

User's Guide

LMR36501EVM User's Guide

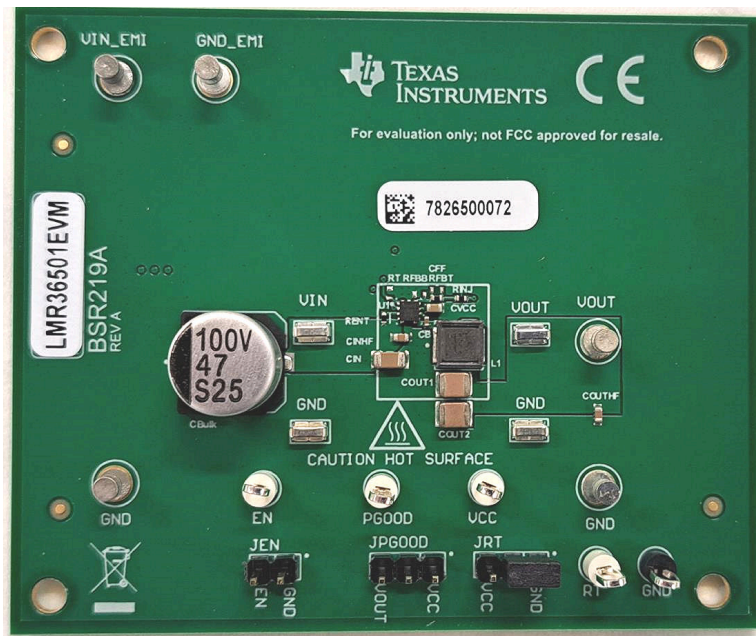


ABSTRACT

The Texas Instruments LMR36501EVM evaluation module (EVM) helps designers evaluate the operation and performance of the LMR36501 wide-input buck converter. The LMR36501 is an easy-to-use, synchronous, step-down voltage converter capable of driving up to 0.1 A of load current from an input voltage of up to 65 V. The LMR36501EVM features an output voltage of 5 V and a switching frequency of 2.2 MHz. See the data sheet for additional features, detailed descriptions, and available options.

Table 1-1. Device and Package Configurations

EVM	U1	FREQUENCY	SPREAD SPECTRUM	CURRENT	PIN 1 TRIM
LMR36501EVM	LMR36501F5RPER	2200 kHz	Disabled	0.1 A	RT



LMR36501EVM PCB

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Trademarks

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1 Setup

This section describes the test points and connectors on the EVM and how to properly connect, set up, and use the LMR36501EVM.

1.1 Test Points

The test points on the board can be used for connecting to the input of a power supply and output load for the EVM. See [Figure 1-1](#) for typical test setup. The functions of the test points connections are:

- **VIN_EMI** — Input supply to EVM including an EMI filter. Connect to a suitable input supply. Connect at this point for EMI test.
- **GND_EMI** — Ground connection for the input supply
- **VIN** — Input supply to the IC. Can be connected to DMM to measure input voltage after EMI filter.
- **VOUT** — Output voltage test point of EVM. Can be connected to a desired load.
- **GND** — Ground test points
- **EN** — This test point is connected to the EN pin. By default, there is a pullup resistor R1 (RENT) to VIN to enable the IC.
- **PGOOD** — This test point is connected to the PGOOD pin from the IC. Can be tied to an external supply through a pullup resistor or left open.
- **RT** — In a RT trim part, this test point is connected to the RT pin of the IC.

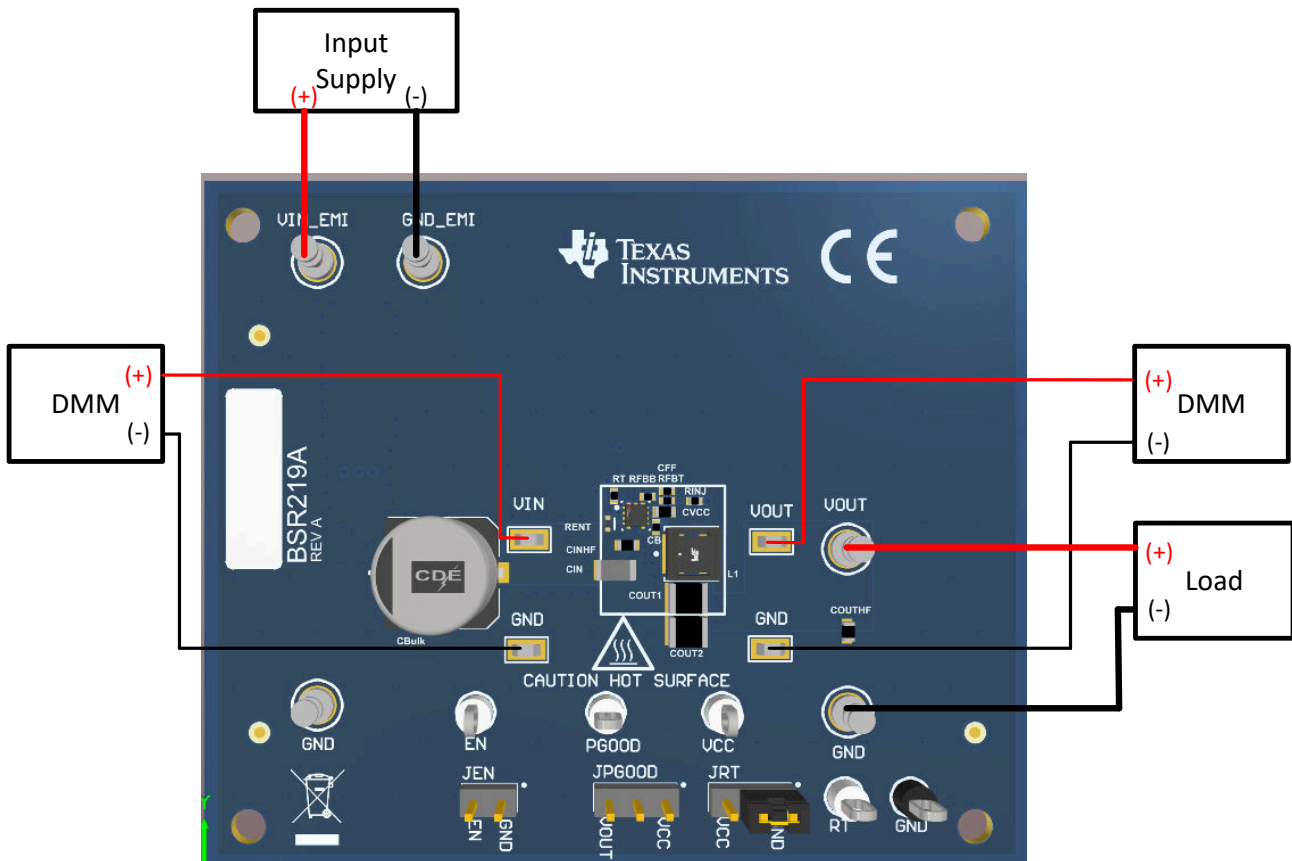


Figure 1-1. EVM Board Connections

1.2 Jumpers

See [Figure 1-2](#) for jumper locations.

- **JEN** - This jumper allows the ENABLE input to be connected to GND in order to disable the IC. By default, this jumper is left open since there is a pullup resistor R2 (RENT) to VIN to enable the IC.
- **JPGOOD** - Use this jumper to select how the PGOOD pin is connected. A jumper can be used to connect pin 2 and 3. In this configuration, the PGOOD pin is pulled up to VOUT through R7 (RPGOOD) with a value of 100 k Ω . When connecting the jumper between pin 1 and 2, the PGOOD pin is pulled up to VCC through R7 (RPGOOD) with a value of 100 k Ω . By default, this jumper is not populated.
- **JRT** - Use this jumper to set the switching frequency. Connecting this jumper from pin 1 and pin 2 sets the switching frequency to 2.2 MHz and connecting this jumper from pin 2 and pin 3 sets the switching frequency to 1 MHz. Leaving this jumper floating results in the frequency being set by the RT resistor. An RT resistor must be present if the JRT jumper is left floating. By default, the jumper is connected between pin 1 and pin 2. Pin 1 is indicated by the dot on the PCB.



Figure 1-2. Jumper Locations

2 Operation

2.1 Quick Start

1. Connect the voltage supply between the VIN_EMI and GND_EMI supply connections.
2. Connect the load between the VOUT and GND test points.
3. Set the supply voltage at an appropriate level between 3.5 V to 36 V. Set the current limit of the supply to an appropriate level.
4. Turn on the power supply. With the default configuration, the EVM powers up and provides $V_{OUT} = 5\text{ V}$.
5. Monitor the output voltage. The maximum load current is rated at 100 mA with the LMR36501 device.

3 Schematic

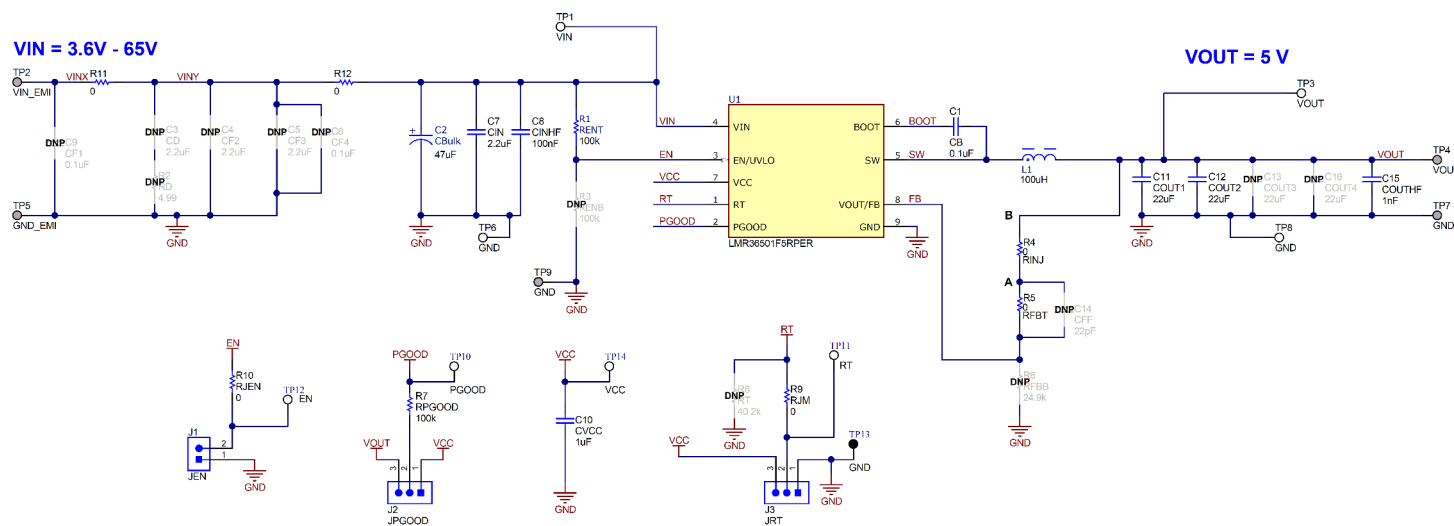


Figure 3-1. LMR36501EVM Schematic

4 Board Layout

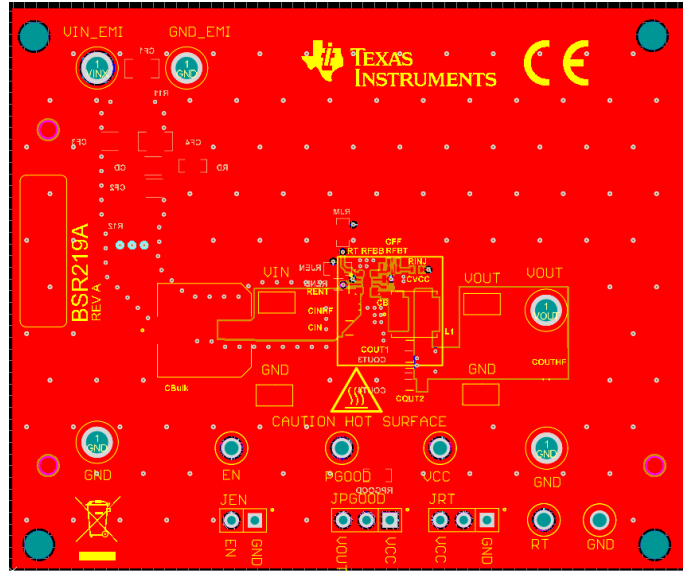


Figure 4-1. Top Silk View

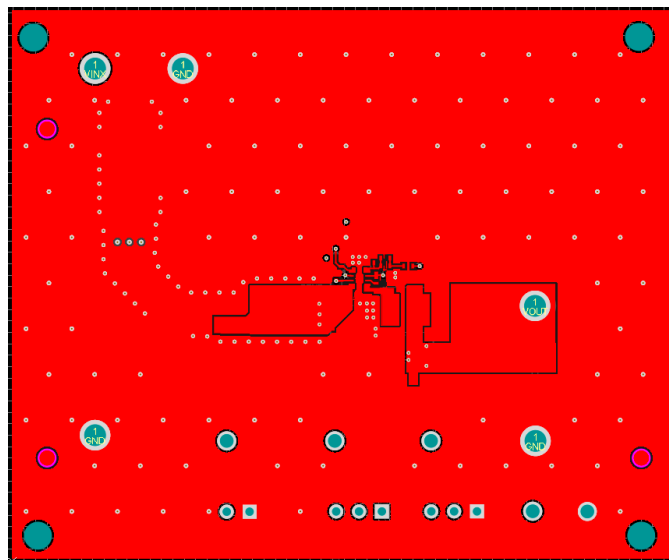


Figure 4-2. Top Copper Layer

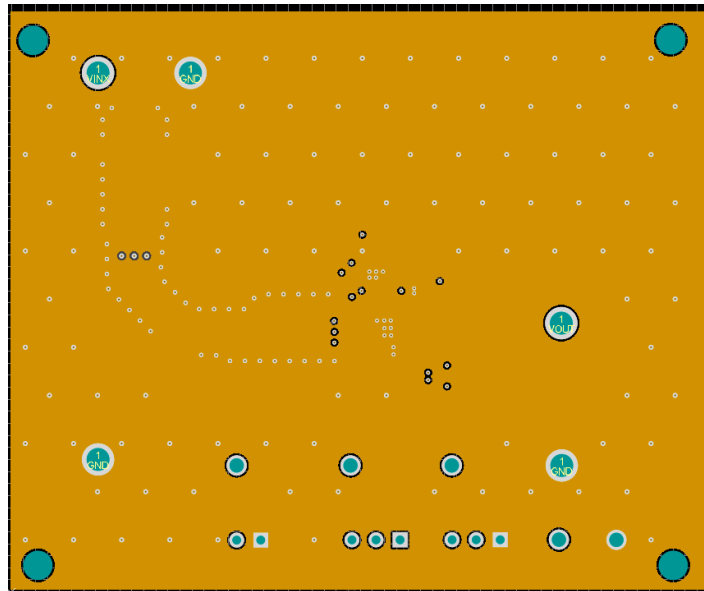


Figure 4-3. Ground Layer

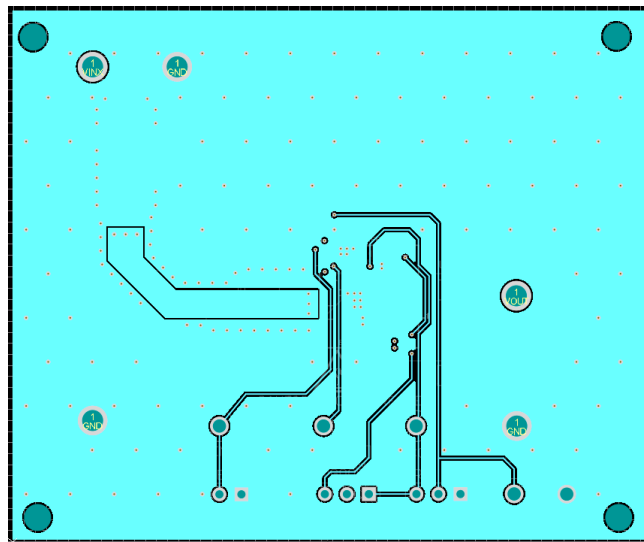


Figure 4-4. Signal Layer

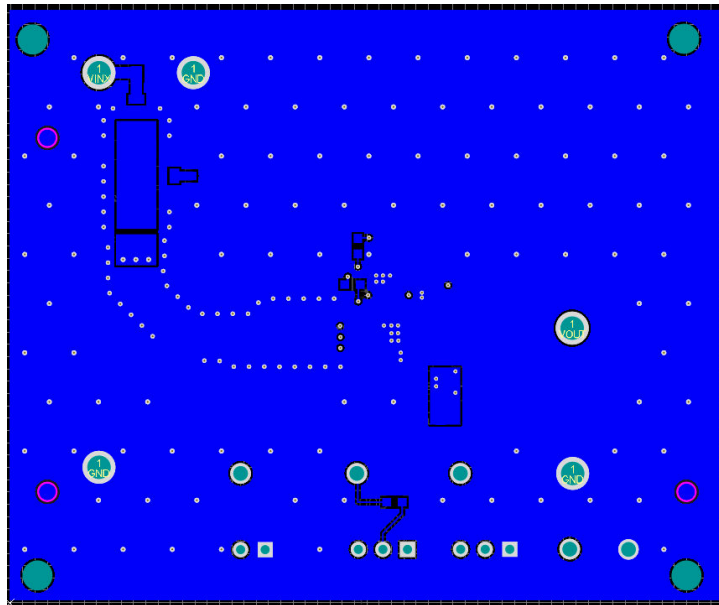


Figure 4-5. Bottom Layer

5 Bill of Materials

Table 5-1. LMR36500EVM BOM (with options)

Designator	Quantity	Value	Description	Part Number
C1	1	0.1 uF	CAP, CERM, 0.1 uF, 25 V, +/- 20%, X7R, 0402	C1005X7R1E104M050BB
C2	1	47 µF	47 µF 100 V Aluminum Electrolytic Capacitors Radial, Can - SMD 3.5274Ohm @ 120 Hz 2000 Hrs at 85°C	476SML100M
C7	1	2.2 uF	CAP, CERM, 2.2 uF, 100 V, +/- 10%, X7S, AEC- Q200 Grade 1, 1206	CGA5L3X7S2A225K160AB
C8	1	0.1 uF	CAP, CERM, 0.1 uF, 100 V, +/- 10%, X7R, 0603	GRM188R72A104KA35D
C10	1	1uF	CAP, CERM, 1 uF, 16 V, +/- 10%, X7R, 0603	885012206052
C11, C12	2	22 uF	CAP, CERM, 22 uF, 25 V, +/- 10%, X7R, 1210	GRM32ER71E226KE15L
C15	1	1000 pF	CAP, CERM, 1000 pF, 100 V, +/- 10%, X7R, 0603	GRM188R72A102KA01D
J1	1		Header, 100mil, 2x1, Gold, TH	HTSW-102-07-G-S
J2, J3	2		Header, 100mil, 3x1, Gold, TH	HTSW-103-07-G-S
L1	1	100 uH	100 µH Shielded Drum Core, Wirewound Inductor 620 mA 600mOhm Max Nonstandard	74406043101
R1	1		Res Thin Film 0402 100K Ohm 0.1% 1/16W ±25ppm/°C Molded SMD SMD Punched Carrier T/R	ERA-2AEB104X
R4, R5	2	0	RES, 0, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW04020000Z0ED
R7	1	100k	RES, 100 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	ERJ-3GEYJ104V
R9, R10	2	0	RES, 0, 5%, 0.1 W, 0603	ERJ-3GEY0R00V
R11, R12	2	0	RES, 0, 1%, 0.5 W, 1206	5108
SH-J1	1	1x2	Shunt, 100mil, Gold plated, Black	SNT-100-BK-G
TP1, TP3, TP6, TP8	4		Test Point, Miniature, SMT	5015
TP2, TP4, TP5, TP7, TP9	5		Terminal, Turret, TH, Double	1502-2
TP10, TP11, TP12, TP14	4		Test Point, Multipurpose, White, TH	5012
TP13	1		Test Point, Multipurpose, Black, TH	5011
U1	1		3-V to 65-V, 100-mA and 150-mA Wide VIN Synchronous Buck Converter Optimized for Size and Light Load Efficiency	LMR36501F5RPER
C3, C4, C5	0	2.2uF	CAP, CERM, 2.2 uF, 100 V, +/- 10%, X7S, 1206	C3216X7S2A225K160AB
C6, C9	0	0.1 uF	CAP, CERM, 0.1 uF, 100 V, +/- 10%, X7R, AEC- Q200 Grade 1, 0805	CGA4J2X7R2A104K125AA
C13, C16	0	22 uF	CAP, CERM, 22 uF, 25 V, +/- 10%, X7R, 1210	GRM32ER71E226KE15L
C14	0	22 pF	CAP, CERM, 22 pF, 50 V, +/- 5%, C0G/NP0, AEC- Q200 Grade 1, 0402	CGA2B2NP01H220J050BA
R2	0	4.99	RES, 4.99, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW06034R99FKEA
R3	0		Res Thin Film 0402 100K Ohm 0.1% 1/16W ±25ppm/°C Molded SMD SMD Punched Carrier T/R	ERA-2AEB104X
R6	0	24.9k	RES, 24.9 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW040224K9FKED
R8	0	40.2k	RES, 40.2 k, 1%, 0.063 W, 0402	CRCW040240K2FKED

6 Test Results

6.1 LMR36501EVM Test Results

Unless otherwise specified, the following conditions apply: LMR36501EVM, $T_A = 25^\circ\text{C}$

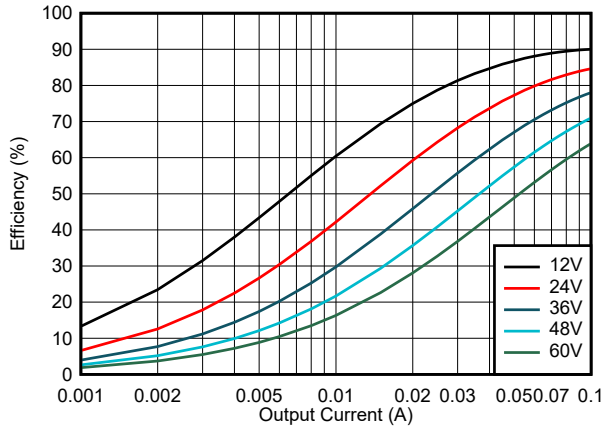


Figure 6-1. Efficiency: 5 V_{OUT} (fixed), 1 MHz, FPWM

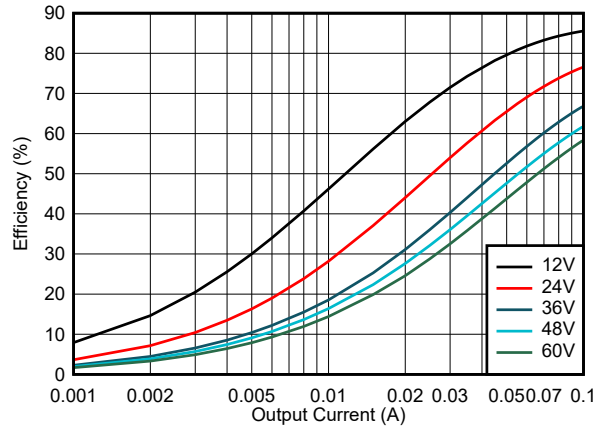


Figure 6-2. Efficiency: 5 V_{OUT} (fixed), 2.2 MHz, FPWM

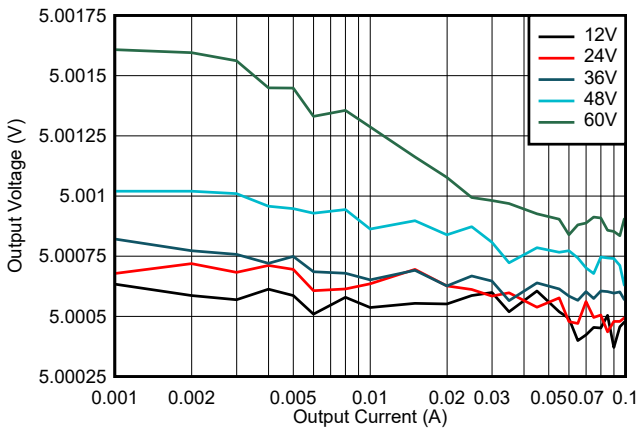


Figure 6-3. Output Regulation: 5 V_{OUT}, 1 MHz, FPWM

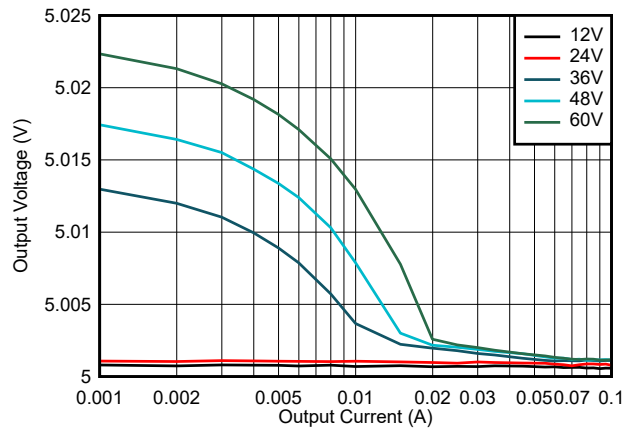


Figure 6-4. Output Regulation: 5 V_{OUT}, 2.2 MHz, FPWM

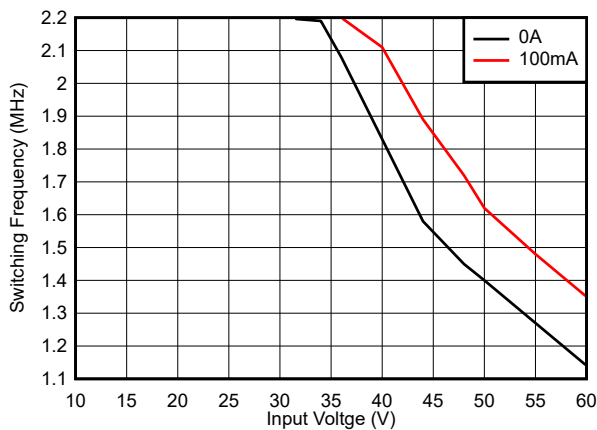
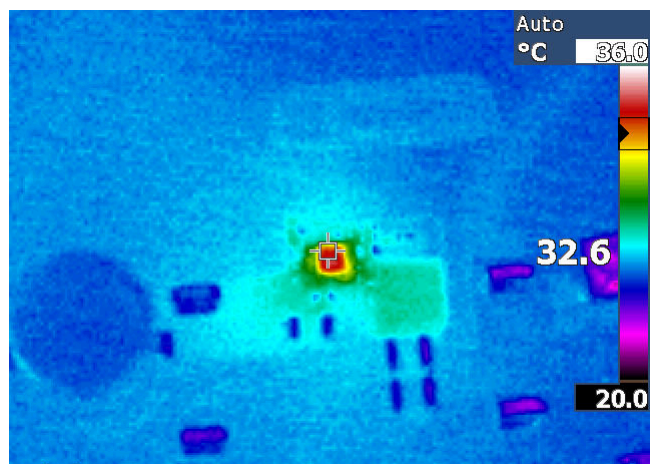
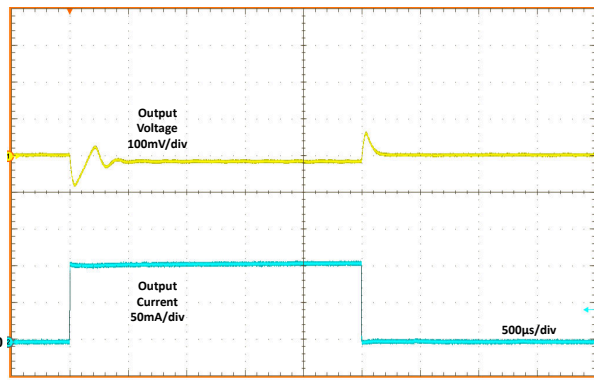


Figure 6-5. Switching Frequency vs Input Voltage: 2.2 MHz, FPWM



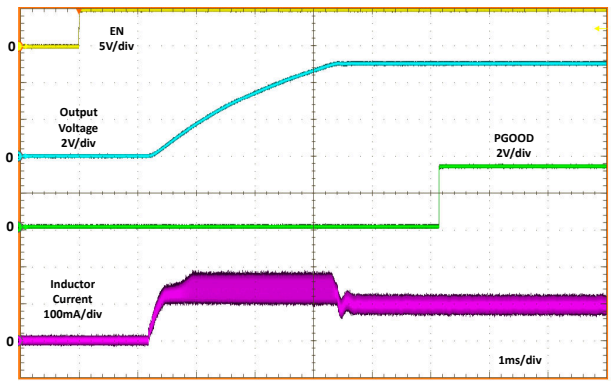
$I_{OUT} = 0.1 \text{ A}$ $V_{IN} = 60 \text{ V}$ $F_{SW} = 2.2 \text{ MHz}$
 $V_{OUT} = 5 \text{ V}$

Figure 6-6. EVM Thermal Image



$I_{OUT} = 0 \text{ A to } 0.1 \text{ A}$, $V_{IN} = 48 \text{ V}$, $F_{SW} = 2.2 \text{ MHz}$
 $1 \mu\text{s}$
 $V_{OUT} = 5 \text{ V}$

Figure 6-7. Load Transient



$I_{OUT} = 100 \text{ mA}$, $V_{IN} = 36 \text{ V}$, $F_{SW} = 2.2 \text{ MHz}$
 $V_{OUT} = 5 \text{ V}$

Figure 6-8. Start-Up From Enable

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.
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 - 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 DEGRADATION 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/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。

<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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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。

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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。 <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:*
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