User's Guide

LM5158EVM-BST Evaluation Module

ABSTRACT

The LM5158EVM-BST evaluation module showcases the features and performance of the LM5158 device as a wide input voltage, non-synchronous boost converter with dual random spread spectrum. The standard configuration is designed to provide regulate a 12V output at 1.2A from an input of 3.3V to 9V (load derated by half from < 6V input), and switching at a frequency of 2.1MHz.

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Trademarks

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1 Features and Electrical Performance

The LM5158EVM-BST supports the following features and performance capabilities:

- Tightly regulated output voltage of 12V with 1% accurate reference voltage
- High conversion efficiency of > 92% at full load
- Constant cycle-by-cycle peak inductor current limit over input voltage range
- Programmable hiccup mode for output overcurrent protection
- User-adjustable soft-start time using C_{SS}
- Output overvoltage protection
- Multiple BIAS pin and VCC pin connections to test multiple configurations
  - BIAS connect to VCC
  - BIAS supplied with external power supply
  - BIAS supplied by output voltage
- Power-good (PGOOD) indicator with selectable pullup source
- 2.1MHz switching frequency
- External clock synchronization
- Programmable dual random spread spectrum reduces the EMI

1.1 Electrical Parameters

Table 1-1. Electrical Performance Standard Configuration

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
INPUT CHARACTERISTICS					
Input voltage range V_{IN}	Operation	3.3	6	9	V
OUTPUT CHARACTERISTICS					
Output voltage V_{OUT}			12		V
Maximum output current I_{OUT}	VIN = 6V~9V		1.2		A
	VIN = 3.3V~6V		0.6		
Output Over-voltage V_{OUT_OV}			13.6		V
SYSTEM CHARACTERISTICS					
Switching frequency			2.1		MHz
External clock synchronization		1.8		2.4	MHz
Full load efficiency	V_{IN} = 6V, I_{OUT} = 1.2A		92.4		%
Junction temperature, T_J		-40		150	C

1.2 Configuration Points

Table 1-2 indicates the available test points and configuration jumpers. These points offer flexibility in configuring the evaluation module and include, but are not limited to:

- The BIAS pin is connected to the following:
  - External supply (VAUX)
  - Input voltage (VIN)
  - Regulated output voltage (VOUT)
  - VCC pin
- The PGOOD pin is supplied by either VCC or VAUX.
- External clock synchronization
- Shutdown signal by pulling the SD pin low
- Four different modes operation to enable and disable the spread spectrum and hiccup mode

Table 1-2. Jumper Description

JUMPER	PIN	DESCRIPTION
TP1	VIN+	Positive input voltage sense connection
TP2	SW	Probe point for the switch node of the LM5158 boost circuit
TP3	VOUT+	Positive output voltage sense connection
TP4	VIN–	Negative input voltage sense connection
TP5	GND	Negative output voltage sense connection
TP6	SYNC	Input for the external clock signal. To implement the external clock synchronization, remove the jumper resistor R10 and tie the external signal to TP6 (SYNC).
TP7	VAUX	Supply the BIAS pin from an external supply.
TP8	VOUT+	Loop response positive injection point
TP9	VOUT–	Loop response negative injection point
TP10	AGND	Negative point for external signals
TP11	SD	High signal pulls the UVLO pin to ground entering shutdown mode
J6	Pin 1 to pin 2	Connect VOUT to the BIAS pin of the LM5158 through D3.
	Pin 2 to pin 3	Directly connect VOUT to the BIAS pin of the LM5158.
J7	Pin 1 to pin 2	Connect VIN to the BIAS pin of the LM5158 through D4.
	Pin 2 to pin 3	Directly connect VIN to BIAS pin of the LM5158.
J8	Pin 1 to pin 2	Directly connect VCC to the BIAS pin.
J9	Pin 1 to pin 2	Directly connect VAUX to the BIAS pin.
J10	Pin 1 to pin 2 (NN)	Hiccup mode disabled, spread spectrum disabled
	Pin 3 to pin 4 (HS)	Hiccup mode enabled, spread spectrum enabled
	Pin 5 to pin 6 (HN)	Hiccup mode enabled, spread spectrum disabled
	Pin 7 to pin 8 (NS)	Hiccup mode disabled, spread spectrum enabled
J11	SS (Pin 1)	Monitor the SS pin.
	COMP (Pin 2)	Monitor the COMP pin.
	AGND (Pin 3)	Connection to AGND plane
	SYNC (Pin 4)	Monitor the EN/UVLO/SYNC pin.
	PGOOD (Pin 5)	Monitor the PGOOD pin.
	BIAS-IC (Pin 6)	Monitor the BIAS pin.
	VCC (Pin 7)	Monitor the VCC pin.
J12	Pin 1	Positive input voltage sense connection
	Pin 2	Negative input voltage sense connection
J13	Pin 1	Positive output voltage sense connection
	Pin 2	Negative output voltage sense connection

2 Application Schematic

The LM5158EVM-BST is capable of multiple configurations. Figure 2-1 shows the standard configuration of the LM5158EVM-BST where the parameters in Table 1-1 are valid. Section 4.2 describes the correct jumper settings and measurement locations recreate the data presented in Section 5.

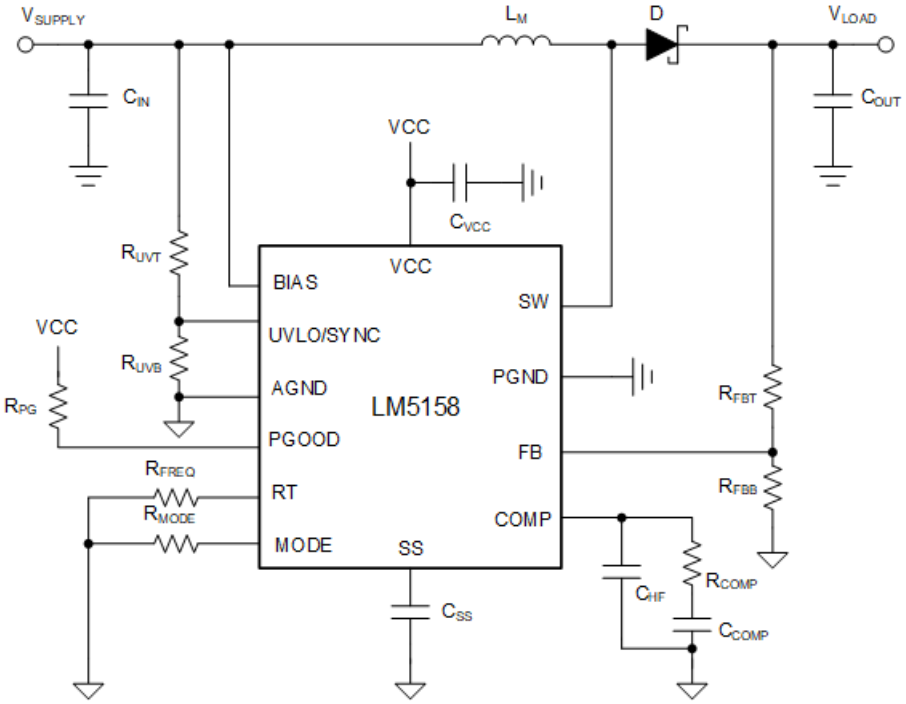

Figure 2-1. Application Circuit

3 EVM Picture

Figure 3-1 shows the 3D-rendered picture of the LM5158EVM-BST. The actual board color can differ.

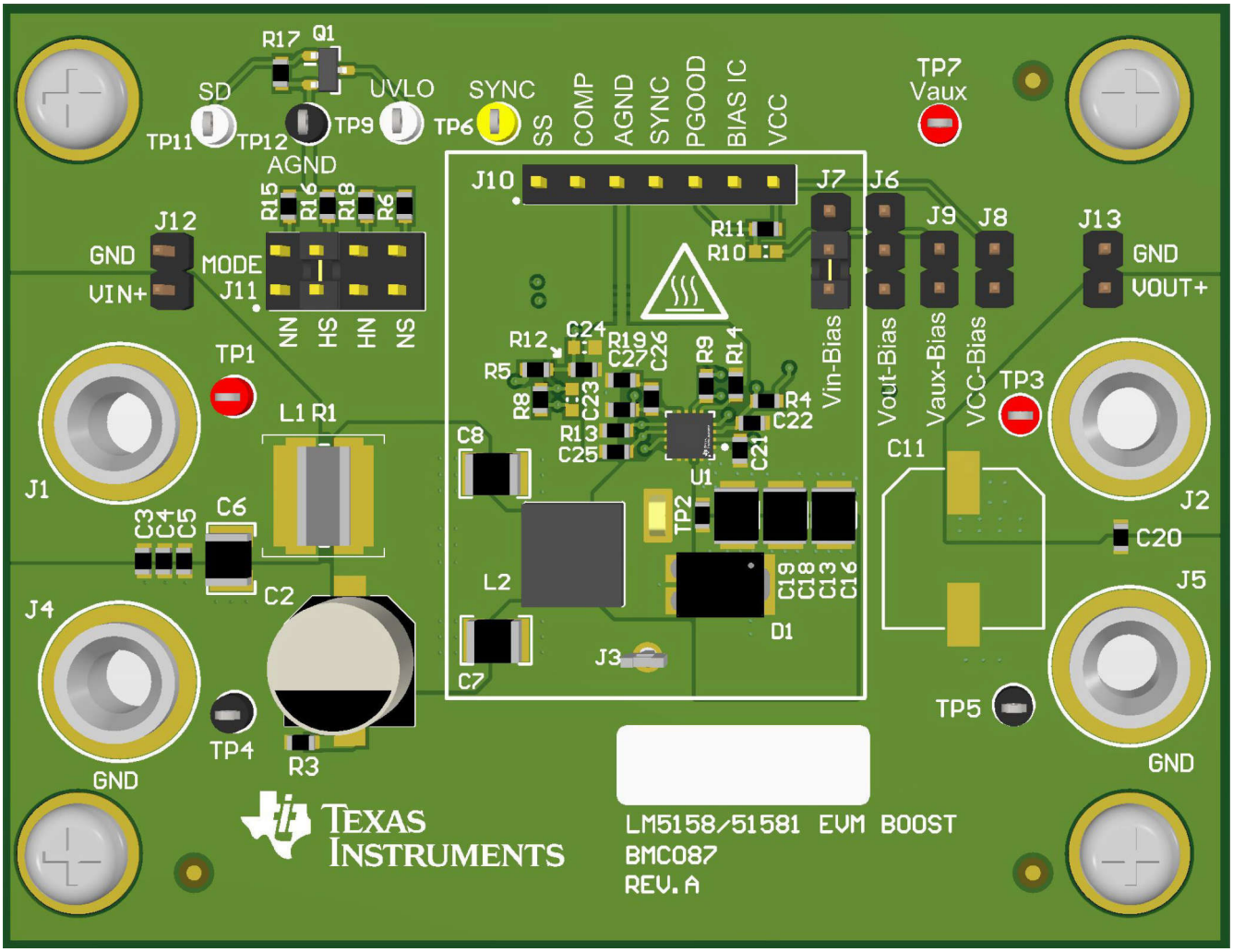

Figure 3-1. EVM Picture

4 Test Setup and Procedure

4.1 Test Setup

Figure 4-1 shows the correct jumper positions to configure the evaluation module for the typical application, as shown in Figure 2-1. The correct equipment connections and measurement points are shown in Table 4-1

Table 4-1. Standard Configuration Jumper Connections

JUMPER	POSITION
J7	Jumper from pin 2 to pin 3
J10	Jumper from pin 3 to pin 4 (HS)

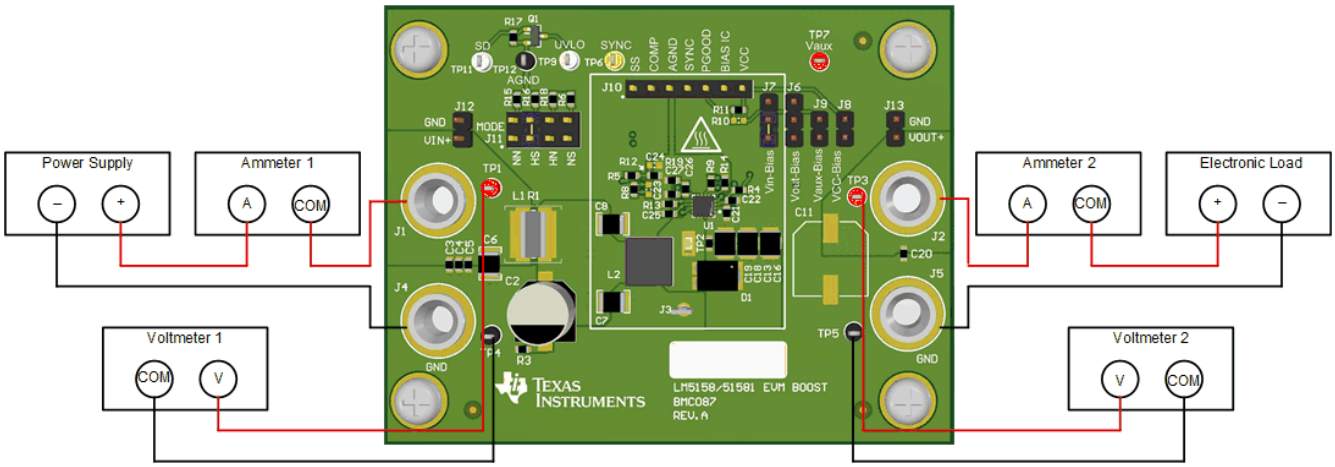

Figure 4-1. Test Setup

4.2 Test Equipment

- **Power Supply**: The input voltage source (VIN) must be a variable supply capable of 0V to 10V and source at least 10A.
- **Multi-meters**:
  - Voltmeter 1: Input voltage. Connect from VIN+ to VIN–.
  - Voltmeter 2: Output voltage. Connect from VOUT+ to GND.
  - Ammeter 1: Input current. Must be able to handle 10A. Shunt resistor can be used as needed.
  - Ammeter 2: Output current. Must be able to handle 2A. Shunt resistor can be used as needed.
- **Electronic Load**: The load is constant resistance (CR) or constant current (CC) capable and safely handles 2A at 12V.
- **Oscilloscope**: 20MHz bandwidth and AC coupling. Measure the output voltage ripple directly across an output capacitor with a short ground lead. TI does not recommend to use a long-leaded ground connection due to the possibility of noise being coupled into the signal. To measure other waveforms, adjust the oscilloscope as needed.

5 Test Results

Figure 5-1 through Figure 5-17 present the typical performance of the LM5158EVM-BST according to the BOM and the configuration described in Section 4. Based on measurement techniques and environmental variables, measurements can differ slightly than the data presented.

5.1 Efficiency Curve

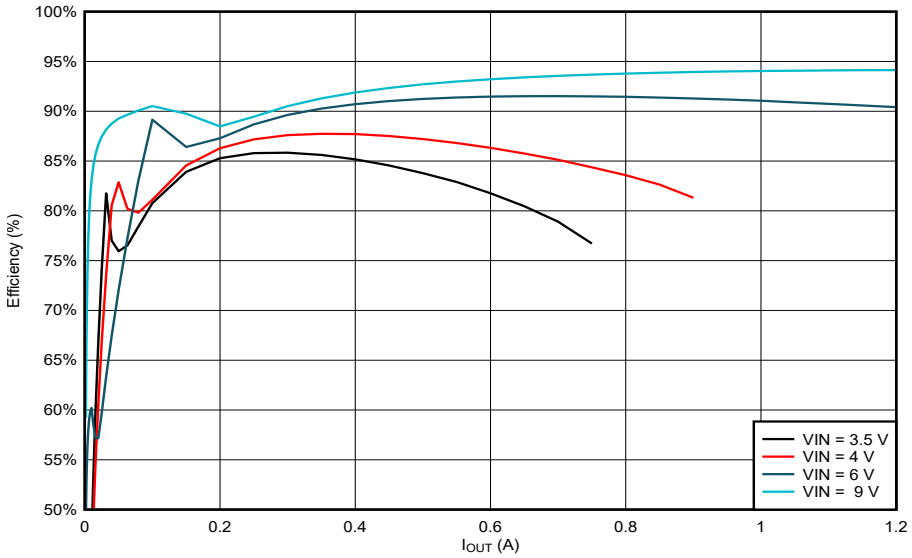

Figure 5-1. Efficiency vs Load

5.2 Load Regulation Curve

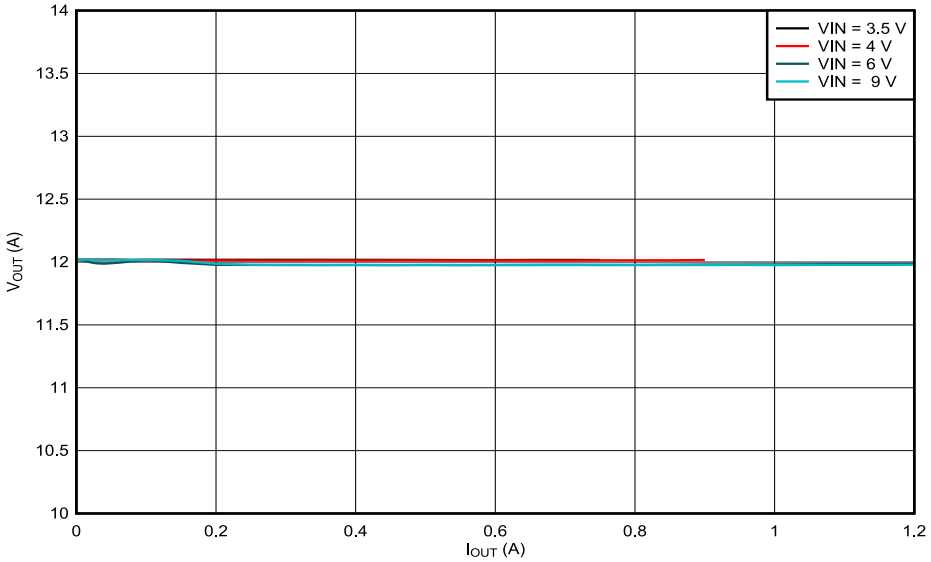

Figure 5-2. Load Regulation

5.3 Thermal Performance

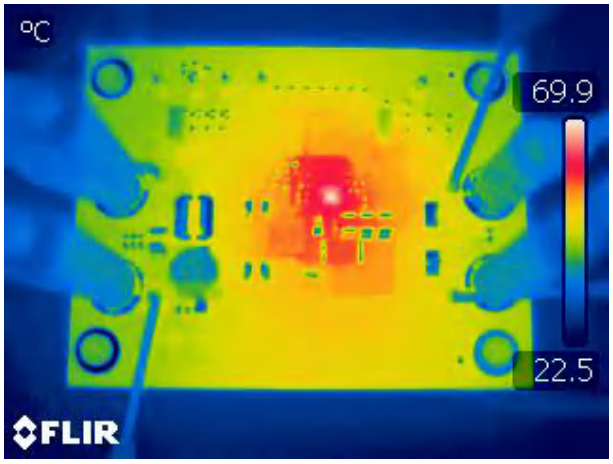

Figure 5-3. Thermal Image: V_{IN} = 3.V, I_{OUT} = 0.6A, V_{BIAS} = 3.3V, No Forced Air Cooling

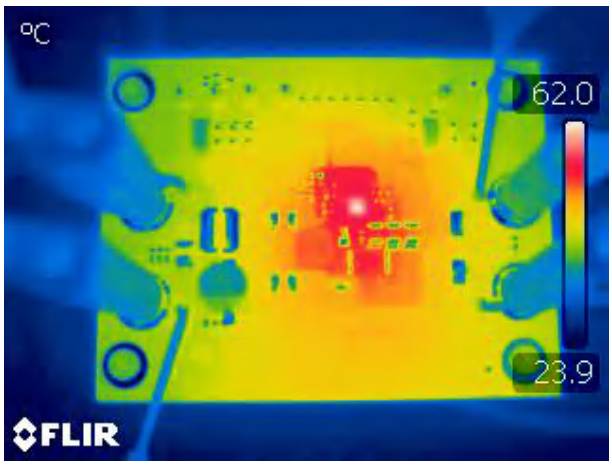

Figure 5-4. Thermal Image: V_{IN} = 3.3V, I_{OUT} = 0.6A, V_{BIAS} = 12V, No Forced Air Cooling

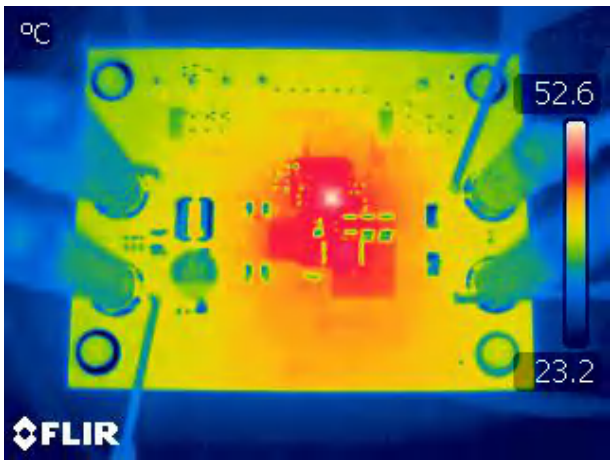

Figure 5-5. Thermal Image: V_{IN} = 6V, I_{OUT} = 1.2A, V_{BIAS} = 6V, No Forced Air Cooling

5.4 Steady State Waveforms

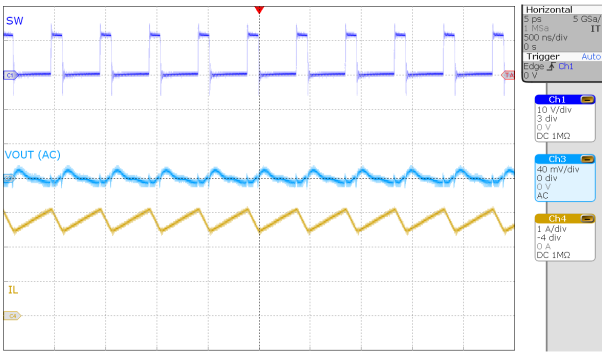

Figure 5-6. Steady State, V_{IN} = 3.3V, I_{OUT} = 0.6A

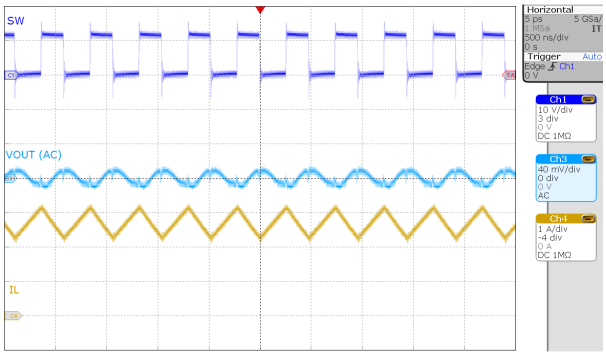

Figure 5-7. Steady State, V_{IN} = 6V, I_{OUT} = 1.2A

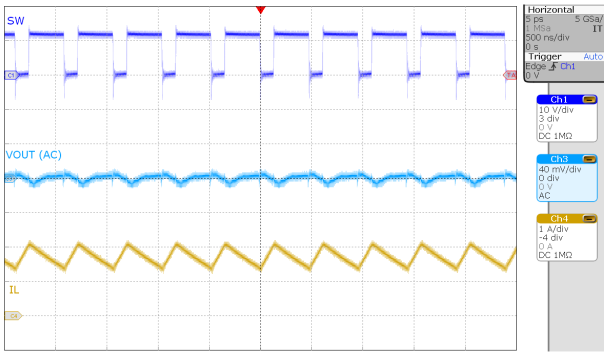

Figure 5-8. Steady State, V_{IN} = 9V, I_{OUT} = 1.2A

5.5 Start-Up Waveforms

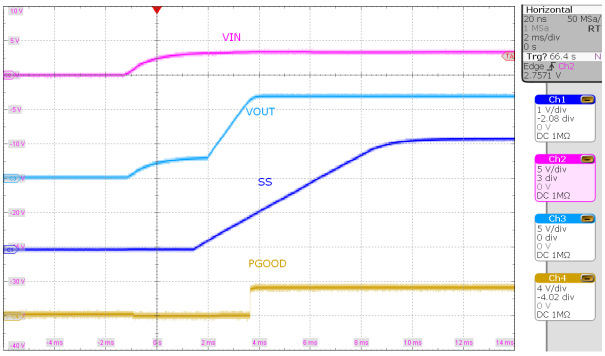

Figure 5-9. Start-Up, V_{IN} = 3.3V, I_{OUT} = 0.6A

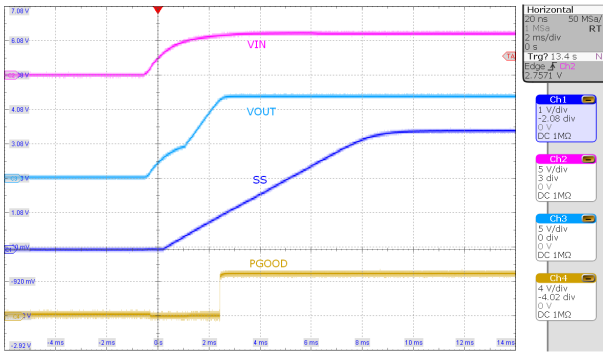

Figure 5-10. Start-Up, V_{IN} = 6V, I_{OUT} = 1.2A

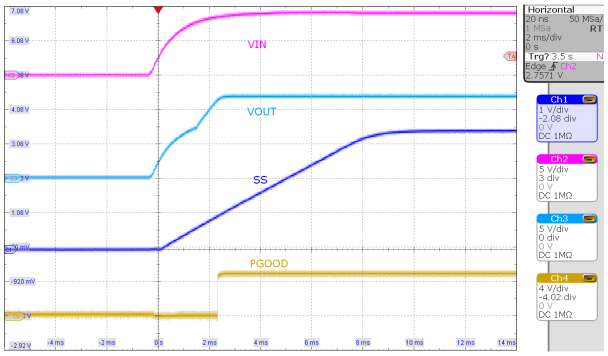

Figure 5-11. Start-Up, V_{IN} = 9V, I_{OUT} = 1.2A

5.6 Load Transient Waveforms

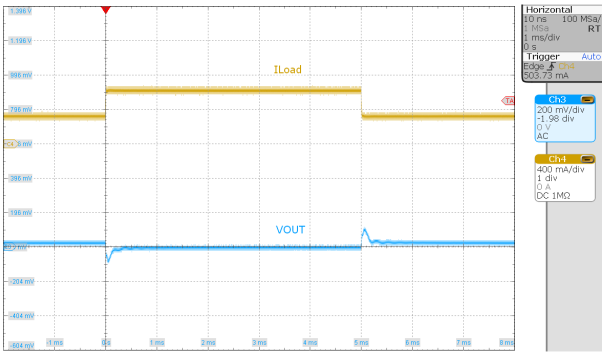

Figure 5-12. Load Transient, V_{IN} = 3.3V, I_{OUT} = 0.4A to 0.8A

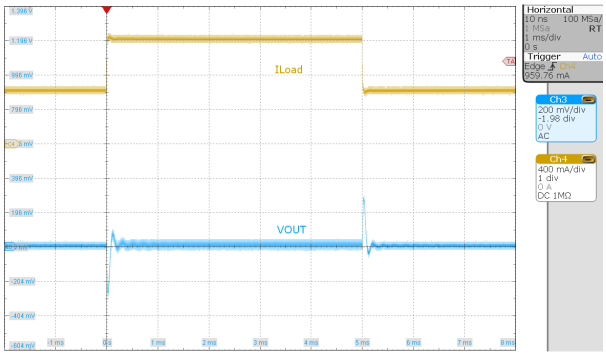

Figure 5-13. Load Transient, V_{IN} = 6V, I_{OUT} = 0.6A to 1.2A

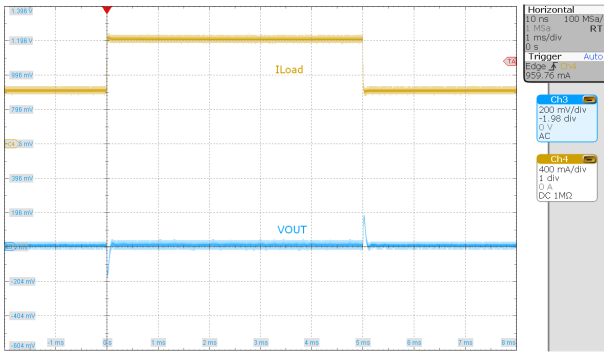

Figure 5-14. Load Transient, V_{IN} = 9V, I_{OUT} = 0.6A to 1.2A

5.7 AC Loop Response Curves

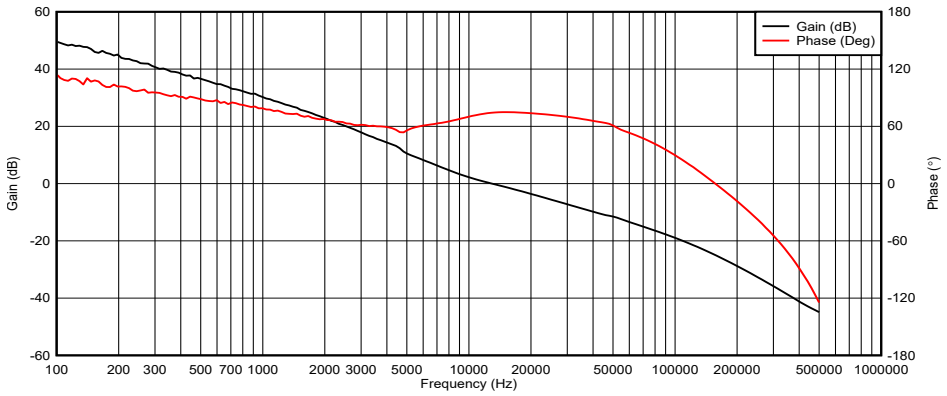

Figure 5-15. Control Loop Response, V_{IN} = 3.3V, I_{OUT} = 0.6A

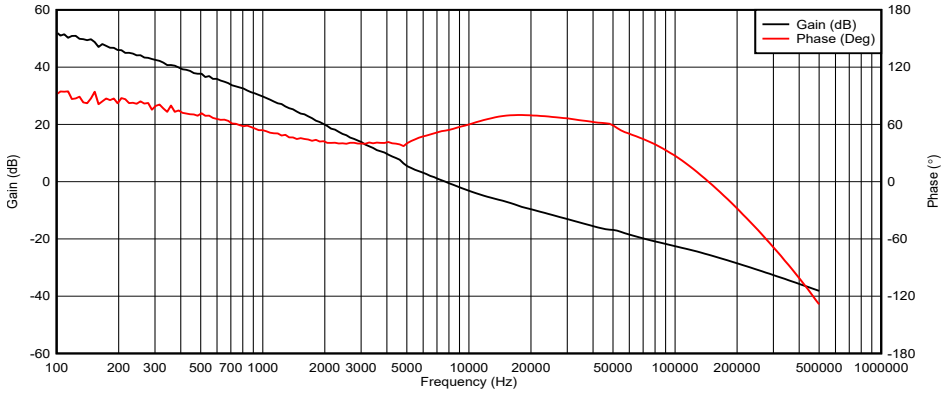

Figure 5-16. Control Loop Response, V_{IN} = 6V, I_{OUT} = 0.6A

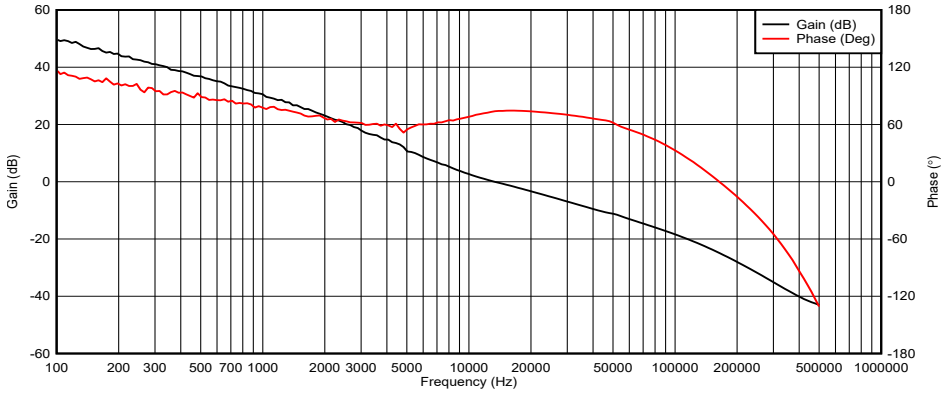

Figure 5-17. Control Loop Response, V_{IN} = 9V, I_{OUT} = 1.2A

6 Design Files

Figure 6-1 through Figure 6-6 illustrate the EVM PCB layout images.

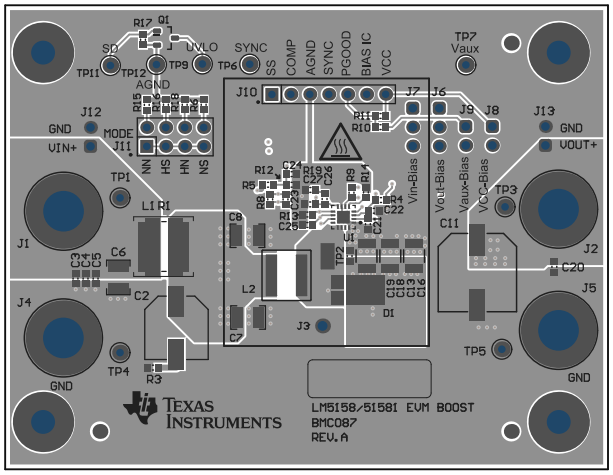

Figure 6-1. Top Layer and Silkscreen

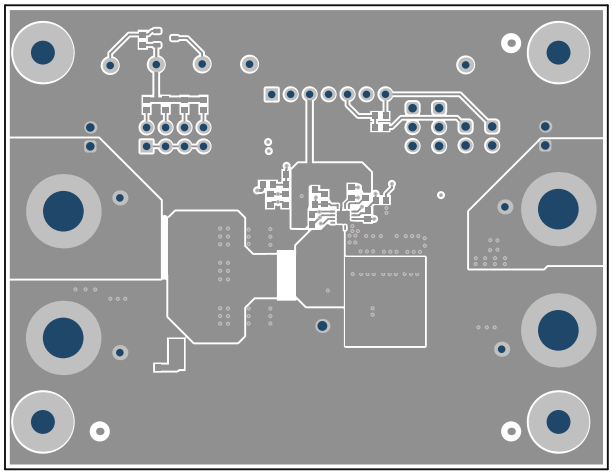

Figure 6-2. Top Layer

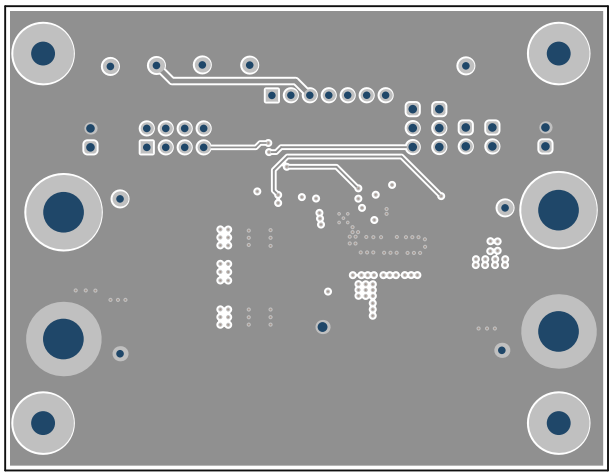

Figure 6-3. Signal Layer 1

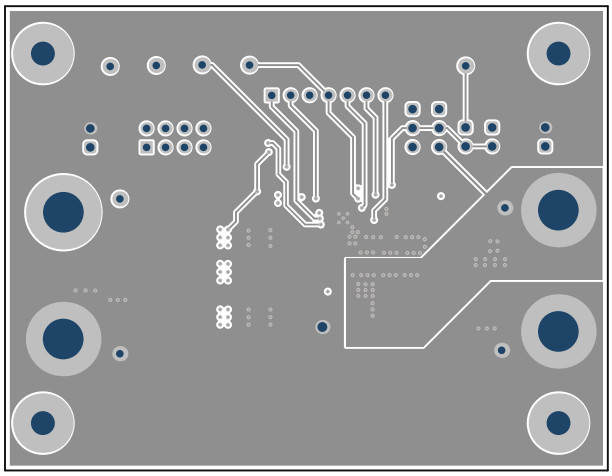

Figure 6-4. Signal Layer 2

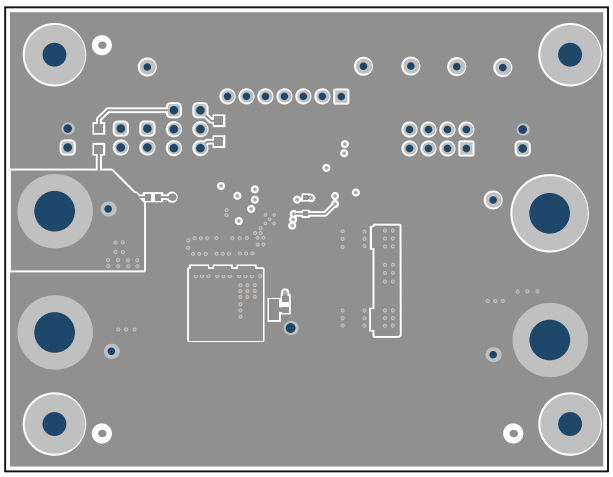

Figure 6-5. Bottom Layer

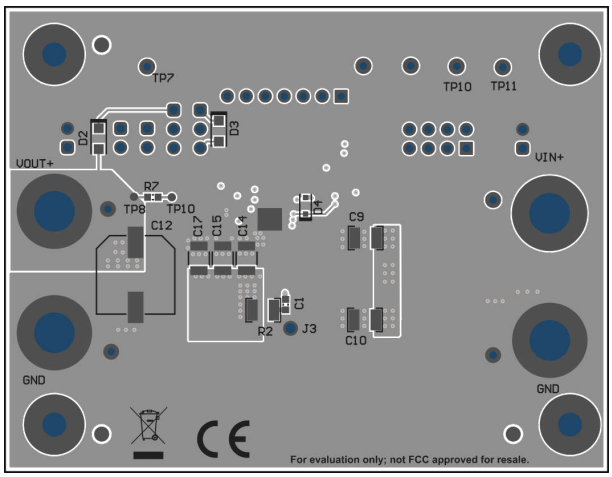

Figure 6-6. Bottom Layer and Silkscreen

6.1 Schematic

Figure 6-7 shows the EVM schematic.

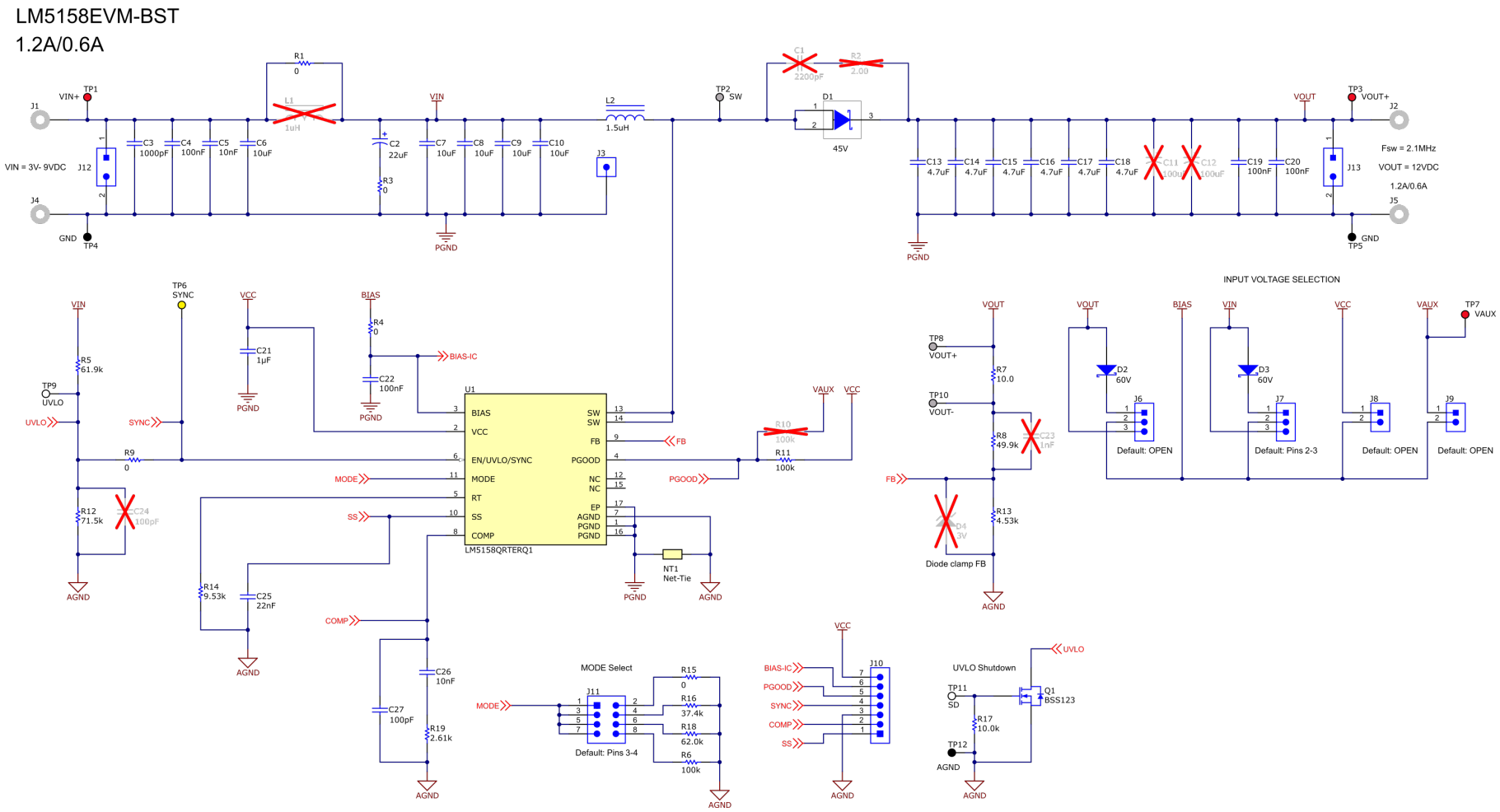

Figure 6-7. LM5158EVM-BST Schematic

6.2 Bill of Materials

LM5158EVM-BST Bill of Materials lists the EVM bill of materials.

Table 6-1. LM5158EVM-BST Bill of Materials

Designator	Quantity	Value	Description	Part Number	Manufacturer
C2	1	22uF	CAP, AL, 22uF, 100V, +/- 20%, 1.3 ohm, AEC-Q200 Grade 2, SMD	EEE-FK2A220P	Panasonic
C3	1	1000pF	CAP, CERM, 1000pF, 50V, +/- 10%, X7R, 0603	C0603X102K5RACTU	Kemet
C4, C19, C20	3	0.1uF	CAP, CERM, 0.1µF, 50V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	C0603C104K5RACAUTO	Kemet
C5, C26	2	0.01uF	CAP, CERM, 0.01uF, 50V, +/- 10%, X7R, 0603	C0603X103K5RACTU	Kemet
C6, C7, C8, C9, C10	5	10uF	CAP, CERM, 10uF, 50V, +/- 10%, X7R, 1210	GRM32ER71H106KA12L	MuRata
C13, C14, C15, C16, C17, C18	6	4.7uF	CAP, CERM, 4.7uF, 50V, +/- 10%, X7R, AEC-Q200 Grade 1, 1210	CGA6P3X7R1H475K250AB	TDK
C21	1	1uF	CAP, CERM, 1µF, 16V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	CGA3E1X7R1C105K080AC	TDK
C22	1	0.1uF	CAP, CERM, 0.1uF, 100V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	GCJ188R72A104KA01D	MuRata
C25	1	0.022uF	CAP, CERM, 0.022uF, 50V, +/- 10%, X7R, 0603	C0603X223K5RACTU	Kemet
C27	1	100pF	CAP, CERM, 100pF, 50V, +/- 5%, C0G/NP0, AEC-Q200 Grade 0, 0603	CGA3E2NP01H101J080AA	TDK
D1	1	45V	Diode, Schottky, 45V, 10A, AEC-Q101, CFP15	PMEG045V100EPDAZ	Nexperia
D2, D3	2	60V	Diode, Schottky, 60V, 1A, SOD-123F	PMEG6010CEH,115	Nexperia
H1, H2, H3, H4	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	NY PMS 440 0025 PH	B&F Fastener Supply
H5, H6, H7, H8	4		Standoff, Hex, 0.5"L #4-40 Nylon	1902C	Keystone
J1, J2, J4, J5	4		Standard Banana Jack, Uninsulated, 8.9mm	575-8	Keystone
J3	1		TEST POINT SLOTTED .118", TH	1040	Keystone
J6, J7	2		Header, 2.54mm, 3x1, Gold, TH	61300311121	Wurth Elektronik
J8, J9, J12, J13	4		Header, 2.54mm, 2x1, Gold, TH	61300211121	Wurth Elektronik
J10	1		Header, 100mil, 7x1, Gold, TH	TSW-107-07-G-S	Samtec
J11	1		Header, 100mil, 4x2, Gold, TH	TSW-104-07-G-D	Samtec

Table 6-1. LM5158EVM-BST Bill of Materials (continued)

Designator	Quantity	Value	Description	Part Number	Manufacturer
L2	1	1.5uH	Inductor, Shielded, Composite, 1.5uH, 14A, 0.01052 ohm, AEC-Q200 Grade 1, SMD	XEL6030-152MEB	Coilcraft
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	THT-14-423-10	Brady
Q1	1	100V	MOSFET, N-CH, 100V, 0.17A, SOT-23	BSS123	Fairchild Semiconductor
R1	1	0	RES, 0, 5%, 2 W, 2512 WIDE	RCL12250000Z0EG	Vishay Draloric
R3, R4, R9, R15	4	0	RES, 0, 5%, 0.1 W, 0603	RC0603JR-070RL	Yageo
R5	1	61.9k	RES, 61.9 k, 1%, 0.1 W, 0603	RC0603FR-0761K9L	Yageo
R6, R11	2	100k	RES, 100 k, 1%, 0.1 W, 0603	RC0603FR-07100KL	Yageo
R7	1	10	RES, 10.0, 1%, 0.1 W, 0603	RC0603FR-0710RL	Yageo
R8	1	49.9k	RES, 49.9 k, 1%, 0.1 W, 0603	RC0603FR-0749K9L	Yageo
R12	1	71.5k	RES, 71.5 k, 1%, 0.1 W, 0603	RC0603FR-0771K5L	Yageo
R13	1	4.53k	RES, 4.53 k, 1%, 0.1 W, 0603	RC0603FR-074K53L	Yageo
R14	1	9.53k	RES, 9.53 k, 1%, 0.1 W, 0603	RC0603FR-079K53L	Yageo
R16	1	37.4k	RES, 37.4 k, 1%, 0.1 W, 0603	RC0603FR-0737K4L	Yageo
R17	1	10.0k	RES, 10.0 k, 1%, 0.1 W, 0603	RC0603FR-0710KL	Yageo
R18	1	62.0k	RES, 62.0 k, 1%, 0.1 W, 0603	RC0603FR-0762KL	Yageo
R19	1	2.61k	RES, 2.61 k, 1%, 0.1 W, 0603	RC0603FR-072K61L	Yageo
SH-JP1, SH-JP2	2		Single Operation 2.54mm Pitch Open Top Jumper Socket	M7582-05	Harwin
TP1, TP3, TP7	3		Test Point, Miniature, Red, TH	5000	Keystone
TP4, TP5, TP12	3		Test Point, Miniature, Black, TH	5001	Keystone
TP6	1		Test Point, Miniature, Yellow, TH	5004	Keystone
TP9, TP11	2		Test Point, Miniature, White, TH	5002	Keystone
U1	1		2.2MHz Wide VIN 85V Boost/Sepic/Flyback Converter with Dual Random Spread Spectrum	LM5158QRTERQ1	Texas Instruments
C1	0	2200pF	CAP, CERM, 2200pF, 100V, +/- 10%, X7R, 0603	GRM188R72A222KA01D	MuRata
C11, C12	0	100uF	CAP, Polymer Hybrid, 100uF, 50V,+/- 20%, 0.028 ohm, AEC-Q200 Grade 1, D10xL10.2mm SMD	EEH-ZC1H101P	Panasonic

Table 6-1. LM5158EVM-BST Bill of Materials (continued)

Designator	Quantity	Value	Description	Part Number	Manufacturer
C23	0	0.068uF	CAP, CERM, 0.068 uF, 50V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	CGA3E2X7R1H683K080AA	TDK
C24	0	100pF	CAP, CERM, 100pF, 50V,+/- 1%, C0G/NP0, 0603	C0603C101F5GACTU	Kemet
D4	0	3V	Diode, Zener, 3V, 200mW, SOD-323	MMSZ5225BS-7-F	Diodes Inc.
L1	0	1uH	Inductor, Shielded, Composite, 1uH, 21.8A, 0.00455 ohm, SMD	XAL7030-102MEB	Coilcraft
R2	0	2	RES, 2.00, 1%, 0.5 W, AEC-Q200 Grade 0, 1210	ERJ-14BQF2R0U	Panasonic
R10	0	100k	RES, 100 k, 1%, 0.1 W, 0603	RC0603FR-07100KL	Yageo

7 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision * (October 2021) to Revision A (February 2024)	Page
• Updated *Bill of Materials* table	15

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

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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.

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8. *Limitations on Damages and Liability:*

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   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM 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.

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