

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



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## SECO-HVDCDC1362-15W-GEVB

## EVAL BOARD USER'S MANUAL

### Introduction

SECO-HVDCDC1362-15W-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 15 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 FFSD0665B-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 12V 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.

### Features

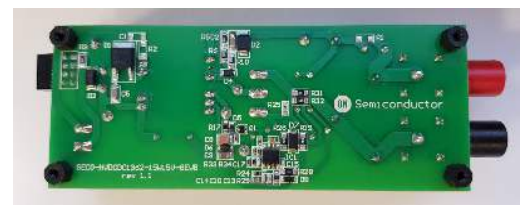
- NCV1362 (Automotive) / NCP1362 (Industrial) Quasi-resonant Peak Current PSR Flyback Controller
- Fully Automotive Qualified Devices
- $V_{in} = 240\text{ V} - 900\text{ V DC}$  Only
- $V_{out} = 15\text{ V} / 15\text{ W}$  Continuous
- Electromagnetic Compatibility (EN 55015 Limits)
- High Efficiency up to 86%
- 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)



(Top View)



(Bottom View)

Figure 1. Board Layout

### 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-HVDCDC1362-15W-GEVB](#)
- [References](#)

# SECO-HVDCDC1362-15W-GEVB

## 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

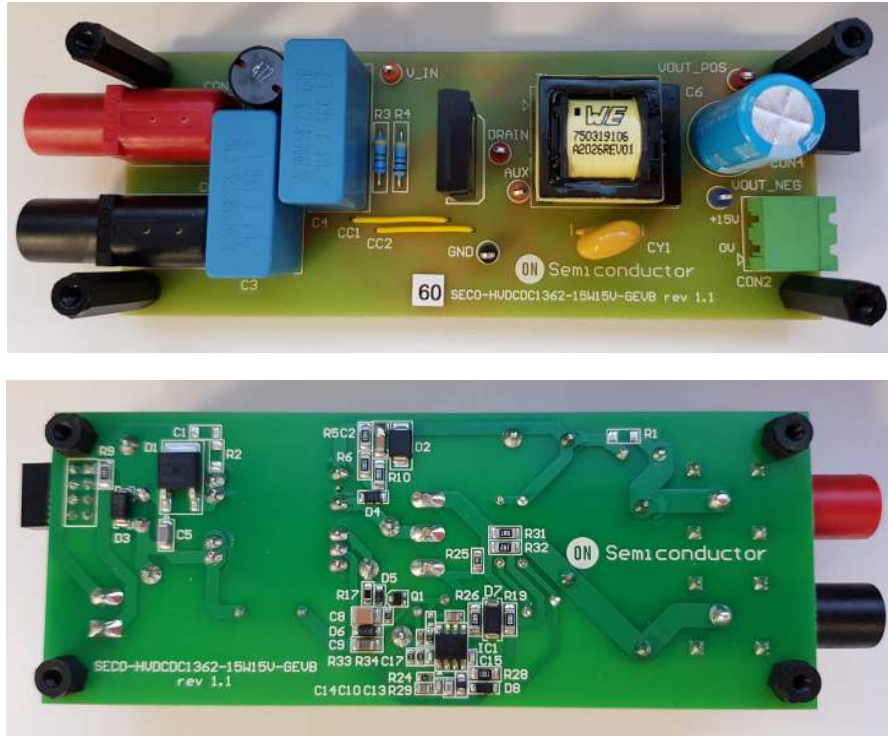


Figure 2. Evaluation Board Photo

## Block Diagram

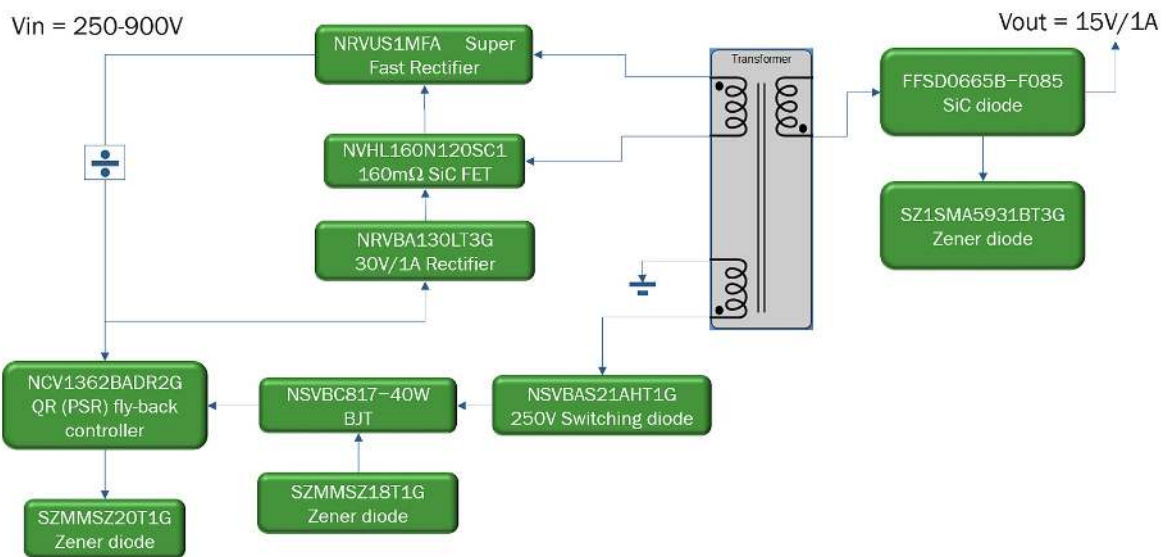


Figure 3. Block Diagram

# SECO-HVDCDC1362-15W-GEVB

## SPECIFICATION

| Parameters   | Values   |
|--|--|
| <b>Input</b>   |  |
| Voltage  | 250-900 VDC  |
| Current  | 71 mA ( $V_{in} = 250$ V), 22 mA ( $V_{in} = 900$ V)                       |
| <b>Output</b>  |  |
| Power  | 15 W   |
| Voltage  | 15 VDC   |
| Current per branch   | 1 A  |
| Total current  | 1 A  |
| Efficiency at full load  | 86% ( $V_{in} = 250$ V)  |
| Temperature at full load   | 98°C ( $V_{in} = 6$ V), 74.5°C ( $V_{in} = 15$ V), 76°C ( $V_{in} = 18$ V) |
| <b>Control</b>   |  |
| Core part  | NCV1362  |
| Topology   | Flyback  |
| Switching frequency  | 50 kHz   |
| Operation mode   | DCM  |
| Primary side peak current  | 0.65 A   |
| <b>Construction</b>  |  |
| Board size   | 26.24 x 16.38 x 16.06 mm   |
| <b>Transformer</b>   |  |
| Dielectric insulation  | 4000 VAC, 1 min.   |
| Inductance   | 1.70 mH $\pm$ 10%  |
| Leakage inductance   | 20 $\mu$ H typ. / 40 $\mu$ H max.  |
| Safety standard  | IEC62368-1   |
| Pollution degree   | 1  |
| <b>Application</b>   |  |
| HEV & EV vehicles, automotive powertrain systems, EV charging and DC-DC conversion |  |

# SECO-HVDCDC1362-15W-GEVB

## Schematic

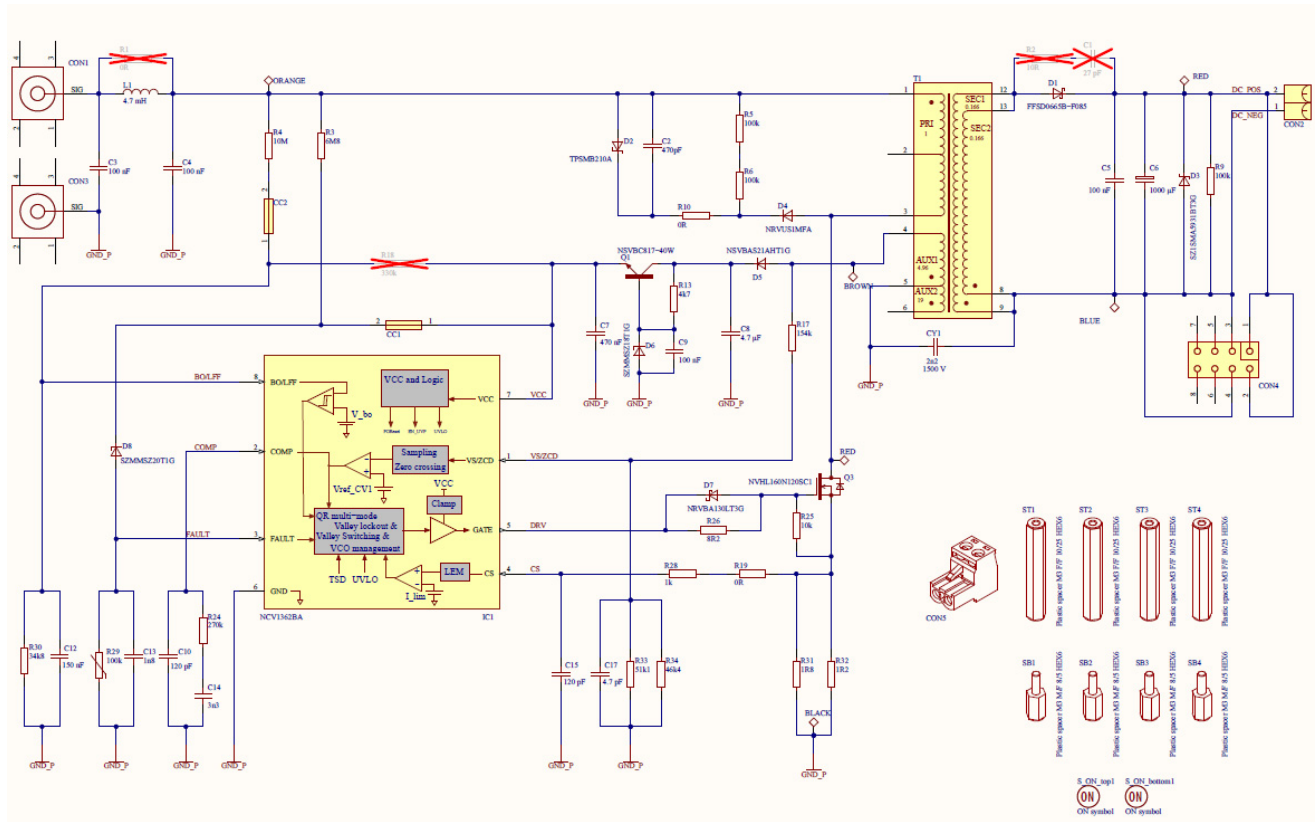


Figure 4. Evaluation Board Schematic

## 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 240V, 500V, 900V 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  $P_{out} \sim 15$  W
- Electronic load: Chroma 6147A used channel 3 as CRH (constant resistance high mode  $15 \Omega \rightarrow 1.0$  A)

List of equipment:

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

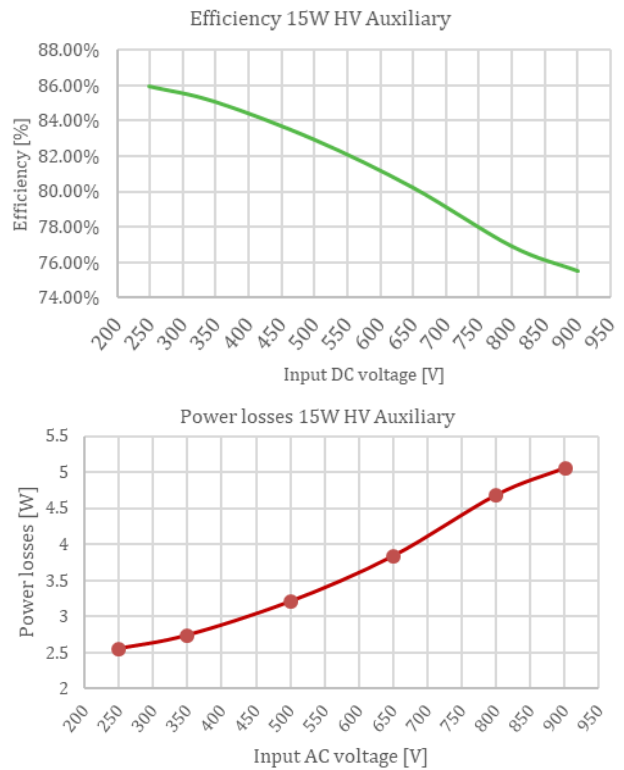


Figure 5.

# SECO-HVDCDC1362-15W-GEVB

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

Measured conditions:

- Output power  $P_{out} \sim 15\text{ W}$
- Electronic load: Chroma 6147A used channel 3 as CRH (constant resistance high mode 15 Ohm  $\rightarrow$  1.0A)

List of equipment:

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

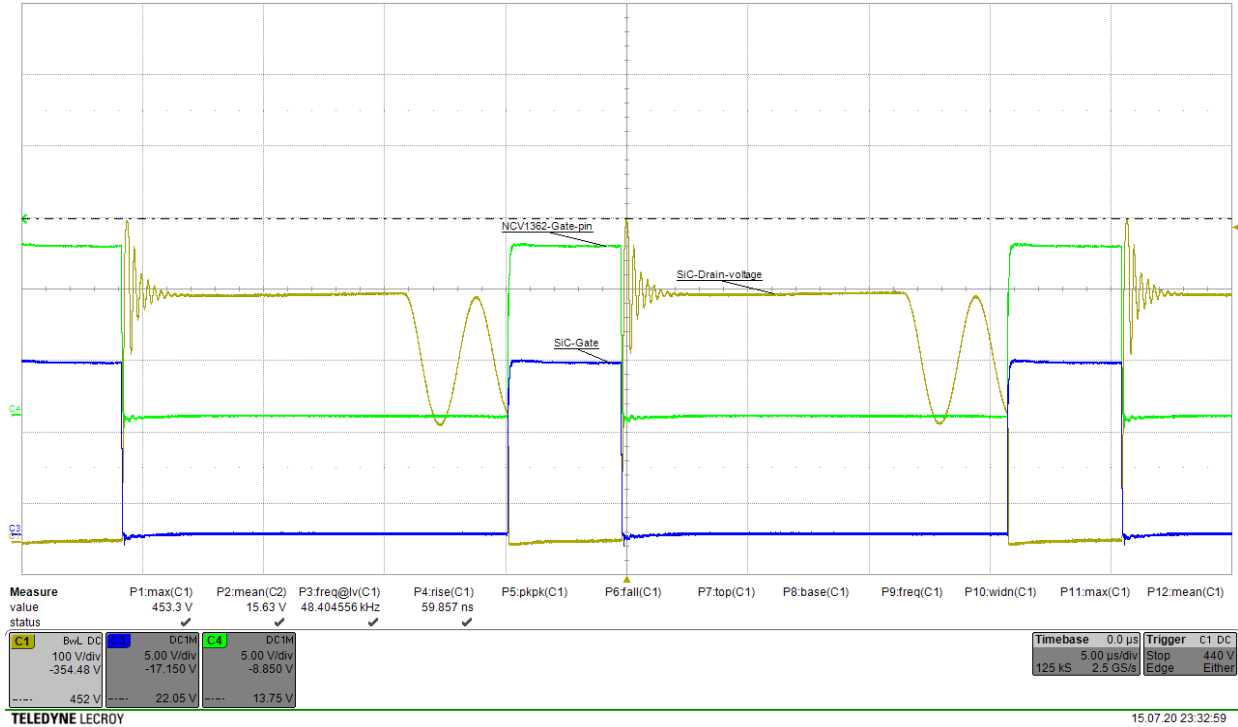


Figure 6. 250 V DC Full Load

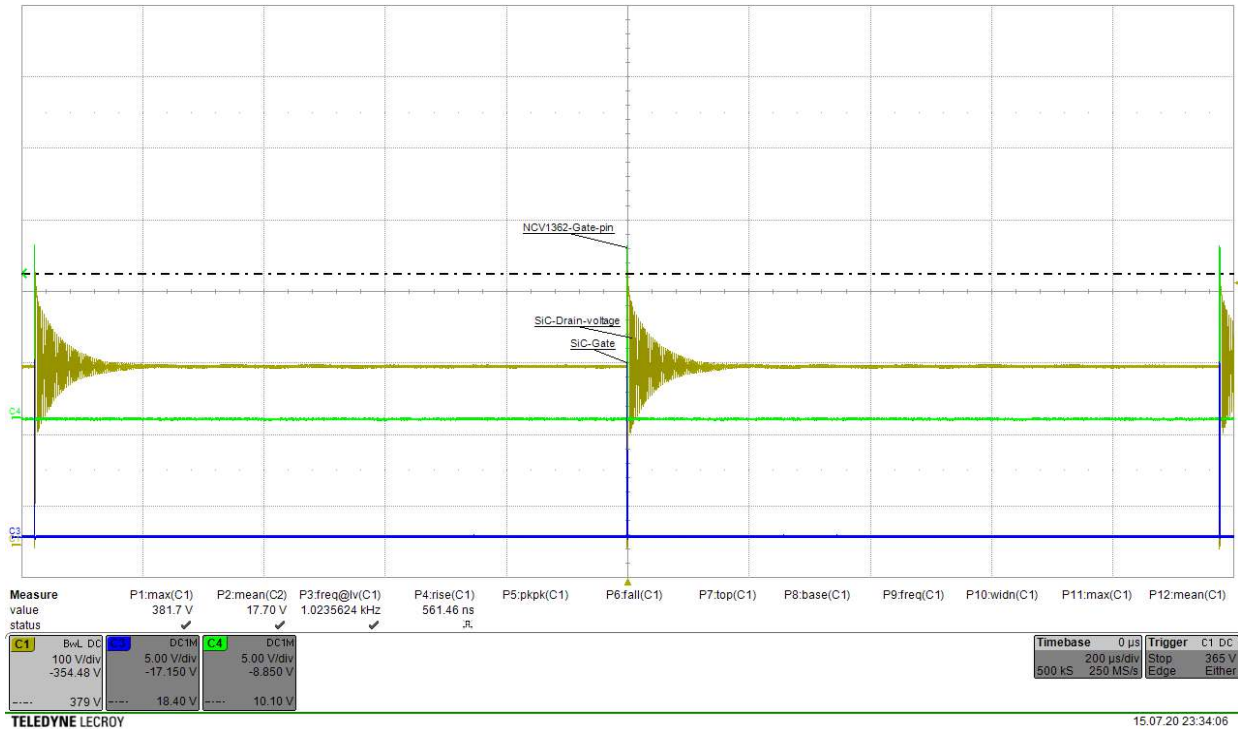


Figure 7. 250 V DC Open Circuit

# SECO-HVDCDC1362-15W-GEVB

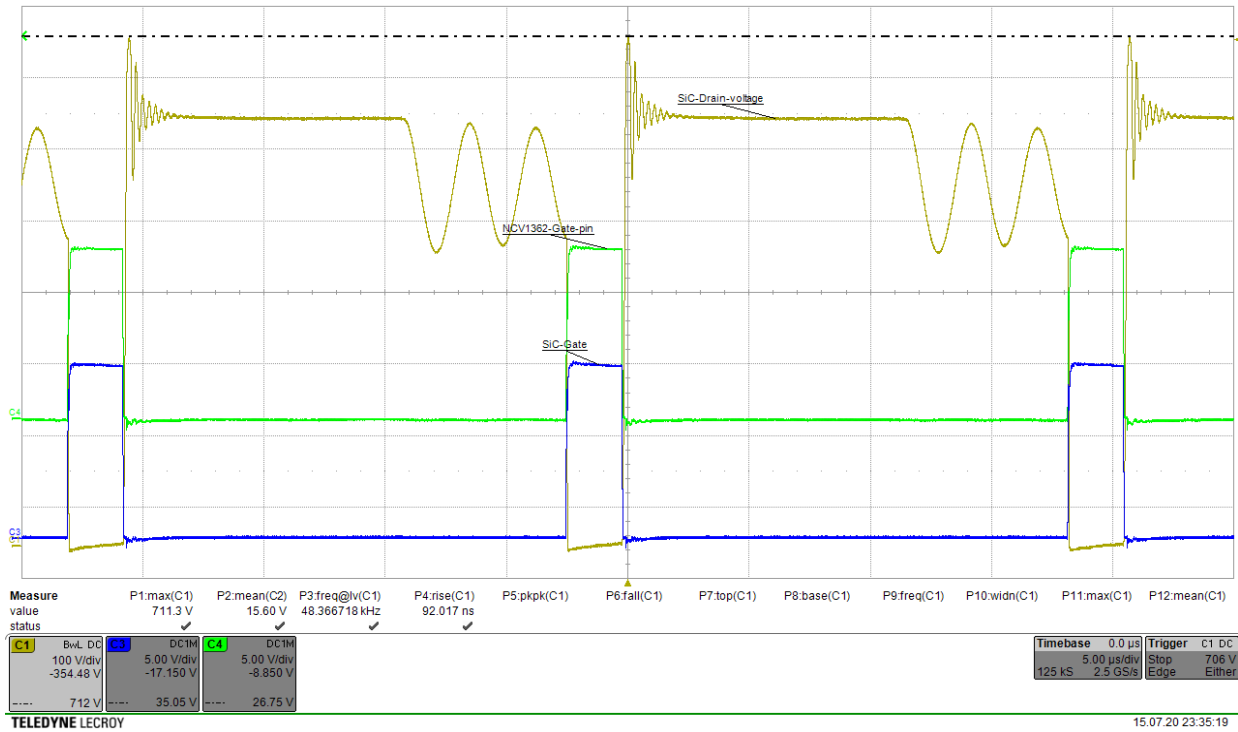


Figure 8. 500 V DC Full Load

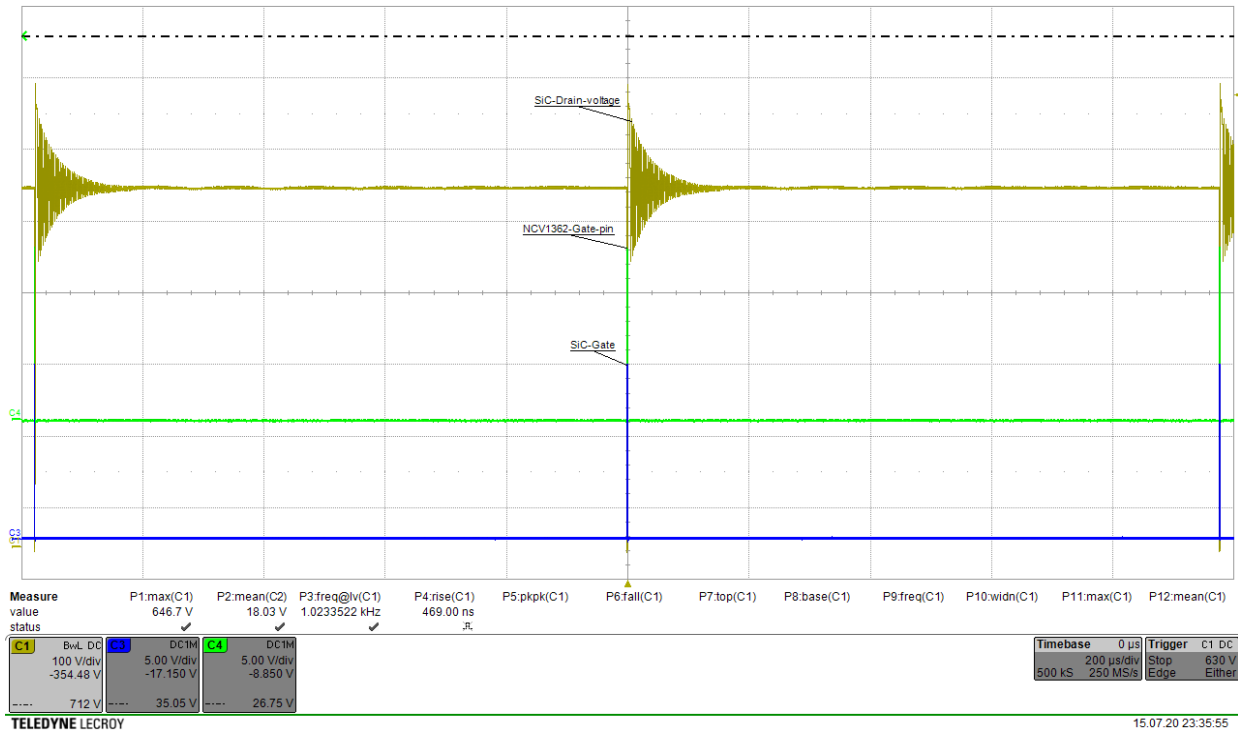


Figure 9. 500 V DC Open Circuit



# SECO-HVDCDC1362-15W-GEVB

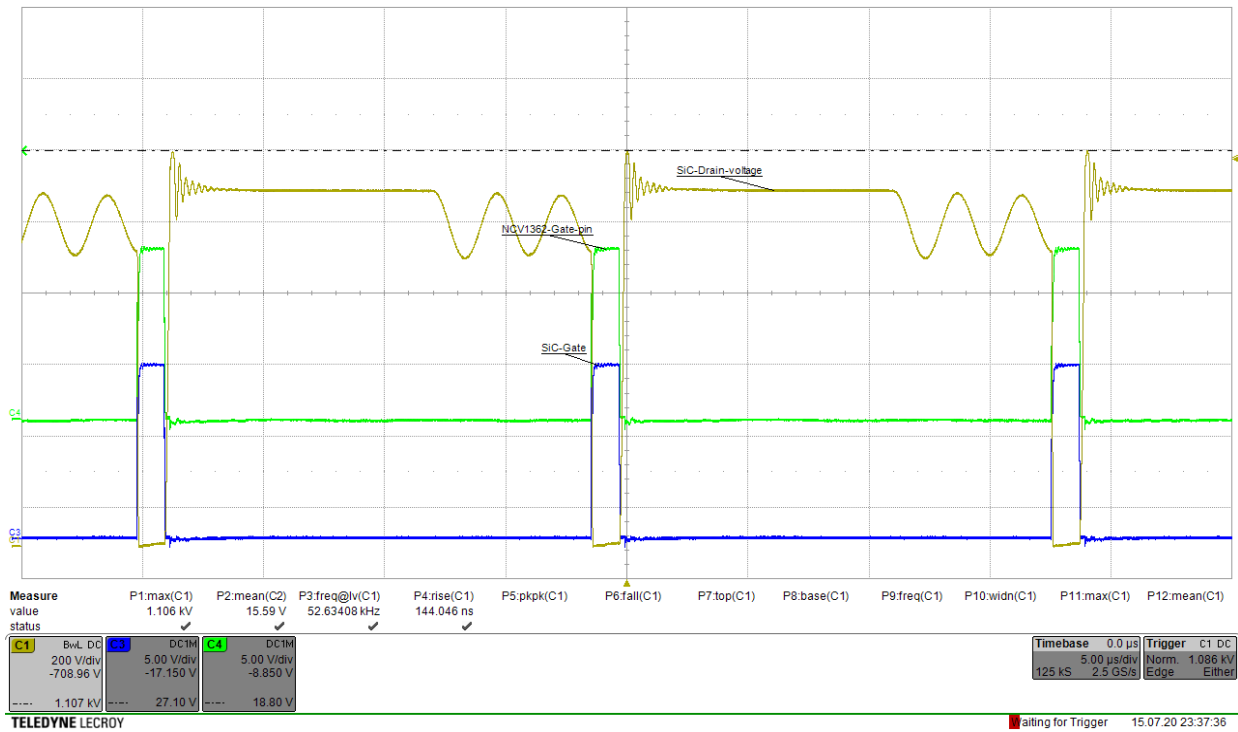


Figure 10. 900 V DC Full Load

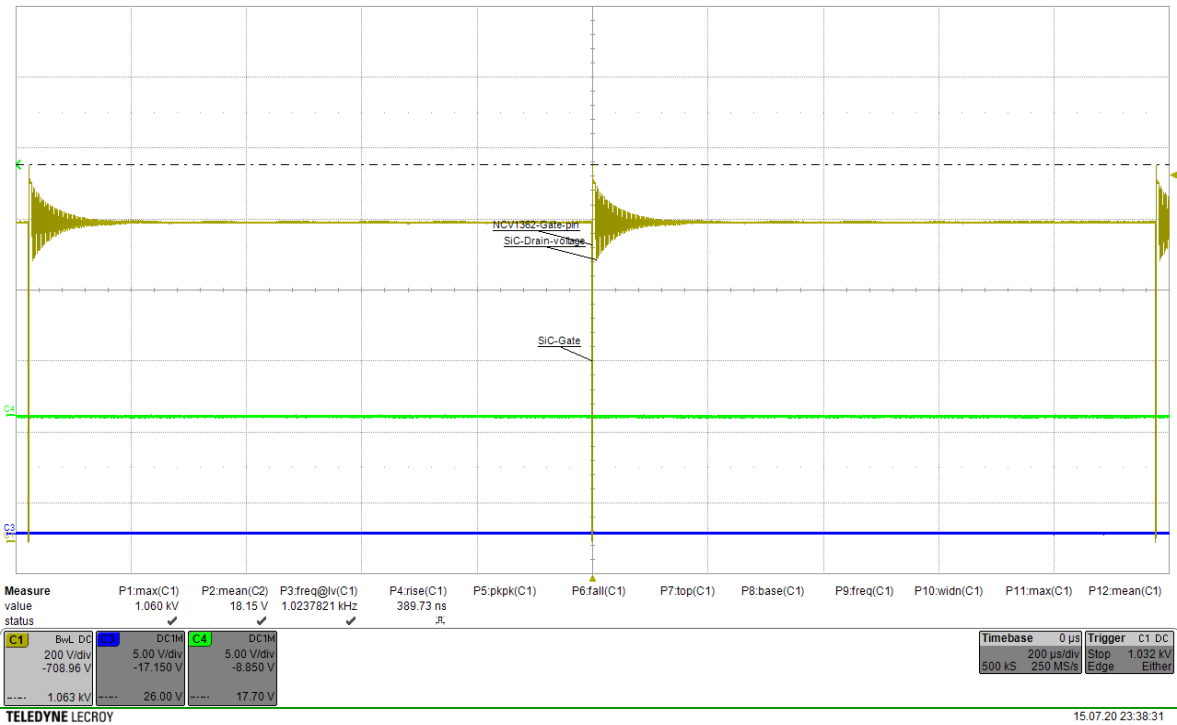


Figure 11. 900 V DC Open Circuit

# SECO-HVDCDC1362-15W-GEVB

## Load Transients 15%–85% and 15%–85% Load

Measured conditions:

- Output power  $P_{out} \sim 15\text{ W}$
- Electronic load: Chroma 6147A used channel 3 as CCDL (constant current dynamic mode 0.15 A  $\rightarrow$  0.85 A)

List of equipment:

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

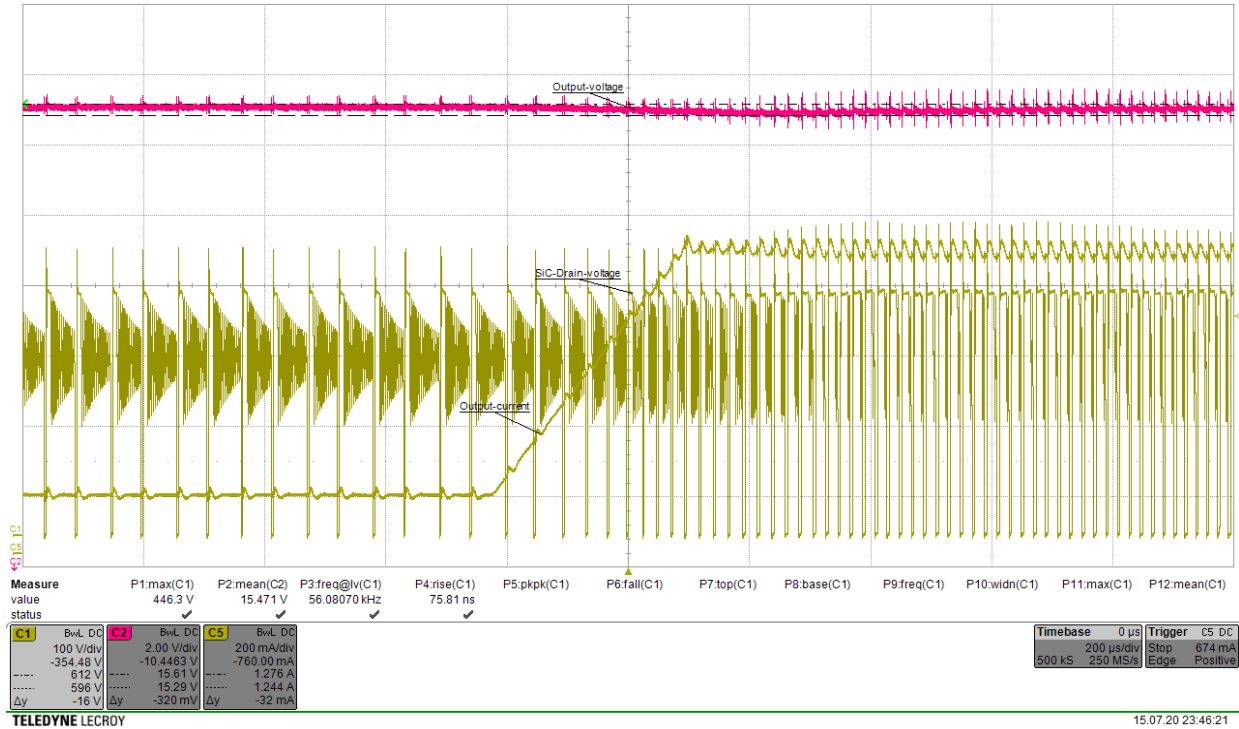


Figure 12. 250 V – 15% to 85%

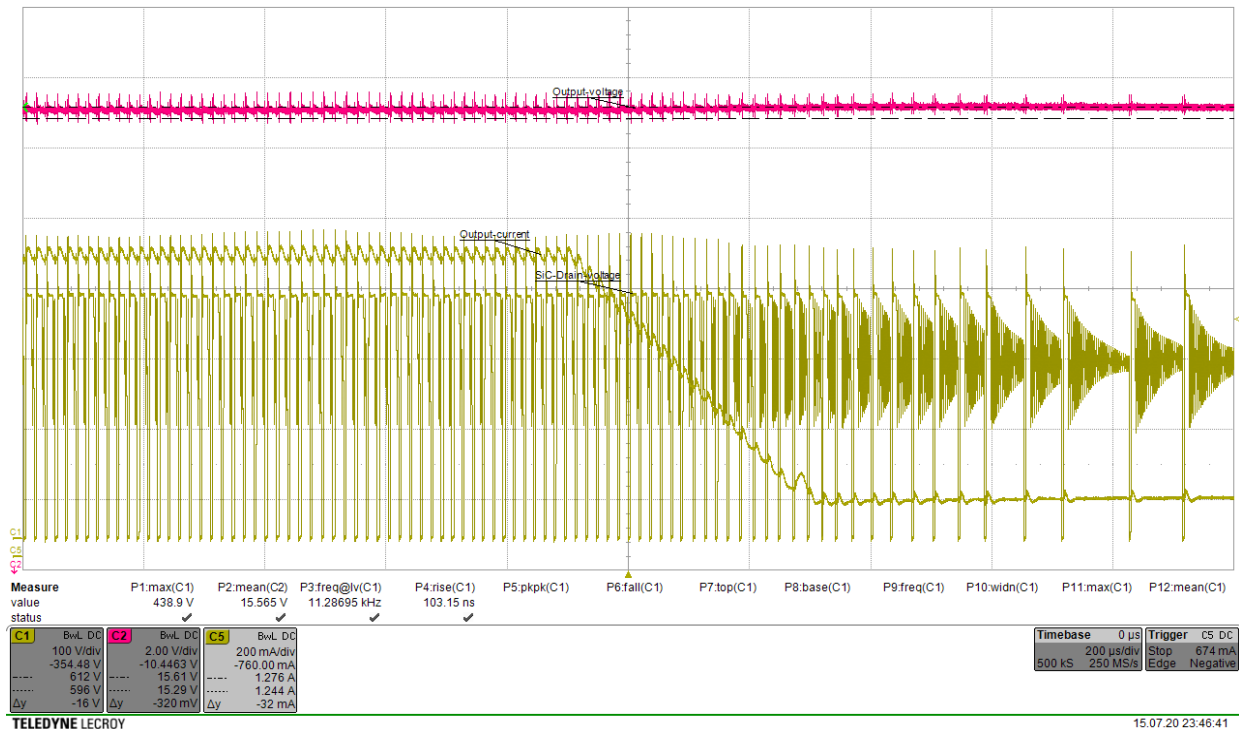


Figure 13. 250 V – 85% to 15%



# SECO-HVDCDC1362-15W-GEVB

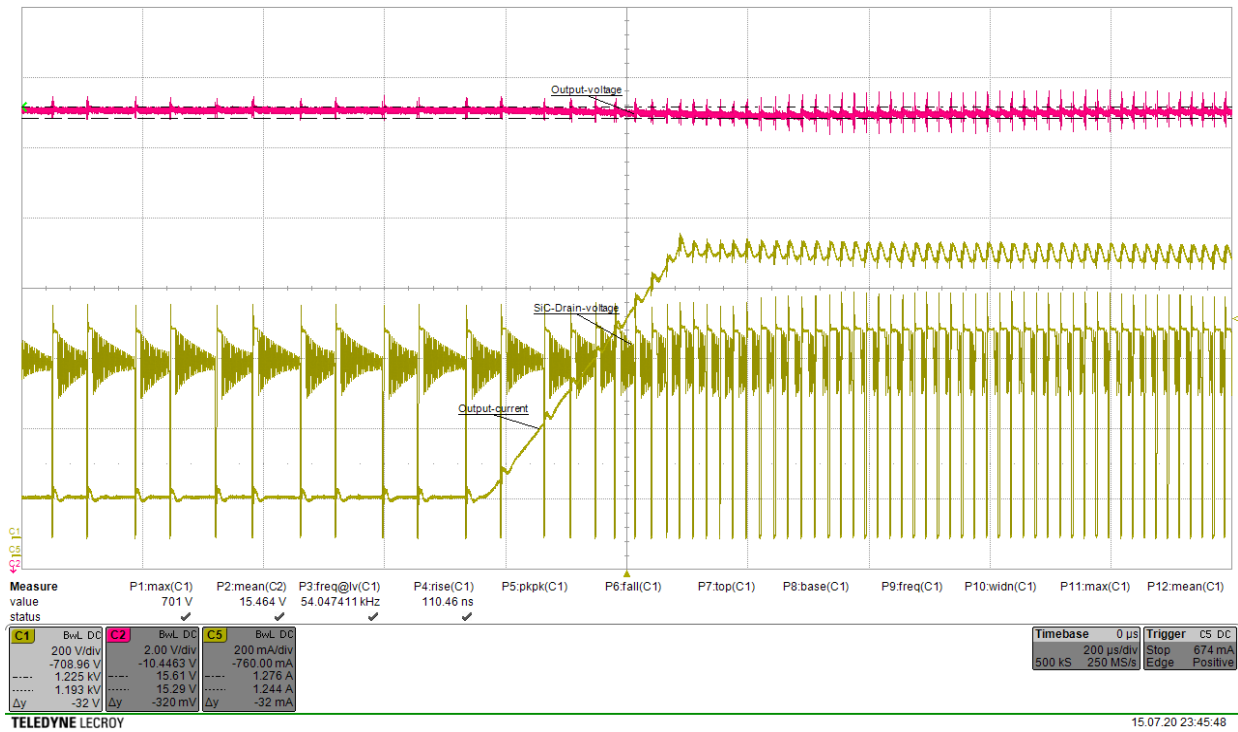


Figure 14. 500 V – 15% to 85%

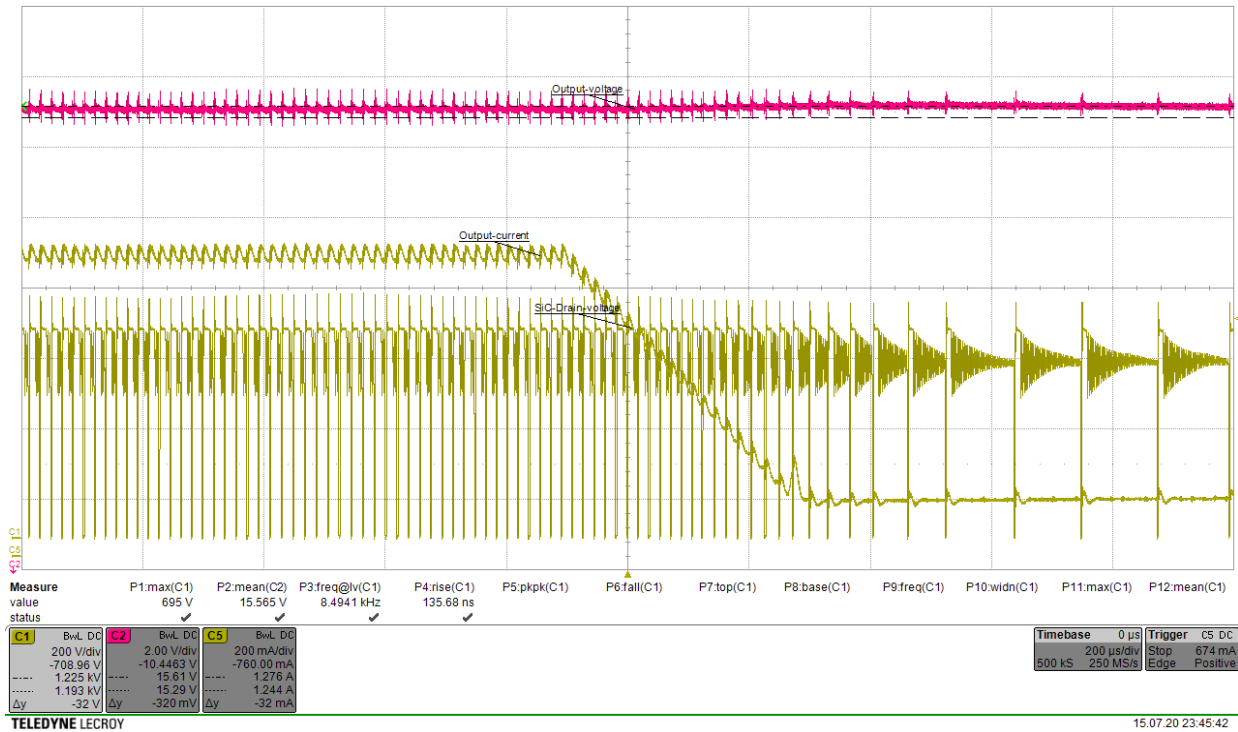


Figure 15. 500 V – 85% to 15%

# SECO-HVDCDC1362-15W-GEVB

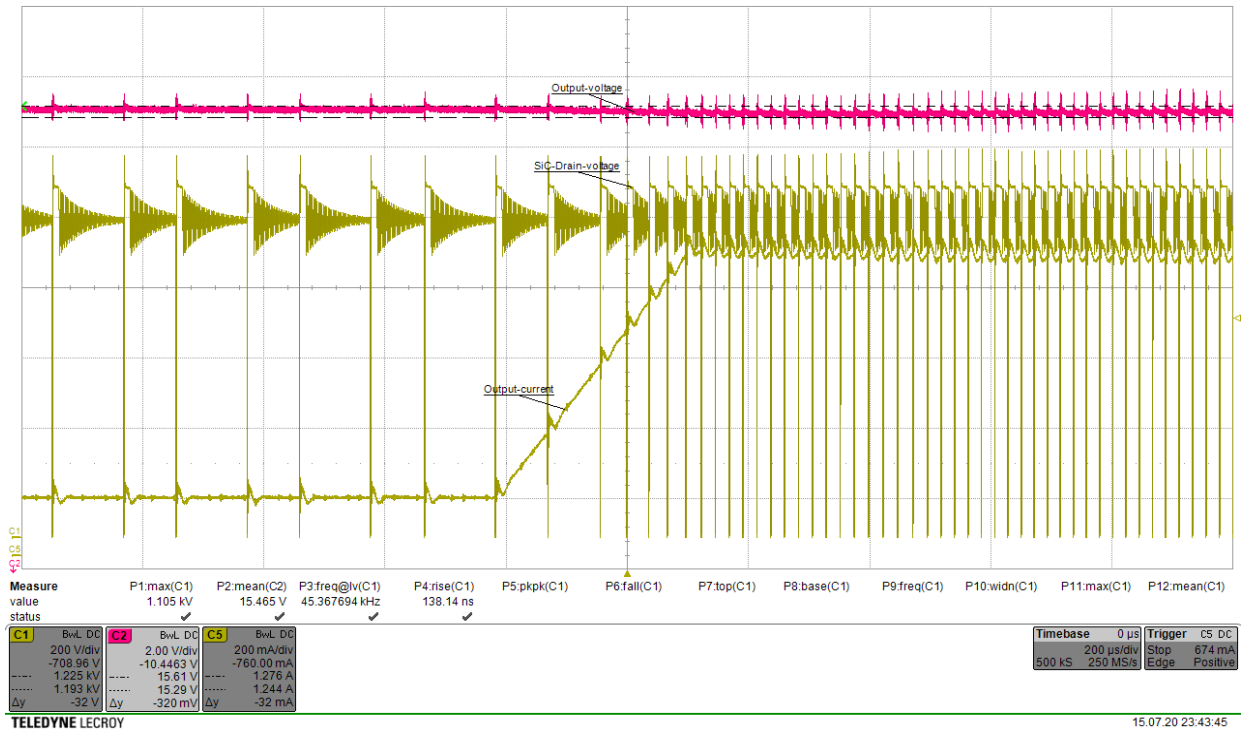


Figure 16. 900 V – 15% to 85%

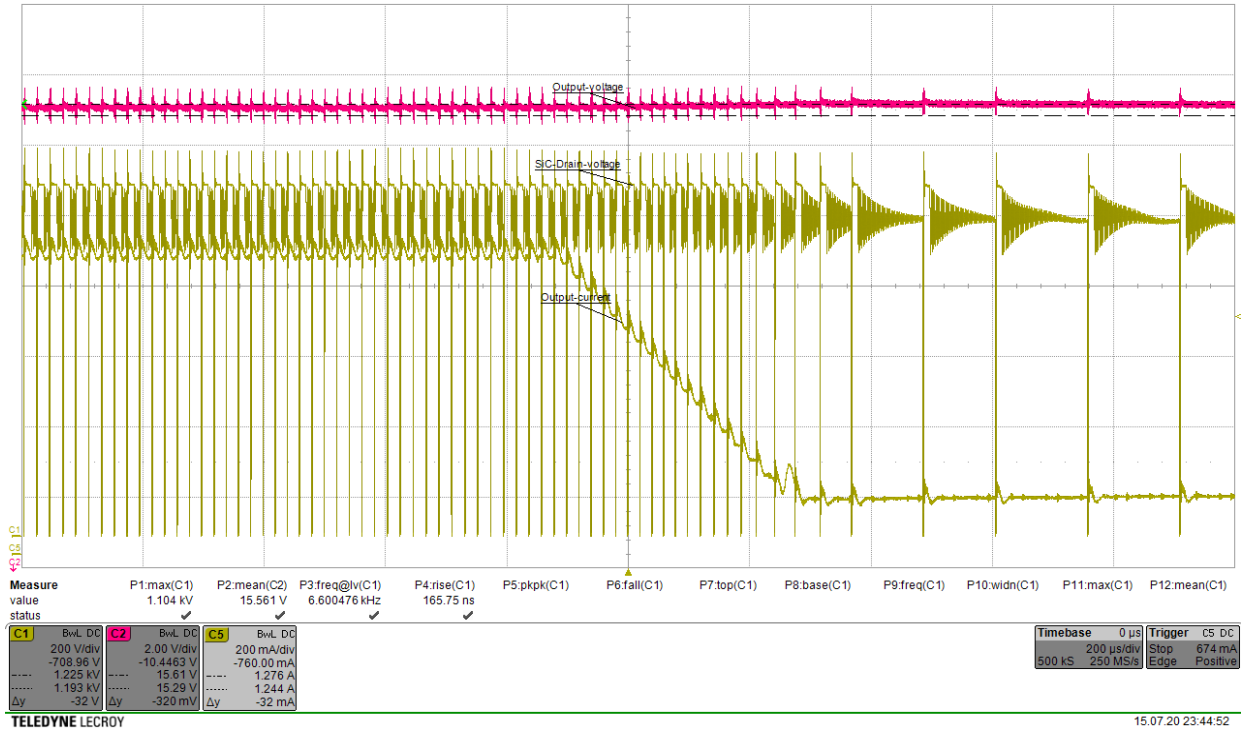


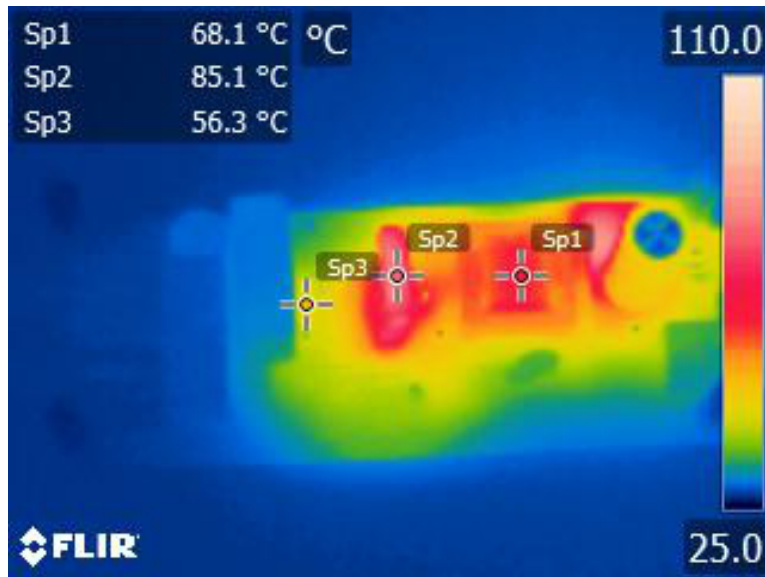
Figure 17. 900 V – 85% to 15%

## SECO-HVDCDC1362-15W-GEVB

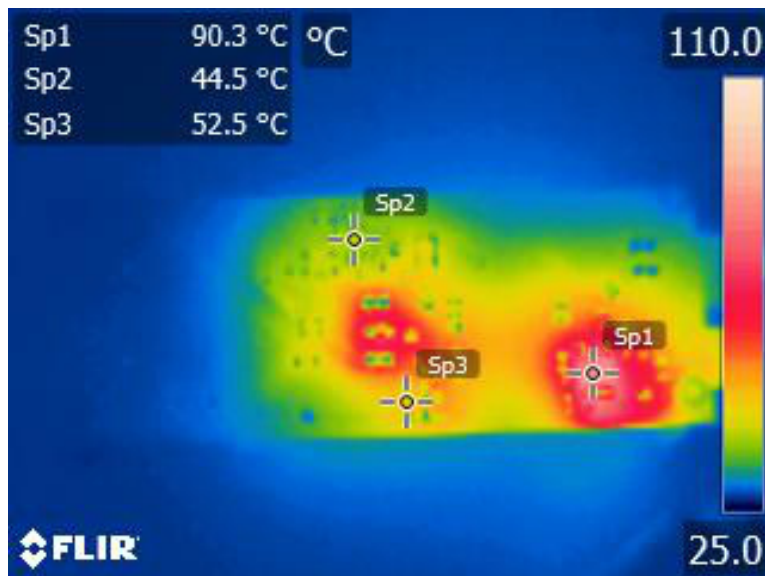
### Thermal Camera View

Measured conditions:

- Output power  $P_{out} \sim 15\text{ W}$
  - Electronic load: Chroma 6147A used channel 3 as CRH (constant resistance high mode  $15\ \Omega \rightarrow 1.0\text{ A}$ )
- Input voltage  $\sim 900\text{ V DC}$
  - After 5 minutes in this conditions



Sp1 – Transformer  
Sp2 – SiC switcher  
Sp3 – Startup high voltage resistor



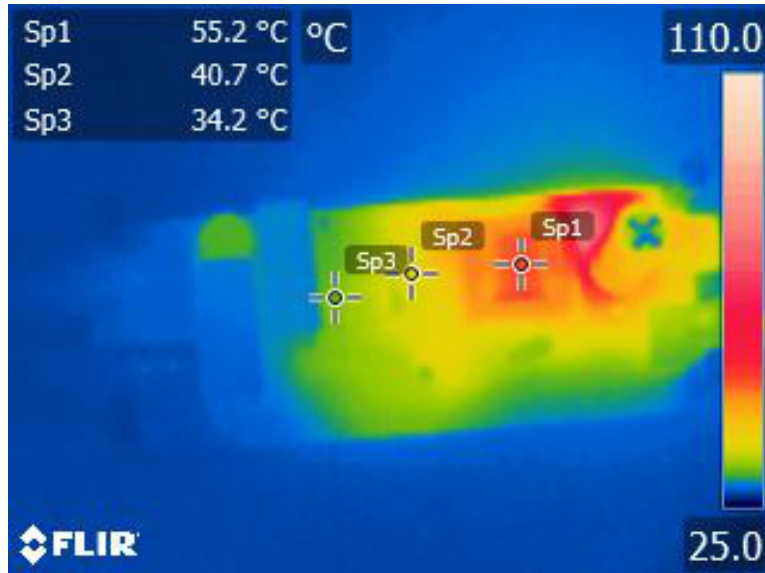
Sp1 – Secondary rectifier  
Sp2 – IC NCV 1362  
Sp3 – Snubber TVS diode

Figure 18.

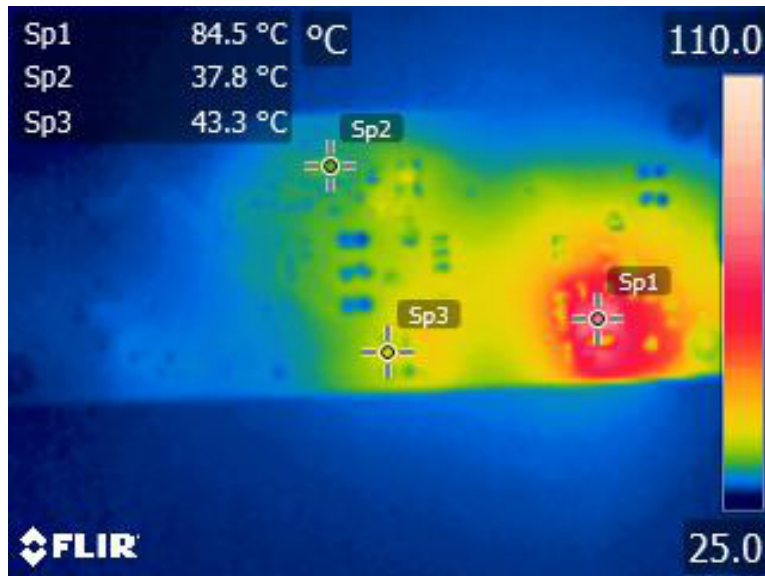
## SECO-HVDCDC1362-15W-GEVB

Measured conditions:

- Output power  $P_{out} \sim 15\text{ W}$
- Electronic load: Chroma 6147A used channel 3 as CRH (constant resistance high mode  $15\ \Omega \rightarrow 1.0\text{ A}$ )
- Input voltage  $\sim 250\text{ V DC}$
- After 5 minutes in this conditions



Sp1 – Transformer  
Sp2 – SiC switcher  
Sp3 – Startup high voltage resistor



Sp1 – Secondary rectifier  
Sp2 – IC NCV 1362  
Sp3 – Snubber TVS diode

Figure 19.

# SECO-HVDCDC1362-15W-GEVB

## Electromagnetic Compatibility – Conducted Emissions EN55015 Limits

Measured conditions:

- Output power  $P_{out} \sim 18 \text{ W}$  resistive load
- Input voltage  $\sim 250 \text{ V}$

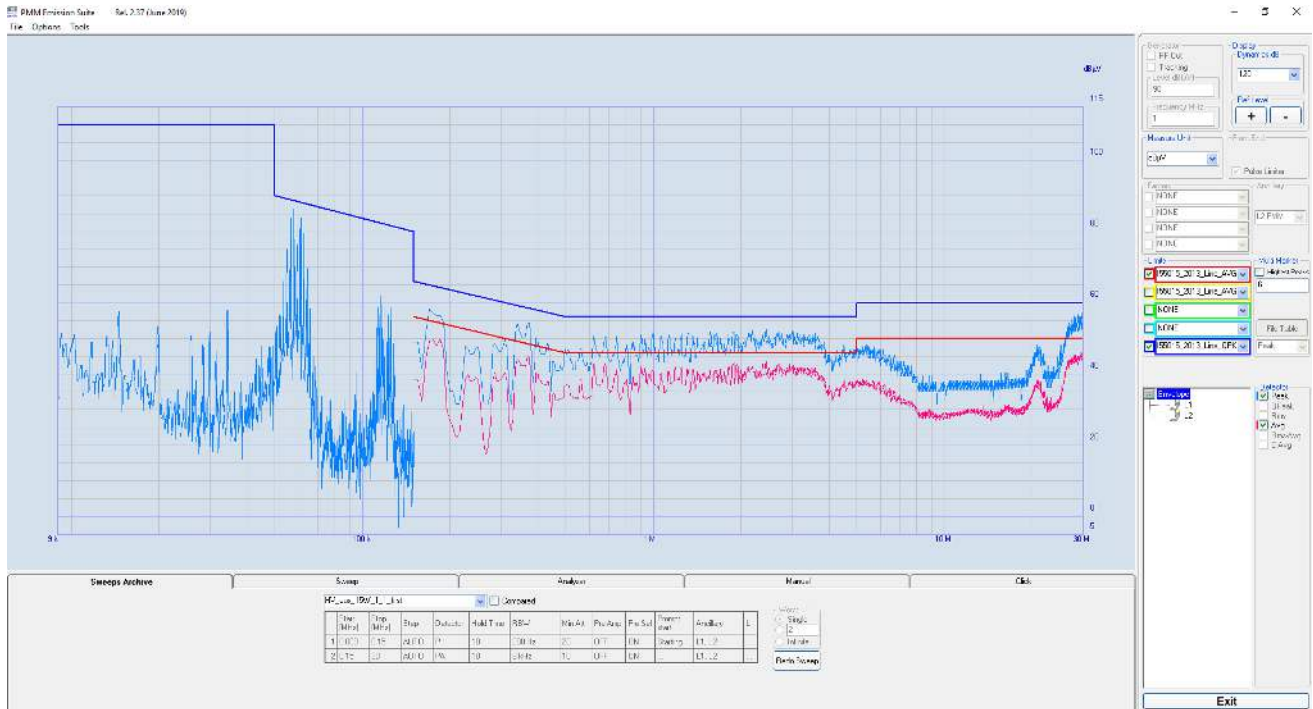


Figure 20.

# SECO-HVDCDC1362-15W-GEVB

## Transformer Design

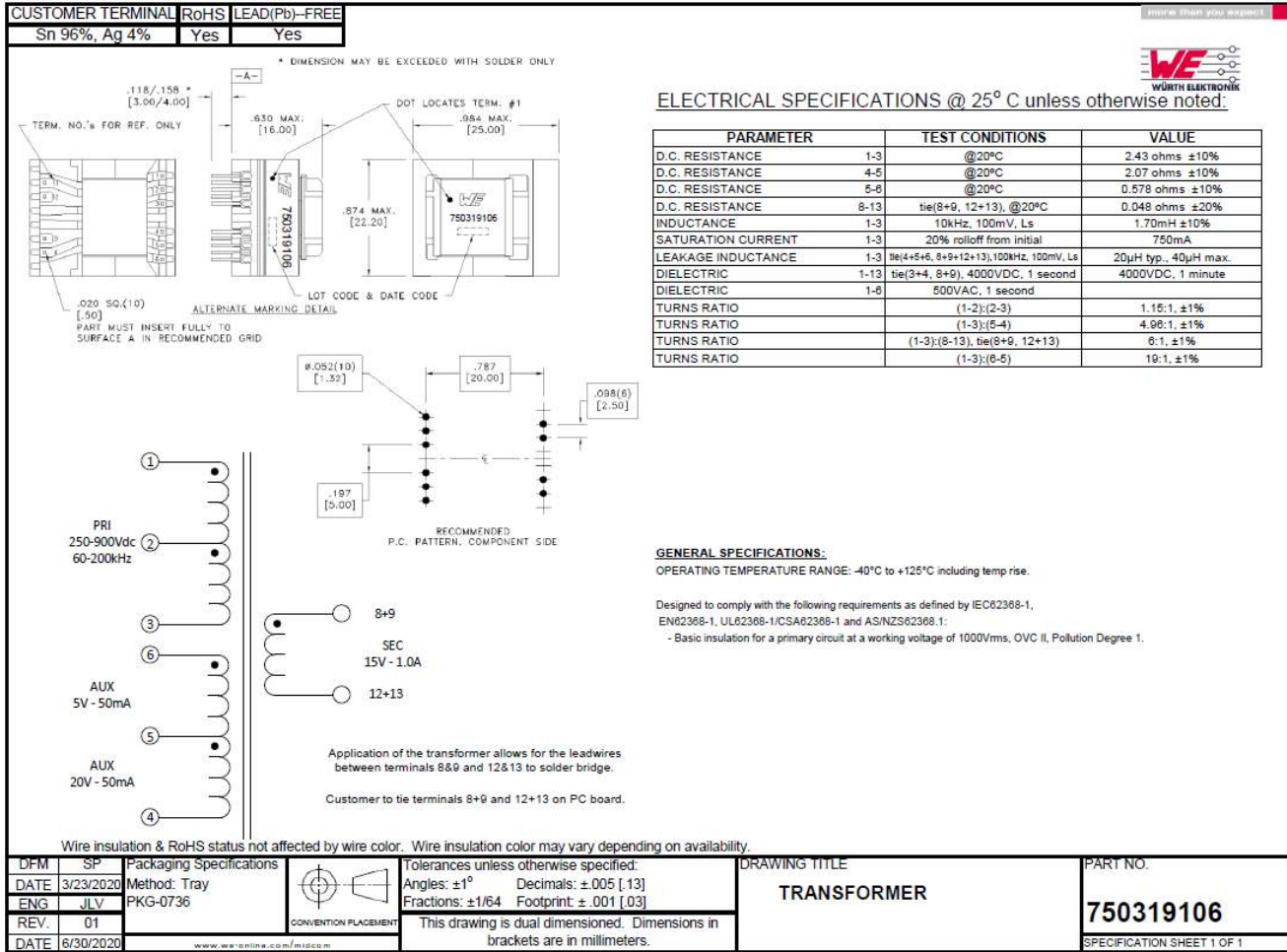


Figure 21. Drawing and Parameters of Used Transformer



## SECO-HVDCDC1362-15W-GEVB

### Development Resources and Tools

Collateral, development files and other development resources listed below are available at [SECO-HVDCDC1362-15W-GEVB](http://www.onsemi.com/SECO-HVDCDC1362-15W-GEVB)

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

**Table 1. BILL OF MATERIAL**

| Des.     | Comment         | Description  | Manufacturer                | Manufacturer Part Number |
|----------|-----------------|--|-----------------------------|--------------------------|
| C2       | 470pF           | MLC capacitor 470pF 1kV ±10% X7R Würth Elektronik  | Würth Elektronik            | 885342208017             |
| C3, C4   | 100 nF          | MMKT film capacitor 100n 500Vac/1600Vdc TDK  | TDK                         | B32643B1104J000          |
| C5       | 100 nF          | Multilayer Ceramic Capacitors MLCC – SMD 1206 25 V 100 nF C0G ± 1 % AEC-Q202 –55 – 125 °C  | Murata                      | GRT31C5C1E104FA02        |
| C6       | 1000 µF         | ALU electrolyte high current ripple 1000 µF 25 V 20% Nichicon                              | NICHICON                    | UBT1E102MHD1TO           |
| C7       | 470 nF          | Multilayer Ceramic Capacitors MLCC – SMD 0805 50 V 470 nF X7R ± 10 % AEC-Q202 –55 – 125 °C | Murata                      | GRT21BR71H474KE01        |
| C8       | 4.7 µF          | Multilayer Ceramic Capacitors MLCC – SMD 1210 50 V 4.7 µF X7R ± 10 % AEC-Q202 –55 – 125 °C | Murata                      | GRT32ER71H475KE01        |
| C9       | 100 nF          | Multilayer Ceramic Capacitors MLCC – SMD 1206 50 V 100 nF C0G ± 5 % AEC-Q202 –55 – 125 °C  | Murata                      | GRT31C5C1H104JA02        |
| C10, C15 | 120 pF          | Multilayer Ceramic Capacitors MLCC – SMD 0603 100 V 120 pF C0G ± 5 % AEC-Q202 –55 – 125 °C | Murata                      | GRT1885C2A121JA02        |
| C12      | 150 nF          | Multilayer Ceramic Capacitors MLCC – SMD 0603 25 V 150 nF X7R ± 10 % AEC-Q202 –55 – 125 °C | Murata                      | GRT188R71E154KE01        |
| C13      | 1n8             | Multilayer Ceramic Capacitors MLCC – SMD 0805 100 V 1n8 C0G ± 5 % AEC-Q202 –55 – 125 °C    | Murata                      | GRT2165C2A182JA02        |
| C14      | 3n3             | Multilayer Ceramic Capacitors MLCC – SMD 0805 100 V 3n3 C0G ± 5 % AEC-Q202 –55 – 125 °C    | Murata                      | GRT2165C2A332JA02        |
| C17      | 4.7 pF          | Multilayer Ceramic Capacitors MLCC – SMD 0603 100 V 4.7 pF C0G ± 5 % AEC-Q200 –55 – 125 °C | Murata                      | GCM1885C2A4R7CA16D       |
| CON1     | RED             | Banana Test Connector, 4mm, Receptacle, PCB Mount, 24 A, 1 kV, Gold Plated Contacts, Red   | CLIFF Electronic Components | FCR7350R                 |
| CON2     | 691 313 510 002 | PCB right angle connector 2 pins 5.08 mm pitch Würth Elektronik                            | Würth Elektronik            | 691313510002             |
| CON3     | BLACK           | Banana Test Connector, 4mm, Receptacle, PCB Mount, 24 A, 1 kV, Gold Plated Contacts, Black | CLIFF Electronic Components | FCR7350B                 |
| CON4     | 613 008 243 121 | WR-PHD 2.54 mm Angled Dual Socket Header 2x4 pins  | Würth Elektronik            | 613008243121             |
| CON5     | 691 351 500 002 | Cable connector series 351 2pins 5.08 mm Würth Elektronik                                  | Würth Elektronik            | 691351500002             |
| CY1      | 2n2             | Disc ceramic capacitor 2n2 1500 VDC Y5U 10 % Vishay AEC-Q200                               | VISHAY                      | AY1222M47Y5UC63L0        |
| D1       | FFSD0665B -F085 | Ultra fast Schottky SiC diode 650V 6A AEC-Q101 ON Semiconductor                            | ON Semiconductor            | FFSD0665B-F085           |
| D2       | TPSMB210A       | TVS 210V 600W SMB unidirectional Littelfuse AEC-Q101                                       | Littelfuse                  | TPSMB210A                |
| D3       | SZ1SMA593 1BT3G | TVS zener diode 18 V 83 mA SMA AEC-Q101 ON Semiconductor                                   | ON Semiconductor            | SZ1SMA5931BT3G           |
| D4       | NRVUS1MF A      | Super Fast diode 1000 V 1 A 75 ns SOD123FA AEC-Q101, ON Semiconductor                      | ON Semiconductor            | NRVUS1MFA                |
| D5       | NSVBAS21A HT1G  | Switching diode 250V 200mA SOD323 AEC-Q101 ON Semiconductor                                | ON Semiconductor            | NSVBAS21AHT1G            |
| D6       | SZMMSZ18 T1G    | Zener Single Diode, 18 V, 500 mW, SOD-123, 5 %, 2 Pins, 150 µC, AEC-Q101                   | ON Semiconductor            | SZMMSZ18T1G              |

## SECO-HVDCDC1362-15W-GEVB

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

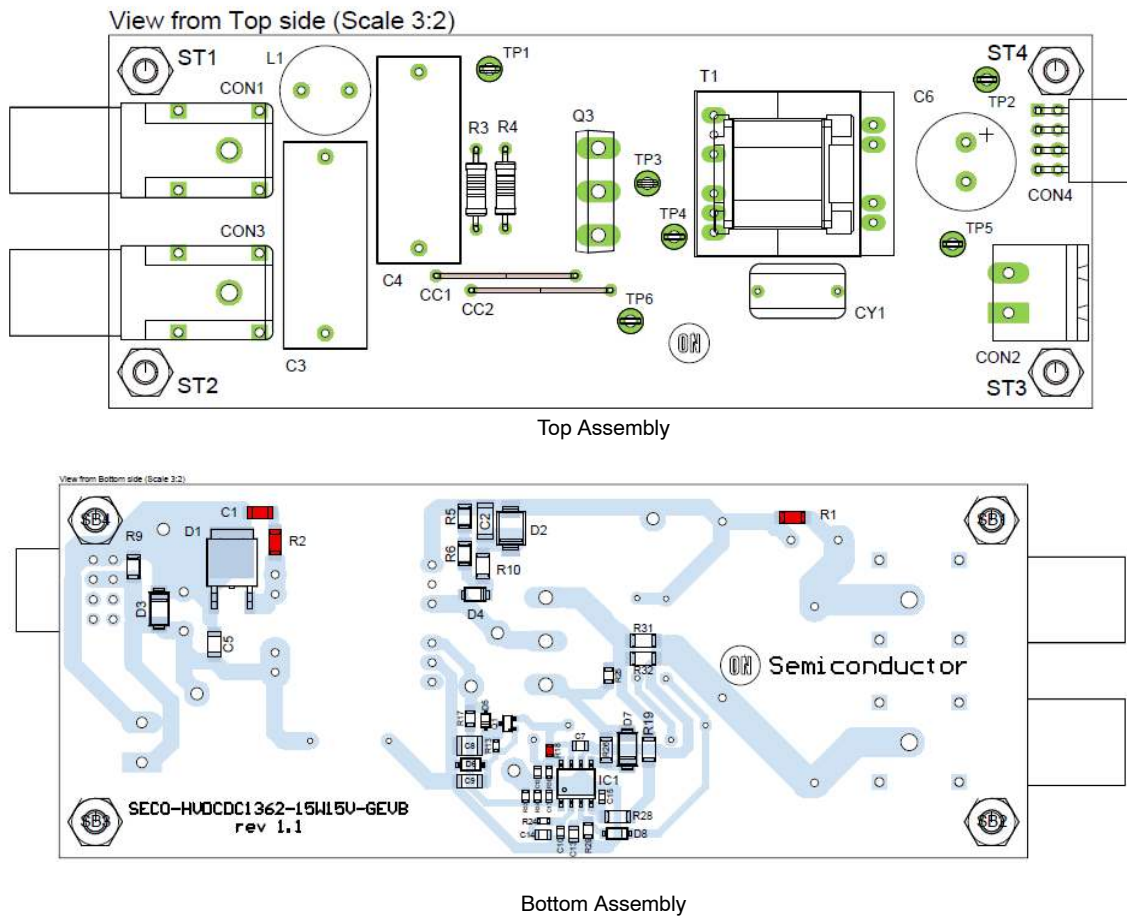
| Des.               | Comment                          | Description   | Manufacturer         | Manufacturer Part Number |
|--------------------|----------------------------------|---|----------------------|--------------------------|
| D7                 | NRVBA130L T3G                    | Schottky diode 30 V 1 A SMA ON Semiconductor  | ON Semiconductor     | NRVBA130LT3G             |
| D8                 | SZMMSZ20 T1G                     | Zener Diodes 20V 500mW SOD123 AEC-Q101 ON Semiconductor   | ON Semiconductor     | SZMMSZ20T1G              |
| IC1                | NCV1362BA                        | Automotive Primary Side Flyback Controller  | ON Semiconductor     | NCV1362BADR2G            |
| L1                 | 4.7 mH                           | Fixed Inductors RFB 1010 Lead Rad 4.7mH 0.28A 9.6 Ω   | Coilcraft            | RFB1010-472L             |
| Q1                 | NSVBC817-40W                     | General purpose NPN transistor 45V 500mA ON Semiconductor                                       | ON Semiconductor     | NSVBC817-40WT1G          |
| Q3                 | NVHL160N1 20SC1                  | SiC NMOS 1200V 17A 160mΩ ON Semiconductor   | ON Semiconductor     | NVHL160N120SC1           |
| R3                 | 6M8                              | High Ohmic / High Voltage Metal Glaze Leaded Resistors 0207 6M8 5% 250mW Vishay                 | Vishay               | VR25000006804JA500       |
| R4                 | 10M                              | High Ohmic / High Voltage Metal Glaze Leaded Resistors 0207 10M 5% 250mW Vishay                 | Vishay               | VR25000001005JA100       |
| R5, R6, R9         | 100k                             | SMD Chip Resistor, 100 kΩ, MCWR Series, 200 V, Thick Film, 1206 [3216 Metric], 250 mW Multicomp | Multicomp            | MCWR12X1003FTL           |
| R10, R19           | 0R                               | SMD Chip Resistor, 0 Ω, ERJ8G Series, 200 V, Thick Film, 1206 [3216 Metric], 250 mW Panasonic   | Panasonic            | ERJ8GEY0R00V             |
| R13                | 4k7                              | SMD thick film resistor 4k7 0603 1% 100 mW Panasonic  | Panasonic            | ERA3AED4701V             |
| R17                | 154k                             | SMD thick film resistor 154k 0805 1% 125 mW Panasonic   | Panasonic            | ERA6AED1543V             |
| R24                | 270k                             | SMD thick film resistor 270k 0603 1% 100 mW Panasonic   | Panasonic            | ERA3AED2703V             |
| R25                | 10k                              | SMD thick film resistor 10k 0805 1% 125 mW Panasonic  | Panasonic            | ERA6AED1002V             |
| R26                | 8R2                              | SMD thick film resistor 8 Ω 1206 1% 500 mW Panasonic  | Panasonic            | ERJ8BQF8R2V              |
| R28                | 1k                               | SMD thick film resistor 1k 1206 1% 250 mW Panasonic   | Panasonic            | ERA8AED1001V             |
| R29                | 100k                             | SMD Thermistor, 100 kΩ, NTCG-S Series, 0805 [2012 Metric], 200 mW TDK                           | TDK                  | NTCG204CH104JT1          |
| R30                | 34k8                             | SMD thick film resistor 34k8 0603 1% 100 mW Panasonic   | Panasonic            | ERA3AED3482V             |
| R31                | 1R8                              | SMD current sense resistor 1R8 1206 1% 330 mW Panasonic   | Panasonic            | ERJ8BQF1R8V              |
| R32                | 1R2                              | SMD thick film resistor 1.2 Ω 1206 1% 500 mW Panasonic  | Panasonic            | ERJ8BQF1R2V              |
| R33                | 51k1                             | SMD thick film resistor 51k1 0603 1% 100 mW Panasonic   | Panasonic            | ERA3AED5112V             |
| R34                | 46k4                             | SMD thick film resistor 46k4 0603 1% 100 mW Panasonic   | Panasonic            | ERA3AED4642V             |
| SB1, SB2, SB3, SB4 | Plastic spacer M3 M/F 8/5 HEX6   | Plastic spacer internal/external M3x8 thread, 5 mm Würth Elektronik                             | Würth Elektronik     | 971050365                |
| ST1, ST2, ST3, ST4 | Plastic spacer M3 F/F 10/25 HEX6 | Plastic spacer internal/internal M3x6 thread, 25 mm Würth Elektronik                            | Würth Elektronik     | 970250365                |
| T1                 | 750319106                        | Transformer for DC-DC (NCV1362 flyback 250V-900VDC@15W) converter from Würth Elektronik         | Würth Elektronik     | TR_WE_750319106          |
| TP1                | ORANGE                           | PTH testpoint eyelet 3.2 mm orange Keystone Electronics   | Keystone Electronics | 5008                     |

# SECO-HVDCDC1362-15W-GEVB

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

| Des.     | Comment | Description  | Manufacturer         | Manufacturer Part Number |
|----------|---------|--|----------------------|--------------------------|
| TP2, TP3 | RED     | PTH testpoint eyelet 3.2 mm red Keystone Electronics   | Keystone Electronics | 5005                     |
| TP4      | BROWN   | PTH testpoint eyelet 3.2 mm brown Keystone Electronics | Keystone Electronics | 5120                     |
| TP5      | BLUE    | PTH testpoint eyelet 3.2 mm blue Keystone Electronics  | Keystone Electronics | 5122                     |
| TP6      | BLACK   | PTH testpoint eyelet 3.2 mm black Keystone Electronics | Keystone Electronics | 5006                     |

## Layout



**Figure 22. Layout**

## References

- NCV1362 Data sheet
- NCV1362 Application notes
- NCV1362 [Evaluation boards](#)
- NCV1362 Design worksheet MathCad

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