LM5140-Q1 Evaluation Module

User's Guide

Texas Instruments

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LM5140-Q1 Evaluation Module

1 Introduction

The LM5140EVM evaluation module helps designers evaluate the operation and performance of the LM5140-Q1 Synchronous Buck Controller. The EVM operates over the input voltage range of 3.8 V to 42 V. The EVM provides two independent outputs, a 3.3-V output with a maximum load current of 6 A, and a 5-V output with a maximum load current of 5 A. The device offers configurability and can be set up to switch at 440 kHz or 2.2 MHz.

2 Features and Performance

This EVM supports the following features and performance capabilities:

- The LM5140-Q1 is qualified to AEC-Q100 grade 1 (–40ºC to 125ºC operating junction temperature)
- V_{IN} 3.8 to 42 V (EVM)
- Two outputs:
    - VOUT1 fixed 3.3 V, 5 V, or adjustable from 1.5 V–15 V
    - VOUT2 fixed 5 V, 8 V, or adjustable from 1.5 V–15 V
- Shutdown mode I_Q: 9 μA
- Low I_Q standby: 35-μA typical (1-channel in regulation, no load)
- The current-limit threshold of VOUT1 and VOUT2 can be externally programmed: 50 mV, or 75 mV
- The outputs can be synchronized to an external clock
- A SYNC output
- A fixed 2.2-MHz, or 440-kHz oscillator frequency
- EN1 enables output 1
- EN2 enables output 2
- Hiccup mode for sustained overload
- Independent power good (PG1 and PG2) signals
- Gate drive with slew rate control for reduced EMI
- Diode emulation or forced pulse-width modulation (FPWM)

Table 1 contains the electrical performance data for this EVM.

Table 1. Electrical Performance

Parameter	Test Condition	MIN	TYP	MAX	Units
Input Characteristics					
Input voltage	3.3-V output	3.8	42		V
Input voltage	5.0-V output	5.5	42		
Output Characteristics					
Output voltage 1	I_{LOAD} = 6 A	3.267	3.3	3.333	V
Output current				6.0	A
Output voltage 2	I_{LOAD} = 5 A	4.95	5.0	5.05	V
Output current				5.0	A
System Characteristics					
Switching frequency		2.0	2.2	2.4	MHz
Full Load efficiency	V_{IN} = 12 V, V_{OUT1} 3.3 V @ 6 A, V_{OUT2} 5.0 V @ 5 A		83.5		%

3 Setup

This section describes the input and output connections to the LM5140EVM, and other functional settings.

3.1 Input/Output Connector Description and Test Points

Table 2 lists the jumper and test point descriptions.

Table 2. Jumper and Test Point Description

Pin Name	Description
J2-1	The + (positive) VIN power for the EVM
J2-2	The – (negative) VIN power for the EVM
TP1	The regulated output voltage for the converter
TP2	The output 1 ground (GND) connection
TP13	The regulated output voltage for the converter
TP14	The output 2 ground (GND) connection
TP3	PG1 an open collector output which goes low if VOUT1 is outside of the regulation window
TP5	EN1 is an active high input (V_{OH} > 2.4 V) enables output 1, or use SW6-1
TP6	SYNCIN the input for an optional external clock. The LM5140 can be synchronized to an external clock; the clock frequency must meet the oscillator guideline, OSC ±15%.
TP7	Use S8 to connect ILSET to VDDA for the 75-mV current-limit threshold, or to ground for the 50-mV current-limit threshold
TP8	VCC test point
TP9	SYNC_OUT is a TTL level output signal 180º out of phase of HO1
TP10	EN2, is an active high input (V_{OH} > 2.4 V) enables Output 2, or use SW6-2
TP11	PG2 is an open collector output which goes low if VOUT1 is outside of the regulation window

Table 3 contains the EVM switch descriptions.

Table 3. Switch Description

Switch	Open/Closed	Description	Comments
VCCX			
S1A	ON	Connect VOUT2 to VCCX	S1A on is the factory default setting
S1B	OFF		

Table 3. Switch Description (continued)

Switch	Open/Closed	Description	Comments
S1A	OFF	Connect VOUT1 to VCCX	
S1B	ON		
VOUT1 Regulation Voltage			
S2A	ON	VOUT1 3.3V	S2A on is the factory default setting
S2B	OFF		
S2C	OFF		
S2A	OFF	Adjustable output	Connect a jumper between J1-1 and J1-2
S2B	ON		
S2C	OFF		
S2A	OFF	VOUT1 5.0V	
S2B	OFF		
S2C	ON		
VOUT2 Regulation Voltage			
S3A	ON	VOUT2 5.0V	S3A on is the factory default setting
S3B	OFF		
S3C	OFF		
S3A	OFF	Adjustable output	Connect a jumper between J10-1 and J10-2
S3B	ON		
S3C	OFF		
S3A	OFF	VOUT2 8.0V	
S3B	OFF		
S3C	ON		
SYNC_IN			
SW4-1	ON	SYNCIN connected to V_{DD}	Disables SYNC_IN
SW4-2	ON	Connects TP6 to the LM5140 SYNCIN pin	Allows an external SYNC_IN factory default setting
SW4-3	ON	SYNCIN to GND	Disables SYNC_IN
FPWM or DEMB			
S5A	ON	FPWM	Better transient response
S5B	OFF		
S5B	OFF	DEMB	For Pre bias start-up
S5B	ON		
Power Good			
S6A	ON	Connects PG1 (through R11) to VCC	Monitor for PG1
S6B	ON	Connects PG2 (through R23) to VCC	Monitor for PG2
EN1 and EN2			
S7-3	ON	EN2	Enables VOUT2
S7-1	OFF	EN2	Disables VOUT2 factory default setting
S9-3	ON	EN1	Enables VOUT2
S9-1	OFF	EN1	Disabled VOUT1 factory default setting
ILSET			
S8-1	ON	ILSET = 75 mV	factory default setting
S8-3	ON	ILSET =50 mV	
S8-2	ON	ILSET open	Do not place SW8 in this position, connect ILSET to VDDA, or GND

3.2 *Setup Input and Loads*

The input voltage range for the EVM is 3.8 V to 42 V. Connect the positive power source lead to J2 (+), and the negative source lead to J2 (–), (refer to Figure 1). If you are using an electronic load, connect the positive load connection to TP1, and the negative load connection to TP2. The EVM output 1 is configured for 3.3 V and is rated for 6.0-A continuous, output 2 is configured for 5.0 V, and is rated for 5-A continuous.

3.3 *Operation*

To properly operate the LM5140-Q1, the ILMIT and SYNCIN pins should not be left floating. The ILIMT pin should be connected to either V_{DD}, or GND by S8 (TP7). If the Sync input is not used (TP6), it should be connected to AGND, by S4 (TP6).

3.4 *Enabling the Outputs*

To enable VOUT1, place switch S9 to the S9-1 position, or connect a jumper from TP5 to V_{IN}. To enable VOUT2, place switch S7 to the S7-1 position, or connect a jumper from TP10 to V_{IN}. The EVM outputs can be enabled prior to applying V_{IN}, or after V_{IN} has been applied to the EVM.

4 Test Equipment

4.1 *Power Supply*

The power supply should be capable of 50 V/10 A.

4.2 *Electronic Loads*

The electronic load should be capable of 10 V/10 A, used in constant current mode.

4.3 *Meters*

One current meter is required to measure input current accurately. The maximum current rating of the meter should be carefully considered. The input current can be as high as 7.5 A at full load current and minimum input voltage. The output voltage is monitored by a voltage meter, which should be capable of measuring to 10 V.

4.4 *Oscilloscope*

Oscilloscope and 10x probe with at least 20-MHz bandwidth is required.

5   Test Setup and Procedure

Please read the LM5140-Q1 datasheet (SNVSA02) before using the EVM. A typical LM5140-Q1 test bench setup is shown in Figure 1. The power supply and the load should be capable of handling the input and output voltage and current rating of the board. **Prior to applying power to the EVM, make sure that Switches S1–S9 are set in the correct position, refer to Table 3.**

- Connect the power and ground connectors VIN (J2+) and GND (J2–) to the power supply.
- Connect an ammeter in series with the input, if needed.
- Connect a DVM from TP1 (+) to TP2 (–).
- Connect a DVM from TP13 (+) to TP14 (–).
- Connect a resistive load or an electronic load across terminals VOUT1 TP1 (+) + and GND (TP2–).
- Connect a resistive load or an electronic load across terminals VOUT2 TP13 (+) and GND (TP14–)
- An ammeter can be inserted in series with the load to observe the load current.
- Refer to Table 3 for the switch setting to enable VOUT1 and VOUT2.
- With the load initially set to no load, set the power supply between 12 V and turn on the power supply. Check for VOUT1 3.3 V and VOUT2 5.0 V at the output.
- Once the output is at the expected target (12 V), increase the load gradually within the operating range.
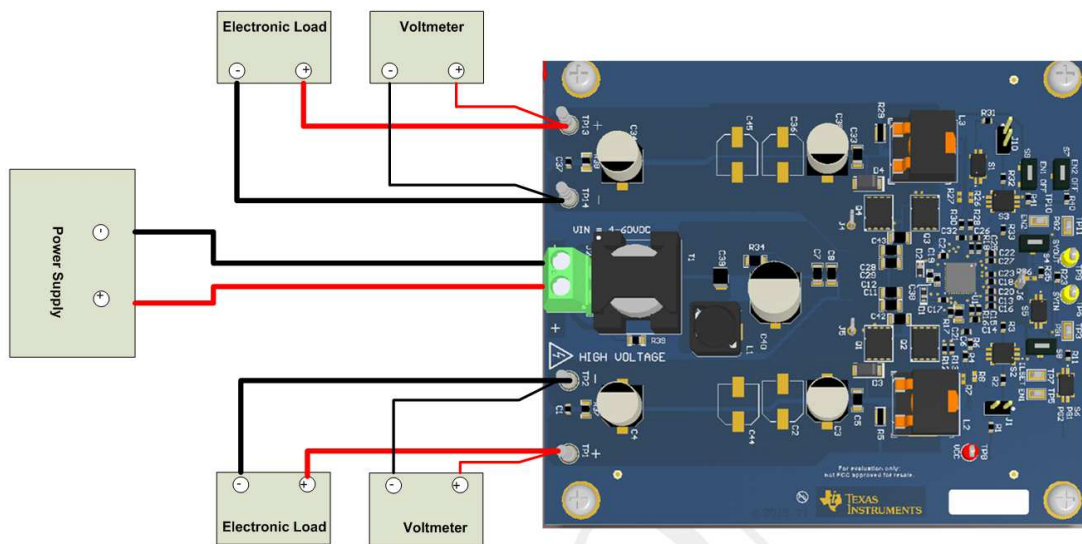

Figure 1. EVM Connections

6 Output Voltage

The LM5140-Q1 comes configured with VOUT1 set to 3.3 V and VOUT2 set to 5.0 V. For additional information on programming the output voltage, refer to the LM5140 datasheet (SNVSA02).

The FB1 and FB2 pin status (either VDD or Ground) is detected on power-up, the output configuration setting is latched and cannot be changed unless the LM5140-Q1 is powered down, and VCC drops below V_{CCUVLO} (3.4-V typical) and then powered back up.

To set the output voltage using an external resistive divider, PWB switch S2B (output 1) must be closed, and S2A and S2C need to be open. A jumper must be connected between, J1-1 and J1-2. An external resistor (R2 and R3) divider sets the output voltage; the recommended output voltage range is between 1.5 V to 15.0 V. The regulation threshold at the FB pin is 1.2 V (V_{REF}), refer to Figure 2. To calculate R_{FB1} and R_{FB2} use Equation 1.

$$R_{FB2} = \left(\frac{V_{OUT}}{V_{REF}} - 1 \right) \times R_{FB1}$$

(1)

The recommended starting point is to select R_{FB1} between 10 kΩ to 20 kΩ.

In order for the LM5140 to detect if there is a feedback divider network connected from VOUT to the FB pin, the Thevenin's equivalent impedance of the resistive divider must be greater than 5 kΩ.

$$R_{FB_{TH}} = \frac{R_{FB1} + R_{FB2}}{R_{FB1} \times R_{FB2}} > 5 \text{ k}\Omega$$
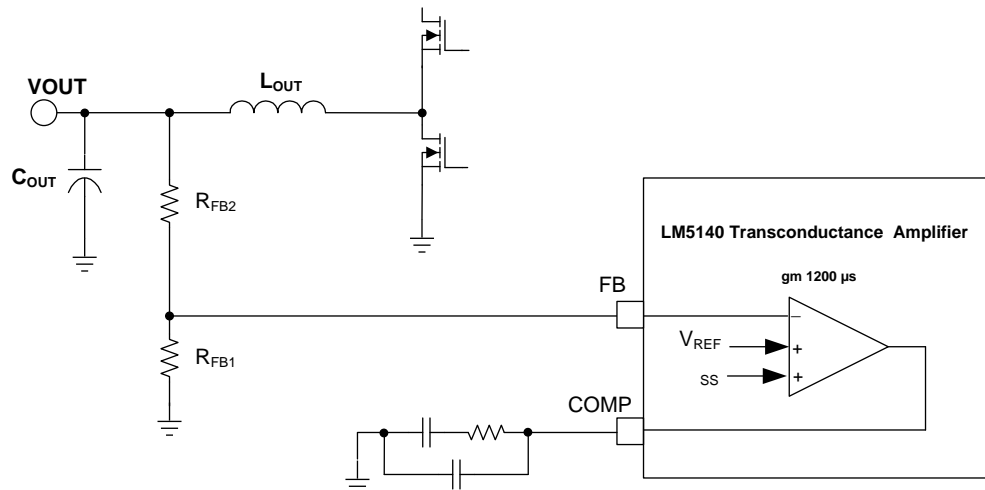
(2)

Figure 2. Feedback Amplifier

7   Changing the Oscillator Frequency to 440 kHz

Turn-off the power source connected to J2. Unsolder the 0-Ω resistors, R35; solder the 0-Ω resistors in to the location marked R36. After configuring the LM5140 for 440 kHz, refer to Table 2 for the complete parts list and changes required for 440-kHz operation.

8   Test Data Performance and Curves

The following curves are presented for reference, the actual field data may differ from these curves. Actual performance data can be affected by measurement techniques, equipment setting and environmental variables.

8.1   *Efficiency Operating at 2.2 MHz*

The efficiency measurements (Figure 3 and Figure 4) were made with VOUT1 and VOUT2 enabled and with the same load current operating at 2.2 MHz.
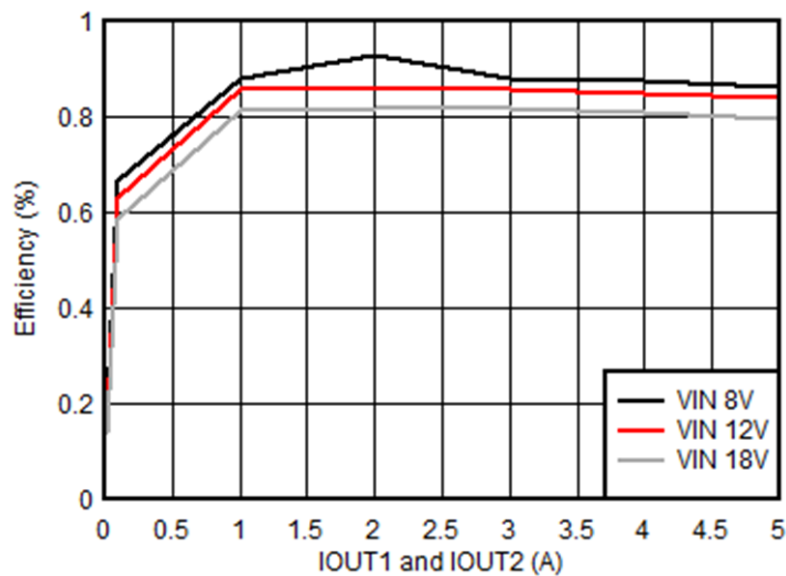
Figure 3. Efficiency in FPWM
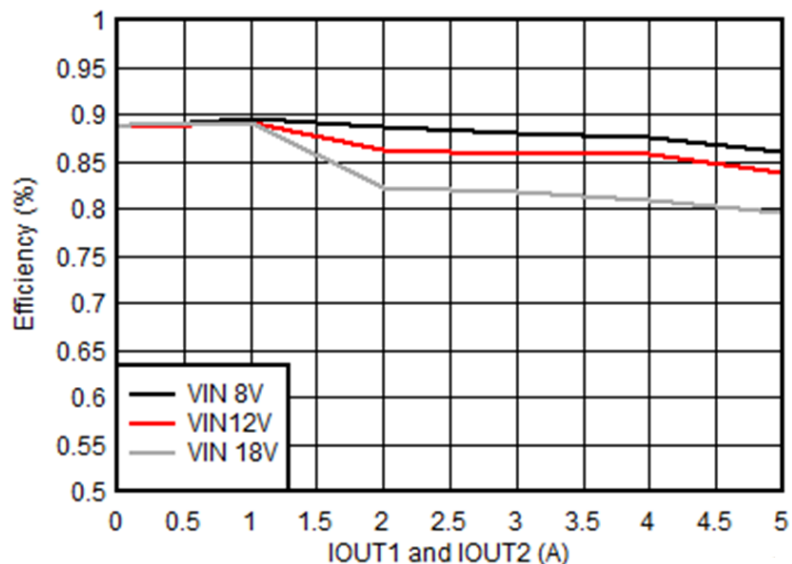
Figure 4. Efficiency in DEMB

8.2 *Voltage Regulation 3.3-V Output Operating at 2.2 MHz*

The efficiency measurements in Figure 5 are with VOUT1 enabled, and VOUT2 disabled, operating at 2.2 MHz.
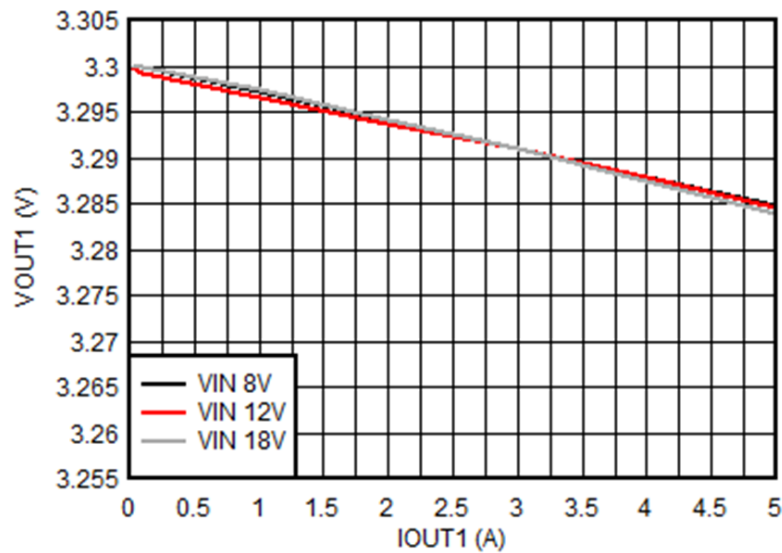
Figure 5. Voltage Regulation 3.3-V Output

8.3 *Voltage Regulation 5.0-V Output Operating at 2.2 MHz*

The efficiency measurement in Figure 6 is with VOUT1 disabled, and VOUT2 enabled, operating at 2.2 MHz.
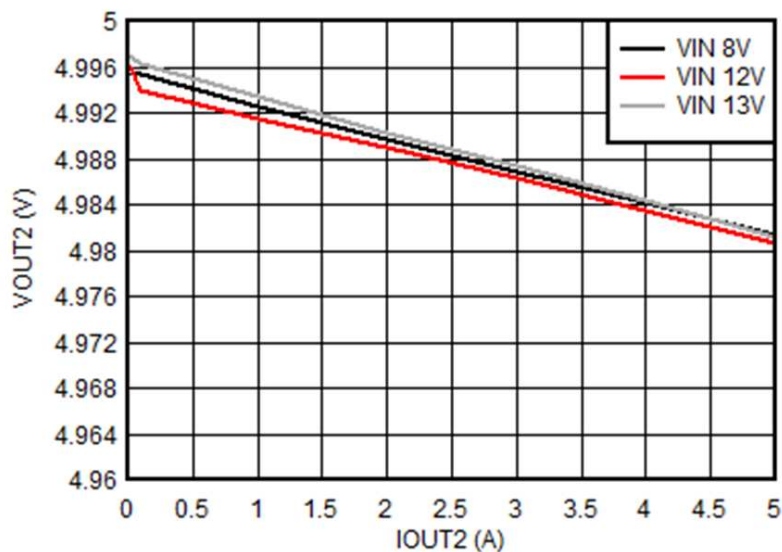
Figure 6. Voltage Regulation 5.0-V Output

8.4 Low V_IN Start-Up (3.8 V) 2.2 MHz

The low V_{IN} start-up test (Figure 7) was run with VOUT1 enabled (3.3 V) with a 4-A load and VOUT2 disabled.
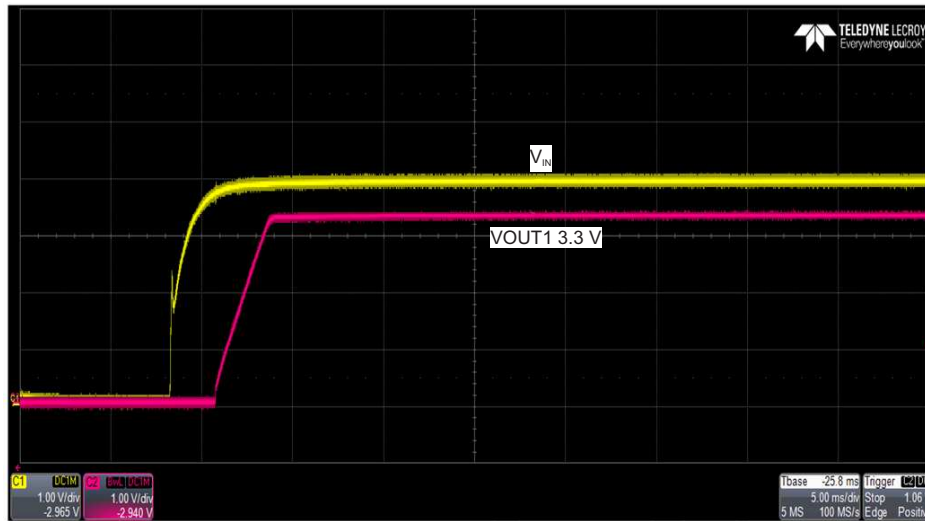
Figure 7. Low V_IN Start-Up

8.5 CISPR Class 5 Limits 2.2 MHz

Figure 8 illustrates CISPR Class 5 limits with 12-V input, 6 A at 3.3-V and 5 A at 5-V outputs, 2.2 MHz, resistive loads, CISPR 25 CE setup.
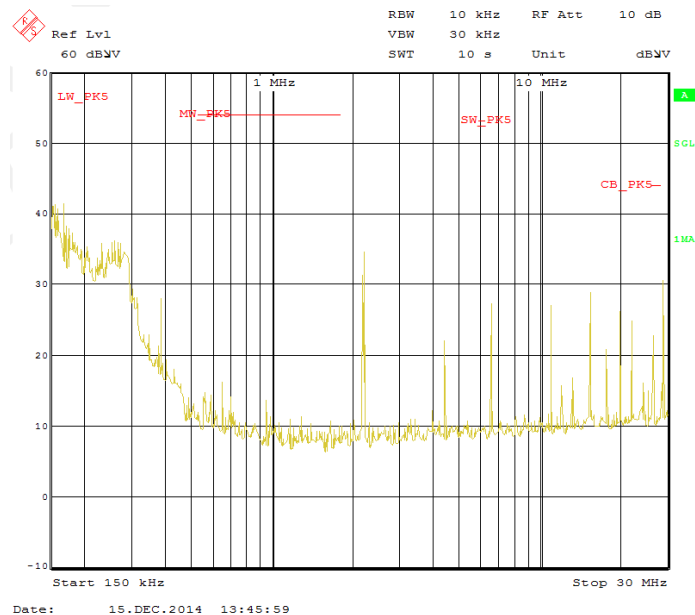
Red line: Class 5 Limit (Peak Detection)

Yellow line: Peak Detection result

Figure 8. CISPR 5, Peak Detection 150 kHz to 30 MHz

Figure 9 illustrates CISPR Class 5 average detection with 12-V input, 6 A at 3.3-V and 5 A at 5-V outputs, 2.2 MHz, resistive loads, CISPR 25 CE setup.
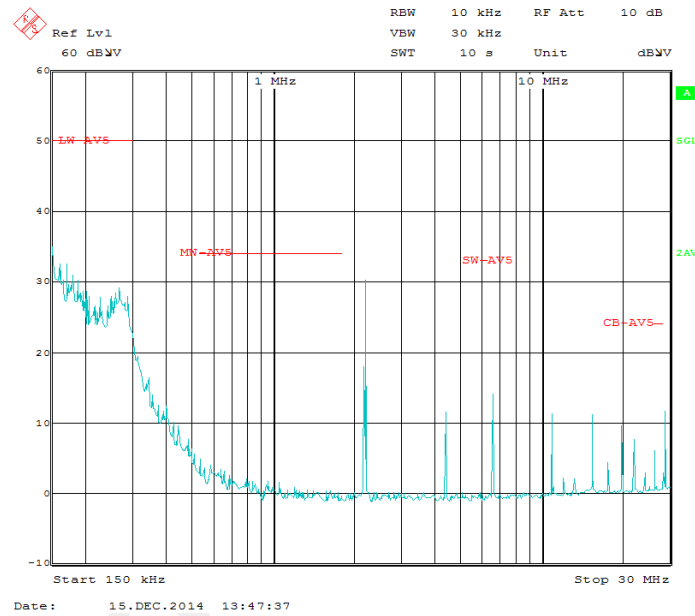
Red line: Class 5 Limit (Average Detection)

Blue line: Average Detection result

Figure 9. CISPR 5, Average Detection 150 kHz to 30 MHz

Figure 10 illustrates CISPR Class 5 peak detection with 12-V input, 6 A at 3.3-V and 5 A at 5-V outputs, 2.2 MHz, resistive loads, CISPR 25 CE setup.
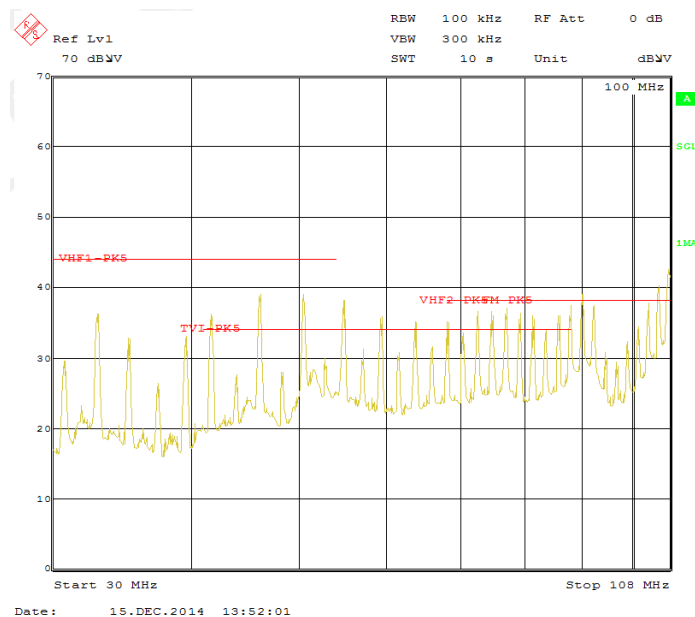
Red line: Class 5 Limit (Peak Detection)

Yellow line: Peak Detection result

Figure 10. CISPR 5, Peak Detection 30 MHz to 108 MHz

Figure 11 illustrates CISPR Class 5 average detection with 12-V input, 6 A at 3.3-V and 5 A at 5-V outputs, 2.2 MHz, resistive loads, CISPR 25 CE setup.
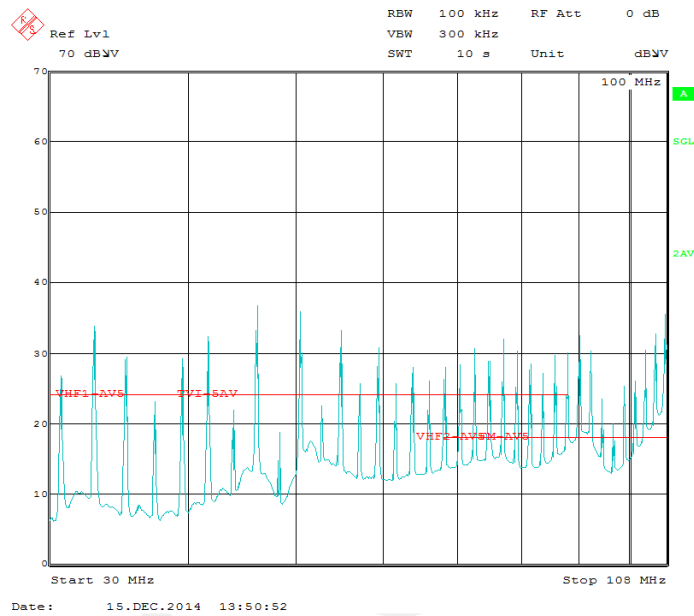
Red line: Class 5 Limit (Average Detection)

Blue line: Average Detection result

Figure 11. CISPR 5, Average Detection 30 MHz to 108 MHz

8.6 *Cold Crank Start-up*

Figure 12 shows the LM5140 EVM under a Cold-Crank Start-Up, VOUT is 3.3 V with a 4-A load, VOUT2 is disabled, refer to the LM5140 datasheet (SNVSA748) for details.
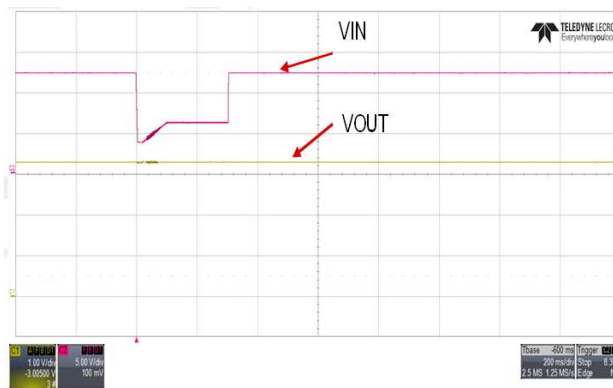
Figure 12. Cold Crank Start-Up

8.7 *Bode Plot*

Figure 13 shows the LM5140 EVM Bode Plot for VOUT1 (3.3 V) with V_{IN} 12 V and a 6-A load on the output.
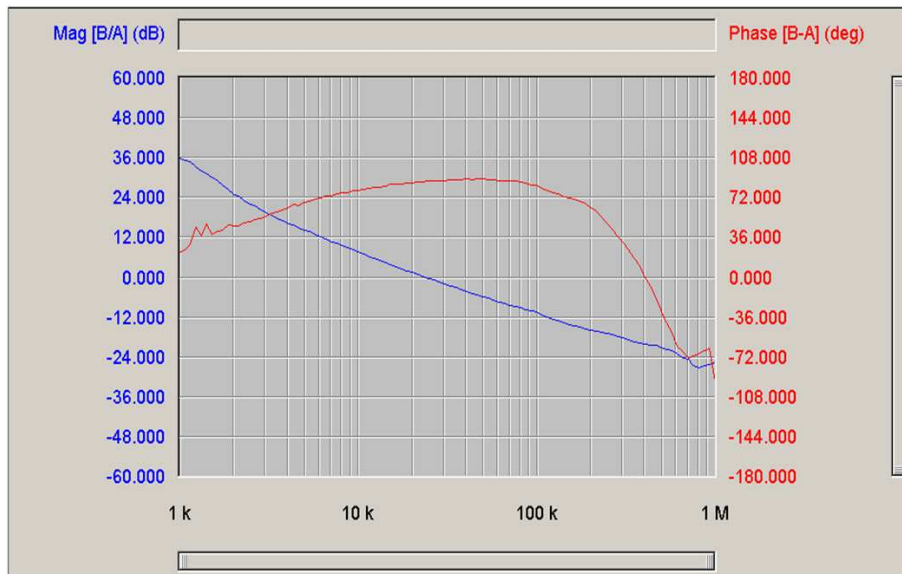
Figure 13. Bode Plot, V$_{IN}$ 12 V, V$_{OUT}$ 3.3 V at 6 A

Figure 14 shows the LM5140 EVM Bode Plot for VOUT2 (5.0 V) with VIN 12 V and a 5-A load on the output.
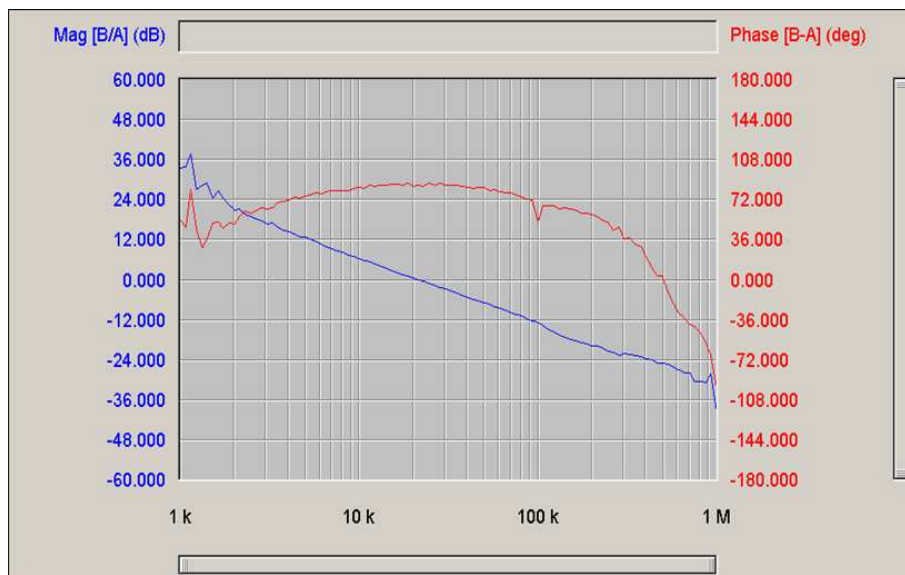
Figure 14. Bode Plot, V$_{IN}$ 12 V, V$_{OUT}$ 5.0 V at 5 A

8.8 *Transient Response*

The transient response test, Figure 15, was run with VOUT1 enabled, operating at 2.2 MHz, and VOUT2 disabled. The load was stepped from 0.6 A to 5.4 A.
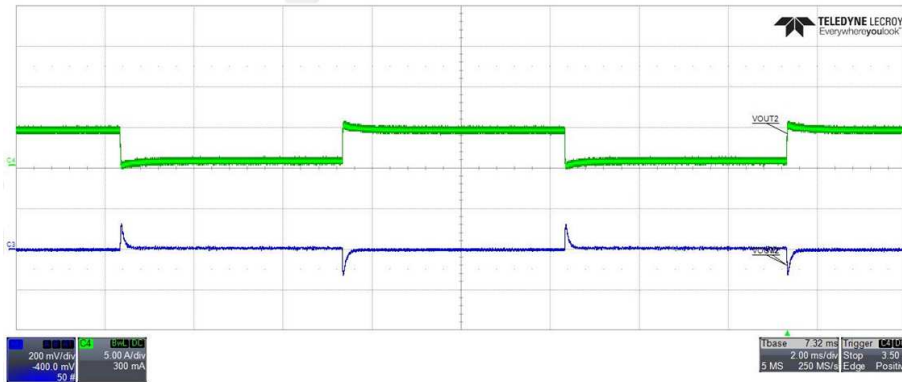
Figure 15. Transient Response 3.3-V Output

The transient response test in Figure 16 was run with VOUT1 enabled, operating at 2.2 MHz, and VOUT2 disabled. The load was stepped from 3 A to 6 A.
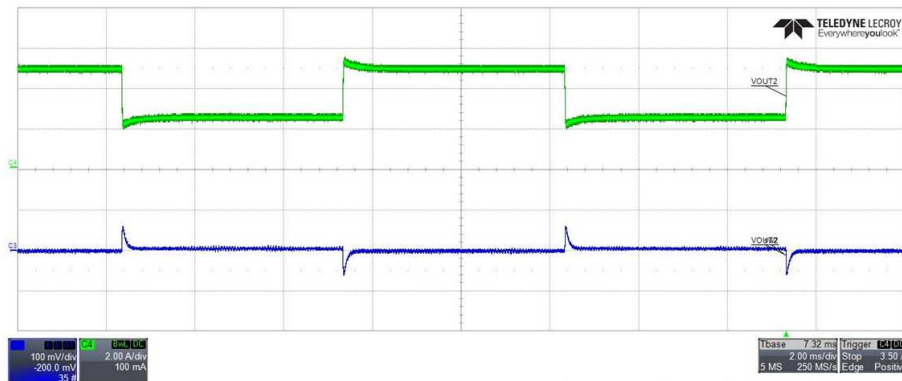
Figure 16. Transient Response, 5.0 V Output

9   Board Layout

The EVM offers resistors and PWB mounted switches to program the output voltages, current-limit threshold, oscillator frequency, and DEM/FPWM of operation. Figure 17 to Figure 20 show the board layout for the PCB. The QFN-40 package allows for a compact leadless IC package for a synchronous buck converter solution. The LM5140RWGEVM is a four-layer board. There are placeholders in the EVM (R7, R8, R9, C9, R25, R26, R27, and C31) which can be populated as required, for DCR current sensing, refer to the LM5140-Q1 datasheet (SNVSA02) for details.

Figure 17. EVM Top Component Layer

Figure 18. EVM Top Copper Layer

Figure 19. EVM Bottom Component Layer

Figure 20. EVM Bottom Copper Layer

10   Schematic and Bill of Materials

Figure 21 illustrates the 2.2-MHz EVM schematic.

Figure 21. EVM Schematic, 2.2 MHz

lists the 2.2-MHz EVM BOM.

Table 4. EVM Bill of Materials 3.3 V/5.0 V, 2.2 MHz

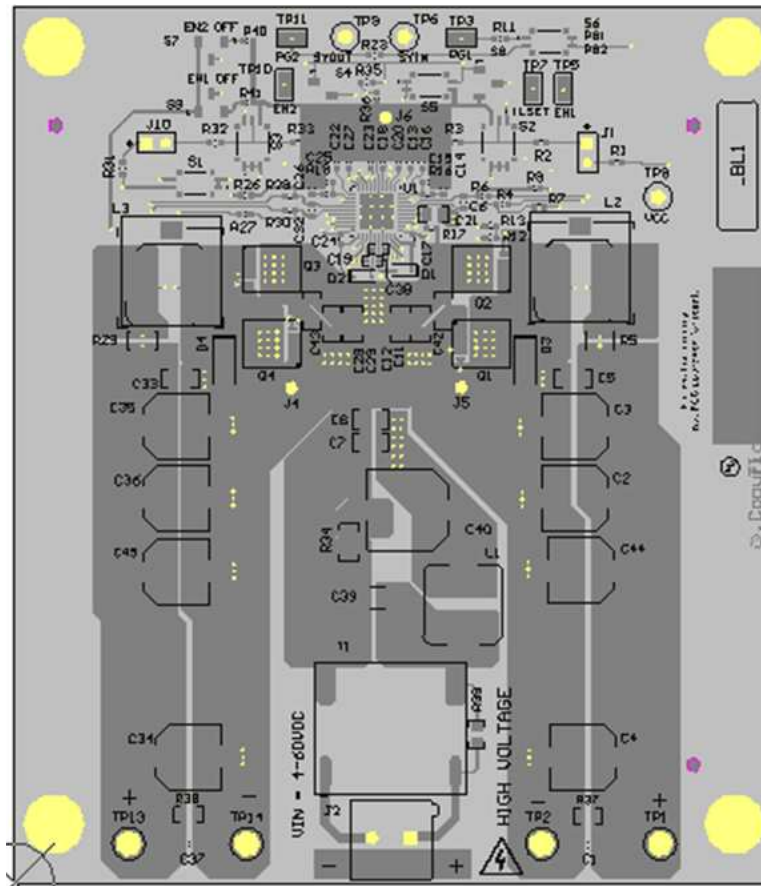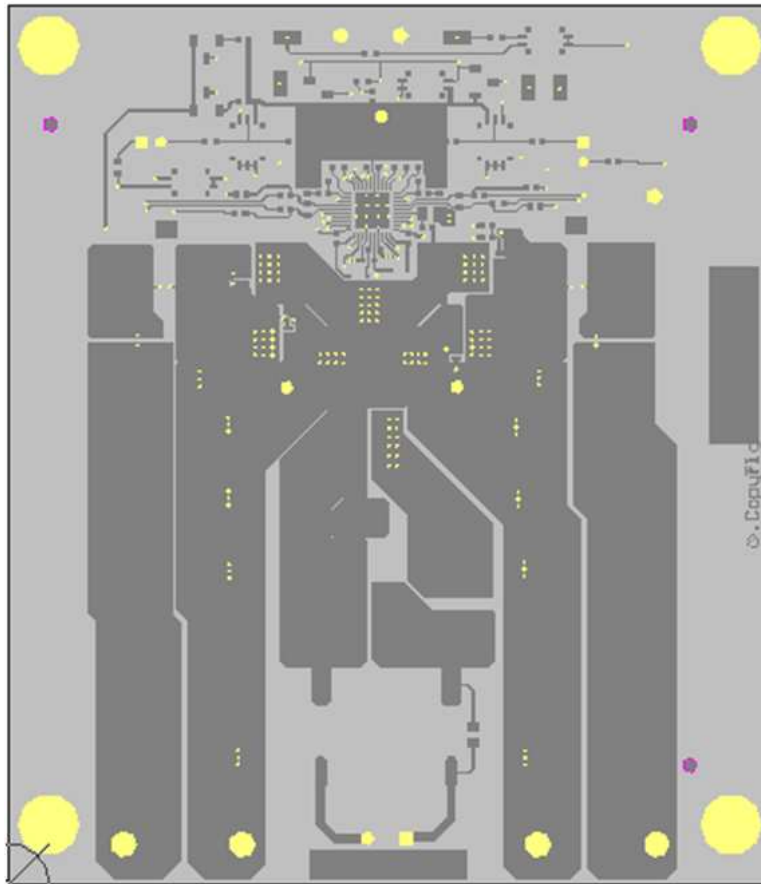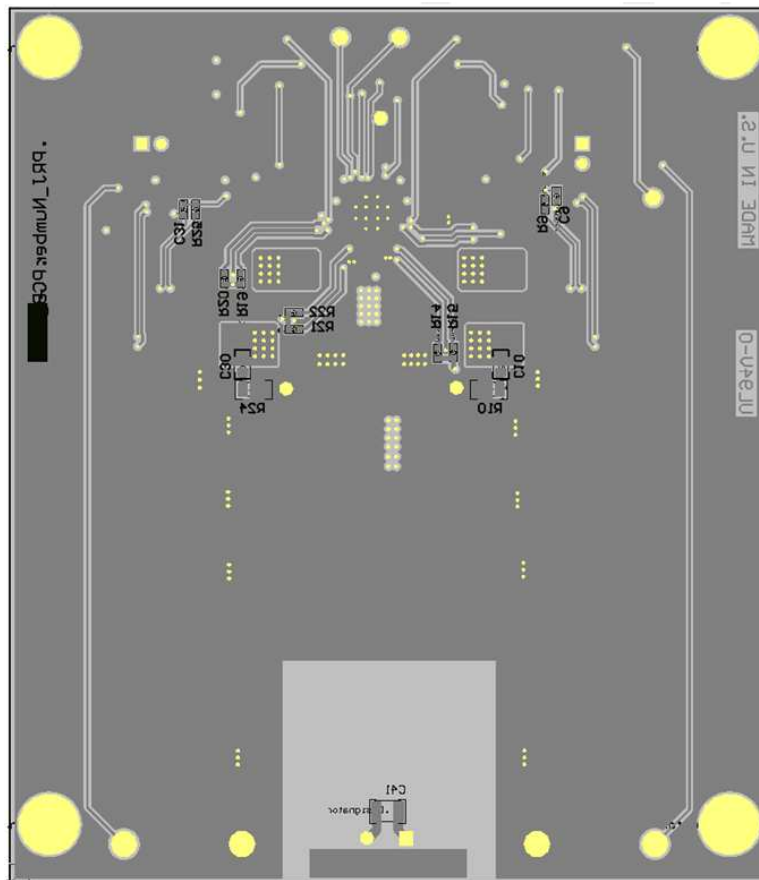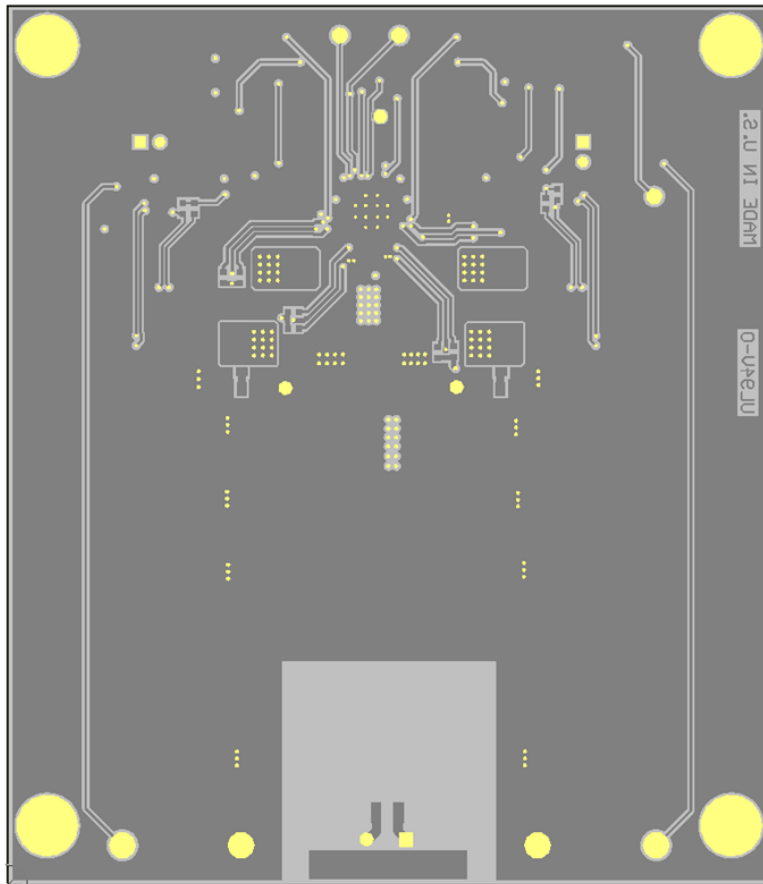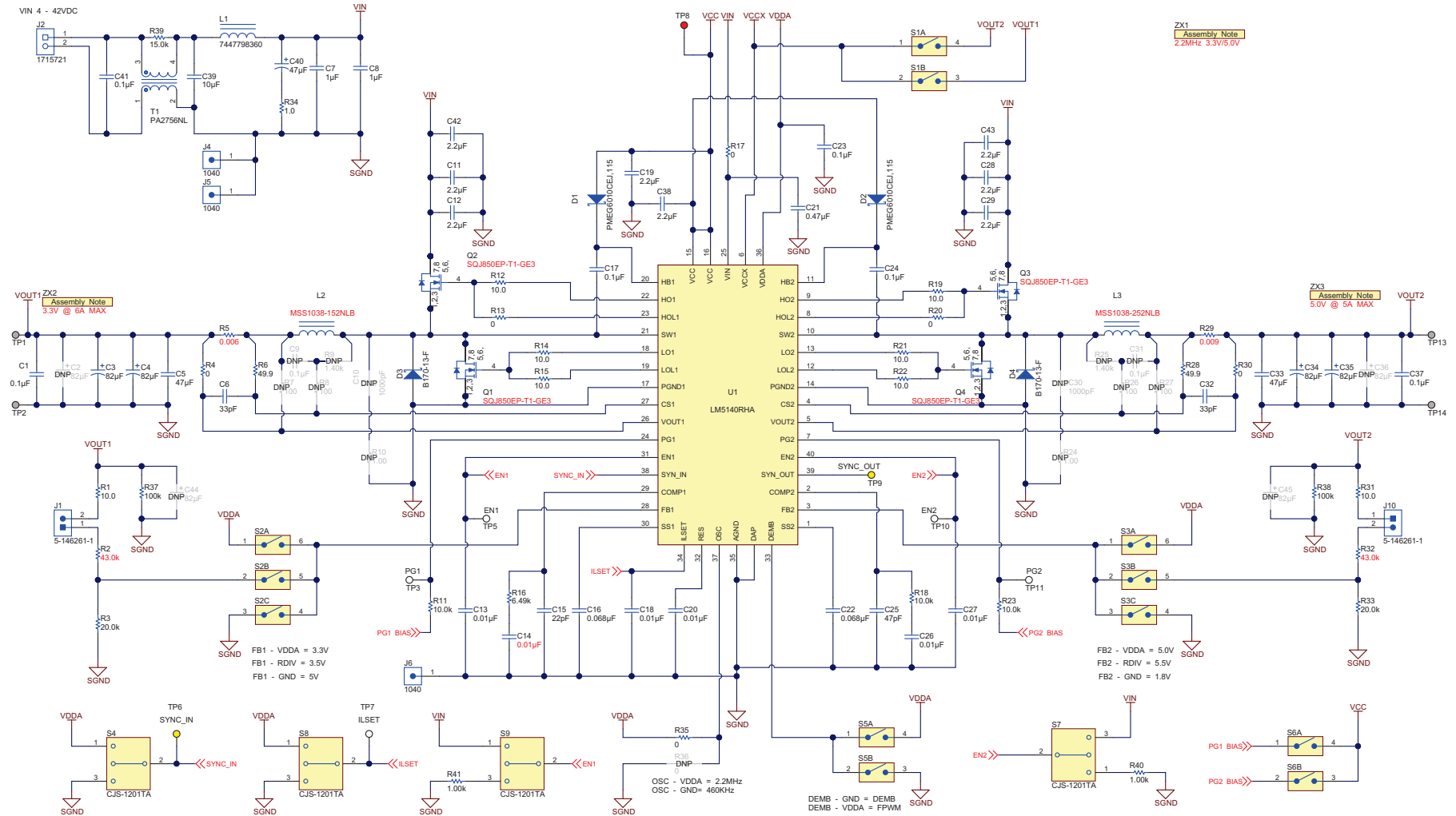| Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
!PCB	1		Printed Circuit Board		LM5140EVM	Any
C1, C17, C24, C37	4	0.1uF	CAP, CERM, 0.1uF, 100V, +/-10%, X7R, 0603	0603	GRM188R72A104KA35D	Murata
C3, C4, C35, C36	4	82uF	CAP, AL, 82uF, 16V, +/-20%, 0.03 ohm, SMD	H70	APXH160ARA820MH70G	Nippon Chemi-Con
C5, C33	2	47uF	CAP, CERM, 47uF, 16V, +/-15%, X5R, 1206	1206	C3216X5R1C476M160AB	TDK
C6, C32	2	33pF	CAP, CERM, 33 pF, 100 V, +/- 5%, C0G/NP0, 0603	0603	06031A330JAT2A	AVX
C7, C8	2	1uF	CAP, CERM, 1uF, 100V, +/-20%, X7R, 1206	1206	C3216X7R2A105M160AA	TDK
C11, C12, C28, C29, C42, C43	6	2.2µF	CAP CER 2.2UF 100V 10% X7R 1206	1206 (3216 Metric)	CL31B225KCHSNNE	Samsung Electro-Mechanics America, Inc
C13, C18, C20, C27	4	0.01uF	CAP, CERM, 0.01uF, 50V, +/-10%, X7R, 0603	0603	GRM188R71H103KA01D	Murata
C14, C26	1	0.01uF	CAP, CERM, 0.01 µF, 50 V, +/- 10%, X7R, 0603	0603	GRM188R71H103KA01D	Murata
C15, C25	2	22pF	CAP, CERM, 22pF, 50V, +/-5%, C0G/NP0, 0603	0603	GRM1885C1H220JA01D	Murata
C16, C22	2	0.068uF	CAP, CERM, 0.068 µF, 25 V, +/- 10%, X7R, 0603	0603	GRM188R71E683KA01D	Murata
C19, C38	2	2.2uF	CAP, CERM, 2.2 µF, 10 V, +/- 20%, X5R, 0603	0603	C0603C225M8PACTU	Kemet
C21	1	0.47uF	CAP, CERM, 0.47uF, 100V, +/-10%, X7R, 0805	0805	GRM21BR72A474KA73L	Murata
C23	1	0.1uF	CAP, CERM, 0.1 µF, 50 V, +/- 10%, X7R, 0603	0603	GRM188R71H104KA93D	Murata
C39	1	4.7uF	CAP, CERM, 4.7uF, 100V, +/-10%, X7S, 1210	1210	C3225X7S2A475K200AB	TDK
C40	1	47uF	CAP, AL, 47 µF, 50 V, +/- 20%, 0.3 ohm, SMD	SMT Radial G	EEE-FC1H470P	Panasonic
C41	1	0.1uF	CAP, CERM, 0.1 µF, 100 V, +/- 10%, X7R, 1210	1210	GRM32NR72A104KA01L	Murata
D1, D2	2	60V	Diode, Schottky, 60 V, 1 A, SOD-323F	SOD-323F	PMEG6010CEJ,115	NXP Semiconductor
D3, D4	2	70V	Diode, Schottky, 70V, 1A, SMA	SMA	B170-13-F	Diodes Inc.
H1, H2, H3, H4	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	Screw	NY PMS 440 0025 PH	B&F Fastener Supply
H5, H6, H7, H8	4		Standoff, Hex, 0.5"L #4-40 Nylon	Standoff	1902C	Keystone
J1, J10	2		Header, 100mil, 2x1, Gold, TH	Header, 2x1, 100mil	5-146261-1	TE Connectivity
J2	1	2x1	Conn Term Block, 2POS, 5.08mm, TH	2POS Terminal Block	1715721	Phoenix Contact
J4, J5, J6	3		TEST POINT SLOTTED .118", TH	Test point, TH Slot Test point	1040	Keystone
L1	1	1.8uH	Inductor, Shielded, Metal Composite, 1.8 µH, 12.8 A, 0.0038 ohm, SMD	10.2 x 6.4 x 10.2mm	7447798180	Wurth Elektronik eiSos
L2	1	1.5uH	Inductor, Shielded Drum Core, Ferrite, 1.5 µH, 7.85 A, 0.01 ohm, SMD	MSS1038	MSS1038-152NLB	Coilcraft
L3	1	2.5uH	Inductor, Shielded Drum Core, Ferrite, 2.5 µH, 6.65 A, 0.01 ohm, SMD	MSS1038	MSS1038-252NLB	Coilcraft
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650"H x 0.200"W	THT-14-423-10	Brady
Q1, Q2, Q3, Q4	4	60V	MOSFET, N-CH, 60 V, 24 A, PowerPAK_SO-8L	PowerPAK_SO-8L	SQJ850EP-T1-GE3	Vishay-Siliconix
R1, R31	2	10.0	RES, 10.0 ohm, 1%, 0.1W, 0603	0603	RC0603FR-0710RL	Yageo America
R2	1	38.3k	RES, 38.3k ohm, 1%, 0.1W, 0603	0603	RC0603FR-0738K3L	Yageo America
R3, R33	2	20.0k	RES, 20.0k ohm, 1%, 0.1W, 0603	0603	RC0603FR-0720KL	Yageo America
R4, R13, R17, R20, R30	5	0	RES, 0, 5%, 0.1 W, 0603	0603	RC0603JR-070RL	Yageo America

Table 4. EVM Bill of Materials 3.3 V/5.0 V, 2.2 MHz (continued)

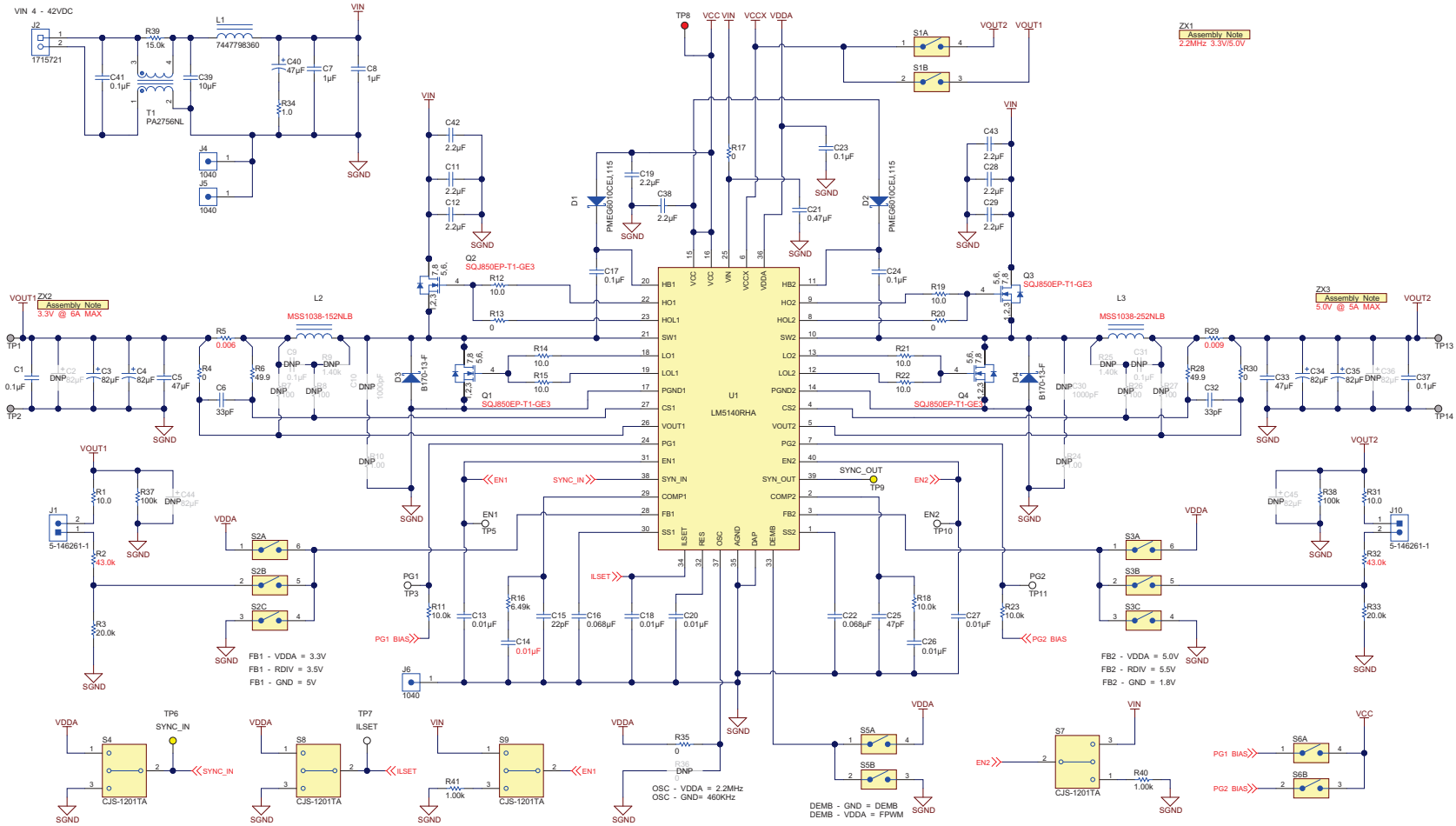| Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
R5	1	0.007	RES, 0.007, 1%, 1 W, 0612	0612	PRL1632-R007-F-T1	Susumu Co Ltd
R6, R28	2	49.9	RES, 49.9, 1%, 0.1 W, 0603	0603	CRCW060349R9FKEA	Vishay-Dale
R11, R18, R23	3	10.0k	RES, 10.0k ohm, 1%, 0.1W, 0603	0603	RC0603FR-0710KL	Yageo America
R12, R14, R15, R19, R21, R22	6	10.0	RES, 10.0, 1%, 0.1 W, 0603	0603	RC0603FR-0710RL	Yageo America
R16	1	6.49k	RES, 6.49 k, 1%, 0.1 W, 0603	0603	RC0603FR-076K49L	Yageo America
R29	1	0.009	RES, 0.009, 1%, 1 W, 0612	0612	PRL1632-R009-F-T1	Susumu Co Ltd
R32	1	71.5k	RES, 71.5k ohm, 1%, 0.1W, 0603	0603	RC0603FR-0771K5L	Yageo America
R34	1	1.0	RES, 1.0 ohm, 5%, 0.25W, 1206	1206	CRCW12061R00JNEA	Vishay-Dale
R35	1	0	RES, 0 ohm, 5%, 0.1W, 0603	0603	RC0603JR-070RL	Yageo America
S1, S5	2		DIP Switch, SPST, 2Pos, Slide, SMT	SW, 4.7x1.45x3mm	CVS-02TB	Copal Electronics
S2, S3	2		DIP Switch, SPST, 3Pos, Slide, SMT	SW, 4.7x1.45x4mm	CVS-03TB	Copal Electronics
T1	1	484 uH	Transformer, 484 uH, SMT	17.02x19.56mm	PA2756NL	Pulse Engineering
TP1, TP2, TP13, TP14	4	Triple	Terminal, Turret, TH, Triple	Keystone1598-2	1598-2	Keystone
TP3, TP4, TP5, TP7, TP10, TP11, TP12	7	SMT	Test Point, Miniature, SMT	Testpoint_Keystone_Miniature	5015	Keystone
TP6, TP9	2	Yellow	Test Point, Compact, Yellow, TH	Yellow Compact Testpoint	5009	Keystone
TP8	1	Red	Test Point, Compact, Red, TH	Red Compact Testpoint	5005	Keystone
U1	1		LM5140 Wide Input Range Dual Synchronous Buck Controller, RHA0040C	RHA0040C	LM5140RHA	Texas Instruments
C9, C31	0	0.1uF	CAP, CERM, 0.1uF, 100V, +/-10%, X7R, 0603	0603	GRM188R72A104KA35D	Murata
C10, C30	0	470pF	CAP, CERM, 470 pF, 100 V, +/- 10%, X7R, 0805	0805	08051C471KAT2A	AVX
C34	0	82uF	CAP, AL, 82uF, 16V, +/-20%, 0.03 ohm, SMD	H70	APXH160ARA820MH70G	Nippon Chemi-Con
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	Fiducial	N/A	N/A
R7, R8, R26, R27	0	100	RES, 100 ohm, 1%, 0.1W, 0603	0603	RC0603FR-07100RL	Yageo America
R9, R25	0	1.40k	RES, 1.40k ohm, 1%, 0.1W, 0603	0603	CRCW06031K40FKEA	Vishay-Dale
R10, R24	0	1.00	RES, 1.00, 1%, 0.5 W, 1206	1206	CSR1206FK1R00	Stackpole Electronics Inc
R36	0	0	RES, 0 ohm, 5%, 0.1W, 0603	0603	RC0603JR-070RL	Yageo America

Figure 22 illustrates the 440-kHz EVM schematic.

Figure 22. EVM Schematic, 440 kHz

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lists the 440-kHz EVM BOM.

Table 5. EVM BOM 3.3V/5.0 V, 440 kHz

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
!PCB	1		Printed Circuit Board		XX####	Any
C1, C17, C24, C37	4	0.1uF	CAP, CERM, 0.1uF, 100V, +/-10%, X7R, 0603	0603	GRM188R72A104KA35D	Murata
C2, C3, C4, C35, C36	5	82uF	CAP, AL, 82uF, 16V, +/-20%, 0.03 ohm, SMD	H70	APXH160ARA820MH70G	Nippon Chemi-Con
C5, C33	2	47uF	CAP, CERM, 47uF, 16V, +/-15%, X5R, 1206	1206	C3216X5R1C476M160AB	TDK
C6, C32	2	33pF	CAP, CERM, 33 pF, 100 V, +/- 5%, C0G/NP0, 0603	0603	06031A330JAT2A	AVX
C7, C8	2	1uF	CAP, CERM, 1uF, 100V, +/-20%, X7R, 1206	1206	C3216X7R2A105M160AA	TDK
C11, C12, C28, C29, C42, C43	6	2.2µF	CAP CER 2.2UF 100V 10% X7R 1206	1206 (3216 Metric)	CL31B225KCHSNNE	Samsung Electro-Mechanics America, Inc
C13, C18, C20, C27	4	0.01uF	CAP, CERM, 0.01uF, 50V, +/-10%, X7R, 0603	0603	GRM188R71H103KA01D	Murata
C14, C26	2	0.022uF	CAP, CERM, 0.022 µF, 25 V, +/- 10%, X7R, 0603	0603	C0603C223K3RACTU	Kemet
C15, C25	2	470pF	CAP, CERM, 470pF, 50V, +/-5%, C0G/NP0, 0603	0603	GRM1885C1H471JA01D	Murata
C16, C22	2	0.068uF	CAP, CERM, 0.068 µF, 25 V, +/- 10%, X7R, 0603	0603	GRM188R71E683KA01D	Murata
C19, C38	2	2.2uF	CAP, CERM, 2.2 µF, 10 V, +/- 20%, X5R, 0603	0603	C0603C225M8PACTU	Kemet
C21	1	0.47uF	CAP, CERM, 0.47uF, 100V, +/-10%, X7R, 0805	0805	GRM21BR72A474KA73L	Murata
C23	1	0.1uF	CAP, CERM, 0.1 µF, 50 V, +/- 10%, X7R, 0603	0603	GRM188R71H104KA93D	Murata
C39	1	4.7uF	CAP, CERM, 4.7uF, 100V, +/-10%, X7S, 1210	1210	C3225X7S2A475K200AB	TDK
C40	1	47uF	CAP, AL, 47 µF, 50 V, +/- 20%, 0.3 ohm, SMD	SMT Radial G	EEE-FC1H470P	Panasonic
C41	1	0.1uF	CAP, CERM, 0.1 µF, 100 V, +/- 10%, X7R, 1210	1210	GRM32NR72A104KA01L	Murata
D1, D2	2	60V	Diode, Schottky, 60 V, 1 A, SOD-323F	SOD-323F	PMEG6010CEJ,115	NXP Semiconductor
H1, H2, H3, H4	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	Screw	NY PMS 440 0025 PH	B&F Fastener Supply
H5, H6, H7, H8	4		Standoff, Hex, 0.5"L #4-40 Nylon	Standoff	1902C	Keystone
H9, H10, H11, H12	4		Bumpon, Hemisphere, 0.44 X 0.20, Clear	Transparent Bumpon	SJ-5303 (CLEAR)	3M
J1, J10	2		Header, 100mil, 2x1, Gold, TH	Header, 2x1, 100mil	5-146261-1	TE Connectivity
J2	1	2x1	Conn Term Block, 2POS, 5.08mm, TH	2POS Terminal Block	1715721	Phoenix Contact
J4, J5, J6	3		TEST POINT SLOTTED .118", TH	Test point, TH Slot Test point	1040	Keystone
L1	1	1.8uH	Inductor, Shielded, Metal Composite, 1.8 µH, 12.8 A, 0.0038 ohm, SMD	10.2 x 6.4 x 10.2mm	7447798180	Wurth Elektronik eiSos
L2	1	8uH	Inductor, Shielded E Core, Ferrite, 8 µH, 7.6 A, 0.01 ohm, SMD	SER1360	SER1360-802KLB	Coilcraft
L3	1	10uH	Inductor, Shielded E Core, Ferrite, 10 µH, 7.2 A, 0.01 ohm, SMD	SER1360	SER1360-103KLB	Coilcraft
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650"H x 0.200"W	THT-14-423-10	Brady
Q1, Q2, Q3, Q4	4	60V	MOSFET, N-CH, 60 V, 24 A, PowerPAK_SO-8L	PowerPAK_SO-8L	SQJ850EP-T1-GE3	Vishay-Siliconix
R1, R31	2	10.0	RES, 10.0 ohm, 1%, 0.1W, 0603	0603	RC0603FR-0710RL	Yageo America
R2	1	38.3k	RES, 38.3 k, 1%, 0.1 W, 0603	0603	CRCW060338K3FKEA	Vishay-Dale
R3, R33	2	20.0k	RES, 20.0k ohm, 1%, 0.1W, 0603	0603	RC0603FR-0720KL	Yageo America
R4, R13, R17, R20, R30	5	0	RES, 0, 5%, 0.1 W, 0603	0603	RC0603JR-070RL	Yageo America
R5	1	0.007	RES, 0.007, 1%, 1 W, 0612	0612	PRL1632-R007-F-T1	Susumu Co Ltd

Table 5. EVM BOM 3.3V/5.0 V, 440 kHz (continued)

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
R6, R28	2	49.9	RES, 49.9, 1%, 0.1 W, 0603	0603	CRCW060349R9FKEA	Vishay-Dale
R11, R23	2	10.0k	RES, 10.0k ohm, 1%, 0.1W, 0603	0603	RC0603FR-0710KL	Yageo America
R12, R14, R15, R19, R21, R22	6	10.0	RES, 10.0, 1%, 0.1 W, 0603	0603	RC0603FR-0710RL	Yageo America
R16, R18	2	6.49k	RES, 6.49 k, 1%, 0.1 W, 0603	0603	CRCW06036K49FKEA	Vishay-Dale
R29	1	0.01	RES, 0.01, 1%, 1 W, 0612	0612	PRL1632-R010-F-T1	Susumu Co Ltd
R32	1	71.5k	RES, 71.5 k, 1%, 0.1 W, 0603	0603	CRCW060371K5FKEA	Vishay-Dale
R34	1	1.0	RES, 1.0 ohm, 5%, 0.25W, 1206	1206	CRCW12061R00JNEA	Vishay-Dale
R36	1	0	RES, 0 ohm, 5%, 0.1W, 0603	0603	RC0603JR-070RL	Yageo America
S1, S5	2		DIP Switch, SPST, 2Pos, Slide, SMT	SW, 4.7x1.45x3mm	CVS-02TB	Copal Electronics
S2, S3	2		DIP Switch, SPST, 3Pos, Slide, SMT	SW, 4.7x1.45x4mm	CVS-03TB	Copal Electronics
T1	1	484 uH	Transformer, 484 uH, SMT	17.02x19.56mm	PA2756NL	Pulse Engineering
TP1, TP2, TP13, TP14	4	Triple	Terminal, Turret, TH, Triple	Keystone1598-2	1598-2	Keystone
TP3, TP4, TP5, TP7, TP10, TP11, TP12	7	SMT	Test Point, Miniature, SMT	Testpoint_Keystone_Miniature	5015	Keystone
TP6, TP9	2	Yellow	Test Point, Compact, Yellow, TH	Yellow Compact Testpoint	5009	Keystone
TP8	1	Red	Test Point, Compact, Red, TH	Red Compact Testpoint	5005	Keystone
U1	1		LM5140 Wide Input Range Dual Synchronous Buck Controller, RHA0040C	RHA0040C	LM5140RHA	Texas Instruments
C9, C31	0	0.1uF	CAP, CERM, 0.1uF, 100V, +/-10%, X7R, 0603	0603	GRM188R72A104KA35D	Murata
C10, C30	0	1000pF	CAP, CERM, 1000pF, 100V, +/-5%, C0G/NP0, 0805	0805	C2012C0G2A102J	TDK
C34	0	82uF	CAP, AL, 82uF, 16V, +/-20%, 0.03 ohm, SMD	H70	APXH160ARA820MH70G	Nippon Chemi-Con
D3, D4	0	70V	Diode, Schottky, 70V, 1A, SMA	SMA	B170-13-F	Diodes Inc.
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	Fiducial	N/A	N/A
R7, R8, R26, R27	0	100	RES, 100 ohm, 1%, 0.1W, 0603	0603	RC0603FR-07100RL	Yageo America
R9, R25	0	1.40k	RES, 1.40k ohm, 1%, 0.1W, 0603	0603	CRCW06031K40FKEA	Vishay-Dale
R10, R24	0	1.00	RES, 1.00, 1%, 0.5 W, 1206	1206	CSR1206FK1R00	Stackpole Electronics Inc
R35	0	0	RES, 0 ohm, 5%, 0.1W, 0603	0603	RC0603JR-070RL	Yageo America

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