# 24.0 GHz to 29.5 GHz Antenna On Board

## FEATURES

- RF range: 24.0 GHz to 29.5 GHz
- Surface-mount, single element antenna
- Supports dual and single polarization
- Antenna gain: 5 dBi
- Return loss: 10 dB (ANT_PORT1, single element in 3 × 3 configuration)
- 3.25 mm × 3.25 mm, 12-terminal land grid array (LGA) package

## APPLICATIONS

- 5G mmWave applications
- Broadband communication

## GENERAL DESCRIPTION

The ADMV2228 is a dual-polarized, surface-mount, single-element antenna on board. The ADMV2228 operates between 24.0 GHz and 29.5 GHz and is capable of operating in the 5G New Radio (NR) N257, N258, and N261 frequency bands. The ADMV2228 simplifies antenna array board design by providing the entire element antenna stackup in a surface-mount component that enables the design and assembly of small or large arrays based on the application.

The ADMV2228 has symmetric feeds and radiation patterns for both polarizations, allowing for rotation of the device on the board depending on the feeding scheme.

The ADMV2228 can operate as a single-polarized antenna by leaving the unused polarity pin floating or grounded. Alternatively, it can be assembled at 45°, with respect to the horizontal plane, to be a dual-polarized antenna with slant (±45°) polarization.

For circular polarization, apply a 90° phase shift (introduced by a delay line or any similar mechanism) to the antenna feed ports.

The ADMV2228 comes in a compact, 3.25 mm × 3.25 mm land grid array [LGA] package and operates from a −55°C to +135°C operating $T_C$ range.

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## REVISION HISTORY

**6/2024—Rev. 0 to Rev. A**

Changes to Evaluation Boards....... 13

**1/2024—Revision 0: Initial Version**

## SPECIFICATIONS

$T_C$ (referenced to the topside of device) = 25°C, unless otherwise noted.

*Table 1. Specifications*

| Parameter | Test Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| OPERATING CONDITIONS | | | | | |
| RF Range | | 24.0 | | 29.5 | GHz |
| Operating $T_C$ Range | | −55 | | +135 | °C |
| Antenna Gain | Single element in 3 × 3 passive array configuration | | 5 | | dBi |
| Half-Power Beam Width | | | | | |
| ANT_PORT_1 (Pin 2) | Single element in 3 × 3 passive array configuration | | 60 | | Degrees |
| ANT_PORT_2 (Pin 5) | Single element in 3 × 3 passive array configuration | | 60 | | Degrees |
| Return Loss | | | | | |
| Pin 2 | Single element in 3 × 3 passive array configuration | | 10 | | dB |
| | Single element in 2 × 2 passive array configuration | | 14 | | dB |
| Pin 5 | Single element in 3 × 3 passive array configuration | | 12 | | dB |
| | Single element in 2 × 2 passive array configuration | | 12 | | dB |
| Self Isolation | Single element in 3 × 3 passive array configuration | | 15 | | dB |

## ABSOLUTE MAXIMUM RATINGS

*Table 2. Absolute Maximum Ratings*

| Parameter | Rating |
|---|---|
| RF Input Power, Antenna Ports | 50 dBm[1] |
| Temperature | |
| Operating $T_C$ Range | −55°C to +135°C |
| Storage Range | −65°C to +150°C |
| Lead (Soldering 60 sec) | 260°C |
| Moisture Sensitivity Level (MSL) Rating | MSL3 |

1 Based on dielectric breakdown.

Stresses at or above those listed under Absolute Maximum Ratings may cause permanent damage to the product. This is a stress rating only; functional operation of the product at these or any other conditions above those indicated in the operational section of this specification is not implied. Operation beyond the maximum operating conditions for extended periods may affect product reliability.

## ELECTROSTATIC DISCHARGE (ESD) RATINGS

The following ESD information is provided for handling of ESD-sensitive devices in an ESD-protected area only.

Human body model (HBM) per ANSI/ESDA/JEDEC JS-001.

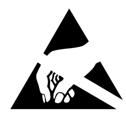
Field induced charged-device model (FICDM) and charged device model (CDM) per ANSI/ESDA/JEDEC JS002.

### ESD Ratings for ADMV2228

*Table 3. ADMV2228, 12-Terminal LGA*

| ESD Model | Withstand Threshold (kV) | Class |
|---|---|---|
| HBM | 2 | 1C |
| FICDM | | |
| RF Pins | 2 | C6 |
| Non-RF Pins | 2 | C6 |

## 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.

## PIN CONFIGURATION AND FUNCTION DESCRIPTION

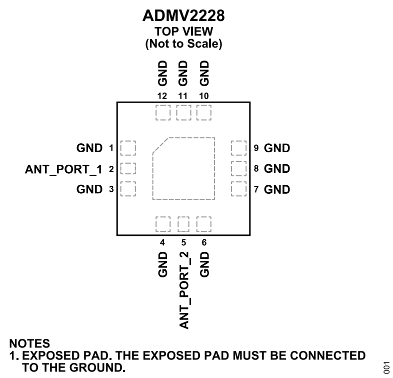



*Figure 1. Pin Configuration*

*Table 4. Pin Function Descriptions*

| Pin No. | Mnemonic | Description |
|---|---|---|
| 1, 3, 4, 6 to 12 | GND | Ground Connections. These pins and the package bottom must be connected to RF ground. |
| 2 | ANT_PORT_1 | Antenna Port 1. |
| 5 | ANT_PORT_2 | Antenna Port 2. |
| | EPAD | Exposed Pad. The exposed pad must be connected to the ground. |

## TYPICAL PERFORMANCE CHARACTERISTICS

$T_C$ (referenced to the topside of the device) = 25°C, unless otherwise noted. CO means antenna copolarization, and CX means antenna crosspolarization.

### MEASUREMENTS COLLECTED WITH 2 × 2 ANTENNA ARRAY EVALUATION BOARD

For further information regarding the passive 2 × 2 antenna array, refer to the Impedance Matching Around Antenna Array with ANSYS HFSS section.

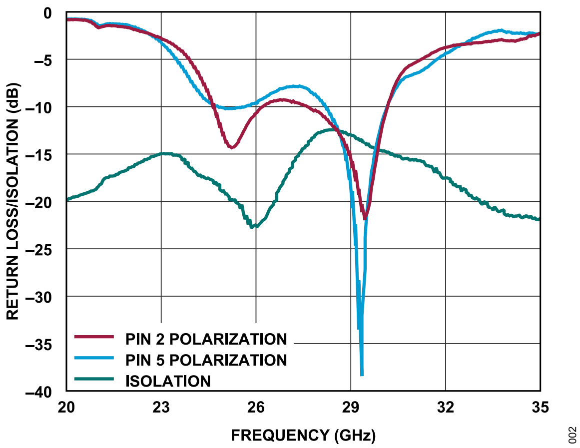



*Figure 2. Return Loss and Isolation for a Passive 2 × 2 Array Configuration*

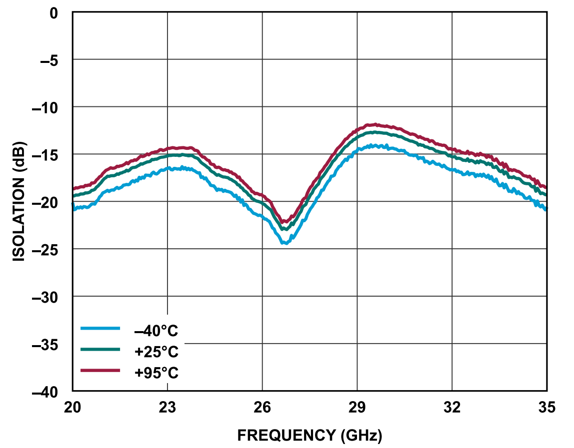



*Figure 4. Isolation Between Pin 2 and Pin 5 vs. Frequency for a Passive 2 × 2 Array Configuration at Various Temperatures*

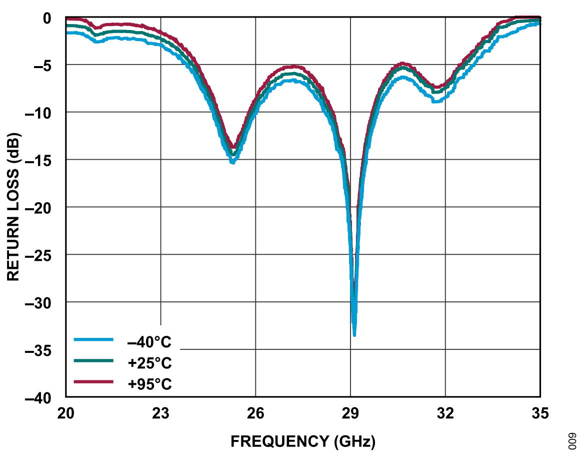



*Figure 3. Pin 5 Return Loss vs. Frequency for a Passive 2 × 2 Array Configuration at Various Temperatures*

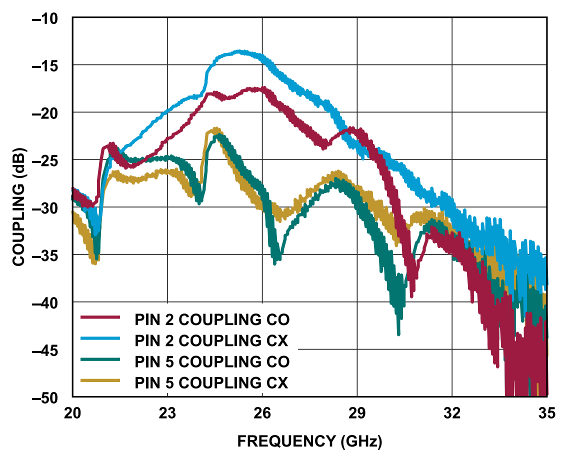



*Figure 5. Coupling vs. Frequency for a Passive 2 × 2 Array Configuration*

## TYPICAL PERFORMANCE CHARACTERISTICS

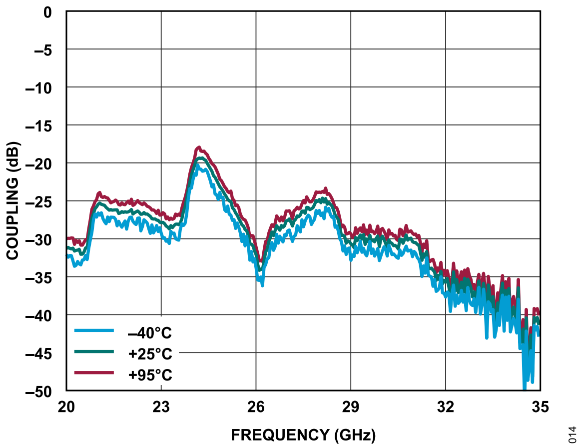



*Figure 6. Pin 2 Coupling Crosspolarization vs. Frequency for a Passive 2 × 2 Array Configuration at Various Temperatures*

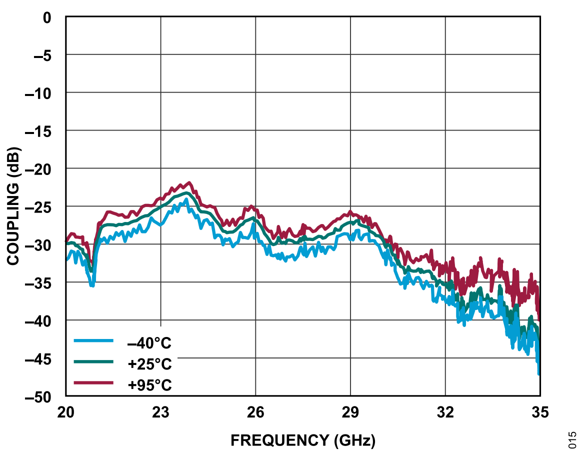



*Figure 7. Pin 5 Coupling Copolarization vs. Frequency for a Passive 2 × 2 Array Configuration at Various Temperatures*

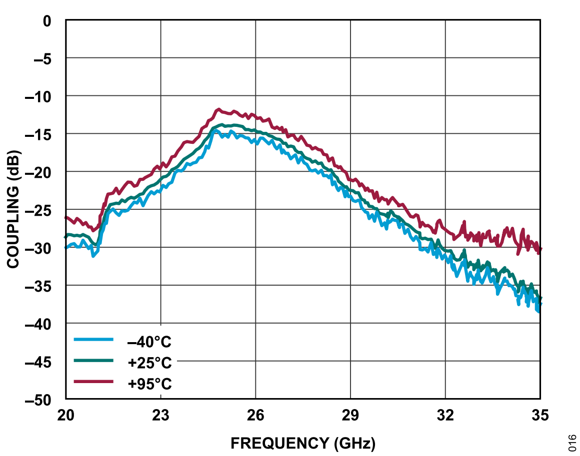



*Figure 8. Pin 2 Coupling Copolarization vs. Frequency for a Passive 2 × 2 Array Configuration at Various Temperatures*

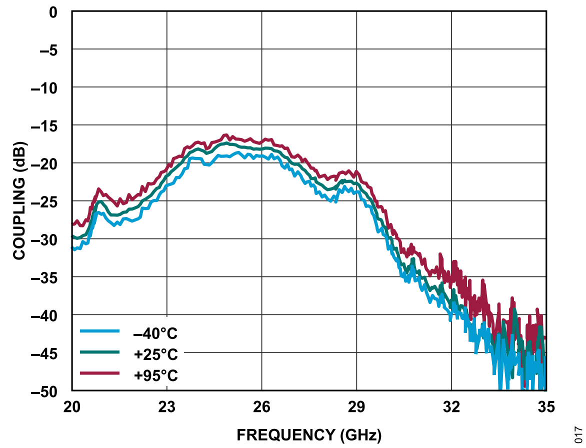



*Figure 9. Pin 5 Coupling Crosspolarization vs. Frequency for a Passive 2 × 2 Array Configuration at Various Temperatures*

## TYPICAL PERFORMANCE CHARACTERISTICS

### MEASUREMENTS COLLECTED WITH 3 × 3 ANTENNA ARRAY EVALUATION BOARD

For further information regarding the passive 3 × 3 antenna array, refer to the Evaluation Board Calibration Guide section.

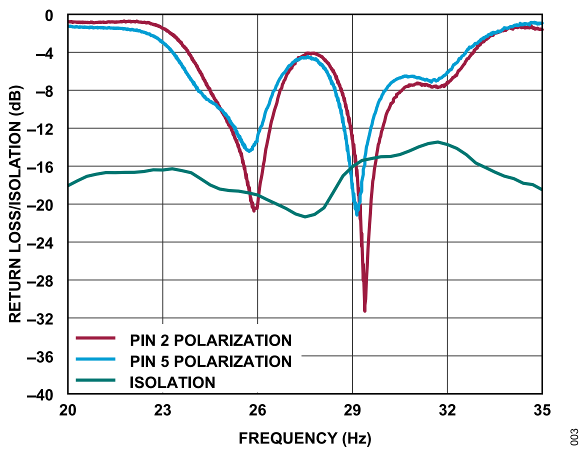



*Figure 10. Return Loss and Isolation for a Passive 3 × 3 Array Configuration*

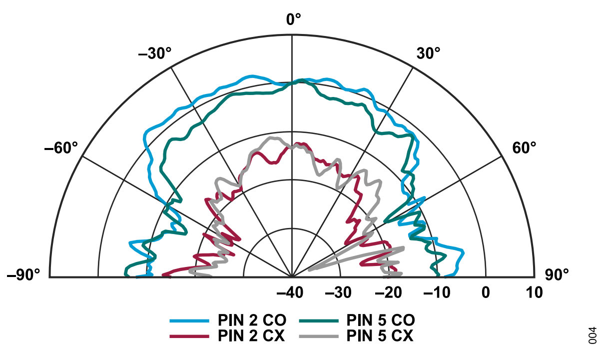



*Figure 11. Normalized Radiation Patterns vs. Mechanical Angle at 24.5 GHz for a Passive 3 × 3 Array Configuration*

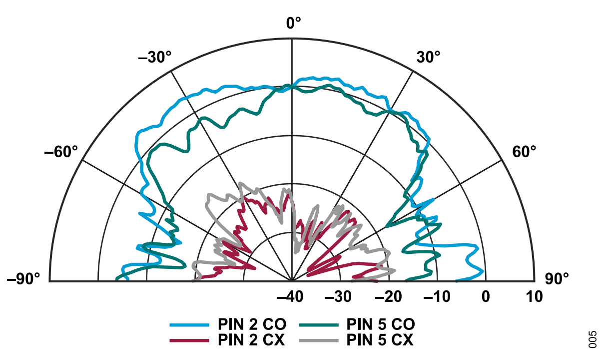



*Figure 12. Normalized Radiation Patterns vs. Mechanical Angle at 26.5 GHz for a Passive 3 × 3 Array Configuration*

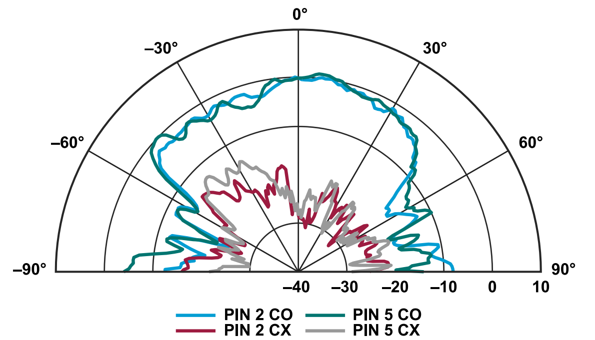



*Figure 13. Normalized Radiation Patterns vs. Mechanical Angle at 28 GHz for a Passive 3 × 3 Array Configuration*

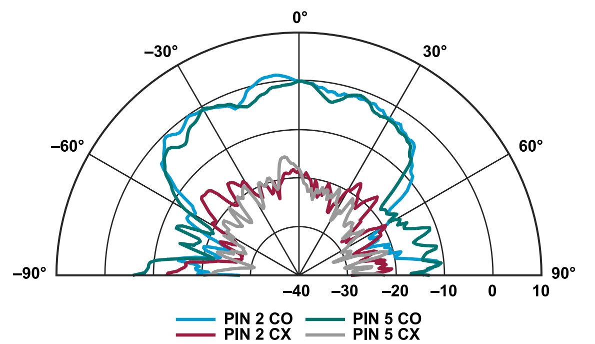



*Figure 14. Normalized Radiation Patterns vs. Mechanical Angle at 29.5 GHz for a Passive 3 × 3 Array Configuration*

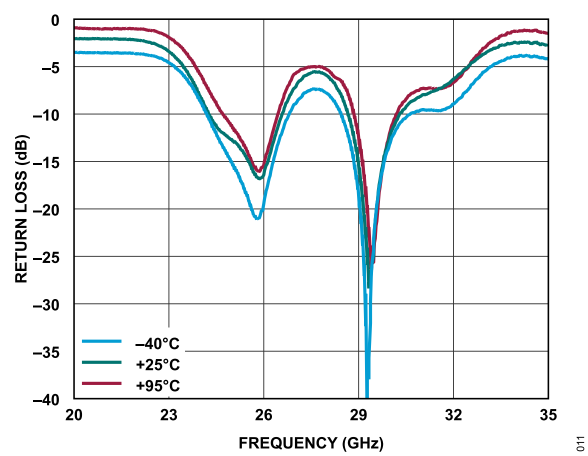



*Figure 15. Pin 2 Return Loss vs. Frequency for a Passive 3 × 3 Array Configuration at Various Temperatures*

## TYPICAL PERFORMANCE CHARACTERISTICS

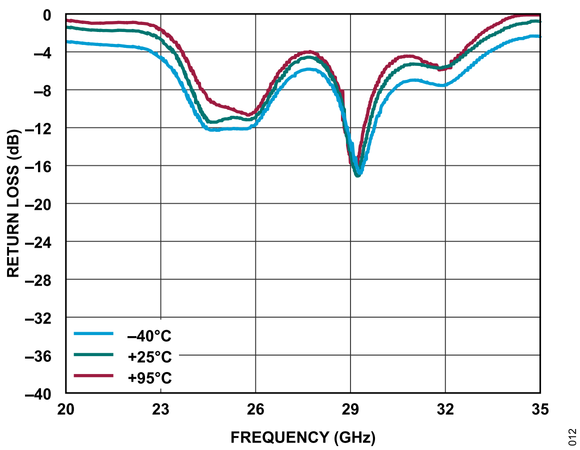



*Figure 16. Pin 5 Return Loss vs. Frequency for a Passive 3 × 3 Array Configuration at Various Temperatures*

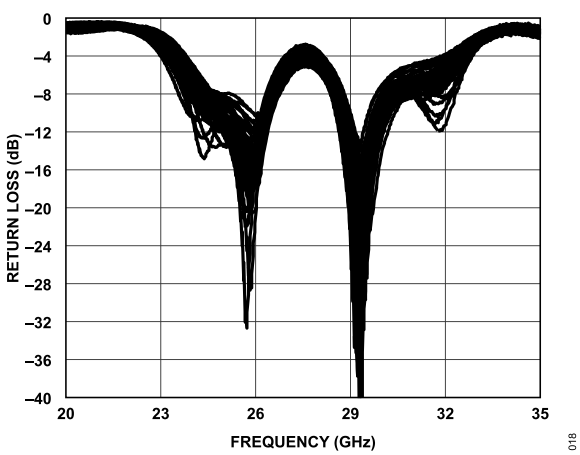



*Figure 17. Distribution of Pin 2 Return Loss vs. Frequency for 50 Passive 3 × 3 Array Boards*

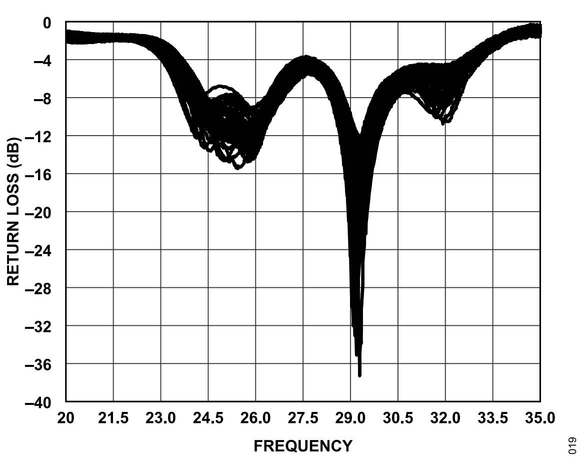



*Figure 18. Distribution of Pin 5 Return Loss vs. Frequency for 50 Passive 3 × 3 Array Boards*

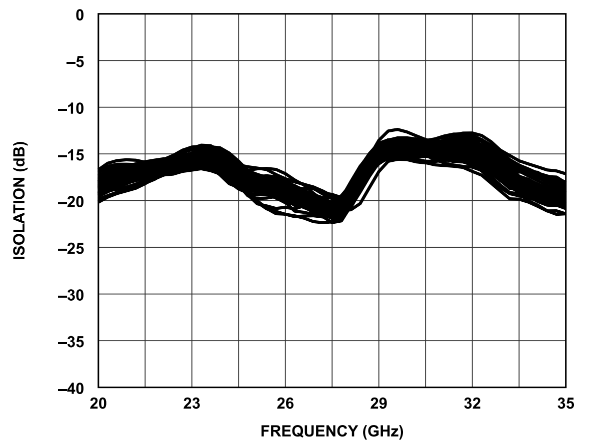



*Figure 19. Distribution of Isolation Between Pin 2 and Pin 5 vs. Frequency for 50 Passive 3 × 3 Array Boards*

## THEORY OF OPERATIONS

The ADMV2228 is a surface-mount antenna with two orthogonal RF antenna ports that operate between 24.0 GHz and 29.5 GHz. The antenna can be used as a dual-polarized antenna by feeding two separate RF traces to either antenna port. Additionally, the ADMV2228 can be used as a single-polarized antenna by grounding or leaving the unused pin as floating. The results in the Measurements Collected with 2 × 2 Antenna Array Evaluation Board section and the Measurements Collected with 3 × 3 Antenna Array Evaluation Board section show the performance of the ADMV2228 in antenna array modules with pitches specifically selected for these array sizes. If the ADMV2228 is used to make an antenna array, parameters (such as the overall return loss, impedance, and coupling) are simulated with the actual selected array pitch to ensure desired performance. The active return loss of the array is determined for proper matching of the antenna with the driving device. If the antenna array is driven with one of the Analog Devices, Inc., 5G beamformers, the load-pull and noise-figure contours of the respective driving device is referenced for proper transformation of the antenna impedance to those beamformer pins. Likewise, the antenna gain depends on the selected array pitch, so the user must not use the gain provided in Table 1 for different array configurations.

# APPLICATIONS INFORMATION

## EVALUATION BOARD CALIBRATION GUIDE

The 3 × 3 antenna array evaluation board uses a thru-reflect-line (TRL) calibration structure to de-embed the cable, trace, and board losses leading up to the central radiating antenna on the board.

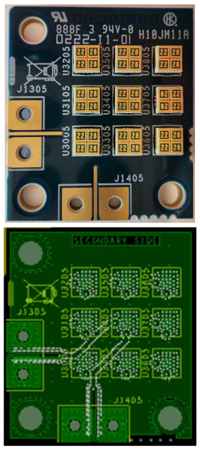



*Figure 20. 3 × 3 Passive Antenna Array of Pitch 5.25 mm in Both X-Axis and Y-Axis with a Central Radiating Antenna and Surrounding Antennas Acting as Parasitic Elements*

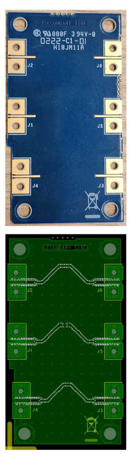


*Figure 21. TRL Calibration Structure Used for Calibrating 3 × 3 Antenna Array Evaluation Board (See Figure 20)*

TRL calibration is used for de-embedding S-parameter data and allows for the measurement of the ADMV2228 while minimizing loss. The top ports (J2 and J6) are the delay line, the middle ports (J1 and J5) are the shorts, and the bottom two ports (J3 and J4) are the thru line. The delay line has a known delay of 7.0541 ps.

It is recommended to use a network analyzer to set up a 2-port calibration profile based on the preceding information to measure the performance of the ADMV2228. Once the network analyzer is calibrated, the two calibrated cables can be used with the 3 × 3 antenna array evaluation board to measure the antenna return loss. This process can differ based on the test equipment manufacturer. Contact mmWave5G@analog.com for additional information.

## RECOMMENDED LAND PATTERN

Solder the exposed ground pads on the underside of the ADMV2228 to a low electrical impedance ground plane. These pads are soldered to an exposed opening in the solder mask on the evaluation board that is connected to a ground via. For more information, refer to the Gerber files provided with the ADMV2228-EVALZ evaluation board.

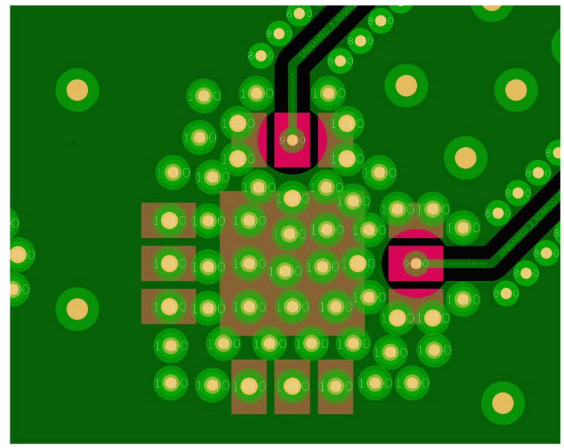


*Figure 22. Evaluation Board Layout for the LGA Package (Not to Scale)*

## ROUTING

Careful attention must be given to how the traces to the antenna ports, Pin 2 and Pin 5, are routed. The antenna traces are routed as striplines and utilize via fencing to maximize isolation between the individual antenna ports. The antenna traces connect to the antenna ports on a designated RF plane through a via.

In small arrays, like 2 × 2 and 2 × 4, RF traces that are well shielded from one another can be routed as coplanar waveguides.

## APPLICATIONS INFORMATION

### USING THE ADMV2228 AS A SINGLE POLE

The ADMV2228 can be used as a single polarized antenna. Figure 23 shows the ADMV2228 with one active antenna pin, and the other pin shorted to ground.

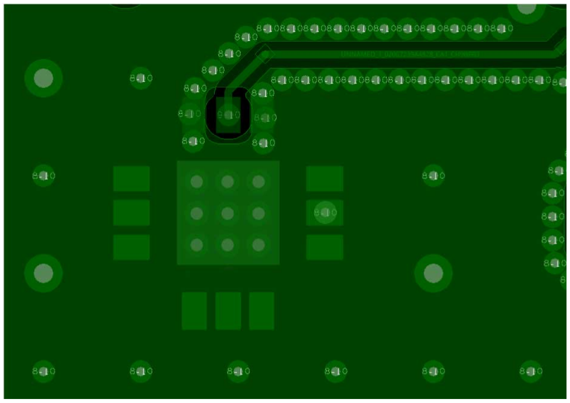


*Figure 23. Evaluation Board Layout for the LGA Package Used as a Single-Pole Antenna (Additional RF Port is Shorted to a Ground Plane with a Via)*

### IMPEDANCE MATCHING AROUND ANTENNA ARRAY WITH ANSYS HFSS

An ANSYS HFSS model for matching the ADMV2228 to the surrounding environment and application is included on the product page and in ANSYS HFSS starting with Version 241. The HFSS model was used to model and simulate the 3 × 3 antenna array evaluation board to ensure desired performance. Instructions for manually importing the antenna model into HFSS can be found in the **README** file and **.PDF** tutorial provided on the product page. Contact mmWave5G@analog.com for additional information.

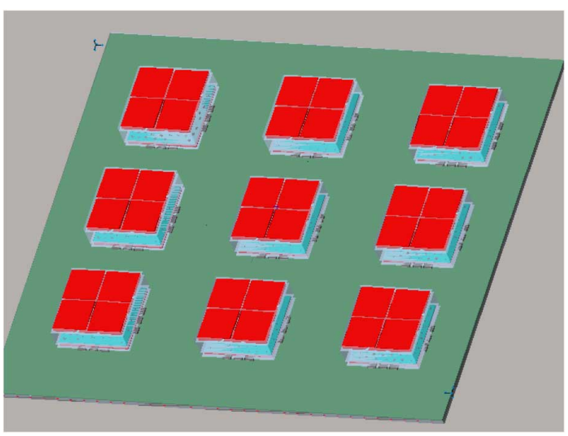


*Figure 24. ANSYS HFSS Model of the 3 × 3 Evaluation Board Shown in Figure 20*

The return loss for Pin 2 and Pin 5 of the central antenna in the modeled evaluation board was simulated and compared to the measured results from a manufactured evaluation board shown in Figure 20.

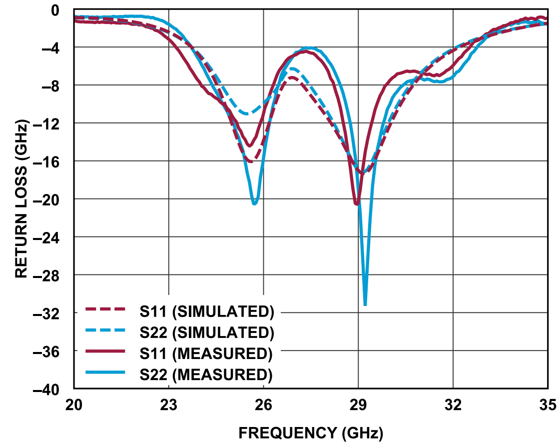



*Figure 25. Simulated vs. Measured Pin 2 and Pin 5 Return Losses for the 3 × 3 Passive Antenna Array Evaluation Board*

As with other antennas, the return loss from an individual ADMV2228 antenna varies based on its surrounding environment. This variance is demonstrated in the measurements collected with a 2 × 2 and 3 × 3 antenna array of the ADMV2228 antennas. The effect of the 2 × 2 antenna array with a pitch of 5.25 mm in both the x-axis and y-axis with all antennas dual fed vs. 3 × 3 antenna array with central antenna-only dual fed can be simulated using the HFSS model.

Return loss gathered from individual antennas in the 2 × 2 antenna array is better than that of the 3 × 3 antenna array. The 3 × 3 antenna array utilizes a single antenna surrounded by eight dummy antennas that serve to provide the central radiating antenna with a known impedance to demonstrate how the ADMV2228 operates in an antenna array application.

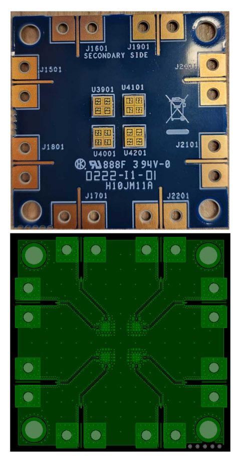


*Figure 26. 2 × 2 Passive Antenna Array of Pitch 5.25 mm in Both X-Axis and Y-Axis with Individually Measurable Antennas*

## OUTLINE DIMENSIONS

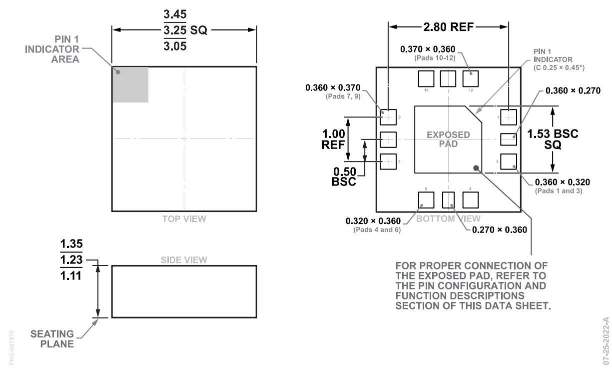



*Figure 27. 12-Terminal Land Grid Array [LGA]*
*(CC-12-8)*
*Dimensions shown in millimeters*

## ORDERING GUIDE

| Model[1] | Temperature Range | Package Description | Packing Quantity | Package Option |
|---|---|---|---|---|
| ADMV2228BCCZ | −40°C to +125°C | LGA/CASON/CH ARRY SO NO LD | | CC-12-8 |
| ADMV2228BCCZ-RL7 | −40°C to +125°C | LGA/CASON/CH ARRY SO NO LD | Reel, 1000 | CC-12-8 |

[1] Z = RoHS Compliant Part.

## EVALUATION BOARDS

| Model[1] | Description |
|---|---|
| ADMV2228P-EVALZ | Passive 3 × 3 Evaluation Board |
| ADMV2228A-EVALZ | Active 4 × 10 Evaluation Board with ADMV1228 |

[1] Z = RoHS Compliant Part.


One Analog Way, Wilmington, MA 01887-2356, U.S.A.