Design Example Report

Title	***19.5 W QC™2.0 / QC™3.0 Compliant Charger / Adapter Using InnoSwitch™-CP INN2215K***
Specification	85 VAC – 265 VAC Input; 3.6 V – 12 V, 3.0 A Output
Application	Cell Phone / USB Charger
Author	Applications Engineering Department
Document Number	DER-494
Date	March 2, 2016
Revision	1.4

Summary and Features

- InnoSwitch-CP industry first AC/DC IC with isolated, safety rated integrated feedback
- QC2.0 and QC3.0 compliance via single secondary side IC CHY103D
- All the benefits of secondary-side control with the simplicity of primary-side regulation
  - Insensitive to transformer variation
  - Built in synchronous rectification for high efficiency
- Meets DOE6 and CoC V5 2016
- <30 mW no-load input power
- Integrated thermal protection
- Primary sensed overvoltage protection
- Output over voltage protection

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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

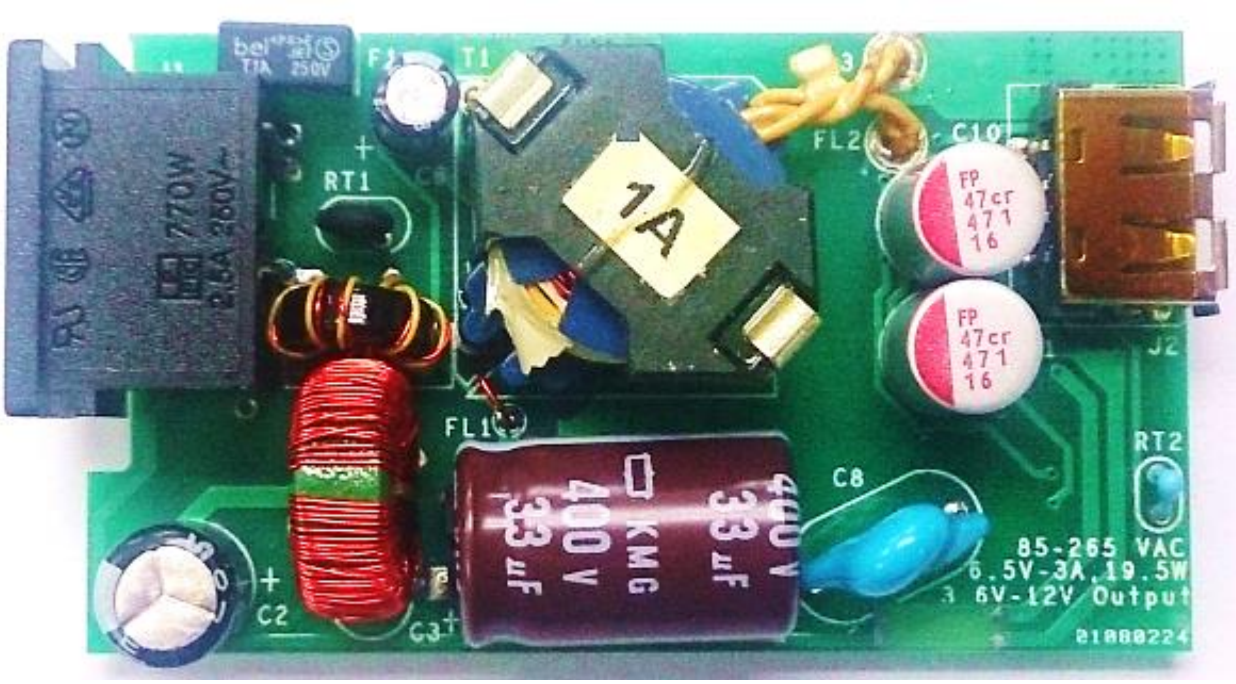

Figure 1 – Populated Circuit Board Photograph, Top.

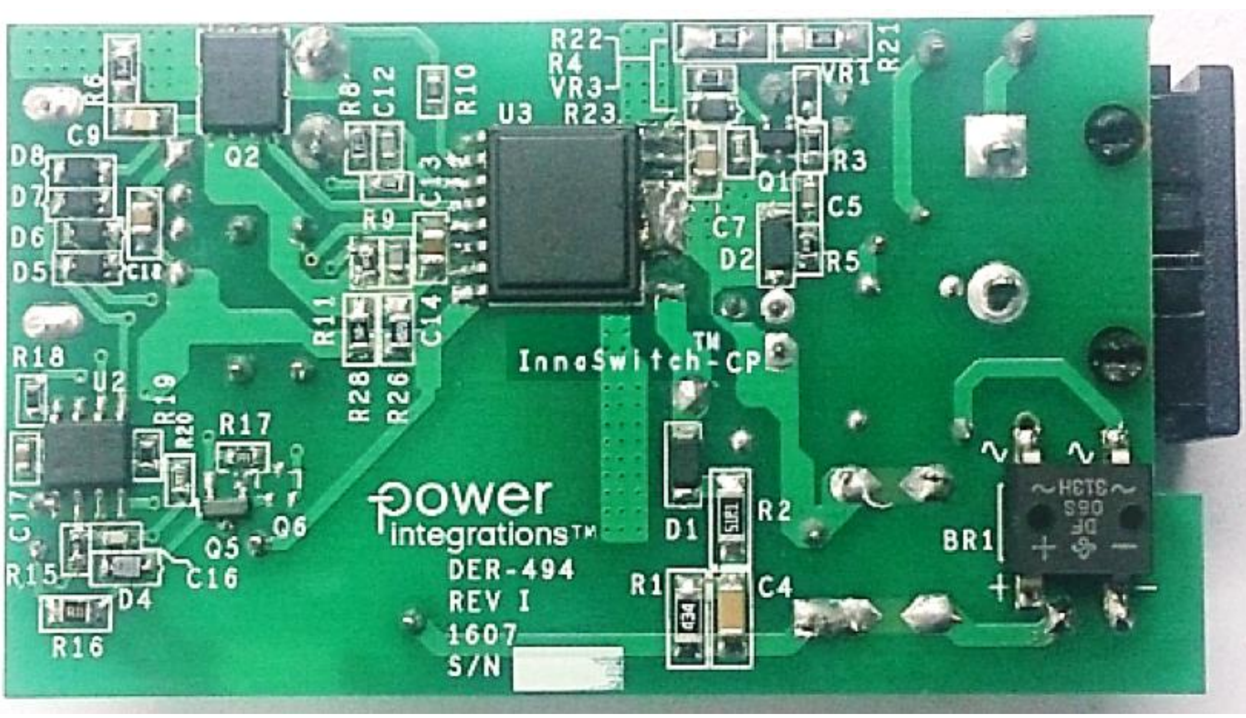

Figure 2 – Populated Circuit Board Photograph, Bottom.

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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	
Frequency	f_{LINE}	47	50/60	64	Hz	
No-load Input Power				25	mW	230 VAC
Output						
Output Voltage	V_{OUT}	3.6		12	V	QC2.0 and QC3.0 Mode
Transient Output Voltage for 5V Operation	$V_{OUT(T)}$	4.2		5.5	V	For 5 V Output 0 to 100% Load Change.
Output Ripple Voltage	V_{RIPPLE}			150	mV	Measured at the End of Cable with a 47 µF. Capacitor Connected at the End of Cable.
Maximum Output Current	I_{OUT}	3.0		3.5	A	Constant Power Characteristic Above 6.5 V.
Turn on Rise Time	t_R			5	ms	
Rated Output Power	P_{OUT}			18	W	
Efficiency						115 VAC, 230 VAC.
Full Load	$\eta_{100\%}$	86.7			%	Measured at Output Terminal for 6.6 V and Above.
		86.7				Measured at Output Terminal for 5 V.
Average 25%, 50%, 75%, and 100%	η_{AVE}	87.1			%	Measured at Output Terminal for 6.6 V and Above.
		87.4			%	Measured at Output Terminal for 5 V.
10%	$\eta_{10\%}$	76.4			%	Measured at Output Terminal for 6.6 V and Above.
		81.5			%	Measured at Output Terminal for 5 V.
Environmental						
Line Surge						
Common Mode (L1/L2-PE)				6	kV	Ring Wave, Common Mode: 12 Ω
Differential Mode				1	kV	Combination, 2 Ω
ESD				±16.5	kV	Contact.
				±8	kV	Air Discharge.
Ambient Temperature	T_{AMB}	0		40	°C	Free Convection, Sea level in Sealed Enclosure.

1 Schematic

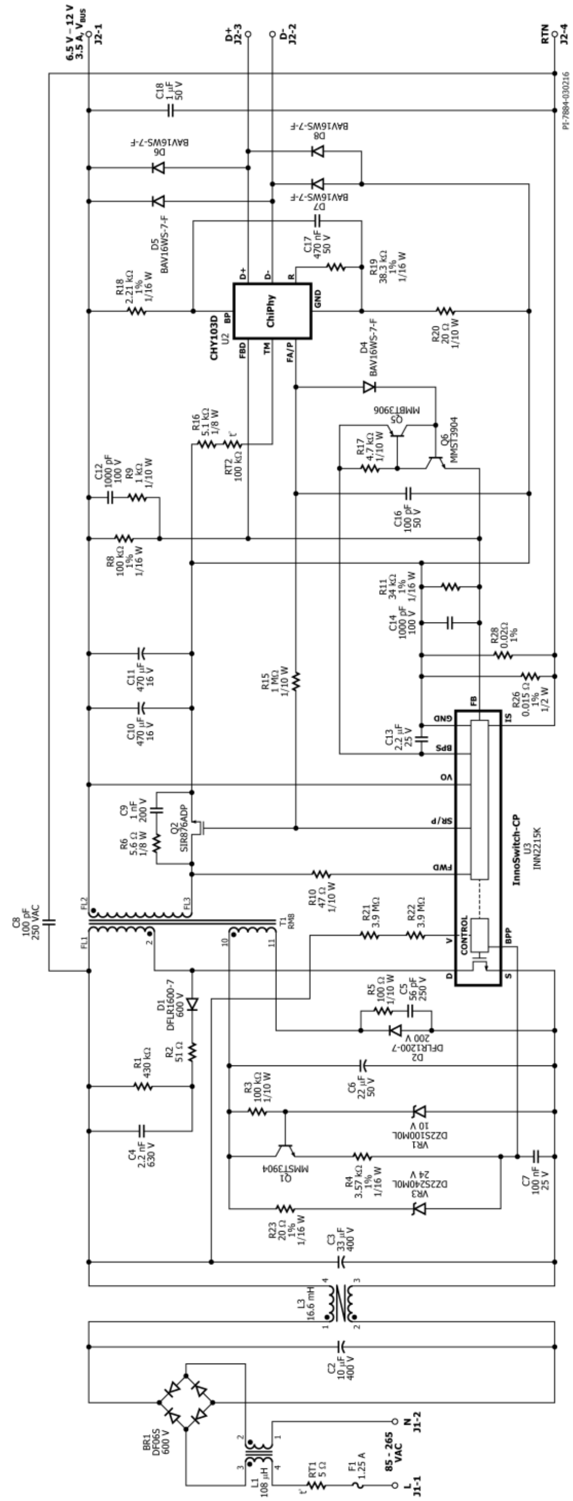

Figure 3 – Schematic.

Note: R28 is not populated and should only be used for trimming CC level.

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2 PCB Layout

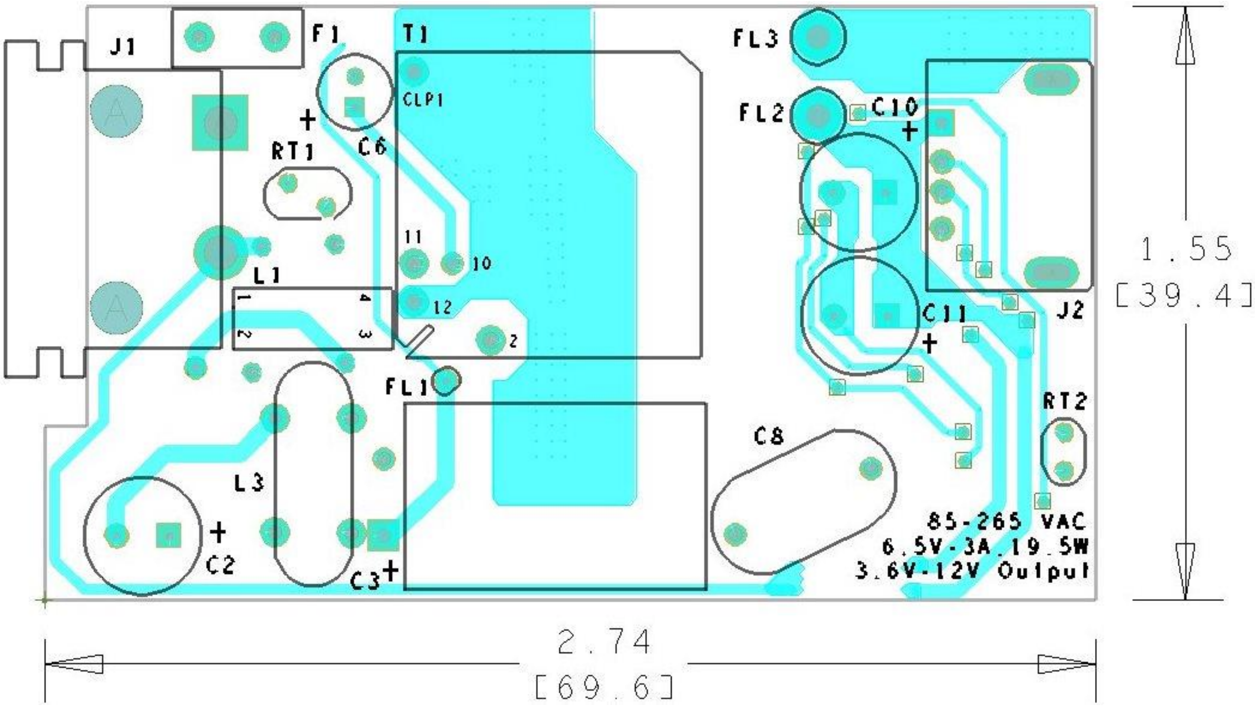

Figure 4 – Printed Circuit Layout, Top.

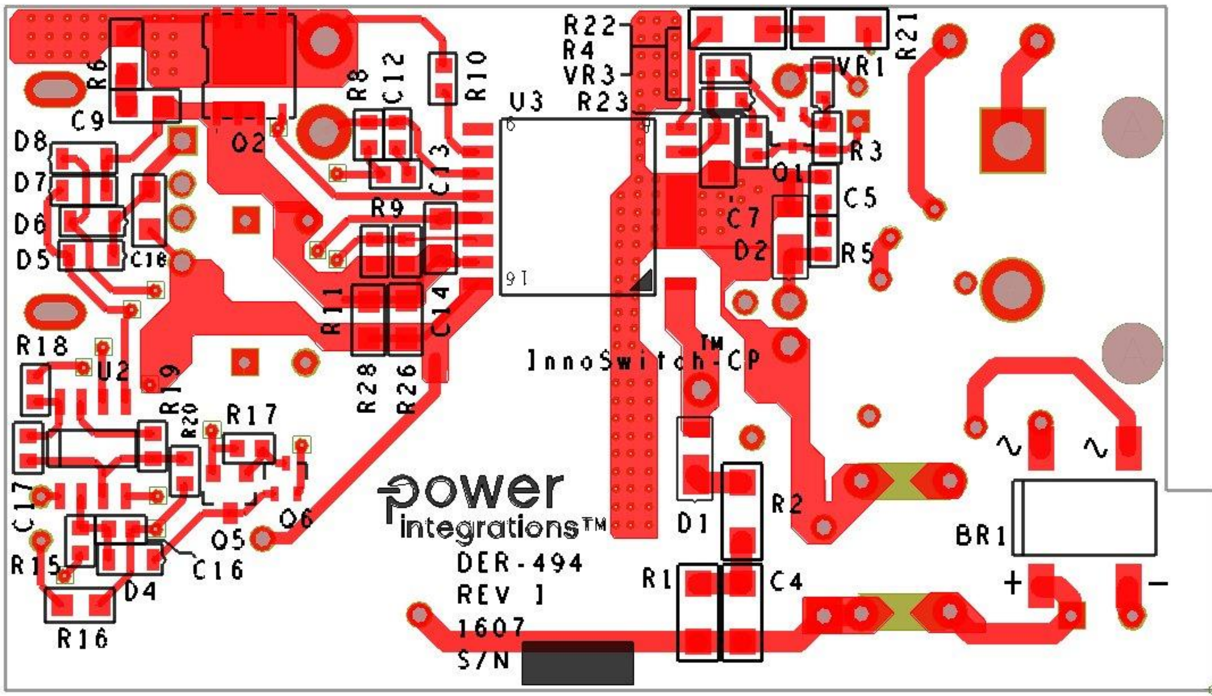

Figure 5 – Printed Circuit Layout, Bottom.

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3 Bill of Materials

Item	Qty	Ref Des	Description	Mfg Part Number	Mfg
1	1	BR1	600 V, 1 A, Bridge Rectifier, SMD, DFS	DF06S-E3/45	Vishay
2	1	C2	10 μF, 400 V, Electrolytic, (8 x 12)	ERK2GM100F12OT	Aishi
3	1	C3	33 μF, 400 V, Electrolytic, (12.5 x 20)	KMG401ELL330MK20S	Nippon Chemi-Con
4	1	C4	2.2 nF, 630 V, Ceramic, X7R, 1206	C3216X7R2J222K	TDK
5	1	C5	56 pF, 250 V, Ceramic, NPO, 0603	GQM1875C2E560JB12D	Murata
6	1	C6	22 μF, 50 V, Electrolytic, (5 x 11)	UPW1H220MDD	Nichicon
7	1	C7	100 nF, 25 V, Ceramic, X7R, 0805	08053C104KAT2A	AVX
8	1	C8	100 pF, 250 VAC, Film, X1Y1	DE1B3KX101KB4BN01F	TDK
9	1	C9	1 nF, 200 V, Ceramic, X7R, 0805	08052C102KAT2A	AVX
10	2	C10 C11	470 μF, 16 V, Al Organic Polymer, 12 mOhm, (8 x 11.5)	RNE1C471MDN1	Nichicon
11	2	C12 C14	1000 pF, 100 V, Ceramic, NPO, 0603	C1608C0G2A102J	TDK
12	1	C13	2.2 μF, 25 V, Ceramic, X7R, 0805	C2012X7R1E225M	TDK
13	1	C16	100 pF 50 V, Ceramic, NPO, 0603	CC0603JRNPO9BN101	Yageo
14	1	C17	470 nF, 50 V, Ceramic, X7R, 0603	UMK107B7474KA-TR	Taiyo Yuden
15	1	C18	1 μF,50 V, Ceramic, X7R, 0805	C2012X7R1H105M	TDK
16	1	D1	600 V, 1 A, Rectifier, Glass Passivated, POWERDI123	DFLR1600-7	Diodes, Inc.
17	1	D2	200 V, 1 A, Rectifier, Glass Passivated, POWERDI123	DFLR1200-7	Diodes, Inc.
18	5	D4 D5 D6 D7 D8	75 V, 0.15 A, Switching,SOD-323	BAV16WS-7-F	Diodes, Inc.
19	1	F1	FUSE, 1.25 A 250 VAC, Slow, 8.35 mm x 4.0 mm x 7.7 mm	RST 1.25-BULK	Bel Fuse
20	1	FL1	Flying Lead, Hole size 30mils	N/A	N/A
21	2	FL2 FL3	Flying Lead, Hole size 70mils	N/A	N/A
22	1	J1	CONN, AC Recept Panel, R/A, PCB pins	770W-X2/10	Qualtek
23	1	J2	CONN, USB TYPE A 2.0, RTANG FMALE, PCB 4 POS, reversed, 1.2mm max bd thick	614104150121	Wurth
24	1	L1	Custom, 108 μH, constructed on Core 35T0375-10H from PI# 30-00275-00		Power Integrations
25	1	L3	16.6 mH, xA, Ferrite Toroid, 4 Pin, Output		
26	2	Q1 Q6	NPN, Small Signal BJT, 40 V, 0.2 A, SOT-323	MMST3904-7-F	Diodes, Inc.
27	1	Q2	100 V, 40 A, N-Channel, PowerPAK SO-8	SIR876ADP-T1-GE3	Vishay
28	1	Q5	PNP, Small Signal BJT, 40 V, 0.2 A, SOT-23	MMBT3906LT1G	On Semi
29	1	R1	RES, 430 kΩ, 5%, 1/4 W, Thick Film, 1206	ERJ-8GEYJ434V	Panasonic
30	1	R2	RES, 51 Ω, 5%, 1/4 W, Thick Film, 1206	ERJ-8GEYJ510V	Panasonic
31	1	R3	RES, 100 kΩ, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ104V	Panasonic
32	1	R4	RES, 3.57 kΩ, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF3571V	Panasonic
33	1	R5	RES, 100 Ω, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ101V	Panasonic
34	1	R6	RES, 5.6 Ω, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ5R6V	Panasonic
35	1	R8	RES, 100 kΩ, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF1003V	Panasonic
36	1	R9	RES, 1 kΩ, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ102V	Panasonic
37	1	R10	RES, 47 Ω, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ470V	Panasonic
38	1	R11	RES, 34 kΩ, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF3402V	Panasonic
39	1	R15	RES, 1 MΩ, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ105V	Panasonic
40	1	R16	RES, 5.1 kΩ, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ512 V	Panasonic
41	1	R17	RES, 4.7 kΩ, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ472V	Panasonic
42	1	R18	RES, 2.21 kΩ, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF2211V	Panasonic
43	1	R19	RES, 38.3 kΩ, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF3832V	Panasonic
44	1	R20	RES, 20 Ω, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ200V	Panasonic
45	2	R21 R22	RES, 3.9 MΩ, 5%, 1/4 W, Thick Film, 1206	ERJ-8GEYJ395V	Panasonic
46	1	R23	RES, 20 Ω, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF20R0V	Panasonic
47	1	R26	RES, 0.015 Ω, 0.5 W, 1%, 0805	ERJ-6BWFR015V	Panasonic
48	1	R28	RES, 0.02 Ω, 1%, 1/4 W, Thick Film, 0805	RL0805FR-7W0R02L	Yageo

49	1	RT1	NTC Thermistor, 5 Ω, 1 A	MF72-005D5	Cantherm
50	1	RT2	NTC Thermistor, 100 kΩ, 0.00046 A	NTSD0WF104EE1B0	Murata
51	1	T1	Bobbin, RM8, Vertical, 12 pins	RM8/12/1	Schwartzpunkt
52	1	U2	ChiPhy, Charger Interface Physical Layer IC	CHY103D	Power Integrations
53	1	U3	InnoSwitch-CP, Off-Line CV/CC Flyback Switcher, ReSOP-16B	INN2215K	Power Integrations
54	1	VR1	10 V, 5%, 150 mW, SSMINI-2	DZ2S100M0L	Panasonic
55	1	VR3	24V, 5%, 150 mW, SSMINI-2	DZ2S240M0L	Panasonic

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4 Magnetics

4.1 *Transformer Specification*

4.1.1 Electrical Diagram

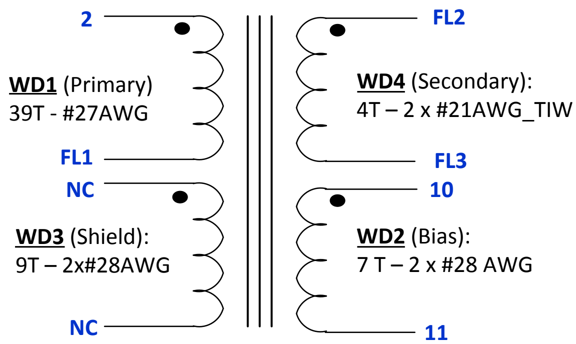

Figure 6 – Transformer Electrical Diagram.

4.1.2 Electrical Specifications

Electrical Strength	1 second, 60 Hz, from pins 2, 10, 11, and FL1 to FL2/FL3.	3000 VAC
Primary Inductance	Pin 2 – FL1, all other windings open, measured at 100 kHz, 0.4 V_{RMS}.	607 μH ±5%
Resonant Frequency	Pin 2 – FL1, all other windings open.	1100 kHz (Min.)
Primary Leakage Inductance	Pin 2 – FL1, with pins FL2/FL3 shorted, measured at 100 kHz, 0.4 V_{RMS}.	16 μH (Max.)

4.1.3 Material List

Item	Description
[1]	Core: TDK PC95 RM08-Z ,PI # 99-00022-00, or equivalent, gapped for ALG of 392 nH/t^2.
[2]	Bobbin: RM8-12pins(6/6), Ferroxcube-CSV-RM8-1S-12P-G, PI#: 25-01022-00; or equivalent.
[3]	Clip: RM8, Allstar Magnetic, CLI/P-RM8/I.
[4]	Magnet Wire: #27 AWG, Solderable Double Coated.
[5]	Magnet Wire: #28 AWG, Solderable Double Coated.
[6]	Magnet Wire: #21 AWG, Triple Insulated Wire.
[7]	Tape: Polyester Film, 3M 1350-1, 9.0 mm Wide.
[8]	Varnish.

4.1.4 Transformer Build Diagram

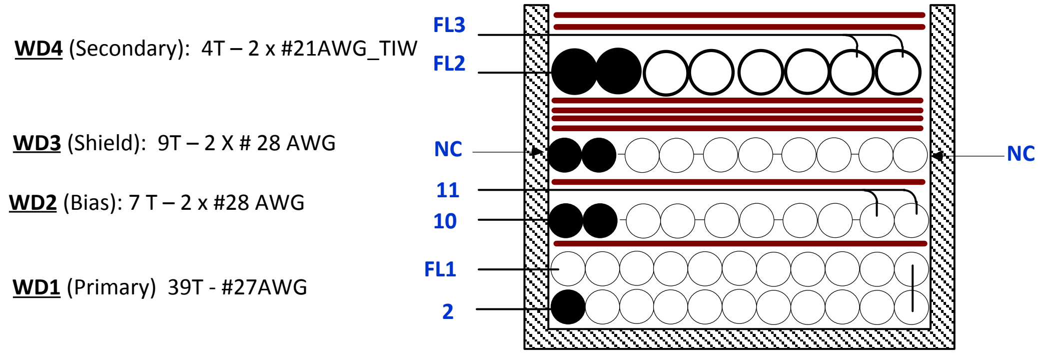

Figure 7 – Transformer Build Diagram.

4.1.5 Transformer Construction

Bobbin Preparation	For the purpose of these instructions, bobbin is oriented on winder such that pin side is on the left side. Winding direction is clockwise direction.
WD1 Primary Winding	Start at pin 2. Wind 39 turns of item [4] in approximately 2 layers. Finish as marked FL1.
Insulation	Use 1 layer of item [7] for insulation.
WD2 Bias Winding	Starting at pin10, wind 8 bifilar turns of item [5]. Spread turns evenly across bobbin. Finish at pin 11.
Insulation	Use 1 layer of item [7] for insulation.
WD3 Shield	Temporarily hang wire item [5] on pin 1 or 2, for start lead, wind 9 bifilar turns of item [5], and spread turns evenly across bobbin. At the last turn cut wire for no-connect, and also cut start lead for no-connect.
Insulation	Use 4 layers of item [7] for insulation.
WD4 Secondary Winding	Take two parallel strands of item [6]. Mark start end as FL2, wind 4 turns of item [6], and finish as FL3.
Insulation	Use 2 layers of item [7] to secure the windings.
Final Assembly	Insert cores, gapped for inductance specified. Secure core halves using clips item [3]. Cut short pins: 1, 3, 4, 5, 6, 7, 8, and 9. Dip varnish item [8].

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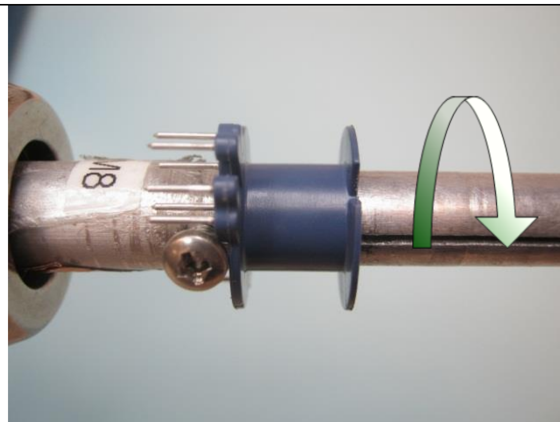
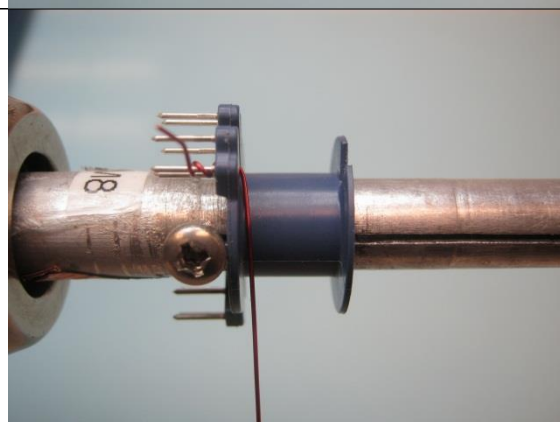
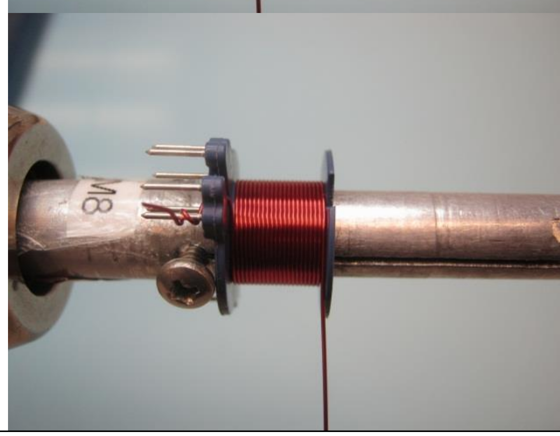
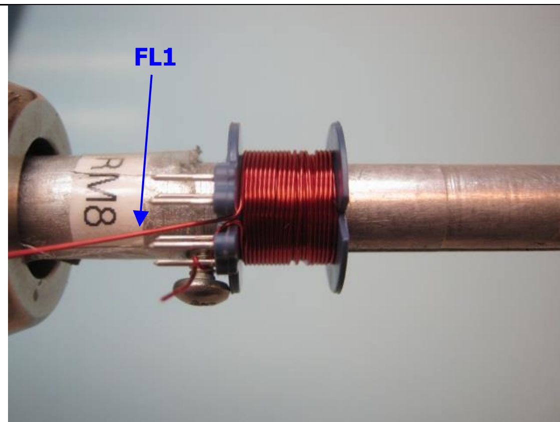
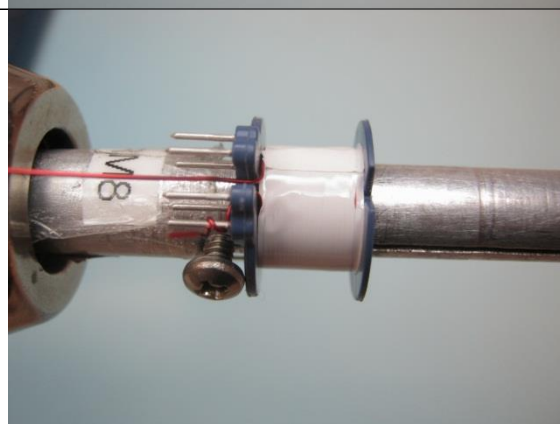
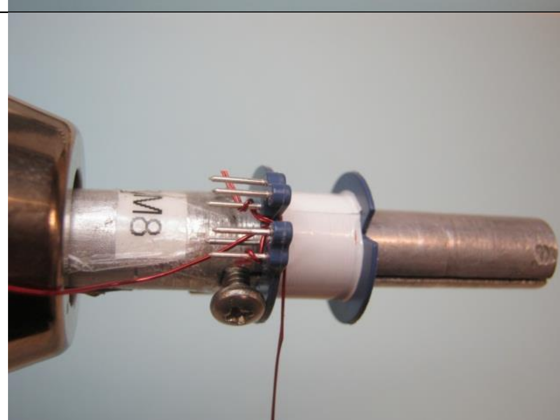
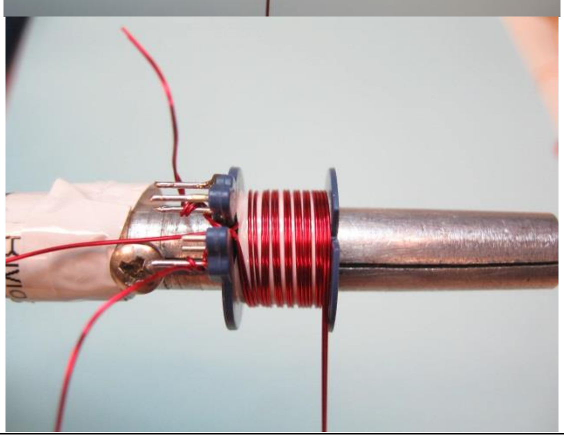
4.1.6 Transformer Winding Illustrations

Bobbin Preparation		For the purpose of these instructions, bobbin is oriented on winder such that pin side is on the left side. Winding direction is clockwise direction.
WD1 **Primary Winding**	 	Start at pin 2. Wind 39 turns of item [4] in approximately 2 layers. Finish as marked FL1.

		
Insulation		Use 1 layer of item [7] for insulation.
WD2 **Bias winding**	 	Starting at pin10, wind 8 bifilar turns of item [5]. Spread turns evenly across bobbin. Finish at pin 11.

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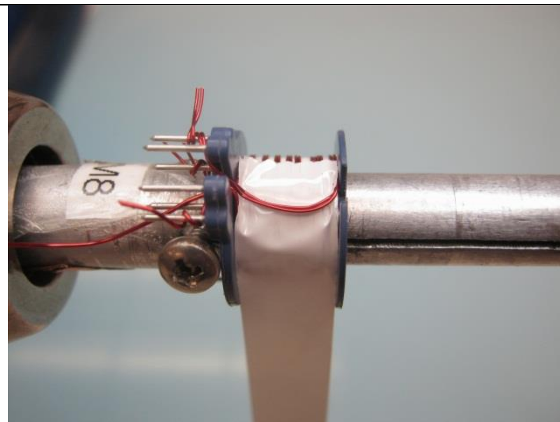
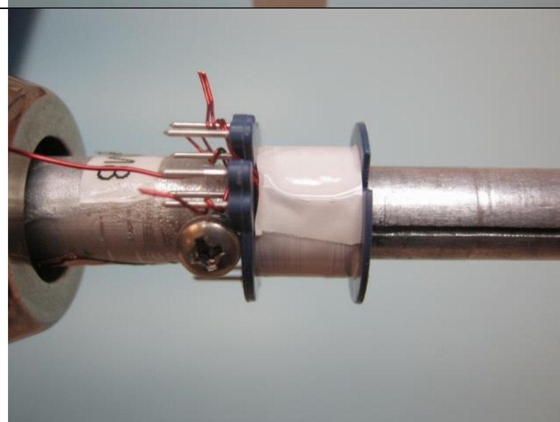
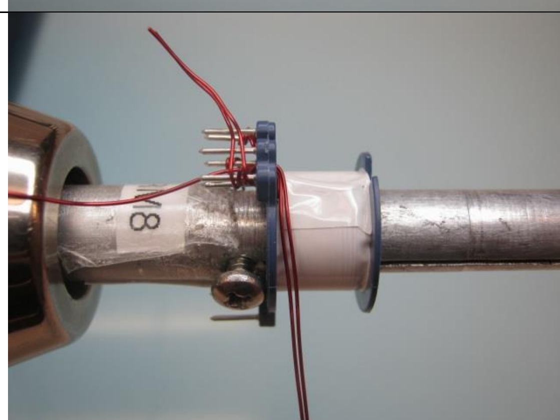
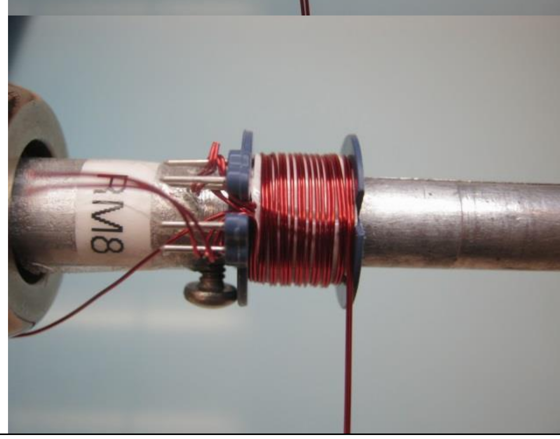
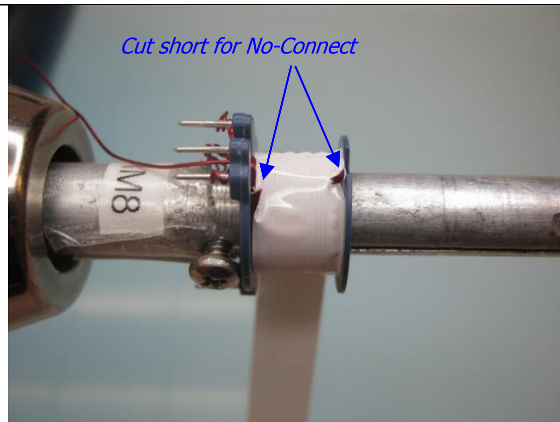
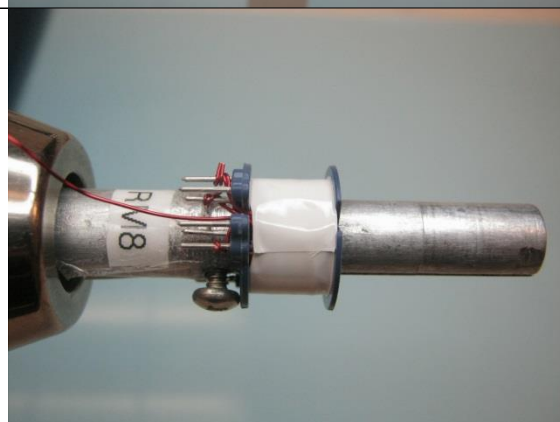
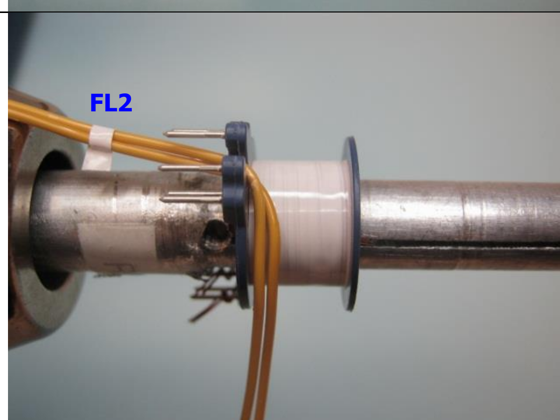
		
Insulation		Use 1 layer of item [7] for insulation.
WD3 **Shield**	 	Temporarily hang wire item [5] on pin 1 or 2, for start lead, wind 9 bifilar turns of item [5], and spread turns evenly across bobbin.

		At the last turn cut wire for no-connect, and also cut start lead for no-connect.
Insulation		Use 4 layers of item [7] for insulation.
WD4 **Secondary winding**	 	Take two parallel strands of item [6]. Mark start end as FL2, wind 4 turns of item [6], and finish as FL3.

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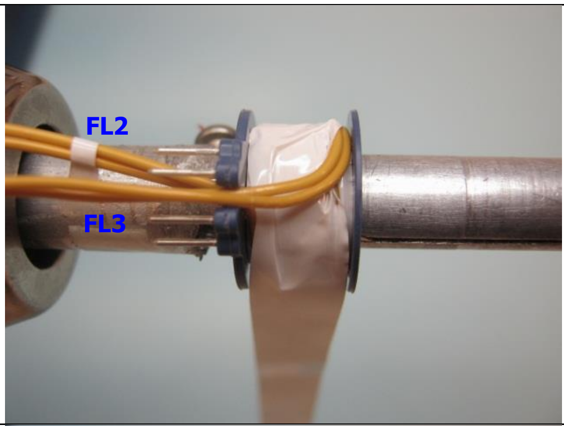
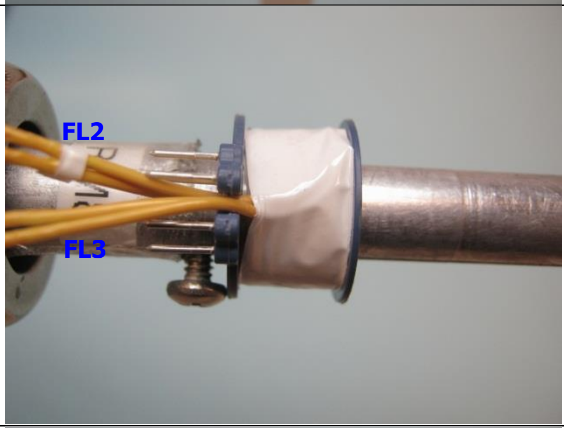
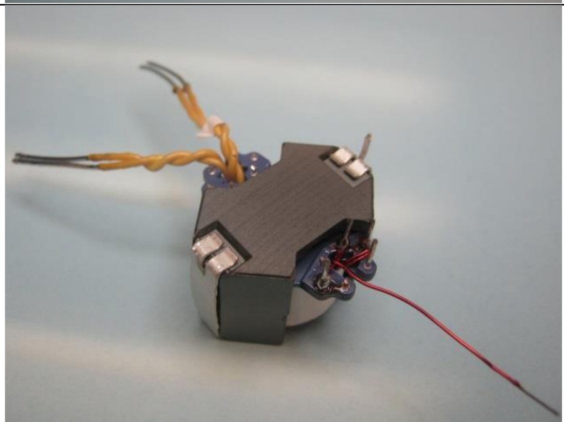
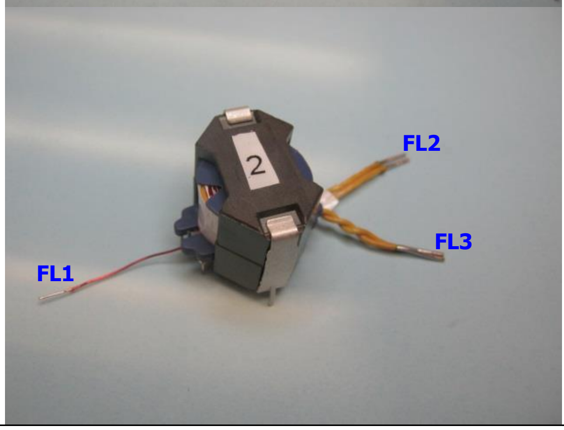
		
Insulation		Use 2 layers of item [7] to secure the windings.
Final Assembly		Insert cores, gapped for inductance specified. Secure core halves using clips item [3]. Cut short pins: 1, 3, 4, 5, 6, 7, 8, and 9. Dip varnish item [8].

4.2 *Common Mode Choke (L1)*

4.2.1 Electrical Diagram

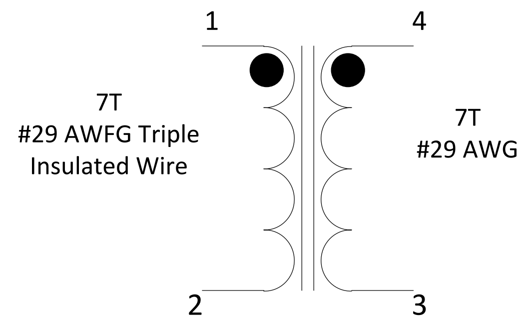


Figure 8 – Common Mode Choke (L1) Electrical Diagram.

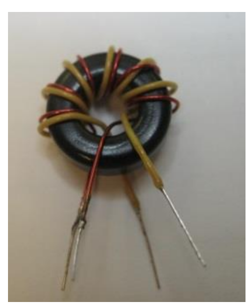
4.2.2 Electrical Specifications

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

4.2.3 Material List

Item	Description
[1]	Toroid: FERRITE INDUCTR TOROID .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: #29 AWG.
[3]	Triple Insulated Wire #29 AWG.

4.2.4 Illustration



Front View.

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4.3 ***Common Mode Choke (L3)***

4.3.1 Electrical Diagram

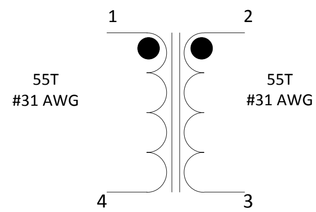


Figure 9 – Common Mode Choke (L3) Electrical Diagram.

4.3.2 Electrical Specifications

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

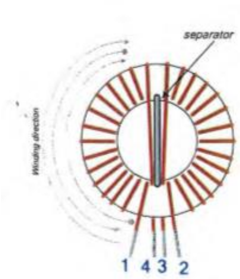
4.3.3 Material List

Item	Description
[1]	Toroid: FERRITE INDUCTR TOROID T14 x 8 x 5.5. PI Part number: #32-00286-00.
	Divider -- Fish paper, insulating cotton rag, 0.010” thick, PI #: 66-00042-00. Cut to size 8 mm x 5.5 mm.
[2]	Magnet Wire: #31 AWG Heavy Nyleze.

4.3.4 Winding Instructions

Use 4 ft of item [2], start at pin 1 wind 55 turns end at pin 4.
Do the same for another half of Toroid, start at pin 2 and end at pin 3.

4.3.5 Illustrations



Top View.

Front View.

5 Transformer Design Spreadsheet

ACDC_InnoSwitch-CP_021616; Rev.1.1; Copyright Power Integrations 2016	INPUT	INFO	OUTPUT	UNIT	InnoSwitch-CP Continuous/Discontinuous Flyback Transformer Design Spreadsheet
ENTER APPLICATION VARIABLES					
VACMIN			85	V	Minimum AC Input Voltage. Universal=85 VAC to 155VAC. High-Line=185 VAC to 215VAC
VACMAX			265	V	Maximum AC Input Voltage
fL			50	Hz	AC line frequency
VO_1	12.00		12.17	V	Desired output voltage at the End of Cable for configuration 1
IO_1	1.63		1.63	A	Output current for configuration 1
Power_1			19.8447	W	Continuous output power, including cable drop compensation for configuration 1
n_1	0.88		0.88		Efficiency Estimate at output terminals for configuration 1. Use 0.8 if no better data available
Z_1	0.50		0.50		Ratio of secondary side losses to the total losses in the power supply for configuration 1. Use 0.5 if no better data available
VO_2	9.00		9.24	V	Desired output voltage at the End of Cable for configuration 2
IO_2	2.20		2.20	A	Power Supply Output Current (corresponding to peak power) for configuration 2
Power_2		Info	20.32	W	Specified output power for this configuration exceeds the device's capability. Please verify performance on bench
n_2	0.88		0.88		Efficiency Estimate at output terminals for configuration 2. Use 0.8 if no better data available
Z_2	0.50		0.50		Ratio of secondary side losses to the total losses in the power supply for configuration 2. Use 0.5 if no better data available
VO_3	6.50		6.80	V	Desired output voltage at the End of Cable for configuration 3
IO_3	2.80		2.80	A	Power Supply Output Current (corresponding to peak power) for configuration 3
Power_3			19.04	W	Continuous Output Power, including cable drop compensation for configuration 3
n_3	0.88		0.88		Efficiency Estimate at output terminals for configuration 3. Use 0.8 if no better data available
Z_3	0.50		0.50		Ratio of secondary side losses to the total losses in the power supply for configuration 3. Use 0.5 if no better data available
VO_4			0.00	V	Configuration 4 is turned off
IO_4			0.00	A	Configuration 4 is turned off
Power_4			0.00	W	Configuration 4 is turned off
n_4	0.80		0.80		Configuration 4 is turned off
Z_4	0.50		0.50		Configuration 4 is turned off
tC			3.00	mS	Bridge Rectifier Conduction Time Estimate
CIN	43.00		43.00	uF	Input capacitor
Enclosure	Adapter		Adapter		Select between Adapter and Open Frame
Cable compensation type	Current Drive		Current Drive		The output voltage is changed by using a current drive
ENTER InnoSwitch-CP VARIABLES					
InnoSwitch-CP	INN2215	Info	INN2215		The device selected cannot deliver the required power, please select a bigger device.
Cable drop compensation	6%		6%		Select Cable Drop Compensation option. Cable compensation applies only for a 5V output

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Complete Part Number			INN2215K		Final part number including package
Chose Configuration	STD		Standard Current Limit		Enter "RED" for reduced current limit, "STD" for standard current limit or "INC" for increased current limit
ILIMITMIN			0.893	A	Minimum Current Limit
ILIMITTYP			0.95	A	Typical Current Limit
ILIMITMAX			1.007	A	Maximum Current Limit
fSmin			93000	Hz	Minimum Device Switching Frequency
I^2fmin			78.52	A^2kHz	Worst case I2f for power delivery
VOR	115		115	V	Reflected output voltage assigned to configuration 1
VDS	1.00		1.00	V	InnoSwitch on-state Drain to Source Voltage
KP			0.515		Minimum Value of KP given all configurations and i2f conditions
KP_TRANSIENT			0.371		Minimum Value of KP_TRANSIENT given all configurations and i2f conditions
ENTER BIAS WINDING VARIABLES					
VB	12.00		12.00	V	Minimum bias winding voltage. Bias voltage will be higher for higher output voltages. Verify performance on the bench.
VDB			0.70	V	Bias Winding Diode Forward Voltage Drop
NB			8.00	V	Minimum bias winding number of turns to ensure the minimum bias winding voltage.
PIVB			122.03	V	Minimum PIV rating of the bias diode given all configurations and i2f conditions.
ENTER TRANSFORMER CORE VARIABLES					
Core Type	RM8		RM8		Enter Transformer Core
Core			PC47RM8Z-12		Enter core part number, if necessary
Bobbin			BRM8-718CPFR		Enter bobbin part number, if necessary
AE			0.64	cm^2	Core Effective Cross Sectional Area
LE			3.80	cm	Core Effective Path Length
AL			1950	nH/T^2	Ungapped Core Effective Inductance
BW			9.05	mm	Bobbin Physical Winding Width
M			0.00	mm	Safety Margin Width (Half the Primary to Secondary Creepage Distance)
LAYERS_PRIMARY			2		Number of Primary Layers
NS			4		Number of Secondary Turns
DC INPUT VOLTAGE PARAMETERS					
VMIN			79	V	Minimum DC Input Voltage
VMAX			375	V	Maximum DC Input Voltage
PRIMARY CURRENT WAVEFORM SHAPE PARAMETERS					
DMAX			0.597		Maximum value of DMAX given all configurations and i2f conditions
IP_AVG			0.280	A	Maximum value of the average primary current given all configurations and i2f conditions
IP_PEAK			1.014	A	Maximum value of the peak primary current given all configurations and i2f conditions
IP_RMS			0.528	A	Maximum value of the primary RMS current given all configurations and i2f conditions
IP_RIPPLE			0.864	A	Maximum value of the primary ripple current given all configurations and i2f conditions
TRANSFORMER PRIMARY DESIGN PARAMETERS					
LP			607	uHenry	Typical Primary Inductance. +/- 5% to ensure a minimum primary inductance of 576 uH
LP_TOLERANCE	5.0		5.0	%	Primary inductance tolerance
NP			39		Primary Winding Number of Turns
ALG			399	nH/T^2	Gapped Core Effective Inductance
BM			2588	Gauss	Maximum operating flux density given all configurations and i2f conditions

BAC			998	Gauss	Maximum AC Flux Density for Core Loss Curves (0.5 X Peak to Peak) given all configurations and i2f conditions
ur			921		Relative Permeability of Ungapped Core
LG			0.16	mm	Gap Length (Lg > 0.1 mm)
BWE			18.1	mm	Effective Bobbin Width
OD			0.46	mm	Maximum Primary Wire Diameter including insulation
INS			0.06	mm	Estimated Total Insulation Thickness (= 2 * film thickness)
DIA			0.40	mm	Bare conductor diameter
AWGP			27	AWG	Primary Wire Gauge (Rounded to next smaller standard AWG value)
CMP			203	Cmils	Bare conductor effective area in circular mils
CMAP			385	Cmils/Amp	Primary wire circular mils per amp
CDP			5.2	A/mm^2	Primary wire current density
SECONDARY CURRENT WAVEFORM SHAPE PARAMETERS					
IS_PEAK			9.818	A	Maximum value of the peak secondary current, given all configurations and i2f conditions
IS_RMS			5.361	A	Maximum value of the secondary RMS current, given all configurations and i2f conditions
IS_RIPPLE			4.571	A	Maximum value of the output capacitor RMS ripple current, given all configurations and i2f conditions
TRANSFORMER SECONDARY DESIGN PARAMETERS					
CMS			1072	Cmils	Secondary Bare Conductor minimum circular mils
CMAS			200	Cmils/Amp	Worst-case secondary wire circular mils per amp given all configurations and i2f conditions
CDS			8.2	A/mm^2	Worst-case secondary wire current density given all configurations and i2f conditions
AWGS			19	AWG	Worst-case secondary wire gauge (Rounded up to next larger standard AWG value) given all configurations and i2f conditions
DIAS			0.91	mm	Minimum Bare Conductor Diameter
ODS			2.26	mm	Maximum Outside Diameter for Triple Insulated Wire
SECONDARY SR FET DESIGN PARAMETERS					
SRFET	Auto		Si7456		Recommended SR FET for the design
RDSON_HOT			0.0420	Ohms	RDSon at 100C
PIV_rated			100	V	Rated voltage of selected SR FET
VD			0.098	V	Output Synchronous Rectification FET Forward Voltage Drop
PD			1.207	W	Output Synchronous Rectification FET Power Dissipation
VOLTAGE STRESS PARAMETERS					
VDRAIN			629	V	Maximum Drain Voltage Estimate
PIVS			66	V	Output Rectifier Maximum Peak Inverse Voltage, assuming the primary has a Voltage spike 40% above VMAX and VO*1.05
DESIGN CONFIGURATION PARAMETERS					
Configuration	1		1		Select the configuration number
VO			12.00	V	Output voltage at the end of the cable for the selected configuration
IO			1.63	A	Output current for the selected configuration
PO			19.84	W	Output power at the end of the cable for the selected configuration
n			0.88		Efficiency for the selected configuration
Z			0.50		Loss allocation factor for the selected configuration

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DMAX			0.597		DMAX for the selected configuration
VOR			117.0	V	VOR for the desired configuration
KP			0.851		KP for the selected configuration
KP_transient			0.685		KP_transient for the selected configuration
IPP			1.01	A	Primary switch peak current given all i2f conditions
IPRMS			0.53	A	Primary switch RMS current given all i2f conditions
IPRIPPLE			0.86	A	Primary switch current ripple given all i2f conditions
ISP			9.82	A	Secondary switch peak current given all i2f conditions
ISRMS			4.23	A	Secondary switch RMS current given all i2f conditions
ISRIPPLE			3.90	A	Secondary switch curent ripple given all i2f conditions

6 Performance Data

6.1 *Average Efficiency (Measured at the Main Output Terminal)*

6.1.1 Specifications

Test	Average	Average	Average	Average	10% Load	10% Load
Model	>6 V Voltage	>6 V Voltage	<6 V Voltage	>6 V Voltage	>6 V Voltage	<6 V Voltage
Effective	Now	2016	2016	2016	2016	2016
Regulation	Energy Star 2	New IESA2007	CoC v5 Tier 2	CoC v5 Tier 2	CoC v5 Tier 2	CoC v5 Tier 2
Required Efficiency	81.1 %	85.5%	81.8%	86.0%	75.5%	72.5%

6.2 *5 V, 110 VAC Input*

Load Setting	Input Measurement	Load Measurement			Efficiency (%)
% Load	P_{IN} (W)	V_{OUT} (V_{DC})	I_{OUT} (A_{DC})	P_{OUT} (W)	
100	18.10	5.27	3.00	15.81	87.24
75	13.36	5.23	2.25	11.77	88.13
50	8.75	5.15	1.50	7.73	88.29
25	4.31	5.05	0.75	3.79	87.95
10	1.76	4.99	0.30	1.50	84.77
			Average Efficiency		87.90

6.3 *5 V, 230 VAC Input*

Load Setting	Input Measurement	Load Measurement			Efficiency (%)
% Load	P_{IN} (W)	V_{OUT} (V_{DC})	I_{OUT} (A_{DC})	P_{OUT} (W)	
100	18.00	5.28	3.00	15.84	87.97
75	13.30	5.24	2.25	11.79	88.65
50	8.75	5.15	1.50	7.73	88.34
25	4.35	5.06	0.75	3.80	87.17
10	1.81	4.99	0.30	1.50	82.19
			Average Efficiency		88.03

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6.4 *6.5 V, 110 VAC Input*

Load Setting	Input Measurement	Load Measurement			Efficiency (%)
% Load	P_{IN} (W)	V_{OUT} (V_{DC})	I_{OUT} (A_{DC})	P_{OUT} (W)	
100	22.28	6.55	3.00	19.64	88.13
75	16.61	6.53	2.25	14.68	88.36
50	10.99	6.50	1.50	9.74	88.65
25	5.48	6.45	0.75	4.83	88.19
10	2.26	6.40	0.30	1.91	84.71
			Average Efficiency		88.33

6.5 *6.5 V, 230 VAC Input*

Load Setting	Input Measurement	Load Measurement			Efficiency (%)
% Load	P_{IN} (W)	V_{OUT} (V_{DC})	I_{OUT} (A_{DC})	P_{OUT} (W)	
100	22.31	6.58	3.00	19.73	88.44
75	16.56	6.54	2.25	14.71	88.85
50	10.99	6.51	1.50	9.76	88.80
25	5.51	6.46	0.75	4.84	87.85
10	2.37	6.40	0.30	1.91	80.78
			Average Efficiency		88.48

6.6 *9 V, 110 VAC Input*

Load Setting	Input Measurement	Load Measurement			Efficiency (%)
% Load	P_{IN} (W)	V_{OUT} (V_{DC})	I_{OUT} (A_{DC})	P_{OUT} (W)	
100	20.37	9.05	2.00	18.08	88.76
75	15.23	9.04	1.50	13.55	89.01
50	10.13	9.01	1.00	9.00	88.85
25	5.16	8.98	0.50	4.48	86.79
10	2.19	8.95	0.20	1.78	81.23
			Average Efficiency		88.35

6.7 *9 V, 230 VAC Input*

Load Setting	Input Measurement	Load Measurement			Efficiency (%)
% Load	P_{IN} (W)	V_{OUT} (V_{DC})	I_{OUT} (A_{DC})	P_{OUT} (W)	
100	20.40	9.11	2.00	18.20	89.21
75	15.23	9.06	1.50	13.58	89.18
50	10.14	9.02	1.00	9.00	88.78
25	5.21	8.98	0.50	4.48	85.94
10	2.27	8.94	0.20	1.78	78.07
			Average Efficiency		88.28

6.8 *12 V, 110 VAC Input*

Load Setting	Input Measurement	Load Measurement			Efficiency (%)
% Load	P_{IN} (W)	V_{OUT} (V_{DC})	I_{OUT} (A_{DC})	P_{OUT} (W)	
100	20.72	12.33	1.50	18.47	89.13
75	15.49	12.30	1.12	13.83	89.26
50	10.26	12.20	0.75	9.14	89.13
25	5.16	12.08	0.37	4.52	87.57
10	2.23	12.01	0.15	1.79	80.23
			Average Efficiency		87.49

6.9 *12 V, 230 VAC Input*

Load Setting	Input Measurement	Load Measurement			Efficiency (%)
% Load	P_{IN} (W)	V_{OUT} (V_{DC})	I_{OUT} (A_{DC})	P_{OUT} (W)	
100	20.72	12.37	1.50	18.55	89.52
75	15.51	12.32	1.12	13.84	89.21
50	10.31	12.20	0.75	9.14	88.62
25	5.46	12.08	0.37	4.52	82.76
10	2.32	12.02	0.15	1.79	77.20
			Average Efficiency		87.53

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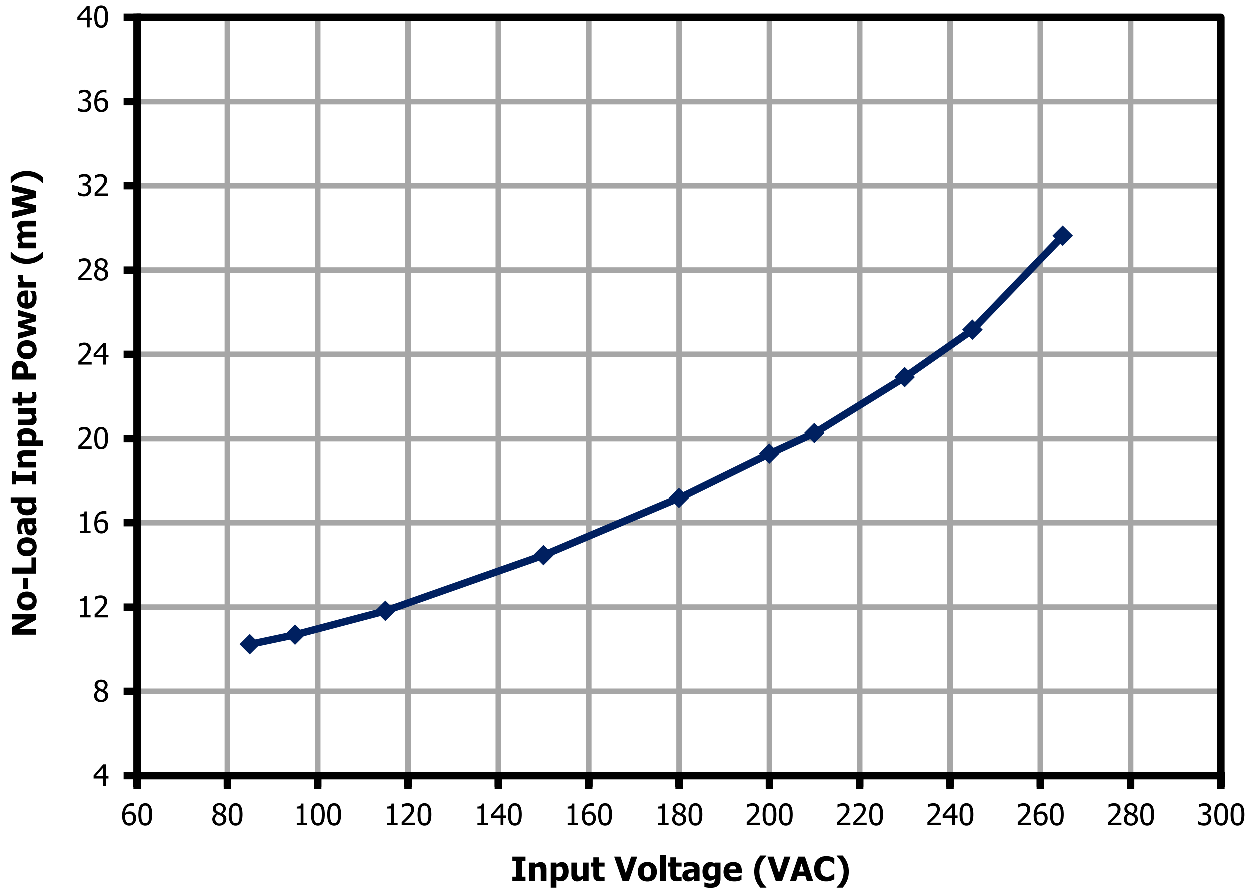
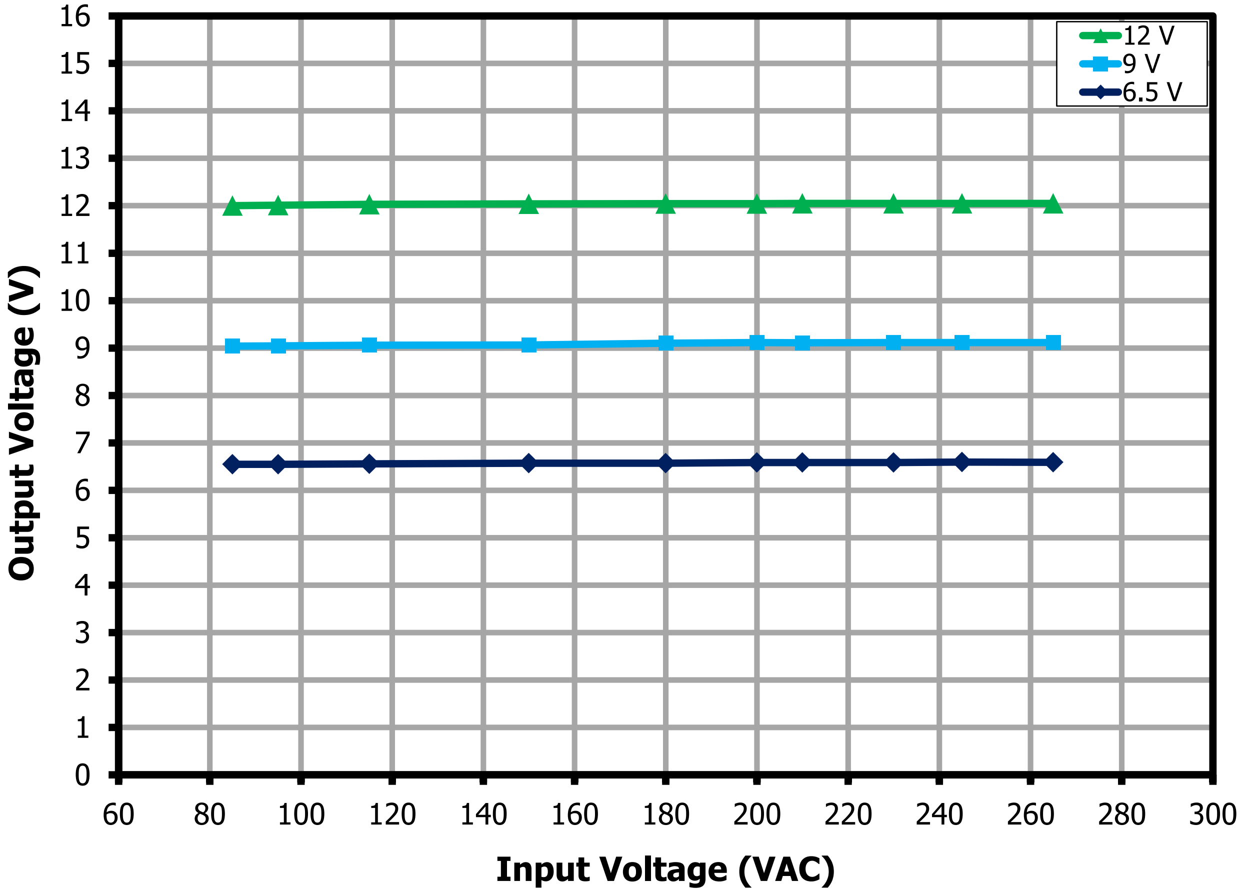
6.10 ***No-Load Input Power (5 V Output)***



Input		Input Measurement (Integration)
VAC (V_{RMS})	**Freq (Hz)**	**Power (mW)**
85	60	10.23
95	60	10.69
115	60	11.81
150	60	14.45
180	60	17.18
200	60	19.27
210	60	20.26
230	60	22.91
245	60	25.16
265	60	29.63

6.11 *Line Regulation Graph Summary (at the Main Output Terminal)*



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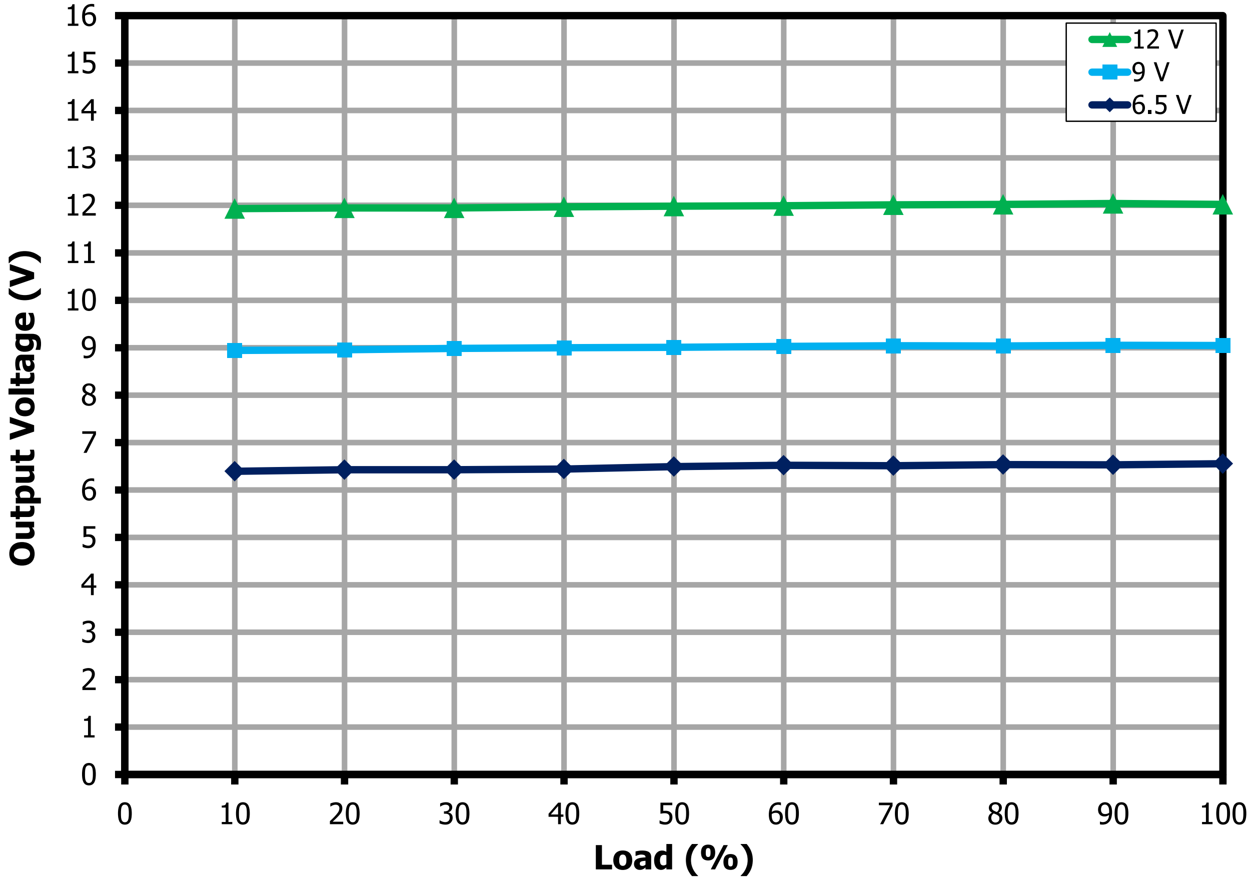
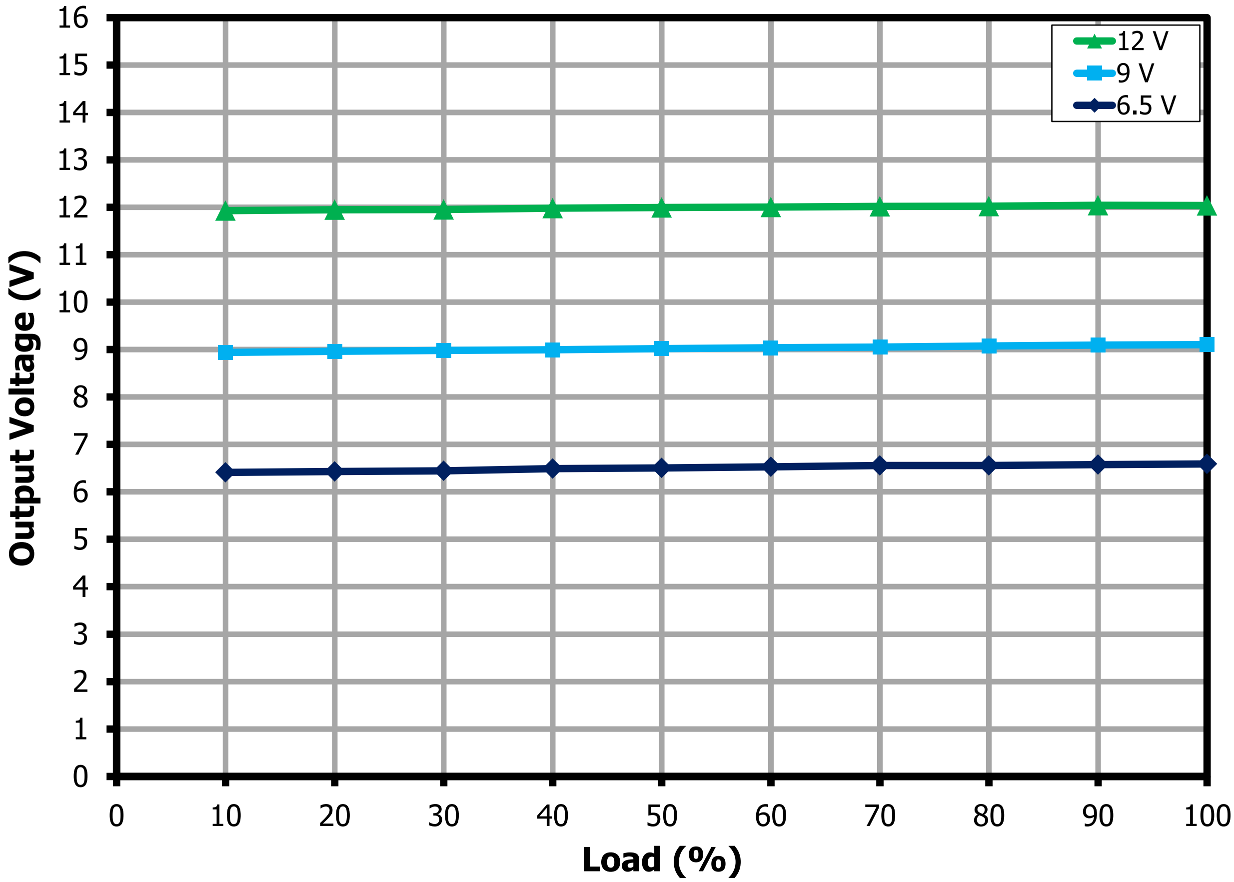
6.12 *Load Regulation Summary Graph at 110 VAC (at the Main Output Terminal)*



6.13 *Load Regulation Summary Graph at 230 VAC (at the Main Output Terminal)*



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7 Waveforms

7.1 *Output Ripple (End of Cable), 6.5 V Output, Full Load*

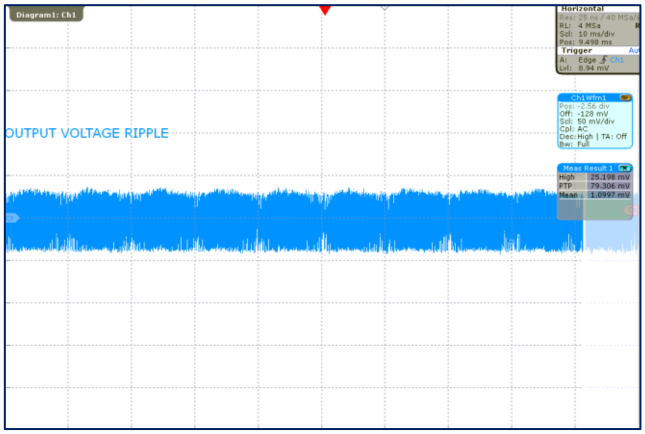

Figure 10 – 85 VAC, 50 Hz.
$V_{OUTRIPPLE}$, 50 mV / div., 10 ms / div.
Measured $V_{OUTRIPPLE}$ = 79 mV_{PK-PK}.

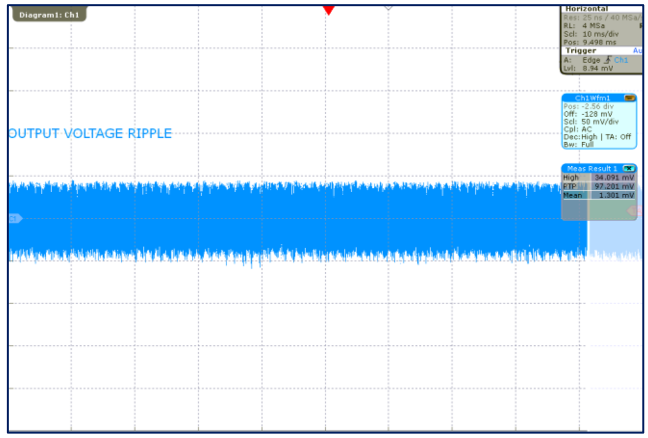

Figure 11 – 265 VAC, 50 Hz.
$V_{OUTRIPPLE}$, 50 mV / div., 10 ms / div.
Measured $V_{OUTRIPPLE}$ = 97 mV_{PK-PK}.

7.2 *Output Ripple (End of Cable), 9 V Output, Full Load*

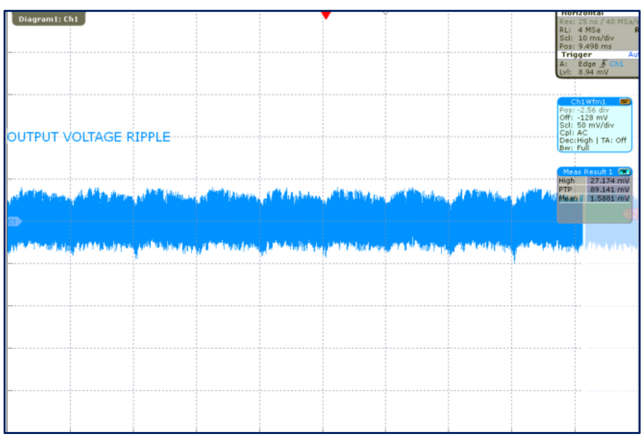

Figure 12 – 85 VAC, 50 Hz.
$V_{OUTRIPPLE}$, 50 mV / div., 10 ms / div.
Measured $V_{OUTRIPPLE}$ = 89 mV_{PK-PK}.

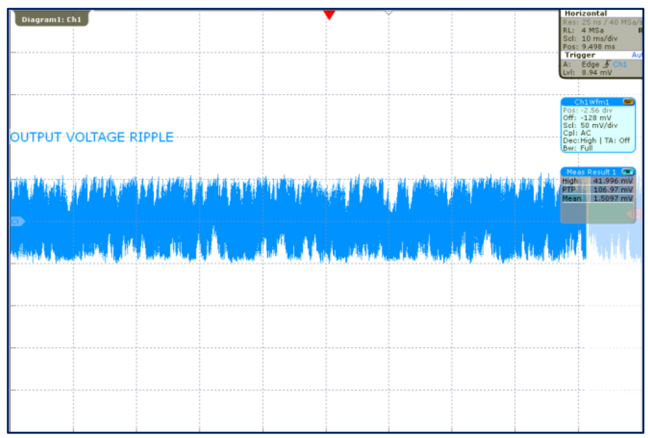

Figure 13 – 265 VAC, 50 Hz.
$V_{OUTRIPPLE}$, 50 mV / div., 10 ms / div.
Measured $V_{OUTRIPPLE}$ = 106 mV_{PK-PK}.

7.3 *Output Ripple (End of Cable), 12 V Output, Full Load*

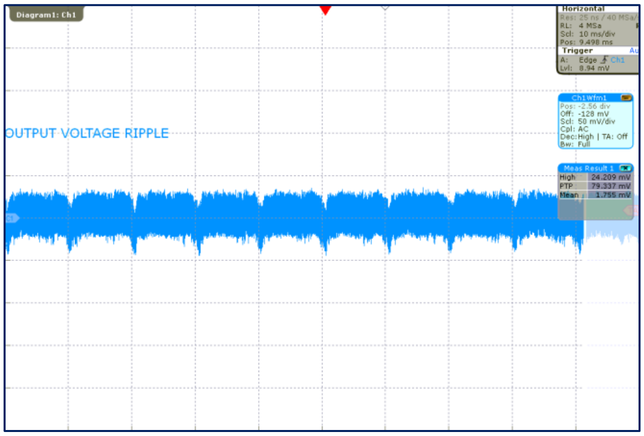

Figure 14 – 85 VAC, 50 Hz.
$V_{OUTRIPPLE}$, 50 mV / div., 10 ms / div.
Measured $V_{OUTRIPPLE}$ = 79 $mV_{PK-PK.}$

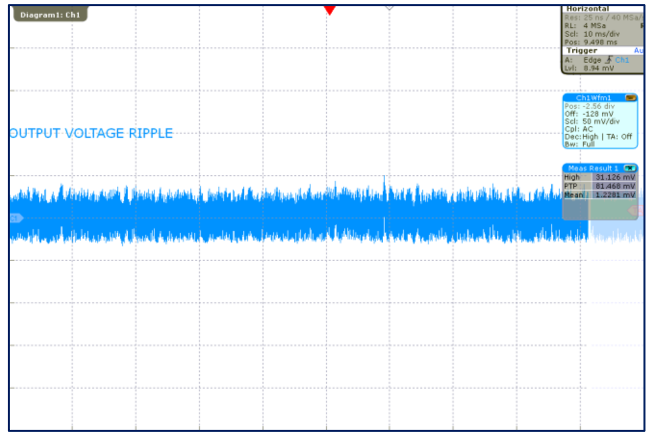

Figure 15 – 265 VAC, 50 Hz.
$V_{OUTRIPPLE}$, 50 mV / div., 10 ms / div.
Measured $V_{OUTRIPPLE}$ = 81 $mV_{PK-PK.}$

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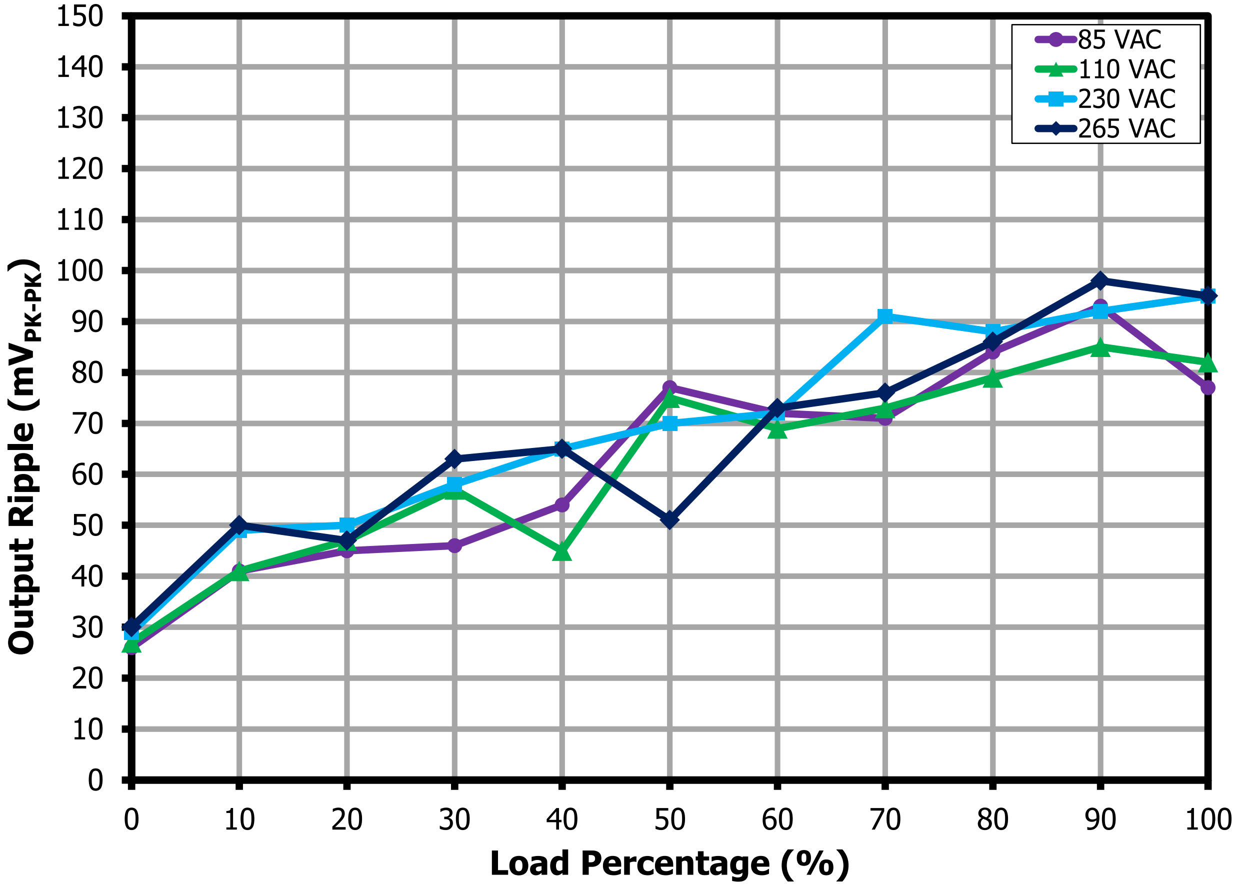
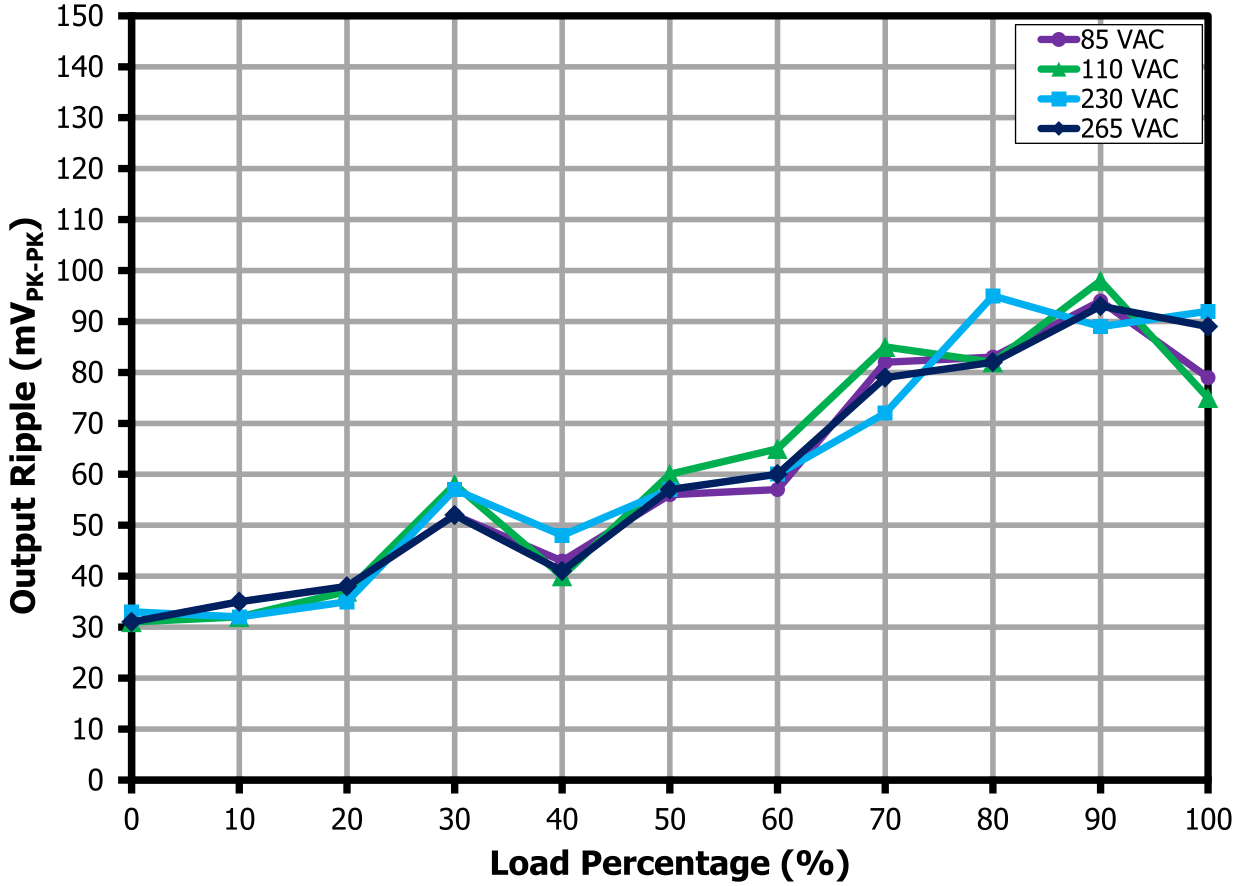
7.4 *Output Ripple (End of Cable) Graph Summary, 6.5 V Output*



7.5 *Output Ripple (End of Cable) Graph Summary, 9 V Output*



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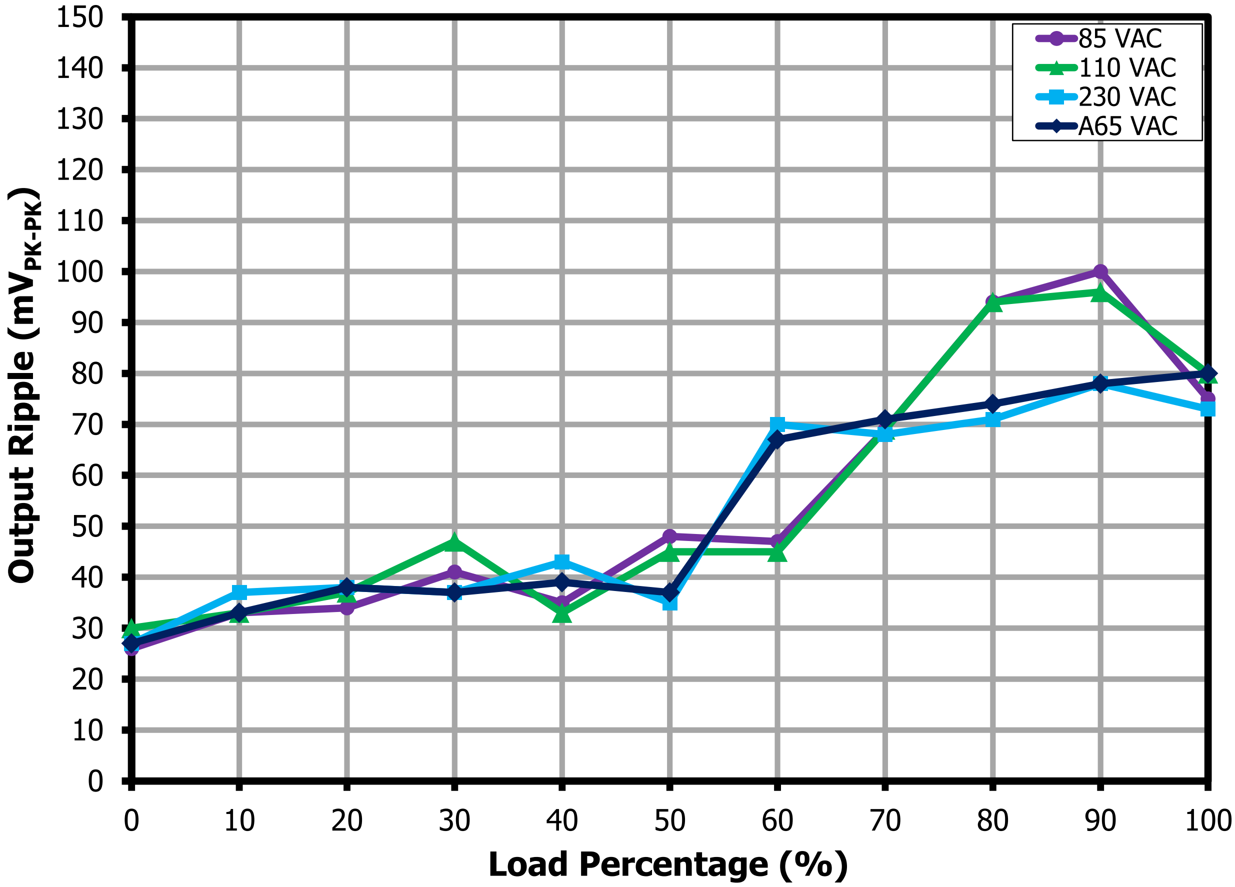
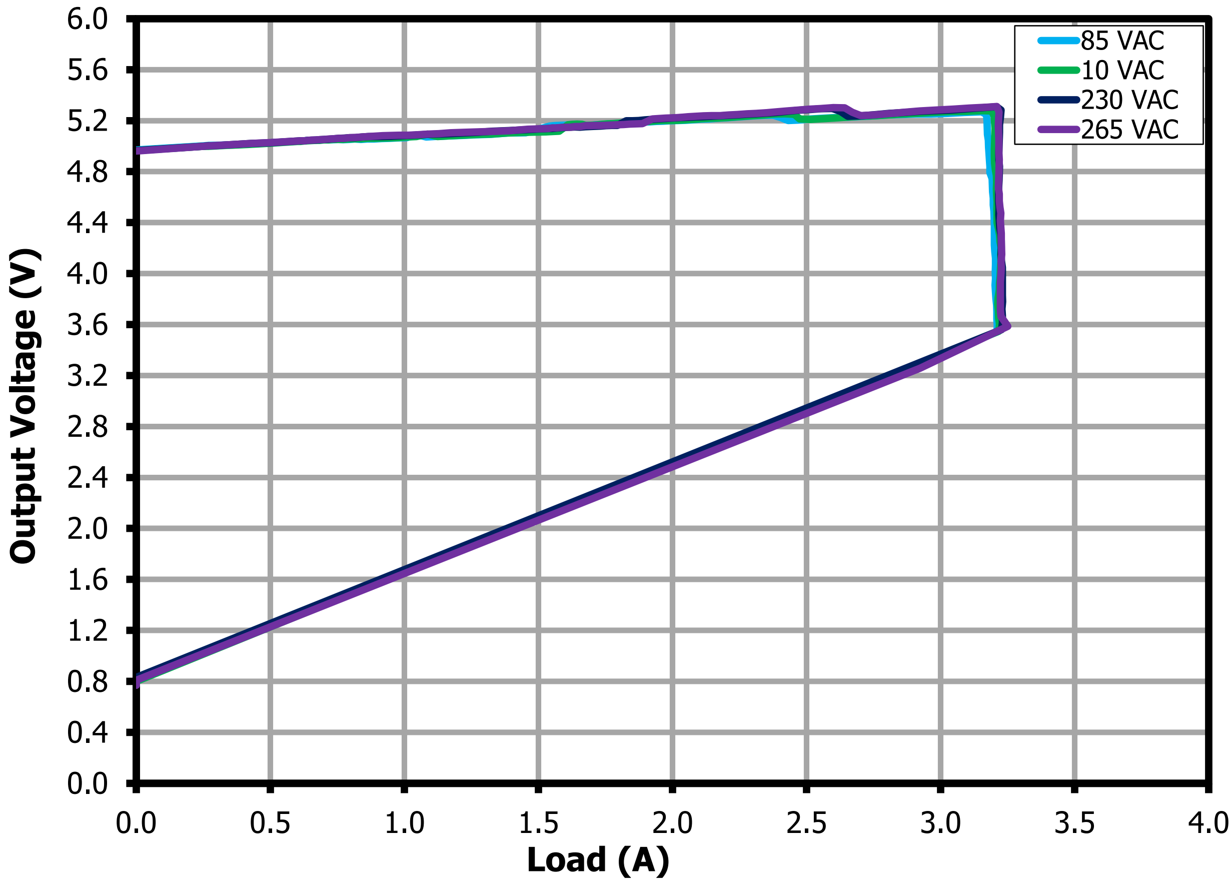
7.6 *Output Ripple (End of Cable) Graph Summary, 12 V Output*



7.7 *CVCC Graph Summary, 5 V Output [Measured at the Board Terminals]*



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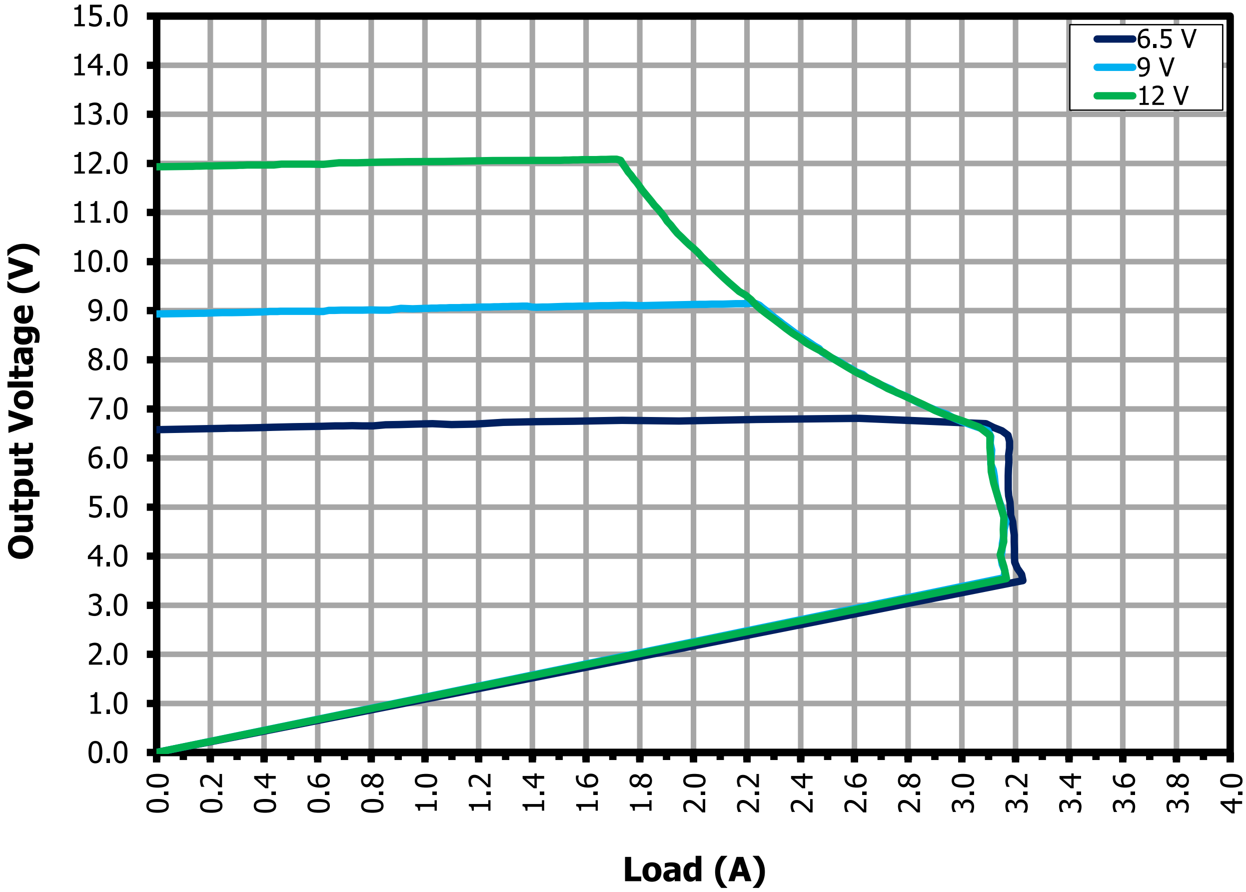
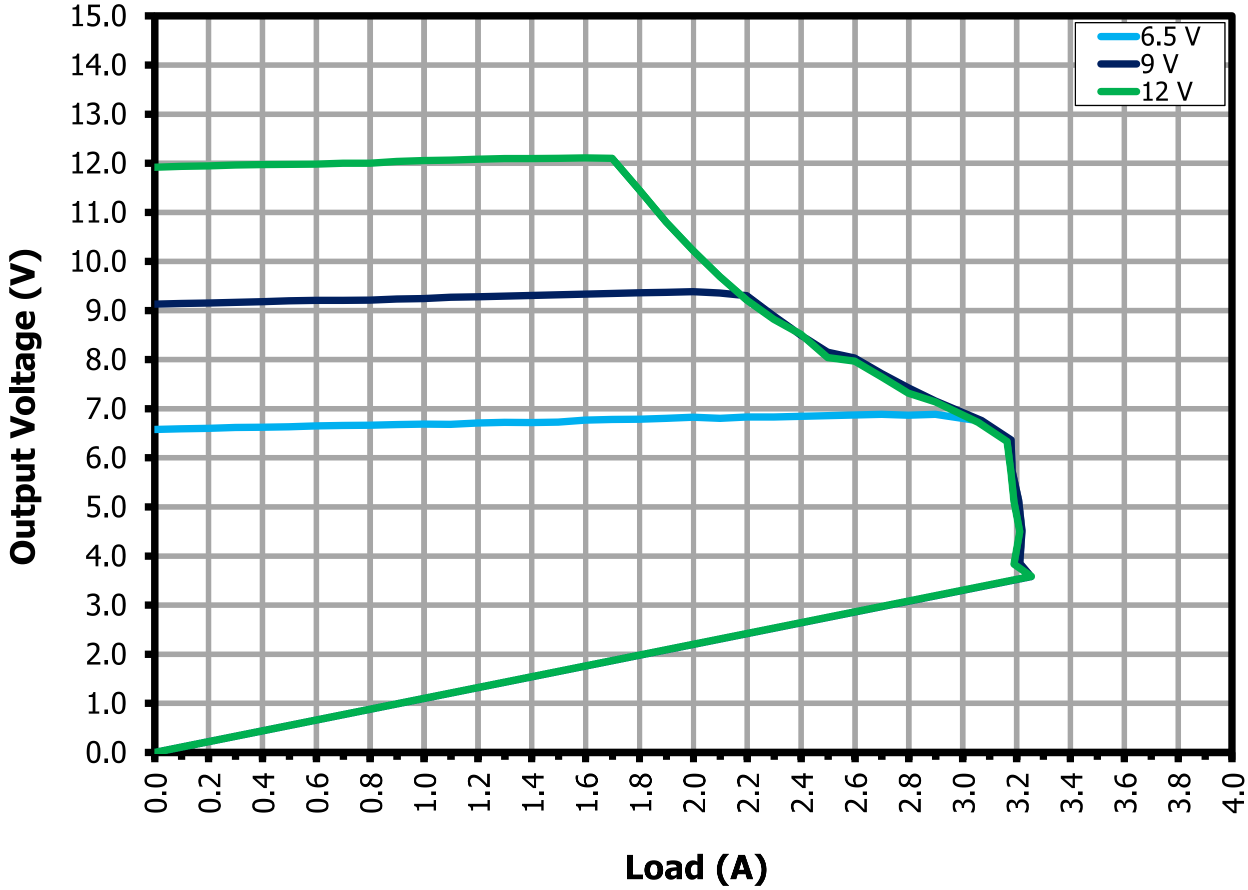
7.8 *CV/CP/CC Graph Summary, 85 VAC*



7.9 *CV/CP/CC Graph Summary, 265 VAC*



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8 Thermal Performance

8.1 *Thermal Performance at 6.5 V, 3 A, T_A = 25 °C*

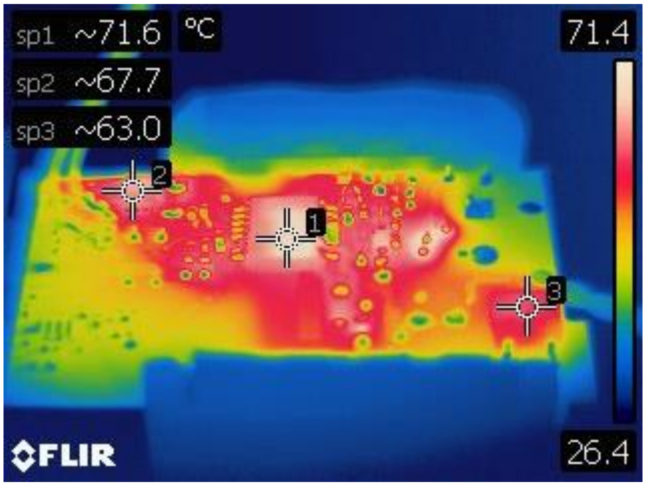

Figure 16 – Ambient Temperature, 26.5 °C.
Sp1 – InnoSwitch-CP, 71.6 °C.
Sp2 – SR FET, 67.7 °C.
Sp3 – Bridge Rectifier, 63 °C.

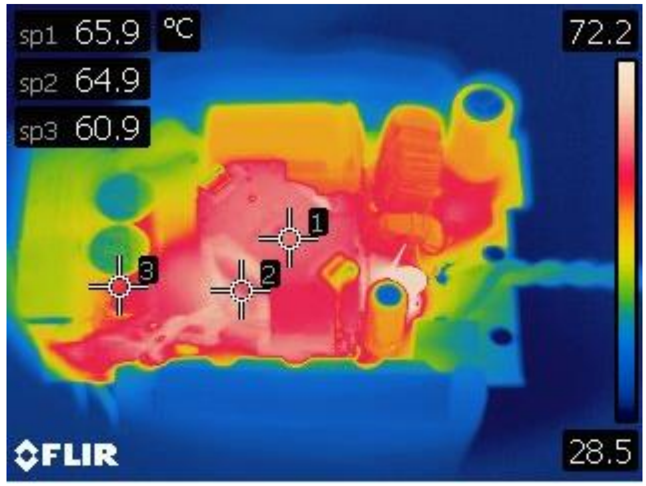

Figure 17 – Ambient Temperature, 26.5 °C.
Sp1 – Transformer Core, 65.9 °C.
Sp2 – Transformer Winding, 64.9 °C.
Sp3 – Output Capacitor, 60.9 °C.

8.2 *Thermal Performance at 6.5 V, 3 A, T_A = 25 °C*

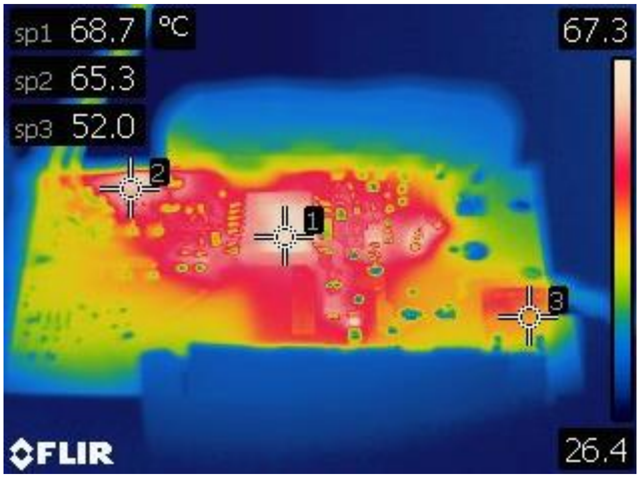

Figure 18 – Ambient Temperature, 26.5 °C.
Sp1 – InnoSwitch-CP, 68.7 °C.
Sp2 – SR FET, 65.3 °C.
Sp3 – Bridge Rectifier, 52 °C.

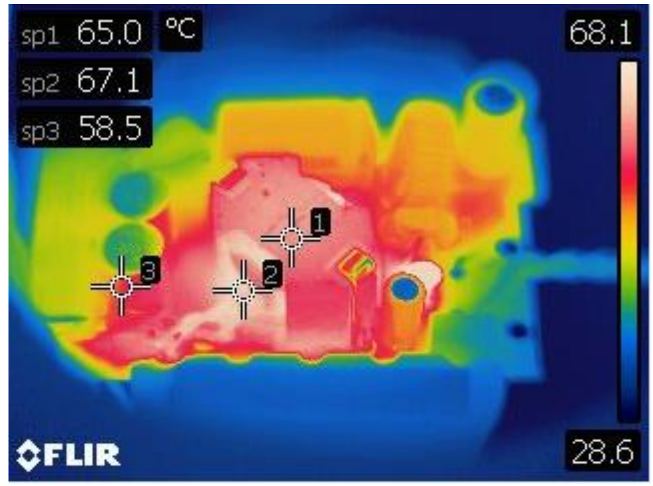

Figure 19 – Ambient Temperature, 26.5 °C.
Sp1 – Transformer Core, 65 °C.
Sp2 – Transformer Winding, 67.1 °C.
Sp3 – Output Capacitor, 58.5 °C.

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8.3 *Thermal Performance at 6.5 V, 3 A, T_A = 25 °C*

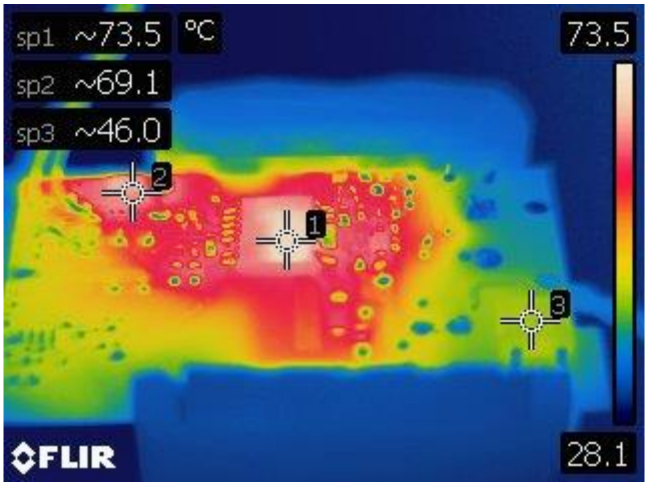

Figure 20 – Ambient Temperature, 26.5 °C.
Sp1 – InnoSwitch-CP, 73.5 °C.
Sp2 – SR FET, 69.1 °C.
Sp3 – Bridge Rectifier, 46 °C.

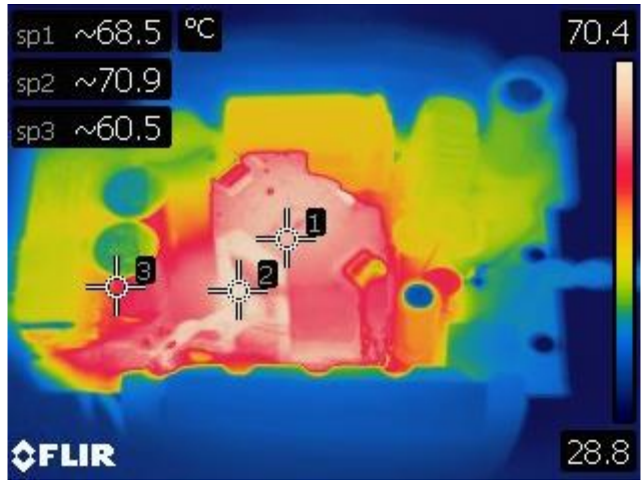

Figure 21 – Ambient Temperature, 26.5 °C.
Sp1 – Transformer Core, 68.5 °C.
Sp2 – Transformer Winding, 70.9 °C.
Sp3 – Output Capacitor, 60.5 °C.

8.4 *Thermal Performance at 6.5 V, 3 A, T_A = 25 °C*

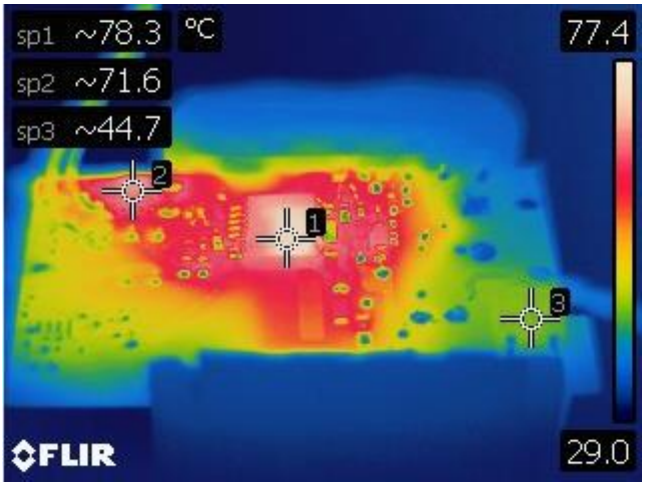

Figure 22 – Ambient Temperature, 26.5 °C.
Sp1 – InnoSwitch-CP, 78.3 °C.
Sp2 – SR FET, 71.6 °C.
Sp3 – Bridge Rectifier, 44.7 °C.

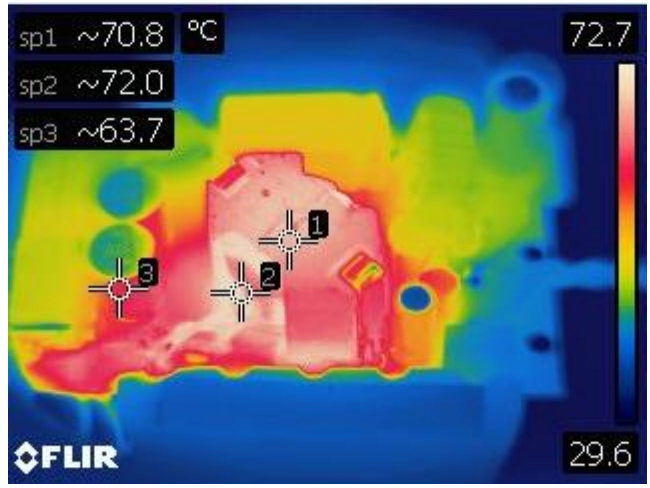

Figure 23 – Ambient Temperature, 26.5 °C.
Sp1 – Transformer Core, 70.8 °C.
Sp2 – Transformer Winding, 72 °C.
Sp3 – Output Capacitor, 63.7 °C.

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9 Waveforms

9.1 *Drain Voltage and Current at 6.5 V, Full Load*

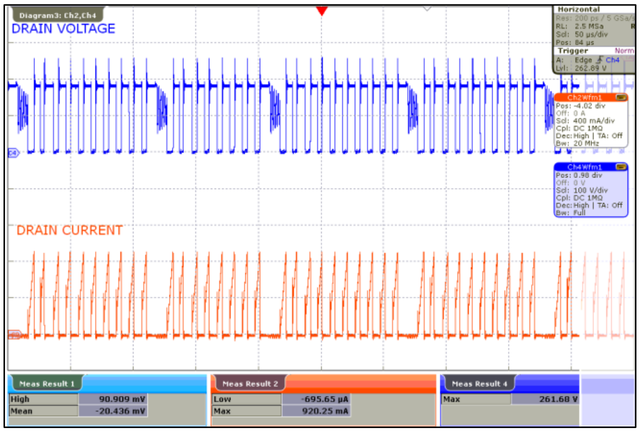

Figure 24 – 85 VAC, 60 Hz.
Upper: V_{DRAIN}, 100 V / div., 50 µs / div.
Lower: I_{DRAIN}, 400 mA / div., 50 µs / div.
Measured V_{PK} = 261 V_{PK}.
Measured I_{PK} = 920 mA_{PK}.

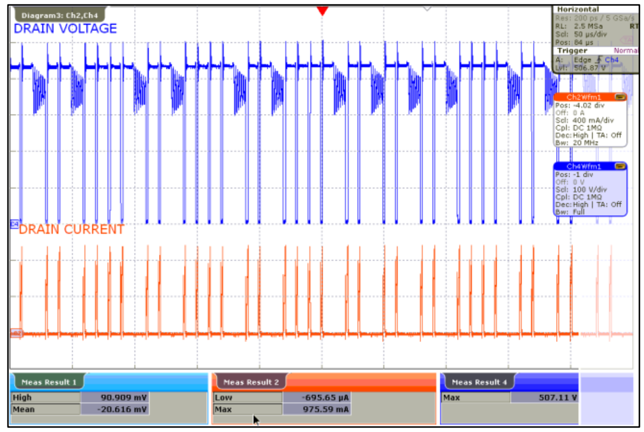

Figure 25 – 265 VAC, 60 Hz.
Upper: V_{DRAIN}, 100 V / div., 50 µs / div.
Lower: I_{DRAIN}, 400 mA / div., 50 µs / div.
Measured V_{PK} = 507 V_{PK}.
Measured I_{PK} = 975 mA_{PK}.

9.2 *Drain Voltage and Current at 9 V, Full Load*

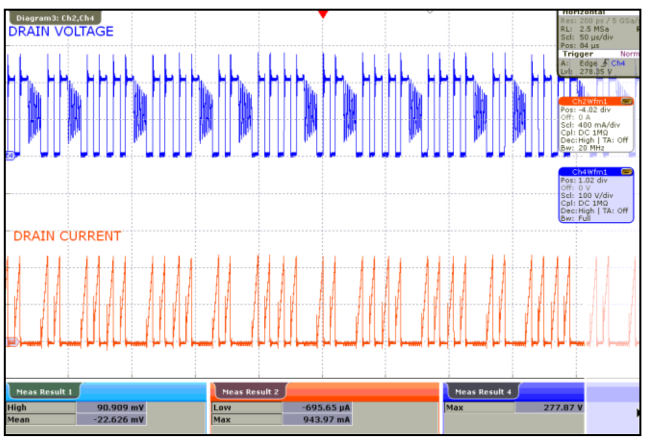

Figure 26 – 85 VAC, 60 Hz.
Upper: V_{DRAIN}, 100 V / div., 50 µs / div.
Lower: I_{DRAIN}, 400 mA / div., 50 µs / div.
Measured V_{PK} = 277 V_{PK}.
Measured I_{PK} = 943 mA_{PK}.

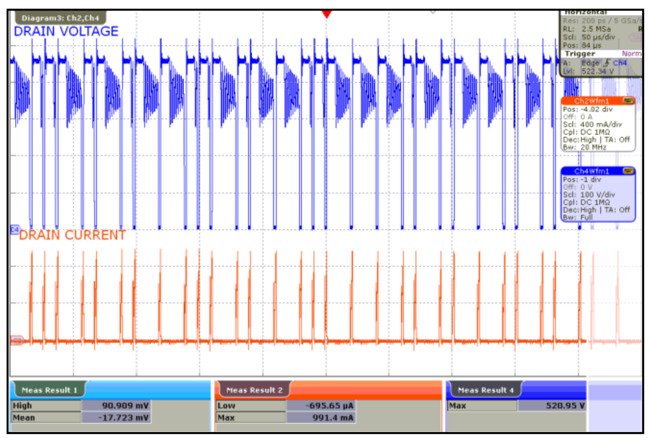

Figure 27 – 265 VAC, 60 Hz.
Upper: V_{DRAIN}, 100 V / div., 50 µs / div.
Lower: I_{DRAIN}, 400 mA / div., 50 µs / div.
Measured V_{PK} = 520 V_{PK}.
Measured I_{PK} = 991 mA_{PK}.

9.3 *Drain Voltage and Current at 12 V, Full Load*

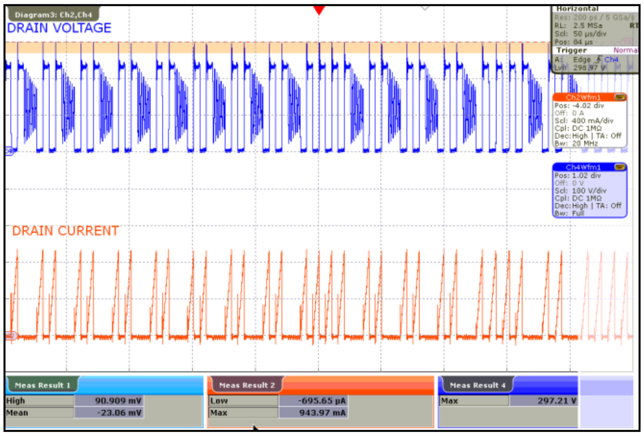

Figure 28 – 85 VAC, 60 Hz.
Upper: V_{DRAIN}, 100 V / div., 50 µs / div.
Lower: I_{DRAIN}, 400 mA / div., 50 µs / div.
Measured V_{PK} = 297 $V_{PK.}$
Measured I_{PK} = 943 $mA_{PK.}$

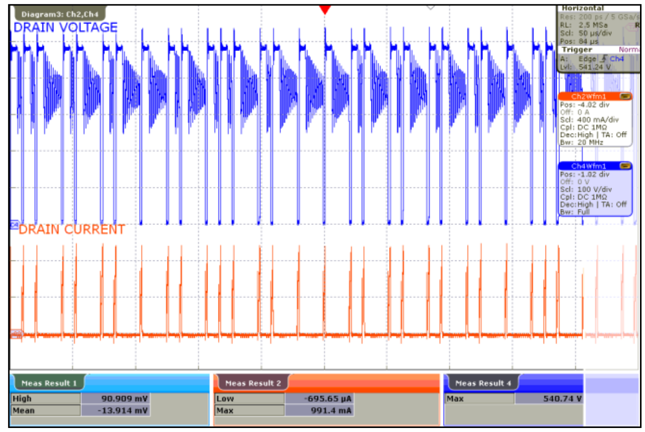

Figure 29 – 265 VAC, 60 Hz.
Upper: V_{DRAIN}, 100 V / div., 50 µs / div.
Lower: I_{DRAIN}, 400 mA / div., 50 µs / div.
Measured V_{PK} = 540 $V_{PK.}$
Measured I_{PK} = 991 $mA_{PK.}$

9.4 *Drain Voltage and Current at Startup for 5 V, Full Load*

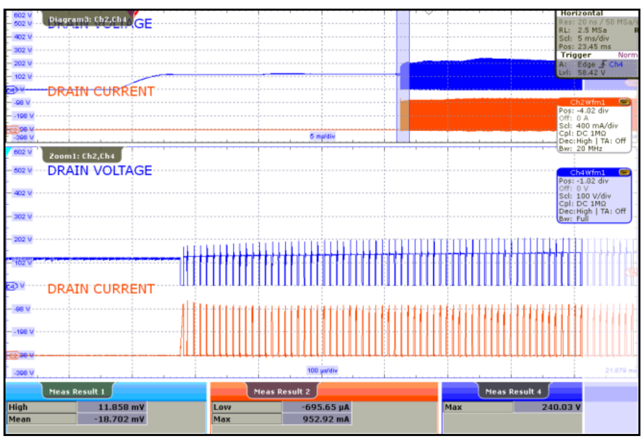

Figure 30 – 85 VAC, 60 Hz.
Upper: V_{DRAIN}, 100 V / div., 50 µs / div.
Lower: I_{DRAIN}, 400 mA / div., 50 µs / div.
Measured V_{PK} = 240 $V_{PK.}$
Measured I_{PK} = 952 $mA_{PK.}$

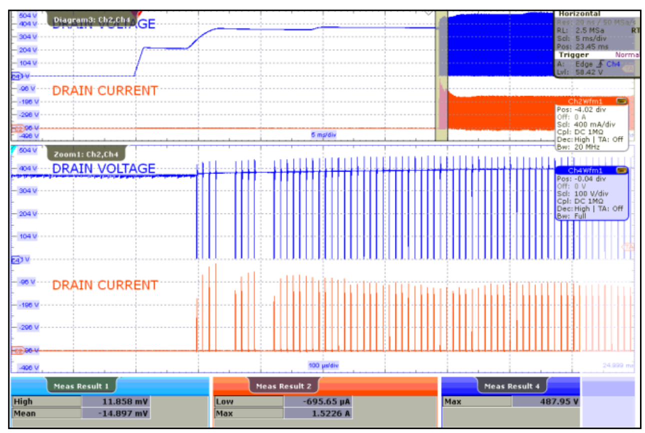

Figure 31 – 265 VAC, 60 Hz.
Upper: V_{DRAIN}, 100 V / div., 50 µs / div.
Lower: I_{DRAIN}, 400 mA / div., 50 µs / div.
Measured V_{PK} = 487 $V_{PK.}$
Measured I_{PK} = 1.52 $A_{PK.}$

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9.5 *Synchronous Rectifier Voltage, 6.5 V, Full Load*

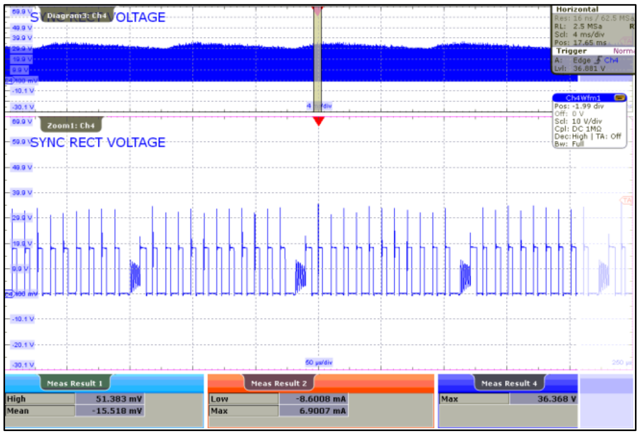

Figure 32 – 85 VAC, 60 Hz.
$V_{SYNCRECT}$, 10 V / div., 4 ms / div.
Measured V_{PK} = 36 V_{PK}.

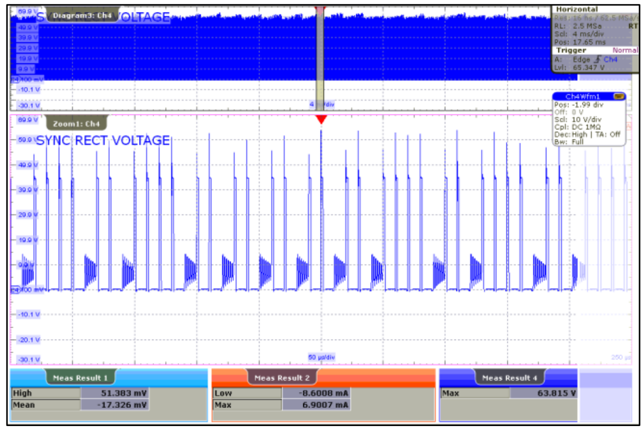

Figure 33 – 265 VAC, 60 Hz.
$V_{SYNCRECT}$, 10 V / div., 4 ms / div.
Measured V_{PK} = 63 V_{PK}.

9.6 *Synchronous Rectifier Voltage, 9 V, Full Load*

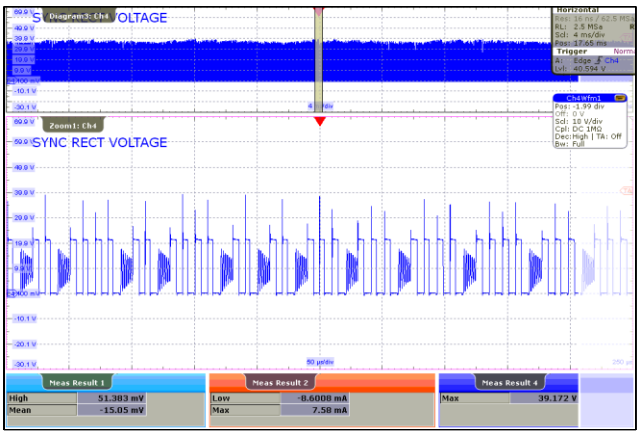

Figure 34 – 85 VAC, 60 Hz.
$V_{SYNCRECT}$, 10 V / div., 4 ms / div.
Measured V_{PK} = 39 V_{PK}.

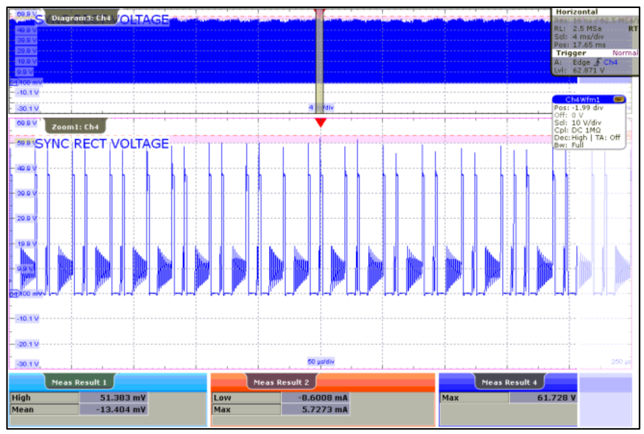

Figure 35 – 265 VAC, 60 Hz.
$V_{SYNCRECT}$, 10 V / div., 4 ms / div.
Measured V_{PK} = 61 V_{PK}.

9.7 *Synchronous Rectifier Voltage, 12 V, Full Load*

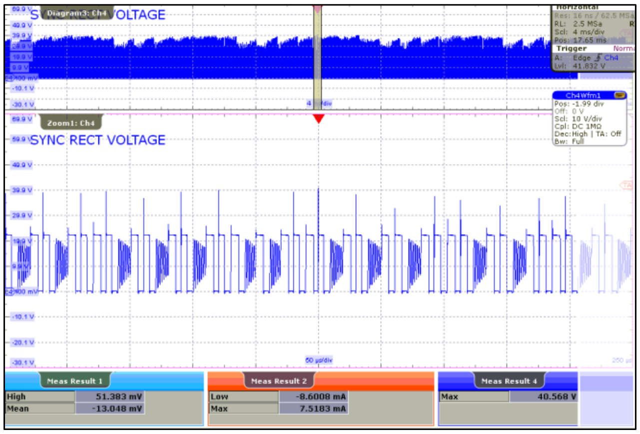

Figure 36 – 85 VAC, 60 Hz.
$V_{SYNCRECT}$, 10 V / div., 4 ms / div.
Measured V_{PK} = 40 V_{PK}.

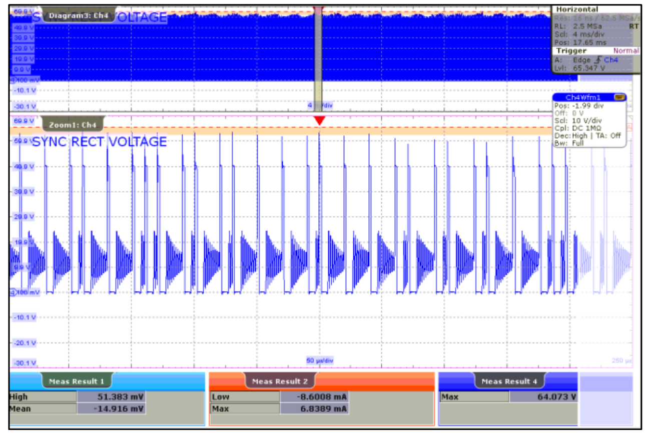

Figure 37 – 265 VAC, 60 Hz.
$V_{SYNCRECT}$, 10 V / div., 4 ms / div.
Measured V_{PK} = 64 V_{PK}.

9.8 *Output Start-Up, 5 V, Full Load (CC Mode)*

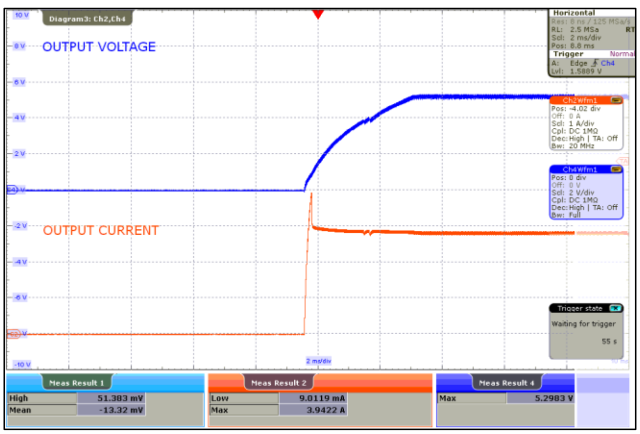

Figure 38 – 85 VAC, 60 Hz.
Upper: V_{OUT}, 2 V / div., 2 ms / div.
Lower: I_{OUT}, 1 A / div., 2 ms / div.
Measured V_{PK} = 5.29 V_{PK}.
Measured I_{PK} = 3.94 A_{PK}.

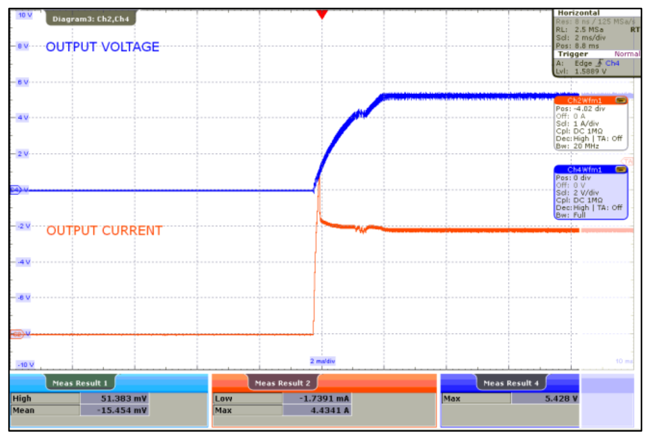

Figure 39 – 265 VAC, 60 Hz.
Upper: V_{OUT}, 2 V / div., 2 ms / div.
Lower: I_{OUT}, 1 A / div., 2 ms / div.
Measured V_{PK} = 5.42 V_{PK}.
Measured I_{PK} = 4.43 A_{PK}.

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9.9 *Output Voltage Change Using QC 2.0 [5V→9V→12V→9V→5V]*

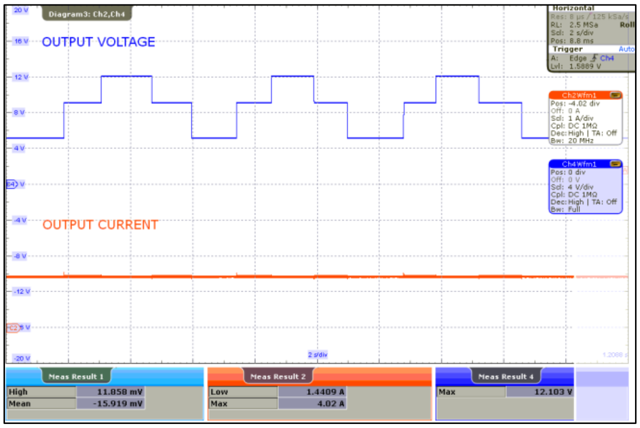

Figure 40 – 85 VAC, 60 Hz.
Upper: V_{OUT}, 4 V / div., 2 s / div.
Lower: I_{OUT}, 1 A / div., 2 s / div.

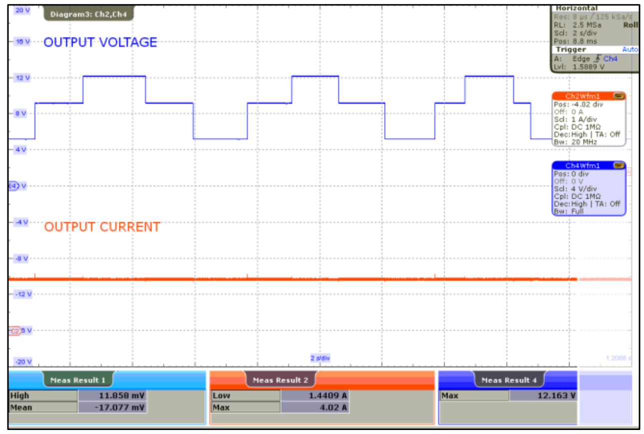

Figure 41 – 265 VAC, 60 Hz.
Upper: V_{OUT}, 4 V / div., 2 s / div.
Lower: I_{OUT}, 1 A / div., 2 s / div.

9.10 *Output Voltage Change Using QC 3.0 [5V→12V→3.6V]*

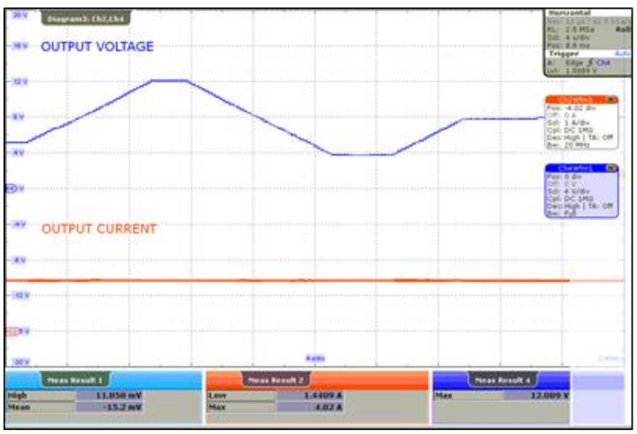

Figure 42 – 85 VAC, 60 Hz.
Upper: V_{OUT}, 4 V / div., 4 s / div.
Lower: I_{OUT}, 1 A / div., 4 s / div.

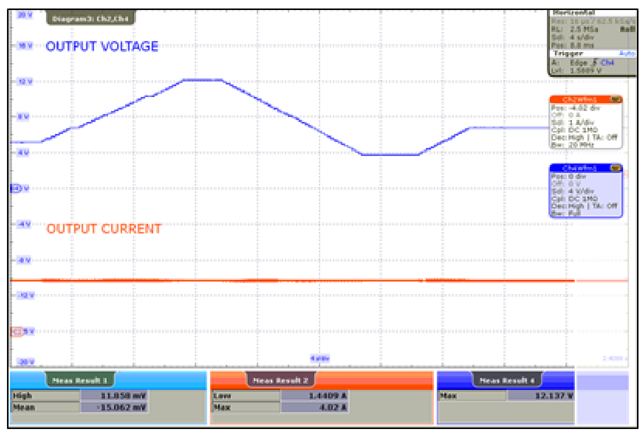

Figure 43 – 265 VAC, 60 Hz.
Upper: V_{OUT}, 4 V / div., 4 s / div.
Lower: I_{OUT}, 1 A / div., 4 s / div.

9.11 *Output Load Transient, 6.5 V, Full Load*

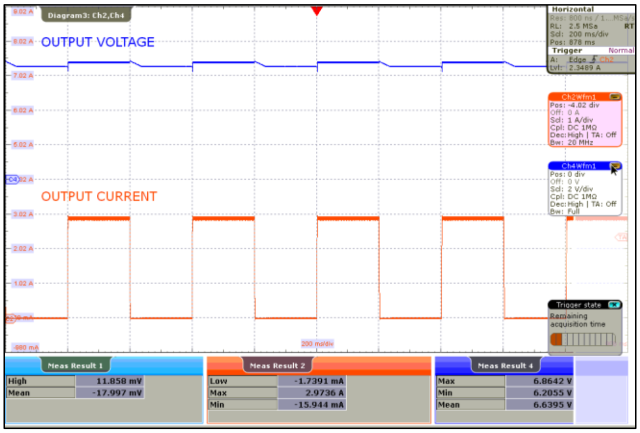

Figure 44 – 85 VAC, 60 Hz.
Upper: V_{OUT}, 2 V / div., 200 ms / div.
Lower: I_{OUT}, 1 A / div., 200 ms / div.
Measured Max Peak Voltage = 6.86 $V_{PK.}$
Measured Min Undershoot = 6.20 $V_{PK.}$

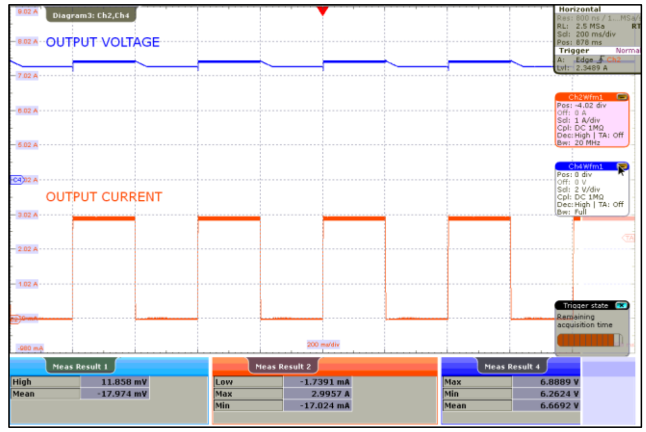

Figure 45 – 265 VAC, 60 Hz.
Upper: V_{OUT}, 2 V / div., 200 ms / div.
Lower: I_{OUT}, 1 A / div., 200 ms / div.
Measured Max Peak Voltage = 6.88 $V_{PK.}$
Measured Min Undershoot = 6.26 $V_{PK.}$

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9.12 ***Output Load Transient, 9 V, Full Load***

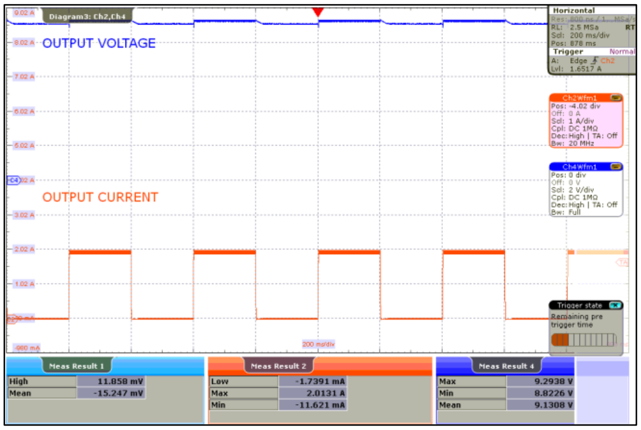

Figure 46 – 85 VAC, 60 Hz.
Upper: V_{OUT}, 2 V / div., 200 ms / div.
Lower: I_{OUT}, 1 A / div., 200 ms / div.
Measured Max Peak Voltage = 9.29 $V_{PK.}$
Measured Min Undershoot = 8.82 $V_{PK.}$

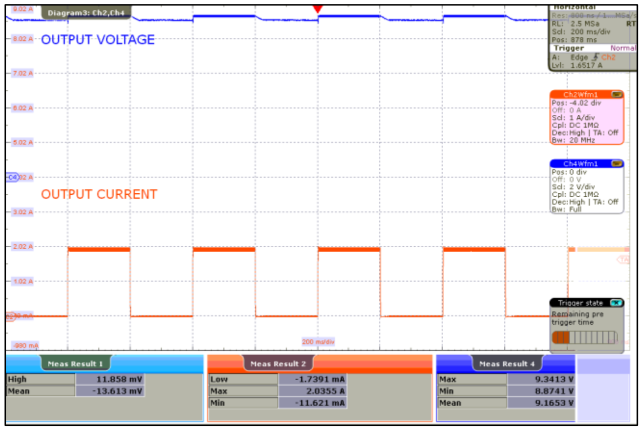

Figure 47 – 265 VAC, 60 Hz.
Upper: V_{OUT}, 2 V / div., 200 ms / div.
Lower: I_{OUT}, 1 A / div., 200 ms / div.
Measured Max Peak Voltage = 9.34 $V_{PK.}$
Measured Min Undershoot = 8.87 $V_{PK.}$

9.13 ***Output Load Transient, 12 V, Full Load***

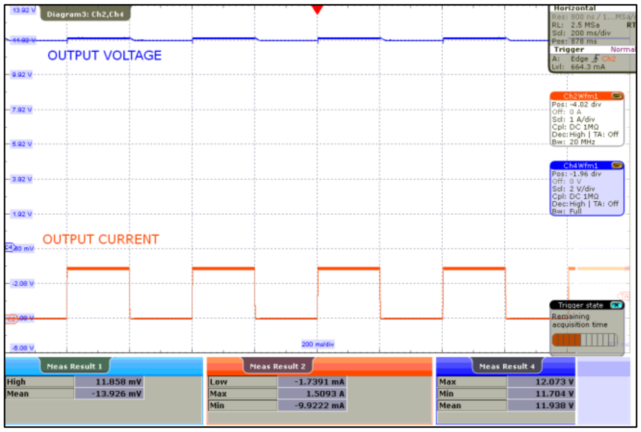

Figure 48 – 85 VAC, 60 Hz.
Upper: V_{OUT}, 2 V / div., 200 ms / div.
Lower: I_{OUT}, 1 A / div., 200 ms / div.
Measured Max Peak Voltage = 12.07 $V_{PK.}$
Measured Min Undershoot = 11.70 $V_{PK.}$

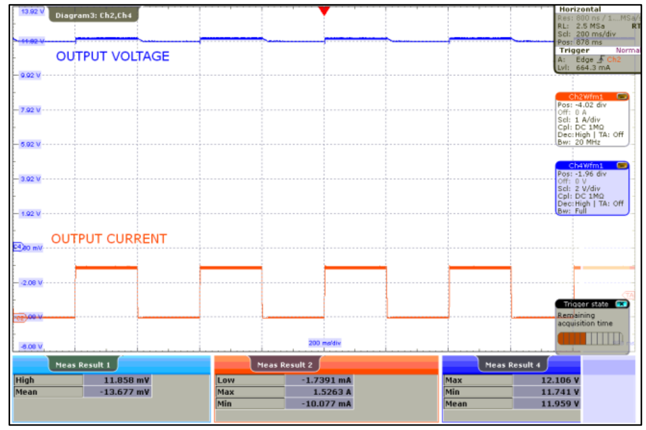

Figure 49 – 265 VAC, 60 Hz.
Upper: V_{OUT}, 2 V / div., 200 ms / div.
Lower: I_{OUT}, 1 A / div., 200 ms / div.
Measured Max Peak Voltage = 12.10 $V_{PK.}$
Measured Min Undershoot = 11.74 $V_{PK.}$

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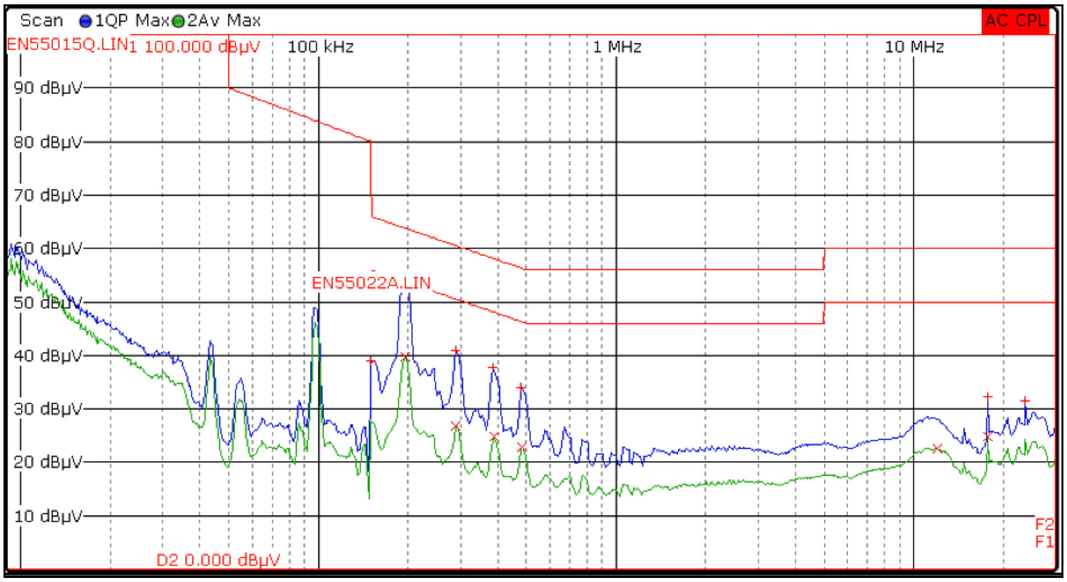
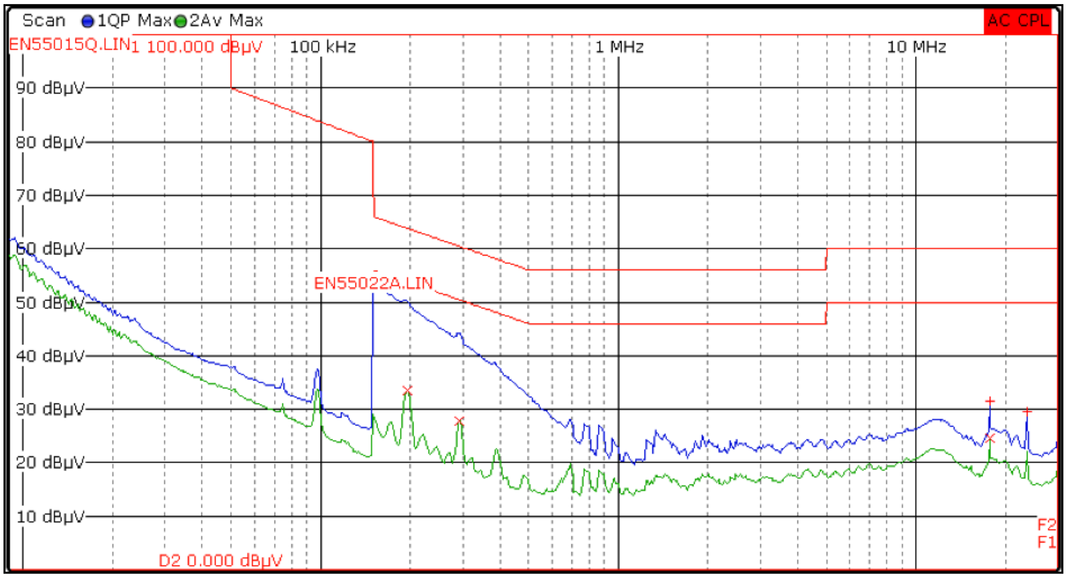
10 EMI Results

10.1 *110 VAC, 6.5 V, Floating Output*



Trace/Detector	Frequency	Level dBµV	DeltaLimit
1 Quasi Peak	150.0000 kHz	38.96 N	-27.04 dB
1 Quasi Peak	192.7500 kHz	53.40 N	-10.52 dB
2 Average	195.0000 kHz	39.74 N	-14.08 dB
1 Quasi Peak	289.5000 kHz	40.86 N	-19.68 dB
2 Average	289.5000 kHz	26.81 N	-23.73 dB
1 Quasi Peak	384.0000 kHz	37.75 N	-20.44 dB
2 Average	388.5000 kHz	24.93 N	-23.17 dB
1 Quasi Peak	480.7500 kHz	33.97 N	-22.36 dB
2 Average	483.0000 kHz	22.73 N	-23.56 dB
2 Average	12.0008 MHz	22.50 N	-27.50 dB
1 Quasi Peak	17.7113 MHz	32.28 L1	-27.72 dB
2 Average	17.7113 MHz	24.85 L1	-25.15 dB
1 Quasi Peak	23.6153 MHz	31.41 L1	-28.59 dB

10.2 *230 VAC, 6.5 V, Floating Output*



Trace/Detector	Frequency	Level dBμV	DeltaLimit
1 Quasi Peak	150.0000 kHz	53.10 L1	-12.90 dB
2 Average	195.0000 kHz	33.51 L1	-20.31 dB
2 Average	291.7500 kHz	27.88 L1	-22.59 dB
2 Average	17.7000 MHz	24.53 L1	-25.47 dB
1 Quasi Peak	17.7023 MHz	31.52 L1	-28.48 dB
1 Quasi Peak	23.6018 MHz	29.52 L1	-30.48 dB

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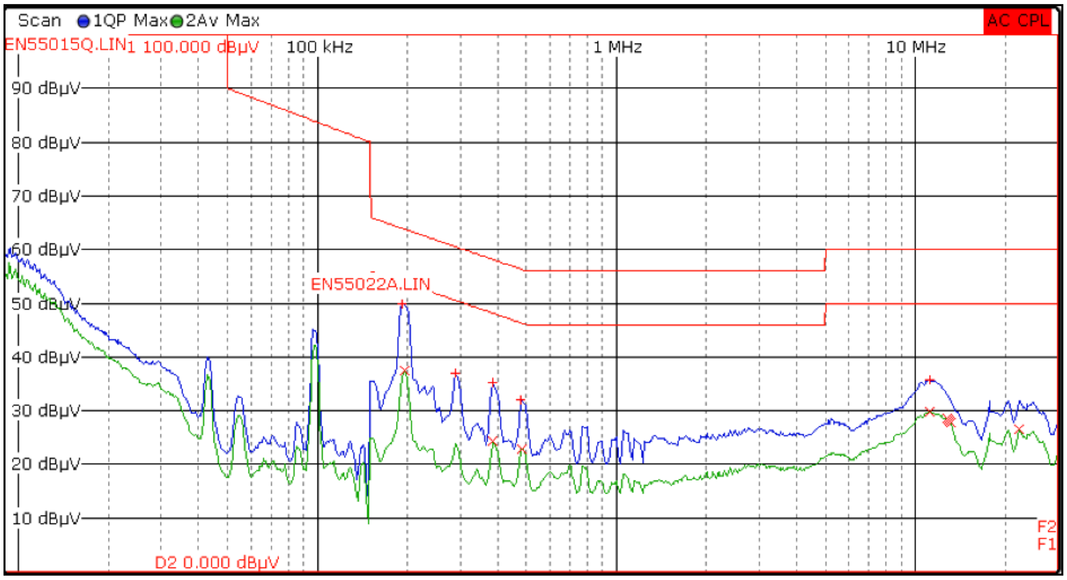
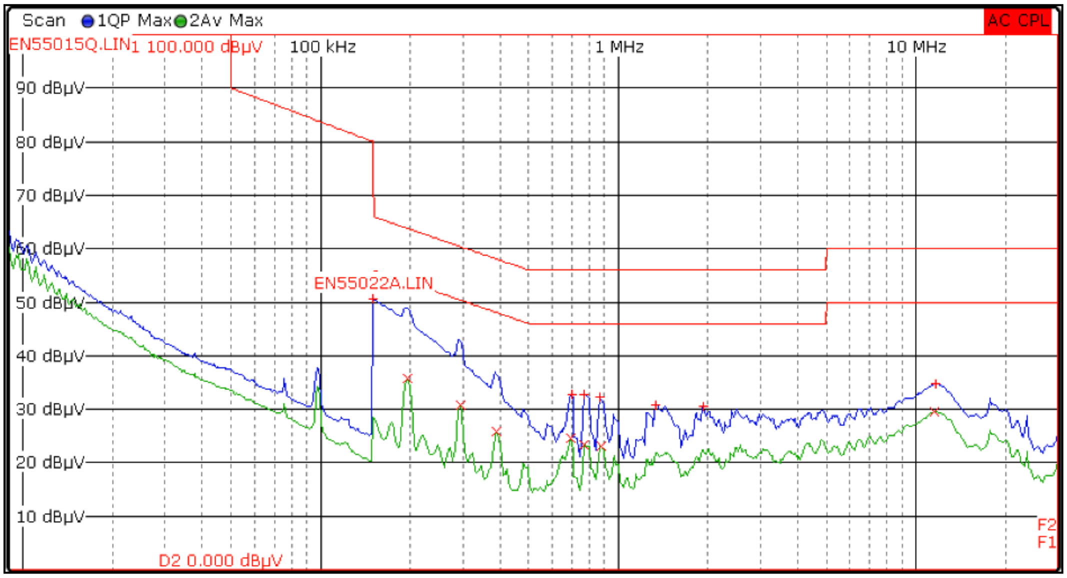
10.3 ***110 VAC, 6.5 V, Artificial Hand***



Trace/Detector	Frequency	Level dBµV	DeltaLimit
1 Quasi Peak	192.7500 kHz	50.00 N	-13.92 dB
2 Average	195.0000 kHz	37.40 N	-16.42 dB
1 Quasi Peak	289.5000 kHz	36.91 N	-23.63 dB
1 Quasi Peak	384.0000 kHz	35.23 L1	-22.96 dB
2 Average	386.2500 kHz	24.37 N	-23.77 dB
1 Quasi Peak	480.7500 kHz	32.02 N	-24.31 dB
2 Average	483.0000 kHz	22.95 N	-23.34 dB
2 Average	11.2290 MHz	29.82 N	-20.18 dB
1 Quasi Peak	11.2312 MHz	35.84 N	-24.16 dB
2 Average	12.8580 MHz	28.43 N	-21.57 dB
2 Average	12.9548 MHz	28.31 N	-21.69 dB
2 Average	13.0515 MHz	28.14 N	-21.86 dB
2 Average	13.1505 MHz	27.88 N	-22.12 dB
2 Average	22.3463 MHz	26.47 L1	-23.53 dB

10.4 ***230 VAC, 6.5 V, Artificial Hand***



Trace/Detector	Frequency	Level dBµV	DeltaLimit
1 Quasi Peak	150.0000 kHz	50.66 L1	-15.34 dB
2 Average	195.0000 kHz	35.79 N	-18.03 dB
2 Average	294.0000 kHz	30.71 N	-19.70 dB
2 Average	11.5643 MHz	29.46 N	-20.54 dB
2 Average	694.5000 kHz	24.64 N	-21.36 dB
2 Average	388.5000 kHz	25.84 N	-22.26 dB
2 Average	768.7500 kHz	23.40 N	-22.60 dB
2 Average	876.7500 kHz	23.17 N	-22.83 dB
1 Quasi Peak	699.0000 kHz	32.86 N	-23.14 dB
1 Quasi Peak	771.0000 kHz	32.75 N	-23.25 dB
1 Quasi Peak	867.7500 kHz	32.27 N	-23.73 dB
1 Quasi Peak	1.3380 MHz	30.88 N	-25.12 dB
1 Quasi Peak	11.7083 MHz	34.64 N	-25.36 dB
1 Quasi Peak	1.9298 MHz	30.63 N	-25.37 dB

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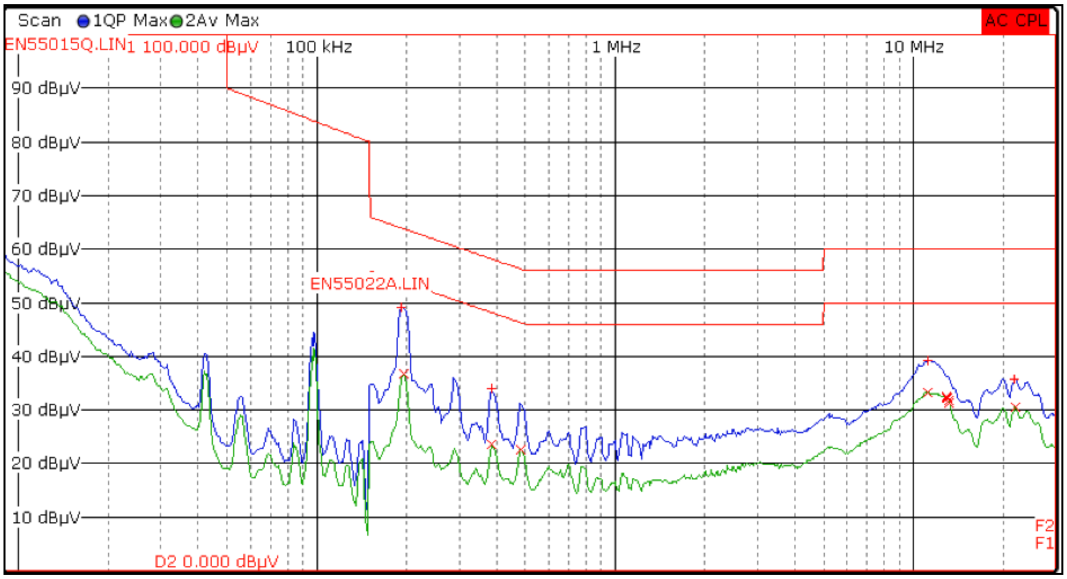
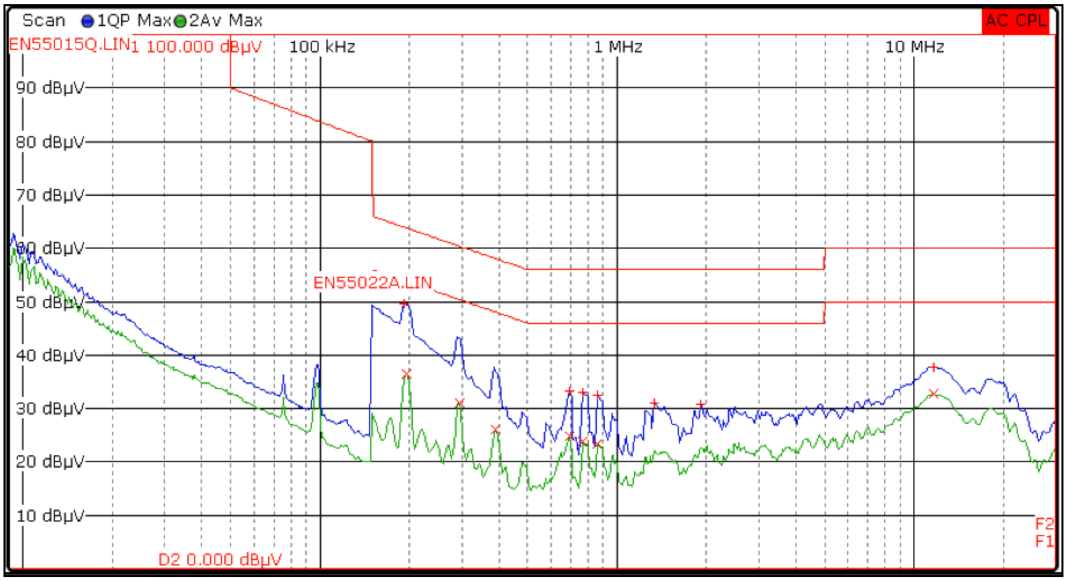
10.5 ***110 VAC, 6.5 V, Earth***



Trace/Detector	Frequency	Level dBµV	DeltaLimit
1 Quasi Peak	192.7500 kHz	49.11 N	-14.81 dB
2 Average	195.0000 kHz	36.69 N	-17.13 dB
1 Quasi Peak	384.0000 kHz	34.08 L1	-24.11 dB
2 Average	386.2500 kHz	23.59 N	-24.55 dB
2 Average	483.0000 kHz	22.63 N	-23.66 dB
2 Average	11.2133 MHz	33.28 L1	-16.72 dB
1 Quasi Peak	11.2155 MHz	39.27 L1	-20.73 dB
2 Average	12.8895 MHz	32.44 L1	-17.56 dB
2 Average	12.9863 MHz	32.32 L1	-17.68 dB
2 Average	13.0335 MHz	32.19 L1	-17.81 dB
2 Average	13.1325 MHz	31.86 L1	-18.14 dB
2 Average	13.2315 MHz	31.24 L1	-18.76 dB
1 Quasi Peak	21.9075 MHz	35.83 L1	-24.17 dB
2 Average	22.0043 MHz	30.48 L1	-19.52 dB

10.6 ***230 VAC, 6.5 V, Earth***



Trace/Detector	Frequency	Level dBµV	DeltaLimit
1 Quasi Peak	192.7500 kHz	49.52 N	-14.40 dB
2 Average	195.0000 kHz	36.55 N	-17.27 dB
2 Average	294.0000 kHz	31.08 N	-19.33 dB
2 Average	388.5000 kHz	26.07 N	-22.03 dB
2 Average	692.2500 kHz	24.84 N	-21.16 dB
1 Quasi Peak	694.5000 kHz	33.24 N	-22.76 dB
1 Quasi Peak	766.5000 kHz	33.03 N	-22.97 dB
2 Average	768.7500 kHz	23.78 N	-22.22 dB
1 Quasi Peak	861.0000 kHz	32.45 N	-23.55 dB
2 Average	863.2500 kHz	23.35 N	-22.65 dB
1 Quasi Peak	1.3380 MHz	31.04 N	-24.96 dB
1 Quasi Peak	1.9118 MHz	30.85 N	-25.15 dB
1 Quasi Peak	11.6542 MHz	37.79 N	-22.21 dB
2 Average	11.6542 MHz	32.77 N	-17.23 dB

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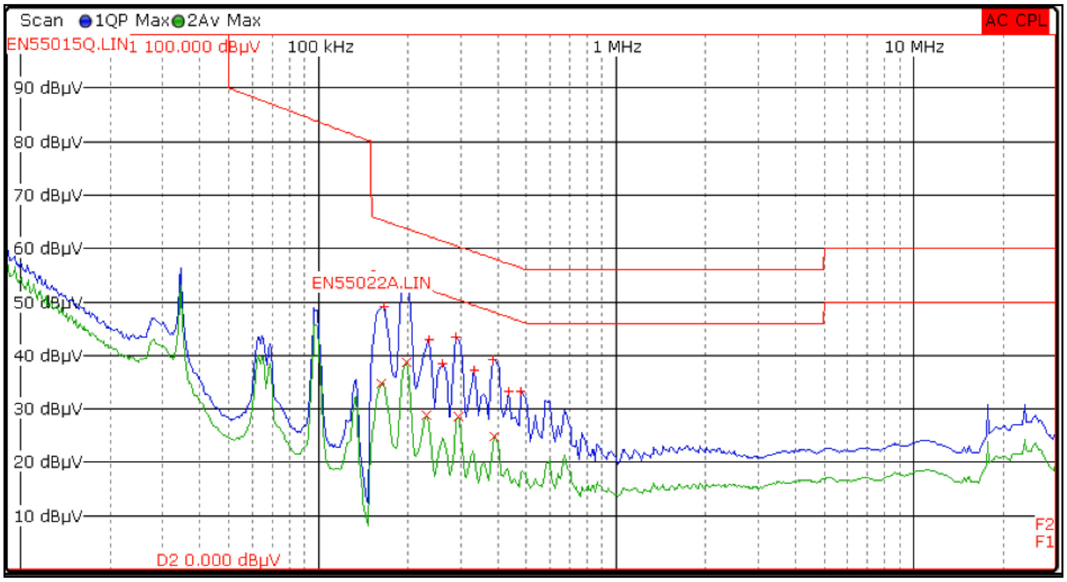
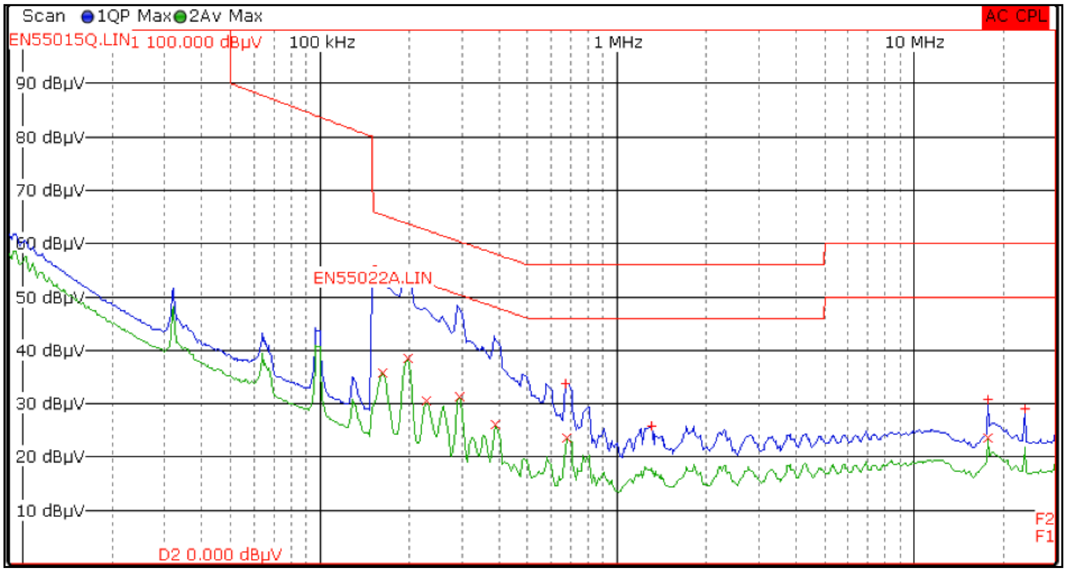
10.7 *110 VAC, 9 V, Floating Output*



Trace/Detector	Frequency	Level dBµV	DeltaLimit
2 Average	163.5000 kHz	34.71 N	-20.57 dB
1 Quasi Peak	165.7500 kHz	49.02 N	-16.15 dB
1 Quasi Peak	192.7500 kHz	52.87 N	-11.05 dB
2 Average	197.2500 kHz	38.62 N	-15.11 dB
2 Average	231.0000 kHz	28.81 N	-23.60 dB
1 Quasi Peak	235.5000 kHz	42.94 N	-19.31 dB
1 Quasi Peak	262.5000 kHz	38.41 N	-22.94 dB
1 Quasi Peak	289.5000 kHz	43.34 N	-17.20 dB
2 Average	294.0000 kHz	28.53 N	-21.88 dB
1 Quasi Peak	334.5000 kHz	37.25 N	-22.09 dB
1 Quasi Peak	386.2500 kHz	39.27 N	-18.87 dB
2 Average	390.7500 kHz	24.81 N	-23.24 dB
1 Quasi Peak	435.7500 kHz	33.22 N	-23.92 dB
1 Quasi Peak	480.7500 kHz	33.32 L1	-23.01 dB

10.8 *230 VAC, 9 V, Floating Output*



Trace/Detector	Frequency	Level dBµV	DeltaLimit
2 Average	163.5000 kHz	35.75 N	-19.53 dB
1 Quasi Peak	195.0000 kHz	54.56 N	-9.26 dB
2 Average	197.2500 kHz	38.42 N	-15.31 dB
2 Average	228.7500 kHz	30.52 N	-21.97 dB
2 Average	294.0000 kHz	31.19 N	-19.22 dB
2 Average	388.5000 kHz	26.01 N	-22.09 dB
1 Quasi Peak	674.2500 kHz	33.78 L1	-22.22 dB
2 Average	676.5000 kHz	23.45 N	-22.55 dB
1 Quasi Peak	1.3133 MHz	25.80 N	-30.20 dB
1 Quasi Peak	17.6955 MHz	30.68 L1	-29.32 dB
2 Average	17.6955 MHz	23.60 L1	-26.40 dB
1 Quasi Peak	23.5950 MHz	29.00 L1	-31.00 dB

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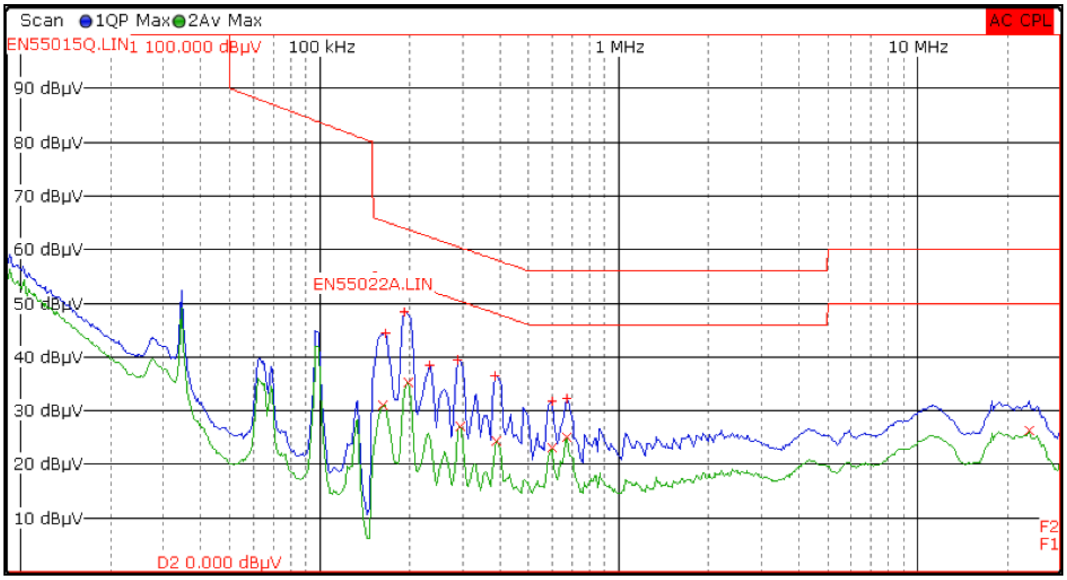
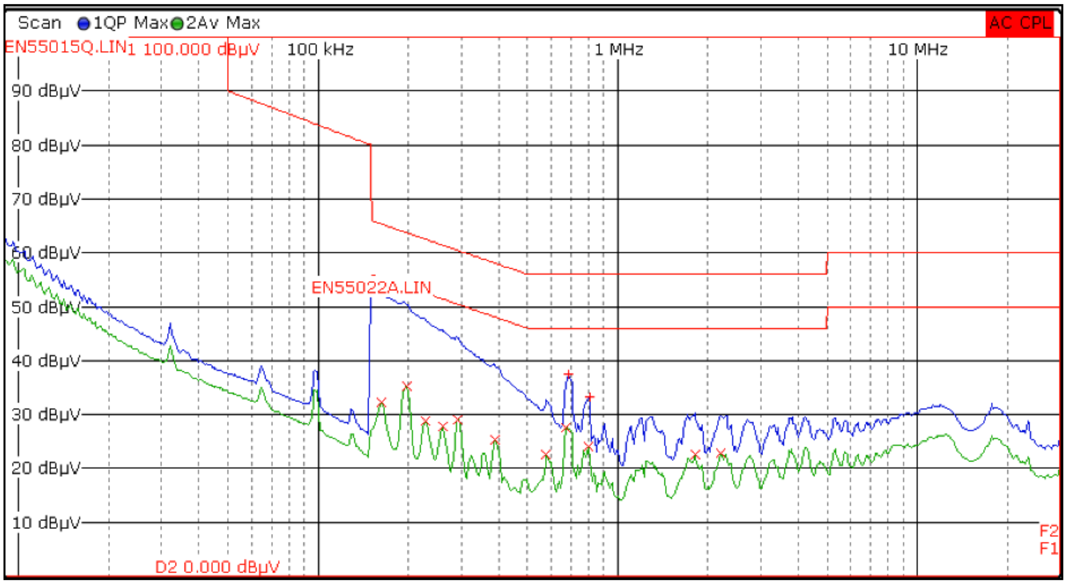
10.9 *110 VAC, 9 V, Artificial Hand*



Trace/Detector	Frequency	Level dBµV	DeltaLimit
2 Average	163.5000 kHz	31.01 N	-24.27 dB
1 Quasi Peak	165.7500 kHz	44.37 N	-20.80 dB
1 Quasi Peak	192.7500 kHz	48.33 N	-15.59 dB
2 Average	197.2500 kHz	35.29 N	-18.44 dB
1 Quasi Peak	233.2500 kHz	38.49 N	-23.84 dB
1 Quasi Peak	289.5000 kHz	39.56 L1	-20.98 dB
2 Average	294.0000 kHz	27.12 N	-23.29 dB
1 Quasi Peak	386.2500 kHz	36.44 N	-21.70 dB
2 Average	390.7500 kHz	24.33 N	-23.72 dB
2 Average	600.0000 kHz	23.01 N	-22.99 dB
1 Quasi Peak	602.2500 kHz	31.82 N	-24.18 dB
1 Quasi Peak	672.0000 kHz	32.20 N	-23.80 dB
2 Average	672.0000 kHz	25.16 N	-20.84 dB
2 Average	23.5748 MHz	26.19 L1	-23.81 dB

10.10 ***230 VAC, 9 V, Artificial Hand***



Trace/Detector	Frequency	Level dBµV	DeltaLimit
1 Quasi Peak	150.0000 kHz	53.54 L1	-12.46 dB
2 Average	163.5000 kHz	32.23 N	-23.05 dB
2 Average	197.2500 kHz	35.31 N	-18.42 dB
2 Average	228.7500 kHz	28.87 N	-23.62 dB
2 Average	260.2500 kHz	27.86 N	-23.56 dB
2 Average	291.7500 kHz	29.10 N	-21.37 dB
2 Average	388.5000 kHz	25.38 N	-22.72 dB
2 Average	577.5000 kHz	22.64 N	-23.36 dB
2 Average	674.2500 kHz	27.43 N	-18.57 dB
1 Quasi Peak	685.5000 kHz	37.46 N	-18.54 dB
2 Average	802.5000 kHz	24.11 N	-21.89 dB
1 Quasi Peak	804.7500 kHz	33.24 N	-22.76 dB
2 Average	1.8150 MHz	22.70 N	-23.30 dB
2 Average	2.2200 MHz	22.76 N	-23.24 dB

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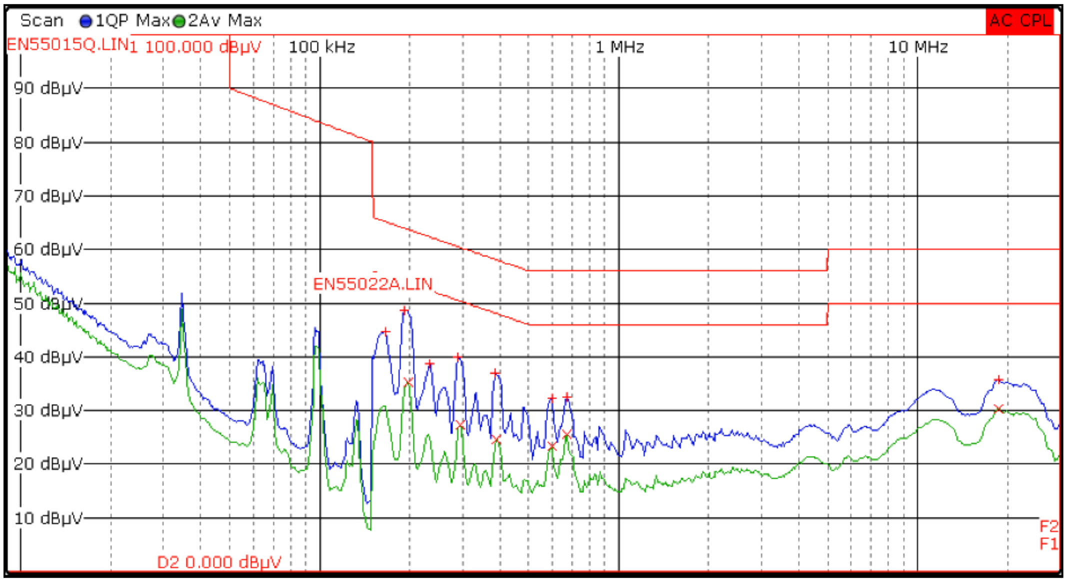
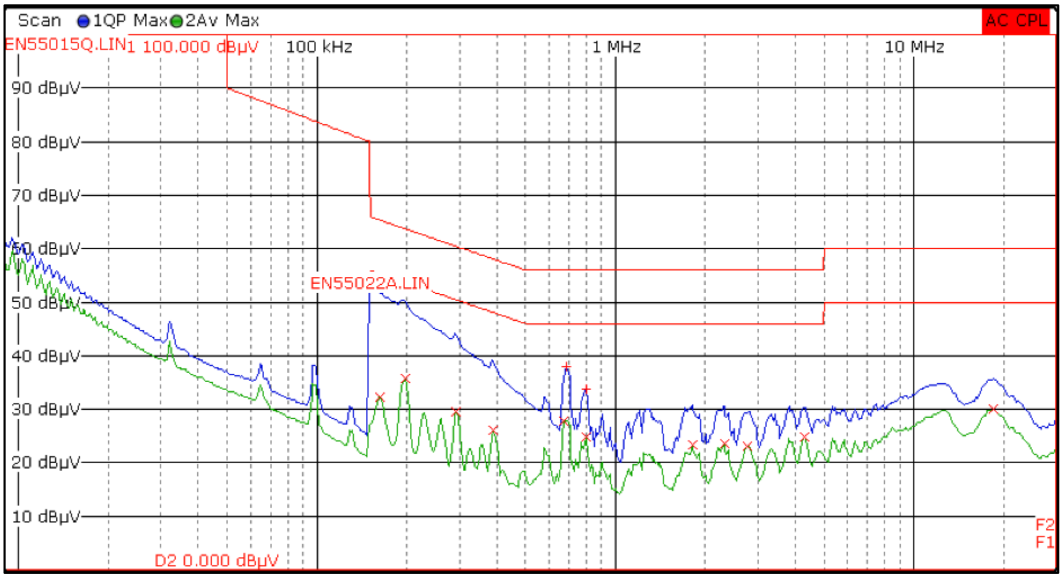
10.11 ***110 VAC, 9 V, Earth***



Trace/Detector	Frequency	Level dBµV	DeltaLimit
1 Quasi Peak	165.7500 kHz	44.59 N	-20.58 dB
1 Quasi Peak	192.7500 kHz	48.73 N	-15.19 dB
2 Average	197.2500 kHz	35.31 N	-18.42 dB
1 Quasi Peak	233.2500 kHz	38.74 N	-23.59 dB
1 Quasi Peak	289.5000 kHz	39.89 L1	-20.65 dB
2 Average	294.0000 kHz	27.25 N	-23.16 dB
1 Quasi Peak	384.0000 kHz	36.85 N	-21.34 dB
2 Average	388.5000 kHz	24.56 N	-23.54 dB
2 Average	600.0000 kHz	23.40 N	-22.60 dB
1 Quasi Peak	602.2500 kHz	32.22 N	-23.78 dB
2 Average	669.7500 kHz	25.48 N	-20.52 dB
1 Quasi Peak	672.0000 kHz	32.49 N	-23.51 dB
1 Quasi Peak	18.7215 MHz	35.78 L1	-24.22 dB
2 Average	18.7215 MHz	30.34 L1	-19.66 dB

10.12 ***230 VAC, 9 V, Earth***



Trace/Detector	Frequency	Level dBµV	DeltaLimit
1 Quasi Peak	150.0000 kHz	52.79 N	-13.21 dB
2 Average	163.5000 kHz	32.38 N	-22.90 dB
2 Average	197.2500 kHz	35.65 N	-18.08 dB
2 Average	291.7500 kHz	29.42 N	-21.05 dB
2 Average	388.5000 kHz	25.94 N	-22.16 dB
2 Average	674.2500 kHz	27.85 N	-18.15 dB
1 Quasi Peak	685.5000 kHz	37.86 N	-18.14 dB
1 Quasi Peak	802.5000 kHz	33.73 N	-22.27 dB
2 Average	802.5000 kHz	24.70 N	-21.30 dB
2 Average	1.8150 MHz	23.23 N	-22.77 dB
2 Average	2.3190 MHz	23.48 N	-22.52 dB
2 Average	2.7825 MHz	23.05 N	-22.95 dB
2 Average	4.3125 MHz	24.93 N	-21.07 dB
2 Average	18.5528 MHz	29.92 L1	-20.08 dB

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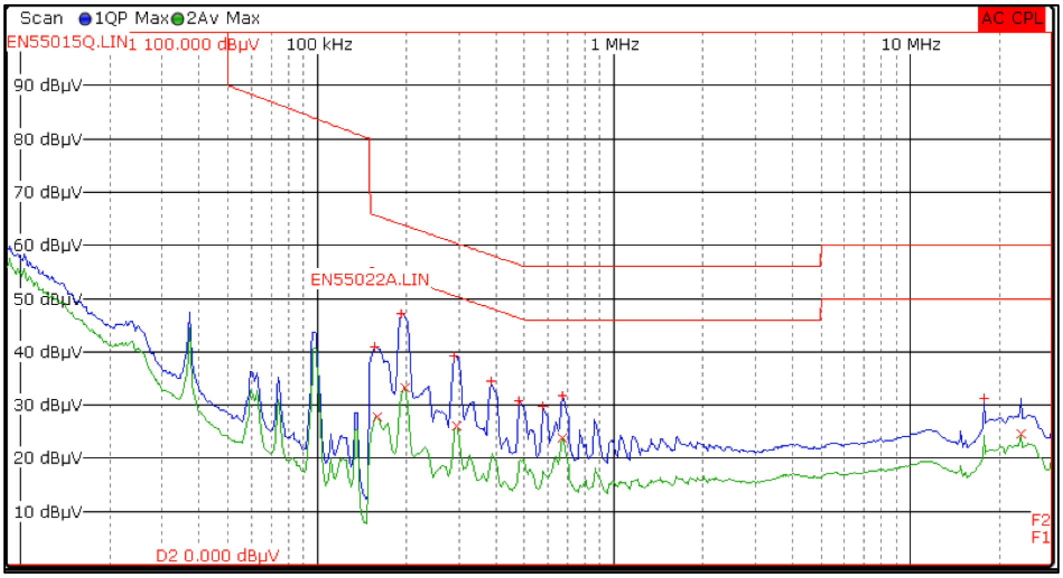
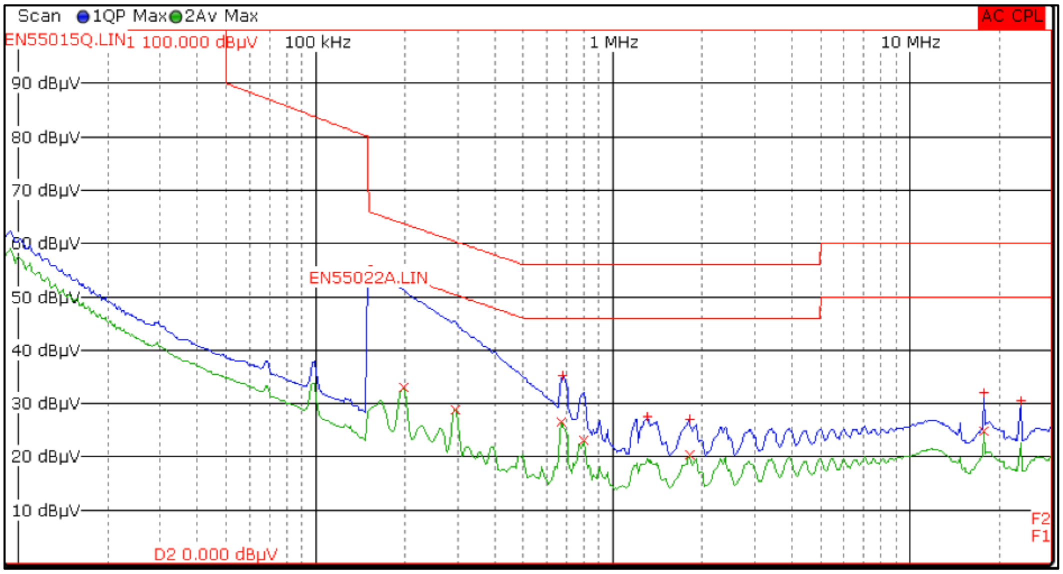
10.13 *110 VAC, 12 V, Floating Output*



Trace/Detector	Frequency	Level dBµV	DeltaLimit
1 Quasi Peak	192.7500 kHz	47.09 N	-16.83 dB
2 Average	197.2500 kHz	33.22 N	-20.51 dB
1 Quasi Peak	289.5000 kHz	39.22 L1	-21.32 dB
2 Average	672.0000 kHz	23.71 N	-22.29 dB
1 Quasi Peak	384.0000 kHz	34.37 L1	-23.82 dB
1 Quasi Peak	672.0000 kHz	31.82 N	-24.18 dB
2 Average	294.0000 kHz	26.14 N	-24.27 dB
1 Quasi Peak	156.7500 kHz	40.89 N	-24.74 dB
2 Average	23.6040 MHz	24.66 L1	-25.34 dB
1 Quasi Peak	480.7500 kHz	30.70 L1	-25.63 dB
1 Quasi Peak	577.5000 kHz	29.78 L1	-26.22 dB
2 Average	159.0000 kHz	27.86 N	-27.66 dB
1 Quasi Peak	17.7023 MHz	31.36 L1	-28.64 dB

10.14 *230 VAC, 12 V, Floating Output*



Trace/Detector	Frequency	Level dBµV	DeltaLimit
1 Quasi Peak	150.0000 kHz	54.74 N	-11.26 dB
2 Average	674.2500 kHz	26.49 N	-19.51 dB
2 Average	197.2500 kHz	33.04 N	-20.69 dB
1 Quasi Peak	676.5000 kHz	35.12 N	-20.88 dB
2 Average	294.0000 kHz	28.90 N	-21.51 dB
2 Average	802.5000 kHz	23.06 N	-22.94 dB
2 Average	17.7000 MHz	24.85 L1	-25.15 dB
2 Average	1.8150 MHz	20.39 N	-25.61 dB
1 Quasi Peak	17.7000 MHz	32.07 L1	-27.93 dB
1 Quasi Peak	1.3110 MHz	27.48 N	-28.52 dB
1 Quasi Peak	1.8150 MHz	27.17 N	-28.83 dB
1 Quasi Peak	23.5995 MHz	30.44 L1	-29.56 dB

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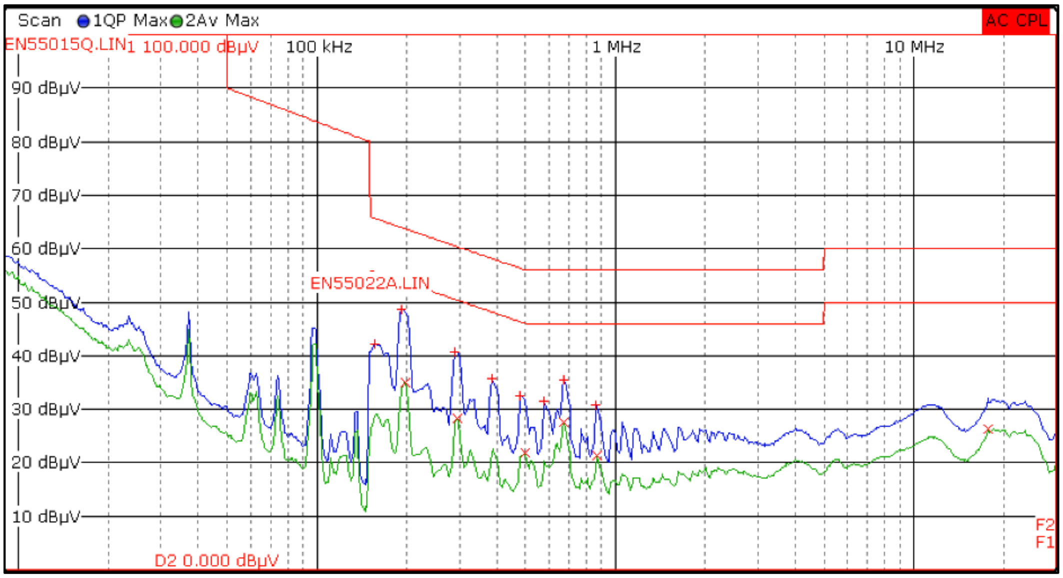
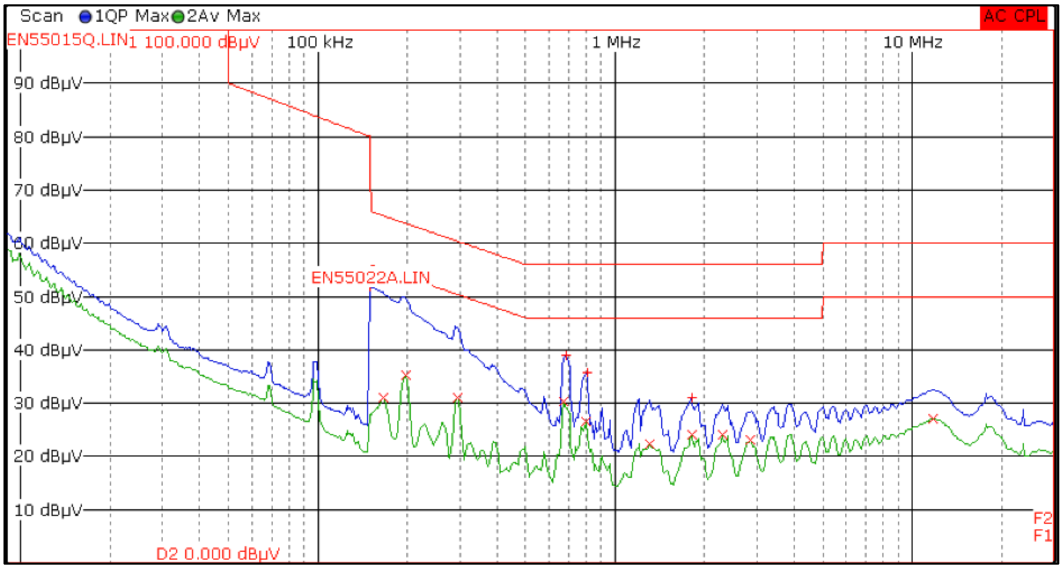
10.15 ***110 VAC, 12 V, Artificial Hand***



Trace/Detector	Frequency	Level dBµV	DeltaLimit
1 Quasi Peak	156.7500 kHz	44.54 L1	-21.09 dB
1 Quasi Peak	192.7500 kHz	51.53 L1	-12.39 dB
2 Average	197.2500 kHz	38.16 L1	-15.57 dB
1 Quasi Peak	289.5000 kHz	42.57 N	-17.97 dB
2 Average	294.0000 kHz	29.26 L1	-21.15 dB
1 Quasi Peak	386.2500 kHz	38.90 L1	-19.24 dB
2 Average	388.5000 kHz	26.95 L1	-21.15 dB
1 Quasi Peak	480.7500 kHz	33.07 N	-23.26 dB
1 Quasi Peak	593.2500 kHz	34.17 N	-21.83 dB
2 Average	597.7500 kHz	24.02 L1	-21.98 dB
1 Quasi Peak	669.7500 kHz	33.00 L1	-23.00 dB
2 Average	672.0000 kHz	25.62 L1	-20.38 dB
2 Average	23.5455 MHz	26.97 N	-23.03 dB

10.16 *230 VAC, 12 V, Artificial Hand*



Trace/Detector	Frequency	Level dBµV	DeltaLimit
1 Quasi Peak	150.0000 kHz	51.91 L1	-14.09 dB
2 Average	165.7500 kHz	31.06 N	-24.11 dB
2 Average	197.2500 kHz	35.12 N	-18.61 dB
2 Average	296.2500 kHz	31.08 N	-19.27 dB
2 Average	674.2500 kHz	30.19 N	-15.81 dB
1 Quasi Peak	683.2500 kHz	39.02 N	-16.98 dB
2 Average	802.5000 kHz	26.53 N	-19.47 dB
1 Quasi Peak	804.7500 kHz	35.66 N	-20.34 dB
2 Average	1.3088 MHz	22.37 N	-23.63 dB
2 Average	1.8128 MHz	24.13 N	-21.87 dB
1 Quasi Peak	1.8150 MHz	30.91 N	-25.09 dB
2 Average	2.2920 MHz	23.98 N	-22.02 dB
2 Average	2.8657 MHz	23.06 N	-22.94 dB
2 Average	11.8073 MHz	27.06 N	-22.94 dB

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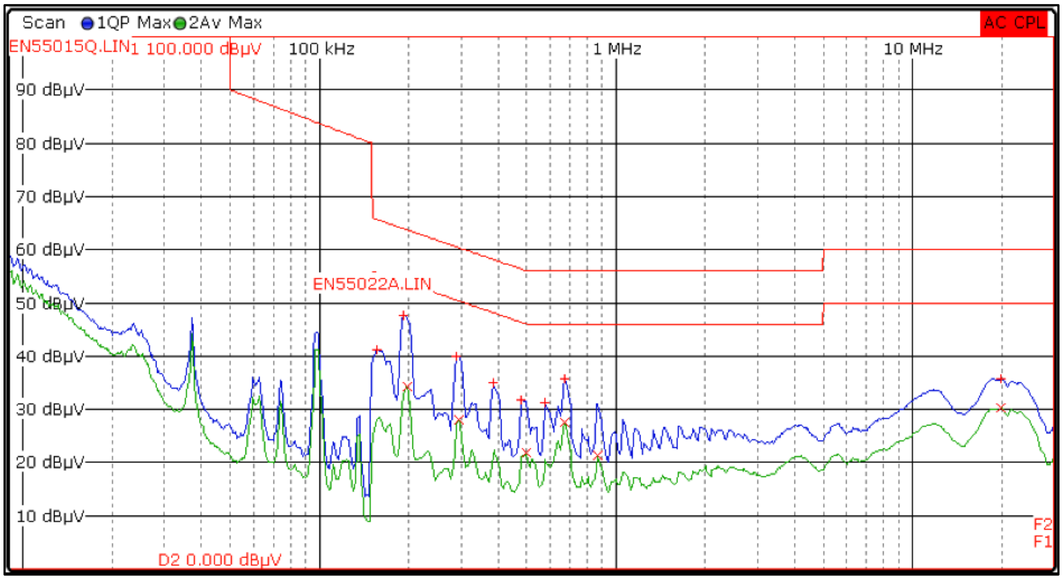
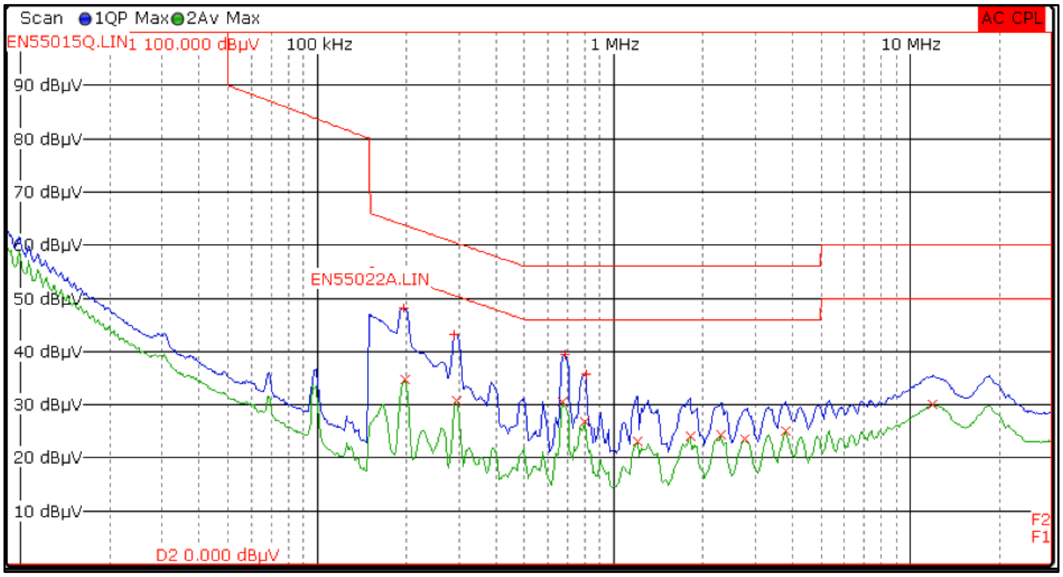
10.17 ***110 VAC, 12 V, Earth***



Trace/Detector	Frequency	Level dBµV	DeltaLimit
1 Quasi Peak	156.7500 kHz	41.20 N	-24.43 dB
1 Quasi Peak	192.7500 kHz	47.61 N	-16.31 dB
2 Average	197.2500 kHz	34.18 N	-19.55 dB
1 Quasi Peak	289.5000 kHz	40.04 N	-20.50 dB
2 Average	294.0000 kHz	27.94 N	-22.47 dB
1 Quasi Peak	384.0000 kHz	34.91 L1	-23.28 dB
1 Quasi Peak	480.7500 kHz	31.81 N	-24.52 dB
2 Average	498.7500 kHz	21.87 N	-24.15 dB
1 Quasi Peak	577.5000 kHz	31.29 L1	-24.71 dB
1 Quasi Peak	672.0000 kHz	35.66 N	-20.34 dB
2 Average	672.0000 kHz	27.63 N	-18.37 dB
2 Average	865.5000 kHz	21.46 N	-24.54 dB
1 Quasi Peak	19.9320 MHz	35.71 L1	-24.29 dB
2 Average	19.9523 MHz	30.20 L1	-19.80 dB

10.18 ***230 VAC, 12 V, Earth***



Trace/Detector	Frequency	Level dBµV	DeltaLimit
1 Quasi Peak	195.0000 kHz	48.07 N	-15.75 dB
2 Average	197.2500 kHz	34.70 N	-19.03 dB
1 Quasi Peak	289.5000 kHz	43.25 N	-17.29 dB
2 Average	296.2500 kHz	30.78 N	-19.57 dB
2 Average	674.2500 kHz	30.55 N	-15.45 dB
1 Quasi Peak	683.2500 kHz	39.42 N	-16.58 dB
2 Average	802.5000 kHz	26.70 N	-19.30 dB
1 Quasi Peak	804.7500 kHz	35.84 N	-20.16 dB
2 Average	1.2075 MHz	23.13 N	-22.87 dB
2 Average	1.8128 MHz	24.17 N	-21.83 dB
2 Average	2.2920 MHz	24.42 N	-21.58 dB
2 Average	2.7735 MHz	23.64 N	-22.36 dB
2 Average	3.8130 MHz	24.99 N	-21.01 dB
2 Average	11.9580 MHz	29.96 N	-20.04 dB

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11 Surge

11.1 *Differential Mode Surge Test*

Differential Surge Level (V)	Input Voltage (VAC)	Injection Location	Injection Phase (°)	Test Result (Pass/Fail)
+1000	230	L to N	0	Pass
-1000	230	L to N	0	Pass
+1000	230	L to N	90	Pass
-1000	230	L to N	90	Pass
+1000	230	L to N	180	Pass
-1000	230	L to N	180	Pass
+1000	230	L to N	270	Pass
-1000	230	L to N	270	Pass

11.2 *Common Mode Ring Wave Surge Test*

Ring Wave Surge Level (V)	Input Voltage (VAC)	Injection Location	Injection Phase (°)	Test Result (Pass/Fail)
+6000	230	L, N to PE	0	Pass
-6000	230	L, N to PE	0	Pass
+6000	230	L, N to PE	90	Pass
-6000	230	L, N to PE	90	Pass
+6000	230	L, N to PE	180	Pass
-6000	230	L, N to PE	180	Pass
+6000	230	L, N to PE	270	Pass
-6000	230	L, N to PE	270	Pass

11.3 *ESD Test (Contact and Air Discharge)*

Level (V)	Input Voltage (VAC)	Discharge	Number of Discharges	Test Result (Pass/Fail)
+8000	230	Contact	10	Pass
-8000	230	Contact	10	Pass
+16500	230	Air	10	Pass
-16500	230	Air	10	Pass

12 Revision History

Date	Author	Revision	Description and Changes	Reviewed
02-Mar-16	PISJ-Apps	1.4	Initial Release	Apps & Mktg

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