# 40 W SiC High-Voltage Auxiliary Power Supply for HEV & BEV Applications Evaluation Board User's Manual

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EVAL BOARD USER'S MANUAL

# SECO-HVDCDC1362-40W-GEVB

### Introduction

SECO−HVDCDC1362−40W−GEVB is highly efficient and primary−side regulated (PSR) auxiliary power supply targeting HEV and EV automotive power trains. The design provides a stable 15 V output and 40 W over a wide input DC voltage range from 250 V to 900 V, and is therefore suitable for 400 V and 800 V battery systems.

The board employs the NCV1362 quasi−resonant peak current PSR flyback controller, the 3−lead cost−optimized NVHL160N120SC1 160 mΩ 1200 V silicon carbide (SiC) MOSFET, and the FFSP0665B−F085 SiC diode.

Thanks to the high blocking voltage capabilities and ultra−low gate charge (34 nC) value of the SiC FET, the switching losses are significantly reduced, and the board exhibits a superior efficiency for the application up to 86% in low line input conditions. The notable driving capabilities of the NCV1362 controller allows for direct operation of the SiC FET at 12 V without a pre−driver, simplifying the layout and cutting down the component count.

The flyback transformer provides 4 kV isolation and is optimized to minimize the losses on the RCD snubber. Consequently the system effectively dampens the drain voltage overshoot at high line, and provides 100 V margin for the SiC FET. The board is fully realized with automotive qualified semiconductors and passive devices. Industrial grade replacements are also available.

(Top View)

(Bottom View)

**Figure 1. Board Layout**

### Features

- NCV1362 (Automotive) / NCP1362 (Industrial) Quasi−resonant Peak Current PSR Flyback Controller
- Fully Automotive Qualified Devices
- Vin = 240 V – 900 V DC Only
- Vout = 15 V / 40 W Continuous
- Electromagnetic Compatibility (EN 55015 Limits)
- High Efficiency up to 85.5%
- SiC FET Directly Operated at 12 V by the IC
- Excellent Thermal Performance

### Applications

- HEV & EV Vehicles Auxiliary Power Supplies
- Automotive Powertrain Systems
- EV Charging and DC−DC Conversion
- Industrial DC−DC Conversion, Solar Inverts (with Industrial Grade)

### Benefits

- Superior Efficiency with SiC Devices
- Stable Performance across a Wide Input Voltage Range (250 Vdc – 900 Vdc)
- Reduced Bill−of−Material and Cost−optimized
- Fully AEC−Q Qualified Parts
- EMC within EN 55015 Limits
- Single Layer PCB

### Collateral

- NVHL160N120SC1
- NCV1362
- SECO−HVDCDC1362−40W−GEVB
- References

### Scope and Purpose

The purpose of this user's manual is to present the design of an auxiliary power supply with automotive qualified parts NCV1362 (NCP1362) and NVHL160N120SC1 SiC FET. The design was tested as described in this document but not qualified regarding safety requirements or manufacturing and operation over the complete operating temperature range or lifetime. The hardware is intended for testing under laboratory conditions and by trained specialists only.

### System Overview

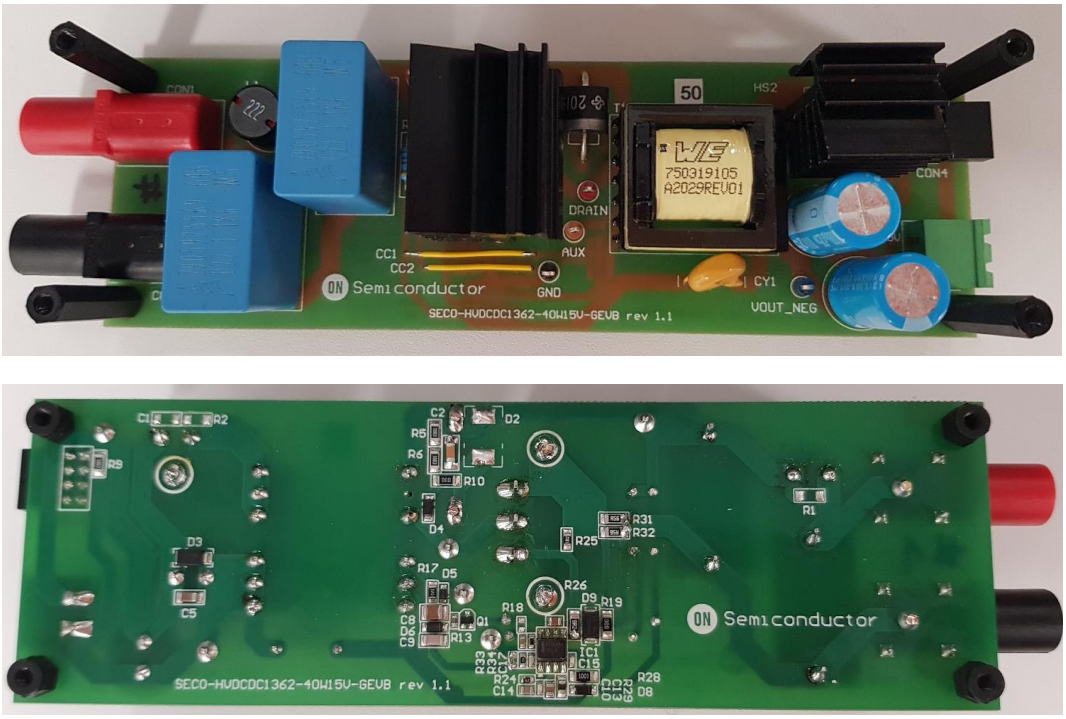



**Figure 2. Evaluation Board Photo**

### Block Diagram

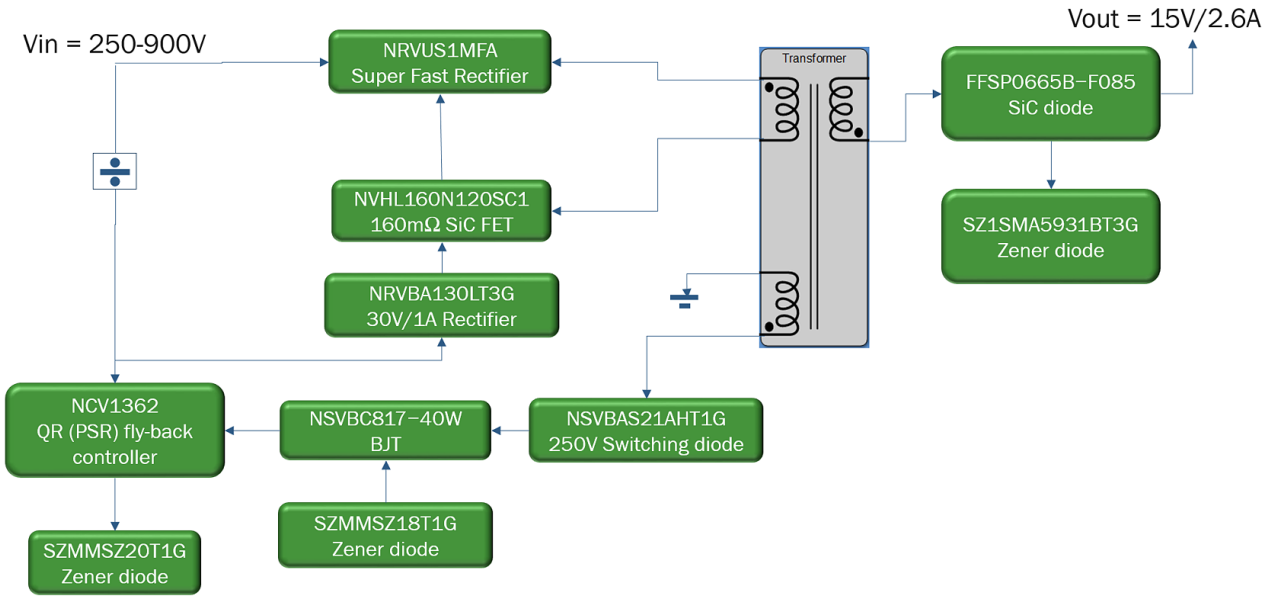



**Figure 3. Block Diagram**

## SPECIFICATION

| Parameters | Values |
|---|---|
| **Input** | |
| Voltage | 250−900 VDC |
| Current | 191 mA (Vin = 250 V), 56 mA (Vin = 900 V) |
| **Output** | |
| Power | 40 W |
| Voltage | 15 VDC |
| Current per branch | 2.66 A |
| Total current | 2.66 A |
| Efficiency at full load | 85.5% (Vin = 250 V) |
| Temperature at full load | 98°C (Vin = 6 V), 74.5°C (Vin = 15 V), 76°C (Vin = 18 V) |
| **Control** | |
| Core part | NCV1362 |
| Topology | Flyback |
| Switching frequency | 50 kHz |
| Operation mode | DCM |
| Primary side peak current | 1.5 A |
| **Construction** | |
| Board size | 52.2 x 164.2 x 40 mm |
| **Transformer** | |
| Dielectric insulation | 4000 VAC, 1 min. |
| Inductance | 0.95 mH ± 10% |
| Leakage inductance | 20 μH typ. / 40 μH max. |
| Safety standard | IEC62368−1 |
| Pollution degree | 1 |
| **Application** | |
| HEV & EV vehicles, automotive powertrain systems, EV charging and DC−DC conversion | |

### Schematic

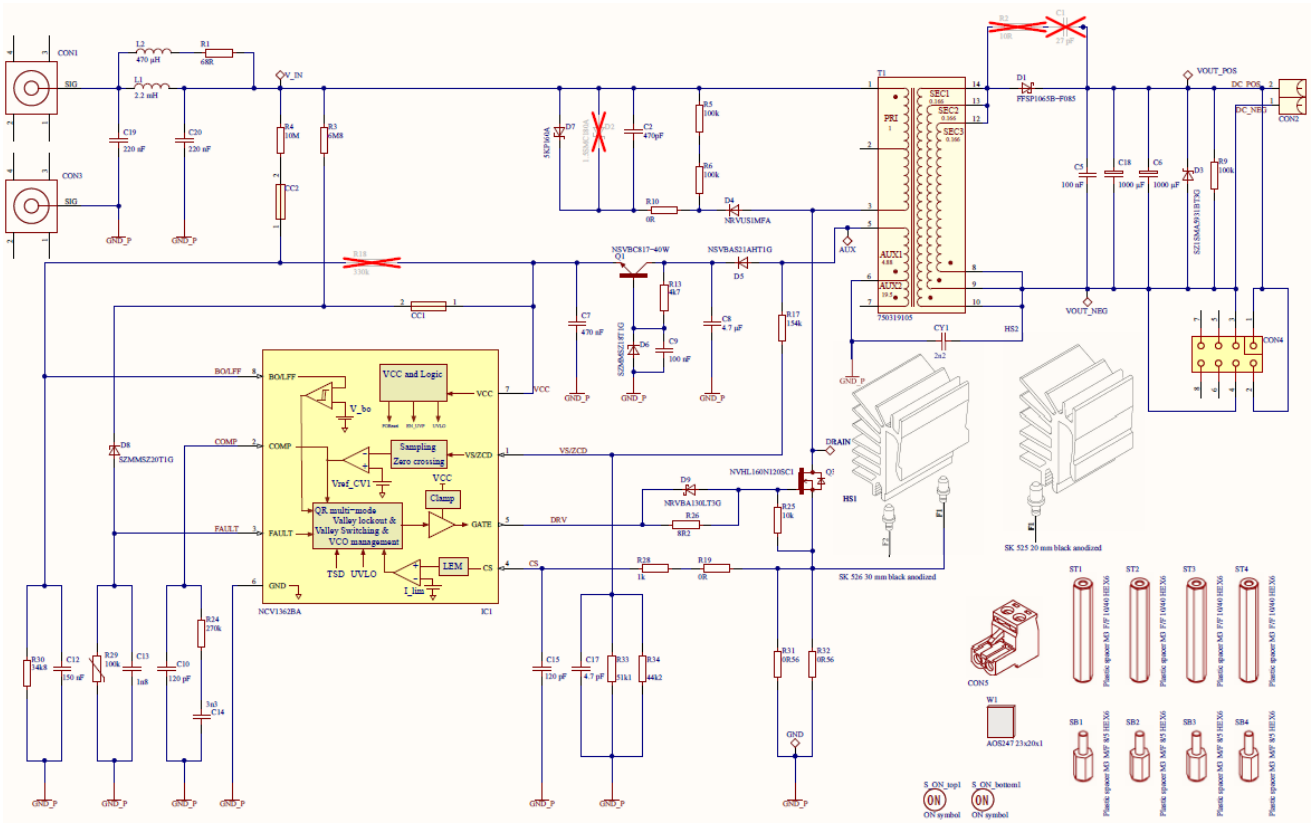



**Figure 4. Evaluation Board Schematic**

## TEST REPORT

This section presents the results of the tests conducted on the power supply.

- Efficiency DC/DC at input voltage range and full load
- Waveforms at 240 V, 500 V, 900 V at full load / open circuit
- Load transients 15%−85% and 15%−85% load
- Thermal camera view
- Electromagnetic compatibility

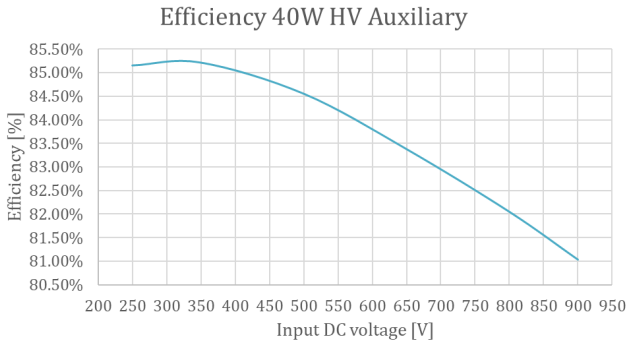
### Efficiency DC/DC at Input Voltage Range and Full Load

Measured conditions:

- Output power Pout ~ 40 W
- Electronic load: Chroma 6147A used channel 3 as CRH (constant resistance high mode 5.5 Ω → 2.66 A)

List of equipment:

- DC source: Magna−Power 0−1000V
- Power analyzer: Textronix PA3000
- Electronic load: Chroma



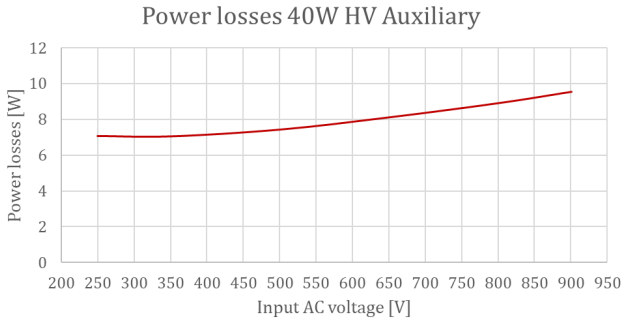




**Figure 5.**

### Waveforms at 240 V, 500 V, 900 V at Full Load / Open Circuit

Measured conditions:

- Output power Pout ~ 40 W
- Electronic load: Chroma 6147A used channel 3 as CRH (constant resistance high mode 5.5 Ω → 2.66 A)

List of equipment:

- DC source: Magna−Power 0−1000V
- Power analyzer: Textronix PA3000
- Electronic load: Chroma
- Oscilloscope: Lecroy HDO8038

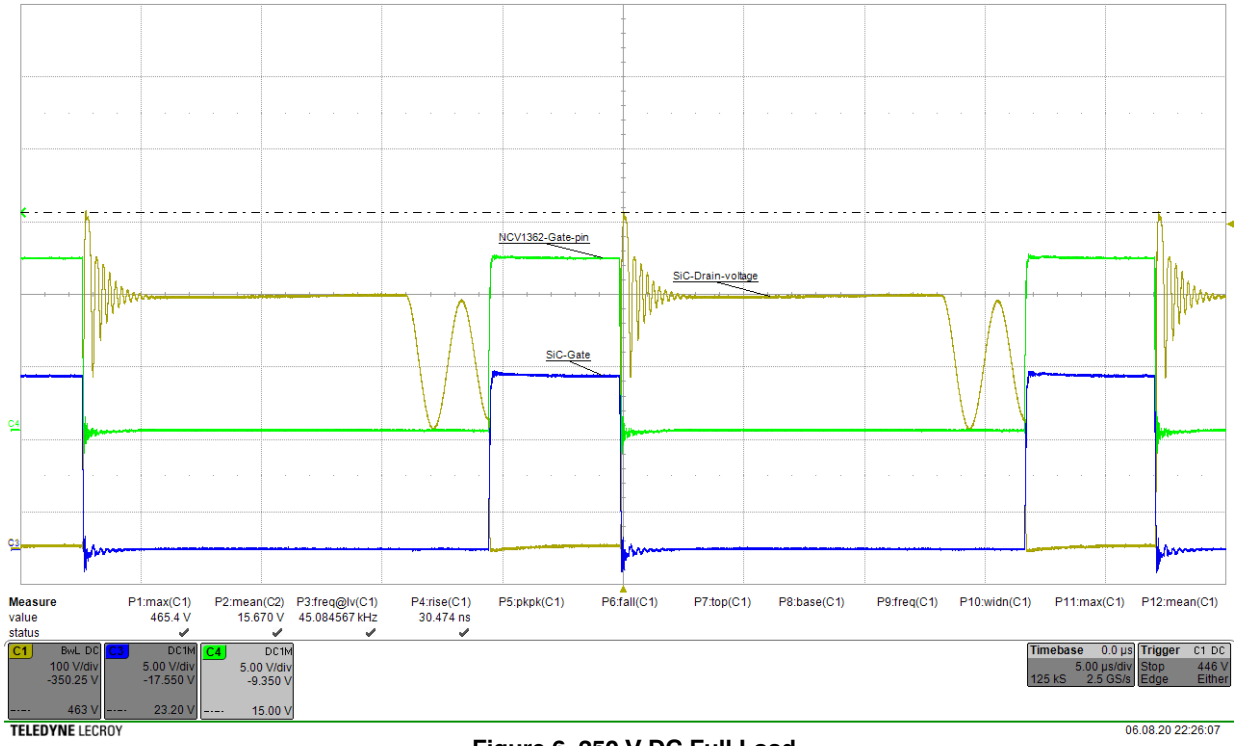



**Figure 6. 250 V DC Full Load**

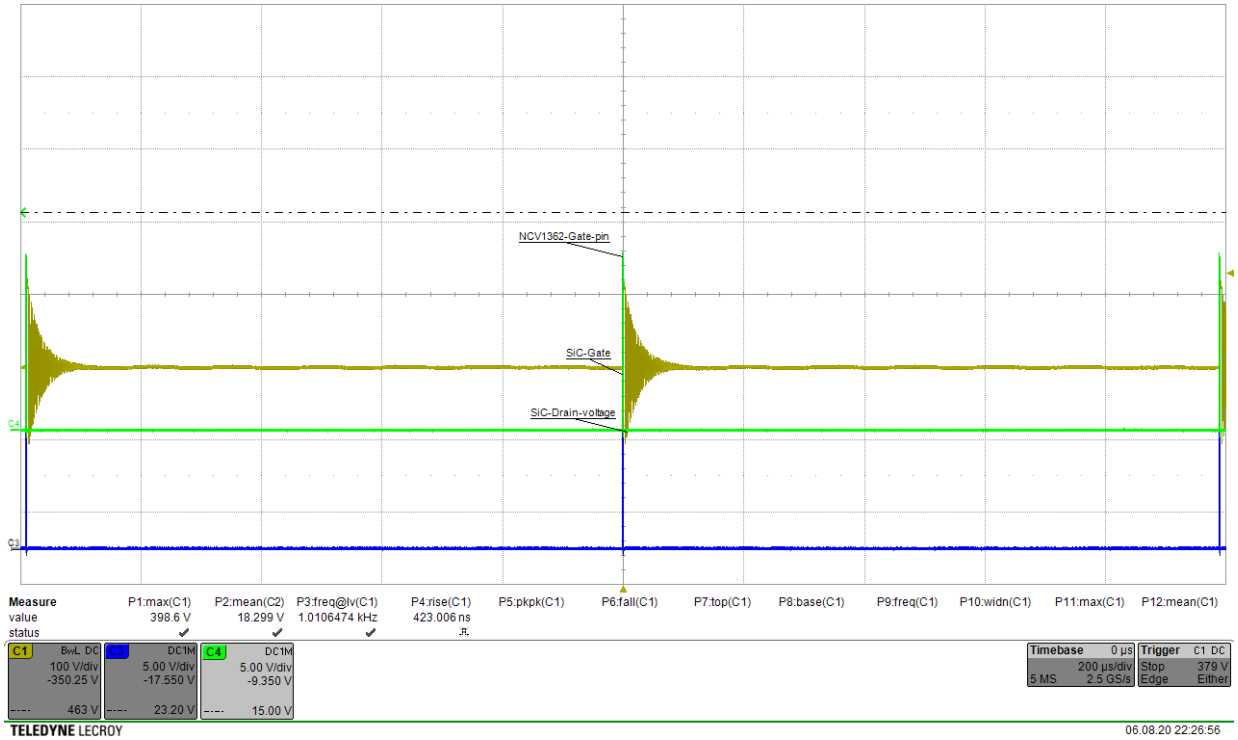



**Figure 7. 250 V DC Open Circuit**

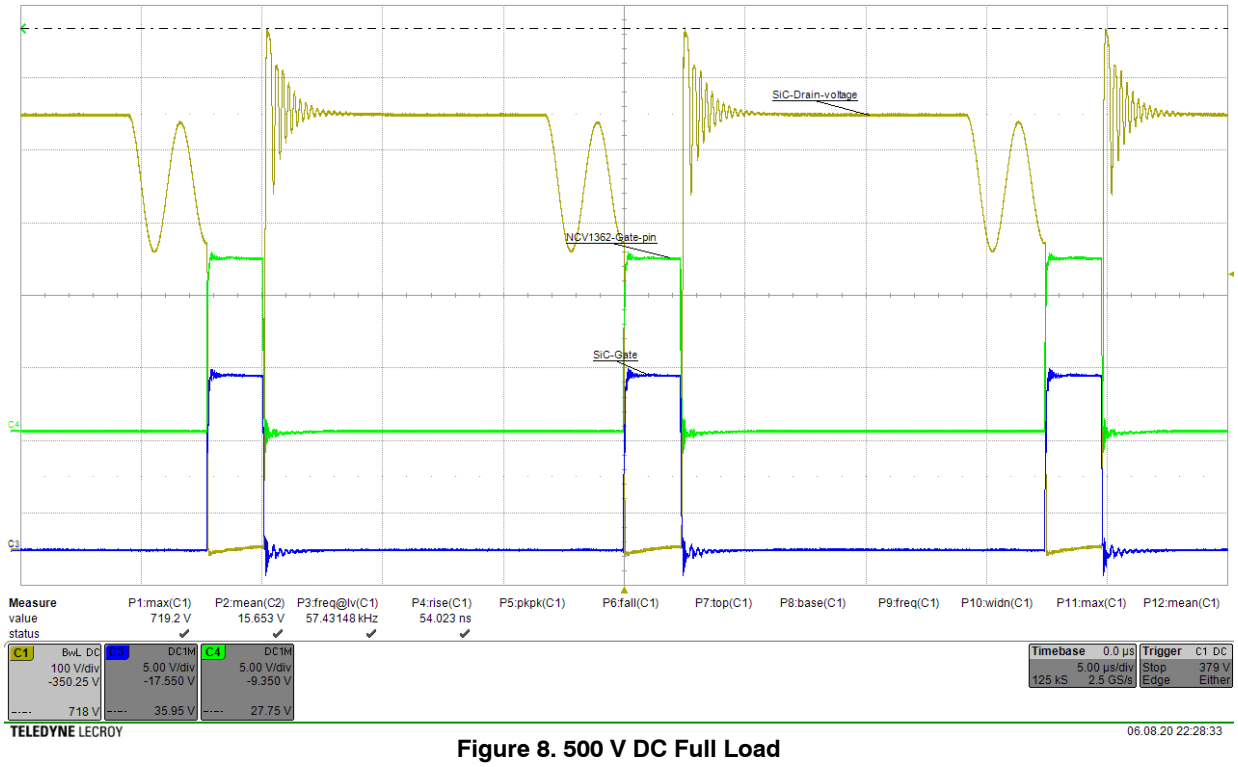



**Figure 8. 500 V DC Full Load**

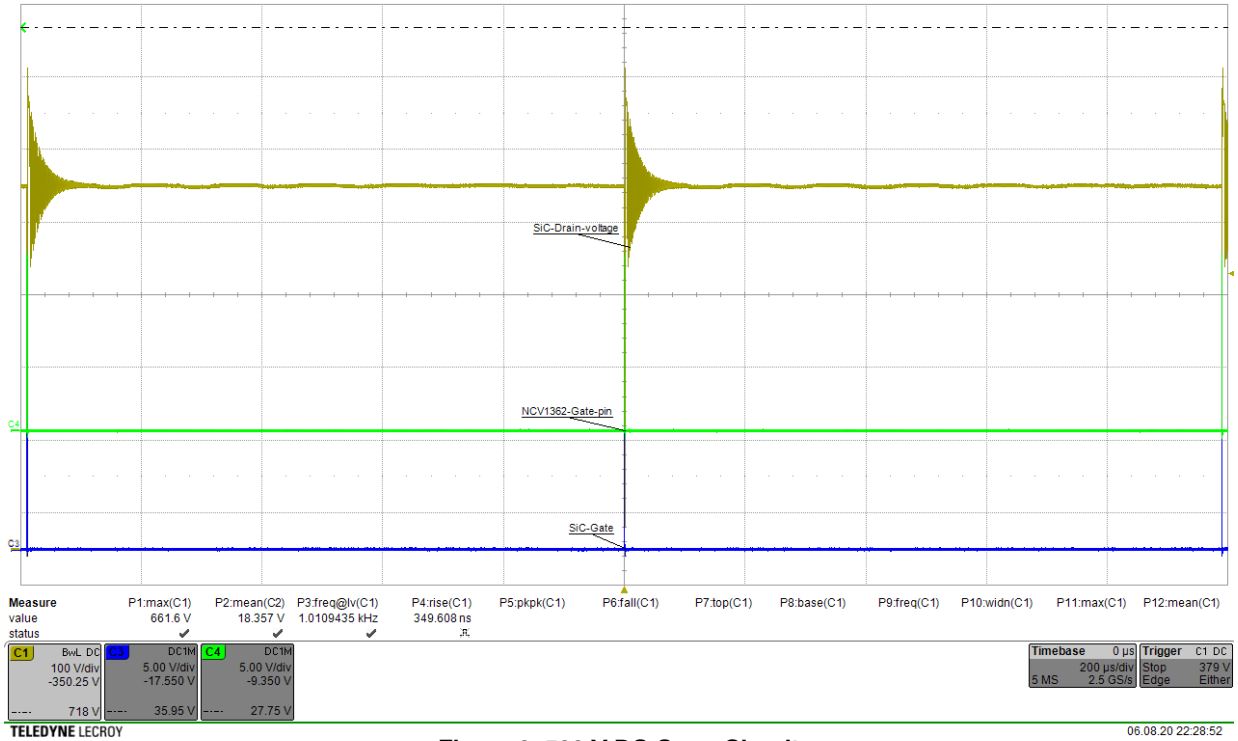



**Figure 9. 500 V DC Open Circuit**

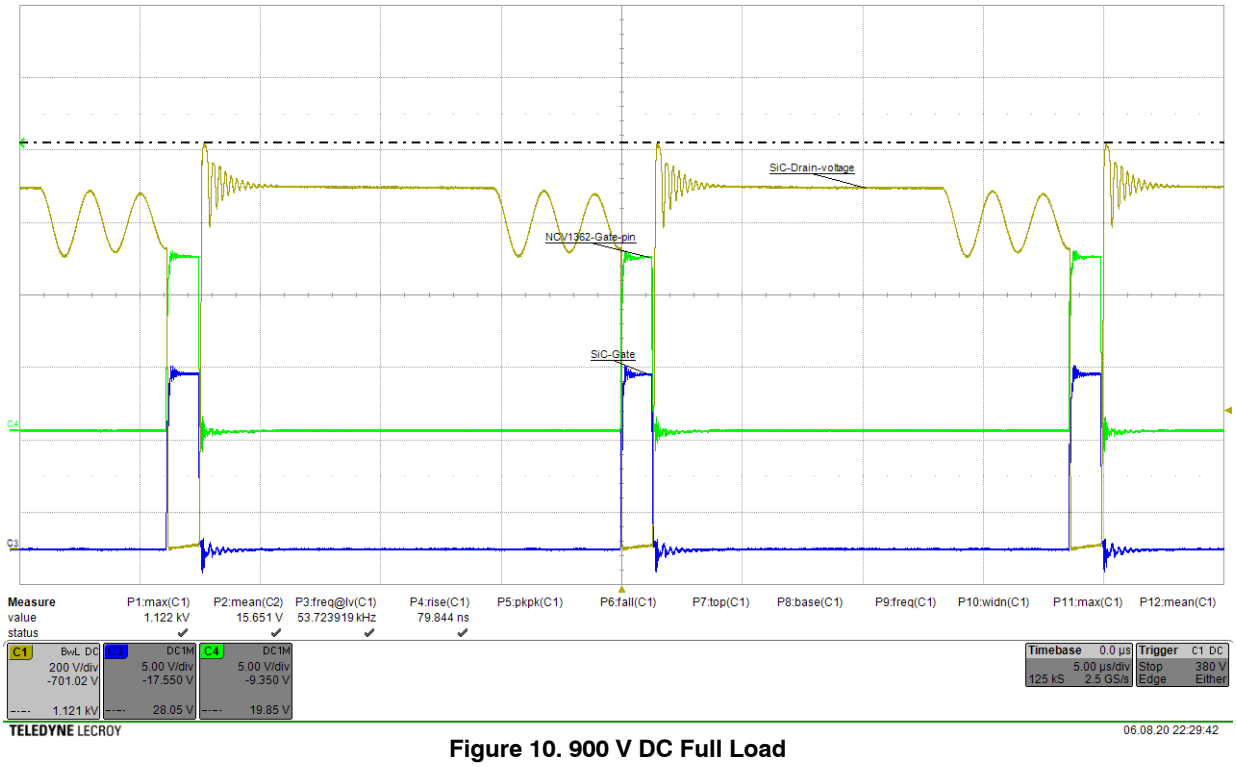



**Figure 10. 900 V DC Full Load**

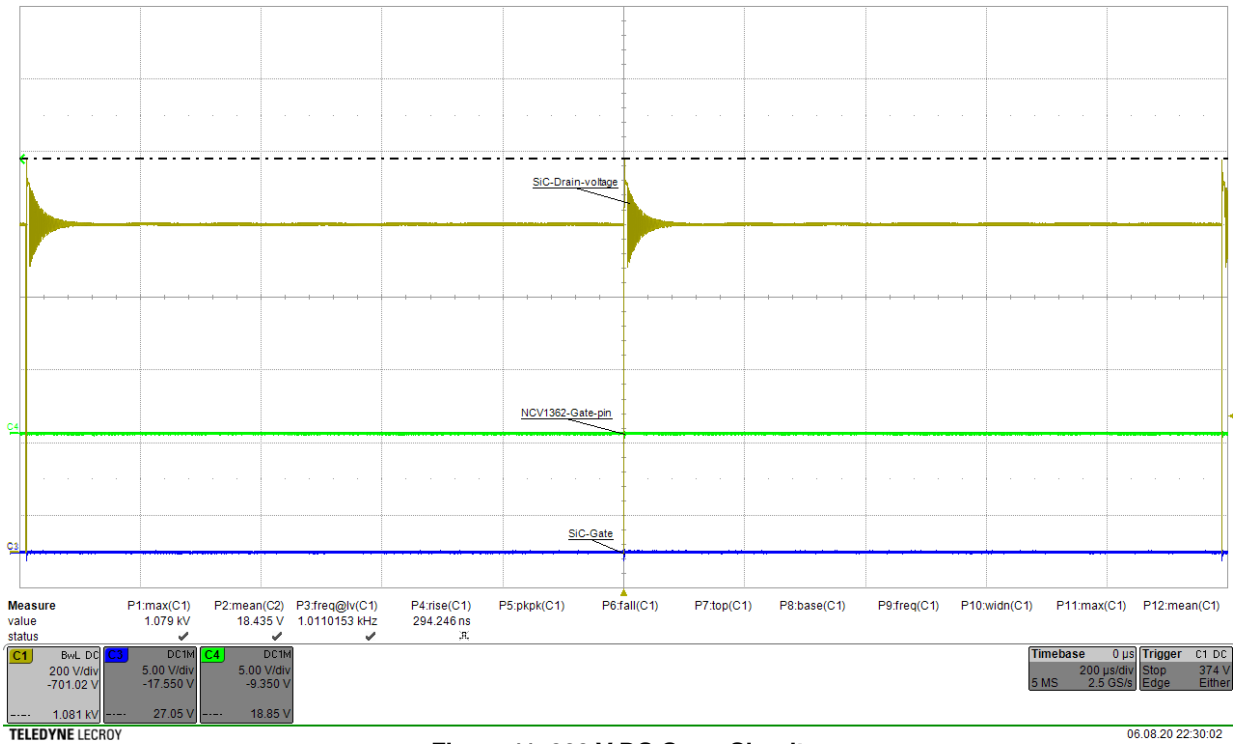



**Figure 11. 900 V DC Open Circuit**

### Load Transients 15%−85% and 15%−85% Load

Measured conditions:

- Output power Pout ~ 40 W
- Electronic load: Chroma 6147A used channel 3 as CCDH (constant current dynamic mode 0.39 A → 2.26 A)

List of equipment:

- DC source: Magna−Power 0−1000V
- Power analyzer: Textronix PA3000
- Electronic load: Chroma
- Oscilloscope: Lecroy HDO8038

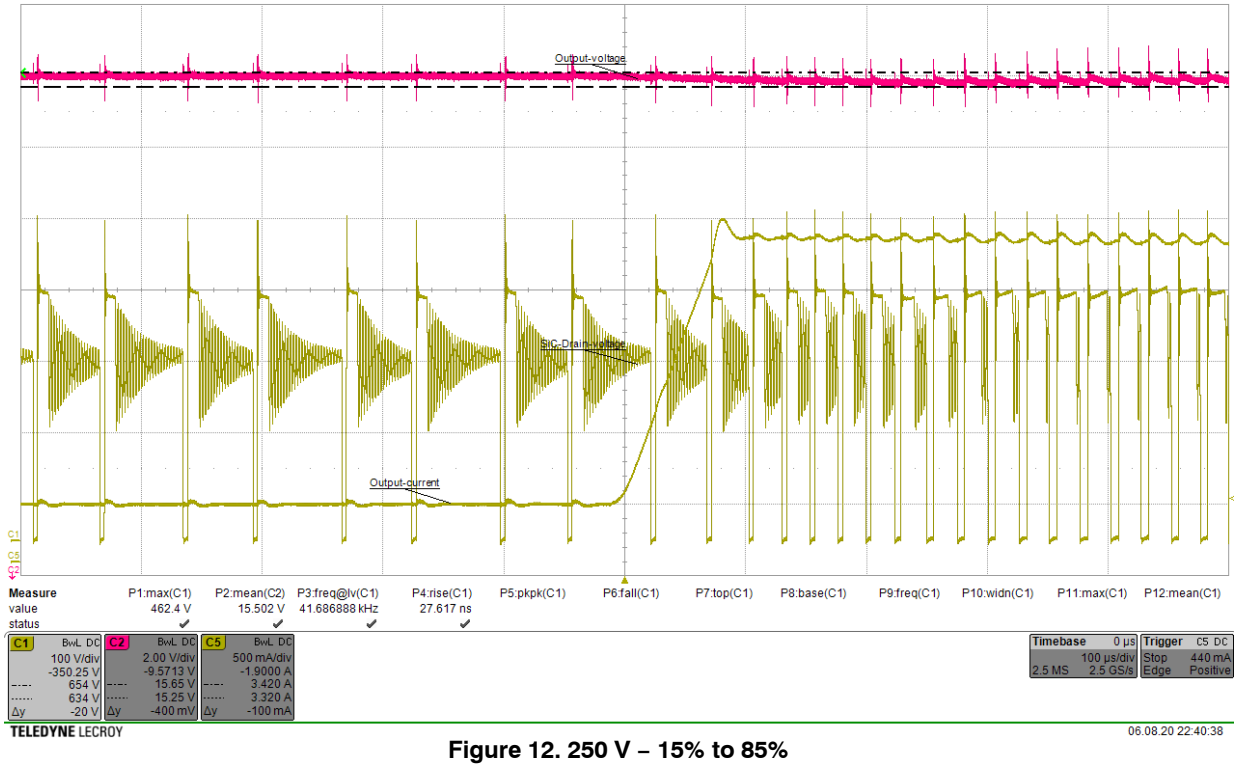



**Figure 12. 250 V – 15% to 85%**

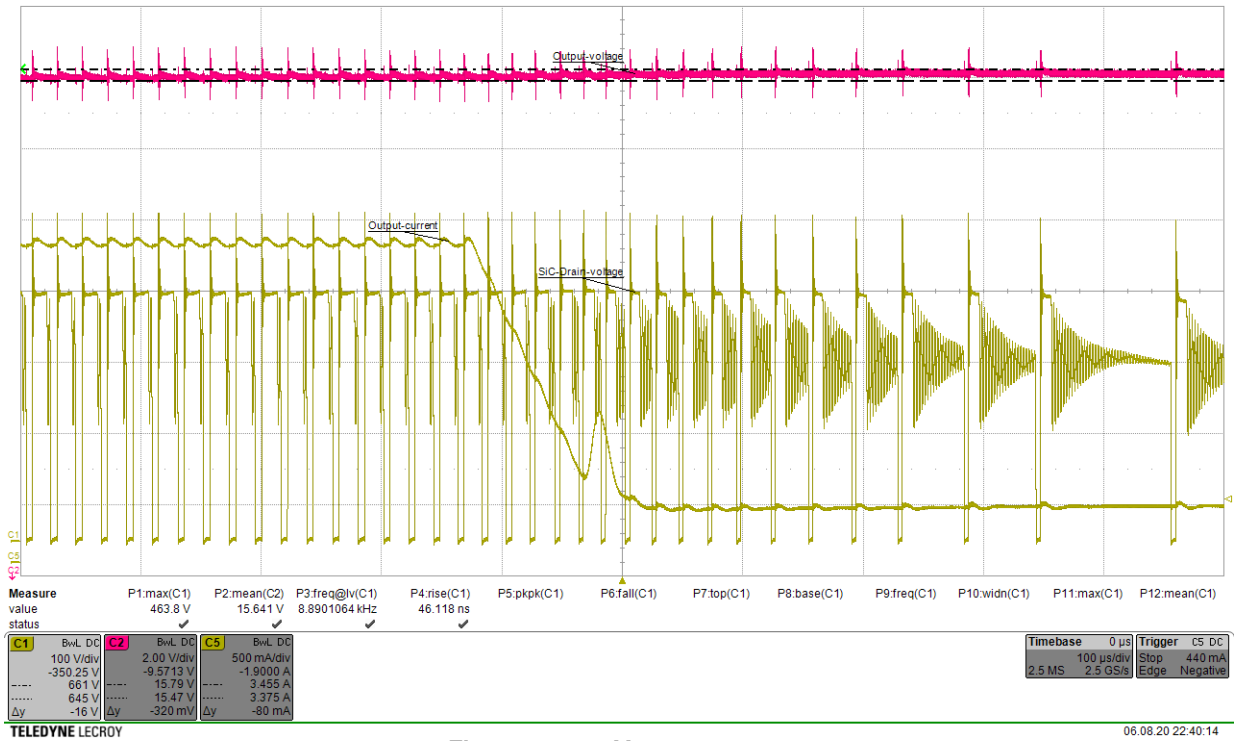



**Figure 13. 250 V – 85% to 15%**

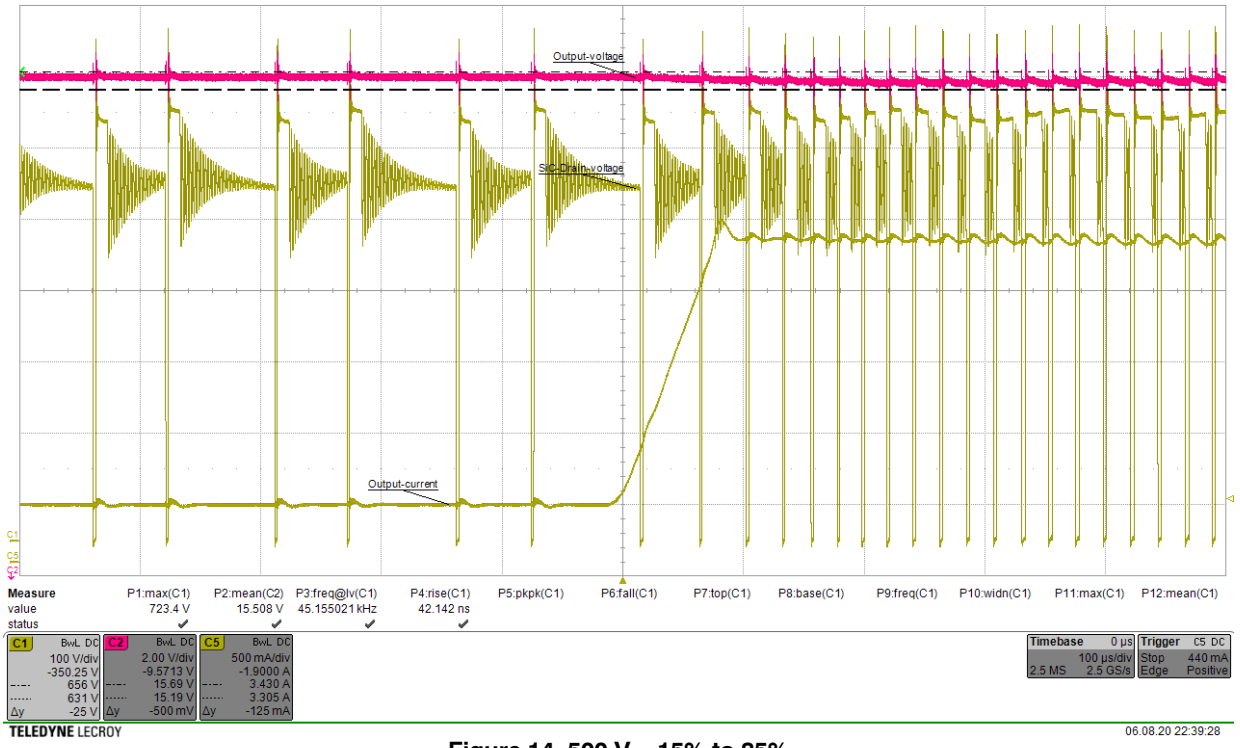



**Figure 14. 500 V – 15% to 85%**

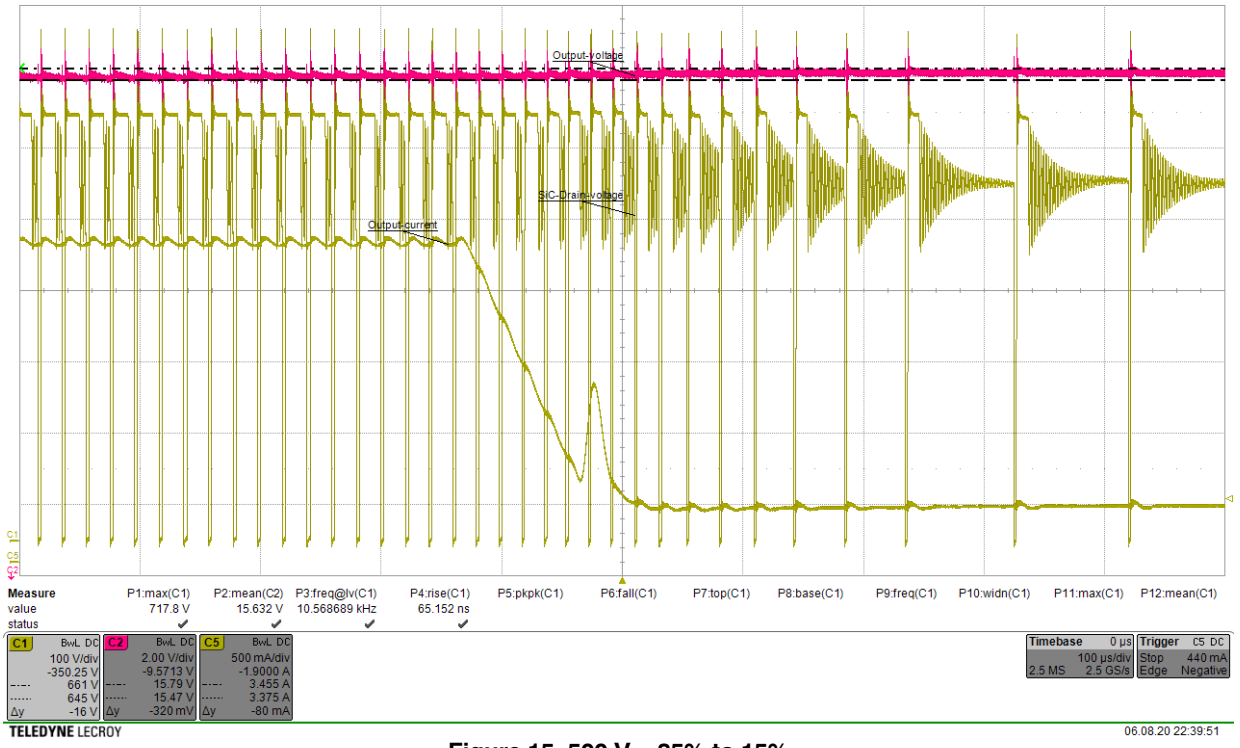



**Figure 15. 500 V – 85% to 15%**

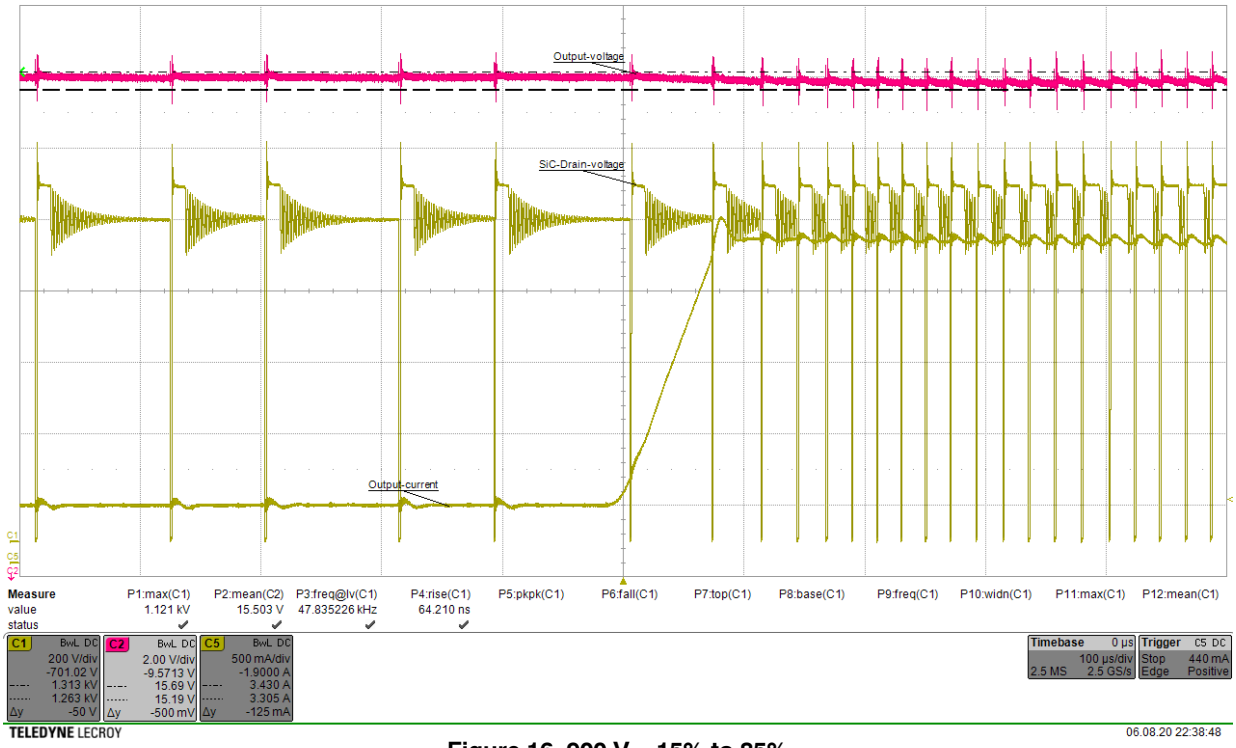



**Figure 16. 900 V – 15% to 85%**

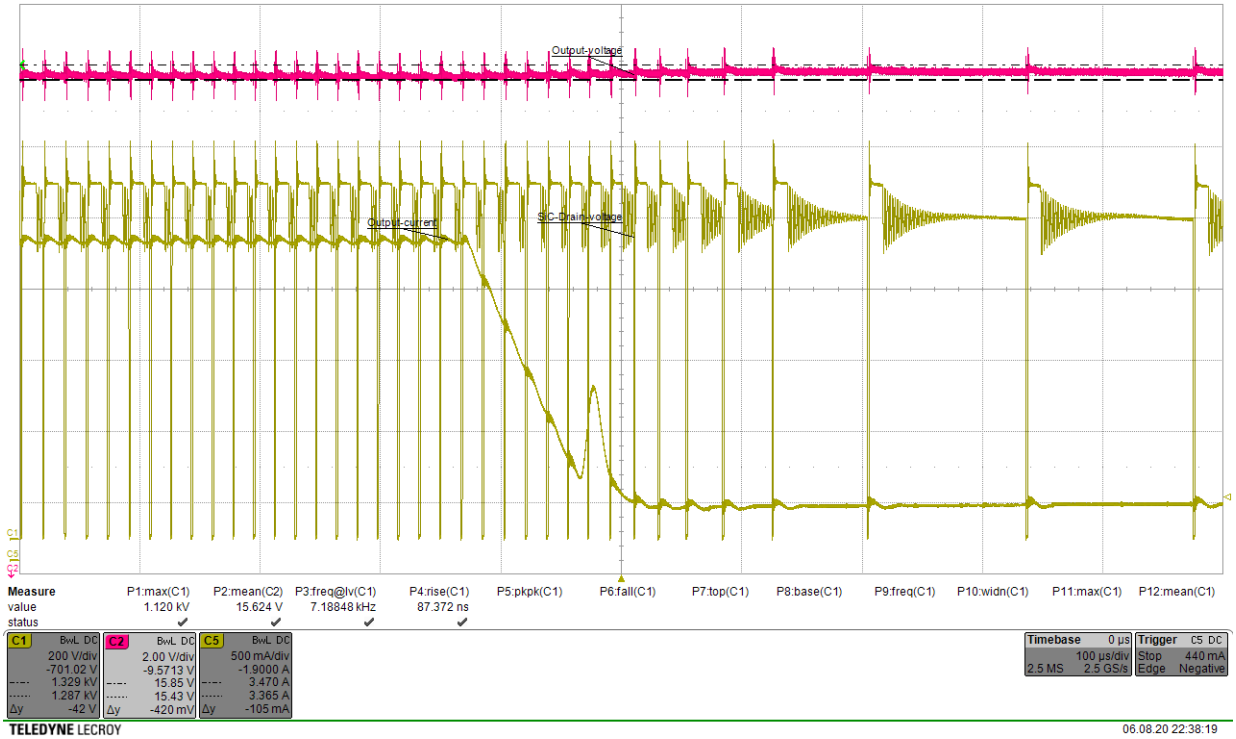
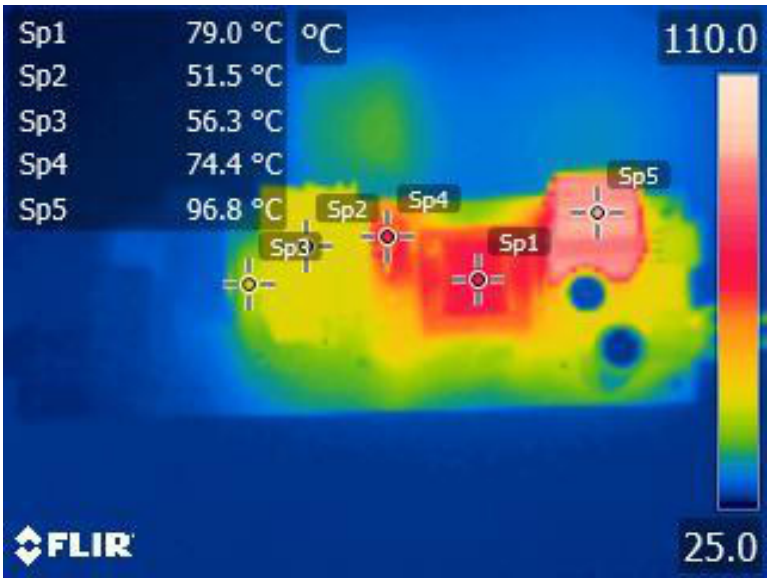



**Figure 17. 900 V – 85% to 15%**

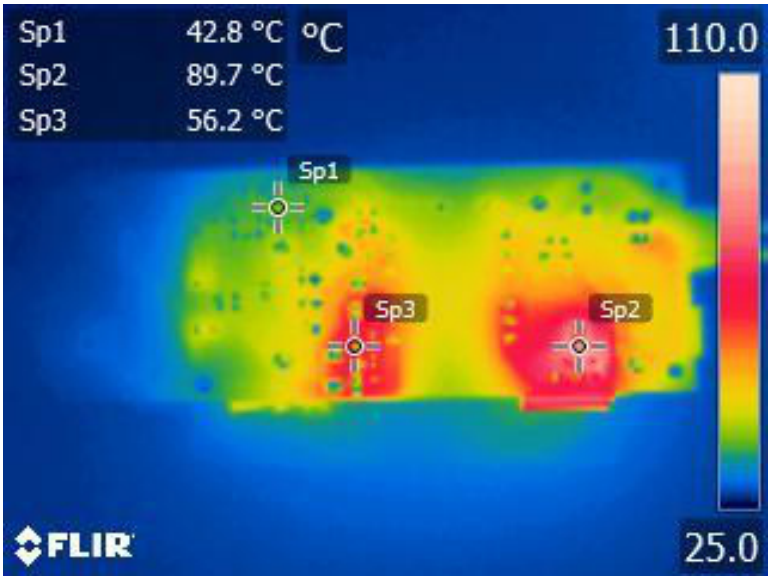
### Thermal Camera View

Measured conditions:

- Output power Pout ~ 40 W
- Electronic load: Chroma 6147A used channel 3 as CRH (constant resistance high mode 5.5 Ω → 2.66 A)
- Input voltage ~ 900 V DC
- After 5 minutes in this conditions




Sp1 – Transformer
Sp2 – SiC switcher heatsink
Sp3 – Startup high voltage resistor
Sp4 – Axial TVS diode
Sp5 – Secondary rectifier heatsink

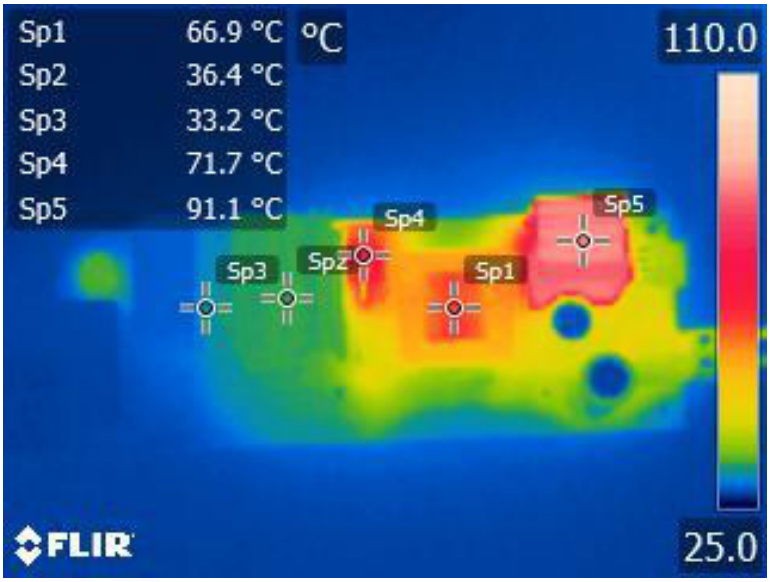



Sp1 – IC NCV 1362
Sp2 – Secondary rectifier heatsink bottom
Sp3 – Axial TVS diode bottom side

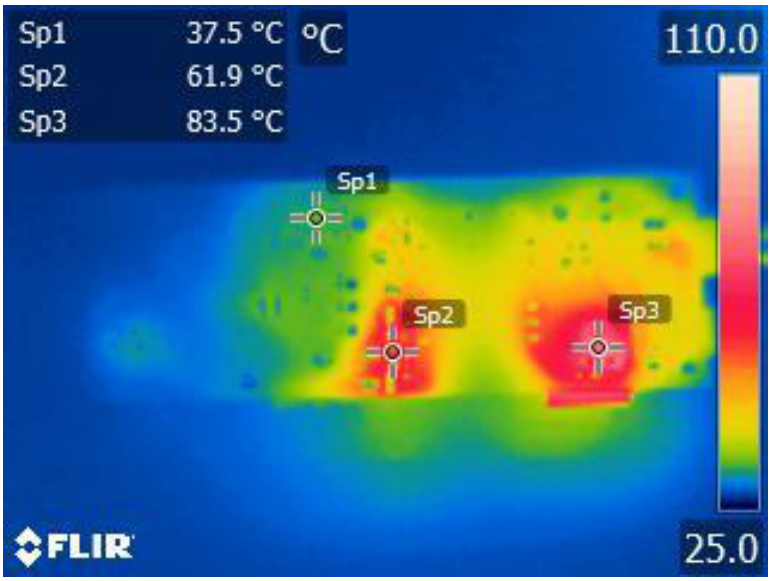
**Figure 18.**

Measured conditions:

- Output power Pout ~ 40 W
- Electronic load: Chroma 6147A used channel 3 as CRH (constant resistance high mode 5.5 Ω → 2.66 A)
- Input voltage ~ 250 V DC
- After 5 minutes in this conditions




Sp1 – Transformer
Sp2 – SiC switcher heatsink
Sp3 – Startup high voltage resistor
Sp4 – Axial TVS diode
Sp5 – Secondary rectifier heatsink




Sp1 – IC NCV 1362
Sp2 – Secondary rectifier heatsink bottom
Sp3 – Axial TVS diode bottom side

**Figure 19.**

**Electromagnetic Compatibility – Conducted Emissions**
**EN55015 Limits**

Measured conditions:

- Output power Pout ~ 18 Ω resistive load
- Input voltage ~ 250 V

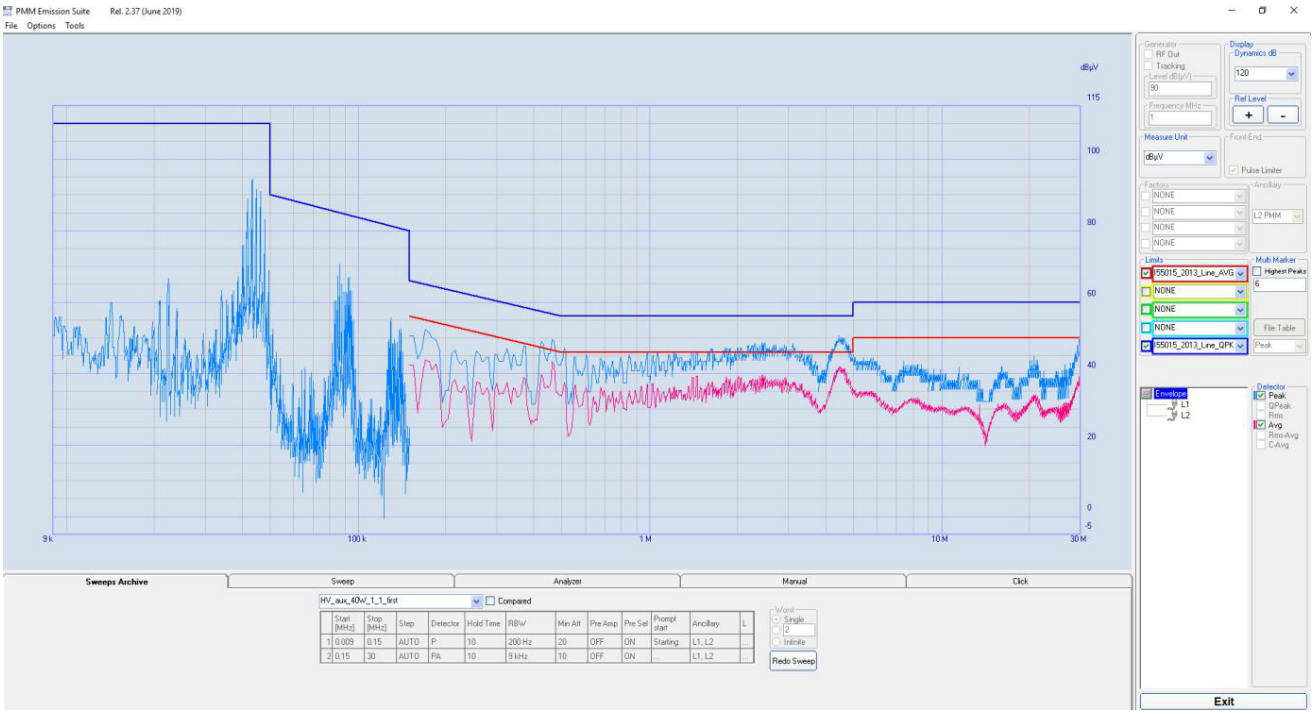



**Figure 20.**

## Transformer Design

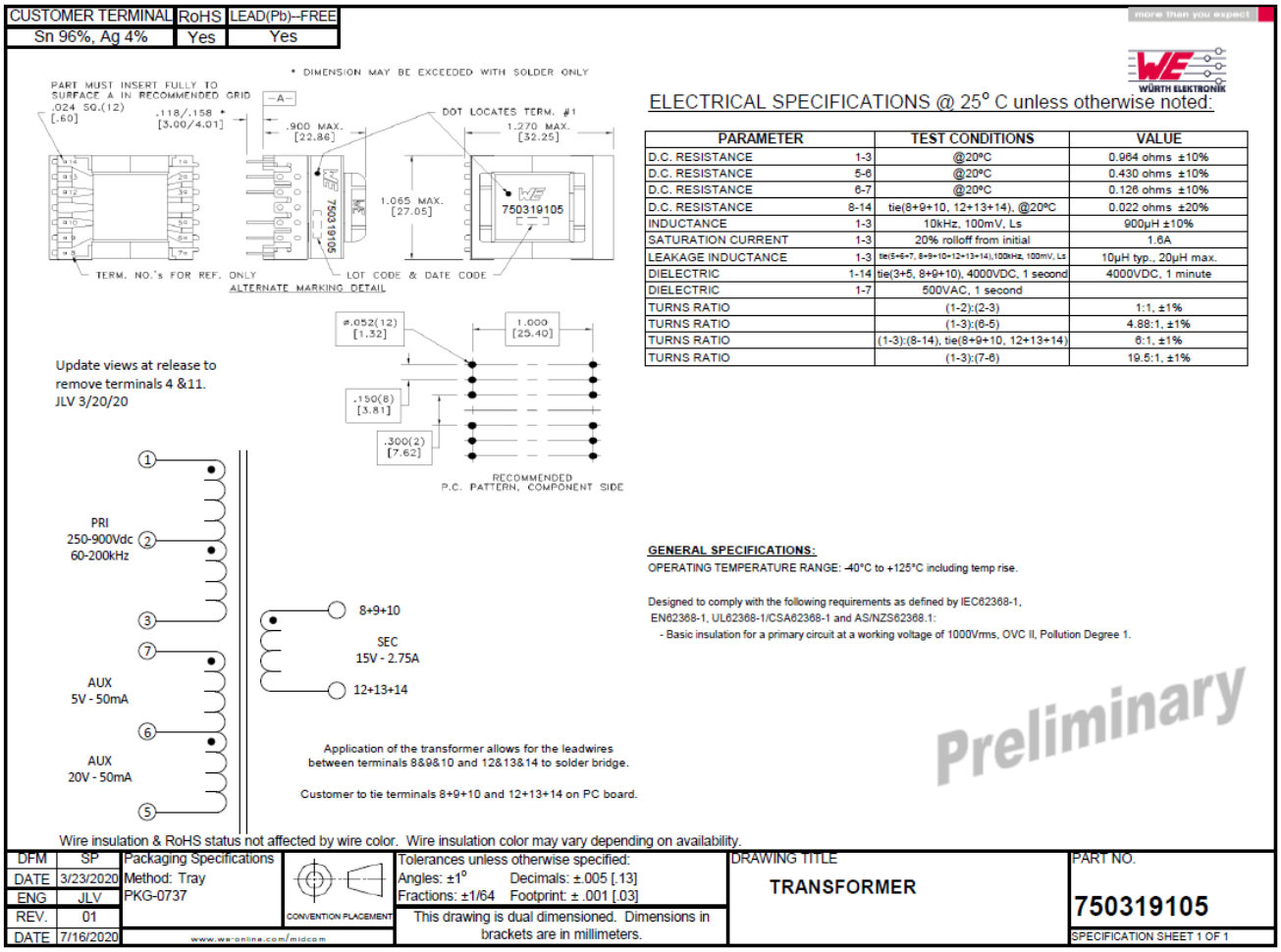



**Figure 21. Drawing and Parameters of Used Transformer**

### Development Resources and Tools

Collateral, development files and other development resources listed below are available at SECO−HVDCDC1362−40W−GEVB

- Schematics
- BOM (below as well)
- Manufacturing files
- PCB layout (below as well)
- Source files
- Simulation model (below as well)

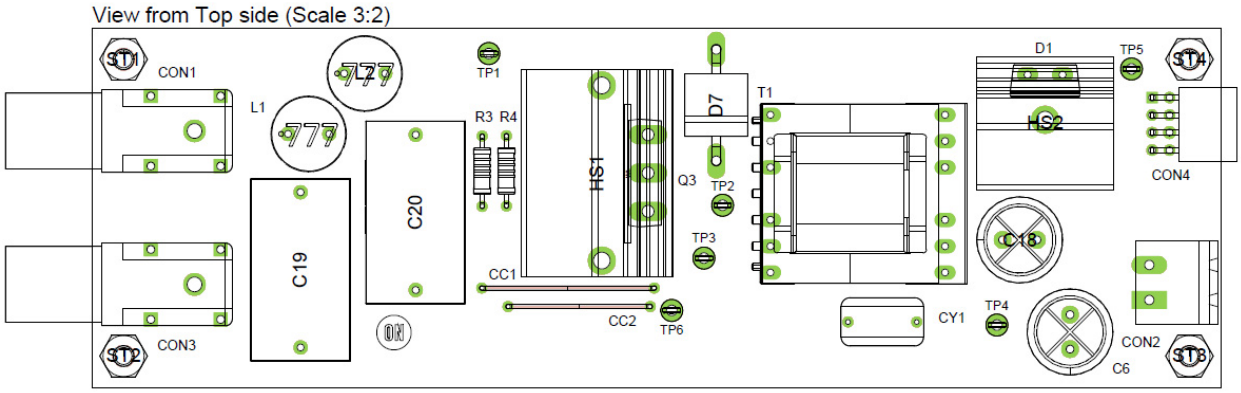
**Table 1. BILL OF MATERIALS**

| # | Designator | Comment | Description |
|---|---|---|---|
| 1. | C2 | 470 pF | MLC capacitor 470pF 1kV ±10% X7R Würth Elektronik |
| 2. | C5 | 100 nF | Multilayer Ceramic Capacitors MLCC − SMD 1206 25 V 100 nF C0G ± 1 % AEC−Q202 −55 − 125 °C |
| 3. | C6, C18 | 1000 μF | ALU electrolyte high current ripple 1000 μF 25V 20% Nichicon |
| 4. | C7 | 470 nF | Multilayer Ceramic Capacitors MLCC − SMD 0805 50 V 470 nF X7R ± 10 % AEC−Q202 −55 − 125 °C |
| 5. | C8 | 4.7 μF | Multilayer Ceramic Capacitors MLCC − SMD 1210 50 V 4.7 μF X7R ± 10 % AEC−Q202 −55 − 125 °C |
| 6. | C9 | 100 nF | Multilayer Ceramic Capacitors MLCC − SMD 1206 50 V 100 nF C0G ± 5 % AEC−Q202 −55 − 125 °C |
| 7. | C10, C15 | 120 pF | Multilayer Ceramic Capacitors MLCC − SMD 0603 100 V 120 pF C0G ± 5 % AEC−Q202 −55 − 125 °C |
| 8. | C12 | 150 nF | Multilayer Ceramic Capacitors MLCC − SMD 0603 25 V 150 nF X7R ± 10 % AEC−Q202 −55 − 125 °C |
| 9. | C13 | 1n8 | Multilayer Ceramic Capacitors MLCC − SMD 0805 100 V 1n8 C0G ± 5 % AEC−Q202 −55 − 125 °C |
| 10. | C14 | 3n3 | Multilayer Ceramic Capacitors MLCC − SMD 0805 100 V 3n3 C0G ± 5 % AEC−Q202 −55 − 125 °C |
| 11. | C17 | 4.7 pF | Multilayer Ceramic Capacitors MLCC − SMD 0603 100 V 4.7 pF C0G ± 5 % AEC−Q200 −55 − 125 °C |
| 12. | C19, C20 | 220 nF | MMKT film capacitor 220n 500Vac/1600Vdc TDK |
| 13. | CON1 | RED | Banana Test Connector, 4mm, Receptacle, PCB Mount, 24 A, 1 kV, Gold Plated Contacts, Red |
| 14. | CON2 | 691 313 510 002 | PCB right angle connector 2 pins 5.08 mm pitch Würth Elektronik |
| 15. | CON3 | BLACK | Banana Test Connector, 4mm, Receptacle, PCB Mount, 24 A, 1 kV, Gold Plated Contacts, Black |
| 16. | CON4 | 613 008 243 121 | WR−PHD 2.54 mm Angled Dual Socket Header 2x4 pins |
| 17. | CON5 | 691 351 500 002 | Cable connector series 351 2pins 5.08 mm Würth Elektronik |
| 18. | CY1 | 2n2 | Disc ceramic capacitor 2n2 1500 VDC Y5U 10 % Vishay AEC−Q200 |
| 19. | D1 | FFSP1065B−F085 | Ultra fast Schottky SiC diode 650V 10A AEC−Q101 ON Semiconductor |
| 20. | D3 | SZ1SMA5931BT3G | TVS zener diode 18 V 83 mA SMA AEC−Q101 ON Semiconductor |
| 21. | D4 | NRVUS1MFA | Super Fast diode 1000 V 1 A 75 ns SOD123FA AEC−Q101, ON Semiconductor |
| 22. | D5 | NSVBAS21AHT1G | Switching diode 250V 200mA SOD323 AEC−Q101 ON Semiconductor |
| 23. | D6 | SZMMSZ18T1G | Zener Single Diode, 18 V, 500 mW, SOD−123, 5 %, 2 Pins, 150 °C, AEC−Q101 |
| 24. | D7 | 5KP160A | TVS 160V 5000W True hole unidirectional VISHAY AEC−Q101 |
| 25. | D8 | SZMMSZ20T1G | Zener Diodes 20V 500mW SOD123 AEC−Q101 ON Semiconductor |
| 26. | D9 | NRVBA130LT3G | Schottky diode 30 V 1 A SMA ON Semiconductor |
| 27. | HS1 | SK 526 30 mm black anodized | Heatsink Fischer Elektronik SK 526 30 mm black anodized |
| 28. | HS2 | SK 525 20 mm black anodized | Heatsink Fischer Elektronik SK 525 20 mm black anodized |
| 29. | IC1 | NCV1362BA | Automotive Primary Side Flyback Controller |
| 30. | L1 | 2.2 mH | Fixed Inductors RFB 1010 Lead Rad 2.2 mH 0.41A 4.1 Ω |

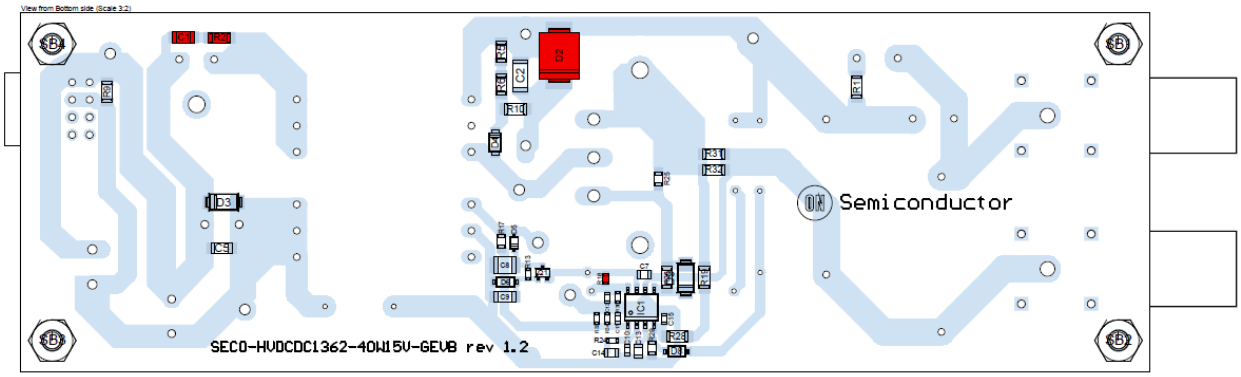
**Table 1. BILL OF MATERIALS** (continued)

| # | Designator | Comment | Description |
|---|---|---|---|
| 31. | L2 | 470 μH | Fixed Inductors RFB 1010 Lead Rad 470 μH 0.9A 0.81 Ω |
| 32. | Q1 | NSVBC817−40W | General purpose NPN transistor 45V 500mA ON Semiconductor |
| 33. | Q3 | NVHL160N120SC1 | SiC NMOS 1200V 17A 160 mΩ ON Semiconductor |
| 34. | R1 | 68R | SMD thick film resistor 68R 1206 1% 660 mW Panasonic |
| 35. | R3 | 6M8 | High Ohmic / High Voltage Metal Glaze Leaded Resistors 0207 6M8 5% 250 mW Vishay |
| 36. | R4 | 10M | High Ohmic / High Voltage Metal Glaze Leaded Resistors 0207 10M 5% 250 mW Vishay |
| 37. | R5, R6, R9 | 100k | SMD Chip Resistor, 100 kΩ, MCWR Series, 200 V, Thick Film, 1206 [3216 Metric], 250 mW Multicomp |
| 38. | R10, R19 | 0R | SMD Chip Resistor, 0 Ω, ERJ8G Series, 200 V, Thick Film, 1206 [3216 Metric], 250 mW Panasonic |
| 39. | R13 | 4k7 | SMD thick film resistor 4k7 0603 1% 100 mW Panasonic |
| 40. | R17 | 154k | SMD thick film resistor 154k 0805 1% 125 mW Panasonic |
| 41. | R24 | 270k | SMD thick film resistor 270k 0603 1% 100 mW Panasonic |
| 42. | R25 | 10k | SMD thick film resistor 10k 0805 1% 125 mW Panasonic |
| 43. | R26 | 8R2 | SMD thick film resistor 8 Ω 1206 1% 500 mW Panasonic |
| 44. | R28 | 1k | SMD thick film resistor 1k 1206 1% 250 mW Panasonic |
| 45. | R29 | 100k | SMD Thermistor, 100 kΩ, NTCG−S Series,0805 [2012 Metric], 200 mW TDK |
| 46. | R30 | 34k8 | SMD thick film resistor 34k8 0603 1% 100 mW Panasonic |
| 47. | R31, R32 | 0R56 | SMD thick film resistor 0.56 Ω 1206 1% 500 mW Panasonic |
| 48. | R33 | 51k1 | SMD thick film resistor 51k1 0603 1% 100 mW Panasonic |
| 49. | R34 | 44k2 | SMD thick film resistor 44k2 0603 1% 100 mW Panasonic |
| 50. | SB1, SB2, SB3, SB4 | Plastic spacer M3 M/F 8/5 HEX6 | Plastic spacer internal/external M3x8 thread, 5 mm Würth Elektronik |
| 51. | ST1, ST2, ST3, ST4 | Plastic spacer M3 F/F 10/40 HEX6 | Plastic spacer internal/internal M3x6 thread, 40 mm Würth Elektronik |
| 52. | T1 | 750319105 | Transformer for DC−DC (NCV1362 flyback 250V−900VDC@40W) converter from Würth Elektronik |
| 53. | TP1 | ORANGE | PTH testpoint eyelet 3.2mm orange Keystone Electronics |
| 54. | TP2, TP5 | RED | PTH testpoint eyelet 3.2mm red Keystone Electronics |
| 55. | TP3 | BROWN | PTH testpoint eyelet 3.2mm brown Keystone Electronics |
| 56. | TP4 | BLUE | PTH testpoint eyelet 3.2mm blue Keystone Electronics |
| 57. | TP6 | BLACK | PTH testpoint eyelet 3.2mm black Keystone Electronics |
| 58. | W1 | AOS247 23x20x1 | Ceramic insulation washer without hole for TO247 1mm Fischer Elektronik |

## Layout




Top Assembly




Bottom Assembly

**Figure 22. Layout**

## References

NCV1362 Data sheet
NCV1362 Application notes
NCV1362 Evaluation boards
NCV1362 Design worksheet MathCad

## ADDITIONAL INFORMATION

**TECHNICAL PUBLICATIONS**:
**Technical Library:** www.onsemi.com/design/resources/technical−documentation
**onsemi Website:** www.onsemi.com

**ONLINE SUPPORT**: www.onsemi.com/support
**For additional information, please contact your local Sales Representative at** www.onsemi.com/support/sales