Design Example Report

Title	***30 W Isolated Flyback Power Supply Using InnoSwitch™ 3-CP INN3267C-H205***
Specification	90 VAC – 265 VAC Input; 18 V, 1.67 A Output
Application	Smart Speaker
Author	Applications Engineering Department
Document Number	DER-849
Date	January 6, 2020
Revision	1.0

Summary and Features

- 30 W constant power output at 18 V to 12 V
- >90% average efficiency at nominal AC input
- <40 mW no-load input power
- Integrate protection and reliability features
    - Output short-circuit
    - Line and output OVP
    - Over temperature shutdown
- Synchronous rectification for higher efficiency
- Input voltage monitor with accurate brown-in/brown-out protection
- Meets EN550022 and CISPR-22 Class B conducted EMI
- Meets IEC 2.0 kV common mode surge, 1.0 kV differential surge
- Meets IEC 4.0 kV common mode EFT, 3.0 kV common mode ring wave
- ±24 kV ESD Class B

Power Integrations
5245 Hellyer Avenue, San Jose, CA 95138 USA.
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

Table of Contents

1 Introduction 4
2 Power Supply Specification 5
3 Schematic 6
4 Circuit Description 7
4.1 Input Rectifier and Filter 7
4.2 InnoSwitch3-CP Primary-Side 7
4.3 InnoSwitch3-CP Secondary-Side 7
5 PCB Layout 9
6 Bill of Materials 10
7 Transformer Specification 12
7.1 Electrical Diagram 12
7.2 Electrical Specifications 12
7.3 Material List 12
7.4 Transformer Build Diagram 13
7.5 Transformer Instructions 13
7.6 Transformer Winding Illustrations 14
9 Transformer Design Spreadsheet 19
10 Performance Data 22
10.1 Efficiency 22
10.1.1 Active Mode Measurement Data 22
10.1.2 Full Load Efficiency vs. Line 23
10.1.3 Efficiency vs. Load 24
10.2 Available Standby Output Power 25
10.3 No-Load Input Power 27
10.4 Line Regulation 28
10.5 Load Regulation 29
10.6 CV-CC-CP Output Characteristic Curve 30
11 Waveforms 31
11.1 Load Transient Response 31
11.1.1 0% - 100% Load Change 31
11.1.2 50% - 100% Load Change 32
11.2 Output Voltage at Start-up 33
11.2.1 CC Mode 33
11.2.2 CR Mode 35
11.3 Switching Waveforms 37
11.3.1 Primary MOSFET Drain-Source Voltage and Current at Normal Operation 37
11.3.2 Primary MOSFET Drain-Source Voltage and Current at Start-up Operation 39
11.3.3 SR FET Voltage and Current at Normal Operation 41
11.3.4 SR FET Voltage and Current at Start-up Operation 43
11.4 Brown-In and Brown-Out 45
11.5 Fault Conditions 46
11.5.1 Output Overvoltage 46
11.5.2 Output Short-Circuit 47

11.6 Output Voltage Ripple 48
11.6.1 Ripple Measurement Technique 48
11.6.2 Measurement Results 49
11.6.3 Output Ripple Voltage Graph from 0% - 100% 54
12 Thermal Performance 55
12.1 Test Set-Up 55
12.2 Thermal Performance at Room Temperature 56
12.2.1 90 VAC at Room Temperature 56
12.2.2 265 VAC at Room Temperature 57
12.3 Thermal Performance at 50 °C 58
12.3.1 90 VAC at 50 °C 58
12.3.2 265 VAC at 50 °C 59
12.4 Over Temperature Protection 60
12.4.1 OTP at 90 VAC 60
12.4.2 OTP at 265 VAC 61
13 Conducted EMI 62
13.1 Test Set-up Equipment 62
13.1.1 Equipment and Load Used 62
13.2 Test Set-up 62
13.3 Test Results 63
14 Line Surge 64
14.1 Differential and Common Mode Surge 64
14.2 Common Mode Ring Wave 65
14.3 Electrical Fast Transient (EFT) 65
15 ESD 66
16 Revision History 67

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.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

1 Introduction

This engineering report describes an isolated flyback converter designed to provide a nominal output voltage of 18 V at 1.67 A load from a wide input voltage range of 90 VAC to 265 VAC. This power supply utilizes the INN3267C-H205 from the InnoSwitch3-CP family of ICs.

This document contains the complete power supply specifications, bill of materials, transformer construction, circuit schematic and printed circuit board layout, along with performance data and electrical waveforms.

Figure 1 – Populated Circuit Board.

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	2 Wire – no P.E.
Frequency	f_{LINE}	47	50/60	64	Hz	
No-load Input Power (230 VAC)				0.040	W	
Output						
Output Voltage	V_{OUT}	17	18	19	V	± 5%
Output Ripple Voltage	V_{RIPPLE}			200	mV	20 MHz Bandwidth.
Output Current	I_{OUT}			1.67	A	
Total Output Power						
Continuous Output Power	P_{OUT}			30	W	
Efficiency						
Full Load	η	90			%	Measured at P_{OUT} 25 °C.
Required average efficiency at 25, 50, 75 and 100 % of P_{OUT}	η_{DOE}	83			%	Measured at Nominal Input 115 VAC and 230 VAC.
Environmental						
Conducted EMI		Meets CISPR22B / EN55022B				
Surge (Differential)				1	kV	1.2/50 μs Surge, IEC 61000-4-5, Series Impedance: Differential Mode: 2 Ω Common Mode: 12 Ω
Surge (Common mode)				2	kV	
Ring Wave				3	kV	
Electrical Fast Transient				4	kV	
ESD – Air Discharge				±24	kV	Class B up to 24 kV, Class A up to 18 kV.
ESD – Contact Discharge				±8		
Ambient Temperature	T_{AMB}	0		50	°C	Free Convection, Sea Level.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

3 Schematic

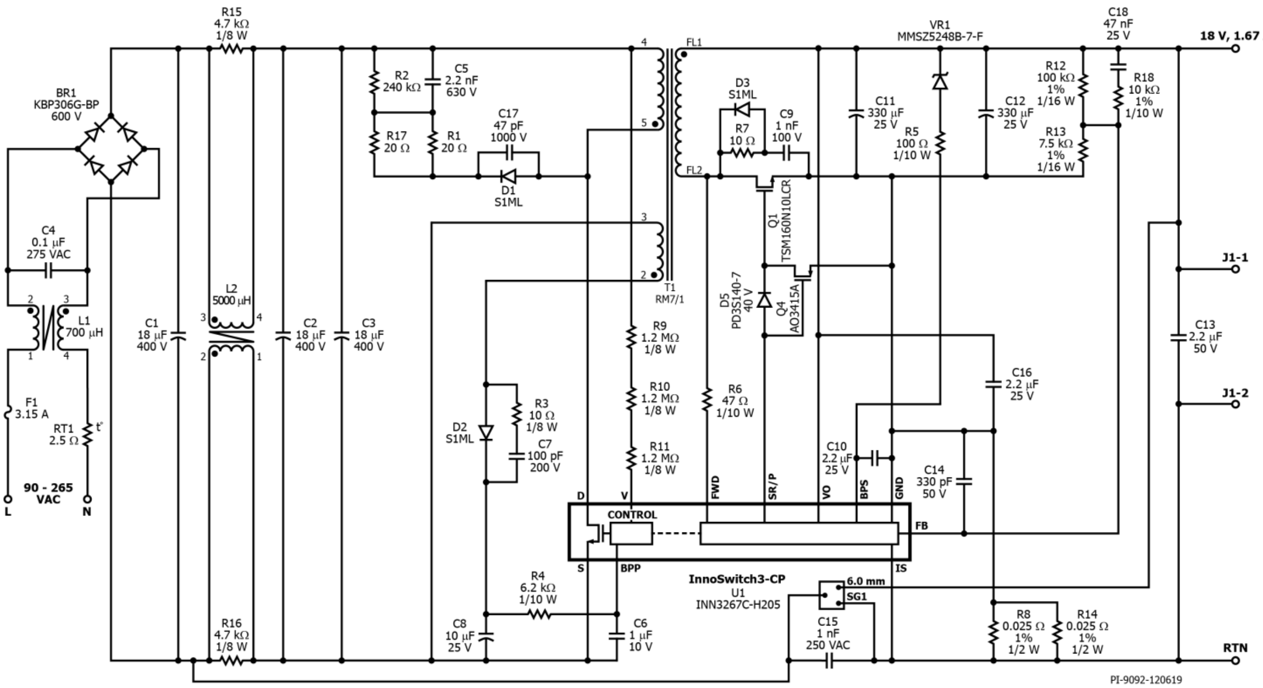


Figure 2 – Schematic.

4 Circuit Description

The InnoSwitch3-CP IC combines primary, secondary and feedback circuits in a single surface mounted off-line flyback switcher IC. The IC incorporates the primary MOSFET, the primary-side controller, the secondary-side controller for synchronous rectification and the Fluxlink™ technology that eliminates the need for an optocoupler needed on a secondary sensed feedback system.

4.1 *Input Rectifier and Filter*

Fuse F1 isolates the circuit and provides protection from component failure. X capacitor C4 and common mode choke L1 form a filter to attenuate common mode noise. Bridge rectifier BR1 converts the AC line voltage into the DC voltage seen across capacitors C1 to C3. A pi-filter is formed from common mode choke L2 and bulk capacitors C1 to C3, providing filtering for both common mode and differential mode noise.

4.2 *InnoSwitch3-CP Primary-Side*

The power transformer T1 is designed for a flyback topology power supply. The start winding of the transformer is connected to the DRAIN pin of the MOSFET inside the INN3267, while the end of the winding is connected to the rectified DC bus. A low cost RCD clamp (consisting of diode D1, resistors R1 R2 R17, and capacitors C5 C17) limit the primary drain to source voltage spike caused by the transformer leakage inductance. The RCD clamp values should be tuned to achieve optimized efficiency and standby power.

The INN3267 V pin is used for line UV/OV sensing and protection. Three 1.2 MΩ resistors R9 R10 R11 are connected between the bulk capacitors DC bus and the V pin. The current passing through these sense resistors provide detection of input undervoltage and overvoltage. The I_{UV+} and I_{UV-} parameter values in the data sheet determine the brown-in and brown-out threshold while the I_{OV-} determines the overvoltage threshold.

At start-up, U1 initially draws current from the DRAIN pin, through an internal high-voltage current source that charges the BPP pin capacitor C6. During normal operation, U1 draws current from the bias winding of T1. The bias winding is configured as a low voltage flyback winding which is rectified by diode D2 and capacitor C8, with an RC snubber R3 C7 that damps the high frequency ringing across D2 that can contribute to radiated EMI. Resistor R4 limits the current supplied to the BPP pin.

4.3 *InnoSwitch3-CP Secondary-Side*

The secondary-side of the INN3267 provides output voltage sensing, output current sensing, and internal gate driver for a synchronous rectifier (SR) MOSFET. The secondary-side is powered by an internal 4.4 V regulated which draws current from either VOUT or FWD pin. Its output is connected to an external decoupling capacitor C10, also referred to as BPS capacitor.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

The FWD pin provides negative edge detection by sensing the transformer's secondary pin through resistor R6. A 47 Ω resistor is the recommended value to ensure sufficient supply current. The voltage sensed by the FWD pin is used for both the primary-secondary handshake at start-up, and for timing the turn-on instant of the SR FET Q1. The voltage sensed by the FWD pin is used to ensure quasi-resonant operation when operating between continuous conduction mode (CCM) and discontinuous conduction mode (DCM).

The SR FET Q1 is driven by U1 SR pin, through Schottky diode D5. Diode D5 and p-channel MOSFET Q4 form a fast turn-off circuit. Secondary RCD snubber (consisting of R7 C9 D3) limit the drain to source voltage spike across the SR FET.

The feedback network comprised of resistors R12 R13 R18 and capacitors C18 C14 is connected between the output voltage and secondary ground. The sensed voltage between R12 and R13 is connected to the FB pin. External current sense resistors R8 and R14 are connected between ISENSE pin and SECONDARY GROUND pin. These resistors determine the constant current mode operation.

Output capacitors C11 and C12 are selected to be low ESR type to provide output filtering and to ensure low output voltage ripple. An external OVP circuit (consisting of resistor R5 and Zener diode VR1) is connected between the OUTPUT VOLTAGE pin and BP pin. In the event of an output overvoltage, VR1 will conduct and current will be injected into the BPS pin causing the device to enter latch mode operation.

5 PCB Layout

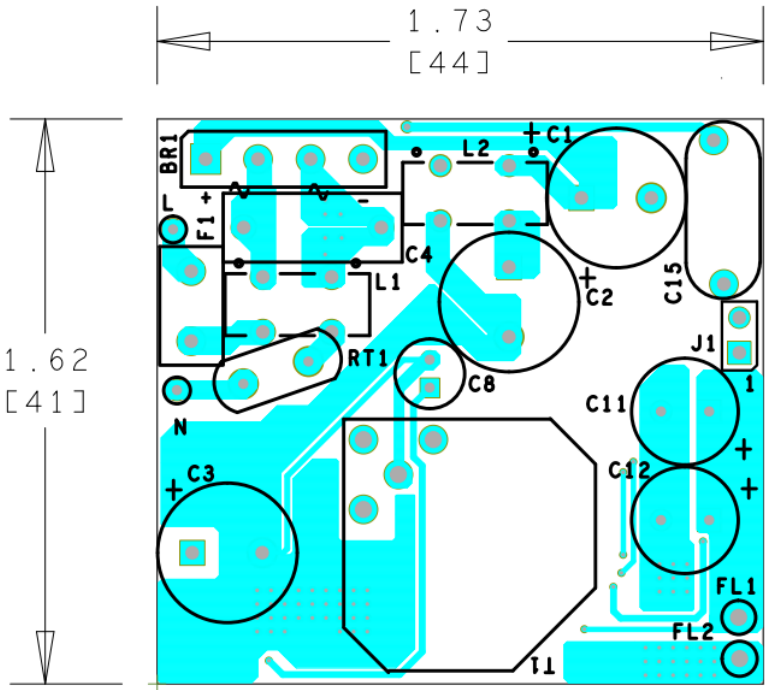


Figure 3 – Populated Circuit Board, Top View.

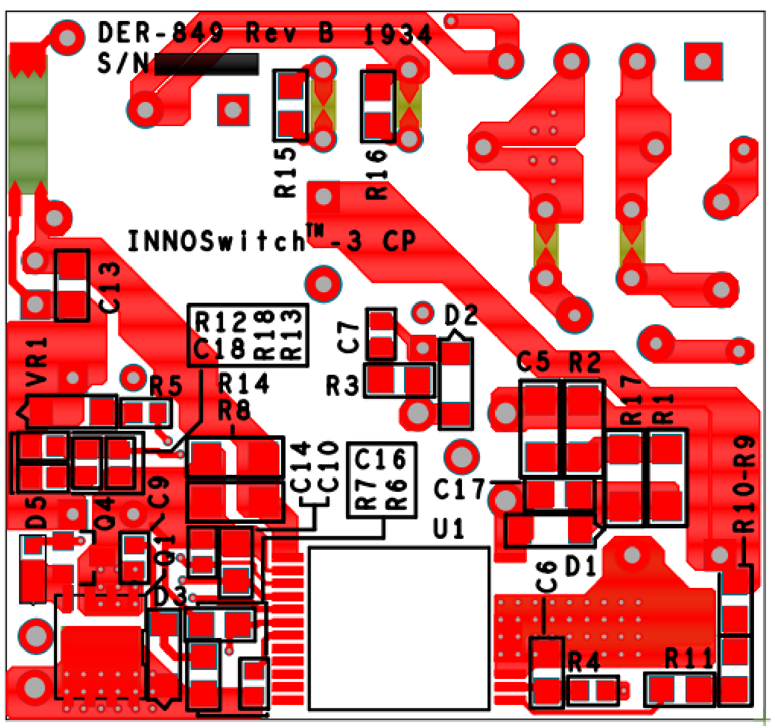


Figure 4 – Populated Circuit Board, Bottom View.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

6 Bill of Materials

Item	Qty	Ref Des	Description	Mfg Part Number	Mfg
1	1	BR1	600 V, 3 A, Bridge Rectifier, GBP	KBP306G-BP	Micro Commercial
2	3	C1 C2 C3	18 µF, 20%, 400 V, Electrolytic, Gen. Purpose, (10 x 16 mm), 2000 Hrs @ 105 °C	400AX18MEFC10X16	Rubycon
3	1	C4	0.1 µF, 20% , 275 VAC, 560 VDC, X2, -40°C ~ 110°C, 5 mm W x 13 mm L x 11.1 mm H	R46KF310000P1M	KEMET
4	1	C5	2.2 nF, 630 V, Ceramic, X7R, 1206	C3216X7R2J222K	TDK
5	1	C6	1 µF, 10 V, Ceramic, X7R, 0805	CL21B105KPFNNNE	Samsung
6	1	C7	100 pF 200 V, Ceramic, NP0, 0603	C0603C101J2GAC7867	Kemet
7	1	C8	10 µF, 25 V, Electrolytic, Gen. Purpose, (5 x 12)	ECA-1EM100	Panasonic
8	1	C9	1000 pF, 100 V, Ceramic, NP0, 0603	C1608C0G2A102J	TDK
9	2	C10 C16	2.2 µF, 25 V, Ceramic, X7R, 0805	C2012X7R1E225M	TDK
10	2	C11 C12	330 µF,±20%, 25 V, Al Organic Polymer, Gen. Purpose, Can, 18 mΩ, 2000 Hrs @ 105 °C, (8 mm x 13 mm)	A750KS337M1EAAE018	KEMET
11	1	C13	2.2 µF, ±10%, 50 V, Ceramic, X7R, 0805	UMK212BB7225KG-T	Taiyo Yuden
12	1	C14	330 pF, ±5%, 50V, Ceramic, C0G, NP0, 0603	C0603C331J5GACAUTO	KEMET
13	1	C15	1 nF, Ceramic, Y1	440LD10-R	Vishay
14	1	C17	47 pF, 1000 V, Ceramic, NP0, 0805	VJ0805A470JXGAT5Z	Vishay
15	1	C18	47 nF 25 V, Ceramic, X7R, 0603	CC0603KRX7R8BB473	Yago
16	3	D1 D2 D3	1 kV, 1 A, Standard Recovery, SMA	S1ML	TAIWAN SEMI
17	1	D5	40 V, 1 A, POWERDI123	PD3S140-7	Diodes, Inc.
18	1	F1	3.15 A, 250 V, Slow, RST	507-1181	Belfuse
19	1	L1	Custom, 700 µH, PI#32-00395-00		Power Integrations
20	1	L2	Custom, 5000 µH, PI#32-00396-00		Power Integrations
21	1	Q1	MOSFET, N-Channel, 100 V, 46 A (Tc), 83 W (Tc) , SMT, 8PDFN, 8-PDFN (5x6)	TSM160N10LCR RLG	Taiwan Semi
22	1	Q4	P-Channel 20 V 5 A (Ta) 1.5 W (Ta) Surface Mount SOT-23-3L , TO-236-3, SC-59, SOT-23-3	AO3415A	Alpha & Omega Semi
23	2	R1 R17	RES, 20 Ω, 5%, 1/4 W, Thick Film, 1206	ERJ-8GEYJ200V	Panasonic
24	1	R2	RES, 240 kΩ, 5%, 1/4 W, Thick Film, 1206	ERJ-8GEYJ244V	Panasonic
25	2	R3 R7	RES, 10 Ω, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ100V	Panasonic
26	1	R4	RES, 6.2 kΩ, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ622V	Panasonic
27	1	R5	RES, 100 Ω, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ101V	Panasonic
28	1	R6	RES, 47 Ω, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ470V	Panasonic
29	2	R8 R14	RES, 0.025 Ω, 1/2 W, 1%, Current Sense	CSR1206FK25L0	Stackpole
30	3	R9 R10 R11	RES, 1.2 MΩ, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ125V	Panasonic
31	1	R12	RES, 100 kΩ, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF1003V	Panasonic
32	1	R13	RES, 7.5 kΩ, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF7501V	Panasonic
33	2	R15 R16	RES, 4.7 kΩ, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ472V	Panasonic
34	1	R18	RES, SMD, 10.0 kΩ, 1%, 1/10W, ±100ppm/°C, -55°C ~ 155°C,0603, Moisture Resistant, Thick Film	RC0603FR-0710KL	Yageo
35	1	RT1	NTC Thermistor, 2.5 Ω, 3 A	SL08 2R503	Ametherm
36	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
37	1	U1	InnoSwitch3-CP Integrated Circuit, InSOP24D	INN3267C-H205	Power Integrations
38	1	VR1	DIODE ZENER 18 V 500 mW SOD123	MMSZ5248B-7-F	Diodes, Inc.

Miscellaneous

Item	Qty	Ref Des	Description	Mfg Part Number	Mfg
1	1	L	Test Point, WHT, Miniature THRU-HOLE MOUNT	5002	Keystone
2	1	N	Test Point, BLK, Miniature THRU-HOLE MOUNT	5001	Keystone
3	1	J1	2 Position (1 x 2) header, 0.1 pitch, Vertical	0022284020	Molex

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

7 Transformer Specification

7.1 *Electrical Diagram*

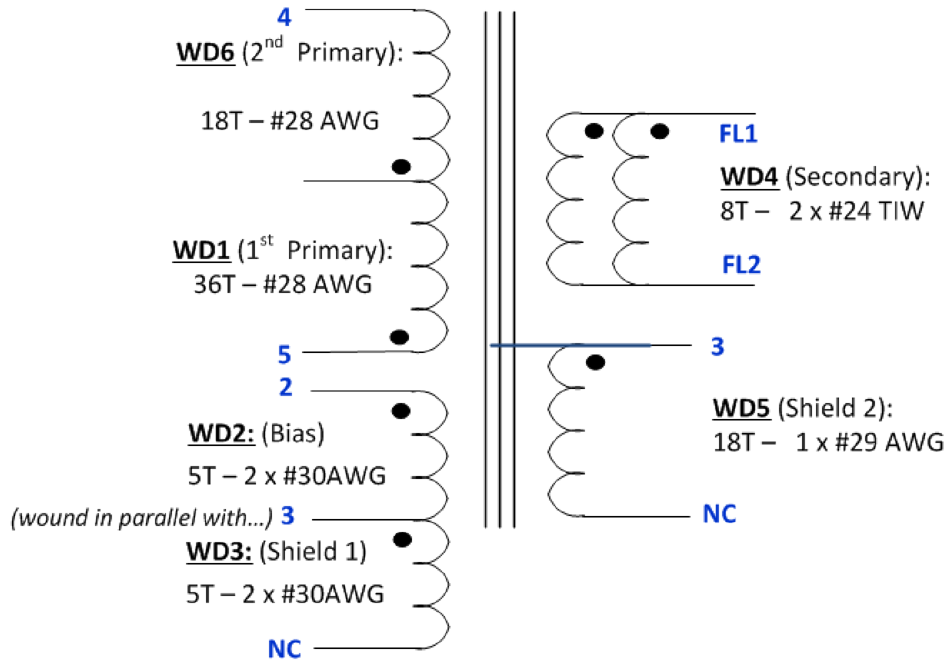


Figure 5 – Transformer Electrical Diagram.

7.2 *Electrical Specifications*

Parameter	Condition	Spec.
Nominal Primary Inductance	Measured at 1 V_{PK-PK}, 100 kHz switching frequency, between pin 4 and pin 5 with all other windings open.	520 μH
Tolerance	Tolerance of Primary Inductance.	±5%
Leakage Inductance	Measured across primary winding with all other windings shorted.	<10 μH

7.3 *Material List*

Item	Description
[1]	Core: RM7 3C95.
[2]	Bobbin: RM7/I, Vertical, 8 pins, PI#25-01014-00.
[3]	Magnet Wire: #30 AWG.
[4]	Magnet Wire: #29 AWG.
[5]	Magnet Wire: #28 AWG.
[6]	Tripe Insulated Wire: #24.
[7]	Polyester Tape: 7.4 mm.
[8]	Polyester Tape: 14 mm.
[9]	Varnish: Dolph BC 359 or Equivalent.
[10]	Bus wire: #28 AWG, Alpha Wire, Tinned Copper, 40.0 mm Length.

7.4 *Transformer Build Diagram*

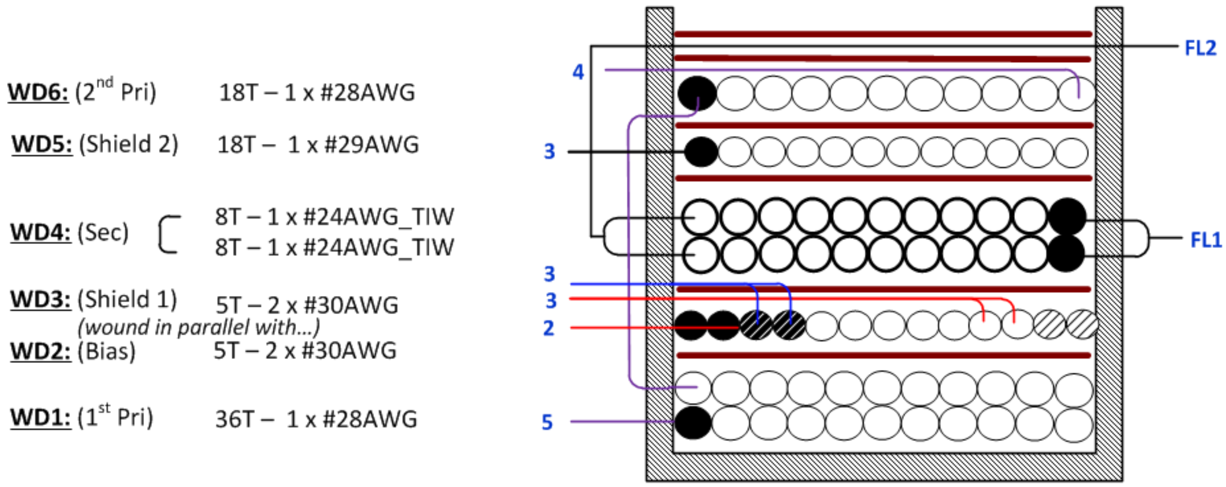


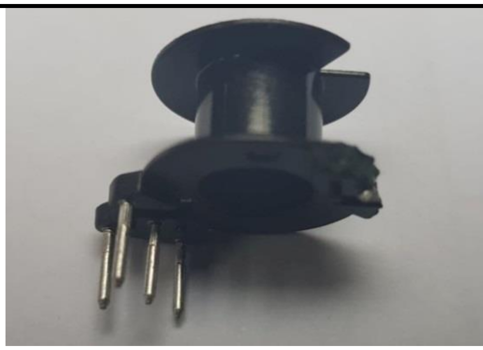
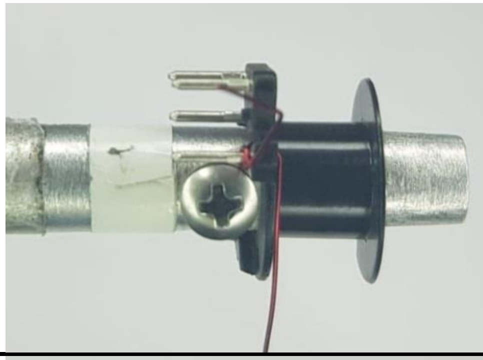
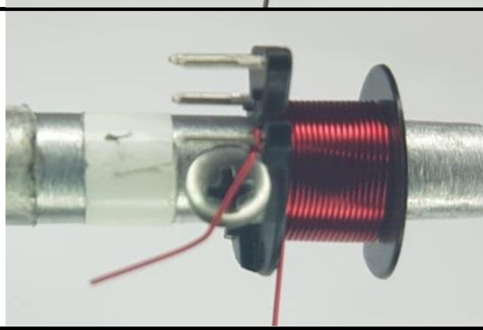
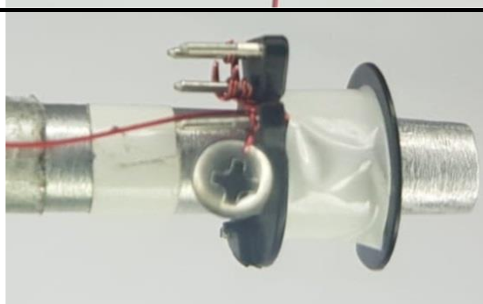
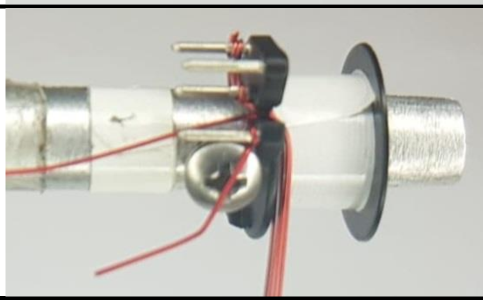
Figure 6 – Transformer Build Diagram.

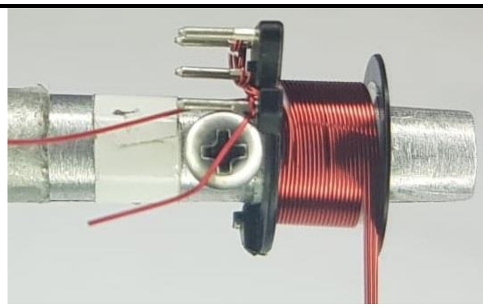
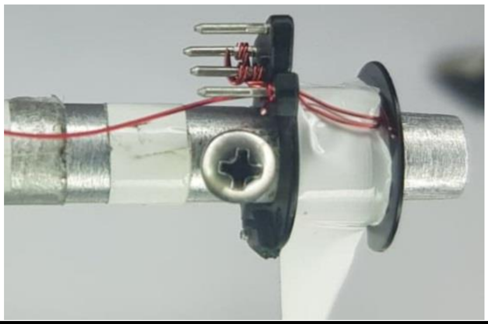
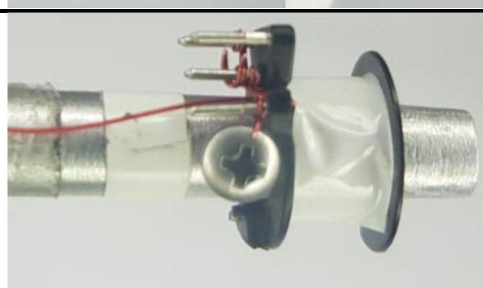
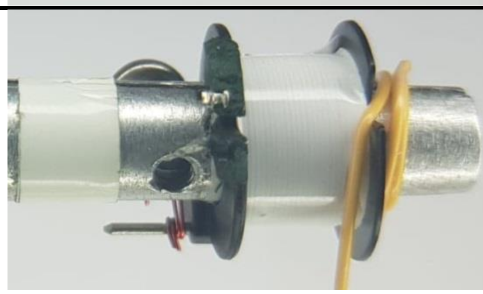
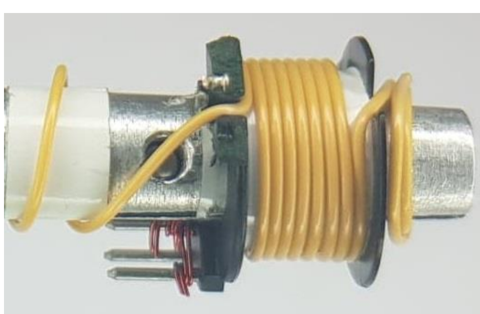
7.5 *Transformer Instructions*

Bobbin Preparation	For the purposes of these instructions, bobbin is oriented on winder such that pin side is on the left side. Winding direction is clockwise. Before winding, remove pins 1, 6, 7 and 8.
WD1 1st Primary	Start at pin 5, wind 36 turns of wire Item [5] in 2 layers. Leave ~4 feet long for 2nd primary winding.
Insulation	1 layer of tape Item [7]
WD2 & WD3 Bias & Shield 1	Prepare 4 strands of wire Item [3]. For WD2, start 2 strands of wire Item [3] at pin 2. For WD3, start the other 2 strands at pin 3. Wind all wires 5 turns in parallel. Finish WD2 at pin 3. Cut WD3 at the end of the last turn with no connection.
Insulation	1 layer of tape Item [7]
WD4 Secondary	Start FL1 at the right side using one strand of TIW Item [6]. Wind 8 turns in 1 layer. Leave FL2 on the left side. Start another layer of FL1 at the right side using one strand of TIW Item [6]. Wind 8 turns in 1 layer. Leave FL2 on the left side.
Insulation	1 layer of tape Item [7]
WD5 Shield 2	Start at pin 3, wind 18 turns of wire Item [4] in 1 layer. Finish the winding at the right side and cut the wire with no connection.
Insulation	1 layer of tape Item [7]
WD6 2nd Primary	Use wire hanging from WD1 and continue winding 18 turns from left to right. At the last turn, finish winding at pin 4.
Insulation	1 layer of tape Item [7], then bring FL2 to the right, then add another 1 layer of tape Item [7].
Finish	Gap cores to get 520 uH. Solder bus wire Item [10] to pin 3 and to the core clip. Wrap the body of transformer with 2 layers of tape Item [9]. Ensure that the bottom and sides are completely wrapped – no air gap. Only the top side of the core is exposed. Varnish using Item [9].

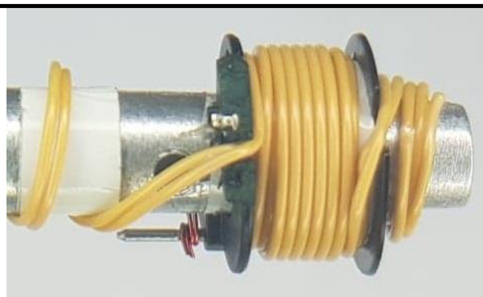
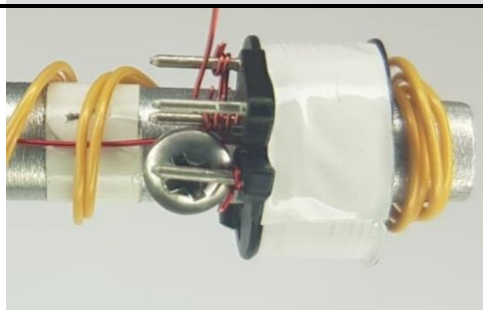
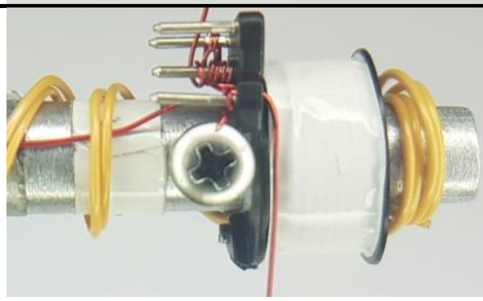
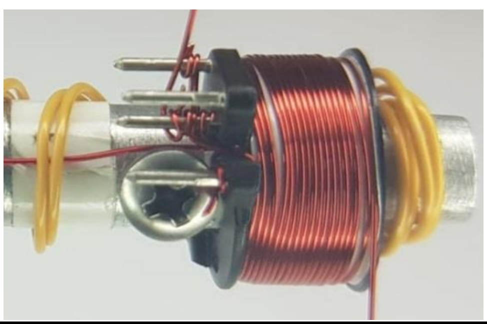
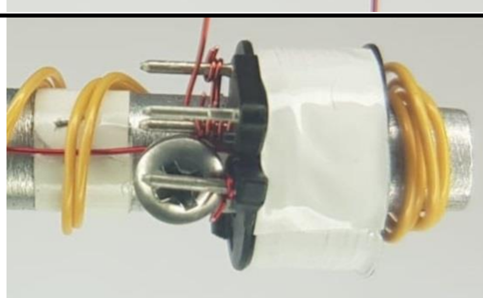
Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

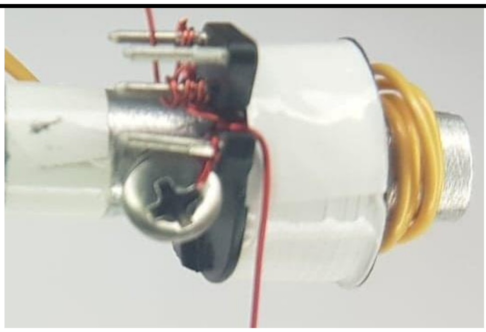
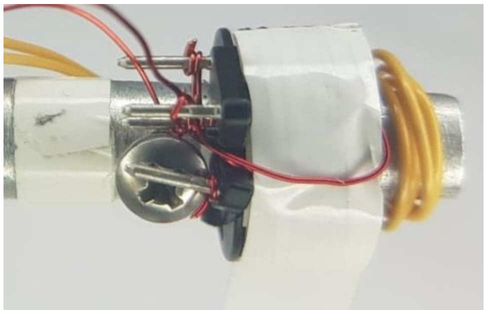
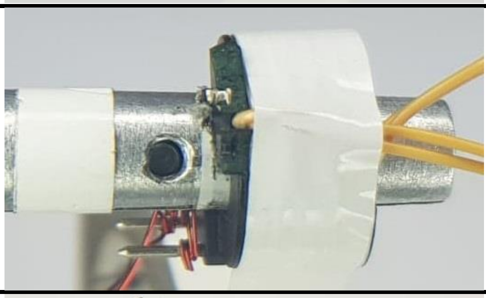
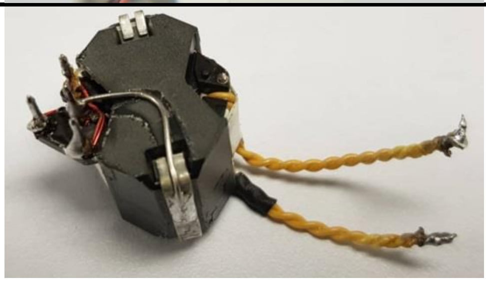
7.6 *Transformer Winding Illustrations*

Bobbin Preparation	 	For the purposes of these instructions, bobbin is oriented on winder such that pin side is on the left side. Winding direction is clockwise. Before winding, remove pins 1, 6, 7 and 8.
WD1 1st Primary		Start at pin 5, wind 36 turns of wire Item [5] in 2 layers. Leave ~4 feet long for 2nd primary winding.
Insulation		1 layer of tape Item [7]
WD2 & WD3 Bias & Shield 1		Prepare 4 strands of wire Item [3]. For WD2, start 2 strands of wire Item [3] at pin 2. For WD3, start the other 2 strands at pin 3. Wind all wires 5 turns in parallel. Finish WD2 at pin 3. Cut WD3 at the end of the last turn with no connection.

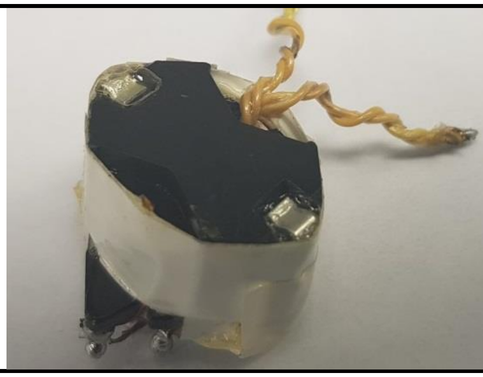
	 	
Insulation		1 layer of tape Item [7]
WD4 Secondary	 	Start FL1 at the right side using one strand of TIW Item [6]. Wind 8 turns in 1 layer. Leave FL2 on the left side. Start another layer of FL1 at the right side using one strand of TIW Item [6]. Wind 8 turns in 1 layer. Leave FL2 on the left side.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

		
Insulation		1 layer of tape Item [7]
WD5 Shield 2	 	Start at pin 3, wind 18 turns of wire Item [4W] in 1 layer. Finish the winding at the right side and cut the wire with no connection.
Insulation		1 layer of tape Item [7]

WD6 **2nd Primary**	 	Use wire hanging from WD1 and continue winding 18 turns from left to right. At the last turn, finish winding at pin 4.
Insulation		1 layer of tape Item [7], then bring FL2 to the right, then add another 1 layer of tape Item [7].
Finish	 	Gap cores to get 520 uH. Solder bus wire Item [10] to pin 3 and to the core clip. Wrap the body of transformer with 2 layers of tape Item [9]. Ensure that the bottom and sides are completely wrapped – no air gap. Only the top side of the core is exposed. Varnish using Item [9].

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

9 Transformer Design Spreadsheet

ACDC_InnoSwitch3-CP_Flyback_073119; Rev.1.5; 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		265	V	Maximum AC input voltage
VAC_RANGE			UNIVERSAL		AC line voltage range
FLINE			60	Hz	AC line voltage frequency
CAP_INPUT	54.0		54.0	uF	Input capacitance
SET-POINT 1					
VOUT1	18.00		18.00	V	Output voltage 1, should be the highest output voltage required
IOUT1	1.670		1.670	A	Output current 1
POUT1			30.06	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
PRIMARY CONTROLLER SELECTION					
ENCLOSURE	ADAPTER		ADAPTER		Power supply enclosure
ILIMIT_MODE	STANDARD		STANDARD		Device current limit mode
VDRAIN_BREAKDOWN	650		650	V	Device breakdown voltage
DEVICE_GENERIC	INN32X7		INN32X7		Device selection
DEVICE_CODE			INN3267C		Device code
PDEVICE_MAX			40	W	Device maximum power capability
RDSON_25DEG			1.17	Ω	Primary switch on-time resistance at 25°C
RDSON_100DEG			1.82	Ω	Primary switch on-time resistance at 100°C
ILIMIT_MIN			1.348	A	Primary switch minimum current limit
ILIMIT_TYP			1.450	A	Primary switch typical current limit
ILIMIT_MAX			1.552	A	Primary switch maximum current limit
VDRAIN_ON_PRSW			0.63	V	Primary switch on-time voltage drop
VDRAIN_OFF_PRSW			563.31	V	Peak drain voltage on the primary switch during turn-off
WORST CASE ELECTRICAL PARAMETERS					
FSWITCHING_MAX	75000		75000	Hz	Maximum switching frequency at full load and the valley of the minimum input AC voltage
VOR	120.0		120.0	V	Voltage reflected to the primary winding (corresponding to set-point 1) when the primary switch turns off
VMIN			91.91	V	Valley of the rectified minimum input AC voltage at full load
KP			1.127		Measure of continuous/discontinuous mode of operation
MODE_OPERATION			DCM		Mode of operation
DUTYCYCLE			0.538		Primary switch duty cycle
TIME_ON			8.63	us	Primary switch on-time
TIME_OFF			6.23	us	Primary switch off-time
LPRIMARY_MIN			496.5	uH	Minimum primary magnetizing inductance
LPRIMARY_TYP			522.6	uH	Typical primary magnetizing inductance
LPRIMARY_TOL			5.0	%	Primary magnetizing inductance tolerance
LPRIMARY_MAX			548.8	uH	Maximum primary magnetizing inductance
PRIMARY CURRENT					
IAVG_PRIMARY			0.348	A	Primary switch average current
IPEAK_PRIMARY			1.455	A	Primary switch peak current
IPEDESTAL_PRIMARY			0.000	A	Primary switch current pedestal
IRIPPLE_PRIMARY			1.455	A	Primary switch ripple current

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

IRMS_PRIMARY			0.581	A	Primary switch RMS current
SECONDARY CURRENT					
IPEAK_SECONDARY			9.822	A	Secondary winding peak current
IPEDESTAL_SECONDARY			0.000	A	Secondary winding pedestal current
IRMS_SECONDARY			3.419	A	Secondary winding RMS current
IRIPPLE_CAP_OUT			2.983	A	Output capacitor ripple current
TRANSFORMER CONSTRUCTION PARAMETERS					
CORE SELECTION					
CORE	RM7	Info	RM7		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	Info	B65819J0000R095		Either custom core code is not entered or a standard core code has been overwritten
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	1326		1326	mm^3	Core volume
BOBBIN NAME	RM7/I		B65820W1008D001		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			54		Primary winding number of turns
BPEAK			3660	Gauss	Peak flux density
BMAX			3309	Gauss	Maximum flux density
BAC			1655	Gauss	AC flux density (0.5 x Peak to Peak)
ALG			179	nH	Typical gapped core effective inductance per turns squared
LG			0.281	mm	Core gap length
LAYERS_PRIMARY			3		Primary winding number of layers
AWG_PRIMARY			28		Primary wire gauge
OD_PRIMARY_INSULATED			0.375	mm	Primary wire insulated outer diameter
OD_PRIMARY_BARE			0.321	mm	Primary wire bare outer diameter
CMA_PRIMARY			275.2	Cmils/A	Primary winding wire CMA
SECONDARY WINDING					
NSECONDARY	8		8		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	mm	Secondary wire bare outer diameter
CMA_SECONDARY			237.0	Cmils/A	Secondary winding wire CMA
BIAS WINDING					
NBIAS			5		Bias winding number of turns
PRIMARY COMPONENTS SELECTION					
LINE UNDERVOLTAGE					
BROWN-IN REQURED			72.00	V	Required line brown-in threshold
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			297.50	V	The device voltage stress will be higher than 585V when overvoltage is trigerred
BIAS WINDING					
VBIAS			9.00	V	Rectified bias voltage at the lowest output

					set-point
VF_BIAS			0.70	V	Bias winding diode forward drop
VREVERSE_BIASDIODE			43.57	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			73.31	V	Secondary rectifier reverse voltage (not accounting parasitic voltage ring)
SRFET	AUTO		AO4482		Secondary rectifier (Logic MOSFET)
VBREAKDOWN_SRFET			100	V	Secondary rectifier breakdown voltage
RDSON_SRFET			42.0	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			7.50	kΩ	Lower feedback resistor required to obtain the output for cable drop compensation
CFB_LOWER			330	pF	Lower feedback resistor decoupling capacitor
SET-POINTS ANALYSIS					
TOLERANCE CORNER					
USER_VAC	90		90	V	Input AC RMS voltage corner to be evaluated
USER_ILIMIT	TYP		1.450	A	Current limit corner to be evaluated
USER_LPRIMARY	TYP		522.6	uH	Primary inductance corner to be evaluated
SET-POINT SELECTION					
SET-POINT	1		1		Select the set-point which needs to be evaluated
FSWITCHING			64352.7	Hz	Maximum switching frequency at full load and the valley of the minimum input AC voltage
VOR			120.0	V	Voltage reflected to the primary winding when the primary switch turns off
VMIN			91.91	V	Valley of the minimum input AC voltage
KP			1.283		Measure of continuous/discontinuous mode of operation
MODE_OPERATION			DCM		Mode of operation
DUTYCYCLE			0.506		Primary switch duty cycle
TIME_ON			7.87	us	Primary switch on-time
TIME_OFF			7.67	us	Primary switch off-time
PRIMARY CURRENT					
IAVG_PRIMARY			0.348	A	Primary switch average current
IPEAK_PRIMARY			1.374	A	Primary switch peak current
IPEDESTAL_PRIMARY			0.000	A	Primary switch current pedestal
IRIPPLE_PRIMARY			1.374	A	Primary switch ripple current
IRMS_PRIMARY			0.564	A	Primary switch RMS current
SECONDARY CURRENT					
IPEAK_SECONDARY			9.272	A	Secondary winding peak current
IPEDESTAL_SECONDARY			0.000	A	Secondary winding pedestal current
IRMS_SECONDARY			3.322	A	Secondary winding RMS current
IRIPPLE_CAP_OUT			2.871	A	Output capacitor ripple current
MAGNETIC FLUX DENSITY					
BPEAK			3257	Gauss	Peak flux density
BMAX			3015	Gauss	Maximum flux density
BAC			1507	Gauss	AC flux density (0.5 x Peak to Peak)

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

10 Performance Data

10.1 *Efficiency*

10.1.1 Active Mode Measurement Data

Measured Performance				Standards		
		V_{IN} (VAC)		DOE6	EC CoC (v5)	
		115	230		2014 Tier 1	2016 Tier 2
		Efficiency (%)				
Load (%)	**10**	86.37	83.68		70	73
	25	90.09	88.94			
	50	90.82	90.70			
	75	90.79	91.06			
	100	90.66	91.17			
	Ave	**90.59**	**90.47**	83	80	83
No-Load Input Power (mW)		**34**	**32**	100	150	75
			Compliant	Y	Y	Y

10.1.2 Full Load Efficiency vs. Line

Test Condition: Soak for 15 minutes for each line.

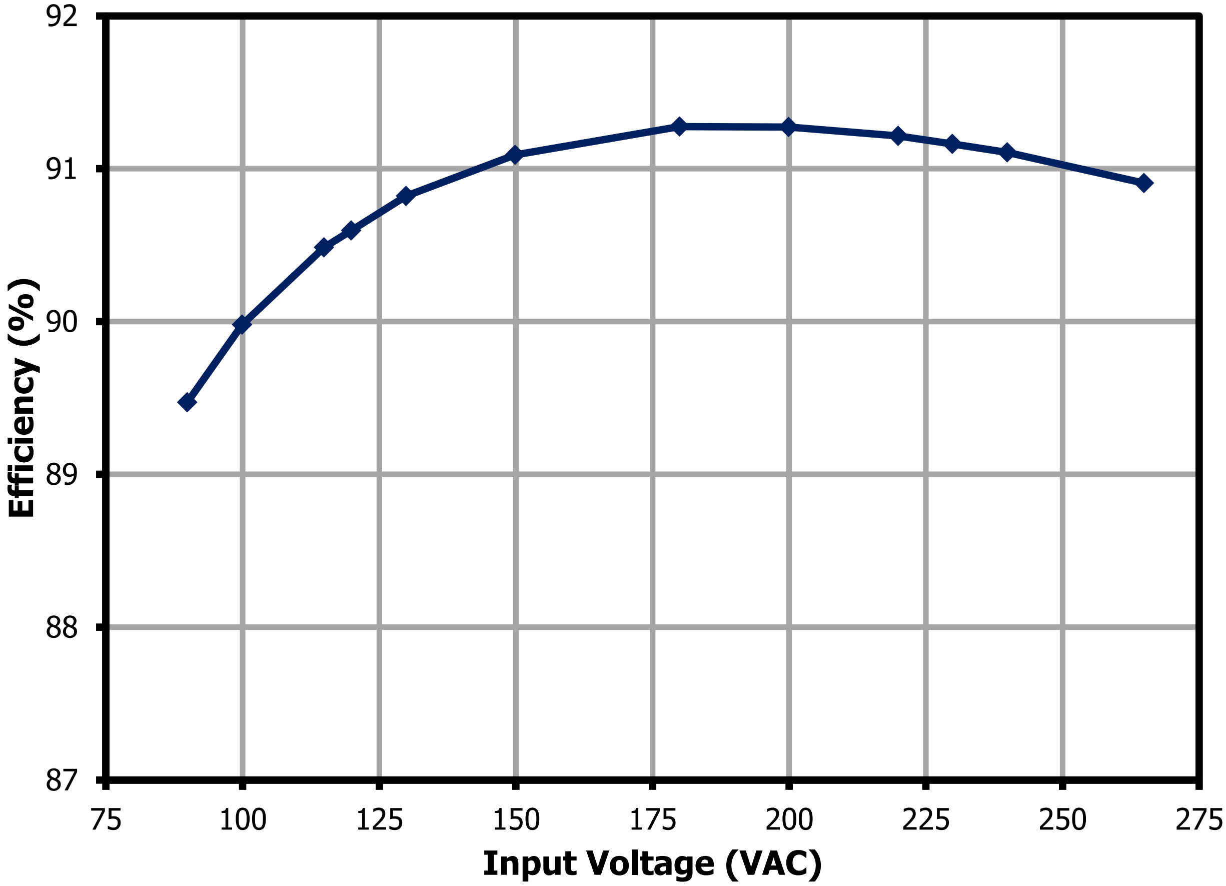


Figure 7 – Full Load Efficiency vs. Line.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

10.1.3 Efficiency vs. Load

Test Condition: Soak for 15 minutes each line, and 5 minutes for each load.

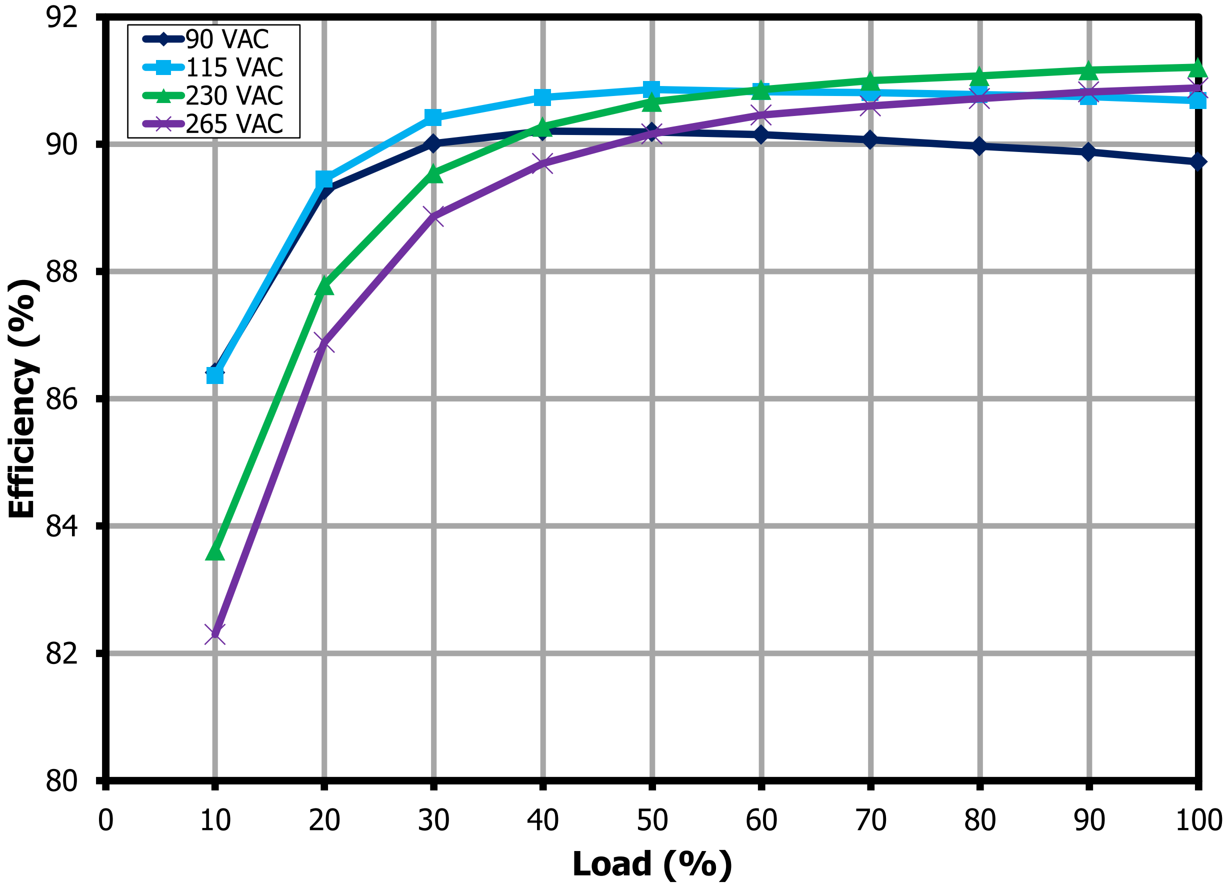


Figure 8 – Efficiency vs. Percentage Load.

10.2 *Available Standby Output Power*

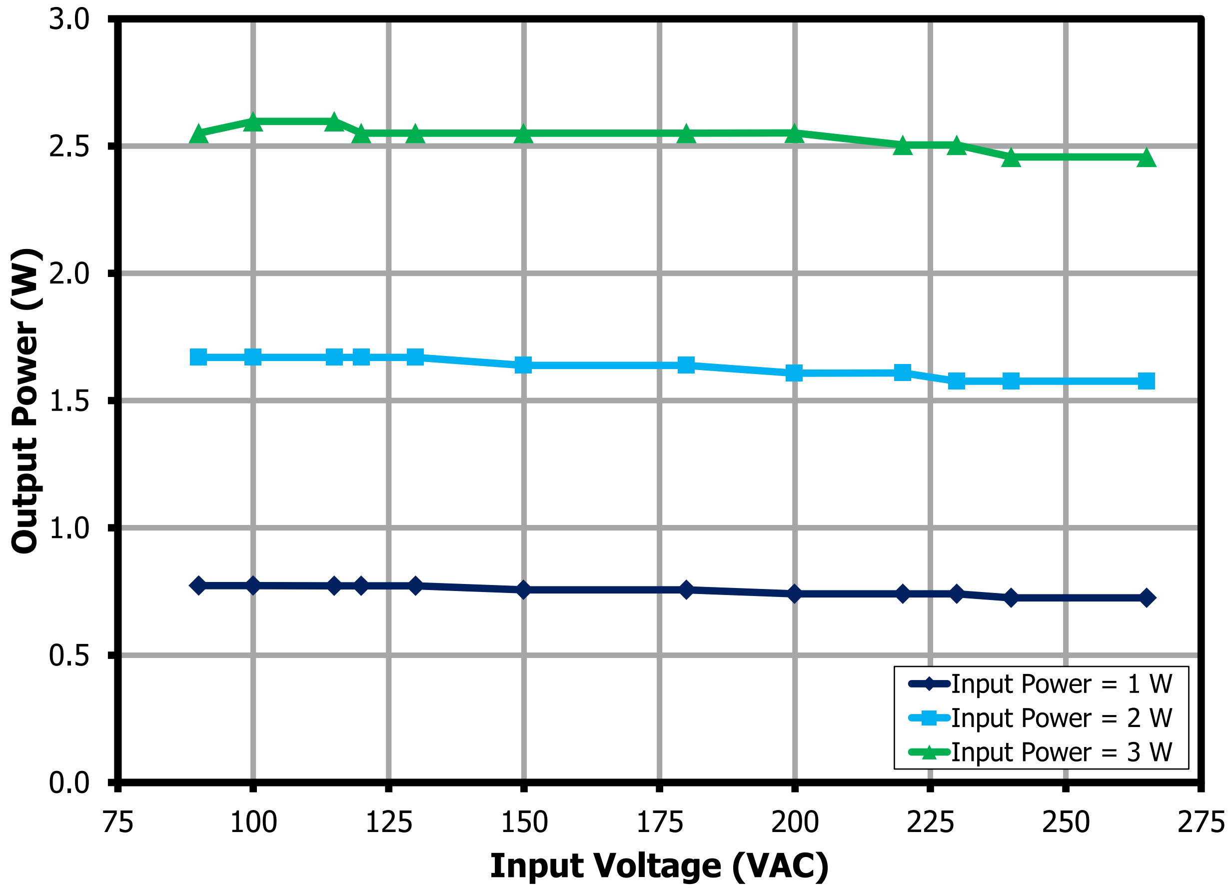


Figure 9 – Available Standby Output Power for 1 W, 2 W and 3 W Input Power.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

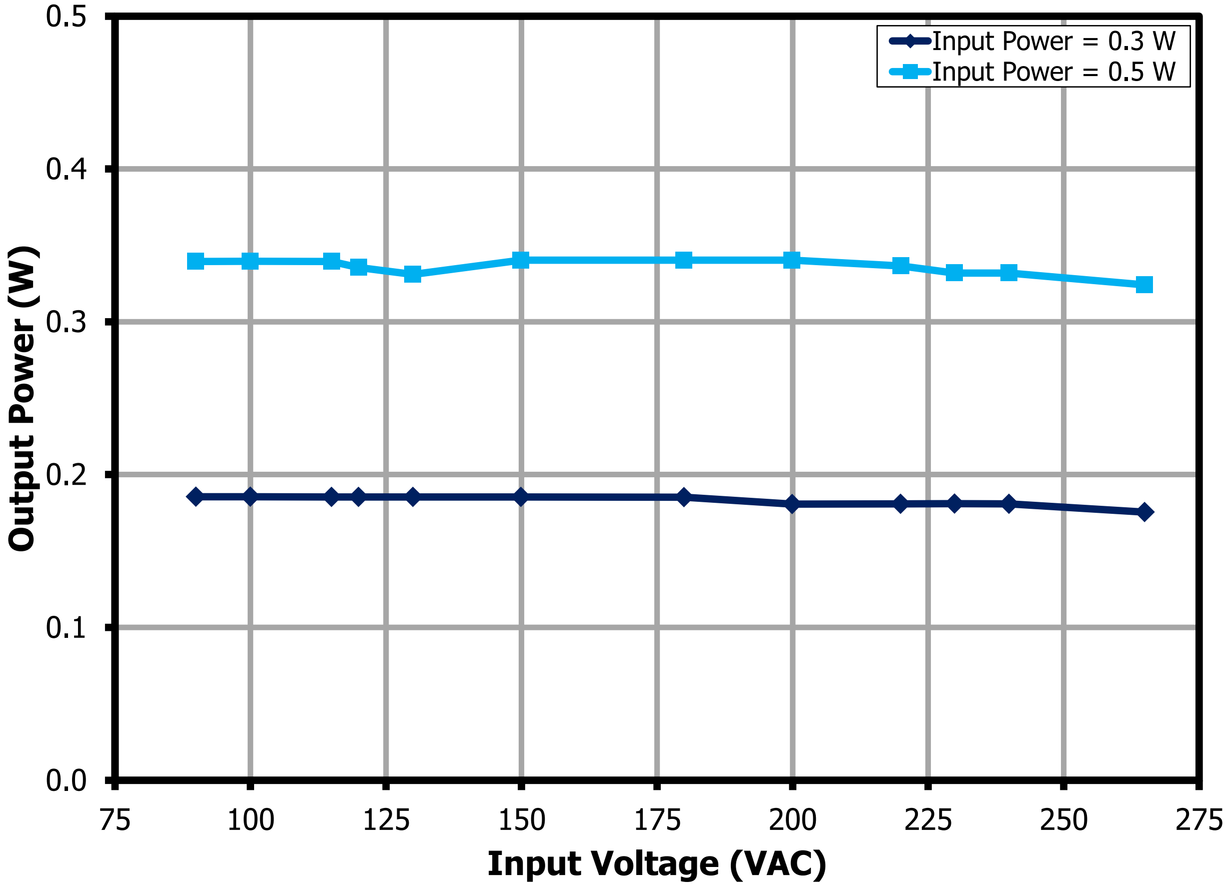


Figure 10 – Available Standby Output Power for 0.3 W and 0.5 W Input Power.

10.3 *No-Load Input Power*

Test Condition: Soak for 15 minutes each line and 1 minute integration time.

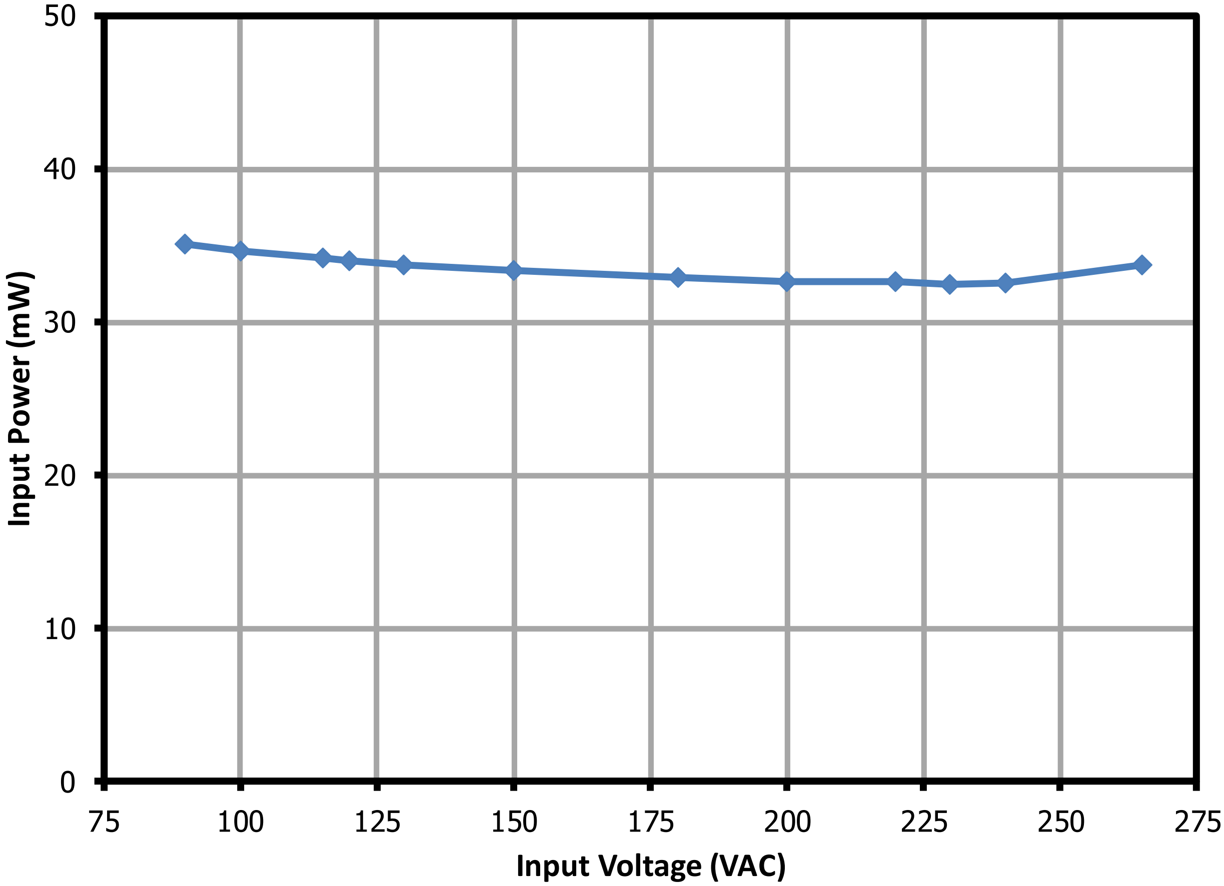


Figure 11 – No-Load Input Power vs. Line at Room Temperature.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

10.4 *Line Regulation*

Test Condition: Soak for 15 minutes for each line.

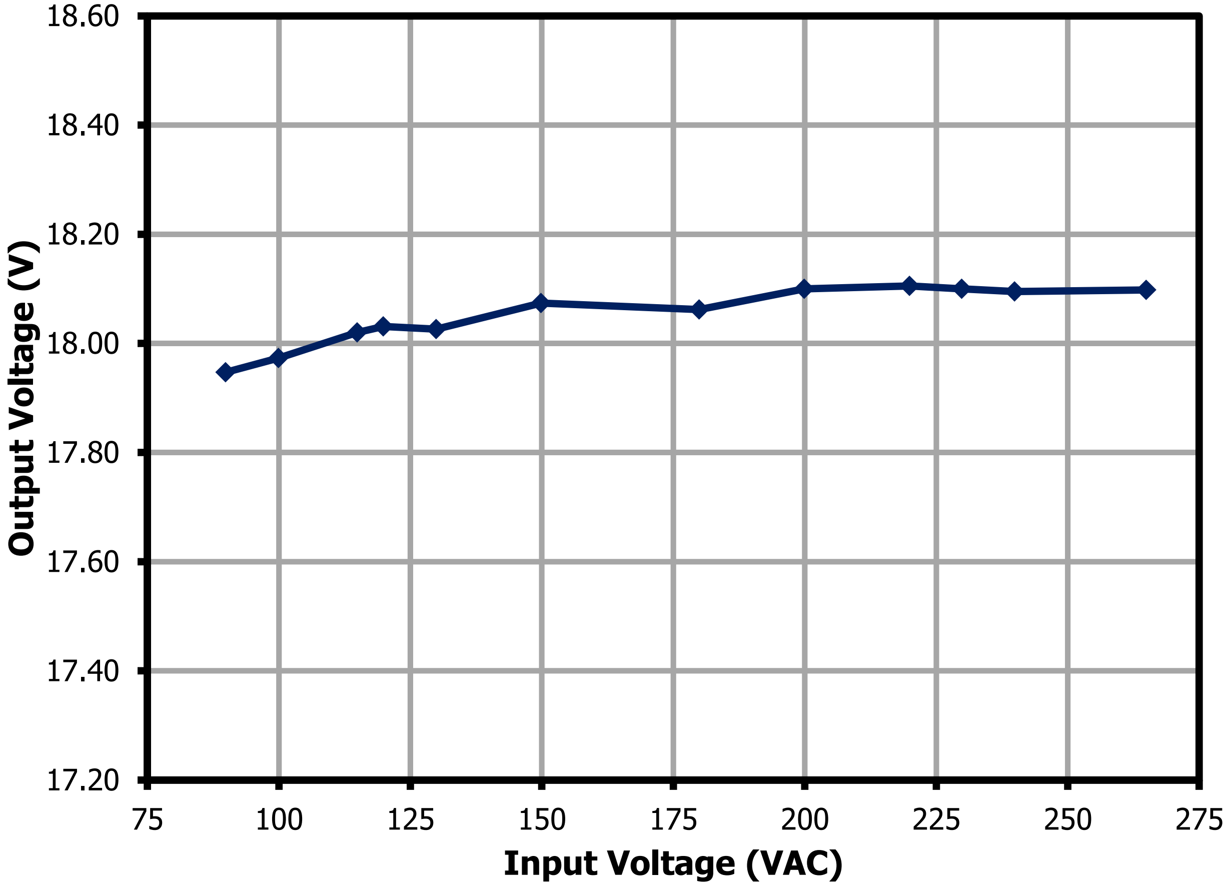


Figure 12 – Output Voltage vs. Line Voltage.

10.5 *Load Regulation*

Test Condition: Soak for 15 minutes each line, and 5 minutes for each load.

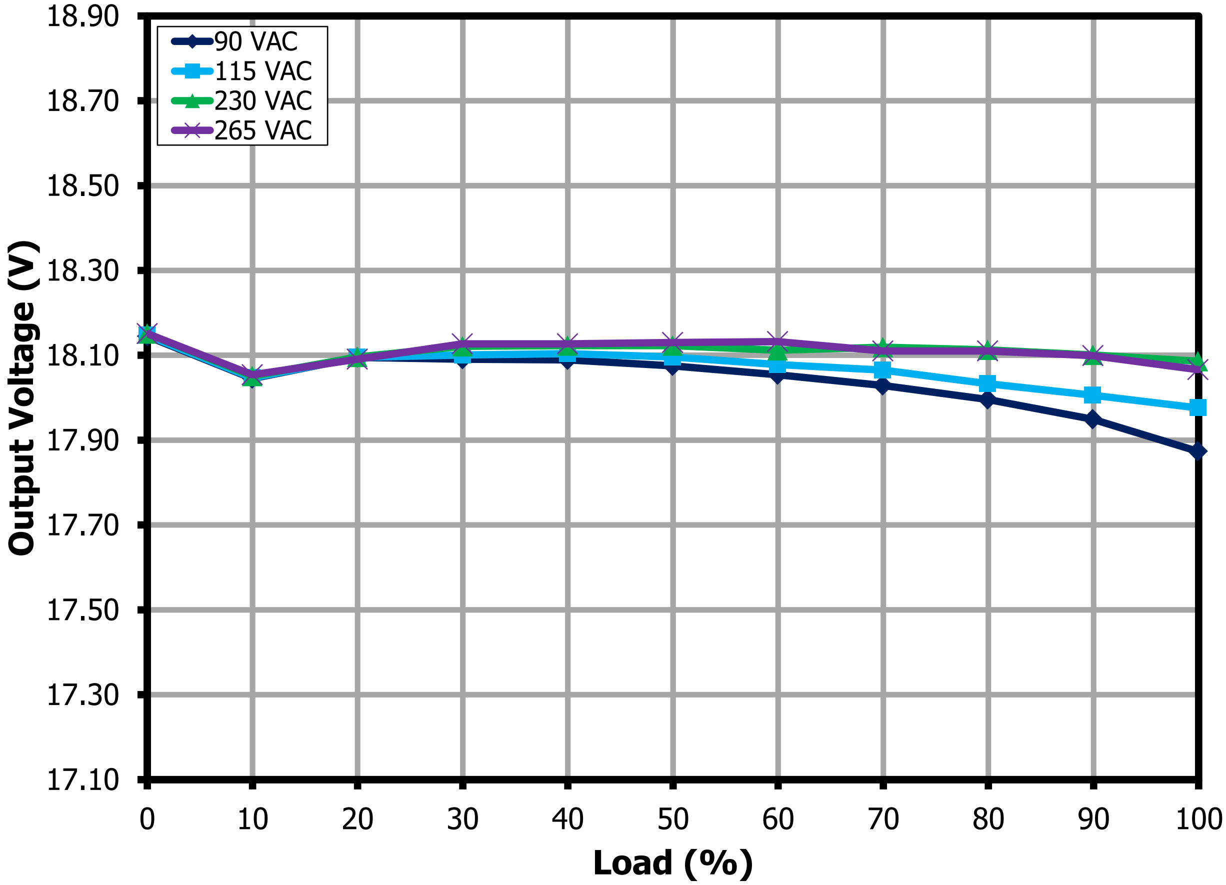


Figure 13 – Output Voltage vs. Percent Load.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

10.6 *CV-CC-CP Output Characteristic Curve*

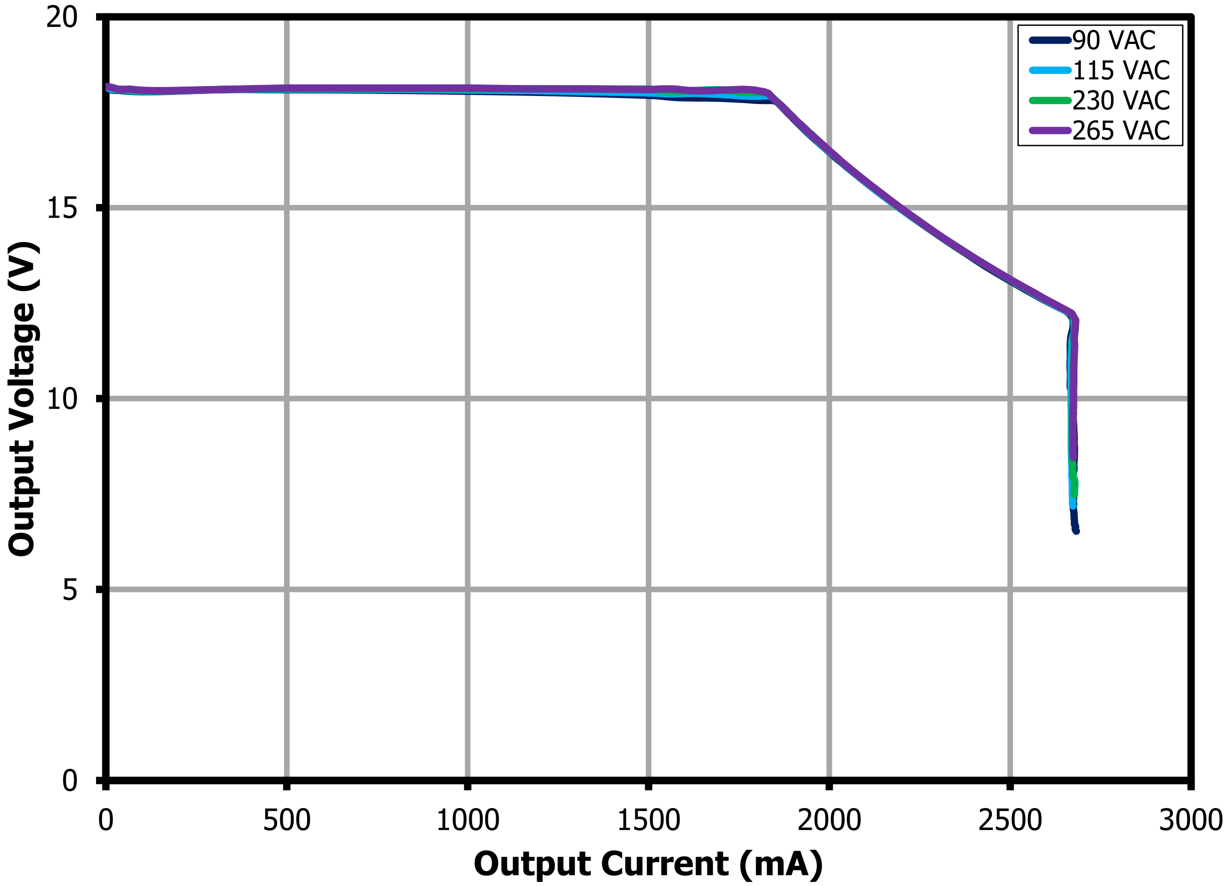


Figure 14 – CV-CC-CP Curve.

11 Waveforms

11.1 *Load Transient Response*

Test Condition: Dynamic load frequency = 1 kHz, Duty cycle = 50 %

11.1.1 0% - 100% Load Change

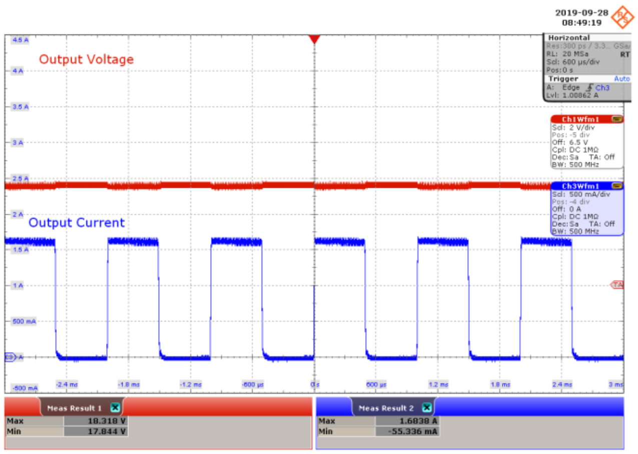


Figure 15 – 90 VAC 60 Hz.
CH1: V_{OUT}, 2 V / div., 600 μs / div.
CH3: I_{OUT}, 500 mA / div., 600 μs / div.
V_{MAX}: 18.318 V, V_{MIN}: 17.844 V.

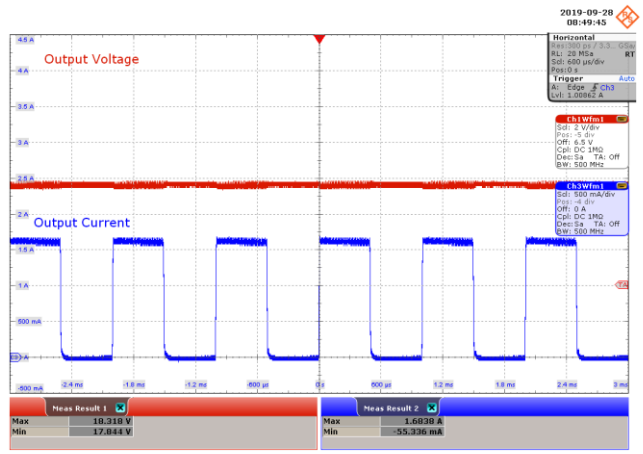


Figure 16 – 115 VAC 60 Hz.
CH1: V_{OUT}, 2 V / div., 600 μs / div.
CH3: I_{OUT}, 500 mA / div., 600 μs / div.
V_{MAX}: 18.318 V, V_{MIN}: 17.844 V.

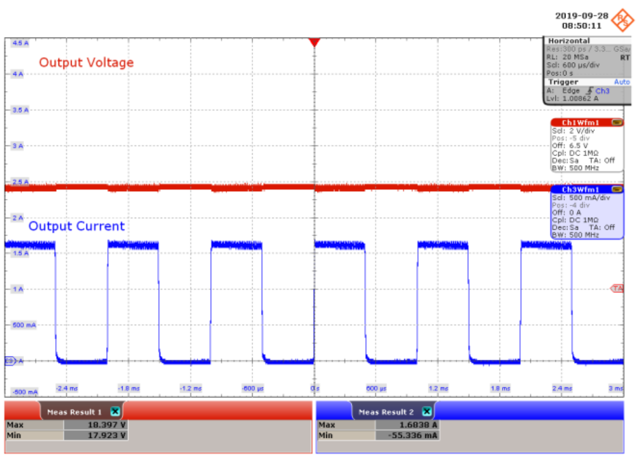


Figure 17 – 230 VAC 50 Hz.
CH1: V_{OUT}, 2 V / div., 600 μs / div.
CH3: I_{OUT}, 500 mA / div., 600 μs / div.
V_{MAX}: 18.397 V, V_{MIN}: 17.923 V.

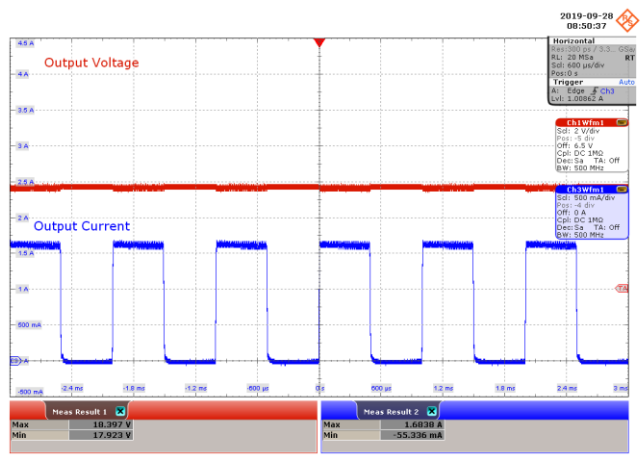


Figure 18 – 265 VAC 50 Hz.
CH1: V_{OUT}, 2 V / div., 600 μs / div.
CH3: I_{OUT}, 500 mA / div., 600 μs / div.
V_{MAX}: 18.397 V, V_{MIN}: 17.923 V.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

11.1.2 50% - 100% Load Change

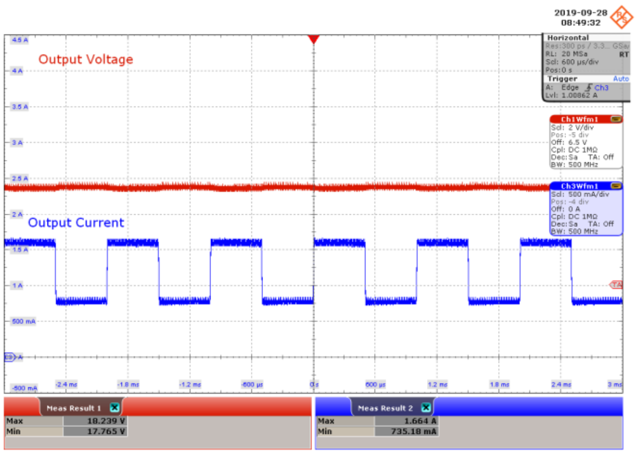


Figure 19 – 90 VAC 60 Hz.
CH1: V_{OUT}, 2 V / div., 600 µs / div.
CH3: I_{OUT}, 500 mA / div., 600 µs / div.
V_{MAX}: 18.239 V, V_{MIN}: 17.765 V.

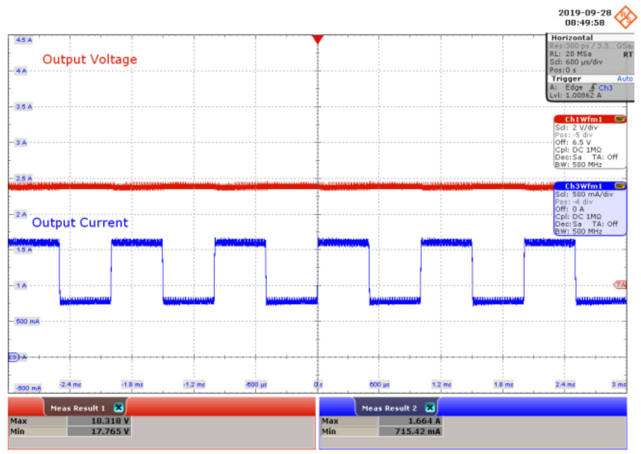


Figure 20 – 115 VAC 60 Hz.
CH1: V_{OUT}, 2 V / div., 600 µs / div.
CH3: I_{OUT}, 500 mA / div., 600 µs / div.
V_{MAX}: 18.318 V, V_{MIN}: 17.765 V.

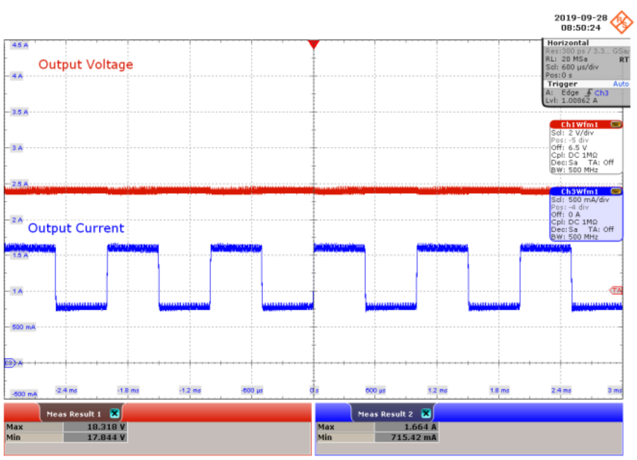


Figure 21 – 230 VAC 50 Hz.
CH1: V_{OUT}, 2 V / div., 600 µs / div.
CH3: I_{OUT}, 500 mA / div., 600 µs / div.
V_{MAX}: 18.318 V, V_{MIN}: 17.844 V.

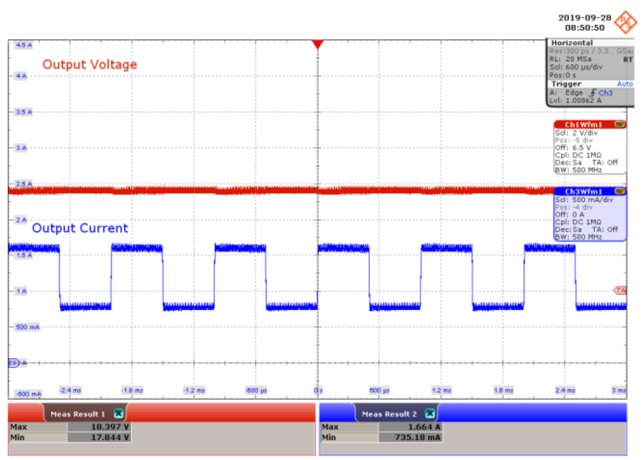


Figure 22 – 265 VAC 50 Hz.
CH1: V_{OUT}, 2 V / div., 600 µs / div.
CH3: I_{OUT}, 500 mA / div., 600 µs / div.
V_{MAX}: 18.397 V, V_{MIN}: 17.844 V.

11.2 *Output Voltage at Start-up*

11.2.1 CC Mode

11.2.1.1 100% Load

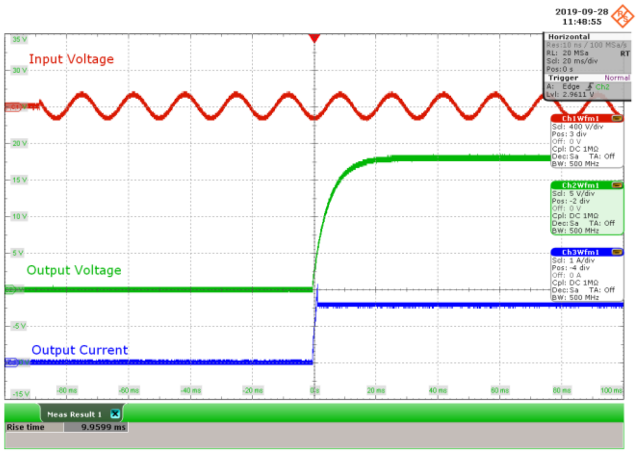


Figure 23 – 90 VAC 60 Hz.
CH1: V_{IN}, 400 V / div., 20 ms / div.
CH2: V_{OUT}, 5 V / div., 20 ms / div.
CH3: I_{OUT}, 1 A / div., 20 ms / div.
Rise Time = 9.96 ms.

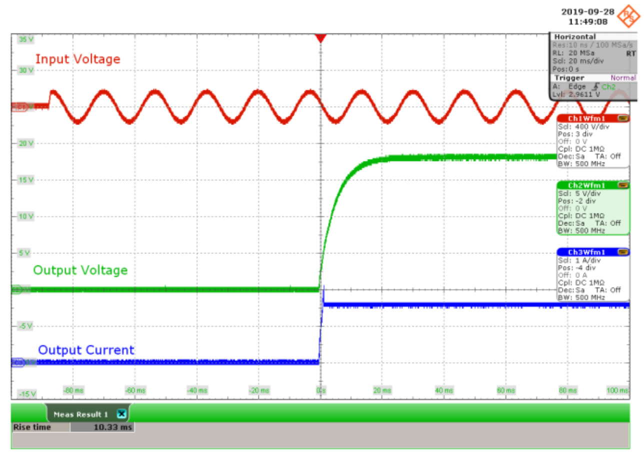


Figure 24 – 115 VAC 60 Hz.
CH1: V_{IN}, 400 V / div., 20 ms / div.
CH2: V_{OUT}, 5 V / div., 20 ms / div.
CH3: I_{OUT}, 1 A / div., 20 ms / div.
Rise Time = 10.33 ms.

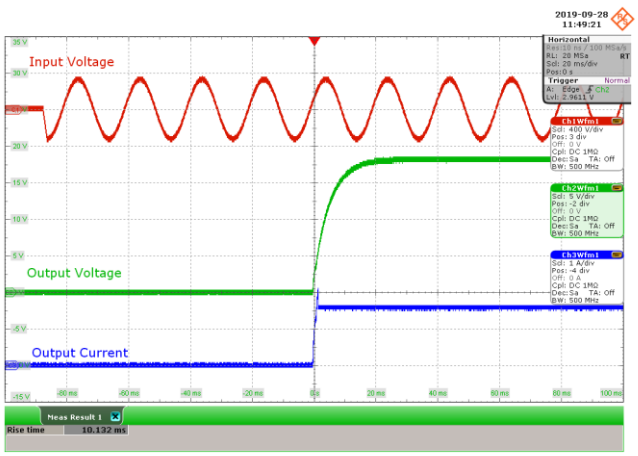


Figure 25 – 230 VAC 50 Hz.
CH1: V_{IN}, 400 V / div., 20 ms / div.
CH2: V_{OUT}, 5 V / div., 20 ms / div.
CH3: I_{OUT}, 1 A / div., 20 ms / div.
Rise Time = 10.132 ms.

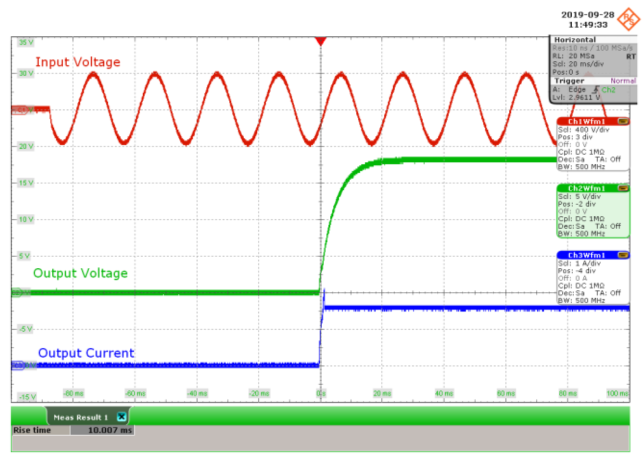


Figure 26 – 265 VAC 50 Hz.
CH1: V_{IN}, 400 V / div., 20 ms / div.
CH2: V_{OUT}, 5 V / div., 20 ms / div.
CH3: I_{OUT}, 1 A / div., 20 ms / div.
Rise Time = 10.01 ms.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

11.2.1.2 0% Load

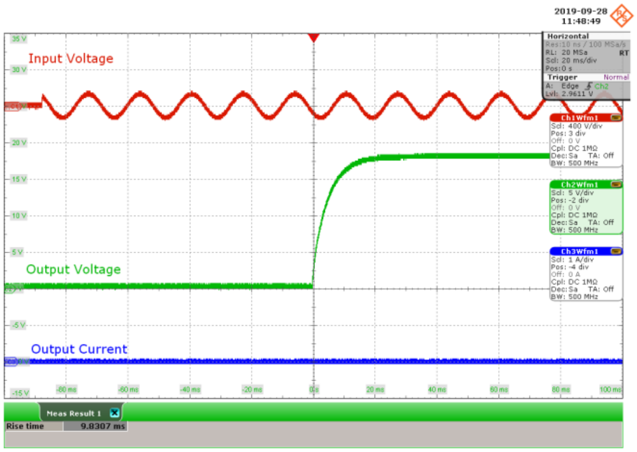


Figure 27 – 90 VAC 60 Hz.
CH1: V_{IN}, 400 V / div., 20 ms / div.
CH2: V_{OUT}, 5 V / div., 20 ms / div.
CH3: I_{OUT}, 1 A / div., 20 ms / div.
Rise Time = 9.83 ms.

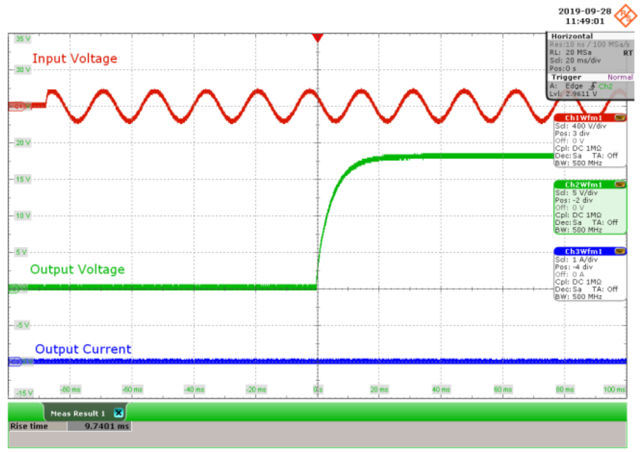


Figure 28 – 115 VAC 60 Hz.
CH1: V_{IN}, 400 V / div., 20 ms / div.
CH2: V_{OUT}, 5 V / div., 20 ms / div.
CH3: I_{OUT}, 1 A / div., 20 ms / div.
Rise Time = 9.74 ms.

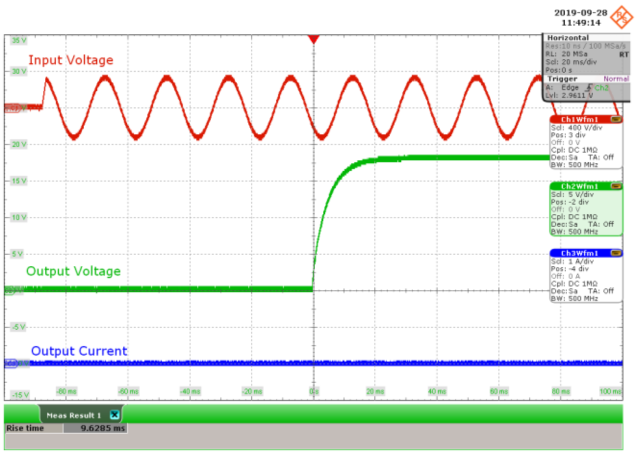


Figure 29 – 230 VAC 50 Hz.
CH1: V_{IN}, 400 V / div., 20 ms / div.
CH2: V_{OUT}, 5 V / div., 20 ms / div.
CH3: I_{OUT}, 1 A / div., 20 ms / div.
Rise Time = 9.63 ms.

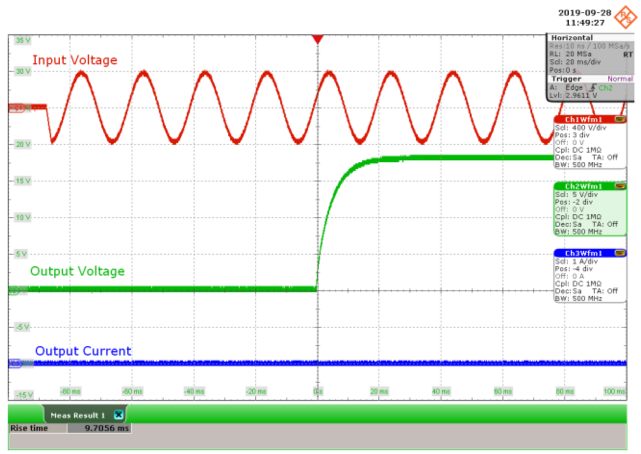


Figure 30 – 265 VAC 50 Hz.
CH1: V_{IN}, 400 V / div., 20 ms / div.
CH2: V_{OUT}, 5 V / div., 20 ms / div.
CH3: I_{OUT}, 1 A / div., 20 ms / div.
Rise Time = 9.71 ms.

11.2.2 CR Mode

11.2.2.1 100% Load

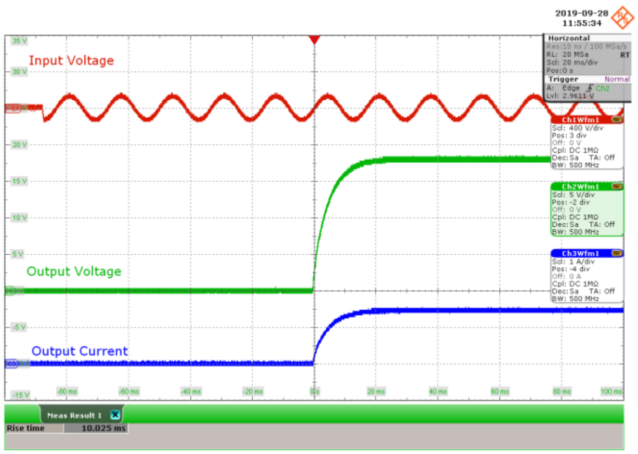


Figure 31 – 90 VAC 60 Hz.
CH1: V_{IN}, 400 V / div., 20 ms / div.
CH2: V_{OUT}, 5 V / div., 20 ms / div.
CH3: I_{OUT}, 1 A / div., 20 ms / div.
Rise Time = 10.03 ms.

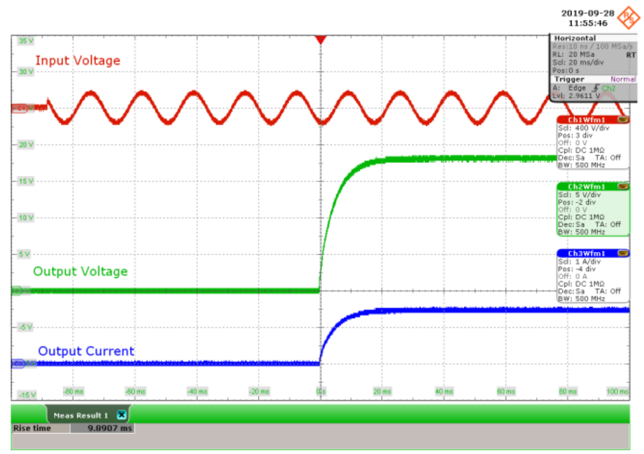


Figure 32 – 115 VAC 60 Hz.
CH1: V_{IN}, 400 V / div., 20 ms / div.
CH2: V_{OUT}, 5 V / div., 20 ms / div.
CH3: I_{OUT}, 1 A / div., 20 ms / div.
Rise Time = 9.89 ms.

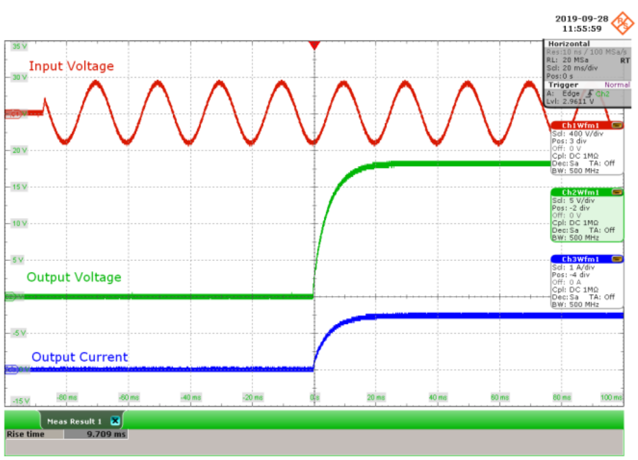


Figure 33 – 230 VAC 50 Hz.
CH1: V_{IN}, 400 V / div., 20 ms / div.
CH2: V_{OUT}, 5 V / div., 20 ms / div.
CH3: I_{OUT}, 1 A / div., 20 ms / div.
Rise Time = 9.71 ms.

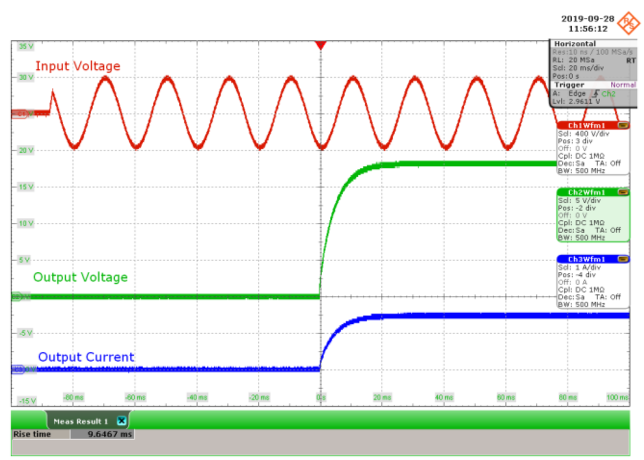


Figure 34 – 265 VAC 50 Hz.
CH1: V_{IN}, 400 V / div., 20 ms / div.
CH2: V_{OUT}, 5 V / div., 20 ms / div.
CH3: I_{OUT}, 1 A / div., 20 ms / div.
Rise Time = 9.65 ms.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

11.2.2.2 0% Load

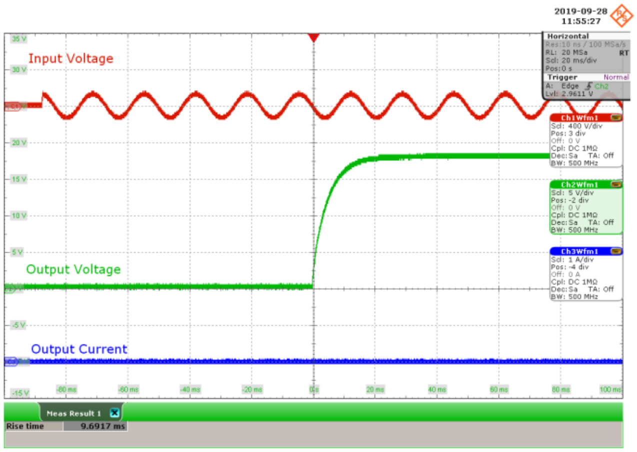


Figure 35 – 85 VAC 60 Hz.
CH1: V_{IN}, 400 V / div., 20 ms / div.
CH2: V_{OUT}, 5 V / div., 20 ms / div.
CH3: I_{OUT}, 1 A / div., 20 ms / div.
Rise Time = 9.69 ms.

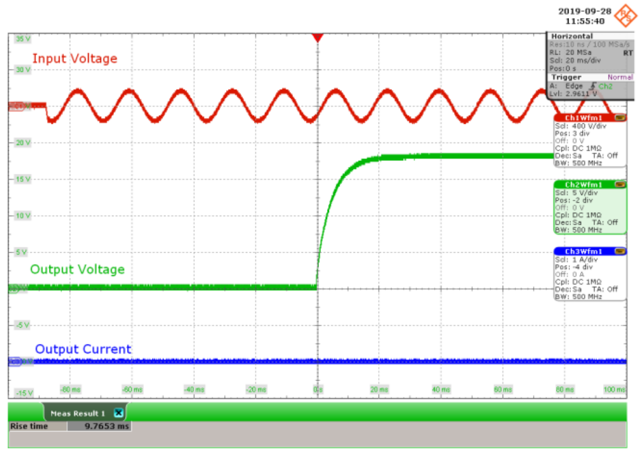


Figure 36 – 115 VAC 60 Hz.
CH1: V_{IN}, 400 V / div., 20 ms / div.
CH2: V_{OUT}, 5 V / div., 20 ms / div.
CH3: I_{OUT}, 1 A / div., 20 ms / div.
Rise Time = 9.77 ms.

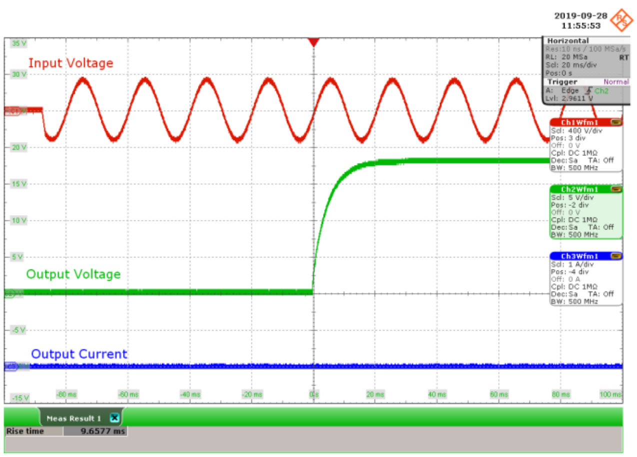


Figure 37 – 230 VAC 50 Hz.
CH1: V_{IN}, 400 V / div., 20 ms / div.
CH2: V_{OUT}, 5 V / div., 20 ms / div.
CH3: I_{OUT}, 1 A / div., 20 ms / div.
Rise Time = 9.66 ms.

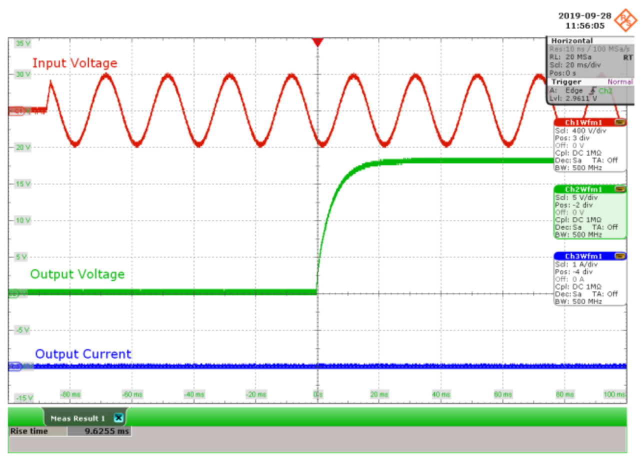


Figure 38 – 265 VAC 50 Hz.
CH1: V_{IN}, 400 V / div., 20 ms / div.
CH2: V_{OUT}, 5 V / div., 20 ms / div.
CH3: I_{OUT}, 1 A / div., 20 ms / div.
Rise Time = 9.63 ms.

11.3 *Switching Waveforms*

11.3.1 Primary MOSFET Drain-Source Voltage and Current at Normal Operation

11.3.1.1 100% Load

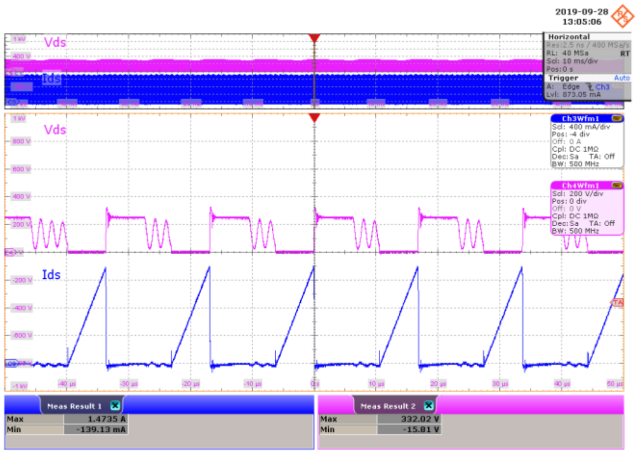


Figure 39 – 90 VAC 60 Hz.
CH3: $I_{DS,}$ 400 mA / div., 10 ms / div.
CH4: V_{DS}, 200 V / div., 10 ms / div.
Zoom: 10 μs / div.
$V_{DS(MAX)}$ = 332.02 V, $I_{DS(MAX)}$ = 1.4735 A.

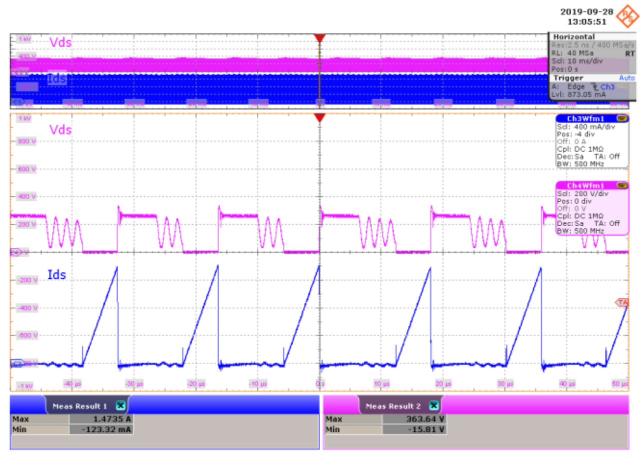


Figure 40 – 115 VAC 60 Hz.
CH3: $I_{DS,}$ 400 mA / div., 10 ms / div.
CH4: V_{DS}, 200 V / div., 10 ms / div.
Zoom: 10 μs / div.
$V_{DS(MAX)}$ = 363.64 V, $I_{DS(MAX)}$ = 1.4735 A.

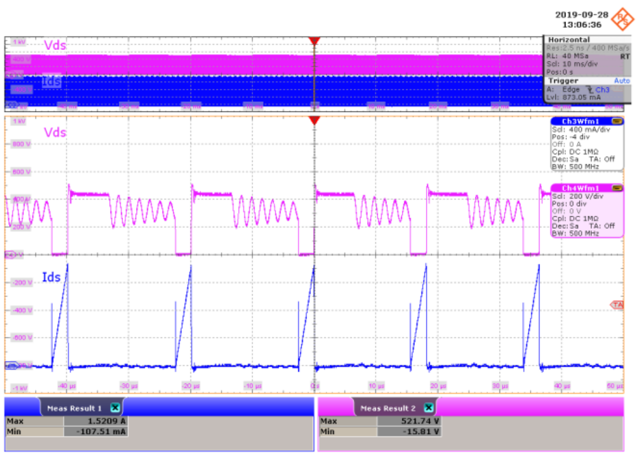


Figure 41 – 230 VAC 50 Hz.
CH3: $I_{DS,}$ 400 mA / div., 10 ms / div.
CH4: V_{DS}, 200 V / div., 10 ms / div.
Zoom: 10 μs / div.
$V_{DS(MAX)}$ = 521.74 V, $I_{DS(MAX)}$ = 1.5209 A.

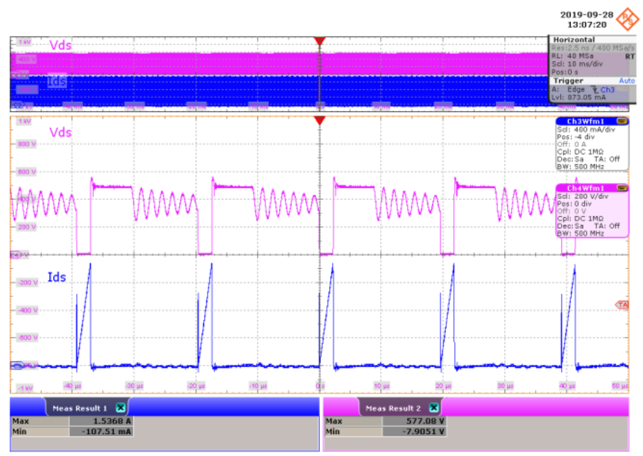


Figure 42 – 265 VAC 50 Hz.
CH3: $I_{DS,}$ 400 mA / div., 10 ms / div.
CH4: V_{DS}, 200 V / div., 10 ms / div.
Zoom: 10 μs / div.
$V_{DS(MAX)}$ = 577.08 V, $I_{DS(MAX)}$ = 1.5368 A.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

11.3.1.2 0% Load

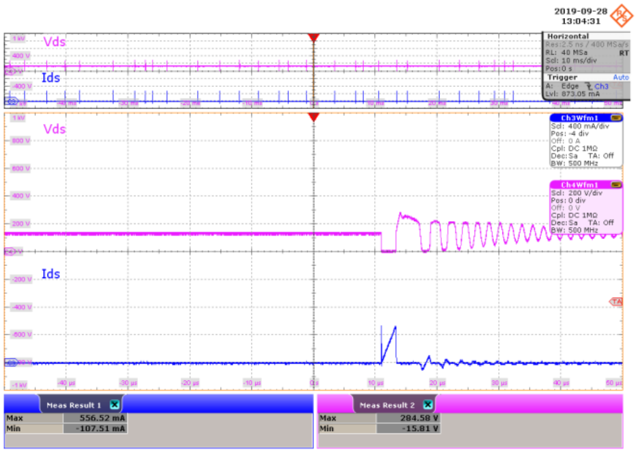


Figure 43 – 90 VAC 60 Hz.
CH3: I_{DS}, 400 mA / div., 10 ms / div.
CH4: V_{DS}, 200 V / div., 10 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 284.58 V, $I_{DS(MAX)}$ = 556.52 mA.

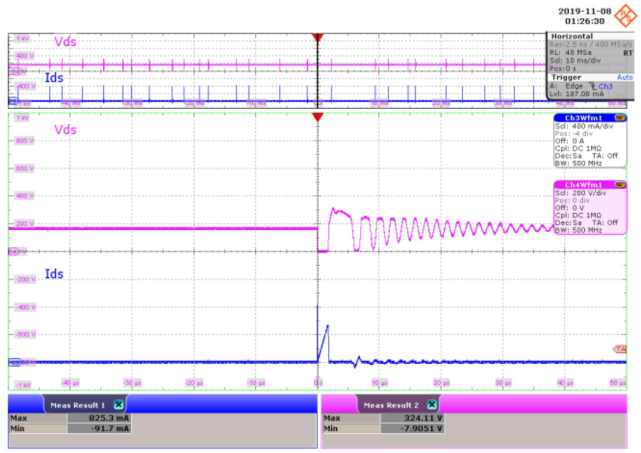


Figure 44 – 115 VAC 60 Hz.
CH3: I_{DS}, 400 mA / div., 10 ms / div.
CH4: V_{DS}, 200 V / div., 10 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 324.11 V, $I_{DS(MAX)}$ = 825.3 mA.

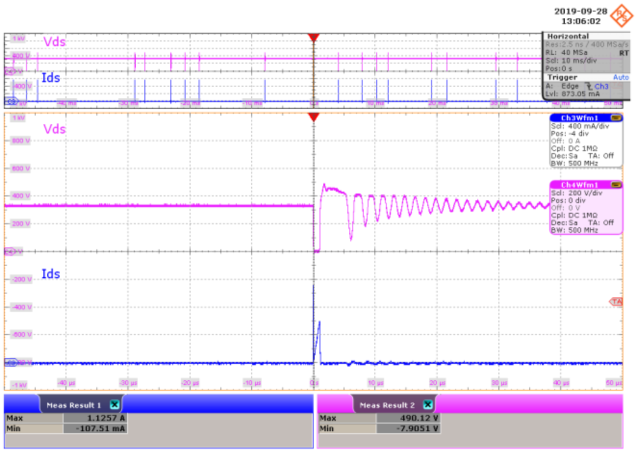


Figure 45 – 230 VAC 50 Hz.
CH3: I_{DS}, 400 mA / div., 10 ms / div.
CH4: V_{DS}, 200 V / div., 10 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 490.12 V, $I_{DS(MAX)}$ = 1.1257 A.

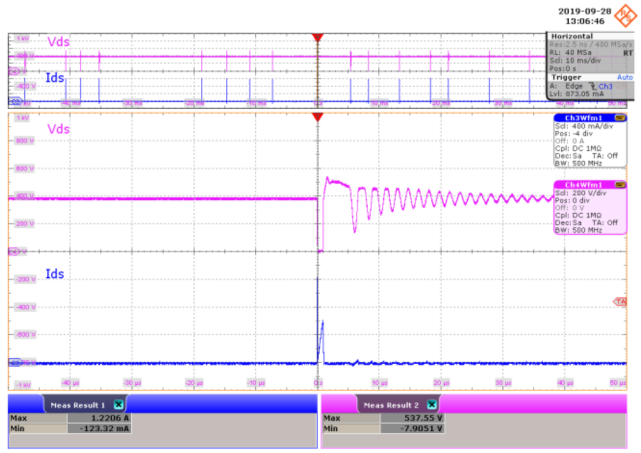


Figure 46 – 265 VAC 50 Hz.
CH3: I_{DS}, 400 mA / div., 10 ms / div.
CH4: V_{DS}, 200 V / div., 10 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 537.55 V, $I_{DS(MAX)}$ = 1.2206 A.

11.3.2 Primary MOSFET Drain-Source Voltage and Current at Start-up Operation

11.3.2.1 100% Load

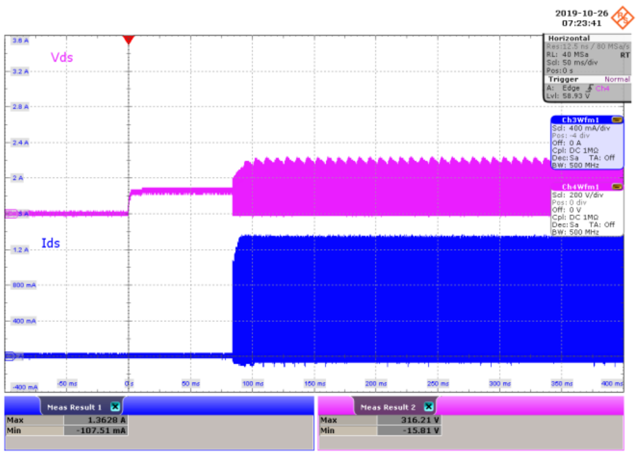


Figure 47 – 90 VAC 60 Hz.
CH3: I_{DS}, 400 mA / div., 50 ms / div.
CH4: V_{DS}, 200 V / div., 50 ms / div.
$V_{DS(MAX)}$ = 316.21 V, $I_{DS(MAX)}$ = 1.3628 A.

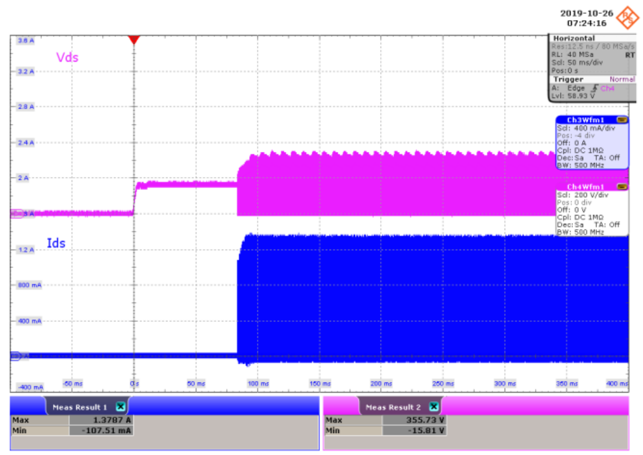


Figure 48 – 115 VAC 60 Hz.
CH3: I_{DS}, 400 mA / div., 50 ms / div.
CH4: V_{DS}, 200 V / div., 50 ms / div.
$V_{DS(MAX)}$ = 355.73 V, $I_{DS(MAX)}$ = 1.3787 A.

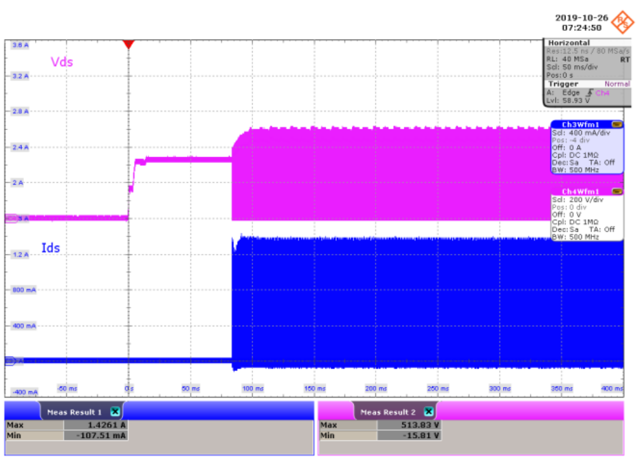


Figure 49 – 230 VAC 50 Hz.
CH3: I_{DS}, 400 mA / div., 50 ms / div.
CH4: V_{DS}, 200 V / div., 50 ms / div.
$V_{DS(MAX)}$ = 513.83 V, $I_{DS(MAX)}$ = 1.4261 A.

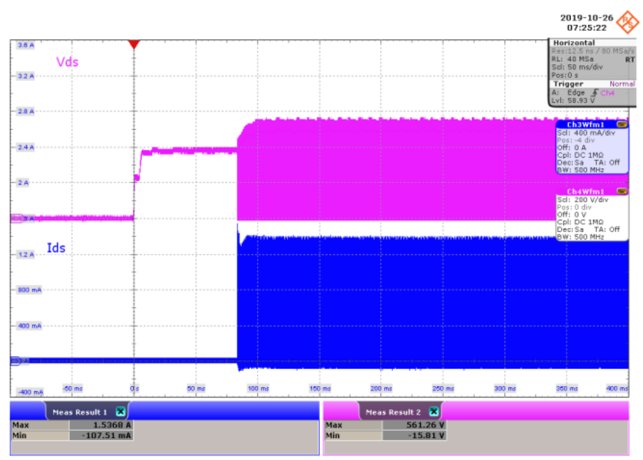


Figure 50 – 265 VAC 50 Hz.
CH3: I_{DS}, 400 mA / div., 50 ms / div.
CH4: V_{DS}, 200 V / div., 50 ms / div.
$V_{DS(MAX)}$ = 561.26 V, $I_{DS(MAX)}$ = 1.5368 A.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

11.3.2.2 0% Load

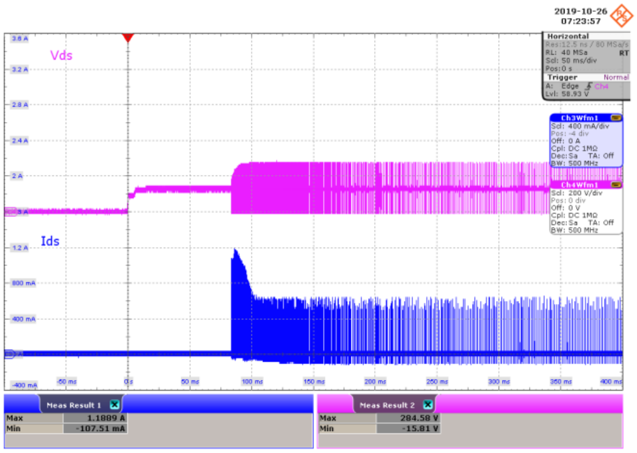


Figure 51 – 90 VAC 60 Hz.
CH3: I_{DS}, 400 mA / div., 50 ms / div.
CH4: V_{DS}, 200 V / div., 50 ms / div.
$V_{DS(MAX)}$ = 284.58 V, $I_{DS(MAX)}$ = 1.1889 A.

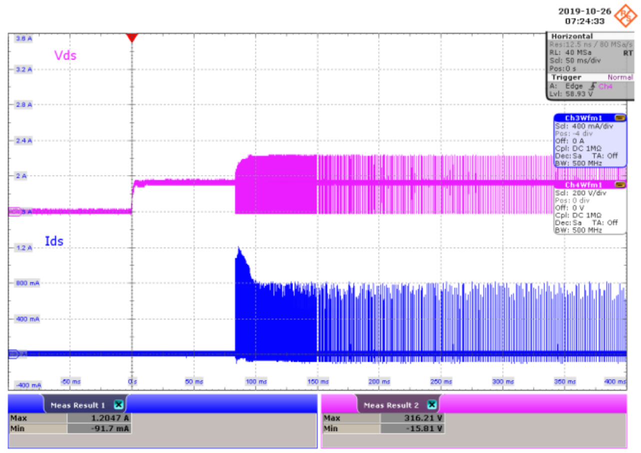


Figure 52 – 115 VAC 60 Hz.
CH3: I_{DS}, 400 mA / div., 50 ms / div.
CH4: V_{DS}, 200 V / div., 50 ms / div.
$V_{DS(MAX)}$ = 316.21 V, $I_{DS(MAX)}$ = 1.2047 A.

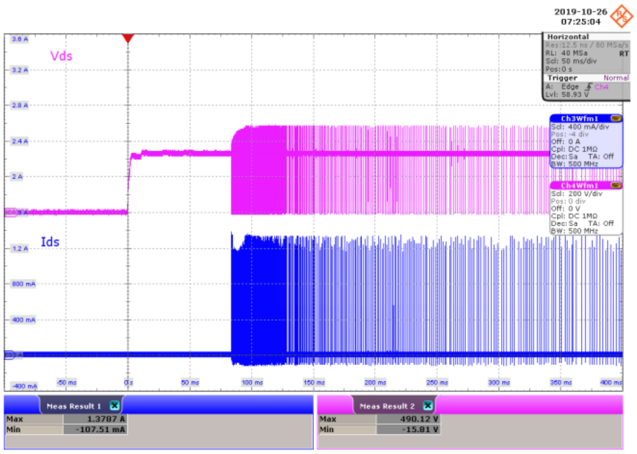


Figure 53 – 230 VAC 50 Hz.
CH3: I_{DS}, 400 mA / div., 50 ms / div.
CH4: V_{DS}, 200 V / div., 50 ms / div.
$V_{DS(MAX)}$ = 490.12 V, $I_{DS(MAX)}$ = 1.3787 A.

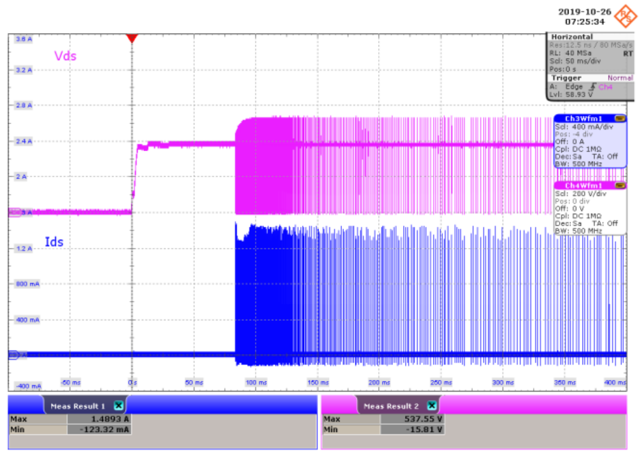


Figure 54 – 265 VAC 50 Hz.
CH3: I_{DS}, 400 mA / div., 50 ms / div.
CH4: V_{DS}, 200 V / div., 50 ms / div.
$V_{DS(MAX)}$ = 537.55 V, $I_{DS(MAX)}$ = 1.4893 A.

11.3.3 SR FET Voltage and Current at Normal Operation

11.3.3.1 100% Load

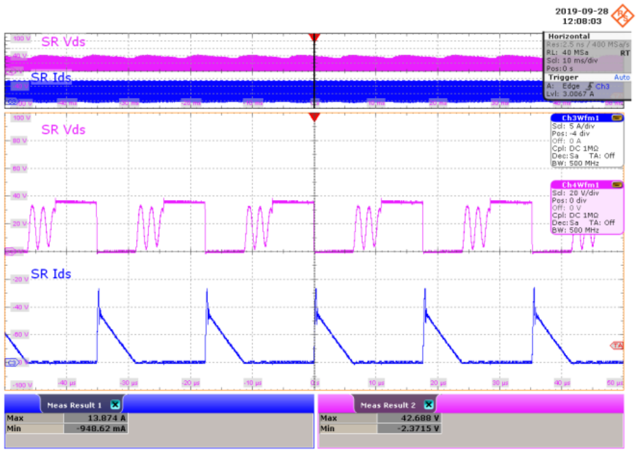


Figure 55 – 90 VAC 60 Hz.
CH3: SR I_{DS}, 5 A / div., 10 ms / div.
CH4: SR V_{DS}, 20 V / div., 10 ms / div.
Zoom: 10 µs / div.
PIV = 42.69 V, $I_{D(MAX)}$ = 13.874 A.

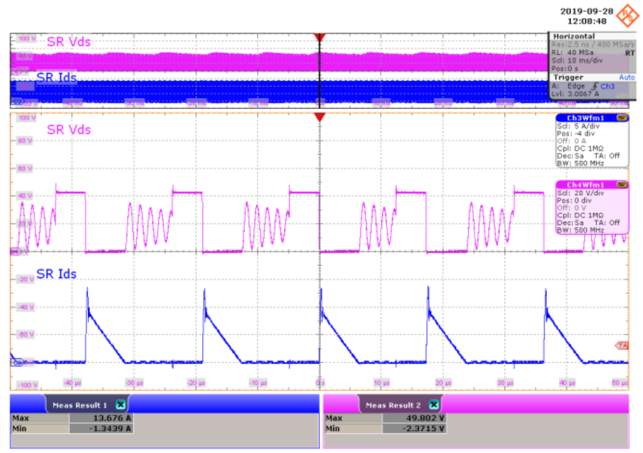


Figure 56 – 115 VAC 60 Hz.
CH3: SR I_{DS}, 5 A / div., 10 ms / div.
CH4: SR V_{DS}, 20 V / div., 10 ms / div.
Zoom: 10 µs / div.
PIV = 49.80 V, $I_{D(MAX)}$ = 13.676 A.

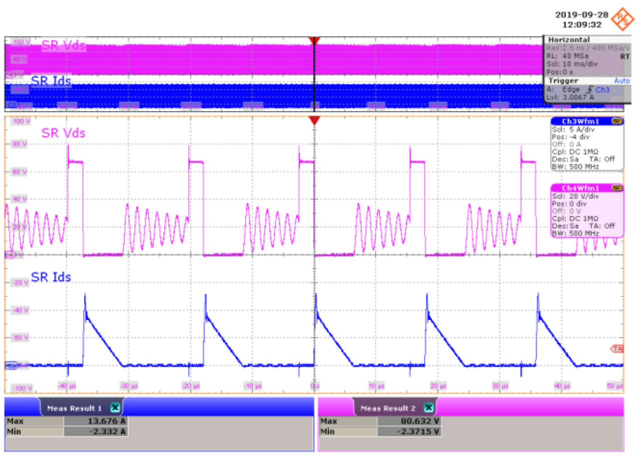


Figure 57 – 230 VAC 50 Hz.
CH3: SR I_{DS}, 5 A / div., 10 ms / div.
CH4: SR V_{DS}, 20 V / div., 10 ms / div.
Zoom: 10 µs / div.
PIV = 80.63 V, $I_{D(MAX)}$ = 13.676 A.

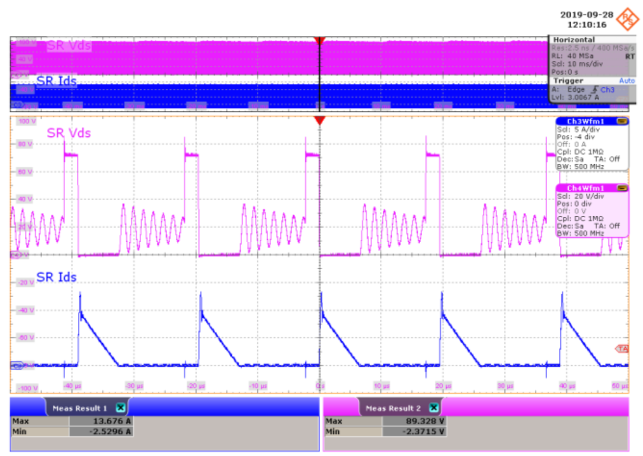


Figure 58 – 265 VAC 50 Hz.
CH3: SR I_{DS}, 5 A / div., 10 ms / div.
CH4: SR V_{DS}, 20 V / div., 10 ms / div.
Zoom: 10 µs / div.
PIV = 89.328 V, $I_{D(MAX)}$ = 13.676 A.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

11.3.3.2 0% Load

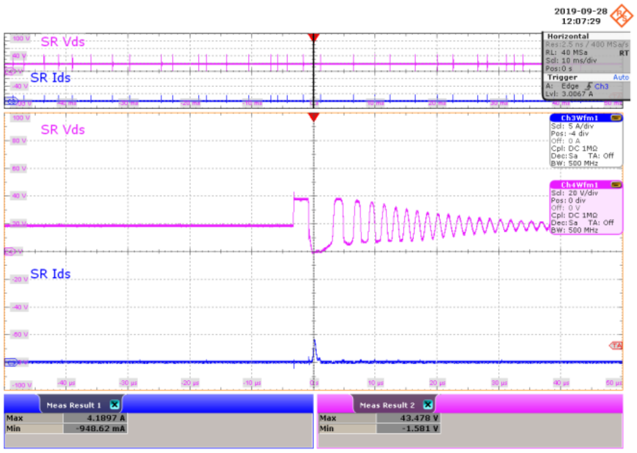


Figure 59 – 90 VAC 60 Hz.
CH3: SR I_{DS}, 5 A / div., 10 ms / div.
CH4: SR V_{DS}, 20 V / div., 10 ms / div.
Zoom: 10 μs / div.
PIV = 43.478 V, $I_{D(MAX)}$ = 4.1897 A.

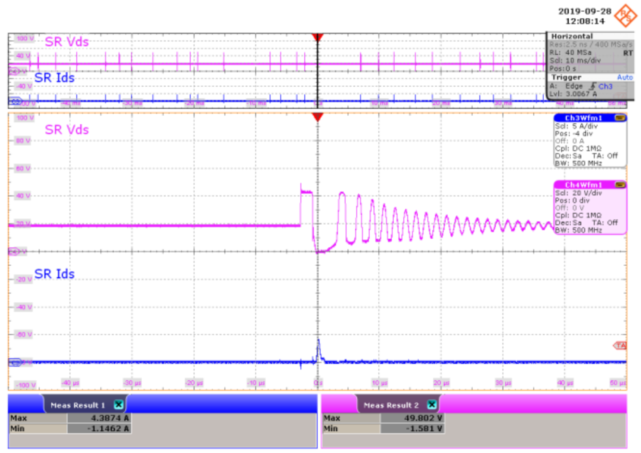


Figure 60 – 115 VAC 60 Hz.
CH3: SR I_{DS}, 5 A / div., 10 ms / div.
CH4: SR V_{DS}, 20 V / div., 10 ms / div.
Zoom: 10 μs / div.
PIV = 49.802 V, $I_{D(MAX)}$ = 4.3874 A.

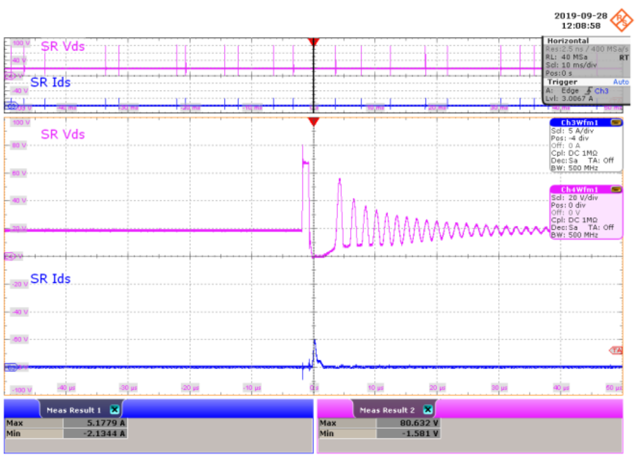


Figure 61 – 230 VAC 50 Hz.
CH3: SR I_{DS}, 5 A / div., 10 ms / div.
CH4: SR V_{DS}, 20 V / div., 10 ms / div.
Zoom: 10 μs / div.
PIV = 80.632 V, $I_{D(MAX)}$ = 5.1779 A.

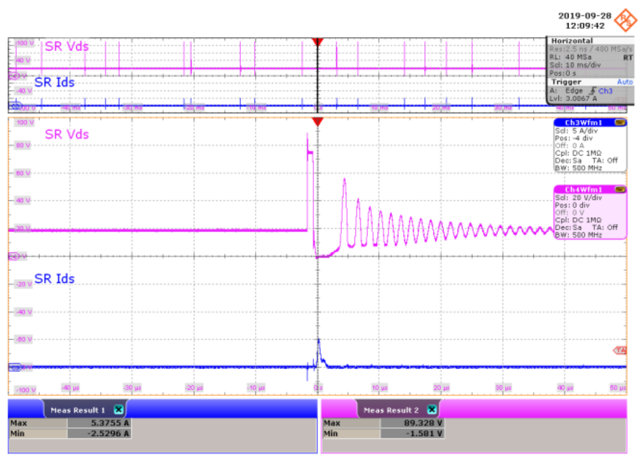


Figure 62 – 265 VAC 50 Hz.
CH3: SR I_{DS}, 5 A / div., 10 ms / div.
CH4: SR V_{DS}, 20 V / div., 10 ms / div.
Zoom: 10 μs / div.
PIV = 89.328 V, $I_{D(MAX)}$ = 5.3755 A.

11.3.4 SR FET Voltage and Current at Start-up Operation

11.3.4.1 100% Load

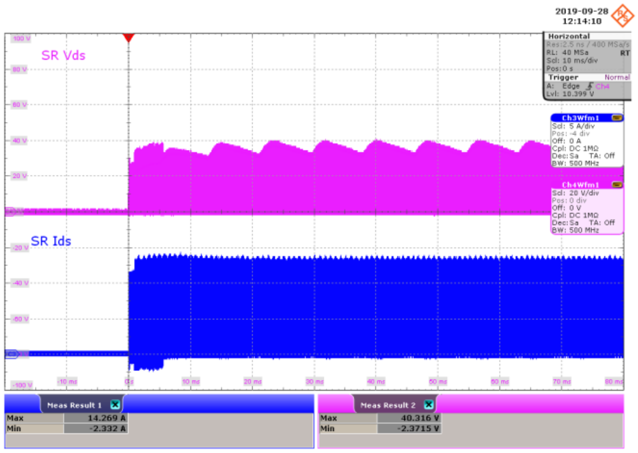


Figure 63 – 90 VAC 60 Hz.
CH3: SR I_{DS}, 5 A / div., 10 ms / div.
CH4: SR V_{DS}, 20 V / div., 10 ms / div.
PIV = 40.316 V, $I_{D(MAX)}$ = 14.369 A.

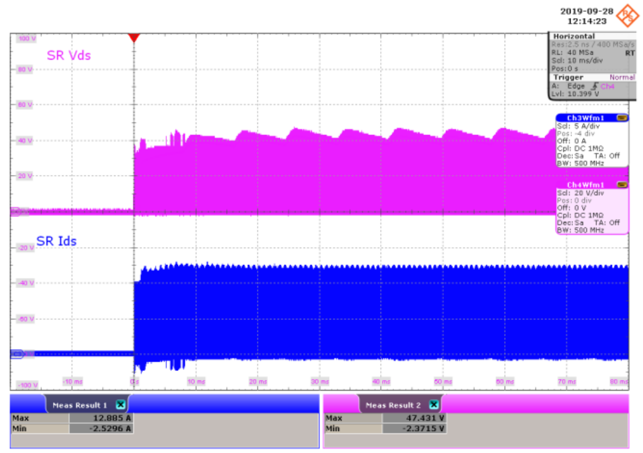


Figure 64 – 115 VAC 60 Hz.
CH3: SR I_{DS}, 5 A / div., 10 ms / div.
CH4: SR V_{DS}, 20 V / div., 10 ms / div.
PIV = 47.431 V, $I_{D(MAX)}$ = 12.885 A.

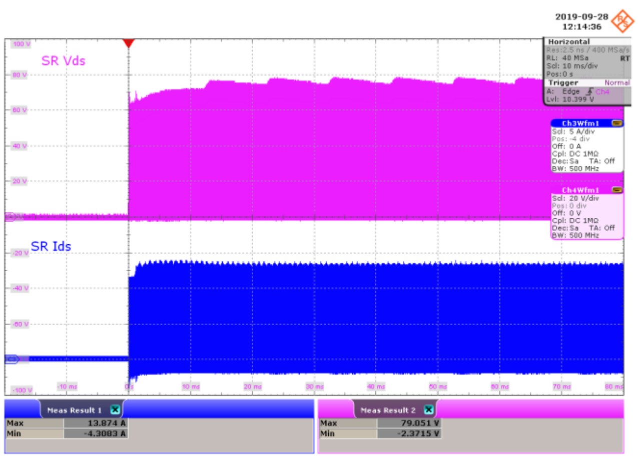


Figure 65 – 230 VAC 50 Hz.
CH3: SR I_{DS}, 5 A / div., 10 ms / div.
CH4: SR V_{DS}, 20 V / div., 10 ms / div.
PIV = 79.051 V, $I_{D(MAX)}$ = 13.874 A.

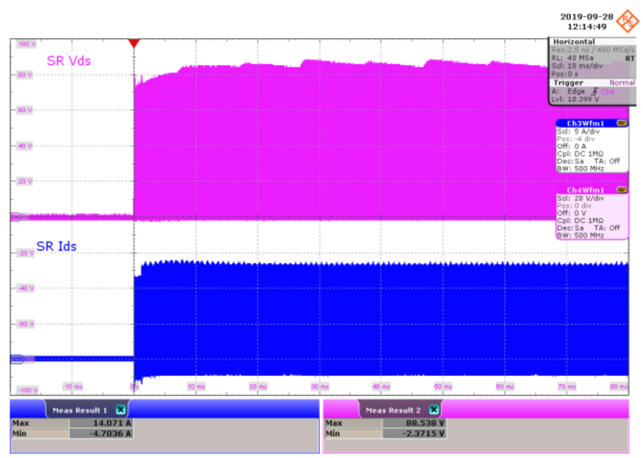


Figure 66 – 265 VAC 50 Hz.
CH3: SR I_{DS}, 5 A / div., 10 ms / div.
CH4: SR V_{DS}, 20 V / div., 10 ms / div.
PIV = 88.538 V, $I_{D(MAX)}$ = 14.071 A.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

11.3.4.2 0% Load

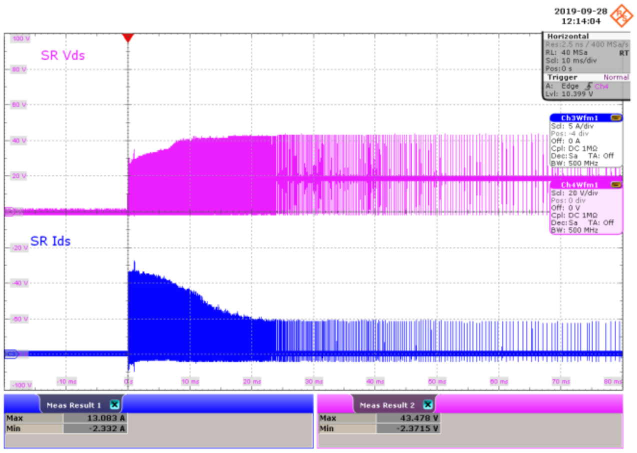


Figure 67 – 90 VAC 60 Hz.
CH3: SR I_{DS}, 5 A / div., 10 ms / div.
CH4: SR V_{DS}, 20 V / div., 10 ms / div.
PIV = 43.478 V, $I_{D(MAX)}$ = 13.083 A.

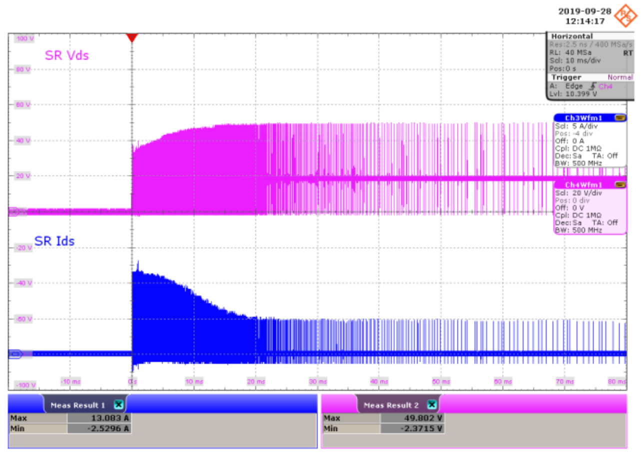


Figure 68 – 115 VAC 60 Hz.
CH3: SR I_{DS}, 5 A / div., 10 ms / div.
CH4: SR V_{DS}, 20 V / div., 10 ms / div.
PIV = 49.802 V, $I_{D(MAX)}$ = 13.083 A.

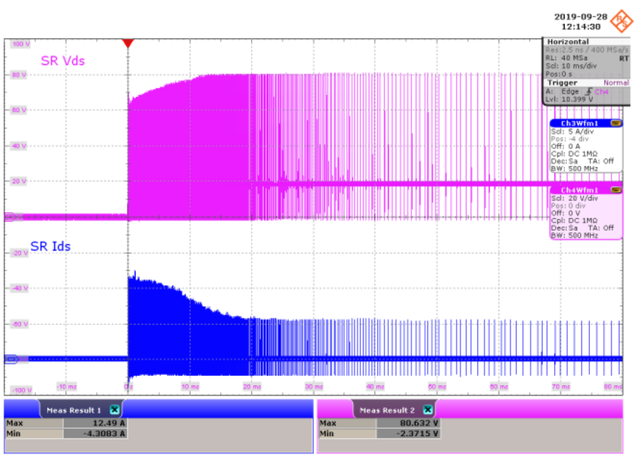


Figure 69 – 230 VAC 50 Hz.
CH3: SR I_{DS}, 5 A / div., 10 ms / div.
CH4: SR V_{DS}, 20 V / div., 10 ms / div.
PIV = 80.632 V, $I_{D(MAX)}$ = 12.49 A.

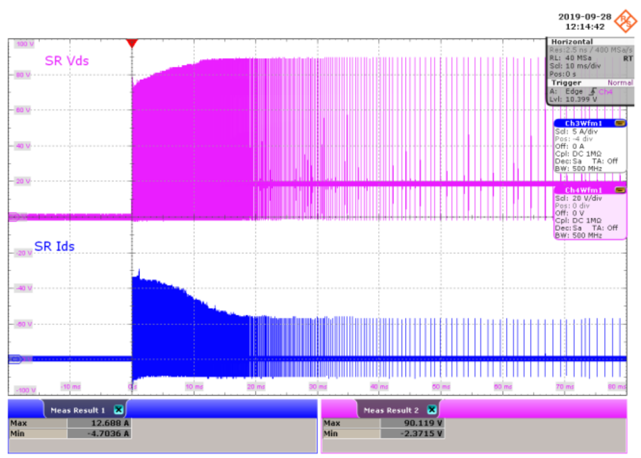


Figure 70 – 265 VAC 50 Hz.
CH3: SR I_{DS}, 5 A / div., 10 ms / div.
CH4: SR V_{DS}, 20 V / div., 10 ms / div.
PIV = 90.119 V, $I_{D(MAX)}$ = 12.688 A.

11.4 *Brown-In and Brown-Out*

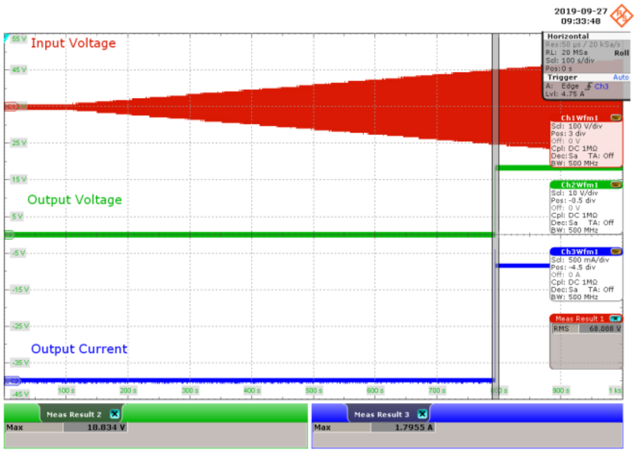


Figure 71 – Brown-In, Full Load.
CH1: V_{IN}, 100 V / div., 100 s / div.
CH2: V_{OUT}, 10 V / div., 100 s / div.
CH3: I_{OUT}, 500 mA / div., 100 s / div.
$V_{IN(UV)}$ = 68.088 V_{RMS}.

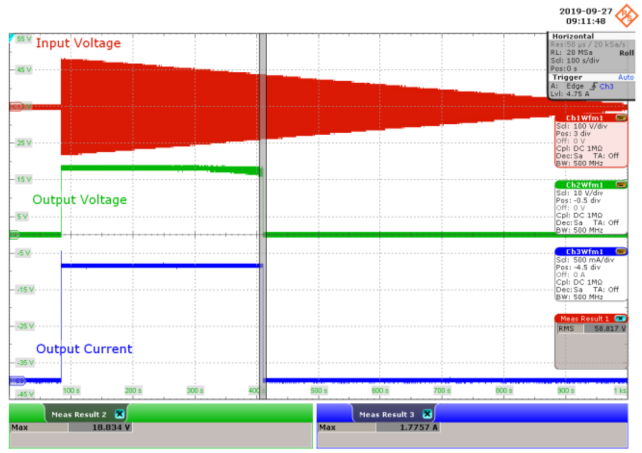


Figure 72 – Brown-Out, Full Load.
CH1: V_{IN}, 100 V / div., 100 s / div.
CH2: V_{OUT}, 10 V / div., 100 s / div.
CH3: I_{OUT}, 500 mA / div., 100 s / div.
$V_{IN(UV)}$ = 58.817 V_{RMS}.

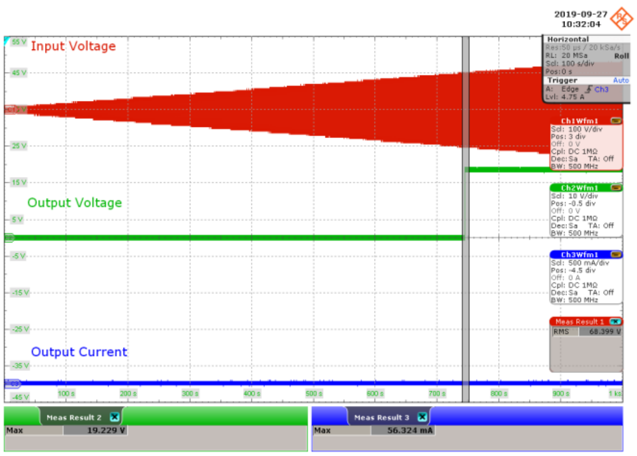


Figure 73 – Brown-In, No Load.
CH1: V_{IN}, 100 V / div., 100 s / div.
CH2: V_{OUT}, 10 V / div., 100 s / div.
CH3: I_{OUT}, 500 mA / div., 100 s / div.
$V_{IN(UV)}$ = 68.399 V_{RMS}.

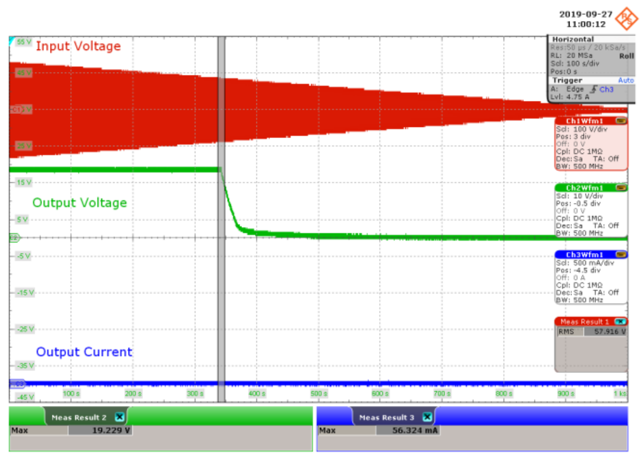


Figure 74 – Brown-Out, No Load.
CH1: V_{IN}, 100 V / div., 100 s / div.
CH2: V_{OUT}, 10 V / div., 100 s / div.
CH3: I_{OUT}, 500 mA / div., 100 s / div.
$V_{IN(UV)}$ = 57.916 V_{RMS}.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

11.5 ***Fault Conditions***

11.5.1 Output Overvoltage

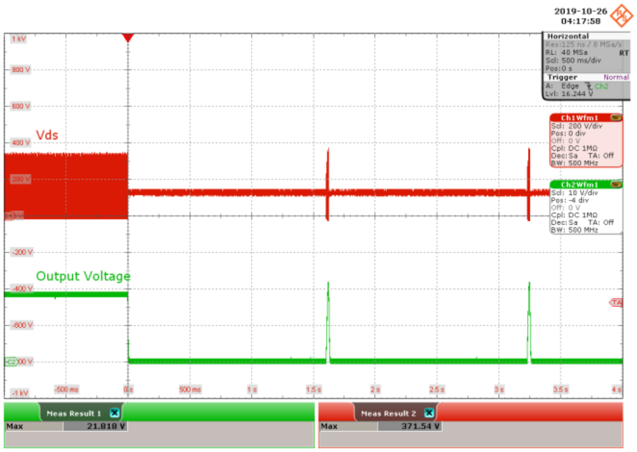


Figure 75 – 90 VAC 60 Hz, Full load
CH1: V_{DS}, 200 V / div., 500 ms / div.
CH2: V_{OUT}, 10 V / div., 500 ms / div.
$V_{DS(MAX)}$ = 371.54 V.
$V_{O(MAX)}$ = 21.818 V.

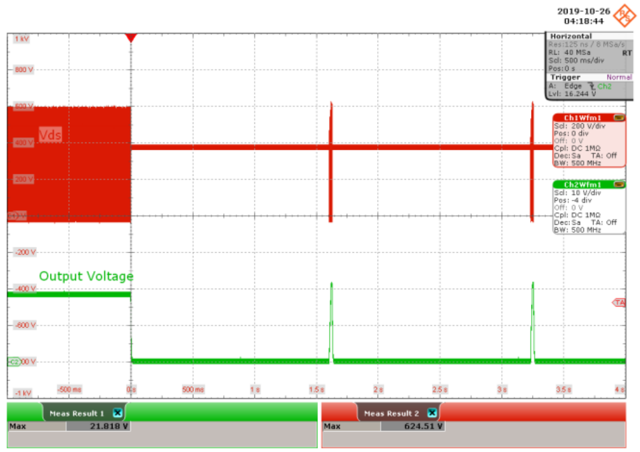


Figure 76 – 265 VAC 60 Hz, Full load
CH1: V_{DS}, 200 V / div., 500 ms / div.
CH2: V_{OUT}, 10 V / div., 500 ms / div.
$V_{DS(MAX)}$ = 624.51 V.
$V_{O(MAX)}$ = 21.818 V.

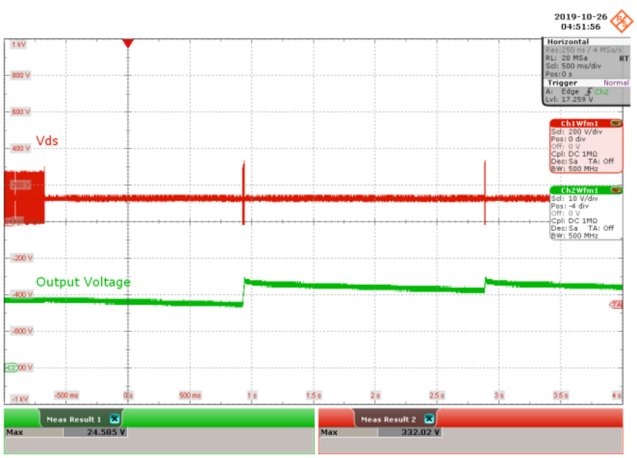


Figure 77 – 90 VAC 60 Hz, No load
CH1: V_{DS}, 200 V / div., 500 ms / div.
CH2: V_{OUT}, 10 V / div., 500 ms / div.
$V_{DS(MAX)}$ = 332.02 V.
$V_{O(MAX)}$ = 24.585 V.

Figure 78 – 265 VAC 60 Hz, No load
CH1: V_{DS}, 200 V / div., 500 ms / div.
CH2: V_{OUT}, 10 V / div., 500 ms / div.
$V_{DS(MAX)}$ = 592.89 V.
$V_{O(MAX)}$ = 24.585 V.

11.5.2 Output Short-Circuit

Test Condition: Short circuit applied at startup

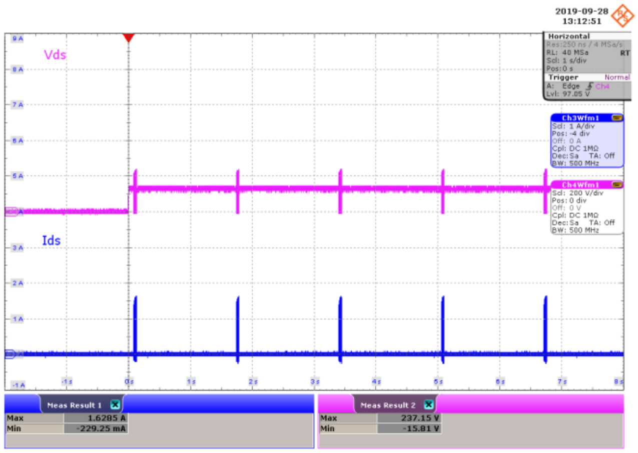


Figure 79 – 90 VAC 60 Hz.
CH3: I_{DS}, 1 A / div., 1 s / div.
CH4: V_{DS}, 200 V / div., 1 s / div.
$V_{DS(MAX)}$ = 237.15 V.
$I_{DS(MAX)}$ = 1.6285 A.

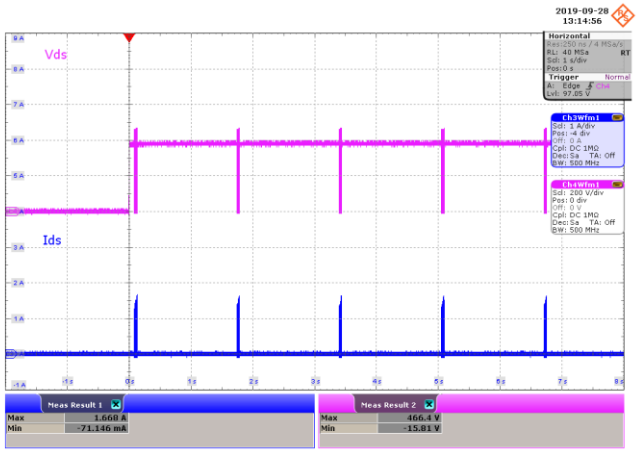


Figure 80 – 265 VAC 60 Hz.
CH3: I_{DS}, 1 A / div., 1 s / div.
CH4: V_{DS}, 200 V / div., 1 s / div.
$V_{DS(MAX)}$ = 466.4 V.
$I_{DS(MAX)}$ = 1.668 A.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

11.6 ***Output Voltage Ripple***

11.6.1 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).

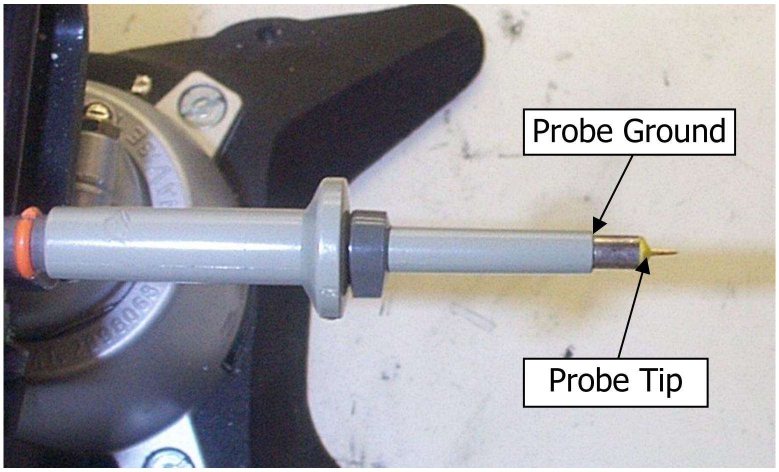


Figure 81 – Oscilloscope Probe Prepared for Ripple Measurement. (End Cap and Ground Lead Removed.)

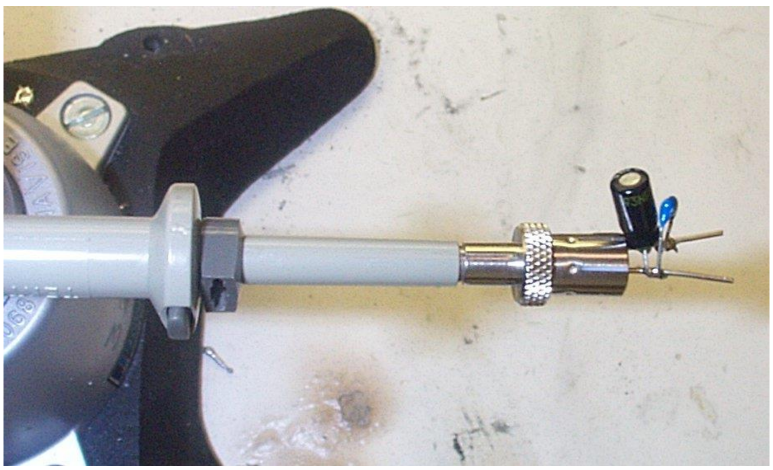


Figure 82 – Oscilloscope Probe with Probe Master (**www.probemaster.com**) 4987A BNC Adapter. (Modified with wires for ripple measurement, and two parallel decoupling capacitors added.)

11.6.2 Measurement Results

Note: All ripple measurements were taken at end of cable.

11.6.2.1 100% Load Condition

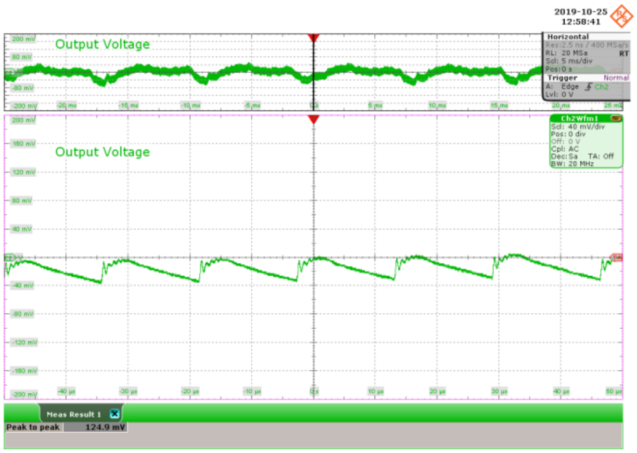


Figure 83 – 90 VAC 60 Hz.
CH2: V_{OUT}, 40 mV / div., 5 ms / div.
Zoom: 10 µs / div.
Output Ripple = 124.9 mV.

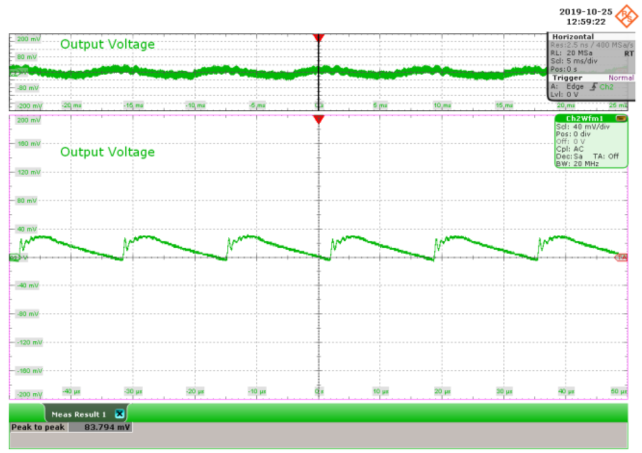


Figure 84 – 115 VAC 60 Hz.
CH2: V_{OUT}, 40 mV / div., 5 ms / div.
Zoom: 10 µs / div.
Output Ripple = 83.794 mV.

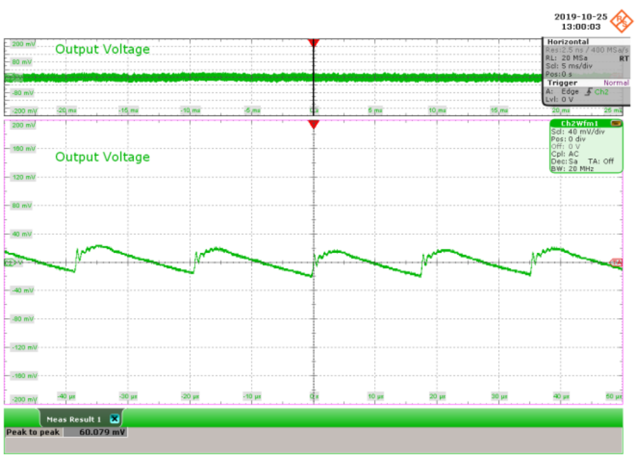


Figure 85 – 230 VAC 50 Hz.
CH2: V_{OUT}, 40 mV / div., 5 ms / div.
Zoom: 10 µs / div.
Output Ripple = 60.079 mV.

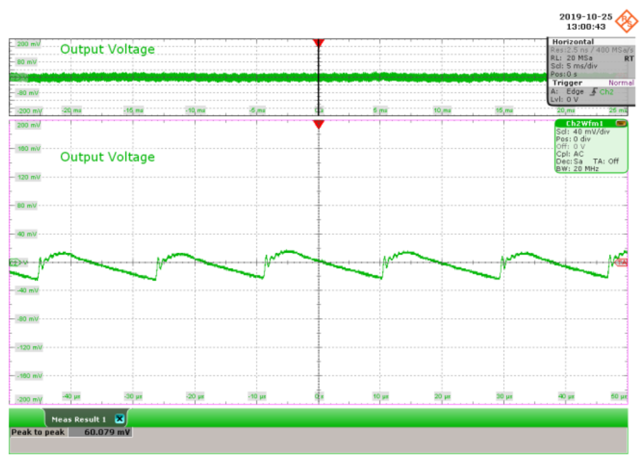


Figure 86 – 265 VAC 50 Hz.
CH2: V_{OUT}, 40 mV / div., 5 ms / div.
Zoom: 10 µs / div.
Output Ripple = 60.079 mV.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

11.6.2.2 75% Load Condition

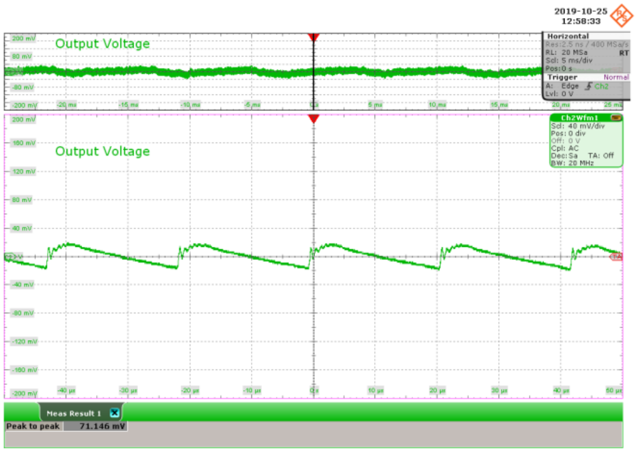


Figure 87 – 90 VAC 60 Hz.
CH2: V_{OUT}, 40 mV / div., 5 ms / div.
Zoom: 10 µs / div.
Output Ripple = 71.146 mV.

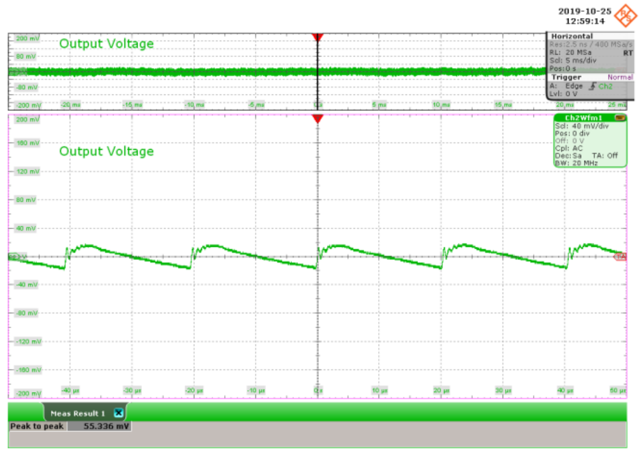


Figure 88 – 115 VAC 60 Hz.
CH2: V_{OUT}, 40 mV / div., 5 ms / div.
Zoom: 10 µs / div.
Output Ripple = 55.336 mV.

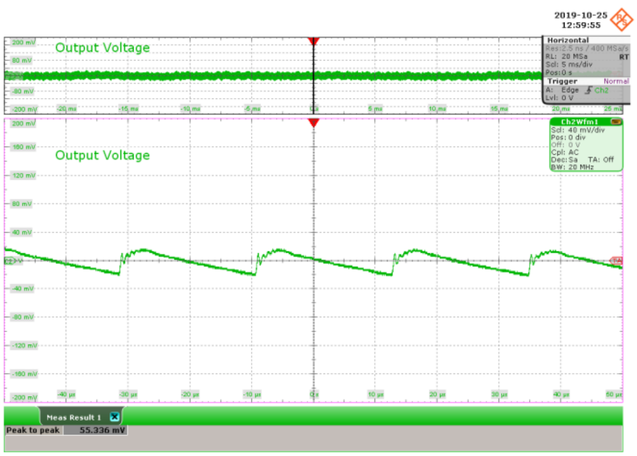


Figure 89 – 230 VAC 50 Hz.
CH2: V_{OUT}, 40 mV / div., 5 ms / div.
Zoom: 10 µs / div.
Output Ripple = 55.336 mV.

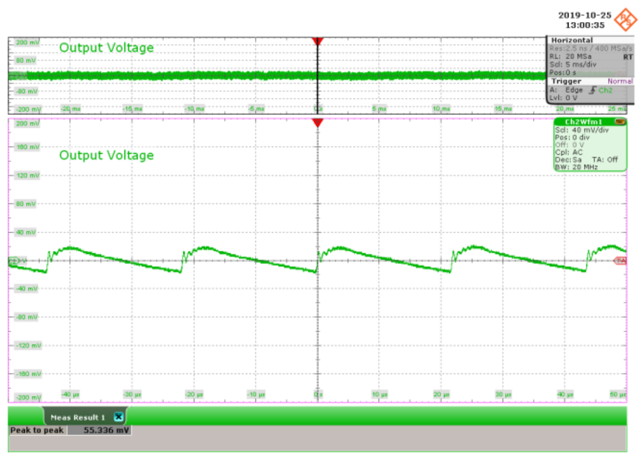


Figure 90 – 265 VAC 50 Hz.
CH2: V_{OUT}, 40 mV / div., 5 ms / div.
Zoom: 10 µs / div.
Output Ripple = 55.336 mV.

11.6.2.3 50% Load Condition

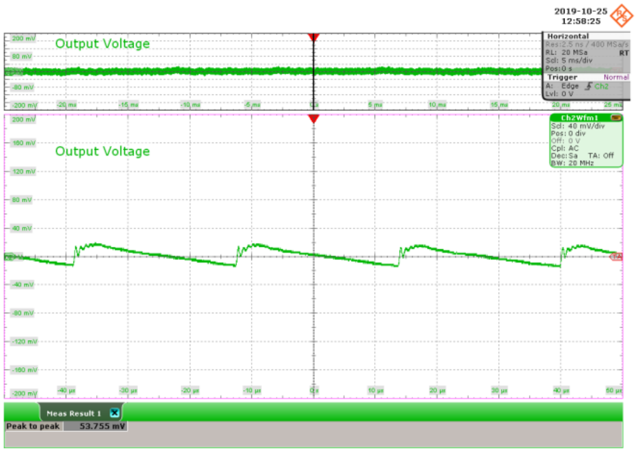


Figure 91 – 90 VAC 60 Hz.
CH2: V_{OUT}, 40 mV / div., 5 ms / div.
Zoom: 10 µs / div.
Output Ripple = 53.755 mV.

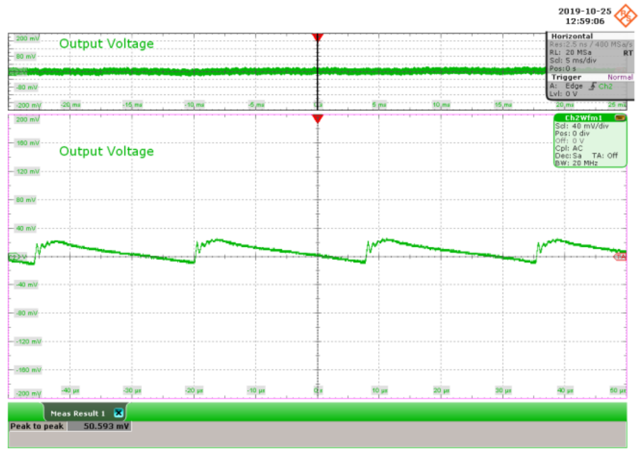


Figure 92 – 115 VAC 60 Hz.
CH2: V_{OUT}, 40 mV / div., 5 ms / div.
Zoom: 10 µs / div.
Output Ripple = 50.593 mV.

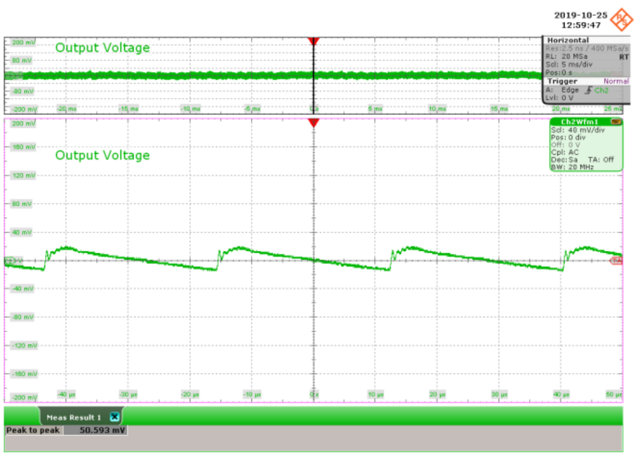


Figure 93 – 230 VAC 50 Hz.
CH2: V_{OUT}, 40 mV / div., 5 ms / div.
Zoom: 10 µs / div.
Output Ripple = 50.593 mV.

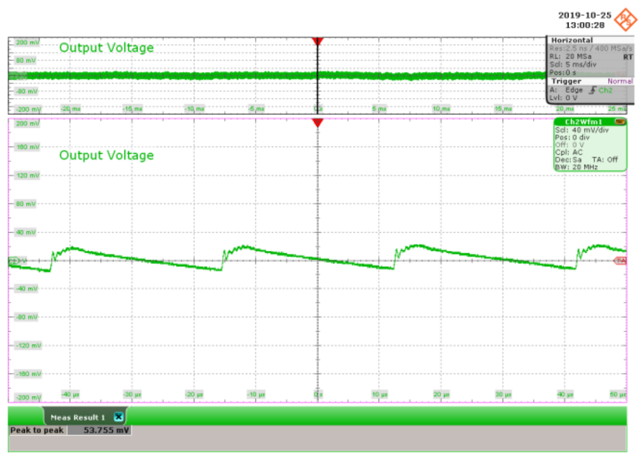


Figure 94 – 265 VAC 50 Hz.
CH2: V_{OUT}, 40 mV / div., 5 ms / div.
Zoom: 10 µs / div.
Output Ripple = 53.755 mV.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

11.6.2.4 25% Load Condition

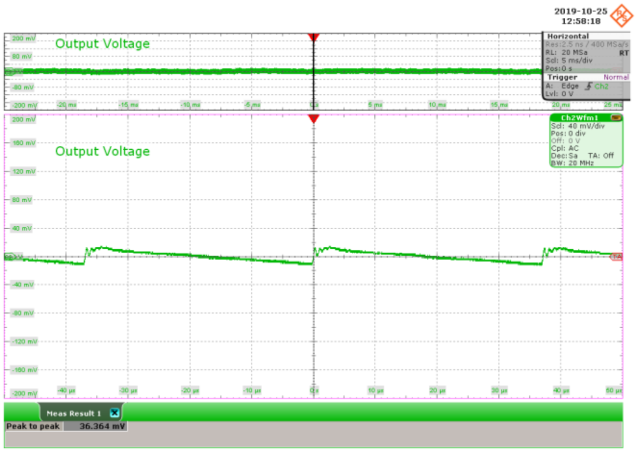


Figure 95 – 90 VAC 60 Hz.
CH2: V_{OUT}, 40 mV / div., 5 ms / div.
Zoom: 10 µs / div.
Output Ripple = 36.364 mV.

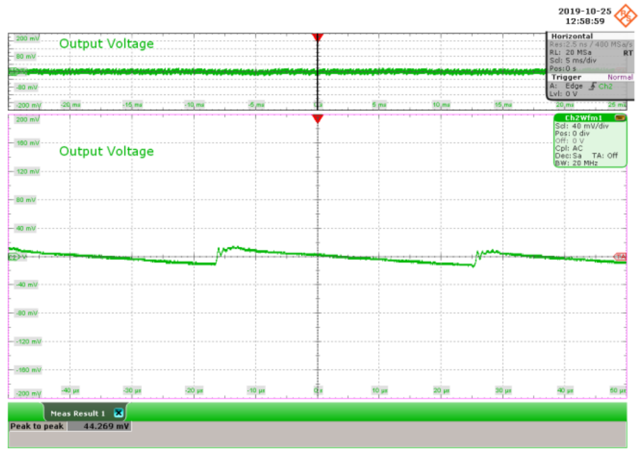


Figure 96 – 115 VAC 60 Hz.
CH2: V_{OUT}, 40 mV / div., 5 ms / div.
Zoom: 10 µs / div.
Output Ripple = 44.269 mV.

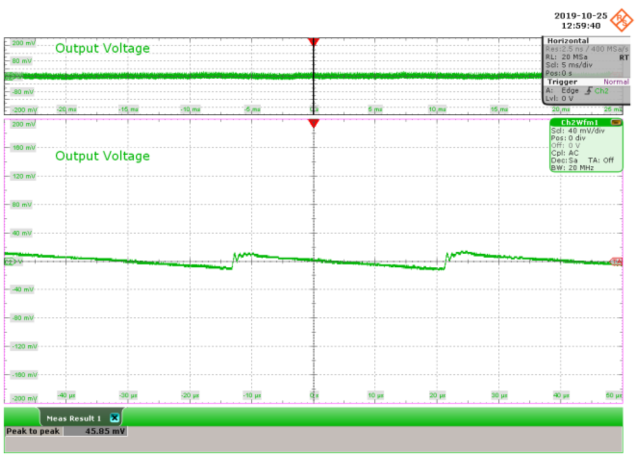


Figure 97 – 230 VAC 50 Hz.
CH2: V_{OUT}, 40 mV / div., 5 ms / div.
Zoom: 10 µs / div.
Output Ripple = 45.85 mV.

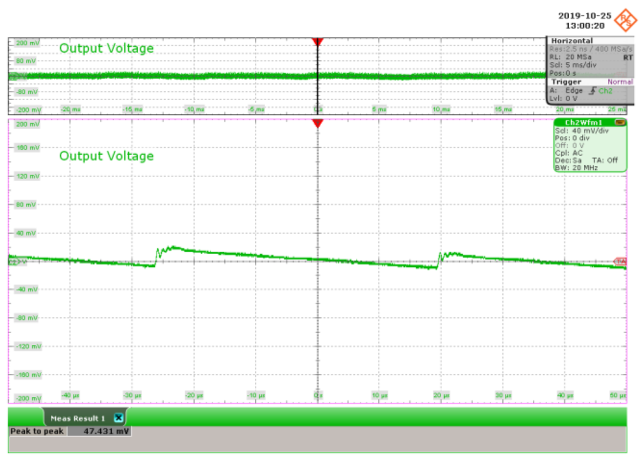


Figure 98 – 265 VAC 50 Hz.
CH2: V_{OUT}, 40 mV / div., 5 ms / div.
Zoom: 10 µs / div.
Output Ripple = 47.431 mV.

11.6.2.5 0% Load Condition

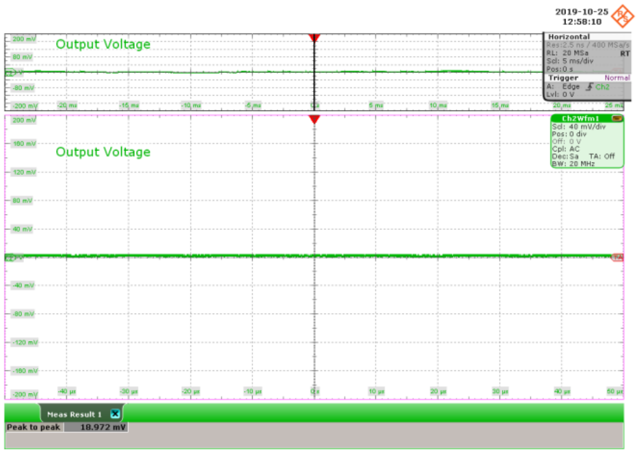


Figure 99 – 90 VAC 60 Hz.
CH2: V_{OUT}, 40 mV / div., 5 ms / div.
Zoom: 10 µs / div.
Output Ripple = 18.972 mV.

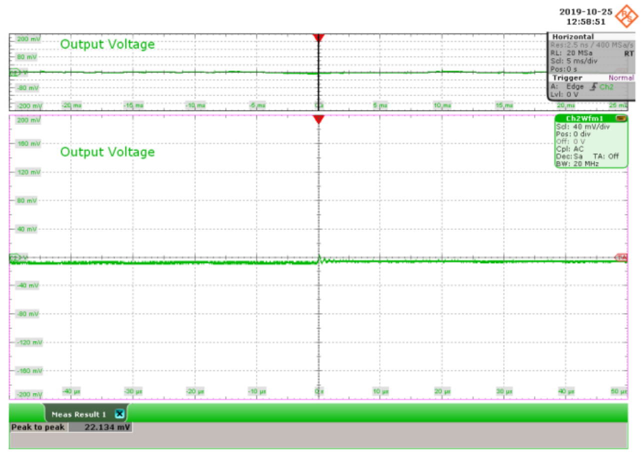


Figure 100 – 115 VAC 60 Hz.
CH2: V_{OUT}, 40 mV / div., 5 ms / div.
Zoom: 10 µs / div.
Output Ripple = 22.134 mV.

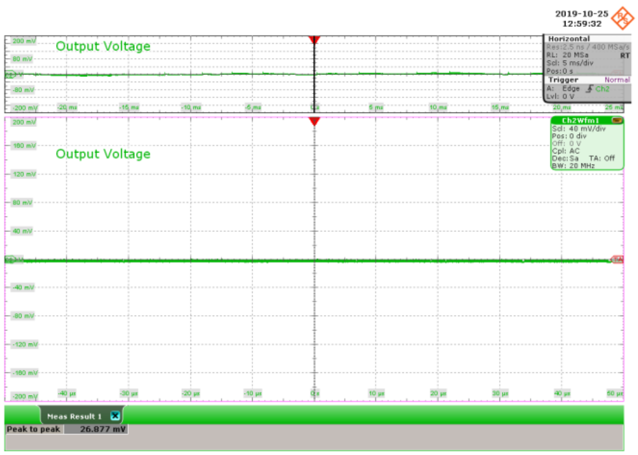


Figure 101 – 230 VAC 50 Hz.
CH2: V_{OUT}, 40 mV / div., 5 ms / div.
Zoom: 10 µs / div.
Output Ripple = 26.877 mV.

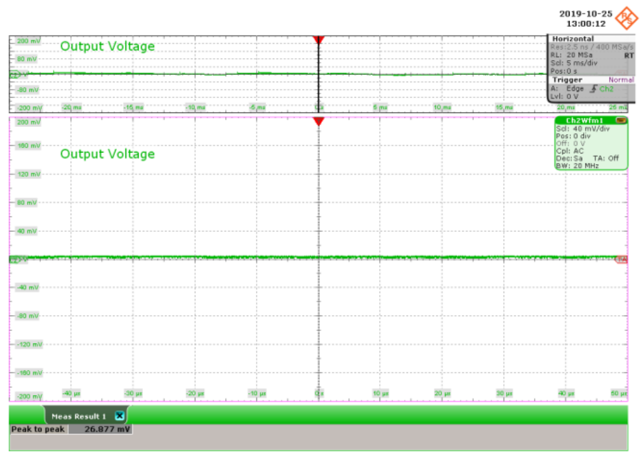


Figure 102 – 265 VAC 50 Hz.
CH2: V_{OUT}, 40 mV / div., 5 ms / div.
Zoom: 10 µs / div.
Output Ripple = 26.877 mV.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

11.6.3 Output Ripple Voltage Graph from 0% - 100%

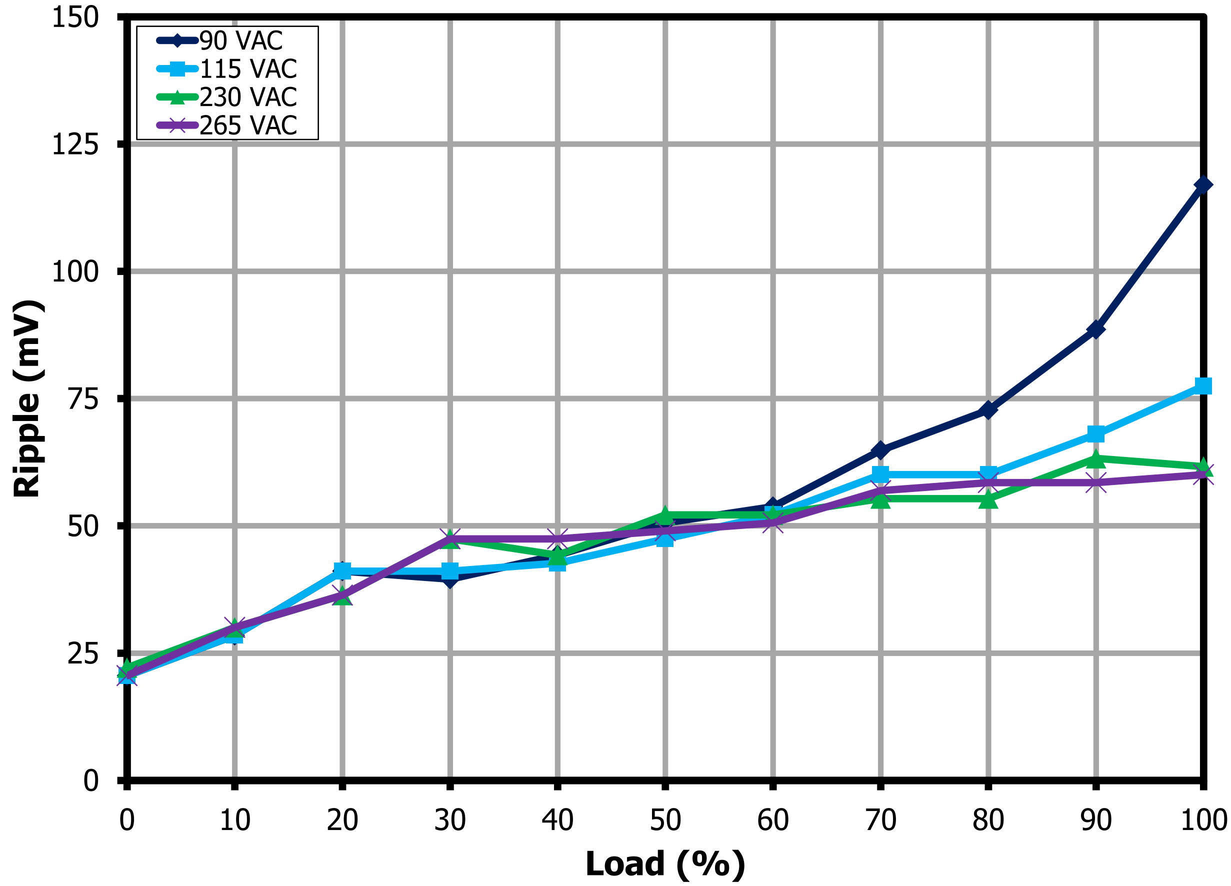


Figure 103 – Measured at the End of 2m Cable, at Room Temperature.

12 Thermal Performance

12.1 *Test Set-Up*

Thermal evaluation was performed under two conditions: (1) room temperature with the circuit board enclosed inside an acrylic box and (2), 50 ºC ambient inside a thermal chamber. In both conditions, the circuit is soaked for one hour under full load conditions.

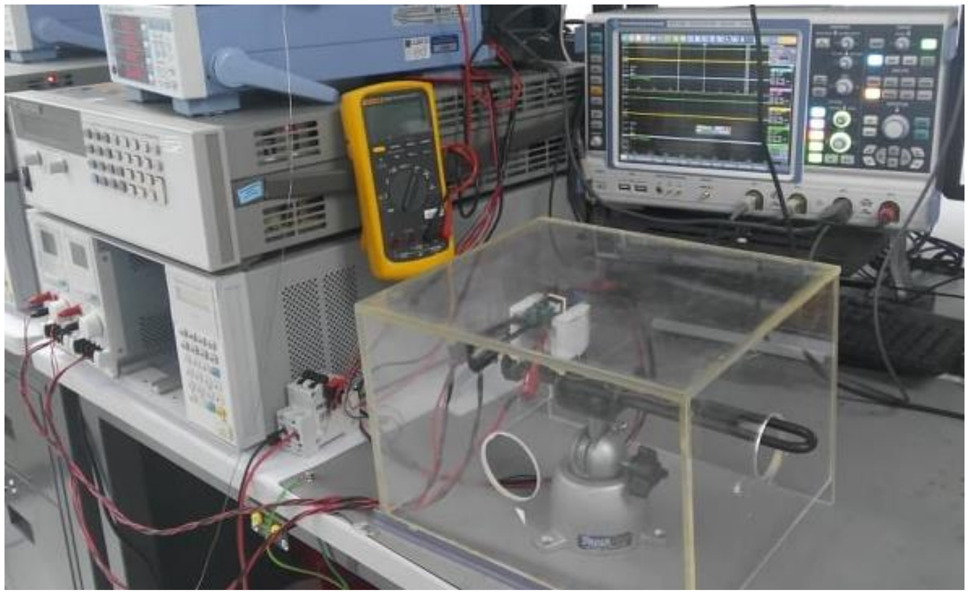


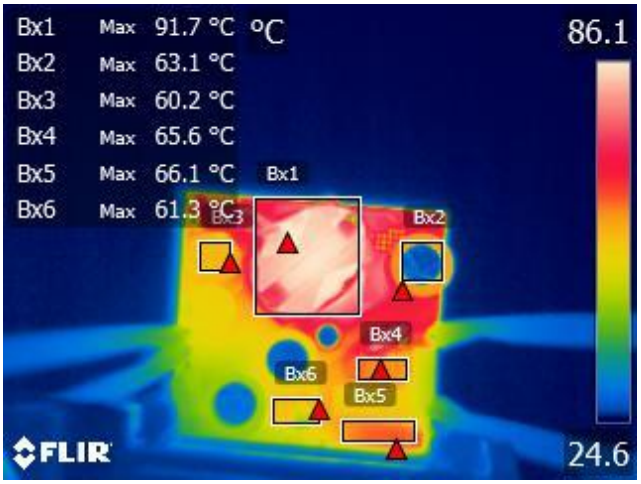
Figure 104 – Thermal Performance Set-up Using an Acrylic Box.

Figure 105 – Thermal Performance Set-up Using Thermal Chamber.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

12.2 ***Thermal Performance at Room Temperature***

12.2.1 90 VAC at Room Temperature



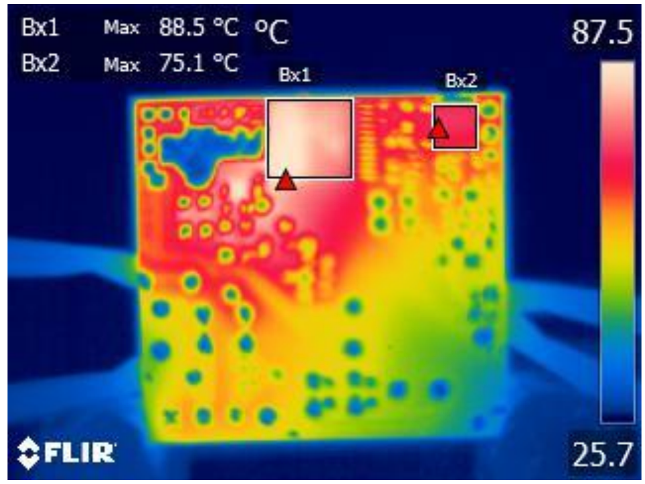


Figure 106 – Thermal Performance at 90 VAC.

Component	Temperature (°C)
Ambient	25.7
Input Capacitor (C3)	63.1
Output Capacitor (C12)	60.2
SR FET	75.1
INN3267 (U1)	88.5
CMC L1	65.6
CMC L2	61.3
Transformer	91.7
Bridge	66.1

12.2.2 265 VAC at Room Temperature

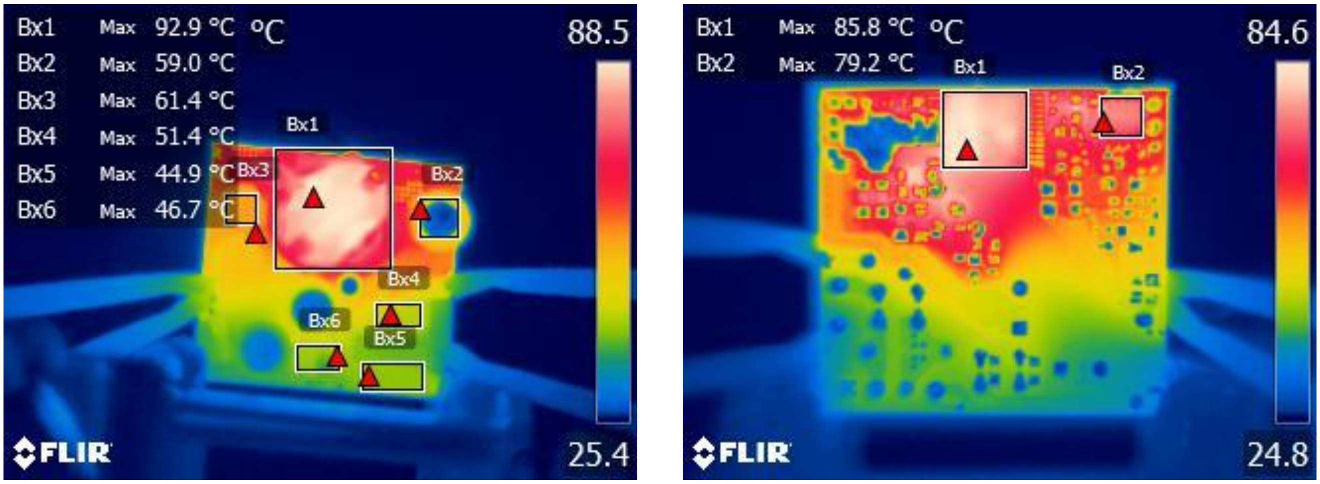


Figure 107 – Thermal Performance at 265 VAC.

Component	Temperature (°C)
Ambient	24.8
Input Capacitor (C3)	59.0
Output Capacitor (C12)	61.4
SR FET	79.2
INN3267 (U1)	85.8
CMC L1	51.4
CMC L2	46.7
Transformer	92.9
Bridge	44.9

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

12.3 ***Thermal Performance at 50 °C***

12.3.1 90 VAC at 50 °C

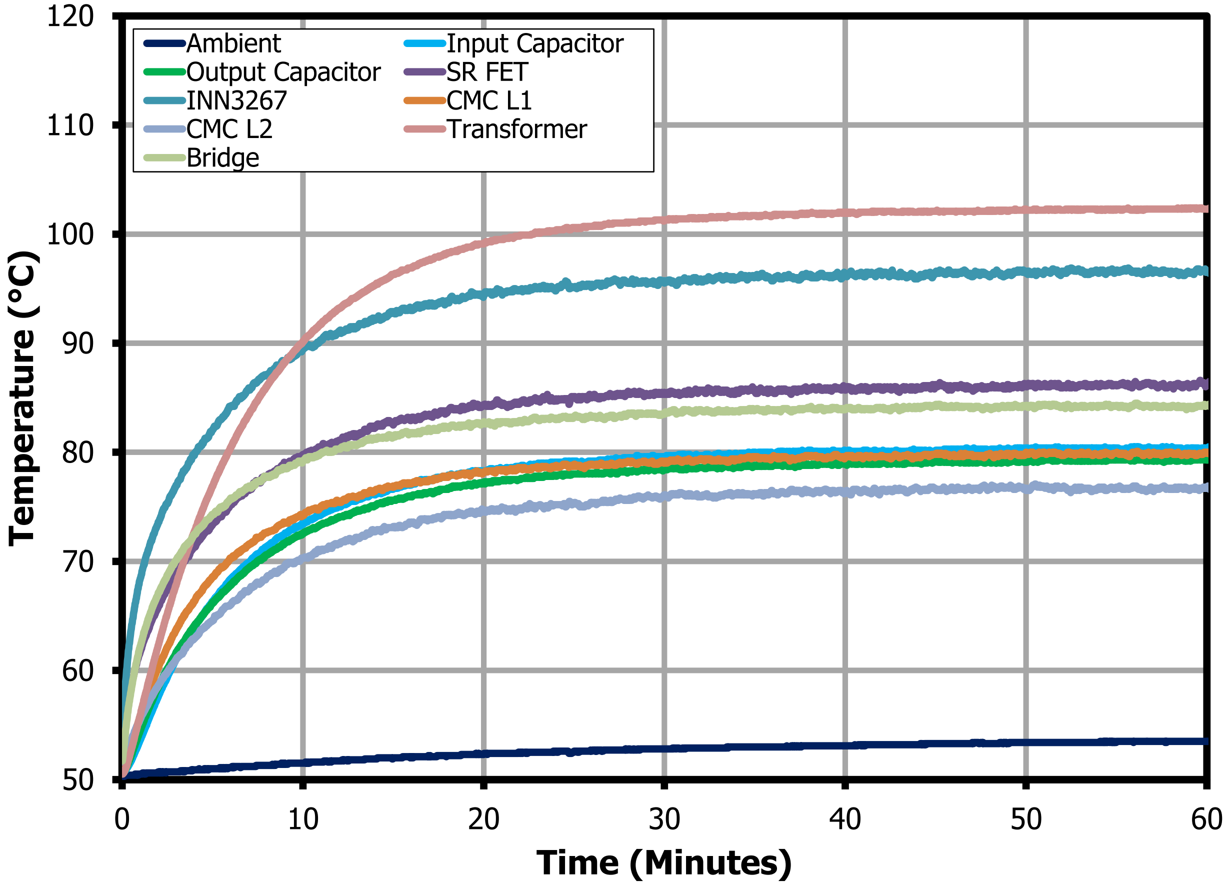


Figure 108 – Thermal Performance at 90 VAC, Full Load.

Component	Temperature (°C)
Ambient	53.5
Input Capacitor (C3)	80.5
Output Capacitor (C12)	79.4
SR FET	86.1
INN3267 (U1)	96.4
CMC L1	79.7
CMC L2	76.6
Transformer	102.4
Bridge	84.1

12.3.2 265 VAC at 50 °C

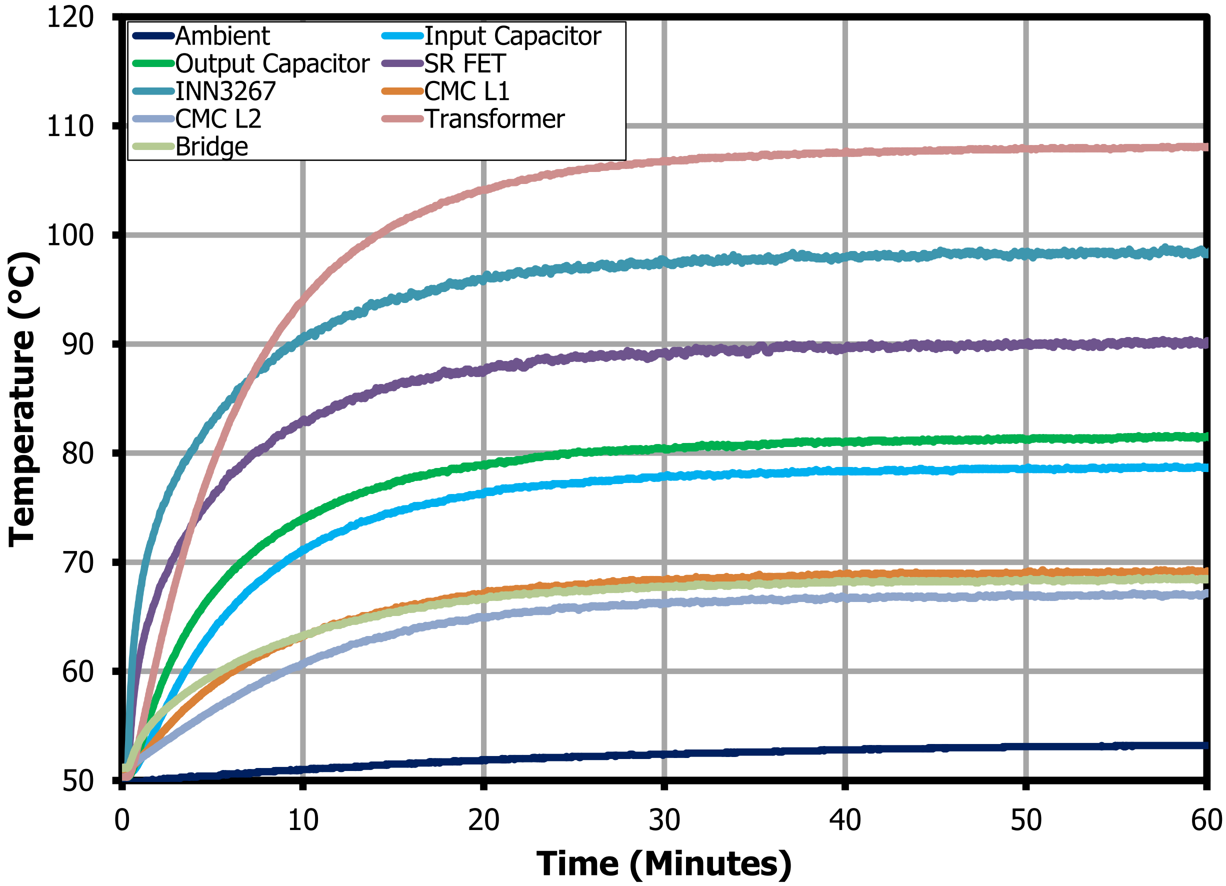


Figure 109 – Thermal Performance at 265 VAC, Full Load.

Component	Temperature (°C)
Ambient	53.4
Input Capacitor (C3)	78.7
Output Capacitor (C12)	81.5
SR FET	90.3
INN3267 (U1)	98.4
CMC L1	69.2
CMC L2	67.1
Transformer	108.2
Bridge	68.6

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

12.4 ***Over Temperature Protection***

12.4.1 OTP at 90 VAC

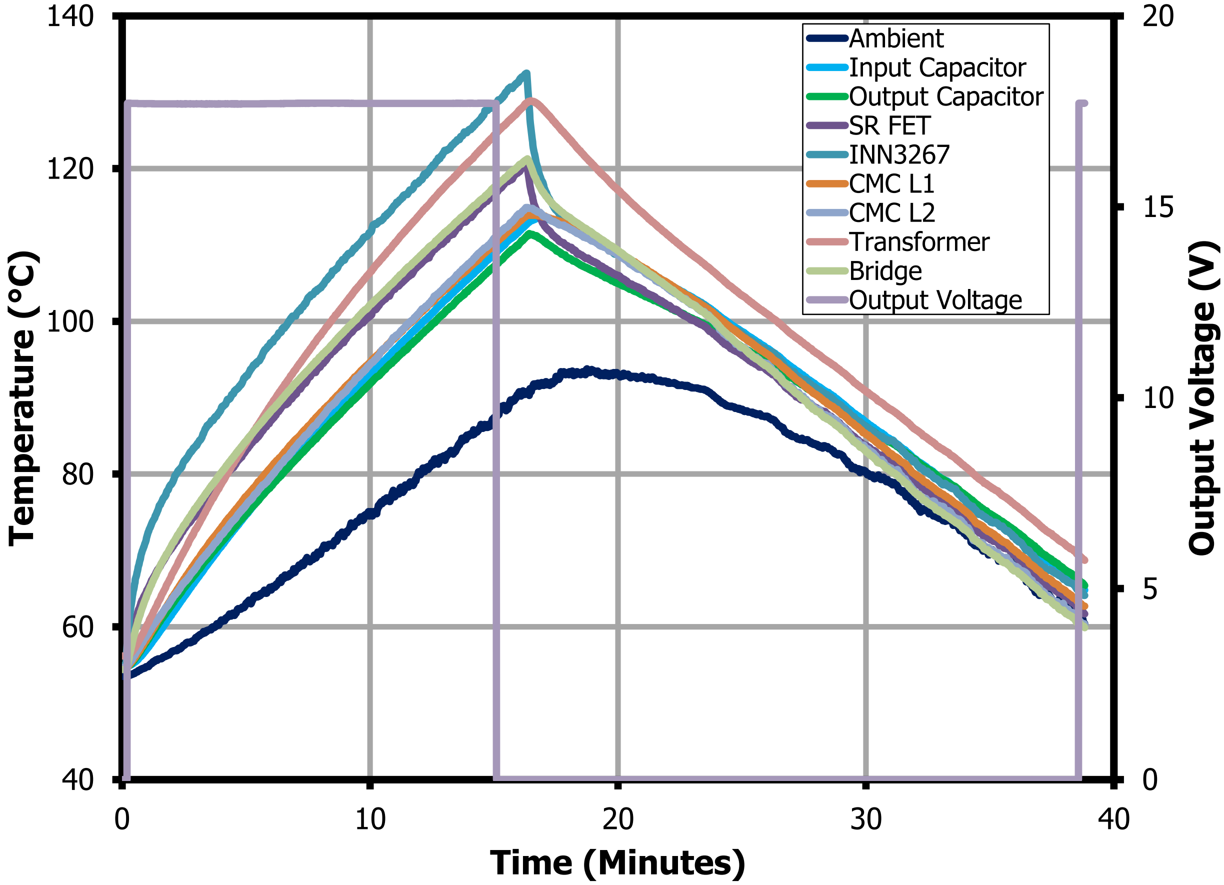


Figure 110 – Over Temperature Protection at 90 VAC.

Component	At OTP Trigger Temperature (°C)	At Recovery Temperature (°C)
Ambient	90.7	59.2
Input Capacitor (C3)	112.7	63.5
Output Capacitor (C12)	111.1	64.1
SR FET	120.7	60
INN3267 (U1)	132.5	62.5
CMC L1	113.9	61.3
CMC L2	114.9	58.5
Transformer	128.6	67.4
Bridge	121.2	58.4

12.4.2 OTP at 265 VAC

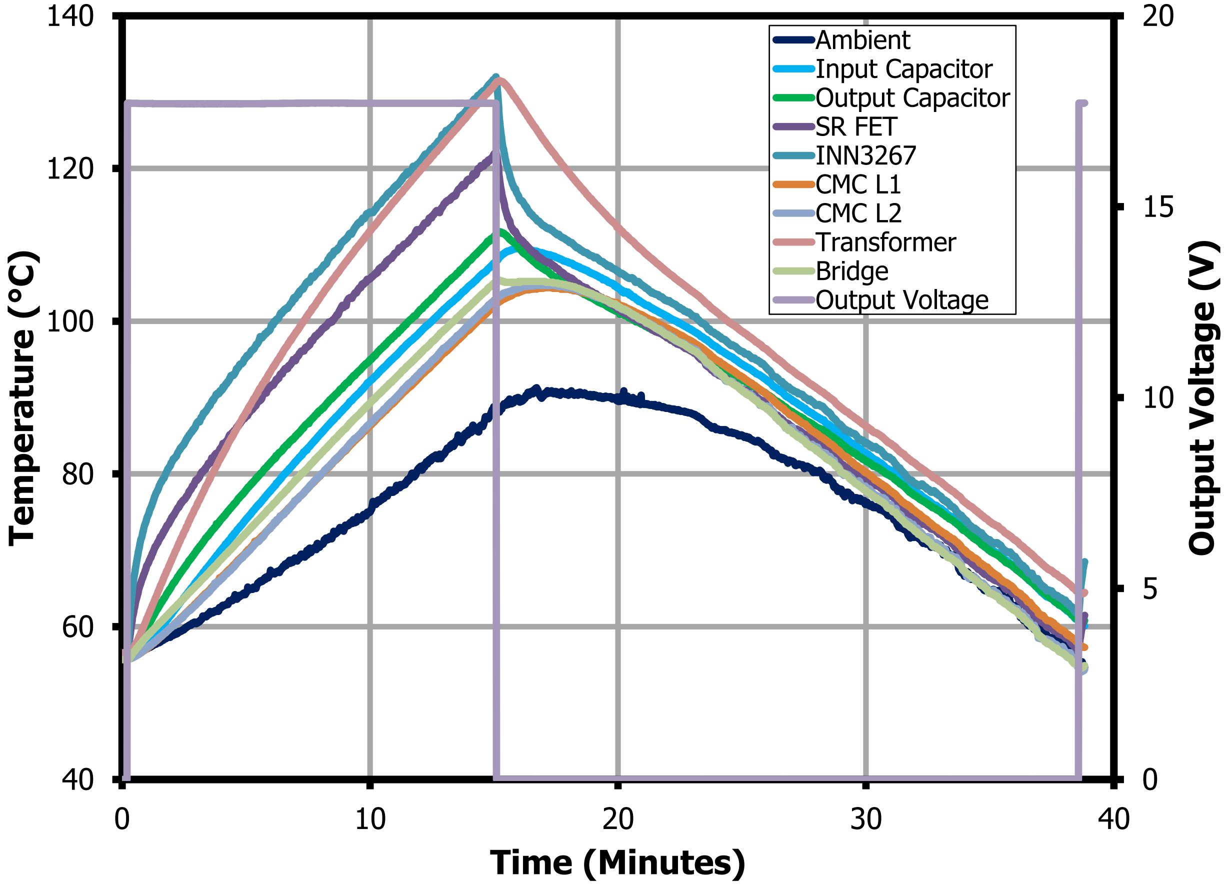


Figure 111 – Over Temperature Protection at 265 VAC.

Component	At OTP Trigger Temperature (°C)	At Recovery Temperature (°C)
Ambient	88.1	55.5
Input Capacitor (C3)	107.9	60.7
Output Capacitor (C12)	111.6	60.9
SR FET	121.9	57.1
INN3267 (U1)	131.7	61.9
CMC L1	102.2	57.7
CMC L2	103	54.7
Transformer	131.3	64.5
Bridge	105.3	54.7

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

13 Conducted EMI

Conducted emissions tests were performed at 115 VAC and 230 VAC at full load (18 V, 1.67 A). Measurements were taken with output grounded and a 2m cable between the PCB and the resistor load.

13.1 *Test Set-up Equipment*

13.1.1 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 Hi-tester.
4. Chroma measurement test fixture.
5. Input voltage set at 115 VAC and 230 VAC.

13.2 *Test Set-up*

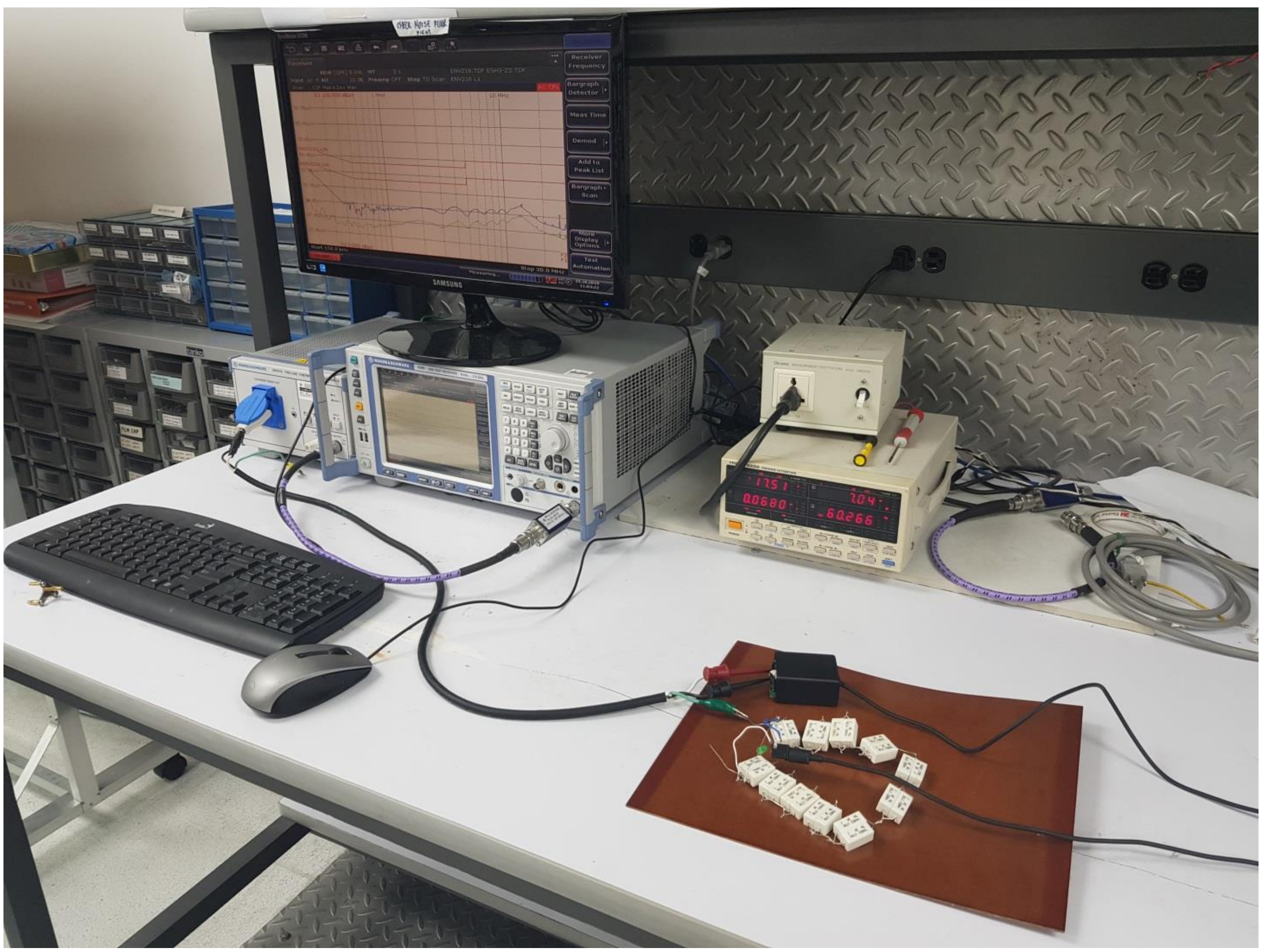


Figure 112 – EMI Test Set-up.

13.3 *Test Results*

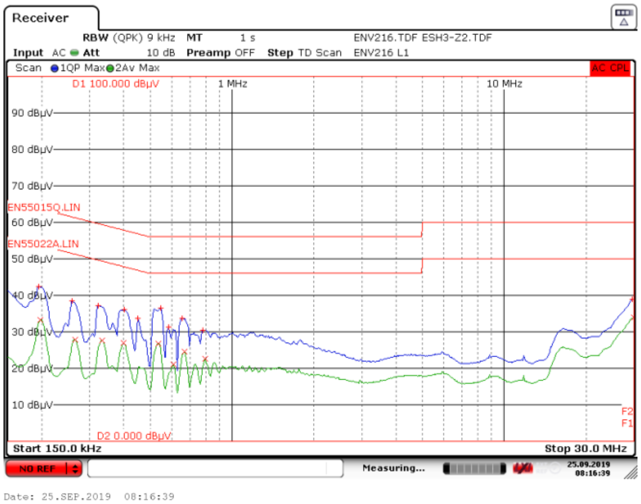


Figure 113 – 115 VAC 60 Hz.
Line with Output Grounded.

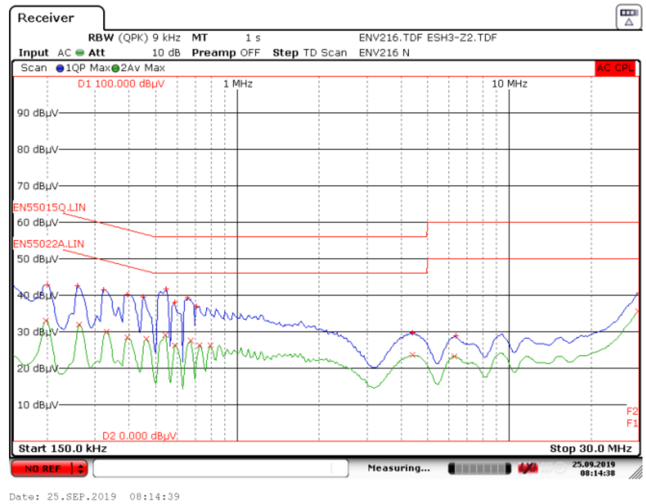


Figure 114 – 115 VAC 60 Hz.
Neutral with Output Grounded.

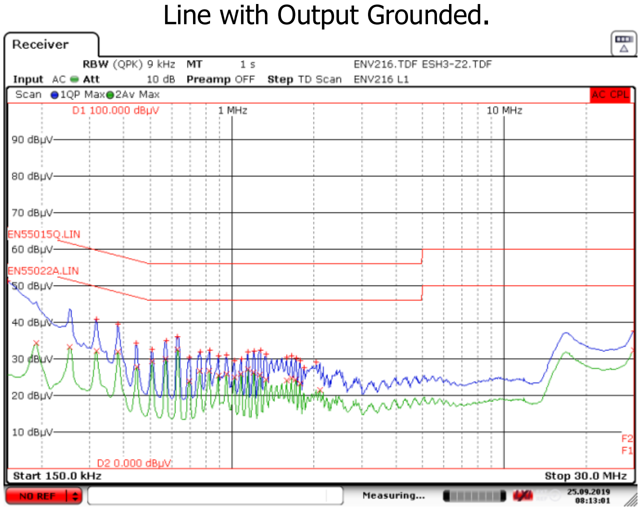


Figure 115 – 230 VAC 60 Hz.
Line with Output Grounded.

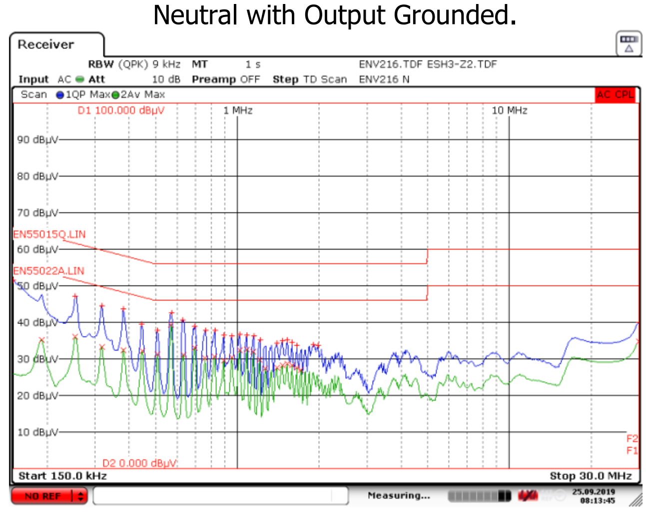


Figure 116 – 230 VAC 60 Hz.
Neutral with Output Grounded.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

14 Line Surge

Differential and common mode input line surge testing was completed on a single test unit to IEC61000-4-5. Input voltage was set at 230 VAC / 60 Hz. Output was loaded at full load and operation was verified following each surge event.

14.1 *Differential and Common Mode Surge*

DM 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

CM Surge Level (V)	Input Voltage (VAC)	Injection Location	Injection Phase (°)	Test Result (Pass/Fail)
+2000	230	L, N to PE	0	Pass
-2000	230	L, N to PE	0	Pass
+2000	230	L, N to PE	90	Pass
-2000	230	L, N to PE	90	Pass
+2000	230	L, N to PE	180	Pass
-2000	230	L, N to PE	180	Pass
+2000	230	L, N to PE	270	Pass
-2000	230	L, N to PE	270	Pass

Note: In all PASS results, no damage and no auto-restart was observed.

14.2 *Common Mode Ring Wave*

Surge Level (V)	Input Voltage (VAC)	Injection Location	Injection Phase (º)	Test Result (Pass/Fail)
+3000	230	L, N to PE	0	Pass
-3000	230	L, N to PE	0	Pass
+3000	230	L, N to PE	90	Pass
-3000	230	L, N to PE	90	Pass
+3000	230	L, N to PE	180	Pass
-3000	230	L, N to PE	180	Pass
+3000	230	L, N to PE	270	Pass
-3000	230	L, N to PE	270	Pass

Note: In all PASS results, no damage and no auto-restart was observed.

14.3 *Electrical Fast Transient (EFT)*

Surge Level (V)	Injection Phase (º)	Frequency (kHz)	T-Burst (μs)	T-Rep (ms)	Test Duration (s)	Injection Location	Result (PASS, FAIL, AR)
+4000	0	100	750	300	120	L, N, PE	Pass
-4000	0	100	750	300	120	L, N, PE	Pass
+4000	90	100	750	300	120	L, N, PE	Pass
-4000	90	100	750	300	120	L, N, PE	Pass
+4000	180	100	750	300	120	L, N, PE	Pass
-4000	180	100	750	300	120	L, N, PE	Pass
+4000	270	100	750	300	120	L, N, PE	Pass
-4000	270	100	750	300	120	L, N, PE	Pass

Note: In all PASS results, no damage and no auto-restart was observed.

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

15 ESD

Note: ESD performance was tested on limited number of units. All ESD strikes were applied at end of cable.

Passed ±8 kV contact discharge

Contact Voltage (kV)	Applied to	Number of Strikes	Test Result
+8	VOUT	10	Pass
	GND	10	Pass
-8	VOUT	10	Pass
	GND	10	Pass

Note: In all PASS results, no damage observed.

Passed ±24 kV Air discharge (Class B). Passed ±18 kV Air discharge (Class A)

Air Discharge Voltage (kV)	Applied to	Number of Strikes	Test Result
+24	VOUT	10	Pass
	GND	10	Pass
-24	VOUT	10	Pass
	GND	10	Pass

Note: In all PASS results, no damage was observed.

16 Revision History

Date	Author	Revision	Description and Changes	Reviewed
06-Jan-20	JPB	1.0	Initial Release.	Apps & Mktg

Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

For the latest updates, visit our website: www.power.com

Power Integrations Worldwide Sales Support Locations

WORLD HEADQUARTERS
5245 Hellyer Avenue
San Jose, CA 95138, USA.
Main: +1-408-414-9200
Customer Service:
Worldwide: +1-65-635-64480
Americas: +1-408-414-9621
e-mail: usasales@power.com

CHINA (SHANGHAI)
Rm 2410, Charity Plaza, No. 88,
North Caoxi Road,
Shanghai, PRC 200030
Phone: +86-21-6354-6323
e-mail: chinasales@power.com

CHINA (SHENZHEN)
17/F, Hivac Building, No. 2, Keji
Nan 8th Road, Nanshan District,
Shenzhen, China, 518057
Phone: +86-755-8672-8689
e-mail: chinasales@power.com

GERMANY (AC-DC/LED Sales)
Einsteinring 24
85609 Dornach/Aschheim
Germany
Tel: +49-89-5527-39100
e-mail: eurosales@power.com

GERMANY (Gate Driver Sales)
HellwegForum 1
59469 Ense
Germany
Tel: +49-2938-64-39990
e-mail: igbt-driver.sales@
power.com

INDIA
#1, 14th Main Road
Vasanthanagar
Bangalore-560052
India
Phone: +91-80-4113-8020
e-mail: indiasales@power.com

ITALY
Via Milanese 20, 3rd. Fl.
20099 Sesto San Giovanni (MI) Italy
Phone: +39-024-550-8701
e-mail: eurosales@power.com

JAPAN
Yusen Shin-Yokohama 1-chome Bldg.
1-7-9, Shin-Yokohama, Kohoku-ku
Yokohama-shi,
Kanagawa 222-0033 Japan
Phone: +81-45-471-1021
e-mail: japansales@power.com

KOREA
RM 602, 6FL
Korea City Air Terminal B/D,
159-6
Samsung-Dong, Kangnam-Gu,
Seoul, 135-728 Korea
Phone: +82-2-2016-6610
e-mail: koreasales@power.com

SINGAPORE
51 Newton Road,
#19-01/05 Goldhill Plaza
Singapore, 308900
Phone: +65-6358-2160
e-mail: singaporesales@power.com

TAIWAN
5F, No. 318, Nei Hu Rd.,
Sec. 1
Nei Hu District
Taipei 11493, Taiwan R.O.C.
Phone: +886-2-2659-4570
e-mail: taiwansales@power.com

UK
Building 5, Suite 21
The Westbrook Centre
Milton Road
Cambridge
CB4 1YG
Phone: +44 (0) 7823-557484
e-mail: eurosales@power.com