EVM User's Guide: LMR36500EVM

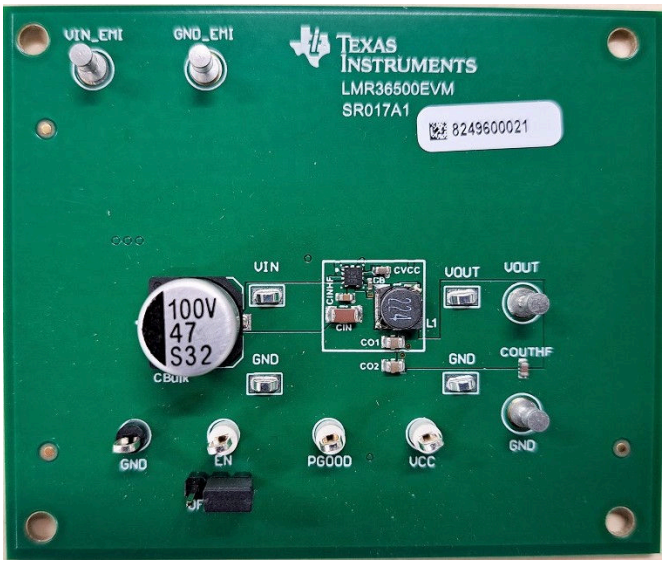
LMR36500 Evaluation Module

Description

The Texas Instruments' LMR36500EVM evaluation module (EVM) helps designers evaluate the operation and performance of the LMR36500 family of wide input voltage buck converters. The LMR36500 is an easy to use synchronous step-down converter capable of supplying up to 50 mA of load current from an input voltage as high as 65-V. See the data sheet (SNVSC41) for more information.

Features

- 3 V to 65 V wide input voltage range
- 5 V fixed default output voltage
- Up to 50 mA output current
- 1 MHz default switching frequency
- Minimized switch node ringing to reduce EMI
- Input transient capability up to 70 V



LMR36500EVM

1 Evaluation Module Overview

1.1 Introduction

The LMR36500EVM is configured to deliver a 5-V output to a load requiring 50 mA or less. The switching frequency is set to 1000 kHz, but can be adjusted by changing the state of the RT pin, or connecting a resistor from the RT pin to ground. The LMR36500EVM can be used in many different configurations by substituting other versions of the LMR36500 and re-configuring the board components. The default EVM uses the LMR36500P5RPER device.

See Section 1.4 for more details.

1.2 Kit Contents

This kit includes one LMR36500EVM.

1.3 Specification

Performance characteristics for the LMR36500EVM, with LMR36500P5RPER, are found in Table 1-1

Unless otherwise stated: V_{IN} = 12 V, T_A = 25ºC.

Table 1-1. LMR36500EVM Electrical Performance Characteristics

Parameter	Test Conditions		MIN	TYP	MAX	UNITS
INPUT CHARACTERISTICS						
Input voltage range, V_{VIN}	EVM input voltage operating range		6	12	65	V
Input current, no load, $I_{IN(NL)}$	I_{OUT} = 0 A	V_{IN} = 12 V		9		µA
Input current, disabled, $I_{IN(OFF)}$	$V_{EN/UVLO}$ = 0 V, no EN divider	V_{IN} = 12 V		0.5		µA
OUTPUT CHARACTERISTICS						
Output voltage, V_O	I_{OUT} = 0 A			5.052		V
	I_{OUT} = 0.05 A			4.99		V
Output voltage regulation, ΔV_{OUT}	Load regulation,	I_{OUT} = 0 A to 0.05 A		62		mV
Output voltage regulation, ΔV_{OUT}	Line regulation, V_{IN} = 6 V to 65 V	I_{OUT} = 0 A		5		
Output voltage regulation, ΔV_{OUT}	Line regulation, V_{IN} = 6 V to 65 V	I_{OUT} = 0.05 A		0.5		
Maximum output current	V_{IN} = 12 V			0.067		A
Soft-start time, t_{SS}				3		ms
SYSTEM CHARACTERISTICS						
Switching frequency	I_{OUT1} = 0.05 A			1000		kHz
Half-load efficiency	I_{OUT} = 0.02 A	V_{IN} = 12 V		82%		
Full load efficiency	I_{OUT} = 0.05 A	V_{IN} = 12 V		86%		
		V_{IN} = 24 V		80%		

1.4 Device Information

The default EMV incorporates the LMR36500P5RPER. Table 1-2 provides a list of additional devices that can be used with the LMR36500EVM.

Table 1-2. LMR36500EVM Device Options

Device OPN	Mode	Output Voltage	Frequency
LMR36500F3RPER	FPWM	3.3V/Adj	1 MHz/2.2MHz/Adj
LMR36500F5RPER	FPWM	5 V/Adj	1 MHz/2.2MHz/Adj
LMR36500P3RPER	AUTO	3.3V/Adj	1 MHz/2.2MHz/Adj
LMR36500P5RPER	AUTO	5 V/Adj	1 MHz/2.2MHz/Adj

2 Hardware

2.1 Additional Images

Figure 2-1 andFigure 2-2 show the front and back of the LMR36500EVM respectively.

Figure 2-1. LMR36500EVM Top Side

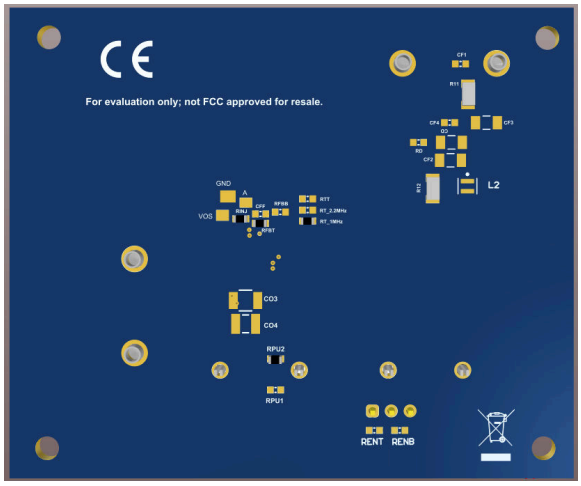


Figure 2-2. LMR36500EVM Bottom Side

2.2 Power Requirements

Any power source in the range of 3.5 V to 65 V, and capable of delivering 50 mA, can be used to evaluate the LMR36500EVM.

2.3 Setup

This section describes the connectors and the test points on the EVM and how to properly connect, set up, and use the LMR36500EVM See Figure 2-3 for location of connectors and jumpers and typical setup.

VOUT Output voltage of the converter

VOUT terminal post. Apply load to this connector. The VOUT test point is used to monitor output voltage.

The default output voltage can be changed by using the device in the ADJ mode. To initiate the ADJ mode, supply resistors RFBB (R10) and RFBT (R9) to the EVM. See the LMR36500 data sheet for proper selection of these resistors.

In ADJ mode, a Bode plot can be taken by using a 10 Ω to 50 Ω resistor in place of Rinj (R8). This resistor becomes the injection point for the frequency response analyzer, allowing the loop frequency response to be taken in the usual way.

GND Ground of the converter

GND terminal post. Apply load ground to this connector. The GND test point is used as ground sense.

VIN_EMI Input voltage to the converter

VIN terminal post. Apply input voltage to this connector. The VIN test point is used to monitor input voltage.

GND_EMI Input ground of converter.

Input GND terminal post. Apply input ground to this connector. The GND test point is used as ground sense.

Input Filter EMI mitigation

An input EMI filter is provided on the EVM. Note that L2 must be installed and R12 remove for the EMI filter to operate. Optional components C3-C6, C9, and R13 can also be installed as required.

EN Jumper Set EN/UVLO pin options

Use this jumper to enable/disable the EVM. The optional resistors connected to this pin, RENT (R1) and RENB (R2), set the input UVLO thresholds. See the LMR36500 data sheet for more details. Note that for accurate shutdown current measurement, these resistors must be removed and the EN input test point grounded.

PGOOD The PGOOD test point is used to monitor the power-good indicator. This flag indicates whether the output voltage has reached the regulation level. PGOOD is an open-drain output that is tied to VCC through a 100-kΩ, resistor RPU2 (R4). Alternatively, RPU2 can be removed and RPU1 (R3) can be used to tie the PGOOD pull-up to Vout.

RT The LMR36500EVM is configured for 1-MHz operation by resistor RT_1MHz (R5). Other switching frequencies can be selected by using one of the other RT setting resistors, RTT (R7) or RT_1.1MHz (R6). See the LMR36500 data sheet for details.

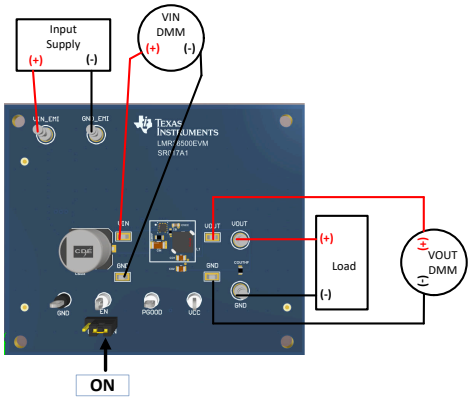


Figure 2-3. LMR36500EVM Setup

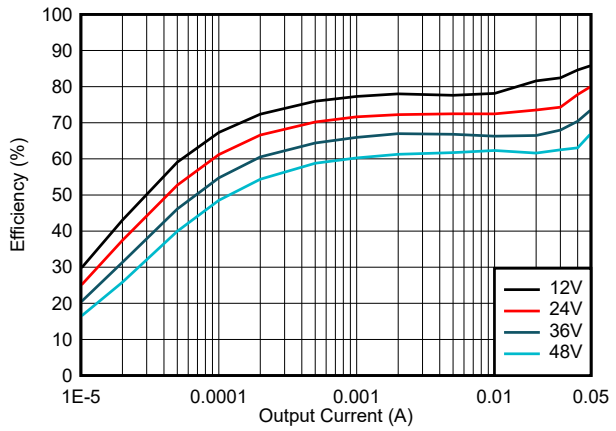
3 Implementation Results

3.1 Evaluation Setup

The LMR36500EVM was used to take the following data with the set-up shown in Figure 2-3.

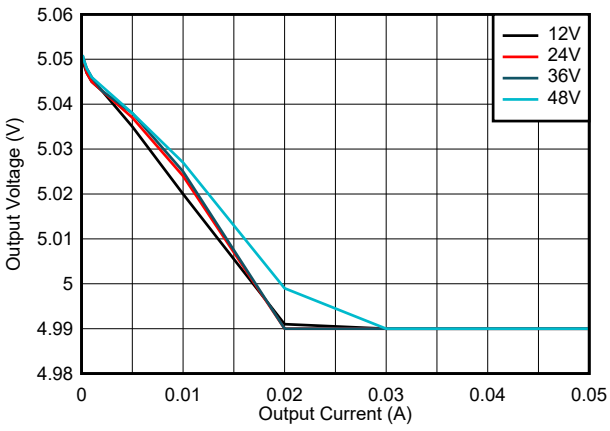
3.2 Performance Data and Results

Unless otherwise specified the following condition apply: T_A = 25ºC, V_{IN} = 12 V.



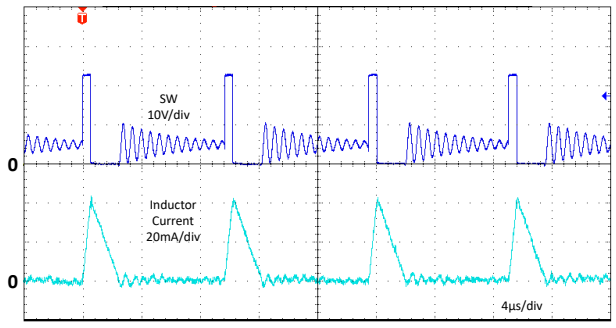
V_{OUT} = 5 V 1 MHz, Auto Mode

Figure 3-1. Efficiency



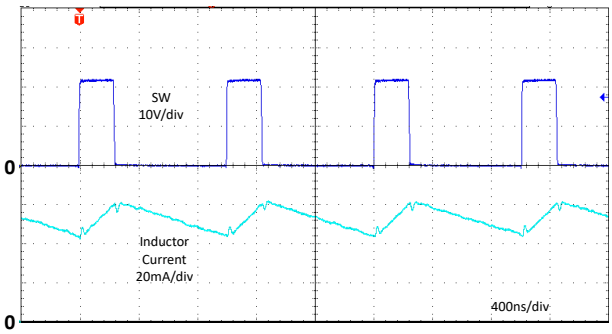
V_{OUT} = 5 V 1 MHz, Auto Mode

Figure 3-2. Line and Load Regulation



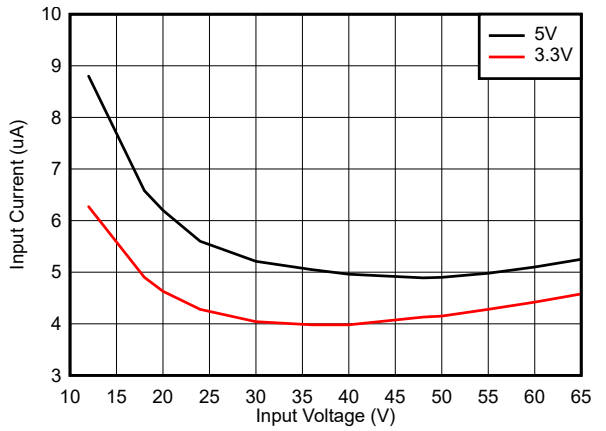
I_{OUT} = 5 mA V_{IN} = 24 V

Figure 3-3. Typical Switching Waveform in PFM



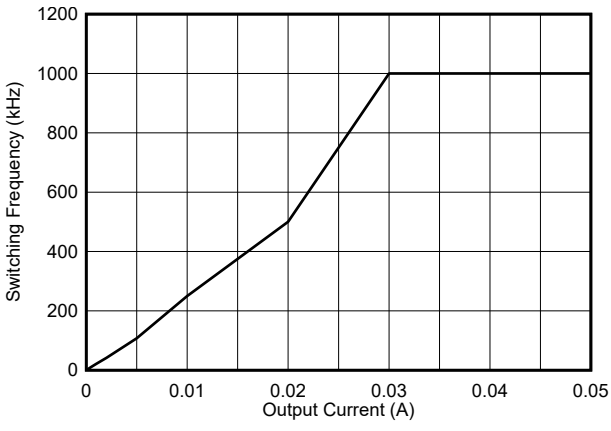
I_{OUT} = 50 mA V_{IN} = 24 V

Figure 3-4. Typical Switching Waveform in PWM



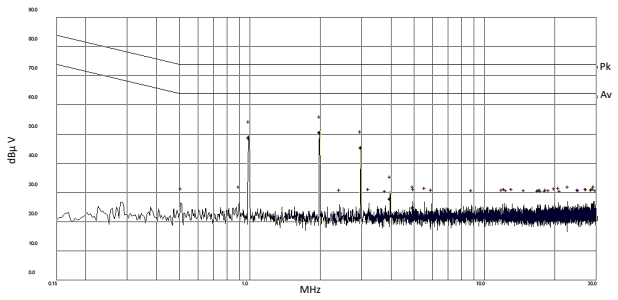
I_{OUT} = 0 mA

Figure 3-5. No Load Input Current



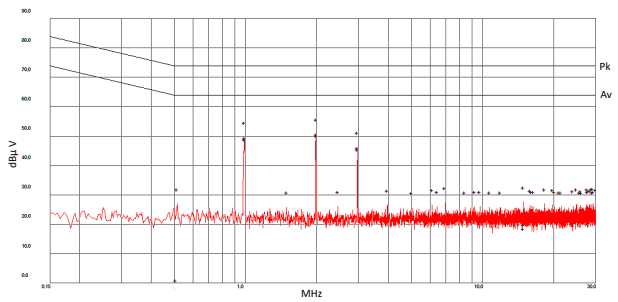
V_{OUT} = 5 V

Figure 3-6. Switching Frequency vs. Output Current



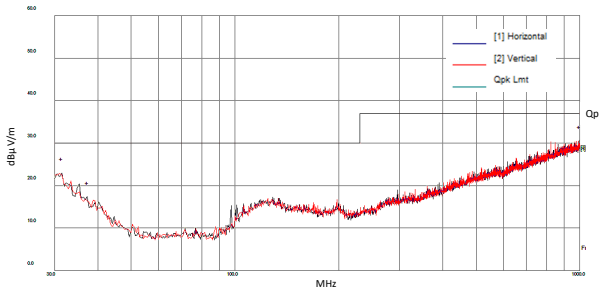
V_{IN} = 24 V I_{OUT} = 50 mA
V_{OUT} = 5 V No EMI Filter

Figure 3-7. Conducted Emissions (Positive)



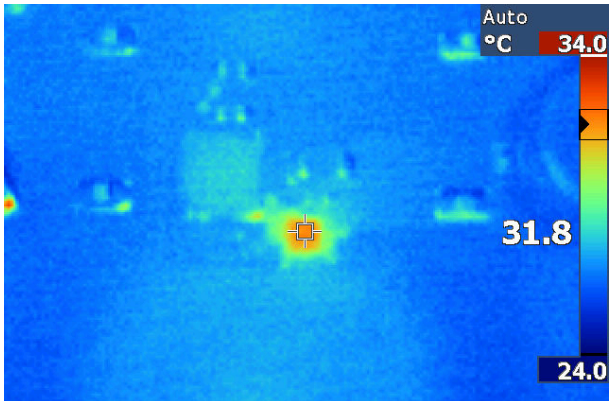
V_{IN} = 24 V I_{OUT} = 50 mA
V_{OUT} = 5 V No EMI Filter

Figure 3-8. Conducted Emissions (Negative)



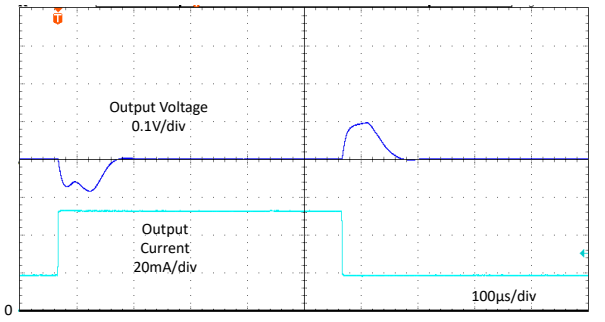
V_{IN} = 24 V I_{OUT} = 50 mA
V_{OUT} = 5 V No EMI Filter

Figure 3-9. Radiated Emissions



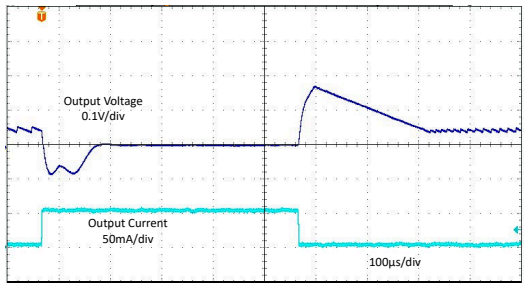
V_{IN} = 65 V I_{OUT} = 50 mA V_{OUT} = 5 V

Figure 3-10. Thermal Image



V_{IN} = 12 V I_{OUT} = 20 mA to 50 mA V_{OUT} = 5 V (fixed)
LMR36500P5 1 MHz (AUTO)

Figure 3-11. Load Transient



V_{IN} = 12 V I_{OUT} = 5 mA to 50 mA V_{OUT} = 5 V (fixed)
LMR36500P5 1 MHz (AUTO)

Figure 3-12. Load Transient

4 Hardware Design Files

4.1 Schematics

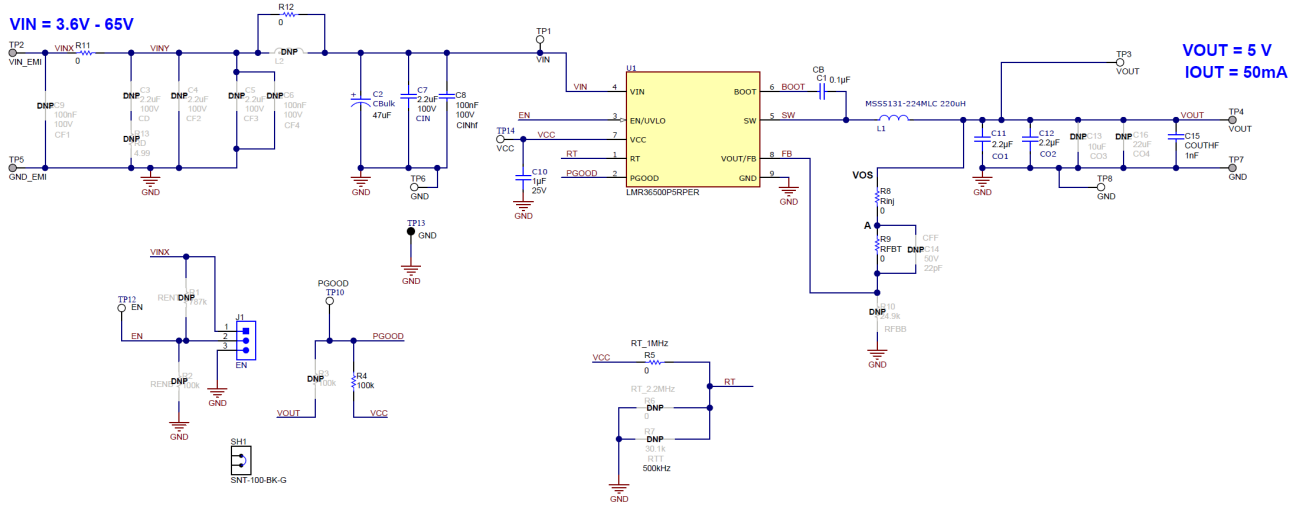


Figure 4-1. LMR36500EVM Schematic

4.2 PCB Layouts

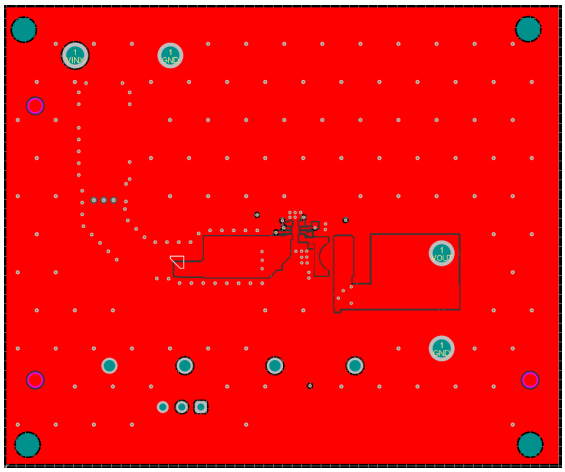


Figure 4-2. PCB Top Layer

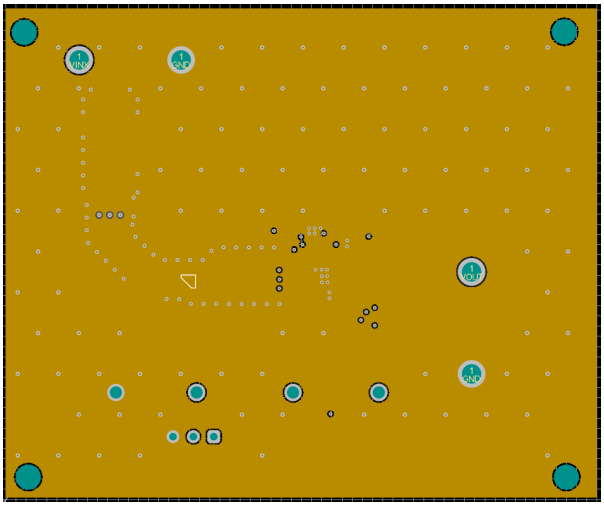


Figure 4-3. PCB Ground Layer (Directly below top layer)

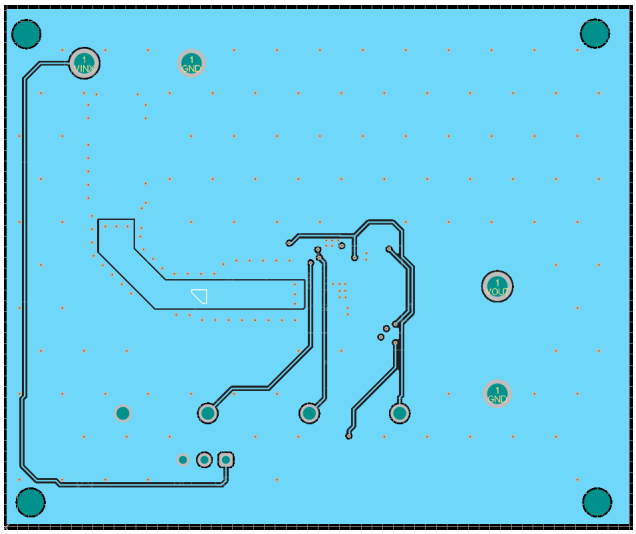


Figure 4-4. PCB Signal Layer

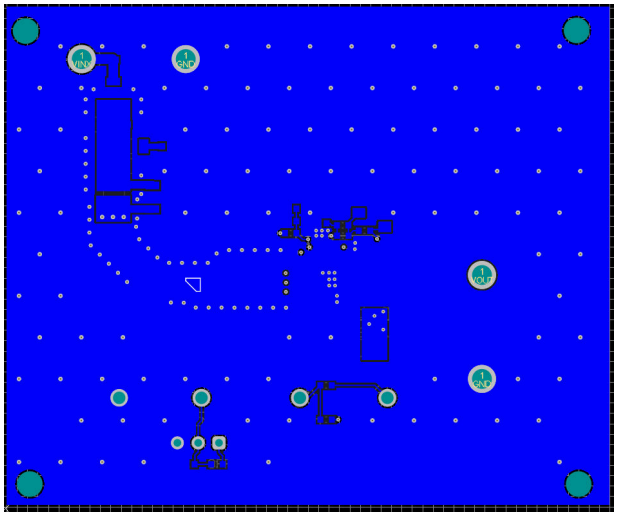


Figure 4-5. PCB Bottom Layer

4.3 Bill of Materials (BOM)

Table 4-1. LMR36500EVM BOM (with options)

Designator	Quant.	Value	Description	Part Number
C1	1	0.1uF	CAP, CERM, 0.1 µF, 25 V,+/- 10%, X7R, AEC-Q200 Grade 1, 0402	CGA2B3X7R1E104K050BB
C2	1	47 µF	47 µF 100 V Aluminum Electrolytic Capacitors Radial, Can - SMD 3.5274Ohm @ 120 Hz 2000 Hrs @ 85°C	476SML100M
C3, C4, C5, C7	4	2.2µF	Cap Ceramic 2.2uF 100 V X7S 10% SMD 1206 125°C Emboss T/R	CL31Y225KCHVPNE
C6, C8, C9	3	0.1uF	CAP, CERM, 0.1 uF, 100 V, +/- 10%, X7R, 0603	GRM188R72A104KA35D
C10	1	1uF	CAP, CERM, 1 uF, 25 V, +/- 10%, X7R, 0603	C1608X7R1E105K080AB
C11, C12	2	2.2µF	Chip Multilayer Ceramic Capacitors for General Purpose, 0805, 2.2uF, X7R, 15%, 10%, 25 V	GRM21BR71E225KE11L
C13	1	10uF	CAP, CERM, 10 uF, 25 V, +/- 10%, X7R, 1210	C1210C106K3RACTU
C14	1	22 pF	CAP, CERM, 22 pF, 50 V, +/- 5%, C0G/NP0, 0603	06035A220JAT2A
C15	1	1000 pF	CAP, CERM, 1000 pF, 100 V, +/- 10%, X7R, 0603	GRM188R72A102KA01D
C16	1	22uF	CAP, CERM, 22 uF, 25 V, +/- 10%, X7R, 1210	GRM32ER71E226KE15L
J1	1		Header, 100mil, 3x1, Gold, TH	TSW-103-07-G-S
L1	1	220uH	Power Inductors - SMD 220uH Shld 20% 0.5A 1.1ohms AEC-Q200	MSS5131-224MLC
L2	1	1uH	1 µH Shielded Inductor 1.3 A 83mOhm Max Nonstandard	XFL2010-102MEC
R1	1	787k	RES, 787 k, 1%, 0.1 W, 0603	RC0603FR-07787KL
R2, R3, R4	3	100k	RES, 100 k, 1%, 0.1 W, 0603	RC0603FR-07100KL
R5, R6, R8, R9	4	0	RES, 0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	RMCF0603ZT0R00
R7	1	30.1k	RES, 30.1 k, 1%, 0.1 W, 0603	RC0603FR-0730K1L
R10	1	24.9k	RES, 24.9 k, 1%, 0.1 W, 0603	CRCW060324K9FKEA
R11, R12	2	0	RES, 0, 1%, 0.5 W, 1206	5108
R13	1	4.99	RES, 4.99, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW06034R99FKEA
U1	1		3-V to 65-V, 50-mA Wide VIN Synchronous Buck Converter Optimized for Size and Light Load Efficiency	LMR36500P5RPER

5 Additional Information

5.1 Trademarks

All trademarks are the property of their respective owners.

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

   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 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 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 a nonconforming EVM if (a) the nonconformity was 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, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, 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.

WARNING

Evaluation Kits 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 shall operate the Evaluation Kit within TI’s recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI’s recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI’s instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 *Regulatory Notices:*

3.1 *United States*

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

FCC NOTICE: 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 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. 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。

https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html

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 to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

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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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使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

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。

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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/lsds/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。https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html

3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

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 MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS 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 EPIDEMIC FAILURE WARRANTY OR 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 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, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

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. 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.

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