

Evaluating the **ADGM1004** 0 Hz/DC to 13 GHz, 2.5 kV HBM ESD, SP4T, MEMS Switch with Integrated Driver

FEATURES

- Single-supply voltage: 3.3 V
- Wide frequency range
- SMA connectors for RF signals
- SMB connectors for switch control signals
- On-board CALIBRATION THRU transmission line for analyzer calibration

EVALUATION KIT CONTENTS

[EVAL-ADGM1004EBZ](#) evaluation board

ONLINE RESOURCES

[ADGM1004](#) data sheet

[EVAL-ADGM1004EBZ](#) user guide

ADDITIONAL EQUIPMENT NEEDED

- 3.3 V dc power supply
- Vector network analyzer (VNA)

GENERAL DESCRIPTION

This user guide describes the [EVAL-ADGM1004EBZ](#) evaluation board for the [ADGM1004](#), a dual-chip, radio frequency (RF) switching solution containing a single-pole, four-throw (SP4T), microelectromechanical systems (MEMS) switch, and a control chip copackaged in a compact, 5 mm × 4 mm, LFCSP package. The SP4T switch uses Analog Devices, Inc., MEMS switch technology, providing optimum performance in terms of bandwidth, power handling capability, and linearity for RF applications. The control chip generates the high voltage signals needed for the MEMS switch and allows the user to control its operation through a simple and flexible complementary metal-oxide semiconductor (CMOS)/low voltage transistor-transistor logic (LVTTTL) compliant parallel interface.

The [EVAL-ADGM1004EBZ](#) comes fitted with connectors for RF and control signals as well as links to control the operation of the switch and evaluate its performance.

For full details on the [ADGM1004](#), see the [ADGM1004](#) data sheet, which should be consulted in conjunction with this user guide when using this evaluation board.

EVAL-ADGM1004EBZ CONNECTION DIAGRAM

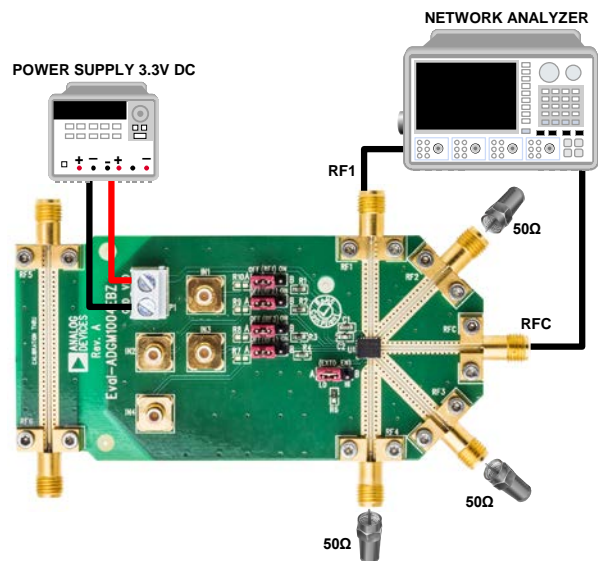


Figure 1.

TABLE OF CONTENTS

Features	1	RF Connectors.....	3
Evaluation Kit Contents.....	1	Switch Control Connectors.....	3
Online Resources	1	Measuring Switch Performance	5
Additional Equipment Needed	1	Network Analyzer Calibration Procedure	7
General Description	1	Handling Guidelines	8
EVAL-ADGM1004EBZ Connection Diagram	1	Evaluation Board Schematic and Artwork.....	9
Revision History	2	Ordering Information.....	11
Evaluation Board Hardware.....	3	Bill of Materials.....	11
Power Supply.....	3		

REVISION HISTORY

1/2017—Revision 0: Initial Version

EVALUATION BOARD HARDWARE

The [ADGM1004](#) evaluation kit contains a fully fitted, printed circuit board (PCB).

The [EVAL-ADGM1004EBZ](#) evaluation board allows the user to connect RF signals to the MEMS switch. The user controls the switch operation using the on-board links or by applying the correct control signals to the appropriate connectors.

The [EVAL-ADGM1004EBZ](#) provides an additional transmission line to facilitate the calibration of the network analyzer to minimize the effects of the PCB tracks that connect the RF signals to the MEMS switch. This user guide describes the calibration process in detail (see the Network Analyzer Calibration Procedure section).

POWER SUPPLY

To operate the [EVAL-ADGM1004EBZ](#), the user must provide an external power supply connected to the power block, P1. The supply voltage is 3.3 V and must be positive with respect to the ground of the [EVAL-ADGM1004EBZ](#). The ground of the [EVAL-ADGM1004EBZ](#) is marked with GND on the silkscreen near P1 (see Figure 12).

RF CONNECTORS

The SMA edge connectors on the [EVAL-ADGM1004EBZ](#) (RF1 to RF4 and RFC) connect to each switch in the [ADGM1004](#) for performance evaluation purposes. The RF5 and RF6 connectors connect to a transmission line to estimate the loss associated with the PCB (see the Measuring Switch Performance section). Table 1 describes the RF connectors to the [ADGM1004](#).

Table 1. Connecting the RF Connectors to the [ADGM1004](#)

Connector	Description
RF1	Port RF1 of the ADGM1004
RF2	Port RF2 of the ADGM1004
RF3	Port RF3 of the ADGM1004
RF4	Port RF4 of the ADGM1004
RFC	Common RF port of the ADGM1004
RF5, RF6	CALIBRATION THRU transmission lines used for calibration

SWITCH CONTROL CONNECTORS

The control integrated circuit (IC) packaged with the MEMS switch internally generates the voltage required to drive the switch. The internal control IC contains a reference clock signal at a nominal 11.5 MHz. In normal operation, set the (EXTD_EN) link to low, enabling the built-in 11.5 MHz oscillator to enable the internal driver IC voltage boost circuitry. Note that in Figure 1, this link is shown in parentheses on the evaluation board. Set (EXTD_EN) to high to disable the internal 11.5 MHz oscillator and drive V_{CP} with 80 V dc from the external voltage supply. Disabling the internal oscillator eliminates the associated 11.5 MHz noise feedthrough into the switch. With the oscillator disabled, the logic interface pins (IN1 to IN4) still control the switch.

The [ADGM1004](#) comes with a standard LVTTTL parallel interface consisting of four input pins, IN1 to IN4. The logic level applied to the IN1 through IN4 inputs controls the state of the MEMS switches.

Table 2. (EXTD_EN) Link Position

Position	Reference Clock Setting
Low (default)	Built in 11.5 MHz oscillator enable
High	Disables the internal oscillator

(RF1), (RF2), (RF3), and (RF4) Mode Mode of Operation

The IN1 to IN4 input pins control the switch state and operation mode of the [ADGM1004](#). The [EVAL-ADGM1004EBZ](#) allows the user to control these pins by using the (RF1) to (RF4) links or by applying external signals to the SMB connectors, IN1 to IN4, respectively (see Table 3).

Table 3. (RF1) to (RF4) Links and IN1 to IN4 SMB Connector Settings

Link Name	Controlled RF Switch	Logic Input	Link Position	RF Switch Status
(RF1)	RF1 to RFC	Header SMB	Off (default setting) On Off	Off On Controlled via the IN1 SMB (low is off, high is on)
(RF2)	RF2 to RFC	Header SMB	Off (default setting) On Off	Off On Controlled via the IN2 SMB (low is off, high is on)
(RF3)	RF3 to RFC	Header SMB	Off (default setting) On Off	Off On Controlled via the IN3 SMB (low is off, high is on)
(RF4)	RF4 to RFC	Header SMB	Off (default setting) On Off	Off On Controlled via the IN4 SMB (low is off, high is on)

MEASURING SWITCH PERFORMANCE

Figure 1 shows the EVAL-ADGM1004EBZ evaluation board of the ADGM1004. Apply a V_{DD} supply to the evaluation board to measure the performance of the switch. The links are set according to the switch under test (see Table 3). After selecting the desired channel and its state, the switch performance data can be collected using a network analyzer. Terminate the RFX edge connectors of unused switch channels into $50\ \Omega$ loads to achieve the full performance of the channel under test.

The EVAL-ADGM1004EBZ, shown in Figure 1, comes with a calibration transmission line, CALIBRATION THRU, on the PCB. This calibration line removes the insertion loss and phase offset of the PCB transmission lines connecting to the switch from the measurement. Figure 2 shows the calibration transmission line and Figure 3 shows its insertion loss and return loss up to 16 GHz. The calibration line is exactly the same length as the distance from any one RFX connector to the RFX pin of the device, plus the distance from the RFC connector to the RFC pin of the device.



Figure 2. EVAL-ADGM1004EBZ Calibration Transmission Line Used for PCB Insertion Loss and Phase Offset Correction

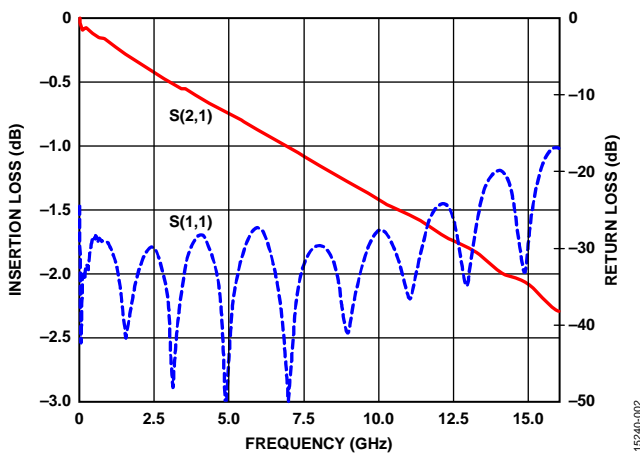


Figure 3. Calibration Transmission Line Insertion Loss and Return Loss

Figure 4 illustrates the calibration line length. All RF traces connecting to the ADGM1004 are of equal length.

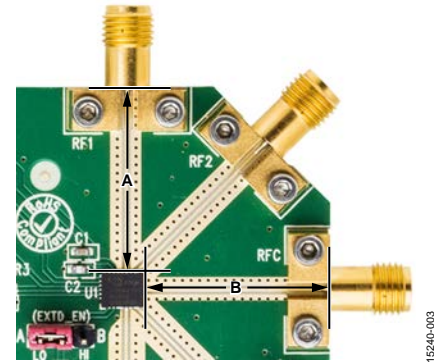


Figure 4. Calibration Transmission Line Length Equal to the $A + B$ Length

To deembed the PCB transmission line insertion loss from the entire switch insertion loss board measurement (the RF1 to RFC path), divide the $S(2,1)$ of measured data by the $|S(2,1)|$ of the CALIBRATION THRU line. Perform this deembedding by using the network analyzer at the time of the measurement or after the measurement using individual measurement data files. Refer to the Network Analyzer Calibration Procedure section for more information.

Use the network analyzer port extension function to deembed the phase offset introduced by the PCB transmission lines. The port extension method uses time delay offset values to correct for phase. Enter the time delays into the port extension menu on the network analyzer corresponding to the phase offset introduced from an RF edge connector to the switch pin. Figure 4 shows an example of these phase offsets on a typical switch measurement, labeled as A and B. Both A and B are identical in length and can be calculated by measuring the time delay of the calibration line and dividing it by two.

Figure 5 shows the ADGM1004 switch insertion loss (network analyzer two-port S(2,1) measurement) measurement results that are deembedded with respect to the PCB transmission line losses. The blue trace is the RF2 to RFC switch channel, and the red trace is the RF1 to RFC switch channel. The dashed traces are the respective return loss traces. The performance of the RF2 switch is identical to the RF3 switch, and the RF1 switch is identical to the RF4 switch.

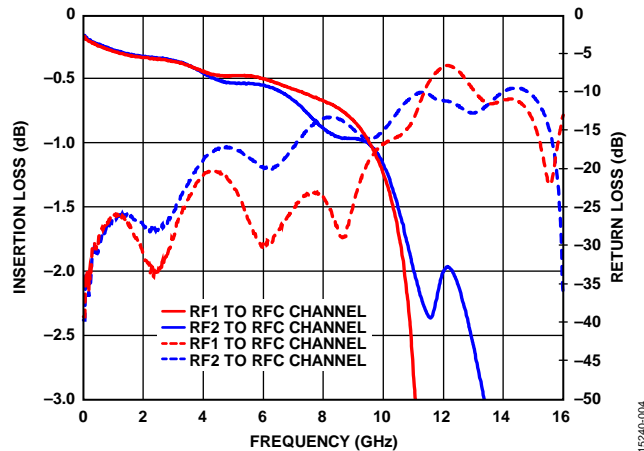


Figure 5. PCB Deembedded ADGM1004 Insertion Loss and Return Loss Performance

Figure 6 shows the ADGM1004 switch off isolation performance measurement results for two channels. The blue trace is the RF2 to RFC switch channel, and the red trace is the RF1 to RFC switch channel. As with insertion loss, the performance of the RF2 switch is identical to the RF3 switch and the RF1 switch is identical to the RF4 switch.

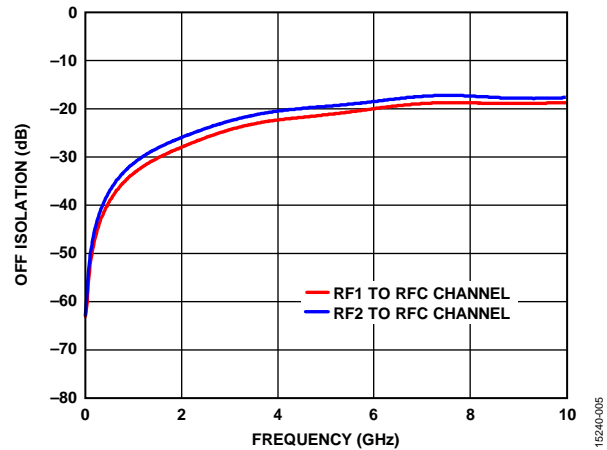


Figure 6. ADGM1004 Off Isolation Performance

NETWORK ANALYZER CALIBRATION PROCEDURE

Use the following procedure in conjunction with the [EVAL-ADGM1004EBZ](#) evaluation board for two-port measurements, assuming the user has a set of manual calibration standards or an electric calibration type unit to perform a short load open through (SLOT) calibration of the network analyzer. The maximum value for the network analyzer frequency sweep for the [EVAL-ADGM1004EBZ](#) PCB can be up to 16 GHz.

1. Perform a full, two-port standard SLOT calibration of the network analyzer.
2. Connect the CALIBRATION THRU calibration line (Connector RF5 and Connector RF6) to the analyzer and measure its insertion loss $S(2,1)$.
3. Save the measured data to the network analyzer memory for later use.
4. Configure the [EVAL-ADGM1004EBZ](#) links and power up the [EVAL-ADGM1004EBZ](#) with a 3.3 V dc power supply.
5. Connect the network analyzer to the desired MEMS switch RF connectors and apply the external control signals, if needed.
6. Measure the complete insertion loss of the [EVAL-ADGM1004EBZ](#). Include the insertion loss of the MEMS switch and test fixture (PCB transmission lines and RF connectors).
7. Deembed the PCB losses from the complete evaluation board measurement using the data saved at Step 3 and the measured data at Step 6. Because the extraction method is dependent on the network analyzer, consult the network analyzer user manual before performing the extraction. Typically, the divide function divides the complete $S(2,1)$ measurement data by the CALIBRATION THRU line $S(2,1)$ data stored in memory.
8. Use the network analyzer port extension function to deembed the phase offset introduced by the PCB transmission lines. The port extension method uses time delay offset values to correct for phase. Enter the time delay values into the port extension menu on the network analyzer for each RF edged connector to switch the pin path equal to the electrical length of the calibration line divided by two.

HANDLING GUIDELINES

Adhere to the following handling guidelines for the evaluation board:

- Always treat the [ADGM1004](#) as a static sensitive device and observe normal handling precautions, including working only on static dissipative surfaces, wearing wrist straps, or other electrostatic discharge (ESD) control devices.
- Take care when connecting signals. Hold the [EVAL-ADGM1004EBZ](#) from the edges to avoid any damage to the device under test (DUT).
- Avoid connecting live signal sources. Ensure that outputs are switched off (preferably grounded) before connecting to the DUT. In addition, ensure all instrumentation shares a common chassis ground.
- Avoid running measurement instruments (for example, digital multimeters (DMMs) in autorange modes). Some instruments can generate large transient compliance voltages when switching ranges.
- Use the highest practical range (that is, lowest resolution) setting for resistance measurements; this minimizes compliance voltages.
- Physically handle the [EVAL-ADGM1004EBZ](#) with care.

EVALUATION BOARD SCHEMATIC AND ARTWORK

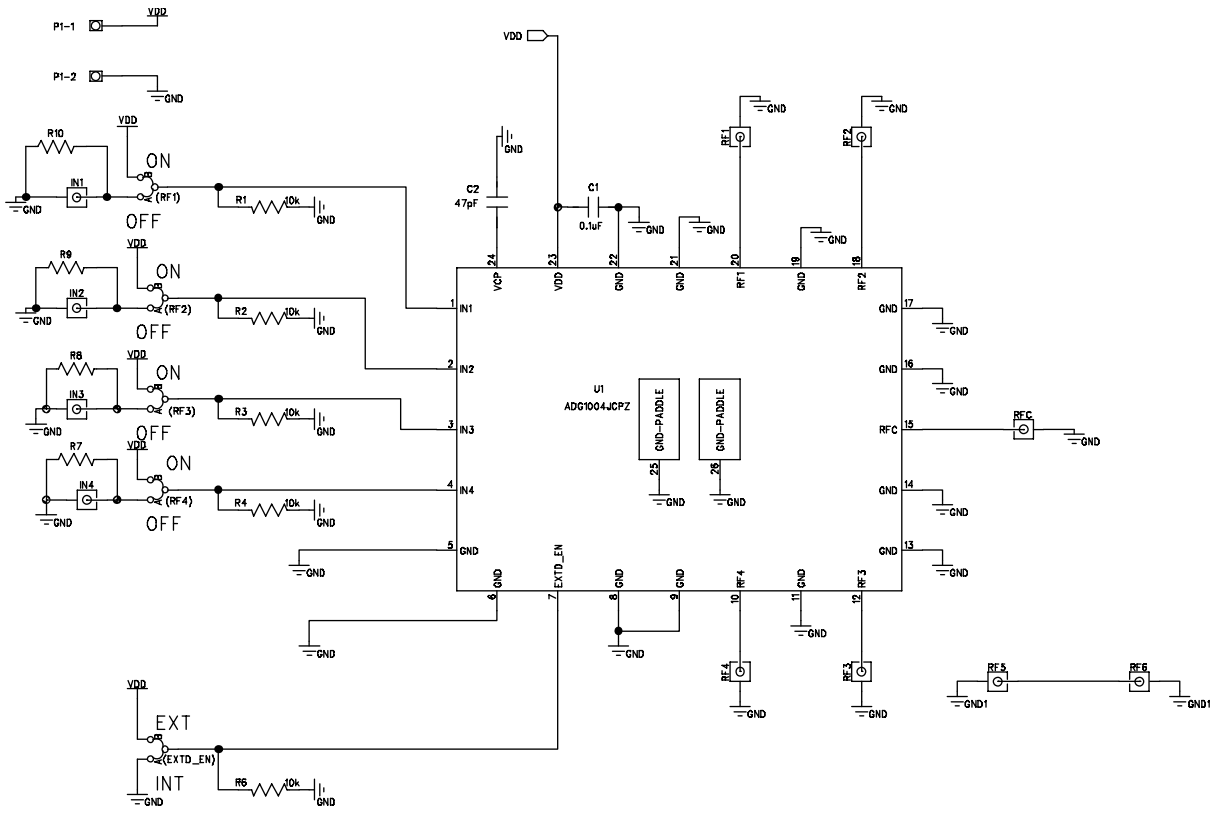


Figure 7. Schematic of the EVAL-ADGM1004EBZ

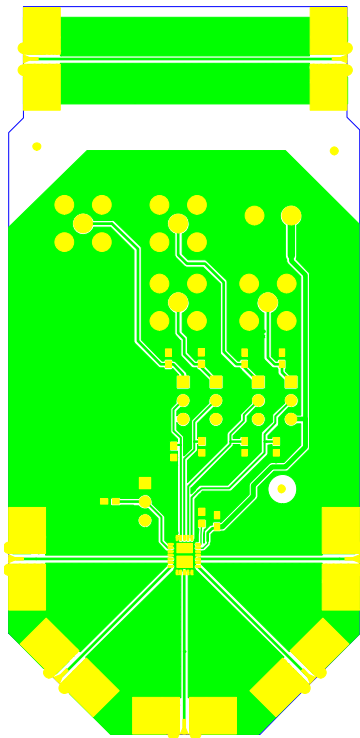


Figure 8. EVAL-ADGM1004EBZ Component Side PCB Drawing (Layer 1)

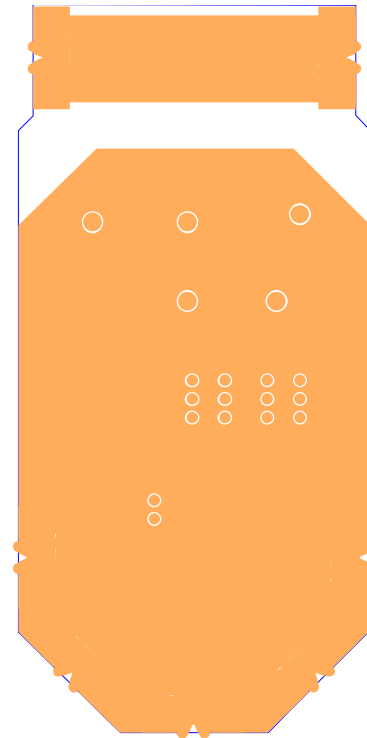


Figure 9. EVAL-ADGM1004EBZ Component Side Ground Plane PCB Drawing (Layer 2)

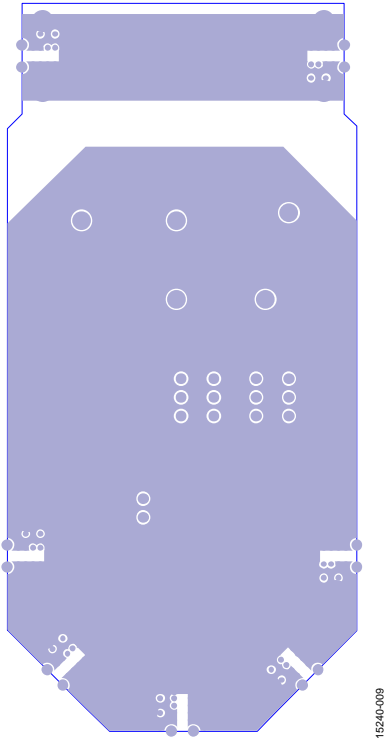


Figure 10. EVAL-ADGM1004EBZ Component Side Ground Plane PCB Drawing (Layer 3)

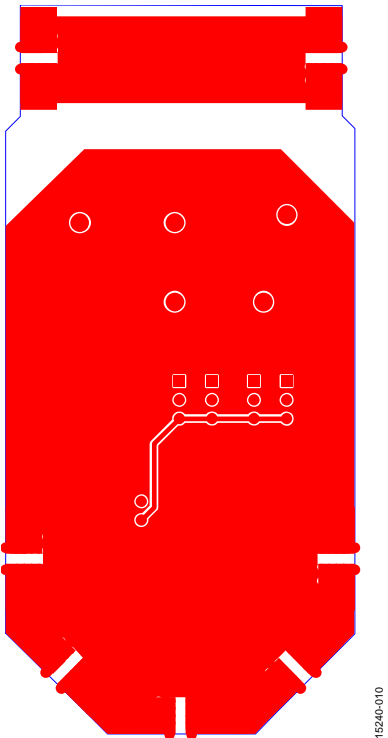


Figure 11. EVAL-ADGM1004EBZ Component Side, Bottom Side PCB Drawing (Layer 4)

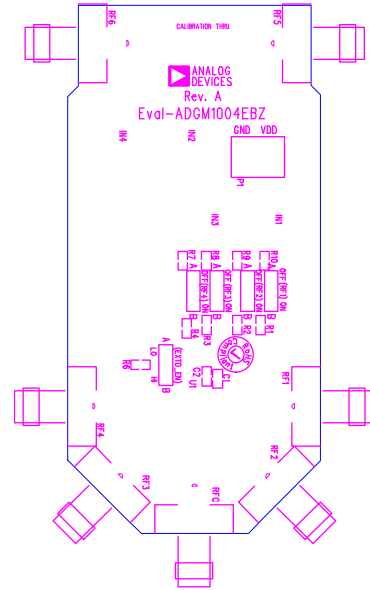


Figure 12. EVAL-ADGM1004EBZ Component Side Silkscreen PCB Drawing (Top)

Metal 1	Finished Copper Plating: 1.5 oz (0.0021 in/53 μ m)
	Rogers RO4003C: 0.008 in laminate, Er 3.38 starting copper weight 0.5 oz/0.5 oz
Metal 2	Copper Weight: 1 oz (0.0014 in/35 μ m)

-0.037 in FR4

Metal 3	Copper Weight: 1 oz (0.0014 in/35 μ m)
	Rogers RO4003C: 0.008 in laminate, Er 3.38 starting copper weight 0.5 oz/0.5 oz
Metal 4	Finished Copper Plating: 1.5 oz (0.0021 in/53 μ m)

CPWG RF trace width: .015 in
 CPWG RF trace to ground gap: .012 in
 Final overall PCB thickness: .062 in
 Final copper plating thickness
 on top and bottom layers: 1.5 oz

Figure 13. EVAL-ADGM1004EBZ PCB Stack Up with Coplanar Waveguide (CPWG) with Ground Dimensions

ORDERING INFORMATION

BILL OF MATERIALS

Table 4.

Reference Designator	Description	Supplier/Number
C1	0.1 μF, 0603 package, 16 V, X7R, SMD ceramic capacitor	FEC 940-6140
C2	47 pF, 0603 package, 100 V, COG/NP0 capacitor	Digi-Key 478-1144-1-ND
IN1 to IN4 (RF1) to (RF4), (EXTD_EN)	50 Ω SMB connector through holes 3-pin SIL headers and shorting links	FEC 111-1349 FEC 102-2248 and FEC 150-411
P1	2-pin terminal blocks (5 mm pitch)	FEC 151-785
R1 to R4, R6	10 kΩ (0603 package) SMD resistors	FEC 933-0399
R7 to R10	Not populated	Not Applicable
RF1 to RF6, RFC	50 Ω side launch 2.92 connectors	Rosenberger 32K243-40ML5
U1	ADGM1004, 0 Hz/dc to 13 GHz, 2.5 kV HBM ESD, SP4T, MEMS switch with integrated driver	Analog Devices
Not applicable ¹	Wideband 50 Ω termination SMA loads	Pasternack PE6081

¹ Screwed on at measurement time (see Figure 1).



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.

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