Evaluation Board with F2 TNPC M3S Module Evaluation Board User's Manual

EVBUM2883/D

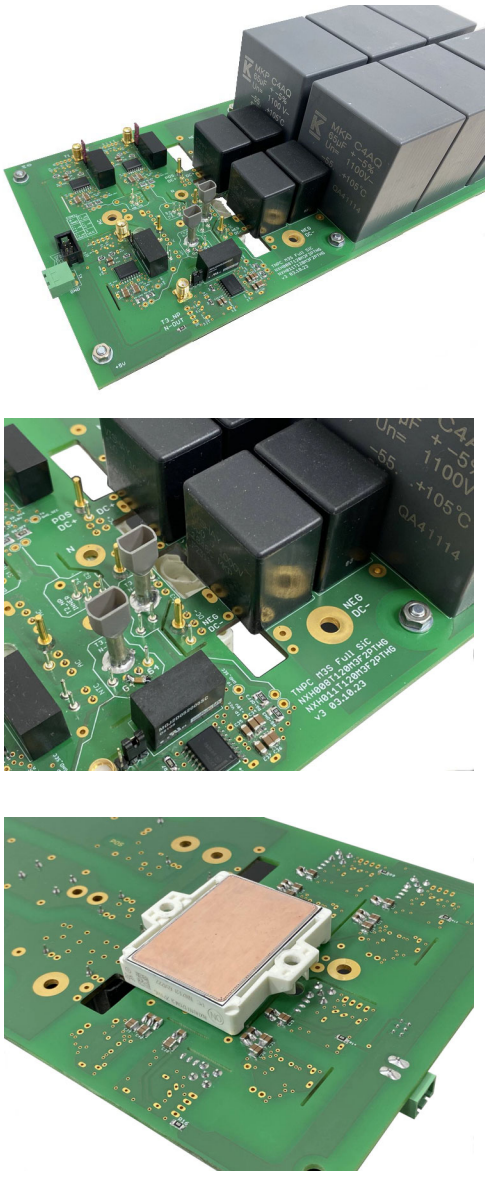

Figure 1. Evaluation Board Photo Views

Evaluation Board Description

This evaluation board supports evaluation of NXH008T120M3F2PTHG or NXH011T120M3F2PTHG –3 level TNPC – Neutral point clamped, T−type, 8 mohm or 11 mohm module consisting of 1200 V M3S SiC MOSFET working together with NCD57100 gate drivers. This demo board should be used as an example for designing an energy infrastructure application, such as PV inverter, UPS, or EV−charger. This manual describes the board function, schematics, bill of material, board layout, thermal properties and operation.

Module is not assembled in power board. Must be installed separately.

The evaluation board can be assembled with 1x SiC mosfet module (PIM) pressed to the PCB using press−fit technology. The gate driver stage consists of 4x NCD57100 high current galvanically isolated gate driver. The driver provides 5 kV insulation between primary and secondary side. Secondary side of the gate is supplied through isolated DC/DC voltage source realized by integrated DC–DC source (05−1803). Recommended operation V_{GS} voltage is 18 V / −3 V.

The evaluation board can be connected to an external controller providing PWM inputs by connector located on the board. Use of an external sensor for over current and over voltage protection is recommended.

Evaluation Board Operation

The board is designed as ROHS compliant. Design of the board was not qualified for manufacturing. No tests were made on whole operating temperature range. No lifetime tests were performed. The board must be used in lab environment only and must be operated by skilled personal familiar with all safety standards. Further details of used components are in respective datasheets.

Features

- Very Low R_{DSon} Module Solution, can handle Power up to 20 kW
- 4x Isolated Gate Driver for individually for Each Switch with 5 kV Insulation
- Module NTC for Temperature Sensing
- Low Inductance PCB Layout
- Press−fit Pin Technology
- VDC Bus Film Capacitors Bank – DC Source can be Connected Directly, Additional Capacity Connection Not Needed

EVALUATION BOARD DESCRIPTION

Evaluation Board Block Diagram

The PCB carries gate driver stage (4x same driver block controlled each switch individually), symmetric voltage power terminals and input PWM terminals and power stage with TNPC module.

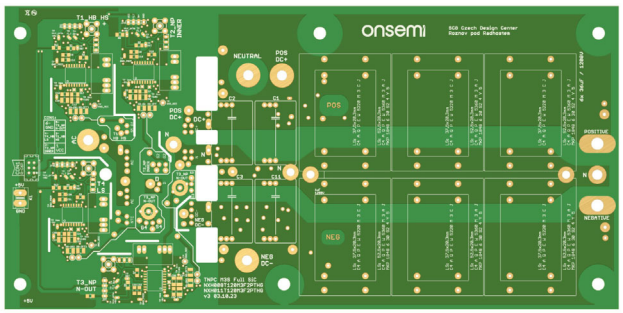

Figure 2. PCB Layout Overview

Mechanical Dimensions

Main board outline dimensions are 304.4 mm x 150 mm. The board outline is shown in Figure 3. Thickness of the main board is 2.47mm. Material is 2−layer FR4 PCB.

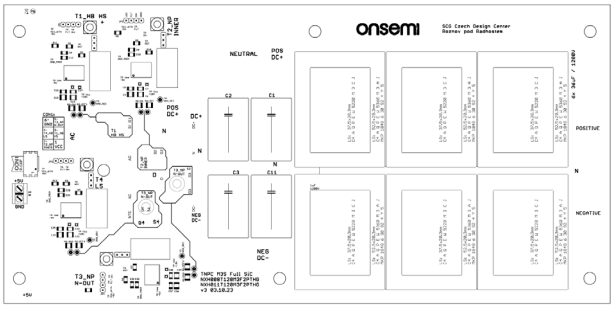

Figure 3. Board Placement Overview

Type: Double sided; Id: D384624 Date: 03.10.2023

2 layer stackup; Tg 135°		RIGID (A)		
Material text	Cu layer	Material	Thick [µm]	Plt drill
Green		Solder mask	20	
Copper (ED)	L1	Copper	35+25 Plt	A
FR4-DE104		Rigid laminate	2330	
Copper (ED)	L2	Copper	35+25 Plt	
Green		Solder mask	20	
Stackup thickness			Thick [µm]	
Estimated			2470	
Required			2400	
Plated drill		Start-stop layer		
Through holes		A = L1 - L2		

Figure 4. PCB Board Stack

Electrical Rating

The board is rated to DC voltage input symmetrical ±400 VDC. Which means 400 VDC between Vdc+ and Neutral, −400 VDC between Vdc− and Neutral and 800 V between Vdc+ and Vdc−. Nominal voltage in the DC link is 800 V (2x400 V). Maximum voltage in the DC link is 1000 V. There is no protection for exceeding maximum DC link voltage. No inrush current limitation is present on the board. There is needed connect symmetrical Vdc source, can be created from two same DC source in series. One DC source is not recommended, as there is not implemented protection against voltage unbalance.

Power Supply Connection

For the primary side of the gate drivers, the user must connect an external regulated voltage of 5 V / 1 A to connector JP1. Typical power board 5 V consumption is about 150 mA.

Secondary side of gate driver is supplied through integrated DC/DC source 5 V / +18 V, −3 V

NOTE: Integrated DC−DC source − Rated output voltage (18 / −3 V) is defined only with current load 80 mA. Without load (0−5 mA) output voltage reach up higher values → typically up to 21.75 V / −4.46 V.

Connector Pinout

For connection of PWM signals into the board the connector CON1, pinout is described below on

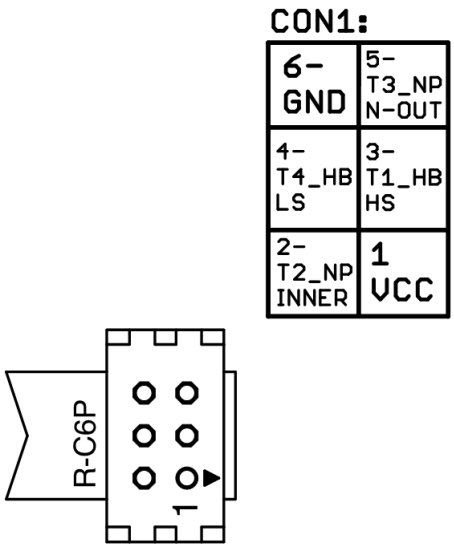

Figure 5. Input Connector Front Side View

Power Terminals Connection

For connection DC Source, Inductor and load is prepared M5 plated holes.

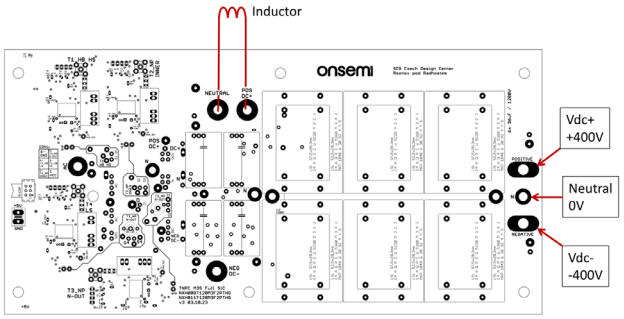

Figure 6. Main Power Terminal Connection

Double Pulse Test Waveforms

Results of double pulse test conducted on the demo board are presented below. As MOSFET has 1200 V rated voltage, acceptable VDC bus voltage is up to 1000 V. Switching speed is mostly depends on used Rg value, recommended range is 2.7−6.8 Ω, maximum Vds overshoot should be below 1200 V.

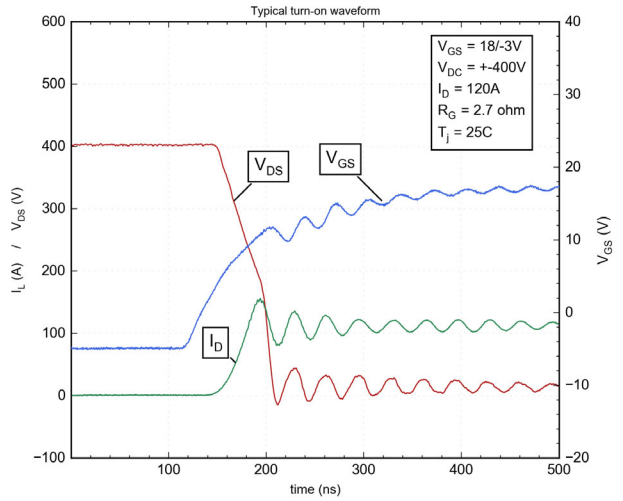

Figure 7. Double Pulse Test Waveform − Turn On (NXH011T120M3F2PTHG)

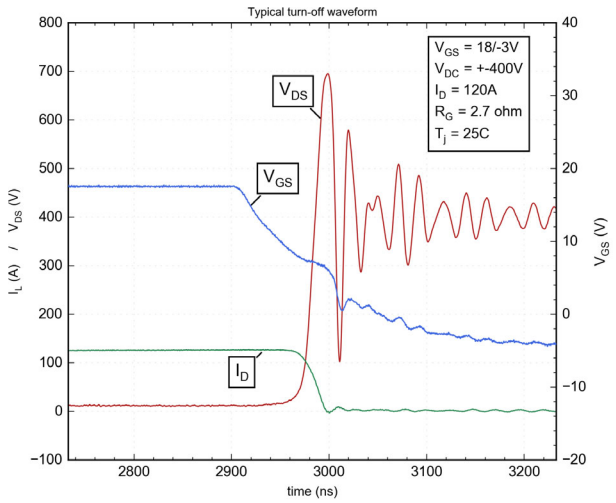

Figure 8. Double Pulse Test Waveform − Turn Off (NXH011T120M3F2PTHG)

11 mR vs. 8 mR Switching Losses

The PCB board is capable to accommodate both version of modules, 8mR TNPC module (NXH008T120M3F2PTHG) or 11 mR TNPC module (NXH011T120M3F2PTHG).

8 mR TNPC module is suitable for power level range up to 25 kW. 11 mR TNPC module is suitable for power level range up to 15 kW.

TNPC commutations paths

TNPC topology has two commutation paths:

- **Halfbridge commutation path** – switching halfbridge MOSFET T1/T4 with freewheeled MOSFET T2+T3 (Body diode D2,D3 conduct during deadtime) in neutral point path
- **Neutral point commutation path** – switching neutral point mosfet T2/T3 with freewheeled halfbridge MOSFET T1 or T4 (Body diode D1 or D4 D3 conduct during deadtime)

For double pulse testing is recommended to test both commutation paths, however as there is same BOM in HB and NP commutation path, we can expect similar waveforms and losses.

Manual – Functional Verification

After assembly board is recommended to do following steps to check properly drivers operation.

For temporary control MOSFET switch there are located jumpers on board. By this jumper can be switch set to permanently OFF or ON for check driver function as output response on input signal. Location of these jumpers are on drawing below.

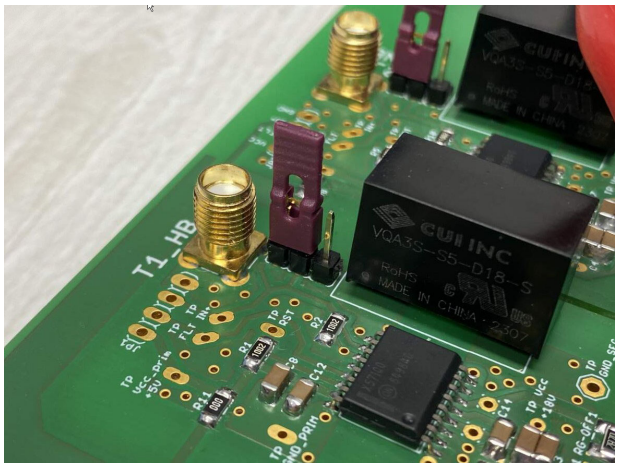

Figure 9. Primary Section of Driver Stage

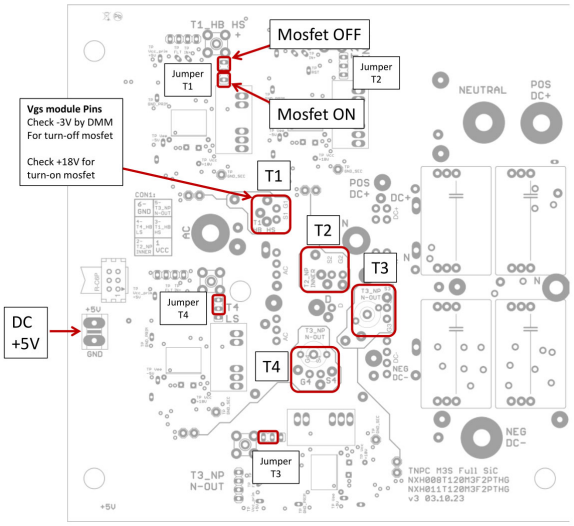

Figure 10. Vgs Module Pin Locations

Basic driver function is to control MOSFET. Input signal is transferred to the output through isolation barrier. If we temporary set input of driver as High by mentioned jumpers, there should positive voltage response on the output, typically 15−18 V. This basic behavior should be check during first board connection, before HV double pulse test. MOSFET driver is recommended to test for input LOW and HIGH state. Input value must correspond with output measured value. We have 4x driver stage for control each switch separately, its recommended to check all 4 drivers with this test.

After test all 4 switches, we can connect symmetrical VDC source with 0.1x nominal voltage ±40 V (80 V from DC− to DC+) for first test double pulse test. Connect PWM signal generator and oscilloscope probes. Detailed test procedure after assembly is in attachments of this file.

BOM – BILL OF MATERIALS

Item	Designator (Main Board)	Qty	Value / F−order_code / Manufacturer part number
1	LSP1, LSP2, LSP3, LSP4, LSP6, LSP7, LSP8, LSP10, LSP11, LSP12, LSP13, LSP14, LSP15, LSP16, LSP17, LSP18, LSP19, LSP20, LSP21, LSP22, LSP23, LSP24, LSP25, LSP26, LSP27, LSP29, LSP30, LSP32, LSP33	29	Not Placed
2	PAD12, PAD13, PAD16, PAD17, PAD25, PAD26, PAD34, PAD35	8	Not Placed
3	PAD6, PAD10, PAD14, PAD18, PAD23, PAD27, PAD32, PAD36	8	Not Placed
4	U$2, U$3, U$4, U$5, U$16, U$18	6	Not Placed
5	U$15, U$20, U$21, U$29, U$30	5	Not Placed
6	DUT1	1	Not Placed
7	U$12, U$14	2	0.8mm Pin−Socket in middle _F1629138_FISCHER ELEKTRONIK MK 221 100 Z
8	R9, R11, R12, R13, R14, R15, R16	7	0R___F1632520___MULTICOMP PRO MC1206S4F0000T5E
9	C5, C10, C12, C16, C21, C25, C33, C37, C7, C14, C23, C35	12	100n_100V__F2392394___KEMET C1206C104K1RACTU
10	R1, R2, R3, R4, R5, R6, R7, R8, R10	9	10k_F2446772__MULTICOMP PRO MCWR12X1002FTL
11	C8, C9, C20, C32	4	10uF/50V__F2672214__MURATA GRT31CR61H106KE01L
12	C6, C13, C17, C18, C19, C22, C26, C27, C29, C30, C31, C34, C38, C39, C40, C28, C4, C15, C24, C36	20	22uF/35V__F2522124__TDK C3216X5R1V226M160AC
13	RG−OFF, RG−OFF1, RG−OFF2, RG−OFF3, RG−ON, RG−ON1, RG−ON2, RG−ON3	8	2R7___MULTICOMP PRO MCWR12W2R70FTL
14	C1, C2, C3, C11	4	KEMET C4AQPBU4330M11J − 3.3UF, 1.2KV
15	JP1, JP2, JP3, JP4, JP5, JP7, JP8,JP6	8	F1462888___MULTICOMP PRO SPC20484__PIN_Header classic
16	X1, X2, X3, X4	4	F2096224__LPRS SMA RA CONNECTOR
17	K1	1	F2527725___CAMDENBOSS CTBP9350/2
18	PAD1, PAD2, PAD3, PAD4, PAD5, PAD7, PAD8, PAD9, PAD11, PAD15, PAD19, PAD20, PAD21, PAD22, PAD24, PAD28, PAD29, PAD30, PAD31, PAD33, GND3, GND8, GND9, GND17, GND18, GND19, GND27, GND28, GND29, GND37, GND38, GND39, LSP5, LSP9, LSP28, LSP31, LSP34	37	F2691435__ETTINGER 013.14.119
19	DR1, DR2, DR3, DR4	4	F3010447__**onsemi** NCD57000DWR2G
20	DC/DC1, DC/DC2, DC/DC3, DC/DC5	4	F4072502__CUI VQA3S−S5−D18−S + F1629138_FISCHER ELEKTRONIK MK 221 100 Z
21	CON1	1	WURTH ELEKTRONIK 61200621621
22	U$1	1	**onsemi** NXH008T120M3F2PTHG
23	U$6, U$7, U$8, U$9, U$19, U$27, U$28	7	Staubli MultiContact − S2D_42.0062
24	U$17, U$22, U$23, U$24, U$25, U$26	6	KEMET C4AQQEW5450M3AJ
25	PCB	1	PCB

Schematic

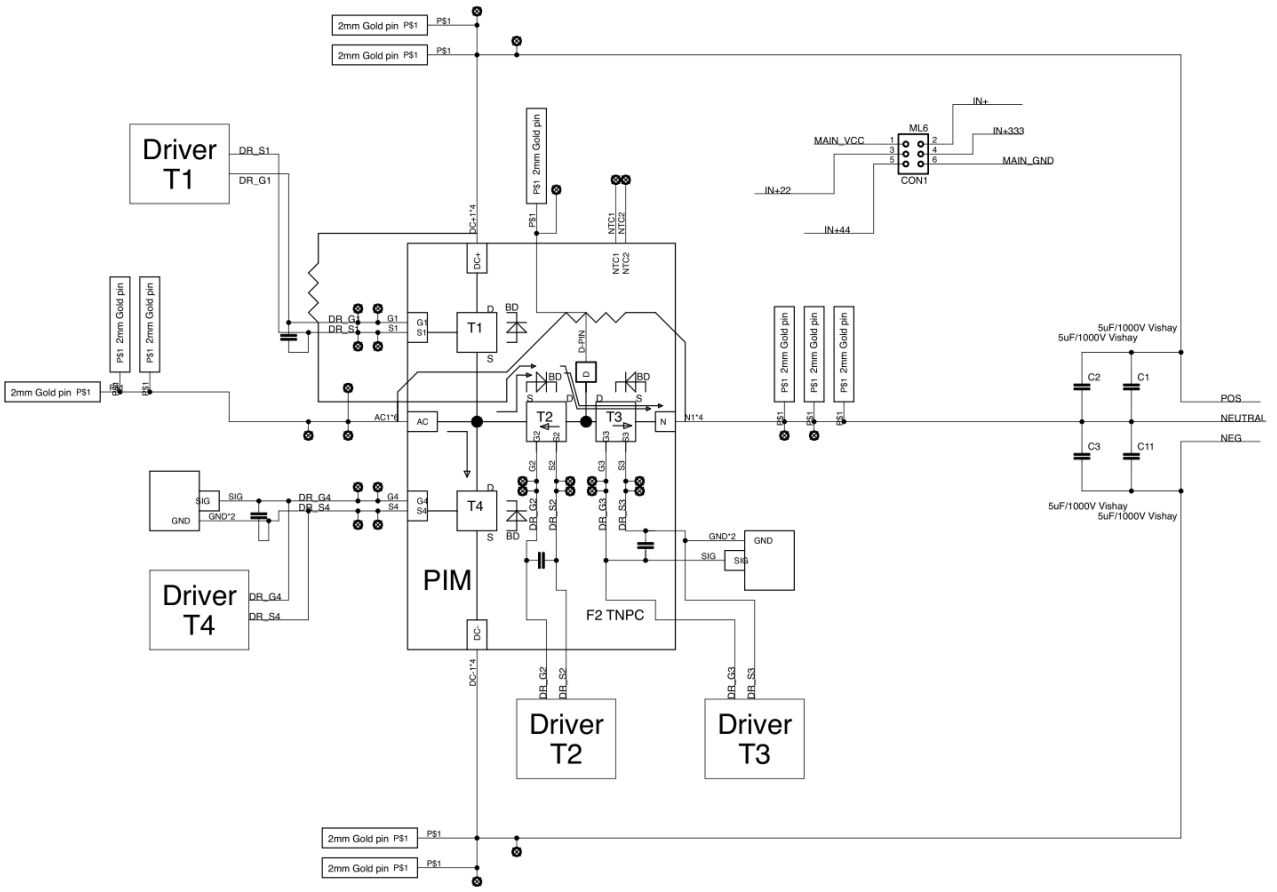

Figure 11. Schematic

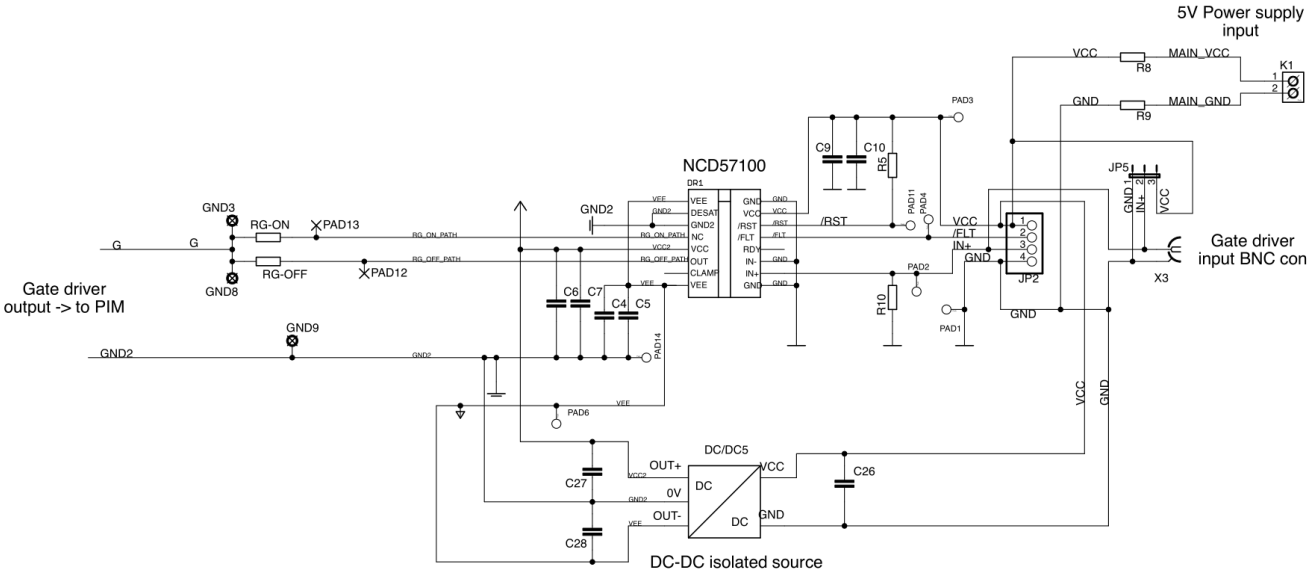

Figure 12. Driver Block T1−T4

PCB Layout (Layers Views)

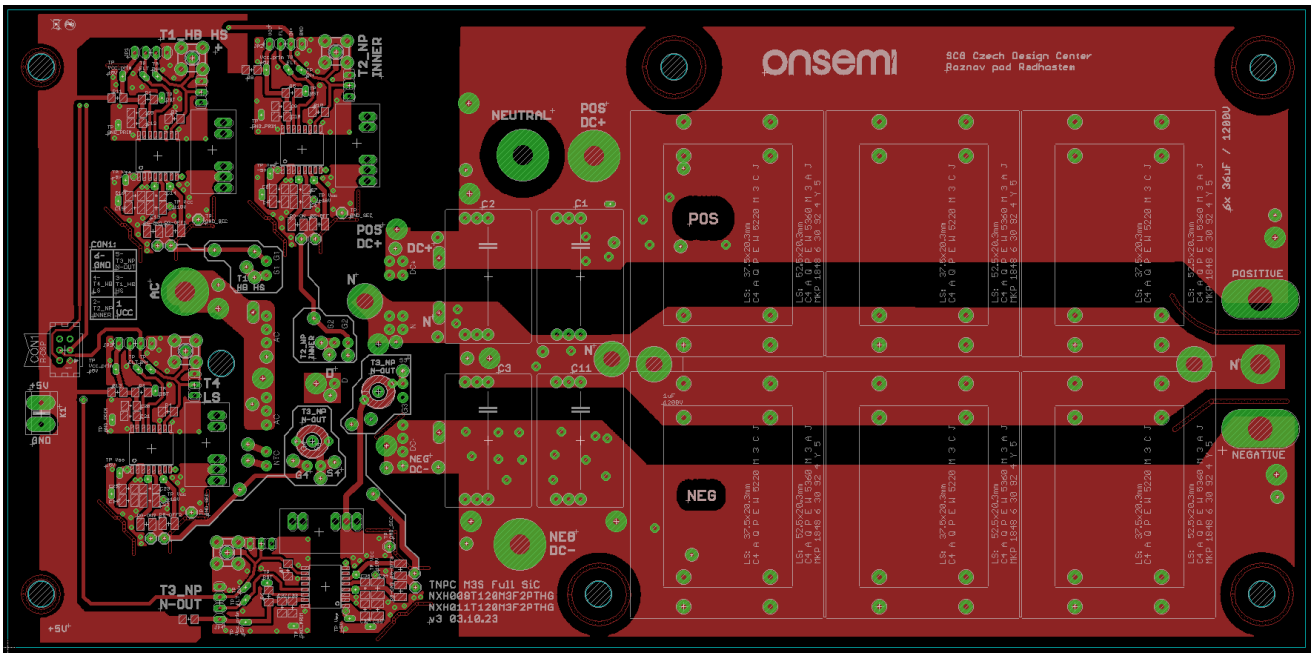

Figure 13. Top Layer

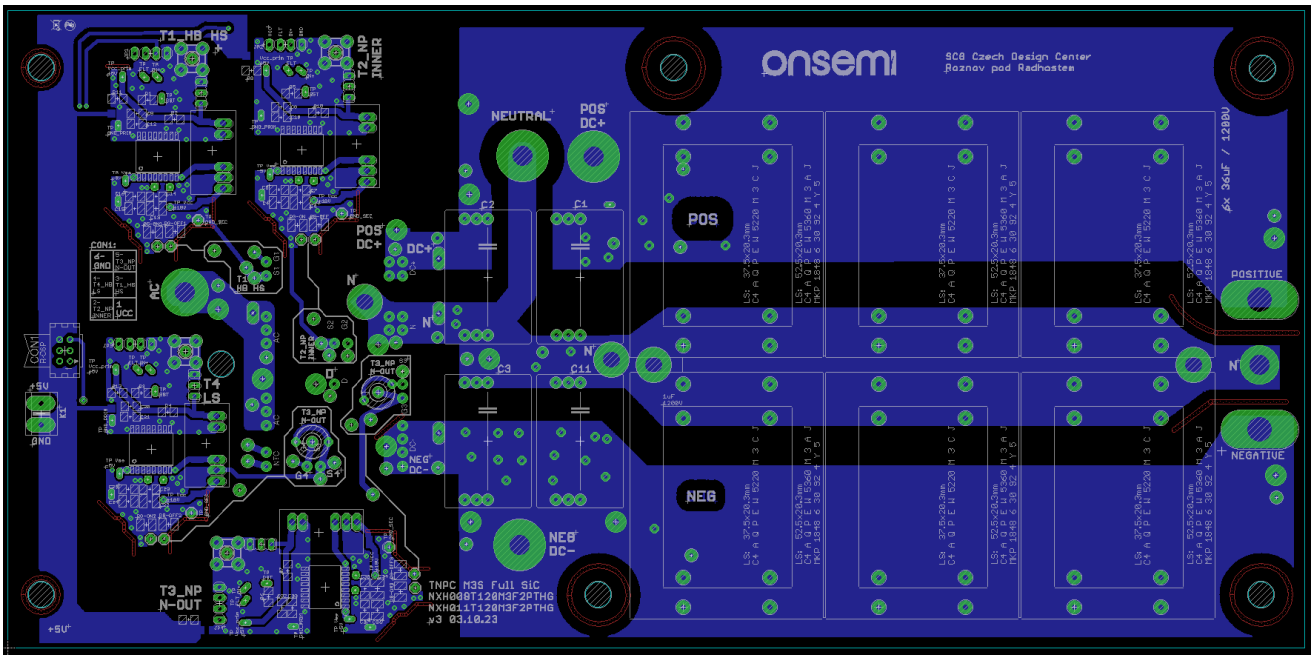

Figure 14. Bottom Layer

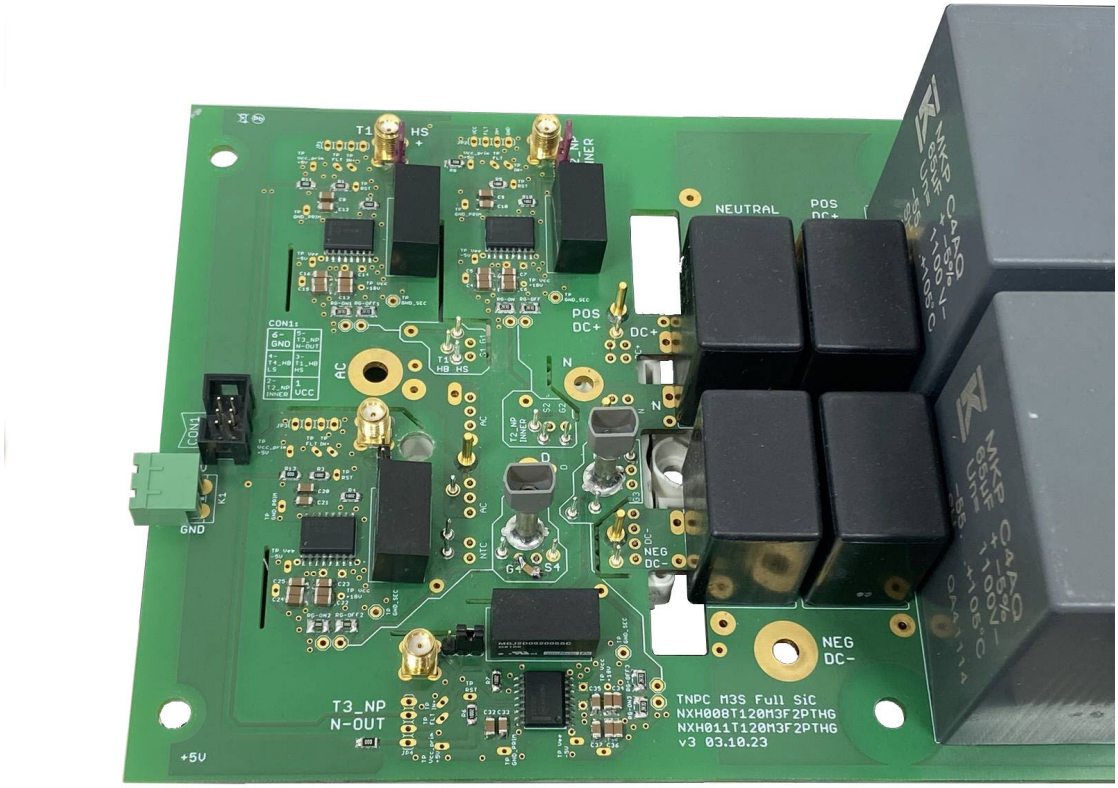
T1
HS
+
NEUTRAL
POS
DC+
CON1
GND
T3_NP
N-OUT
T1
HB
LS
T1
HB
HS
T2_NP
INNER
VCC
AC
N
T2_NP
INNER
D
NTC
G1
S1
NEG
DC-
GND
T3_NP
N-OUT
+5V
TNPC M3S Full SiC
NXH008T120M3F2PTHG
NXH011T120M3F2PTHG
v3 03.10.23

Figure 15.

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