Efficiency-Optimized, Synchronous Flyback, High-Power PoE Controller/Converter

The TPS23754 is an IEEE 802.3at-compliant, powered-device (PD) controller and power supply controller optimized for isolated converter topologies. TPS23754EVM-420 (SLVU301) is targeted at 25-W, synchronous, flyback converter applications. The PMP6672B reference design starts with the TPS23754EVM-420 platform and improves the overall efficiency of the design.

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1 Description

The PMP6672B allows reference circuitry evaluation of the TPS23754. It contains input and output power connectors and an array of onboard test points for circuit evaluation. Modifications to TPS23754EVM-420 (SLVU301) are noted on the schematic shown in Figure 1.

1.1 Design Improvement Summary

- New flyback transformer design
- Better selection of magnetizing inductance for CCM operation
- New winding strategy to reduce copper losses
- Uses same core and bobbin size and footprint
- RCD clamp improvements
- Diode used for faster primary FET turnoff
- New dead-time resistor value for optimum efficiency at full load and acceptable efficiency at no load.
- Use of feedforward resistor for better control of peak current and voltage at higher input voltage.
- Other updates: Compensation, improved slope compensation, 40-V synchronized FET for low drain-source stress.
- Other benefits
- Lower primary MOSFET peak drain-source voltage during overloads
- Much better current-limit control

1.2 Typical Applications

- Voice over Internet Protocol – IP telephones
- Wireless LAN – wireless access points
- Security – wired IP cameras

1.3 Features

- Efficient, general market design
- Self-driven, synchronous, rectified secondary
- 25-W output power from Power over Ethernet (PoE) or from a 48-V adapter
- 5-V output voltage

2 Electrical Performance Specifications

Table 1. PMP6672B Electrical Performance Specifications (at 25°C)

Parameter	Condition		Min	Typ	Max	Units
Power Interface						
Input voltage	Applied to the power pins of connectors J2 or J3		0	-	57	V
Operating voltage	After start-up		30	-	57	V
Input UVLO	Rising input voltage		-	-	36	V
	Falling input voltage		30	-	-	
Detection voltage	At device terminals		1.6	-	10	V
Classification voltage	At device terminals		10	-	23	V
Classification current	Rclass = 63.4 Ω		36	-	44	mA
Inrush current-limit			100	-	180	
Operating current-limit			850	-	1100	
DC/DC Converter						
Output voltage	21.6 V ≤ Vin ≤ 57 V, ILOAD ≤ ILOAD (max)	5-V output	4.75	5	5.25	V
Output current	21.6 V ≤ Vin ≤ 57 V	5-V output	-	-	5	A
Output ripple voltage, peak-to-peak	Vin = 48 V, ILOAD = 5 A	5-V output	-	50	-	mV
Efficiency, Vin at J2 Efficiency, Vin at J3 Efficiency, Converter	Vin = 48 V, ILOAD = 5 A	5-V output		89% 91% 92%		
Switching frequency			225	-	275	kHz

3 Schematic

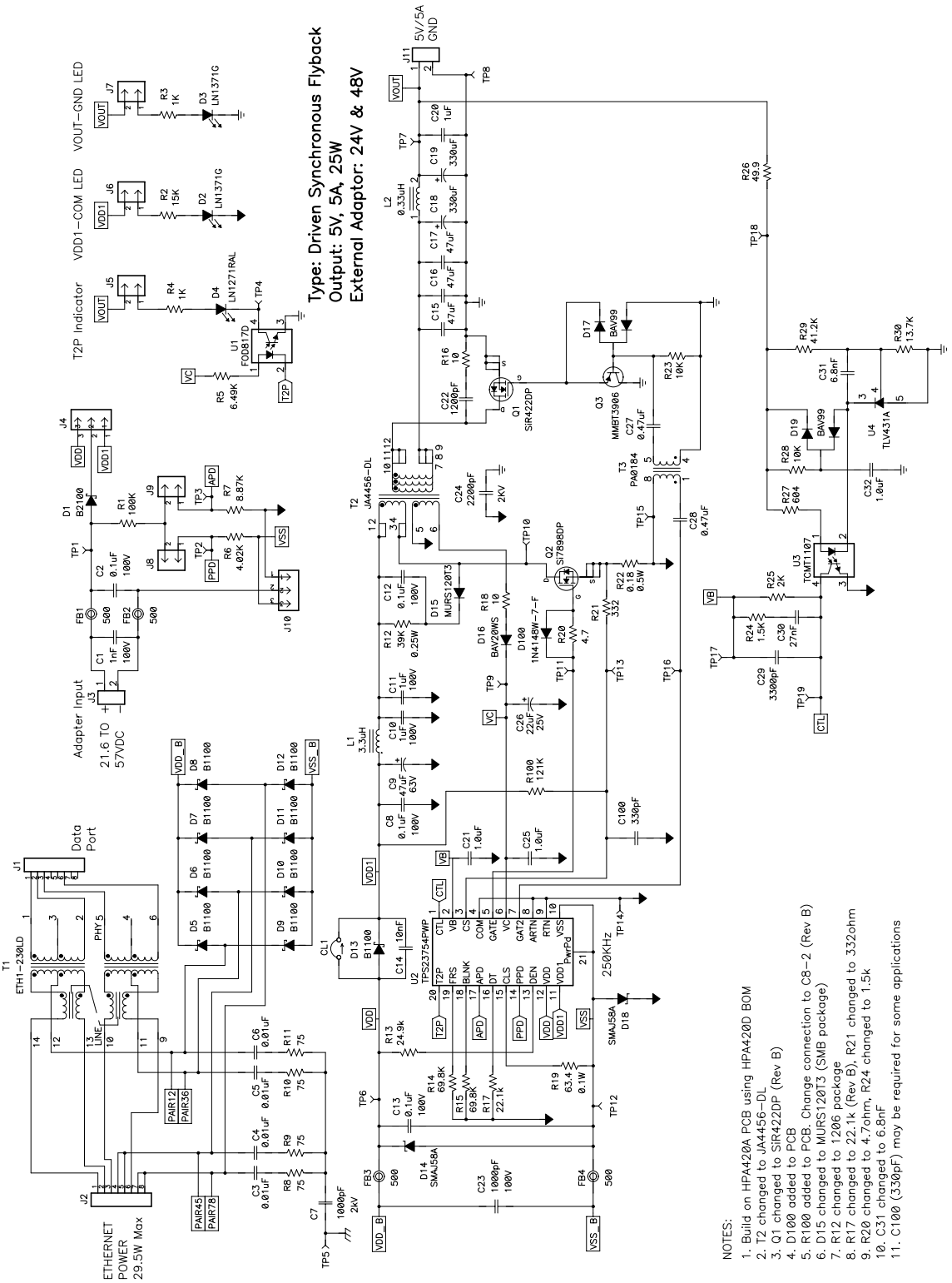

Figure 1. PMP6672B Schematic

4 Performance Data and Typical Characteristic Curves

Figure 2 through Figure 9 present typical performance curves for the PMP6672B.

4.1 Efficiency

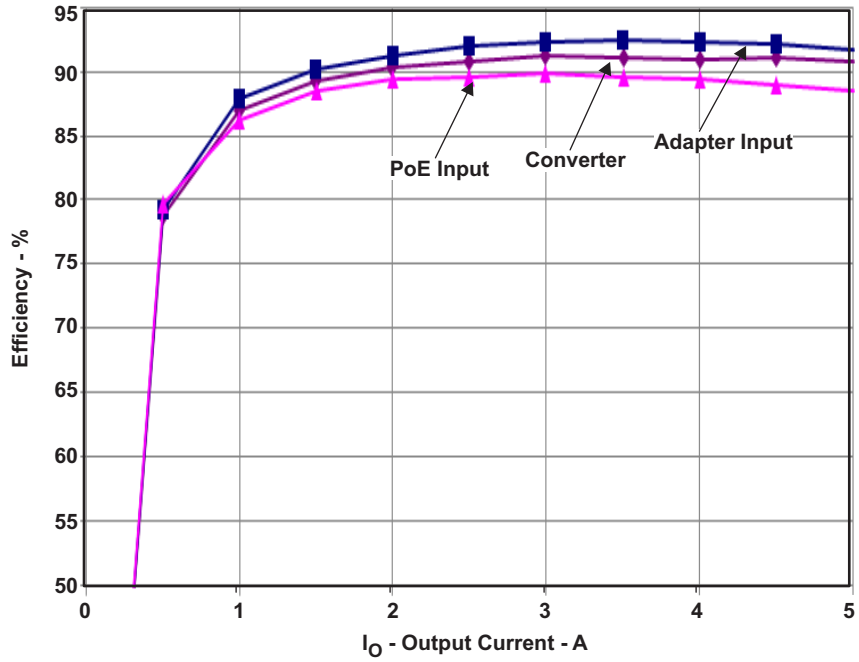

Figure 2. PMP6672B Efficiency

4.2 Load Regulation

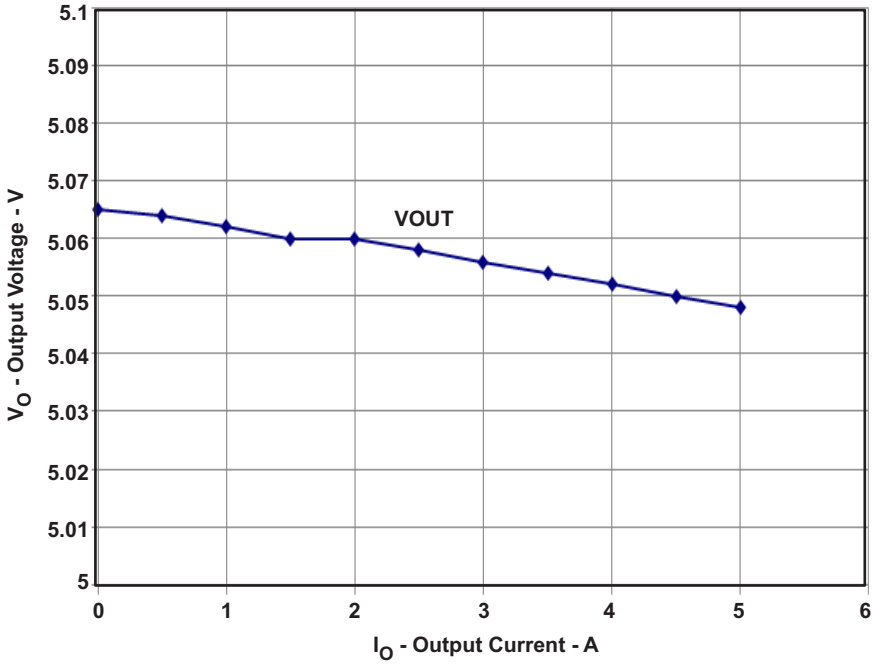

Figure 3. PMP6672B Load Regulation

4.3 Bode Plot

Input voltage	48 Vdc	
Gain/Phase	Crossover	Phase Margin
PMP6672B (5 V)	4.723 kHz	92°

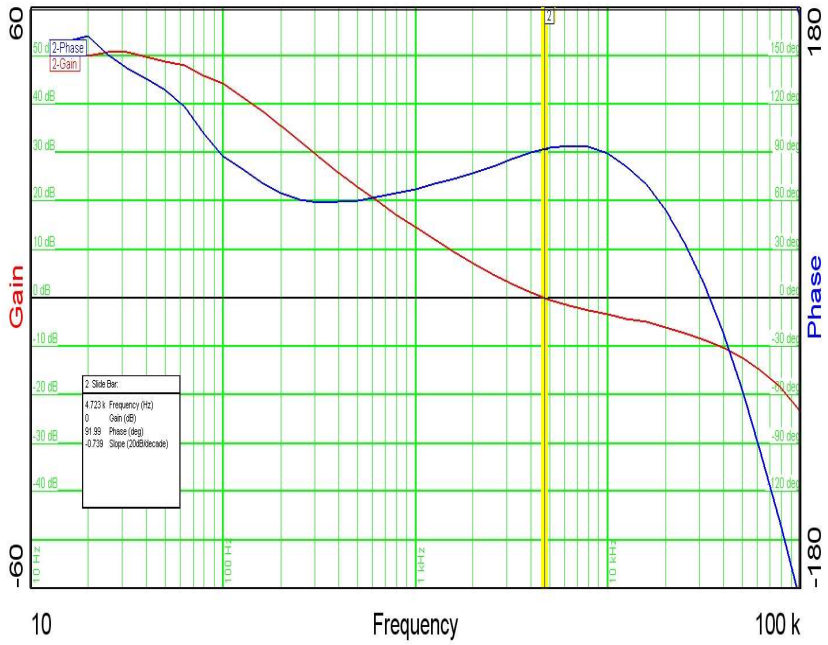

Figure 4. PMP6672B Loop Response Gain and Phase

4.4 Transient Response

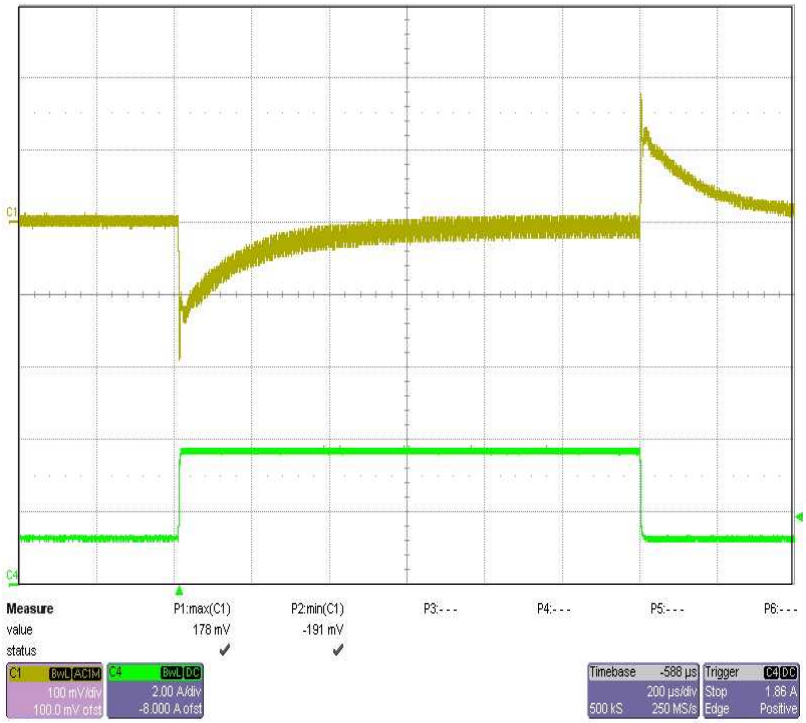

Figure 5. PMP6672B Load Transient

4.5 Output Ripple

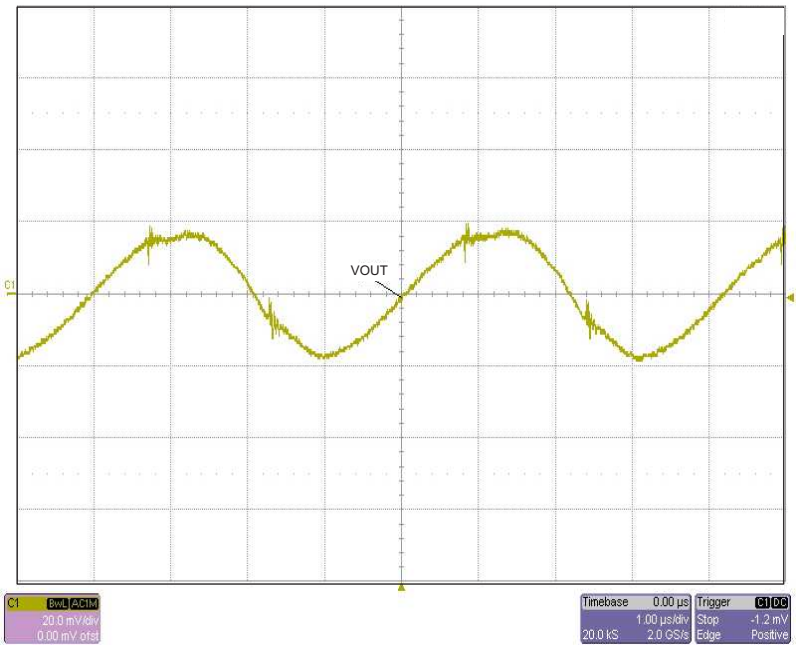

Figure 6. Output Ripple

4.6 Switch Node Voltage

The following scope plot shows the waveforms on the drain of the secondary-side FET (Ch1) and primary-side FET (Ch2). The output is loaded at 5 A. Vin = 48 Vdc at J2.

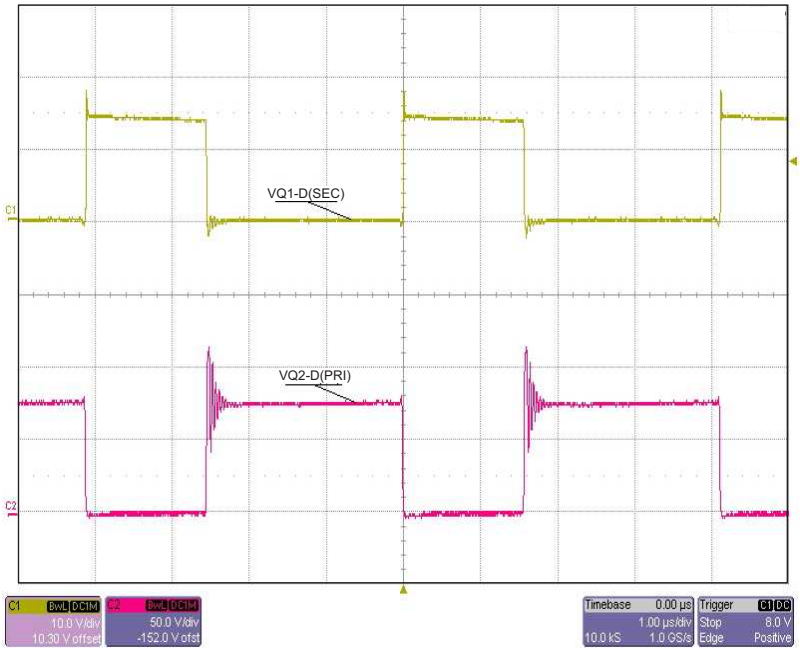

Figure 7. Switching Node Waveform

4.7 Turnon Waveform

The following scope plot shows the 5-V output voltage start-up waveform after the application of 48 Vdc at J2 (PoE). The output was loaded to 0 A.

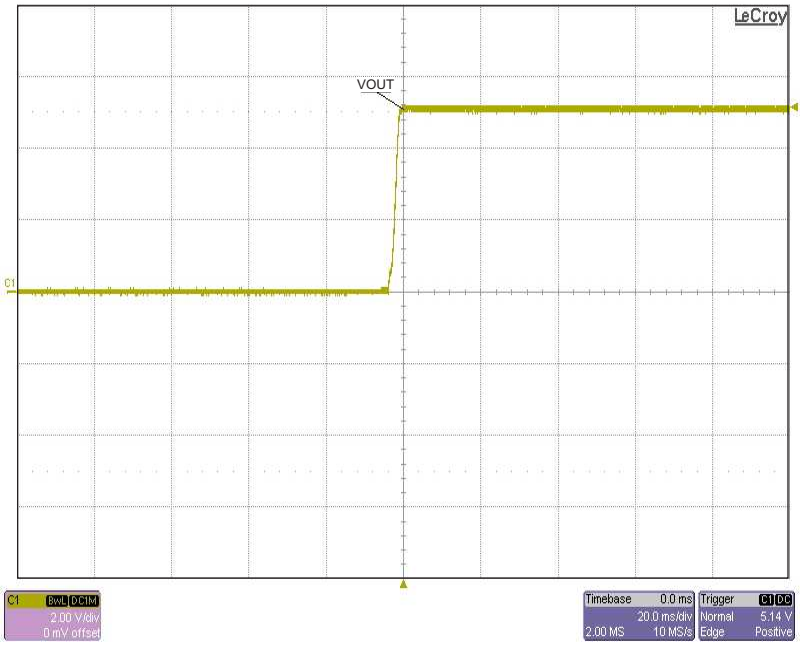

Figure 8. Enable Turnon Waveform – No Output Load

The following scope plot shows the 5-V output voltage start-up waveform after the application of 48-Vdc at J2 (PoE). The output was loaded to 5 A.

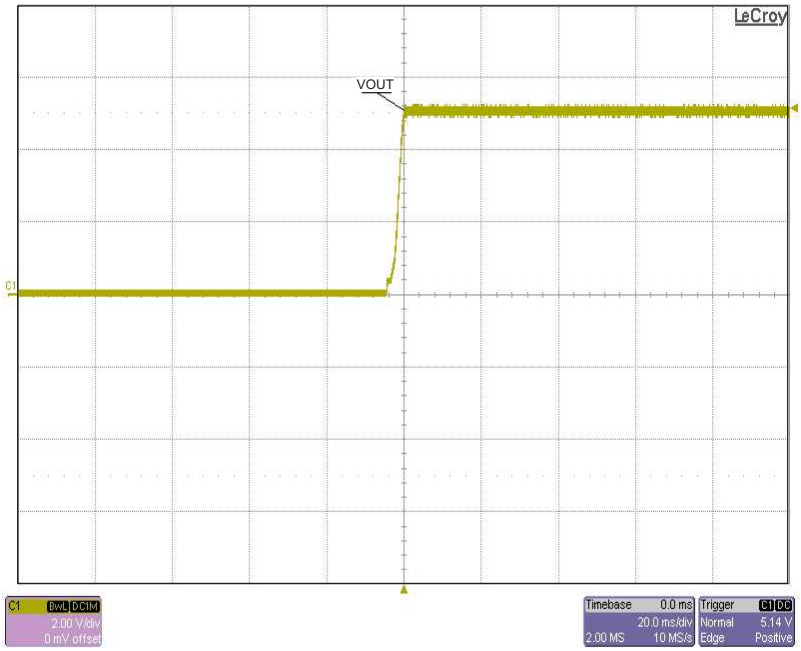

Figure 9. Enable Turnon Waveform – Output Fully Loaded

5 PMP6672B Assembly Drawing and PCB Layout

Figure 10 and Figure 11 show the design of the PMP6672B printed-circuit board. Note that the same circuit board used on TPS23754EVM-420 (SLVU301) is used for PMP6672B.

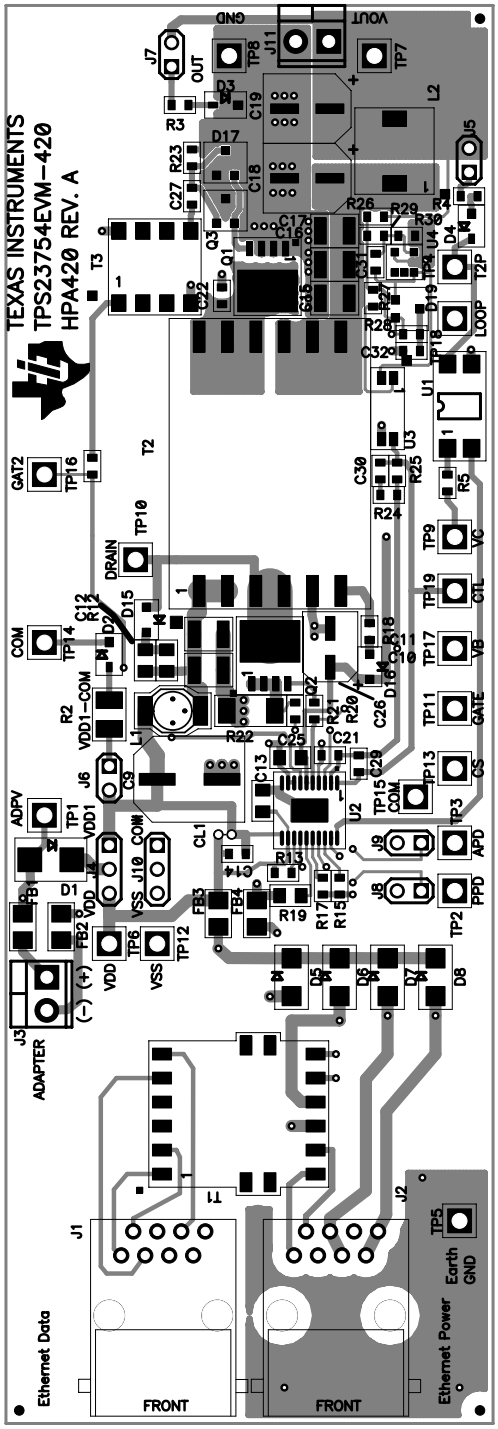

Figure 10. Top-Side Layout

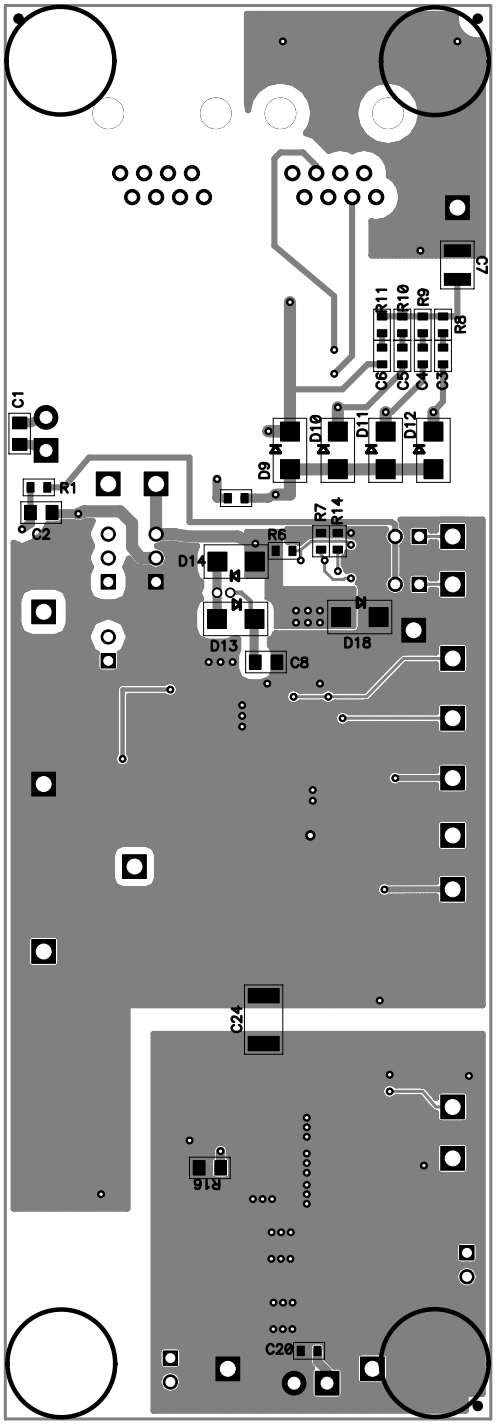

Figure 11. Bottom-Side Layout

6 Bill of Materials

Table 2. PMP6672B Components List According to the Schematic Shown in Figure 1

Count	RefDes	Value	Description	Size	Part Number	MFR
1	C1	1nF	Capacitor, Ceramic, 100V, X7R, 10%	0805	Std	Std
1	C100	330pF	Capacitor, Ceramic, 100V, X7R, 10%	0603	Std	Std
2	C10, C11	1uF	Capacitor, Ceramic, 1uF, 100V, X7R, 15%	1210	Std	Std
1	C14	10nF	Capacitor, Ceramic, 100V, X7R, 10%	0603	Std	Std
3	C15, C16, C17	47uF	Capacitor, Ceramic, 10V, X5R, 15%	1210	Std	Std
2	C18, C19	330uF	Capacitor, Aluminum, 6.3V, 20%	0.260 x 0.276 inch	EEVFK0J331XP	Panasonic
1	C2	0.1uF	Capacitor, Ceramic, 100V, X7R, 10%	0805	Std	Std
1	C20	1uF	Capacitor, Ceramic, 16V, X7R, 15%	0603	Std	Std
2	C21, C32	1.0uF	Capacitor, Ceramic, 16V, X7R, 10%	0603	Std	Std
1	C22	1200pF	Capacitor, Ceramic, 50V, X7R, 15%	0603	Std	Std
1	C23	1000pF	Capacitor, Ceramic, 100V, X7R, 15%	0603	Std	Std
1	C24	2200pF	Capacitor, Ceramic, 2KV, X7R, 15%	1812	Std	Std
1	C25	1.0uF	Capacitor, Ceramic, 25V, X7R, 10%	0805	Std	Std
1	C26	22uF	Capacitor, Aluminum, 25V, 20%	5x5.8mm	EEVFK1E220R	Panasonic
2	C27, C28	0.47uF	Capacitor, Ceramic, 16V, X7R, 15%	0603	Std	Std
1	C29	3300pF	Capacitor, Ceramic, 50V, X7R, 15%	0603	Std	Std
4	C3, C4, C5, C6	0.01uF	Capacitor, Ceramic, 100V, X7R, 15%	0603	Std	Std
1	C30	27nF	Capacitor, Ceramic, 50V, X7R, 15%	0603	Std	Std
1	C31	6.8nF	Capacitor, Ceramic, 50V, X7R, 15%	0603	Std	Std
1	C7	1000pF	Capacitor, Ceramic, 2kV, X7R, 15%	1210	Std	Std
3	C8, C12, C13	0.1uF	Capacitor, Ceramic, 100V, X7R, 15%	0805	Std	Std
1	C9	47uF	Capacitor, Aluminum, 63V, ±20%	0.328 x 0.390 inch	EEVFK1J470P	Panasonic
1	CL1	NA	Current Loop, 0.025 holes	0.120 X 0.075 inch	NA	NA
1	D1	B2100	Diode, Schottky, 2-A, 100-V	SMB	B2100-13	Diodes Inc
1	D100	1N4148W-7-F	Diode, Signal, 300-mA, 75-V, 350-mW	SOD-123	1N4148W-7-F	Diodes
2	D14, D18	SMAJ58A	Diode, TVS, 58-V, 1W	SMA	SMAJ58A	Diodes Inc.
1	D15	MURS120T3	Diode, UltraFast Rectifier, 1-A, 200-V	SMB	MURS120T3	On Semi
1	D16	BAV20WS	Diode, Small Signal, 250mA, 150V	SOD-323	BAV20WS	Micro Commercial Components
2	D17, D19	BAV99	Diode, Dual Ultra Fast, Series, 200-mA, 70-V	SOT23	BAV99	Fairchild
2	D2, D3	LN1371G	Diode, LED, Green, 10-mA, 2.6-mcd	0.114 X 0.049 inch	LN1371G	Panasonic
1	D4	LN1271RAL	Diode, LED, Ultra Bright Red, 10-mA, 5-mcd	0.114 X 0.049 inch	LN1271RAL	Panasonic
9	D5, D6, D7, D8, D9, D10, D11, D12, D13	B1100	Diode, Schottky, 1A, 100V	SMA	B1100	Diodes, Inc
4	FB1, FB2, FB3, FB4	500	Bead, Ferrite, 2000mA, 60mΩ	1206	MI1206L501R-10	Steward
2	J1, J2	5520252-4	Connector, Jack, Modular, Rt. Angle,8 POS	0.705 x 0.820 inch	5520252-4	AMP
2	J3, J11	ED1514	Terminal Block, 2-pin, 6-A, 3.5mm	0.27 x 0.25	ED1514	
2	J4, J10	PTC36SAAN	Header, Male 3-pin, 100mil spacing, (36-pin strip)	0.100 inch x 3	PTC36SAAN	Sullins
5	J5, J6, J7, J8, J9	PTC36SAAN	Header, Male 2-pin, 100mil spacing, (36-pin strip)	0.100 inch x 2	PTC36SAAN	Sullins
1	L1	3.3uH	Inductor, SMT, 2.0A, 80-mΩ	4.45x6.6mm	DO1608C-332	Coilcraft
1	L2	0.33uH	Inductor, SMT, 6.26A, 7.4-mΩ	0.300 sq"	DR74-R33	Cooper
1	Q1	SiR422DP	MOSFET, NChan, 40V, 50A, 2.8 mΩ	PWRPAK S0-8	SiR422DP	Vishay-Siliconix
1	Q2	Si7898DP or FDMS2572	MOSFET, NChannel, 150V, 4.8A, 85-mΩ	PWRPAK S0-8 or POWER 56	Si7898DP or FDMS2572	Vishay or Fairchild
1	Q3	MMBT3906	Bipolar, PNP, 40V, 200mA, 225mW	SOT23	MMBT3906LT1	On Semi
1	R1	100K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R100	121K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R12	39K	Resistor, Metal Film, 1/4 watt, ± 5%	1206	Std	Std
1	R13	24.9k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
2	R14, R15	69.8K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R16	10	Resistor, Chip, 1/10W, 1%	0805	Std	Std

Table 2. PMP6672B Components List According to the Schematic Shown in Figure 1 (continued)

Count	RefDes	Value	Description	Size	Part Number	MFR
1	R17	22.1k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R18	10	Resistor, Chip, 1/16W, 5%	0603	Std	Std
1	R19	63.4	Resistor, Chip, 1/10W, 1%	0805	Std	Std
1	R2	15K	Resistor, Chip, 1/4W, 1%	1210	Std	Std
1	R20	4.7	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R21	332	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R22	0.18	Resistor, Chip, 1/2W, 1%	2010	Std	Std
2	R23, R28	10K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R24	1.5K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R25	2K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R26	49.9	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R27	604	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R29	41.2K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
2	R3, R4	1K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R30	13.7K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R5	6.49K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R6	4.02K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R7	8.87K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
4	R8, R9, R10, R11	75	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	T1	ETH1-230LD	XFMR, Mid-Power PoE Magnetics	S0 14 Wide	ETH1-230LD	Coilcraft
1	T2	JA4456-DL	Transformer, SMT For PoE/PD, 25W, 2.8A	0.810 x 1.181 inch	JA4456-DL	Coilcraft
1	T3	PA0184	XFMR, SMT Gate Drive	0.355 X 0.340 inch	PA0184	Pulse
1	U1	FOD817D	IC, Optocoupler, 70-V, 300 - 600% CTR	SMT-4PDIP	FOD817DS	Fairchild
1	U2	TPS23754PWP	IC, IEEE 802.3at PoE Interface and Isolated Converter Controller	PWP20	TPS23754PWP	TI
1	U3	TCMT1107	IC, Photocoupler, 3750VRMS, 80-160% CTR	MF4	TCMT1107	Vishay
1	U4	TLV431A	IC, Shunt Regulator, 6V, 10mA, 1%	SOT23-5	TLV431ACDBVR	TI
6	—		Shunt, Black	100-mil	929950-00	3M
1	—		PCB, 5.90 In x 2.03 In x 0.062 In		HPA420	Any

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