User's Guide
SNVA612B–January 2012–Revised April 2013

AN-2200 LM5017 Evaluation Board

1 Introduction

The LM5017 evaluation board provides the design engineer with a fully functional buck regulator, employing the constant on-time (COT) operating principle. This evaluation board provides a 10 V output over an input range of 12.5 V to 100 V.

The board's specifications are:

- Input Range: 12.5 V to 95 V, transients up to 100 V (absolute maximum)
- Output Voltage: 10 V
- Output Current: 600 mA
- Nominal Switching Frequency ~ 200 kHz
- Measured Efficiency: 92.4% at 400 mA and V_{IN} = 24 V
- Board size: 2.95 in. x 1.8 in.

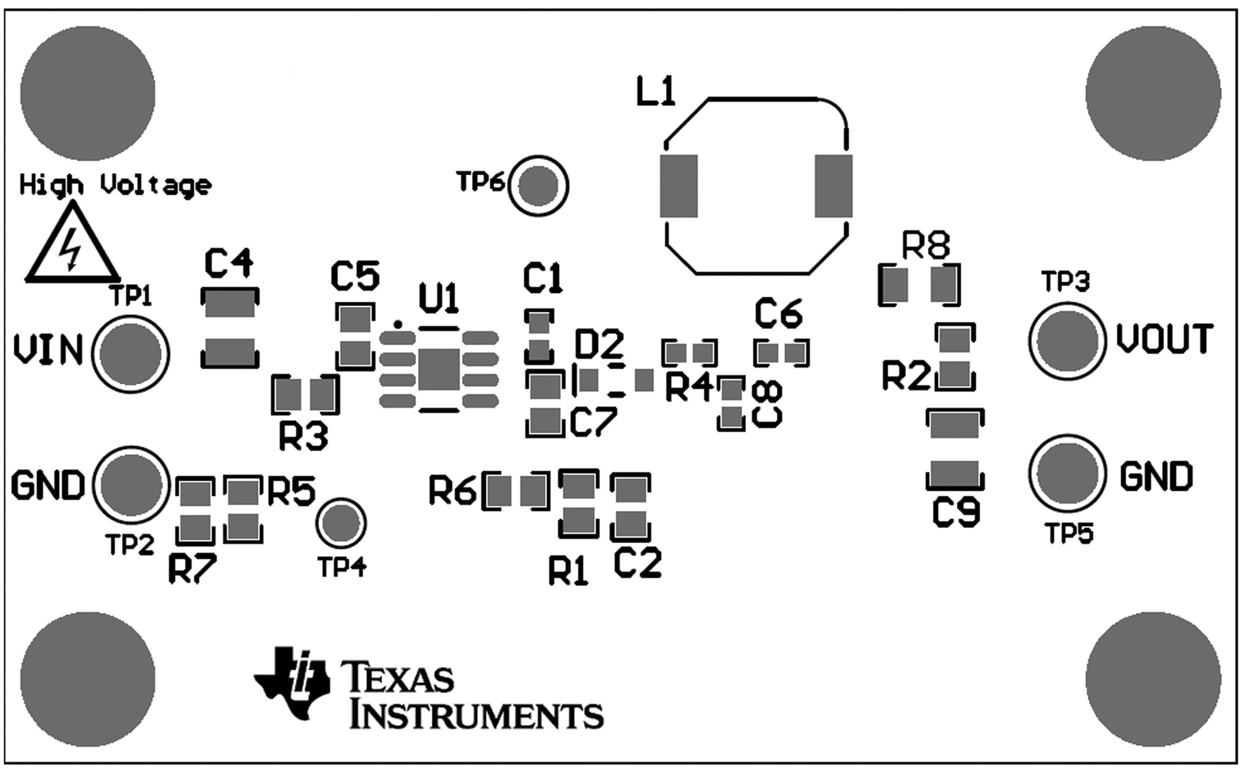


Figure 1. Evaluation Board (Top View)

All trademarks are the property of their respective owners.

2 Theory of Operation

When the circuit is in regulation, the buck switch is turned on each cycle for a time determined by R3 and V_{IN} according to Equation 1:

$$T_{ON} = \frac{10^{-10} \times R3}{V_{IN}} \tag{1}$$

The on-time of this evaluation board ranges from 5.56 µs at V_{IN} = 12 V to 702 ns at V_{IN} = 95 V. The on-time varies inversely with input voltage. At the end of each on-time, the buck switch is off for at least 144 ns. In normal operation, the off-time is much longer. During the off-time, the load current is supplied by the output capacitor (C9). When the output voltage falls sufficiently that the voltage at FB is below 1.225 V, the regulation comparator initiates a new on-time period. For stable, fixed frequency operation, a minimum of 25 mV of ripple is required at FB to switch the regulation comparator. For a more detailed block diagram and a complete description of the various functional blocks, see the *LM5017 100V, 600mA Constant On-Time Synchronous Buck Regulator Data Sheet* (SNVS783).

3 UVLO

The UVLO resistors (R5, R7) are selected using Equation 2:

$$V_{IN(HYS)} = I_{HYS} R_5 \tag{2}$$

and Equation 3:

$$V_{IN\ (UVLO,rising)} = 1.225V \times \left(\frac{R_5}{R_7} + 1\right) \tag{3}$$

On this evaluation board, R5 = 127 kΩ and R7 = 14.0 kΩ, resulting in UVLO rising threshold at V_{IN} = 12 V and a hysteresis of 2.5 V.

Figure 2 shows the evaluation board schematic.

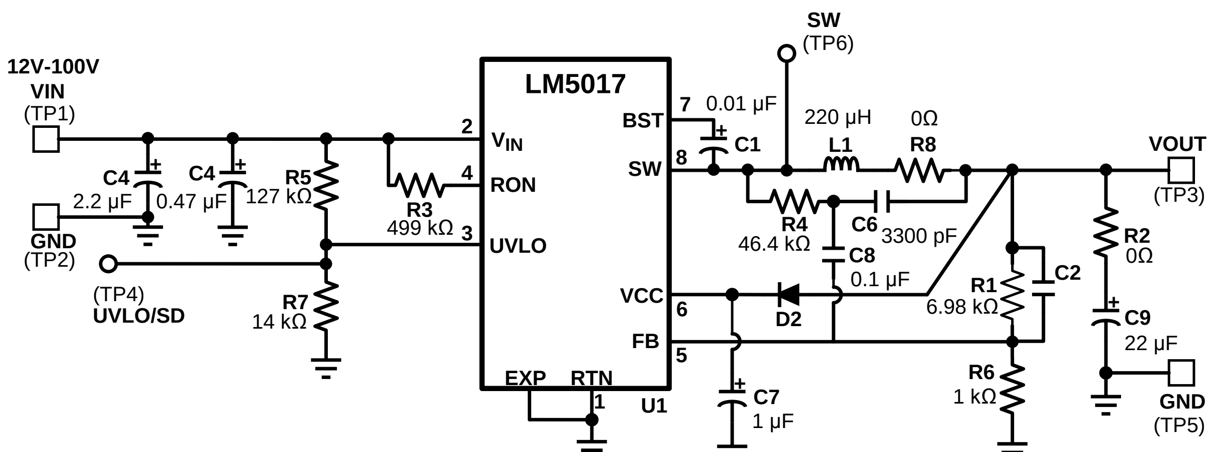


Figure 2. Complete Evaluation Board Schematic for LM5017-Based Buck Converter

4 Board Connection and Start-up

The input connections are made to the TP1 (V_{IN}) and TP2 (GND) terminals. The load is connected to the TP3 (V_{OUT}) AND TP5 (GND) terminals. Ensure the wires are adequately sized for the intended load current. Before start-up, a voltmeter should be connected to the input and output terminals. The load current should be monitored with an ammeter or a current probe. It is recommended that the input voltage be increased gradually to 12 V, at which time the output voltage should be 10 V. If the output voltage is correct, increase the input voltage as desired and proceed with evaluating the circuit. DO NOT EXCEED 100 V AT V_{IN}.

Table 1. Bill of Materials (BOM)

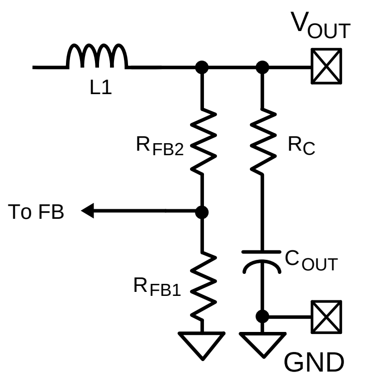
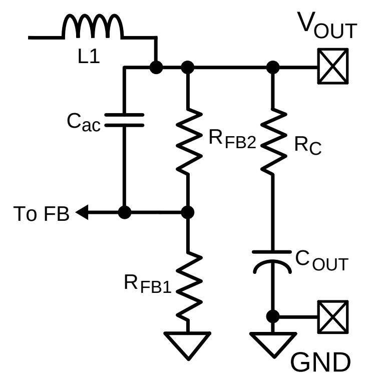
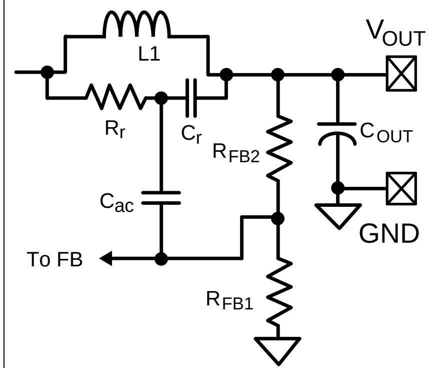
Item	Description	Mfg. Part Number	Package	Value
U1	Sync Switching Regulator	Texas Instruments, LM5017	SO PowerPAD-8	100 V, 0.6A
L1	Inductor	Wurth, 7447714221	10 mm x 10 mm	220 µH, 1.2A
	Alternate Inductor	Bourns, SRR1260–221k	12.5 mm x 12.5 mm	220 µH, 1.38A
	Alternate Inductor	Coilcraft, MSS1246–224K	12.3 mm x 12.3 mm	220 µH, 1.4A
D2	Diode	Central Semi, CMMSH1–40	SOD-123F	40 V, 1A
	Alternate Diode	NXP, BAS40H, 115	SOD123F	40 V, 120 mA
C1	Ceramic Capacitor	Murata, GRM188R71C103KA01D	0603	0.01 µF, 16V, X7R
C2				NA
C4	Ceramic Capacitor	Murata, GRM32ER72A225KA35L	1210	2.2 µF, 100 V, X7R
C5	Ceramic Capacitor	Murata, GRM21BR72A474KA73L	0805	0.47 µF, 100 V, X7R
C6	Ceramic Capacitor	TDK, C1608X7R1H332K	0603	3300 pF, 50 V, X7R
C7	Ceramic Capacitor	TDK, C2012X7R1C105K	0805	1 µF, 16 V, X7R
C8	Ceramic Capacitor	Murata, GRM188R71E104KA01D	0603	0.1 uF, 25 V, X7R
C9	Ceramic Capacitor	Murata, GRM32ER71E226KE15L	1210	22 uF, 25 V, X7R
R1	Resistor	Vishay–Dale, CRCW08056K98FKEA	0805	6.98k Ω, 1%
R2	Resistor	Panasonic, ERJ-6GEY0R00V	0805	0 Ω
R3	Resistor	Panasonic, ERJ-6ENF4993V	0805	499k Ω, 1%
R4	Resistor	Panasonic, ERJ-3EKF4642V	0603	46.4k Ω, 1%
R5	Resistor	Vishay-Dale, CRCW0805127KFKEA	0805	127k Ω, 1%
R6	Resistor	Vishay-Dale, CRCW08051K00FKEA	0805	1.0k Ω, 1%
R7	Resistor	Vishay-Dale, CRCW080514K0FKEA	0805	14.0k Ω, 1%
R8	Resistor	Yageo, RC1206JR-070RL	1206	0 Ω

5 Ripple Configuration

The LM5017 is a COT buck and requires adequate ripple at feedback (FB) node. Three commonly used ripple generation methods are shown in Table 2.

LM5017 evaluation board has been supplied with minimum ripple configuration (Type 3), but can be configured to Type 1 or Type 2 with modifications as suggested in Table 2.

Table 2. Ripple Configuration

Type 1 **Lowest Cost Configuration**	**Type 2** **Reduced Ripple Configuration**	**Type 3** **Minimum Ripple Configuration**
		
R4, C6, C8 open. Select R2: $R2 \geq \frac{40\ mV}{\Delta I_{L(MIN)}} \times \frac{V_{OUT}}{V_{REF}}$ (4)	R4 open, C6 = 0 Ω. Select R2 and C8: $C8 \geq \frac{5}{f_{SW}(R_1 \parallel R_6)}$ $R2 \geq \frac{40\ mV}{\Delta I_L}$ (5)	R2 = 0 Ω. Select R4, C6, and C8: C6 = 3300 pF C8 = 100 nF $R4 \times C6 \leq \frac{(V_{IN(MIN)} - V_{OUT})T_{ON}}{40\ mV}$ (6)

6 Performance Curves

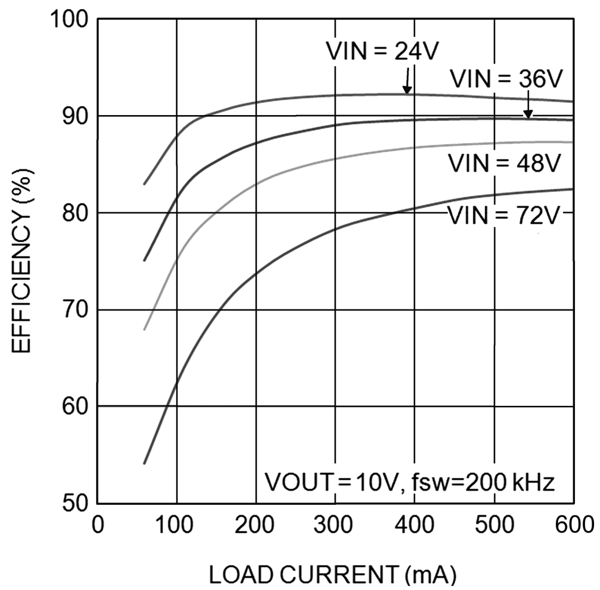


Figure 3. Efficiency vs Load Current

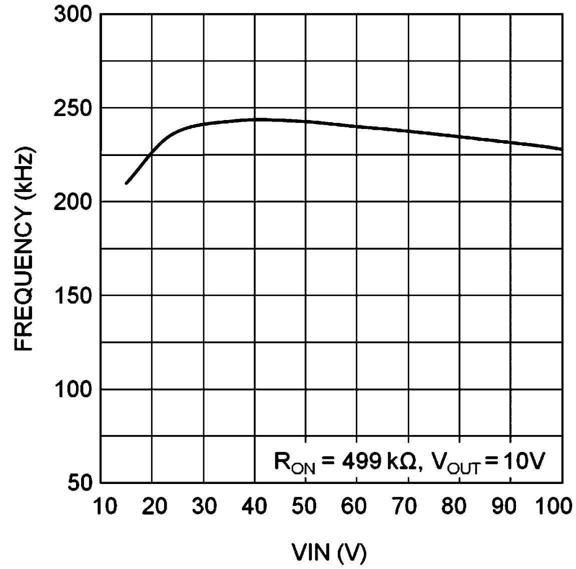


Figure 4. Frequency vs Input Voltage

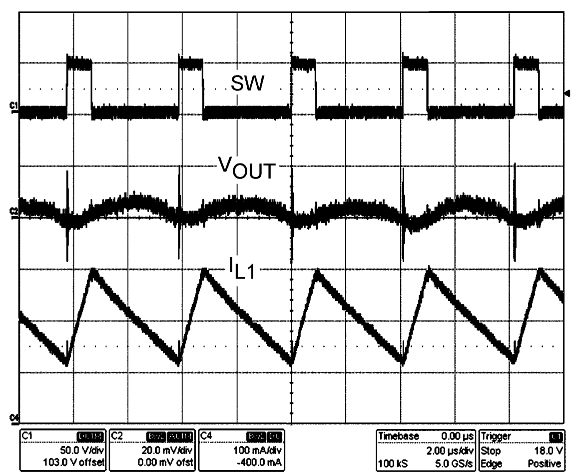


Figure 5. Typical Switching Waveform (V_{IN} = 48 V, I_{out} = 200 mA)

7 PC Board Layout

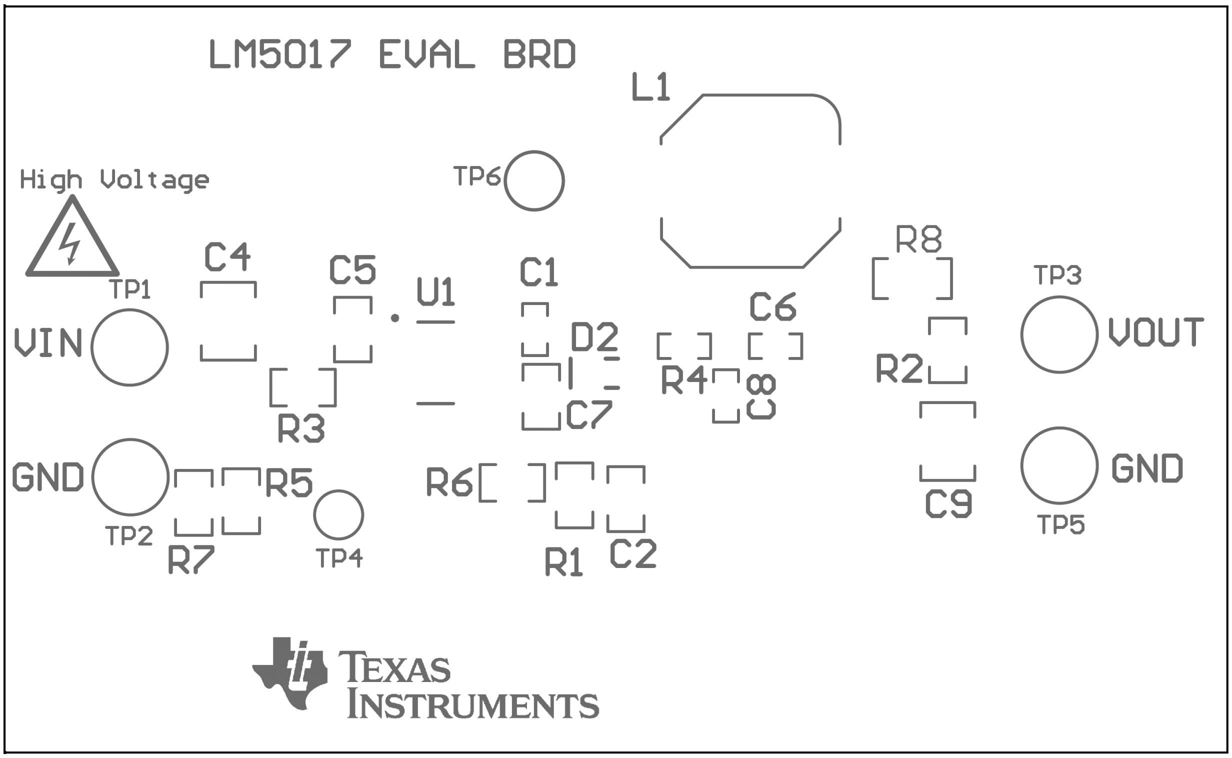


Figure 6. Board Silkscreen

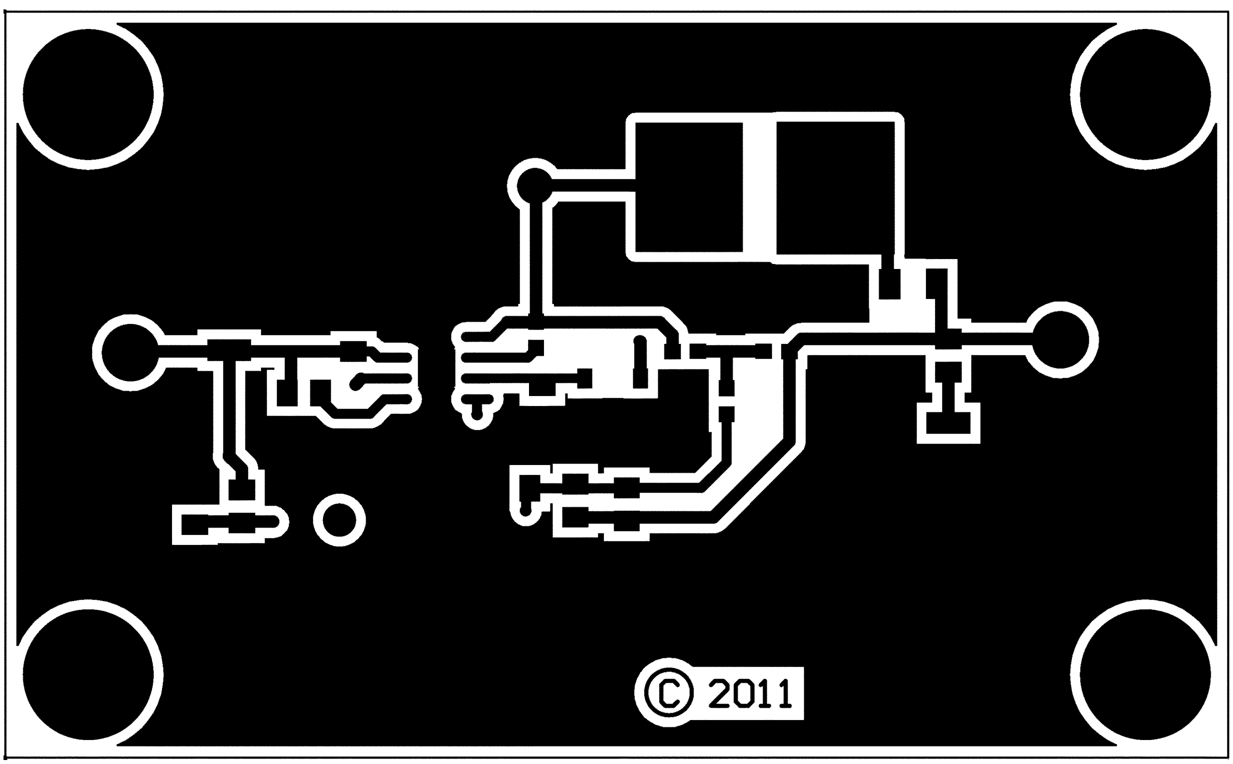


Figure 7. Board Top Layer

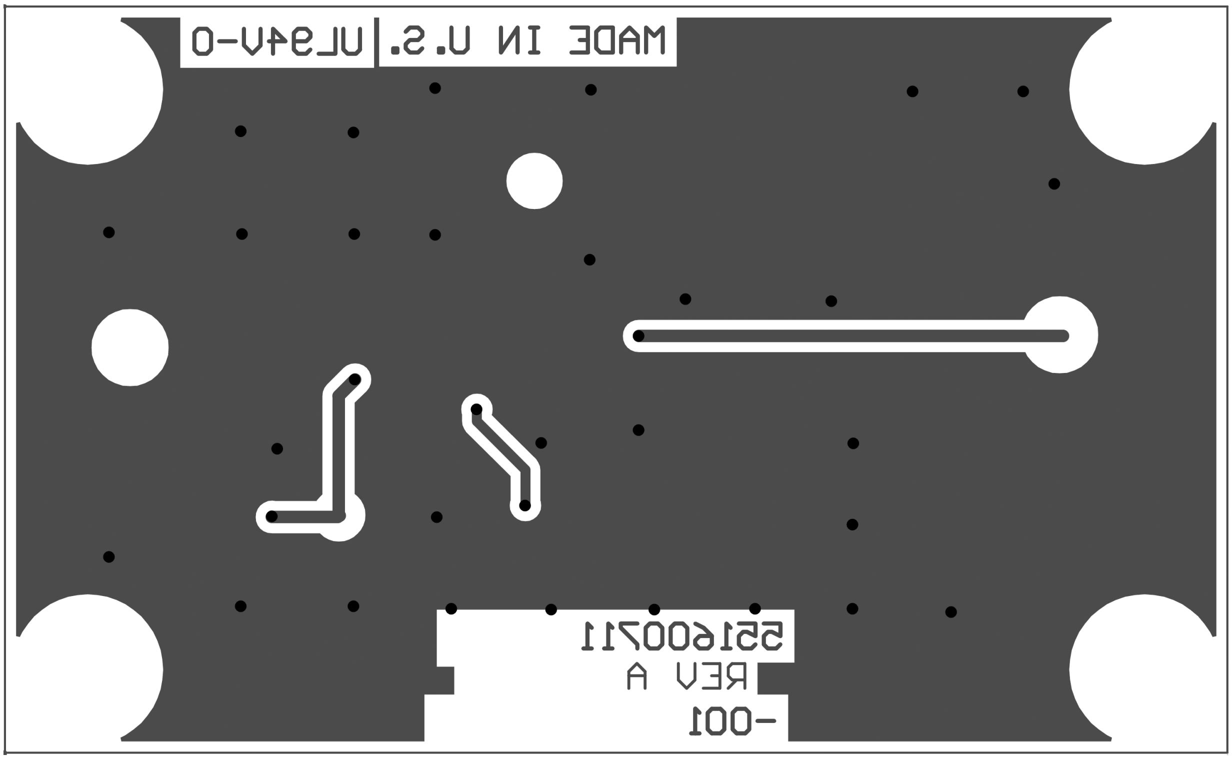


Figure 8. Board Bottom Layer

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 as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

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