AN-2281 LMR61428 Evaluation Module

1 Introduction

The LMR61428 evaluation module is designed to provide the power supply design engineer with a fully functional regulator design. The evaluation module takes the input from a single Li-Ion battery and boosts the voltage up to 5V at a constant load capability of 500mA. The switching frequency of the boost regulator is set to about 1200 kHz which helps in reducing the solution size and keeping switching noise out of the AM radio band. The printed circuit board consists of 4 layers of copper on FR4 material. The first middle layer is a solid ground layer which helps in minimizing the AC current loop. This user's guide contains the evaluation module schematic, a quick setup procedure using a bench power supply, and a Bill-of-Materials (BOM). For complete circuit design information, see *LMR61428 SIMPLE SWITCHER 14Vout, 2.85A Step-Up Voltage Regulator in VSSOP* (SNVS815).

2 Features

- One cell Li-Ion battery for Input Voltage
- 5V Output Voltage at 500mA Output Current
- Switching Frequency of 1.2 MHz
- Small Solution Size: 2.287 × 1.058 inches (58.09 × 26.87 mm)

3 Evaluation Board Schematic

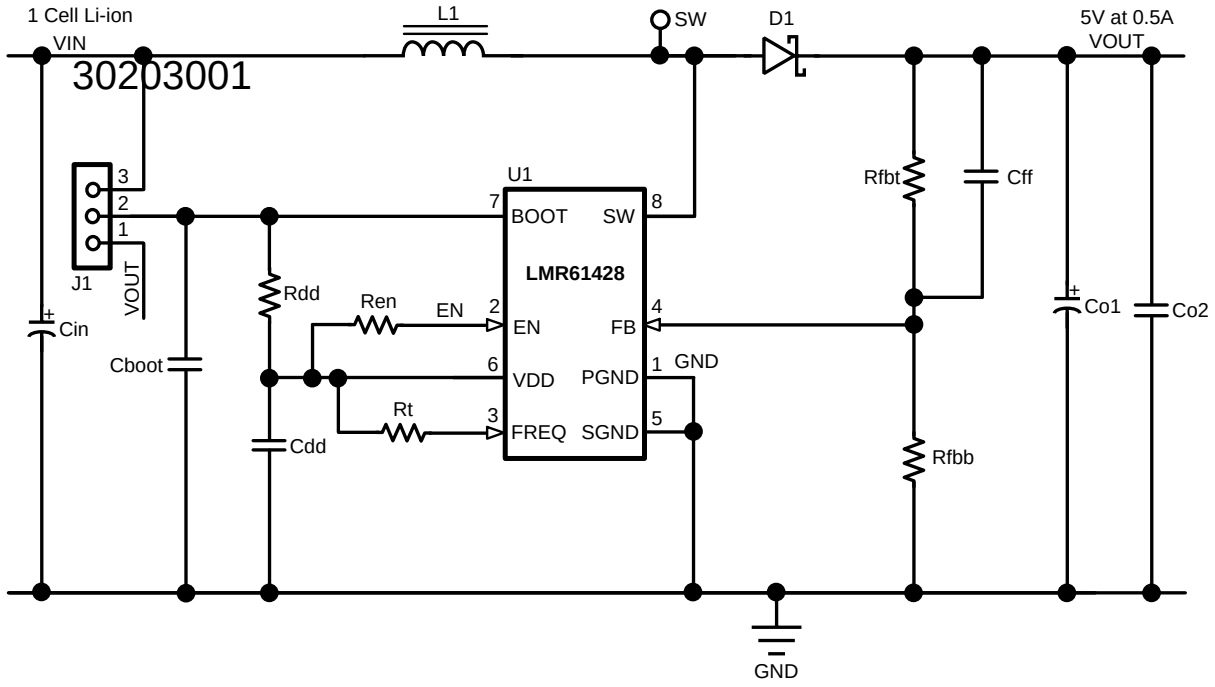


Figure 1. LMR61428 Evaluation Module Schematic

4 Powering and Loading Considerations

Read this entire section prior to attempting to power the evaluation board.

4.1 Quick Start Procedure

Step 1: Set the bench power supply current limit to 3A. Set the power supply voltage to 3.5V. Turn off the power supply output. Connect the power supply to the LMR61428 demo board. Positive connection to V_{IN} and negative connection to GND.

Step 2: Connect a load, as high as 0.5A, to the V_{OUT} terminal. Positive connection to V_{OUT} and negative connection to GND.

Step 3: Connect the shunt so as to short the pins 1 and 2 of the jumper J1. This sets the bootstrap to V_{OUT}

Step 4: The EN pin should be left open for normal operation.

Step 5: Turn on the bench power supply with no load applied to the LMR61428. If the shunt for the jumper J1 was in place, the V_{OUT} would be in regulation at a nominal 5V.

Step 6: Gradually increase the load and V_{OUT} should remain in regulation as the load is increased up to 0.5 Amps.

4.2 Shutdown Operation

The EVM includes a pull-up resistor Ren to enable the device. Use the EN post to disable the device by pulling this node to GND.

4.3 Bootstrap Operation

The EVM has a jumper installed to select the bootstrap option. The default condition is that the jumper be set such that the bootstrap voltage is obtained from the output. For more information, see *LMR61428 SIMPLE SWITCHER 14Vout, 2.85A Step-Up Voltage Regulator in VSSOP* (SNVS815).

4.4 Setting the Output Voltage

The output voltage of the step-up regulator can be set between 1.24V and 14V. But because of the gated oscillator scheme, the maximum possible input to output boost ratio is fixed. For a boost regulator,

$$V_{OUT} / V_{IN} = 1 / [1 - D] \quad (1)$$

The LMR61428 has a fixed duty cycle, D, of 70% typical. Therefore,

$$V_{OUT} / V_{IN} = 1 / 0.3 \quad (2)$$

This sets the maximum possible boost ratio of V_{IN} to V_{OUT} to about 3 times. The user can now estimate what the minimum design inputs should be in order to achieve a desired output, or what the output would be when a certain minimum input is applied. For example, if the desired V_{OUT} was 14V, then the least V_{IN} should be higher than V_{OUT} / 3. If the input voltage fell below this threshold, the output voltage would not be regulated because of the fixed duty cycle. If the minimum V_{IN} was guaranteed at 2V, the max possible V_{OUT} would be $V_{IN} \times 3$.

The V_{OUT} is set by connecting a feedback resistive divider made of R_{fbt} and R_{fbb}. The feedback resistor values are selected as follows:

$$R_{fbb} = R_{fbt} /[(V_{OUT}/ 1.24) - 1] \quad (3)$$

A value of 150kΩ is suggested for R_{fbt}. Then, R_{fbb} can be selected using Equation 3. A 39pF capacitor (C_{ff}) connected across R_{fbt} helps in feeding back most of the AC ripple at V_{OUT} to the FB pin. This helps reduce the peak-to-peak output voltage ripple as well as improve the efficiency of the step-up regulator, because a set hysteresis of 30mV at the FB pin is used for the gated oscillator control scheme.

4.5 Typical Test Setup

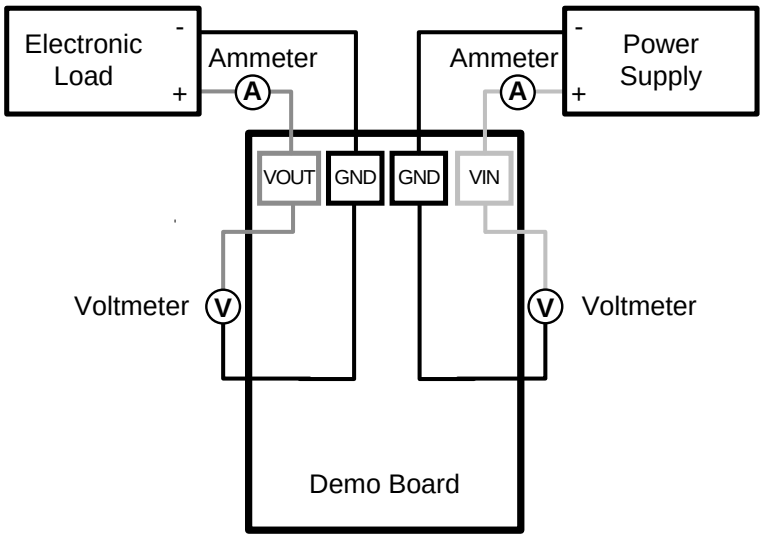


Figure 2. Efficiency Measurements

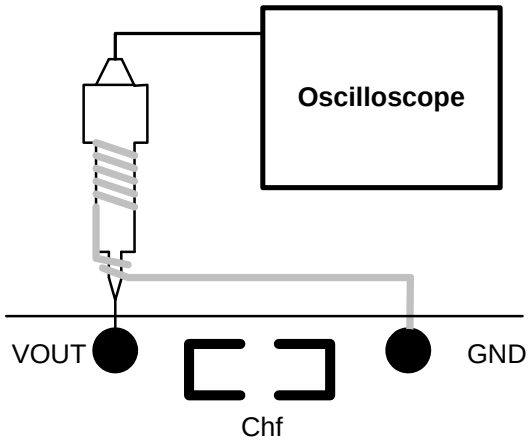


Figure 3. Voltage Ripple Measurements

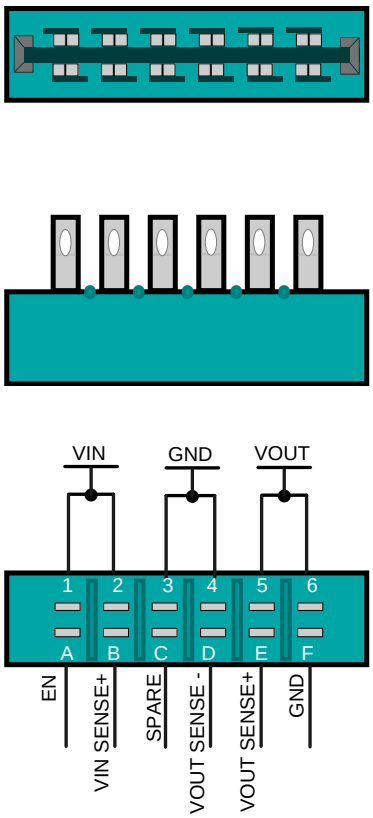


Figure 4. Edge Connector Schematic

4.6 Board Images

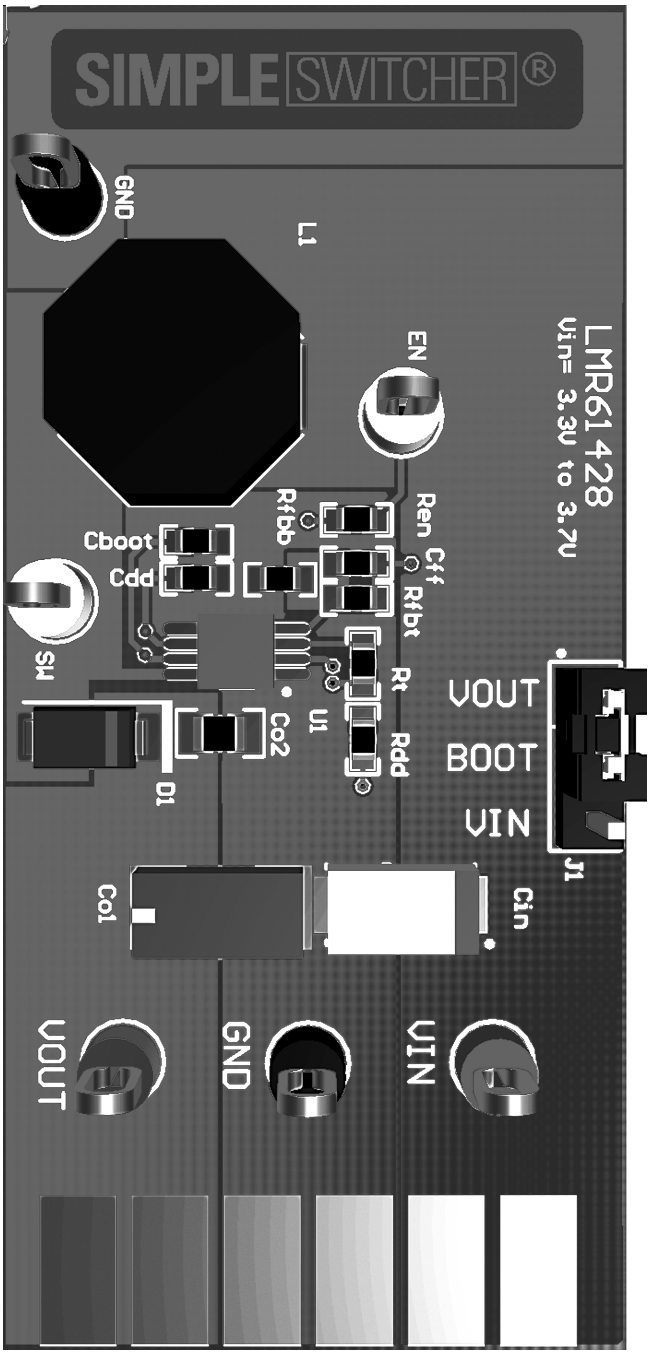


Figure 5. Top Side

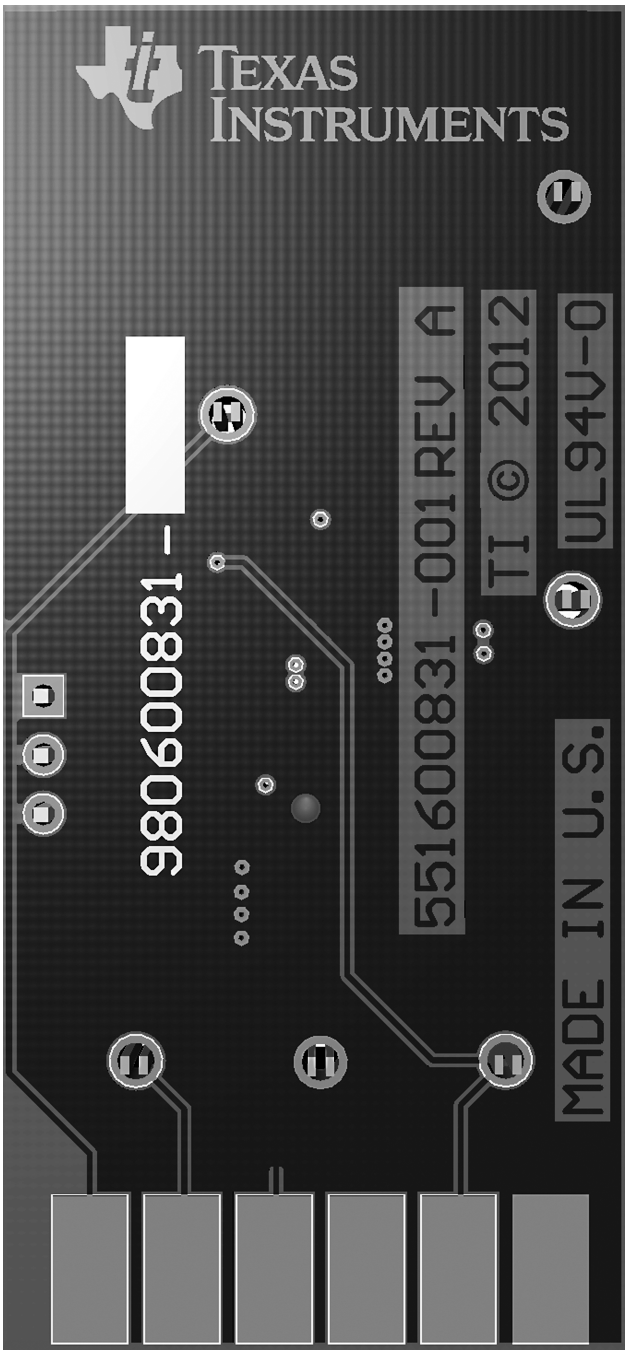
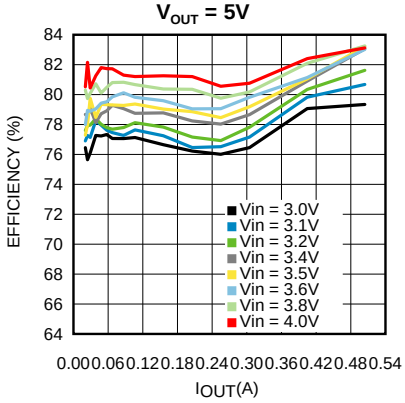


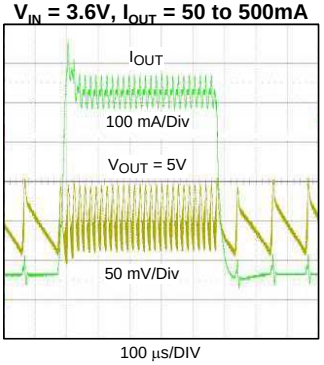
Figure 6. Bottom Side

5 Typical Performance Characteristics

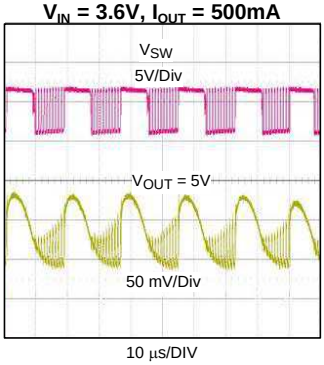
Efficiency vs. Load Current
V_{OUT} = 5V



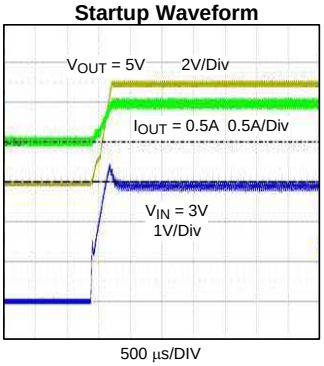
Load Transient Waveforms
V_{IN} = 3.6V, I_{OUT} = 50 to 500mA



Switching Node and Output Voltage Waveforms
V_{IN} = 3.6V, I_{OUT} = 500mA



Startup Waveform



6 Bill of Materials

ID	Part Number	Type	Size	Parameters	Qty	Vendor
U1	LMR61428	Boost Regulator	SOT-23		1	Texas Instruments
L1	SRU1048-8R2Y	Inductor	SMD	8.2uH, 4.6A, 0.015 ohm,	1	Bourns
D1	B220A-13-F	Diode	SMA	Schottky, 20V, 2A	1	Toshiba
Cin	293D226X9010C2TE3	Capacitor	SMD	Tantalum, 22uF, 10V	1	Vishay-Sprague
Co1	594D686X0010C2T	Capacitor	SMD	Tantalum, 68uF, 10V	1	Vishay-Sprague
Co2	08053D105KAT2A	Capacitor	0805	Ceramic, 1uF, 25V, X5R	1	AVX
Cdd	C0603C105K4PACTU	Capacitor	0603	Ceramic, 1uF, 16V, X5R	1	Kemet
Cff	GRM1885C2A390JA01D	Capacitor	0603	Ceramic, 39pF, 100V, C0G/NP0	1	MuRata
Rfbt	RG1608P-154-B-T5	Resistor	0603	150 kΩ	1	Susumu Co Ltd
Rfbb	RG1608P-4992-B-T5	Resistor	0603	49.9 kΩ	1	Susumu Co Ltd
Rt	CRCW0603118KFKEA	Resistor	0603	118 kΩ	1	Vishay-Dale
Rdd	CRCW060349R9FKEA	Resistor	0603	49.9 Ω	1	Vishay-Dale
Ren	CRCW060310K0FKEA	Resistor	0603	10.0 kΩ	1	Vishay-Dale
EN	5014	Test Point Loop		Yellow	1	Keystone
VIN	5010	Test Point Loop		Red	1	Keystone
VOUT	5013	Test Point Loop		Orange	1	Keystone
GND	5011	Test Point Loop		Black	2	Keystone
SW	5012	Test Point Loop		White	1	Keystone
J1	PBC03SAAN	Header		100mil, 1x3	1	Sullins Connector Solutions
SH-J1	969102-0000-DA	Shunt		100mil, Black	1	3M

7 PCB Layout

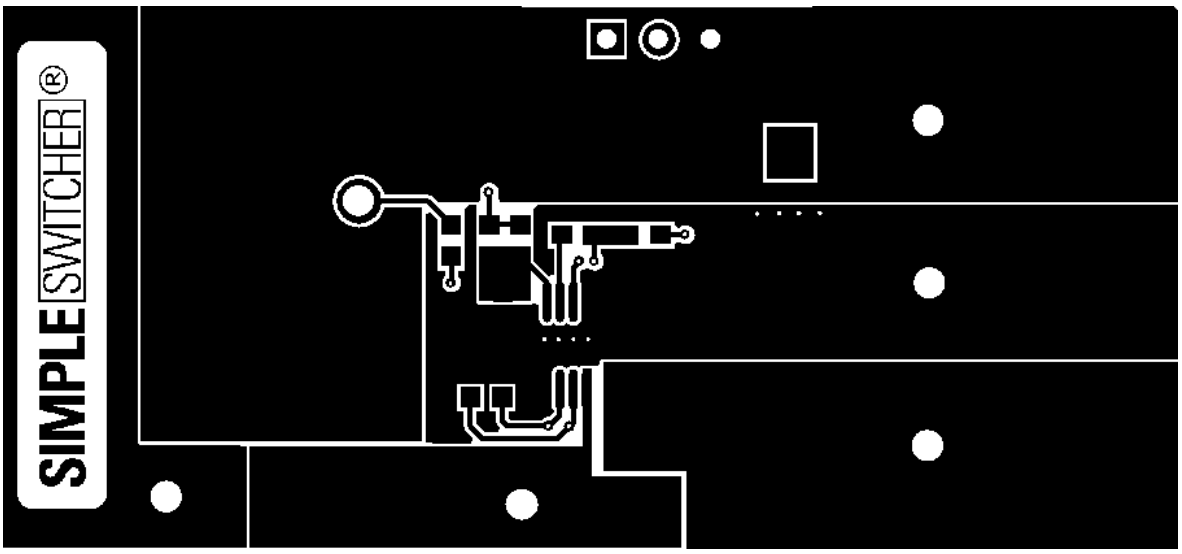


Figure 7. Top Copper

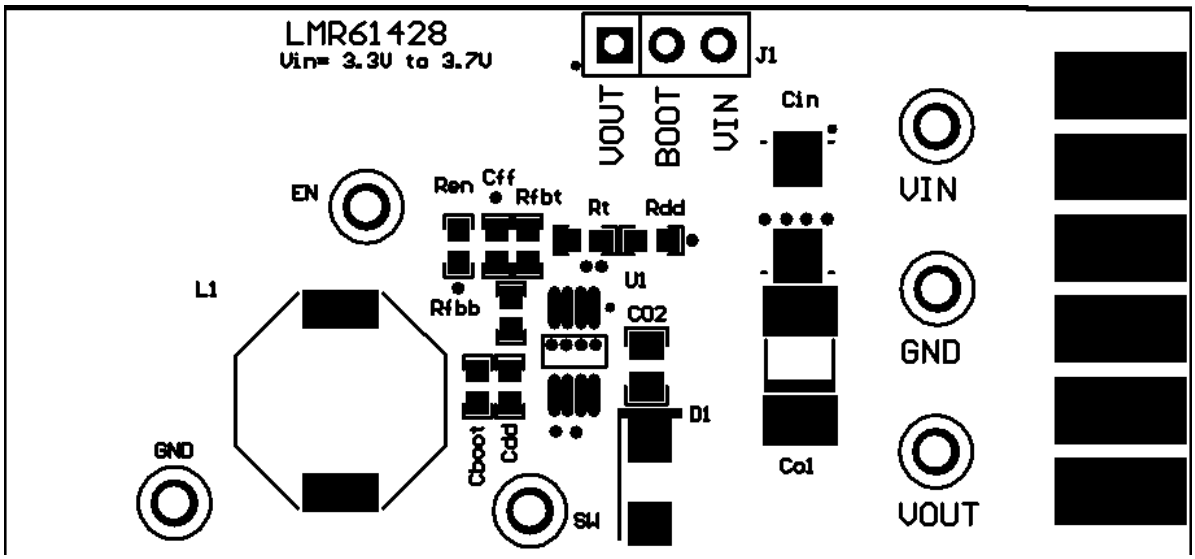


Figure 8. Top Overlay

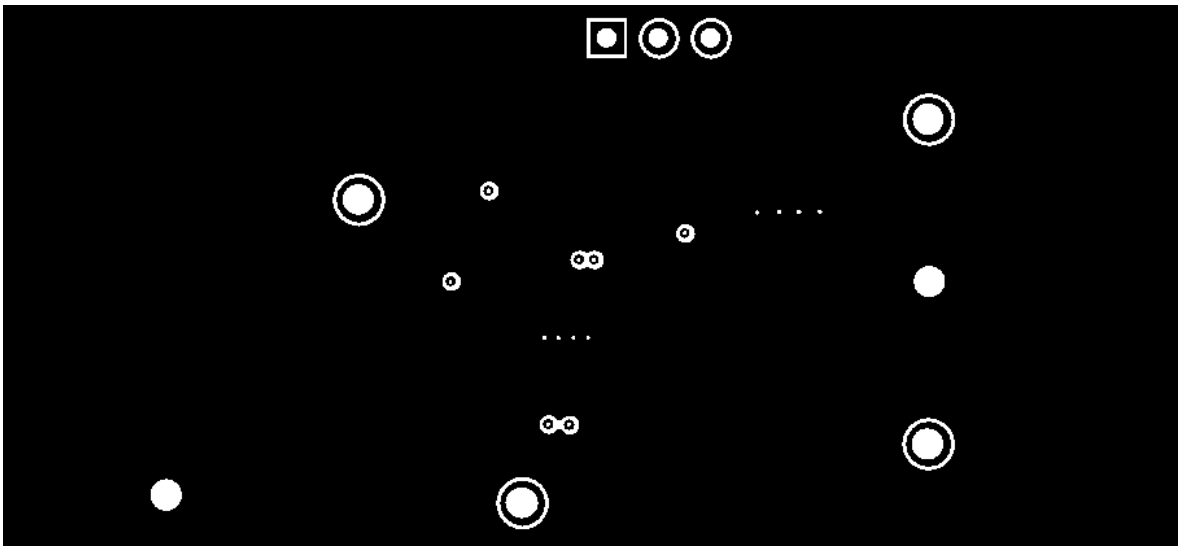


Figure 9. Internal Layer 1

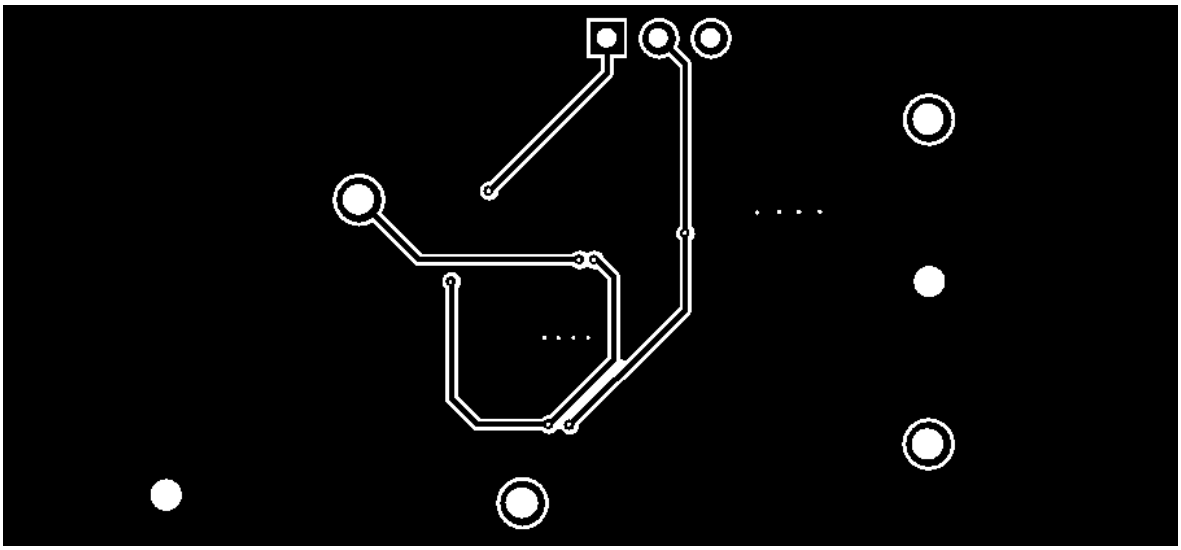


Figure 10. Internal Layer 2

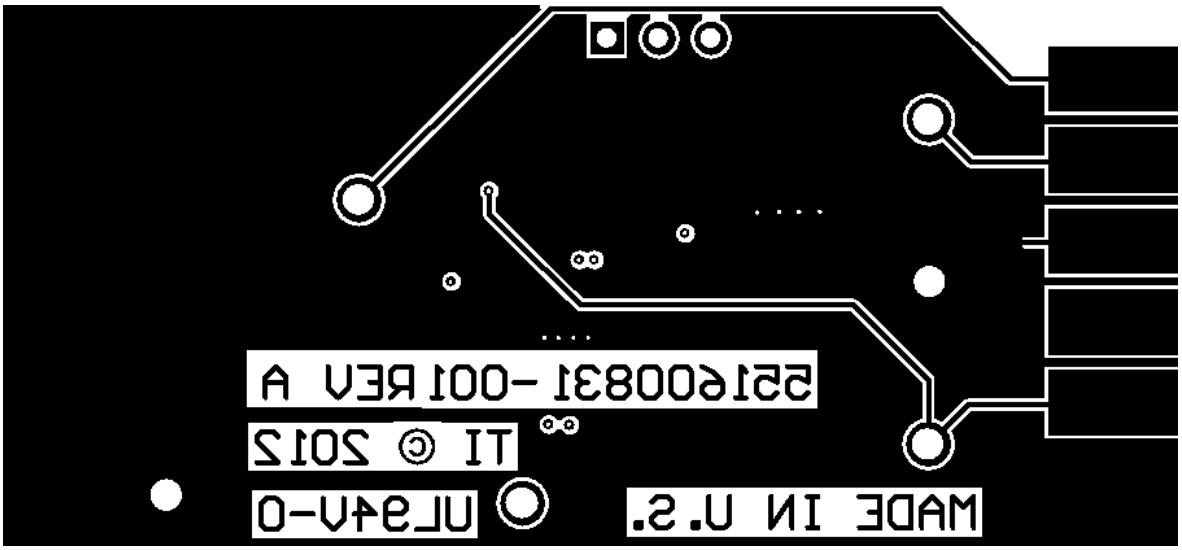


Figure 11. Bottom Copper

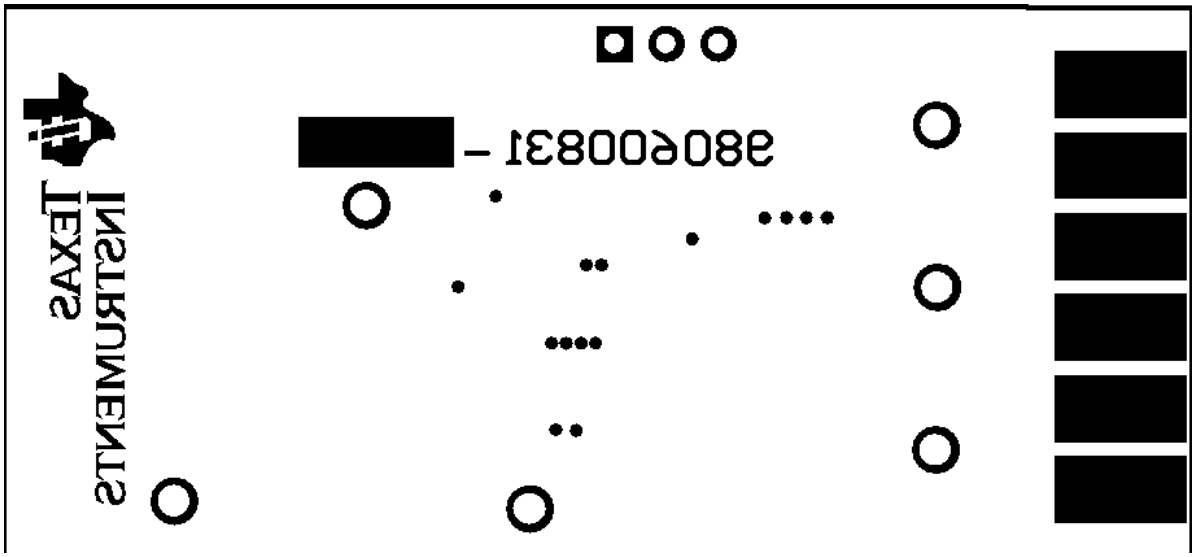


Figure 12. Bottom Overlay

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NOTE:

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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.

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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.

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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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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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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.

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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.

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