Design Example Report

Title	***10 W or 18 W Quick Charger Using InnoSwitch3-CP INN3264C***
Specification	90 VAC – 265 VAC Input; 5 V / 2 A or 9 V / 2.0 A Output
Application	Cell Phone / USB Charger
Author	Applications Engineering Department
Document Number	DER-665
Date	July 11, 2019
Revision	1.1

Summary and Features

- InnoSwitch3-CP – industry's first AC/DC IC with isolated, safety rated integrated feedback
- 5 V / 2 A, 9 V / 2 A 18 W Quick Charge compliance via single secondary-side IC CHY103D
- Built in synchronous rectification for high efficiency
- All the benefits of secondary-side control with the simplicity of primary-side regulation
    - Insensitive to transformer variation
    - Extremely fast transient response independent of load timing
- Meets DOE6 and CoC V5 tier 2
- <30 mW no-load input power
- Primary sensed output overvoltage protection (OVP) eliminates optocoupler for fault 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.

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1 Introduction

This document is an engineering report describing a 9 V / 5 V, 2 A output quick charger embedded power supply utilizing InnoSwitch3-CP.

This design shows the high power density and efficiency that is possible due to the high level of integration while still providing exceptional performance.

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

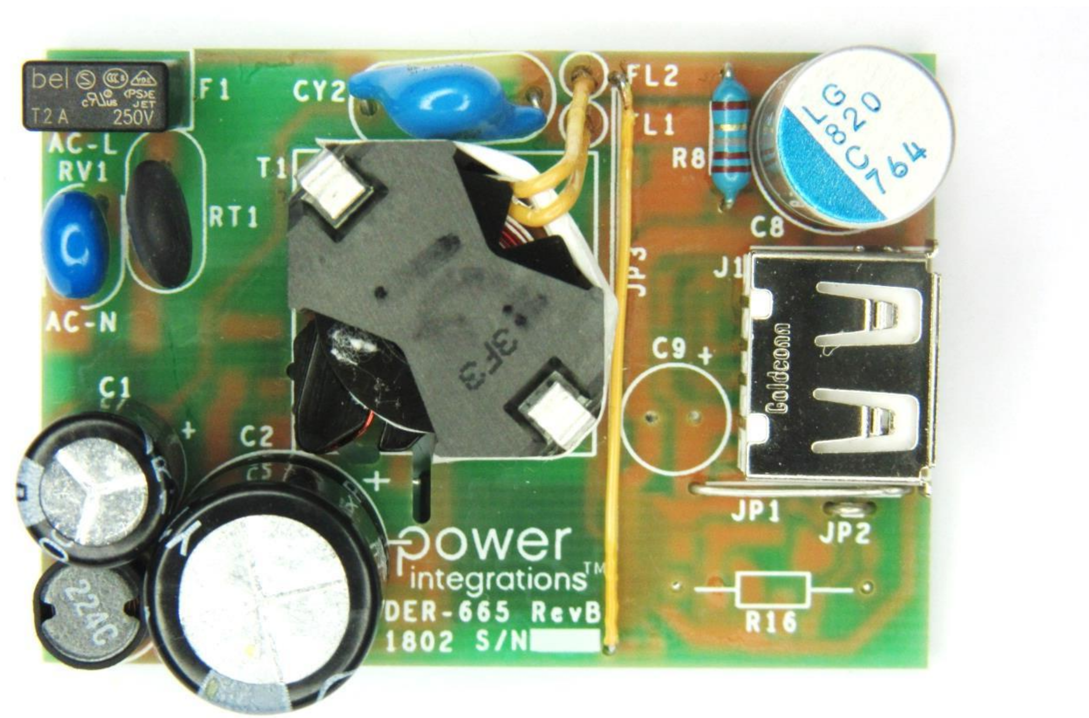

Figure 1 – Populated Circuit Board Photograph, Top.

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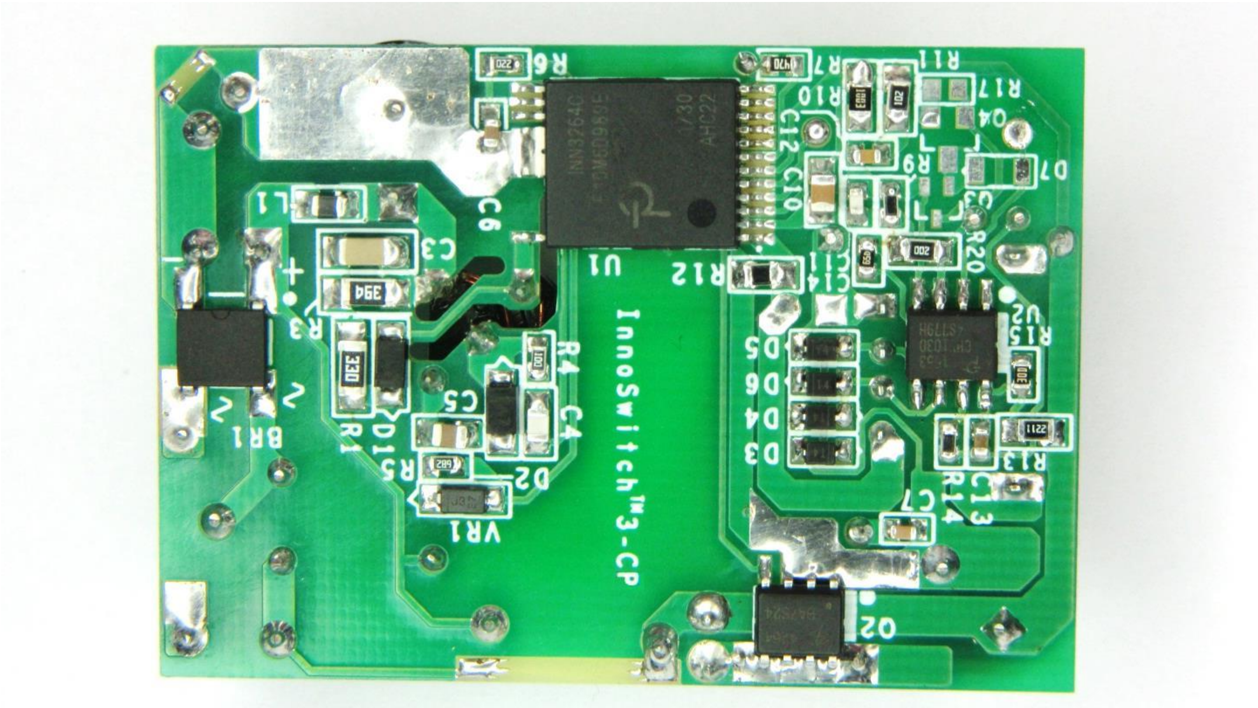

Figure 2 – Populated Circuit Board Photograph, Bottom.

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}	90		265	VAC	
Frequency	f_{LINE}	47	50/60	63	Hz	
No-load Input Power				30	mW	230 VAC
Output						
Output Voltage	V_{OUT}	4.75	5	5.25	V	Measured at End of 1m Cable
Output Current	I_{OUT}	2			A	
Output Ripple Voltage	V_{RIPPLE}			150	mV	Measured at End of Cable with a 47 µF. Capacitor Connected at End of 1 m Cable.
Output Voltage	V_{OUT}	8.55	9	9.45	V	Measured at End of 1 m Cable
Output Current	I_{OUT}	2			A	
Output Ripple Voltage	V_{RIPPLE}			150	mV	Measured at End of Cable with a 47 µF. Capacitor Connected at End of 1 m Cable.
Continuous Output Power	P_{OUT}	18			W	
Efficiency						115 VAC, 230 VAC. Meets DOE6 and COC V5 tier2.
Full Load	$\eta_{100\%}$	87			%	Measured at Output Terminal for 9 V.
		86			%	Measured at Output Terminal for 5 V.
Average 25%, 50%, 75%, and 100%	η_{AVE}	87			%	Measured at Output Terminal for 9 V.
		86			%	Measured at Output Terminal for 5 V.
10%	$\eta_{10\%}$	80			%	Measured at Output Terminal for 9 V.
		80			%	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	kV	Contact.
				±8	kV	Air Discharge.
Ambient Temperature	T_{AMB}	0		40	ºC	Free Convection, Sea level in Sealed Enclosure.

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3 Schematic

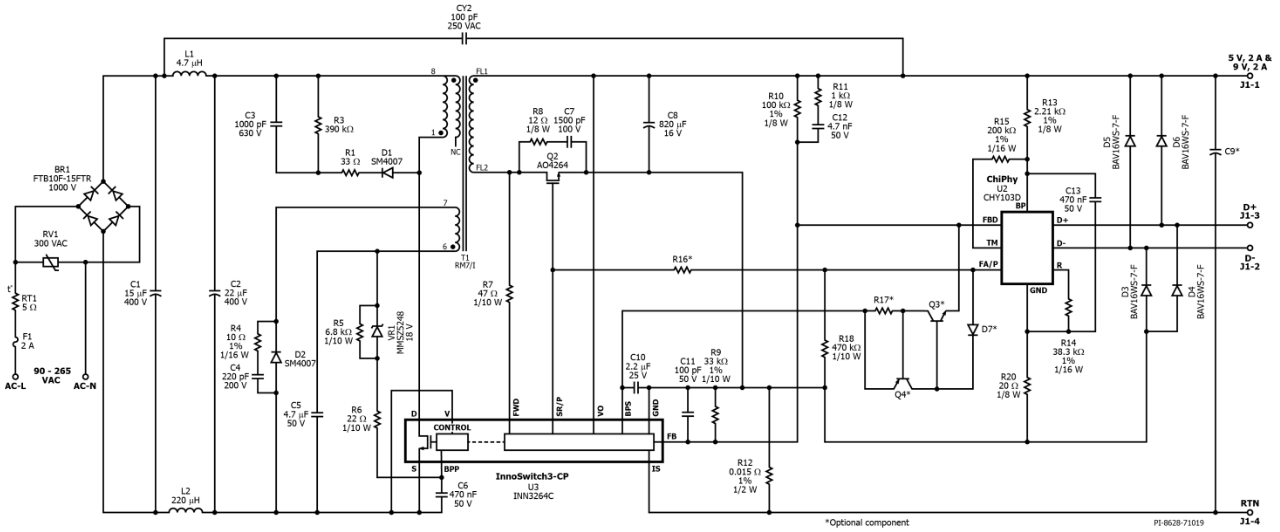

Figure 3 – Schematic.

4 Circuit Description

4.1 *Input EMI Filtering*

Fuse F1 isolates the circuit and provides protection from component failure and thermistor RT1 suppresses inrush current. Varistor RV1 suppresses energy going to the circuit during a lightning surge. Bridge rectifier BR1 rectifies the AC line voltage and provides a full wave rectified DC across the input capacitor, C2 and C2. Inductors L1 and L2 provides EMI filtering together with C1 and C2.

4.2 *InnoSwitch3-CP Primary*

One end of the transformer primary winding is connected to the rectified DC bus, the other is connected to the integrated power MOSFET inside the InnoSwitch3-CP IC (U1).

A low cost RCD clamp formed by D1, R1, R3, and C3 limits the peak Drain voltage due to the effects of transformer leakage inductance.

The IC is self-starting, using an internal high-voltage current source to charge the BPP pin capacitor, C6, when AC is first applied. During normal operation the primary-side block is powered from an auxiliary winding on the transformer. The output of this is configured as a flyback winding which is rectified and filtered using diode D2 and capacitor C5, and fed in the BPP pin via current limiting resistors R5 and R6.

Zener diode VR1 in series with the PRIMARY BYPASS pin capacitor provides overvoltage sensing when output voltage goes high which is proportional to bias and secondary turns ratio. If the voltage across the Zener diode exceeds threshold then it will start to conduct and if the current at PRIMARY BYPASS pin exceeds ~4 mA, the device will enter into auto-restart.

4.3 *InnoSwitch3-CP IC Secondary*

The secondary-side of the InnoSwitch3-CP provides output voltage, output current sensing and drive to a MOSFET providing synchronous rectification.

Output rectification is provided by SR FET Q2. Very low ESR capacitor C8 provide filtering and additional capacitor C9 could be added if lower output voltage ripple is desired. RC snubber network comprising R8 and C7 for Q2 damps high frequency ringing across SR FETs, which results from leakage inductance of the transformer windings and the secondary trace inductances. The gate of Q2 is turned on based on the winding voltage sensed via R7 and the FWD pin of the IC. In continuous conduction mode operation, the power MOSFET is turned off just prior to the secondary-side controller commanding a new switching cycle from the primary. In discontinuous mode the MOSFET is turned off when the voltage drop across the MOSFET falls below ground. Secondary-side control of the primary-side MOSFET ensure that it is never on simultaneously with the synchronous rectification MOSFET. The MOSFET drive signal is output on the SR pin.

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The secondary-side of the IC is self-powered from either the secondary winding forward voltage or the output voltage. The output voltage powers the device which is fed into the VO pin. It will charge the decoupling capacitor C10 via an internal regulator.

Resistors R10 and R9 form a voltage divider network that senses the output voltage. InnoSwitch3-CP IC has an internal reference of 1.265 V. Capacitor C11 provides decoupling from high frequency noise affecting power supply operation. The output current is sensed by R12 with a threshold of approximately 35 mV to reduce losses. Once the current sense threshold across these resistors is exceeded, the device adjusts the number of switch pulses to maintain a fixed output current.

4.4 *Quick Charger-Secondary Control*

The CHY103 IC is a USB mobile device charger interface IC which implements Quick Charge specification for adaptive voltage battery charging. The CHY103 IC provides a suite of system level protection features protecting the power supply and connected Powered Device (PD) from excessive output voltages, secondary-side thermal overload, and faulty power delivery while adapter is unplugged. Additionally, it allows the PD to remotely shutdown the power supply through USB data lines. The shutdown type can be configured as either hysteretic or latching.

The output voltage powers CHY103 IC which is fed into BP pin through resistor R13 and C13. Quick Charge interface/handshake is delivered through D+ and D- from USB terminal from Powered Device.

5 PCB Layout

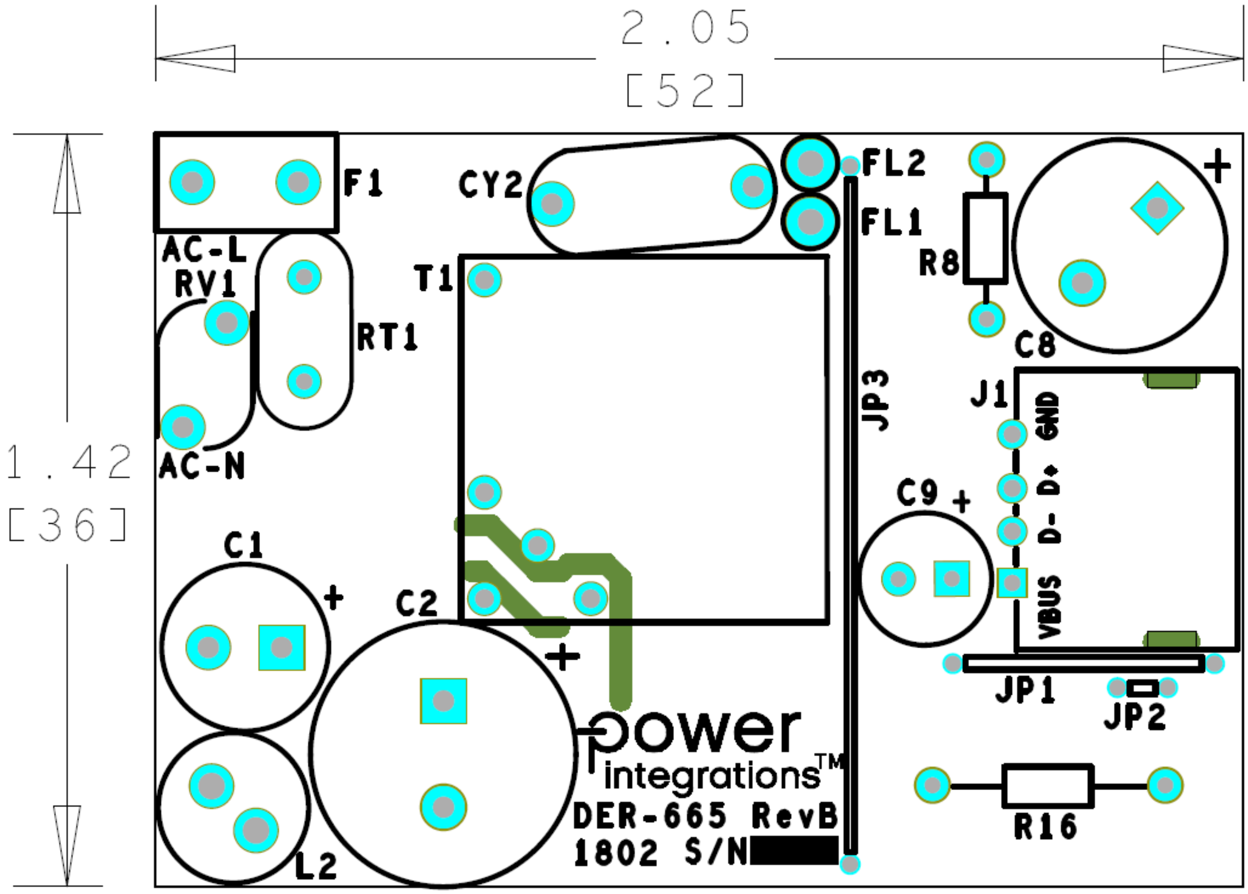

Figure 4 – Printed Circuit Layout, Top.

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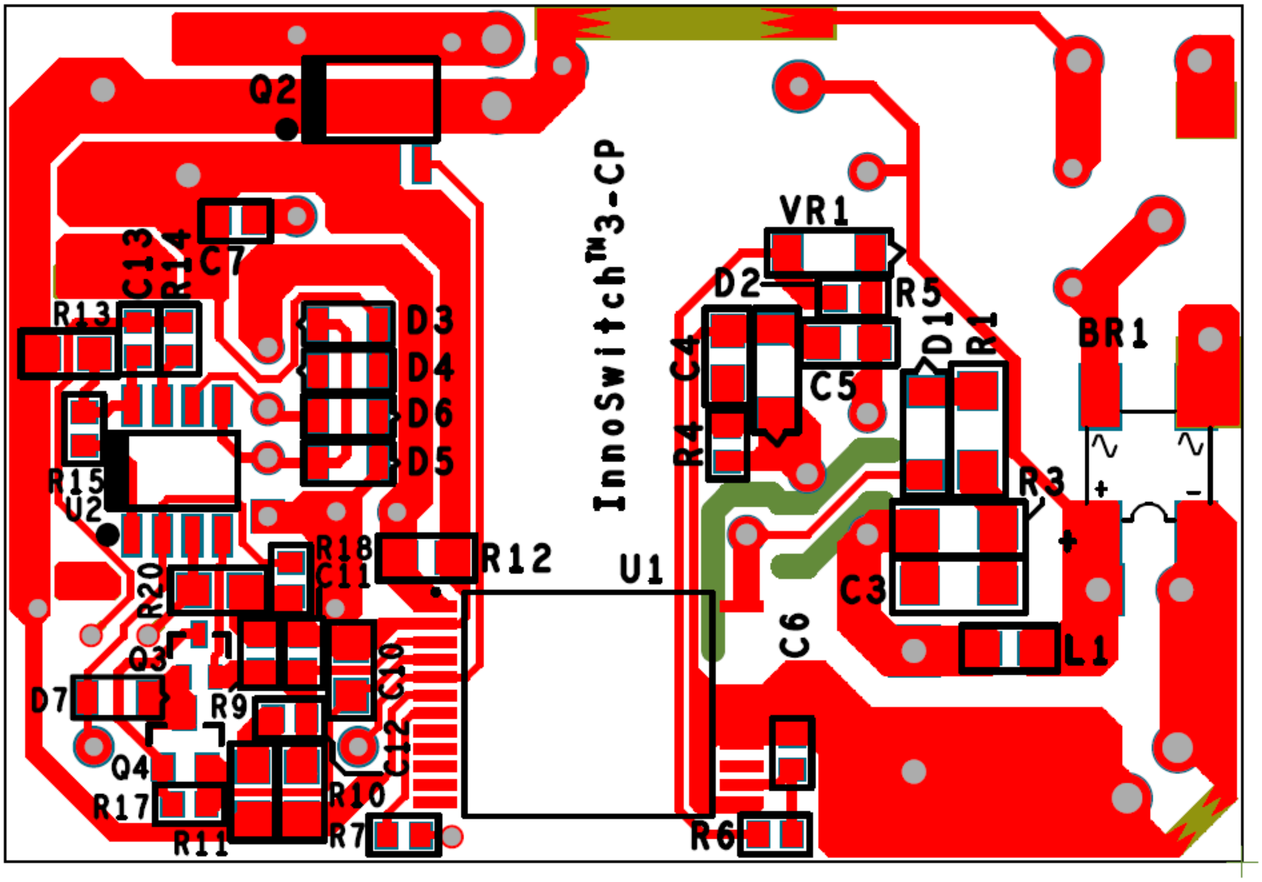

Figure 5 – Printed Circuit Layout, Bottom.

6 Bill of Materials

Item	Qty	Ref Des	Description	Mfg Part Number	Mfg
1	1	BR1	BRIDGE RECT, 1PH, 1KV, 1.5A, 4-SMD	FTB10F-15FTR	SMC Diode
2	1	C1	15 µF, 400 V, 20%,Electrolytic, (8 x 16)	ERK2GM150F16OTO	AiSHi
3	1	C2	22 µF, 400 V, Electrolytic, (12.5 x 16)	TYB2GM220J160	Ltec
4	1	C3	1000 pF, 630 V, Ceramic, X7R, 1206	C1206C102KBRACTU	Kemet
5	1	C4	220 pF, ±10%, 200V, X7R, 0805	08051C221KAT2A	Samsung
6	1	C5	4.7 µF, 50 V, Ceramic, X5R, 0805	CL21A475KBQNNNE	Samsung
7	2	C6 C13	470 nF, 50 V, Ceramic, X7R, 0603	CL21B221KDCNFNC	Taiyo Yuden
8	1	C7	1500 pF, 100 V, Ceramic, X8R, 0603	CGA3E2X8R2A152K080AA	TDK
9	1	C8	820 µF, ±20%,16 V, Aluminum Polymer, Gen. Purpose, -55 °C ~ 105 °C, 2000 Hrs @ 105°C	PLG1C821MDO1	Nichicon
10	1	C10	2.2 µF, 25 V, Ceramic, X7R, 0805	C2012X7R1E225M	TDK
11	1	C11	100 pF 50 V, Ceramic, NP0, 0603	CC0603JRNPO9BN101	Yageo
12	1	C12	4.7 nF 50 V, Ceramic, X7R, 0603	GRM188R71H472KA01D	Murata
13	1	CY2	100 pF, 250 VAC, Film, X1Y1	DE1B3KX101KB4BN01F	TDK
14	2	D1 D2	1000 V, 1 A, Standard Recovery, SOD-123FL	SM4007PL-TP	Micro Commercial
15	5	D3 D4 D5 D6	75 V, 0.15 A, Switching,SOD-323	BAV16WS-7-F	Diodes, Inc.
16	1	F1	2 A, 250 V, Slow, Long Time Lag, RST	RST 2	Belfuse
17	2	FL1 FL2	Flying Lead, Hole size 50 mils	N/A	N/A
18	1	J1	CONN USB FEMALE TYPE A	USB-AF-DIP-094-H	GOLDCONN
19	2	JP1 JP2	Wire Jumper, Insulated, TFE, #22 AWG, 1.0 in	C2004-12-02	Alpha
20	1	L1	4.7 µH, ±20%,400 mA,300 mA Saturation, 340 mΩ, SMD INDUCTOR, 0805	MLZ2012M4R7HT000	TDK
21	1	L2	Inductor, Fixed, 220 µH 0.43 A 5.4 MHz, Radial Lead	22R224C	Murata
22	1	Q2	MOSFET, N-CH, 60 V, 12 A, 8SOIC	AO4264	Alpha & Omega Semi
23	1	R1	RES, 33 Ω, 5%, 1/4 W, Thick Film, 1206	ERJ-8GEYJ330V	Panasonic
24	1	R3	RES, 390 kΩ, 5%, 1/4 W, Thick Film, 1206	ERJ-8GEYJ394V	Panasonic
25	1	R4	RES, 10 Ω, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF10R0V	Panasonic
26	1	R5	RES, 6.8 kΩ, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ682V	Panasonic
27	1	R6	RES, 22 Ω, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ220V	Panasonic
28	1	R7	RES, 47 Ω, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ470V	Panasonic
29	1	R8	RES, 12 Ω, 5%, 1/8 W, Carbon Film	CF18JT12R0	Stackpole
30	1	R9	RES, SMD, 33 KΩ, 1%, 1/10 W, ±100ppm/°C, 0603	RC0603FR-0733KL	Yageo
31	1	R10	RES, 100 kΩ, 1%, 1/8 W, Thick Film, 0805	ERJ-6ENF1003V	Panasonic
32	1	R11	RES, 1 kΩ, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ102V	Panasonic
33	1	R12	RES, 0.015 Ω, 0.5 W, 1%, 0805	ERJ-6BWFR015V	Panasonic
34	1	R13	RES, 2.21 kΩ, 1%, 1/8 W, Thick Film, 0805	ERJ-6ENF2211V	Panasonic
35	1	R14	RES, 38.3 kΩ, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF3832V	Panasonic
36	1	R15	RES, 200 kΩ, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF2003V	Panasonic
37	1	R18	RES, 470 kΩ, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ474V	Panasonic
38	1	R20	RES, 20 Ω, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ200V	Panasonic
39	1	RT1	Inrush Current Limiter, 5 Ω, ±20%, 2 A	MF72-005D7	Cantherm
40	1	RV1	300 VAC, 15 J, 5 mm, RADIAL	S05K300E2	Epcos
41	1	T1	Bobbin, RM7/I, Vertical, 8 pins with mtg clip CLI/P-RM7	CSV-RM7-1S-8P-C. Clip PN CLI/P-RM7	Ferroxcube
42	1	U1	InnoSwitch3-CP, InSOP24D	INN3264C	Power Integrations
43	1	U2	Charger Interface Physical Layer IC	CHY103D	Power Integrations
44	1	VR1	DIODE ZENER 18 V 500 mW SOD123	MMSZ5248B-7-F	Diodes, Inc.

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7 Magnetics

7.1 *Transformer Specification*

7.1.1 Electrical Diagram

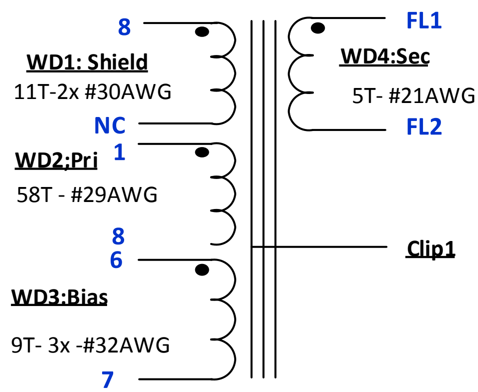

Figure 6 – Transformer Electrical Diagram.

7.1.2 Electrical Specifications

Primary Inductance	Measured at 1 V_{PK-PK}, 100 kHz switching frequency, between pin 1 and 8, with all other windings open.	1044 µH ±5%
Primary Leakage Inductance	Between pin 1 and 8, with 6, 7, FL1, FL2 shorted.	20 µH (Max).

7.1.3 Material List

Item	Description
[1]	Core: C-RM7 Allstar Magnetics, 3F3.
[2]	Bobbin: B-RM7-V-8(4/4), BOBBIN (CSV-RM7-1S-8P-C).
[3]	Clip: RM7, Allstar Magnetic, CLI/P-RM7/I.
[4]	Magnet Wire: #30 AWG, Solderable Double Coated.
[5]	Magnet Wire: #29 AWG, Solderable Double Coated.
[6]	Magnet Wire: #32 AWG, Solderable Double Coated.
[7]	Magnet Wire: #21 AWG, Triple Insulated Wire.
[8]	Tape: Polyester Film, 3M 1350-1, 6.9 mm Wide.
[9]	Varnish.

7.1.4 Transformer Build Diagram

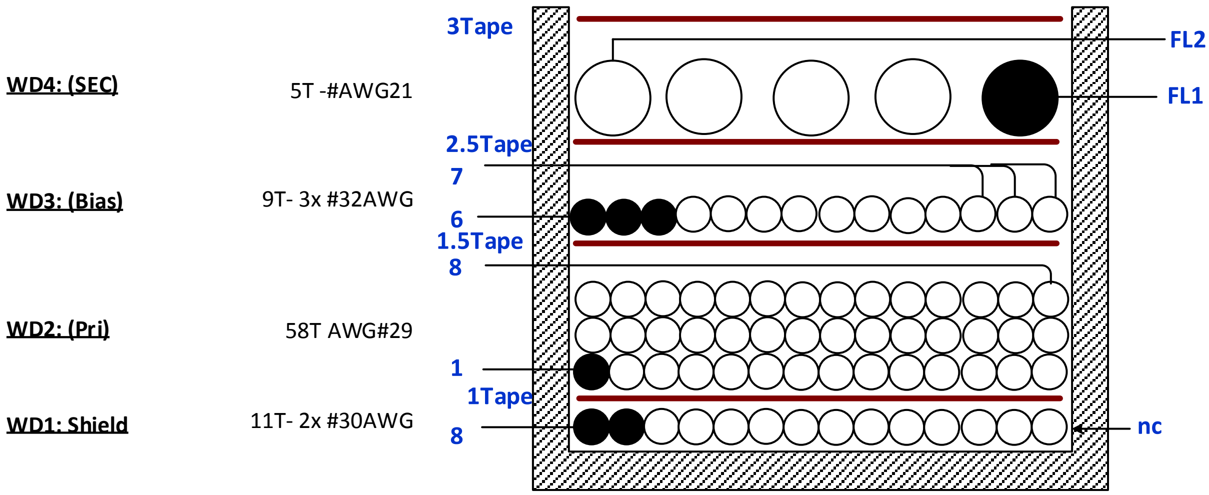

Figure 7 – Transformer Build Diagram.

7.1.5 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 Cancellation Winding	Before winding, remove pins 2, 3, 4 and 5. Start at pin 8. Wind 11 bifilar turns of Item [4] in 1 layer and cut finish for no-connection.
Insulation	Use 1 layer of Item [8] for insulation.
WD2 Primary Winding	Starting at pin 1, wind 58 turns of Item [5] in 3 layer. Return wire to the left and finish at pin 8.
Insulation	Use 1.5 layer of Item [8] for insulation.
WD3 Bias	Starting at pin 6, wind 9 trifilar turns of Item [6] in 1 layer. Return wire to the left and finish at pin 7.
Insulation	Use 2.5 layers of Item [8] for insulation.
WD4 Secondary Winding	Starting at the right mark start as FL1, wind 5 turns of Item [7]. Return wire to the right and finish as FL2.
Insulation	Use 3 layers of Item [8] to secure the windings.
Final Assembly	Insert cores, gapped for inductance specified. Secure core halves using clips Item [3]. Dip varnish Item [8].

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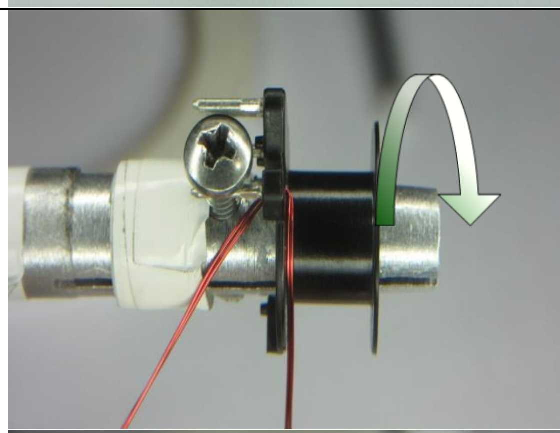
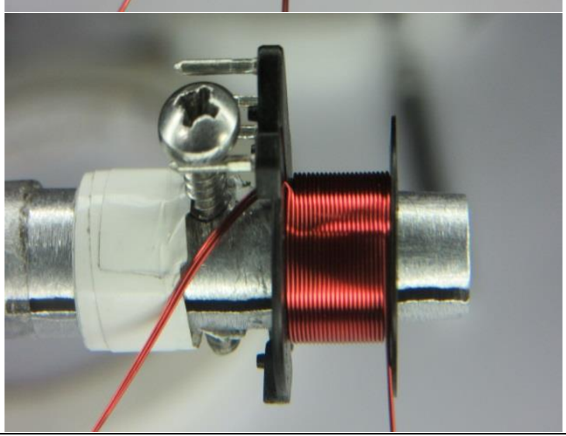
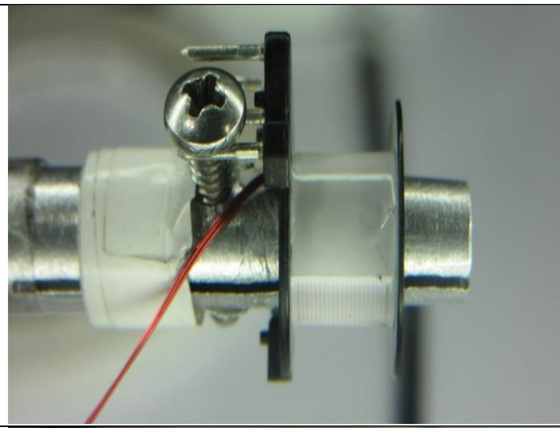
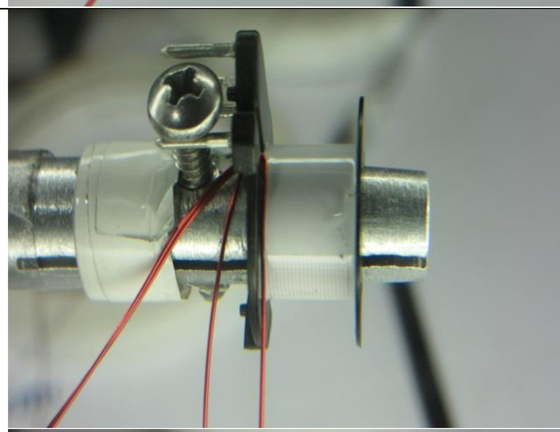
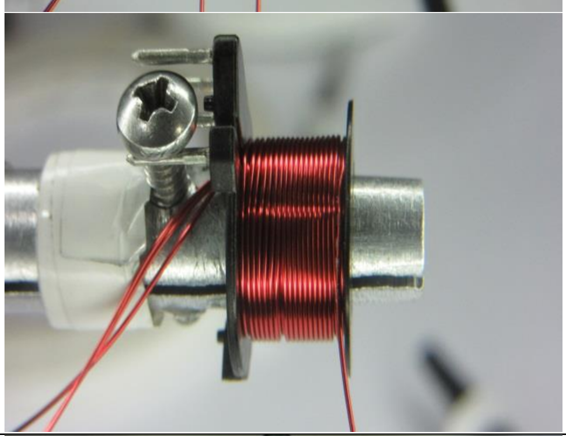
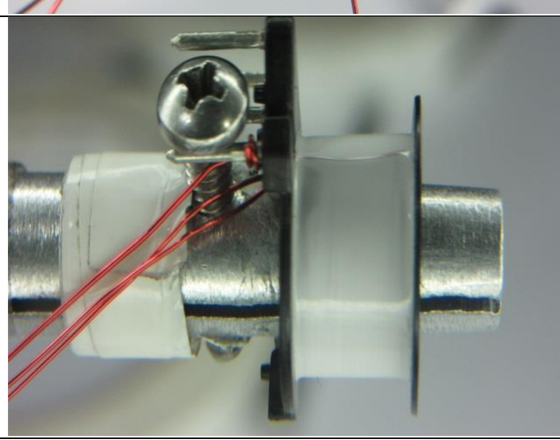
7.1.6 Transformer Winding Illustrations

Bobbin Preparation		Remove pins 2, 3, 4 and 5 before winding.
WD1 **Cancellation winding**	 	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. Start at pin 8. Wind 11 bifilar turns of Item [4] in 1 layer and cut finish for no-connection.

Insulation		Use 1 layer of Item [8] for insulation.
WD2 **Primary winding**	 	Starting at pin 1, wind 58 turns of Item [5] in 3 layer. Return wire to the left and finish at pin 8.
Insulation		Use 1.5 layer of Item [8] for insulation.

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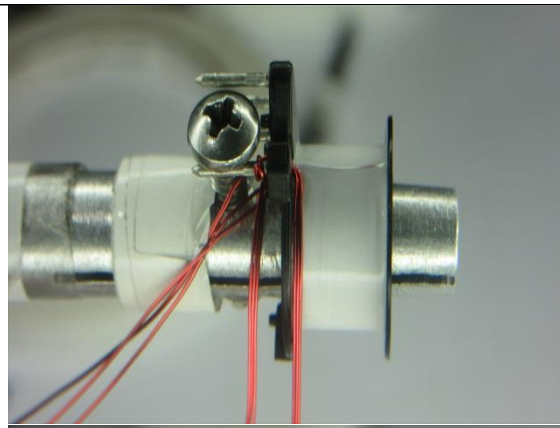
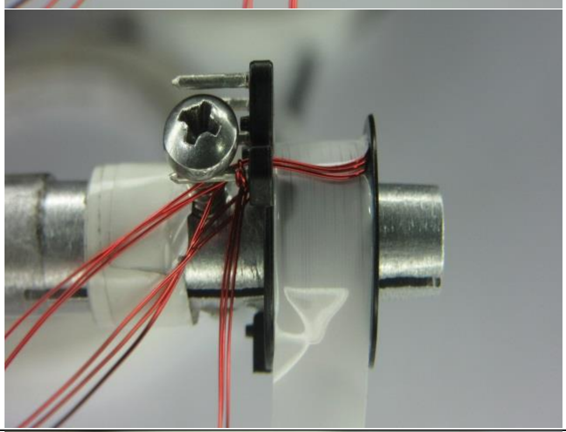
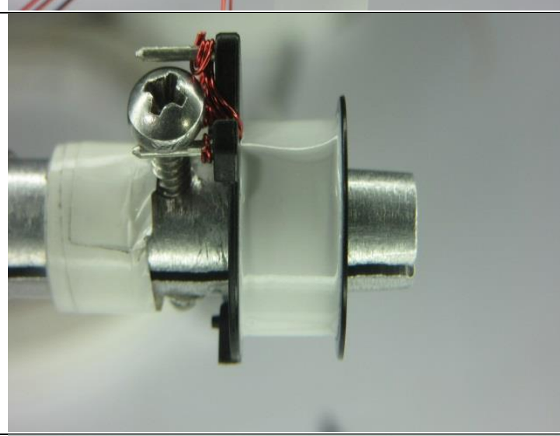
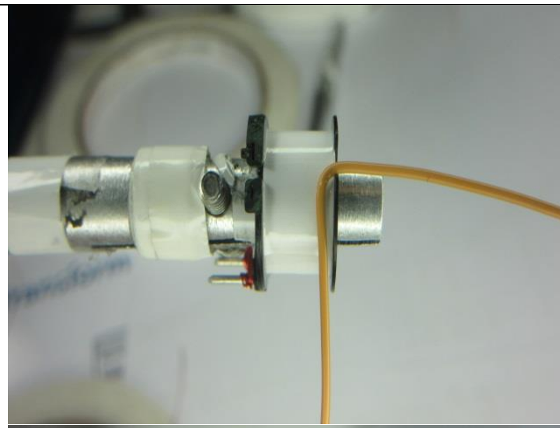
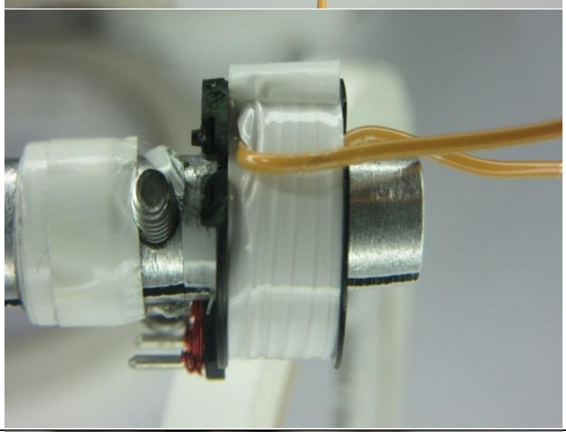
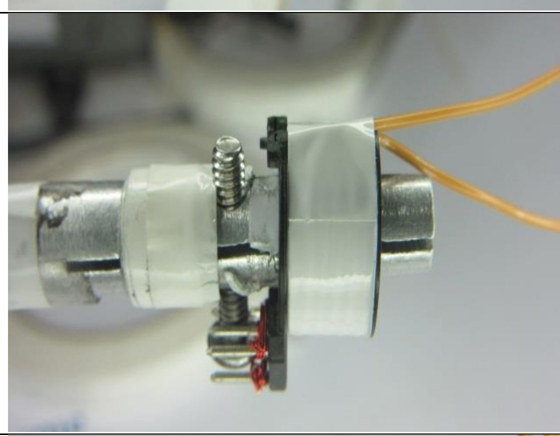
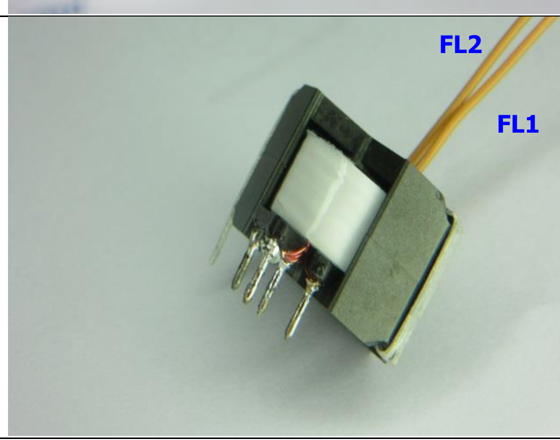
WD3 **Bias**	 	Starting at pin 6, wind 9 trifilar turns of Item [6] in 1 layer. Return wire to the left and finish at pin 7.
Insulation		Use 2.5 layers of Item [8] for insulation.
Cancelation, Primary and Bias winding termination		

WD4 **Secondary winding**	 	Starting at the right mark start as FL1, wind 5 turns of Item [7]. Return wire to the right and finish as FL2.
Insulation		Use 3 layers of Item [8] to secure the windings.
Final Assembly		Insert cores, gapped for inductance specified. Secure core halves using clips Item [3]. Dip varnish Item [9].

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8 Transformer Design Spreadsheet

ACDC_InnoSwitch3-CP_Flyback_022018; Rev.1.2; Copyright Power Integrations 2018	INPUT	INFO	OUTPUT	UNITS	InnoSwitch3-CP Flyback Design Spreadsheet
APPLICATION VARIABLES					
VAC_MIN	90		90	V	Minimum AC line voltage
VAC_MAX			265	V	Maximum AC input voltage
VAC_RANGE			UNIVERSAL		AC line voltage range
FLINE			60	Hz	AC line voltage frequency
CAP_INPUT	37.0		37.0	uF	Input capacitance
SETPOINT 1					
VOUT1	9.00		9.00	V	Output voltage 1, should be the highest output voltage required
IOUT1	2.000		2.000	A	Output current 1
POUT1			18.00	W	Output power 1
EFFICIENCY1	0.90		0.90		Converter efficiency for output 1
Z_FACTOR1	0.50		0.50		Z-factor for output 1
SETPOINT 2					
VOUT2	5.00		5.00	V	Output voltage 2
IOUT2	2.000		2.000	A	Output current 2
POUT2			10.00	W	Output power 2
EFFICIENCY2	0.90		0.90		Converter efficiency for output 2
Z_FACTOR2	0.50		0.50		Z-factor for output 2
PERCENT_CDC	0%		0%		Percentage (of output voltage) cable drop compensation desired at full load
CDC_SCALING_SETPOINT	3		3		Select the setpoint number for the voltage used for cable drop compensation (typically the 5V output)
PRIMARY CONTROLLER SELECTION					
ENCLOSURE	OPEN FRAME		OPEN FRAME		Power supply enclosure
ILIMIT_MODE	STANDARD		STANDARD		Device current limit mode
VDRAIN_BREAKDOWN	650		650	V	Device breakdown voltage
DEVICE_GENERIC	Auto		INN32X4		Device selection
DEVICE_CODE			INN3264C		Device code
PDEVICE_MAX			20	W	Device maximum power capability
RDSON_25DEG			3.68	Ω	Primary MOSFET on-time resistance at 25°C
RDSON_100DEG			5.70	Ω	Primary MOSFET on-time resistance at 100°C
ILIMIT_MIN			0.697	A	Primary MOSFET minimum current limit
ILIMIT_TYP			0.750	A	Primary MOSFET typical current limit
ILIMIT_MAX			0.803	A	Primary MOSFET maximum current limit
VDRAIN_ON_MOSFET			1.14	V	Primary MOSFET on-time voltage drop
VDRAIN_OFF_MOSFET			548.31	V	Peak drain voltage on the primary MOSFET during turn-off
WORST CASE ELECTRICAL PARAMETERS					
FSWITCHING_MAX	83000		83000	Hz	Maximum switching frequency at full load and the valley of the minimum input AC voltage
VOR	105.0		105.0	V	Voltage reflected to the primary winding (corresponding to setpoint 1) when the primary MOSFET turns off
VMIN			96.34	V	Valley of the rectified minimum input AC voltage at full load
KP			0.876		Measure of continuous/discontinuous mode of operation
MODE_OPERATION			CCM		Mode of operation

DUTYCYCLE			0.524		Primary MOSFET duty cycle
TIME_ON			8.61	us	Primary MOSFET on-time
TIME_OFF			5.73	us	Primary MOSFET off-time
LPRIMARY_MIN			992.6	uH	Minimum primary magnetizing inductance
LPRIMARY_TYP			1044.8	uH	Typical primary magnetizing inductance
LPRIMARY_TOL			5.0		Primary magnetizing inductance tolerance
LPRIMARY_MAX			1097.0	uH	Maximum primary magnetizing inductance
PRIMARY CURRENT					
IAVG_PRIMARY			0.200	A	Primary MOSFET average current
IPEAK_PRIMARY			0.763	A	Primary MOSFET peak current
IPEDESTAL_PRIMARY			0.084	A	Primary MOSFET current pedestal
IRIPPLE_PRIMARY			0.763	A	Primary MOSFET ripple current
IRMS_PRIMARY			0.319	A	Primary MOSFET RMS current
SECONDARY CURRENT					
IPEAK_SECONDARY			8.853	A	Secondary MOSFET peak current
IPEDESTAL_SECONDARY			0.975	A	Secondary MOSFET pedestal current
IRMS_SECONDARY			3.520	A	Secondary MOSFET RMS current
IRIPPLE_CAP_OUT			2.896	A	Output capacitor ripple current
TRANSFORMER CONSTRUCTION PARAMETERS					
CORE SELECTION					
CORE	Custom	Info	Custom		The transformer windings may not fit: pick a bigger core or bobbin and refer to the Transformer Parameters tab for fit calculations
CORE NAME	RM7		RM7		Core code
AE	44.1		44.1	mm^2	Core cross sectional area
LE	30.0		30.0	mm	Core magnetic path length
AL	2000		2000	nH	Ungapped core effective inductance per turns squared
VE	1325		1325	mm^3	Core volume
BOBBIN NAME	RM7/I		RM7/I		Bobbin name
AW	21.0		21.0	mm^2	Bobbin window area
BW	6.85		6.85	mm	Bobbin width
MARGIN			0.0	mm	Bobbin safety margin
PRIMARY WINDING					
NPRIMARY			58		Primary winding number of turns
BPEAK			3525	Gauss	Peak flux density
BMAX			3234	Gauss	Maximum flux density
BAC			1602	Gauss	AC flux density (0.5 x Peak to Peak)
ALG			311	nH	Typical gapped core effective inductance per turns squared
LG			0.151	mm	Core gap length
LAYERS_PRIMARY	3		3		Primary winding number of layers
AWG_PRIMARY			29		Primary wire gauge
OD_PRIMARY_INSULATED			0.337	mm	Primary wire insulated outer diameter
OD_PRIMARY_BARE			0.286	mm	Primary wire bare outer diameter
CMA_PRIMARY			397.7	Cmils/A	Primary winding wire CMA
SECONDARY WINDING					
NSECONDARY	5		5		Secondary winding number of turns
AWG_SECONDARY			21		Secondary wire gauge
OD_SECONDARY_INSULATED			1.029	mm	Secondary wire insulated outer diameter
OD_SECONDARY_BARE			0.723		Secondary wire bare outer diameter
CMA_SECONDARY			230.2	Cmils/A	Secondary winding wire CMA
BIAS WINDING					
NBIAS			9		Bias winding number of turns
PRIMARY COMPONENTS SELECTION					
LINE UNDERVOLTAGE					
BROWN-IN REQURED			72.00	V	Required line brown-in threshold

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RLS			3.56	MΩ	Connect two 1.78 MOhm resistors to the V-pin for the required UV/OV threshold
BROWN-IN ACTUAL			71.40	V	Actual brown-in threshold using standard resistors
BROWN-OUT ACTUAL			64.58	V	Actual brown-out threshold using standard resistors
LINE OVERVOLTAGE					
OVERVOLTAGE_LINE		Warning	297.50	V	The device voltage stress will be higher than 90% of the breakdown voltage when overvoltage is trigerred
BIAS WINDING					
VBIAS	8.00	Info	8.00	V	The rectified bias voltage maybe too low to supply the BP pin: Increase the rectified bias voltage to a value higher than 9V
VF_BIAS			0.70	V	Bias winding diode forward drop
VREVERSE_BIASDIODE			65.93	V	Bias diode reverse voltage (not accounting parasitic voltage ring)
CBIAS			22	uF	Bias winding rectification capacitor
CBPP			0.47	uF	BPP pin capacitor
SECONDARY COMPONENTS SELECTION					
RECTIFIER					
VDRAIN_OFF_SRFET			41.18	V	Secondary rectifier reverse voltage (not accounting parasitic voltage ring)
SRFET	AO4264		AO4264		Secondary rectifier (Logic MOSFET)
VBREAKDOWN_SRFET			60	V	Secondary rectifier breakdown voltage
RDSON_SRFET			13.5	mΩ	SRFET on time drain resistance at 25degC for VGS=4.4V
FEEDBACK COMPONENTS					
RFB_UPPER			100.00	kΩ	Upper feedback resistor (connected to the output terminal)
RFB_LOWER			34.00	kΩ	Lower feedback resistor required to obtain the output for cable drop compensation
CFB_LOWER			330	pF	Lower feedback resistor decoupling capacitor
VARIABLE OUTPUTS ANALYSIS					
TOLERANCE CORNER					
CORNER_VAC			90	V	Input AC RMS voltage corner to be evaluated
CORNER_ILIMIT	TYP		0.750	A	Current limit corner to be evaluated
CORNER_LPRIMARY	TYP		1044.8	uH	Primary inductance corner to be evaluated
SETPOINT SELECTION					
SETPOINT	1		1		Select the setpoint which needs to be evaluated
FSWITCHING			70378.7	Hz	Maximum switching frequency at full load and the valley of the minimum input AC voltage
VOR			105.0	V	Voltage reflected to the primary winding when the primary MOSFET turns off
VMIN			96.34	V	Valley of the minimum input AC voltage
KP			0.943		Measure of continuous/discontinuous mode of operation
MODE_OPERATION			CCM		Mode of operation
DUTYCYCLE			0.524		Primary MOSFET duty cycle
TIME_ON			7.45	us	Primary controller's maximum on-time
TIME_OFF			6.76	us	Primary controller's minimum off-time
PRIMARY CURRENT					
IAVG_PRIMARY			0.200	A	Primary MOSFET average current
IPEAK_PRIMARY			0.720	A	Primary MOSFET peak current
IPEDESTAL_PRIMARY			0.041	A	Primary MOSFET current pedestal

IRIPPLE_PRIMARY			0.679	A	Primary MOSFET ripple current
IRMS_PRIMARY			0.310	A	Primary MOSFET RMS current
SECONDARY CURRENT					
IPEAK_SECONDARY			8.353	A	Secondary MOSFET peak current
IPEDESTAL_SECONDARY			0.476	A	Secondary MOSFET pedestal current
IRMS_SECONDARY			3.424	A	Secondary MOSFET RMS current
IRIPPLE_CAP_OUT			2.779	A	Output capacitor ripple current
MAGNETIC FLUX DENSITY					
BPEAK			3136	Gauss	Peak flux density
BMAX			2941	Gauss	Maximum flux density
BAC			1387	Gauss	AC flux density (0.5 x Peak to Peak)

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9 Performance Data

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

9.1.1 Specifications

Test	Average	Average	10% Load	Average	Average	10% Load
Model	**High Voltage**	**High Voltage**	**High Voltage**	**Low Voltage**	**Low Voltage**	**Low Voltage**
Power [W]	**DOE 6**	**CoC v5 Tier 2**	**CoC v5 Tier 2**	**DOE 6**	**CoC v5 Tier 2**	**CoC v5 Tier 2**
10 (5 V / 2 A)	-	-	-	78.70%	79.00%	69.73%
18 (9 V / 2 A)	85.00%	85.45%	75.45%	-	-	-

9.2 *5 V Output*

$V_{IN(RMS)}$	% Load	P_{IN} (W)	V_{OUT} (V)	I_{OUT} (mA)	P_{OUT} (W)	Efficiency (%)	Average Efficiency (%)	Requirement
90	100	12.12	5.20	1999.19	10.39	85.72	86.72	DOE VI Ave=78.7% COC V5 10%=69.73% Ave=79.0%
	75	9.00	5.19	1499.21	7.78	86.37		
	50	5.94	5.17	999.22	5.17	87.08		
	25	2.92	5.14	499.14	2.56	87.72		
	10	1.17	5.10	199.13	1.02	86.60		
115	100	12.08	5.21	1999.28	10.42	86.26	87.09	
	75	8.97	5.20	1499.21	7.79	86.87		
	50	5.91	5.18	999.22	5.17	87.49		
	25	2.92	5.14	499.24	2.56	87.72		
	10	1.18	5.10	199.13	1.02	86.02		
230	100	12.11	5.24	1999.10	10.48	86.50	86.24	
	75	9.04	5.23	1499.21	7.84	86.72		
	50	5.99	5.20	999.22	5.19	86.64		
	25	3.02	5.14	499.14	2.57	85.09		
	10	1.26	5.10	199.13	1.02	80.51		
265	100	12.20	5.26	1999.19	10.51	86.12	85.47	
	75	9.10	5.23	1499.39	7.84	86.14		
	50	6.05	5.20	999.13	5.19	85.84		
	25	3.07	5.14	499.24	2.57	83.79		
	10	1.30	5.11	199.23	1.017	78.41		

9.3 *9 V Output*

$V_{IN(RMS)}$	% Load	I_{IN} (mA)	P_{IN} (W)	V_{OUT} (V)	I_{OUT} (mA)	P_{OUT} (W)	Efficiency (%)	Average Efficiency (%)	Requirement
90	100	396.82	20.98	9.03	1999.35	18.05	86.03	86.90	DOE VI Ave=85.0% COC V5 10%=75.45% Ave=85.45%
	75	306.61	15.55	9.03	1498.58	13.54	87.04		
	50	217.94	10.37	9.07	998.55	9.05	87.28		
	25	120.40	5.18	9.06	498.53	4.52	87.27		
	10	56.74	2.13	9.03	199.34	1.80	84.47		
115	100	330.92	20.71	9.07	1998.98	18.13	87.56	87.75	
	75	259.10	15.46	9.06	1498.58	13.58	87.84		
	50	184.73	10.31	9.08	998.93	9.07	87.93		
	25	102.03	5.16	9.06	498.90	4.52	87.67		
	10	48.09	2.13	9.03	198.59	1.79	84.02		
230	100	206.43	20.56	9.07	1998.98	18.13	88.19	87.50	
	75	163.34	15.46	9.09	1498.58	13.62	88.07		
	50	115.01	10.34	9.09	998.93	9.08	87.77		
	25	64.71	5.26	9.07	498.90	4.53	85.96		
	10	30.67	2.22	9.03	198.96	1.80	80.80		
265	100	189.50	20.64	9.078	1998.98	18.13	87.82	86.93	
	75	149.65	15.55	9.10	1498.58	13.63	87.65		
	50	105.34	10.42	9.09	998.93	9.08	87.18		
	25	59.21	5.32	9.07	498.90	4.53	85.08		
	10	28.16	2.27	9.04	198.96	1.80	79.24		

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

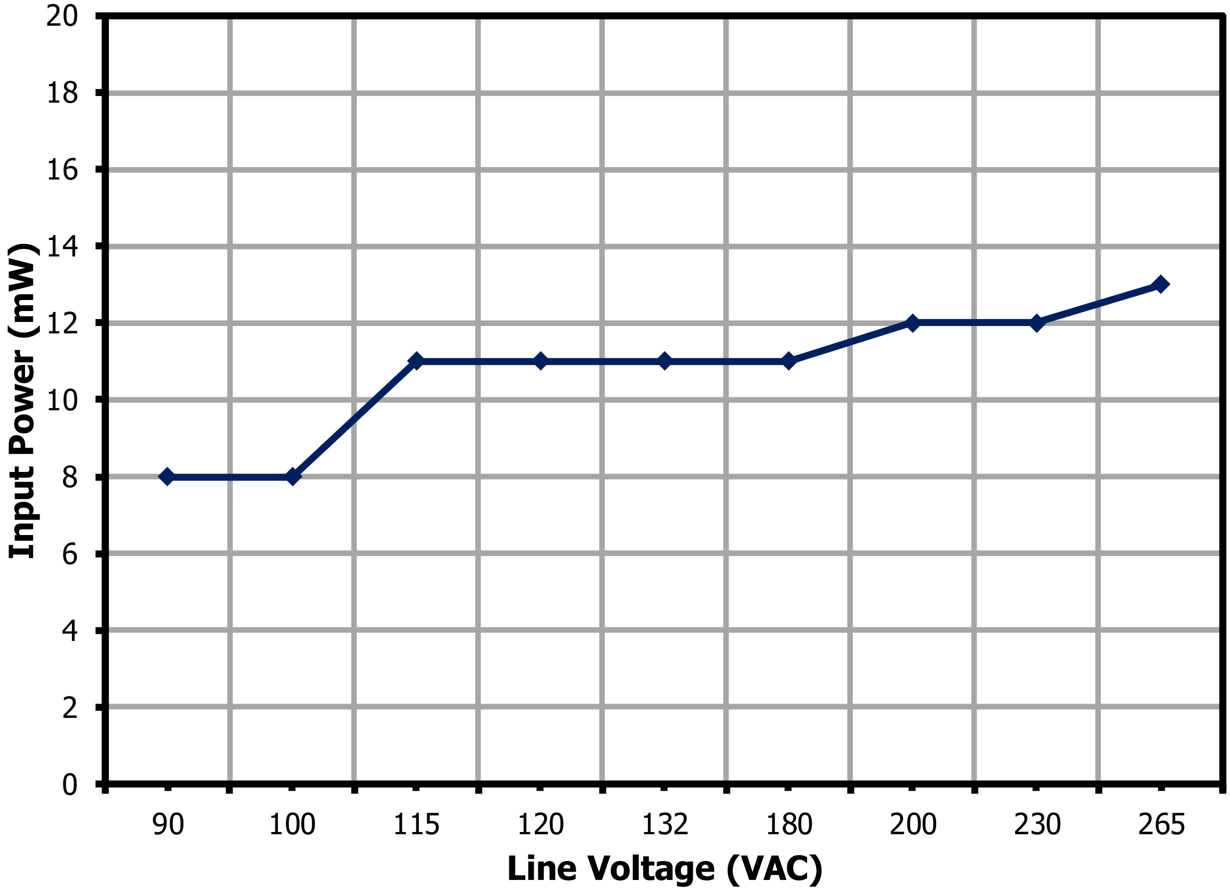

Figure 8 – No-Load Input Power vs. Input Line Voltage, Room Temperature.

Input		Input Measurement (Integration)
VAC (V_{RMS})	Freq (Hz)	Power (mW)
90	60	8.0
100	60	8.0
115	60	11.0
120	60	11.0
132	60	11.0
180	60	11.0
200	60	12.0
230	60	12.0
265	60	13.0

9.5 *Line Regulation (at the Main Output Terminal)*

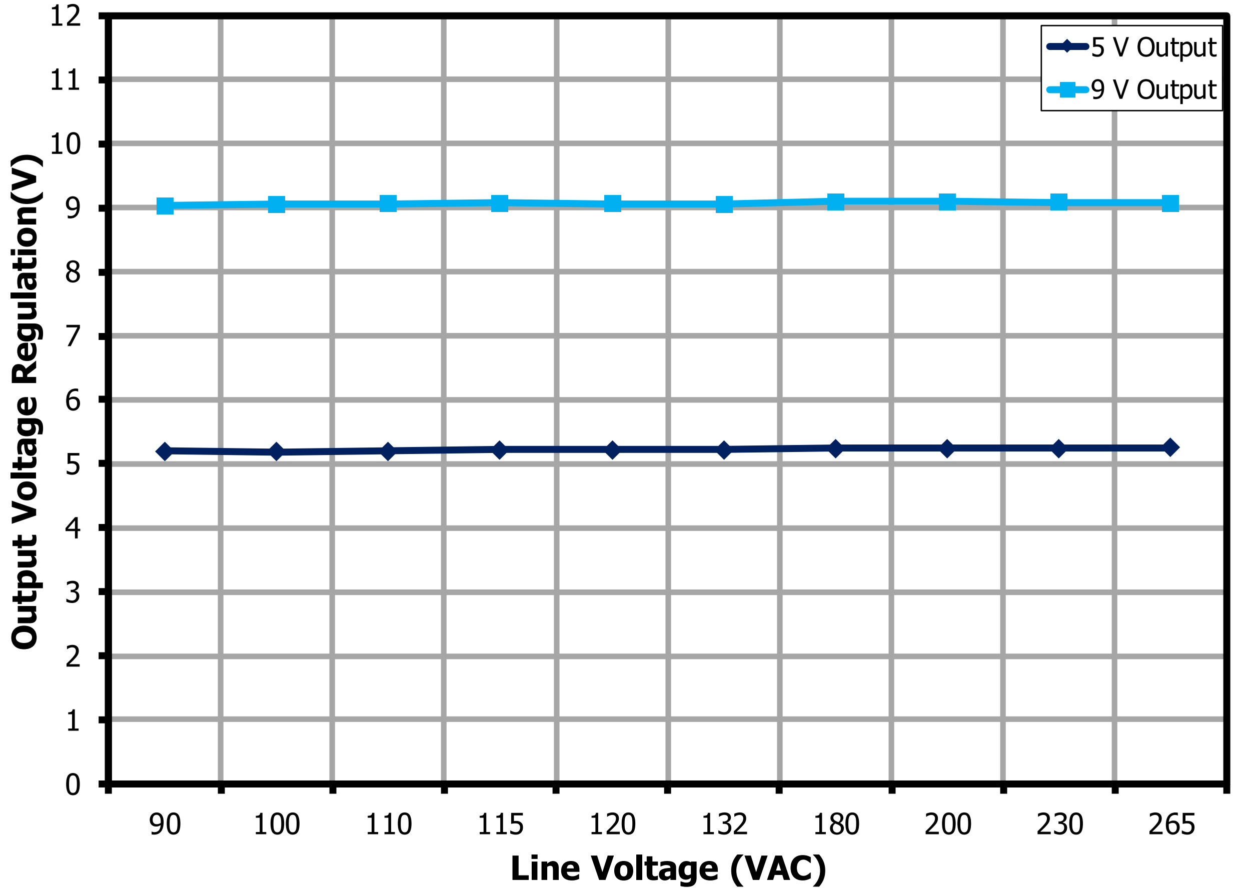

Figure 9 – Output Voltage at Output Terminal vs. Input Line Voltage, Room Temperature.

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9.6 *Line Regulation (at End of Cable)*

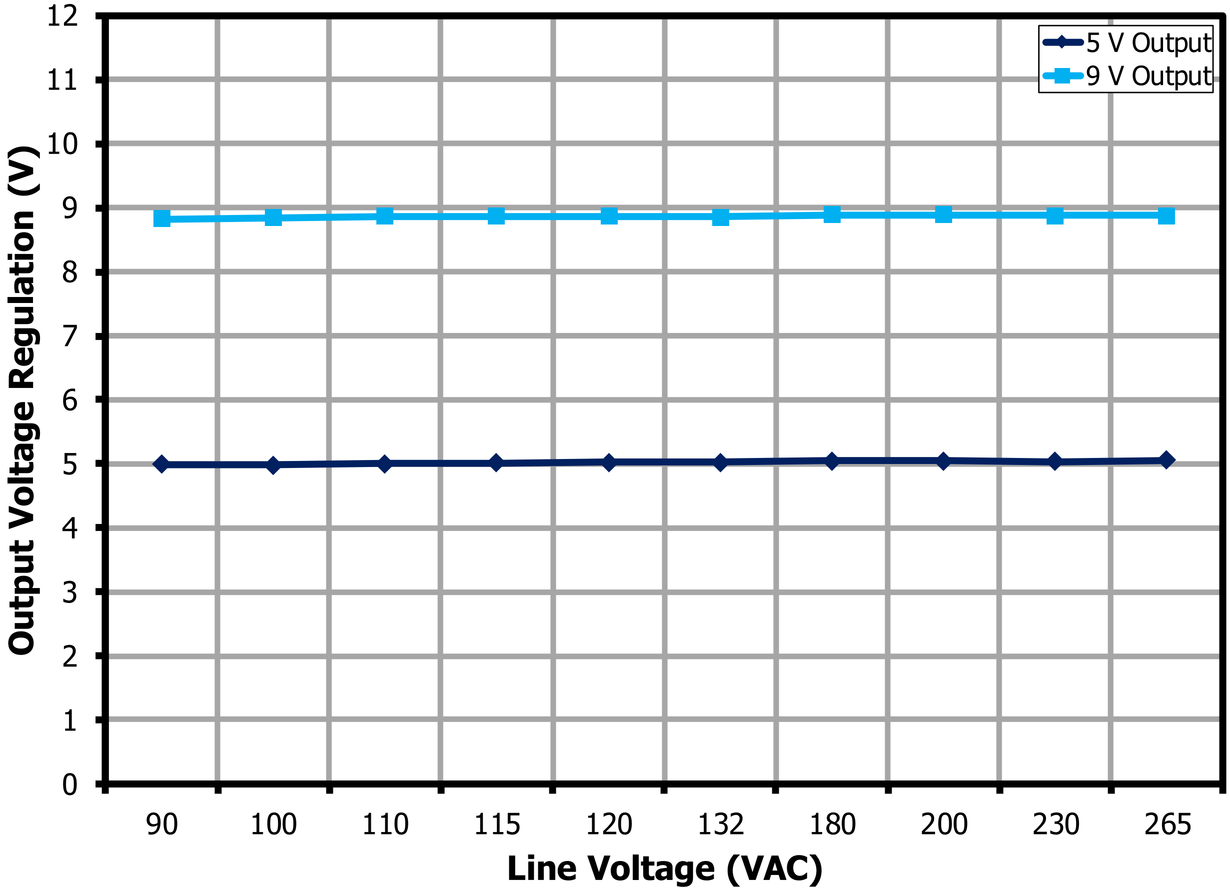

Figure 10 – Output Voltage at 1m End of Cable vs. Input Line Voltage, Room Temperature.

9.7 *Load Regulation (at the Main Output Terminal)*

9.7.1 90 VAC

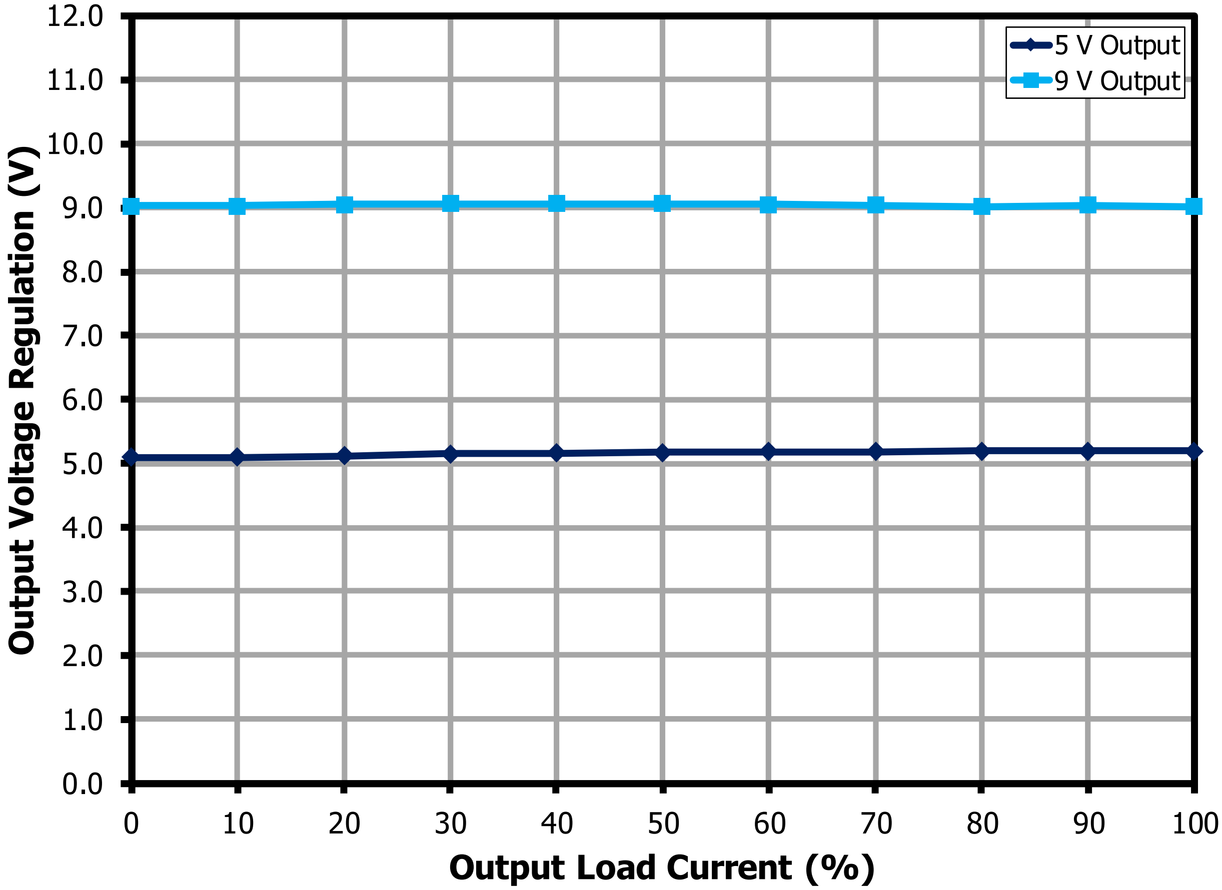

Figure 11 – Output Voltage at Output Terminal vs. Output Load, 90 VAC Input Room Temperature.

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9.7.2 265 VAC

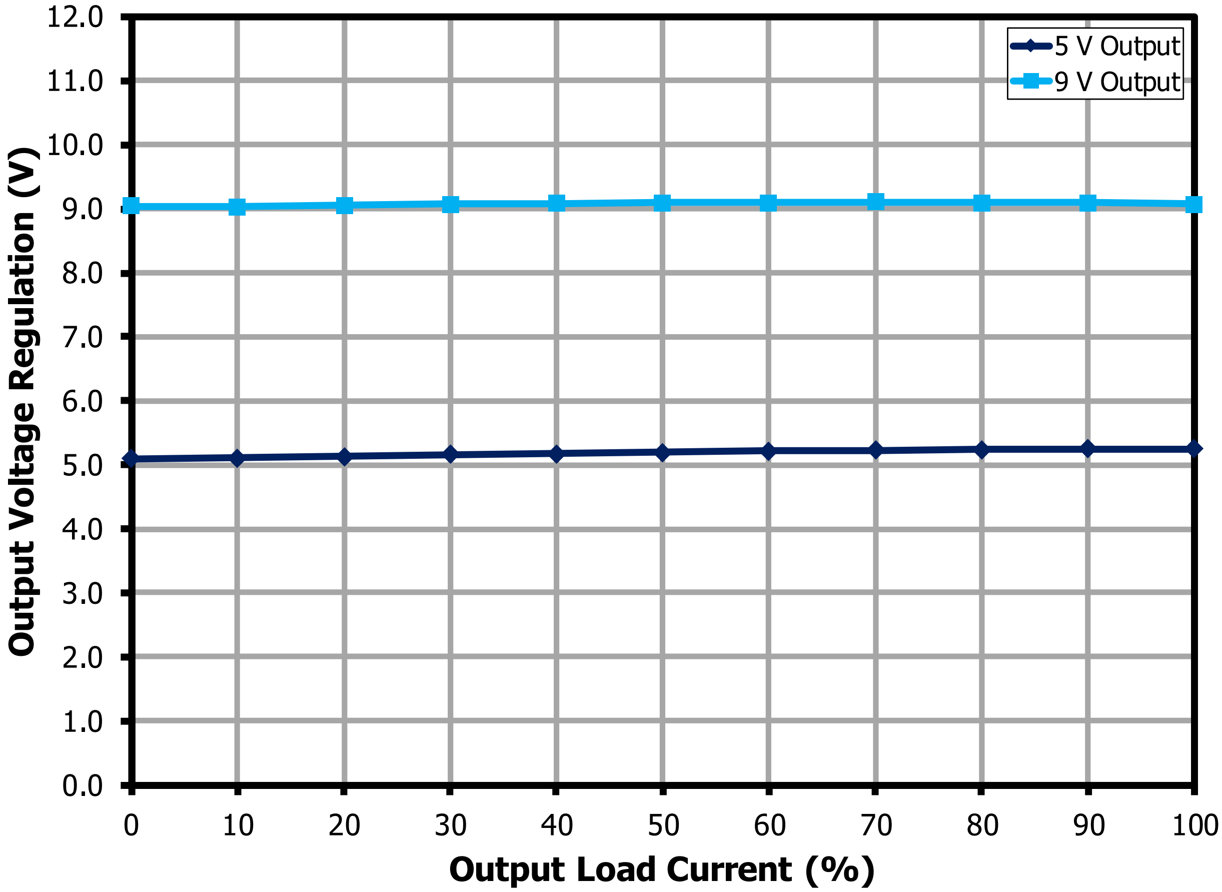

Figure 12 – Output Voltage at Output Terminal vs. Output Load, 265 VAC Input Room Temperature.

9.8 *Load Regulation (at End of Cable)*

9.8.1 90 VAC

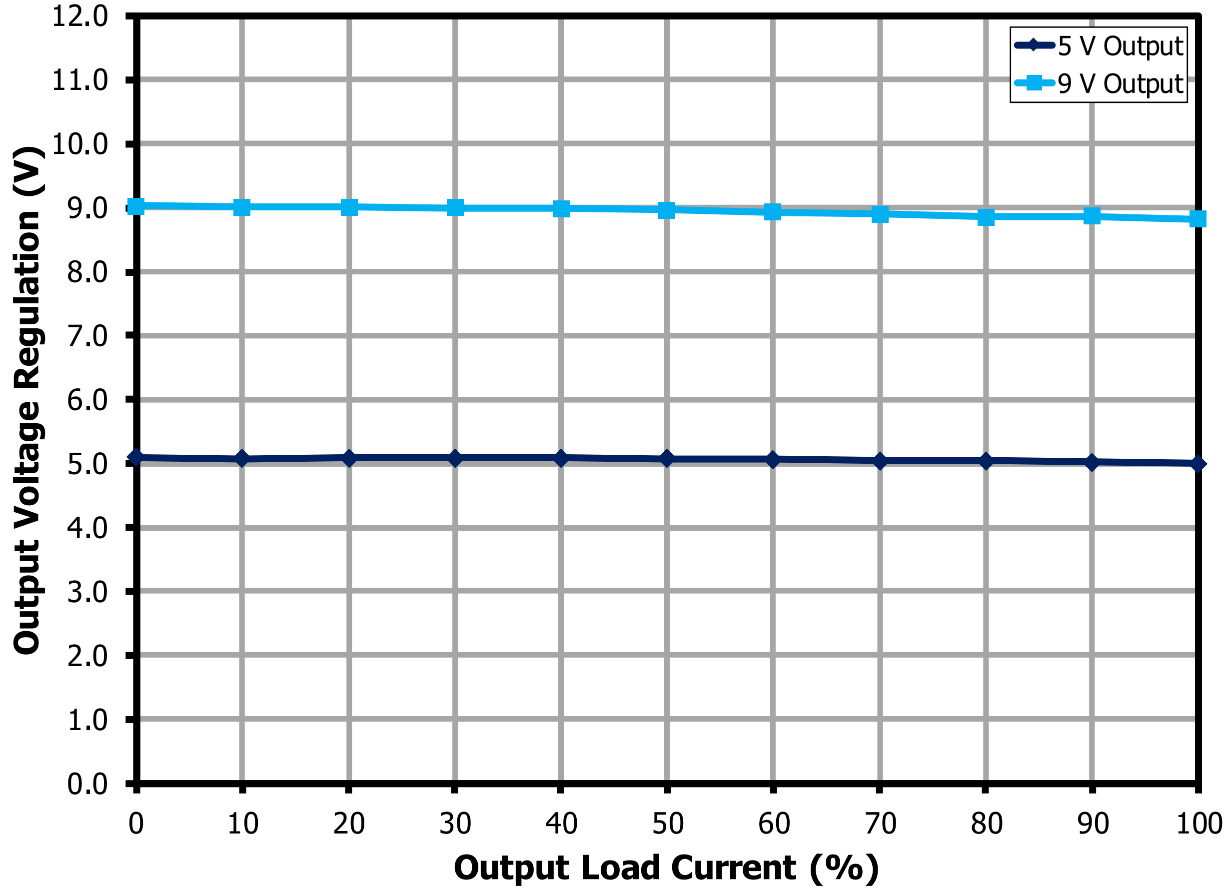

Figure 13 – Output Voltage at 1m End of Cable vs. Output Load, 90 VAC Input Room Temperature.

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9.8.2 265 VAC

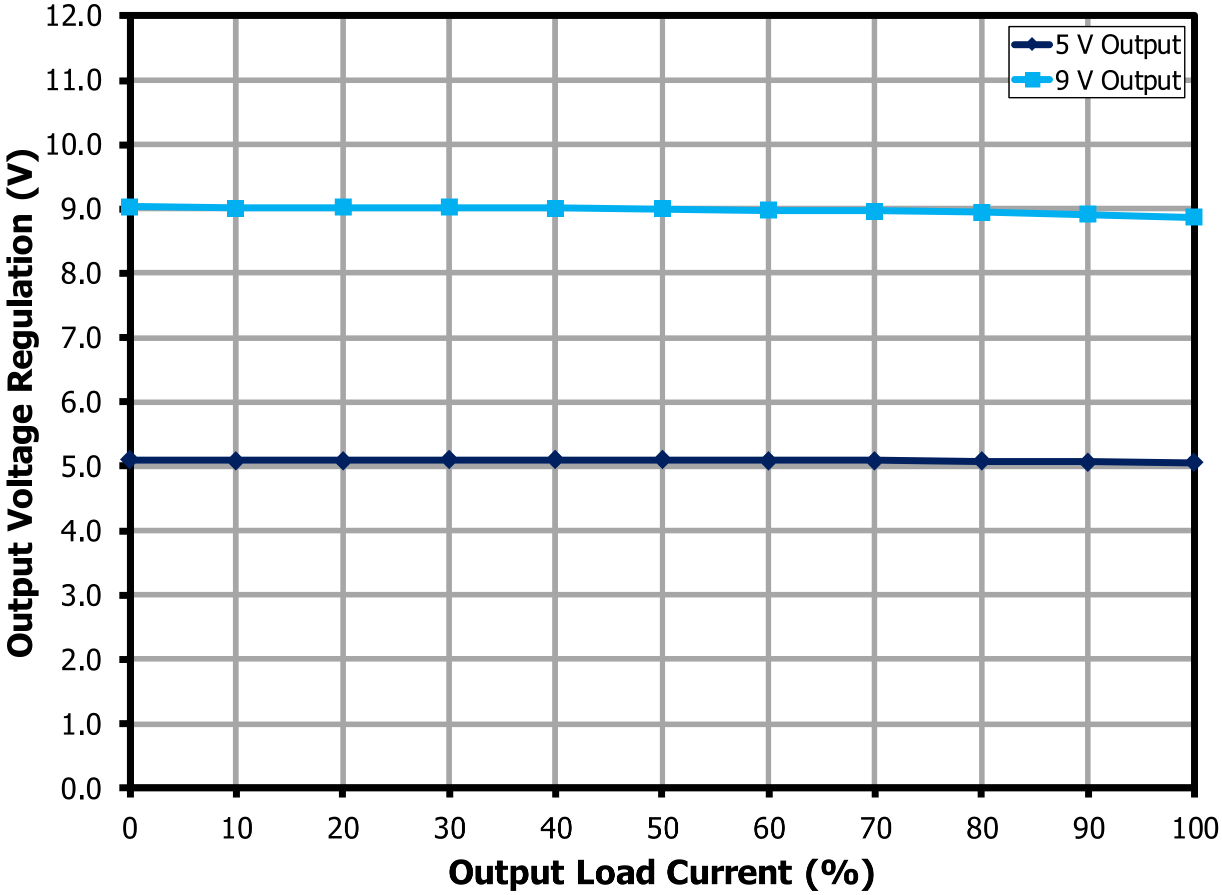

Figure 14 – Output Voltage at 1m end of cable vs. Output Load, 265 VAC Input Room Temperature

9.9 ***Output Ripple Measurements***

9.9.1 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).

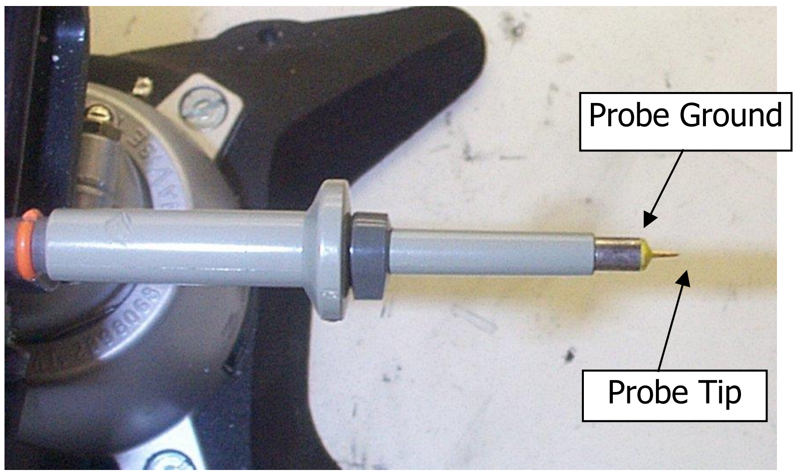

Figure 15 – Oscilloscope Probe Prepared for Ripple Measurement. (End Cap and Ground Lead Removed)

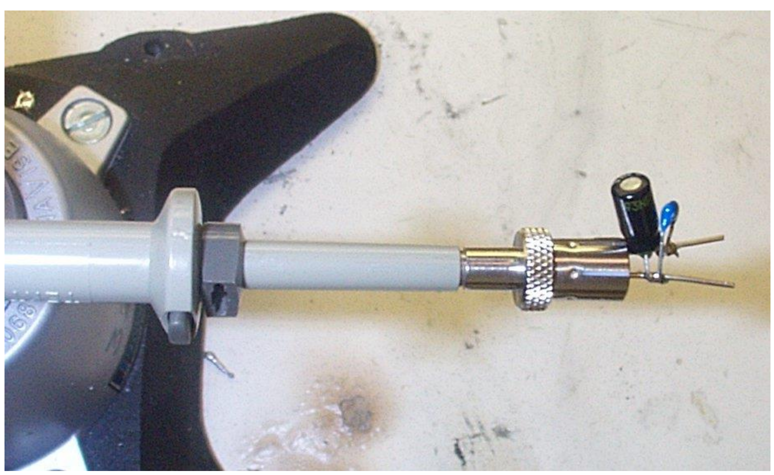

Figure 16 – Oscilloscope Probe with Probe Master (**www.probemaster.com**) 4987A BNC Adapter. (Modified with wires for ripple measurement, and two parallel decoupling capacitors added)

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9.10 *Output Ripple (End of Cable), 5 V Output, Full Load*

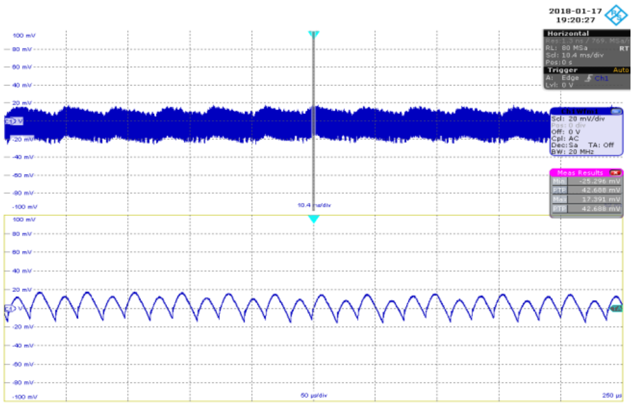

Figure 17 – 90 VAC, 60 Hz.
$V_{OUTRIPPLE}$, 20 mV / div., 10.4 ms / div.
Measured $V_{OUTRIPPLE}$ = 42 mV_{PK-PK}.

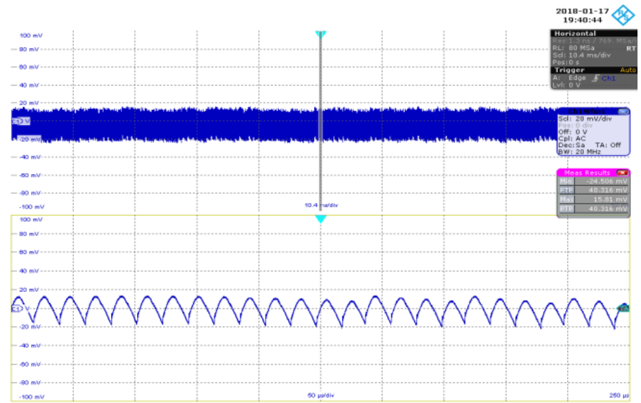

Figure 18 – 265 VAC, 50 Hz.
$V_{OUTRIPPLE}$, 20 mV / div., 10.4 ms / div.
Measured $V_{OUTRIPPLE}$ = 40 mV_{PK-PK}.

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

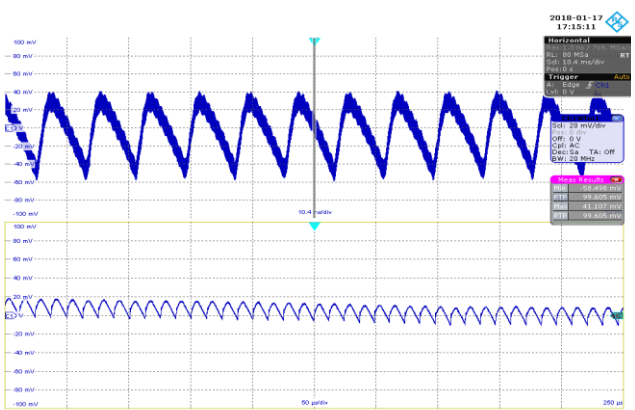

Figure 19 – 90 VAC, 60 Hz.
$V_{OUTRIPPLE}$, 20 mV / div., 10.4 ms / div.
Measured $V_{OUTRIPPLE}$ = 99 mV_{PK-PK}.

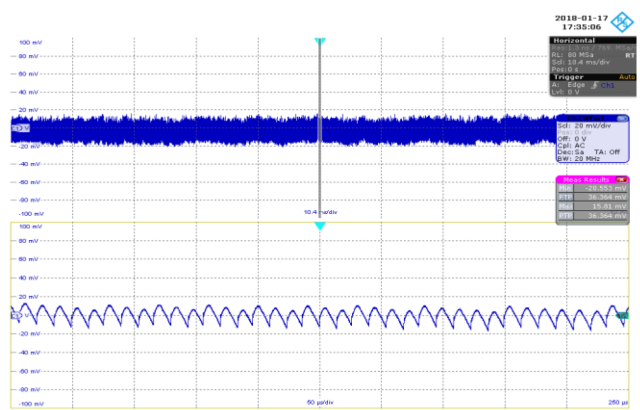

Figure 20 – 265 VAC, 50 Hz.
$V_{OUTRIPPLE}$, 20 mV / div., 10.4 ms / div.
Measured $V_{OUTRIPPLE}$ = 36 mV_{PK-PK}.

9.12 ***Output Ripple (End of Cable) Graph Summary, 5 V Output***

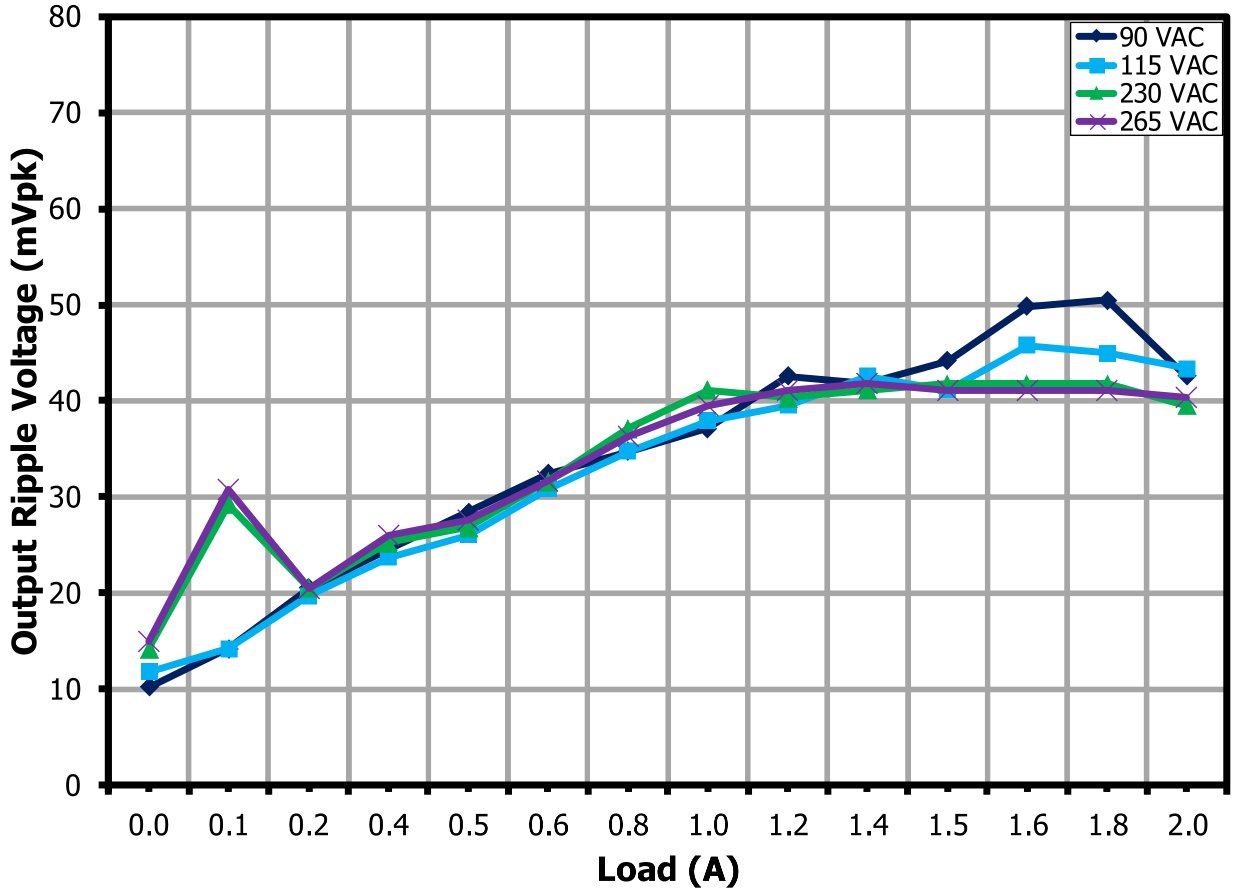

Figure 21 – 5 V Output Voltage Ripple at 1m End of Cable vs. Output Load, Room Temperature.

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

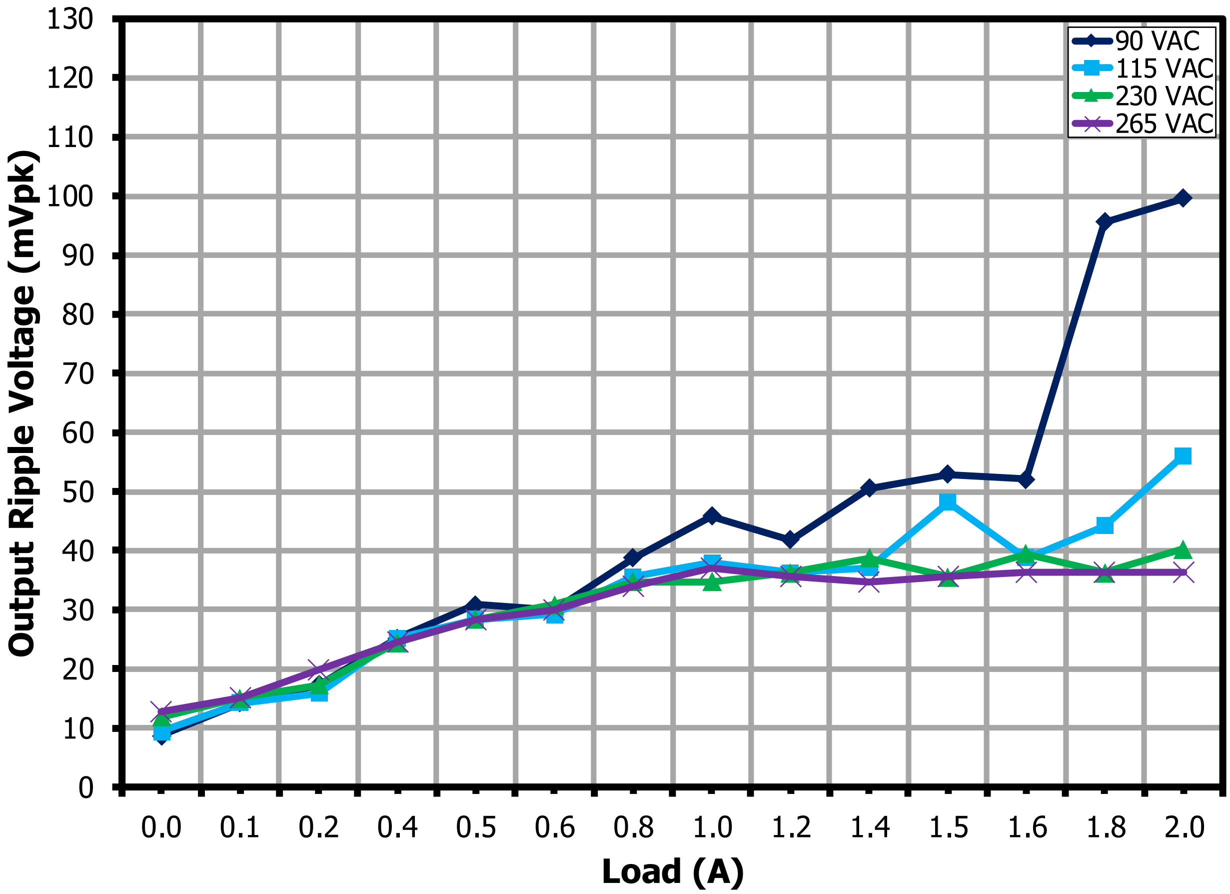

Figure 22 – 9V Output Voltage Ripple at 1m End of Cable vs. Output Load, Room Temperature.

9.14 *CV/CC Graph Summary, 5 V Output [Measured at the Board Terminals]*

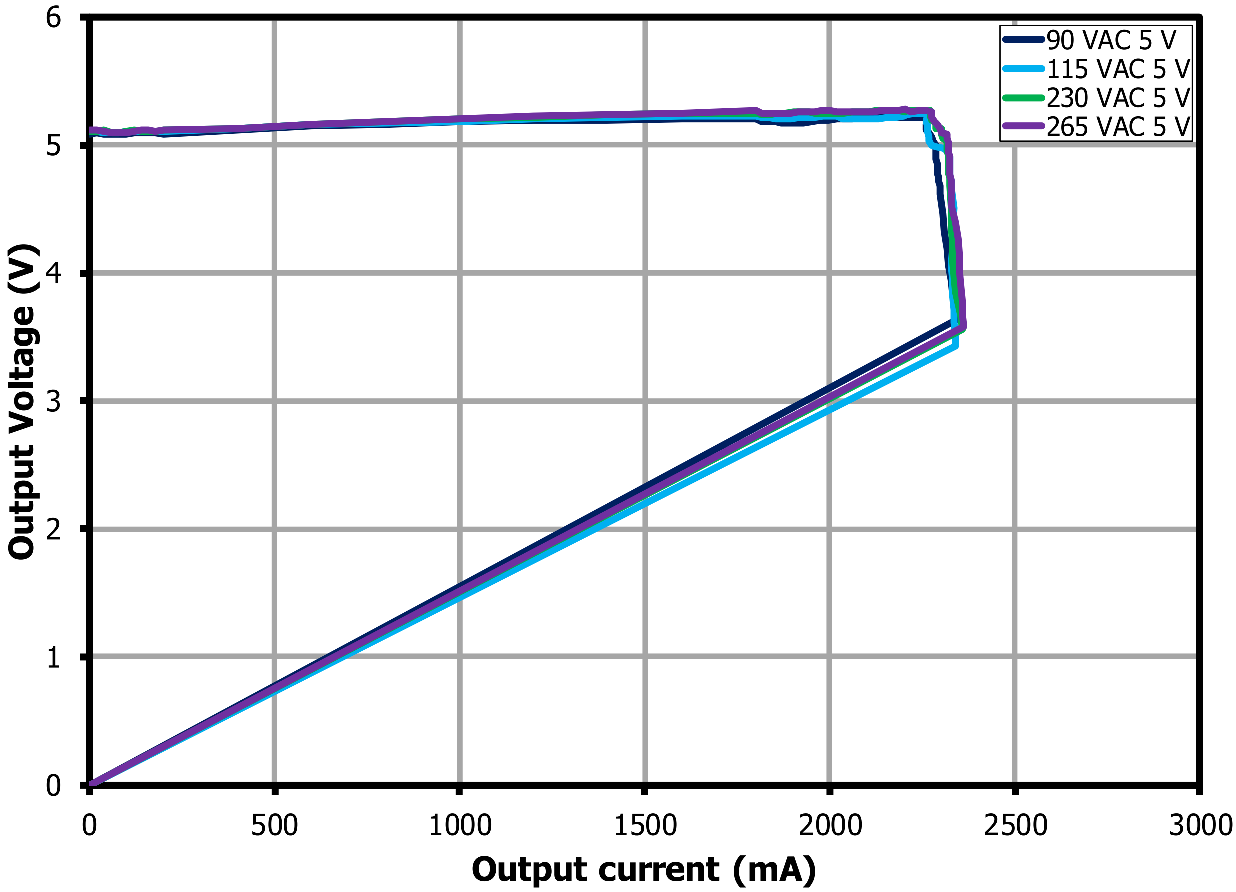

Figure 23 – 5 V CV/CC Characteristic Measured at Output Terminal, Room Temperature.

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9.15 ***CV/CC Graph Summary, 9 V Output [Measured at the Board Terminals]***

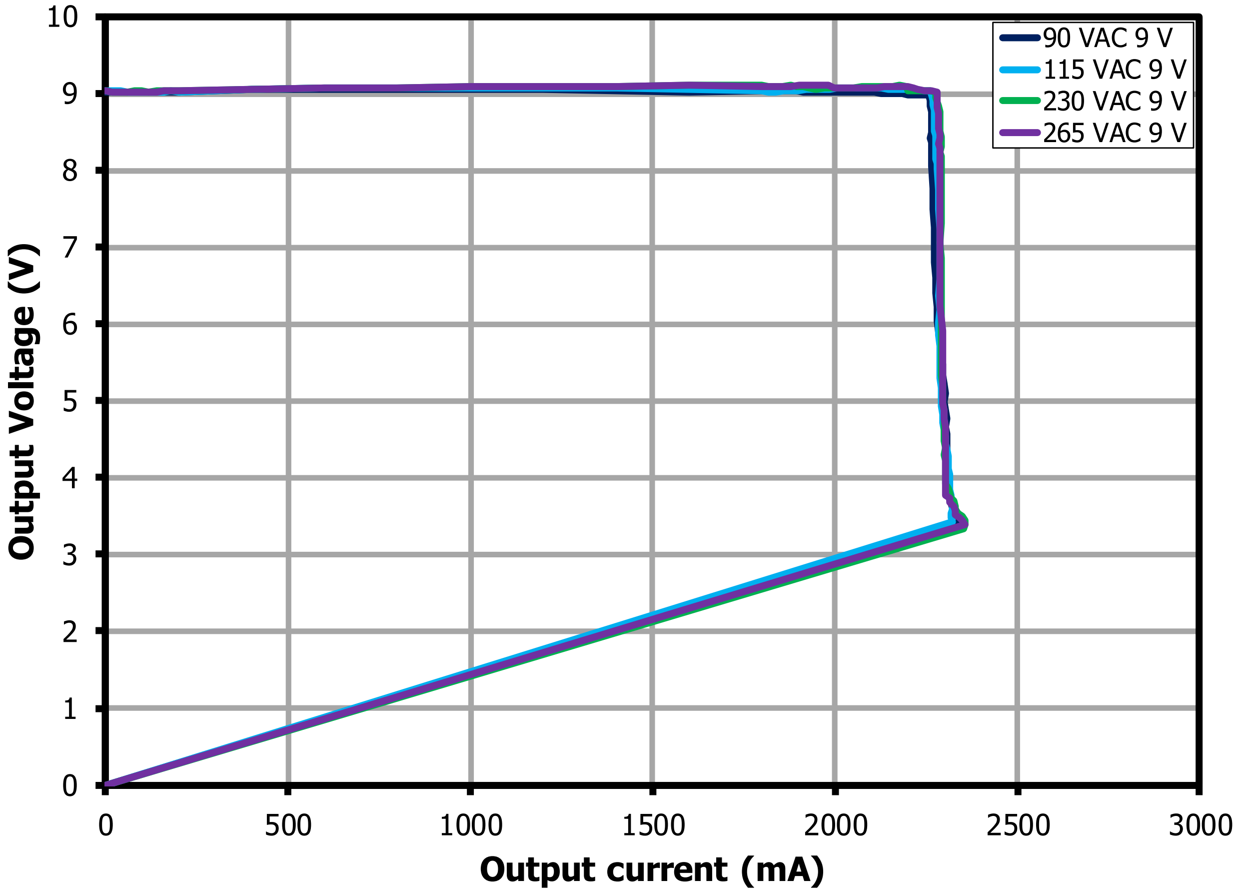

Figure 24 – 9 V CV/CC Characteristic Measured at Output Terminal, Room Temperature.

10 Thermal Performance

10.1 *Thermal Performance at 5 V, 2 A, T_A = 25 °C*

10.1.1 90 VAC

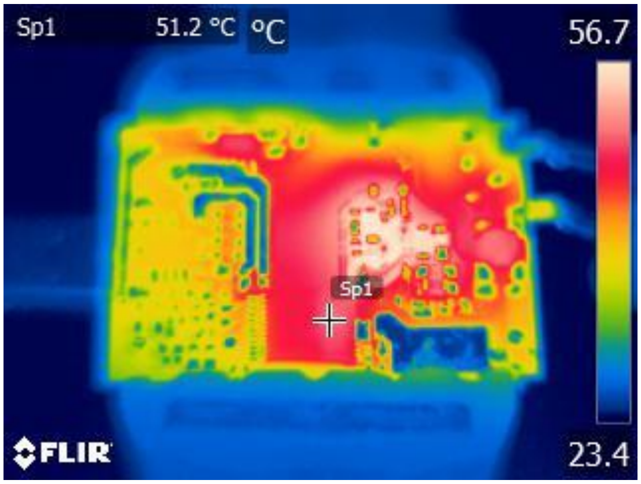

Figure 25 – Ambient Temperature, 25.1 °C.
D2 – Aux Diode, 59.3 °C.
D1 – Primary Diode Snubber, 56.1 °C.
U1 – InnoSwitch3-CP, 51.2 °C.
Q2 – SR FET, 49.7 °C.

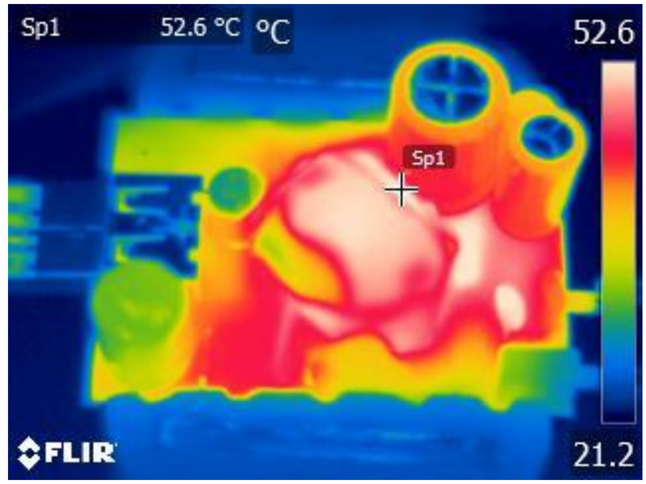

Figure 26 – Ambient Temperature, 25.1 °C.
T1 – Transformer, 52.6 °C.
RT1 – Thermistor, 53.5 °C.

10.1.2 265 VAC

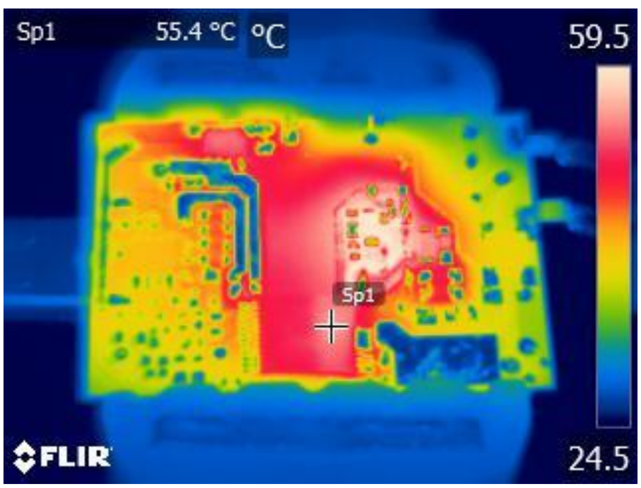

Figure 27 – Ambient Temperature, 25.1 °C.
D2 – Aux Diode, 61.7 °C.
D1 – Primary Diode Snubber, 56.4 °C.
U1 – InnoSwitch3-CP, 55.4 °C.
Q2 – SR FET, 54.0 °C.

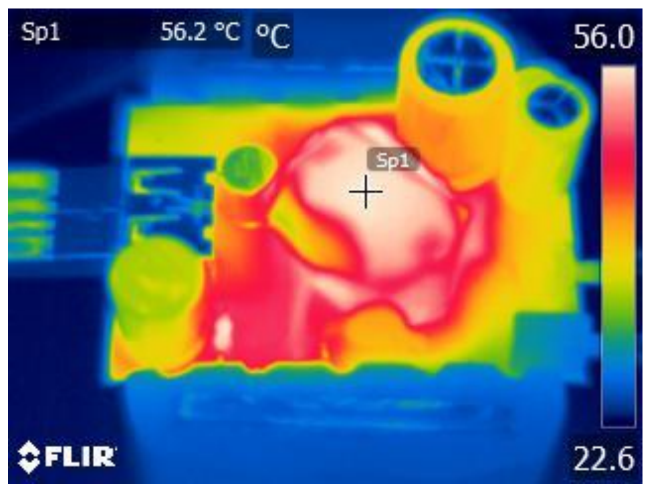

Figure 28 – Ambient Temperature, 25.1 °C.
T1 – Transformer, 56.2 °C.
RT1 – Thermistor, 41.7 °C.

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10.2 ***Thermal Performance at 9 V, 2 A, T_A = 25 °C***

10.2.1 90 VAC

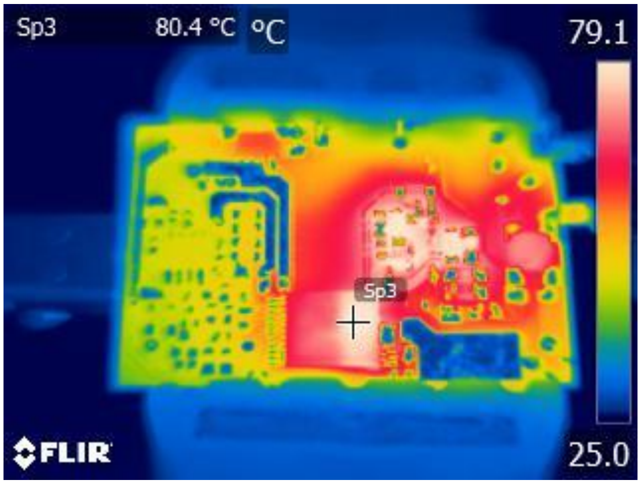

Figure 29 – Ambient Temperature, 25.1 °C.
D2 – Aux Diode, 82.8 °C.
D1 – Primary Diode Snubber, 79.1 °C.
U1 – InnoSwitch3-CP, 80.4 °C.
Q2 – SR FET, 61.6 °C.

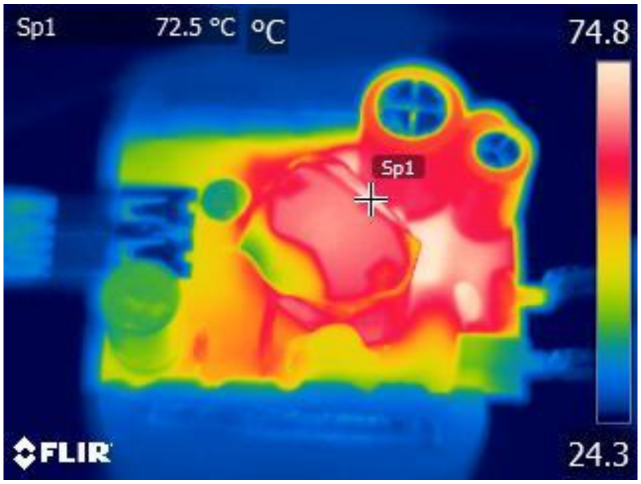

Figure 30 – Ambient Temperature, 25.1 °C.
T1 – Transformer, 72.5°C.
RT1 – Thermistor, 74.1 °C.

10.2.2 265 VAC

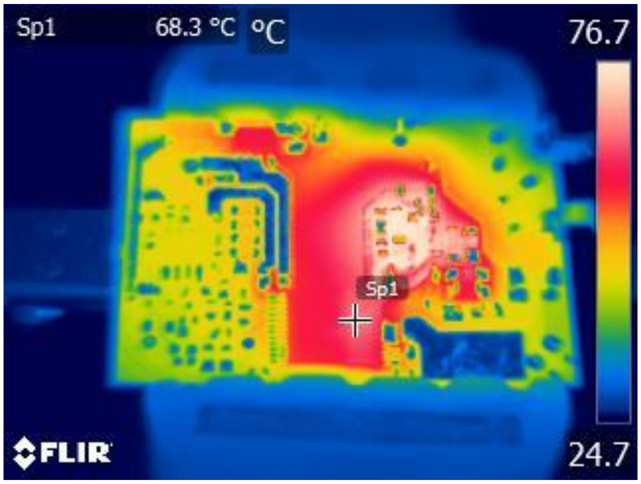

Figure 31 – Ambient Temperature, 25.1 °C.
D2 – Aux Diode, 81.2 °C.
D1 – Primary Diode Snubber, 73.3 °C.
U1 – InnoSwitch3-CP, 68.3 °C.
Q2 – SR FET, 62.6 °C.

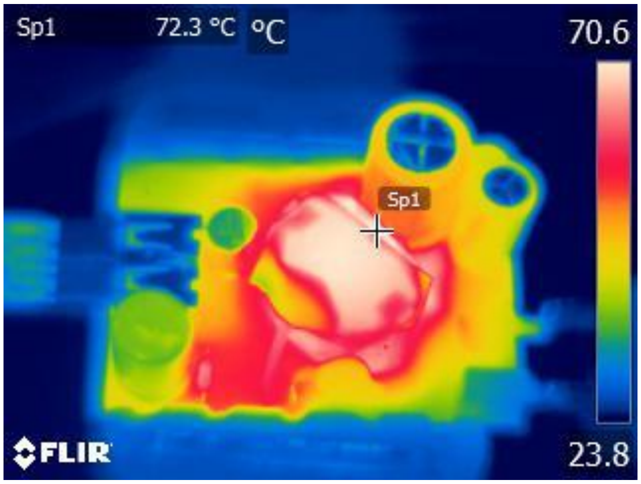

Figure 32 – Ambient Temperature, 25.1 °C.
T1 – Transformer, 72.3°C.
RT1 – Thermistor, 53.7 °C.

11 Waveforms

11.1 *Drain Voltage and Current at 5 V, Full Load*

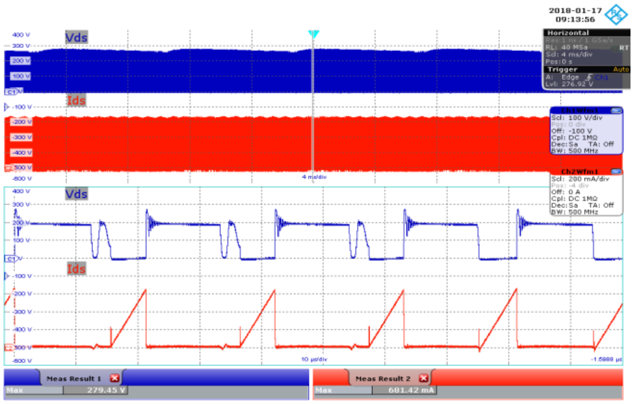

Figure 33 – 90 VAC, 60 Hz.
Upper: V_{DRAIN}, 100 V / div., 4 ms / div.
Lower: I_{DRAIN}, 200 mA / div., 4 ms / div.
Zoom: 10 µs / div.
Measured V_{PK} = 279 V_{PK}.
Measured I_{PK} = 681 mA_{PK}.

Figure 34 – 265 VAC, 50 Hz.
Upper: V_{DRAIN}, 200 V / div., 4 ms / div.
Lower: I_{DRAIN}, 200 mA / div., 4 ms / div.
Zoom:10 µs / div.
Measured V_{PK} = 519 V_{PK}.
Measured I_{PK} = 855 mA_{PK}.

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

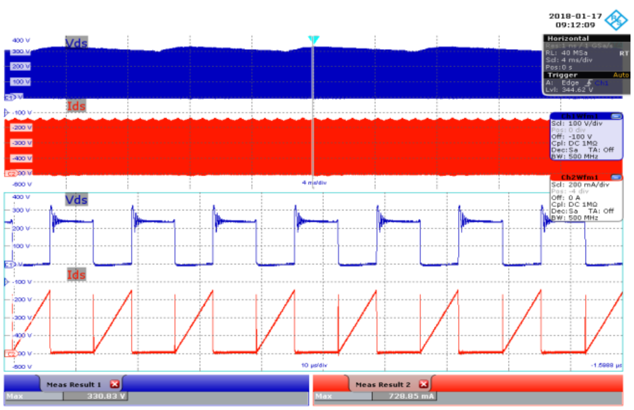

Figure 35 – 90 VAC, 60 Hz.
Upper: V_{DRAIN}, 100 V / div., 4 ms / div.
Lower: I_{DRAIN}, 200 mA / div., 4 ms / div.
Zoom: 10 µs / div.
Measured V_{PK} = 330 V_{PK}.
Measured I_{PK} = 728 mA_{PK}.

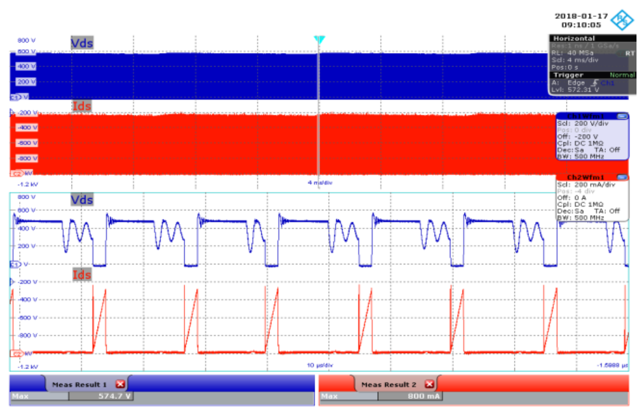

Figure 36 – 265 VAC, 50 Hz.
Upper: V_{DRAIN}, 200 V / div., 4 ms / div.
Lower: I_{DRAIN}, 200 mA / div., 4 ms / div.
Zoom: 10 µs / div.
Measured V_{PK} = 574 V_{PK}.
Measured I_{PK} = 800 mA_{PK}.

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

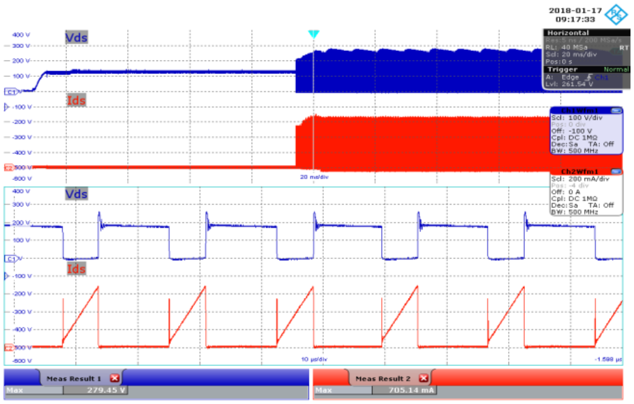

Figure 37 – 90 VAC, 60 Hz.
Upper: V_{DRAIN}, 100 V / div., 20 ms / div.
Lower: I_{DRAIN}, 200 mA / div., 20 ms / div.
Zoom: 10 µs / div.
Measured V_{PK} = 279 V_{PK}.
Measured I_{PK} = 705 mA_{PK}.

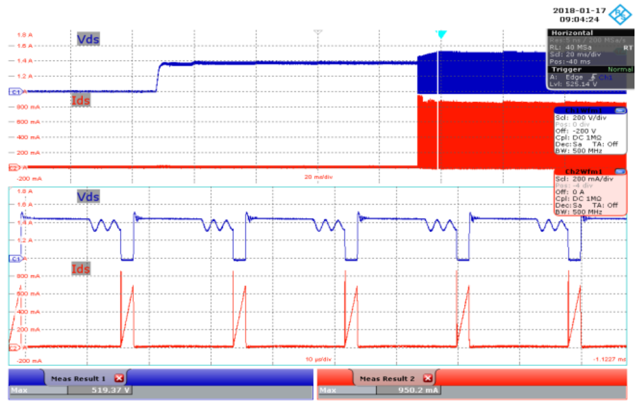

Figure 38 – 265 VAC, 50 Hz.
Upper: V_{DRAIN}, 200 V / div., 20 ms / div.
Lower: I_{DRAIN}, 200 mA / div., 20 ms / div.
Zoom: 10 µs / div.
Measured V_{PK} = 519 V_{PK}.
Measured I_{PK} = 950 mA_{PK}.

11.4 *Drain Voltage and Current at 5 V to 9 V transition, Full Load*

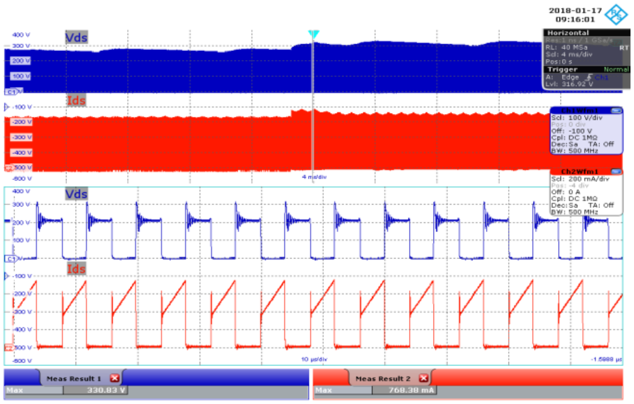

Figure 39 – 90 VAC, 60 Hz.
Upper: V_{DRAIN}, 100 V / div., 4 ms / div.
Lower: I_{DRAIN}, 200 mA / div., 4 ms / div.
Zoom: 10 µs / div.
Measured V_{PK} = 330 $V_{PK.}$
Measured I_{PK} = 768 $mA_{PK.}$

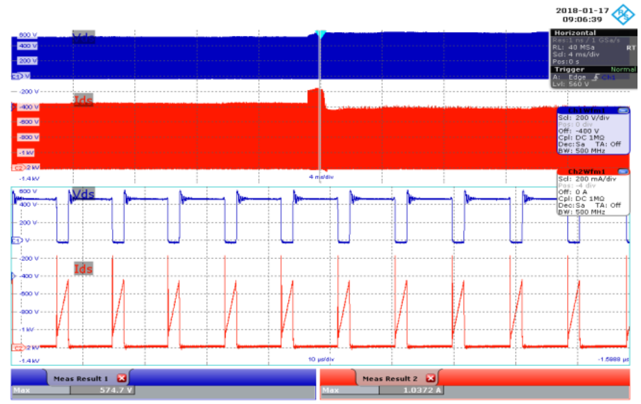

Figure 40 – 265 VAC, 50 Hz.
Upper: V_{DRAIN}, 200 V / div., 4 ms / div.
Lower: I_{DRAIN}, 200 mA / div., 4 ms / div.
Zoom: 10 µs / div.
Measured V_{PK} = 574 $V_{PK.}$
Measured I_{PK} = 1.04 $A_{PK.}$

11.5 *Synchronous Rectifier Voltage, 5 V, Full Load*

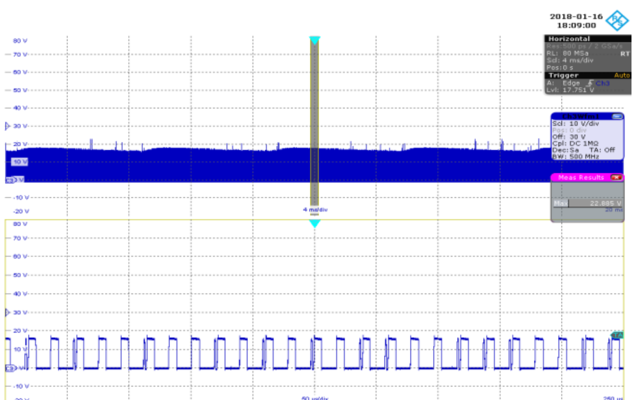

Figure 41 – 90 VAC, 60 Hz.
$V_{SYNCRECT}$, 10 V / div., 4 ms / div.
Zoom: 50 µs / div.
Measured V_{PK} = 22 $V_{PK.}$

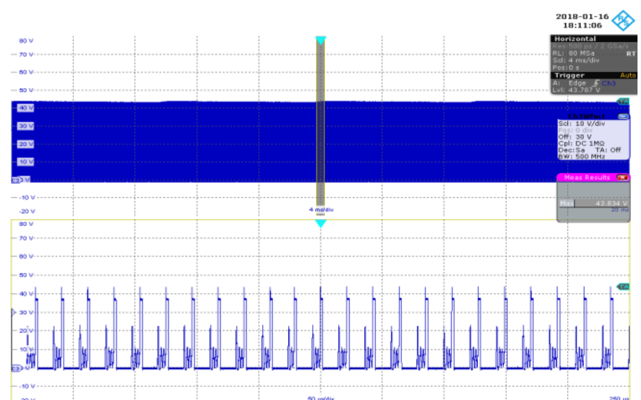

Figure 42 – 265 VAC, 50 Hz.
$V_{SYNCRECT}$, 10 V / div., 4 ms / div.
Zoom: 50 µs / div.
Measured V_{PK} = 43 $V_{PK.}$

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

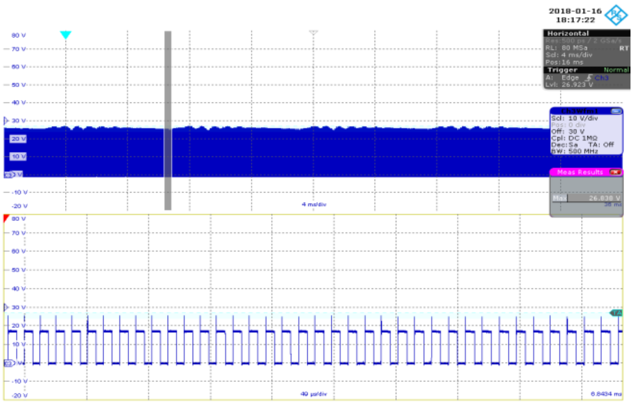

Figure 43 – 90 VAC, 60 Hz.
$V_{SYNCRECT}$, 10 V / div., 4 ms / div.
Zoom: 49 μs / div.
Measured V_{PK} = 26 V_{PK}.

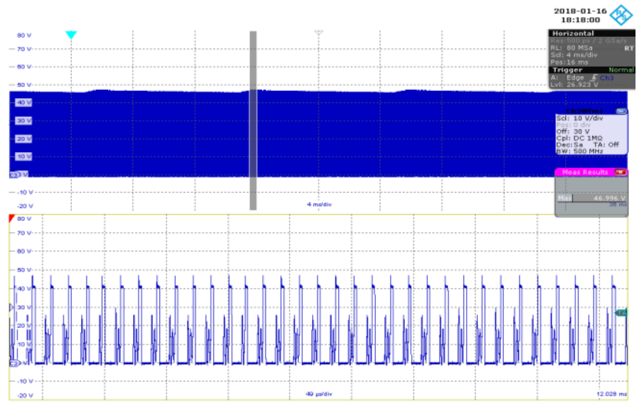

Figure 44 – 265 VAC, 50 Hz.
$V_{SYNCRECT}$, 10 V / div., 4 ms / div.
Zoom: 49 μs / div.
Measured V_{PK} = 46 V_{PK}.

11.7 *Synchronous Rectifier Voltage, Start-up at 5 V, Full Load*

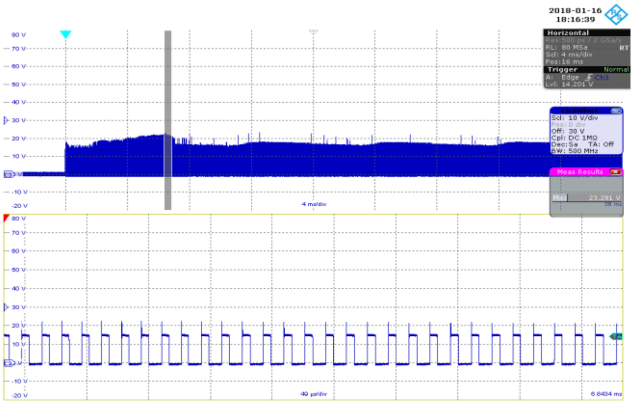

Figure 45 – 90 VAC, 60 Hz.
$V_{SYNCRECT}$, 10 V / div., 4 ms / div.
Zoom: 49 µs / div.
Measured V_{PK} = 23 V_{PK}.

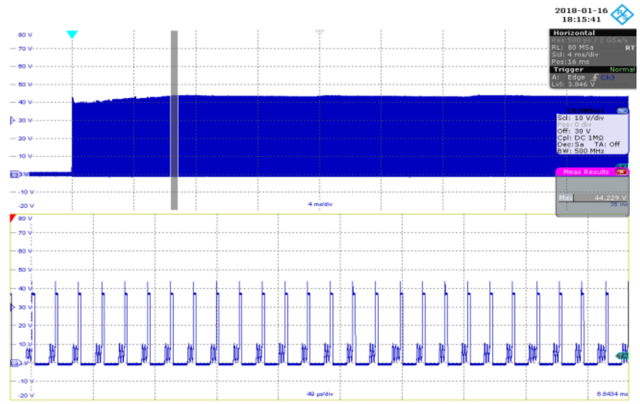

Figure 46 – 265 VAC, 50 Hz.
$V_{SYNCRECT}$, 10 V / div., 4 ms / div.
Zoom: 49 µs / div.
Measured V_{PK} = 44 V_{PK}.

11.8 *Synchronous Rectifier Voltage, Transition from 5 V to 9 V, Full Load*

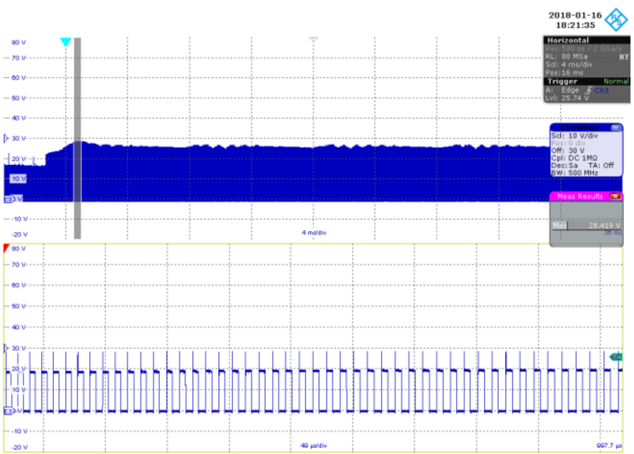

Figure 47 – 90 VAC, 60 Hz.
$V_{SYNCRECT}$, 10 V / div., 4 ms / div.
Zoom: 49 µs / div.
Measured V_{PK} = 28 V_{PK}.

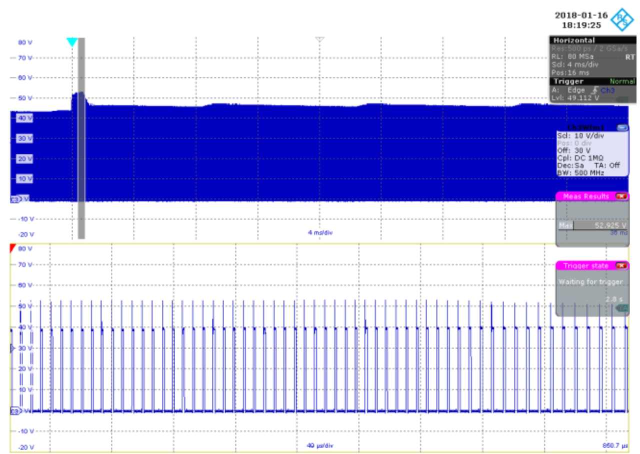

Figure 48 – 265 VAC, 50 Hz.
$V_{SYNCRECT}$, 10 V / div., 4 ms / div.
Zoom: 49 µs / div.
Measured V_{PK} = 52 V_{PK}.

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

11.9.1 Full Load (2 A)

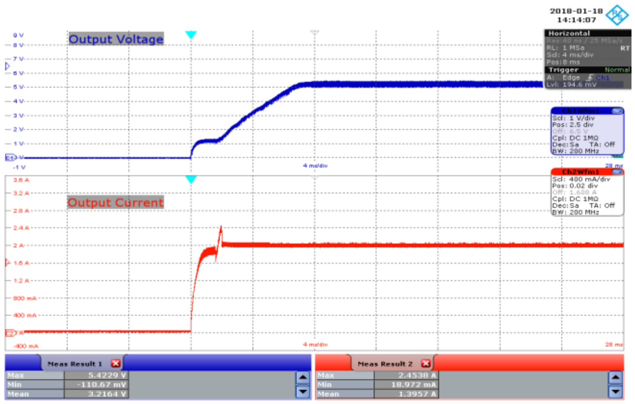

Figure 49 – 90 VAC, 60 Hz.
Upper: V_{OUT}, 1 V / div., 4 ms / div.
Lower: I_{OUT}, 400 mA / div., 4 ms / div.
Measured V_{PK} = 5.42 V_{PK}.
Measured I_{PK} = 2.45 A_{PK}.

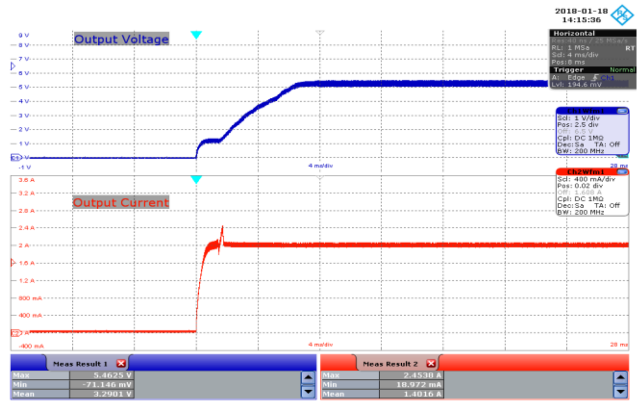

Figure 50 – 265 VAC, 50 Hz.
Upper: V_{OUT}, 1 V / div., 4 ms / div.
Lower: I_{OUT}, 400 mA / div., 4 ms / div.
Measured V_{PK} = 5.46 V_{PK}.
Measured I_{PK} = 2.45 A_{PK}.

11.9.2 No-Load

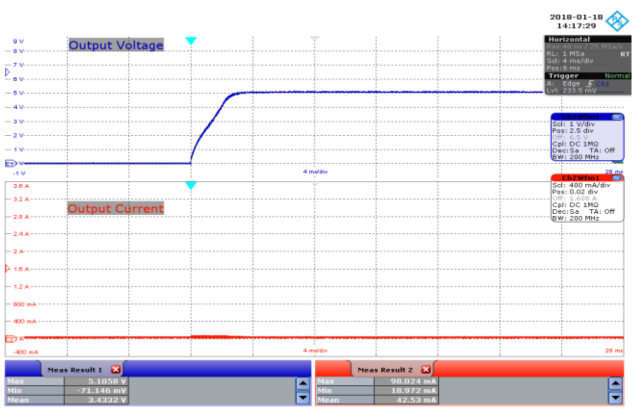

Figure 51 – 90 VAC, 60 Hz.
Upper: V_{OUT}, 1 V / div., 4 ms / div.
Lower: I_{OUT}, 400 mA / div., 4 ms / div.
Measured V_{PK} = 5.18 V_{PK}.
Measured I_{PK} = 0.98 A_{PK}.

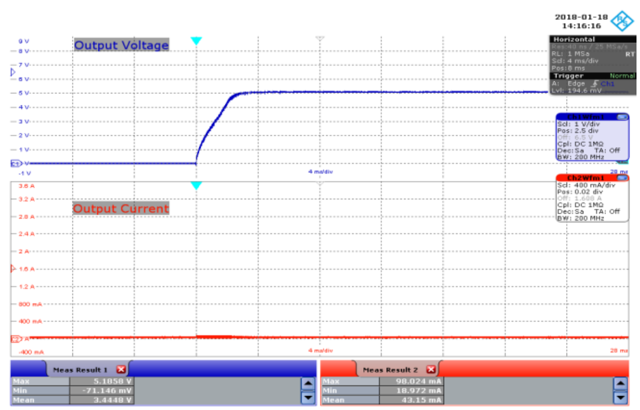

Figure 52 – 265 VAC, 50 Hz.
Upper: V_{OUT}, 1 V / div., 4 ms / div.
Lower: I_{OUT}, 400 mA / div., 4 ms / div.
Measured V_{PK} = 5.18 V_{PK}.
Measured I_{PK} = 0.98 A_{PK}.

11.10 *Output Voltage Change [5 V→ 9 V→ 5 V]*

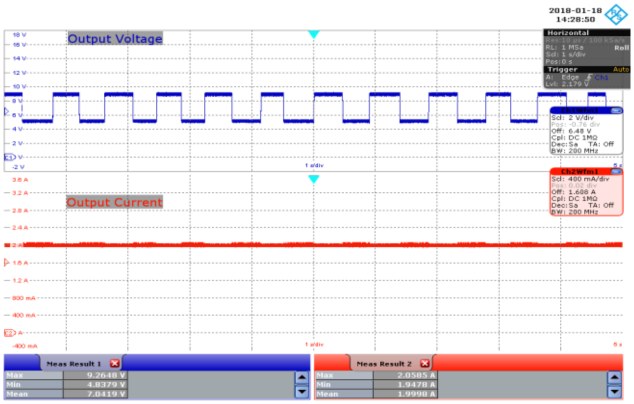

Figure 53 – 90 VAC, 60 Hz.
Upper: V_{OUT}, 2 V / div., 1 s / div.
Lower: I_{OUT}, 400 mA / div., 1 s / div.

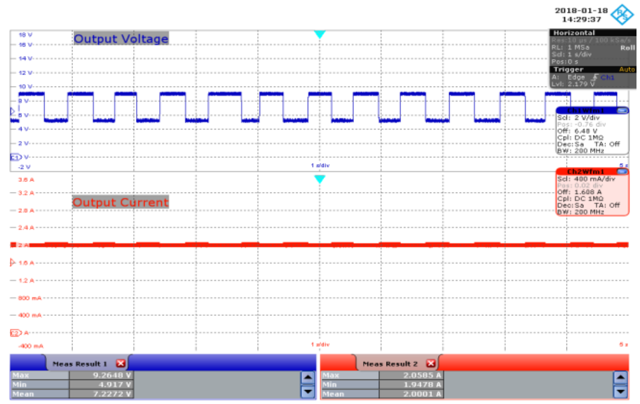

Figure 54 – 265 VAC, 50 Hz.
Upper: V_{OUT}, 2 V / div., 1 s / div.
Lower: I_{OUT}, 400 mA / div., 1 s / div.

11.11 *Output Load Transient, 5 V, Full Load*

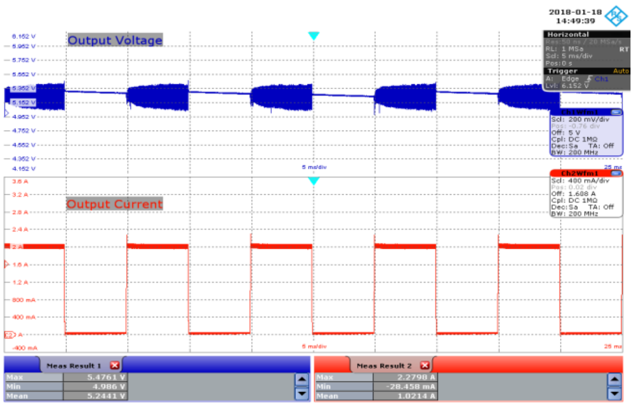

Figure 55 – 90 VAC, 60 Hz.
Upper: V_{OUT}, 200 mV / div., 5 ms / div.
Lower: I_{OUT}, 400 mA / div., 5 ms / div.
Measured Max Peak Voltage = 5.47 V_{PK}.
Measured Min Undershoot = 4.98 V_{PK}.

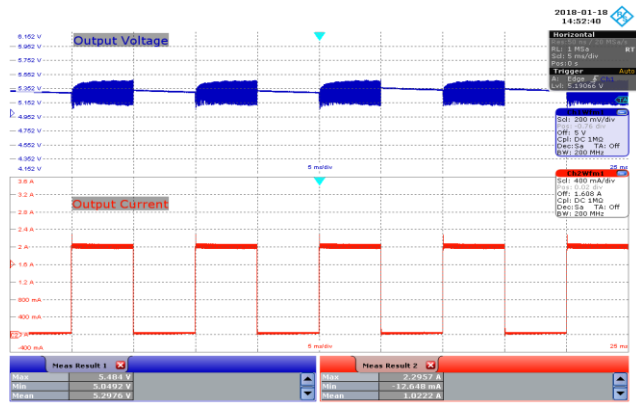

Figure 56 – 265 VAC, 50 Hz.
Upper: V_{OUT}, 200 mV / div., 5 ms / div.
Lower: I_{OUT}, 400 mA / div., 5 ms / div.
Measured Max Peak Voltage = 5.48 V_{PK}.
Measured Min Undershoot = 5.04 V_{PK}.

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

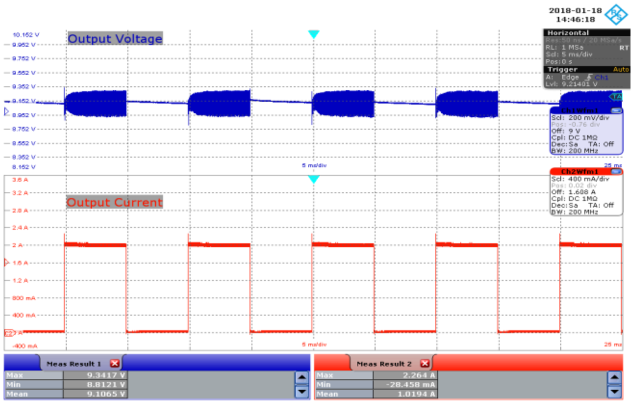


Figure 57 – 90 VAC, 60 Hz.
Upper: V_{OUT}, 200 mV / div., 5 ms / div.
Lower: I_{OUT}, 400 mA / div., 5 ms / div.
Measured Max Peak Voltage = 9.34 $V_{PK.}$
Measured Min Undershoot = 8.81 $V_{PK.}$

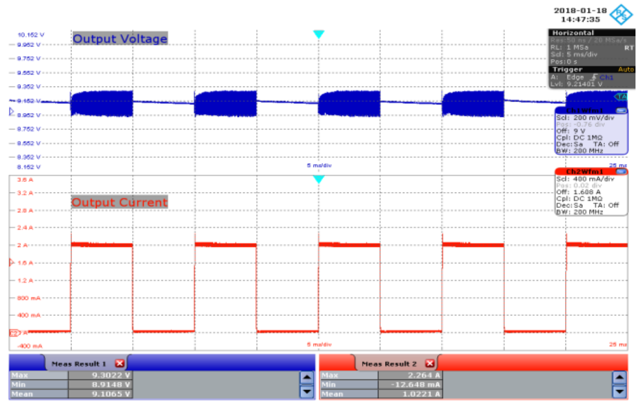
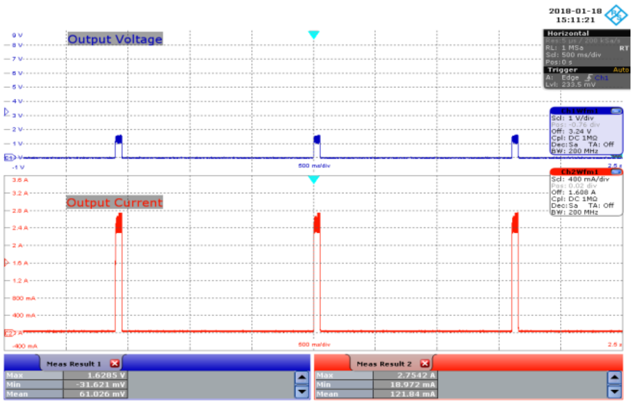


Figure 58 – 265 VAC, 50 Hz.
Upper: V_{OUT}, 200 mV / div., 5 ms / div.
Lower: I_{OUT}, 400 mA / div., 5 ms / div.
Measured Max Peak Voltage = 9.30 $V_{PK.}$
Measured Min Undershoot = 8.91 $V_{PK.}$

11.13 *Output Voltage and Current Waveforms with Shorted Output*



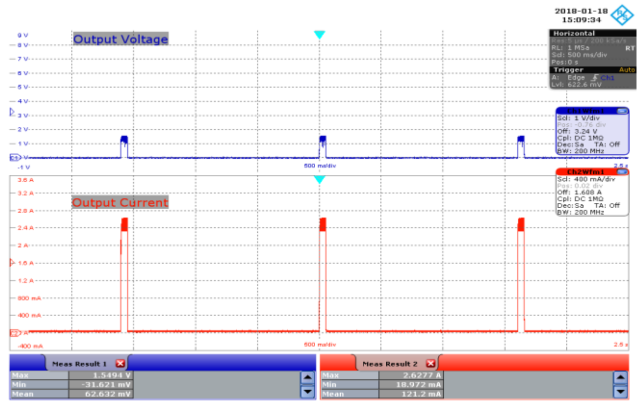
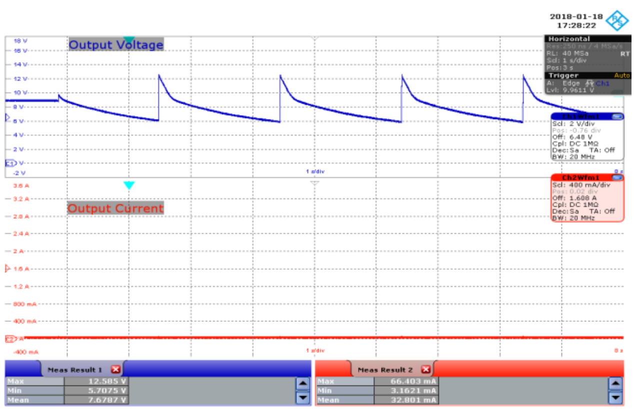


Figure 59 – 90 VAC, 60 Hz.
Upper: V_{OUT}, 1 V / div., 500 ms / div.
Lower: I_{OUT}, 400 mA / div., 500 ms / div.
Max Peak Voltage = 1.62 $V_{PK.}$
Max Peak Current = 2.75 $A_{PK.}$

Figure 60 – 265 VAC, 50 Hz.
Upper: V_{OUT}, 1 V / div., 500 ms / div.
Lower: I_{OUT}, 400 mA / div., 500 ms / div.
Max Peak Voltage = 1.54 $V_{PK.}$
Max Peak Current = 2.62 $A_{PK.}$

11.14 *Output Voltage and Current Waveforms with Open Feedback*

11.14.1 No-Load



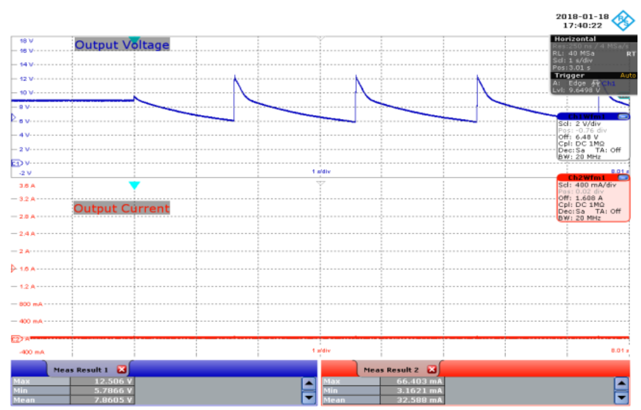


Figure 61 – 90 VAC, 60 Hz.
Upper: V_{OUT}, 2 V / div., 1 s / div.
Lower: I_{OUT}, 400 mA / div., 1 s / div.
Max Peak Voltage = 12.58 $V_{PK.}$

Figure 62 – 265 VAC, 50 Hz.
Upper: V_{OUT}, 2 V / div., 1 s / div.
Lower: I_{OUT}, 400 mA / div., 1 s / div.
Max Peak Voltage = 12.50 $V_{PK.}$

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11.14.2 Full Load

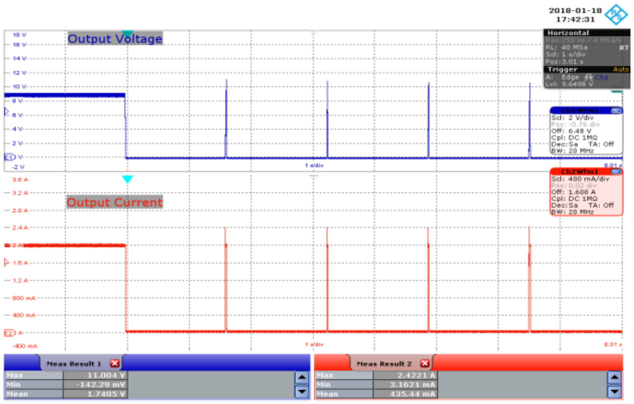

Figure 63 – 90 VAC, 60 Hz.
Upper: V_{OUT}, 2 V / div., 1 s / div.
Lower: I_{OUT}, 400 mA / div., 1 s / div.
Max Peak Voltage = 11.00 $V_{PK.}$

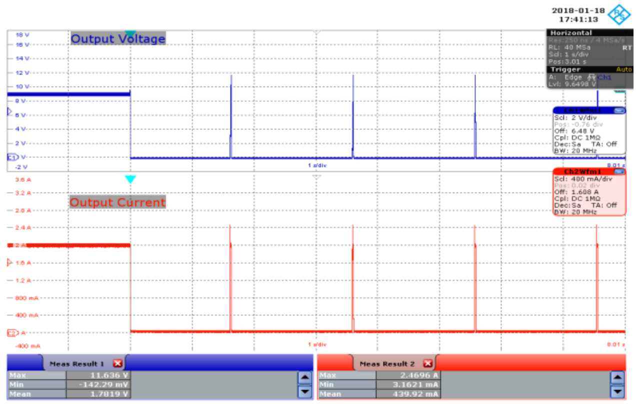

Figure 64 – 265 VAC, 50 Hz.
Upper: V_{OUT}, 2 V / div., 1 s / div.
Lower: I_{OUT}, 400 mA / div., 1 s / div.
Max Peak Voltage = 11.63 $V_{PK.}$

12 EMI Results

12.1 *Test Set-up*

12.2 *Equipment and Load Used*

1. Rohde and Schwarz ENV216 two line V-network.
2. Rohde and Schwarz ESRP EMI test receiver.
3. Hioki 3322 power hitester.
4. Chroma measurement test fixture.
5. Full load with input voltage set at 230 VAC 50 Hz and 110 VAC.

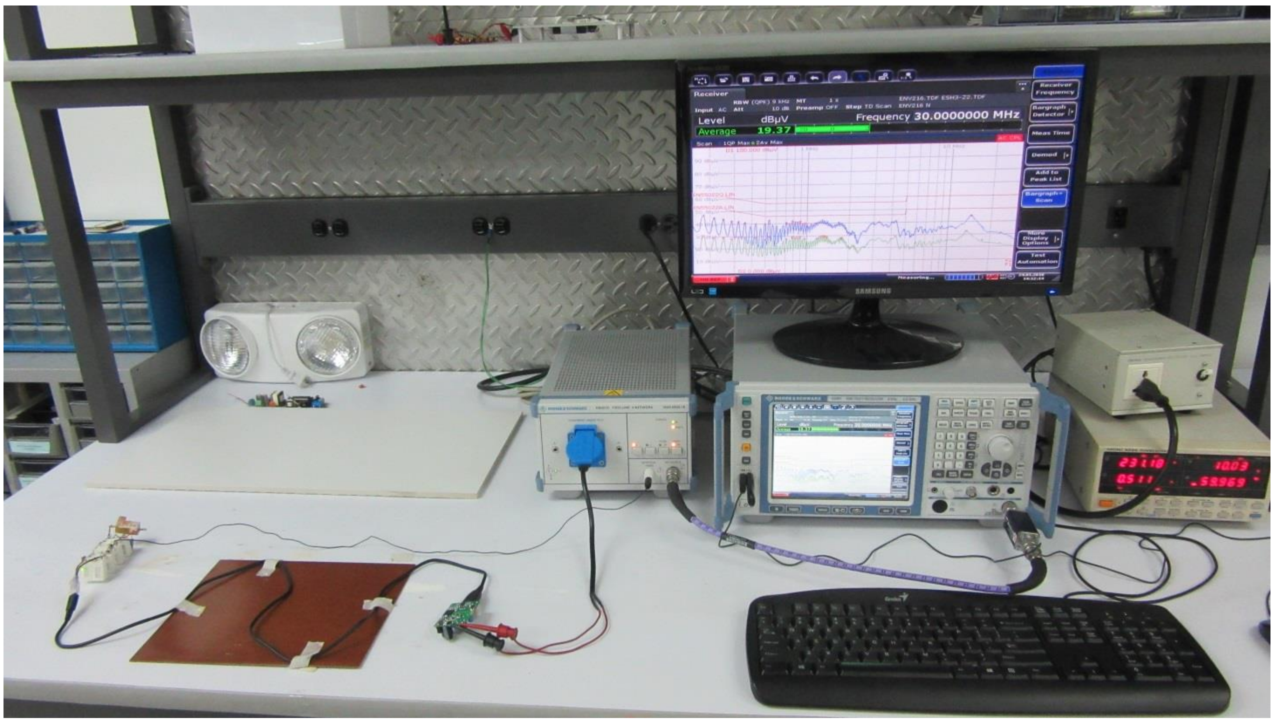

Figure 65 – Conducted EMI Test Set-up.

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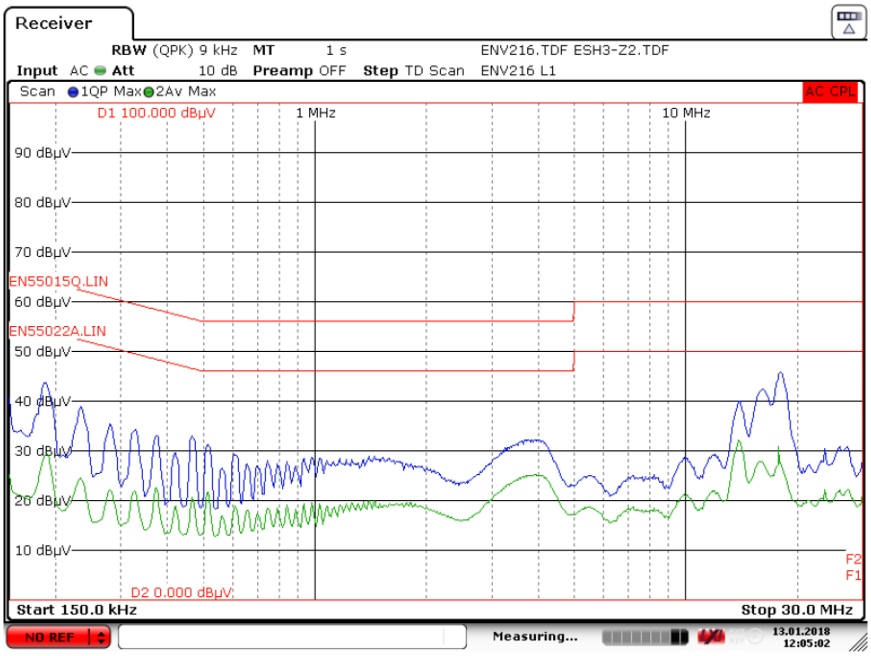
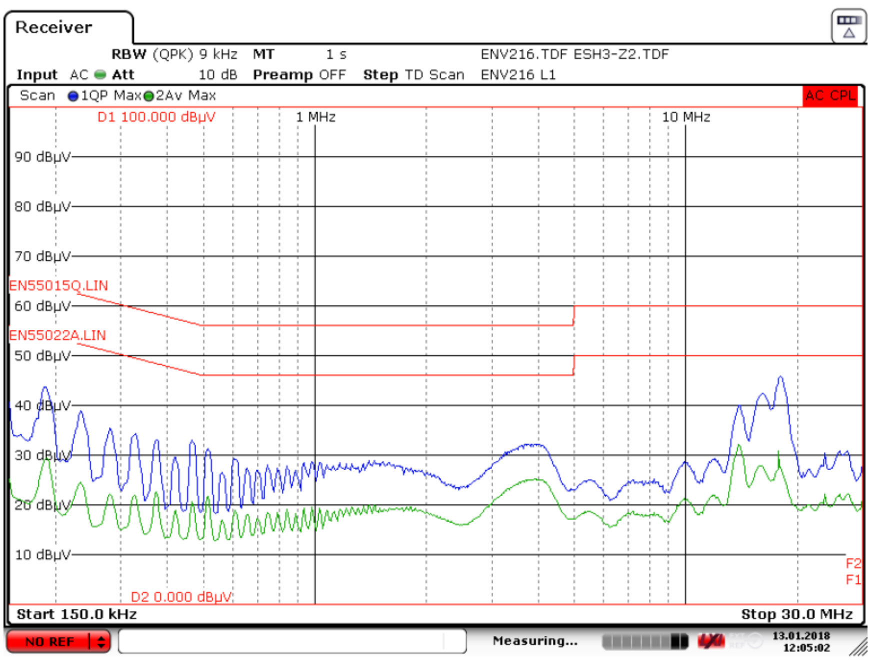
12.3 ***110 VAC, 5 V, Floating Output***

12.3.1 Line



Date: 13.JAN.2018 12:05:02

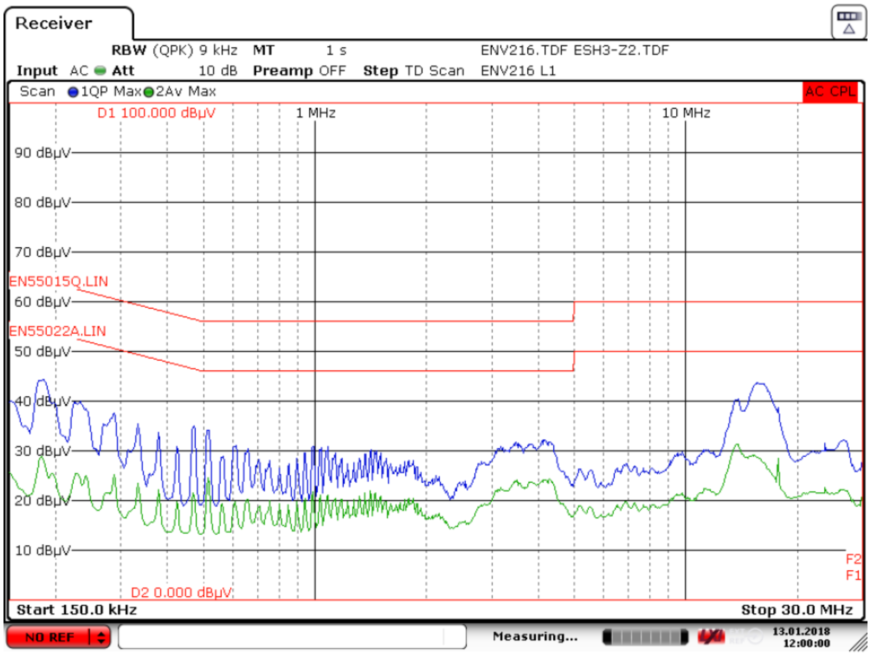
12.3.2 Neutral



Date: 13.JAN.2018 12:05:02

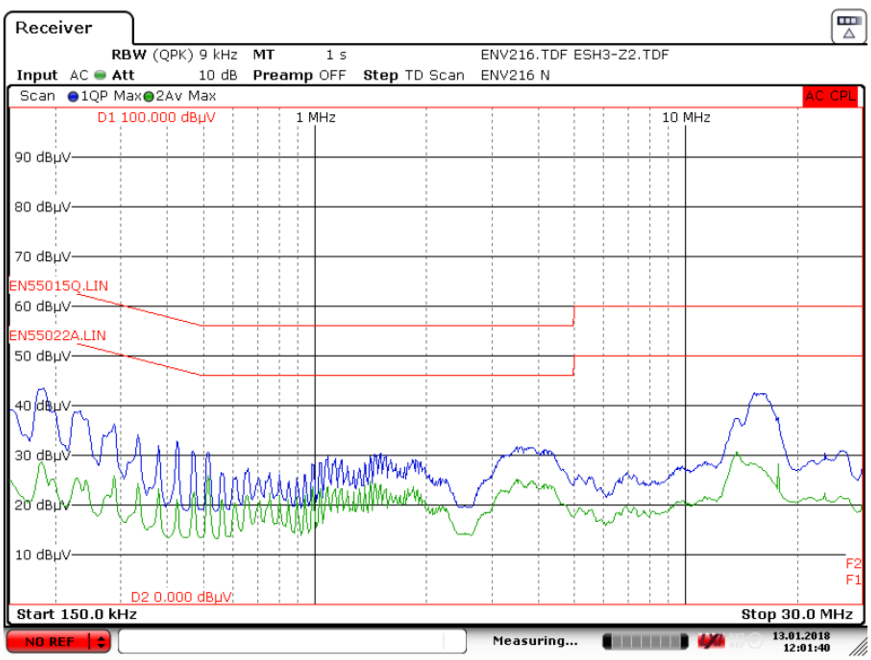
12.4 ***230 VAC, 5 V, Floating Output***

12.4.1 Line



Date: 13.JAN.2018 12:00:00

12.4.2 Neutral



Date: 13.JAN.2018 12:01:40

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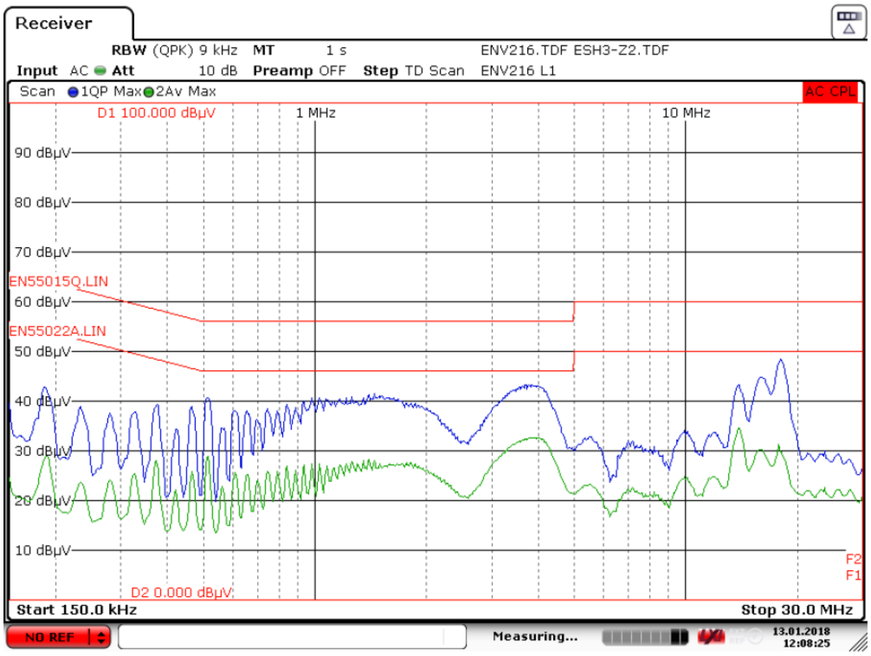
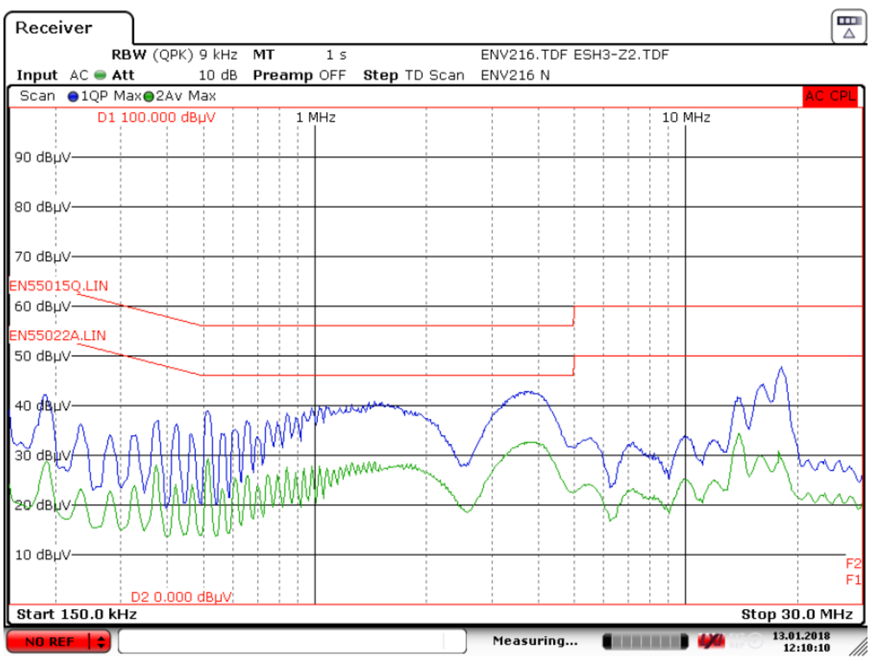
12.5 ***110 VAC, 5 V, Artificial Hand***

12.5.1 Line



Date: 13.JAN.2018 12:08:25

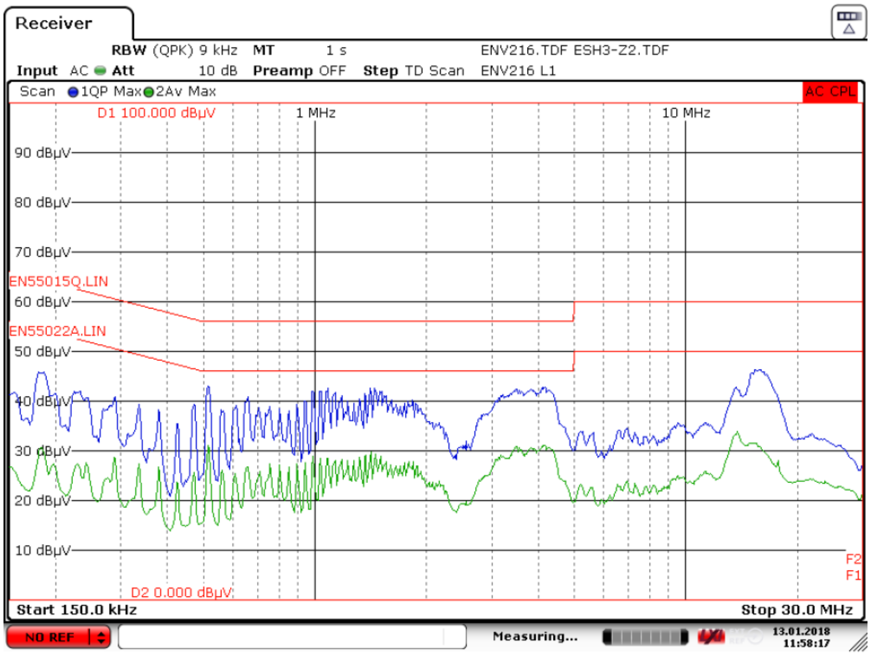
12.5.2 Neutral



Date: 13.JAN.2018 12:10:10

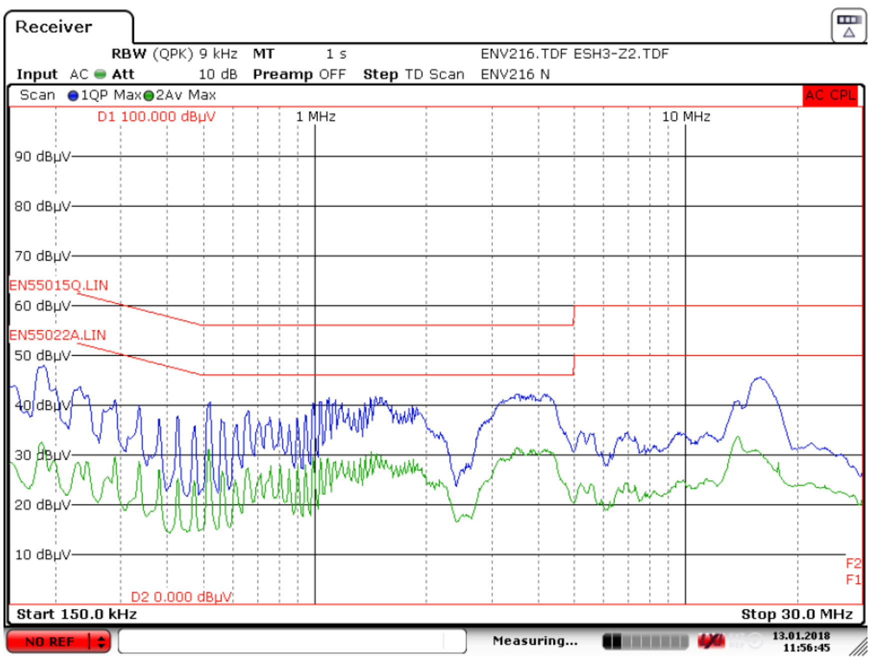
12.6 *230 VAC, 5 V, Artificial Hand*

12.6.1 Line



Date: 13.JAN.2018 11:58:17

12.6.2 Neutral



Date: 13.JAN.2018 11:56:45

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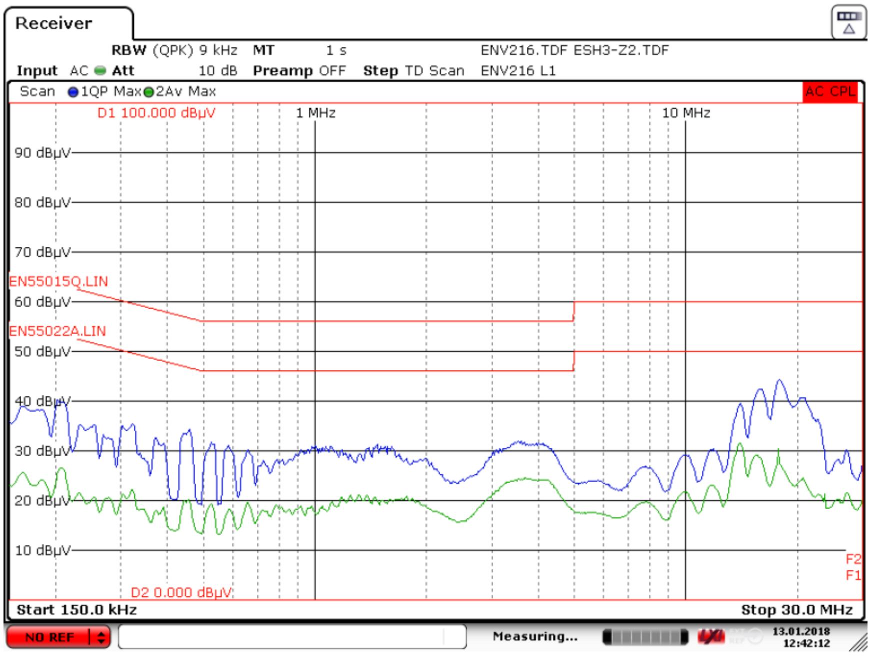
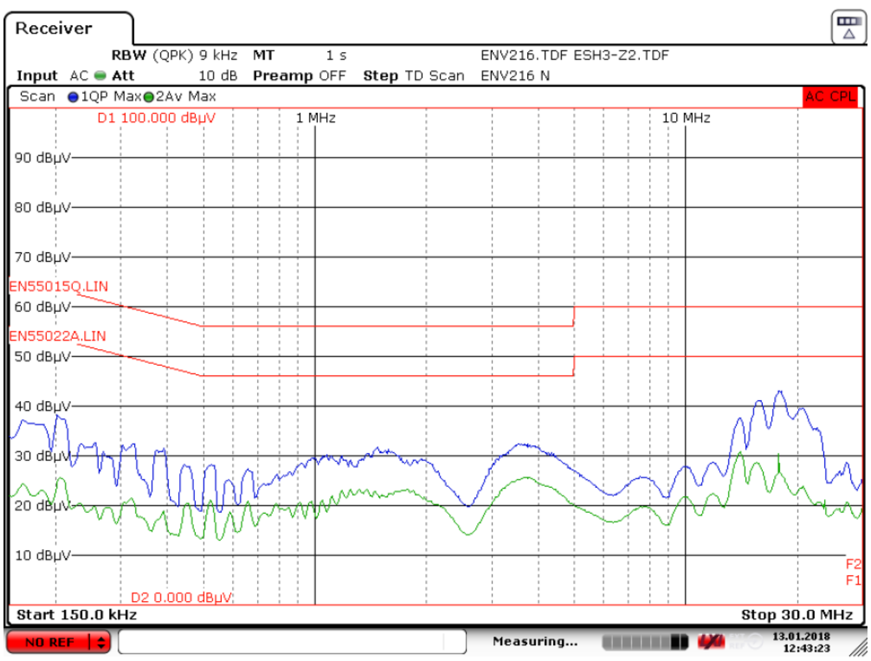
12.7 *110 VAC, 9 V, Floating Output*

12.7.1 Line



Date: 13.JAN.2018 12:42:12

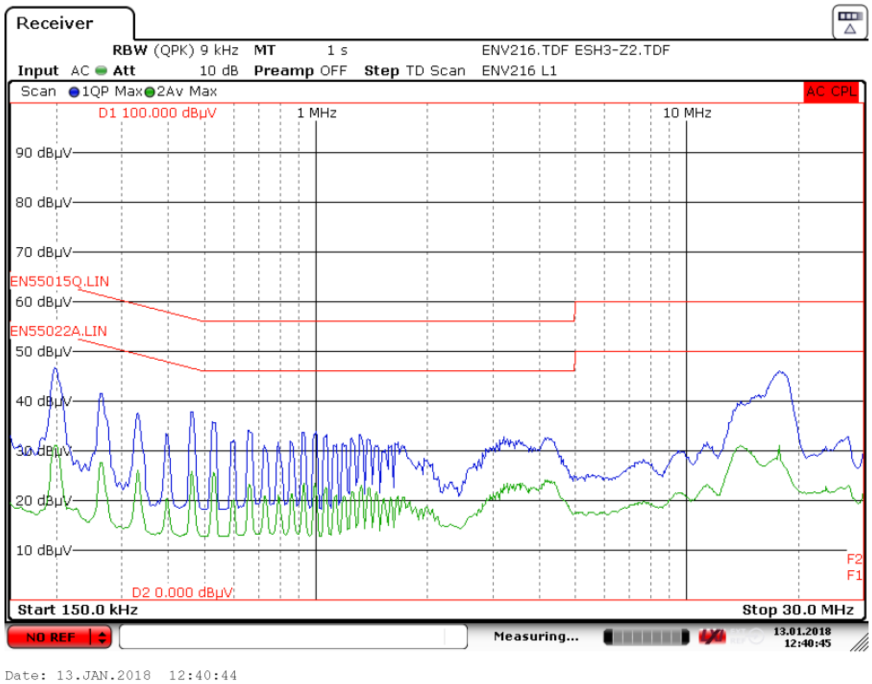
12.7.2 Neutral



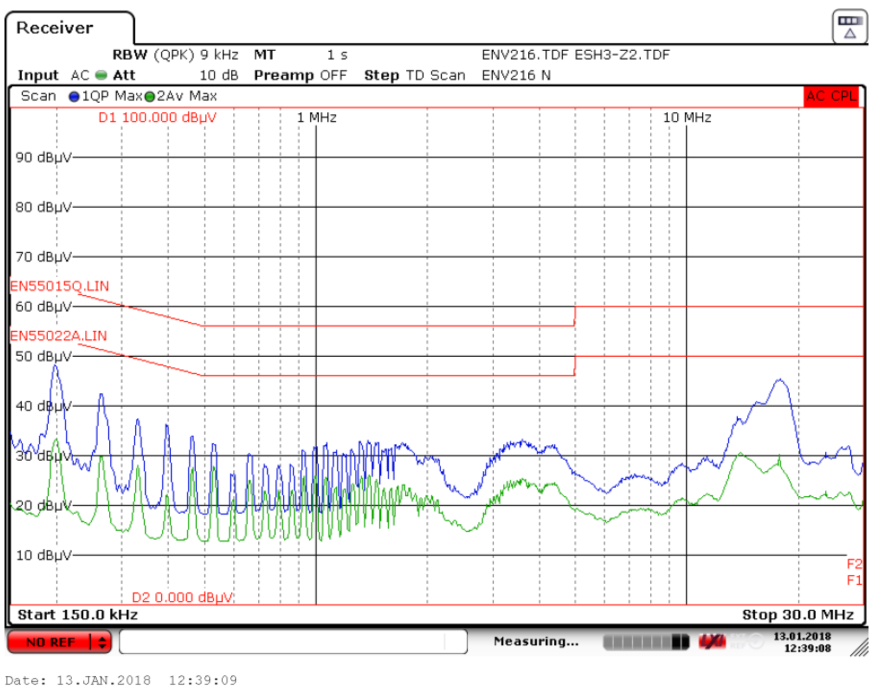
Date: 13.JAN.2018 12:43:24

12.8 ***230 VAC, 9 V, Floating Output***

12.8.1 Line



12.8.2 Neutral



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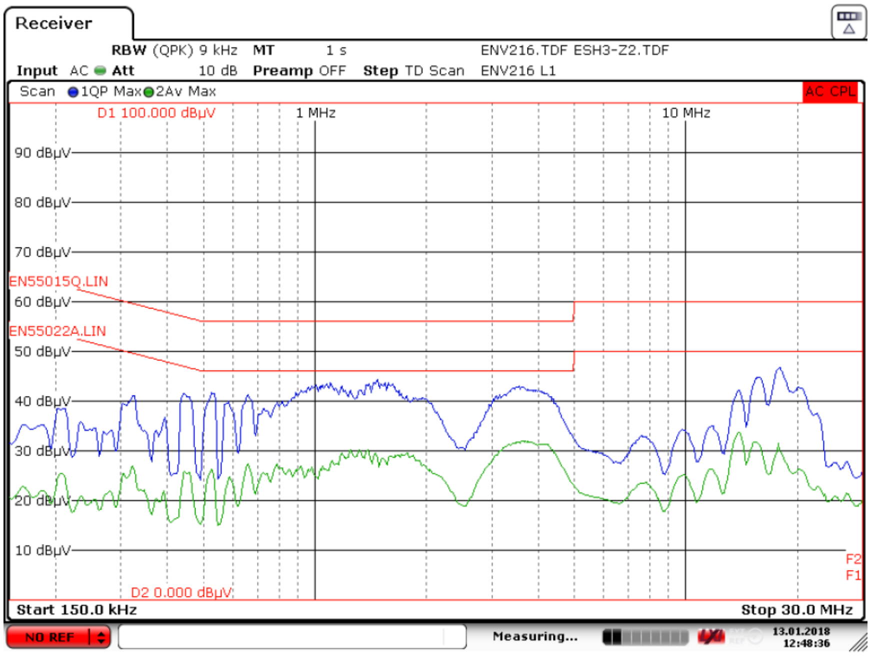
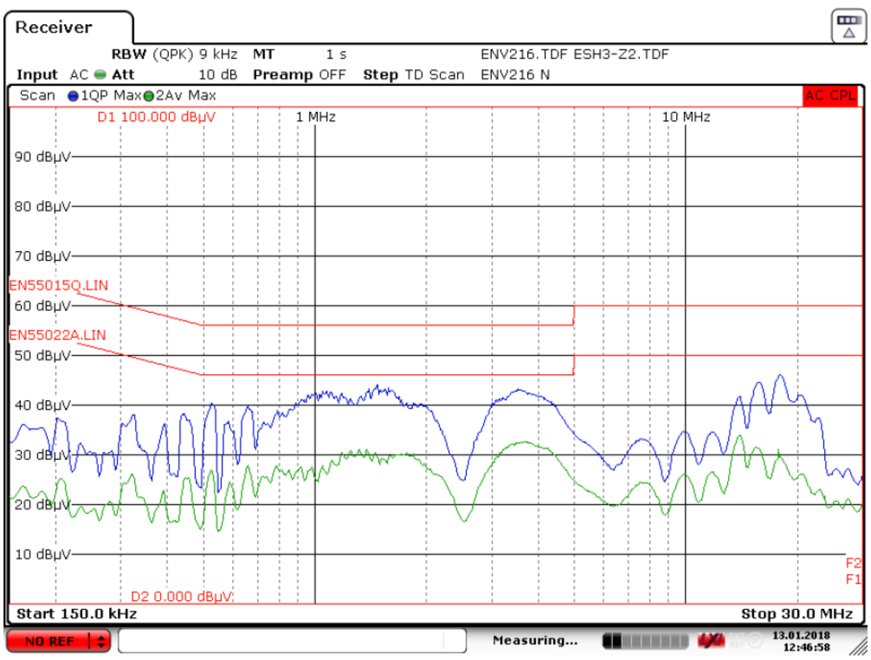
12.9 ***110 VAC, 9 V, Artificial Hand***

12.9.1 Line



Date: 13.JAN.2018 12:48:37

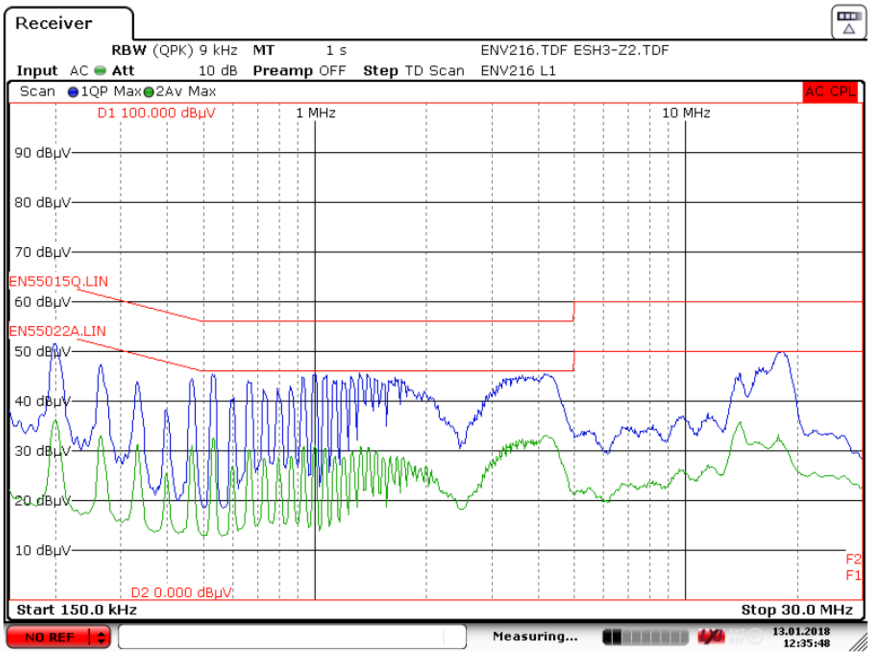
12.9.2 Neutral



Date: 13.JAN.2018 12:46:58

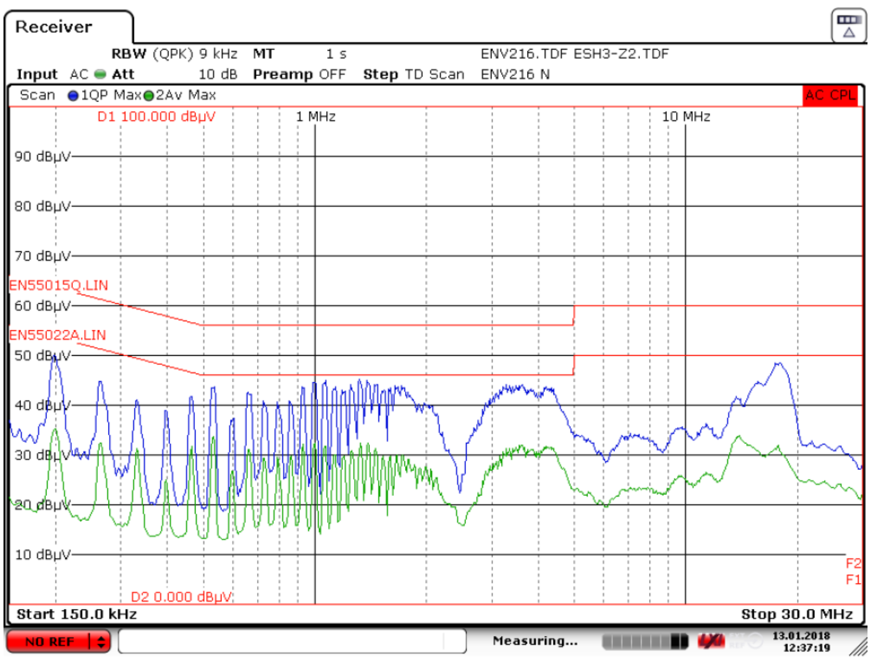
12.10 ***230 VAC, 9 V, Artificial Hand***

12.10.1 Line



Date: 13.JAN.2018 12:35:48

12.10.2 Neutral



Date: 13.JAN.2018 12:37:19

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13 Surge

13.1 *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

13.2 *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

14 ESD Test (Contact and Air Discharge)

Passed ±8 KV contact discharge.

Contact Voltage (kV)	Applied to	Number of Strikes	Test Result
8	Positive	10	Pass (No Damage, No Auto-Restart)
-8	Negative	10	Pass (No Damage, No Auto-Restart)

Passed ±16 KV Air discharge.

Differential Voltage (kV)	Applied to	Number of Strikes	Test Result
16	Positive	10	Pass (No Damage, Auto-Restart)
-16	Negative	10	Pass (No Damage, Auto-Restart)

15 Revision History

Date	Author	Revision	Description and Changes	Reviewed
27-Mar-18	JRV	1.0	Initial Release.	Apps & Mktg
11-Jul-19	KM	1.1	Updated Schematic.	Apps & Mktg

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