# Design Example Report

| | |
|---|---|
| **Title** | ***60 W USB PD Type C Power Supply Using InnoSwitch™ 3-CP GaN-based INN3279C-H215*** |
| **Specification** | 90 VAC – 265 VAC Input;<br>5 V / 3 A; 9 V / 3 A; 15 V / 3 A and 20 V / 3 A Outputs |
| **Application** | Mobile Phone / Tablet / Laptop Adapter |
| **Author** | Applications Engineering Department |
| **Document Number** | DER-601 |
| **Date** | July 24, 2019 |
| **Revision** | 1.0 |


**Summary and Features**

- InnoSwitch-3 is industry first AC/DC IC with isolated, safety rated integrated feedback
- All the benefits of secondary-side control with the simplicity of primary-side regulation
  - Insensitive to transformer variation
  - Built in synchronous rectification for high efficiency
- Meets DOE6 and CoC Tier 2 V5 2016
- <40 mW no-load input power with estimated 10 mW consumption by Weltrend WT6615F USB PD controller
- Primary sensed overvoltage protection
- Very high power density using GaN switch
  - 17.4 W / inch$^3$ with enclosure
  - 11W / inch$^3$ without enclosure
- Very low component count
  - Power stage - 45 components
  - USB PD controller stage - 38 components
- >6 db margin on conducted EMI



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

- Very high average efficiency
    - 5 V Output – 92.0% at 115 VAC and 91.2% at 230 VAC
    - 9 V Output – 92.7% at 115 VAC and 92.7% at 230 VAC
    - 15 V Output – 92.8% at 115 VAC and 93.3% at 230 VAC
    - 20 V Output – 92.7% at 115 VAC and 93.4% at 230 VAC

PATENT INFORMATION
The products and applications illustrated herein (including transformer construction and circuits external to the products) may be covered by one or more U.S. and foreign patents, or potentially by pending U.S. and foreign patent applications assigned to Power Integrations. A complete list of Power Integrations' patents may be found at www.power.com. Power Integrations grants its customers a license under certain patent rights as set forth at https://www.power.com/company/intellectual-property-licensing/.

# Table of Contents





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

**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 document is an engineering report describing a 5 V / 3 A or 9 V / 3 A or 15 V / 3 A or 20 V / 3 A output USB Type-C and USB-PD charger using the InnoSwitch-3 and Weltrend WT6615F USB Type-C USB PD Controller. This design shows the high power density and efficiency that is possible due to the high level of integration of the InnoSwitch3-CP controller providing exceptional performance.

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

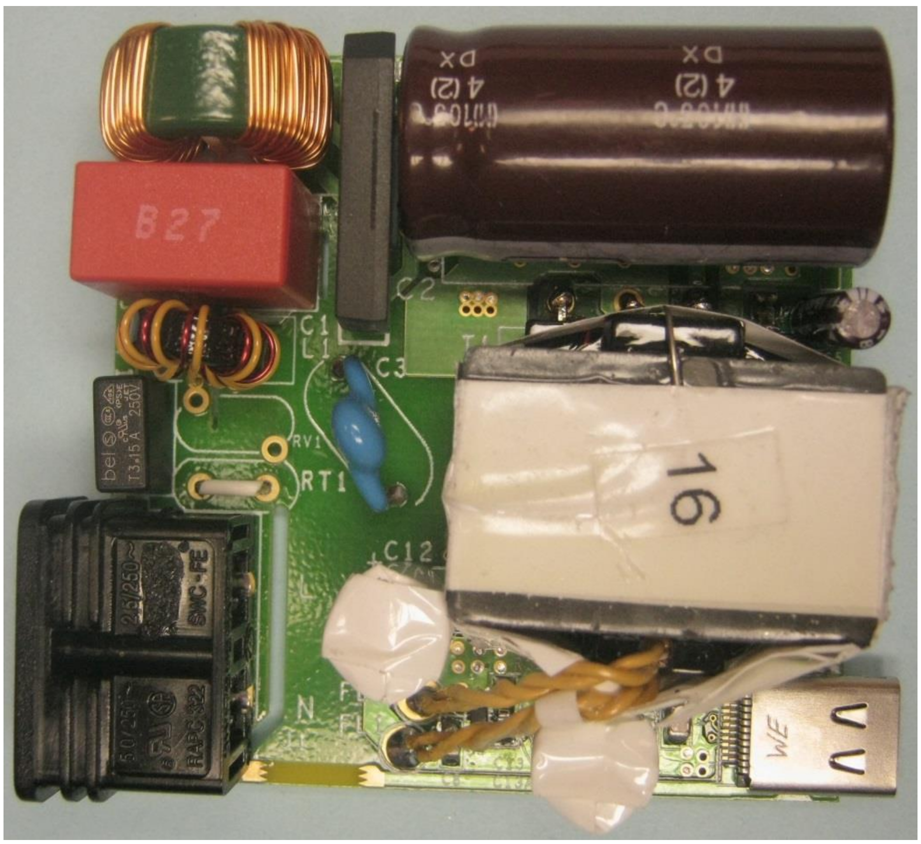


**Figure 1 –** Populated Circuit Board Photograph, Top.

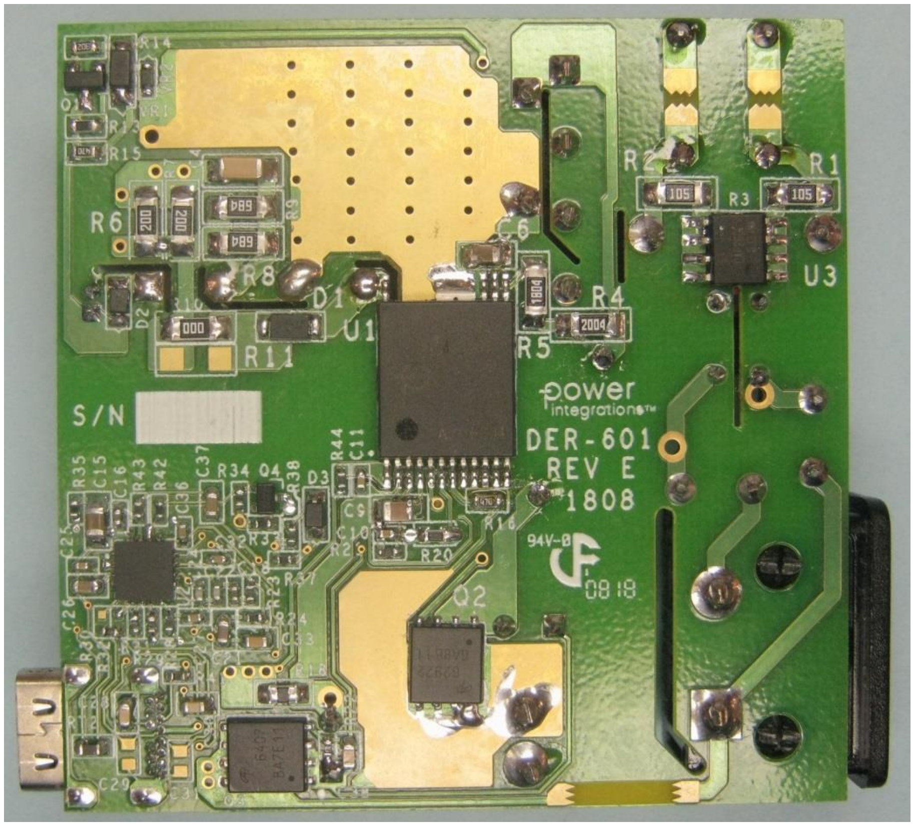


**Figure 2 –** Populated Circuit Board Photograph, Bottom.



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

# 2 Power Supply Specification

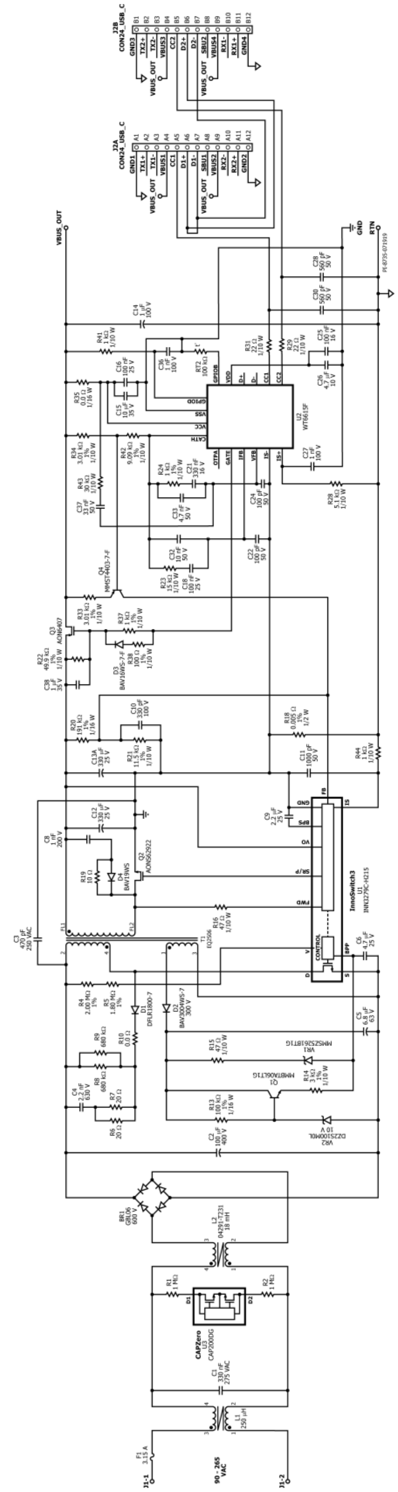
The table below represents the minimum acceptable performance of the design. Actual performance is listed in the results section.

| 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) | | | 25 | 28.2 | mW | Measured at 230 VAC. |
| **5 V Output** | | | | | | |
| Output Voltage | $V_{OUT1}$ | | 5 | | V | ±3% |
| Output Ripple Voltage | $V_{RIPPLE1}$ | | | 250 | mV | On Board. |
| Output Current | $I_{OUT1}$ | 3 | | | A | On Board. |
| **9 V Output** | | | | | | |
| Output Voltage | $V_{OUT1}$ | | 9 | | V | ±3% |
| Output Ripple Voltage | $V_{RIPPLE1}$ | | | 250 | mV | On Board. |
| Output Current | $I_{OUT1}$ | 3 | | | A | On Board. |
| **15 V Output** | | | | | | |
| Output Voltage | $V_{OUT1}$ | | 15 | | V | ±3% |
| Output Ripple Voltage | $V_{RIPPLE1}$ | | | 250 | mV | On Board. |
| Output Current | $I_{OUT1}$ | 3 | | | A | On Board. |
| **20 V Output** | | | | | | |
| Output Voltage | $V_{OUT1}$ | | 20 | | V | ±3% |
| Output Ripple Voltage | $V_{RIPPLE1}$ | | | 250 | mV | On Board. |
| Output Current | $I_{OUT1}$ | 3 | | | A | On Board. |
| Continuous Output Power | $P_{OUT}$ | | | 60 | W | |
| **Conducted EMI** | | Meets CISPR22B / EN55022B | | | | |
| Safety | | Designed to meet IEC60950 / UL1950 Class II | | | | |
| Ambient Temperature | $T_{AMB}$ | 0 | | 45 | ºC | Enclosed in Adapter, Sea Level. |

Note: In order to upgrade this design to 65 W following changes are needed.

1. Need to redesign the transformer in order to deliver 65 W.
2. Contact Weltrend for firmware update to support 65 W on this design.
3. Check the thermal performance while the power supply is delivering 65 W output.

# 3 Schematic



*Do not populate R30, R32, C29 and C31

*Place a 0603 0E jumper across R30 and R32 to short D+ and D- lines on the connector

**Figure 3 –** USB PD Controller Stage Schematic.



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

# 4 Circuit Description

## 4.1 *Input EMI Filtering*

Fuse F1 isolates the circuit and provides protection from component failure, and the common mode choke L1 and L2 with capacitor C1 attenuation for EMI. Bridge rectifier BR1 rectifies the AC line voltage and provides a full wave rectified DC across the filter capacitor C2.

Resistors R1 and R2 along with U3 discharges capacitor C1 when the power supply is disconnected from AC mains.

## 4.2 InnoSwitch-3 IC Primary

One end of the transformer (T1) primary is connected to the rectified DC bus; the other is connected to the drain terminal of the SWITCH inside the InnoSwitch-3 IC (U1). Resistors R4 and R5 provide Input voltage sense protection for undervoltage and overvoltage conditions.

A low cost RCD clamp formed by diode D1, resistors R6, R7, R8 and R9, and capacitor C4 limits the peak drain voltage of U1 at the instant of turn off of the SWITCH inside U1. The clamp helps to dissipate the energy stored in the leakage reactance of transformer T1.

The IC is self-starting, using an internal high-voltage current source to charge the BPP pin capacitor (C7) when AC is first applied. During normal operation the primary side block is powered from an auxiliary winding on the transformer T1. Output of the auxiliary (or bias) winding is rectified using diode D2 and filtered using capacitor C5. Resistor R14 limits the current being supplied to the BPP pin of the InnoSwitch-3 IC (U1). A linear regulator comprising of resistor R13, BJT Q1 and Zener diode VR2 prevent any change in current through R14.

Zener diode VR1 along with R15 offers primary sensed output over voltage protection. In a flyback converter, output of the auxiliary winding tracks the output voltage of the converter. In case of over voltage at output of the converter, the auxiliary winding voltage increases and causes breakdown of VR1 which then causes a current to flow into the BPP pin of InnoSwitch3-CP IC U1. If the current flowing into the BPP pin increases above the $I_{SD}$ threshold, the InnoSwitch3-CP controller will latch off and prevent any further increase in output voltage.

## 4.3 InnoSwitch3-CP IC Secondary

The secondary-side of the InnoSwitch3-CP IC provides output voltage, output current sensing and drive to a MOSFET providing synchronous rectification. The secondary of the transformer is rectified by MOSFET Q2 and filtered by capacitors C12 and C13A. High frequency ringing during switching transients that would otherwise create radiated EMI is reduced via a RCD snubber R19, C8 and D4. Diode D4 was used to minimize the dissipation in resistor R19.

The gate of Q2 is turned on by secondary side controller inside IC U1, based on the winding voltage sensed via resistor R16 and fed into the FWD pin of the IC.

In continuous conduction mode of operation, the MOSFET is turned off just prior to the secondary side commanding a new switching cycle from the primary. In discontinuous mode of operation, the power MOSFET is turned off when the voltage drop across the MOSFET falls below a threshold of approximately 3 mV. Secondary-side control of the primary-side power SWITCH avoids any possibility of cross conduction of the two SWITCHES and provides extremely reliable synchronous rectification.

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

During CC operation, when the output voltage falls, the device will power itself from the secondary winding directly. During the on-time of the primary-side power SWITCH, the forward voltage that appears across the secondary winding is used to charge the decoupling capacitor C13 via resistor R16 and an internal regulator. This allows output current regulation to be maintained down to ~3.4 V. Below this level the unit enters auto-restart until the output load is reduced.

Output current is sensed by monitoring the voltage drop across resistor R18 between the IS and GND pins with a threshold of approximately 35 mV to reduce losses. RC filter R44 and C11 provides filtering on the IS pin from external noise.

Below the CC threshold, the device operates in constant voltage mode. Output voltage is regulated so as to achieve a voltage of 1.265 V on the FB pin. Capacitor C10 provides noise filtering of the signal at the FB pin.

### 4.4 **USB Type-C and PD Interface**

In this design, Weltrend WT6615F (U2) is the USB Type-C and PD controller. Output of the InnoSwitch3-CP powers the WT6615F device directly from Vbus.

Resistors R20 and R21 form the feedback divider network to sense the output voltage and provide feedback to the InnoSwitch IC. Resistor R33, R34, Q4, R42 and U2 together will inject the current into the resistor R21 to change the output voltage to required level when there is a request through CC1 and CC2 lines. The default output voltage is maintained at 5 V.


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

USB PD protocol is communicated over either CC1 or CC2 line depending on the orientation in which Type-C plug is connected.

P-MOSFET Q3 makes the USB Type-C receptacle cold socket when no device is attached to the charger as per the USB Type-C specification. VBUS_OUT is discharged via resistor R41 and U2.

# 5 PCB Layout

PCB copper thickness is 2.0 oz.

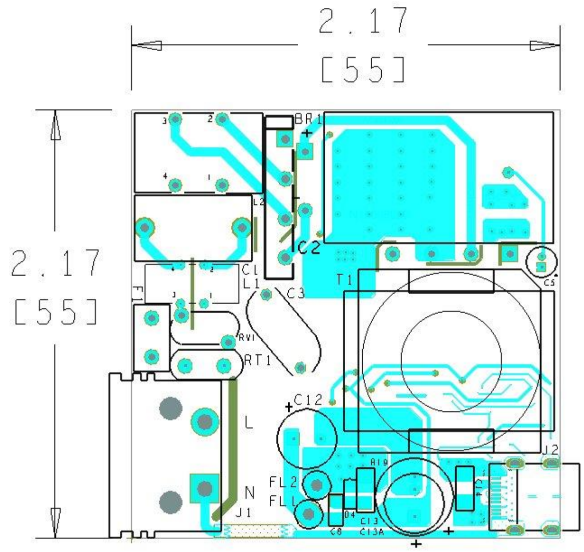


**Figure 4 –** Printed Circuit Layout, Top.

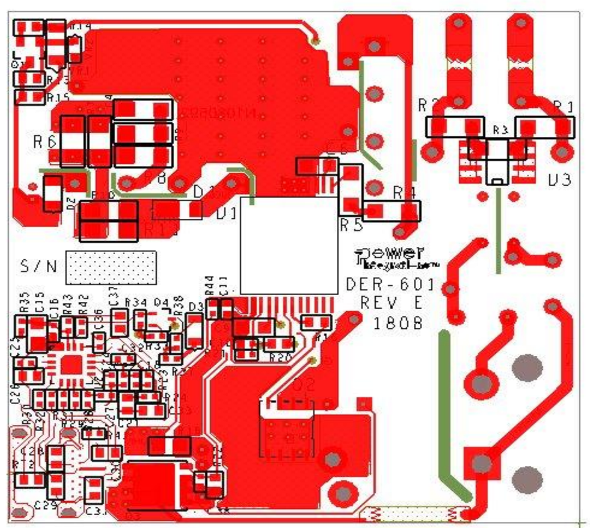


**Figure 5 –** Printed Circuit Layout, Bottom.



**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 | DIODE BRIDGE 600V 4A GB | GBL06 | Genesic Semi |
| 2 | 1 | C1 | 330 nF, ±10%, 275 VAC, Polypropylene Film, X2, 15.00 mm x 8.50 mm | 890324024003CS | Wurth |
| 3 | 1 | C10 | 330 pF, +/-10%, 100 V, Ceramic, X7R, 0402 | C0402C331K4RACTU | Kemet |
| 4 | 1 | C11 | 1000 pF, ±10%, 50 V,X7R, -55°C ~ 125°C, Low ESL, 0402 | C0402C102K5RACTU | Kemet |
| 5 | 2 | C12 C13A | 330 μF,±20%, 25 V, Al Organic Polymer, Gen. Purpose, Can, 18 mΩ, 2000 Hrs @ 105°C, (8 mm x 13 mm) | A750KS337M1EAAE018 | KEMET |
| 6 | 1 | C2 | 100 uF, 400 V, Electrolytic, Low ESR, (16 x 30) | EPAG401ELL101ML30S | Nippon Chemi-Con |
| 7 | 1 | C3 | 470 pF, Ceramic, Y1 | DE1B3KX471KN4A | Murata |
| 8 | 1 | C4 | 2.2 nF, 630 V, Ceramic, X7R, 1206 | C3216X7R2J222K | TDK |
| 9 | 1 | C5 | 6.8 μF, ±20%, 63 V, Electrolytic, Gen Purpose, (4 mm x 11 mm) | UPW1J6R8MDD6 | Nichicon |
| 10 | 1 | C6 | 4.7 uF, ±10%, 25 V, Ceramic, X7R, -55°C ~ 125°C, 0805 | TMK212AB7475KG-T | Taiyo Yuden |
| 11 | 1 | C8 | 1 nF, 200 V, Ceramic, X7R, 0805 | 08052C102KAT2A | AVX |
| 12 | 1 | C9 | 2.2 μF, 25 V, Ceramic, X7R, 0805 | C2012X7R1E225M | TDK |
| 13 | 1 | C14 | 1 μF, 100 V, Ceramic, X7R, 1206 | C3216X7R2A105K | TDK |
| 14 | 1 | C15 | 10 μF, 35 V, Ceramic, X5R, 0805 | C2012X5R1V106K085AC | TDK |
| 15 | 2 | C16 C18 | 100 nF, 25 V, Ceramic, Y5V, 0402 | CL05A104KA5NNNC | Samsung |
| 16 | 1 | C21 | 330 nF, ±10%, 16 V, Ceramic, X7R, 0603 | CC0603KRX7R7BB334 | Yageo |
| 17 | 2 | C22 C24 | 100 pF, ±10%, 50 V, Ceramic Capacitor X7R, 0402 | 04025C101KAT2A | AVX |
| 18 | 1 | C25 | 100 nF 16 V, Ceramic, X7R, 0402 | L05B104KO5NNNC | Samsung |
| 19 | 1 | C26 | 4.7 μF, 10 V, Ceramic, X5R, 0603 | C1608X5R1A475M/0.50 | TDK |
| 20 | 2 | C27 C36 | 1 nF 100 V, Ceramic, X7R, 0402 | GCM155R72A102KA37D | Murata |
| 21 | 2 | C28 C30 | 560 pF, 50 V, Ceramic, X7R, 0603, 0.063" L x 0.031" W (1.60 mm x 0.80 mm) | CL10B561KB8NNNC | Samsung |
| 22 | 1 | C32 | 10 nF 50 V, Ceramic, X7R, 0402 | CL05B103KB5NNNC | Samsung |
| 23 | 1 | C33 | 4.7 nF 50 V, Ceramic, X7R, 0603 | CL10B472KB8NNNC | Samsung |
| 24 | 1 | C37 | 33 nF 50 V, Ceramic, X7R, 0603 | 06035C333JAT2A | AVX |
| 25 | 1 | C38 | 1 μf 35 V, Ceramic, X7R, 0603 | C1608X7R1V105M | TDK |
| 26 | 1 | D1 | 800 V, 1 A, Rectifier, POWERDI123 | DFLR1800-7 | Diodes, Inc. |
| 27 | 1 | D2 | DIODE, GEN PURP, FAST RECOVERY, 300 V, 225 mA, SOD323 | BAV3004WS-7 | Diodes, Inc. |
| 28 | 1 | D3 | 75 V, 0.15 A, Switching,SOD-323 | BAV16WS-7-F | Diodes, Inc. |
| 29 | 1 | D4 | 100 V, 0.2 A, Fast Switching, 50 ns, SOD-323 | BAV19WS-7-F | Diodes, Inc. |
| 30 | 1 | F1 | 3.15 A, 250 V, Slow, RST | 507-1181 | Belfuse |
| 31 | 1 | J1 | Power Entry Connector Receptacle, Male Pins, IEC 320-C8, Non-Polarized, Panel Mount, Snap-In; Through Hole, Right Angle | RAPC322X | Switchcraft |
| 32 | 1 | J2 | Connector, "Certified", USB - C, USB 3.1, For 0.031" PCB Material!,Superspeed+, Receptacle Connector, 24 Position, SMT, Right Angle, TH | 632723100011 | Wurth |
| 33 | 1 | L1 | 250 μH, Toroidal Common Mode Choke | | Power Integrations |
| 34 | 1 | L2 | CMC, 18 mH @ 10 kHz, Toroidal, 17.5 mm OD x 11.0 mm thick. 40 turns x 2, 0.40 mm wire 190 mΩ max | 04291-T231 | Sumida |
| 35 | 1 | Q1 | NPN, Small Signal BJT, 80 V, 0.5 A, SOT-23 | MMBTA06LT1G | On Semi |
| 36 | 1 | Q2 | MOSFET, N-CH, 120 V, 85 A (at VGS=10V), Trench Power AlphaSGT 120 V TM technology, DFN5X6 | AONS62922 | Alpha & Omega Semi. |
| 37 | 1 | Q3 | MOSFET, P-Channel, 30 V, 32 A (Ta), 85 A (Tc), 7.3 W (Ta), 83 W (Tc), 8-DFN (5x6), 8DFN | AON6407 | Alpha & Omega Semi |
| 38 | 1 | Q4 | PNP, Small Signal BJT, 40 V, 0.6 A, SC70-3, SOT-323 | MMST4403-7-F | Diodes, Inc. |

| | | | | | |
|---|---|---|---|---|---|
| 39 | 2 | R1 R2 | RES, 1 MΩ, 5%, 1/4 W, Thick Film, 1206 | ERJ-8GEYJ105V | Panasonic |
| 40 | 1 | R4 | RES, 2.00 MΩ, 1%, 1/4 W, Thick Film, 1206 | ERJ-8ENF2004V | Panasonic |
| 41 | 1 | R5 | RES, 1.80 MΩ, 1%, 1/4 W, Thick Film, 1206 | ERJ-8ENF1804V | Panasonic |
| 42 | 2 | R6 R7 | RES, 20 Ω, 5%, 1/4 W, Thick Film, 1206 | ERJ-8GEYJ200V | Panasonic |
| 43 | 2 | R8 R9 | RES, 680 kΩ, 5%, 1/4 W, Thick Film, 1206 | ERJ-8GEYJ684V | Panasonic |
| 44 | 1 | R10 | RES, 0 Ω, 5%, 1/4 W, Thick Film, 1206 | ERJ-8GEY0R00V | Panasonic |
| 45 | 1 | R13 | RES, 100 kΩ, 1%, 1/16 W, Thick Film, 0603 | ERJ-3EKF1003V | Panasonic |
| 46 | 1 | R14 | RES, 3 kΩ, 5%, 1/10 W, Thick Film, 0603 | ERJ-3GEYJ302V | Panasonic |
| 47 | 2 | R15 R16 | RES, 47 Ω, 5%, 1/10 W, Thick Film, 0603 | ERJ-3GEYJ470V | Panasonic |
| 48 | 1 | R18 | RES, 0.005 Ω, ±1%, 0.5W, 1/2W, 0805 (2012 Metric), Current Sense, Thick Film,±300ppm/°C,-55°C ~ 155°C | ERJ-6LWFR005V | Panasonic |
| 49 | 1 | R19 | RES, 10 Ω, 5%, 1/4 W, Thick Film, 1206 | ERJ-8GEYJ100V | Panasonic |
| 50 | 1 | R20 | RES, 191 kΩ, 1%, 1/16 W, Thick Film, 0603 | ERJ-3EKF1913V | Panasonic |
| 51 | 1 | R21 | RES, 11.5 kΩ, 1%, 1/10 W, Thick Film, 0402 | ERJ-2RKF1152X | Panasonic |
| 52 | 1 | R22 | RES, 49.9 kΩ, 1%, 1/10 W, Thick Film, 0402 | ERJ-2RKF4992X | Panasonic |
| 53 | 1 | R23 | RES, 15 kΩ, 5%, 1/10 W, Thick Film, 0402 | ERJ-2GEJ153X | Panasonic |
| 54 | 2 | R24 R37 | RES, 1.00 kΩ, 1%, 1/10 W, Thick Film, 0402 | ERJ-2RKF1001X | Panasonic |
| 55 | 1 | R28 | RES, 5.1 kΩ, 5%, 1/10 W, Thick Film, 0402 | ERJ-2GEJ512X | Panasonic |
| 56 | 2 | R29 R31 | RES, 22 Ω, 5%, 1/10 W, Thick Film, 0402 | ERJ-2GEJ220X | Panasonic |
| 57 | 2 | R33 R34 | RES, 3.01 kΩ, 1%, 1/10 W, Thick Film, 0402 | ERJ-2RKF3011X | Panasonic |
| 58 | 1 | R35 | RES, 0 Ω, 1/16 W, Thick Film, 0402 | CRCW04020000Z0ED | Panasonic |
| 59 | 1 | R38 | RES, 100 Ω, 1%, 1/10 W, Thick Film, 0402 | ERJ-2RKF1000X | Panasonic |
| 60 | 2 | R41 R44 | RES, 1 kΩ, 5%, 1/10 W, Thick Film, 0402 | ERJ-2GEJ102X | Panasonic |
| 61 | 1 | R42 | RES, 9.09 kΩ, 1%, 1/10 W, Thick Film, 0402 | ERJ-2RKF9091X | Panasonic |
| 62 | 1 | R43 | RES, 30 kΩ, 5%, 1/10 W, Thick Film, 0402 | ERJ-2GEJ303X | Panasonic |
| 63 | 1 | RT2 | NTC Thermistor, 100 kΩ, 3%, 0603 | NCP18WF104E03RB | Murata |
| 64 | 1 | T1 | Bobbin, EQ2506, 4 pins, 4pri, 0sec | EQ-2506 | Shen Zhen Xin Yu Jia Technology |
| 65 | 1 | U1 | InnoSwitch-3, INN3279C-H215 | | Power Integrations |
| 66 | 1 | U2 | Custom IC, 16-QFN (4X4) | WT6615F | Weltrend |
| 67 | 1 | U3 | CAPZero-2, SO-8C | CAP200DG | Power Integrations |
| 68 | 1 | VR1 | DIODE ZENER 47 V 500 mW SOD123 | MMSZ5261BT1G | ON Semi |
| 69 | 1 | VR2 | 10 V, 5%, 150 mW, SSMINI-2 | DZ2S100M0L | Panasonic |


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

# 7 Transformer Specification

## 7.1 Electrical Diagram

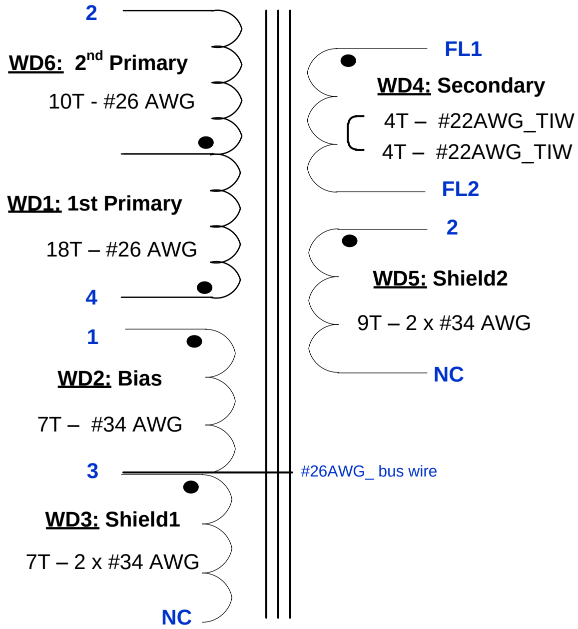



**Figure 6 –** Transformer Electrical Diagram.

## 7.2 *Electrical Specifications*

| | | |
|---|---|---|
| **Electrical Strength** | 60 second, 60 Hz, from Pins 1, 2, 3, 4 to FL1-FL2. | 3000 VAC |
| **Nominal Primary Inductance** | Measured at 1 V pk-pk, 100 kHz switching frequency, between pin 2 and 4, with all other windings open. | 469 μH ±5% |
| **Resonant Frequency** | Between pin 2 and 4, other windings open | 1,200 kHz (Min.) |
| **Primary Leakage Inductance** | Between pin 2 and 4, with pins:FL1-FL2 shorted | 6.5 μH (Max.) |

## 7.3 Material List

| Item | Description |
|---|---|
| **[1]** | Core: EQ27 |
| **[2]** | Bobbin: EQ2506-Vertical - 4pins (4/0), PI#: 25-01095-00. |
| **[3]** | Magnet Wire: #26 AWG, Double Coated. |
| **[4]** | Magnet Wire: #34 AWG, Double Coated. |
| **[5]** | Magnet Wire: #22 AWG, Triple Insulated Wire. |
| **[6]** | Bus wire: #26AWG, Alpha Wire, Tinned Copper, 40.0 mm Length. |
| **[7]** | Tape: 3M 13450-F, Polyester Film, 1 mil Thickness, 4.2 mm Width. |
| **[8]** | Tape: 3M 13450-F, Polyester Film, 1 mil Thickness, 33 mm x 54 mm. |
| **[9]** | Varnish: Dolph BC-359. |

## 7.4 Transformer Build Diagram

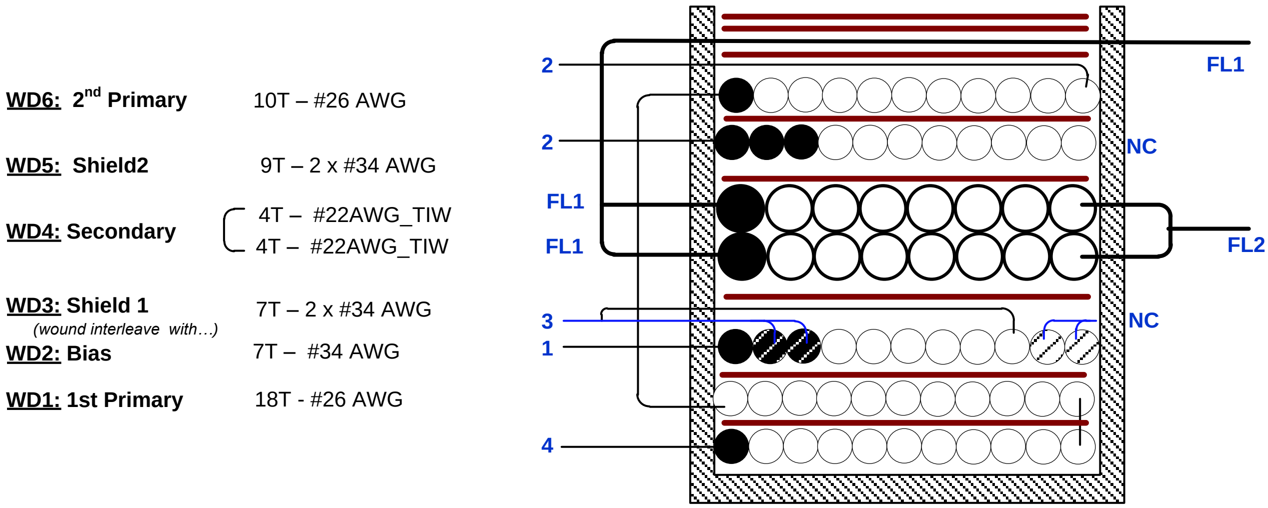


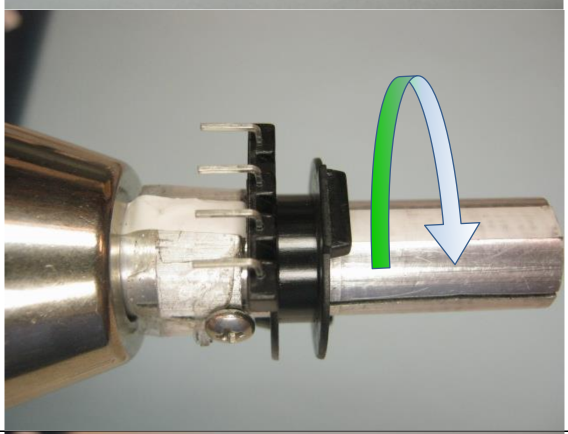
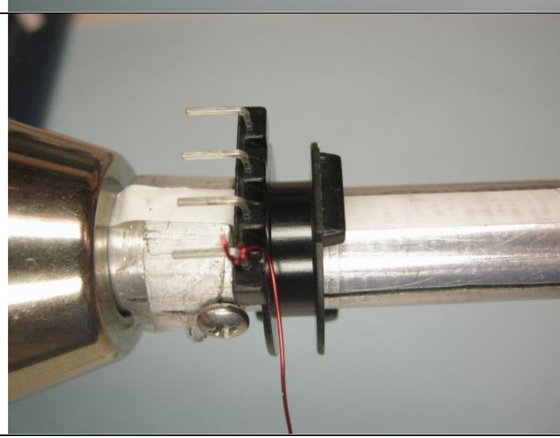

**Figure 7 –** Transformer Build Diagram.


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

## 7.5 *Transformer Construction*

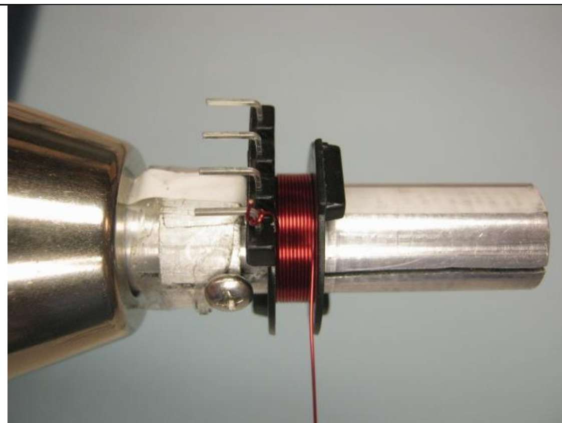
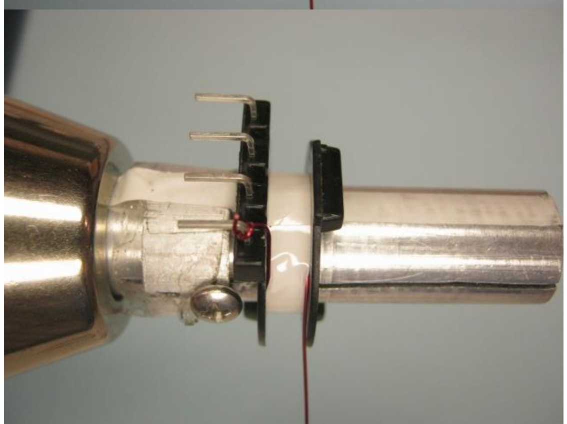
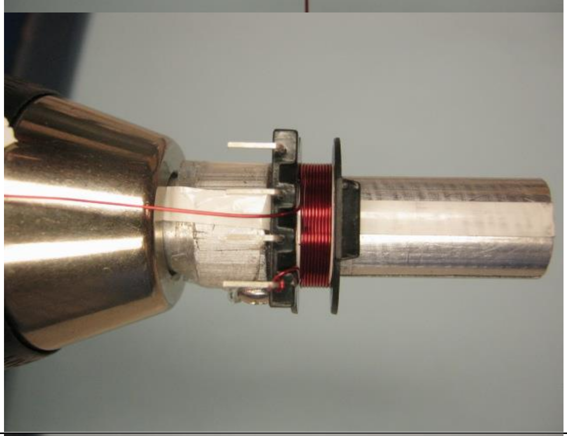
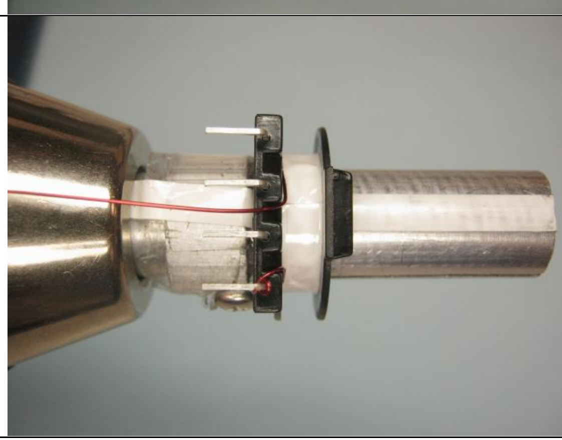
| | |
|---|---|
| **Winding Preparation** | Make slots on both sides of secondary flanges, (see picture below). Position the bobbin Item [2] on the mandrel such that the pin side of the bobbin is on the left side. Winding direction is clock-wise direction. |
| **WD1 1st Primary** | Start at pin 4, wind 9 turns of wire Item [3] in 1 layer, from left to right, and place 1 layer of tape Item [7]. Continue winding another 9 turns from right to left, at the last turn exit the wire out of the bobbin leave ~ 2 ft for WD6:2$^{nd}$ Primary. |
| **Insulation** | 1 layer of tape Item [7]. |
| **WD2 & WD3 Bias & Shield 1** | Start at pin 1, with 1 wire Item [4] for WD2 and start pin 3 with 2 wires also Item [4] for WD3. Wind all 3 wires 7 turns in parallel, at the last turn, finish 1 wire for WD2 at pin 3, cut short 2 wires for WD3 as No-Connect. |
| **Insulation** | 1 layer of tape Item [7]. |
| **WD4 Secondary** | Start at the slot on the left on secondary flange of the bobbin, use 1 wire Item [5], leave ~2" floating, and mark as FL1, wind 4 turns in 1 layer. At the last turn, exit the wire at the slot on the right, also leave ~1.5" floating and mark as FL2 for 1$^{st}$ halves of Secondary.<br>Repeat another winding as above for 2$^{nd}$ halves of Secondary which is parallel with 1$^{st}$ halves Secondary. |
| **Insulation** | 1 layer of tape Item [7]. |
| **WD5 Shield 2** | Start at pin 2, wind 9 bi-filar turns of wire Item [4]. At the last turn cut short the wires as No-Connect. |
| **Insulation** | 1 layer of tape Item [7]. |
| **WD6 2$^{nd}$ Primary** | Use wire floating from WD1, wind 10 turns from left to right. At the last turn, bring the wire back to the left to finish at pin 2. |
| **Insulation** | 1 layer of tape Item [7] and bring the secondary wires FL1 to the right in between layers of tape. |
| **Finish** | Gap cores to get 469 μH, solder bus wire Item [6] to pin 3which leans along with core halves, and secure with tape.<br>Varnish Item [9].<br>Places 2 layers of tape Item [8] at the bottom of transformer and wrap up to cover secondary side of transformer.<br>Wrap around the body of transformer 1 layer of tape Item [7], *(see illustration beside).* |

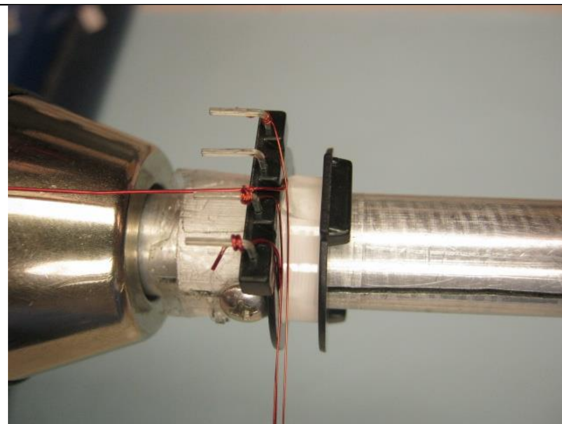
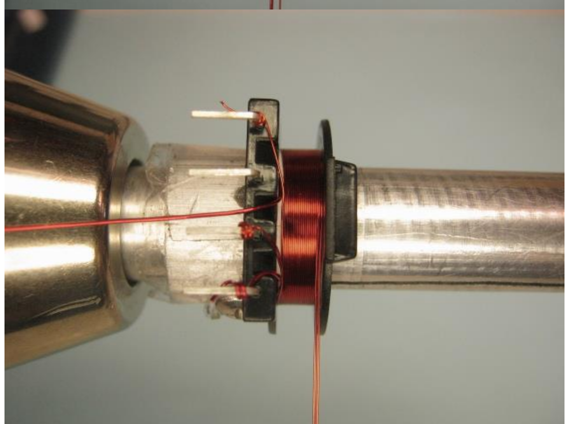
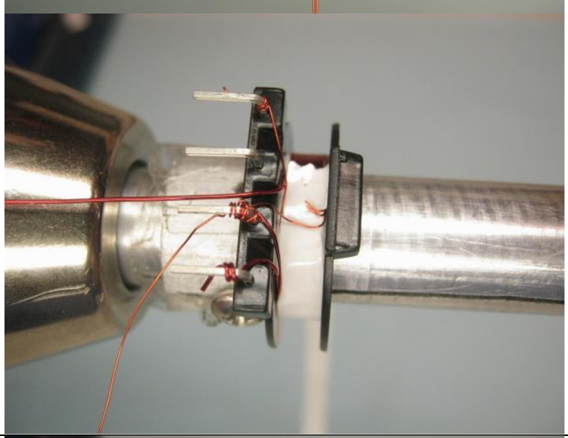
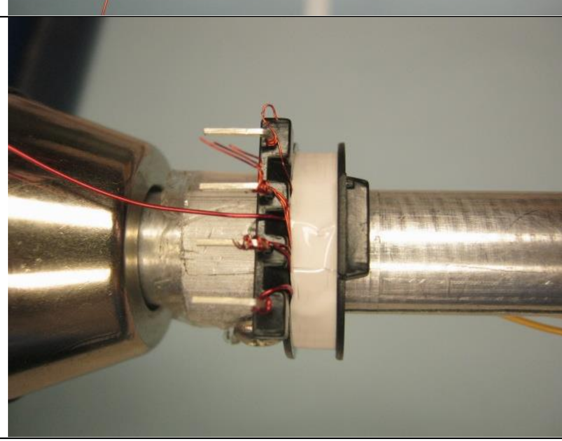
## 7.6 ***Winding Illustrations***

| | | |
|---|---|---|
| **Winding preparation** |   | Make slots on both sides of secondary flange.<br>Position the bobbin Item [2] on the mandrel such that the pin side of the bobbin is on the left side.<br>Winding direction is clock-wise direction. |
| **WD1**<br>**1st Primary** |  | Start at pin 4, wind 9 turns of wire Item [3] in 1 layer, from left to right, and place 1 layer of tape Item [7]. Continue winding another 9 turns from right to left, at the last turn exit the wire out of the bobbin leave ~ 2 ft for WD6:2nd Primary. |

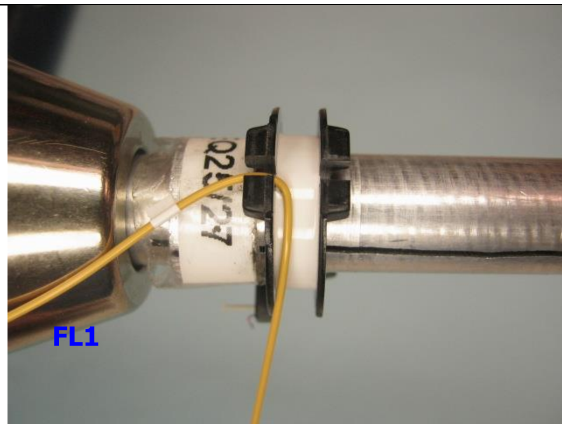
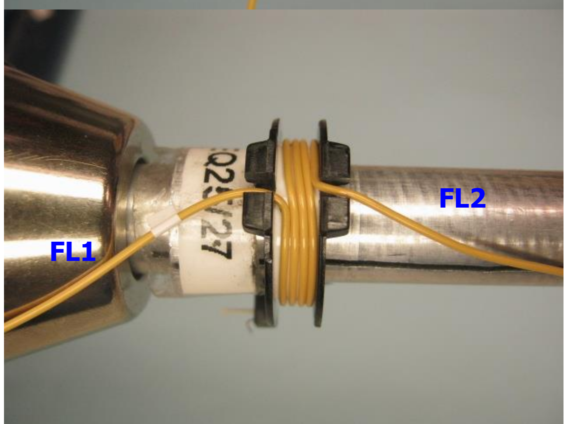
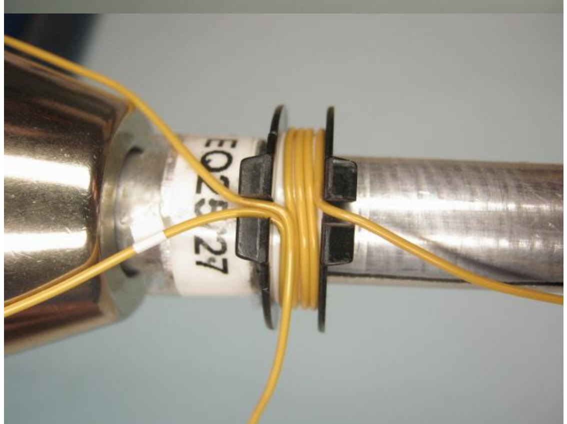
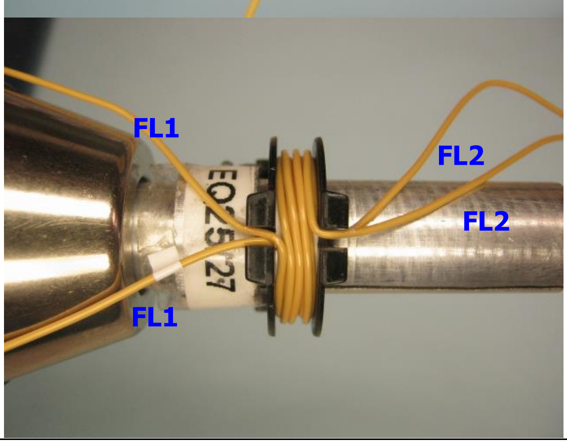


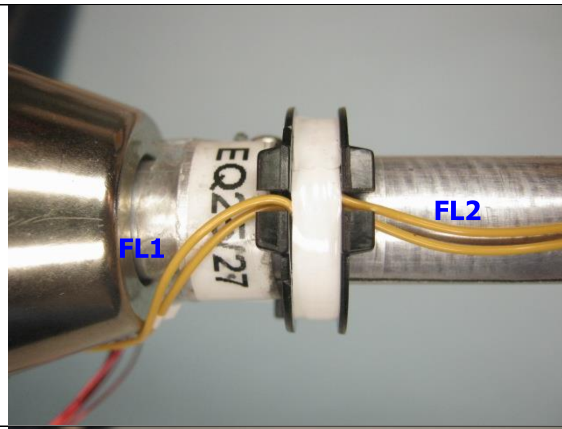
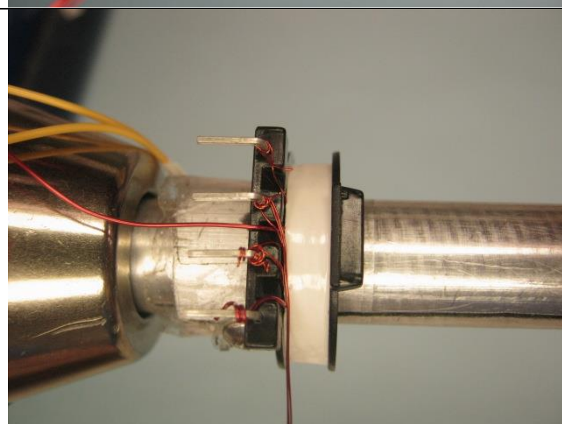
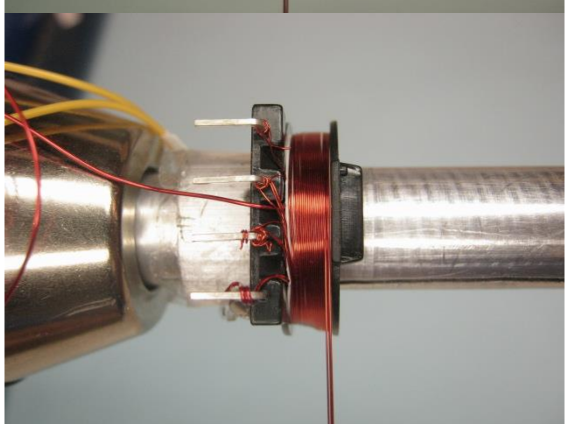
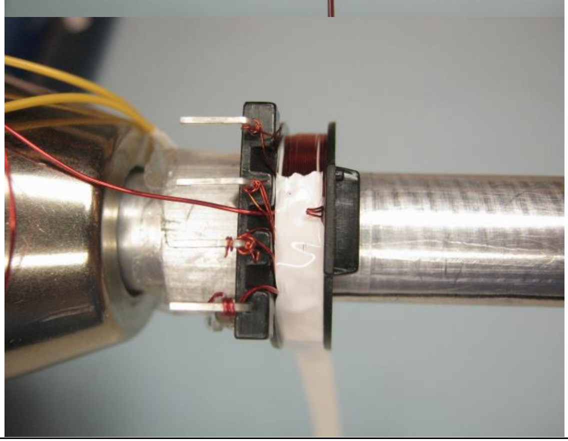
**Power Integrations**
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

| | | |
|---|---|---|
| |    | |
| **Insulation** |  | 1 layer of tape Item [7]. |

| | | |
|---|---|---|
| **WD2 & WD3**<br>**Bias & Shield 1** |  | Start at pin 1, with 1 wire Item [4] for WD2 and start pin 3 with 2 wires also Item [4] for WD3. Wind all 3 wires 7 turns in parallel, at the last turn, finish 1 wire for WD2 at pin 3, cut short 2 wires for WD3 as No-Connect. |
| **Insulation** |  | 2 layers of tape Item [7]. |

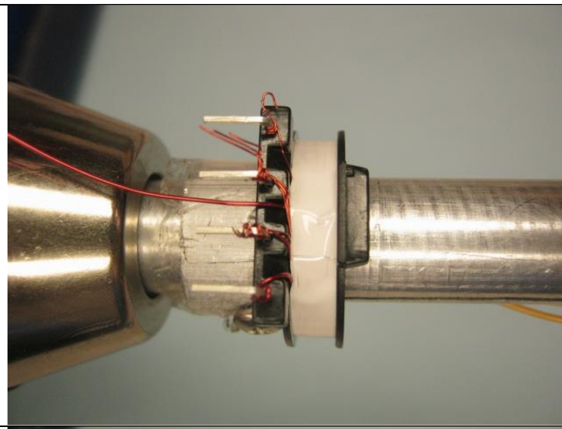
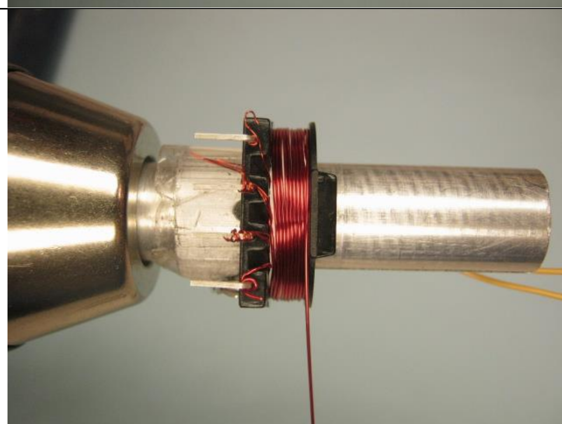
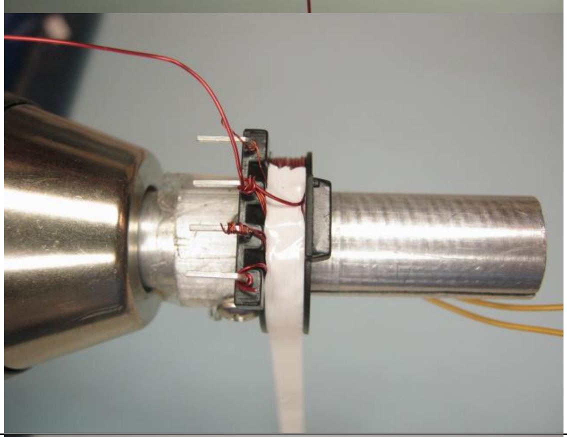
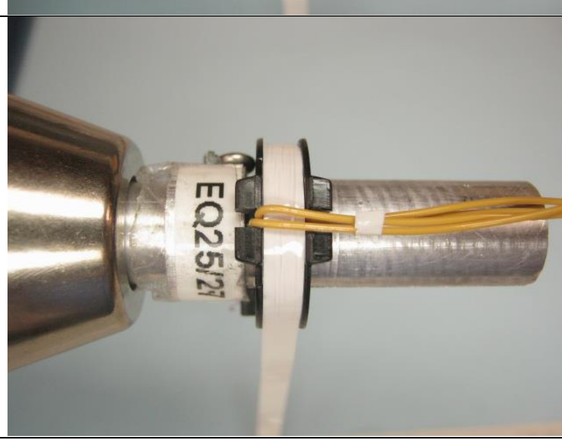

**Power Integrations**
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

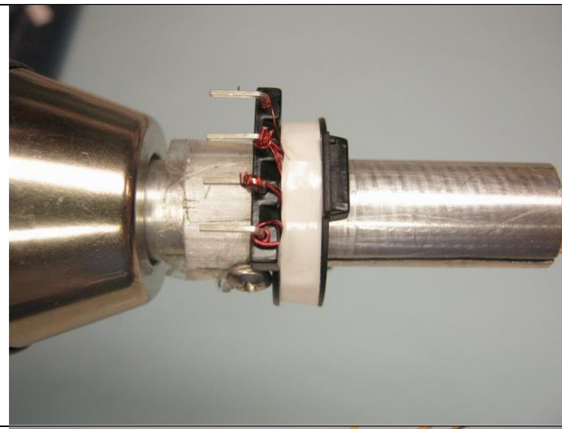
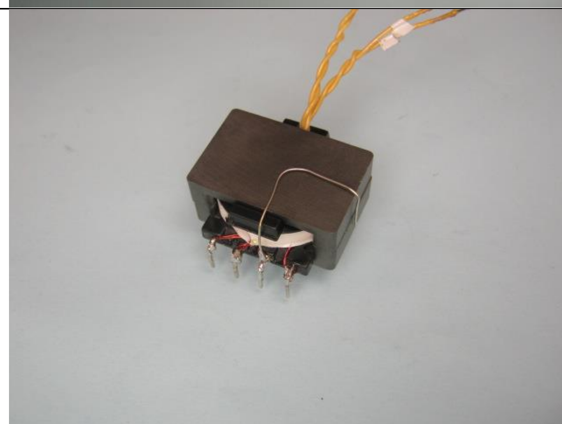
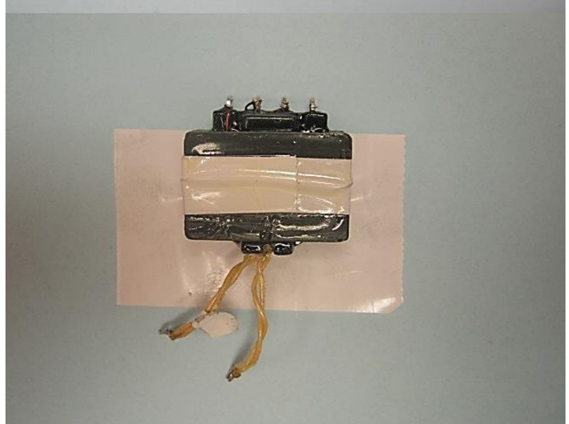
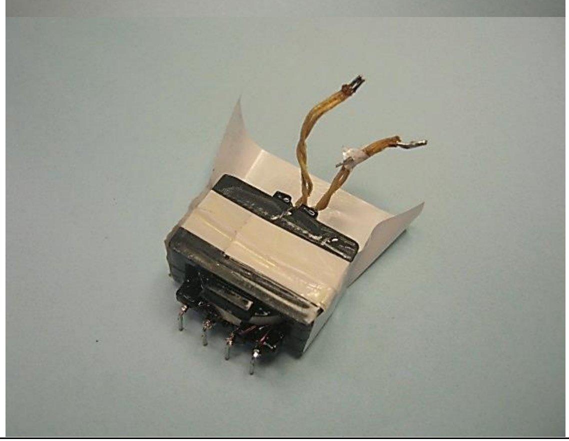
| | | |
|---|---|---|
| **WD4**<br>**Secondary** | <br><br><br> | Start at the slot on the left on secondary flange of the bobbin, use 1 wire Item [5], leave ~2" floating, and mark as FL1, wind 4 turns in 1 layer. At the last turn, exit the wire at the slot on the right, also leave ~1.5" floating and mark as FL2 for 1st halves of Secondary.<br>Repeat another winding as above for 2nd halves of Secondary which is parallel with 1st halves Secondary. |

<table>
<tr>
<td>Insulation</td>
<td>
</td>
<td>2 layers of tape Item [7].</td>
</tr>
<tr>
<td>WD5<br>Shield 2</td>
<td><br><br></td>
<td>Start at pin 2, wind 9 bi-filar turns of wire Item [4]. At the last turn cut short the wires as No-Connect.</td>
</tr>
</table>

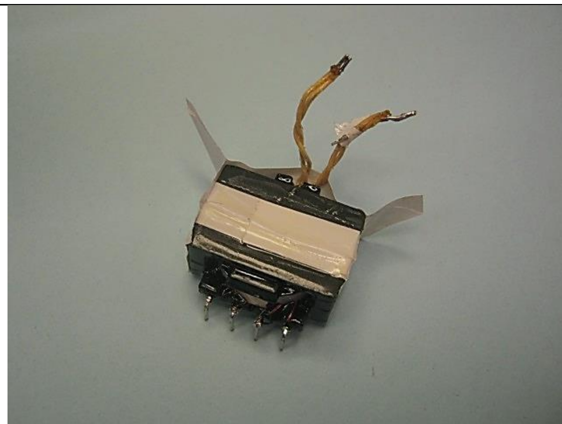
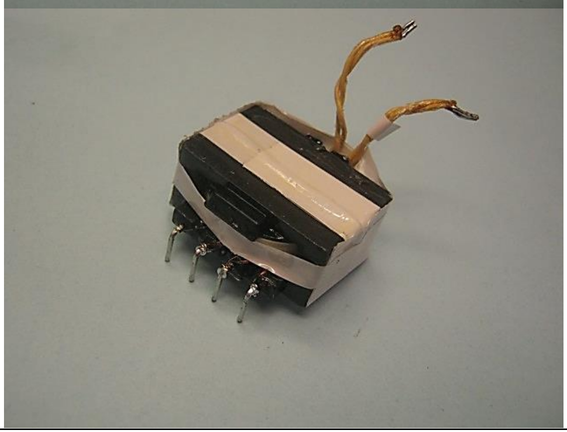


**Power Integrations**
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

| | | |
|---|---|---|
| **Insulation** |  | 1 layer of tape Item [7]. |
| **WD6**<br>**$2^{nd}$ Primary** | <br> | Use wire floating from WD1, wind 10 turns from left to right. At the last turn, bring the wire back to the left to finish at pin 2. |
| **Insulation** |  | 3 layers of tape Item [7] and bring the secondary wires FL1 to the right in between layers of tape. |

| | | |
|---|---|---|
| |  | |
| **Finish** |    | Gap cores to get 469 μH, solder bus wire Item [6] to pin 3which leans along with core halves, and secure with tape.<br>Varnish Item [9].<br>Places 2 layers of tape Item [8] at the bottom of transformer and wrap up to cover secondary side of transformer.<br>Wrap around the body of transformer 1 layer of tape Item [7], *(see illustration beside).* |


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

| | | |
|---|---|---|
| |   | |

# 8 Common Mode Choke Specifications

## 8.1 *250 μH Common Mode Choke (L1)*

### 8.1.1 Electrical Diagram

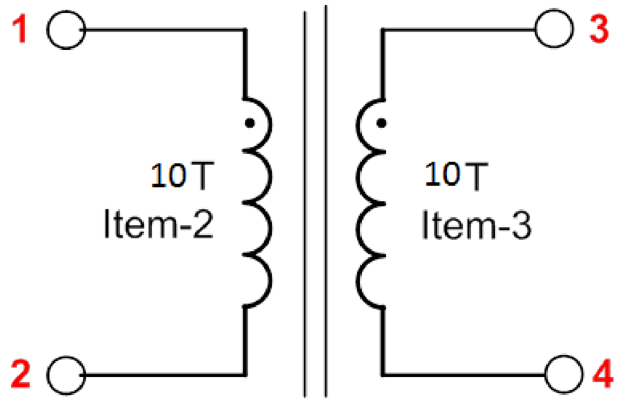



**Figure 8 –** Inductor Electrical Diagram.

### 8.1.2 Electrical Specifications

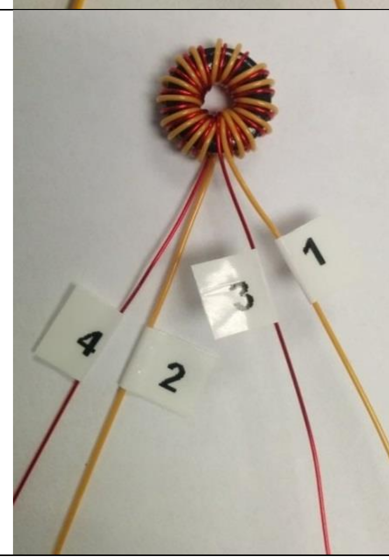
| | | |
|---|---|---|
| **Inductance** | Pins 1-2 measured at 100 kHz, 0.4 RMS. | 250 μH ±20% |
| **Primary Leakage Inductance** | Pins 1-2, with 3-4 shorted. | 1 μH |

### 8.1.3 Material List

| Item | Description |
|---|---|
| **[1]** | Toroid: FERRITE INDUCTOR TOROID .415" O.D.;Mfg Part Number: 35T0375-10H.<br>Dim: 9.53 mm O.D. x 4.75 mm I.D. x 3.18 mm L. |
| **[2]** | Magnet Wire: #27 AWG. |
| **[3]** | Triple Insulated Wire #27 AWG. |


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

### 8.1.4 Common Mode Choke Construction

| | |
|---|---|
| Mark the start end of the winding as 1 and wind 10 turns of Item [2] on Item [1]. Mark the end of this winding as 2 |  |
| Repeat the same procedure as above for the other winding using Item [3], making sure that the start/end and the direction of winding is the same as the first winding.<br>Varnish using Item [4]. Mark the start of this winding as 3 and the end as 4. |  |

# 9 Transformer Design Spreadsheet

| **1** | **ACDC_6201_Flyback_041318; Rev.0.1; Copyright Power Integrations 2018** | **INPUT** | **INFO** | **OUTPUT** | **UNITS** | **6201 Flyback Design Spreadsheet** |
|---|---|---|---|---|---|---|
| **2** | **APPLICATION VARIABLES** | | | | | **Design Title** |
| 3 | VAC_MIN | 90 | | 90 | V | Minimum AC line voltage |
| 4 | VAC_MAX | | | 265 | V | Maximum AC input voltage |
| 5 | VAC_RANGE | | | UNIVERSAL | | AC line voltage range |
| 6 | FLINE | | | 60 | Hz | AC line voltage frequency |
| 7 | CAP_INPUT | 100.0 | | 100.0 | uF | Input capacitance |
| **9** | **SETPOINT 1** | | | | | |
| 10 | VOUT1 | 20.00 | | 20.00 | V | Output voltage 1, should be the highest output voltage required |
| 11 | IOUT1 | 3.000 | | 3.000 | A | Output current 1 |
| 12 | POUT1 | | | 60.00 | W | Output power 1 |
| 13 | EFFICIENCY1 | 0.90 | | 0.90 | | Converter efficiency for output 1 |
| 14 | Z_FACTOR1 | 0.50 | | 0.50 | | Z-factor for output 1 |
| **16** | **SETPOINT 2** | | | | | |
| 17 | VOUT2 | 15.00 | | 15.00 | V | Output voltage 2 |
| 18 | IOUT2 | 3.000 | | 3.000 | A | Output current 2 |
| 19 | POUT2 | | | 45.00 | W | Output power 2 |
| 20 | EFFICIENCY2 | 0.92 | | 0.92 | | Converter efficiency for output 2 |
| 21 | Z_FACTOR2 | 0.50 | | 0.50 | | Z-factor for output 2 |
| **23** | **SETPOINT 3** | | | | | |
| 24 | VOUT3 | 9.00 | | 9.00 | V | Output voltage 3 |
| 25 | IOUT3 | 3.000 | | 3.000 | A | Output current 3 |
| 26 | POUT3 | | | 27.00 | W | Output power 3 |
| 27 | EFFICIENCY3 | 0.91 | | 0.91 | | Converter efficiency for output 3 |
| 28 | Z_FACTOR3 | 0.50 | | 0.50 | | Z-factor for output 3 |
| **30** | **SETPOINT 4** | | | | | |
| 31 | VOUT4 | 5.00 | | 5.00 | V | Output voltage 4 |
| 32 | IOUT4 | 3.000 | | 3.000 | A | Output current 4 |
| 33 | POUT4 | | | 15.00 | W | Output power 4 |
| 34 | EFFICIENCY4 | 0.90 | | 0.90 | | Converter efficiency for output 4 |
| 35 | Z_FACTOR4 | 0.50 | | 0.50 | | Z-factor for output 4 |
| **37** | **SETPOINT 5** | | | | | |
| 38 | VOUT5 | | | 0.00 | V | Output voltage 5 |
| 39 | IOUT5 | | | 0.000 | A | Output current 5 |
| 40 | POUT5 | | | 0.00 | W | Output power 5 |
| 41 | EFFICIENCY5 | | | 0.00 | | Converter efficiency for output 5 |
| 42 | Z_FACTOR5 | | | 0.00 | | Z-factor for output 5 |
| **44** | **SETPOINT 6** | | | | | |
| 45 | VOUT6 | | | 0.00 | V | Output voltage 6 |
| 46 | IOUT6 | | | 0.000 | A | Output current 6 |
| 47 | POUT6 | | | 0.00 | W | Output power 6 |
| 48 | EFFICIENCY6 | | | 0.00 | | Converter efficiency for output 6 |
| 49 | Z_FACTOR6 | | | 0.00 | | Z-factor for output 6 |
| **51** | **SETPOINT 7** | | | | | |
| 52 | VOUT7 | | | 0.00 | V | Output voltage 7 |
| 53 | IOUT7 | | | 0.000 | A | Output current 7 |
| 54 | POUT7 | | | 0.00 | W | Output power 7 |
| 55 | EFFICIENCY7 | | | 0.00 | | Converter efficiency for output 7 |
| 56 | Z_FACTOR7 | | | 0.00 | | Z-factor for output 7 |
| **58** | **SETPOINT 8** | | | | | |
| 59 | VOUT8 | | | 0.00 | V | Output voltage 8 |


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

| | | | | | | |
|---|---|---|---|---|---|---|
| 60 | IOUT8 | | | 0.000 | A | Output current 8 |
| 61 | POUT8 | | | 0.00 | W | Output power 8 |
| 62 | EFFICIENCY8 | | | 0.00 | | Converter efficiency for output 8 |
| 63 | Z_FACTOR8 | | | 0.00 | | Z-factor for output 8 |
| **65** | **SETPOINT 9** | | | | | |
| 66 | VOUT9 | | | 0.00 | V | Output voltage 9 |
| 67 | IOUT9 | | | 0.000 | A | Output current 9 |
| 68 | POUT9 | | | 0.00 | W | Output power 9 |
| 69 | EFFICIENCY9 | | | 0.00 | | Converter efficiency for output 9 |
| 70 | Z_FACTOR9 | | | 0.00 | | Z-factor for output 9 |
| 71 | | | | | | |
| 72 | PERCENT_CDC | 0% | | 0% | | Percentage (of output voltage) cable drop compensation desired at full load |
| 73 | CDC_SCALING_SETPOINT | 3 | | 3 | | Select the setpoint number for the voltage used for cable drop compensation (typically the 5V output) |
| **77** | **PRIMARY CONTROLLER SELECTION** | | | | | |
| 78 | ENCLOSURE | ADAPTE R | | ADAPTER | | Power supply enclosure |
| 79 | ILIMIT_MODE | INCREA SED | | INCREASED | | Device current limit mode |
| 80 | VDRAIN_BREAKDOWN | 725 | | 725 | V | Device breakdown voltage |
| 81 | DEVICE_GENERIC | Auto | | INN3279C | | Device selection |
| 82 | DEVICE_CODE | | | INN3279C | | Device code |
| 83 | PDEVICE_MAX | | | 65 | W | Device maximum power capability |
| 84 | RDSON_25DEG | | | 0.25 | Ω | Primary SWITCH on-time resistance at 25°C |
| 85 | RDSON_100DEG | | | 0.60 | Ω | Primary SWITCH on-time resistance at 100°C |
| 86 | ILIMIT_MIN | | | 1.981 | A | Primary SWITCH minimum current limit |
| 87 | ILIMIT_TYP | | | 2.130 | A | Primary SWITCH typical current limit |
| 88 | ILIMIT_MAX | | | 2.279 | A | Primary SWITCH maximum current limit |
| 89 | VDRAIN_ON_SWITCH | | | 0.43 | V | Primary SWITCH on-time voltage drop |
| 90 | VDRAIN_OFF_SWITCH | | | 583.31 | V | Peak drain voltage on the primary SWITCH during turn-off |
| **94** | **WORST CASE ELECTRICAL PARAMETERS** | | | | | |
| 95 | FSWITCHING_MAX | 79500 | Info | 79500 | Hz | The worst case minimum operating frequency is less than 25kHz: may result in audible noise |
| 96 | VOR | 140.0 | | 140.0 | V | Voltage reflected to the primary winding (corresponding to setpoint 1) when the primary MOSFET turns off |
| 97 | VMIN | | | 89.14 | V | Valley of the rectified minimum input AC voltage at full load |
| 98 | KP | | | 0.781 | | Measure of continuous/discontinuous mode of operation |
| 99 | MODE_OPERATION | | | CCM | | Mode of operation |
| 100 | DUTYCYCLE | | | 0.612 | | Primary SWITCH duty cycle |
| 101 | TIME_ON | | | 10.59 | us | Primary SWITCH on-time |
| 102 | TIME_OFF | | | 4.88 | us | Primary SWITCH off-time |
| 103 | LPRIMARY_MIN | | | 445.6 | uH | Minimum primary magnetizing inductance |
| 104 | LPRIMARY_TYP | | | 469.0 | uH | Typical primary magnetizing inductance |
| 105 | LPRIMARY_TOL | | | 5.0 | | Primary magnetizing inductance tolerance |
| 106 | LPRIMARY_MAX | | | 492.5 | uH | Maximum primary magnetizing inductance |
| **108** | **PRIMARY CURRENT** | | | | | |
| 109 | IAVG_PRIMARY | | | 0.714 | A | Primary SWITCH average current |
| 110 | IPEAK_PRIMARY | | | 2.147 | A | Primary SWITCH peak current |
| 111 | IPEDESTAL_PRIMARY | | | 0.418 | A | Primary SWITCH current pedestal |
| 112 | IRIPPLE_PRIMARY | | | 2.059 | A | Primary SWITCH ripple current |
| 113 | IRMS_PRIMARY | | | 1.014 | A | Primary SWITCH RMS current |

| | | | | | | |
|---|---|---|---|---|---|---|
| **115** | **SECONDARY CURRENT** | | | | | |
| 116 | IPEAK_SECONDARY | | | 15.028 | A | Secondary MOSFET peak current |
| 117 | IPEDESTAL_SECONDARY | | | 2.929 | A | Secondary MOSFET pedestal current |
| 118 | IRMS_SECONDARY | | | 5.652 | A | Secondary MOSFET RMS current |
| 119 | IRIPPLE_CAP_OUT | | | 4.790 | A | Output capacitor ripple current |
| **123** | **TRANSFORMER CONSTRUCTION PARAMETERS** | | | | | |
| **124** | **CORE SELECTION** | | | | | |
| 125 | CORE | Custom | | Custom | | Core selection |
| 126 | CORE NAME | EQ27 | | EQ27 | | Core code |
| 127 | AE | 108.0 | | 108.0 | mm^2 | Core cross sectional area |
| 128 | LE | 36.3 | | 36.3 | mm | Core magnetic path length |
| 129 | AL | 7700 | | 7700 | nH | Ungapped core effective inductance per turns squared |
| 130 | VE | 3920 | | 3920 | mm^3 | Core volume |
| 131 | BOBBIN NAME | EQ2506 | | EQ2506 | | Bobbin name |
| 132 | AW | 52.0 | | 52.0 | mm^2 | Bobbin window area |
| 133 | BW | 4.50 | | 4.50 | mm | Bobbin width |
| 134 | MARGIN | | | 0.0 | mm | Bobbin safety margin |
| **136** | **PRIMARY WINDING** | | | | | |
| 137 | NPRIMARY | | | 28 | | Primary winding number of turns |
| 138 | BPEAK | | | 3799 | Gauss | Peak flux density |
| 139 | BMAX | | | 3453 | Gauss | Maximum flux density |
| 140 | BAC | | | 1651 | Gauss | AC flux density (0.5 x Peak to Peak) |
| 141 | ALG | | | 598 | nH | Typical gapped core effective inductance per turns squared |
| 142 | LG | | | 0.209 | mm | Core gap length |
| 143 | LAYERS_PRIMARY | | | 3 | | Primary winding number of layers |
| 144 | AWG_PRIMARY | | | 26 | | Primary wire gauge |
| 145 | OD_PRIMARY_INSULATED | | | 0.465 | mm | Primary wire insulated outer diameter |
| 146 | OD_PRIMARY_BARE | | | 0.405 | mm | Primary wire bare outer diameter |
| 147 | CMA_PRIMARY | | | 250.5 | Cmils/A | Primary winding wire CMA |
| **149** | **SECONDARY WINDING** | | | | | |
| 150 | NSECONDARY | 4 | | 4 | | Secondary winding number of turns |
| 151 | AWG_SECONDARY | | | 19 | | Secondary wire gauge |
| 152 | OD_SECONDARY_INSULATED | | | 1.217 | mm | Secondary wire insulated outer diameter |
| 153 | OD_SECONDARY_BARE | | | 0.912 | | Secondary wire bare outer diameter |
| 154 | CMA_SECONDARY | | | 227.9 | Cmils/A | Secondary winding wire CMA |
| **156** | **BIAS WINDING** | | | | | |
| 157 | NBIAS | | | 7 | | Bias winding number of turns |
| **161** | **PRIMARY COMPONENTS SELECTION** | | | | | |
| **162** | **LINE UNDERVOLTAGE** | | | | | |
| 163 | BROWN-IN REQURED | 75.00 | | 75.00 | V | Required line brown-in threshold |
| 164 | RLS | | | 3.74 | MΩ | Connect two 1.87 MOhm resistors to the V-pin for the required UV/OV threshold |
| 165 | BROWN-IN ACTUAL | | | 74.98 | V | Actual brown-in threshold using standard resistors |
| 166 | BROWN-OUT ACTUAL | | | 67.82 | V | Actual brown-out threshold using standard resistors |
| **168** | **LINE OVERVOLTAGE** | | | | | |
| 169 | OVERVOLTAGE_LINE | | | 312.52 | V | Actual AC RMS line over-voltage threshold |
| 170 | | | | | | |
| 171 | BIAS WINDING | | | | | |
| 172 | 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 |
| 173 | VF_BIAS | | | 0.70 | V | Bias winding diode forward drop |



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

| | | | | | | |
|---|---|---|---|---|---|---|
| 174 | VREVERSE_BIASDIODE | | | 101.33 | V | Bias diode reverse voltage (not accounting parasitic voltage ring) |
| 175 | CBIAS | | | 22 | uF | Bias winding rectification capacitor |
| 176 | CBPP | | | 4.70 | uF | BPP pin capacitor |
| **180** | **SECONDARY COMPONENTS SELECTION** | | | | | |
| **181** | **RECTIFIER** | | | | | |
| 182 | VDRAIN_OFF_SRFET | | | 73.33 | V | Secondary rectifier reverse voltage (not accounting parasitic voltage ring) |
| 183 | SRFET | AONS62922 | | AONS62922 | | Secondary rectifier (Logic MOSFET) |
| 184 | VBREAKDOWN_SRFET | | | 120 | V | Secondary rectifier breakdown voltage |
| 185 | RDSON_SRFET | | | 7.1 | mΩ | SRFET on time drain resistance at 25degC for VGS=4.4V |
| **187** | **FEEDBACK COMPONENTS** | | | | | |
| 188 | RFB_UPPER | | | 191 | kΩ | Upper feedback resistor (connected to the output terminal) |
| 189 | RFB_LOWER | | | 11.50 | kΩ | Lower feedback resistor required to obtain the output for cable drop compensation |
| 190 | CFB_LOWER | | | 330 | pF | Lower feedback resistor decoupling capacitor |
| **194** | **VARIABLE OUTPUTS ANALYSIS** | | | | | |
| **195** | **TOLERANCE CORNER** | | | | | |
| 196 | CORNER_VAC | | | 90 | V | Input AC RMS voltage corner to be evaluated |
| 197 | CORNER_ILIMIT | TYP | | 2.130 | A | Current limit corner to be evaluated |
| 198 | CORNER_LPRIMARY | TYP | | 469.0 | uH | Primary inductance corner to be evaluated |
| **200** | **SETPOINT SELECTION** | | | | | |
| 201 | SETPOINT | 1 | | 1 | | Select the setpoint which needs to be evaluated |
| 202 | FSWITCHING | | | 66998.9 | Hz | Maximum switching frequency at full load and the valley of the minimum input AC voltage |
| 203 | VOR | | | 140.0 | V | Voltage reflected to the primary winding when the primary SWITCH turns off |
| 204 | VMIN | | | 89.14 | V | Valley of the minimum input AC voltage |
| 205 | KP | | | 0.851 | | Measure of continuous/discontinuous mode of operation |
| 206 | MODE_OPERATION | | | CCM | | Mode of operation |
| 207 | DUTYCYCLE | | | 0.612 | | Primary SWITCH duty cycle |
| 208 | TIME_ON | | | 9.14 | us | Primary controller's maximum on-time |
| 209 | TIME_OFF | | | 5.79 | us | Primary controller's minimum off-time |
| **211** | **PRIMARY CURRENT** | | | | | |
| 212 | IAVG_PRIMARY | | | 0.714 | A | Primary SWITCH average current |
| 213 | IPEAK_PRIMARY | | | 2.030 | A | Primary SWITCH peak current |
| 214 | IPEDESTAL_PRIMARY | | | 0.302 | A | Primary SWITCH current pedestal |
| 215 | IRIPPLE_PRIMARY | | | 1.728 | A | Primary SWITCH ripple current |
| 216 | IRMS_PRIMARY | | | 0.992 | A | Primary SWITCH RMS current |
| **218** | **SECONDARY CURRENT** | | | | | |
| 219 | IPEAK_SECONDARY | | | 14.212 | A | Secondary MOSFET peak current |
| 220 | IPEDESTAL_SECONDARY | | | 2.115 | A | Secondary MOSFET pedestal current |
| 221 | IRMS_SECONDARY | | | 5.530 | A | Secondary MOSFET RMS current |
| 222 | IRIPPLE_CAP_OUT | | | 4.646 | A | Output capacitor ripple current |
| **224** | **MAGNETIC FLUX DENSITY** | | | | | |
| 225 | BPEAK | | | 3381 | Gauss | Peak flux density |
| 226 | BMAX | | | 3149 | Gauss | Maximum flux density |
| 227 | BAC | | | 1340 | Gauss | AC flux density (0.5 x Peak to Peak) |

# 10 Adapter Case Dimensions

## 10.1 *Case Bottom Dimensions*

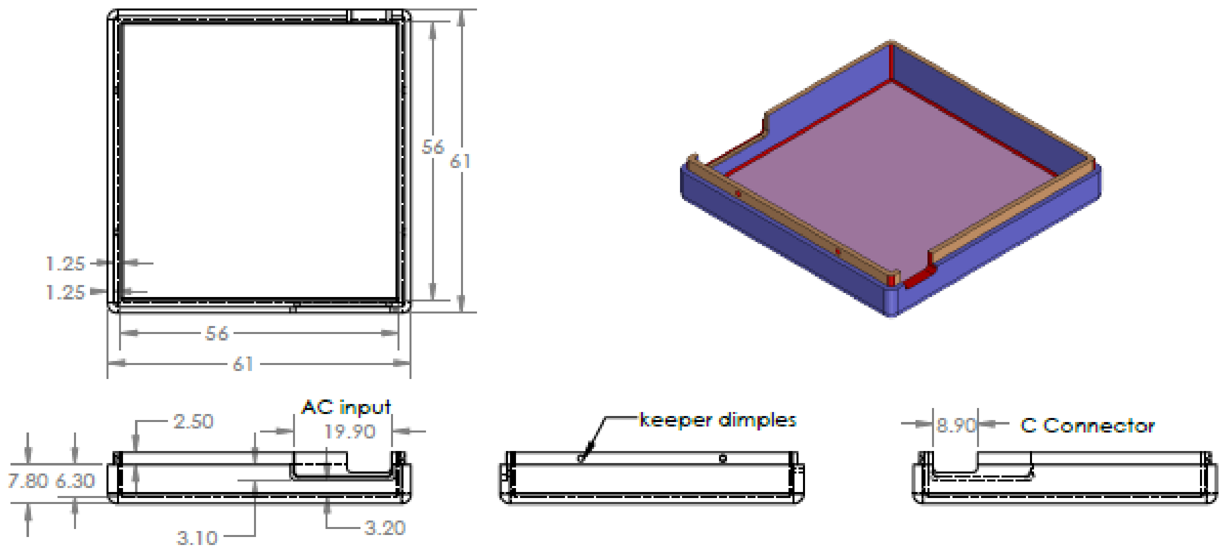



**Figure 9 –** DER-601 Adapter Case Bottom.

## 10.2 *Case Top Dimensions*

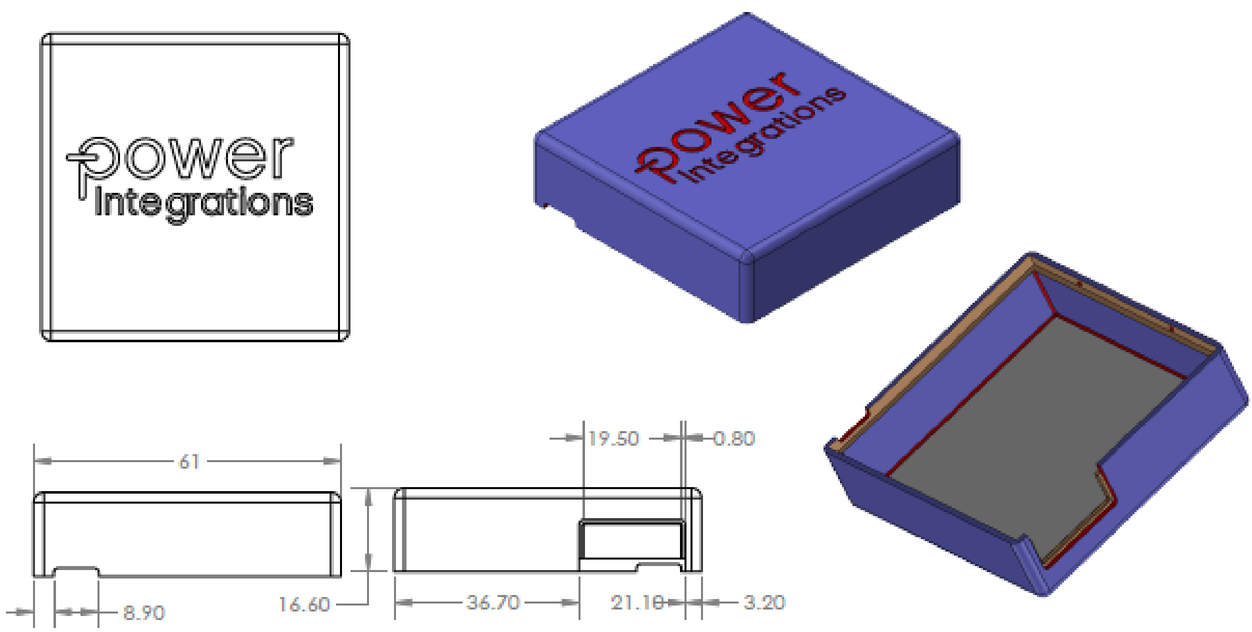



**Figure 10** – DER-601 Adapter Case Top.


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

## 10.3 *Adapter Assembly Drawing*

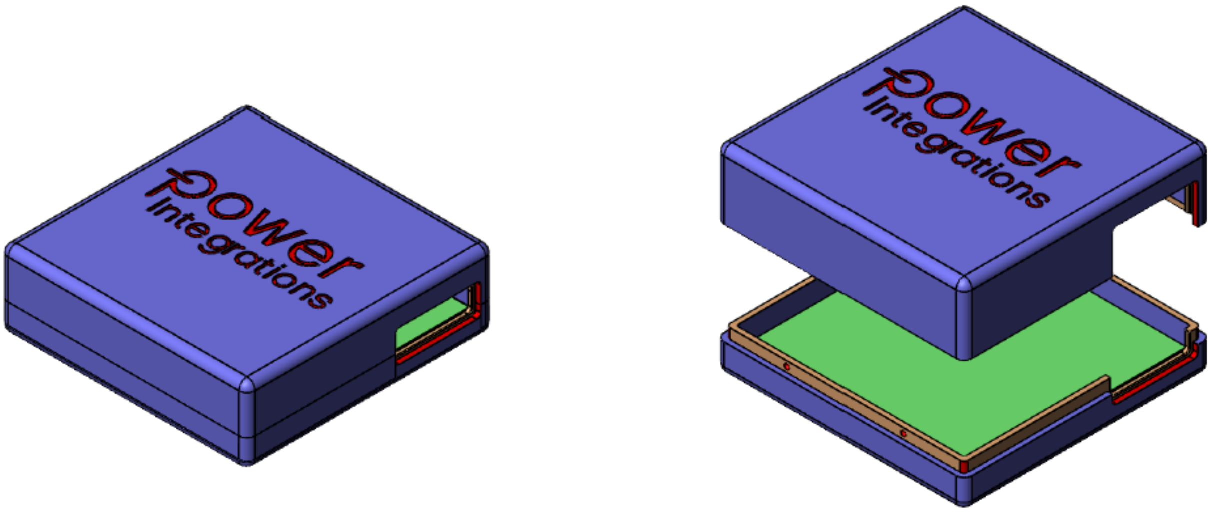
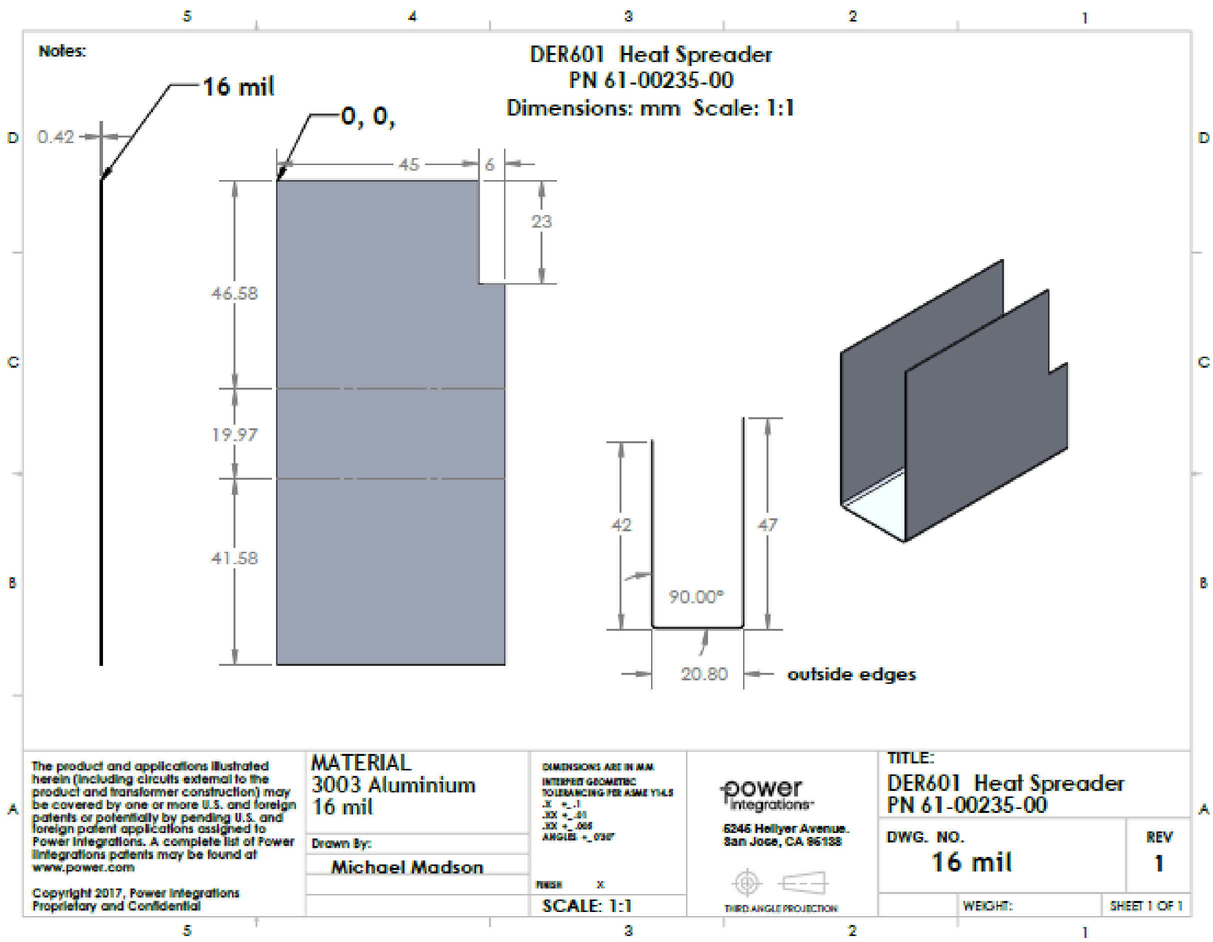


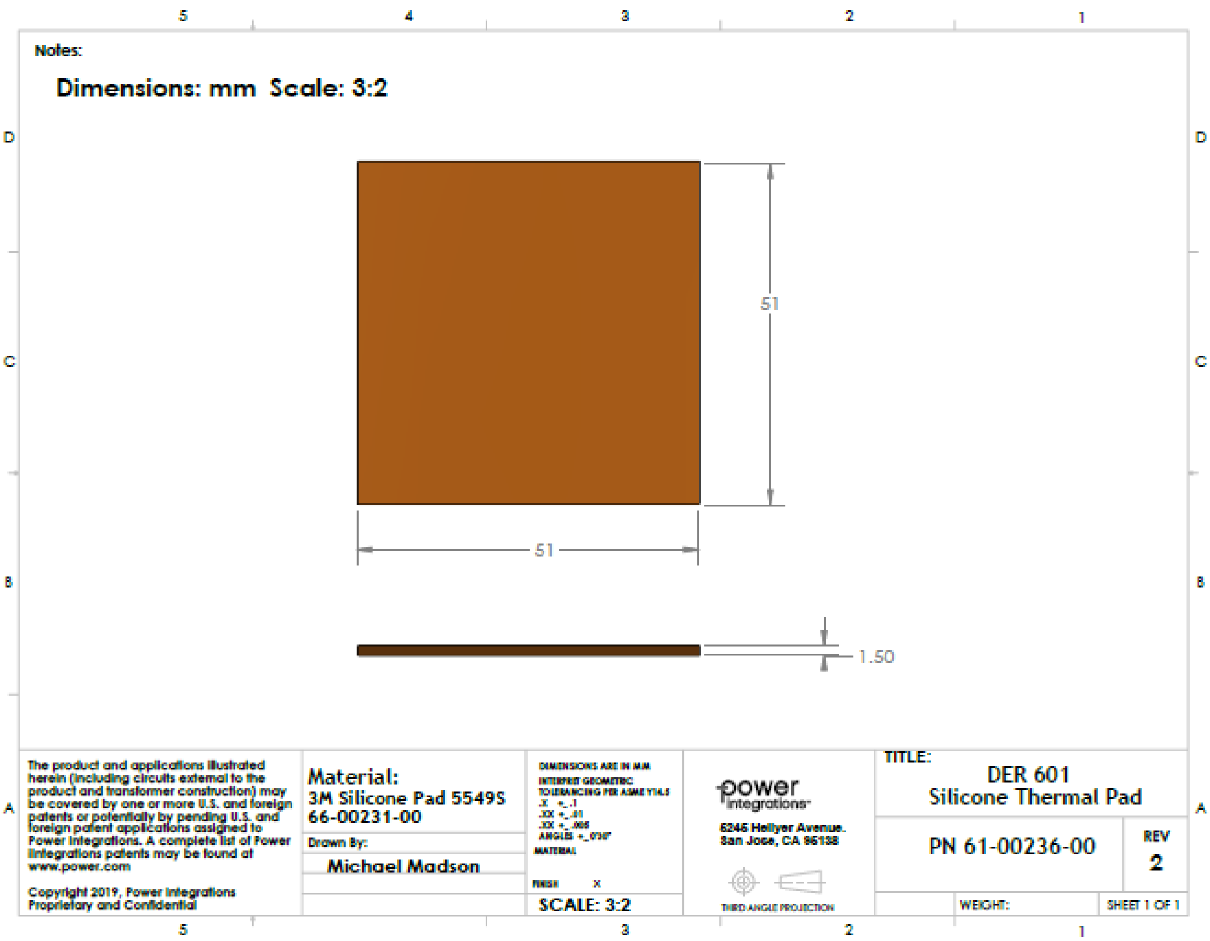

**Figure 11** – DER-601 Adapter Assembly Drawing.

# 11 Heat Spreader Drawings

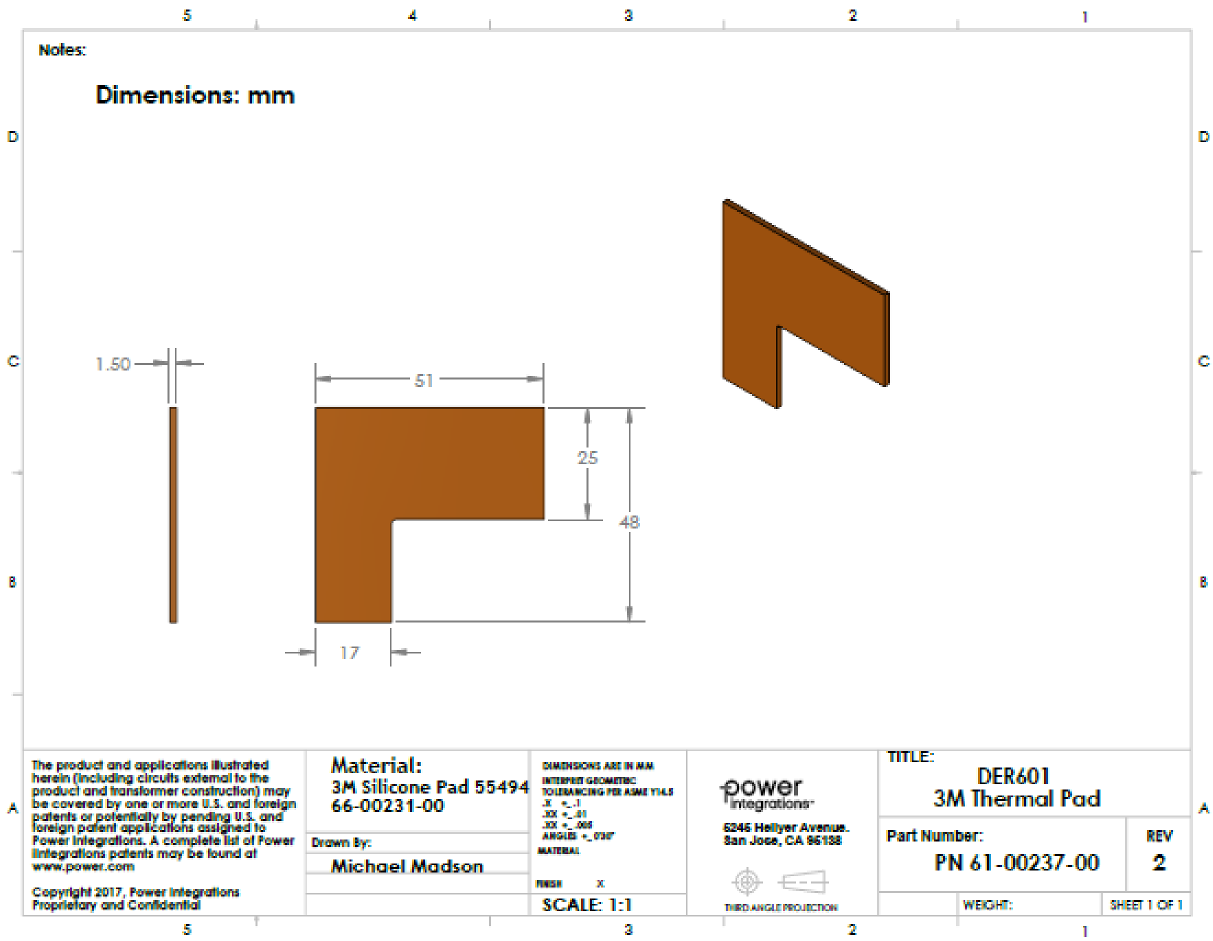





**Power Integrations**
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com



Notes:
Dimensions: mm Scale: 3:2
51
51
1.50
The product and applications illustrated herein (including circuits external to the product and transformer construction) may be covered by one or more U.S. and foreign patents or potentially by pending U.S. and foreign patent applications assigned to Power Integrations. A complete list of Power Integrations patents may be found at www.power.com
Copyright 2019, Power Integrations Proprietary and Confidential
Material:
3M Silicone Pad 5549S
66-00231-00
Drawn By:
Michael Madson
SCALE: 3:2
5245 Hellyer Avenue, San Jose, CA 95138
THIRD ANGLE PROJECTION
TITLE:
DER 601
Silicone Thermal Pad
PN 61-00236-00
REV
2
WEIGHT:
SHEET 1 OF 1

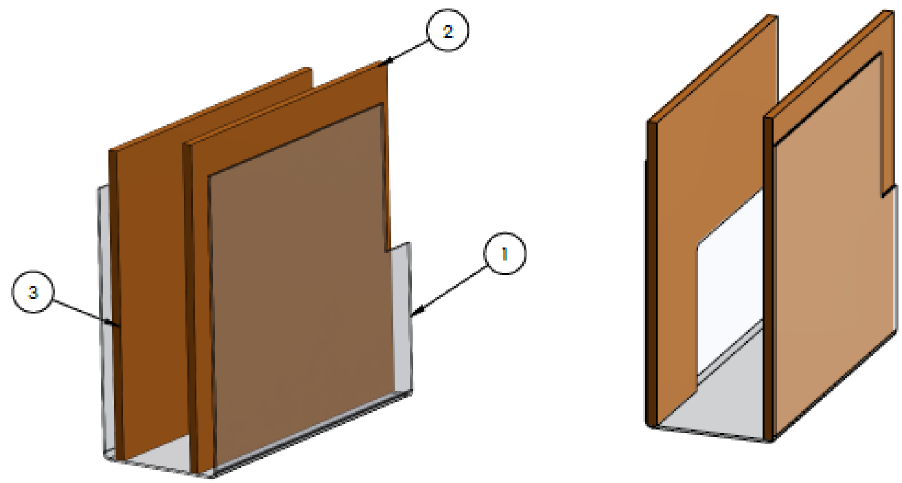




Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

Notes:

Dimensions: mm Scale 3:2




| ITEM NO. | PART NUMBER | DESCRIPTION | QTY. |
|---|---|---|---|
| 1 | 61-00235-00 | 16 Mil folded aluminum | 1 |
| 2 | 61-00236-00 | 3M Thermal Pad PN 55494 | 1 |
| 3 | 61-00237-00 | 3M Thermal Pad 55494 | 1 |



3003 Aluminum and thermal Pad

Drawn By: Michael Madson

DIMENSIONS ARE IN MM
INTERPRET GEOMETRIC TOLERANCING PER ASME Y14.5
.X ±.1
.XX ±.01
.XXX ±.005
ANGLES ±.030°
MATERIAL
FINISH X

SCALE: 3:2

power integrations
5245 Hellyer Avenue, San Jose, CA 95138
THIRD ANGLE PROJECTION

TITLE: DER601 Heat Sink Assembly

DWG. NO. 61-00235-02

REV 1

WEIGHT:

SHEET 1 OF 1

**Figure 12** – Heat Spreader, Thermal Pad Drawings and Assembly.

# 12 Heat Spreader Assembly Instructions

## 12.1 *Materials*

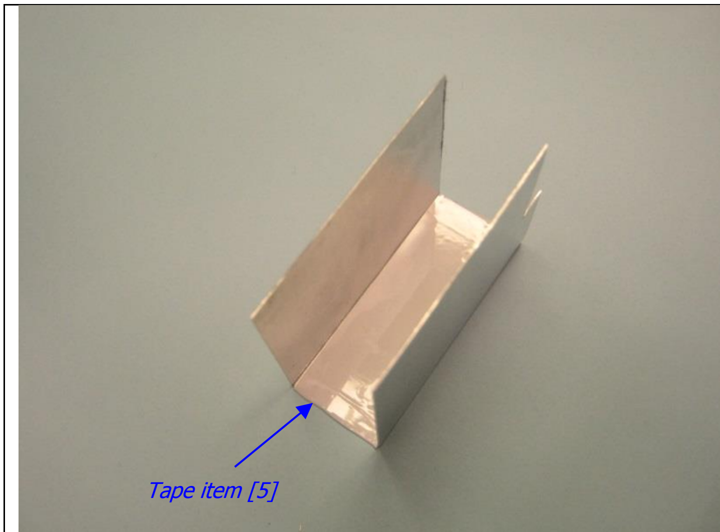
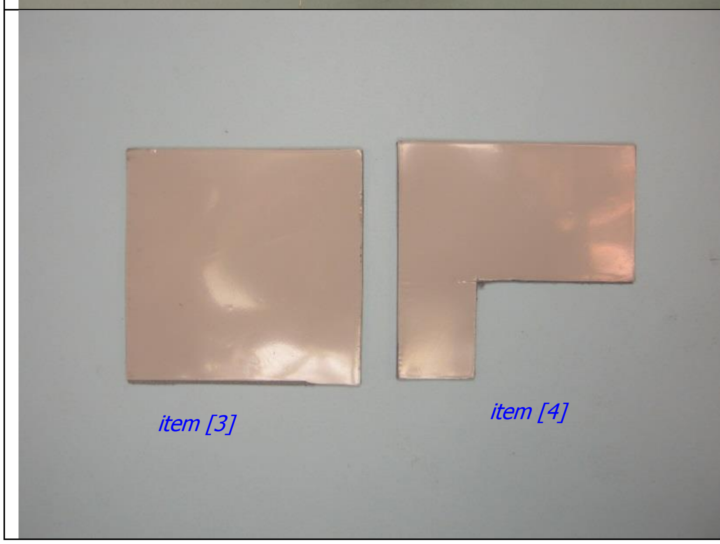
| Item | Description |
|---|---|
| **[1]** | Heat spreader; PI#: 61-00235-00. |
| **[2]** | Thermal pad, PI#: 66-00231-00. |
| **[3]** | Use item [2] cut into "Square" shape with dimension as shown in fig.1. |
| **[4]** | Use item [2] cut into "L" shape with dimension as shown in fig.1. |
| **[5]** | Tape: 3M 1298 Polyester Film, 1 mil thick, 20.0mm wide, 51mm long. |
| **[6]** | Tape: 3M 1298 Polyester Film, 1 mil thick, 14.0mm wide, 51mm long. |

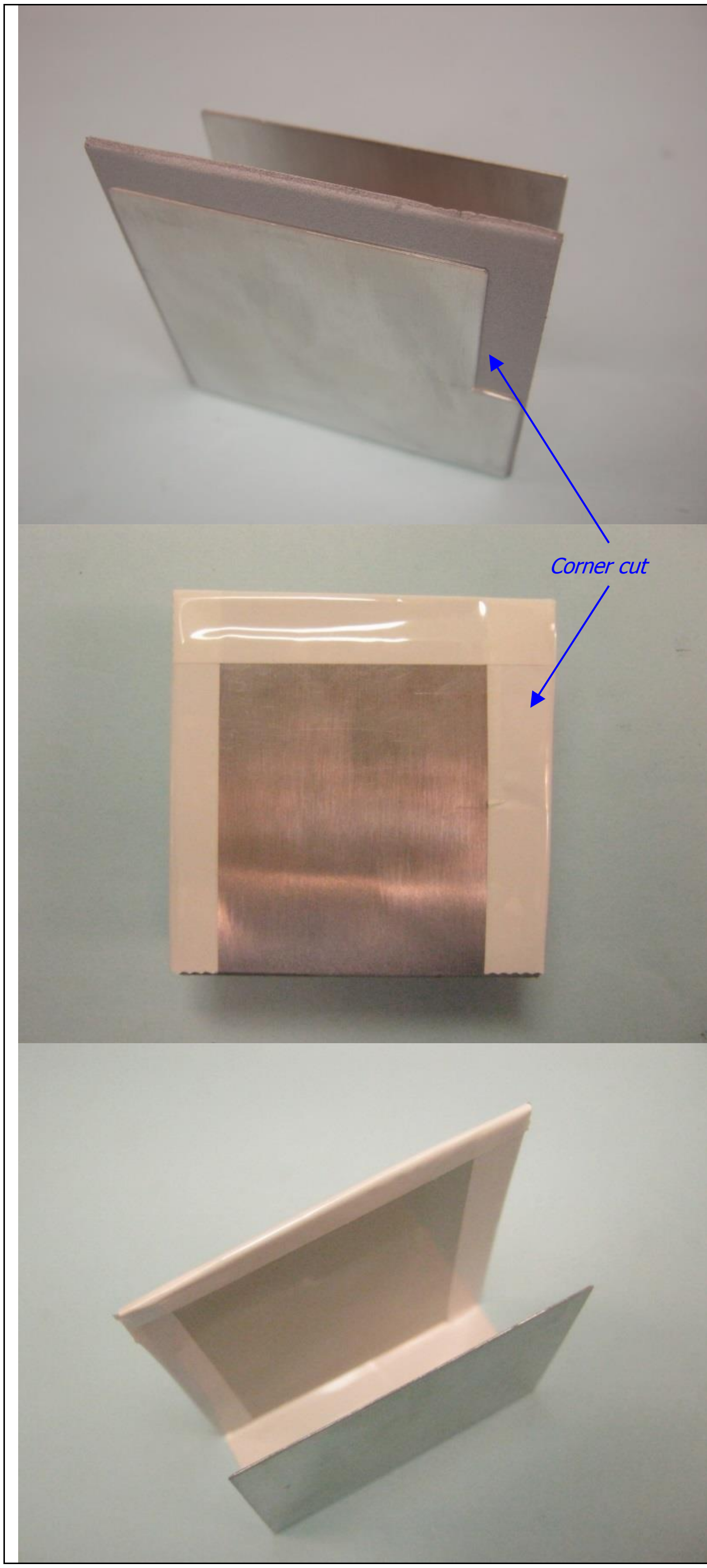
## 12.2 *Assembly Instructions*


Use proper flush cutters such as shown in this picture to have all pin of PCB to be flush cut in order to avoid any pins poking into the thermal pads. *(see illustration beside).*

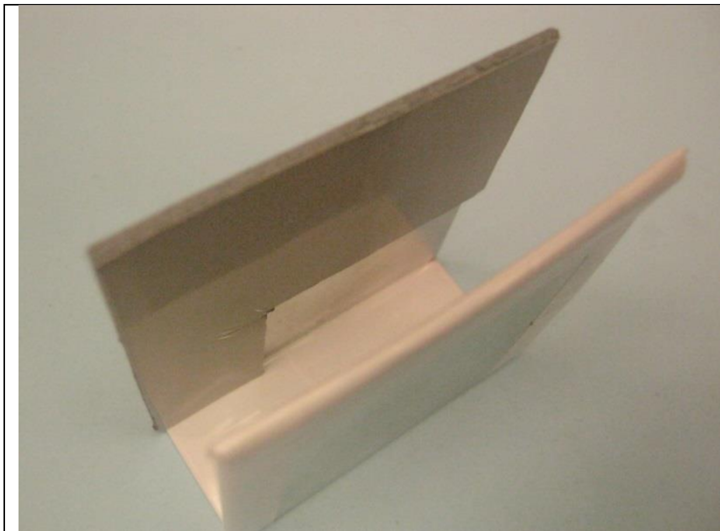
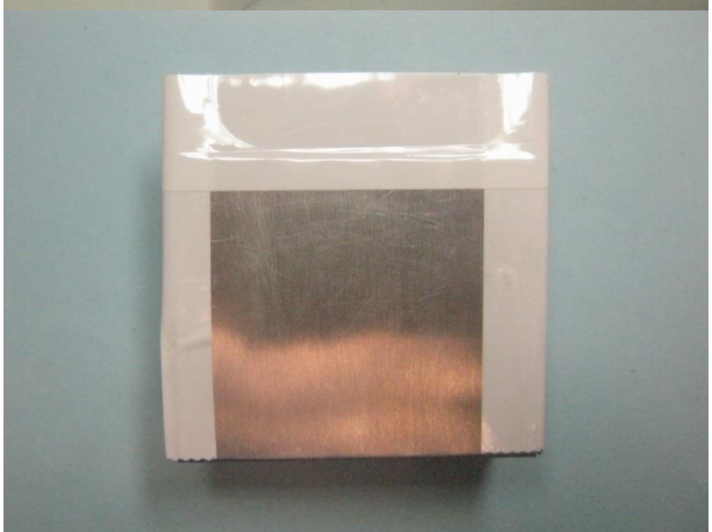
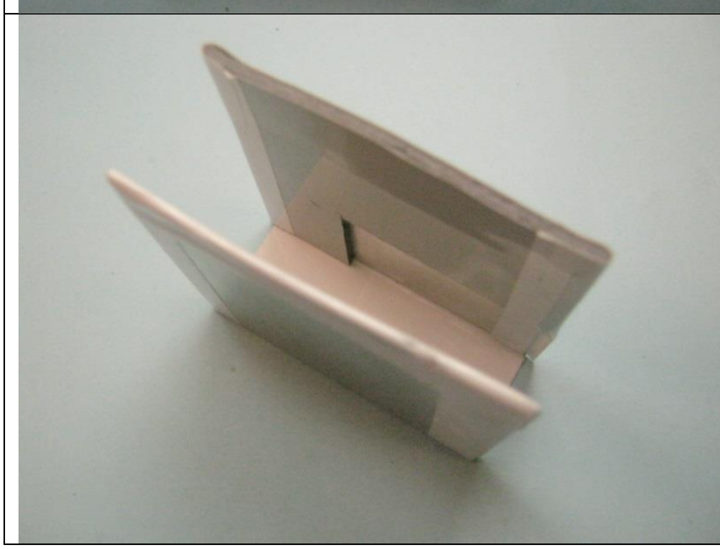


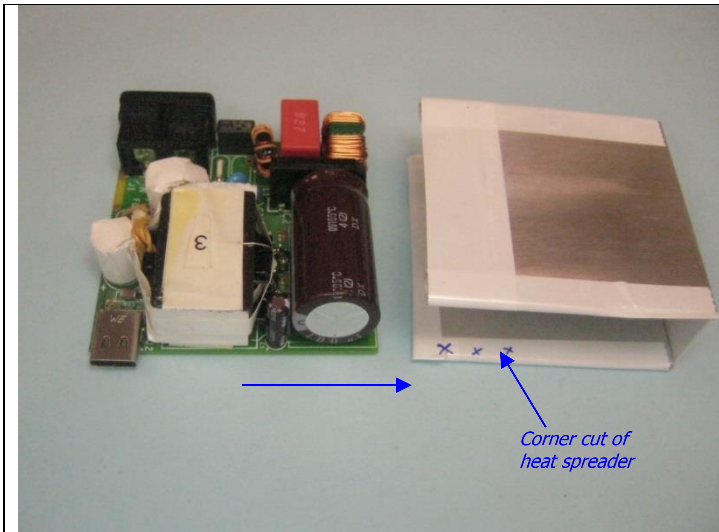
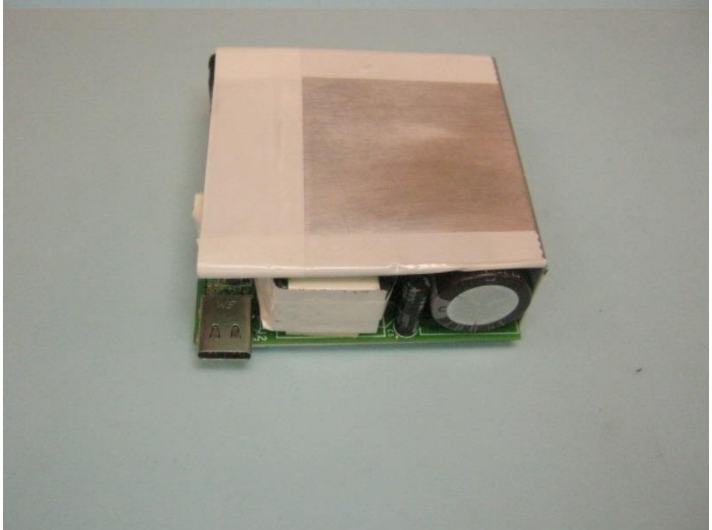
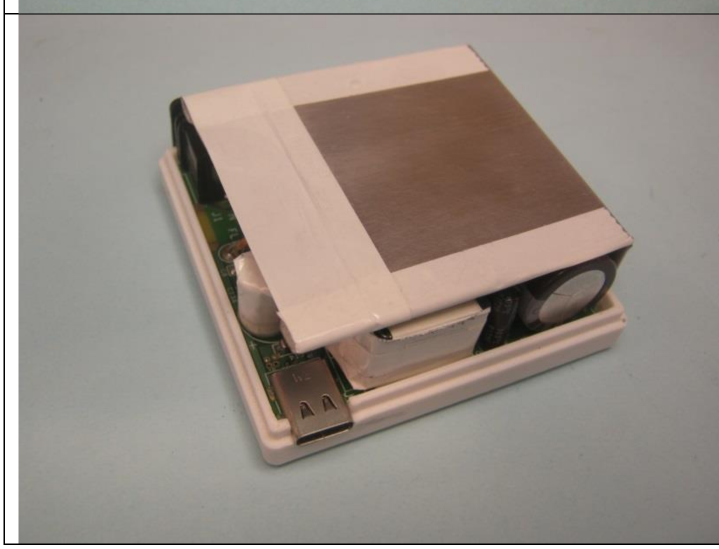
**Power Integrations**
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

| | |
|---|---|
|  | Place 1 layer of tape item [5] at inner edge of heat spreader item [1]. |
|  | Prepare item [3] and item [4] |

| | |
|---|---|
|  | Use item [3], peel the clear plastic cover (sticky side) and attach this side to one side heat spreader item [1], which has corner cut.<br>Wrap around 3 edges with tape item [6]. |


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

| | |
|---|---|
|   | Use item [4], peel the clear plastic cover (sticky side) and attach this side to other side of heat spreader item [1].<br>Wrap around 3 edges with tape item [6]. |
|  | The complete heat spreader assembly. |

| | |
|---|---|
|    | Insert board into heat spreader assembly. |
|  | Place whole set onto bottom half of the case and snap top half in place. |


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

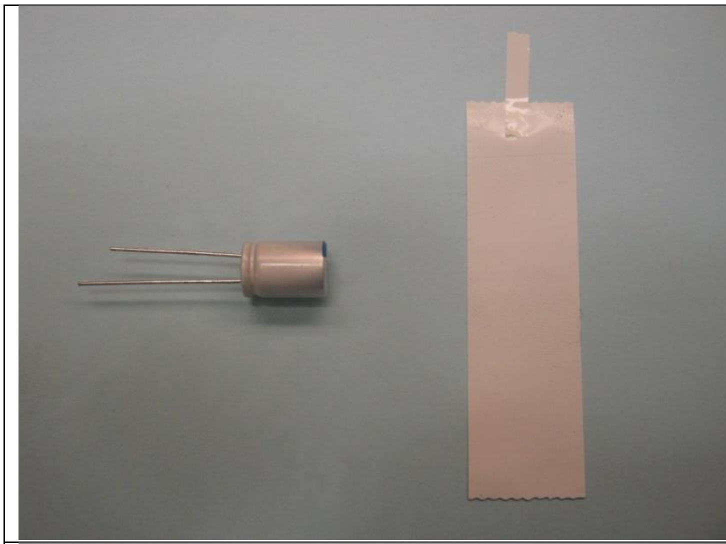
| | |
|---|---|
|  | |

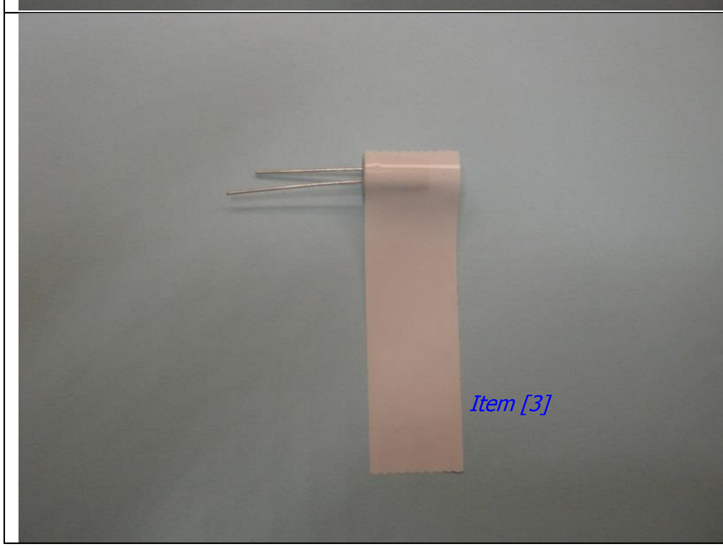
# 13 Output Capacitor and Transformer Assembly Instructions

## 13.1 *Materials*

| Item | Description |
|---|---|
| **[1]** | Capacitor C13 on DER-601 Schematic. |
| **[2]** | Capacitor C13A on DER-601 Schematic. |
| **[3]** | Tape: 3M 1298 Polyester Film, 1 mil Thick, 16.4 mm Wide, 25 mm Long. |
| **[4]** | Tape: 3M 1298 Polyester Film, 1 mil Thick, 5.0 mm Wide, 15 mm Long. |
| **[5]** | Tape: 3M 4026W Double Coated Urethane Foam Tape 1.6 mm Thick, 12.7 mm Wide, 22 mm Long. |

## 13.2 *Output Capacitor and Transformer Assembly Instructions*

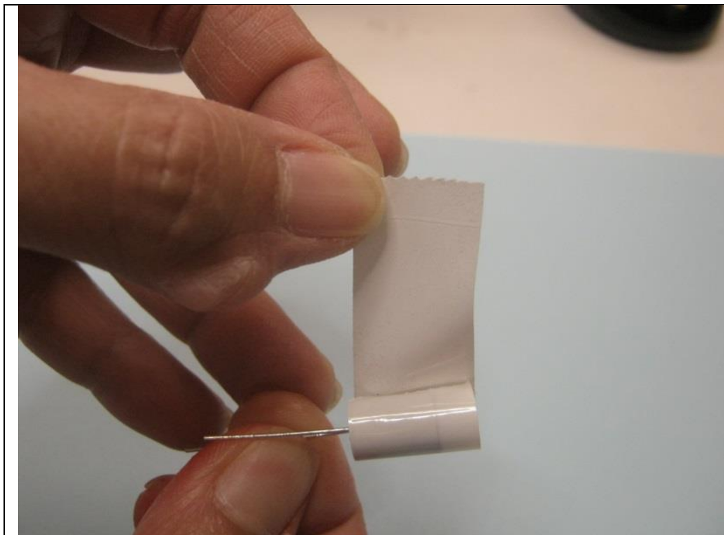


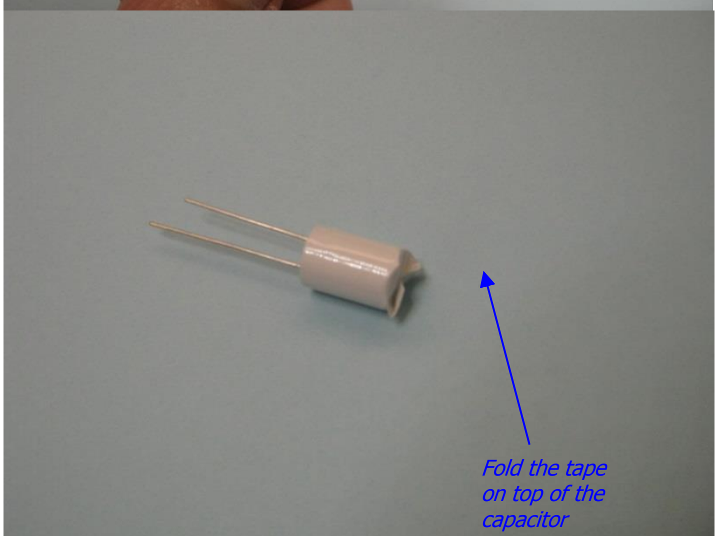


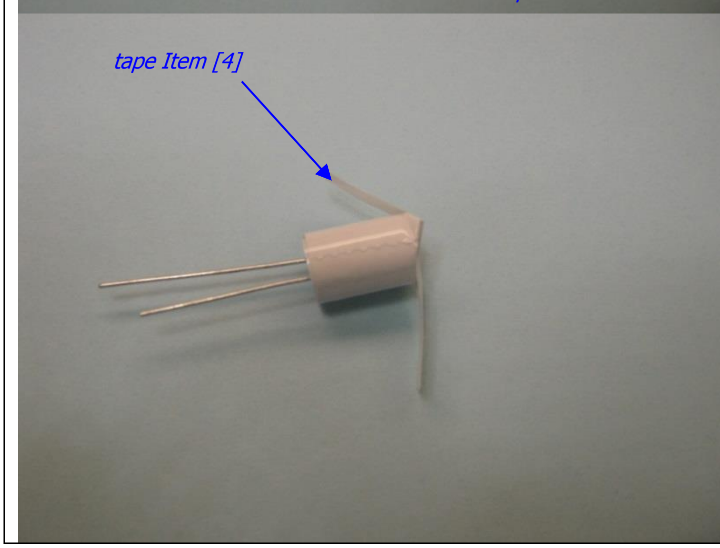

Wrap C13 and C13A with tape Item [3] to insulate the capacitor form transformer core.

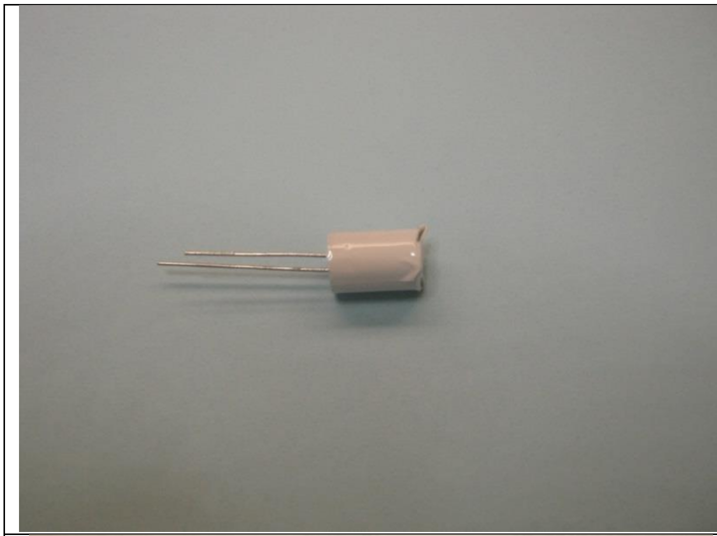
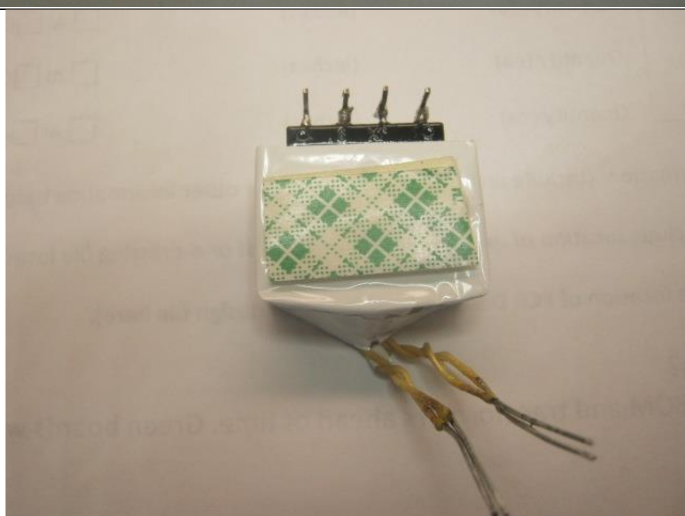


Power Integrations
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com




Fold the tape
on top of the
capacitor


tape Item [4]

| | |
|---|---|
|  | |
|  | Peel off the tape cover of Item [5] and stick to the transformer in the center. Peel off the tape cover on the other side off the tape before assembling it on to the board. |
|  | Finish assembly. |

**Note:** cut all the TH (PTH and NPTH) pins to <0.5 mm on the bottom side of the board after completing the assembly.



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

# 14 Performance Data

All the performance data have been taken on the board unless otherwise specifically mentioned.

## 14.1 *Efficiency vs. Line*

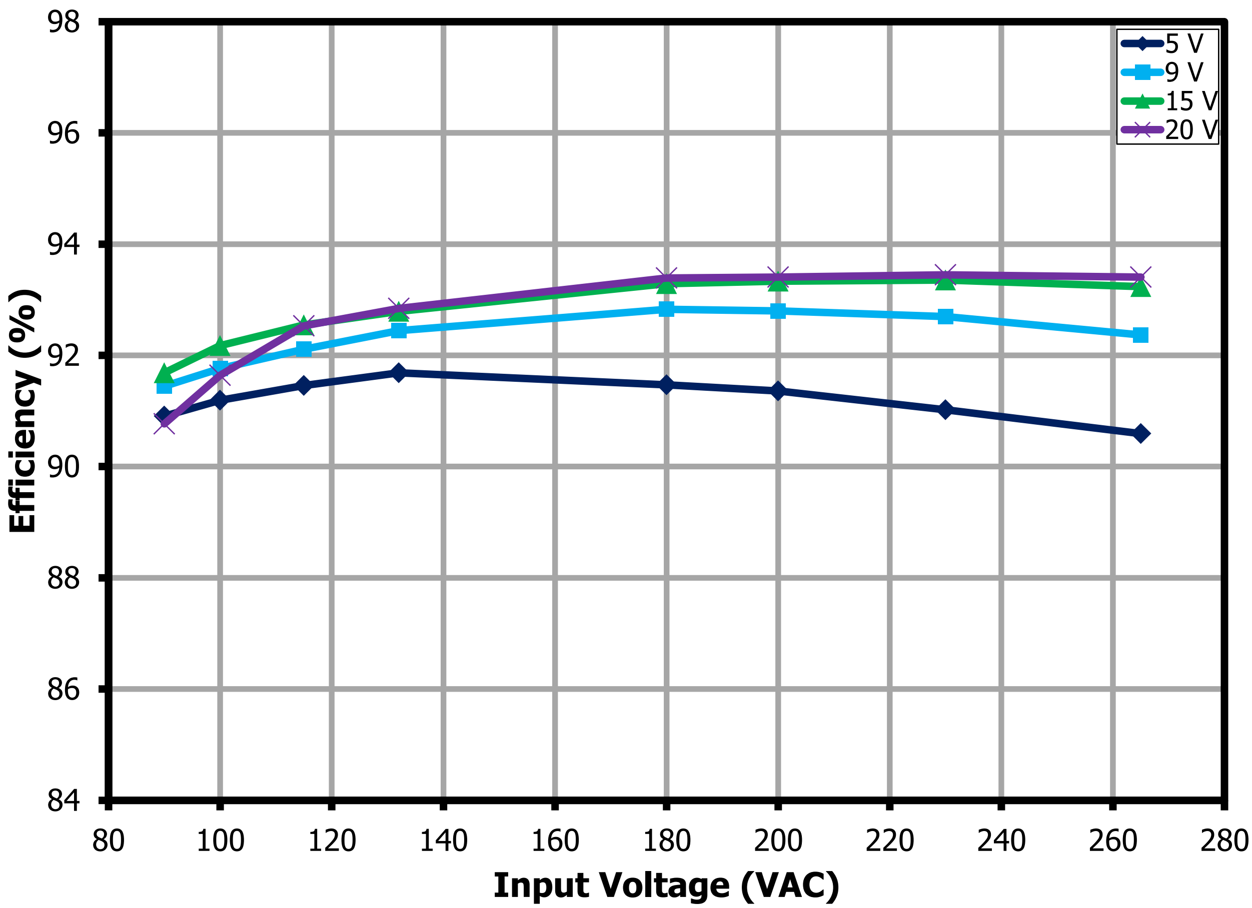



**Figure 13 –** Efficiency vs. Line, Room Ambient.

## 14.2 *No-Load Input Power at 5 $V_{OUT}$*

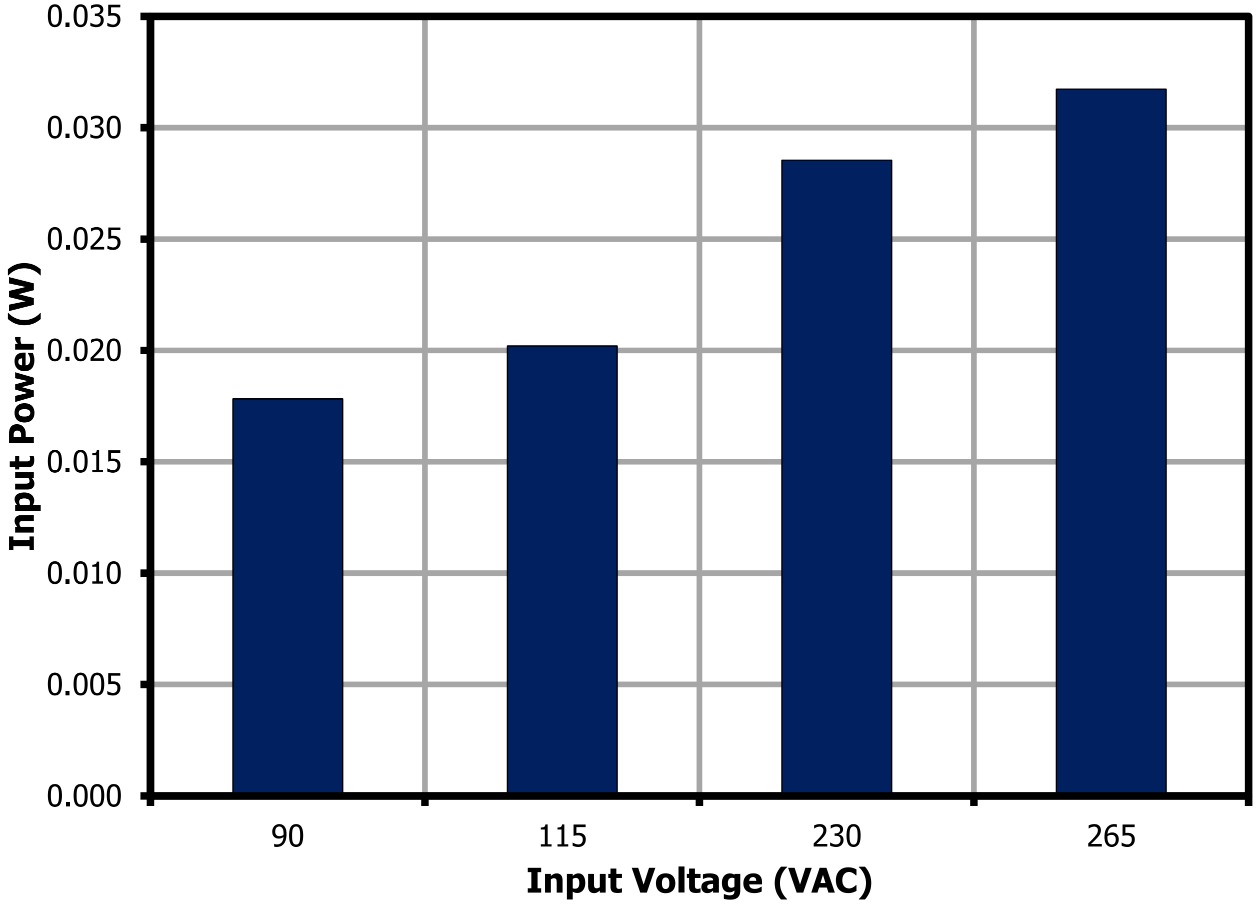



**Figure 14 –** No-Load Input Power vs. Input Line Voltage, Room Temperature.



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

## 14.3 Average Efficiency

### 14.3.1 Average Efficiency Requirements

| Output Votlage | Model | Test Power [W] | Average DOE6 Limit | Average CoC v5 Tier 1 | Average CoC v5 Tier 2 | 10% Load CoC v5 Tier 1 | 10% Load CoC v5 Tier 2 |
|---|---|---|---|---|---|---|---|
| 5 | <6 V | 15 | 81.84% | 79.05% | 81.84% | 69.50% | 72.48% |
| 9 | >6 V | 27 | 86.62% | 85.23% | 87.30% | 75.23% | 77.30% |
| 15 | >6 V | 45 | 87.73% | 88.43% | 88.85% | 78.43% | 78.85% |
| 20 | >6 V | 60 | 88.00% | 89.00% | 89.00% | 79.00% | 79.00% |

## 14.4 Average and 10% Efficiency at 115 VAC Input

### 14.4.1 $V_{OUT}$ = 5 V

| % Load | $P_{OUT}$ (W) | Efficiency (%) | Average Efficiency (%) |
|---|---|---|---|
| 100 | 15.28 | 91.51 | 91.94 |
| 75 | 11.58 | 91.91 | |
| 50 | 7.89 | 92.20 | |
| 25 | 4.20 | 92.12 | |
| 10 | 1.52 | 91.09 | |

### 14.4.2 $V_{OUT}$ = 9 V

| % Load | $P_{OUT}$ (W) | Efficiency (%) | Average Efficiency (%) |
|---|---|---|---|
| 100 | 27.27 | 92.20 | 92.65 |
| 75 | 20.58 | 92.68 | |
| 50 | 14.04 | 92.95 | |
| 25 | 7.49 | 92.77 | |
| 10 | 2.71 | 90.98 | |

### 14.4.3 $V_{OUT}$ = 15 V

| % Load | $P_{OUT}$ (W) | Efficiency (%) | Average Efficiency (%) |
|---|---|---|---|
| 100 | 45.22 | 92.58 | 92.8 |
| 75 | 34.14 | 92.76 | |
| 50 | 23.28 | 92.99 | |
| 25 | 12.42 | 92.84 | |
| 10 | 4.50 | 90.47 | |

### 14.4.4 $V_{OUT}$ = 20 V

| % Load | $P_{OUT}$ (W) | Efficiency (%) | Average Efficiency (%) |
|---|---|---|---|
| 100 | 60.32 | 92.57 | 92.69 |
| 75 | 45.54 | 92.71 | |
| 50 | 31.04 | 92.71 | |
| 25 | 16.57 | 92.76 | |
| 10 | 6.00 | 90.12 | |

## 14.5 **Average and 10% Efficiency at 230 VAC Input**

### 14.5.1 $V_{OUT}$ = 5 V

| % Load | $P_{OUT}$ (W) | Efficiency (%) | Average Efficiency (%) |
|---|---|---|---|
| 100 | 15.28 | 91.50 | 91.18 |
| 75 | 11.58 | 91.55 | |
| 50 | 7.89 | 91.31 | |
| 25 | 4.20 | 90.34 | |
| 10 | 1.52 | 88.30 | |

### 14.5.2 $V_{OUT}$ = 9 V

| % Load | $P_{OUT}$ (W) | Efficiency (%) | Average Efficiency (%) |
|---|---|---|---|
| 100 | 27.27 | 92.98 | 92.69 |
| 75 | 20.59 | 93.02 | |
| 50 | 14.04 | 92.84 | |
| 25 | 7.49 | 91.91 | |
| 10 | 2.72 | 89.02 | |

### 14.5.3 $V_{OUT}$ = 15 V

| % Load | $P_{OUT}$ (W) | Efficiency (%) | Average Efficiency (%) |
|---|---|---|---|
| 100 | 45.23 | 93.58 | 93.3 |
| 75 | 34.14 | 93.63 | |
| 50 | 23.28 | 93.50 | |
| 25 | 12.42 | 92.65 | |
| 10 | 4.50 | 89.31 | |


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

### 14.5.4 $V_{OUT}$ = 20 V

| % Load | $P_{OUT}$ (W) | Efficiency (%) | Average Efficiency (%) |
|---|---|---|---|
| 100 | 60.32 | 93.71 | 93.44 |
| 75 | 45.54 | 93.72 | |
| 50 | 31.05 | 93.58 | |
| 25 | 16.57 | 92.74 | |
| 10 | 6.01 | 89.11 | |

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

## 14.6 **Line and Load Regulation**

### 14.6.1 $V_{OUT}$ = 5 V

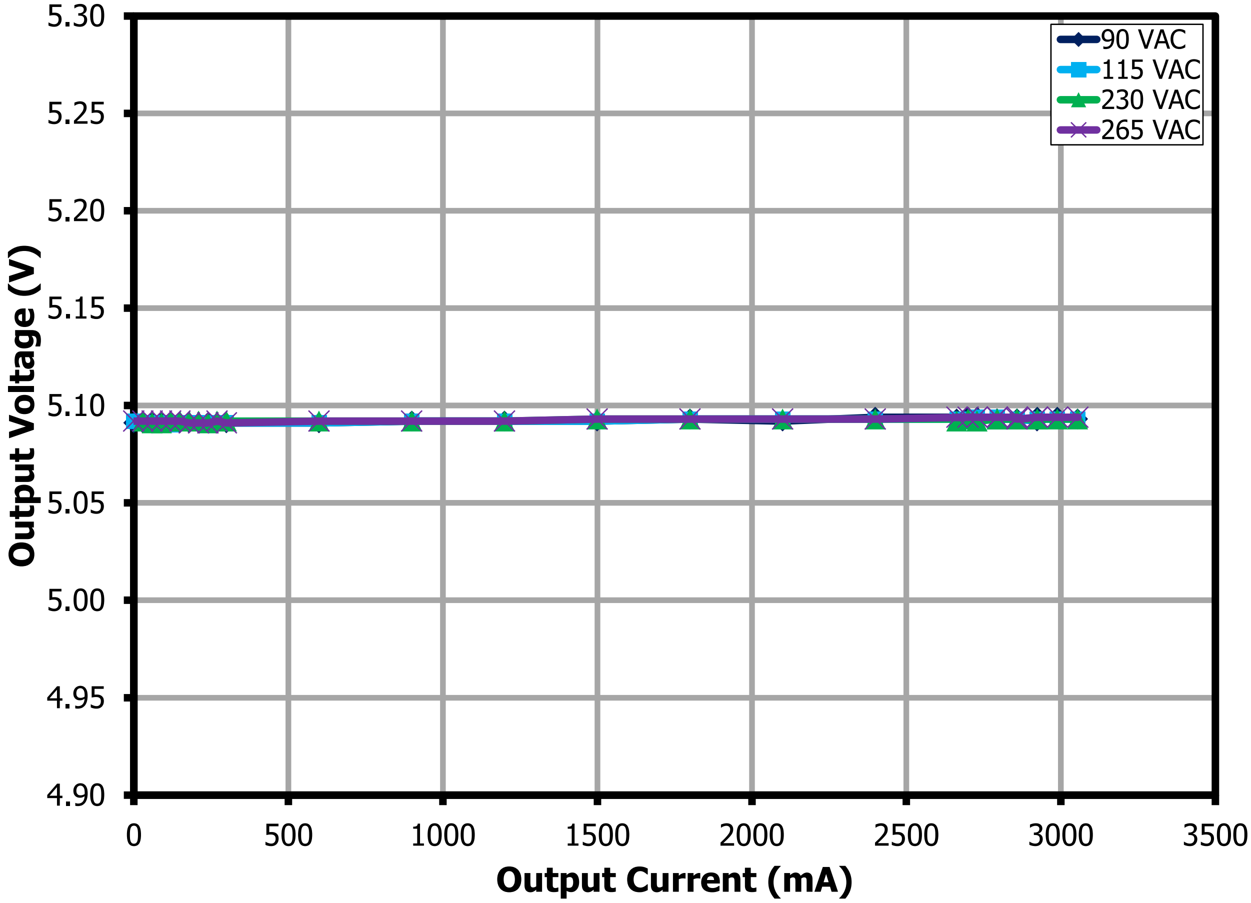



**Figure 15 –** Output Voltage vs. Load current across AC Input Voltage, Room Temperature.



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

### 14.6.2 $V_{OUT}$ = 9 V

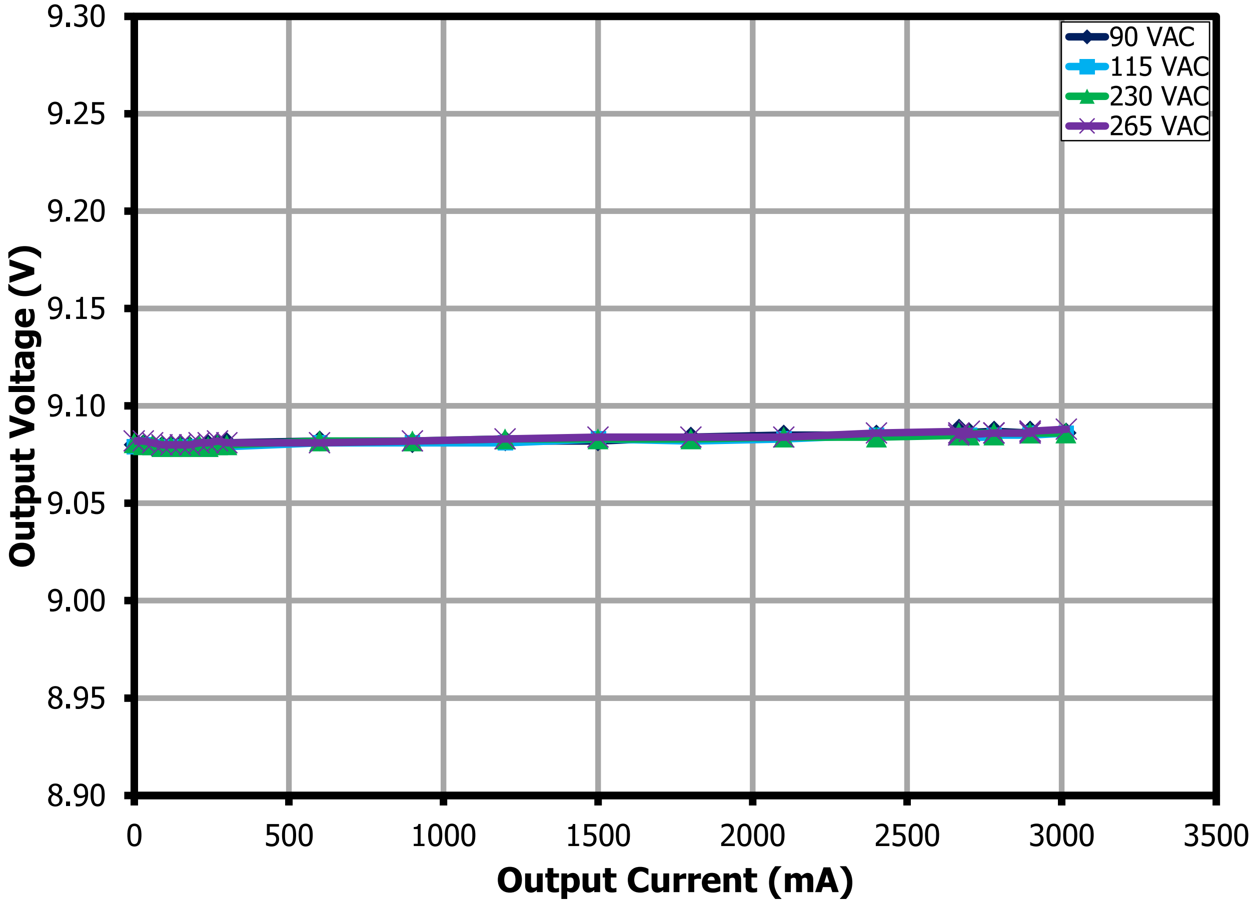



**Figure 16 –** Output Voltage vs. Load Current Across AC Input Voltage, Room Temperature.

14.6.3 $V_{OUT}$ = 15 V

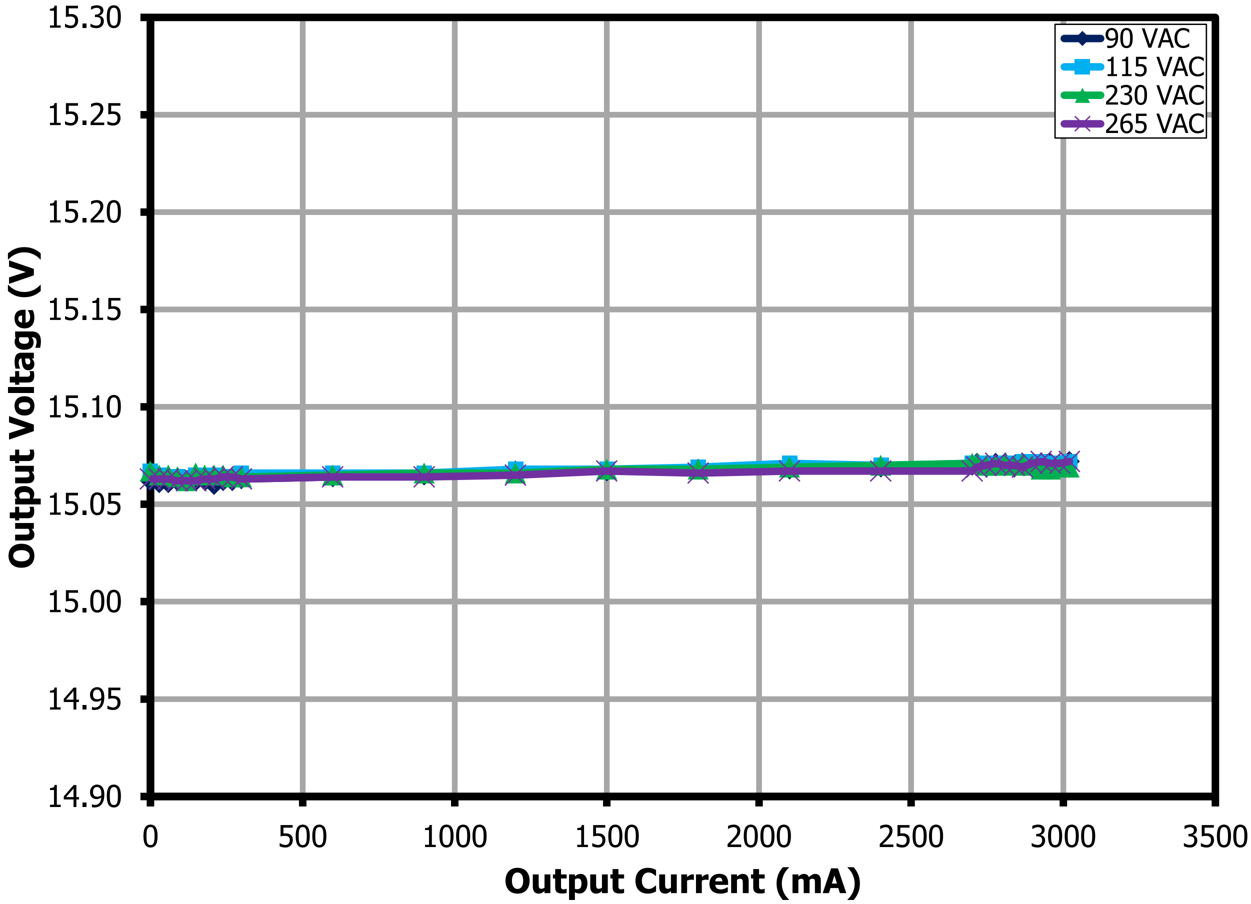



**Figure 17 –** Output Voltage vs. Load Current Across AC Input Voltage, Room Temperature.



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

14.6.4 $V_{OUT}$ = 20 V

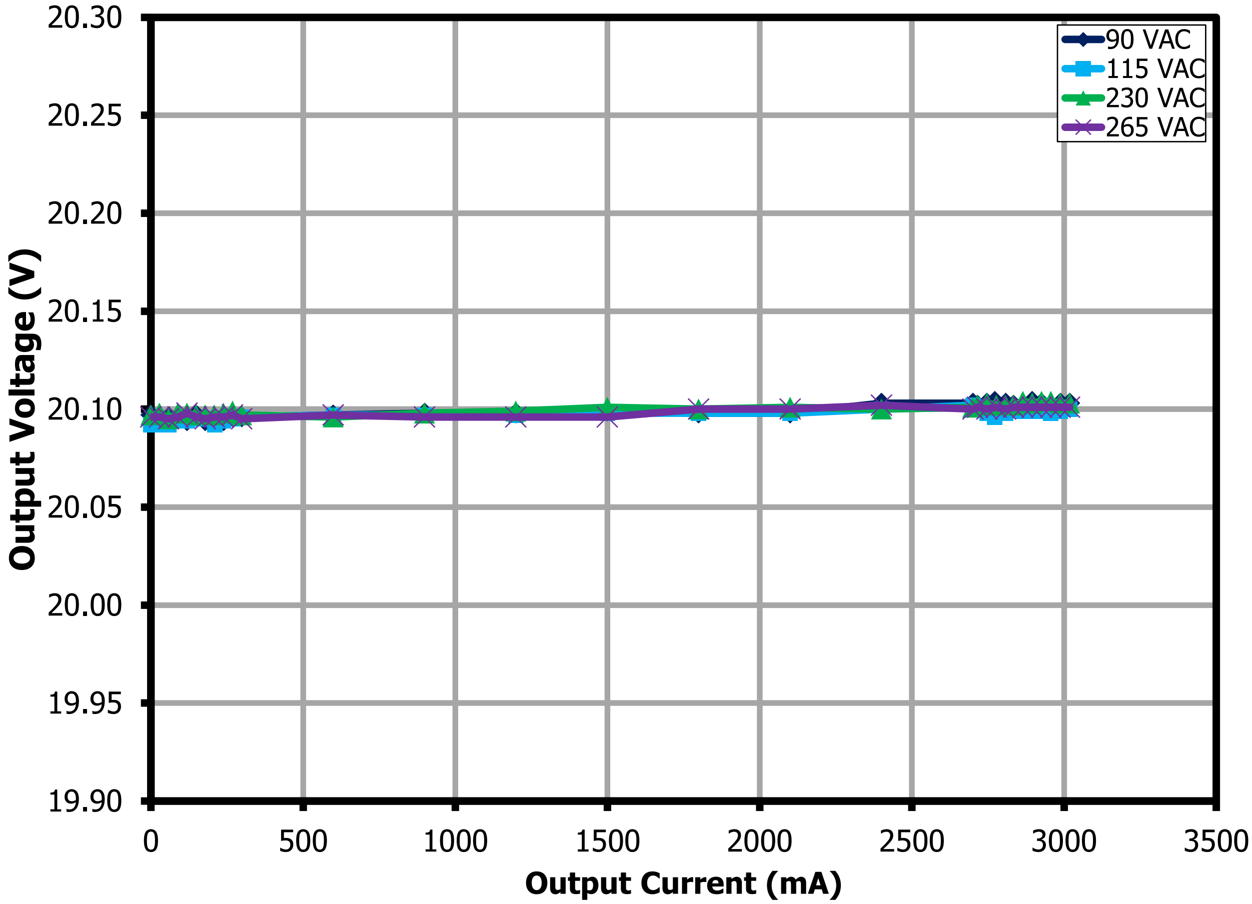



**Figure 18 –** Output Voltage vs. Load Current Across AC Input Voltage, Room Temperature.

## 14.7 **CV/CC**

### 14.7.1 $V_{OUT}$ = 5 V

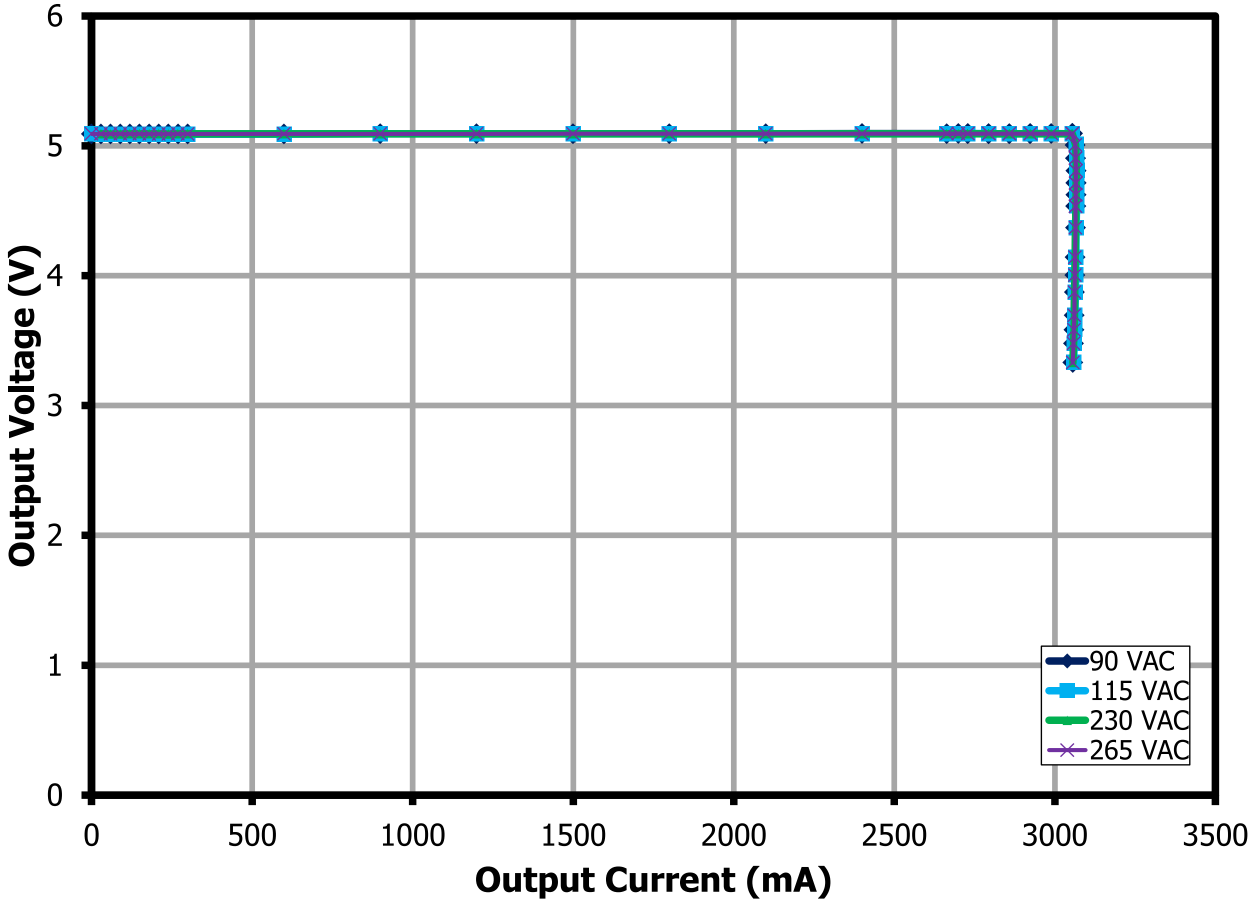



**Figure 19 –** Output Voltage vs. Output Current Across AC Input Voltage, Room Temperature, 5 V.



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

14.7.2 $V_{OUT}$ = 9 V

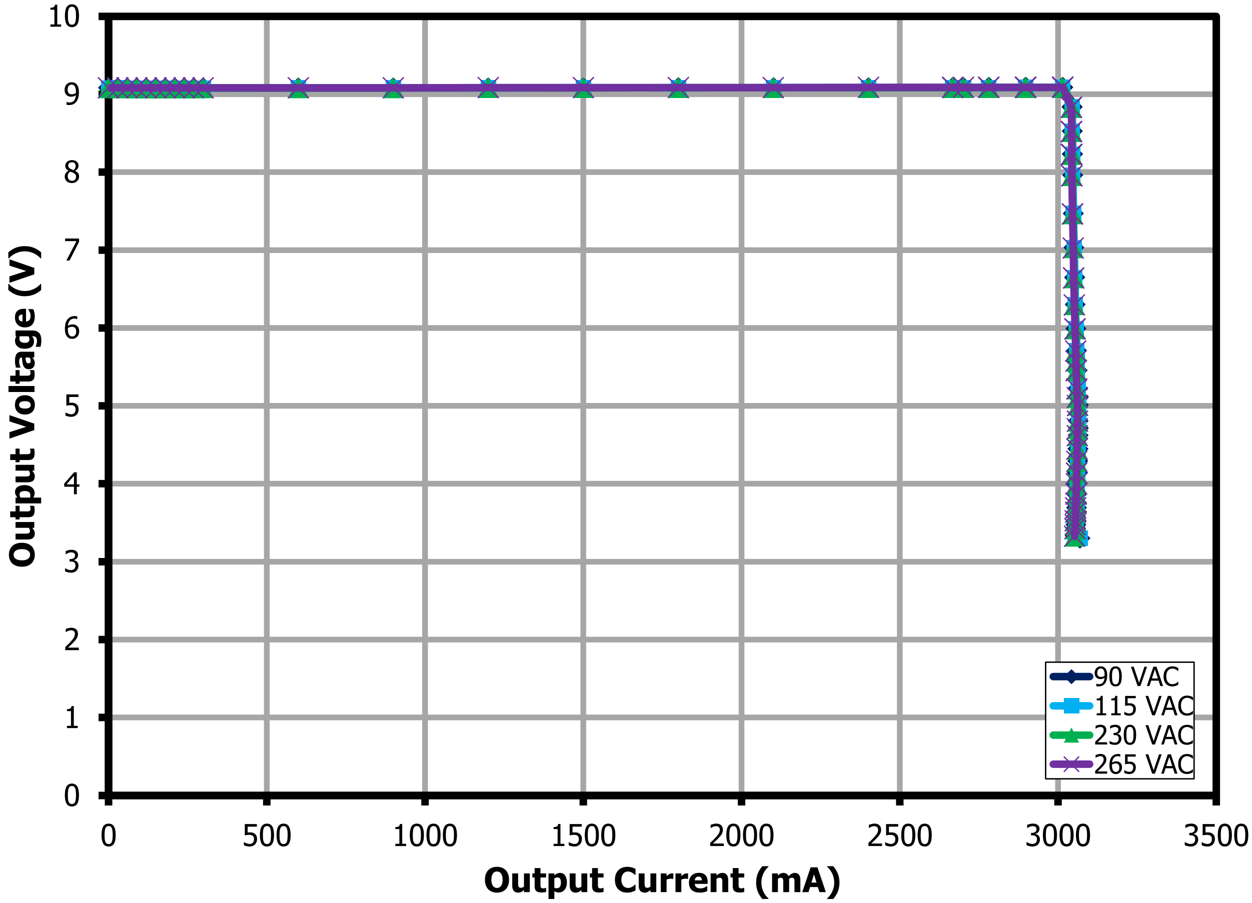



**Figure 20 –** Output Voltage vs. Output Current Across AC Input Voltage, Room Temperature, 9 V.

14.7.3 $V_{OUT}$ = 15 V

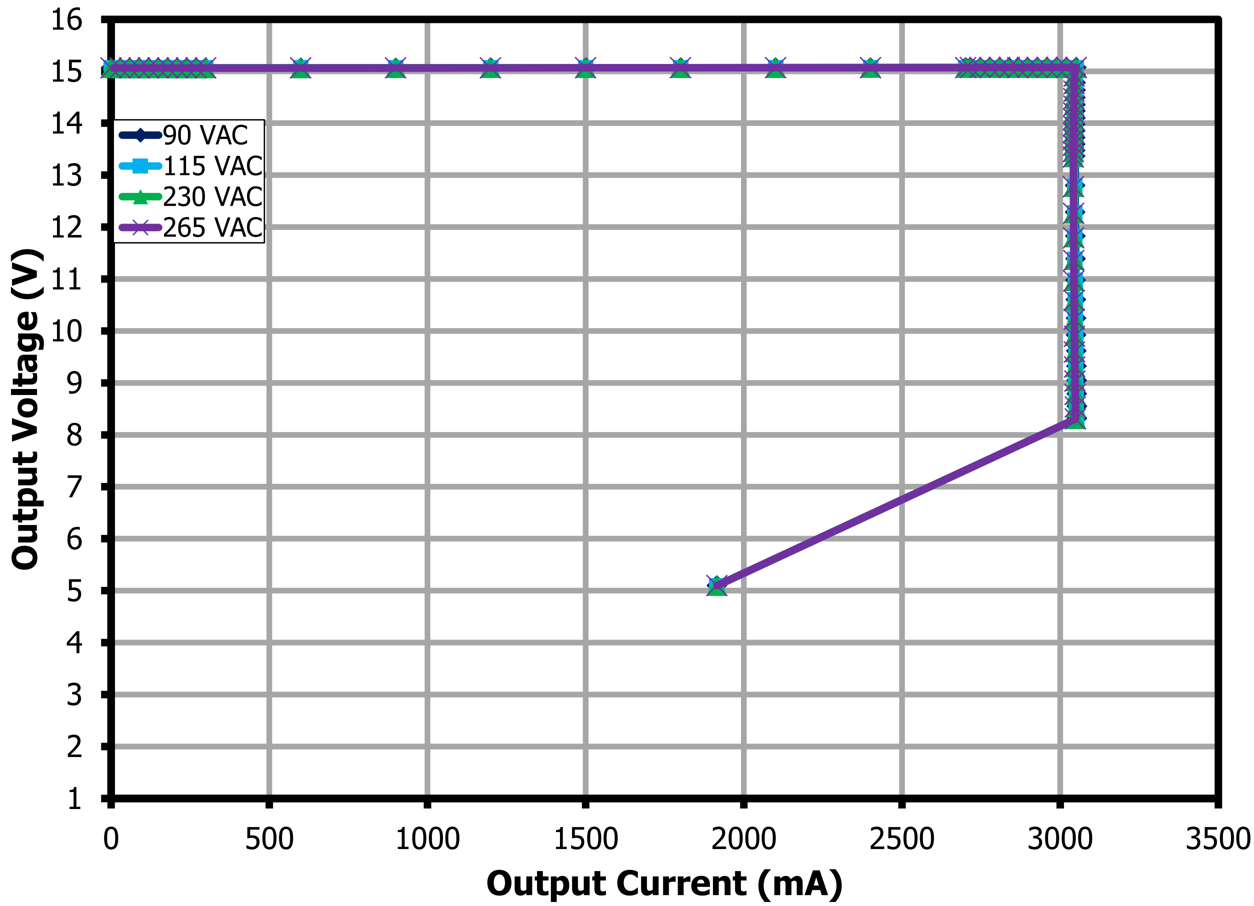



**Figure 21 –** Output Voltage vs. Output Current Across AC Input Voltage, Room Temperature, 15 V.



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

14.7.4 $V_{OUT}$ = 20 V

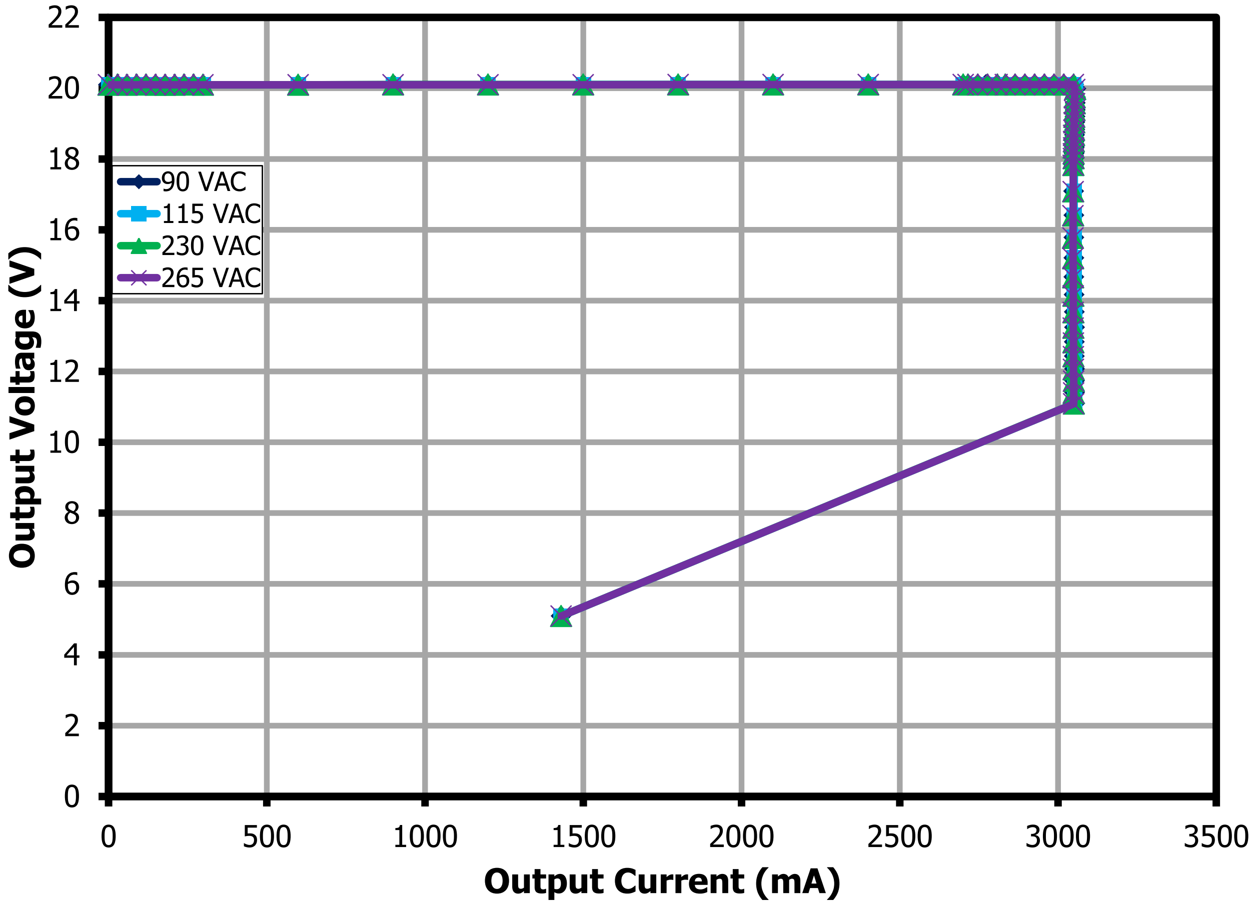



**Figure 22 –** Output Voltage vs. Output Current Across AC Input Voltage, Room Temperature, 20 V.

# 15 Thermal Performance

Thermal performance is measured in thermal chamber by using an adapter case enclosure.

## 15.1 *90 VAC Input 20 V, 3 A at 26.1 ºC Ambient*

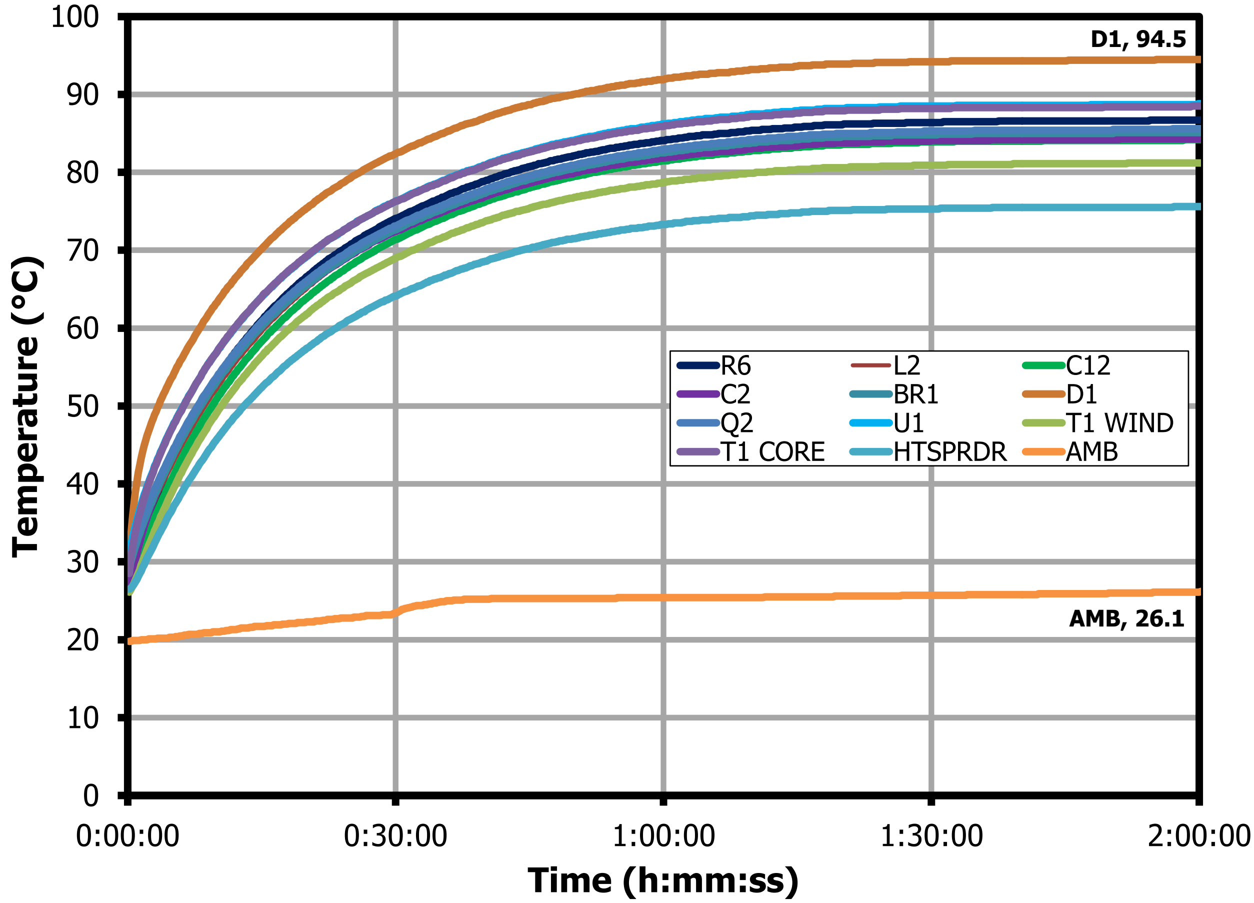



**Figure 23 –** Thermal performance Over Time.

**Note:** Adapter case temperature is 67.4 ºC at an ambient of 26.1 ºC.



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

## 15.2 **90 VAC Input 20 V, 3 A at 45.2 ºC Ambient**

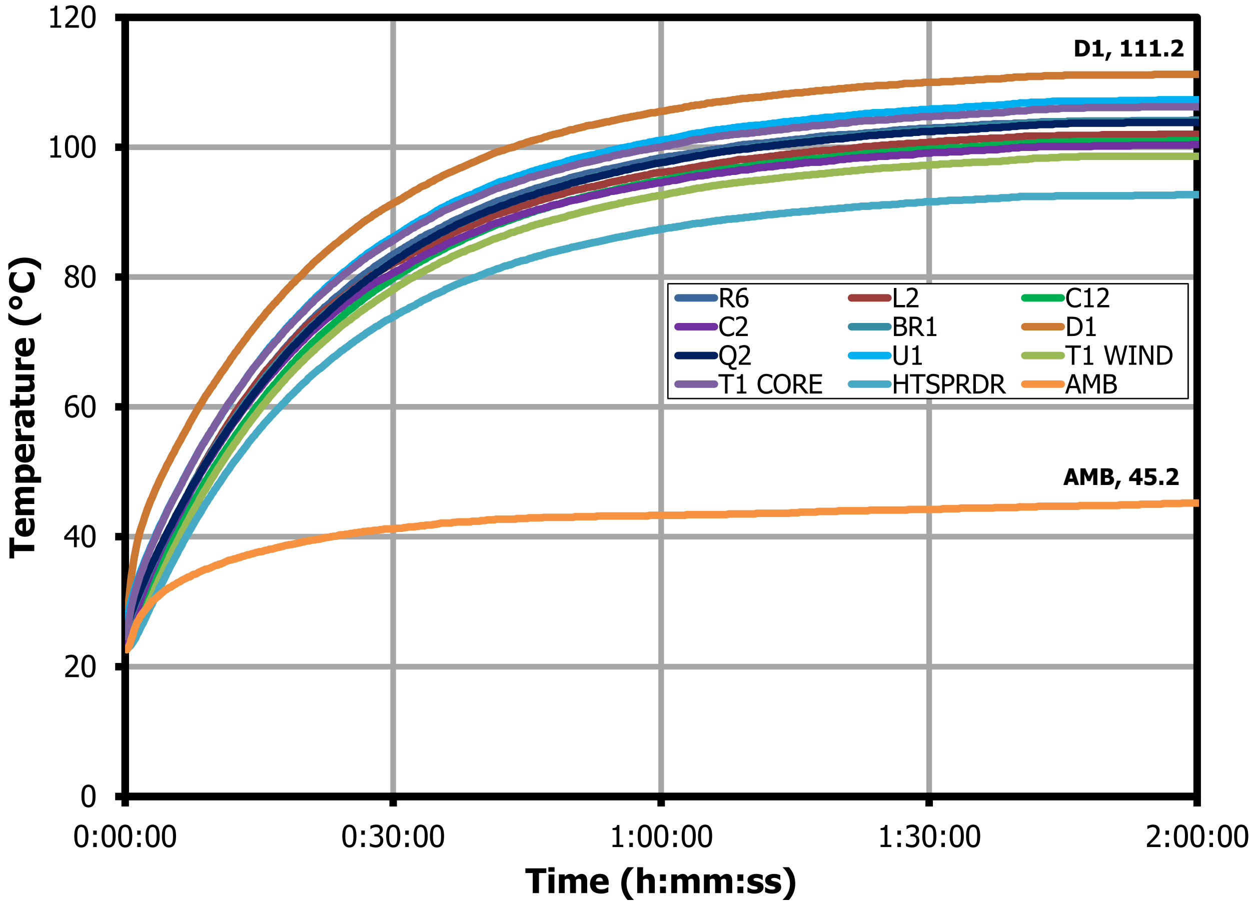



**Figure 24 –** Thermal Performance Over Time.

**Note:** Adapter Case Temperature is 85.2 ºC at an Ambient of 45.2 ºC.

## 15.3 *115 VAC Input 20 V, 3 A at 45.2 ºC Ambient*

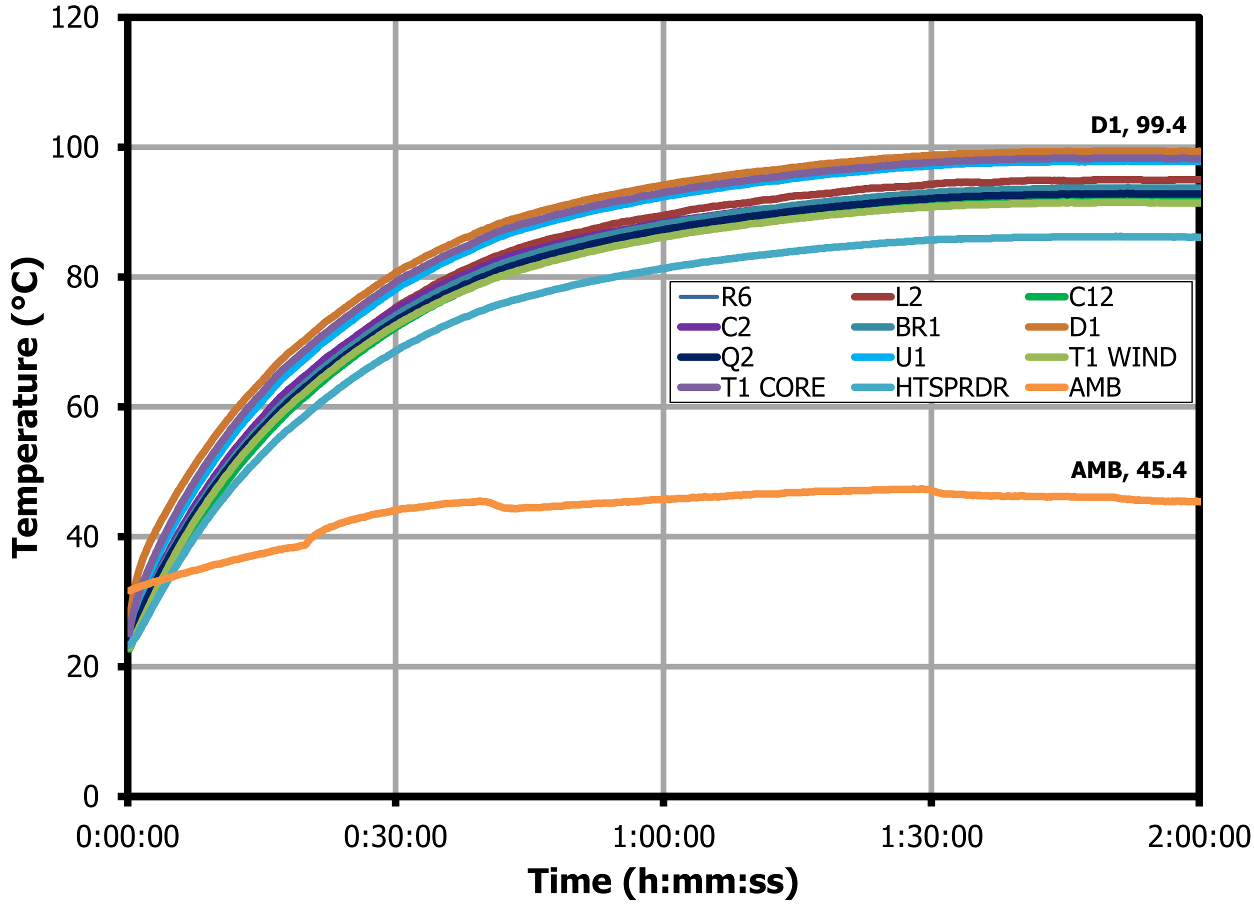



**Figure 25 –** Thermal performance over time

**Note:** Adapter case temperature is 78.8 ºC at an ambient of 45.4 ºC.



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

## 15.4 265 VAC Input 20 V, 3 A at 42.9 ºC Ambient

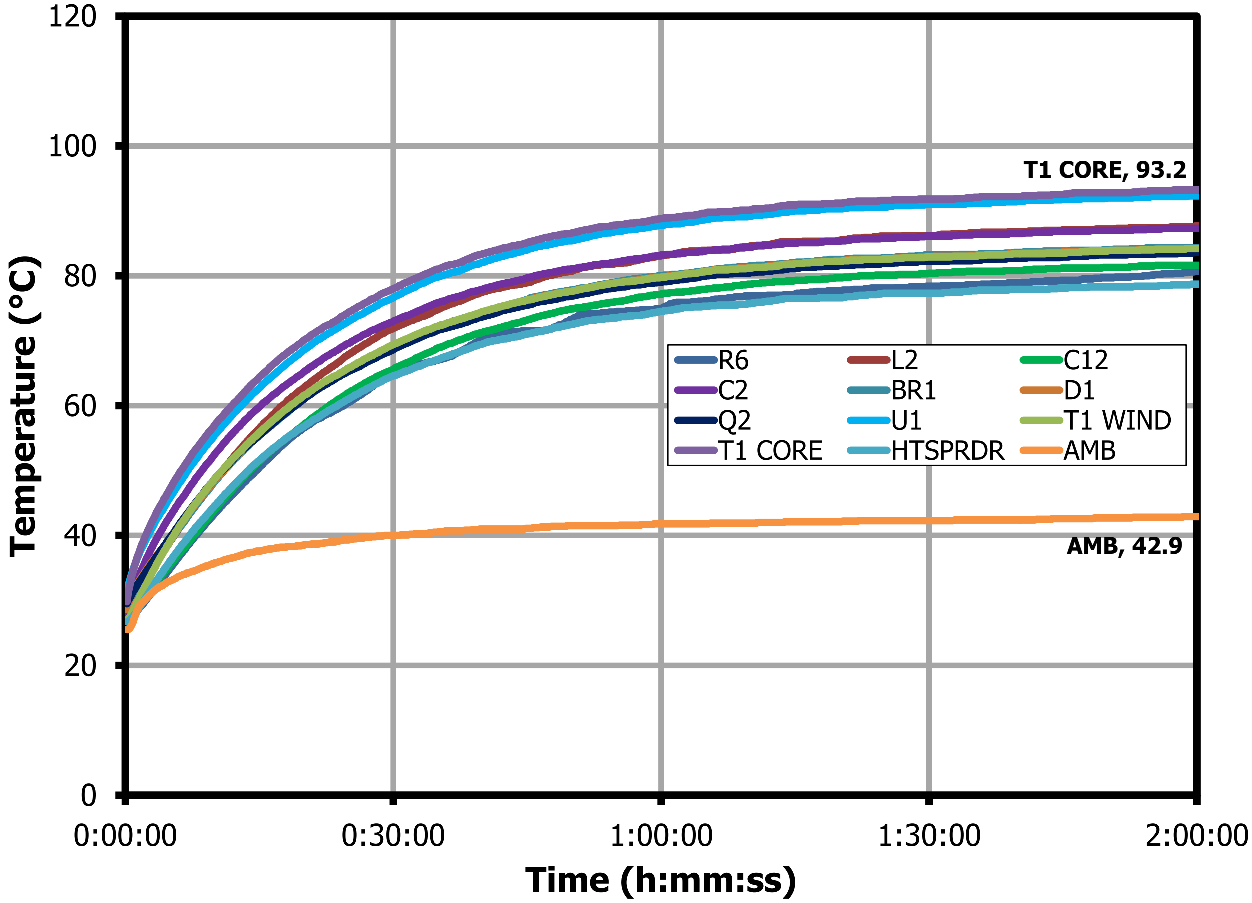



**Figure 26 –** Thermal Performance Over Time.

**Note:** Adapter case temperature is 73.7 ºC at an ambient of 42.9 ºC.

# 16 Waveforms

## 16.1 Load Transient Response (On the Board)

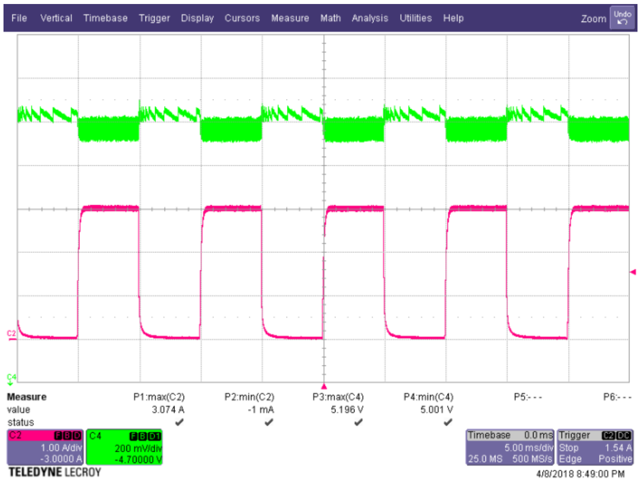



**Figure 27 –** Transient Response.
90 VAC, 5.0 V, 0 – 3 A Load Step.
$V_{MIN}$ 5.001 V, $V_{MAX}$: 5.196 V.
Upper: $V_{OUT}$, 0.2 V / div., 5 ms / div.
Lower: $I_{LOAD}$, 1 A / div.

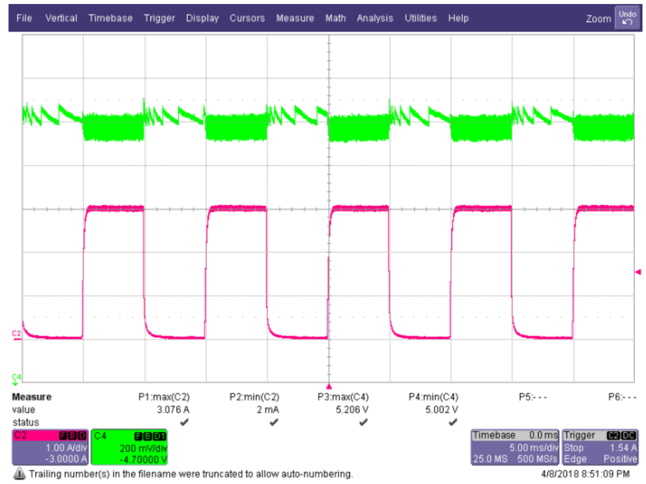



**Figure 28 –** Transient Response.
265 VAC, 5.0 V, 0 – 3 A Load Step.
$V_{MIN}$ : 5.002 V, $V_{MAX}$: 5.206 V.
Upper: $V_{OUT}$, 0.2 V / div., 5 ms / div.
Lower: $I_{LOAD}$, 1 A / div.

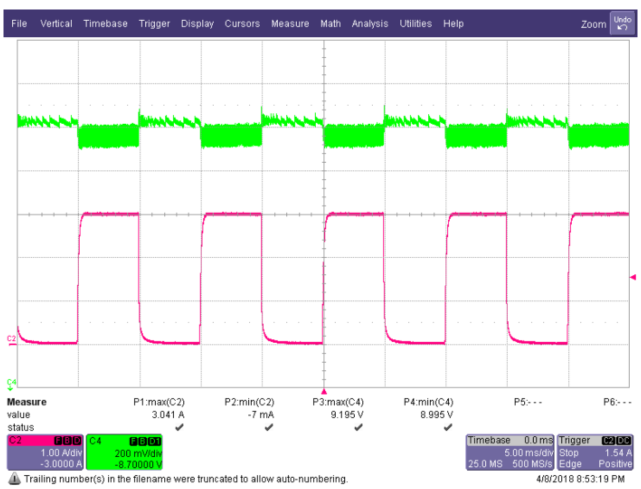



**Figure 29 –** Transient Response.
90 VAC, 9 V, 0 – 3 A Load Step.
$V_{MIN}$: 8.995 V, $V_{MAX}$: 9.195 V.
Upper: $V_{OUT}$, 0.2 V / div., 5 ms / div.
Lower: $I_{LOAD}$, 1 A / div.

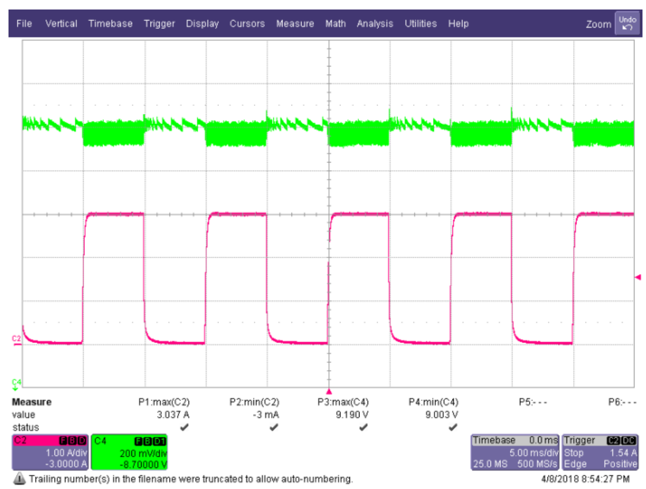



**Figure 30 –** Transient Response.
265 VAC, 9 V, 0 – 3 A Load Step.
$V_{MIN}$: 9.003 V, $V_{MAX}$: 9.19 V.
Upper: $V_{OUT}$, 0.2 V / div., 5 ms / div.
Lower: $I_{LOAD}$, 1 A / div.


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

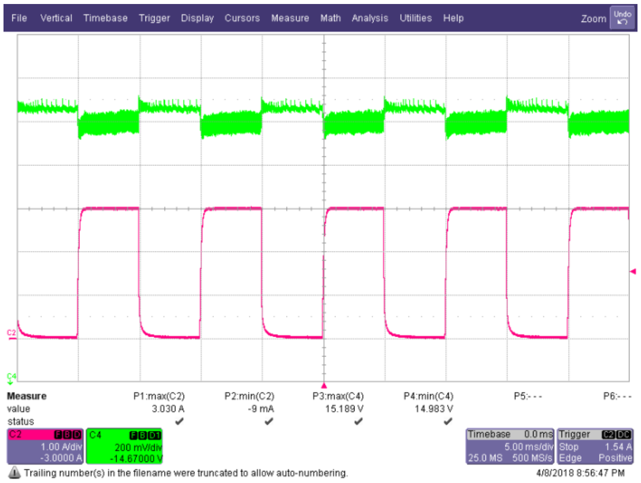



**Figure 31 –** Transient Response.
90 VAC, 15 V, 0 – 3 A Load Step.
$V_{MIN}$: 14.983 V, $V_{MAX}$: 15.189 V.
Upper: $V_{OUT}$, 0.2 V / div., 5 ms / div.
Lower: $I_{LOAD}$, 1 A / div.

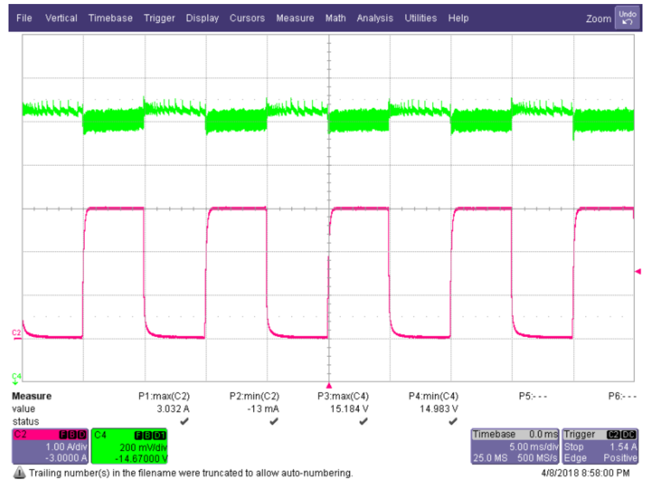



**Figure 32 –** Transient Response.
265 VAC, 15 V, 0 – 3 A Load Step.
$V_{MIN}$: 14.983 V, $V_{MAX}$: 15.184 V.
Upper: $V_{OUT}$, 0.2 V / div., 5 ms / div.
Lower: $I_{LOAD}$, 1 A / div.

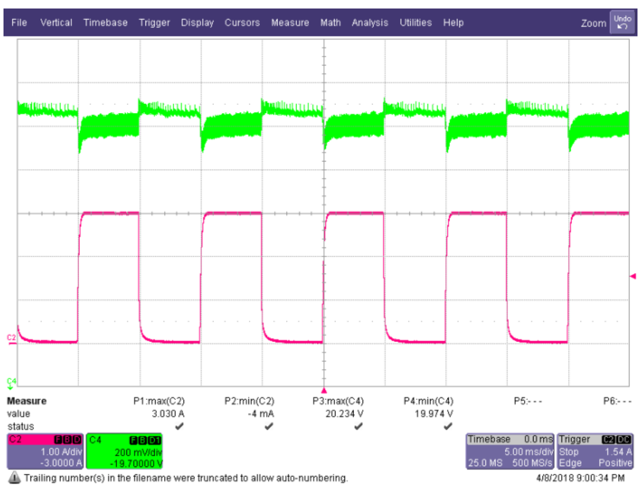



**Figure 33 –** Transient Response.
90 VAC, 20 V, 0 – 3 A Load Step.
$V_{MIN}$ 19.974 V, $V_{MAX}$: 20.234 V.
Upper: $V_{OUT}$, 0.2 V / div., 5 ms / div.
Lower: $I_{LOAD}$, 1 A / div.

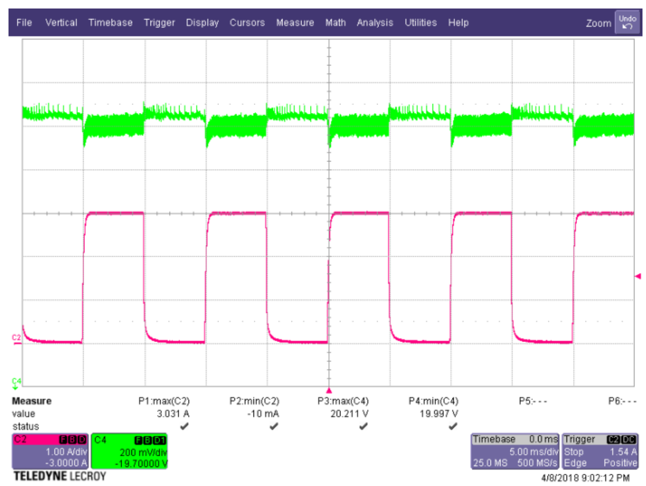



**Figure 34 –** Transient Response.
265 VAC, 20 V, 0 – 3 A Load Step.
$V_{MIN}$ : 19.997 V, $V_{MAX}$: 20.211 V.
Upper: $V_{OUT}$, 0.2 V / div., 5 ms / div.
Lower: $I_{LOAD}$, 1 A / div.

## 16.2 ***Switching Waveforms***

### 16.2.1 Drain Voltage and Current


**Figure 35 –** Drain Voltage and Current Waveforms.
90 VAC, 5.0 V, 3 A Load, (209.5 $V_{MAX}$).
Upper: $V_{DRAIN}$, 100 V / div.
Lower: $I_{DRAIN}$, 1 A / div., 10 µs / div.


**Figure 36 –** Drain Voltage and Current Waveforms.
265 VAC, 5 V, 5 A Load, (451 $V_{MAX}$).
Upper: $V_{DRAIN}$, 200 V / div.
Lower: $I_{DRAIN}$, 1 A / div, 10 µs / div.

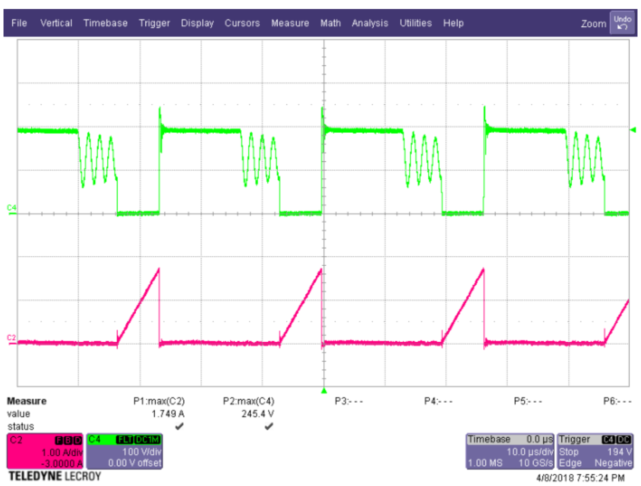



**Figure 37** – Drain Voltage and Current Waveforms.
90 VAC, 9.0 V, 3 A Load, (245.4 $V_{MAX}$).
Upper: $V_{DRAIN}$, 100 V / div.
Lower: $I_{DRAIN}$, 1 A / div., 10 µs / div.

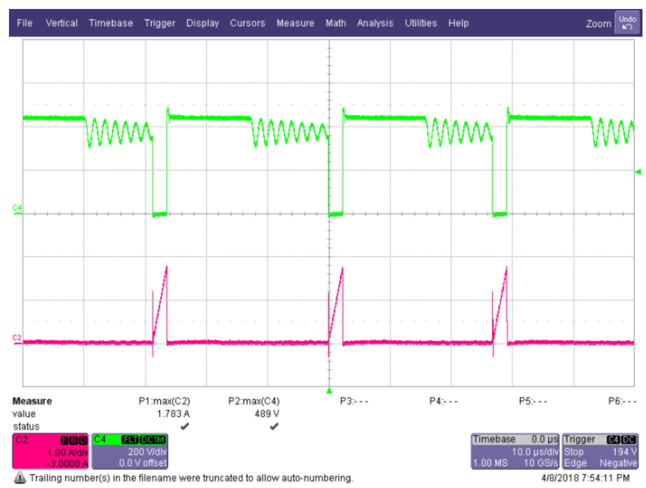



**Figure 38 –** Drain Voltage and Current Waveforms.
265 VAC, 9.0 V, 3 A Load, (489 $V_{MAX}$).
Upper: $V_{DRAIN}$, 200 V / div.
Lower: $I_{DRAIN}$, 1 A / div., 10 µs / div.


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

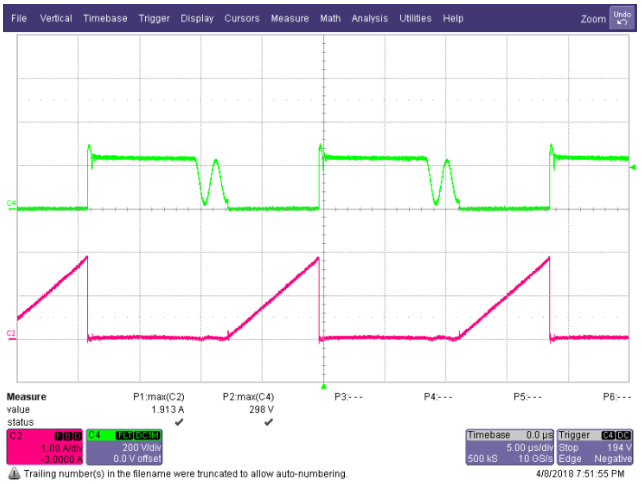



**Figure 39 –** Drain Voltage and Current Waveforms.
90 VAC, 15 V, 3 A Load, (298 $V_{MAX}$).
Upper: $V_{DRAIN,}$ 200 V / div.
Lower: $I_{DRAIN,}$ 1 A / div., 5 µs / div.

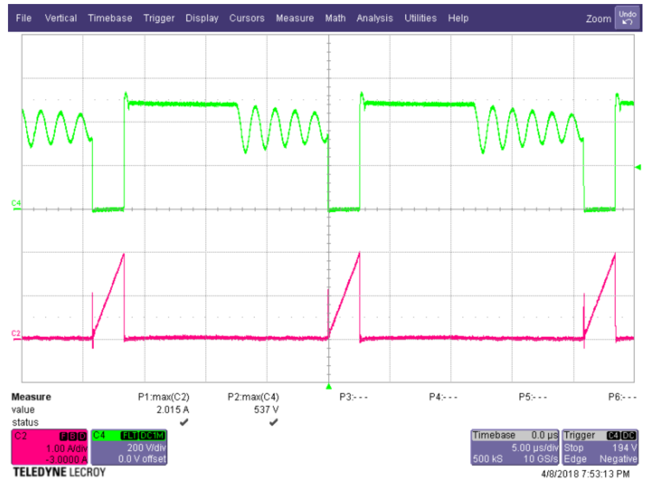



**Figure 40 –** Drain Voltage and Current Waveforms.
265 VAC, 15 V, 3 A Load, (537 $V_{MAX}$).
Upper: $V_{DRAIN,}$ 200 V / div.
Lower: $I_{DRAIN}$ 1 A / div., 5 µs / div.


**Figure 41 –** Drain Voltage and Current Waveforms.
90 VAC, 20 V, 3 A Load, (328 $V_{MAX}$).
Upper: $V_{DRAIN,}$ 200 V / div.
Lower: $I_{DRAIN,}$ 1 A / div., 5 µs / div.

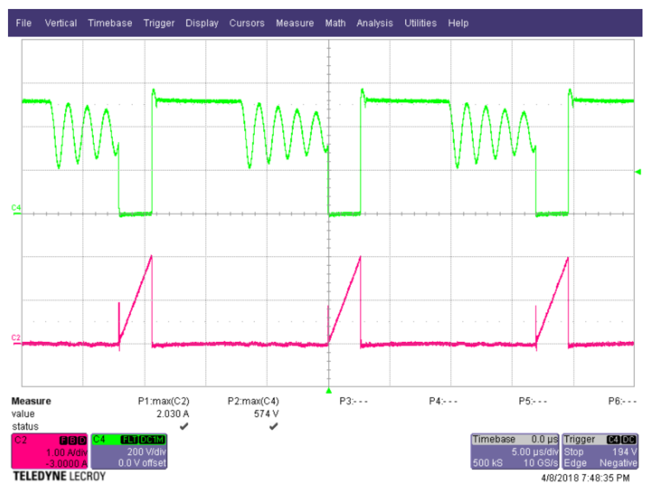



**Figure 42 –** Drain Voltage and Current Waveforms.
265 VAC, 9.0 V, 3 A Load, (574 $V_{MAX}$).
Upper: $V_{DRAIN,}$ 200 V / div.
Lower: $I_{DRAIN,}$ 1 A / div., 5 µs / div.

### 16.2.2 SR FET Voltage

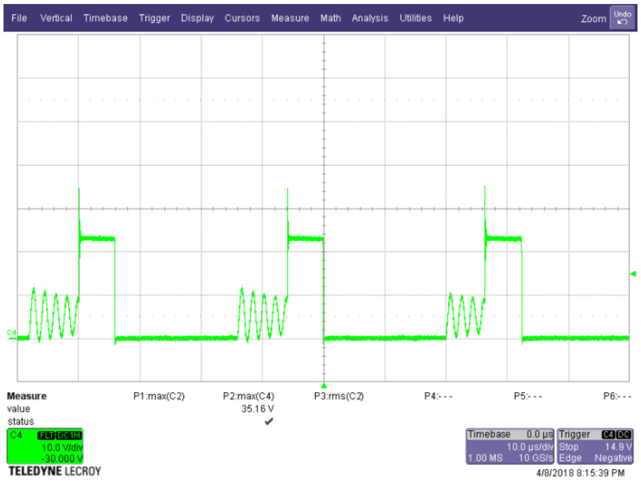



**Figure 43 –** SR FET Voltage Waveforms.
90 VAC, 5 V, 3 A Load, (35.16 $V_{MAX}$).
C4: SR_$V_{DRAIN}$, 10 V / div., 10 µs / div.

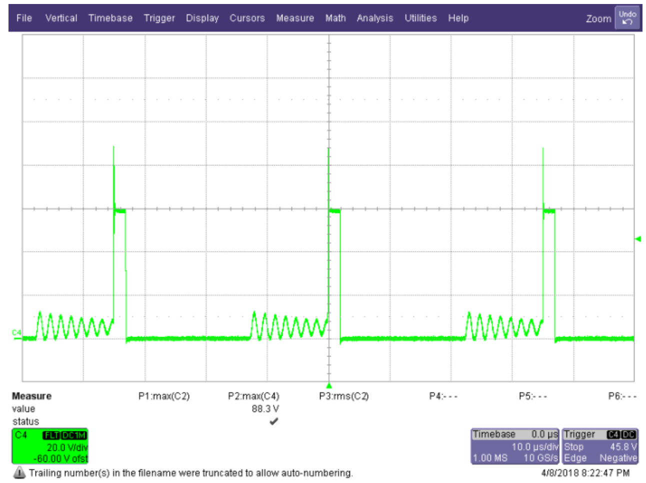



**Figure 44 –** SR FET Voltage Waveforms.
265 VAC, 5 V, 3 A Load, (88.3 $V_{MAX}$).
C4: SR_$V_{DRAIN}$, 20 V / div., 10 µs / div.


**Figure 45 –** SR FET Voltage Waveforms.
90 VAC, 9 V, 3 A Load, (36.83 $V_{MAX}$).
C4: SR_$V_{DRAIN}$, 10 V / div., 10 µs / div.


**Figure 46 –** SR FET Voltage Waveforms.
265 VAC, 9 V, 3 A Load, (88.1 $V_{MAX}$).
C4: SR_$V_{DRAIN}$, 20 V / div., 10 µs / div.


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

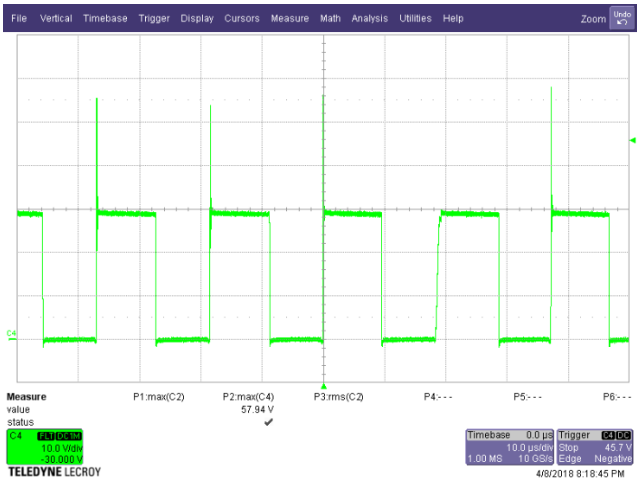



**Figure 47 –** SR FET Voltage Waveforms.
90 VAC, 15 V, 3 A Load, (57.94 $V_{MAX}$).
C4: SR_$V_{DRAIN}$, 10 V / div., 10 µs / div.

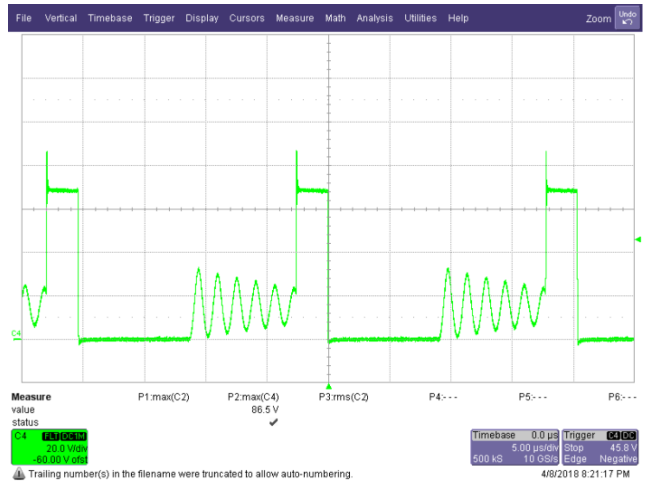



**Figure 48 –** SR FET Voltage Waveforms.
265 VAC, 15 V, 3 A Load, (86.5 $V_{MAX}$).
C4: SR_$V_{DRAIN}$, 20 V / div., 5 µs / div.

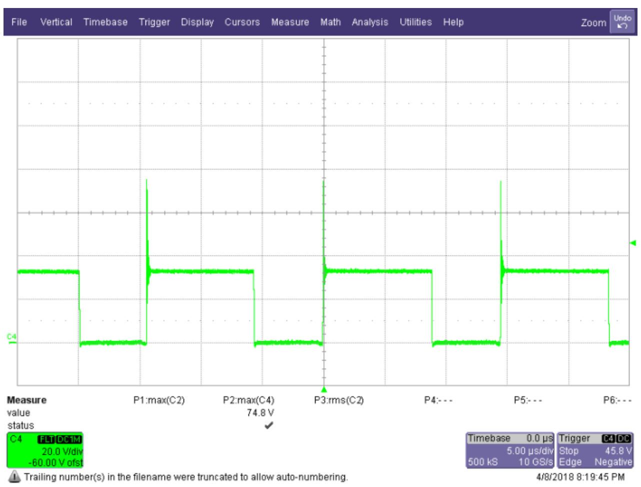



**Figure 49 –** SR FET Voltage Waveforms.
90 VAC, 20 V, 3 A Load, (74.8 $V_{MAX}$).
C4: SR_$V_{DRAIN}$, 20 V / div., 5 µs / div.

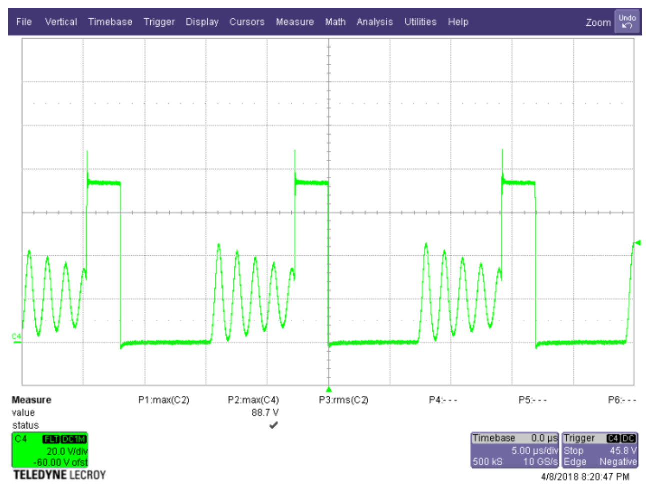



**Figure 50 –** SR FET Voltage Waveforms.
265 VAC, 20 V, 3 A Load, (88.7 $V_{MAX}$).
C4: SR_$V_{DRAIN}$, 20 V / div., 5 µs / div.

## 16.3 ***Output Ripple Measurements***

### 16.3.1 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).

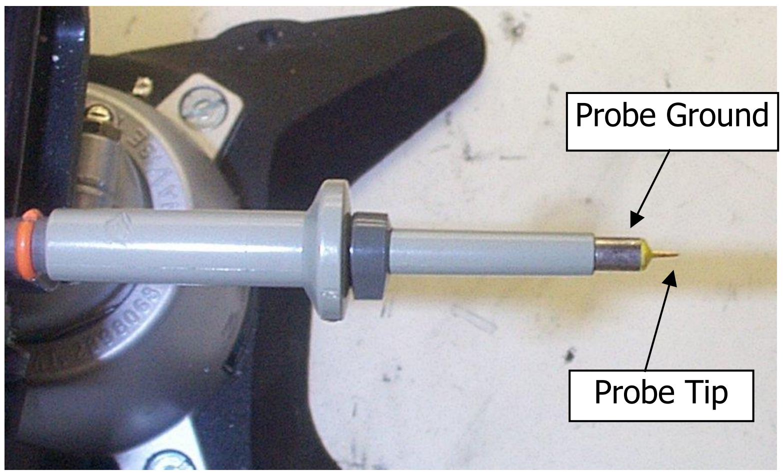



**Figure 51 –** Oscilloscope Probe Prepared for Ripple Measurement. (End Cap and Ground Lead Removed)

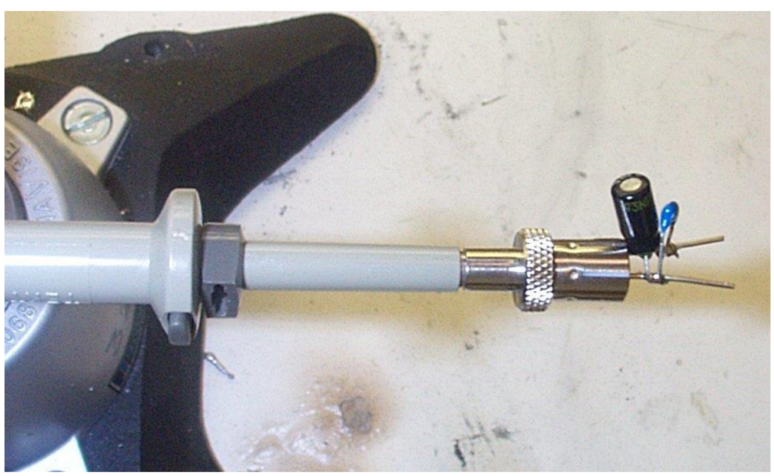
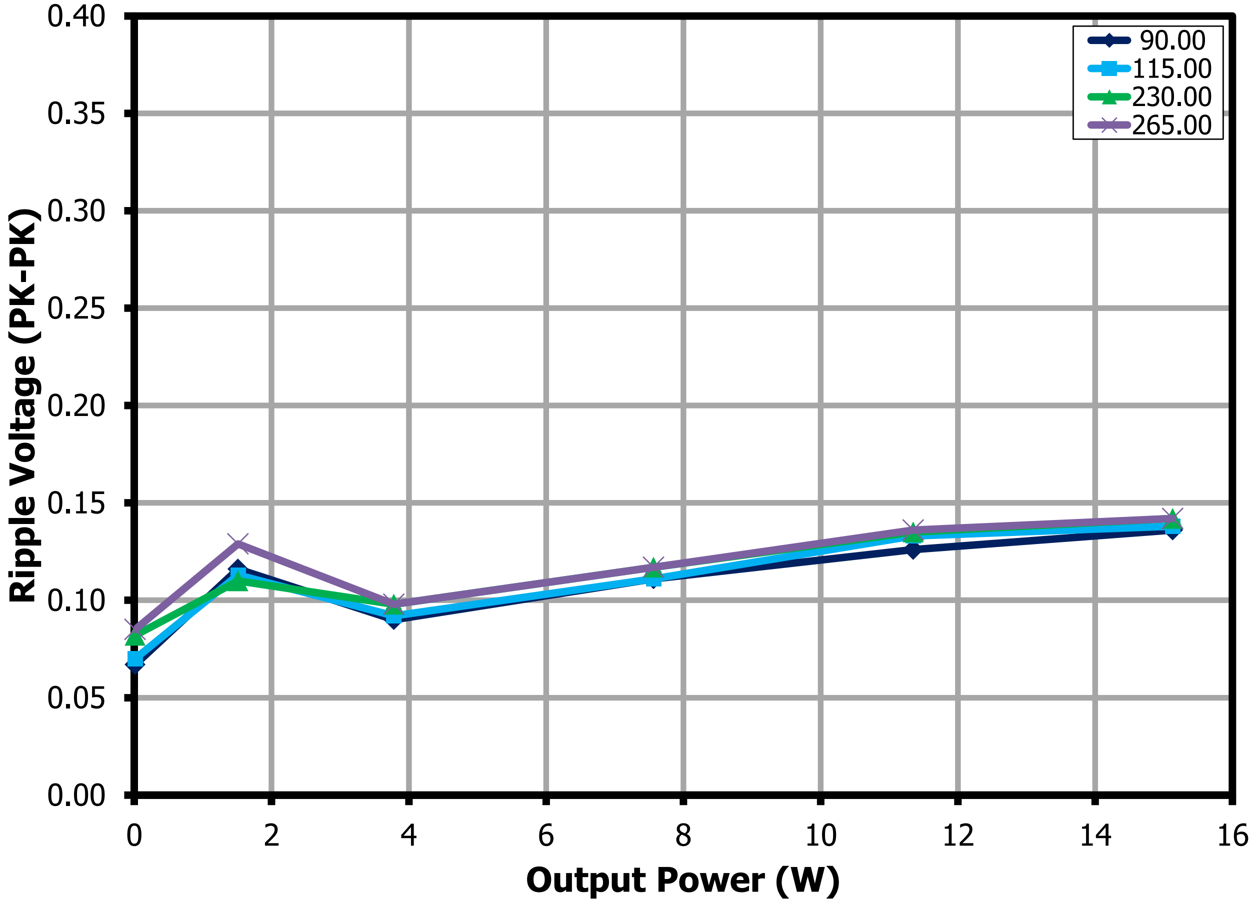


**Figure 52 –** Oscilloscope Probe with Probe Master (**www.probemaster.com**) 4987A BNC Adapter. (Modified with wires for ripple measurement, and two parallel decoupling capacitors added)


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

### 16.3.2 Ripple Amplitude vs. Line

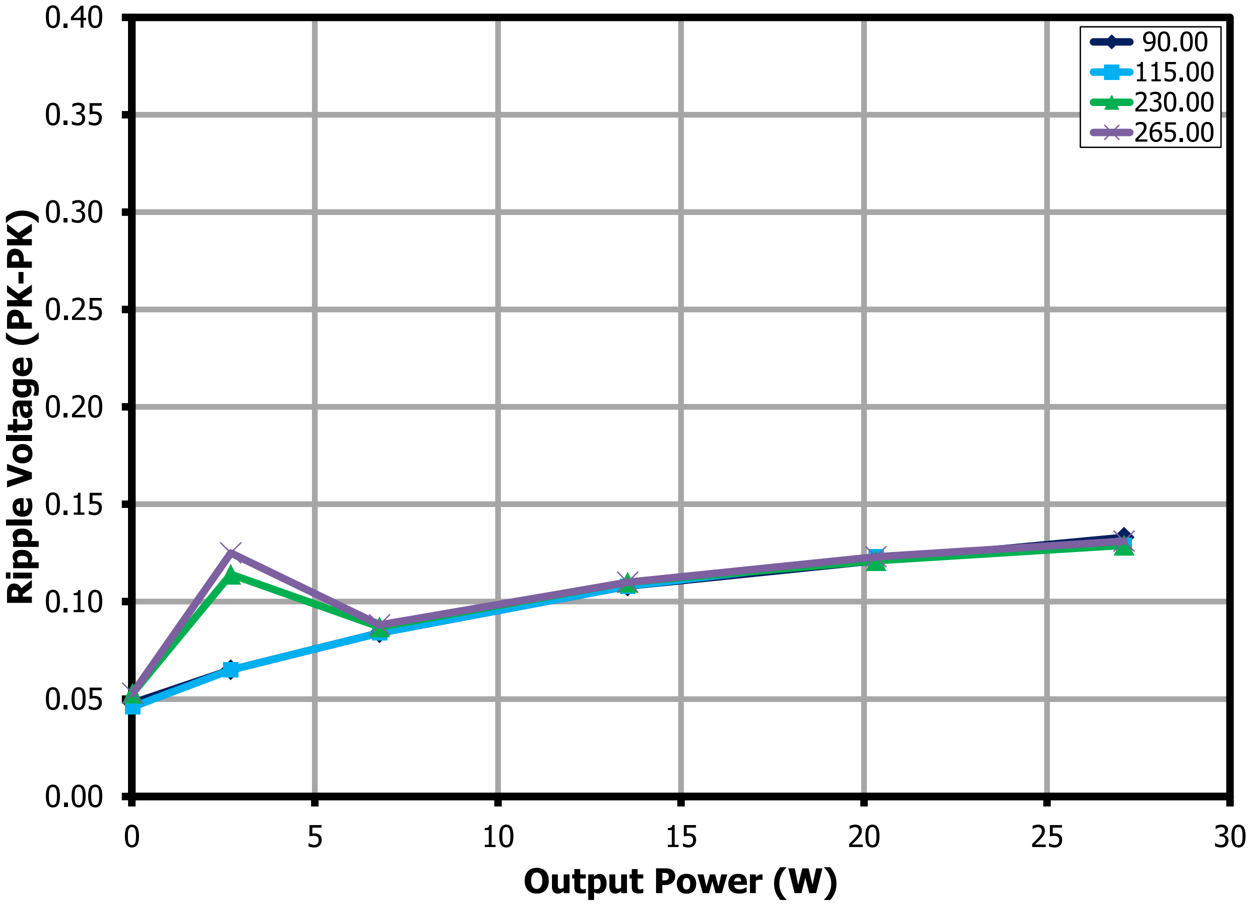
#### 16.3.2.1 5.0 V Ripple Plot




| Input | 90 VAC | 115 VAC | 230 VAC | 265 VAC |
|---|---|---|---|---|
| **Max Ripple (mV)** | 136 | 138 | 142 | 142 |

**Figure 53 –** Ripple Amplitude vs. Output Power 5 V.

16.3.2.2 9.0 V Ripple Plot

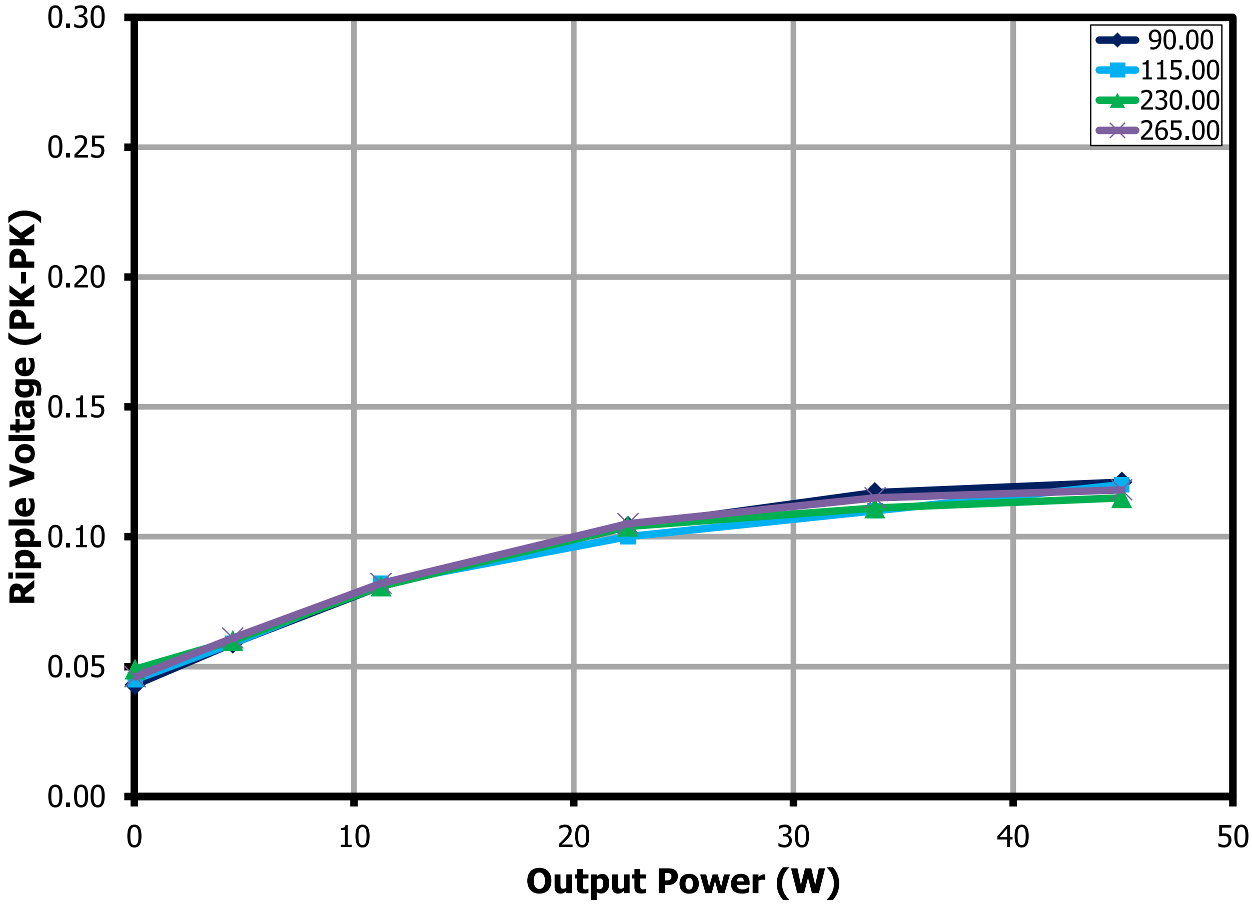



| Input | 90 VAC | 115 VAC | 230 VAC | 265 VAC |
|---|---|---|---|---|
| Max Ripple (mV) | 133 | 129 | 129 | 131 |

**Figure 54 –** Ripple Amplitude vs. Output Power 9 V.


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

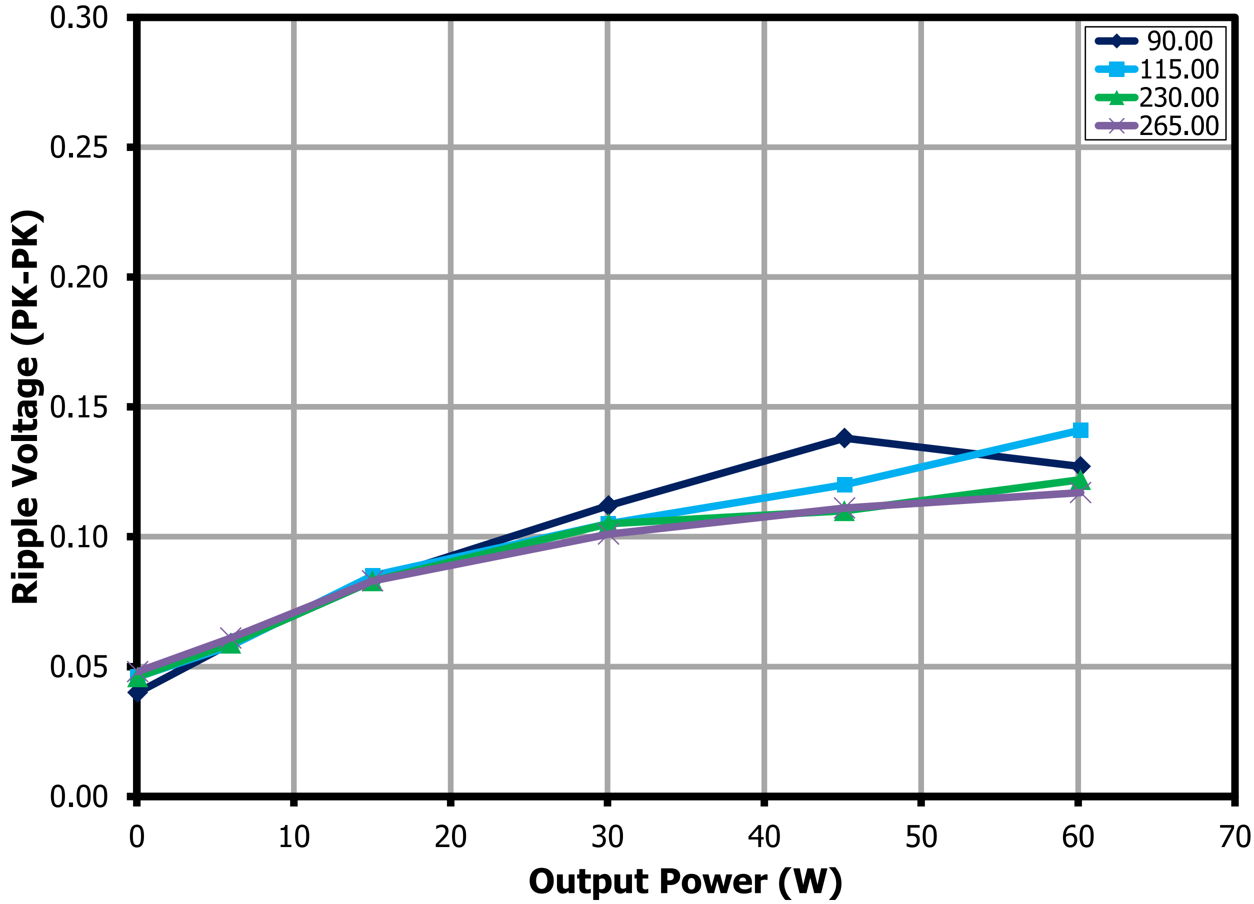
16.3.2.3 15.0 V Ripple Plot




| Input | 90 VAC | 115 VAC | 230 VAC | 265 VAC |
|---|---|---|---|---|
| Max Ripple (mV) | 121 | 120 | 115 | 118 |

**Figure 55 –** Ripple Amplitude vs. Output Power 15 V.

16.3.2.4 20.0 V Ripple Plot




| Input | 90 VAC | 115 VAC | 230 VAC | 265 VAC |
|---|---|---|---|---|
| **Max Ripple (mV)** | 127 | 141 | 122 | 117 |

**Figure 56 –** Ripple Amplitude vs. Output Power 20 V.


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

### 16.3.2.5 5 V Ripple waveforms

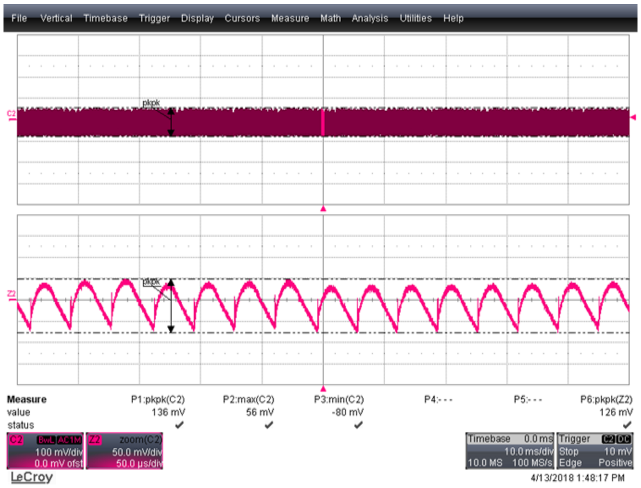



**Figure 57 –** Output Ripple.(pk-pk – 136 mV)
90 VAC Input 5.0 V, 3 A Load.
$V_{OUT}$, 100 mV / div., 10 ms / div.

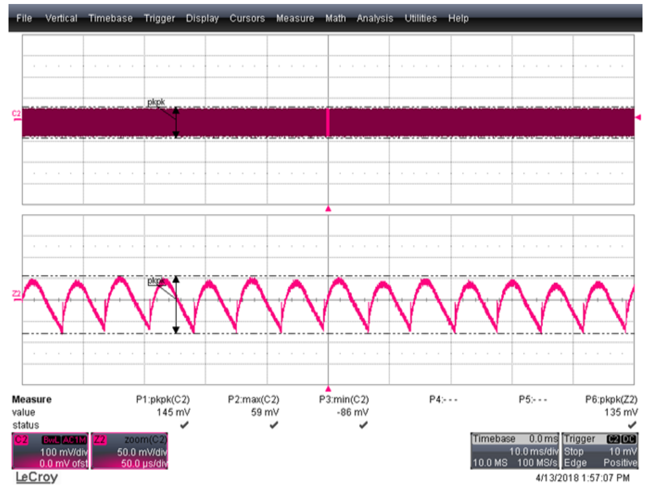



**Figure 58 –** Output Ripple.(pk-pk – 145 mV)
265 VAC Input 5.0 V,3 A Load.
$V_{OUT}$, 100 mV / div., 10 ms / div.

### 16.3.2.6 9 V Ripple waveforms

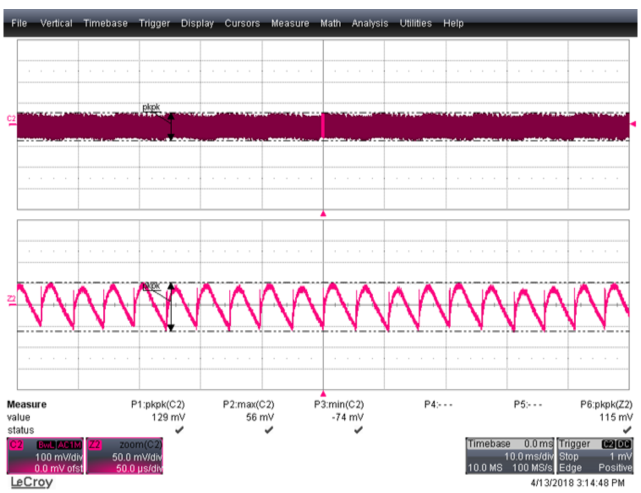



**Figure 59 –** Output Ripple.(pk-pk – 129 mV)
90 VAC Input, 9.0 V, 3 A Load.
$V_{OUT}$, 100 mV / div., 10 ms / div.

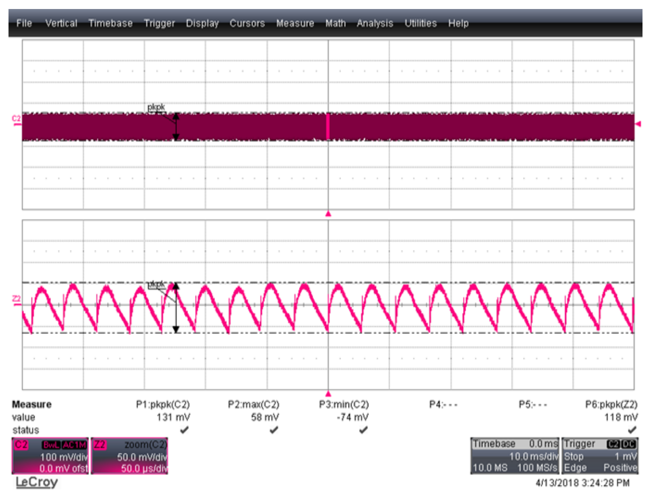



**Figure 60 –** Output Ripple.(pk-pk – 131 mV)
265 VAC Input 9.0 V, 3 A Load.
$V_{OUT}$, 100 mV / div., 10 ms / div.

#### 16.3.2.7 15 V Ripple waveforms

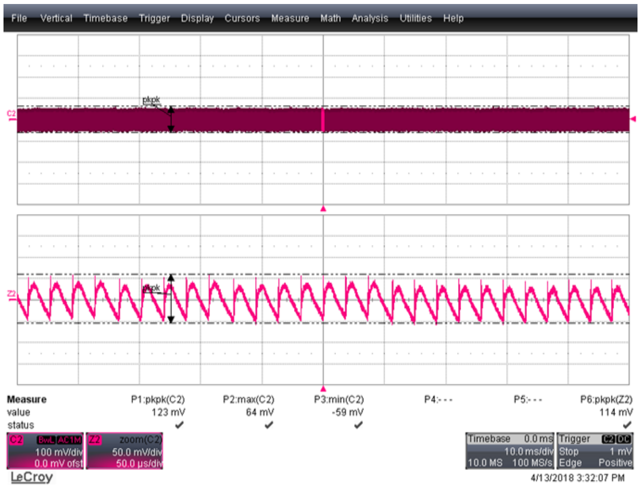



**Figure 61 –** Output Ripple.(pk-pk – 123 mV)
90 VAC Input, 15.0 V, 3 A Load.
$V_{OUT}$, 100 mV / div., 10 ms / div.

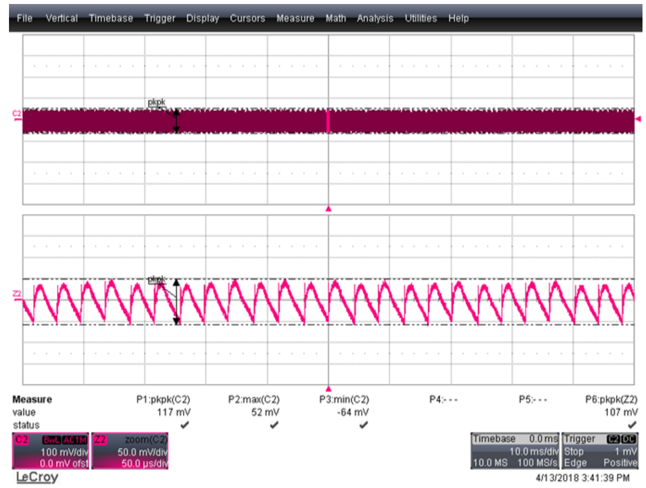



**Figure 62 –** Output Ripple.(pk-pk – 117 mV)
265 VAC Input 15.0 V, 3 A Load.
$V_{OUT}$, 100 mV / div., 10 ms / div.

#### 16.3.2.8 20 V Ripple waveforms

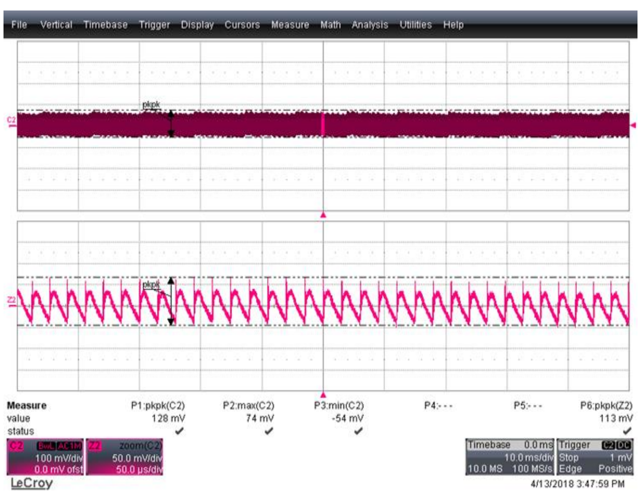



**Figure 63 –** Output Ripple.(pk-pk – 128 mV)
90 VAC Input, 20.0 V, 3 A Load.
$V_{OUT}$, 100 mV / div., 10 ms / div.

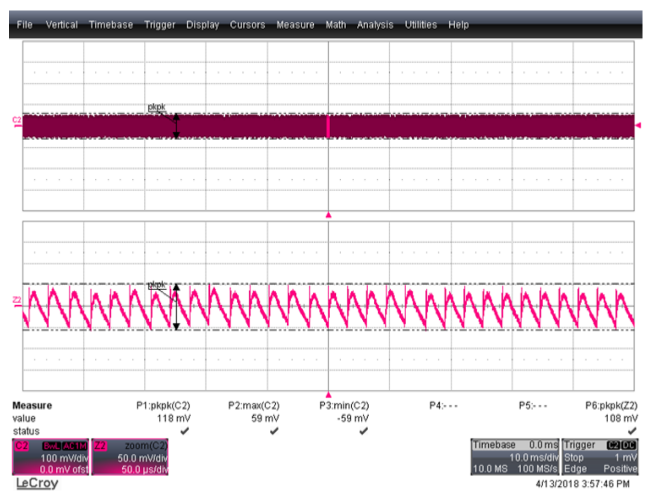



**Figure 64 –** Output Ripple.(pk-pk – 118 mV)
265 VAC Input 15.0 V, 3 A Load.
$V_{OUT}$, 100 mV / div., 10 ms / div.


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

# 17 Conducted EMI

## 17.1 Floating Output (PK / AV)

### 17.1.1 5 V, 3 A

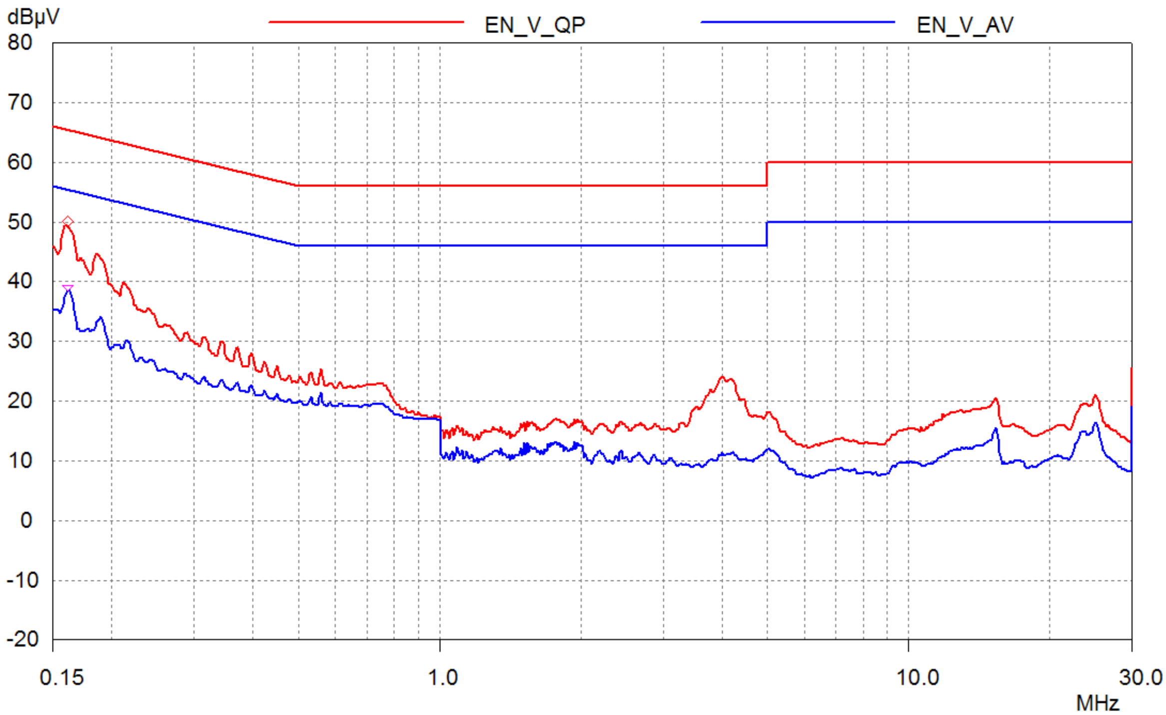



**Figure 65 –** Floating Ground EMI, 5 V / 3 A Load for 115 VAC

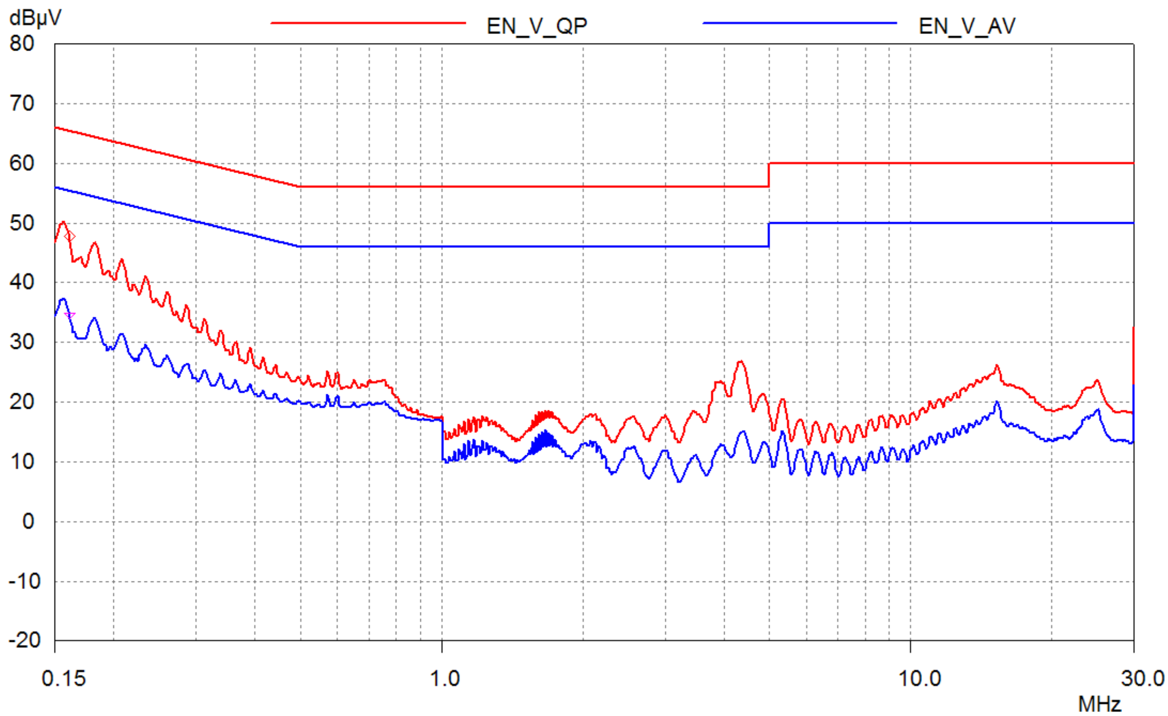



**Figure 66 –** Floating Ground EMI, 5 V / 3 A Load for 230 VAC.


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

### 17.1.2 9 V, 3 A

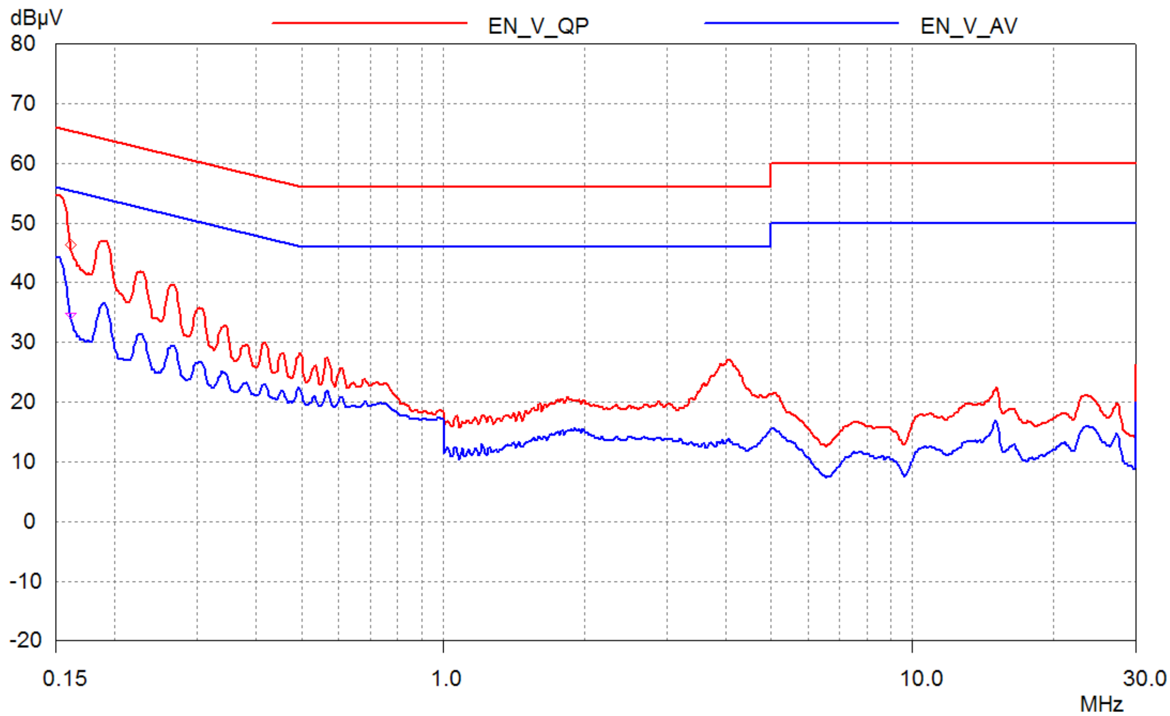



**Figure 67 –** Floating Ground EMI, 9 V / 3 A Load for 115 VAC.

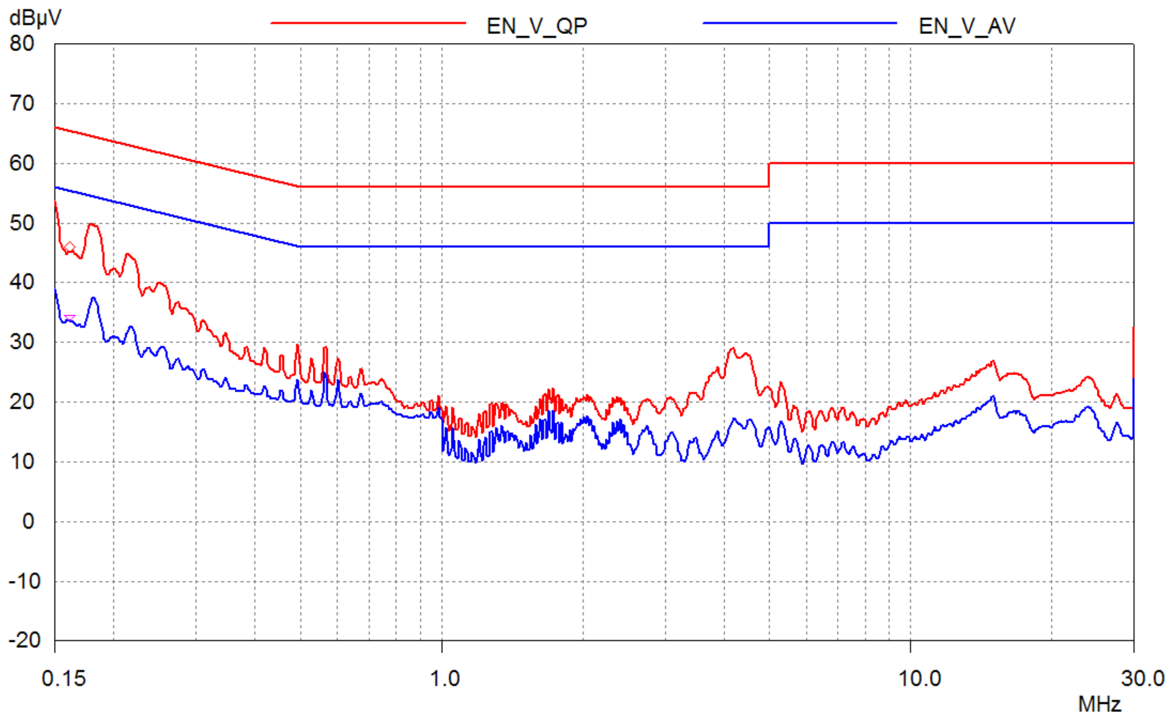



**Figure 68 –** Floating Ground EMI, 9 V / 3 A Load for 230 VAC.


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

### 17.1.3 15 V, 3 A

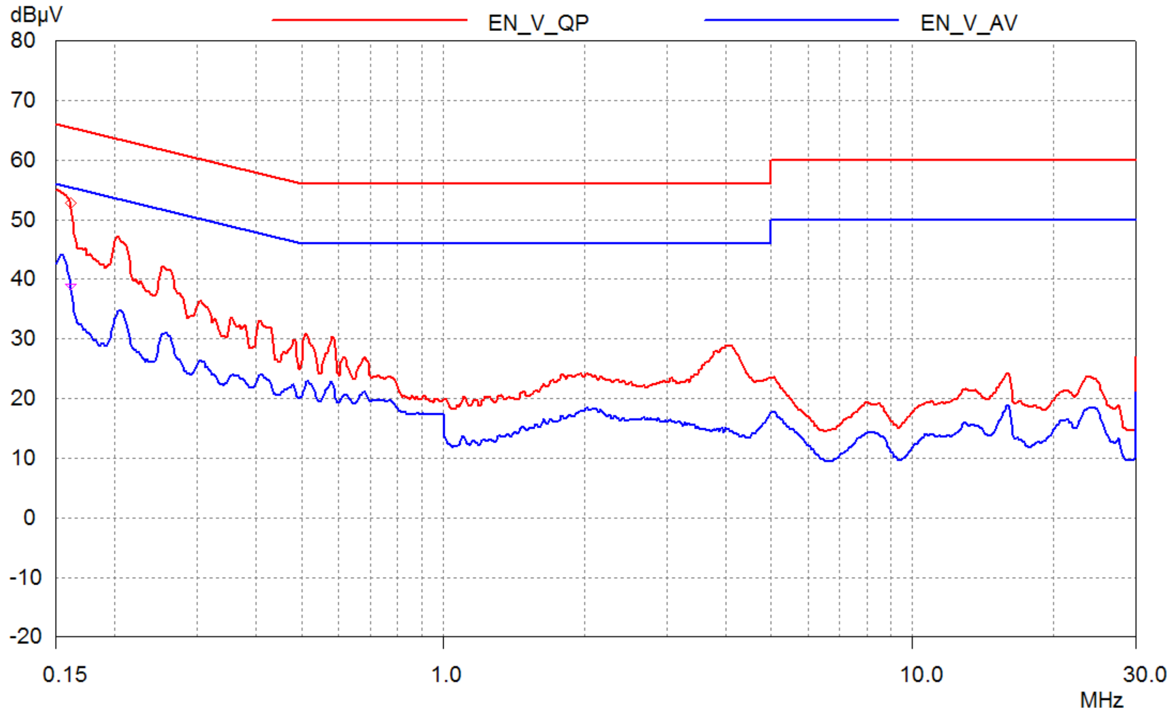



**Figure 69 –** Floating Ground EMI, 15 V / 3 A Load for 115 VAC.

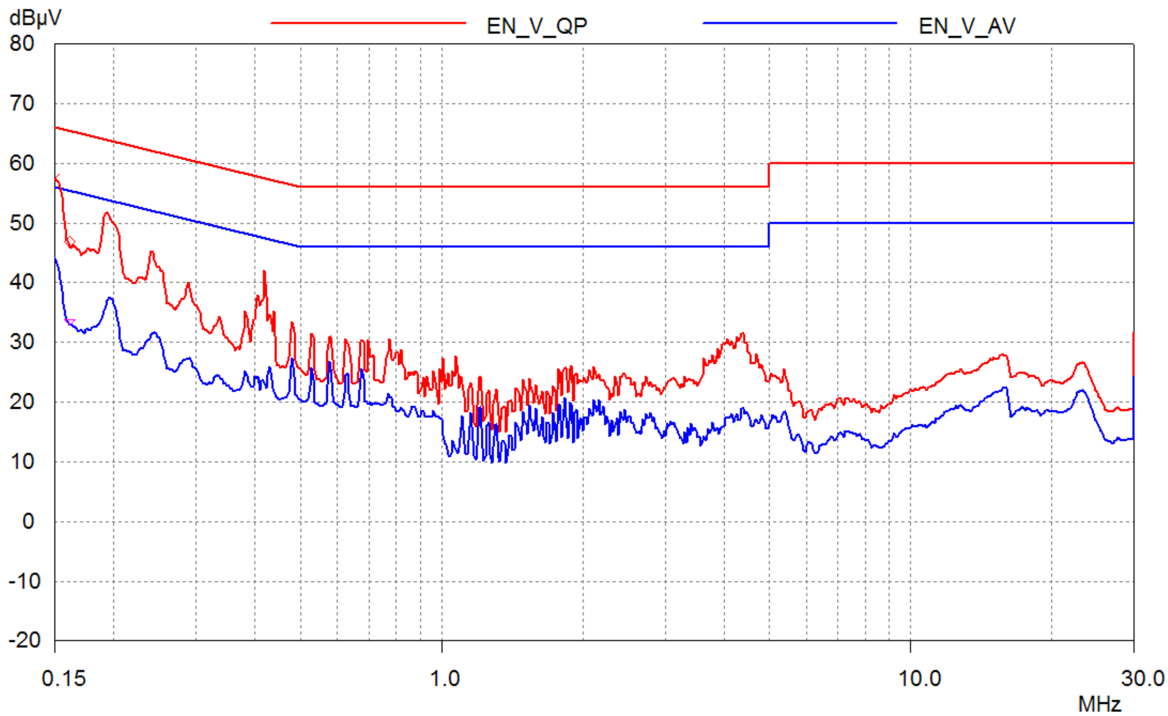



**Figure 70 –** Floating Ground EMI, 15 V / 3 A Load for 230 VAC.


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

### 17.1.4 20 V, 3 A

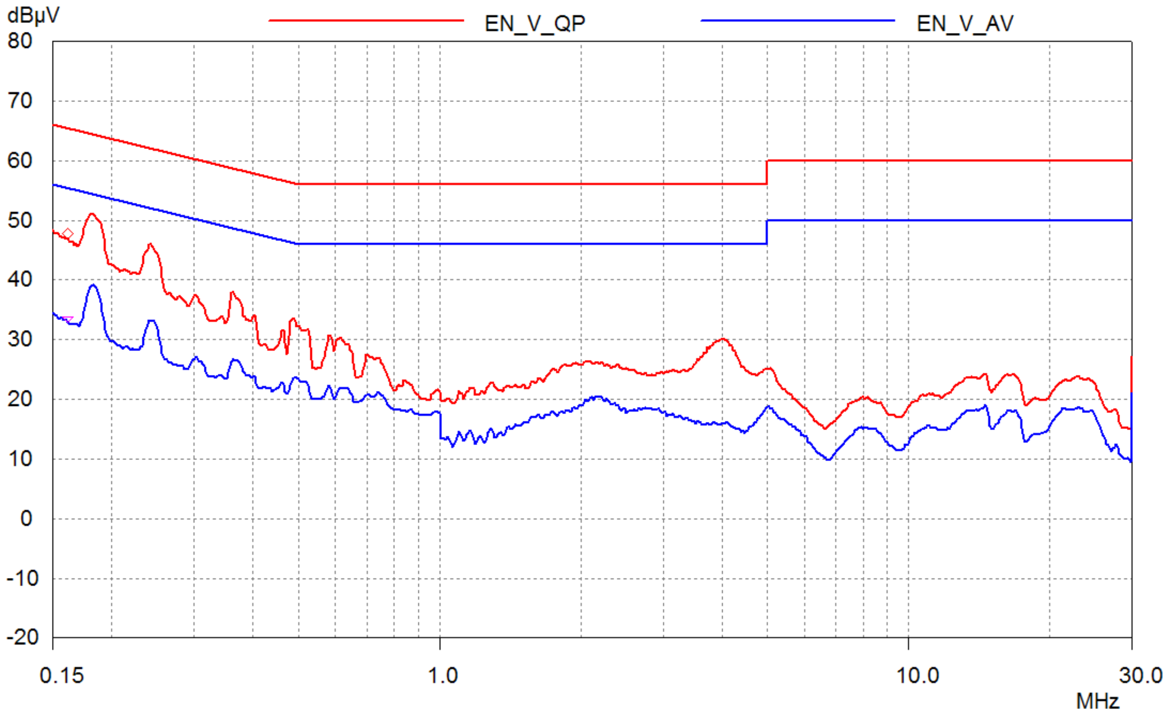



**Figure 71 –** Floating Ground EMI, 20 V / 3 A Load for 115 VAC.

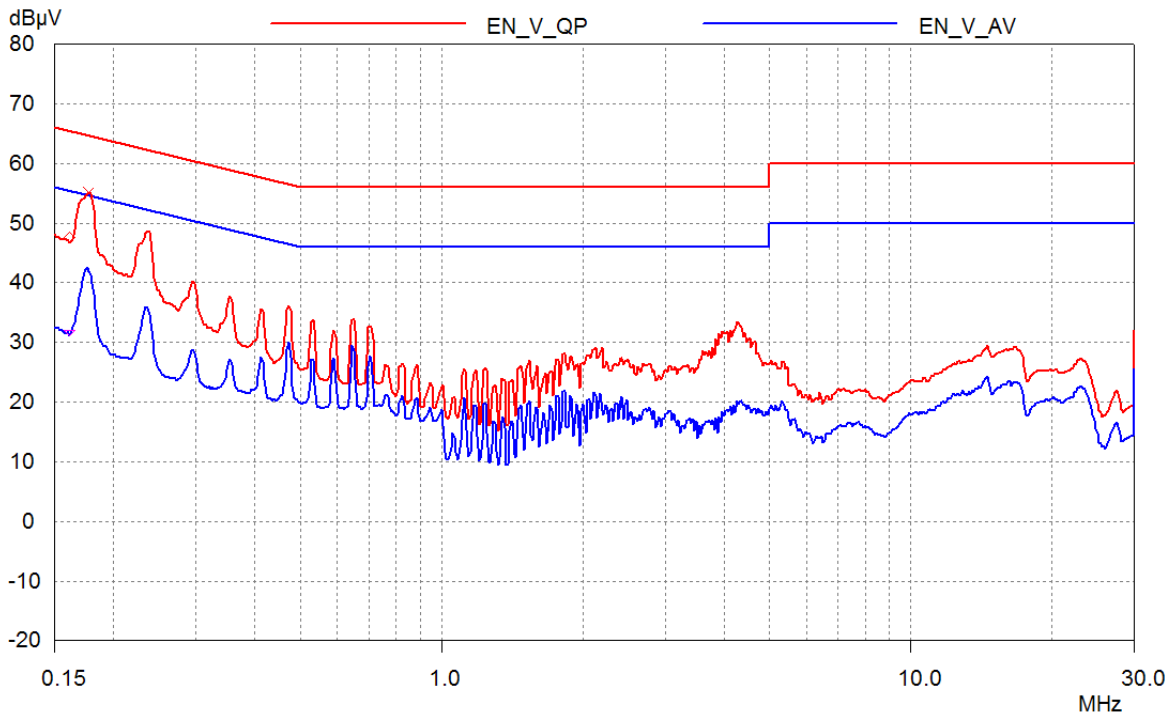



**Figure 72 –** Floating Ground EMI, 20 V / 3 A Load for 230 VAC.


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

## 17.2 **Earth Ground (PK / AV)**

### 17.2.1 5 V, 3 A

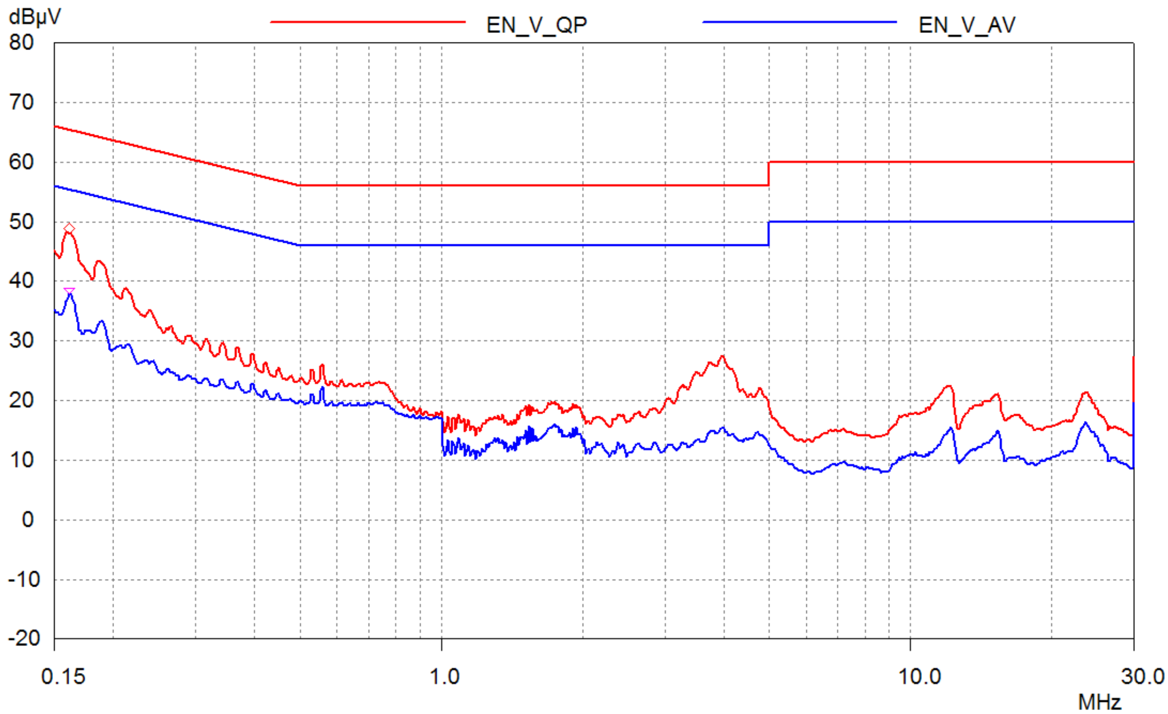



**Figure 73 –** Earth Ground EMI, 5 V / 3 A Load for 115 VAC.

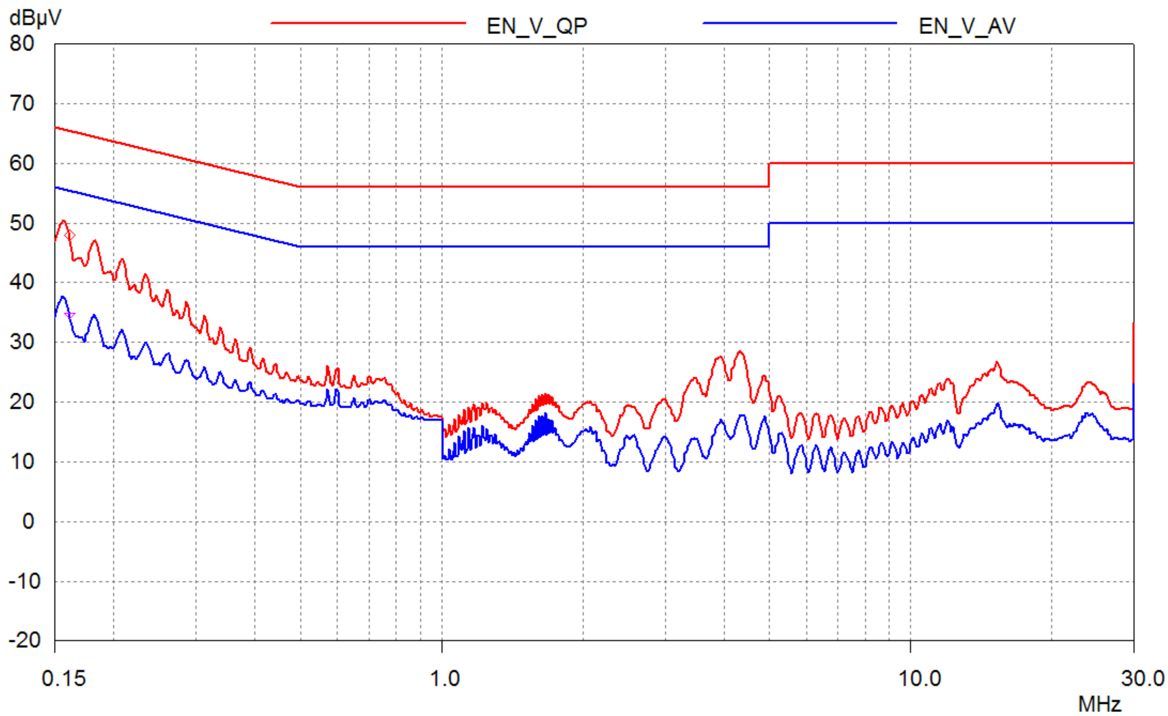



**Figure 74 –** Earth Ground EMI, 5 V / 3 A Load for 230 VAC.



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

### 17.2.2 9 V, 3 A

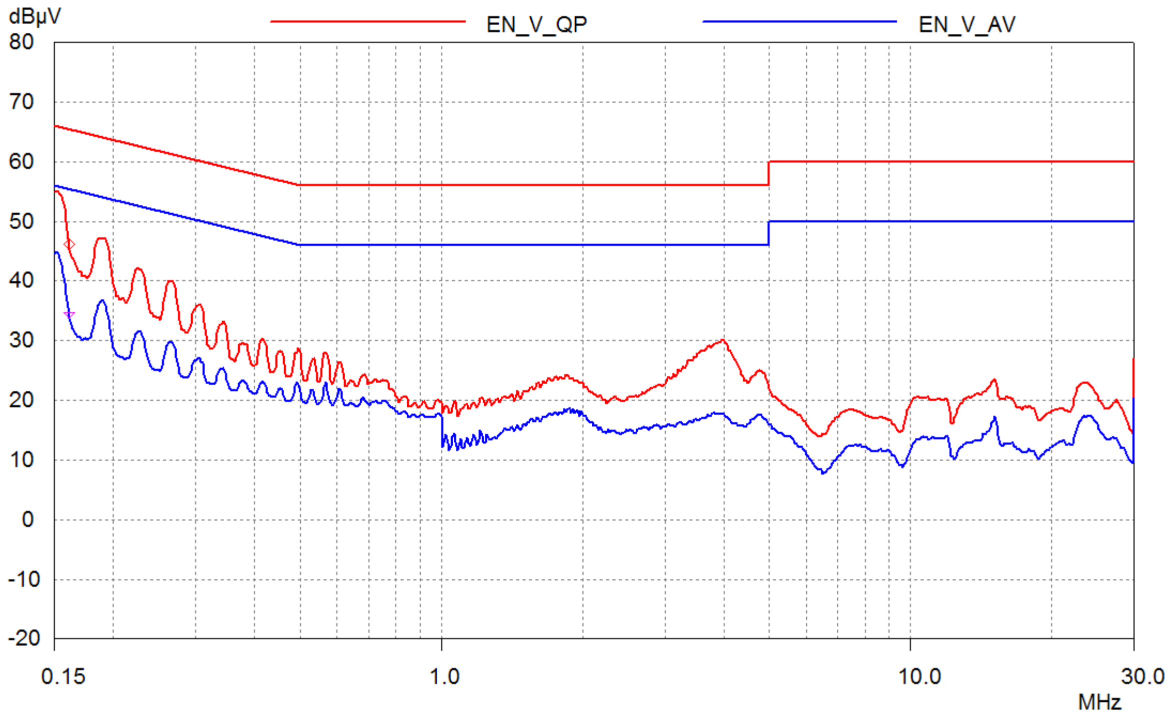



**Figure 75 –** Earth Ground EMI, 9 V / 3 A Load for 115 VAC.

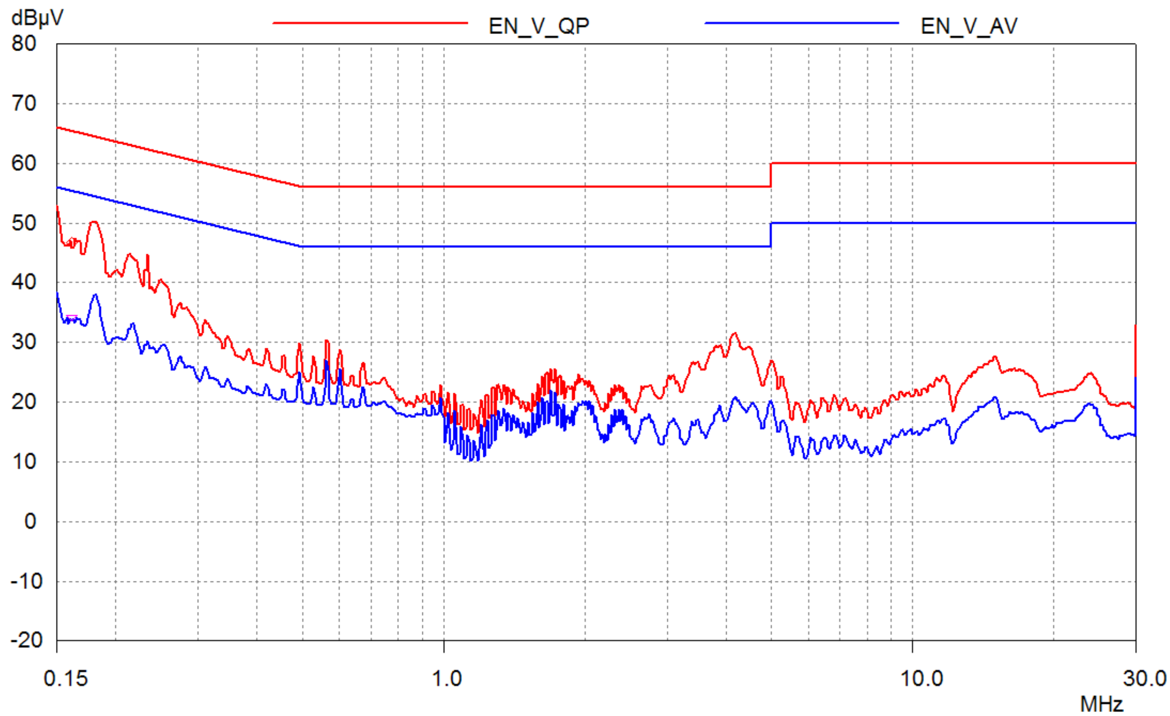



**Figure 76 –** Earth Ground EMI, 9 V / 3 A Load for 230 VAC.



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

### 17.2.3 15 V, 3 A

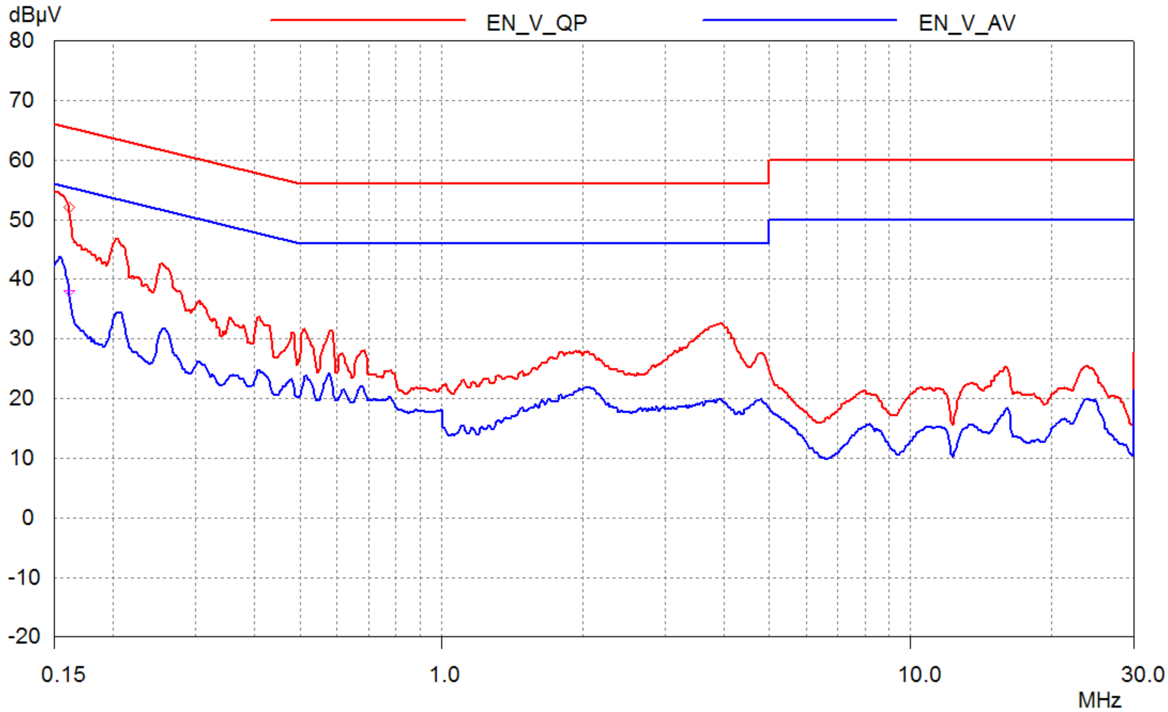



**Figure 77 –** Earth Ground EMI, 15 V / 3 A Load for 115 VAC.

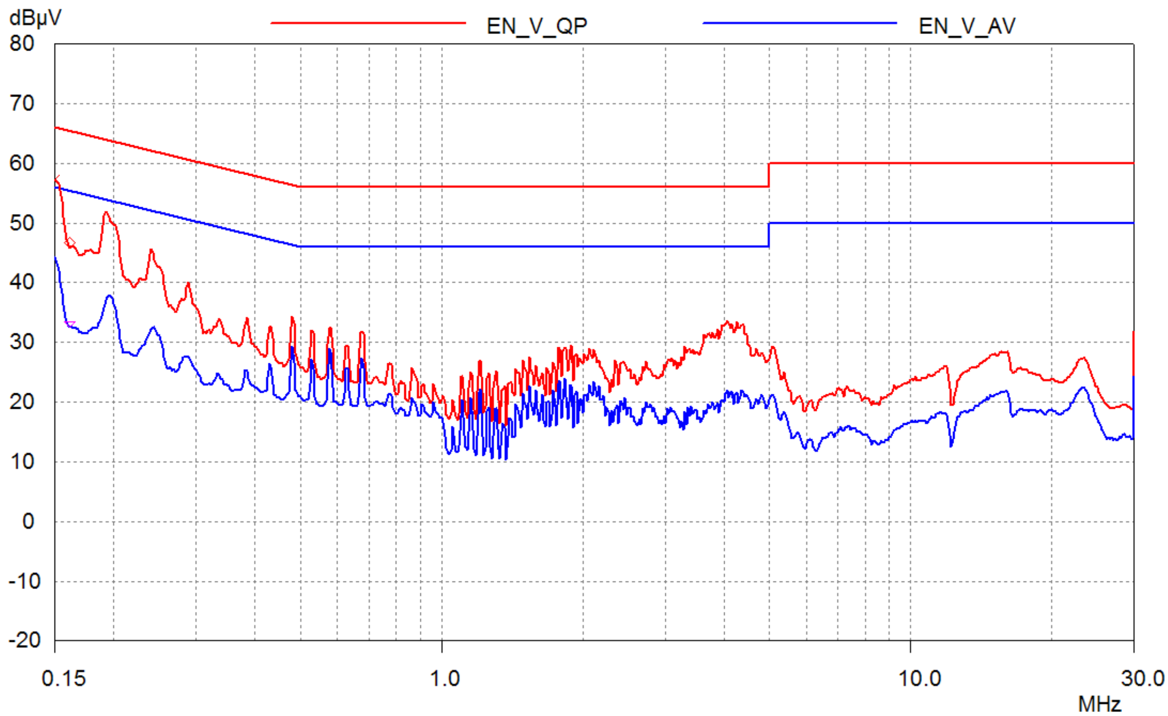



**Figure 78 –** Earth Ground EMI, 15 V / 3 A Load for 230 VAC.



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

### 17.2.4 20 V, 3 A

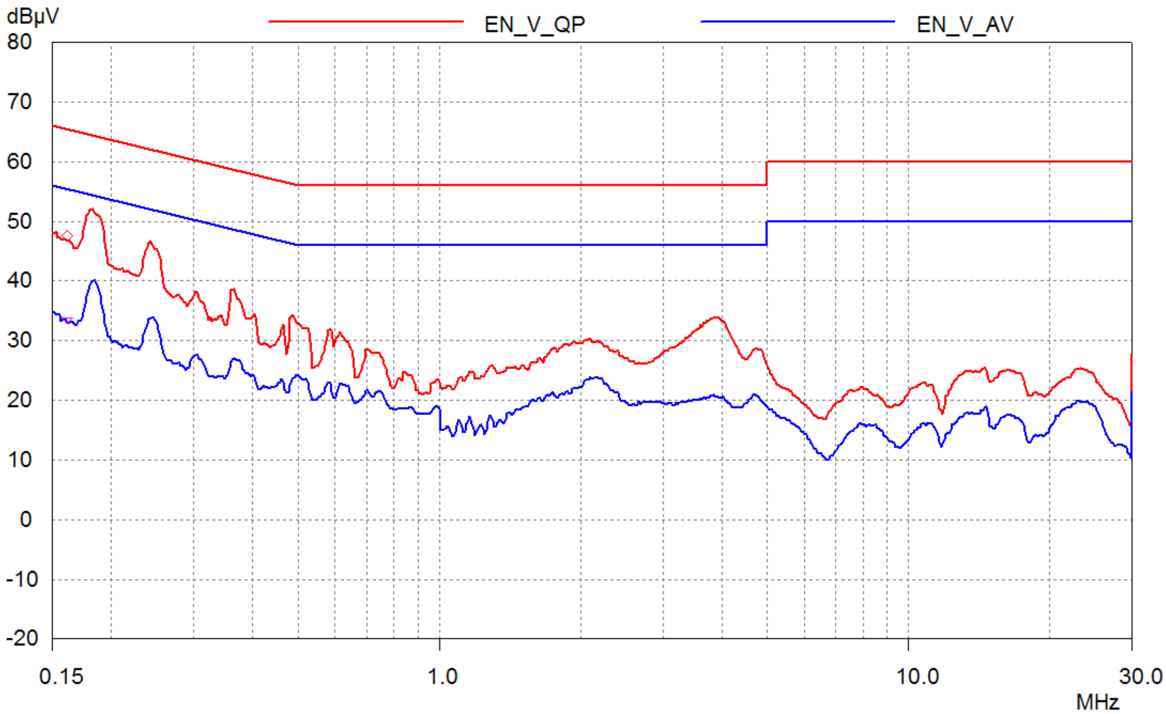



**Figure 79 –** Earth Ground EMI, 20 V / 3 A Load for 115 VAC.

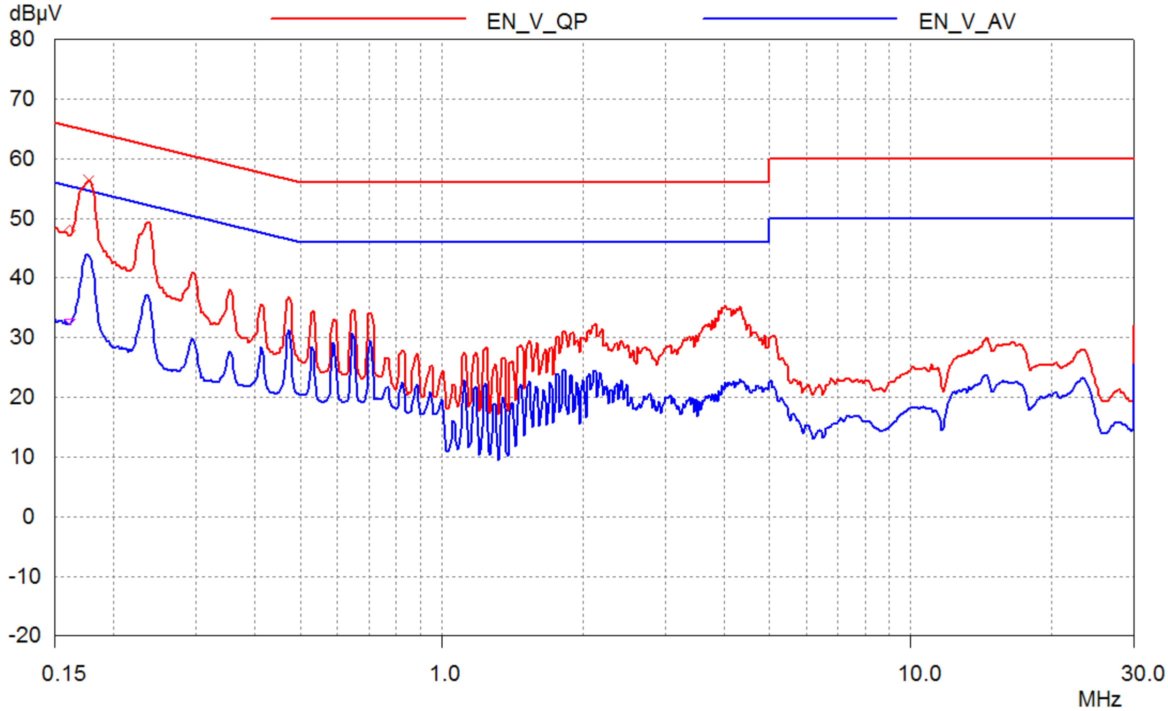



**Figure 80 –** Earth Ground EMI, 20 V / 3 A Load for 230 VAC.



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

# 18 Line Surge

## 18.1 *Combination Wave Differential Mode Test*

Passed ±1 kV.

| Surge Voltage (kV) | Phase Angle (°) | Generator Impedance (W) | Number of Strikes | Test Result |
|---|---|---|---|---|
| ±1 | 0 | 2 | 10 | PASS |
| ±1 | 90 | 2 | 10 | PASS |
| ±1 | 180 | 2 | 10 | PASS |
| ±1 | 270 | 2 | 10 | PASS |

**Note:** Input line OVP gets triggered when the test is done at no load.

# 19 ESD

ESD is done on GND pin since only GND is accessible to the user from the adapter.

Passed ±16.5 kV air discharge and 8 kV contact discharge GND pin.

| Air Discharge (kV) | Number of Strikes | Test Result |
|---|---|---|
| +16.5 | 10 | PASS |
| -16.5 | 10 | PASS |

| Contact Discharge (kV) | Number of Strikes | Test Result |
|---|---|---|
| +8 | 10 | PASS |
| -8 | 10 | PASS |

# 20 Revision History

| Date | Author | Revision | Description & Changes | Reviewed |
|---|---|---|---|---|
| 24-Jul-19 | SS | 1 | First draft | NZ |
| | | | | |
| | | | | |
| | | | | |
| | | | | |



**Power Integrations**
Tel: +1 408 414 9200 Fax: +1 408 414 9201
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