# Using the UCC272xxEVM-328

# User's Guide

Texas Instruments

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# Using the UCC27212EVM-328 and UCC27201AEVM-328

**Cautions and Warnings**

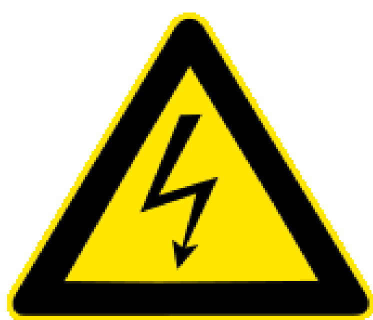
**CAUTION:**

**Caution! Do not leave EVM powered when unattended.**

**HOT SURFACE:**

**Caution Hot Surface! Contact may cause burns. Do not touch. Please take the proper precautions when operating.**

**HIGH VOLTAGE:**



**Danger High Voltage! Electric shock possible when connecting board to live wire. Board should be handled with care by a professional. For safety, use of isolated test equipment with overvoltage/overcurrent protection is highly recommended.**

## General Texas Instruments High Voltage Evaluation (TI HV EMV) User Safety Guidelines

**WARNING**

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 those working around you. Contact TI's Product Information Center http://ti.com/support for further information.

**Save all warnings and instructions for future reference.**

> **WARNING**
>
> **Failure to follow warnings and instructions may result in personal injury, property damage or death due to electrical shock and 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 suitable qualified, you should immediately stop from further use of the HV EVM.

1. Work Area Safety:
   (a) Keep work area clean and orderly.
   (b) Qualified observer(s) must be present anytime circuits are energized.
   (c) 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.
   (d) All interface circuits, power supplies, evaluation modules, instruments, meters, scopes, and other related apparatus used in a development environment exceeding 50Vrms/75VDC must be electrically located within a protected Emergency Power Off EPO protected power strip.
   (e) Use stable and non-conductive work surface.
   (f) Use adequately insulated clamps and wires to attach measurement probes and instruments. No freehand testing whenever possible.
2. Electrical Safety:
   As a precautionary measure, it is always good engineering practice to assume that the entire EVM may have fully accessible and active high voltages.
   (a) De-energize the TI HV EVM and all its inputs, outputs and electrical loads before performing any electrical or other diagnostic measurements. Revalidate that TI HV EVM power has been safely de-energized.
   (b) 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.
   (c) Once EVM readiness is complete, energize the EVM as intended.

**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.**

3. Personal Safety
   (a) Wear personal protective equipment e.g. latex gloves 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.

# Using the UCC27212EVM-328 and UCC27201AEVM-328

## 1 Introduction

UCC27212EVM-328 and UCC27201AEVM-328 is the evaluation module designed to primarily evaluate UCC27212 and UCC27201A performance. The same board can be used to evaluate other pin to pin compatible parts in the supported package. These drivers are 120-V boot voltage, high-side and low-side driver with high source and sink peak currents for driving two N-Channel MOSFETs. The board is developed in such a way that multiple converter topologies such as half-bridge and high voltage synchronous buck can be configured out of it. The UCC272xx's low pullup and pulldown resistance allows for driving large power MOSFETs with minimized switching losses during the transition through the Miller Plateau of the MOSFET. The input of these devices can handle negative voltage which increases robustness and also allows direct interface to gate-drive transformers without using rectification diodes. The inputs are also independent of supply voltage and have a 20-V maximum rating.

## 2 Description

The UCC272xx evaluation board has one screw terminal block that allows connection to the input or bus voltage, HV+, switch node, HS, and the ground, GND. It has three headers, one for the high-side PWM input, one for the low-side PWM input and the third one for the power supply of the driver. This EVM also has a variety of testing points to easily analyze most of the key features of UCC27212 and UCC27201A. As EVM need to incorporate various test points and MOSFET footprint that can accommodate a wide variety of MOSFETs, the layout is not optimal for very high power converter configurations. The guidelines for optimal layout can be found in the driver datasheet. User must install electrolytic capacitor at theinput for any type of power testing. The board has ceramic capacitors at the input to facilitate no load testing of the topology such as synchronous buck. For detailed device information, please refer to UCC27212 Datasheet and UCC27201A Datasheet.

### *2.1 Features*

- Features UCC27201A or UCC27212 gate driver.
- 3 terminal block allows easy connection of high voltage input bus HV+, switch node, HS, and ground, GND.
- Easily configured into different topologies such as synchronous buck, synchronous boost, and half-bridge converter.
- Quickly check the effect of different external components such as bootstrap capacitor, bootstrap diode, gate resistor, gate diode, etc.
- Allows quick verification of most of the datasheet parameters.
- Open loop power stage allows user to quickly fund out whether the application issues are driver related or related to other parameters in the application.
- Easily perform chip level tests by removing power MOSFETs and replacing gate resistors with 0-Ω resistor and replacing gate to source resistor with appropriate load capacitor.
- Power stage featuring 100 V, N-Channel MOSFETS.
- Features popular pinouts for FETs, D2PACK and TO-220.

## 2.2 I/O Description

**Table 1. Connection Descriptions**

| CONNECTIONS | DESCRIPTION |
|---|---|
| J1 | High voltage input HV+, high-side source HS, GND |
| Jext1 | Positive power supply for the lower-gate driver VCC |
| Jext2 | Low-side input LI |
| Jext3 | High-side input HI |

# 3 Electrical Specifications

**Table 2. UCC272xxEVM-328 Electrical Specifications**

| CONNECTIONS | DESCRIPTION |
|---|---|
| J1 | 100 V max on HV+, 1 A max |
| Jext1 | 5-V-17-V VDD operating voltage range |
| Jext2 | 5-V to 17-V PWM signals |
| Jext3 | 5-V to 17-V PWM signals |
| QH1,QL1 | N-channel,100 V |

# 4 Test Setup

## *4.1 Definitions*

This procedure details how to configure the UCC27212 evaluation board. Within this test procedure the following naming conventions are followed. Refer to the UCC27212EVM schematic, Figure 10 for details.

**DMM:** Digital Multi-Meters

**UUT:** Unit Under Test

**EVM:** Evaluation Module assembly, in this case the UUT

## *4.2 Equipment*

### 4.2.1 Power Supplies

Two DC power supply with voltage/current above 25 V/1 A, for example: Agilent E3634A.

### 4.2.2 Function Generators

One two-channel function generator over 20 MHz, for example, Tektronics AFG3252

## 4.3 Equipment Setup

### 4.3.1 DC Power Supply Settings

- DC power supply #1
  - Voltage setting: 10 V
  - Current limit: 0.05 A
- DC power supply #2
  - Voltage setting: 50 V
  - Current limit: 2.5 A

### 4.3.2 Digital Multi-Meter Settings

- Digital multi-meter #1
  - DC current measurement, auto-range. Expected current is within 1 mA to 15 mA
- Digital multi-meter #2
  - DC current measurement, auto-range, expected current is within 2 mA to 2.5 mA

### 4.3.3 Two-Channel Function Generator Settings

**Table 3. Two-Channel Function Generator Settings**

| CHANNEL | MODE | FREQUENCY | DUTY CYCLE | DELAY | HIGH | LOW | OUTPUT IMPEDANCE |
|---|---|---|---|---|---|---|---|
| **Channel A** | Pulse | 100 kHz | 20% | 0 ns | 5 V | 0 V | High Z |
| **Channel B** | | | 70% | 2.5 µs | | | |

### 4.3.4 Oscilloscope Setting

**Table 4. Oscilloscope Settings**

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

### 4.3.5 Bench Setup Diagram

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

Please follow the connection procedure below, and Figure 1 can be used as a reference.

- Make sure all the output of the function generator, voltage source are disabled before connection.
- Function generator channel-A channel applied on Jext3/HI.
- 
- Function generator channel-B channel applied on Jext2/LI.
- Power supply #1: positive node connected to input of DMM#1 and DMM#1 output connected to Jext1 pin.
- Power supply #2: positive node connected to input of DMM #2 and DMM #2 output connected to J1 pin-3 (marked as HV), negative node of Power Supply #2 connected directly to J1 pin-1 (marked as GND).
- Connect oscilloscope Ch-1 probes to test points marked as HO↔GND, smaller measurement loop is preferred.
- Connect oscilloscope Ch-2 probes to test points marked as HS↔GND, smaller measurement loop is preferred.
- Connect oscilloscope Ch-3 probes to test points marked as LO↔GND, smaller measurement loop is preferred.

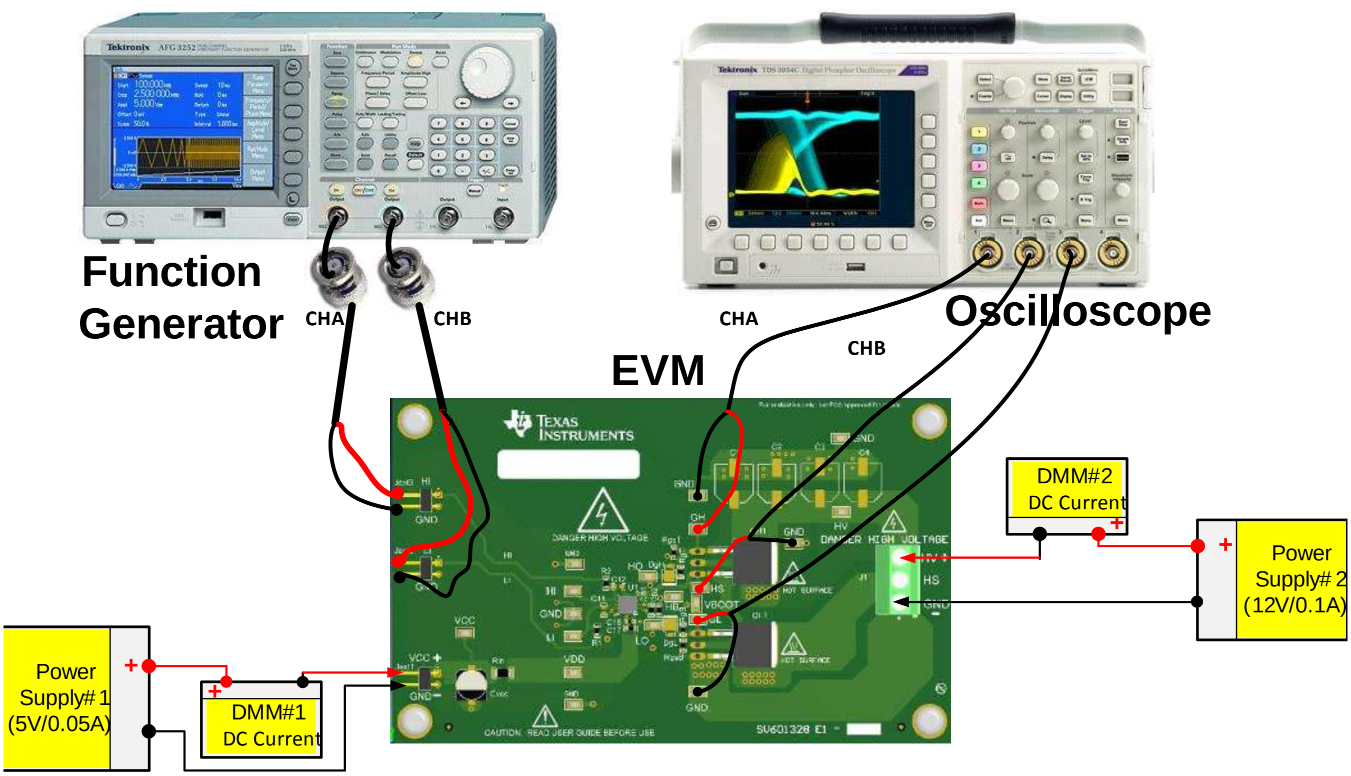



**Figure 1. Bench Setup Diagram and Configuration**

# 5 Power Up and Power Down Procedure

## *5.1 Power Up*

1. Before preceding the power-up test procedure, please make sure that Figure 1 is implemented for setting up all the equipment. Figure 1 could be used as reference
2. Enable supply #1.
3. Enable supply #2, if the current on DMM1 is less than 2 mA and current in DMM2 is less than 2 mA, it is normal operation and can proceed to next step. Otherwise, the EVM fails.
4. Enable function generator two channel output channel-A and channel-B.
5. There will be:
   (a) Stable pulse output on the channel-A, channel-B, and channel-C on the oscilloscope.
   (b) Frequency measurement should 100 kHz ± 2 kHz.
   (c) DMM #1 should read measurement 11 mA, ± 2 mA.

## *5.2 Power Down*

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

# 6 Typical Performance Waveforms

## *6.1 Rise and Fall Times*

Following waveforms could be observed with setup explained in Section 4.

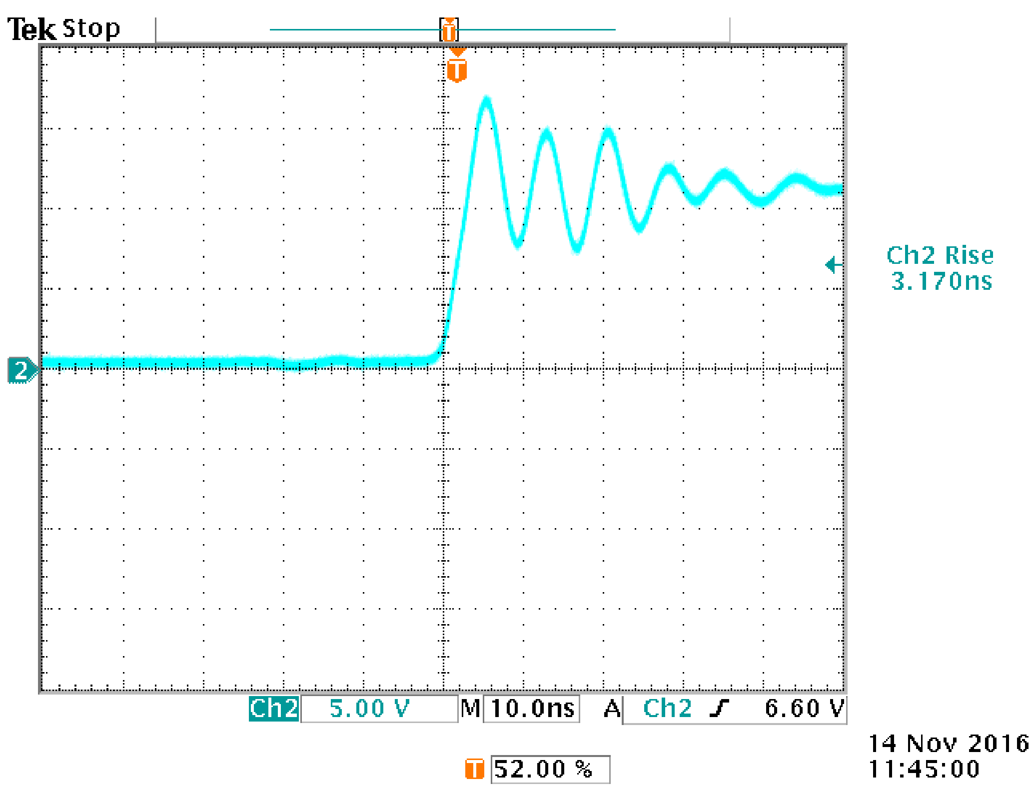



**Figure 2. HO Rise Time**

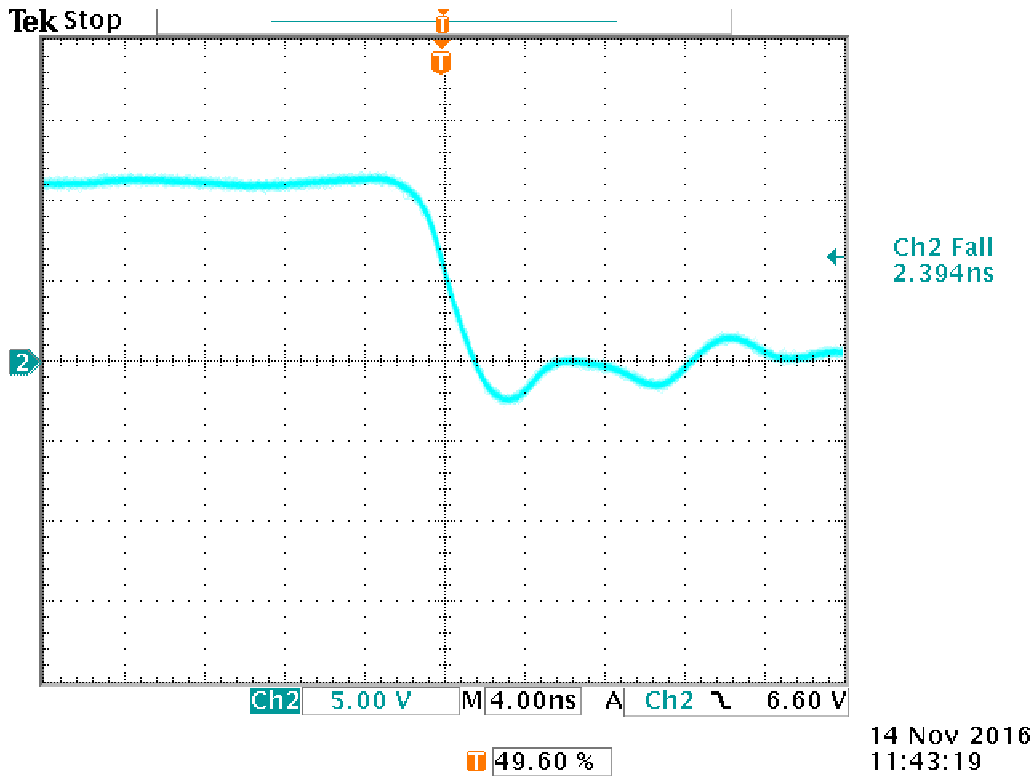



**Figure 3. HO Fall Time**

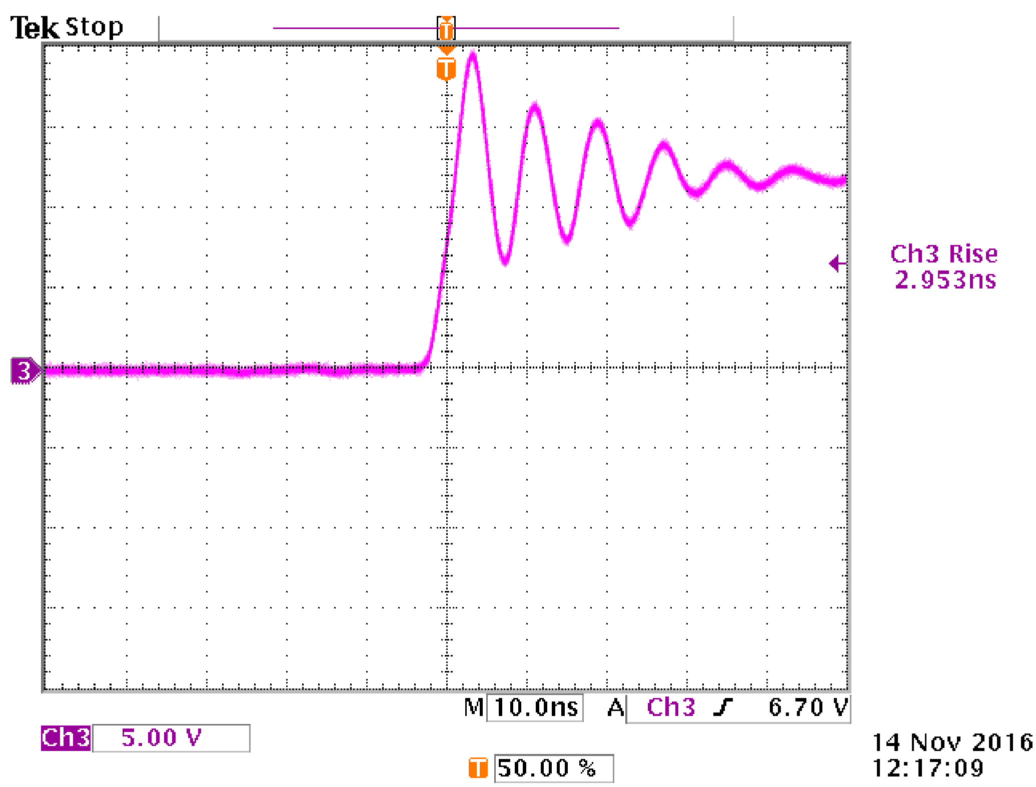



**Figure 4. LO Rise Time**

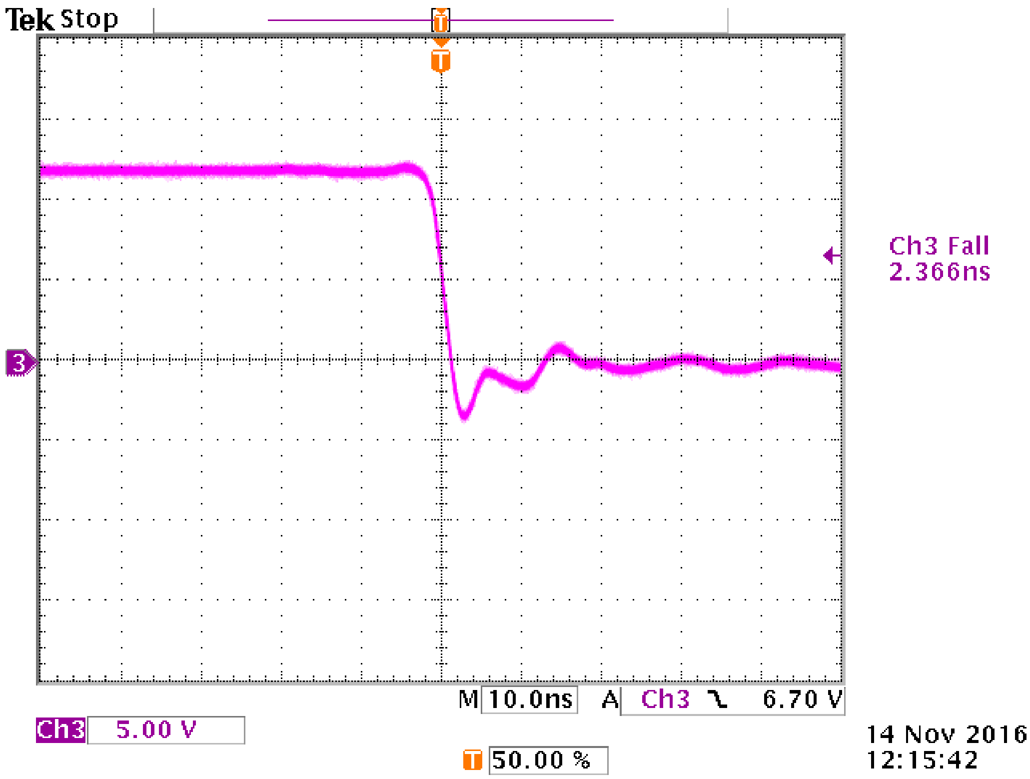



**Figure 5. LO Fall Time**

## 6.2 Propagation Delays

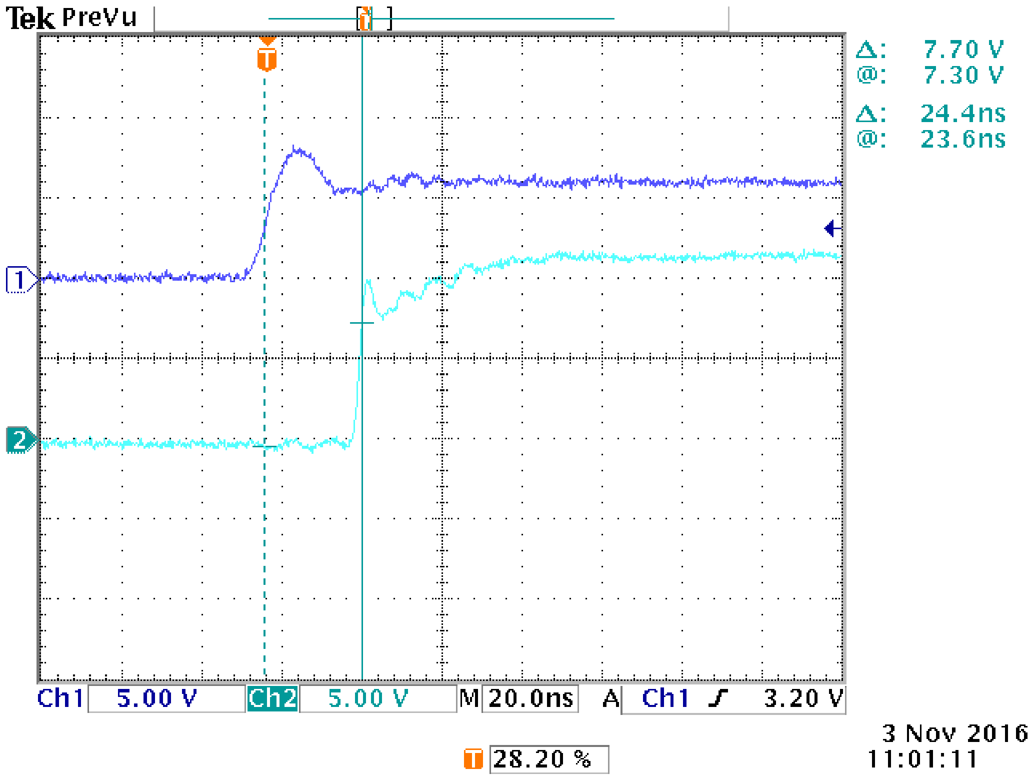



**Figure 6. HI and HO Propagation Delay**

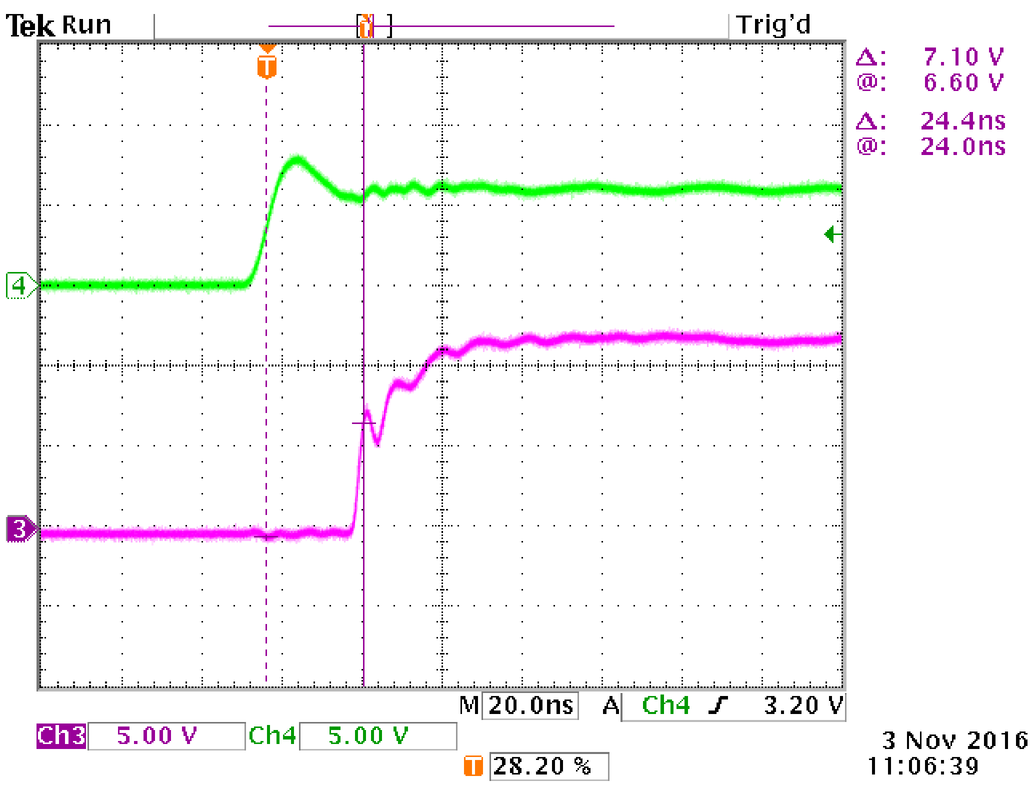



**Figure 7. LI and LO Propagation Delay**

### 6.3 Configuring UCC272xx EVM into a Synchronous Buck Converter

The UCC272xxEVM can easily be used to form a synchronous buck converter by connecting an inductor, capacitor and load to the EVM as shown in the diagram below. The inductor, capacitor, and load are not supplied with the EVM. Connect up to 100 V on the bus supply HV+; this will be the buck converter's input. The UCC272xxEVM brings its switch node out onto HS in order to connect external components.

For example, 48 V is a common bus voltage and it frequently needs to be bucked down to 24 V or 12 V. The board has been tested when configured as synchronous buck convereter with a 100-µH inductor and a 100-µF capacitor are connected to the HS and GND connection point as shown in diagram below. Input voltage, output voltage, HO, and inductor current waveforms are shown in figures below. A film capacitor is recommended at the buck output for high frequency filtering.

One can notice the high frequency noise on the board. The buck converter design can be found in many publicly available literature. It should be noted that there is no heat-sink on the power MOSFET and therefore, for high power testing it is highly recommended that some sort of heat sink should be provided. Gate resistors can be increased to reduce the dv/dt related noise. The board has also provided placement option of external bootstrap capacitor to test effect of different types of bootstrap capacitors. Board does not come with input electrolytic capacitors installed, but it is highly recommended that user should install them. Board has provision if different source and sink capability is desired by choosing different gate resistor value and different diode-resistor values.

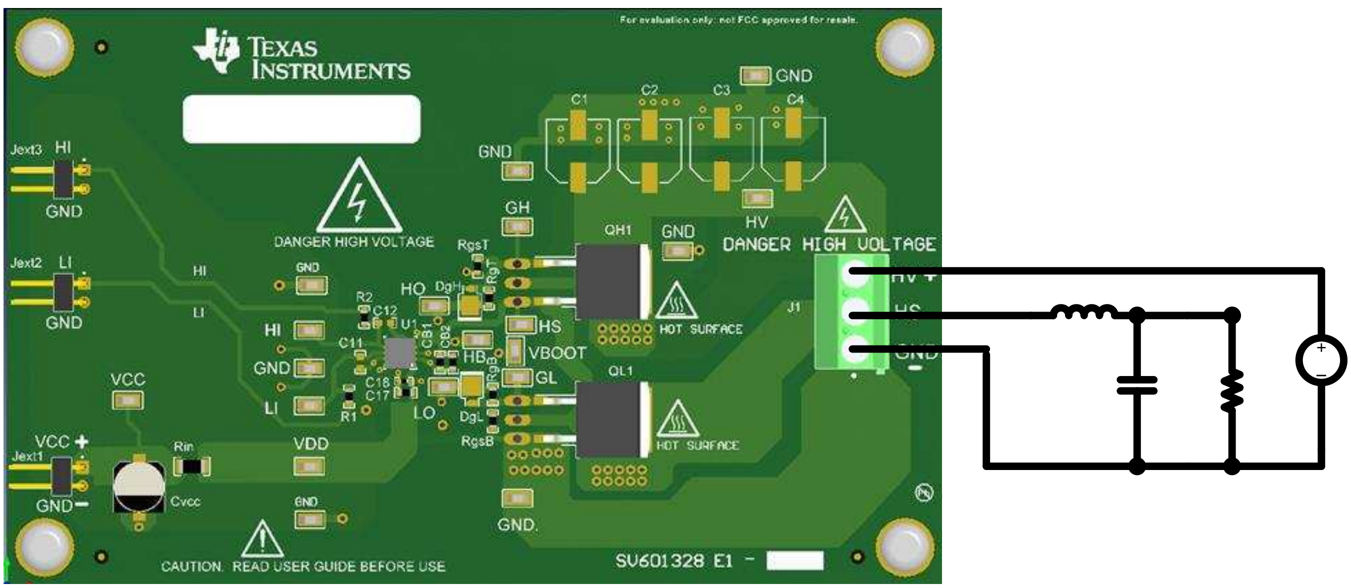



**Figure 8. Buck Converter Example**

**Table 5. UCC27212 Parameters**

| PARAMETERS | VALUE |
|---|---|
| Output voltage ($V_{OUT}$) | 12 V |
| Output current ($I_{OUT}$) | 8 A |
| Input voltage ($V_{IN}$) | 48 V |
| Switching frequency $f_{(SW)}$ | 100 kHz |
| $P_{O(max)}$ | 100 W |

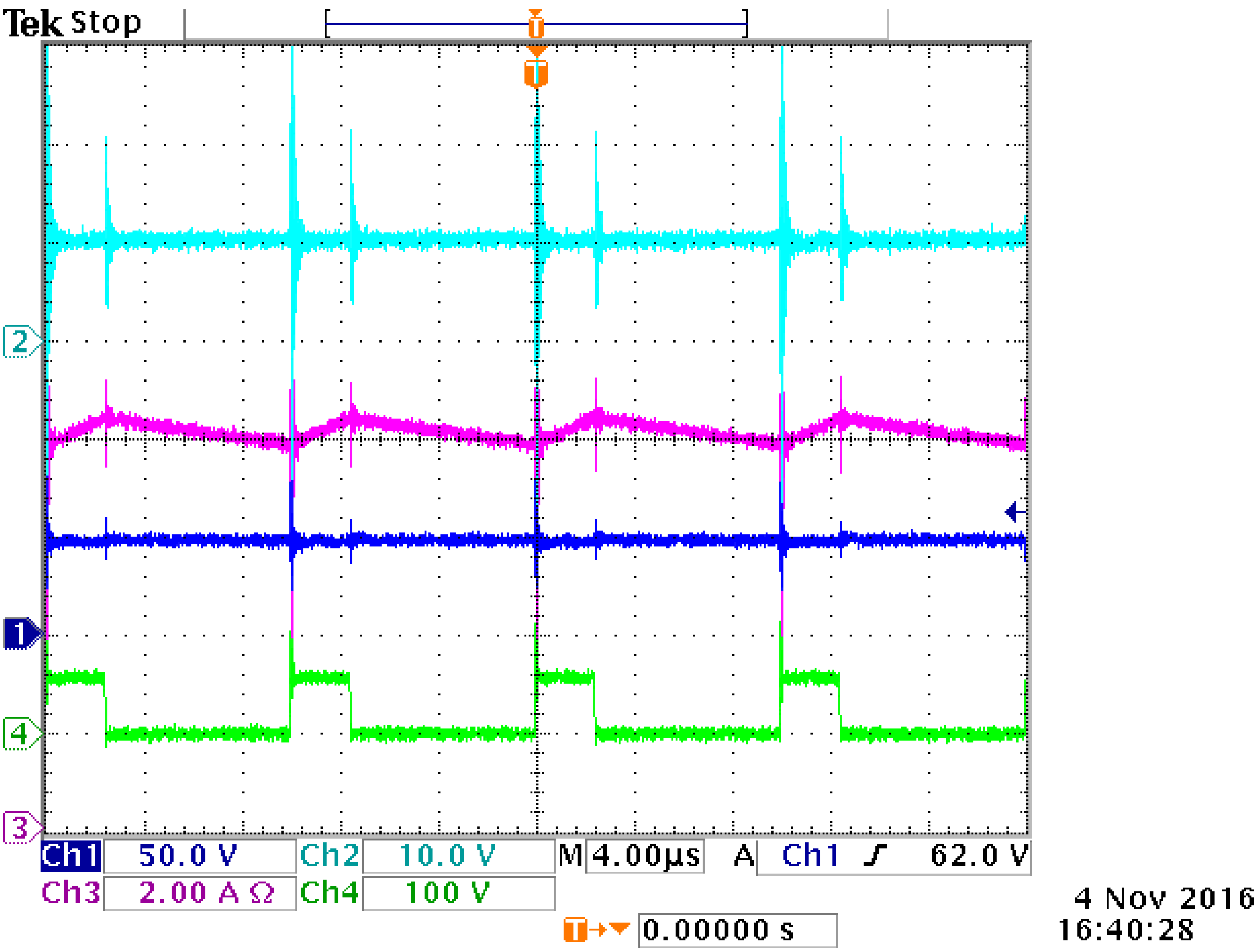



**Figure 9. Buck Converter $V_{IN}$, $V_{OUT}$, $I_L$, and HO**

**Table 6. Waveforms Figure Channel Descriptions**

| CHANNEL | DESCRIPTION |
|---|---|
| CH 1 | Input voltage |
| CH 2 | Output voltage |
| CH 3 | Inductor current |
| CH 4 | HO |

# 7 Schematic

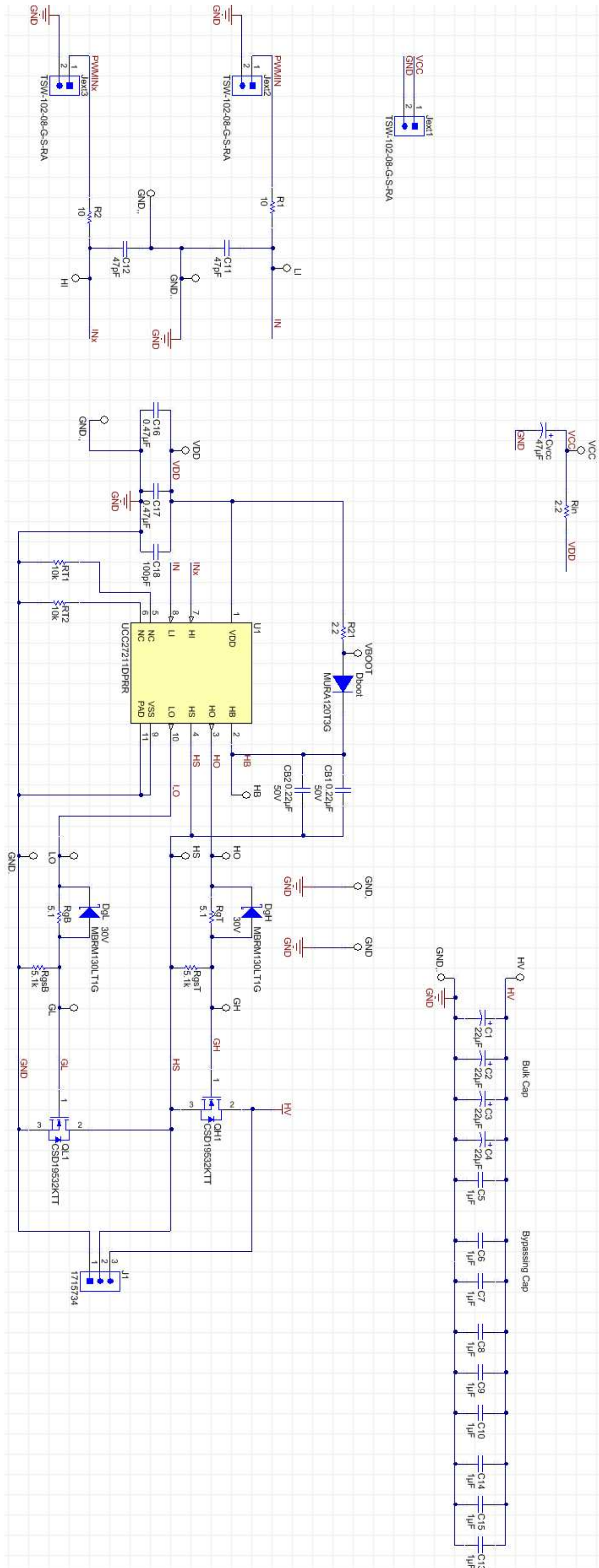



**Figure 10. UCC272xx Schematic**

# 8 Layout Diagrams

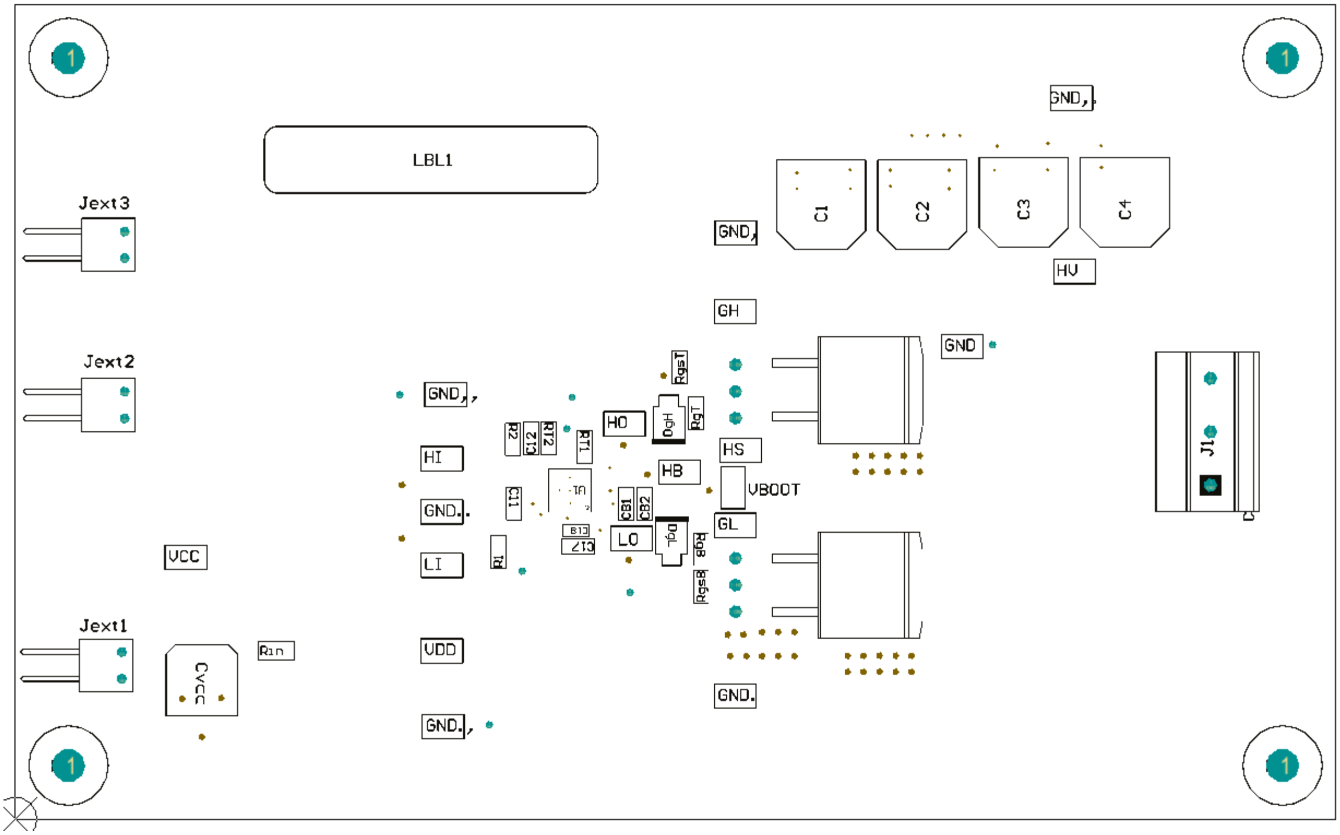



**Figure 11. Assembly Top Layer**

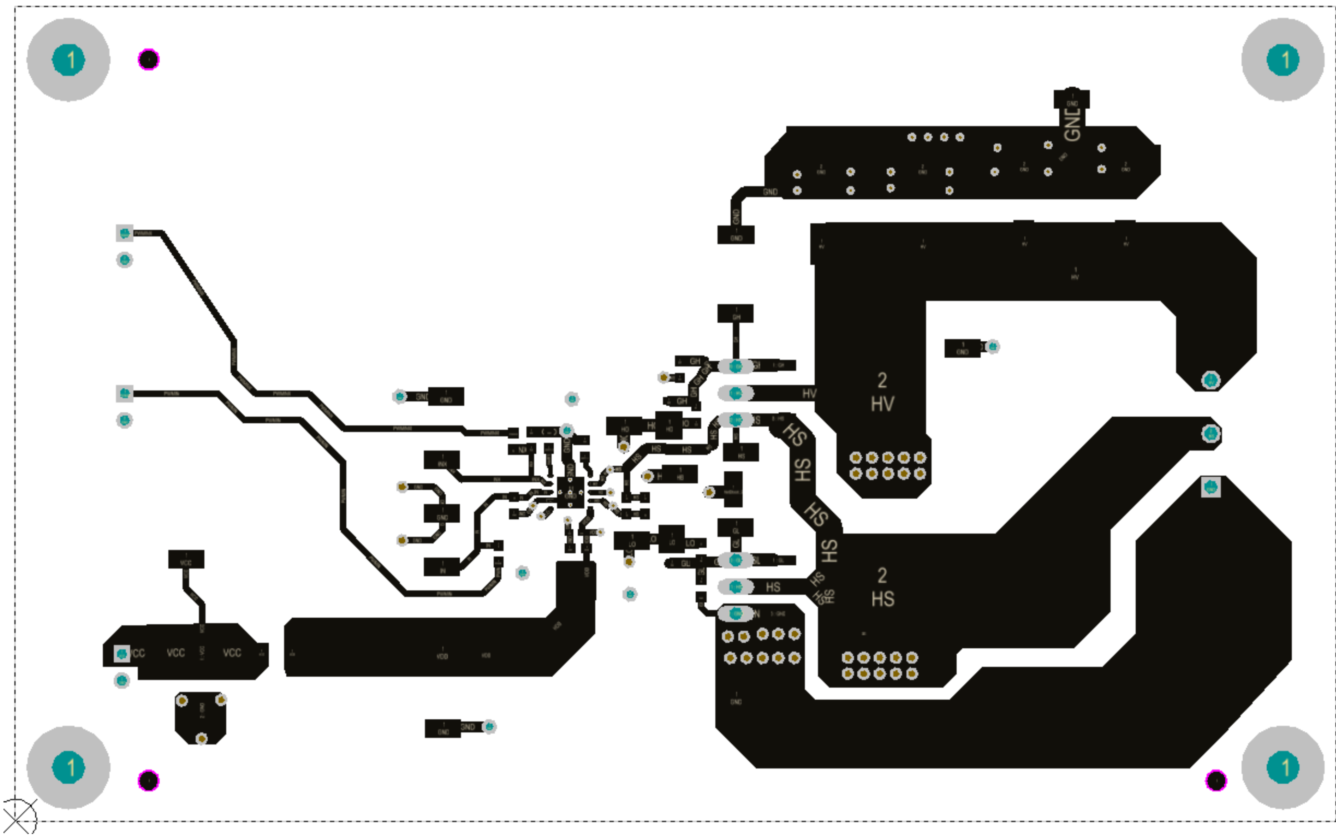



**Figure 12. Top Layer**

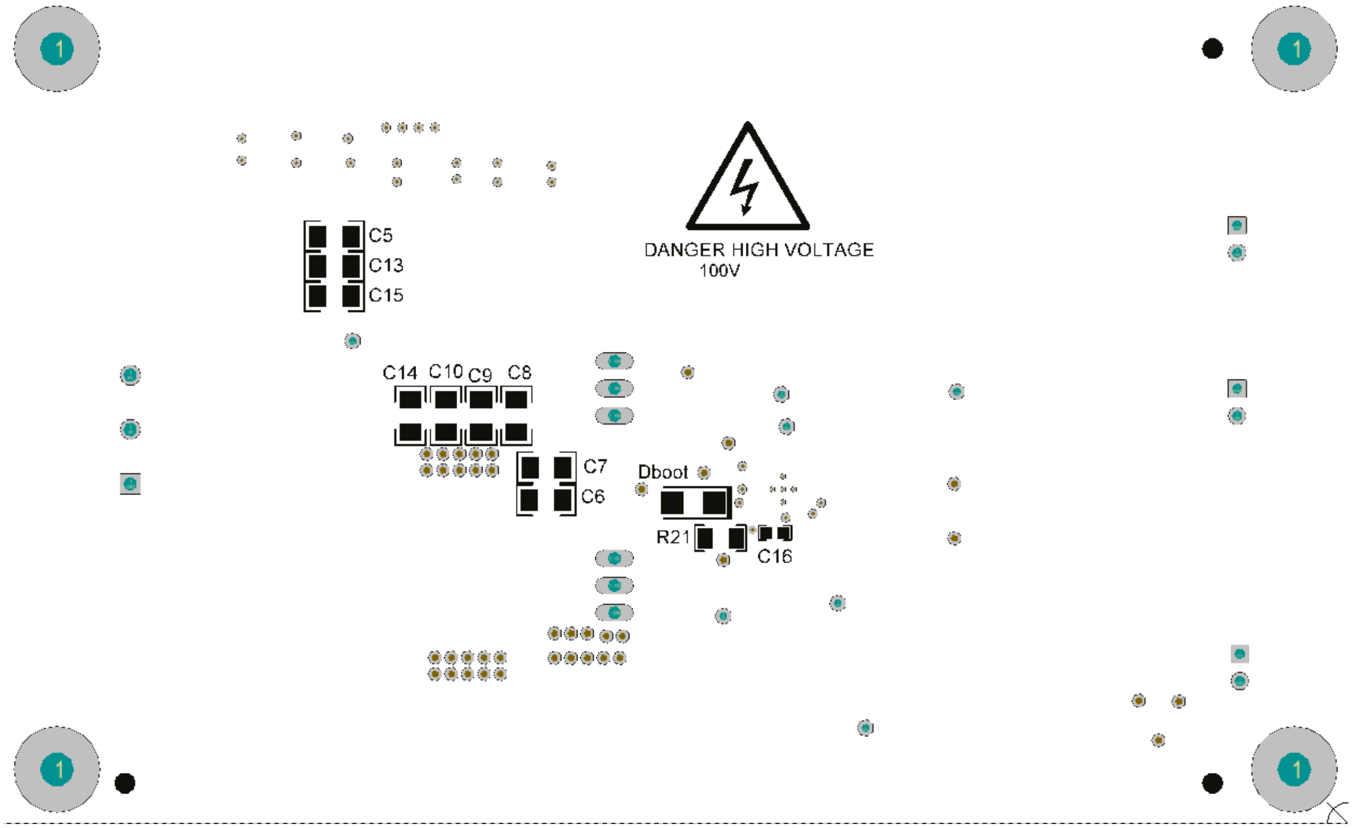



**Figure 13. Bottom Overlay**

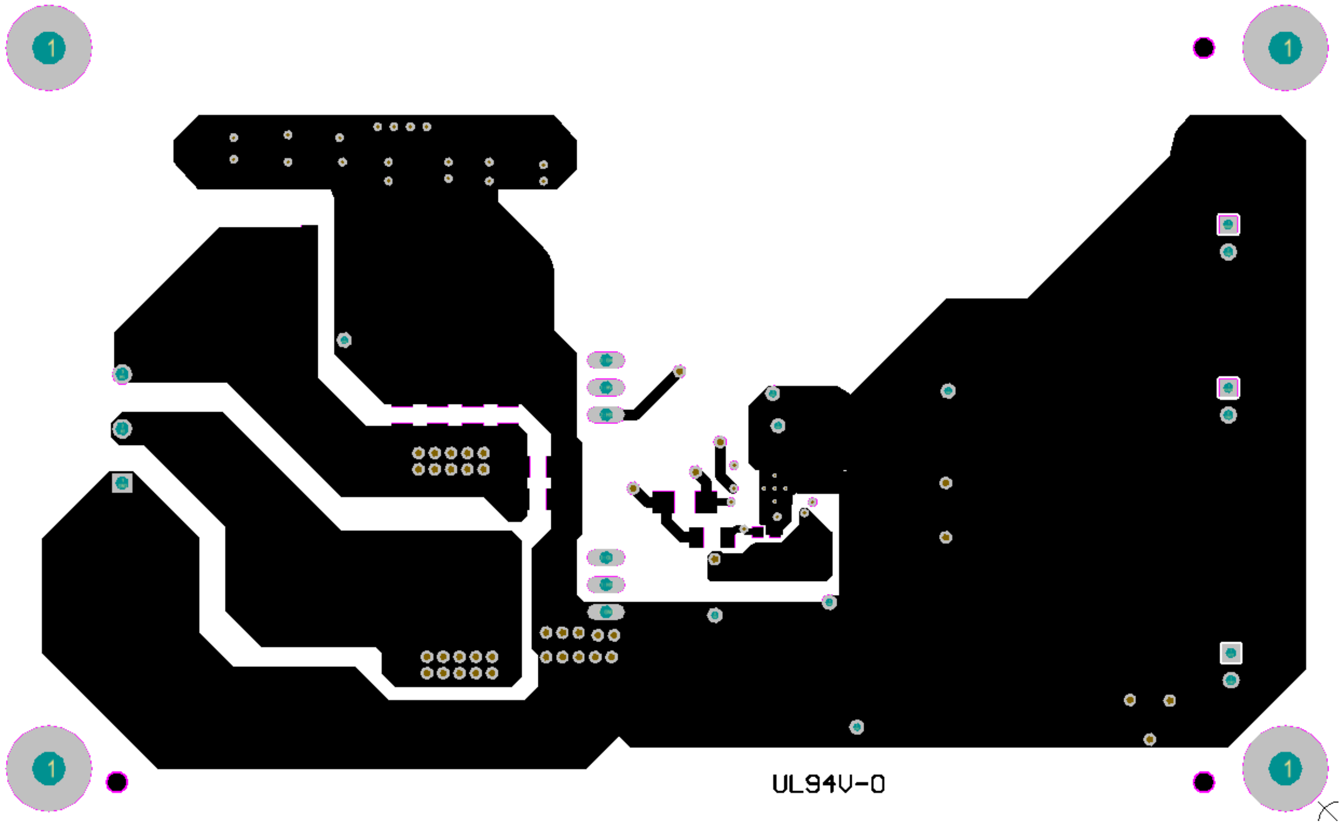



**Figure 14. Bottom Layer**

# 9 List of Materials

**Table 7. UCC272xxEVM-328 List of Materials**

| QTY | DES | DESCRIPTION | MANUFACTURE | PART NUMBER |
|---|---|---|---|---|
| 1 | !PCB | Printed Circuit Board | Any | SV601328 |
| 4 | C1, C2, C3, C4 | Capacitor, aluminum, 22 µF, 100 V, ±20%, 1.3 Ω, SMD | Panasonic | EEE-FK2A220P |
| 9 | C5, C6, C7, C8, C9, C10, C13, C14, C15 | Capacitor, ceramic, 1 µF, 100 V, ±10%, X7R, 1206 | MuRata | GRM31CR72A105KA01L |
| 2 | C11, C12 | Capacitor, ceramic, 47 pF, 50 V, ±5%, C0G/NP0, 0603 | MuRata | GRM1885C1H470JA01D |
| 2 | C16, C17 | Capacitor, ceramic, 0.47 µF, 50 V, ±10%, X7R, 0603 | TDK | C1608X7R1H474K080AC |
| 1 | C18 | Capacitor, ceramic, 100 pF, 50 V, ±5%, C0G/NP0, 0402 | Wurth Elektronik | 885012005061 |
| 2 | CB1, CB2 | Capacitor, ceramic, 0.22 µF, 50 V, ±10%, X7R, 0603 | TDK | C1608X7R1H224K080AB |
| 1 | Cvcc | Capacitor, aluminum, 47 µF, 50 V, ±20%, 0.68 Ω, SMD | Nichicon | UUD1H470MCL1GS |
| 1 | Dboot | Diode, Ultrafast, 200 V, 1 A, SMA | ON Semiconductor | MURA120T3G |
| 2 | DgH, DgL | Diode, Schottky, 30 V, 1 A, powermite | ON Semiconductor | MBRM130LT1G |
| 6 | FID1, FID2, FID3, FID4, FID5, FID6 | Fiducial mark. There is nothing to buy or mount. | N/A | N/A |
| 19 | GH, GL, GND, HB, HI, HO, HS, HV, LI, LO, VBOOT, VCC, VDD | Test point, miniature, SMT | Keystone | 5015 |
| 4 | H1, H2, H3, H4 | Machine screw, round, #4-40 x 1/4, nylon, philips panhead | B&F Fastener Supply | NY PMS 440 0025 PH |
| 4 | H5, H6, H7, H8 | Standoff, Hex, 0.5"L #4-40 Nylon | Keystone | 1902C |
| 1 | J1 | TERM BLOCK 3POS 5.08MM, TH | Phoenix Contact | 1715734 |
| 3 | Jext1, Jext2, Jext3 | Header, 100 mil, 2x1, gold, R/A, TH | Samtec | TSW-102-08-G-S-RA |
| 1 | LBL1 | Thermal transfer printable labels, 1.250" W x 0.250" H - 10,000 per roll | Brady | THT-13-457-10 |
| 2 | QH1, QL1 | MOSFET, N-channel, 100 V, 136 A, KTT0002A | Texas Instruments | CSD19532KTT |
| 2 | R1, R2 | Resistor, 0 Ω, 5%, 0.1 W, 0603 | Panasonic | ERJ-3GEY0R00V |
| 2 | R21, Rin | Resistor, 2.2 Ω, 5%, 0.25 W, 1206 | Vishay-Dale | CRCW12062R20JNEA |
| 2 | RgB, RgT | Resistor, 5.1 Ω, 5%, 0.1 W, 0603 | Vishay-Dale | CRCW06035R10JNEA |
| 2 | RgsB, RgsT | Resistor, 5.1 kΩ, 5%, 0.1 W, 0603 | Vishay-Dale | CRCW06035K10JNEA |
| 2 | RT1, RT2 | Resistor, 10 kΩ, 5%, 0.1 W, 0603 | Vishay-Dale | CRCW060310K0JNEA |
| 1 | U1 | 120-V Boot, High Frequency High-Side and Low-Side Driver, DPR0010A (WSON-10) | Texas Instruments | UCC27211DPRR or UCC27201ADPR |