NCV7546 FLEXMOS™ Hex Half-Bridge MOSFET Pre-driver Evaluation Board User's Manual

NCV7546VTFS5C460GEVB
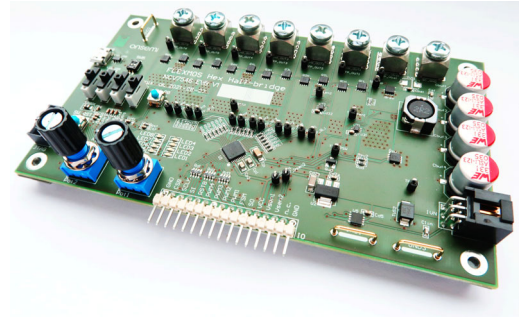

Figure 1. Evaluation Board Photo

Introduction

This document describes the NCV7546 evaluation board for the **onsemi** NCV7546 6−channel FLEXMOS™ MOSFET pre−driver. The functionality and major parameters can be evaluated with the NCV7546 evaluation board.

The NCV7546 programmable four channel half−bridge MOSFET pre−driver is one of a family of FLEXMOS automotive grade products for driving logic−level N−channel MOSFETs. The product is controllable by a combination of CMOS−compatible serial SPI and parallel inputs. The FLEXMOS family of products offers application scalability through choice of external MOSFETs.

Evaluation Board Features

- Six Half−Bridges for Motor Control
- Reverse Protection and Safety Switch
- Power MOSFETs in u8FL Package
- On−board +5 V LDO
- MCU with USB Interface
- On−board Current Sense Shunt Resistors and Current Amplifiers
- Good Thermal Connection of the Power MOSFETs allowing High Current Capability
- Oscilloscope Test−Points on All Important Signals
- M4 Screw Connectors for Power Signals (Battery, Ground, Outputs)
- Switches and Potentiometers for Standalone Mode Operation
- LEDs for Diagnostics
- One−row Pin Header, providing the Circuit Signals, enables Easy Insertion of the Evaluation Board into a more complex Application Setup
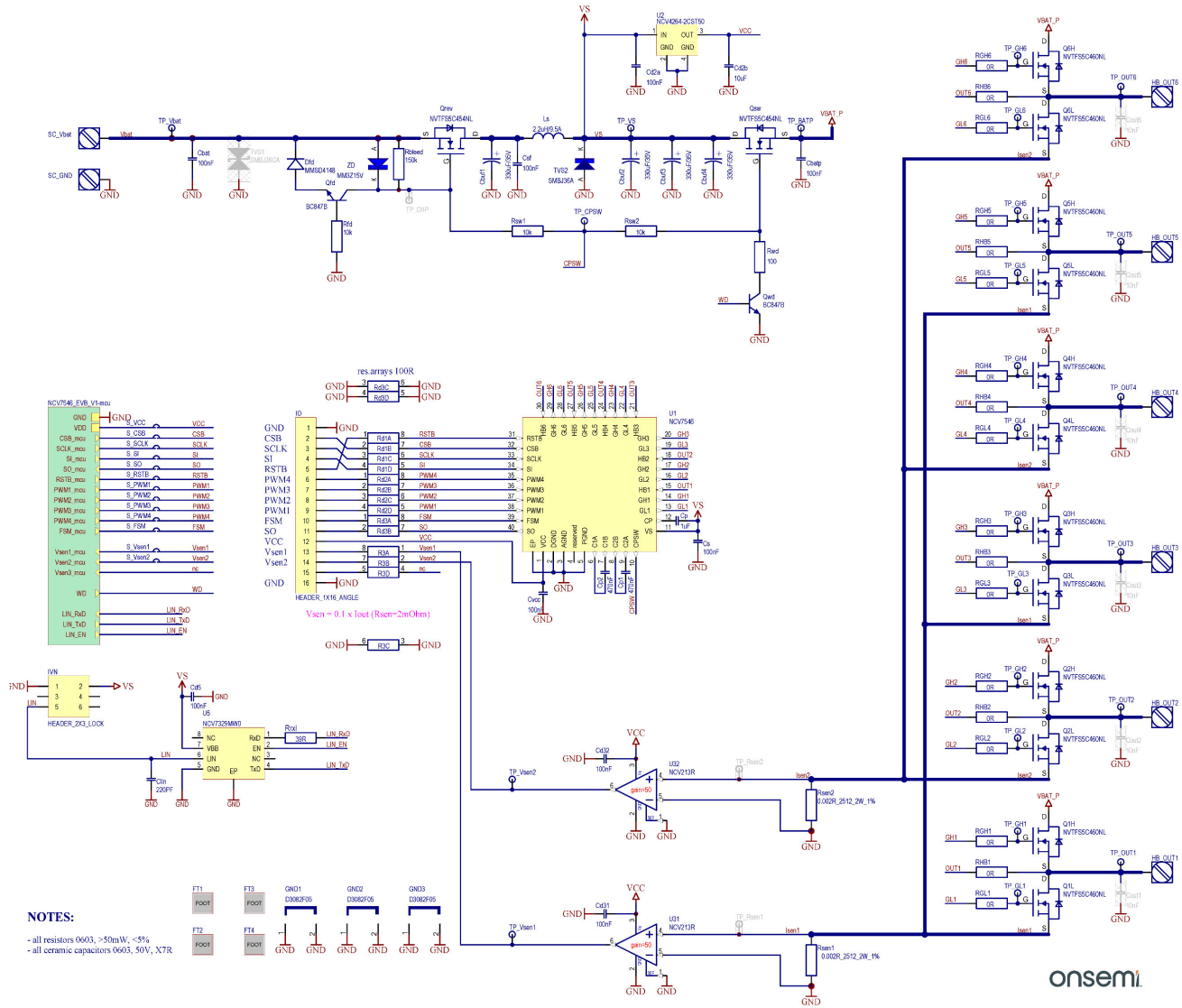
SCHEMATIC

Figure 2. NCV7546 Evaluation Board Schematic – Application Part

NCV7546VTFS5C460GEVB

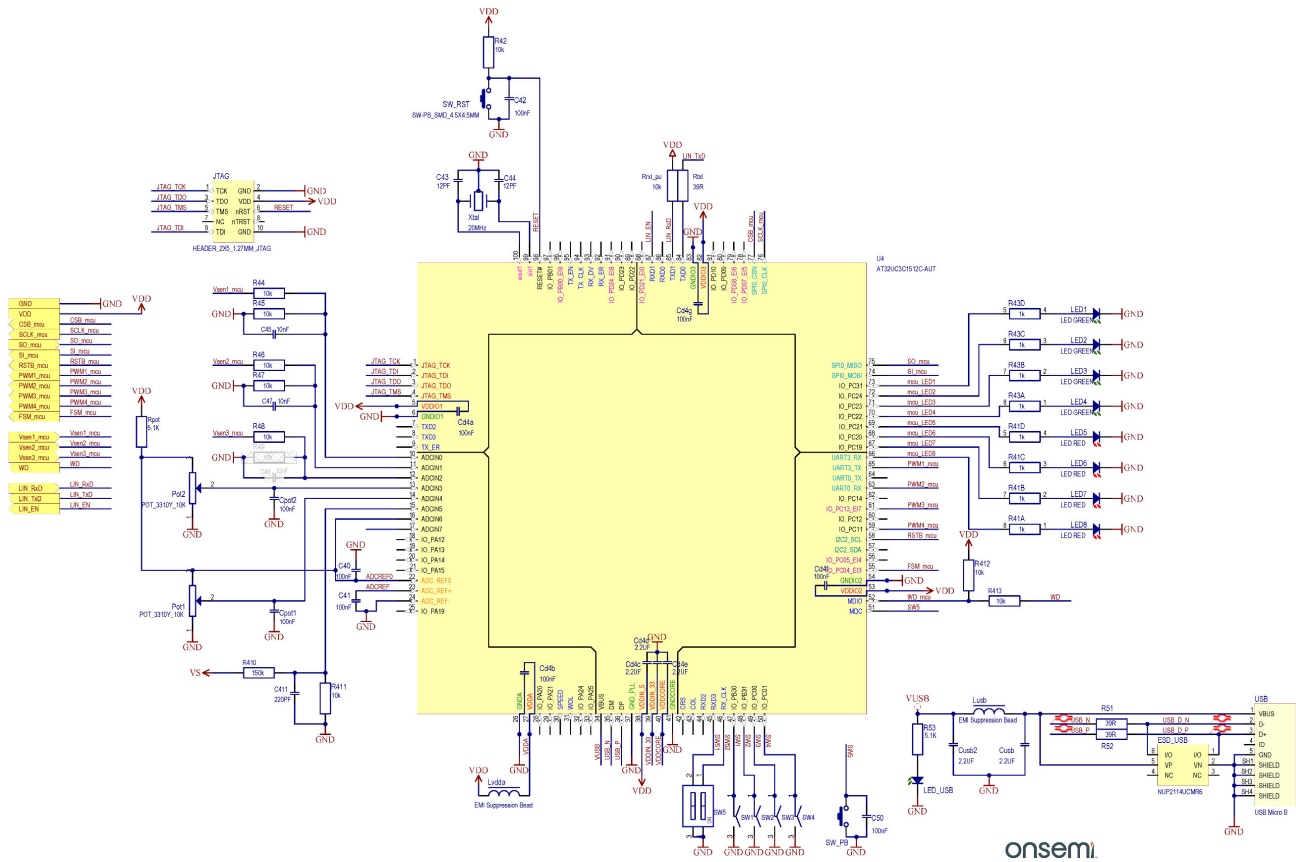**Figure 3. NCV7546 Evaluation Board Schematic – Control Part**

Table 1. ABSOLUTE MAXIMUM RATINGS

Rating	External Pin	Min	Max	Unit
Power Supply voltage	Vbat	−40	40	V
Digital Supply voltage (on−board supply)	VCC	−0.3	5.5	V
Digital inputs/outputs voltage	CSB, SCLK, SI, SO, RSTB, PWM1−4	−0.3	VCC+0.3	V
Current sense output voltage	Vsen1−2	−0.3	VCC+0.3	
Current sense output current	Vsen1−2	Limited internally		A
H−bridge outputs DC voltage	HB_OUT1−6	−0.3	Vbat + 0.3	V
H−bridge outputs DC current	HB_OUT1−6	Limited internally		A
NCV7546 junction temperature	–	−40	+150	°C
Qrev, Qsw, QxH, QxL junction temperature	–	−55	+175	°C
Board temperature	–	−40	+125	°C

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

Table 2. RECOMMENDED BOARD OPERATING CONDITIONS

Rating	External Pin	Min	Max	Unit
Power Supply voltage	Vbat	6	28	V
Digital Supply voltage	VCC	+5 V ± 2% (on−board supply)		V
Digital inputs/outputs voltage	CSB, SCLK, SI, SO, RSTB, PWM1−4	0	VCC	V
Current sense output voltage	Vsen1−2	Generated internally		
Current sense output current	Vsen1−2	Internally limited		A

Table 2. RECOMMENDED BOARD OPERATING CONDITIONS (continued)

Rating	External Pin	Min	Max	Unit
H−bridge outputs DC voltage	HB_OUT1−6	0	Vbat	V
H−bridge outputs DC current	HB_OUT1−6	−10	10	A
NCV7546 junction temperature	–	−40	+150	°C
Qrev, Qsw, QxH, QxL junction temperature	–	−55	+175	°C
Board temperature	–	−40	+105	°C

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

OPERATIONAL GUIDELINES

The evaluation board contains all the components necessary for NCV7546 application: half−bridge output MOSFETs, a control MCU, USB interface, +5 V LDO supply for NCV7546 logic, MCU and current sense amplifiers.

In addition, two potentiometers, four slide switches, a push button and eight LEDs can be used to control the board.

To demonstrate full functionality, a PC can be connected through a micro USB connector.

Alternatively, an external MCU can be connected through the IO connector to control all functions and settings of NCV7546.
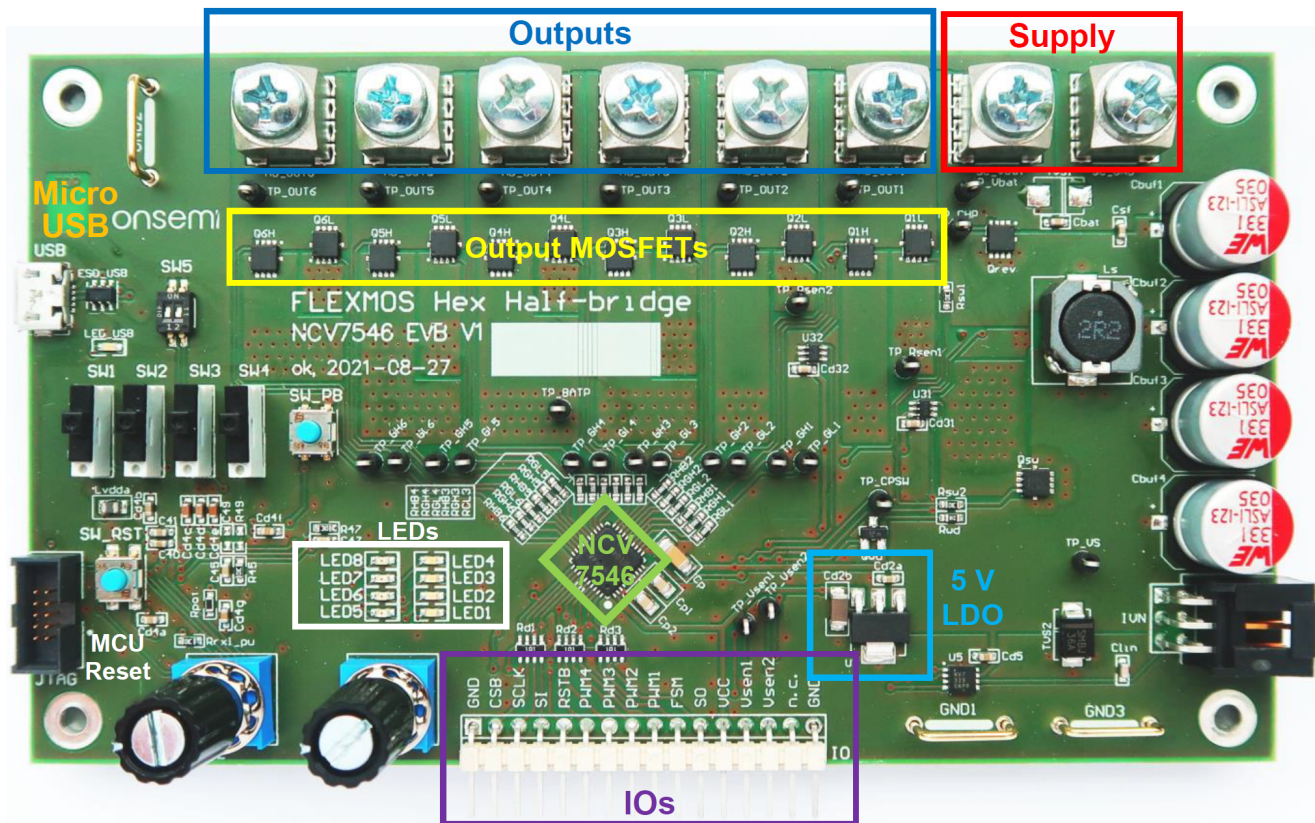
Figure 4. NCV7546 Evaluation Board Picture, Top Side
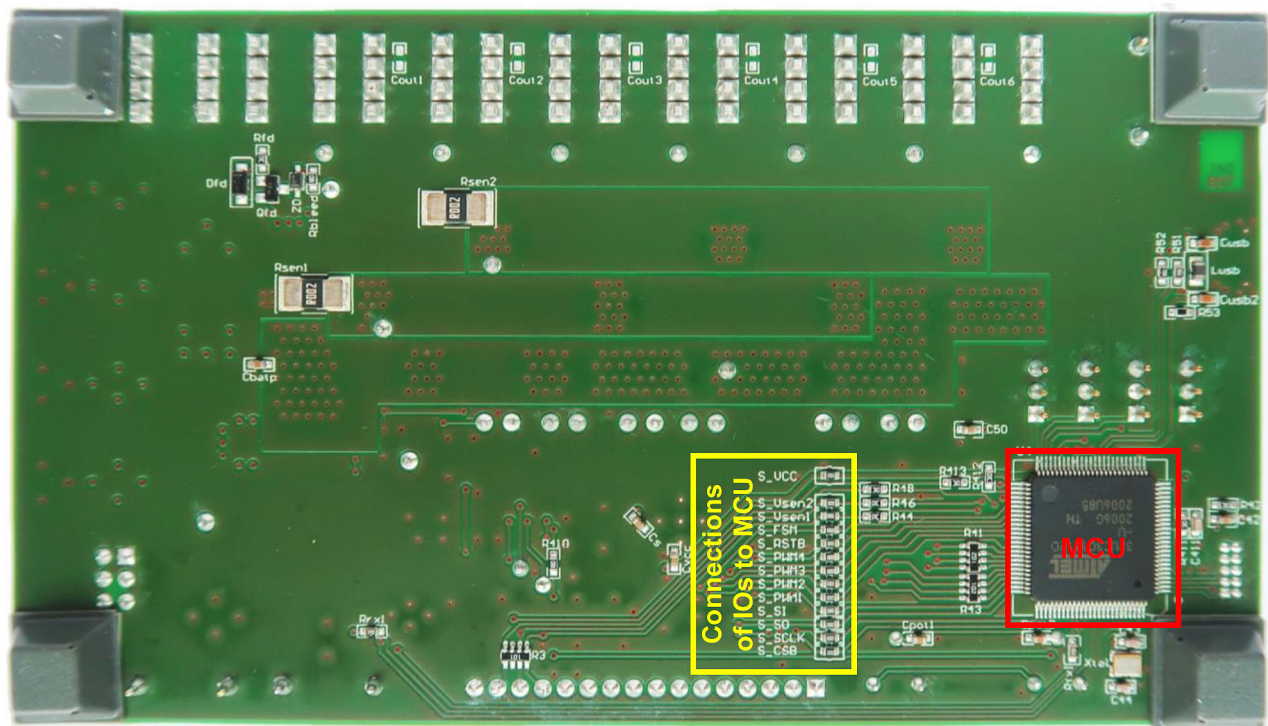
Figure 5. NCV7546 Evaluation Board Picture, Bottom Side

FUNCTIONAL DESCRIPTION

Power Supply

The output stage of NCV7546 pre−driver is supplied via VS pin. N−MOSFET Qrev ensures battery−reverse protection, while Qsw can disconnect the half−bridges' supply.

By default, half−bridges' power supply is buffered by four low−ESR capacitors covering high current peaks caused by the inrush current or PWM operation and absorbing energy stored in motor coils in case the supply voltage disappears.

Safety Features

In order to have full control over the loads, NCV7546 has integrated watchdog function. The microcontroller has to send a watchdog service periodically, otherwise NCV7546 enters the Fail−safe mode.

In addition, Qwd immediately pulls down Qrev and Qsw gates in case the microcontroller is reset.

The load current is limited internally to protect the MOSFETs and PCB. The MOSFETs activation time is limited if the maximum DC operational current is exceeded. The corresponding LED indicates an overload. After a cool−down time, the error has to be cleared by a SW_PB push−button.

Current Sensing Amplifiers

NCV7546 evaluation board contains three low−side sense resistors and operational amplifiers for the outputs current sensing.

The power MOSFETs type as well as sensing resistors' Rsen1−2 value are selected according to maximum application DC current. Higher current is possible for limited time as long as the junction and board temperatures are not exceeded.

The used dedicated current−sensing amplifier (NCV213R) has a fixed gain of 50 and the output is referenced to GND.

The resulting A−V ratio (with Rsen = 2 mΩ) is:

V_{sen} [V] = 0.1 x I_{out} [A]

GETTING STARTED

The board supports three ways of NCV7546 device control:

1. Standalone mode – PWM duty−cycle (motor speed) can be changed via on−board switches on two loads (motors).
2. PC control – the user has full control over NCV7546 settings using PC connected to the board via USB.

3. External MCU control – external MCU controls the all the NCV7546 settings directly via SPI and PWM1−4 pins. The on−board MCU has to be disconnected from these signals (S_xxx 0R resistors on the bottom side have to be removed).

Standalone Mode

1. Connect the loads to the screw bush connectors (see Figure 6). Supported loads are:
   a. A motor between HB_OUT1 and HB_OUT3
   b. A motor between HB_OUT2 and HB_OUT4
   c. A load between HB_OUT5 and GND
   d. A load between HB_OUT6 and GND
2. Connect the main supply (typ. 12 V) to "Vbat" and "GND" screw bush connectors (see Figure 6). The MCU starts in the Standalone mode automatically and NCV7546 is configured.
3. LED1 is on, other LEDs indicate NCV7546 status as listed in the table below.
4. SW1−4 and SW_PB have functions listed in the table below, Potentiometers Pot1 and Pot2 control the motors' speed.

Table 3. FUNCTIONS OF SWITCHES

Switch	Function	SW Down Position	SW Up Position
SW1	Motor direction	HB1 LS / HB3 HS	HB1 HS / HB3 LS
SW2	Motor direction	HB2 LS / HB4 HS	HB2 HS / HB4 LS
SW3	HB5 control	HB5 LS	HB5 HS
SW4	HB6 control	HB6 off	HB6 HS
SW_PB	Error clear	–	–

Table 4. FUNCTIONS OF LEDS

LED	Function	Color
LED1	Standalone mode	Green
LED2	reserved	Green
LED3	Remote mode (USB control)	Green
LED4	Firmware flashing	Green
LED5	Overload	Red
LED6	Over−Current (SR0.HB_QSB)	Red
LED7	Charge Pump Low (SR0.CPL)	Red
LED8	Charge Pump Fail (SR0.CPF)	Red

To safely enter the Standalone mode from PC controlled mode, the supply of the board needs to be disconnected.

PC Control Mode

1. Install the PC software and wait for drivers' installation, if needed.
2. Connect loads to the bush connectors (see Figure 6).
3. Connect main supply to "Vbat" and "GND" bush connectors (see Figure 6).
4. Connect the board by a Micro−USB connector to a PC (see Figure 6).
5. Run NCV7546 EVB software.
6. In the startup frame select corresponding virtual COM port (see Figure 7). You may need click the Refresh button several times.
7. Click "Connect" button.
8. The software should connect to the board. If the connection was successful, "Basic" window opens and the Standalone mode is left, which is indicated by LED3 on.
9. The device SPI registers are reset and pre−defined values are loaded.
10. Several level of control abstractions are available through "Window" item in the menu bar.
11. "Basic" window (Figure 8) demonstrates simple control of two loads including direction and speed

control. The translated commands are reflected in lower levels, down to SPI communication frames.
12. "Board" window (Figure 9) demonstrates application controls of two channels including device mode control, status readout, MCU PWM generators and load current measurements.
13. "HB Controller" (Figure 10) contains all the SPI settings grouped per output channel and MCU PWM generators.
14. "SPI Controller" (Figure 11) window provides direct access to all NCV7546 SPI registers.
15. "SPI Raw" window provides direct SPI communication without any limitation and free baud rate setting.
16. "Chip ID" window allows readout of NCV7546 ID Register.

Firmware Updates

The board and PC software supports firmware updates through the USB. The update procedure is described in a separate document. The update is normally not necessary, the boards are delivered with a programmed MCU.
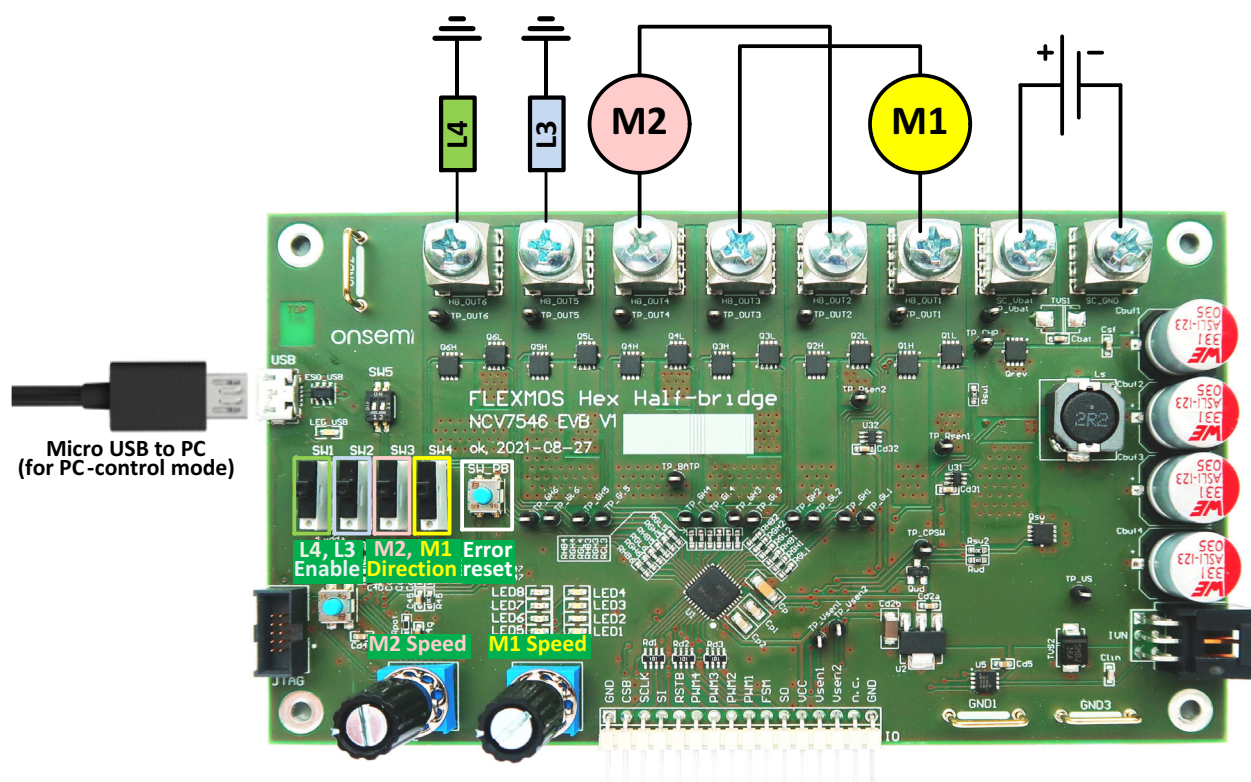
Figure 6. NCV7546 Evaluation Board Connections

NOTE: The PC software allows any combination of NCV7546 setting. Certain combination of pre−driver gate currents and timings may lead to a damage of the MOSFETs. Please ensure the setting is correct and the temperature of the power MOSFETs and loads stay in the safe operating range.

NCV7546VTFS5C460GEVB
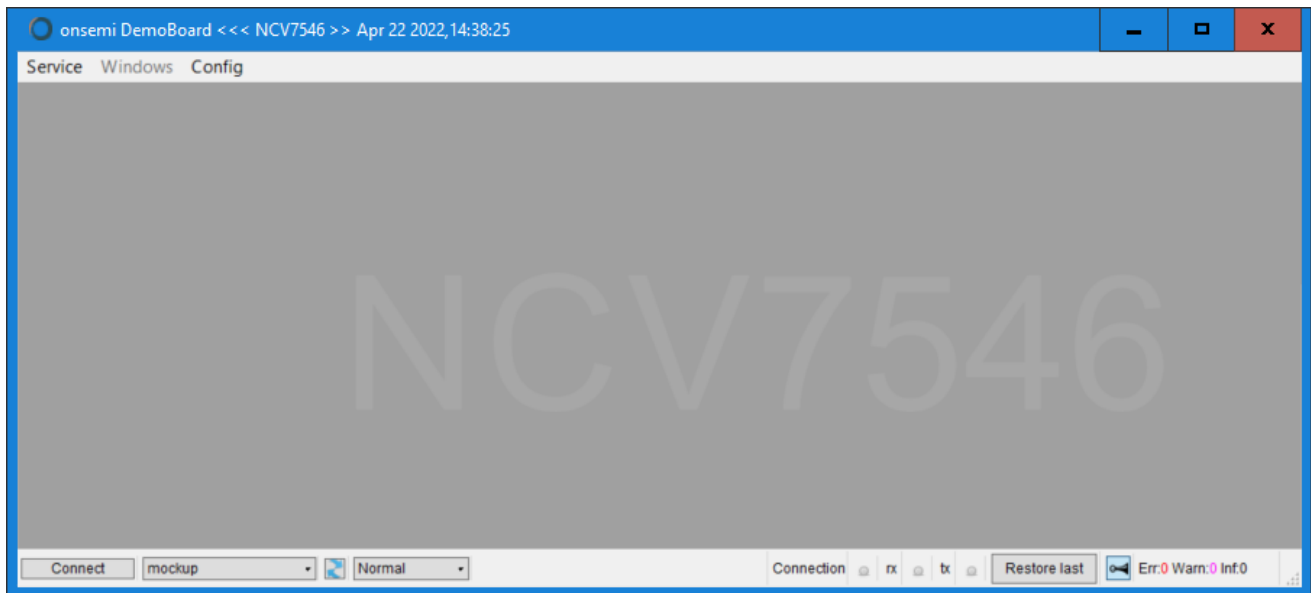
Figure 7. NCV7546 Controller Framework
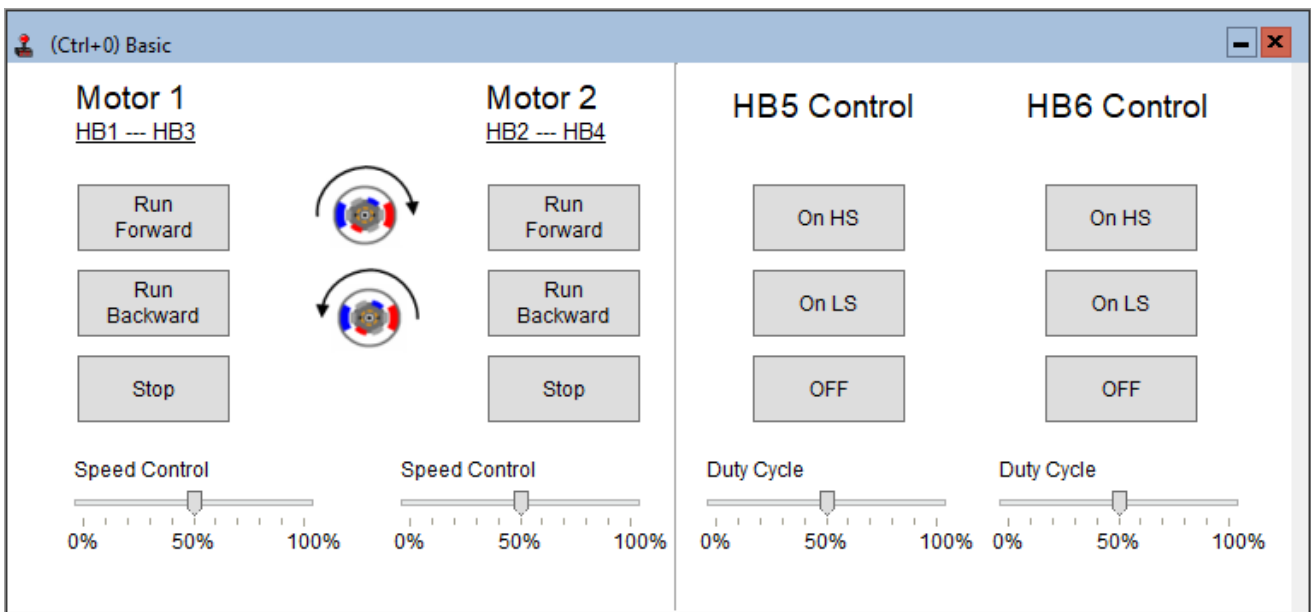
Figure 8. NCV7546 Controller Framework, Basic Window
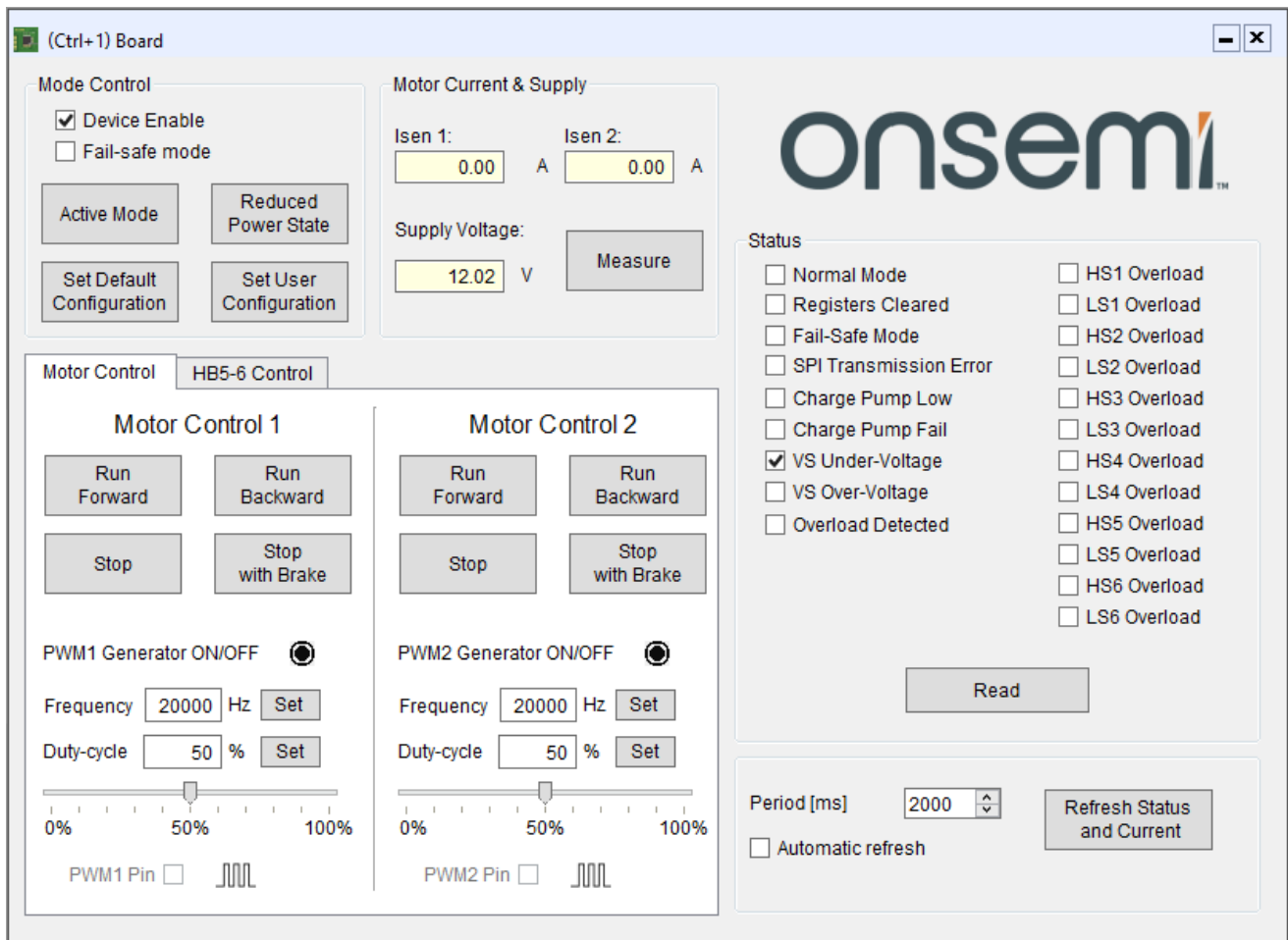
Figure 9. NCV7546 Controller Framework, Board Window
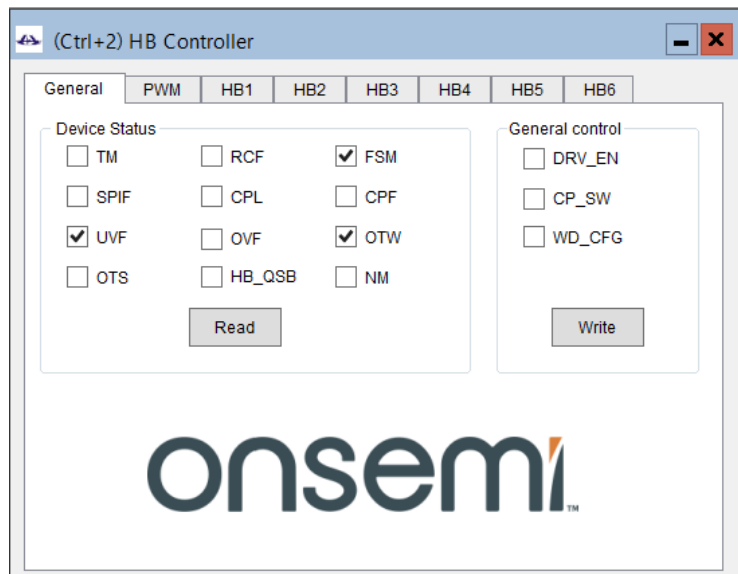
Figure 10. NCV7546 Controller Framework, HB Controller

(Ctrl+3) SPI Controller

Control

| CR0|1 | CR2|3 | CR5|6 | CR7|8 | CR9|10 | CR4|12|14 |

CR0 - Status Output Mode and HBx Enable

SOA[2:0]   SR0 ▾   Write

☐ HB1_EN   ☐ HB2_EN   ☐ HB3_EN   ☐ HB4_EN

☐ HB5_EN   ☐ HB6_EN   ☐ SOA_mode

CR1 - HBx Mode

☐ HB_MODE1   ☐ WD_CFG

☐ HB_MODE2   ☐ CP_SW

☐ HB_MODE3   ☐ DRV_EN

☐ HB_MODE4

☐ HB_MODE5   Write

☐ HB_MODE6

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Status

| SR0|5 | SR1|2|3 | SR4 |

SR4 - HBx Calibration Result

Read   ☐ CAL_RDY

CAL_DLY_R[1:0]   VHBx < 15 % ▾

CAL_PC_R[1:0]   VHBx < 5%   ▾

CAL_DLY_F[1:0]   VHBx > 85%   ▾

CAL_PC_F[1:0]   VHBx > 95%   ▾

Figure 11. NCV7546 Controller Framework, SPI Controller

PCB DRAWINGS

Assembly Drawings
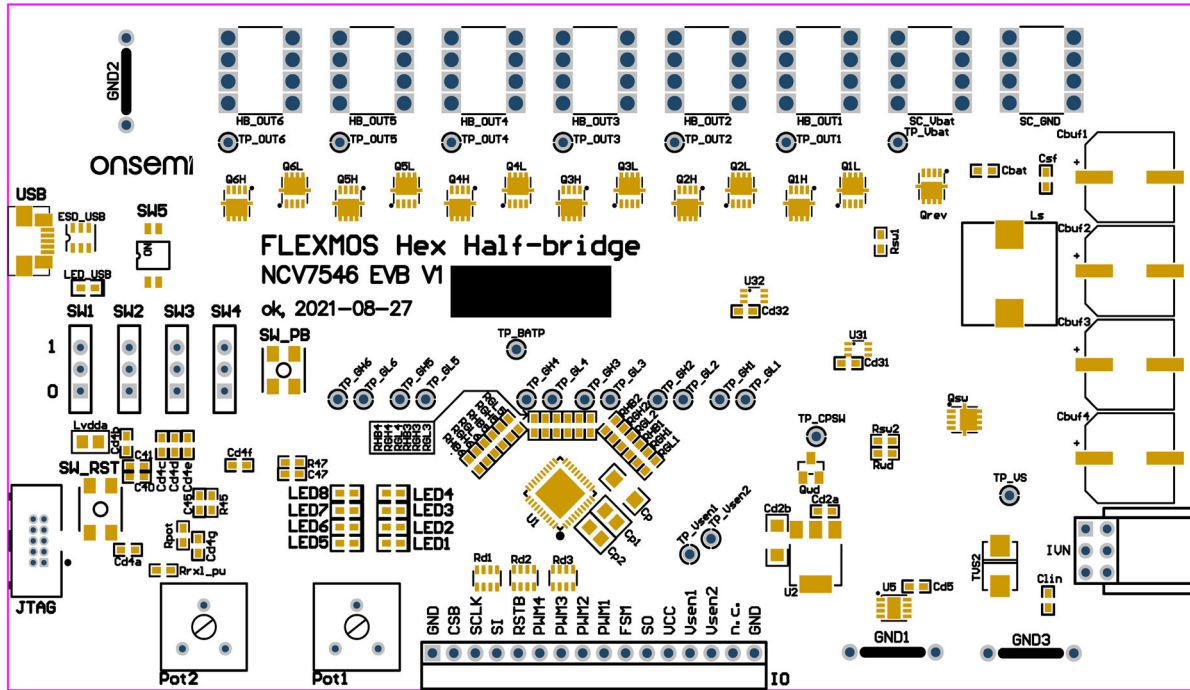
Figure 12. NCV7546 EVB PCB Top Assembly Drawing
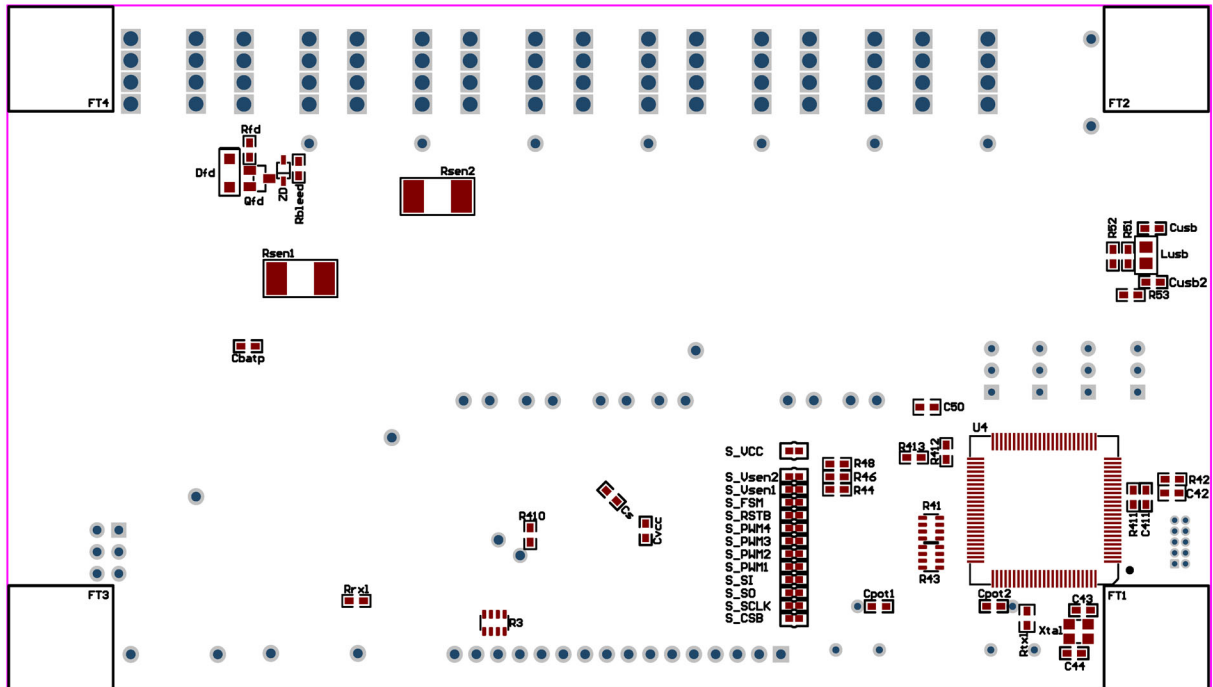
Figure 13. NCV7546 EVB PCB Bottom Assembly Drawing

Composite Drawings
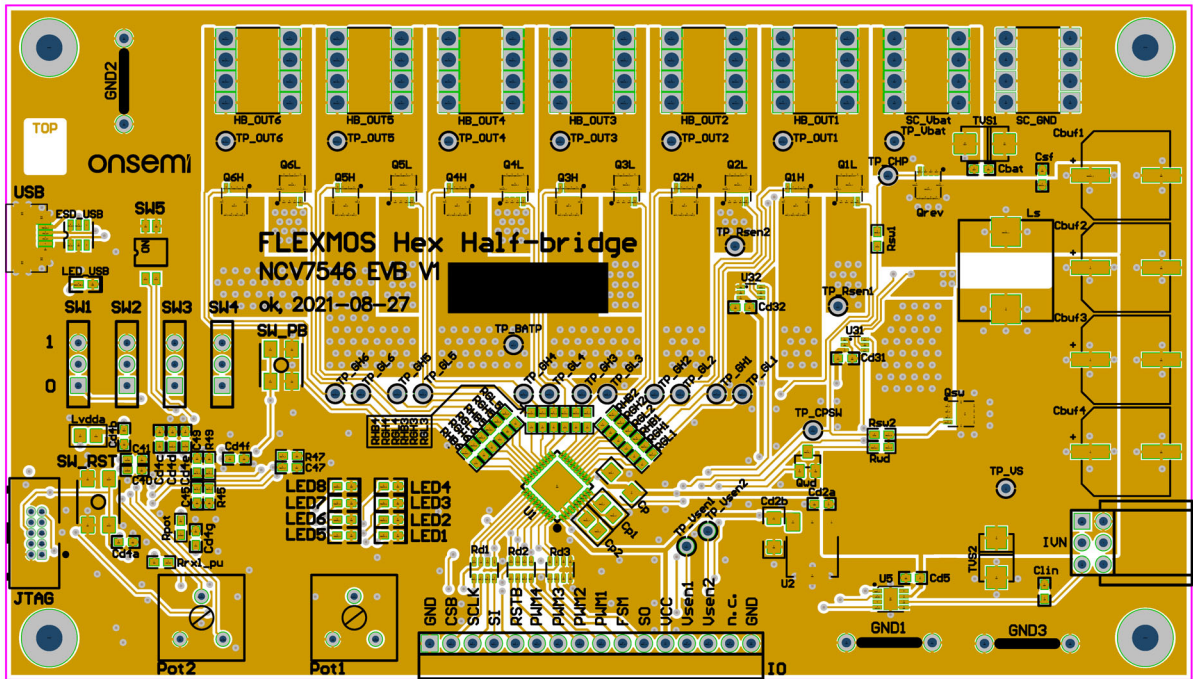
Figure 14. NCV7546 EVB PCB Top Composite Drawing
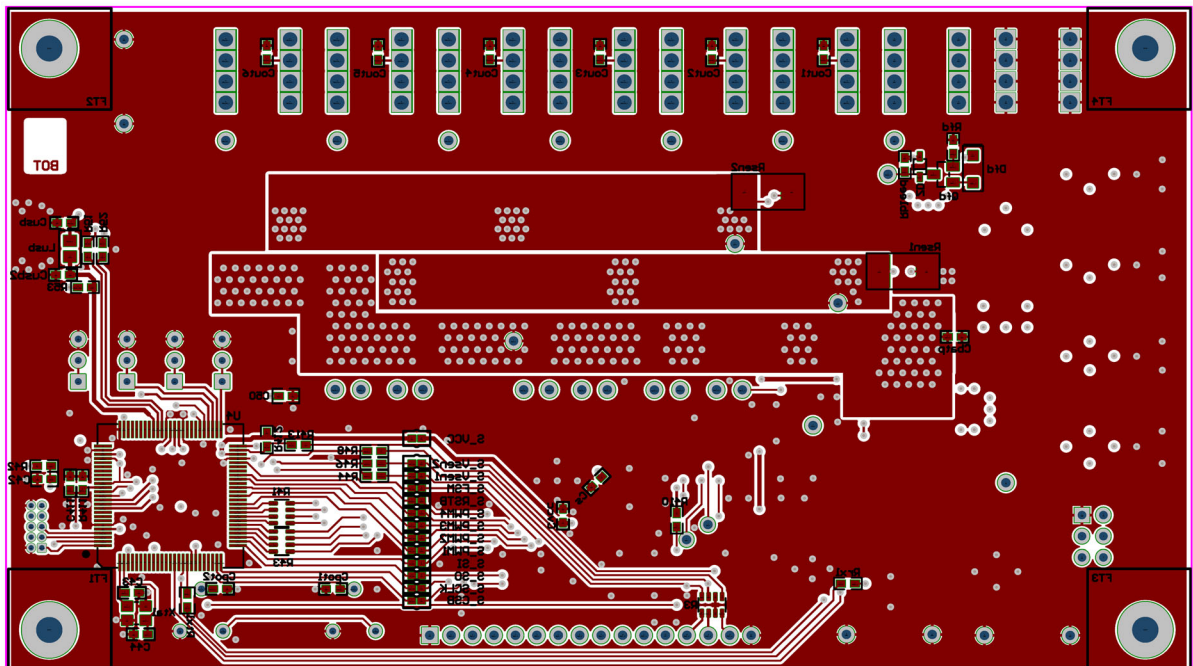
Figure 15. NCV7546 EVB PCB Bottom Composite Drawing
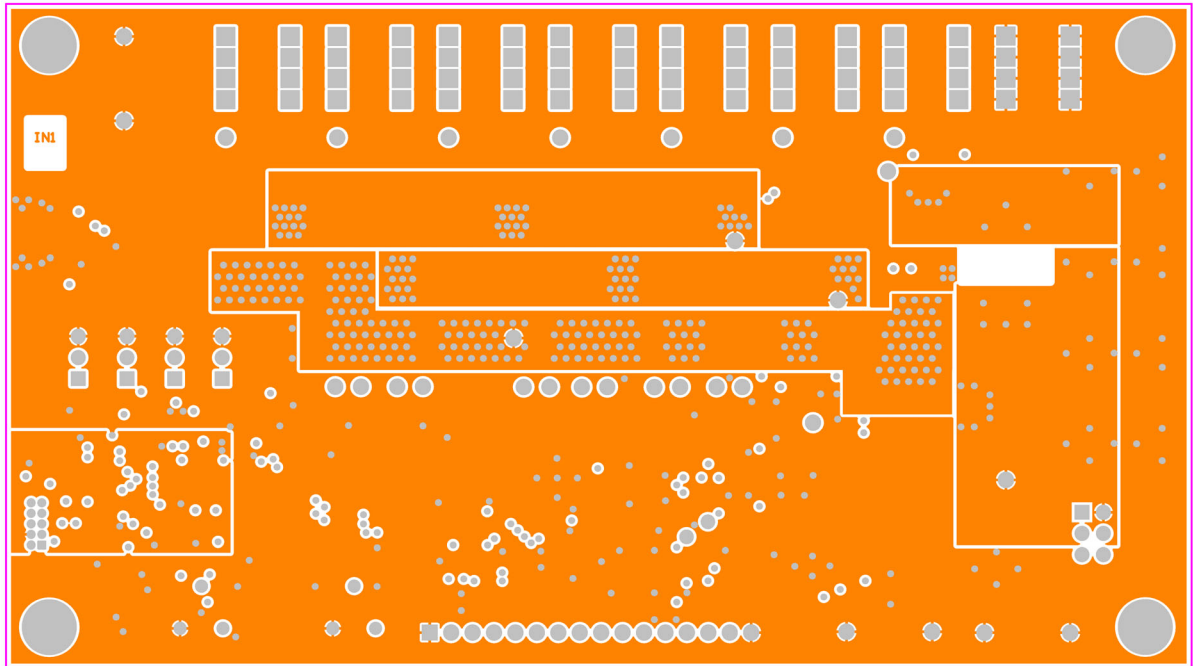
Figure 16. NCV7546 EVB PCB Internal Plane 1 Drawing
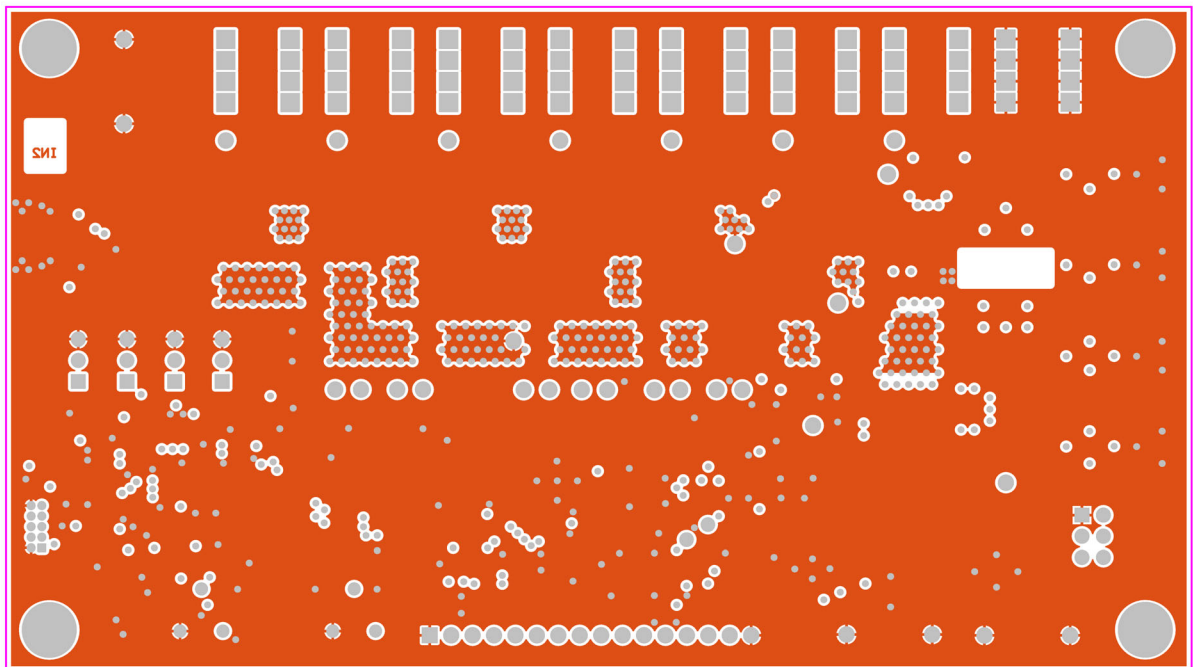
Figure 17. NCV7546 EVB PCB Internal Plane 2 Drawing

ADDITIONAL INFORMATION

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

ONLINE SUPPORT: www.onsemi.com/support
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