User's Guide

LM5152EVM-BST Evaluation Module

ABSTRACT

The LM5152EVM-BST evaluation module (EVM) showcases the features and performance of the LM5152-Q1 wide input voltage synchronous boost controller, including the following:

- Low I_Q operation
- Internal feedback resistors
- Bypass mode operation when VIN is greater than the VOUT regulation target
- Dynamic output voltage tracking
- STATUS indicator
- Programmable frequency
- Clock dithering
- Programmable UVLO

The EVM is designed to maintain the minimum output of 8.5 V at 440 kHz during the automotive cranking down to 2.5-V boost input.

This EVM is designed for ease of configuration, enabling a user to evaluate the device for an automotive application. Functionality includes the following:

- Low I_Q operation
- Internal feedback resistors
- Bypass mode operation when V_{IN} is greater than V_{OUT}
- Dynamic output voltage tracking
- STATUS indicator
- Programmable frequency dithering
- Programmable undervoltage lockout (UVLO)
- Overvoltage protection

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Trademarks

All trademarks are the property of their respective owners.

1 Introduction

The LM5152EVM-BST evaluation module is designed to evaluate the operation and performance of the LM5152-Q1 low-I_Q synchronous boost controller. The EVM operates over an input voltage range of 2.5 V to 36 V and requires minimum of 7-V input to start up. The EVM provides a 8.5-V output with a maximum load current of 4 A at 2.5-V input or 6 A at 4.5-V input. Figure 1-1 shows the standard application circuit for the LM5152EVM-BST evaluation module.

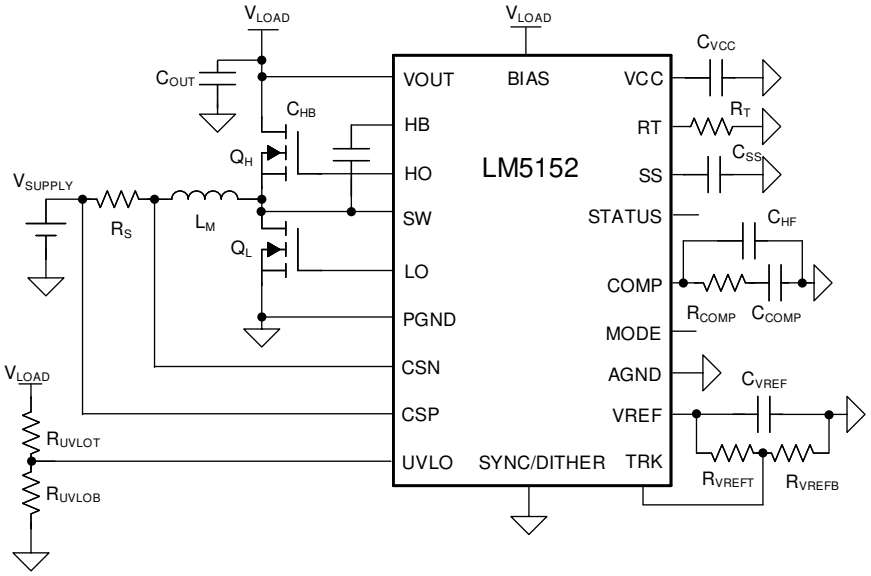

Figure 1-1. Typical Application Circuit

1.1 Applications

- Automotive start-stop application
- Automotive backup power supply application

1.2 Features

The LM5152EVM-BST has the following features:

- Input voltage range from 2.5 V to 36 V (7 V to start up)
- Internal low leakage current high-impedance feedback resistors with programmable output voltage
- Operating frequency of 440 kHz with externally clock synchronization up or down by 20%
- Bypass mode operation when V_{IN} is greater than V_{OUT}
- Selectable forced PWM (FPWM), skip mode, or diode emulation using the MODE pin
- High power conversion efficiency across a wide operating range
- Cycle-by-cycle peak current limiting
- Optional frequency dithering for improved EMI performance
- Boost STATUS indicator
- Programmable soft-start time
- Programmable line undervoltage lockout (UVLO)

2 EVM Setup

Section 2 describes the operating conditions for the EVM, as well as the configuration points of the evaluation module.

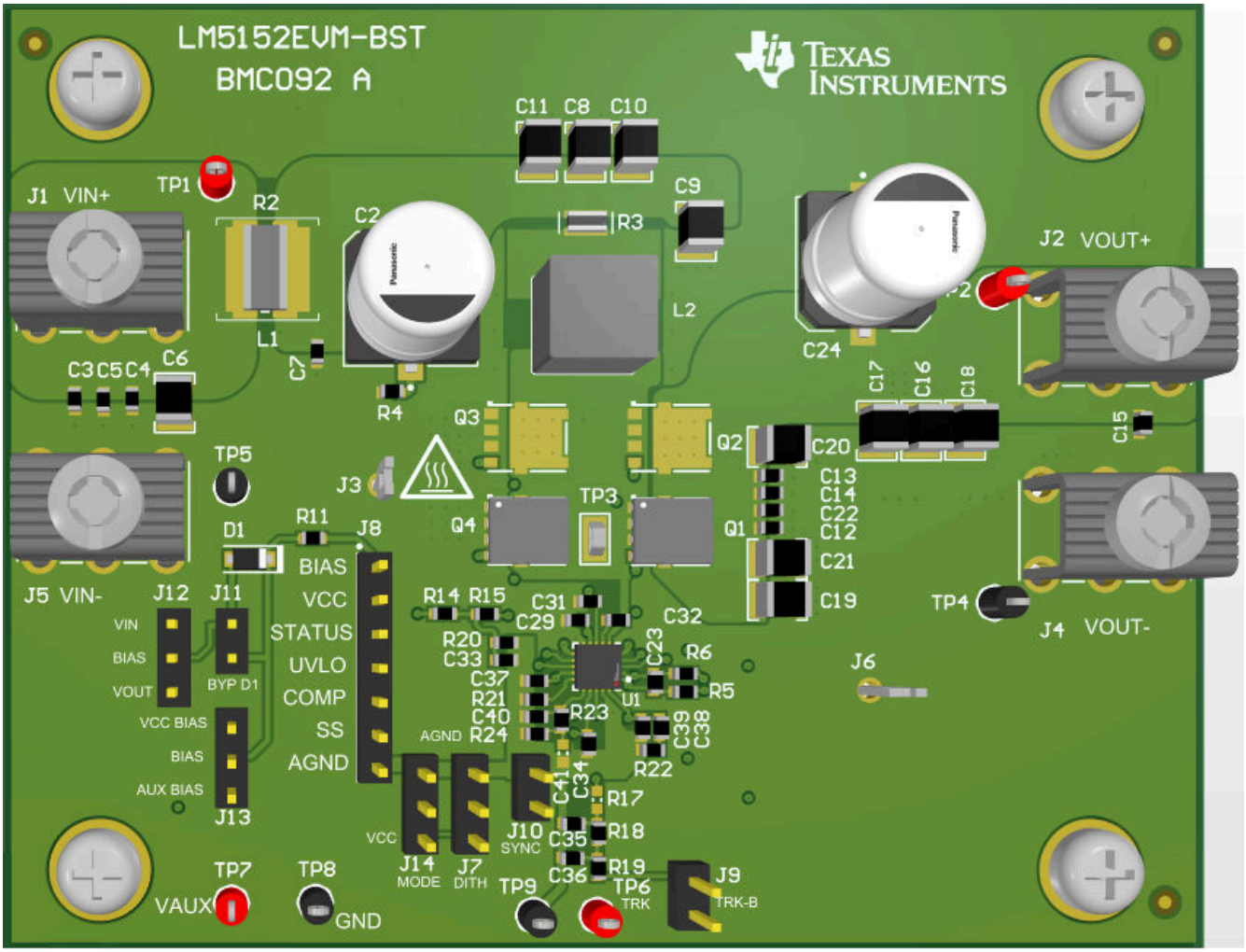

Figure 2-1. EVM Photo

CAUTION

Prolonged operation with low input voltage at full power will cause heating of Q1, Q4, L2, and R3. Board surface is hot. Do not touch! Contact may cause burns.

2.1 EVM Characteristics

Table 2-1 details the EVM characteristics.

Table 2-1. EVM Characteristics

PARAMETER	TEST CONDITION	MIN	TYP	MAX	UNIT
Input voltage range	Operation	2.5	13.5	36	V
	Start-up voltage		7		V
Input current				17	A
Output voltage			8.5		V
Output current1	2.5 V ≤ V_{SUPPLY} < 4.5 V			4	A
Output current2	4.5 V ≤ V_{SUPPLY} < 36 V			6	A
Switching frequency			440		kHz

2.2 EVM Connectors and Test Points

Section 2 describes the connection points of the evaluation module. Table 2-2 to Table 2-4 describe these connections. Table 2-2 lists the power connections of the evaluation module. These connections are intended to handle relatively large currents.

Table 2-2. Power Connections

JUMPER	PIN	DESCRIPTION
J1	VIN+	Positive input voltage power for the evaluation module
J2	VOUT+	Positive output voltage power for the evaluation module
J4	GND	Negative output voltage power for the evaluation module
J5	VIN–	Negative input voltage power for the evaluation module

Table 2-3 lists the EVM jumpers and test points that configure the LM5152-Q1 as desired. These jumpers can set different modes of operation or provide signals to different pins of the LM5152-Q1.

Table 2-3. Programmable Jumper Connections

JUMPER	PINS	DESCRIPTION	DEFAULT CONNECTION
J7	Pin 1 to Pin 2	SYNC/DITHER/VH/CP is pulled to VCC through a 1-kΩ resistor to enable the internal charge pump or enable the VCC holdup functionality. This connection must not be made if the J10 is populated.	
	Pin 2 to Pin 3	SYNC/DITHER/VH/CP is pulled to AGND through a 1-kΩ resistor to disable the internal charge-pump and VCC holdup functionality.	
	Open	If an external clock synchronization on J10 is used, leave this jumper open.	X
J9	VTRK_D	PWM signal applied through a two stage low-pass filters to the TRK pin. R17 must be populated.	
J10	Pin 1 to Pin 2	SYNC/DITHER/VH/CP pulled to ground, disabling dithering, internal charge-pump functionality, and VCC holdup functionality. J10 must not be populated when J7 is populated between pin 1 and pin 2.	X
	Open	Dithering is enabled. To synchronize to an external clock, remove C37.	
J11	Pin 1 to Pin 2	Bypass D1 to tie either V_{IN} or V_{OUT} nets to the BIAS pin.	X
	Open	Either V_{IN} or V_{OUT} is supplied through D1 to the BIAS pin.	
J12	Pin 1 to Pin 2	V_{IN} is supplied to the BIAS pin. This is the default connection.	X
	Pin 2 to Pin 3	V_{OUT} is supplied to the BIAS pin.	

Table 2-3. Programmable Jumper Connections (continued)

JUMPER	PINS	DESCRIPTION	DEFAULT CONNECTION
J13	Pin 1 to Pin 2	Connect an auxiliary power supply that can be used to supply power to the BIAS pin. J11 must be open if this is populated.	
	Pin 2 to Pin 3	Connect VCC to BIAS.	
	Open		X
J14	Pin 1 to Pin 2	Configures light-load switching operation to be FPWM	X
	Pin 2 to Pin 3	Configures light-load switching operation to be diode emulation	
	Open	Configures light-load switching operation to be skip	
TP6		Positive input to the VAUX net	
TP7		Negative input to the VAUX net	
TP8		Positive input to the TRK pin	
TP9		Negative input to the TRK pin	

Table 2-4 indicates the dedicated voltage probe points of the EVM. These points are used to make measurements on the EVM.

Table 2-4. Probe Points

SENSE POINT	NAME	DESCRIPTION
TP1	VIN+	Sense point for the positive input voltage
TP2	VOUT+	Sense point for the positive output voltage
TP3	SW	Sense point for the switch node of the boost controller
TP4	GND	Sense point for the negative output voltage
TP5	VIN–	Sense point for the negative input voltage
J3	PGND	Power ground connection
J6	PGND	Power ground connection
J8	1	BIAS
	2	VCC
	3	STATUS
	4	UVLO
	5	COMP
	6	SS
	7	AGND

3 Test Setup and Procedures

Figure 3-1 shows the required test setup to recreate the results found in Section 4.

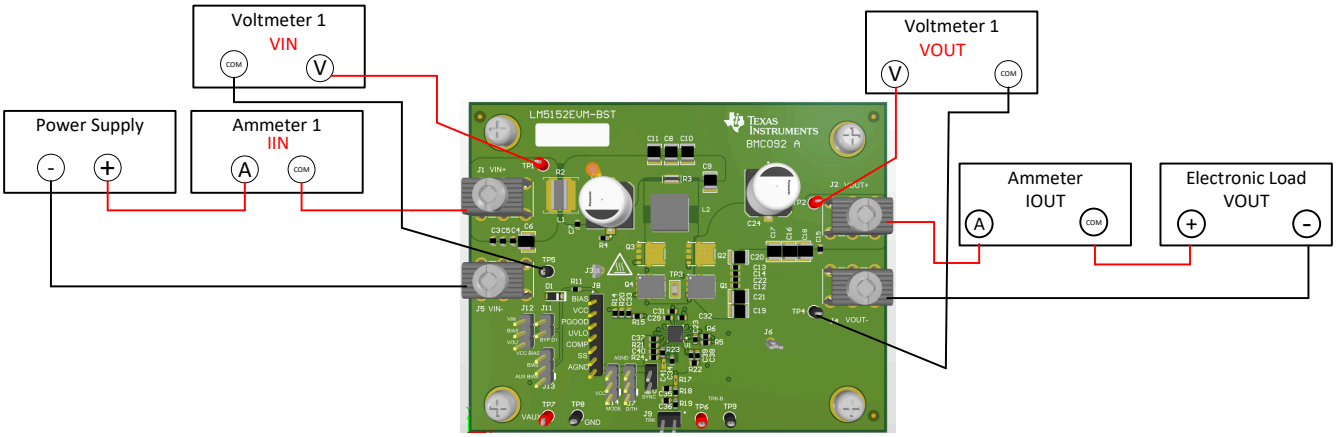

Figure 3-1. EVM Test Setup

3.1 Equipment

The following test equipment is needed to test the LM5152EVM-BST as shown in Figure 3-1.

- Power supply: The input voltage source (V_{IN}) must be a variable supply with minimum efficiency level V. The power supply must source 2.5 V to 36 V and be able to supply more than 20 A of current. TI recommends using an external power supply that complies with applicable regional safety standards such as (by example) the following:
  - UL
  - CSA
  - VDE
  - PSE
- Electronic load: Load connected to the output of the evaluation module. The electronic load must be able to handle up to 36 V and dissipate 100 W at 8.5 V.
- Multimeters: For DC measurements
  - Voltmeter 1 (V_{IN}): Capable of measuring the input voltage range up to 36 V
  - Voltmeter 2 (V_{OUT}): Capable of measuring output voltage of 36 V
  - Ammeter 1 (I_{IN}): Capable of 20-A DC measurement. A shunt resistor can also be used to measure the input current.
  - Ammeter 2 (I_{OUT}): Capable of at least 6-A DC measurement
- Oscilloscope: Minimum of 20-MHz bandwidth and 10x probes

4 Test Results

Section 4 covers the test results of the evaluation module.

4.1 Efficiency

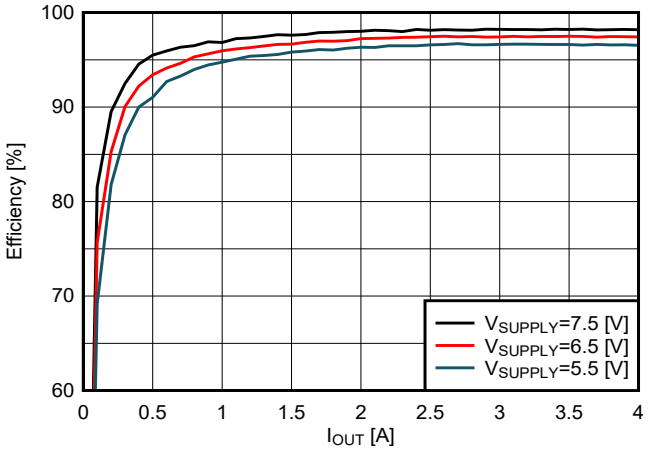

Figure 4-1. Efficiency: V_{OUT} = 8.5 V, FPWM Mode

4.2 Loop Response

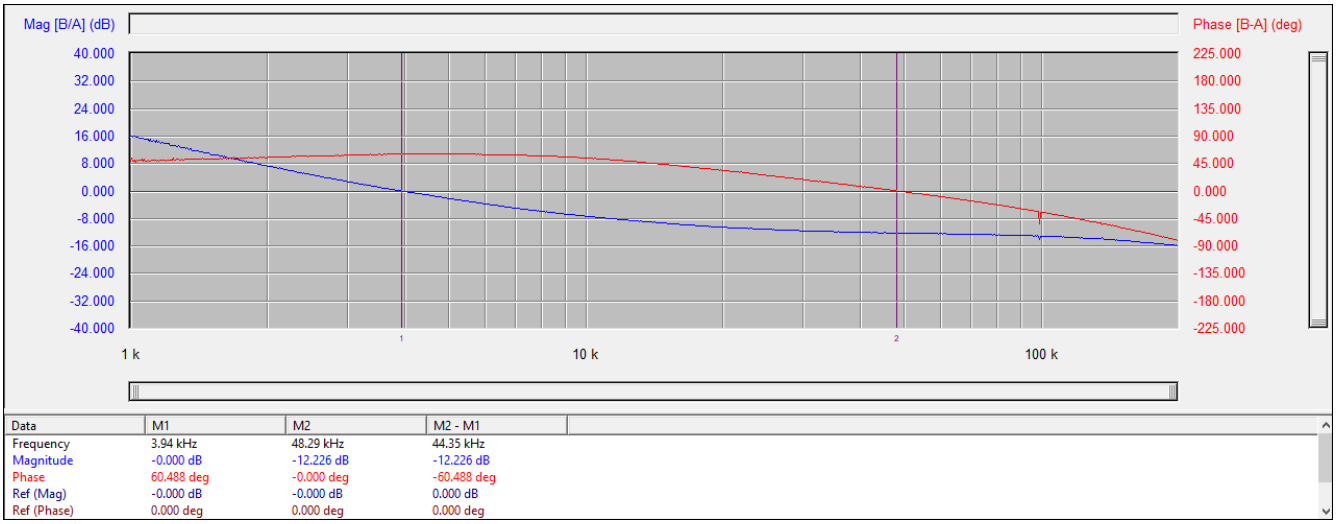

Figure 4-2. 2.5-V Loop Response at 4-A Load

4.3 Thermal Performance

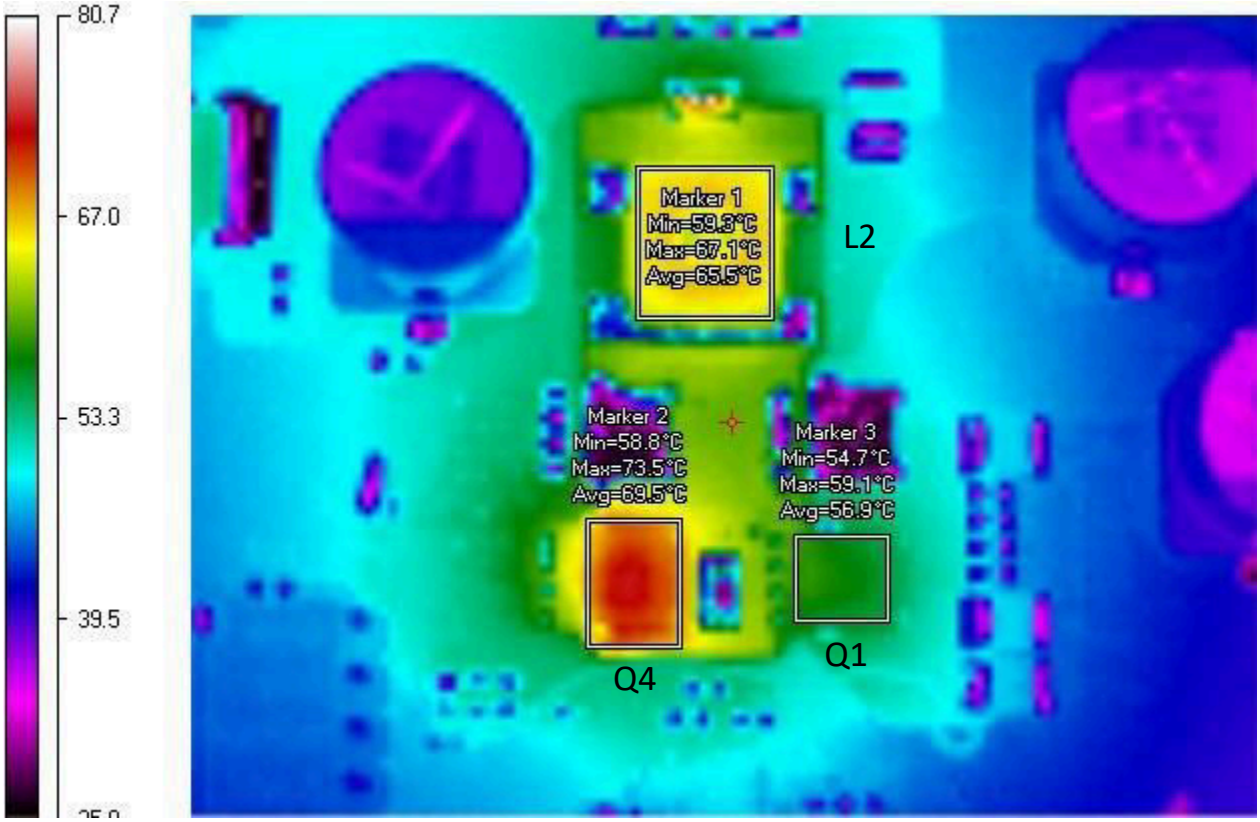

Figure 4-3. Thermal Performance: V_{IN} = 2.5 V, V_{OUT} = 8.5 V, I_{OUT} = 4 A, No Forced Airflow

4.4 Typical Waveforms

Texas Instruments HVAL068A automotive cranking simulator is used during cranking test.

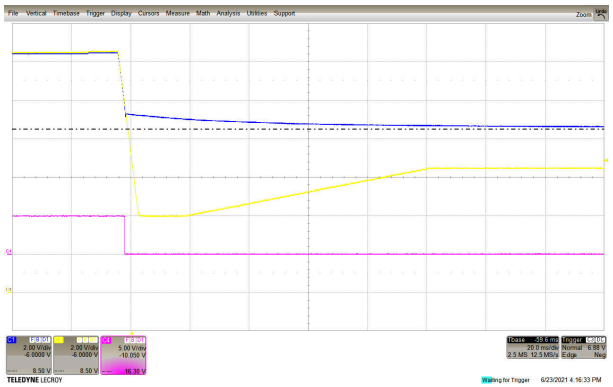

Figure 4-4. Program 1, DaimlerChrysler Engine-Cranking Test Pulse, DC-10615 (C1: VOUT, C3: VIN, C4: STATUS)

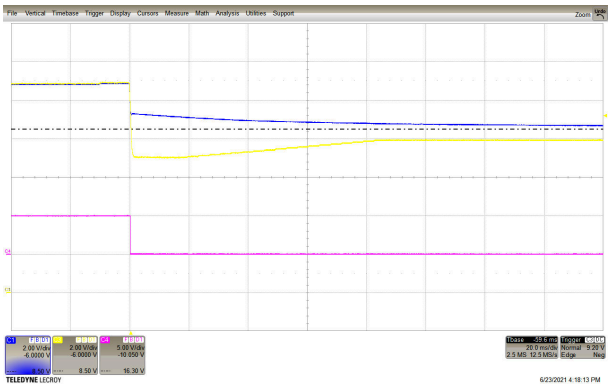

Figure 4-5. Program 2, Volkswagen Warm-Start Test Pulse, VW80000 (C1: VOUT, C3: VIN, C4: STATUS)

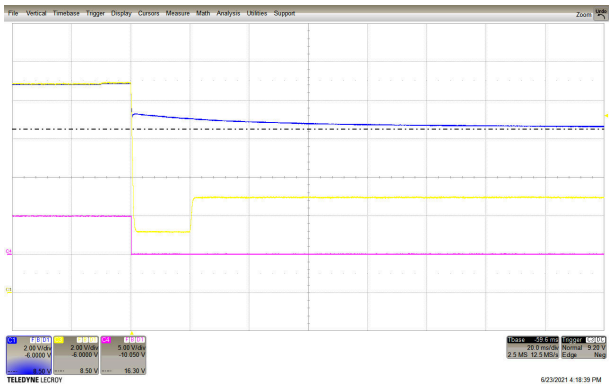

Figure 4-6. Program 3, Volkswagen Cold-Start Test Pulse, VW80000 (C1: VOUT, C3: VIN, C4: STATUS)

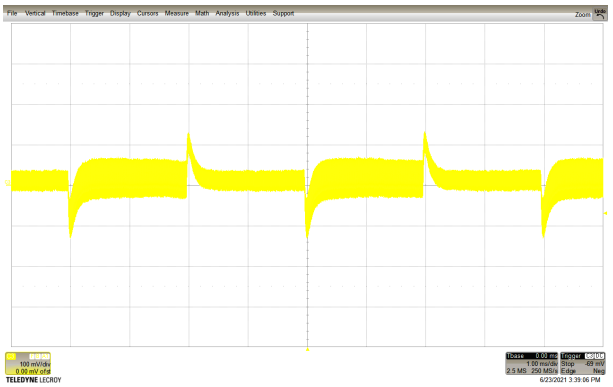

Figure 4-7. Load Transient Test (2 A to 4 A to 2 A at 4-V Input)

5 PCB Layers

Figure 5-1 through Figure 5-6 illustrate the EVM PCB layout.

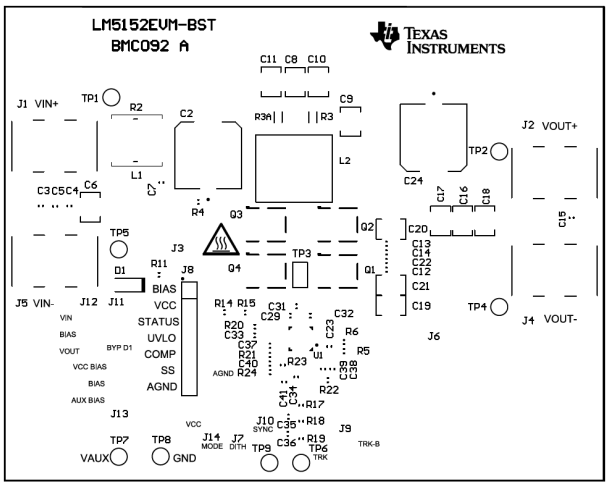

Figure 5-1. Layout: Top Silk Screen

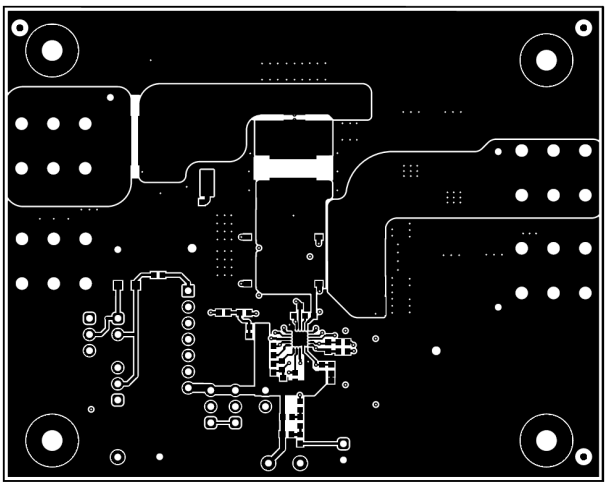

Figure 5-2. Layout: Top Layer

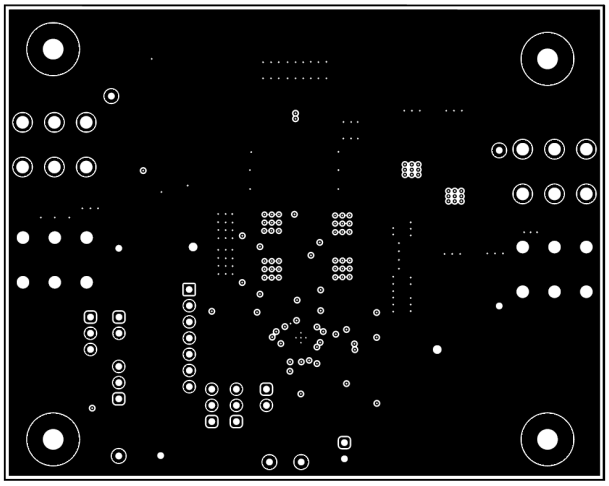

Figure 5-3. Layout: Signal Layer 1

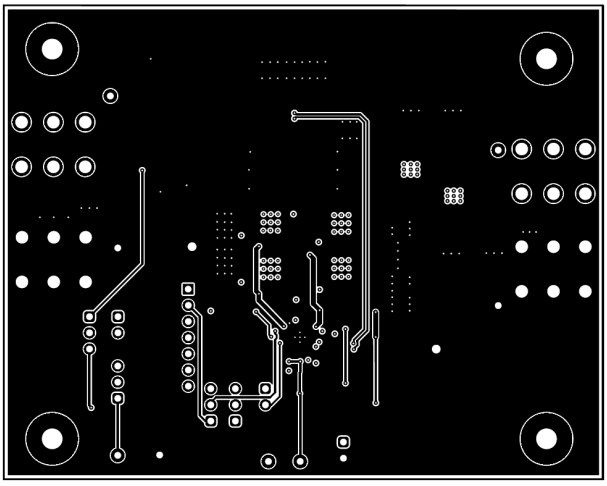

Figure 5-4. Layout: Signal Layer 2

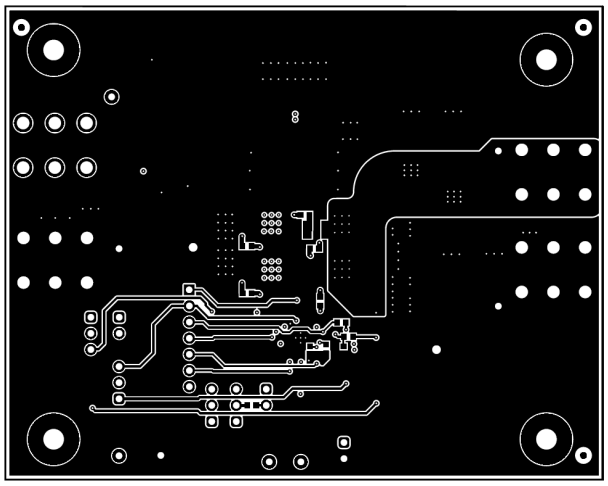

Figure 5-5. Layout: Bottom Layer

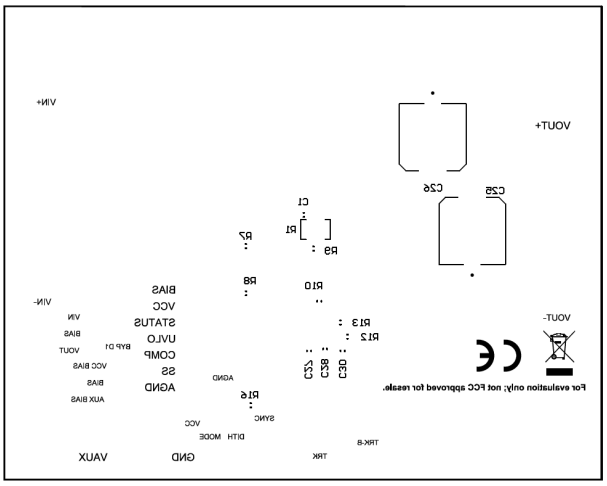

Figure 5-6. Layout: Bottom Silk Screen

6 Schematic

Figure 6-1 illustrates the EVM schematic.

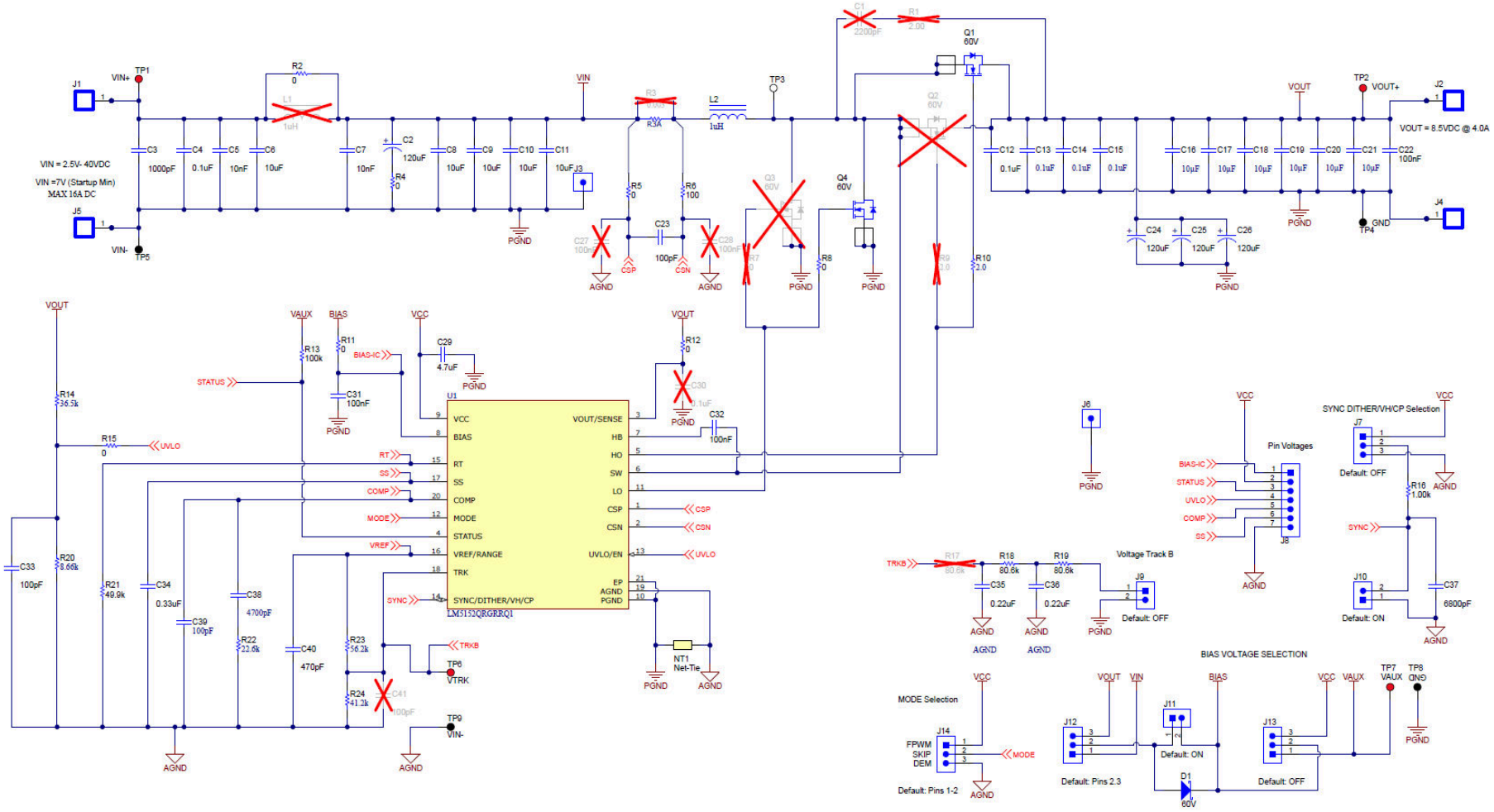

Figure 6-1. Schematic

7 Bill of Materials

Section 7 details the EVM bill of materials.

Table 7-1. Bill of Materials

DESIGNATOR	QTY	VALUE	DESCRIPTION	PACKAGE REFERENCE	PART NUMBER	MANUFACTURER
C2, C24, C25, C26	4	120 µF	CAP ALUM POLY HYB 120UF 50 V SMD	RADIAL	EEH-ZC1H121P	Panasonic
C3	1	1000 pF	CAP, CERM, 1000 pF, 50 V, ±10%, X7R, 0603	603	C0603X102K5RACTU	Kemet
C4	1	0.1 µF	CAP, CERM, 0.1 µF, 50 V, ±10%, X7R, 0603	603	C1608X7R1H104K080AA	TDK
C5, C7	2	0.01 µF	CAP, CERM, 0.01 µF, 100 V, ±10%, X7R, 0603	603	885012206114	Wurth Elektronik
C6, C8, C9, C10, C11	5	10 µF	CAP, CERM, 10 µF, 50 V, ±10%, X7R, 1210	1210	GRM32ER71H106KA12L	MuRata
C12, C13, C14, C15, C22, C31, C32	7	0.1 µF	CAP, CERM, 0.1 µF, 100 V, ±10%, X7R, AEC-Q200 Grade 1, 0603	603	GCJ188R72A104KA01D	MuRata
C16, C17, C18, C19, C20, C21	6	10 µF	CAP, CERM, 10 µF, 50 V, ±10%, X7R, 1210	1210	CL32B106KBJNNWE	Samsung
C23	1	100 pF	CAP, CERM, 100 pF, 50 V, ±5%, C0G/NP0, AEC-Q200 Grade 0, 0603	603	CGA3E2NP01H101J080AA	TDK
C29	1	4.7 µF	CAP, CERM, 4.7 µF, 16 V, ±10%, X6S, 0603	603	C1608X6S1C475K080AC	TDK
C33	1	100 pF	CAP, CERM, 100 pF, 50 V, ±1%, C0G/NP0, 0603	603	C0603C101F5GACTU	Kemet
C34	1	0.33 µF	CAP, CERM, 0.33 µF, 10 V, ±10%, X5R, 0603	603	C0603C334K8PACTU	Kemet
C35, C36	2	0.22 µF	CAP, CERM, 0.22 µF, 50 V, ±10%, X7R, AEC-Q200 Grade 1, 0603	603	CGA3E3X7R1H224K080AB	TDK
C37	1	6800 pF	CAP, CERM, 6800 pF, 50 V, ±5%, C0G/NP0, 0603	603	GRM1885C1H682JA01D	MuRata
C38	1	4700 pF	CAP, CERM, 4700 pF, 100 V, ±5%, C0G/NP0, 0603	603	C0603C472J1GAC7867	Kemet
C39	1	100 pF	CAP, CERM, 100 pF, 50 V, ±5%, C0G/NP0, 0603	603	C0603C101J5GACTU	Kemet
C40	1	470 pF	CAP, CERM, 470 pF, 50 V, ±5%, C0G/NP0, 0603	603	06035A471JAT2A	AVX
D1	1	60 V	Diode, Schottky, 60 V, 1 A, SOD-123F	SOD-123F	PMEG6010CEH,115	Nexperia
H1, H2, H3, H4	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	Screw	NY PMS 440 0025 PH	B&F

Table 7-1. Bill of Materials (continued)

DESIGNATOR	QTY	VALUE	DESCRIPTION	PACKAGE REFERENCE	PART NUMBER	MANUFACTURER
H5, H6, H7, H8	4		Standoff, Hex, 0.5"L #4-40 Nylon	Standoff	1902C	Keystone
J1, J2, J4, J5	4		TERMINAL SCREW PC 30AMP, TH	12.9 × 6.3 × 7.9 mm	8199	Keystone
J3, J6	2		TEST POINT SLOTTED .118", TH	Slot	1040	Keystone
J7, J12, J13, J14	4		Header, 100 mil, 3 × 1, Gold, TH	3 × 1 Header	TSW-103-07-G-S	Samtec
J8	1		Header, 100mil, 7 × 1, Gold, TH	7 × 1 Header	TSW-107-07-G-S	Samtec
J9, J10, J11	3		Header, 100 mil, 2 × 1, Gold, TH	2 × 1 Header	TSW-102-07-G-S	Samtec
L2	1	1 µH	Inductor, Shielded, Composite, 1 µH, 25 A, 0.00255 Ω, SMD	7.2 × 7 × 7.5 mm	XAL7070-102MEB	Coilcraft
Q1	1	60 V	MOSFET, N-CH, 60 V, 100 A, AEC-Q101, SO-8FL	SO-8FL	NVMFS5C645NLWFAFT1G	ON Semiconductor
	ALT	40 V	MOSFET N-CH 40-V 27-A/100-A TDSON	TDSON-8 FL	BSC022N04LS6	Infineon
Q4	1	60 V	MOSFET, N-CH, 60 V, 17 A, AEC-Q101, SO-8FL	SO-8FL	NVMFS5C670NLWFAFT1G	ON Semiconductor
	ALT	40 V	MOSFET N-CH 40-V 27-A/100-A TDSON	TDSON-8 FL	BSC022N04LS6	Infineon
R2	1	0	RES, 0, 5%, 2 W, 2512 WIDE	2512 WIDE	RCL12250000Z0EG	Vishay Draloric
R3A	1	3 m	3 ±1% 1-W Chip Resistor Wide 1206	1206	WSL06123L000FEA	Vishay
R4, R5, R8, R11, R15	5	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	ERJ-3GEY0R00V	Panasonic
R6	1	100	RES, 100, 1%, 0.1 W, 0603	603	RC0603FR-07100RL	Yageo
R10	1	2	RES, 2.0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW06032R00JNEA	Vishay-Dale
R12	1	0	RES, 0, 5%, 0.1 W, 0603	603	RC0603JR-070RL	Yageo
R13	1	100 k	RES, 100 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW0603100KFKEA	Vishay-Dale
R14	1	36.5 k	RES, 36.5 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW060336K5FKEA	Vishay-Dale
R16	1	1.00 k	RES, 1.00 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW06031K00FKEA	Vishay-Dale
R18, R19	2	80.6 k	RES, 80.6 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW060380K6FKEA	Vishay-Dale
R20	1	8.66 k	RES, 8.66 k, 1%, 0.1 W, 0603	603	RC0603FR-078K66L	Yageo
R21	1	49.9 k	RES, 49.9 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	603	ERJ-3EKF4992V	Panasonic
R22	1	22.6 k	RES, 22.6 k, 1%, 0.1 W, 0603	603	RC0603FR-0722K6L	Yageo
R23	1	56.2 k	RES, 56.2 k, 1%, 0.1 W, 0603	603	RC0603FR-0756K2L	Yageo

Table 7-1. Bill of Materials (continued)

DESIGNATOR	QTY	VALUE	DESCRIPTION	PACKAGE REFERENCE	PART NUMBER	MANUFACTURER
R24	1	41.2 k	RES, 41.2 k, 1%, 0.1 W, 0603	603	RC0603FR-0741K2L	Yageo
SH-J1, SH-J2, SH-J3, SH-J4	4		Single Operation 2.54mm Pitch Open Top Jumper Socket	2.54mm	M7582-05	Harwin
TP1, TP2, TP6, TP7	4		Test Point, Miniature, Red, TH	Red Miniature	5000	Keystone
TP3	1		Test Point, Miniature, SMT	Miniature	5015	Keystone
TP4, TP5, TP8, TP9	4		Test Point, Miniature, Black, TH	Black Miniature	5001	Keystone
U1	1		Automotive Low-IQ Synchronous Boost Controller for Start-stop	VQFN20	LM5152QRGRRQ1	Texas Instruments
C1	0	2200 pF	CAP, CERM, 2200 pF, 100 V, ±10%, X7R, 0603	603	GRM188R72A222KA01D	MuRata
C27, C28	0	0.1 µF	CAP, CERM, 0.1 µF, 100 V, ±10%, X7R, AEC-Q200 Grade 1, 0603	603	GCJ188R72A104KA01D	MuRata
C30	0	0.1 µF	CAP, CERM, 0.1 µF, 50 V, ±10%, X7R, 0603	603	C1608X7R1H104K080AA	TDK
C41	0	100 pF	CAP, CERM, 100 pF, 50 V, ±1%, C0G/NP0, 0603	603	C0603C101F5GACTU	Kemet
L1	0	1 µH	Inductor, Shielded, Composite, 1 µH, 21.8 A, 0.00455 Ω, SMD	XAL7030	XAL7030-102MEB	Coilcraft
Q2	0	60 V	MOSFET, N-CH, 60 V, 100 A, AEC-Q101, SO-8FL	SO-8FL	NVMFS5C645NLWFAFT1G	ON Semiconductor
Q3	0	60 V	MOSFET, N-CH, 60 V, 17 A, AEC-Q101, SO-8FL	SO-8FL	NVMFS5C670NLWFAFT1G	ON Semiconductor
R1	0	2	RES, 2.00, 1%, 0.5 W, AEC-Q200 Grade 0, 1210	1210	ERJ-14BQF2R0U	Panasonic
R3	0	0.003	RES, 0.003, 1%, 3 W, AEC-Q200 Grade 0, 2512 WIDE	2512 WIDE	KRL6432E-M-R003-F-T1	Susumu Co Ltd
R7	0	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	ERJ-3GEY0R00V	Panasonic
R9	0	2	RES, 2.0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW06032R00JNEA	Vishay-Dale
R17	0	80.6k	RES, 80.6 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW060380K6FKEA	Vishay-Dale

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