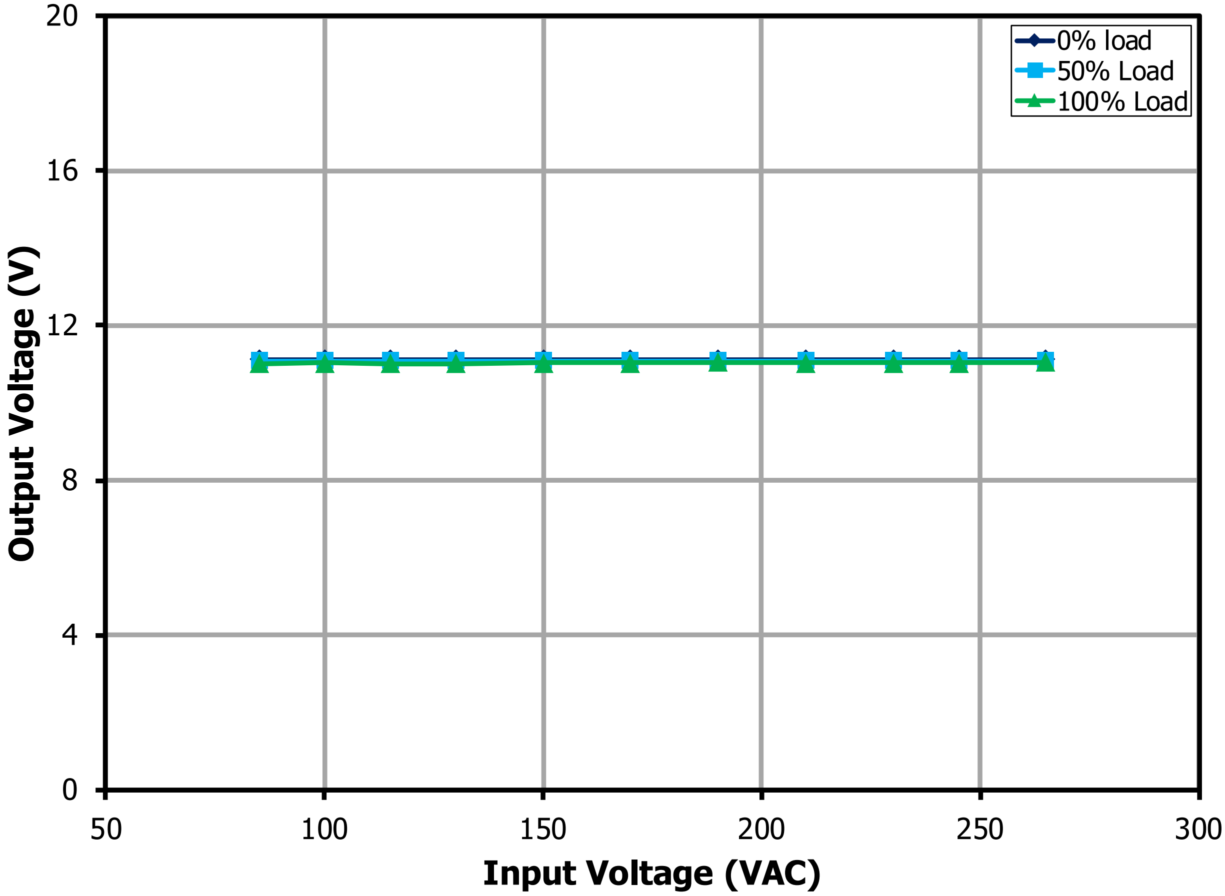

Figure 30 – Output Voltage vs. Input Line Voltage for 15 V Output, Room Temperature.

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11.6.4 3.3 V Output

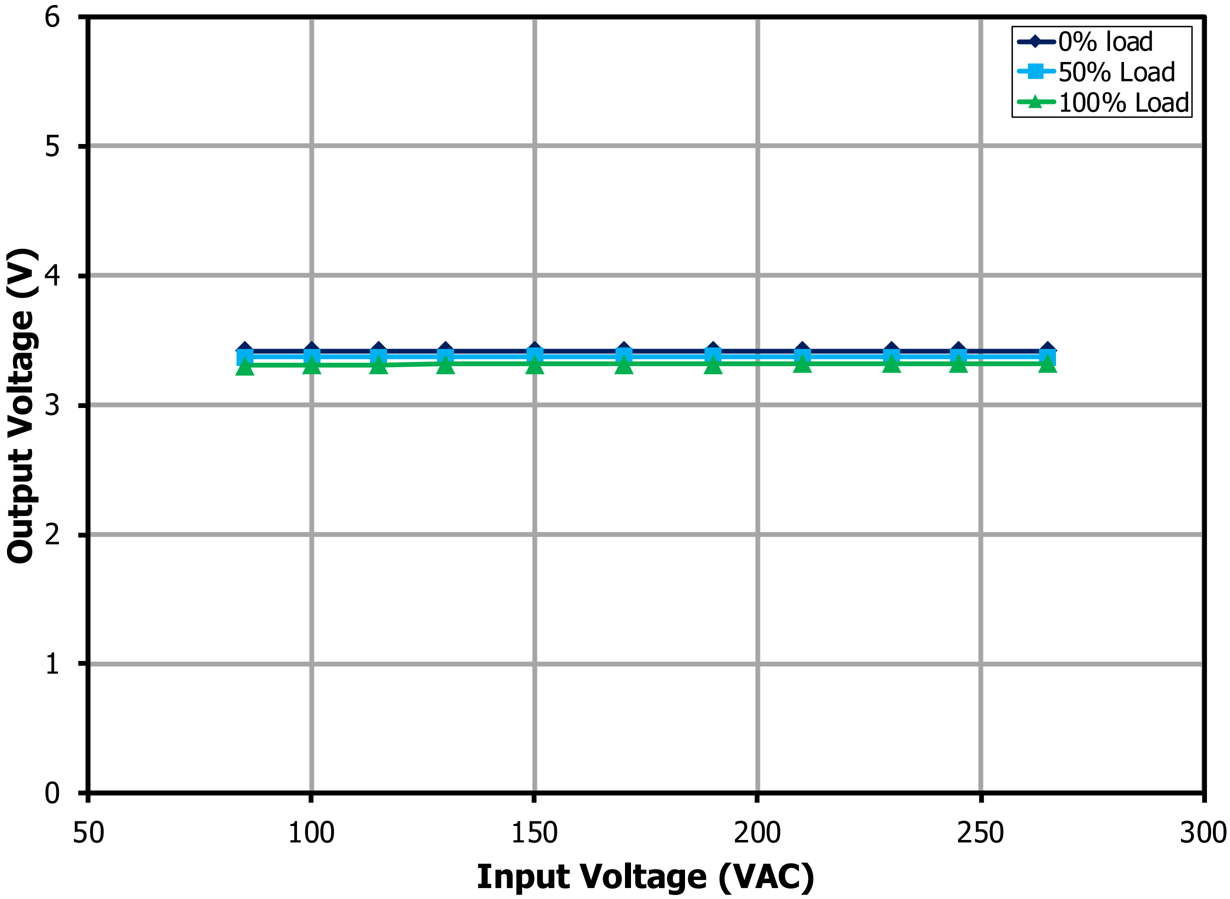

Figure 31 – Output Voltage vs. Input Line Voltage for 20 V Output, Room Temperature.

11.7 Load Regulation (On Board)

11.7.1 5.0 V Output

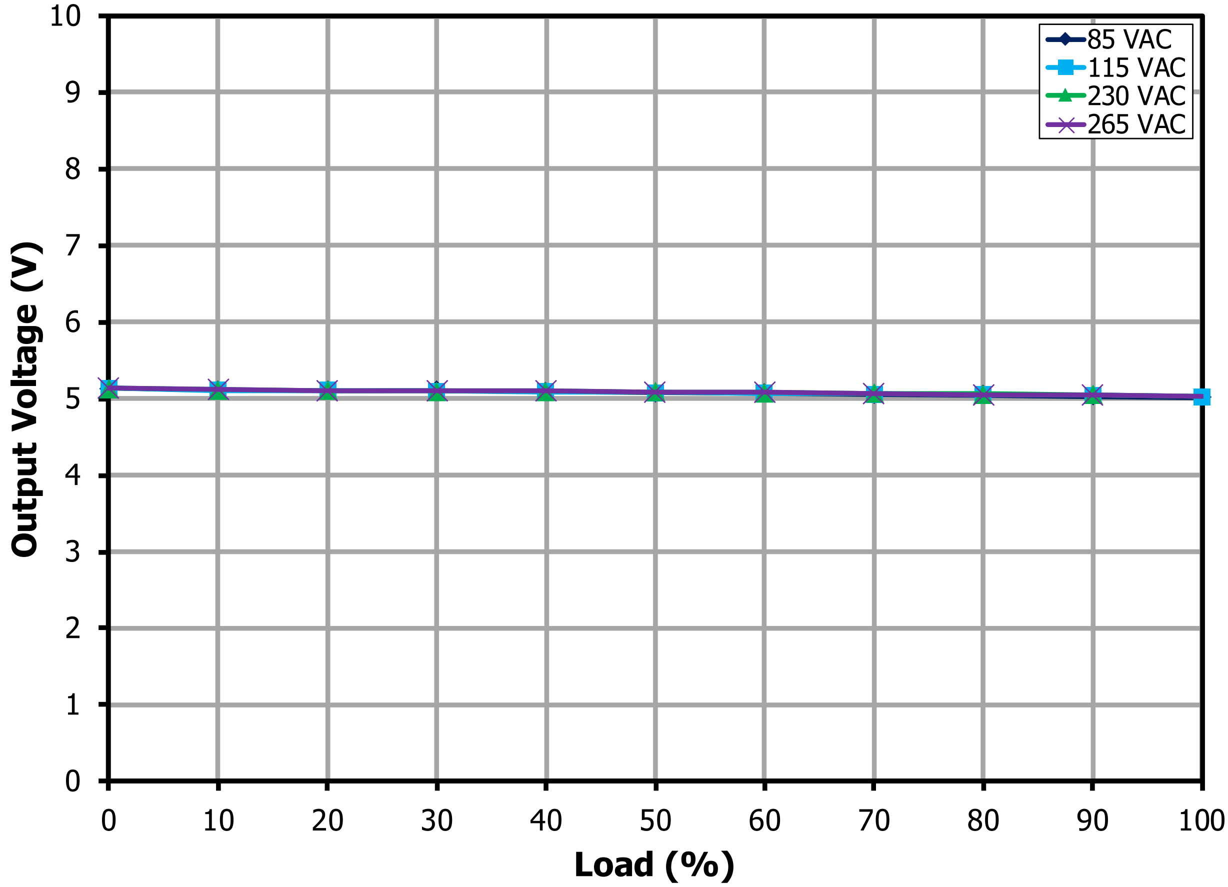

Figure 32 – Output Voltage vs. Output Load for 5 V Output, Room Temperature.

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11.7.2 9.0 V Output

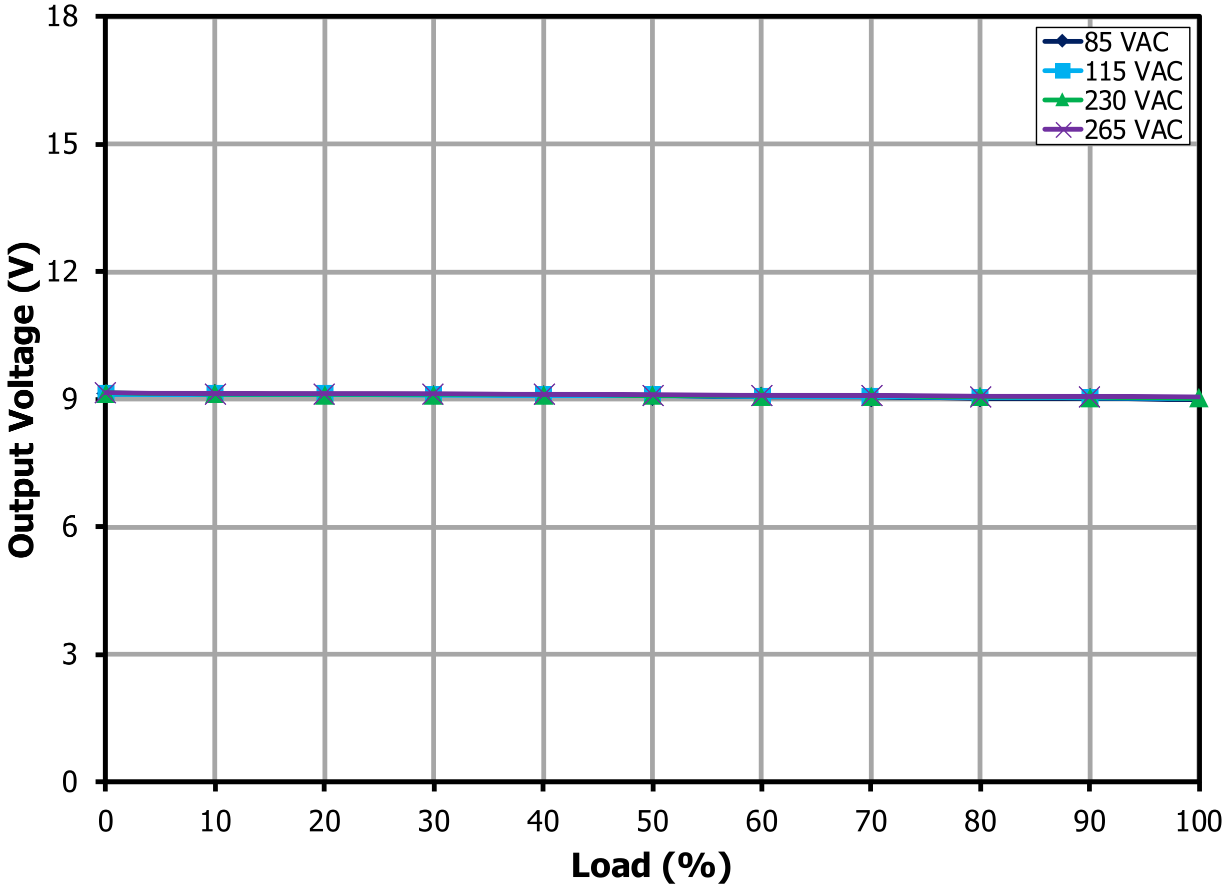

Figure 33 – Output Voltage vs. Output Load for 9 V Output, Room Temperature.

11.7.3 11.0 V Output

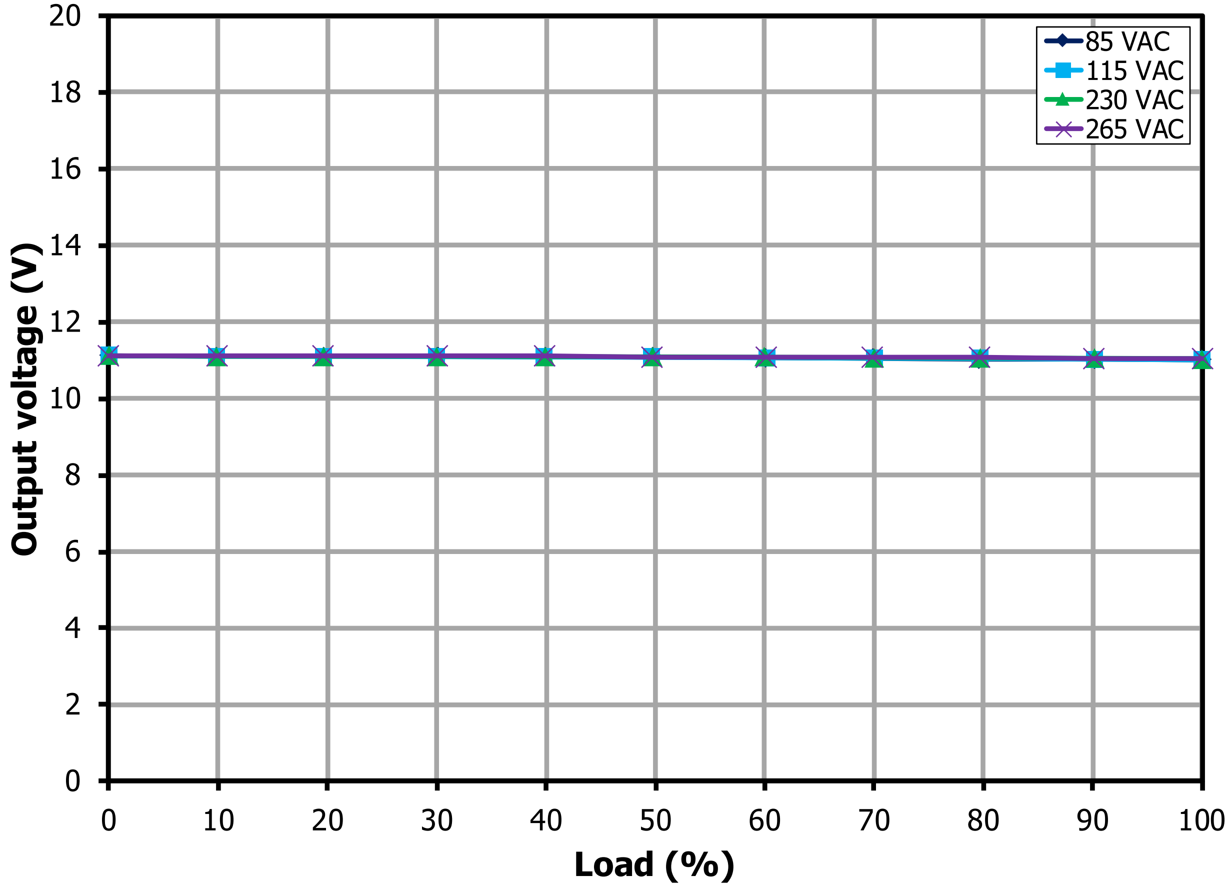

Figure 34 – Output Voltage vs. Output Load for 15 V Output, Room Temperature.

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11.7.4 3.3 V Output

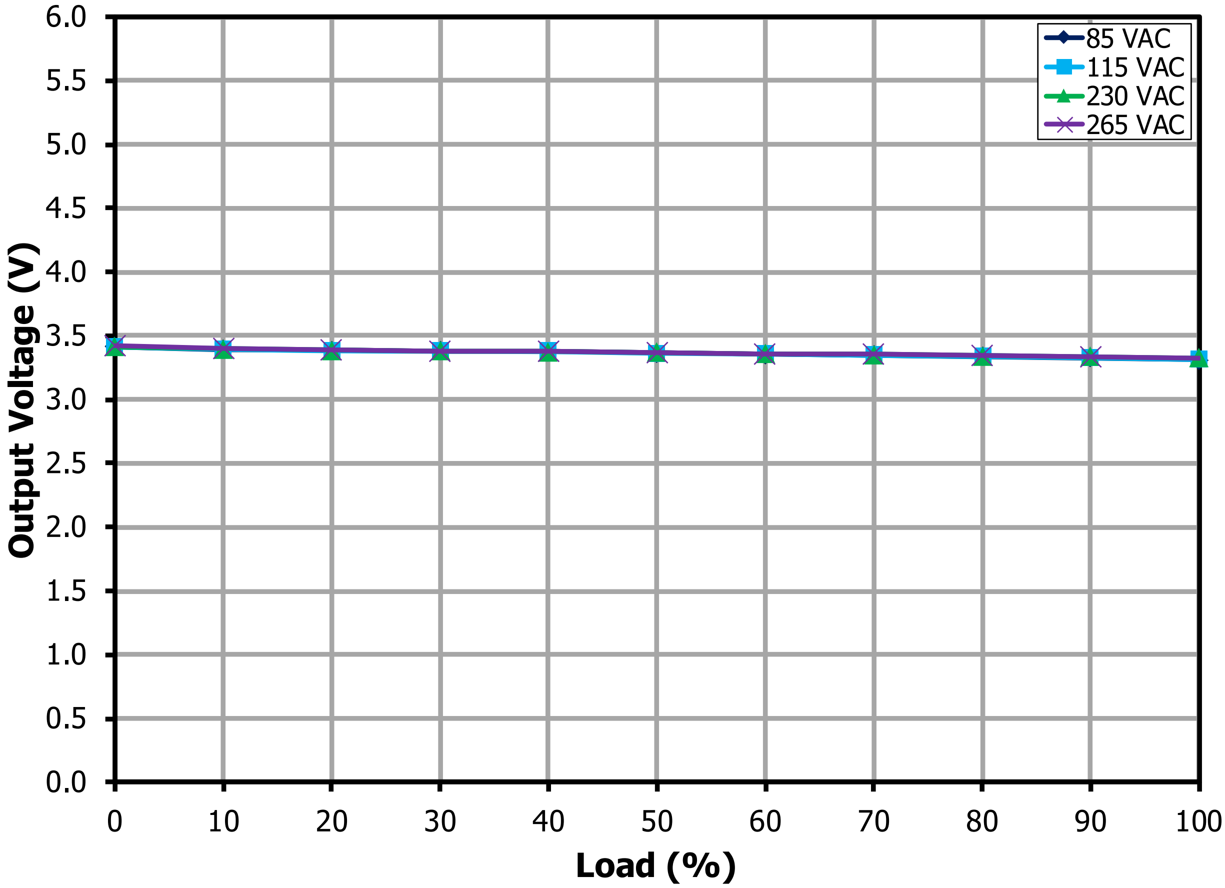

Figure 35 – Output Voltage vs. Output Load for 20 V Output, Room Temperature.

12 Thermal Performance in Open Case

Note: For plastic enclosed adapters, this design requires use of a metallic heat spreader and suitable thermally conductive insulator to ensure sufficiently low temperature of the InnoSwitch-3 Pro IC and Transformer. The performance data below is for open case operation and does not use the heat spreader for cooling.

12.1 5 V, 3 A

12.1.1 85 VAC Input

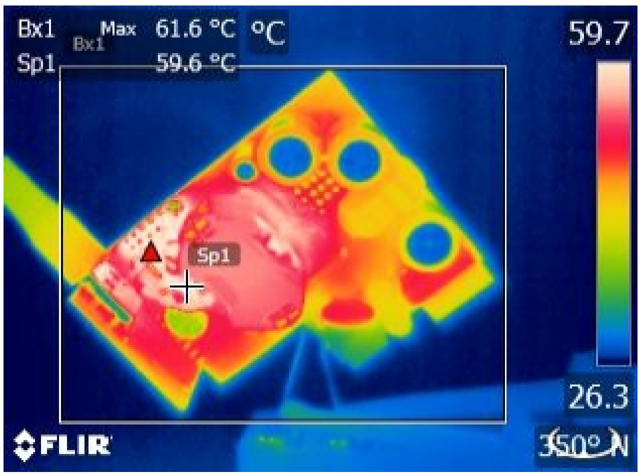

Figure 36 – Transformer Side.
Ambient = 27.1 ºC.
Transformer Secondary = 61.6 ºC.

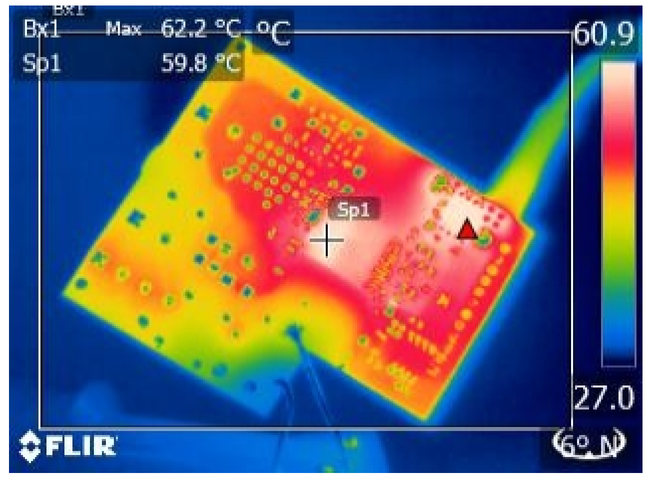

Figure 37 – InnoSwitch3-Pro Side.
Ambient = 27.1 ºC.
InnoSwitch3-Pro = 59.8 ºC.
SR FET Q2 = 62.2 ºC.

12.1.2 265 VAC Input

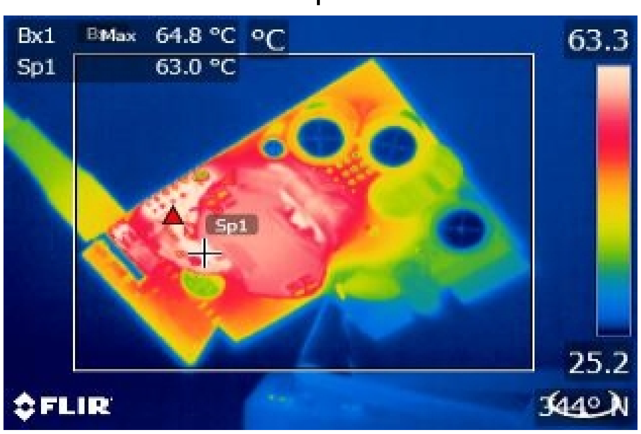

Figure 38 – Transformer Side.
Ambient = 25.3 ºC.
Transformer Secondary = 64.8 ºC.

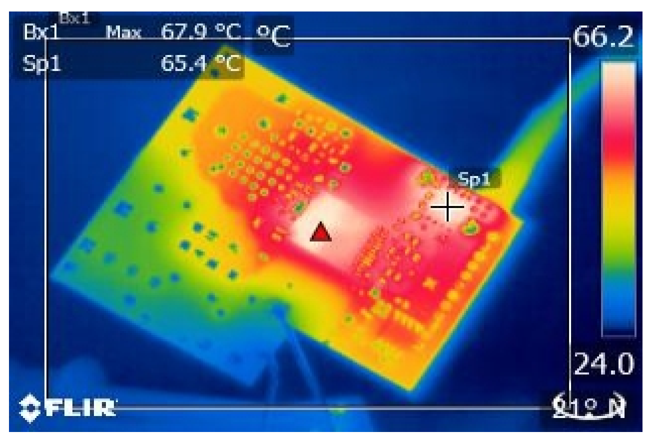

Figure 39 – InnoSwitch3-Pro Side.
Ambient = 25.3 ºC.
InnoSwitch3-Pro = 67.9 ºC.
SR FET Q2 = 65.4 ºC.

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12.2 9 V, 3 A

12.2.1 85 VAC Input

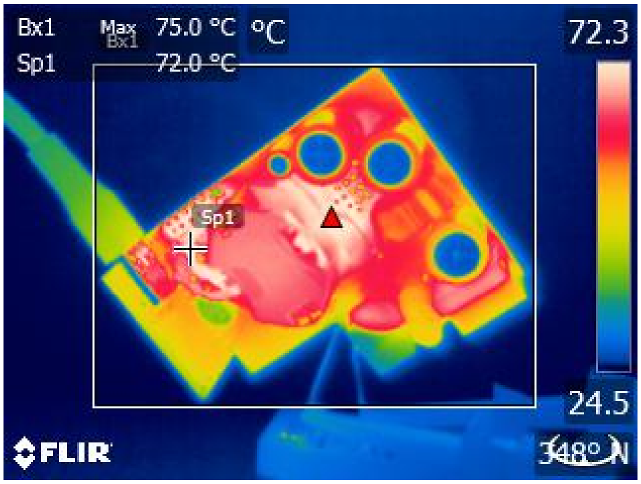

Figure 40 – Transformer Side.
Ambient = 25.5 ºC.
Transformer Secondary = 75 ºC.

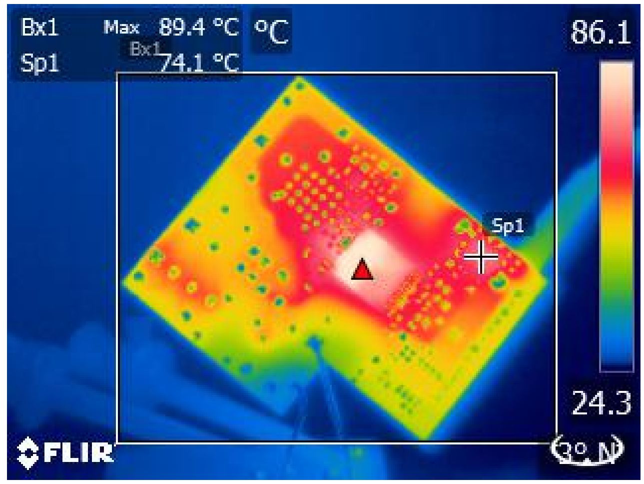

Figure 41 – InnoSwitch3-Pro Side.
Ambient = 25.5 ºC.
InnoSwitch3-Pro = 89.4 ºC.
SR FET Q2= 74.1 ºC.

12.2.2 265 VAC Input

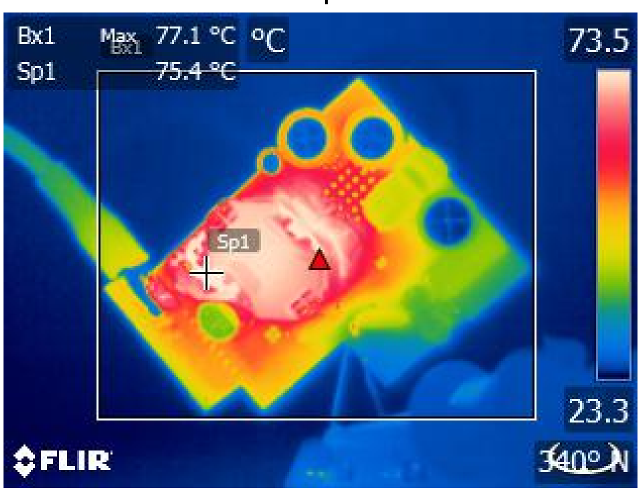

Figure 42 – Transformer Side.
Ambient = 25.3 ºC.
Transformer Secondary = 77.1 ºC.

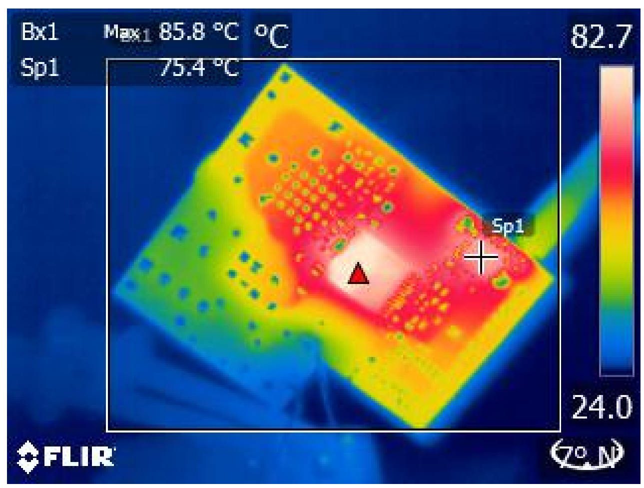

Figure 43 – InnoSwitch3-Pro Side.
Ambient = 25.3 ºC.
InnoSwitch3-Pro = 85.8 ºC.
SR FET Q 2= 75.4 ºC.

12.3 11 V, 2.45 A

12.3.1 85 VAC Input

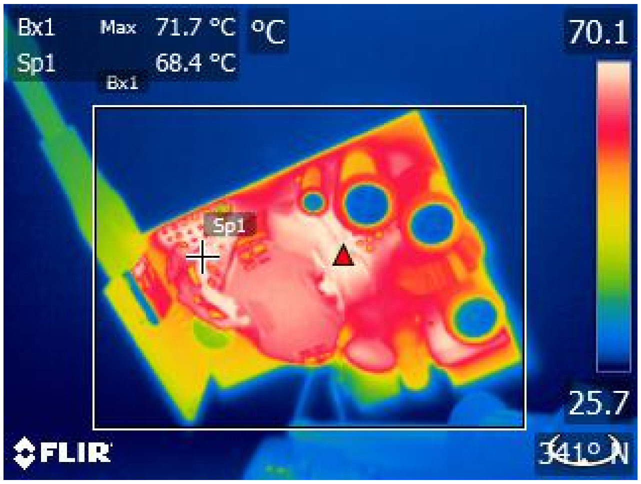

Figure 44 – Transformer Side.
Ambient = 27.1 ºC.
Transformer Secondary = 71.7 ºC.

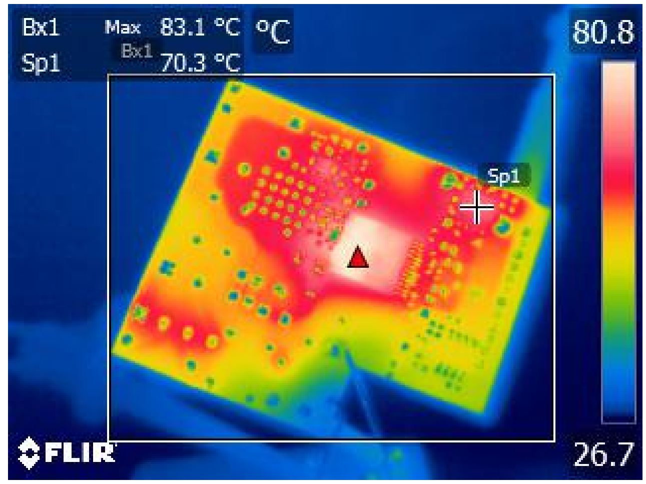

Figure 45 – InnoSwitch3-Pro Side.
Ambient = 27.1 ºC.
InnoSwitch3-Pro = 83.1 ºC.
SR FET Q2 = 70.3 ºC.

12.3.2 265 VAC Input

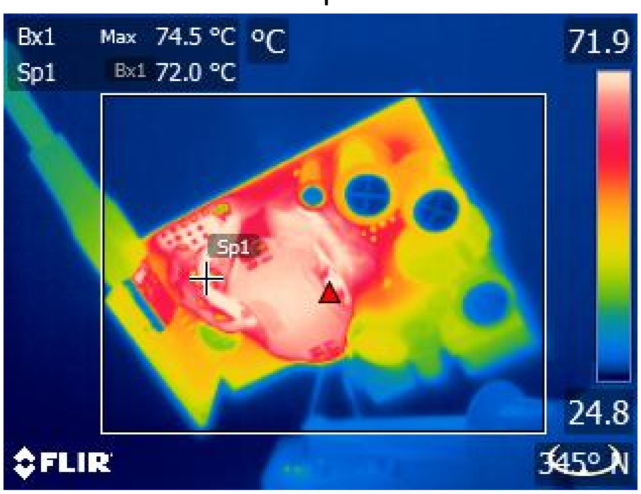

Figure 46 – Transformer Side.
Ambient = 24.3 ºC.
Transformer Secondary = 74.5 ºC.

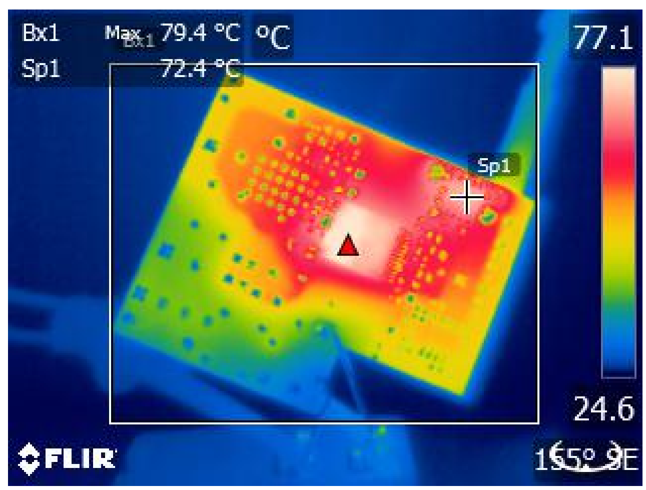

Figure 47 – InnoSwitch3-Pro Side.
Ambient = 24.3 ºC.
InnoSwitch3-Pro = 79.4 ºC.
SR FET Q2 = 72.4 ºC.

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12.4 3.3V, 3 A

12.4.1 85 VAC Input

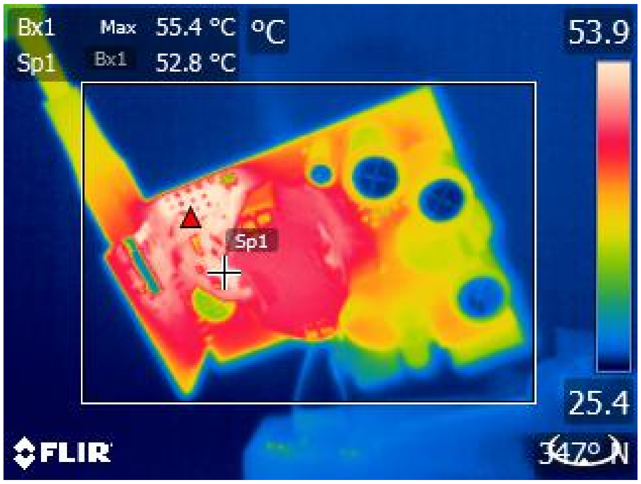

Figure 48 – Transformer Side.
Ambient = 26.1 ºC.
Transformer Secondary = 55.4 ºC.

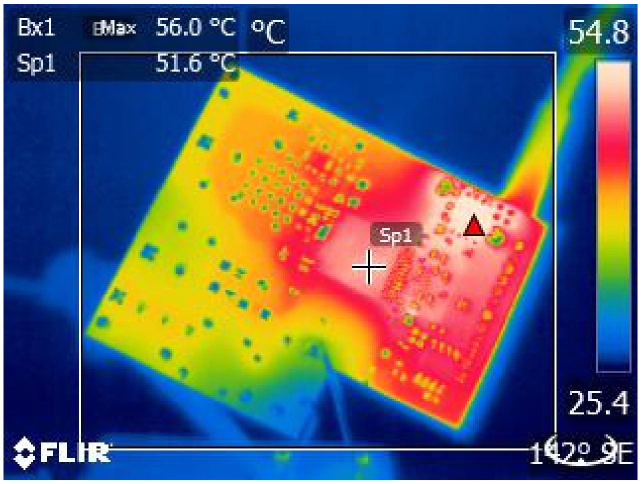

Figure 49 – InnoSwitch3-Pro Side.
Ambient = 26.1 ºC.
InnoSwitch3-Pro = 56.0 ºC.
SR FET Q2 = 51.6 ºC.

12.4.2 265 VAC Input

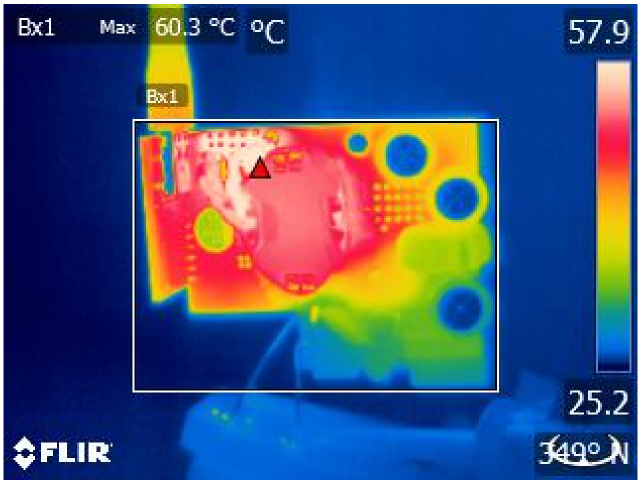

Figure 50 – Transformer Side.
Ambient = 25.6 ºC.
Transformer Secondary = 60.3 ºC.

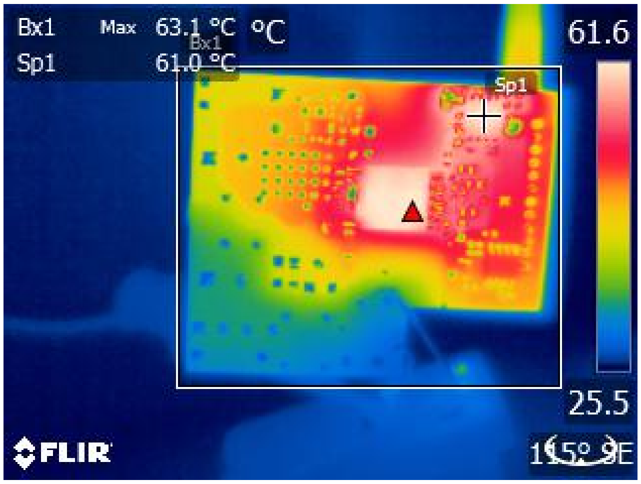

Figure 51 – InnoSwitch3-Pro Side.
Ambient = 25.6 ºC.
InnoSwitch3-Pro = 63.1 ºC.
SR FET, Q2 = 61 ºC.

13 Waveforms

13.1 Load Transient Response (End of 100 mΩ Cable)

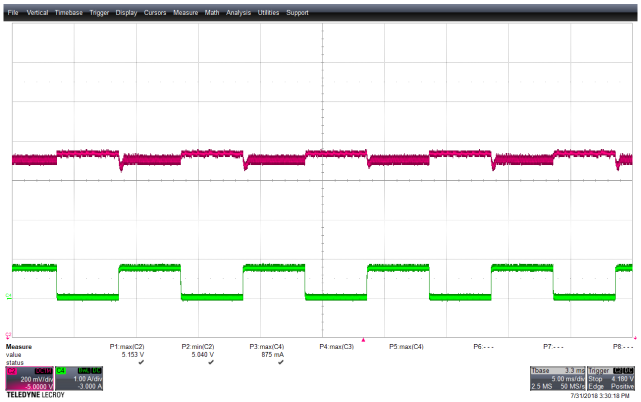

Figure 52 – Transient Response.
85 VAC, 5.0 V, 0 – 0.75 A Load Step.
V_{MIN}: 5.040 V, V_{MAX}: 5.153 V.
Upper: V_{OUT}, 0.2 V / div., 5 ms / div.
Lower: I_{LOAD}, 1 A / div.

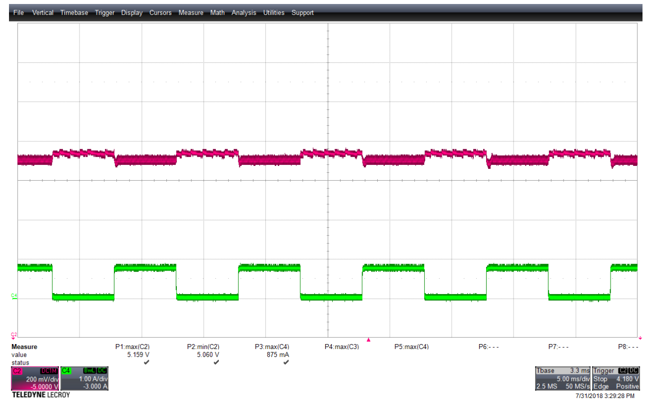

Figure 53 – Transient Response.
265 VAC, 5.0 V, 0 – 0.75 A Load Step.
V_{MIN} : 5.060 V, V_{MAX}: 5.159 V.
Upper: V_{OUT}, 0.2 V / div., 5 ms / div.
Lower: I_{LOAD}, 1 A / div.

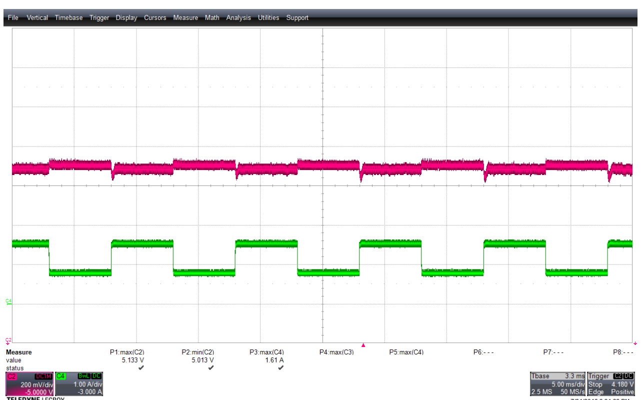

Figure 54 – Transient Response.
85 VAC, 5.0 V, 0.75 – 1.5 A Load Step.
V_{MIN}: 5.013 V, V_{MAX}: 5.133 V.
Upper: V_{OUT}, 0.2 V / div., 5 ms / div.
Lower: I_{LOAD}, 1 A / div.

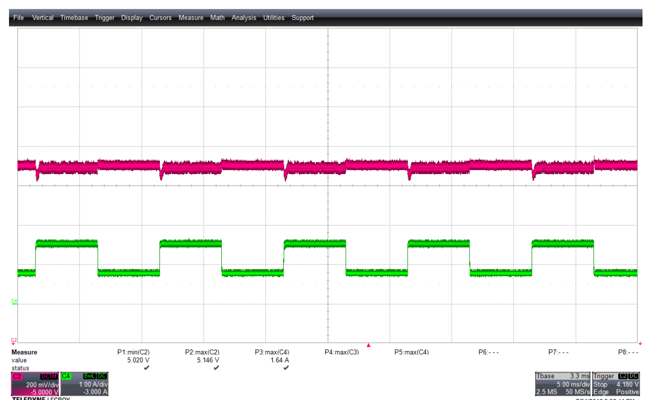

Figure 55 – Transient Response.
265 VAC, 5.0 V, 0.75 – 1.5 A Load Step.
V_{MIN}: 5.020 V, V_{MAX}: 5.146 V.
Upper: V_{OUT}, 0.2 V / div., 5 ms / div.
Lower: I_{LOAD}, 1 A / div.

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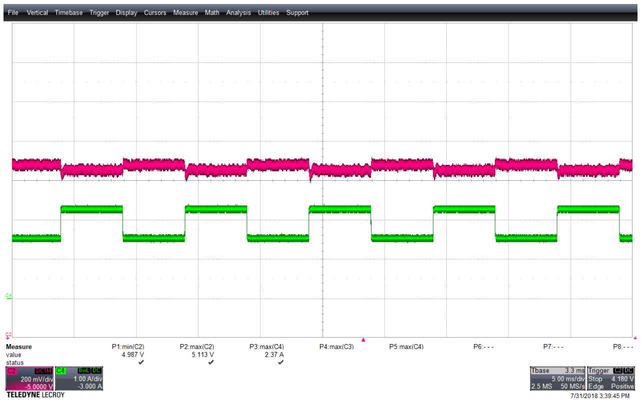

Figure 56 – Transient Response.
85 VAC, 5.0 V, 1.5 – 2.25 A Load Step.
V_{MIN}: 4.987 V, V_{MAX}: 5.113 V.
Upper: V_{OUT}, 0.2 V / div., 5 ms / div.
Lower: I_{LOAD}, 1 A / div.

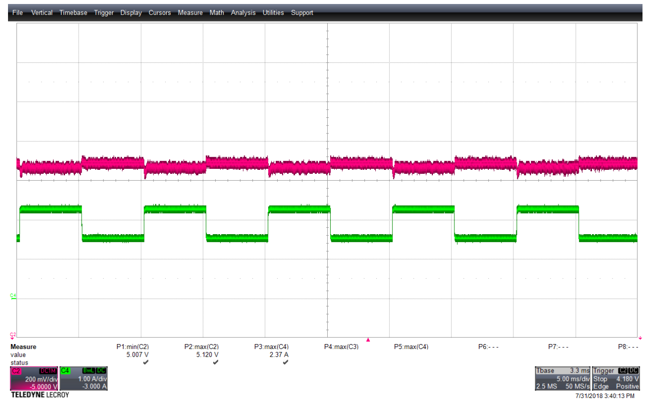

Figure 57 – Transient Response.
265 VAC, 5.0 V, 1.5 – 2.25 A Load Step.
V_{MIN}: 5.007 V, V_{MAX}: 5.120 V.
Upper: V_{OUT}, 0.2 V / div., 5 ms / div.
Lower: I_{LOAD}, 1 A / div.

Figure 58 – Transient Response.
85 VAC, 5.0 V, 2.25 – 3 A Load Step.
V_{MIN}: 4.954 V, V_{MAX}: 5.086 V.
Upper: V_{OUT}, 0.2 V / div., 5 ms / div.
Lower: I_{LOAD}, 1 A / div.

Figure 59 – Transient Response.
265 VAC, 5.0 V, 2.25 – 3 A Load Step.
V_{MIN}: 4.973 V, V_{MAX}: 5.100 V.
Upper: V_{OUT}, 0.2 V / div., 5 ms / div.
Lower: I_{LOAD}, 1 A / div.

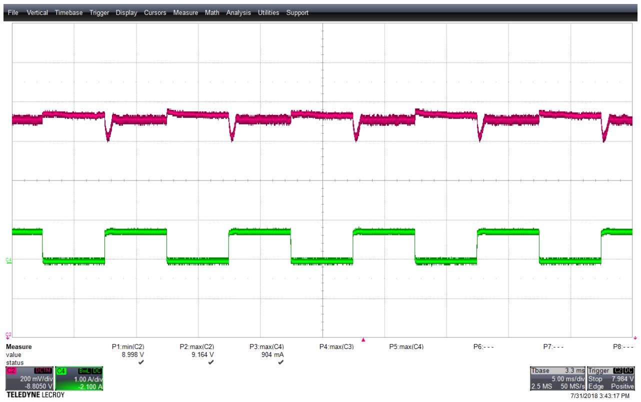

Figure 60 – Transient Response.
85 VAC, 9.0 V, 0 – 0.75 A Load Step.
V_{MIN}: 8.998 V, V_{MAX}: 9.164 V.
Upper: V_{OUT}, 0.2 V / div., 5 ms / div.
Lower: I_{LOAD}, 1 A / div.

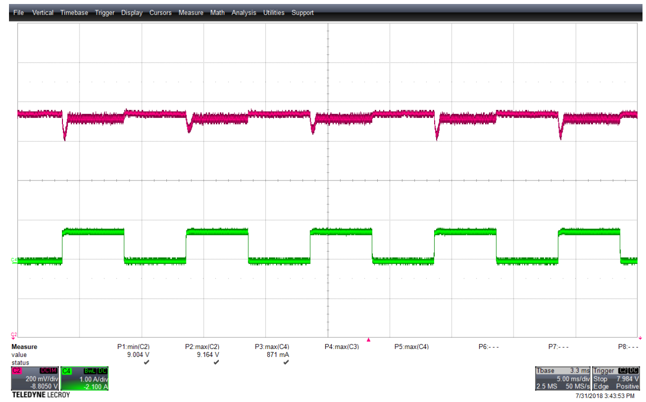

Figure 61 – Transient Response.
265 VAC, 9.0 V, 0 – 0.75 A Load Step.
V_{MIN} 9.004 V, V_{MAX}: 9.164 V.
Upper: V_{OUT}, 0.2 V / div., 5 ms / div.
Lower: I_{LOAD}, 1 A / div.

Figure 62 – Transient Response.
85 VAC, 9.0 V, 0.75 – 1.5 A Load Step.
V_{MIN}: 9.011 V, V_{MAX}: 9.150 V.
Upper: V_{OUT}, 0.2 V / div., 5 ms / div.
Lower: I_{LOAD}, 1 A / div.

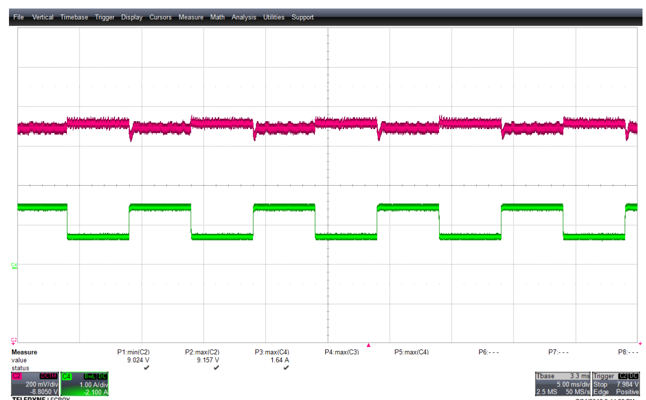

Figure 63 – Transient Response.
265 VAC, 9.0 V, 0.75 – 1.5 A Load Step.
V_{MIN}: 9.024 V, V_{MAX}: 9.157 V.
Upper: V_{OUT}, 0.2 V / div., 5 ms / div.
Lower: I_{LOAD}, 1 A / div.

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Figure 64 – Transient Response.
85 VAC, 9.0 V, 1.5 – 2.25 A Load Step.
V_{MIN}: 8.984 V, V_{MAX}: 9.124 V.
Upper: V_{OUT}, 0.2 V / div., 5 ms / div.
Lower: I_{LOAD}, 1 A / div.

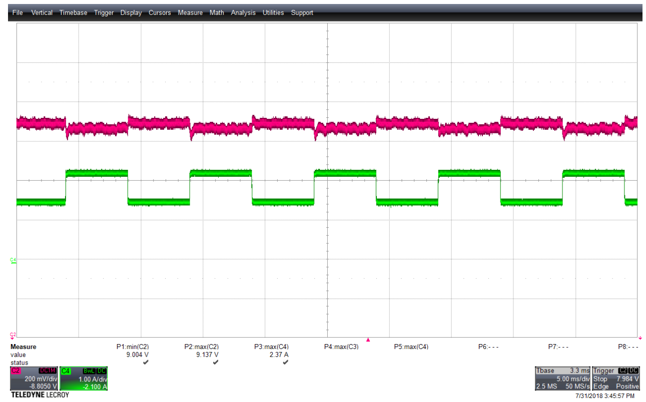

Figure 65 – Transient Response.
265 VAC, 9.0 V, 1.5 – 2.25 A Load Step.
V_{MIN}: 9.004 V, V_{MAX}: 9.137 V.
Upper: V_{OUT}, 0.2 V / div., 5 ms / div.
Lower: I_{LOAD}, 1 A / div.

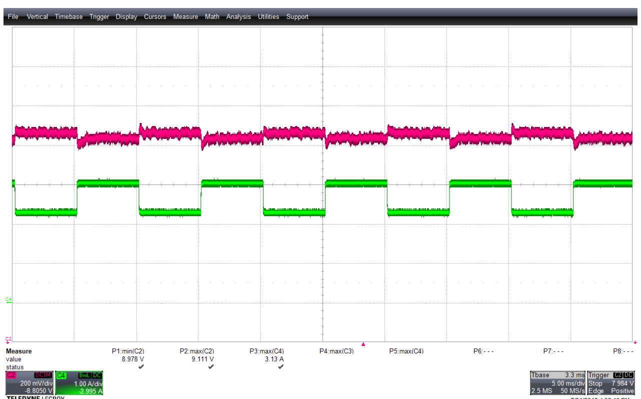

Figure 66 – Transient Response.
85 VAC, 9.0 V, 2.25 – 3 A Load Step.
V_{MIN}: 8.978 V, V_{MAX}: 9.111 V.
Upper: V_{OUT}, 0.2 V / div., 5 ms / div.
Lower: I_{LOAD}, 1 A / div.

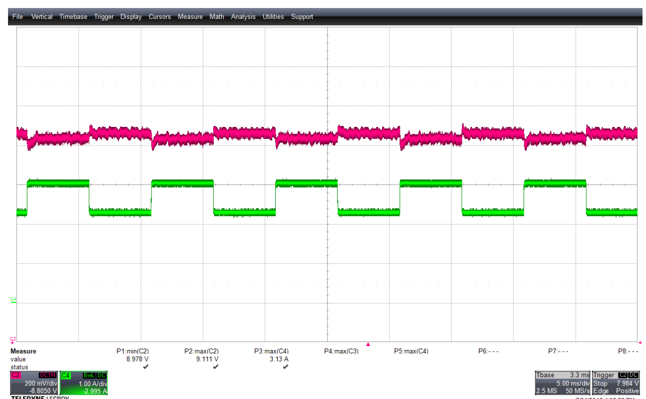

Figure 67 – Transient Response.
265 VAC, 9.0 V, 2.25 – 3 A Load Step.
V_{MIN}: 8.978 V, V_{MAX}: 9.111 V.
Upper: V_{OUT}, 0.2 V / div., 5 ms / div.
Lower: I_{LOAD}, 1 A / div..

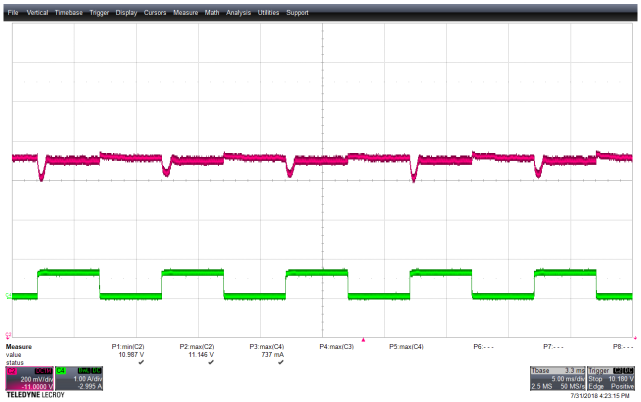

Figure 68 – Transient Response.
85 VAC, 11.0 V, 0 – 0.61 A Load Step.
V_{MIN}: 10.987 V, V_{MAX}: 11.146 V.
Upper: V_{OUT}, 0.2 V / div., 5 ms / div.
Lower: I_{LOAD}, 1 A / div.

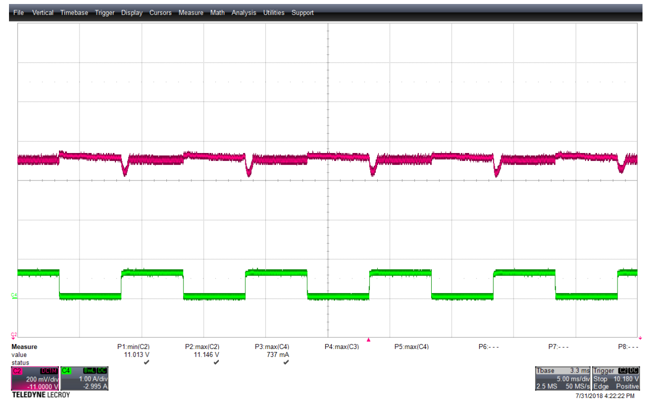

Figure 69 – Transient Response.
265 VAC, 11.0 V, 0 – 0.61 A Load Step.
V_{MIN}: 11.013 V, V_{MAX}: 11.146 V.
Upper: V_{OUT}, 0.2 V / div., 5 ms / div.
Lower: I_{LOAD}, 1 A / div..

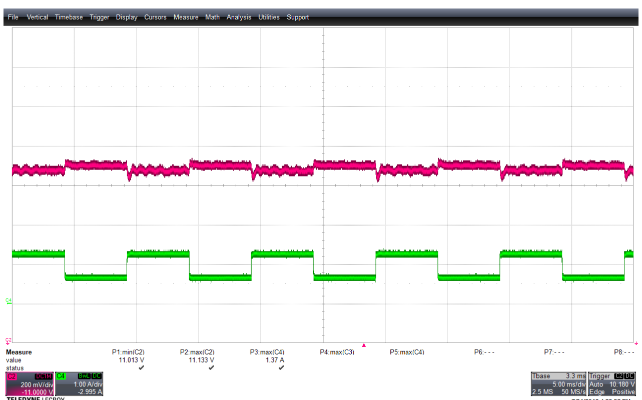

Figure 70 – Transient Response.
85 VAC, 11.0 V, 0.61 – 1.22 A Load Step.
V_{MIN}: 11.013 V, V_{MAX}: 11.133 V.
Upper: V_{OUT}, 0.2 V / div., 5 ms / div.
Lower: I_{LOAD}, 1 A / div.

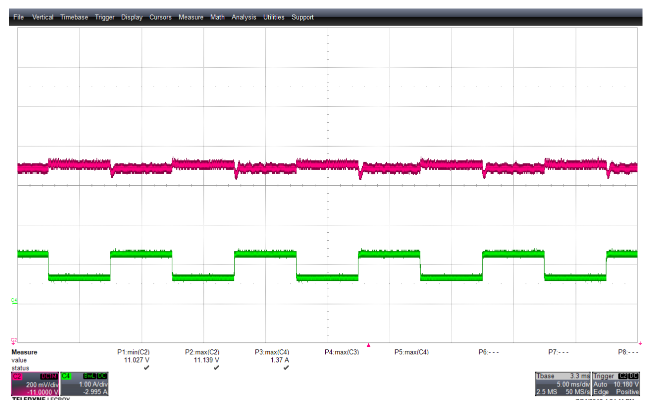

Figure 71 – Transient Response.
265 VAC, 11.0 V, 0.61 – 1.22 A Load Step.
V_{MIN}: 11.027 V, V_{MAX}: 11.139 V.
Upper: V_{OUT}, 0.2 V / div., 5 ms / div.
Lower: I_{LOAD}, 1 A / div.

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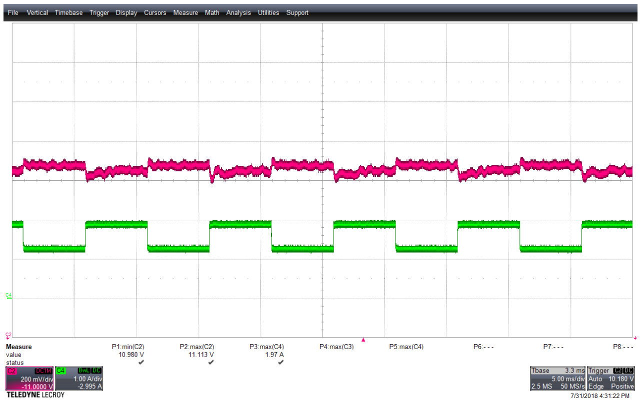

Figure 72 – Transient Response.
85 VAC, 11 V, 1.22 – 1.835 A Load Step.
V_{MIN}: 10.980 V, V_{MAX}: 11.113 V.
Upper: V_{OUT}, 0.2 V / div., 5 ms / div.
Lower: I_{LOAD}, 1 A / div.

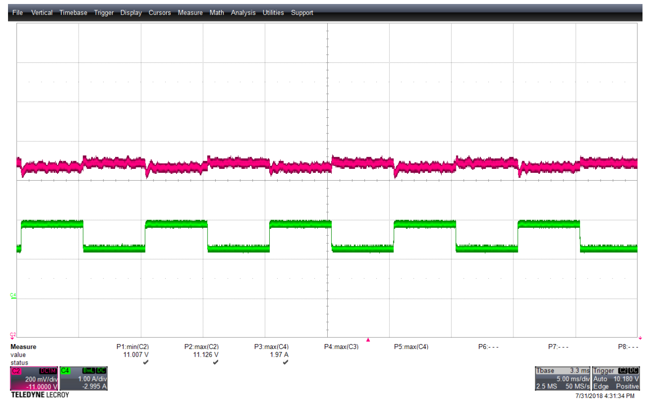

Figure 73 – Transient Response.
265 VAC, 11 V, 1.22 – 1.835 A Load Step.
V_{MIN}: 11.007 V, V_{MAX}: 11.126 V.
Upper: V_{OUT}, 0.2 V / div., 5 ms / div.
Lower: I_{LOAD}, 1 A / div.

Figure 74 – Transient Response.
85 VAC, 11 V, 1.835 – 2.45 A Load Step.
V_{MIN}: 10.940 V, V_{MAX}: 11.093 V.
Upper: V_{OUT}, 0.2 V / div., 5 ms / div.
Lower: I_{LOAD}, 1 A / div.

Figure 75 – Transient Response.
265 VAC, 11 V, 1.83 – 2.45 A Load Step.
V_{MIN}: 10.987 V, V_{MAX}: 11.106 V.
Upper: V_{OUT}, 0.2 V / div., 5 ms / div.
Lower: I_{LOAD}, 1 A / div.

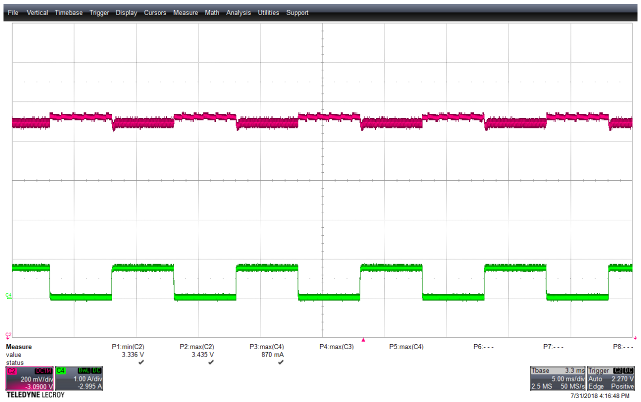

Figure 76 – Transient Response.
85 VAC, 3.3 V, 0 – 0.75 A Load Step.
V_{MIN}: 3.336 V, V_{MAX}: 3.435 V.
Upper: V_{OUT}, 0.2 V / div., 5 ms / div.
Lower: I_{LOAD}, 1 A / div.

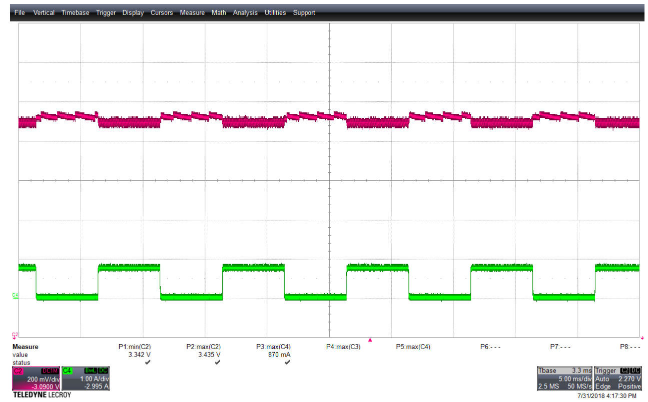

Figure 77 – Transient Response.
265 VAC, 3.3 V, 0 – 0.75A Load Step.
V_{MIN}: 3.342 V, V_{MAX}: 3.435.
Upper: V_{OUT}, 0.2 V / div., 5 ms / div.
Lower: I_{LOAD}, 2 A / div.

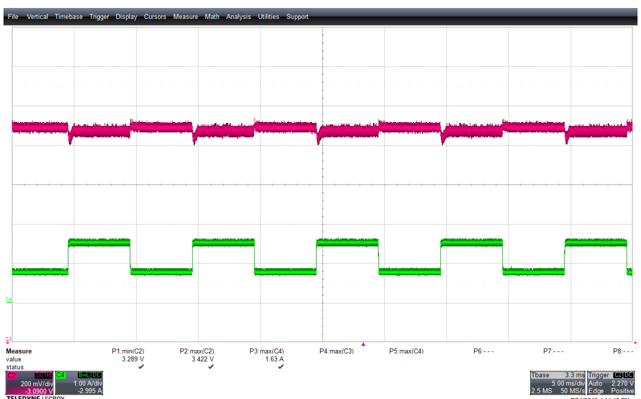

Figure 78 – Transient Response.
85 VAC, 3.3 V, 0.75 – 1.5 A Load Step.
V_{MIN}: 3.289 V, V_{MAX}: 3.422 V.
Upper: V_{OUT}, 0.2 V / div., 5 ms / div.
Lower: I_{LOAD}, 1 A / div.

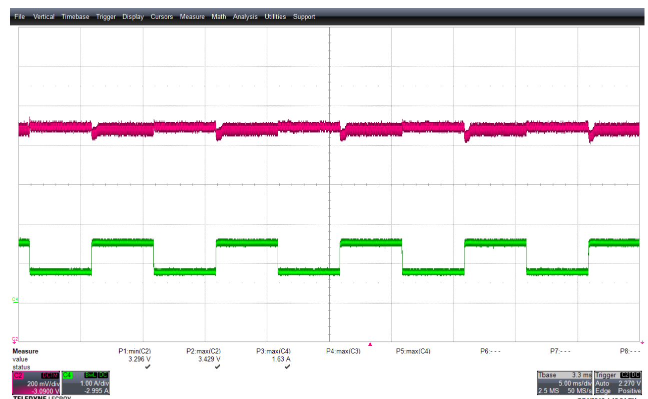

Figure 79 – Transient Response.
265 VAC, 3.3 V, 0.75 – 1.5 A Load Step.
V_{MIN}: 3.296 V, V_{MAX}: 3.429 V.
Upper: V_{OUT}, 0.2 V / div., 5 ms / div.
Lower: I_{LOAD}, 2 A / div.

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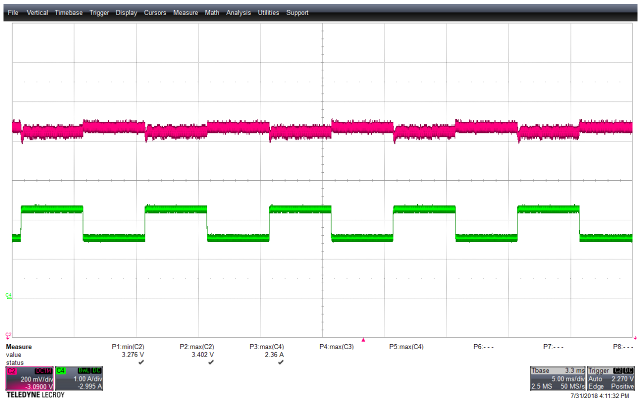

Figure 80 – Transient Response.
85 VAC, 3.3 V, 1.5 – 2.25 A Load Step.
V_{MIN}: 3.276 V, V_{MAX}: 3.402 V.
Upper: V_{OUT}, 0.2 V / div., 5 ms / div.
Lower: I_{LOAD}, 1 A / div.

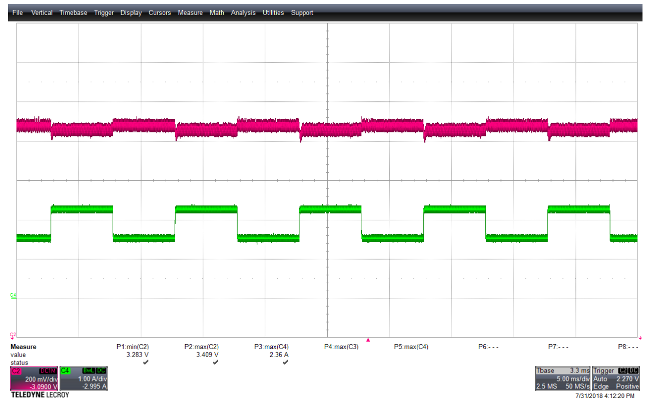

Figure 81 – Transient Response.
265 VAC, 3.3 V, 1.5 – 2.25 A Load Step.
V_{MIN}: 3.283 V, V_{MAX}: 3.409 V.
Upper: V_{OUT}, 0.2 V / div., 5 ms / div.
Lower: I_{LOAD}, 2 A / div.

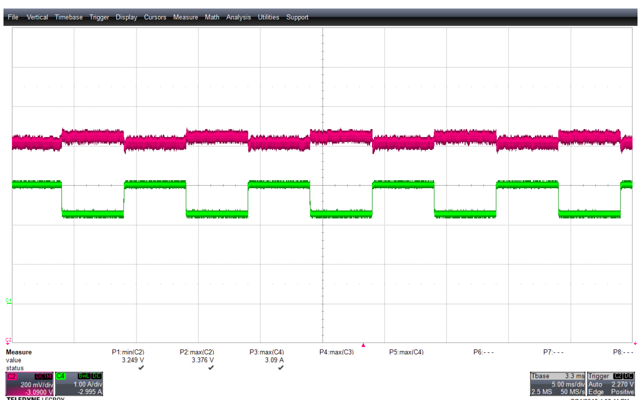

Figure 82 – Transient Response.
85 VAC, 3.3 V, 2.25 – 3 A Load Step.
V_{MIN}: 3.249 V, V_{MAX}: 3.376 V.
Upper: V_{OUT}, 0.2 V / div., 5 ms / div.
Lower: I_{LOAD}, 1 A / div.

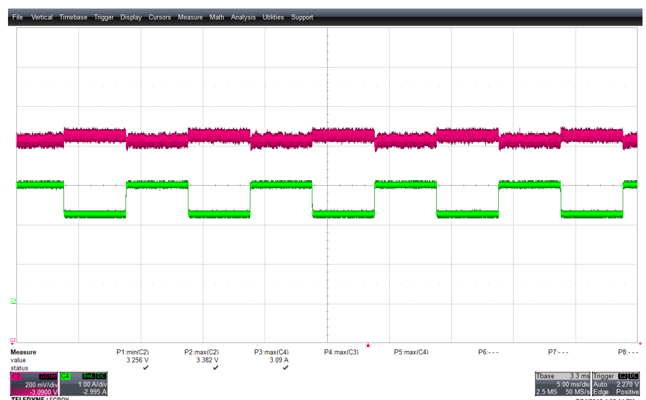

Figure 83 – Transient Response.
265 VAC, 3.3 V, 2.25 – 3 A Load Step.
V_{MIN}: 3.256 V, V_{MAX}: 3.382 V.
Upper: V_{OUT}, 0.2 V / div., 50 ms / div.
Lower: I_{LOAD}, 2 A / div.

13.2 Switching Waveforms

13.2.1 Primary Drain Voltage and Current

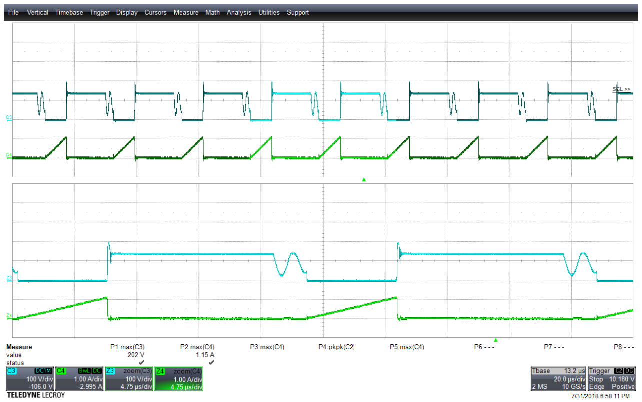

Figure 84 – Drain Voltage and Current Waveforms.
85 VAC, 5.0 V, 3 A Load (202 V_{MAX}).
Upper: V_{DRAIN}, 100 V, 20 µs / div.
Lower: I_{DRAIN}, 1 A / div.
Zoom: 4.75 µs / div.

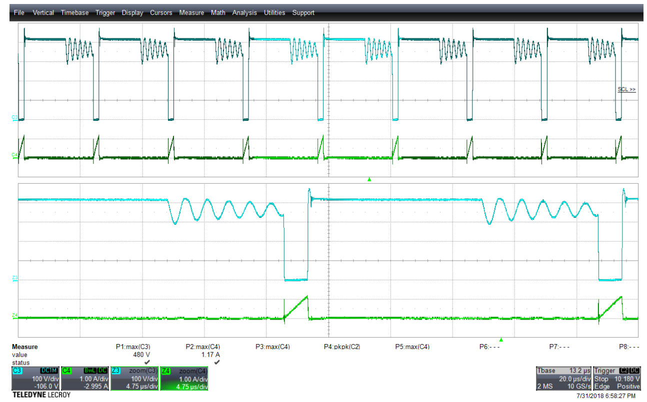

Figure 85 – Drain Voltage and Current Waveforms.
265 VAC, 5.0 V, 3 A Load (480 V_{MAX}).
Upper: V_{DRAIN}, 100 V, 20 µs / div.
Lower: I_{DRAIN}, 1 A / div.
Zoom: 4.75 µs / div.

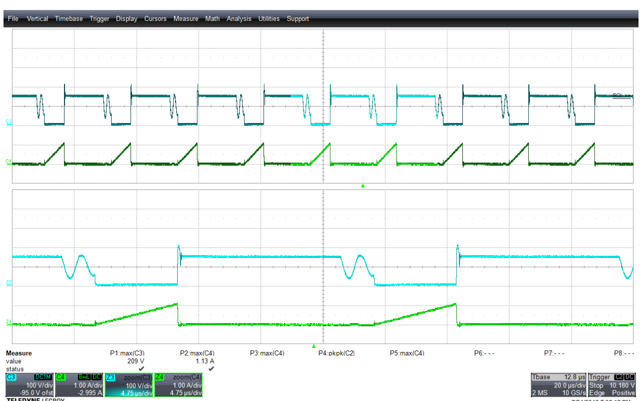

Figure 86 – Drain Voltage and Current Waveforms.
85 VAC, 9.0 V, 3 A Load (209 V_{MAX}).
Upper: V_{DRAIN}, 100 V, 20 µs / div.
Lower: I_{DRAIN}, 1 A / div.
Zoom: 4.75 µs / div.

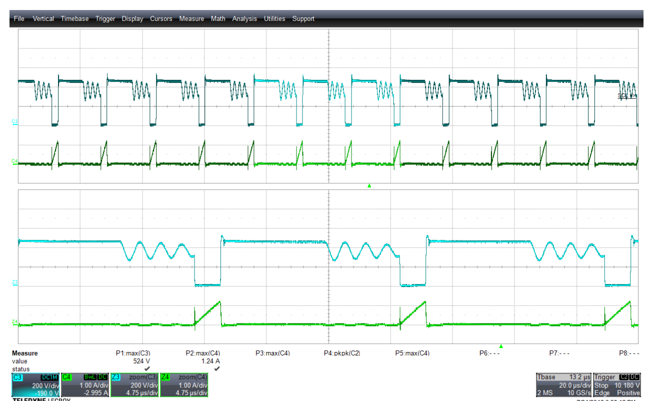

Figure 87 – Drain Voltage and Current Waveforms.
265 VAC, 9 V, 3 A Load (524 V_{MAX}).
Upper: V_{DRAIN}, 200 V, 20 µs / div.
Lower: I_{DRAIN}, 1 A / div.
Zoom: 4.75 µs / div.

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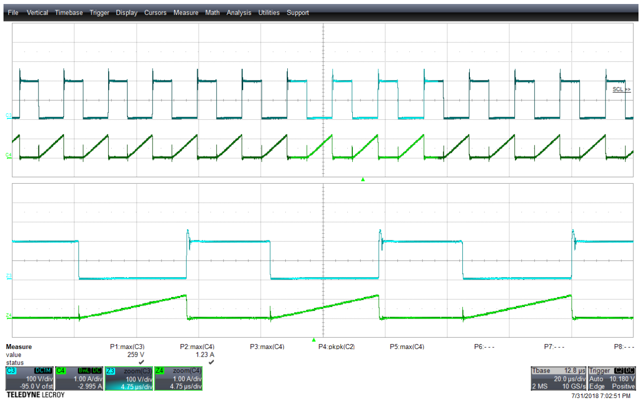

Figure 88 – Drain Voltage and Current Waveforms.
85 VAC, 11.0 V, 2.45 A Load (250 V_{MAX}).
Upper: V_{DRAIN}, 100 V, 20 μs / div.
Lower: I_{DRAIN}, 1 A / div.
Zoom: 4.75 μs / div.

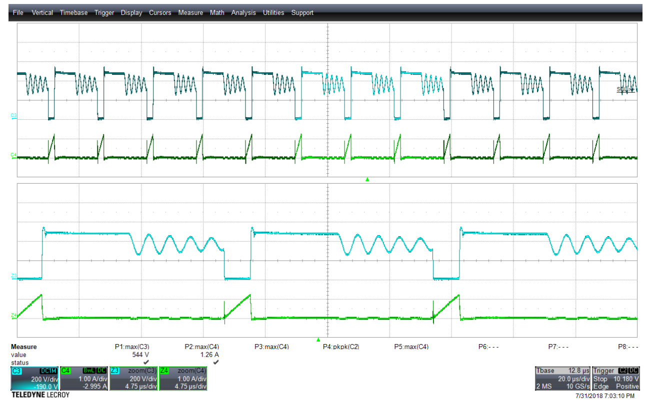

Figure 89 – Drain Voltage and Current Waveforms.
265 VAC, 11.0 V, 2.45 A Load (544 V_{MAX}).
Upper: V_{DRAIN}, 200 V, 20 μs / div.
Lower: I_{DRAIN}, 1 A / div.
Zoom: 4.75 μs / div.

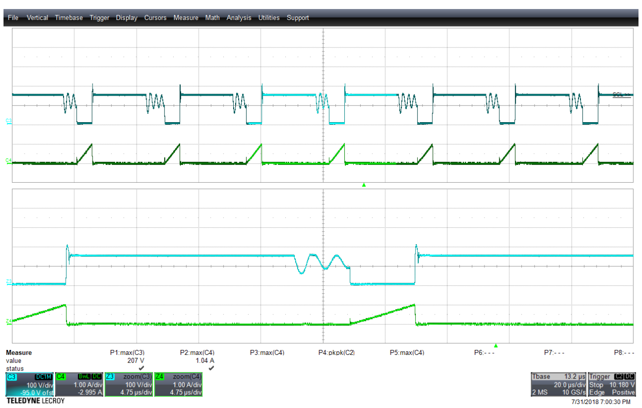

Figure 90 – Drain Voltage and Current Waveforms.
85 VAC, 3.3 V, 3 A Load (207 V_{MAX}).
Upper: V_{DRAIN}, 100 V, 20 μs / div.
Lower: I_{DRAIN}, 1 A / div.
Zoom: 4.75 μs / div.

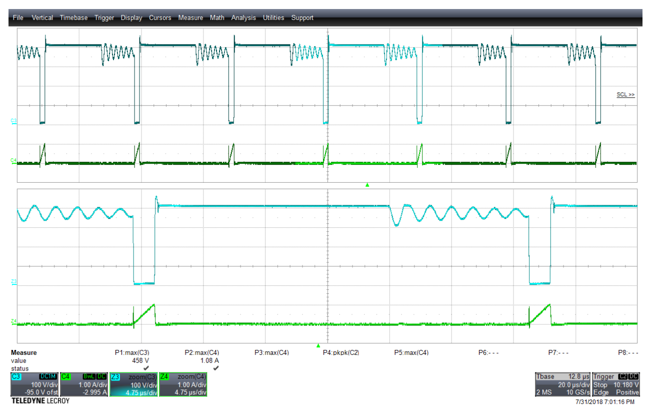

Figure 91 – Drain Voltage and Current Waveforms.
265 VAC, 3.3 V, 3 A Load (458 V_{MAX}).
Upper: V_{DRAIN}, 100 V, 20 μs / div.
Lower: I_{DRAIN}, 1 A / div.
Zoom: 4.75 μs / div.

13.2.2 SR FET Voltage

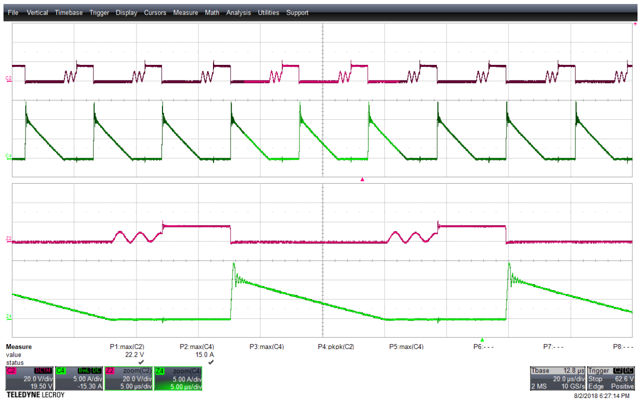

Figure 92 – SR FET Voltage Waveforms.
85 VAC, 5.0 V, 3 A Load (22.2 V_{MAX}).
Upper: V_{DRAIN}, 20 V, 20 µs / div.
Lower: I_{DRAIN}, 5 A / div.
Zoom: 5 µs / div.

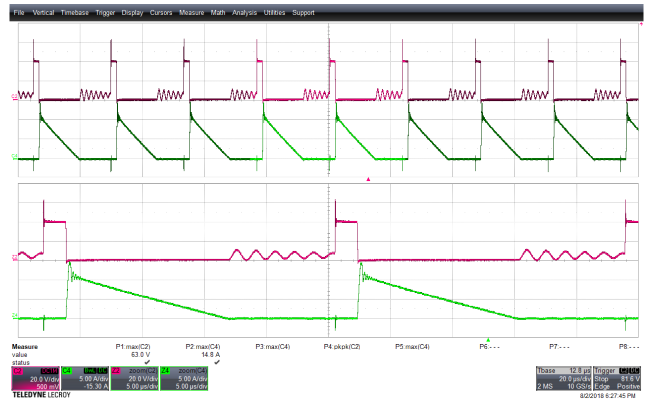

Figure 93 – SR FET Voltage Waveforms.
265 VAC, 5.0 V, 3 A Load (63 V_{MAX}).
Upper: V_{DRAIN}, 50 V, 20 µs / div.
Lower: I_{DRAIN}, 5 A / div.
Zoom: 5 µs / div.

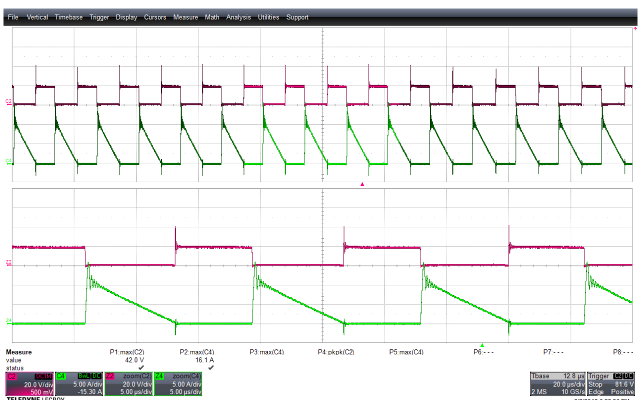

Figure 94 – SR FET Voltage Waveforms.
85 VAC, 9.0 V, 3 A Load (42 V_{MAX}).
Upper: V_{DRAIN}, 20 V, 20 µs / div.
Lower: I_{DRAIN}, 5 A / div.
Zoom: 5 µs / div.

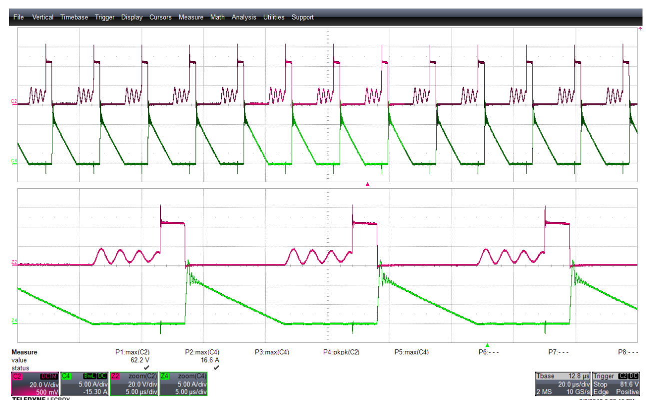

Figure 95 – SR FET Voltage Waveforms.
265 VAC, 9.0 V, 3 A Load (62.2 V_{MAX}).
Upper: V_{DRAIN}, 20 V, 20 µs / div.
Lower: I_{DRAIN}, 5 A / div.
Zoom: 5 µs / div.

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Figure 96 – SR FET Voltage Waveforms.
85 VAC, 11.0 V, 2.45 A Load (42.9 V_{MAX}).
Upper: V_{DRAIN}, 20 V, 20 μs / div.
Lower: I_{DRAIN}, 5 A / div.
Zoom: 2 μs / div.

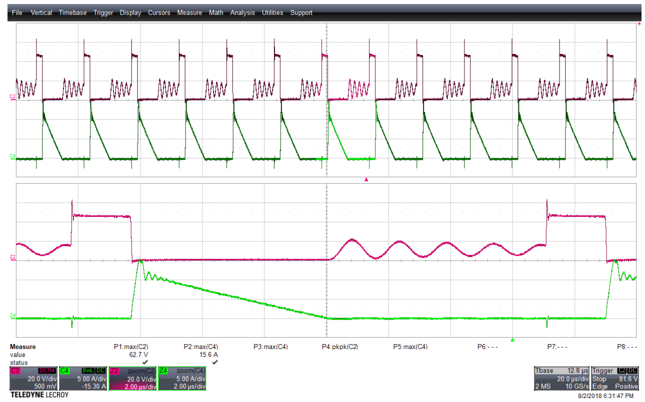

Figure 97 – SR FET Voltage Waveforms.
265 VAC,11.0 V,2.45 A Load (62.7 V_{MAX}).
Upper: V_{DRAIN}, 20 V, 20 μs / div.
Lower: I_{DRAIN}, 5 A / div.
Zoom: 2 μs / div.

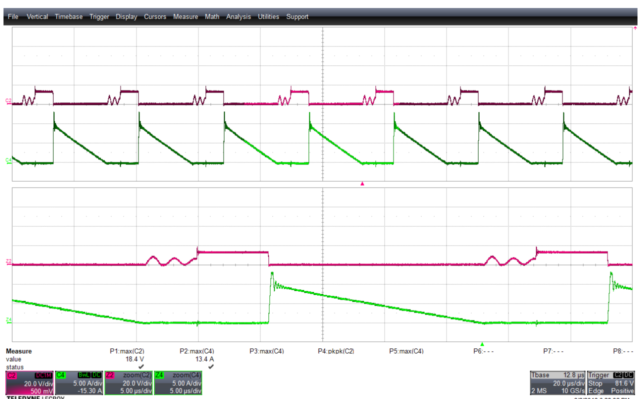

Figure 98 – SR FET Voltage Waveforms.
85 VAC, 3.3 V, 3 A Load (18.4 V_{MAX}).
Upper: V_{DRAIN}, 20 V, 20 μs / div.
Lower: I_{DRAIN}, 5 A / div.
Zoom: 5 μs / div.

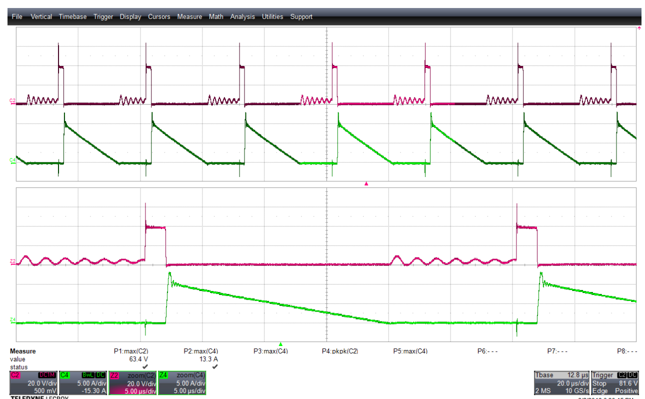

Figure 99 – SR FET Voltage Waveforms.
265 VAC, 3.3 V, 3 A Load (63.4 V_{MAX}).
Upper: V_{DRAIN}, 20 V, 20 μs / div.
Lower: I_{DRAIN}, 5 A / div.
Zoom: 5 μs / div.

13.3 Start-up

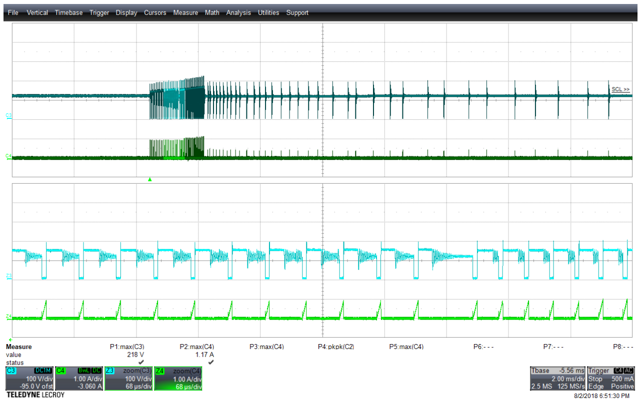

Figure 100 – Drain Voltage and Current Waveforms.
85 VAC, 5.0 V, 3 A Load (218 V_{MAX}).
Upper: V_{DRAIN}, 100 V, 2 ms / div.
Lower: I_{DRAIN}, 1 A / div.
Zoom: 68 µs / div.

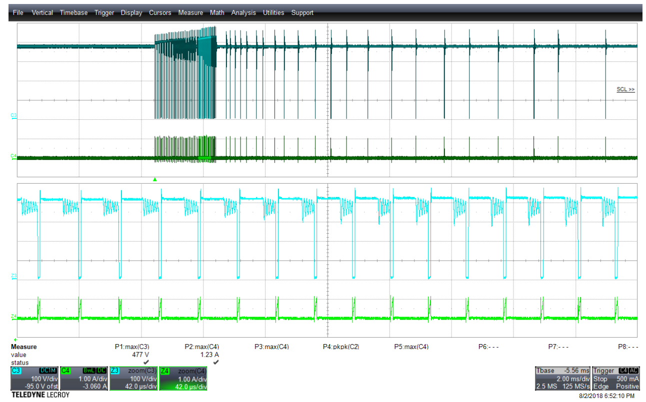

Figure 101 – Drain Voltage and Current Waveforms.
265 VAC, 5.0 V, 3 A Load (477.0 V_{MAX}).
Upper: V_{DRAIN}, 100 V, 2 ms / div.
Lower: I_{DRAIN}, 1 A / div.
Zoom: 42 µs / div.

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13.4 Output Ripple Measurements

13.4.1 Ripple Measurement Technique

For DC output ripple measurements, a modified oscilloscope test probe must be utilized in order to reduce spurious signals due to pick-up. Details of the probe modification are provided in the Figures below.

The 4987BA probe adapter is affixed with two capacitors tied in parallel across the probe tip. The capacitors include one (1) 0.1 μF/50 V ceramic type and one (1) 47 μF/50 V aluminum electrolytic. The aluminum electrolytic type capacitor is polarized, so proper polarity across DC outputs must be maintained (see below).

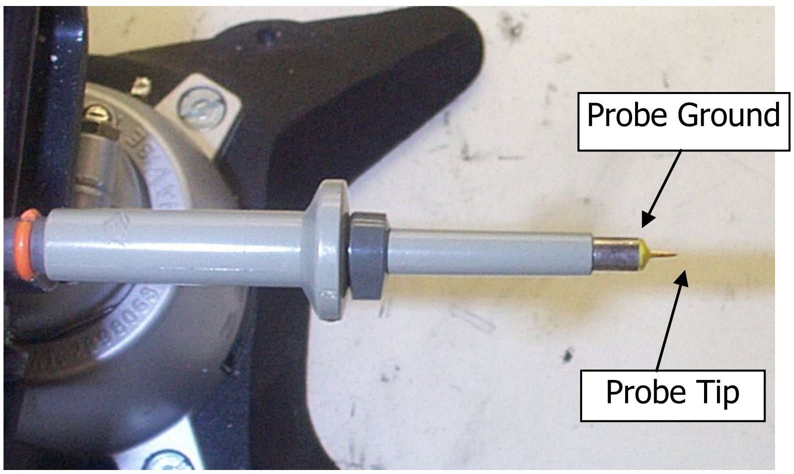

Figure 102 – Oscilloscope Probe Prepared for Ripple Measurement. (End Cap and Ground Lead Removed)

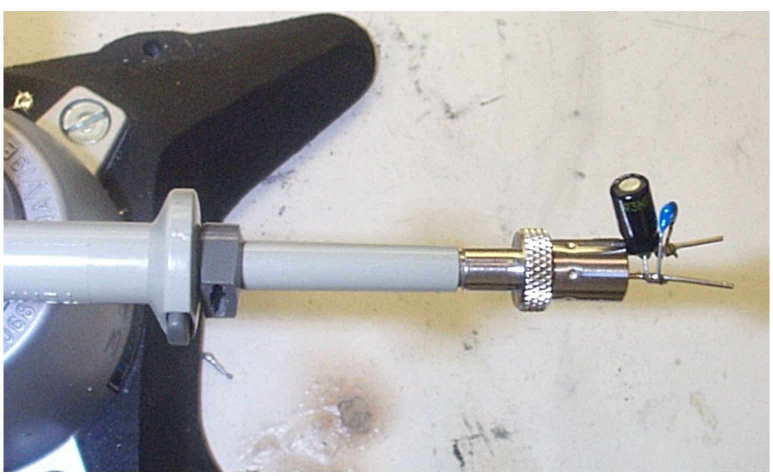

Figure 103 – Oscilloscope Probe with Probe Master (**www.probemaster.com**) 4987A BNC Adapter. (Modified with wires for ripple measurement, and two parallel decoupling capacitors added)

13.4.1.1 5 V (End of 100 mΩ Type-C Cable)

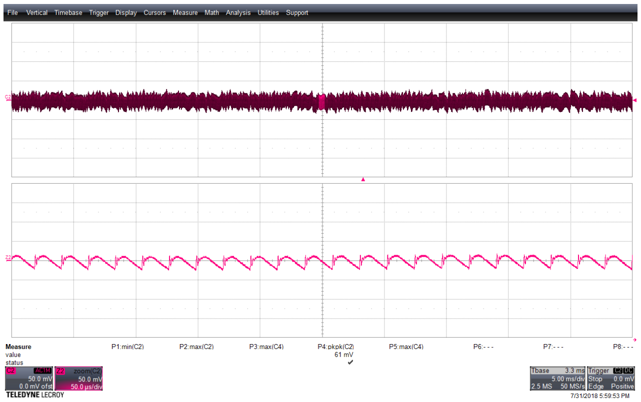

Figure 104 – Output Ripple. PK-PK = 61 mV.
85 VAC_{IN} 5.0 V, 3 A Load.
V_{OUT}, 50 mV / div., 5 ms / div.
Zoom: 50 µs / div.

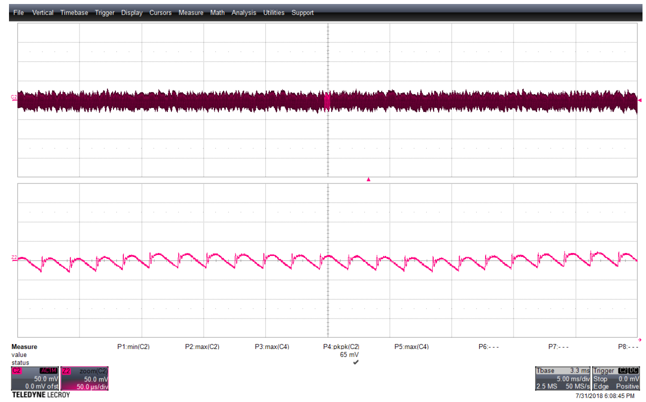

Figure 105 – Output Ripple. PK-PK = 65 mV.
115 VAC_{IN} 5.0 V, 3 A Load.
V_{OUT}, 50 mV / div., 5 ms / div.
Zoom: 50 µs / div.

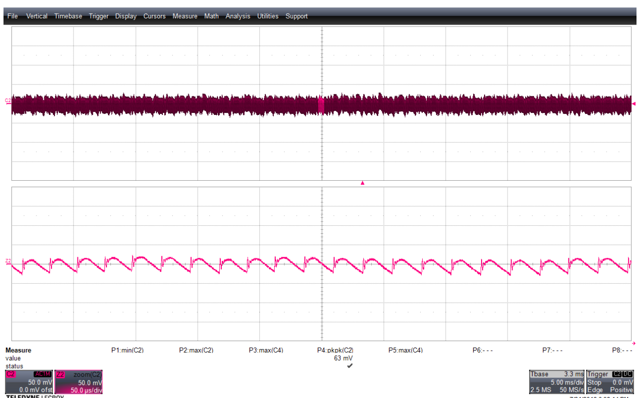

Figure 106 – Output Ripple. PK-PK = 63 mV.
115 VAC_{IN} 5.0 V, 3 A Load.
V_{OUT}, 50 mV / div., 5 ms / div.
Zoom: 50 µs / div.

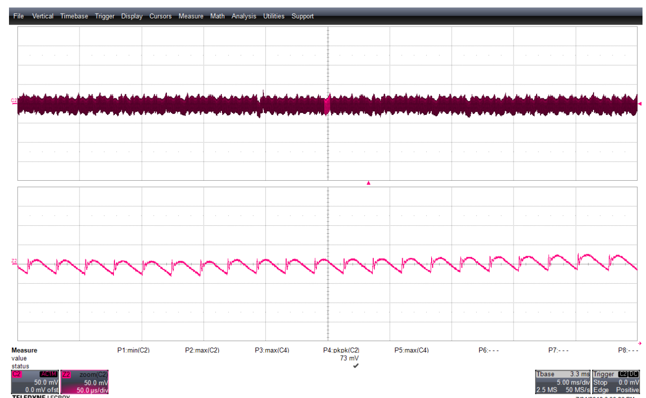

Figure 107 – Output Ripple. PK-PK = 73 mV.
265 VAC_{IN} 5.0 V, 3 A Load.
V_{OUT}, 50 mV / div., 5 ms / div.
Zoom: 50 µs / div.

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13.4.1.2 9 V (End of 100 mΩ Type-C Cable)

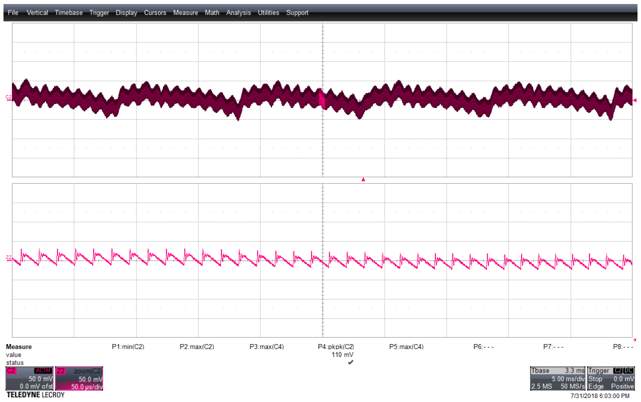

Figure 108 – Output Ripple. PK-PK = 110 mV
85 VAC_{IN} 9.0 V, 3 A Load.
V_{OUT}, 50 mV / div., 5 ms / div.
Zoom: 50 µs / div.

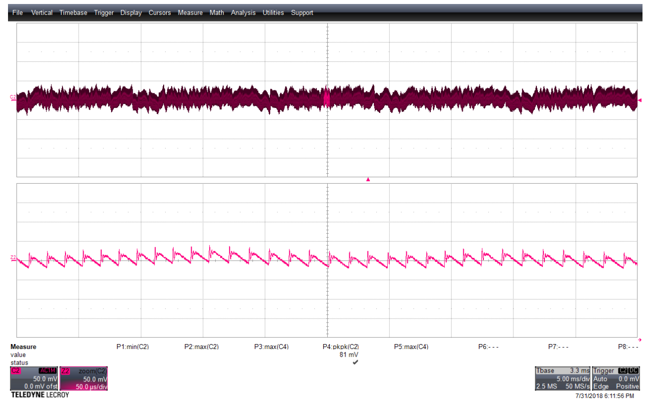

Figure 109 – Output Ripple. PK-PK = 83 mV
115 VAC_{IN} 9.0 V, 3 A Load.
V_{OUT}, 50 mV / div., 5 ms / div.
Zoom: 50 µs / div.

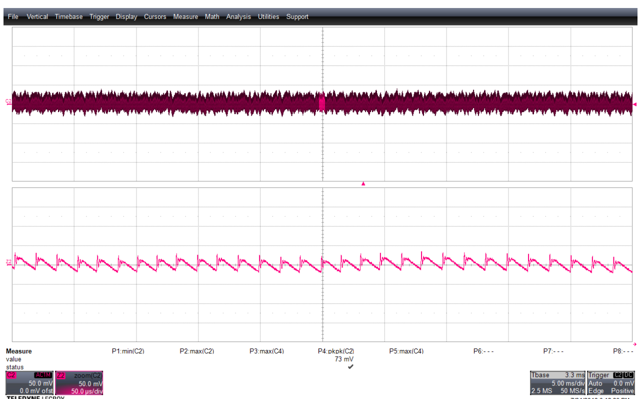

Figure 110 – Output Ripple. PK-PK = 73 mV
230 VAC_{IN} 9.0 V, 3 A Load.
V_{OUT}, 50 mV / div., 5 ms / div.
Zoom: 50 µs / div.

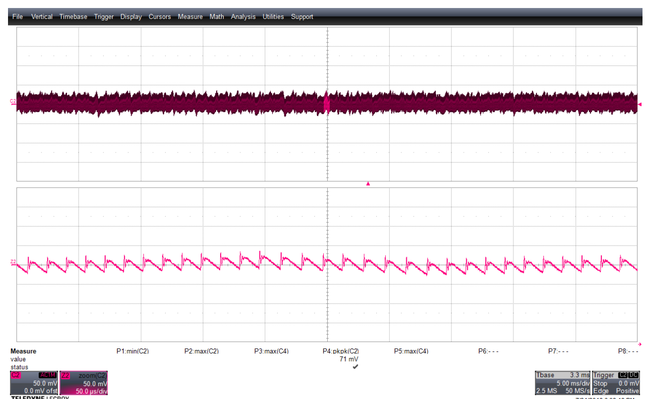

Figure 111 – Output Ripple. PK-PK = 71 mV
265 VAC_{IN} 9.0 V, 3 A Load.
V_{OUT}, 50 mV / div., 5 ms / div.
Zoom: 50 µs / div.

13.4.1.3 11 V (end of 100 mΩ Type-C cable)

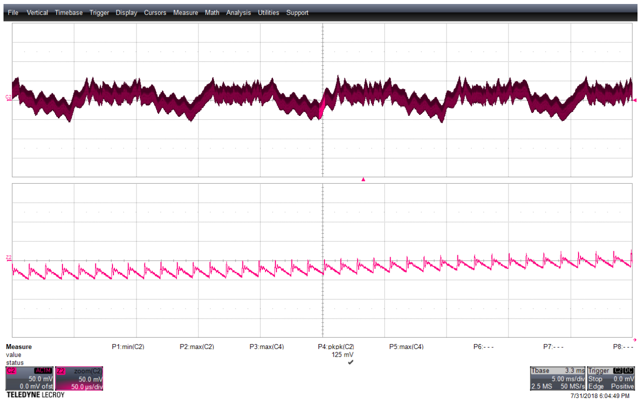

Figure 112 – Output Ripple. PK-PK = 125 mV.
85 VAC_{IN}, 11.0 V, 2.45 A Load.
V_{OUT}, 50 mV / div., 5 ms / div.
Zoom: 50 µs / div.

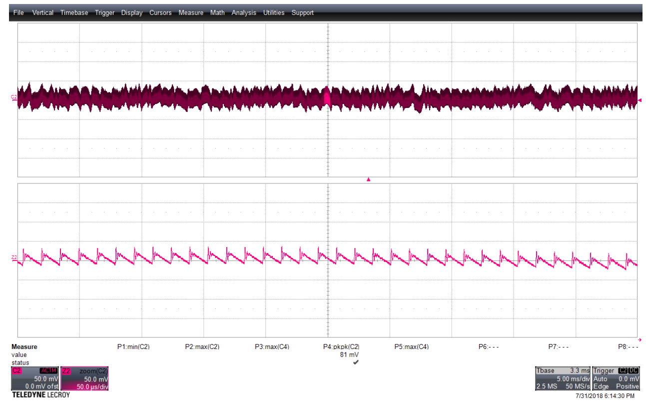

Figure 113 – Output Ripple. PK-PK = 81 mV.
265 VAC_{IN} 11.0 V, 2.45 A Load.
V_{OUT}, 50 mV / div., 5 ms / div.
Zoom: 50 µs / div.

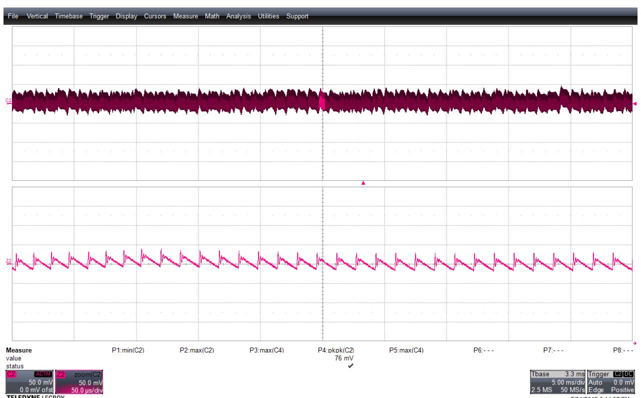

Figure 114 – Output Ripple. PK-PK = 76 mV.
265 VAC_{IN} 11.0 V, 2.45 A Load.
V_{OUT}, 50 mV / div., 5 ms / div.
Zoom: 50 µs / div.

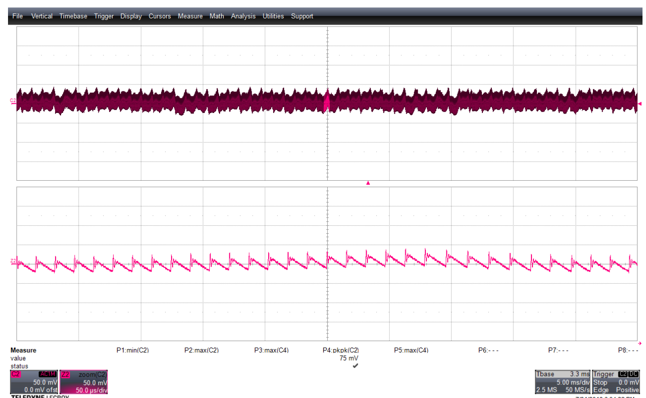

Figure 115 – Output Ripple. PK-PK = 75 mV.
265 VAC_{IN} 11.0 V, 2.45 A Load.
V_{OUT}, 50 mV / div., 5 ms / div.
Zoom: 50 µs / div.

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13.4.1.4 3.3 V (End of 100 mΩ Type-C Cable)

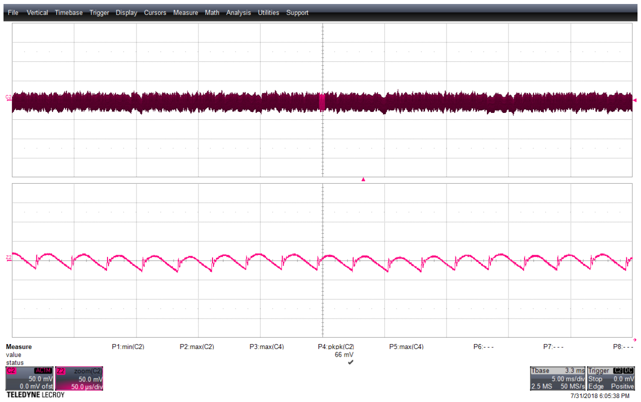

Figure 116 – Output Ripple. PK-PK = 66 mV.
85 VAC_{IN}, 3.3 V, 3 A Load.
V_{OUT}, 50 mV / div., 5 ms / div.
Zoom: 50 µs / div.

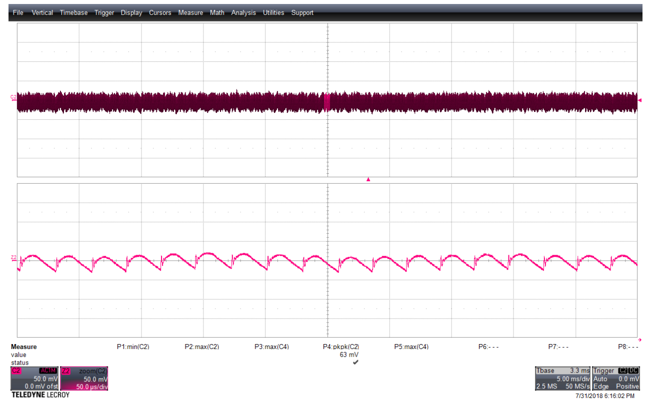

Figure 117 – Output Ripple. PK-PK = 63 mV.
115 VAC_{IN}, 3.3 V, 3 A Load.
V_{OUT}, 50 mV / div., 5 ms / div.
Zoom: 50 µs / div.

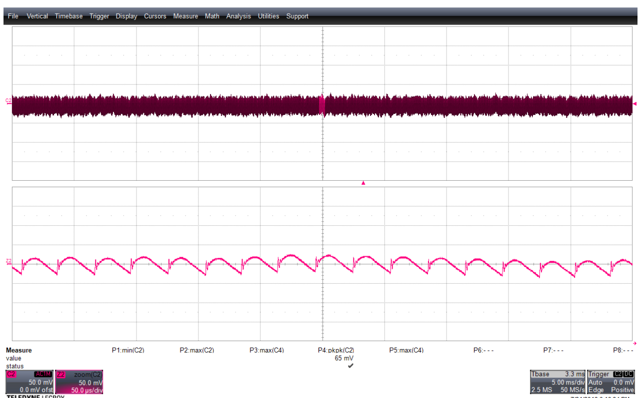

Figure 118 – Output Ripple. PK-PK = 61 mV.
230 VAC_{IN} 3.3 V, 3 A Load.
V_{OUT}, 50 mV / div., 5 ms / div.
Zoom: 50 µs / div.

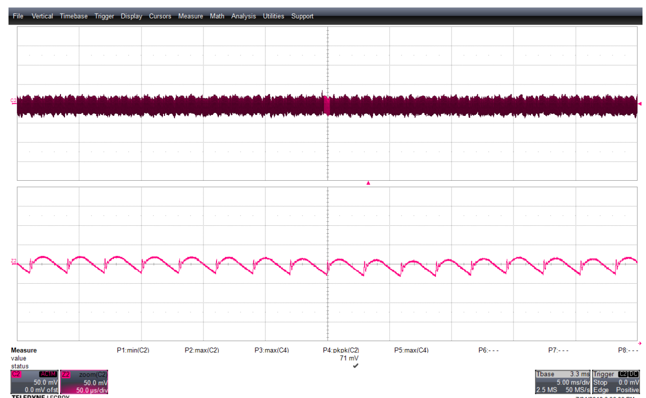

Figure 119 – Output Ripple. PK-PK = 71 mV.
265 VAC_{IN} 3.3 V, 3 A Load.
V_{OUT}, 50 mV / div., 5 ms / div.
Zoom: 50 µs / div.

14 CV/CC Profile

Note:

1. Voltage is measured at the end of cable. Drop in voltage is due to cable drop.
2. Positive slope in CC region is per the guidelines of USB PD3.0 PPS specification.

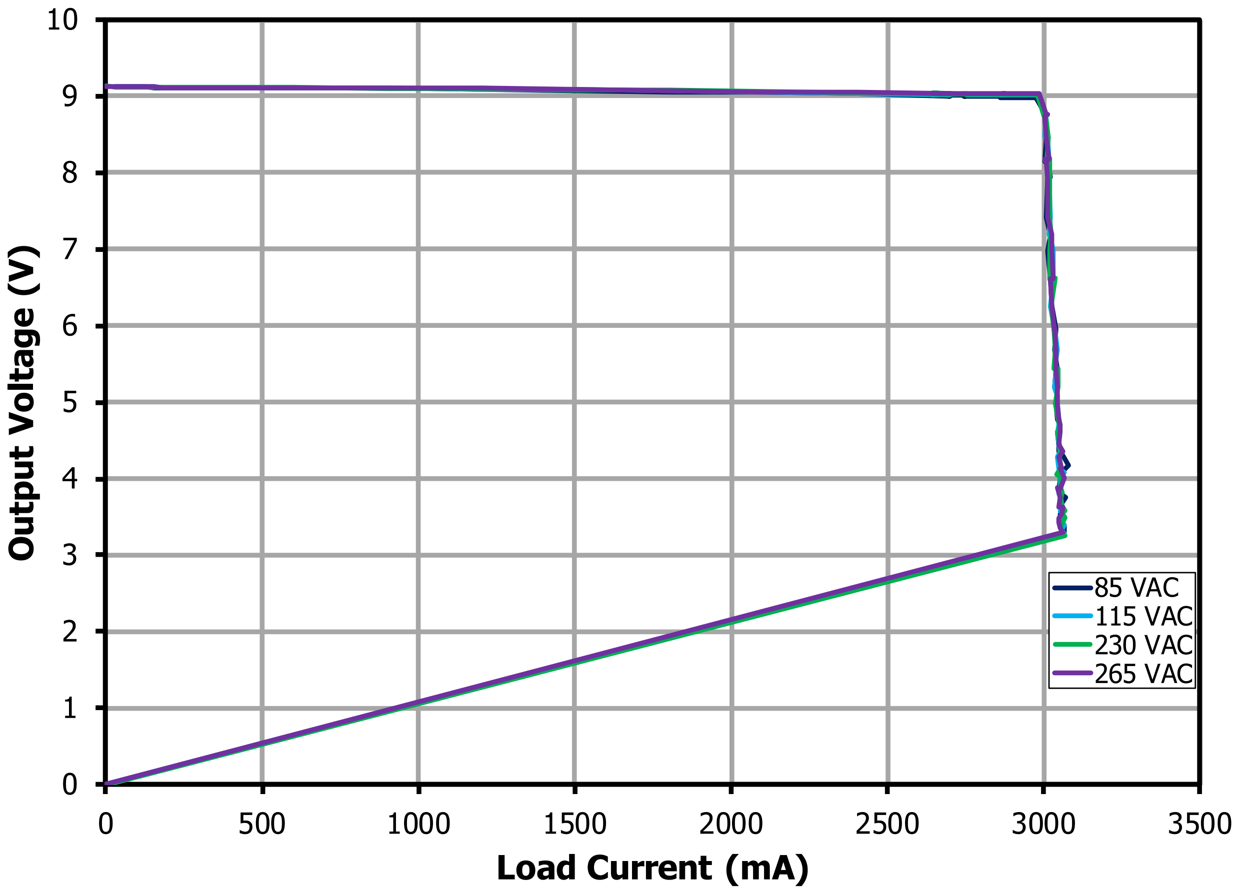

Figure 120 – CV/CC Profile with Output 9 V, 3 A.

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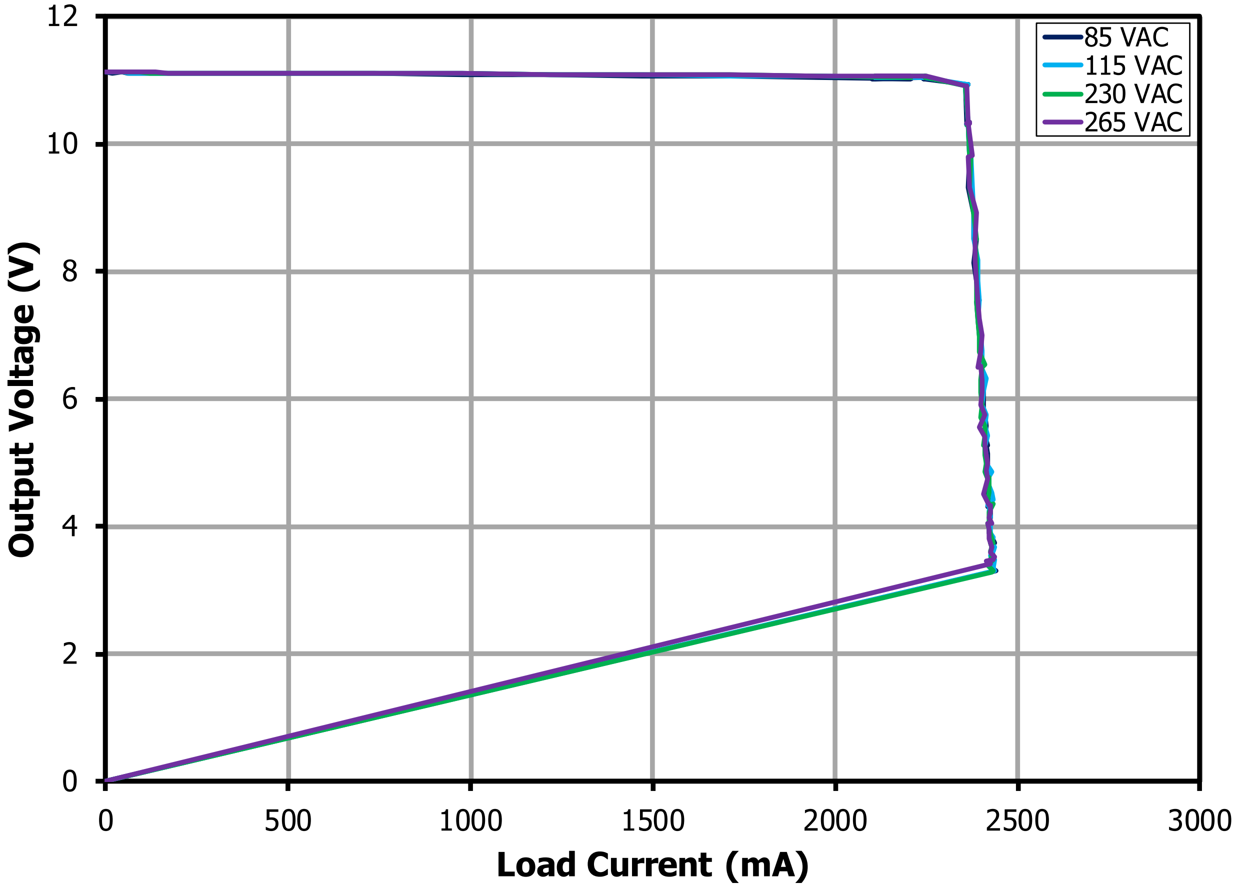

Figure 121 – CV/CC Profile with Output 11 V, 2.45 A.

15 Voltage and Current Step Test using Quadramax and Total Phase Analyzer

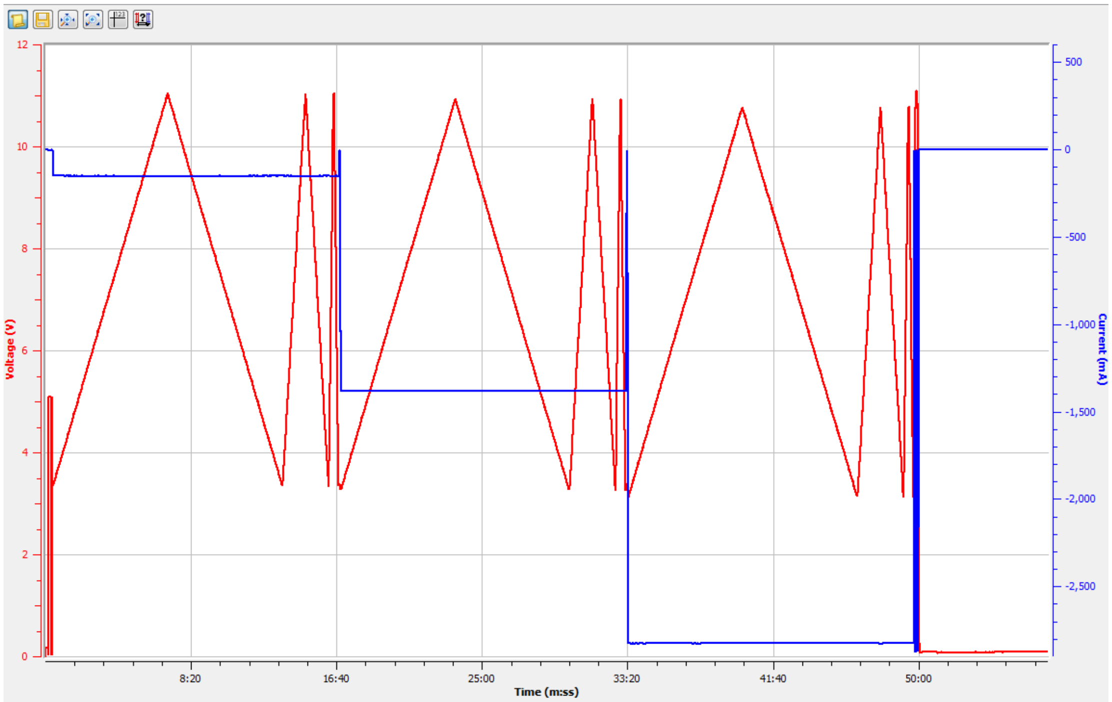

Figure 122 – Plot of SPT.6 VST Test from Total Phase Analyzer.

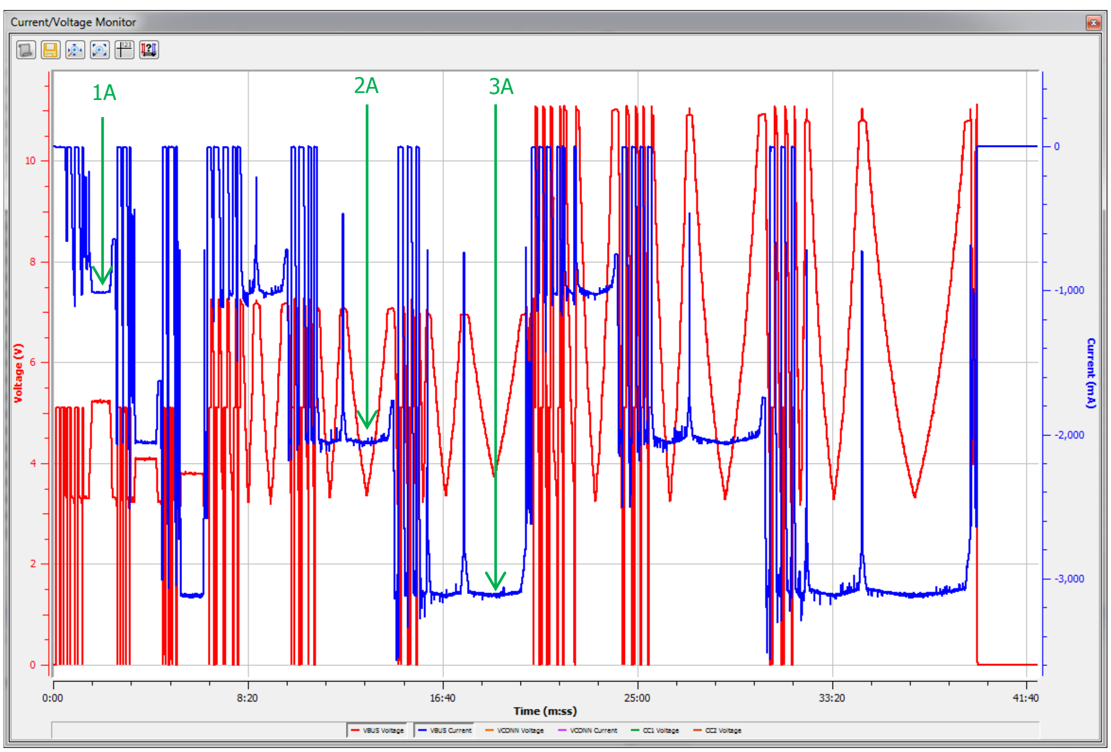

Figure 123 – B Plot of SPT.7 CLT Test from Total Phase Analyzer.

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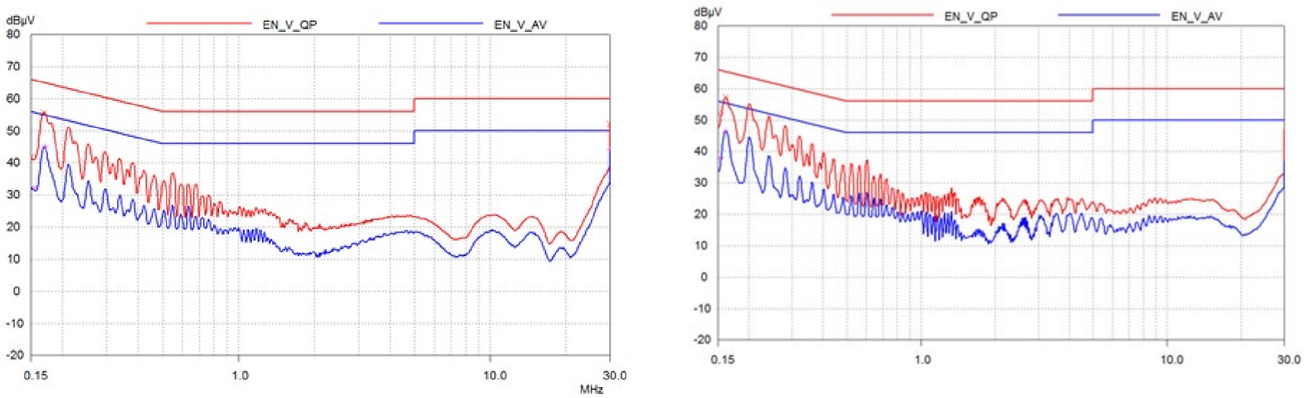
16 Conducted EMI

16.1 Floating Ground (QPK / AV)

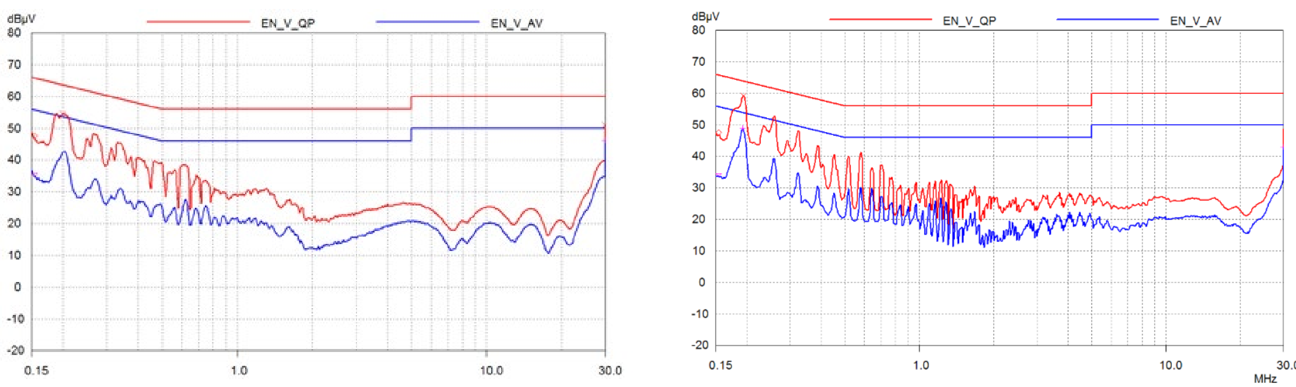
16.1.1 5 V, 3 A



115 VAC_{IN}. 230 VAC_{IN}.

Figure 124 – Floating Ground EMI, 5 V / 3 A Load [Neutral Scan].

16.1.2 9 V, 3 A

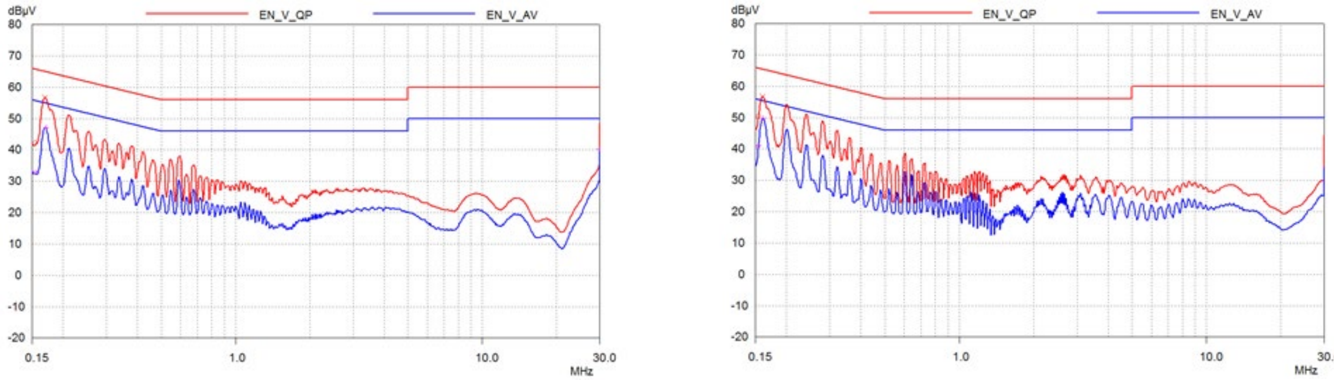


115 VAC_{IN}. 230 VAC_{IN}.

Figure 125 – Floating Ground EMI, 9 V / 3 A Load [Neutral Scan].

16.2 Artificial Hand Ground (QPK / AV)

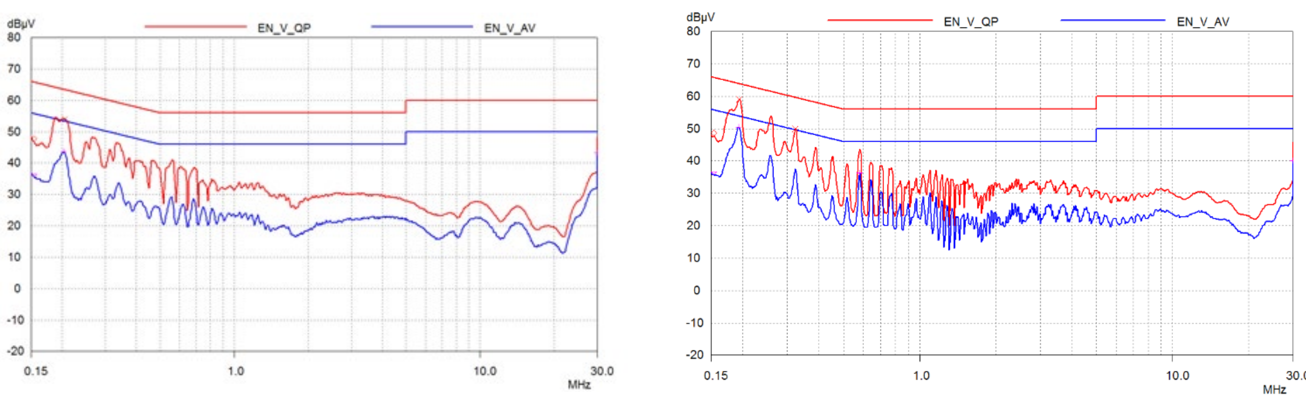
16.2.1 5 V, 3 A



115 VAC_{IN}. 230 VAC_{IN}.

Figure 126 – Artificial Hand Ground EMI, 5 V / 3 A Load [Neutral Scan].

16.2.2 9 V, 3 A



115 VAC_{IN}. 230 VAC_{IN}.

Figure 127 – Artificial Hand Ground EMI, 9 V / 3 A Load [Neutral Scan].

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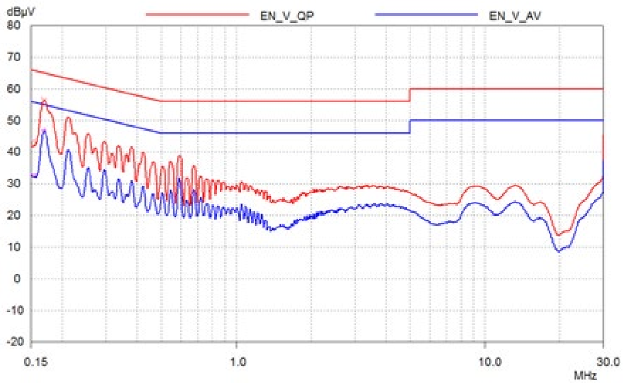
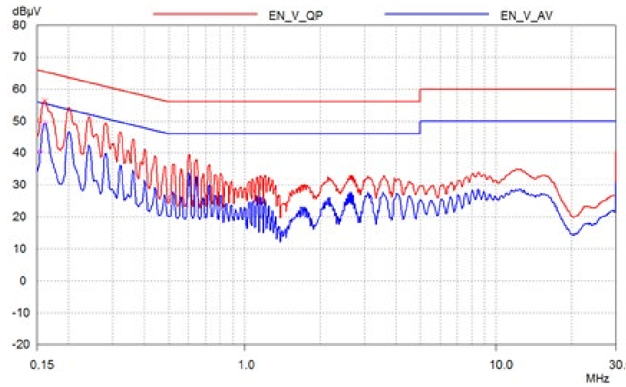
16.3 Earth Ground (QPK / AV)

16.3.1 5 V, 3 A

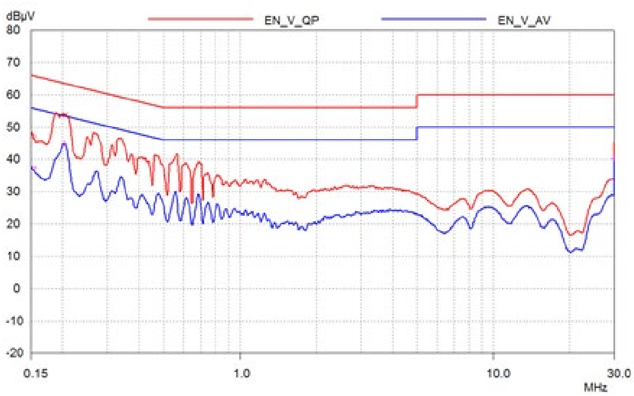


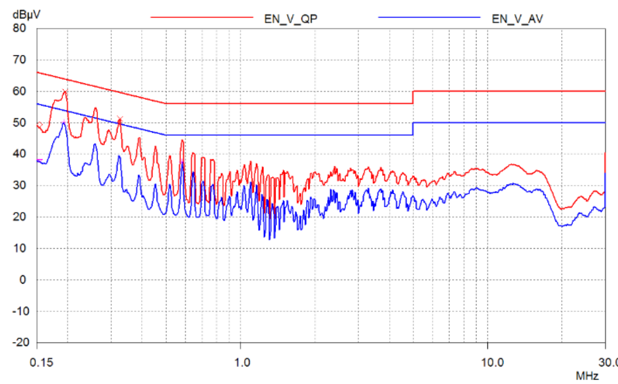


115 VAC_{IN}. 230 VAC_{IN}.

Figure 128 – Earth Ground EMI, 5 V / 3 A Load [Neutral Scan].

16.3.2 9 V, 3 A





115 VAC_{IN}. 230 VAC_{IN}.

Figure 129 – Earth Ground EMI, 9 V / 3 A Load [Neutral Scan].

17 Revision History

Date	Author	Revision	Description & Changes	Reviewed
05-Sep-18	AP	1.0	Initial Release.	Apps & Mktg
28-Jun-19	AP	1.1	Updated Schematic and BOM	Apps & Mktg

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