# Low Noise Amplifier, 0.01 GHz to 10 GHz

## FEATURES

- Low noise figure: 1.7 dB typical
- Single positive supply (self biased)
- High gain: 15.5 dB typical
- High OIP3: 34 dBm typical
- 6-lead, 2 mm × 2 mm LFCSP

## APPLICATIONS

- Test instrumentation
- Military communications

## FUNCTIONAL BLOCK DIAGRAM

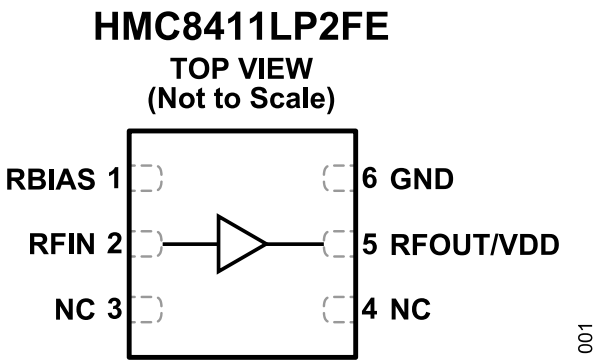


*Figure 1.*

## GENERAL DESCRIPTION

The HMC8411LP2FE is a gallium arsenide (GaAs), monolithic microwave integrated circuit (MMIC), pseudomorphic high electron mobility transistor (pHEMT), low noise wideband amplifier that operates from 0.01 GHz to 10 GHz.

The HMC8411LP2FE provides a typical gain of 15.5 dB, a 1.7 dB typical noise figure, and a typical output third-order intercept (OIP3) of 34 dBm, requiring only 55 mA from a 5 V supply voltage. The saturated output power ($P_{SAT}$) of 19.5 dBm typical enables the low noise amplifier (LNA) to function as a local oscillator (LO) driver for many of Analog Devices, Inc., balanced, in-phase/quadrature (I/Q), or image rejection mixers.

The HMC8411LP2FE also features inputs and outputs that are internally matched to 50 Ω, making the device ideal for surface-mounted technology (SMT)-based, high capacity microwave radio applications.

The HMC8411LP2FE is housed in a RoHS-compliant, 2 mm × 2 mm, 6-lead LFCSP.

Multifunction pin names may be referenced by their relevant function only.

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## REVISION HISTORY

**9/2022—Rev. B to Rev. C**

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## SPECIFICATIONS

### 0.01 GHZ TO 1 GHZ FREQUENCY RANGE

$V_{DD}$ = 5 V, supply current ($I_{DQ}$) = 55 mA, and $T_A$ = 25°C, unless otherwise noted.

*Table 1.*

| Parameter | Symbol | Min | Typ | Max | Unit | Test Conditions/Comments |
|---|---|---|---|---|---|---|
| FREQUENCY RANGE | | 0.01 | | 1 | GHz | |
| GAIN | | 12.5 | 15.5 | | dB | |
| Gain Variation over Temperature | | | 0.005 | | dB/°C | |
| NOISE FIGURE | | | 1.8 | | dB | |
| RETURN LOSS | | | | | | |
| Input | | | 22 | | dB | |
| Output | | | 17 | | dB | |
| OUTPUT | | | | | | |
| Output Power for 1 dB Compression | P1dB | 17 | 20 | | dBm | |
| Saturated Output Power | $P_{SAT}$ | | 20.5 | | dBm | |
| Output Third-Order Intercept | OIP3 | | 33.5 | | dBm | Measurement taken at output power ($P_{OUT}$) per tone = 6 dBm |
| Output Second-Order Intercept | OIP2 | | 43 | | dBm | Measurement taken at $P_{OUT}$ per tone one = 6 dBm |
| POWER ADDED EFFICIENCY | PAE | | 30 | | % | Measured at $P_{SAT}$ |
| SUPPLY CURRENT | $I_{DQ}$ | | 55 | | mA | |
| SUPPLY VOLTAGE | $V_{DD}$ | 2 | 5 | 6 | V | |

### 1 GHZ TO 6 GHZ FREQUENCY RANGE

$V_{DD}$ = 5 V, $I_{DQ}$ = 55 mA, and $T_A$ = 25°C, unless otherwise noted.

*Table 2.*

| Parameter | Symbol | Min | Typ | Max | Unit | Test Conditions/Comments |
|---|---|---|---|---|---|---|
| FREQUENCY RANGE | | 1 | | 6 | GHz | |
| GAIN | | 12 | 15 | | dB | |
| Gain Variation over Temperature | | | 0.01 | | dB/°C | |
| NOISE FIGURE | | | 1.7 | | dB | |
| RETURN LOSS | | | | | | |
| Input | | | 25 | | dB | |
| Output | | | 18 | | dB | |
| OUTPUT | | | | | | |
| Output Power for 1 dB Compression | P1dB | 17 | 20 | | dBm | |
| Saturated Output Power | $P_{SAT}$ | | 21 | | dBm | |
| Output Third-Order Intercept | OIP3 | | 34 | | dBm | Measurement taken at $P_{OUT}$ per tone = 6 dBm |
| Output Second-Order Intercept | OIP2 | | 39 | | dBm | Measurement taken at $P_{OUT}$ per tone = 6 dBm |
| POWER ADDED EFFICIENCY | PAE | | 34 | | % | Measured at $P_{SAT}$ |
| SUPPLY CURRENT | $I_{DQ}$ | | 55 | | mA | |
| SUPPLY VOLTAGE | $V_{DD}$ | 2 | 5 | 6 | V | |

### 6 GHZ TO 10 GHZ FREQUENCY RANGE

$V_{DD}$ = 5 V, $I_{DQ}$ = 55 mA, and $T_A$ = 25°C, unless otherwise noted.

*Table 3.*

| Parameter | Symbol | Min | Typ | Max | Unit | Test Conditions/Comments |
|---|---|---|---|---|---|---|
| FREQUENCY RANGE | | 6 | | 10 | GHz | |
| GAIN | | 11 | 14 | | dB | |

## SPECIFICATIONS

*Table 3.*

| Parameter | Symbol | Min | Typ | Max | Unit | Test Conditions/Comments |
|---|---|---|---|---|---|---|
| Gain Variation over Temperature | | | 0.018 | | dB/°C | |
| NOISE FIGURE | | | 2 | | dB | |
| RETURN LOSS | | | | | | |
| Input | | | 15 | | dB | |
| Output | | | 17 | | dB | |
| OUTPUT | | | | | | |
| Output Power for 1 dB Compression | P1dB | 13 | 16 | | dBm | |
| Saturated Output Power | $P_{SAT}$ | | 19.5 | | dBm | |
| Output Third-Order Intercept | OIP3 | | 33 | | dBm | Measurement taken at $P_{OUT}$ per tone = 6 dBm |
| Output Second-Order Intercept | OIP2 | | 40 | | dBm | Measurement taken at $P_{OUT}$ per tone = 6 dBm |
| POWER ADDED EFFICIENCY | PAE | | 23 | | % | Measured at $P_{SAT}$ |
| SUPPLY CURRENT | $I_{DQ}$ | | 55 | | mA | |
| SUPPLY VOLTAGE | $V_{DD}$ | 2 | 5 | 6 | V | |

## ABSOLUTE MAXIMUM RATINGS

*Table 4.*

| Parameter[1] | Rating |
|---|---|
| Drain Bias Voltage ($V_{DD}$) | 7 V |
| Radio Frequency Input ($RF_{IN}$) Power | 20 dBm |
| Channel Temperature | 175°C |
| Continuous Power Dissipation ($P_{DISS}$), T = 85°C (Derate 8.7 mW/°C Above 85°C) | 0.78 W |
| Storage Temperature Range | −65°C to +150°C |
| Operating Temperature Range | −40°C to +85°C |
| Electrostatic Discharge (ESD) Sensitivity | |
| Human Body Model (HBM) | 500 V, Class 1B passed |

[1] 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 full pin names of multifunction pins, refer to the Pin Configuration and Function Descriptions section.

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.

## THERMAL RESISTANCE

Thermal performance is directly linked to printed circuit board (PCB) design and operating environment. Close attention to PCB thermal design is required.

$\theta_{JC}$ is the junction to case thermal resistance.

*Table 5. Thermal Resistance*

| Package Type | $\theta_{JC}$ | Unit |
|---|---|---|
| CP-6-12 | 115.35 | °C/W |

## 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

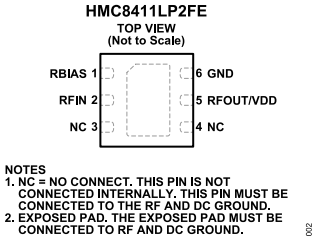


*Figure 2. Pin Configuration*

*Table 6. Pin Function Descriptions*

| Pin No. | Mnemonic | Description |
|---|---|---|
| 1 | RBIAS | Bias Setting Resistor. Connect a resistor between RBIAS and VDD to set the quiescent drain current. See Figure 3 for the interface schematic. |
| 2 | RFIN | RF Input. The RFIN pin is ac-coupled and matched to 50 Ω. See Figure 4 for the interface schematic. |
| 3, 4 | NC | No Connect. This pin is not connected internally. For normal operation, this pin should be connected to ground. |
| 5 | RFOUT/VDD | RF Output and Drain Bias Voltage: The RF output is dc coupled and also serves as the drain biasing node. Connect a dc bias network to provide the drain current and ac-couple the RF output path. See Figure 5 for the interface schematic. |
| 6 | GND | Ground. This pin must be connected to the RF and dc ground. See Figure 6 for the interface schematic. |
| | EPAD | Exposed Ground Paddle. Connect the exposed Paddle to a ground plane which has low electrical and thermal impedance. |

## INTERFACE SCHEMATICS

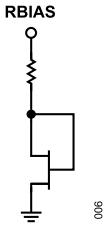


*Figure 3. RBIAS Interface Schematic*

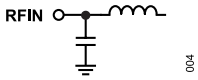


*Figure 4. RFIN Interface Schematic*

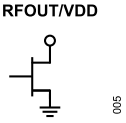


*Figure 5. RFOUT/VDD Interface Schematic*


*Figure 6. GND Interface Schematic*

## TYPICAL PERFORMANCE CHARACTERISTICS

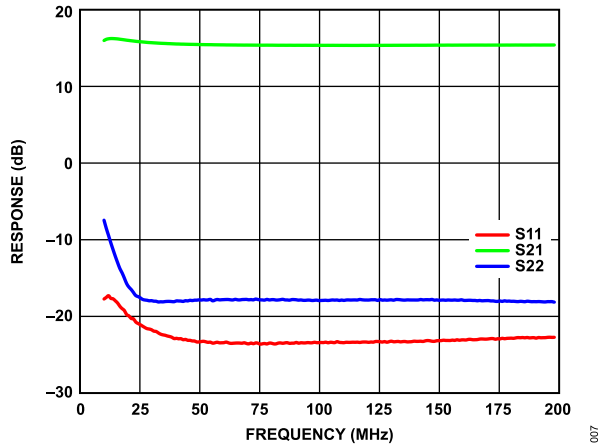


*Figure 7. Gain and Return Loss (Response) vs. Frequency, 10 MHz to 200 MHz, $V_{DD}$ = 5 V, $I_{DQ}$ = 55 mA*

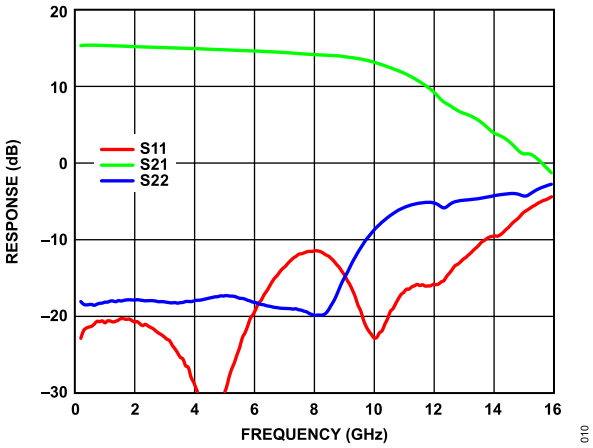


*Figure 10. Broadband Gain and Return Loss (Response) vs. Frequency, 200 MHz to 16 GHz, $V_{DD}$ = 5 V, $I_{DQ}$ = 55 mA*

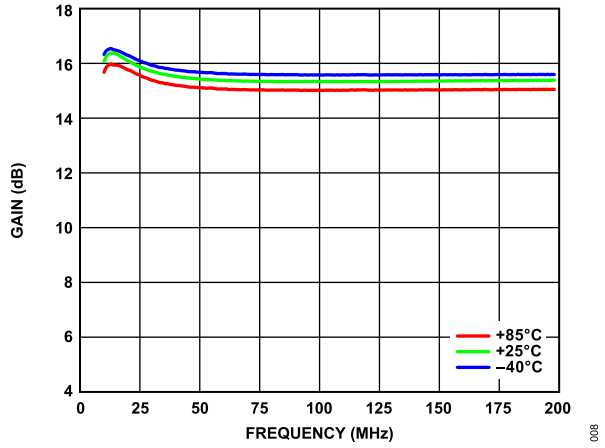


*Figure 8. Gain vs. Frequency, 10 MHz to 200 MHz, for Various Temperatures, $V_{DD}$ = 5 V, $I_{DQ}$ = 55 mA*

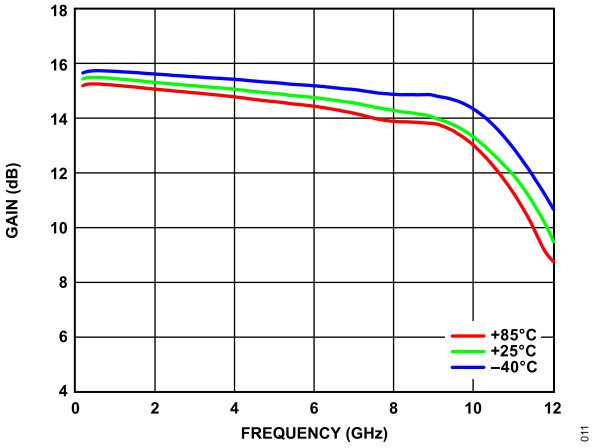


*Figure 11. Gain vs. Frequency, 200 MHz to 12 GHz, for Various Temperatures, $V_{DD}$ = 5 V, $I_{DQ}$ = 55 mA*

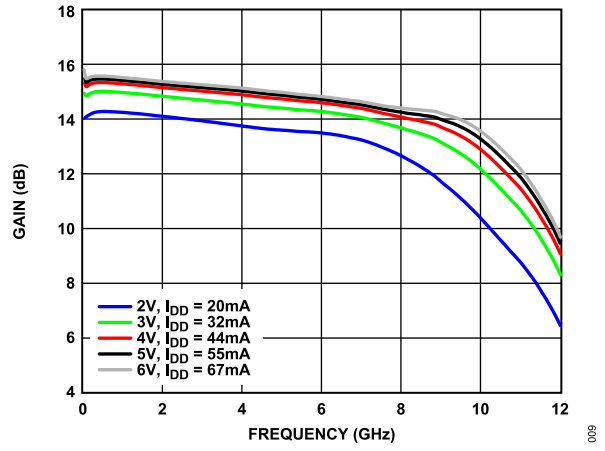


*Figure 9. Gain vs. Frequency for Various Supply Voltages and Currents ($I_{DD}$), $R_{BIAS}$ = 1.1 kΩ*

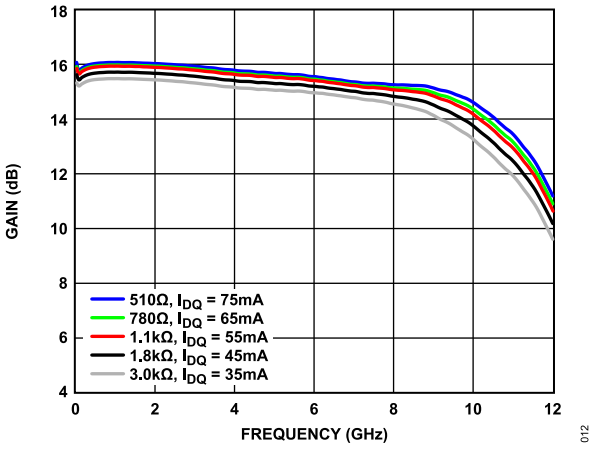


*Figure 12. Gain vs. Frequency for Various Bias Resistor Values and $I_{DQ}$, $V_{DD}$ = 5 V*

## TYPICAL PERFORMANCE CHARACTERISTICS

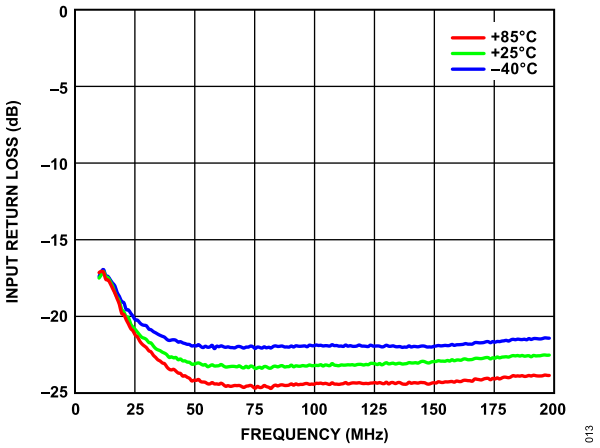


*Figure 13. Input Return Loss vs. Frequency, 10 MHz to 200 MHz, for Various Temperatures, $V_{DD}$ = 5 V, $I_{DQ}$ = 55 mA*

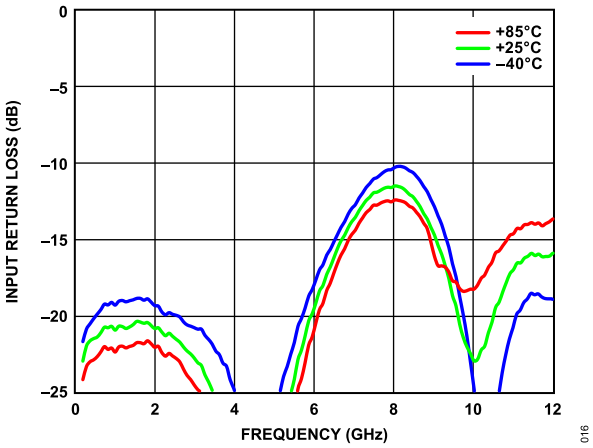


*Figure 16. Input Return Loss vs. Frequency, 200 MHz to 12 GHz, for Various Temperatures, $V_{DD}$ = 5 V, $I_{DQ}$ = 55 mA*

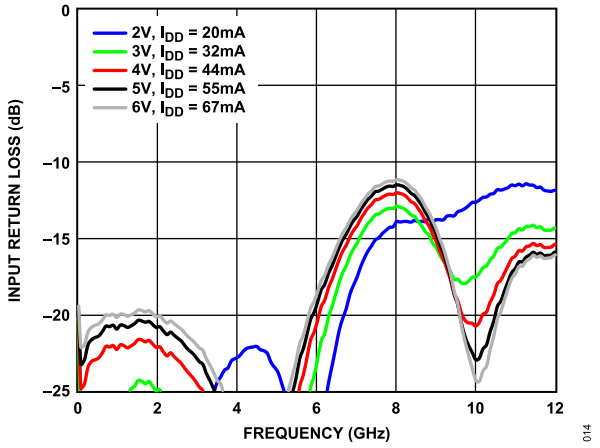


*Figure 14. Input Return Loss vs. Frequency for Various Supply Voltages and $I_{DD}$, $R_{BIAS}$ = 1.1 kΩ*

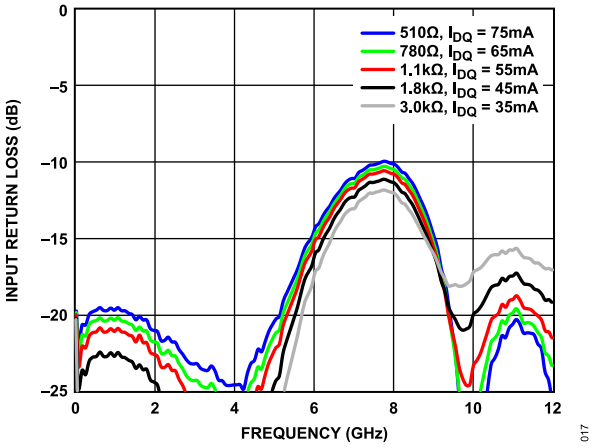


*Figure 17. Input Return Loss vs. Frequency for Various Bias Resistor Values and $I_{DQ}$, $V_{DD}$ = 5 V*

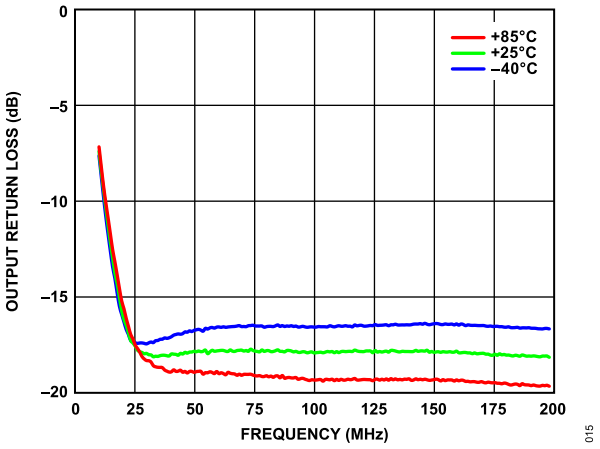


*Figure 15. Output Return Loss vs. Frequency, 10 MHz to 200 MHz, for Various Temperatures, $V_{DD}$ = 5 V, $I_{DQ}$ = 55 mA*

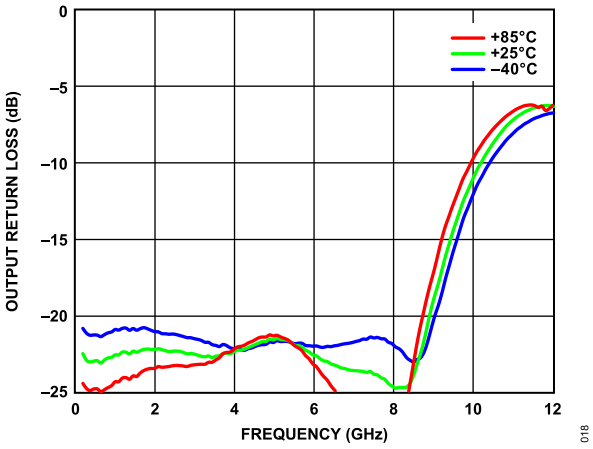


*Figure 18. Output Return Loss vs. Frequency, 200 MHz to 12 GHz, for Various Temperatures, $V_{DD}$ = 5 V, $I_{DQ}$ = 55 mA*

## TYPICAL PERFORMANCE CHARACTERISTICS

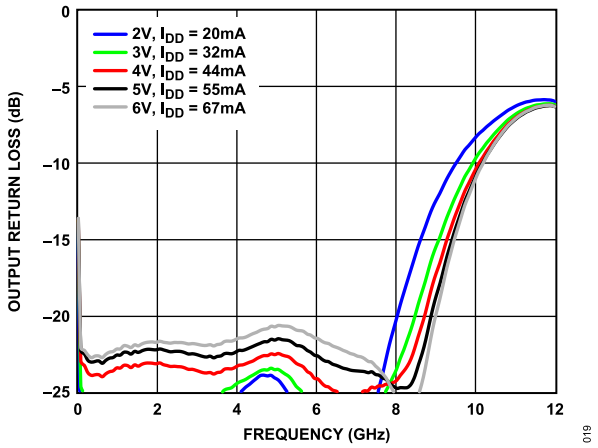


*Figure 19. Output Return Loss vs. Frequency for Various Supply Voltages and $I_{DD}$, $R_{BIAS}$ = 1.1 kΩ*

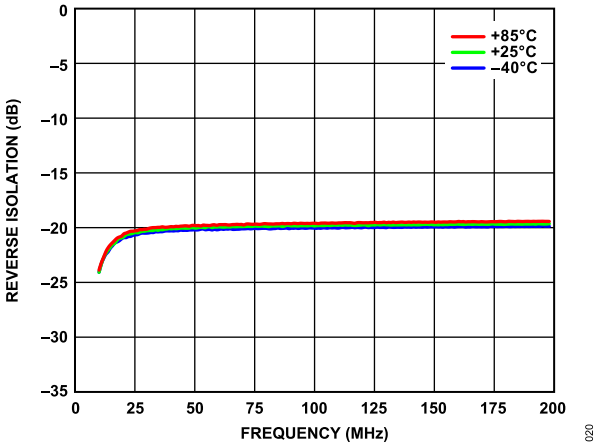


*Figure 20. Reverse Isolation vs. Frequency, 10 MHz to 200 MHz, for Various Temperatures, $V_{DD}$ = 5 V, $I_{DQ}$ = 55 mA*

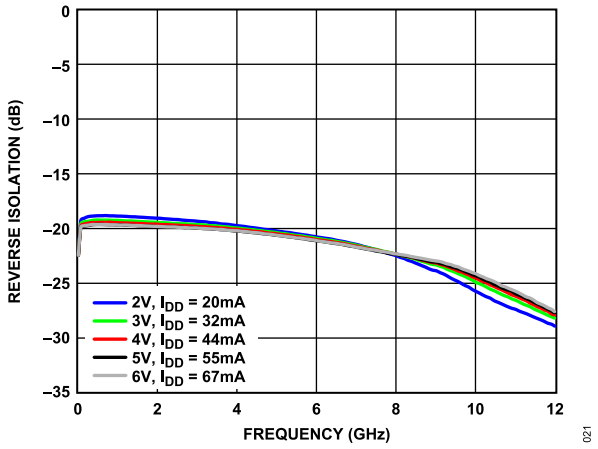


*Figure 21. Reverse Isolation vs. Frequency for Various Supply Voltages and $I_{DD}$, $R_{BIAS}$ = 1.1 kΩ*

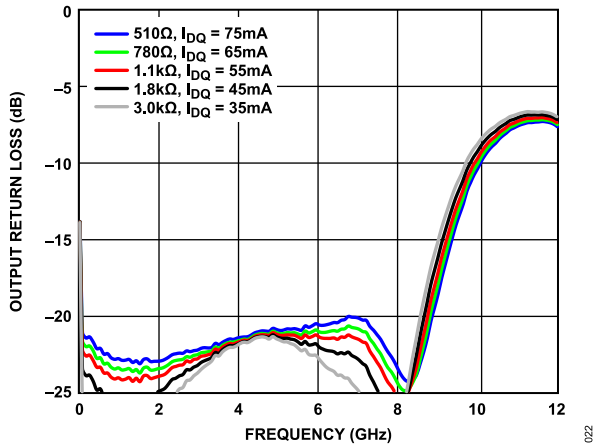


*Figure 22. Output Return Loss vs. Frequency for Various Bias Resistor Values and $I_{DQ}$, $V_{DD}$ = 5 V*

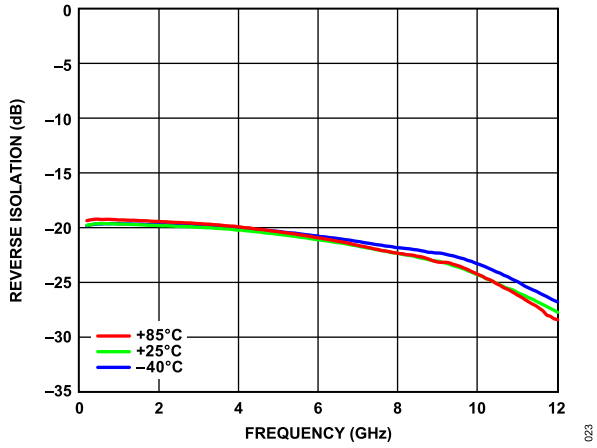


*Figure 23. Reverse Isolation vs. Frequency, 200 MHz to 12 GHz, for Various Temperatures, $V_{DD}$ = 5 V, $I_{DQ}$ = 55 mA*

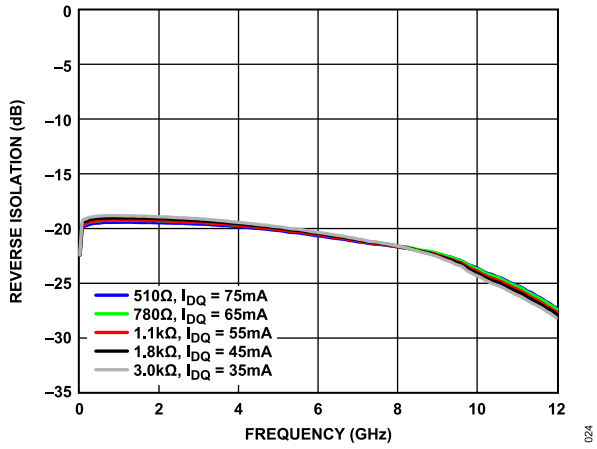


*Figure 24. Reverse Isolation vs. Frequency for Various Bias Resistor Values and $I_{DQ}$, $V_{DD}$ = 5 V*

## TYPICAL PERFORMANCE CHARACTERISTICS

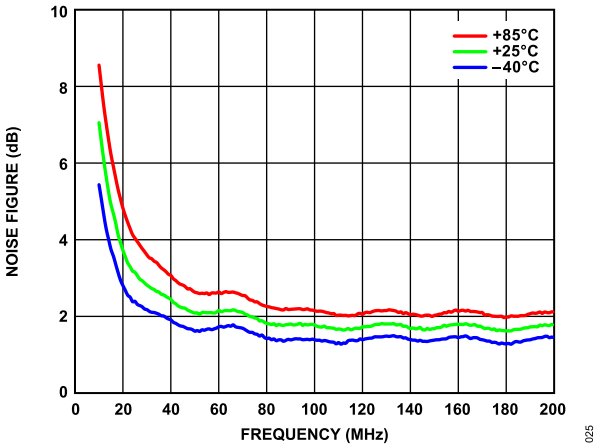


*Figure 25. Noise Figure vs. Frequency, 10 MHz to 200 MHz, for Various Temperatures, $V_{DD}$ = 5 V, $I_{DQ}$ = 55 mA*

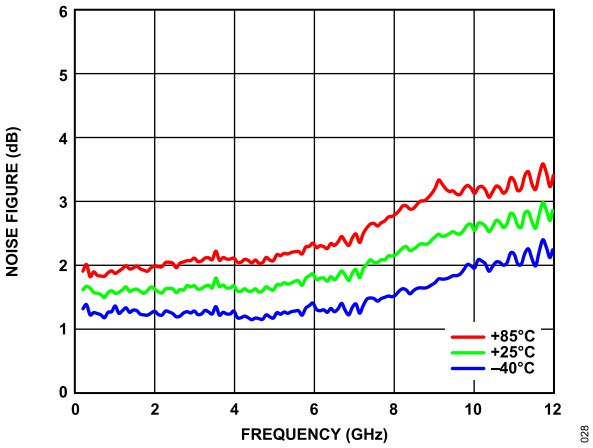


*Figure 28. Noise Figure vs. Frequency, 200 MHz to 12 GHz, for Various Temperatures, $V_{DD}$ = 5 V, $I_{DQ}$ = 55 mA*

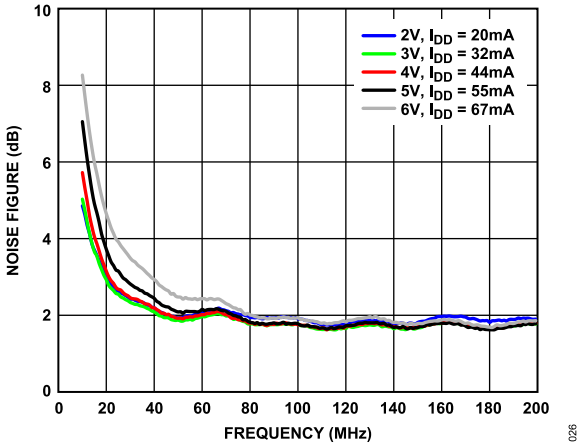


*Figure 26. Noise Figure vs. Frequency, 10 MHz to 200 MHz, for Various Supply Voltages and $I_{DD}$, $R_{BIAS}$ = 1.1 kΩ*

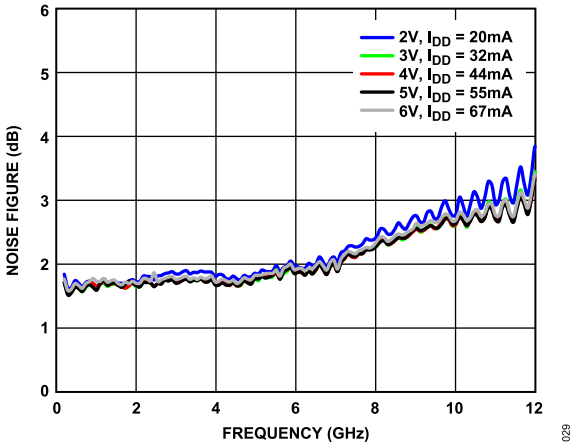


*Figure 29. Noise Figure vs. Frequency, 200 MHz to 12 GHz, for Various Supply Voltages and $I_{DD}$, $R_{BIAS}$ = 1.1 kΩ*

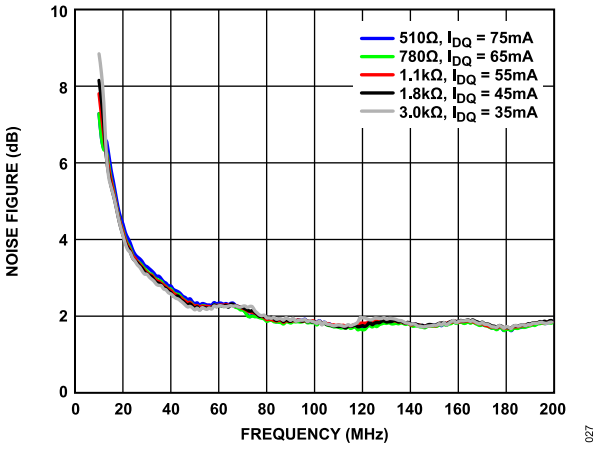


*Figure 27. Noise Figure vs. Frequency, 10 MHz to 200 MHz, for Various Bias Resistor Values and $I_{DQ}$, $V_{DD}$ = 5 V*

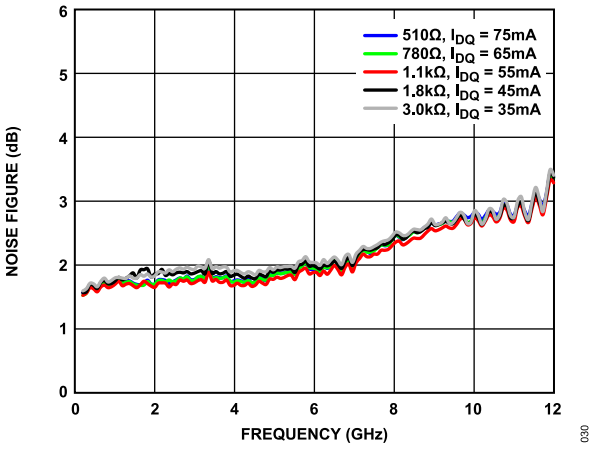


*Figure 30. Noise Figure vs. Frequency, 200 MHz to 12 GHz, for Various Bias Resistor Values and $I_{DQ}$, $V_{DD}$ = 5 V*

## TYPICAL PERFORMANCE CHARACTERISTICS

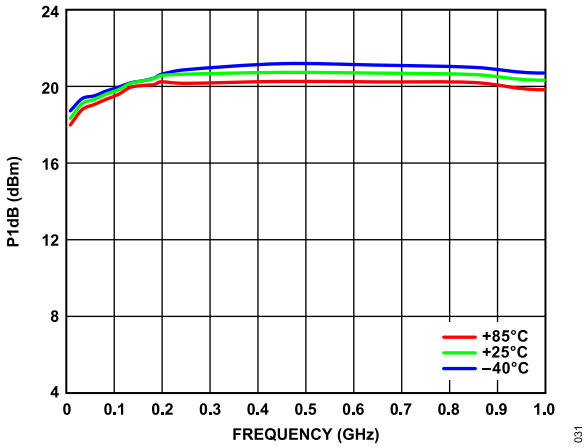


*Figure 31. P1dB vs. Frequency, 0.01 GHz to 1.0 GHz, for Various Temperatures, $V_{DD}$ = 5 V, $I_{DQ}$ = 55 mA*

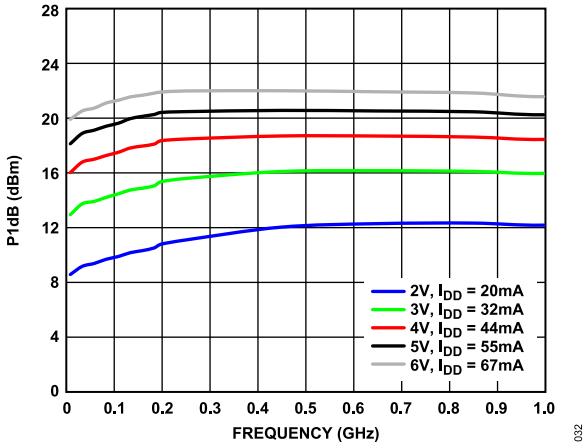


*Figure 32. P1dB vs. Frequency, 0.01 GHz to 1.0 GHz, for Various Supply Voltages and $I_{DD}$, $R_{BIAS}$ = 1.1 kΩ*

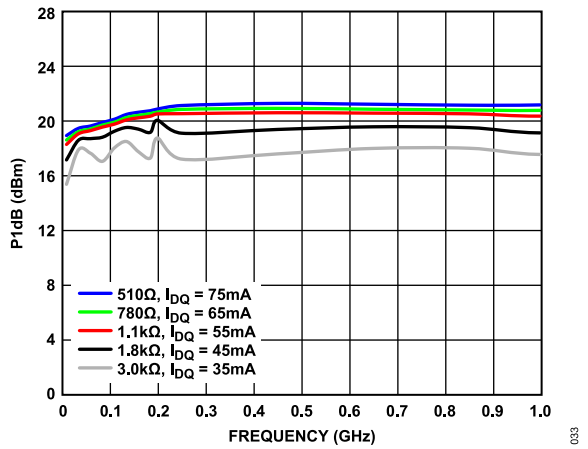


*Figure 33. P1dB vs. Frequency, 0.01 GHz to 1.0 GHz, for Various Bias Resistor Values and $I_{DQ}$, $V_{DD}$ = 5 V*

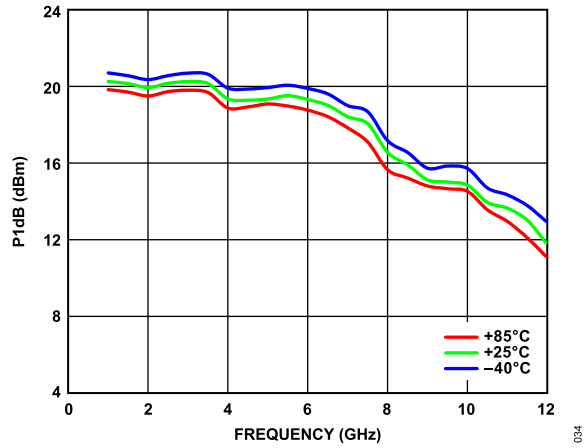


*Figure 34. P1dB vs. Frequency, 1 GHz to 12 GHz, for Various Temperatures, $V_{DD}$ = 5 V, $I_{DQ}$ = 55 mA*

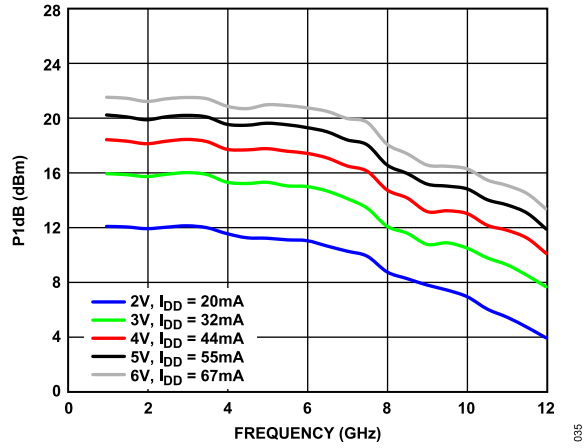


*Figure 35. P1dB vs. Frequency, 1 GHz to 12 GHz, for Various Supply Voltages and $I_{DD}$, $R_{BIAS}$ = 1.1 kΩ*

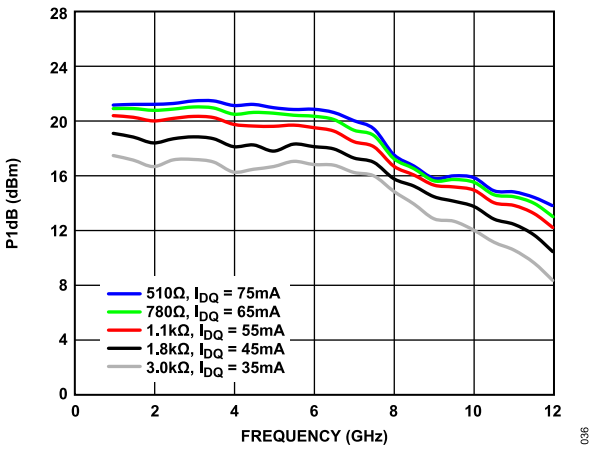


*Figure 36. P1dB vs. Frequency, 1 GHz to 12 GHz, for Various Bias Resistor Values and $I_{DQ}$, $V_{DD}$ = 5 V*

## TYPICAL PERFORMANCE CHARACTERISTICS

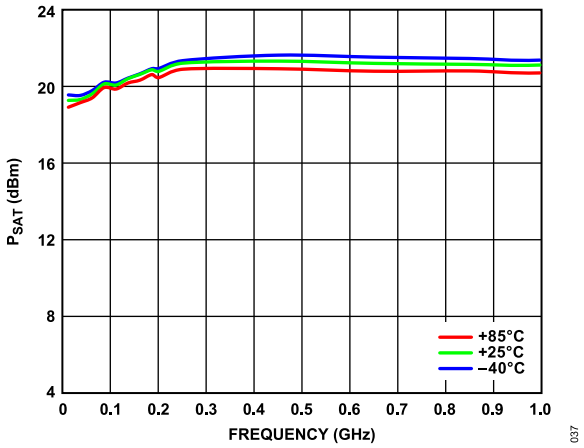


*Figure 37. $P_{SAT}$ vs. Frequency, 0.01 GHz to 1.0 GHz, for Various Temperatures, $V_{DD}$ = 5 V, $I_{DQ}$ = 55 mA*

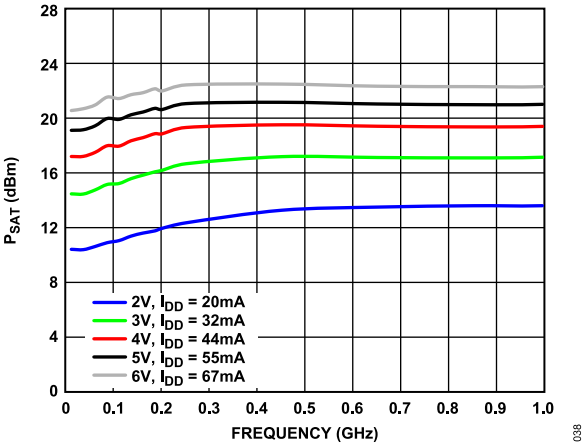


*Figure 38. $P_{SAT}$ vs. Frequency, 0.01 GHz to 1.0 GHz, for Various Supply Voltages and $I_{DD}$, $R_{BIAS}$ = 1.1 kΩ*

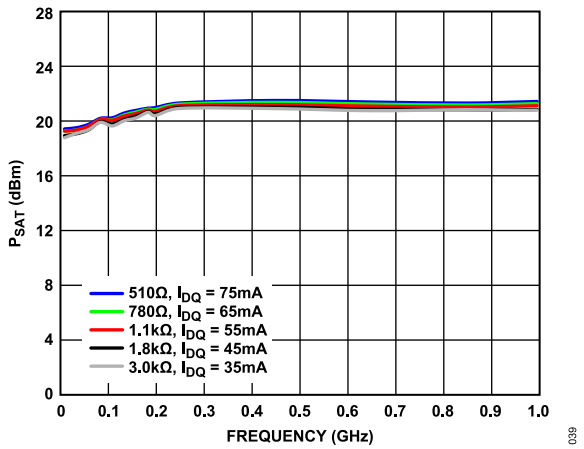


*Figure 39. $P_{SAT}$ vs. Frequency, 0.01 GHz to 1.0 GHz, for Various Bias Resistor Values and $I_{DQ}$, $V_{DD}$ = 5 V*

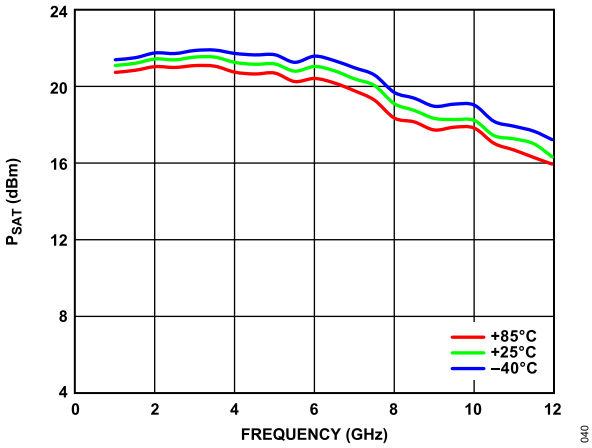


*Figure 40. $P_{SAT}$ vs. Frequency, 1 GHz to 12 GHz, for Various Temperatures, $V_{DD}$ = 5 V, $I_{DQ}$ = 55 mA*

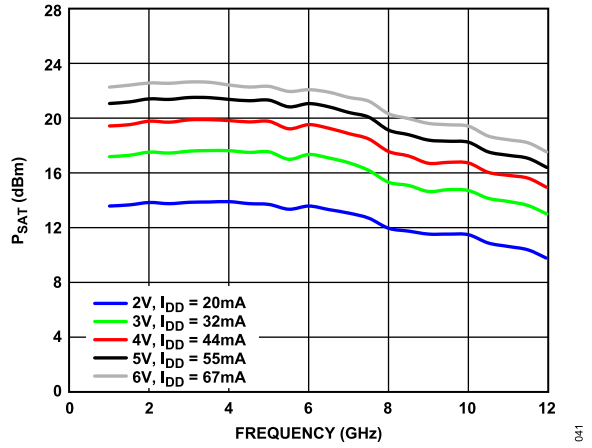


*Figure 41. $P_{SAT}$ vs. Frequency, 1 GHz to 12 GHz, for Various Supply Voltages and $I_{DD}$, $R_{BIAS}$ = 1.1 kΩ*

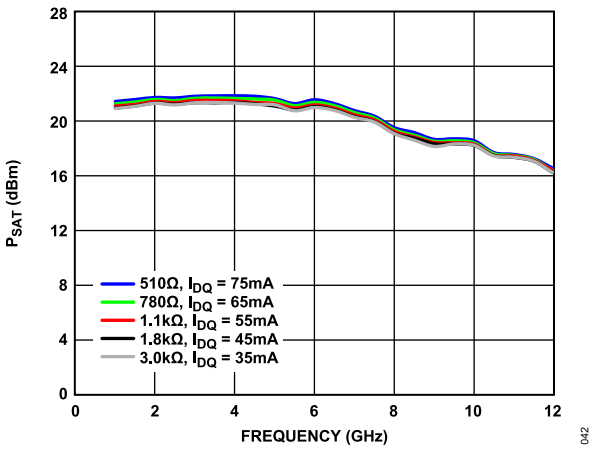


*Figure 42. $P_{SAT}$ vs. Frequency, 1 GHz to 12 GHz, for Various Bias Resistor Values and $I_{DQ}$, $V_{DD}$ = 5 V*

## TYPICAL PERFORMANCE CHARACTERISTICS

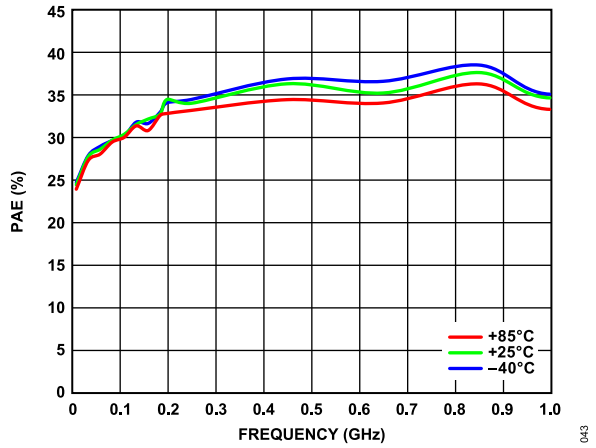


*Figure 43. PAE vs. Frequency, 0.01 GHz to 1.0 GHz, for Various Temperatures, $V_{DD}$ = 5 V, $I_{DQ}$ = 55 mA*

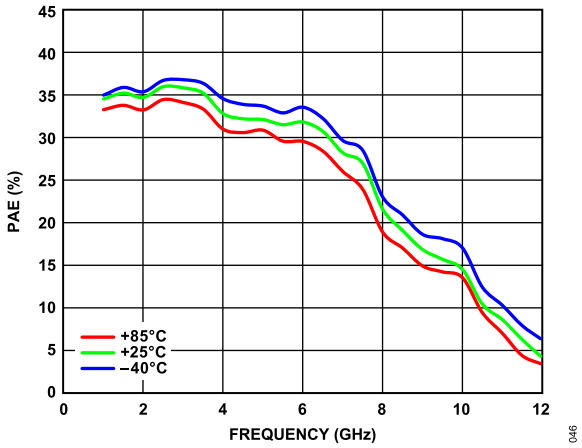


*Figure 46. PAE vs. Frequency, 1 GHz to 12 GHz, for Various Temperatures, $V_{DD}$ = 5 V, $I_{DQ}$ = 55 mA*

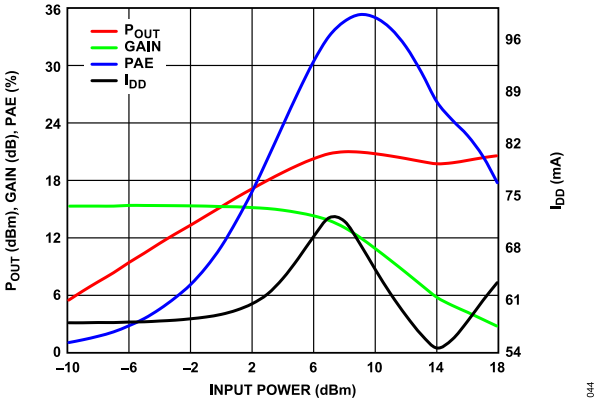


*Figure 44. $P_{OUT}$, Gain, PAE, and $I_{DD}$ vs. Input Power, Power Compression at 1 GHz, $V_{DD}$ = 5 V, $I_{DQ}$ = 55 mA*

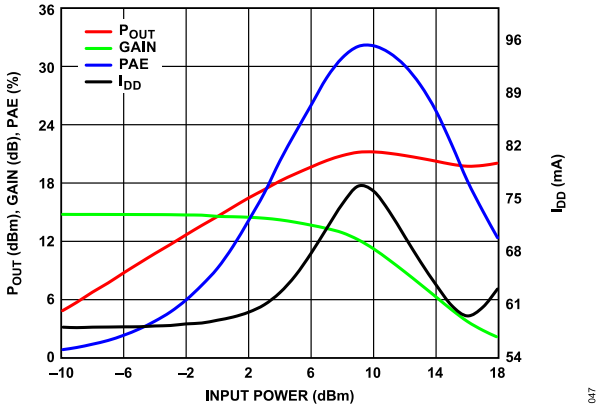


*Figure 47. $P_{OUT}$, Gain, PAE, and $I_{DD}$ vs. Input Power, Power Compression at 5 GHz, $V_{DD}$ = 5 V, $I_{DQ}$ = 55 mA*

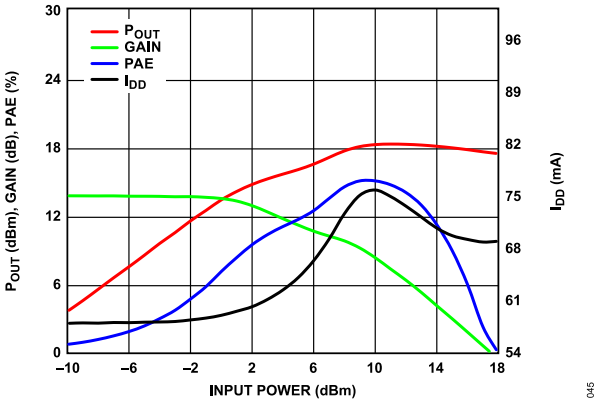


*Figure 45. $P_{OUT}$, Gain, PAE, and $I_{DD}$ vs. Input Power, Power Compression at 10 GHz, $V_{DD}$ = 5 V, $I_{DQ}$ = 55 mA*

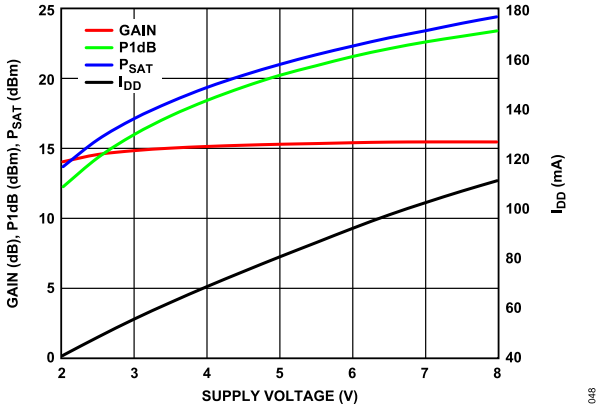


*Figure 48. P1dB, Gain, PAE, and $I_{DD}$ vs. Supply Voltage, Power Compression at 1 GHz, $R_{BIAS}$ = 1.1 kΩ*

## TYPICAL PERFORMANCE CHARACTERISTICS

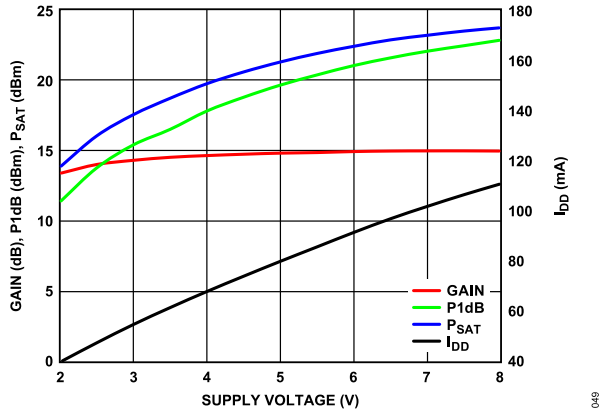


Figure 49. P1dB, Gain, PAE, and $I_{DD}$ vs. Input Power, Power Compression at 5 GHz, $R_{BIAS}$ = 1.1 kΩ

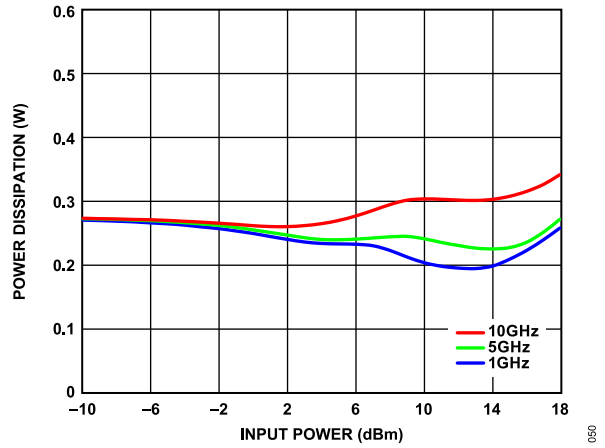


Figure 50. Power Dissipation vs. Input Power at $T_A$ = 85°C, $V_{DD}$ = 5 V, $I_{DQ}$ = 55 mA

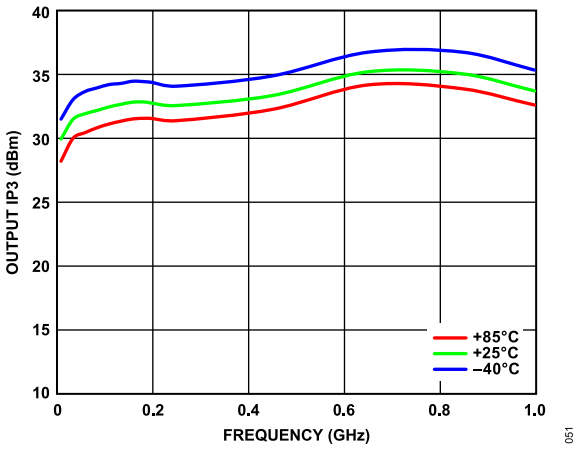


Figure 51. OIP3 vs. Frequency, 0.01 GHz to 1.0 GHz, for Various Temperatures, $V_{DD}$ = 5 V, $I_{DQ}$ = 55 mA

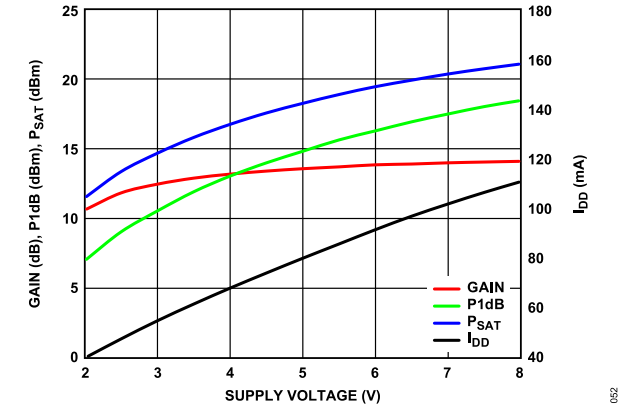


Figure 52. P1dB, Gain, PAE, and $I_{DD}$ vs. Input Power, Power Compression at 10 GHz, $R_{BIAS}$ = 1.1 kΩ

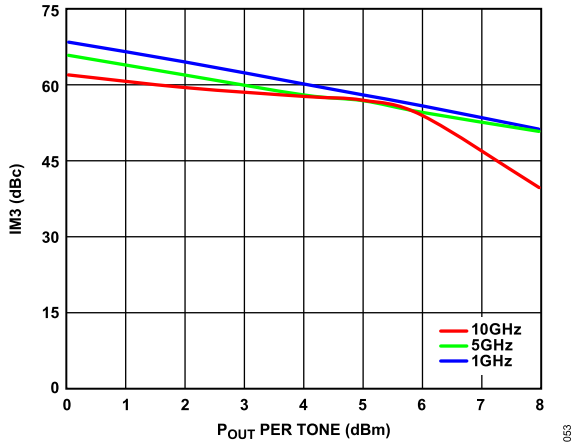


Figure 53. IM3 vs. $P_{OUT}$ per Tone for Various Frequencies, $V_{DD}$ = 5 V, $I_{DQ}$ = 55 mA

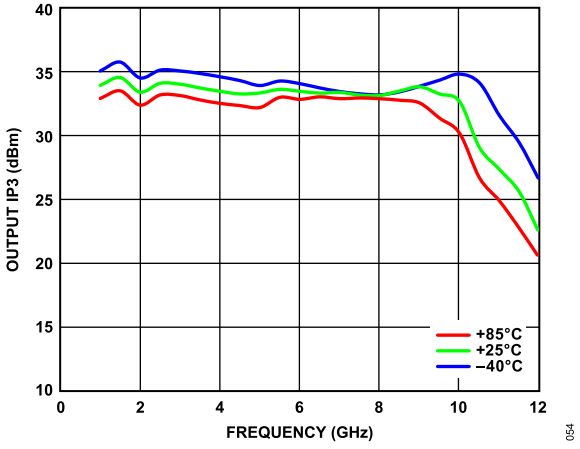


Figure 54. OIP3 vs. Frequency, 1 GHz to 12 GHz, for Various Temperatures, $V_{DD}$ = 5 V, $I_{DQ}$ = 55 mA

## TYPICAL PERFORMANCE CHARACTERISTICS

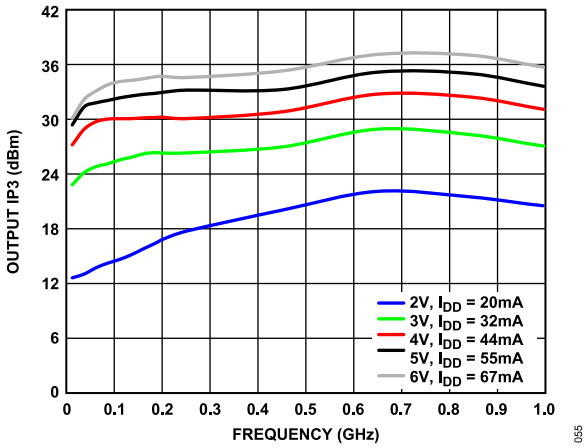


*Figure 55. OIP3 vs. Frequency, 0.01 GHz to 1.0 GHz, for Various Supply Voltages and $I_{DD}$, $R_{BIAS}$ = 1.1 kΩ*

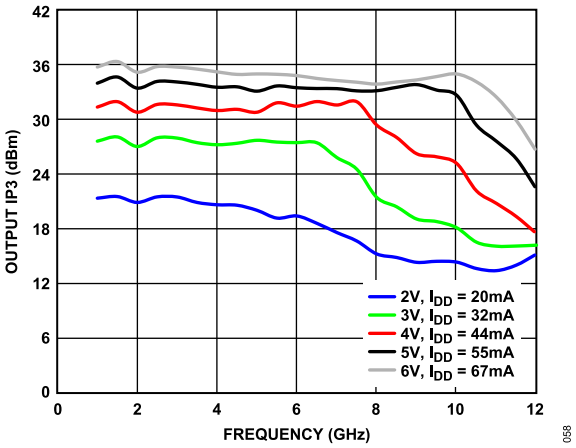


*Figure 58. OIP3 vs. Frequency, 1 GHz to 12 GHz, for Various Supply Voltages and $I_{DD}$, $R_{BIAS}$ = 1.1 kΩ*

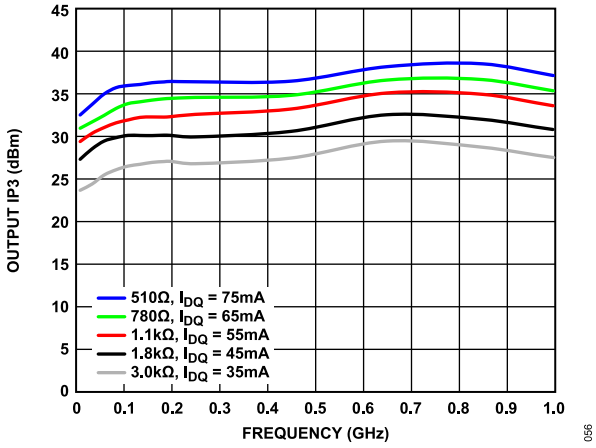


*Figure 56. OIP3 vs. Frequency, 0.01 GHz to 1.0 GHz, for Various Bias Resistor Values and $I_{DQ}$, $V_{DD}$ = 5 V*

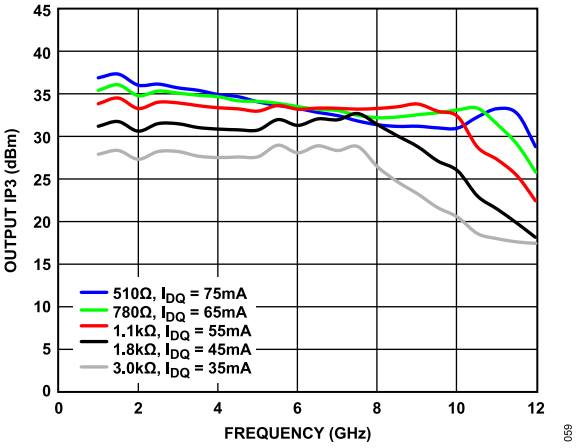


*Figure 59. OIP3 vs. Frequency, 1 GHz to 12 GHz, for Various Bias Resistor Values and $I_{DQ}$, $V_{DD}$ = 5 V*

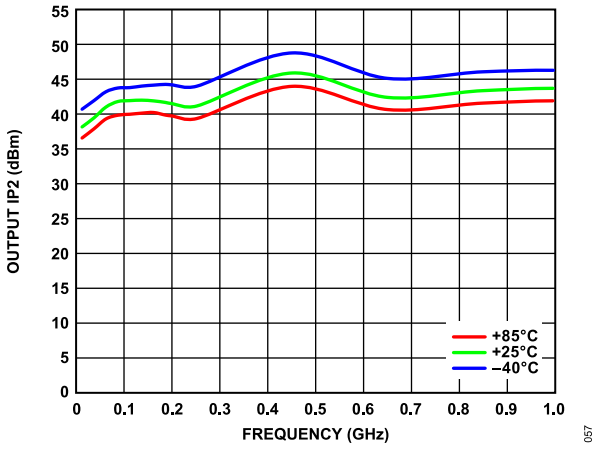


*Figure 57. OIP2 vs. Frequency, 0.01 GHz to 1.0 GHz, for Various Temperatures, $V_{DD}$ = 5 V, $I_{DQ}$ = 55 mA*

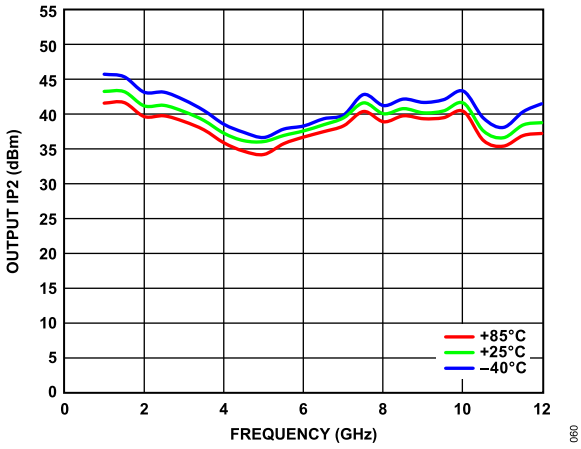


*Figure 60. OIP2 vs. Frequency, 1 GHz to 12 GHz, for Various Temperatures, $V_{DD}$ = 5 V, $I_{DQ}$ = 55 mA*

## TYPICAL PERFORMANCE CHARACTERISTICS

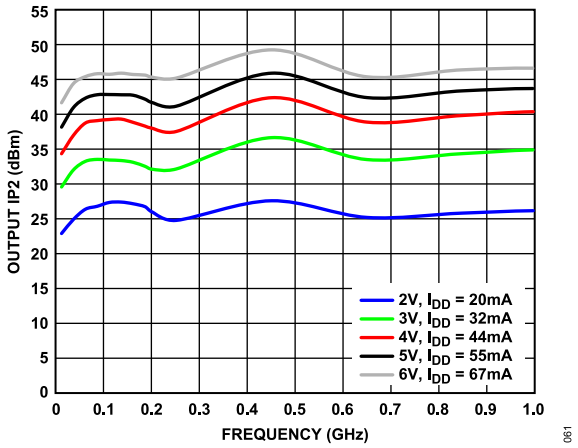


*Figure 61. OIP2 vs. Frequency, 0.01 GHz to 1.0 GHz, for Various Supply Voltages and $I_{DD}$, $R_{BIAS}$ = 1.1 kΩ*

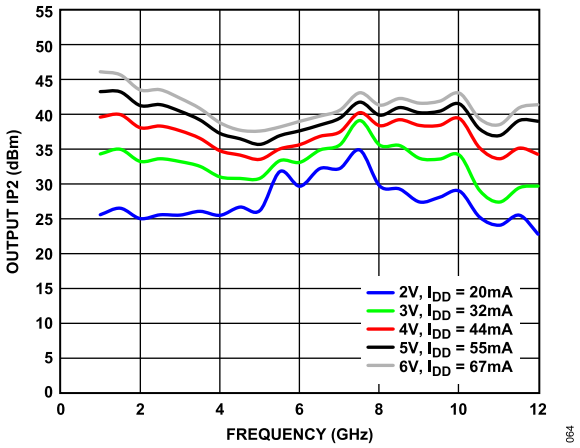


*Figure 64. OIP2 vs. Frequency, 1 GHz to 12 GHz, for Various Supply Voltages and $I_{DD}$, $R_{BIAS}$ = 1.1 kΩ*

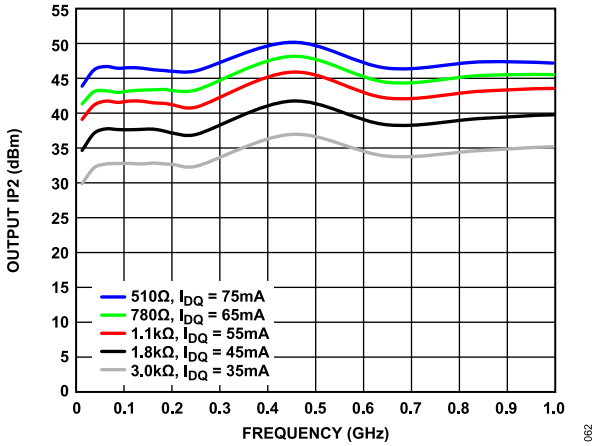


*Figure 62. OIP2 vs. Frequency, 0.01 GHz to 1.0 GHz, for Various Bias Resistor Values and $I_{DQ}$, $V_{DD}$ = 5 V*

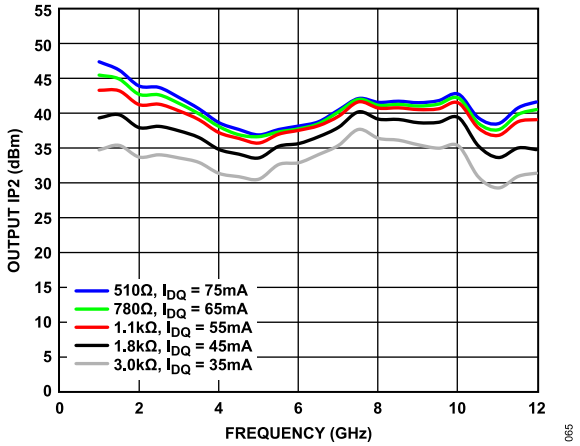


*Figure 65. OIP2 vs. Frequency, 1 GHz to 12 GHz, for Various Bias Resistor Values and $I_{DQ}$, $V_{DD}$ = 5 V*

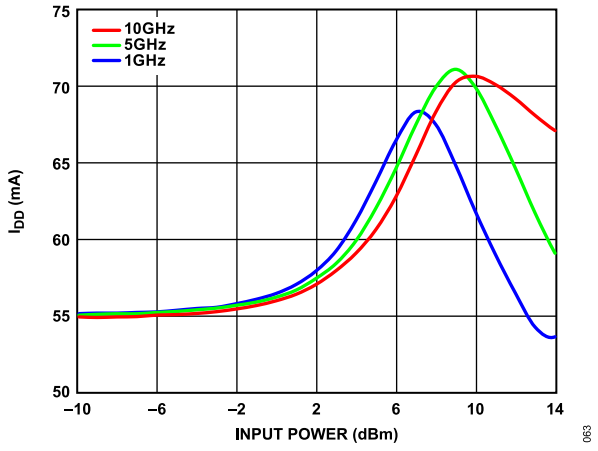


*Figure 63. $I_{DD}$ vs. Input Power for Various Frequencies, $V_{DD}$ = 5 V*


*Figure 66. Additive Phase Noise vs. Offset Frequency, RF Frequency = 6 GHz, RF Input Power = 0 dBm*

## TYPICAL PERFORMANCE CHARACTERISTICS

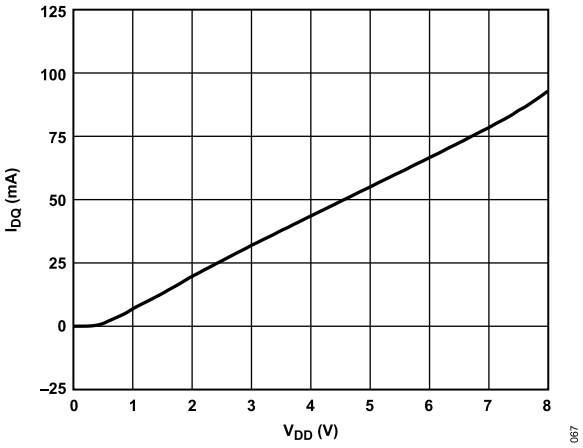


*Figure 67. $I_{DQ}$ vs. $V_{DD}$, Representative of a Typical Device, $R_{BIAS}$ = 1.1 kΩ*

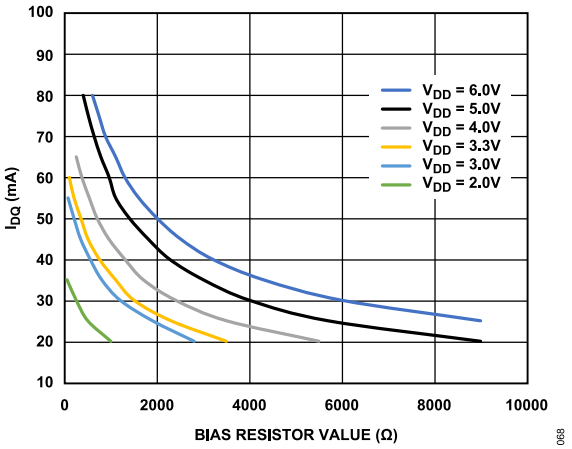


*Figure 68. $I_{DQ}$ vs. Bias Resistor Value and at Various $V_{DD}$ Values*

## THEORY OF OPERATION

The HMC8411LP2FE is a GaAs, MMIC, pHEMT, low noise wideband amplifier.

The HMC8411LP2FE has single-ended input and output ports with impedances that nominally equal 50 Ω over the 0.01 GHz to 10 GHz frequency range. As a result, the device can be directly inserted into a 50 Ω system with external components on the RF input and output, as shown in Figure 70, without narrow-banded matching solutions. An external bias inductor and dc blocking capacitor are required on the VDD/RFOUT pin. A dc blocking capacitor is also required on the RFIN pin. On the RF input, there is an additional resistor, inductor, and capacitor (RLC) shunt network that ensures unconditional stability below 100 MHz. The bias current of the device is set by a resistor that is connected between the RBIAS pin and the supply voltage.

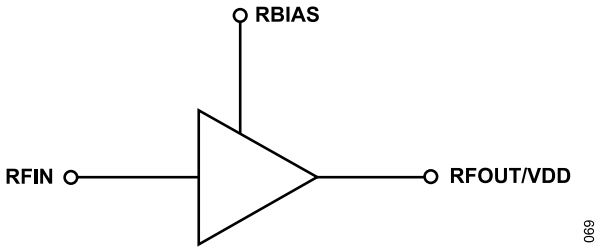


*Figure 69. Simplified HMC8411LP2FE Block Diagram*

## APPLICATIONS INFORMATION

The basic connections for operating the HMC8411LP2FE are shown in Figure 70. AC couple the input and output of the HMC8411LP2FE with appropriately sized capacitors. 100 nF capacitors are recommended (ATC531Z104KT16T). A 5 V dc bias is supplied to the amplifier through the choke inductor connected to the VDD/RFOUT pin.

A 1.1 kΩ resistor connected between the RBIAS pin and the 5 V supply voltage sets the bias current to 55 mA .

Refer to Table 7 and Figure 68 for the recommended resistor values to set different bias currents.

## RECOMMENDED BIAS SEQUENCING

### During Power-Up

The recommended bias sequence during power-up follows:

1. Set $V_{DD}$ to 5 V.
2. Apply the RF signal.

### During Power-Down

The recommended bias sequence during power-down follows:

1. Turn off the RF signal.
2. Set $V_{DD}$ to 0 V.

*Table 7. Recommended Bias Resistor Values*

| $R_{BIAS}$ (Ω) | $I_{DQ}$ (mA) | $I_{DQ\_AMP}$ (mA) | $I_{RBIAS}$ (mA) |
|---|---|---|---|
| 400 | 80 | 75.97 | 4.03 |
| 510 | 75 | 71.32 | 3.68 |
| 635 | 70 | 66.64 | 3.36 |
| 780 | 65 | 61.95 | 3.05 |
| 960 | 60 | 57.27 | 2.73 |
| 1100 | 55 | 52.47 | 2.53 |
| 1400 | 50 | 47.82 | 2.18 |
| 1800 | 45 | 43.16 | 1.84 |
| 2270 | 40 | 38.45 | 1.55 |
| 3000 | 35 | 33.75 | 1.25 |
| 4000 | 30 | 29.15 | 0.85 |
| 5700 | 25 | 24.93 | 0.07 |
| 9000 | 20 | 19.95 | 0.05 |

## TYPICAL APPLICATION CIRCUIT

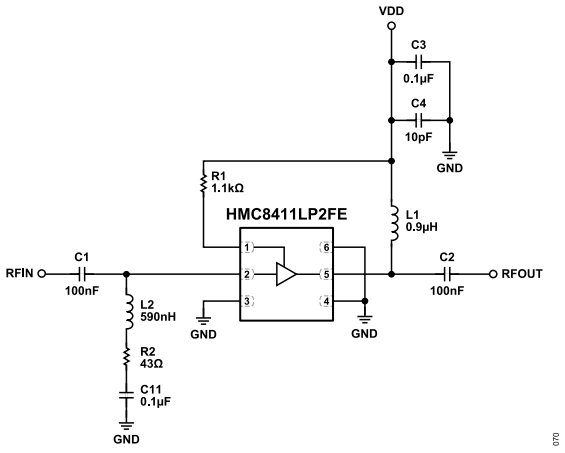


*Figure 70. Typical Application Circuit*

## EVALUATION BOARD

The EV1HMC8411LP2F evaluation board is a 4-layer board fabricated using Rogers 4350 and using best practices for high frequency RF design. The RF input and RF output traces have a 50 Ω characteristic impedance.

The evaluation board and populated components operate over the −40°C to +85°C ambient temperature range. For proper bias sequence, see the Applications Information section.

The evaluation board schematic is shown in Figure 72.

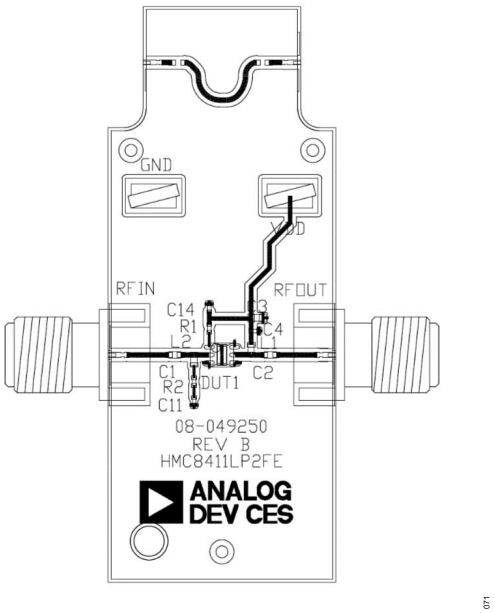


*Figure 71. EV1HMC8411LP2F Printed Circuit Board (PCB)*

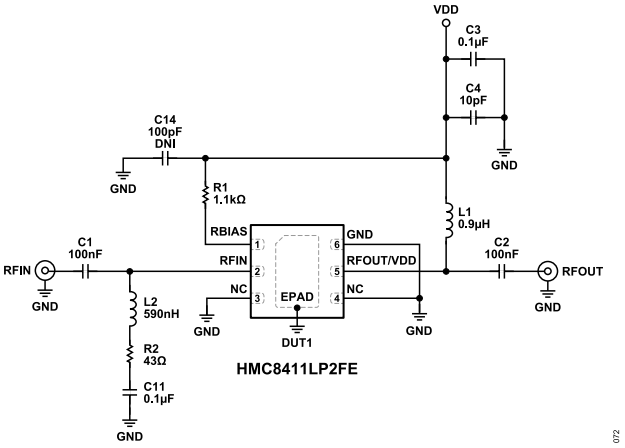


*Figure 72. EV1HMC8411LP2F Evaluation Board Schematic*

*Table 8. Bill of Materials for Evaluation PCB EV1HMC8411LP2F*

| Item | Description |
|---|---|
| RFIN, RFOUT | PCB mount SMA RF connectors, SRI 21-146-1000-01 |
| VDD, GND | DC bias test points |
| C1, C2 | 100 nF broadband dc blocking capacitors, ATC531Z104KT16T |
| C3 | Capacitor, 0.1 µF, 0402 package |
| C4 | Capacitor, 10 pF, 0201 package |
| C11 | Capacitor, 0.1 µF, 0201 package |
| L1 | Inductor, 0.9 µH, 0402, 5% ferrite, Coilcraft 0402DF-901XJRW |

## EVALUATION BOARD

*Table 8. Bill of Materials for Evaluation PCB EV1HMC8411LP2F*

| Item | Description |
|---|---|
| L2 | Inductor, 590 nH, 0402, 5% ferrite, Coilcraft 0402DF-591XJRU |
| R1 | 1.1 kΩ resistor, 0201 package |
| R2 | 43 Ω resistor, 0201 package |
| DUT1 | IC, HMC8411LP2FE |