LM3481-FlybackEVM

User's Guide

Literature Number: SNVU528
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Contents

LM3481-FlybackEVM User's Guide

1 Introduction

The LM381-Flyback Evaluation Module helps designers evaluate the operation and performance of the LM3481 boost controller in an isolated flyback design with a wide input voltage. The design accepts an input voltage range of 5 V to 32 V and provides an isolated output of 12 Vout capable of supplying 2 A of current to the load. The switching frequency is externally set at a nominal 130 kHz.

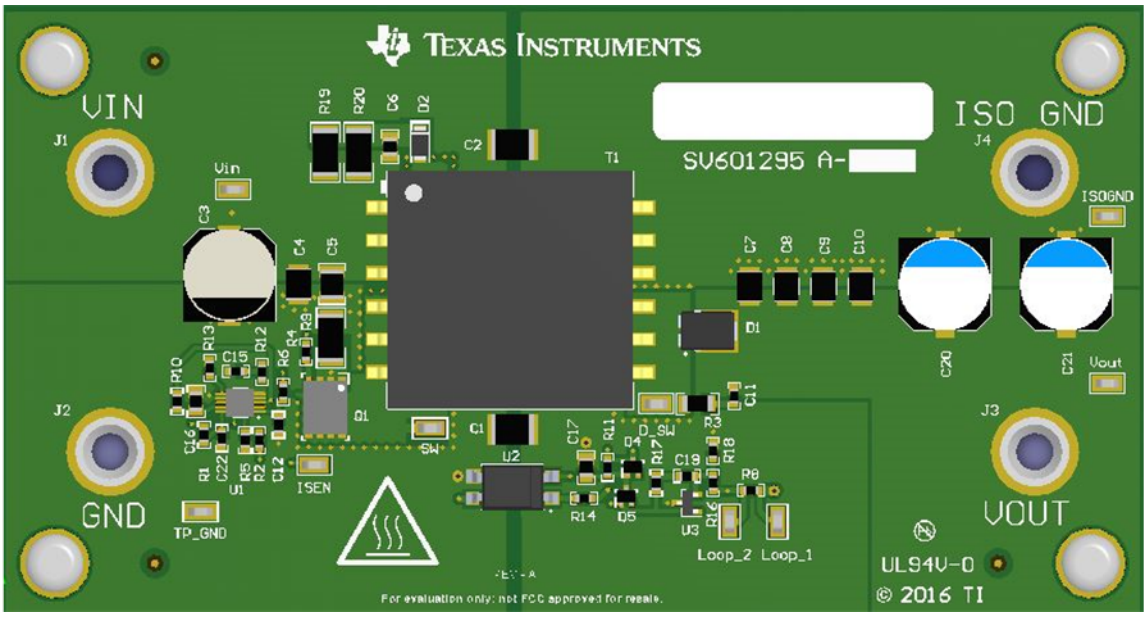


Figure 1. LM3481-Flyback Evaluation Board – Top View

The LM3481 device is a versatile low-side N-FET high-performance controller for switching regulators. The device is designed for use in Boost, SEPIC, and Flyback converters and topologies requiring a low-side FET as the primary switch. The switching frequency of the LM3481 device can be adjusted to any value between 100 kHz and 1 MHz by using a single external resistor or by synchronizing it to an external clock. Current mode control provides superior bandwidth and transient response in addition to cycle-by-cycle current limiting. Current limit can be programmed with a single external resistor. The LM3481 data sheet (SNVS346) gives a complete description of the part, operation, and application information.

2 Specification Summary

A summary of the LM3481-FlybackEVM specifications is provided in Table 1. The ambient temperature is 25°C for all measurements, unless otherwise noted.

Table 1. LM3481-FlybackEVM Specification Summary

Specification[1]	Test Conditions	MIN	TYP	MAX	UNIT
V_{IN} voltage range		5	12	32	V
Output voltage			12		V
Line regulations	I_{OUT} = 2 A ,V_{IN} = 5 V to 32 V		±0.1%		
Operating frequency			130		kHz
Maximum output current		2			A
Efficiency	V_{IN} = 24 V, I_{OUT} = 2 A		88%		

(1) Specifications are at T_A = 25°C

3 Setup

This section describes how to connect, set up, and use the LM3481-Flyback Evaluation Board input and output connectors.

3.1 Input and Output Connector Descriptions

Table 2 describes input and output connectors on the LM3481-FlybackEVM.

Table 2. Input and Output Connectors

Ref	Name	Description
J1	VIN	Positive input power terminal for the EVM.
J2	GND	Return input power terminal for the EVM.
J3	VOUT	Positive output power terminal for the EVM.
J4	ISO GND	Isolated ground or return terminal for the output.
Vin	Vin	Input voltage sense terminal.
TP_GND	TP_GND	Input ground sense terminal.
Vout	Vout	Output voltage sense terminal.
ISOGND	ISOGND	Isolated output ground sense terminal.

3.2 Test Points

Table 3 describes the test points on the LM3481-FlybackEVM.

Table 3. Test Points

Ref	Name	Description
SW	SW	Primary switch node test point.
ISEN	ISEN	Primary side current sense test point.
D_SW	D_SW	Secondary switch node test point.
Loop_1 Loop_2	Loop_1 Loop_2	Loop response measurement test points.

3.3 Test Bench Setup

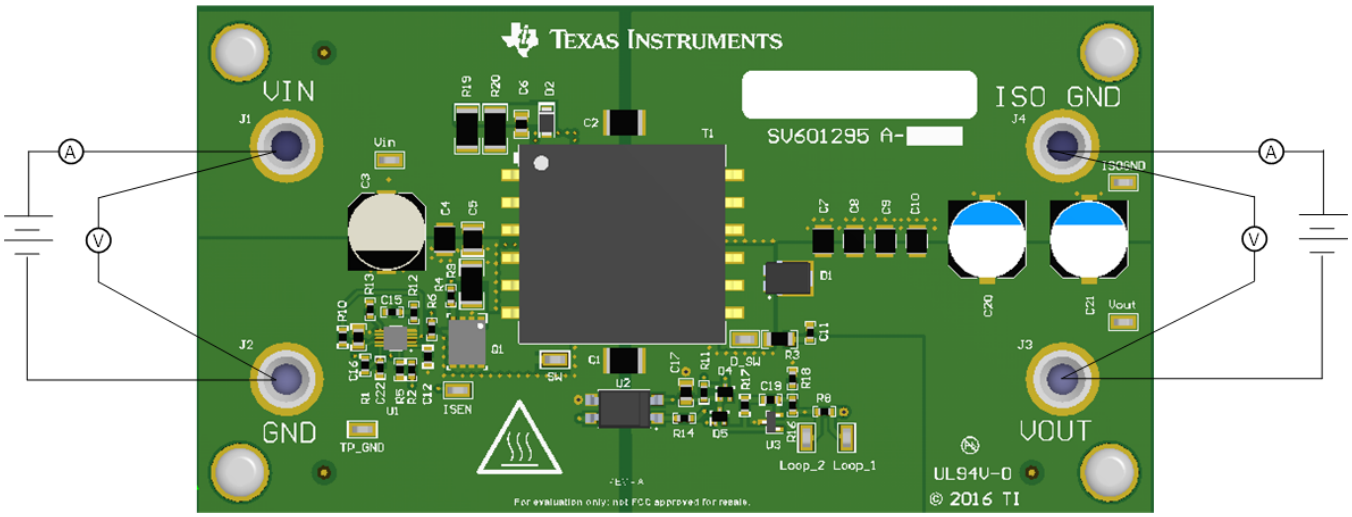


Figure 2. Test Bench Setup

Figure 2 shows a typical test bench setup for the LM3481-FlybackEVM. The power supply and the load should be capable of handling the input and output voltage and current rating of the board. Follow these steps to properly set up the LM3481-FlybackEVM.

1. Connect the power and ground connectors VIN (J1) and GND (J2) to the power supply.
2. Connect an ammeter in series with the input if needed.
3. Connect a voltmeter across the input terminals (Vin, TP_GND).
4. Connect a resistive load or an electronic load across terminals VOUT (J3) and ISO GND (J4).
5. An ammeter can be inserted in series with the load to observe the load current.
6. Connect a voltmeter across the output sense terminals (Vout, ISOGND) to observe the output voltage.
7. With the load initially set to no load, set the power supply between 5 V and 32 V and turn on the power supply. Check for 12 V at the output.
8. Once the output is at the expected target (12 V), increase the load gradually within the operating range (0–2 A).

4 Performance

Figure 3 shows how to place the scope probe for measuring the input or output capacitor.

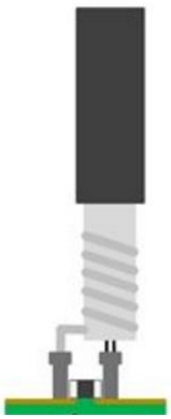


Figure 3. Proper Scope Probe Placements for Measuring Input or Output Capacitor

4.1 Efficiency

Figure 4 shows the efficiency for the LM3481-Flyback Evaluation Module.

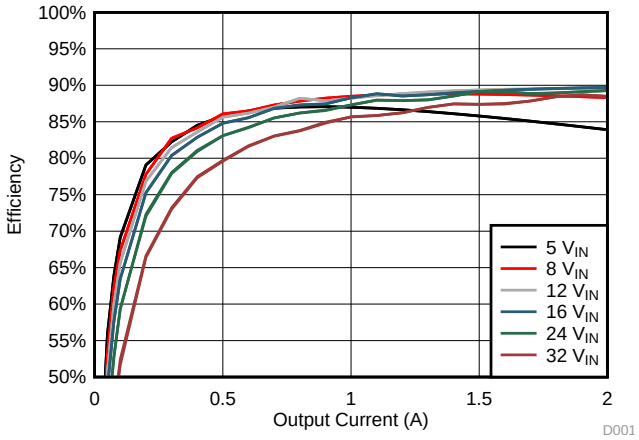
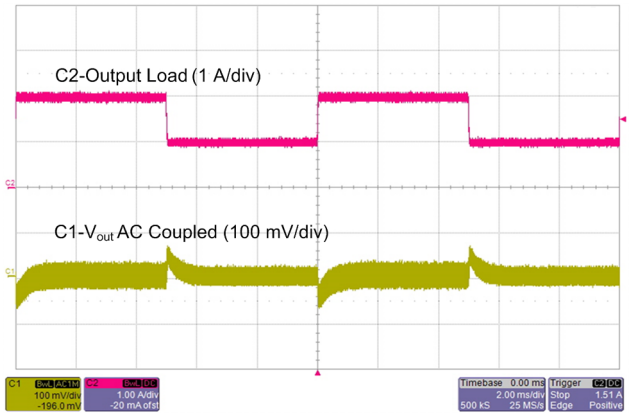


Figure 4. Efficiency vs Output Load

4.2 Load Transient

Figure 5 shows the LM3481-FlybackEVM response to load transients. The current step is from 50% to 100% of maximum rated load at VIN = 12 V. The current step slew rate is 70 mA/µs. Total peak-to-peak voltage variations is as shown, including ripple and noise on the output. Figure 6 shows the LM3481-FlybackEVM loop-response characteristics. Gain and phase plots are shown for VIN voltage of 12 V with load current of 2 A. The loop-response measurement is taken by replacing R8 with a 49.9-Ω resistor. The signal is then injected across R8 with test points Loop_1 and Loop_2.



Time base: 2 mS/div

Figure 5. Load Transient Response at 12 VIN

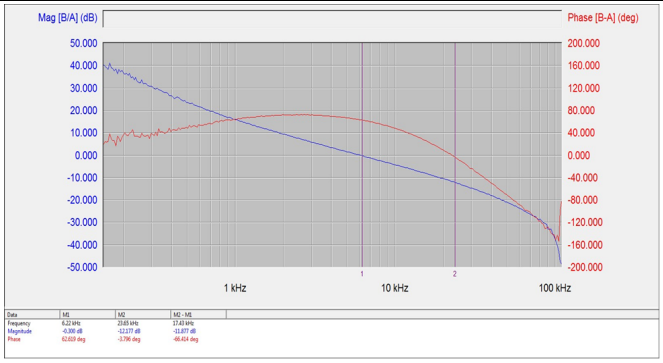
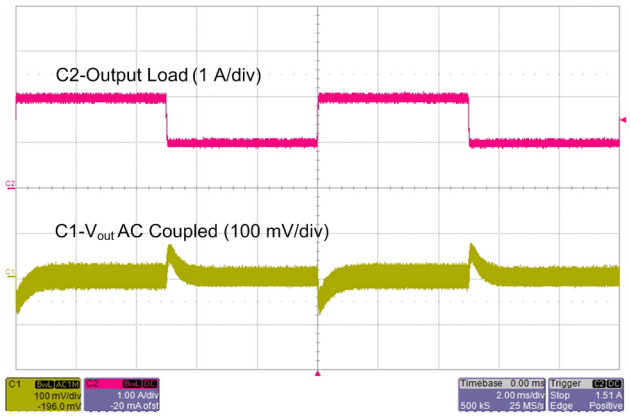


Figure 6. Loop Response at 12 VIN

Figure 7 shows the LM3481-FlybackEVM response to load transients at 20 VIN. Figure 8 shows the LM3481-FlybackEVM loop-response characteristics. Gain and phase plots are shown for VIN voltage of 20 V with load current of 2 A.



Time base: 2 mS/div

Figure 7. Load Transient Response at 20 VIN

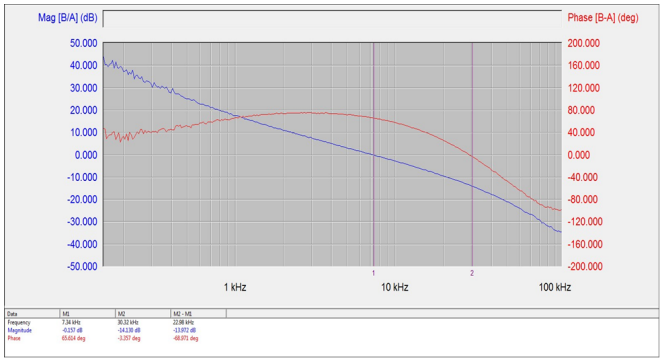
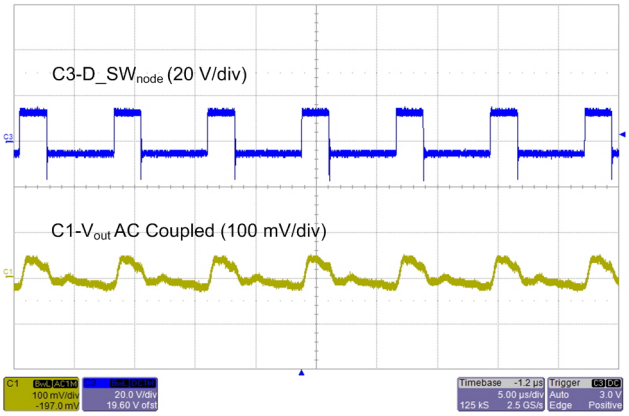


Figure 8. Loop Response at 20 VIN

4.3 Output Voltage Ripple

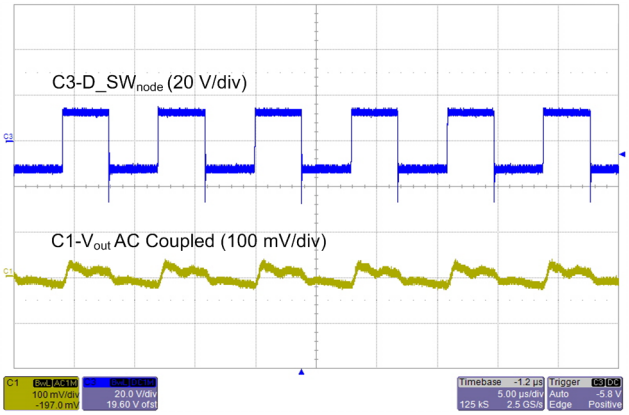
Figure 9 shows the output voltage ripple and rectifier diode switching waveform (anode to ISO GND) for the LM3481-FlybackEVM. The output current is the rated full load of 2 A and VIN = 5.5 V. The ripple voltage is measured directly across C10.



Time base: 5 µs/div

Figure 9. Maximum Load Output Voltage Ripple at VIN = 5.5 V

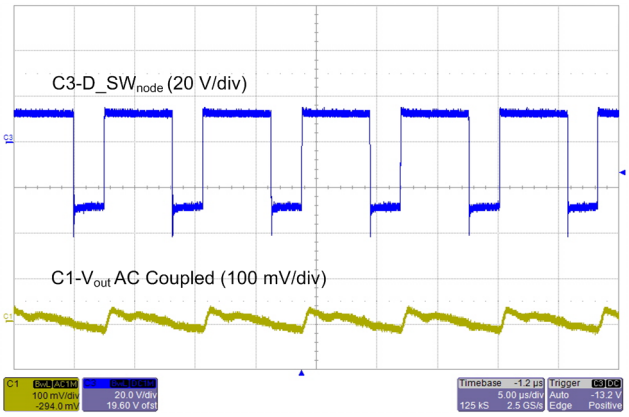
Figure 10 shows the output voltage ripple and rectifier diode switching waveform (anode to ISO GND) for the LM3481-FlybackEVM at 12 VIN and 2 A of output Load.



Time base: 5 µs/div

Figure 10. Maximum Load Output Voltage Ripple at VIN = 12 V

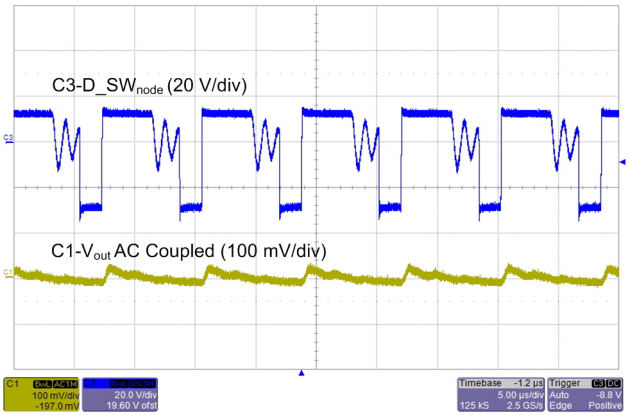
Figure 11 shows the output voltage ripple and rectifier diode switching waveform (anode to ISO GND) for the LM3481-FlybackEVM at 28 VIN and 2 A of output Load.



Time base: 5 µs/div

Figure 11. Maximum Load Output Voltage Ripple at VIN = 28 V

Figure 12 shows the output voltage ripple and switching waveform for the LM3481-FlybackEVM while operating in discontinuous conduction mode (DCM). The input voltage is 28 V and the output is loaded with 0.75 A of Load.

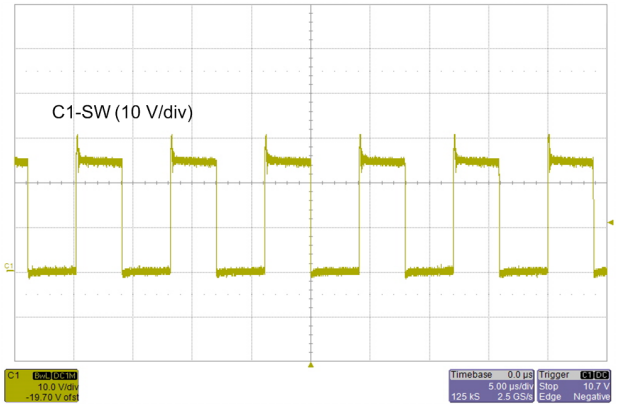


Time base: 5 µs/div

Figure 12. DCM Output Voltage Ripple

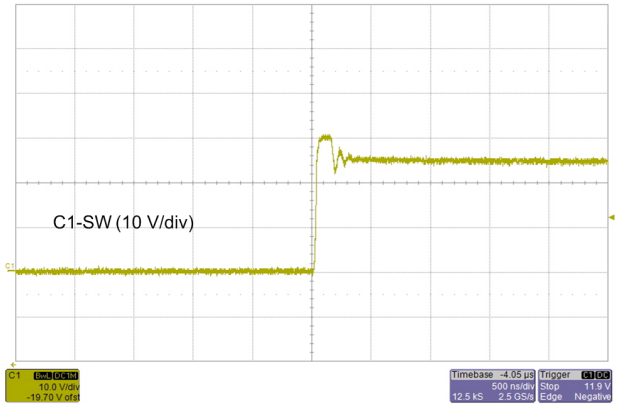
4.4 Voltage Overshoot on SW Pin

Figure 13 and Figure 14 show the voltage overshoot on the primary SW pin with 200 MHz bandwidth. This is measured with 12 V input voltage and 2 A output current.



Time base: 5 µs/div

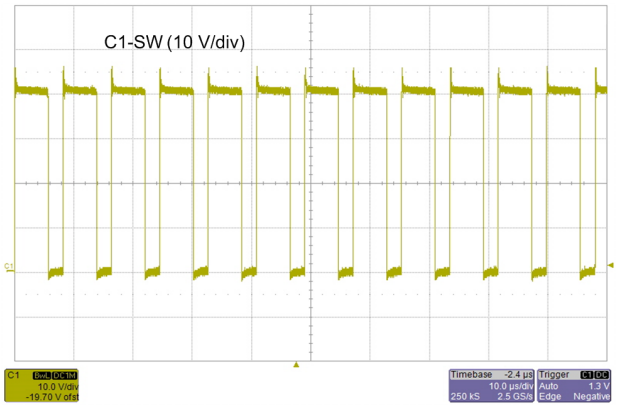
Figure 13. Primary Switch Node at 12 VIN



Time base: 500 ns/div

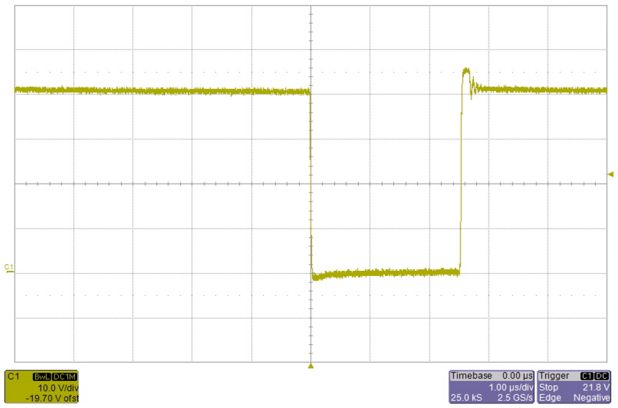
Figure 14. Primary Switch Node Overshoot- Zoomed in at 12 VIN

Figure 15 and Figure 16 show the voltage overshoot on the primary SW pin with 200 MHz bandwidth. This is measured with 12 V input voltage and 2 A output current.



Time base: 10 µs/div

Figure 15. Primary Switch Node at 28 VIN



Time base: 1 µs/div

Figure 16. Primary Switch Node Overshoot Zoomed in at 28 VIN

5 Complete Schematic

Figure 17 shows the schematic of the LM3481-Flyback evaluation board.

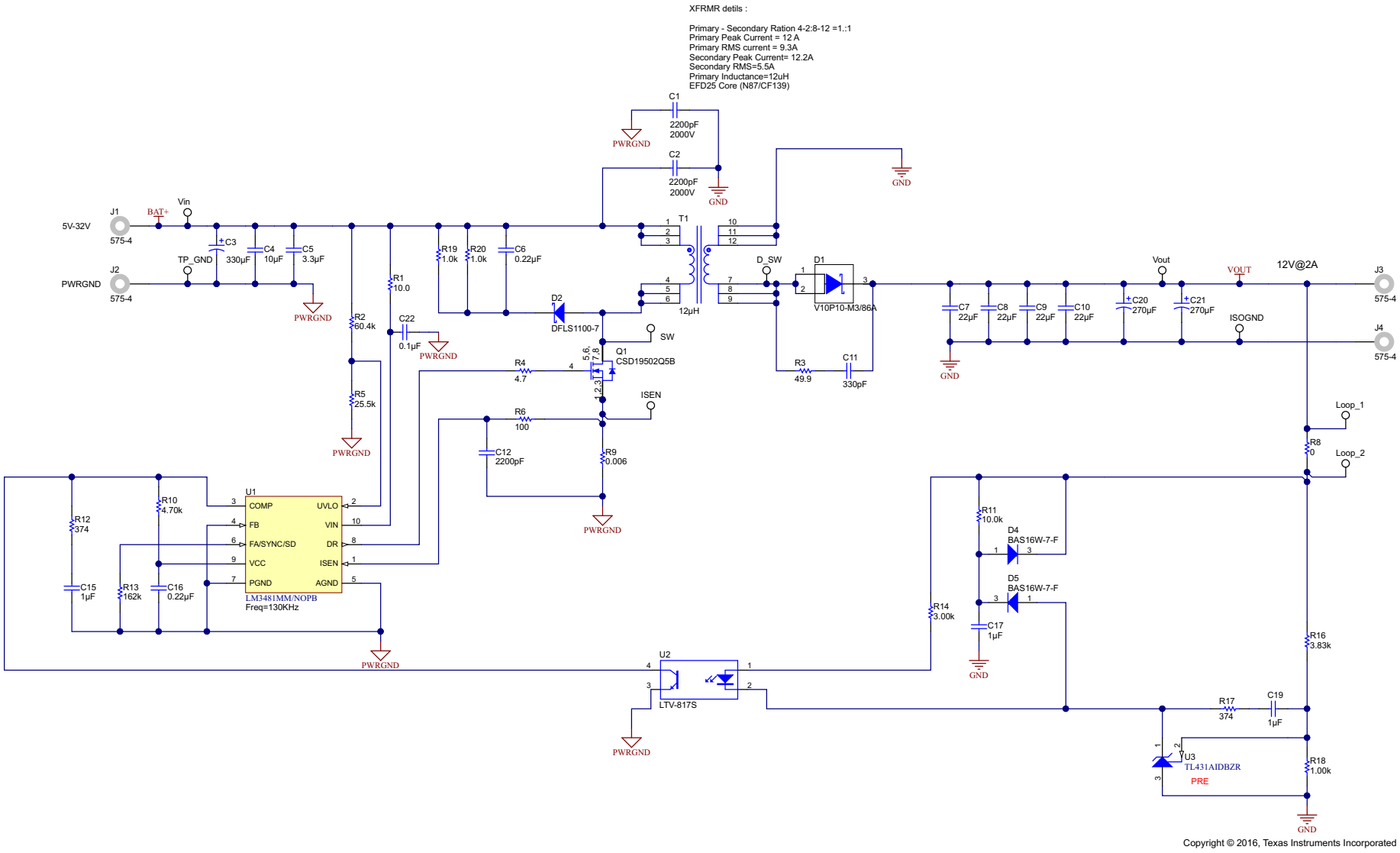


Figure 17. LM3481-FlybackEVM Schematic

6 Bill of Materials

Table 4. Bill of Materials

Item	Designator	Description	Manufacturer	Part Number	Qty
1	!PCB1	Printed Circuit Board	Any	SV601295	1
2	C1, C2	CAP, CERM, 2200 pF, 2000 V, ±10%, X7R, 1812	TDK	C4532X7R3D222K130KA	2
3	C3	CAP, AL, 330 µF, 35 V, ±20%, 0.06 Ω, SMD	Panasonic	EEE-FP1V331AP	1
4	C4	CAP, CERM, 10 µF, 50 V, ±20%, X7R, 1210	TDK	C3225X7R1H106M250AC	1
5	C5	CAP, CERM, 3.3 µF, 50 V, ±10%, X7R, 1210	MuRata	GRM32DR71H335KA88L	1
6	C6	CAP, CERM, 0.22 µF, 100 V, ±10%, X7R, 0805	Samsung Electro-Mechanics	CL21B224KCFSNWE	1
7	C7, C8, C9, C10	CAP, CERM, 22 µF, 25 V, ±20%, X5R, 1210	AVX	12103D226MAT2A	4
8	C11	CAP, CERM, 330 pF, 100 V, ±10%, X7R, 0603	AVX	06031C331KAT2A	1
9	C12	CAP, CERM, 2200 pF, 50 V, ±10%, X7R, 0603	Kemet	C0603C222K5RACTU	1
10	C15, C19	CAP, CERM, 1 µF, 25 V, ±10%, X7R, 0603	Kemet	C0603C105K3RACTU	2
11	C16	CAP, CERM, 0.22 µF, 50 V, ±10%, X7R, 0805	TDK	C2012X7R1H224K125AA	1
12	C17	CAP, CERM, 1 µF, 50 V, ±10%, X7R, 0805	TDK	C2012X7R1H105K125AB	1
13	C20, C21	CAP, Aluminum Polymer, 270 µF, 25 V, ±20%, 0.027 Ω, D10xL12.7 mm SMD	Nichicon	PCV1E271MCL1GS	2
14	C22	CAP, CERM, 0.1 µF, 50 V, ±10%, X7R, 0603	TDK	C1608X7R1H104K080AA	1
15	D1	Diode, Schottky, 100 V, 10 A, TO-277A	Vishay-Semiconductor	V10P10-M3/86A	1
16	D2	Diode, Schottky, 100 V, 1 A, PowerDI123	Diodes Inc.	DFLS1100-7	1
17	D4, D5	Diode, Switching, 75 V, 0.15 A, SOT-323	Diodes Inc.	BAS16W-7-F	2
18	D_SW, ISEN, ISOGND, Loop_1, Loop_2, SW, TP_GND, Vin, Vout	Test Point, Miniature, SMT	Keystone	5015	9
19	H1, H2, H3, H4	Machine Screw, Round, #4-40 × 1/4, Nylon, Philips panhead	B&F Fastener Supply	NY PMS 440 0025 PH	4
20	H5, H6, H7, H8	Standoff, Hex, 0.5"L #4-40 Nylon	Keystone	1902C	4
21	J1, J2, J3, J4	Standard Banana Jack, Uninsulated, 5.5 mm	Keystone	575-4	4
22	LBL1	Thermal Transfer Printable Labels, 1.250" W × 0.250" H - 10,000 per roll	Brady	THT-13-457-10	1
23	Q1	MOSFET, N-CH, 80 V, 100 A, DNK0008A	Texas Instruments	CSD19502Q5B	1
24	R1	RES, 10.0, 1%, 0.1 W, 0603	Vishay-Dale	CRCW060310R0FKEA	1
25	R2	RES, 60.4 k, 1%, 0.1 W, 0603	Vishay-Dale	CRCW060360K4FKEA	1
26	R3	RES, 49.9, 1%, 0.25 W, 1206	Yageo America	RC1206FR-0749R9L	1
27	R4	RES, 4.7 Ω, 5%, 0.1W, 0603	Vishay-Dale	CRCW06034R70JNEA	1
28	R5	RES, 25.5 k, 0.1%, 0.1 W, AEC-Q200 Grade 0, 0603	Panasonic	ERA-3AEB2552V	1
29	R6	RES, 100, 1%, 0.1 W, 0603	Vishay-Dale	CRCW0603100RFKEA	1
30	R8	RES, 0, 5%, 0.1 W, 0603	Vishay-Dale	CRCW06030000Z0EA	1
31	R9	RES, 0.006, 1%, 1 W, 2010	Rohm	PMR50HZPFU6L00	1
32	R10	RES, 4.70 k, 1%, 0.1 W, 0603	Yageo America	RC0603FR-074K7L	1
33	R11	RES, 10.0 kΩ, 1%, 0.1W, 0603	Vishay-Dale	CRCW060310K0FKEA	1

Table 4. Bill of Materials (continued)

Item	Designator	Description	Manufacturer	Part Number	Qty
34	R12, R17	RES, 374, 1%, 0.1 W, 0603	Vishay-Dale	CRCW0603374RFKEA	2
35	R13	RES, 162 k, 1%, 0.1 W, 0603	Vishay-Dale	CRCW0603162KFKEA	1
36	R14	RES, 3.00 k, 1%, 0.1 W, 0603	Yageo America	RC0603FR-073KL	1
37	R16	RES, 3.83 k, 0.1%, 0.1 W, 0603	Susumu Co Ltd	RG1608P-3831-B-T5	1
38	R18	RES, 1.00 k, 0.1%, 0.1 W, 0603	Susumu Co Ltd	RG1608P-102-B-T5	1
39	R19, R20	RES, 1.0 k, 5%, 0.75 W, 2010	Vishay-Dale	CRCW20101K00JNEF	2
40	T1	Transformer, 12 uH, SMT	Wurth Elektronik	750316152	1
41	U1	High Efficiency Low-Side N-Channel Controller for Switching Regulators, 10-pin MSOP, Pb-Free	Texas Instruments	LM3481MM/NOPB	1
42	U2	Optocoupler, 5 kV, 50-600% CTR, TH-4	Lite-On	LTV-817S	1
43	U3	Adjustable Precision Shunt Regulator, 34 ppm / °C, 100 mA, –40 to 85 °C, 3-pin SOT-23 (DBZ), Green (RoHS and no Sb/Br)	Texas Instruments	TL431AIDBZR	1
44	FID1, FID2, FID3	Fiducial mark. There is nothing to buy or mount.	N/A	N/A	0

7 PCB Layout

Figure 18 through Figure 21 shows the board layout for the LM3481-FLyback EVM.

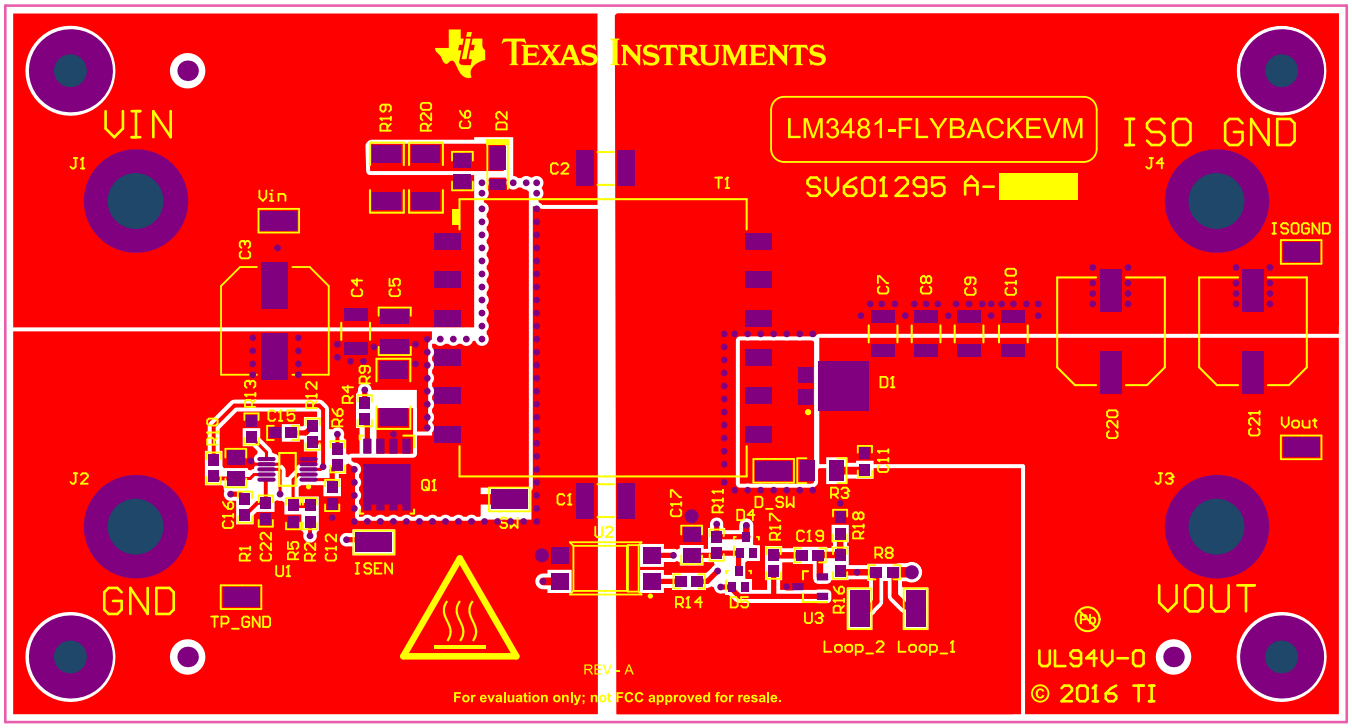


Figure 18. Top Layer

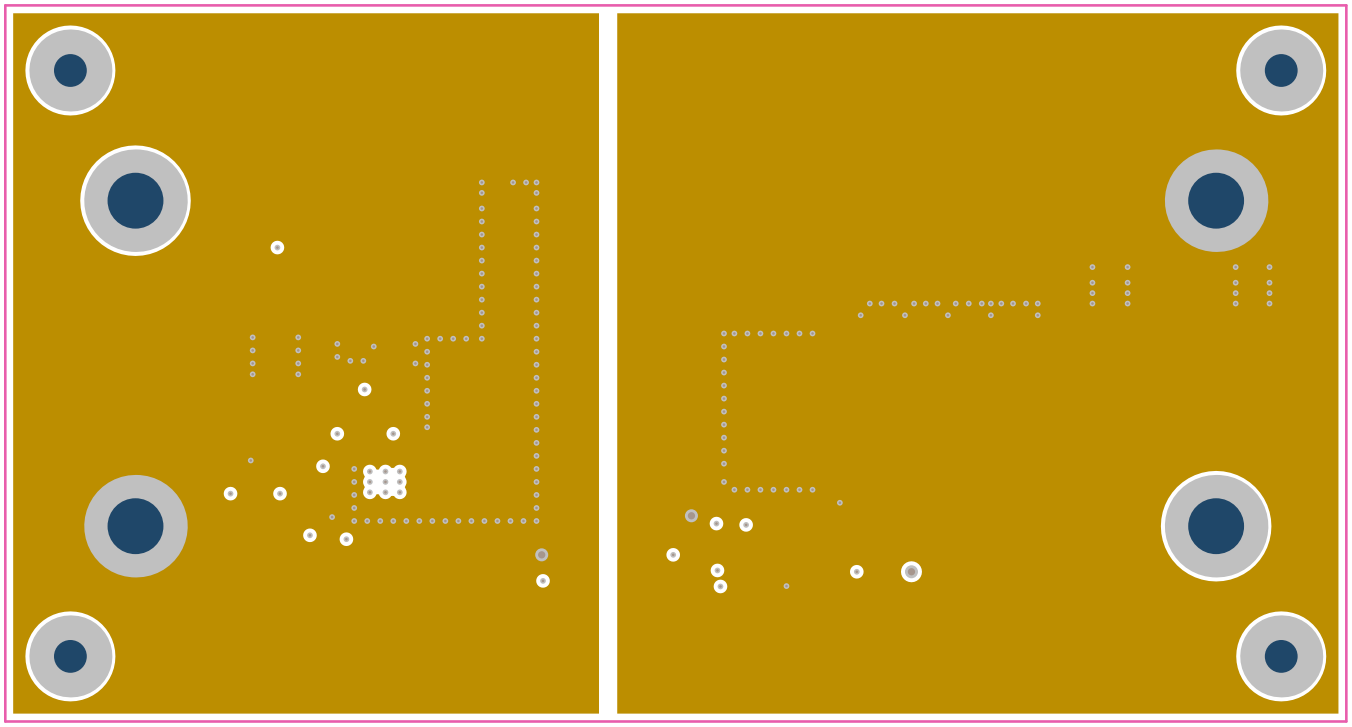


Figure 19. Mid Layer 1

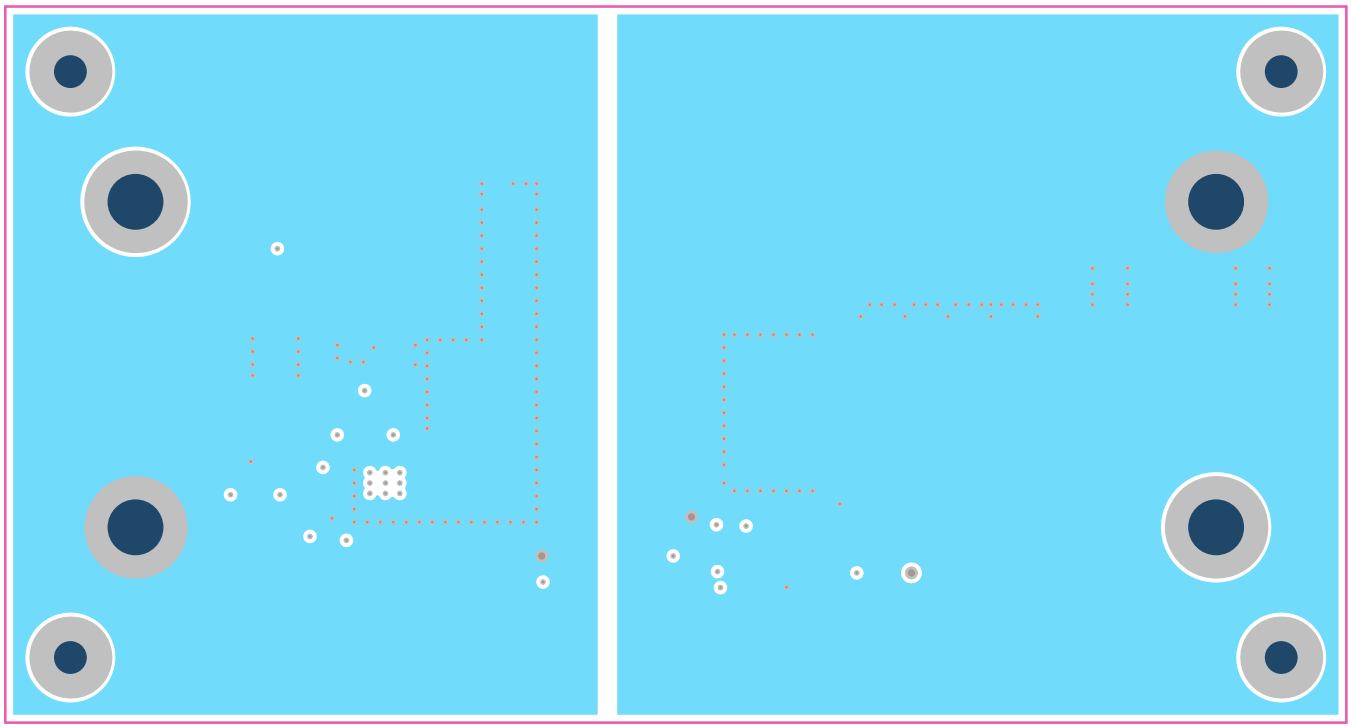


Figure 20. Mid Layer 2

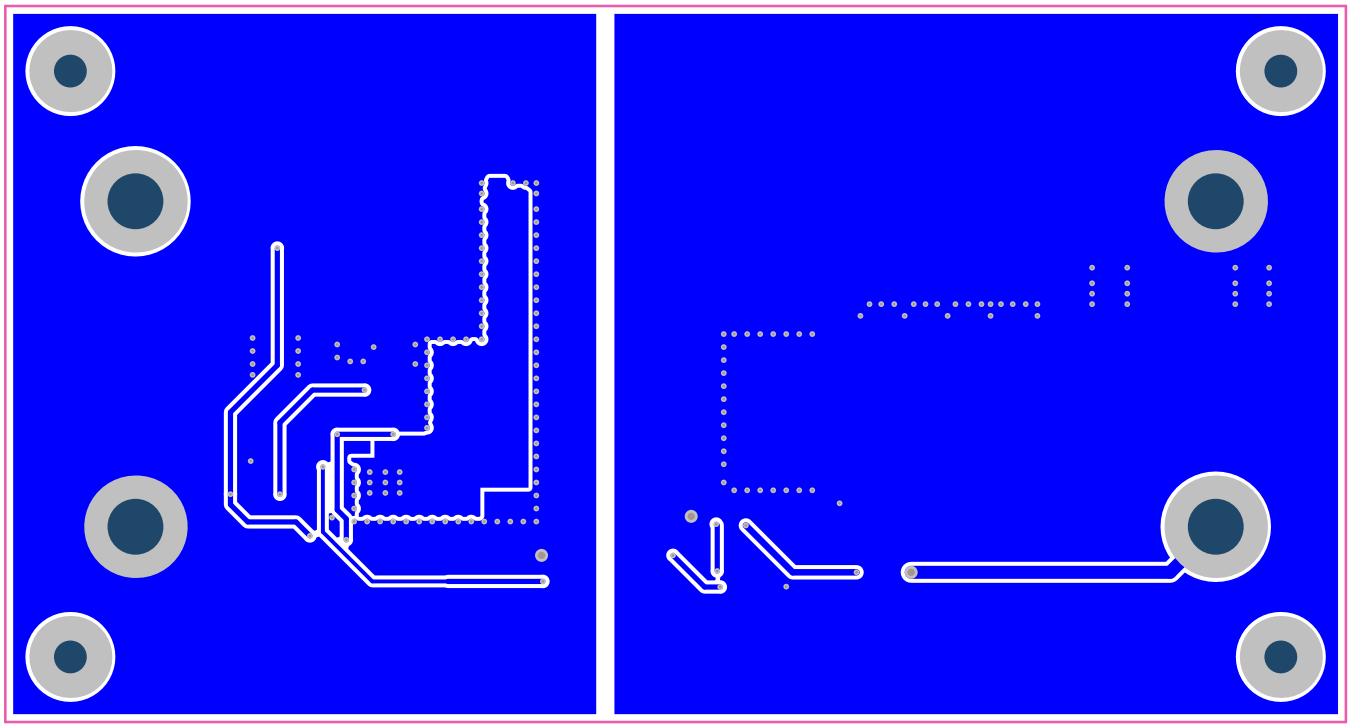


Figure 21. Bottom Layer

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/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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3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

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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.

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:*

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