User's Guide

LM5157 SEPIC Evaluation Module

ABSTRACT

The LM5157EVM-SEPIC Evaluation Module (EVM) is designed to showcase the LM5157 wide input voltage converter, implementing a SEPIC converter with a coupled inductor. The EVM operates at 2.1 MHz, and it produces a regulated output of 12 V, 12 W from an input of 4 V to 32 V. When the input voltage is between 4 V to 6 V, the output power is derated down to 6 W. The factory-installed converter is the LM5157-Q1. However, by replacing the IC, the EVM can also be used to demonstrate the performance of the LM51571-Q1, LM5157, LM51571, LM51581-Q1, LM5158-Q1, LM51581, and LM5158. The difference between the LM5157-Q1 and LM51571-Q1, or between the LM5157 and LM51571, is that the latter has a lower switch current limit for applications with less output current need.

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Trademarks

1 Features and Electrical Performance

The LM5157EVM-SEPIC supports the following features and performance capabilities:

- Wide input voltage range from 4 V to 32 V, to cover typical automotive battery voltage ranges
- Tightly regulated output voltage of 12 V with a 1% accurate reference voltage
- Supports 1 A full load when V_{IN} is greater than 6 V
- Supports 0.5 A load current when V_{IN} drops to 4 V
- 2.1 MHz switching frequency
- Peak efficiency > 88 %
- Can be used to evaluate LM51571-Q1, LM5157-Q1, and LM51571 ICs, by replacing the factory installed IC with the corresponding IC
- Selection capability for several BIAS connections

The electrical performance of the EVM is show in Table 1-1. The EVM terminals and signal test points are listed in Table 1-2. The typical application circuit is shown in Figure 2-1. The EVM complete schematic is shown in Figure 6-1.

1.1 Electrical Parameters

Refer to the LM5157 data sheet for the full range of recommended operating specifications and design guidelines. Section 1.1 provides a summary of the tested LM5157EVM-SEPIC performance specifications.

Table 1-1. Electrical Performance

Parameter	Test Conditions	MIN	TYP	MAX	UNIT
INPUT CHARACTERISTICS					
Input voltage Range V_{IN}	Normal operation, 1 A full load	6	12	32	V
	Power derating from 1 A down to 0.5 A	4		6	V
Input voltage turn on $V_{IN(ON)}$	Adjusted by the UVLO/SYNC resistors		3.9		V
Input voltage turn off $V_{IN(OFF)}$			3.7		V
OUTPUT CHARACTERISTICS					
Output Voltage V_{OUT}			12		V
Maximum Output Current I_{OUT}	V_{IN} > 6 V	1			A
	4 V < V_{IN} < 6 V	0.5		1	A
SYSTEM CHARACTERISTICS					
Switching Frequency			2.1		MHz
Full Load Efficiency	V_{IN} = 12 V, I_{OUT} = 1 A		92		%
Ambient Temperature, T_A		-40		125	°C

1.2 EVM Power Derating Curve

The LM5157EVM-SEPIC is designed to support a full load of 1 A when the input voltage is higher than 6 V. When the input voltage is below 6 V, the output power needs to be derated, owing to the peak current limitation of the selected inductor on the EVM. Figure 1-1 shows the power derating curve.

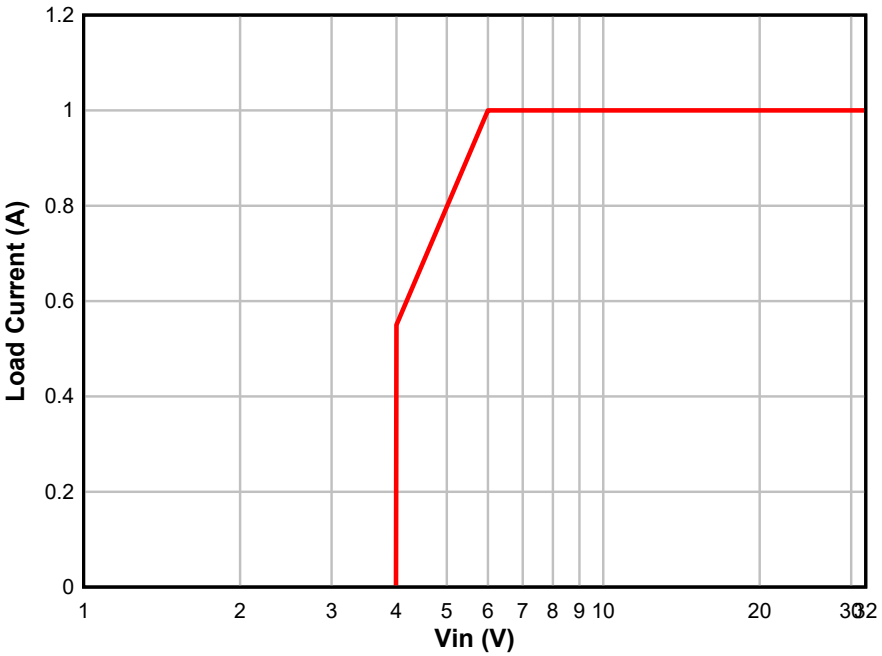

Figure 1-1. Power Derating vs. Input Voltage

1.3 Terminals and Signal Test Points

Table 1-2 summarizes the EVM terminals and signal test points.

Table 1-2. EVM Terminals and Signal Test Points

Terminal	SIGNAL	PINS	FUNCTION DESCRIPTION
J1	VIN+		Input Connector
J2	VOUT+		Output Connector
J3	GND		Input Return Connector
J4	PGND		PGND Signal
J5	GND		Output Return Connector
J6	VOUT	Pin 1 to 2	Connect VOUT to BIAS pin of the LM5157 through D2
		Pin 2 to 3	Directly connect VOUT to BIAS pin of the LM5157
J7	VIN	Pin 1 to 2	Connect VIN to BIAS pin of the LM5157 through D3
		Pin 2 to 3	Directly connect VIN to BIAS pin of the LM5157
J8	VCC	Pin 1 to 2	Directly connect VCC to BIAS pin of the LM5157
J9	VAUX	Pin 1 to 2	Connect VAUX to BIAS
J10	MODE	Pin 1 to 2	MODE pin connected to AGND. Hiccup mode protection is disabled and spread spectrum is disabled
		Pin 3 to 4	MODE pin connected to AGND with 34.4 kOhm. Hiccup mode protection is enabled and spread spectrum is enabled
		Pin 5 to 6	MODE pin connected to AGND with 62.0 kOhm. Hiccup mode protection is enabled and spread spectrum is disabled
		Pin 7 to 8	MODE pin connected to AGND with 100 kOhm. Hiccup mode protection is disabled and spread spectrum is enabled
J11	SS	Pin 1	IC SS Pin Signal
	COMP	Pin 2	IC COMP Pin Signal
	AGND	Pin 3	IC AGND Pin Signal
	UVLO	Pin 4	IC UVLO Pin Signal and External Enable Control
	PGOOD	Pin 5	IC PGOOD Pin Signal
	BIAS-IC	Pin 6	IC BIAS Pin Signal
	VCC	Pin 7	IC VCC Pin Signal
TP1	VIN+		Input Voltage Sense Point
TP2	VOUT+		Output Voltage Sense Point
TP3	PGND		Input Return Sense Point
TP4	PGND		Output Return Sense Point
TP5	VOUT+		Positive terminal for AC injection
TP6	SW		Switch node
TP7	VOUT-		Negative terminal for AC injection
TP8	VAUX		Auxiliary winding
TP9	GND		Ground signal for AUX voltage

2 Application Schematic

Figure 2-1 shows a typical LM5157 SEPIC schematic employing a coupled inductor. Note that the same schematic is applicable to the LM51571, LM5157-Q1, and LM51571-Q1. Refer to Figure 6-1 for the complete EVM schematic.

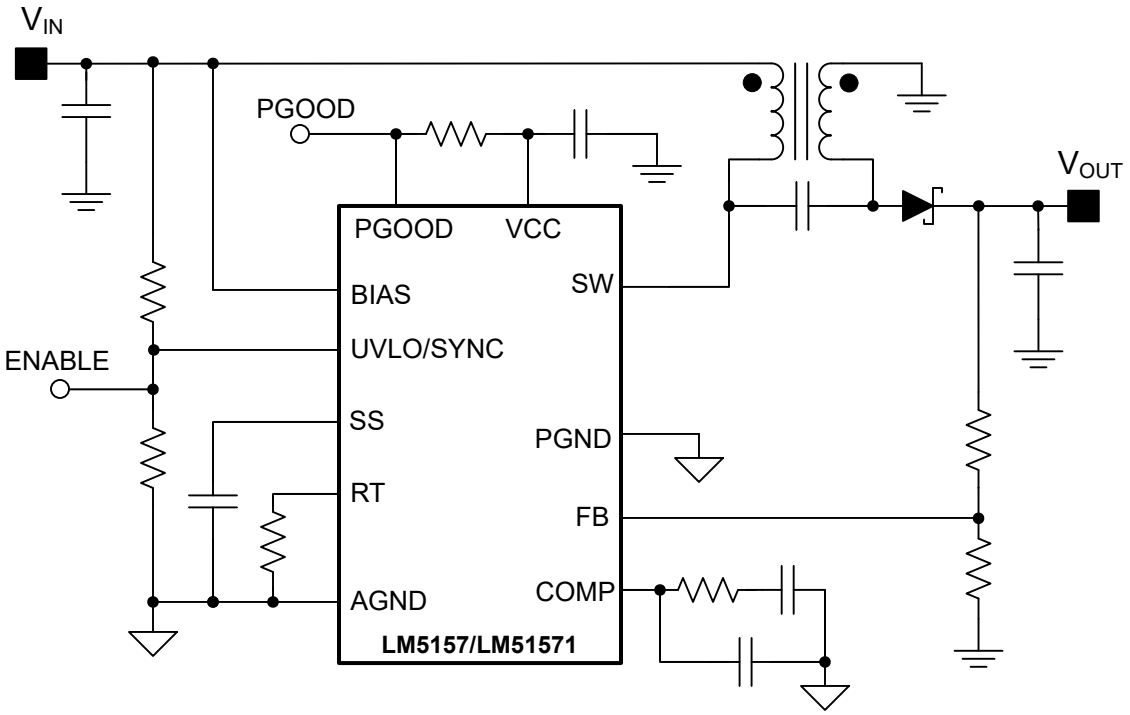

Figure 2-1. Typical SEPIC Schematic Employing the LM5157/LM51571 and Coupled Inductor

3 EVM Picture

Figure 3-1 shows a 3D-rendered picture of the LM5157EVM-SEPIC. The actual board color may differ.

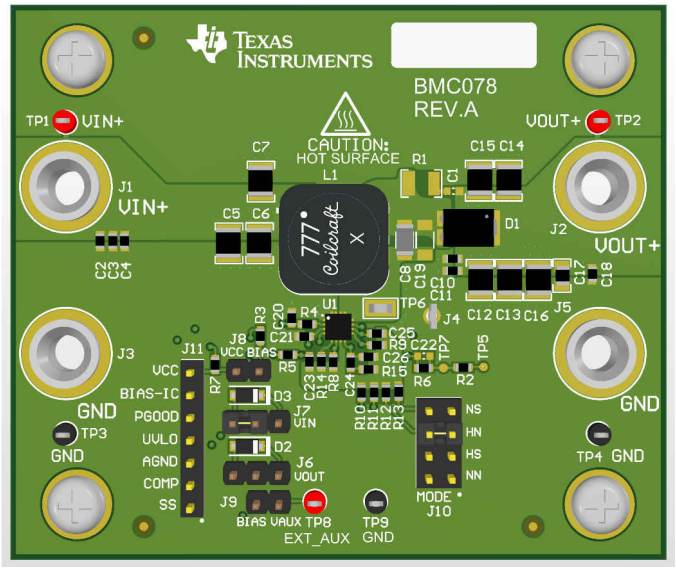

Figure 3-1. LM5157EVM-SEPIC 3D-Rendered Picture

4 Test Setup and Procedure

4.1 Bench Setup

Figure 4-1 shows the bench setup. The Load can be an electronic load or a resistor load.

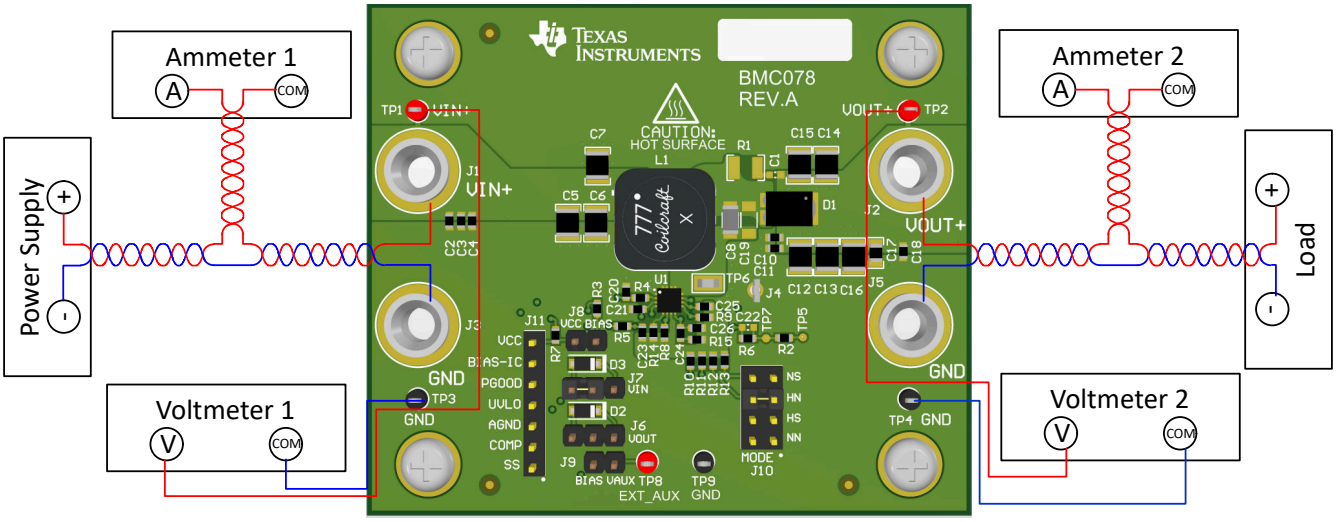

Figure 4-1. Test Setup

4.2 Test Equipment

Power Supply: The input voltage source (VIN) should be an adjustable power supply capable of 0 V to 32 V and source at least 10 A.

Electronic Loads: The E-Load should be capable of at least 20 V and 5 A.

Multimeters:

- Voltmeter 1: Input voltage, connect from VIN to GND
- Voltmeter 2: Output voltage, connect from VOUT to GND
- Ammeter 1: Input current, must be able to handle 10 A. A shunt resistor can be used as needed.
- Ammeter 2: Output current, must be able to handle 5 A. A shunt resistor can be used as needed.

Oscilloscope: An oscilloscope and 10× probes with at least 20-MHz bandwidth is required. Measure the output voltage ripple directly across an output capacitor with a short ground lead. Do not use a long-lead ground connection due to the possibility of noise being coupled into the signal. To measure other waveforms, adjust the oscilloscope as needed.

Input and Output Cables: Cables capable of conducting 10 A current are recommended. Avoid the use of overly-long cables. Cable impedance, especially the inductances, may affect the circuit operation. To minimize the cable impedance effects, *twist the pair of cables* at both input and output ports.

4.3 Precautions

CAUTION

Prolonged operation with low input at full power will cause heating of the MOSFET (Q1).
Board surface is hot. Do not touch. Contact may cause burns.

5 Test Data

Figure 5-1 through Figure 5-12 show the typical performance of the LM5157EVM-SEPIC according to the Bill of Materials and the configuration described in Section 6. Based on measurement techniques and environmental variables, measurements might differ slightly from the data presented.

5.1 Efficiency

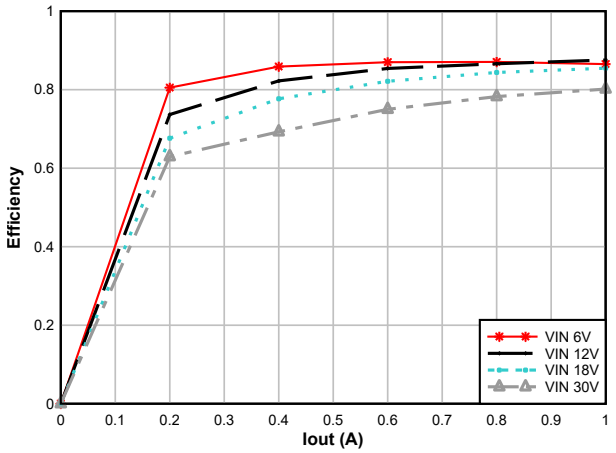

Figure 5-1. Efficiency vs. Load under Normal V_{IN}, F_{SW} = 2.1 MHz

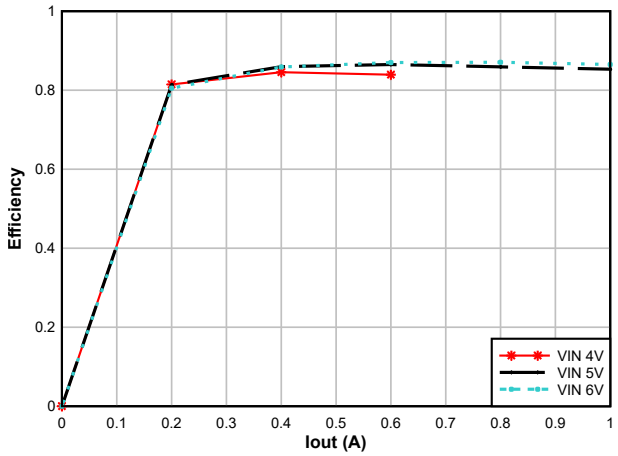

Figure 5-2. Efficiency vs. Load under Low V_{IN}, F_{SW} = 2.1 MHz

5.2 Output Regulation

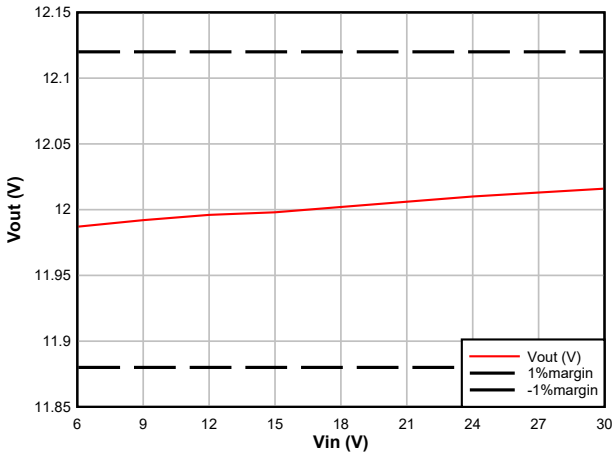

Figure 5-3. Output Regulation vs Input Voltage, I_{OUT} = 1 A

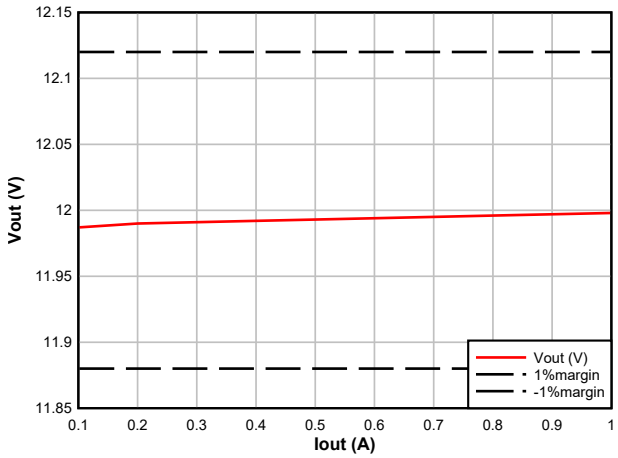

Figure 5-4. Output Regulation vs Load, v_{IN} = 12 V

5.3 Thermal Performance

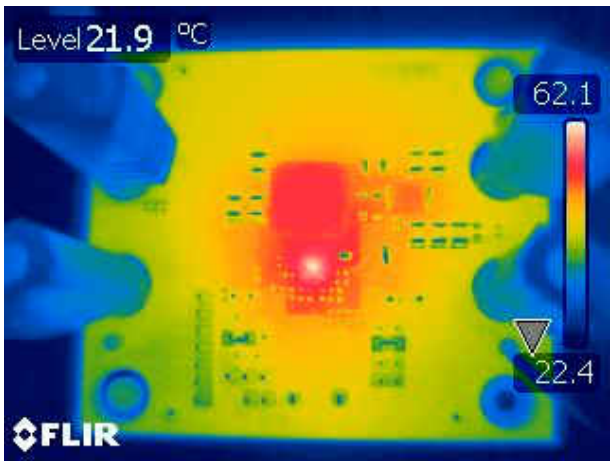

Figure 5-5. Thermal Image: V_{IN} = 6 V, I_{OUT} = 1 A, V_{BIAS} = 6 V, No Forced Air Cooling

5.4 Typical Power Up

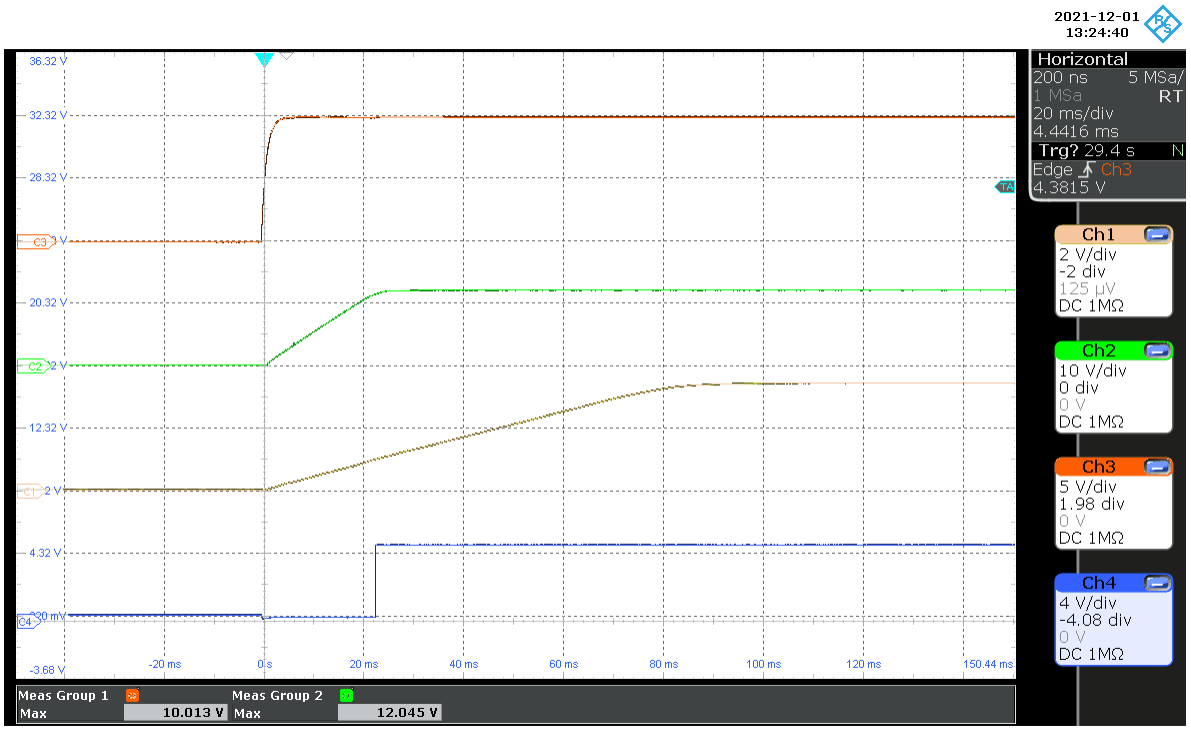

Figure 5-6. EVM Power Up under I_{OUT} = 1 A.

Channel 1 (yellow) : SS pin

Channel 2 (green) : Vout

Channel 3 (orange) : Vin

Channel 4 (blue) : PGOOD pin

5.5 Output Ripple Voltage

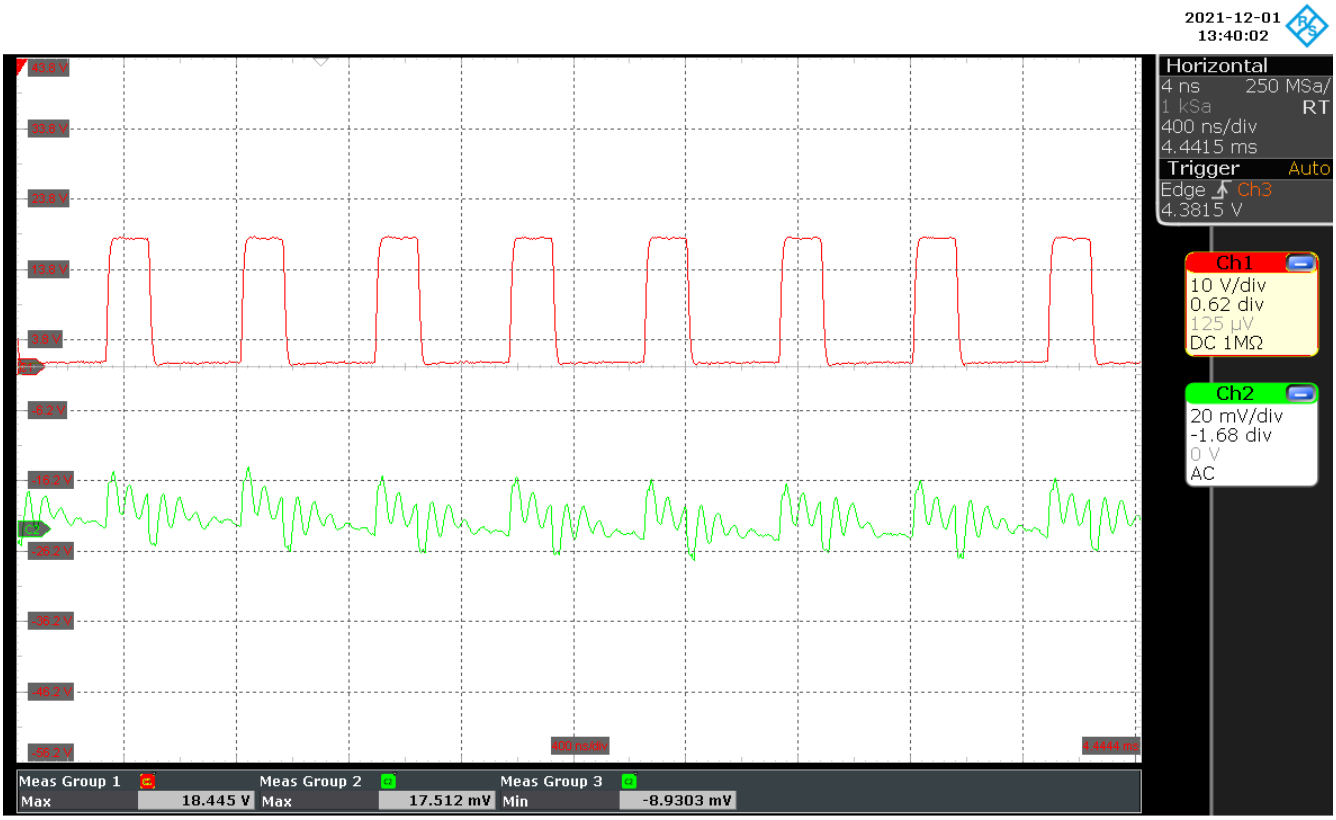

Figure 5-7. Output Ripple Voltage under V_{IN} = 6 V and I_{OUT} = 1 A

Channel 1 (yellow) : switch node

Channel 2 (green) : Vout

Figure 5-8. Output Ripple Voltage under V_{IN} = 18 V and I_{OUT} = 1 A

Channel 1 (yellow) : switch node

Channel 2 (green) : Vout

5.6 Step Load Response

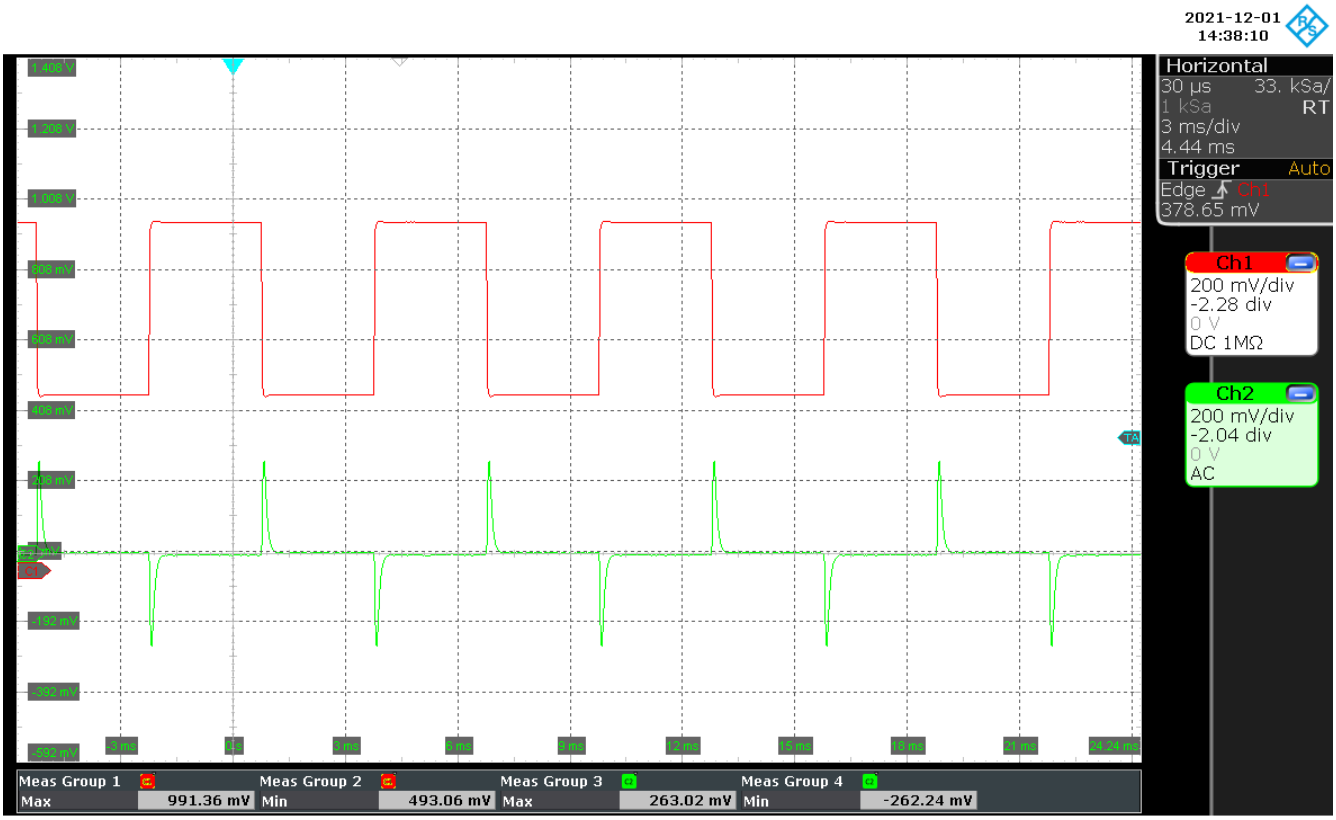

Figure 5-9. Step Load Response under V_{IN} = 6 V, I_{OUT} = 0.5 to 1 A Step

Channel 1 (yellow) : Iout

Channel 2 (green) : Vout

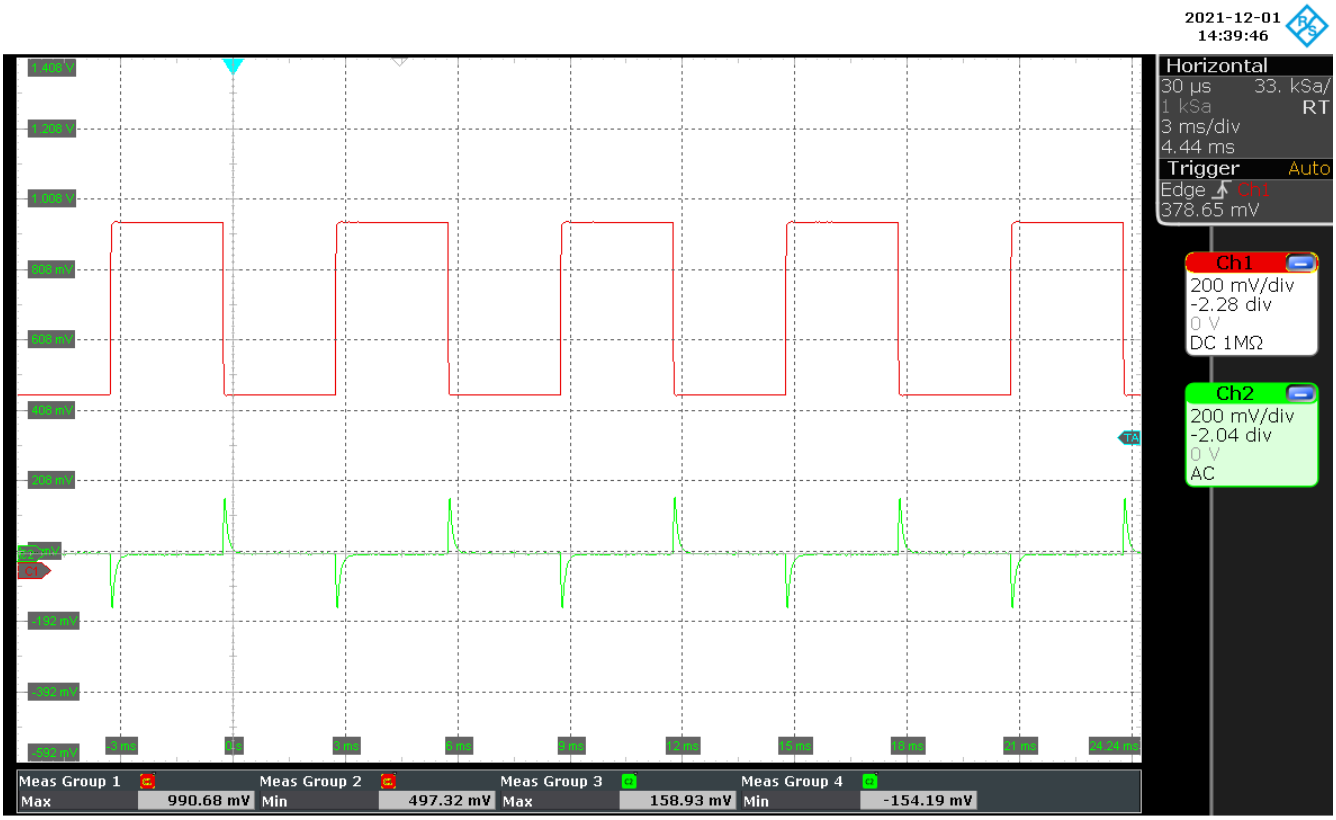

Figure 5-10. Step Load Response under V_{IN} = 12 V, I_{OUT} = 0.5 to 1 A Step

Channel 1 (yellow) : Iout

Channel 2 (green) : Vout

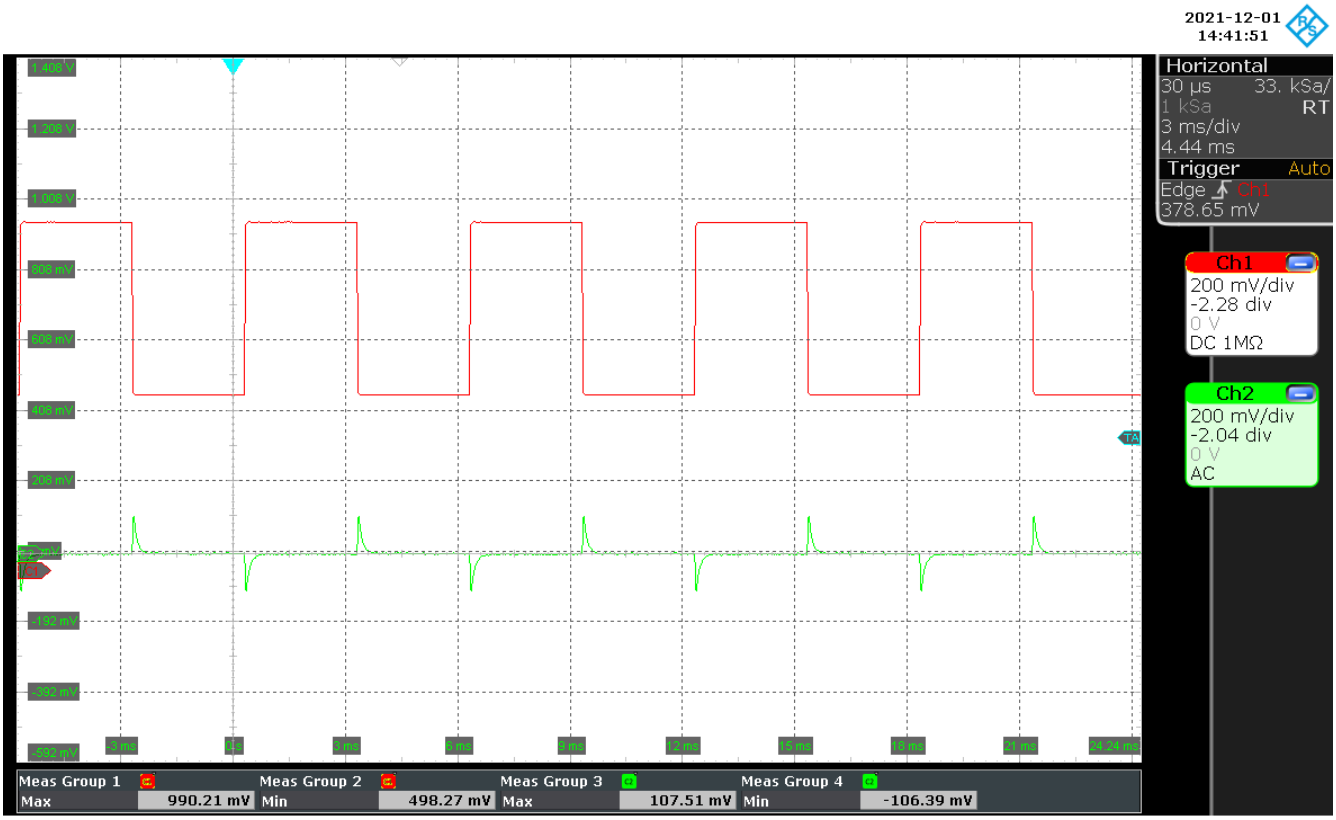

Figure 5-11. Step Load Response under V_{IN} = 30 V, I_{OUT} = 0.5 to 1 A Step

Channel 1 (yellow) : Iout

Channel 2 (green) : Vout

5.7 Bode Plots

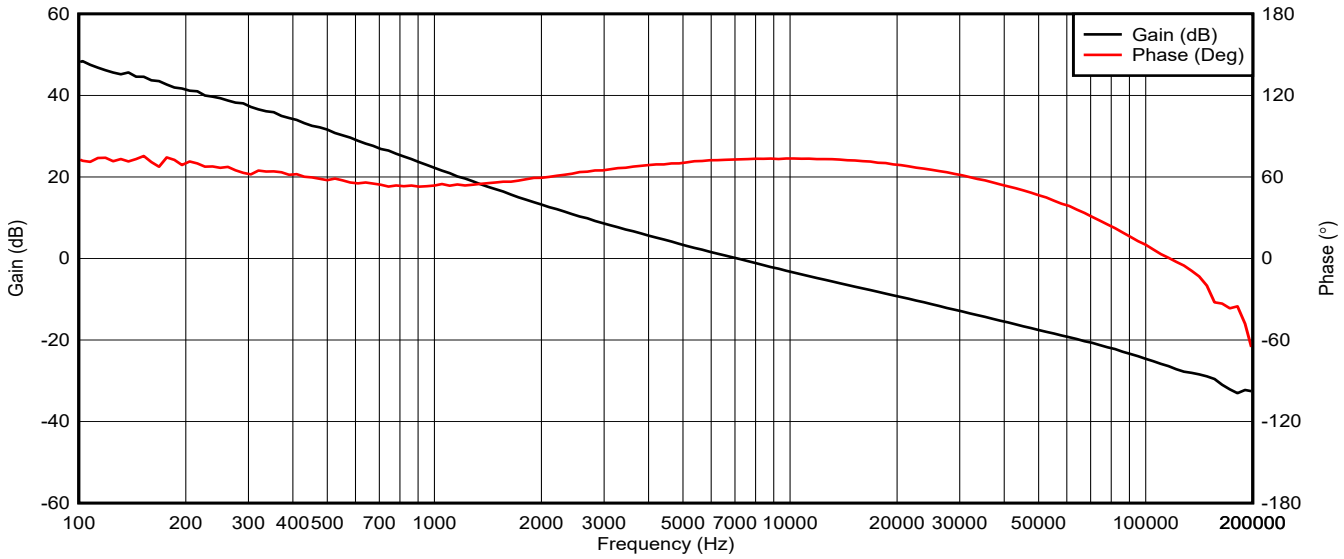

Figure 5-12. EVM Bode Plots, Vin = 12 V, Vout = 12V, Iout = 1 A

6 Schematics

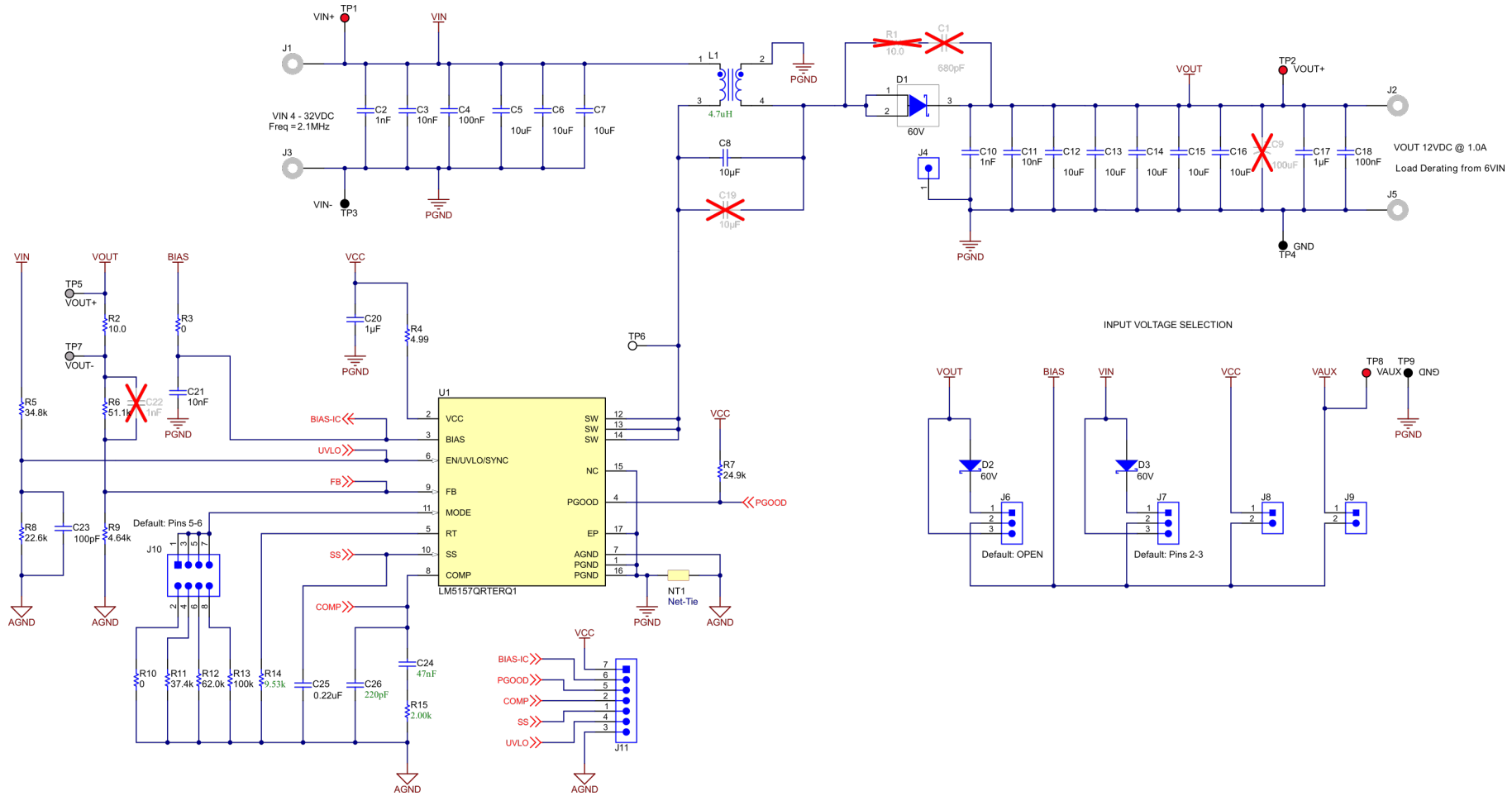

Figure 6-1. EVM Schematic

7 Bill of Materials

Table 7-1. LM5157EVM-SEPIC Bill of Materials

Designator	Quantity	Description	PartNumber	Manufacturer
PCB	1	Printed Circuit Board	BMC078	Any
C2, C10	2	CAP, CERM, 1000 pF, 50 V, +/- 10%, X7R, 0603	C0603X102K5RACTU	Kemet
C3, C11, C21	3	CAP, CERM, 0.01 uF, 50 V, +/- 10%, X7R, 0603	C0603X103K5RACTU	Kemet
C4, C18	2	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0603	C1608X7R1H104K080AA	TDK
C5, C6, C7, C12, C13, C14, C15, C16	8	CAP, CERM, 10 uF, 50 V, +/- 10%, X7R, 1210	GRM32ER71H106KA12L	MuRata
C8	1	CAP, CERM, 10 µF, 50 V,+/- 10%, X7R, AEC-Q200 Grade 1, 1206	CGA5L1X7R1H106K160AC	TDK
C17	1	CAP, CERM, 1 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805	CGA4J3X7R1H105K125AB	TDK
C20	1	CAP, CERM, 1 µF, 16 V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	CGA3E1X7R1C105K080AC	TDK
C23	1	CAP, CERM, 100 pF, 50 V, +/- 5%, C0G/NP0, 0603	C0603C101J5GACTU	Kemet
C24	1	CAP, CERM, 0.047 uF, 50 V, +/- 10%, X5R, 0603	C1608X5R1H473K080AA	TDK
C25	1	CAP, CERM, 0.22 uF, 25 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	GCM188R71E224KA55D	MuRata
C26	1	CAP, CERM, 220 pF, 50 V, +/- 5%, C0G/NP0, 0603	C0603C221J5GACTU	Kemet
D1	1	Diode, Schottky, 60 V, 10 A, AEC-Q101, CFP15	PMEG060V100EPDZ	Nexperia
D2, D3	2	Diode, Schottky, 60 V, 1 A, 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, J3, J5	4	Standard Banana Jack, Uninsulated, 8.9mm	575-8	Keystone
J4	1	TEST POINT SLOTTED .118", TH	1040	Keystone
J6, J7	2	Header, 2.54 mm, 3x1, Gold, TH	61300311121	Wurth Elektronik
J8, J9	2	Header, 2.54 mm, 2x1, Gold, TH	61300211121	Wurth Elektronik
J10	1	Header, 100mil, 4x2, Gold, TH	TSW-104-07-G-D	Samtec
J11	1	Header, 100mil, 7x1, Gold, TH	TSW-107-07-G-S	Samtec
L1	1	Coupled inductor, 4.7 uH, 10.3 A, 0.036 ohm, TH	MSD1260-472ML	Coilcraft
LBL1	1	Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	THT-14-423-10	Brady
R2	1	RES, 10.0, 1%, 0.1 W, 0603	RC0603FR-0710RL	Yageo
R3, R10	2	RES, 0, 5%, 0.1 W, 0603	RC0603JR-070RL	Yageo
R4	1	RES, 4.99, 1%, 0.1 W, 0603	RC0603FR-074R99L	Yageo

Table 7-1. LM5157EVM-SEPIC Bill of Materials (continued)

Designator	Quantity	Description	PartNumber	Manufacturer
R5	1	RES, 34.8 k, 1%, 0.1 W, 0603	RC0603FR-0734K8L	Yageo
R6	1	RES, 51.1 k, 1%, 0.1 W, 0603	RC0603FR-0751K1L	Yageo
R7	1	RES, 24.9 k, 1%, 0.1 W, 0603	RC0603FR-0724K9L	Yageo
R8	1	RES, 22.6 k, 1%, 0.1 W, 0603	RC0603FR-0722K6L	Yageo
R9	1	RES, 4.64 k, 1%, 0.1 W, 0603	RC0603FR-074K64L	Yageo
R11	1	RES, 37.4 k, 1%, 0.1 W, 0603	RC0603FR-0737K4L	Yageo
R12	1	RES, 62.0 k, 1%, 0.1 W, 0603	RC0603FR-0762KL	Yageo
R13	1	RES, 100 k, 1%, 0.1 W, 0603	RC0603FR-07100KL	Yageo
R14	1	RES, 9.53 k, 1%, 0.1 W, 0603	RC0603FR-079K53L	Yageo
R15	1	RES, 2.00 k, 0.01%, 0.15 W, 0603	PLTU0603U2001LST5	Vishay-Dale
SH-JP1, SH-JP2	2	Single Operation 2.54mm Pitch Open Top Jumper Socket	M7582-05	Harwin
TP1, TP2, TP8	3	Test Point, Miniature, Red, TH	5000	Keystone
TP3, TP4, TP9	3	Test Point, Miniature, Black, TH	5001	Keystone
TP6	1	Test Point, Miniature, SMT	5015	Keystone
U1	1	2.2MHz Wide VIN Boost/Sepic/Flyback Converter with Dual Random Spread Spectrum, RTE0016K (WQFN-16)	LM5157QRTERQ1	Texas Instruments
C1	0	CAP, CERM, 680 pF, 50 V, +/- 5%, C0G/NP0, 0603	C0603C681J5GACTU	Kemet
C9	0	CAP, Polymer Hybrid, 100 uF, 50 V,+/- 20%, 0.028 ohm, AEC-Q200 Grade 1, D10xL10.2mm SMD	EEH-ZC1H101P	Panasonic
C19	0	CAP, CERM, 10 µF, 50 V,+/- 10%, X7R, AEC-Q200 Grade 1, 1206	CGA5L1X7R1H106K160AC	TDK
C22	0	CAP, CERM, 0.068 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	CGA3E2X7R1H683K080AA	TDK
FID1, FID2, FID3, FID4, FID5, FID6	0	Fiducial mark. There is nothing to buy or mount.	N/A	N/A
R1	0	RES, 10.0, 1%, 0.75 W, AEC-Q200 Grade 0, 1210	CRCW121010R0FKEAHP	Vishay-Dale

8 Board Layout

The EVM PC Board consists of two copper layers, and the board includes various headers for flexible configurations suitable for different applications. Figure 8-1 through Figure 8-4 show the EVM PCB artwork.

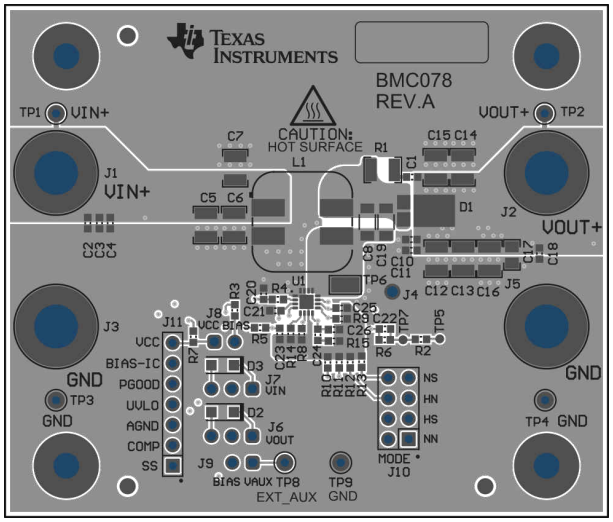

Figure 8-1. EVM Top Layer Silkscreen (view from top)

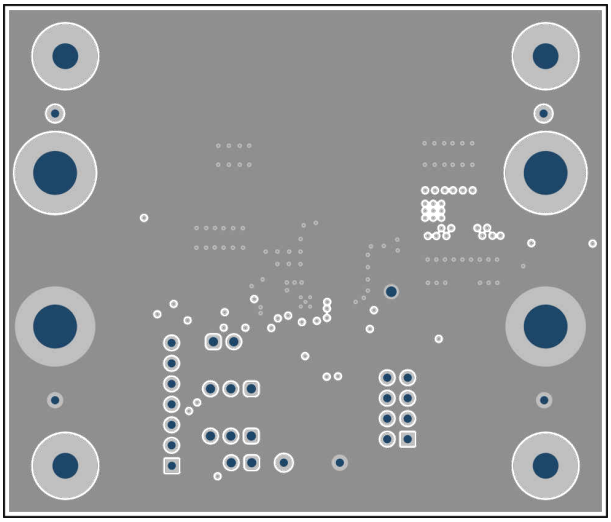

Figure 8-2. EVM Middle Layer 1 (view from top)

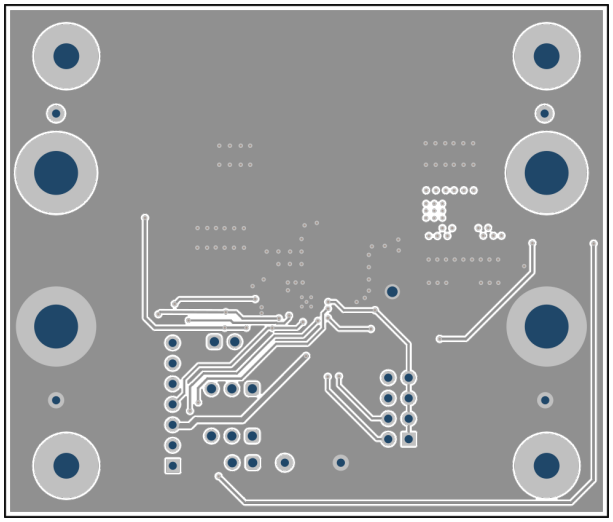

Figure 8-3. EVM Middle Layer 2 (view from top)

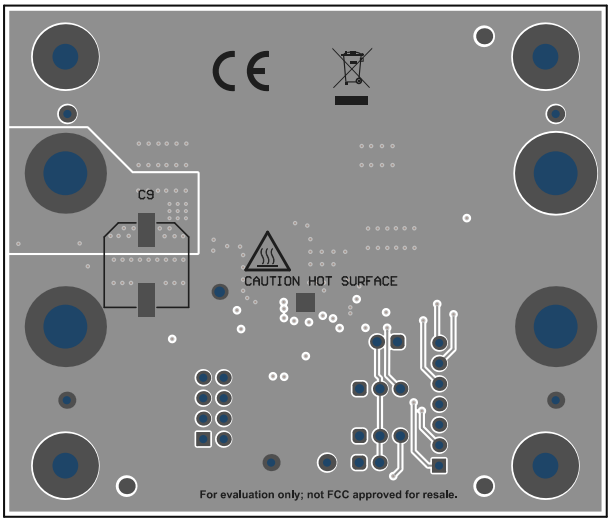

Figure 8-4. EVM Bottom Layer Silkscreen (view from bottom)

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