LM53600NAEVM and LM53601LAEVM

User's Guide

Literature Number: SNAU191
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Contents

Introduction

The LM53600/01 Evaluation Module helps a designer evaluate the operation and performance of the LM53600/01 wide input voltage automotive Buck regulator. This board enables the user to test external synchronization, RESET/Power Good output, precision enable, and operation in both Auto mode for high efficiency at light load and FPWM mode which maintains a constant frequency while lightly loaded. Both the EN and SYNC/MODE pins are rated for operation up to 36 V with excursions to 42 V. Please refer to the LM53600/01 data sheet for more information.

Note that there is a separate EVM for adjustable versions of the LM53600/01 which can be found at www.TI.com/product/lm53601-q1.

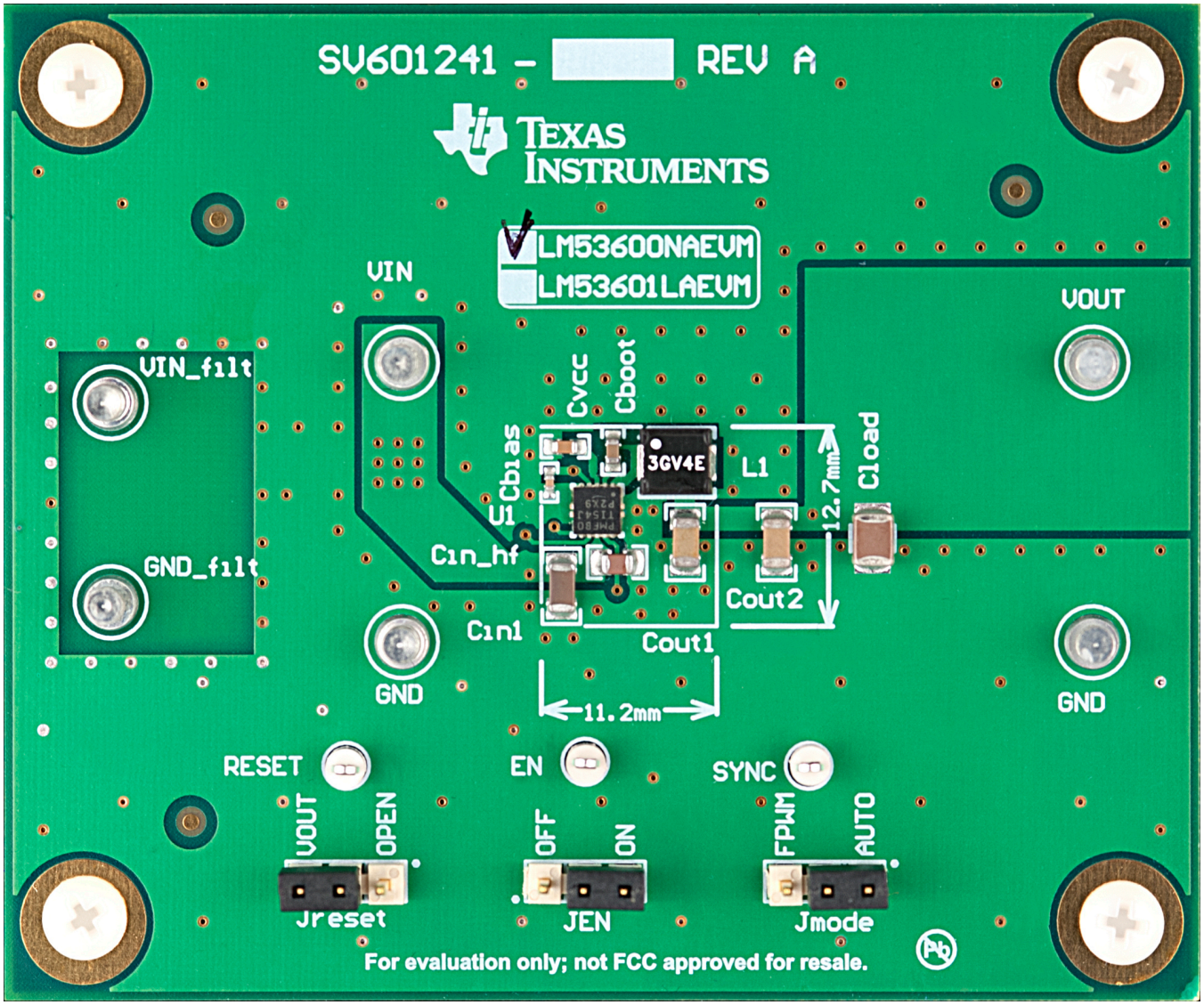


Figure 1-1. LM53600NAEVM

Setup

Both the LM53600NAEVM and LM53601LAEVM are ready to operate. There are two sets of input terminals. The first pair, labeled VIN_filt and GND_filt, connects the power source to the LM53600/01 regulator through and EMI filter. The second set of terminals, labeled VIN and GND, connects the power source directly to the LM53600/01, bypassing the EMI filter. Output terminals are labeled VOUT and GND.

There are three connectors that are used in order to control the LM53600/01. A jumper can be connected on each of these connectors. Refer to the schematic in Chapter 6 for details on the connection of these jumpers.

2.1 Jumper Options

Designator	LM53600/01 Function	Jumper Position	Result
Jreset	RESET output	VOUT	Pulls up RESET output to VOUT through a 100 kΩ resistor. Since RESET output is open drain, pull up is necessary to observe operation.
		OPEN	RESET output pull-up disconnected: A user can connect to pull-up source of her/his choice (<6 V) through RESET TP with a pull-up resistor in series limiting current when RESET pin goes low.
JEN	Enable	ON	Connects EN to VIN through a 100 kΩ resistor: Enables the part.
		OFF	Connects EN to GND through a 100 kΩ resistor: Disables the part.
Jmode	FPWM / Auto modes	AUTO	Connects SYNC/MODE pin to ground through a 100 kΩ resistor activating Auto mode. During Auto mode, the part lowers frequency while lightly loaded to increase efficiency, diode emulation active.
		FPWM	Connects SYNC/MODE pin to VIN through a 100 kΩ resistor activating FPWM mode. In FPWM mode, the part operates without diode emulation and does not reduce frequency under light load. Note that since there is also a 100 kΩ resistor to ground there will be leakage – remove Rsync to eliminate this leakage.

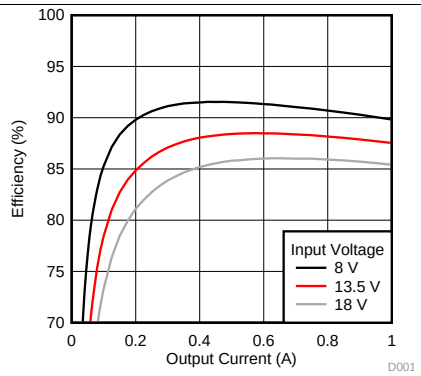
2.2 Test Points and Connectors

Group	Purpose	Marking	Position
EMI filter power input	Apply power here for testing that involves filtered ripple testing such as conducted EMI testing	VIN_filt	Turret type located on the left side of the board
		GND_filt	Turret type located on the left side of the board
Unfiltered power input	Apply power here when testing only concerns properties of the LM53600/01's Buck regulator on this board.	VIN	Turret type located near the center of the board
		GND	Turret type located near the center of the board
Power output	This pair connects to the LM53600/01's output	VOUT	Turret type located on the right side of the board
		GND	Turret type located on the right side of the board
Reset TP	Connects directly to the LM53600/01's RESET output. Use this TP to monitor the state of RESET. A user can connect to pull-up source of her/his choice (<6 V) with a pull-up resistor in series limiting current when RESET pin goes low.	RESET	Loop type located on the lower left side of the board
Enable TP	Connects directly to the LM53600/01 EN input. Use this TP to monitor the voltage on EN or apply voltage to EN.	EN	Loop type located on the lower center of the board
Sync TP	Connects directly to the LM53600/01 SYNC/MODE input. Use this TP to monitor the voltage on SYNC/MODE or apply voltage to SYNC/MODE. Note that a when synchronizing the LM53600/01 to an external clock, the clock should be applied to this TP not at Jmode since the 100 kΩ protection resistor, Rmode, will slow a clock signal applied through Jmode. Also note that this node has a 100 kΩ pull down resistor, Rsync, making Auto mode this board's default. This resistor may be removed if a high value pull down is not desirable.	SYNC	Loop type located on the lower right side of the board

2.3 Quick Start

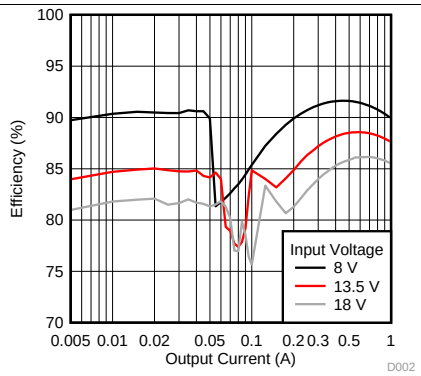
Connect the power supply to either the VIN_filt, GND_filt terminal pair, or the VIN, GND terminal pair. The only jumper that need be installed is on JEN and should be in the ON position as marked on the board. The default mode of operation is normal or *Auto* mode (Light load mode enabled; see data sheet).

Operating Curves



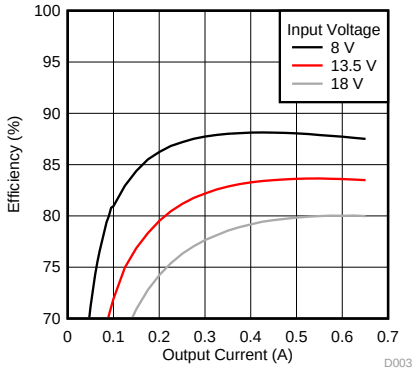
FPWM Mode

Figure 1. LM53601LAEVM Efficiency



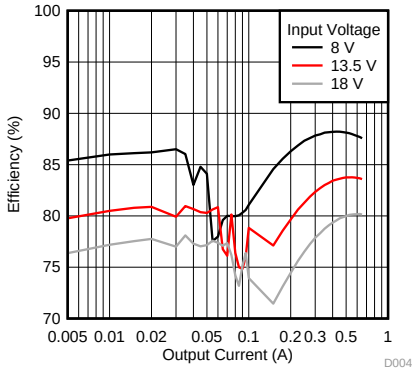
Auto Mode

Figure 2. LM53601LAEVM Efficiency



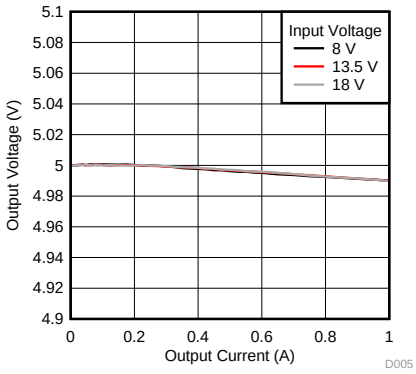
FPWM Mode

Figure 3. LM53600NAEVM Efficiency



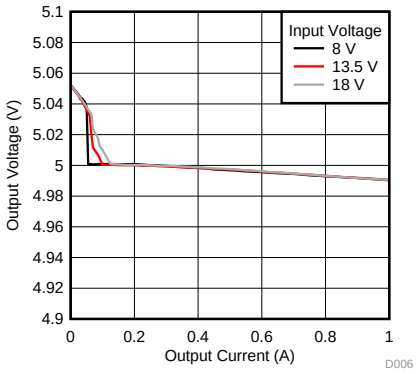
Auto Mode

Figure 4. LM53600NAEVM Efficiency Auto Mode



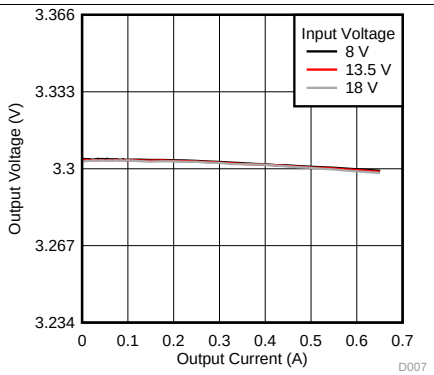
FPWM Mode

Figure 5. LM53601LAEVM Load Reg



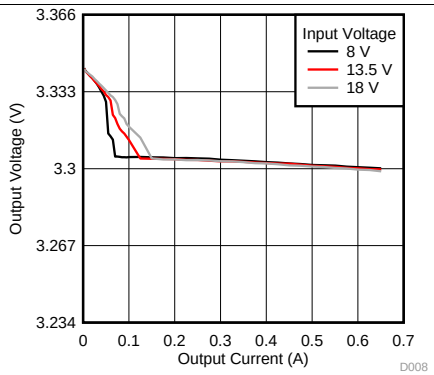
Auto Mode

Figure 6. LM53601LAEVM Load Reg



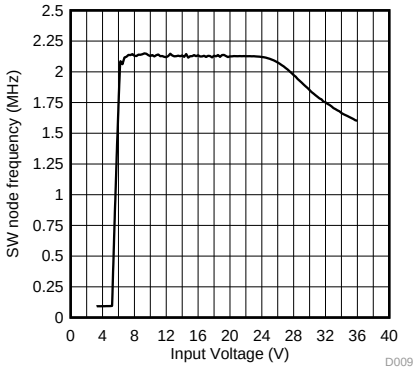
FPWM Mode

Figure 7. LM53600NAEVM Load Reg



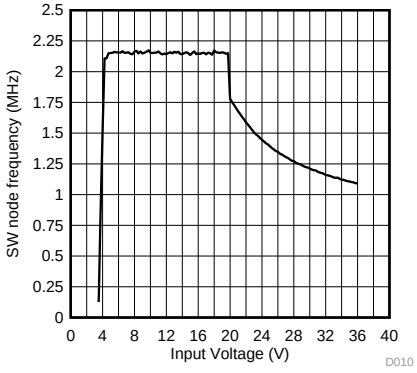
Auto Mode

Figure 8. LM53600NAEVM Load Reg



500 mA Load

Figure 9. LM53601LAEVM SW Frequency



500 mA Load

Figure 10. LM53600NAEVM SW Frequency

BOM

Table 4-1. BOM for LM53600NAEVM

Designator	Qty	Value	Description	Part Number
Cbias	1	0.01 µF	CAP, CERM, 0.01 µF, 16 V, ±10%, X7R, 0402	C1005X7R1C103K050BA
Cboot	1	0.1 µF	CAP, CERM, 0.1 µF, 50 V, ±10%, X7R, 0603	GCM188R71H104KA57D
Cd	1	1 µF	CAP, CERM, 1 µF, 25 V, ±10%, X7R, AEC-Q200 Grade 1, 1206	GCM31MR71E105KA37L
Cfilt, Cin_hf	2	0.1 µF	CAP, CERM, 0.1 µF, 100 V, ±10%, X7R, 0805	C2012X7R2A104K125AA
Cin1, Cin2	2	4.7 µF	CAP, CERM, 4.7 µF, 50 V, ±10%, X7R, 1206	GRM31CR71H475KA12L
Cload	1	22 µF	CAP, CERM, 22 µF, 16 V, ±20%, X7R, AEC-Q200 Grade 1, 1210	CGA6P1X7R1C226M250AC
Cout1, Cout2	2	10 µF	CAP, CERM, 10 µF, 16 V, ±10%, X7R, 1206	GRM31CR71C106KAC7L
Cvcc	1	1 µF	CAP, CERM, 1 µF, 16 V, ±10%, X7R, AEC-Q200 Grade 1, 0603	GCM188R71C105KA64D
H1, H2, H3, H4	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	NY PMS 440 0025 PH
H5, H6, H7, H8	4		Standoff, Hex, 0.5"L #4-40 Nylon	1902C
JEN, Jmode, Jreset	3		Header, 100 mil, 3x1, Gold, TH	HTSW-103-07-G-S
L1	1	4.7 µH	Inductor, Shielded, 4.7 µH, 2.3 A, 0.092 Ω, SMD	MPI4040R3-4R7-R
Lfilt	1	600 Ω	Ferrite Bead, 600 Ω @ 100 MHz, 3 A, 1210	FBMH3225HM601NT
Rd	1	4.99	RES, 4.99, 1%, 0.1 W, 0603	CRCW06034R99FKEA
REN, Rmode, Rreset, Rsync	4	100k	RES, 100 k, 1%, 0.1 W, 0603	CRCW0603100KFKEA
SH-J1, SH-J2, SH-J3	3	1x2	Shunt, 100 mil, Gold plated, Black	969102-0000-DA
TP1, TP2, TP3, TP4, TP5, TP6	6	Double	Terminal, Turret, TH, Double	1502-2
TP7, TP8, TP9	3	White	Test Point, Miniature, White, TH	5002
U1	1		Synchronous Buck Regulator for 650-mA Space Constraint Applications, DSX0010A, 3.3-V Output	LM53600NQDSXRQ1

Table 4-2. LM53601LAEVM Differences from LM53600NAEVM

Designator	Qty	Value	Description	Part Number
Cload	1	22 µF	Do not populate	DNP
U1	1		Synchronous Buck Regulator for 1000-mA Space Constraint Applications, DSX0010A, 5-V Output	LM53601LQDSXRQ1

Layout

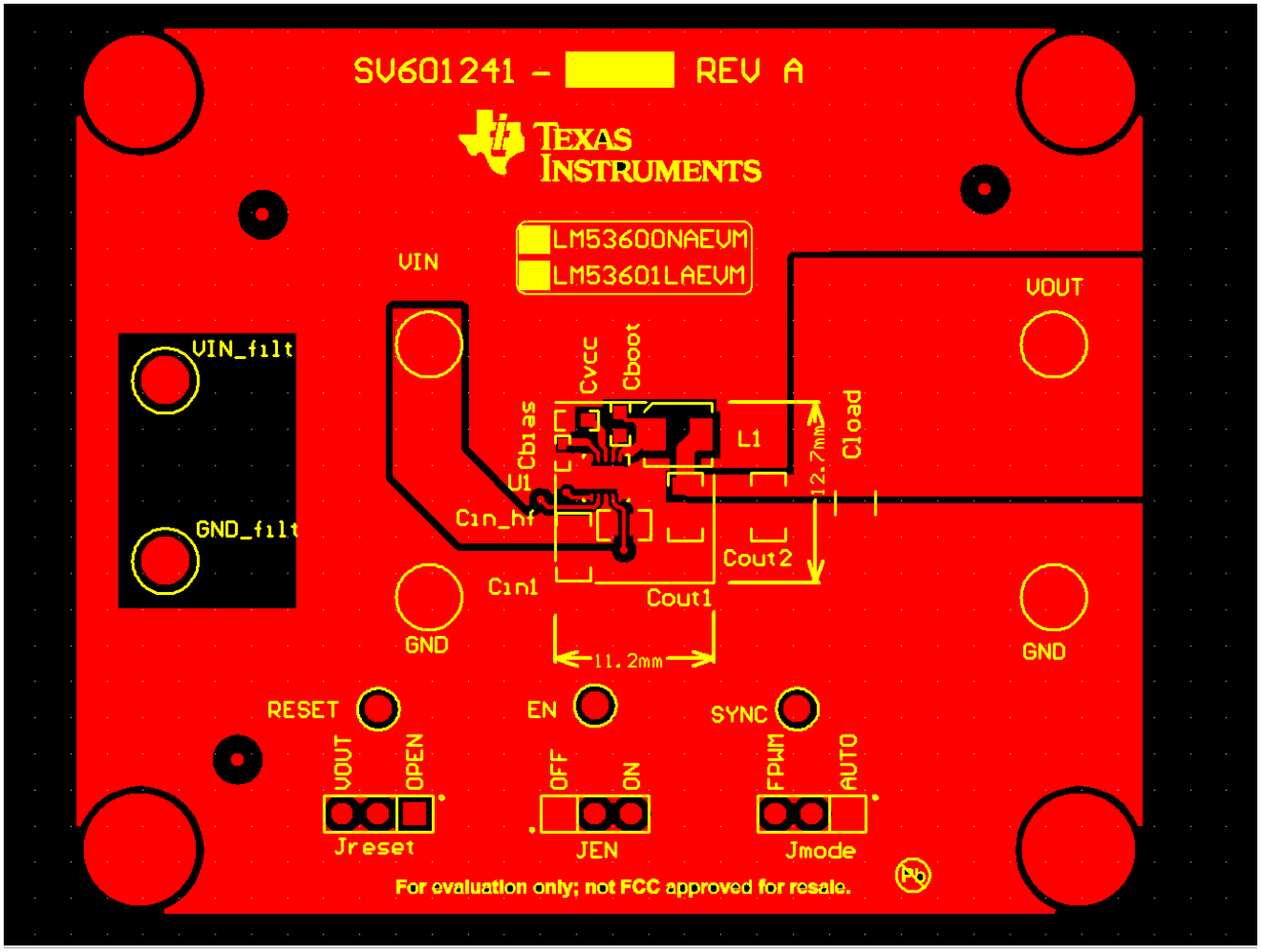


Figure 5-1. Top Layer with Overlay

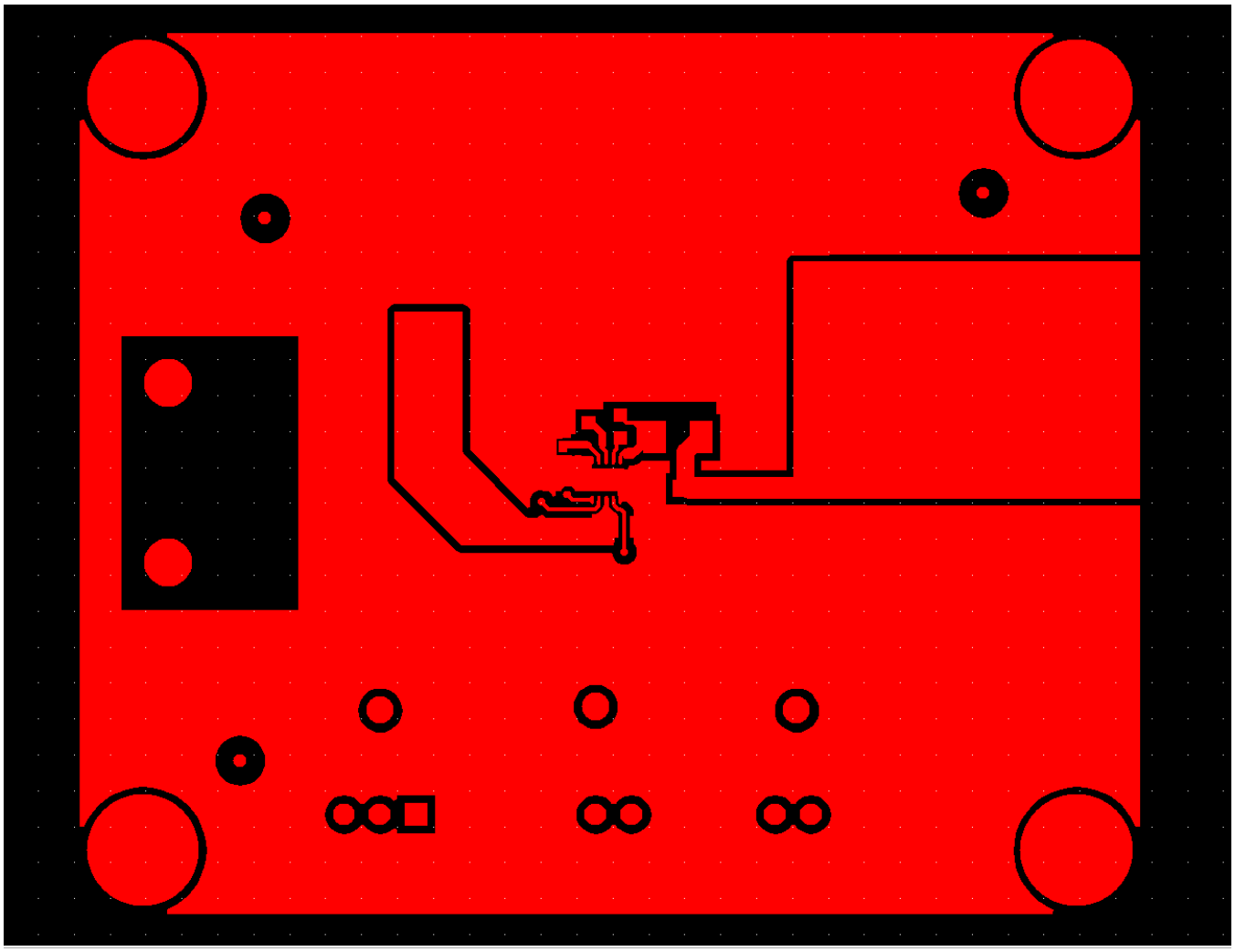


Figure 5-2. Top Layer

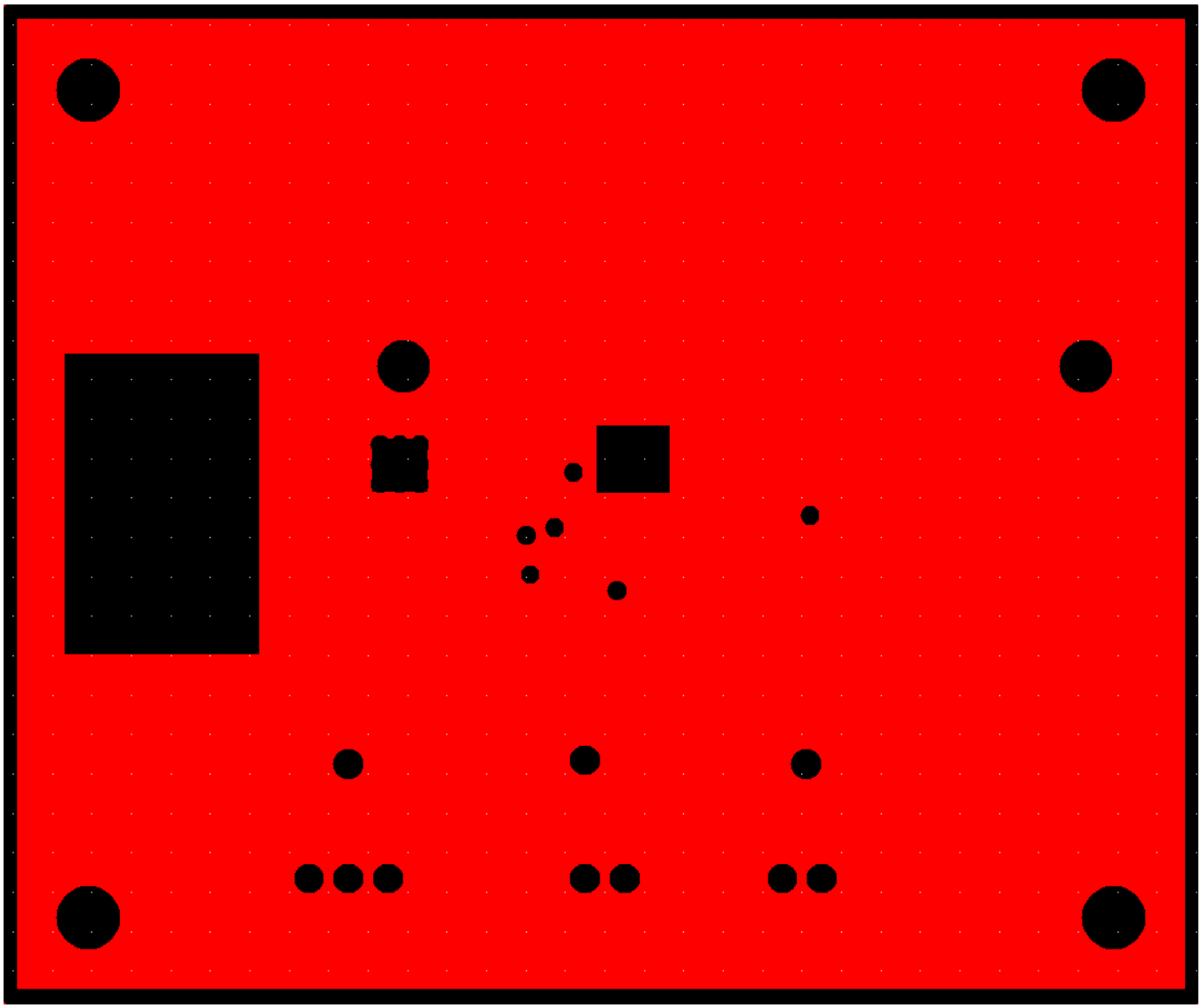


Figure 5-3. GND Plane (Layer 2)

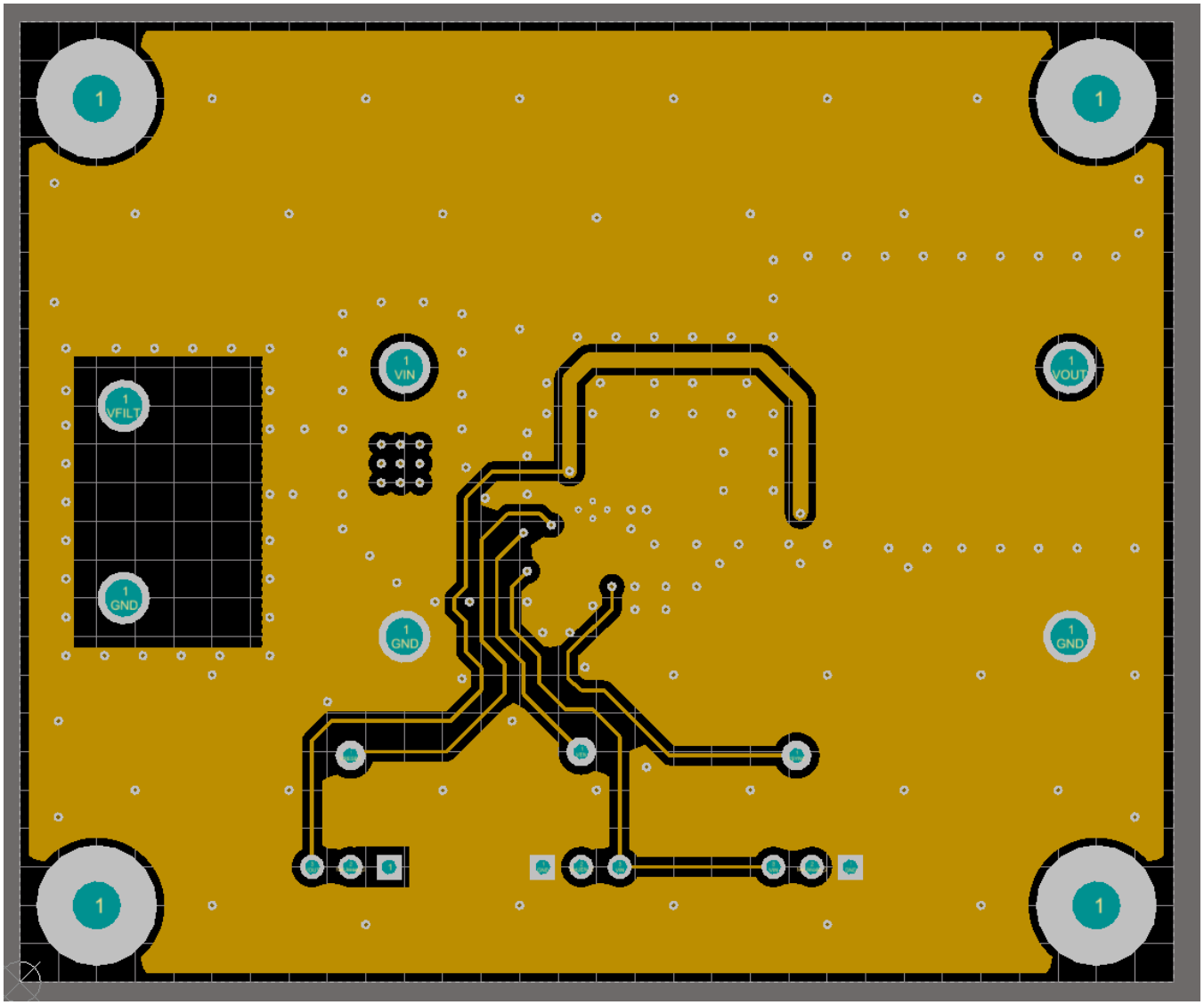


Figure 5-4. Mid Layer (Layer 3)

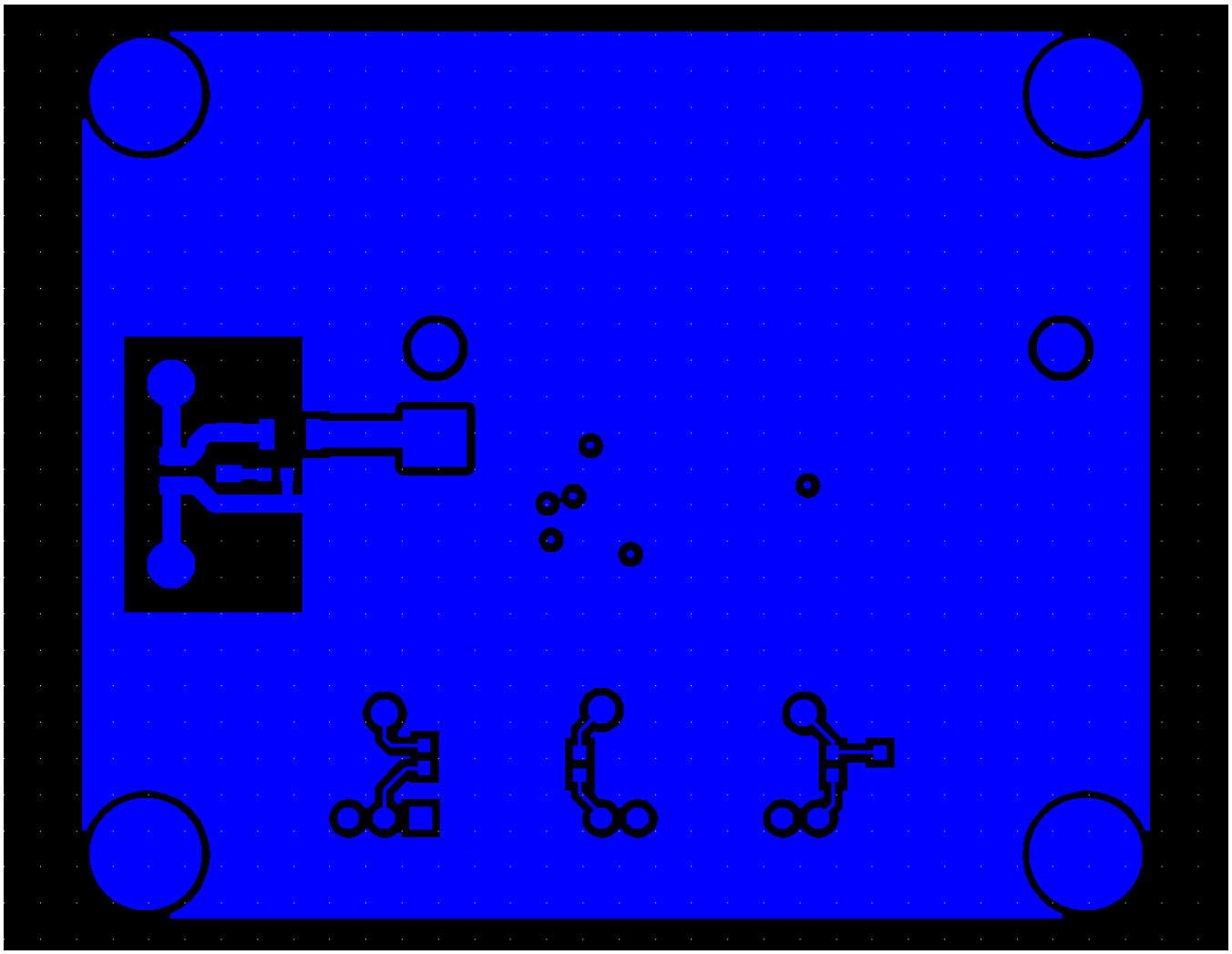


Figure 5-5. Bottom Layer (X-Ray)

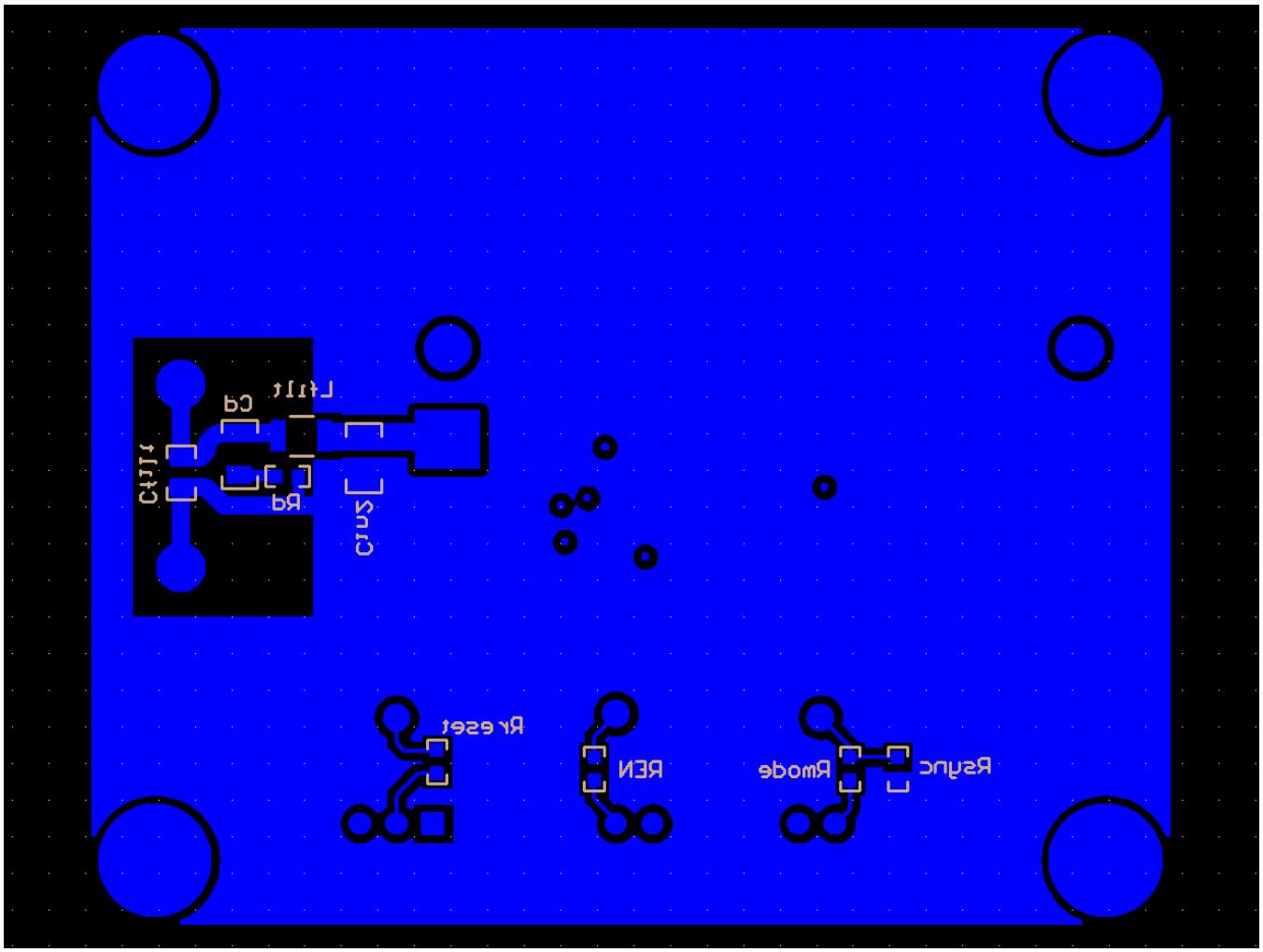
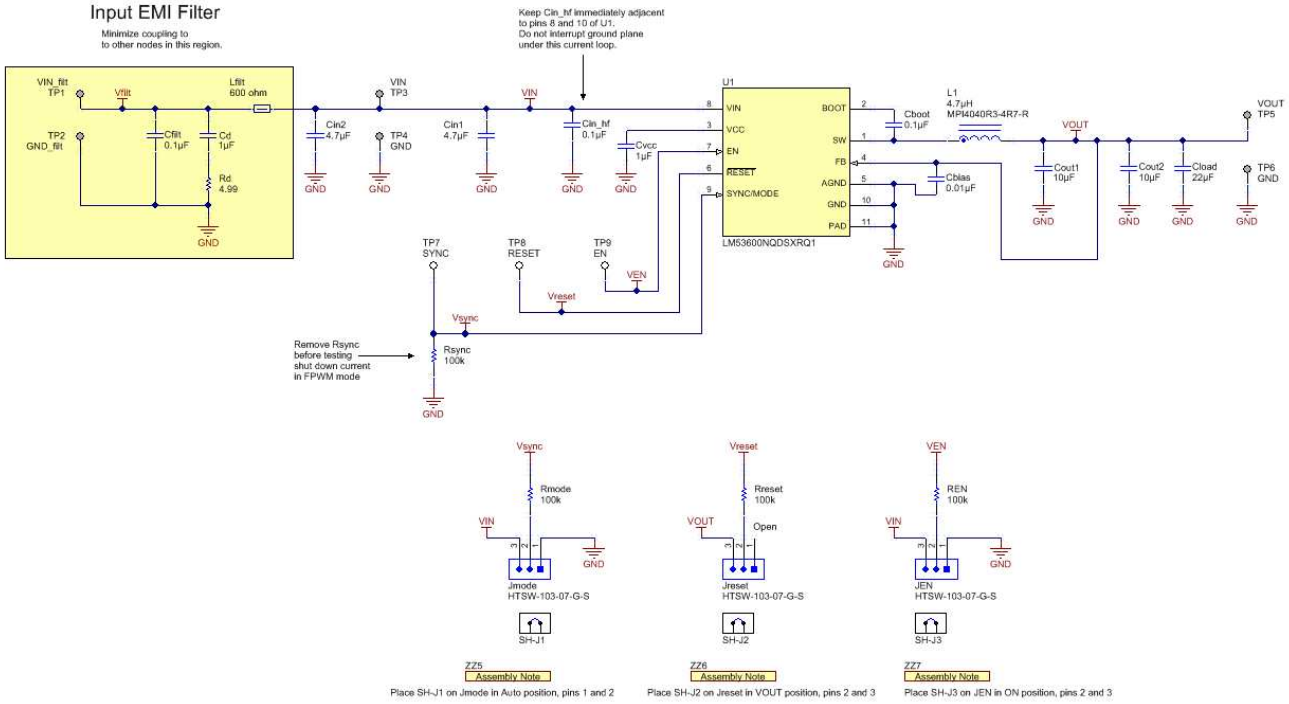


Figure 5-6. Bottom Layer with Overlay (X-Ray)

Schematic



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   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for any defects that are caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.

   2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

3 *Regulatory Notices:*

   3.1 *United States*

      3.1.1 *Notice applicable to EVMs not FCC-Approved:*

      This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

      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*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-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.

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

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

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 *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.

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