Using the UCC23513-1EVM-014

User's Guide

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Using the UCC23513-1EVM-014

1 Introduction

The UCC23513-1EVM-014 evaluation module is designed for evaluation of TI's 5-kV_{RMS} isolated single-channel gate drivers with opto-compatible input, and UCC23511. The input is current driven, requiring between 7 mA and 16 mA for device turn-on, and can be reverse biased for turnoff. The UCC23513 is a 4-A source and 5-A peak sink current driver while the UCC23511 is capable of 1.5-A source and 2-A sink peak output current for driving Si MOSFETs, IGBTs, and SiC transistors. This user's guide covers the UCC23513-1EVM-014, which is used for evaluation of the UCC23513 and UCC23511, which are pin-to-pin compatible devices.

Developed for high voltage applications where isolation and reliability are required, the UCC2351x family of devices deliver reinforced isolation of 5 kV_{RMS} and a surge immunity tested up to 8 kV along with a common mode transient immunity (CMTI) greater than 150 V/ns. It offers lower propagation delay, lower-part to-part delay skew, higher CMTI, smaller Pulse Width Distortion, and higher operating temperature, which provides significant performance upgrade over opto isolated gate drivers, while still maintaining pin-to-pin compatibility.

The input current and voltage characteristics of the *e*-diode™ functionally mimics the primary side of an opto-isolator. The output side VCC has a wide recommended operating range from 14-V to 33-V and allows the device to be used in a low-side or high-side configuration along with bipolar supplies for SiC Power FETs. The pin-to-pin compatibility enables designers to use the UCC23513 and UCC23511 in existing designs and new designs for motor drives, industrial power supplies, solar inverters, and UPS.

2 Description

The UCC23513-1EVM-014 evaluation board utilizes a SN74LVC2G17DBVR (dual Schmitt-Trigger buffer) to drive signal current on the primary side of the device. The board is populated with clips and 2-position headers for flexibility in connecting power and signal inputs, along with signal test points and large GND vias to enable installation of ground springs. The PCB layout is optimized with minimal loop area in the input and output paths and showcases design for high voltage between the primary side and secondary side with >8 mm creepage. For detailed device information, refer to the UCC23513 and UCC23511 datasheets and TI's Isolated gate driver solutions.

Table 1. EVM Compatible Devices

Part Number	Description	Package
UCC23513	4-A source / 5-A sink, output current	Stretched SO-6 package with >8.5-mm creepage and clearance
UCC23511	1-A source / 2-A sink, output current	Stretched SO-6 package with >8.5-mm creepage and clearance

2.1 Features

- Evaluation module for the UCC23513 and UCC23511 in stretched SO-6 package
- 5-V input buffer, and 14-V to 33-V VCC power supply range
- 4-A and 5-A source/sink current capability (UCC23513)
- 1.5-A and 2-A source/sink current capability (UCC23511)
- 5-kV_{RMS} Isolation for 1 minute per UL 1577

(1) *e*-diode is a trademark of Texas Instruments.

- Buffer disconnect headers for custom input drive solution
- PCB layout showcases high voltage isolation design between primary side and secondary side
- Unpopulated pads for bootstrap supply, split supply, and turn on/turn off resistance

2.2 I/O Description

Table 2. Jumpers Setting

PINS	DESCRIPTION
J1–1	Anode Buffer input
J1–2	GND input
J2–1	Cathode Buffer input
J2–2	GND input
J3–1	Anode Buffer Jumper
J3–2	Anode Buffer Jumper
J4–1	Cathode Buffer Jumper
J4–2	Cathode Buffer Jumper
J5–1	Cathode Resistor to GND Jumper
J5–2	Cathode Resistor to GND Jumper
J6–1	VG to 1 nF Load Jumper
J6–2	VG to 1 nF Load Jumper
J7–1	VG to 180 nF Load Jumper
J7–2	VG to 180 nF Load Jumper
P1–1	+5 V Buffer Supply
P1-2	GND
P2-1	+14 V–33 V Output Side Supply
P2-2	VSS

2.3 Jumpers (Shunt) Options

Table 3. Jumpers Setting

JACK	Jumper Setting Options		FACTORY SETTING
J1	Option A:	Jumper not installed, IN/PWM signal provided by external signal	Option A
	Option B:	Jumper on J1-1 and J1-2 set Anode Buffer Input low	
J2	Option A:	Jumper on J2-1 and J2-2 set Cathode Buffer Input low	Option A
	Option B:	Jumper not installed, IN/PWM signal provided by external signal	
J3	Option A:	Jumper on J3-1 and J3-2, pass signal to Anode Resistor	Option A
	Option B:	Jumper not installed, Anode_R left floating for external drive	
J4	Option A:	Jumper on J4-1 and J4-2, pass signal to Cathode Resistor	Option A
	Option B:	Jumper not installed, Cathode_R left floating for external drive	
J5	Option A:	Jumper not installed, Cathode_R left floating from GND	Option A
	Option B:	Jumper on J5-1 and J5-2, ties Cathode_R to GND	
J6	Option A:	Jumper installed, VG tied to 1nF test load	Option A
	Option B:	Jumper not installed, VG floating	
J7	Option A:	Jumper not installed, VG floating	Option A
	Option B:	Jumper installed, VG tied to 180nF test load	

3 Electrical Specifications

Table 4. UCC23513-1EVM-014 Electrical Specifications

DESCRIPTION		MIN	TYP	MAX	UNIT
V_{DD}	Primary-side power supply	4.5		5.5	V
V_{CC}	Driver output power supply	14		33	V
F_S	Switching frequency	0		1	MHz
T_J	Operating junction temperature range	-40		150	°C

4 Test Summary

In this section, the UCC23513-1EVM-014 is tested in its default configuration. Different jumper settings, PWM signal input options, and voltage source settings can be found in Section 3 Electrical Specifications.

4.1 Definitions

This procedure details how to configure the UCC23513 evaluation board. Within this test procedure, the following naming conventions are followed. Refer to the UCC23513-1EVM-014 schematic, Section 8, for details.

V_{XX}: External voltage supply name

$V_{(TPxx)}$: Voltage at test point TPxx. For example, V(TP12) means the voltage at TP12.

$V_{(Jxx)}$: Voltage at jack terminal Jxx

$J_{xx(yy)}$: Terminal or pin yy of jack xx

DMM: Digital multi-meters

UUT: Unit under test

EVM: Evaluation module assembly. In this case, the UUT assembly drawings have location for jumpers, test points, and individual components.

4.2 Equipment

4.2.1 Power Supplies

Two DC power supply with voltage/current above 5-V/0.1-A and 35-V/0.5-A (for example: Agilent E3634A)

4.2.2 Function Generators

One function generator over 1 MHz (for example: Tektronics AFG3252)

4.3 Equipment Setup

4.3.1 DC Power Supply Settings

- DC power supply #1
  - Voltage setting: 5-V
  - Current limit: 0.05-A
- DC power supply #2
  - Voltage setting: 15-V for the UCC23513 and UCC23511
  - Current limit: 0.1 A

4.3.2 Digital Multi-Meter Settings

- Digital multi-meter #1

  - DC current measurement, auto-range
- Digital multi-meter #2
  - DC current measurement, auto-range

4.3.3 Function Generator Settings

Table 5. Function Generator Settings

	MODE	FREQUENCY	DUTY	DELAY	HIGH	LOW	OUTPUT IMPEDANCE
Channel Output	Pulse	DC ~ 100 kHz	50%	0 ns	5 V	0 V	High Z

4.3.4 Oscilloscope Setting

Table 6. Oscilloscope Settings

	BANDWIDTH	COUPLING	TERMINATION	SCALE SETTINGS	INVERTING
Channel A	500 MHz or above	DC	1 MΩ or automatic	10× or automatic	OFF
Channel B	500 MHz or above	DC	1 MΩ or automatic	10× or automatic	OFF

4.3.5 Jumper (Shunt) Settings

Default shunt configuration should be adequate for this test.

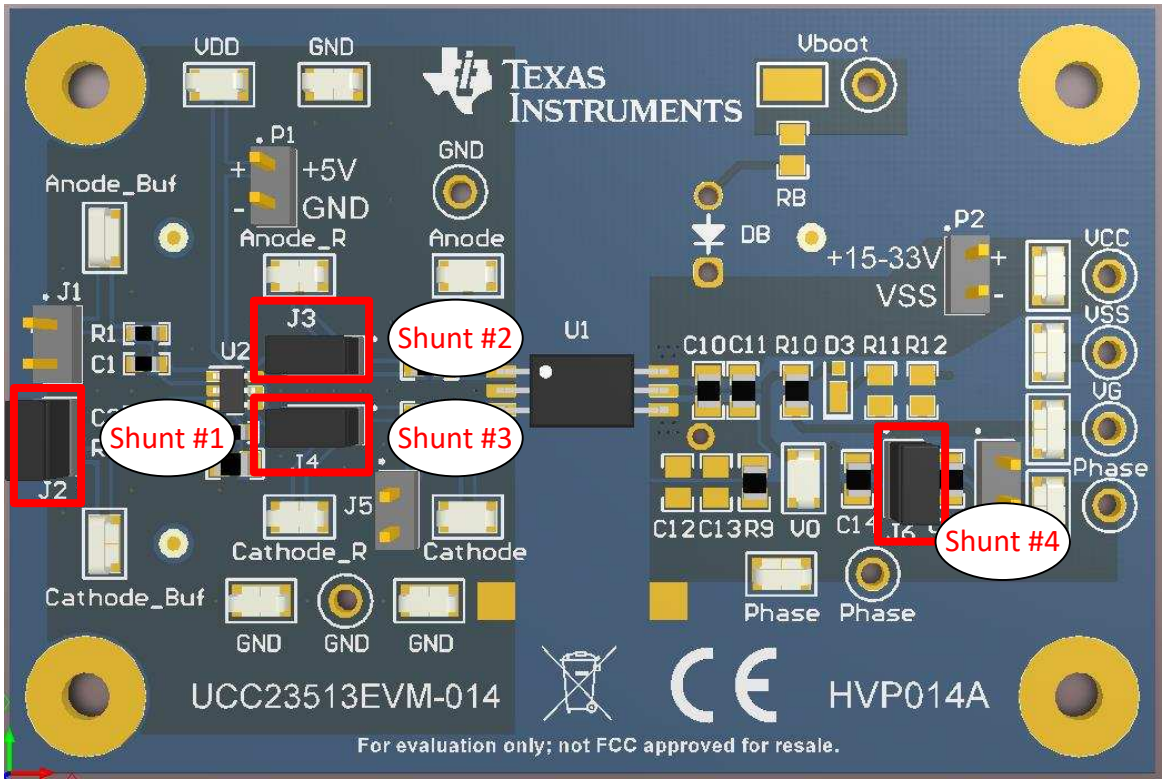

Figure 1. Default Jumper Settings

4.3.6 Bench Setup Diagram

The current bench setup diagram includes the function generator and oscilloscope connections.

Follow the connection procedure below. Figure 2 can be used as a reference.

- Make sure the output of the function generator and voltage sources are disabled before connection.
- Function generator channel applied on J1-1 ⟷ J1-2 (see in Figure 2)
- Power supply #1: positive node connected to input of DMM #1 with DMM #1 output connected to P1-1 (or VDD), and negative node applied on P1-2 (or GND).
- Power supply #2: positive node connected to input of DMM #2 with DMM #2 output connected to P2-1 (or VCC), negative node connected directly to P2-2 (or VSS).
- Oscilloscope channel-A probes Anode_R ⟷ GND, smaller measurement loop is preferred.
- Oscilloscope channel-B probes VG (or J7-1) ⟷ VSS, smaller measurement loop is preferred.

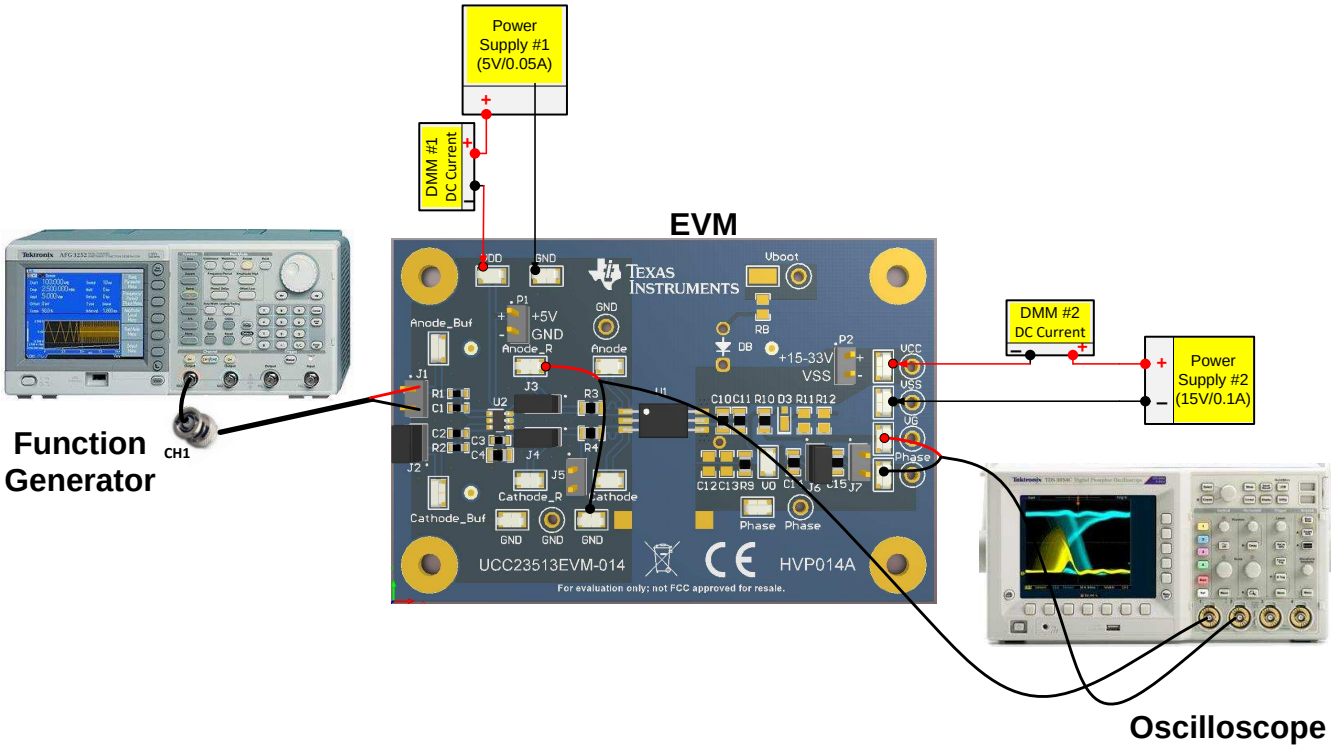

Figure 2. Bench Setup Diagram and Configuration

5 Power Up and Power Down Procedure

5.1 Power Up (C_L = 1000 pF)

1. Before proceeding to the power up procedure, make sure that Section 4.3.6 is implemented for setting up all the equipment. Figure 3 can be used as reference.
2. Enable supply #1.
3. Enable supply #2.The quiescent current on DMM1 and DMM2 ranges in 1 mA to 3 mA if everything is set correctly.
4. Enable function generator output.
5. Afterward, the following occurs:
    1. Stable pulse output on the channel-A and channel-B in the oscilloscope. See Figure 3.
    2. Scope frequency measurement is the same as function generator output.
    3. DMM #1 and #2 should read measurement results around 5 mA–10 mA under no load conditions. For more information about operating current, refer to UCC23513 datasheet.

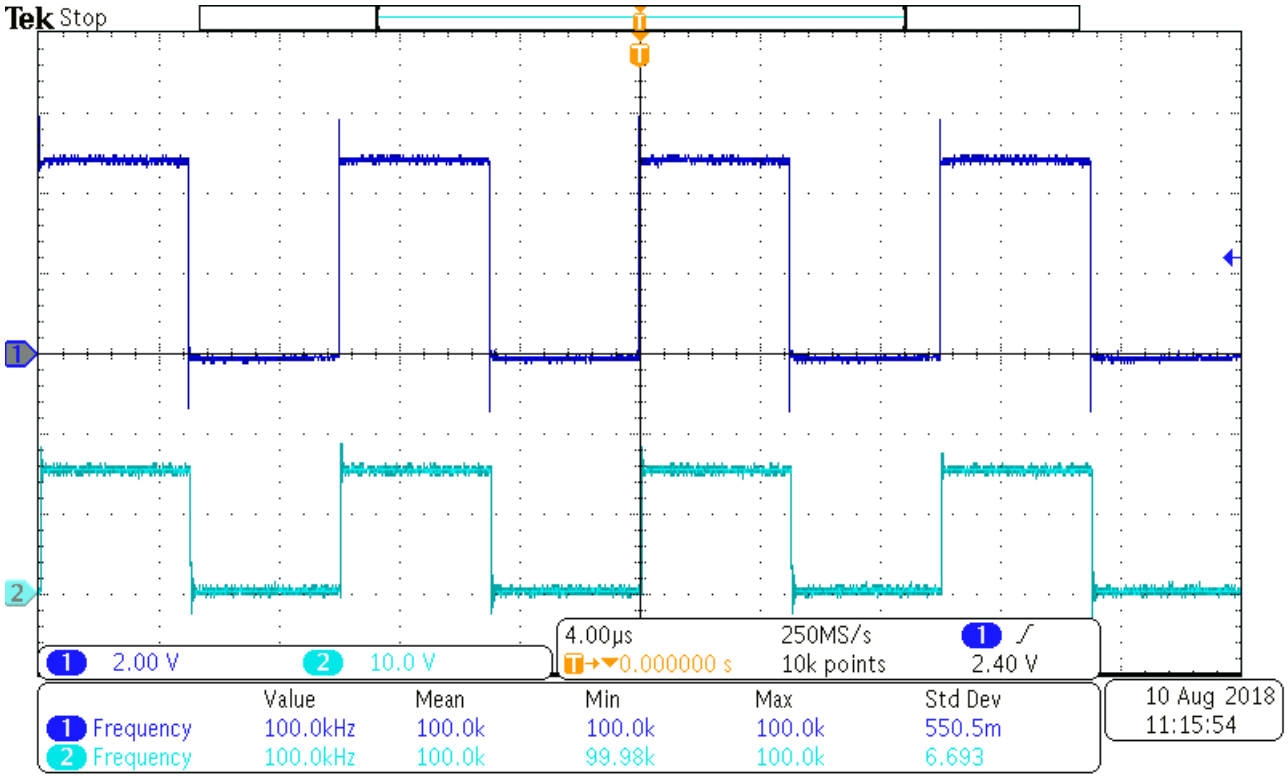

Figure 3. Example Input and Output Waveforms (Ch1 is PWM Input, Ch2 is Outputs)

5.2 Power Down

1. Disable function generator.
2. Disable power supply #2.
3. Disable power supply #1.
4. Disconnect cables and probes.

6 Test Waveforms with Different Input/Output Configurations

6.1 Input Side Reverse Bias

The default configuration grounds input to cathode buffer. Cathode buffer can alternatively be driven with a function generator to reverse bias input diode on turn-off. With J2 jumper (shunt) removed, cathode and anode buffers are driven 180º out-of-phase, which showcases the reverse blocking capability of the UCC23513.

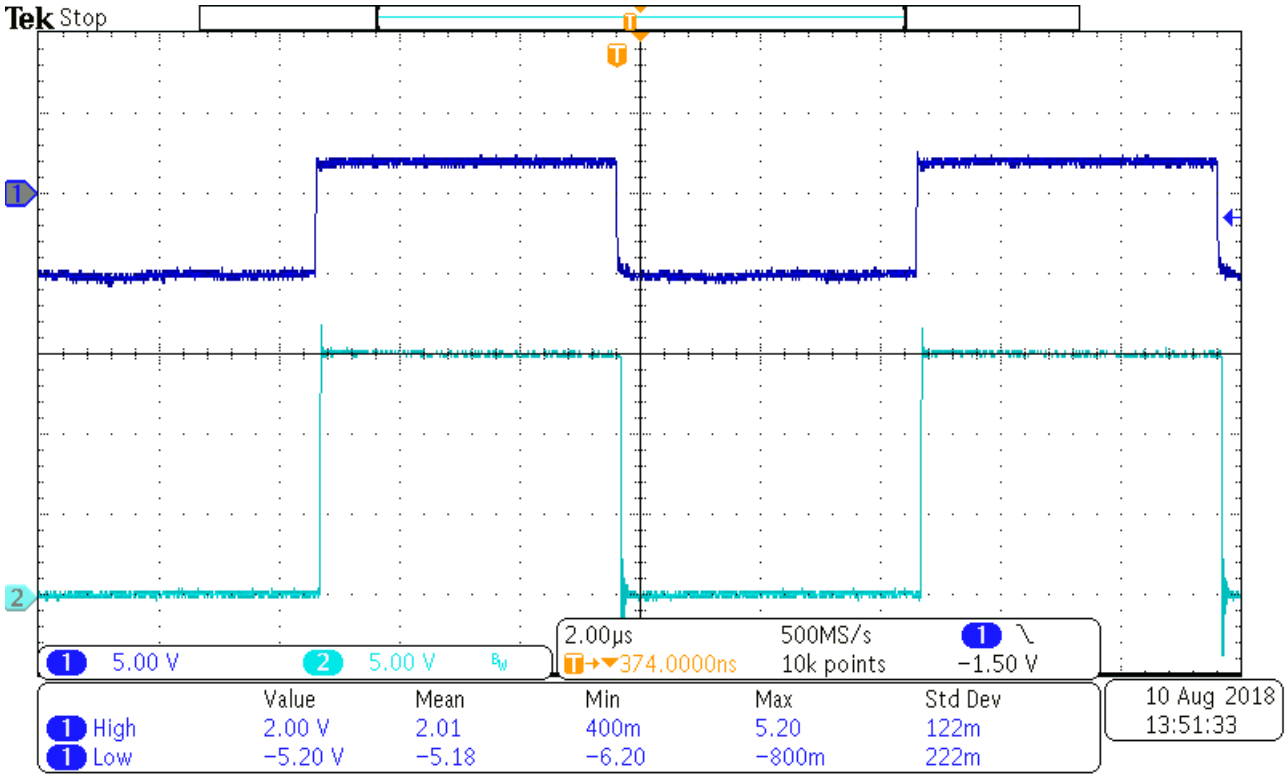

Figure 4. Input e-Diode driven +/-5 V (Ch1 is PWM Input, Ch2 is Output)

6.2 Output Split Supply

The output can be configured to provide split supply operation through two unique methods.

Single supply: Remove R9 and install C6 = C7 = 1 µF, R7 = 7.5 k, D2 = 5.1 V Zener, and R8 jumper.

Dual supply: Remove R9 and install C11 = 0.1 µF, C12 = 2.2 µF, apply V+ from VCC to VSS, and V- from VSS to Phase.

These configurations allow output operation from -5 V off, to VCC-5V on which is commonly found in SiC power stage configurations. Figure 5 shows operation with the latter method.

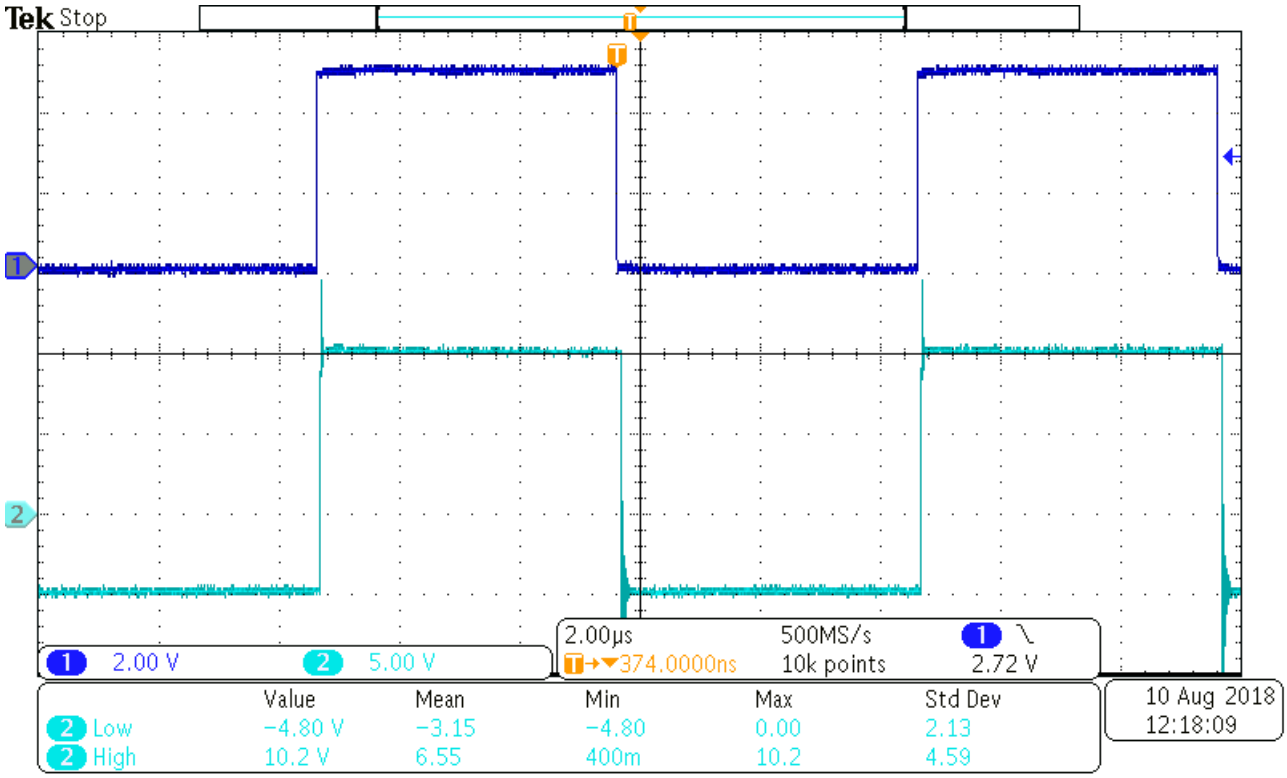

Figure 5. Output Split Supply Operation (Ch1 is PWM Input, Ch2 is Output)

6.3 Peak Output Current Measurement Using 180nF Load

The output can be configured to measure peak output current by moving the jumper from J6 to J7. This jumpers are in a 180 nF load capacitor, C15, which can be used to indirectly measure the output current as seen in the *Understanding Peak Source and Sink Current Parameters Application Note* (SLLA387). Input PWM is set to 200 Hz to avoid excessive power dissipation in the driver.

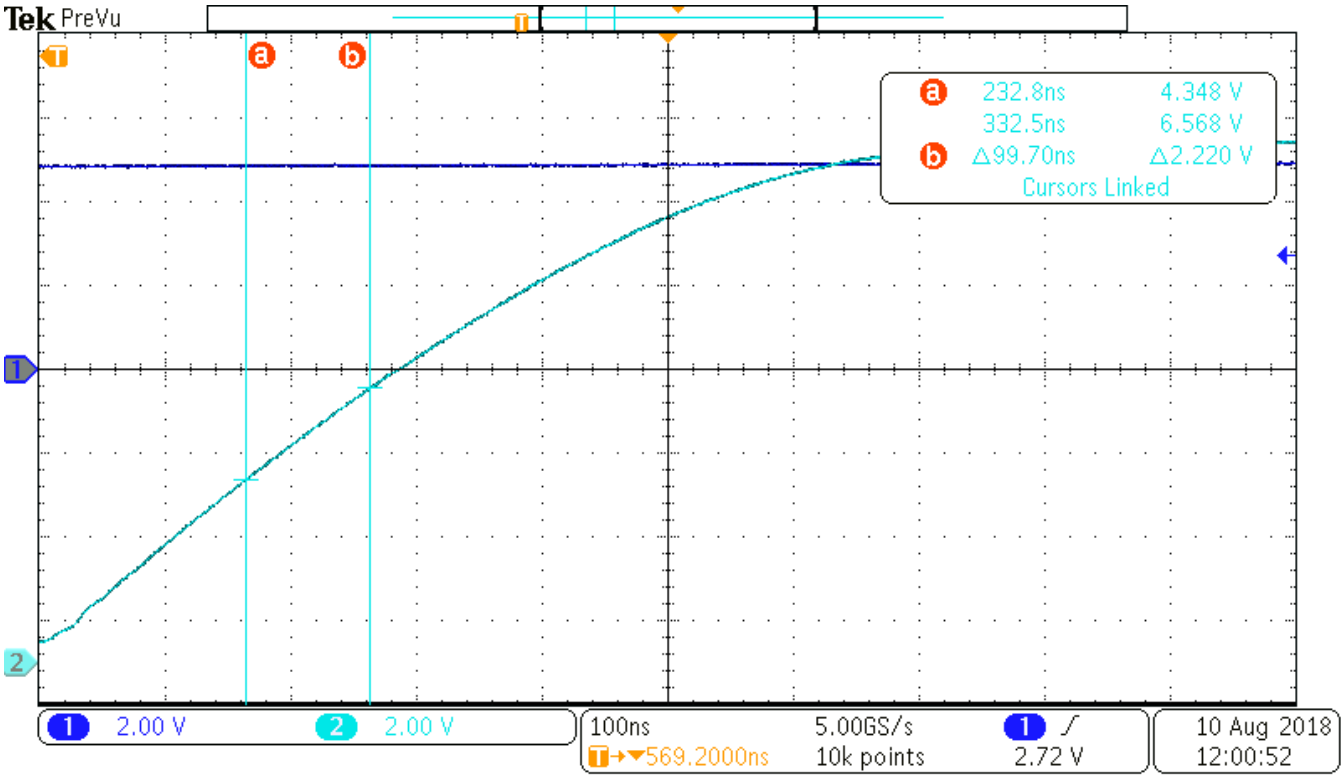

Figure 6. Source dv/dt Measurement

Peak source current is calculated at 4.008 A for the UCC23513.

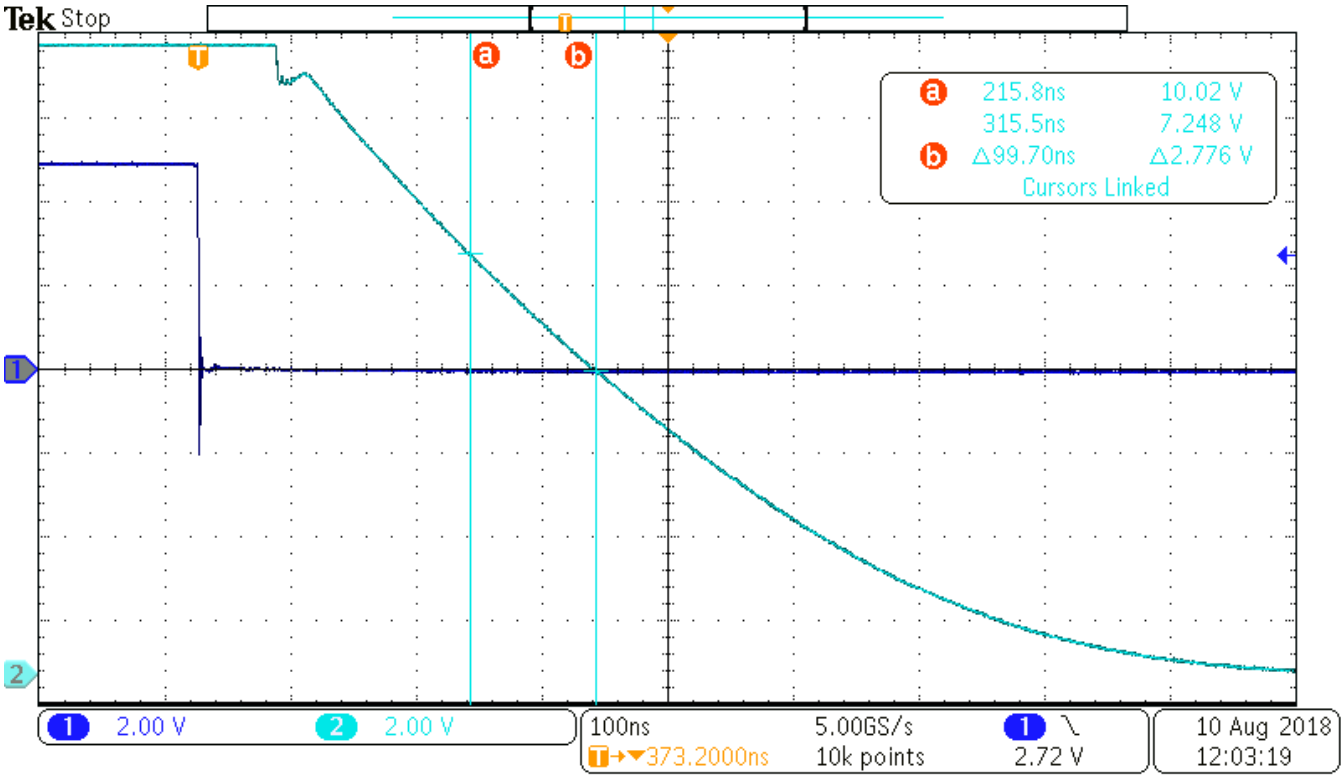

Figure 7. Sink dv/dt Measurement

Peak sink current is calculated at 5.011 A for the UCC27513.

7 UCC23511 Test Implementation

Replace the UCC23513 with the UCC23511 from the default configuration on the EVM. Solder the UCC23511 sample and use Table 7 to adjust the value of R_{10} to observe the desired peak current out of the driver.

Table 7. Minimum Gate Resistor (Ω)

Gate driver supply VCC-VEE (V)	Minimum total gate resistance (Ω) = (R_{GON} + R_{G_int}) or (R_{GOFF} + R_{G_int})
15	4
23	7
30	10

8 Schematic

Figure 8 shows only the schematic diagram for the UCC23513-1EVM-014. For evaluation of the UCC23511, use the UCC23513DWY for U1.

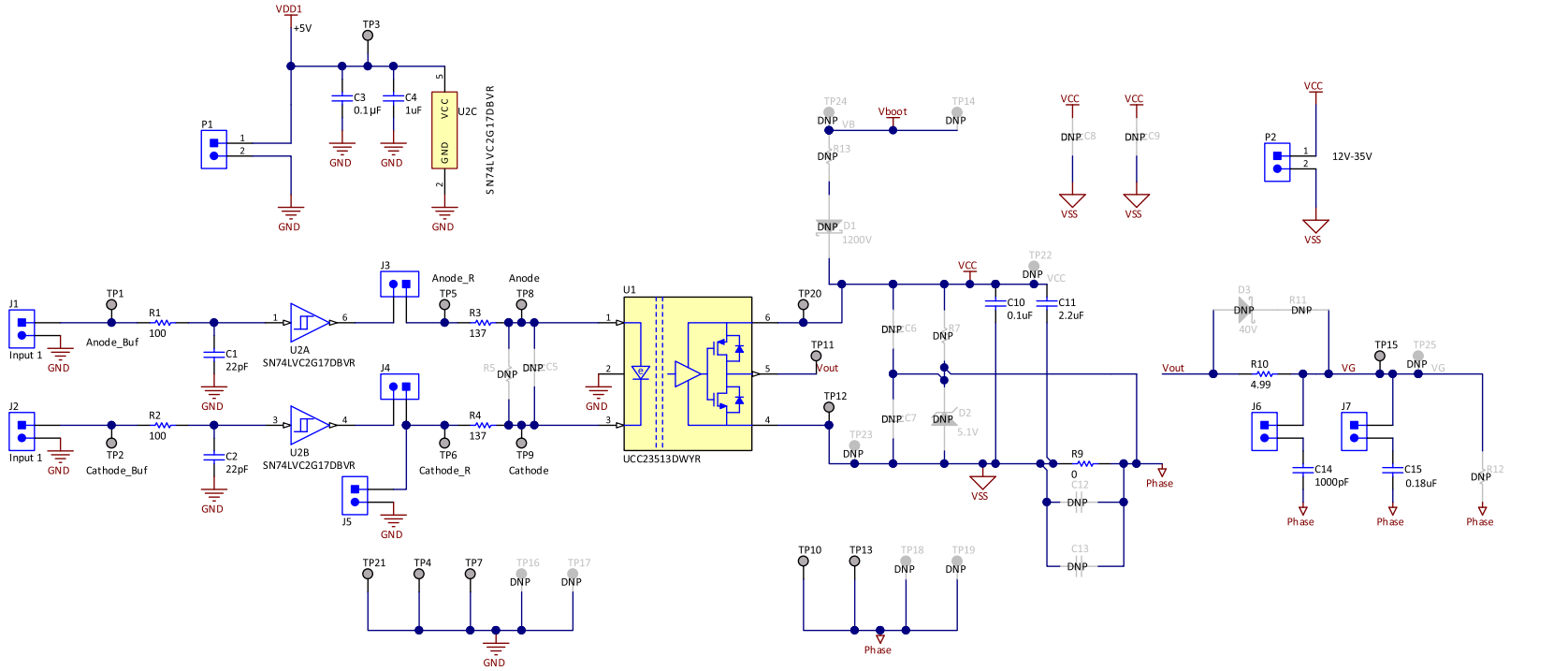

Figure 8. UCC23513-1EVM-014 Schematic

9 Layout Diagrams

Figure 9, Figure 10, Figure 11, and Figure 12 show the PCB layout information for the UCC23513-1EVM-014.

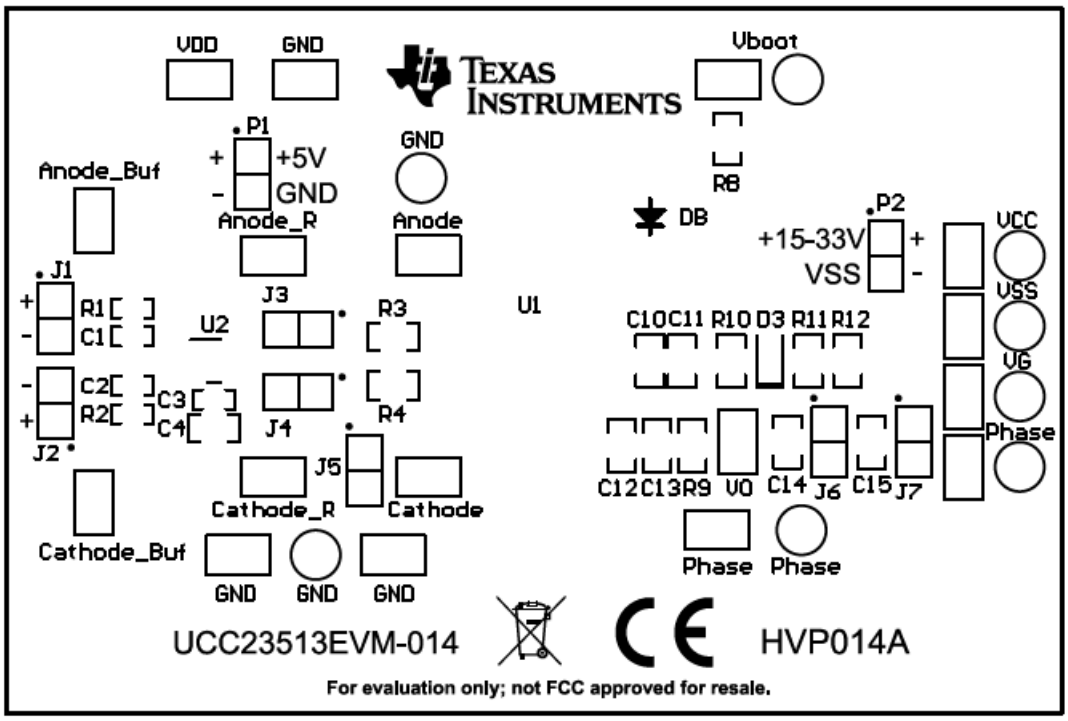

Figure 9. Top Overlay

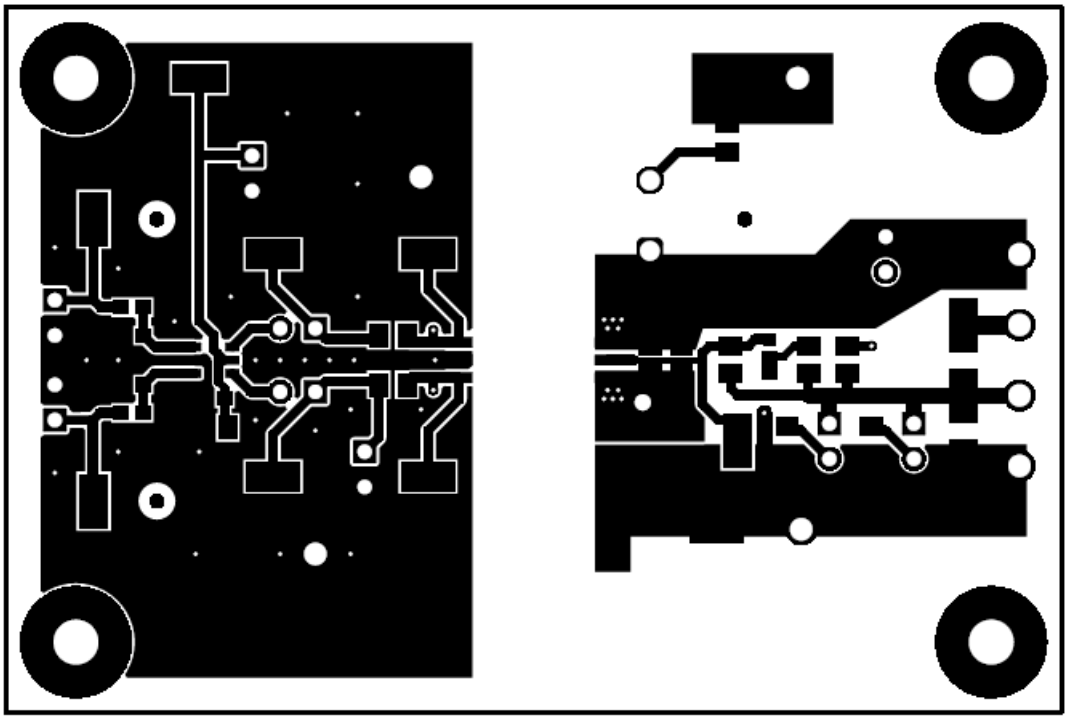

Figure 10. Top Layer

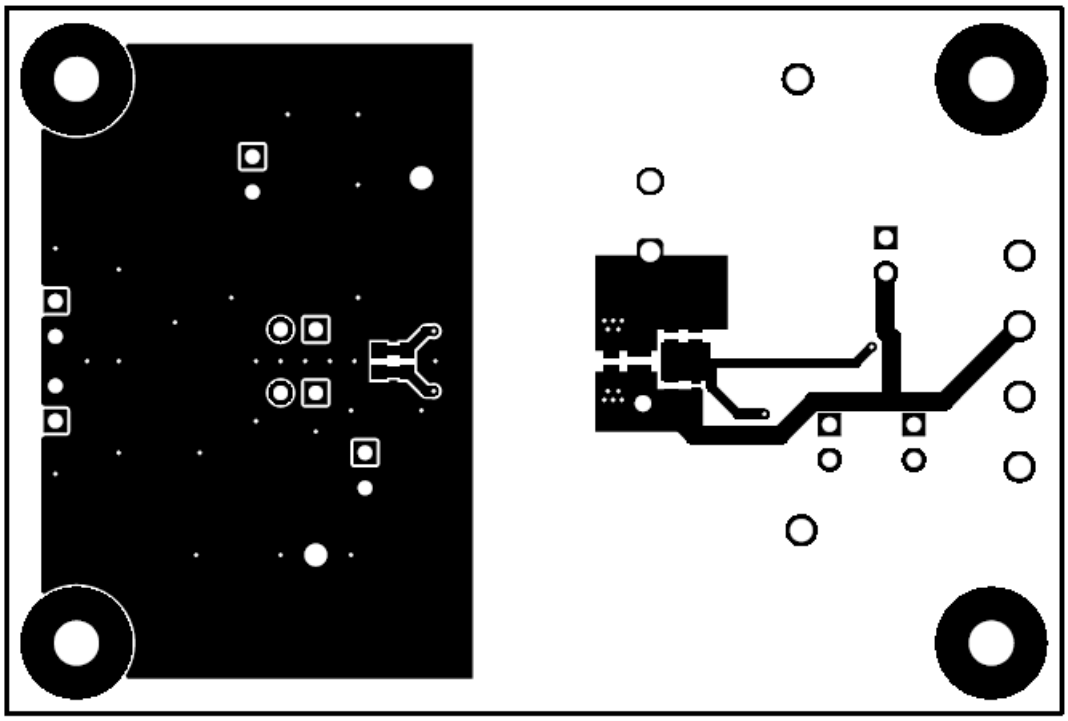

Figure 11. Bottom Layer

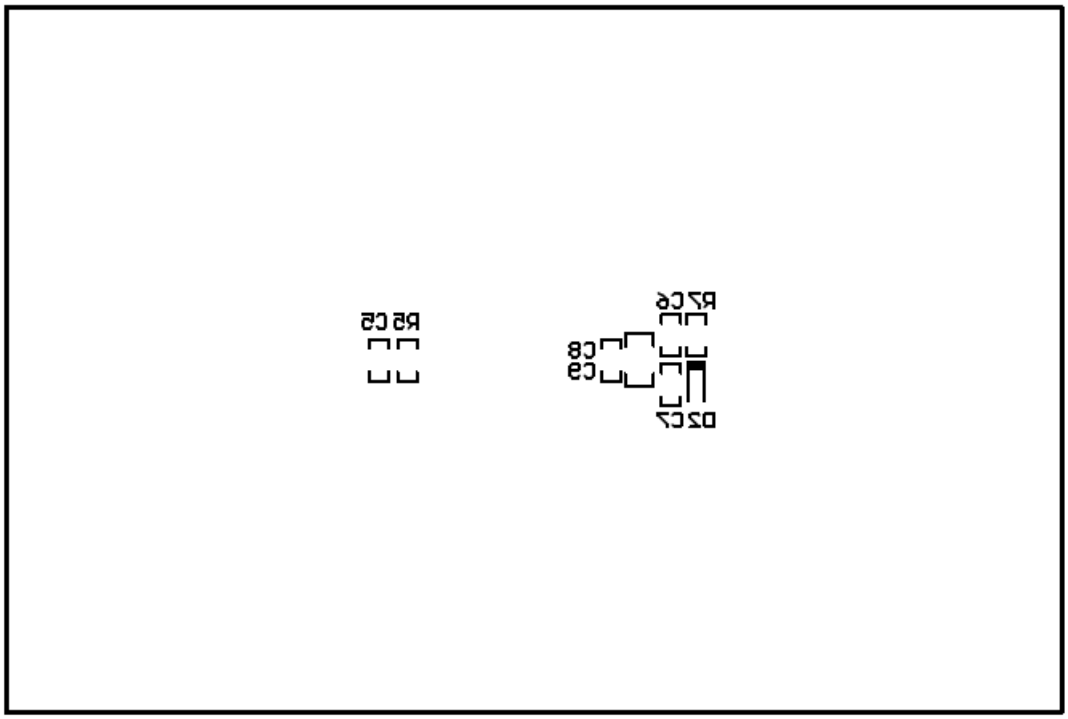

Figure 12. Bottom Overlay

10 List of Materials

Table 8. UCC23513-1EVM-014 List of Materials

Quantity	Designator	Description	Part Number	Manufacturer
1	U1	5-kVRMS, 3-A Single Channel Isolated Gate Driver with Opto Compatible Input, DWY0006A (SOIC-6)	UCC23513DWYR	Texas Instruments
1	U2	Dual Schmitt-Trigger Buffer, DBV0006A, LARGE T&R	SN74LVC2G17DBVR	Texas Instruments
2	C1, C2	CAP, CERM, 22 pF, 100 V, +/- 5%, C0G/NP0, 0603	Std	Std
1	C3	CAP, CERM, 0.1 µF, 50 V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	Std	Std
1	C4	CAP, CERM, 1 µF, 50 V, +/- 10%, X7R, 0805	Std	Std
1	C10	CAP, CERM, 0.1 µF, 50 V, +/- 20%, X7R, 0805	Std	Std
1	C11	CAP, CERM, 2.2 µF, 50 V, +/- 10%, X5R, 0805	Std	Std
1	C14	CAP, CERM, 1000 pF, 50 V, +/- 1%, C0G/NP0, 0805	Std	Std
1	C15	CAP, CERM, 0.18 µF, 50 V, +/- 10%, X7R, 0805	Std	Std
9	J1, J2, J3, J4, J5, J6, J7, P1, P2	Header, 100mil, 2x1, Gold, TH	Std	Std
2	R1, R2	RES, 100, 1%, 0.1 W, 0603	Std	Std
2	R3, R4	RES, 137, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	Std	Std
2	R9	RES, 0, 5%, 0.125 W, 0805	Std	Std
1	R10	RES, 4.99, 1%, 0.125 W, 0805	Std	Std
4	SH-J2, SH-J3, SH-J4, SH-J6	Shunt, 100mil, Flash Gold, Black	Std	Std
16	TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP15, TP20, TP21	Test Point, Miniature, SMT	Std	Std
0	C5, C6, C7	CAP, CERM, 1 µF, 50 V, +/- 10%, X7R, 0603	Std	Std
0	C8	CAP, CERM, 0.1 µF, 50 V, +/- 10%, X7R, 0603	Std	Std
0	C9, C12, C13	CAP, CERM, 1 µF, 50 V, +/- 10%, X7R, 0805	Std	Std
0	D1	Diode, Schottky, 1200 V, 8 A, TH	Std	Std
0	D2	Diode, Zener, 5.1 V, 300 mW, SOD-523	Std	Std
0	D3	Diode, Schottky, 40 V, 1 A, MicroSMP	Std	Std
0	H1, H3, H5, H7	Standoff, Hex, 0.5"L #4-40 Nylon	Std	Std
0	H2, H4, H6, H8	Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	Std	Std
0	R5	RES, 1.0 k, 5%, 0.1 W, 0603	Std	Std
0	R7	RES, 7.50 k, 1%, 0.1 W, 0603	Std	Std
0	R11	RES, 10.0, 1%, 0.125 W, 0805	Std	Std
0	R12	RES, 4.7 k, 5%, 0.125 W, 0805	Std	Std
0	R13	RES, 10, 5%, 0.125 W, AEC-Q200 Grade 0, 0805	Std	Std
0	TP14	Test Point, Miniature, SMT	Std	Std

Table 8. UCC23513-1EVM-014 List of Materials (continued)

Quantity	Designator	Description	Part Number	Manufacturer
0	TP16, TP17, TP18, TP19, TP22, TP23, TP24, TP25	Test Point, Compact, Black, TH	Std	Std

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 From "UCC23513" to "UCC23513 and UCC23511" 2
- Deleted "GaN" to "Si MOSFETs, IGBTs and SiC" 2
- Changed "UCC23513EVM-014" to "UCC23513-1EVM-014" 2
- Added "Which are pin-to-pin compatible devices" 2
- Changed "100V/ns" to "150 V/ns" 2
- Changed from "15-V to 33-V" to "14-V to 33-V" 2
- Added Table 1 2
- Changed to "–40" from "-55" 5
- Added content to Section 7 12
- Added Table 7 12

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Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265