

## FEATURES

- ▶ Low noise figure: 1.4 dB typical at 0.4 GHz to 3 GHz
- ▶ Single positive supply (self biased)
- ▶ High gain:  $\leq 15.5$  dB typical
- ▶ High OIP3:  $\leq 33$  dBm typical
- ▶ RoHS compliant, 2 mm  $\times$  2 mm, 6-lead LFCSP

## ENHANCED PRODUCT FEATURES

- ▶ Supports defense and aerospace applications (AQEC standard)
- ▶ Military temperature range ( $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ )
- ▶ Controlled manufacturing baseline
- ▶ 1 assembly/test site
- ▶ 1 fabrication site
- ▶ Product change notification
- ▶ Qualification data available on request

## APPLICATIONS

- ▶ Test instrumentation
- ▶ Telecommunications
- ▶ Military radar and communication
- ▶ Electronic warfare
- ▶ Aerospace

## FUNCTIONAL BLOCK DIAGRAM

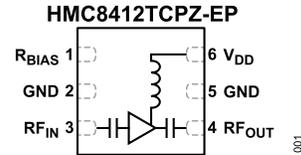


Figure 1.

## GENERAL DESCRIPTION

The HMC8412TCPZ-EP is a gallium arsenide (GaAs), monolithic microwave integrated circuit (MMIC), pseudomorphic high electron mobility transistor (pHEMT), low noise, wideband amplifier that operates from 0.4 GHz to 11 GHz.

The HMC8412TCPZ-EP provides a typical gain of  $\leq 15.5$  dB, a typical 1.4 dB noise figure at 0.4 GHz to 3 GHz, and a typical output third-order intercept (OIP3) of  $\leq 33$  dBm, requiring only 60 mA from a 5 V drain supply voltage. The typical saturated output power ( $P_{\text{SAT}}$ ) of  $\leq 20.5$  dBm enables the low noise amplifier (LNA) to function as a local oscillator (LO) driver for many Analog Devices, Inc., balanced, inphase and quadrature (I/Q) or image rejection mixers.

The HMC8412TCPZ-EP also features inputs and outputs that are internally matched to 50  $\Omega$ , making the device ideal for surface-mount technology (SMT)-based, high capacity microwave radio applications.

The HMC8412TCPZ-EP is housed in an [RoHS compliant, 2 mm  \$\times\$  2 mm, 6-lead LFCSP](#).

Additional application and technical information can be found in the [HMC8412](#) data sheet.

**TABLE OF CONTENTS**

Features.....	1	Thermal Resistance.....	5
Enhanced Product Features.....	1	Electrostatic Discharge (ESD) Ratings.....	5
Applications.....	1	Power Derating Curves.....	5
Functional Block Diagram.....	1	ESD Caution.....	5
General Description.....	1	Pin Configuration and Function Descriptions.....	6
Specifications.....	3	Interface Schematics.....	6
0.4 GHz to 3 GHz Frequency Range.....	3	Typical Performance Characteristics.....	7
3 GHz to 9 GHz Frequency Range.....	3	Outline Dimensions.....	10
9 GHz to 11 GHz Frequency Range.....	4	Ordering Guide.....	10
Absolute Maximum Ratings.....	5		

**REVISION HISTORY****3/2024—Rev. 0 to Rev. A**

Change to Gain Variation over Temperature Parameter, Table 1.....	3
Change to Gain Variation over Temperature Parameter, Table 2.....	3
Change to Gain Variation over Temperature Parameter, Table 3.....	4

**10/2020—Revision 0: Initial Version**

## SPECIFICATIONS

## 0.4 GHZ TO 3 GHZ FREQUENCY RANGE

$V_{DD} = 5\text{ V}$ , supply current ( $I_{DQ}$ ) = 60 mA,  $R_{BIAS} = 1.47\text{ k}\Omega$ , and  $T_A = 25^\circ\text{C}$ , unless otherwise noted.

Table 1.

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
FREQUENCY RANGE	0.4		3	GHz	
GAIN	13	15.5		dB	
Gain Variation over Temperature		0.010		dB/ $^\circ\text{C}$	
NOISE FIGURE		1.4		dB	
RETURN LOSS					
Input		14		dB	
Output		13		dB	
OUTPUT					
Power for 1 dB Compression (OP1dB)	15	18		dBm	
$P_{SAT}$		20.5		dBm	
OIP3		32		dBm	Measurement taken at output power ( $P_{OUT}$ ) per tone = 0 dBm
Second-Order Intercept (OIP2)		40		dBm	Measurement taken at $P_{OUT}$ per tone = 0 dBm
POWER ADDED EFFICIENCY (PAE)		28		%	Measured at $P_{SAT}$
SUPPLY					
$I_{DQ}$		60		mA	
$V_{DD}$	2	5	6	V	

## 3 GHZ TO 9 GHZ FREQUENCY RANGE

$V_{DD} = 5\text{ V}$ ,  $I_{DQ} = 60\text{ mA}$ ,  $R_{BIAS} = 1.47\text{ k}\Omega$ , and  $T_A = 25^\circ\text{C}$ , unless otherwise noted.

Table 2.

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
FREQUENCY RANGE	3		9	GHz	
GAIN	13	15		dB	
Gain Variation over Temperature		0.012		dB/ $^\circ\text{C}$	
NOISE FIGURE		1.5		dB	
RETURN LOSS					
Input		15		dB	
Output		16		dB	
OUTPUT					
OP1dB	15.5	18		dBm	
$P_{SAT}$		20.5		dBm	
OIP3		33		dBm	Measurement taken at $P_{OUT}$ per tone = 0 dBm
OIP2		41.5		dBm	Measurement taken at $P_{OUT}$ per tone = 0 dBm
PAE		29		%	Measured at $P_{SAT}$
SUPPLY					
$I_{DQ}$		60		mA	
$V_{DD}$	2	5	6	V	

## SPECIFICATIONS

## 9 GHZ TO 11 GHZ FREQUENCY RANGE

$V_{DD} = 5\text{ V}$ ,  $I_{DQ} = 60\text{ mA}$ ,  $R_{BIAS} = 1.47\text{ k}\Omega$ , and  $T_A = 25^\circ\text{C}$ , unless otherwise noted.

Table 3.

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
FREQUENCY RANGE	9		11	GHz	
GAIN	12	14		dB	
Gain Variation over Temperature		0.022		dB/°C	
NOISE FIGURE		1.8		dB	
RETURN LOSS					
Input		14		dB	
Output		10		dB	
OUTPUT					
OP1dB	11	14		dBm	
$P_{SAT}$		18		dBm	
OIP3		31		dBm	Measurement taken at $P_{OUT}$ per tone = 0 dBm
OIP2		49.5		dBm	Measurement taken at $P_{OUT}$ per tone = 0 dBm
PAE		15.5		%	Measured at $P_{SAT}$
SUPPLY					
$I_{DQ}$		60		mA	
$V_{DD}$	2	5	6	V	

## ABSOLUTE MAXIMUM RATINGS

Table 4.

Parameter	Rating
$V_{DD}$	7 V
RF Input Power	25 dBm
Continuous Power Dissipation ( $P_{DISS}$ )	
$T_{CASE} = 85^{\circ}\text{C}$	0.82 W
$T_{CASE} = 125^{\circ}\text{C}$	0.46 W
Temperature	
Storage Range	$-65^{\circ}\text{C}$ to $+150^{\circ}\text{C}$
Operating Range	$-55^{\circ}\text{C}$ to $+125^{\circ}\text{C}$
Peak Reflow (Moisture Sensitivity Level 1 (MSL1)) <sup>1</sup>	$260^{\circ}\text{C}$
Junction Temperature to Maintain 1,000,000 Hours Mean Time to Failure (MTTF)	$175^{\circ}\text{C}$
Nominal Junction Temperature ( $T_A = 125^{\circ}\text{C}$ , $V_{DD} = 5\text{ V}$ , $I_{DQ} = 60\text{ mA}$ )	$157.8^{\circ}\text{C}$

<sup>1</sup> See the [Ordering Guide](#) 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.

### 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	109.3	$^{\circ}\text{C}/\text{W}$

## 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 HMC8412TCPZ-EP

Table 6. HMC8412TCPZ-EP, 6-Lead LFCSP

ESD Model	Withstand Threshold (V)	Class
HBM	$\pm 500$	1B

## POWER DERATING CURVES

Figure 2 shows the maximum power dissipation vs. case temperature.

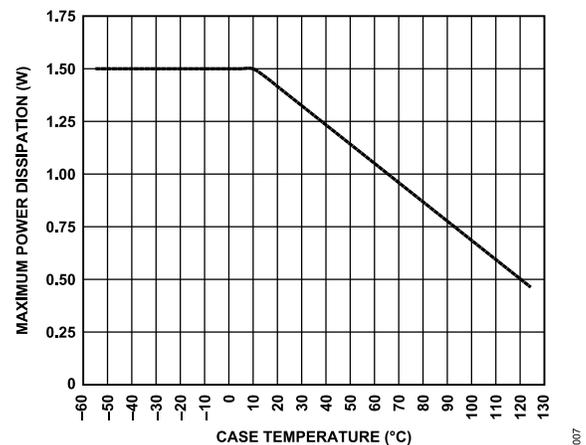


Figure 2. Maximum Power Dissipation vs. Case Temperature

## 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**

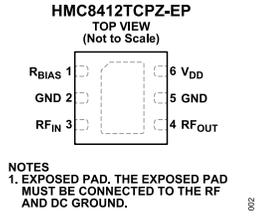


Figure 3. Pin Configuration

Table 7. Pin Function Descriptions

Pin No.	Mnemonic	Description
1	R <sub>BIAS</sub>	Current Mirror Bias Resistor. Use the R <sub>BIAS</sub> pin to set the quiescent current by connecting the external bias resistor. Refer to the <a href="#">HMC8412</a> data sheet for the bias resistor connection and for recommended bias resistor values. See <a href="#">Figure 4</a> for the interface schematic.
2, 5	GND	Ground. The GND pin must be connected to RF and dc ground. See <a href="#">Figure 7</a> for the interface schematic.
3	RF <sub>IN</sub>	RF Input. The RF <sub>IN</sub> pin is ac-coupled and matched to 50 Ω. See <a href="#">Figure 5</a> for the interface schematic.
4	RF <sub>OUT</sub>	RF Output. The RF <sub>OUT</sub> pin is ac-coupled and matched to 50 Ω. See <a href="#">Figure 6</a> for the interface schematic.
6	V <sub>DD</sub>	Drain Supply Voltage for the Amplifier. See <a href="#">Figure 6</a> for the interface schematic.
	EPAD	Exposed Pad. The exposed pad must be connected to the RF and dc ground.

**INTERFACE SCHEMATICS**

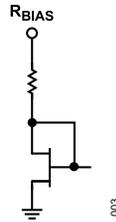


Figure 4. R<sub>BIAS</sub> Interface Schematic

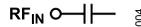


Figure 5. RF<sub>IN</sub> Interface Schematic

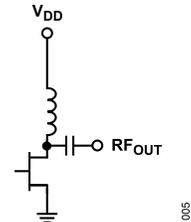


Figure 6. V<sub>DD</sub> and RF<sub>OUT</sub> Interface Schematic



Figure 7. GND Interface Schematic

TYPICAL PERFORMANCE CHARACTERISTICS

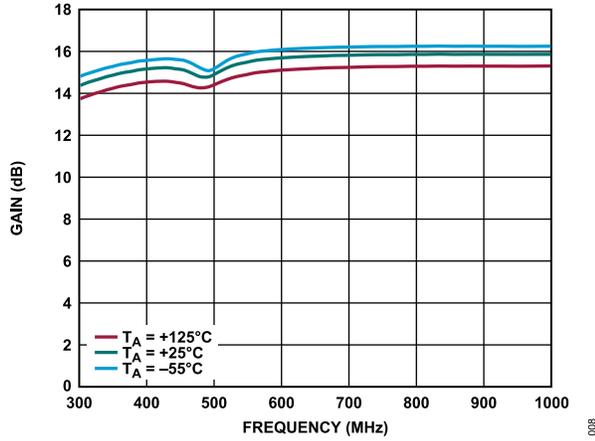


Figure 8. Gain vs. Frequency for Various Temperatures, 300 MHz to 1 GHz,  $V_{DD} = 5\text{ V}$ ,  $I_{DQ} = 60\text{ mA}$ ,  $R_{BIAS} = 1.47\text{ k}\Omega$

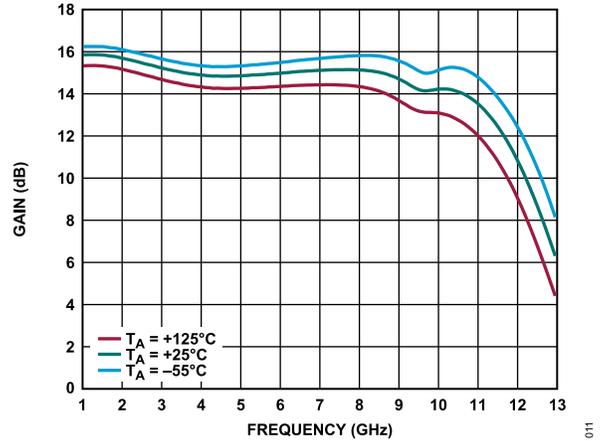


Figure 11. Gain vs. Frequency for Various Temperatures, 1 GHz to 13 GHz,  $V_{DD} = 5\text{ V}$ ,  $I_{DQ} = 60\text{ mA}$ ,  $R_{BIAS} = 1.47\text{ k}\Omega$

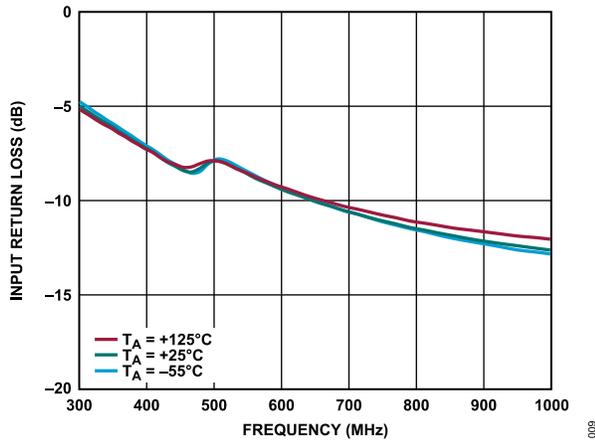


Figure 9. Input Return Loss vs. Frequency for Various Temperatures, 300 MHz to 1 GHz,  $V_{DD} = 5\text{ V}$ ,  $I_{DQ} = 60\text{ mA}$ ,  $R_{BIAS} = 1.47\text{ k}\Omega$

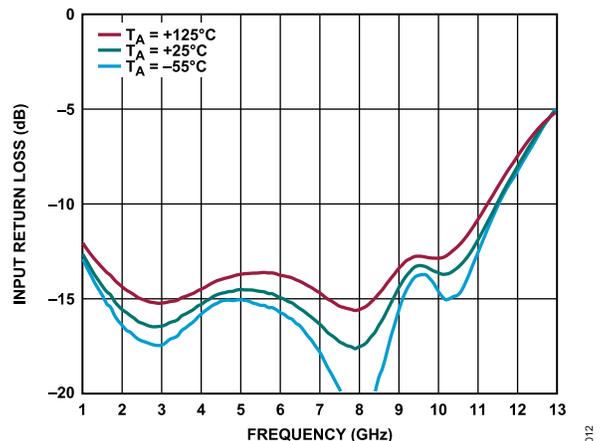


Figure 12. Input Return Loss vs. Frequency for Various Temperatures, 1 GHz to 13 GHz,  $V_{DD} = 5\text{ V}$ ,  $I_{DQ} = 60\text{ mA}$ ,  $R_{BIAS} = 1.47\text{ k}\Omega$

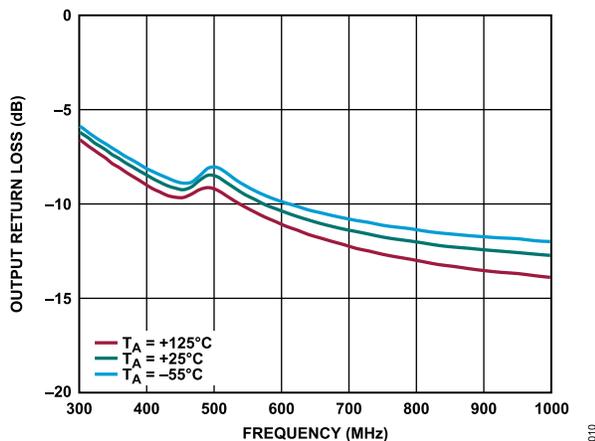


Figure 10. Output Return Loss vs. Frequency for Various Temperatures, 300 MHz to 1 GHz,  $R_{BIAS} = 1.47\text{ k}\Omega$

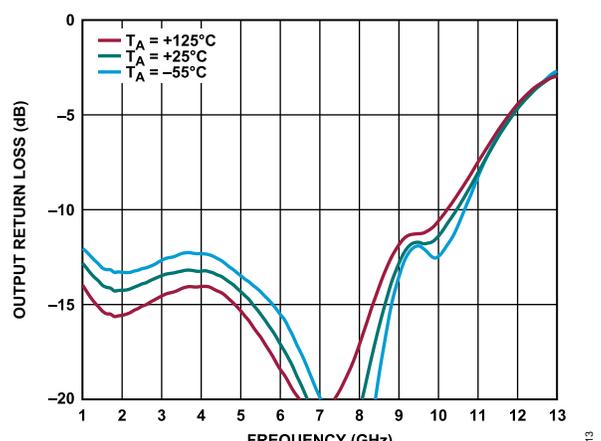


Figure 13. Output Return Loss vs. Frequency for Various Temperatures, 1 GHz to 13 GHz,  $V_{DD} = 5\text{ V}$ ,  $I_{DQ} = 60\text{ mA}$ ,  $R_{BIAS} = 1.47\text{ k}\Omega$

TYPICAL PERFORMANCE CHARACTERISTICS

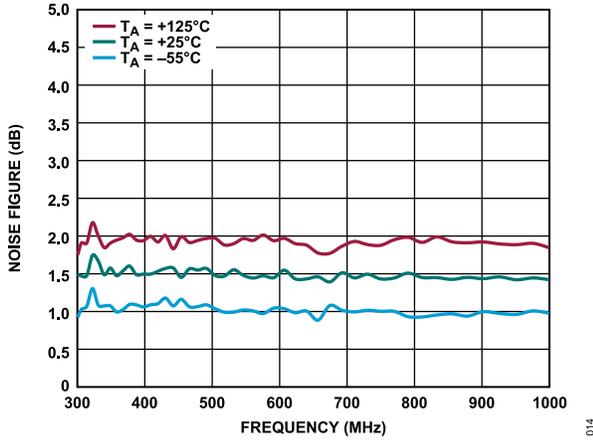


Figure 14. Noise Figure vs. Frequency for Various Temperatures, 300 MHz to 1 GHz,  $V_{DD} = 5\text{ V}$ ,  $I_{DQ} = 60\text{ mA}$ ,  $R_{BIAS} = 1.47\text{ k}\Omega$

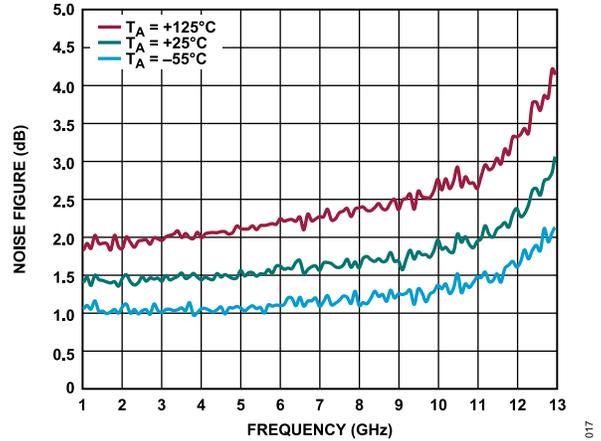


Figure 17. Noise Figure vs. Frequency for Various Temperatures, 1 GHz to 13 GHz,  $V_{DD} = 5\text{ V}$ ,  $I_{DQ} = 60\text{ mA}$ ,  $R_{BIAS} = 1.47\text{ k}\Omega$

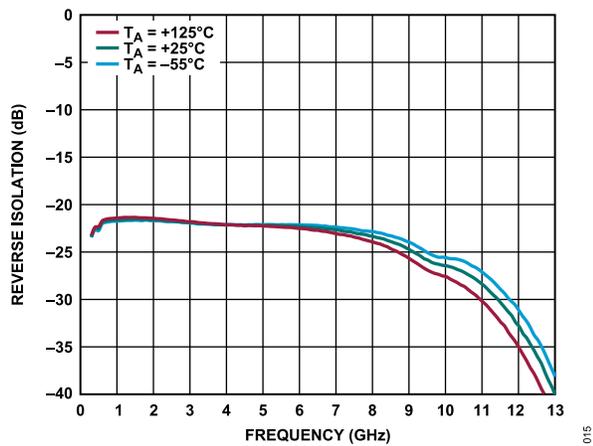


Figure 15. Reverse Isolation vs. Frequency for Various Temperatures, 300 MHz to 13 GHz,  $V_{DD} = 5\text{ V}$ ,  $I_{DQ} = 60\text{ mA}$ ,  $R_{BIAS} = 1.47\text{ k}\Omega$

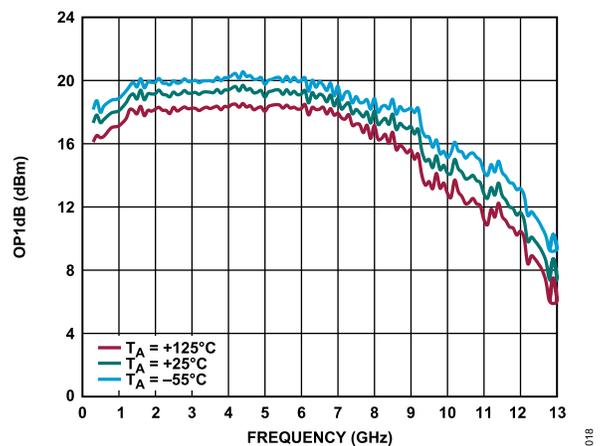


Figure 18. OP1dB vs. Frequency for Various Temperatures, 300 MHz to 13 GHz,  $V_{DD} = 5\text{ V}$ ,  $I_{DQ} = 60\text{ mA}$ ,  $R_{BIAS} = 1.47\text{ k}\Omega$

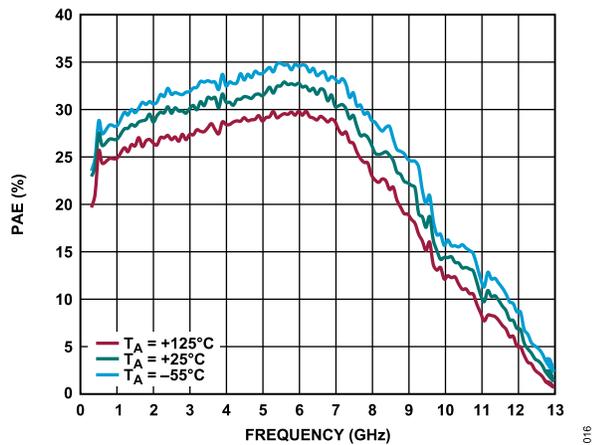


Figure 16. PAE vs. Frequency for Various Temperatures, 300 MHz to 13 GHz,  $V_{DD} = 5\text{ V}$ ,  $I_{DQ} = 60\text{ mA}$ ,  $R_{BIAS} = 1.47\text{ k}\Omega$

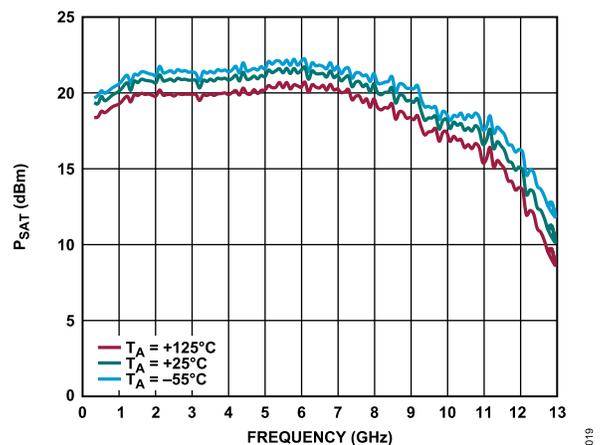


Figure 19.  $P_{SAT}$  vs. Frequency for Various Temperatures, 300 MHz to 13 GHz,  $V_{DD} = 5\text{ V}$ ,  $I_{DQ} = 60\text{ mA}$ ,  $R_{BIAS} = 1.47\text{ k}\Omega$

TYPICAL PERFORMANCE CHARACTERISTICS

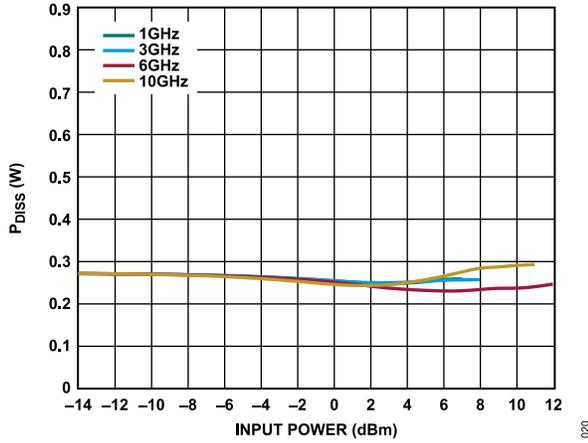


Figure 20.  $P_{DISS}$  vs. Input Power at  $T_A = 125^\circ\text{C}$ ,  $V_{DD} = 5\text{ V}$ ,  $I_{DQ} = 60\text{ mA}$ ,  $R_{BIAS} = 1.47\text{ k}\Omega$

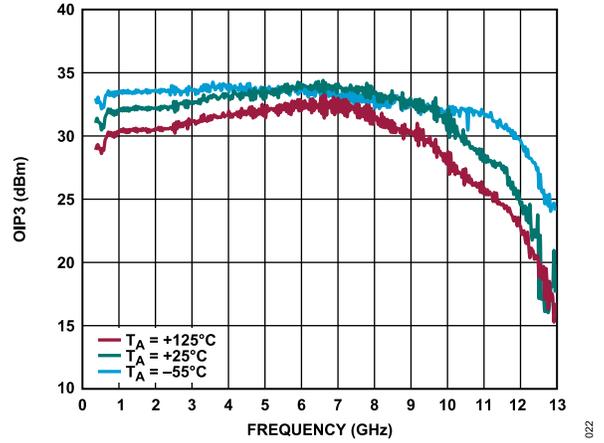


Figure 22. OIP3 vs. Frequency for Various Temperatures, 300 MHz to 13 GHz,  $V_{DD} = 5\text{ V}$ ,  $I_{DQ} = 60\text{ mA}$ ,  $R_{BIAS} = 1.47\text{ k}\Omega$ ,  $P_{OUT}$  per Tone = 0 dBm

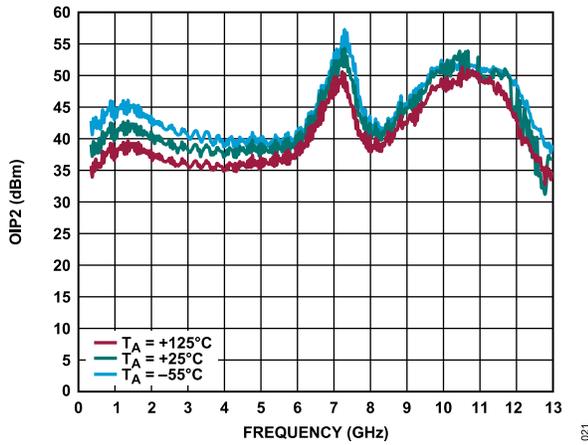


Figure 21. OIP2 vs. Frequency for Various Temperatures, 300 MHz to 13 GHz,  $V_{DD} = 5\text{ V}$ ,  $I_{DQ} = 60\text{ mA}$ ,  $R_{BIAS} = 1.47\text{ k}\Omega$ ,  $P_{OUT}$  per Tone = 0 dBm

## OUTLINE DIMENSIONS

Package Drawing (Option)	Package Type	Package Description
<a href="#">CP-6-12</a>	LFCSP	6-Lead, Lead Frame Chip Scale Package

For the latest package outline information and land patterns (footprints), go to [Package Index](#).

## ORDERING GUIDE

Model <sup>1</sup>	Temperature Range	MSL Rating <sup>2</sup>	Package Description <sup>3</sup>	Package Option
HMC8412TCPZ-EP-PT	-55°C to +125°C	MSL1	6-Lead, Lead Frame Chip Scale Package [LFCSP]	CP-6-12
HMC8412TCPZ-EP-R7	-55°C to +125°C	MSL1	6-Lead, Lead Frame Chip Scale Package [LFCSP]	CP-6-12

<sup>1</sup> The HMC8412TCPZ-EP-PT and HMC8412TCPZ-EP-R7 are RoHS compliant parts.

<sup>2</sup> See the [Absolute Maximum Ratings](#) section for additional information.

<sup>3</sup> The lead finish of the HMC8412TCPZ-EP-PT and HMC8412TCPZ-EP-R7 is nickel palladium gold (NiPdAu).