



MMIC SURFACE MOUNT

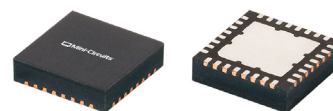
Power Amplifier

PMA5-223+

50Ω 0.01 to 22 GHz Wideband Amplifier

THE BIG DEAL

- Wide Bandwidth 10 MHz to 22 GHz
- P_{SAT} , Typ. +33 dBm
- Linear Gain, Typ. 15.5 dB
- IM3, Typ. -46 dBc @ $P_{OUT} = +20$ dBm/tone
- Supply Voltage, +15 V at 500 mA
- 5×5 mm 32-Lead QFN-Style Package

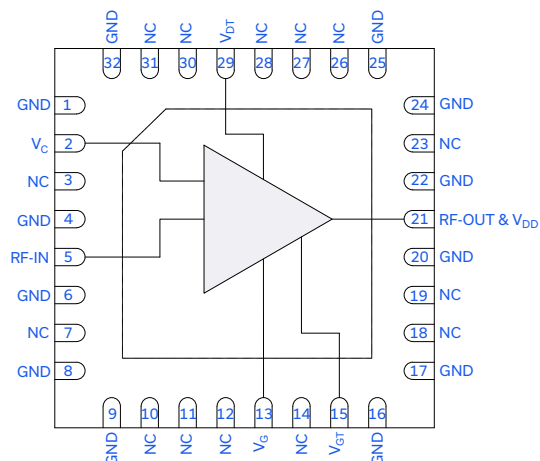


Generic photo used for illustration purposes only

APPLICATIONS

- Test and Measurement Equipment
- 5G MIMO and Backhaul Radio
- Satellite Communication
- Radar, EW, and ECM Defense Systems

FUNCTIONAL DIAGRAM (TOP VIEW)



PRODUCT OVERVIEW

The PMA5-223+ is a GaAs pHEMT MMIC power amplifier operating from 0.01 to 22 GHz. The wideband distributed amplifier provides 15.5 dB of linear gain, +33 dBm saturated output power, and achieves +43 dBm output IP3 at 10 GHz. The device operates from a +15 V supply and consumes 500 mA of quiescent current. The amplifier is 50Ω matched at the input and output, making it easy to implement and comes in an industry standard 5×5 mm 32-Lead QFN-Style package for ease of integration into dense circuit board layouts. These characteristics make it ideally suited for wideband test instrumentation, satellite communication, and defense systems that require high operating output power, while maintaining very low distortion characteristics.

KEY FEATURES

Feature	Advantages
Gain, Typ. 15.5 dB P_{SAT} , Typ. +33 dBm	Flat, broadband gain and high output power without high frequency roll-off make this device excellent for wideband systems from 0.01 to 22 GHz that require at least 1 W of operating output power over the full band.
At $P_{OUT} = +20$ dBm/tone: • OIP2, Typ. +44 dBm • OIP3, Typ. +43 dBm	High operating OIP2 and OIP3 provide low in-band IM distortion products, enabling minimal signal-to-noise degradation in high fidelity measurement systems and communication systems.
Wide Bandwidth: 10 MHz to 22 GHz	Supports a variety of broadband and narrowband applications without the need to reconfigure circuitry.
5×5 mm 32-Lead QFN-Style Package	Small footprint saves space in dense layouts while providing low inductance, repeatable transitions, and excellent thermal contact to the PCB. Industry standard packaging allows for ease of assembly in high volume manufacturing processes.





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Mini-Circuits

50Ω 0.01 to 22 GHz Wideband Amplifier

ELECTRICAL SPECIFICATIONS¹ AT +25 °C, $V_{DD} = +15$ V, UNLESS NOTED OTHERWISE

Parameter	Conditions (GHz)	Min.	Typ.	Max.	Units
Frequency Range		0.01		22	GHz
Gain	0.1	19.2	22.0		dB
	1	15.7	17.1		
	5	12.2	13.5		
	10	13.4	15.5		
	15	15.4	18.0		
	22	16.5	17.5		
Input Return Loss	0.1		20		dB
	1		19		
	5		11		
	10		12		
	15		17		
	22		13		
Output Return Loss	0.1		23		dB
	1		14		
	5		9		
	10		11		
	15		24		
	22		16		
Isolation	0.1 - 22		44		dB
Output Power at 1 dB Compression (P _{1dB})	0.1		+28.5		dBm
	1		+31.2		
	5		+31.4		
	10		+31.5		
	15		+29.5		
	22		+26.5		
Output Power at Saturation (P _{SAT}) ²	0.1		+34.3		dBm
	1		+34.7		
	5		+34.1		
	10		+33.0		
	15		+32.5		
	22		+30.0		
Output Third-Order Intercept (P _{OUT} = +20 dBm/Tone)	0.1		+41		dBm
	1		+44		
	5		+44		
	10		+43		
	15		+41		
	22		+36		
2nd Harmonic (P _{OUT} = +20 dBm)	0.1		-37.9		dBc
	1		-42.8		
	5		-31.2		
	10		-26.9		
	15		-28.0		
	22		-44.2		
Noise Figure	1		7.0		dB
	5		3.5		
	10		3.0		
	15		3.3		
	22		6.0		
Device Operating Voltage (V _{DD})		+12	+15	+15	V
Device Operating Current (I _{DD}) ³		300	500		mA
Control Voltage (V _C)		+7.5	+9.5		V
Gate Voltage (V _G)			-0.5		V
Device Gate Current on V _G (I _G)			3.56		μA
Device Control Current on V _C (I _C)			380		μA
DC Current Variation vs. Temperature ⁴			167.87		μA/°C
DC Current Variation vs. Voltage ⁵			0.26		μA/mV

1. Tested on Mini-Circuits Characterization Test Board TB-PMA5-223C+. See Figure 2. Board loss de-embedded to the device.

2. P_{SAT} is defined as when the Output Power changes 0.1 dB per 1 dB change in Input Power.3. Current at P_{IN} = -15 dBm. Increases to 590 mA at P_{1dB}.

4. (Current at +85 °C - Current at -40 °C) / (125 °C).

5. (Current at +15 V - Current at +12 V) / (+15 V - +12 V).





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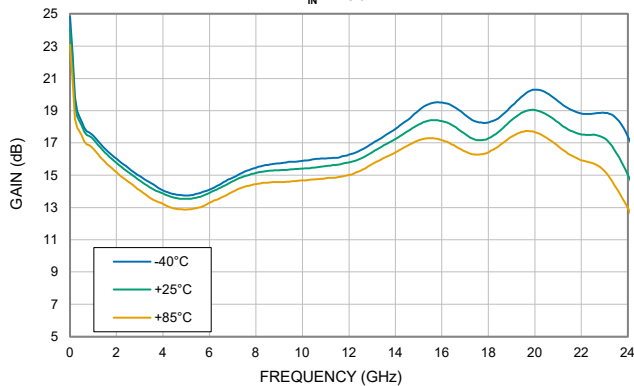
PMA5-223+

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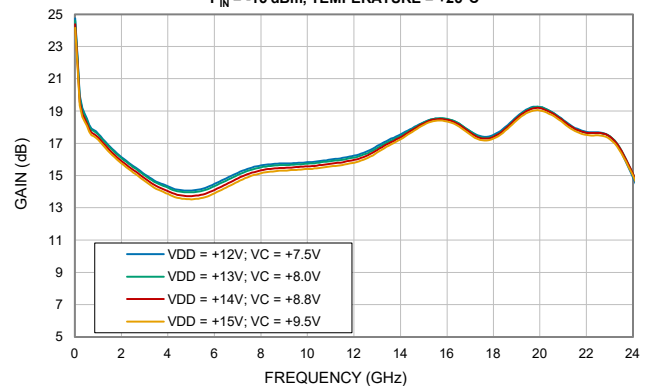
TYPICAL PERFORMANCE GRAPHS

Note: The following data was taken on a Mini-Circuits Characterization Test Board with external Bias-T (Figure 2). All data taken at nominal condition of $V_{DD} = +15\text{ V}$, $V_C = +9.5\text{ V}$ and $I_{DD} = 500\text{ mA}$ unless noted otherwise. V_G was adjusted at each voltage and temperature level to achieve $I_{DD} = 500\text{ mA}$.

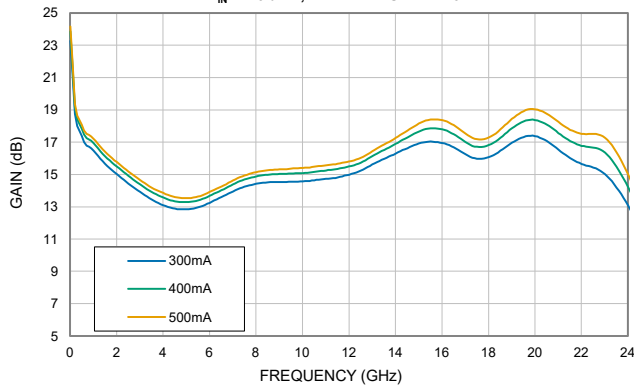
GAIN vs. TEMPERATURE
 $P_{IN} = -15\text{ dBm}$



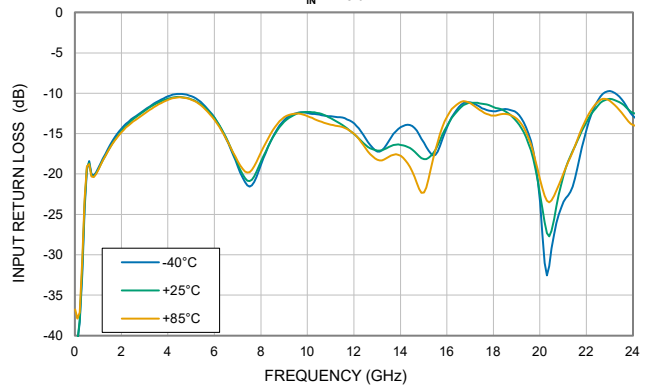
GAIN vs. DEVICE VOLTAGE (V_{DD})
 $P_{IN} = -15\text{ dBm}$, TEMPERATURE = $+25^\circ\text{C}$



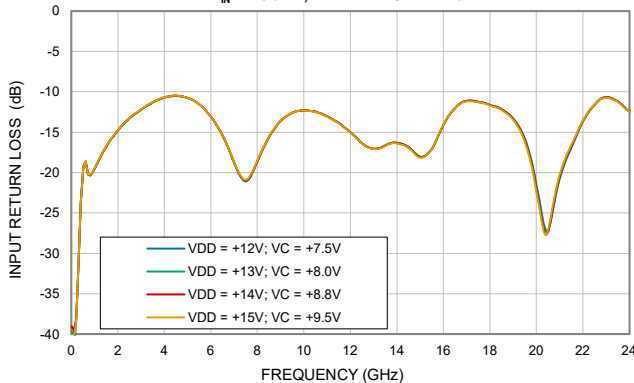
GAIN vs. DEVICE CURRENT (I_{DD})
 $P_{IN} = -15\text{ dBm}$, TEMPERATURE = $+25^\circ\text{C}$



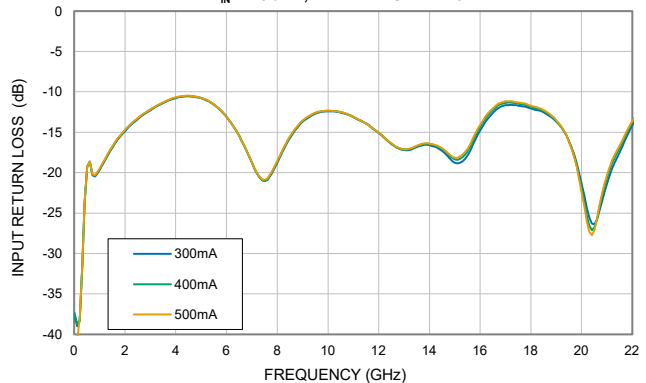
INPUT RETURN LOSS vs. TEMPERATURE
 $P_{IN} = -15\text{ dBm}$



INPUT RETURN LOSS vs. DEVICE VOLTAGE (V_{DD})
 $P_{IN} = -15\text{ dBm}$, TEMPERATURE = $+25^\circ\text{C}$



INPUT RETURN LOSS vs. DEVICE CURRENT (I_{DD})
 $P_{IN} = -15\text{ dBm}$, TEMPERATURE = $+25^\circ\text{C}$





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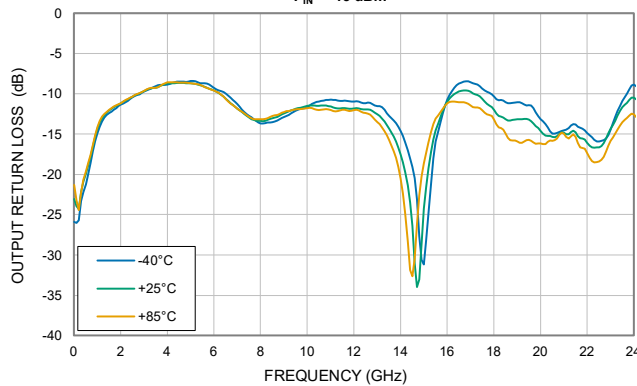
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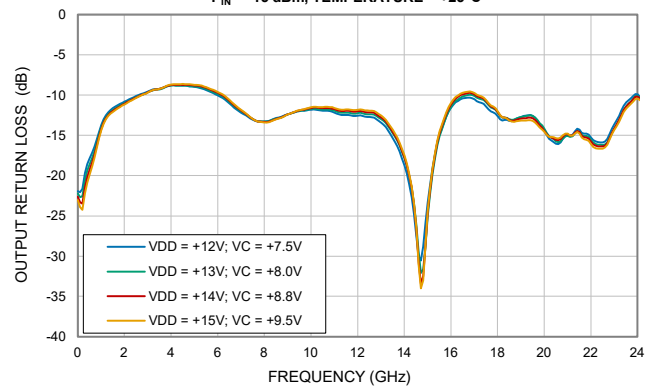
OUTPUT RETURN LOSS vs. TEMPERATURE

$P_{IN} = -15$ dBm



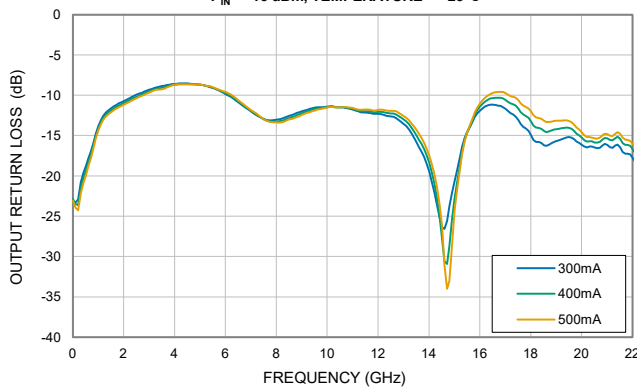
OUTPUT RETURN LOSS vs. DEVICE VOLTAGE (V_{DD})

$P_{IN} = -15$ dBm, TEMPERATURE = +25°C



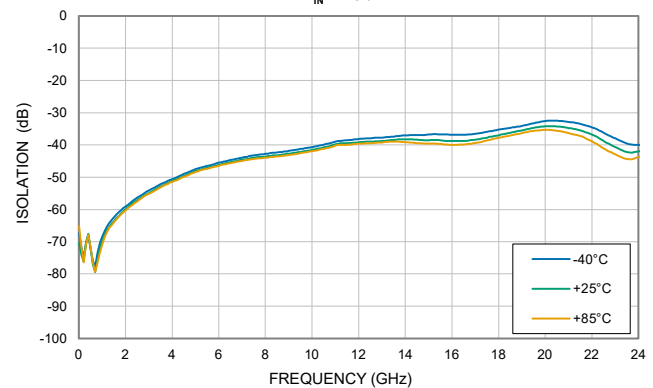
OUTPUT RETURN LOSS vs. DEVICE CURRENT (I_{DD})

$P_{IN} = -15$ dBm, TEMPERATURE = +25°C



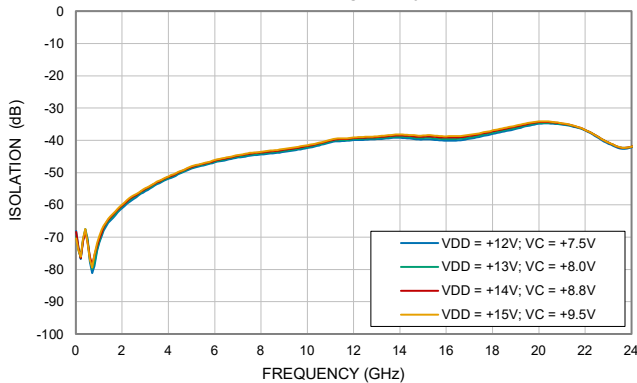
ISOLATION vs. TEMPERATURE

$P_{IN} = -15$ dBm



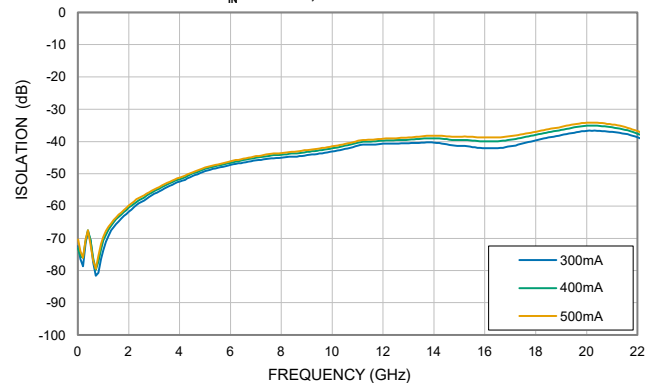
ISOLATION vs. DEVICE VOLTAGE (V_{DD})

TEMPERATURE = +25°C



ISOLATION vs. DEVICE CURRENT (I_{DD})

$P_{IN} = -15$ dBm, TEMPERATURE = +25°C



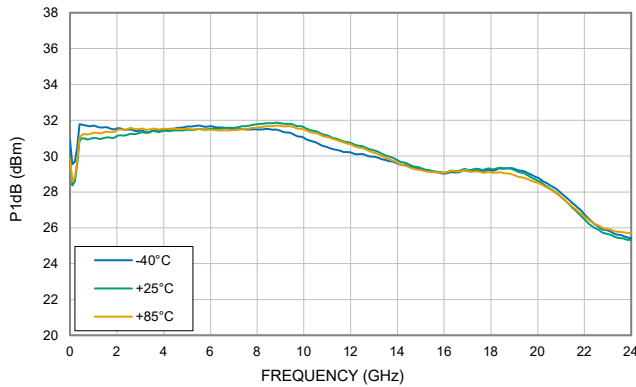
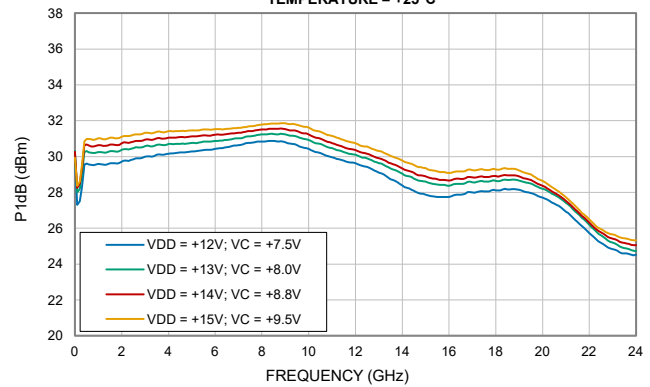
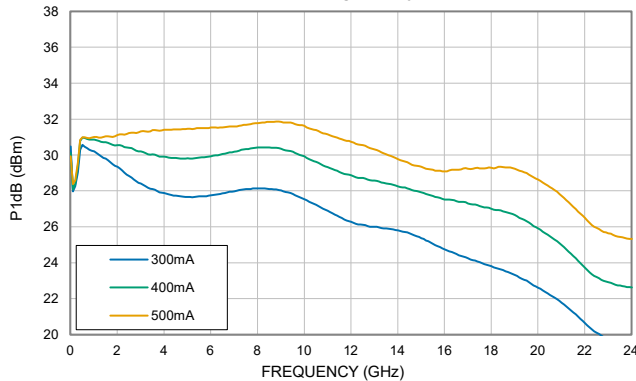
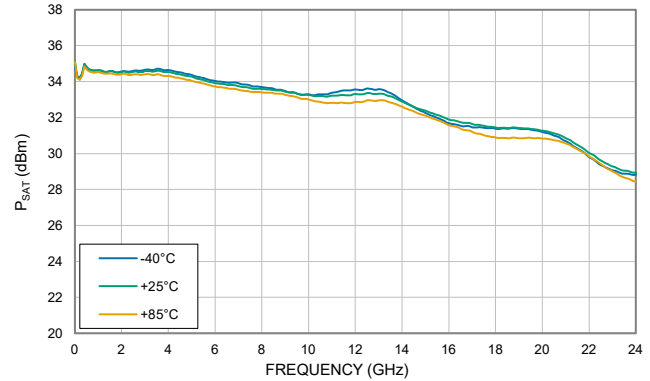
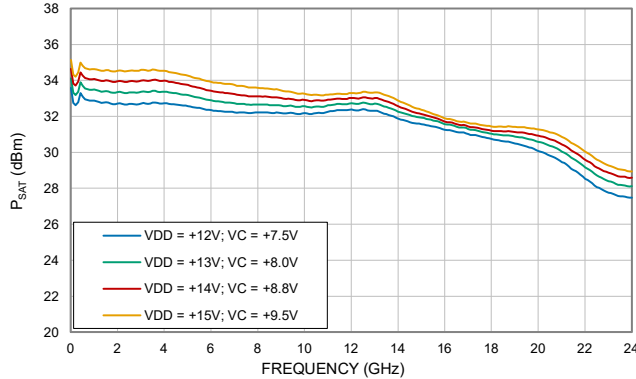
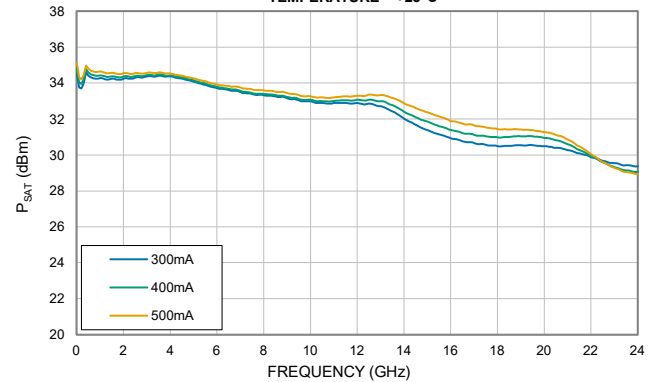
Mini-Circuits



TYPICAL PERFORMANCE GRAPHS

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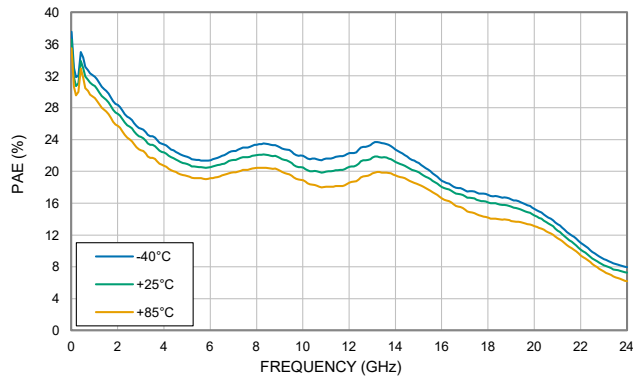
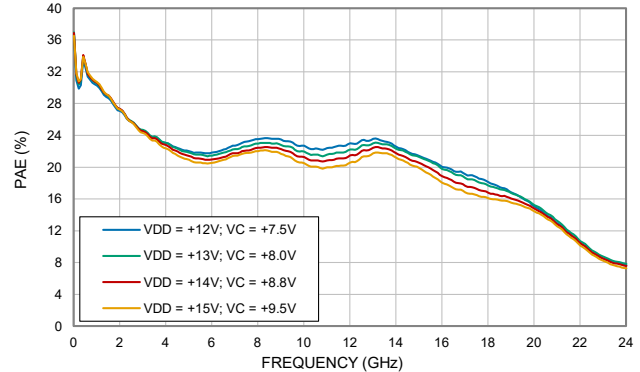
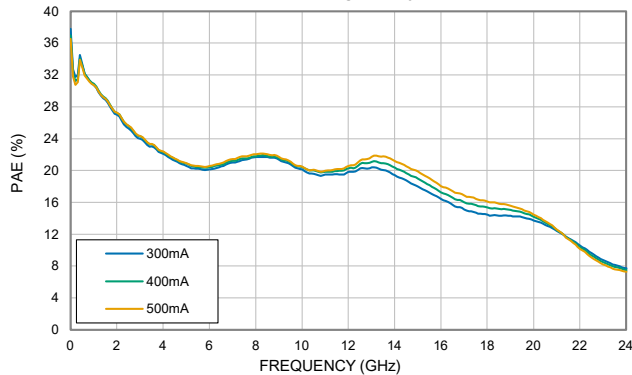
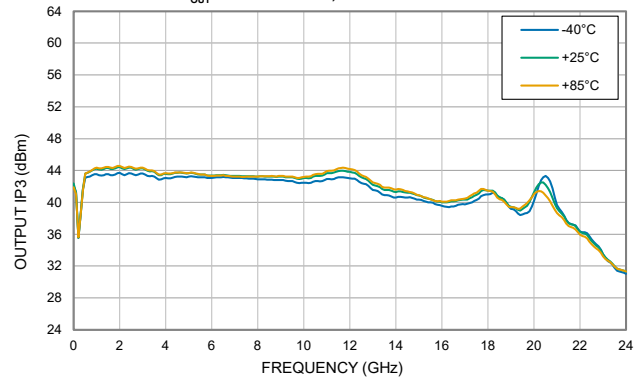
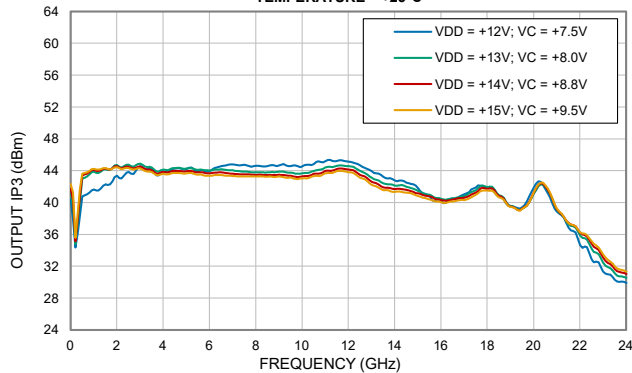
P1dB vs. TEMPERATURE

P1dB vs. DEVICE VOLTAGE (V_{DD})
TEMPERATURE = +25°CP1dB vs. DEVICE CURRENT (I_{DD})
TEMPERATURE = +25°CP_{SAT} vs. TEMPERATUREP_{SAT} vs. DEVICE VOLTAGE (V_{DD})
TEMPERATURE = +25°CP_{SAT} vs. DEVICE CURRENT (I_{DD})
TEMPERATURE = +25°C



TYPICAL PERFORMANCE GRAPHS

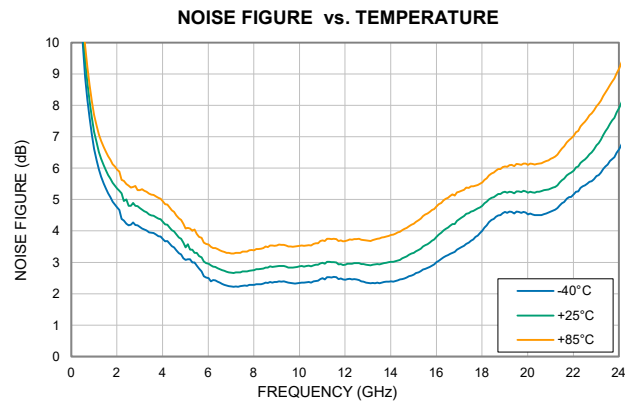
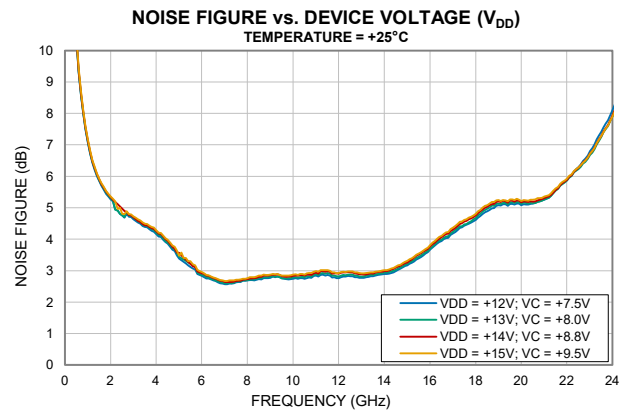
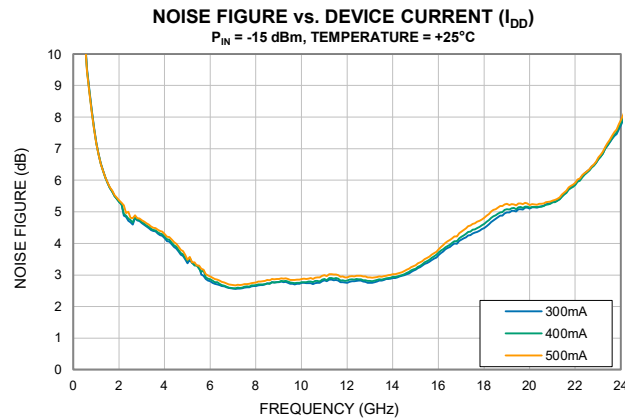
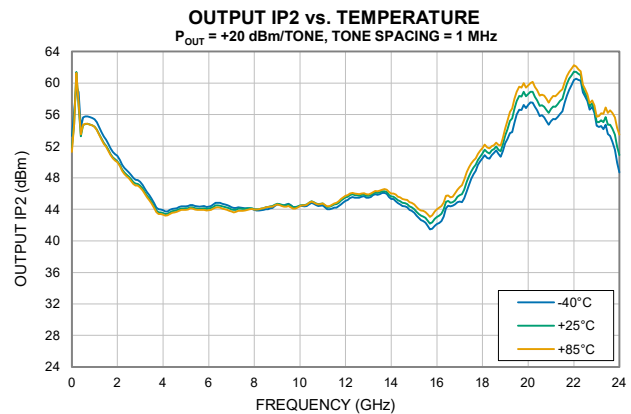
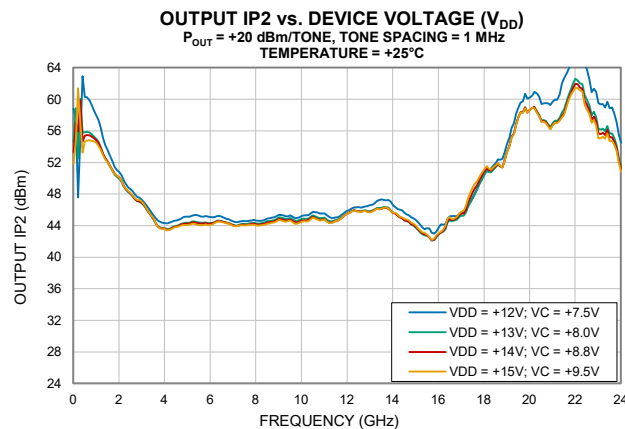
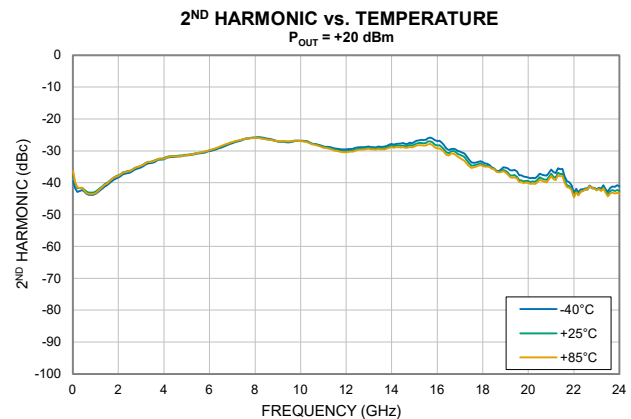
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PAE @ P_{SAT} vs. TEMPERATUREPAE @ P_{SAT} vs. DEVICE VOLTAGE (V_{DD})
TEMPERATURE = +25°CPAE @ P_{SAT} vs. DEVICE CURRENT (I_{DD})
TEMPERATURE = +25°COUTPUT IP3 vs. TEMPERATURE
 $P_{OUT} = +20\text{ dBm/TONE}$, TONE SPACING = 1 MHzOUTPUT IP3 vs. DEVICE VOLTAGE (V_{DD})
 $P_{OUT} = +20\text{ dBm/TONE}$, TONE SPACING = 1 MHz
TEMPERATURE = +25°C



TYPICAL PERFORMANCE GRAPHS

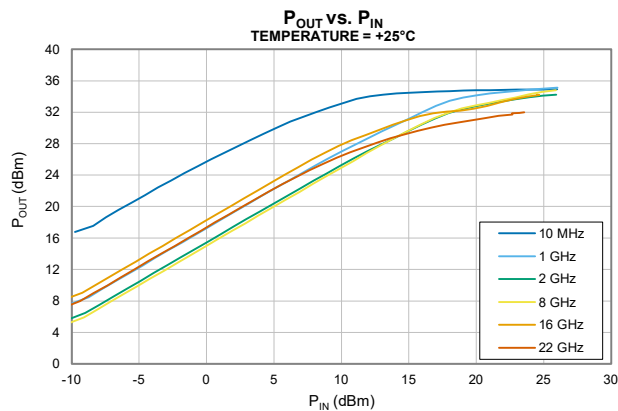
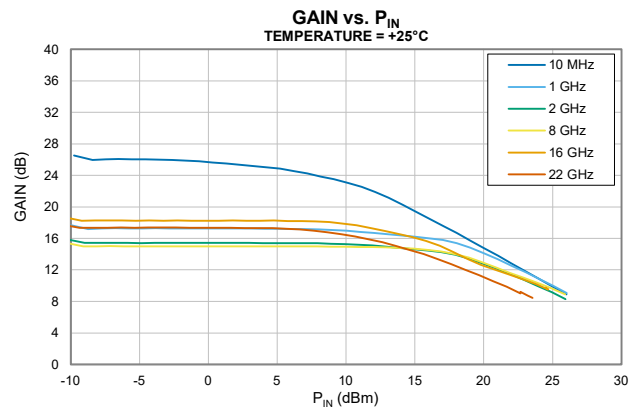
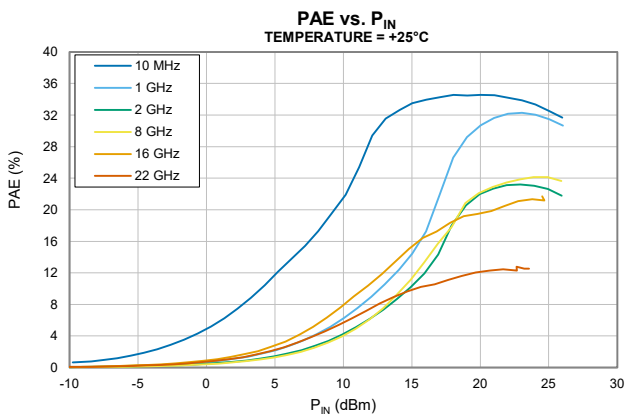
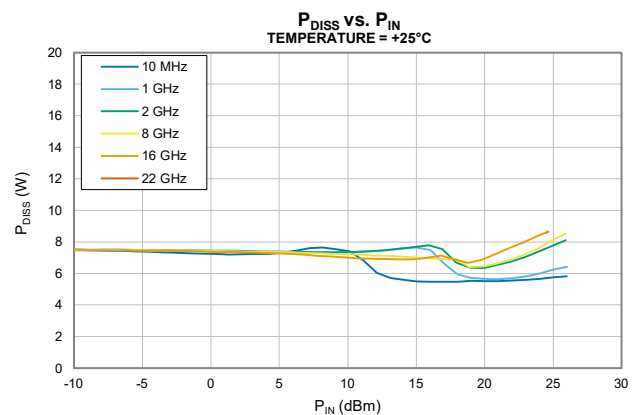
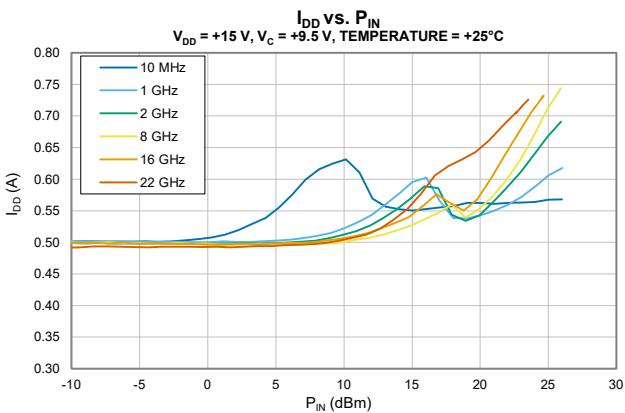
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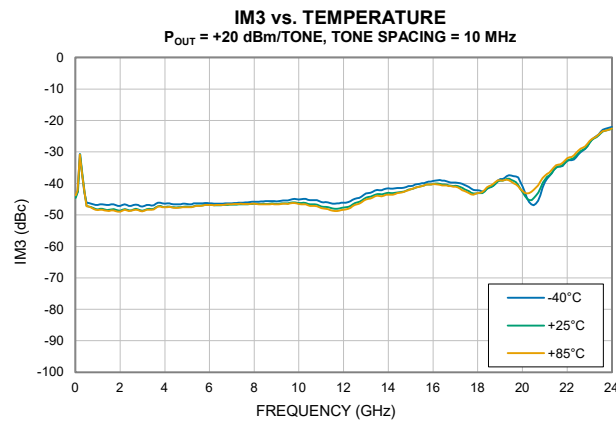
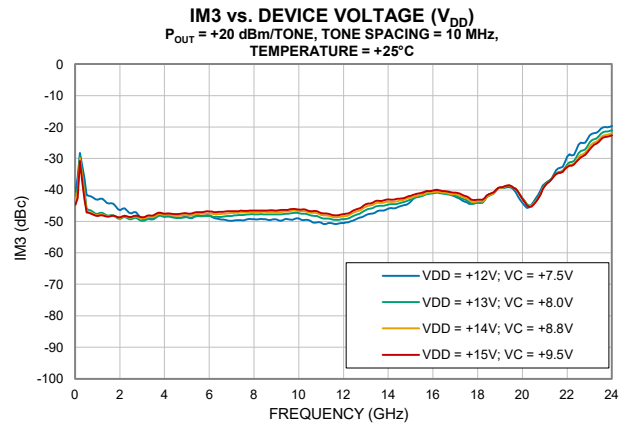
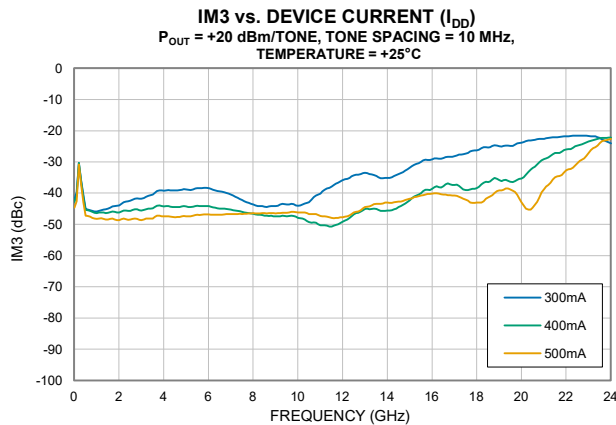
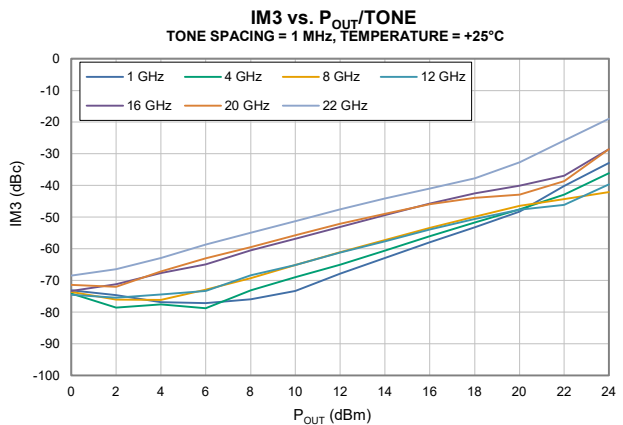
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ABSOLUTE MAXIMUM RATINGS⁶

Parameter	Ratings
Operating Temperature	-40 °C to +85 °C
Storage Temperature	-65 °C to +150 °C
Junction Temperature ⁷	+175 °C
Total Power Dissipation	11 W
Input Power (CW), $V_{DD} = +15$ V	+27 dBm
DC Drain Voltage at RF-OUT & V_{DD}	+16 V
DC Gate Voltage at V_G	-0.25 V
DC Control Voltage at V_C	+10.3 V
DC Drain Current I_{DD}	800 mA
DC Gate Current I_G	0.6 mA
DC Control Current I_C	8.2 mA

6. Permanent damage may occur if any of these limits are exceeded. Maximum ratings are not intended for continuous normal operation.

7. Peak Temperature on top of Die.

THERMAL RESISTANCE

Parameter	Ratings
Thermal Resistance (Θ_{JC}) ⁸	8.2 °C/W

8. Θ_{JC} = (Hot Spot Temperature on Die - Temperature at Ground Lead) / Dissipated Power.

ESD RATING

	Class	Voltage Range	Reference Standard
HBM	1B	500 to < 750	ANSI/ESDA/JEDEC JS-001-2023
CDM	C3	≥ 1000	ANSI/ESDA/JEDEC JS-002-2025



ESD HANDLING PRECAUTION: This device is designed to be Class 1B for HBM. Static charges may easily produce potentials higher than this with improper handling and can discharge into DUT and damage it. As a preventive measure Industry standard ESD handling precautions should be used at all times to protect the device from ESD damage.

MSL RATING

Moisture Sensitivity: MSL3 in accordance with IPC/JEDEC J-STD-020E/JEDEC J-STD-033C





FUNCTIONAL DIAGRAM

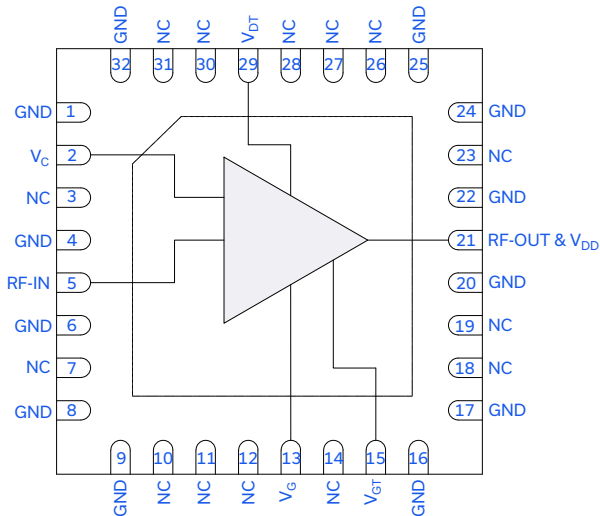


Figure 1. PMA5-223+ Functional Diagram

PAD DESCRIPTION

Function	Pad Number	Description (Refer to Figure 2)
RF-IN ⁹	5	RF-IN Pad connects to RF Input port.
RF-OUT & V _{DD} ¹⁰	21	RF-OUT Pad connects to RF Output port.
V _C ¹¹	2	DC Input pad connects to control voltage Input port, V _C .
V _G ¹¹	13	DC Input pad connects to voltage Input port, V _G .
V _{GT} ¹¹	15	DC Input pad connects to voltage Input port for gate termination, V _{GT} .
V _{DT} ¹¹	29	DC Input pad connects to voltage Input port for drain termination, V _{DT} .
GND	1, 4, 6, 8, 9, 16, 17, 20, 22, 24, 25, 32 & Paddle	Connects to ground.
NC	3, 7, 10-12, 14, 18, 19, 23, 26-28, 30, 31	Not used internally. Connected to ground on test board.

9. DC Blocking Capacitor is required.

10. V_{DD} is applied via external Bias-T.

11. Require Bypass Capacitor.

CHARACTERIZATION TEST BOARD

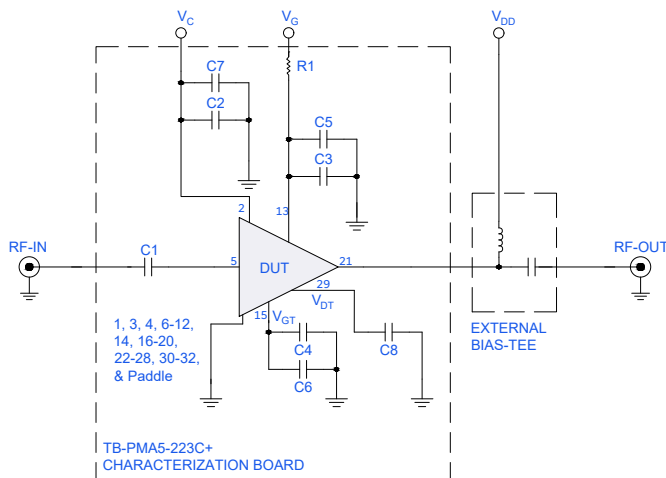


Figure 2. PMA5-223+ Characterization Circuit

Electrical Parameters and Conditions

Gain, Return Loss, Output Power at 1dB Compression (P_{1dB}), Output IP3 (OIP3), Output Power at Saturation (P_{SAT}), and Noise Figure measured using PNA-X N5245B Microwave Network Analyzer.

Conditions:

1. Gain and Return Loss: P_{IN} = -15 dBm
2. Output IP3 (OIP3): Two tones, spaced 1 MHz apart, +20 dBm/Tone at output.
3. V_{DD} = +15 V, V_C = +9.5 V

Power ON/Power OFF Sequence

Caution: Permanent damage to the device will occur if the Power ON and Power OFF sequences are not followed.

POWER ON:

- 1) Ensure V_G, V_C and V_{DD} are OFF.
- 2) Set V_G = -1.5 V. Apply V_G.
- 3) Set V_C = +9.5 V. Apply V_C.
- 4) Set V_{DD} = +15 V. Apply V_{DD}.
- 5) Increase V_G to obtain the desired I_{DD} as shown in specification table.
- 6) Apply RF Signal.

POWER OFF:

- 1) Turn off RF Signal.
- 2) Adjust V_G to -1.5 V.
- 3) Turn off V_{DD}.
- 4) Turn off V_C.
- 5) Turn off V_G.

Component	Value	Size	Part Number	Manufacturer
C1	0.1 μF	0201	0201BB104KW160	PASSIVE PLUS
C2-C4	0.1 μF	0402	GRM155R71E104KE14D	MURATA
C5-C8	1 μF	0603	06035C105KAT2A	AVX CORP.
R1	0 Ω	0402	RK73Z1ETTP	KOA SPEER



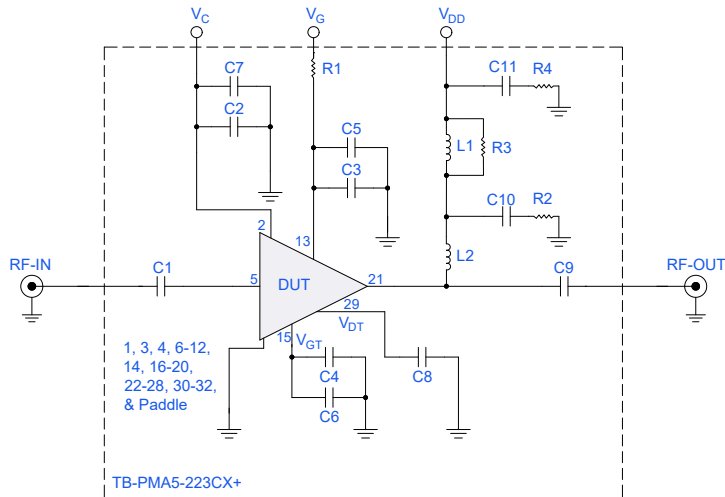
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EVALUATION BOARD



Electrical Parameters and Conditions

Gain, Return Loss, Output Power at 1dB Compression (P1dB), and Output Power at Saturation (PSAT) measured using PNA-X N5245B Microwave Network Analyzer.

Conditions:

1. Gain and Return Loss: $P_{IN} = -15$ dBm
2. $V_{DD} = +15$ V, $V_C = +9.5$ V

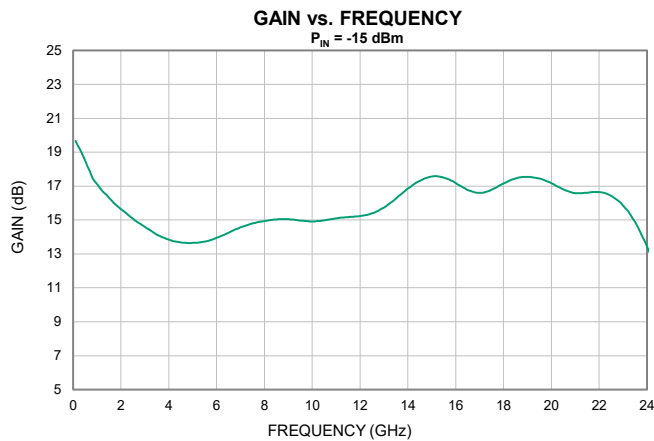
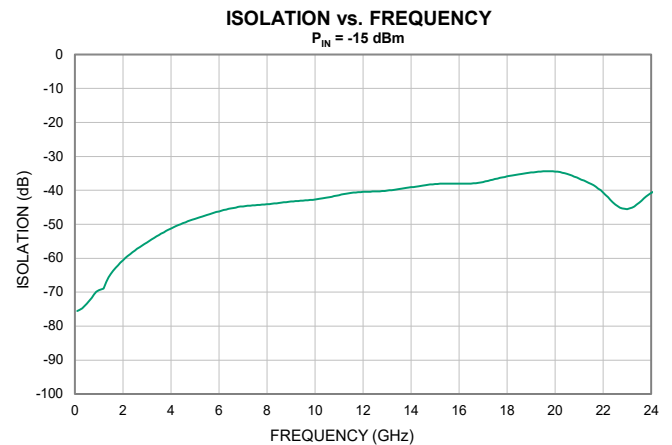
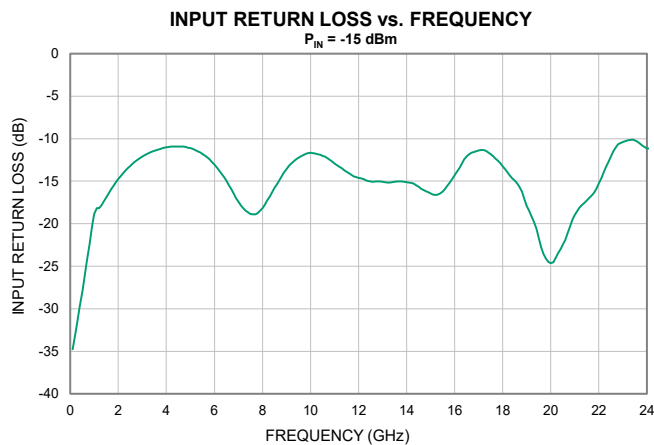
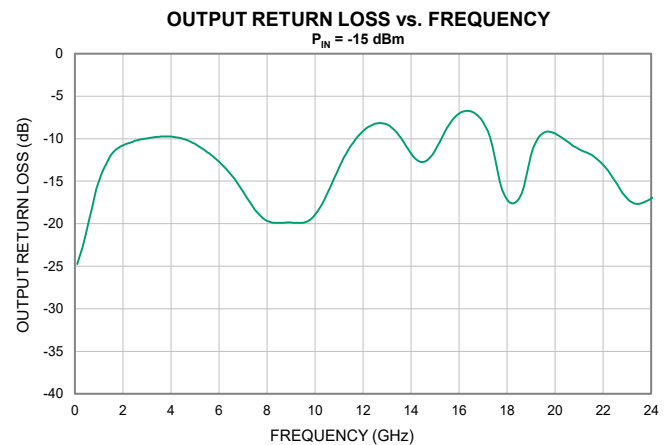
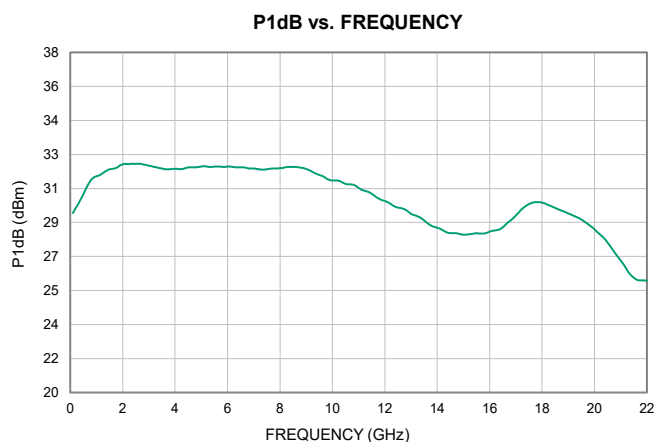
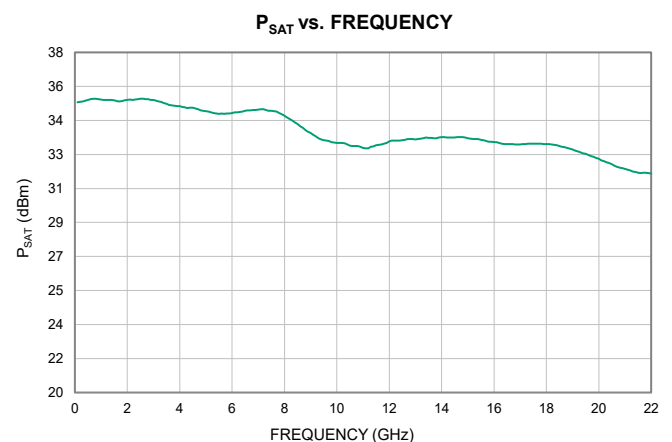
Figure 3. PMA5-223+ 10 MHz - 22 GHz Evaluation and Application Circuit

Component	Value	Size	Part Number	Manufacturer
C1	0.1 μ F	0201	0201BB104KW160	PASSIVE PLUS
C2-C4	0.1 μ F	0402	GRM155R71E104KE14D	MURATA
C5-C8	1 μ F	0603	06035C105KAT2A	AVX CORP.
C9-C10	0.001 μ F	0402	GRM1555C1H102JA01D	MURATA
C11	0.1 μ F	0402	0402BB104KW500	PASSIVE PLUS
R1, R4	0 Ω	0402	RK73Z1ETTP	KOA SPEER
R2	100 Ω	0402	RK73H1ETTP1000F	KOA SPEER
R3	200 Ω	0402	RK73H1ETTP2000F	KOA SPEER
L1	1.2 μ H	0805	0805PB-331XMRC	COILCRAFT
L2	0.425 μ H	1510	CC21T36K240G5-C	PICONICS



TYPICAL EVALUATION BOARD PERFORMANCE GRAPHS

Note: The following data was taken on Mini-Circuits Characterization Test Board TB-PMA5-223CX+ (Figure 3). All data taken at nominal condition of $V_{DD} = +15\text{ V}$, $V_G = +9.5\text{ V}$, and Temperature = $+25^\circ\text{C}$ unless noted otherwise. V_G was adjusted to achieve $I_{DD} = 500\text{ mA}$.





MMIC SURFACE MOUNT

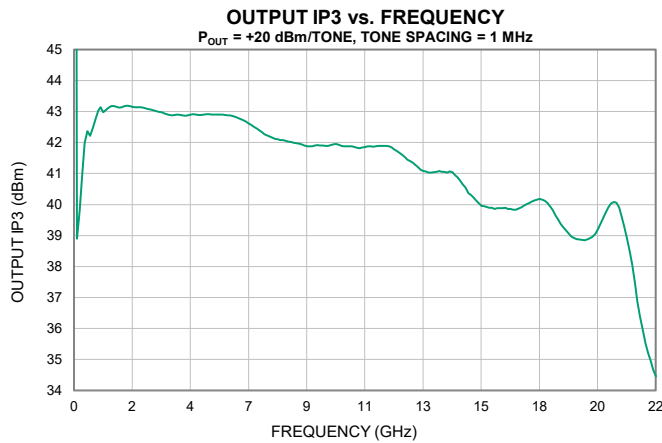
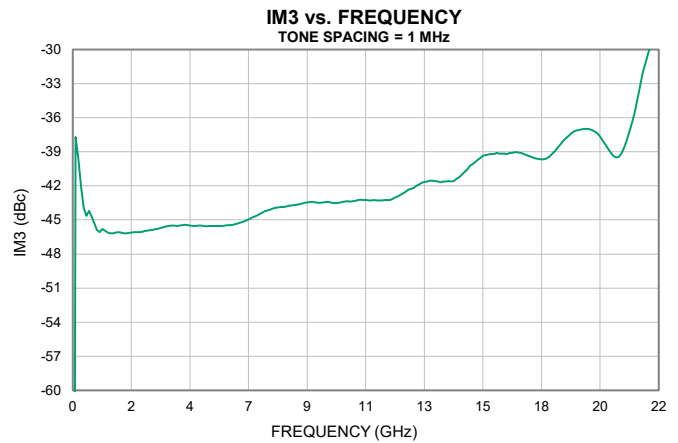
Power Amplifier

PMA5-223+

50 Ω 0.01 to 22 GHz Wideband Amplifier

TYPICAL EVALUATION BOARD PERFORMANCE GRAPHS

Note: The following data was taken on Mini-Circuits Characterization Test Board TB-PMA5-223CX+ (Figure 3). All data taken at nominal condition of $V_{DD} = +15$ V, $V_C = +9.5$ V, and Temperature = +25°C unless noted otherwise. V_G was adjusted to achieve $I_{DD} = 500$ mA.





MMIC SURFACE MOUNT

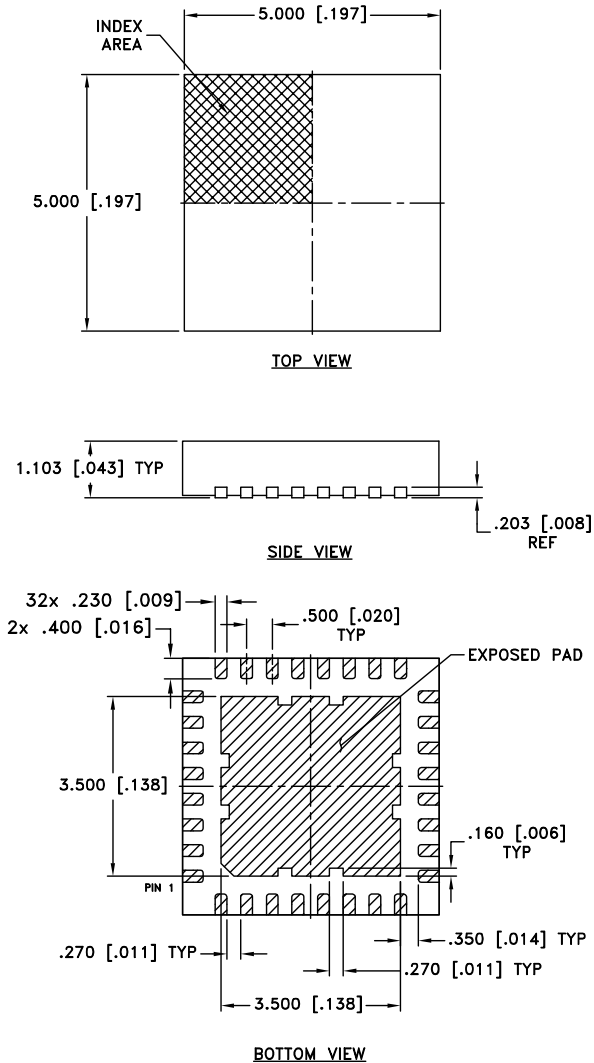
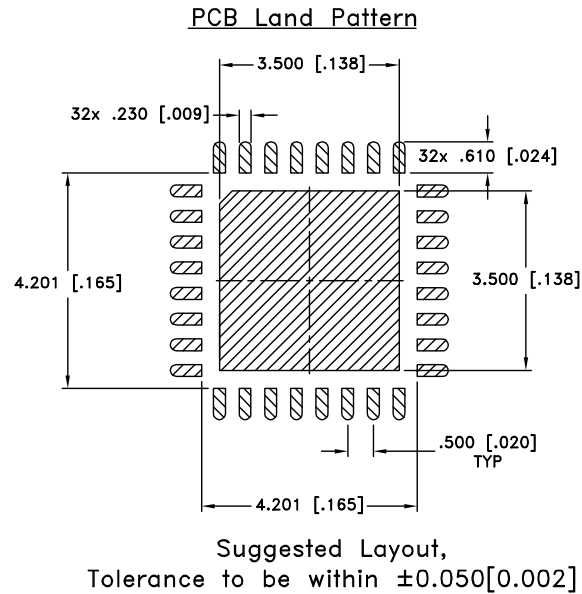
Power Amplifier

PMA5-223+

Mini-Circuits

50Ω 0.01 to 22 GHz Wideband Amplifier

CASE STYLE DRAWING

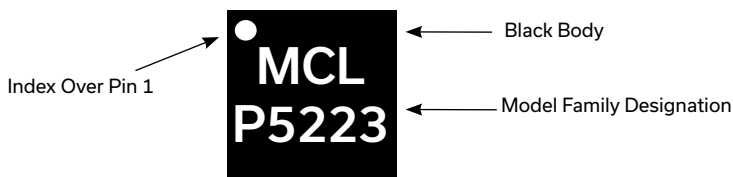


DENOTES METALLIZATION

Weight: .056 Grams

Dimensions are in mm [Inches]. Tolerances: 2 Pl. $\pm 0.254 [0.01]$; 3 Pl. $\pm 0.127 [0.005]$ mm [inches]

PRODUCT MARKING



Marking may contain other features or characters for internal lot control.

Mini-Circuits



Mini-Circuits

MMIC SURFACE MOUNT

Power Amplifier

PMA5-223+

50Ω 0.01 to 22 GHz Wideband Amplifier

ADDITIONAL DETAILED INFORMATION IS AVAILABLE ON OUR DASHBOARD

[CLICK HERE](#)

Performance Data & Graphs	Data
	Graphs
	S-Parameter (S2P Files) Data Set (.zip file)
Case Style	DG1677-8. Plastic package, exposed paddle, Lead Finish: Nickel Palladium Gold
RoHS Status	Compliant
Tape & Reel	F102
Standard Quantities Available on Reel	7" reels with 20, 50, 100, 200, 500 devices 13" reels with 1000 devices
Suggested Layout for PCB Design	PL-872
Evaluation Board	TB-PMA5-223CX+
	Gerber File
Environmental Ratings	ENV08T1
Product Handling	The use of no-clean solder is recommended. This package cannot be subjected to aqueous wash

NOTES

- Performance and quality attributes and conditions not expressly stated in this specification document are intended to be excluded and do not form a part of this specification document.
- Electrical specifications and performance data contained in this specification document are based on Mini-Circuits' applicable established test performance criteria and measurement instructions.
- The parts covered by this specification document are subject to Mini-Circuits' standard limited warranty and terms and conditions (collectively, "Standard Terms"); Purchasers of this part are entitled to the rights and benefits contained therein. For a full statement of the standard terms and the exclusive rights and remedies thereunder, please visit Mini-Circuits' website at www.minicircuits.com/terms/viewterm.html

