TPS57160EVM User's Guide

1 Introduction

1.1 Background

The TPS57160EVM evaluation module (EVM) is optimized to meet the Class 5 level of the CISPR25 EMC Standard for automotive components. See the emissions report, SLVA629. As listed in Table 1, the EVM requires an input voltage between 9 V and 16 V and provides an output voltage of 5 V at 1 A. The layout has been designed to reduce emissions to levels deemed acceptable by the aforementioned standard. The EVM features the TPS57160-Q1 step-down DC-DC converter which is a wide input voltage (3.5 V to 60 V) 1.5-A capable power device.

Along with the EMC optimization, this evaluation module also demonstrates the small printed-circuit-board (PCB) areas that can be achieved when designing with the TPS57160-Q1 regulator. The switching frequency is externally set at a nominal 2 MHz. The compensation components are external to the integrated circuit (IC) and have been selected to optimize the transient performance of the device. An external divider allows for an adjustable output voltage. Additionally, the TPS57160-Q1 device provides adjustable slow start and undervoltage lockout through a resistor divider on the EN pin.

Table 1. Input and Output Summary

EVM	INPUT VOLTAGE RANGE	OUTPUT RANGE
TPS57160EVM	VIN = 9 V to 16 V	5 V at currents up to 1 A

1.2 Performance Specification Summary

Table 2 lists a summary of the TPS57160EVM performance specifications. Specifications are given for an input voltage of V_I = 12 V and an output voltage of V_O = 5 V, unless otherwise specified. The TPS57160EVM is designed and tested for V_I = 9 V to 16 V. The ambient temperature is 25°C for all measurements, unless otherwise noted.

Table 2. TPS57160EVM Performance Specification Summary

SPECIFICATION	TEST CONDITION	MIN	TYP	MAX	UNIT
VIN operating voltage range		9	12	16	V
VIN start voltage			6.45		V
VIN stop voltage			5.41		V
Output voltage set point			5		V
Output current range	V_I = 9 V to 16 V	0		1	A
Output ripple voltage	I_O = 1 A		10		mV_{PP}
Operating frequency			2000		kHz

1.3 Modifications

This evaluation module is designed to provide access to the features of the TPS57160-Q1 device. Some modifications can be made to the module.

1.3.1 Output Voltage Set Point

The voltage dividers R7 and R8 are used to set the output voltage. To change the output voltage of the EVM, change the value of the resistor, R8. Changing the value of R8 can change the output voltage above Vsense which is 0.8 V. Use Equation 1 to calculate the value of R8 for a specific output voltage.

$$R8 = \frac{R7}{\frac{V_O}{V_{(VSENSE)}} - 1} \quad (1)$$

1.3.2 Slow-Start Time

The slow-start time can be adjusted by changing the value of C5. Use Equation 2 to calculate the required value of C5 for a desired slow-start time.

$$C5 = \frac{T_{(SS)}\ (ms) \times I_{(SS)}\ (\mu A)}{V_{ref}\ (V) \times 0.8} \quad (2)$$

where

- $I_{(SS)}$ is 2 µA
- C5 is set to 0.015 µF on the EVM for a default slow-start time of 7.82 ms.

NOTE: The slow-start capacitor should remain lower than 0.47 µF and higher than 0.47 nF.

1.3.3 Adjustable Undervoltage Lockout

The undervoltage lockout (UVLO) can be adjusted externally using R3 and R4. The EVM is set for a start voltage of 6.45 V and a stop voltage of 5.41 V using R3 = 348 kΩ and R4 = 78.7 kΩ. Use Equation 3 and Equation 4 along with notes included in the TPS57160-Q1 datasheet (SLVSAP1) to calculate required resistor values for different start and stop voltages.

$$R3 = \frac{V_{(start)} - V_{(stop)}}{2.9 \times 10^{-6}\ A} \quad (3)$$

$$R4 = \frac{1.25\ V}{\frac{V_{(start)} - V_{(stop)}}{R3} + 0.9 \times 10^{-6}\ A} \quad (4)$$

2 Test Setup and Results

This section describes how to properly connect, set up, and use the TPS57160EVM evaluation module. The section also includes the measured output voltage ripple of the EVM.

2.1 Input/Output Connections

The TPS57160EVM is provided with input connectors, output connectors, and test points as shown in Table 3. A power supply capable of supplying 1 A must be connected to J1 through a pair of 20 AWG (0.52 mm^2) or larger wires. The load must be connected to J2 through a pair of 20 AWG (0.52 mm^2) or larger wires. The maximum load-current capability must be at least 1 A to use the full capability of this EVM. Wire lengths must be minimized to reduce losses in the wires.

Table 3. EVM Connectors and Test Points

Reference Designator	Function
J1	V_I (see Table 1 for V_I range)
J2	V_O, 5 V at 1 A maximum
TP1	GND Test Points
TP2	
TP3	
TP4	

2.2 Output Voltage Ripple

Figure 1 shows the TPS57160EVM output voltage ripple. The output current is the rated full load current of 1 A and V_I = 12 V. The ripple voltage is measured directly across the output capacitor.

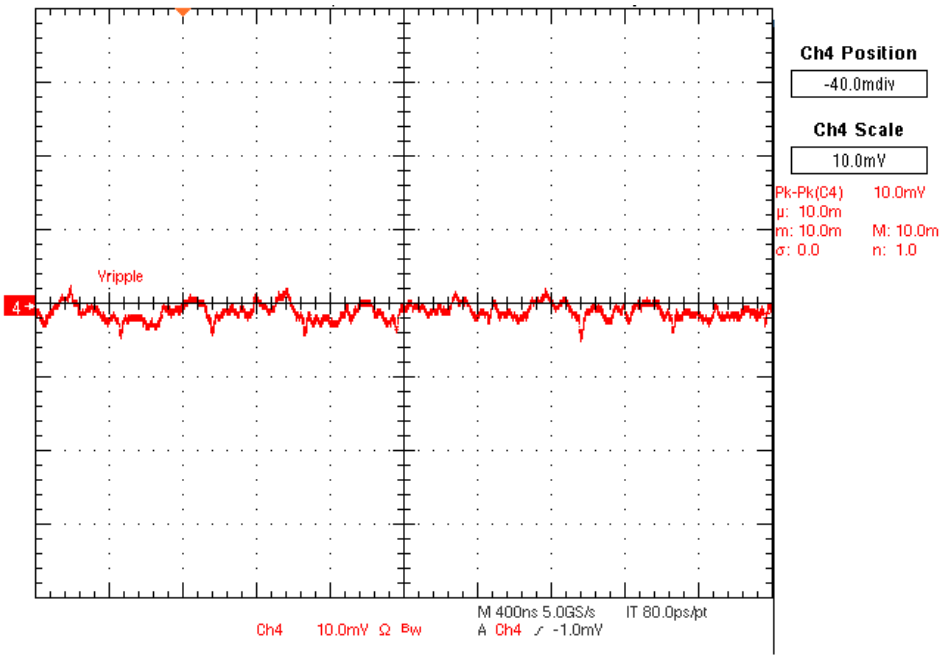

Figure 1. TPS57160EVM Output Ripple

3 Board Layout

This section provides a description of the TPS57160EVM board layout and includes the layer figures.

3.1 Layout

Figure 2, Figure 3, Figure 4, Figure 5, Figure 5, and Figure 7 show the board layout for the TPS57160EVM.

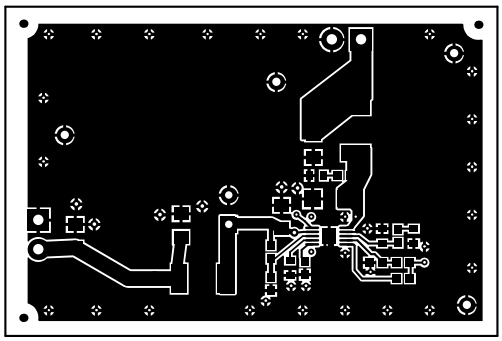

Figure 2. Top Layer

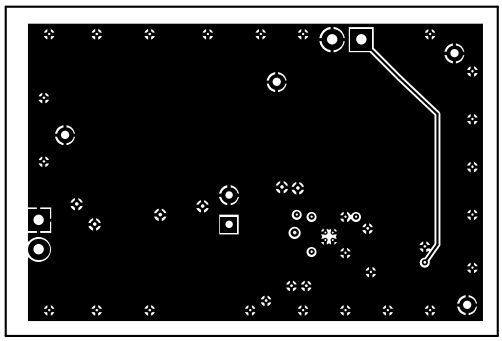

Figure 3. Inner Layer 1

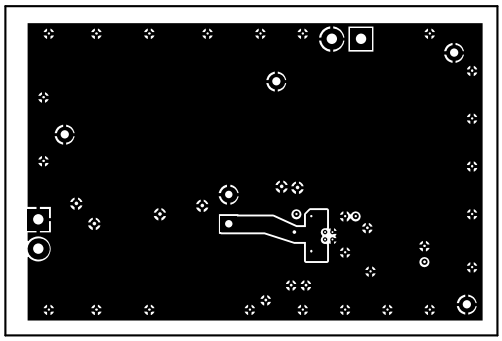

Figure 4. Inner Layer 2

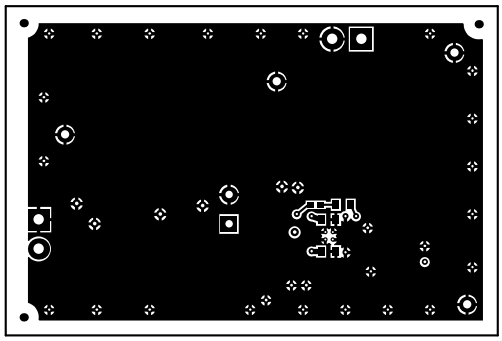

Figure 5. Bottom Layer

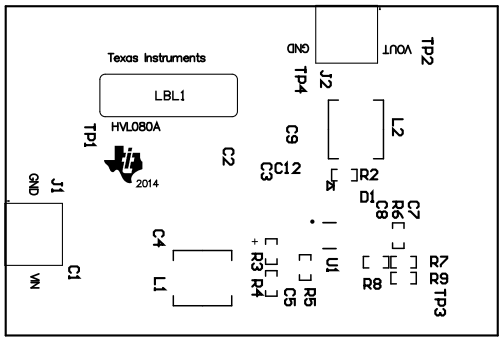

Figure 6. Top Overlay

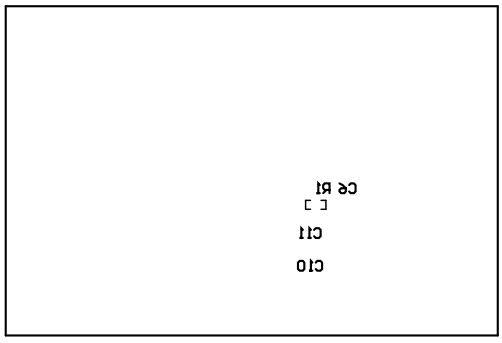

Figure 7. Bottom Overlay

4 Schematic and Bill of Materials

4.1 Schematic

Figure 8 shows the schematic of the TPS57160EVM.

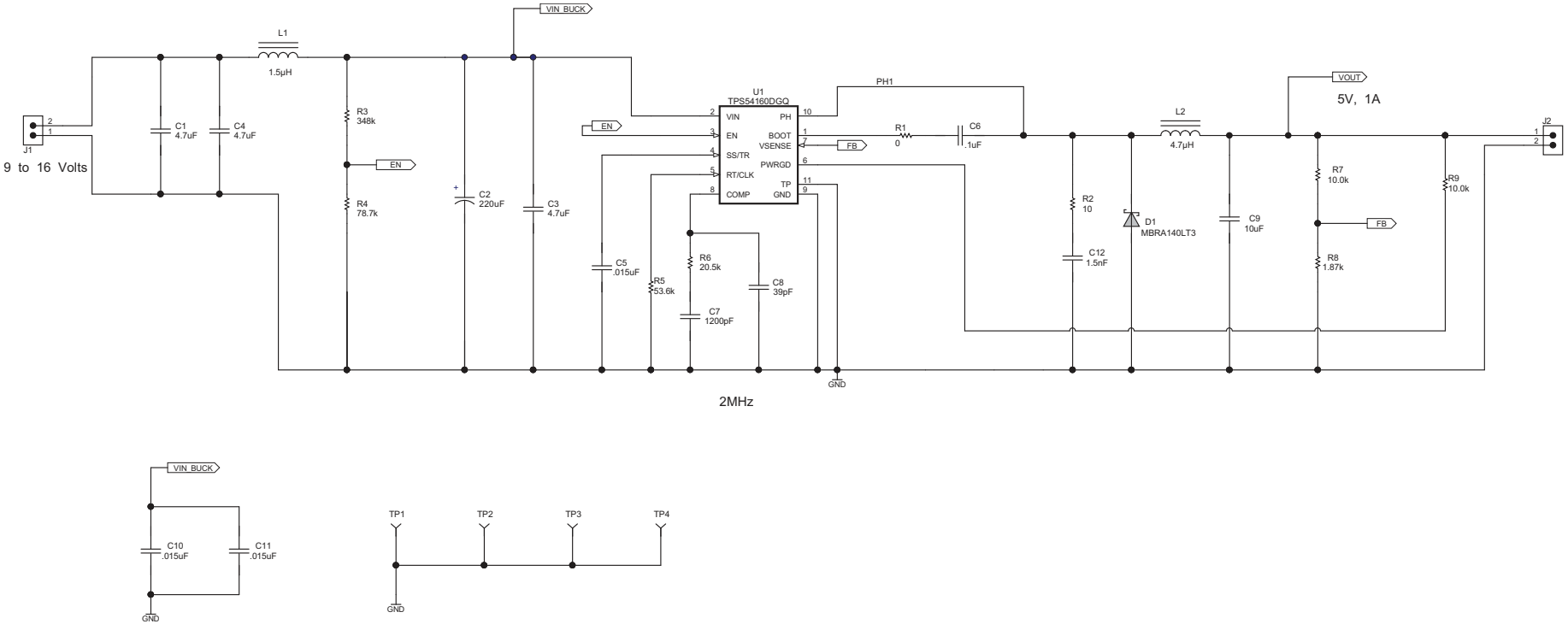

Figure 8. TPS57160EVM Schematic

4.2 Bill of Materials

Table 4 lists the bill of materials for the TPS57160EVM

Table 4. TPS57160EVM Bill of Materials

DESIGNATOR	QTY.	VALUE	DESCRIPTION	PACKAGE REFERENCE	PART NUMBER	MANUFACTURER
PCB	1		Printed Circuit Board		HVL080	Any
C1 C3 C4	3	4.7 µF	Capacitor, ceramic, 25-V, X7R, 10%	1206	C3216X7R1E475K	TDK
C2	1	220 µF	Capacitor, aluminum, electrolytic, 25-V, 20%	0.315 inch	25ZL220M8X11.5	Rubycon
C5, C10 C11	3	.015 µF	Capacitor, ceramic, 50-V, X7R, 10%	0603	C1608X7R1H153K	TDK
C6	1	0.1 µF	Capacitor, ceramic, 50-V, X7R, 10%	0603	C1608X7R1H104K	TDK
C7	1	1200 pF	Capacitor, ceramic, 50-V, C0G, 5%	0603	C1608COG1H122J	TDK
C8	1	39 pF	Capacitor, ceramic, 50-V, C0G, 5%	0603	C1608COG1H390J	TDK
C9	1	10 µF	Capacitor, ceramic, 16-V, X7R, 10%	1206	C3216X7R1C106K	TDK
C12	1	1.5 nF	Capacitor, ceramic, 50-V, X7R, 10%	0603	C1608X7R1H153K	TDK
D1	1	MBRA140LT3	Diode, Schottky, 1-A, 40-V	SMA	MBRA130LT3	Motorola
FID1 FID2 FID3 FID4 FID5 FID6	6		Fiducial mark. There is nothing to buy or mount.	Fiducial	N/A	N/A
J1 J2	2		Terminal block, 6-A, 3.5-mm pitch, 2-Pos, TH	7.0 × 8.2 × 6.5mm	ED555/2DS	On-Shore Technology
L1	1	1.5 µH	Inductor, SMT, 9-A, 15-mΩ	IHLP-2525CZ	IHLP2525CZER1R5M01	Vishay-Dale
L2	1	4.7 µH	Inductor, SMT, 4.5-A, 40-mΩ	IHLP-2525CZ	IHLP2525CZER4R7M01	Vishay-Dale
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650"H × 0.200"W	THT-14-423-10	Brady
R1	1	0	RES, 0 -Ω, 5%, 0.063-W, 0402	0402	RC0402JR-070RL	Yageo America
R2	1	10	RES, 10 -Ω, 5%, 0.1-W, 0603	0603	CRCW060310R0JNEA	Vishay-Dale
R3	1	348 kΩ	RES, 348-kΩ, 1%, 0.1-W, 0603	0603	CRCW0603348KFKEA	Vishay-Dale
R4	1	78.7 kΩ	RES, 78.7-kΩ, 1%, 0.1-W, 0603	0603	CRCW060378K7FKEA	Vishay-Dale
R5	1	53.6 kΩ	RES, 53.6-kΩ, 1%, 0.1-W, 0603	0603	CRCW060353K6FKEA	Vishay-Dale

Table 4. TPS57160EVM Bill of Materials (continued)

DESIGNATOR	QTY.	VALUE	DESCRIPTION	PACKAGE REFERENCE	PART NUMBER	MANUFACTURER
R6	1	20.5 kΩ	RES, 20.5-kΩ, 1%, 0.1-W, 0603	0603	CRCW060320K5FKEA	Vishay-Dale
R7	2	10 kΩ	RES, 10-kΩ, 1%, 0.1-W, 0603	0603	CRCW060310K0FKEA	Vishay-Dale
R9						
R8	1	1.87 kΩ	RES, 1.87-kΩ, 1%, 0.1-W, 0603	0603	CRCW06031K87FKEA	Vishay-Dale
TP1	4	5001	Test Point, Black, Thru Hole, Color Keyed	0.100 × 0.100 inch	5001	Keystone
TP2						
TP3						
TP4						
U1	1	TPS57160QDGQ	IC, DC-DC Converter, 60-V, 1.5-A	DGQ0010D	TPS57160QDGQ	Texas Instruments

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