User's Guide

TPS23730EVM-093 Evaluation Module

ABSTRACT

This user's guide describes the TPS23730 evaluation module (EVM). The TPS23730 evaluation module (TPS23730EVM-093) contains evaluation and reference circuitry for the TPS23730, which is a IEEE802.3bt Type 3 PoE PD, EA Gen 2 Ready, controller suitable for Type 3 (51 W) PoE PD applications. The TPS23730EVM-093 is targeted for a 12-V active clamp forward high efficiency 50-W solution.

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Trademarks

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1 Introduction

The TPS23730EVM-093 allows reference circuitry evaluation of the TPS23730 device. It contains input and output power connectors and an array of onboard test points for circuit evaluation.

1.1 Features

- IEEE802.3bt Type 3 compliant PoE PD
- Integrated PWM Controller for Active Clamp Forward Configuration
- Frequency Dithering for EMI Reduction
- Soft-Start Control with Advanced Startup and Hiccup Mode Overload Protection
- Soft-Stop Shutdown

1.2 Applications

- IEEE 802.3bt Compliant Devices
- Video and VoIP Telephones
- Access Points
- Pass-through System
- Security Cameras
- Redundant Power Feeds or Power Sharing

2 Electrical Specifications

Table 2-1. TPS23730EVM-093 Electrical and Performance Specifications at 25°C

Design Example Specifications					
Parameter	**Test Conditions**	**MIN**	**TYP**	**MAX**	**Unit**
Power Interface					
Input Voltage Range	Applied to the PoE Input	37	48	57	V
	Applied ot the Adapter Input		48		
Detection Voltage	At device terminals	2.7		10.1	
Classification Voltage	At device terminals	14.5		20.5	
Classification			6		
Inrush current-limit			140		mA
Operating Current Limit			1.85		A
DC-to-DC Converter					
Output Voltage	Vin = 48 V, iload <=iload (max)		12		V
Output Current	37 V <= Vin <= 57 V		5		A
Output Ripple Voltage peak-to-peak	Vin = 48 V, iload = 1 A		82		mV
Efficiency, End to End	Vin = 48 V, iload = 500 mA		71		%
	Vin = 48 V, iload = 2.5 A		89.9		
	Vin = 48 V, iload = 5 A		91		
Switching Frequency			250		kHz

3 Description

The TPS23730VM-093 enables full evaluation of the TPS23730 device. Refer to the schematic shown in Figure 4-1 and Figure 4-2. Ethernet power is applied from J2 and is dropped to the bridge rectifier (Q1-Q4, D1-D4 and other passives). The Power over Ethernet (PoE) transformer needed to transfer power or data is T1. The Bob Smith Terminations help balance the Ethernet cabled impedance and are critical for ESD and EMI or EMC performance. The EMI or EMC filter and transient protection for the TPS23730 device are at the output of the bridge rectifier.

Input power can also be applied at J3 from a DC source when power at J1 is not present.

The TPS23703 (U1) PD and DC-to-DC converter circuitry is shown in Figure 1. R36 provides the detection signature. The switched side of the PD controller is to the right of U1. The TPS23730 RTN pin(s) provides inrush limited turn on and charge of the bulk capacitor, C19.

The DC-to-DC converter is a high-efficiency active clamp forward converter.

R43 provides a means for error injection to measure the frequency response of the converter.

4 Schematic and Bill of Materials

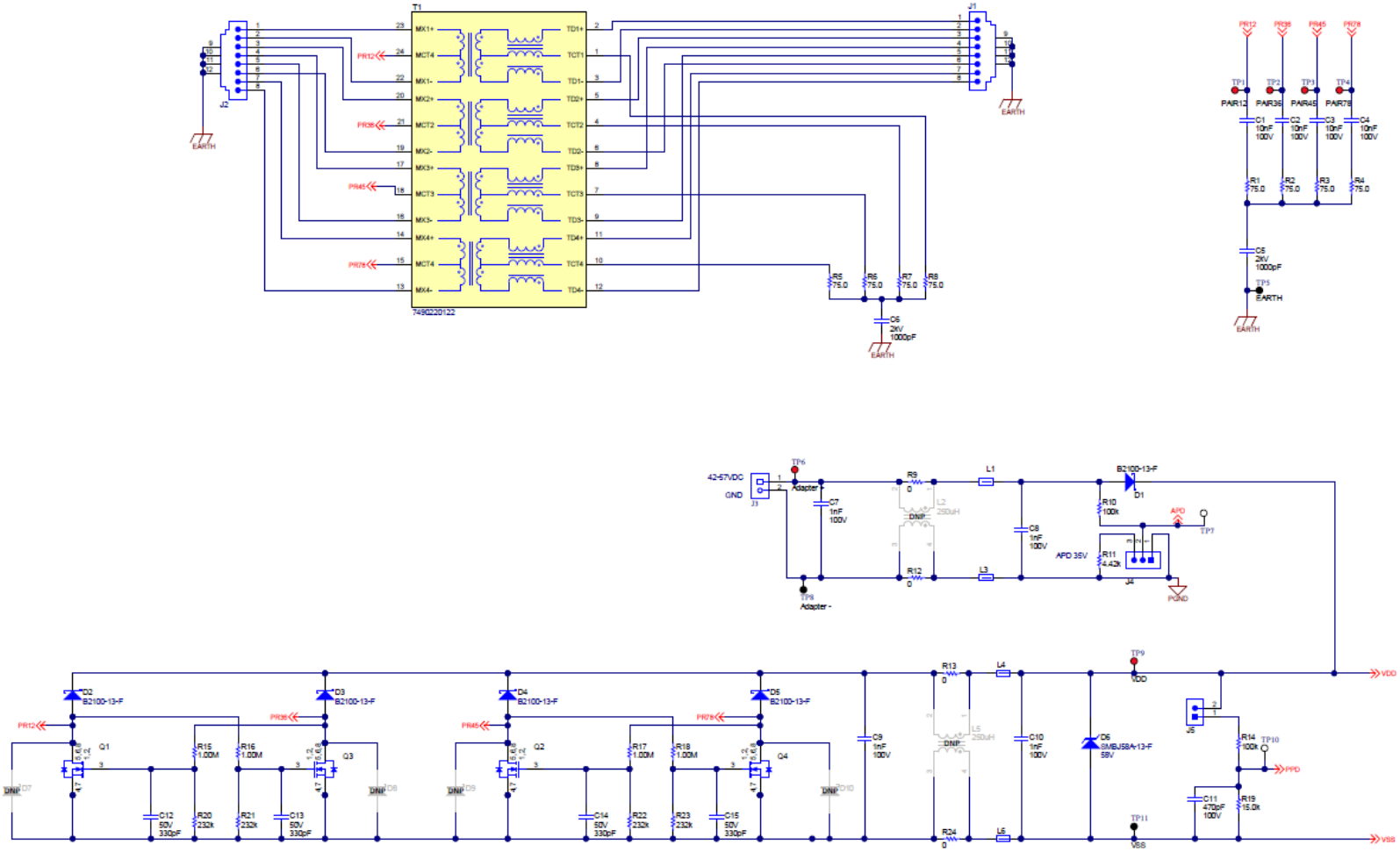

Figure 4-1. TPS23730EVM-093 Schematic Page One

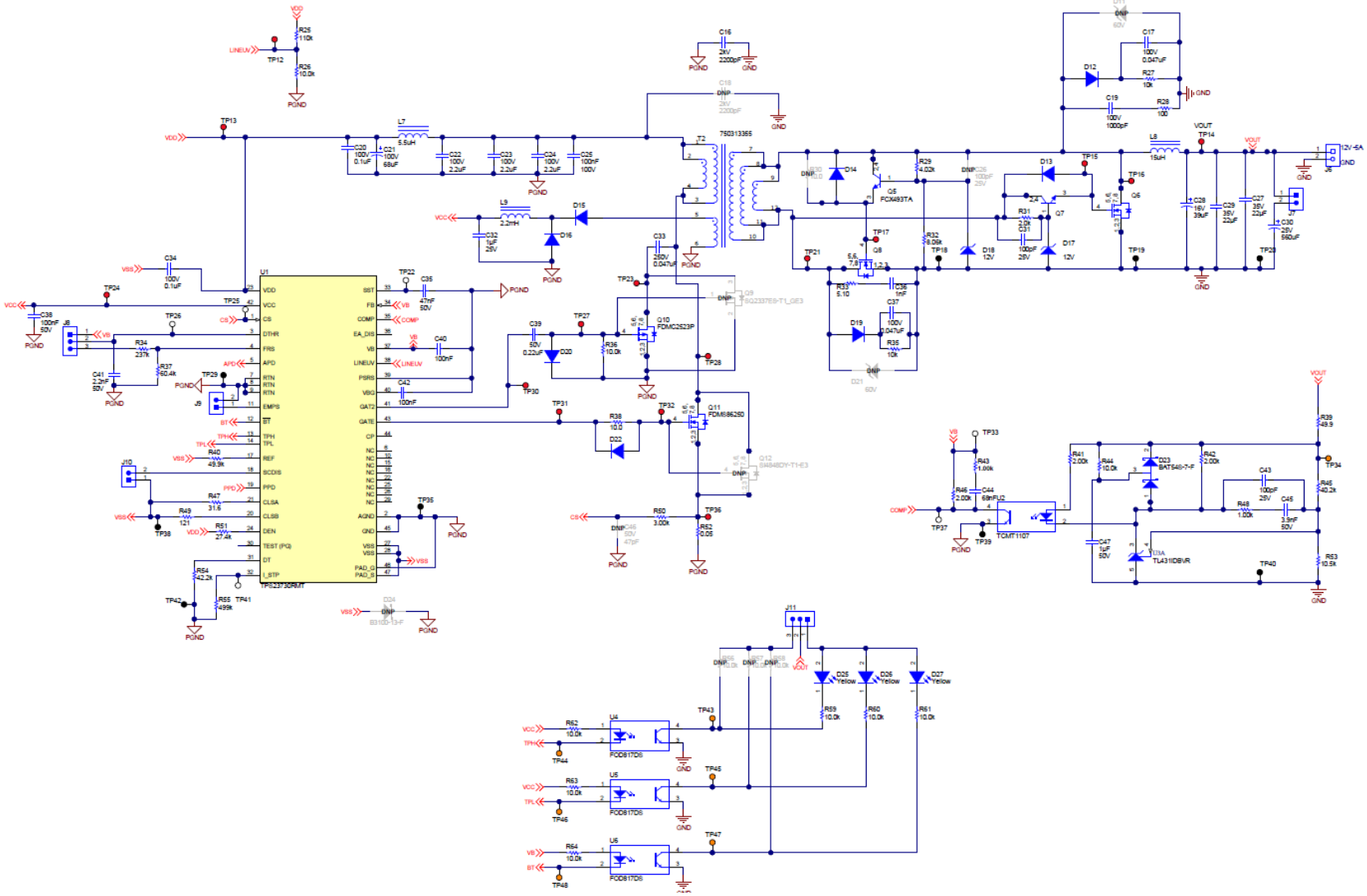

Figure 4-2. TPS23730EVM-093 Schematic Page Two

5 General Configuration and Description

5.1 Physical Access

Table 5-1 lists the EVM connector functionality. Table 5-2 describes the test point availability and jumper functionality.

Table 5-1. Connector Functionality

Connector	Description
J8	connects DTH to either FRS or VB
J4	Enable or disable APD for adapter input from J3
J5	connects PPD divider, which allows a lower turn on voltage
J9	Enable or disable EMPS
J10	Select TPL serial or parallel
J11	Select TPH, TPL, BT to output on resistor, LED, or leave open
J7	Connects extra output capacitance C15

Table 5-2. Test Points

Test Point	Description
TP1	Pair 12
TP2	Pair 36
TP3	Pair 45
TP4	Pair 78
TP5	Earth
TP6	Adapter Positive Input
TP7	PPD
TP8	Adapter Negative Input
TP9	VDD
TP10	APD
TP11	VSS
TP12	LINEUV
TP13	VDD
TP14	VOUT
TP15	Gate of Q6
TP16	Drain of Q6
TP17	Gate of Q8
TP18	GND
TP19	GND
TP20	GND
TP21	Drain of Q8
TP22	SST
TP23	Drain of Q10
TP24	VCC
TP25	CS
TP26	DTHR
TP27	Gate of Q10
TP28	Drain of Q11
TP29	RTN
TP30	GAT2
TP31	GATE
TP32	Gate of Q11

Table 5-2. Test Points (continued)

Test Point	Description
TP33	VB
TP34	Loop
TP35	PGND
TP36	Source of Q11 - Sense Resistor
TP37	COMP
TP38	VSS
TP39	PGND
TP40	GND
TP41	I_STP
TP42	PGND
TP43	TPH Opto Output
TP44	TPH
TP45	TPL Opto Output
TP46	TPL
TP47	BT Opto Output
TP48	BT

6 TPS23730EVM-093 Performance Data

6.1 Startup to PSE and DCDC Startup

Figure 6-1 shows the startup response of the TPS23730EVM-093. Figure 6-1

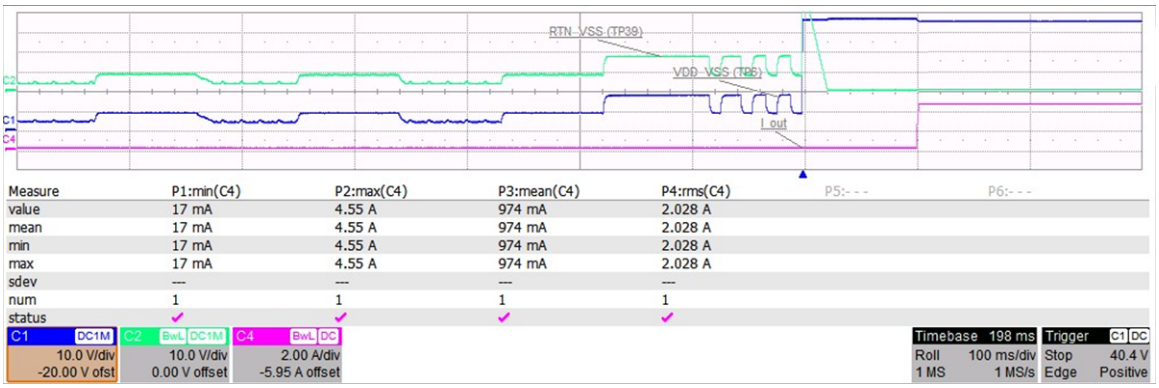

Figure 6-1. Startup Response When Connected to a PoE PSE

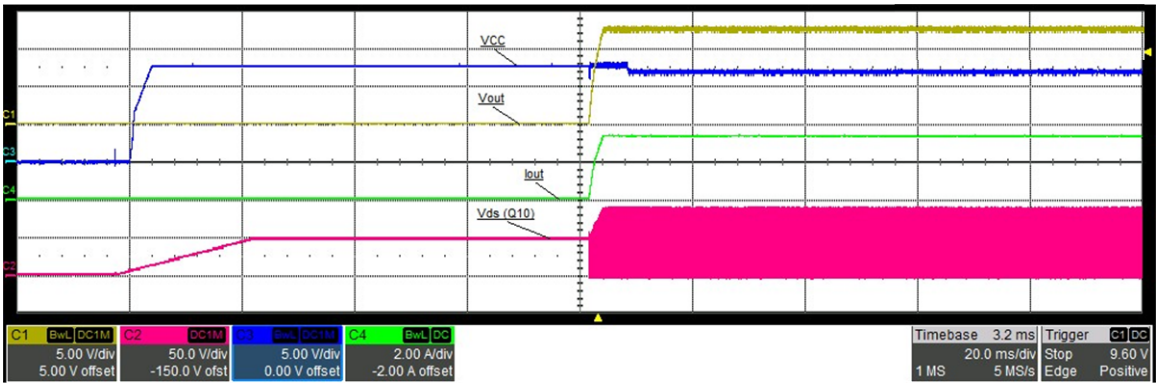

Figure 6-2. DC/DC Startup

6.2 Soft-Stop Response

The TPS23730 has a soft stop feature that enables a controlled discharge of the output bulk capacitance. Please refer to SLVAEY9 for more information. Figure 6-3 and Figure 6-4 show the 5-V output waveform after the input voltage is removed.

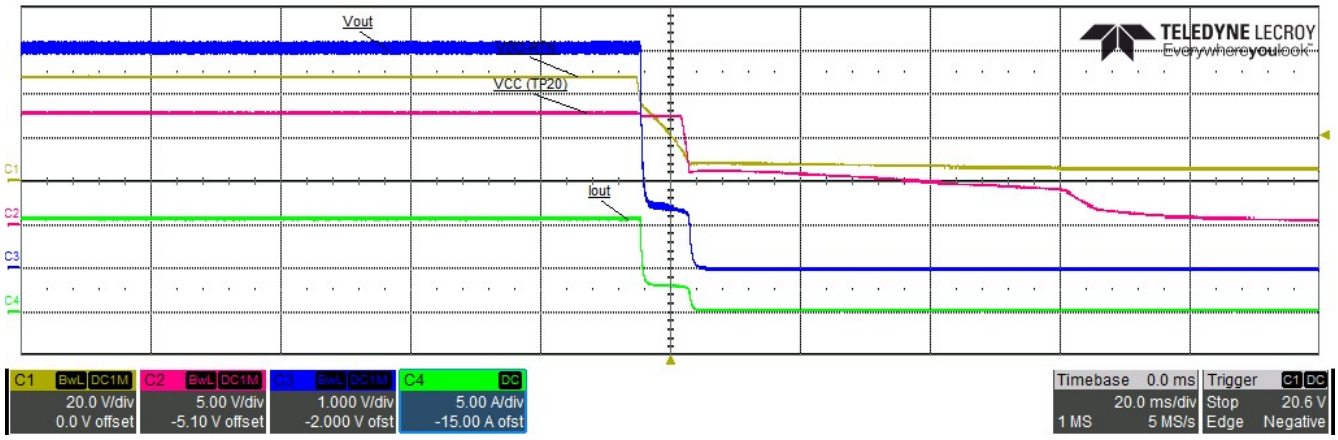

Figure 6-3. Shutdown Waveform 10-A Load

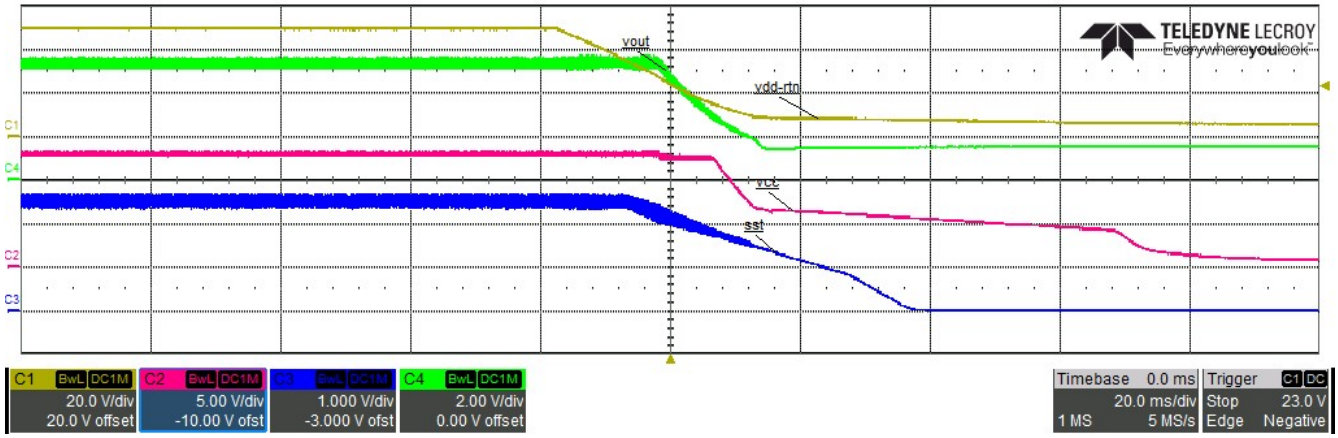

Figure 6-4. Shutdown Waveform 0-A Load

Figure 6-5 shows the primary MOSFET Q11 during shutdown.

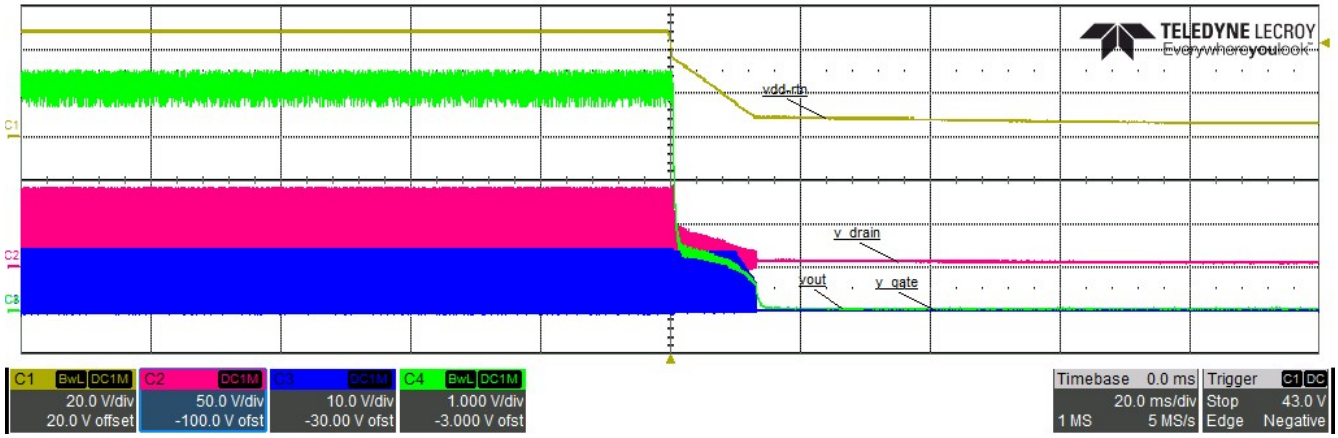

Figure 6-5. Shutdown Waveform Primary MOSFET with 10-A Load

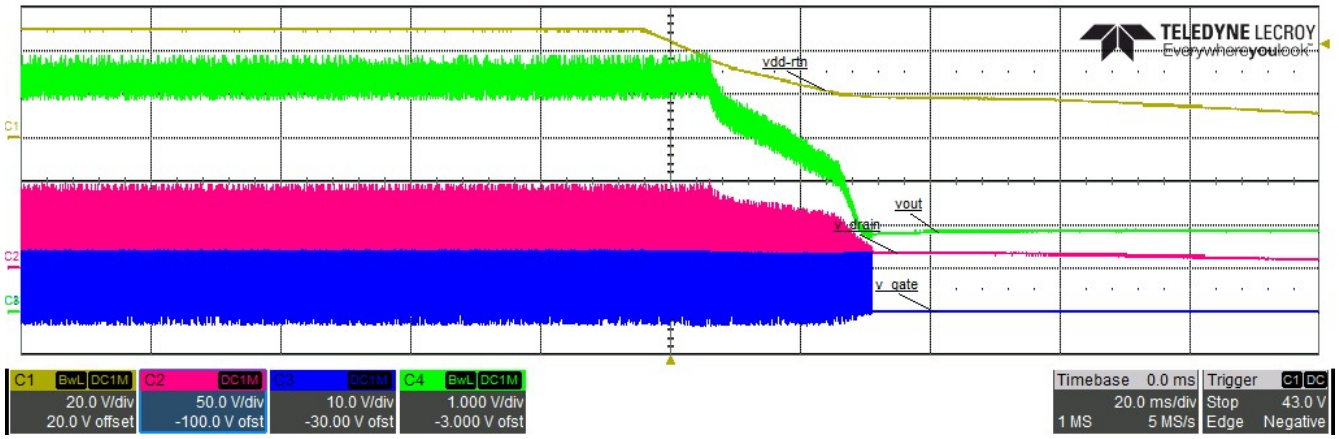

Figure 6-6. Shutdown Waveform Primary MOSFET with 0-A Load

Figure 6-7 and Figure 6-8 show the primary sync MOSFET Q10 during shutdown.

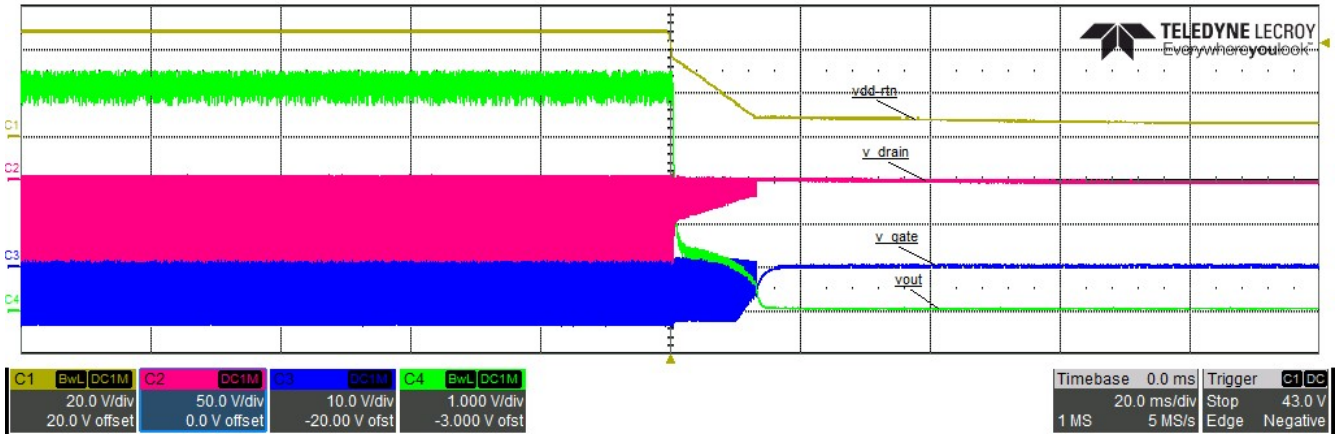

Figure 6-7. Shutdown Waveform Synchronous MOSFET with 10-A Load

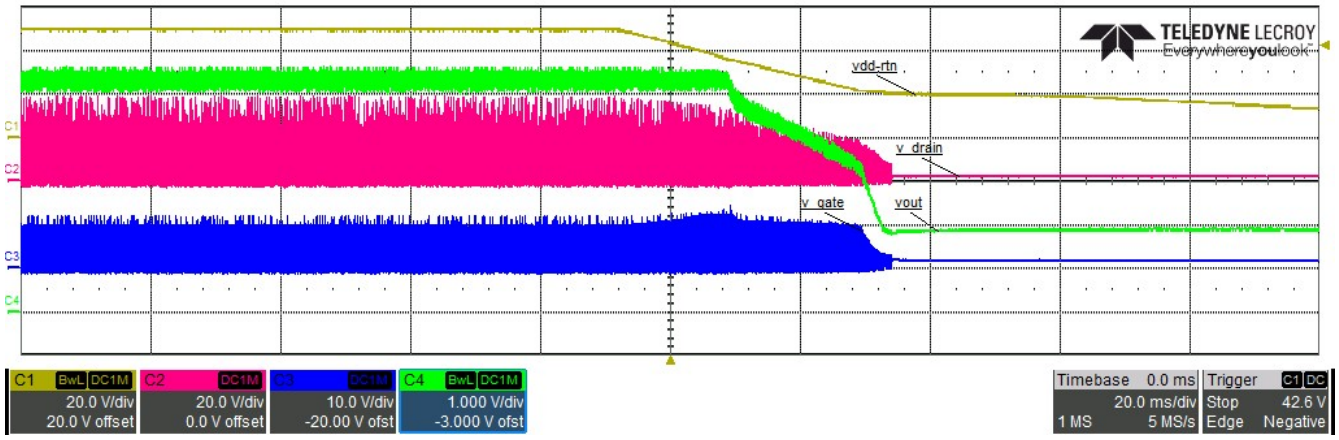

Figure 6-8. Shutdown Waveform Synchronous MOSFET with 0-A Load

Figure 6-9 and Figure 6-10 show the secondary series MOSFET Q8 during shutdown.

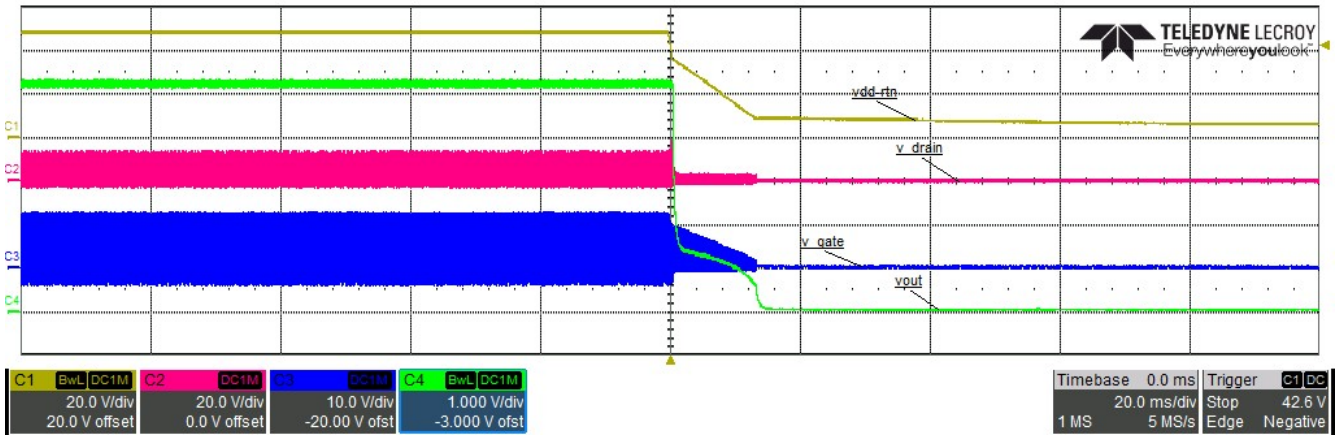

Figure 6-9. Shutdown Waveform Secondary Series MOSFET 10-A Load

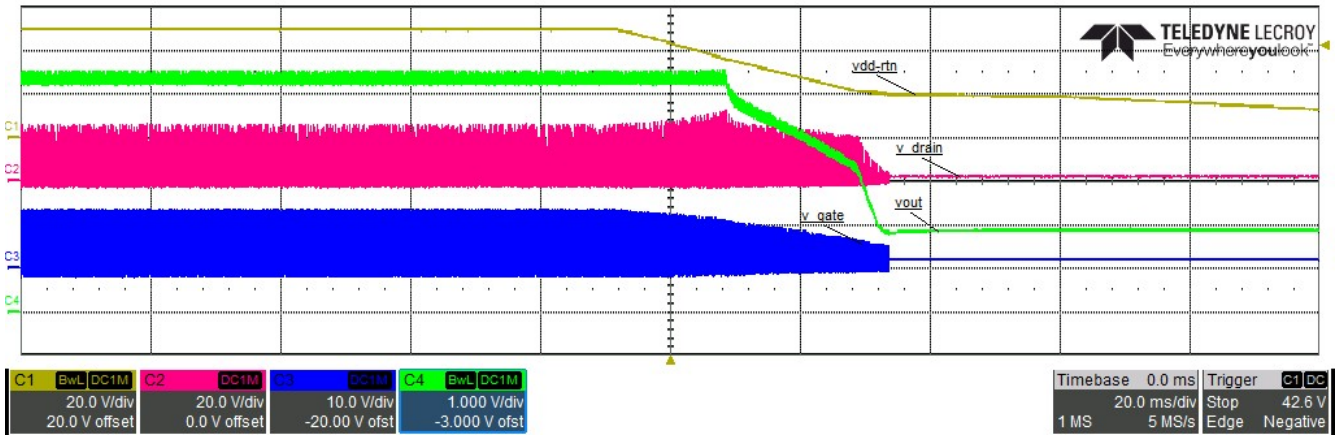

Figure 6-10. Shutdown Waveform Secondary Series MOSFET 0-A Load

Figure 6-11 and Figure 6-12 show the secondary parallel MOSFET Q6 during shutdown.

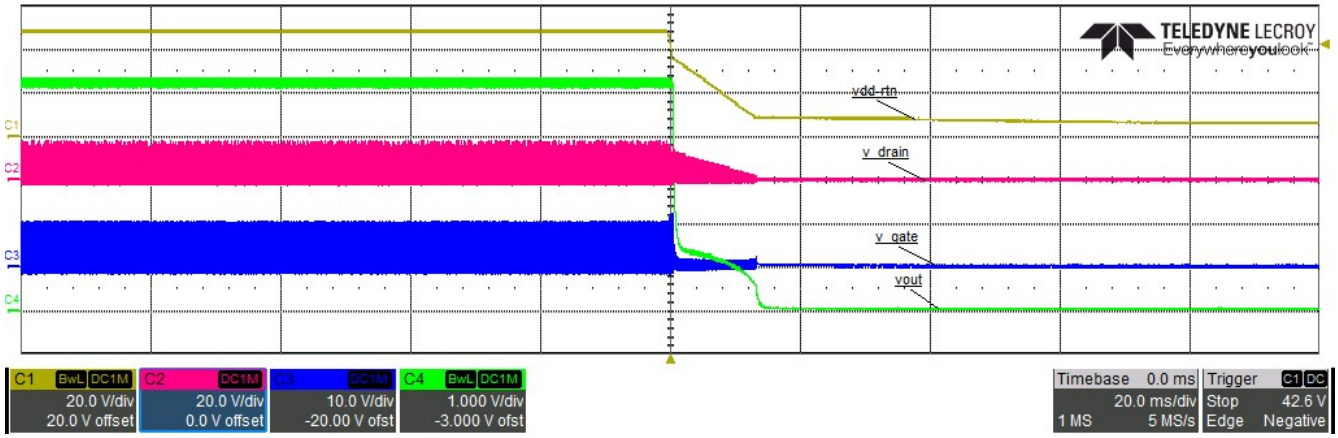

Figure 6-11. Shutdown Waveform Secondary Parallel MOSFET with 10-A Load

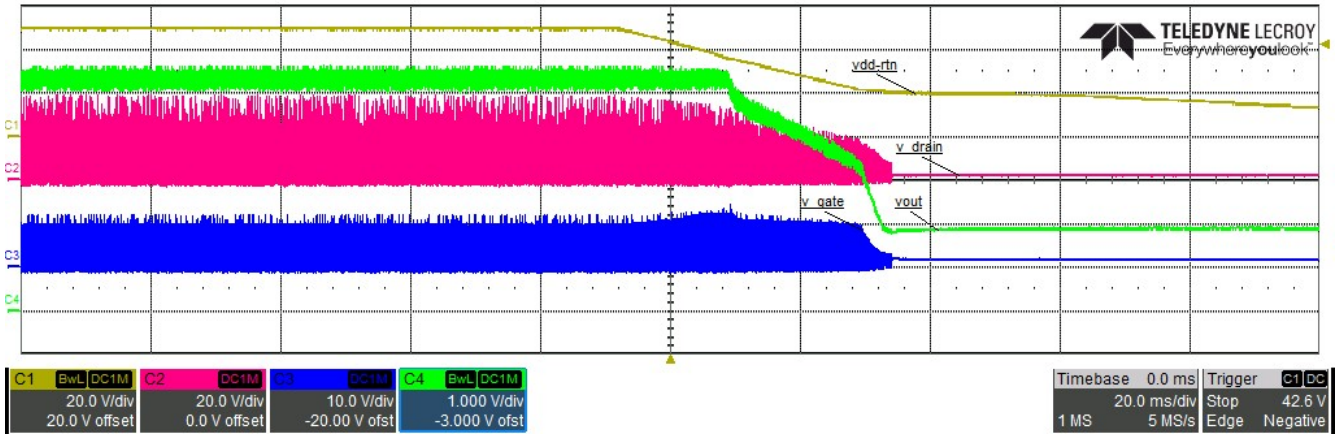

Figure 6-12. Shutdwon Waveform Secondary Parallel MOSFET 0-A Load

6.3 Efficiency

Figure 6-13 shows the efficiency of the TPS23730EVM-093

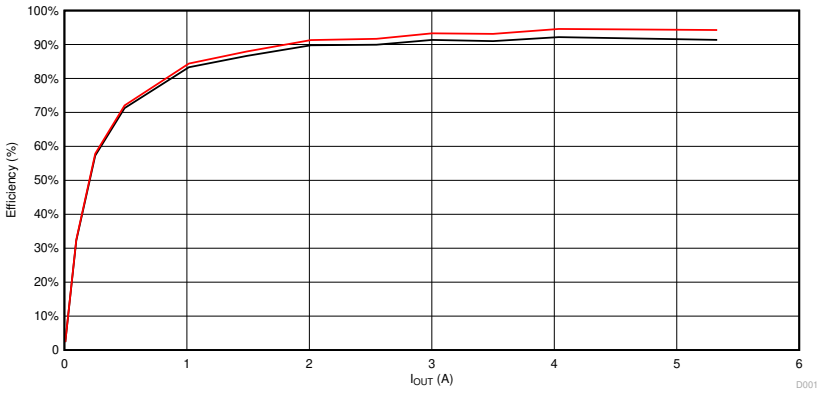

Figure 6-13. Efficiency of the TPS23730EVM-093

6.4 Load Regulation

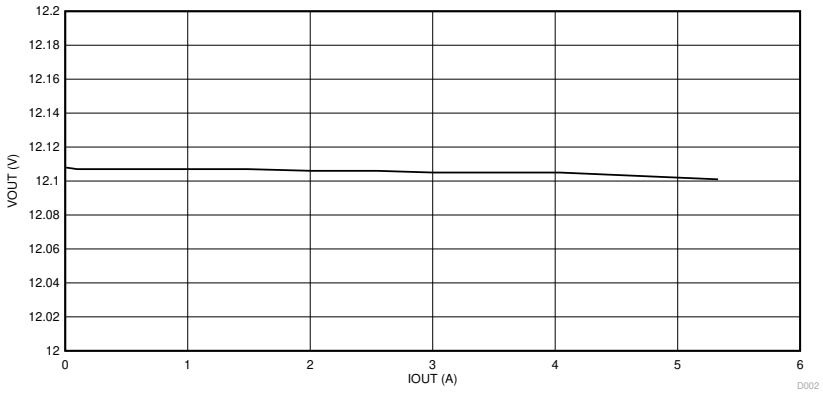

Figure 6-14. TPS23730EVM-093 Load Regulation

6.5 Hiccup Performance During an Output Short

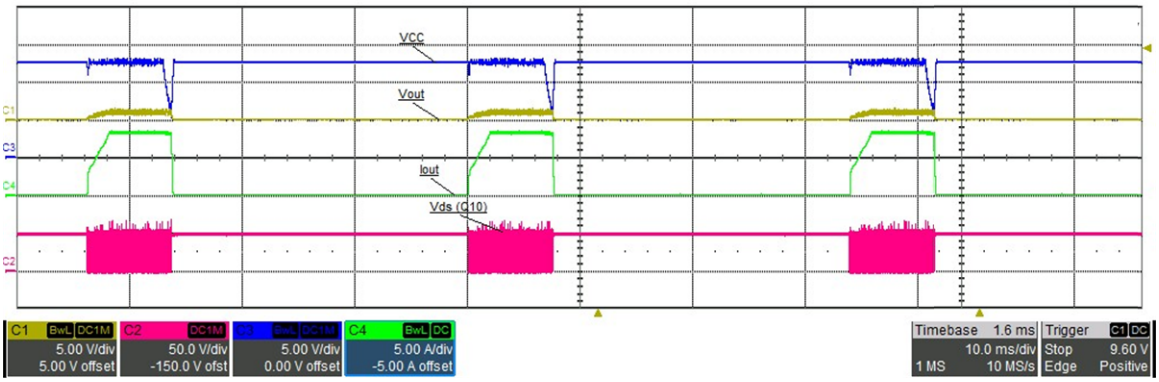

Figure 6-15. DCDC Hiccup Performance during an Output Short

6.6 Bode Plot

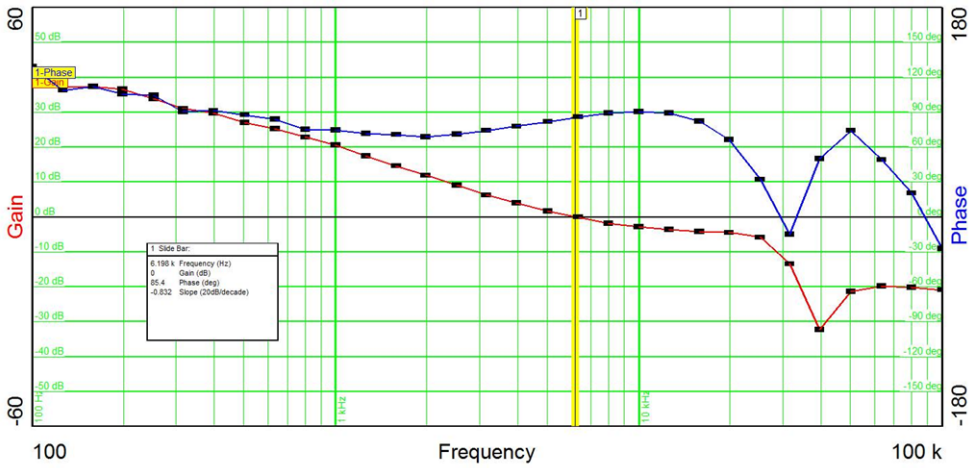

Figure 6-16. Bode Plot Response of the TPS23730EVM-093 with 5-A Load

7 EVM Assembly Drawings and Layout Guidelines

7.1 PCB Drawings

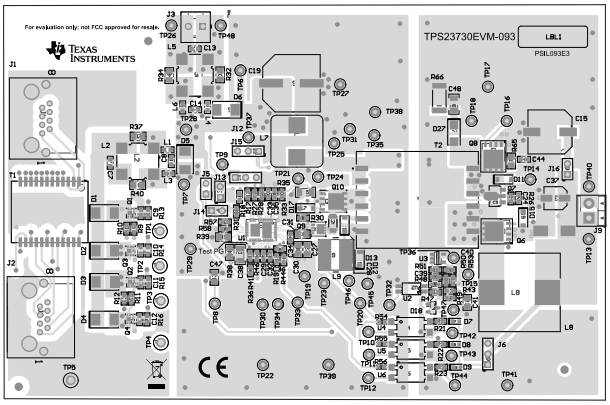

Figure 7-1. Top-Side Routing and Component Placement

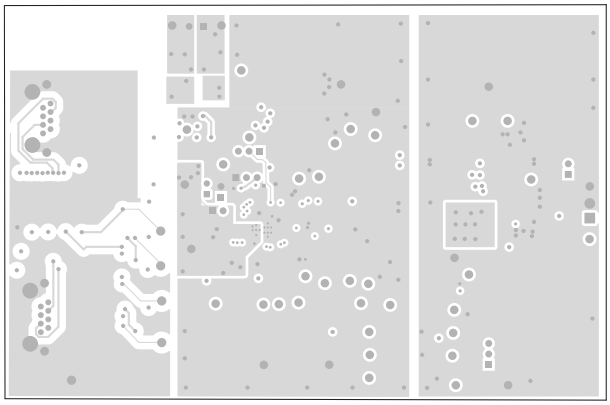

Figure 7-2. Layer 2 Routing

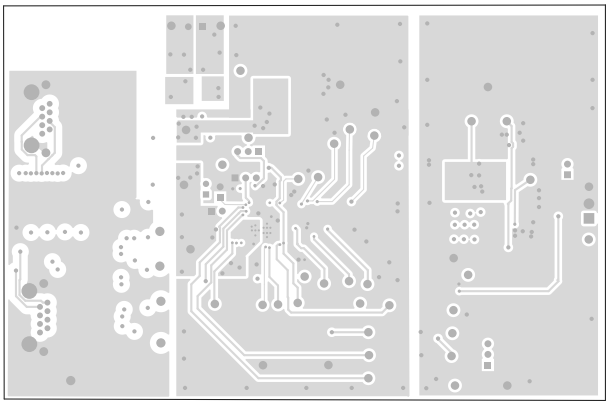

Figure 7-3. Layer 3 Routing

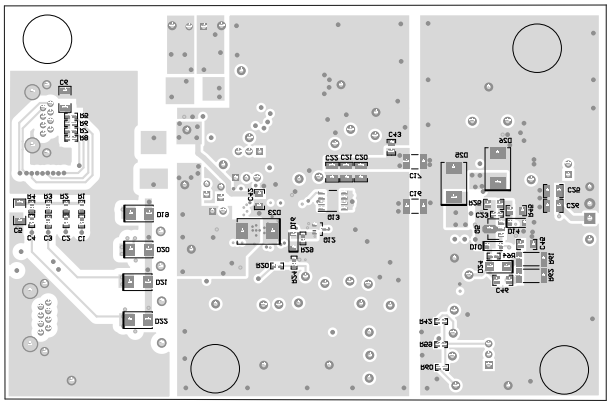

Figure 7-4. Bottom Side Routing and Component Placement

7.2 Layout Guidelines

The layout of the PoE front end should follow power and EMI or ESD best-practice guidelines. A basic set of recommendations includes:

- It is recommended having at least 8 vias (PAD G) and 5 vias on (PAD S) connecting the exposed thermal pad through a top layer plane (2 oz copper recommended) to a bottom VSS plane (2 oz. copper recommended) to help with thermal dissipation.
- The primary MOSFET (Q10 in TPS23730EVM093) should be near the power transformer and the current sense resistor should be close to source of the MOSFET to minimize the primary loop. The same is true for the secondary MOSFETs. Keep the MOSFETs close to the transformer, and associated components as close together as possible to minimize the loop.
- Parts placement must be driven by power flow in a point-to-point manner; RJ-45, Ethernet transformer, diode bridges, TVS and 0.1-µF capacitor, and TPS23730 converter input bulk capacitor.
- Make all leads as short as possible with wide power traces and paired signal and return.
- No crossovers of signals from one part of the flow to another are allowed.
- Spacing consistent with safety standards like IEC60950 must be observed between the 48-V input voltage rails and between the input and an isolated converter output.
- Use large copper fills and traces on SMT power-dissipating devices, and use wide traces or overlay copper fills in the power path.

- Place the Schotty diode between VSS and RTN as close to the IC as possible, preferably on directly on the opposite side of the board (ex. The TPS23730EVM-093 places the IC on the top side, so the diode is on the bottom side directly underneath it).

The DC-to-DC converter layout benefits from basic rules such as:

- Having at least 4 vias (VDD) near the power transformer pin connected to VDD through multiple layer planes to help with thermal dissipation of the power transformer.
- Having at least 6 vias (secondary ground) near the power transformer pin connected to secondary ground through multiple layer planes to help with thermal dissipation of the power transformer.
- Pair signals to reduce emissions and noise, especially the paths that carry high-current pulses, which include the power semiconductors and magnetics
- Minimize the trace length of high current power semiconductors and magnetic components
- Use the ground plane for the switching currents carefully
- Keep the high-current and high-voltage switching away from low-level sensing circuits including those outside the power supply
- Proper spacing around the high-voltage sections of the converter

7.3 EMI Containment

- Use compact loops for dv/dt and di/dt circuit paths (power loops and gate drives)
- Use minimal, yet thermally adequate, copper areas for heat sinking of components tied to switching nodes (minimize exposed radiating surface). Hide copper associated with switching nodes under shielded magnetics, where possible
- Use copper ground planes (possible stitching) and top-layer copper floods (surround circuitry with ground floods)
- Use a 4-layer PCB, if economically feasible (for better grounding)
- Minimize the amount of copper area associated with input traces (to minimize radiated pickup)
- Heat sink the quiet side of components instead of the switching side, where possible (like the output side of inductor)
- Use Bob Smith terminations, Bob Smith EFT capacitor, and Bob Smith plane. Use Bob Smith plane as a ground shield on input side of PCB (creating a phantom or literal earth ground)
- Use LC filter at DC-to-DC input
- Dampen high-frequency ringing on all switching nodes, if present (allow for possible snubbers)
- Control rise times with gate-drive resistors and possibly snubbers
- Switching frequency considerations
- Use of EMI bridge capacitor across isolation boundary (isolated topologies)
- Observe the polarity dot on inductors (embed noisy end)
- Use of ferrite beads on input (allow for possible use of beads or 0-Ω resistors)
- Maintain physical separation between input-related circuitry and power circuitry (use ferrite beads as boundary line)
- Balance efficiency versus acceptable noise margin
- Possible use of common-mode inductors
- Possible use of integrated RJ-45 jacks (shielded with internal transformer and Bob Smith terminations)
- End-product enclosure considerations (shielding)

8 Bill of Materials

The table below lists the TPS2730EVM-093 Bill of Materials (BOM).

Designator (1)	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer	Alternate PartNumber	Alternate Manufacturer
!PCB1	1		Printed Circuit Board		PSIL093	Any		
C1, C2, C3, C4	4	0.01uF	CAP, CERM, 0.01 uF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E2X7R2A103K080AA	TDK		
C5, C6	2	1000pF	CAP, CERM, 1000 pF, 2000 V, +/- 10%, X7R, 1808	1808	GR442QR73D102KW01L	MuRata		
C7, C8, C9, C10	4	1000pF	CAP, CERM, 1000 pF, 100 V, +/- 10%, X7R, 0603	0603	C1608X7R2A102K080AA	TDK		
C11	1	470pF	CAP, CERM, 470 pF, 100 V, +/- 10%, X7R, 0805	0805	08051C471KAT2A	AVX		
C12, C13, C14, C15	4	330pF	CAP, CERM, 330 pF, 50 V, +/- 5%, C0G/NP0, 0603	0603	885012006060	Wurth Elektronik		
C16	1	2200pF	CAP, CERM, 2200 pF, 2000 V, +/- 10%, X7R, 1812	1812	C4532X7R3D222K130KA	TDK		
C17, C37	2	0.047uF	CAP, CERM, 0.047 uF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 1206	1206	CGA5H2X7R2A473K115AA	TDK		
C19	1	1000pF	CAP, CERM, 1000 pF, 100 V, +/- 10%, X7R, 1206	1206	12061C102KAT2A	AVX		
C20, C34	2	0.1uF	CAP, CERM, 0.1 uF, 100 V, +/- 10%, X7R, 1206	1206	GRM319R72A104KA01D	MuRata		
C21	1	68uF	CAP, AL, 68 uF, 100 V, +/- 20%, 0.32 ohm, AEC-Q200 Grade 2, SMD	SMT Radial H13	EEV-FK2A680Q	Panasonic		

Designator (1)	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer	Alternate PartNumber	Alternate Manufacturer
C22, C23, C24	3	2.2uF	CAP, CERM, 2.2 uF, 100 V, +/- 10%, X7R, 1210	1210	GRM32ER72A225KA35L	MuRata		
C25	1	0.1uF	CAP, CERM, 0.1 uF, 100 V, +/- 10%, X7R, 0805	0805	GRM21BR72A104KAC4L	MuRata		
C27, C29	2	22uF	CAP, CERM, 22 µF, 35 V,+/- 20%, X5R, 1210	1210	GMK325BJ226MM-P	Taiyo Yuden		
C28	1	39uF	CAP, Aluminum Polymer, 39 uF, 16 V, +/- 20%, 0.05 ohm, 6.3x5.8 SMD	6.3x5.8	16SVP39M	Panasonic		
C30	1	560uF	CAP, AL, 560 uF, 25 V, +/- 20%, 0.08 ohm, AEC-Q200 Grade 2, SMD	D10xL10.2mm	EEEFPE561UAP	Panasonic		
C31, C43	2	100pF	CAP, CERM, 100 pF, 25 V, +/- 10%, X7R, 0603	0603	06033C101KAT2A	AVX		
C32	1	1uF	CAP, CERM, 1 uF, 25 V, +/- 10%, X7R, 0805	0805	GRM21BR71E105KA99L	MuRata		
C33	1	0.047uF	CAP, CERM, 0.047 uF, 250 V, +/- 10%, X7R, 1206	1206	GRM31CR72E473KW03L	MuRata		
C35	1	0.047uF	CAP, CERM, 0.047 uF, 50 V, +/- 10%, X7R, 0603	0603	GRM188R71H473KA61D	MuRata		
C36	1	1000pF	CAP, CERM, 1000 pF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E2X7R2A102K080AA	TDK		
C38	1	0.1uF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805	0805	GCM21BR71H104KA37K	MuRata		
C39	1	0.22uF	CAP, CERM, 0.22 uF, 50 V, +/- 10%, X5R, 0805	0805	C2012X5R1H224K125AA	TDK		

Designator (1)	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer	Alternate PartNumber	Alternate Manufacturer
C40	1	0.1uF	CAP, CERM, 0.1 uF, 25 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E2X7R1E104K080AA	TDK		
C41	1	2200pF	CAP, CERM, 2200 pF, 50 V, +/- 10%, X7R, 0603	0603	C0603C222K5RAC	Kemet		
C42	1	0.1uF	CAP, CERM, 0.1 uF, 25 V, +/- 5%, X7R, 0603	0603	C0603C104J3RACTU	Kemet		
C44	1	0.068uF	CAP, CERM, 0.068 uF, 16 V, +/- 10%, X7R, 0603	0603	GRM188R71C683KA01D	MuRata		
C45	1	3900pF	CAP, CERM, 3900 pF, 50 V, +/- 10%, X7R, 0603	0603	GRM188R71H392KA01D	MuRata		
C47	1	1uF	CAP, CERM, 1 uF, 50 V, +/- 10%, X7R, 0805	0805	C2012X7R1H105K125AB	TDK		
D1, D2, D3, D4, D5	5	100V	Diode, Schottky, 100 V, 2 A, SMB	SMB	B2100-13-F	Diodes Inc.		
D6	1	58V	Diode, TVS, Uni, 58 V, 93.6 Vc, SMB	SMB	SMBJ58A-13-F	Diodes Inc.		
D12, D19	2	100V	Diode, Ultrafast, 100 V, 2 A, SMA	SMA	MURA110T3G	ON Semiconductor		
D13, D14, D15, D16, D20, D22	6	100V	Diode, Switching, 100 V, 0.2 A, SOD-123	SOD-123	MMSD914T1G	ON Semiconductor		
D17, D18	2	12V	Diode, Zener, 12 V, 500 mW, SOD-123	SOD-123	MMSZ5242B-7-F	Diodes Inc.		
D23	1	30V	Diode, Schottky, 30 V, 0.2 A, SOT-23	SOT-23	BAT54S-7-F	Diodes Inc.		
D25, D26, D27	3	Yellow	LED, Yellow, SMD	LED_0603	150060YS75000	Wurth Elektronik		
FID1, FID2, FID3	3		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A		
H1, H2, H3, H4	4		Bumpon, Hemisphere, 0.44 X 0.20, Clear	Transparent Bumpon	SJ-5303 (CLEAR)	3M		

Designator (1)	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer	Alternate PartNumber	Alternate Manufacturer
J1, J2	2		RJ45, No LED, tab up, R/A, TH	16.26x14.54x15.75	1-406541-1	TE Connectivity		
J3	1		Terminal Block, 3.5 mm, 2x1, Tin, TH	Terminal Block, 3.5 mm, 2x1, TH	39357-0002	Molex		
J4, J8, J11	3		Header, 100mil, 3x1, Tin, TH	Header, 3x1, 100mil, TH	5-146278-3	TE Connectivity		
J5	1		Header, 100mil, 2x1, Tin, TH	Header, 2 PIN, 100mil, Tin	PEC02SAAN	Sullins Connector Solutions		
J6	1		Terminal Block, 3.5mm Pitch, 2x1, TH	7.0x8.2x6.5mm	ED555/2DS	On-Shore Technology		
J7, J9, J10	3		Header, 100mil, 2x1, Tin, TH	Header, 2x1, 100mil, TH	5-146278-2	TE Connectivity		
L1, L3, L4, L6	4	300 ohm	Ferrite Bead, 300 ohm @ 100 MHz, 2 A, 0603	0603	742792641	Wurth Elektronik		
L7	1	5.5uH	Inductor, Shielded Drum Core, Superflux, 5.5 uH, 10 A, 0.0112 ohm, SMD	WE-HC6	744325550	Wurth Elektronik		
L8	1	15uH	Inductor, Shielded Drum Core, Ferrite, 15 uH, 14 A, 0.009 ohm, SMD	18.3x8.9x18.2mm	74435571500	Wurth Elektronik		
L9	1	2.2mH	Inductor, Unshielded Drum Core, Metal Composite, 2.2 mH, 0.15 A, 6 ohm, SMD	7x5x7.8mm	768775322	Wurth Elektronik		
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650 x 0.200 inch	THT-14-423-10	Brady		
Q1, Q2, Q3, Q4	4	100V	MOSFET, N-CH, 100 V, 4.5 A, DQK0006C (WSON-6)	DQK0006C	CSD19538Q2	Texas Instruments		None

Designator (1)	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer	Alternate PartNumber	Alternate Manufacturer
Q5, Q7	2	100 V	Transistor, NPN, 100 V, 1 A, SOT-89	SOT-89	FCX493TA	Diodes Inc.		
Q6, Q8	2	80V	MOSFET, N-CH, 80 V, 100 A, PG-TDSON-8	PG-TDSON-8	BSC057N08NS3 G	Infineon Technologies		None
Q10	1	-150V	MOSFET, P-CH, -150 V, -3 A, QFN-8	QFN-8	FDMC2523P	Fairchild Semiconductor		None
Q11	1	150V	MOSFET, N-CH, 150 V, 6.7 A, PQFN08A	PQFN08A	FDMS86250	Fairchild Semiconductor		None
R1	1	75.0	RES, 75.0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060375R0FKEA	Vishay-Dale		
R2, R3, R4, R5, R6, R7, R8	7	75.0	RES, 75.0, 1%, 0.1 W, 0603	0603	CRCW060375R0FKEA	Vishay-Dale		
R9, R12, R13, R24	4	0	RES, 0, 0%, W, AEC-Q200 Grade 0, 0805	0805	PMR10EZPJ000	Rohm		
R10, R14	2	100k	RES, 100 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603100KFKEA	Vishay-Dale		
R11	1	4.42k	RES, 4.42 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06034K42FKEA	Vishay-Dale		
R15, R16, R17, R18	4	1.00Meg	RES, 1.00 M, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06031M00FKEA	Vishay-Dale		
R19	1	15.0k	RES, 15.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060315K0FKEA	Vishay-Dale		
R20, R21, R22, R23	4	232k	RES, 232 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603232KFKEA	Vishay-Dale		
R25	1	110k	RES, 110 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603110KFKEA	Vishay-Dale		

Designator (1)	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer	Alternate PartNumber	Alternate Manufacturer
R26, R36, R44, R59, R60, R61, R62, R63, R64	9	10.0k	RES, 10.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060310K0FKEA	Vishay-Dale		
R27, R35	2	10k	RES, 10 k, 5%, 1 W, AEC-Q200 Grade 0, 2512	2512	CRCW251210K0JNEG	Vishay-Dale		
R28	1	100	RES, 100, 5%, 1 W, AEC-Q200 Grade 0, 2512	2512	CRCW2512100RJNEG	Vishay-Dale		
R29	1	4.02k	RES, 4.02 k, 1%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	CRCW12064K02FKEA	Vishay-Dale		
R31	1	2.0k	RES, 2.0 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06032K00JNEA	Vishay-Dale		
R32	1	8.06k	RES, 8.06 k, 1%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	CRCW12068K06FKEA	Vishay-Dale		
R33	1	5.10	RES, 5.10, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	ERJ-6RQF5R1V	Panasonic		
R34	1	237k	RES, 237 k, 1%, 0.1 W, 0603	0603	RC0603FR-07237KL	Yageo		
R37	1	60.4k	RES, 60.4 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060360K4FKEA	Vishay-Dale		
R38	1	10.0	RES, 10.0, 1%, 0.1 W, 0603	0603	CRCW060310R0FKEA	Vishay-Dale		
R39	1	49.9	RES, 49.9, 1%, 0.1 W, 0603	0603	RC0603FR-0749R9L	Yageo		
R40	1	49.9k	RES, 49.9 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060349K9FKEA	Vishay-Dale		
R41, R46	2	2.00k	RES, 2.00 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06032K00FKEA	Vishay-Dale		
R42	1	2.00k	RES, 2.00 k, 1%, 0.1 W, 0603	0603	Y16362K00000F9R	Vishay Foil Resistors		

Designator (1)	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer	Alternate PartNumber	Alternate Manufacturer
R43	1	1.00k	RES, 1.00 k, 1%, 0.1 W, 0603	0603	RC0603FR-071KL	Yageo		
R45	1	40.2k	RES, 40.2 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060340K2FKEA	Vishay-Dale		
R47	1	31.6	RES, 31.6, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	CRCW080531R6FKEA	Vishay-Dale		
R48	1	1.00k	RES, 1.00 k, 1%, 0.1 W, 0603	0603	CRCW06031K00FKEA	Vishay-Dale		
R49	1	121	RES, 121, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	CRCW0805121RFKEA	Vishay-Dale		
R50	1	3.00k	RES, 3.00 k, 1%, 0.1 W, 0603	0603	RC0603FR-073KL	Yageo		
R51	1	27.4k	RES, 27.4 k, 1%, 0.1 W, 0603	0603	RC0603FR-0727K4L	Yageo		
R52	1	0.05	RES, 0.05, 1%, 1 W, AEC-Q200 Grade 0, 1206	1206	ERJ-8CWFR050V	Panasonic		
R53	1	10.5k	RES, 10.5 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060310K5FKEA	Vishay-Dale		
R54	1	42.2k	RES, 42.2 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060342K2FKEA	Vishay-Dale		
R55	1	499k	RES, 499 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603499KFKEA	Vishay-Dale		
SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J7	7		Shunt, 2.54mm, Gold, Black	Shunt, 2.54mm, Black	60900213421	Wurth Elektronik		
T1	1	350uH	Transformer, 350 uH, SMT	14.7x18.29mm	7490220122	Wurth Elektronik		

Designator (1)	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer	Alternate PartNumber	Alternate Manufacturer
T2	1		Power Over Ethernet (PoE) For Configurable (For DC/DC) SMPS Transformer 1500Vrms Isolation Surface Mount	SMT_XFRMR_29MM08_23MM1	750313355	Wurth Electronics		
TP1, TP2, TP3, TP4	4		Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint	5010	Keystone		
TP5	1		Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone		
TP6, TP9, TP12, TP13, TP14, TP15, TP16, TP17, TP21, TP23, TP24, TP27, TP28, TP30, TP31, TP32, TP36	17		Test Point, Miniature, Red, TH	Red Miniature Testpoint	5000	Keystone		
TP7, TP10, TP22, TP25, TP26, TP33, TP37, TP41	8		Test Point, Miniature, White, TH	White Miniature Testpoint	5002	Keystone		
TP8, TP11, TP18, TP19, TP20, TP29, TP35, TP38, TP39, TP40, TP42	11		Test Point, Miniature, Black, TH	Black Miniature Testpoint	5001	Keystone		
TP34, TP43, TP44, TP45, TP46, TP47, TP48	7		Test Point, Miniature, Orange, TH	Orange Miniature Testpoint	5003	Keystone		
U1	1		TPS23730RMT, RMT0045A (VQFN-45)	RMT0045A	TPS23730RMT	Texas Instruments		Texas Instruments
U2	1		Optocoupler, 3.75 kV, 80-160% CTR, SMT	SOP-4	TCMT1107	Vishay-Semiconductor		

Designator (1)	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer	Alternate PartNumber	Alternate Manufacturer
U3	1		Adjustable Precision Shunt Regulator, 34 ppm / degC, 100 mA, -40 to 85 degC, 5-pin SOT-23 (DBV), Green (RoHS & no Sb/Br)	DBV0005A	TL431IDBVR	Texas Instruments		
U4, U5, U6	3		Optocoupler, 5 kV, 300-600% CTR, SMT	DIP-4L Gullwing	FOD817DS	Fairchild Semiconductor		
C18	0	2200pF	CAP, CERM, 2200 pF, 2000 V, +/- 10%, X7R, 1812	1812	C4532X7R3D222K130KA	TDK		
C26	0	100pF	CAP, CERM, 100 pF, 25 V, +/- 10%, X7R, 0603	0603	06033C101KAT2A	AVX		
C46	0	47pF	CAP, CERM, 47 pF, 50 V, +/- 5%, C0G/NP0, 0603	0603	GRM1885C1H470JA01D	MuRata		
D7, D8, D9, D10	0	100V	Diode, Schottky, 100 V, 2 A, SMB	SMB	B2100-13-F	Diodes Inc.		
D11, D21	0	60V	Diode, TVS, Uni, 60 V, SMC	SMC	SMCJ60A	Fairchild Semiconductor		
D24	0	100V	Diode, Schottky, 100 V, 3 A, SMC	SMC	B3100-13-F	Diodes Inc.		
L2, L5	0	250uH	Coupled inductor, 250 uH, A, 0.035 ohm, SMD	8.7x10mm	744272251	Wurth Elektronik		
Q9	0	-80V	MOSFET, P-CH, -80 V, -2.2 A, AEC-Q101, SOT-23	SOT-23	SQ2337ES-T1_GE3	Vishay-Siliconix		None
Q12	0	150V	MOSFET, N-CH, 150 V, 2.7 A, SOIC-8	SOIC-8	SI4848DY-T1-E3	Vishay-Siliconix		None
R30	0	10.0	RES, 10.0, 1%, 0.25 W, AEC-Q200 Grade 0, 0603	0603	CRCW060310R0FKEAHP	Vishay-Dale		

Designator (1)	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer	Alternate PartNumber	Alternate Manufacturer
R56, R57, R58	0	10.0k	RES, 10.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060310K0FKEA	Vishay-Dale		

(1) Unless otherwise noted in the *Alternate Part Number* and *Alternate Manufacturer* columns, all parts may be substituted with equivalents.

Revision History

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

Changes from Revision * (May 2020) to Revision A (December 2020)	Page
• Updated the numbering format for tables, figures and cross-references throughout the document	1
• Updated the schematic	5
• Added Soft-Stop Response section	9
• Updated the Bill of Materials	16

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