

SECO-NCP51530HB-GEVB Evaluation Board User's Manual



ON Semiconductor®

www.onsemi.com

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)

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 (μ 8FL) | NVTFS5C453NL (Note 2) |

1. [168](#) MOSFETs available in this package from ON Semiconductor.
2. [65](#) MOSFETs available in this package from ON Semiconductor.

EVAL BOARD USER'S MANUAL



Figure 1. Evaluation Board Photo

EVBUM2703/D

Schematic

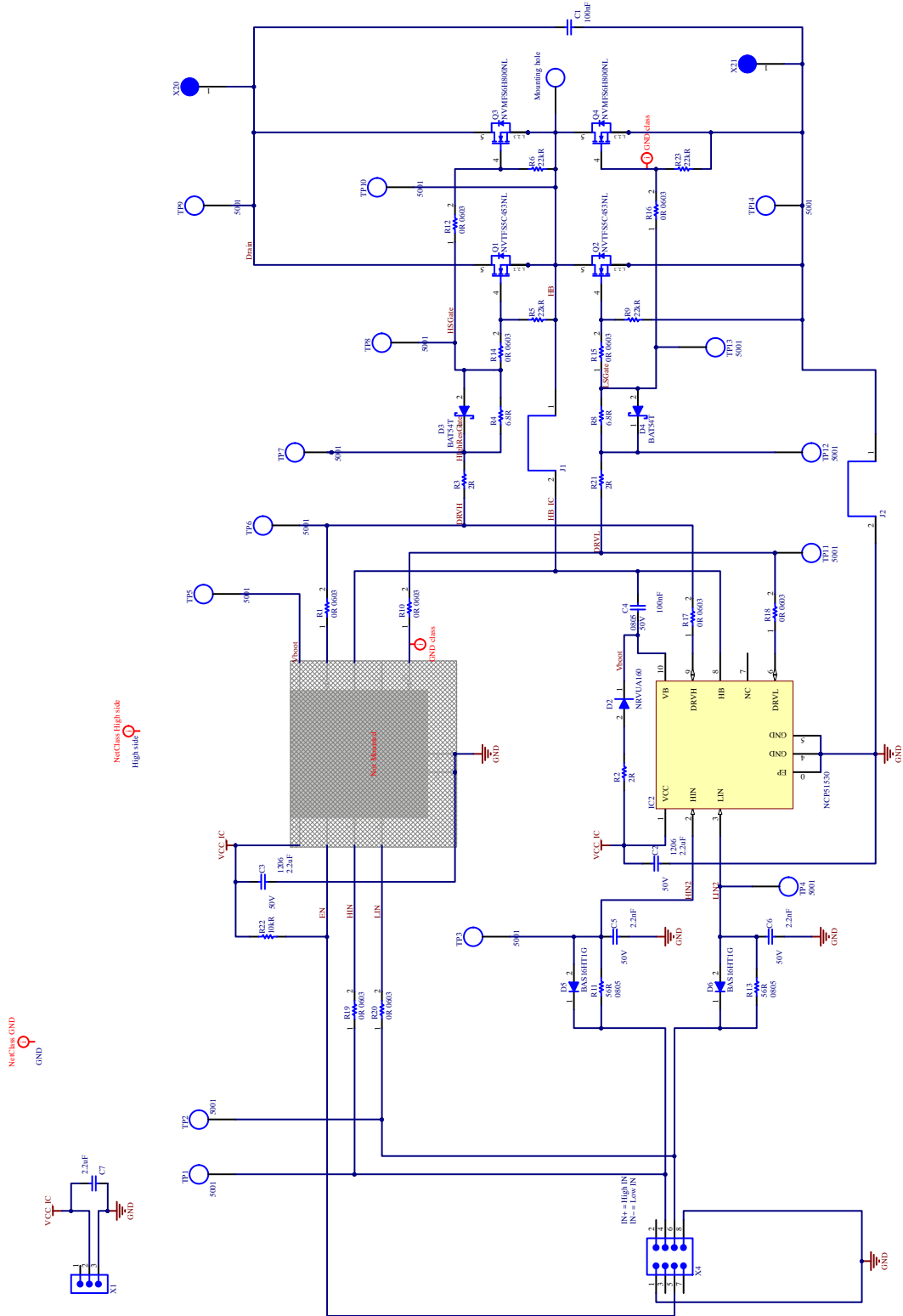


Figure 2. EVB Schematic

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:

- μ 8FL
- 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 **μ 8FL** 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:

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

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.

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

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

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

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.

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

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

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

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 driver voltage to maintain and voltage drop on bootstrap diode. The value of bootstrap capacitor is calculated by:

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

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 |

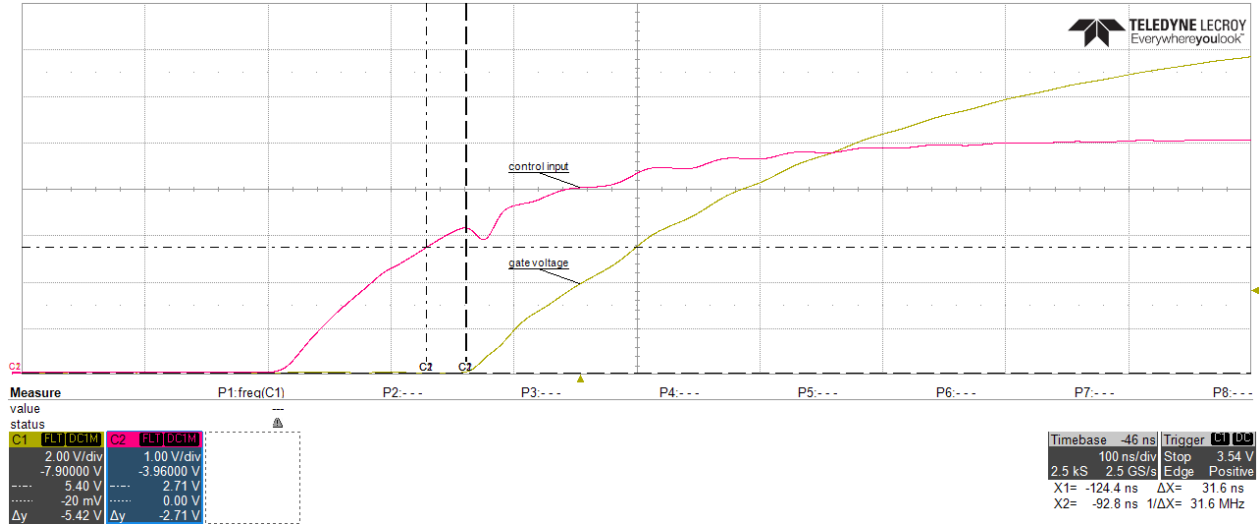


Figure 3. Delay Propagation – Low Side

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

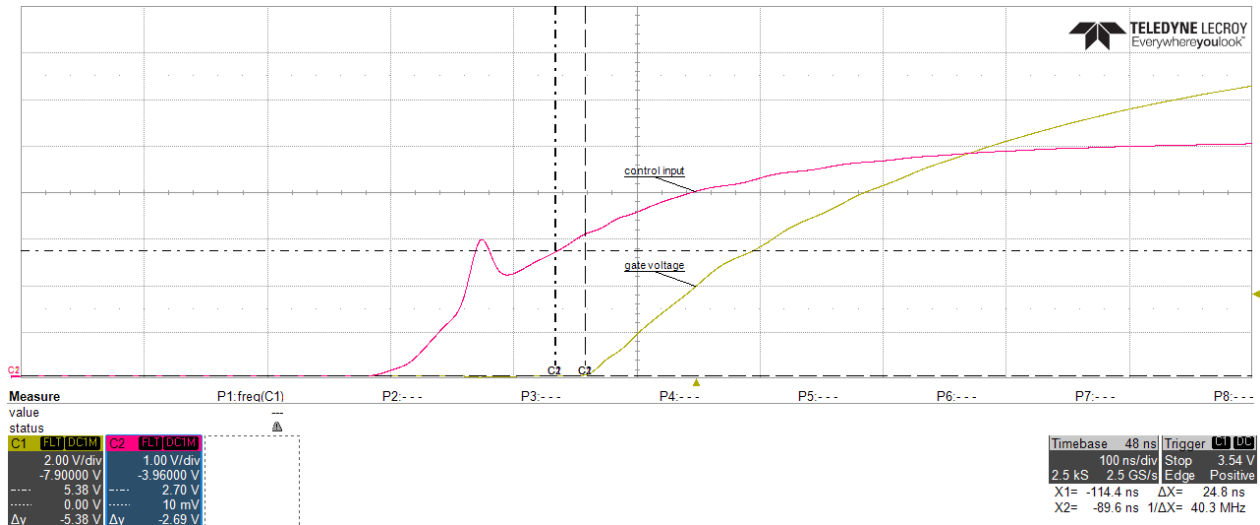


Figure 4. Delay Propagation – High Side

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

Delay matching: $31.6 - 24.8 = 6.8 \text{ ns}$

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 |

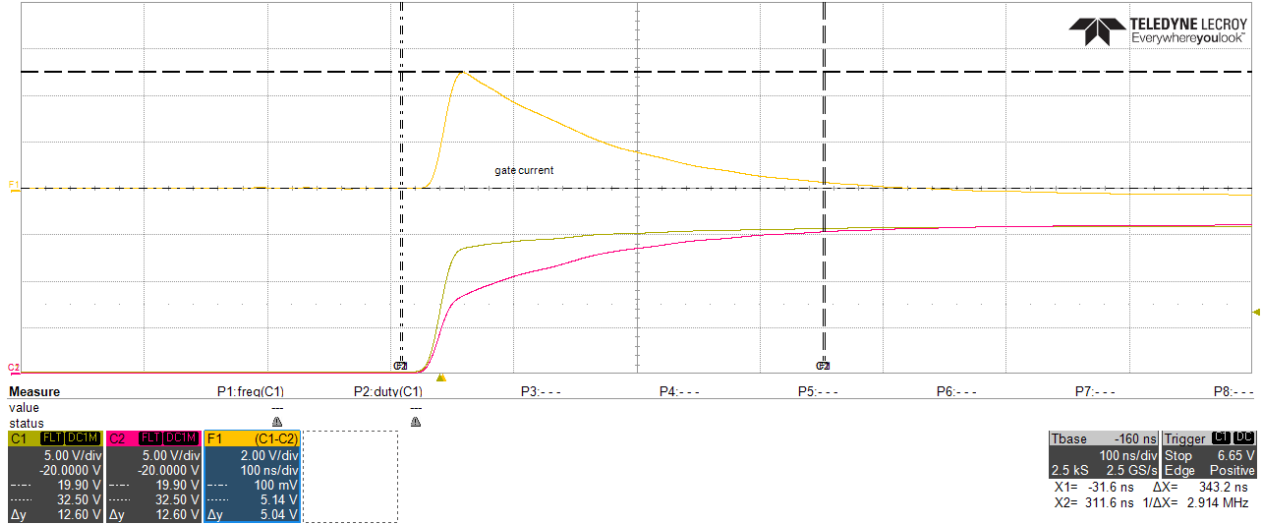


Figure 5. Turn ON Gate Current

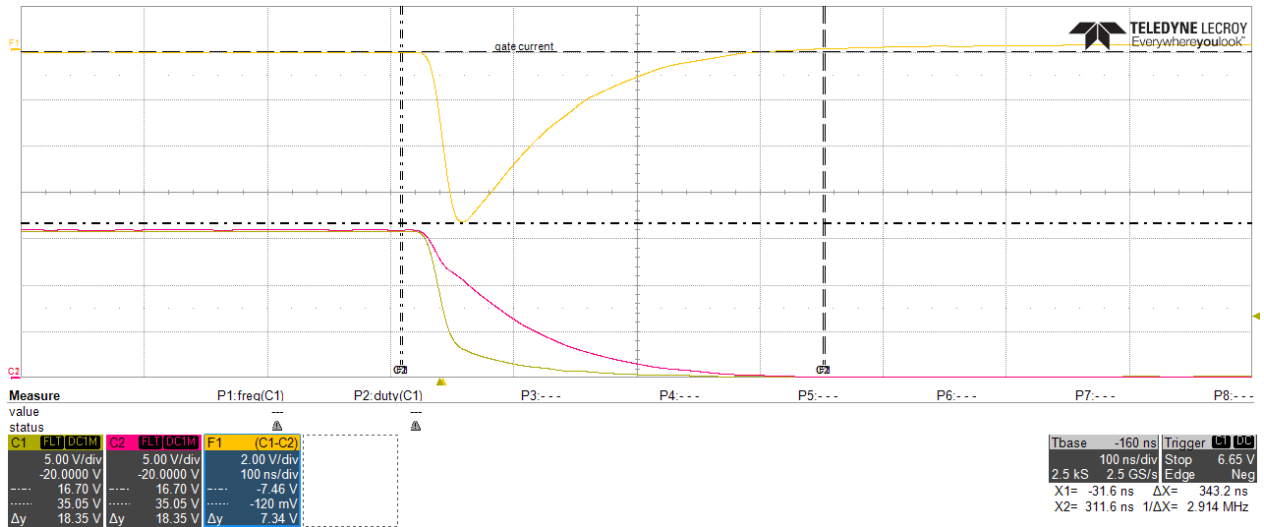


Figure 6. Turn OFF Current

EVBUM2703/D

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: $R11 = R13 = 56 \Omega$, $C = 2.2 \text{ nF}$. User can define these values to meet application requirements.

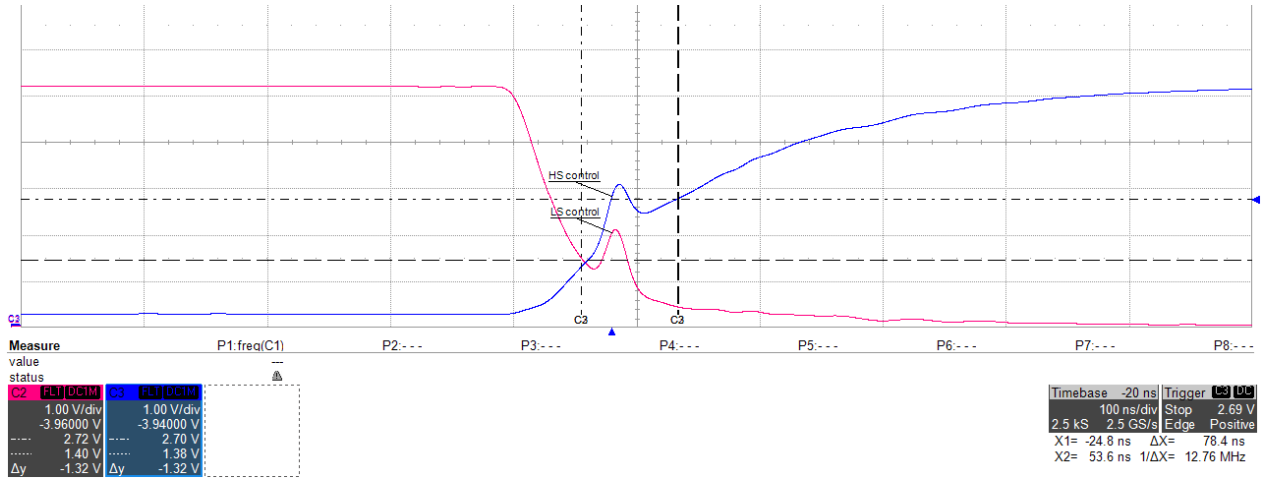


Figure 7. Dead Time Control

Test Setup 2:

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

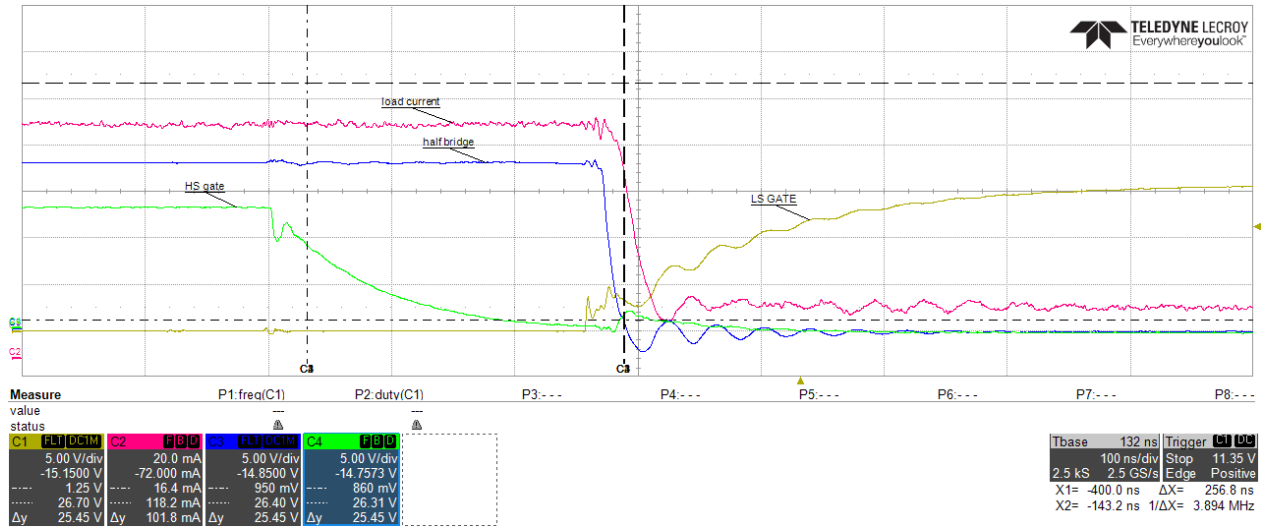


Figure 8. Turn OFF Switching Node

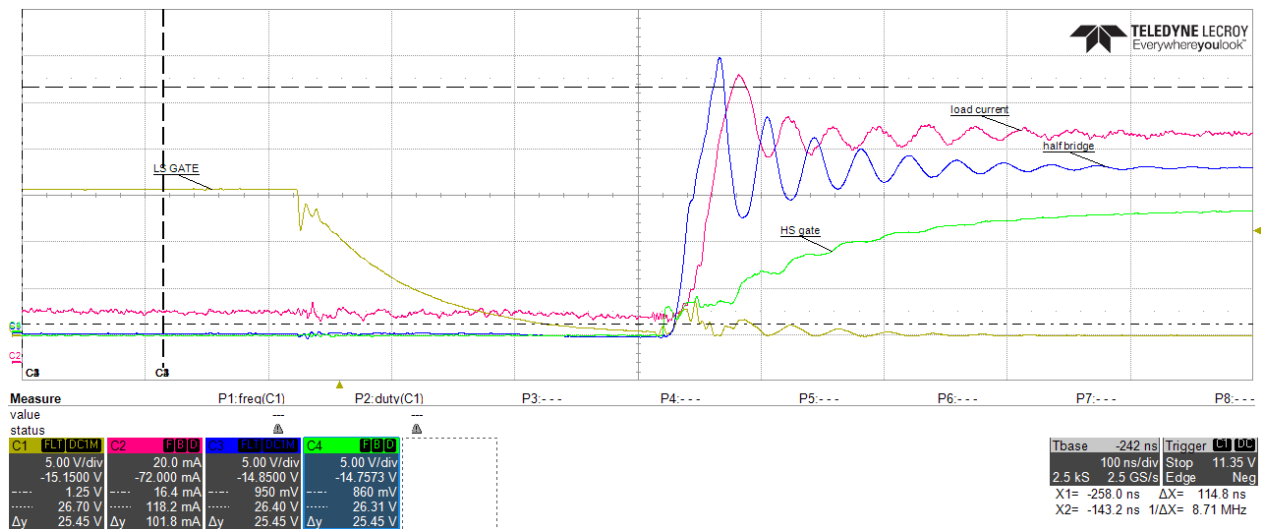


Figure 9. Turn ON Switching Node

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

EVBUM2703/D

PCB ASSEMBLY

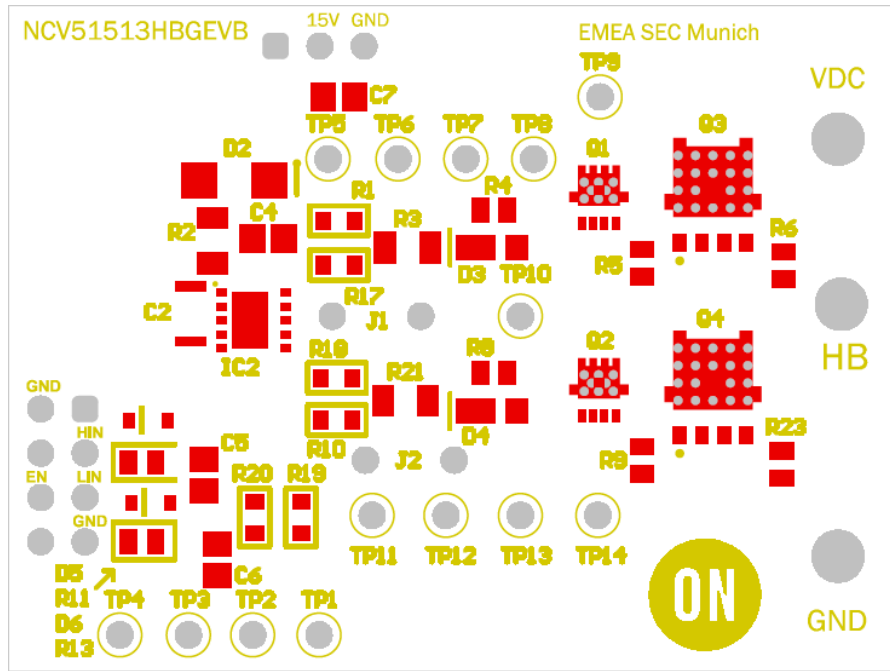


Figure 10. Top Side Assembly

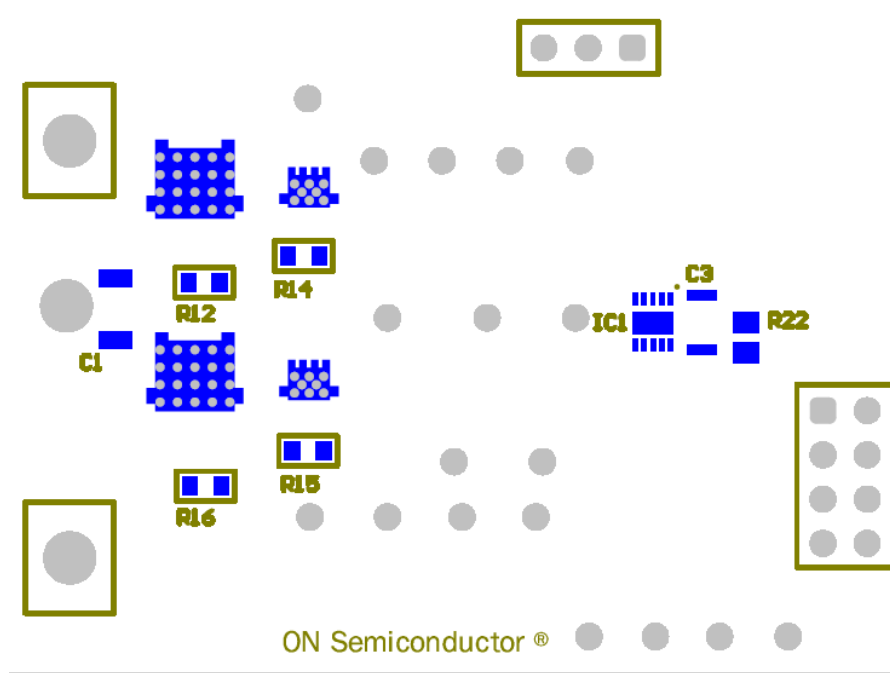


Figure 11. Bottom Side Assembly

EVBUM2703/D

3D VIEW

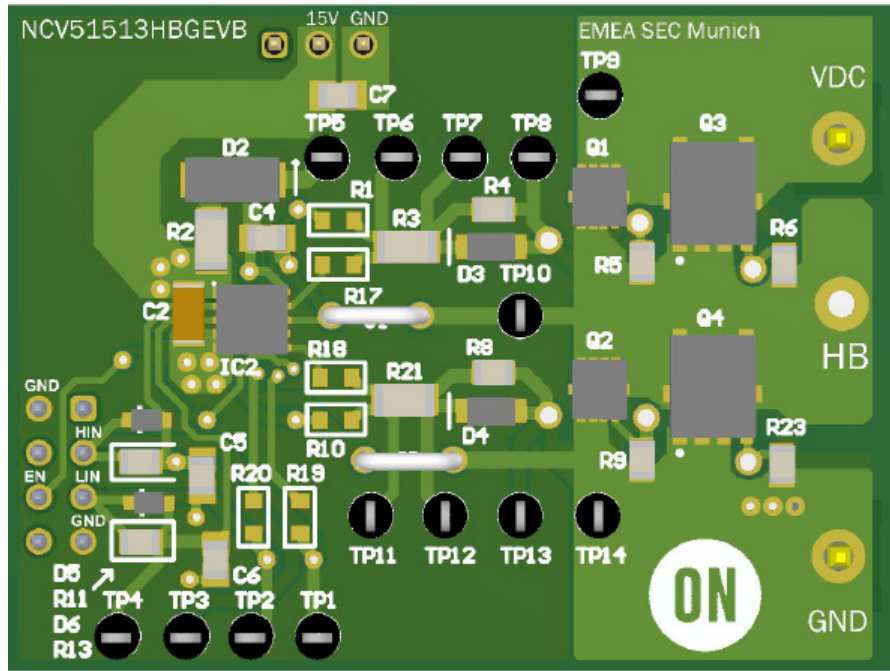


Figure 12. Board Top Side

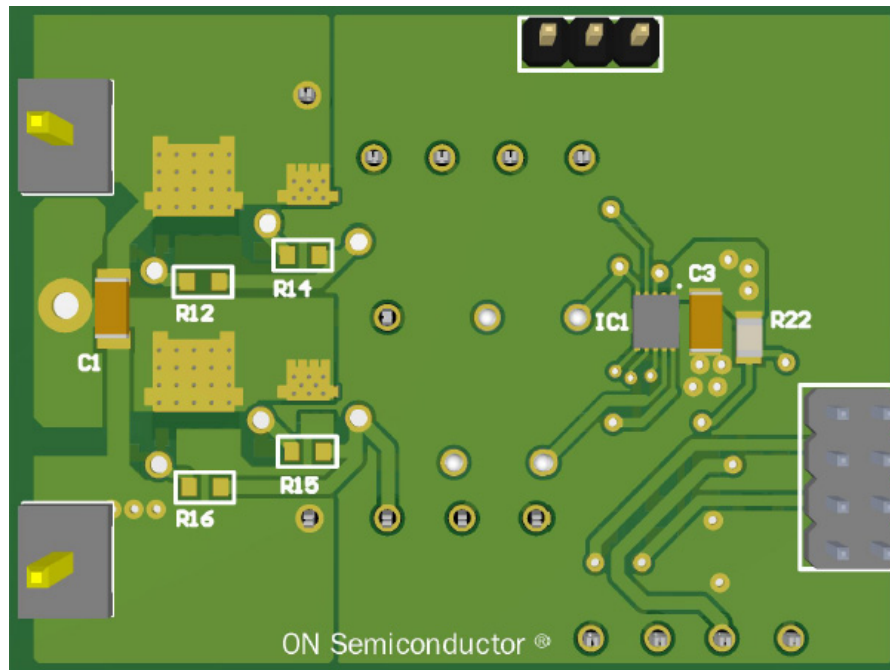


Figure 13. Board Bottom Side

EVBUM2703/D

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 m Ω , 107 A | WDFN8 3.3x3.3 |
| 2 | Q3, Q4 | NVMFS6H800NLT1G | ON Semiconductor | Single, N-Channel, 80 V, 1.9 m Ω , 224 A | ONSC-DFN-5-488AA_V |
| 1 | C1 | C1206C104K2RACTU | KEMET | Capacitor, C Series, 0.1 μ F, 10%, X7R, 200 V, 1206 [3216 Metric] | 1206 |
| 2 | C2, C3 | C1206C225K5RAC | KEMET | Cap Ceramic 2.2 μ F 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 μ F 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 \pm 100 ppm/ $^{\circ}$ 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 \pm 50 ppm/ $^{\circ}$ C Conformal Melf SMD Blister T/R | 0204 |
| 1 | R22 | ERJ-6ENF1002V | Panasonic | Res Thick Film 0805 10 k Ω 1% 1/8 W \pm 100 ppm/ $^{\circ}$ 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 k Ω 5% 1/8 W \pm 200 ppm/ $^{\circ}$ 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 | Würth 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 | Würth Electronics | Conn header 4x2 2.54 mm | 4x2 PCB connector |

ON Semiconductor and the ON Semiconductor logo are trademarks of Semiconductor Components Industries, LLC dba ON Semiconductor or its subsidiaries in the United States and/or other countries. ON Semiconductor owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of ON Semiconductor's product/patent coverage may be accessed at www.onsemi.com/site/pdf/Patent-Marking.pdf. ON Semiconductor is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

The evaluation board/kit (research and development board/kit) (hereinafter the "board") is not a finished product and is as such not available for sale to consumers. The board is only intended for research, development, demonstration and evaluation purposes and should as such only be used in laboratory/development areas by persons with an engineering/technical training and familiar with the risks associated with handling electrical/mechanical components, systems and subsystems. This person assumes full responsibility/liability for proper and safe handling. Any other use, resale or redistribution for any other purpose is strictly prohibited.

The board is delivered "AS IS" and without warranty of any kind including, but not limited to, that the board is production-worthy, that the functions contained in the board will meet your requirements, or that the operation of the board will be uninterrupted or error free. ON Semiconductor expressly disclaims all warranties, express, implied or otherwise, including without limitation, warranties of fitness for a particular purpose and non-infringement of intellectual property rights.

ON Semiconductor reserves the right to make changes without further notice to any board.

You are responsible for determining whether the board will be suitable for your intended use or application or will achieve your intended results. Prior to using or distributing any systems that have been evaluated, designed or tested using the board, you agree to test and validate your design to confirm the functionality for your application. Any technical, applications or design information or advice, quality characterization, reliability data or other services provided by ON Semiconductor shall not constitute any representation or warranty by ON Semiconductor, and no additional obligations or liabilities shall arise from ON Semiconductor having provided such information or services.

The boards are not designed, intended, or authorized for use in life support systems, or any FDA Class 3 medical devices or medical devices with a similar or equivalent classification in a foreign jurisdiction, or any devices intended for implantation in the human body. Should you purchase or use the board for any such unintended or unauthorized application, you shall indemnify and hold ON Semiconductor and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that ON Semiconductor was negligent regarding the design or manufacture of the board.

This evaluation board/kit does not fall within the scope of the European Union directives regarding electromagnetic compatibility, restricted substances (RoHS), recycling (WEEE), FCC, CE or UL, and may not meet the technical requirements of these or other related directives.

FCC WARNING – This evaluation board/kit is intended for use for engineering development, demonstration, or evaluation purposes only and is not considered by ON Semiconductor to be a finished end product fit for general consumer use. It may generate, use, or radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment may cause interference with radio communications, in which case the user shall be responsible, at its expense, to take whatever measures may be required to correct this interference.

ON Semiconductor does not convey any license under its patent rights nor the rights of others.

LIMITATIONS OF LIABILITY: ON Semiconductor shall not be liable for any special, consequential, incidental, indirect or punitive damages, including, but not limited to the costs of requalification, delay, loss of profits or goodwill, arising out of or in connection with the board, even if ON Semiconductor is advised of the possibility of such damages. In no event shall ON Semiconductor's aggregate liability from any obligation arising out of or in connection with the board, under any theory of liability, exceed the purchase price paid for the board, if any.

For more information and documentation, please visit www.onsemi.com.

PUBLICATION ORDERING INFORMATION

LITERATURE FULFILLMENT:

Email Requests to: orderlit@onsemi.com

ON Semiconductor Website: www.onsemi.com

TECHNICAL SUPPORT

North American Technical Support:

Voice Mail: 1 800-282-9855 Toll Free USA/Canada

Phone: 011 421 33 790 2910

Europe, Middle East and Africa Technical Support:

Phone: 00421 33 790 2910

For additional information, please contact your local Sales Representative