Evaluating the ADRF5700, 2 dB LSB, 5-Bit, Silicon Digital Attenuator, 100 MHz to 22 GHz

FEATURES

- Full featured evaluation board for the ADRF5700
- Simple connection to test equipment
- Through line for calibration

EQUIPMENT NEEDED

- DC power supplies
- Network analyzer

GENERAL DESCRIPTION

The ADRF5700 is a 100 MHz to 22 GHz, 2 dB LSB, 5-bit digital attenuator manufactured in the silicon process.

This user guide describes the ADRF5700-EVALZ evaluation board, which was designed to simply evaluate the features and performance of the ADRF5700. A photograph of the evaluation board is shown in Figure 1.

The ADRF5700 data sheet provides full specifications for the ADRF5700. Consult the ADRF5700 data sheet in conjunction with this user guide when using the ADRF5700-EVALZ.

ADRF5700-EVALZ EVALUATION BOARD PHOTOGRAPH

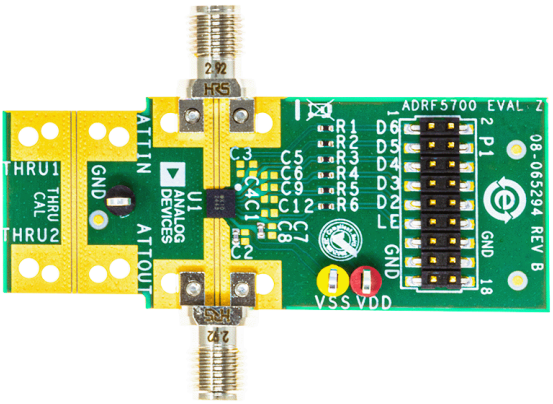

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Figure 1. Evaluation Board Photograph

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REVISION HISTORY

10/2023—Revision 0: Initial Version

EVALUATION BOARD HARDWARE

OVERVIEW

The ADRF5700-EVALZ is a connectorized board, assembled with the ADRF5700 and its application circuitry. All components are placed on the primary side of ADRF5700-EVALZ. An assembly drawing for the ADRF5700-EVALZ is shown in Figure 6 and an evaluation board schematic is shown in Figure 5.

BOARD LAYOUT

The ADRF5700-EVALZ was designed using RF circuit design techniques on a 4-layer printed circuit board (PCB). The PCB stack up is shown in Figure 2.

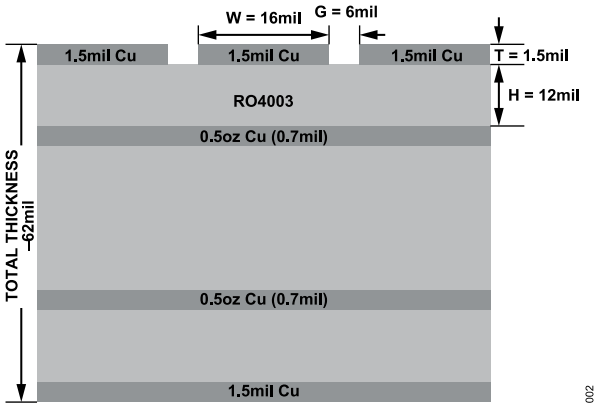

Figure 2. Evaluation Board Stack Up

The outer copper layers are 1.5 mil thick and the inner layers are 0.7 mil thick.

The top dielectric material is 12 mil Rogers 4003, which provides 50 Ω controlled impedance and optimizes the high-frequency performance. All RF traces are routed on the top layer, and the second layer is used as the ground plane for RF transmission lines. The remaining two layers are also ground planes filled with FR4 material to manage the thermal rise during high-power operations and are supported with dense and filled vias to the PCB bottom for thermal relief. The overall board thickness is approximately 62 mil for mechanical strength.

The RF transmission lines are designed using a coplanar waveguide (CPWG) model with a width of 16 mil and ground spacing of 6 mil to have a characteristic impedance of 50 Ω. Ground via fences are arranged on both sides of a CPWG to improve isolation between nearby RF lines and other signal lines.

The exposed ground pad of the ADRF5700, which is soldered on the PCB ground pad, is the main thermal conduit for heat dissipation. The PCB ground pad is densely populated with filled, through vias to provide the lowest possible thermal resistance path from the top to the bottom of the PCB. The connections from the package ground leads to ground are kept as short as possible.

POWER SUPPLY AND CONTROL INPUTS

The ADRF5700-EVALZ has two power supply inputs, six control inputs, and a ground, as shown in Table 1. The DC test points are populated on VDD, VSS, LE, D2, D3, D4, D5, D6, and GND. A 3.3 V supply is connected to the DC test point on VDD and a −3.3 V supply is connected to the DC test point on VSS. Ground reference can be connected to GND. Connect the control inputs, LE, D2, D3, D4, D5, and D6 to 3.3 V or 0 V. The typical total current consumption for the ADRF5700 is 0.87 mA for control inputs = 0 V, and 0.67 mA for control inputs = 3.3 V.

The VDD and VSS supply pins of the ADRF5700 are decoupled with 100 pF capacitors.

Table 1. Power Supply and Control Inputs

Test Points	Description
VDD	+3.3 V supply voltage
VSS	−3.3 V supply voltage
LE	Latch enable input
D2	Parallel control input for 2 dB attenuator bit
D3	Parallel control input for 4 dB attenuator bit
D4	Parallel control input for 8 dB attenuator bit
D5	Parallel control input for the first 16 dB attenuator bit
D6	Parallel control input for the second 16 dB attenuator bit
GND	Ground

RF INPUTS AND OUTPUTS

The ADRF5700-EVALZ has four edge mounted, 2.92 mm connectors for the RF inputs and outputs, as shown in Table 2.

Table 2. RF Inputs and Outputs

2.92 mm Connectors	Description
ATTIN	Attenuator input
ATTOUT	Attenuator output
THRU1	Through line input and output
THRU2	Through line input and output

The through calibration line, connecting the THRU1 and THRU2 RF connectors, calibrates out the board loss effects from the measurements of the ADRF5700-EVALZ to determine the device performance at the pins of the IC. Figure 3 shows the typical board loss for the ADRF5700-EVALZ at room temperature, as well as the embedded and deembedded insertion loss for the ADRF5700.

EVALUATION BOARD HARDWARE

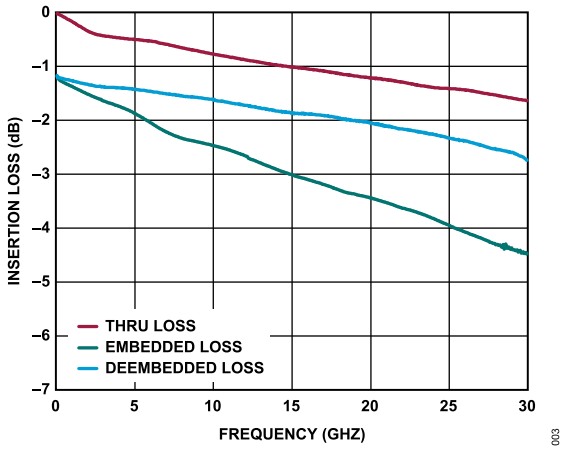

Figure 3. Insertion Loss vs. Frequency

TEST PROCEDURE

BIASING SEQUENCE

To bias up the ADRF5700-EVALZ, perform the following steps:

1. Ground the GND test point.
2. Bias up the VDD test point.
3. Bias up the VSS test point
4. Bias up the LE, D2, D3, D4, D5, and D6 test points.
5. Apply an RF input signal.

The ADRF5700-EVALZ is shipped fully assembled and tested. Figure 4 provides a basic test setup diagram to evaluate the S-parameters using a network analyzer. Perform the following steps to complete the test setup and to verify the operation of the ADRF5700-EVALZ in direct parallel mode:

1. Connect the GND test point to the ground terminal of the power supply.
2. Connect the VDD test point to the voltage output terminal of the +3.3 V supply.
3. Connect the VSS test point to the voltage output terminal of the −3.3 V supply.
4. Connect the LE, D2, D3, D4, D5, and D6 test points to the voltage output terminal of the 3.3 V supply. The ADRF5700 can be configured to have different attenuation levels by connecting the control test points to 3.3 V or 0 V, as shown in Table 3.
5. Connect a calibrated network analyzer to the ATTIN and ATTOUT 2.92 mm connectors. Sweep the frequency from 100 MHz to 22 GHz and set the power to −10 dBm.

Additional test equipment is needed to fully evaluate the ADRF5700-EVALZ functions and performance.

For third-order intercept point evaluation, use two signal generators and a spectrum analyzer. A high isolation power combiner is also recommended.

For power compression and power handling evaluations, use a 2-channel power meter and a signal generator. A high enough power amplifier is also recommended at the input. Test accessories, such as couplers and attenuators, must have enough power handling.

Note that the measurements performed at the 2.92 mm connectors of the ADRF5700-EVALZ include the losses of the 2.92 mm connectors and the PCB. The through line must be measured to calibrate out the effects on the ADRF5700-EVALZ. The through line is the summation of an RF input line and an RF output line that are connected to the ADRF5700-EVALZ and equal in length.

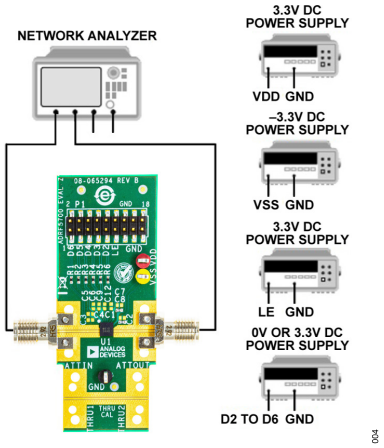

Figure 4. Test Setup Diagram

Table 3. Truth Table

Digital Control Input[1]					
D6[2]	D5[2]	D4	D3	D2	Attenuation State (dB)
Low	Low	Low	Low	Low	0 (reference)
Low	Low	Low	Low	High	2
Low	Low	Low	High	Low	4
Low	Low	High	Low	Low	8
Low	High	Low	Low	Low	16 (D5)
High	Low	Low	Low	Low	16 (D6)
High	High	High	High	High	46

[1] Any combination of the V_{CTRL} input states provides an attenuation equal to the sum of the bits selected.

[2] D5 and D6 both correspond to the 16 dB state. D5 has slightly better state accuracy at higher frequencies.

EVALUATION BOARD SCHEMATIC AND ARTWORK

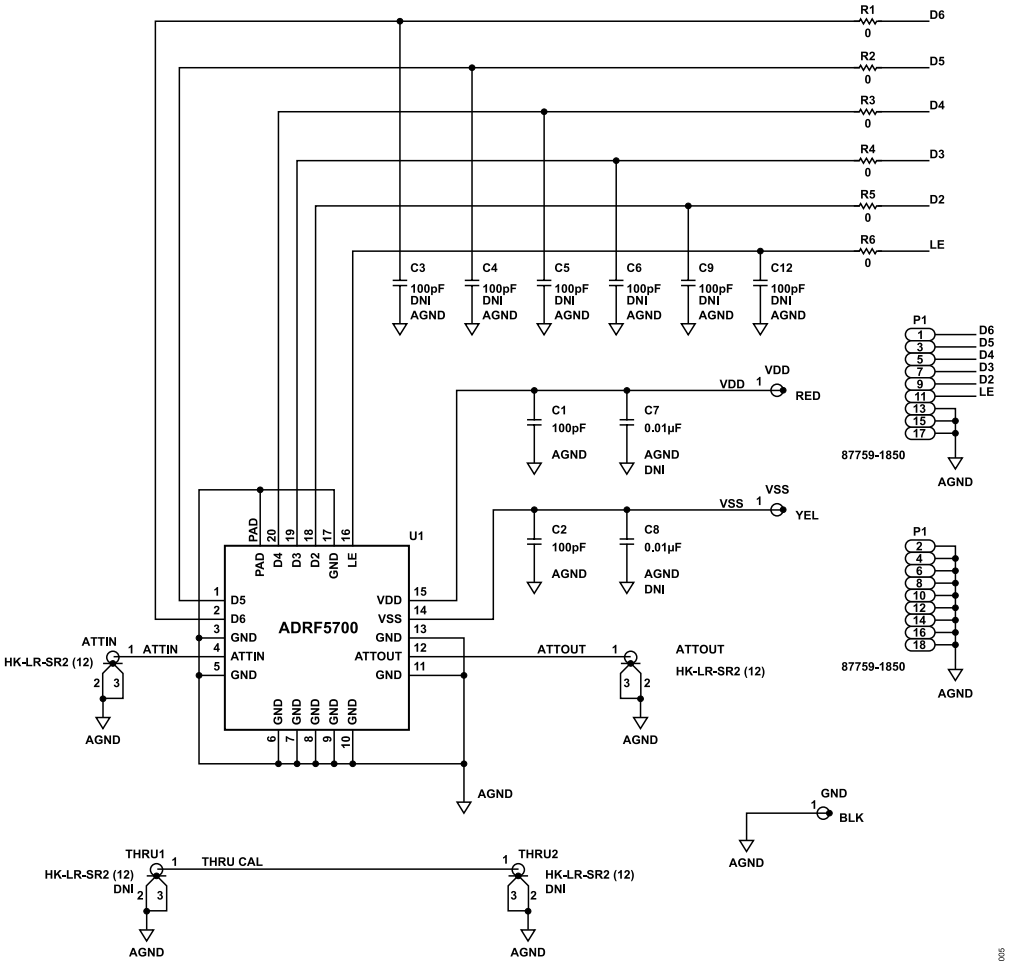

Figure 5. ADRF5700-EVALZ Evaluation Board Schematic

EVALUATION BOARD SCHEMATIC AND ARTWORK

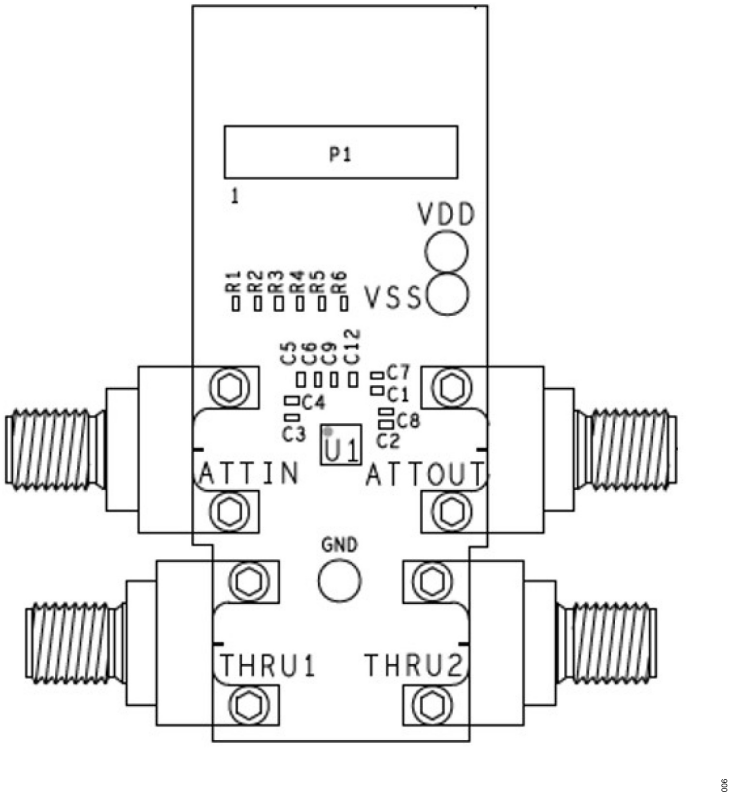

Figure 6. ADRF5700-EVALZ Evaluation Board Assembly Diagram

ORDERING INFORMATION

BILL OF MATERIALS

Table 4. Bill of Materials for the ADRF5700-EVALZ

Quantity	Reference Designator	Description	Manufacturer	Part Number
2	C1, C2	Capacitors, 100 pF, 50 V, C0402 package	Murata	GCM1555C1H101JA16D
6	R1, R2, R3, R4, R5, R6	Resistor, 0 Ω, 0402 package	Yageo	RC0402JR-070RL
2	ATTIN, ATTOUT	Edge mount 2.92 mm connectors	Hirose Electric	HK-LR-SR2(12)
2	THRU1, THRU2	Edge mount 2.92 mm connectors do not insert (DNI)	Hirose Electric	HK-LR-SR2(12)
2	VDD, VSS	Through hole, hold mount test points	Components Corporation	TP-104-01-00
1	P1	18-pin male header, double row	Molex	87759-1850
1	U1	Silicon, 2 dB LSB, 5-bit digital attenuator, 100 MHz to 22 GHz	Analog Devices, Inc.	ADRF5700BCCZN
1	PCB	ADRF5700-EVALZ	Analog Devices	BR-065294

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.