Using the LM3248 Evaluation Module

User's Guide

Literature Number: SNAA196
September 2013

LM3248 2.7MHz, 2.5A Boost-Buck DC/DC Converter Evaluation Module

1 Introduction

The LM3248 evaluation module is a working demonstration of a PWM/PFM Boost-Buck DC/DC converter designed to provide efficient utilization of battery power for 2G/3G/4G and 3GPP/LTE RF subsystems.

The LM3248 incorporates a step-up (Boost) and a variable output step-down (Buck) DC-DC converter. The Boost converter provides the RF power subsystem the capability to operate at lower battery voltages as well as increased PA linearity and transmit power margins over a wider battery voltage supply range.

This application note contains information specific to the evaluation board. For device details and electrical characteristics, please refer to the LM3248 data sheet. If you are considering using the LM3248 in a system design, please see the "PCB Layout Considerations" section of the device data sheet.

2 Operating Conditions

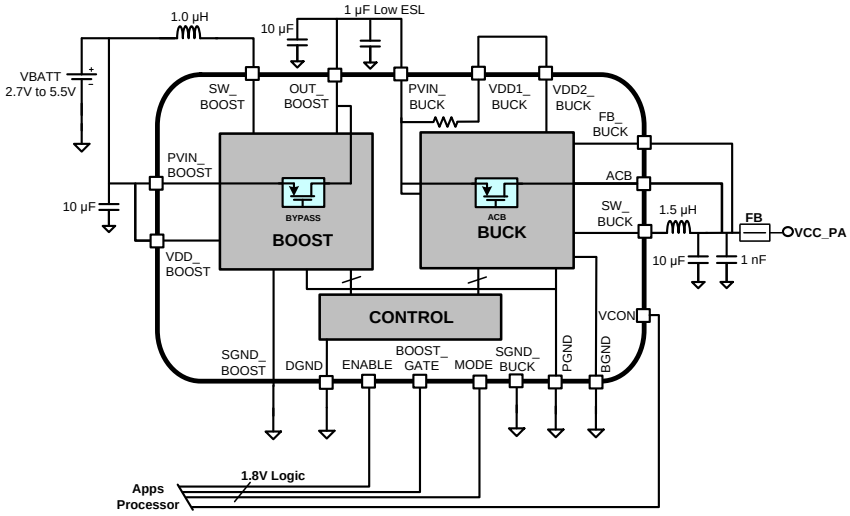
The device will operate under the following conditions:

- V_{IN} range: 2.7V to 5.5V
- V_{OUT} Range: 0.4V to 4.0V
- I_{OUT} range: 0A to 2.5A

3 Package

The LM3248 is available in a 30-bump (0.4 mm pitch) lead-free DSBGA package.

4 Typical LM3248 Boost-Buck Application Diagram



5 LM3248 Bill of Materials

Designator	Qty.	Description	Manufacturer	Mfr Part Number	Supplier 1	Supplier 2
BOOST_OUT, BUCK_OUT, VBATT	3	Standard Banana Jack, Insulated, Red	Keystone	6091	Digi-Key	
C1, C7, C8	3	CAP, CERM, 10µF, 6.3V, ±20%, X5R, 0402	Samsung	CL05A106MQ5NUNC	Digi-Key	
C10	1	CAP, CERM, 4.7µF, 10V, ±20%, X5R, 0402	MuRata	GRM155R61A475M	See Mfr.	
C14	1	CAP, CERM, 0.22µF, 6.3V, ±20%, X5R, 0201	TDK	C0603X5R0J224M	Digi-Key	Mouser
C16, C19	2	CAP, CERM, 3300pF, 6.3V, ±10%, X5R, 01005	TDK	C0402X5R0J332K020BC	Digi-Key	
C18	1	CAP, CERM, 1µF, 10V, ±20%, X5R, 0201	Samsung	CL03A105MP3NSNC	Digi-Key	
C2	1	CAP, CERM, 1µF, 10V, ±20%, X5R, 0306	Taiyo Yuden	LWK107BJ105MV	See Mfr.	
C20	1	CAP, CERM, 0.01µF, 6.3V, ±10%, X5R, 0201	TDK	C0603X5R0J103K	Digi-Key	Mouser
C3	1	CAP, CERM, 100pF, 25V, ±10%, X5R, 0201	MuRata	GRM033R71E102KA01D	Digi-Key	Arrow
C5, C6	2	CAP, TANT, 470µF, 10V, ±10%, 0.04Ω, 7260-38 SMD	Kemet	T495E477K010ATE040	Digi-Key	
C9, C34	2	CAP, CERM, 1000pF, 25V, ±10%, X7R, 0201	MuRata	GMR022R71E102KA01D	Digi-Key	Farnell
GND, GND_BST, GND_BUCK	3	Standard Banaka Jack, Insulated, Black	Keystone	6092	Digi-Key	
H1, H2, H3, H4	4	Machine Screw, Roun, #4-40 x 1/4, Nylon, Philips panhead	B&F Fastener Supply	NY PMS 440 0025 PH	Digi-Key	
H5, H6, H7, H8	4	Standoff, Hex, 0.5"L #4-40 x 1/4, Nylon	Keystone	1902C	Digi-Key	
L1	1	Inductor, Shielded, Metal Composite, 1µH, 2.6A, 0.062Ω, 3225	Toko	1276AS-H-1R0N	See Mfr.	
L3	1	Inductor, Shielded, Metal Composite, 1.5µH, 1.6A, 0.144Ω, 2016	Toko	1285AS-H-1R5M	See Mfr.	
P1	1	Header (shrouded) 100 mil, 10x2, TH	TE Connectivity	5103309-5	Digi-Key	Mouser
R1, R5	2	RES 0Ω, 5%, 0.1W, 0603	Vishay-Dale	CRCW06030000Z0EA	Digi-Key	Farnell
R3, R4, R6, R7	4	RES, 499Ω, 1%, 0.05W, 0201	Vishay-Dale	CRCW0201499RFKED	Digi-Key	Mouser
U1	1	LM3248 Boost-Buck DC-DC Converter	Texas Instrument	LM3248TME	T.I.	
VOUT	1	Connector, RF Co-ax, 50Ω, 6GHz, Vertical, TH	Emerson Network Power	135-3701-201	Digi-Key	Mouser
ACB, ATB0, ATB1, ATB2, BG, BK UT, BST_OUT, EN, lBST, L BUCK, MOD, OUT_BST, PVIN BST, SW BST, SW BUCK, VCON, VCON_S	17	Header, TH, 100mil, 2x1, Gold-plated, 230mil above insulator	Samtec, Inc.	TSW-102-07-G-S	Digi-Key	
C11	1	CAP, CERM, 2.2µF, 6.3V ±20%, X5R, 0402	MuRata	DNI	Digi-Key	Mouser
C17	1	CAP, CERM, 4.7µF, 10V ±20%, X5R, 0402	MuRata	DNI	Digi-Key	

C21	1	CAP, CERM, 2.2µF, 6.3V ±20%, X5R, 0402	MuRata	DNI	Digi-Key	
R2	1	RES, 0Ω, 5%, 0.063W, 0402	Dale	DNI	Digi-Key	
FB1, FB2	2	(Not installed) 3.5A Ferrite Bead, 60Ω @ 100MHz, SMD	TDK	MPZ1608S600A	Digi-Key	Mouser

6 LM3248 Evaluation Module Photo

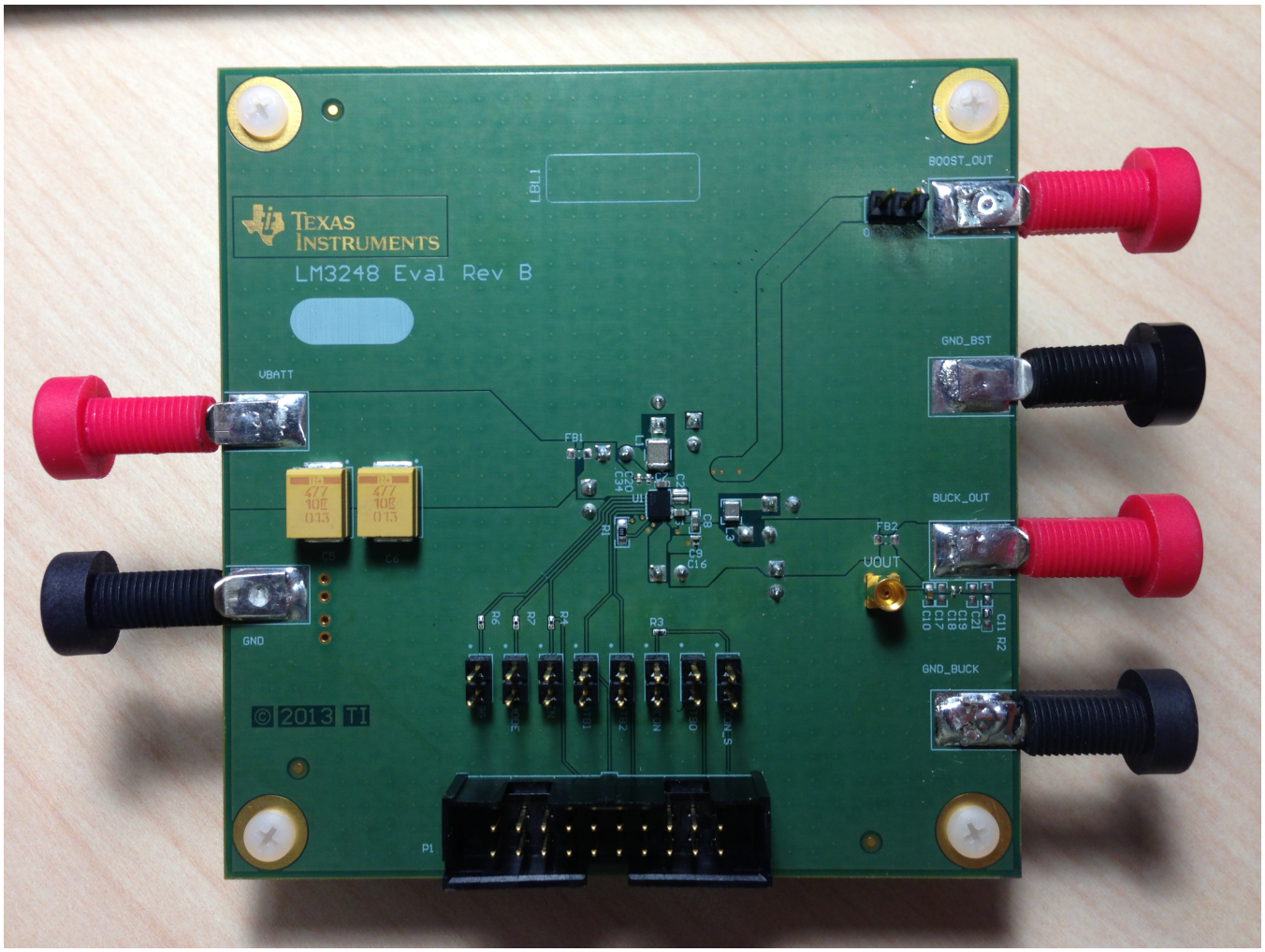


Figure 1. LM3248 Evaluation Board

7 Connecting to the LM3248 Evaluation Module

NOTE: All of the control signals (BOOST_GATE (“BG”), MODE, ENABLE (“EN”) and VCON) can be accessed on the bank of test access points just above connector P1, as shown in Figure 1. The pins next to each of the silkscreened signal names are all grounded, with the exception of the one labeled “VCON_S.” The pins with silkscreened dots indicate the active signal pins.

1. LM3248 EVM Jumper Settings
   - The LBST, L BUCK & ACB 0.1” center slide-on jumpers located on the back side of the LM3248 Evaluation Board must be installed for proper operation. See Figure 8 for locations on back side of EVM.
   - The OUT_BST shunt on the top side of the LM3248 Evaluation Board adjacent to the BOOST_OUT banana jack is not required for normal operation, but must be in place if this banana jack is used for monitoring the Boost Output voltage.
2. Connect the EN pin signal source with the signal source set to 0V.
3. Connect the VBATT supply to the red (+) and black (ground) banana connector pins on the left side of the module.
4. Connect the other control signals (BOOST_GATE, MODE, and VCON) to the evaluation module, making sure the signal sources are first set to 0V.

NOTE: BOOST_GATE is a logic level signal (see the LM3248 data sheet) which represents the TTI frame interval. A pulse or function generator should be used to drive this pin, but should be configured to drive a high impedance load so that the level seen on the instrument panel is the same as that measured into a high-Z load (50Ω mode will put out 2X the indicated voltage when driving a high-Z load). Set the period to 2G=4.616 ms, 3G=10 ms or 4G=1 ms, and the pulse width to 45 µs, to emulate the corresponding intervals that the boost "bias" circuits need to run in these respective modes.

5. Connect the load (resistor, electronic load , or PA module) to the BUCK_OUT red (+) and GND_BUCK black (ground) banana jacks.

8 Turn-on Sequencing

1. After insuring that ENABLE, BOOST_GATE and MODE pins are all at 0V, turn VBATT ON, and then turn ON the ENABLE, BOOST_GATE and MODE signals (MODE=LOW for 3G/4G, HIGH for 2G). For best accuracy, measure VBATT across the "PVIN BST" test points on the bottom of the EVM.
2. Turn on and adjust VCON to obtain the desired BUCK OUT voltage level (VCON = VOUT/2.5), which, for best accuracy, is measured across the "BK OUT" test points on the bottom side of the EVM.

9 Turn-off Sequencing

1. Switch ENABLE, BOOST_GATE and VCON to 0V.
2. Turn off VBATT supply.

10 Bottom Layer Test and Jumper Pairs

The signals below may be monitored by attaching scope probes or clip leads to the corresponding pins. The dotted pin is the signal. The adjacent (undotted) is the ground pin.

Test Points:

- PVIN BST - Boost input node (VBATT connection)
- SW BST - Boost switch node
- BST_OUT - Boost output node
- SW BUCK - Buck switch node
- BK OUT - Buck output note

Jumpers (see Figure 8 for locations):

- LBST - Boost inductor jumper
- L BUCK - Buck inductor jumper
- ACB - ACB jumper

11 LM3248 Evaluation Board Layout

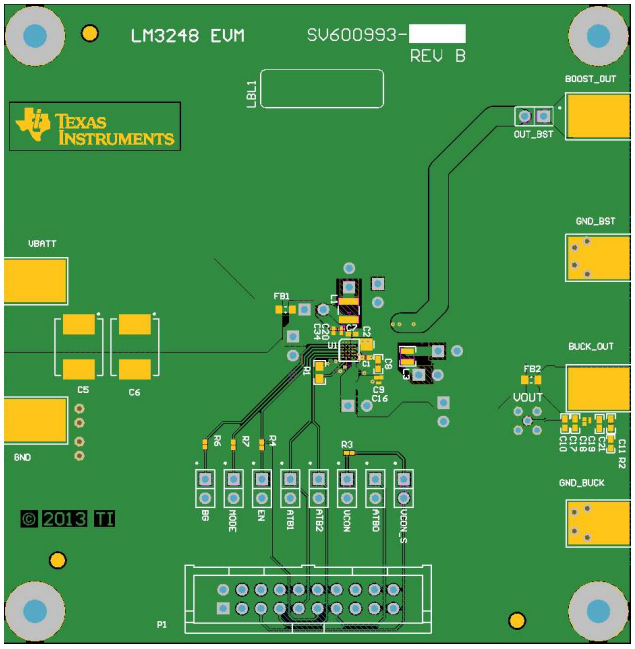


Figure 2. Top Layer

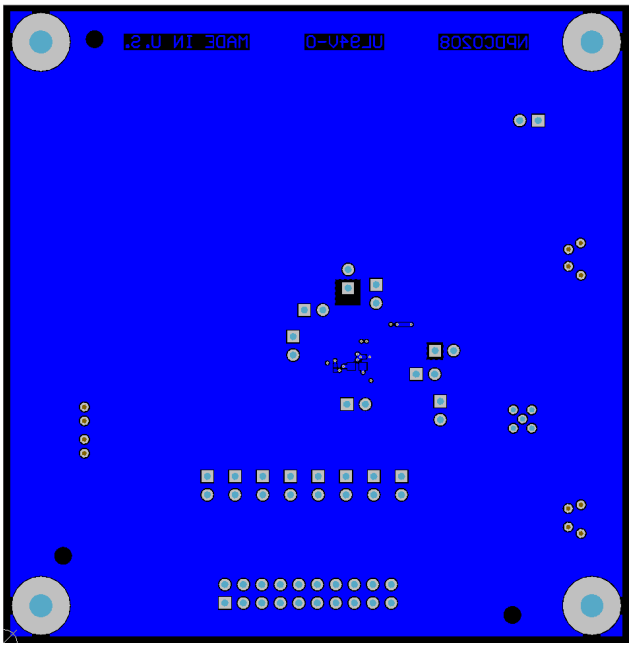


Figure 3. Bottom Layer

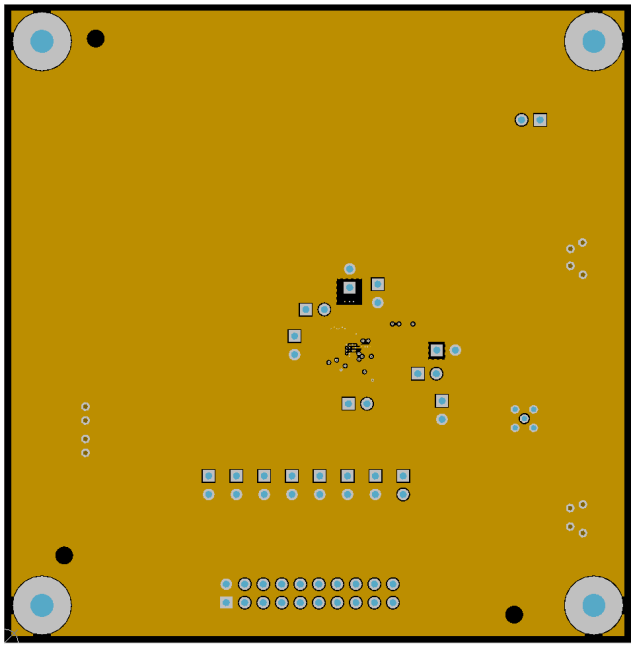


Figure 4. Mid Layer 1

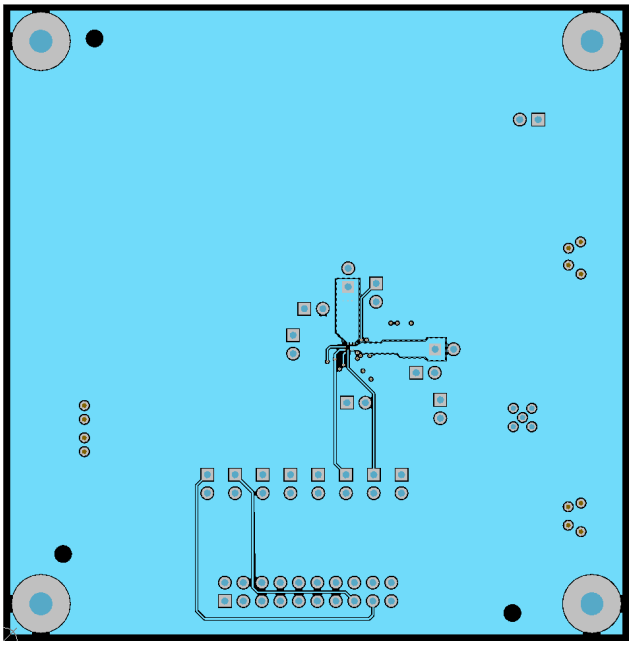


Figure 5. Mid Layer 2

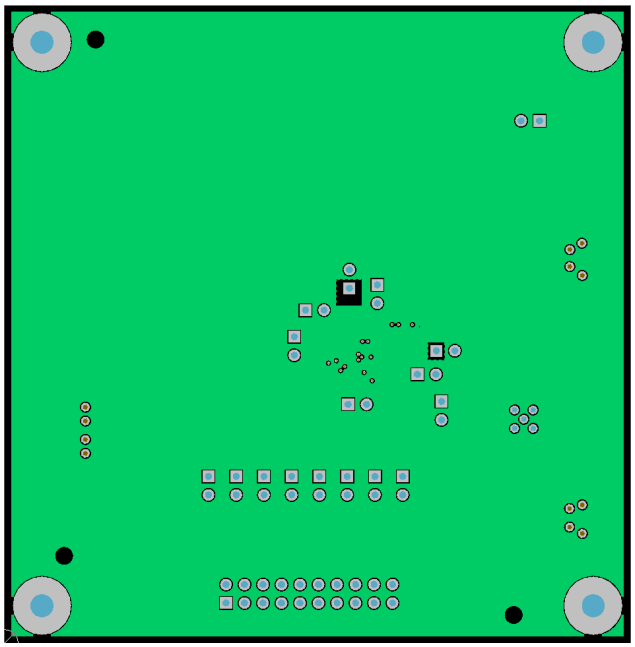


Figure 6. Mid-Layer 3

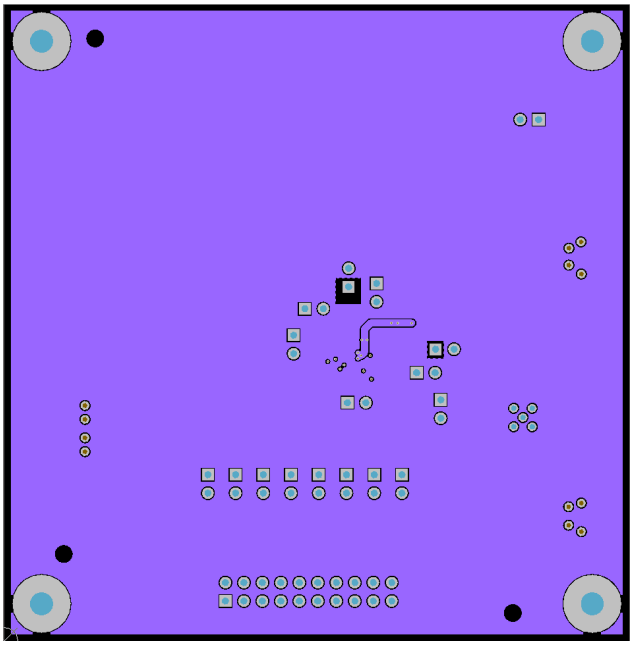


Figure 7. Mid Layer 4

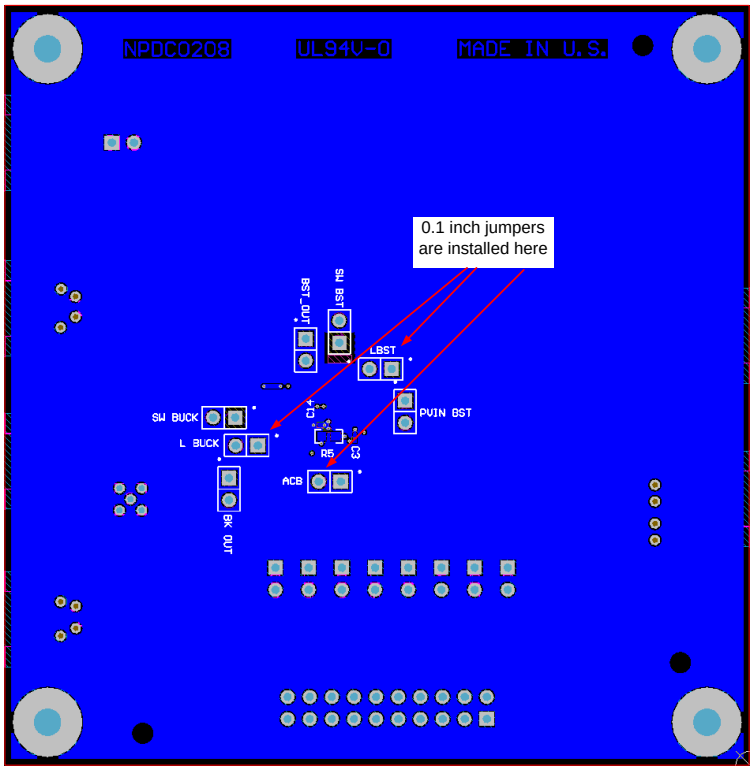


Figure 8. Bottom Layer (Mirrored)

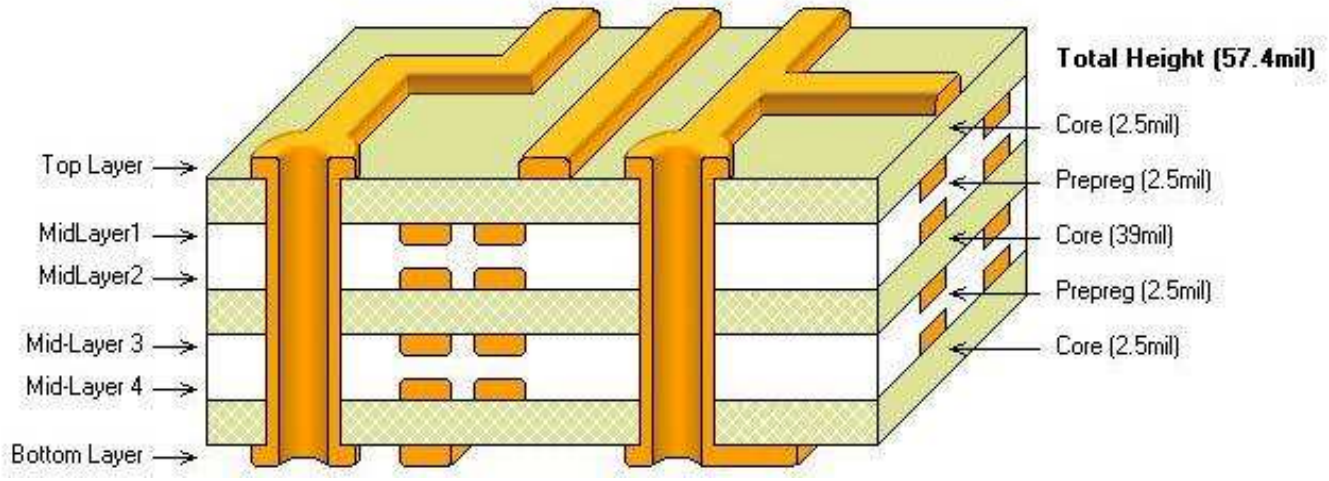
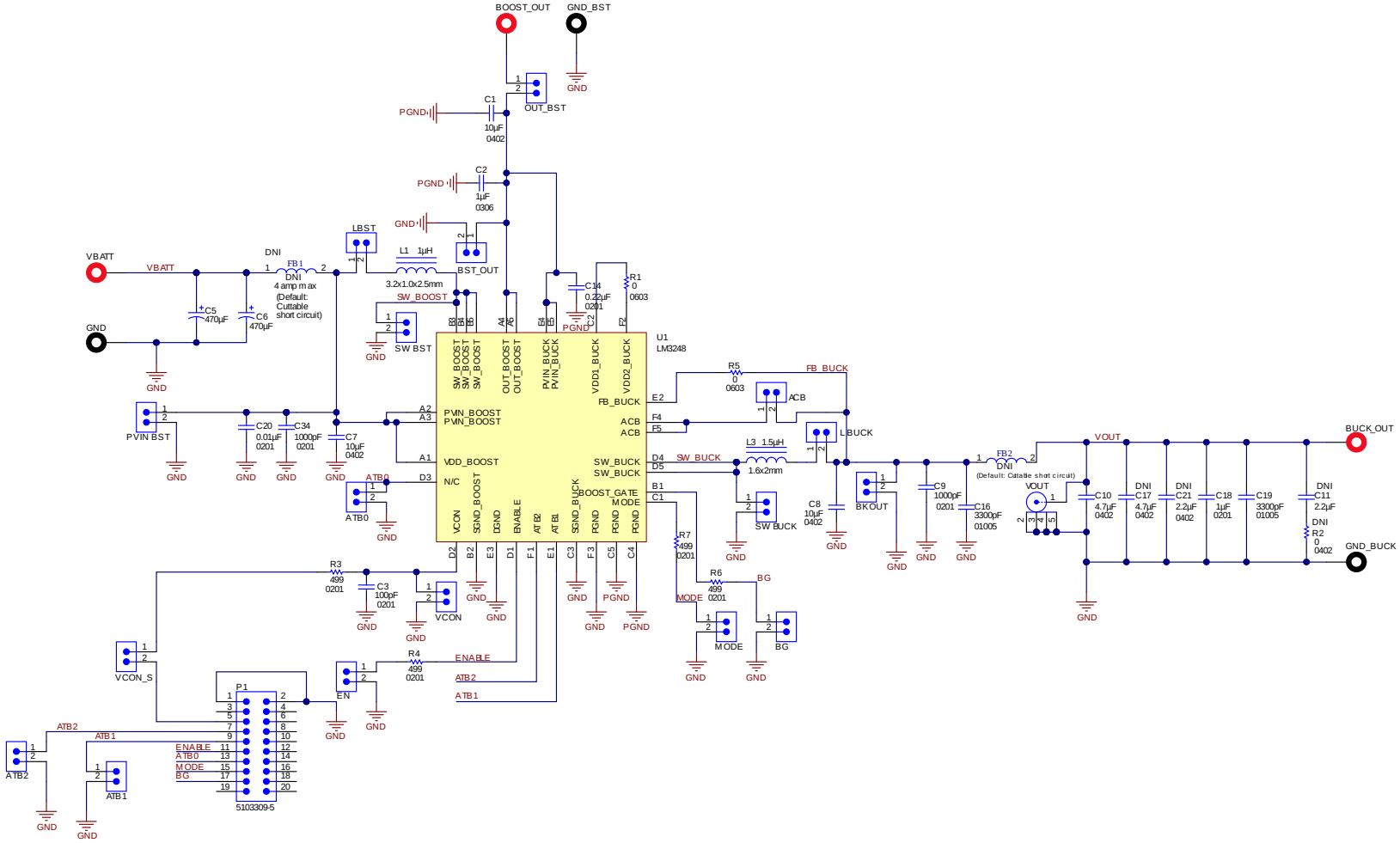


Figure 9. Stackup

12 LM3248 Evaluation Module Schematic



13 Connection Diagram

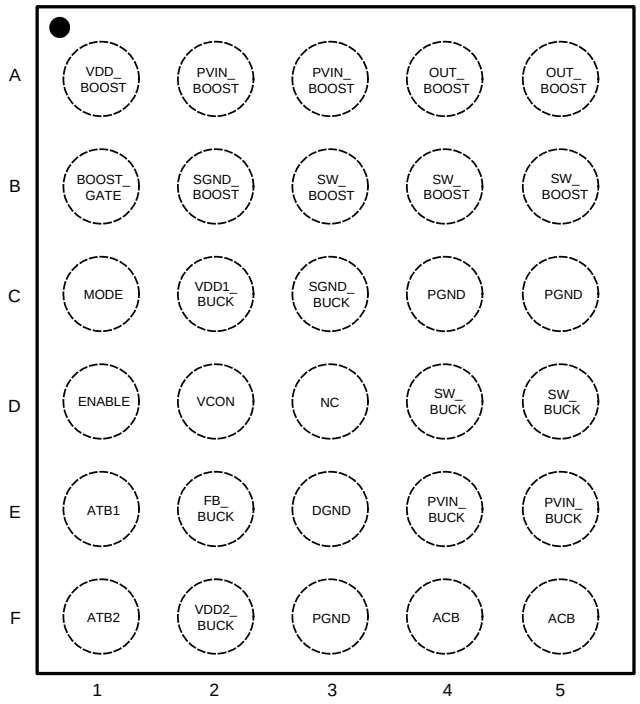


Figure 10. Top View (Bumps Down)

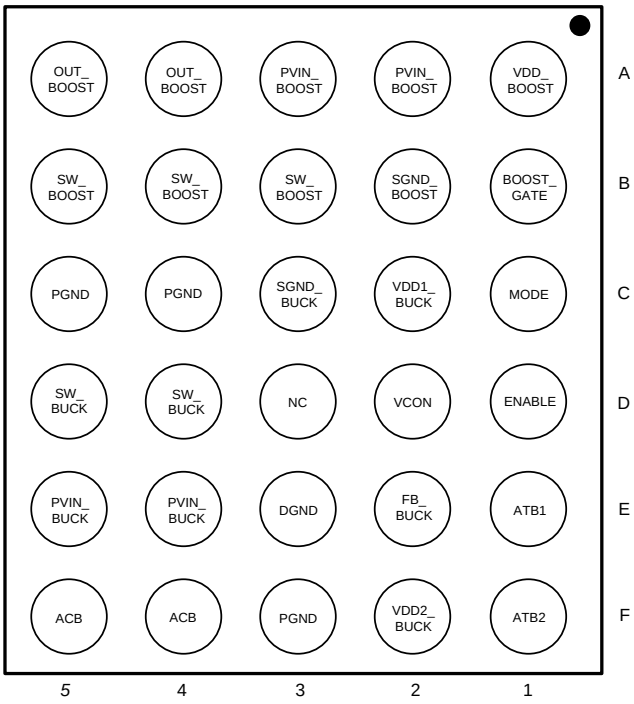


Figure 11. Bottom View (Bumps Up)

14 Pin Descriptions

Pin #	Name	I/O	Description
A1	VDD_BOOST	-	Power supply voltage input for Boost Analog blocks. Connected to VBATT supply.
A2	PVIN_BOOST	-	Power supply voltage input for Boost Bypass FET.
A3			
A4	OUT_BOOST	0	Boost converter output. When Boost and Buck are active, OUT_BOOST must be externally connected to PVIN_BUCK. A 10 µF capacitor must be placed between this node and GND. Internally connected to BUCK voltage input and feedback to inverting input of Boost error amplifier.
A5			
B1	BOOST_GATE	I	Digital input. A Low to High transition wakes up the boost converter and positions it to a high level in preparation for a possible VCON change.
B2	SGND_BOOST	-	Analog Ground for the Boost Analog blocks.
B3	SW_BOOST	I/O	Boost converter switch node. When Boost and Buck are active, SW_BOOST is typically connected to VBATT supply through external power inductor.
B4			
B5			
C1	MODE	I	Digital input. Low = 3G/4G operation; High = 2G operation.
C2	VDD1_BUCK	-	Power supply voltage input for Buck Analog PWM blocks. Internally connected to PVIN_BUCK when used with Boost.
C3	SGND_BUCK	-	Analog Ground for the Buck Analog Blocks.
C4	PGND	-	Power Ground for output FETs.
C5			
F3			
D1	ENABLE	I	Input. Chip enable. Setting ENABLE = High biases up the Buck and initiates VCON regulation by the Buck.
D2	VCON	I	Analog voltage control input which controls Buck output voltage.
D3	NC	-	No Connect; leave this pin floating.
D4	SW_BUCK	0	Buck converter switch node for external filter inductor connection
D5			
E1	ATB1	-	Test pin. Connect to SGND or System Ground.
E2	FB_BUCK	-	Feedback input to inverting input of error amplifier. Connect Buck output voltage directly to this node.
E3	DGND	-	Ground for Boost, Buck and digital blocks.
E4	PVIN_BUCK	-	Power supply input for Buck PFET and ACB FET. A 10 µF capacitor must be placed between this node and PGND. Must be externally connected to OUT_BOOST.
E5			
F1	ATB2	-	Test pin. Connect to SGND or System Ground.
F2	VDD2_BUCK	-	Power supply voltage input for Buck Analog PWM blocks. Internally connected to PVIN_BUCK when used with Boost.
F4	ACB	-	Active Current Assist and Bypass output. Connected to the Buck converter output filter capacitor.
F5			

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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。
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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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2. 実験局の免許を取得後ご使用いただく。
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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.

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.

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