LM60440AQEVM User's Guide

The Texas Instruments LM60440AQEVM evaluation module helps designers evaluate the operation and performance of the LM60440-Q1 wide-input buck converters. The LM60440-Q1 is an easy-to-use synchronous step-down DC/DC converter capable of driving up to 4.0 A of load current from an input voltage of up to 36 V. The LM60440AQEVM features an adjustable output voltage of 5 V and a switching frequency of 400 kHz. See the *LMR60440-Q1 3.8-V to 36-V, 4-A Synchronous Step-down Voltage Converter Data Sheet* data sheets for additional features, detailed descriptions, and available options.

Table 1. Device and Package Configurations

EVM	U1	FREQUENCY	CURRENT
LM60440AQEVM	LM60440AQRPKRQ1	400 kHz	4.0 A

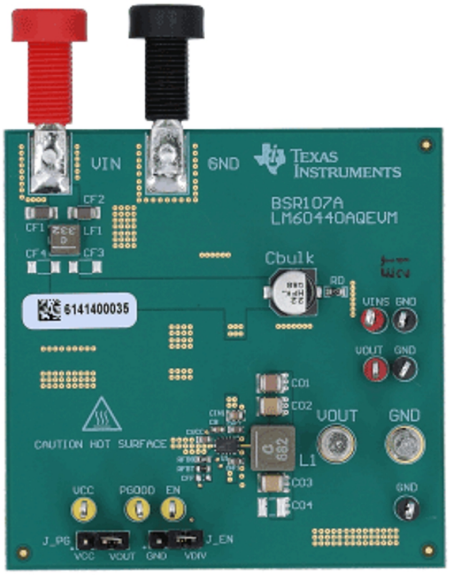

Figure 1. LM60440AQEVM Board

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1 Setup

This section describes the test points and connectors on the EVM and how to properly connect, set up, and use the LM60440AQEVM.

1.1 Test Points

The test points on the top of the board can be used for connecting to the input and output of the EVM. See Figure 2 for typical test setup. The functions of the test points connections are:

- **VIN --** Input supply to EVM including an EMI filter. Connect to a suitable input supply. Connect at this point for conducted EMI test.
- **VINS --** Input voltage sense to the IC. Connect to a DMM to measure input voltage after EMI filter.
- **VOUT --** Output voltage of EVM. Connect to a desired load.
- **VOUTS --** Output voltage sense test point. This test point is a direct short to VOUT. Connecte to a DMM to measure the output voltage.
- **GND --** Ground connections for the input supply, desired load, or test points.
- **VCC --** This test point is connected to the VCC pin. Connect to a DMM to monitor VCC regulation.
- **EN --**This test point is connected to the EN pin. By default, a resistor divider (REN1 and REN2) from VIN is used to enable the IC.
- **PGOOD --** This test point is connected to the PGOOD pin from the IC. It is an open-drain output of the PGOOD pin. Can be tied to external supply through a pullup resistor or left open.

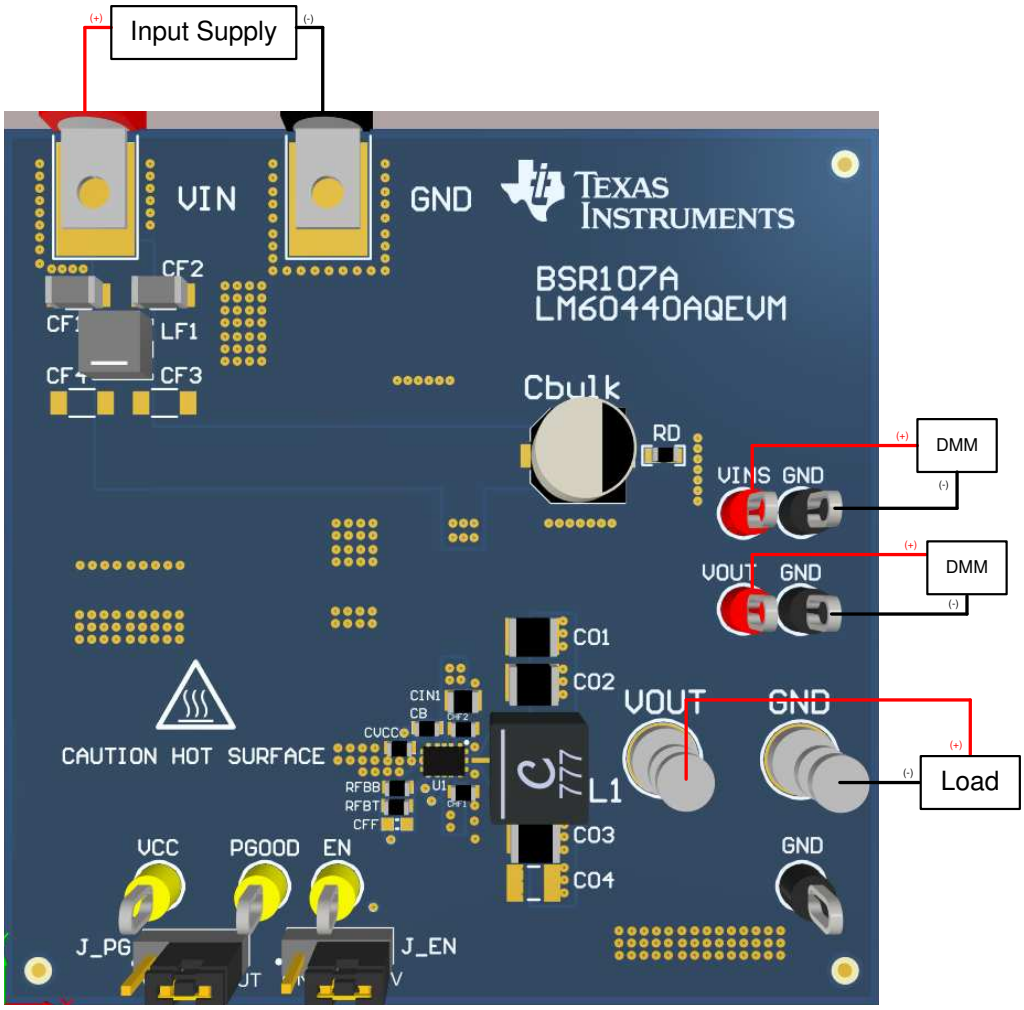

Figure 2. EVM Board Connections

1.2 Jumpers and Test Points

See Figure 3 for jumper locations.

- **J_EN -** This jumper allows the ENABLE input to be connected to GND in order to disable the IC. By default, a resistor divider (REN1 and REN2) from VIN is used to enable the IC.
- **J_PG -** Use this jumper to select how the PGOOD pin can be connected. By default, a jumper connects the pin with a pullup resistor to the output voltage.

Figure 3. Jumper Locations

2 Operation

2.1 Quick Start

1. Connect the voltage supply between VIN and GND banana jacks inputs.
2. Connect the load between VOUT and GND test points.
3. Set the supply voltage at an appropriate level between 4.8 V to 36 V. Set the current limit of the supply to an appropriate level.
4. Turn on the power supply. With the default configuration, the EVM powers up and provides V_{OUT} = 5 V.
5. Monitor the output voltage. The maximum load current must be 4.0 A with the LM60440-Q1 device.

3 Schematic

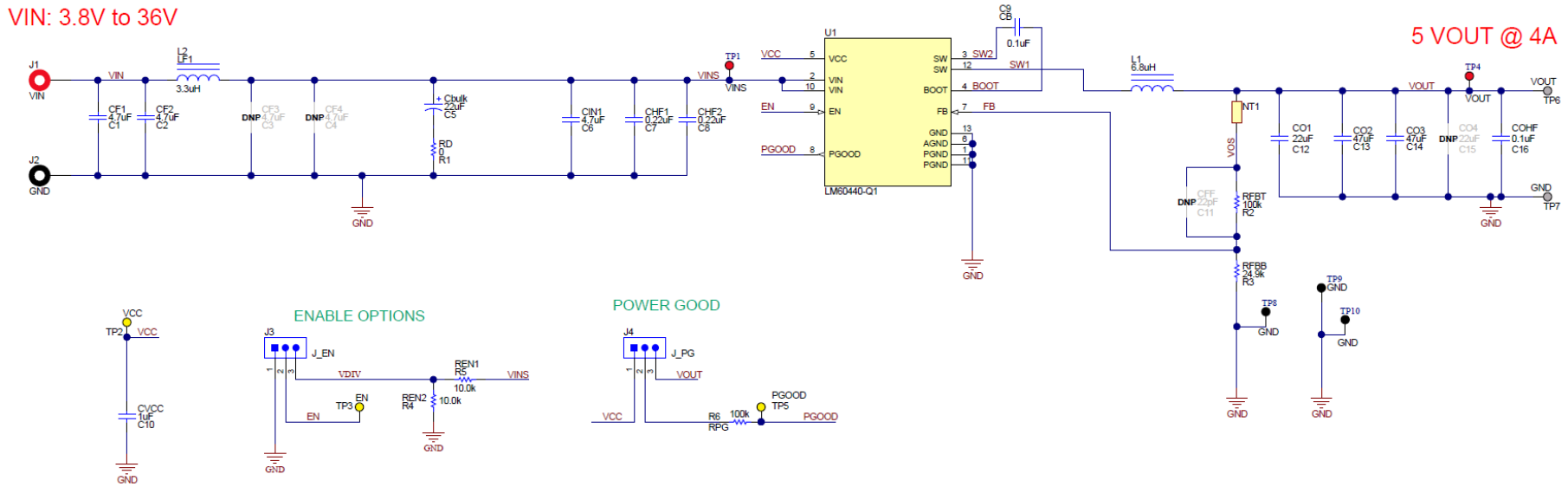

Figure 4. LM60440AQEVM Schematic

4 Board Layout

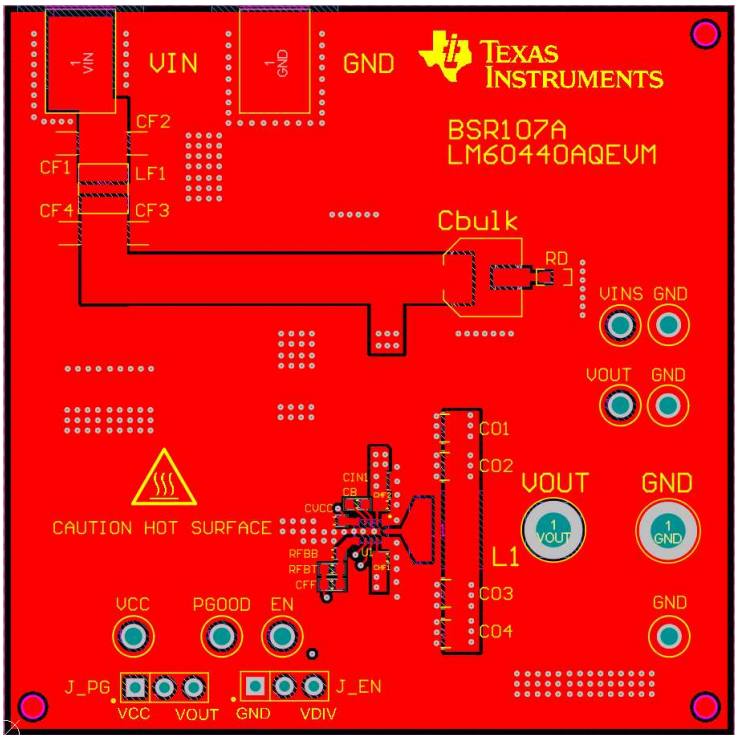

Figure 5. Top View of EVM

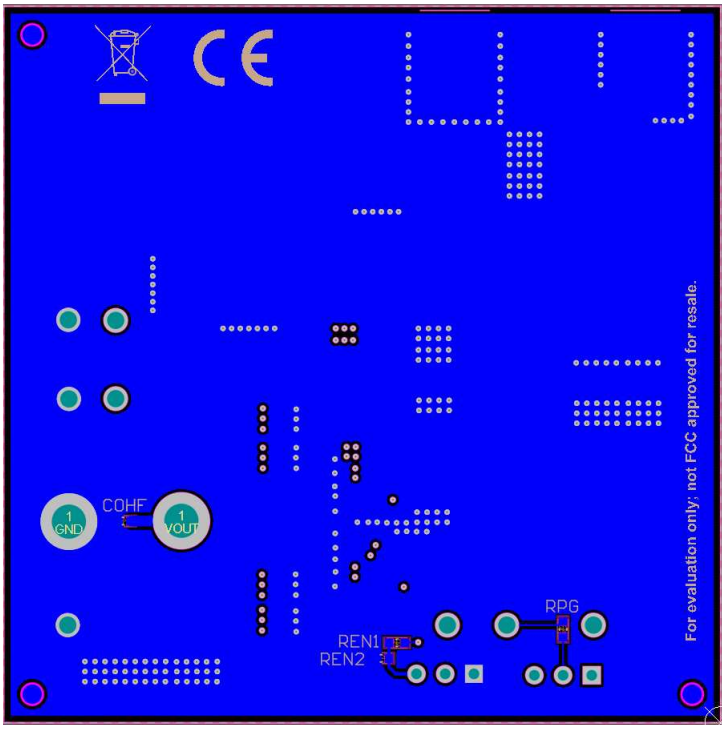

Figure 6. Bottom View of EVM

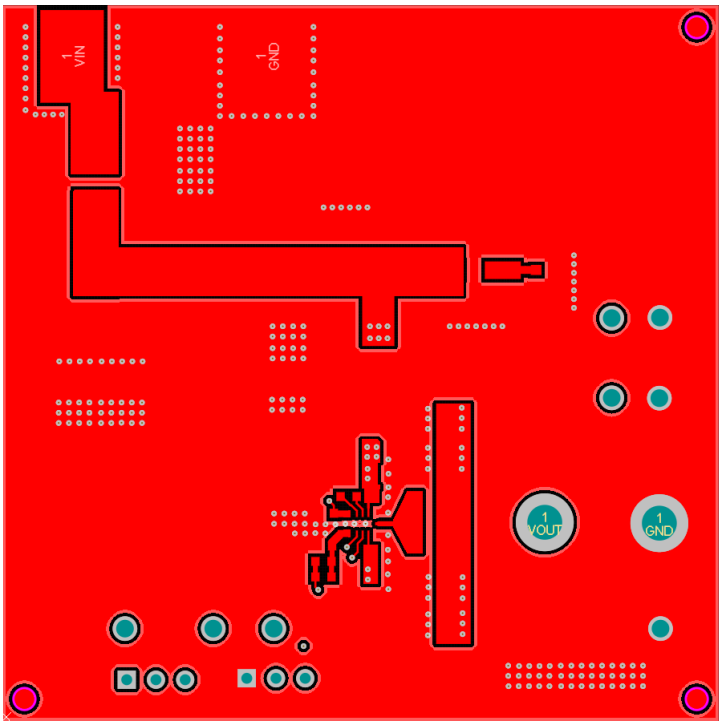

Figure 7. EVM Top Copper Layer

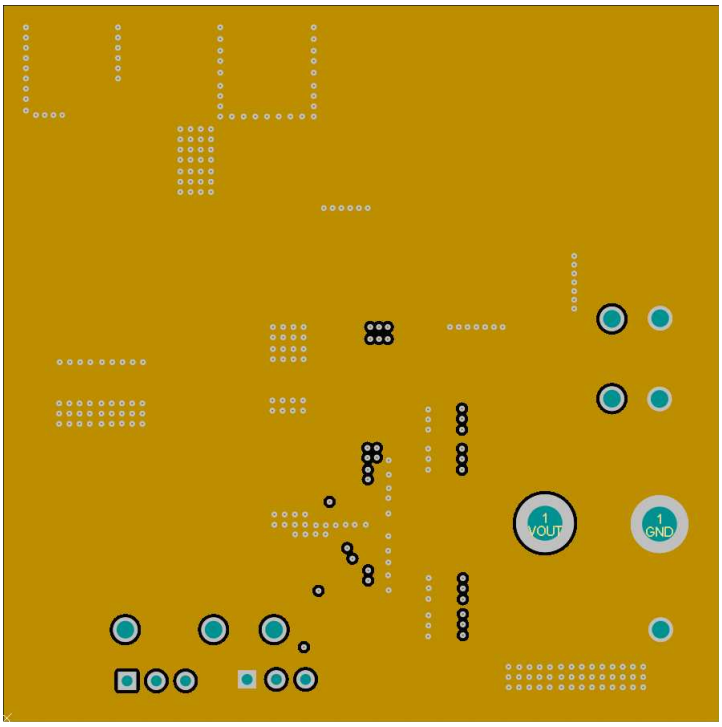

Figure 8. EVM Mid Layer One

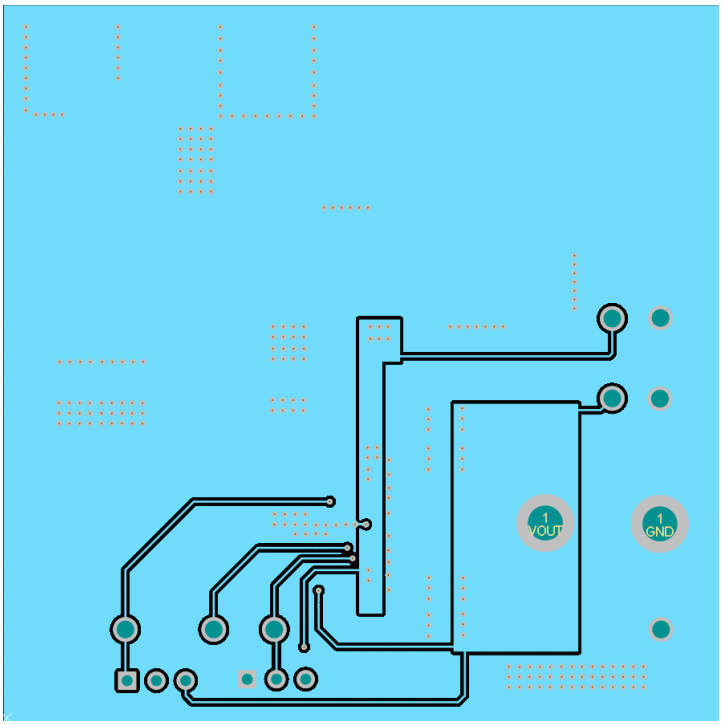

Figure 9. EVM Mid Layer Two

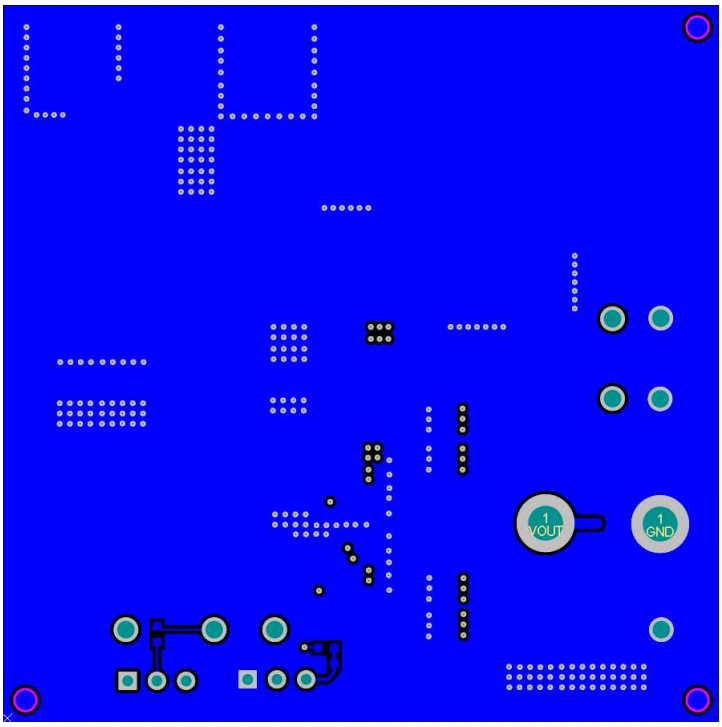

Figure 10. EVM Bottom Copper Layer

5 Bill of Materials

Table 2. Bill of Materials

DESIGNATOR	COMMENT	DESCRIPTION	PART NUMBER	MANUFACTURER	QUANTITY
C1, C2	CF1, CF2	CAP, CERM, 4.7 µF, 50 V, ±10%, X7R, 1206	GRM31CR71H475KA12L	MuRata	2
C5	Cbulk	CAP, AL, 22 µF, 50 V, ±20%, 0.88 Ω, AEC-Q200 Grade 2, SMD	EEE-FK1H220P	Panasonic	1
C6	CIN1	CAP, CERM, 4.7 µF, 50 V, ±10%, X5R, 0805	C2012X5R1H475K125AB	TDK	1
C7, C8	CHF1, CHF2	CAP, CERM, 0.22 µF, 50 V, ±10%, X7R, 0603	C1608X7R1H224K080AB	TDK	2
C9, C16	CB, COHF	CAP, CERM, 0.1 µF, 25 V, ±10%, X7R, 0603	06033C104KAT2A	AVX	2
C10	CVCC	CAP, CERM, 1 µF, 25 V, ±10%, X7R, 0603	885012206076	Wurth Elektronik	1
C12	CO1	CAP, CERM, 22 µF, 25 V, ±10%, X5R, 1210	CL32A226KAJNNNE	Samsung Electro-Mechanics	1
C13, C14	CO2, CO3	CAP, CERM, 47 µF, 16 V, ±10%, X5R, 1210	GRM32ER61C476KE15L	MuRata	2
J1	VIN	Standard Banana Jack, Insulated, Red	6091	Keystone	1
J2	VOUT	Standard Banana Jack, Insulated, Black	6092	Keystone	1
J3, J4	J_EN, J_PG	Header, 100 mil, 3x1, Gold, TH	HTSW-103-07-G-S	Samtec	2
L1	L1	Inductor, Shielded, Composite, 6.8 µH, 9 A, 0.0208 Ω, AEC-Q200 Grade 1, SMD	XAL6060-682MEB	Coilcraft	1
L2	LF1	Inductor, Shielded, Composite, 3.3 µH, 5.5 A, 0.026 Ω, SMD	XAL4030-332MEB	Coilcraft	1
R1	RD	RES, 0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	RMCF0603ZT0R00	Stackpole Electronics Inc	1
R2	RFBT	RES, 100 k, 1%, 0.1 W, 0603	RC0603FR-07100KL	Yageo	1
R3	RFBB	RES, 24.9 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW060324K9FKEA	Vishay-Dale	1
R4, R5	REN1, REN2	RES, 10.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW060310K0FKEA	Vishay-Dale	2
R6	RPG	RES, 100 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW0603100KFKEA	Vishay-Dale	1
SH-J1, SH-J2	SNT-100-BK-G	Shunt, 100 mil, Gold plated, Black	SNT-100-BK-G	Samtec	2

Table 2. Bill of Materials (continued)

DESIGNATOR	COMMENT	DESCRIPTION	PART NUMBER	MANUFACTURER	QUANTITY
TP1, TP4	VINS, VOUTS	Test Point, Multipurpose, Red, TH	5010	Keystone	2
TP2, TP3, TP5	VCC, EN, PGOOD	Test Point, Multipurpose, Yellow, TH	5014	Keystone	3
TP6, TP7	VOUT, GND	Terminal, Turret, TH, Double	1503-2	Keystone	2
TP8, TP9, TP10	GND	Test Point, Multipurpose, Black, TH	5011	Keystone	3
U1	LM60440AQRPKRQ1	LM60440-Q1, RPK0013A (VQFN-12)	LM60440AQRPKRQ1	Texas Instruments	1
C3, C4	CF3, CF4	CAP, CERM, 4.7 µF, 50 V, ±10%, X7R, 1206	GRM31CR71H475KA12L	MuRata	0
C11	CFF	CAP, CERM, 22 pF, 50 V, ±5%, C0G/NP0, 0603	GRM1885C1H220JA01D	MuRata	0
C15	CO4	CAP, CERM, 22 µF, 25 V, ±10%, X5R, 1210	CL32A226KAJNNNE	Samsung Electro-Mechanics	0
FID1, FID2, FID3, FID4, FID5, FID6	Fiducial	Fiducial mark. There is nothing to buy or mount.	N/A	N/A	0

6 Test Results (Preliminary)

Section 6.1 details the test results from the LM60440AQEVM variant.

6.1 LM60440AQEVM Test Results

The LM60440AQEVM variant is used for all figures from Figure 12 to Figure 20.

6.1.1 Efficiency and Load Regulation

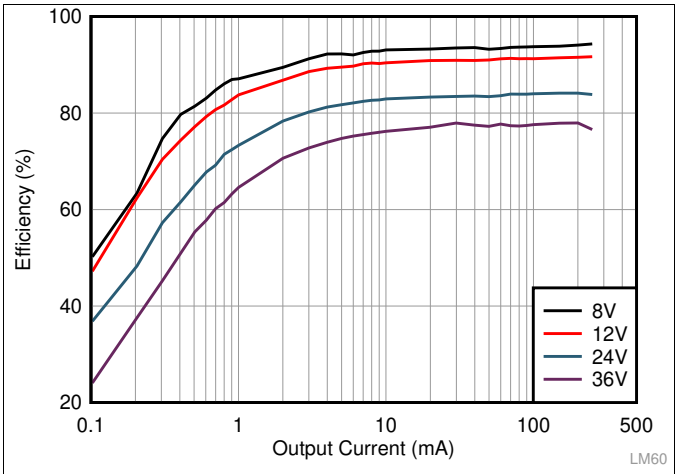

Figure 11. LM60440AQEVM 5 V_{OUT} Low Load Efficiency

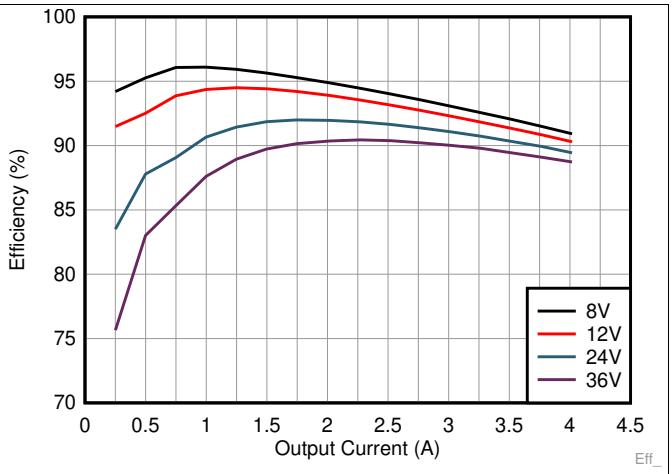

Figure 12. LM60440AQEVM 5 V_{OUT} High Load Efficiency

6.1.2 Start-up and Load Regulation

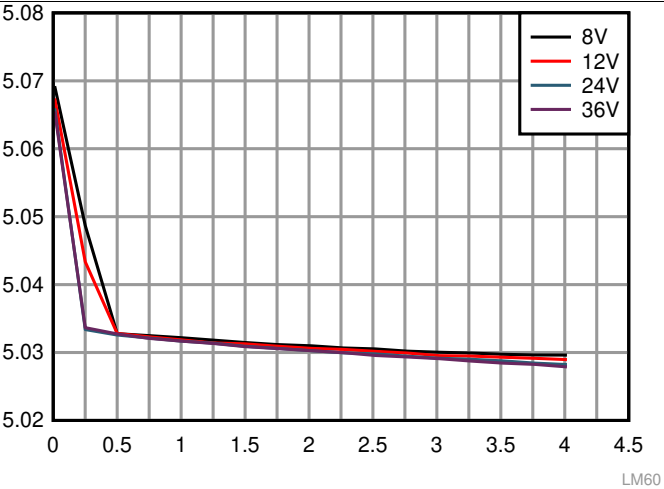

Figure 13. LM60440AQEVM 5 V_{OUT} Load Regulation

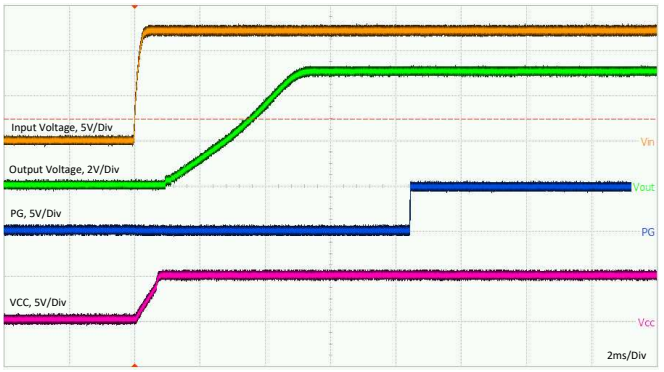

Figure 14. LM60440AQEVM 5 V_{OUT}, 4 A Load Start-up

6.1.3 Load Transients

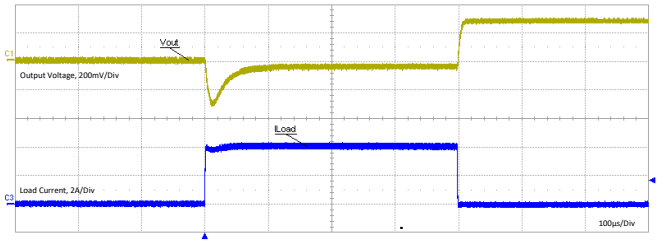

Figure 15. LM60440AQEVM Load Transient
12 V_{IN}, 5 V_{OUT}, I_{OUT} = 0 A to 4 A, T_R = T_F = 4 µs
CH1 = VOUT, CH3 = IOUT

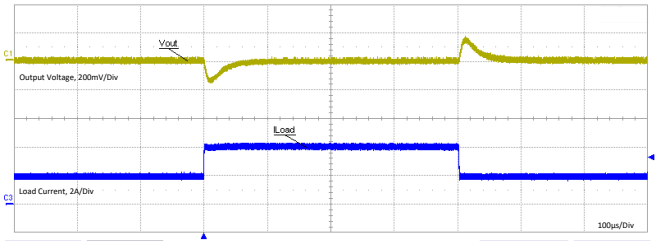

Figure 16. LM60440AQEVM Load Transient
12 V_{IN}, 5 V_{OUT}, I_{OUT} = 0 A to 2 A, T_R = T_F = 2 µs
CH1 = VOUT, CH3 = IOUT

6.1.4 Thermal Picture

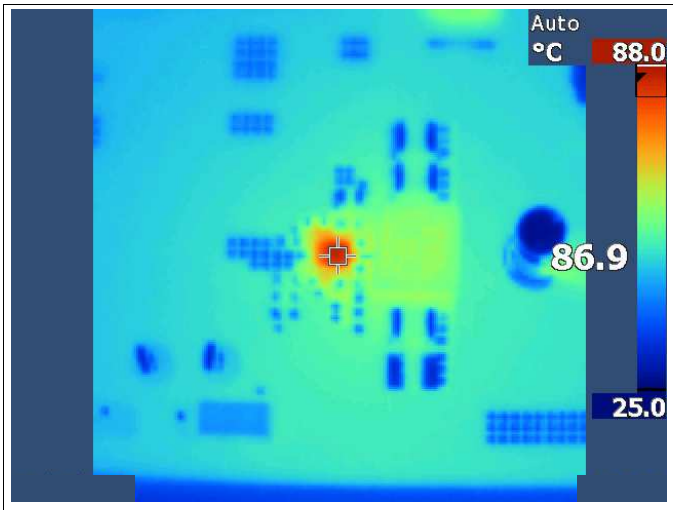

Figure 17. LM60440AQEVM 5 V_{OUT} Thermal Capture,
12 V_{IN}, 4 A Load, 400 kHz

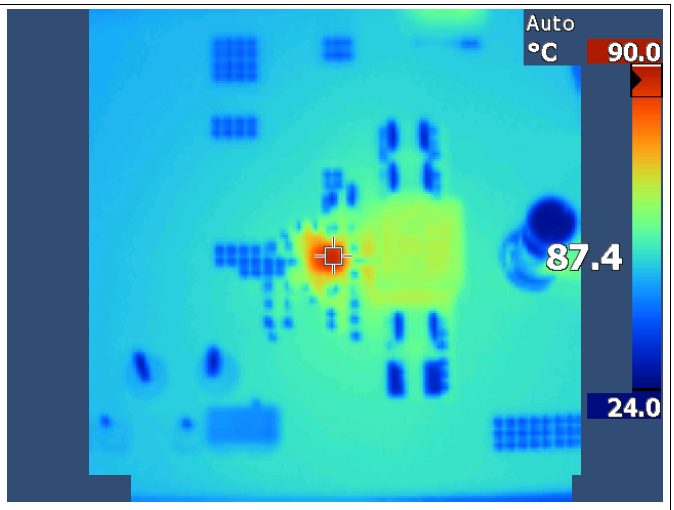

Figure 18. LM60440AQEVM 5 V_{OUT} Thermal Capture,
24 V_{IN}, 4 A Load, 400 kHz

6.1.5 Conducted EMI

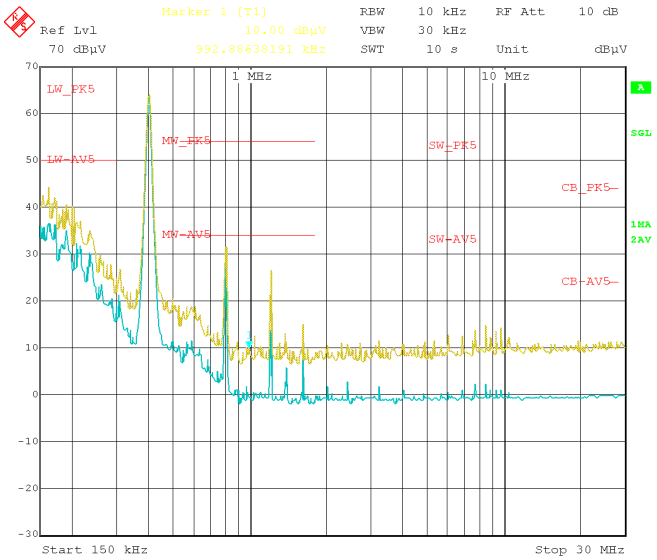

Figure 19. LM60440AQEVM Low Frequency Conducted EMI Results
13.5 V_{IN}, 5 V_{OUT}, I_{OUT}= 4 A
(Blue-Average and Yellow-Peak)

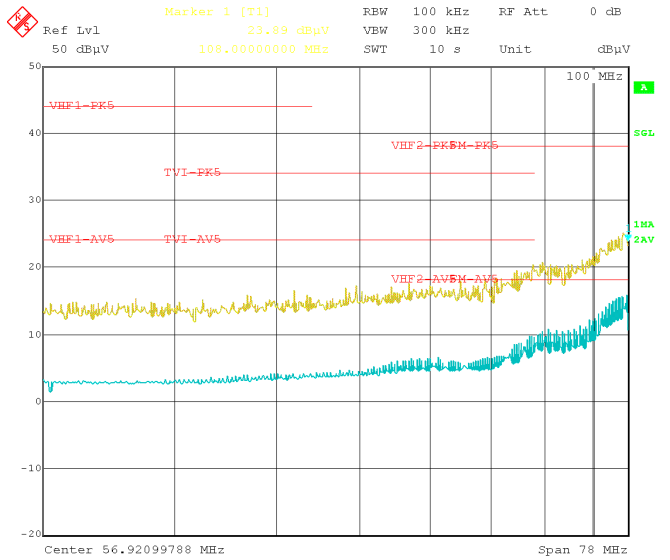

Figure 20. LM60440AQEVM High Frequency Conducted EMI Results
13.5 V_{IN}, 5 V_{OUT}, I_{OUT}= 4 A
(Blue-Average and Yellow-Peak)

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