Using LMZ31506HEVM-692, LMZ31503EVM-692 and LMZ31506EVM-692 Evaluation Module

User's Guide

Literature Number: SNVU295
JULY 2013

LMZ31506H, LMZ31503 and LMZ31506 Simple Switcher® Power Module Evaluation Module

This user's guide contains background information for the LMZ31506H, LMZ31503, and LMZ31506 and support documentation for the LMZ31506HEVM-692, LMZ31503EVM-692 and LMZ31506EVM-692 evaluation module (LMZ3150xEVM-692).

1 Introduction

The LMZ31506H & LMZ31506 Simple Switcher® power modules provide up to 6-A of output current and the LMZ31503 provides up to 3-A of output current. These power modules have dual-voltage inputs for the power stage and control circuitry. The power stage input (PVIN) is rated for 1.6 V to 14.5 V whereas the control input (VIN) is rated for 4.5 V to 14.5 V. The LMZ3150xEVM-692 provides both inputs but is designed and tested with PVIN connected to VIN. Rated input voltage and output current range for the evaluation module are given in Table 1.

1.1 Features

- Complete Integrated Power Module Allows Small Footprint, Low-Profile Design
- Efficiencies Up To 96%
- Wide-Output Voltage Adjust 0.6 V to 5.5 V, with 1% Reference Accuracy
- Adjustable Switching Frequency

1.2 Background

This evaluation module is designed to demonstrate the small printed-circuit-board areas that may be achieved when designing with the LMZ31506H, LMZ31503, and LMZ31506 power modules. The high-side and low-side MOSFETs are incorporated inside the device's package along with the gate drive circuitry. The low drain-to-source on-resistance of the MOSFET allows the LMZ31506H, LMZ31503, and LMZ31506 to achieve high efficiencies and helps keep the junction temperature low at high output currents. The compensation components are internal to the device, and external resistors and jumpers allow for adjustable output voltage and frequency adjustment. Additionally, the LMZ31506H, LMZ31503, and LMZ31506 provide adjustable slow start, tracking, and undervoltage lockout inputs. The absolute maximum input voltage is 15 V.

Table 1. Input Voltage and Output Current Summary

EVM	INPUT VOLTAGE RANGE	OUTPUT CURRENT RANGE
LMZ31506HEVM-692	PVIN = VIN = 4.5 V to 14.5 V	0 A to 6 A
LMZ31503EVM-692	PVIN = VIN = 4.5 V to 14.5 V	0 A to 3 A
LMZ31506EVM-692	PVIN = VIN = 4.5 V to 14.5 V	0 A to 6 A

2 Schematic

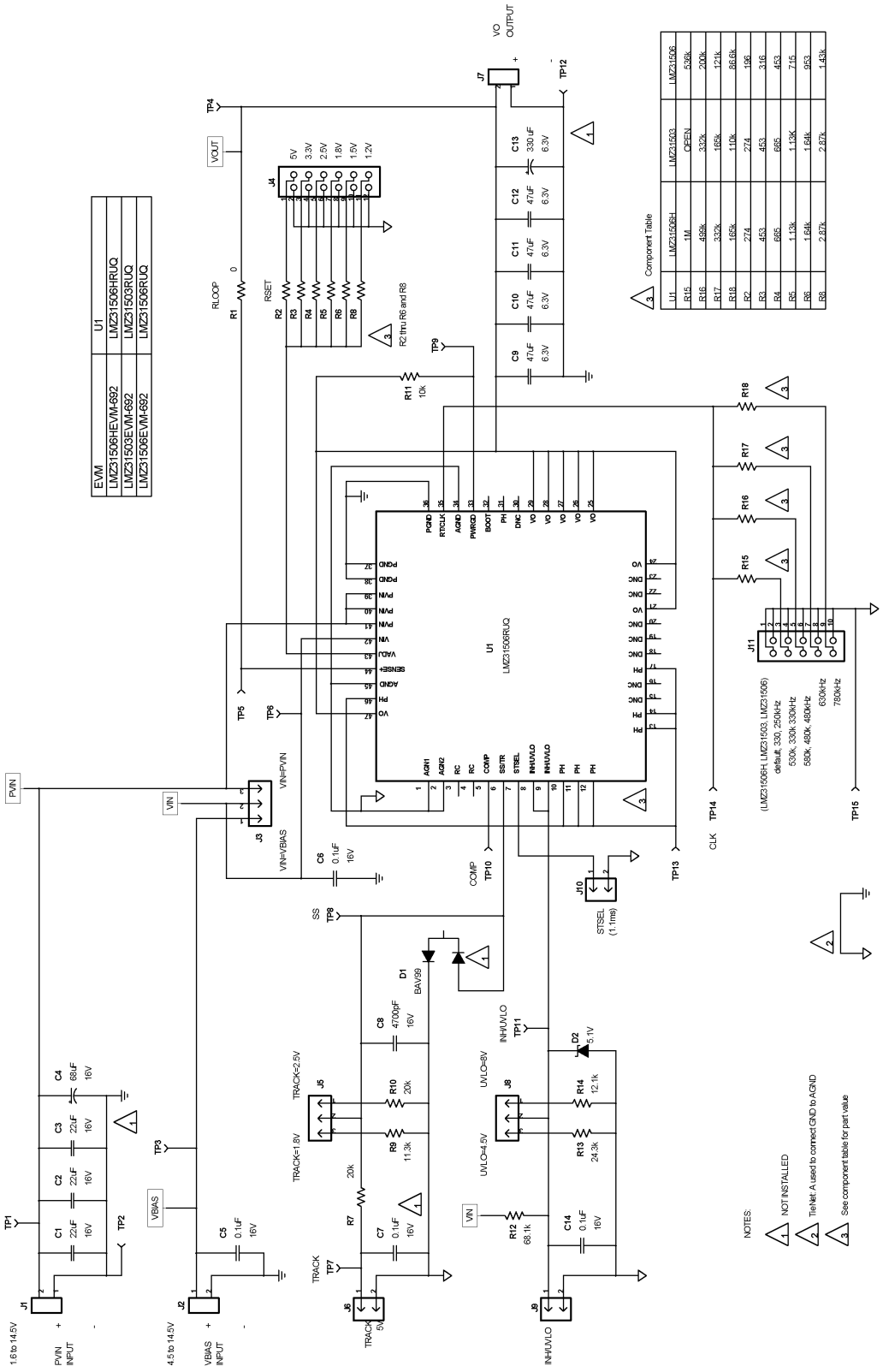

Figure 1. LMZ3150XEVM-692 Schematic

3 Modifying the EVM

These evaluation modules are designed to provide access to the features of the LMZ31506H, LMZ31503, and LMZ31506.

3.1 Output Voltage Setpoint

Select the output voltage at J4. Use the silk screen to select the desired voltage preprogrammed on the module (see Figure 13). If a different voltage is needed, the RSET resistor (any of R2 thru R6 and R8) may be changed to a value listed in the component data sheet (LMZ31506H, LMZ31503, and LMZ31506).

When all jumpers on J4 are open, the default output voltage for the components is selected. See Table 2.

Table 2. Component Default Output Voltage

COMPONENT	DEFAULT VOLTAGE
LMZ31506H	Not recommended
LMZ31503	0.8 V
LMZ31506	0.6 V

3.2 Frequency Select

The Switching frequency is selected at J11. Table 3 shows the selection options for each of the three evaluation modules.

Table 3. Selection Options

JUMPER POSITION	LMZ31506HEVM-692	LMZ31503EVM-692	LMZ31506EVM-692
MIN	480 kHz	330 kHz	250 kHz
1	530 kHz	330 kHz	330 kHz
2	580 kHz	480 kHz	480 kHz
3	630 kHz	630 kHz	630 kHz
MAX	780 kHz	780 kHz	780 kHz

3.3 Slow Start Time

The slow start time can be adjusted by changing the value of C8. See the slow start table in the LMZ31506H, LMZ31503, and LMZ31506 data sheets for more information. The EVM is set for a slow start time of 2.8 ms, (C8 = 4700 pF and J10 installed).

3.4 Track In

The LMZ31506H, LMZ31503, and LMZ31506 can track an external voltage during start-up. The J6 connector is provided to allow connection to an external voltage. Ratio-metric or simultaneous tracking can be implemented using the provided resistor dividers with J5. See the product data sheet for details.

3.5 Adjustable UVLO

The undervoltage lockout (UVLO) can be adjusted as described in the LMZ31506H, LMZ31503 and LMZ31506 data sheets. The EVM provides two selectable UVLO setpoints using the provided resistor dividers and J8. J9 provides an inhibit input.

3.6 Input Voltage Rails

The EVM is designed to accommodate different input voltage levels for the power stage and control logic. During normal operation, the PVIN and VIN inputs are connected using a jumper across the top two pins of J3 (VIN = PVIN position). The single input voltage is supplied at J1. If desired, input voltage may be separated by moving the J3 jumper to the lower two pins (VIN = VBIAS position). Dual input voltages must then be provided at both J1 and J2.

4 TEST SET-UP

This section describes how to properly set-up and use the LMZ3150xEVM-692 evaluation module.

4.1 Input/Output Connections

The LMZ3150xEVM-692 is provided with input/output connectors and test points as shown in Table 4. A power supply capable of supplying 4 A must be connected to J1 through a pair of 20 AWG wires. The jumper across J3 must be in place. See Section 3.6 for split input voltage rail operation. The load must be connected to J7 through a pair of 20 AWG wires. The maximum load current capability must be 6 A. Wire lengths must be minimized to reduce losses in the wires. Test-point TP1 provides a place to monitor the V_{IN} input voltages with TP2 providing a convenient ground reference. TP4 is used to monitor the output voltage with TP12 as the ground reference.

Table 4. EVM Connectors and Test Points

REF DES	LABEL	DESCRIPTION
J1	PVIN	Primary VIN connector
J2	VBIAS	VBIAS input voltage input connector
J3	VIN	Jumper used to connect VIN to PVIN. EVM default setting connects VIN to PVIN.
J7	VOUT	VOUT connector
J4	VADJ	VOUT selection. Default VOUT is 3.3 V.
J11	FREQ	Switching frequency selection. Default frequency is 630 kHz.
J6	TR_IN	TRACK IN connector. J5 provides two divider settings.
J5	SS_TR	Track voltage select jumper. Used with J6.
J9	INH_UVLO	Enable jumper. Install shunt to inhibit the power supply.
J8	INH_UVLO	Selects UVLO for power supply turn on. Default setting is for 8-V UVLO.
J10	STSEL	Internal slow start select jumper. Install shunt for internal slow start.
TP1	PVIN	PVIN circuit point
TP3	VBIAS	VBIAS circuit point
TP6	VIN	VIN circuit point
TP4	VOUT	VOUT circuit point
TP2, TP12	GND	Power grounds
TP15	AGND	Analog ground
TP7	TR_IN	Track input
TP8	SS_TR	Tracking input after divider
TP9	PWRGD	Power good status
TP14	RT/CLK	SYNC input
TP10	COMP	Error amplifier output
TP13	PH	Switch node
TP11	INH_UVLO	Inhibit and UVLO input
TP5	SENSE+	VOUT remote sense node connected to J7 pin 2. TP5 can be used for measuring the loop response along with changing R1 to 49.9 Ω.

5 Typical Performance Data

Figure 2 though Figure 12 present characteristic performance data taken from the LMZ31506HEVM-692 only. For data regarding the LMZ31503 and the LMZ31506 please see the product data sheet.

5.1 Efficiency vs Input Voltage

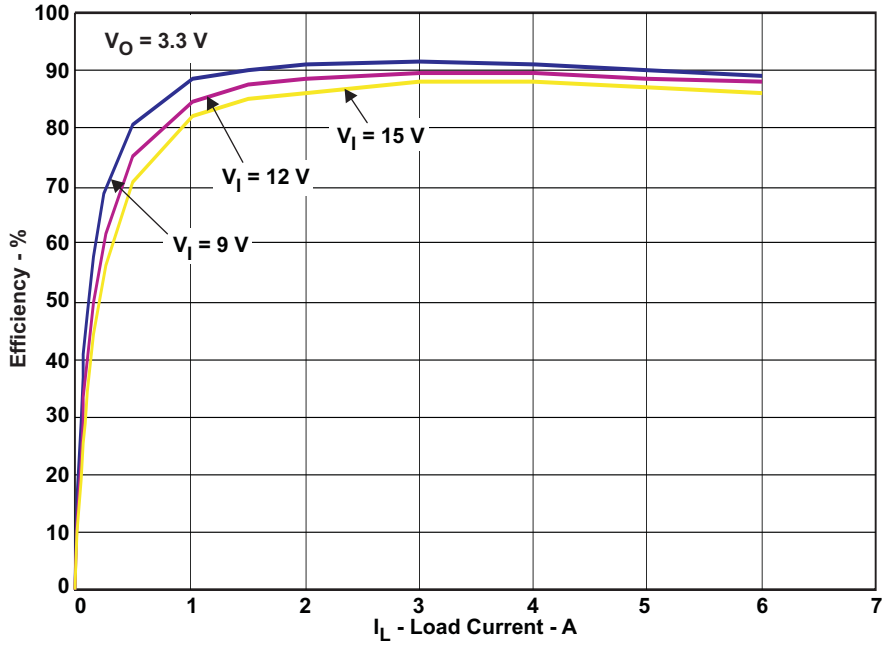

Figure 2. Efficiency vs Voltage at 25°C

5.2 Light-Load Efficiency vs Input Voltage

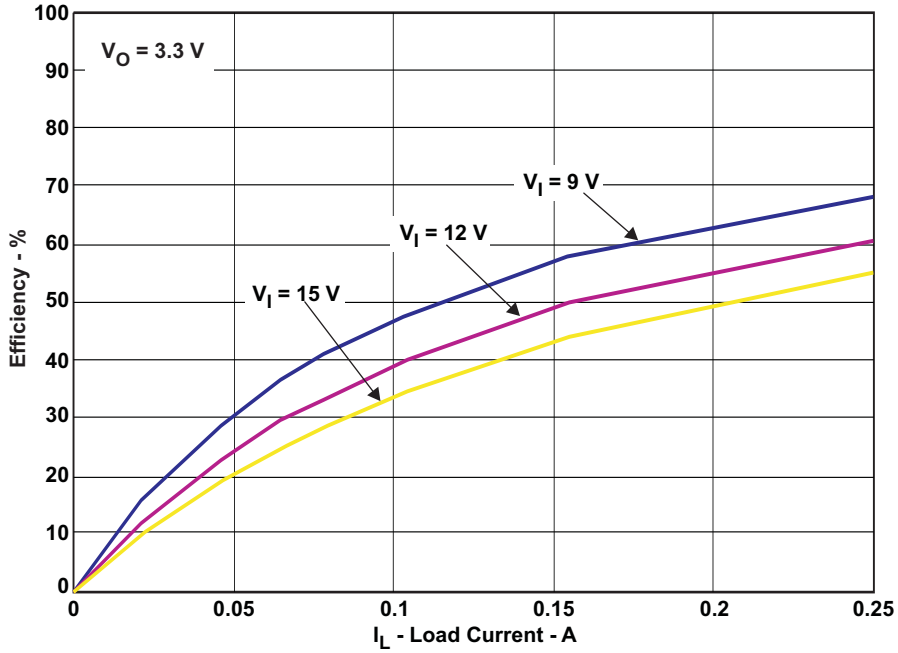

Figure 3. Light-Load Efficiency vs Input Voltage at 25°C

5.3 Efficiency vs Output Voltage/Frequency, PVIN = 12 V

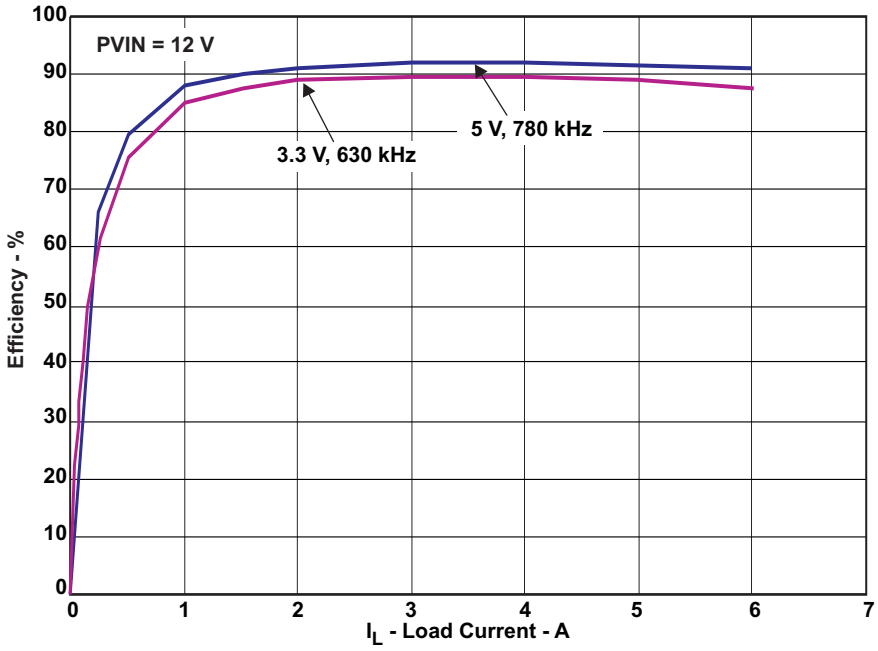

Figure 4. Efficiency vs Output Voltage at 25°C

5.4 Efficiency vs Output Voltage/Frequency, PVIN = 5 V

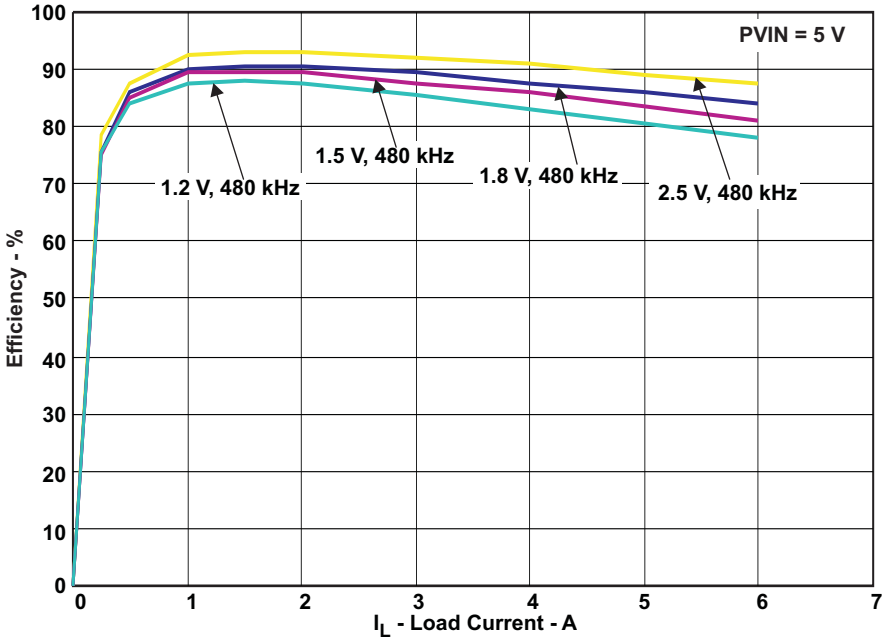

Figure 5. Efficiency vs Output Voltage/Frequency at 25°C

5.5 Output Voltage Load Regulation

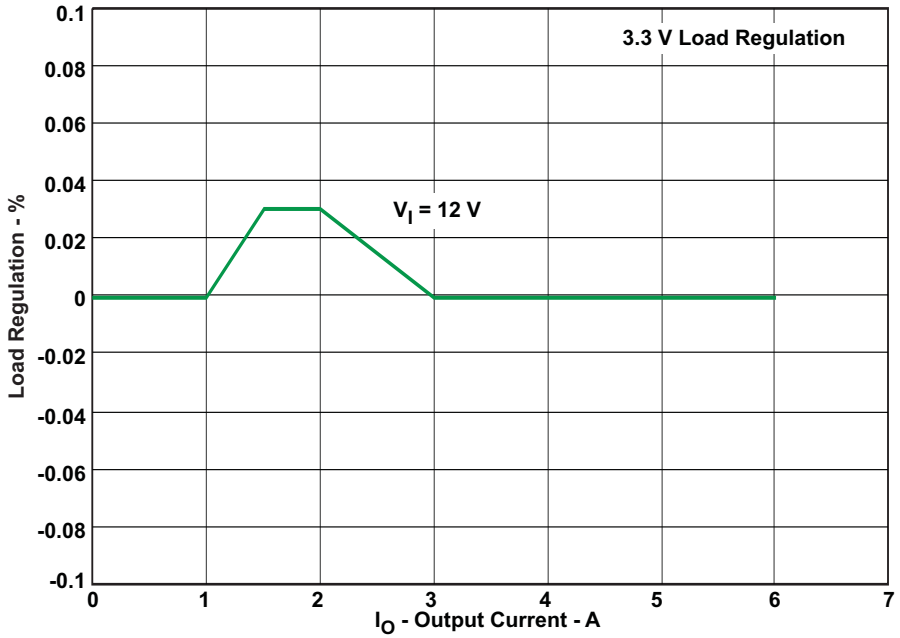

Figure 6. Load Regulation at 25°C

5.6 Output Voltage Line Regulation

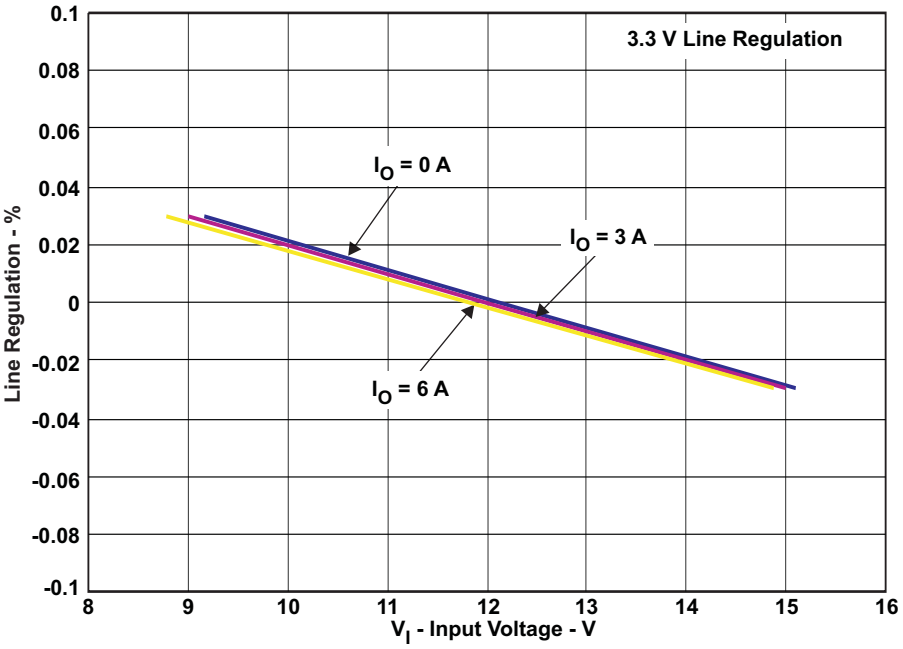

Figure 7. Line Regulation at 25°C

5.7 3.3-V LMZ31506EVM-692 Response to Load Transients

Figure 8 shows the LMZ31506EVM-692 response to load transients. The current step is from 1.5 A to 4.5 A at 12-V input. Total peak-to-peak voltage variation is as shown, including ripple and noise on the output.

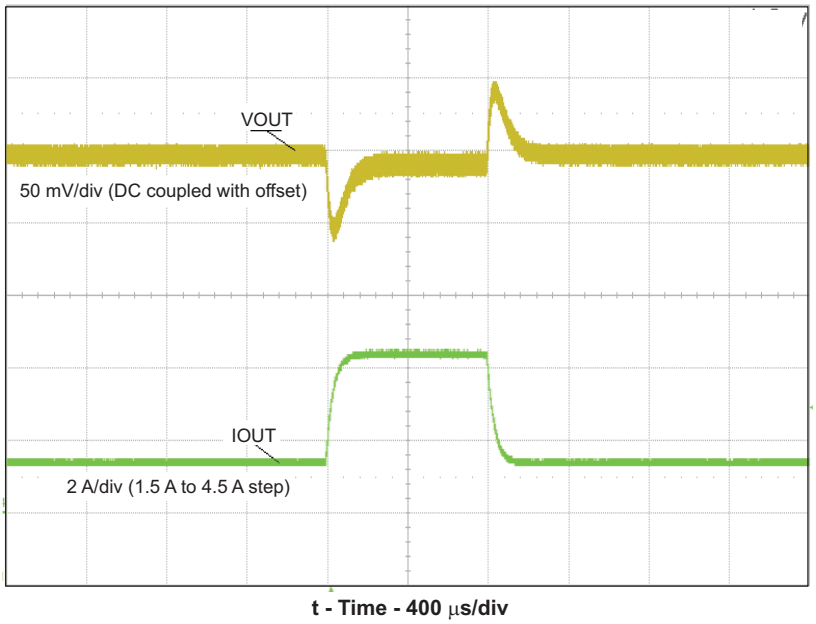

Figure 8. 3.3-V LMZ31506HEVM-692 Transient Response at 25°C

5.8 LMZ31506 Loop Response

Figure 9 shows the LMZ31506EVM-692 loop response. The unity gain bandwidth is 50 kHz, phase margin is 70 degrees, gain margin is 19 dB and the gain slope is –1.

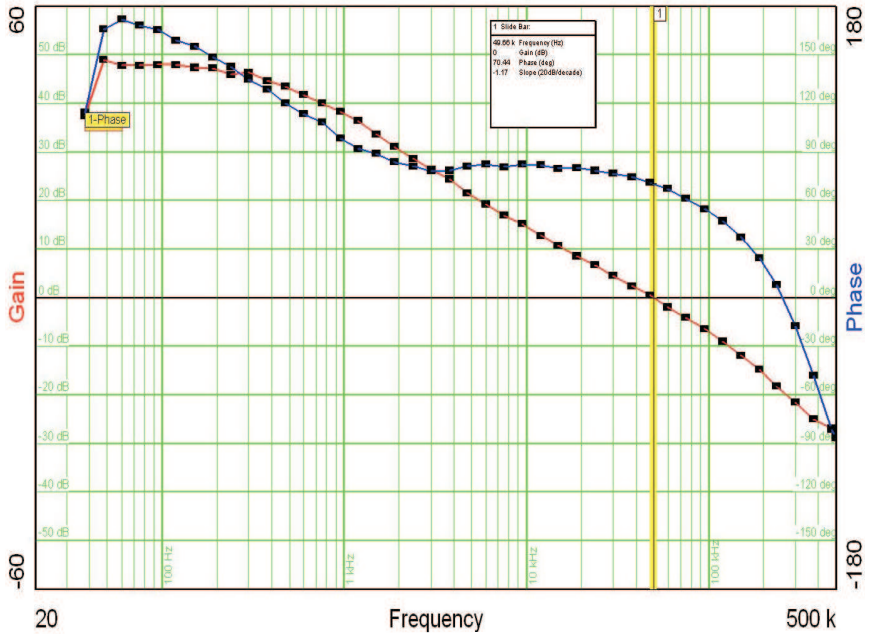

Figure 9. LMZ31506EVM-692 Loop Response at 25°C

5.9 LMZ31506EVM-692 Voltage Ripple

Figure 10 shows the LMZ31506EVM-692 output voltage ripple when operating from 12 V with an output load of 6 A.

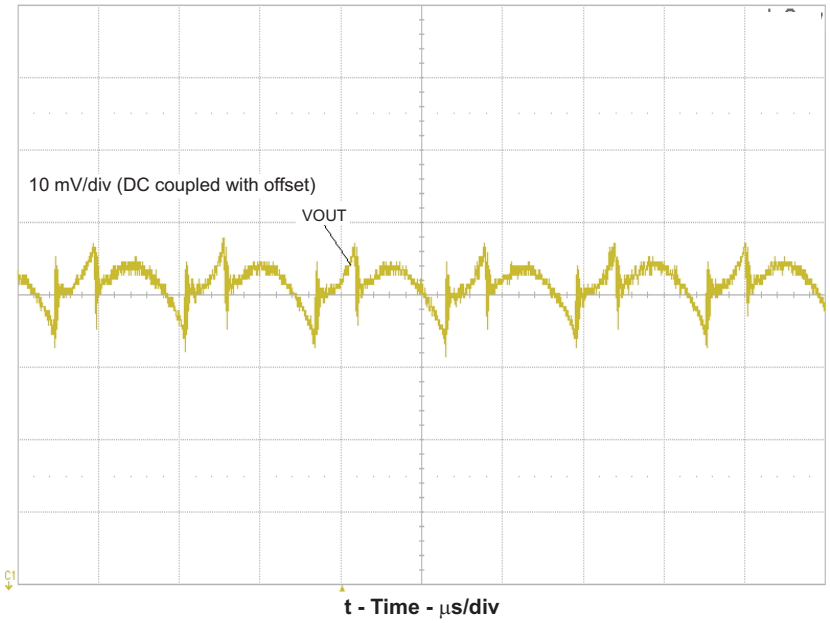

Figure 10. LMZ31506EVM-692 Output Voltage Ripple

Figure 11 shows the LMZ31506EVM-692 input voltage ripple when operating from 12 V with an output load of 6 A.

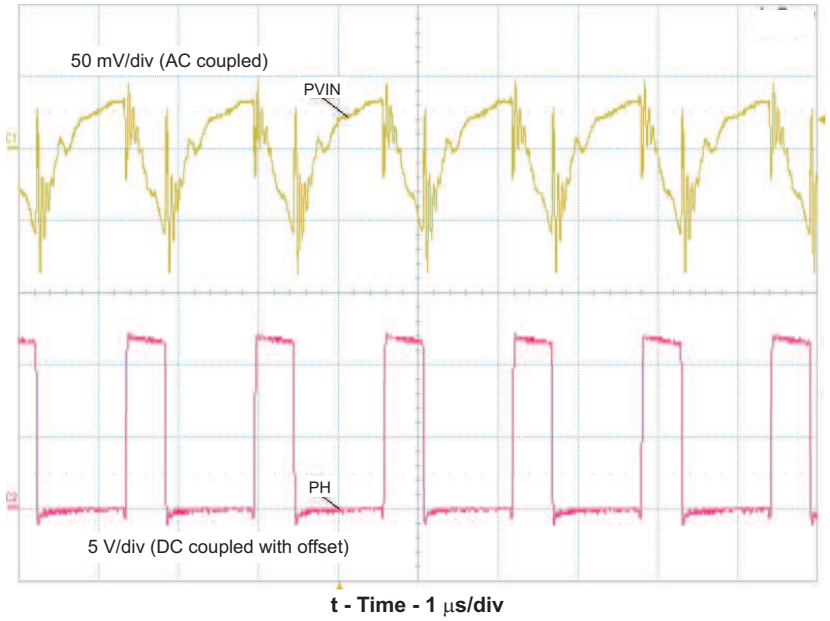

Figure 11. LMZ31506EVM-692 Input Voltage Ripple

5.10 Power Up

Figure 12 shows the LMZ31506EVM-692 start-up waveforms with rising PVIN. In Figure 12, the output starts to rise when PVIN reaches the rising UVLO of 8 V. J9 can also be used to inhibit VOUT when PVIN is present.

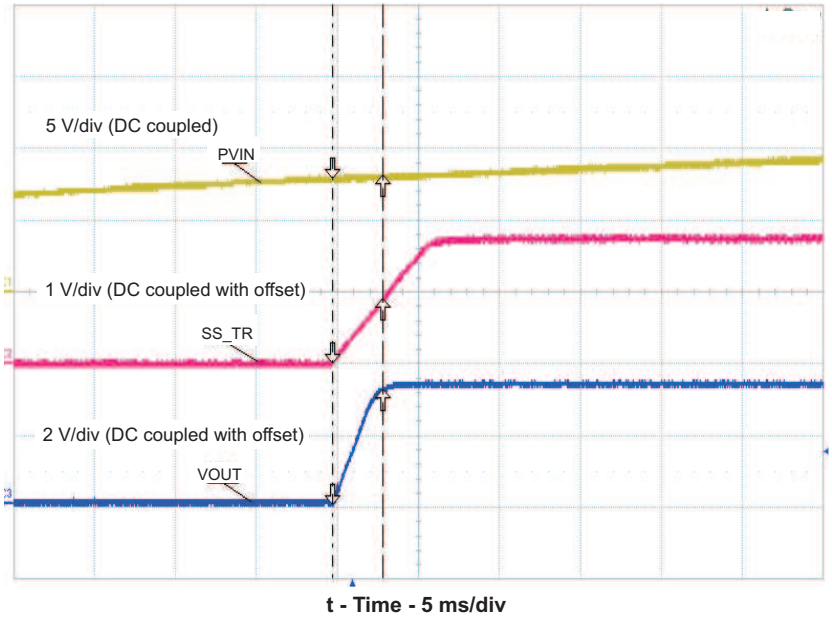

Figure 12. LMZ31506EVM-692 Start-Up Waveforms With Rising PVIN

6 Board Layout/Assembly Drawing

This section provides a description of the LMZ3150xEVM-692, board layout, and layer illustrations.

6.1 Layout

The board layout for the LMZ3150xEVM-692 is shown in Figure 13 through Figure 16. The topside layer of the EVM is laid out with test points and jumpers to easily evaluate the power module in any operating condition. The top, bottom, and internal layers are 2-oz. copper. A basic set of layout guidelines include:

- Place the input capacitors close to the PVIN and PGND terminals.
- Place the output capacitors close to the VO and PGND terminals.
- AGND is a 0-Vdc reference for the analog control circuitry.
- Connect AGND to PGND at a single point.
- AGND, terminal 45 provides a means to remove heat from the device and must be connected to an AGND plane with multiple vias as shown in the product data sheet.
- The SENSE+ pin (pin 44) provides a remote sense function for the device. Connect the SENSE+ pin to VO near the load.
- Analog control pins: Connect the analog control pins (VADJ, RT/CLK, INH/UVLO, STSEL, and SS/TR) to AGND using the recommended circuit components.

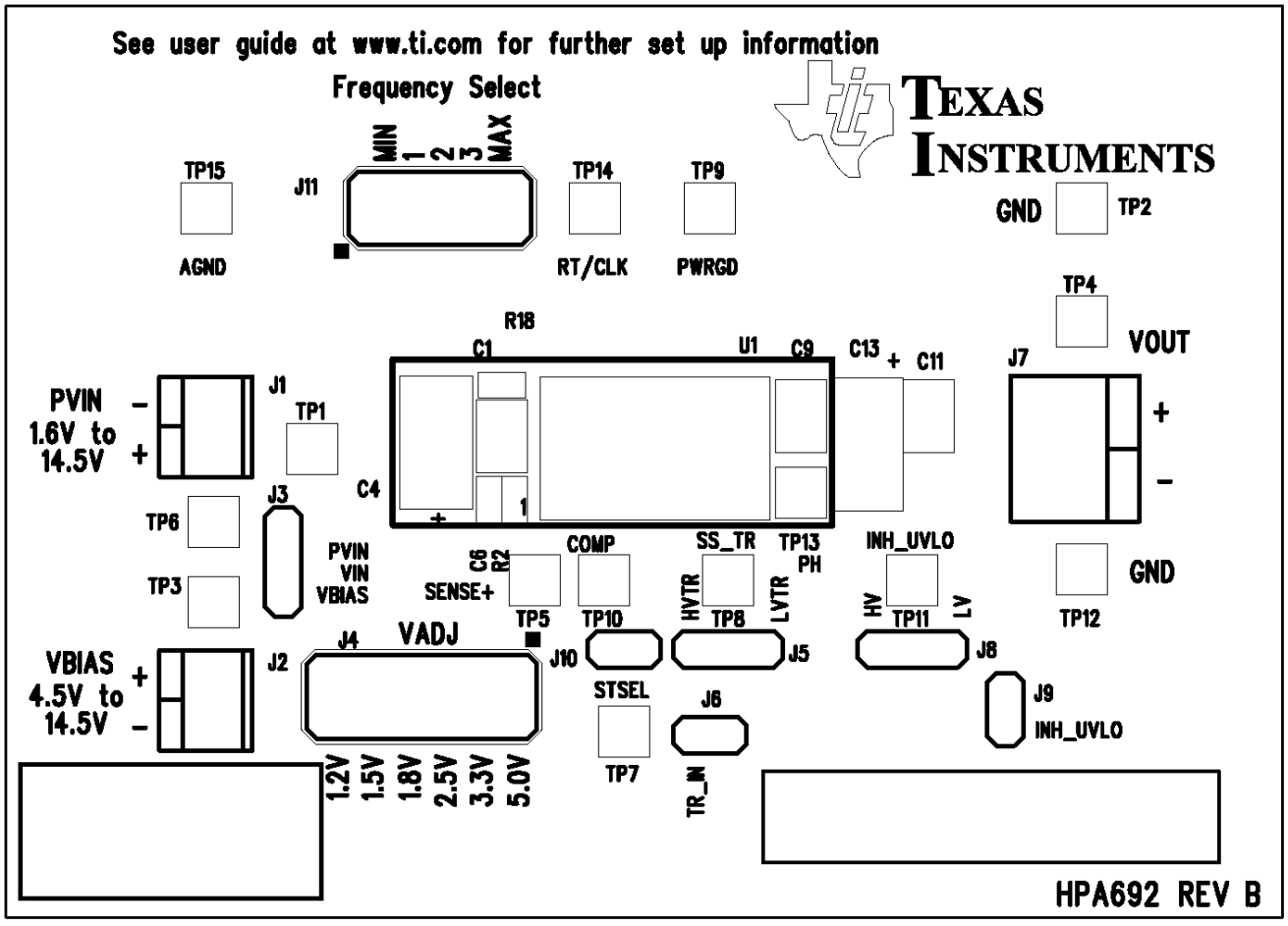

Figure 13. LMZ3150xEVM-692 Top-Side Layer and Assembly

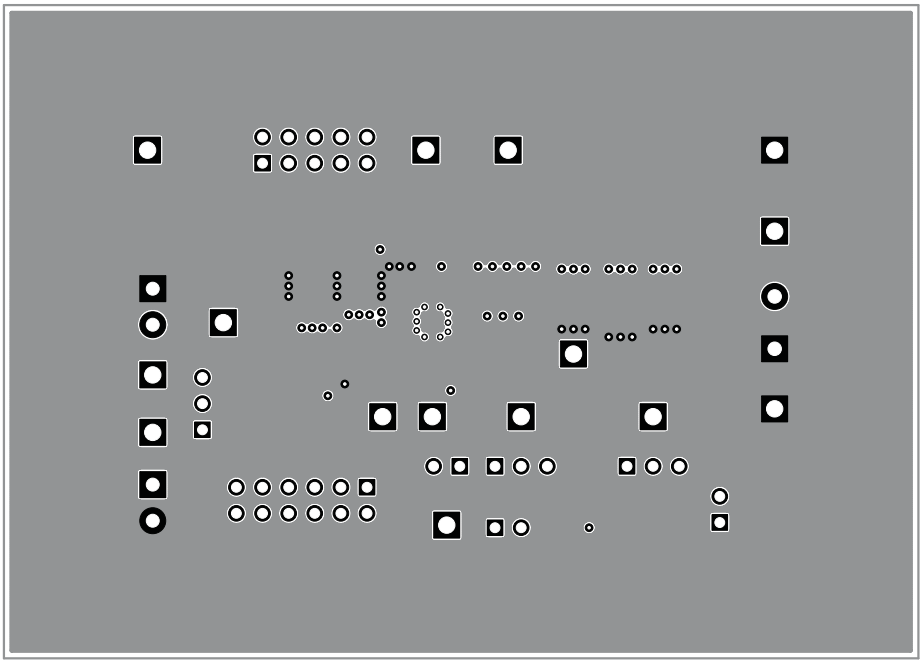

Figure 14. LMZ3150xEVM-692 Layer 2

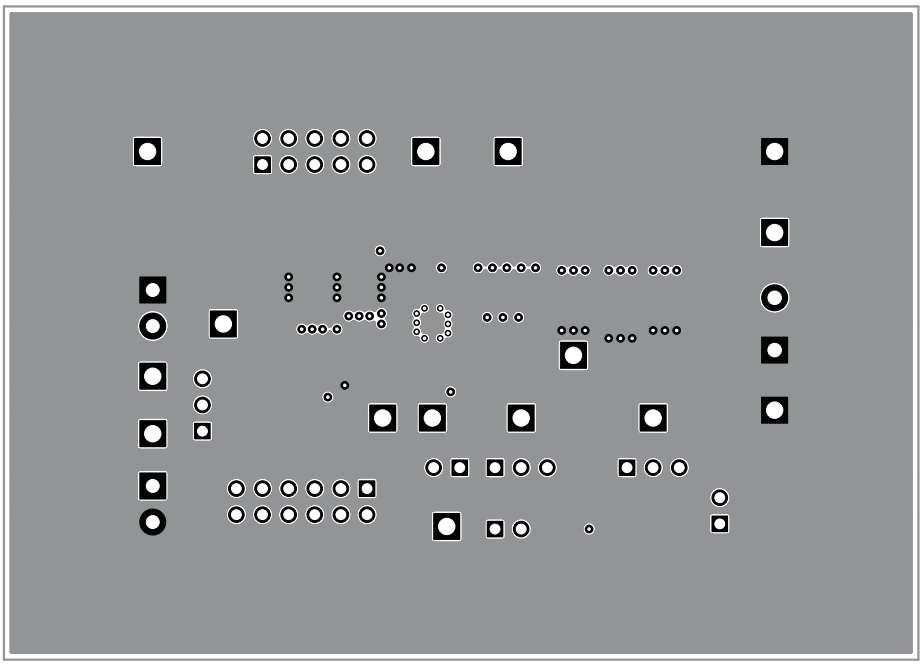

Figure 15. LMZ3150xEVM-692 Layer 3

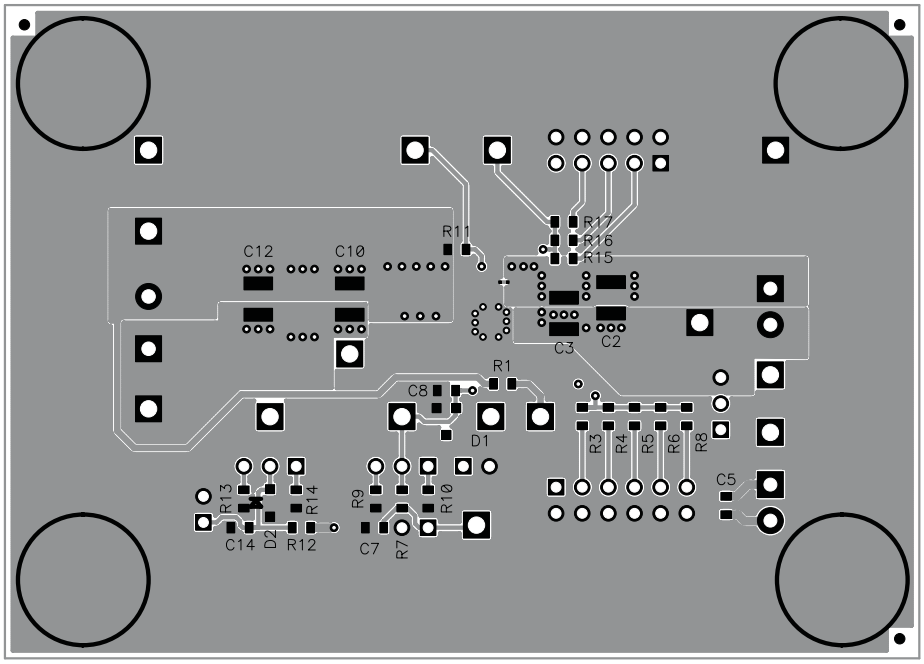

Figure 16. LMZ3150xEVM-692 Bottom-Side Layer and Assembly

6.2 Estimated Circuit Area

The estimated printed-circuit board area for the components used in this design is 0.55 in^2 (354 mm^2). This area does not include test point or connectors.

7 List of Materials

Table 5 presents the List of Materials for the LMZ31506HEVM-692, LMZ31503EVM-692 and LMZ31506EVM-692.

Table 5. LMZ3150xEVM-692 List of Materials

-003	-002	-001	REF DES	DESCRIPTION	PART NUMBER	MFR
2	2	2	C1, C2	Capacitor, ceramic, 16 V, X5R, 10%, 22 µF, 1210	GRM32ER61E226K	Murata
0	0	0	C3	Capacitor, ceramic, 16 V, X5R, 10%, 22 µF, 1210	GRM32ER61E226K	Murata
0	0	0	C13	Capacitor, polymer tant, 6.3 V, ±20%, 330 µF, 7343(D)	T530D337M006ATE006	Kemet
1	1	1	C4	Capacitor, polymer tantalum, 16 V, 20%, 68 µF, 7343(D)	16TQC68M	Sanyo
3	3	3	C5, C6, C14	Capacitor, ceramic, 16 V, X7R, 10%, 0.1 µF, 0603	Std	Std
0	0	0	C7	Capacitor, ceramic, 16 V, X7R, 10%, 0.1 µF, 0603	Std	Std
1	1	1	C8	Capacitor, ceramic, 16 V, X7R, 10%, 4700 pF, 0603	Std	Std
4	4	4	C9, C10, C11, C12	Capacitor, ceramic, 6.3 V, X5R, 10%, 47 µF, 1210	GRM32ER60J476M	Murata
0	0	0	D1	Diode, dual ultra fast, series, 200 mA, 70 V, BAV99, SOT23	BAV99	Fairchild
1	1	1	D2	Diode, Zener, 200 mW, 5.1 V, SOD-323	BZT52C5V1S	Diodes Inc.
2	2	2	J1, J2	Terminal block, 2 pin, 6 A, 3.5 mm, 0.27 inch x 0.25 inch	ED555/2DS	OST
1	1	1	J11	Header, male 2x5 pin, 100-mil spacing, 0.100 inch x 5 inch x 2 inch	PEC05DAAN	Sullins
3	3	3	J3, J5, J8	Header, male 3 pin, 100-mil spacing, 0.100 inch x 3 inch	PEC03SAAN	Sullins
1	1	1	J4	Header, male 2x6 pin, 100-mil spacing, 0.100 inch x 2 inch x 6 inch	PEC06DAAN	Sullins
3	3	3	J6, J9, J10	Header, male 2-pin, 100mil spacing, 0.100 inch x 2 inch	PEC02SAAN	Sullins
1	1	1	J7	Terminal block, 2 pin, 15 A, 5.1 mm, 0.40 inch x 0.35 inch	ED120/2DS	OST
1	1	1	R1	Resistor, chip, 1/10 W, -100/+600 ppm/°C, 0 Ω, 0603	Std	Std

Table 5. LMZ3150xEVM-692 List of Materials (continued)

-003	-002	-001	REF DES	DESCRIPTION	PART NUMBER	MFR
1	1	1	R11	Resistor, chip, 1/16 W, 1%, 10 kΩ, 0603	Std	Std
1	1	1	R12	Resistor, chip, 1/16 W, 1%, 68.1 kΩ, 0603	Std	Std
1	1	1	R13	Resistor, chip, 1/16 W, 1%, 24.3 kΩ, 0603	Std	Std
1	1	1	R14	Resistor, chip, 1/16 W, 1%, 12.1 kΩ, 0603	Std	Std
0	0	1	R15	Resistor, chip, 1/16 W, 1%, 1 MΩ, 0603	Std	Std
1	0	0	R15	Resistor, chip, 1/16 W, 1%, 536 kΩ, 0603	Std	Std
0	0	1	R16	Resistor, chip, 1/16 W, 1%, 499 kΩ, 0603	Std	Std
0	1	0	R16	Resistor, chip, 1/16 W, 1%, 332 kΩ, 0603	Std	Std
1	0	0	R16	Resistor, chip, 1/16 W, 1%, 200 kΩ, 0603	Std	Std
0	0	1	R17	Resistor, chip, 1/16 W, 1%, 332 kΩ, 0603	Std	Std
0	1	0	R17	Resistor, chip, 1/16 W, 1%, 165 kΩ, 0603	Std	Std
1	0	0	R17	Resistor, chip, 1/16 W, 1%, 121 kΩ, 0603	Std	Std
0	0	1	R18	Resistor, chip, 1/16 W, 1%, 165 kΩ, 0603	Std	Std
0	1	0	R18	Resistor, chip, 1/16 W, 1%, 110 kΩ, 0603	Std	Std
1	0	0	R18	Resistor, chip, 1/16 W, 1%, 86.6 kΩ, 0603	Std	Std
0	1	1	R2	Resistor, chip, 1/16 W, 1%, 274 Ω, 0603	Std	Std
1	0	0	R2	Resistor, chip, 1/16 W, 1%, 196 Ω, 0603	Std	Std
0	1	1	R3	Resistor, chip, 1/16 W, 1%, 453 Ω, 0603	Std	Std
1	0	0	R3	Resistor, chip, 1/16 W, 1%, 316 Ω, 0603	Std	Std
0	1	1	R4	Resistor, chip, 1/16 W, 1%, 665 Ω, 0603	Std	Std
1	0	0	R4	Resistor, chip, 1/16 W, 1%, 453 Ω, 0603	Std	Std
0	1	1	R5	Resistor, chip, 1/16 W, 1%, 1.13 kΩ, 0603	Std	Std
1	0	0	R5	Resistor, chip, 1/16 W, 1%, 715 Ω, 0603	Std	Std
0	1	1	R6	Resistor, chip, 1/16 W, 1%, 1.64 kΩ, 0603	Std	Std
1	0	0	R6	Resistor, chip, 1/16 W, 1%, 953 Ω, 0603	Std	Std
0	1	1	R8	Resistor, chip, 1/16 W, 1%, 2.87 kΩ, 0603	Std	Std
1	0	0	R8	Resistor, chip, 1/16 W, 1%, 1.43 kΩ, 0603	Std	Std
2	2	2	R7, R10	Resistor, chip, 1/16 W, 1%, 20 kΩ, 0603	Std	Std
0	0	0	R6	Resistor, chip, 1/16 W, 1%, 0603	Std	Std
1	1	1	R9	Resistor, chip, 1/16 W, 1%, 11.3 kΩ, 0603	Std	Std

Table 5. LMZ3150xEVM-692 List of Materials (continued)

-003	-002	-001	REF DES	DESCRIPTION	PART NUMBER	MFR
4	4	4	TP1, TP3, TP4, TP6	Test point, red, thru hole, 5010, 0.125 inch x 0.125 inch	5010	Keystone
3	3	3	TP2, TP12, TP15	Test point, black, thru hole, 5011, 0.125 inch x 0.125 inch	5011	Keystone
3	3	3	TP5, TP10, TP13	Test point, orange, thru hole, 5013, 0.125 inch x 0.125 inch	5013	Keystone
5	5	5	TP7, TP8, TP9, TP11, TP14	Test point, white, thru hole, 5012, 0.125 inch x 0.125 inch	5012	Keystone
0	0	1	U1	5-V Input, 6-A Sync. Buck, SWIFT Module, QFN	LMZ31506HRUQ	TI
0	1	0	U1	5-V Input, 3-A Sync. Buck, SWIFT Module, QFN	LMZ31503RUQ	TI
1	0	0	U1	5-V Input, 6-A Sync. Buck, SWIFT Module, QFN	LMZ31506RUQ	TI
4	4	4		Bumpon hemisphere 0.44 x 0.20 black	SJ-5003	3M
5	5	5		Shunt, black, 100 mil	929950-00	3M
1	1	1	--	PCB, 3.5 inch x 2.5 inch x 0.062 inch	HPA692	Any

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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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。
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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。http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

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 WRITTEN DESIGN MATERIALS PROVIDED WITH THE EVM (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 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 AND CONDITIONS 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 MADE, CONCEIVED OR ACQUIRED PRIOR TO OR AFTER DELIVERY OF THE EVM.

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 AND CONDITIONS. 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.

8. *Limitations on Damages and Liability:*

   8.1 *General Limitations*. IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS ANDCONDITIONS OR THE USE OF THE EVMS PROVIDED HEREUNDER, REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN ONE YEAR AFTER THE RELATED CAUSE OF ACTION HAS OCCURRED.

   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY WARRANTY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS AND CONDITIONS, OR ANY USE OF ANY TI EVM PROVIDED HEREUNDER, EXCEED THE TOTAL AMOUNT PAID TO TI FOR THE PARTICULAR UNITS SOLD UNDER THESE TERMS AND CONDITIONS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM AGAINST THE PARTICULAR UNITS SOLD TO USER UNDER THESE TERMS AND CONDITIONS SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

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