Parallelable, I^{2}C, Remote Sense 6A, 10A, 12A, 15A Power Module Evaluation Module

TEXAS INSTRUMENTS

Description

The TPSM8287AxxxxxEVM evaluation module (EVM) facilitates the evaluation of the TPSM8287Axx, which supports up to 15A load current in a pin-to-pin compatible step-down power module with an I^{2}C interface, remote sense, and frequency synchronization in a 4.5mm × 6.8mm over molded QFN package. The EVMs provide an adjustable output voltage, with 0.8% accuracy, between 0.4V and 3.35V from input voltages from 2.7V to 6V.

Features

- 6A, 10A, 12A, and 15A output current power module with integrated inductor in an over molded QFN package
- Excellent thermal performance (θ_{JA} = 19.5 °C/W)
- 4.5mm x 6.8mm power module provides 77mm^2 total solution-size
- Start-up output voltage adjustable through jumpers to 1 of 59 values
- Highly accurate output voltage with remote sense and adjustable control loop compensation
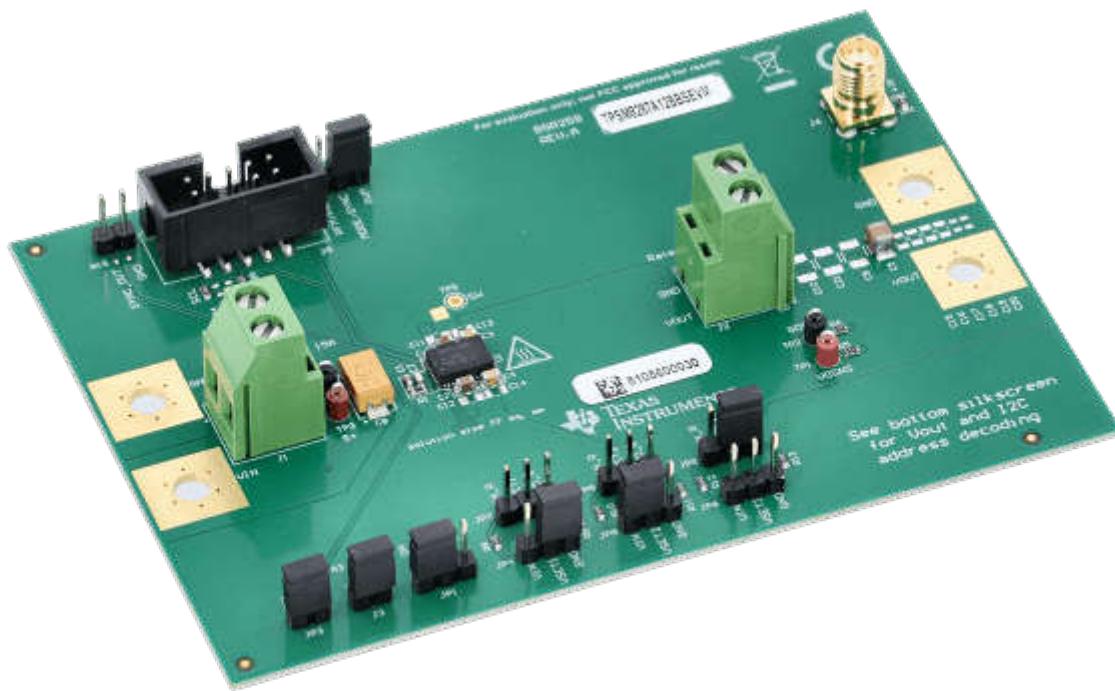
1 Evaluation Module Overview

1.1 Introduction

The TPSM8287AxxxxxEVM enables evaluation of the TPSM8287Axx power module in a typical, stand-alone, step-down converter application. The TPSM8287Axx are high-efficiency, high-accuracy, small and thin point-of-load (POL) power modules in applications such as the core supply for FPGAs, ASICs, DDR memory, optical modules, storage, test and measurement, and other space-limited applications.

1.2 Kit Contents

The TPSM8287AxxxxxEVM box (the kit) includes a PCB (BSR259) with which to evaluate the TPSM8287Axx device in a typical stand-alone (not paralleled) application. To evaluate the device using TI's TPSM8287Axx EVM GUI to operate the I^{2}C bus, order the USB2ANY adapter EVM separately.

1.3 Specification

Table 1-1 provides a summary of the TPSM8287AxxxxxEVM performance specifications.

Table 1-1. Performance Specification Summary

SPECIFICATION	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Input voltage		2.7	5	6	V
Output voltage	V_{IN} > V_{OUT} + 1.4V	0.4	0.9	3.35	V
Output current	TPSM8287A06BASEVM (BSR259-001)	0		6	A
	TPSM8287A12BBSEVM (BSR259-002)	0		12	A
	TPSM8287A10BAHEVM (BSR259-003)	0		10	A
	TPSM8287A15BBHEVM (BSR259-004)	0		15	A

1.4 Device Information

The TPSM8287Axx is a family of pin-to-pin compatible 6A, 10A, 12A, and 15A power modules, which integrate the inductor. The devices use an I^{2}C interface to fine tune the output voltage to precisely match the needs of processor cores. The devices can be operated without the I^{2}C interface to provide a high current, fixed-output-voltage power supply.

2 Hardware

2.1 Safety Instructions

WARNING
⚠️
Hot surface. Contact can cause burns. Do not touch.

WARNING
High currents can be present on the input and output.

2.2 Header Information

J1 – VIN/GND	Input and return connections from the input supply to the EVM. This connector accepts up to 12 AWG wire.
MH1/2 – VIN/GND	Alternate input and return connections from the input supply to the EVM. These holes are sized for M4 or #8 bolts.
J2 – VOUT/GND	Input and return connections from the EVM to the load. This connector accepts up to 12 AWG wire.
MH3/4 – VOUT/GND	Alternate input and return connections from the EVM to the load. These holes are sized for M4 or #8 bolts.
J3 – PG/GND	The PG output appears on pin 2 of this header with ground on pin 1.
J4 – SYNC_OUT/GND	The SYNC_OUT signal appears on pin 1 of this header with ground on pin 2.
J6 – VOUT SMA	Measure the output voltage waveform at this SMA connector.

2.3 Jumper Information

JP1 – EN	EN pin input jumper. Place the supplied jumper across ON and EN to turn on the module. Place the jumper across OFF and EN to turn off the module. With the jumper installed across ON and EN, users can create a precise turn-on voltage with R2 and R18. Keep the value of R2 above 15kΩ.
JP2 – MODE/SYNC	MODE/SYNC pin input jumper. Place the supplied jumper across PWM and MODE/SYNC to operate the IC in Forced PWM mode. Place the jumper across PFM/PWM and MODE/SYNC to operate the IC in PFM/PWM mode. Remove the jumper to apply a synchronization signal on the MODE/SYNC pin.
JP3 – PG Pull-up	PG pin pull-up voltage jumper. Place the supplied jumper on JP3 to connect the PG pin pullup resistor to VIN. Alternatively, the jumper can be removed and a different voltage can be supplied on pin 1 to pull up the PG pin to a different level. This externally applied voltage must remain below 6.5V.
JP4 and JP7 – VSET1	VSET1 setting jumper. Place the supplied jumper on either JP4 and JP7 but not both.
JP5 and JP8 – VSET2	VSET2 setting jumper. Place the supplied jumper on either JP5 and JP8 but not both.
JP6 and JP9 – VSET3	VSET3 setting jumper. Place the supplied jumper on either JP6 and JP9 but not both.

To properly set the start-up voltage, the 3 jumpers for VSETx must be set before VIN is applied. Changing the jumpers after VIN is applied has no effect.

WARNING
Before applying VIN, verify that all 3 jumpers are installed: to JP4 or JP7, JP5 or JP8, and JP6 or JP9.   Do not leave the VSETx pins floating.

2.4 Interfaces

J5 – I²C	I²C adapter connection. Connect the 10-pin ribbon cable from the USB2ANY adapter EVM to this header to communicate with the device over the I²C bus through the TPSM8287Axx EVM GUI. This header is keyed to prevent backwards installation. The TPSM8287AxxxxxEVM does not require the USB2ANY EVM to operate.

2.5 Test Points

TP1/2 – VOUT/GND	Output voltage sense connections. Measure the output voltage at this point.
TP3/4 – VIN/GND	Input voltage sense connections. Measure the input voltage at this point.
TP5 – SW	SW node test point. Measure the SW node at this point. This test point is not installed.

3 Software

The TPSM8287Axx EVM GUI is provided on the TPSM8287A12BBSEVM tool folder to communicate with the device over the I²C bus through the USB2ANY adapter EVM. A valid input voltage must be applied.

The GUI automatically connects to the EVM. If this does not happen, then click either the *Connect* button at the top right of the GUI or the *link* symbol at the very bottom left of the GUI.

4 Implementation Results

The TPSM8287AxxxxxEVM was used to take all the data in the *TPSM8287Ax 2.7V to 6V Input, 6A, 10A, 12A and 15A, Parallel-able Synchronous Step-Down Power Module with I²C Interface and Remote Sense data sheet*. See the device data sheet for the performance of this EVM.

4.1 Evaluation Setup

4.1.1 Ripple Measurement Setup

The SMA connector, J6, is used to measure the output voltage ripple and transient response. Connect the SMA connector directly to the oscilloscope with a coaxial (coax) cable, instead of using a 10x oscilloscope probe, to achieve the best results. This enables the use of the smallest V/div setting on the oscilloscope to view the ripple. The EVM contains a 49.9Ω resistor in series with the SMA connector to block reflections on the coax cable. Either the high-impedance or 50Ω terminated setting on the oscilloscope can be used.

4.1.2 Operation With Output Voltages Above 2V

When operating with output voltages above 2V, add another 220µF output cap (at C9) to maintain stable operation with the reduced effective output capacitance at the higher output voltage.

4.1.3 Loop Response Measurement

The loop response can be measured by replacing R5 with a 10Ω resistor and applying the injection signal across. Figure 4-5, Figure 4-6, Figure 4-7, and Figure 4-8 show the loop response measurement results.

4.1.4 Precise Turn-on Voltage

With the jumper on JP1 installed, R2 and R18 can be modified to create a precise turn-on voltage. See *Achieving a Clean Start-up by Using a DC/DC Converter with a Precise Enable-pin Threshold technical brief* for details. Keep the value of R2 above 15kΩ.

4.2 Performance Data and Results

Figure 4-1 shows the thermal performance of the TPSM8287A12BBSEVM.
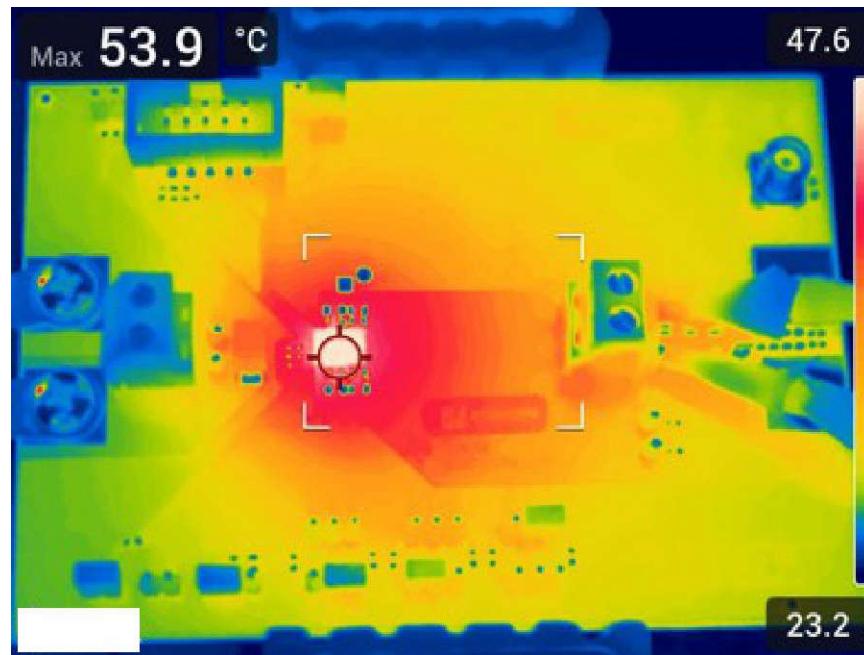
Figure 4-1. Thermal Performance (TPSM8287A12BBSEVM, V_{IN} = 5V, V_{OUT} = 0.9V, I_{OUT} = 12A)

Figure 4-2 shows the thermal performance of the TPSM8287A06BASEVM.
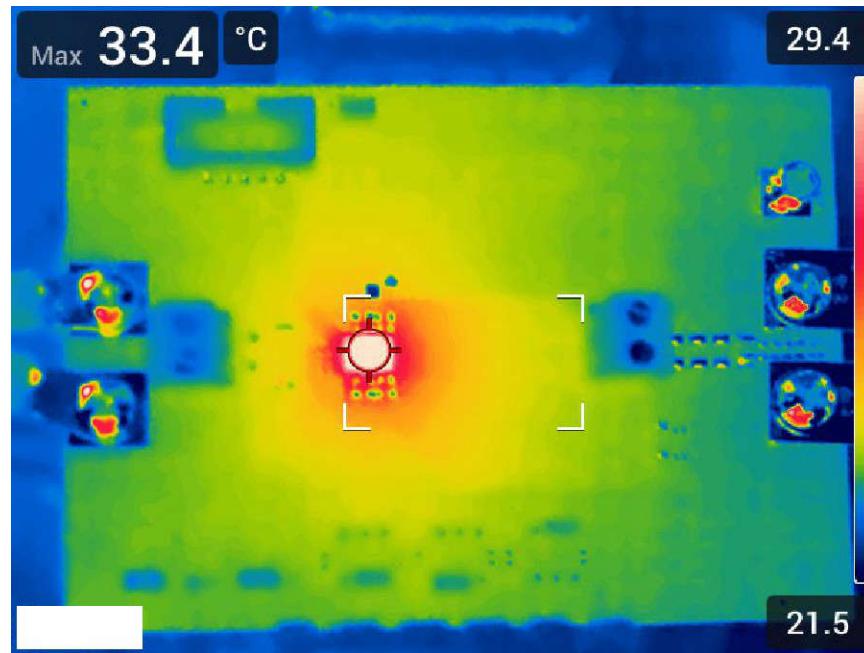
Figure 4-2. Thermal Performance (TPSM8287A06BASEVM, V_{IN} = 5V, V_{OUT} = 0.9V, I_{OUT} = 6A)

Figure 4-3 shows the thermal performance of the TPSM8287A10BAHEVM.
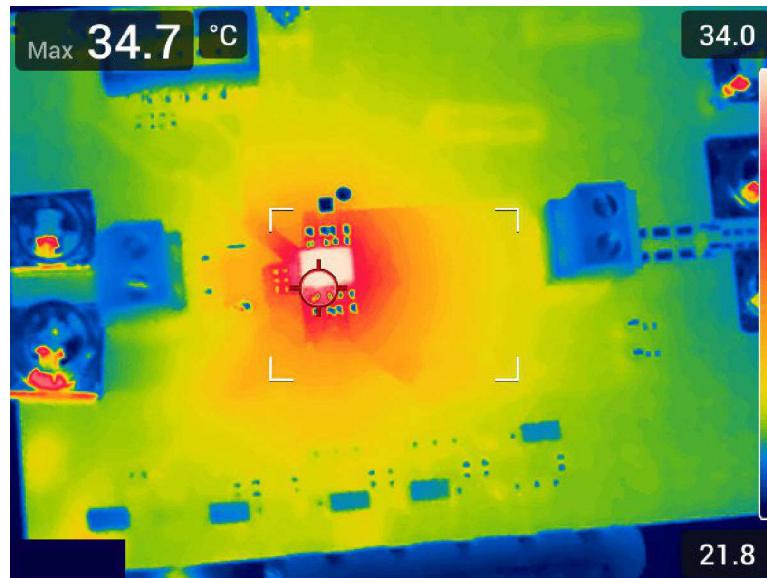
Figure 4-3. Thermal Performance (TPSM8287A10BAHEVM, V$_{IN}$ = 5V, V$_{OUT}$ = 0.9V, I$_{OUT}$ = 10A)

Figure 4-4 shows the thermal performance of the TPSM8287A15BBHEVM.
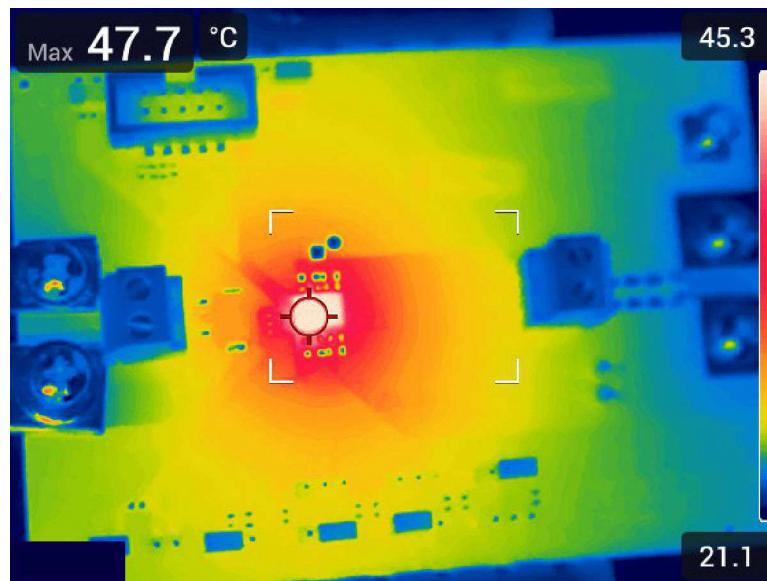
Figure 4-4. Thermal Performance (TPSM8287A15BBHEVM, V$_{IN}$ = 5V, V$_{OUT}$ = 0.9V, I$_{OUT}$ = 15A)

Figure 4-5 shows the loop response measurement of the TPSM8287A12BBSEVM.
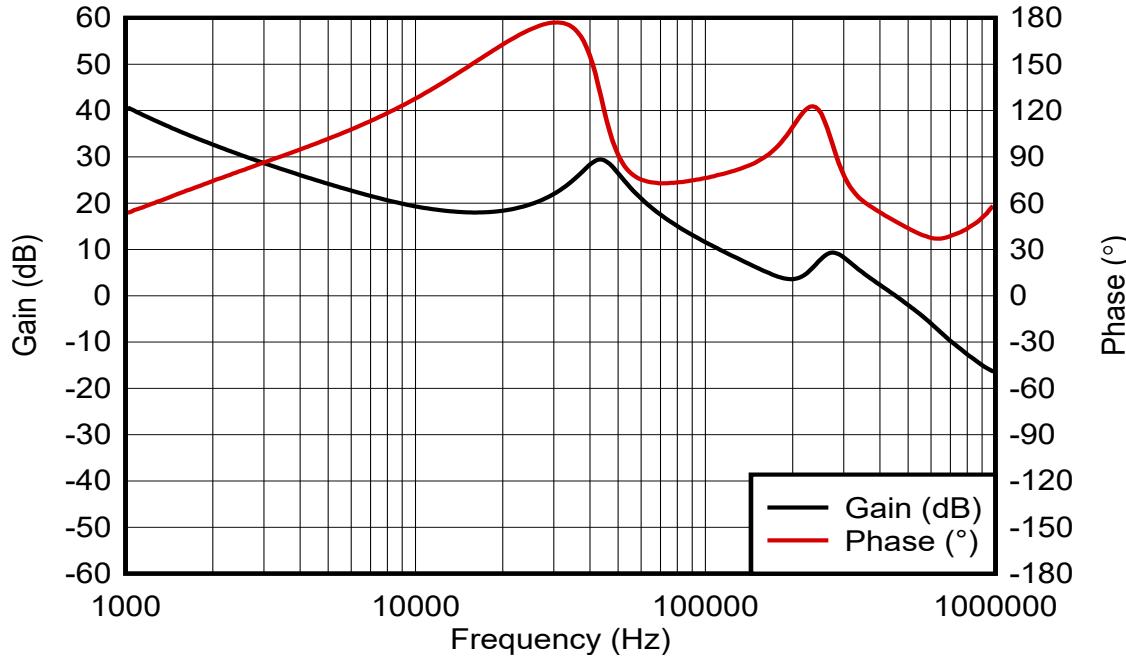
Figure 4-5. Loop Response Measurement (V$_{IN}$ = 5V, V$_{OUT}$ = 0.9V, I$_{OUT}$ = 12A)

Figure 4-6 shows the loop response measurement of the TPSM8287A06BASEVM.
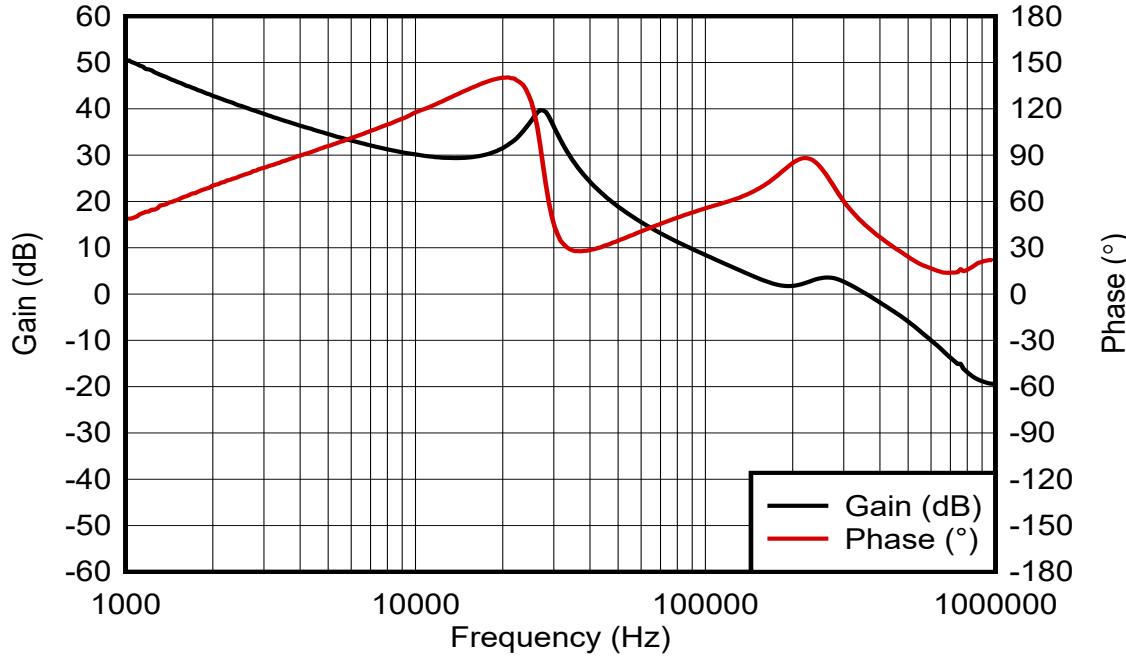
Figure 4-6. Loop Response Measurement (V$_{IN}$ = 5V, V$_{OUT}$ = 0.9V, I$_{OUT}$ = 6A)

Figure 4-7 shows the loop response measurement of the TPSM8287A10BAHEVM.
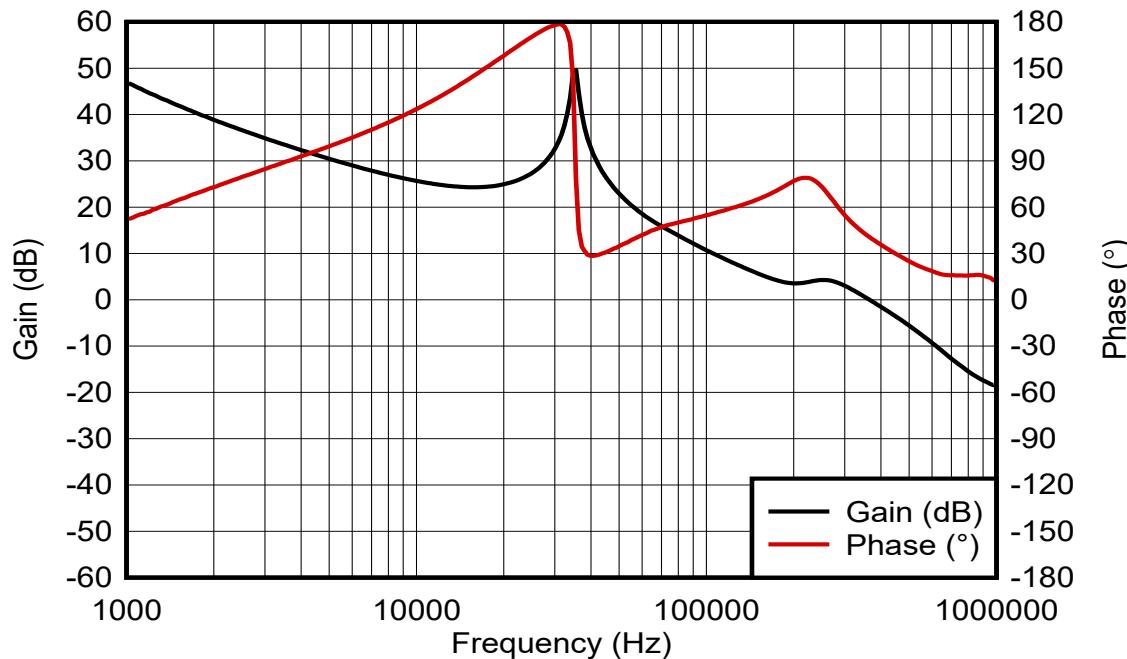
Figure 4-7. Loop Response Measurement (V_IN = 5V, V_OUT = 0.9V, I_OUT = 10A)

Figure 4-8 shows the loop response measurement of the TPSM8287A15BBHEVM.
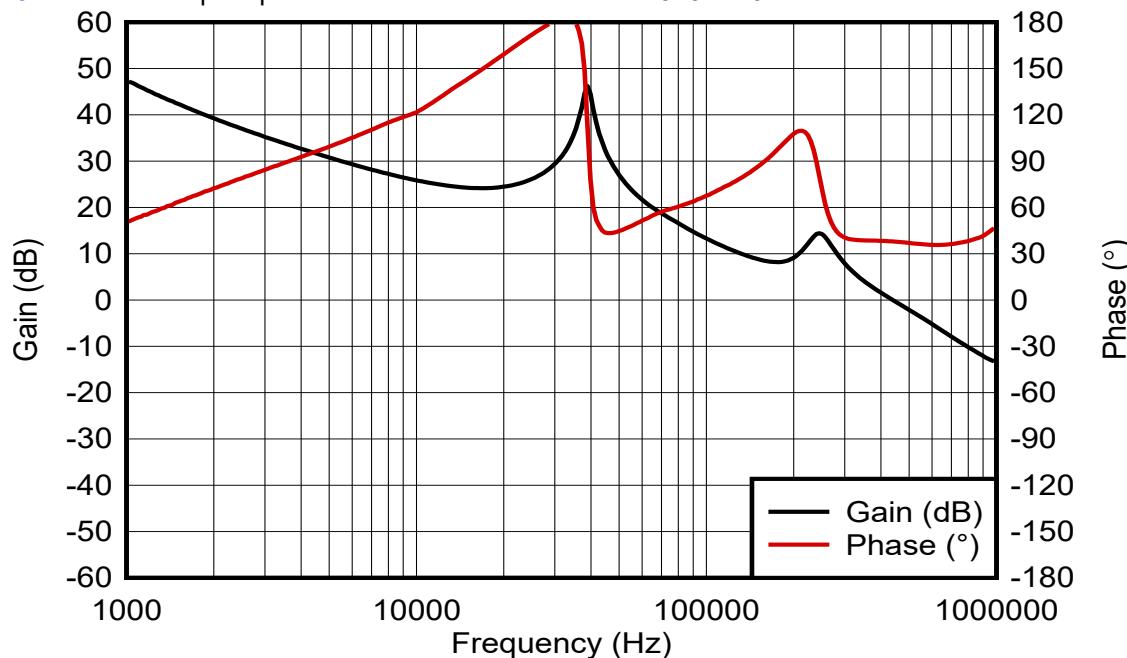
Figure 4-8. Loop Response Measurement (V_IN = 5V, V_OUT = 0.9V, I_OUT = 15A)

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5 Hardware Design Files

5.1 Schematics

, , , and show the EVM schematics.

The TPSM8287A06BASEVM uses the TPSM8287A06BASRDVR IC.

The TPSM8287A12BBSEVM uses the TPSM8287A12BBSRDVR IC.

The TPSM8287A10BAHEVM uses the TPSM8287A10BAHRDWR IC.

The TPSM8287A15BBHEVM uses the TPSM8287A15BBHRDWR IC.
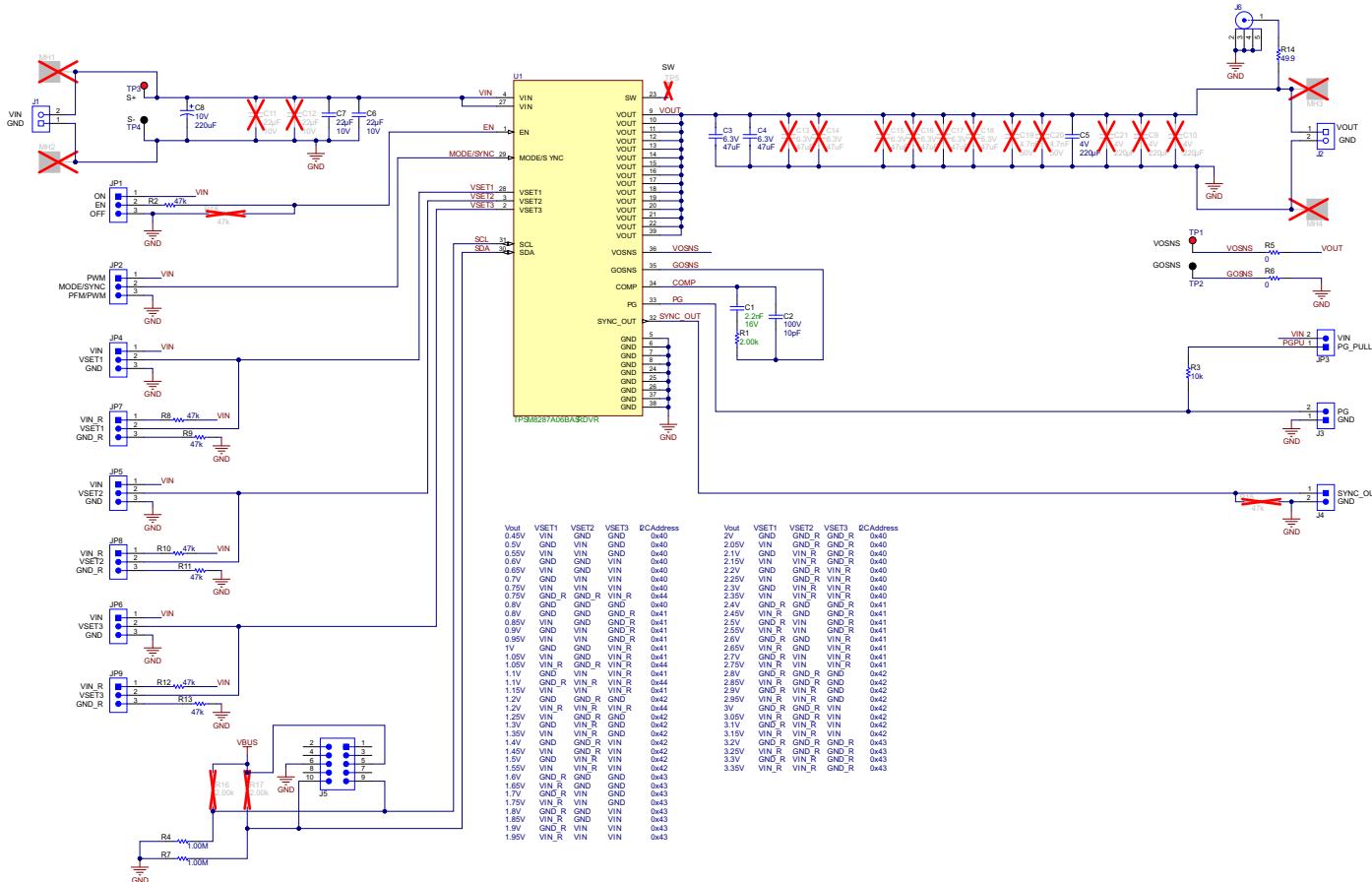
Figure 5-1. TPSM8287A06BASEVM Schematic
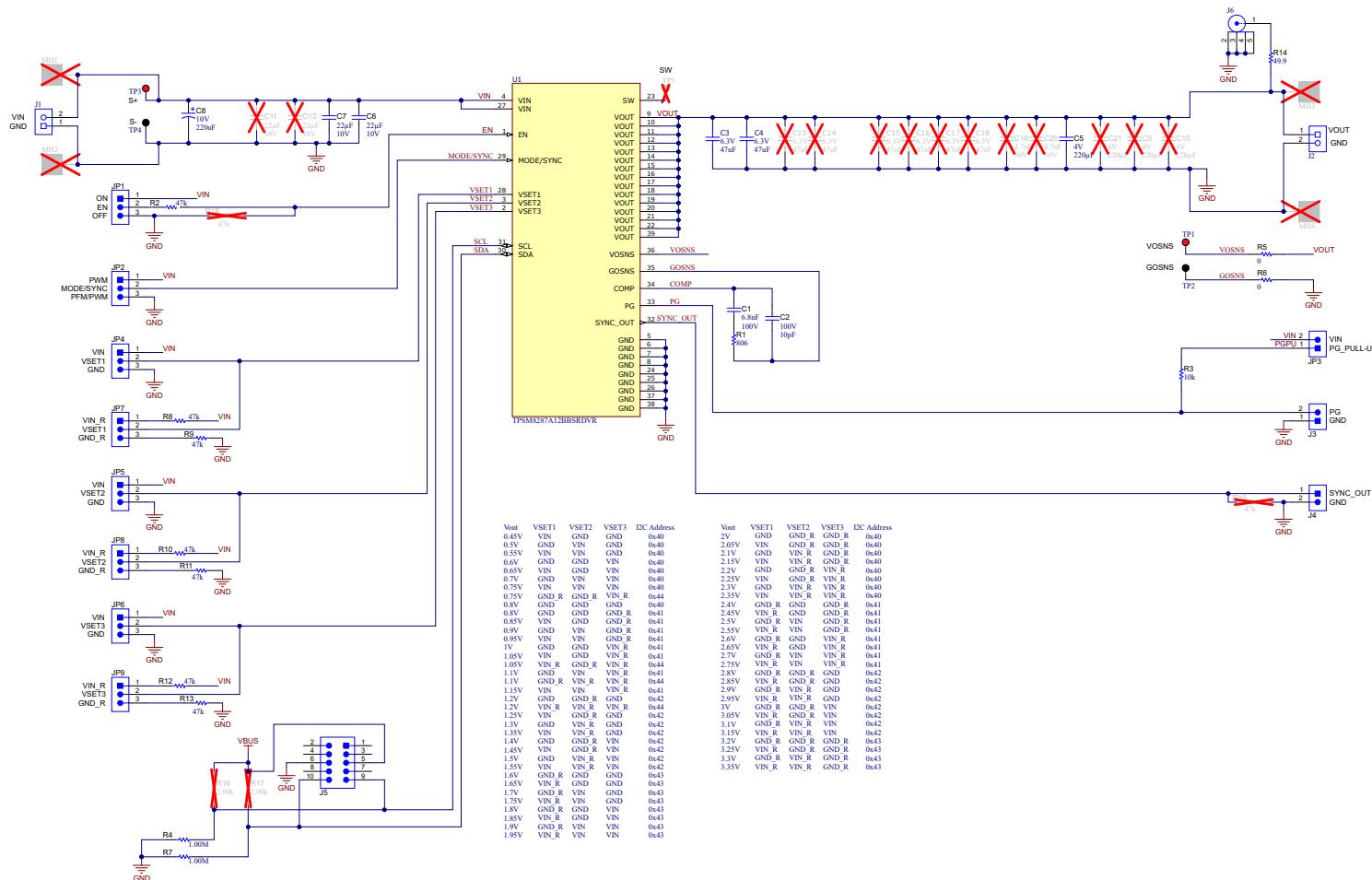
Figure 5-2. TPSM8287A12BBSEVM Schematic

Figure 5-3. TPSM8287A10BAHEVM Schematic

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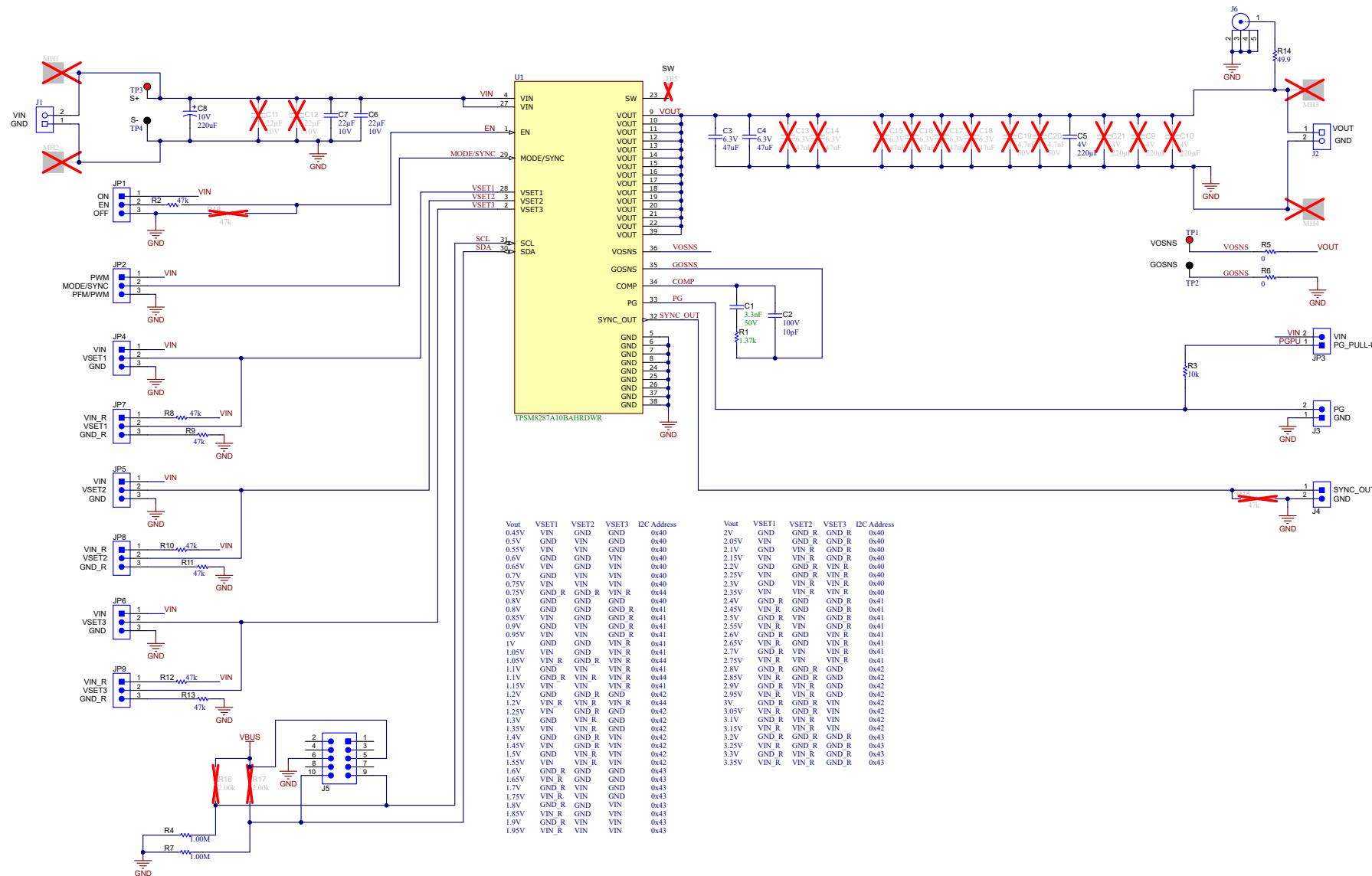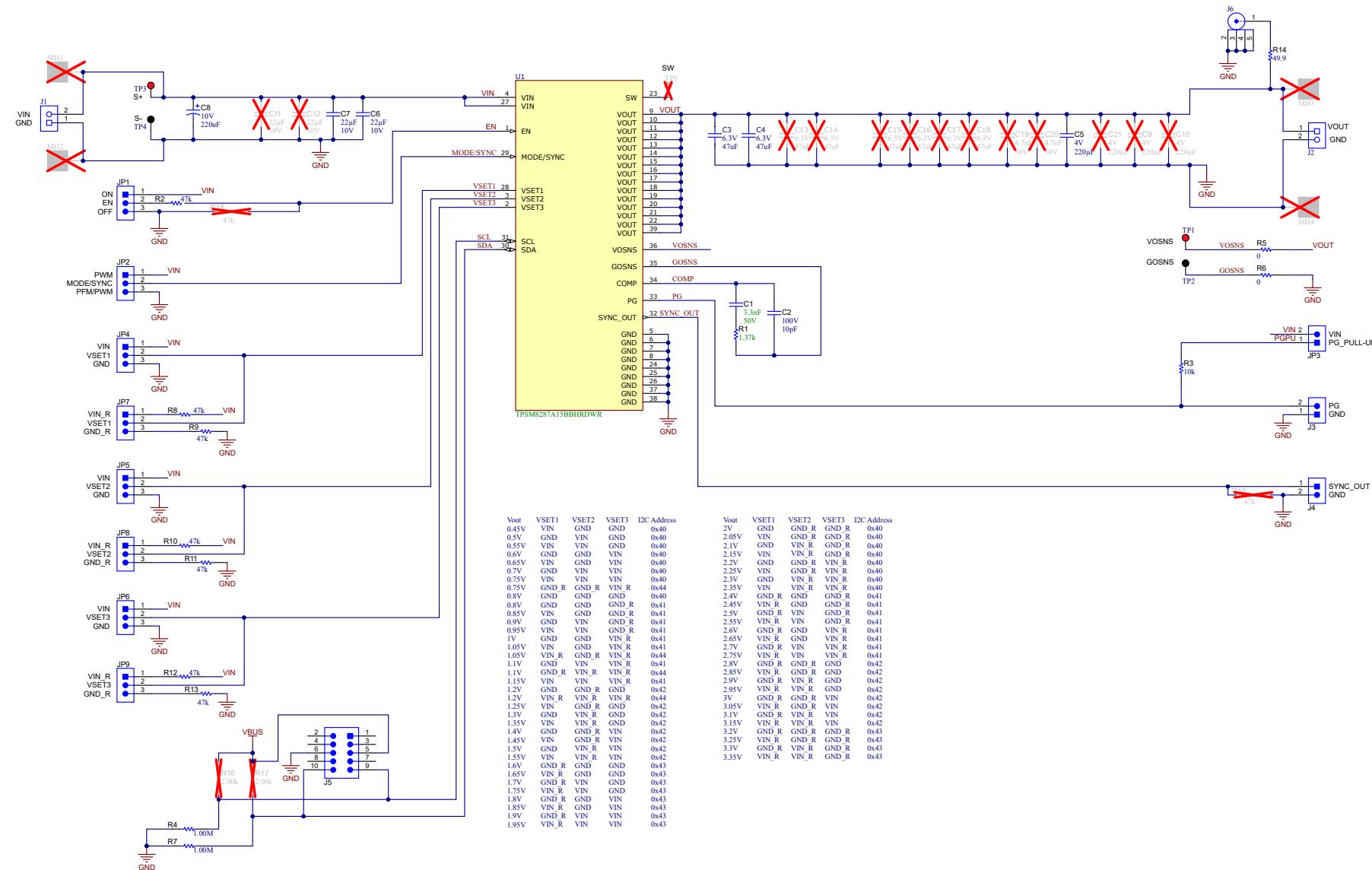
Figure 5-4. TPSM8287A15BBHEVM Schematic

Vout	VSET1	VSET2	VSET3	I2C Address
0.45V	VIN	GND	GND	0x40
0.5V	GND	VIN	GND	0x40
0.55V	VIN	VIN	GND	0x40
0.6V	GND	GND	GND	0x40
0.65V	VIN	GND	VIN	0x40
0.7V	GND	VIN	VIN	0x40
0.75V	VIN	VIN	VIN	0x40
0.75V	GND_R	GND_R	GND_R	0x44
0.8V	GND	GND	GND_R	0x40
0.85V	VIN	GND	GND_R	0x41
0.9V	GND	VIN	GND_R	0x41
0.95V	VIN	VIN	GND_R	0x41
1V	GND	GND	VIN_R	0x41
1.05V	VIN	GND	VIN_R	0x41
1.05V	VIN_R	GND_R	VIN_R	0x44
1.1V	GND_R	VIN_R	VIN_R	0x44
1.1V	GND	VIN	VIN_R	0x41
1.15V	VIN	VIN	VIN_R	0x41
1.2V	GND	GND_R	VIN_R	0x42
1.2V	VIN_R	VIN_R	VIN_R	0x44
1.25V	VIN	GND_R	GND	0x42
1.3V	GND	VIN_R	GND	0x42
1.35V	VIN	VIN_R	GND	0x42
1.4V	GND	GND_R	GND	0x42
1.45V	VIN	GND_R	GND	0x42
1.5V	GND	VIN_R	GND	0x42
1.55V	VIN	VIN_R	GND	0x42
1.6V	GND_R	GND	GND	0x43
1.65V	VIN_R	GND	GND	0x43
1.7V	GND_R	VIN	GND	0x43
1.75V	VIN_R	VIN	GND	0x43
1.8V	GND_R	GND	VIN	0x43
1.85V	VIN_R	GND	VIN	0x43
1.9V	GND_R	VIN	VIN	0x43
1.95V	VIN_R	VIN	VIN	0x43

Vout	VSET1	VSET2	VSET3	I2C Address
2V	GND	GND_R	GND_R	0x40
2.05V	VIN	GND_R	GND_R	0x40
2.1V	GND	VIN_R	GND_R	0x40
2.15V	VIN	VIN_R	GND_R	0x40
2.2V	GND	GND_R	VIN_R	0x40
2.25V	VIN	GND_R	VIN_R	0x40
2.3V	GND	VIN_R	VIN_R	0x40
2.35V	VIN	VIN_R	VIN_R	0x40
2.4V	GND_R	GND	GND_R	0x41
2.45V	VIN_R	GND	GND_R	0x41
2.5V	GND_R	VIN	GND_R	0x41
2.55V	VIN_R	VIN	GND_R	0x41
2.6V	GND_R	GND	VIN_R	0x41
2.65V	VIN_R	GND	VIN_R	0x41
2.7V	GND_R	VIN	VIN_R	0x41
2.75V	VIN_R	VIN	VIN_R	0x41
2.8V	GND_R	GND_R	GND	0x42
2.85V	VIN_R	GND_R	GND	0x42
2.9V	GND_R	VIN_R	GND	0x42
2.95V	VIN_R	VIN_R	GND	0x42
3V	GND_R	GND_R	VIN	0x42
3.05V	VIN_R	GND_R	VIN	0x42
3.1V	GND_R	VIN_R	VIN	0x42
3.15V	VIN_R	VIN_R	VIN	0x42
3.2V	GND_R	GND_R	GND_R	0x43
3.25V	VIN_R	GND_R	GND_R	0x43
3.3V	GND_R	VIN_R	GND_R	0x43
3.35V	VIN_R	VIN_R	GND_R	0x43

5.2 PCB Layouts

This section provides the TPSM8287AxxxxxEVM board layout (BSR259). The Gerber files are available on the TPSM8287A12BBSEVM tool folder. All six layers use 2-ounce copper.
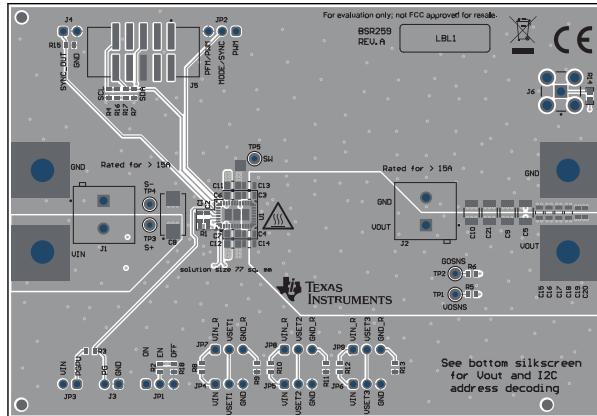
**Figure 5-5. Top Assembly**
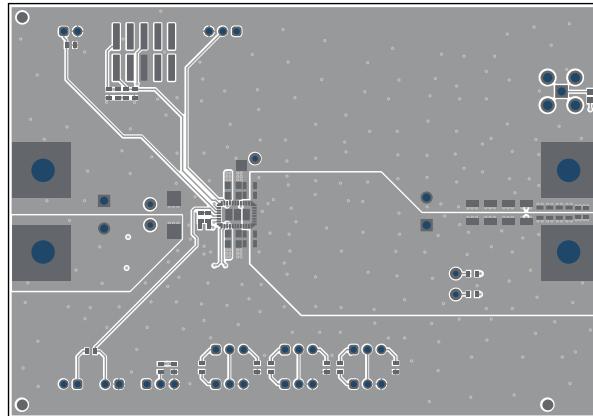
Figure 5-6. Top Layer
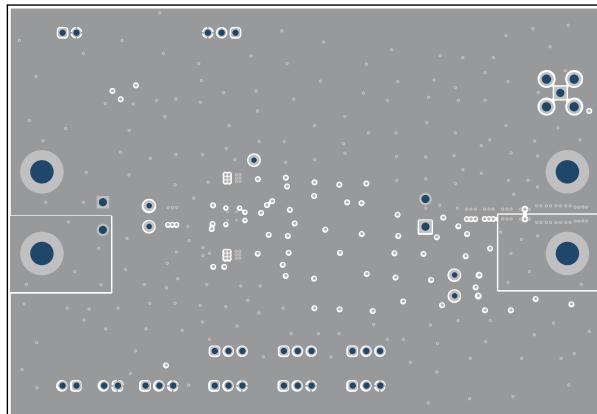
Figure 5-7. Internal Layer 1
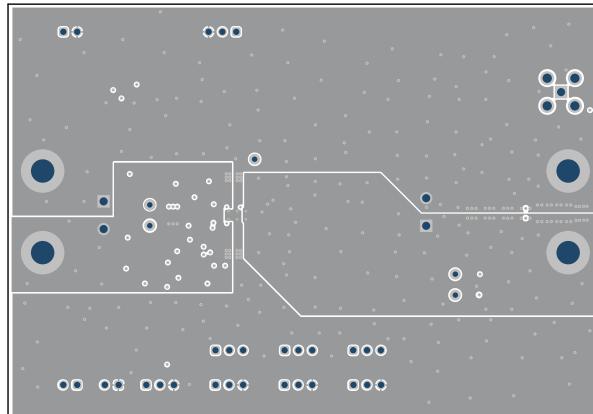
**Figure 5-8. Internal Layer 2**
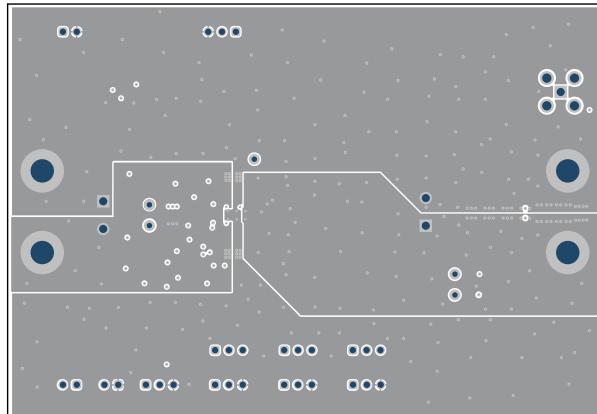
Figure 5-9. Internal Layer 3
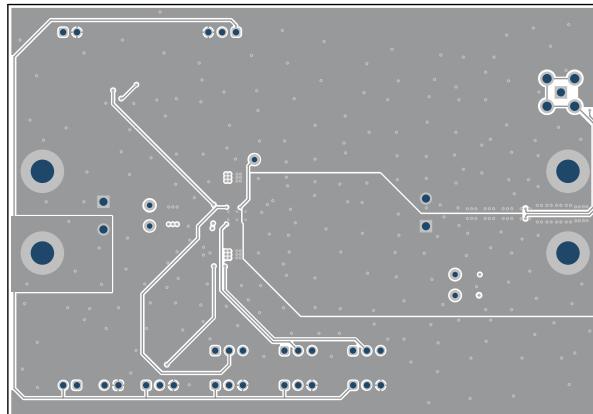

Figure 5-10. Internal Layer 4
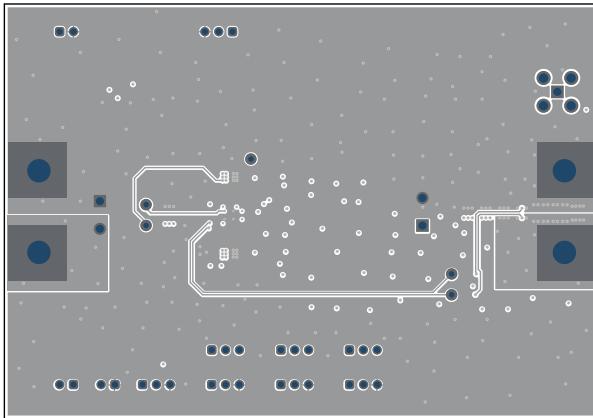
Figure 5-11. Bottom Layer
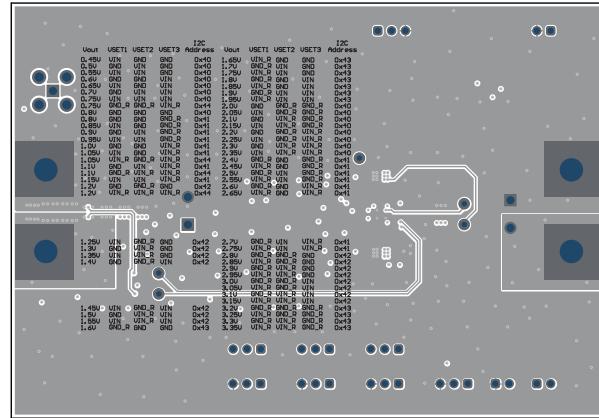
Figure 5-12. Bottom Assembly (Mirrored)

5.3 Bill of Materials (BOM)

lists the BOM for this EVM.

Table 5-1. TPSM8287AxxxxxEVM (BSR259-00x) Bill of Materials

QUANTITY				REF DES	VALUE	DESCRIPTION	SIZE	PART NUMBER	MANUFAC TURER
-001	-002	-003	-004						
0	1	0	0	C1	6800pF	Ceramic Capacitor, 16V, X7R	0603	Std	Std
1	0	0	0	C1	2200pF	Ceramic Capacitor, 16V, X7R	0603	Std	Std
0	0	1	1	C1	3300pF	Ceramic Capacitor, 16V, X7R	0603	Std	Std
1	1	1	1	C2	10pF	Ceramic Capacitor, 100V, C0G/NP0	0603	Std	Std
2	2	2	2	C3, C4	47µF	Ceramic Capacitor, 6.3V, X6S	0805	GRM21BC80J476ME01L	Murata
1	1	1	1	C5	220µF	Ceramic Capacitor, 4V, X6S	1210	GRM32EC80G227ME05L	Murata
2	2	2	2	C6, C7	22µF	Ceramic Capacitor, 10V, X7R	0805	GRM21BZ71A226ME15L	Murata
1	1	1	1	C8	220µF	Tantalum Capacitor, 10V, 50mΩ ESR	7343	TPSD227M010R0050	AVX
0	1	0	0	R1	806Ω	Resistor 1%, 0.1 W	0603	Std	Std
1	0	0	0	R1	2.00kΩ	Resistor 1%, 0.1 W	0603	Std	Std
0	0	1	1	R1	1.37kΩ	Resistor 1%, 0.1 W	0603	Std	Std
7	7	7	7	R2, R8, R9, R10, R11, R12, R13	47kΩ	Resistor 5%, 0.1 W	0603	Std	Std
1	1	1	1	R3	10kΩ	Resistor 5%, 0.1 W	0603	Std	Std
2	2	2	2	R4, R7	1.0MΩ	Resistor 5%, 0.1 W	0603	Std	Std
2	2	2	2	R5, R6	0Ω	Resistor 5%, 0.1 W	0603	Std	Std
1	1	1	1	R14	49.9Ω	Resistor 1%, 0.1 W	0603	Std	Std
1	0	0	0	U1		6A, Parallelable Synchronous Step-Down Power Module with I^{2}C Interface and Remote Sense	4.5mm × 6.8mm	TPSM8287A06BASRDVR	Texas Instruments
0	1	0	0	U1		12A, Parallelable Synchronous Step-Down Power Module with I^{2}C Interface and Remote Sense	4.5mm × 6.8mm	TPSM8287A12BBSRDVR	Texas Instruments
0	0	1	0	U1		10A, Parallelable Synchronous Step-Down Power Module with I^{2}C Interface and Remote Sense	4.5mm × 6.8mm	TPSM8287A10BAHRDWR	Texas Instruments
0	0	0	1	U1		15A, Parallelable Synchronous Step-Down Power Module with I^{2}C Interface and Remote Sense	4.5mm × 6.8mm	TPSM8287A15BBHRDWR	Texas Instruments

6 Additional Information

6.1 Trademarks

All trademarks are the property of their respective owners.

7 Revision History

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

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