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ADP2450ACPZ-3-EVBZ User Guide
UG-1398

Evaluating the ADP2450 Power Management IC for Circuit Breaker Applications

FEATURES

Full featured evaluation board for the ADP2450
Compact solution size
4-layer high glass transition temperature (T_G) PCB for superior thermal performance
Connections through vertical printed circuit tail pin headers
Compatible with ac current source input or CT input
Supports single coil and dual coil application
Adjustable output for buck regulator
On-board precision reference
On-board PGA gain setting
Supports analog trip function
Supports power detection function
Voltage monitor and reset output
Flexible connection with external MCU

APPLICATIONS

Full evaluation of ADP2450

EVALUATION KIT CONTENTS

ADP2450ACPZ-3-EVBZ evaluation board

DOCUMENT NEEDED

ADP2450 data sheet

EQUIPMENT NEEDED

AC current source or current transformer
Electronic load
Oscilloscope

GENERAL DESCRIPTION

The ADP2450ACPZ-3-EVBZ evaluation board provides a complete and compact solution that allows users to evaluate the performance of the ADP2450 with a near ideal printed circuit board (PCB) layout. The evaluation board is compatible with current transformer (CT) or ac current source as its input power source.

The main device on the evaluation board, the ADP2450, integrates a boost shunt controller with power detection, a high efficiency buck regulator, four low offset and low power consumption programmable gain amplifiers (PGAs), a low offset operation amplifier, a fast analog trip circuit, and an actuator driver.

With an external microcontroller unit (MCU) connected, the evaluation board is suitable for quick system evaluation of circuit breaker applications.

Full details on the ADP2450 are provided in the ADP2450 data sheet, available from Analog Devices, Inc. Consult the data sheet in conjunction with this user guide when working with the ADP2450ACPZ-3-EVBZ.

EVALUATION BOARD PHOTOGRAPH

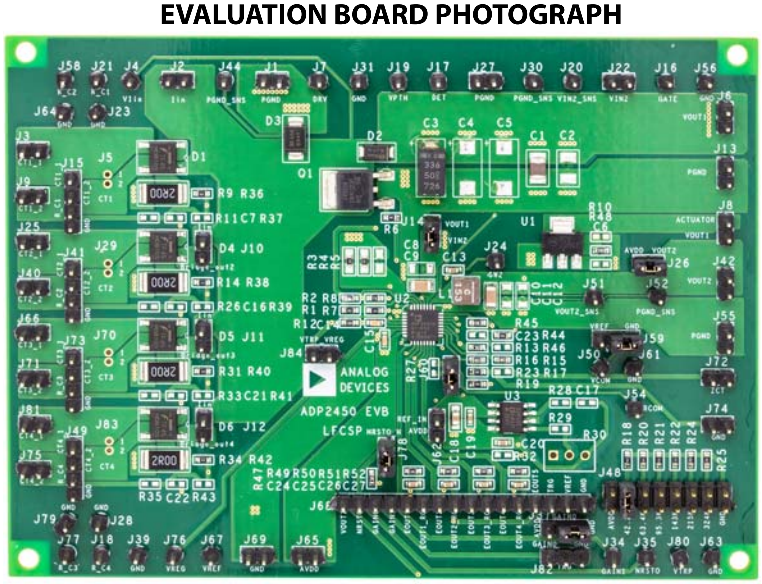

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Figure 1.

PLEASE SEE THE LAST PAGE FOR AN IMPORTANT WARNING AND LEGAL TERMS AND CONDITIONS.

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REVISION HISTORY

8/2018—Revision 0: Initial Version

USING THE EVALUATION BOARD

POWERING UP THE EVALUATION BOARD

The ADP2450ACPZ-3-EVBZ evaluation board is supplied fully assembled and tested. Before applying any power to the ADP2450ACPZ-3-EVBZ follow the procedures in this section to configure the board as a single coil, one phase application.

Jumper J10, Jumper J11, and Jumper J12

Leave J10, J11, and J12 open for a one phase application.

Jumper J14

Short J14 to connect the boost shunt output to the buck input.

Jumper J26

Short J26 to connect the buck output to AVDD.

Jumper J37

Short the middle pin of J37 to GND to connect GAIN0 to GND.

Jumper J48

Short Pin 3 and Pin 4 of J48 to connect the 42.2 kΩ resistor between GAIN1 and GND (see Figure 2).

Jumper J59

Short the middle pin of J59 to GND to connect V_{COM} to GND.

Jumper J60

Short J60 to connect R_{COM} to GND.

Jumper J78

Short J78 to pull $\overline{\text{RSTO}}$ to high.

Input Power Source

If the ac current source is used, connect the terminals of the ac current source to J3 (CT1_1) and J9 (CT1_2) of the evaluation board.

If a CT is used as the input power source, connect the CT secondary side terminals to J5 (CT1) of the evaluation board.

Output Voltmeters

Measure the output voltages of the boost shunt controller and buck regulator using voltmeters. Ensure the voltmeters are connected to the positive terminal and negative terminal of the evaluation board. If the voltmeters are not connected directly to the evaluation board, the measured voltages are incorrect because of the voltage drop across the leads and/or connections between the evaluation board and the power source.

To measure the output voltage of the boost shunt controller, connect the positive terminal of the voltmeter to J6 (VOUT1) and the negative terminal to J13 (PGND). To measure the output voltage of the buck regulator, connect the positive terminal of the voltmeter to J51 (VOUT2_SNS) and the negative terminal to J52 (PGND_SNS).

Turning On the Evaluation Board

When the input power source and voltmeters are connected to the ADP2450ACPZ-3-EVBZ, take the following steps to power on the ADP2450ACPZ-3-EVBZ:

1. Set the input ac rms current higher than 15 mA.
2. Set the frequency of the input ac current to 50 Hz.
3. Turn on the ac current source and monitor the output voltages of the boost shunt controller and the buck regulator.

MEASURING EVALUATION BOARD PERFORMANCE

Measuring the Metal-Oxide-Semiconductor (MOSFET) Driver Waveform of the Boost Shunt Controller

To observe the driver waveform of the external MOSFET (Q1) with an oscilloscope, place the oscilloscope probe tip at the J7 test point (DRV) with the probe ground at J31 (PGND). Set the scope to dc with the appropriate voltage and time divisions. The driver waveform limits alternate approximately between 0 V and 8 V.

Measuring the Switching Waveform of Buck Regulator

To observe the switching waveform of the buck regulator with an oscilloscope, place the oscilloscope probe tip at J24 test point (SW) with the probe ground at J31 (PGND). Set the scope to dc with the appropriate voltage and time divisions based on the input voltage of the buck regulator. The switching waveform limits alternate approximately between 0 V and the input voltage of the buck regulator.

Measuring the PGA Output Waveform

Take PGA1 as an example. To observe the output waveform of PGA1 with an oscilloscope, place the oscilloscope probe tip at Pin 5 (EOUT1) of J68 with the probe ground at J39 (PGND). Set the scope to dc with the appropriate voltage and time divisions. The PGA1 output waveform is 100 Hz positive, half sinusoid with the same amplitude of the PGA1 input signal.

MODIFYING THE EVALUATION BOARD

To modify the ADP2450ACPZ-3-EVBZ board configuration, unsolder, replace, or remove the appropriate passive components or jumpers on the board.

Change the Output Voltage of the Boost Shunt Controller

The output voltage of the boost shunt controller is preset to 12 V and can be changed by replacing the feedback resistors of the boost shunt controller, R1 and R7.

To limit the output voltage accuracy degradation because of the FB1 pin bias current (0.1 µA maximum) to less than 0.5% (maximum), ensure the bottom divider string resistor, R7, is less than 60 kΩ.

Use the following equation to calculate the top resistor, R1, value:

$$R1 = R7 \times (V_{OUT1} - 1.2\ \text{V})/1.2\ \text{V}$$

Change the Output Voltage of the Buck Regulator

The output voltage of the buck regulator is preset to 5 V and can be changed by replacing the feedback resistors of the buck regulator, R44 and R45.

Use the following equation to calculate the feedback resistor string values:

$$V_{OUT2} = 0.6\ \text{V} \times (1 + R44/R45)$$

Change the V_{PTH} Threshold

The V_{PTH} rising threshold is preset to 9 V and falling threshold is preset to 7 V. These thresholds can be changed by replacing the V_{PTH} resistors, R2 and R8.

Use the following equations to calculate the V_{PTH} resistor string values:

$$R2 = \frac{1.09\ \text{V} \times V_{PTH\_RISING} - 1.22\ \text{V} \times V_{PTH\_FALLING}}{1.09\ \text{V} \times 4.8\ \mu\text{A} - 1.22\ \text{V} \times 1\ \mu\text{A}}$$

$$R8 = \frac{1.22\ \text{V} \times R2}{V_{PTH\_RISING} - R2 \times 4.8\ \mu\text{A} - 1.22\ \text{V}}$$

Change the Analog Trip Threshold

The analog trip threshold is preset to 1 V and can be changed by replacing the analog trip setting resistor, R12.

Use the following equation to calculate the analog trip threshold:

$$V_{TRP}\ (\text{V}) = 0.01 \times \text{R12}\ (\text{k}\Omega)$$

Change the PGA Gain

The default PGA gain of the ADP2450ACPZ-3-EVBZ board is set to ×1. The gain can be changed by shorting different pins of J37 and J48 (see Figure 2).

Table 1 shows the relationship between PGA gain values and the GAIN0 and GAIN1 configurations.

Table 1. Gain Setting for PGAx

	GAIN	
Resistance on GAIN1 (kΩ)	**GAIN0 = GND**	**GAIN0 = AVDD**
0	0.75	3
42.2	1	4
63.4	1.25	5
95.3	1.5	6
143	1.75	7
215	2	8
324	2.5	10
AVDD	4	16

Change to Dual Coil Application

The ADP2450ACPZ-3-EVBZ board supports a dual coil input application. To change the board to a one phase, dual coil configuration, take the following steps:

1. Remove the ac current source connected on J3 and J9 or the CT connected on J5.
2. Unsolder R36 and solder R37 with 0 Ω resistor.
3. Solder the RC filter on R11 and C7.
4. Leave Jumper J60 open.
5. Solder R27 with a resistor with a value equal or close to the internal impedance of the dual coil.
6. Short the middle pin of J59 to Pin 1 to connect V_{COM} to VREF.
7. Short Jumper J62 to connect AVDD to the input of the ADR433.
8. Replace R12 with 280 kΩ resistor to set the analog trip threshold to 2.8 V.
9. Connect the power coil to Pin 3 and Pin 4 of J15.
10. Connect the signal coil to Pin 2 of J15.

If multiple phase application are required, repeat the same modification of the other three phases as the phase previously described and short J10, J11, and J12.

EVALUATION BOARD SCHEMATIC AND PCB LAYOUT

SCHEMATIC

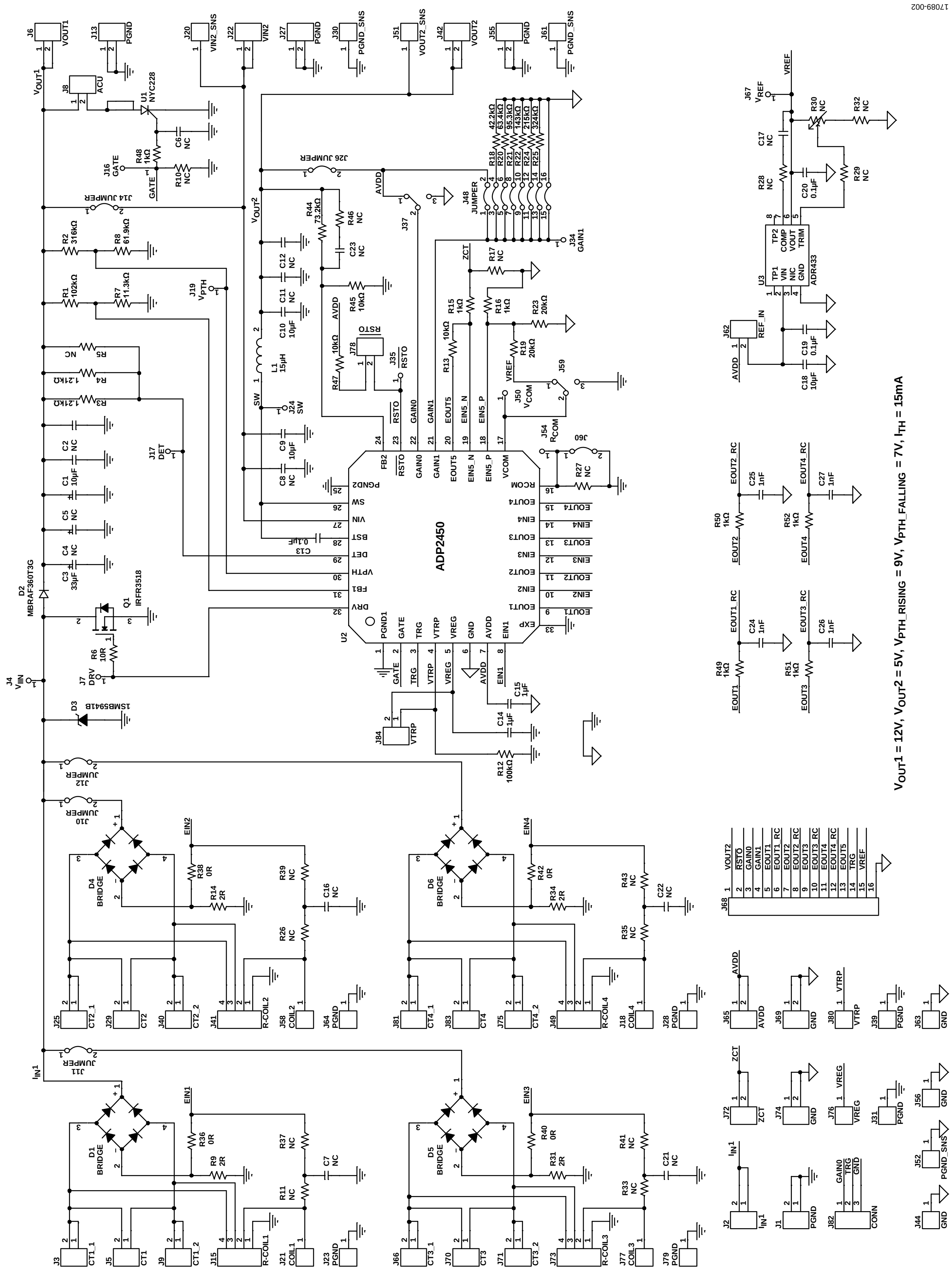

Figure 2. Evaluation Board Schematic for the ADP2450ACPZ-3-EVBZ

PCB LAYOUT

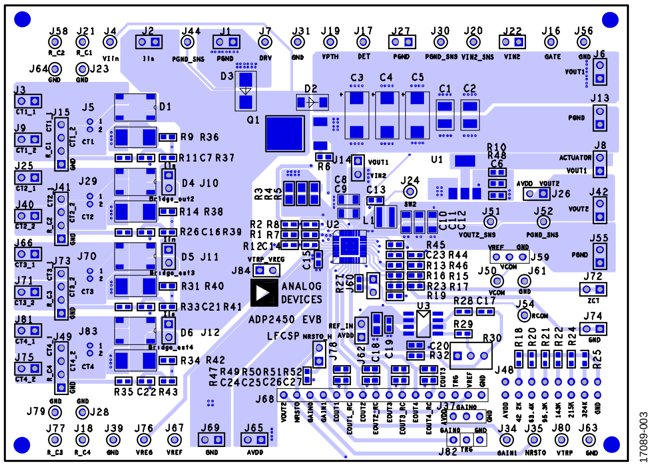

Figure 3. ADP2450ACPZ-3-EVBZ Layer 1, Component Side

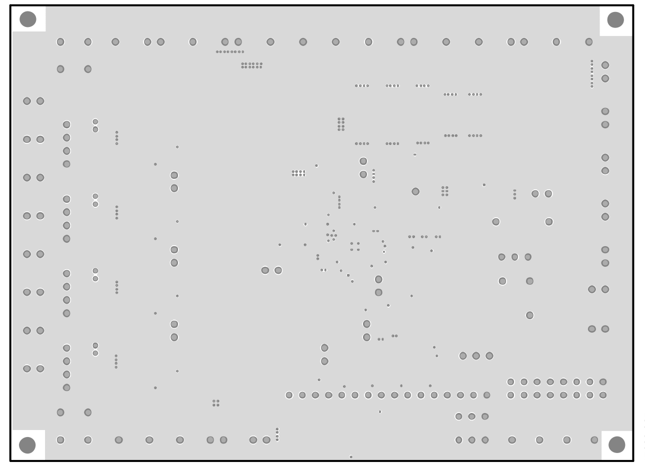

Figure 5. ADP2450ACPZ-3-EVBZ Layer 2, Ground Plane

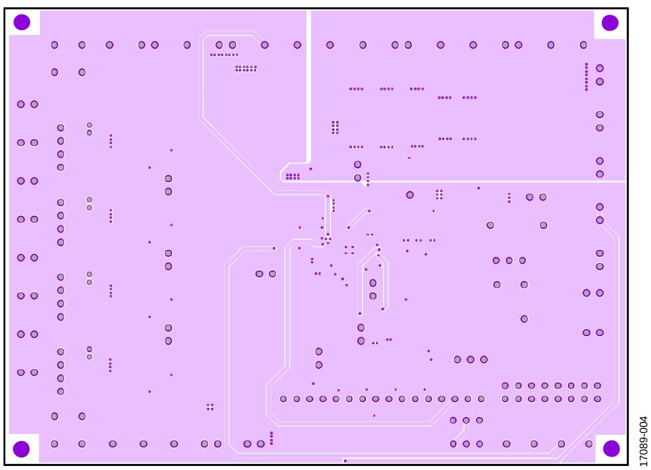

Figure 4. ADP2450ACPZ-3-EVBZ Layer 3, Power Plane

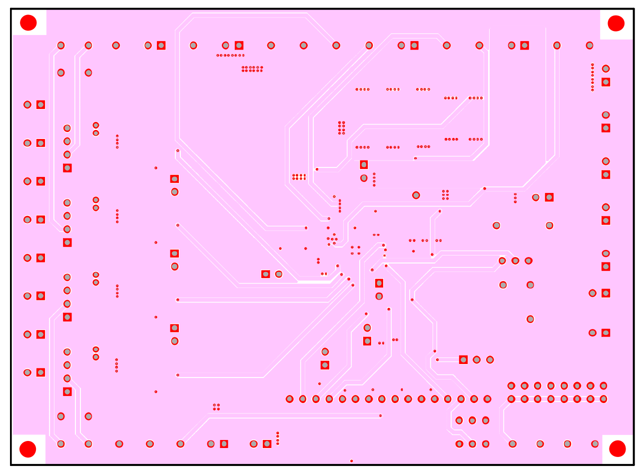

Figure 6. ADP2450ACPZ-3-EVBZ Layer 4, Bottom Side

ORDERING INFORMATION

BILL OF MATERIALS

Table 2.

Qty	Reference Designator	Description	Part Number/Vendor	Vendor
1	C1	10 µF, 50 V, X7R, capacitor, 1210	GRM32ER71H106MA12L	Murata
1	C2	Optional capacitor, 1210	Optional	Murata
1	C3	33 µF, 50 V, X7R, capacitor, D7343	T521X336M050ATE075	KEMET
2	C4, C5	Optional capacitors, D7374	Optional	KEMET
7	C6, C7, C16, C17, C21 to C23	Optional capacitors, 0603	Optional	Murata
3	C8, C11, C12	Optional capacitors, 1206	Optional	Murata
2	C9, C10	10 µF, 50 V, X7R, capacitors, 1206	GRM31CR61H106KA12	Murata
3	C13, C19, C20	0.1 µF, 16 V, X7R, capacitors, 0603	GCM188R71C104KA37	Murata
2	C14, C15	1 µF, 16 V, X7R, capacitors, 0603	GCM188R71C105KA64	Murata
1	C18	10 µF, 6.3 V, X7R, capacitor, 0805	GCM21BR70J106KE22	Murata
4	C24, C25, C26, C27	1 nF, 25 V, X7R, capacitors, 0603	GCM188R71E102KA37D	Murata
4	D1, D4, D5, D6	1 A, MicroDIP, single-phase bridge rectifiers	MDB10S	FAIRCHILD
1	D2	3 A, 60 V, Schottky barrier rectifier	MBRAF360T3G	ON Semiconductor
1	D3	3 W, surface mount power Zener diode	1SMB5941B	DIODES
1	L1	Inductor, 15 µH	XAL4040-153ME	Coil Craft
1	Q1	80 V, 30 A, power MOSFET	IRFR3518	International Rectifier
1	R1	102 kΩ, 1%, resistor, 0603	CRCW0603102KFKEA	Vishay Dale
1	R2	316 kΩ, 1%, resistor, 0603	CRCW0603316KFKEA	Vishay Dale
2	R3, R4	1.21 kΩ, 1%, resistors, 0805	CRCW06031K21FKEA	Vishay Dale
1	R5	Optional resistor, 0805	Optional	Vishay Dale
1	R6	10 Ω, 1%, resistor, 0603	CRCW060310R0FKEA	Vishay Dale
1	R7	11.3 kΩ, 1%, resistor, 0603	CRCW060311K3FKEA	Vishay Dale
1	R8	61.9 kΩ, 1%, resistor, 0603	CRCW060361K9FKEA	Vishay Dale
4	R9, R14, R31, R34	2 Ω, 1%, resistors, 1 W	WSC25152R000FEA	Vishay Dale
15	R10, R11, R17, R26 to R29, R32, R33, R35, R37, R39, R41, R43, R46	Optional resistors, 0603	Optional	Vishay Dale
1	R12	100 kΩ, 1%, resistor, 0603	CRCW0603100KFKEA	Vishay Dale
7	R15, R16, R48 to R52	1 kΩ, 1%, resistors, 0603	CRCW06031K00FKEA	Vishay Dale
3	R13, R45, R47	10 kΩ, 1%, resistors, 0603	CRCW060310K0FKEA	Vishay Dale
1	R18	42.2 kΩ, 1%, resistor, 0603	CRCW060342K2FKEA	Vishay Dale
2	R19, R23	20 kΩ, 1%, resistors, 0603	CRCW060320K0FKEA	Vishay Dale
1	R20	63.4 kΩ, 1%, resistor, 0603	CRCW060363K4FKEA	Vishay Dale
1	R21	95.3 kΩ, 1%, resistor, 0603	CRCW060395K3FKEA	Vishay Dale
1	R22	143 kΩ, 1%, resistor, 0603	CRCW0603143KFKEA	Vishay Dale
1	R24	215 kΩ, 1%, resistor, 0603	CRCW0603215KFKEA	Vishay Dale
1	R25	324 kΩ, 1%, resistor, 0603	CRCW0603324KFKEA	Vishay Dale
1	R30	Optional resistor, through hole	3296W-1-103LF	Bourns
4	R36, R38, R40, R42	0 Ω, 1%, resistors, 0603	CRCW06030000Z0EA	Vishay Dale
1	R44	73.2 kΩ, 1%, resistor, 0603	CRCW060373K2FKEA	Vishay Dale
1	U1	Silicon controlled rectifier, 1.5 A rms current, 600 V, SOT-223	NYC228	ON Semiconductor
1	U2	Power management IC for industrial application, 32-lead LFCSP with exposed paddle	ADP2450	Analog Devices
1	U3	Ultralow noise XFET® voltage reference	ADR433	Analog Devices

Qty	Reference Designator	Description	Part Number/Vendor	Vendor
30	J1 to J3, J6, J8 to J14, J22, J25 to J27, J40, J42, J55, J60, J62, J65, J66, J69, J71, J72, J74, J75, J78, J81, J84	2 position header connectors, 2.54 mm pitch, through hole, gold	61300211121	Wurth
31	J4, J7, J16 to J21, J23, J24, J28, J30, J31, J34, J35, J39, J44, J50 to J52, J54, J56, J58, J61, J63, J64, J67, J76, J77, J79, J80	1 position header connectors, through hole, gold	61300111121	Wurth
4	J5, J29, J70, J83	Optional header connectors	Optional	Wurth
4	J15, J41, J49, J73	4 position header connectors, 2.54 mm pitch, through hole, gold	61300411121	Wurth
3	J37, J59, J82	3 position header connectors, 2.54 mm pitch, through hole, gold	61300311121	Wurth
1	J48	16 position header connector, dual, 2.54 mm pitch, through hole, gold	61301621121	Wurth
1	J68	16 position header connector, 2.54 mm pitch, through hole, gold	61301611121	Wurth