

UCC217XX Family Driving and Protecting SiC and IGBT Power Modules and Transistors

This User's Guide describes the characteristics, operation and use of the UCC21732QDWEVM-025 Evaluation Module (EVM). This TI EVM provides driving and protection for popular Silicon Carbide (SiC) MOSFETs and Si IGBTs both in discrete and Power Module implementations. The EVM is using feature rich isolated driver device UCC21732 that is part of family of UCC217XX drivers. A complete schematic diagram, printed-circuit board layouts, and bill of materials are included in this document.

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Trademarks

1 Overview

The UCC217XXQDWEVM-025 is a compact, single channel isolated gate driver board providing drive, bias voltages, protection and diagnostic needed for SiC MOSFET and Si IGBT Power Modules housed in 150 x 62 x 17 mm and 106 x 62 x 30 mm packages. The board can be set for UCC21710, UCC21732 or UCC21750 drivers of the same UCC217XX family This TI EVM is based on 5.7-kVrms reinforced isolation drivers UCC217XX in SOIC-16DW package with 8.0 mm creepage and clearance. The EVM includes SN6505B based isolated DC-DC transformer bias supplies. Isolated temperature and input rail monitoring is provided using analog sensor and PWM output integrated into UCC217XX. Compact form factor 62 x 48 x 6.6 mm allows direct connection of two boards to drive and protect standard half-bridge modules with up to 1700 V rail.

1.1 Features

- 10-A peak split sink/source drive current for fast turn ON and turn OFF time
- 2-W bias supply with UVLO and OVLO protection set by default at 4.5 V to 5.5 V
- Drive voltages by default are 17/-5 V with single 5-V input supply
- Drive voltages can be also programmed independently from 11 V to 19 V for turn ON and from -3.3 V to -6 V for turn OFF by using two input supplies from 3.3 V to 5.5 V
- Noise-immune design with CMTI >150 V/ns
- 5.7-kVrms reinforced isolation
- OC short-circuit shunt resistor sensing with two-level (UCC21732) or single level (UCC21710) soft turn-OFF protection
- OC signal setting either for positive or negative polarity
- DeSat short-circuit sensing for UCC21750
- Active Miller clamp using external FET (UCC21732) or internal (UCC21710)
- Output short circuit clamp
- Fault feedback with reset
- Isolated temperature and input rail monitoring

1.2 Applications

- Solar inverters
- Motor drives
- HEV/EV chargers

1.3 Description

1.3.1 Specification

High voltage SiC and IGBT power modules in the popular 150-mm and 10-mm packages are the building blocks of various power systems at power levels up to megaWatts. Recently, 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 UCC21732QDWEVM-025 supports SiC modules by reducing parasitics, minimizing switching loss, EMI and providing full required protection and diagnostics features. Electrical parameters of the board are shown in [Table 1](#).

Table 1. Electrical Specifications

PARAMETER		TEST CONDITIONS	MIN	NOM	MAX	UNIT
SUPPLY VOLTAGES AND CURRENTS						
VCC	Primary supply voltage		4.5	5.0	5.5	V
IVCCQ	Primary quiescent current	IN+, IN- low		5		mA
IVCCS	Primary supply current	FSW = 10kHz, CLOAD = 10nF		50		mA
VCCUR	Vcc rising UVLO threshold			4.5	4.6	V
VCCUF	Vcc falling UVLO threshold		4.2	4.3		V
VCCUH	Vcc UVLO hysteresis			0.2		V
VCCOR	Vcc rising OVLO threshold			5.7	5.8	V
VCCOF	Vcc falling OVLO threshold		5.4	5.5		V
VCCOH	Vcc UVLO hysteresis			0.2		V
VCC2U, VCC2L	Drive voltages	Transformer 750342879	15	17	19	V
VCC2U, VCC2L	Drive voltages	Transformer 750313734	-5.9	-5	-4.7	V
DRIVE CURRENT AND POWER						
IOH	Peak source current	CLOAD = 10nF		10		A
IOL	Peak sink current	CLOAD = 10nF		10		A
PDRV	Drive power	At 25°C			2.0	W
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 = 10 nF, Rg = 0.4 Ω		27		ns
TFALL	Drive output fall time	CLOAD = 10 nF, Rg = 0.4 Ω		21		ns
TPROP	Propagation delay	CLOAD = 100 pF		90		ns
TGLITCH	Input glitch filter		28	40		ns
SHORT CIRCUIT PROTECTION						
VOC	Nominal overcurrent threshold		0.63	0.7	0.77	V
TDEGLIT CH	Blanking time			150		ns
TSR90	Response time to 90% VDR	CLOAD = 10nF		200		ns
V2LOFF	2LOFF voltage			11.0		V
T2LOFF	2LOFF voltage time			2.5		μs
ITL3	Soft turn OFF pull down current			100		mA
VCLAMP	Miller clamp threshold		1.5	2.0	2.5	V
ICLAMP	Miller clamp current			4		A

Table 1. Electrical Specifications (continued)

PARAMETER		TEST CONDITIONS	MIN	NOM	MAX	UNIT
ISOLATION						
CMTI		CMTI	150			V/ns
VISO	Withstand isolation voltage	Reinforced, 60s	5.7			kVrms
CI	Barrier capacitance				20	pF
TA	Operating Ambient Temperature		-40	25	125	oC
SIZE						
Board size					62 x 48 x 6.6	mm

1.3.2 Block Diagram

The block diagram shown in [Figure 1](#) details the UCC217XXQDWEVM-025 EVM. The EVM core is an isolated driver device, UCC217XX, providing optimal drive protection and diagnostic of IGBT and SiC power devices. The isolated drive and control voltages on the secondary side are provided by push-pull transformer drivers SN6505B supplied by a 5-V power source on primary side. The EVM provides either temperature, or input voltage bus monitoring using analog an isolated channel available from UCC217XX. There is also board level logic block providing diagnostic and overlapping protection when two EVMs operate together to drive the FETs in half-bridge power stage configurations. The input and output signals and voltages are provided through miniature 2 x 10 connector. The EVM also includes numerous test points and 2 x 6 header to allow access to key signals during evaluation.

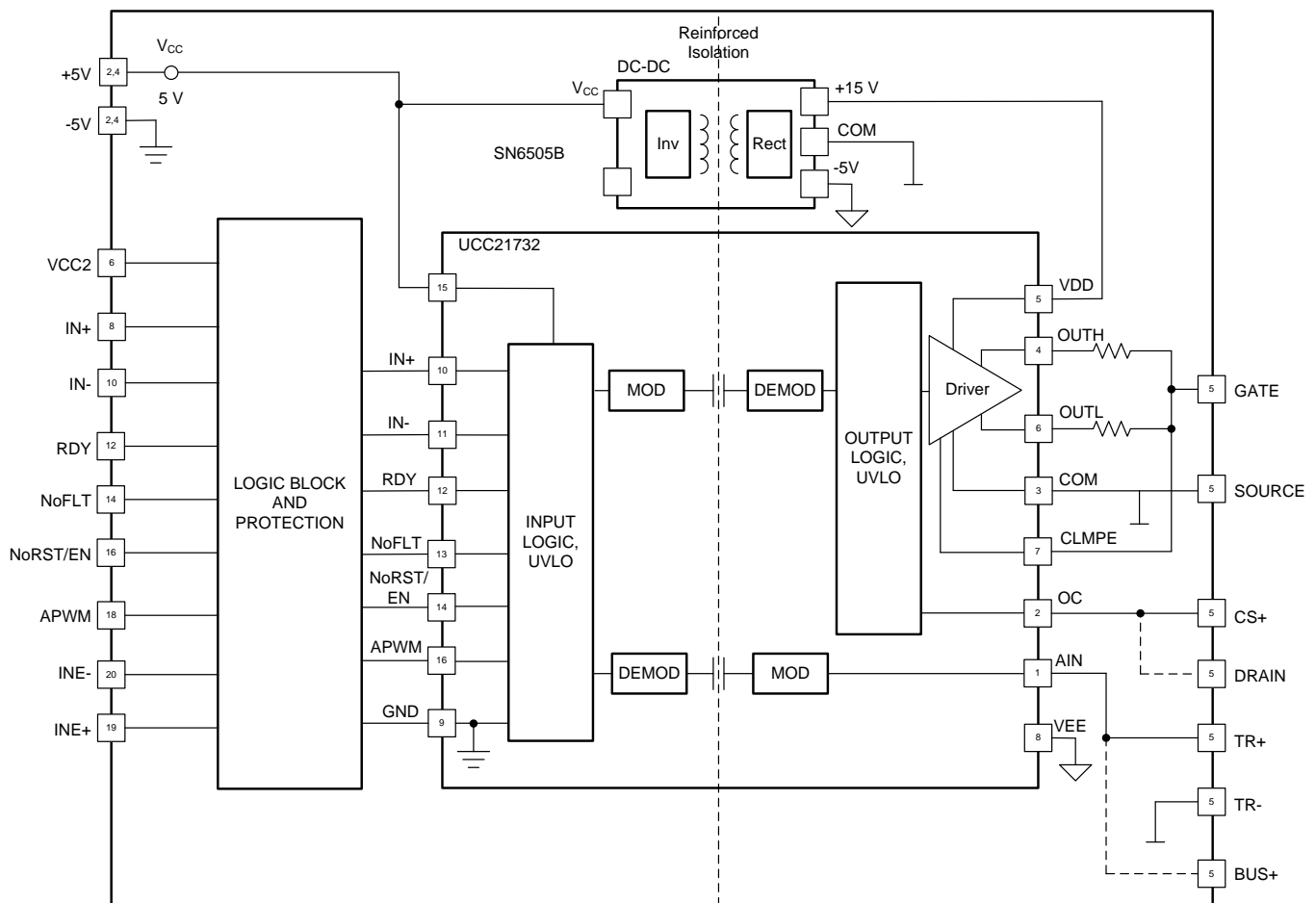


Figure 1. UCC21732QDWEVM-025 Block Diagram

The UCC217XXQDWEVM-025 EVM includes the following key functional blocks shown in schematic in Figure 2.

1. B1: Split rail bias supply using 424 kHz transformer drivers SN6505B to generate separately +17-V rail for turn ON and -5-V rail for turn OFF
2. B2: Input diagnostic, protection and logic block
3. B3: 10-A source/sink 5.0-kVrms Isolated driver using UCC217XX driver device with short circuit protection and Miller clamp circuits
4. B4: Isolated temperature or input voltage rail monitoring block

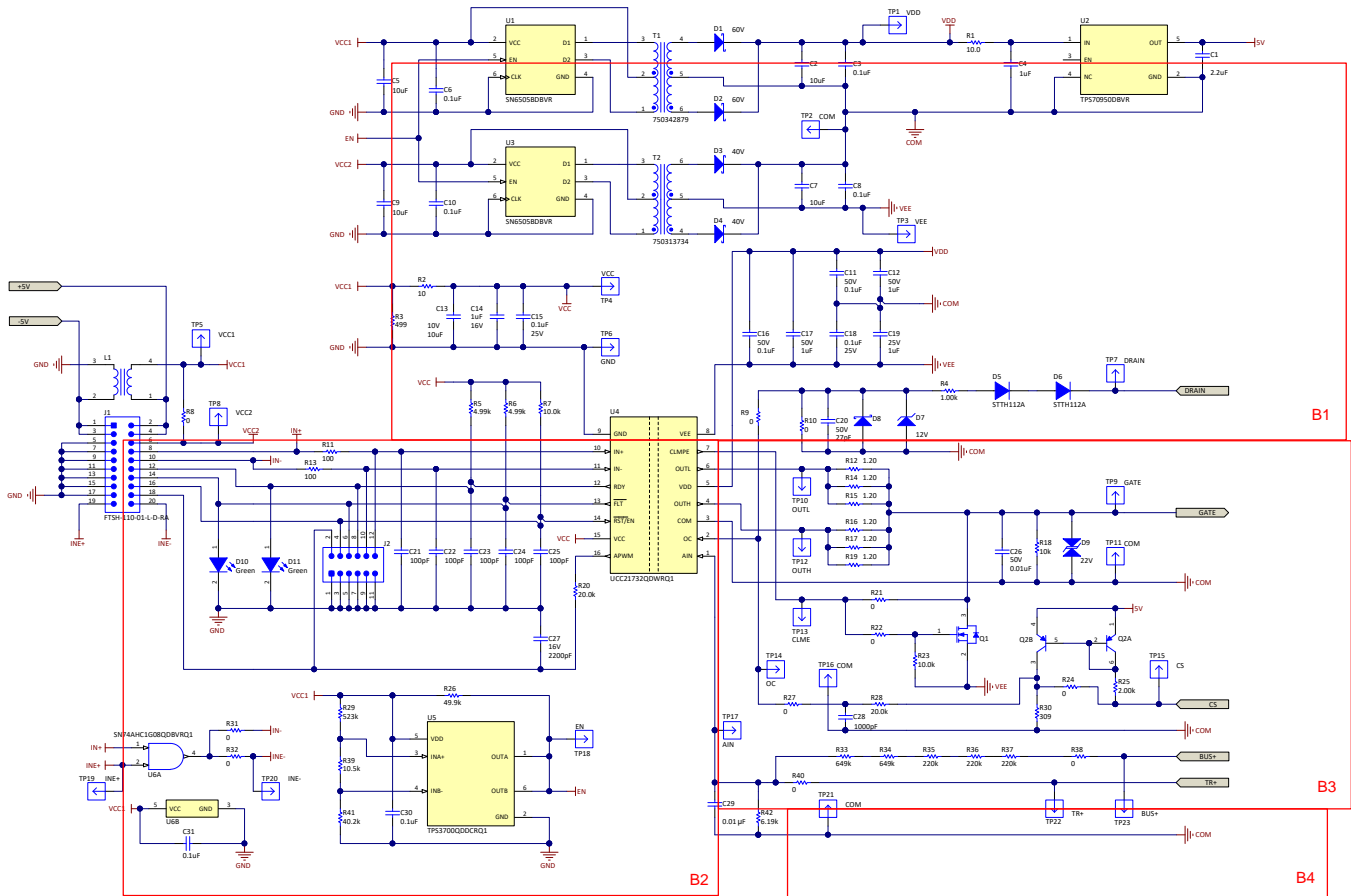


Figure 2. UCC21732QDWEVM-025 Functional Blocks

The location of key functional blocks on the board view are shown in Figure 3.

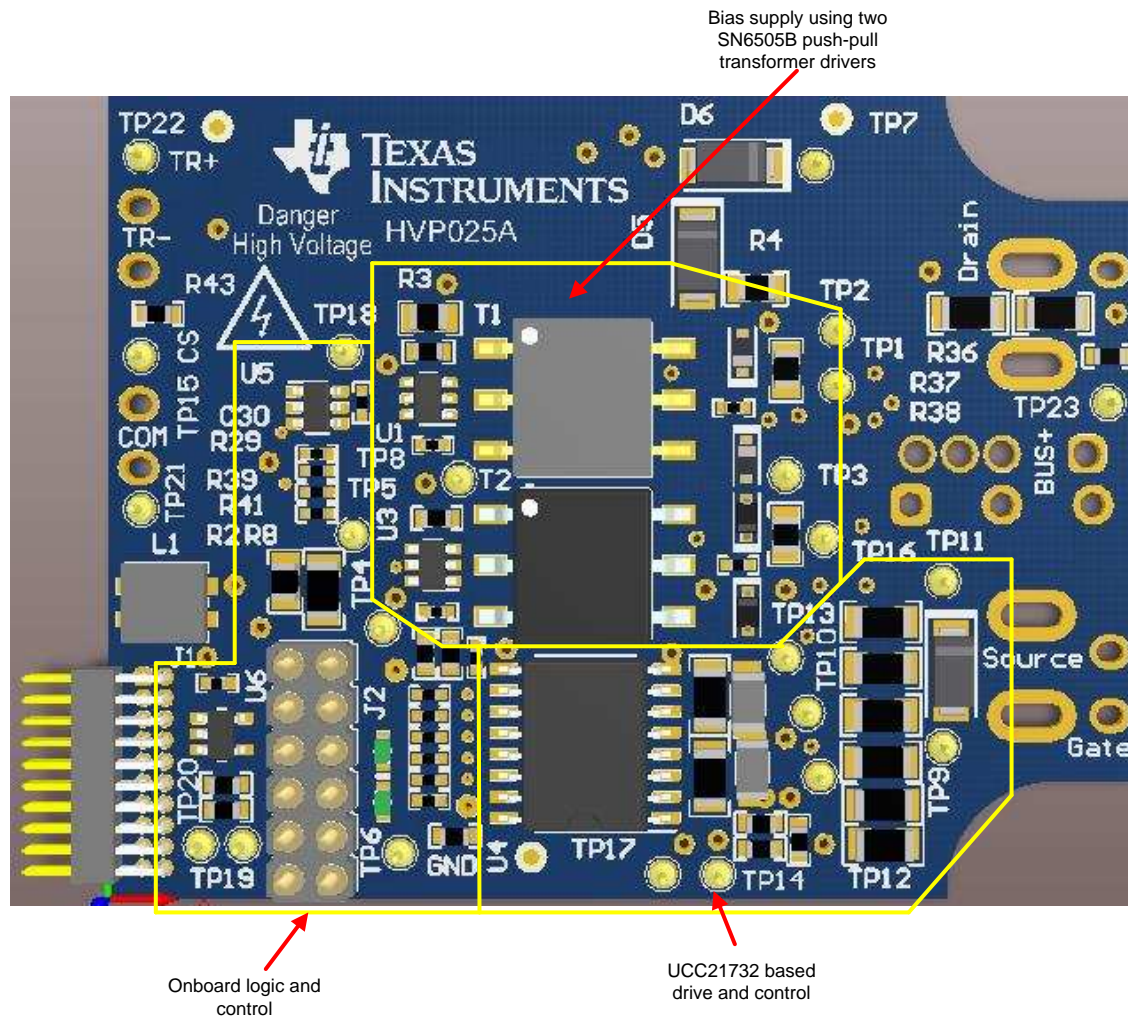


Figure 3. Location of Key Functional Blocks on Board View

1.3.3 Isolated Gate Driver Family UCC217XX

The UCC217XX family of isolated drivers in SOIC-16 DW package with 8.0-mm creepage and clearance providing 5.7-kVrms reinforced isolation, includes all main short circuit protection features for driving SiC and IGBT modules along with discrete power transistors. The UCC217XX family employs TI proprietary high voltage, low propagation delay, CMTI immune capacitive isolation technology. The list of isolation safety certifications from agencies like VDE, CSA, UL and CQC is provided in related datasheet. [Table 2](#) lists UCC217XX family members [UCC21710](#), [UCC21732](#), [UCC21750](#) and their differences, while related block diagrams are shown in [Figure 4](#).

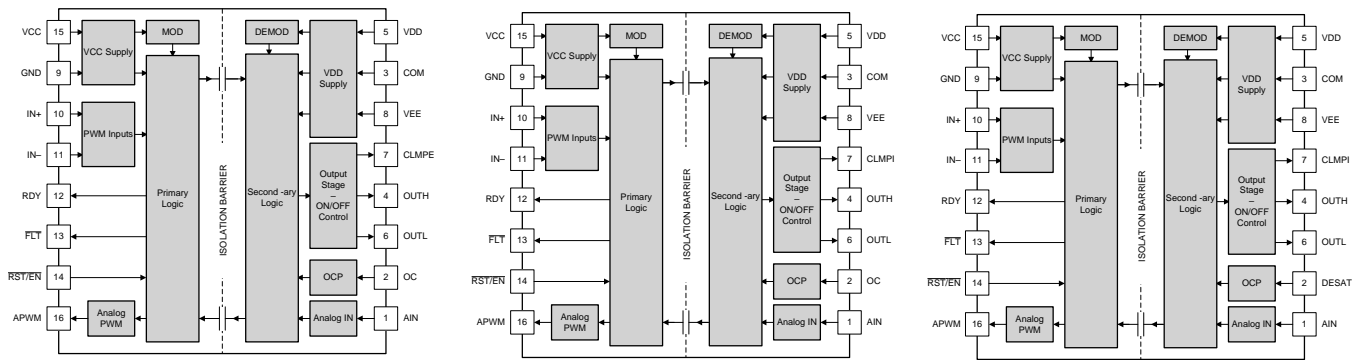


Figure 4. Simplified Block Diagrams of the UCC21732, UCC21710 and UCC21750

Table 2. UCC217XX Isolated Driver Family

DEVICE OPTIONS	AIN-APWM	±PEAK IO	OC/DESAT	MILLER CLAMP	FLT SHUTDOWN	OUTPUT
UCC21710	YES	10 A	OC	Internal	Int. Soft OFF	Split
UCC21732	YES	10 A	OC	External	2-level Int. Soft OFF	Split
UCC21750	YES	10 A	DESAT	Internal	Int. Soft OFF	Split

The UCC217XX family demonstrates short and accurate 90-ns propagation delay allowing accurate control of power devices. Primary side voltage VCC is controlled by UVLO1 circuit with 2.95 V_{max} rising threshold and 2.5 V_{typ} falling threshold. Inverting and non-inverting input signals IN+ and IN- have CMOS thresholds derived from Vcc voltage: 0.7 x VCC max rising and 0.3 x VCC min falling accordingly. Secondary side voltage VDD can go up to 36 V_{abs.} max. Turn ON drive voltage between VDD and COM pins is controlled by UVLO2 circuit with 12.8 V_{max} rising threshold and 10.4 V_{min} falling threshold. The split sink/source ±10-A output allows setting optimal turn ON and turn OFF time by selecting gate resistors between driver output and power device. This family has all necessary short circuit protection features using OC current sensing with 0.7-V tripping threshold and either, soft two-level short circuit turn OFF with external Miller gate clamp, like UCC21732, or single level soft turn OFF with internal Miller clamp, like UCC21710 or DESAT V_{ds} sensing method used in UCC21750. All family provides “Fault”, “Power Ready” and accepts “Reset/Enable” signals.

1.3.4 Split Rail Bias Supply using SN6505B

Split rail bias supply generates 17 V turn ON, and -5V turn OFF voltages using two push-pull transformer drivers SN6505B operating at 424kHz and housed in 6-pin small SOT-23 package. Functional block diagram of SN6505B is shown in Figure 5.

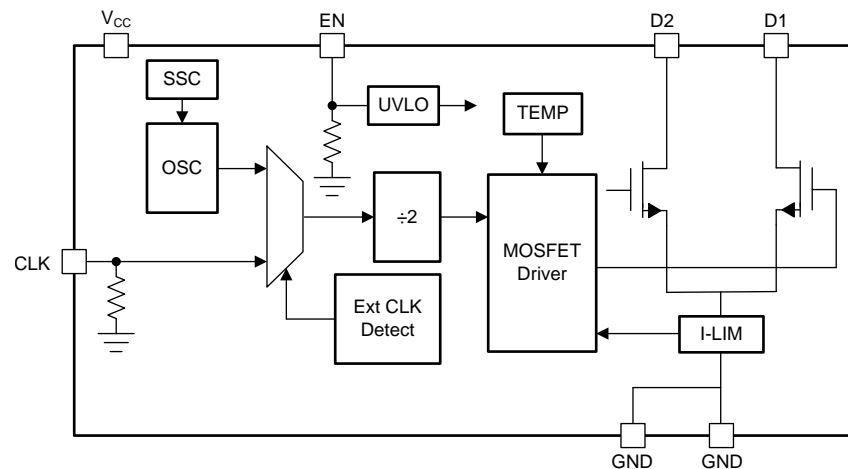


Figure 5. SN6505B Block Diagram

The **SN6505B** is supplied through V_{cc} terminal from external source in the range from 2.25 to 5.5V. Input voltage is controlled by UVLO circuit having rising threshold 2.25Vmax and falling threshold 1.7V min. Internal oscillator operates at 424kHz typical frequency within range from 363 kHz min. to 517 kHz max. It can be synchronized by external logic level clock signal from 100 kHz min to 1600 kHz max. The SN6505 employs spread spectrum clocking technique to minimize EMI. The output stage includes 1A push-pull switches rated up to 16 V abs. max. The switches are protected by current limit circuit tripped at 1.7 A typ. level. The device also protected by thermal shutdown circuit triggered at 168°C typical threshold and returning back to normal operation at 150°C typical. Additional features include soft start and Enable signal. Because there is no closed feedback loop in this inexpensive bias solution, it operates like DC-DC transformer and requires low tolerance primary voltage to maintain output voltages within $\pm 10\%$ range.

1.3.5 Input Diagnostics, Protection and Logic Block

Input diagnostic, protection and logic block fulfills the following functions:

1. Provides additional UVLO and OVLO protection of secondary side drive voltages using sensing on primary side. This approach is accurate enough because the bias supply operates as DC-DC transformer. This UVLO/OVLO circuit is based on window comparator TPS3700
2. Provides optional overlapping protection for two boards driving half-bridge power module using CMOS logic AND SN74AHC1G08QDBVRQ1
3. Provides isolated filtered signal using APWM output coming from temperature or input rail monitoring circuits using AIN input

1.3.6 Output Protection and Diagnostics

The output protection and diagnostic blocks fulfill the following functions:

1. Determine short circuit conditions using OC shunt resistor sensing programmable for either positive, or negative OC signal
2. Analog isolated sensing APWM signal using AIN input for either temperature monitoring using thermistor inside the module, or input rail sensing
3. Includes external active Miller clamp circuit

2 Quick Initial Evaluation

Quick initial evaluation is starting point before using the board to drive power modules as part of power system. To start evaluation, nominal 5V is applied through terminals J1:2,4 (positive) and J1:1,3(GND). Input signal IN+ not exceeding VCC level is applied through J1:8 terminal. The 5-V VCC voltage generates +17 V turn ON drive voltage and -5.3 V turn OFF voltage on secondary side. The switching frequency range is limited by maximum power dissipated on board and should not exceed 2 W at room temperature if no forced cooling is available. Thus, if the supply current exceeds 400 mA, the IN+ signal must be stopped by bringing it to low level and supply power source turned OFF.

By default the EVM includes capacitive load C26 for drive switching waveforms evaluation, but it also has footprints for standard TO-247 package and for 4-pin package with separate source terminal available for SiC FETs. When evaluating with power device, the capacitor C26 has to be removed.

2.1 Equipment

Below is the list of needed equipment

- Power Supplies
 - At least up to 6-V and 1-A two power supplies for powering EVM, for example: BK Precision, series 1715
- Function Generator and accessories
 - One 2-channel function generator, for example: Tektronix AFG3102
 - Two standard 50-Ω BNC coaxial cables
 - Two 50-Ω BNC male to female feed-thru terminators, for example: Tektronix 011-0049-02
- Oscilloscope and accessories
 - Oscilloscope 500-MHz or higher with at least 4 channels, for example: Tektronix DPO7104
 - At least 500-MHz bandwidth four passive voltage probes, for example: P6139A
- Digital Multi-Meters
 - Four DMMs, for example Fluke 187
- Other
 - Connection wires of various length with Pomona clips and connectors

2.2 Test Setups and Procedures

List of initial tests include:

- Power up and bias supply voltages test
- Input and output pulse switching waveforms test
- Overcurrent and two-level soft turn OFF test
- Isolated analog input/output test

NOTE: Before start testing make sure to follow all electrical safety and ESD protection requirements implemented at your company!

2.2.1 Power Up and Bias Supply Voltages Test

Test setup is shown in Figure 6. Additionally, connect TP15 to TP21.

Figure 6. Power Up and Bias Supply Voltages Test Setup

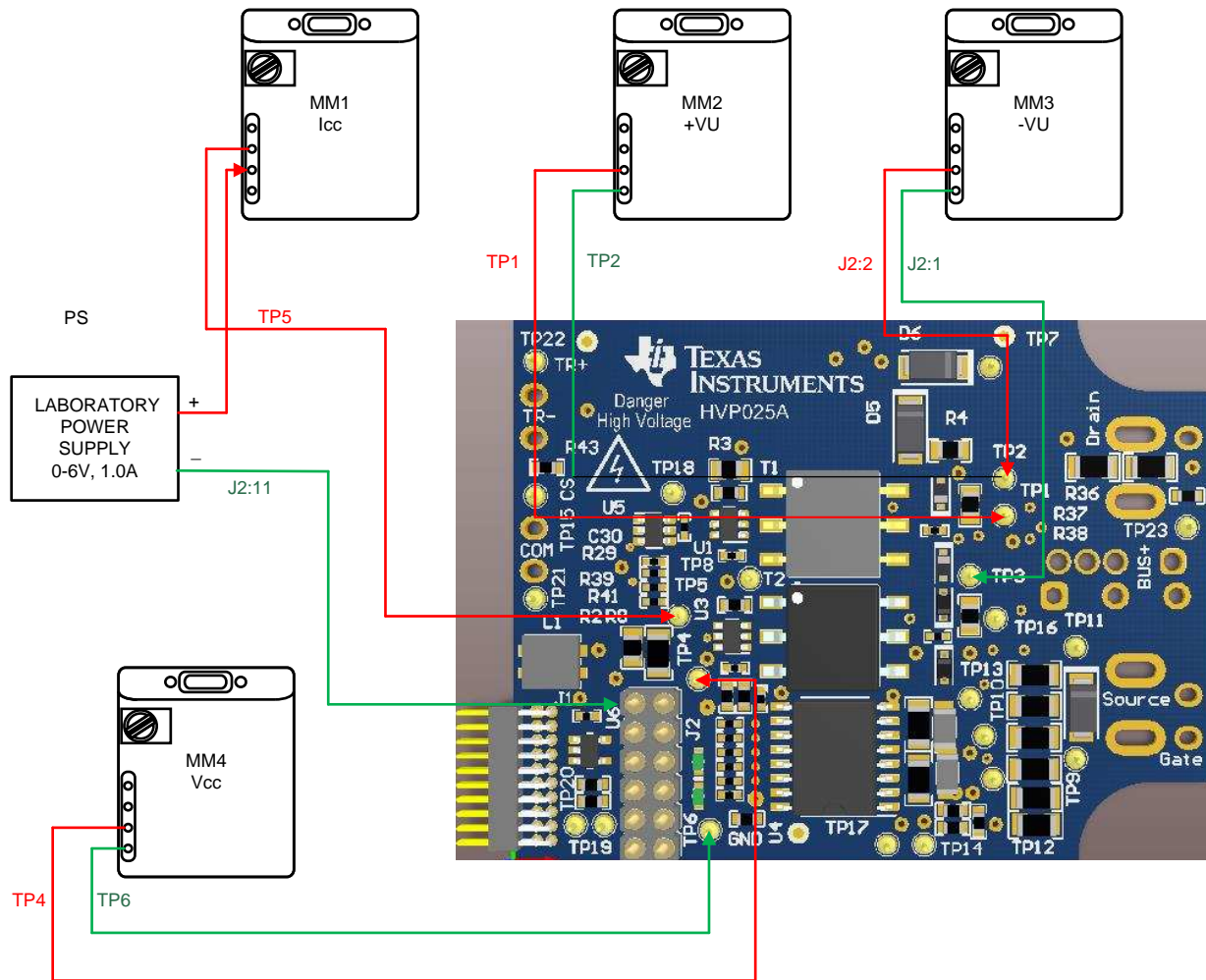


Figure 7.

Because of small size of EVM board it must be fixed on bench area using either standard clamp, or simply the sticking isolation tape.

Digital Multi-meter settings

MM2, MM3, MM4 are set for DC voltage measurements, auto-range.

MM1 is set for DC current measurements with expected range up to 500 mA

The following is power up and bias supply voltages test procedure.

1. Enable power supply PS
2. Gradually increase the voltage at PS and monitor voltage using MM4 and current using MM1
3. Verify measured voltage and current in accordance to [Table 3](#). If current or voltage is outside of the specified range, stop increasing the voltage at PS and return to initial stage
4. Gradually reduce the voltage at PS1 to 0 V and disable it

Table 3. Voltages and Currents During Power Up Test

MM4	MM1	MM2	MM3	LED D10 (NoFLT)	LED D11 (RDY)
2.95 V-3.05 V	<4 mA	<±0.1 V	<±0.1 V	Starts illuminating	Dark
4.65 V-4.75 V	35 mA-72 mA	15.7 V-16.7 V	4.5 V-5.2 V	Light	Light
4.95 V-5.05 V	38 mA-75 mA	16.8 V-17.7 V	5.0 V-5.6 V	Light	Light

Table 3. Voltages and Currents During Power Up Test (continued)

MM4	MM1	MM2	MM3	LED D10 (NoFLT)	LED D11 (RDY)
5.4 V-5.45 V	40 mA-77 mA	17.7 V-19.2 V	5.5 V-6.2 V	Light	Light
>5.7 V, but <6 V	<6 mA	<±0.1 V	<±0.1 V	Light	Dark

2.2.2 Input and Output Switching Waveforms Test

Test setup for input and output switching waveforms is shown in Figure 8. The EVM by default includes 10-nF load capacitor CXX. Connect TP7 to SOURCE terminal for UCC21750 only.

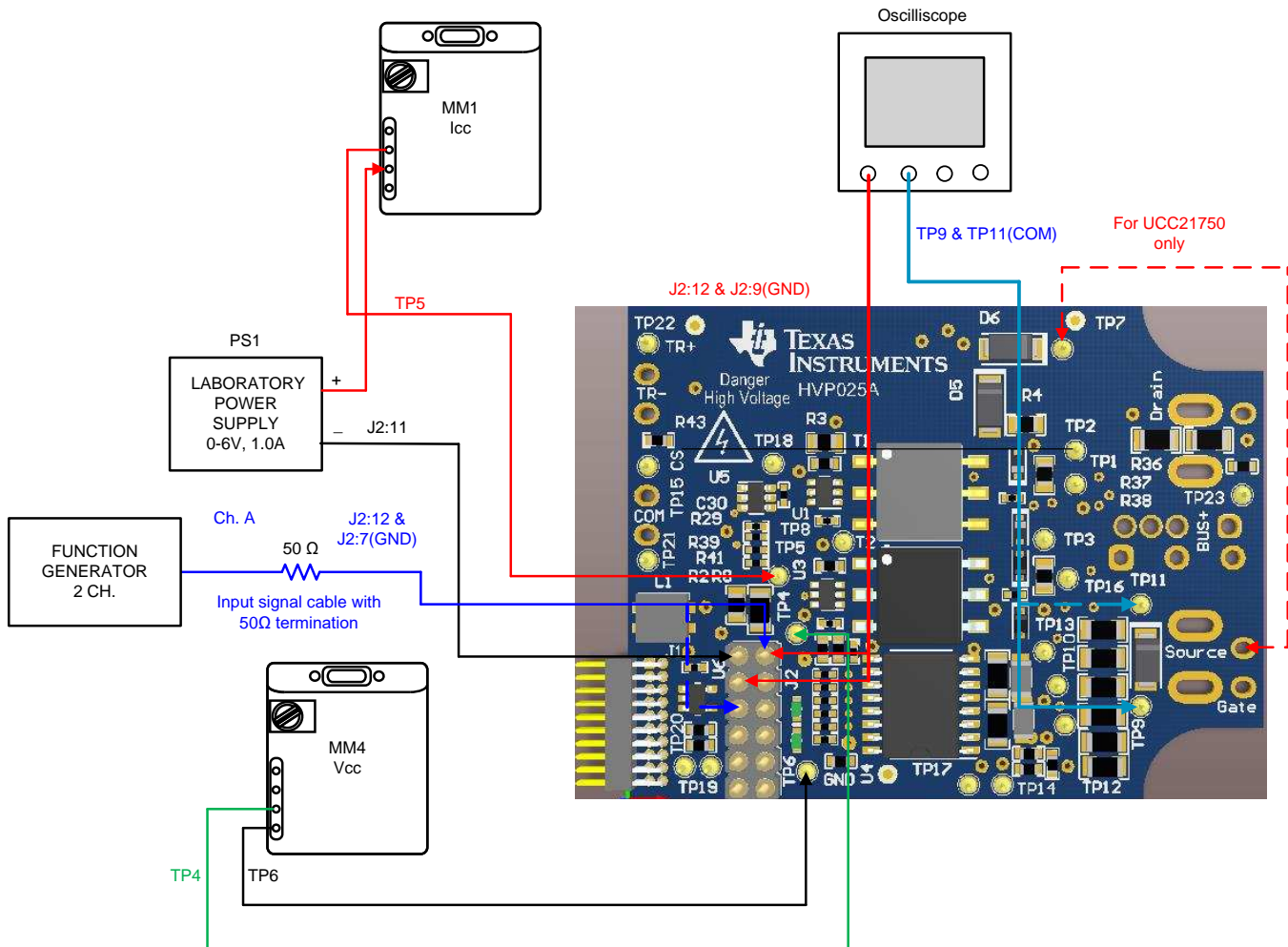


Figure 8. Input and Output Switching Waveforms Test Setup

Function generator settings are shown in Table 4.

Table 4. Function Generator Settings

CHANNEL	MODE	FREQ.	WIDTH	DELAY	AMPL.	OFFSET	LOAD IMPED.
A (Ch.1)	Pulse	10 kHz	50 μs	0	4 Vpp	2.0 V	50 Ω

Oscilloscope settings are shown in Table 5. See also waveforms and settings in .

Table 5. Oscilloscope Settings

CHANNEL	VERTICAL SCALE	HORIZONTAL SCALE	BANDWIDTH	COUPL.	TERMINATION	SYNC.	RESOLUTION
Ch. 1(yellow)	3 V/div	20 μ s/div	500 MHz or above	DC	1 M Ω	Ch. 1	High
Ch. 2(blue)	10 V/div						

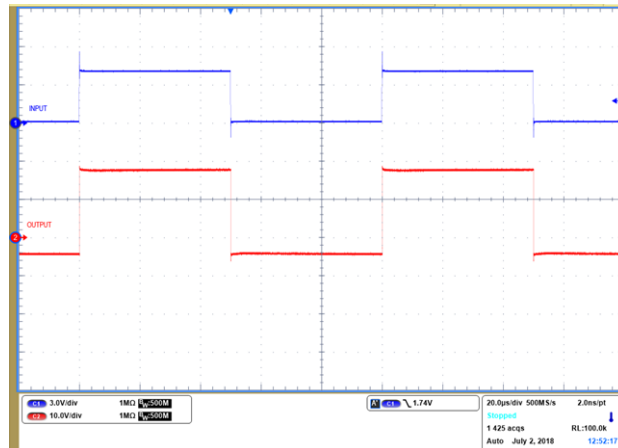


Figure 9. Input and Output Switching Waveforms with $C_{LOAD} = 10$ nF

The following is input and output switching waveforms test procedure.

1. Enable power supply PS
2. Gradually increase the voltage at PS into 4.95 V to 5.05 V range and monitor current using MM1 that should not exceed 75 mA
3. Enable channel A (ch.1) of function generator
4. Monitor current increase at MM1 but does not exceed 90 mA
5. Compare waveforms with typical screen shot shown in [Figure 9](#)
6. Disable function generator channels
7. Gradually reduce voltage at PS down to 0 and disable it (Make sure function generator outputs are disabled before this action!)

2.2.3 Overcurrent and Short Circuit Soft Turn OFF Test

The test setup is shown in Figure 10. For UCC21750 there is no need to connect channel B (Ch.2) of function generator.

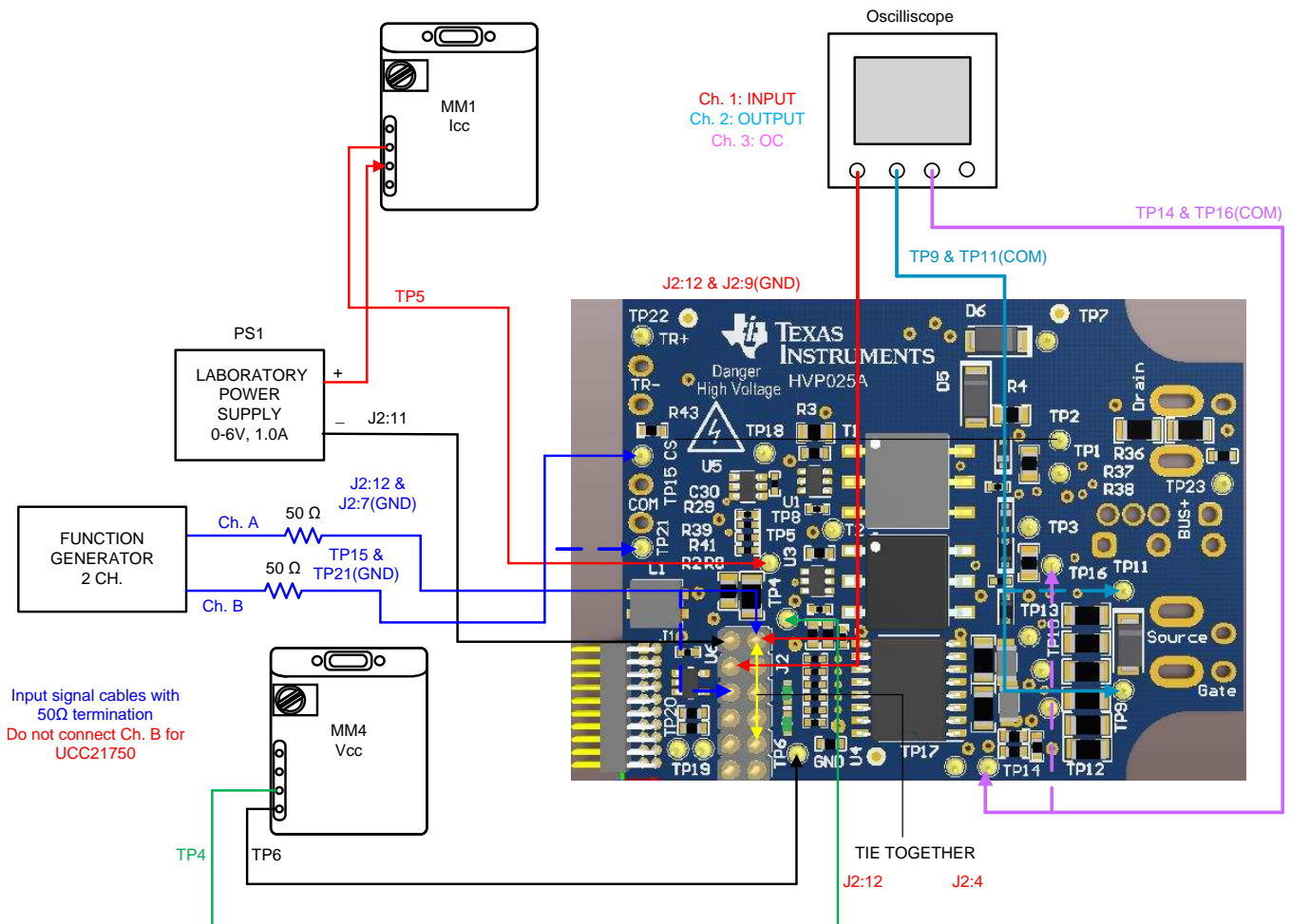


Figure 10. Overcurrent and Short Circuit Test Setup

Function generator settings are shown in Table 6.

Table 6. Function Generator Settings

Channel	Mode	Freq. kHz	Duty	Delay	Ampl. V	Offset, V	Load Imped.	Frequency set	Comment
A (Ch.1)	Pulse	10	50%	0	4	2.0	50 Ω		
B (Ch.2)	Ramp	10	50%	2700	1.2	0.6	50 Ω	Ch1=Ch2, ON	N/A for UCC21750

Oscilloscope settings for UCC21710 and UCC21732 based EVMs are shown in Table 7 and in Figures 10 through 12.

Table 7. Oscilloscope Settings for UCC21710 and UCC21732 EVMs

Channel	Vertical scale	Horizontal scale	Bandwidth	Coupling	Termination	Sync.	Resolution
Ch. 1(yellow)	10 V/div	200 μ s/div	500 MHz or above	DC	1 M Ω		High
Ch. 2(blue)	2 V/div					Ch. 2	
Ch. 3(pink)	500 mV/div						

Figure 11. Short Circuit Test Waveforms

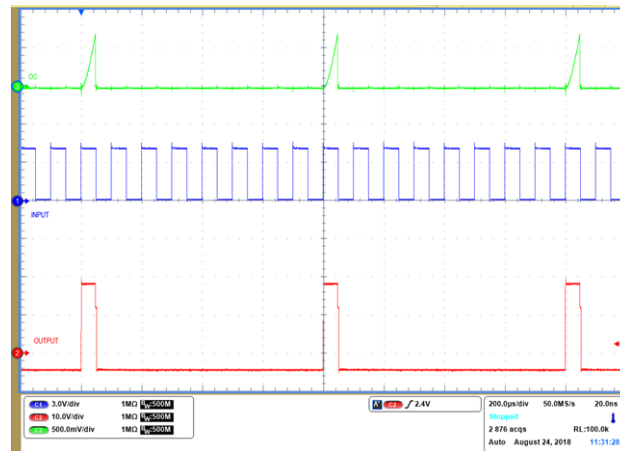


Figure 12. Expanded Short Circuit Waveforms for UCC21732

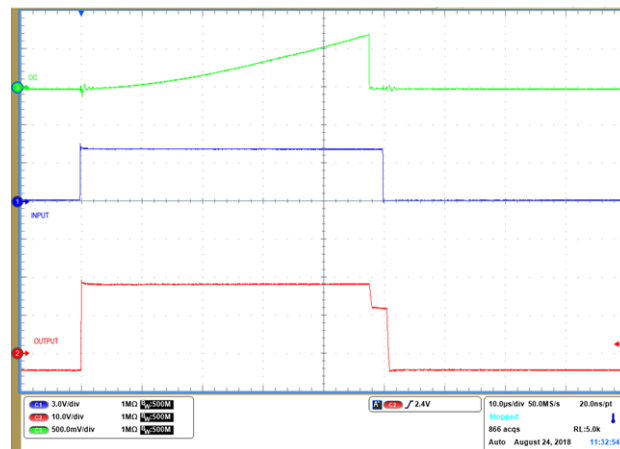
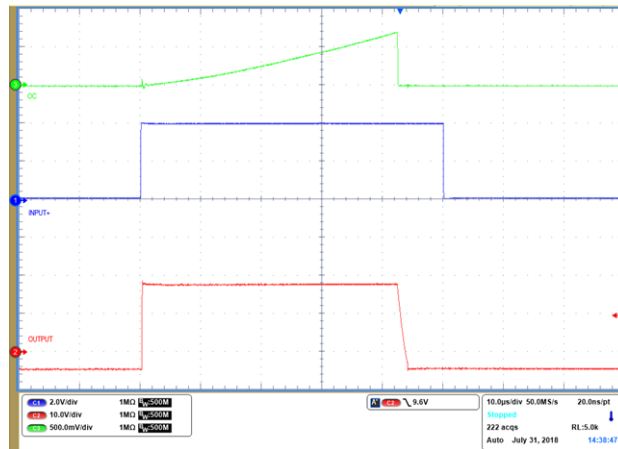


Figure 13. Expanded Short Circuit Waveforms for UCC21710

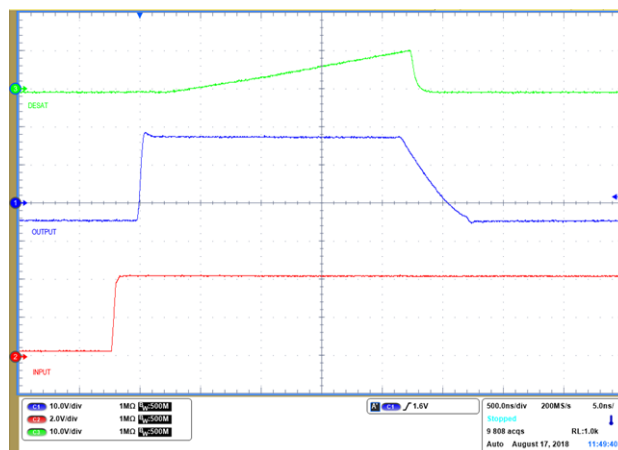


Oscilloscope settings for UCC21750 based EVM are shown in Table 8 and in Figure 13.

Table 8. Oscilloscope Settings for UCC21750 EVM

Channel	Vertical scale	Horizontal scale	Bandwidth	Coupling	Termination	Sync.	Resolution
Ch. 1(yellow)	10 V/div	500 ns/div	500 MHz or above	DC	1 MΩ	Ch. 1	High
Ch. 2(blue)	2 V/div						
Ch. 3(pink)	10 V/div						

Figure 14. Expanded Short Circuit Waveforms for UCC21750



The following is overcurrent and short circuit turn OFF test procedure.

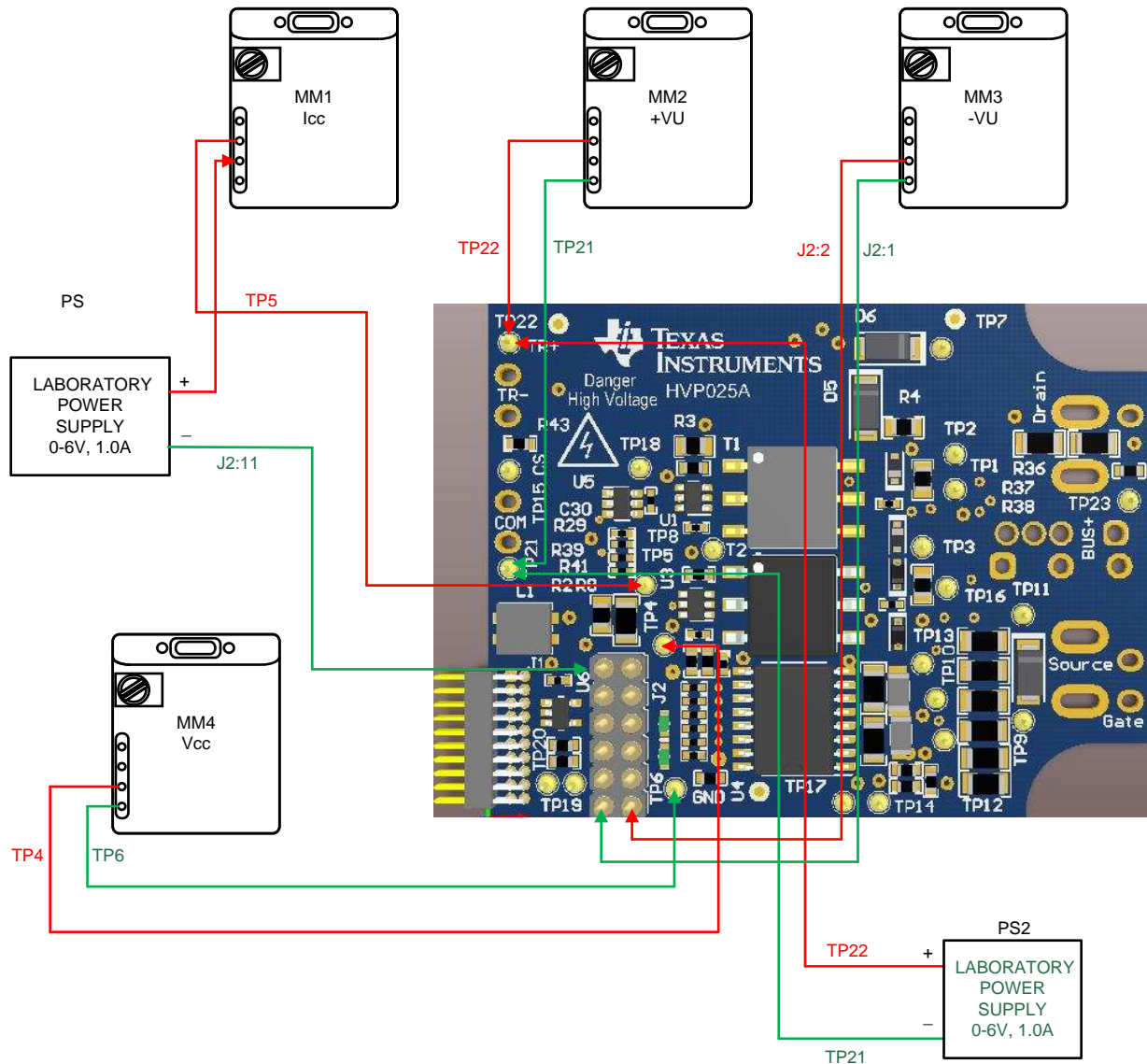
1. Enable power supply PS
2. Gradually increase the voltage at PS into 4.95 V to 5.05 V range and monitor current using MM1 that should not exceed 6075 mA
3. Enable channel A (ch.1) and channel B (ch.2) of function generator
4. LED D10 should go dark indicating fault
5. Compare waveforms with typical screen shot shown in Fig. 10
6. Expand waveforms into scale 10 µs/div and compare with Fig. 11 for UCC21732, Fig. 12 for UCC21710 and with scale 500 ns/div in Fig. 13 for UCC21750
7. Disable function generator channels
8. Gradually reduce voltage at PS down to 0 and disable it (Make sure function generator outputs are

disabled before this action!)

2.2.4 Isolated Analog Input and Output Test

The test setup is shown in Figure 14. Additionally, connect TP15 to TP21.

Figure 15. Isolated Analog Input and Output Test Setup



The following is isolated analog input/output test procedure.

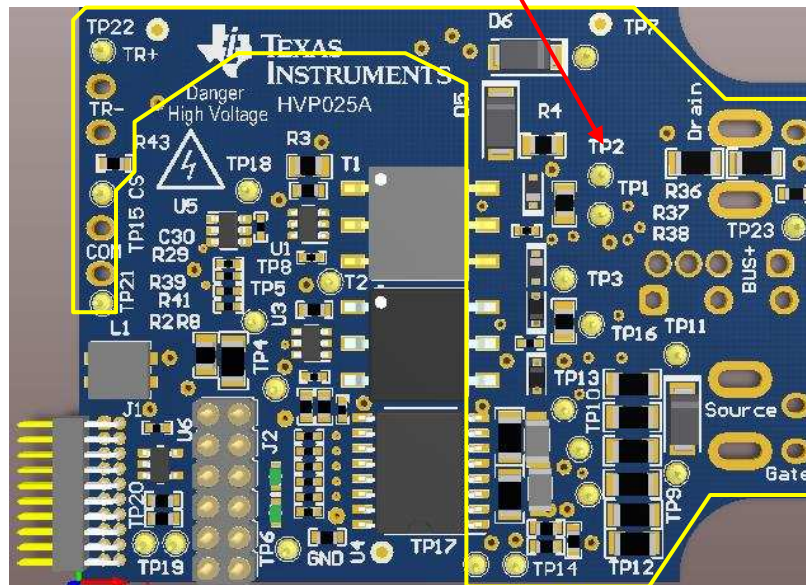
1. Enable power supply PS1
2. Gradually increase the voltage at PS1 into 4.95 V to 5.05 V range and monitor current using MM1 that should not exceed 75 mA
3. Enable power supply PS2
4. Gradually increase the voltage of power supply PS2 from 0 V up to 4.5 V and monitor voltage at multi-meter MM3. The voltage at MM3 is gradually reducing from 4.4 V-4.8 V to 0.1 V-0.7 V, while the voltage at multi-meter MM2 is increasing following power supply PS2
5. Gradually decrease the voltage of power supply PS2 down to 0 and disable it
6. Gradually reduce the voltage of power supply PS1 down to 0 V and disable it

3 Advanced Evaluation with Power Modules

The board view is shown in Figure 15. For evaluation with power device, the 5-V nominal input voltage is supplied through 0.05" pitch connector J1 on the left side. The user has to use proper receptacle and design input/output cable based on own needs. All signals on primary side are available through header J2.

Figure 16. The Board View with Potential High Voltage Area

High Voltage is present in the area surrounded by yellow line when the EVM is connected to Power Device in system



NOTE: The area outlined by yellow line in Figure 15 has high voltage present when the EVM is connected to power device in system. Depending on power system, this high voltage can be up to 1500 V.

To minimize risk of electric shock hazard always follow safety practices normally followed in a development laboratory. Refer to TI's EVM High Voltage guideline accompanying this EVM.

All critical voltage signals are accessible through numerous test points shown in the schematic and assembly top and bottom views (Figures 16 through 18).

Figure 17. Electrical Schematic

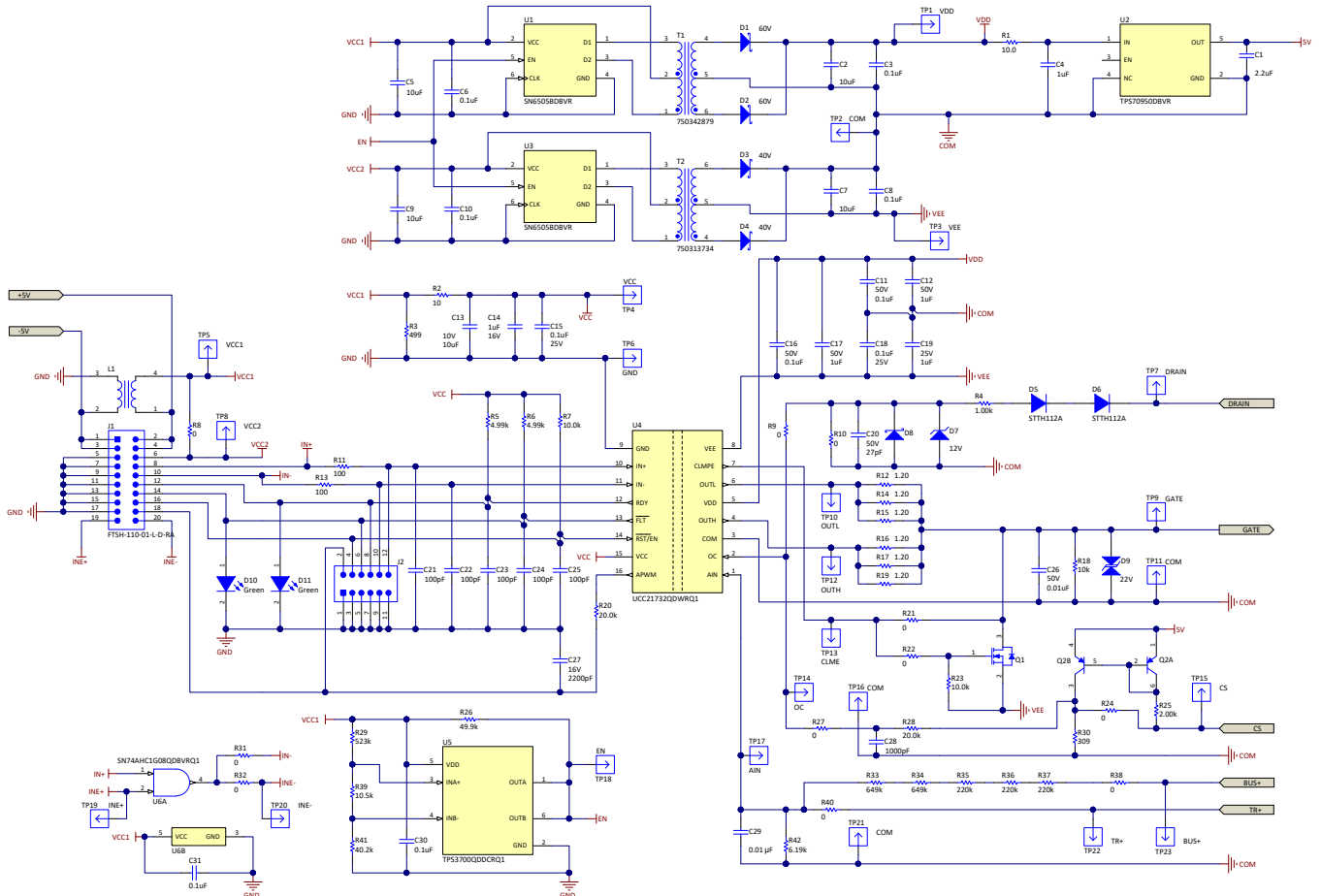


Figure 18. EVM Top View

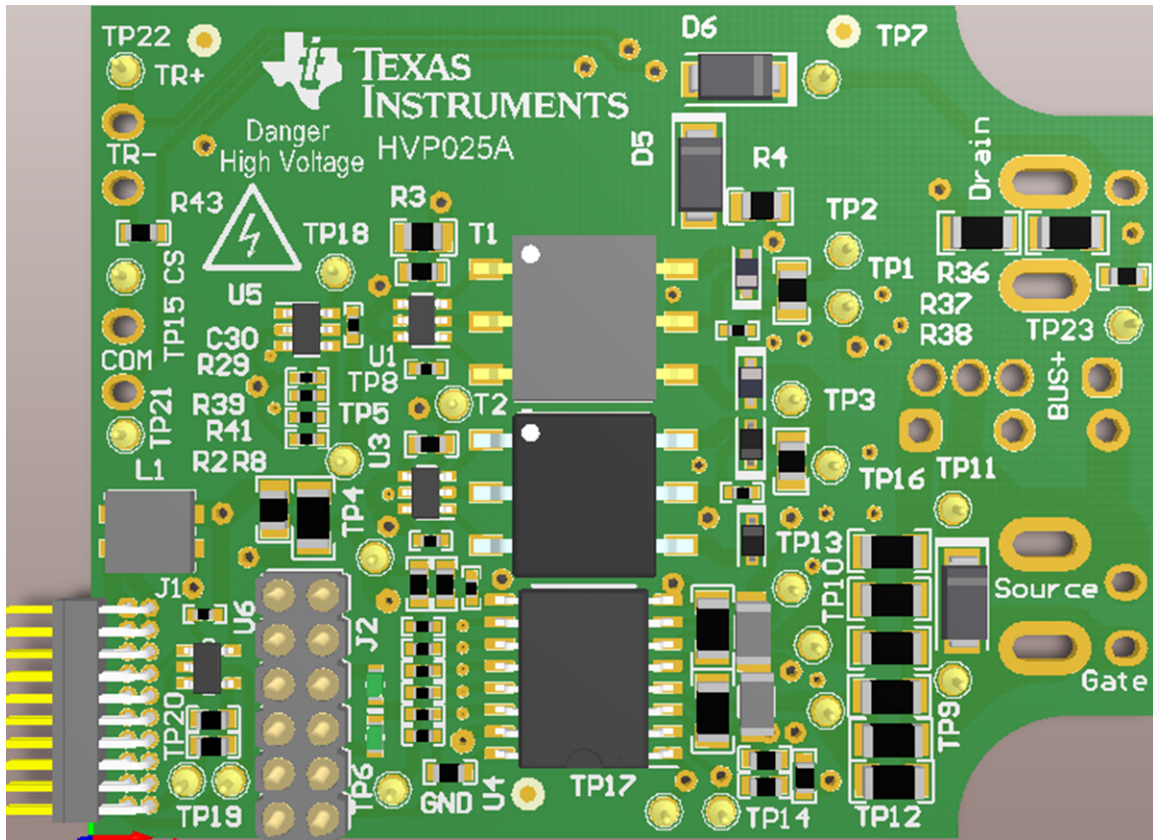
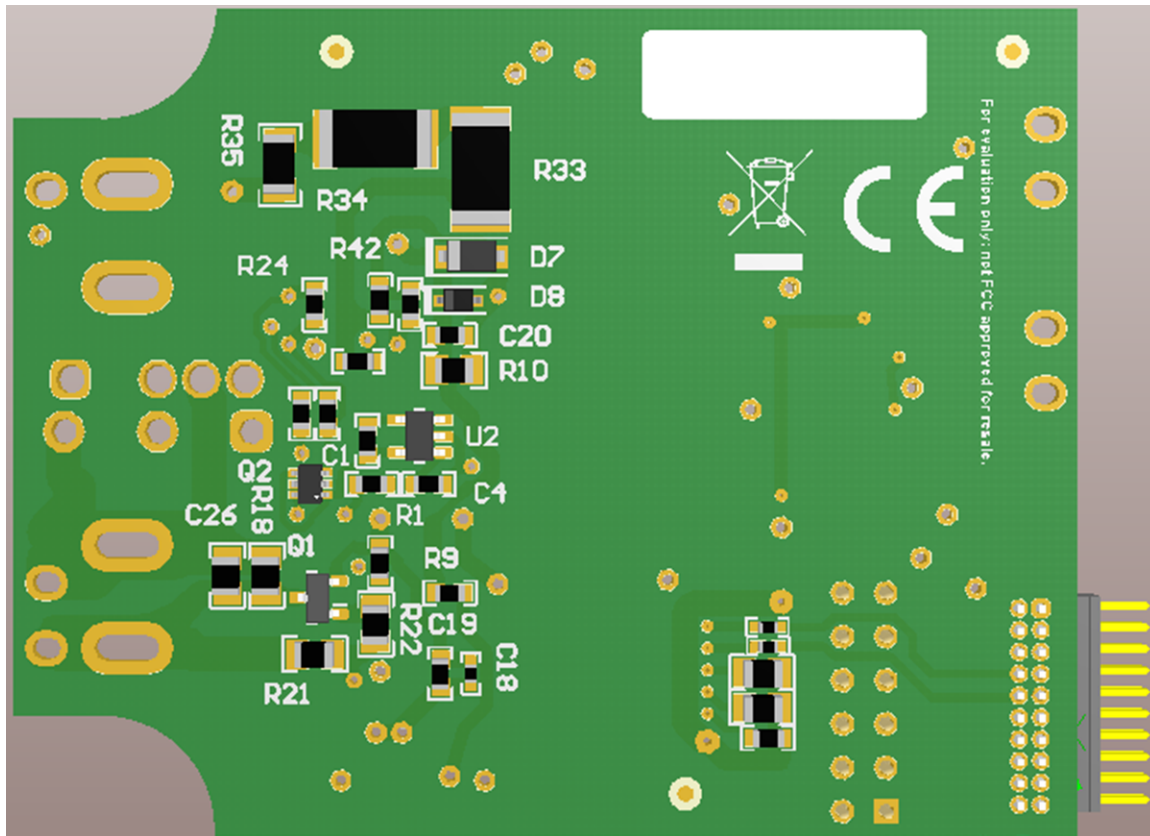


Figure 19. EVM Bottom View


3.1 EVM Default Settings and Recommendations

Most drive, protection and diagnostic functions are integrated within TI ICs used in the board. The board setting can be either for isolated driver UCC21710, UCC21732, or UCC21750 as it is shown on board label and on its bag.

The default settings for UCC21732 driver are shown in Figures 19 and 20.

Figure 20. UCC21732QDWEVM-025 Top Assembly View

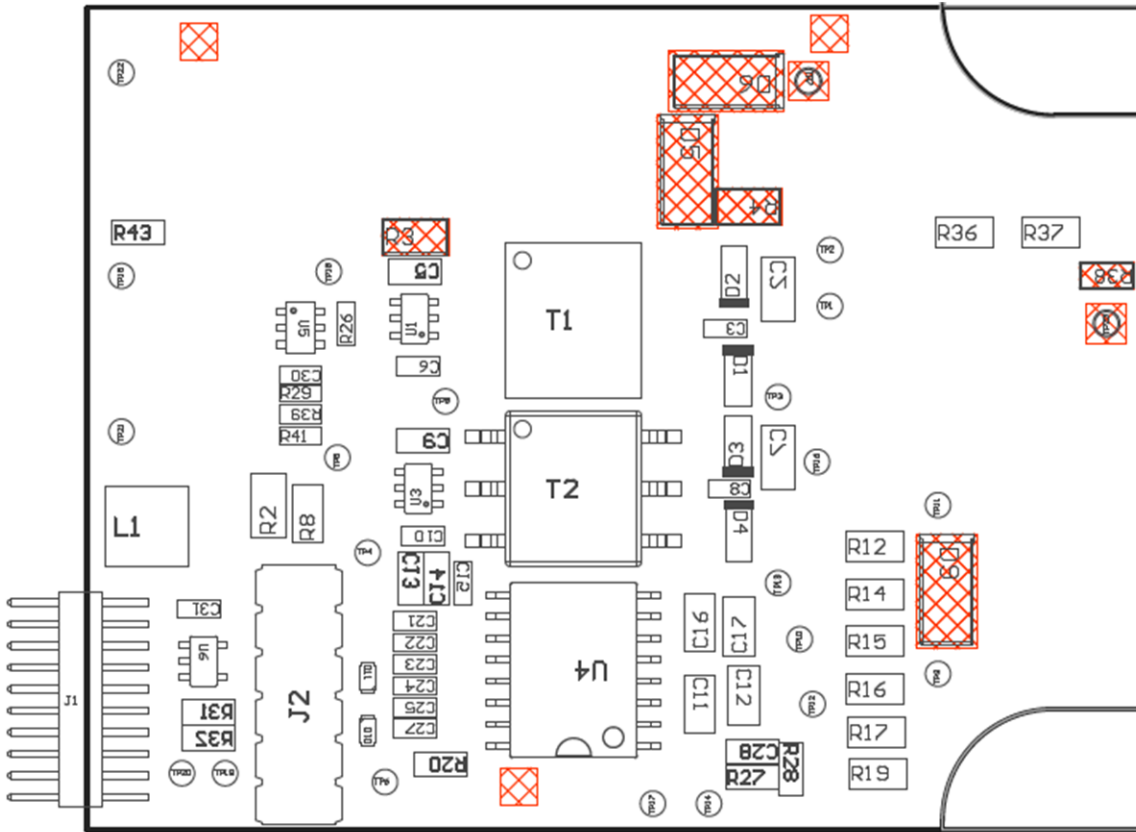
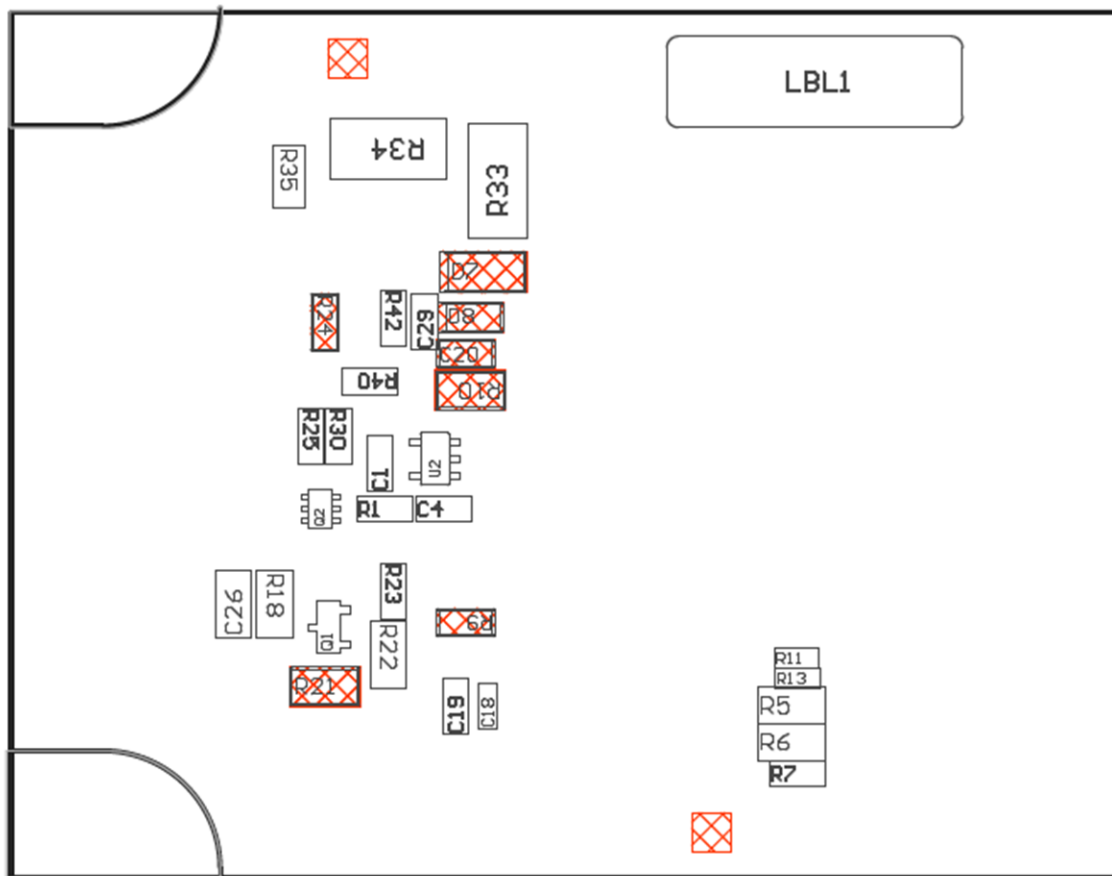


Figure 21. UCC21732QDWEVM-025 Bottom Assembly View


- Remove R9 – to disable desaturation protection feature and allow OC protection provided by UCC21710 and UCC21732, but leave R9 and remove R27 and R10 for UCC21750
- Remove R21 – to disable internal Miller clamp and allow external FET Miller clamp for UCC21732
- Keep R21 and remove R22 and Q1 to allow internal Miller clamp for UCC21710 and UCC21750
- Remove R38 – to allow temperature monitoring using thermistor inside the power module. Putting back R38 and removing R40 allows input voltage rail monitoring and disables temperature monitoring
- Remove R30, R25 and Q2 and use R24 to connect directly to CS+. This setting by default allows positive OC signal sensing. Resistor R28 is used for high frequency OC noise rejection and its value depends on system needs and can be selected differently
- For negative OC signal sensing, keep R30, R25 and Q2 and remove R24
- C26 is 10 nF capacitor to emulate C_{gs} charge of power module. When connecting to power module this capacitor must be removed
- By default R3 is not populated. This resistor is used in the systems where the driver is turned OFF at some conditions by external switch in series with VCC. In this case R3 provides relatively fast discharge path for input VCC capacitances

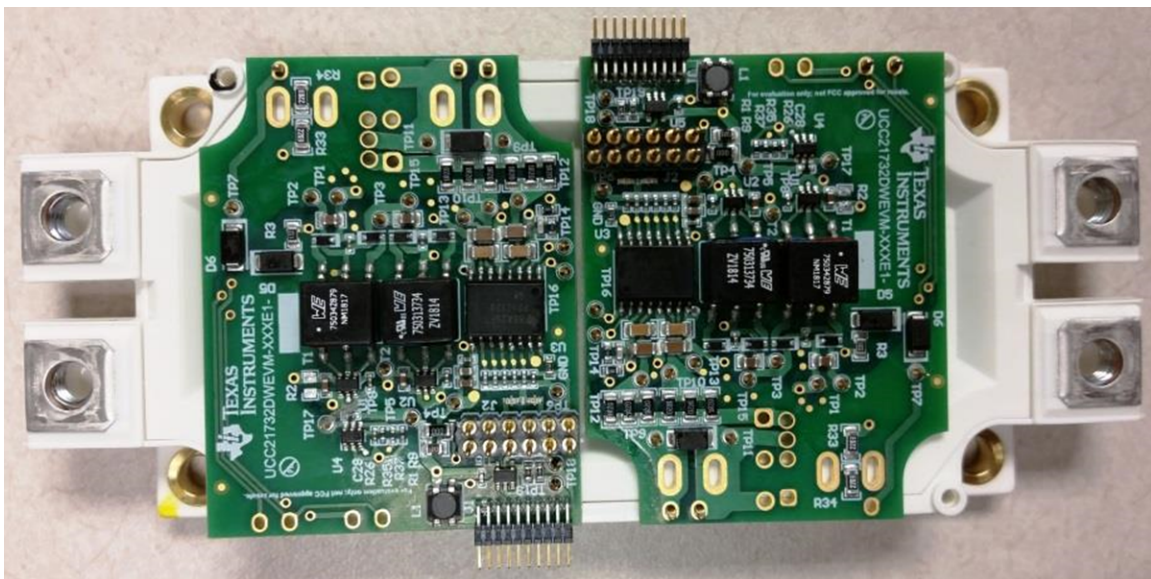
In many systems half-bridge power stage is used as key functional block for power conversion. Thus, two EVMs can be used to drive standard half-bridge power modules as shown in Figures 21 and 22.

Figure 22. EVM Boards with Standard 106 mm Half-Bridge Module



In 106-mm half-bridge module configuration two boards are placed one on top of another and the bottom board is flipped over. The supply voltage and input signals are provided through connectors J1 on each board. By connecting IN+ and INE- terminals on one board to INE+ and IN- terminals accordingly on another board, the overlapping protection circuit using logic U5 is engaged. This circuit could be disabled by removing resistors R31 and R32 in case of overlapping is required in the system.

Figure 23. EVM Boards with Standard 150 mm Half-Bridge Module



In 150-mm half-bridge module configuration two boards are placed one next to another but one board rotated 180°. The vias for Vgs drive and temperature and input rail sensing will be aligned based on boards form factor. If the power module has standard terminals for shunt resistor current sensing, these terminals also will be aligned with CS+ and COM inputs of driver board. Isolated analog input of driver IC is referenced to COM pin. Thus, input voltage rail sensing requires to be used by the EVM on right side in Figure 22, because it shares the same reference as input voltage rail. The connection of VIN+ terminal to Drain via needs to be done by wire. The thermistor for temperature sensing in power modules is usually electrically isolated. Thus, analog isolated input of left side EVM can be used for temperature sensing. The connection of thermistor pins to TR+ and TR- vias needs to be done by using twisted wires.

NOTE: While operating with power modules as part of power system, the input supply current limit 400mA to each driver board, the isolation working voltage 1500V, and voltage and temperature limits, set by power module vendors to the module, should never be exceeded!

3.2 PCB Board Design

The 4-layer PCB board is used for EVM to minimize EMI by using ground planes in internal layers. The layout of all 4 layers is shown in Figures 23 through 26.

Figure 24. Top Layer

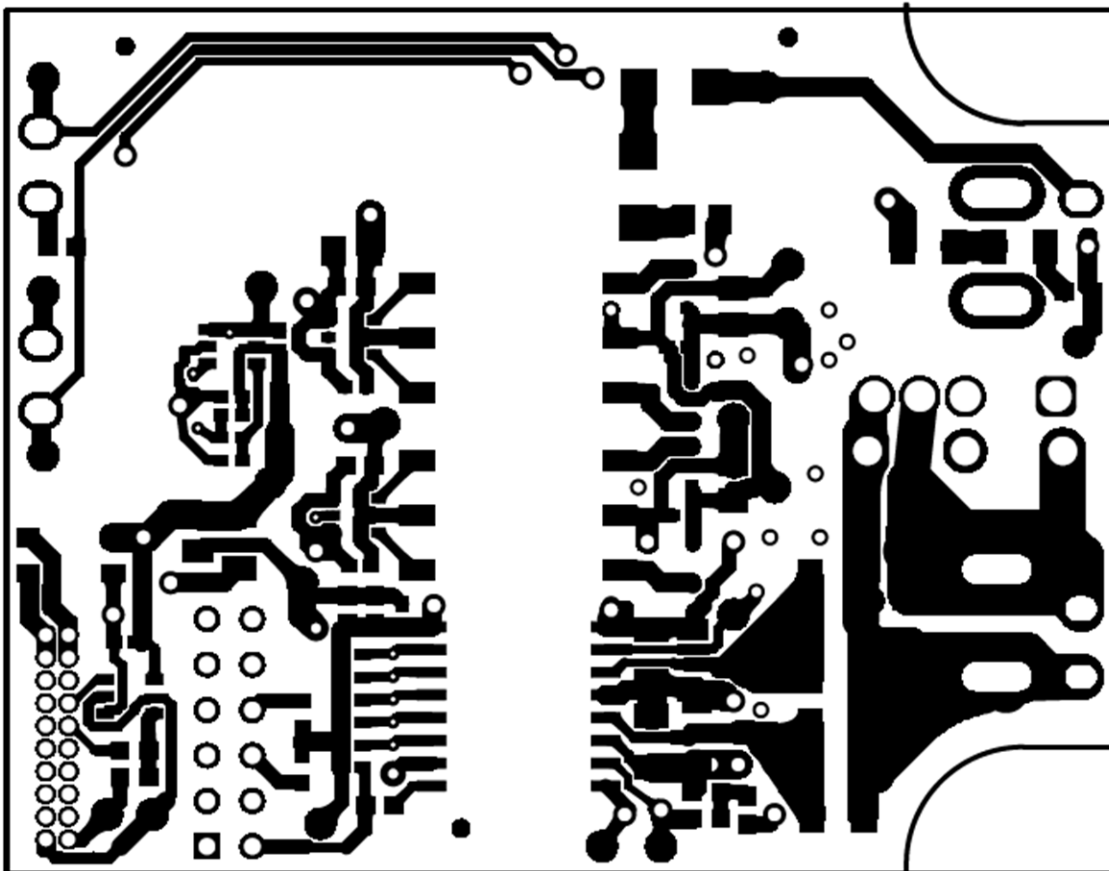


Figure 25. Internal Signal Layer 1

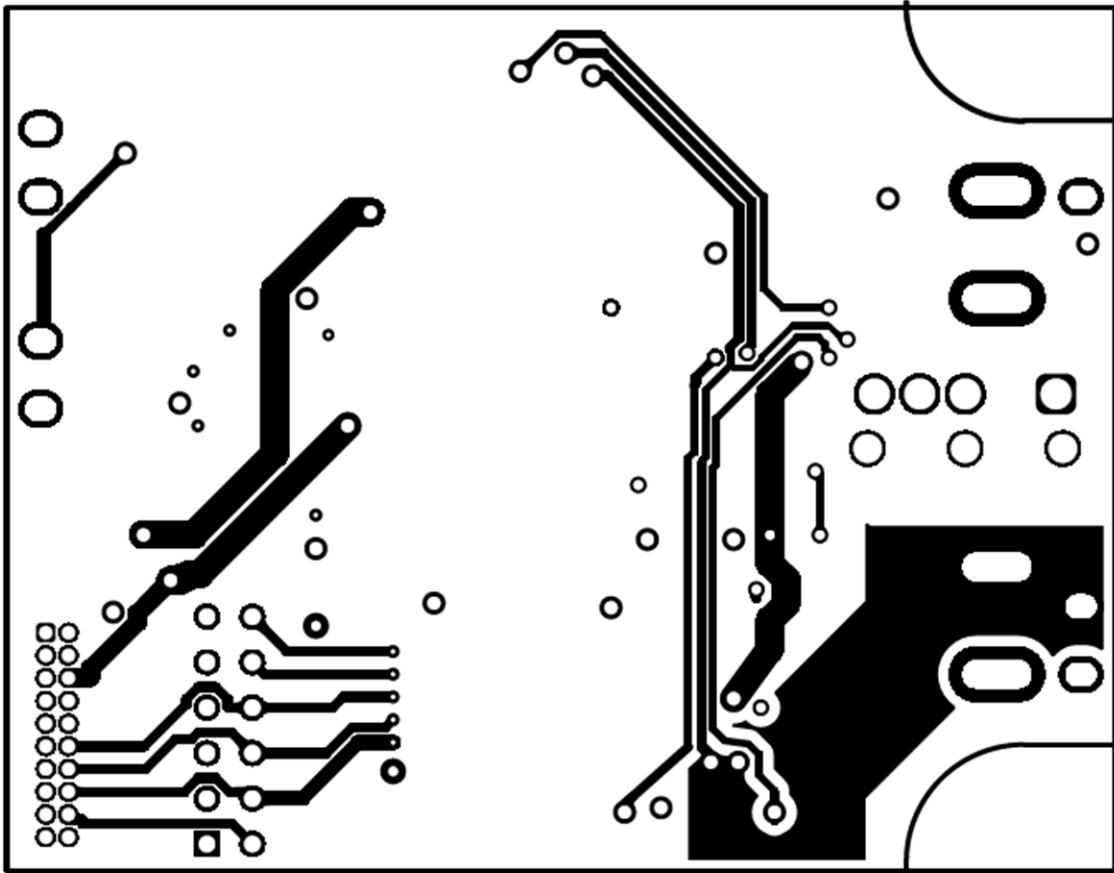


Figure 26. Internal Singal Layer 2

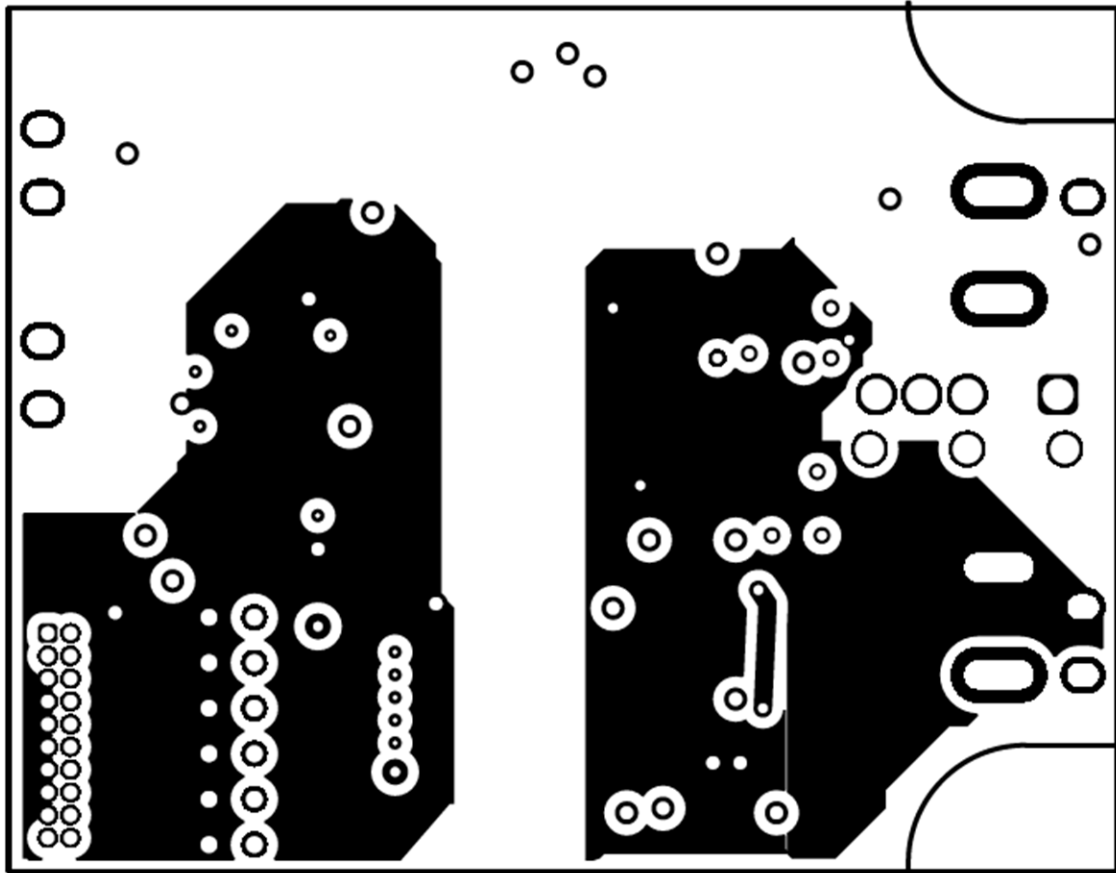


Figure 27. Bottom Layer



3.3 List of Materials

List of materials for the UCC21732QDWEVM-025.

Table 9. UCC21732QDWEVM-025 List of Materials

DES	QTY	DESCRIPTION	MANUFACTURER	PART NUMBER
!PCB1	1	Printed Circuit Board	Any	HVP025
C1	1	Capacitor, ceramic, 2.2 uF, 16 V, +/- 10%, X7R, 0603	Taiyo Yuden	EMK107BB7225M A-T
C2, C7	2	Capacitor, ceramic, 10 uF, 25 V, +/- 10%, X5R, 0805	TDK	C2012X5R1E106 K125AB
C3, C8	2	Capacitor, ceramic, 0.1 uF, 50 V, +/- 10%, X7R, 0402	TDK	C1005X7R1H104 K050BB
C4	1	Capacitor, ceramic, 1 uF, 50 V, +/- 10%, X7R, 0603	Taiyo Yuden	UMK107AB7105K A-T
C5, C9, C13	3	Capacitor, ceramic, 10 uF, 10 V, +/- 20%, X5R, 0603	MuRata	GRM188R61A106 MAALD
C6, C10, C30, C31	4	Capacitor, ceramic, 0.1 uF, 10 V, +/- 10%, X5R, 0402	MuRata	GRM155R61A104 KA01D
C11, C16	2	Capacitor, ceramic, 0.1 uF, 50 V, +/- 5%, X7R, 1206	Kemet	C1206C104J5RA CTU
C12, C17	2	Capacitor, ceramic, 1 uF, 50 V, +/- 10%, X7R, 1206	TDK	C3216X7R1H105 K160AB

Table 9. UCC21732QDWEVM-025 List of Materials (continued)

DES	QTY	DESCRIPTION	MANUFACTURE R	PART NUMBER
C14	1	Capacitor, ceramic, 1.5 uF, 10 V, +/- 10%, X7R, 0603	TDK	C1608X7R1A155 K080AC
C15	1	Capacitor, ceramic, 0.1 uF, 25 V, +/- 10%, X7R, 0402	MuRata	GRM155R71E104 KE14D
C18	1	Capacitor, ceramic, 0.1 uF, 16 V, +/- 10%, X7R, 0402	MuRata	GCM155R71C104 KA55D
C19	1	Capacitor, ceramic, 1 uF, 25 V, +/- 10%, X7R, 0603	Kemet	C0603C105K3RA CTU
C21, C22, C23, C24, C25	5	Capacitor, ceramic, 100 pF, 50 V, +/- 5%, COG/NP0, 0402	Yageo America	CC0402JRNPO9B N101
C26	1	Capacitor, ceramic, 0.01 uF, 50 V, +/- 10%, X7R, 0805	Wurth Elektronik	885012207092
C27	1	Capacitor, ceramic, 2200 pF, 16 V, +/- 10%, X7R, 0402	MuRata	GRM155R71C222 KA01D
C28	1	Capacitor, ceramic, 1000 pF, 50 V, +/- 5%, X7R, AEC-Q200 Grade 1, 0603	Kemet	C0603C102J5RA CAUTO
C29	1	Capacitor, ceramic, 0.01 uF, 25 V, +/- 10%, X7R, 0603	Presidio Components	SR0603X7R103K 1NT95(F)#M123A
D1, D2	2	Diode, Schottky, 60 V, 1 A, SOD-323F	Nexperia	PMEG6010CEJ,1 15
D3, D4	2	Diode, Schottky, 40 V, 0.5 A, SOD-323	Diodes Inc.	B0540WS-7
D10, D11	2	LED, Green, SMD	OSRAM	LG L29K-G2J1- 24-Z
FID4	1	Fiducial mark. There is nothing to buy or mount.	N/A	N/A
J1	1	Header, 1.27mm, 10x2, Gold with Tin tail, R/A, TH	Samtec	FTSH-110-01-L- D-RA
J2	1	Header, 2.54 mm, 6x2, Gold, TH	Mill-Max	802-10-012-10- 001000
L1	1	Coupled inductor, 2.8 A, 0.055 ohm, SMD	TDK	ACM4520-421- 2P-T000
LBL1	1	Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	Brady	THT-14-423-10
Q1	1	MOSFET, N-CH, 40 V, 5.6 A, SOT-23	Vishay-Siliconix	SI2318CDS-T1- GE3
Q2	1	Transistor, Dual PNP, 60 V, 0.6 A, SOT-363	Diodes Inc.	MMDT2907A-7-F
R1	1	Resistor, 10.0, 1%, 0.1 W, 0603	Yageo	RC0603FR- 0710RL
R2	1	Resistor, 10, 5%, 0.125 W, 0805	Vishay-Dale	CRCW080510R0J NEA
R5, R6	2	Resistor, 4.99 k, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	Vishay-Dale	CRCW08054K99F KEA
R7	1	Resistor, 10.0 k, 1%, 0.1 W, 0603	Panasonic	ERJ-3EKF1002V
R8	1	Resistor, 0, 5%, 0.25 W, 1206	Vishay-Dale	CRCW12060000Z 0EA
R11, R13	2	Resistor, 100, 1%, 0.063 W, 0402	Vishay-Dale	CRCW0402100R FKED
R12, R14, R15, R16, R17, R19	6	Resistor, 1.20, 1%, 0.25 W, AEC-Q200 Grade 0, 1206	Vishay-Dale	CRCW12061R20 FKEA
R18	1	Resistor, 10 k, 5%, 0.125 W, 0805	Panasonic	ERJ-6GEYJ103V
R20	1	Resistor, 20.0 k, 0.5%, 0.1 W, 0603	Yageo America	RT0603DRE0720 KL
R22	1	Resistor, 0, 5%, 0.125 W, AEC-Q200 Grade 0, 0805	Vishay-Dale	CRCW08050000Z 0EA
R23	1	Resistor, 10.0 k, 1%, 0.1 W, 0603	TT Electronics/IRC	M55342K12B10E 0T

Table 9. UCC21732QDWEVM-025 List of Materials (continued)

DES	QTY	DESCRIPTION	MANUFACTURE R	PART NUMBER
R25, R28	2	Resistor, 2.00 k, 1%, 0.1 W, 0603	Yageo	RC0603FR-072KL
R26	1	Resistor, 49.9 k, 1%, 0.063 W, 0402	Vishay-Dale	CRCW040249K9F KED
R24, R27, R40, R43	3	Resistor, 0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	Stackpole Electronics Inc	RMCF0603ZT0R0 0
R29	1	Resistor, 523 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	Vishay-Dale	CRCW0402523KF KED
R30	1	Resistor, 309, 1%, 0.1 W, 0603	Yageo	RC0603FR- 07309RL
R31, R32	2	Resistor, 0, 5%, 0.1 W, 0603	Panasonic	ERJ-3GEY0R00V
R33, R34	2	Resistor, 649 k, 1%, 1 W, AEC-Q200 Grade 0, 2512	Vishay-Dale	CRCW2512649KF KEG
R35, R36, R37	3	Resistor, 220 k, 1%, 0.25 W, 1206	Yageo America	RC1206FR- 07220KL
R39	1	Resistor, 10.5 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	Vishay-Dale	CRCW040210K5F KED
R41	1	Resistor, 40.2 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	Vishay-Dale	CRCW040240K2F KED
R42	1	Resistor, 6.19 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	Vishay-Dale	CRCW06036K19F KEA
T1	1	Transformer, 50 uH, SMT	Würth Elektronik	750342879
T2	1	Transformer, 340 uH, TH	Würth Elektronik	750313734
TP1, TP2, TP3, TP4, TP5, TP6, TP8, TP9, TP10, TP11, TP12, TP13, TP14, TP15, TP16, TP17, TP18, TP19, TP20, TP21, TP22	21	PCB Pin, 20mil Dia, Gold, TH	Mill-Max	0508-0-00-15-00- 00-03-0
U1, U3	2	Low-Noise 1 A, 420 kHz Transformer Driver, DBV0006A (SOT-23-6)	Texas Instruments	SN6505BDBVR
U2	1	150-mA, 30-V, Ultra-Low IQ, Wide Input Low- Dropout Regulator with Reverse Current Protection, DBV0005A (SOT-23-5)	Texas Instruments	TPS70950DBVR
U4	1	Single Channel Isolated Gate Driver for SiC/IGBT with Advanced Protection and High-CMTI, DW0016B (SOIC-16)	Texas Instruments	UCC21732QDWR Q1
U5	1	Automotive, High-Voltage (18V) Window Comparator with Over- and Undervoltage Detection, DDC0006A (SOT-23-T-6)	Texas Instruments	TPS3700QDDCR Q1
U6	1	Automotive Catalog Single 2-Input Positive-AND Gate, DBV0005A, LARGE T&R	Texas Instruments	
C20	0	Capacitor, ceramic, 27 pF, 50 V, +/- 5%, COG/NP0, 0603	Kemet	C0603C270J5GA CTU
D5, D6	0	Diode, Ultrafast, 1200 V, 1 A, SMA	STMicroelectronic s	STTH112A
D7	0	Diode, Zener, 12 V, 500 mW, SOD-123	Diodes Inc.	MMSZ5242B-7-F
D8	0	Diode, Schottky, 30 V, 0.2 A, SOD-323	Diodes Inc.	BAT54WS-7-F
D9	0	Diode, TVS, Bi, 22 V, SMA	Littelfuse	SMAJ22CA
FID1, FID2, FID3, FID5, FID6	0	Fiducial mark. There is nothing to buy or mount.	N/A	N/A
R3	0	Resistor, 499, 1%, 0.125 W, 0805	Vishay-Dale	CRCW0805499R FKEA

Table 9. UCC21732QDWEVM-025 List of Materials (continued)

DES	QTY	DESCRIPTION	MANUFACTURE R	PART NUMBER
R4	0	Resistor, 1.00 k, 1%, 0.125 W, 0805	Vishay-Dale	CRCW08051K00F KEA
R9, R24, R38	0	Resistor, 0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	Stackpole Electronics Inc	RMCF0603ZT0R0 0
R10, R21	0	Resistor, 0, 5%, 0.125 W, AEC-Q200 Grade 0, 0805	Vishay-Dale	CRCW08050000Z 0EA
TP7, TP23	0	PCB Pin, 20mil Dia, Gold, TH	Mill-Max	0508-0-00-15-00- 00-03-0

Revision History

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

Changes from Original (October 2018) to A Revision
Page

-
- Changed marketing status from select disclosure to catalog. [2](#)
-

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 DEGRADATION 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/lstds/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。
http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_01.page

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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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。

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

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:*
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