Evaluating the ADAQ8088 Dual-, Differential, Low-Pass Filter µModule with Gain and ADC Driver

FEATURES

▶ 3 common signal processing and conditioning blocks, a preamplifier, an 8-pole filter, and an ADC driver integrated to support a variety of demodulator applications
▶ No external components required for proper operation

EVALUATION KIT CONTENTS

▶ EVAL-ADAQ8088EBZ evaluation board

EQUIPMENT NEEDED

▶ Bench supply of 2.7 V to 3.3 V
▶ SMA cables
▶ 4-port or 2-port network analyzer
▶ AD9681-125EBZ evaluation kit
▶ HSC-ADC-EVALEZ evaluation kit
▶ Keysight 33600A generator
▶ Allen Avionics LPF #F3056-7P7 (2 pieces)
▶ PC running Windows®

EVAL-ADAQ8088EBZ PHOTOGRAPH
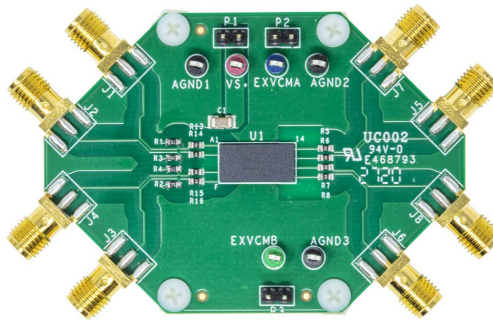
GENERAL DESCRIPTION

The EVAL-ADAQ8088EBZ evaluates the ADAQ8088 and requires a 2.7 V to 3.3 V power supply for proper operation. The EVAL-ADAQ8088EBZ accepts baseband differential in-phase/quadrature (I/Q) inputs via Subminiature A (SMA) connectors (Jx) and drives pipeline analog-to-digital converters (ADCs) via SMA output connectors. The EVAL-ADAQ8088EBZ contains the ADAQ8088 µModule, which is a dual-channel analog system in package (SIP) that integrates three common signal processing and conditioning blocks to support a variety of demodulator applications and data acquisition applications. The device integrates all active and passive components to form a complete signal chain between the output of an I/Q demodulator and the input to an ADC. For full details on the ADAQ8088, see the ADAQ8088 data sheet, which must be consulted in conjunction with this user guide when using the EVAL-ADAQ8088EBZ.

Figure 1.

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REVISION HISTORY

EVALUATION BOARD HARDWARE

SETTING UP THE EVALUATION BOARD

Figure 2 shows the simplified EVAL-ADAQ8088EBZ block diagram. The ADAQ8088 μModule that is soldered to the EVAL-ADAQ8088EBZ requires a supply voltage from 2.7 V to 3.3 V. The EVAL-ADAQ8088EBZ allows the user to set the I_OUT_V$_{OCM}$ pin and Q_OUT_V$_{OCM}$ pin of the EVAL-ADAQ8088EBZ through the EXVCMA and EXVCMB jumpers.

ANALOG INPUTS

The EVAL-ADAQ8088EBZ I inputs (I_INP and I_INN) are connected through the J1 and J2 SMA connectors, respectively, and the Q inputs (Q_INP and Q_INN) are connected through the J4 and J3 SMA connectors, respectively.

Table 1. Jumper Details with Factory Default Settings

Link	Default	Function	Comment
P1	Not populated	VS+	ADAQ8088 supply.

Table 1. Jumper Details with Factory Default Settings

Link	Default	Function	Comment
P2	Not populated	EXVCMA	Connect EXVCMA to the common-mode output of the ADC I-channel. This jumper can also be left floating.
P3	Not populated	EXVCMB	Connect EXVCMB to the common-mode output of the ADC Q-channel. This jumper can also be left floating.

Note that the I-channel and the Q-channel correspond to Channel A and Channel B, respectively, of the ADAQ8088 data sheet.
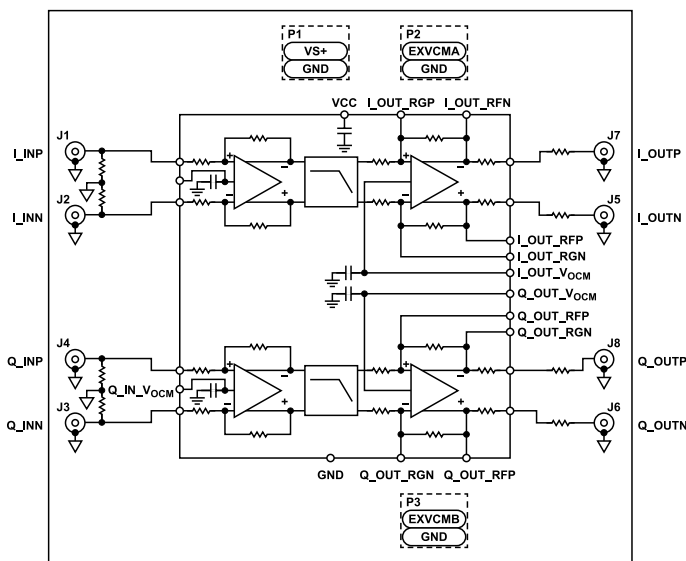

Figure 2. Simplified EVAL-ADAQ8088EBZ Block Diagram

MAGNITUDE AND PHASE RESPONSE MEASUREMENTS USING A FOUR-PORT NETWORK ANALYZER

MEASURING THE MAGNITUDE AND PHASE OF THE I-CHANNEL

To measure the magnitude and phase of the I-channel using a four-port network analyzer (see Figure 3), take the following steps:

1. Use an SMA cable to connect J1 of the EVAL-ADAQ8088EBZ to Port 1 of the network analyzer.
2. Use an SMA cable to connect J2 of the EVAL-ADAQ8088EBZ to Port 2 of the network analyzer.
3. Use an SMA cable to connect J7 of the EVAL-ADAQ8088EBZ to Port 3 of the network analyzer.
4. Use an SMA cable to connect J5 of the EVAL-ADAQ8088EBZ to Port 4 of the network analyzer.
5. Set the network analyzer output, Port 1 and Port 2, to a power level of −20 dBm (63 mV p-p).
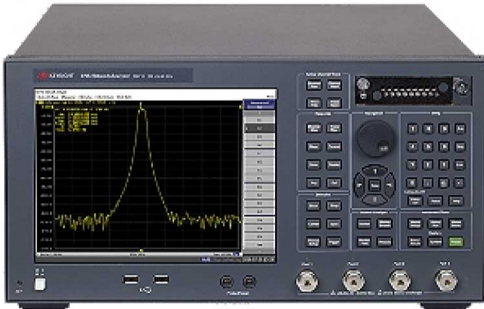6. Observe the output phase on Port 3 and Port 4 of the network analyzer.

Figure 3. Four-Port Network Analyzer (E5071C Model)

MEASURING THE MAGNITUDE AND PHASE OF THE Q-CHANNEL

To measure the magnitude and phase of the Q-channel using a four-port network analyzer (see Figure 3), take the following steps:

1. Use an SMA cable to connect J4 of the EVAL-ADAQ8088EBZ to Port 1 of the network analyzer.
2. Use an SMA cable to connect J3 of the EVAL-ADAQ8088EBZ to Port 2 of the network analyzer.
3. Use an SMA cable to connect J8 of the EVAL-ADAQ8088EBZ to Port 3 of the network analyzer.
4. Use an SMA cable to connect J6 of the EVAL-ADAQ8088EBZ to Port 4 of the network analyzer.
5. Set the network analyzer output, Port 1 and Port 2, to a power level of −20 dBm (63 mV p-p).
6. Observe the output phase on Port 3 and Port 4 of the network analyzer.

CALIBRATION PROCEDURE

First ensure that the four-port network analyzer is calibrated using either the ECal (electronic calibration) module, or the manual short, open, and load method. When the network analyzer is calibrated using one of these two methods, take the following steps to complete the network analyzer through calibration:

1. Use an SMA cable to connect a through connector from Port 1 to Port 3 of the network analyzer.
2. Use an SMA cable to connect a through connector from Port 2 to Port 4 of the network analyzer.
3. Press the **Cal** button on the network analyzer.
4. Click **Calibrate** > **Response (Thru)** > **Select Ports** on the network analyzer, and then take the following steps to start calibration:
   a. Select **3-1** and click **Thru** on the network analyzer to start the calibration on Port 3 and Port 1.
   b. When the calibration on Port 3 and Port 1 is complete, select **4-2** and click **Thru** on the network analyzer to start calibration on Port 4 and Port 2.
5. Use an SMA cable to connect a through connector from Port 1 to Port 4 of the network analyzer.
6. Use an SMA cable to connect a through connector from Port 2 to Port 3 of the network analyzer.
7. Press the **Cal** button on the network analyzer.
8. Click **Calibrate** > **Response (Thru)** > **Select Ports** on the network analyzer, and then take the following steps to start calibration:
   a. Select **4-1** and click **Thru** on the network analyzer to start the calibration on Port 4 and Port 1.
   b. When the calibration on Port 4 and Port 1 is complete, select **3-2** and click **Thru** on the network analyzer to start calibration on Port 3 and Port 2.

MAGNITUDE AND FREQUENCY RESPONSE MEASUREMENTS USING A TWO-PORT NETWORK ANALYZER

MEASURING THE MAGNITUDE AND FREQUENCY RESPONSE OF THE I-CHANNEL

I_INP as the Active Input

To measure the magnitude and frequency response of the I-channel with the I_INP input as the active input and using a two-port network analyzer (see Figure 4), take the following steps:

1. Install 56.2 Ω at R1 and 26.7 Ω at R3 to properly balance the input impedance.
2. Use an SMA cable to connect J1 of the EVAL-ADAQ8088EBZ to Port 1 of the network analyzer.
3. Leave J2 of the EVAL-ADAQ8088EBZ floating.
4. To measure the frequency response at the I_OUTP output of the EVAL-ADAQ8088EBZ, take the following steps:

   a. Use an SMA cable to connect J7 of the EVAL-ADAQ8088EBZ to Port 2 of the network analyzer.
   b. Terminate J5 to 50 Ω.
   c. Set the network analyzer output, Port 1, to a power level of −20 dBm.
   d. Observe the frequency response on Port 2 of the network analyzer.

5. To measure the frequency response at the I_OUTN output of the EVAL-ADAQ8088EBZ, take the following steps:

   a. Use an SMA cable to connect J5 of the EVAL-ADAQ8088EBZ to Port 2 of the network analyzer.
   b. Terminate J7 to 50 Ω.
   c. Set the network analyzer output, Port 1, to a power level of −20 dBm.
   d. Observe the frequency response on Port 2 of the network analyzer.

I_INN as the Active Input

To measure the magnitude and frequency response of the I-channel with the I_INN input as the active input and using a two-port network analyzer (see Figure 4), take the following steps:

1. Install 56.2 Ω at R3 and 26.7 Ω at R1 to properly balance the input impedance.
2. Use an SMA cable to connect J2 of the EVAL-ADAQ8088EBZ to Port 1 of the network analyzer.
3. Leave J1 of the EVAL-ADAQ8088EBZ floating.
4. To measure the frequency response at the I_OUTP and I_OUTN outputs of the EVAL-ADAQ8088EBZ, repeat Step 4 and Step 5 of the procedure in the I_INP as the Active Input section.

Figure 4. Two-Port Network Analyzer (E5071 Model)

MEASURING THE MAGNITUDE AND FREQUENCY RESPONSE OF THE Q-CHANNEL

Q_INP as the Active Input

To measure the magnitude and frequency response of the Q-channel with the Q_INP input as the active input and using a two-port network analyzer (see Figure 4), take the following steps:

1. Install 56.2 Ω at R4 and 26.7 Ω at R2 to properly balance the input impedance.
2. Use an SMA cable to connect J4 of the EVAL-ADAQ8088EBZ to Port 1 of the network analyzer.
3. Leave J3 of the EVAL-ADAQ8088EBZ floating.
4. To measure the frequency response at the Q_OUTP output of the EVAL-ADAQ8088EBZ, take the following steps:

   a. Use an SMA cable to connect J8 of the EVAL-ADAQ8088EBZ to Port 2 of the network analyzer.
   b. Terminate J6 to 50 Ω.
   c. Set the network analyzer output, Port 1, to a power level of −20 dBm.
   d. Observe the frequency response on Port 2 of the network analyzer.

5. To measure the frequency response at the Q_OUTP output of the EVAL-ADAQ8088EBZ, take the following steps:

   a. Use an SMA cable to connect J6 of the EVAL-ADAQ8088EBZ to Port 2 of the network analyzer.
   b. Terminate J8 to 50 Ω.
   c. Set the network analyzer output, Port 1, to a power level of −20 dBm.
   d. Observe the frequency response on Port 2 of the network analyzer.

Q_INN as the Active Input

To measure the magnitude and frequency response of the Q-channel with the Q_INN input as the active input and using a two-port network analyzer (see Figure 4), take the following steps:

MAGNITUDE AND FREQUENCY RESPONSE MEASUREMENTS USING A TWO-PORT NETWORK ANALYZER

1. Install 56.2 Ω at R2 and 26.7 Ω at R4 to properly balance the input impedance.
2. Use an SMA cable to connect J3 of the EVAL-ADAQ8088EBZ to Port 1 of the network analyzer.
3. Leave J4 of the EVAL-ADAQ8088EBZ floating.
4. To measure the frequency response at the Q_OUTP and Q_OUTN outputs of the EVAL-ADAQ8088EBZ, repeat Step 4 and Step 5 of the procedure in the Q_INP as the Active Input section.

CALIBRATION PROCEDURE

First ensure that the two-port network analyzer is calibrated using either the ECal (electronic calibration) module, or the manual short, open, and load method. When the network analyzer is calibrated using one of these two methods, take the following steps to complete the network analyzer through calibration:

1. Use an SMA cable to connect a through connector from Port 1 to Port 2 of the network analyzer.
2. Press the **Cal** button on the network analyzer.
3. Click **Calibrate** > **Response (Thru)** > **Select Ports** on the network analyzer.
4. Select **2-1**, and click **Thru**.

EVALUATING THE ADAQ8088 BY DRIVING THE AD9681 ADC

CONFIGURING THE EVAL-ADAQ8088EBZ, AD9681-125EBZ, AND HSC-ADC-EVALEZ

Before using the software for testing, take the following steps to configure the EVAL-ADAQ8088EBZ, AD9681-125EBZ, and HSC-ADC-EVALEZ:

1. Take the following steps to modify the EVAL-ADAQ8088EBZ:
   a. Remove the R5, R6, R7, and R8 resistors.
   b. Install a 40 Ω resistor on R5, R6, R7, and R8.
2. Take the following steps to modify the AD9681-125EBZ (FMC connector version) of each channel selected (Figure 6 shows Channel A1 and Channel A2 selected for use):
   a. Install an SMA connector on the J102 and J104 ports.
   b. Remove the R14, R16, C3, C4, J6, J7, C7 to C10, R36 to R39, and T17 to T20.
   c. Install a 0 Ω resistor on R321, R415, C3, C4, J6, J7, C7 to C10, and R36 to R39.
   d. Connect a jumper wire from Pin 3 to Pin 4 of T1.
   e. Connect a jumper wire from Pin 1 to Pin 6 of T1.
   f. Connect a jumper wire from Pin 3 to Pin 4 of T2.
   g. Connect a jumper wire from Pin 1 to Pin 6 of T2.
3. Connect the EVAL-ADAQ8088EBZ to the AD9681-125EBZ, as shown in Figure 6, and then connect the AD9681-125EBZ to the HSC-ADC-EVALEZ by aligning each of their field programmable gate array mezzanine card (FMC) connector and carefully press them together. Note that FMC connectors often come from the factory with a sticker that prevents connection. Remove this sticker (if needed) before attempting to make the connection.
4. On the EVAL-ADAQ8088EBZ, confirm that the jumpers are installed as shown in Figure 8.
5. Connect one 6 V, 2.5 A switching power supply (such as the CUI, Inc., EPS060250UH-PHP-SZ supplied in the AD9681-125EBZ evaluation kit) to the AD9681-125EBZ.
6. Connect the 12 V, 3.3 A switching power supply to the HSC-ADC-EVALEZ board.
7. Connect the HSC-ADC-EVALEZ to the PC using a USB cable (supplied in the HSC-ADC-EVALEZ evaluation kit).
8. On the EVAL-ADAQ8088EBZ, replace the value of R5, R6, R7, and R8 with 40 Ω each and use a clean signal generator with low phase noise to provide an input signal.
9. Connect the output signal from either J5 and J7 or J6 and J8 to the selected channel of the AD9681-125EBZ.

MEASUREMENT RESULTS WHEN DRIVING THE AD9681 USING THE ADAQ8088 AS A DRIVER

The configurations of the EVAL-ADAQ8088EBZ and the AD9681-125EBZ used during testing include the following:

▶ The input source dual-channel generator (Keysight 33600A differential signal generator) is set to 6 MHz, 52 mV p-p for −1 dbFS.
▶ The input filter (Allen Avionics low-pass filter (LPF), F3056-7P7) is set to a 7.7 MHz cutoff frequency. Another LPF can be selected with a cutoff frequency above the input frequency and below the first harmonic.
▶ The I-channel and Q-channel are driven and measured (refer to Figure 6). A sample FFT of the measurement is shown in Figure 5.
▶ The output loading is configured as follows:
   ▶ 10 Ω internal to μModule.
   ▶ 40 Ω on the EVAL-ADAQ8088EBZ.
   ▶ 33 Ω and 5 pF LPF on the EVAL-ADAQ8088EBZ (still allows for optimization).

For details on the correct EVAL-ADAQ8088EBZ jumper positions, modes of operation, and using the ADC data capture software for testing, see the AD9681-125EBZ user guide page at https://wiki.analog.com/resources/eval/ad9681-125ebz.
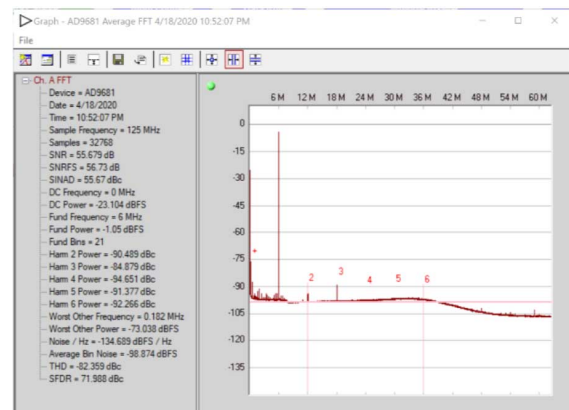

Figure 5. Fast Fourier Transform (FFT) Result

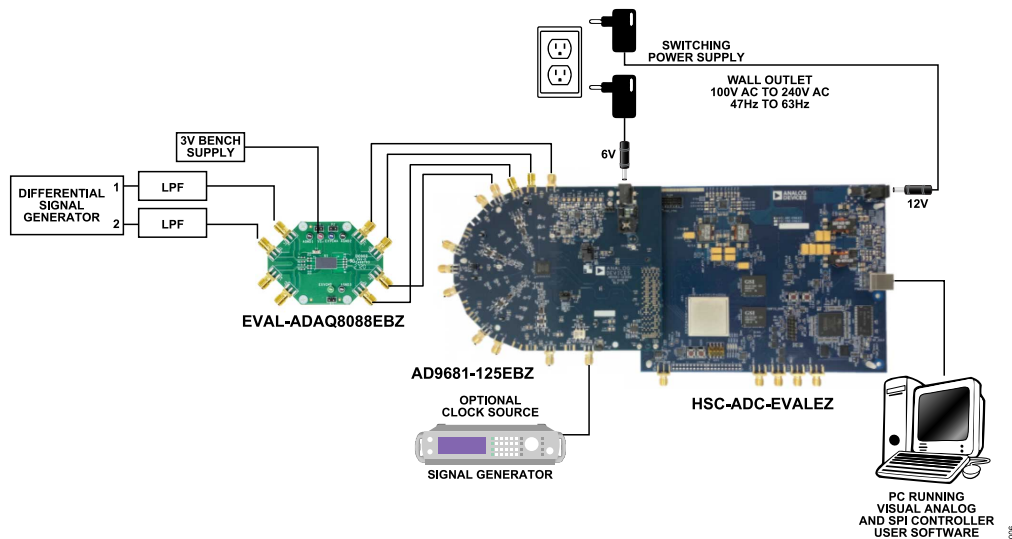## EVALUATING THE ADAQ8088 BY DRIVING THE AD9681 ADC

Figure 6. EVAL-ADAQ8088EBZ, AD9681-125EBZ, and HSC-ADC-EVALEZ Connections

TROUBLESHOOTING TIPS

If the FFT appears normal but the performance is poor, check for the following:

► Ensure that the output signal of the ADAQ8088 is clean (low phase noise).
► Ensure that the connection between the output of the EVAL-ADAQ8088EBZ to the AD9681-125EBZ is tight. Using a smaller length of cable or connector is recommended.
► Ensure that an appropriate filter is used on the analog input.
► Ensure that the signal generator for the clock is clean (low phase noise).
► Slightly change the analog input frequency if noncoherent sampling is used.
► Ensure that the SPI configuration file matches the device being evaluated.

For further details on troubleshooting while evaluating the ADAQ8088 by driving the AD9681 ADC, see the AD9681-125EBZ user guide page at https://wiki.analog.com/resources/eval/ad9681-125ebz.

EVALUATION BOARD SCHEMATICS AND ARTWORK
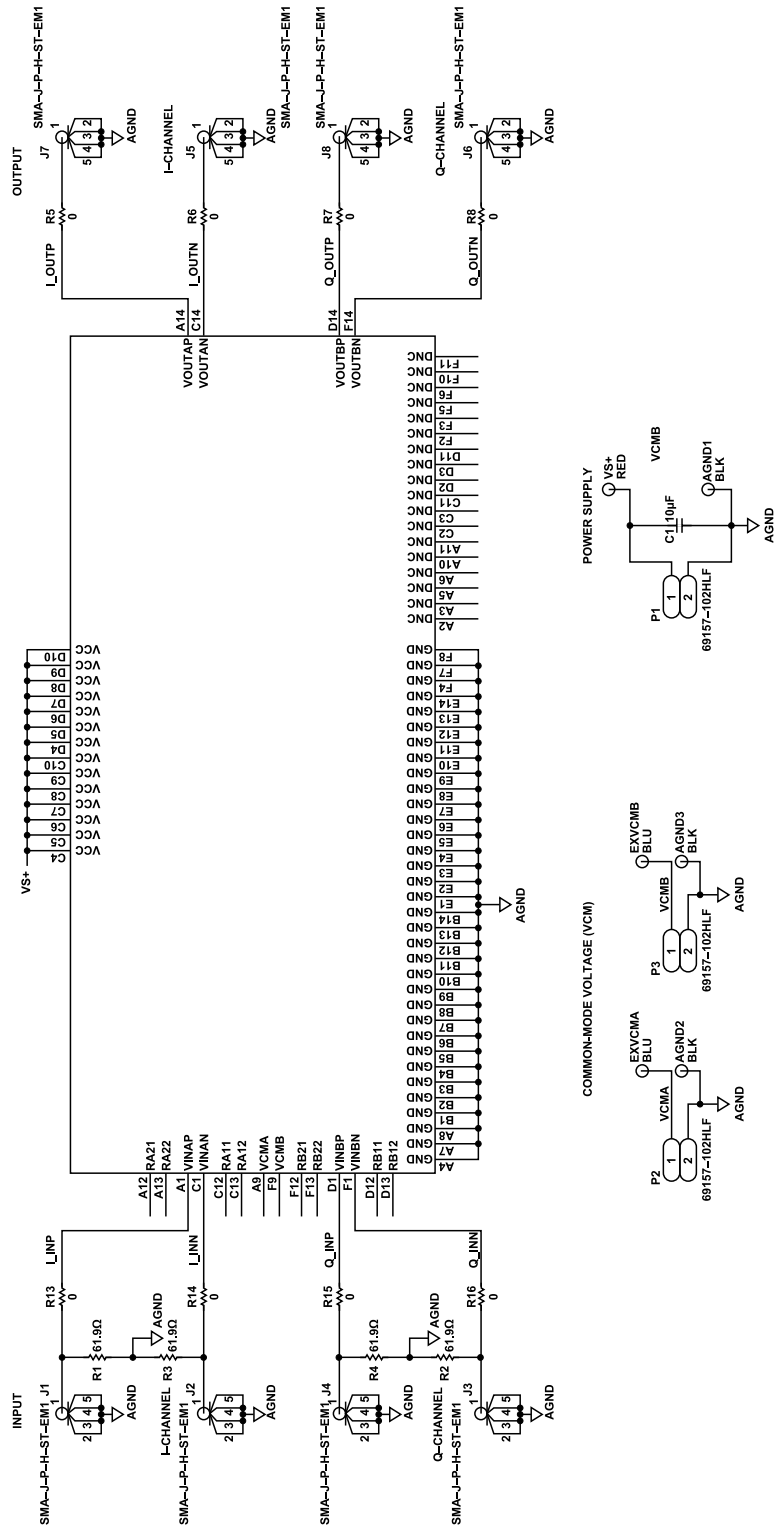
Figure 7. EVAL-ADAQ8088EBZ Schematic

EVALUATION BOARD SCHEMATICS AND ARTWORK
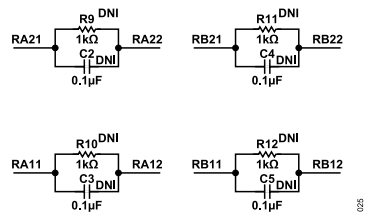
Figure 8. EVAL-ADAQ8088EBZ Feedback Resistor/Capacitor Placeholders
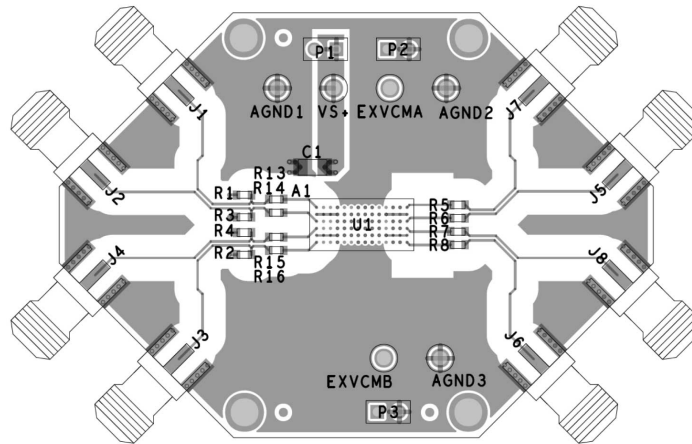
Figure 9. EVAL-ADAQ8088EBZ Top Copper Layer
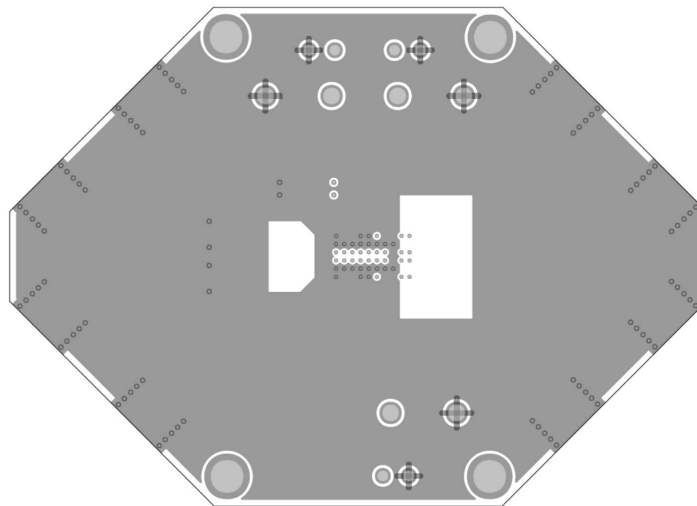
Figure 10. EVAL-ADAQ8088EBZ GND Plane

EVALUATION BOARD SCHEMATICS AND ARTWORK
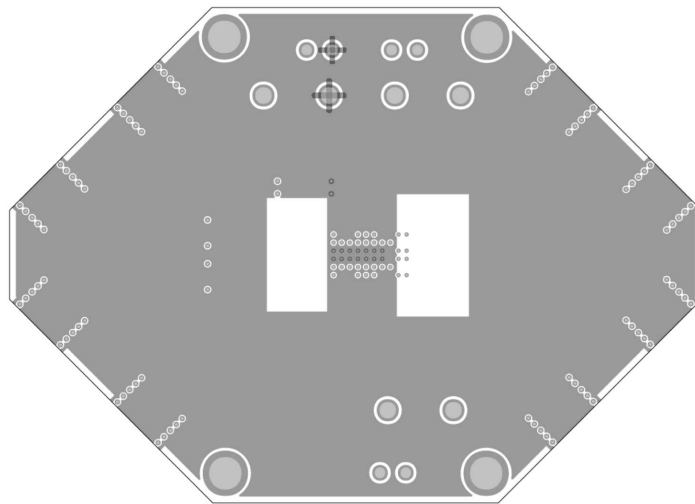
Figure 11. EVAL-ADAQ8088EBZ Power Plane
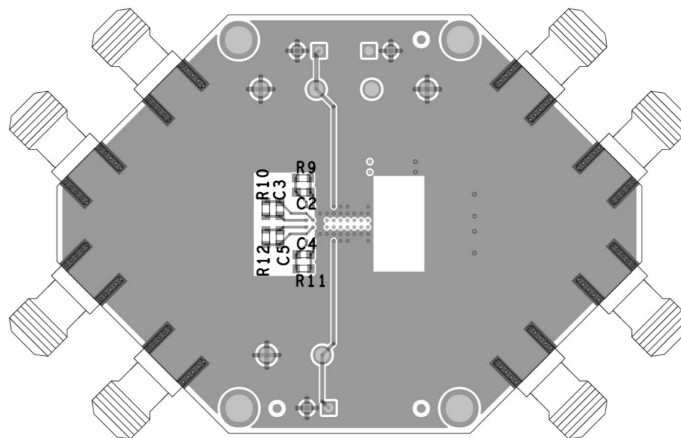
Figure 12. EVAL-ADAQ8088EBZ Bottom Copper Layer

ORDERING INFORMATION

BILL OF MATERIALS

Table 2.

Qty	Reference Designator	Description	Part Number	Manufacturing
3	AGND1, AGND2, AGND3	Connectors, PCB, test point, black	TP-104-01-00	Components Corporation
1	C1	Ceramic capacitor, 10 µF, 35 V, 10%, X7R, 1206	GMK316AB7106KL-TR	Taiyo Yuden
1	EXVCMA	Connector, PCB, test point, blue	TP104-01-06	Components Corporation
1	EXVCMB	Connector, PCB, test point, green	TP104-01-05	Components Corporation
8	J1, J2, J3, J4, J5, J6, J7, J8	Connectors, PCB, SMA, straight, edge mount	SMA-J-P-H-ST-EM1	Samtec
3	P1, P2, P3	Connectors, PCB, jumper, straight, male, 2-piece	69157-102HLF	Amphenol FCI
4	R1, R2, R3, R4	Resistors, SMD, 61.9 Ω, 1%, 1/10 W, AEC-Q200	AC0603FR-0761R9L	Yageo
8	R5, R6, R7, R8, R13, R14, R15, R16	Resistors, film, SMD, 0 Ω, 1/10 W, 0603	CRCW06030000Z0EA	Vishay
1	U1	IC, demodulator, I/Q signal conditioner, dual-ADC driver in µModule	ADAQ8088BBCZ	Analog Devices, Inc.
1	VS+	Connector, PCB, test point, red	TP-104-01-02	Components Corporation
4	Not applicable	Standoff, nylon hex, female, 6.35 MM, OD, #4, 40 threads per inch, 1/2 inch long	1902C	Keystone Electronics Corp
4	Not applicable	Screw, machine nylon pan head, Philips, #4, 40 threads per inch, 1/4 inch long	NY PMS 440 0025 PH	B&F Fastener Supply

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.