DC–22 GHz GaAs 2W Distributed MMIC Amplifier

MMA155AA

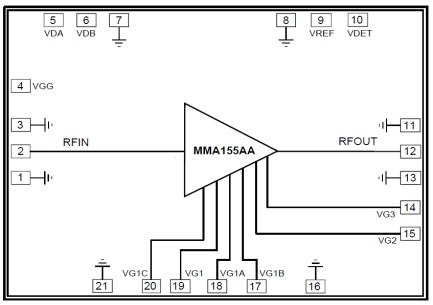
Product Overview

The MMA155AA is a DC–22 GHz Gallium Arsenide (GaAs) Monolithic Microwave Integrated Circuit (MMIC) pseudomorphic High Electron Mobility Transistor (pHEMT) amplifier fabricated using a space–qualified process. Nominally biased at 15V and 750 mA, the amplifier offers a gain of 15 dB with a positive gain slope, noise figure of 3.5 dB, Psat of 33 dBm, and an OIP3 of 20 dBm. It is ideal for test instrumentation, SATCOM and other A&D applications requiring instantaneously wide bandwidth and high power. The MMIC amplifier is DC coupled and features RF I/O's that are nominally matched to 50Ω.

Key Features

- Broadband performance: DC to 22 GHz
- High gain: 15 dB
- Positive gain slope
- High P_{sat}: 33 dBm at 20 GHz
- Supply: 15V at 750 mA
- Integrated temperature compensated power detector
- 50Ω matched input/output
- Die size: 3.34 mm × 1.675 mm × 0.07 mm
- 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 Curves

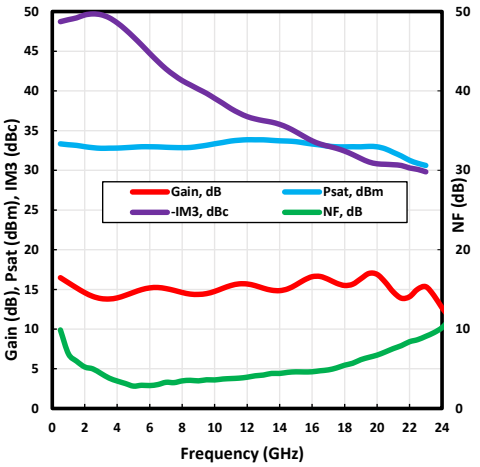


Table 1. Performance Overview

Parameter	Typ.	Units
Operational frequency range	DC – 22	GHz
Gain	15	dB
P_{sat}	+33	dBm
IM3 (20 dBm per tone)	–40	dBc
Current at +15V supply	750	mA

Export Classification: EAR99

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1. Electrical Performances

1.1. Typical Electrical Performance

Table 1-1. Typical Electrical Performance at 25 °C, V_{DD} = 15V, I_{DD} = 750 mA (unless specified otherwise).

Parameter	Frequency Range	Min	Typ.	Max	Units
Frequency range		DC		22	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		13		dB
	6 GHz–12 GHz		14		
	12 GHz–22 GHz		14		
Output return loss	DC–6 GHz		9		dB
	6 GHz–12 GHz		9		
	12 GHz–22 GHz		9		
P1dB	DC–6 GHz	31	32.5		dBm
	6 GHz–12 GHz	31	32.5		
	12 GHz–22 GHz	30	32		
P_{sat}	DC–6 GHz	32	33		dBm
	6 GHz–12 GHz	32	33		
	12 GHz–20 GHz	30	33		
OIP3	DC–6 GHz		35		dBm
	6 GHz–12 GHz		34		
	12 GHz–20 GHz		32		
IM3 at 20 dBm	DC–6 GHz		-45		dBc
	6 GHz–12 GHz		-40		
	12 GHz–20 GHz		-35		
OIP2(low) (2^{nd} order intercept point F2–F1)			40		dBm

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1.2. Absolute Maximum Ratings

The following table shows the absolute maximum ratings of the MMA155AA device at 25 °C, unless otherwise specified. Exceeding any of the maximum ratings could cause damage and/or latent defects to the device.

Table 1-2. Absolute Maximum Ratings

Parameter	Rating
Drain bias voltage (V_{DD})	17V
Gate bias voltage (V_G)	–2V to +0.5V
RF input power (Pin)	26 dBm
Channel temperature	165 °C
V_{DD} current (I_{DD})	800 mA
DC power dissipation (T = 85 °C) at P_{sat}	9.4W
DC power dissipation (T = +85 °C) at low power	12.1W
Thermal resistance at P_{sat}	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 graphs shown in Figures 1-1 through 1-30 represent the Typical Performance versus Temperature curves of the MMA155AA device under specific bias conditions. All measurements were taken using the test circuit shown in Figure 3-2.

Figure 1-1. Gain vs. Temperature at 11V/470 mA

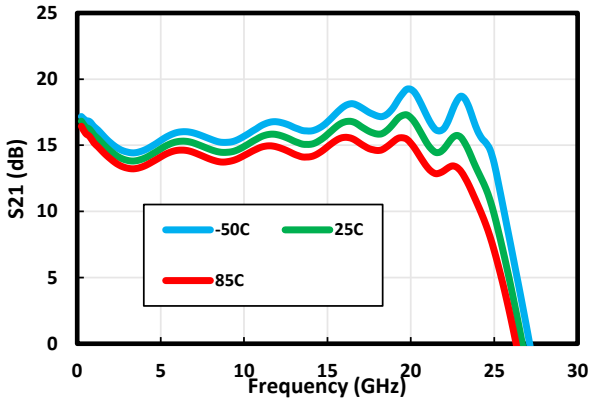
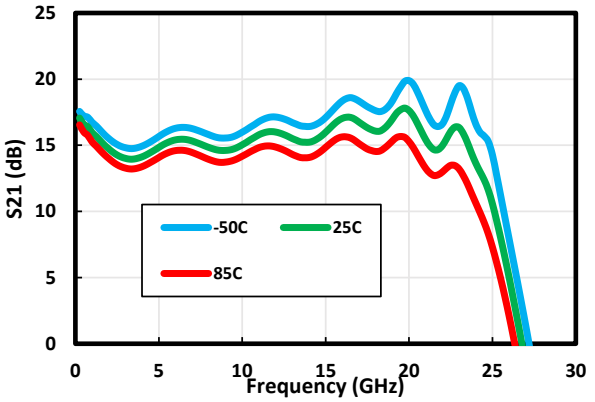


Figure 1-2. Gain vs. Temperature at 13V/640 mA



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Figure 1-3. Gain vs. Temperature at 15V/750 mA

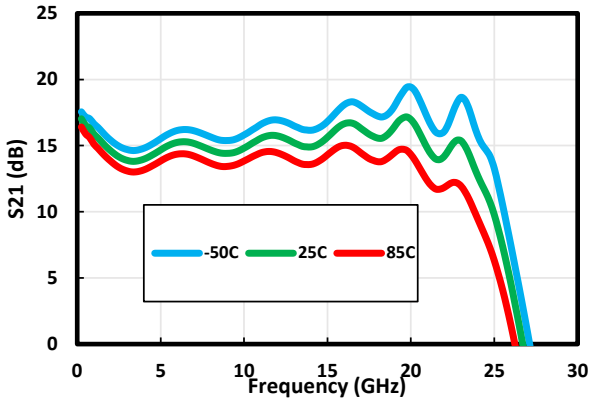


Figure 1-4. S11 vs. Temperature at 11V/470 mA

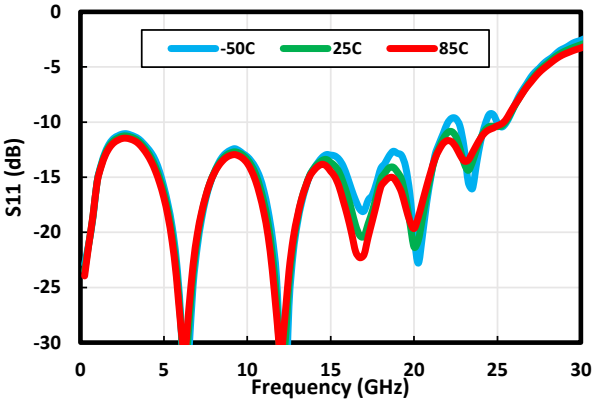


Figure 1-5. S11 vs. Temperature at 13V/640 mA

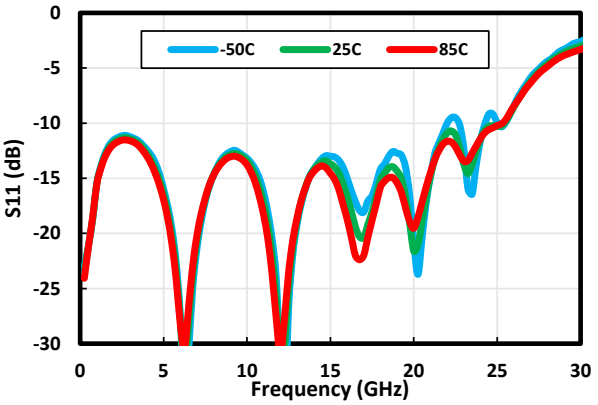


Figure 1-6. S11 vs. Temperature at 15V/750 mA

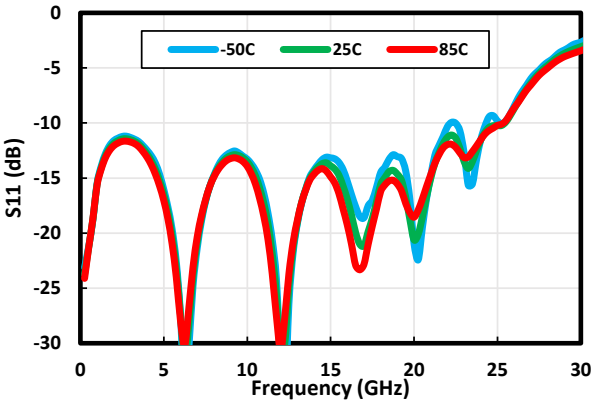


Figure 1-7. S22 vs. Temperature at 11V/470 mA

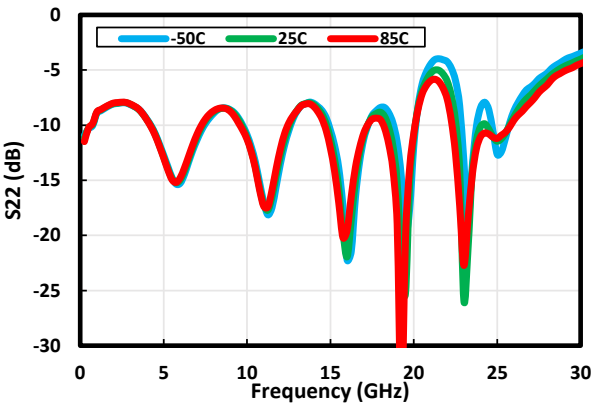
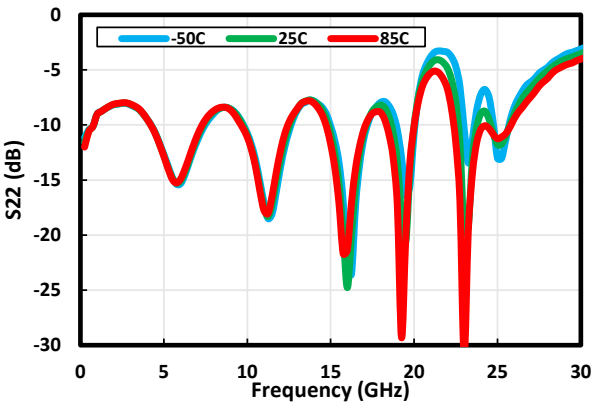


Figure 1-8. S22 vs. Temperature at 13V/640 mA



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Figure 1-9. S22 vs. Temperature at 15V/750 mA

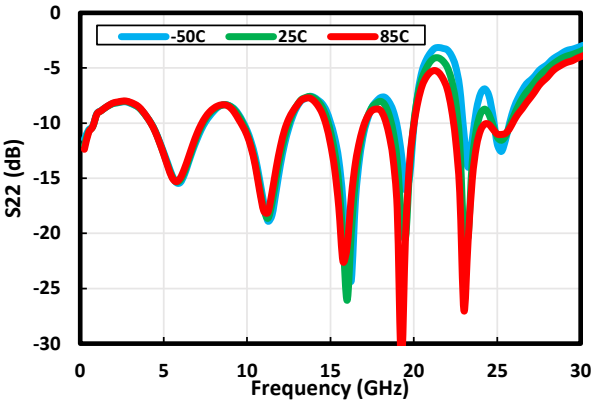


Figure 1-10. S12 vs. Temperature at 11V/470 mA

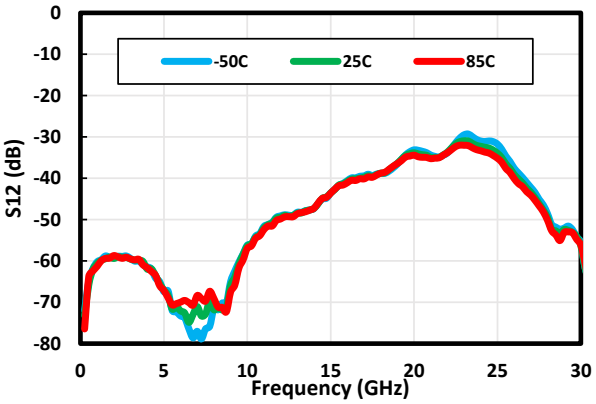


Figure 1-11. S12 vs. Temperature at 13V/640 mA

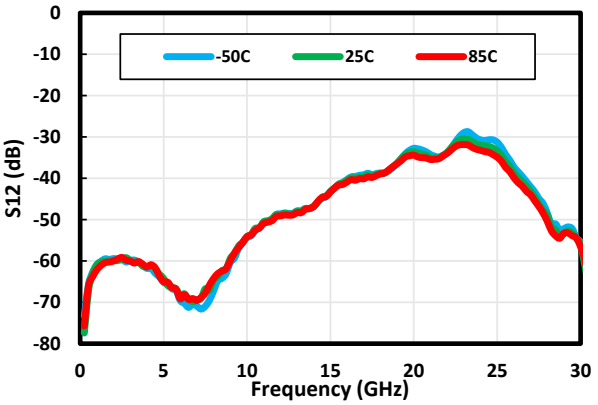


Figure 1-12. S12 vs. Temperature at 15V/750 mA

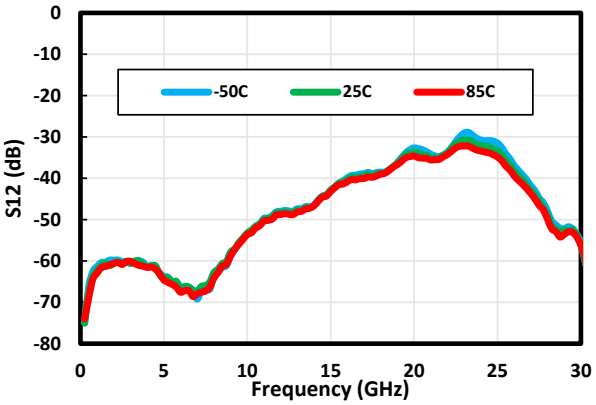


Figure 1-13. NF vs. Temperature at 11V/470 mA

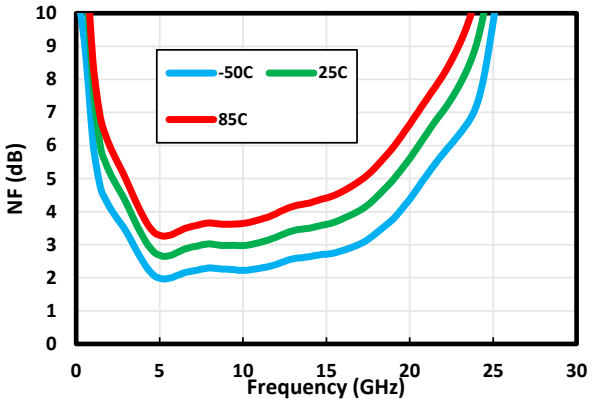
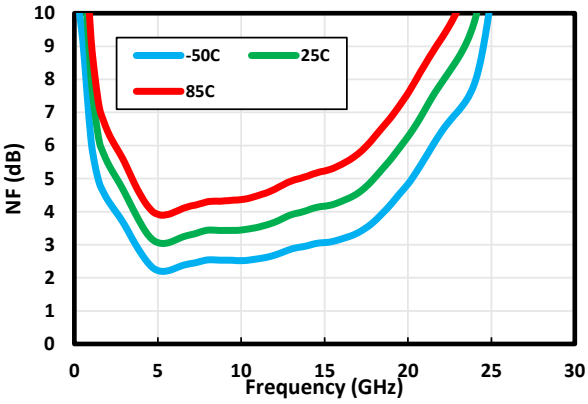


Figure 1-14. NF vs. Temperature at 13V/640 mA



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Figure 1-15. NF vs. Temperature at 15V/750 mA

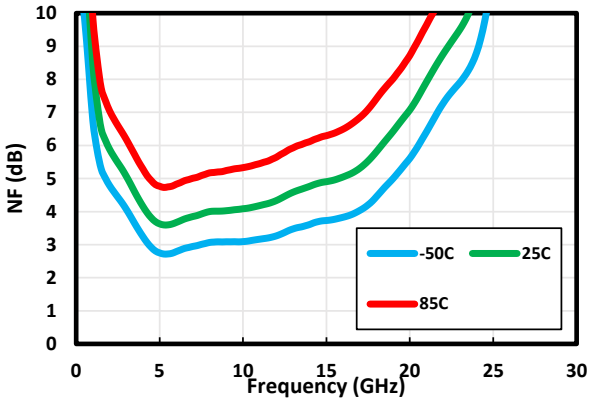


Figure 1-16. P1dB vs. Temperature at 11V/470 mA

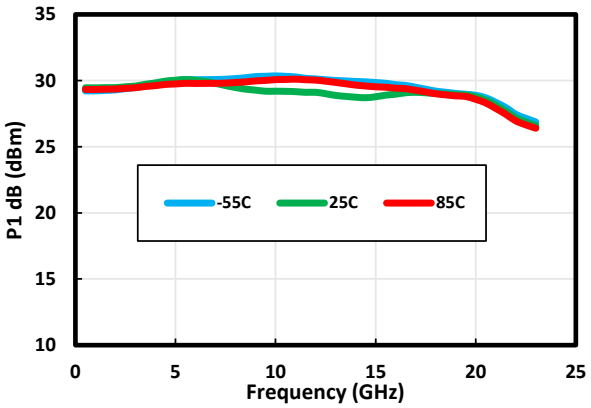


Figure 1-17. P1dB vs. Temperature at 13V/640 mA

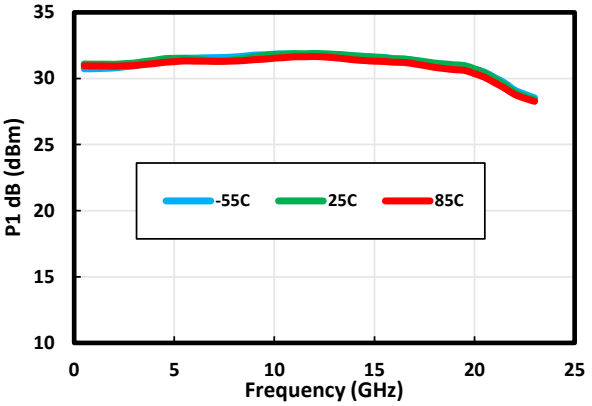


Figure 1-18. P1dB vs. Temperature at 15V/750 mA

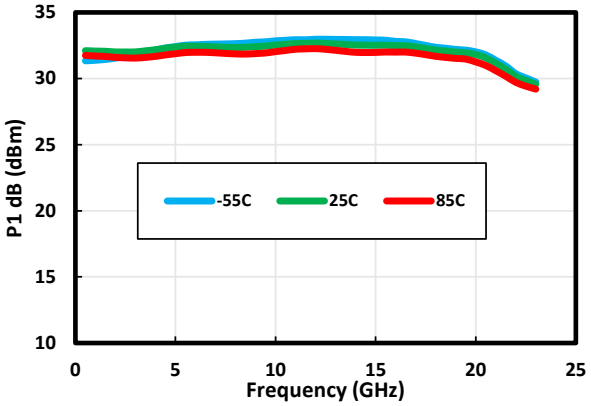


Figure 1-19. P_{sat} vs. Temperature at 11V/470 mA

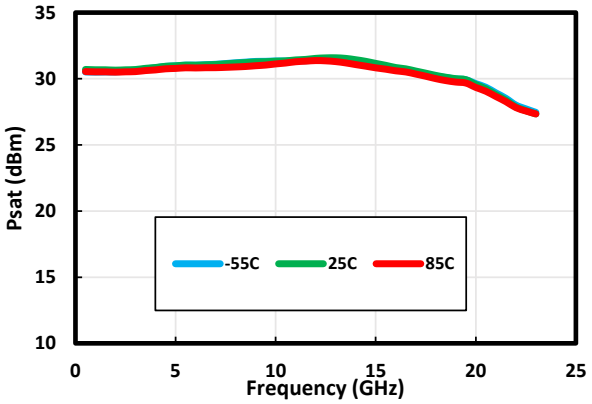
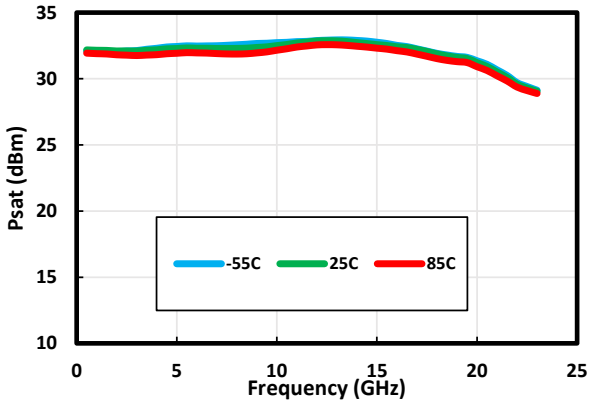


Figure 1-20. P_{sat} vs. Temperature at 13V/640 mA



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Figure 1-21. P_{sat} vs. Temperature at 15V/750 mA

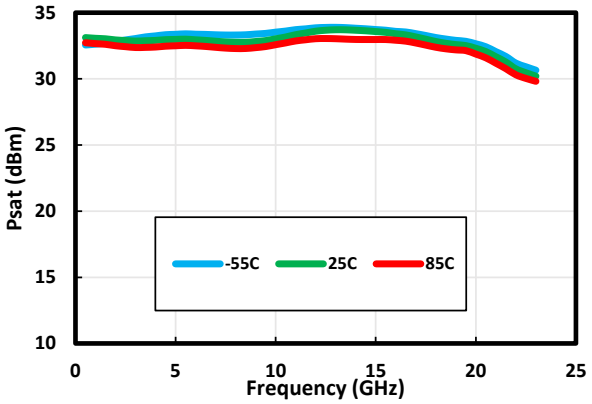


Figure 1-22. OIP3 vs. Temperature at 11V/470 mA

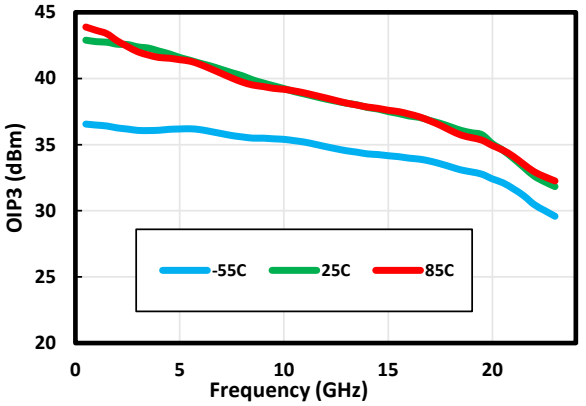


Figure 1-23. OIP3 vs. Temperature at 13V/640 mA

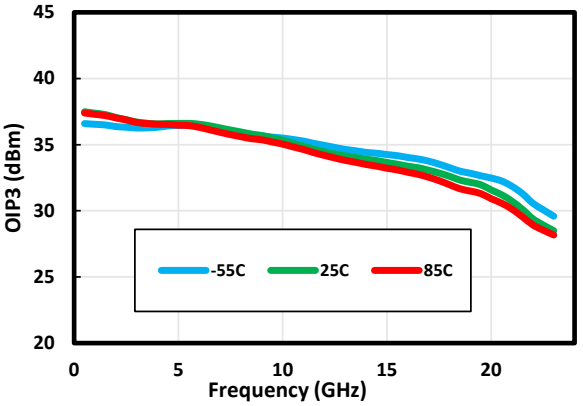


Figure 1-24. OIP3 vs. Temperature at 15V/750 mA

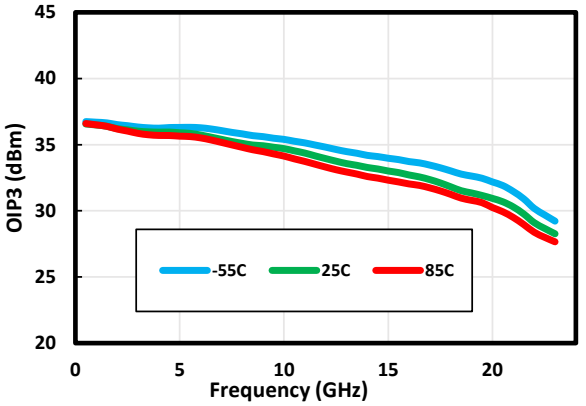


Figure 1-25. OIP2 (low) vs. Temperature at 11V/470 mA

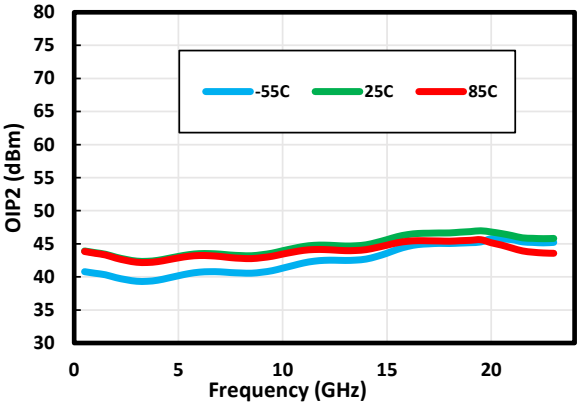
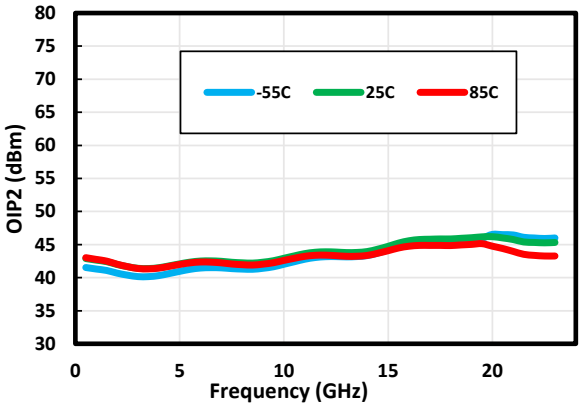


Figure 1-26. OIP2 vs. Temperature at 13V/640 mA



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Figure 1-27. OIP2 vs. Temperature at 15V/750 mA

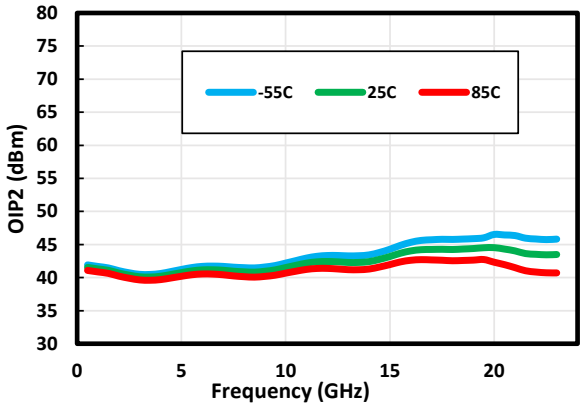


Figure 1-28. IM3 vs. Temperature at 11V/470 mA, 20 dBm (per tone)

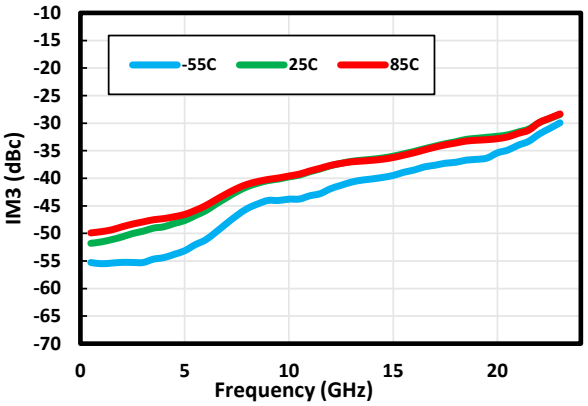


Figure 1-29. IM3 vs. Temperature at 13V/640 mA, 20 dBm (per tone)

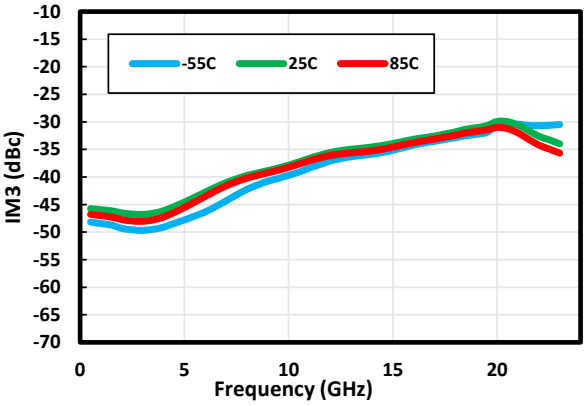
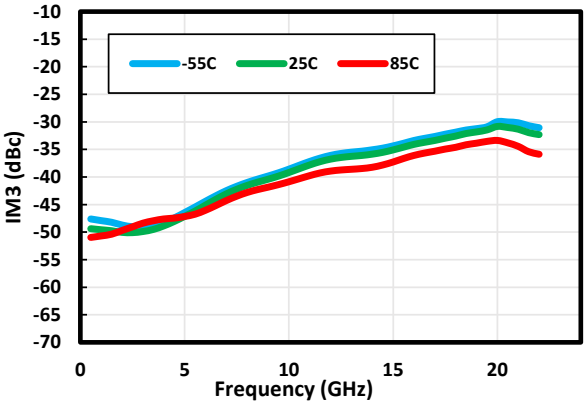


Figure 1-30. IM3 vs. Temperature at 15V/750 mA, 20 dBm (per tone)



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1.3.2. Typical Performances vs. Bias

The graphs shown in Figures 1-31 through 1-41 represent the Typical Performance versus Bias curves of the MMA155AA under constant temperature of 25 °C. All measurements were taken using the test circuit shown in Figure 3-2.

Figure 1-31. Gain vs. V_{DD} at 470 mA

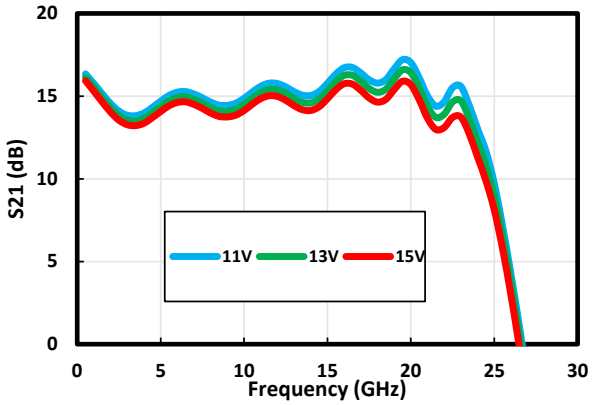


Figure 1-32. Gain vs. V_{DD} at 640 mA

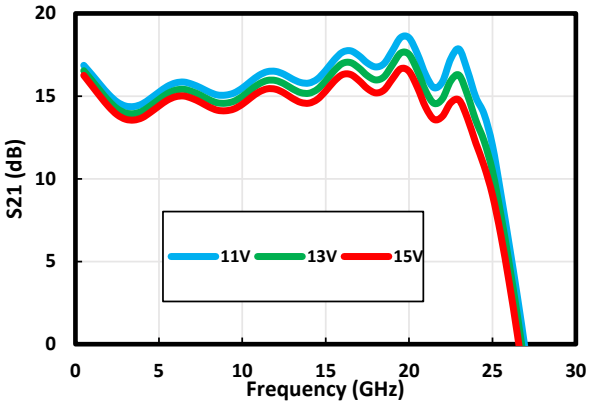


Figure 1-33. Gain vs. V_{DD} at 750 mA

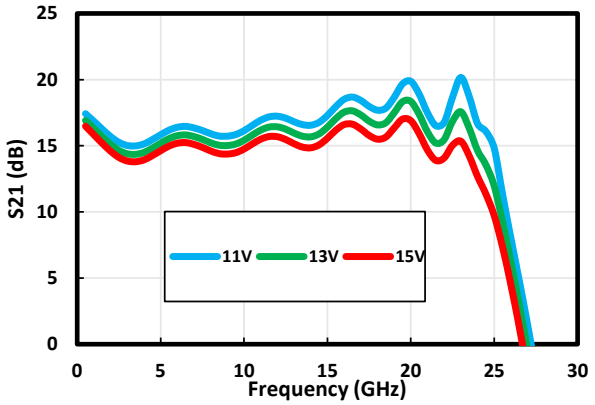


Figure 1-34. NF vs. V_{DD} at 470 mA

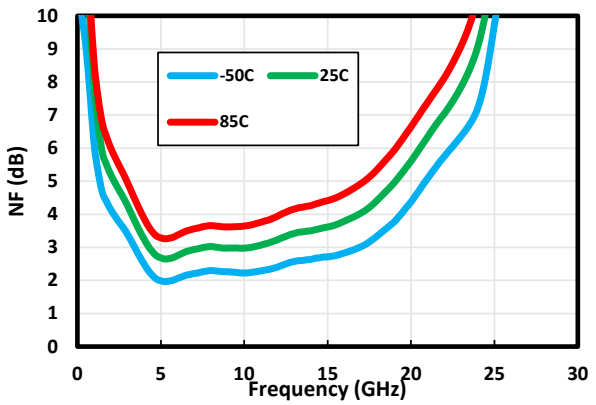


Figure 1-35. NF vs. V_{DD} at 640 mA

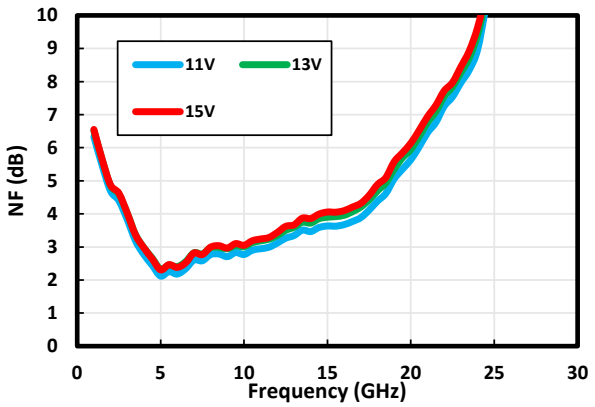
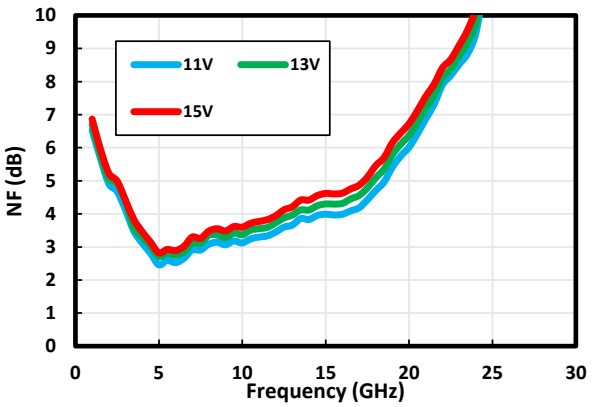


Figure 1-36. NF vs. V_{DD} at 750 mA



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Figure 1-37. P1dB vs. V_{DD}/I_{DD}

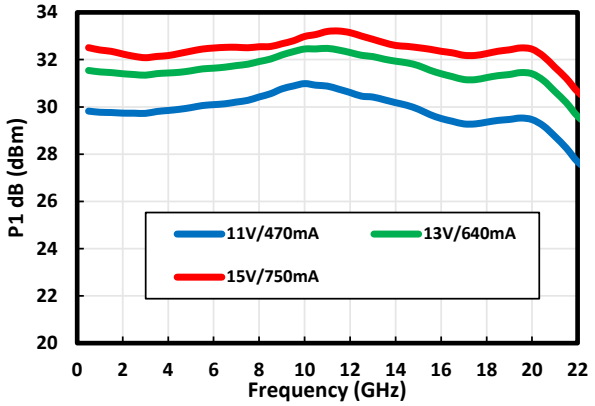


Figure 1-38. P_{sat} vs. V_{DD}/I_{DD}

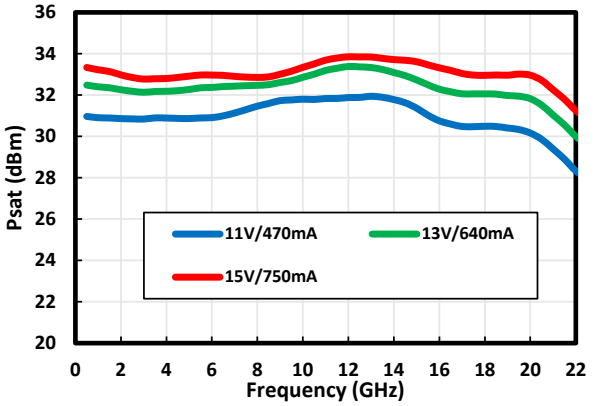


Figure 1-39. OIP3 vs. V_{DD}/I_{DD}

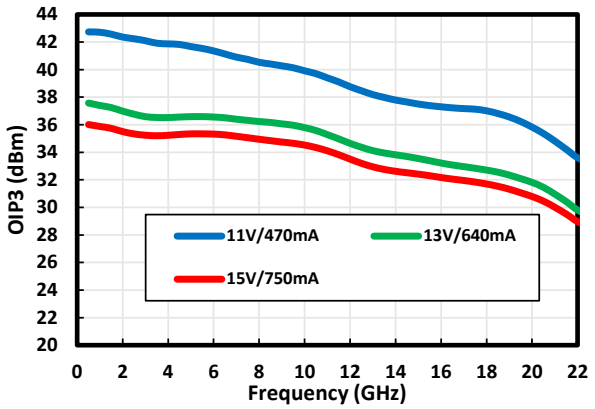


Figure 1-40. OIP2 Low at = 10 MHz vs. V_{DD}/I_{DD}

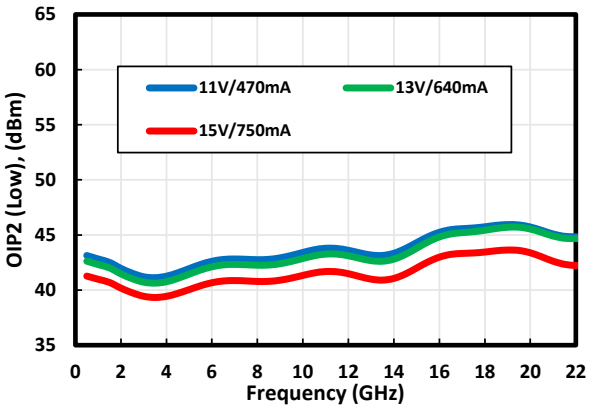
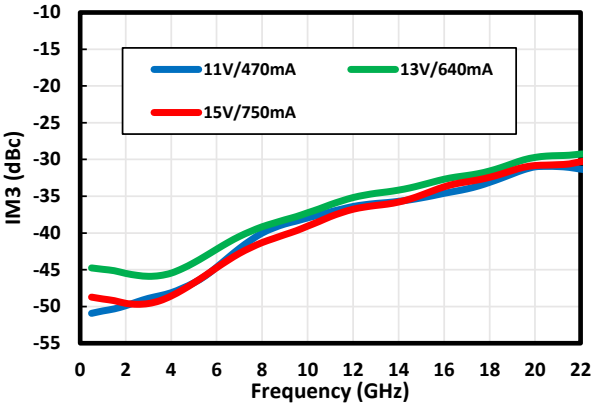


Figure 1-41. IM3 vs. V_{DD}/I_{DD}, 20 dBm (per tone)



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1.3.3. Typical Performances vs. Output Power

The graphs shown in Figures 1-42 through 1-52 represent the Typical Performance versus Output power curves of the MMA155AA under constant temperature of 25 °C. All measurements were taken using the test circuit shown in Figure 3-2.

Figure 1-42. IM2 vs. Power at 11V/470 mA

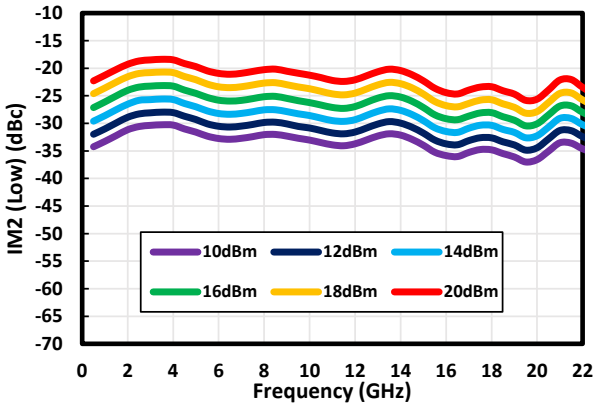


Figure 1-43. IM2 vs. Power at 13V/640 mA

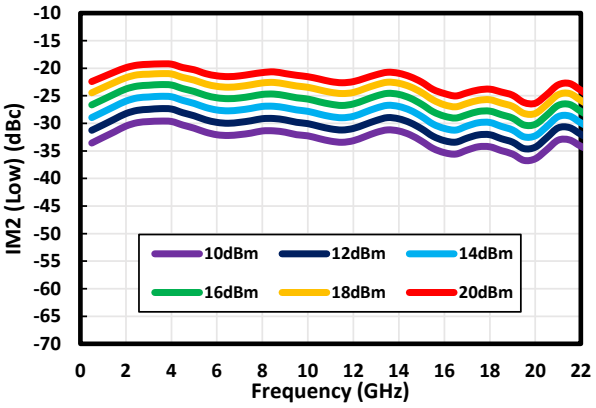


Figure 1-44. IM2 vs. Power at 15V/750 mA

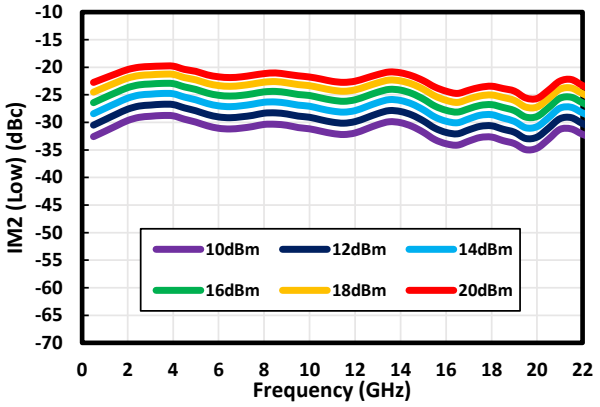


Figure 1-45. IM3 vs. Power at 11V/470 mA

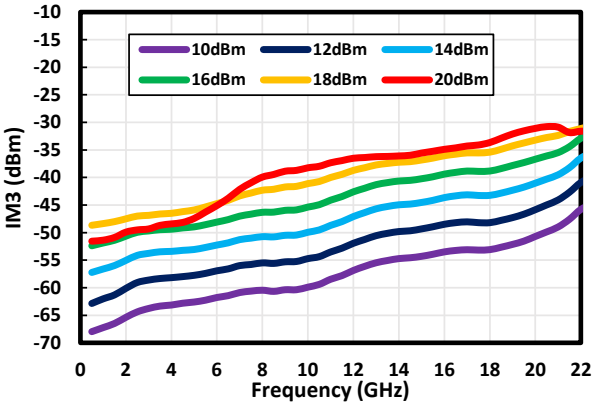


Figure 1-46. IM3 vs. Power at 13V/640 mA

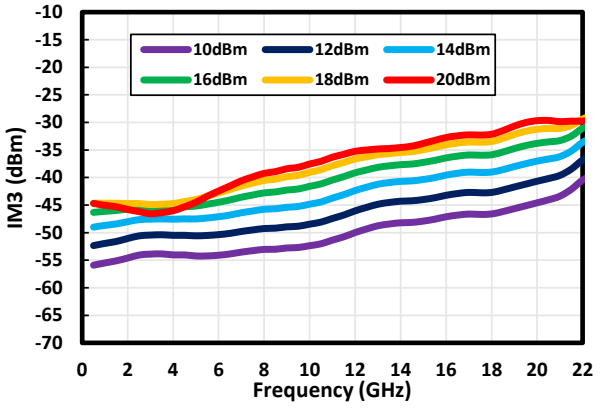
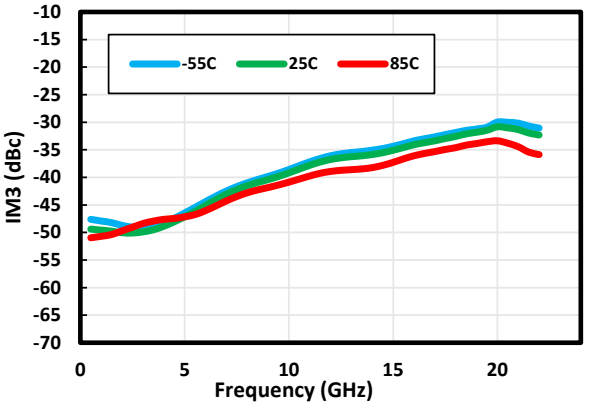


Figure 1-47. IM3 vs. Power at 15V/750 mA



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Figure 1-48. 2nd Harmonic vs. Power at 11V/470 mA

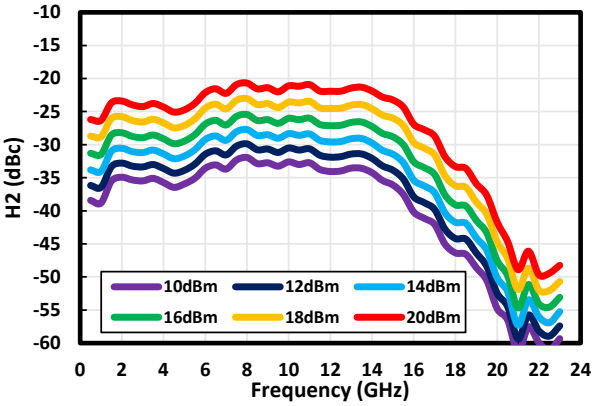


Figure 1-49. 2nd Harmonic vs. Power at 13V/640 mA

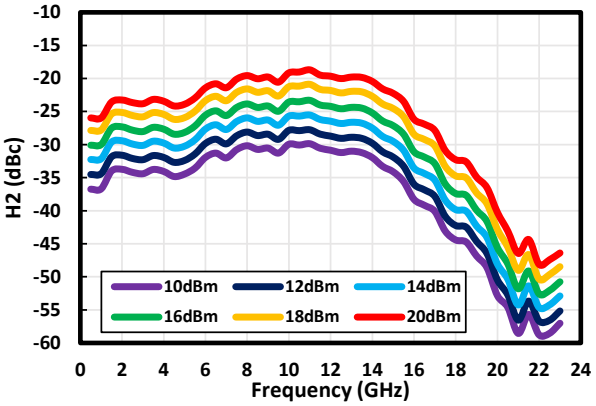


Figure 1-50. 2nd Harmonic vs. Power at 15V/750 mA

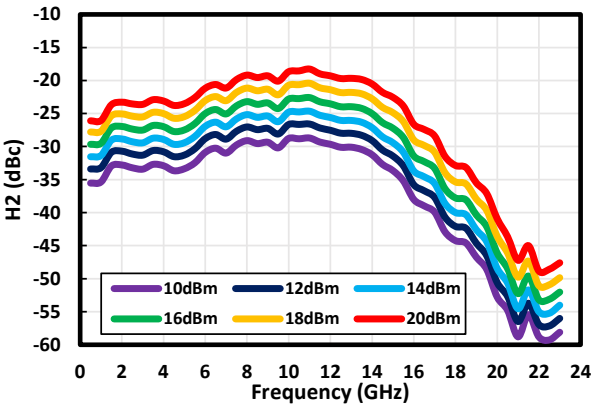


Figure 1-51. Detector vs. Power, Frequency

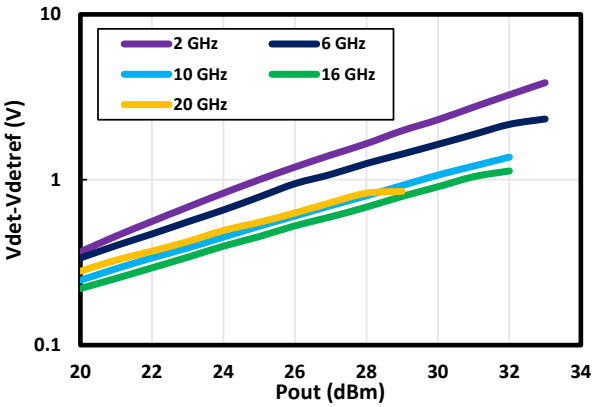
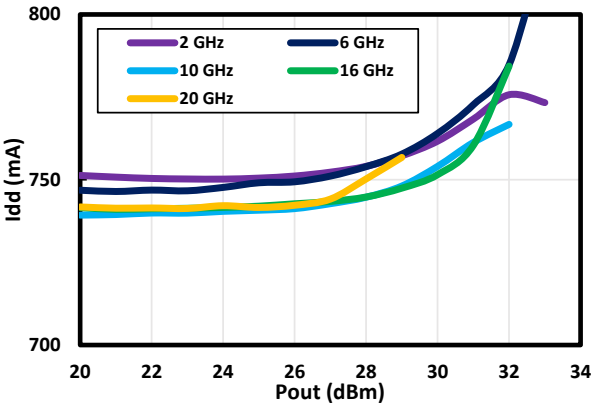


Figure 1-52. I_{DD} Current vs. Power, Frequency at 15V

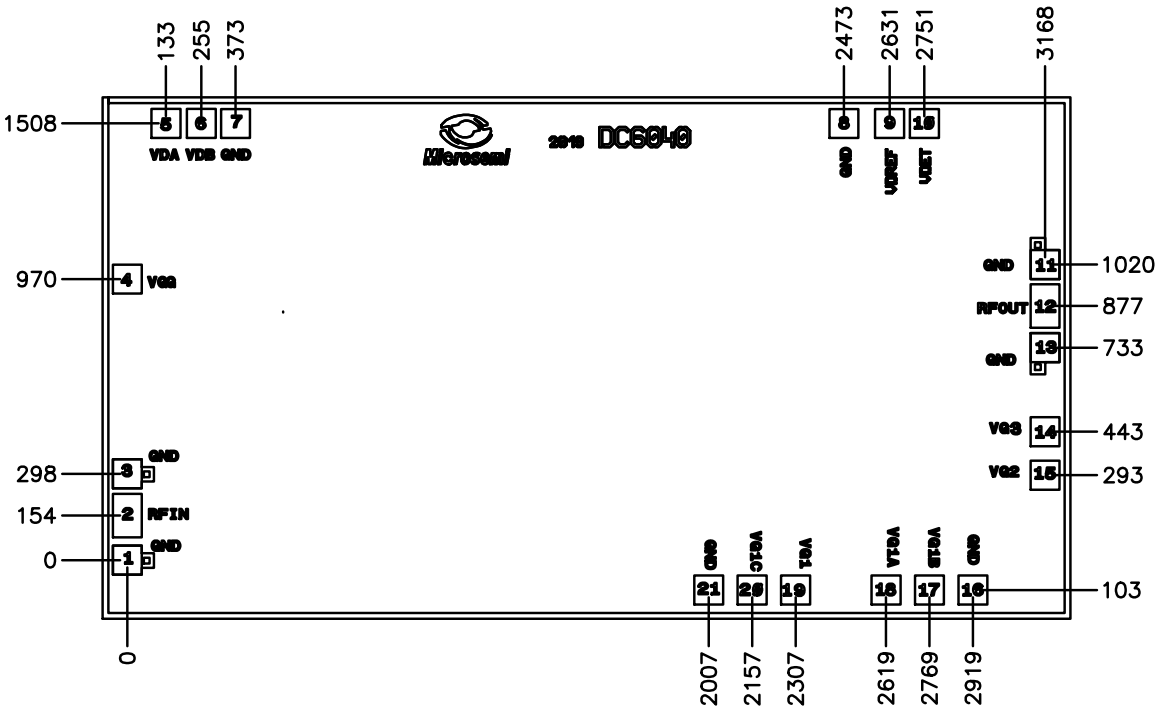


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2. Die Specifications

Figure 2-1 illustrates the chip outline of the MMA155AA device. Dimensions are in microns and are relative to the zero datum location shown in the drawing. Nominal die dimensions are 3.34 mm × 1.675 mm × 0.07 mm. The minimum bond pad size is 0.1 mm × 0.1 mm. Both the bond pad surface and the backside metal have 8.3 µm–thick gold. The die thickness is 0.07 mm. The backside is the DC/RF ground. Die is fully passivated with 8 µm BCB for ease of handling and MMIC protection.

Figure 2-1. Die Outline Drawing



PAD NO.	DESCRIPTION	µm PAD SIZES	PAD NO.	DESCRIPTION	µm PAD SIZES
1	GND	100x100	12	RFOUT	100x150
2	RFIN	100x150	13	GND	100x100
3	GND	100x100	14	VG3	
4	VGG		15	VG2	
5	VDA		16	GND	
6	VDB		17	VG1B	
7	GND		18	VG1A	
8	GND		19	VG1	
9	VREF		20	VG1C	
10	VDET		21	GND	
11	GND				

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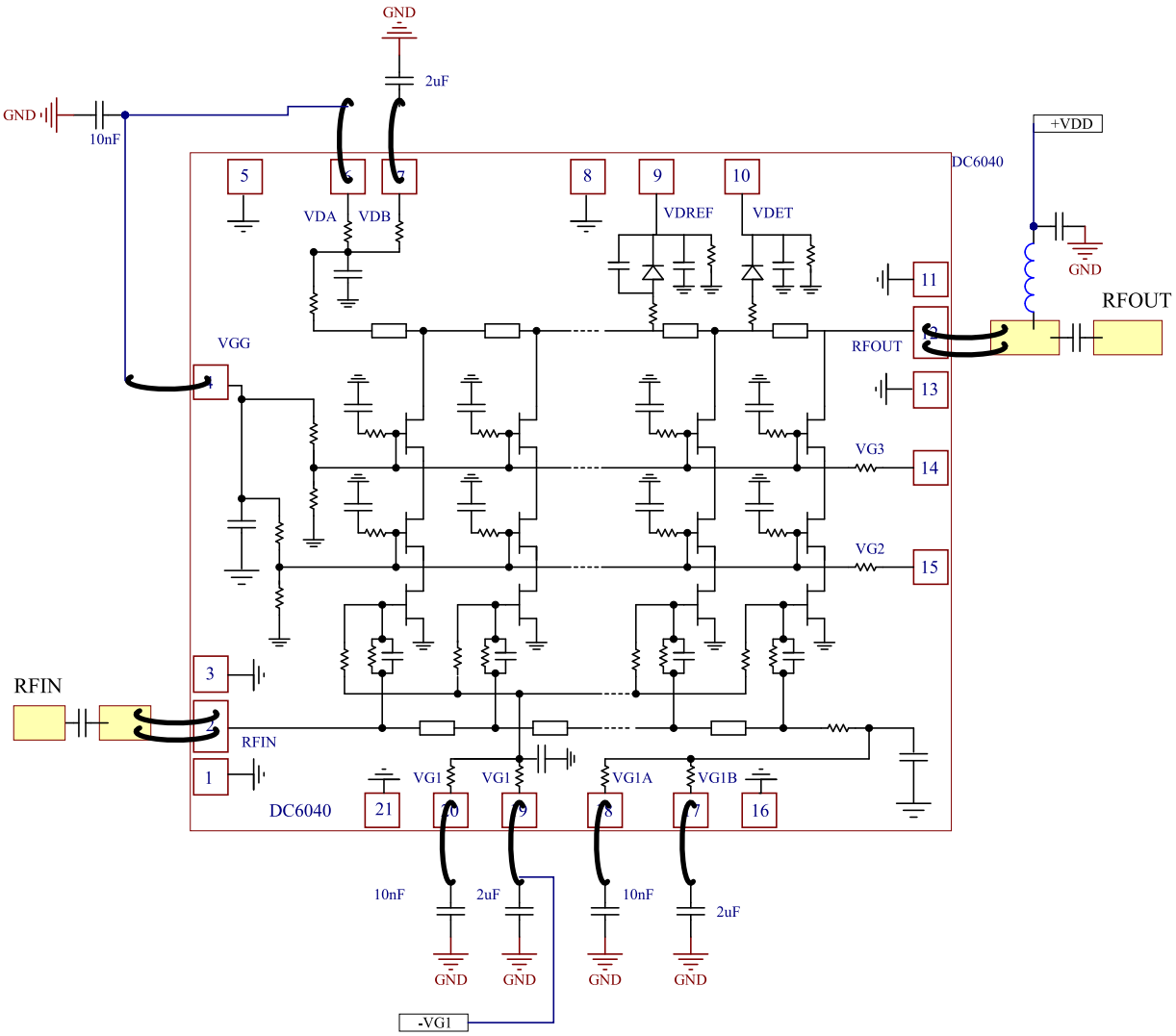
Table 2-1. I/O Pad Description

Pad Number	Pad Name	Pad Description
2	RF_{IN}	This pad is DC-coupled and matched to 50Ω. External large DC blocking capacitor is required to extend performance to very low frequencies
12	RF_{OUT}	This pad is DC-coupled and matched to 50Ω. External VDD bias network is required to provide I_{DD} as per application circuit
4	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)
5 and 6	V_{DA} and 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.
9	V_{DETREF}	Detector reference voltage
10	V_{DET}	Detector pin, with DC voltage as function of output power, for correct operation of detector use VDET-VDETREF at external comparator.
19, 20	V_{G1}, V_{G1C}	First Gate Bias (Negative), should always be activated before VDD applied, and removed after VDD is OFF. V_{G1C} is low frequency complimentary termination.
18, 17	V_{G1A}, V_{G1B}	Low-frequency terminations for input 50Ω ballast resistor
1, 3, 7, 8, 11, 13, 16 & 21	GND	Complimentary ground pads used mostly during die test.
14, 15	V_{G3}, V_{G2}	Complimentary Gate 3 and Gate 2 access (not recommended for use, interfering with those terminals may lead to unintentional VDD distribution and destruction of the die).

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3. Application Circuit

Figure 3-1. Application Circuit: Schematic



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Figure 3-2. Die Test Circuit: Assembly Drawing

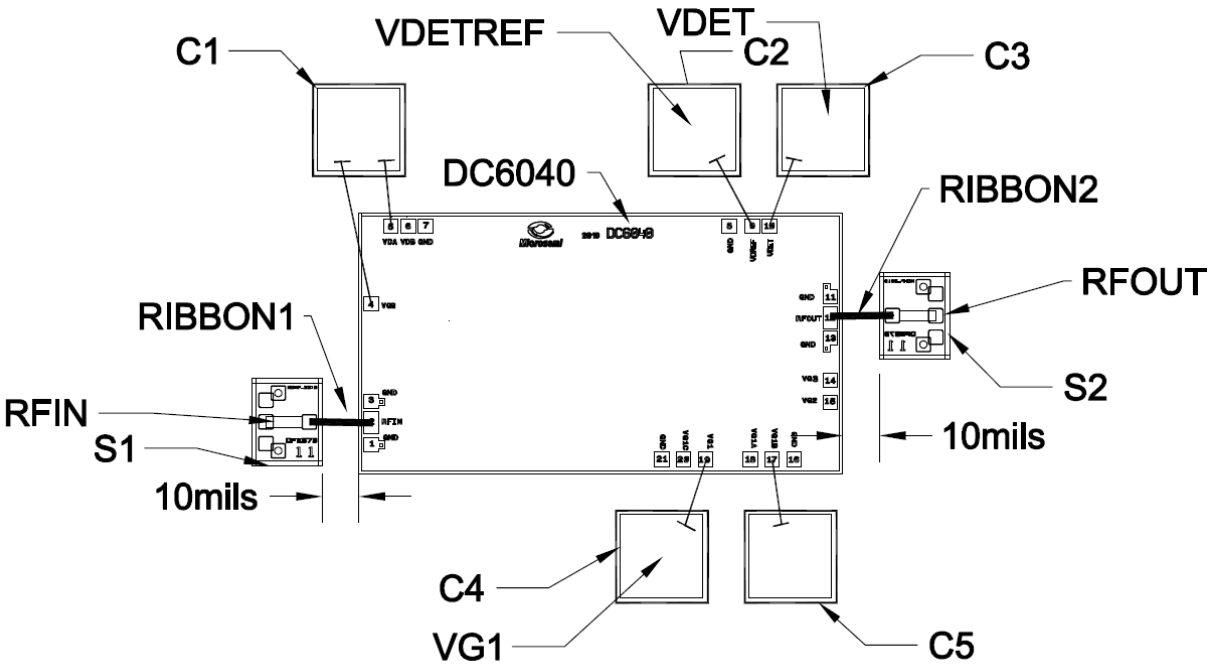


Table 3-1. List of Material for Test Circuit

Reference	Part Number	Description
DC6040	MMA155AA	MMA155AA Amplifier Die
C1...C5	160U02A102MT4W	Johanson Dielectric, Cer.Cap 1 nF
S1, S2	E57311	Probe launchers
Epoxy	EpoTech H20E	Conductive epoxy for die and cap mount

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4. Ordering, Shipping, and Handling

4.1. 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 Microchip application note AN01: GaAs MMIC Handling and Die Attach Recommendations.

4.2. Ordering Information

For additional ordering information, contact your Microchip sales representative.

Part Number	Package
MMA155AA	Die
MMA155PP5	Package Part in QFN 5 x 5 mm
MMA155PP5E	Evaluation PCB for Packaged Part

4.3. Packing Information

Standard Format	Description
Gel Pack	50 Pieces per Pack
MMA155PP5/TR	Tape and Reel

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5. Revision History

Table 5-1. Revision History

Revision	Date	Description
B	03/2025	Formatting layouts throughout.
A	12/2021	Document created.

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