User's Guide
SNVU580–November 2018

LMR360xxxEVM User's Guide

The Texas Instruments LMR36015A and LMR36006B evaluation modules (EVM) help designers evaluate the operation and performance of the LMR36015 and LMR36006 wide-input buck regulators. The LMR36015 is an easy-to-use synchronous step-down DC/DC converter capable of driving up to 1.5 A of load current from an input voltage of up to 60 V. The LMR36006 uses the same EVM PCB and components, but the current limit is modified to 0.6 A. The LMR360xxxEVMs feature a selectable output voltage of 3.3 V or 5 V and a switching frequency of 400 kHz and 1 MHz. See the LMR36006 and LMR36015 data sheets for additional features, detailed descriptions, and available options.

The EVM options are found in Table 1.

Table 1. Device and Package Configurations

EVM	U1	FREQUENCY	Output Current
LMR36015AEVM	LMR36015	400 kHz	1.5 A
LMR36006BEVM	LMR36006	1 MHz	600 mA

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Trademarks

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1 Posts, Probes, and Jumpers

This section describes the test points and connectors on the EVM and how to properly connect, set up, and use the LMR36015AEVM and the LMR36006BEVM.

1.1 Screw Terminal Connectors

The screw terminals on the top of the board can be used for connecting to the input and output of the EVM. See Figure 1 for the screw terminal connections. The functions of the screw terminal connections are:

- **VIN -** Input supply to EVM. Connect to a suitable input supply. See LMR36006 data sheet and LMR36015 data sheet for input supply requirements.
- **GND -** System ground.
- **IN+ -** Input supply to EVM including an EMI filter. Connect to a suitable input supply. See LMR36006 data sheet and LMR36015 data sheet for input supply requirements.
- **IN– -** System ground including an EMI filter.
- **VOUT -** Output of EVM — connect to desired load.

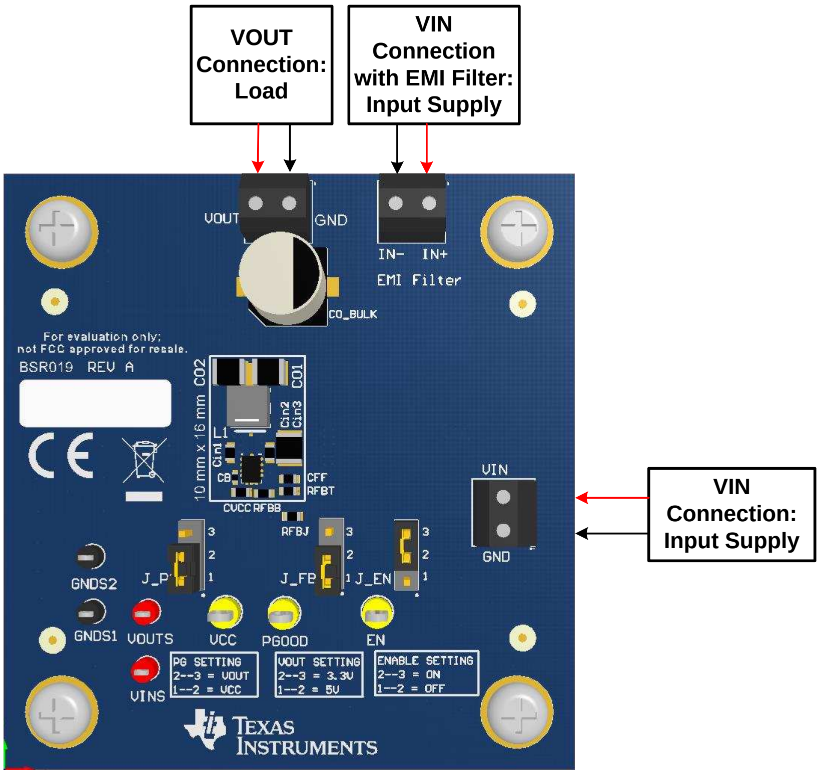

Figure 1. EVM Board Connections

1.2 Jumpers

See Figure 2 for jumper locations.

- **EN -** This jumper allows the ENABLE input to be connected to either GND (OFF) or VIN (ON). The 2-to-3 position enables the device; while the 1-to-2 position disables the device. Remove this jumper to allow an external logic signal to control the EN function.
- **VOUT -** Use this jumper to select one of the two pre-defined output voltages. The 2-to-3 position provides a 3.3-V output; while the 1-to-2 position provides a 5-V output.
- **PGOOD -** Use this jumper to select the PGOOD pullup configuration. PGOOD can be connected to either VOUT or VCC. The 2-to-3 position connects PGOOD to VOUT, while the 1-to-2 position connects PGOOD to VCC.

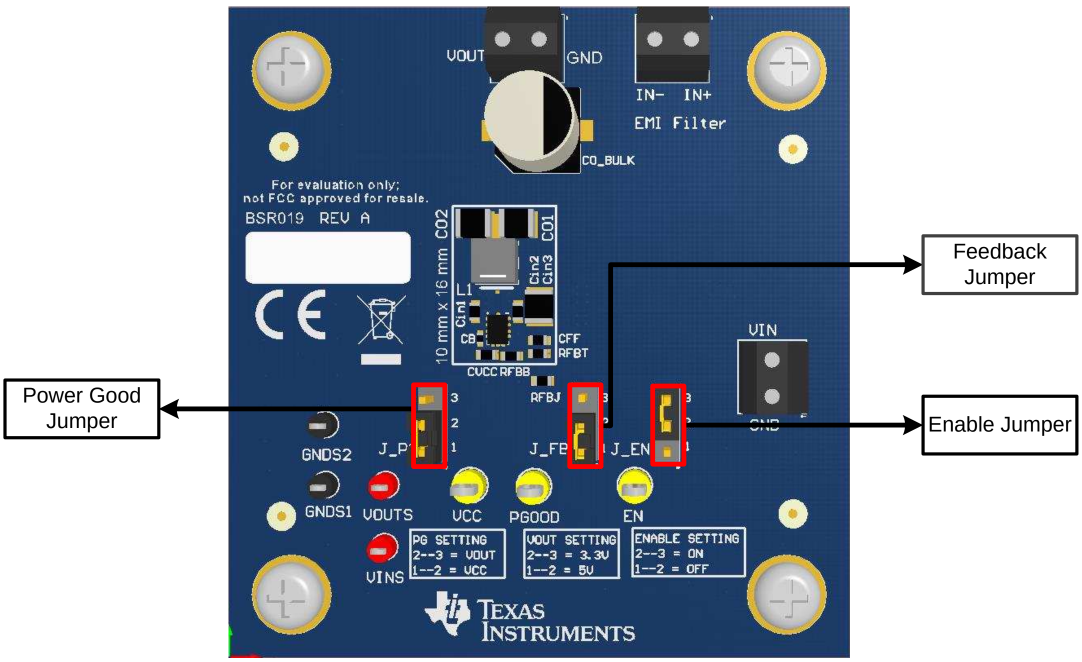

Figure 2. Jumper Locations

1.3 Test Points

- **VOUTS -** Output voltage sense connection; connect to DMM. Also, use for frequency response analyzer connection.
- **VINS -** Input voltage sense connection; connect to DMM.
- **GNDS1 and GNDS2 -** Ground sense point for analog measurements; connect to DMM.
- **VCC -** Test point to measure internal VCC of device; approximately 5 V.
- **EN -** Connection for external EN logic input. Remove EN jumper and connect controlling logic to EN test point for external enable control.
- **PGOOD -** Power-good flag output. This test point is connected to VCC or VOUT through a 100-kΩ resistor. The power-good function can be monitored at this test point.

2 Operation

2.1 Quick Start

1. Connect the voltage supply between VIN and GND screw terminal connectors using short and thick wires.
2. Connect the load between VOUT and GND screw terminal connectors using short and thick wires.
3. Set the supply voltage at an appropriate level between 4.2 V to 60 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 V.
5. Monitor the output voltage. The maximum load current must be 1.5 A with the LMR36015 device or 600 mA with the LMR36006 device.

2.2 Efficiency Measurement

1. Connect power supply to VIN and GND screw terminal connectors and make sure the power supply provides sufficient current.

NOTE: There is no reverse polarity protection or fuse on the evaluation board.

2. Connect electronic load to VOUT and GND screw terminal connectors. For all power wires it is preferable to use twisted lab wires. If the power supply wires are very long > 50 cm, solder an additional 470-µF, 100-V bulk capacitor to posts VIN and GND. Use sufficient power wires to avoid voltage drops, and use short sense probe connection for the measurement.

NOTE: These sense lines are not designed to carry power.

3. To accurately sense input and output voltage use the test points VINS, VOUTS, and GNDS. Alternatively, sense wires can be soldered directly over input capacitors C_{IN1} or C_{IN2} and the output capacitors C_{O1} or C_{O2}.
4. Make sure the IC is enabled by having jumper J5 set to [EN-VIN] and check that test point EN is driven high. While measuring I_Q (unloaded input current) remove all the input and output voltage probes that are most likely causing additional current draw.

2.3 Measure Load Transient

1. Connect power supply to VIN and GND screw terminal connectors, and make sure the power supply can provide sufficient peak current.

NOTE: There is no reverse polarity protection or fuse on the evaluation board.

2. Connect transient load to VOUT and GND screw terminal connectors. For all power wires use preferable twisted lab wires. If the power supply wires are very long > 50 cm, solder an additional 470-µF, 100-V bulk capacitor to posts VIN and GND. Use short sense probe connection for the measurement.
3. To accurately sense the output voltage, place the scope probe directly over the output capacitors C_{O1} or C_{O2}. Make sure to connect scope probe GND ring directly to the output capacitor GND pad for minimal ground loop. Ground loops can introduce ringing in observed waveforms, which is an artifact and not present on the PCB. Alternatively, use differential probe over output capacitors C_{O1} or C_{O2}. Do not use wires to differential probe and always probe directly with shortest possible pins. Make sure the IC is enabled by having jumper J5 set to [EN-VIN] and check test point EN is driven high and not drooping during the load transient.

3 Schematic

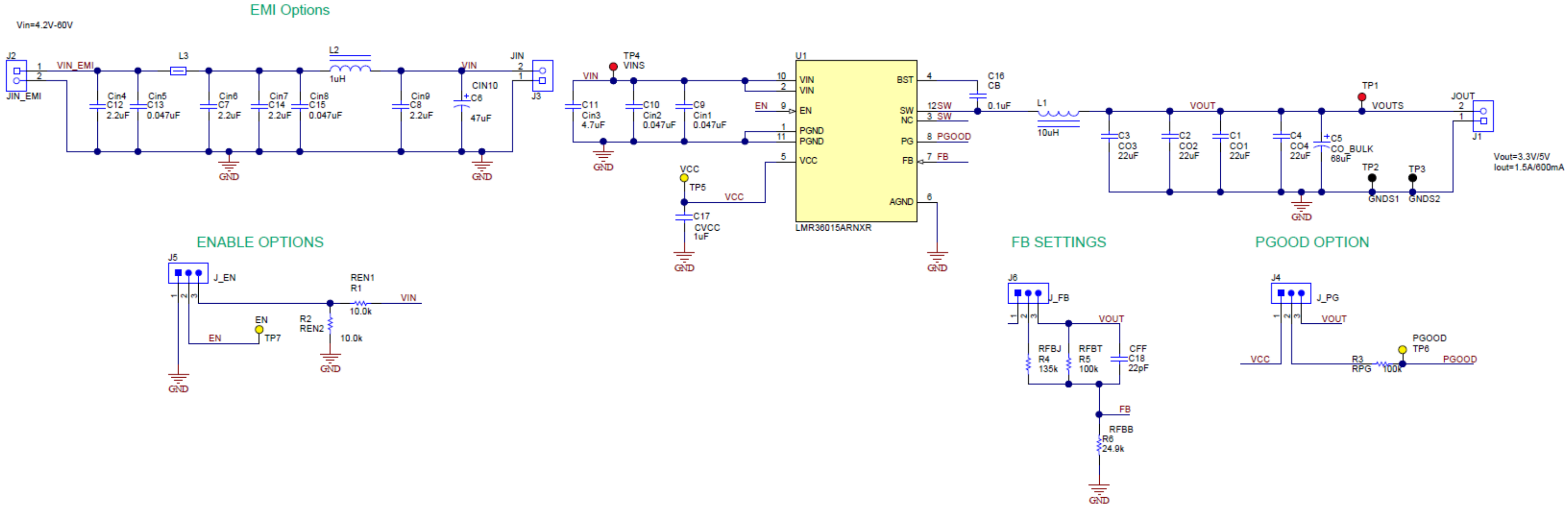

Figure 3. LMR360xxxEVM Schematic

4 Board Layout

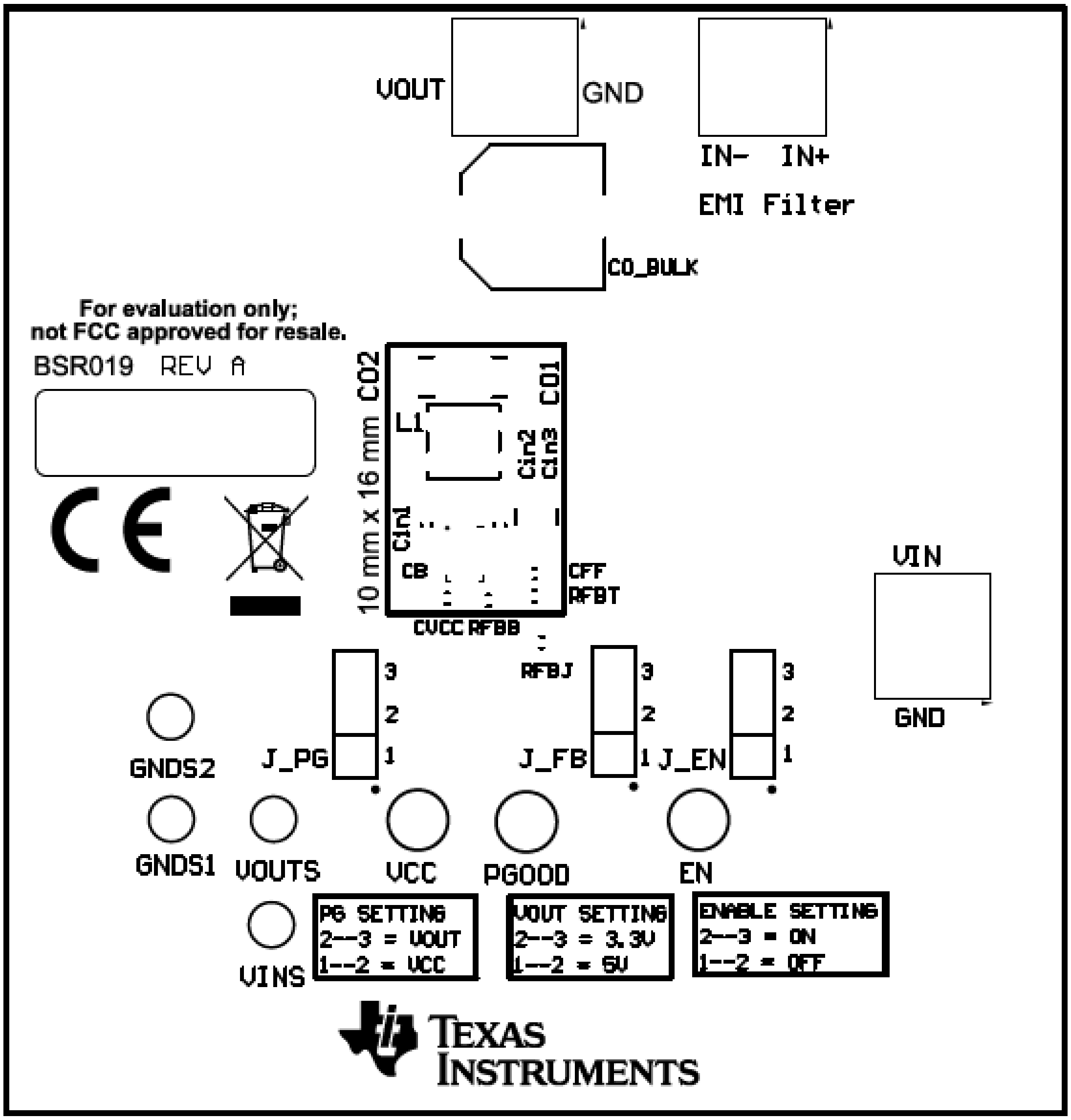

Figure 4. Top View of EVM

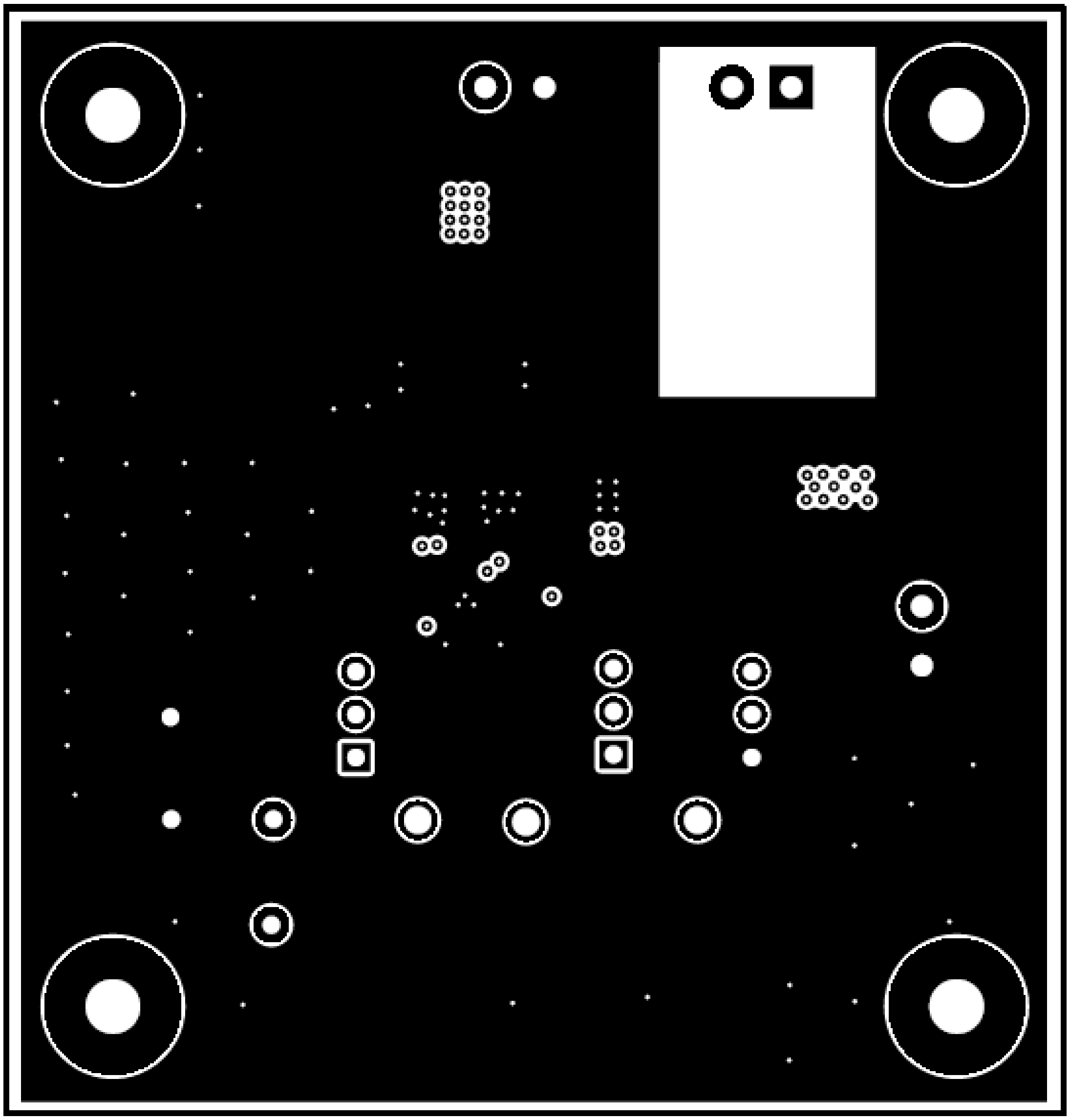

Figure 5. EVM Top Copper Layer

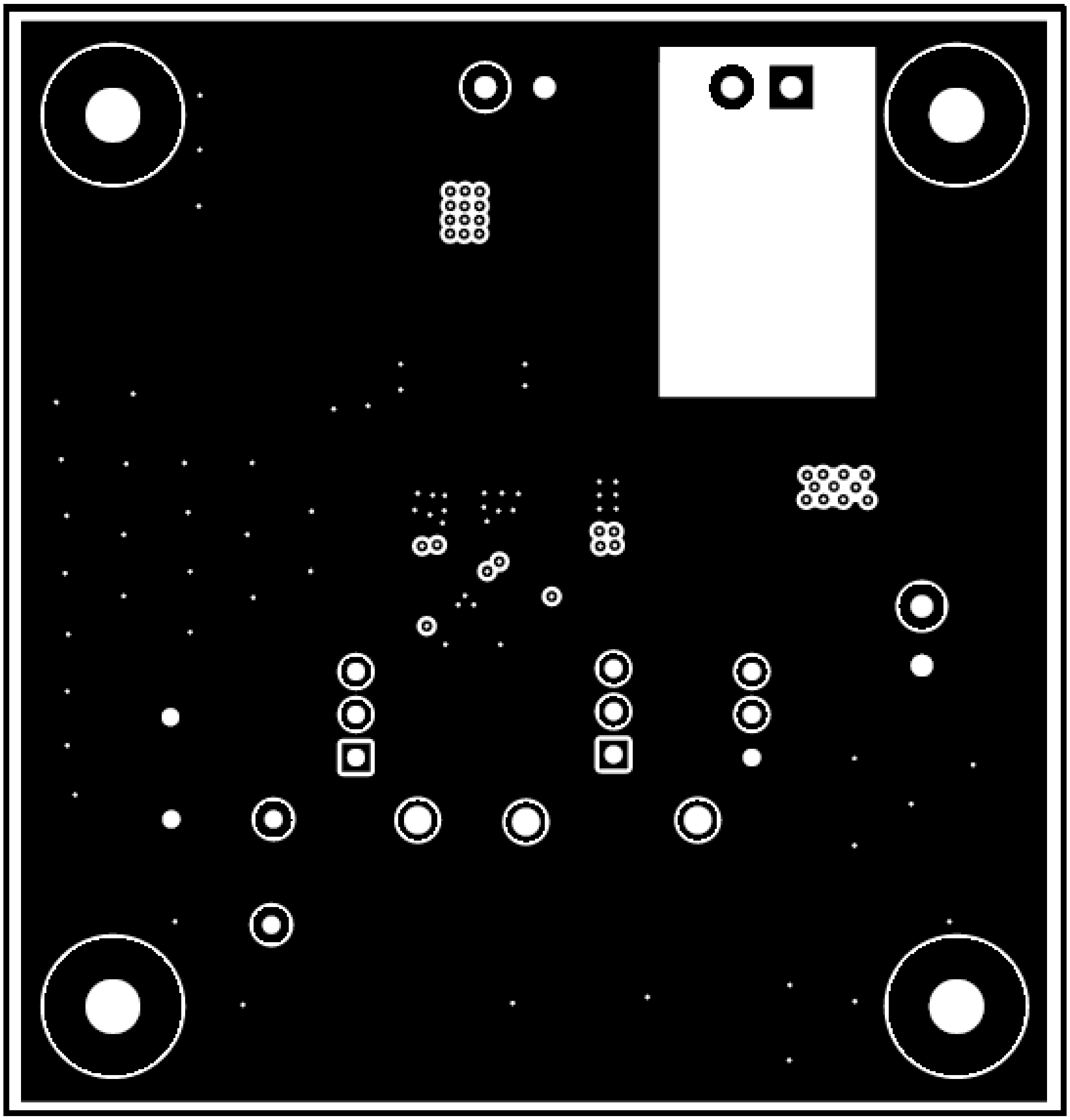

Figure 6. EVM Mid Layer One

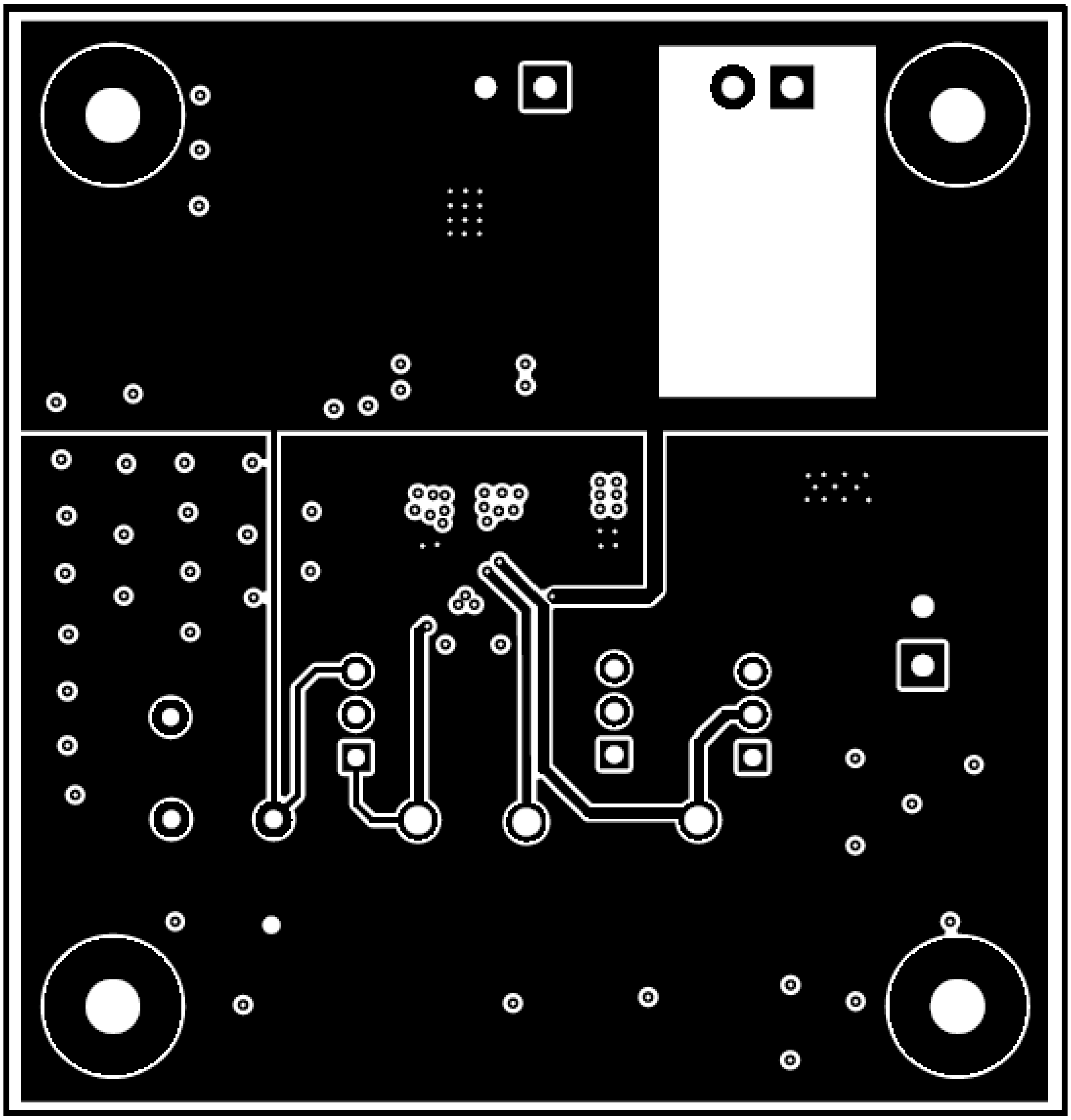

Figure 7. EVM Mid Layer Two

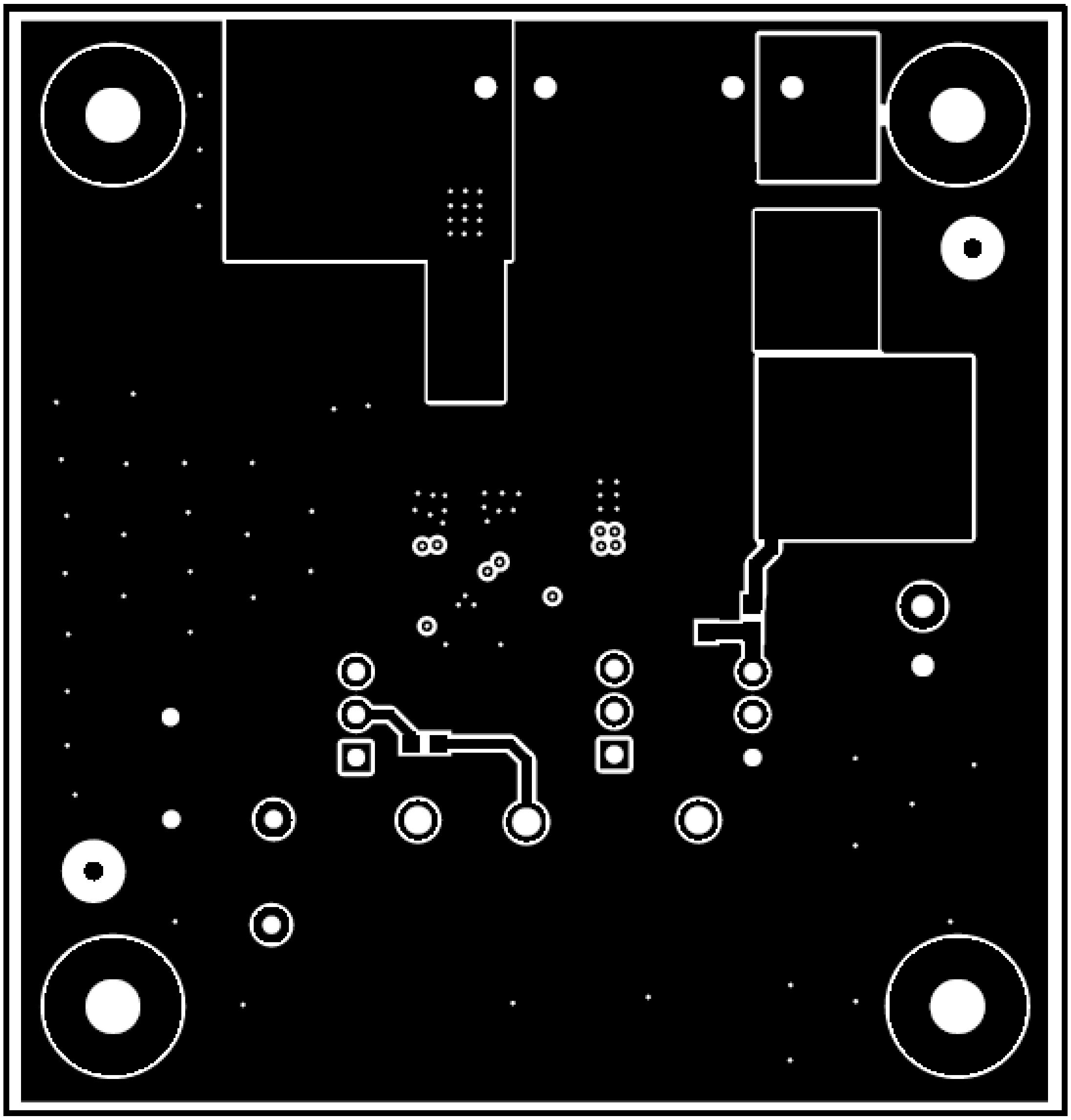

Figure 8. EVM Bottom Copper Layer

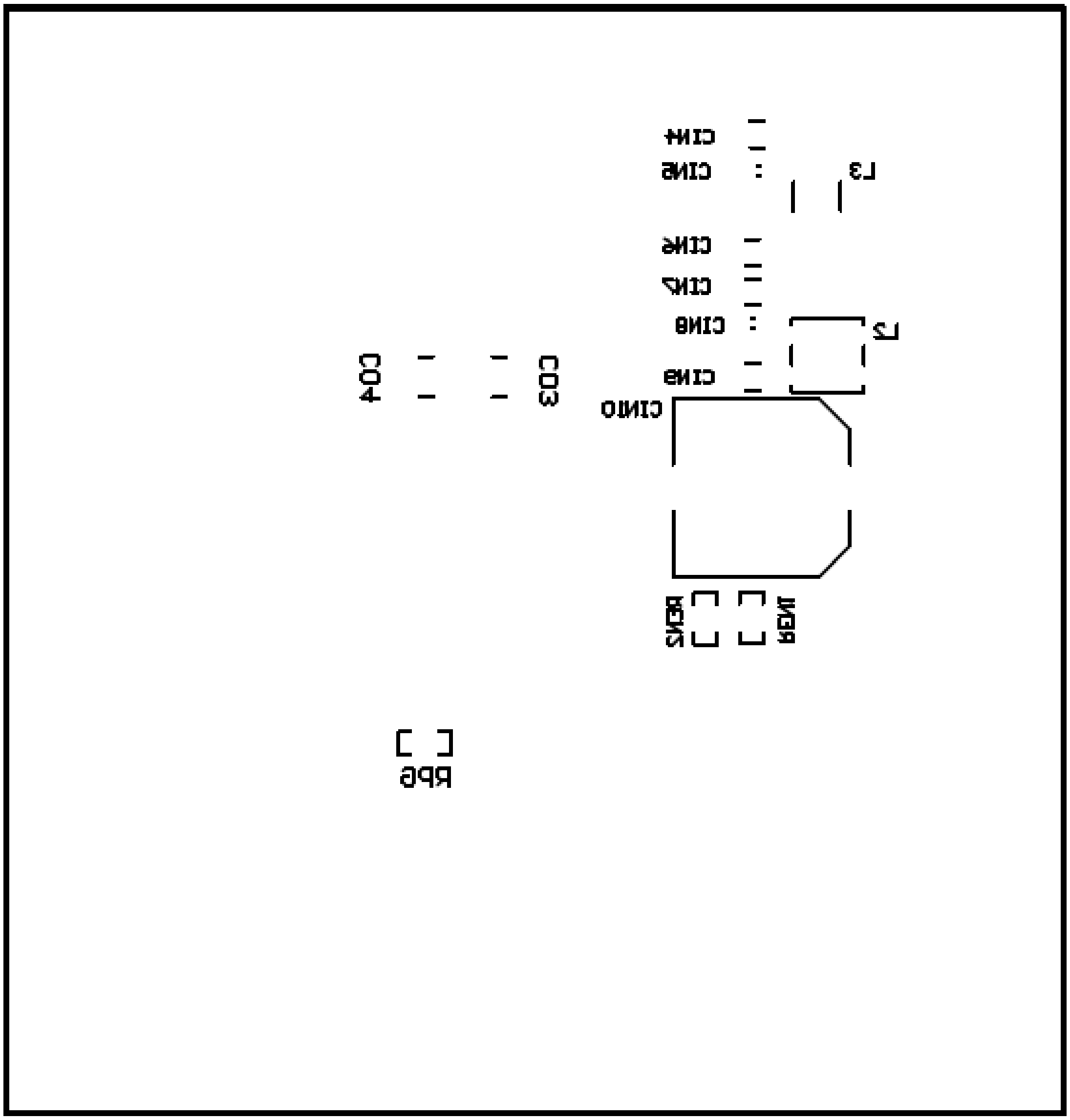

Figure 9. EVM Bottom View

5 Bill of Materials

Table 2. Bill of Materials

Designator	Description	Manufacturer	Part Number	Quantity
C5	CAP, AL, 68 µF, 63 V, +/- 20%, 0.65 ohm, AEC-Q200 Grade 2, SMD	Panasonic	EEE-FK1J680UP	0
C9, C10	CAP, CERM, 0.047 µF, 100 V, +/- 10%, X7S, 0603	TDK	CGA3E3X7S2A473K080AB	2
C11	CAP, CERM, 4.7 µF, 100 V, +/- 10%, X7S, AEC-Q200 Grade 1, 1210	TDK	CGA6M3X7S2A475K200A	1
C16	CAP, CERM, 0.1 uF, 25 V, +/- 10%, X7R, 0402	MuRata	GRM155R71E104KE14D	1
C17	CAP, CERM, 1 uF, 25 V, +/- 10%, X7R, 0603	TDK	C1608X7R1E105K080AB	1
C18	CAP, CERM, 22 pF, 50 V,+/- 5%, C0G/NP0, AEC-Q200 Grade 1, 0603	TDK	CGA3E2C0G1H220J080AA	1
H1, H2, H3, H4	Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	B&F Fastener Supply	NY PMS 440 0025 PH	2
H5, H6, H7, H8	Standoff, Hex, 0.5"L #4-40 Nylon	Keystone	1902C	4
J1, J2, J3	Terminal Block, 3.5mm Pitch, 2x1, TH	On-Shore Technology	ED555/2DS	3
J4, J5, J6	Header, 100mil, 3x1, Gold, TH	Samtec	HTSW-103-07-G-S	3
LBL1	Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	Brady	THT-14-423-10	1
R1, R2	RES, 10.0 k, 1%, 0.1 W, 0603	Vishay-Dale	CRCW060310K0FKEA	2
R3	RES, 100 k, 1%, 0.1 W, 0603	Vishay-Dale	CRCW0603100KFKEA	1
R4	RES, 135 k, 0.1%, 0.1 W, 0603	Yageo America	RT0603BRD07135KL	1
R5	RES, 100 k, 1%, 0.1 W, 0603	Yageo America	RC0603FR-07100KL	1
R6	RES, 24.9 k, 1%, 0.1 W, 0603	Vishay-Dale	CRCW060324K9FKEA	1
SH-J1, SH-J2, SH-J3	Shunt, 100mil, Gold plated, Black	3M	969102-0000-DA	3
TP1, TP4	Test Point, Multipurpose, Red, TH	Keystone	5000	2
TP2, TP3	Test Point, Multipurpose, Black, TH	Keystone	5001	2
TP5, TP6, TP7	Test Point, Multipurpose, Yellow, TH	Keystone	5014	3
LMR36015AEVM: Adjustable 3.3V/5V Output, 400kHz, 1.5A				
U1	4.2V to 60V, 1.5A Synchronous Step-Down	Texas Instruments	LMR36015	1
L1	Inductor, Shielded, Composite, 10 uH, 3 A, 0.084 ohm, SMD	Coilcraft	XAL4040-153MEB	1
L2	Inductor, Shielded, Composite, 1 uH, 8.75 A, 0.01 ohm, SMD	Coilcraft	XAL4040-102MEB	1
L3	Ferrite Bead, 600 ohm @ 100 MHz, 3 A, 1210	Taiyo Yuden	FBMH3225HM601NT	1
C1, C2, C3, C4	CAP, CERM, 22 µF, 16 V, +/- 10%, X7R, 1210	MuRata	GRM32ER71C226KE18L	4
C6	CAP, AL, 47 uF, 80 V, +/- 20%, 0.7 ohm, SMD	Chemi-Con	EMZA800ADA470MJA0G	1
C7, C8, C12, C14	CAP, CERM, 2.2 µF, 100 V,+/- 10%, X7R, 1206	MuRata	GRM31CR72A225KA73L	4
C13, C15	CAP, CERM, 0.047 µF, 100 V, +/- 10%, X7S, 0603	TDK	CGA3E3X7S2A473K080AB	2
LMR36006BEVM: Adjustable 3.3V/5V Output, 1MHz, 0.6A				
U1	4.2V to 60V, 0.6A Synchronous Step-Down	Texas Instruments	LMR36006	1
L1	Inductor, Shielded, Composite, 15 uH, 2.8 A, 0.109 ohm, SMD	Coilcraft	XAL4040-153MEB	1
C1, C2, C3	CAP, CERM, 22 µF, 16 V, +/- 10%, X7R, 1210	MuRata	GRM32ER71C226KE18L	3

6 Test Results

Section 6.1 details the test results from the LMR36015AEVM variant. Section 6.2 details the test results from the LMR36006BEVM.

6.1 LMR36015AEVMTest Results

The LMR36015AEVM variant is used for all figures from Figure 10 to Figure 17 variant.

6.1.1 Efficiency and Load Regulation

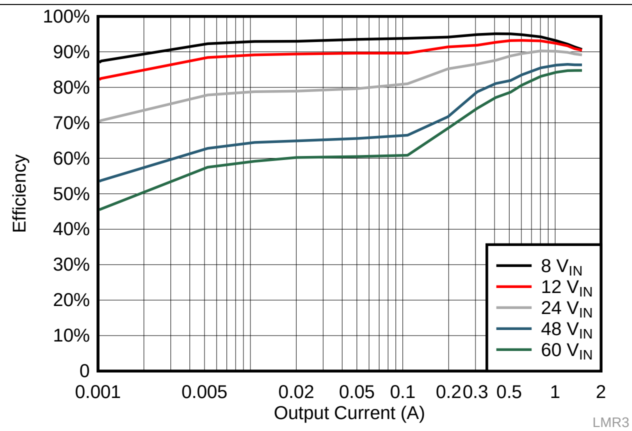

Figure 10. LMR36015AEVM 5 V_{OUT} Efficiency

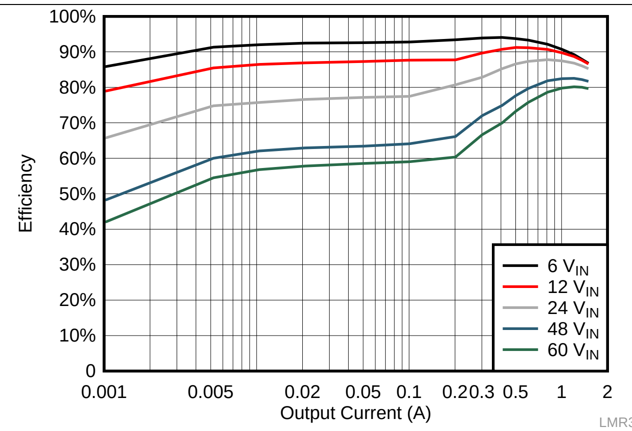

Figure 11. LMR36015AEVM 3.3 V_{OUT} Efficiency

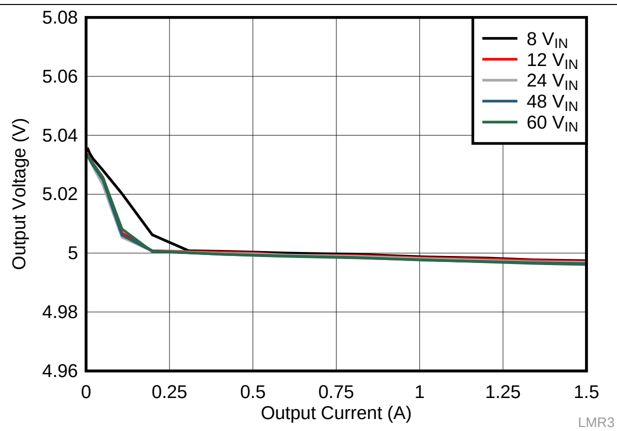

Figure 12. LMR36015AEVM 5 V_{OUT} Load Regulation

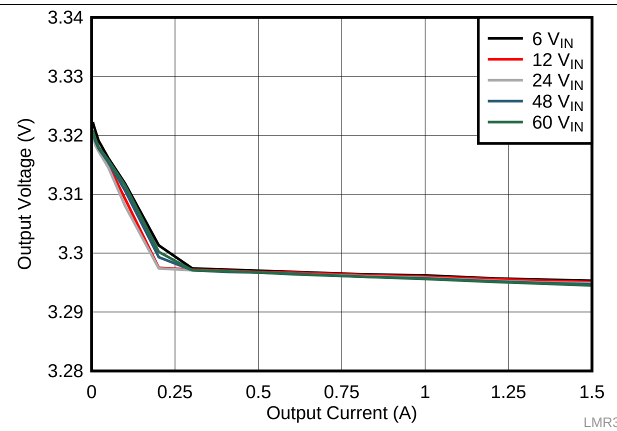

Figure 13. LMR36015AEVM 3.3 V_{OUT} Load Regulation

6.1.2 Load Transients

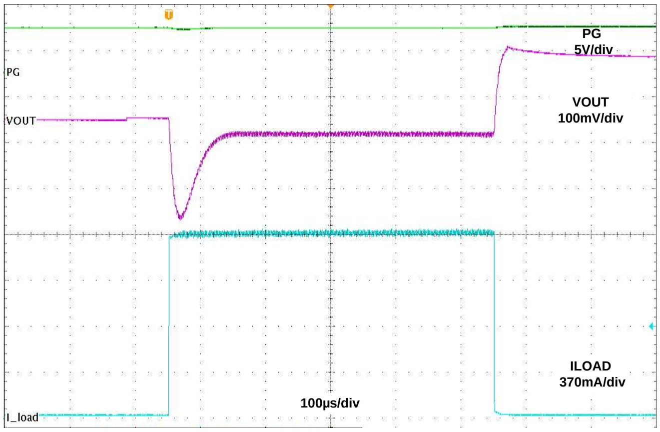

Figure 14. LMR36015AEVM 5 V_{OUT} Load Transient, 24 V_{IN}, I_{OUT} = 0 A to 1.5 A, T_R = T_F = 1 µs

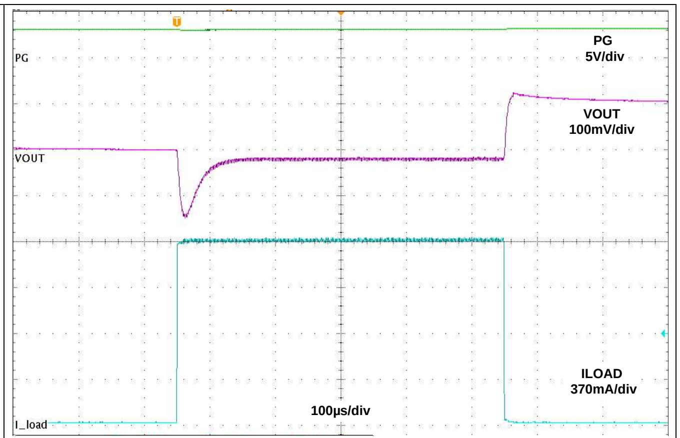

Figure 15. LMR36015AEVM 3.3 V_{OUT} Load Transient, 24 V_{IN}, I_{OUT} = 0 A to 1.5 A, T_R = T_F = 1 µs

6.1.3 Start Up Waveforms

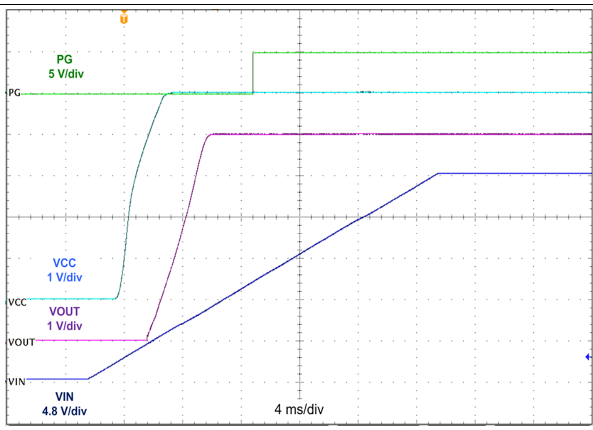

Figure 16. LMR36015AEVM 5 V_{OUT} Start-Up Waveform, 24 V_{IN},1.5 A Load

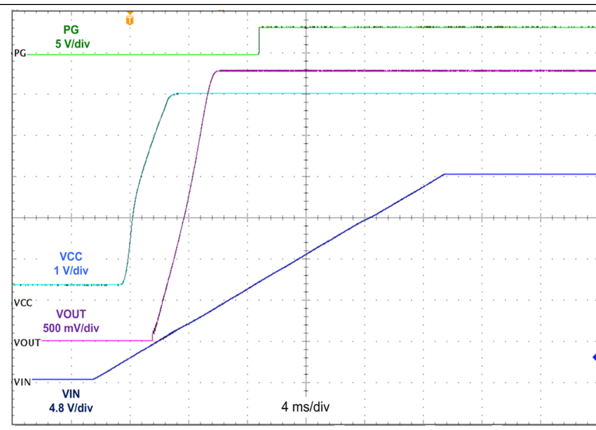

Figure 17. LMR36015AEVM 3.3 V_{OUT} Start-Up Waveform, 24 V_{IN},1.5 A Load

6.2 LMR36006BEVM Test Results

The LMR36006BEVM variant is used for all figures from Figure 18 to Figure 25.

6.2.1 Efficiency and Load Regulation

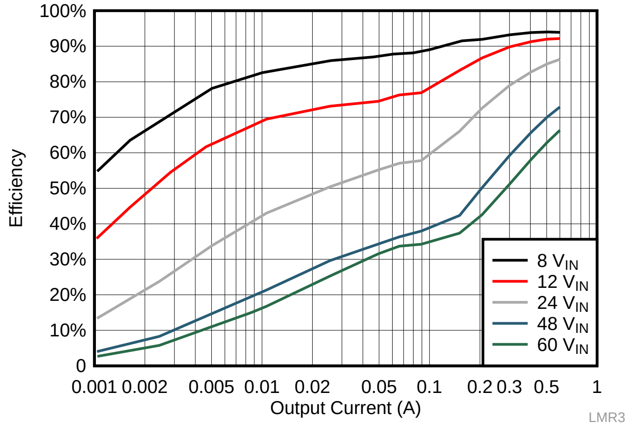

Figure 18. LMR36006BEVM 5 V_{OUT} Efficiency

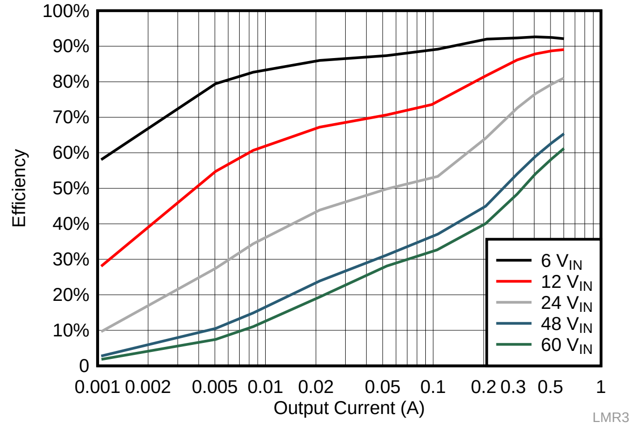

Figure 19. LMR36006BEVM 3.3 V_{OUT} Efficiency

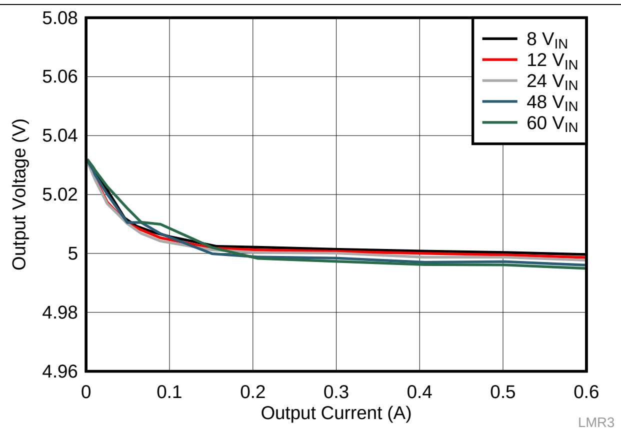

Figure 20. LMR36006BEVM 5 V_{OUT} Load Regulation

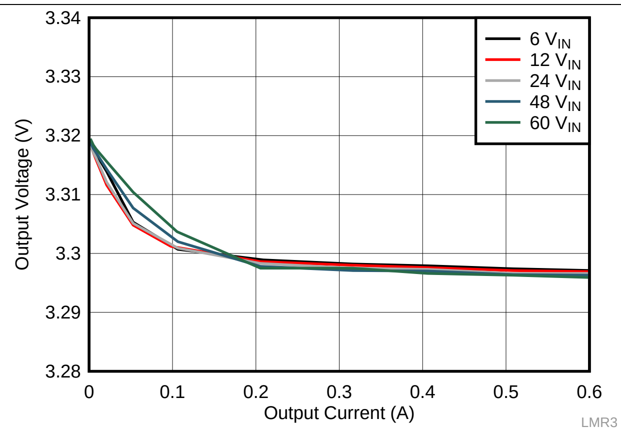

Figure 21. LMR36006BEVM 3.3 V_{OUT} Load Regulation

6.2.2 Load Transients

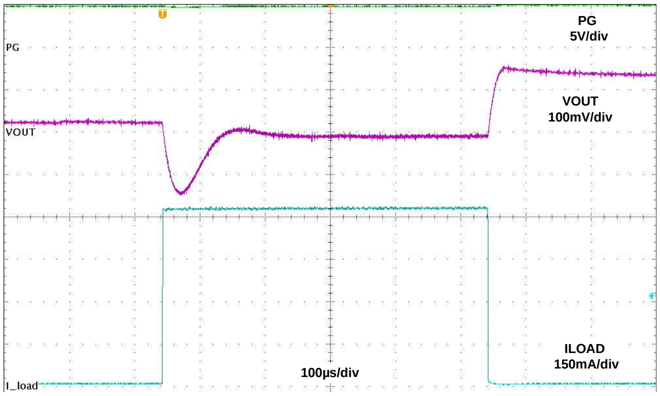

Figure 22. LMR36006BEVM 5 V_{OUT} Load Transient, 24 V_{IN}, I_{OUT} = 0 A to 0.6 A, T_R = T_F = 1 µs

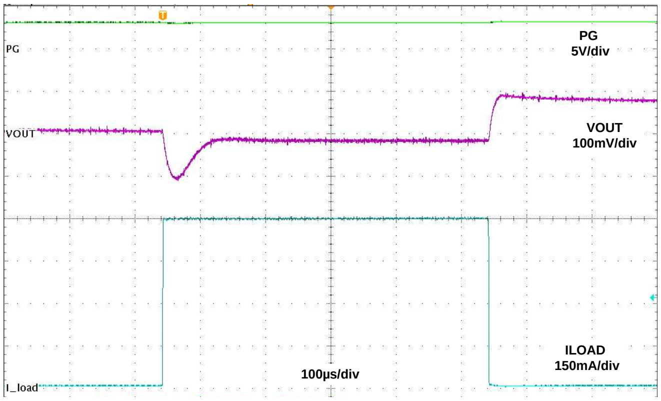

Figure 23. LMR36006BEVM 3.3 V_{OUT} Load Transient, 24 V_{IN}, I_{OUT} = 0 A to 0.6 A, T_R = T_F = 1 µs

6.2.3 Start Up Waveforms

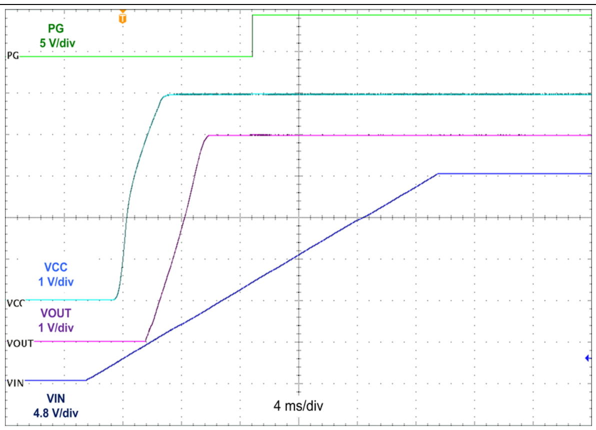

Figure 24. LMR36006BEVM 5 V_{OUT} Start-Up Waveform, 24 V_{IN},1.5 A Load

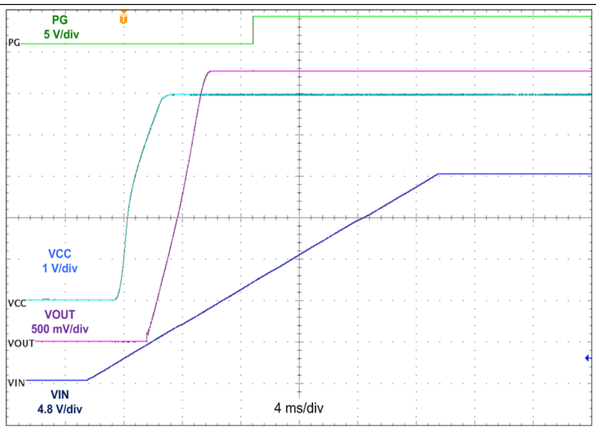

Figure 25. LMR36006BEVM 3.3 V_{OUT} Start-Up Waveform, 24 V_{IN},1.5 A Load

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