DC–22 GHz 32dBm Distributed Power Amplifier

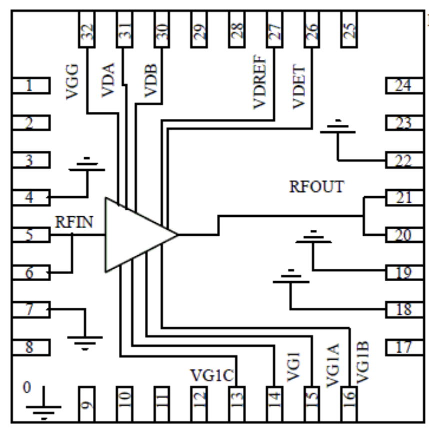
Product Overview

MMA155PP5 is a gallium arsenide (GaAs) monolithic microwave integrated circuit (MMIC) pseudomorphic high electron-mobility transistor (pHEMT) distributed amplifier that operates between DC and 22 GHz. It is ideal for test instrumentation and wide-band military and space applications. The amplifier provides a gain of 15 dB, 3.5 dB noise figure, and 32 dBm of output power at 3 dB gain compression with a nominal bias condition of 640 mA from a 13V supply. Output IP3 is typically 35 dBm. The MMA155PP5 amplifier is DC coupled and features RF I/Os that are internally matched to 50 Ω.

Key Features

- **Broadband performance: DC to 22 GHz**
- **High Gain: 15 dB**
- **Positive Gain Slope**
- **High Psat: 33 dBm at 12 GHz**
- **Supply: 13 V at 640 mA**
- **Integrated Temperature Compensated Power Detector**
- **50 Ohm matched Input/Output**
- **Molded QFN 5x5mm Package**
- **Passivated space-qualified process listed on EPPL007-38**

Functional Block Diagram



Applications

- Test and measurement instrumentation
- Military and space, SATCOM, Phased Array
- EW, ECCM, RADAR
- Wireless infrastructure
- Wideband microwave radios

Performance Overview

Parameter	Typ.	Units
Operational frequency range	DC-22	GHz
Gain	15	dB
Psat	+33	dBm
IM3 (20dBm per tone)	-40	dBc
Current @ +13V Supply	640	mA

Export Classification: EAR-99

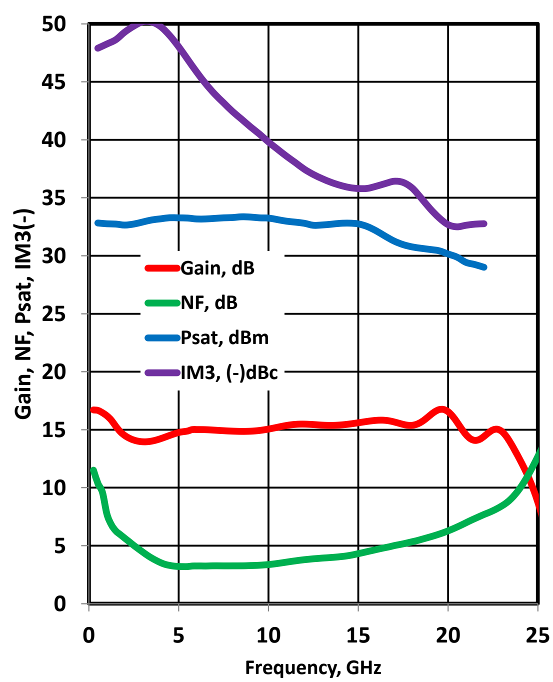


Figure 1 - Featured Performances

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1. Electrical Specifications

1.1. Typical Electrical Performance

Table 1 - Typical Electrical Performance at 25 C, Vdd=13V, Idd=640 mA (Unless otherwise mentioned)

Parameter	Frequency Range	Min	Typ.	Max	Units
Frequency range		DC		24	GHz
Gain	DC–6 GHz	14	15		dB
	6 GHz–12 GHz	14	15		
	12 GHz – 22 GHz	14	15		
Gain flatness	4 GHz - 12 GHz		+/- 0.5		dB
	12 GHz – 22 GHz		+/- 1		
Noise figure	2 GHz–6 GHz		3.5	6	dB
	6 GHz–12 GHz		3	3.5	
	12 GHz – 20 GHz		3.5	6	
Input return loss	DC–6 GHz		15		dB
	6 GHz–12 GHz		17		
	12 GHz – 22 GHz		10		
Output return loss	DC–6 GHz		12		dB
	6 GHz–12 GHz		14		
	12 GHz – 22 GHz		10		
P1dB	DC–6 GHz	30	31.5		dBm
	6 GHz–12 GHz	30	31.5		
	12 GHz – 22 GHz	28	30		
Psat	DC–6 GHz	31	33		dBm
	6 GHz–12 GHz	31	33		
	12 GHz – 20 GHz	29	30.5		
OIP3	DC–6 GHz		33		dBm
	6 GHz–12 GHz		34		
	12 GHz – 20 GHz		32		
IM3 @ 20dBm	DC–6 GHz		-45		dBc
	6 GHz–12 GHz		-40		
	12 GHz – 20 GHz		-35		
Phase Noise			TBD		dBm/Hz
OIP2(low) (2-nd Order Intercept point F2-F1)			46		dBm
VDD (drain voltage supply)			13	15	V
IDD (drain current)			640	750	mA

1.2. Absolute Maximum Ratings

The following table shows the absolute maximum ratings of the MMA155PP5 device at 25 °C, unless otherwise specified. Exceeding one or any of the maximum ratings potentially could cause damage or latent defects to the device.

Table 2 - Absolute Maximum Ratings

Parameter	Rating
Drain bias voltage (V_{DD})	17 V
Gate bias voltage (V_G)	–2 V to 0.5 V
RF input power (Pin)	26 dBm (or 6 dB Compression)
Channel temperature	165 °C
V_{DD} current (I_{DD})	800 mA
DC power dissipation (T = 85 °C) at Psat	9.4 W
DC Power dissipation (T = 85 °C) at Low Power	12.1 W
Thermal resistance at Psat	9.6°C/W
Thermal resistance at Low Power	7.4°C/W
Storage temperature	–65 °C to 150 °C
Operating temperature	–55 °C to 85 °C

ESD Sensitive Device

1.3. Typical Performance Curves

1.3.1 Typical Performances vs. Temperature

The following graphs show the typical performance curves of the MMA155PP5 device at specific bias conditions, measurements performed using application circuit shown on **Error! Reference source not found.** below.

Figure 2 - Gain vs. Temperature @ 11V/470mA

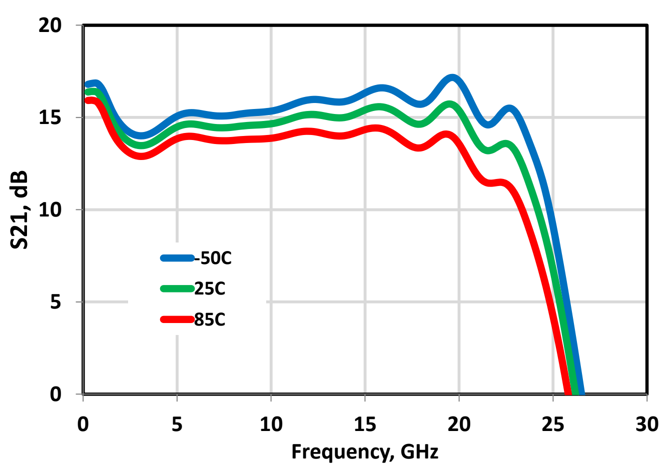


Figure 3 - Gain vs. Temperature @ 13V/640mA

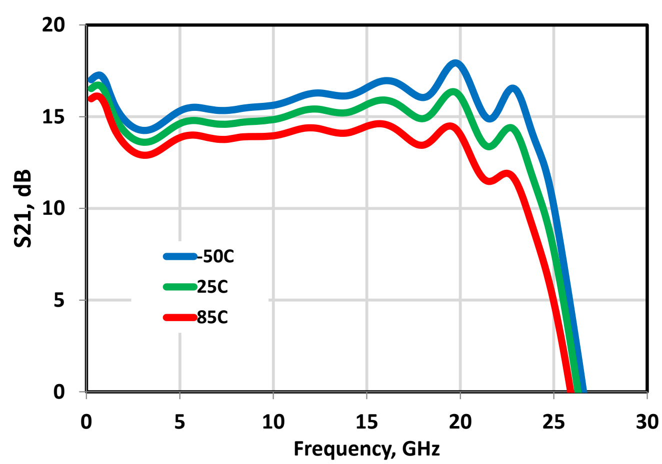


Figure 4 - Gain vs. Temperature @ 15V/750mA

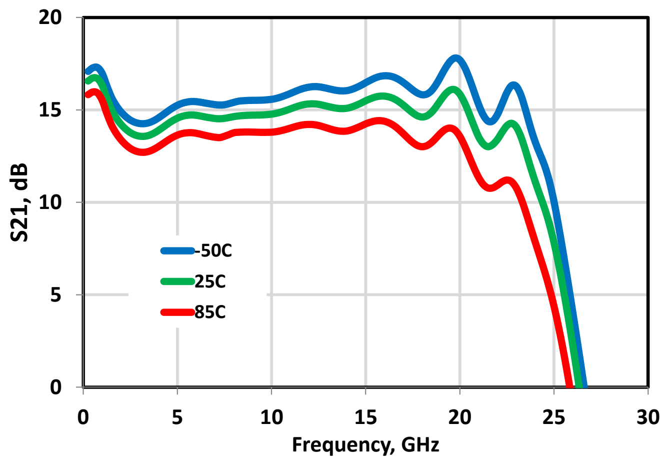


Figure 5 - S11 vs. Temperature @ 11V/470mA

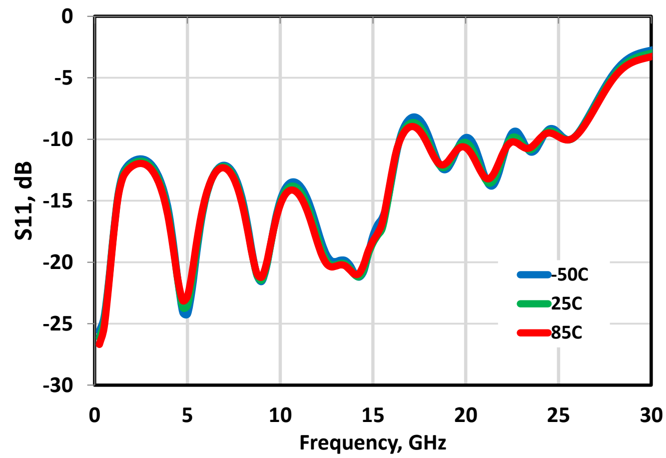


Figure 6 - S11 vs. Temperature @ 13V/640mA

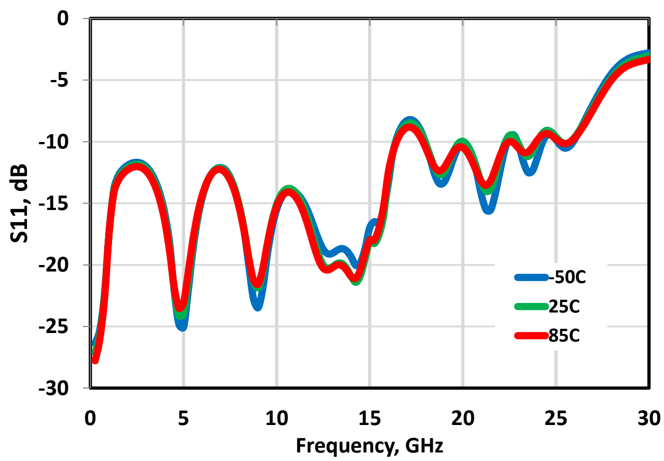


Figure 7 - S11 vs. Temperature @ 15V/750mA

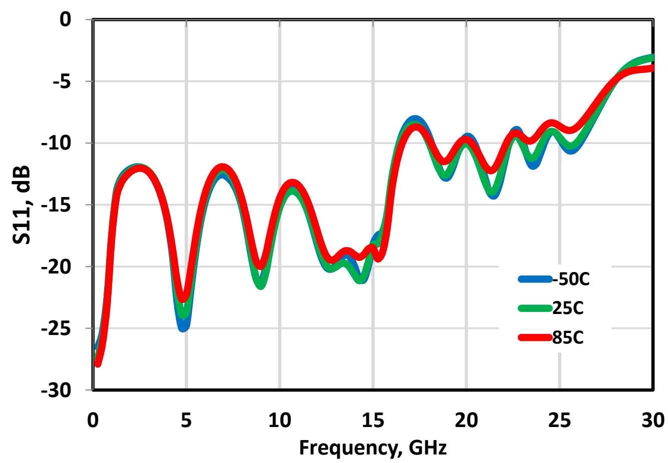


Figure 8 - S22 vs. Temperature @ 11V/470mA

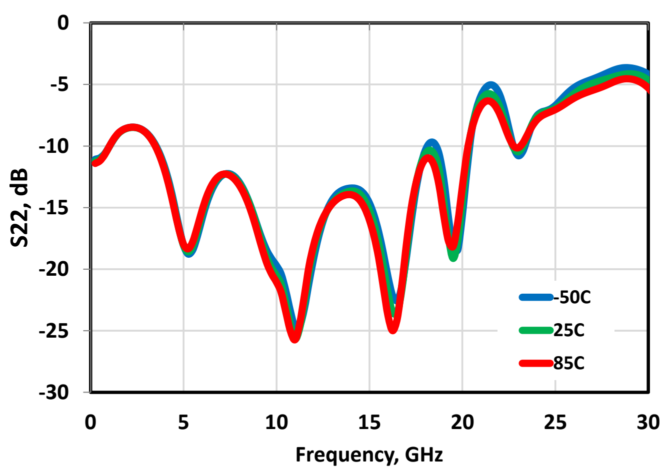


Figure 9 - S22 vs. Temperature @ 13V/640mA

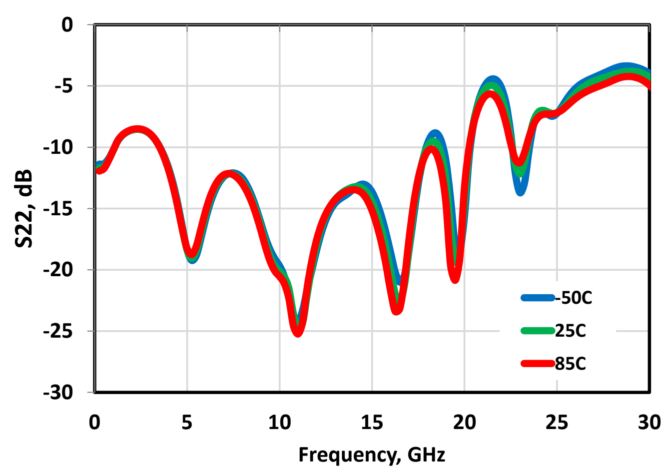


Figure 10 - S22 vs. Temperature @ 15V/750mA

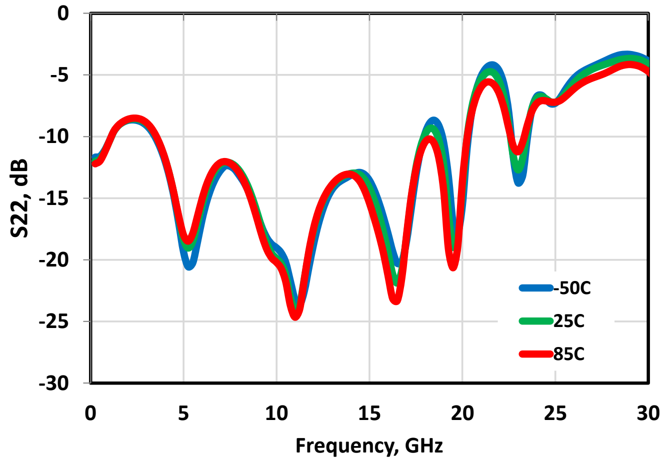


Figure 11 - S12 vs. Temperature @ 11V/470mA

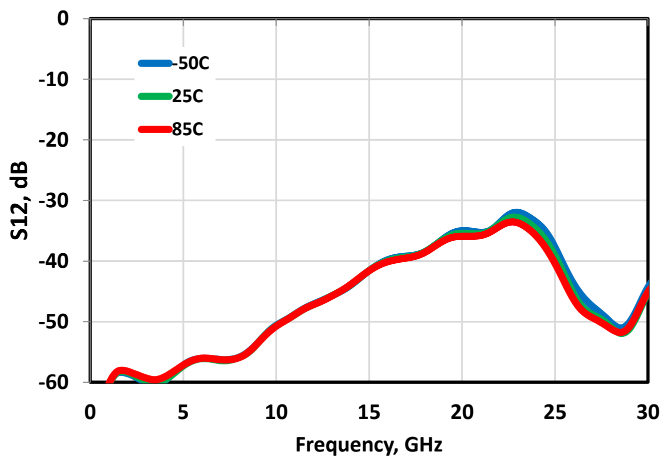


Figure 12 - S12 vs. Temperature @ 13V/640mA

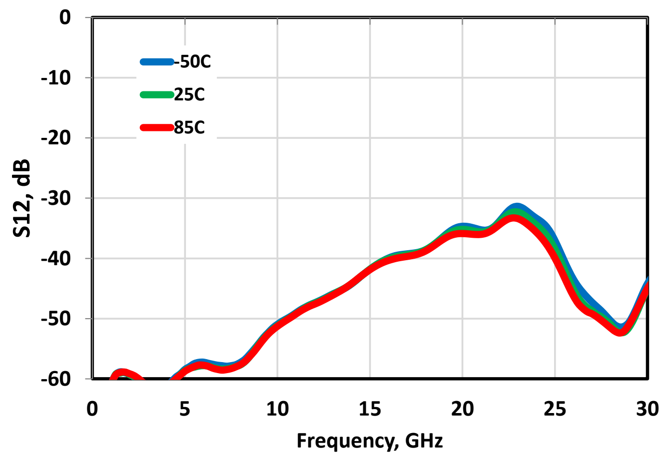


Figure 13 - S12 vs. Temperature @ 15V/750mA

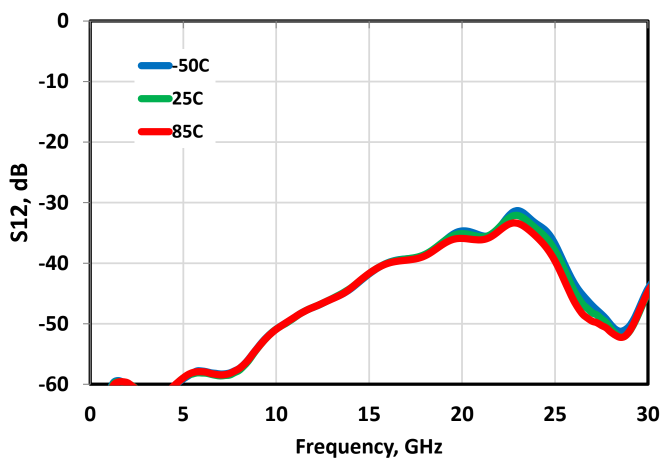


Figure 14 - NF vs. Temperature @ 11V/470mA

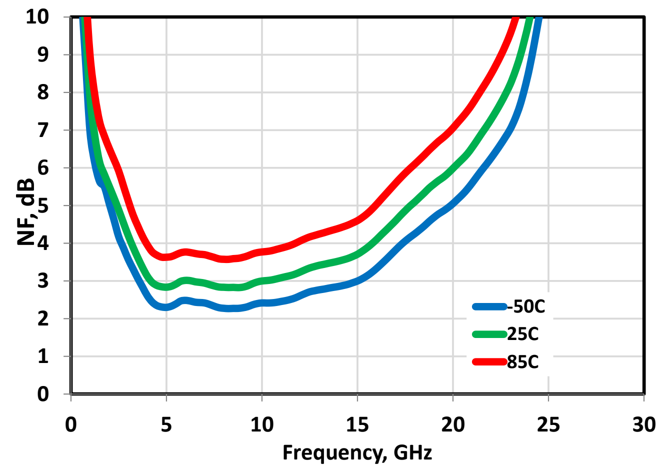


Figure 15 - NF vs. Temperature @ 13V/640mA

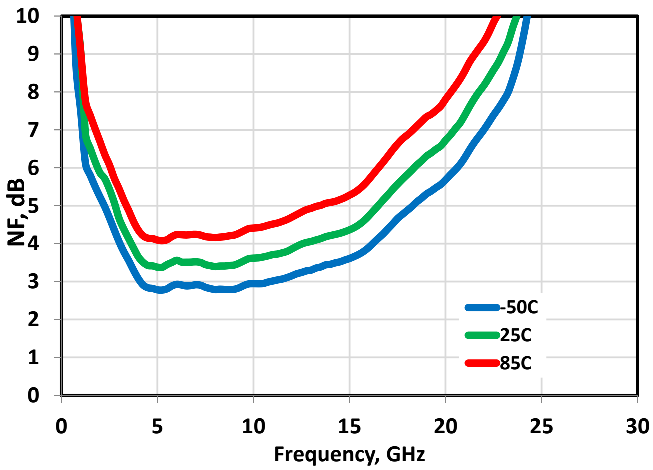


Figure 16 - NF vs. Temperature @ 15V/750mA

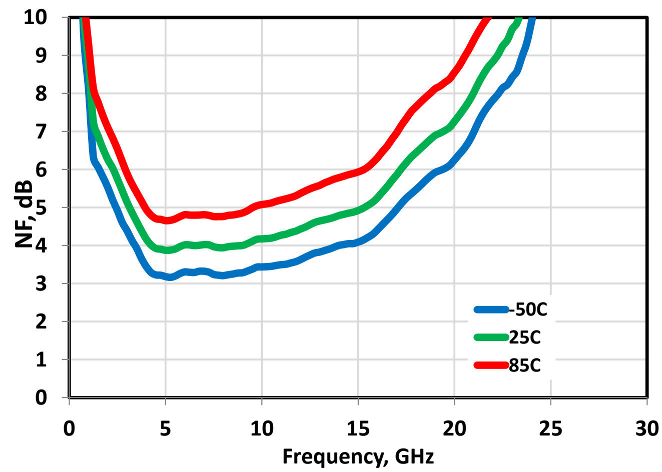


Figure 17 - P1dB vs. Temperature @ 11V/470mA

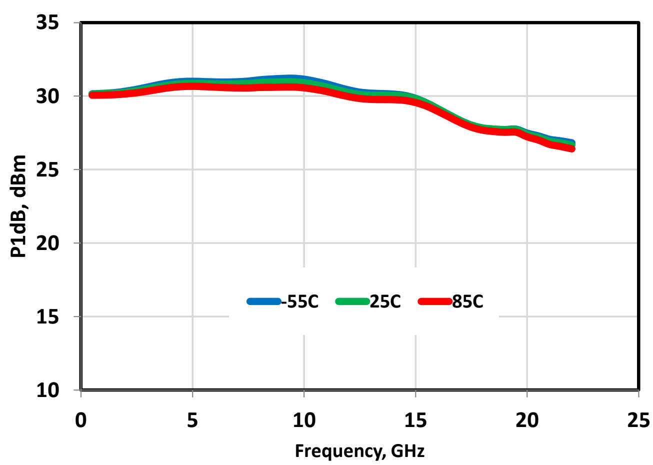


Figure 18 - P1dB vs. Temperature @ 13V/640mA

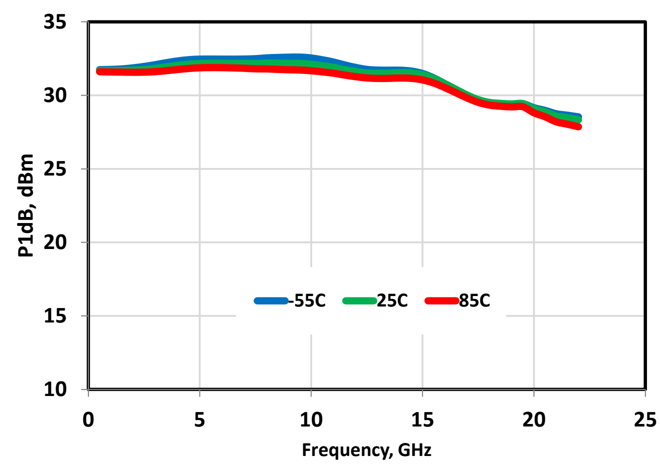


Figure 19 - P1dB vs. Temperature @ 15V/750mA

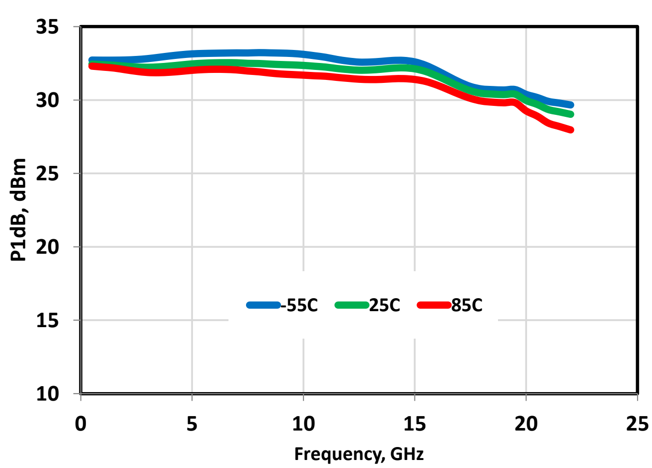


Figure 20 - Psat vs. Temperature @ 11V/470mA

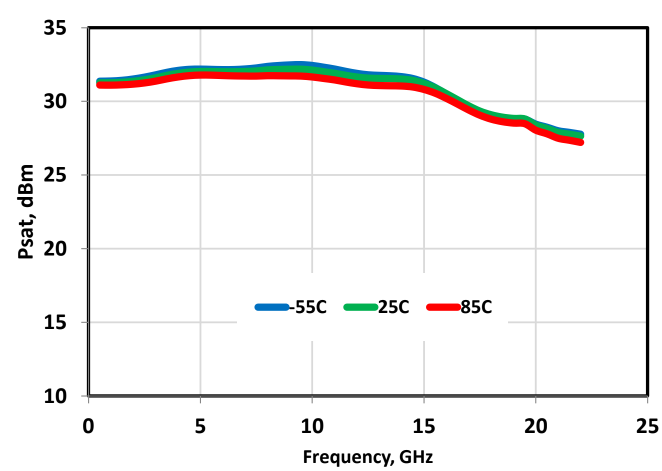


Figure 21 - Psat vs. Temperature @ 13V/640mA

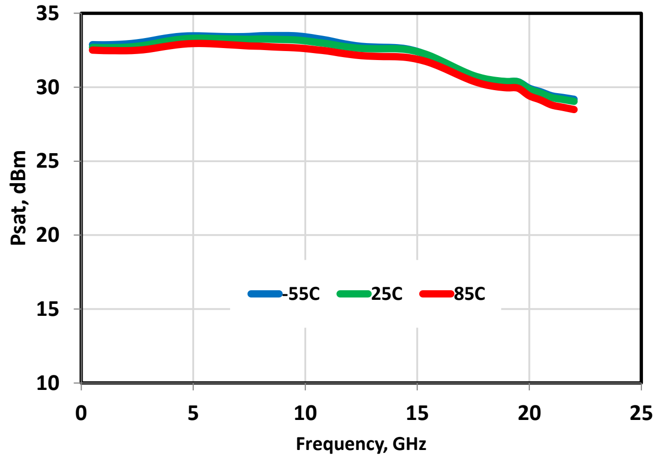


Figure 22 - Psat vs. Temperature @ 15V/750mA

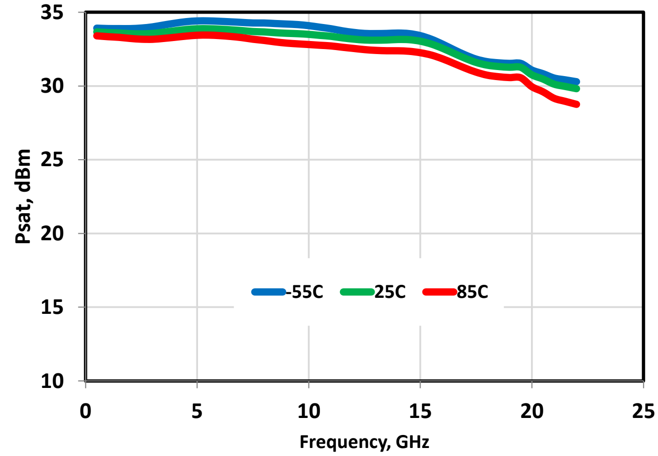


Figure 23 - OIP3 vs. Temperature @ 11V/470mA

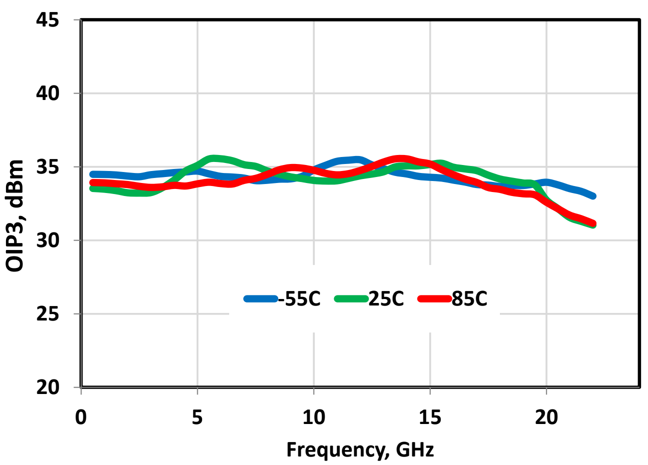


Figure 24 - OIP3 vs. Temperature @ 13V/640mA

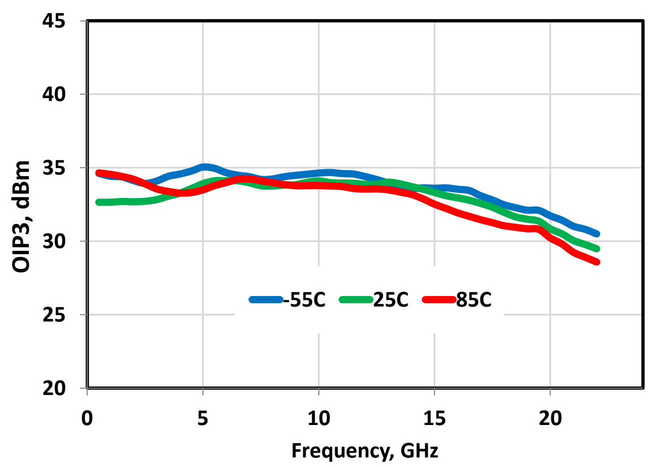


Figure 25 - OIP3 vs. Temperature @ 15V/750mA

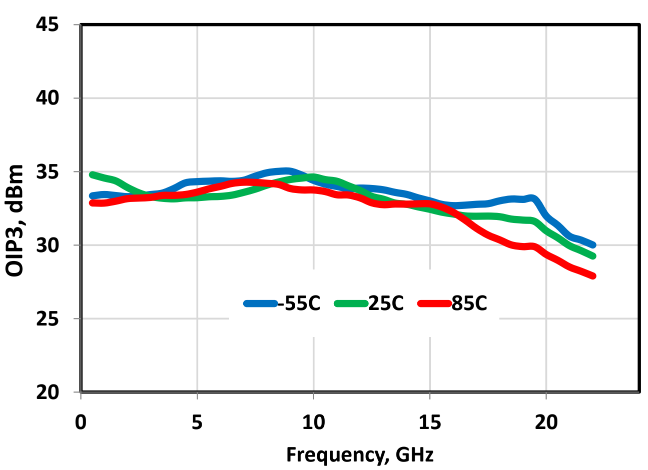


Figure 26 - OIP2(low) vs. Temperature @ 11V/470mA

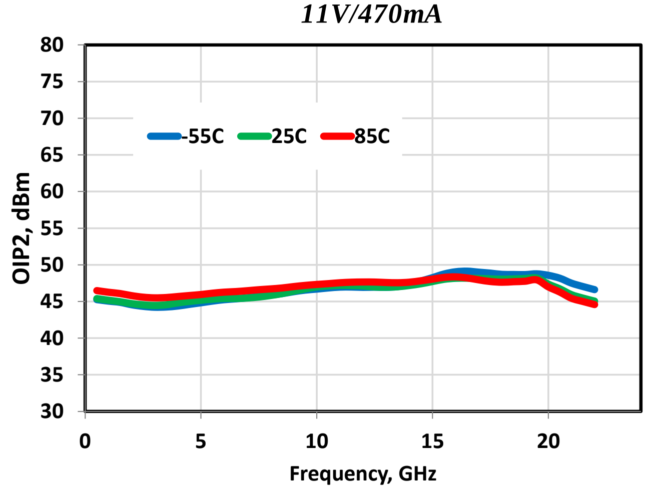


Figure 27 - OIP2(low) vs. Temperature @ 13V/640mA

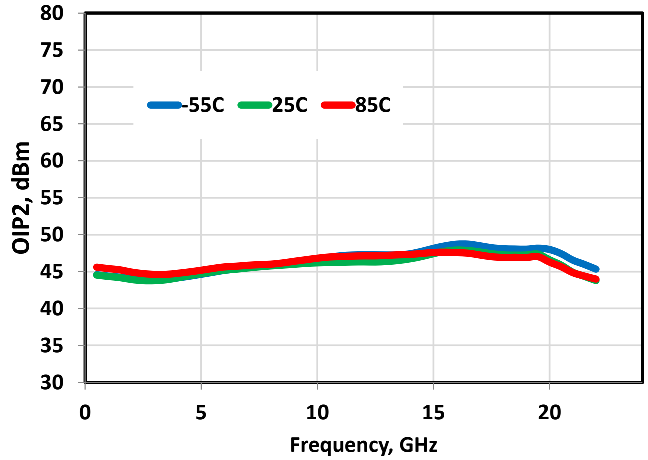


Figure 28 - OIP2(low) vs. Temperature @ 15V/750mA

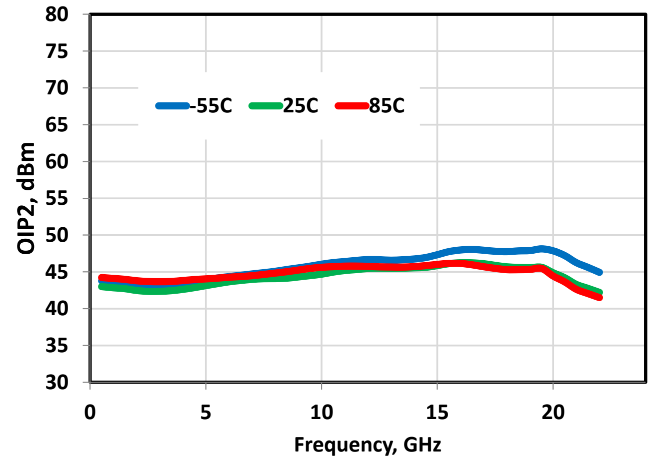


Figure 29 - IM3 vs. Temperature @ 11V/470mA, 20dBm(per tone)

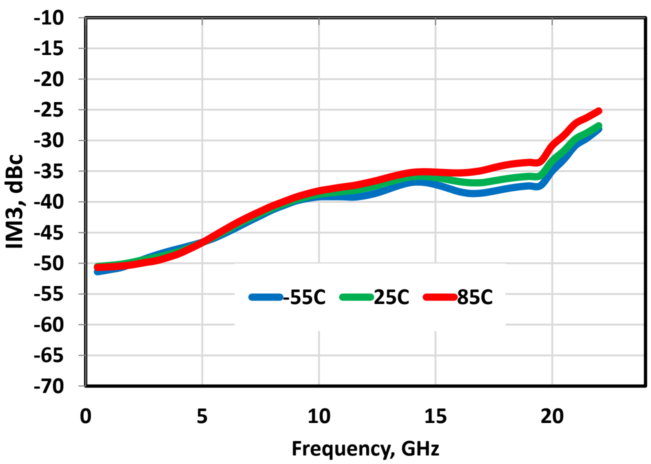


Figure 30 - IM3 vs. Temperature @ 13V/640mA, 20dBm (per tone)

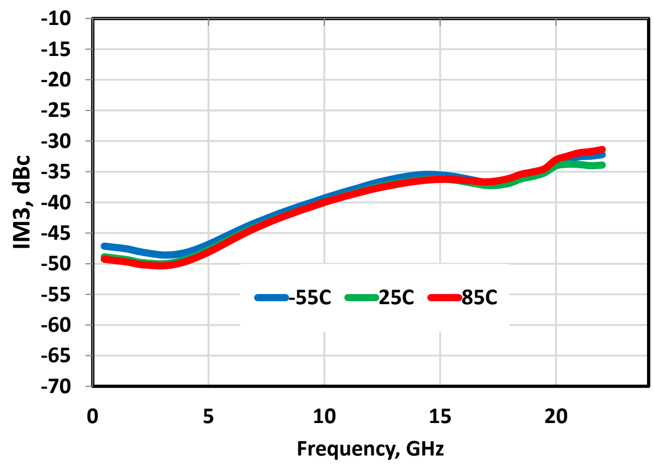
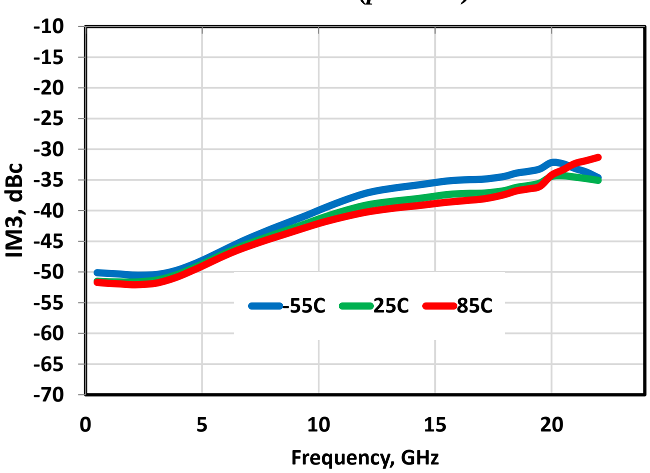


Figure 31 - IM3 vs. Temperature @ 15V/750mA, 20dBm(per tone)



1.3.2 Typical Performances vs. Bias

The following graphs show the typical performance curves of the MMA155PP5 device at 25 °C vs. Bias conditions, measurements performed using application circuit shown on **Error! Reference source not found.** below.

Figure 32 - Gain vs. V_{DD} @ 470mA

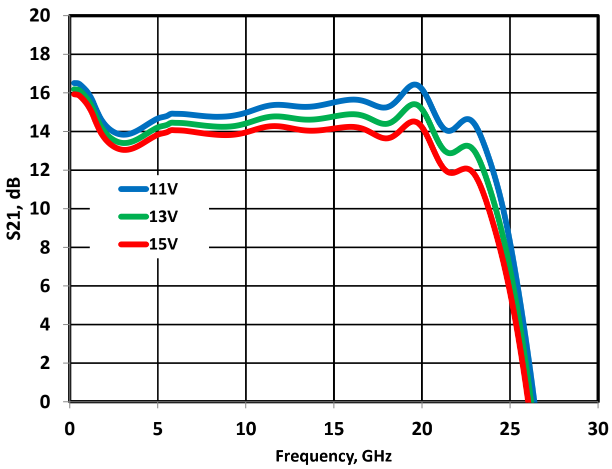


Figure 33 - Gain vs. V_{DD} @ 640mA

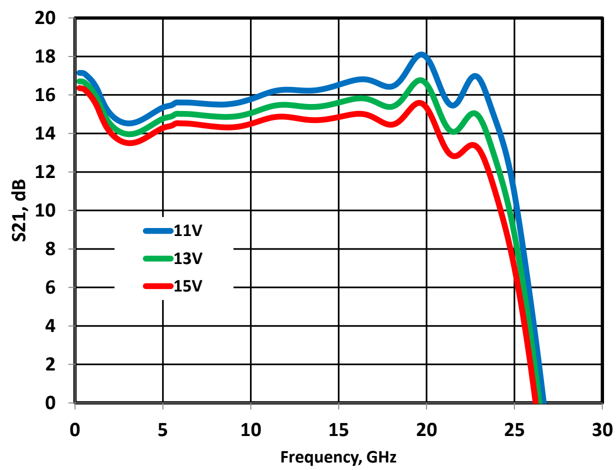


Figure 34 - Gain vs. V_{DD} @ 750mA

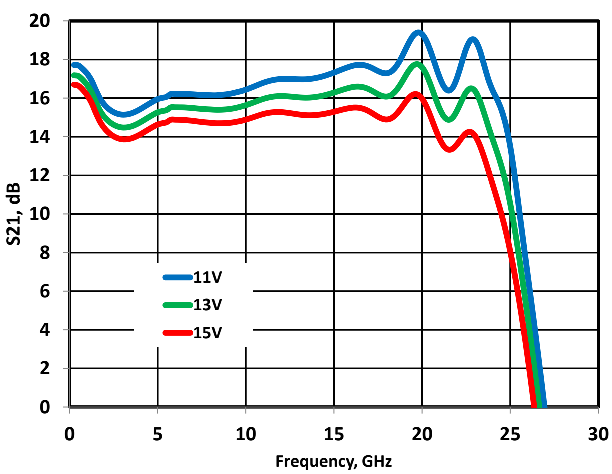


Figure 35 - NF vs. V_{DD} @ 470mA

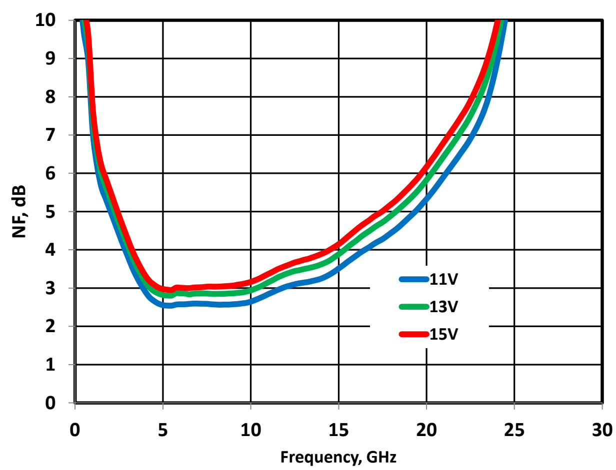


Figure 36 - NF vs. V_{DD} @ 640mA

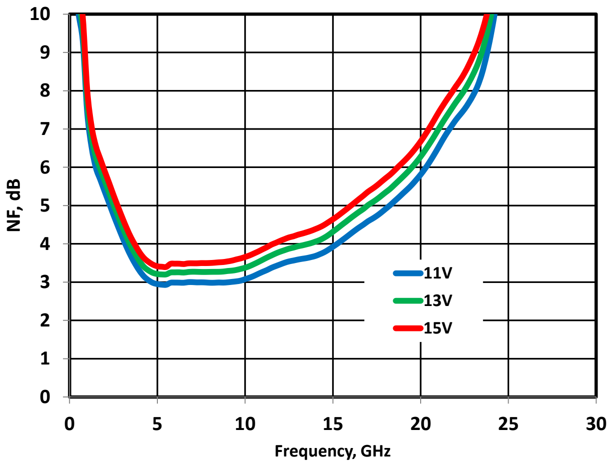


Figure 37 - NF vs. V_{DD} @ 750mA

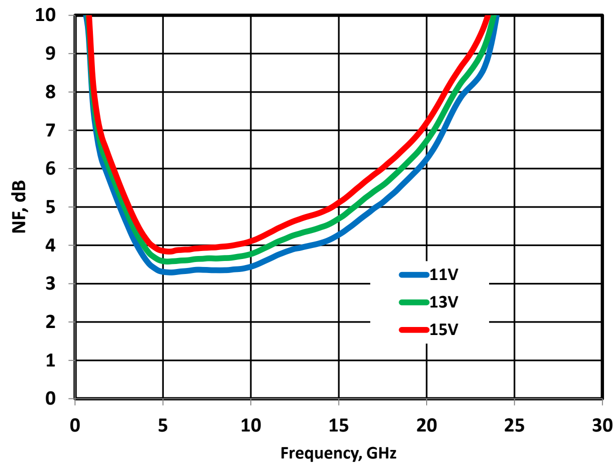


Figure 38 - P1dB vs. V_{DD}/I_{DD}

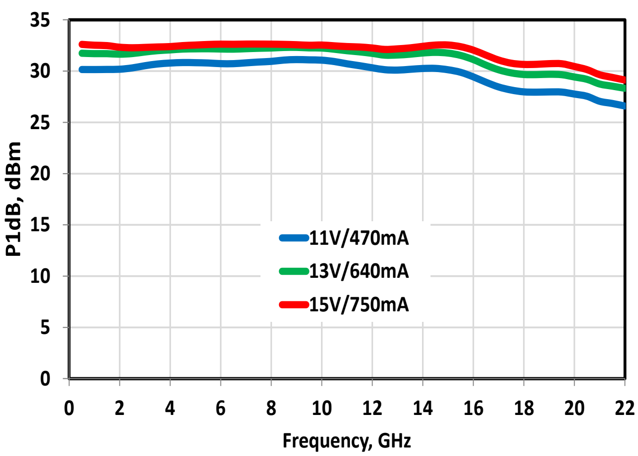


Figure 39 - Psat vs. V_{DD}/I_{DD}

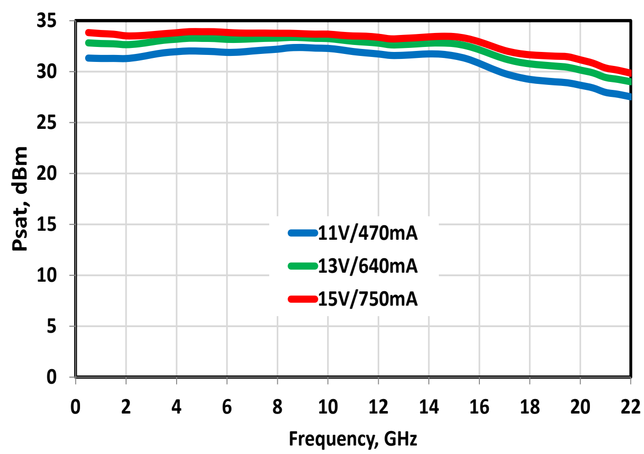


Figure 40 - OIP3 vs. V_{DD}/I_{DD}

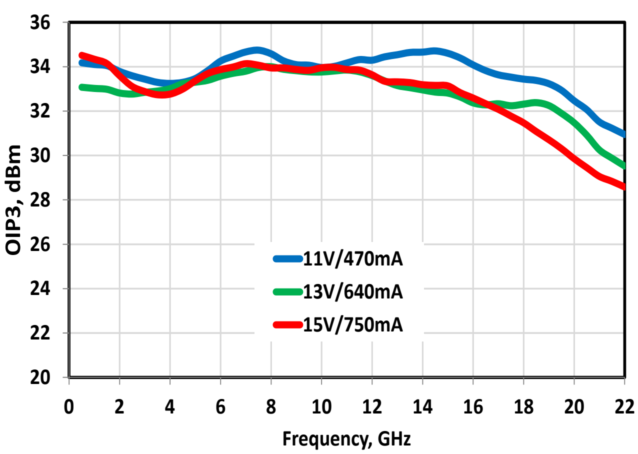


Figure 41 - OIP2 Low at D=10MHz vs. V_{DD}/I_{DD}

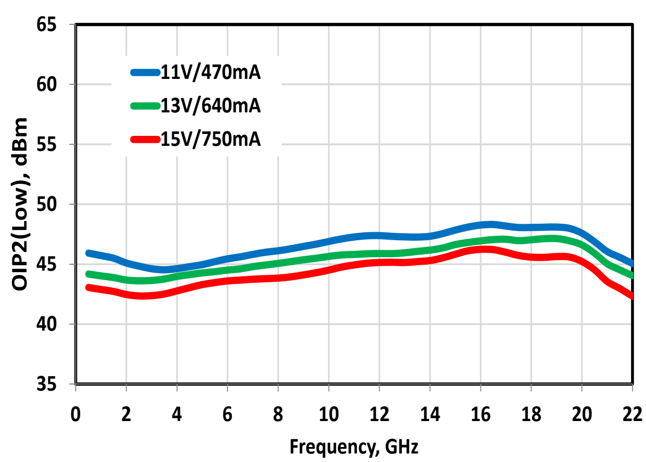
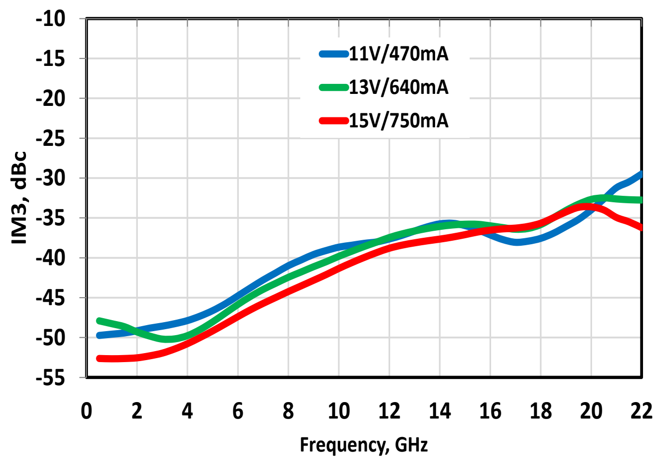


Figure 42 - IM3 vs. V_{DD}/I_{DD}, 20dBm(per tone)



1.3.3 Typical Performances vs. Output Power

The following graphs show the typical performance curves of the MMA155PP5 device at 25 °C vs. Output Power conditions, measurements performed using application circuit shown on **Error! Reference source not found.** below.

Figure 43 - IM2 vs. Power @ 11V/470mA

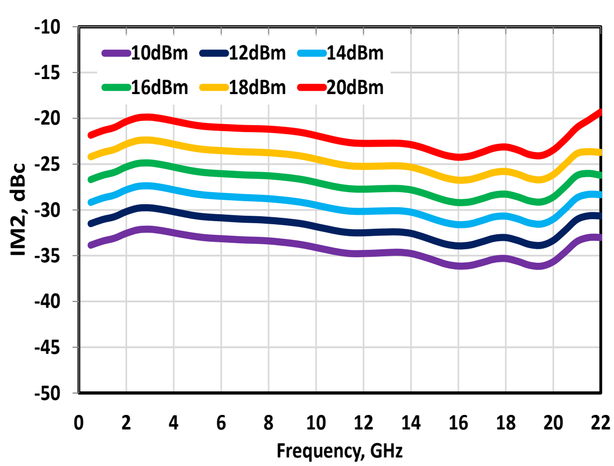


Figure 44 - IM2 vs. Power @ 13V/640mA

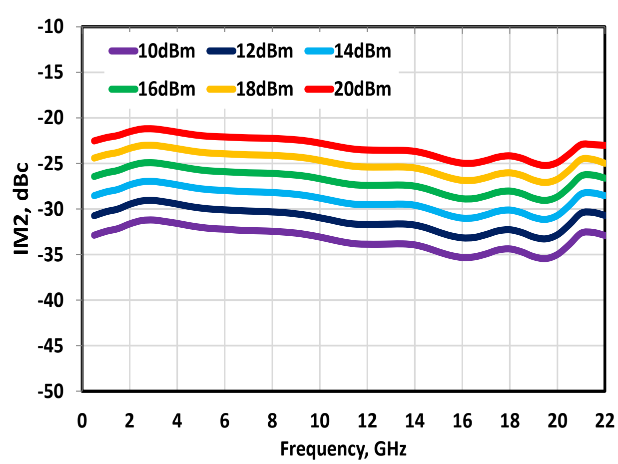


Figure 45 - IM2 vs. Power @ 15V/750mA

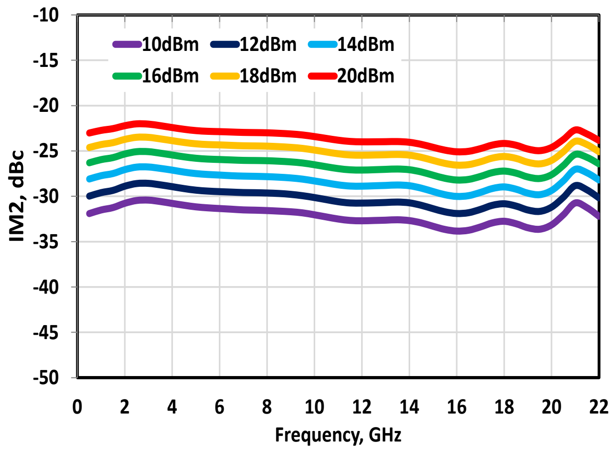


Figure 46 - IM3 vs. Power @ 11V/470mA

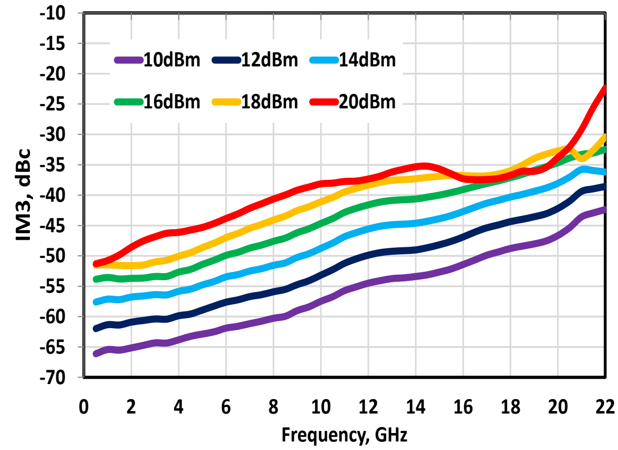


Figure 47 - IM3 vs. Power @ 13V/640mA

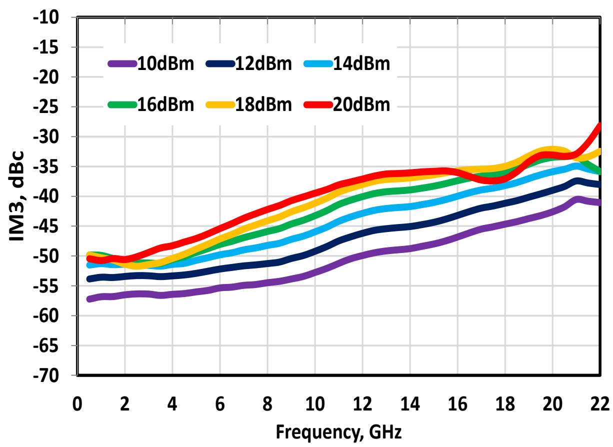


Figure 48 - IM3 vs. Power @ 15V/750mA

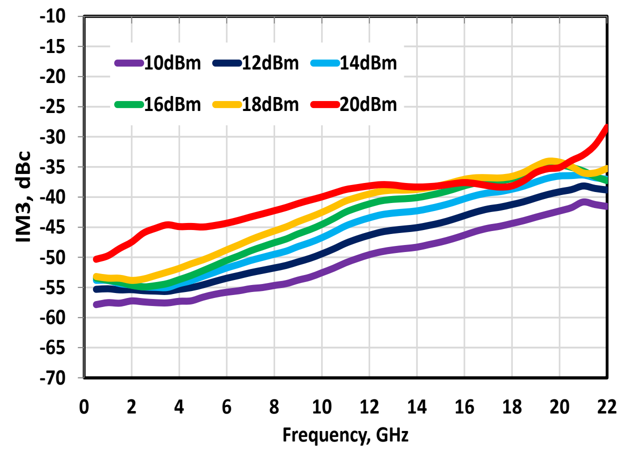


Figure 49 - 2-nd Harmonic vs. Power @ 13V/640mA

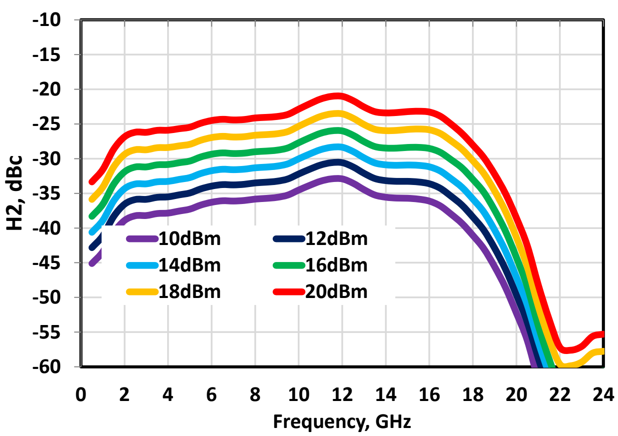


Figure 50 - 2-nd Harmonic vs. Power @ 13V/650mA

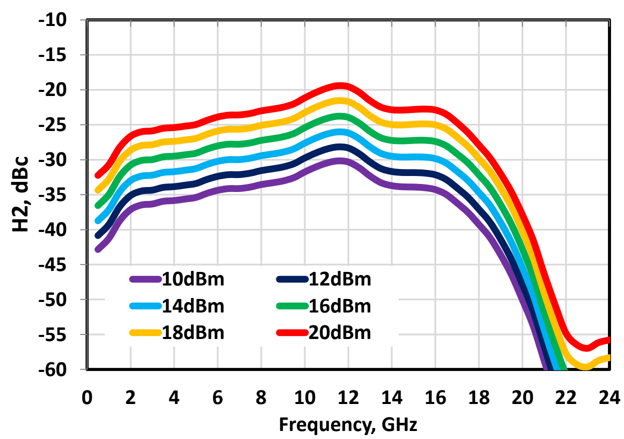


Figure 51 - 2-nd Harmonic vs. Power @ 15V/750mA

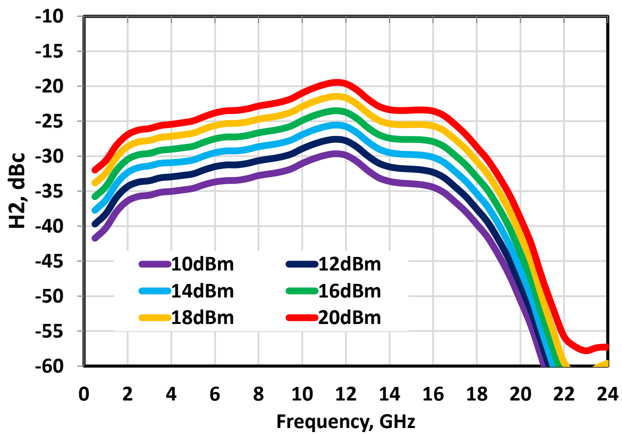


Figure 52 - Detector vs. Power, Frequency

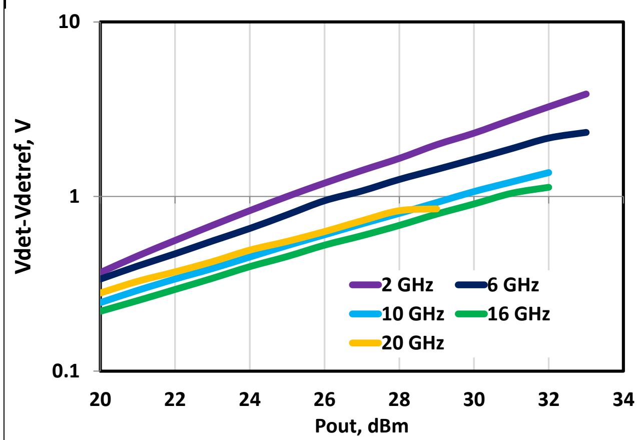
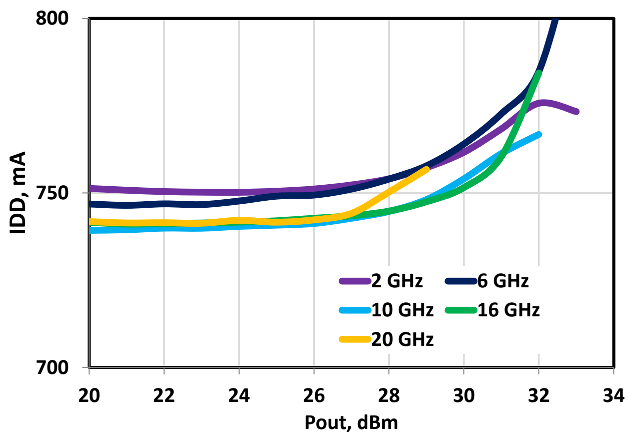


Figure 53 - I_{DD} Current vs. Power, Frequency at 15V



2. Package Specifications

The following illustration shows the package outline of the MMA155PP5 device. Dimensions are in millimeters [inches].

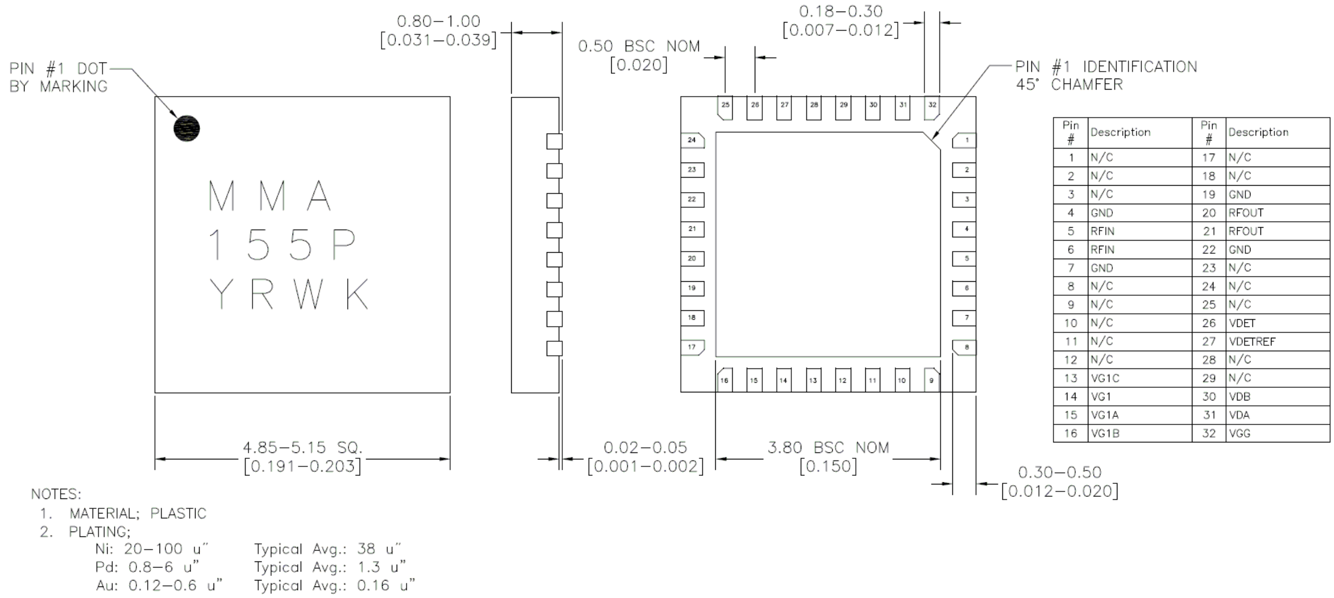


Figure 54 - MMA155PP5 Package Outline Drawing (mm)

Table 3 – Package Materials

Package	5mm X 5mm 32L Plastic QFN
Lead Frame	C194 Cu
Plating	Ni/Pd/Au
Package Body Material	RoHS Compliant Low-stress injection molded plastic

Table 4 - I/O Description

Pad Number	Pad Name	Pad Description
5, 6	RF_{IN}	Pin 5 and 6 must be merged on the layout and are matched to 50 Ω, and DC coupled to gate 1.
20, 21	RF_{OUT}	Pin 20 and 21 must be merged on the layout and are matched to 50 Ω, These pins are used for VDD Bias.
32	V_{GG}	Bias for VG2, must be coupled to VDD by connecting it to VDA or VDB externally for nominal operation (Alternately, this pin could be used for gain/linearity fine tuning)
14	V_{G1}	First Gate Bias, should have ceramic shunt capacitor to reduce noise impact on the die
15, 16, 13	V_{G1A}, V_{G1B}, V_{G1C}	Low-Frequency Terminations for Gate1
26	V_{DET}	Detector pin, with DC voltage as function of output power, for correct operation of detector use VDET-VDETREF at external comparator
27	V_{DETREF}	Detector reference voltage
31, 30	V_{DA} ,V_{DB}	DC linked to VDD internally. External bypass capacitors are required to extend RF match and gain flatness below 2 GHz. Not intended for VDD bias
4, 7, 19, 22, Middle Pad	Ground	Should be connected to RF/DC ground with as many vias as possible, see our recommended landing pattern as example

1, 2, 3, 8, 9, 10, 11, 12, 17, 18, 23, 24, 25, 28, 29	N/C	These pins are not connected internally. All data was measured with these pins connected to RF/DC ground externally, which is recommended connection.

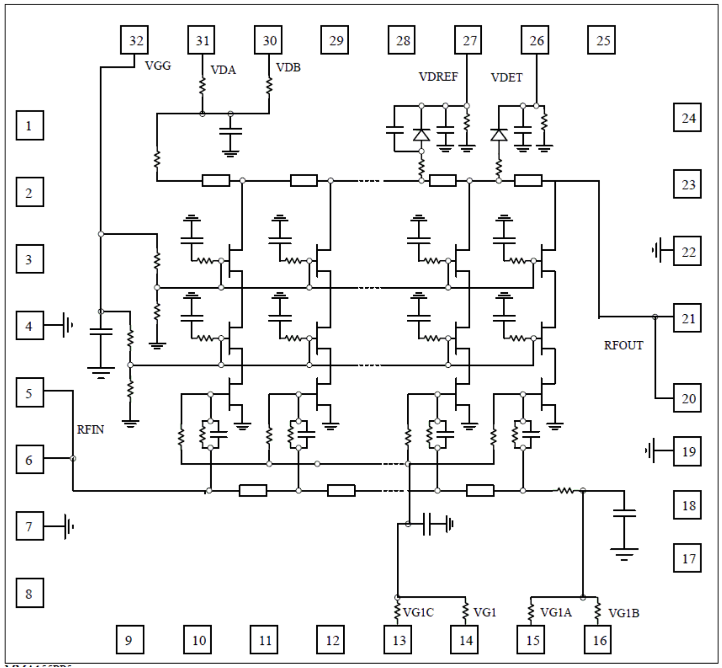


Figure 55 - Amplifier Functional Schematic

3. Application Circuits: Evaluation Board

Figure 56 shows the MMA155PP5E application circuit. Negative Gate bias (VG1) is provided through connector J6 (PIN 7) and the detector voltage outputs through connector J3 (PINS 3 & 4). Th MMA155PP5E does not have direct V_{DD} connection. Instead, V_{DD} must be applied through the RF-output, 2.92 mm, Connector J4. When applying this V_{DD}, a Bias T capable of handling up to 1A of current is necessary (e.g., BTN1-0026, which has the added advantage of not having a resonating response to pulses). To protect the amplifier, it is important to connect the Bias T as close to the output J4 connector as possible and add sufficient bypass capacitive loading to avoid possibility of resonant or voltage spiking behavior in the DC supply path. Microchip has observed the possibly of undesired DC pulsing occurring when using some types of characterization equipment, notably PNAx. Short lead lengths and sufficient capacitive bypassing will ensure smooth pulse transitions and limit over voltage possibilities. It is also noted that both DC and RF signals are present at the RF-input Connector J5. It is recommended that the RF input port have a DC block connected when testing. The MMA155PP5E evaluation board will dissipate a significant amount of power as heat. It is recommended that MMA155PP5E is attached to additional heat sinking either using a clamp or better still by attaching the MMA155PP5E evaluation to the additional heat sink using the threaded holes on the backside of the metal.

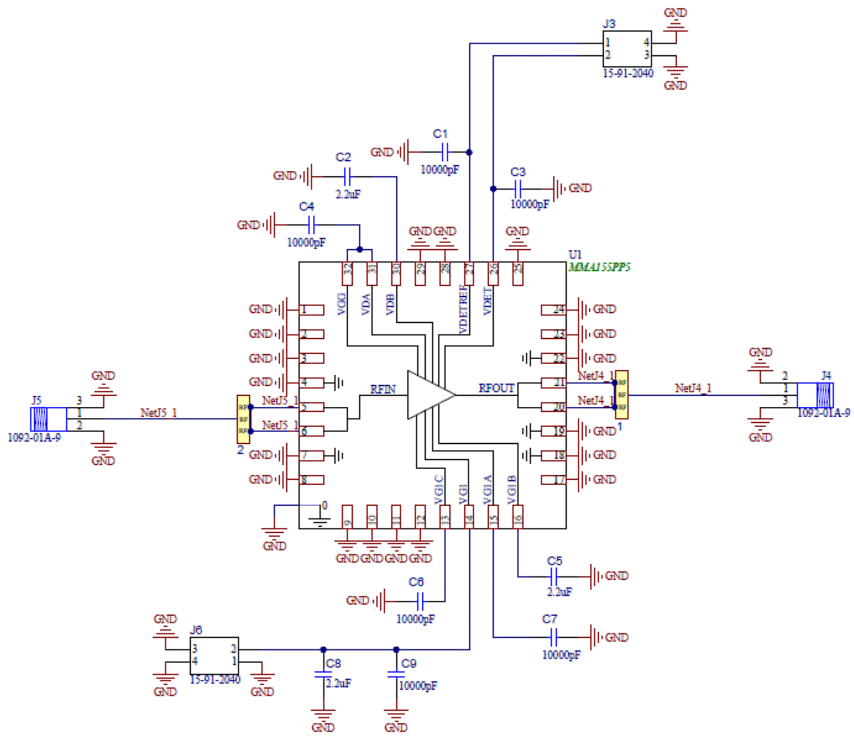
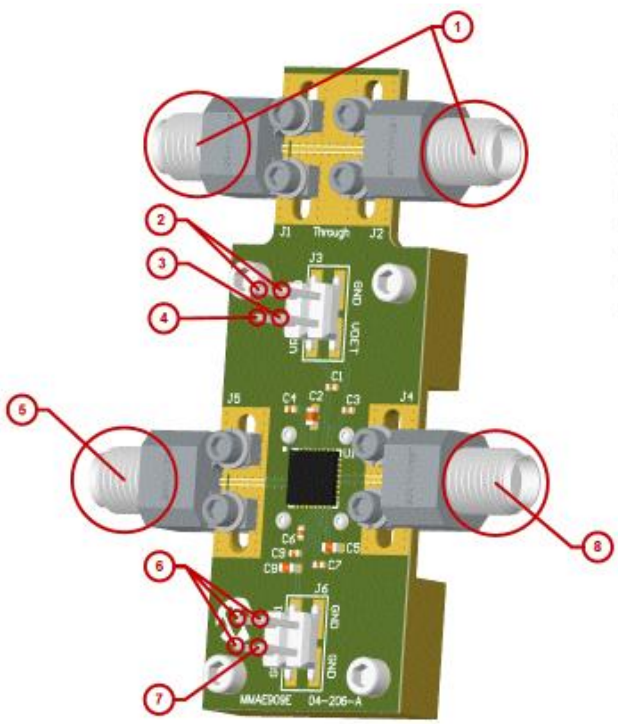


Figure 56 - MMA155PP5E Evaluation PCB schematic



DESCRIPTION

1. Optional 2.92mm connectors for through calibration
2. Ground pins
3. Voltage detector pin
4. Voltage detector reference pin
5. RF + DC Input 2.92mm
6. Ground pins
7. VG1 Access pin
8. RF + DC Output 2.92mm

MMA155PP5E Bias Procedure

Step	Instruction
1	Make sure all DC and RF connections are attached before activating any DC voltage power supplies.
	Note: DC supply for VG1 can be attached either through an external bias-T on the RF + DC input port (J5) or through the marked pin on J6.
	Note: DC supply for VDD should be fed through an external bias-T on the RF + DC output port (J4).
2	Set VG1 at -1.0V
3	Set VDD at 8/9/10.0V with current compliance at 50mA and 600mA accordingly.
4	Power supply sequencing should always be VG1 then VDD (VDD always last on and first off)
5	Adjust VG1 gradually, increasing voltage with 0.01V steps, until IDD reaches target current.
CAUTION: ENSURE NOT TO SHORT VDET OR VREF PINS TO AVOID DAMAGE TO PART	

Figure 57 - Evaluation Board MMA155PP5E

Table 3.2 Bill of Materials for MMA155PP5E

Parts	Description	Part Number	Manufacturer
C1, C3, C4, C6, C7, C9	10000 pF ±10% 50V Ceramic Capacitor X7R 0402	GCM155R71H103KA55D	Murata
C2, C5, C8	2.2 µF ±10% 16V Ceramic Capacitor X7S 0603	C1608X7S1C225K080AC	TDK
J1, J2, J4, J5	Connector, 2.92mm (F) End Launch, Narrow Block	1092-01A-9	Southwest Microwave
J3, J6	Connector Surface Mount, 4 position Header, 0.100"	15-91-2040	Molex
U1	MMIC, DC-22 GHz, 2.0W, Power Amp, QFN 5x5	MMA155PP5	Microchip

4. Handling Recommendations

Gallium arsenide integrated circuits are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. It is recommended to follow all procedures and guidelines outlined in the Microsemi application note AN01: GaAs MMIC Handling and Die Attach Recommendations.

5. Ordering Information

For additional ordering information, contact your Microchip sales representative.

Part Number	Package
MMA155AA	Die
MMA155PP5	Package Part
MMA155PP5E	Evaluation PCB

5.1. Packing Information

Part Number	Description
MMA155PP5-TR	Tape and Reel

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