8 GHz to 14 GHz, Low Noise Amplifier

FEATURES

- Single positive supply (self biased) typical: 1.5 V and 35 mA
- RBIAS drain current adjustment pin
- Gain: 28.5 dB from 8 GHz to 10 GHz
- Noise figure: 1 dB from 8 GHz to 10 GHz
- Extended operating temperature range: −55°C to +125°C
- Internally matched and AC-coupled
- RoHS-compliant, 2 mm × 2 mm, 8-lead LFCSP

APPLICATIONS

- Satellite communications
- Radar
- Telecommunications

GENERAL DESCRIPTION

The ADL8143 is a low noise amplifier (LNA) that operates from 8 GHz to 14 GHz. The typical gain, noise figure, output power for 1 dB compression (OP1dB), and output third-order intercept (OIP3) are 28.5 dB, 1 dB, 7.5 dBm, and 19.5 dBm, respectively, from 8 GHz to 10 GHz. The nominal quiescent current (I_{DQ}), which can be adjusted, is 35 mA from a 1.5 V supply voltage (V_{DD}). The ADL8143 also features inputs and outputs that are AC-coupled and internally matched to 50 Ω.

The ADL8143 is housed in an RoHS-compliant, 2 mm × 2 mm, 8-lead lead frame chip scale package [LFCSP] and is specified for operation from −55°C to +125°C.

FUNCTIONAL BLOCK DIAGRAM

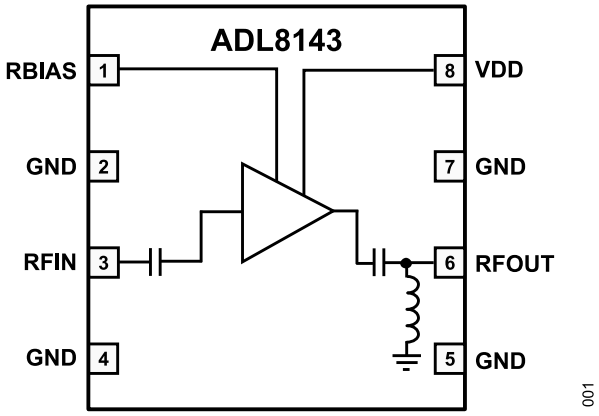

Figure 1. Functional Block Diagram

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REVISION HISTORY

7/2024—Revision 0: Initial Version

SPECIFICATIONS

8 GHZ TO 10 GHZ FREQUENCY RANGE

Supply voltage (V_{DD}) = 1.5 V, quiescent current (I_{DQ}) = 35 mA, bias resistance (R_{BIAS}) = 487 Ω, and T_{CASE} = 25°C, unless otherwise noted.

Table 1. 8 GHz to 10 GHz Frequency Range

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
FREQUENCY RANGE	8		10	GHz	
GAIN	26.5	28.5		dB	
Gain Variation over Temperature		0.026		dB/°C	
NOISE FIGURE		1		dB	
RETURN LOSS					
Input (S11)		11		dB	
Output (S22)		19		dB	
OUTPUT					
OP1dB	5.5	7.5		dBm	
Saturated Output Power (P_{SAT})		9		dBm	
OIP3		19.5		dBm	Measurement taken at output power (P_{OUT}) per tone = −6 dBm
Second-Order Intercept (OIP2)		14		dBm	Measurement taken at P_{OUT} per tone = −6 dBm
POWER ADDED EFFICIENCY (PAE)		15.53		%	Measured at P_{SAT}

10 GHZ TO 14 GHZ FREQUENCY RANGE

V_{DD} = 1.5 V, I_{DQ} = 35 mA, R_{BIAS} = 487 Ω, and T_{CASE} = 25°C, unless otherwise noted.

Table 2. 10 GHz to 14 GHz Frequency Range Specifications

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
FREQUENCY RANGE	10		14	GHz	
GAIN	26.5	28.5		dB	
Gain Variation over Temperature		0.029		dB/°C	
NOISE FIGURE		1.1		dB	
RETURN LOSS					
S11		17		dB	
S22		15		dB	
OUTPUT					
OP1dB	6.5	8.5		dBm	
P_{SAT}		10		dBm	
OIP3		22		dBm	Measurement taken at P_{OUT} per tone = −6 dBm
OIP2		22.5		dBm	Measurement taken at P_{OUT} per tone = −6 dBm
PAE		19.91		%	

DC SPECIFICATIONS

Table 3. DC Specifications

Parameter	Min	Typ	Max	Unit
SUPPLY CURRENT				
I_{DQ}		35		mA
Amplifier Current (I_{DQ_AMP})		33.2		mA
R_{BIAS} Current (I_{RBIAS})		1.8		mA
SUPPLY VOLTAGE				
V_{DD}	1.2	1.5	3.5	V

ABSOLUTE MAXIMUM RATINGS

Table 4. Absolute Maximum Ratings

Parameter	Rating
V_{DD}	4 V
RF Input Power (RF_{IN})	20 dBm
Continuous Power Dissipation (P_{DISS}), T_{CASE} = 85°C (Derate 10.6 mW/°C Above 85°C)	0.95 W
Temperature	
Storage Range	−65°C to +150°C
Operating Range	−55°C to +125°C
Quiescent Channel (T_{CASE} = 85°C, V_{DD} = 1.5 V, I_{DQ} = 35 mA, Input Power (P_{IN}) = Off)	89.95°C
Maximum Channel	175°C

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. Careful attention to PCB thermal design is required.

θ_{JC} is the channel-to-case thermal resistance.

Table 5. Thermal Resistance

Package Type	θ_{JC}	Unit
CP-8-30		
Quiescent, T_{CASE} = 25°C	80.4	°C/W
Worst Case,[1] T_{CASE} = 85°C	94.3	°C/W

[1] Worst case across all specified operating conditions.

ELECTROSTATIC DISCHARGE (ESD) RATINGS

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

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

ESD Ratings for ADL8143

Table 6. ADL8143, 8-Lead LFCSP

ESD Model	Withstand Threshold (V)	Class
HBM	±300	1A

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

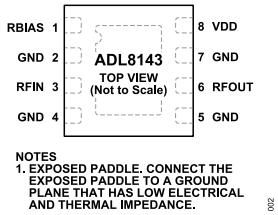

Figure 2. Pin Configuration

Table 7. Pin Function Descriptions

Pin No.	Mnemonic	Description
1	RBIAS	Bias Setting Resistor. Connect a resistor between RBIAS and VDD to set the I_{DQ}. See Figure 49 and Table 8 for more details. See Figure 3 for the interface schematic.
2, 4, 5, 7	GND	Ground. Connect to a ground plane that has low electrical and thermal impedance. See Figure 6 for the interface schematic.
3	RFIN	RF Input. The RFIN pin is AC-coupled and matched to 50 Ω. See Figure 4 for the interface schematic.
6	RFOUT	RF Output. The RFOUT pin has a resistive path to ground and an AC-coupling capacitor in the RF signal path and matched to 50 Ω. If the DC bias level of the next stage is not equal to 0 V, externally AC-couple the RFOUT pin. See Figure 5 for the interface schematic.
8	VDD	Drain Bias. Connect the VDD pin to the supply voltage. See Figure 5 for the interface schematic.
	GROUND PADDLE	Ground Paddle. Connect the ground paddle to a ground plane that has low electrical and thermal impedance.

INTERFACE SCHEMATICS

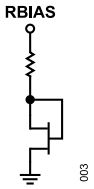

Figure 3. RBIAS Interface Schematic

Figure 4. RFIN Interface Schematic

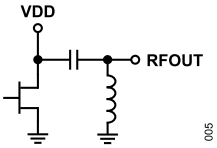

Figure 5. RFOUT/VDD Interface Schematic

Figure 6. GND Interface Schematic

TYPICAL PERFORMANCE CHARACTERISTICS

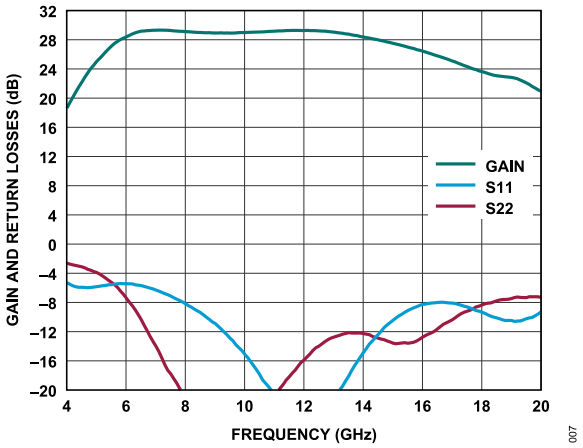

Figure 7. Gain and Return Loss vs. Frequency, 4 GHz to 20 GHz, V_{DD} = 1.5 V, I_{DQ} = 35 mA, and R_{BIAS} = 487 Ω

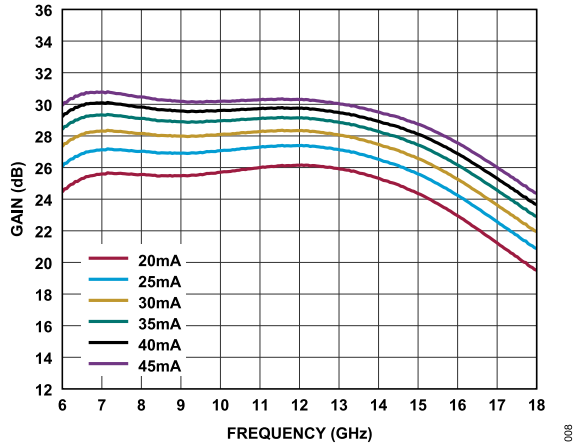

Figure 8. Gain vs. Frequency for Various I_{DQ}, V_{DD} = 1.5 V

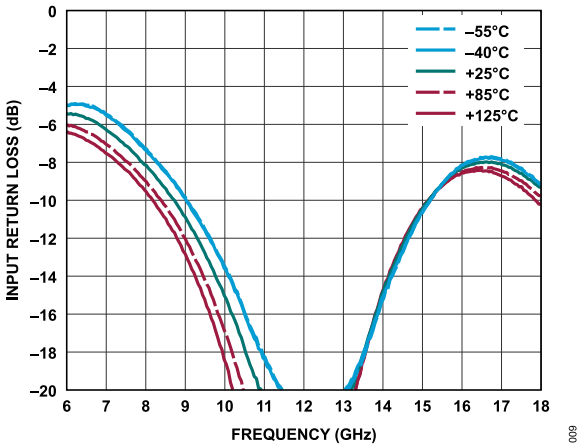

Figure 9. Input Return Loss vs. Frequency for Various Temperatures, V_{DD} = 1.5 V , I_{DQ} = 35 mA, and R_{BIAS} = 487 Ω

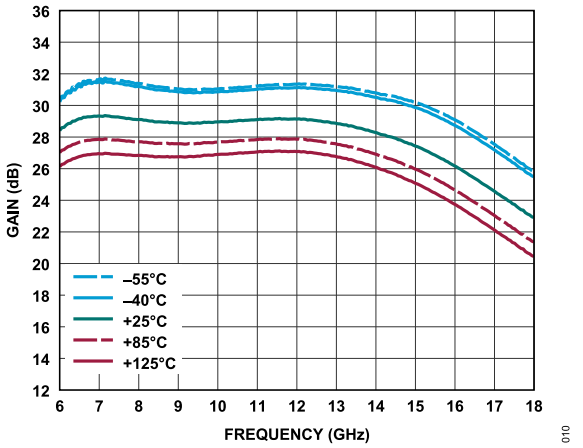

Figure 10. Gain vs. Frequency for Various Temperatures, V_{DD} = 1.5 V, I_{DQ} = 35 mA, and R_{BIAS} = 487 Ω

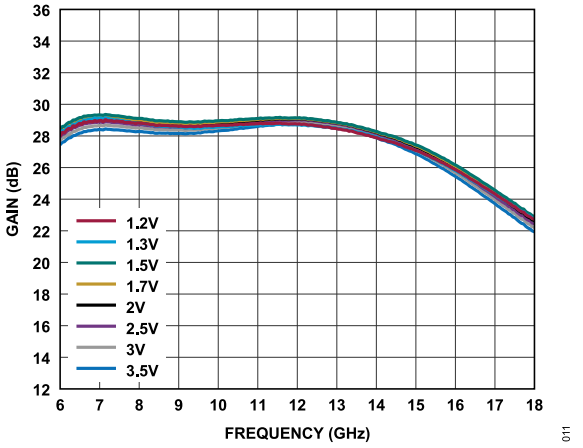

Figure 11. Gain vs. Frequency for Various Supply Voltages, I_{DQ} = 35 mA

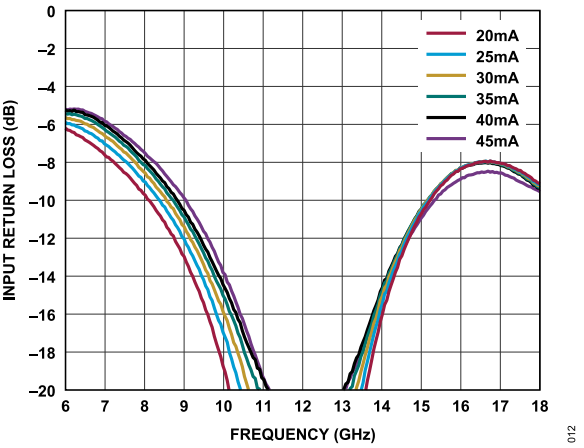

Figure 12. Input Return Loss vs. Frequency for Various I_{DQ}, V_{DD} = 1.5 V

TYPICAL PERFORMANCE CHARACTERISTICS

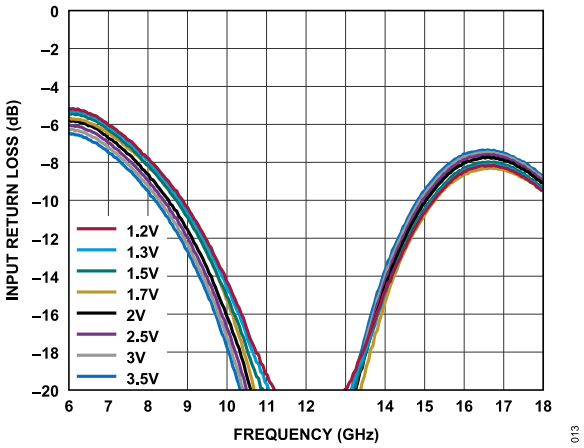

Figure 13. Input Return Loss vs. Frequency for Various Supply Voltages, I_{DQ} = 35 mA

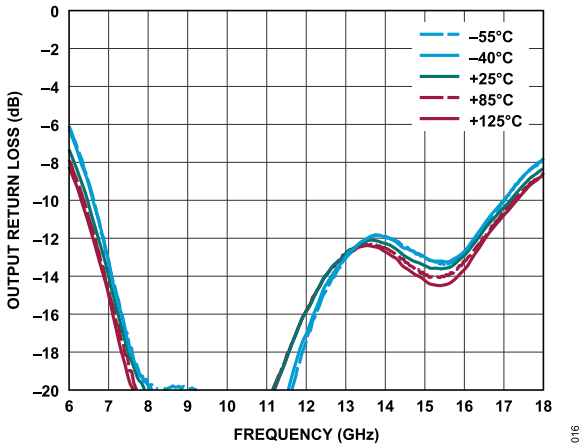

Figure 16. Output Return Loss vs. Frequency for Various Temperatures, V_{DD} = 1.5 V, I_{DQ} = 35 mA, and R_{BIAS} = 487 Ω

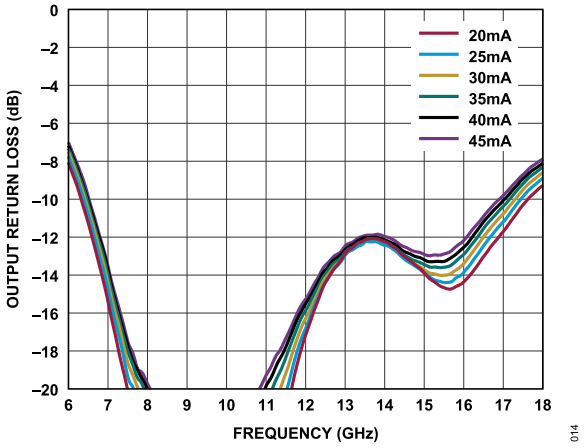

Figure 14. Output Return Loss vs. Frequency for Various I_{DQ}, V_{DD} = 1.5 V

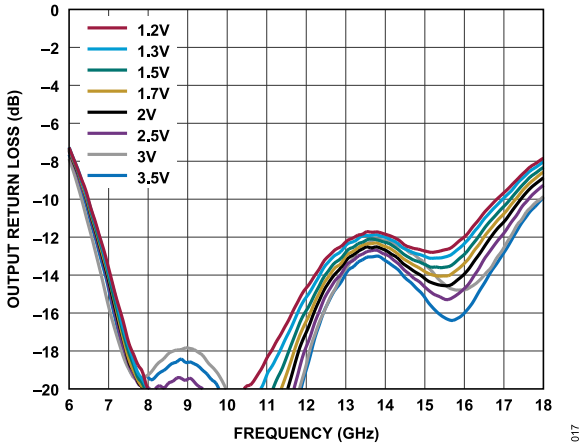

Figure 17. Output Return Loss vs. Frequency for Various Supply Voltages, I_{DQ} = 35 mA

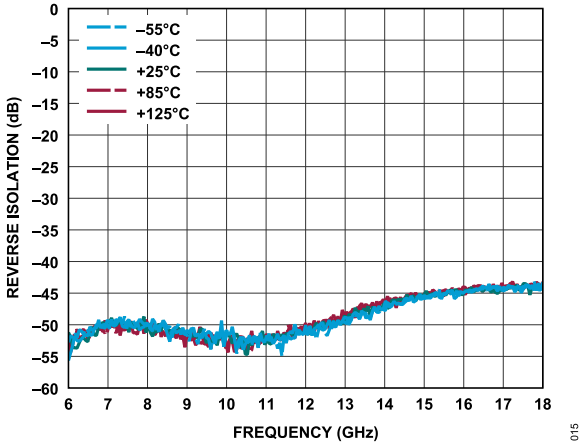

Figure 15. Reverse Isolation vs. Frequency for Various Temperatures, V_{DD} = 1.5 V, I_{DQ} = 35 mA, and R_{BIAS} = 487 Ω

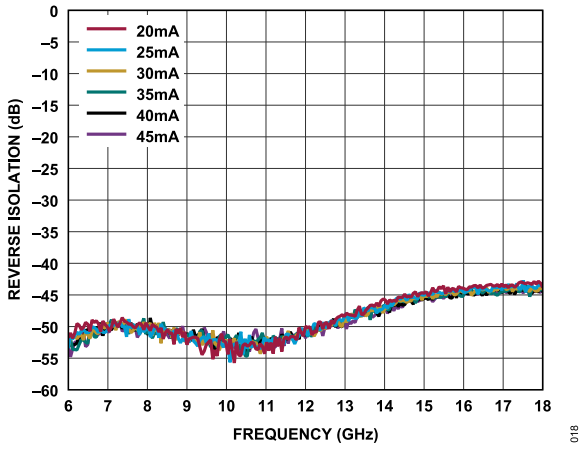

Figure 18. Reverse Isolation vs. Frequency for Various I_{DQ}, V_{DD} = 1.5 V

TYPICAL PERFORMANCE CHARACTERISTICS

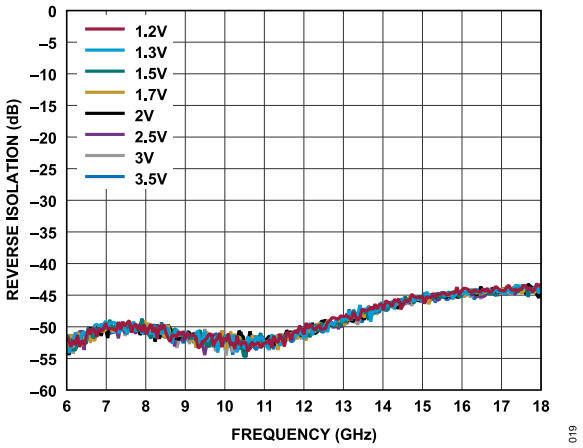

Figure 19. Reverse Isolation vs. Frequency for Various Supply Voltages, I_{DQ} = 35 mA

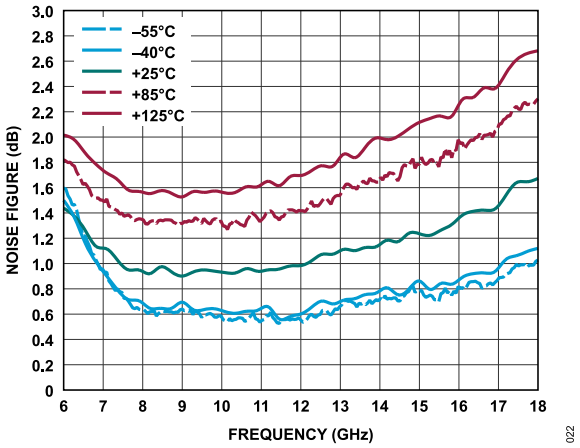

Figure 22. Noise Figure vs. Frequency for Various Temperatures, V_{DD} = 1.5 V, I_{DQ} = 35 mA, and R_{BIAS} = 487 Ω

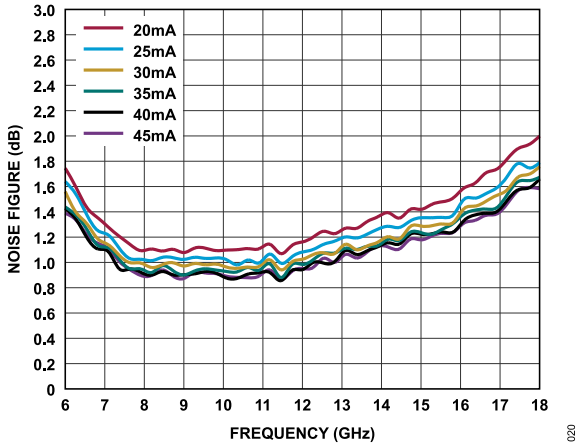

Figure 20. Noise Figure vs. Frequency for Various I_{DQ}, V_{DD} = 1.5 V

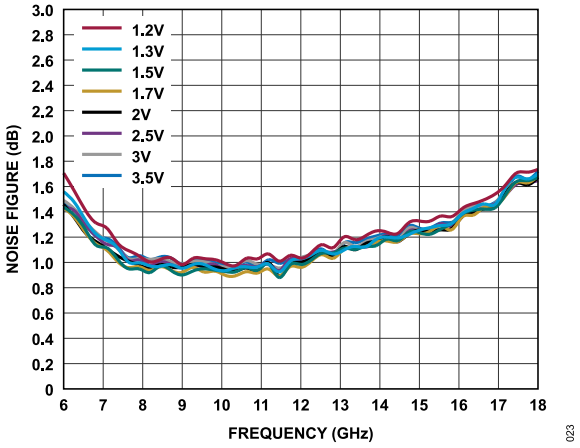

Figure 23. Noise Figure vs. Frequency for Various Supply Voltages, I_{DQ} = 35 mA

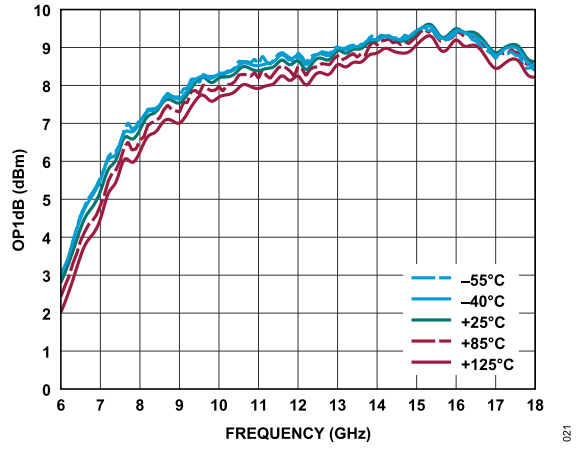

Figure 21. OP1dB vs. Frequency for Various Temperatures, V_{DD} = 1.5 V, I_{DQ} = 35 mA, and R_{BIAS} = 487 Ω

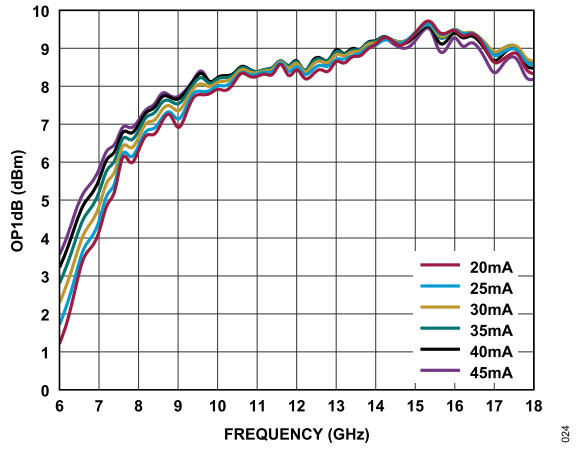

Figure 24. OP1dB vs. Frequency for Various I_{DQ}, V_{DD} = 1.5 V

TYPICAL PERFORMANCE CHARACTERISTICS

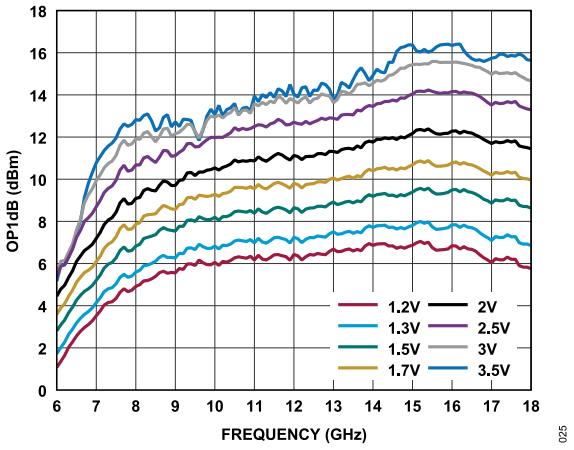

Figure 25. OP1dB vs. Frequency for Various Supply Voltages, I_{DQ} = 35 mA

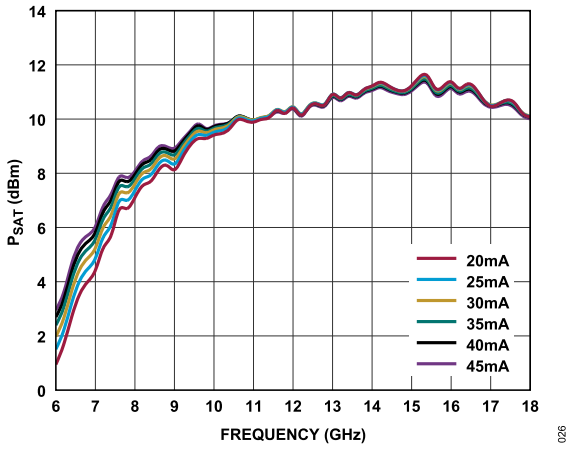

Figure 26. P_{SAT} vs. Frequency for Various I_{DQ}, V_{DD} = 1.5 V

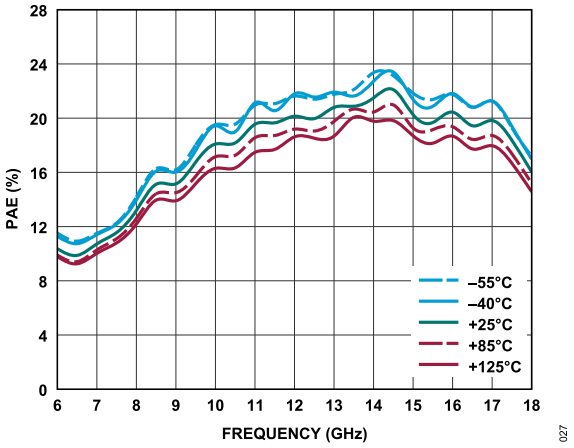

Figure 27. PAE measured at P_{SAT} vs. Frequency for Various Temperatures, V_{DD} = 1.5 V, I_{DQ} = 35 mA, and R_{BIAS} = 487 Ω

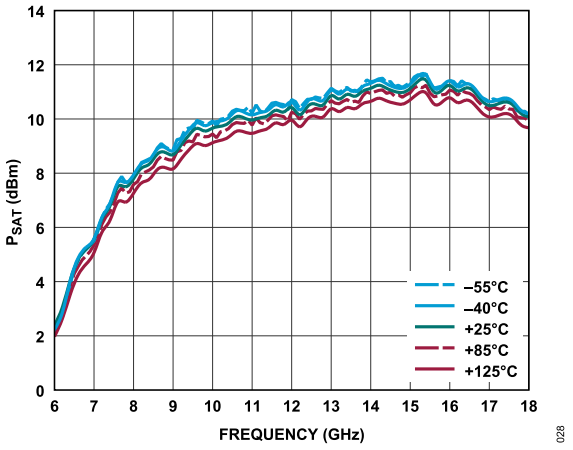

Figure 28. P_{SAT} vs. Frequency for Various Temperatures, V_{DD} = 1.5 V, I_{DQ} = 35 mA, and R_{BIAS} = 487 Ω

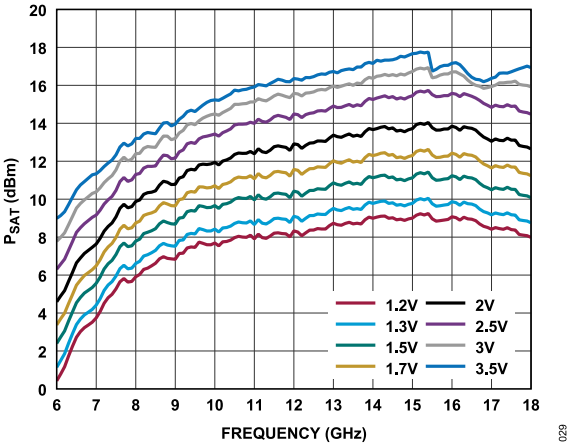

Figure 29. P_{SAT} vs. Frequency for Various Supply Voltages, I_{DQ} = 35 mA

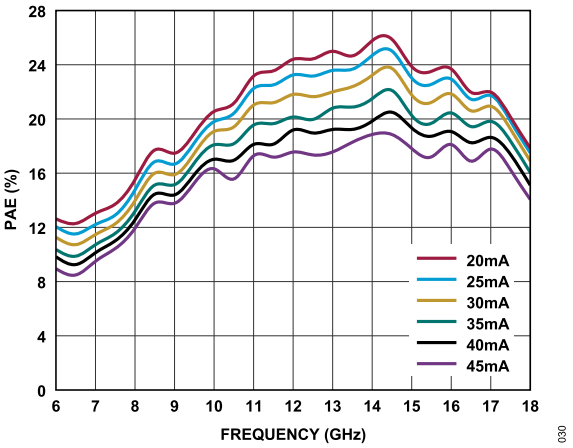

Figure 30. PAE Measured at P_{SAT} vs. Frequency for Various I_{DQ}, V_{DD} = 1.5 V

TYPICAL PERFORMANCE CHARACTERISTICS

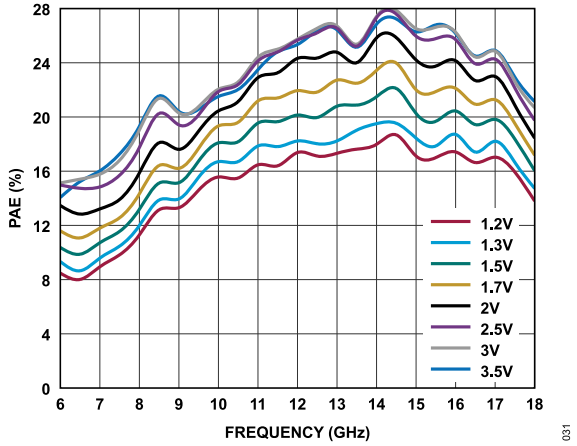

Figure 31. PAE Measured at P_{SAT} vs. Frequency for Various Supply Voltages, I_{DQ} = 35 mA

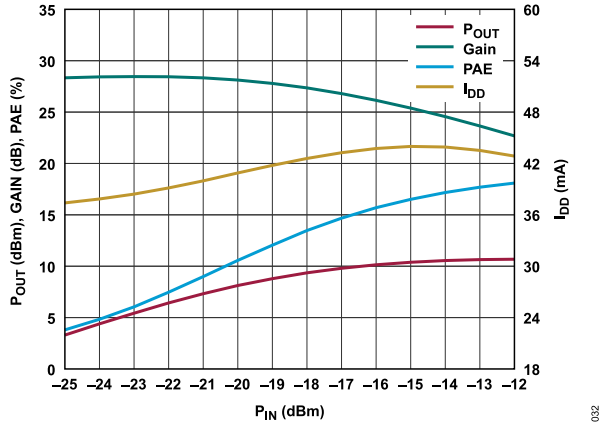

Figure 32. P_{OUT}, Gain, PAE, and I_{DD} vs. P_{IN}, Power Compression at 10 GHz, V_{DD} = 1.5 V, and R_{BIAS} = 487 Ω

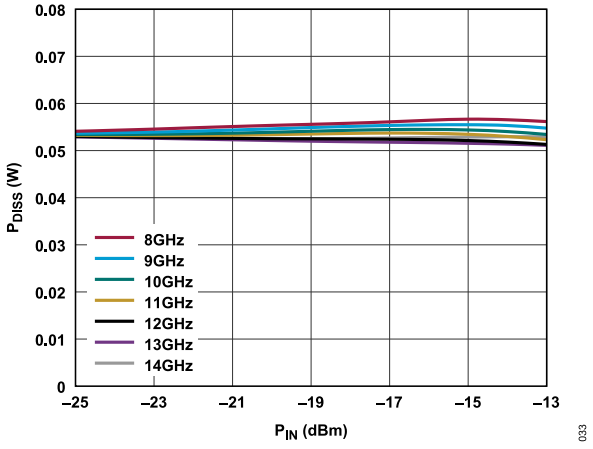

Figure 33. P_{DISS} vs. P_{IN} at Various Frequencies, T_{CASE} = 85°C and V_{DD} = 1.5 V

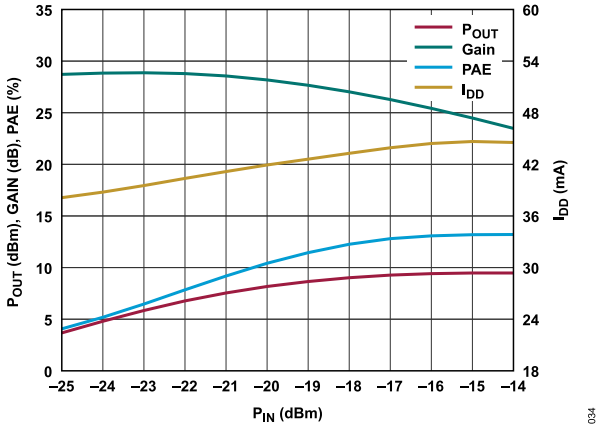

Figure 34. P_{OUT}, Gain, PAE, and I_{DD} vs. P_{IN}, Power Compression at 8 GHz, V_{DD} = 1.5 V, and R_{BIAS} = 487 Ω

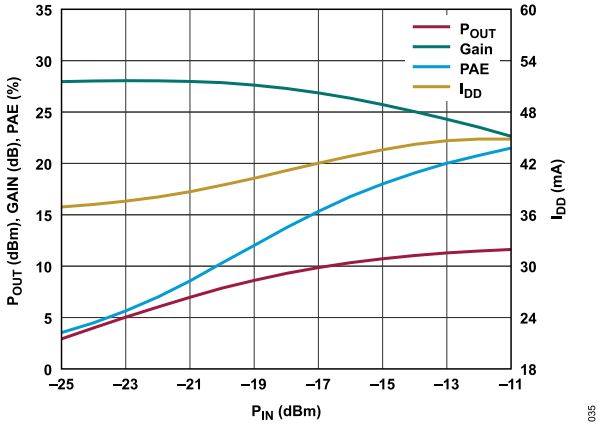

Figure 35. P_{OUT}, Gain, PAE, and I_{DD} vs. P_{IN}, Power Compression at 14 GHz, V_{DD} = 1.5 V, and R_{BIAS} = 487 Ω

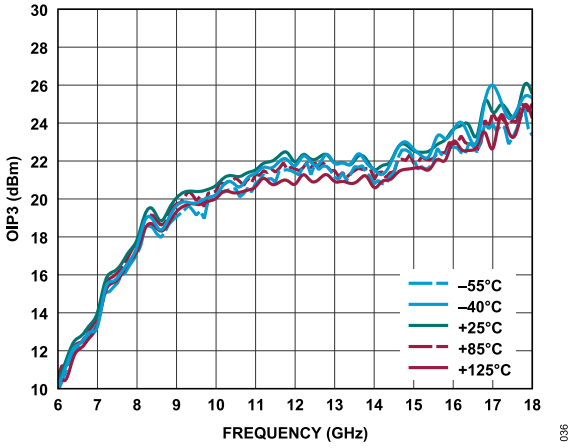

Figure 36. OIP3 vs. Frequency for Various Temperatures, V_{DD} = 1.5 V, I_{DQ} = 35 mA, and R_{BIAS} = 487 Ω

TYPICAL PERFORMANCE CHARACTERISTICS

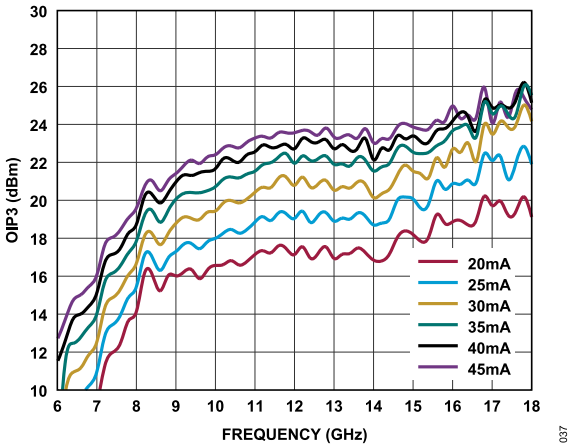

Figure 37. OIP3 vs. Frequency for Various I_{DQ}, V_{DD} = 1.5 V

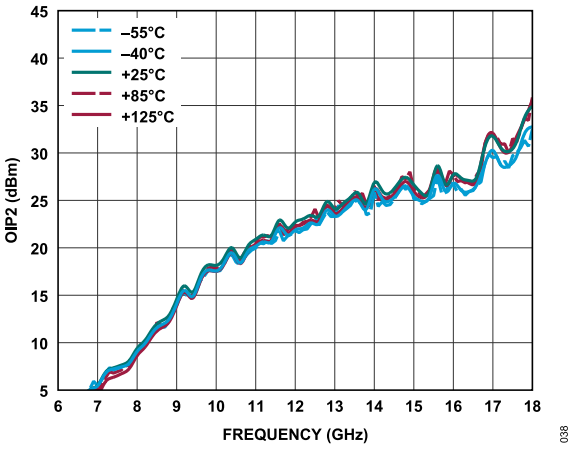

Figure 38. OIP2 vs. Frequency for Various Temperatures, V_{DD} = 1.5 V, I_{DQ} = 35 mA, and R_{BIAS} = 487 Ω

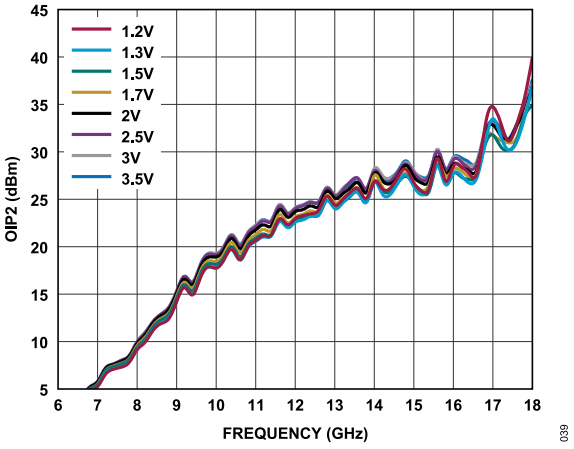

Figure 39. OIP2 vs. Frequency for Various Supply Voltages, I_{DQ} = 35 mA

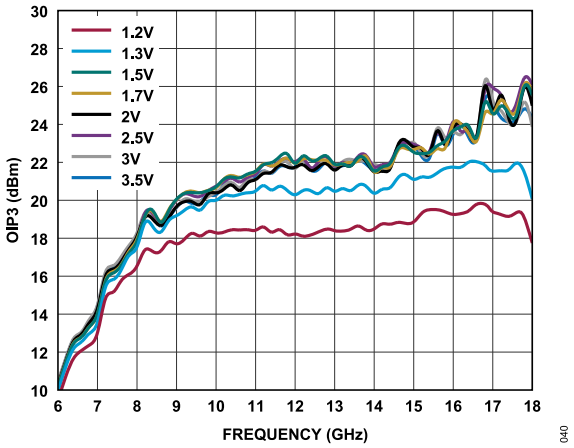

Figure 40. OIP3 vs. Frequency for Various Supply Voltages, I_{DQ} = 35 mA

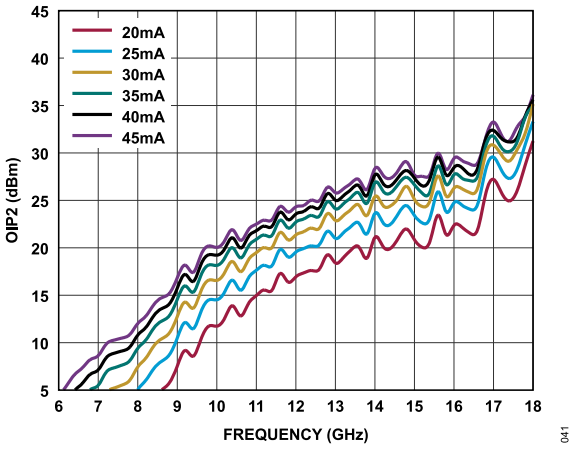

Figure 41. OIP2 vs. Frequency for Various I_{DQ}, V_{DD} = 1.5 V

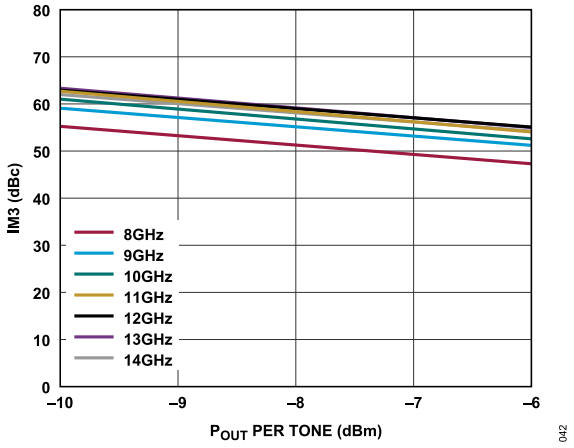

Figure 42. IM3 vs. P_{OUT} Per tone for Various Frequencies, V_{DD} = 1.5 V and R_{BIAS} = 487 Ω

TYPICAL PERFORMANCE CHARACTERISTICS

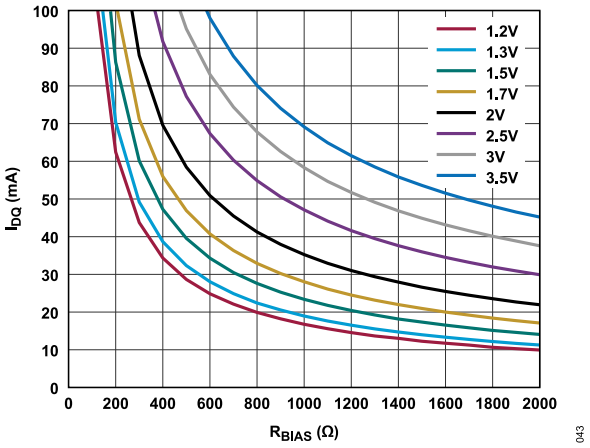

Figure 43. I_{DQ} vs. R_{BIAS} at Various Supply Voltages, 0 Ω to 2 kΩ

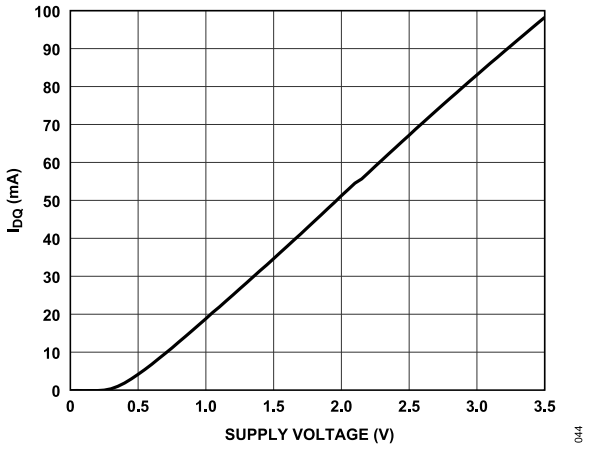

Figure 44. I_{DQ} vs. Supply Voltage, R_{BIAS} = 487 Ω

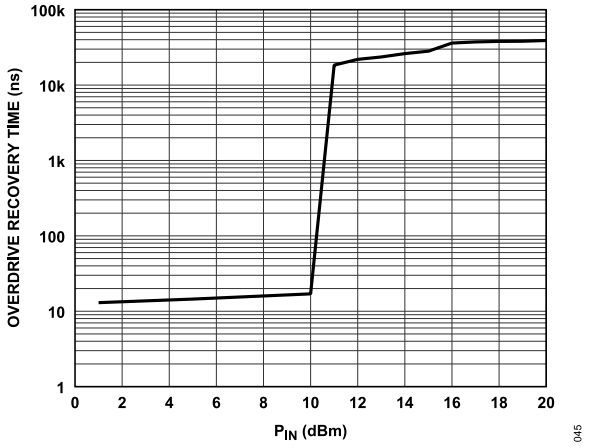

Figure 45. Overdrive Recovery Time vs. P_{IN} at 12 GHz, Recovery to Within 90% of Small Signal Gain Value, V_{DD} = 1.5 V, and R_{BIAS} = 487Ω

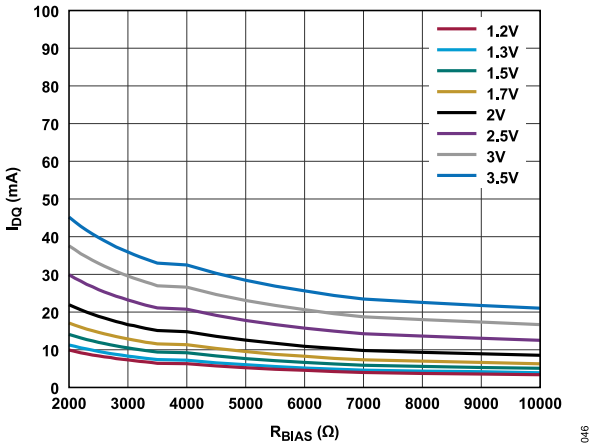

Figure 46. I_{DQ} vs. R_{BIAS} at Various Supply Voltages, 2 kΩ to 10 kΩ

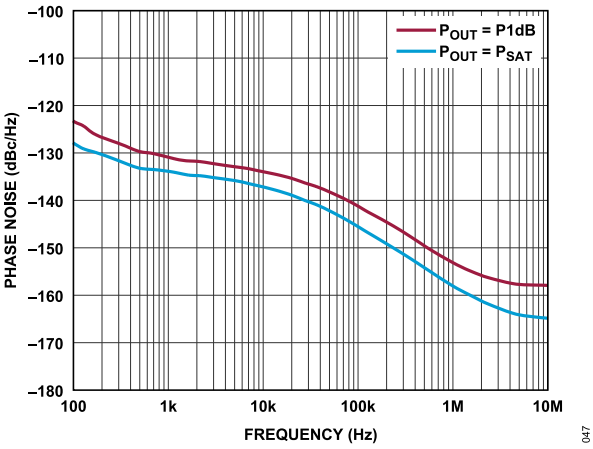

Figure 47. Phase Noise vs. Frequency at 10 GHz for Various P_{OUT} Values

THEORY OF OPERATION

The ADL8143 is a wideband LNA that operates from 8 GHz to 14 GHz. A simplified block diagram is shown in Figure 48.

The ADL8143 has internally AC-coupled, single-ended input and output ports with an impedance that is nominally equal to 50 Ω over the specified frequency range. While the RF output path is AC-coupled, there is a DC path to ground on the RFOUT side of the AC-coupling capacitor. No external matching components are required. To adjust I_{DQ}, connect an external resistor near the RBIAS pin.

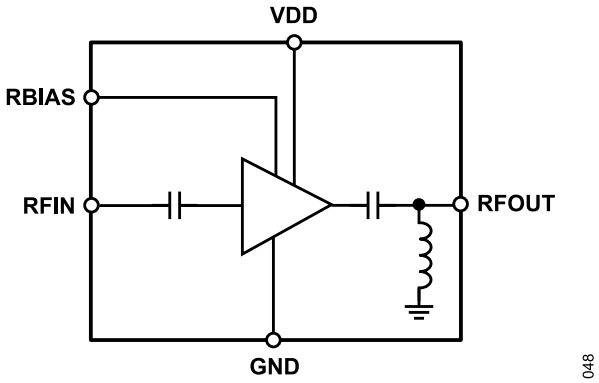

Figure 48. Simplified Schematic

APPLICATIONS INFORMATION

The basic connections for operating the ADL8143 from 8 GHz to 14 GHz are shown in Figure 49. No external biasing inductor is required, allowing a 1.5 V supply to be connected to the VDD pin. It is recommended to use 0.1 µF and 100 pF power supply decoupling capacitors. The power supply decoupling capacitors shown in Figure 49 represent the configuration used to characterize and qualify the ADL8143.

To set the I_{DQ}, connect a resistor, R2, between the RBIAS and VDD pins. A default value of 487 Ω is recommended that results in a nominal I_{DQ} of 35 mA. The RBIAS pin also draws a current that varies with the value of R_{BIAS}. Table 8 and Table 9 show the recommended R_{BIAS} values with the associated I_{DQ} values. Do not leave the RBIAS pin open.

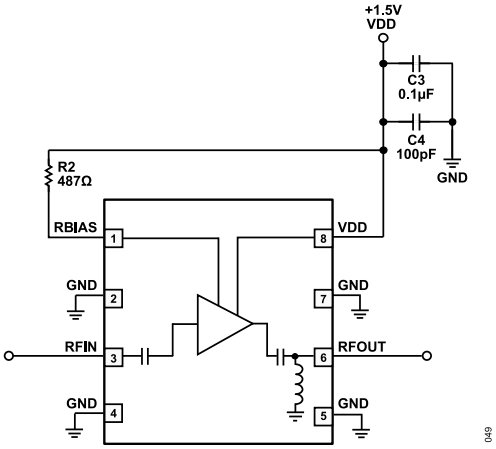

Figure 49. Typical Application Circuit

RECOMMENDED BIAS SEQUENCING

The correct sequencing of the DC and RF power is required to safely operate the ADL8143. During power-up, apply V_{DD} before the RF power is applied to RFIN, and during power-off, remove the RF power from RFIN before V_{DD} is powered off.

Table 8. Recommended Bias Resistor Values for Various I_{DQ} Values, V_{DD} = 1.5 V

R_{BIAS} (Ω)	I_{DQ} (mA)	I_{DQ_AMP} (mA)	I_{RBIAS} (mA)
1171	20	19.1	0.9
835	25	23.8	1.2
629	30	28.5	1.5
487	35	33.1	1.9
398	40	37.8	2.2
329	45	42.4	2.6

Table 9. Recommended Bias Resistor Values for Various Supply Voltages, I_{DQ} = 35 mA

R_{BIAS} (Ω)	V_{DD} (V)
295	1.2
356	1.3
487	1.5
652	1.7
933	2.0
1494	2.5
2190	3.0
3091	3.5

USING RBIAS AS A FAST ENABLE AND DISABLE FUNCTION

The RBIAS pin can be used as a fast enable and disable control input. By incorporating a single-pole, double throw (SPDT) switch to the RBIAS pin, an enable and/or disable circuit can be implemented as shown in Figure 50. The ADG719 complementary metal-oxide semiconductor (CMOS) switch is used to connect the RBIAS resistor between GND and 1.8 V. When the RBIAS resistor is connected to ground and the RF input level is −20 dBm, the overall current consumption reduces to less than 1 mA. Figure 51 shows a plot of the turn on and/or turn off response time of the RF output envelope when the IN pin of the ADG719 is pulsed. Note that because the ADG719 has a minimum supply voltage of 1.8 V, the supply voltage for ADG719 and ADL8143 has been set to 1.8 V instead of 1.5 V to satisfy that requirement.

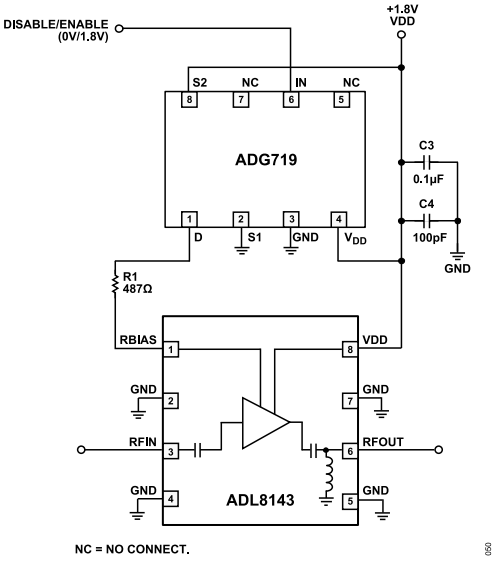

Figure 50. Fast Enable and Disable Using a 0 V to 1.8 V Pulse on the RBIAS Resistor

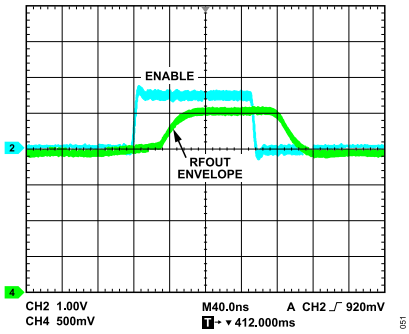

Figure 51. On and/or Off Response of the RFOUT Envelope When the IN Pin of the ADG719 Is Pulsed

RECOMMENDED POWER MANAGEMENT CIRCUIT

Figure 52 shows a recommended power management circuit that uses the LT3083 low dropout (LDO) regulator. The LT3083 output load current is supplied to the IN pin. Power for the on-board control is applied to the $V_{CONTROL}$ pin. A voltage that is at least 1.4 V higher than the output voltage must be applied to the $V_{CONTROL}$ pin. In Figure 52, $V_{CONTROL}$ has been set to 5 V but could be set as low as 2.9 V for a 1.5 V output voltage. The current into the $V_{CONTROL}$ pin is typically 1.7% of the total output current.

The LT3083 can provide up to 3 A of load current. In a phased array application, a single LT3083 can easily provide bus power for all of the ADL8143 devices in a 64-element array. A dropout voltage of 500 mV is assumed based on a load current of 3 A. If the required load current is lower, the voltage on the IN pin of the LT3083 can be reduced to improve efficiency. For example, for a load current of 1 A, the dropout voltage drops to a worst-case value of 160 mV.

For applications that require a lower dropout voltage, the LT3033 can be used. For a 3 A load, the worst-case dropout voltage is 240 mV in the LT3033.

Table 10 provides recommended resistor values to set the other output voltages. In each case, the minimum V_{IN} voltage is specified based on a 3 A load and a 500 mV dropout voltage.

Table 10. Recommended Resistor Values for the Various LDO Output Voltages

LDO V_{OUT} (V)	R2 (kΩ)	Minimum V_{DD} (V)
1.2	24.3	1.7
1.5	30.1	2.0
2.0	40.2	2.5
2.5	49.9	3.0
3.0	60.4	3.5
3.3	66.5	3.8
3.5	69.8	4.0

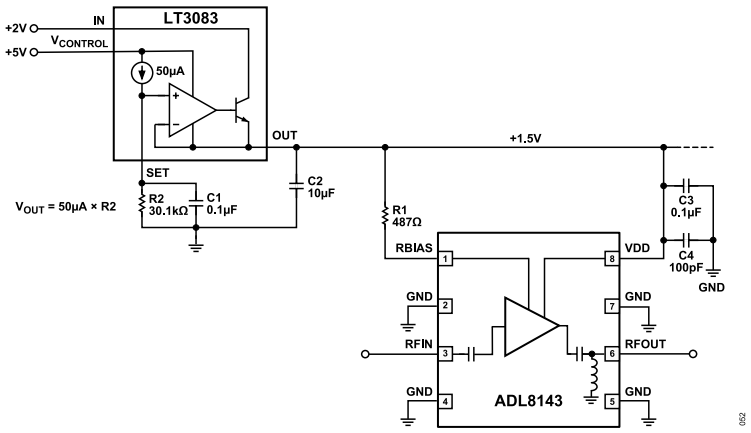

Figure 52. Recommended Power Management Circuit

OUTLINE DIMENSIONS

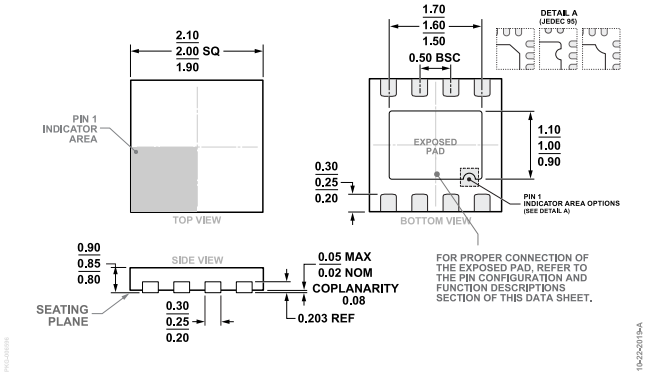

Figure 53. 8-Lead Lead Frame Chip Scale Package [LFCSP]
2 mm × 2 mm Body and 0.85 mm Package Height
(CP-8-30)
Dimensions shown in millimeters

ORDERING GUIDE

Model[1,2]	Temperature Range	Package Description	Packing Quantity	Package Option
ADL8143ACPZN	−55°C to +125°C	8-Lead LFCSP, 2 mm × 2 mm × 0.85 mm	Tape, 1	CP-8-30
ADL8143ACPZN-R7	−55°C to +125°C	8-Lead LFCSP, 2 mm × 2 mm × 0.85 mm	Reel, 3000	CP-8-30

[1] Z = RoHS Compliant Part.

[2] The lead finish of ADL8143ACPZN and ADL8143ACPZN-R7 is nickel palladium gold.

EVALUATION BOARDS

Model[1]	Description
ADL8143-EVALZ	Evaluation Board

[1] Z = RoHS Compliant Part.

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Analog Devices Inc.:

ADL8143ACPZN-R7-CSL ADL8143ACPZN-CSL