15 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-HVDCDC1362-15W-GEVB

Introduction

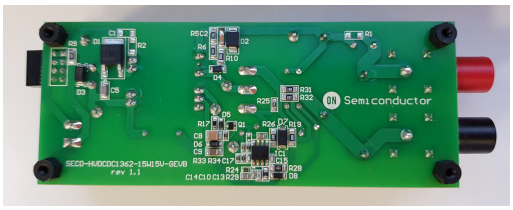
SECO−HVDCDC1362−15W−GEVB is highly efficient and primary−side regulated (PSR) auxiliary power supply targeting HEV and EV automotive power trains. The design provides a stable 15 V output and 15 W over a wide input DC voltage range from 250 V to 900 V, and is therefore suitable for 400 V and 800 V battery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

(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 / 15 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)

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

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EVBUM2752/D

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

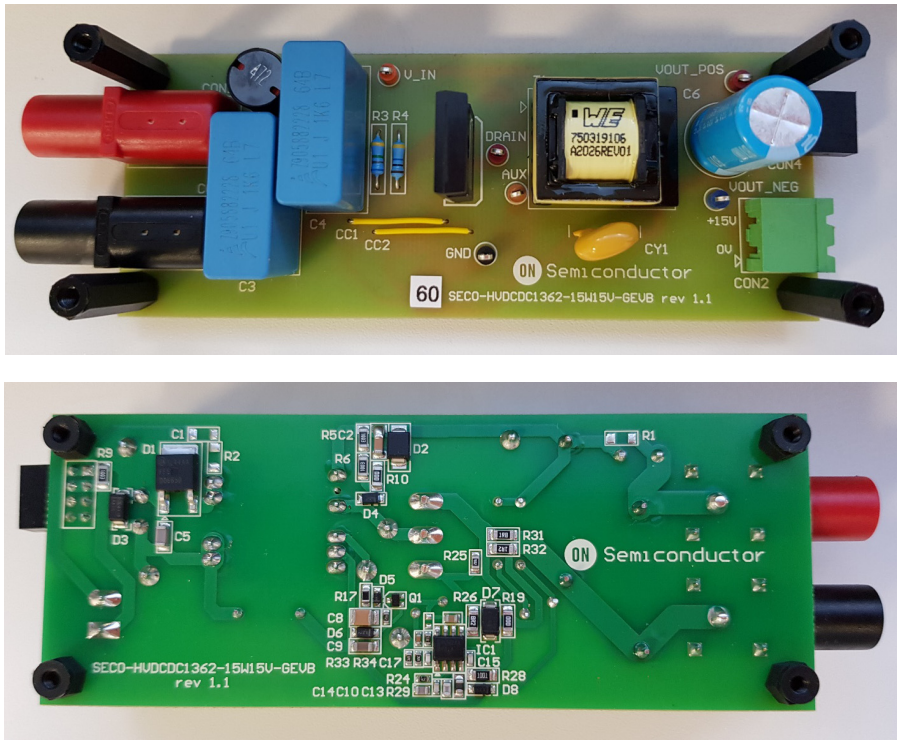


Figure 2. Evaluation Board Photo

Block Diagram

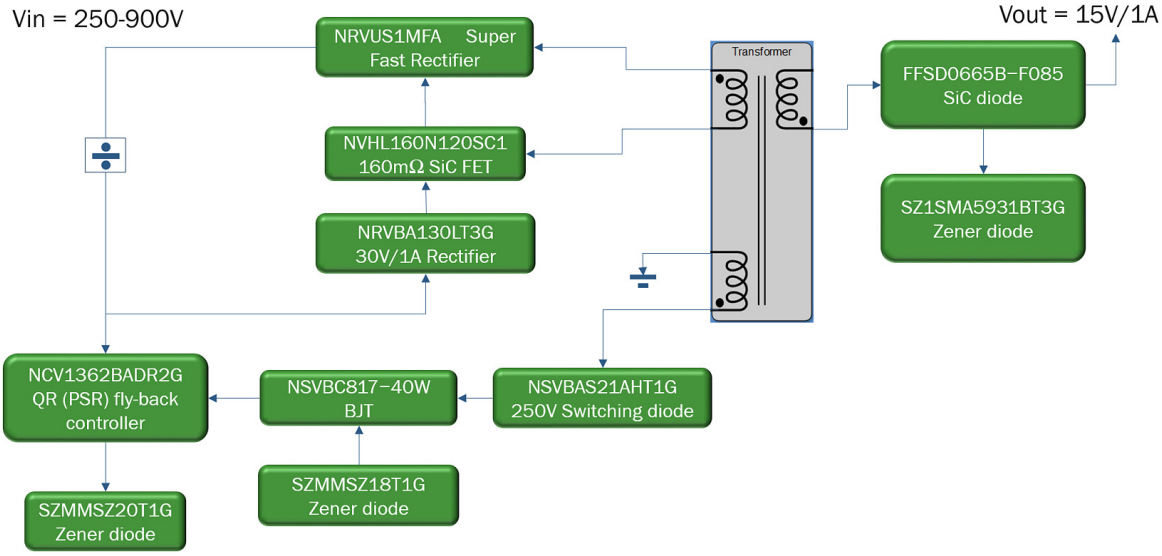


Figure 3. Block Diagram

SPECIFICATION

Parameters	Values
Input	
Voltage	250−900 VDC
Current	71 mA (Vin = 250 V), 22 mA (Vin = 900 V)
Output	
Power	15 W
Voltage	15 VDC
Current per branch	1 A
Total current	1 A
Efficiency at full load	86% (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	0.65 A
Construction	
Board size	26.24 x 16.38 x 16.06 mm
Transformer	
Dielectric insulation	4000 VAC, 1 min.
Inductance	1.70 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

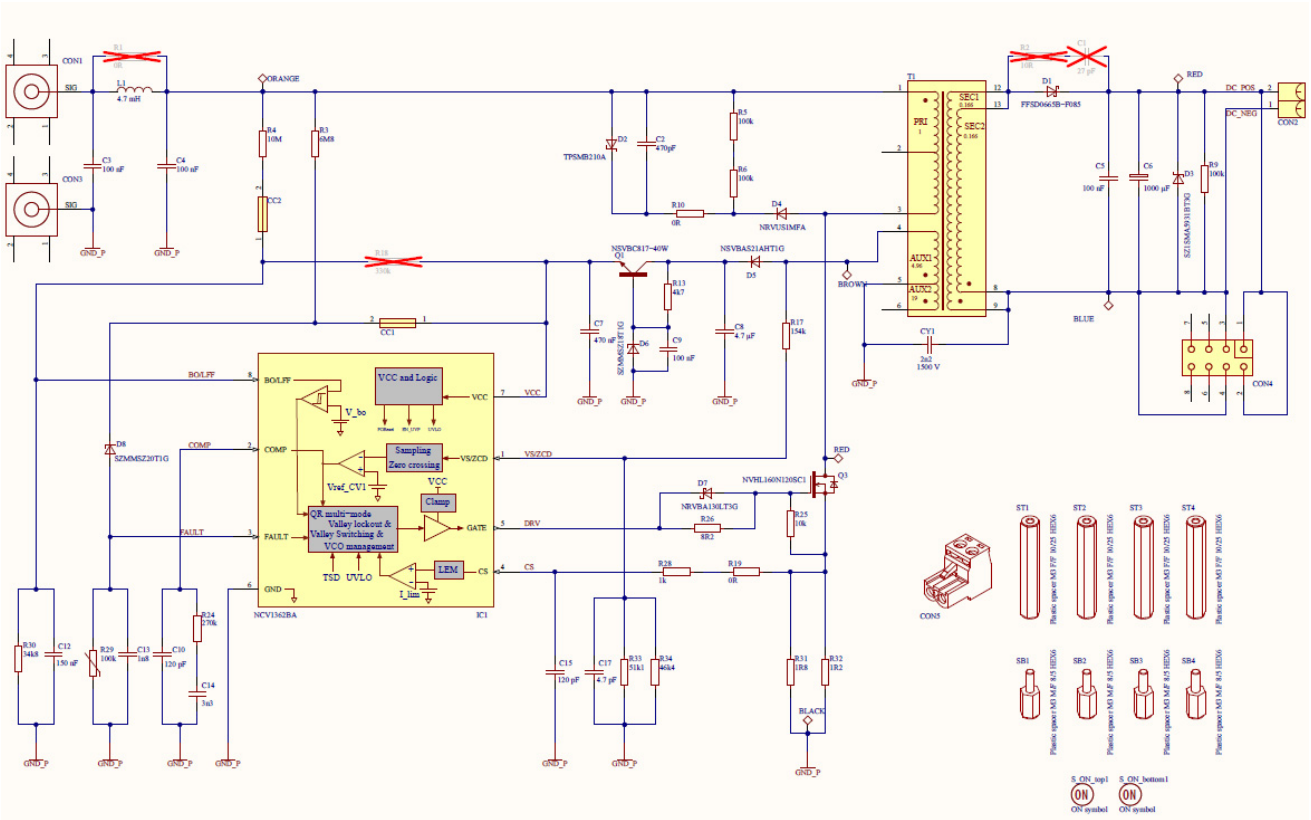


Figure 4. Evaluation Board Schematic

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

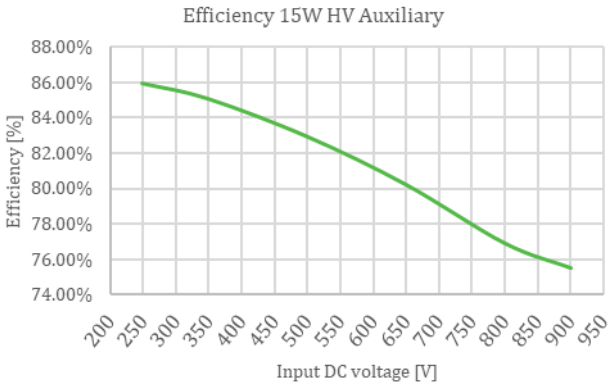
Efficiency DC/DC at Input Voltage Range and Full Load

Measured conditions:

- Output power Pout ~ 15 W
- Electronic load: Chroma 6147A used channel 3 as CRH (constant resistance high mode 15 Ω → 1.0 A)

List of equipment:

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



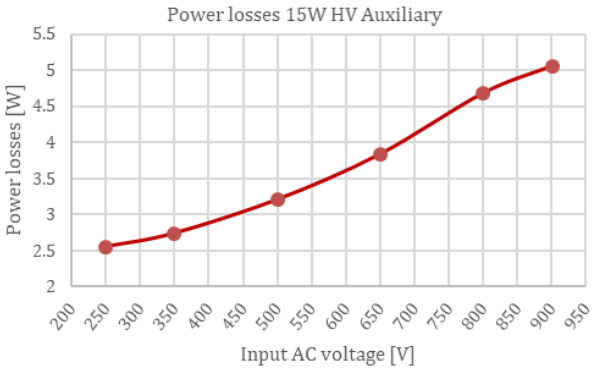


Figure 5.

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

Measured conditions:

- Output power Pout ~ 15 W
- Electronic load: Chroma 6147A used channel 3 as CRH (constant resistance high mode 15 Ohm −> 1.0A)

List of equipment:

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

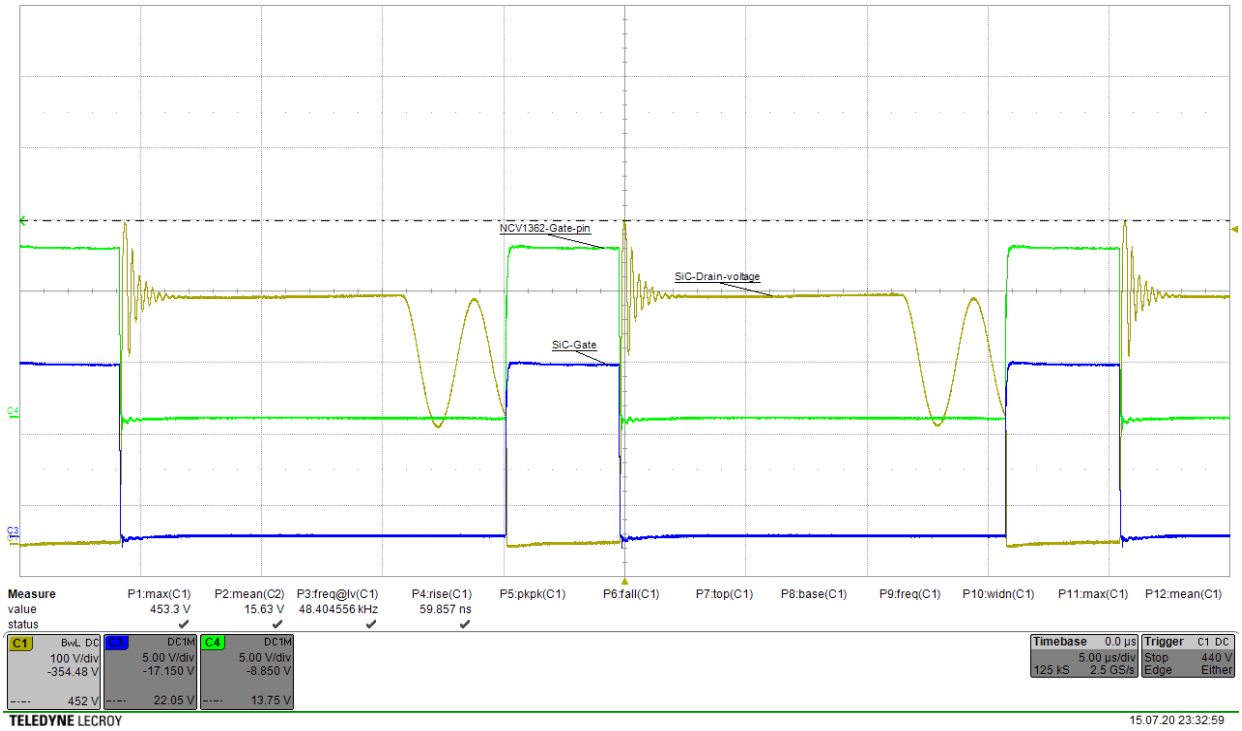


Figure 6. 250 V DC Full Load

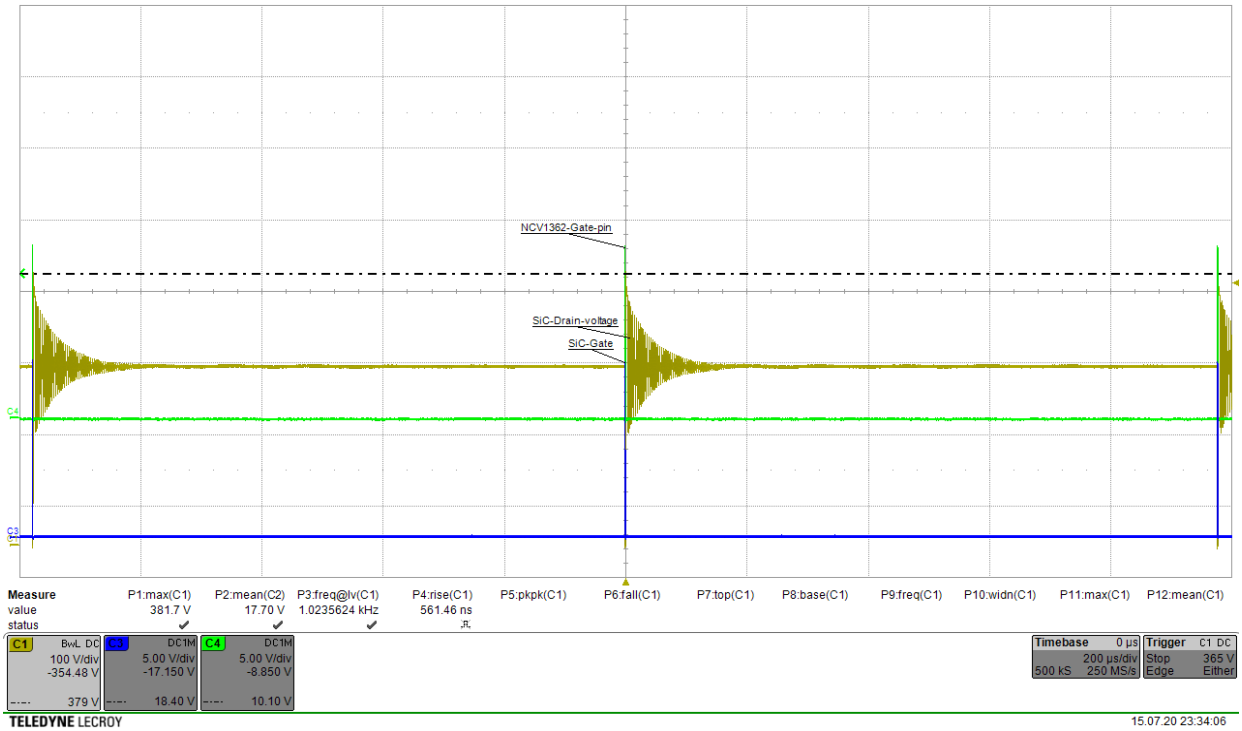


Figure 7. 250 V DC Open Circuit

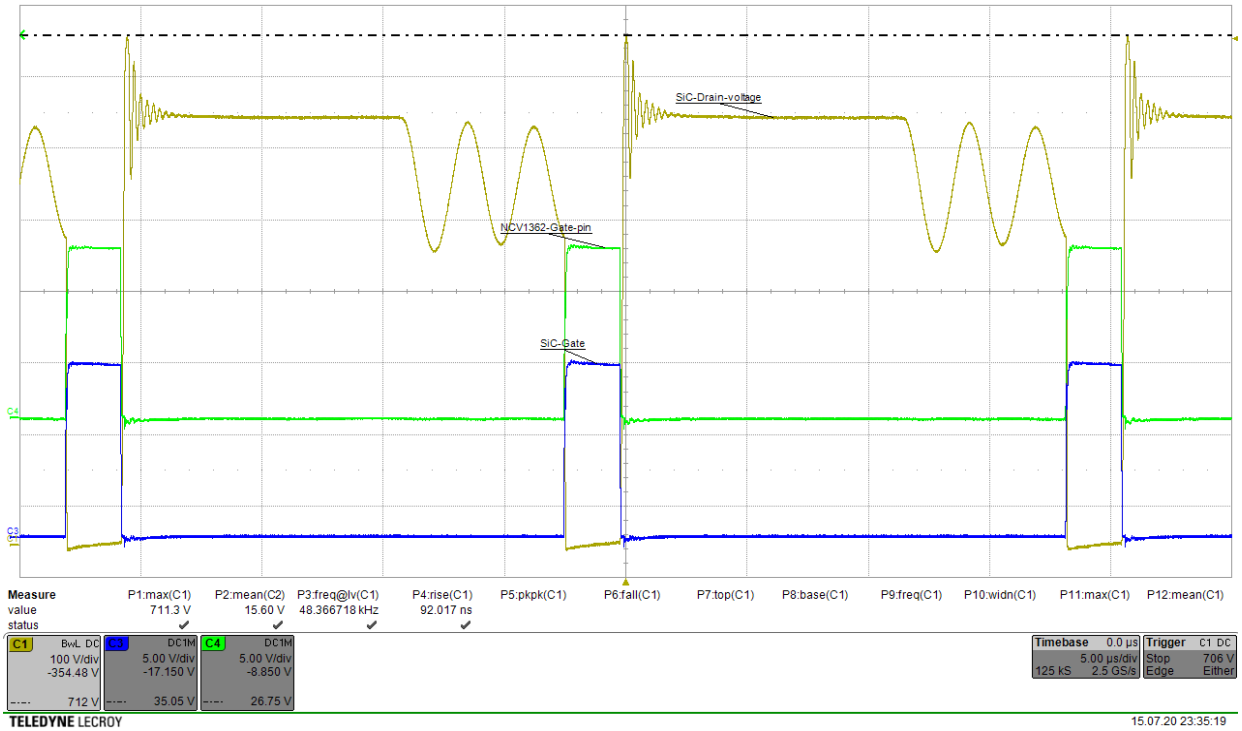


Figure 8. 500 V DC Full Load

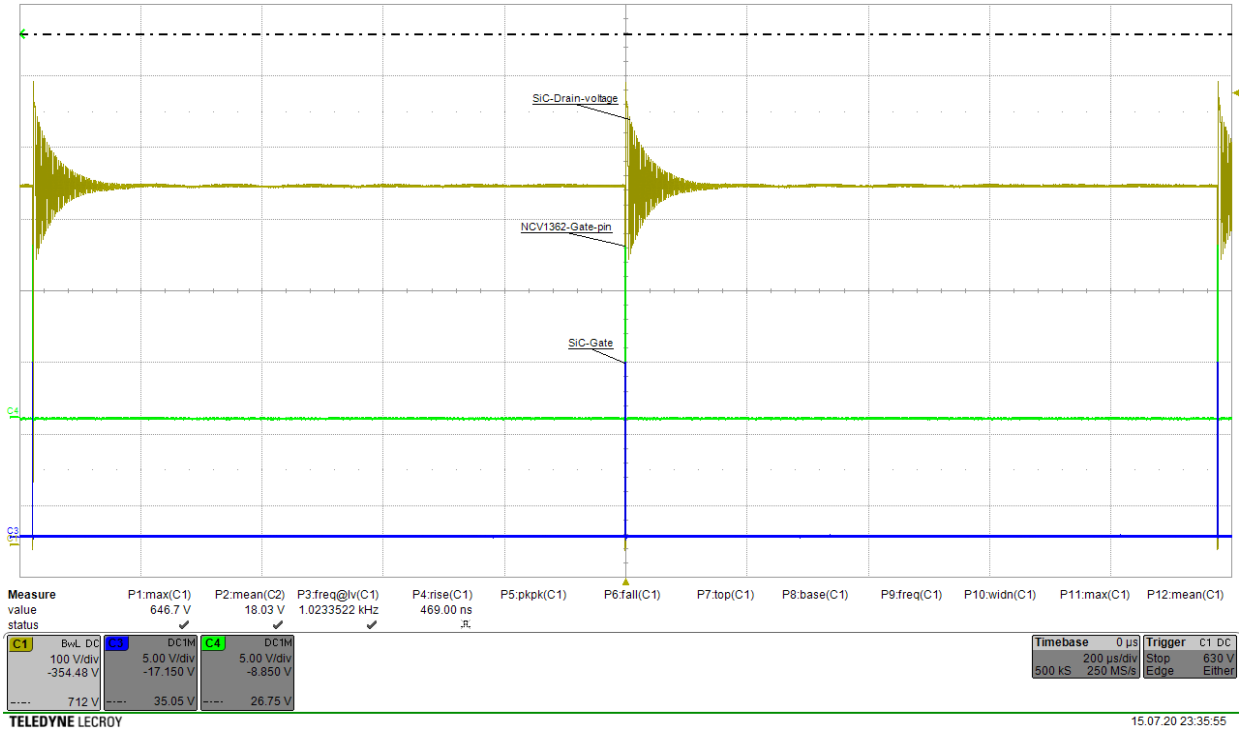


Figure 9. 500 V DC Open Circuit

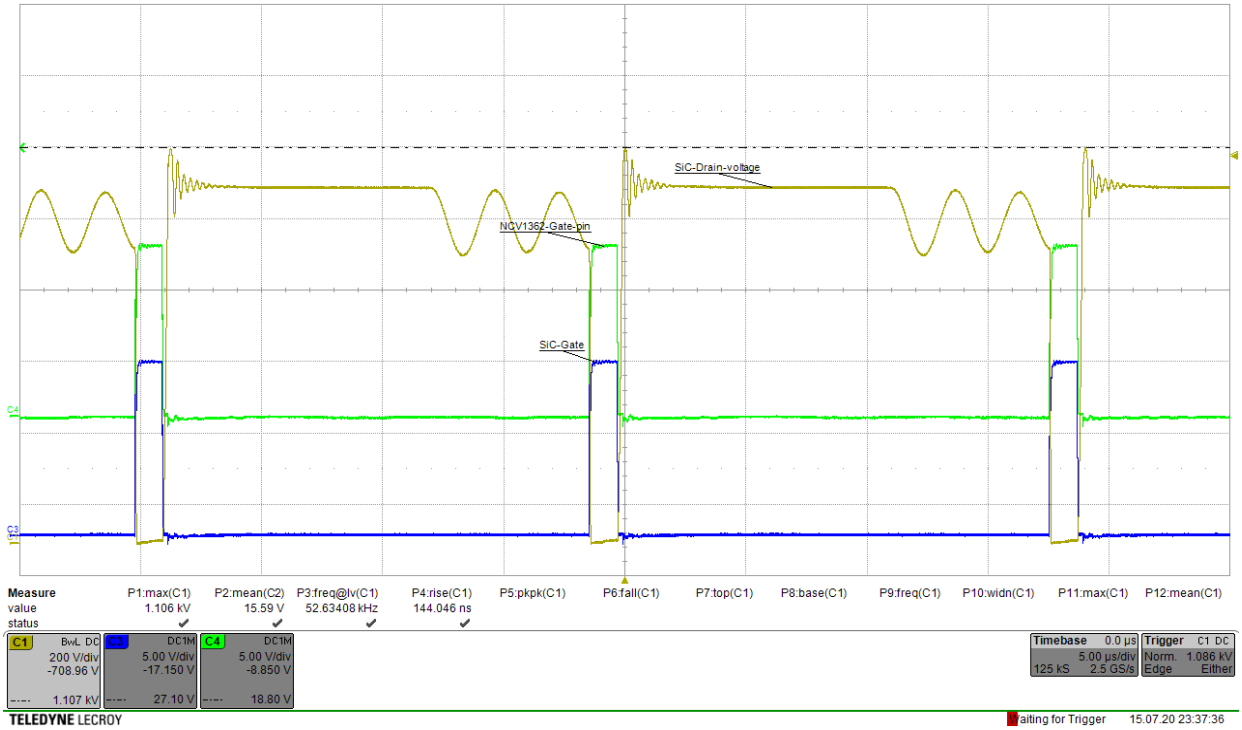


Figure 10. 900 V DC Full Load

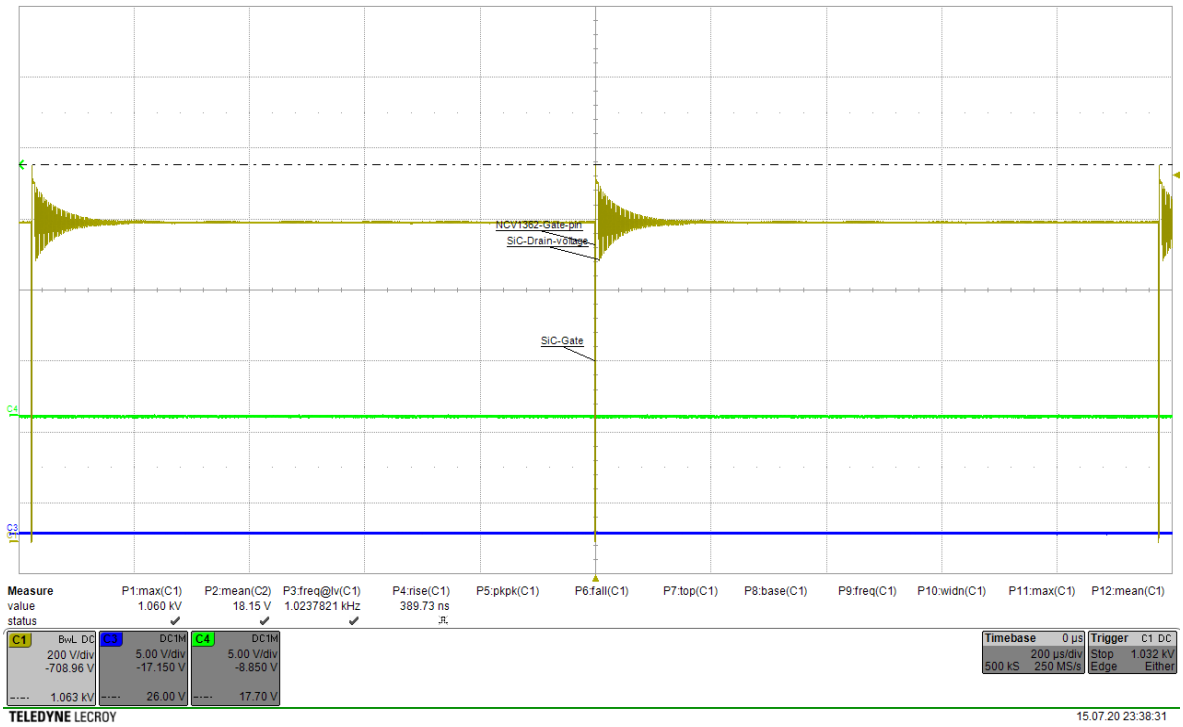


Figure 11. 900 V DC Open Circuit

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

Measured conditions:

- Output power Pout ~ 15 W
- Electronic load: Chroma 6147A used channel 3 as CCDL (constant current dynamic mode 0.15 A → 0.85 A)

List of equipment:

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

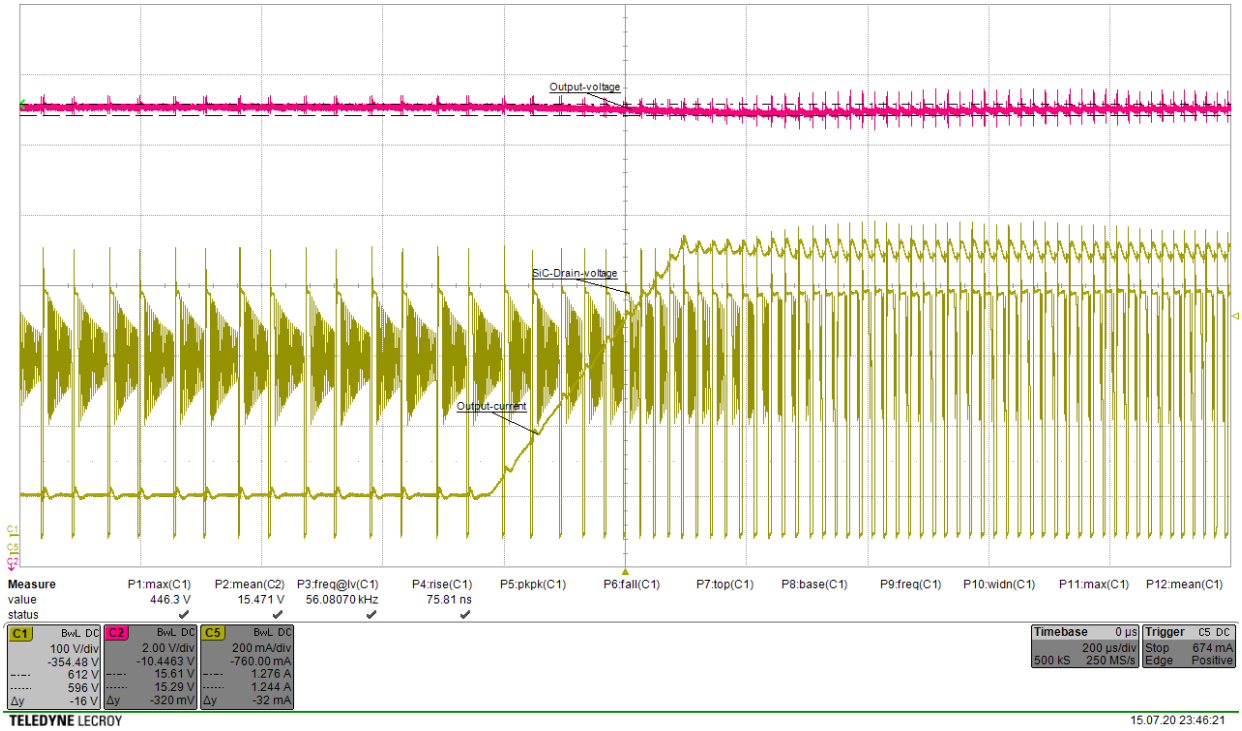


Figure 12. 250 V – 15% to 85%

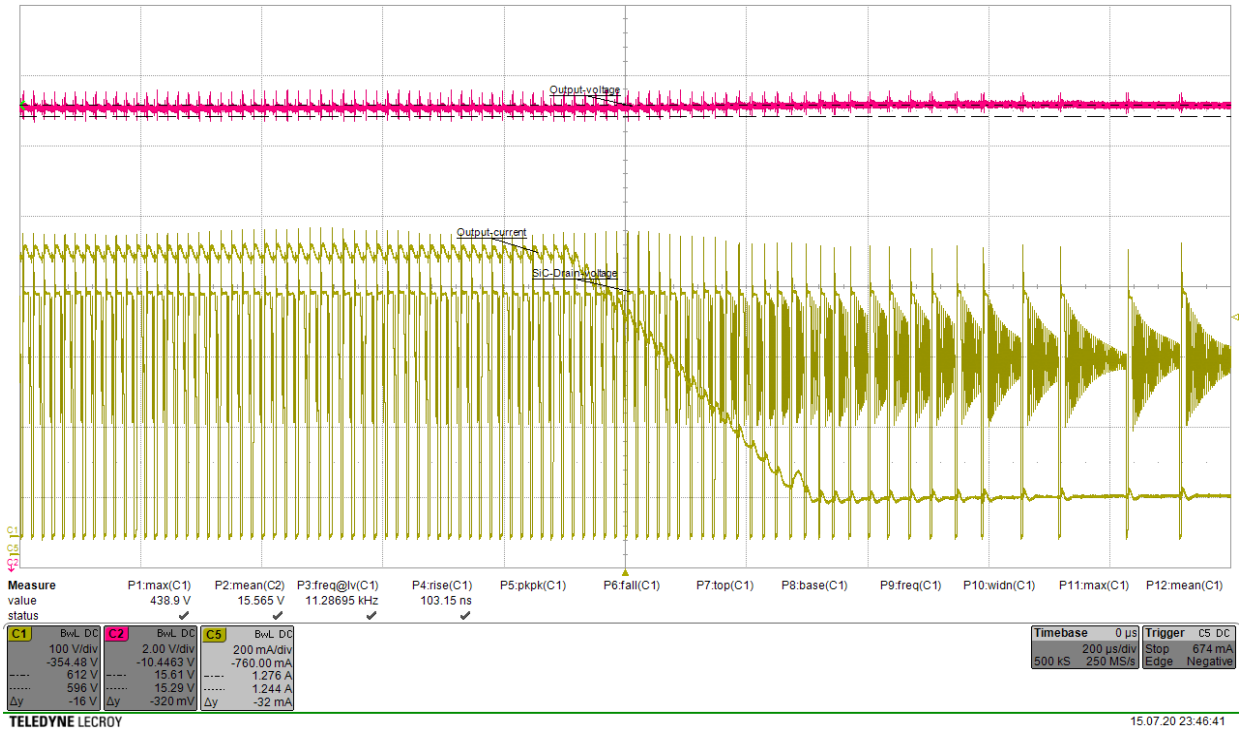


Figure 13. 250 V – 85% to 15%

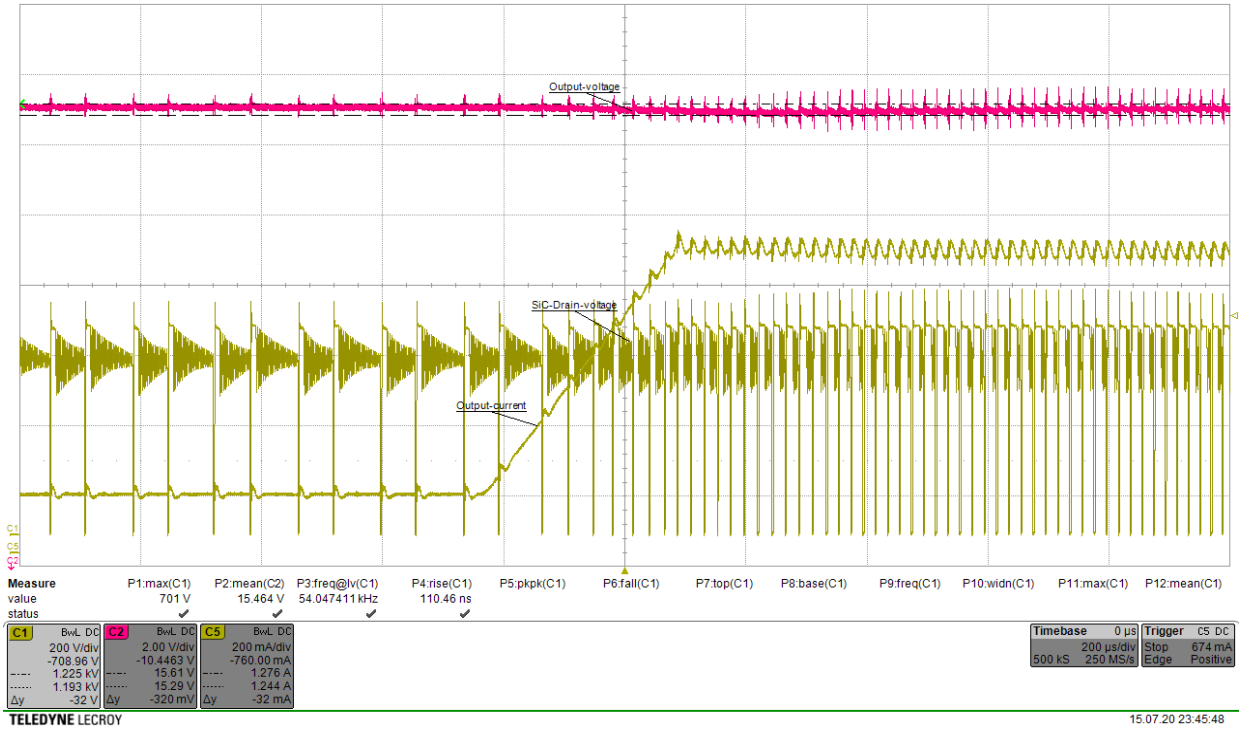


Figure 14. 500 V – 15% to 85%

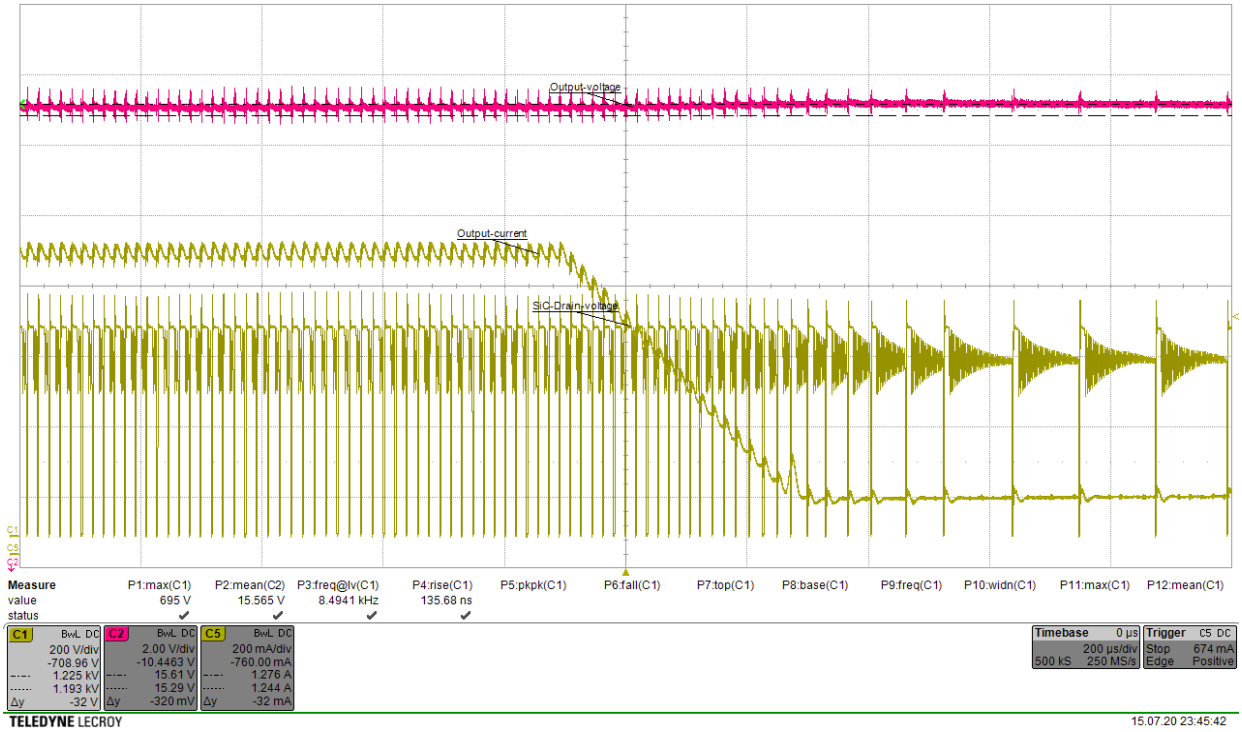


Figure 15. 500 V – 85% to 15%

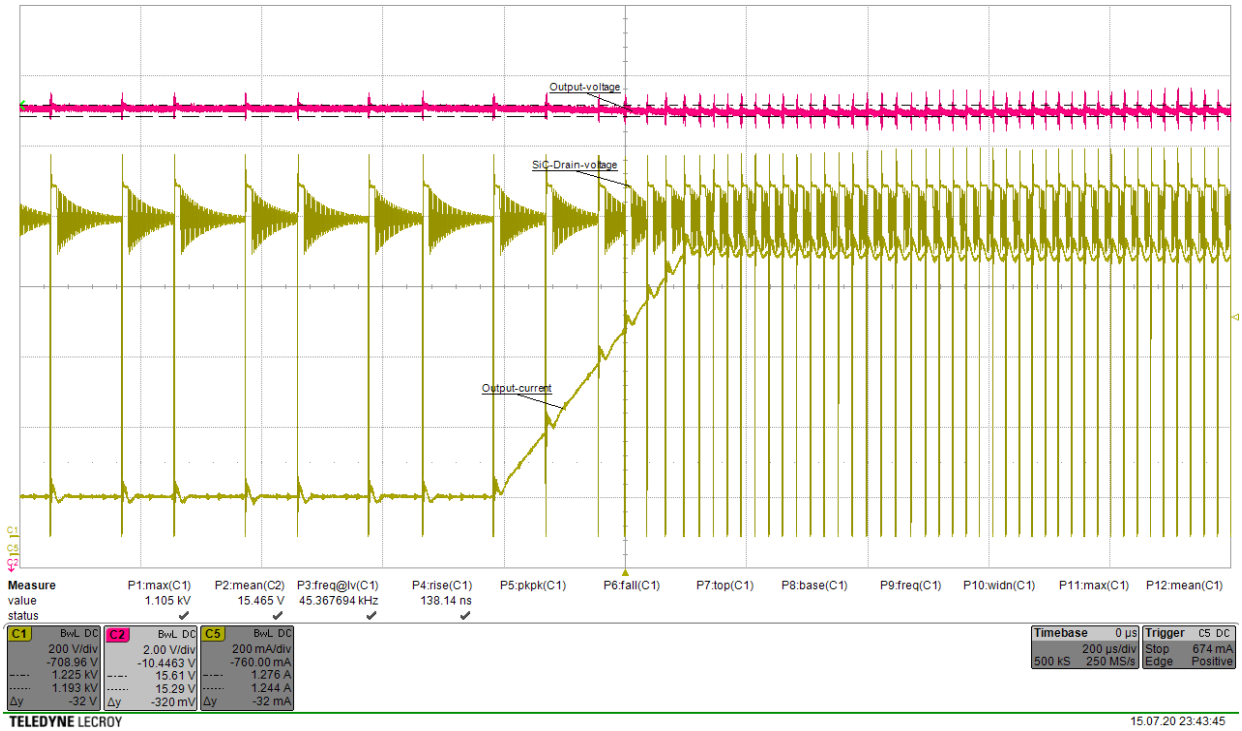


Figure 16. 900 V – 15% to 85%

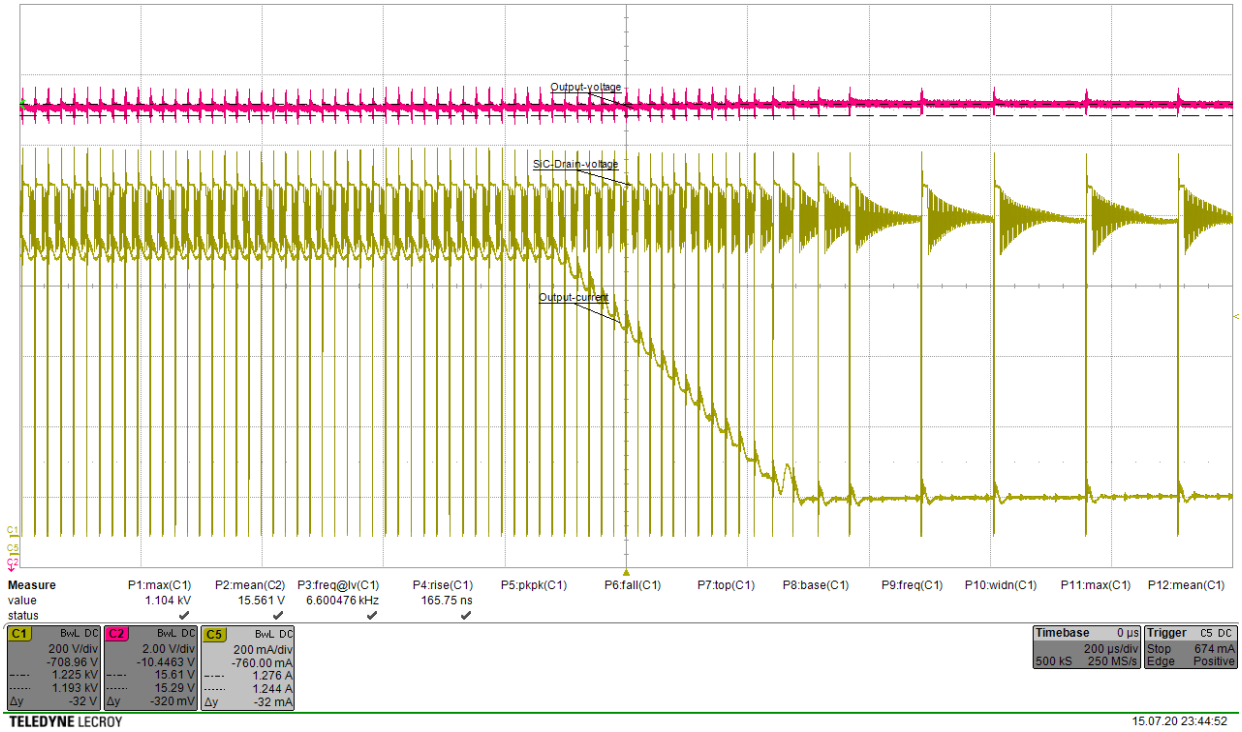
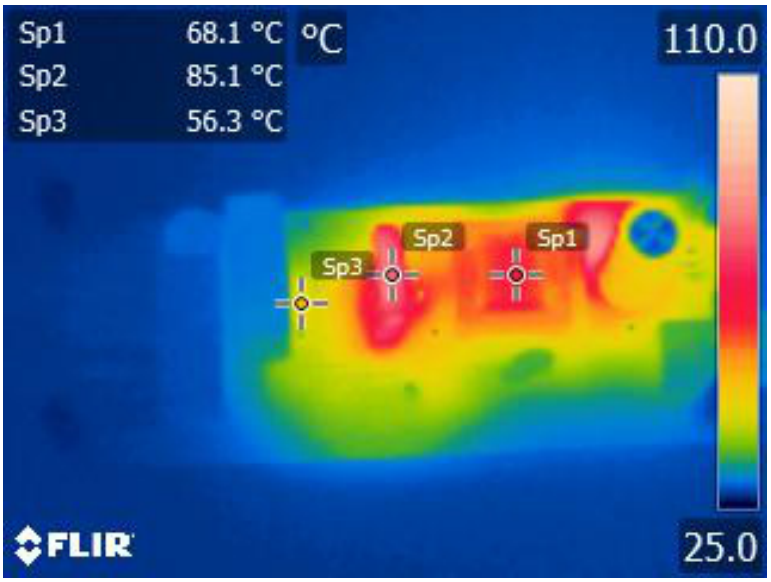


Figure 17. 900 V – 85% to 15%

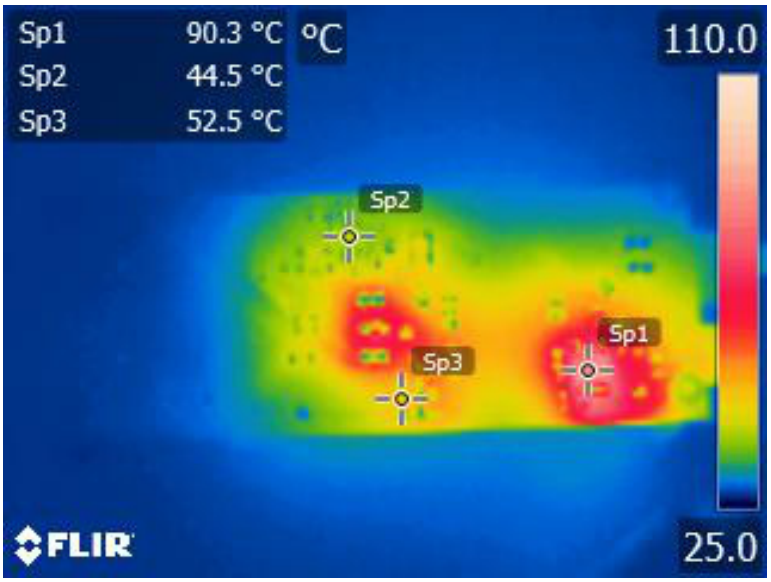
Thermal Camera View

Measured conditions:

- Output power Pout ~ 15 W
- Electronic load: Chroma 6147A used channel 3 as CRH (constant resistance high mode 15 Ω → 1.0 A)
- Input voltage ~ 900 V DC
- After 5 minutes in this conditions



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

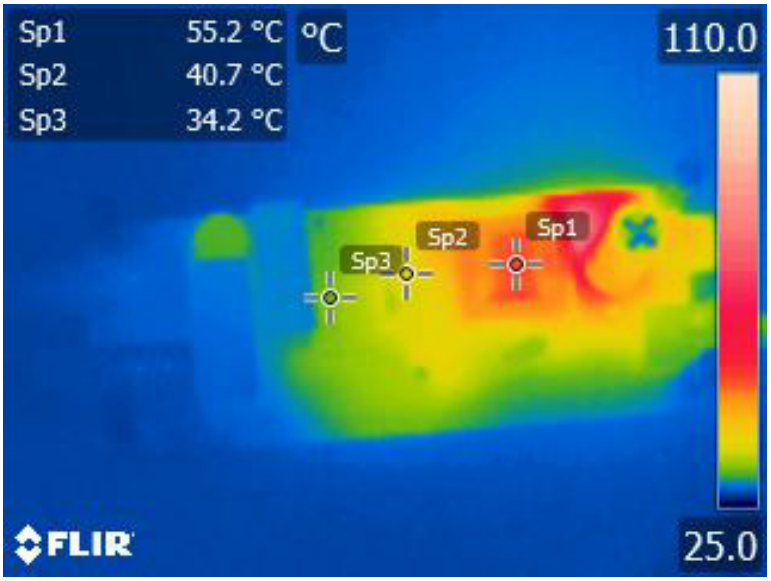


Sp1 – Secondary rectifier
Sp2 – IC NCV 1362
Sp3 – Snubber TVS diode

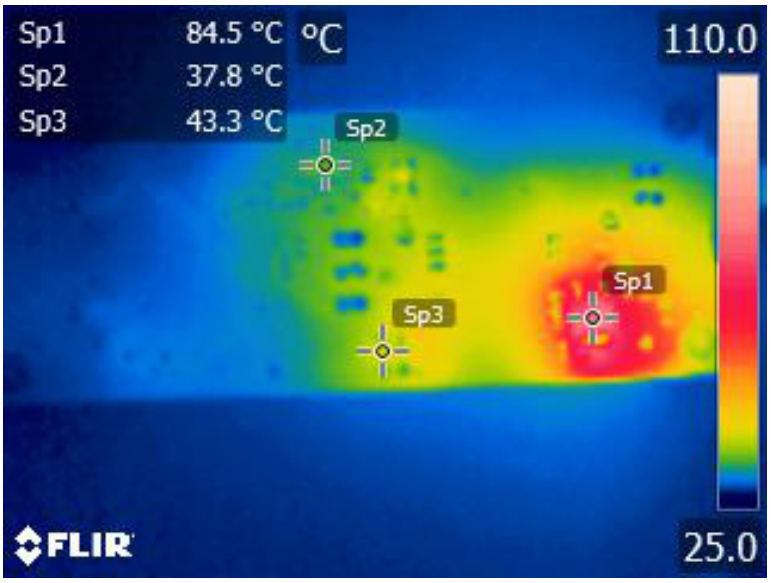
Figure 18.

Measured conditions:

- Output power Pout ~ 15 W
- Electronic load: Chroma 6147A used channel 3 as CRH (constant resistance high mode 15 Ω → 1.0 A)
- Input voltage ~ 250 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.

Electromagnetic Compatibility – Conducted Emissions
EN55015 Limits

Measured conditions:

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

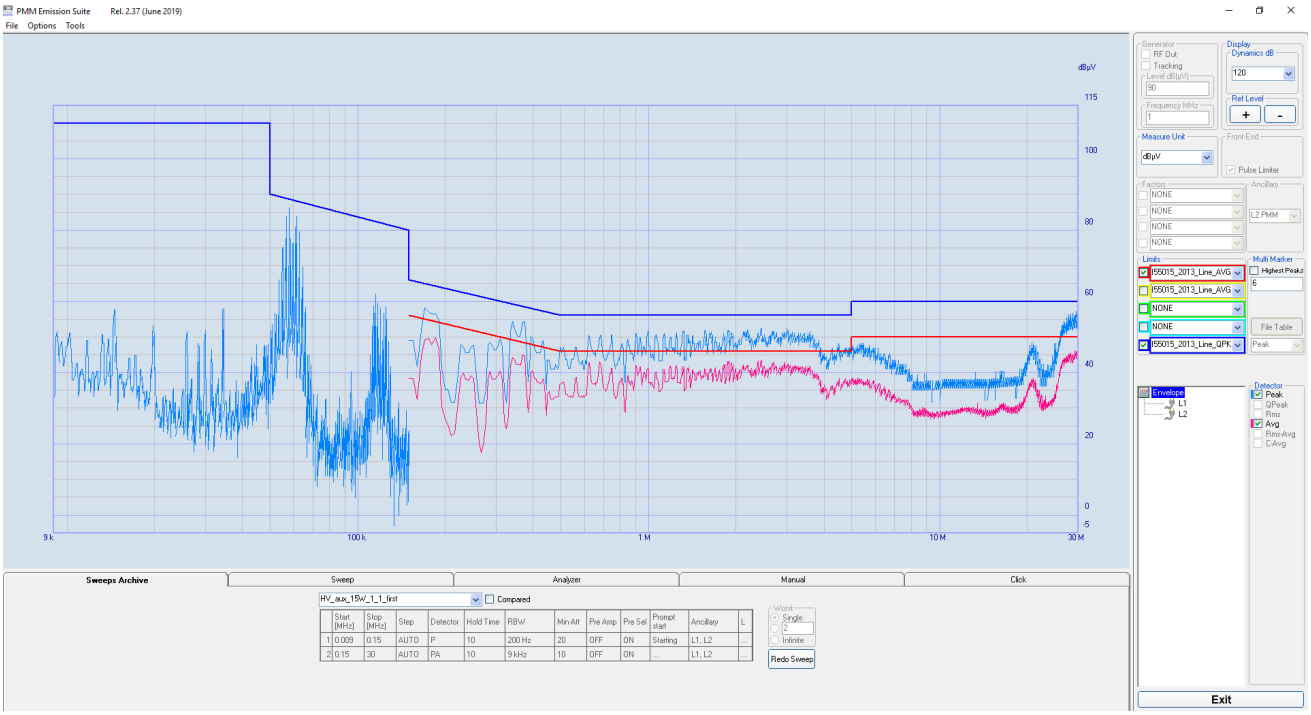
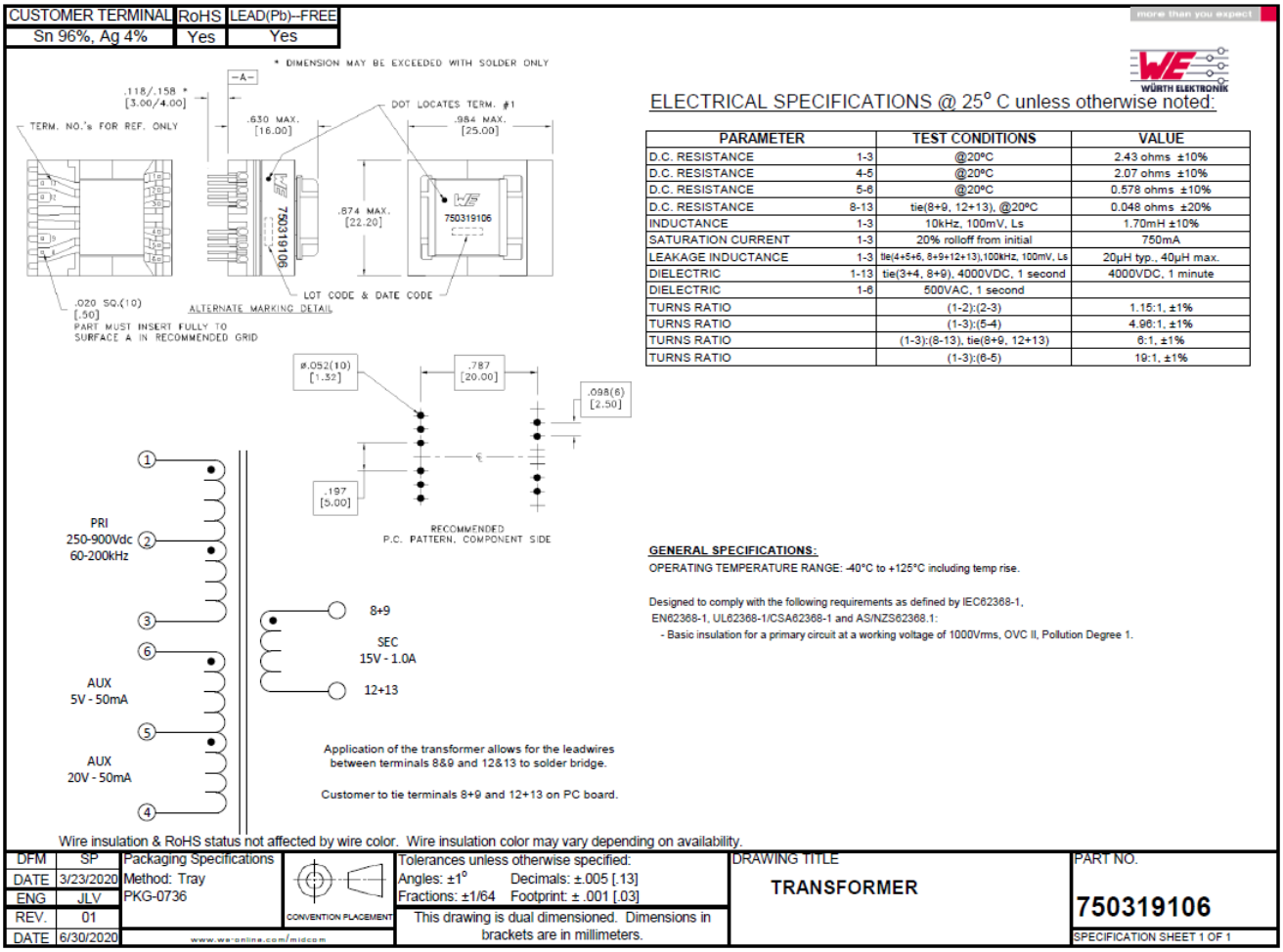


Figure 20.

Transformer Design

CUSTOMER TERMINAL	RoHS	LEAD(Pb)−FREE
Sn 96%, Ag 4%	Yes	Yes



ELECTRICAL SPECIFICATIONS @ 25° C unless otherwise noted:

PARAMETER		TEST CONDITIONS	VALUE
D.C. RESISTANCE	1-3	@20ºC	2.43 ohms ±10%
D.C. RESISTANCE	4-5	@20ºC	2.07 ohms ±10%
D.C. RESISTANCE	5-6	@20ºC	0.578 ohms ±10%
D.C. RESISTANCE	8-13	tie(8+9, 12+13), @20ºC	0.048 ohms ±20%
INDUCTANCE	1-3	10kHz, 100mV, Ls	1.70mH ±10%
SATURATION CURRENT	1-3	20% rolloff from initial	750mA
LEAKAGE INDUCTANCE	1-3	tie(4+5+6, 8+9+12+13),100kHz, 100mV, Ls	20µH typ., 40µH max.
DIELECTRIC	1-13	tie(3+4, 8+9), 4000VDC, 1 second	4000VDC, 1 minute
DIELECTRIC	1-6	500VAC, 1 second	
TURNS RATIO		(1-2):(2-3)	1.15:1, ±1%
TURNS RATIO		(1-3):(5-4)	4.96:1, ±1%
TURNS RATIO		(1-3):(8-13), tie(8+9, 12+13)	6:1, ±1%
TURNS RATIO		(1-3):(6-5)	19:1, ±1%

GENERAL SPECIFICATIONS:

OPERATING TEMPERATURE RANGE: -40°C to +125°C including temp rise.

Designed to comply with the following requirements as defined by IEC62368-1, EN62368-1, UL62368-1/CSA62368-1 and AS/NZS62368.1:

- Basic insulation for a primary circuit at a working voltage of 1000Vrms, OVC II, Pollution Degree 1.

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−HVDCDC1362−15W−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 Electronik	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

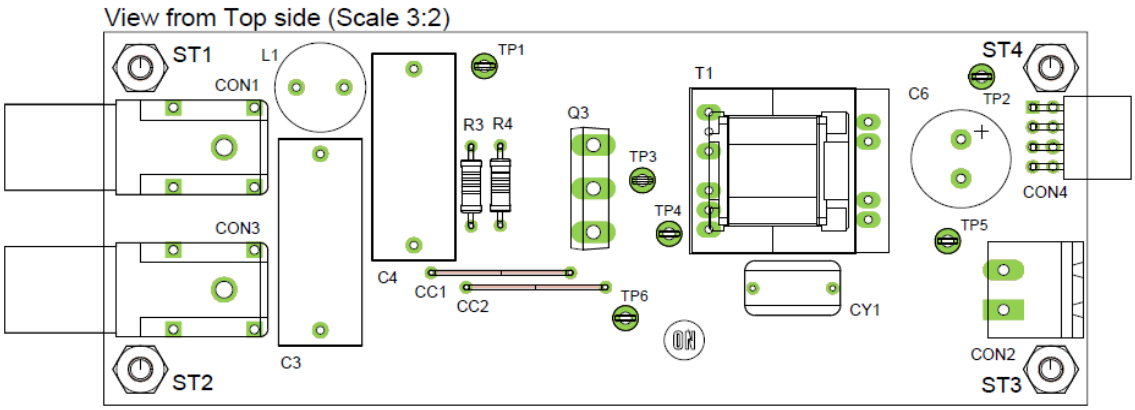
Table 1. BILL OF MATERIAL (continued)

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

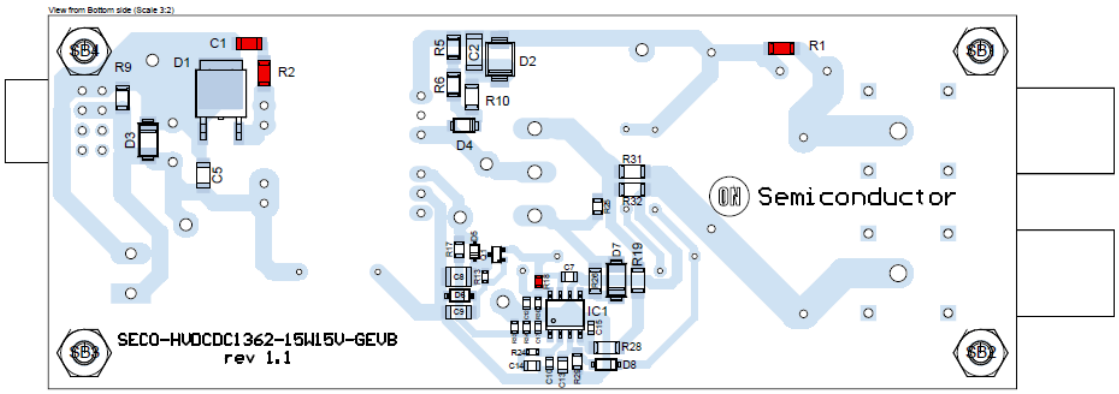
Table 1. BILL OF MATERIAL (continued)

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



Top Assembly



Bottom Assembly

Figure 22. Layout

References

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

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