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 × 4 × 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)

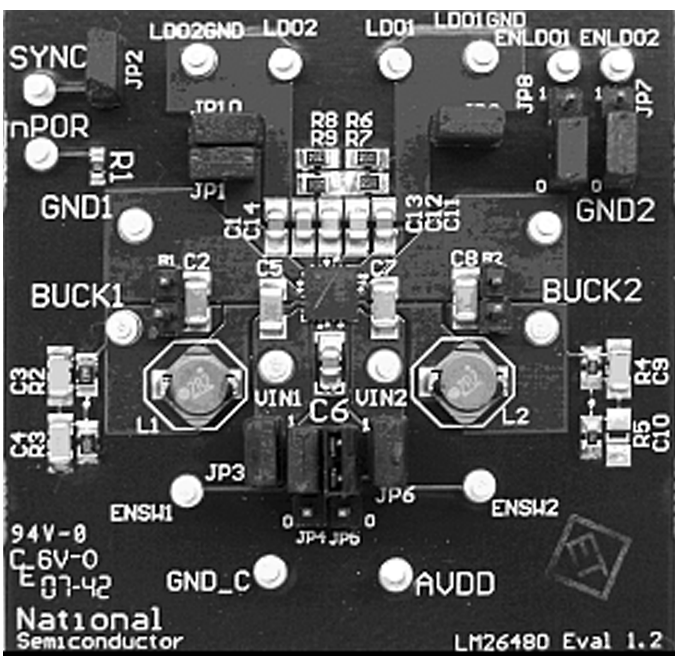


Figure 1. LM26480 Evaluation Board

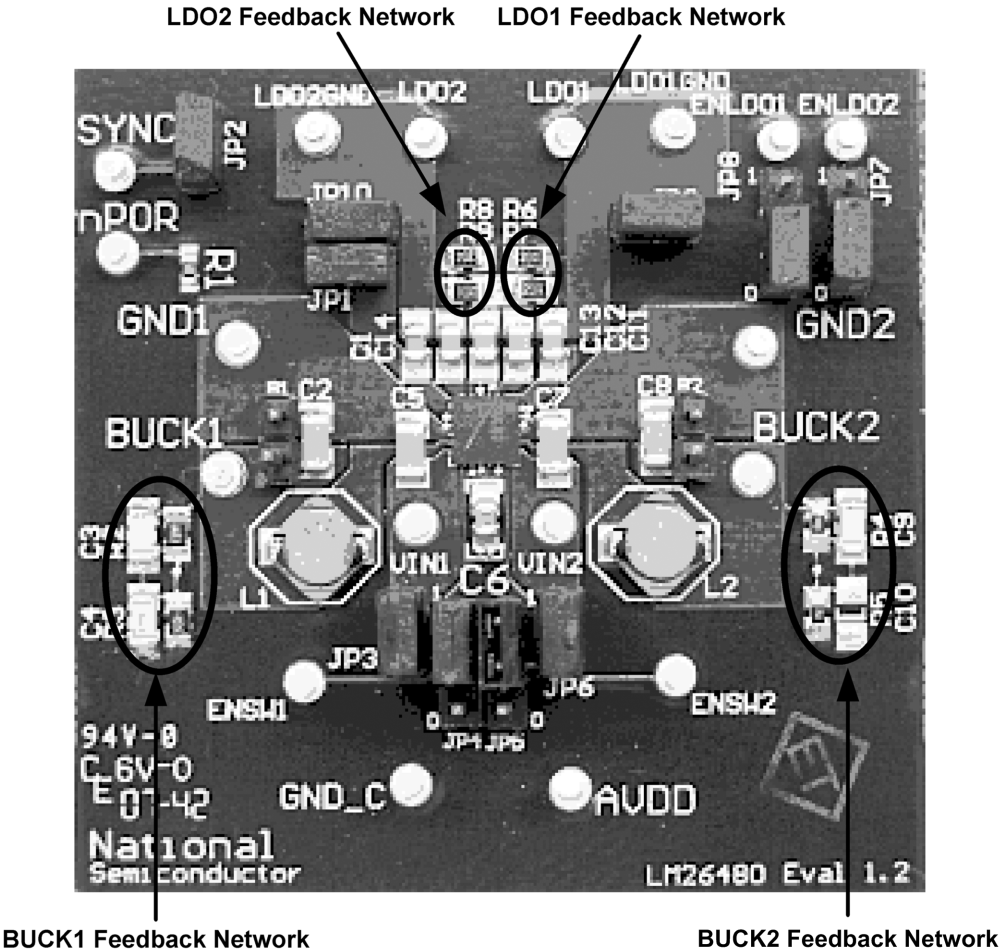


Figure 2. Feedback Network Locations

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.

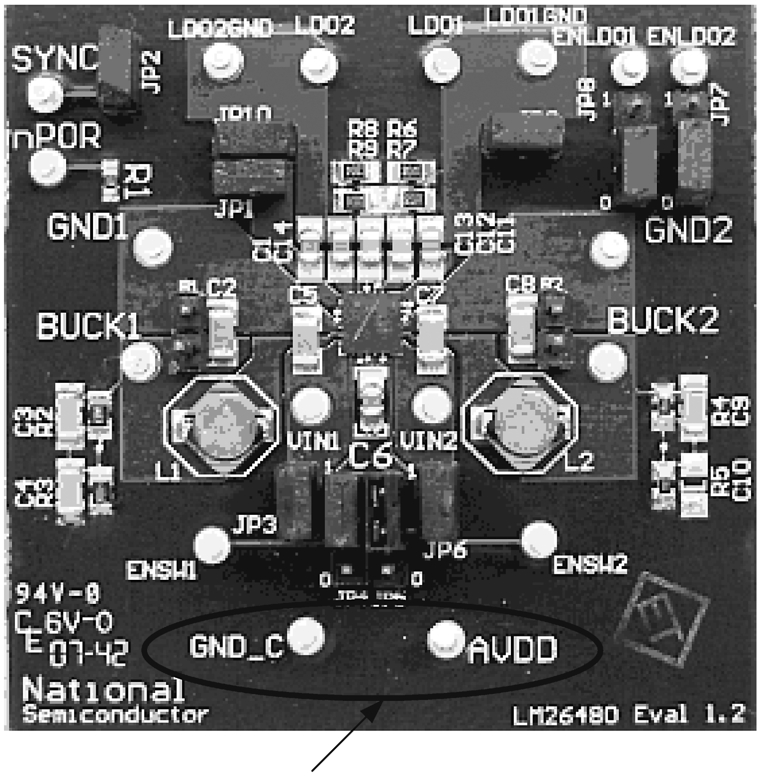


Figure 3. Board Power Pins

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.

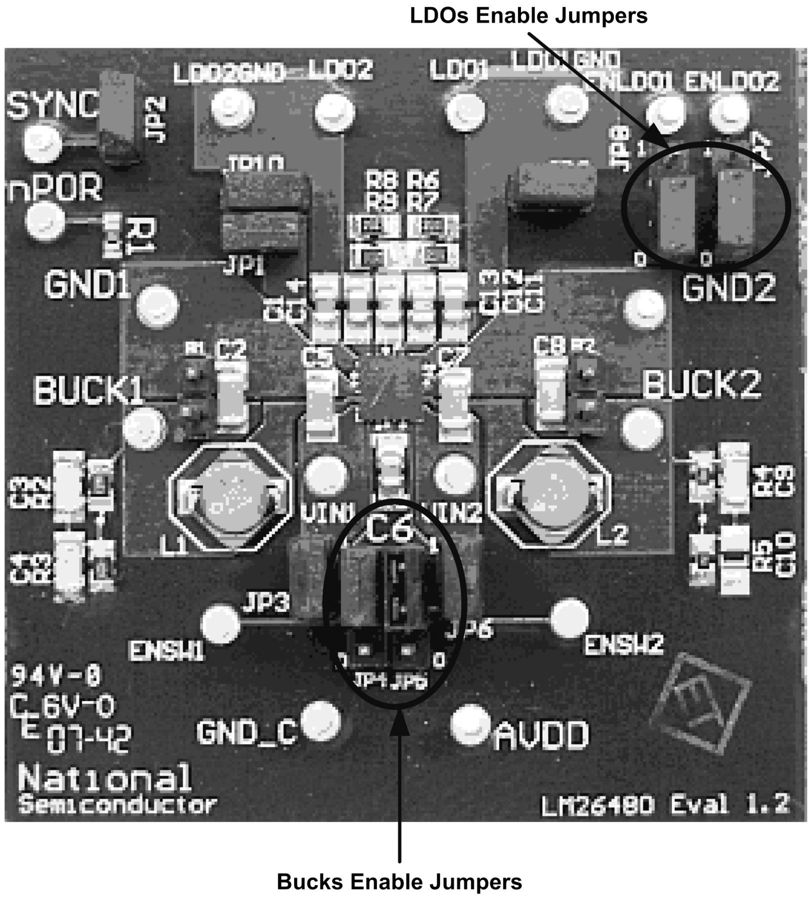


Figure 4. Regulator Enables

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:

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

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

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

Table 1. Component Values for SW1 and SW2

	Ideal Resistor Values		Common R Values		Actual V_{OUT} w/ Com/R (V)	Actual V_{OUT} Delta from Target (V)	Feedback Capacitors		
Target V_{OUT} (V)	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%.

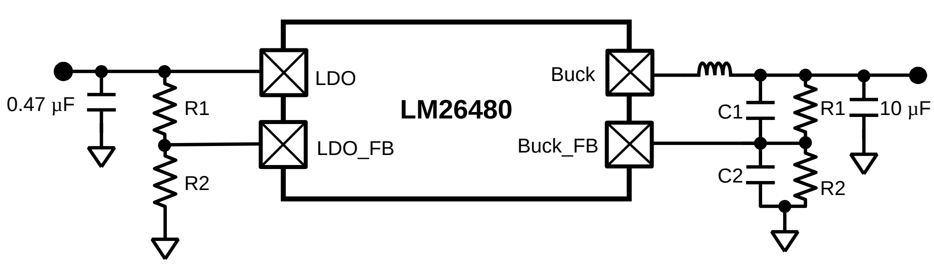


Figure 5. Feedback Network for Bucks and LDOs

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_{IN}s 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 AVDDM 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.

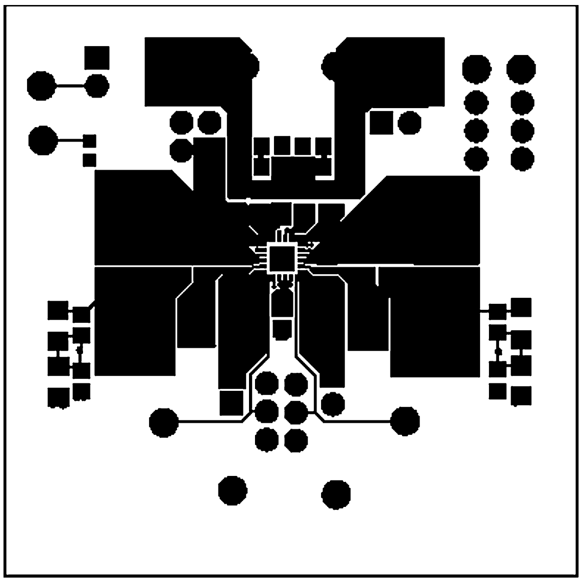


Figure 6. Top Layer

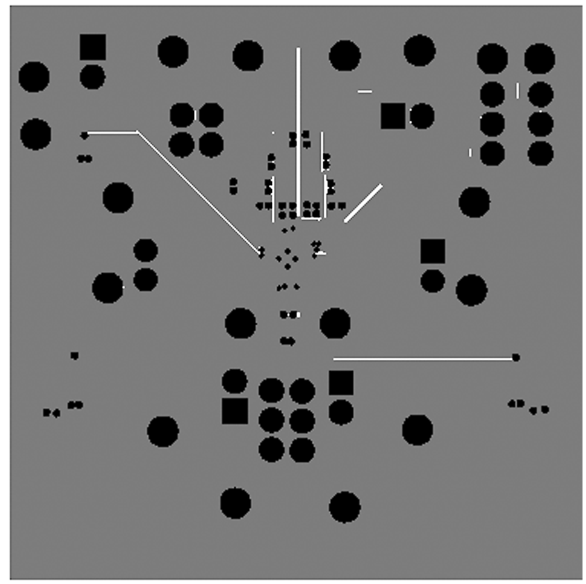


Figure 7. Bottom Layer

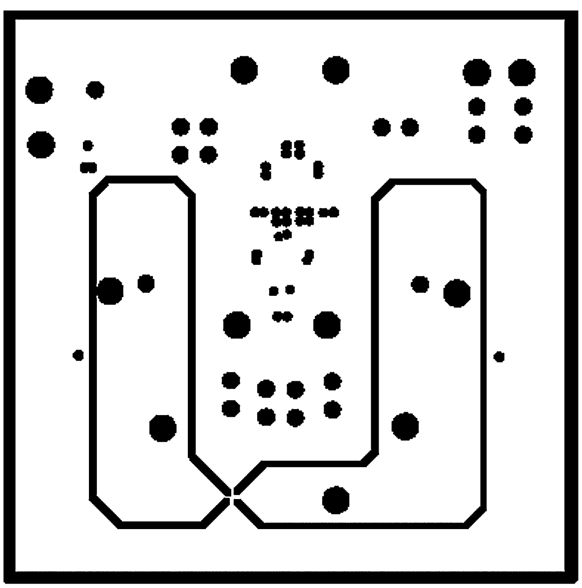


Figure 8. GND Plane

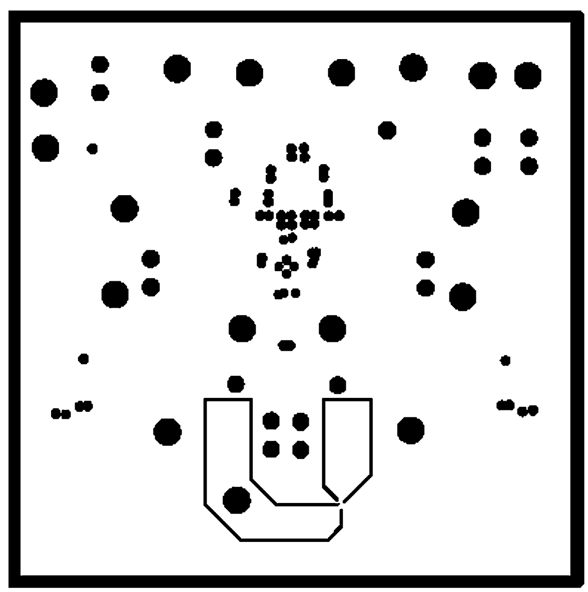
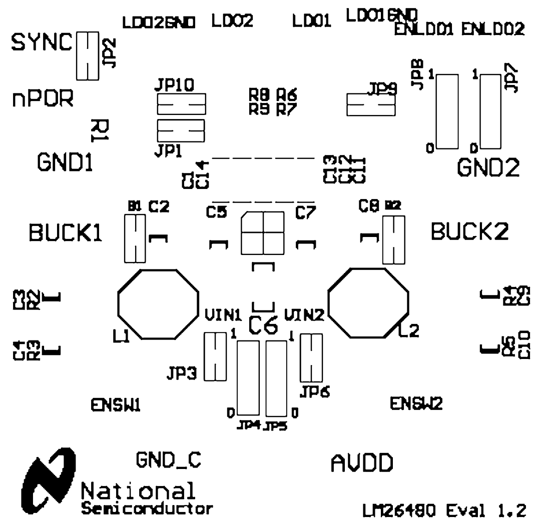


Figure 9. VDD Plane



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 µF, 16V, X7R, 0805	C2012X7R1C105K	TDK
C5, C7, C2, C8	10 µF, 16V, X7R, 1206	C3216X7R1C106M	TDK
C12, C13	0.47 µF, 25V, X7R, 0805	C2012X7R1E474K	TDK
R1,R2	22 KΩ 1/10W 1% 0603 SMD	MCR03EZPFX2202	Rohm
R11, R13	0Ω 0603 SMD	MCR03EZPJ000	Rohm
S1,S2		SMB Connector 131–1701–206	Emerson
L1,L2	2.2 µH @ 1sat 2A	Coil inductor NP04SZB 2R2N	TaiyoYuden
WQFN package	4 × 4 mm WQFN-24 package	Power management IC	Texas Instruments LM26480

11 LM26480 Evaluation Board Schematic

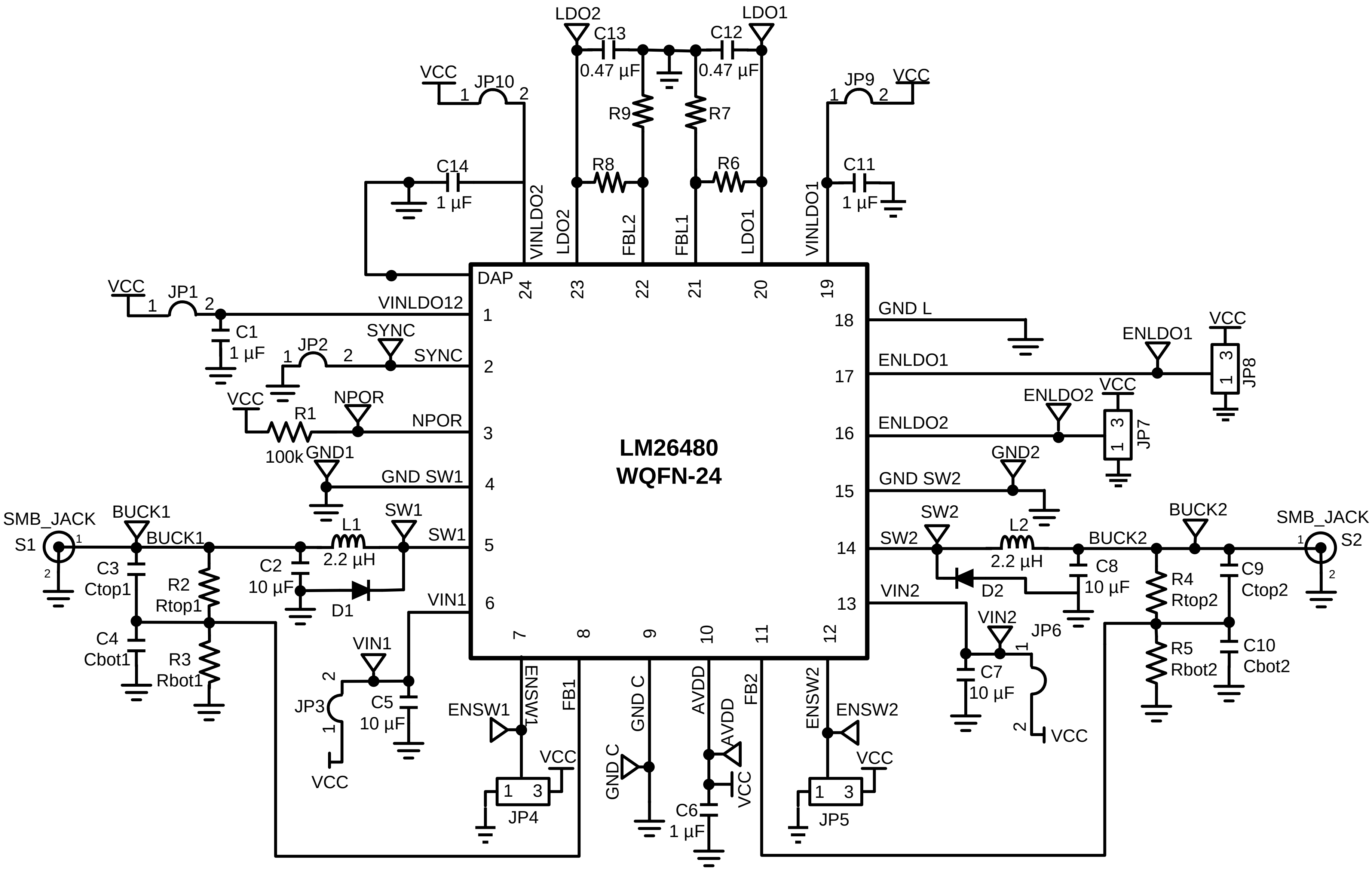


Figure 10. LM26480 Evaluation Board Schematic

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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

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

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.

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

Concerning EVMs including radio transmitters

This device complies with Industry Canada licence-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.

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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.

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Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada.

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2. Use this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or
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2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the EVM. Further, you are responsible to assure 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.
3. You will employ reasonable safeguards to ensure that your use of the EVM will not result in any property damage, injury or death, even if the EVM should fail to perform as described or expected.
4. You will take care of proper disposal and recycling of the EVM’s electronic components and packing materials.

Certain Instructions. It is important to operate this EVM within TI’s recommended specifications and environmental considerations per the user guidelines. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please 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 result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM User's 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, some circuit components may have case temperatures greater than 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use these EVMs.

Agreement to Defend, Indemnify and Hold Harmless. You agree to 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 use of the EVM that is not in accordance with the terms of the agreement. This obligation shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if the EVM fails to perform as described or expected.

Safety-Critical or Life-Critical Applications. If you intend to evaluate the components for possible use in safety critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, such as devices which are classified as FDA Class III or similar classification, then you must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

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