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ABSTRACT

The LMQ62440-Q1 evaluation module (EVM) is designed to help you evaluate the performance of the LMQ62440-Q1 synchronous, step-down voltage converter. This EVM implements the LMQ62440-Q1 in a 14-pin wettable flank Hotrod™ package (VQFN-HR). It achieves best-in-class EMI performance due to the integrated VIN bypass capacitors, low-inductance and symmetrical package, spread spectrum scheme, and dedicated optional slew rate control. The LMQ62440-Q1 is capable of delivering up to 4 A with exceptional efficiency and output accuracy in a very small solution size. The EVM was optimized for EMI and thermal performance in a reasonable fashion, such that the layout practices can be replicated in your own application.

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1 Introduction

1.1 LMQ62440-Q1 Synchronous Step-Down Voltage Converter

The LMQ62440-Q1 device is capable of driving up to 4 A of load current from a supply voltage ranging from 3 V to 36 V. The LMQ62440-Q1 is a peak current mode controlled device. The following are additional features that provide both flexible and easy-to-use solutions for a wide range of applications:

- Integrated VIN bypass capacitors to achieve exceptional EMI performance, even in optimization-constrained layouts
- Factory programmed 2.1-MHz switching frequency
- Synchronization to an external clock
- Pin-selectable forced pulse width modulation mode (FPWM) for constant frequency operation
- Pin-selectable auto mode for improved light load efficiency
- Pin-selectable spread spectrum enable/disable
- Power-good flag
- Precision enable for programmable undervoltage lockout
- Automatic frequency foldback at light load and optional external bias to improve efficiency over the entire load range
- Package optimized for low noise and easy thermal management

Protection features include the following:

- Thermal shutdown
- Input undervoltage lockout
- Cycle-by-cycle current limiting
- Hiccup short-circuit protection

The pin configuration of the LMQ62440-Q1 is shown in [Figure 1-1](#) and the application circuit is shown in [Figure 1-2](#). Refer to the [LMQ62440-Q1 Automotive 3-V to 36-V, 4-a, Low-Noise Synchronous Step-Down Converter Data Sheet](#) for more detailed feature descriptions and design guide.

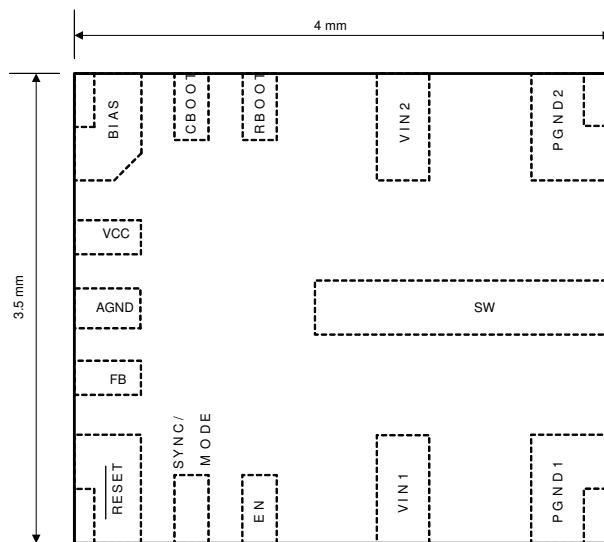


Figure 1-1. LMQ62440-Q1 Pin Configuration (14-Pin WQFN-HR Package Top View)

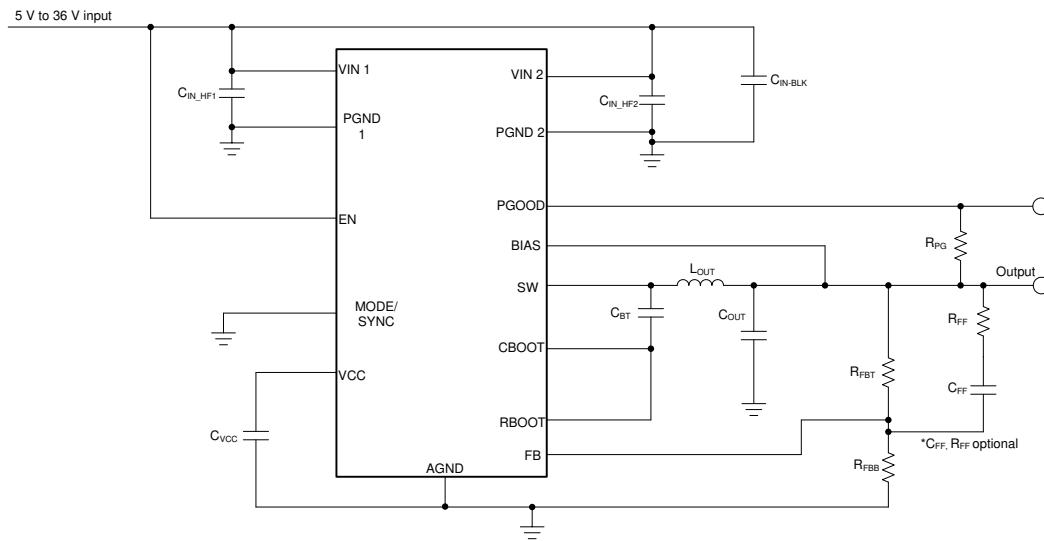


Figure 1-2. LMQ62440-Q1 Application Circuit

2 Quick Start

1. Connect the input voltage supply between the VIN and GND connectors or between VIN_EMI and GND_EMI to include the on-board input filter in the input path. Use short and thick gauge wires to minimize inductance and I-R drop. Note that current-limited sense points for VIN (VINS) and VOUT (VOUTS) are provided. **Do not** connect input voltage supply to VINS, as series current-limiting resistor has low power rating.
2. Connect the load of the converter between VOUT and GND connectors using short and thick wires. **Do not** connect load to VOUTS, as series current-limiting resistor has low power rating.
3. Set the supply voltage between 3 V to 36 V. Account for dropout of converter by setting supply to approximately 6 V to have 5 V output, as an example.
4. Set the current limit of the supply to an appropriate level to supply needed current and protection.
5. Turn on the power supply. With the default configuration, the EVM powers up and provides VOUT = 5 V.
6. Monitor the output voltage. The maximum (DC) load current is 4 A with the LMQ62440-Q1.

See [Figure 2-1](#) for the location of the connectors.

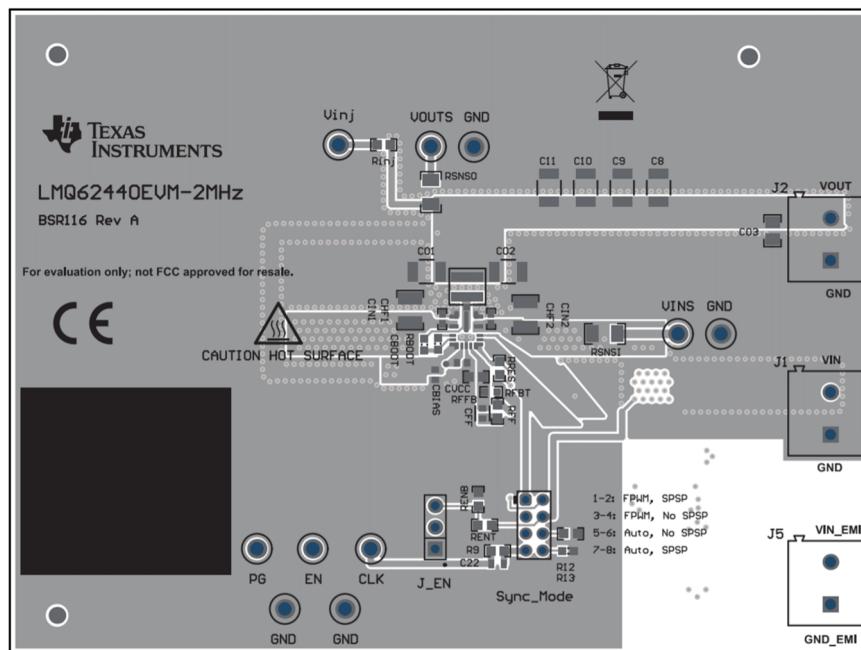


Figure 2-1. Top Component View of LMQ62440EVM-PP-2MHz

3 Detailed Descriptions

This section describes the connectors on the EVM and how to properly connect, set up, and use the EVM. See [Figure 2-1](#) for a top view of the EVM.

VOUT	Output voltage of the converter
	Connect the load between the VOUT connector and the GND. Connect the loading device with short, thick wires to handle the required output current. For measuring output ripple, measurement should done across the output capacitor with low inductance ground loop on probe, or active probe.
GND	Ground of the converter
	The GND connections next to VIN, VIN_EMI, and VOUT connectors are meant for current return path for the supply voltage and load, respectively. Other GND connectors are for signal measurement and probing.
VIN	Input voltage to the converter
	Connect the power supply between VIN and GND connectors as power input to the device. The voltage range must be higher than 3.9 V for the device to start up. VIN higher than 6 V provides regulated 5-V output voltage. VIN must be no higher than 36 V to avoid damaging the device. After start-up, the device stays active until VIN drops below 3 V. The current limit on the supply must be high enough to provide the needed supply current. Otherwise, the supply voltage will not maintain the desired voltage. The supply voltage must be connected to the board with short and thick wires to handle the pulsing input current. If long cables are used to power up the board, damping must be provided by adding CFLT3 and RFLT3 to avoid oscillation between the cable parasitic inductance and the low-ESR ceramic capacitors.
VIN-EMI	Input voltage to input filter of the converter
	If the input filter is desired between the input supply and the LMQ62440-Q1, connect the supply voltage between VIN_EMI and GND_EMI. The supply voltage must be connected to the board with short and thick wires to handle pulsing input current. The input filter consists of the following: CF1, CF2, CF3, CF4, and LF1. CD1 and RD1 are provided as placeholders for a possible damping network. The output of the filter is connected to VIN, which is connected to the VIN pins of the LMQ62440-Q1 and the input capacitors. Conducted EMI arises from the normal operation of switching circuits. The ON and OFF actions of the power switches generate large discontinuous currents. The discontinuous currents are present at the input side of buck converters. Voltage ripple generated by discontinuous currents can be conducted to the voltage supply for the buck converter. Without filtering, excessive input voltage ripple can compromise operation of other circuits connected to this source. The input filter helps smooth out the voltage perturbations leading to less noise at the power source.
GND-EMI	Ground return for the input filter
	This is the current return path for the supply connected to VIN_EMI. It provides a short-loop connection to the input filter capacitors to best filter the conducted noise generated from the PCB. Use the VIN_EMI and GND_EMI connection if a conducted EMI test is desired.
CLK	For clock synchronization
	The CLK input connector is designed for external clock input to the MODE/SYNC pin. Switching action of the buck is synchronized to the external clock when it is present. The operation mode changes to forced PWM mode and disables spread spectrum automatically, maintaining a constant switching frequency at light load. This signal must be at least 3.3 Vpp, but not exceed the pin absolute maximum voltage rating. Refer to the LMQ62440-Q1 Automotive 3-V to 36-V, 4-a, Low-Noise Synchronous Step-Down Converter Data Sheet for more detailed timing information.
EN	Test point to monitor the EN pin of the device

This test point is used to monitor the voltage on the device EN pin. By default, the EN pin is connected to the mid-point of an enable divider. Note that the lower resistor in this divider, RENB, is not populated since it affects input bias current.

PG Test point to monitor the PGOOD pin

The PGOOD flag indicates whether the output voltage is within the regulation band. The PGOOD pin of the device is an open-drain output and it is pulled up to VOUT on this board through a pullup resistor. This flag is high impedance when the output voltage is in regulation.

Vinj To aid when making bode plots

There is a low value resistor, Rinj, between VOUT and this node. This feedback divider of the board is connected to this node as well. Stimulus can be applied between this node and VOUT when taking measurements for bode plots.

VOUTS Kelvin sensing for VOUT

This connector is provided to allow VOUT to be measured more easily. For measuring output ripple, measurement must done across output capacitor with low inductance ground loop on probe, or active probe.

VINS Kelvin sensing for VIN

This connector is provided to allow VIN to be measured more easily.

4 EVM Performance

4.1 Board Efficiency, Load Regulation, Transient, and Steady-state Curves

See the applications section of the [LMQ62440-Q1 Automotive 3-V to 36-V, 4-a, Low-Noise Synchronous Step-Down Converter Data Sheet](#) for typical performance curves taken on the EVM with their respective component selection listed.

4.2 EMI Test Results

See the applications section of the [LMQ62440-Q1 Automotive 3-V to 36-V, 4-a, Low-Noise Synchronous Step-Down Converter Data Sheet](#) for EMC results. Data shown was taken in a Texas Instruments EMI lab, which is not CISPR certified, though shows strong correlation to CISPR compliant labs for conducted EMI measurements.

4.3 Thermal Picture

Figure 4-1 captures the thermal performance of the board operating at 13.5 VIN, 5 VOUT, with a 4 A load.

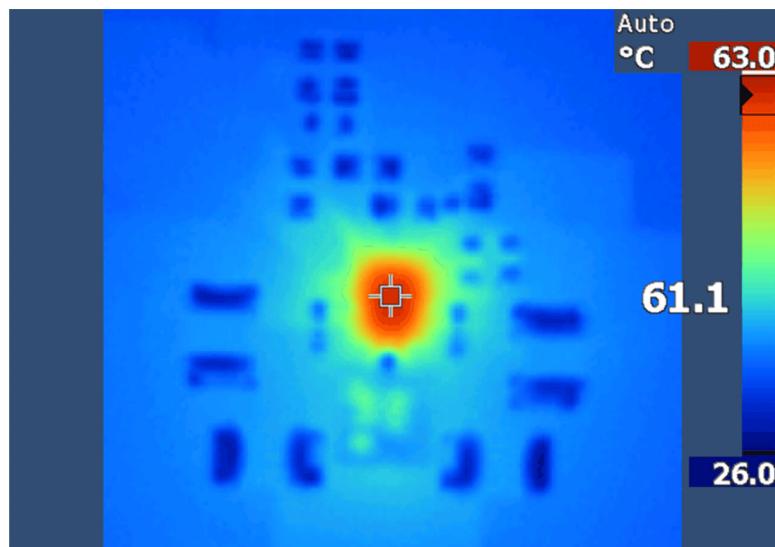


Figure 4-1. Thermal Capture of EVM with 13.5 V Input and 5 V at 4 A Load

5 EVM Schematic Entry

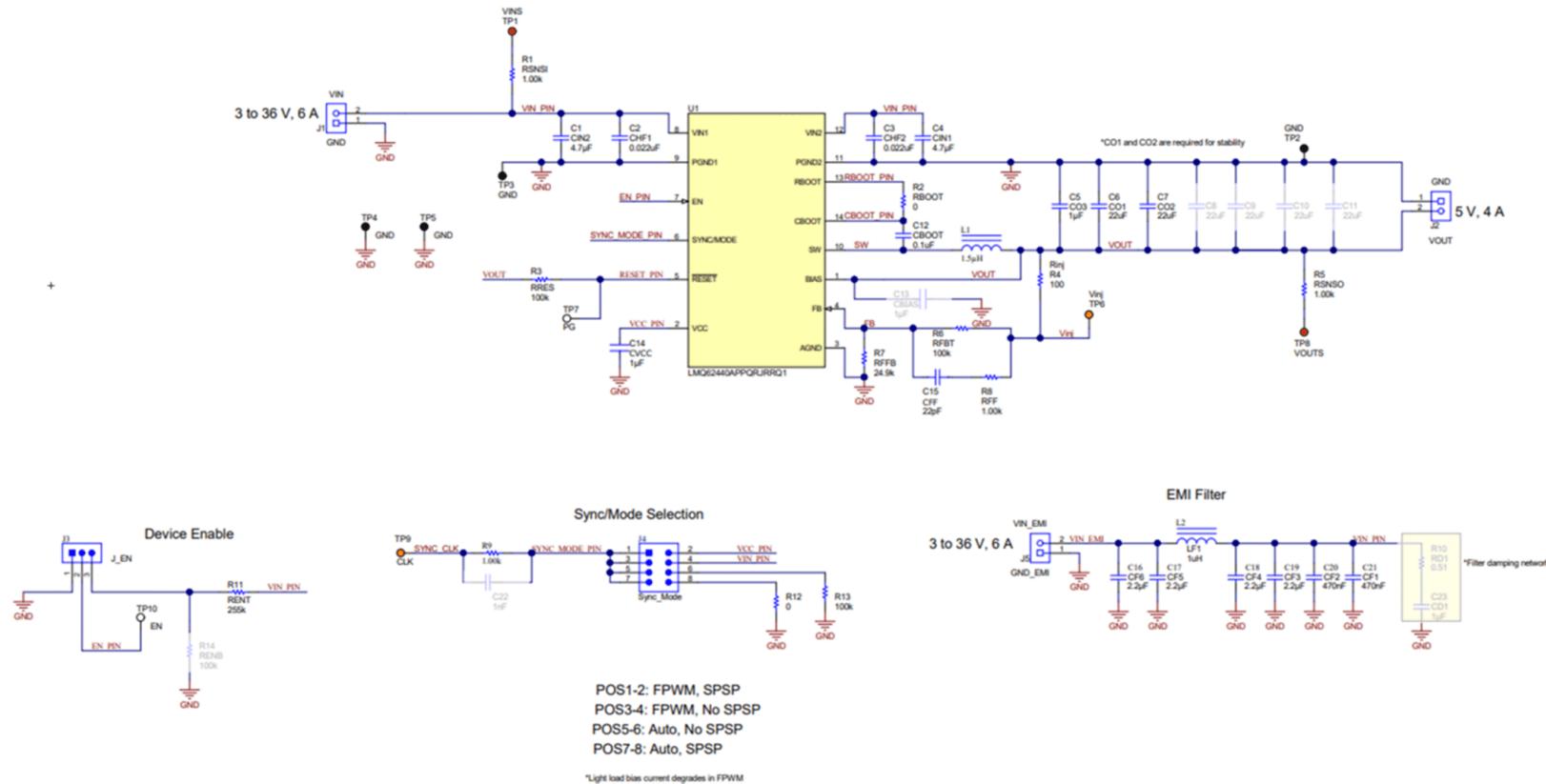


Figure 5-1. LMQ62440EVM-2MHz Schematic

6 Bill of Materials

Table 6-1. LMQ62440EVM-2MHz Bill of Materials

DESIGNATOR	QUANTITY	VALUE	DESCRIPTION	PACKAGE REFERENCE	PART NUMBER	MANUFACTURER
C1, C4	2	4.7 μ F	CAP, CERM, 4.7 μ F, 50 V, \pm 20%, X7R, AEC-Q200 Grade 1, 1210	1210	UMK325B7475MMHT	Taiyo Yuden
C2, C3	2	0.022 μ F	CAP, CERM, 0.022 μ F, 50 V, \pm 10%, X7R, 0402	0402	GRM155R71H223KA12D	MuRata
C5	1	1 μ F	CAP, CERM, 1 μ F, 25 V, \pm 10%, X7R, 0805	0805	C0805C105K3RACTU	Kemet
C6, C7	2	22 μ F	CAP, CERM, 22 μ F, 16 V, \pm 20%, X7R, AEC-Q200 Grade 1, 1210	1210	CGA6P1X7R1C226M250AC	TDK
C12	1	0.1 μ F	CAP, CERM, 0.1 μ F, 10 V, \pm 10%, X7R, 0603	0603	C0603X104K8RACTU	Kemet
C14	1		CAP CER 0603 1UF 10V X7R 10%	0603 (1608 Metric)	C0603C105K8RACAUTO	KEMET
C15	1		C0603 22 pF X7R 30ppm/ $^{\circ}$ C 10.00% 50 V	0603	C0603C220K5RACAUTO	KEMET
C16, C17, C18, C19	4	2.2 μ F	CAP, CERM, 2.2 μ F, 50 V, \pm 10%, X7R, AEC-Q200 Grade 1, 0805	0805	CGA4J3X7R1H225K125AB	TDK
C20, C21	2	0.47 μ F	CAP, CERM, 0.47 μ F, 50 V, \pm 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E3X7R1H474K080AE	TDK
J1, J2, J5	3		Terminal Block, 5 mm, 2x1, Tin, TH	Terminal Block, 5 mm, 2x1, TH	691 101 710 002	Wurth Elektronik
J3	1		Header, 100 mil, 3x1, Gold, TH	Header, 100 mil, 3x1, TH	HTSW-103-07-G-S	Samtec
J4	1		Header, 2 mm, 4x2, Tin, TH	Header, 2 mm, 4x2, TH	TMM-104-03-T-D	Samtec
L1	1	1.5 μ H	Inductor, Shielded, Metal Composite, 1.5 μ H, 5.8 A, 0.019 Ω , SMD	4.1x4.1 mm	74438356015	Wurth Elektronik
L2	1	1 μ H	Inductor, Shielded, 1 μ H, 7.2 A, 0.012 Ω , SMD	4.1x4.1 mm	74438356010	Wurth Elektronik
R1, R5	2	1.00 k	RES, 1.00 k, 1%, 0.25 W, 1206	1206	RC1206FR-071KL	Yageo America
R2, R12	2	0	RES, 0, 5%, 0.1 W, 0603	0603	RC0603JR-070RL	Yageo
R3, R6, R13	3	100 k	RES, 100 k, 1%, 0.1 W, 0603	0603	RC0603FR-07100KL	Yageo
R4	1	100	RES, 100, 1%, 0.1 W, 0603	0603	RC0603FR-07100RL	Yageo
R7	1	24.9 k	RES, 24.9 k, 1%, 0.1 W, 0603	0603	RC0603FR-0724K9L	Yageo
R8	1	1.00 k	RES, 1.00 k, 1%, 0.1 W, 0603	0603	ERJ-3EKF1001V	Panasonic
R9	1	1.00 k	RES, 1.00 k, 1%, 0.1 W, 0603	0603	RC0603FR-071KL	Yageo
R11	1	255 k	RES, 255 k, 1%, 0.1 W, 0603	0603	RC0603FR-07255KL	Yageo
SH-J1, SH-J2	2		Shunt, 100 mil, Gold plated, Black	Shunt 2 pos. 100 mil	881545-2	TE Connectivity
TP1, TP8	2		Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint	5010	Keystone
TP2, TP3, TP4, TP5	4		Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone
TP6, TP9	2		Test Point, Multipurpose, Orange, TH	Orange Multipurpose Testpoint	5013	Keystone
TP7, TP10	2		Test Point, Multipurpose, White, TH	White Multipurpose Testpoint	5012	Keystone
U1	1		Automotive 4 A Low Noise Synchronous Buck Regulators, RJR0014A (VQFN-HR-14)	RJR0014A	LMQ62440APPQRJRRQ1	Texas Instruments
C8, C9, C10, C11	0	22 μ F	CAP, CERM, 22 μ F, 16 V, \pm 20%, X7R, AEC-Q200 Grade 1, 1210	1210	CGA6P1X7R1C226M250AC	TDK
C13	0		CAP CER 0603 1UF 10V X7R 10%	0603 (1608 Metric)	C0603C105K8RACAUTO	KEMET
C22	0	1000 pF	CAP, CERM, 1000 pF, 50 V, \pm 10%, X7R, 0603	0603	C0603C102K5RACTU	Kemet
C23	0	1 μ F	CAP, CERM, 1 μ F, 50 V, \pm 10%, X7R, 0603	0603	UMK107AB7105KA-T	Taiyo Yuden

Table 6-1. LMQ62440EVM-2MHz Bill of Materials (continued)

DESIGNATOR	QUANTITY	VALUE	DESCRIPTION	PACKAGE REFERENCE	PART NUMBER	MANUFACTURER
R10	0	0.51	RES, 0.51, 1%, 0.25 W, 0805	0805	CRM0805-FX-R510ELF	Bourns
R14	0	100 k	RES, 100 k, 1%, 0.1 W, 0603	0603	RC0603FR-07100KL	Yageo

7 Board Layout

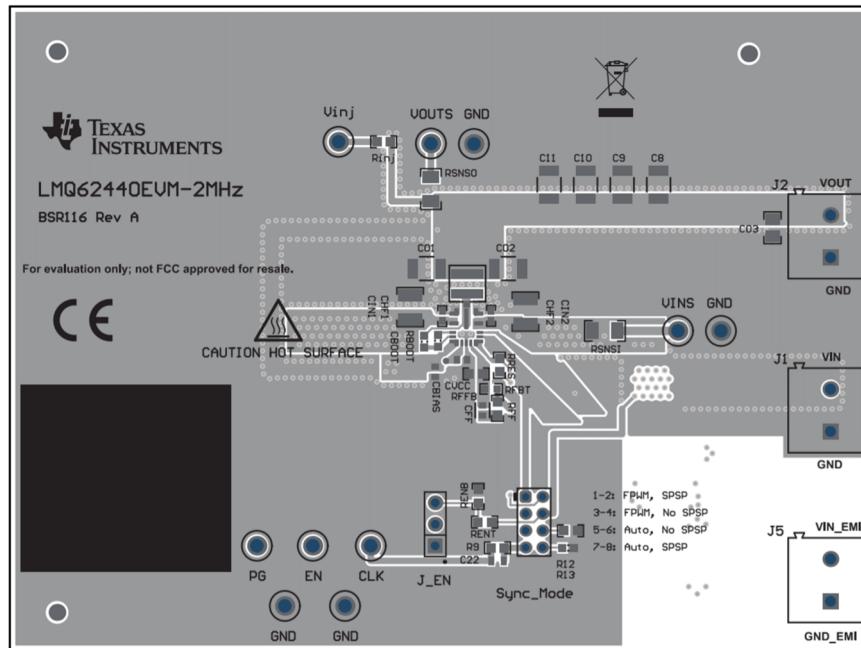


Figure 7-1. Top Component Layer and Silkscreen

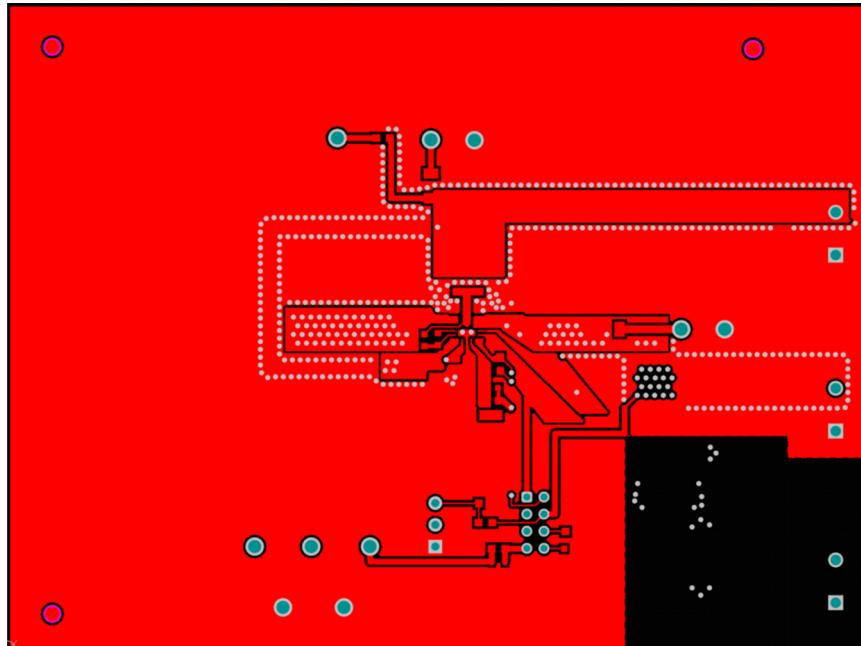


Figure 7-2. Top Layer Routing

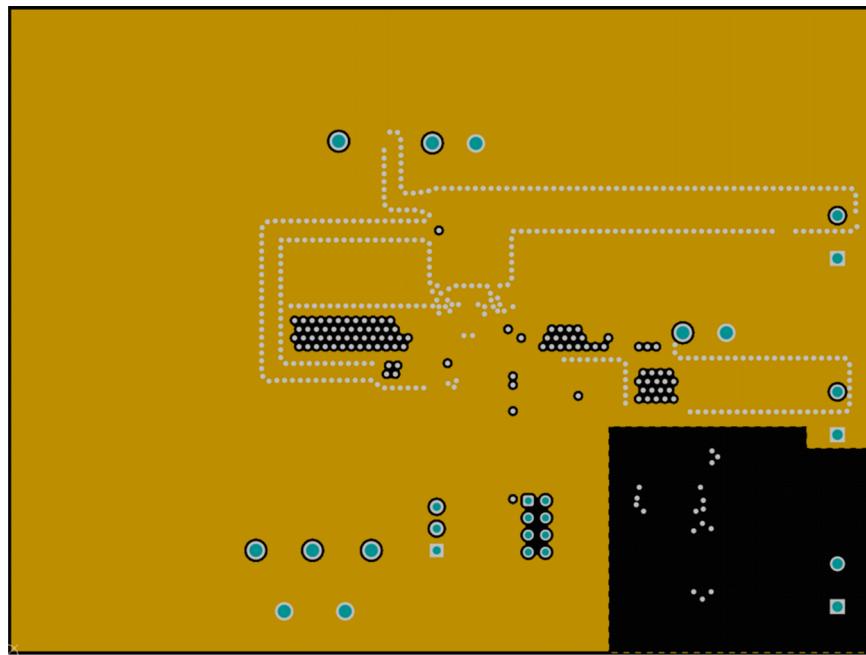


Figure 7-3. Mid-layer 1 Routing

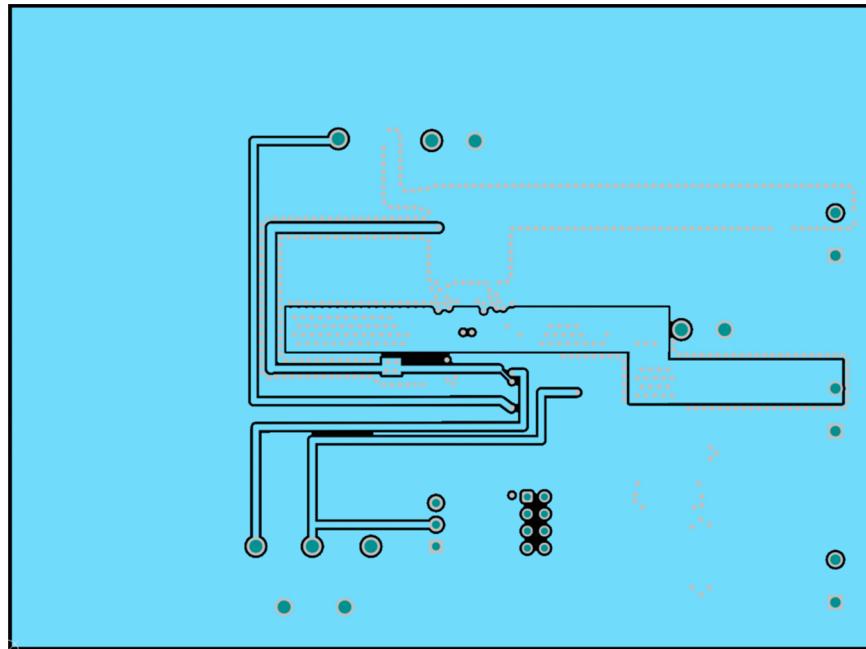


Figure 7-4. Mid-layer 2 Routing

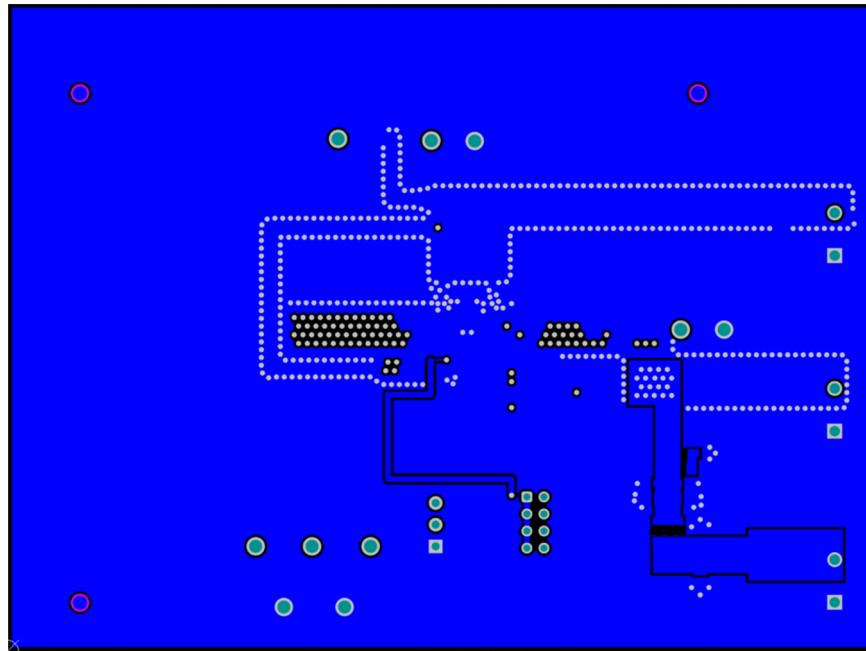


Figure 7-5. Bottom Layer Routing

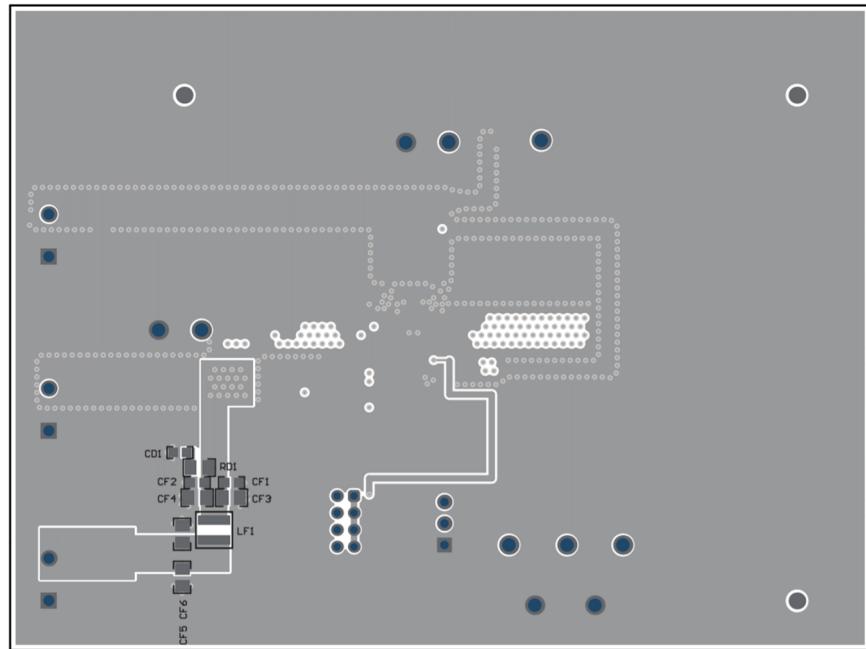


Figure 7-6. Bottom Component Layer and Silkscreen

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