EVM User's Guide: UCC218002QEVM-111

UCC218XXXEVM-111 Half-Bridge EVM User's Guide for Wolfspeed 1200-V SiC Platforms

ABSTRACT

The UCC218XXXEVM-111 is a compact, half-bridge gate driver board consisting of two single-channel isolated gate drivers. It provides isolated bias supply, drive current, protection and monitoring needed for driving several different models of Wolfspeed silicon-carbide (SiC) MOSFET modules and other IGBT or SiC MOSFET modules with a similar pinout. The on-board isolated bias can provide adjustable isolated voltage with passive component change.

The board's compact form factor, combined with UCC218XXX's 5kVrms reinforced isolation, makes it a good candidate for doing high voltage tests, such as double-pulse tests and short-circuit tests, with the Wolfspeed SiC modules. The board can also be used with all variants of the UCC218xxx with minimal on-board modifications.

This user's guide describes the characteristics, operation and use of the UCC218XXXEVM-111 Evaluation Module (EVM). It currently supports 2 different variants:

- UCC218200EVM-111
- UCC218002EVM-111

Each variant can be ordered separately based on the variant order number information.

A complete schematic diagram, printed circuit board layouts, and bill of materials are included in this document.

1 General TI High Voltage Evaluation User Safety Guidelines

Always follow TI's set-up and application instructions, including use of all interface components within their recommended electrical rated voltage and power limits. Always use electrical safety precautions to help ensure your personal safety and the safety of those working around you. Contact TI's Product Information Center http://support/ti./com for further information.

Save all warnings and instructions for future reference.

Failure to follow warnings and instructions may result in personal injury, property damage, or death due to electrical shock and/or burn hazards.

The term TI HV EVM refers to an electronic device typically provided as an open framed, unenclosed printed circuit board assembly. It is intended strictly for use in development laboratory environments, solely for qualified professional users having training, expertise, and knowledge of electrical safety risks in development and application of high-voltage electrical circuits. Any other use and/or application are strictly prohibited by Texas Instruments. If you are not suitably qualified, you must immediately stop from further use of the HV EVM.

- **Work Area Safety:**
  - Maintain a clean and orderly work area .
  - Qualified observer(s) must be present anytime circuits are energized.
  - Effective barriers and signage must be present in the area where the TI HV EVM and its interface electronics are energized, indicating operation of accessible high voltages may be present, for the purpose of protecting inadvertent access.
  - All interface circuits, power supplies, evaluation modules, instruments, meters, scopes and other related apparatus used in a development environment exceeding 50 V_{RMS}/75 VDC must be electrically located within a protected Emergency Power Off (EPO) protected power strip.
  - Use a stable and non-conductive work surface.
  - Use adequately insulated clamps and wires to attach measurement probes and instruments. No freehand testing whenever possible.
- **Electrical Safety:**

  As a precautionary measure, it is always a good engineering practice to assume that the entire EVM may have fully accessible and active high voltages.

  - De-energize the TI HV EVM and all its inputs, outputs, and electrical loads before performing any electrical or other diagnostic measurements. Confirm that TI HV EVM power has been safely de-energized.
  - With the EVM confirmed de-energized, proceed with required electrical circuit configurations, wiring, measurement equipment hook-ups and other application needs, while still assuming the EVM circuit and measuring instruments are electrically live.
  - When EVM readiness is complete, energize the EVM as intended.

  WARNING

  WARNING: While the EVM is energized, never touch the EVM or its electrical circuits as they could be at high voltages capable of causing electrical shock hazard.
- **Personal Safety:**
  - Wear personal protective equipment, for example, latex gloves and/or safety glasses with side shields or protect EVM in an adequate lucent plastic box with interlocks from accidental touch.
- **Limitation for Safe Use:**
  - EVMs are not to be used as all or part of a production unit.

Safety and Precautions

The EVM is designed for professionals who have received the appropriate technical training, and is designed to operate from an AC power supply or a high-voltage DC supply. Please read this user guide and the safety-related documents that come with the EVM package before operating this EVM.

CAUTION

Do not leave the EVM powered when unattended.

WARNING

High Voltage! Electric shock is possible when connecting board to live wire. Board must be handled with care by a professional.

For safety, use of isolated test equipment with overvoltage and overcurrent protection is highly recommended.

2 Module and Gate Driver Compatibility

2.1 Supported Wolfspeed Modules and Evaluation Platforms

Below is a list of Wolfspeed evaluation platforms and SiC modules supported by the half-bridge gate driver board.

Table 2-1. Wolfspeed Evaluation Platforms and SiC Modules Supported

Wolfspeed Design	Wolfspeed Parts Supported	Description
SpeedVal Kit	650-1200V Discrete MOSFETs, FM Half-Bridge Modules	Dynamic Characterization and Power Testing Platform
KIT-CRD-CIL12N-XM3	1200V XM Power Modules	Dynamic Characterization Platform
KIT-CRD-CIL12N-GMA	1200V GM Half-Bridge Modules	Dynamic Characterization Platform
KIT-CRD-CIL12N-FMA	1200V Half-Bridge FM Power Modules	Dynamic Characterization Platform
KIT-CRD-CIL12N-FMB	1200V FM Full-Bridge Modules	Dynamic Characterization Platform
KIT-CRD-CIL12N-FMC	1200V 6-Pack FM Power Modules	Dynamic Characterization Platform

Other SiC MOSFET modules and IGBT modules with similar pinouts are directly supported as well.

2.2 Supported Gate Drivers

Table 2-2. Supported Gate Drivers

Gate Driver	Support	EVM Part Number	Miller Clamp	Peak Current Rating	SC Protection	External Buffer	Modifications Neeeded
UCC218002-Q1	Available as EVM	UCC218002EVM-111	Internal	5A	DESAT (9V)	Not populated by default	None
UCC218200-Q1	Available as EVM	UCC218200EVM-111	Internal	15A	DESAT (9V)	Not populated by default	None

3 System Overview and Functions

3.1 Features

- Fully compatible with UCC218xxx family of isolated gate drivers
- Directly compatible with Wolfspeed's FM3 and XM3 modules
- UCC34141 isolated bias supplies up to 1.5 W to each driver
  - Only a +12-V input voltage needed to generate the primary-side and secondary-side bias voltages
- Status LEDs indicate power-good and fault feedback from each driver
- Test points for all critical nodes to expedite debugging
- Ability to install external buffer to increase drive strength

3.2 Specifications

Wide bandgap SiC FET based power modules are introduced in power electronics instead of Si IGBT because of their excellent conduction and switching performance. Compact driver board UCC218XXXEVM-111 supports SiC modules by reducing parasitics, minimizing switching loss, EMI and providing full required protection and diagnostics features.

Table 3-1. Electrical Specifications: UCC218002EVM-111

Parameter		Test Conditions	Min	Nom	Max	Unit
SUPPLY VOLTAGES AND CURRENTS						
Vcc	VCC supply voltage		4.5	5.0	5.5	V
Vdd2u, Vdd2l	VDD supply voltages	From transformer and LDO		15		V
Vee2u, Vee2l	VEE supply voltages	From transformer and shunt regulator		-4		V
DRIVE CURRENT						
Ioh	Peak source current	CLOAD = 10nF		5		A
Iol	Peak sink current	CLOAD = 10nF		5		A
INPUT/OUTPUT SIGNALS						
Vinr, Vrstr	IN+, IN-, RST/EN rising threshold				0.7 x VCC	V
Vinf, Vrstf	IN+, IN-, RST/EN falling threshold		0.3 x VCC			V
Vinh, Vrsth	INL+, INU+, RST hysteresis			0.1 x VCC		V
TIMING PARAMETERS						
Trise	Drive output rise time	CLOAD = 1.8nF		5		ns
Tfall	Drive output fall time	CLOAD = 1.8 nF		11		ns
Tprop	Propagation delay	CLOAD = 100 pF		90		ns
SHORT CIRCUIT PROTECTION - DESAT						
Ichg	Blanking capacitor charging current			500		uA
Tdesatleb	Leading edge blank time			225		ns
Tdesatfil	DESAT deglitch filter			125		ns
Issd	Peak sink soft shutdown peak current	CL = 0.18µF, fS = 1kHz		1		A
Vclmpi	Miller Clamp threshold	Reference to VEE	1.5	2.1	2.5	V
Iclmpi	Miller Clamp current	VCLMPI = 0 V, VEE = –2.5 V		2.5		A
ISOLATION						
Viso	Withstand isolation voltage for gate driver	Reinforced, 60s		5000		Vrms
Cio	Barrier capacitance for gate driver			1.2		pF

Table 3-1. Electrical Specifications: UCC218002EVM-111 (continued)

Parameter		Test Conditions	Min	Nom	Max	Unit
Ta	Operating Ambient Temperature for gate driver		-40	25	125	°C

Figure 3-1. Electrical Specifications: UCC218200EVM-111

Parameter		Test Conditions	Min	Nom	Max	Unit
SUPPLY VOLTAGES AND CURRENTS						
Vcc	VCC supply voltage		4.5	5.0	5.5	V
Vdd2u, Vdd2l	VDD supply voltages	From transformer and LDO		15		V
Vee2u, Vee2l	VEE supply voltages	From transformer and shunt regulator		-4		V
DRIVE CURRENT						
Ioh	Peak source current	CLOAD = 10nF		15		A
Iol	Peak sink current	CLOAD = 10nF		15		A
INPUT/OUTPUT SIGNALS						
Vinr, Vrstr	IN+, IN-, RST/EN rising threshold				0.7 x VCC	V
Vinf, Vrstf	IN+, IN-, RST/EN falling threshold		0.3 x VCC			V
Vinh, Vrsth	INL+, INU+, RST hysteresis			0.1 x VCC		V
TIMING PARAMETERS						
Trise	Drive output rise time	CLOAD = 1.8nF		5		ns
Tfall	Drive output fall time	CLOAD = 1.8 nF		11		ns
Tprop	Propagation delay	CLOAD = 100 pF		90		ns
SHORT CIRCUIT PROTECTION - DESAT						
Ichg	Blanking capacitor charging current			500		uA
Tdesatleb	Leading edge blank time			200		ns
Tdesatfil	DESAT deglitch filter			125		ns
Issd	Peak sink soft shutdown peak current	CL = 0.18µF, fS = 1kHz		2.5		A
Vclmpi	Miller Clamp threshold	Reference to VEE	1.5	2.1	2.5	V
Iclmpi	Miller Clamp current	VCLMPI = 0 V, VEE = –2.5 V		4		A
ISOLATION						
Viso	Withstand isolation voltage for gate driver	Reinforced, 60s		5000		Vrms
Cio	Barrier capacitance for gate driver			1.2		pF
Ta	Operating Ambient Temperature for gate driver		-40	25	125	°C

3.3 PCB Pinout

Table 3-2. PCB Pinout

Pinout	Location (top/bottom)	Function
J1	Top	12V selection VHK_12/ VIN_12V
J2	Top	16-pin connector to connect differential signals to the EVM

Table 3-2. PCB Pinout (continued)

Pinout	Location (top/bottom)	Function
VHK_12	Top, white	Board 12V Input
VIN_HS	Top	HS_Bias input voltage (12V)
VCC_1	Top	5V
J3	Top	LS gate/source connection
J4	Top	LS DESAT drain connection
J5	Top	HS DESAT drain connection
J6	Bottom	HS gate/source connection
J8	Top	LS_Bias Enable
J9	Top	Connect Vin_12V to VIN_HS,VIN_LS
J10	Top	HS_Bias Enable
HS_PWM1	Top	HS_PWM signal Measurement
LS_PWM1	Top	LS_PWM signal Measurement
LS_RST/EN1	Top	LS_EN/RST signal Measurement
LS_SAFE1	Top	LS_Safe signal Measurement
RDY_HS	Top, orange	HS RDY
FLT_LS	Top, red	LS nFLT
FLT_HS	Top, red	HS nFLT
RDY_LS	Top, orange	LS RDY
VDD_HS	Top, red	HS VDD Voltage
VEE_HS	Top, red	HS VEE Voltage
COM_HS	Top, black	HS Side COM
VDD_LS	Top, red	LS VDD Voltage
VEE_LS	Top, red	LS VEE Voltage
COM_LS	Top, black	LS Side COM
OC_DST_HS1	Top, white	HS DESAT pin mesasurement , MMCX Connector
OC_DST_LS1	Top, white	LS DESAT pin mesasurement , MMCX connector
LS_PWM	Top, blue	LS PWM input
Pin7_HS	Top, Brown	Pin7 HS output
Pin7_LS	Top, Brown	Pin7 LS output
Pin9_HS	Top, orange	Pin9 HS output
Pin9_LS	Top, orange	Pin9 LS output
HS_PWM	Top, green	HS PWM input
RESET	Top, white	HS and LS combined nRST
S1	Top	Switch to reset HS/LS gate driver/bias
GATE_HS1	Top	MMCX connector, HS gate
GATE_LS1	Top	MMCX connector, LS gate
GND, GND_HK	Top	Primary side GND

3.4 EVM Information

3.4.1 Primary-Side Power

The primary-side power supply block fulfills the following functions:

- Provides +12-V input to the board via the connector or the test point hooks.
- Converts the +12-V input voltage to +5-V VCC for the gate drivers. This functionality is realized by a TPS7A25 LDO.

- The +12-V power supply and the PWM signals should be connected to the same board, either the differential board or the EVM. Failure to do so might result in EVM component damage.

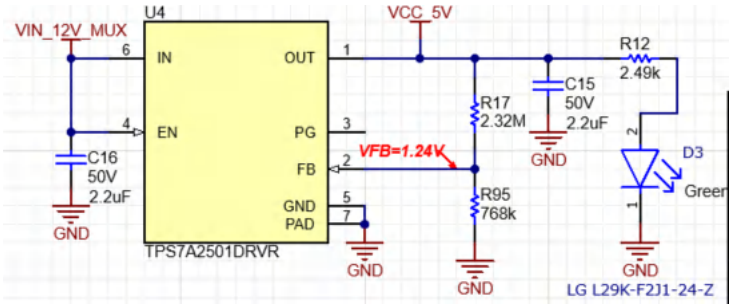


Figure 3-2. Primary-Side Power

3.4.2 Primary-Side I/O and Diagnostics

The primary-side I/O and diagnostic block fulfills the following functions:

- Provides signal input, including high-side and low-side PWM and RESET, as well as +12-V voltage input to the half-bridge board.
  - If the power and signal inputs are given via the differential board connector, the status output pin of a power MUX, TPS2121, is used to turn on the SN65C1167 dual differential driver and receiver. The dual differential driver and receiver then converts the differential gate driver inputs to single-ended gate driver inputs, and converts single-ended gate driver outputs to differential outputs that will be transmitted to the differential board.
  - If the power and signal inputs are given via the test point hooks on this EVM, the power MUX turns off the SN65C1167 dual differential driver and receiver. This protects the dual differential driver and receiver from damage.
- Filters out the high frequency noise in the high-side and low-side differential signals through RLC filters.
- Combines high-side and low-side RDY and nFLT signal into one FLT_OUT signal through an SN74LV21 AND gate.
- Combines the nRST signal coming from the differential board and the on-board reset button into one RESET signal through an SN74LV21 AND gate.

  The +12-V power supply and the PWM signals should be connected to the same board, either the differential board or the EVM. Failure to do so might result in EVM component damage.

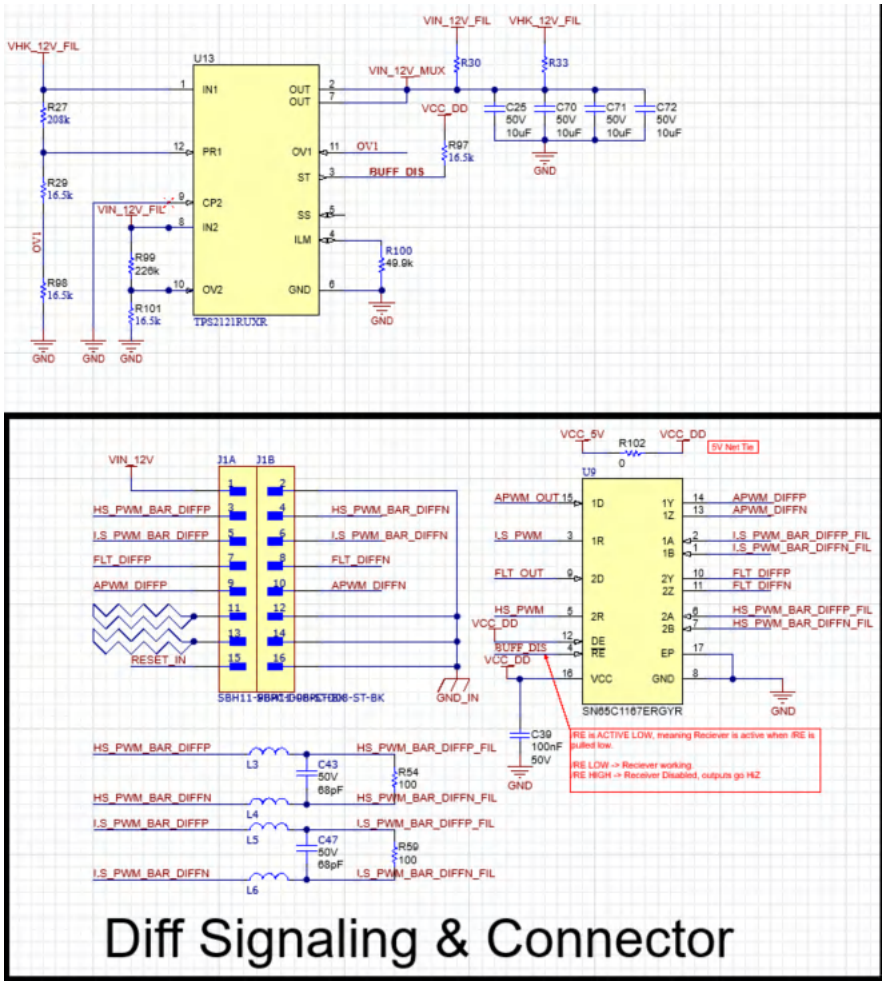


Figure 3-3. Primary-Side I/O

3.4.3 Secondary-Side Bias Supply

The secondary-side power supply block converts the +12-V input voltage to +15-V/-4-V bipolar bias voltage supply for the secondary side of the gate drivers. Each gate driver has its own bias supply. This is achieved by using one UCC34141 Isolated Bias. The bias supply voltage can be adjusted by changing the FBVDD, FBVEE resistor and capacitor values. The details will be added in the next revision of the user guide.

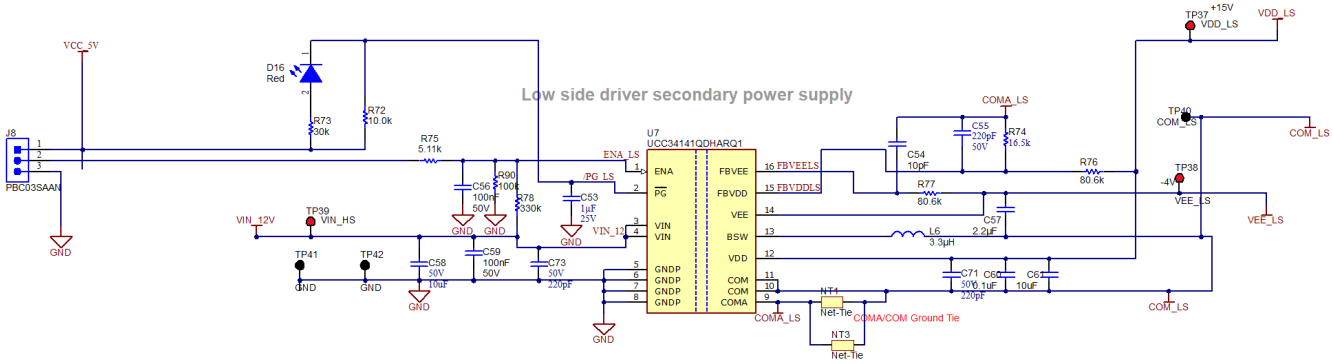


Figure 3-4. Secondary-Side Bias Supply

3.4.4 Output Stage Gate Loop

The gate driver output block consists of the turn-on gate resistor, the turn-off gate resistor, and the connectors to the SiC MOSFET/IGBT module. Test points are also placed near the output pins for easy measurement of the gate voltage.

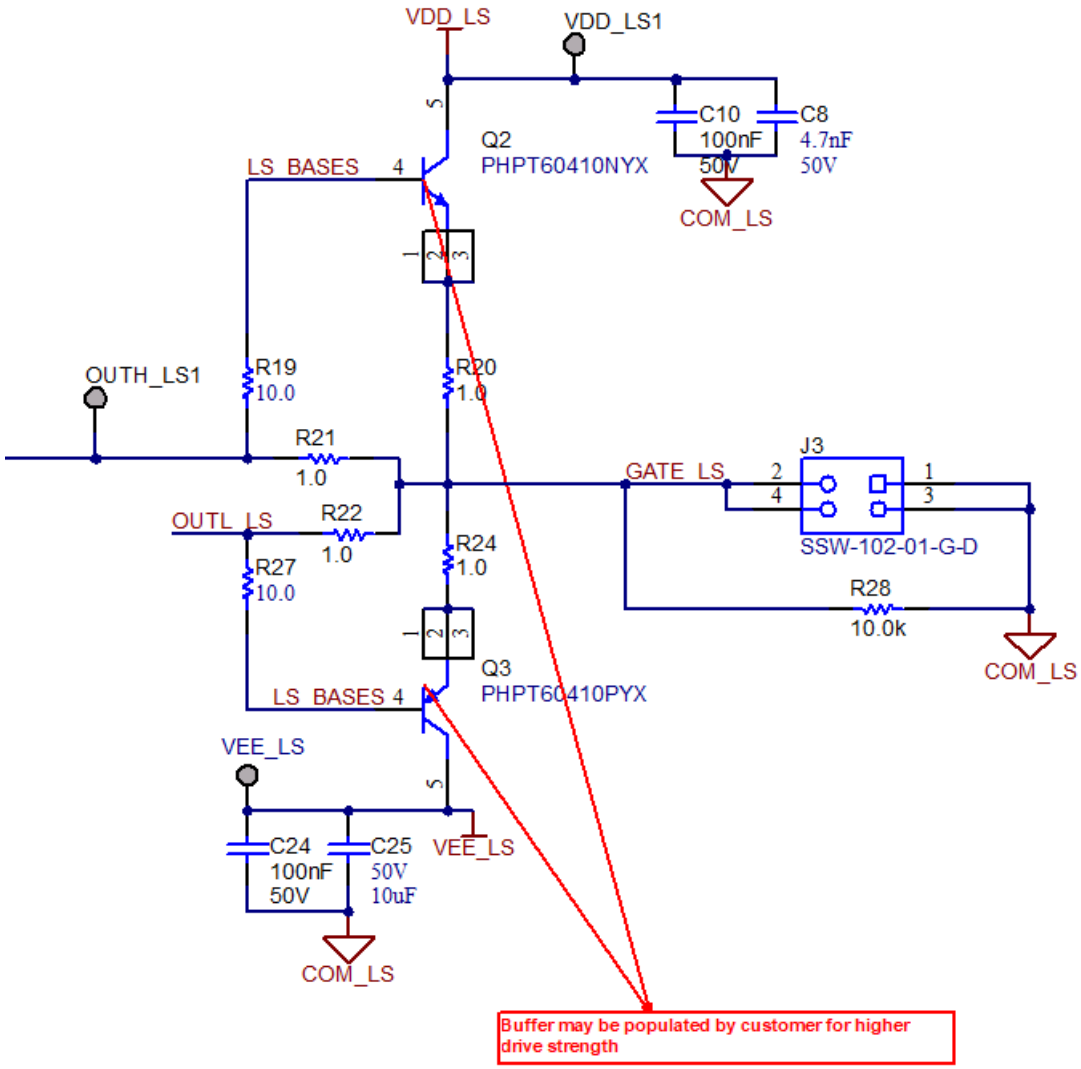


Figure 3-5. Output Stage Gate Loop

3.4.5 Current Booster

The current booster is optional and not populated by default, but can be populated as desired to increase the gate drive strength. To use the current booster, install all the DNI components of the current booster circuitry. There is also an RC damper circuit connected to the bases of the current booster circuit. This RC damper circuit helps with the soft turn-off functionality to reduce Vds overshoot during a short-circuiting event.

3.4.6 Short-Circuit Detection System

The short-circuit detection system on the board provides protection in case of a short-circuit event. When a short circuit is detected, the gate driver pulls the OUTL low with a fixed current soft turn-off, and the FLT flag will be raised on the primary side. If the short-circuit detection system is not used or if an IGBT/MOSFET is not connected to the board, J4and J5 should be shorted to respective HS and LS COM to prevent false short-circuit triggering.

3.4.6.1 Short-Circuit Detection - DESAT

The detailed DESAT, OC protection approach and the design guide is explained in the APP note. Please refer this APP note for the design choise of the compoents and the formulae details, Choosing Appropriate Protection Approach for IGBT and SiC Power Modules.

$$V_{DET} = V_{DESAT} - V_Z - n \times V_F - I_{chg} \times R_{lim} \quad (1)$$

The Vds voltage detection threshold can be calculated with the equation,

With the 9V internal DESAT detection threshold, the two STTH122A diode with forward voltage of 0.6 V each, the 475-Ω limiting resistor, the Zener diode with 2.7-V Zener voltage, and the 500-µA internal charging current, the Vds DESAT detection threshold is calculated to be 4.86 V. If another Vds voltage detection threshold is desired, use different Rlim, diodes to create the needed detection voltage.

The DESAT charging current can be increased by installing R25 and R29. Increasing the DESAT charging current can decrease the blanking time of the capacitor and provide better protection for SiC MOSFETs.

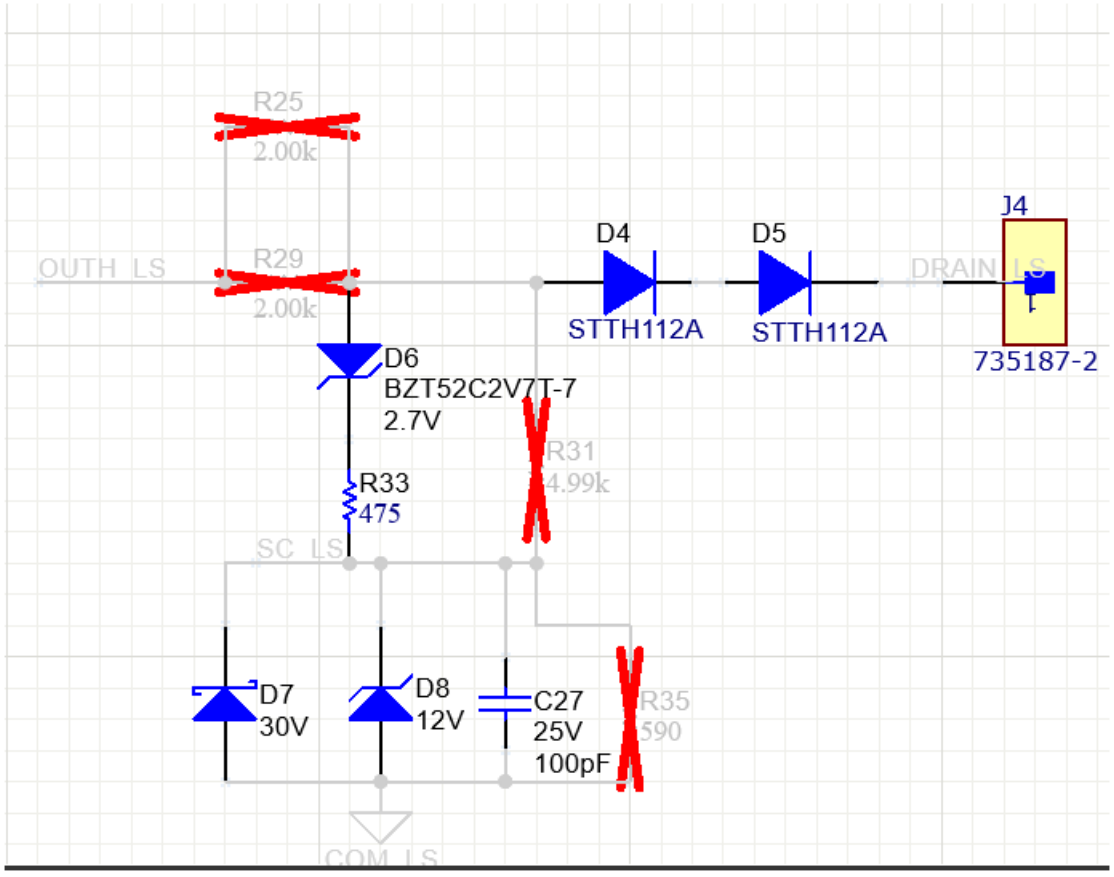


Figure 3-6. DESAT Circuit

3.4.6.2 Short-Circuit Detection - OC

This EVM implemented to configure for OC detection as well for the future variants which can support OC short circuit detection approach instead of DESAT. The Vds voltage detection threshold can be calculated with the equation below mentioned

$$V_{DET} = V_{OCTH} \times \frac{R_2 + R_3}{R_3} - V_Z - n \times V_F \quad (2)$$

With the 0.7-V internal OC detection threshold, the two STTH122A diode with forward voltage of 0.6 V each, R2 = 1K Ω, R2=5K Ω, and R3 = 590 Ω, the Vds DESAT detection threshold is calculated to be 5.43 V. This detection threshold is valid for VDD = 15 V. If another Vds voltage detection threshold is desired, the R1, R2, R3, Cblk and the diodes values can be adjusted to update voltage detection threshold.

With a 100-pF blanking capacitor, the blanking time is calculated to be 40 ns. This blanking time is valid for VDD = 15 V.

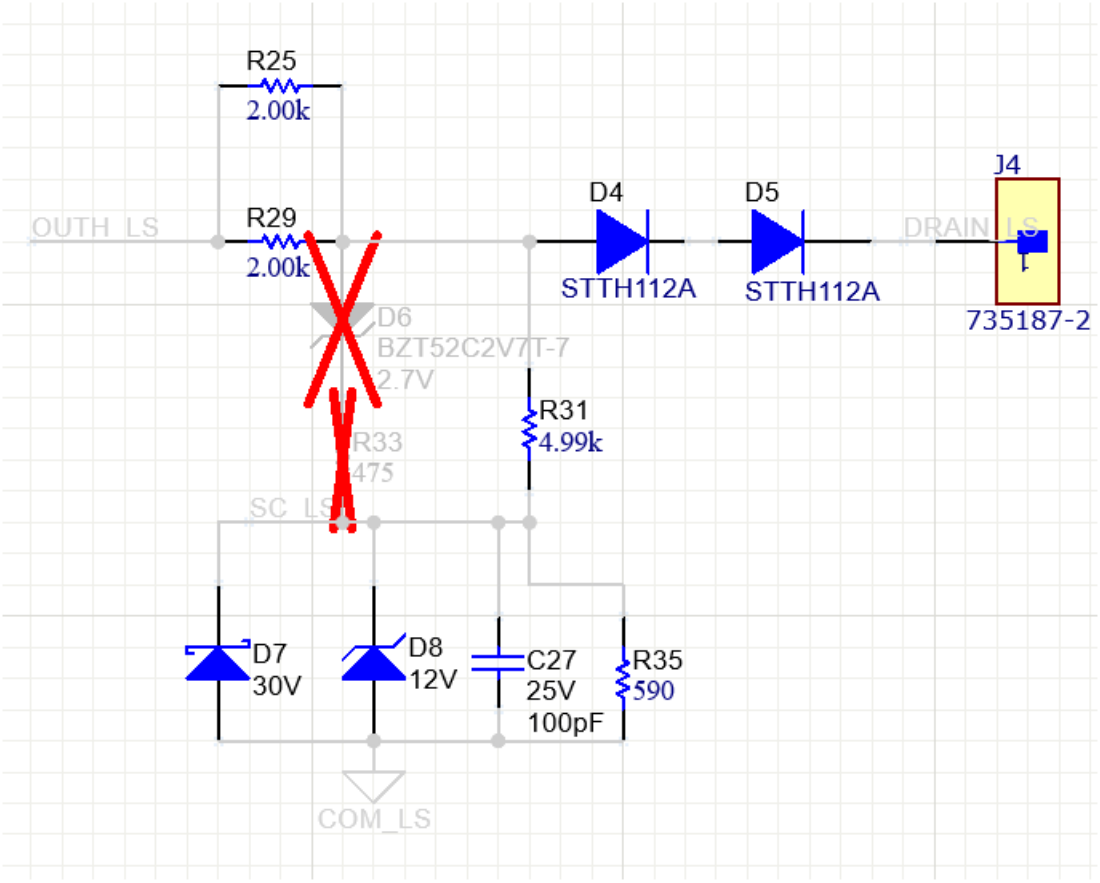


Figure 3-7. OC Circuit

4 Using the EVM

4.1 Equipment List and Board Setup

- Power Supplies
  - Need to provide at least 12 V and 1 A to power up the EVM
- Function Generator and Accessories
  - One 2-channel function generator
  - Two standard 50-Ω BNC coaxial cables
- Oscilloscope and Accessories
  - Oscilloscope 500 MHz or higher with at least four channels
  - Four passive voltage probes with at least 500-MHz bandwidth
- Digital Multimeters
  - Two digital multimeters
- Other
  - Connection wires of various length

4.2 Test Setups and Procedures

4.2.1 Power-On and Bias Supply Check

Note

This is a low voltage only test; do not attempt to manually probe the test points when a high bus voltage is applied to this EVM.

1. Board setup
   a. Please plan jumpers as shown below (totally 5 jumpers).
   b. Power supply set at 12V, 0.8A. Connect power supply to **VHK_12V** (power) and **GND_HK** (GND)
   c. Tie **OC_DST_HS to COM_HS**, and **OC_DST_LS to COM_LS**. See diagram below for blue connection points
2. Probe the VCC-GND voltage between the VCC TP and any GND TP with a multimeter. This value should be 5V.
3. Probe the high side VDD-COM voltage by using the VDD TP and the COM TP from HS. Probe the low side VDD-COM voltage by using the VDD TP and the COM TP from LS. These values should be ~15V.
4. Probe the high side VEE-COM voltage by using the VEE TP and the COM TP. Probe the low side VEE-COM voltage by using the VEE TP and the COM TP. These values should be ~ -4V.
5. Make sure the 5V LED (green), the HS BIAS LED (RED), and the LS BIAS LED (RED) are on. Other than the 3 LEDs marked, no other LEDs should be ON.

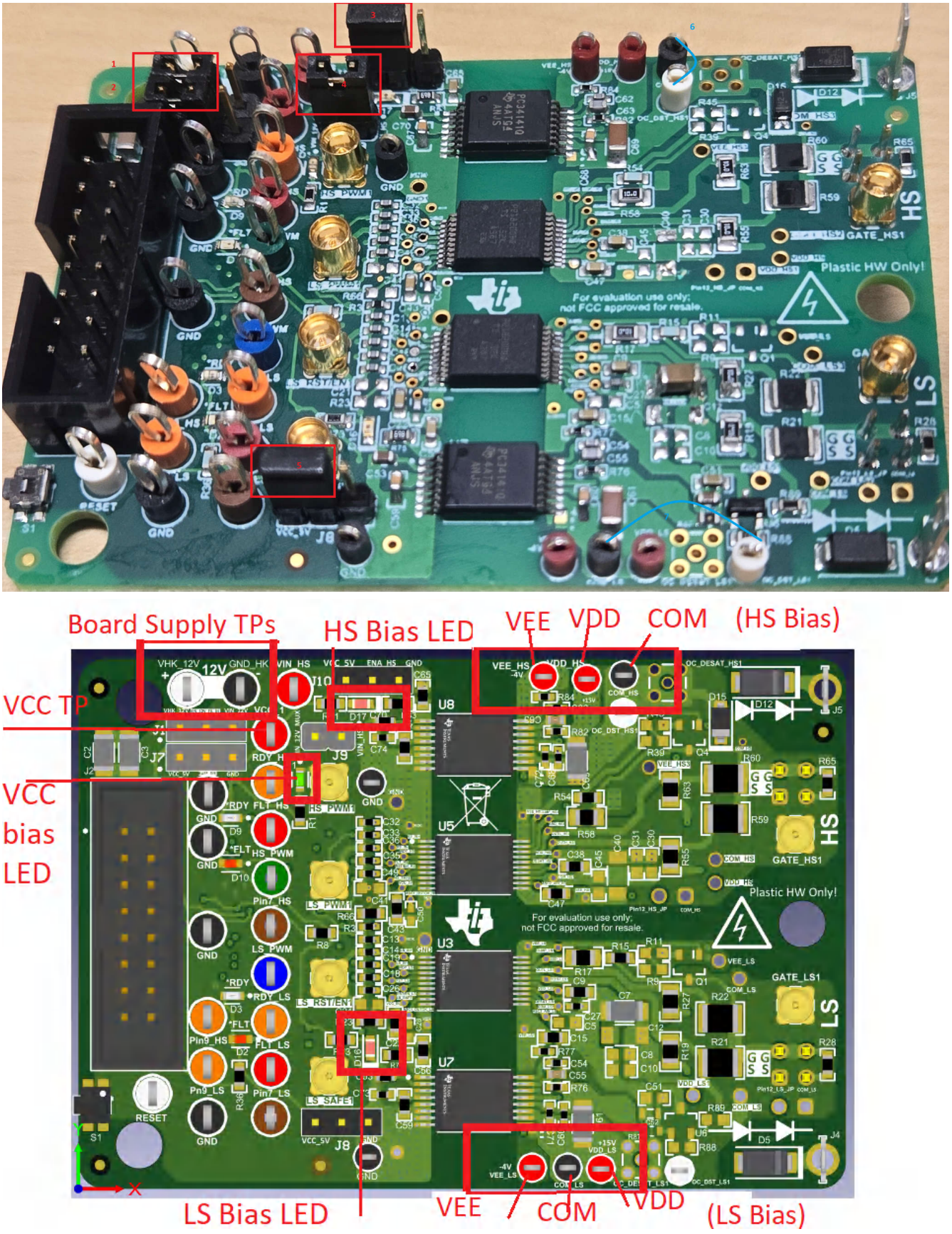


Figure 4-1. Jumper Settings and Test Points

4.2.2 Output Switching

To perform this test, make sure tests in Section 4.2.1 has been performed and the gate drivers are powered up properly.

1. Generate two 10kHz 0V-5V complementary PWM waves on two function generator channels. Deadtime can be added between the two PWM waves.
2. Connect these channel probes to the test points on the EVM; connect the high-side PWM channel probe to **HS_PWM** and the low-side PWM channel probe to **LS_PWM**.
3. Measure the high-side gate voltage with the MMCX connector **GATE_HS1**, and measure the low-side gate voltage with the MMCX connector **GATE_LS1.**
4. **GATE_HS1** waveform should match high-side PWM input signal with a small delay (~100ns).
5. **GATE_LS1** waveform should match low-side PWM input signal with a small delay (~100ns).

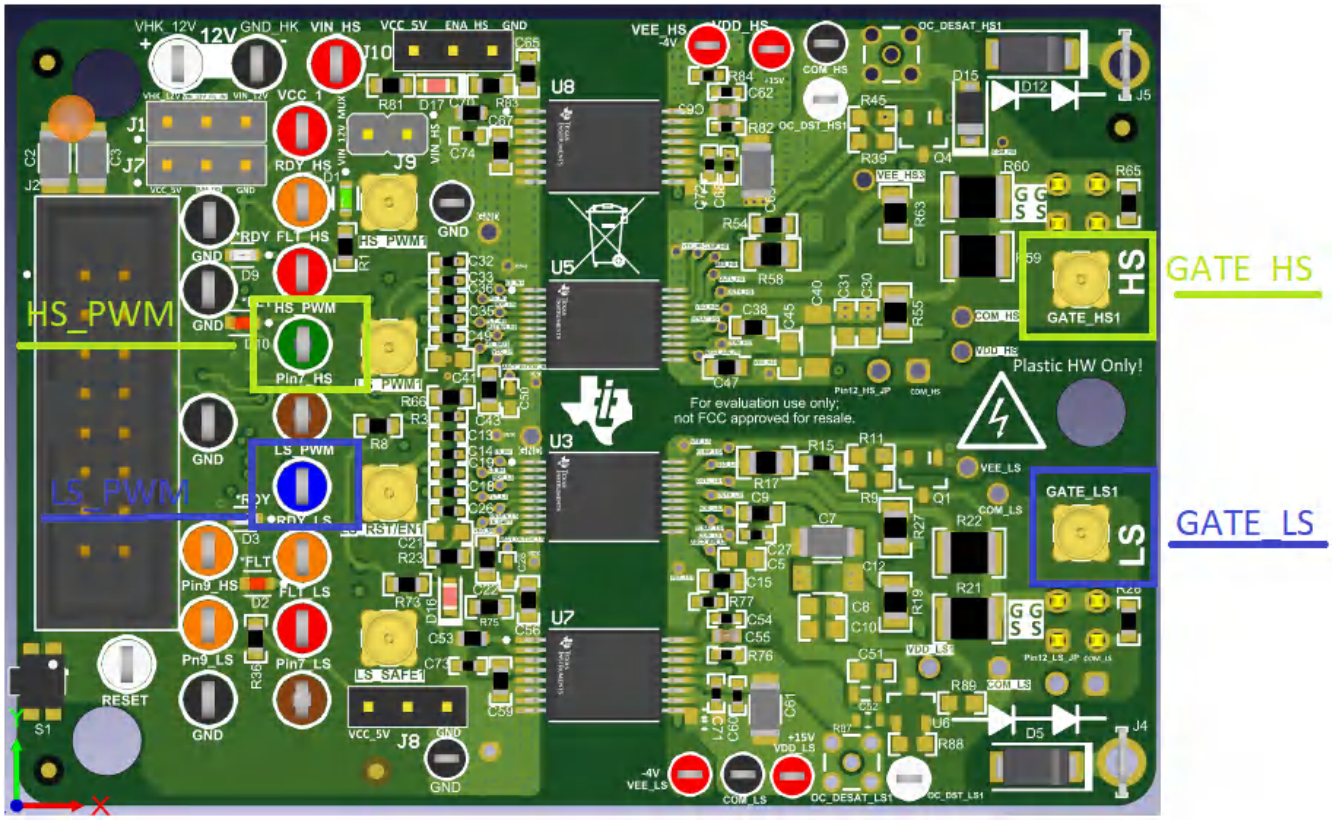
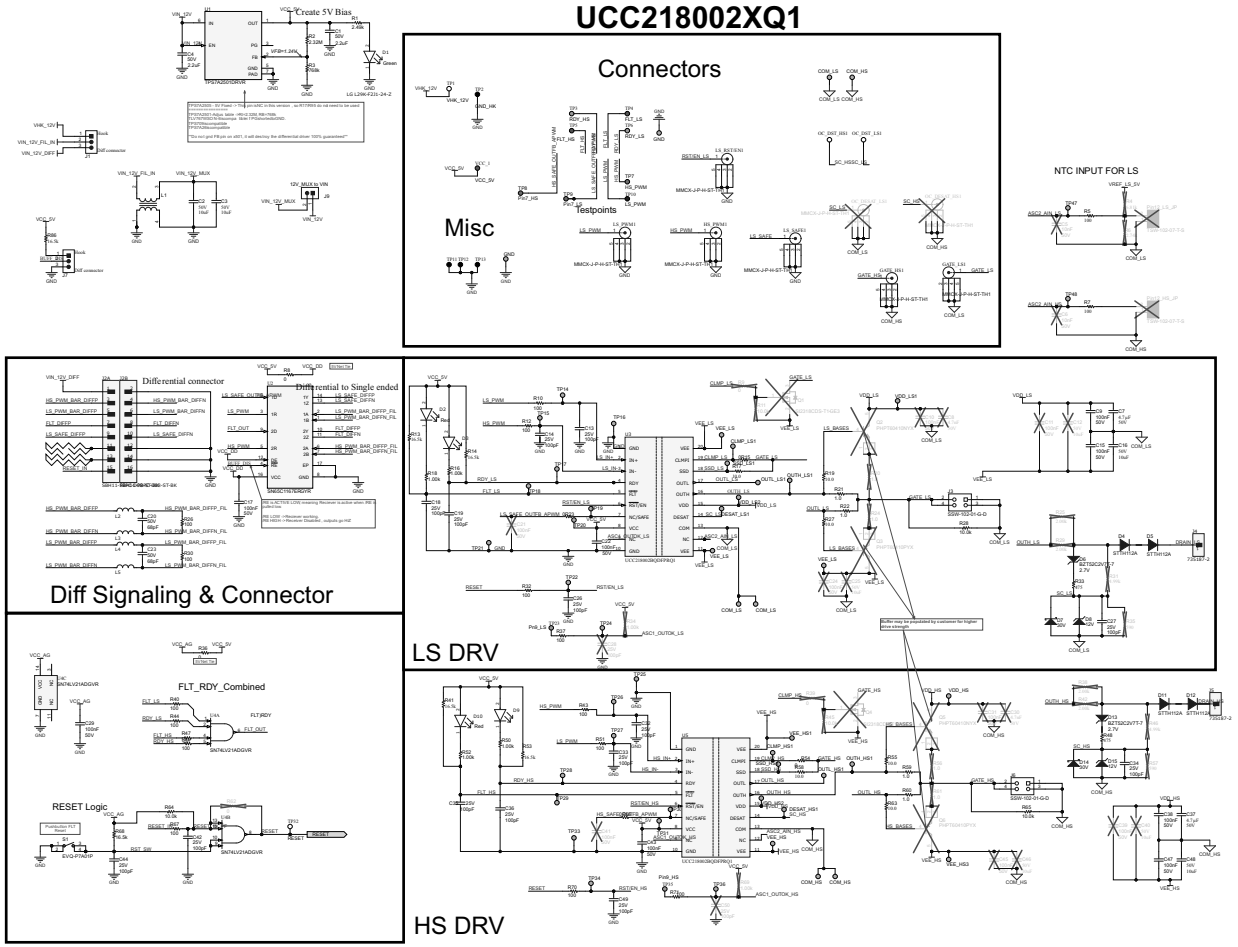


Figure 4-2. Test Point Locations for Output Switching Check

5 Hardware Design Files

5.1 Schematics



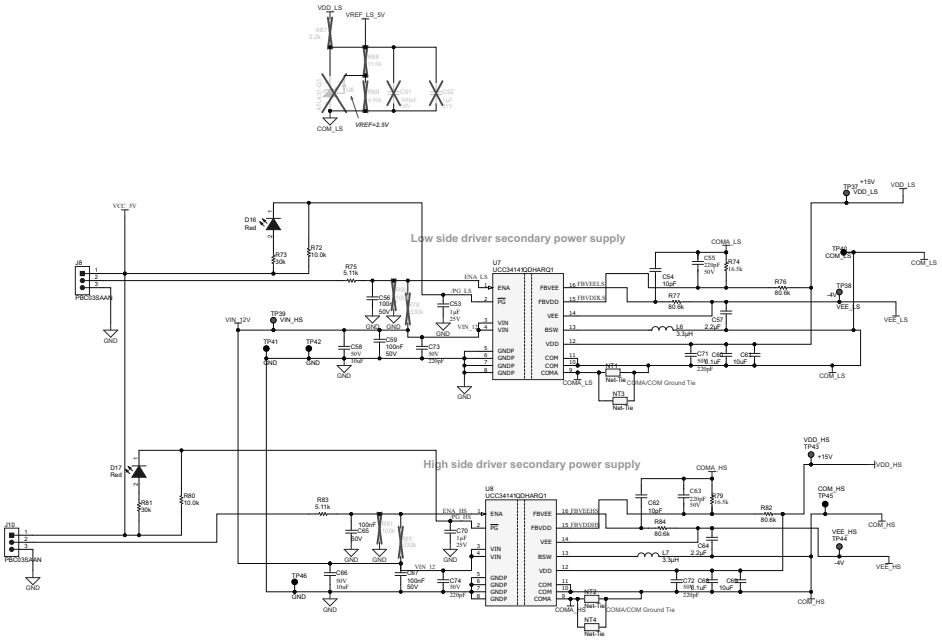
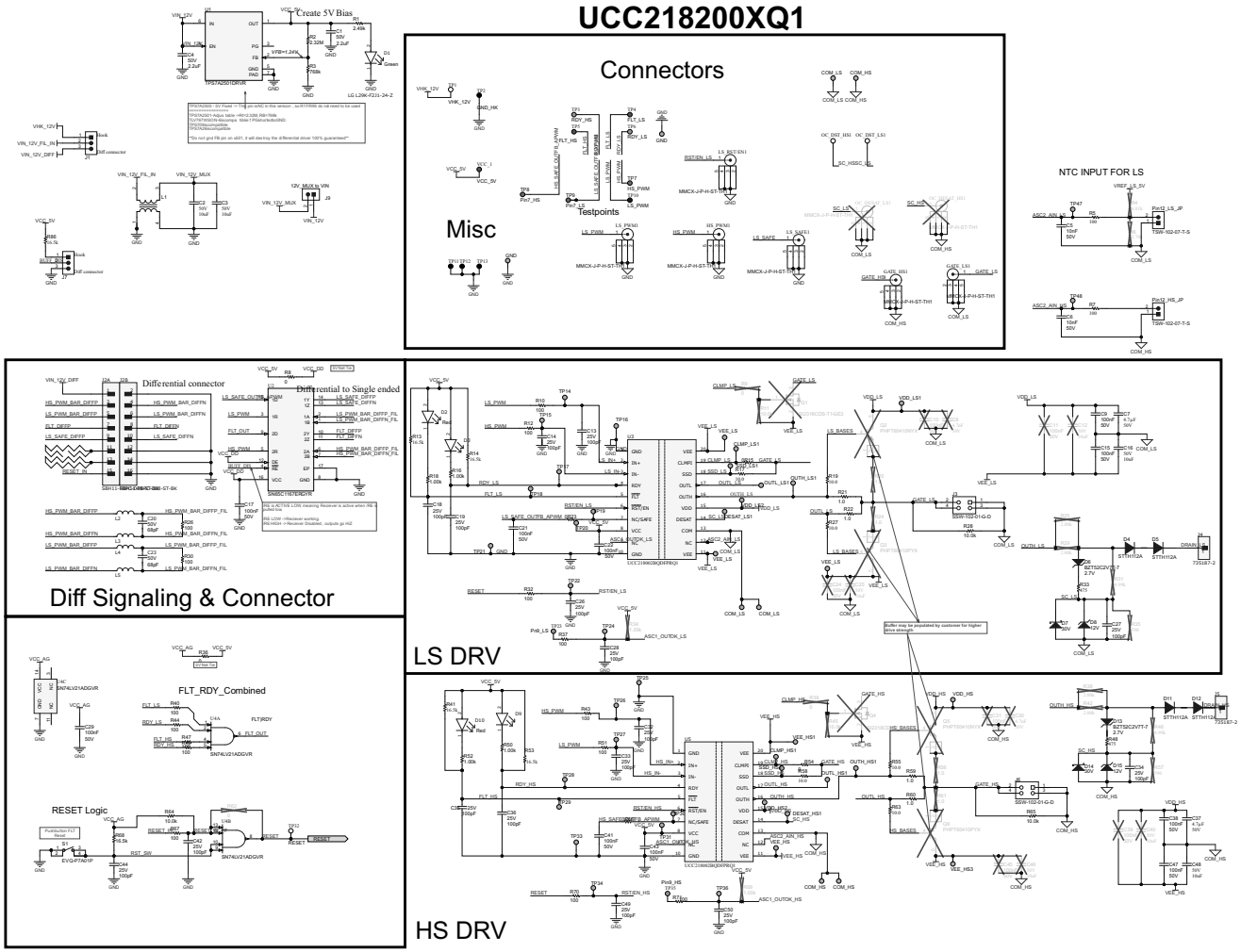


Figure 5-1. UCC218002EVM-111 EVM Schematics



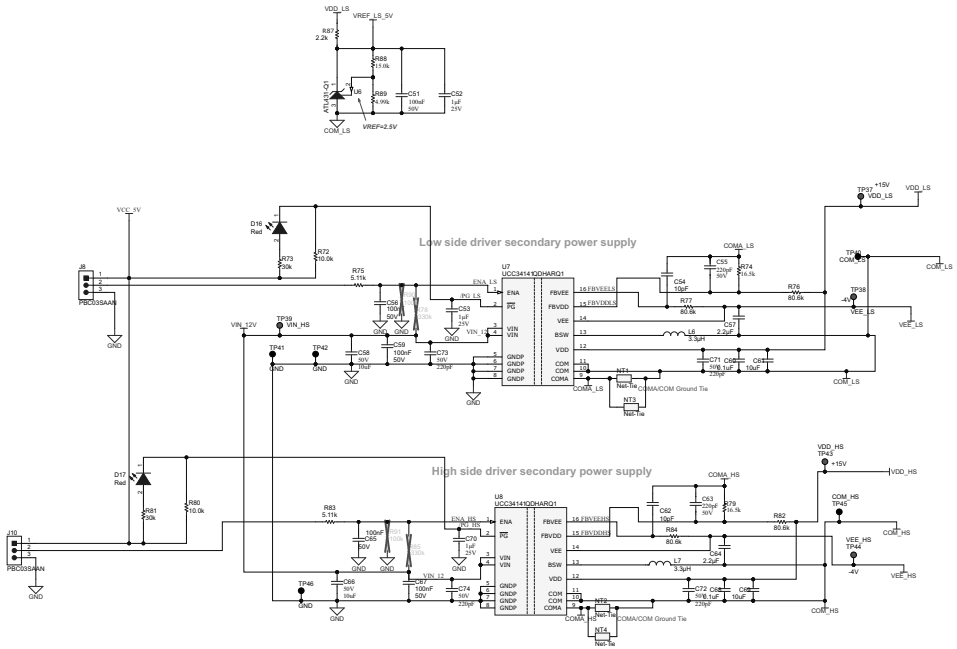


Figure 5-2. UCC218200EVM-111 EVM Schematics

5.2 PCB Layouts

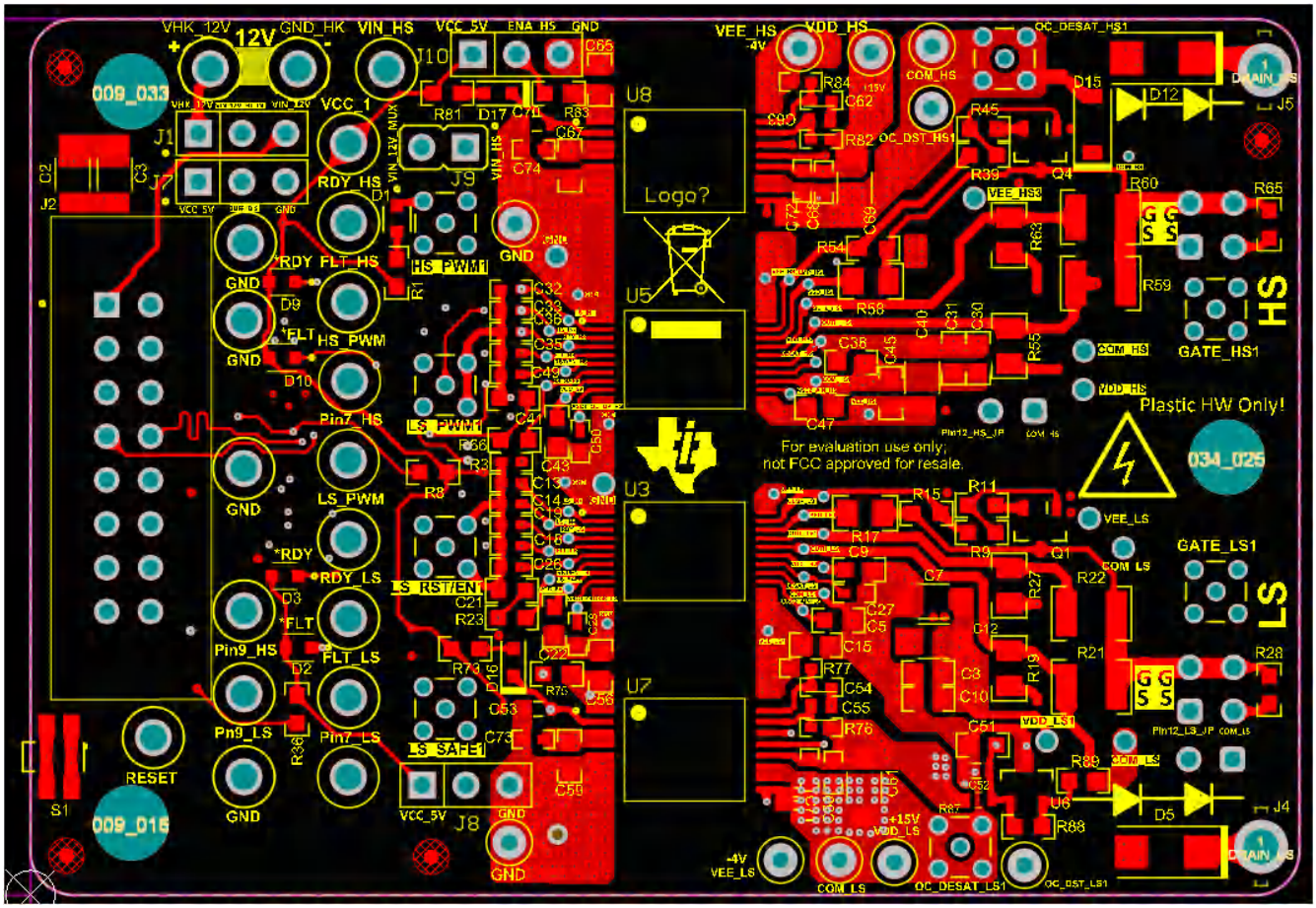


Figure 5-3. Top Layer

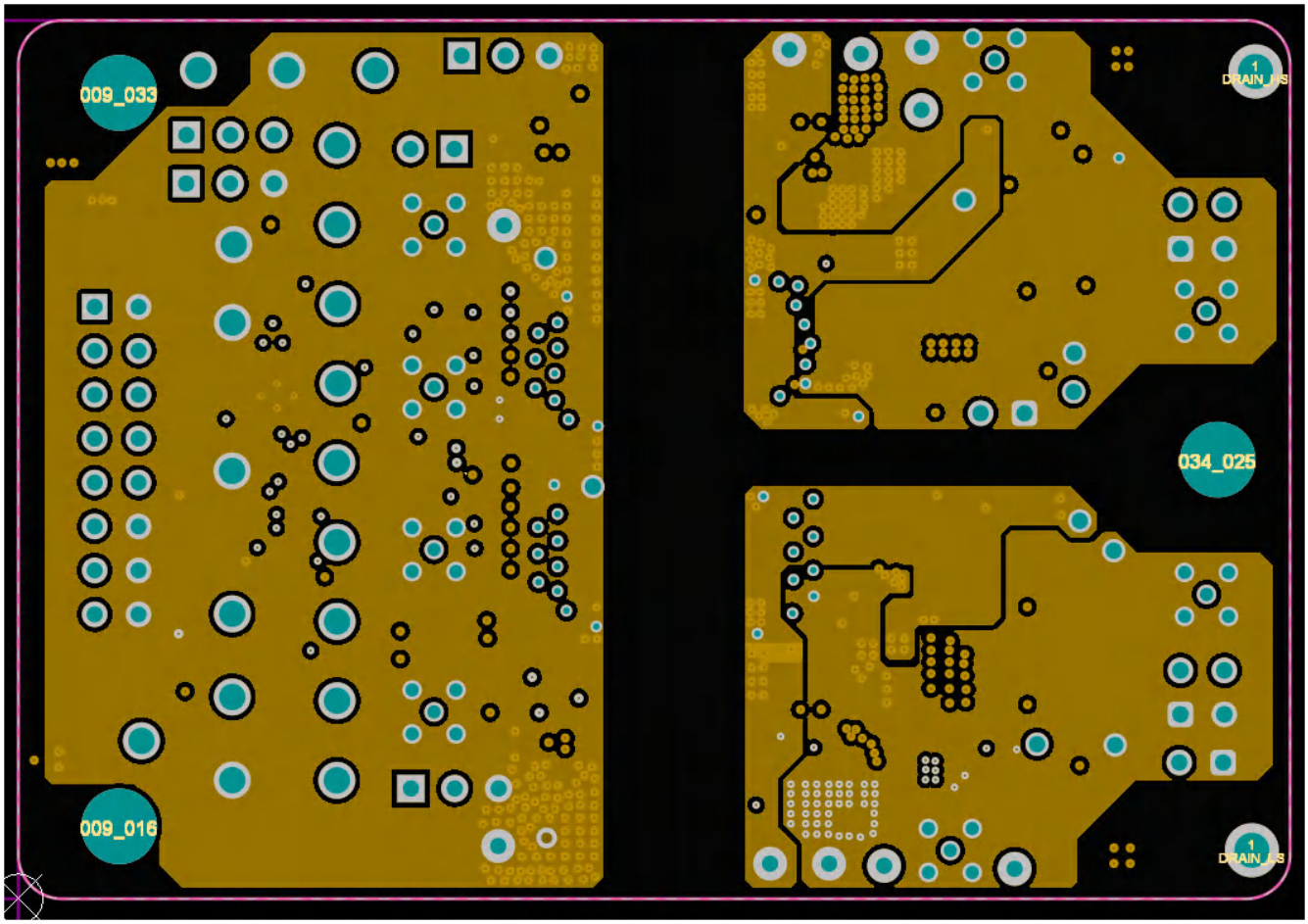


Figure 5-4. Signal Layer 1

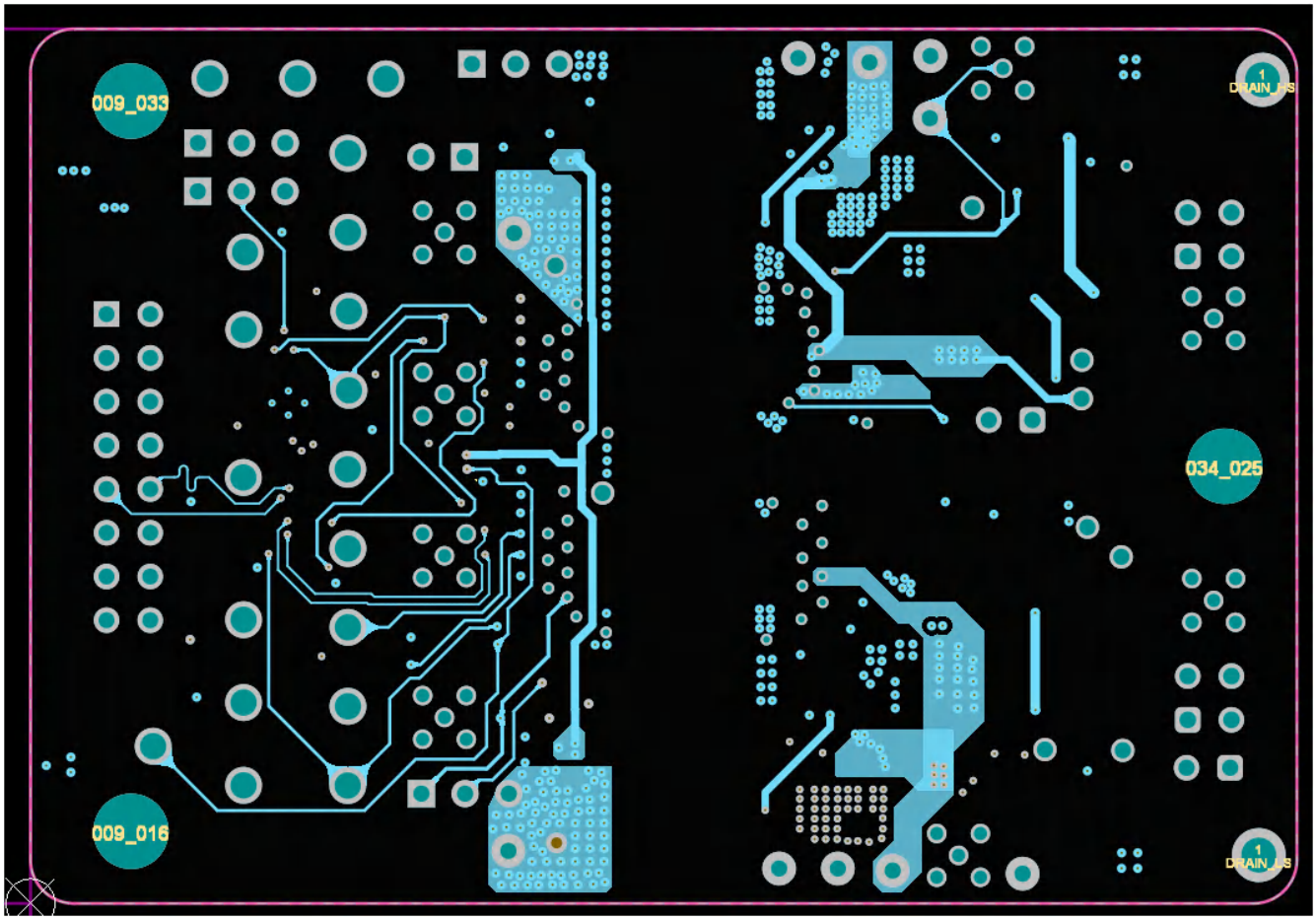


Figure 5-5. Signal Layer 2

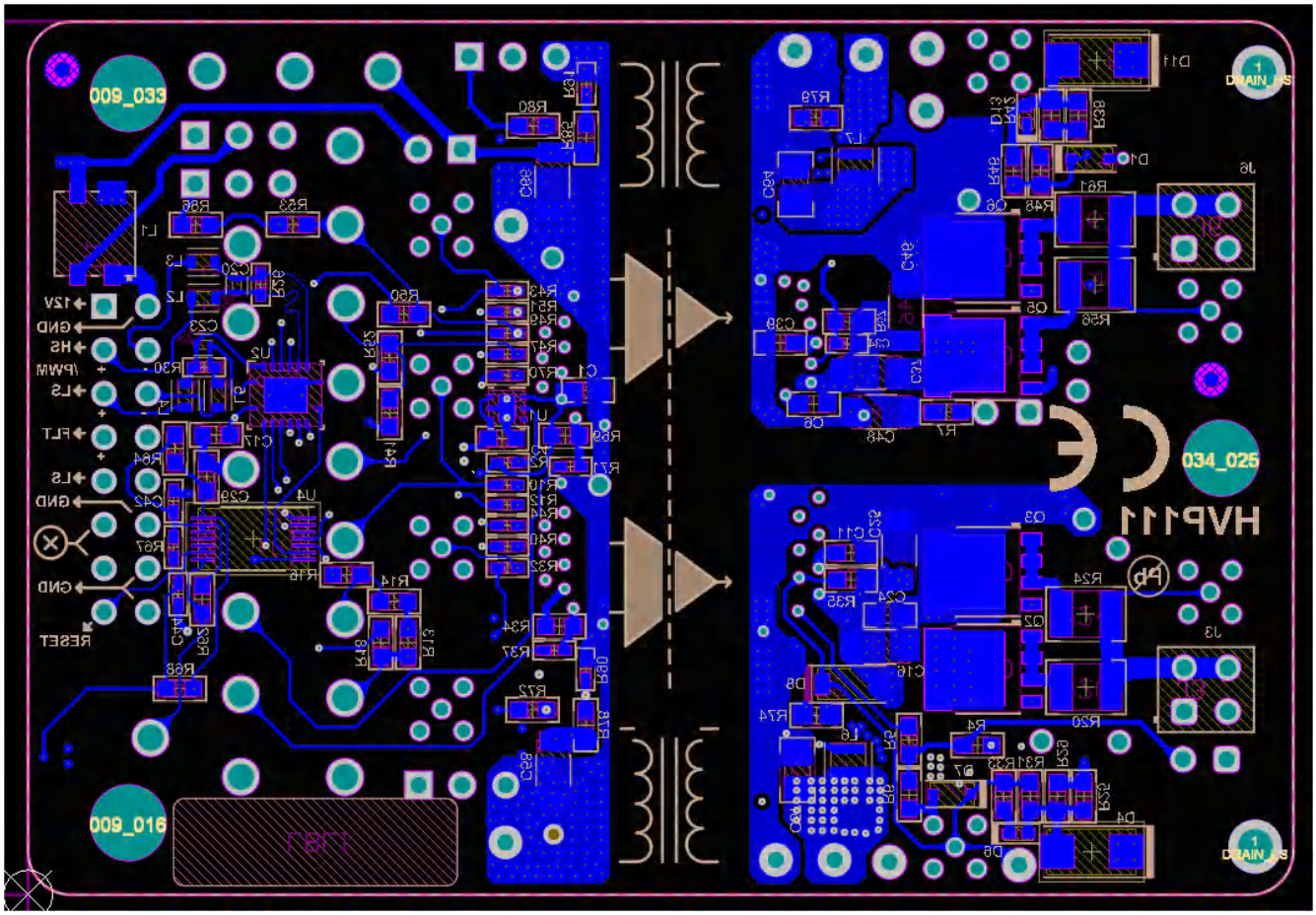


Figure 5-6. Bottom Layer

5.3 Bill of Materials (BOM)

Table 5-1. UCC218200EVM-111 EVM BOM

Designator	Description	PartNumber	Quantity
!PCB1	Printed Circuit Board	UCC218200QEVM_111	1
C1, C4	CAP, CERM, 2.2 uF, 50 V, +/- 10%, X5R, 0603	GRM188R61H225KE11D	2
C2, C3, C16, C48, C58, C66	CAP, CERM, 10 uF, 50 V, +/- 10%, X7R, 1206	CL31B106KBHNNNE	6
C5, C6	CAP, CERM, 0.01 uF, 50 V, +/- 10%, X7R, 0603	C0603X103K5RACTU	2
C7, C37	CAP, CERM, 4.7 µF, 50 V,+/- 10%, X7R, AEC-Q200 Grade 1, 1206	CGA5L3X7R1H475K160AE	2
C9, C15, C17, C21, C22, C29, C38, C41, C43, C47, C51, C56, C59, C65, C67	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0603	C0603C104K5RACTU	15
C13, C14, C18, C19, C26, C27, C28, C32, C33, C34, C35, C36, C42, C44, C49, C50	CAP, CERM, 100 pF, 25 V, +/- 5%, C0G/NP0, 0402	C0402C101J3GACTU	16
C20, C23	68pF ±5% 50V Ceramic Capacitor C0G, NP0 0402 (1005 Metric)	GCM1555C1H680JA16D	2
C52, C53, C70	CAP, CERM, 1 µF, 25 V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	CGA3E1X7R1E105K080AC	3
C54, C62	CAP, CERM, 10 pF, 50 V, +/- 5%, C0G/NP0, AEC-Q200 Grade 1, 0402	CGA2B2C0G1H100D050BA	2

Table 5-1. UCC218200EVM-111 EVM BOM (continued)

Designator	Description	PartNumber	Quantity
C55, C63	220 pF ±5% 50V Ceramic Capacitor C0G, NP0 0603 (1608 Metric)	C0603C221J5GAC7867	2
C57, C64	CAP, CERM, 2.2 uF, 16 V, +/- 10%, X7R, 0805	C2012X7R1C225K125AB	2
C60, C68	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0402	GCM155R71H104KE02D	2
C61, C69	CAP, CERM, 10 uF, 35 V, +/- 10%, X7R, AEC-Q200 Grade 1, 1206_190	CGA5L1X7R1V106K160AC	2
C71, C72, C73, C74	CAP, CERM, 220 pF, 50 V,+/- 5%, C0G/NP0, AEC-Q200 Grade 1, 0402	CGA2B2C0G1H221J050BA	4
D1	Green 570nm LED Indication - Discrete 1.7V 0603 (1608 Metric)	LG L29K-F2J1-24-Z	1
D2, D10	Red 630nm LED Indication - Discrete 1.5V 0603 (1608 Metric)	LS L29K-G1J2-1-Z	2
D3, D9	LED Uni-Color Amber 622nm 2-Pin SMD T/R	LA L296-Q2R2-1-0-20-R18-Z	2
D4, D5, D11, D12	Diode, Ultrafast, 1200 V, 1 A, SMA	STTH112A	4
D6, D13	Diode, Zener, 2.7 V, 300 mW, SOD-523	BZT52C2V7T-7	2
D7, D14	Diode, Schottky, 30 V, 0.2 A, SOD-323	BAT54WS-7-F	2
D8, D15	Diode, Zener, 12 V, 500 mW, SOD-123	MMSZ5242B-7-F	2
D16, D17	LED, Red, SMD	150060RS75000	2
FID1, FID2, FID3	Fiducial mark. There is nothing to buy or mount.	N/A	3
GATE_HS1, GATE_LS1, HS_PWM1, LS_PWM1, LS_RST/EN1, LS_SAFE1	Connector, MMCX 50 ohm, TH	MMCX-J-P-H-ST-TH1	6
J1, J7	Header, 100mil, 3x1, Gold, TH	HTSW-103-07-G-S	2
J2		SBH11-PBPC-D08-ST-BK	1
J3, J6	Receptacle, 2.54mm, 2x2, Gold, TH	SSW-102-01-G-D	2
J4, J5	FASTON 110, PCB Terminals, Tab, Tab, PCB Terminal Mating Tab Width .11 in [2.8 mm], PCB Terminal Mating Tab Thickness .02 in [.51 mm]	735187-2	2
J8, J10	Header, 100mil, 3x1, Gold, TH	PBC03SAAN	2
J9	Header, 100mil, 2x1, Gold, TH	PBC02SAAN	1
L1	Coupled inductor, 2.8 A, 0.055 ohm, SMD	ACM4520-421-2P-T000	1
L2, L3, L4, L5	1µH Shielded Multilayer Inductor 600mA 150mOhm 0603 (1608 Metric)	MLZ1608A1R0WT000	4
L6, L7	Inductor Power Shielded Wirewound 3.3uH 20% 100KHz Ferrite 0.88A 0.3Ω DCR T/R	NRV2010T3R3MGF	2
LBL1	Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	THT-14-423-10	1
OC_DST_HS1, OC_DST_LS1	Test Point, Miniature, White, TH	5002	2
Pin12_HS_JP, Pin12_LS_JP	Header, 2.54 mm, 2x1, Tin, TH	TSW-102-07-T-S	2
R1	RES, 2.49 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW06032K49FKEA	1
R2	RES, 2.32 M, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW04022M32FKED	1
R3	RES, 768 k, 1%, 0.063 W, 0402	CRCW0402768KFKED	1
R5, R7	RES, 100, 1%, 0.1 W, 0603	RC0603FR-07100RL	2
R8, R15, R23, R36, R54, R66	RES, 0, 5%, 0.125 W, 0603	MCT06030Z0000ZP500	6
R10, R12, R26, R30, R32, R37, R40, R43, R44, R47, R49, R51, R67, R70, R71	RES, 100, 5%, 0.063 W, 0402	CRCW0402100RJNED	15

Table 5-1. UCC218200EVM-111 EVM BOM (continued)

Designator	Description	PartNumber	Quantity
R13, R14, R41, R53, R68, R74, R79, R86	RES, 16.5 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	ERJ-3EKF1652V	8
R16, R18, R50, R52	RES, 1.00 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW06031K00FKEA	4
R17, R19, R27, R55, R58, R63	RES, 10.0, 1%, 0.5 W, AEC-Q200 Grade 0, 0805	ERJ-P06F10R0V	6
R21, R22, R59, R60	RES, 1.0, 5%, 0.5 W, 1210	RC1210JR-071RL	4
R28, R64, R65, R72, R80	RES, 10.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW060310K0FKEA	5
R33, R48	RES, 475, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW0603475RFKEA	2
R73, R81	RES, 30 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW060330K0JNEA	2
R75, R83	RES, 5.11 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW06035K11FKEA	2
R76, R77, R82, R84	RES, 80.6 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW040280K6FKED	4
R87	2.2kΩ ±5% 0.25W 0603 Anti-Surge Chip Resistor AEC-Q200	ESR03EZPJ222	1
R88	RES, 15.0 k, 0.1%, 0.1 W, 0603	RG1608P-153-B-T5	1
R89	RES, 4.99 k, 0.1%, 0.1 W, 0603	RT0603BRD074K99L	1
S1	Switch, Tactile, SPST-NO, 0.05A, 12V , SMD	EVQ-P7A01P	1
TP1, TP32	Test Point, Multipurpose, White, TH	5012	2
TP2, TP11, TP12, TP13, TP41	Test Point, Multipurpose, Black, TH	5011	5
TP3, TP6, TP23, TP35	Test Point, Multipurpose, Orange, TH	5013	4
TP4, TP5, TP39, VCC_1	Test Point, Multipurpose, Red, TH	5010	4
TP7	Test Point, Multipurpose, Green, TH	5126	1
TP8, TP9	Test Point, Multipurpose, Brown, TH	5125	2
TP10	Test Point, Multipurpose, Blue, TH	5127	1
TP37, TP38, TP43, TP44	Test Point, Miniature, Red, TH	5000	4
TP40, TP42, TP45, TP46	Test Point, Miniature, Black, TH	5001	4
U1	300-mA, 18-V, Low IQ, Low Dropout Voltage Regulator with Power Good, DRV0006A (WSON-6)	TPS7A2501DRVR	1
U2	Dual Differential Driver and Receiver with +/-15-kV IEC ESD Protection, 2 TX / 2 RX, 5V, -40 to 85 degC, 16-Pin VQFN(RGY), Green (RoHS & no Sb/Br)	SN65C1167ERGYR	1
U3, U5	15A Source/Sink Reinforced Isolated Single Channel Gate Driver for SiC/IGBT with Advanced Protection	UCC218200BQDFPRQ1	2
U4	Dual 4-Input Positive-AND Gate, DGV0014A (TVSOP-14)	SN74LV21ADGVR	1
U6	Programmable Shunt Regulator with Optimized Reference Current, DBZ0003A (SOT-23-3)	ATL431LIBQDBZRQ1	1
U7, U8	Automotive 1.5W, 12V-Vin, 25V-Vout, High Efficiency, High-Density, >5 kVRMS, Isolated DC-DC Module	UCC34141QDHARQ1	2

Table 5-2. UCC218002EVM-111 EVM BOM

Designator	Description	PartNumber	Quantity
!PCB1	Printed Circuit Board	UCC218002QEVM_111	1
C1, C4	CAP, CERM, 2.2 uF, 50 V, +/- 10%, X5R, 0603	GRM188R61H225KE11D	2
C2, C3, C16, C48, C58, C66	CAP, CERM, 10 uF, 50 V, +/- 10%, X7R, 1206	CL31B106KBHNNNE	6
C7, C37	CAP, CERM, 4.7 µF, 50 V,+/- 10%, X7R, AEC-Q200 Grade 1, 1206	CGA5L3X7R1H475K160AE	2
C9, C15, C17, C22, C29, C38, C43, C47, C56, C59, C65, C67	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0603	C0603C104K5RACTU	12
C13, C14, C18, C19, C26, C27, C32, C33, C34, C35, C36, C42, C44, C49	CAP, CERM, 100 pF, 25 V, +/- 5%, C0G/NP0, 0402	C0402C101J3GACTU	14
C20, C23	68pF ±5% 50V Ceramic Capacitor C0G, NP0 0402 (1005 Metric)	GCM1555C1H680JA16D	2
C53, C70	CAP, CERM, 1 µF, 25 V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	CGA3E1X7R1E105K080AC	2
C54, C62	CAP, CERM, 10 pF, 50 V, +/- 5%, C0G/NP0, AEC-Q200 Grade 1, 0402	CGA2B2C0G1H100D050BA	2
C55, C63	220 pF ±5% 50V Ceramic Capacitor C0G, NP0 0603 (1608 Metric)	C0603C221J5GAC7867	2
C57, C64	CAP, CERM, 2.2 uF, 16 V, +/- 10%, X7R, 0805	C2012X7R1C225K125AB	2
C60, C68	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0402	GCM155R71H104KE02D	2
C61, C69	CAP, CERM, 10 uF, 35 V, +/- 10%, X7R, AEC-Q200 Grade 1, 1206_190	CGA5L1X7R1V106K160AC	2
C71, C72, C73, C74	CAP, CERM, 220 pF, 50 V,+/- 5%, C0G/NP0, AEC-Q200 Grade 1, 0402	CGA2B2C0G1H221J050BA	4
D1	Green 570nm LED Indication - Discrete 1.7V 0603 (1608 Metric)	LG L29K-F2J1-24-Z	1
D2, D10	Red 630nm LED Indication - Discrete 1.5V 0603 (1608 Metric)	LS L29K-G1J2-1-Z	2
D3, D9	LED Uni-Color Amber 622nm 2-Pin SMD T/R	LA L296-Q2R2-1-0-20-R18-Z	2
D4, D5, D11, D12	Diode, Ultrafast, 1200 V, 1 A, SMA	STTH112A	4
D6, D13	Diode, Zener, 2.7 V, 300 mW, SOD-523	BZT52C2V7T-7	2
D7, D14	Diode, Schottky, 30 V, 0.2 A, SOD-323	BAT54WS-7-F	2
D8, D15	Diode, Zener, 12 V, 500 mW, SOD-123	MMSZ5242B-7-F	2
D16, D17	LED, Red, SMD	150060RS75000	2
FID1, FID2, FID3	Fiducial mark. There is nothing to buy or mount.	N/A	3
GATE_HS1, GATE_LS1, HS_PWM1, LS_PWM1, LS_RST/EN1, LS_SAFE1	Connector, MMCX 50 ohm, TH	MMCX-J-P-H-ST-TH1	6
J1, J7	Header, 100mil, 3x1, Gold, TH	HTSW-103-07-G-S	2
J2		SBH11-PBPC-D08-ST-BK	1
J3, J6	Receptacle, 2.54mm, 2x2, Gold, TH	SSW-102-01-G-D	2
J4, J5	FASTON 110, PCB Terminals, Tab, Tab, PCB Terminal Mating Tab Width .11 in [2.8 mm], PCB Terminal Mating Tab Thickness .02 in [.51 mm]	735187-2	2
J8, J10	Header, 100mil, 3x1, Gold, TH	PBC03SAAN	2
J9	Header, 100mil, 2x1, Gold, TH	PBC02SAAN	1
L1	Coupled inductor, 2.8 A, 0.055 ohm, SMD	ACM4520-421-2P-T000	1
L2, L3, L4, L5	1µH Shielded Multilayer Inductor 600mA 150mOhm 0603 (1608 Metric)	MLZ1608A1R0WT000	4

Table 5-2. UCC218002EVM-111 EVM BOM (continued)

Designator	Description	PartNumber	Quantity
L6, L7	Inductor Power Shielded Wirewound 3.3uH 20% 100KHz Ferrite 0.88A 0.3Ω DCR T/R	NRV2010T3R3MGF	2
LBL1	Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	THT-14-423-10	1
OC_DST_HS1, OC_DST_LS1	Test Point, Miniature, White, TH	5002	2
R1	RES, 2.49 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW06032K49FKEA	1
R2	RES, 2.32 M, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW04022M32FKED	1
R3	RES, 768 k, 1%, 0.063 W, 0402	CRCW0402768KFKED	1
R5, R7	RES, 100, 1%, 0.1 W, 0603	RC0603FR-07100RL	2
R8, R15, R23, R36, R54, R66	RES, 0, 5%, 0.125 W, 0603	MCT06030Z0000ZP500	6
R10, R12, R26, R30, R32, R37, R40, R43, R44, R47, R49, R51, R67, R70, R71	RES, 100, 5%, 0.063 W, 0402	CRCW0402100RJNED	15
R13, R14, R41, R53, R68, R74, R79, R86	RES, 16.5 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	ERJ-3EKF1652V	8
R16, R18, R50, R52	RES, 1.00 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW06031K00FKEA	4
R17, R19, R27, R55, R58, R63	RES, 10.0, 1%, 0.5 W, AEC-Q200 Grade 0, 0805	ERJ-P06F10R0V	6
R21, R22, R59, R60	RES, 1.0, 5%, 0.5 W, 1210	RC1210JR-071RL	4
R28, R64, R65, R72, R80	RES, 10.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW060310K0FKEA	5
R33, R48	RES, 475, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW0603475RFKEA	2
R73, R81	RES, 30 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW060330K0JNEA	2
R75, R83	RES, 5.11 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW06035K11FKEA	2
R76, R77, R82, R84	RES, 80.6 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW040280K6FKED	4
S1	Switch, Tactile, SPST-NO, 0.05A, 12V , SMD	EVQ-P7A01P	1
TP1, TP32	Test Point, Multipurpose, White, TH	5012	2
TP2, TP11, TP12, TP13, TP41	Test Point, Multipurpose, Black, TH	5011	5
TP3, TP6, TP23, TP35	Test Point, Multipurpose, Orange, TH	5013	4
TP4, TP5, TP39, VCC_1	Test Point, Multipurpose, Red, TH	5010	4
TP7	Test Point, Multipurpose, Green, TH	5126	1
TP8, TP9	Test Point, Multipurpose, Brown, TH	5125	2
TP10	Test Point, Multipurpose, Blue, TH	5127	1
TP37, TP38, TP43, TP44	Test Point, Miniature, Red, TH	5000	4
TP40, TP42, TP45, TP46	Test Point, Miniature, Black, TH	5001	4
U1	300-mA, 18-V, Low IQ, Low Dropout Voltage Regulator with Power Good, DRV0006A (WSON-6)	TPS7A2501DRVR	1
U2	Dual Differential Driver and Receiver with +/-15-kV IEC ESD Protection, 2 TX / 2 RX, 5V, -40 to 85 degC, 16-Pin VQFN(RGY), Green (RoHS & no Sb/Br)	SN65C1167ERGYR	1
U3, U5	Automotive 5-A Reinforced Isolated Single Channel Gate Driver for SiC/IGBT with Active Protection, Dedicated Soft Shut Down and High-CMTI	UCC218002BQDFPRQ1	2
U4	Dual 4-Input Positive-AND Gate, DGV0014A (TVSOP-14)	SN74LV21ADGVR	1
U7, U8	Automotive 1.5W, 12V-Vin, 25V-Vout, High Efficiency, High-Density, >5 kVRMS, Isolated DC-DC Module	UCC34141QDHARQ1	2

6 Additional Information

6.1 Trademarks

All trademarks are the property of their respective owners.

7 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

DATE	REVISION	NOTES
June 2025	*	Initial Release

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software

   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

User shall operate the Evaluation Kit within TI’s recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI’s recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI’s instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 *Regulatory Notices:*

3.1 *United States*

3.1.1 *Notice applicable to EVMs not FCC-Approved:*

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。

https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

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東京都新宿区西新宿 6 丁目 2 4 番 1 号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html

3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. *Disclaimers:*

6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

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