Half-Bridge Power Module Based on NCP58921 650 V Integrated Driver GaN Evaluation Board User's Manual

EVBUM2920/D

Description

The evaluation board user's manual provides basic information about the Half-Bridge Power Module with DC-DC power supply which is based on NCP58921 650 V Integrated Driver GaN Power Switch. It is designed as a universal building block for that is suitable for the most topologies requiring Half-Bridge (HB) arrangement. This building was designed to easily test NCP58921 performance in various converter types. Evaluation board contains Power HB Stage using NCP58921 or other member of family (NCP58922), the dual insulated DC-DC power supply dedicated for each power switch, and it's driven by NCP1392, Galvanically Insulated Driver NCP51561 which is supplied with 5 V LDO regulator NCP718. Simple modification of HB Module enables to implement it into LLC Stage. The Half-Bridge Power Module was designed to offer 600 V insulation level while its dimensions are still compact. Insulation level is possible to enhance with stretching PCB size. The NCP5892x integrated implementation significantly reduces circuit and package parasitics while enabling more compact design. The NCP58921 integrates a high-performance, high frequency, driver and a 650 V, 50 mΩ Gallium-Nitride (GaN) High Electron Mobility Transistors (HEMT) in a single switch structure while NCP58922 is a very similar device that integrates 650 V, 78 mΩ GaN HEMT. The Insulated Metal Substrate (IMS) board was selected to extend thermal performance of NCP5892x devices. HB Power Module utilizes flux canceling loop (FCL) to reduce stray inductance of power path and minimize switching node overshoots. This manual provides brief information about Integrated Driver GaN implementation, its schematic diagram and interfacing. Please use links in the literature section to get detailed technical information about NCP58921, NCP58922, NCP51561, NCP1392 and NCP718 devices that manual refers to.

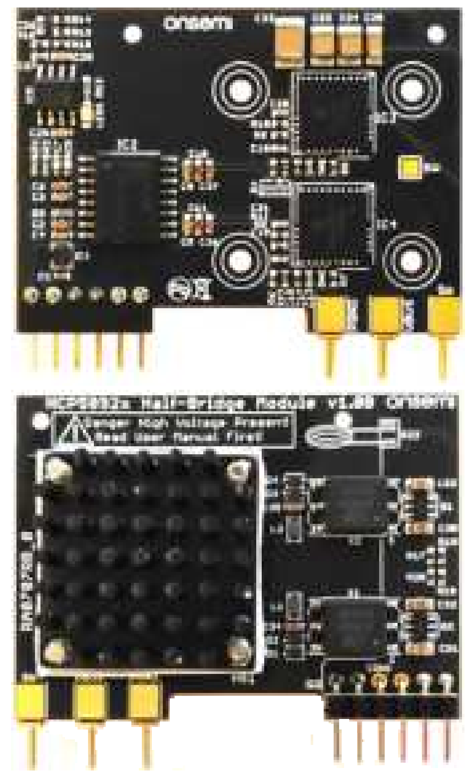


Figure 1. Board Photo

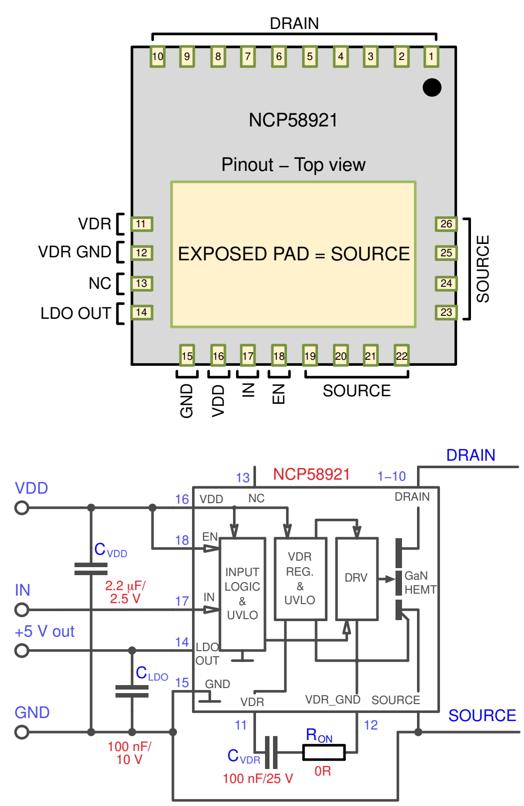


Figure 2. NCP58921 Pin Assignment with its Minimum Component Schematic

November, 2024 − Rev. 0
Publication Order Number:
EVBUM2920/D

Basic Parameters

- 400 V recommended V_{BUS} voltage (limited by MLLC rating)
- 12 V recommended V_{DD} supply voltage
- DC-DC supply for independent supplying of low and high side parts
- Design ensures working insulation level 600 V
- Implemented ISO Driver NCP51561 for simple PWM driving
- Implemented minimum deadtime 100 ns, adjustable with resistor
- Suitable for up to 1 kW HB LLC Stage using forced cooling
- Suitable for up to 2 kW FB LLC Stage using two modules and forced cooling
- Suitable for up to 1 kW CCM using forced cooling
- Low Thermal resistance $R_{\theta JA}$ = 6.5 °C/W per device (measured with FAN EBM Papst 422JN)
- 600 V functional insulation for input signals
- Compact dimensions 52 x 38 mm

NCP58921 Device Basic Description

The NCP58921 integrates a high-performance, high frequency, driver utilizing state-of-the-art silicon technology and a 650 V, 50 mΩ Gallium-Nitride (GaN) High Electron Mobility Transistors (HEMT) in a single switch structure. The powerful combination of the Si driver and power GaN HEMT switch provides superior performance compared to monolithic GaN power modules. The NCP58921 integrated implementation significantly reduces circuit and package parasitic while enabling more compact design. The other NCP5892x family members offer 150 mΩ – NCP58920 and 78 mΩ – NCP58922. Integrating the driver and GaN HEMT into one package is a logical step in development. Short Kelvin-connection between GaN switch and driver diminishes coupling link from Source common inductance of power terminal and minimizes the inductances between the driver output and GaN switch Gate terminals. Integrated solution offers clean driving waveforms, higher dv/dt immunity and simplified PCB design layout as well as reduces required PCB area. The NCP58921, its pin assignment and minimum component schematic diagram is depicted in Figure 2. The NCP58921 device itself requires a minimum component count that is shown in Figure 2 or application schematic diagram in Figure 7. To find more information about NCP58921 or other family members refer to the individual datasheet of each device.

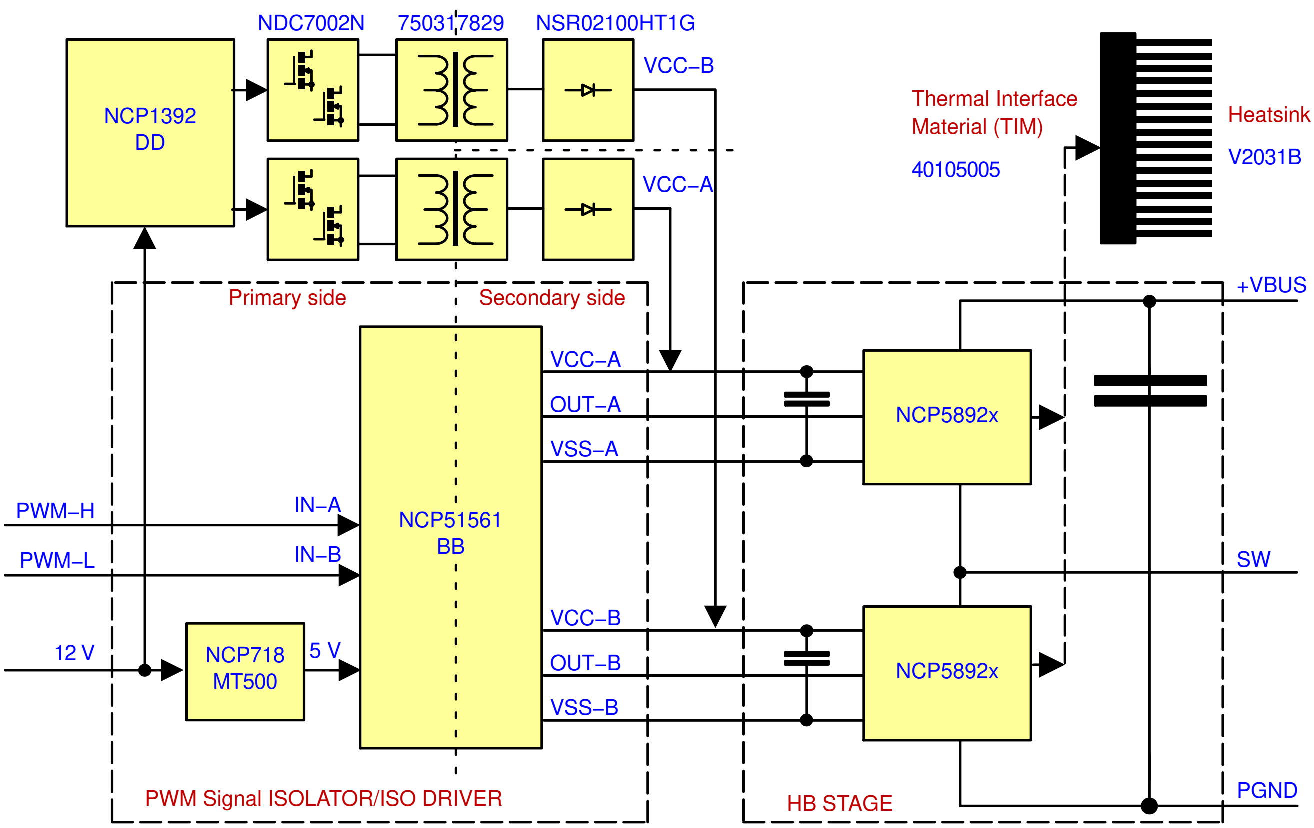


Figure 3. Insulated Half-Bridge Module Simplified Block Diagram

Principle Block Diagram Description

The Half-Bridge Power Module with DC-DC power supply principal block diagram is shown in Figure 3. The Half-Bridge Power Module with DC-DC power supply is standardly based on NCP58921 while the PCB layout implements universal connectivity that allows to accept all three part-numbers from NCP5892x family (NCP58920, NCP58921 and NCP58922). The Half-Bridge Power Module is built on three basic blocks:

- Dual DC-DC supply
- PWM Signal Isolator and LDO regulator
- Half-Bridge Stage

The first Half-Bridge Power Module portion is the Dual DC-DC supply that is driven by the NCP1392 which provides PWN signal without feedback (open loop system). Thus, DC-DC supply output voltage is not regulated and relies on converter gain versus loading characteristics. The NCP1392 is driving two small dual MOSFETs that are forming two independent Push-pull DC-DC converters utilizing the two 750317829 insulation transformers. The output of each transformer is center tapped (two identical windings with center node) so this enables to use simple two diodes rectifier to rectify its output voltage which is subsequently filtered with set of Multi-Layer Ceramic Capacitors (MLCC) and common mode inductor. Each DC-DC branch supplies independently high-side and low-side section of power stage as well as insulated driver.

The second Half-Bridge Power Module portion is a PWM Signal Isolator based on NCP5156. This insulated driver is securing insulation between primary PWM signals and its secondary side driver outputs. The insulated driver outputs are connected to NCP5892x inputs via RC filters. The primary side of NCP51561 is supplied from LDO regulator NCP718 which regulates 12 V input voltage down to 5 V which is suitable VDD supply level. The third Half-Bridge Power Module portion is Half-Bridge power stage made of two NCP5892x devices. The power Stage also includes MLCC capacitors that are local decoupling devices covering AC currents needed during transition events and thus reducing switching node over-shoots.

Isolated Driver and Half-bridge Power Stage Schematic Diagram Description

This section of the manual refers to the schematic diagram depicted in Figure 7. The CON1 is the Half-Bridge Power Module primary side connection interface that has 6 pins with following meaning:

1. HS_DRV – PWM Input for High-side
2. LS_DRV – PWM Input for Low-side
3. +12 V – Supply voltage terminal (+12 V)
4. GND – Supply Ground (0 V)
5. TEMP – NTC Thermistor output, may be optionally mounted on PCB
6. RESERVED – reserved pin for future functions

The LS_DRV and HS_DRV terminals are providing PWM signal to the NCP51561 through RC low pass filters made of R1/C5 and R2/C7. These filters are used to filter out potential noise coming from power device transition while noise injection level increasing especially with hard-switched operation.

+12 V Supply voltage terminal distributes 12 V to IC1 (NCP718) which 5 V LDO regulator that creates 5 V supply voltage suitable for IC2 NCP51561. The C1 and C4 are Input/Output decoupling capacitors intended to regulator while C2, C3 and C6 are VDD decoupling capacitors dedicated to Insulated driver or IC2. Resistor R3 serves as dead-time adjustment for NCP51561, while its value 10 kΩ gives approximately 100 ns dead time. The dead time (DT) between both outputs is set according to: DT (in ns) = 10 x RDT (in kΩ) as it shows Figure 4.

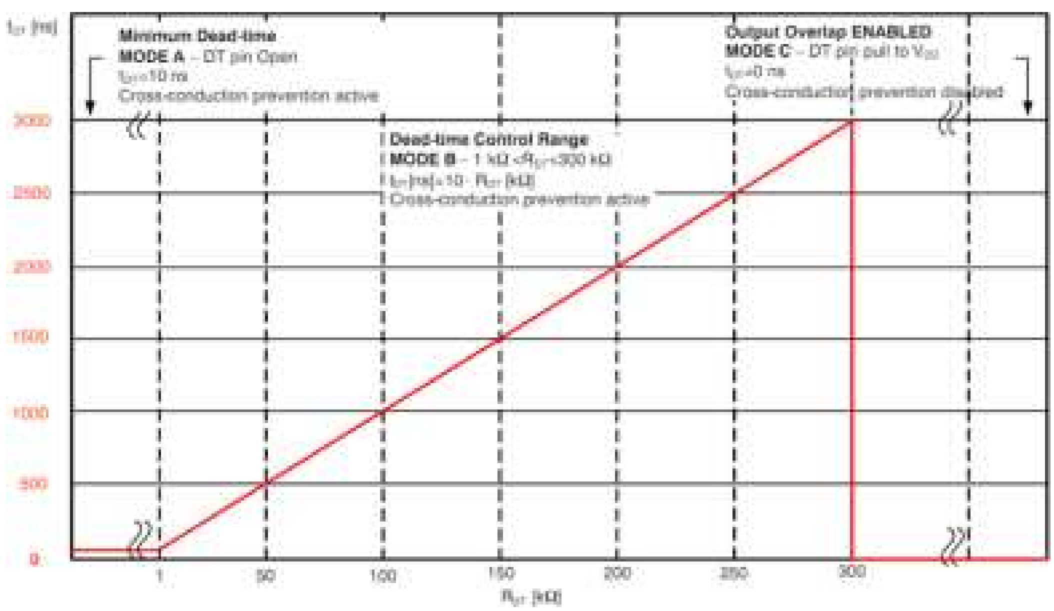


Figure 4. NCP51561 Dead Time Adjustment

NCP51561 allows to set the input signal configuration through the ANB pin which is grounded in this case and that means dual input operation so both inputs/ outputs are controlled independently while deadtime is always applied to prevent cross conduction. NCP51561BB version has dedicated DIS input for disabling devices when this input is pulled high, however, this feature is not used, and input is grounded in schematics which gave us always enabled or ready device. For more detailed features explanation refer to NCP51561 datasheet. The output portion of NCP51561 uses capacitor C8−C11 to decouple driver supply and driver output signal is passed through RC low-pass filter (R5−C12/R7−C13), filtered signal is used for driving IC3 and IC4 (NCP5892x). RC filters are used to filter out noise from active signals and create room for users that may adjust filtering level depending on final application. Half-bridge power stage devices IC3 and IC4 are supplied via R4/R6 resistors that ensure current limitation (peak current level) during transient operation that can lead to charge exchange between capacitor placed on different location having same supply lines. IC3 and IC4 are set always ready via EN pin which is pulled high via R21/R23 resistors. Both mentioned devices use same set of two VDD decoupling capacitors C14−C16/C15−C17, while for 5 V LDO out (IC3/4 pin 14) is always necessary decoupling capacitor C18/C19. NCP5892x IC3/IC4 have two driver regulator dedicated pins: VDR and VDR_GND. These pins serve for connection VDR regulator decoupling capacitor (C20/C21) with series resistor (R10/R11) that allows to adjust turn-on dv/dt level. Resistors R8/R9 are very important as interconnect device input ground with so-called driver ground. IC3/IC4 power terminal DRAIN-SOURCE are connected in such way that forms Half-bridge stage, while this stage is decoupled using multiple capacitors C22−C25 with various values of High-voltage MLCC capacitor. For additional information about power stage decoupling refer to next section that contains important information about capacitor rating.

Maximum V_{BUS} Voltage Limit and Half-bridge Power Stage Decoupling

The supply VBUS voltage is recommended in the range of 380 to 450 V dc to keep safety margins while it's strongly recommended to check C22−C25 the Half-Bridge Stage decoupling capacitors temperature – see Figure 7. Ceramic capacitors can dissipate significant levels of power losses while they are covering or decoupling AC portion of current during switching transitions and converter operation, especially when converter operates with high ripple current. Capacitor temperature rise is caused by heat which is result of multiplying the capacitor RMS ripple current squared and the capacitor's ESR resistance.

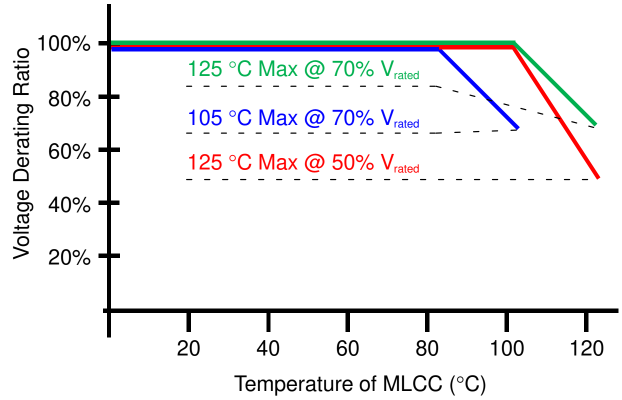


Figure 5. MLCC Capacitor Voltage Derating Examples

If capacitors are too hot (typically above 105 °C) its Voltage rating may drop to 50% (or other level depends on capacitor manufacturer and material) as well as capacitance can be significantly impacted. It is strongly recommended to limit application maximum voltage to 400−420 V and keep safety margin and avoid capacitors failure. For MLCC derating examples, refer to Figure 5 which depicts operating voltage derating vs. temperature. In Figure 6 is capacitance vs. temperature behavior for various dielectric materials also we can say in other words that is capacitance derating characteristic.

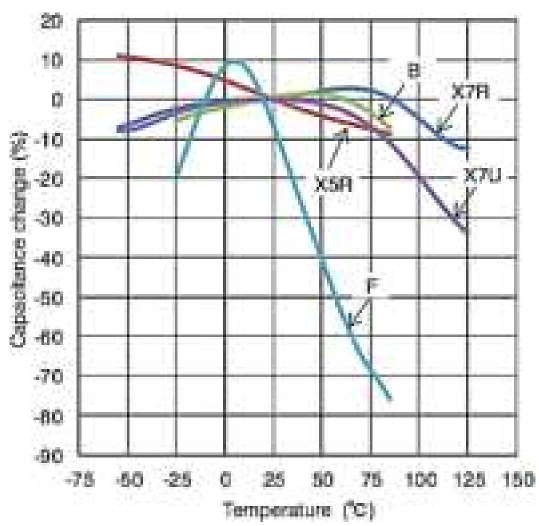


Figure 6. MLCC Capacitor Capacitance vs. Temperature Example (Source: Rohm)

If a user requires higher operating voltage, then it's necessary to replace the mentioned capacitors with new ones with higher voltage rating. Use at least one high-voltage

100 nF MLCC for Half-Bridge Stage +V_{BUS} supply decoupling. In general, it’s strongly recommended to implement more capacitors, the mixture of multiple values to ensure more advanced filtering similarly as shown schematic diagram in Figure 7. It should be noted that minimum capacitance should be more than 250 nF, meaning sum of all capacitor’s (C22−C25) capacitance, while the lower capacitance is utilized, there is higher risk of capacitor damage as it might not accept all energy stored in the power loop stray inductance. If the user needs to replace used capacitors, the new capacitors must be re-evaluated to find out if they are complying with desired performance. In case that decoupling capacitor are still too hot, then the two or more capacitors may be stacked on pile to increase capacitance as well as permissible ripple current. On the other hand, reducing capacitor’s ESR resistance will result in lower capacitors ESR related losses which subsequently betters te. Additionally, must be noted that capacitors are preheated by HB stage power devices IC3 and IC4. For better understanding refer to the thermal section where DC power measurement shows capacitors temperature increase despite, they don’t operate.

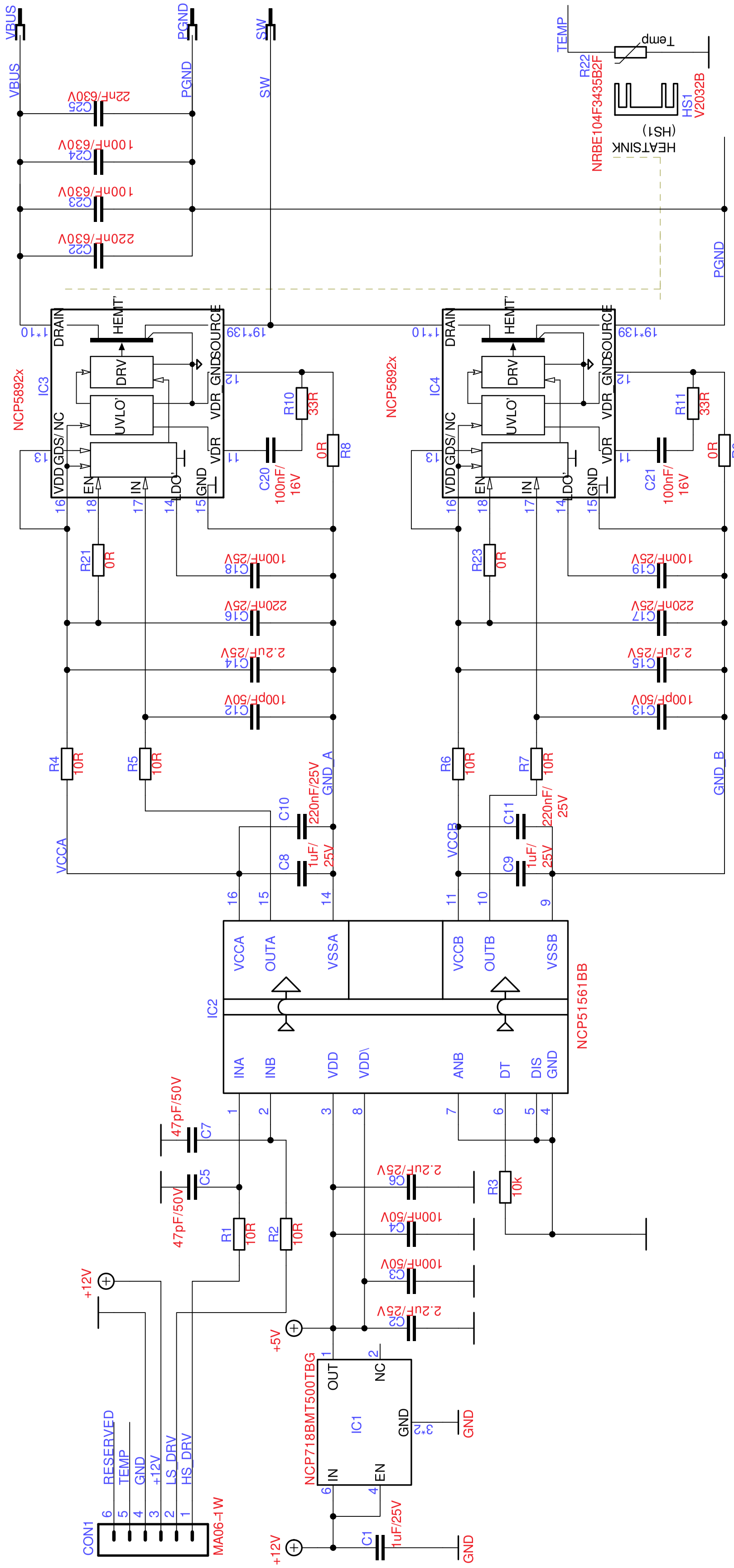


Figure 7. Isolated Driver and Half-bridge Power Stage Schematic Diagram

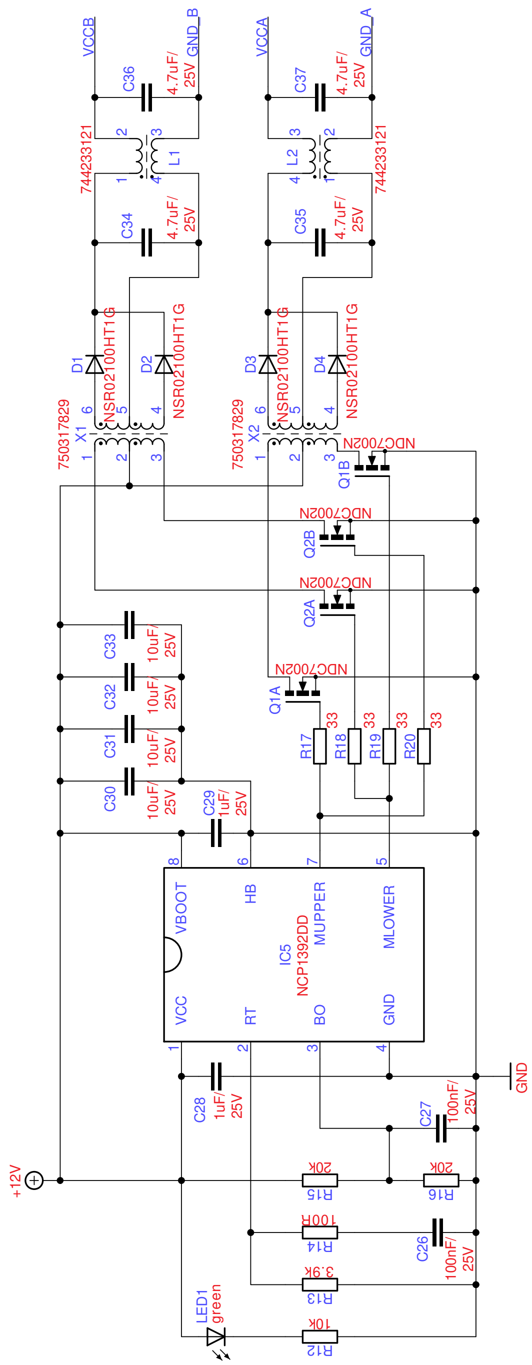


Figure 8. Half-bridge Module Insulated Power Supply Schematic Diagram

Insulated Power Supply Description

The following text section refers to schematic diagram of the Half-bridge Module Insulated Power Supply depicted in Figure 8. As it can be seen from schematic diagram the Half-bridge Module Insulated Power Supply is based on NCP1392 that is High Voltage Half-bridge driver. The used version NCP1392D is a self-oscillating high voltage MOSFET driver primarily tailored for the applications using half bridge topology, however, in this case is device connection is modified to enable operation in push-pull converter topology. Modifications require following steps:

- HB pin is grounded (merged with GND) to ground floating section of driver and refer both driver cell outputs to ground.
- Bootstrap circuit is removed; thus, bootstrap diode and resistor are not needed anymore.
- VCC and VBOOT are merged to same supply voltage node, while local decoupling capacitors C28 and C29 for each supply pin are kept
- Brown-Out (BO) Pin divider is tied and fitted to VCC supply node/ level.

NCP1392 has inbuilt Under-Voltage Lock-Out protection (UVLO) that enables device drivers when the input VCC voltage rise above 10 V while floating section VBOOT must be above 8.8 V. Once VCC/VBOOT levels are high enough to satisfy UVLO, then the Brown-Out pin level is considered as enable for switching operation. BO levels are adjusted with divider R15 and R16 while C27 is only filter capacitor that introduces small delay. In this case BO levels are set very low (BO on ~2.36 V / BO Off 2.0 V), however, user may adjust them according to needs via changing R15. If user changes R15 to 150 kΩ the BO levels are following: BO on ~11.23 V / BO Off ~8.5 V. Related to supply management and BO, it should be noted that device has implemented PFC Delay feature that delays (B version 100 ms, D version 12.6 ms) start after VCC supply voltage rise above VCC UVLO ON level, for detailed explanation refer to device datasheet.

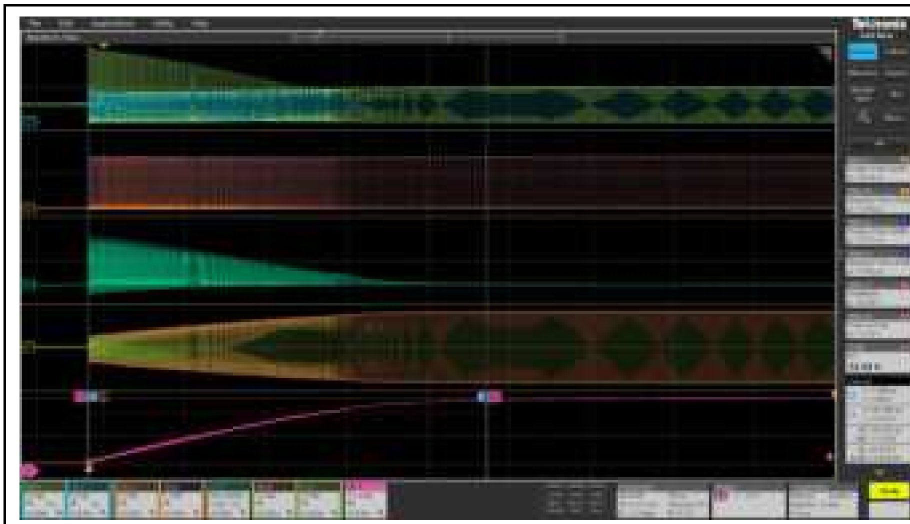
The NCP1392 internal dead-time helps to prevent cross conduction between the upper and lower power transistors however, in this case, both low-side transistors Q1A/Q1B (or second pair Q2A/Q2B) cannot be switched-on at same time too. The NCP1392 outputs drive two dual MOSFETs Q1and Q2 via gate resistors R17–R20, so one driver services two transformers (via Q1/Q2) at once. The NCP1392 offers two fixed Dead-Time values, NCP1392D version provides 305 ns typically while NCP1392B version offers 610 ns typ. The NCP1392D version with shorter dead-time was implemented which enables higher switching frequency that better matches used transformers X1, and X2 (750 317 829). The operating frequency can be adjusted from 25 kHz to 480 kHz using a single resistor R13 connected to RT pin. When the resistor R13 is equal to 3.9 kΩ, it sets switching frequency to ~426 kHz while 4.7 kΩ adjusts frequency to ~358 kHz, see waveforms in Figure 9 and Figure 10. The series RC circuit made of R14 & C26 that is also connected to RT pin, sets the soft-start sequence duration. The soft-start sequence takes approximately 150–160 μs (V_{CC_X} = 10 V) while output voltage is built to 11.95 V after 190 μs refer to Figure 11. Additionally, should be noted, as it’s visible from Figure 9 and Figure 10 primary transistors Q1 & Q2 operate in or very close to Zero Voltage Switching (ZVS), then the secondary side rectifies diodes (D1/D2 or D3/D4 in Figure 8) may achieve Zero Current Switching (ZCS) thanks to turning off at zero current. The last one portion of the Insulated power supply is the CLC filter C34/L1/C36 and C35/L2/C37 using the common mode chokes, that limit AC current forced by switching operation.

CH1/CH2 – Drain-Source Voltage of Q1A/Q1B
CH5/CH6 – IC5 MLOWER / IC5 MUPPER
CH8 – X1 primary current (Pin 2)
CH3/CH4 – X1 Secondary Voltage Pins 6/4
CH7 – Output Voltage VCC_A

Figure 9. DC-DC Converter Waveforms Using R13 = 3.9 kΩ. Operating Frequency 426 kHz

CH1/CH2 – Drain-Source Voltage of Q1A/Q1B
CH5/CH6 – IC5 MLOWER / IC5 MUPPER
CH8 – X1 primary current (Pin 2)
CH3/ CH4 – X1 Secondary Voltage Pins 6/4
CH7 – Output Voltage VCC_A

Figure 10. DC-DC Converter Waveforms Using R13 = 4.7 kΩ. Operating Frequency 358 kHz



CH1/CH2 – Drain-Source Voltage of Q1A/Q1B
CH5/CH6 – IC5 MLOWER / IC5 MUPPER
CH8 – X1 primary current (Pin 2)
CH3/CH4 – X1 Secondary Voltage Pins 6/4
CH7 – Output Voltage VCC_A

Figure 11. DC-DC Converter Start-up Sequence Waveforms

Half-bridge Module Construction Description

This section provides comments on the construction of the Half-Bridge Power Module and mainly relies on Figure 12, that is based on three pictures.

The top-left photograph shows the HB Power Module component from topside and identify basic building parts. As it may be seen from photograph, VBUS decoupling MLCC capacitors are located very close to the Drain of HB stage high-side device. Both power switch devices are close to each other on this side of the PCB together with insulated driver NCP51561 which simplifies PCB layout and allows implement signal shielding copper polygons (see PCB layout description). The LDO regulator NCP718 is next to NCP51561 together with VCC supply decoupling capacitors for straightforward copper routing and connection with primary side of NCP51561. The NCP1392 was placed on the same side due to free area space and requirement to keep it off from transformer side. The mounting hole positions is a very important thing that should be highlighted here. Considering tradeoffs, the mounting holes were placed as symmetrically as possible surrounding the power devices to create adequate mounting force distribution. User needs to be aware that minimum mounting hole count should be at least two as using only one hole/ screw may introduce PCB deformation which leading to worsening thermal resistance from device to heatsink. However, optimal mechanical solution is a PCB with four holes, and such a solution will prevent PCB warping as well as thermal resistance increase.

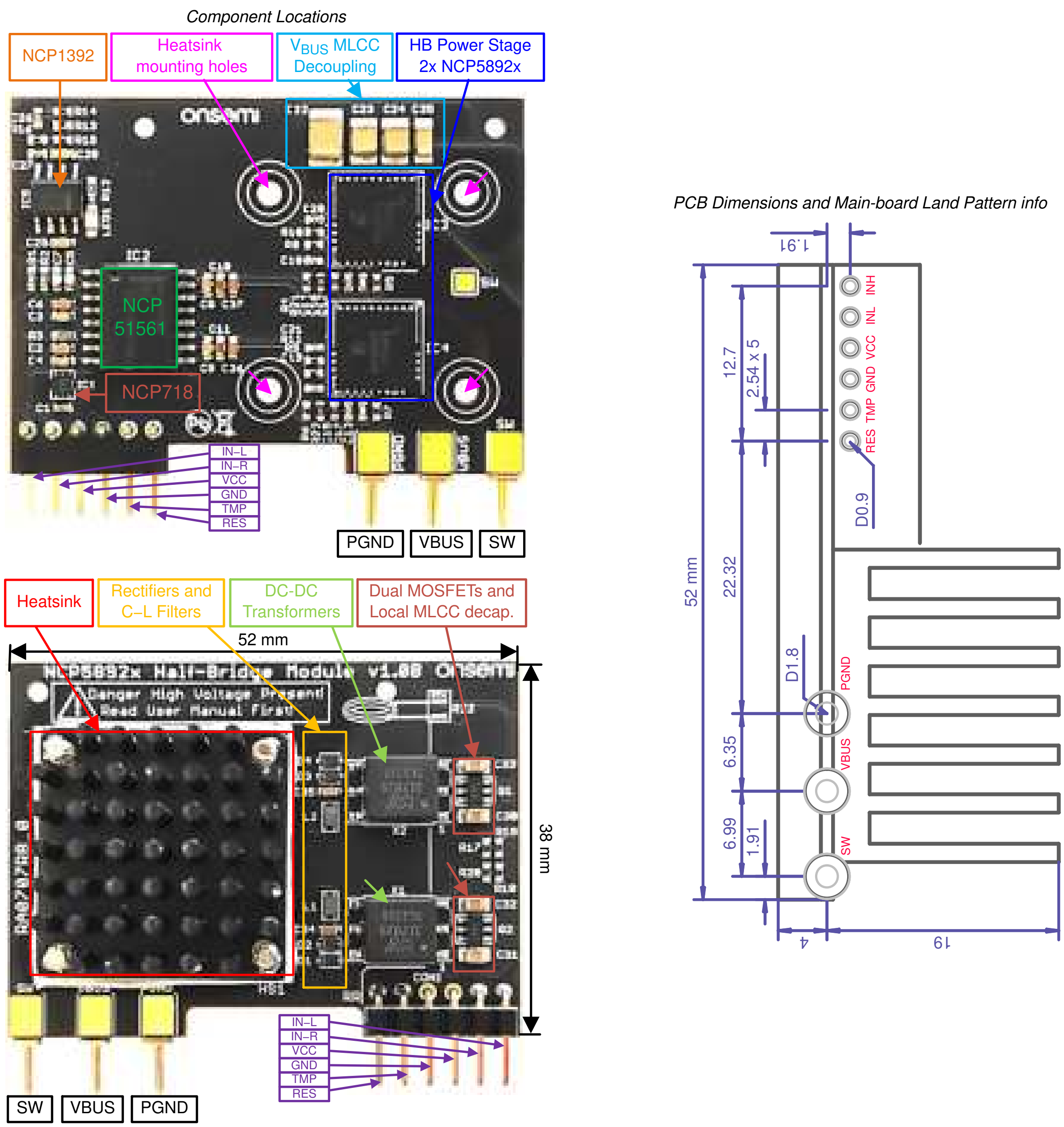
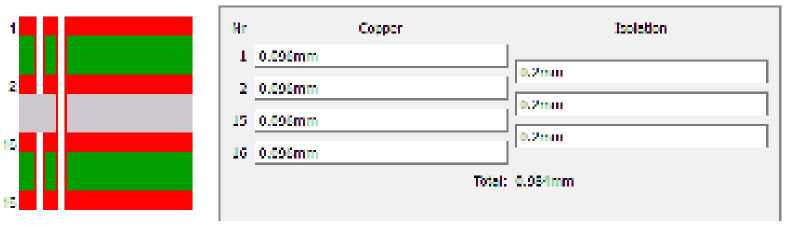


Figure 12. HB Power Module Photographs and Assembling Description

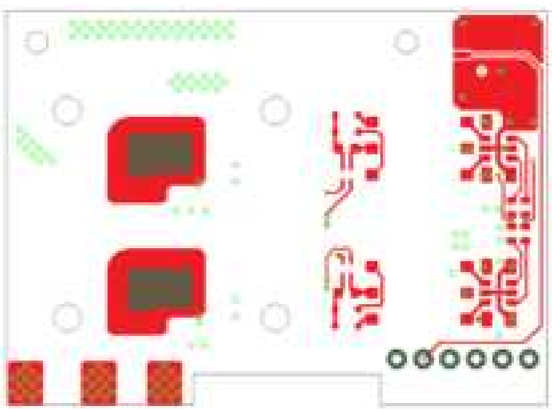
In Figure 12 picture right, is a drawing that shows information about module dimensions (all dimensions are shown in units of mm) as well as recommended drill size and positions for creating land pattern. Red tags in this drawing refer to terminals assignment as is shown in photographs and schematic diagram in Figure 7. The recommended drill diameter for power terminals (VBUS, PGND, SW) is 1.8 mm when dedicated pin socket (0327−0−15−15−34−27−10−0) is used. Advised drill diameter for signal pin header (IN−L, IN−R, +12 V, GND, ...) is 0.9 mm, however, user may adjust it based on used pin-header socket.

Half-bridge Module PCB Layout Description

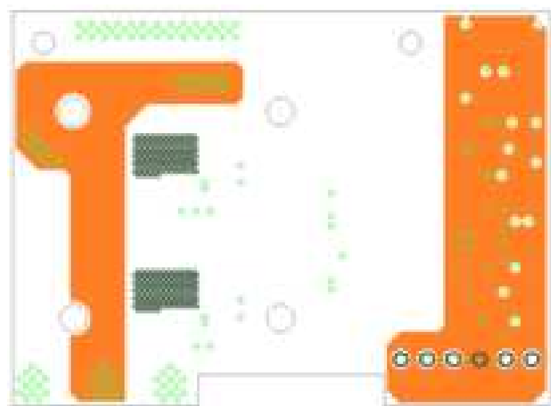
This portion provides basic technical information about PCB construction, see top picture in Figure 13 and layout depiction as well in Figure 13 four pictures below. As top picture in Figure 13 shows PCB stack, the PCB has four copper layers with 96 μm thickness while laminates thickness is 200 μm. The 96 μm copper thickness is minimum recommended copper thickness that enables sufficient cooling of power device. It should be noted that copper plating level is also very important as bigger plating creates vias with thicker copper walls that cut down thermal resistance. In left portion of top picture in Figure 13 PCB vias structure is illustrated, there are three via types.; The first one type of via provides bond to all layers, second type of one via, is connecting top layer (red) with 2nd inner layer (orange). The last via type is interconnecting 15th inner layer (violet) with bottom layer (blue). Above mentioned via structure arrangement was selected to simplify the PCB layout and utilize space better for components instead of wasting it for unused via with necessary clearance.



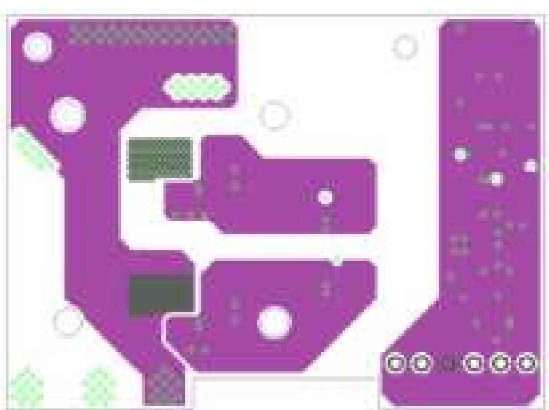
PCB Layer Stack Parameters



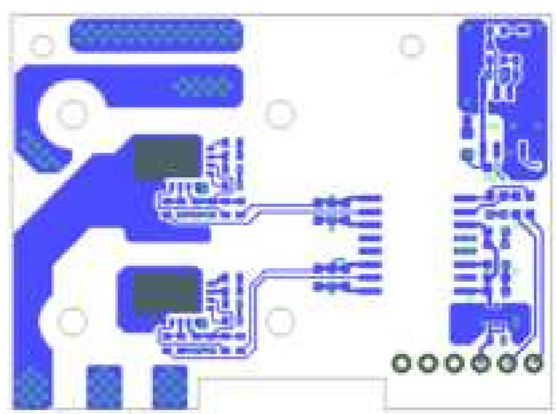
Top Layer (1)



Inner Layer (2)

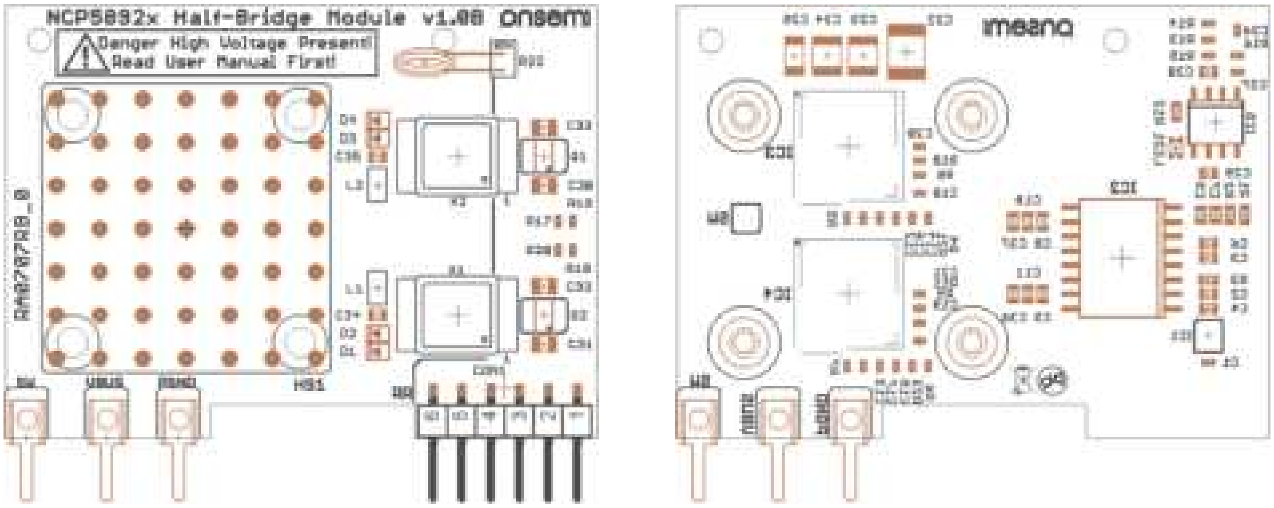


Inner Layer (15)



Bottom Layer (16)

Figure 13. HB Power Module PCB Layout



Top Assembly Bottom Assembly

Figure 14. HB Power Module PCB Assembly

Half-bridge Module PCB Assembly Description

Figure 14 show PCB assembling top (picture left) and bottom side (picture left). As it's visible from top side assembly figure, the main components are DC-DC converter transformers with dual driving MOSFET transistors with decoupling MLCC caps, output rectifiers diodes, filter capacitors with common mode inductors and finally the biggest component is the heatsink. It must be reminded that between heatsink and PCB the thermal interface material (TIM) is placed. In this case the TIM ensures heatsink electrical insulation from SOURCE of each switching device. Another important feature of the TIM part is gap filling thus improving thermal coupling between two opposite sides, thus, the heat transfer from the PCB copper pads or polygons and heatsink surface. More information about thermal resistance of independent parts and thermal performance of this demo-board is described further in the Thermal performance section. Refer to section with Bill of Material list (BOM) to find used part numbers for used devices as well as thermal interface materials and the others.

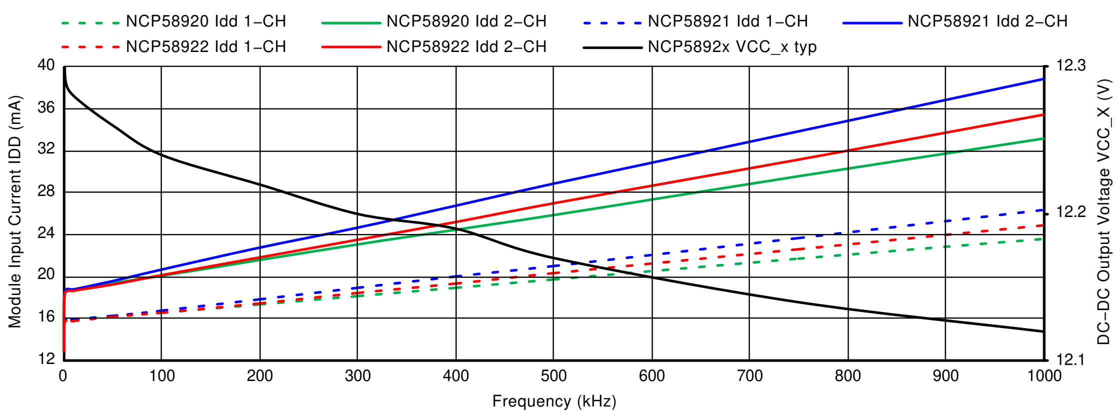


Figure 15. HB Power Module Supply Current Consumption vs. Operating Frequency

Half-bridge Module Operating Consumption

In Figure 15 is depicted HB Power Module I_{DD} Supply current consumption vs. switching frequency for various device options (NCP58920 − green, NCP58921 − blue, NCP58922 − red) and with one (1-CH, one channel switches and second channel is idle) or two (2-CH) channels operation. Black curve in Figure 15 shows module DC-DC supply typical output voltage with y axe on the right side of the chart. As is visible, the maximum consumption is 38 mA @ 1 MHz while NCP5892x supply voltage is stable withing 0.2 V range for given frequency range.

Half-bridge Module Turn-on Speed or dv_{DS}/dt vs. R_{ON}

Refer to waveforms in Figure 16 and 17 to see how R_{ON} influences dv_{DS}/dt slew rate. Both figures demonstrate waveforms measurement in Double-Pulse-Tester (DPT) setup where inductor current is ramped up through various levels, from 0 A up to 10 A. The turn-on resistors R10 and R11 that are shown in Figure 7 were changed across various measurements in the DPT. Overall summary of dv_{DS}/dt slew characteristic can be found in Figure 18 in which dv_{DS}/dt is displayed as function of R_{ON} for all NCP5892x versions.

For the initial evaluation in application is recommended to start with $R_{ON} = 33\ \Omega$.

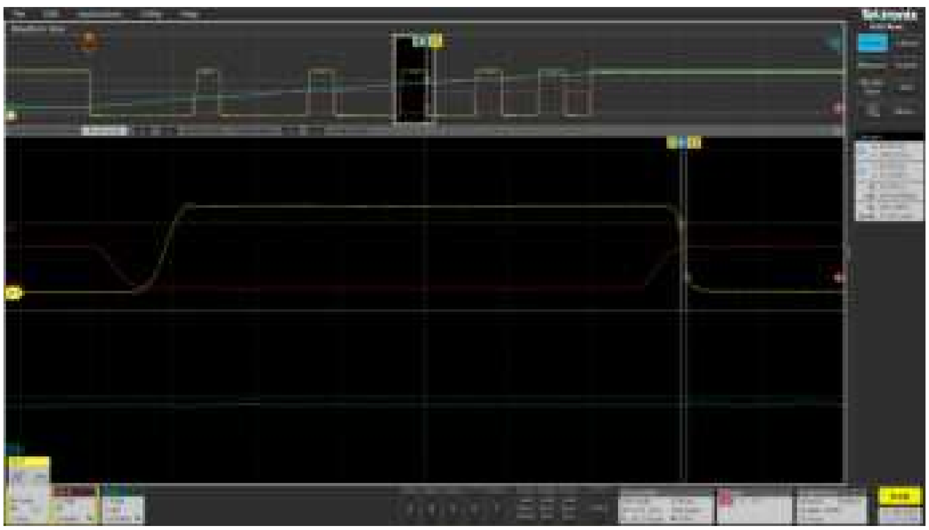
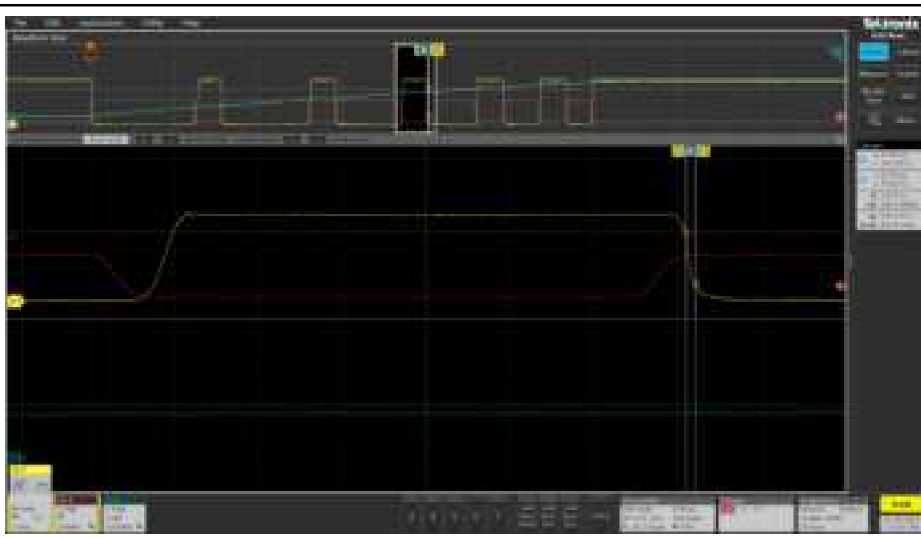
$R_{ON} = 0\ \Omega$		CH1 – $V_{SW}(t)$ Switching node Voltage CH3 – $V_{DRV}(t)$ Low−side IN Input Voltage CH8 – $I_L(t)$ Inductor Current
$R_{ON} = 10\ \Omega$		CH1 – $V_{SW}(t)$ Switching node Voltage CH3 – $V_{DRV}(t)$ Low−side IN Input Voltage CH8 – $I_L(t)$ Inductor Current
$R_{ON} = 20\ \Omega$		CH1 – $V_{SW}(t)$ Switching node Voltage CH3 – $V_{DRV}(t)$ Low−side IN Input Voltage CH8 – $I_L(t)$ Inductor Current

Figure 16. Half-Bridge Power Module Waveform vs. Various R_{ON} Resistance 0−20 Ω (NCP58921)

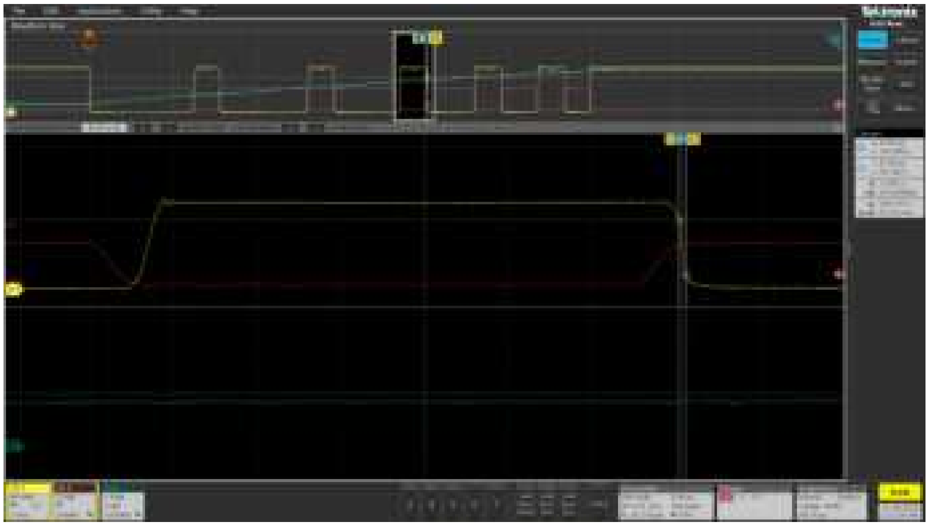
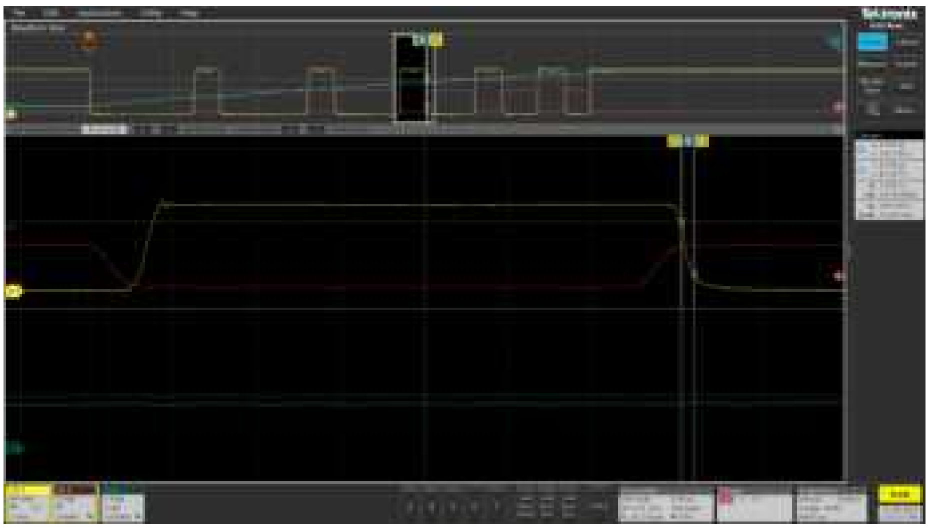
R_{ON} = 33 Ω		CH1 – V_{SW}(t) Switching node Voltage CH3 – V_{DRV}(t) Low−side IN Input Voltage CH8 – I_L(t) Inductor Current
R_{ON} = 47 Ω		CH1 – V_{SW}(t) Switching node Voltage CH3 – V_{DRV}(t) Low−side IN Input Voltage CH8 – I_L(t) Inductor Current

Figure 17. Half-Bridge Power Module Waveform vs. Various R_{ON} Resistance 33–47 Ω (NCP58921)

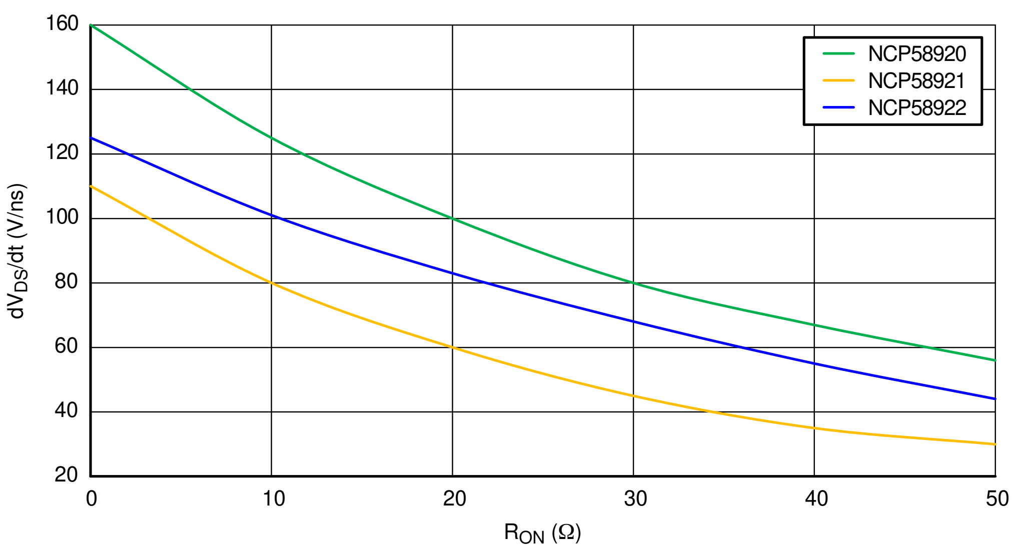
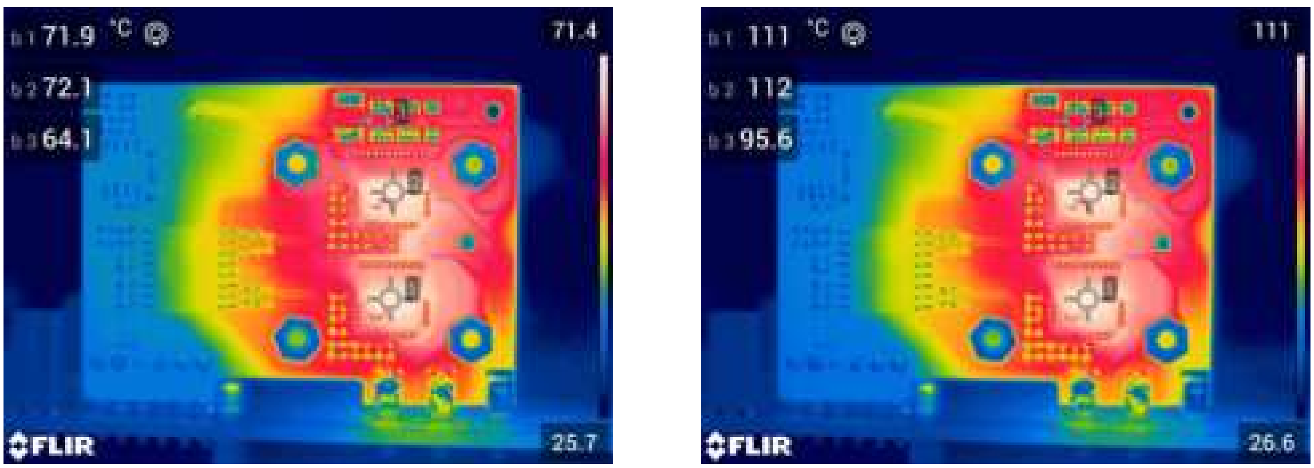


Figure 18. Half-Bridge Power Module Switch-node dv/dt vs. R_{ON} for All Devices in Family

Thermal Performance

NCP5892x power devices may dissipate significant amounts of power losses depending on operation and setup. NCP5892x family offers devices housed in TQFN26 that are bottom cooled and generated heat is extracted from its exposed pad through subsequent cooling chain parts. It's recommended to estimate power dissipation level and calculate maximal thermal resistance of cooling chain for allowable temperature rise or maximum junction temperature T_{jmax}. For that purpose, refer to datasheet section "Thermal Guidelines" However, the most difficult task is to estimate exact power dissipation level from the temperature rise and thermal resistance. For that purpose, the thermal resistance of given PCB prototype must be measured or mapped using exact DC power level while real cooling conditions are applied. For generating sufficient power lost is ideal to force flow current in device third quadrant (3rd Q) of VA characteristic. Thanks to GaN higher voltage drop in 3rd Q which is few units of Volt, the current doesn't have to be so high to generate required heat. Once, DC power based thermal measurement is done and thermal resistance is known, then it's easy to calculate losses back from temperature rise. The temperature rise versus DC power losses of HB Module was evaluated for conditions where natural convection cooling and forced cooling with fan where applied. Figure 19 displays thermal images of HB Module at 3 W and 6 W power dissipation levels for natural convection cooling while Figure 20 shows thermal images with fan forced cooling. It is important to note that when HB Module uses passive or natural convention cooling, the HV ceramic decoupling capacitors may operate at very temperature due to heating effect and user must be aware of capacitors derating limitations. For estimation NCP58921 temperature rise vs. device power dissipation level at various cooling conditions refer to Figure 21.

It should be noted that device was measured always in HB Module configuration at 25 °C and for others ambient temperatures chart curves were predicted from base at 25 °C.

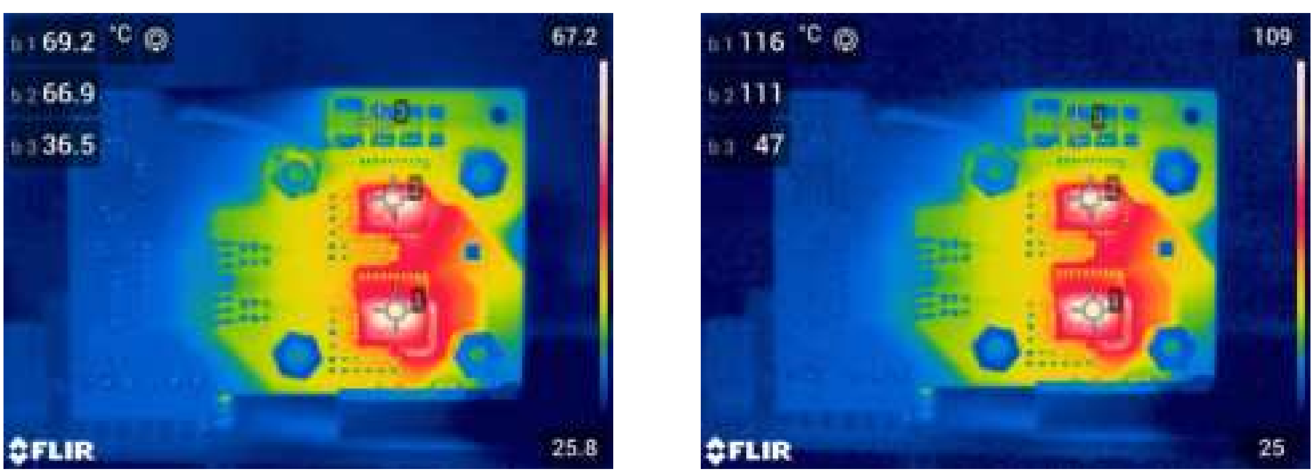


P_{Dtot} = 3 W

P_{Dtot} = 6 W

Figure 19. Thermal Images at P_{Dtot} = 4 W and 8 W Natural Convection

(Conditions: Exact DC power, Heatsink V2031B, Natural airflow)

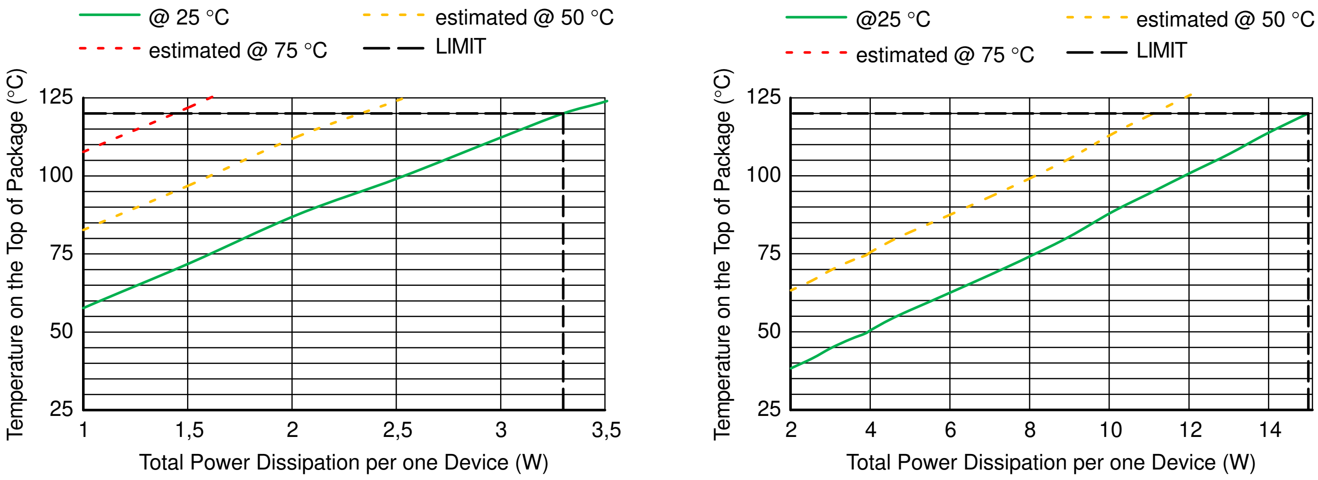


P_{Dtot} = 3 W

P_{Dtot} = 6 W

Figure 20. Thermal Images at P_{Dtot} = 14 W and 28 W with Forced Cooling

(Conditions: Exact DC power, Heatsink V2031B, Forced airflow with fan EBM PAPST 422JN (12 V/0.33 A))



Passive Cooling *Forced Airflow*

Figure 21. Device TOP Side Temperature vs. its Dissipation Power

Application Examples

This section shortly covers two application examples First example shows the Buck-Boost Main-board (Figure 22 left) and the second example is a Full-bridge DC-DC Power Stage (Figure 22 right) that emulates 1.5 kW application using energy recycling operation. Buck-Boost Main-board that is dedicated to accepting the Half-Bridge Power Module with DC-DC power supply. The Buck-Boost Main-board was created as a simple Buck-Boost converter that is suitable for evaluation of the Half-Bridge Power Module. Buck or Boost mode can be selected just by swapping Input and Output power terminals. The Buck-Boost Main-board enables to easily test NCP58921 performance (or other members of family like NCP58922 or NCP58920). The Buck-Boost Evaluation board requires inserting the HB Power Module and simple PWM Generator Module or interconnecting a standard generator with using BNC connectors. The generator needs to be set PWM signals to ensure proper operation. A user adjusts the desired operating Frequency and Duty Cycle depending on desired gain and/or inductor current operating mode (DCM, CrM, CCM) considering inductance. For more detailed demo-board description refer to TND6467/D.

The Full-bridge DC-DC Power Stage uses two Half-Bridge Power Modules. This DC-DC Power Stage operates in such a way that in the first cycle of working period stores energy into power inductor while in second cycle inductor stored energy is returned to bulk or bus capacitor. Power inductor current can be positive as well as negative depending on switching signals sequencing (PWM Duty cycle and shift). Main purpose of this Full-bridge DC-DC Power Stage is to emulate real application operating conditions, cycling sufficient power level in the power stage while its consumption covers only power losses. This is a modern approach to build and perform reliability test applications.

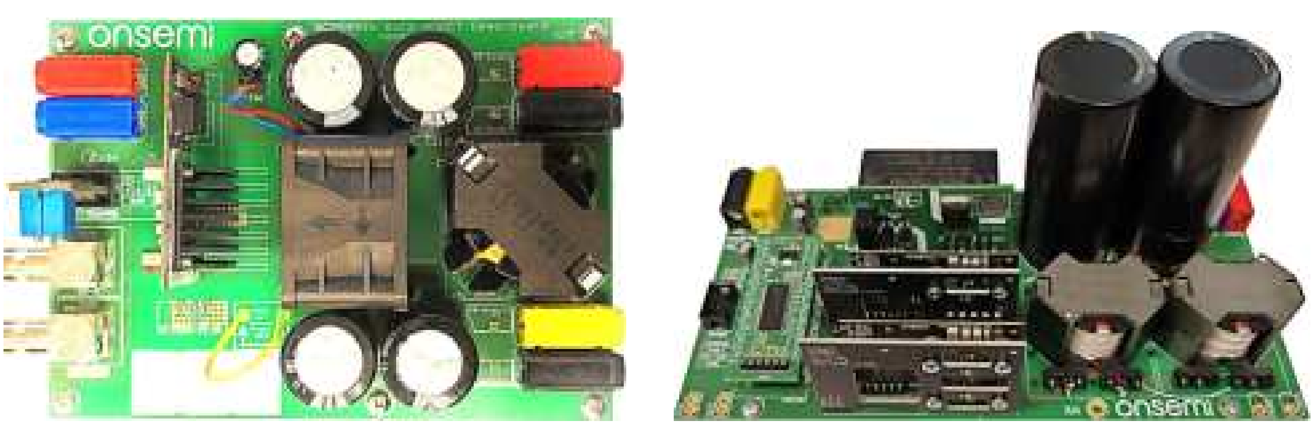


Figure 22. Half-Bridge Power Module Application Examples

USEFUL LINKS

NCP58920, Enhanced Mode GaN Power Switch with Integrated Driver
https://www.onsemi.com/download/data–sheet/pdf/ncp58920–d.pdf

NCP58921, Enhanced Mode GaN Power Switch with Integrated Driver
https://www.onsemi.com/download/data–sheet/pdf/ncp58921–d.pdf

NCP58922, Enhanced Mode GaN Power Switch with Integrated Driver
https://www.onsemi.com/download/data–sheet/pdf/ncp58922–d.pdf

NCP1392, MOSFET Driver, High Voltage, Half Bridge, with Inbuilt Oscillator
https://www.onsemi.com/download/data–sheet/pdf/ncp1392–d.pdf

NCP51561, 5 kV RMS Isolated Dual Channel 4.5/9 A Gate Driver
https://www.onsemi.com/download/data–sheet/pdf/ncp51561–d.pdf

NCP718, LDO Regulator, 300 mA, Wide Vin, Ultra-Low Iq
https://www.onsemi.com/download/data–sheet/pdf/ncp718–d.pdf

NDC7002N, Dual N-Channel Enhancement Mode Field Effect Transistor 50 V, 0.51 A, 2 Ω
https://www.onsemi.com/download/data–sheet/pdf/ndc7002n–d.pdf

NSR02100HT1G, 200 mA, 100 V, Schottky Barrier Diode
https://www.onsemi.com/download/data–sheet/pdf/nsr02100ht1–d.pdf

Buck-Boost Main-board for NCP58921 Based Module User’s Guide
https://www.onsemi.com/download/reference–designs/pdf/tnd6467–d.pdf

BILL OF MATERIALS

Parts	Qty	Value	Device	Package	Tolerance	P/N	Manufacturer
C1	1	1 μF/25 V	Capacitor	C0402	±20%	various	various
C10, C11	2	220 nF/25 V	Capacitor	C0603	±20%	885012206073	Wurth
C12, C13	2	100 pF/50 V	Capacitor	C0402	±5%	885012205055	Wurth
C14, C15	2	2.2 μF/25 V	Capacitor	C0402	±20%	various	various
C16, C17	2	220 nF/25 V	Capacitor	C0402	±20%	various	various
C18, C19, C26, C27	4	100 nF/25 V	Capacitor	C0402	±20%	885012205092	Wurth
C2, C6	2	2.2 μF/25 V	Capacitor	C0603	±20%	various	various
C20, C21	2	100 nF/16 V	Capacitor	C0402	±20%	885012205037	Wurth
C22	1	220 nF/630 V	Capacitor	C1812	±20%	various	various
C23, C24	2	100 nF/630 V	Capacitor	C1210	±20%	various	various
C25	1	22 nF/630 V	Capacitor	C1206	±20%	885342208014	Wurth
C3, C4	2	100 nF/50 V	Capacitor	C0603	±20%	885382206004	Wurth
C30, C31, C32, C33	4	10 μF/25 V	Capacitor	C0805	±20%	885012107027	Wurth
C34, C35, C36, C37	4	4.7 μF/25 V	Capacitor	C0603	±20%	various	various
C5, C7	2	47 pF/50 V	Capacitor	C0603	±20%	885012006055	Wurth
C8, C9, C28, C29	4	1 μF/25 V	Capacitor	C0603	±20%	885012206076	Wurth
CON1	1	MA06–1W	Connector	MA06–1W	–	various	various
D1, D2, D3, D4	4	NSR02100H	Diode	SOD323	–	NSR02100HT1G	**onsemi**
HS1	1	V2031B	Heatsink	25 x 25 mm	–	V2031B	Assmann WSW Components
TIM	1	40105005	TIM	N/A	–	40105005	Wurth
SPACER	4	M2.5 x 05	Spacer	M2.5	–	DSL–DA5M2.5x05	various
SCREW	4	M2.5 x 5	Screw	M2.5x5	–	varSK_PH_K–M2.5x5 DIN7985ious	various
SCREW NUT	4	MK–M2.5	Screw Nut	M2.5	–	various	various
IC1	1	NCP718BMT500TBG	V Regularor	WDFN6_2X2–0.65	–	NCP718BMT500TBG	**onsemi**
IC2	1	NCP51561BB	ISO Driver	SO16W–IOSL	–	NCP51561BBDWR2G	**onsemi**
IC3, IC4	2	NCP58921MNTWG	iGaN	TQFN26	–	NCP58921MNTWG	**onsemi**
IC5	1	NCP1392DD	IC – HB Driver	SOIC8	–	NCP1392DDR2G	**onsemi**
L1, L2	2	744233121	CM Indutor	805	–	744233121	Wurth
LED1	1	Green	LED	805	–	150080GS75000	Wurth
PGND, SW, VBUS	3	3620–2–32–15–00–00–08–0	PCB Edge Connector	–	–	3620–2–32–15–00–00–08–0	Mill–Max Manufacturing Corp.
Q1, Q2	2	NDC7002N	DUAL N–MOSFET	TSOT23–6	–	NDC7002N	**onsemi**
R1, R2	2	10 Ω	Resistor	R0603	±1%	various	various
R10, R11	2	33 Ω	Resistor	R0402	±1%	various	various
R13	1	3.9 kΩ	Resistor	R0402	±1%	various	various
R14	1	100 Ω	Resistor	R0402	±1%	various	various
R15, R16	2	20 kΩ	Resistor	R0402	±1%	various	various
R17, R18, R19, R20	4	33 Ω	Resistor	R0402	±1%	various	various
R22	1	NRBE104F3435B2F	Thermistor	NRBE	±1%	various	various
R3, R12	2	10 kΩ	Resistor	R0603	±1%	various	various
R4, R5, R6, R7	4	10 Ω	Resistor	R0402	±1%	various	various
R8, R9	2	0 Ω	Resistor	R0402	±1%	various	various
X1, X2	2	750317829	Transformer	7.14 x 6.73 mm	–	750317829	Wurth

ADDITIONAL INFORMATION

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

ONLINE SUPPORT: www.onsemi.com/support
For additional information, please contact your local Sales Representative at www.onsemi.com/support/sales

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