

AN-1800 Evaluation Kit for LM26480 - Dual DC/DC Buck Regulators with Dual Low-Noise Linear Regulators

1 LM26480 Overview

The LM26480 is a multi-function, programmable Power Management Unit, optimized for low-power digital applications. This device integrates two highly efficient 1.5A step-down DC/DC converters and two 300 mA Linear Regulators. The LM26480 is offered in a tiny $4 \times 4 \times 0.8$ mm WQFN 24-pin package.

2 Evaluation Kit Overview

The LM26480 Evaluation kit comes preassembled with VOUT Buck1 set to 1.8V, VOUT Buck2 set to 3.3V, VOUT LDO1 set to 1.0V, and VOUT LDO2 set to 1.2V. These may not be what the user would like for their evaluation, so it is possible to change any of the regulator outputs by adjusting its feedback network. Details are in this document.

The LM26480 Evaluation Kit allows the user to effectively utilize all of the functions of the LM26480. The evaluation kit consists of:

- LM26480 evaluation board
- LM26480 datasheet
- Evaluation Manual (this document)

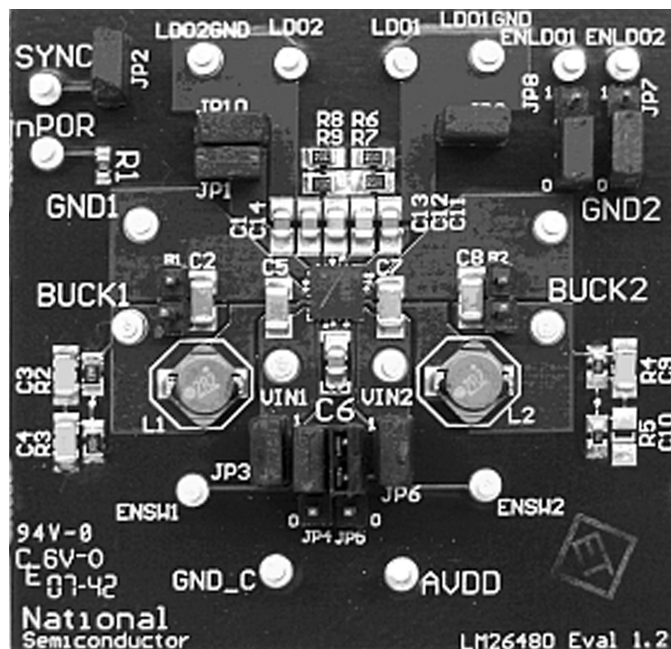


Figure 1. LM26480 Evaluation Board

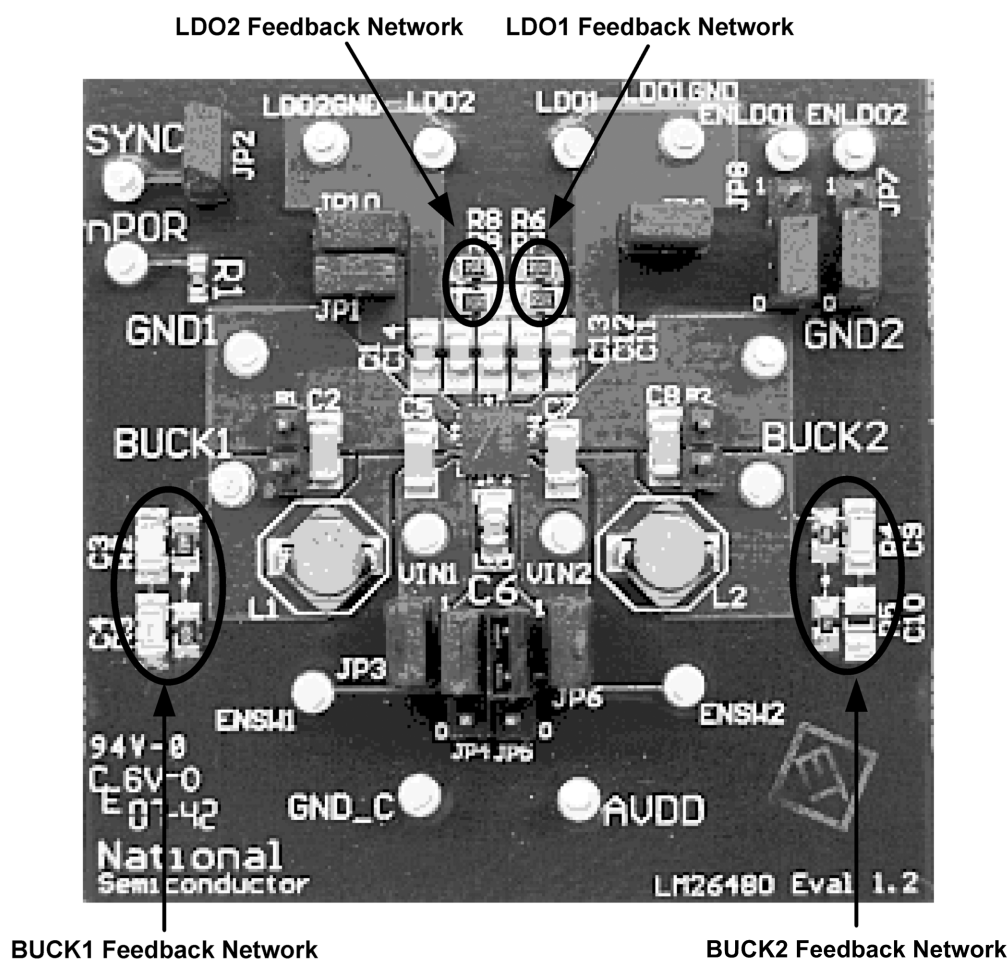


Figure 2. Feedback Network Locations

3 Evaluation Kit Setup

Please use ESD protection to prevent any unwanted damaging ESD events!

The user of the LM26480 Evaluation Board can leave the regulator outputs as is or can change them at any time. In order to change them, remove the existing feedback network and reconfigure it using the optimal resistors and capacitors for a designated output voltage which can be chosen from [Table 1](#) and [Table 2](#).

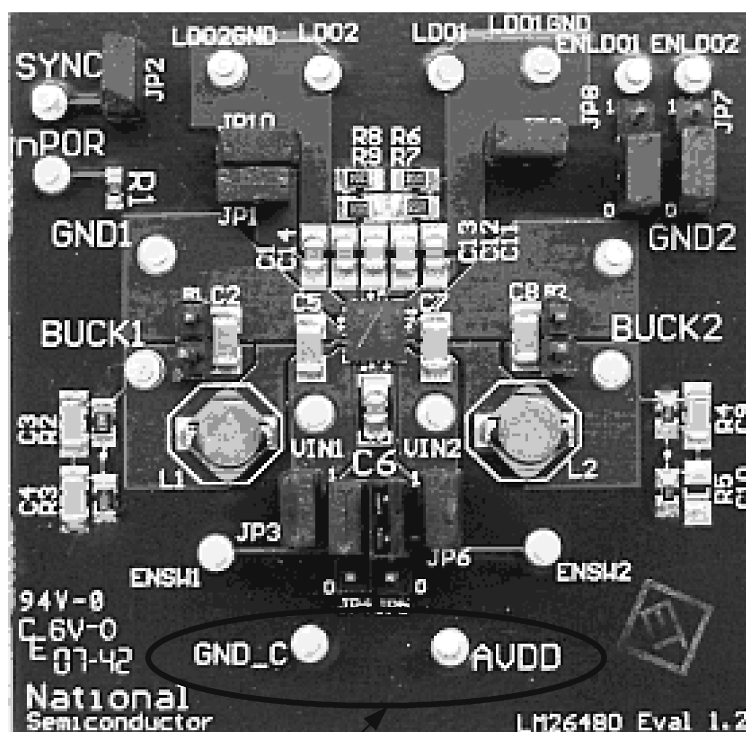
4 Cautionary Notes

Turrets may be placed somewhat close together on the board. Be careful not to short adjacent pins to each other!

5 Getting Started

When the LM26480 evaluation board is configured as needed, and has been properly cleaned, supply the board with power through the GND and AVDD pins. (See [Figure 3](#)).

You should be able to see the regulators supply the desired voltage.



Board Power Input Pins

Figure 3. Board Power Pins

6 Using the Evaluation Board

6.1 Enabling the LM26480 Board

The LM26480 evaluation board allows the user to enable the regulators through a jumper, or by applying a voltage to the regulator's enable pin.

JP4 and JP5 mark the jumpers for enabling Buck1 and Buck2, respectively. When jumpers are in the lower position, it shorts the enable pin to GND. Inversely, when the jumpers are in the upper position, the enable pin is shorted to VDD.

JP7 and JP8 mark the jumpers for enabling LDO2 and LDO1, respectively. When jumpers are in the lower position, it shorts the enable pin to GND. Inversely, when the jumpers are in the upper position, the enable pin is shorted to VDD.

If enabling the regulators by applying a voltage to the turret, make sure to remove the jumper for that specific regulator.

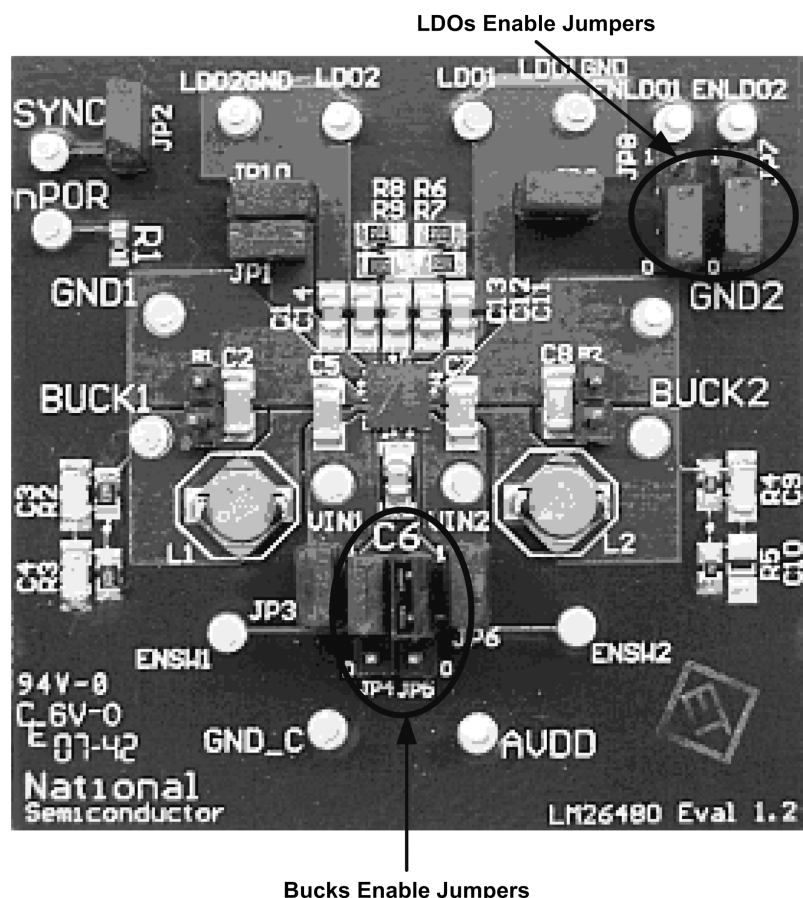


Figure 4. Regulator Enables

6.2 Component Selection for SW1 and SW2

Table 1 shows ideal resistor values to establish buck voltages from 0.8V to 3.5V along with common resistor values to establish these voltages. Common resistors do not always produce the target value; error is given in the delta column. In addition to the resistor feedback, capacitor feedback C1 is always required, and depending on the output voltage capacitor, C2 is also required. See Figure 5.

The output voltages of the bucks of the LM26480 are established by the feedback resistor dividers R1 and R2 shown on Figure 5.

The equation for determining V_{OUT} is:

$$V_{OUT} = V_{FB} \times (R1 + R2)/R2 \text{ where } V_{FB} \text{ is the voltage on the Buck FBx pin.}$$

The buck control loop will force V_{FB} to be $0.50V \pm 3\%$.

NOTE: Accuracy depends on device process corners, external components tolerance and matching, and temperature.

Table 1. Component Values for SW1 and SW2

Target V _{OUT} (V)	Ideal Resistor Values		Common R Values		Actual V _{OUT} w/ Com/R (V)	Actual V _{OUT} Delta from Target (V)	Feedback Capacitors		
	R1(KΩ)	R2(KΩ)	R1(KΩ)	R2(KΩ)			C1(pF)	C2(pF)	
0.8	120	200	121	200	0.803	0.002	15	none	Buck 1 Only
0.9	160	200	162	200	0.905	0.005	15	none	
1	200	200	200	200	1	0	15	none	Buck 1 and Buck 2
1.1	240	200	240	200	1.1	0	15	none	
1.2	280	200	280	200	1.2	0	12	none	
1.3	320	200	324	200	1.31	0.01	12	none	
1.4	360	200	357	200	1.393	-0.008	10	none	
1.5	400	200	402	200	1.505	0.005	10	none	
1.6	440	200	442	200	1.605	0.005	8.2	none	
1.7	427	178	432	178	1.713	0.013	8.2	none	
1.8	463	178	464	178	1.803	0.003	8.2	none	
1.9	498	178	499	178	1.902	0.002	8.2	none	
2	450	150	453	150	2.01	0.01	8.2	none	
2.1	480	150	475	150	2.083	-0.017	8.2	none	Buck 2 Only
2.2	422	124	422	124	2.202	0.002	8.2	none	
2.3	446	124	442	124	2.282	-0.018	8.2	none	
2.4	471	124	475	124	2.415	0.015	8.2	none	
2.5	400	100	402	100	2.51	0.01	8.2	none	
2.6	420	100	422	100	2.61	0.01	8.2	none	
2.7	440	100	442	100	2.71	0.01	8.2	33	
2.8	460	100	464	100	2.82	0.02	8.2	33	
2.9	480	100	475	100	2.875	-0.025	8.2	33	
3	500	100	499	100	2.995	-0.005	6.8	33	
3.1	520	100	523	100	3.115	0.015	6.8	33	
3.2	540	100	536	100	3.18	-0.02	6.8	33	
3.3	560	100	562	100	3.31	0.01	6.8	33	
3.4	580	100	576	100	3.38	-0.02	6.8	33	
3.5	600	100	604	100	3.52	0.02	6.8	33	

6.3 Component Selection for LDO1 and LDO2

Table 2 shows ideal resistor values to establish LDO voltages from 1.0 V to 3.5 V along with common resistor values to establish these voltages. Common resistors do not always produce the target value; error is given in the final column.

Table 2. Component Values for LDO1 and LDO2

Target V _{OUT} (V)	Ideal Resistor Values		Common R Values		Actual V _{OUT} W/Com/R (V)
	R1 (KΩ)	R2 (KΩ)	R1 (KΩ)	R2 (KΩ)	
1	200	200	200	200	1
1.1	240	200	240	200	1.1
1.2	280	200	280	200	1.2
1.3	320	200	324	200	1.31
1.4	360	200	357	200	1.393
1.5	400	200	402	200	1.505
1.6	440	200	442	200	1.605
1.7	480	200	562	232	1.711
1.8	520	200	604	232	1.802
1.9	560	200	562	200	1.905
2	600	200	604	200	2.01
2.1	640	200	715	221	2.118
2.2	680	200	681	200	2.203
2.3	720	200	806	226	2.283
2.4	760	200	845	221	2.412
2.5	800	200	750	187	2.505
2.6	840	200	909	215	2.614
2.7	880	200	1100	249	2.709
2.8	920	200	1150	249	2.809
2.9	960	200	1210	255	2.873
3	1000	200	1000	200	3
3.1	1040	200	1000	191	3.118
3.2	1080	200	1000	187	3.174
3.3	1120	200	1210	215	3.314
3.4	1160	200	1210	210	3.381
3.5	1200	200	1210	200	3.525

The output voltages of the LDOs of the LM26480 are established by the feedback resistor dividers R1 and R2 shown on Figure 5.

The equation for determining V_{OUT} is:

$V_{OUT} = V_{FB} \times (R1+R2)/R2$, where V_{FB} is the voltage on the LDO_FB_x pin.

The LDO control loop will force V_{FB} to be 0.50V ±3%.

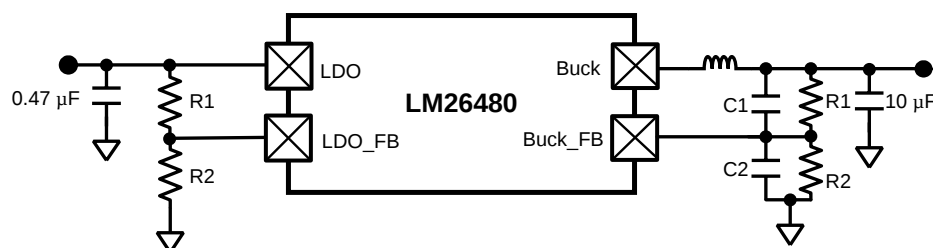


Figure 5. Feedback Network for Bucks and LDOs

As seen in [Figure 5](#), R1 refers to the top resistor which corresponds to R2 and R4 for the bucks, and R6 and R8 for the LDOs. Similarly, R2 is the bottom resistor which corresponds to R3 and R5 for the bucks, and R7 and R9 for the LDOs.

C1 corresponds to C3 and C9 top feedback caps for the bucks, and C2 refers to the bottom feedback caps C4 and C10. For a more detailed diagram of the evaluation board, please refer to [Section 11](#).

7 LM26480 Hardware Block Description

The LM26480 evaluation board is designed to allow the user to test the blocks independently as well as in the system. Jumpers 1-6 as described in the Jumper table allow the VDD and GND path of each of the blocks to be separated from the rest of the blocks.

To look at each of the blocks, follow the instructions below:

1. Start with all the jumpers connected.
2. Remove the connecting jumpers (JP3, JP6, JP9, or JP10) based on the jumper table to isolate the power and ground planes of the block under test.
3. Connect a power supply ($V_{OUT} + 0.3V$) to the input of the desired block referenced to its corresponding ground.
4. Enable the block and proceed with normal testing.

The output voltage of the low dropout regulators can be accessed at the 'Turrets' (LDO1 and LDO2) referenced to GND_M. These are marked on the silkscreen of the evaluation board.

The output voltage of the two buck regulators can be accessed at the 'Turrets' BUCK1, BUCK2 referenced to GND1, and GND2.

External power supplies can be attached to AVDD referenced to GND_C. The voltage supplied to the system must be between the range of 2.8V to 5.5V.

Table 3. Jumper Settings

Jumper	Purpose	Note
JP 1,3,6,9,10	These jumpers connect different V_{INS} to the system VDD (AVDD): JP1 connects VINLDO1 to AVDD JP3 connects VIN1 to AVDD JP6 connects the VIN2 to AVDD JP9 connects VINLDO1 to AVDD JP10 connects VINLDO2 to AVDD	JP3 and JP6 allow the bucks to be powered from the system power. JP9 and JP10 allow the LDOs to be powered from the system power. JP1 powers the internal bias and error amplifiers from the system power. The voltage applied to AVDD and VINLDO12 should be in the range of 2.8 – 5.5V.
JP 4,5,7,8	These jumpers tie the enables of each regulator to VDD: JP4 - Buck1 JP5 - Buck2 JP7- LDO2 JP8 - LDO1	When connected, these jumpers enable the regulators. If disconnected, the regulator will power off.
JP 2	This jumper connects the SYNC pin to GND.	SYNC is default OFF. Please contact the Texas Instruments Sales Office if you wish to use this feature.

8 Gerber Files

The LM26480 is a four layer board. Below are the Gerber files for the board, constructed in Altium Designer.

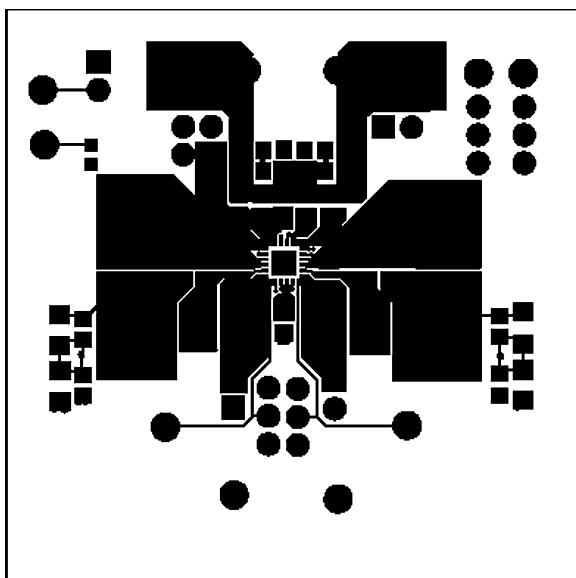


Figure 6. Top Layer

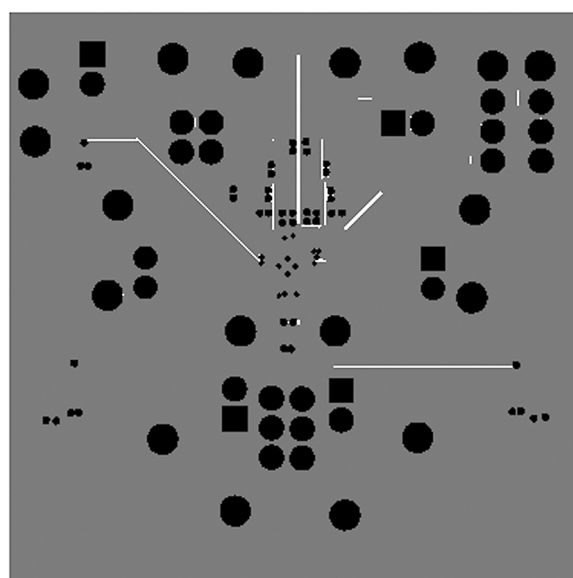


Figure 7. Bottom Layer

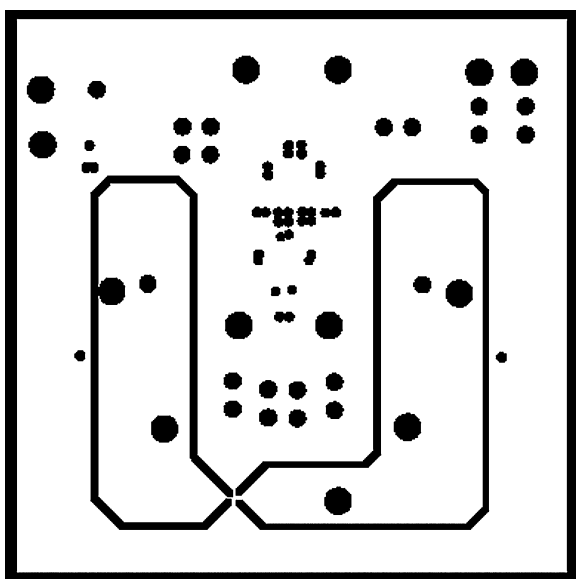


Figure 8. GND Plane

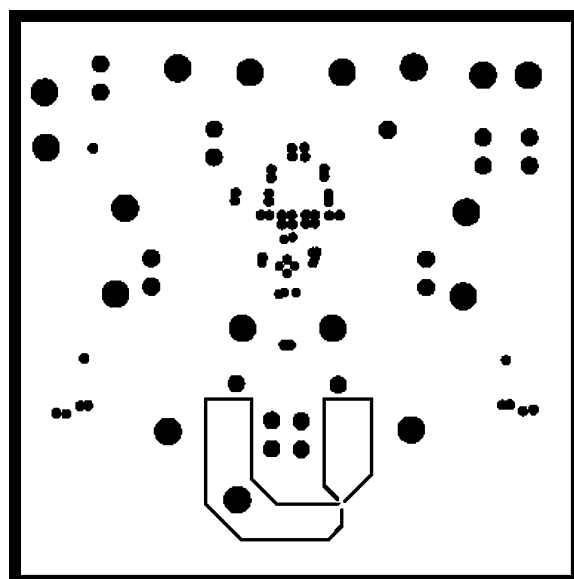
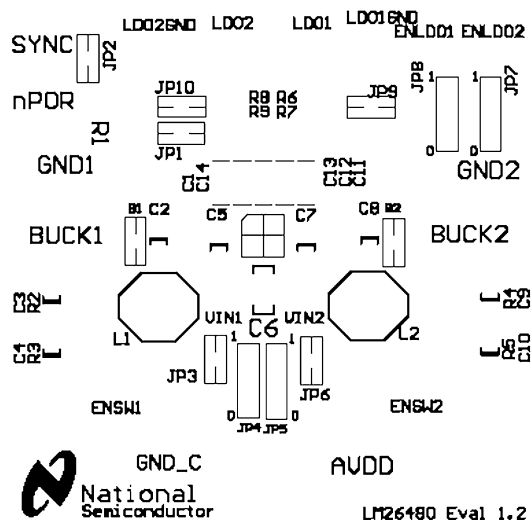


Figure 9. VDD Plane



9 PCB Layout Considerations

The evaluation board layers from top to bottom are:

1. Top, component side
2. Ground plane
3. Mid signal section
4. Bottom, solder side

For good performance of the circuit, it is essential to place the input and output capacitors very close to the circuit and use wide routing for the traces allowing high currents.

Sensitive components should be placed far from those components with high pulsating current.

Decoupling capacitors should be close to circuit's V_{IN} pins. Digital and analog ground should be routed separately and connected together in a star connection.

It's good practice to minimize high current and switching current paths.

9.1 Low Drop Out Regulators

Place the filter capacitors very close to the input and output pins. Use large trace width for high current carrying traces and the returns to ground.

9.2 Buck Regulators

Place the supply bypass, filter capacitor, and inductor close together and keep the traces short. The traces between these components carry relatively high switching current and act as antennas. Following these rules reduces radiated noise.

Arrange the components so that the switching current loops curl in the same direction.

Connect the buck ground and the ground of the capacitors together using generous component-side copper fill as a pseudo-ground plane. Then connect this back to the general board system ground plane at a single point. Place the pseudo-ground plane below these components and then have it tied to system ground of the output capacitor outside of the current loops. This prevents the switched current from injecting noise into the system ground. These components along with the inductor and output should be placed on the same side of the circuit board, and their connections should be made on the same layer.

Route noise sensitive traces such as the voltage feedback path away from the inductor. This is done by routing it on the bottom layer or by adding a grounded copper area between switching node and feedback path. To reduce noisy traces between the power components, keep any digital lines away from this section. Keep the Feedback node as small as possible so that the ground pin and ground traces will shield it from the SW or buck output.

Use wide traces between the power components and for power connections to the DC-DC converter circuit to reduce voltage errors caused by resistive losses.

For the sense lines, make sure to use a Kelvin contact connection.

10 Bill of Materials

Table 4. LM26480 Evaluation Board Bill of Materials

Reference Designator	Value, Size, Tolerance	Description	Vendor/Type
C1, C6, C11,C14	1 μ F, 16V, X7R, 0805	C2012X7R1C105K	TDK
C5, C7, C2, C8	10 μ F, 16V, X7R, 1206	C3216X7R1C106M	TDK
C12, C13	0.47 μ F, 25V, X7R, 0805	C2012X7R1E474K	TDK
R1,R2	22 K Ω 1/10W 1% 0603 SMD	MCR03EZPFX2202	Rohm
R11, R13	0 Ω 0603 SMD	MCR03EZPJ000	Rohm
S1,S2		SMB Connector 131–1701–206	Emerson
L1,L2	2.2 μ H @ 1sat 2A	Coil inductor NP04SZB 2R2N	TaiyoYuden
WQFN package	4 $\times$ 4 mm WQFN-24 package	Power management IC	Texas Instruments LM26480

11 LM26480 Evaluation Board Schematic

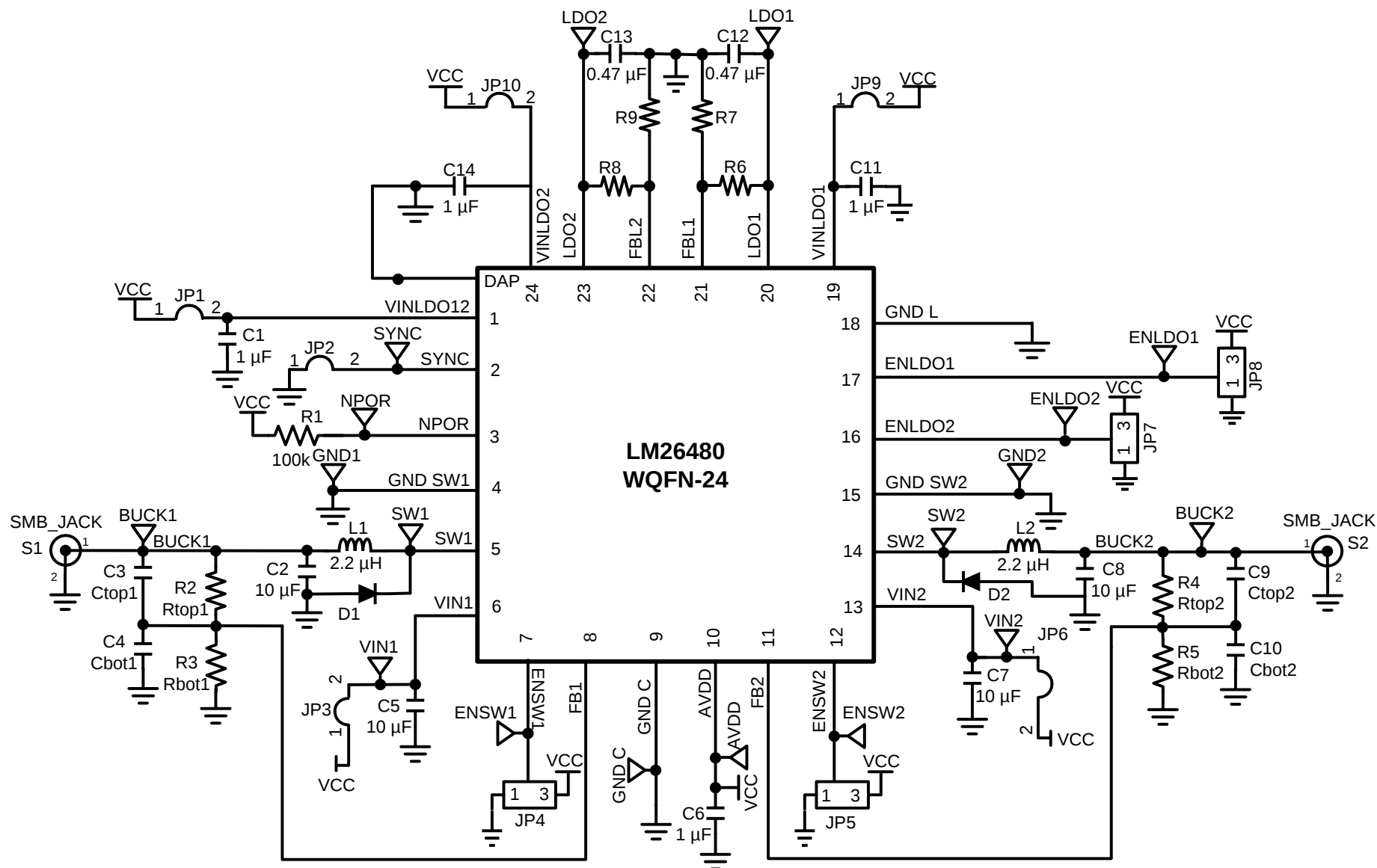


Figure 10. LM26480 Evaluation Board Schematic

STANDARD TERMS AND CONDITIONS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, or documentation (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms and conditions set forth herein. Acceptance of the EVM is expressly subject to the following terms and conditions.

- 1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM ("Software") shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms and conditions that accompany such Software
- 1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

- 2 *Limited Warranty and Related Remedies/Disclaimers:*

- 2.1 These terms and conditions do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.
- 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/lstds/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/lstds/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.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご利用いただく。
2. 実験局の免許を取得後ご利用いただく。
3. 技術基準適合証明を取得後ご利用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。日本テキサス・インスツルメンツ株式会社
東京都新宿区西新宿 6 丁目 2 4 番 1 号
西新宿三井ビル

3.3.3 *Notice for EVMS for Power Line Communication:* Please see http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_02.page
電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_02.page

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.

6. *Disclaimers:*

6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY WRITTEN DESIGN MATERIALS PROVIDED WITH THE EVM (AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS AND CONDITIONS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT MADE, CONCEIVED OR ACQUIRED PRIOR TO OR AFTER DELIVERY OF THE EVM.

7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS AND CONDITIONS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

8.1 *General Limitations.* IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS AND CONDITIONS OR THE USE OF THE EVMS PROVIDED HEREUNDER, REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN ONE YEAR AFTER THE RELATED CAUSE OF ACTION HAS OCCURRED.

8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY WARRANTY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS AND CONDITIONS, OR ANY USE OF ANY TI EVM PROVIDED HEREUNDER, EXCEED THE TOTAL AMOUNT PAID TO TI FOR THE PARTICULAR UNITS SOLD UNDER THESE TERMS AND CONDITIONS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM AGAINST THE PARTICULAR UNITS SOLD TO USER UNDER THESE TERMS AND CONDITIONS SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2015, Texas Instruments Incorporated

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

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Applications Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Automotive and Transportation	www.ti.com/automotive
Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Video and Imaging	www.ti.com/video

TI E2E Community

e2e.ti.com