Using the UCC25230EVM-662

User's Guide

Literature Number: SLUU863
February 2012

Biased Half-Bridge Converter with UCC28250 Secondary-Side Control for 48-V Telecom Applications

1 Introduction

This EVM is used to evaluate bias power supply with UCC25230 used in the UCC28250, based on a secondary-side controlled, half-bridge DC-to-DC converter. The UCC25230EVM-662 is actually a combination of two released EVMs, UCC28250EVM-564 and UCC25230EVM-754. The UCC28250EVM-564 is an EVM of secondary-side controlled symmetrical half-bridge DC-to-DC converter. The UCC25230EVM-754 is used to bias the UCC28250EVM-564 and allow for stand-alone operation in the UCC28250EVM-564. The targeted application is telecom module design with nominal 48-V input. UCC28250 is a PWM controller that can be used for primary-side control or secondary-side control. In this EVM, the UCC28250 is placed at the secondary side to make secondary-side control. The UCC25230 is a highly integrated PWM controller operating as an isolated Forward-Flyback, or Flybuck™ controller. It has integrated high-side and low-side power switches and a control circuit with all the key converter functions included.

2 Description

The EVM is a 100-W symmetrical half-bridge DC-to-DC converter that converts 36 V to 72 V DC to a regulated output voltage of 3.3 V and a maximum of 30-A load current. The EVM is designed in stand-alone operation without additional external auxiliary power sources.

2.1 Typical Applications

- 48-V Telecom Modular Applications With Secondary-Side Control
- Server Systems
- Datacom
- DSP's, ASIC's, and FPGA's

2.2 Features

- Start Up Directly from Telecom Input Voltage 36 V to 72 V DC
- Regulated Output Voltage 3.3 V (with maximum 30-A load current)
- Smooth and Monotonic Output Voltage Turn On (with Up to 90% pre-biased output voltage)
- Output Voltage Regulation (from no load to full load, and from low line to high line)
- Primary-Side Enable ON/OFF Function and Manual Switch for Line-Under Voltage On or Off
- Secondary-Side Control
- Control-Driven Synchronous Rectifier
- Non-Latching Output Over-Voltage Protection and Hiccup Over-Current Protection
- Telecom Isolation from Primary-to-Secondary 1500 V_{DC}
- Test Points to Facilitate the Device Evaluation

3 Electrical Performance Specifications

Table 1. UCC25230EVM-662 Electrical Performance Specifications

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Input Characteristics					
Voltage range		36	48	72	V
Maximum input current	V_{IN} = 36 V and I_{OUT} = 30 A			3.5	A
No load input current	V_{IN} = 72 V			90	mA
Output Characteristics					
Output voltage, V_{OUT}	Output current = 0 A	3.25	3.30	3.35	V
Output load current, I_{OUT}				30	A
Output voltage ripple	I_{OUT} = 30A			50	mV_{pp}
Output over current inception point		32			A
Systems Characteristics					
Switching frequency			200		kHz
IC clock frequency			400		
Peak efficiency			91%		
Full load efficiency			90%		
Operating temperature	Min 200 LFM forced air flow		25		ºC

4 Schematic

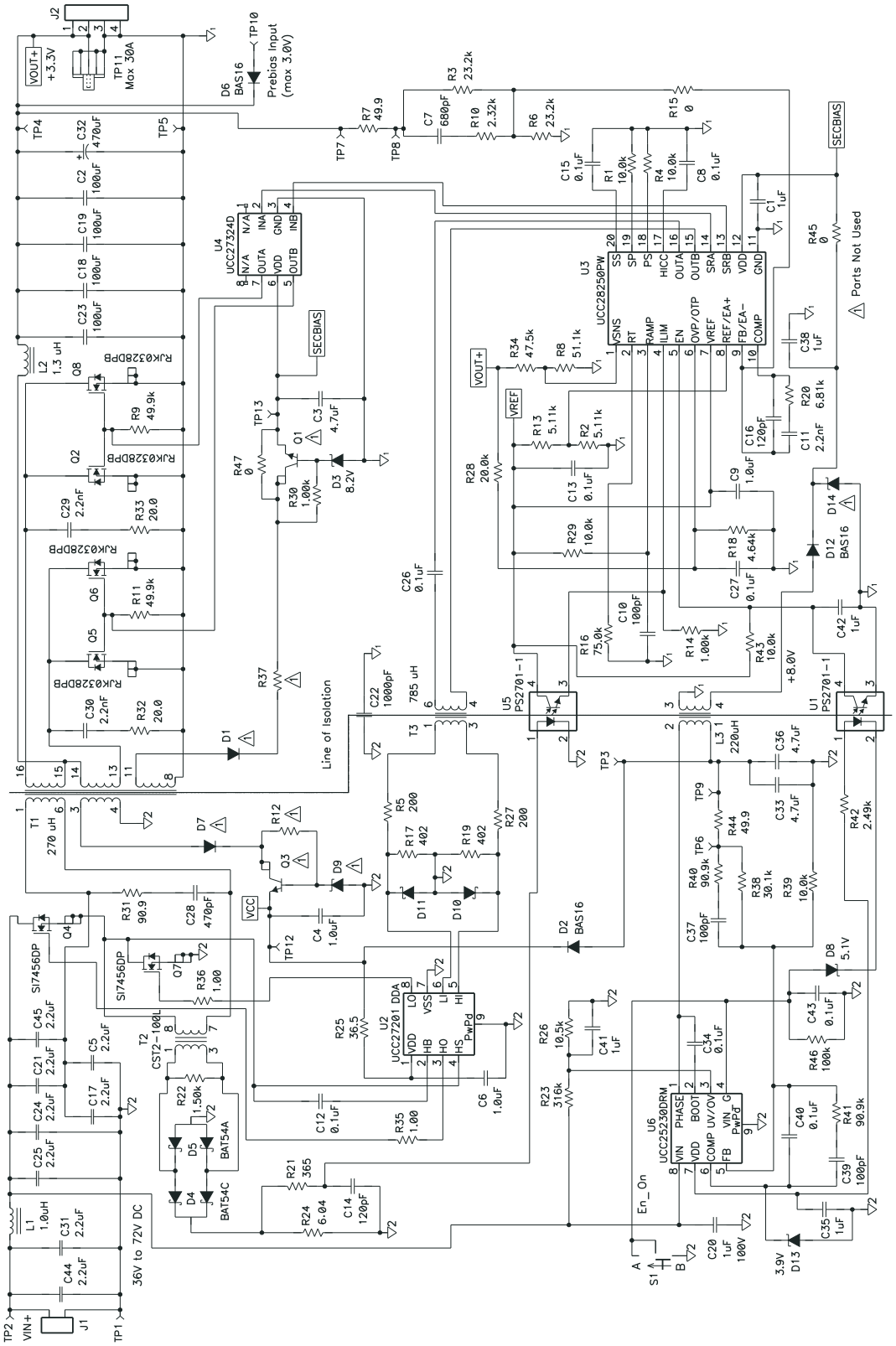

Figure 1. UCC25230EVM-662 Schematic

5 Test Setup

5.1 Test Equipment

Voltage Source: HP 6015A DC power supply, or equivalent to provide 36 V_{DC} to 72 V_{DC}, and minimum 3.5 A.

Multimeters: Fluke 45 dual display multimeter, or equivalent.

Output Load: HPA 6060A DC electronic load, or equivalent capable of 3.3 V and 30 A.

Oscilloscope: A 20-MHz or equivalent analog or digital oscilloscope.

Recommended Wire Gauge: AWG #18 for input voltage connection. AWG #16 for output load connection.

Ventilation Fan: 200 LFM minimum compatible.

5.2 Recommended Test Setup

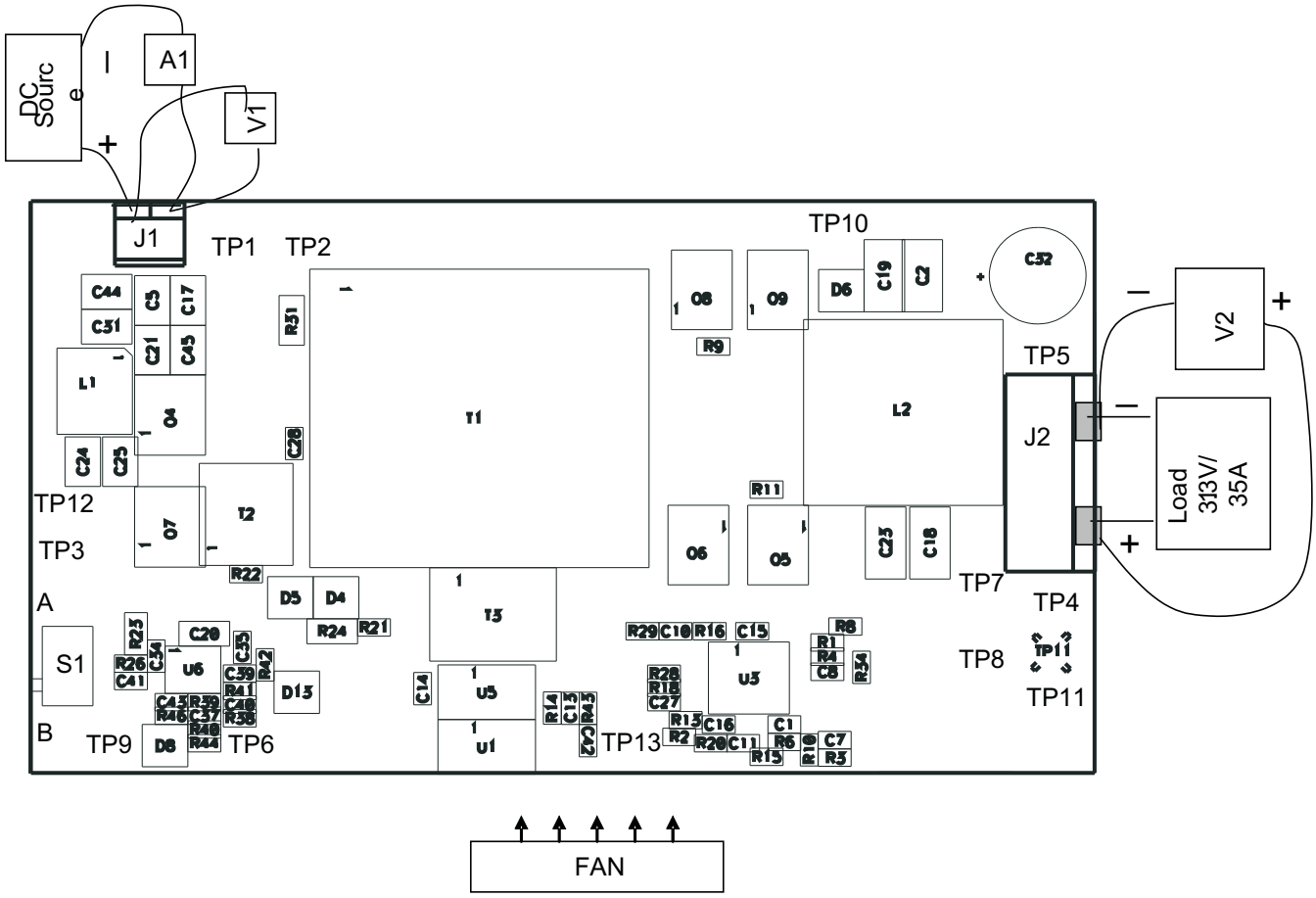

Figure 2. UCC25230EVM-662 Recommended Test Set Up

5.3 List of Test Points

Table 2. Test Point Functions

TEST POINTS	NAME	DESCRIPTION
TP1	PGND	Input voltage negative test point, for efficiency test
TP2	Vin+	Input voltage positive test point, for efficiency test
TP3	Bias_P1	Primary bias, 9V.
TP4	VOUT+	Output voltage positive test point for efficiency
TP5	VOUT-	Output voltage negative test point for efficiency
TP6	Loop+	Feedback loop injection for UCC25230
TP7	Loop+	Feedback loop injection for UCC28250
TP8	Loop-	Feedback loop injection for UCC28250
TP9	Loop-	Primary side signal ground
TP10	Prebias+	Prebias output positive input
TP11	Vo_Ripple	Output voltage ripple test
TP12	Bias_P	Primary bias, 9 V
TP13	Bias_S	Secondary bias, 8 V
J1	INPUT	Input voltage terminals
J2	OUTPUT	Output voltage terminals

6 Test Procedure

Set up the EVM based on Figure 2.

CAUTION

High voltage and high temperature present when the EVM is in operation!

6.1 Line/Load Regulation and Efficiency Measurement Procedure

1. Connect the ammeter A1 (0 A to 10 A range) between DC Source and J1 as shown in Figure 2.
2. Prior to connecting the DC source, it is advisable to limit the source current to 4 A maximum. Make sure the DC source is initially set to 0 V and connected to J1 and A1 as shown in Figure 2.
3. Connect voltmeter, V1 across the DC source as shown in Figure 2.
4. Connect Load1 to J2 as shown in Figure 2. Set Load1 to constant current mode to sink 0 A_{DC} before the input voltage on J1 is applied.
5. Connect voltmeter, V2 to J2 as shown in Figure 2.
6. Turn on the ventilation fan making sure to blow air directly on the EVM.
7. Set switch S1 to position B.
8. Increase the DC source voltage from 0 V to 36.0 V_{DC}.
9. Measure VOUT (V2), IOUT, VIN (V1) and I_{IN} (A1).
10. Vary LOAD1 from 0 A to a higher value, up to 30 A_{DC}.
11. Increase input voltage to a different value, up to 72 V, and repeat 9 and 10.

6.2 Equipment Shutdown

1. Decrease Load-1 to 0 A.
2. Decrease VIN to 0 V.
3. Shut down VIN and the fan.
4. Shut down the load.

7 Performance Data and Typical Characteristic Curves

Figure 3 through Figure 11 present typical performance curves for UCC25230EVM-662.

7.1 Efficiency

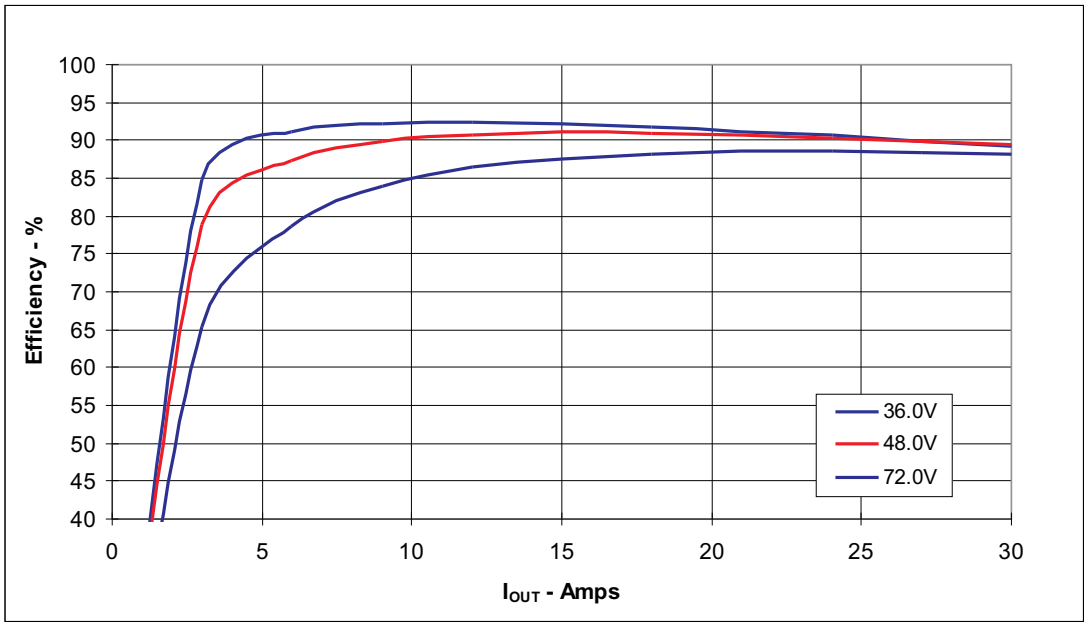

Figure 3. UCC25230EVM-662 Efficiency

7.2 Load Regulation

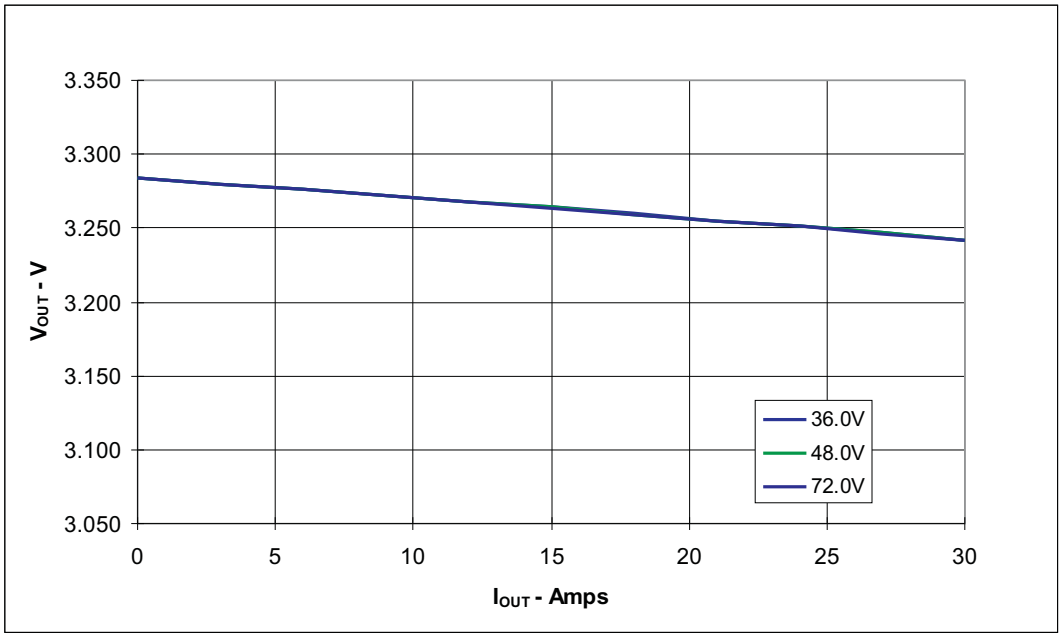

Figure 4. UCC25230EVM-662 Load Regulation

7.3 Bode Plots

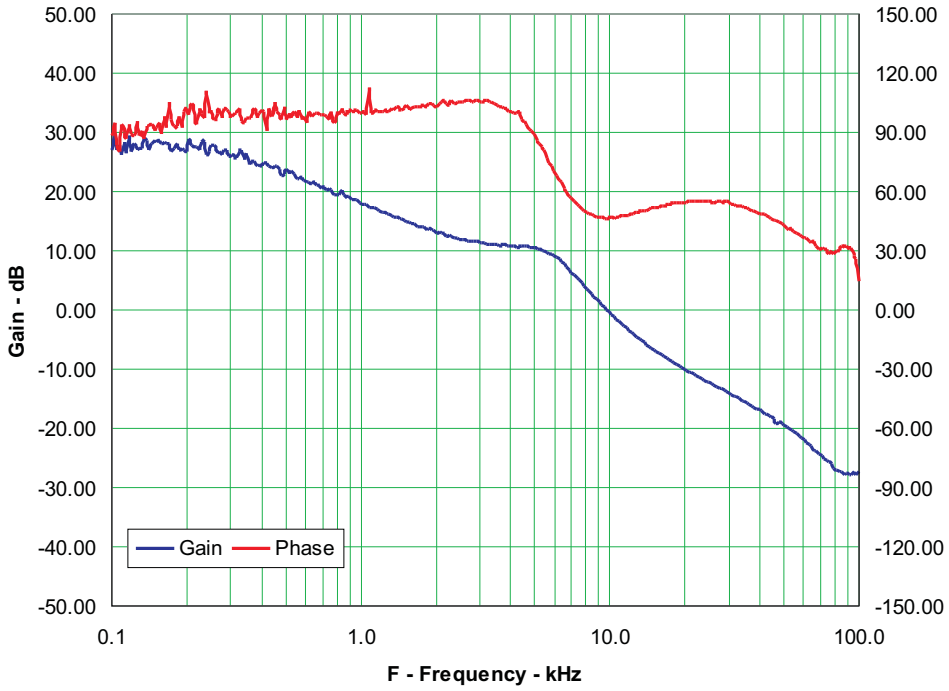

Figure 5. UCC25230EVM-662 Feedback Loop Bode Plots (V_{IN} = 48 V, I_O = 15 A)

7.4 Turn-On Waveform

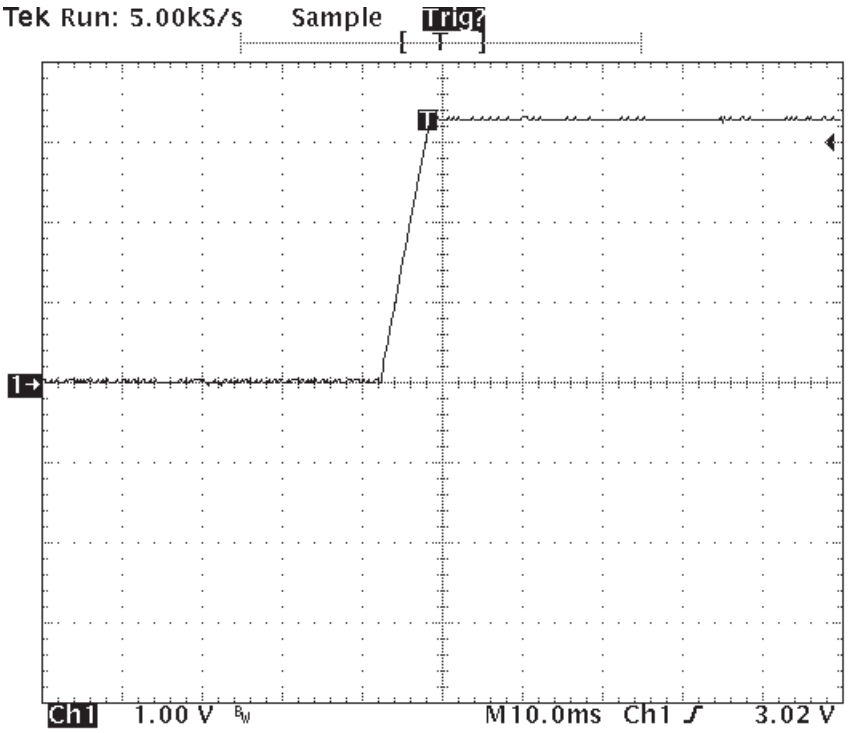

Figure 6. Output Voltage Turn On (V_{IN} = 48 V, I_O = 15 A)

7.5 Turn-on Waveform with Pre-bias Output Voltage

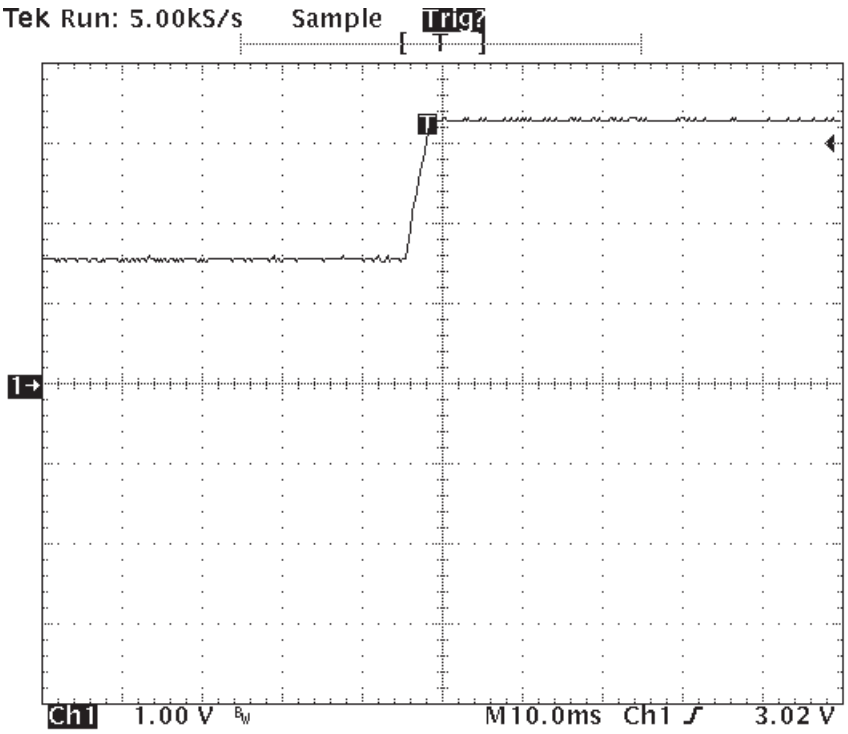

Figure 7. Output Voltage Turn on with Pre bias. (V_{IN} = 48 V, I_O = 0 A, Pre bias = 1.5 V)

7.6 Turn-On Waveform with Pre-bias Output Voltage

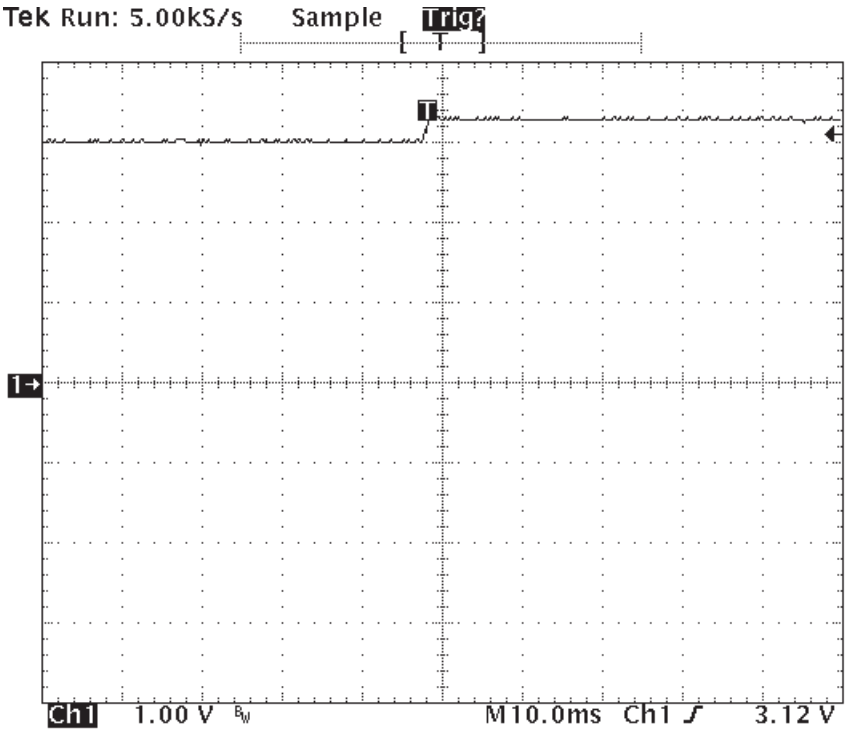

Figure 8. Output Voltage Turn On with Pre bias.
(V_{IN} = 48 V, I_O = 0 A, Pre bias = 3.0 V)

7.7 Turn-On Waveform with Pre-biased Output Voltage

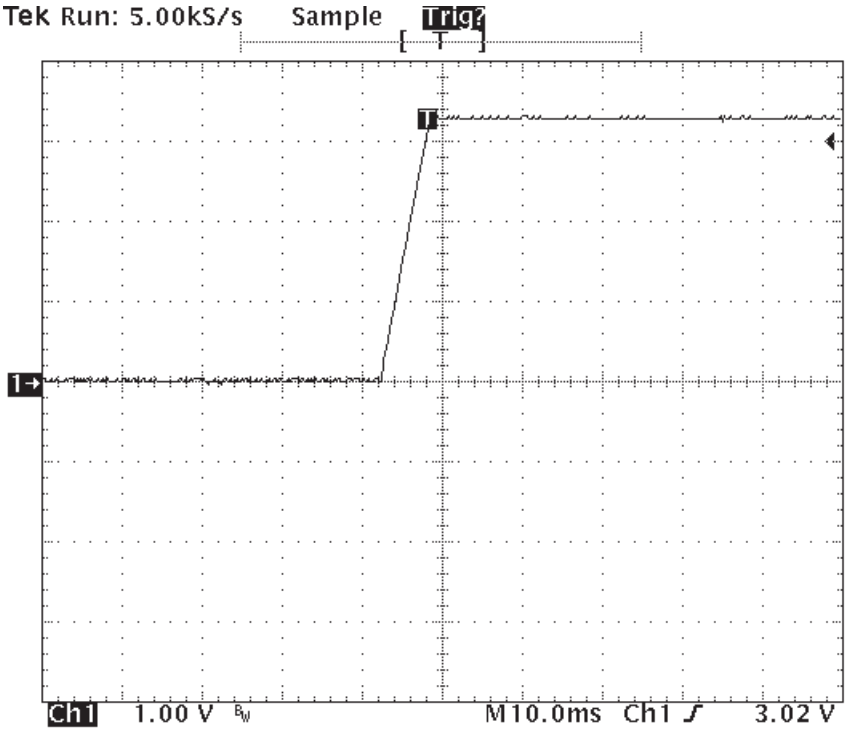

Figure 9. Output Voltage Turn On with Pre bias
(V_{IN} = 48 V, I_O = 0 A, Pre bias = 0 V)

7.8 Turn-Off Waveform

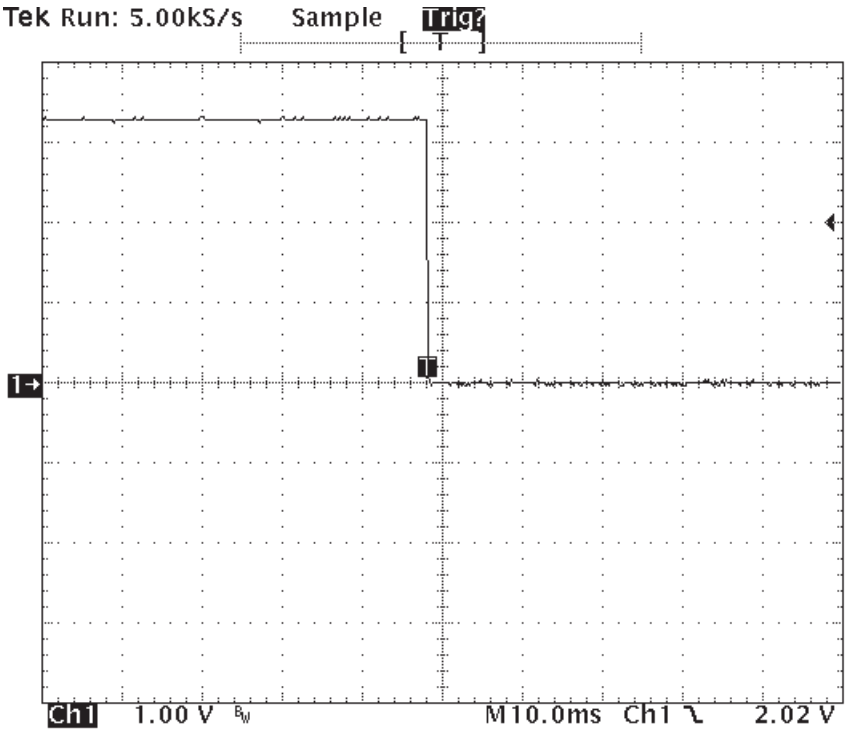

Figure 10. Turn-Off Waveform
(V_{IN} = 48 V, I_O = 15 A)

7.9 Output Ripple

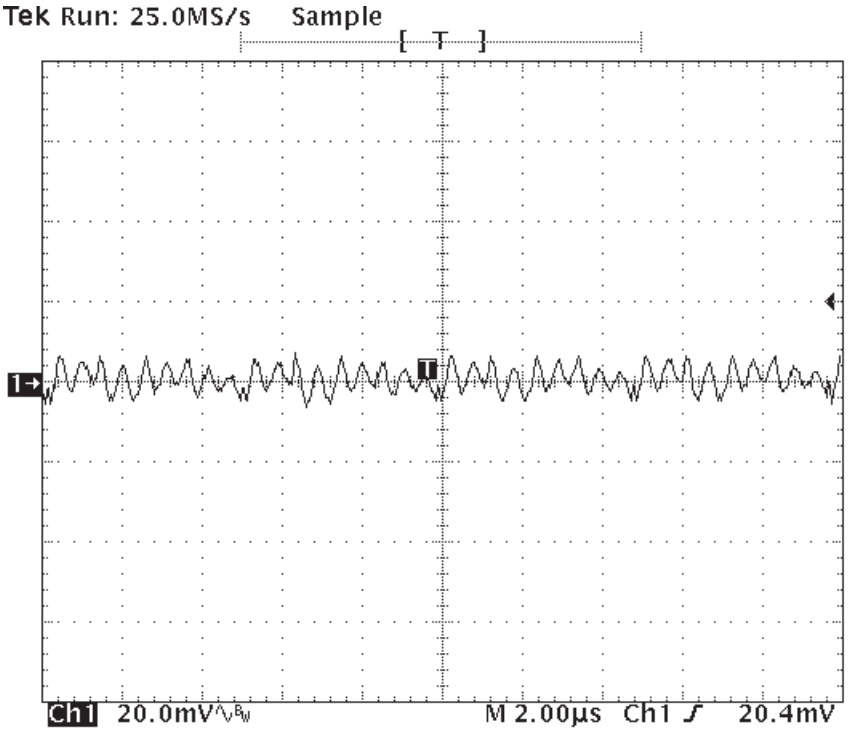

Figure 11. Output Ripple
(V_{IN} = 48 V, I_O = 15 A, without external capacitance)

8 EVM Assembly Drawing and PCB layout

Figure 12 through Figure 17 show the design of the UCC25230EVM-754 printed circuit board. PCB dimensions: L x W = 4.2 inch x 2.3 inch, PCB material: FR406 or compatible, four layers and 2-ounce copper on each layer.

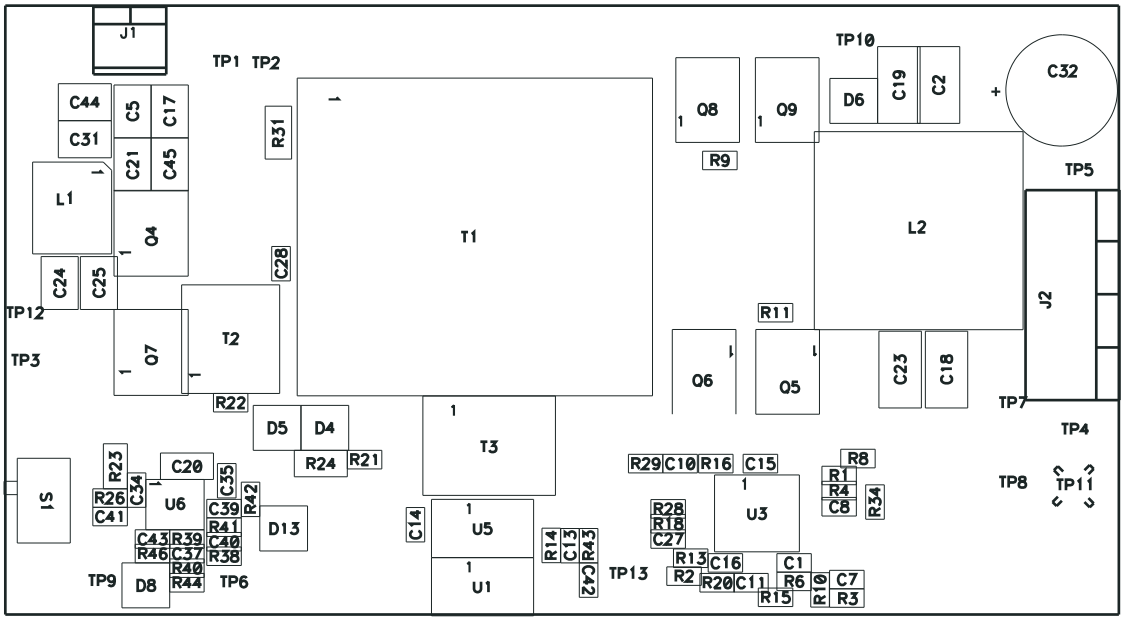

Figure 12. UCC25230EVM-662 Top Layer Assembly Drawing (top view)

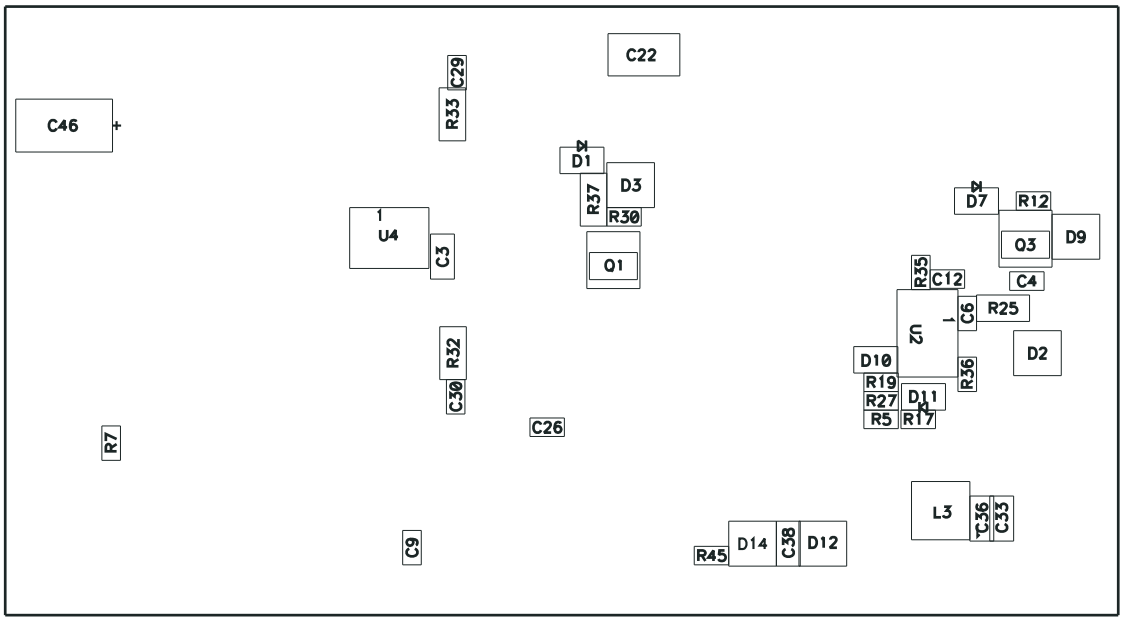

Figure 13. UCC25230EVM-662 Bottom Assembly Drawing (Bottom view)

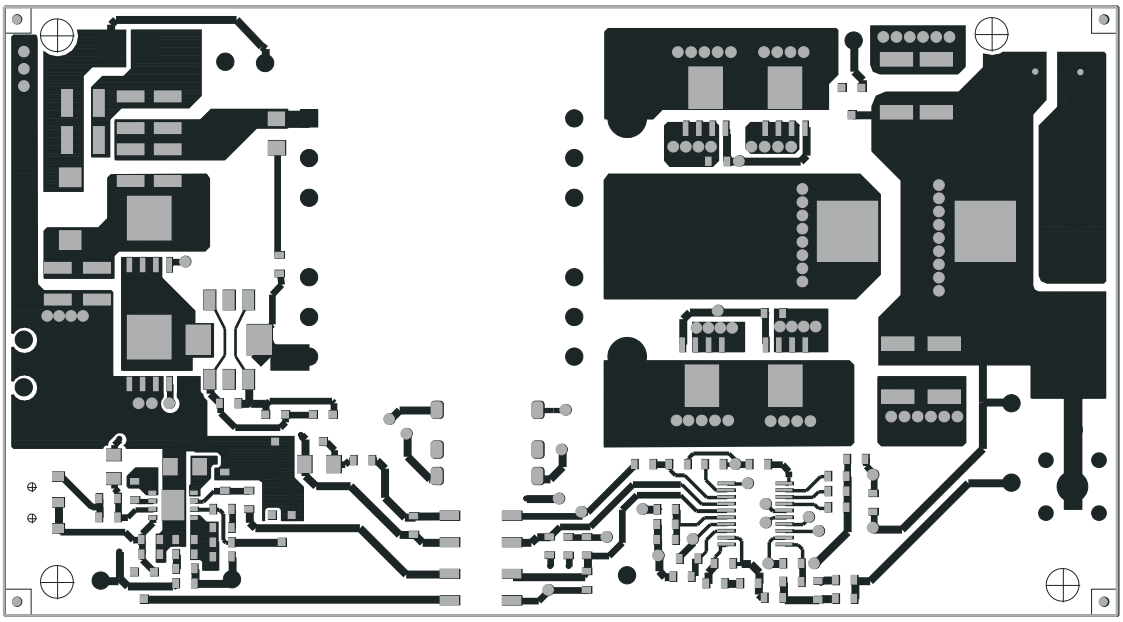

Figure 14. UCC25230EVM-662 Top Copper (top view)

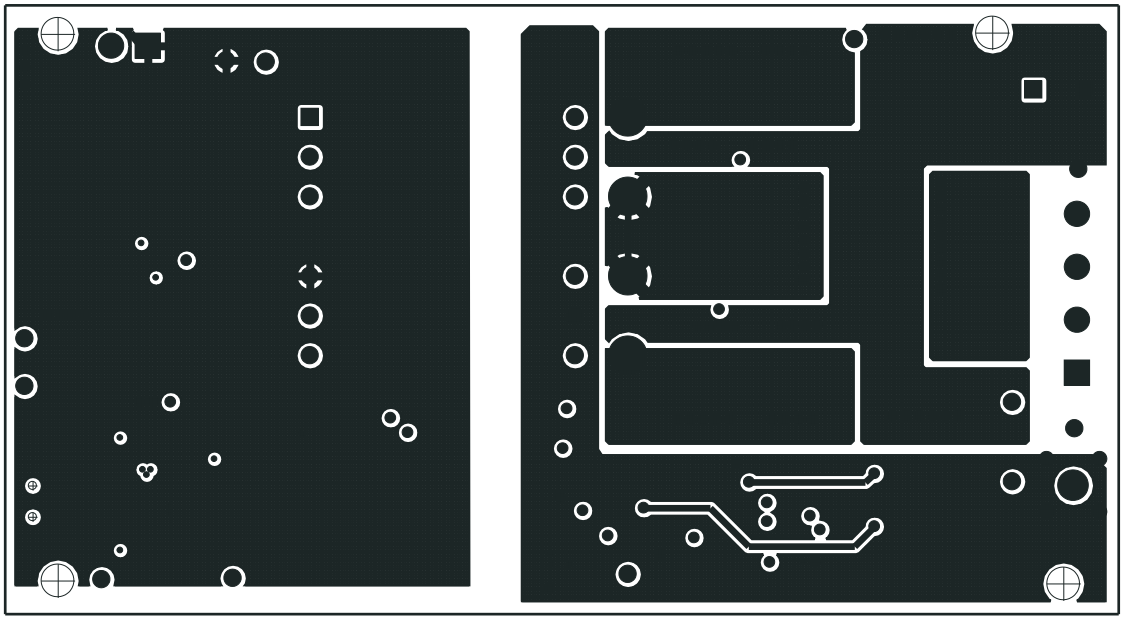

Figure 15. UCC25230EVM-662 Internal Layer 1 (top view)

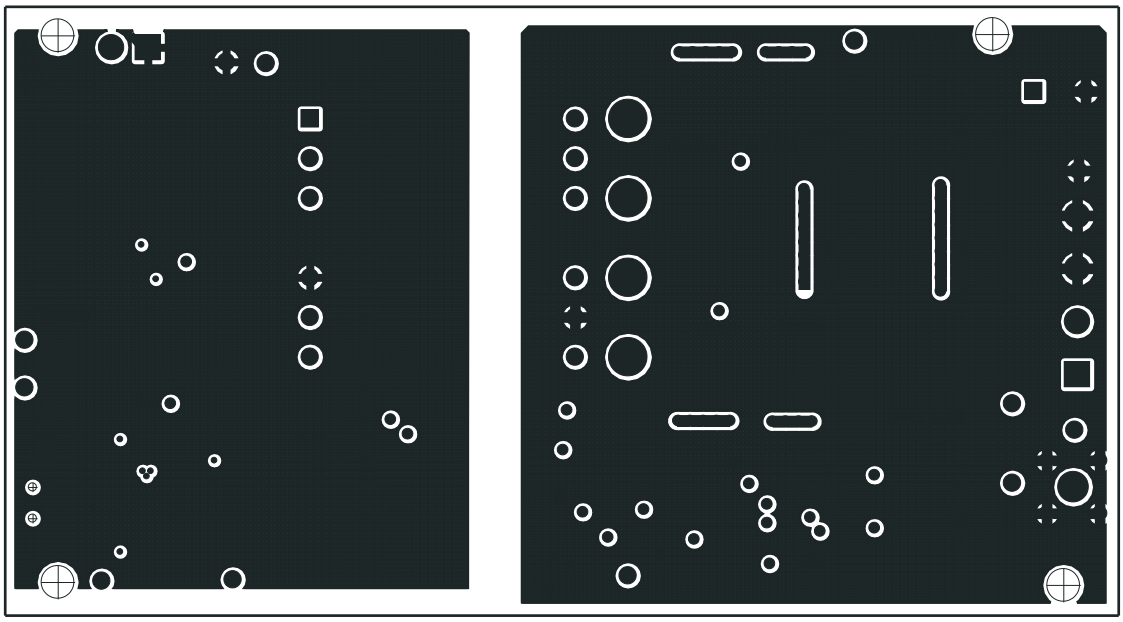

Figure 16. UCC25230EVM-662 Internal Layer 2 (top view)

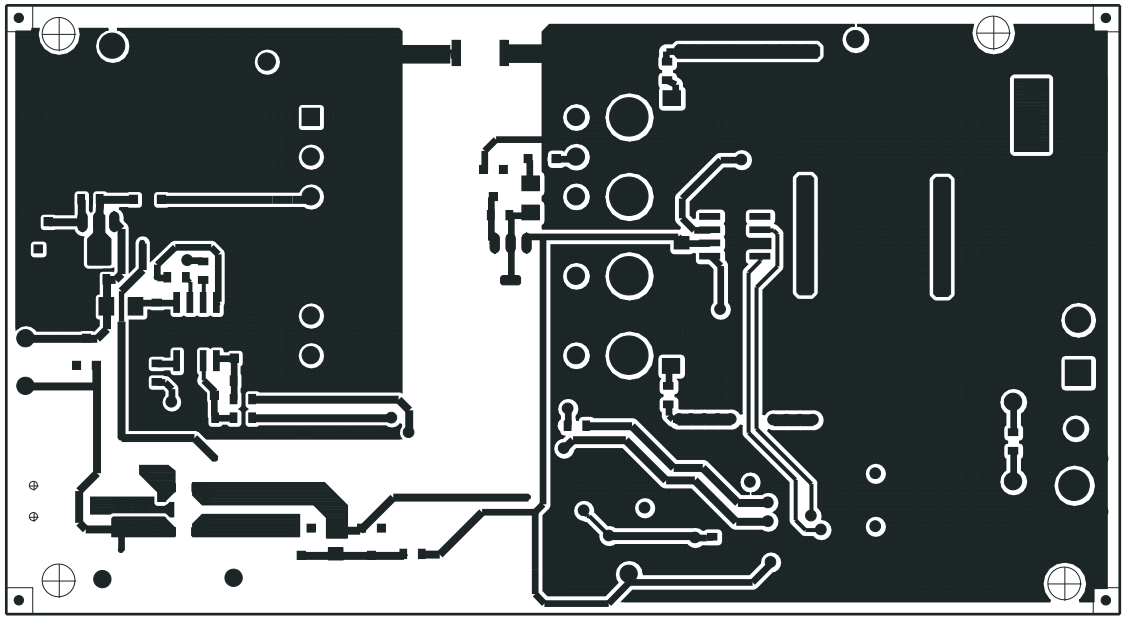

Figure 17. UCC25230EVM-662 Bottom Copper (top view)

9 List of Materials

The EVM components list according to the schematic shown in Figure 1

Table 3. UCC25230EVM-662 List of Materials

QTY	REF DES	DESCRIPTION	PART NUMBER	MFR
4	C1, C35, C41, C42	Capacitor, ceramic, 16 V, X7R, ±10%, 1 µF, 0603	Std	Std
3	C10, C37, C39	Capacitor, ceramic, 50 V, NP0, ±10%, 100 pF, 0603	Std	Std
3	C11, C29, C30	Capacitor, ceramic, 50 V, X7R, ±10%, 2.2 nF, 0603	Std	Std
2	C14, C16	Capacitor, ceramic, 50 V, NP0, ±5%, 120 pF, 0603	Std	Std
4	C2, C18, C19, C23	Capacitor, ceramic, 6.3 V, X5R, ±10%, 100 µF, 1812	Std	Std
1	C20	Capacitor, ceramic, 100 V, X7R, ±10%, 1 µF, 1206	Std	std
1	C22	Capacitor, ceramic, 2 kV, X7R, ±10%, 1000 pF, 1808	Std	Std
1	C28	Capacitor, ceramic, 50 V, X7R, ±10%, 470 pF, 0603	Std	Std
3	C3, C33, C36	Capacitor, ceramic, 16 V, X5R, ±10%, 4.7 µF, 0805	Std	Std
1	C32	Capacitor, aluminum, 25 V, ±20%, 470 µF, 0.315 inch	UVZ1E471MPD	Nichicon
1	C34	Capacitor, ceramic, 16 V, X7R, ±10%, 0.1 µF, 0603	Std	Std
1	C38	Capacitor, ceramic, 16 V, X5R, ±10%, 1 µF, 0805	Std	Std
3	C4, C6, C9	Capacitor, ceramic, 50 V, X5R, ±10%, 1.0 µF, 0603	Std	Std
8	C5, C17, C21, C24, C25, C31, C44, C45	Capacitor, ceramic, 100 V, X7R, ±10%, 2.2 µF, 1210	Std	Std
1	C7	Capacitor, ceramic, 50 V, X7R, ±10%, 680 pF, 0603	Std	Std
8	C8, C12, C13, C15, C26, C27, C40, C43	Capacitor, ceramic, 50 V, X7R, ±10%, 0.1 µF, 0603	Std	Std
0	D1, D7	Diode, switching, 90 V, 100 mA, high speed, open, SOD-323	1SS355TE-17	Rohm
2	D10, D11	Diode, Schottky, 40 V, 350 mA, SOD-323	SD103AWS-7-F	Diodes Inc
1	D13	Diode, Zener, 3.9 V, 20 mA, 225 mW, 5%, SOT23	BZX84C3V9LT1G	Onsemi
0	D14	Diode, Zener, 12 V, 20 mA, 225 mW, 5%, open, SOT23	BZX84C12LT1G	Onsemi
3	D2, D6, D12	Diode, switching, 150 mA, 75 V, 350 mW, SOT23	BAS16-V	Vishay-Liteon
1	D3	Diode, Zener, 8.2 V, 20 mA, 350 mW, 8.2 V, SOT23	MMBZ5237B-7-F	Diodes Inc
1	D4	Diode, dual Schottky, 200 mA, 30 V, SOT23	BAT54C	Vishay-Liteon
1	D5	Diode, dual Schottky, 300 mA, 30 V, SOT23	BAT54AFILM	ST
1	D8	Diode, Zener, 5.1 V, 20- mA, 225 mW, 5%, 5.1 V, SOT23	BZX84C5V1LT1G	Onsemi
0	D9	Diode, Zener, 11 V, 20 mA, 350 mW, open, SOT23	MMBZ5241B-7-F	Diodes Inc
1	J1	Terminal block, 2 pin, 6 A, 3.5 mm, 0.27 inch x 0.25 inch	OSTTE020161	OST
1	J2	Terminal block, 4 pin, 15 A, 5.1 mm, 0.80 inch x 0.35 inch	ED120/4DS	OST
1	L1	Inductor, SMT, 6 A, 8.8 mΩ, 1.0 µH, 0.28 inch x 0.27 inch	RLF7030T-1R0N6R4	TDK
1	L2	Inductor, power choke, ±20%, 1.3 µH, 18 mm x 18 mm	7443556130	Wurth Elektronik
1	L3	Inductor, SMT, 220 mA, 5.25 Ω, 220 µH, 0.19 inch x 0.19 inch	MA5401-AE	Coilcraft
0	Q1, Q3	Transistor, NPN, VCE = 100 V, IC = 1 A, open, SOT89	FCX493TA	Zetex
4	Q2, Q5, Q6, Q8	MOSFET, N-channel, 30 V, 50 A, 2.6 mΩ, LFPAK	RJK0328DPB	Renesas
2	Q4, Q7	MOSFET, N-channel, 100 V, 5.7 A, 25 mΩ, PWRPAK	SI7456DP-T1	Vishay
5	R1, R4, R29, R39, R43	Resistor, chip, 1/16 W, ± 1%, 10.0 kΩ, 0603	Std	Std
1	R10	Resistor, chip, 1/16 W, ±1%, 2.32 kΩ, 0603	Std	Std
0	R12	Resistor, chip, 1/16 W, ±1%, open, 0603	Std	Std
2	R14, R30	Resistor, chip, 1/16 W, ±1%, 1.00 kΩ, 0603	Std	Std

Table 3. UCC25230EVM-662 List of Materials (continued)

QTY	REF DES	DESCRIPTION	PART NUMBER	MFR
3	R15, R45, R47	Resistor, chip, 1/16 W, ±1%, 0 Ω, 0603	Std	Std
1	R16	Resistor, chip, 1/16 W, ±1%, 75.0 kΩ, 0603	Std	Std
2	R17, R19	Resistor, chip, 1/16 W, ±1%, 402 Ω, 0603	Std	Std
1	R18	Resistor, chip, 1/16 W, ±1%, 4.64 kΩ, 0603	Std	Std
2	R2, R13	Resistor, chip, 1/16 W, ±1%, 5.11 kΩ, 0603	Std	Std
1	R20	Resistor, chip, 1/16 W, ±1%, 6.81 kΩ, 0603	Std	Std
1	R21	Resistor, chip, 1/16 W, ±1%, 365 Ω, 0603	Std	Std
1	R22	Resistor, chip, 1/16 W, ±1%, 1.50 kΩ, 0603	Std	Std
1	R23	Resistor, chip, 1/8 W, ±1%, 316 kΩ, 0805	std	std
1	R24	Resistor, chip, 1/4 W, ±1%, 17.8 Ω, 1206	Std	Std
1	R25	Resistor, chip, 1/4 W, ±1%, 36.5 Ω, 1206	Std	Std
1	R26	Resistor, chip, 1/16 W, ±1%, 10.5 kΩ, 0603	Std	Std
1	R28	Resistor, chip, 1/16 W, ±1%, 20.0 kΩ, 0603	Std	Std
2	R3, R6	Resistor, chip, 1/16 W, ±1%, 23.2 kΩ, 0603	Std	Std
1	R31	Resistor, chip, 1/4 W, ±1%, 90.9 Ω, 1206	Std	Std
2	R32, R33	Resistor, chip, 1/4 W, ±1%, 20 Ω, 1206	Std	Std
1	R34	Resistor, chip, 1/16 W, ±1%, 47.5 kΩ, 0603	Std	Std
2	R35, R36	Resistor, chip, 1/16 W, ±1%, 1 Ω, 0603	Std	Std
0	R37	Resistor, chip, 1/4 W, ±1%, open, 1206	Std	Std
1	R38	Resistor, chip, 1/16 W, ±1%, 30.1 kΩ, 0603	std	std
2	R40, R41	Resistor, chip, 1/16 W, 1%, 90.9 kΩ, 0603	std	std
1	R42	Resistor, chip, 1/16 W, 1%, 2.49 kΩ, 0603	Std	Std
1	R46	Resistor, chip, 1/16 W, ±1%, 100 kΩ, 0603	Std	Std
2	R5, R27	Resistor, chip, 1/16 W, ±1%, 200 Ω, 0603	Std	Std
2	R7, R44	Resistor, chip, 1/16 W, ±1%, 49.9 Ω, 0603	Std	Std
1	R8	Resistor, chip, 1/16 W, ±1%, 51.1 kΩ, 0603	Std	Std
2	R9, R11	Resistor, chip, 1/16 W, ±1%, 49.9 kΩ, 0603	Std	Std
1	T1	Transformer, half bridge ±30%, 270 µH, 1.120 inch x 1.273 inch	AF5096	Vitec Electronics
1	T2	Xfmr, current sense, 100:1, 0.315 inch x 0.320 inch	CST2-100L	Coilcraft
1	T3	Transformer, 1 primary, 1 secondary, 785 µH, 0.460 inch x 0.340i inch	PA0185	Pulse
2	U1, U5	Photocoupler, SOP-4	PS2701-1	NEC
1	U2	120-V Boot, 3-A Peak, High-Side Low-Side Driver, SO8	UCC27201DDA	TI
1	U3	Advanced PWM Controller with Pre-Bias Operation, TSSOP-20	UCC28250PW	TI
1	U4	Dual 4-A Peak Low-Side MOSFET Driver, SO8	UCC27324D	TI
1	U6	12-V to 100-V Input, 0.2-A Output Switching Converter, VSON	UCC25230DRM	TI

Evaluation Board/Kit Important Notice

Texas Instruments (TI) provides the enclosed product(s) under the following conditions:

This evaluation board/kit is intended for use for **ENGINEERING DEVELOPMENT, DEMONSTRATION, OR EVALUATION PURPOSES ONLY** and is not considered by TI to be a finished end-product fit for general consumer use. Persons handling the product(s) must have electronics training and observe good engineering practice standards. As such, the goods being provided are not intended to be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including product safety and environmental measures typically found in end products that incorporate such semiconductor components or circuit boards. This evaluation board/kit does not fall within the scope of the European Union directives regarding electromagnetic compatibility, restricted substances (RoHS), recycling (WEEE), FCC, CE or UL, and therefore may not meet the technical requirements of these directives or other related directives.

Should this evaluation board/kit not meet the specifications indicated in the User's Guide, the board/kit may be returned within 30 days from the date of delivery for a full refund. THE FOREGOING WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE.

The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies TI from all claims arising from the handling or use of the goods. Due to the open construction of the product, it is the user's responsibility to take any and all appropriate precautions with regard to electrostatic discharge.

EXCEPT TO THE EXTENT OF THE INDEMNITY SET FORTH ABOVE, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

TI currently deals with a variety of customers for products, and therefore our arrangement with the user **is not exclusive.**

TI assumes **no liability for applications assistance, customer product design, software performance, or infringement of patents or services described herein.**

Please read the User's Guide and, specifically, the Warnings and Restrictions notice in the User's Guide prior to handling the product. This notice contains important safety information about temperatures and voltages. For additional information on TI's environmental and/or safety programs, please contact the TI application engineer or visit www.ti.com/esh.

No license is granted under any patent right or other intellectual property right of TI covering or relating to any machine, process, or combination in which such TI products or services might be or are used.

FCC Warning

This evaluation board/kit is intended for use for **ENGINEERING DEVELOPMENT, DEMONSTRATION, OR EVALUATION PURPOSES ONLY** and is not considered by TI to be a finished end-product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment in other environments may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of and the output voltage range of 3.2 V to 3.4 V.

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's 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, some circuit components may have case temperatures greater than 60°C. The EVM is designed to operate properly with certain components above 60°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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

EVALUATION BOARD/KIT/MODULE (EVM) ADDITIONAL TERMS

Texas Instruments (TI) provides the enclosed Evaluation Board/Kit/Module (EVM) under the following conditions:

The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies TI from all claims arising from the handling or use of the goods.

Should this evaluation board/kit not meet the specifications indicated in the User's Guide, the board/kit may be returned within 30 days from the date of delivery for a full refund. THE FOREGOING LIMITED WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. EXCEPT TO THE EXTENT OF THE INDEMNITY SET FORTH ABOVE, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

Please read the User's Guide and, specifically, the Warnings and Restrictions notice in the User's Guide prior to handling the product. This notice contains important safety information about temperatures and voltages. For additional information on TI's environmental and/or safety programs, please visit www.ti.com/esh or contact TI.

No license is granted under any patent right or other intellectual property right of TI covering or relating to any machine, process, or combination in which such TI products or services might be or are used. TI currently deals with a variety of customers for products, and therefore our arrangement with the user is not exclusive. TI assumes no liability for applications assistance, customer product design, software performance, or infringement of patents or services described herein.

REGULATORY COMPLIANCE INFORMATION

As noted in the EVM User's Guide and/or EVM itself, this EVM and/or accompanying hardware may or may not be subject to the Federal Communications Commission (FCC) and Industry Canada (IC) rules.

For EVMs **not** subject to the above rules, this evaluation board/kit/module is intended for use for ENGINEERING DEVELOPMENT, DEMONSTRATION OR EVALUATION PURPOSES ONLY and is not considered by TI to be a finished end product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or ICES-003 rules, which are designed to provide reasonable protection against radio frequency interference. Operation of the equipment may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

General Statement for EVMs including a radio

User Power/Frequency Use Obligations: This radio is intended for development/professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability of this EVM and its development application(s) must comply with local laws governing radio spectrum allocation and power limits for this evaluation module. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by Texas Instruments unless user has obtained appropriate experimental/development licenses from local regulatory authorities, which is responsibility of user including its acceptable authorization.

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

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

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.

For EVMs annotated as IC – INDUSTRY CANADA Compliant

This Class A or B digital apparatus complies with Canadian ICES-003.

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

Concerning EVMs including radio transmitters

This device complies with Industry Canada licence-exempt RSS standard(s). 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.

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.

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada.

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

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.

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.

【Important Notice for Users of this Product in Japan】

This development kit is NOT certified as Confirming to Technical Regulations of Radio Law of Japan

If you use this product in Japan, you are required by Radio Law of Japan to follow the instructions below with respect to this product:

1. Use this product 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 this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or
3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

Texas Instruments Japan Limited
(address) 24-1, Nishi-Shinjuku 6 chome, Shinjuku-ku, Tokyo, Japan

http://www.tij.co.jp

【ご使用にあたっての注】

本開発キットは技術基準適合証明を受けておりません。

本製品のご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

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。

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。

日本テキサス・インスツルメンツ株式会社
東京都新宿区西新宿６丁目２４番１号
西新宿三井ビル
http://www.tij.co.jp

EVALUATION BOARD/KIT/MODULE (EVM)
WARNINGS, RESTRICTIONS AND DISCLAIMERS

For Feasibility Evaluation Only, in Laboratory/Development Environments. Unless otherwise indicated, this EVM is not a finished electrical equipment and not intended for consumer use. It is intended solely for use for preliminary feasibility evaluation in laboratory/development environments by technically qualified electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems and subsystems. It should not be used as all or part of a finished end product.

Your Sole Responsibility and Risk. You acknowledge, represent and agree that:

1. You have unique knowledge concerning Federal, State and local regulatory requirements (including but not limited to Food and Drug Administration regulations, if applicable) which relate to your products and which relate to your use (and/or that of your employees, affiliates, contractors or designees) of the EVM for evaluation, testing and other purposes.
2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the EVM. Further, you are responsible to assure 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.
3. You will employ reasonable safeguards to ensure that your use of the EVM will not result in any property damage, injury or death, even if the EVM should fail to perform as described or expected.
4. You will take care of proper disposal and recycling of the EVM's electronic components and packing materials.

Certain Instructions. It is important to operate this EVM within TI's recommended specifications and environmental considerations per the user guidelines. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please 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 result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM User's 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, some circuit components may have case temperatures greater than 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use these EVMs.

Agreement to Defend, Indemnify and Hold Harmless. You agree to 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 use of the EVM that is not in accordance with the terms of the agreement. This obligation shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if the EVM fails to perform as described or expected.

Safety-Critical or Life-Critical Applications. If you intend to evaluate the components for possible use in safety critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, such as devices which are classified as FDA Class III or similar classification, then you must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

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

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as “components”) are sold subject to TI’s terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI’s terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers’ products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers’ products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have ***not*** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components which meet ISO/TS16949 requirements, mainly for automotive use. Components which have not been so designated are neither designed nor intended for automotive use; and TI will not be responsible for any failure of such components to meet such requirements.

Products		**Applications**	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
Data Converters	dataconverter.ti.com	Computers and Peripherals	www.ti.com/computers
DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
Clocks and Timers	www.ti.com/clocks	Industrial	www.ti.com/industrial
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Applications Processors	www.ti.com/omap	**TI E2E Community**	e2e.ti.com
Wireless Connectivity	www.ti.com/wirelessconnectivity		

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