Evaluation Board for the ADF5901, ADF5904, and ADF4159 Chipset for a 24 GHz FMCW Radar

FEATURES
Evaluates the chipset containing the ADF5901 24 GHz Tx MMIC, the ADF5904 24 GHz Rx MMIC, and the ADF4159 13 GHz PLL
Accompanying software controls all functions from a PC

GENERAL DESCRIPTION
The EV-RADAR-MMIC2 evaluation board is designed to evaluate the performance of the ADF5901, a 24 GHz transmitter (Tx) monolithic microwave integrated circuit (MMIC); the ADF5904, a 24 GHz receiver (Rx) MMIC; and the ADF4159, a 13 GHz phase-locked loop (PLL) for a frequency modulated continuous wave (FMCW) radar system. Figure 1 shows the evaluation board, which evaluates the ADF5901, ADF5904, and ADF4159 chipset, six high frequency K type connectors for the two Tx outputs and four Rx inputs, banana connectors for the power supply, and a connector for a system demonstration platform (SDP) serial interface.

EVALUATION KIT CONTENTS
EV-RADAR-MMIC2 evaluation board
EV-ADAR-D2S evaluation board

ADDITIONAL EQUIPMENT
PC running Windows XP or a more recent software version
SDP-S or SDP-B board
Spectrum analyzer
Oscilloscope
5 V power supply
±9 V power supply

DOCUMENTS NEEDED
ADF5901 data sheet
ADF5904 data sheet
ADF4159 data sheet

REQUIRED SOFTWARE
Analog Devices, Inc., EV-RADAR-MMIC

The EV-ADAR-D2S adapter board contains the eight AD8129 differential receiver amplifiers that convert the baseband ADF5904 differential signals to single-ended signals with a 20 dB gain.

The evaluation kit also contains the Analog Devices EV-RADAR-MMIC Software, which is compatible with Windows® XP and later Windows versions to allow easy programming of the device.

The EV-RADAR-MMIC2 evaluation board requires an SDP-S or SDP-B board (not supplied with the kit). The SDP board allows software programming of all the devices.

Full specifications for the ADF5901, ADF5904, and ADF4159 are listed in the ADF5901 data sheet, the ADF5904 data sheet, and the ADF4159 data sheet available from Analog Devices and should be consulted in conjunction with this user guide when using the evaluation board.
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REVISION HISTORY

Updated EV-RADAR-MMIC2 Link, EV-RADAR-MMIC Link,
and EV-ADAR-D2S Link ............................................ Throughout

2/2017—Rev. 0 to Rev. A
Changes to General Description Section .................... 1
  Added Figure 24; Renumbered Sequentially and Figure 25 .... 21
  Added Figure 26 and Figure 27 .................................... 22
  Added Figure 28 ...................................................... 23
  Added Figure 31 ........................................................ 26
  Change to Table 2 .................................................... 27
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12/2015—Revision 0: Initial Version
Figure 1.
QUICK START GUIDE

Follow these steps to evaluate the ADF5901, ADF5904, and ADF4159 devices:

1. Connect the power supply to the EV-RADAR-MMIC2.
   a. Supply 5 V to the VSUPPLY (P3) banana connector.
   b. Connect GND to the GND (P2) banana connector.
2. Connect the power supplies to the EV-ADAR-D2S.
   a. Supply 9 V to the VPOS SMA connector.
   b. Supply −9 V to the VNEG SMA connector.
3. Connect the EV-ADAR-D2S board to the EV-RADAR-MMIC2 evaluation board.
4. Install the EV-RADAR-MMIC software.
5. Connect the SDP motherboard to the PC and to the EV-RADAR-MMIC2.
6. Follow the hardware driver installation procedure that displays after the SDP motherboard connects to the PC.
7. Connect an antenna or a delay cable to the Tx (J9) and Rx (J6) connectors (see Figure 8 and Figure 9).
8. Run the EV-RADAR-MMIC software.
9. Select the EV-RADAR-MMIC2 (the ADF5901, ADF5904, and ADF4159 devices) and the SDP board in the Select Device and Connection tab.
10. Check that SDP board connected appears on the status bar.
11. Click the ADF5904 Controls tab and then click Initialize.
12. Click the ADF4159 Controls tab and then click Write All Registers.
13. Click the ADF5901 Controls tab and then click Initialize ADF5901.
14. Click the Ramps and Shift Keying tab under the ADF4159 Controls tab to enable the ramp and then click Write R0.
15. Measure the output baseband signals on the EV-ADAR-D2S board.
EVALUATION BOARD HARDWARE

The EV-RADAR-MMIC2 evaluation board requires an SDP-S or SDP-B motherboard to program the device. These SDP boards are not included with the evaluation board and must be purchased separately.

POWER SUPPLIES

The EV-RADAR-MMIC2 evaluation board is powered via one external supply of 5 V connected to VSUPPLY as described in the Quick Start Guide section.

The EV-ADAR-D2S board is powered via two external supplies: +9 V connected to VPOS and −9 V connected to VNEG, as described in the Quick Start Guide section.

INPUT SIGNALS

The on-board, 100 MHz temperature compensated crystal oscillator (TCXO) provides the necessary reference signal. Use an external REFIN signal, if desired.

RADIO FREQUENCY (RF) INPUT SIGNALS

The RF input pins on the ADF5904 contain a dc bias voltage and must be ac-coupled to the EV-RADAR-MMIC2 evaluation board. The RF inputs are on the J2 (RX1_RFIN), J3 (RX2_RFIN), J4 (RX3_RFIN), and J6 (RX4_RFIN) SMA connectors.

RF OUTPUT SIGNALS

The Tx outputs from the ADF5901 contain a dc bias voltage and must be ac-coupled. The Tx outputs are available on the J8 (TX_OUT1) and J9 (TX_OUT2) output SMA connectors.

CHANNEL MAPPING

Table 1 shows the pin mapping from the ADF5904 RXx_xx to baseband outputs on the EV-ADAR-D2S evaluation board.

<table>
<thead>
<tr>
<th>EV-RADAR-MMIC2 Connector</th>
<th>ADF5904 Input</th>
<th>EV-ADAR-D2S Connector</th>
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<tbody>
<tr>
<td>J2</td>
<td>RX1_RFIN</td>
<td>O7</td>
</tr>
<tr>
<td>J3</td>
<td>RX2_RFIN</td>
<td>O8</td>
</tr>
<tr>
<td>J4</td>
<td>RX3_RFIN</td>
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<td>J6</td>
<td>RX4_RFIN</td>
<td>O5</td>
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</table>

DEFAULT OPERATION

All components necessary for operation are inserted on the board.
EVALUATION BOARD SOFTWARE

The control software for the EV-RADAR-MMIC2 accompanies the EV-RADAR-MMIC2 on a CD. For the software installation procedure, see the UG-476 user guide, PLL Software Installation Guide.

To run the software, click the EV-RADAR-MMIC2 file on the desktop or in the Start menu.

On the Select Device and Connection tab, select EV-RADAR-MMIC2 (ADF5901, ADF5904, ADF4159) and click Connect. Confirm that SDP connected displays at the bottom left of the window on the status bar (see Figure 2). Otherwise, the software has no connection to the evaluation board.

Note that, when connecting the evaluation board, it takes about 5 sec to 10 sec for the status label to change.

![Figure 2. Select Device and Connection Tab](image)
**ADF5904 CONTROLS**

The ADF5904 Controls tab controls the ADF5904 device settings (see Figure 3).

General options are available for the ADF5904 in this section, including power-up and power-down controls and register readback.

When the device initially powers up, click the **Initialize** button to perform the initialization sequence as described in the ADF5904 data sheet.

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![Figure 3. ADF5904 Controls](image-url)
ADF901 CONTROLS

The ADF901 Controls tab controls the ADF901 device settings (see Figure 4).

Use the RF Settings pane to control the output frequency. Type the desired output frequency, in MHz, in the VCO Frequency field.

To the right of the RF Settings pane, general options are available for the registers of the ADF901, including calibration control and register readback.

When the device initially powers up, click Initialize ADF901 to perform the initialization sequence as described in the ADF901 data sheet.

Following the initialization sequence, the device powers up and all the ADF901 blocks calibrate.

Figure 4. ADF901 Controls
ADF4159 CONTROLS

The ADF4159 Controls tab controls the ADF4159 device settings (see Figure 5).

**ADF4159 Main Controls**

Use the Main Controls tab to select the RF and PLL settings. In the RF Settings pane, set the RF VCO Output Frequency value to half the ADF5901 VCO output. Set the Reference Frequency value to the same frequency as the applied reference signal (TCXO or external signal) as described in the Input Signals section. The phase frequency detector (PFD) frequency is calculated from the reference frequency, the R counter, the reference doubler, and the reference divided by 2. Ensure that the PFD Frequency value matches the value specified in the loop filter design.

In the PLL Settings section, program the Charge Pump Setting to the value designed for the loop.

Program the Phase Detector Polarity to negative when using an inverting active loop filter configuration (use a passive loop filter on the EV-RADAR-MMIC).

Select the signal that is connected to the output of the MUXOUT pin from the Muxout drop down menu.

The register values are shown at the bottom of the window. When the background of a register value is green, it indicates the value changed and must be written to the device. Clicking the button below each register value writes that value to the device.

![Figure 5. Main Controls Tab](image-url)
ADF4159 Ramps and Shift Keying

In the Ramps and Shift Keying tab, configure the ramping functionality of the ADF4159.

Select the ramp type in the Ramp mode drop down menu; the various ramp parameters can be set in the CLK1 spin box and in the Up Ramp pane.

Example of Ramp Setup

Figure 6 shows the ramping settings for a continuous triangular ramp of 1000 up ramp steps over 200 MHz at the ADF5901 Tx output with a ramp time of 5 ms.

For 200 MHz, the PLL is programmed for a 100 MHz ramp because the evaluation board uses the ADF5901 auxiliary output with a 12 GHz output signal. After each parameter is set in the software, each register must be written to the device.

The other options in this tab allow configuration of the various ramps and shift keying controls of the ADF4159.
**EVALUATION AND TEST PROCEDURES**

To evaluate and test the performance of the ADF5901, ADF5904, and ADF4159, use the following procedure:

1. Install the **EV-RADAR-MMIC2** evaluation software.
2. Connect the **EV-ADAR-D2S** board to the **EV-RADAR-MMIC2** evaluation board.
3. Connect the SDP board to the **EV-RADAR-MMIC2**.
4. Connect the dc blocked TX_OUT2 connector (J9) to the spectrum analyzer.
5. Connect the 24.026 GHz, −50 dBm dc blocked signal from the signal source to the RX4_RFIN connector (J6).
6. Run the **EV-RADAR-MMIC** software.
7. Select the SDP board and the **EV-RADAR-MMIC2** (ADF5901, ADF5904, and ADF4159) device in the **Select Device and Connection** tab of the software window.
8. The software is set with default settings for the following setup:
   a. Lock the ADF4159 to 12.0125 GHz (24.025 GHz on the ADF5901).
   b. Calibrate the ADF5901 to 24.125 GHz.

9. In the **ADF5904 Controls** tab, click **Initialize** to power up the ADF5904.
10. In the **ADF4159 Controls** tab under the **Main Controls** section, click **Write All Registers** to power up the ADF4159.
11. In the **ADF5901 Controls** tab, click **Initialize ADF5901** to power up and calibrate the ADF5901. See Figure 7 for a typical setup.
12. Measure a 24.025 GHz signal on TX_OUT2 (J9) on the spectrum analyzer.
13. Measure a 1 MHz baseband output signal on the O5 connector on the **EV-ADAR-D2S** board.

![Figure 7. Typical Evaluation Setup](image-url)
For another method to evaluate and test the performance of the ADF5901, ADF5904, and ADF4159, use the following procedure:

1. Install the EV-RADAR-MMIC evaluation software.
2. Connect the EV-ADAR-D2S evaluation board to the EV-RADAR-MMIC2 evaluation board.
3. Connect the SDP board to the EV-RADAR-MMIC2.
4. Connect the dc blocked TX_OUT2 (J9) connector to a delay cable or antenna.
5. Connect a delay cable or antenna to RX4_RFIN (J6) connector.
6. Run the EV-RADAR-MMIC software.
7. Select the SDP board and the EV-RADAR-MMIC2 (ADF5901, ADF5904, and ADF4159) device in the Select Device and Connection tab of the software window.

8. The software is set with default conditions for the following setup:
   a. Lock the ADF4159 to 12.0125 GHz (24.025 GHz on ADF5901).
   b. Calibrate the ADF5901 to 24.125 GHz.
   c. Generate a 5 ms, 200 MHz triangular ramp (24.025 GHz to 24.225 GHz).
9. In the ADF5904 Controls tab, click Initialize to power up the ADF5904.
10. In the ADF4159 Controls tab under the Main Controls section, click Write All Registers to power up the ADF4159.
11. In the ADF5901 Controls tab, click Initialize ADF5901 to power up and calibrate the ADF5901. See Figure 8 and Figure 9 for the typical setups.
12. In the ADF4159 Ramps and Shift Keying tab, enable the ramp and click Write R0 to enable the ramping of the ADF5901 Tx outputs.
13. Measure the baseband output signal on the O5 connector on the EV-ADAR-D2S board.
Figure 8. Typical Evaluation Setup with Cables
Figure 9. Typical Evaluation Setup with Antenna
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# ORDERING INFORMATION

## BILL OF MATERIALS

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<thead>
<tr>
<th>Qty</th>
<th>Reference Designator</th>
<th>Description</th>
<th>Manufacturer</th>
<th>Part Number</th>
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Table 3. EV-ADAR-D2S Board

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<th>Manufacturer</th>
<th>Part Number</th>
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<td>U2 to U8</td>
<td>10 pF capacitors</td>
<td>AVX</td>
<td>04025A100DAT2A</td>
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<td>270 MHz differential amplifiers</td>
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<td>AD8130ARZ</td>
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<td>80-pin socket connector</td>
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</table>

**LEGAL TERMS AND CONDITIONS**

By using the evaluation board discussed herein (together with any tools, components documentation or support materials, the “Evaluation Board”), you are agreeing to be bound by the terms and conditions set forth below (“Agreement”) unless you have purchased the Evaluation Board, in which case the Analog Devices Standard Terms and Conditions of Sale shall govern. Do not use the Evaluation Board until you have read and agreed to the Agreement. Your use of the Evaluation Board shall signify your acceptance of the Agreement. This Agreement is made by and between you (“Customer”) and Analog Devices, Inc. (“ADI”), with its principal place of business at One Technology Way, Norwood, MA 02062, USA. Subject to the terms and conditions of the Agreement, ADI hereby grants to Customer a free, limited, personal, temporary, non-exclusive, non-sublicensable, non-transferable license to use the Evaluation Board for EVALUATION PURPOSES ONLY. Customer understands and agrees that the Evaluation Board is provided for the sole and exclusive purpose referenced above, and agrees not to use the Evaluation Board for any other purpose. Furthermore, the license granted is expressly made subject to the following additional limitations: Customer shall not (i) rent, lease, display, sell, transfer, assign, sublicense, or distribute the Evaluation Board; and (ii) permit any Third Party to access the Evaluation Board. As used herein, the term “Third Party” includes any entity other than ADI, Customer, their employees, affiliates and in-house consultants. The Evaluation Board is NOT sold to Customer; all rights not expressly granted herein, including ownership of the Evaluation Board, are reserved by ADI. CONFIDENTIALITY: This Agreement and the Evaluation Board shall all be considered the confidential and proprietary information of ADI. Customer may not disclose or transfer any portion of the Evaluation Board to any other party for any reason. Upon discontinuation of use of the Evaluation Board or termination of this Agreement, Customer agrees to promptly return the Evaluation Board to ADI. ADDITIONAL RESTRICTIONS: Customer may not disassemble, decompile or reverse engineer chips on the Evaluation Board. Customer shall inform ADI of any occurred damages or any modifications or alterations it makes to the Evaluation Board, including but not limited to soldering or any other activity that affects the material content of the Evaluation Board. Modifications to the Evaluation Board must comply with applicable law, including but not limited to the RoHS Directive. TERMINATION: ADI may terminate this Agreement at any time upon giving written notice to Customer. Customer agrees to return to ADI the Evaluation Board at that time. LIMITATION OF LIABILITY: THE EVALUATION BOARD PROVIDED HEREUNDER IS PROVIDED “AS IS” AND ADI MAKES NO WARRANTIES OR REPRESENTATIONS OF ANY KIND WITH RESPECT TO IT. ADI SPECIFICALLY DISCLAIMS ANY REPRESENTATIONS, ENDORSEMENTS, WARRANTIES, EXPRESS OR IMPLIED, RELATED TO THE EVALUATION BOARD INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTY OF MERCHANTABILITY, TITLE, FITNESS FOR A PARTICULAR PURPOSE OR NONINFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS. IN NO EVENT WILL ADI AND ITS LICENSORS BE LIABLE FOR ANY INCIDENTAL, SPECIAL, INDIRECT, OR CONSEQUENTIAL DAMAGES RESULTING FROM CUSTOMER’S POSSESSION OR USE OF THE EVALUATION BOARD, INCLUDING BUT NOT LIMITED TO LOST PROFITS, DELAY COSTS, LABOR COSTS OR LOSS OF GOODWILL. ADI’S TOTAL LIABILITY FOR ANY AND ALL CAUSES SHALL BE LIMITED TO THE AMOUNT OF ONE HUNDRED US DOLLARS ($100.00). EXPORT: Customer agrees that it will not directly or indirectly export the Evaluation Board to another country, and that it will comply with all applicable United States federal laws and regulations relating to exports. GOVERNING LAW: This Agreement shall be governed by and construed in accordance with the substantive laws of the Commonwealth of Massachusetts (excluding conflict of law rules). Any legal action regarding this Agreement will be heard in the state or federal courts having jurisdiction in Suffolk County, Massachusetts, and Customer hereby submits to the personal jurisdiction and venue of such courts. The United Nations Convention on Contracts for the International Sale of Goods shall not apply to this Agreement and is expressly disclaimed.