Evaluating the ADuM4122 Single-/Dual-Supply, High Voltage, Isolated SiC Gate Driver with Slew Rate Control

FEATURES

- Optimized for use with Wolfspeed SiC MOSFETs and power modules
- Compatible with Wolfspeed CIL test boards and half bridge evaluation boards
- High frequency, ultrafast switching operation
- Selectable slew rate control
- Jumper for easy slew rate setting
- Input and output side undervoltage lockout (UVLO)
- Differential inputs for increased noise immunity
- Isolated NTC thermistor measurement
- On board 2 W isolated power supplies

EVALUATION KIT CONTENTS

- EVAL-ADuM4122WHB1Z evaluation board

EQUIPMENT NEEDED

- Wolfspeed SpeedVal Kit™ Modular Evaluation Platform
- Wolfspeed differential transceiver board (CGD12HB00D)
- For evaluating Wolfspeed half-bridge modules
  - CAB011M12FM3 or CAB016M12FM3
  - Wolfspeed CIL board (KIT-CRD-CIL12N-FMA)
- For evaluating Wolfspeed six-pack modules
  - CCB021M12FM3 or CCB032M12FM3
  - Wolfspeed CIL board (KIT-CRD-CIL12N-FMC)

DOCUMENTS NEEDED

- ADuM4122 data sheet

GENERAL DESCRIPTION

The EVAL-ADuM4122WHB1Z is a half bridge gate drive board that allows simple evaluation of the performance of the ADuM4122 when driving advanced Wolfspeed silicon carbide (SiC) metal-oxide semiconductor field-effect transistors (MOSFETs) and power modules. The EVAL-ADuM4122WHB1Z is intended to be used with the Wolfspeed SpeedVal Kit Modular Evaluation Platform and Wolfspeed clamped inductive load (CIL) test boards or half bridge evaluation boards and differential transceiver boards.

The EVAL-ADuM4122WHB1Z has an isolated return channel that is configured to read a negative temperature coefficient (NTC) thermistor and provides a variable frequency output corresponding to the resistance and temperature of the NTC.

The control and input interface for the EVAL-ADuM4122WHB1Z uses RS-422 signaling for improved noise and disturbance immunity, and the interface includes a 12 V power input for the EVAL-ADuM4122WHB1Z.

For full details on the ADuM4122, see the ADuM4122 data sheet, which must be consulted when using the EVAL-ADuM4122WHB1Z.

EVALUATION BOARD PHOTOGRAPH

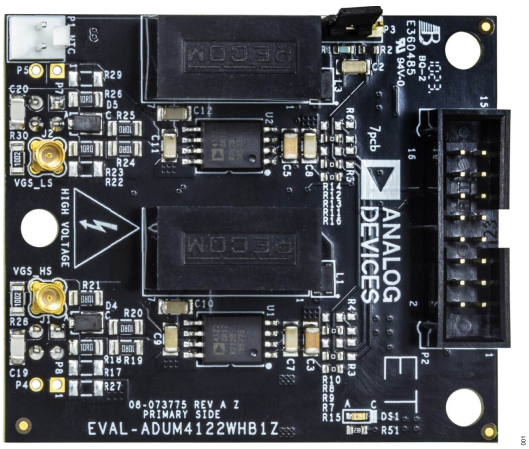

Figure 1. EVAL-ADuM4122WHB1Z Evaluation Board

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REVISION HISTORY

6/2023—Revision 0: Initial Version

EVALUATION BOARD HARDWARE

LOGIC SIDE DIFFERENTIAL INTERFACE

The P2 logic side interface connector is a 16-position, 100 mil (2.54 mm) pitch, dual row header that is compatible with standard insulation displacement contact (IDC) connectors. The pinout for this interface is described in Table 1.

Table 1. Control Interface (P2) Pinout

Pin No.	Mnemonic [1]	Description
1	V_{DC}	12 V nominal power supply input.
2	Common	Common.
3	HS-P	Positive line of the 5 V differential, high-side, pulse-width modulation (PWM) signal pair.
4	HS-N	Negative line of the 5 V differential, high-side, PWM signal pair.
5	LS-P	Positive line of the 5 V differential, low-side, PWM signal pair.
6	LS-N	Negative line of the 5 V differential, low-side, PWM signal pair.
7	No connection	No connection.
8	No connection	No connection.
9	RTD-P	Positive line of the 5 V differential, temperature dependent resistor, output signal pair.
10	RTD-N	Negative line of the 5 V differential, temperature dependent resistor, output signal pair.
11	No connection	No connection.
12	Common	Common.
13	No connection	No connection.
14	Common	Common.
15	No connection	No connection.
16	Common	Common.

[1] Pin 3 to Pin 10 are differential pairs.

OUTPUT CONNECTIONS TO POWER SWITCH

The P7 and P8 output connectors connect to the power switch interface board using a 4-position header, 100 mil (2.54 mm) pitch, through hole, gold plated connector (Samtec SSW-102-01-G-D).

The P4 and P5 output connectors provide Miller clamp connection to the power switch interface board using a 2-position header, 100 mil (2.54 mm) pitch, through hole, gold plated connector (Samtec SSW-101-01-G-D).

NTC THERMISTOR TEMPERATURE FEEDBACK

The EVAL-ADuM4122WHB1Z provides a varying frequency square wave on Pin 9 and Pin 10 of the P2 interface connector that is related to the resistance of an NTC thermistor. Note that one terminal of the thermistor is electrically connected to the low-side switch source.

The ADuM4190 isolated amplifier measures the voltage generated by the biased NTC thermistor and provides a scaled voltage that is galvanically isolated from the thermistor. The LTC6990 voltage-controlled oscillator (VCO) generates a varying frequency square wave based on this scaled voltage.

Table 2 shows the output frequency as a function of the NTC temperature when the EVAL-ADuM4122WHB1Z NTC input is connected to a Littelfuse SM502F1K NTC thermistor.

The temperature reported by the NTC differs largely from the junction temperature of the SiC MOSFETs. Therefore, it is not recommended to use the temperature reported by the NTC as an accurate junction temperature measurement.

Table 2. Temperature to Output Frequency

NTC Thermistor Temperature (°C)	NTC Thermistor Resistance (Ω)	Output Frequency (kHz)
0	14,283	6.71
25	5,000	20.38
50	2,059	30.29
75	963	35.70
100	499	38.45
125	281	39.85
150	169	40.60
175	108	41.02

SLEW RATE CONTROL

The $\overline{SRC}$ pin of the ADuM4122 controls whether the VOUT_SRC pin is set to high-Z or follows the logic of the user supplied PWM input at the VIN+ pin. When the external series gate resistors combine the outputs from the VOUT and VOUT_SRC pins, one isolated gate driver has two easily selectable slew rates.

When $\overline{SRC}$ is active low, an extra boost on the output is available by holding the $\overline{SRC}$ pin low.

The jumper selection on P3 enables an easy selection of the desired slew rate.

TEST POINTS

The EVAL-ADuM4122WHB1Z contains test points that allow the testing and monitoring of key signals on the gate drive board.

EVALUATION BOARD HARDWARE

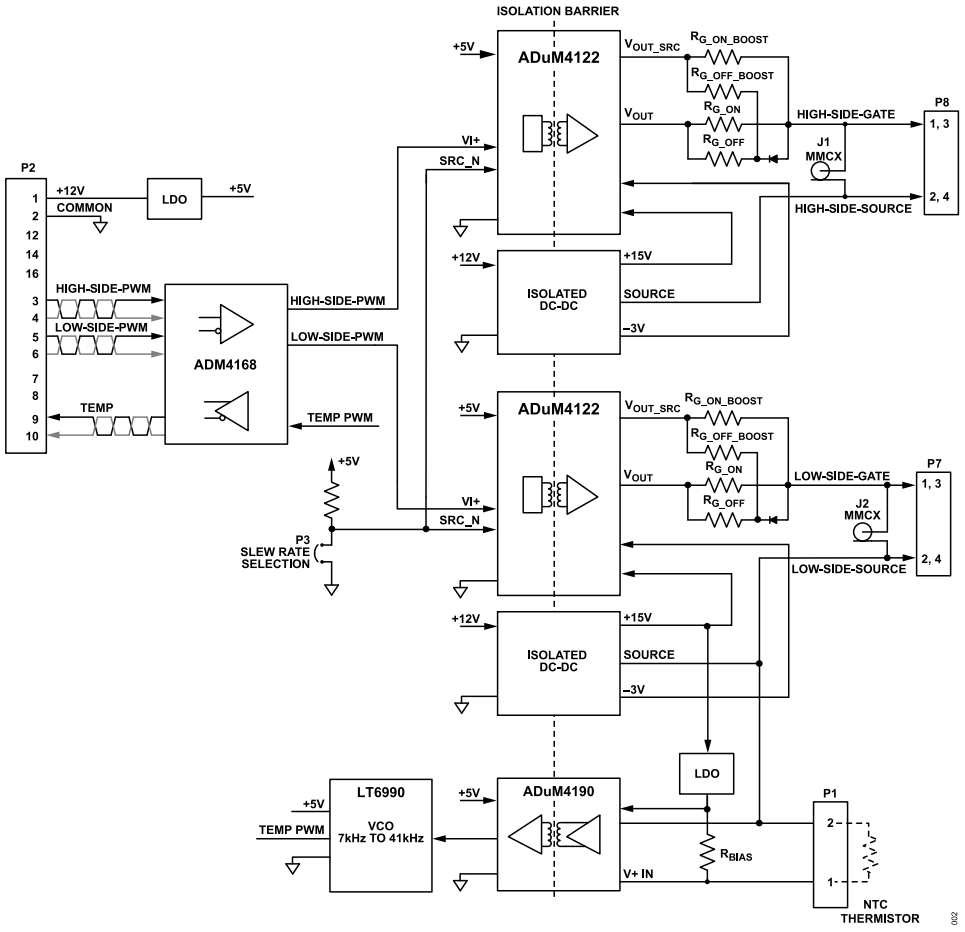

Figure 2. Functional Block Diagram

EVALUATION BOARD HARDWARE

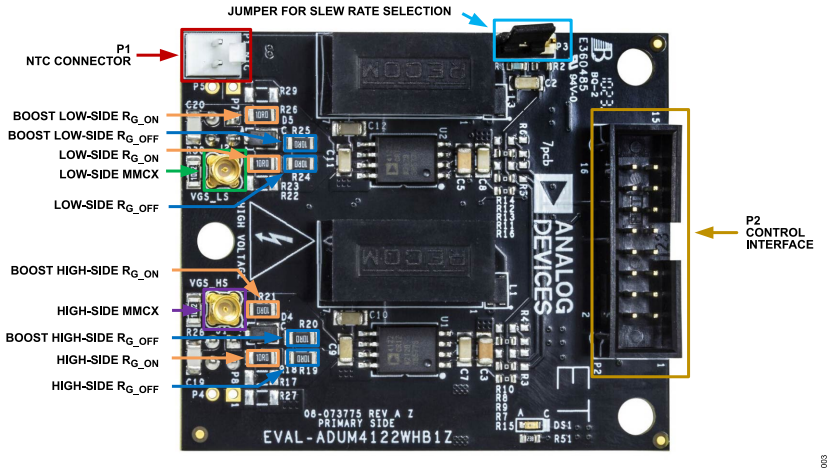

Figure 3. Top Side Feature Locations

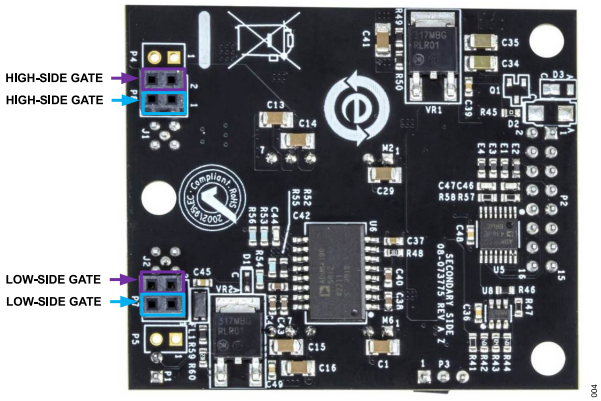

Figure 4. Bottom Side Feature Locations

BOARD USE AND CONFIGURATION

GATE DRIVE RESISTOR SELECTION

In addition to the slew rate selection capability offered by ADuM4122, the EVAL-ADuM4122WHB1Z provides two separate output paths for turn on and turn off of the power switch. The benefit of this approach is that the user can select a total of four different series resistances, two for the turn on and two for the turn off, which allows for additional differentiation of the drive strength. It is generally desired to have the turn off occur faster than the turn on.

To select the series resistance, choose the maximum allowed peak current (I_{PEAK}) for the switch. Knowing the voltage swing on the gate, as well as the internal resistance of the gate driver, an external gate resistor (R_{G_OFF} or R_{G_ON}) can be chosen.

$$I_{PEAK} = (V_{DD2} - V_{SS2}) / (R_{DSON\_N} + R_{G\_OFF}) \quad (1)$$

where R_{DSON_N} is the pull-down NMOS on resistance.

Solve for R_{G_OFF} using the following equation:

$$R_{G\_OFF} = \frac{(V_{DD2} - V_{SS2}) - I_{PEAK} \times R_{DSON\_N}}{I_{PEAK}} \quad (2)$$

For example, if the turn off peak current is 4 A with a nominal R_{DSON_N} value of 0.6 Ω and a (V_{DD2} − V_{SS2}) value of 18 V, the R_{G_OFF} is 3.9 Ω, as shown in the following equation:

$$R_{G\_OFF} = (18\ V - 4\ A \times 0.6\ \Omega) / 4\ A = 3.9\ \Omega \quad (3)$$

After R_{G_OFF} is selected, a slightly larger R_{G_ON} can be selected to arrive at a slower turn on time.

If the selected switch has a nonzero internal gate resistance (R_G), then this resistance must be subtracted from the calculated R_{G_OFF} to arrive at the final R_{G_OFF}.

POWER DISSIPATION

The power required by the gate driver is a function of the switch gate charge, switching frequency, and gate voltage swing. For one channel, the power is calculated using the following equation:

$$P_{SW} = Q_G \times F_{SW} \times (V_{DD2} - V_{SS2}) \quad (4)$$

where:
Q_G is the switch gate charge.
F_{SW} is the switching frequency.
V_{DD2} and V_{SS2} are the isolated supply voltages.

For the EVAL-ADuM4122WHB1Z, V_{DD2} = 15 V and V_{SS2} = −3 V.

EVALUATION BOARD SCHEMATIC

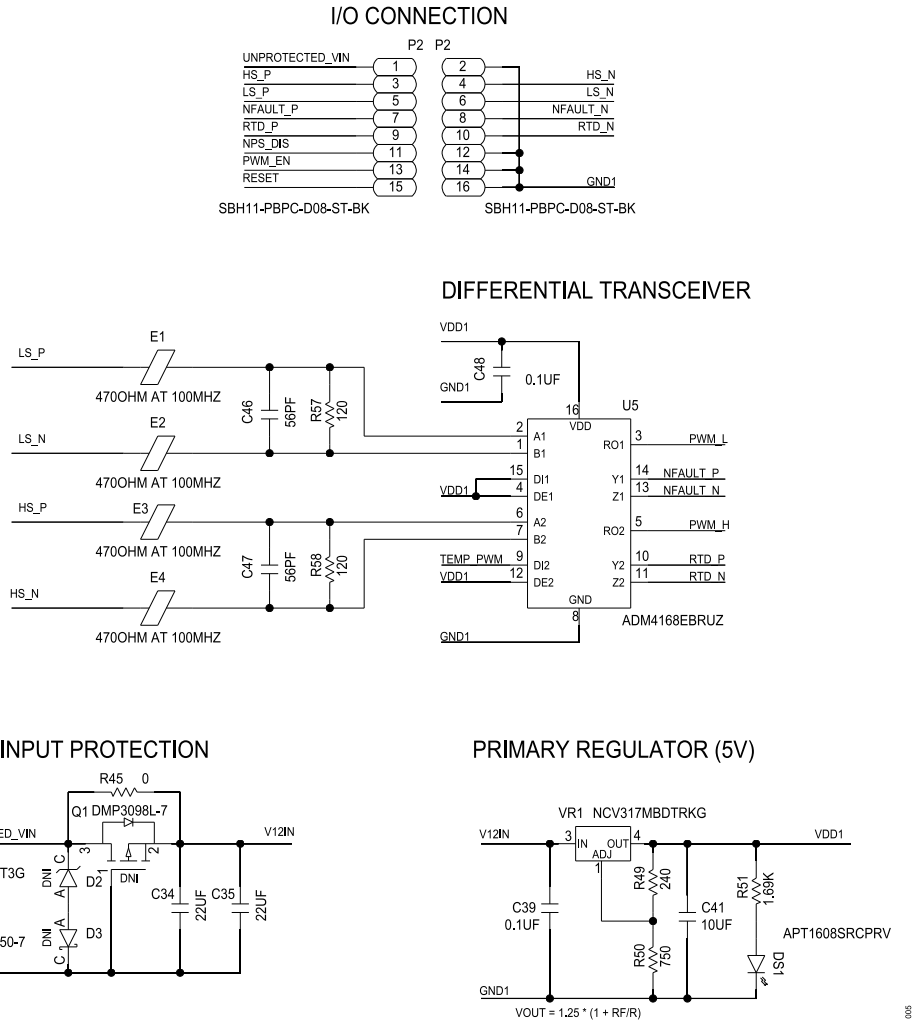

Figure 5. Circuit Schematic–Connectors and Power Section

EVALUATION BOARD SCHEMATIC

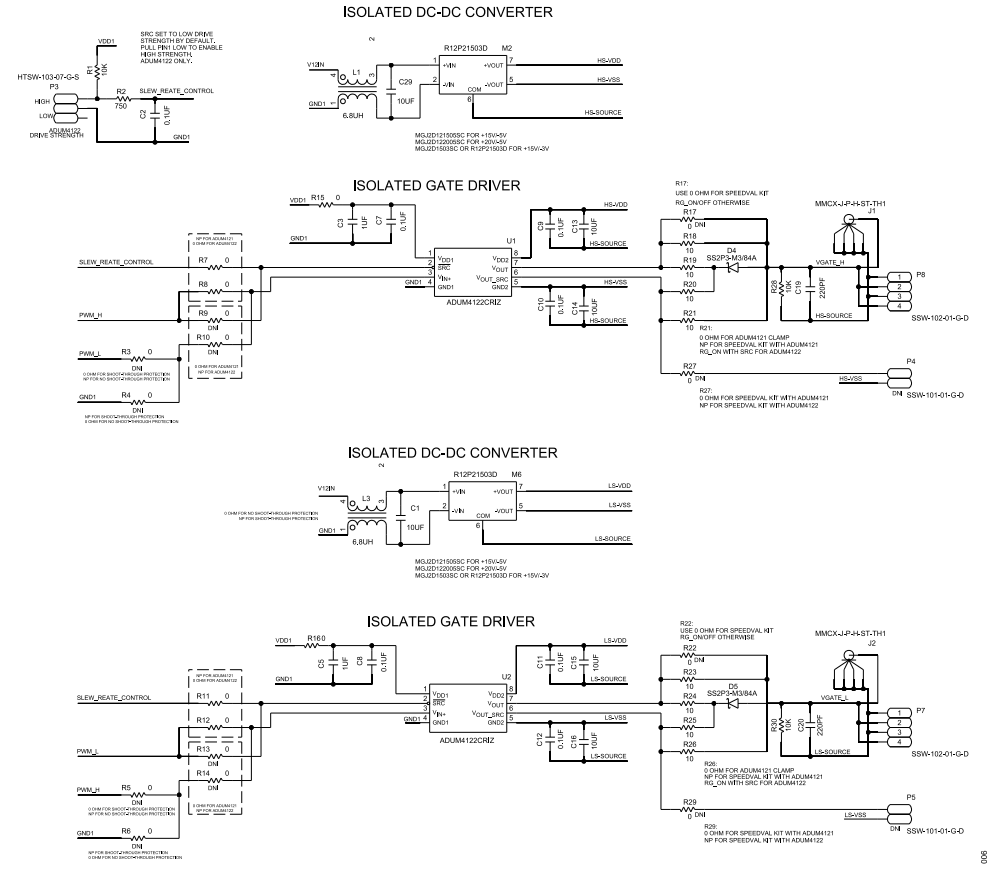

Figure 6. Circuit Schematic–Gate Drive Section

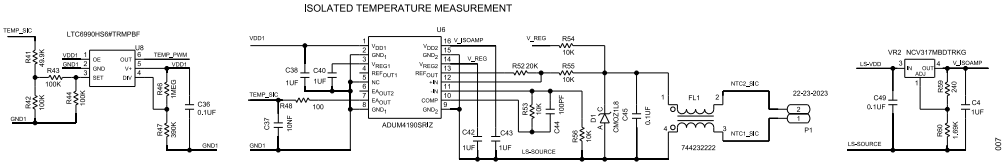

Figure 7. Circuit Schematic–Temperature Measurement Section

EVALUATION BOARD LAYOUT

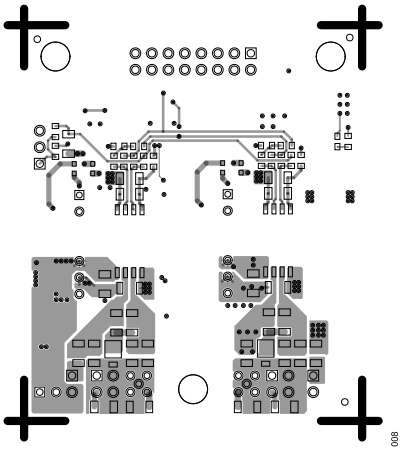

Figure 8. EVAL-ADuM4122WHB1Z Layout—L1 Top Layer

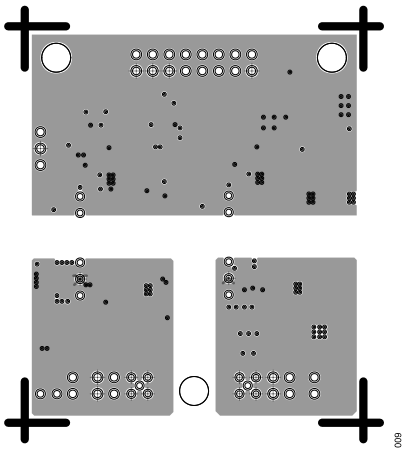

Figure 9. EVAL-ADuM4122WHB1Z Layout—L2 Second Layer

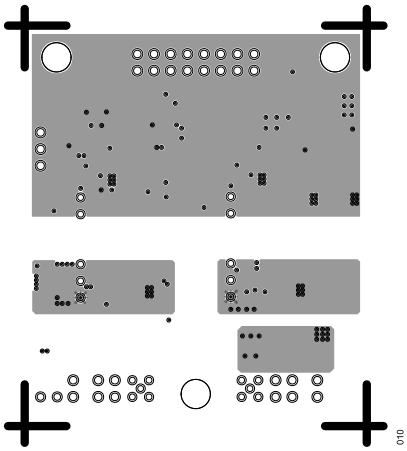

Figure 10. EVAL-ADuM4122WHB1Z Layout—L3 Third Layer

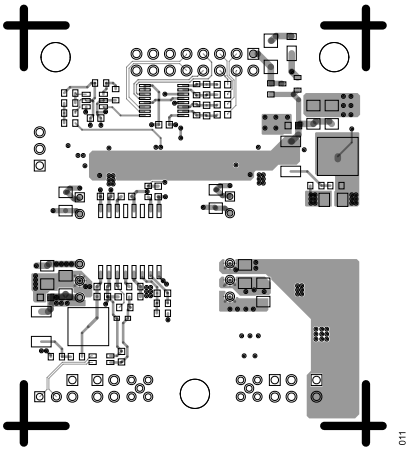

Figure 11. EVAL-ADuM4122WHB1Z Layout—L4 Bottom Layer

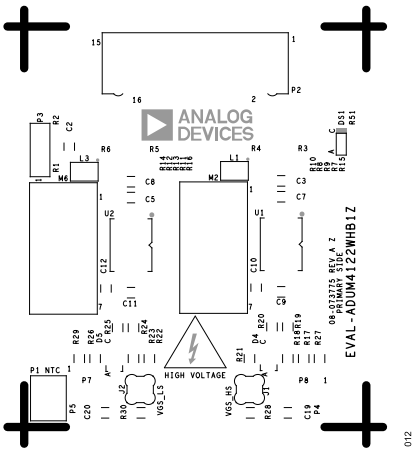

Figure 12. EVAL-ADuM4122WHB1Z Layout—Silkscreen Top

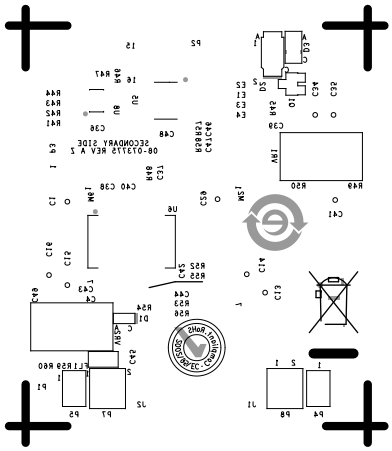

Figure 13. EVAL-ADuM4122WHB1Z Layout—Silkscreen Bottom

ORDERING INFORMATION

BILL OF MATERIALS

Table 3. Bill of Materials

Reference Designator	Description	Manufacturer Part No.	Manufacturer
C1, C13, C14, C15, C16, C29, C41	Ceramic capacitors, 10 µF, 50 V, 10%, X7R 1206	CGA5L1X7R1H106K160AC	TDK Corporation
C2, C7, C8, C9, C10, C11, C12	Ceramic capacitors, 0.1 µF, 50 V, 5%, X7R 1206	12065C104JAT2A	AVX Corporation
C19, C20	Ceramic capacitors, 220 pF, 500 V, 5%, C0G 1206	12067A221JAT2A	AVX Corporation
C3, C5	Ceramic capacitors, 1 µF, 25 V, 10%, X7R 1206	C1206R105K3RAC7800	KEMET Corporation
C34, C35	Ceramic capacitors, 22 µF, 25 V, 20%, X5R 1206	TMK316BBJ226ML-T	TAIYO YUDEN CO.
C36, C39, C45, C48, C49	Ceramic capacitors, 0.1 µF, 50 V, 10%, X7R 0603	06035C104KAT2A	AVX Corporation
C37	Ceramic capacitor, 10 nF, 100 V, 10%, X7R 0603	GCM188R72A103KA37J	Murata Manufacturing Co.
C4, C38, C40, C42, C43	Ceramic capacitors, 1 µF, 35 V, 10%, X7R 0603	C1608X7R1V105K080AC	TDK Corporation
C44	Ceramic capacitor, 100 pF, 50 V, 10%, X7R 0603	C0603C101K5RAC	KEMET Corporation
C46, C47	Ceramic capacitors, 56 pF, 50 V, 5%, C0G 0603	223886715569	Phycomp (YAGEO Corporation)
D1	Zener diode	CMOZ1L8 PBFREE	Central Semiconductor
D4, D5	Schottky diode barrier rectifiers	SS2P3-M3/84A	Vishay Intertechnology
DS1	1.6 mm x 0.8 mm SMD chip, LED lamp, red 640 nm	APT1608SRCPRV	Kingbright Electronic Co.
E1, E2, E3, E4	Ferrite bead inductors, 0.150 mΩ maximum DC resistance (DCR), 1 A	MPZ1608B471ATA00	TDK Corporation
FL1	Common mode, choke data line filter with noise suppression	744232222	Würth Elektronik
J1, J2	PCB Connectors, 50 Ω, male MMCX steel plug	MMCX-J-P-H-ST-TH1	Samtec
L1, L3	Coupled chip inductors, common mode choke, 0.630 Ω DCR, 0.7 A	PFD3215-682MEC	Coilcraft Inc.
M2, M6	DC-to-DC converters, 2 W, 12 V voltage input, +15 V to −3 V voltage output	R12P21503D	RECOM Power
P1	PCB connector, two position, male header socket 2.54 mm pitch, 3.68 mm solder tail	22232023	Molex
P2	PCB connector, 16 position, male header socket, dual row 2.54 mm pitch	SBH11-PBPC-D08-ST-BK	Sullins Connector Solutions
P3	PCB connector, three position, male header unshrouded single row socket, 2.54 mm pitch	HTSW-103-07-G-S	Samtec
P7, P8	PCB connectors, four position, female header double row socket, 2.54 mm pitch	SSW-102-01-G-D	Samtec
R7, R8, R11, R12, R15, R16, R45	SMD resistors, 0 Ω jumper 1/10 W, 0603	RC0603JR-070RL	YAGEO Corporation
R18, R19, R20, R21, R23, R24, R25, R26	SMD resistors, 10 Ω, 1%, 1/2 W, 1206	RCS120610R0FKEA	Vishay Intertechnology
R28, R30	SMD resistors, 10 kΩ, 1%, 1/4 W, 1206	ERJ-8ENF1002V	Panasonic
R41	SMD resistor, 49.9 kΩ, 1%, 1/10 W, 0603	ERJ-3EKF4992V	Panasonic
R42, R43, R44	SMD resistors, 100 kΩ, 5%, 1/10 W, 0603	RC0603JR-07100KL	YAGEO Corporation
R46	SMD resistor, 1 MΩ, 1%, 1/10 W, 0603	CRCW06031M00FKEA	Vishay Intertechnology
R47	SMD resistor, 390 kΩ, 1%, 0.1 W, 0603	ERJ-S03F3903V	Panasonic
R48	SMD resistor, 100 Ω, 0.1%, 1/10 W, 0603	ERA-3AEB101V	Panasonic
R49, R59	SMD resistors, 240 Ω ,1%, 1/10 W, 0603	CRCW0603240RFKEA	Vishay Intertechnology
R2, R50	SMD resistors, 750 Ω, 1%, 1/10 W, 0603	CRCW0603750RFKEA	Vishay Intertechnology
R51, R60	SMD resistors, 1.69 kΩ, 1%, 1/10 W, 0603	RC0603FR-071K69L	YAGEO Corporation
R52	SMD resistor, 20 kΩ, 1%, 1/10 W, 0603	CRCW060320K0FKEA	Vishay Intertechnology
R1, R53, R54, R55, R56	SMD resistors, 10 kΩ, 1%, 1/8 W, 0603	MCT06030C1002FP500	Vishay Intertechnology
R57, R58	SMD resistors, 120 Ω, 1%, 1/10 W, 0603	ERJ-3EKF1200V	Panasonic
U1, U2	Single gate, adjustable slew rate, isolated drivers	ADUM4122ARIZ	Analog Devices, Inc.
U5	ESD protected, dual RS-422 transceiver	ADM4168EBRUZ	Analog Devices, Inc.
U6	High stability isolated error amplifier	ADUM4190SRIZ	Analog Devices, Inc.
U8	Voltage controlled silicon oscillator	LTC6990HS6#TRMPBF	Analog Devices, Inc.
VR1, VR2	0.5 A, adjustable output, positive voltage regulators	NCV317MBDTRKG	onsemi

ORDERING INFORMATION

Table 3. Bill of Materials (Continued)

Reference Designator	Description	Manufacturer Part No.	Manufacturer
D2	1.5 W, plastic surface mount Zener voltage regulator	1SMA5931BT3G	onsemi
D3	1 A, SMT Schottky barrier rectifier	DFLS1150-7	Diodes Incorporated
P4, P5	PCB connectors, two position female header double row solder tail, 2.54 mm pitch	SSW-101-01-G-D	Samtec
Q1	P-channel enhancement mode MOSFET	DMP3098L-7	Diodes Incorporated
R3, R4, R5, R6, R9, R10, R13, R14	SMD resistors, 0 Ω jumper, 1/10 W 0603	RC0603JR-070RL	YAGEO Corporation
R17, R22, R27, R29	SMD resistors, 0 Ω jumper, 1/4 W 1206	ERJ-8GEY0R00V	Panasonic

ESD Caution
ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.