AN-2112 LM25117 Evaluation Board

1 Introduction

The LM25117 evaluation board provides the design engineer with a fully functional synchronous buck converter based on Emulated Current Mode Control to evaluate the LM25117 controller IC. The evaluation board provides 3.3V output with a 9A current capability in addition with average output current information. The input voltage ranges from 6V to 36V.

2 Performance of the Evaluation Board

- Input Voltage Range: 6V to 36V
- Output Voltage: 3.3V
- Output Current: 9A
- Nominal Switching Frequency: 230 kHz
- Synchronous Buck Operation: Yes
- Diode Emulation Mode: Yes
- Hiccup Mode Overload Protection: Yes
- External VCC Sourcing: No
- Current Monitor Output: Yes

3 Powering and Loading Consideration

3.1 Proper Board Connection

When applying power to the LM25117 evaluation board certain precautions need to be followed. A misconnection can damage the assembly.

The input connection is made to the J1 (VIN+) and J2 (VIN-) connectors. The load is connected to the J3 (VOUT+) and J4 (VOUT-). Be sure to choose the correct connector and wire size when attaching the source power supply and the load. The average output current can be monitored at J5. Use RCA jack to remotely sense the current monitor output. TP5 is directly connected to UVLO and can be used as an input of the remote shutdown signal.

3.2 Source Power

The power supply and cabling must present low impedance to the evaluation board. Insufficient cabling or a high impedance power supply will droop during power supply application with the evaluation board inrush current. If large enough, this droop will cause a chattering condition upon power up. During power down, this insufficient cabling or a high impedance power supply will overshoot, results in a non-monotonic decay on the output.

An additional external bulk input capacitor may be required unless the output voltage droop/overshoot of the source power supply is less than 0.5V.

3.3 Loading

When using an electronic load, it is strongly recommended to power up the evaluation board at light load and then slowly increase the load. If it is desired to power up the evaluation board at maximum load, resistor bank must be used. In general, electronic load is best suited for monitoring steady state waveforms.

3.4 Air Flow

Prolonged operation with high input voltage at full power will cause the MOSFETs to overheat. A fan with a minimum of 200LFM should be always provided.

3.4.1 Quick Start-up Procedure

1. Set the power supply current limit to at least 11A. Connect the power supply to J1 and J2.
2. Connect the load with a 9A capacity between J3 and J4.
3. Set input voltage to 6V and turn it on.
4. Measure the output voltage. The output should be regulated at 3.3V.
5. Slowly increase the load current while monitoring the output voltage. The output should remain in regulation up to full load current.
6. Slowly sweep the input voltage from 6V to 36V while monitoring the output voltage. The output should remain in regulation.

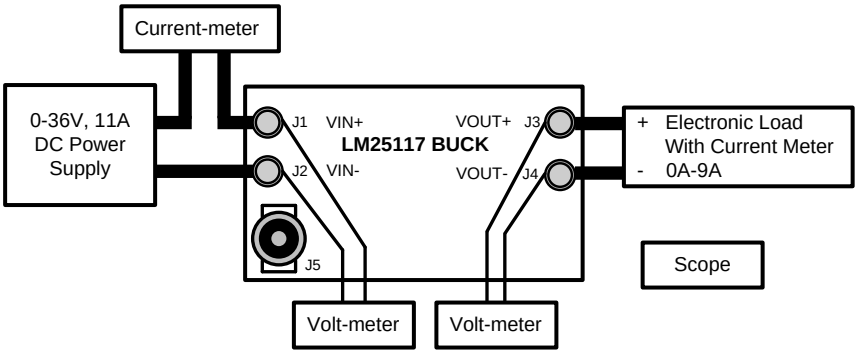
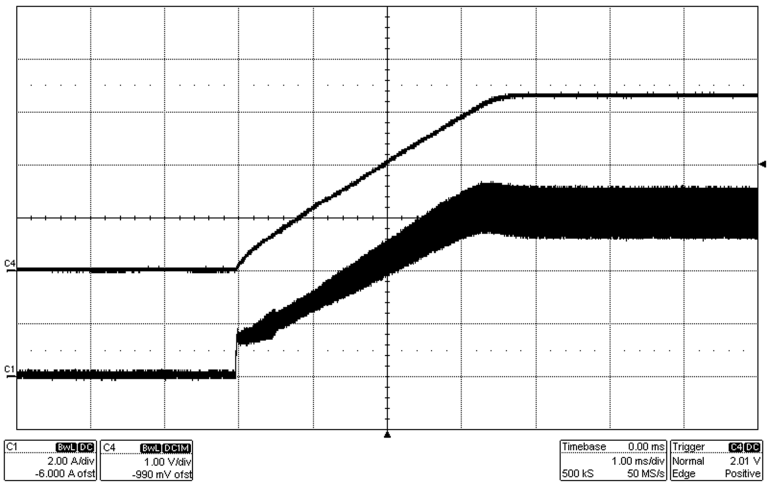


Figure 1. Typical Evaluation Setup

3.5 Waveforms

3.5.1 Soft Start

When applying power to the LM25117 evaluation board a certain sequence of events occurs. Soft-start capacitor and other components allow for a linear increase in output voltage. Figure 2 shows the output voltage during a typical start-up with a load of 0.5Ω

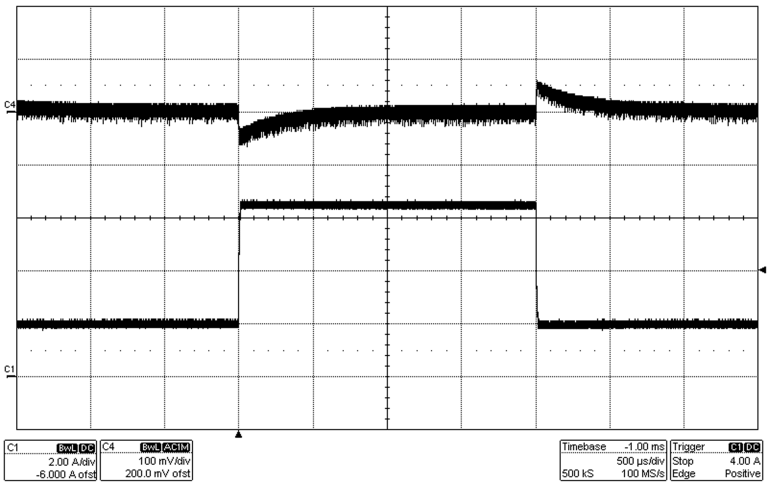


Conditions:
Input Voltage = 24VDC
0.5Ω Load on the output
Traces:
Top Trace: Output Voltage, Volt/div = 1V
Bottom Trace: Inductor Current, Amp/div=2A
Horizontal Resolution = 1ms/div

Figure 2. Start-Up with Resistive Load

3.5.2 Load Transient

Figure 3 shows the transient response for a load of change from 2A to 6.5A. The upper waveform shows output voltage droop and overshoot during the sudden change in output current shown by the lower waveform.

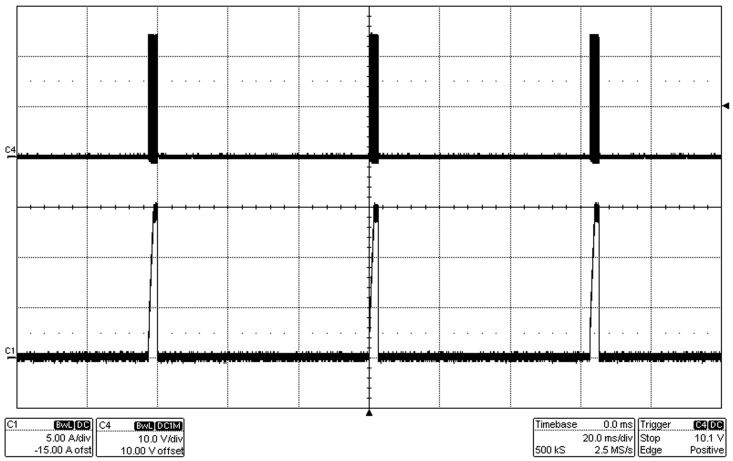


Conditions:
Input Voltage = 24VDC
Output Current 2A to 6.5A
Traces:
Top Trace: Output Voltage
Volt/div = 100mV, AC coupled
Bottom Trace: Load Current, Amp/div = 2A
Horizontal Resolution = 0.5ms/div

Figure 3. Load Transient Response

3.5.3 Overload Protection

The evaluation board is configured with hiccup mode overload protection. The restart time can be programmed by C20 restart capacitor. Figure 4 shows hiccup mode operation in the event of an output short.

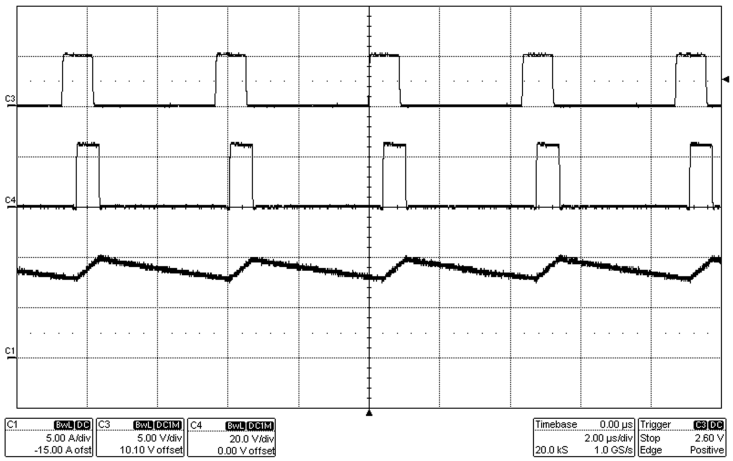


Conditions:
Input Voltage = 24VDC
Output Short
Traces:
Top Trace: SW Voltage Volt/div = 10V
Bottom Trace: Inductor Current, Amp/div = 5A
Horizontal Resolution = 20ms/div

Figure 4. Short Circuit

3.5.4 External Clock Synchronization

A TP3 (SYNC) test point has been provided on the evaluation board in order to synchronize the internal oscillator to the external clock. Figure 5 shows the synchronized switching operation.

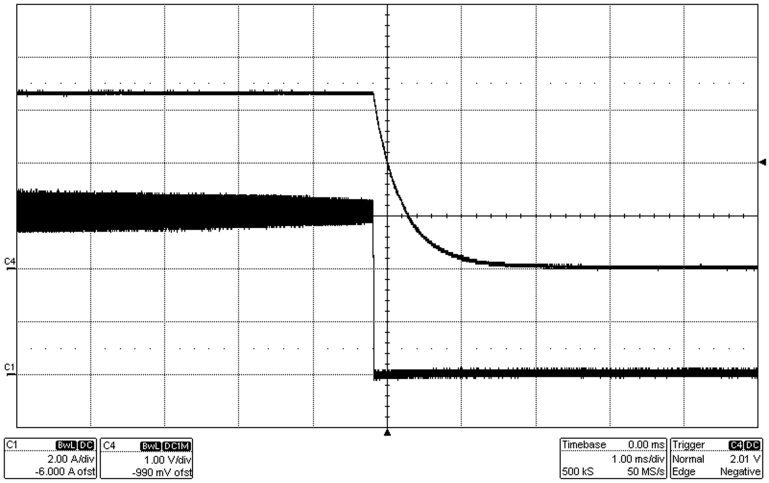


Conditions:
Input Voltage = 24VDC
Load Current = 9A
Traces:
Top Trace: SYNC pulse, 20% duty cycle, Volt/div = 5V
Middle Trace: SW voltage, Volt/div = 20V
Bottom Trace: Inductor Current, Amp/div = 5A
Horizontal Resolution = 2µs/div

Figure 5. Clock Synchronization

3.5.5 Shutdown

Figure 6 shows the shutdown procedure by powering off the source power. When UVLO pin voltage is less than 1.26V, the switching stops and soft-start capacitor is discharged by internal switches.



Conditions:
Input Voltage = 24VDC
0.5Ω Load on the Output
Traces:
Top Trace: Output Voltage, Volt/div = 1V
Bottom Trace: Inductor Current, Amp/div = 2A
Horizontal Resolution = 1ms/div

Figure 6. Shutdown

3.6 Performance Characteristics

Figure 7 shows the efficiency curves. During the efficiency measurement, monitor the current into and out of the evaluation board and monitor the voltage directly at the input and output terminals of the evaluation board.

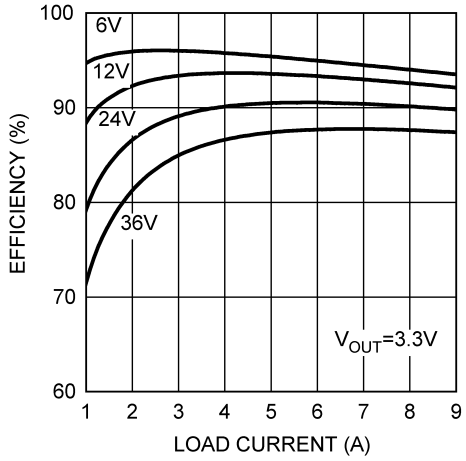


Figure 7. Typical Efficiency vs Load Current

3.7 Board Configuration

3.7.1 Loop Response

TP6 and TP7 have been provided in order to measure the loop transfer function. Refer to AN-1889(SNVA364) for detail information about the loop transfer function measurement.

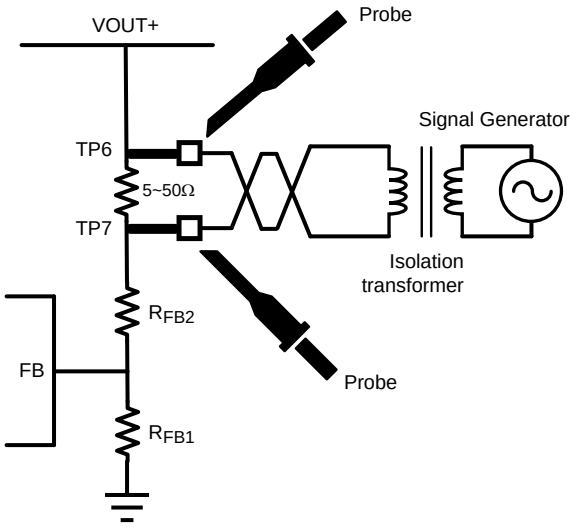
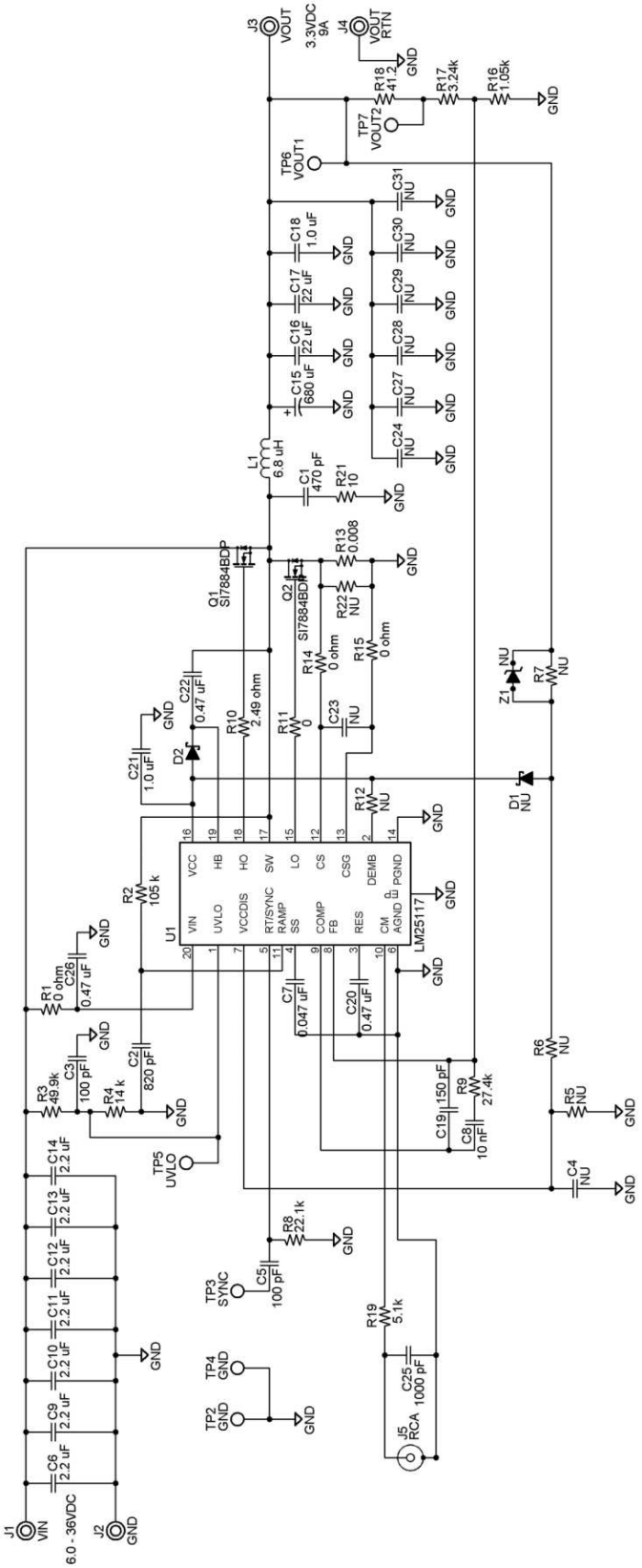


Figure 8. Loop Response Measurement Setup

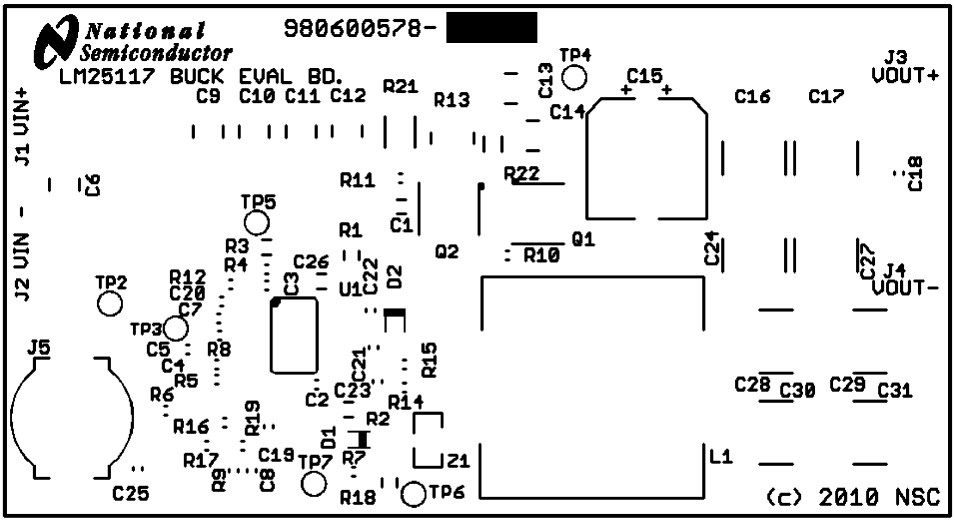
3.8 Evaluation Board Schematic



3.9 Bill of Materials

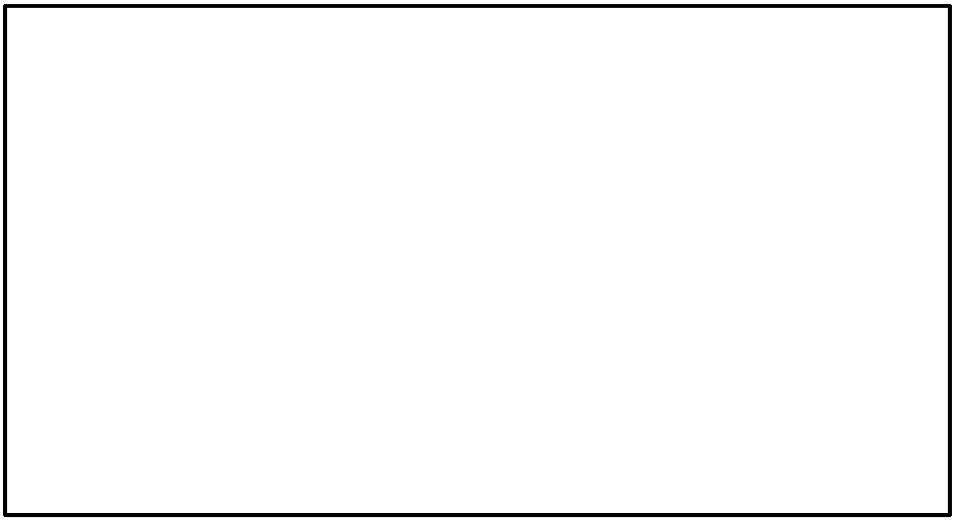
Part	Value	Package	Part Number	Manufacturer
C1	470pF, 100V, C0G	0805	C2012C0G2A471J	TDK
C2	820pF, 50V, C0G	0603	C1608C0G1H821J	TDK
C3, C5	100pF, 50V, C0G	0603	C1608C0G1H101J	TDK
C4, C23	NU	0603		
C6, C9, C10, C11, C12, C13, C14	2.2µF,50V, X7R	1210	C3225X7R1H225K	TDK
C7	0.047µF, 16V, X7R	0603	C1608X7R1C473K	TDK
C8	0.01µF, 25V, C0G	0603	C1608C0G1E103J	TDK
C15	680µF, 6.3V, 10mΩ	Φ10	APXA6R3ARA681MJC0G	UNITED CHEMICON
C16, C17	22µF, 16V, X7R	2220	C5750X7R1C226M	TDK
C18, C21	1µF, 16V, X7R	0603	C1608X7R1C105K	TDK
C19	150pF, 50V, C0G	0603	C1608C0G1H151J	TDK
C20, C22	0.47µF, 25V, X7R	0603	GRM188R71E474KA12	MURATA
C24, C27, C28, C29, C30, C31	NU	2220		
C25	1000pF, 50V, X7R	0603	C1608X7R1H102K	TDK
C26	0.47µF, 50V, X7R	0805	GRM21BR71H474KA88L	MURATA
R1	0 ohm	0805	MCR10EZPJ000	ROHM
R2	105k, 1%	0805	CRCW0805105KFKEA	VISHAY
R3	49.9k, 1%	0805	CRCW080549K9FKEA	VISHAY
R4	14k, 1%	0603	CRCW060314K0FKEA	VISHAY
R5, R6, R7, R12	NU	0603		
R11, R14, R15	0 ohm	0603	MCR03EZPJ000	ROHM
R8	22.1k, 1%	0603	CRCW060322K1FKEA	VISHAY
R9	27.4k, 1%	0603	CRCW060327K4FKEA	VISHAY
R10	2.49 ohm, 1%	0603	CRCW06032R49FKEA	VISHAY
R13	0.008 ohm, 1W, 1%	0815	RL3720WT-R008-F	SUSUMU
R16	1.05k ohm, 1%	0603	CRCW06031K05FKEA	VISHAY
R17	3.24k, 1%	0603	CRCW06033K24FKEA	VISHAY
R18	41.2 ohm, 1%	0805	CRCW080541R2FKEA	VISHAY
R19	5.1k, 5%	0603	CRCW06035K10JNEA	VISHAY
R21	10 ohm, 1%	2010	CRCW201010R0FKEF	VISHAY
R22	NU	1206		
D1	NU	PowerDI323		
D2	60V, 1A	SOD123F	PMEG6010CEH	NXP
Z1	NU	SOT89		
L1	6.8µH, 18.5A / 27A	18.2x18.3	7443556680	WE
Q1, Q2	40V, 58A	PowerPAK SO-8	SI7884BDP	VISHAY
U1		HTSSOP-20	LM25117	Texas Instruments
J1, J2, J3, J4	Terminal-Turret		1509	KEYSTONE
J5	RCA Jack, Blue		RCJ-025	CUI
TP2, TP3, TP4, TP5, TP6, TP7	Test Point		1040	KEYSTONE

3.10 PC Board Layout



TOP SILKSCREEN (.PLC) LAYER AS VIEWED FROM TOP

880600578-001



BOTTOM SILKSCREEN (.BPL) LAYER AS VIEWED FROM TOP

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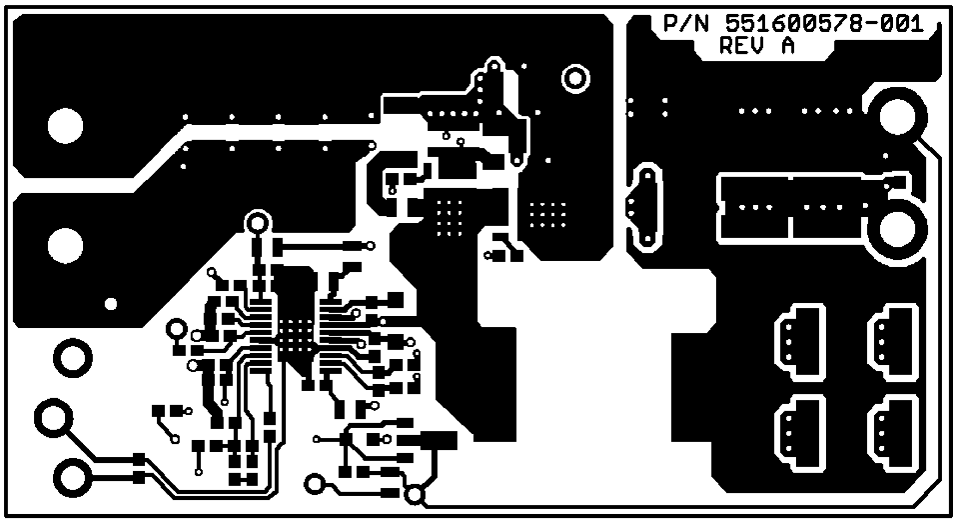

TOP (.CMP) LAYER AS VIEWED FROM TOP

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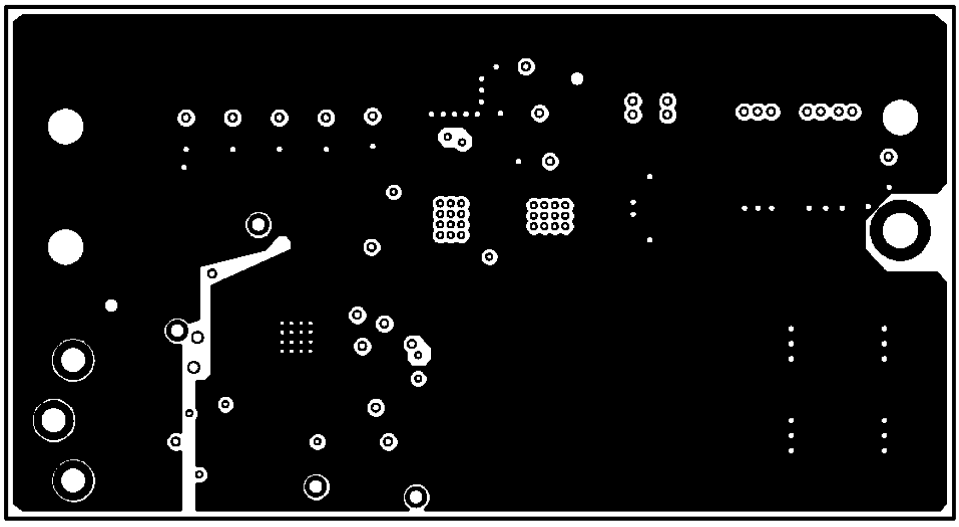

LAYER 2 (.LY2) AS VIEWED FROM TOP

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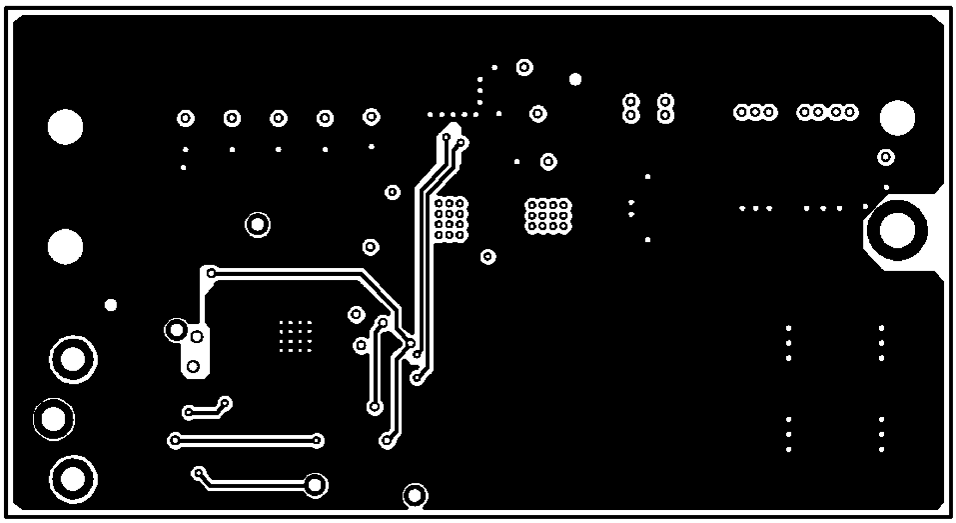

LAYER 3 (.LY3) AS VIEWED FROM TOP

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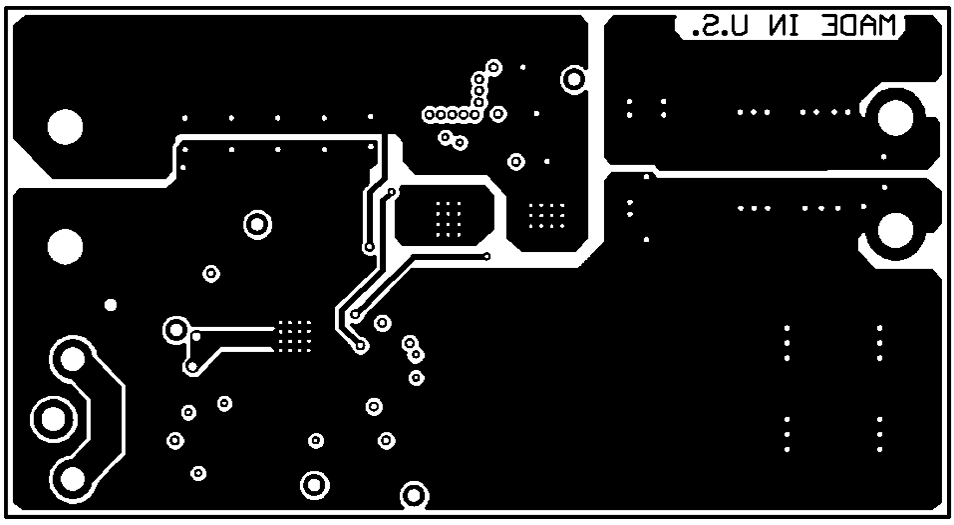

BOTTOM (.SOL) LAYER AS VIEWED FROM TOP

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NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

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3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

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

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

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https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html

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If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should 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 also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user 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, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure 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. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

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