# EVBUM2703/D

# SECO-NCP51530HB-GEVB Evaluation Board User's Manual

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## EVAL BOARD USER'S MANUAL

### Description

This evaluation board is a part of system level support for applications in which high voltage (half bridge) gate driver is required. Its purpose is to simplify and accelerate design phase of switching parts (gate driver + power device) in application. The board showcases the Half−Bridge gate driver NCP51530 and two different MOSFET packages (DFN5 and WDFN8), with numerous test points, board offers simplified selection process for gate driver and power device, in order to obtain optimal performance. User is able to adjust gate resistances, bootstrap circuit and dead time and to monitor switching behavior. This daughter card is compatible with the SECO−GDBB−EVB gate drivers' baseboard, which allows testing up to 3 half bridge daughter cards simultaneously and comparing performances.

### Features

- NCP51530 High/Low Side Gate Driver
- 2 Different MOSFET Packages
- Adjustable Gate Resistance
- Adjustable Dead Time (Through External Resistors and Capacitor)
- Adjustable Bootstrap
- Gate Current and Gate Voltage Measurement
- Interface to Baseboard (Plug and Play)

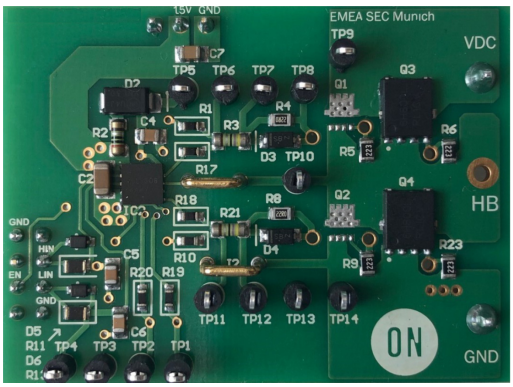


**Figure 1. Evaluation Board Photo**

**Table 1. AVAILABLE GATE DRIVERS**

| Gate Driver | Package |
|---|---|
| NCP51530 | DFN10 4x4 |

**Table 2. AVAILABLE FOOTPRINTS FOR MOSFETS**

| Footprint | MOSFETs |
|---|---|
| DFN5 (SO−8FL) | NVMFS6H800NL (Note 1) |
| WDFN8 (μ8FL) | NVTFS5C453NL (Note 2) |

1. 168 MOSFETs available in this package from ON Semiconductor.
2. 65 MOSFETs available in this package from ON Semiconductor.

## Schematic

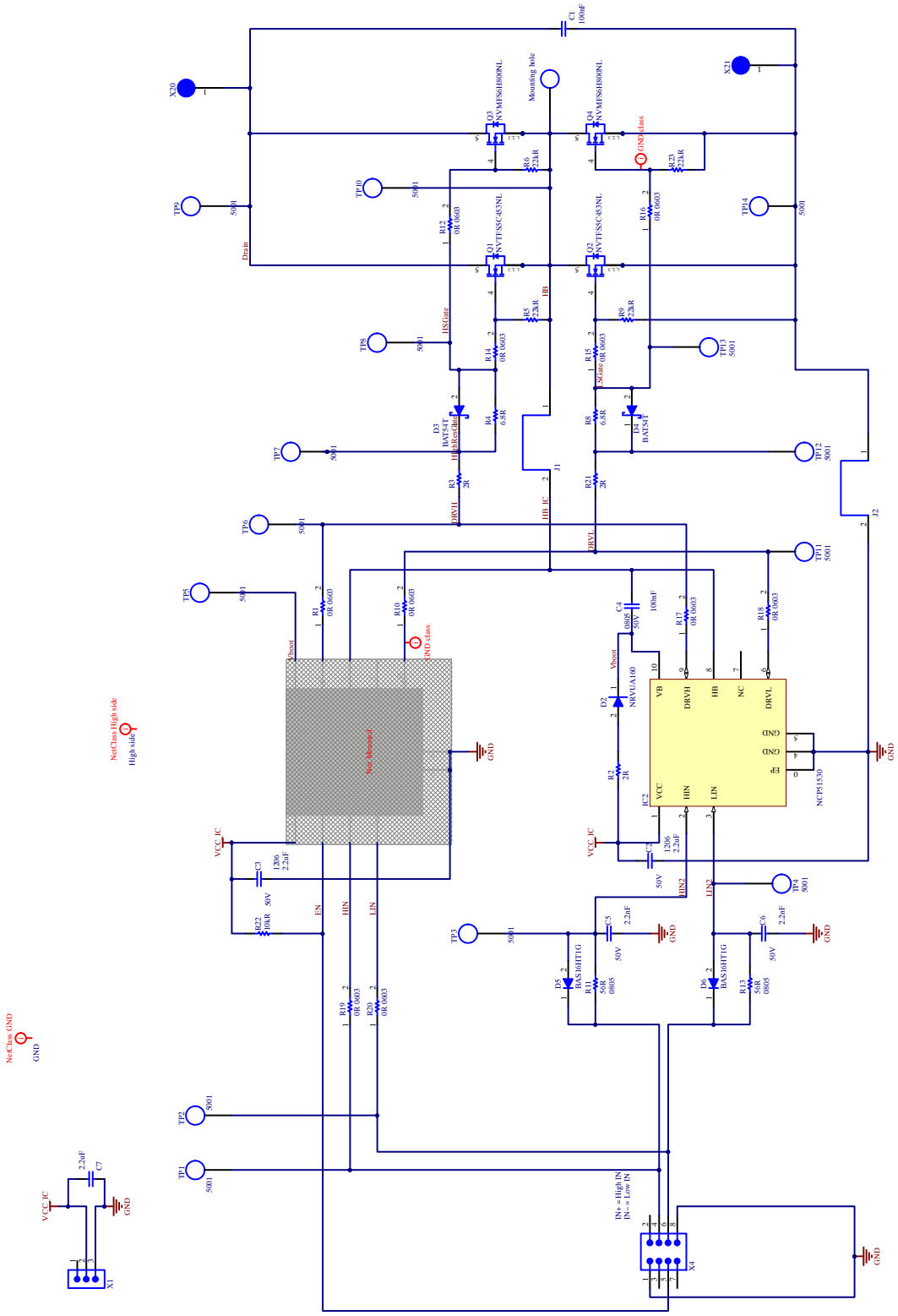

**Figure 2. EVB Schematic**

### I/O Connectors

**Table 3. DESCRIPTION OF CONNECTORS' PINS**

| Ref Des | Pin | Name | Type | Description |
|---|---|---|---|---|
| X1 | 1 | Not used | Na | Na |
| X1 | 2 | VCC_IC | Power | Voltage supply +15 V |
| X1 | 3 | GND | Power | Voltage supply reference |
| X4 | 1 | GND | Power | Voltage reference for control signals |
| X4 | 2 | Not used | Na | Na |
| X4 | 3 | Not used | Na | Na |
| X4 | 4 | HIN | Input | High side control |
| X4 | 5 | EN | Input | Enable |
| X4 | 6 | LIN | Input | Low side control |
| X4 | 7 | Not used | Na | Na |
| X4 | 8 | GND | Power | Voltage reference for control signals |
| X20 | 1 | VDC | Power | Half bridge DC bus voltage |
| X21 | 1 | GND | Power | Half bridge GND reference |
| Mounting hole | 1 | HB | Load | Half bridge load connection |

### Gate Driver and MOSFET Selection

This EVB consists of half bridge gate driver NCP51530 and two MOSFET package footprints:

- µ8FL
- SO8FL

User has multiple variants with MOSFETs in noted footprints.

To use **NCP51530** driver, place:

- R11 (value is defined based on dead time requirement),
- R13 (value is defined based on dead time requirement),
- R17 (0 Ω resistor),
- R18 (0 Ω resistor).

Remove:

- R1, R10, R19, R20

To use **µ8FL** package place:

- R14 (0 Ω resistor),
- R15 (0 Ω resistor)

Remove:

- R12, R16

To use **SO8FL** package place:

- R12 (0 Ω resistor),
- R16 (0 Ω resistor)

Remove:

- R14, R15

### Dead Time Setup

We use RC circuit with C = 2.2 nF. To choose resistor based on $t_{dead}$, use following formula:

$$R = \frac{t_{dead}}{0.693 \times 2.2\ nF} \qquad \text{(eq. 1)}$$

Default values for R11 and R133 are 56 Ω (for 80 ns dead time, same as NCV51513 driver).

Adjust dead time in accordance with application (gate resistors, load, switching frequency, etc.).

### Test Points Description

**Table 4. TEST POINTS**

| Test Point | Description |
|---|---|
| TP1 | High side control input |
| TP2 | Low side control input |
| TP3 | High side control input with dead time delay for NCP51530 |
| TP4 | Low side control input with dead time delay for NCP51530 |
| TP5 | Bootstrap voltage (measure in respect to half bridge TP10) |
| TP6 | High side drive |
| TP7 | High side drive after gate resistor (R3 – current measurement, differential) |
| TP8 | High side gate (on MOSFET side) |
| TP9 | Drain voltage |
| TP10 | Half bridge |
| TP11 | Low side drive |
| TP12 | Low side drive after gate resistor (R21 – current measurement, differential) |
| TP13 | Low side gate (on MOSFET side) |
| TP14 | GND |

### Measurement Instructions

High Side Gate: Use differential probe and measure between TP8 and TP10

High Side Current: Use differential probe and measure between TP6 and TP7 or use Rogowski coil and measure around J1

Low Side Gate: Measure between TP13 and TP14

Low Side Current: Use differential probe and measure between TP11 and TP12 or use Rogowski coil and measure around J2

Bootstrap Voltage: Use differential probe and measure between TP5 and TP10

### Sizing Turn ON Gate Resistor

Turn on resistor is chosen to obtain the desired switching time. Depends on supply voltage, gate threshold voltage and Miller capacitance.

$$R_{total} = \frac{V_{DD} - V_{gs(th)}}{C_{rss} \times \frac{dV_{Out}}{dt}} \quad \text{(eq. 2)}$$

$$R_{total} = R_{drv} + R_{ON}$$

$$R_{drv} = 1.7\ \Omega$$

### Sizing Turn OFF Gate Resistor

Turn OFF resistor must be sized according to the application worst case. Equation relates gate threshold voltage to the drain dv/dt.

$$R_{gOFF} \leq \frac{V_{gs(th)}}{C_{gd} \times \frac{dV_{OUT}}{dt}} - R_{drv} \quad \text{(eq. 3)}$$

Other possibility is to define these values to obtain maximum peak gate current.

$$I_{peak} = \frac{V_{CC}}{R_{gate}} \quad \text{(eq. 4)}$$

### Selecting Bootstrap Capacitor

The bootstrap capacitor is charged every time the low side driver is on and the half−bridge pin is below the supply voltage of the gate driver (VCC_IC). The bootstrap capacitor is discharged only when the high side switch is turned on. It is the supply voltage for the high side circuit section. The first parameter to take care of is voltage drop on capacitor during its discharge. Maximum voltage drop depends on the minimum gate drier voltage to maintain and voltage drop on bootstrap diode. The value of bootstrap capacitor is calculated by:

$$C_{boot} = \frac{Q_{TOTAL}}{\Delta V_{boot}} \quad \text{(eq. 5)}$$

where $Q_{TOTAL}$ is the total amount of the charge supplied by the capacitor. Depends mainly on gate charge and leakage currents in bootstrap circuit.

### Selecting Bootstrap Resistor

Bootstrap resistor limits the peak current, introduces an additional voltage drop and increases charging time for the capacitor. All these effects should be taken into consideration when calculating its value.

### Selecting Bootstrap Diode

Bootstrap diode must be able to block DC bus voltage, is the first requirement. Other requirements are fast recovery, low parasitic capacitance and low reverse current.

### Test Results – Setup 1

| | |
|---|---|
| Gate Driver: | NCP51530B |
| Supply Voltage: | 15 V |
| Switching Frequency: | 100 kHz |
| Duty Cycle: | 50% |
| Turn ON Resistance: | 9.4 Ω |
| Turn OFF Resistance: | 4.7 Ω |
| Switching Power Device: | NVMFS6H800NL |
| Half Bridge Supply: | 30 V |
| Load: | No load |
| Temperature: | 25°C |

Values for gate resistors are defined in a conservative way. User shall calculated them to meet application requirements.

### Delay Input/Output

| | |
|---|---|
| Input Rising Threshold | 1.7 V Typical |
| Input Falling Threshold | 1.4 V Typical |
| Input Hysteresis | 1.3 V |

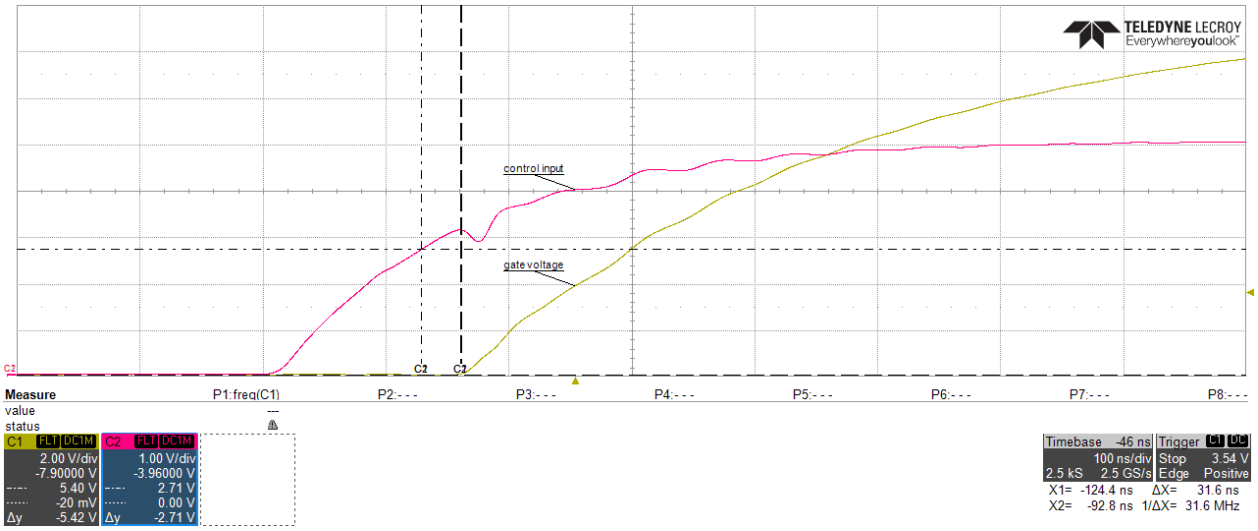


**Figure 3. Delay Propagation – Low Side**

Propagation delay: **31.6 ns** (measured from the moment rising threshold triggered to the moment gate voltage starts rising).

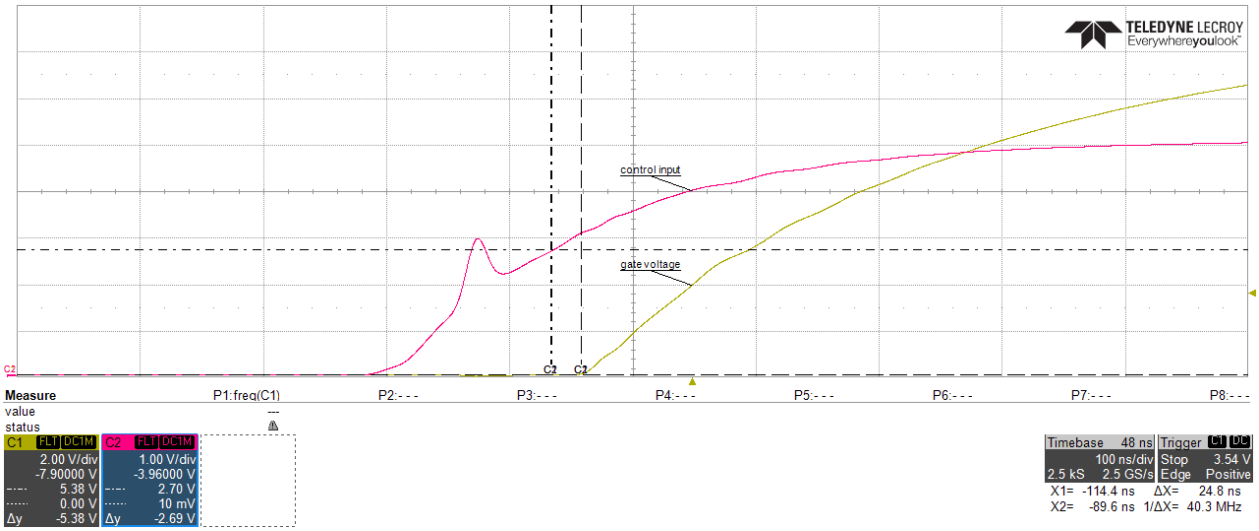


**Figure 4. Delay Propagation – High Side**

Propagation delay: **24.8 ns** (measured from the moment rising threshold triggered to the moment gate voltage starts rising).

Delay matching: **31.6 – 24.8 = 6.8 ns**

### Gate Peak Current

Currents measured differentially across 4.7 Ω gate resistor.

| | | |
|---|---|---|
| Peak Turn ON Current | Rg = 9.4 Ω | 1.1 A |
| Peak Turn OFF Current | Rg = 4.7 Ω | 1.6 A |

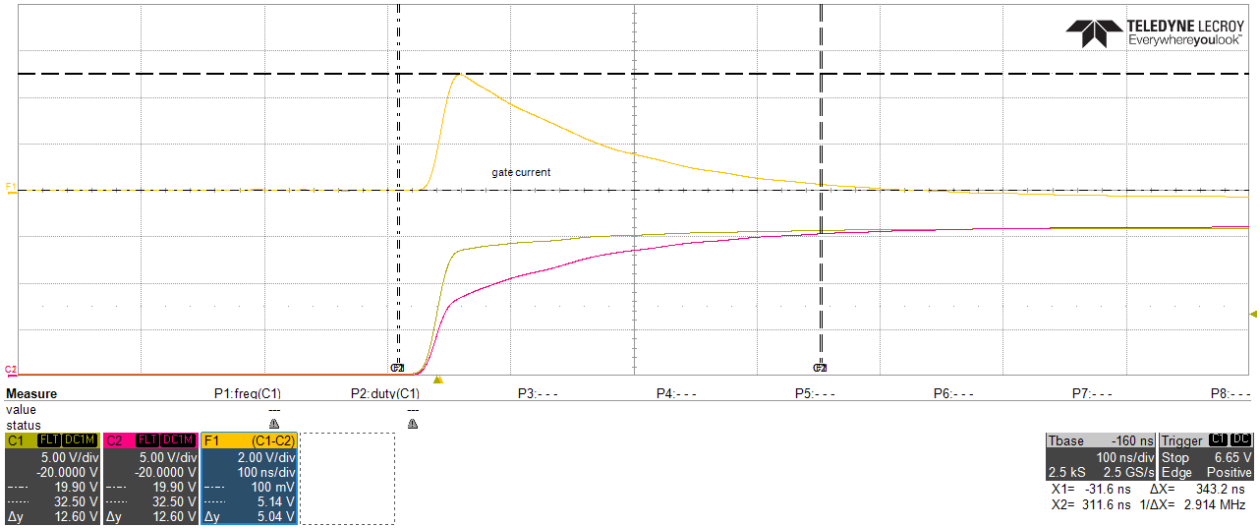


**Figure 5. Turn ON Gate Current**

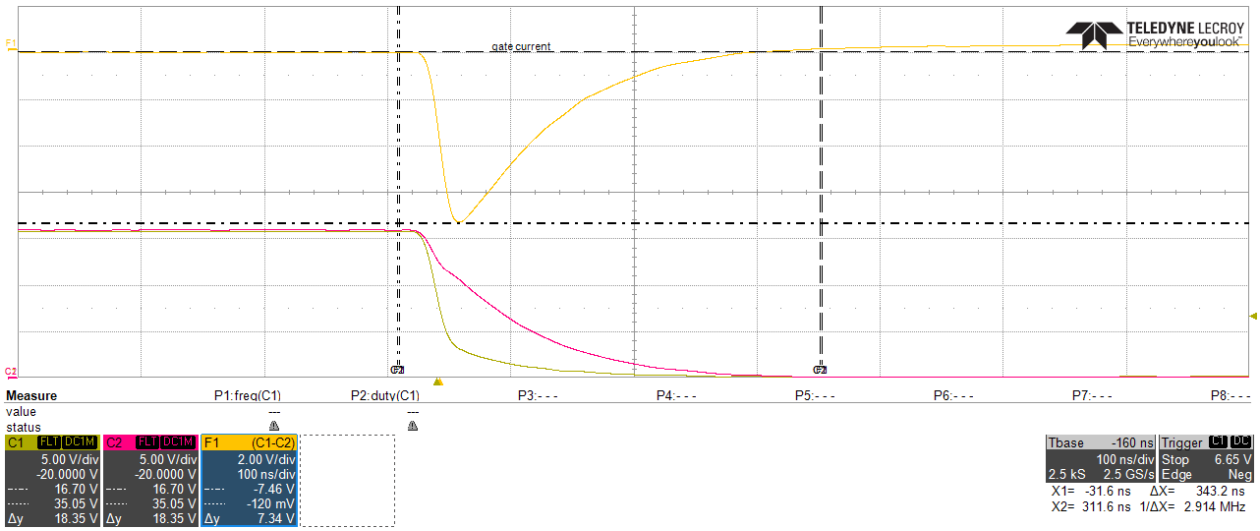


**Figure 6. Turn OFF Current**

### Dead Time

Time between falling threshold of low side (1.4 V) and rising threshold of high side (2.7 V), **78.4 ns**.

Components values for dead time are: R11 = R13 = 56 Ω, C = 2.2 nF. User can define these values to meet application requirements.

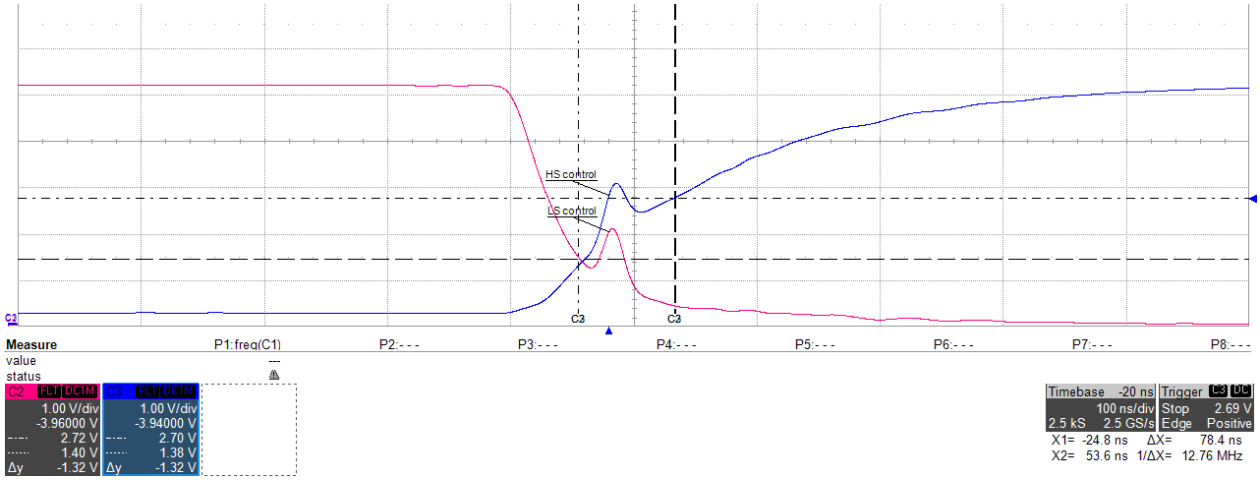


**Figure 7. Dead Time Control**

**Test Setup 2:**

- Resistive load 220 Ω
- Supply voltage 20 V
- MOSFET: NVMFS6H800NL

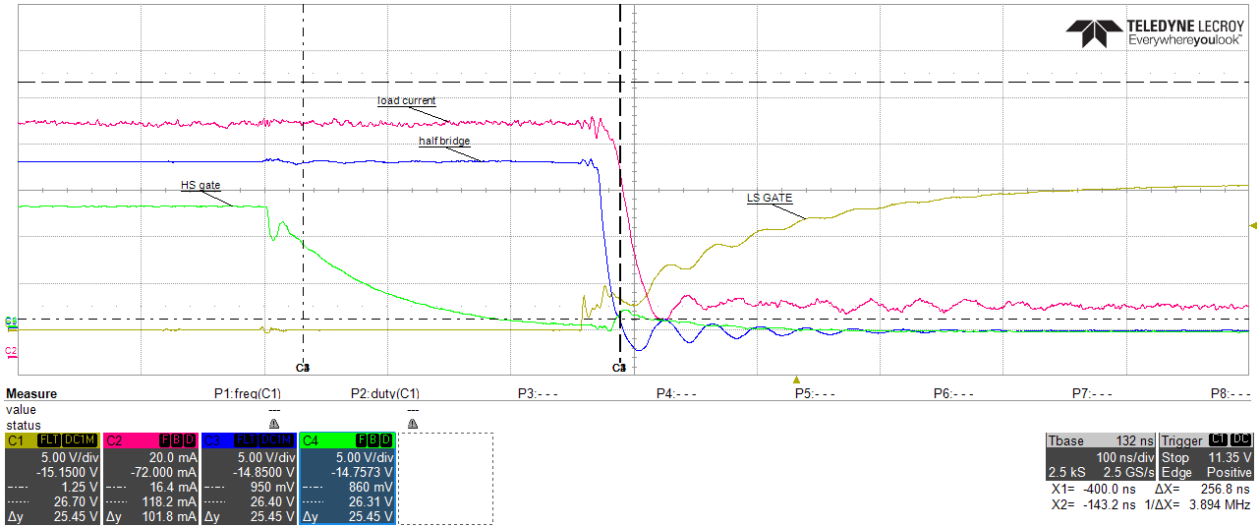


**Figure 8. Turn OFF Switching Node**

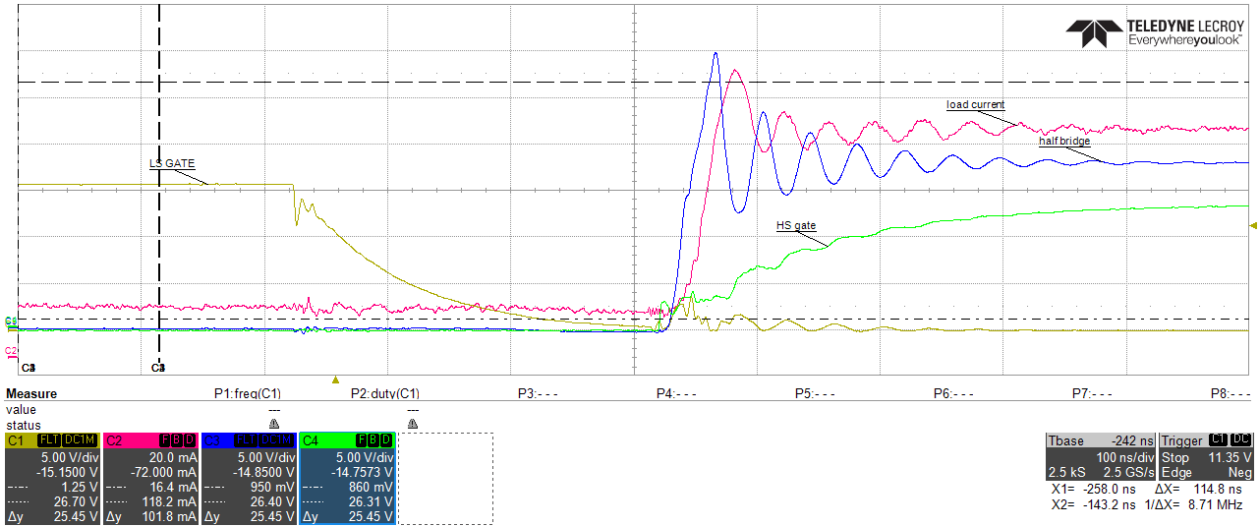


**Figure 9. Turn ON Switching Node**

Figure 8 and Figure 9 present rising and falling times of a half bridge under low load (100 mA).

## PCB ASSEMBLY

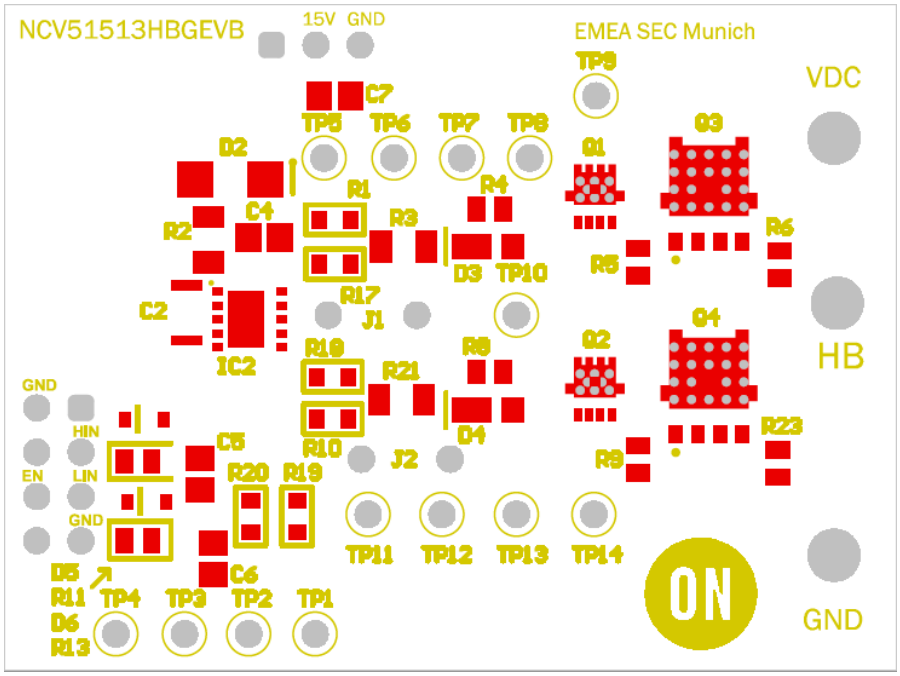


Figure 10. Top Side Assembly

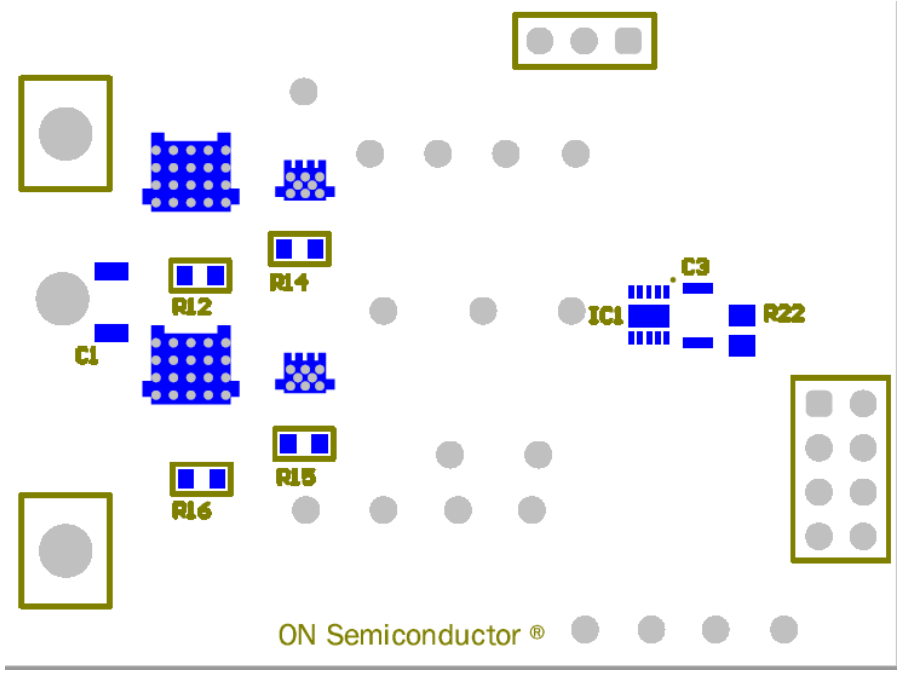


Figure 11. Bottom Side Assembly

## 3D VIEW

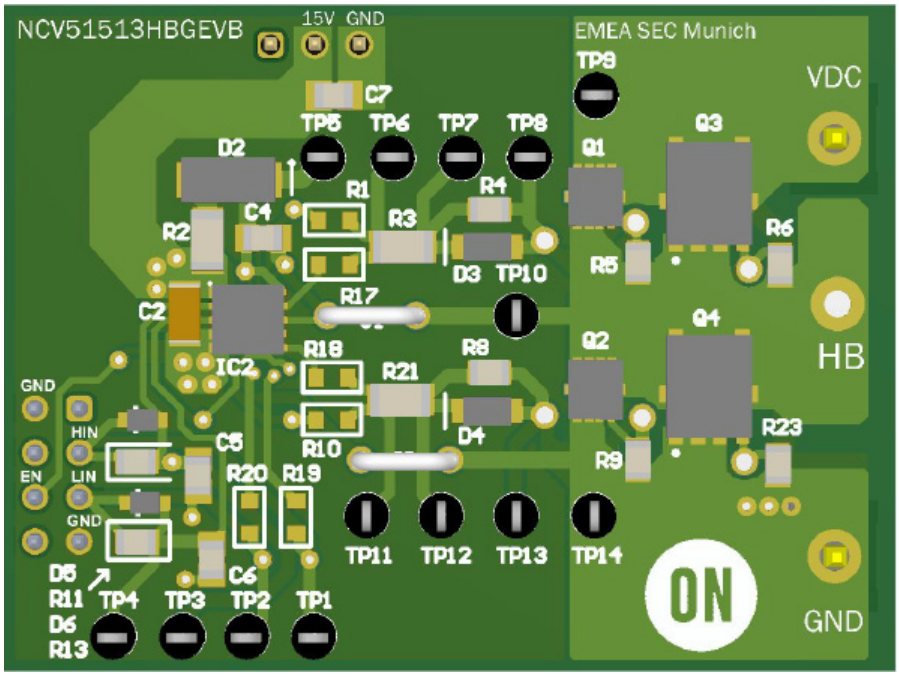


**Figure 12. Board Top Side**

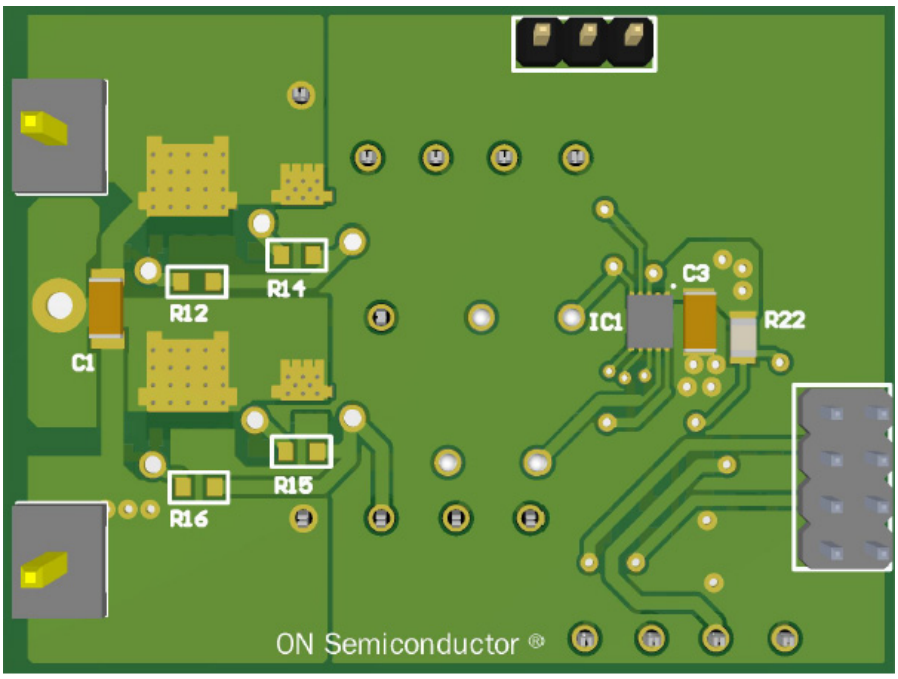


**Figure 13. Board Bottom Side**

## BILL OF MATERIALS

**Table 5. BILL OF MATERIALS**

| Qty | Designator | Manufacturer Part Number | Manufacturer | Description | Footprint |
|---|---|---|---|---|---|
| 1 | D2 | NRVUA160VT3G | ON Semiconductor | Ultrafast power rectifier 600 V | SMA |
| 2 | D3, D4 | BAT54T1G | ON Semiconductor | DIODE SCHOTTKY 30 V 200 mA SOD123 | ONSC−SOD−123HE−2−425−04_V |
| 2 | D5, D6 | SBAS16HT1G | On Semiconductor | Switching Diode, 2−Pin SOD−323, Pb−Free, Tape and Reel | ONSC−SOD−323−2−477−02_V |
| 1 | IC2 | NCP51530BMNTWG | ON Semiconductor | High and Low side gate driver 700 V 3.5/3 A | DFN10 4x4 |
| 2 | Q1, Q2 | NVTFS5C453NLWFTAG | ON Semiconductor | Single, N−Channel, 40 V, 3.1 mΩ, 107 A | WDFN8 3.3x3.3 |
| 2 | Q3, Q4 | NVMFS6H800NLT1G | ON Semiconductor | Single, N−Channel, 80 V, 1.9 mΩ, 224 A | ONSC−DFN−5−488AA_V |
| 1 | C1 | C1206C104K2RACTU | KEMET | Capacitor, C Series, 0.1 μF, 10%, X7R, 200 V, 1206 [3216 Metric] | 1206 |
| 2 | C2, C3 | C1206C225K5RAC | KEMET | Cap Ceramic 2.2 μF 50 V X7R 10% SMD 1206 125°C Bulk | 1206 |
| 1 | C4 | C0805C104J5RACTU | Kemet | CAP CER 100 nF 50 V X7R 0805 | 0805 |
| 2 | C5, C6 | C0805C222J5RACTU | KEMET | MLCC − SMD/SMT 50 V 2.2 nF X7R 5% | 0805 |
| 1 | C7 | CC0805KKX7R8BB225 | Yageo | CAP CER 2.2 μF 25 V 0805 | 0805 |
| 2 | J1, J2 | 1430−1 | Keystone Electronics | Jumper TH 5.08 mm | Jumper 5.08 mm |
| 10 | R1, R10, R12, R14, R15, R16, R17, R18, R19, R20 | CRCW06030000Z0EB | Vishay Dale | Res Thick Film 0603 0 Ω Molded SMD Automotive Paper T/R | 0603 |
| 2 | R11, R13 | CRCW080556R0FKEA | Vishay | Res Thick Film 0805 56 Ω 1% 1/8 W ±100 ppm/°C Molded SMD SMD Paper T/R | 0805 |
| 3 | R2, R3, R21 | SMM02040C2008FB300 | Vishay | Res Thin Film 0204(1406) 2 Ω 1% 1/4 W ±50 ppm/°C Conformal Melf SMD Blister T/R | 0204 |
| 1 | R22 | ERJ−6ENF1002V | Panasonic | Res Thick Film 0805 10 kΩ 1% 1/8 W ±100 ppm/°C Molded SMD Punched Carrier T/R | 0805 |
| 2 | R4, R8 | CRCW08056R80JNEA | Vishay Dale | RES SMD 6.8 Ω 5% 1/8 W 0805 | 0805 |
| 4 | R5, R6, R9, R23 | CRCW080522K0JNEAIF | Vishay | Res Thick Film 0805 22 kΩ 5% 1/8 W ±200 ppm/°C Molded SMD Paper T/R | 0805 |
| 14 | TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP14 | 5001 | Keystone Electronics | TH Test point (2.54 mm dia) | TH Test point |
| 1 | X1 | 61300311121 | Wurth Electronics | Header 3x1 2.54 mm | 3x1 male header PCB connector |
| 2 | X20, X21 | FWS−01−01−T−S | Samtec | 1x1 male pin header. 19 mm overall length. 11 mm contact length | 1x1 pin header |
| 1 | X4 | 61300821121 | Wurth Electronics | Conn header 4x2 2.54 mm | 4x2 PCB connector |

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