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## REVISION HISTORY

### 3/2020—Rev. D to Rev. E

|                                                  |    |
|--------------------------------------------------|----|
| Changes to Figure 16 .....                       | 8  |
| Deleted Figure 38; Renumbered Sequentially ..... | 13 |
| Added Figure 38; Renumbered Sequentially .....   | 13 |
| Changes to Theory of Operation Section .....     | 13 |
| Changes to Table 6 .....                         | 16 |

### 6/2019—Rev. C to Rev. D

|                            |    |
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| Changes to Table 4 .....   | 5  |
| Changes to Figure 11 ..... | 7  |
| Changes to Figure 25 ..... | 10 |

### 1/2019—Rev. B to Rev. C

|                                                |    |
|------------------------------------------------|----|
| Changes to Figure 11 .....                     | 7  |
| Added Figure 16, Renumbered Sequentially ..... | 8  |
| Updated Outline Dimensions .....               | 17 |

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### 9/2018—Rev. A to Rev. B

|                                                 |    |
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| Changes to Return Loss Parameter, Table 2 ..... | 3  |
| Changes to Return Loss Parameter, Table 3 ..... | 4  |
| Changes to Figure 38 .....                      | 14 |

### 11/2017—Rev. 0 to Rev. A

|                                                                                |    |
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| Change to Noise Figure Parameter, Table 1 .....                                | 3  |
| Change to Continuous Power Dissipation ( $P_{DISS}$ ) Parameter, Table 4 ..... | 5  |
| Changes to Figure 11 .....                                                     | 7  |
| Changes to Figure 17 .....                                                     | 8  |
| Changes to Figure 18 and Figure 20 Caption .....                               | 9  |
| Changes to Figure 33 and Figure 34 Caption .....                               | 11 |
| Added Figure 36; Renumbered Sequentially .....                                 | 12 |
| Updated Outline Dimensions .....                                               | 17 |
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### 7/2016—Revision 0: Initial Version

## ELECTRICAL SPECIFICATIONS

### 0.01 GHz TO 3 GHz FREQUENCY RANGE

$T_A = 25^\circ\text{C}$ ,  $V_{DD} = 5\text{ V}$ , and  $I_{DQ} = 65\text{ mA}$ , unless otherwise noted.

Table 1.

| Parameter                         | Symbol    | Min  | Typ  | Max | Unit                 | Test Conditions/Comments                                    |
|-----------------------------------|-----------|------|------|-----|----------------------|-------------------------------------------------------------|
| FREQUENCY RANGE                   |           | 0.01 |      | 3   | GHz                  |                                                             |
| GAIN                              |           | 17.5 | 19.5 |     | dB                   |                                                             |
| Gain Variation Over Temperature   |           |      | 0.01 |     | dB/ $^\circ\text{C}$ |                                                             |
| NOISE FIGURE                      |           |      | 1.1  | 1.6 | dB                   | 0.3 GHz to 3 GHz                                            |
| RETURN LOSS                       |           |      |      |     |                      |                                                             |
| Input                             |           |      | 15   |     | dB                   |                                                             |
| Output                            |           |      | 24   |     | dB                   |                                                             |
| OUTPUT                            |           |      |      |     |                      |                                                             |
| Output Power for 1 dB Compression | P1dB      | 19.0 | 21.0 |     | dBm                  |                                                             |
| Saturated Output Power            | $P_{SAT}$ |      | 22.5 |     | dBm                  |                                                             |
| Output Third-Order Intercept      | IP3       |      | 33   |     | dBm                  |                                                             |
| SUPPLY CURRENT                    | $I_{DQ}$  |      | 65   | 80  | mA                   | Adjust $V_{GG1}$ to achieve $I_{DQ} = 65\text{ mA}$ typical |
| SUPPLY VOLTAGE                    | $V_{DD}$  | 2    | 5    | 6   | V                    |                                                             |

### 3 GHz TO 8 GHz FREQUENCY RANGE

$T_A = 25^\circ\text{C}$ ,  $V_{DD} = 5\text{ V}$ , and  $I_{DQ} = 65\text{ mA}$ , unless otherwise noted.

Table 2.

| Parameter                         | Symbol    | Min  | Typ  | Max | Unit                 | Test Conditions/Comments                                    |
|-----------------------------------|-----------|------|------|-----|----------------------|-------------------------------------------------------------|
| FREQUENCY RANGE                   |           | 3    |      | 8   | GHz                  |                                                             |
| GAIN                              |           | 15.5 | 18   |     | dB                   |                                                             |
| Gain Variation Over Temperature   |           |      | 0.01 |     | dB/ $^\circ\text{C}$ |                                                             |
| NOISE FIGURE                      |           |      | 1.4  | 1.9 | dB                   |                                                             |
| RETURN LOSS                       |           |      |      |     |                      |                                                             |
| Input                             |           |      | 10   |     | dB                   |                                                             |
| Output                            |           |      | 16   |     | dB                   |                                                             |
| OUTPUT                            |           |      |      |     |                      |                                                             |
| Output Power for 1 dB Compression | P1dB      | 18.0 | 21.0 |     | dBm                  |                                                             |
| Saturated Output Power            | $P_{SAT}$ |      | 22.5 |     | dBm                  |                                                             |
| Output Third-Order Intercept      | IP3       |      | 31.5 |     | dBm                  |                                                             |
| SUPPLY CURRENT                    | $I_{DQ}$  |      | 65   | 80  | mA                   | Adjust $V_{GG1}$ to achieve $I_{DQ} = 65\text{ mA}$ typical |
| SUPPLY VOLTAGE                    | $V_{DD}$  | 2    | 5    | 6   | V                    |                                                             |

**8 GHz TO 10 GHz FREQUENCY RANGE**

$T_A = 25^\circ\text{C}$ ,  $V_{DD} = 5\text{ V}$ , and  $I_{DQ} = 65\text{ mA}$ , unless otherwise noted.

**Table 3.**

| Parameter                         | Symbol    | Min  | Typ  | Max | Unit                 | Test Conditions/Comments                                    |
|-----------------------------------|-----------|------|------|-----|----------------------|-------------------------------------------------------------|
| FREQUENCY RANGE                   |           | 8    |      | 10  | GHz                  |                                                             |
| GAIN                              |           | 13   | 16   |     | dB                   |                                                             |
| Gain Variation Over Temperature   |           |      | 0.01 |     | dB/ $^\circ\text{C}$ |                                                             |
| NOISE FIGURE                      |           |      | 1.7  | 2.2 | dB                   |                                                             |
| RETURN LOSS                       |           |      |      |     |                      |                                                             |
| Input                             |           |      | 8    |     | dB                   |                                                             |
| Output                            |           |      | 7    |     | dB                   |                                                             |
| OUTPUT                            |           |      |      |     |                      |                                                             |
| Output Power for 1 dB Compression | P1dB      | 17.5 | 19.5 |     | dBm                  |                                                             |
| Saturated Output Power            | $P_{SAT}$ |      | 21.5 |     | dBm                  |                                                             |
| Output Third-Order Intercept      | IP3       |      | 33   |     | dBm                  |                                                             |
| SUPPLY CURRENT                    | $I_{DQ}$  |      | 65   | 80  | mA                   | Adjust $V_{GG1}$ to achieve $I_{DQ} = 65\text{ mA}$ typical |
| SUPPLY VOLTAGE                    | $V_{DD}$  | 2    | 5    | 6   | V                    |                                                             |

## ABSOLUTE MAXIMUM RATINGS

Table 4.

| Parameter <sup>1</sup>                                                                                                                  | Rating                                          |
|-----------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|
| Drain Bias Voltage ( $V_{DD}$ )                                                                                                         | 7 V dc                                          |
| Radio Frequency (RF) Input Power (RFIN)                                                                                                 | 20 dBm                                          |
| Continuous Power Dissipation ( $P_{DISS}$ , $T = 85^{\circ}\text{C}$<br>(Derate 7.8 mW/ $^{\circ}\text{C}$ above $85^{\circ}\text{C}$ ) | 0.7 W                                           |
| Channel Temperature                                                                                                                     | $175^{\circ}\text{C}$                           |
| Storage Temperature Range                                                                                                               | $-65^{\circ}\text{C}$ to $+150^{\circ}\text{C}$ |
| Operating Temperature Range                                                                                                             | $-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$  |
| Thermal Resistance (Channel to Ground<br>Paddle)                                                                                        | $128.92^{\circ}\text{C/W}$                      |
| Maximum Peak Reflow Temperature (MSL3) <sup>2</sup>                                                                                     | $260^{\circ}\text{C}$                           |
| ESD Sensitivity                                                                                                                         |                                                 |
| Human Body Model (HBM)                                                                                                                  | Class1B Passed<br>500 V                         |

<sup>1</sup> When referring to a single function of a multifunction pin in the parameters, only the portion of the pin name that is relevant to the specification is listed. For the full pin names of multifunction pins, refer to the Pin Configuration and Function Descriptions section.

<sup>2</sup> See the Ordering Guide section for more information.

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.

### 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 DESCRIPTIONS

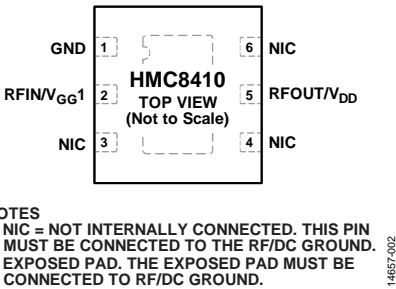


Figure 2. Pin Configuration

Table 5. Pin Function Descriptions

| Pin No. | Mnemonic              | Description                                                                                                                                                                                                                                     |
|---------|-----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1       | GND                   | Ground. This pin must be connected to the RF/dc ground. See Figure 3 for the interface schematic.                                                                                                                                               |
| 2       | RFIN/V <sub>GG1</sub> | RF Input (RFIN). This pin is ac-coupled and matched to 50 Ω. See Figure 4 for the interface schematic.<br>Gate Bias of the Amplifier (V <sub>GG1</sub> ). This pin is ac-coupled and matched to 50 Ω. See Figure 4 for the interface schematic. |
| 3, 4, 6 | NIC                   | Not Internally Connected. This pin must be connected to the RF/dc ground.                                                                                                                                                                       |
| 5       | RFOUT/V <sub>DD</sub> | RF Output (RFOUT). This pin is ac-coupled and matched to 50 Ω. See Figure 5 for the interface schematic.<br>Drain Bias for Amplifier (V <sub>DD</sub> ). This pin is ac-coupled and matched to 50 Ω. See Figure 5 for the interface schematic.  |
|         | EPAD                  | Exposed Pad. The exposed pad must be connected to RF/dc ground.                                                                                                                                                                                 |

INTERFACE SCHEMATICS



Figure 3. GND Interface Schematic

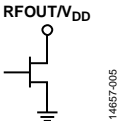


Figure 5. RFOUT/V<sub>DD</sub> Interface Schematic

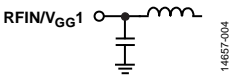


Figure 4. RFIN/V<sub>GG1</sub> Interface Schematic

## TYPICAL PERFORMANCE CHARACTERISTICS

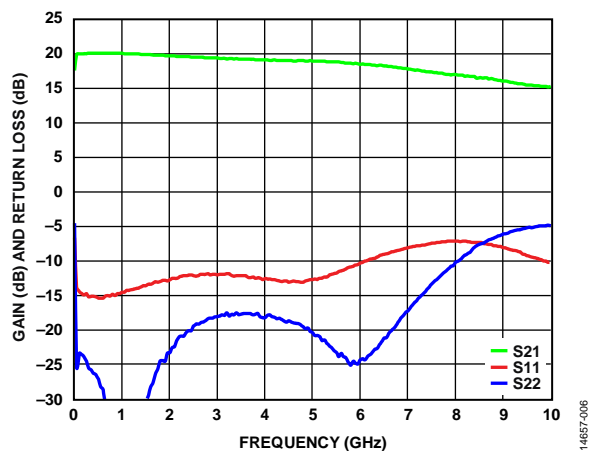


Figure 6. Gain and Return Loss vs. Frequency

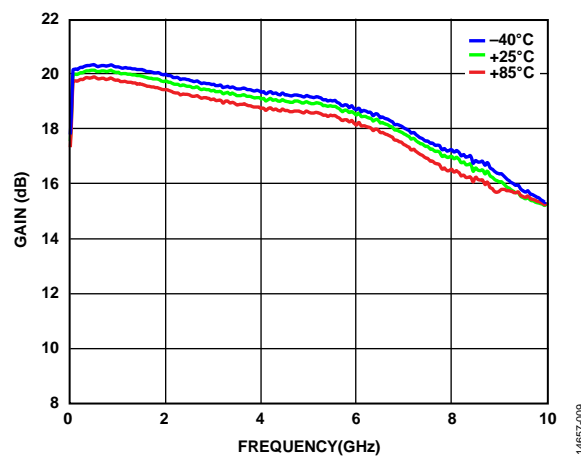


Figure 9. Gain vs. Frequency for Various Temperatures

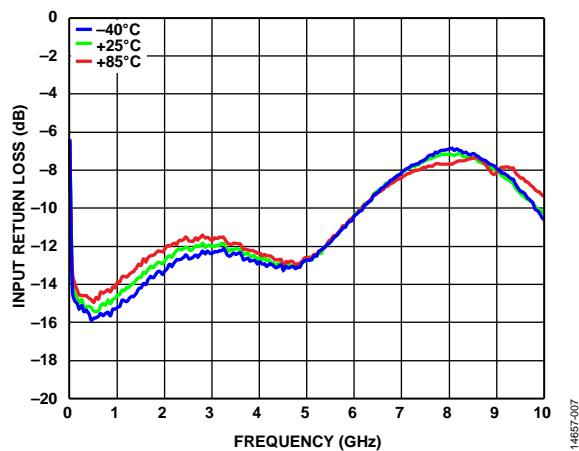


Figure 7. Input Return Loss vs. Frequency for Various Temperatures

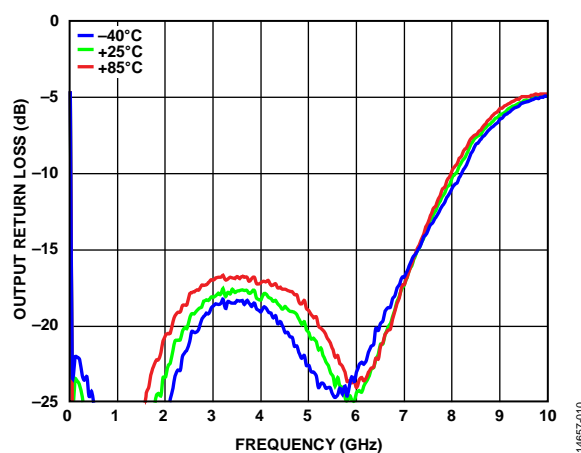


Figure 10. Output Return Loss vs. Frequency for Various Temperatures

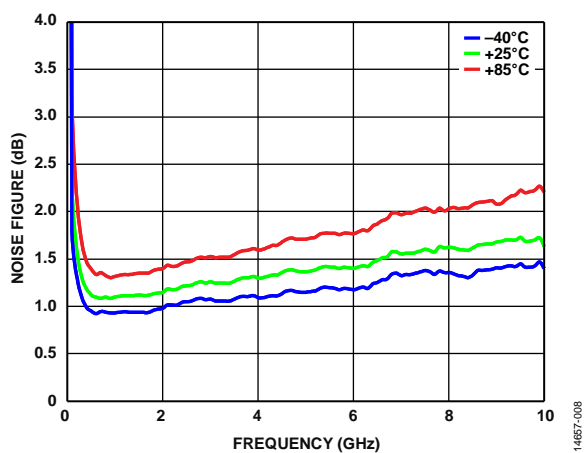


Figure 8. Noise Figure vs. Frequency for Various Temperatures

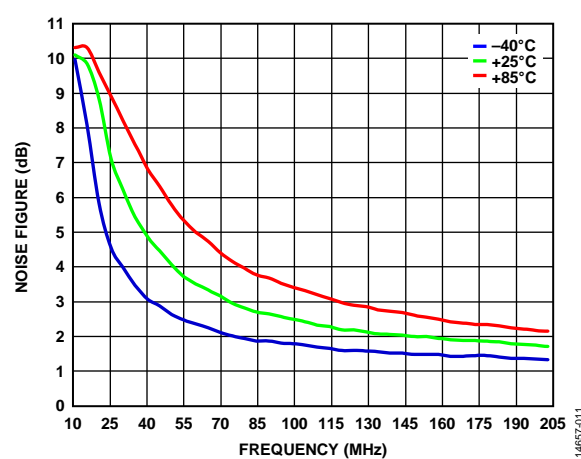


Figure 11. Noise Figure vs. Frequency for Various Temperatures, 10 MHz to 200 MHz

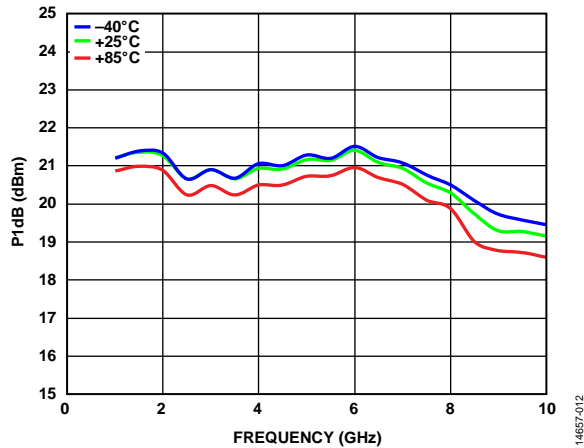


Figure 12. P1dB vs. Frequency for Various Temperatures

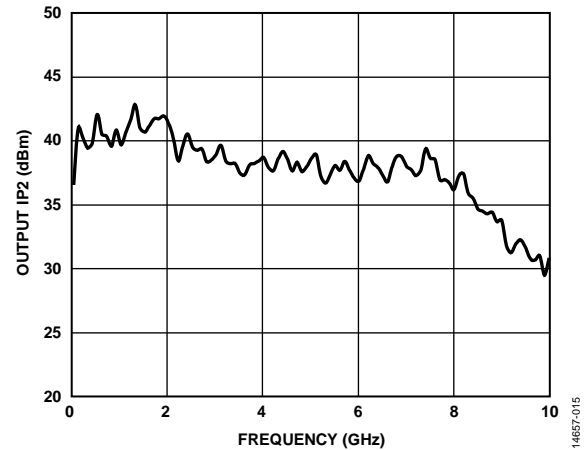
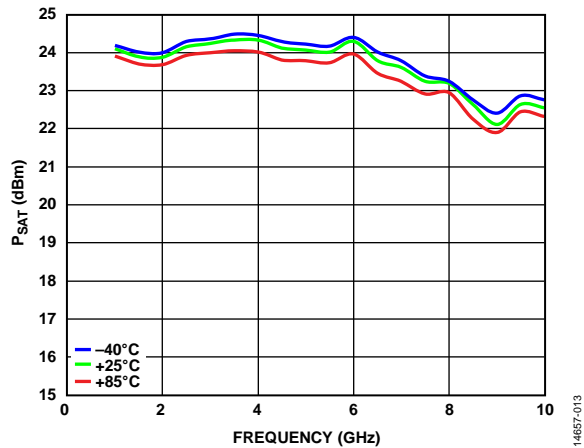
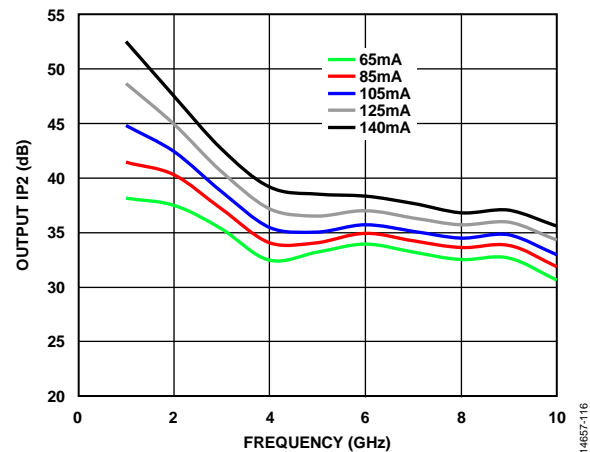
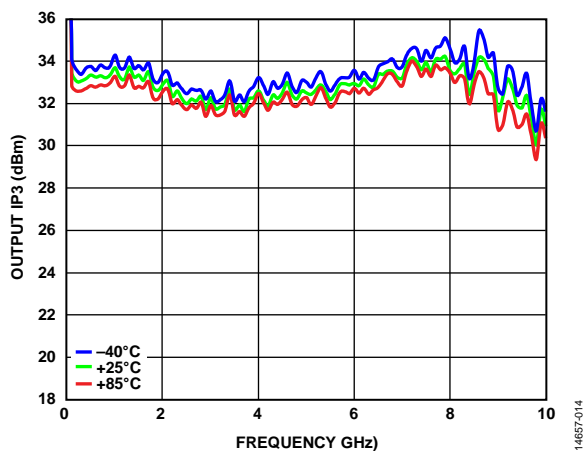
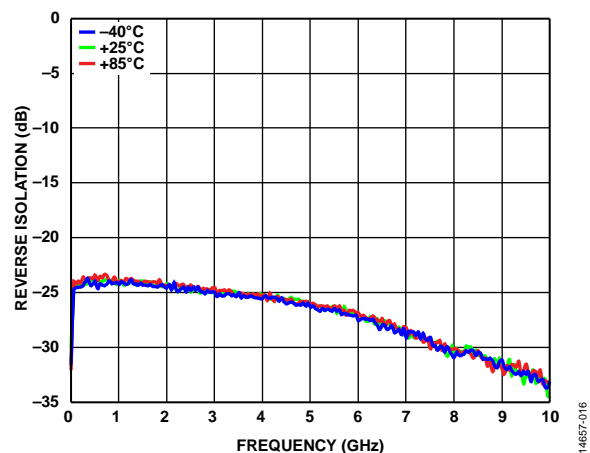
Figure 15. Output IP2 vs. Frequency at  $P_{OUT}/Tone = 5$  dBmFigure 13.  $P_{SAT}$  vs. Frequency for Various TemperaturesFigure 16. Output IP2 vs. Frequency for Various Supply Currents ( $IDQ$ ),  $P_{OUT}/Tone=5$  dBm,  $V_{DD}=5$  VFigure 14. Output IP3 vs. Frequency for Various Temperatures, Output Power ( $P_{OUT}$ )/Tone = 5 dBm

Figure 17. Reverse Isolation vs. Frequency for Various Temperatures

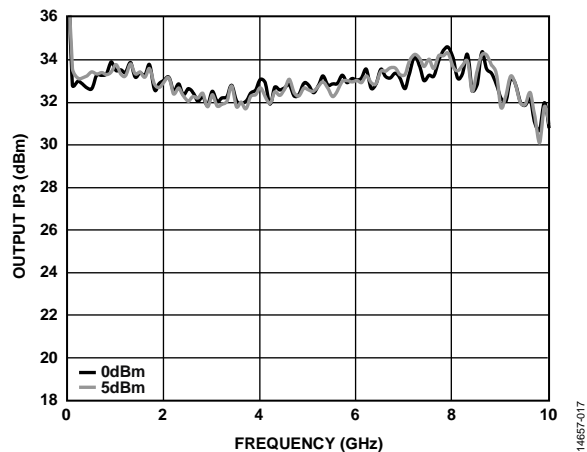
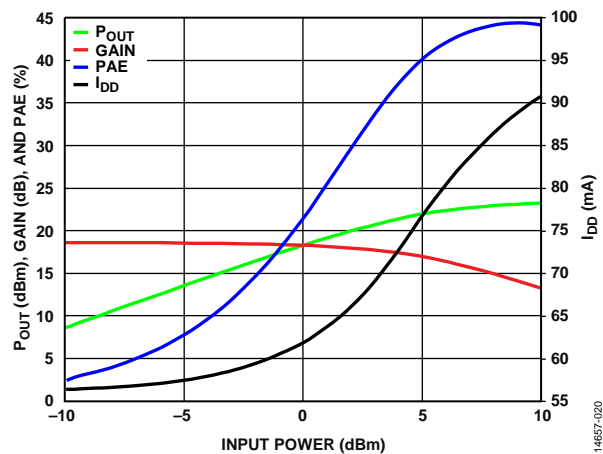
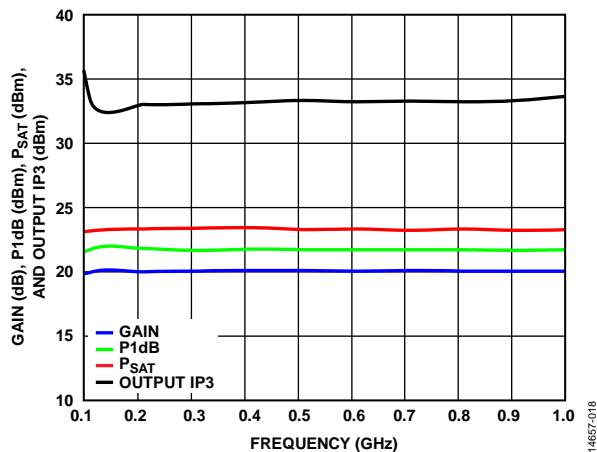
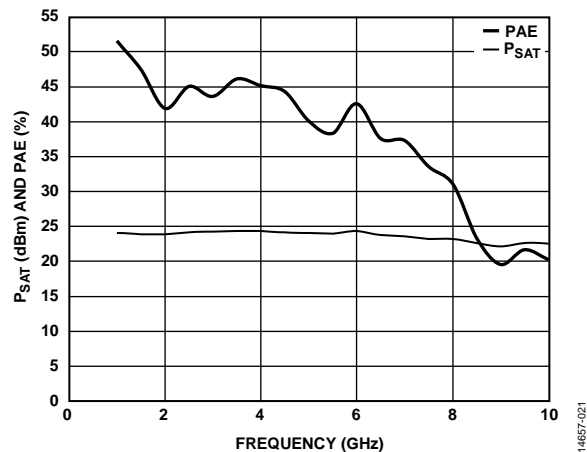
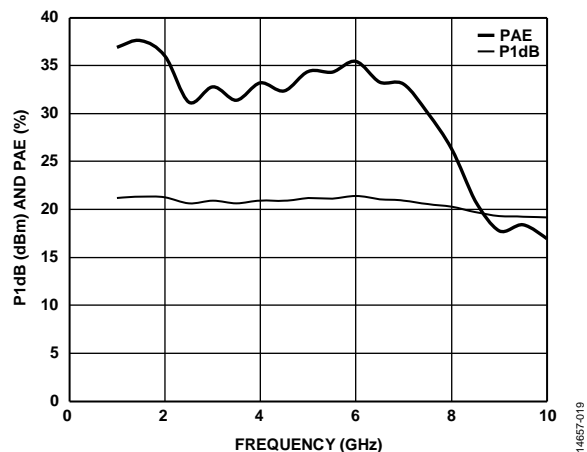
Figure 18. Output IP3 vs. Frequency for Various  $P_{out}$ /ToneFigure 21.  $P_{out}$ , Gain, PAE, and Supply Current with RF Applied ( $I_{DD}$ ) vs. Input Power at 5 GHzFigure 19. Gain, P1dB,  $P_{SAT}$ , and Output IP3 vs. FrequencyFigure 22.  $P_{SAT}$  and PAE vs. Frequency

Figure 20. P1dB and Power Added Efficiency (PAE) vs. Frequency

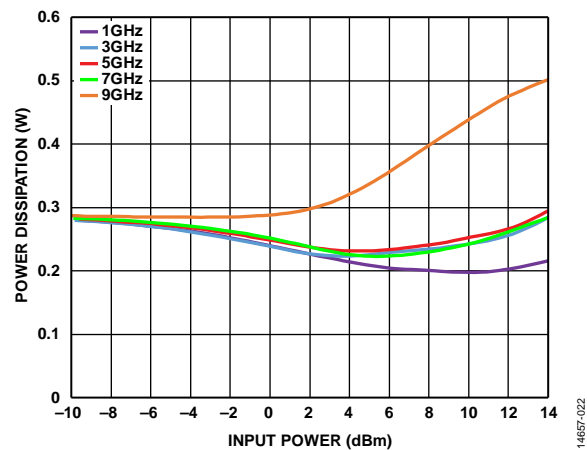
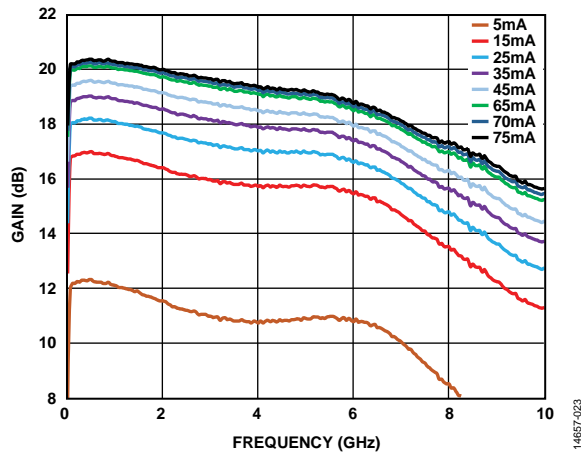
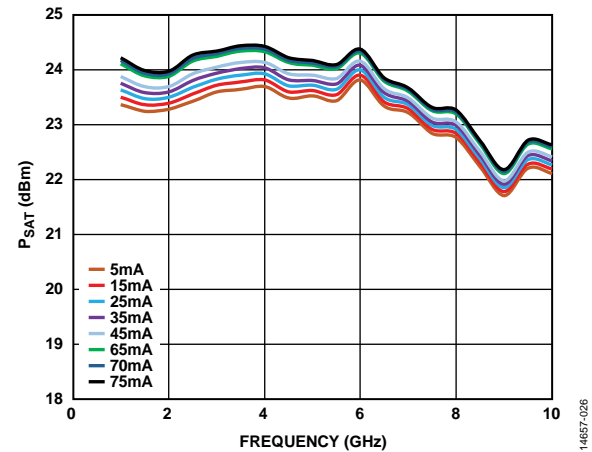
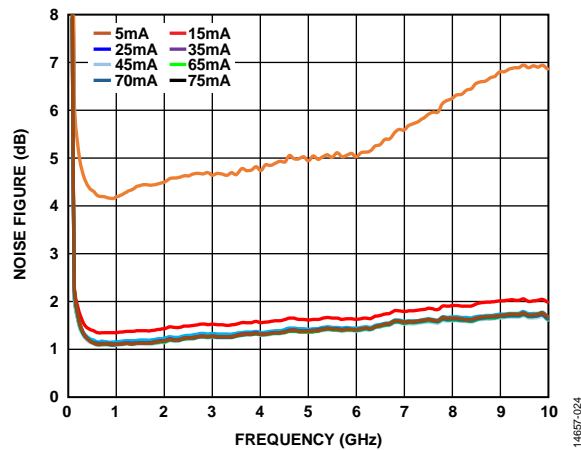
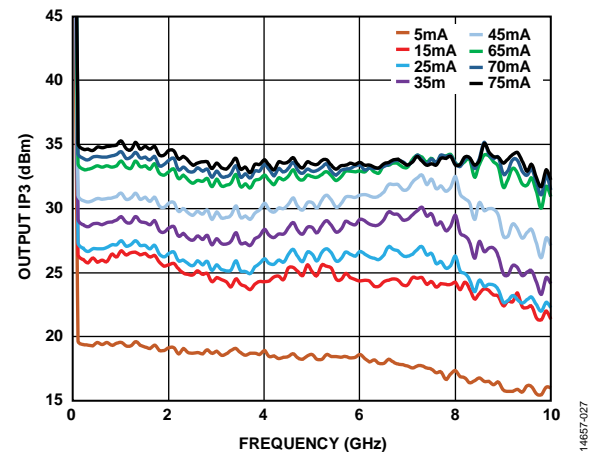
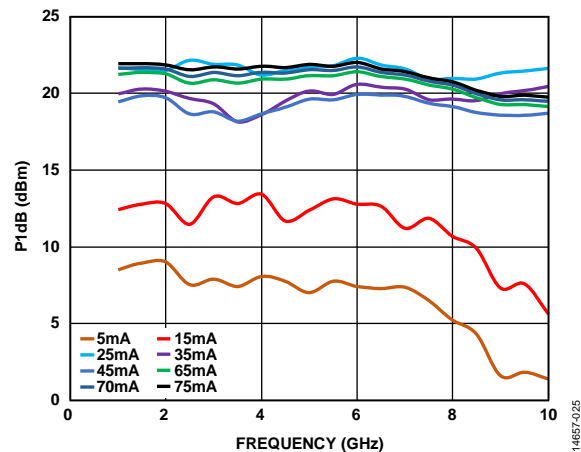
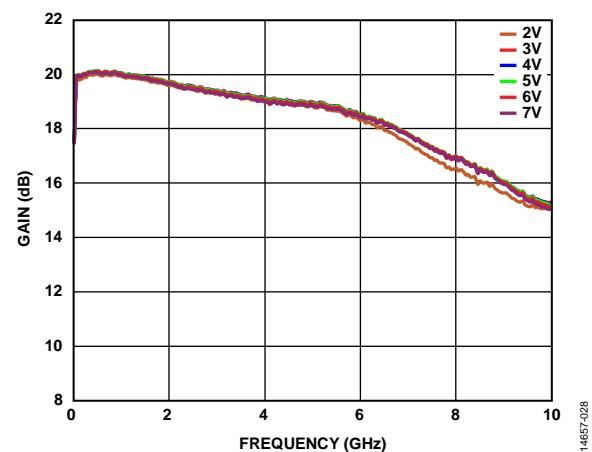


Figure 23. Power Dissipation at 85°C vs. Input Power at Various Frequencies



Figure 24. Gain vs. Frequency for Various Supply Currents,  $V_{DD} = 5\text{ V}$ Figure 27.  $P_{SAT}$  vs. Frequency for Various Supply Currents ( $I_{DD}$ ),  $V_{DD} = 5\text{ V}$ Figure 25. Noise Figure vs. Frequency for Various Supply Currents ( $I_{DD}$ ),  $V_{DD} = 5\text{ V}$ Figure 28. Output  $IP_3$  vs. Frequency for Various Supply Currents ( $I_{DD}$ ),  $P_{OUT}/Tone = 5\text{ dBm}$ ,  $V_{DD} = 5\text{ V}$ Figure 26.  $P_{1dB}$  vs. Frequency for Various Supply Currents ( $I_{DD}$ ),  $V_{DD} = 5\text{ V}$ Figure 29. Gain vs. Frequency for Various Supply Voltages,  $I_{DD} = 65\text{ mA}$

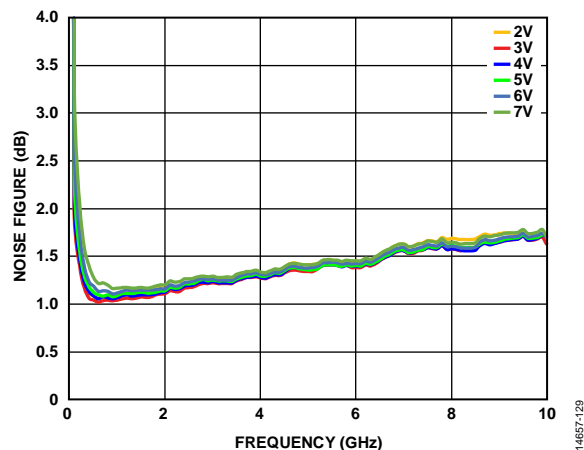


Figure 30. Noise Figure vs. Frequency for Various Supply Voltages,  $I_{DQ} = 65$  mA

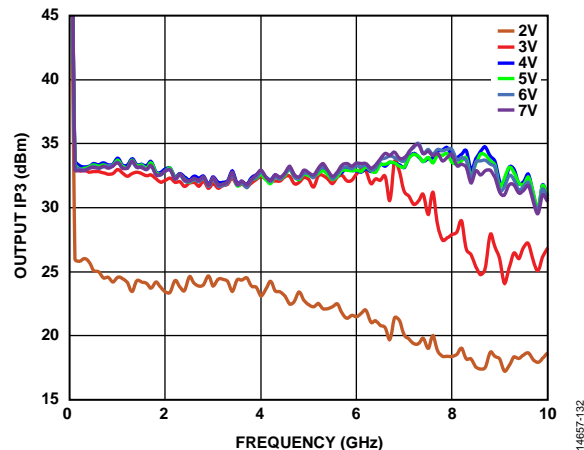


Figure 33. Output IP3 vs. Frequency for Various Supply Voltages,  $P_{OUT}/Tone = 5$  dBm

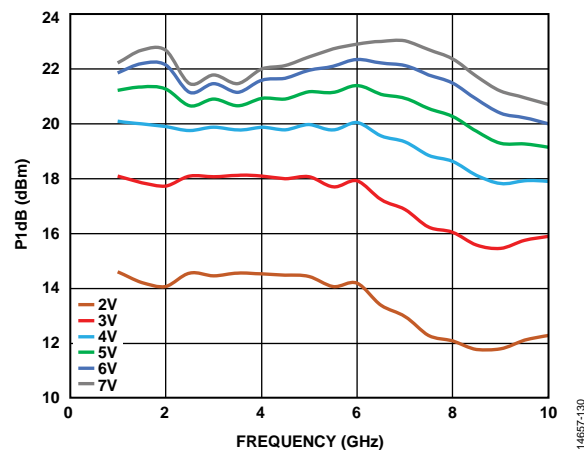


Figure 31. P1dB vs. Frequency for Various Supply Voltages,  $I_{DQ} = 65$  mA

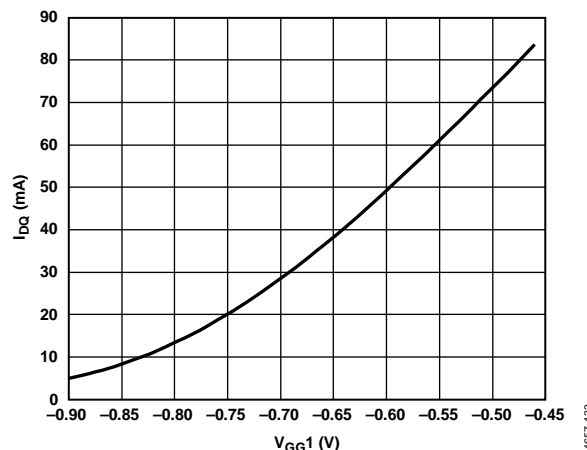


Figure 34. Supply Current ( $I_{DQ}$ ) vs.  $V_{GG1}$ ,  $V_{DD} = 5$  V, Representative of a Typical Device

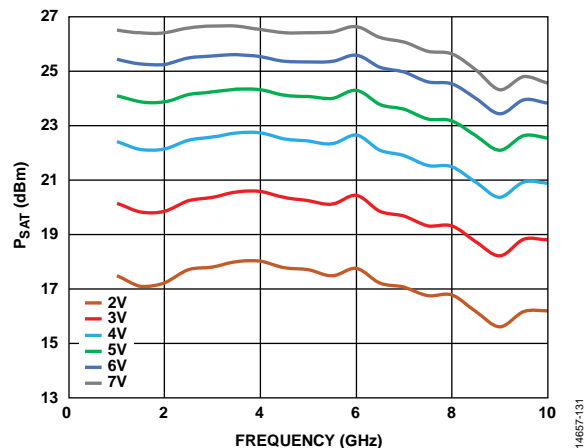


Figure 32.  $P_{SAT}$  vs. Frequency for Various Supply Voltages,  $I_{DQ} = 65$  mA

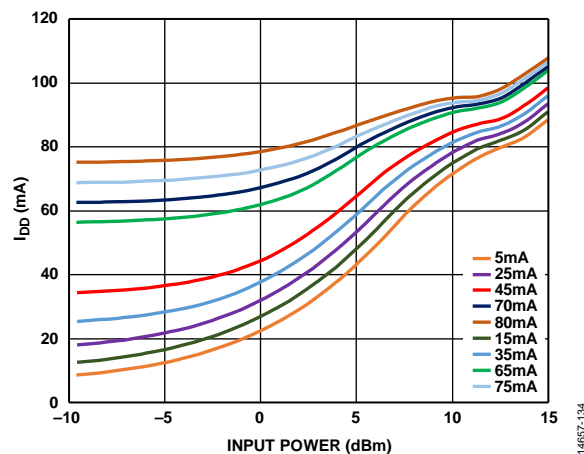


Figure 35. Supply Current with RF Applied ( $I_{DD}$ ) vs. Input Power for Various Supply Currents ( $I_{DQ}$ ) at 5 GHz,  $V_{DD} = 5$  V

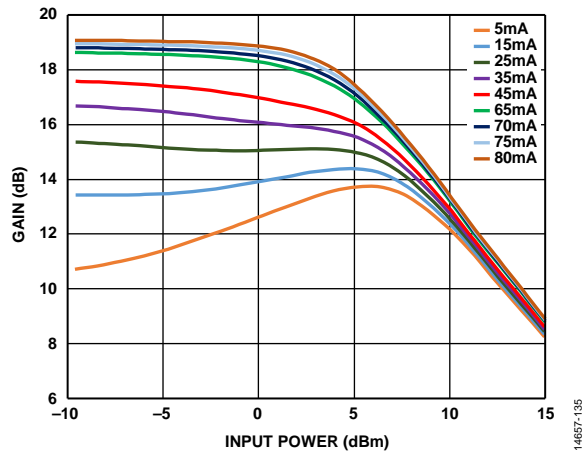


Figure 36. Gain vs. Input Power for Various Supply Currents ( $I_{DQ}$ ) at 5 GHz,  $V_{DD} = 5$  V

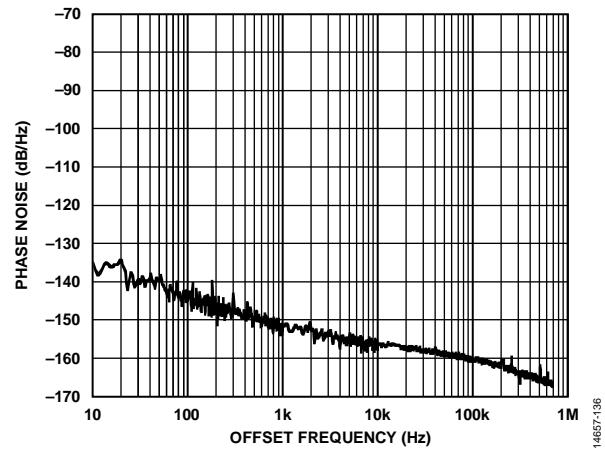


Figure 37. Additive Phase Noise vs. Offset Frequency, RF Frequency = 5 GHz, RF Input Power = 3 dBm ( $P_{1dB}$ )

## THEORY OF OPERATION

The HMC8410 is a gallium arsenide (GaAs), monolithic microwave integrated circuit (MMIC), pseudomorphic (pHEMT), low noise wideband amplifier.

The HMC8410 has single-ended input and output ports whose impedances are nominally equal to  $50\ \Omega$  over the 0.01 GHz to 10 GHz frequency range. Consequently, it can directly insert into a  $50\ \Omega$  system with no required impedance matching circuitry, which also means that multiple HMC8410 amplifiers can be cascaded back to back without the need for external matching circuitry.

The input and output impedances are sufficiently stable vs. variations in temperature and supply voltage that no impedance matching compensation is required.

Note that it is critical to supply very low inductance ground connections to the ground pins as well as to the backside exposed paddle to ensure stable operation.

To achieve optimal performance from the HMC8410 and prevent damage to the device, do not exceed the absolute maximum ratings.

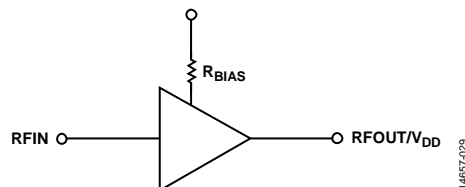


Figure 38. Simplified HMC8410 Architecture

## APPLICATIONS INFORMATION

Figure 39 shows the basic connections for operating the HMC8410. AC couple the input and output of the HMC8410 with appropriately sized capacitors. DC block capacitors and RF choke inductors are supplied on the RFIN and RFOUT pins of the HMC8410 evaluation board. See Table 6 for additional information. These dc block capacitors and RF choke inductors form wideband bias tees on the input and output ports to provide both ac coupling and the necessary supply voltages to the RFIN and RFOUT pins. A 5 V dc bias is supplied to the amplifier through the choke inductor connected to the RFOUT pin, and the negative  $V_{GG1}$  voltage is supplied to the RFIN pin through the choke inductor.

### RECOMMENDED BIAS SEQUENCING

To not damage the amplifier, follow the recommended bias sequencing.

#### During Power-Up

The recommended bias sequence during power-up for the HMC8410 follows:

1. Connect to GND.
2. Set  $V_{GG1}$  to  $-2$  V.
3. Set  $V_{DD}$  to 5 V.
4. Increase  $V_{GG1}$  to achieve a typical supply current ( $I_{DQ}$ ) = 65 mA.
5. Apply the RF signal.

#### During Power-Down

The recommended bias sequence during power-down for the HMC8410 follows:

1. Turn off the RF signal.
2. Decrease  $V_{GG1}$  to  $-2$  V to achieve a typical  $I_{DQ} = 0$  mA.
3. Decrease  $V_{DD}$  to 0 V.
4. Increase  $V_{GG1}$  to 0 V.

The bias conditions previously listed ( $V_{DD} = 5$  V and  $I_{DQ} = 65$  mA) are the recommended operating points to achieve optimum performance. The data used in this data sheet was taken with the recommended bias conditions. When using the HMC8410 with different bias conditions, different performance than what is shown in the Typical Performance Characteristics section can result.

Figure 19, Figure 31, and Figure 32 show that increasing the voltage from 2 V to 7 V typically increases  $P_{1dB}$  and  $P_{SAT}$  at the expense of power consumption with minor degradation on noise figure (NF).

### TYPICAL APPLICATION CIRCUIT

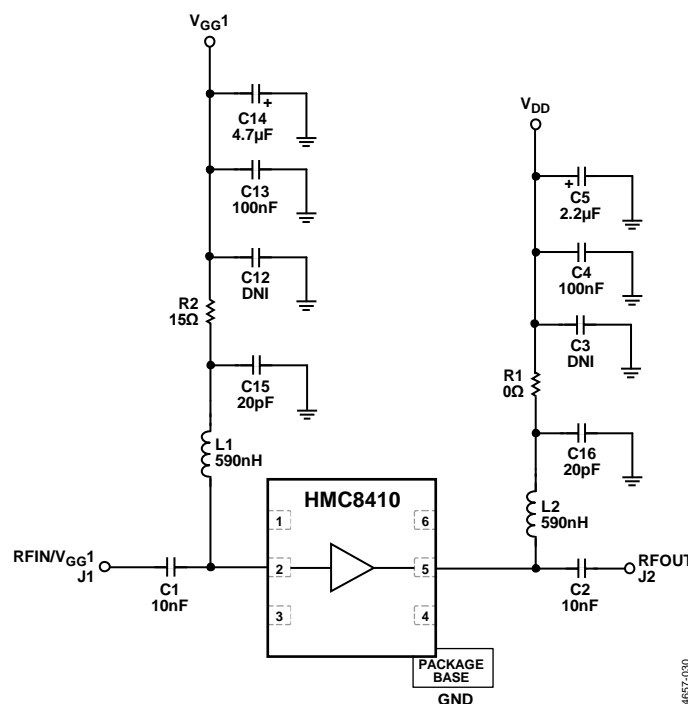


Figure 39. Typical Application Circuit

## EVALUATION BOARD

The [HMC8410](#) evaluation board is a 4-layer board fabricated using a Rogers 4350 and the best practices for high frequency RF design. The RF input and RF output traces have a  $50\ \Omega$  characteristic impedance.

The [HMC8410](#) evaluation board and populated components operate over the  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  ambient temperature range. For proper bias sequence, see the Applications Information section.

The [HMC8410](#) evaluation board schematic is shown in Figure 41. A fully populated and tested evaluation printed circuit board (PCB) is available from Analog Devices, Inc., upon request (see Figure 40).

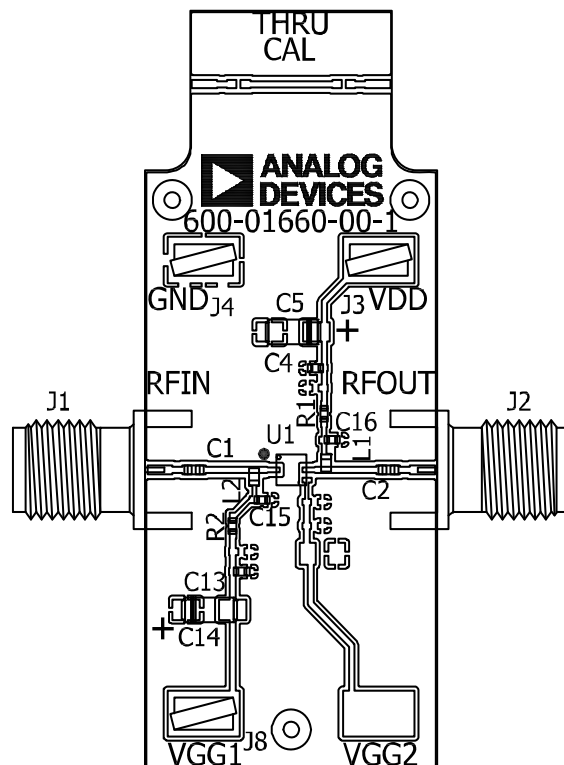


Figure 40. [HMC8410](#) Evaluation PCB

14657-031

## EVALUATION BOARD SCHEMATIC

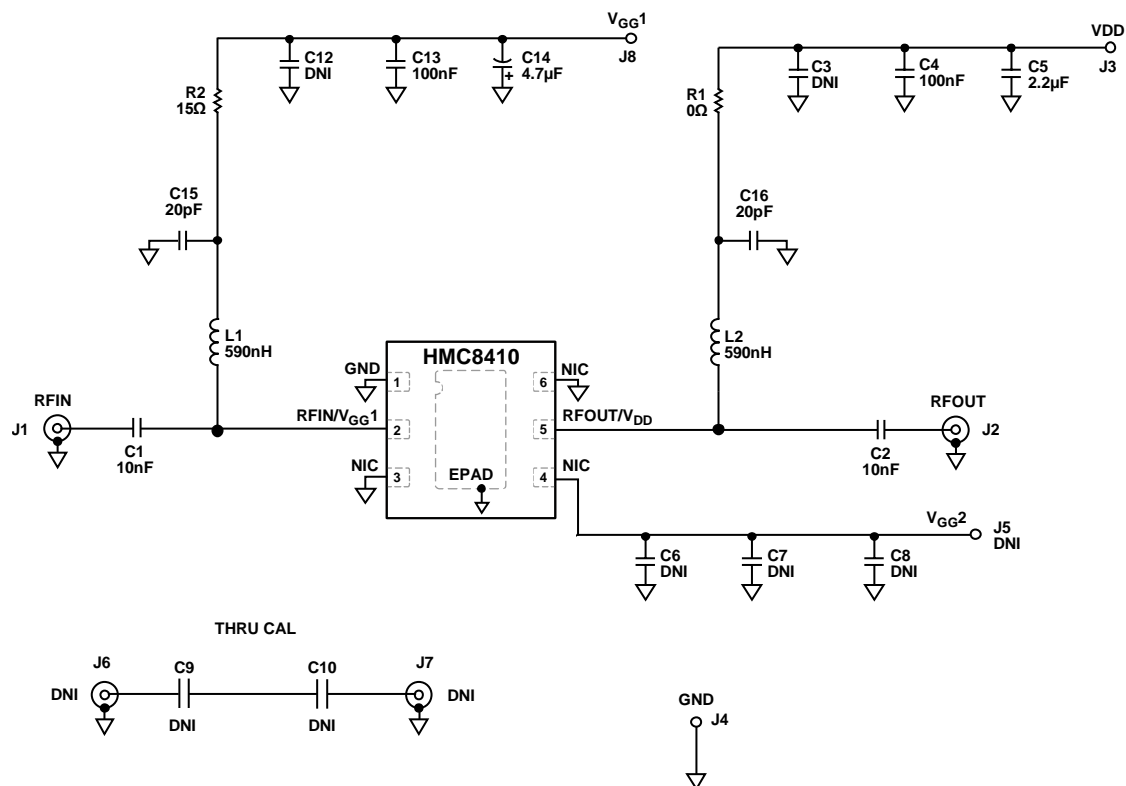


Figure 41. **HMC8410** Evaluation Board Schematic

**Table 6. Bill of Materials for Evaluation PCB EV1HMC8410LP2F**

| Item                         | Description                                                                        |
|------------------------------|------------------------------------------------------------------------------------|
| J1, J2                       | PCB mount SMA RF connectors, SRI 21-146-1000-01                                    |
| J3, J4, J8                   | DC bias test points                                                                |
| C1, C2                       | Capacitors, broadband, 100 nF and 82 pF, 0502, 160 kHz and 40 GHz; ATC531Z104KT16T |
| C3, C6 to C10, C12, J5 to J7 | Do not install (DNI)                                                               |
| C4, C13                      | Capacitors, ceramic, 100 nF, 0402 package                                          |
| C5                           | Capacitor, tantalum, 2.2 $\mu$ F, Size A                                           |
| C14                          | Capacitor, tantalum, 4.7 $\mu$ F, 3216 package                                     |
| C15, C16                     | Capacitors, ceramic, 20 pF, 0402 package                                           |
| L1, L2                       | Inductors, 590 nH, 0402, 5%, ferrite DF, Coilcraft 0402DF-591XJRU                  |
| R1                           | 0 $\Omega$ resistor                                                                |
| R2                           | 15 $\Omega$ resistor, 0402 package                                                 |
| U1                           | Amplifier, <a href="#">HMC8410</a>                                                 |
| Heat sink                    | Heat sink                                                                          |
| PCB                          | 600-01660-00 evaluation PCB; circuit board material: Rogers 4350                   |

## OUTLINE DIMENSIONS

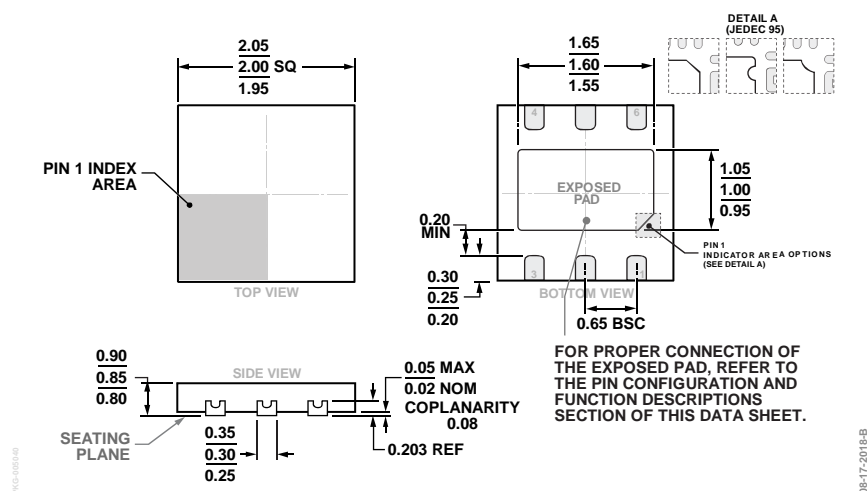


Figure 42. 6-Lead Lead Frame Chip Scale Package [LFCSP]  
 2 mm × 2 mm Body and 0.85 mm Package Height  
 (CP-6-9)  
 Dimensions shown in millimeters

## ORDERING GUIDE

| Model <sup>1</sup> | Temperature Range | MSL Rating <sup>2</sup> | Lead Finish   | Package Description | Package Option |
|--------------------|-------------------|-------------------------|---------------|---------------------|----------------|
| HMC8410LP2FE       | −40°C to +85°C    | MSL3                    | 100% Matte Sn | 6-Lead LFCSP        | CP-6-9         |
| HMC8410LP2FETR     | −40°C to +85°C    | MSL3                    | 100% Matte Sn | 6-Lead LFCSP        | CP-6-9         |
| EV1HMC8410LP2F     |                   |                         |               | Evaluation PCB      |                |

<sup>1</sup> The HMC8410LP2FE and HMC8410LP2FETR are RoHS Compliant Parts.

<sup>2</sup> See the Absolute Maximum Ratings section for additional information.