X-Band High-Input-Power Low Noise Amplifier

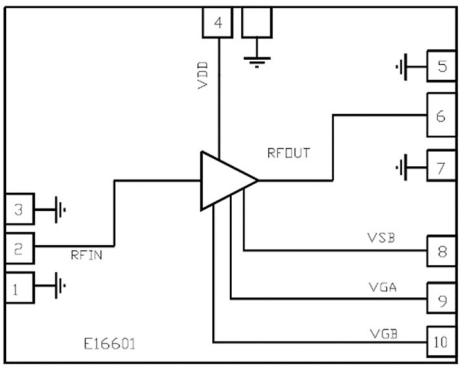
Product Overview

MMA047AA is a Gallium Arsenide (GaAs) monolithic microwave integrated circuit (MMIC) pHEMT distributed amplifier specifically made to operate between 5 and 14 GHz. The bare die amplifier provides reliable operation with up to 30dBm of input RF CW power having 1.5dB of noise, 22.5dB of gain, 34dBm output IP3, and 22.5dBm of output power at 1 dB compression. Die was designed to handle more Input power (more than 35dBm CW and 43dBm pulsed) with external PIN diode, having minimum external circuit requirements and excellent noise figure. The MMA047AA amplifier features compact die size and I/Os that are internally matched to 50 Ohm.

Key Features

- **Frequency range: 5 to 14 GHz**
- **Gain: 22 dB**
- **High IP3: 34 dBm**
- **Low Noise: 1.5 dBm**
- **Die Input Power handling: >30dBm (CW)**
- **Adjustable Self-Bias Operation**
- **On-die Choke**
- **Supply: 7V @ 180mA**
- **100% ESD Protection**
- **50 Ohm Matched Input/Output**
- **Die: 2.02 x 1. 47 x 0.1 mm**

Functional Block Diagram



Applications

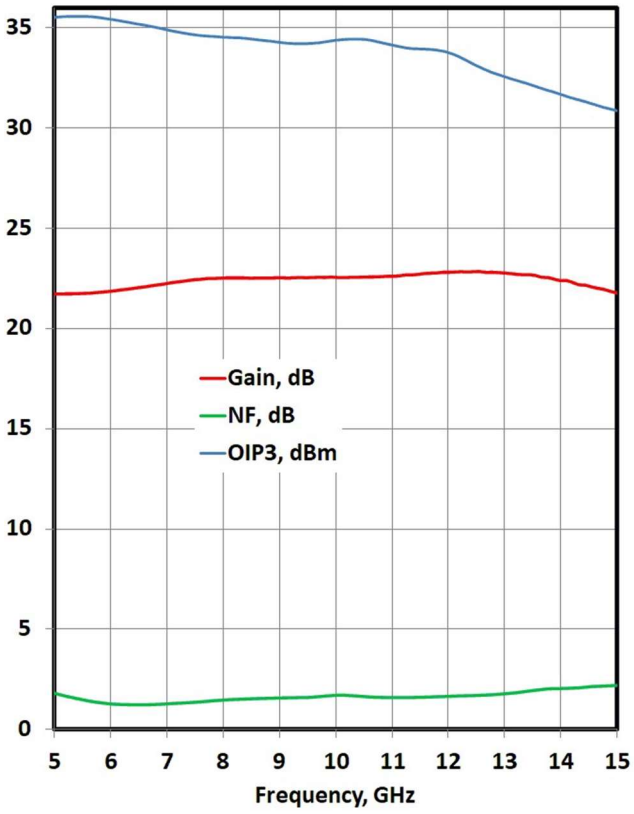
- Test and measurement instrumentation
- Electronic warfare (EW), electronic countermeasures (ECM), and electronic counter-countermeasures (ECCM)
- Military, A&D, space, SATCOM
- Telecom infrastructure
- Wideband microwave radios
- Microwave and millimeter-wave communications systems

Performance Overview

Parameter	Typ.	Units
Operational frequency range	5-14	GHz
Gain	22	dB
Noise Figure	1.5	dB
P1dB	22	dBm
OIP3	34	dBm

Export Classification: EAR-99

Figure 1 - Typical Responses



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1. Electrical Specifications

1.1. Typical Electrical Performance

Table 1 - Typical Electrical Performance at 25 C, Vdd=7V, Idd=180 mA (Unless otherwise mentioned)

Parameter	Frequency Range	Min	Typ.	Max	Units
Frequency range		5		14	GHz
Gain	6 GHz -12 GHz	21		23	dB
Gain flatness	6 GHz -12 GHz		±0.5		dB
Noise figure	6 GHz -12 GHz		1.5	2	dB
Input return loss	6 GHz -12 GHz		10		dB
Output return loss	6 GHz -12 GHz		15		dB
P1dB	6 GHz -12 GHz	21	22		dBm
Psat	6 GHz -12 GHz		23		dBm
OIP3	6 GHz -12 GHz	33	34		dBm
Hot Switching (ON/OFF)	6 GHz -12 GHz		50	60	ns
Phase Noise	100Hz Offset		-135		dBc/Hz
	1kHz Offset		-135		dBc/Hz
	10kHz Offset		-150		dBc/Hz
	100kHz Offset		-150		dBc/Hz
Stability k-factor	6 GHz -12 GHz	1.5			
Input Power Survivability (CW)	6 GHz -12 GHz	30		32	dBm
VDD (drain voltage supply)			7		V
IDD (drain current)			180		mA

1.2. Absolute Maximum Ratings

The following table shows the absolute maximum ratings of the MMA047AA 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})	8 V
Drain bias current (I_{DD})	200 mA
Gate bias voltage (V_G)	–2 V to 0.5 V
RF input power (Pin)	+32 dBm (CW)
Channel temperature	150 °C
Thermal resistance	12 °C/W
Storage temperature	–65 °C to 150 °C
Operating temperature	–55 °C to 85 °C

1.3. Typical Performance Curves

1.3.1 Typical Performances vs. Temperature

The following graphs show the typical performance curves of the MMA047AA device at specific bias conditions, measurements performed using application circuit shown on Figure 71 -below.

Figure 2 - Gain vs. Temperature @ 5V/120mA

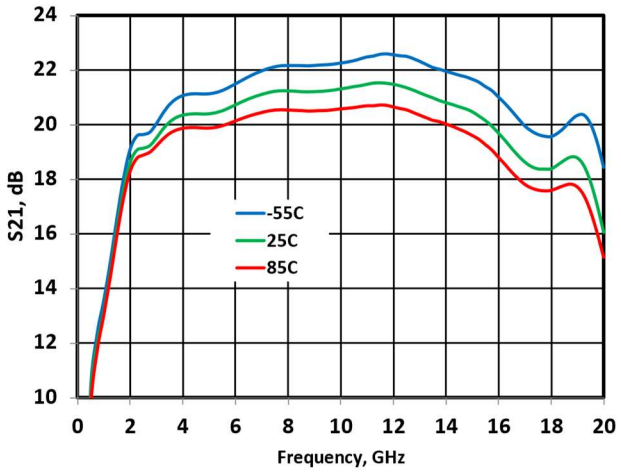


Figure 3 - Gain vs. Temperature @ 6V/150mA

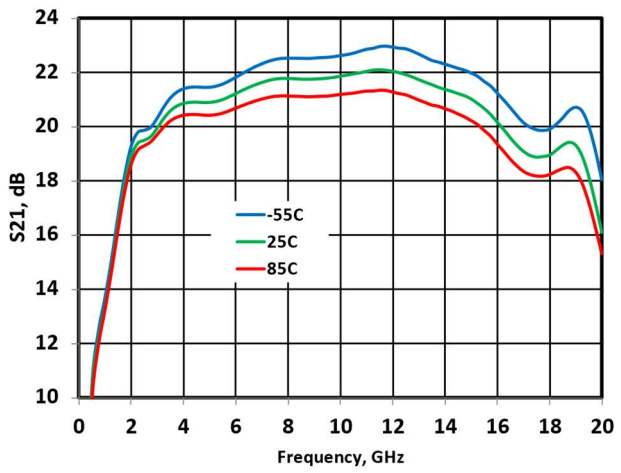


Figure 4 - Gain vs. Temperature @ 7V/180mA

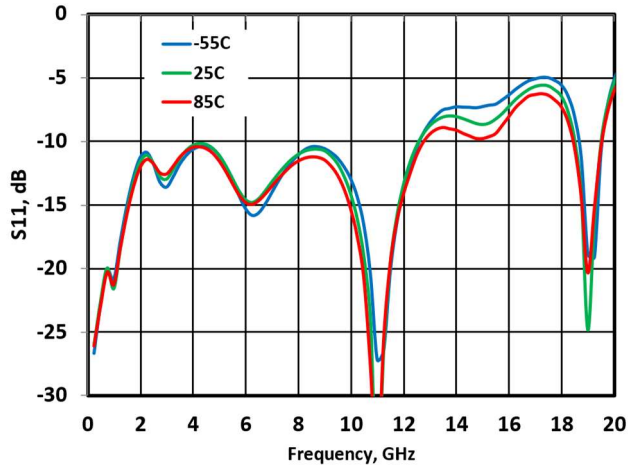


Figure 5 - S11 vs. Temperature @ 5V/120mA

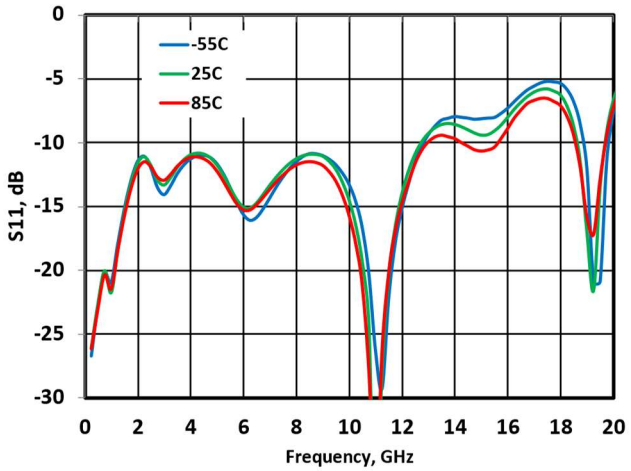


Figure 6 - S11 vs. Temperature @ 6V/150mA

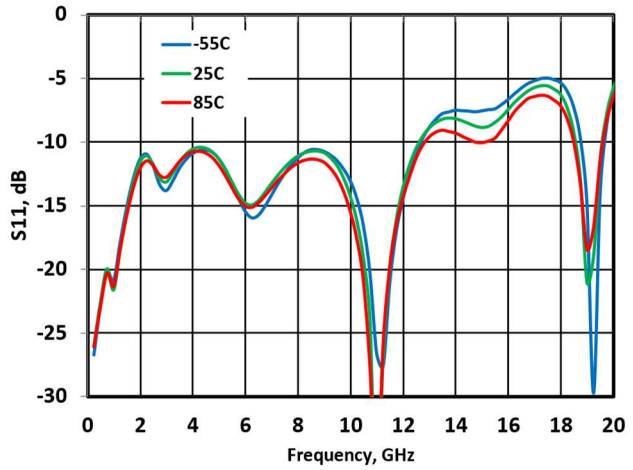


Figure 7 - S11 vs. Temperature @ 7V/180mA

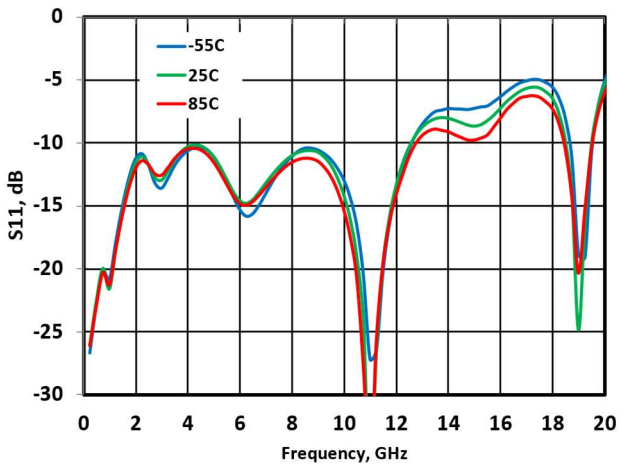


Figure 8 - S22 vs. Temperature @ 5V/120mA

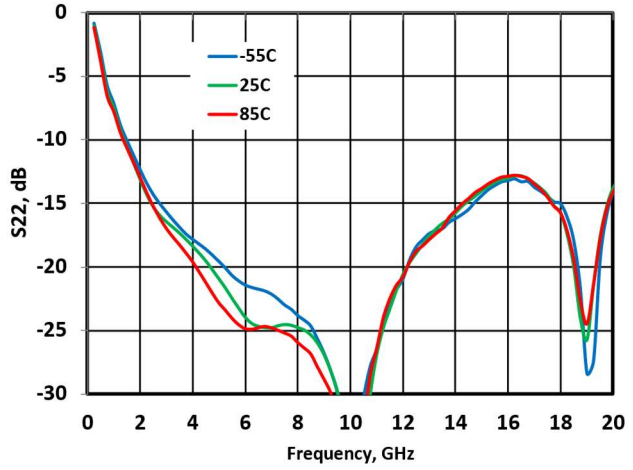


Figure 9 - S22 vs. Temperature @ 6V/150mA

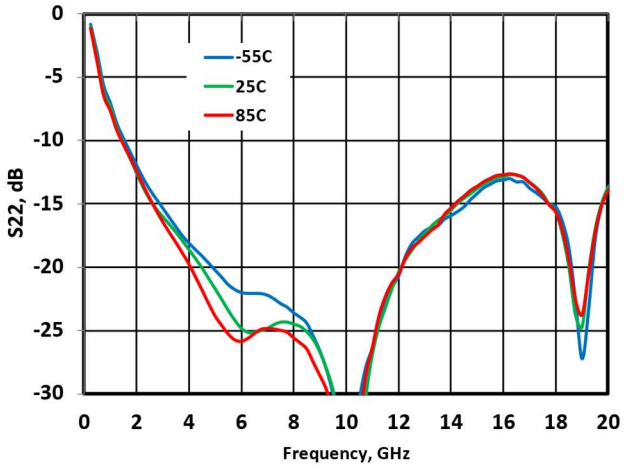


Figure 10 - S22 vs. Temperature @ 7V/180mA

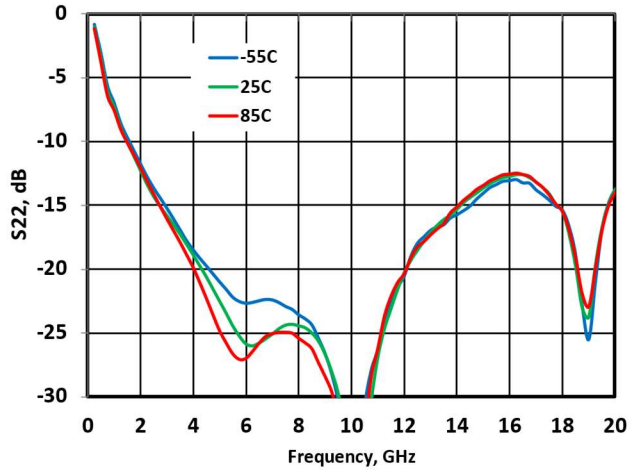


Figure 11 - S12 vs. Temperature @ 5V/120mA

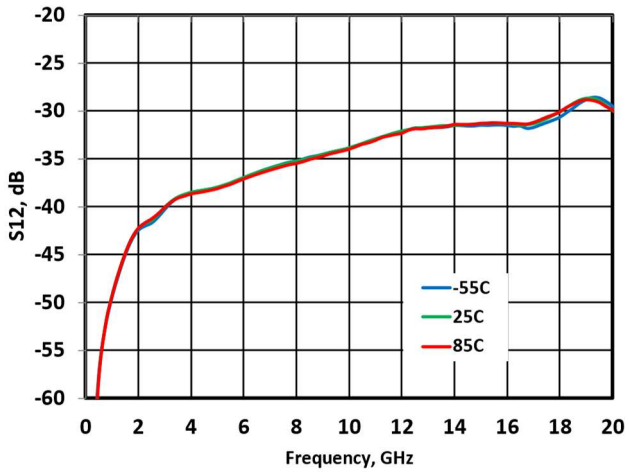


Figure 12 - S12 vs. Temperature @ 6V/150mA

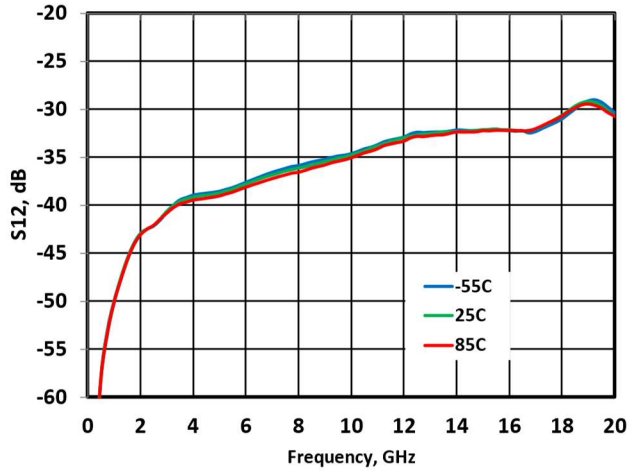


Figure 13 - S12 vs. Temperature @ 7V/180mA

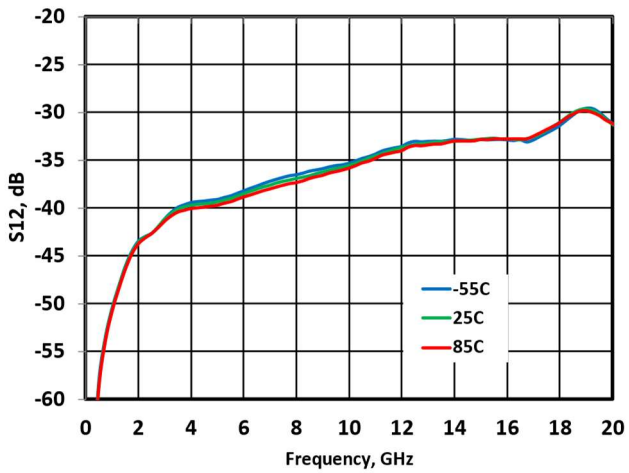


Figure 14 - NF vs. Temperature @ 5V/120mA

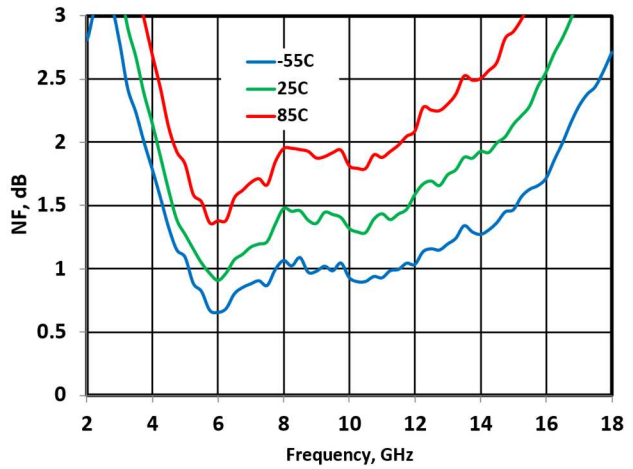


Figure 15 - NF vs. Temperature @ 6V/120mA

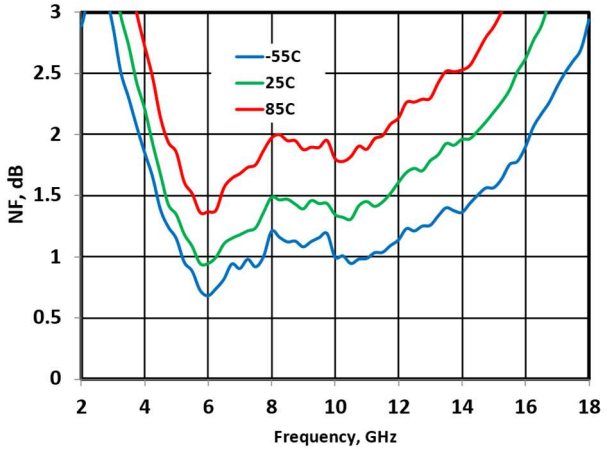


Figure 16 - NF vs. Temperature @ 7V/180mA

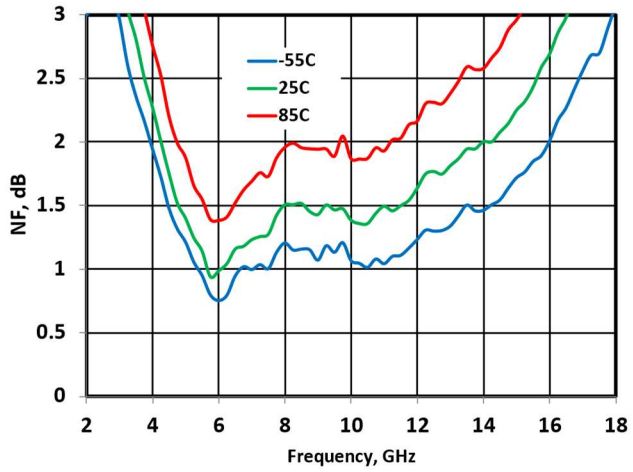


Figure 17 - P1dB vs. Temperature @ 5V/120mA

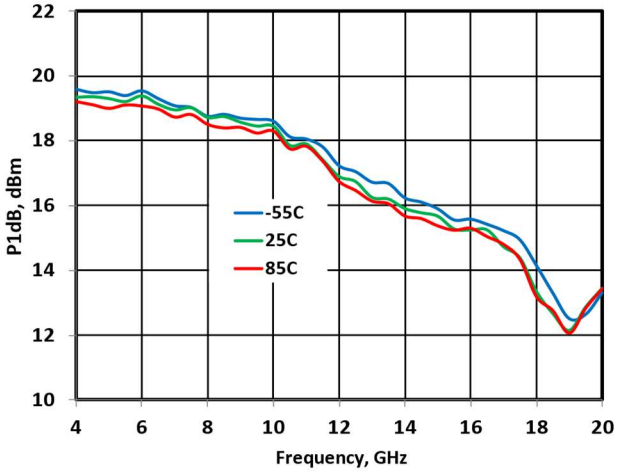


Figure 18 - P1dB vs. Temperature @ 6V/150mA

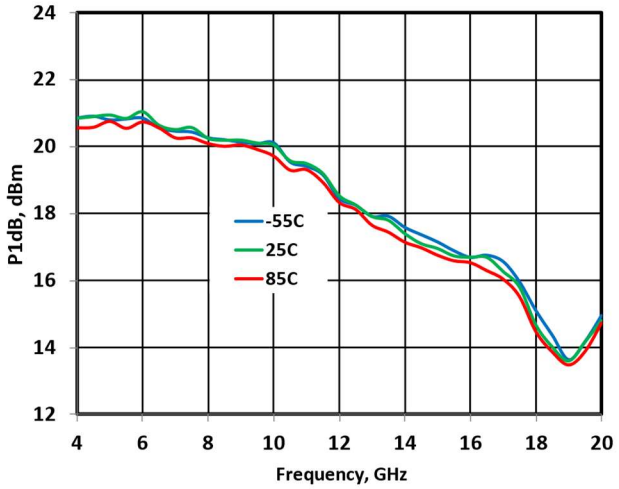


Figure 19 - P1dB vs. Temperature @ 7V/180mA

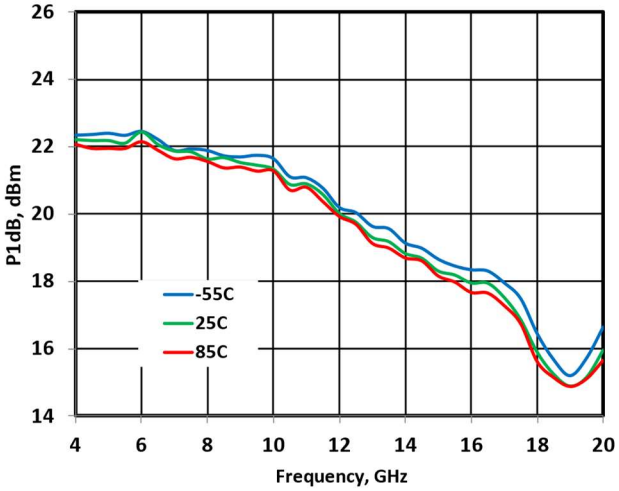


Figure 20 - Psat vs. Temperature @ 5V/120mA

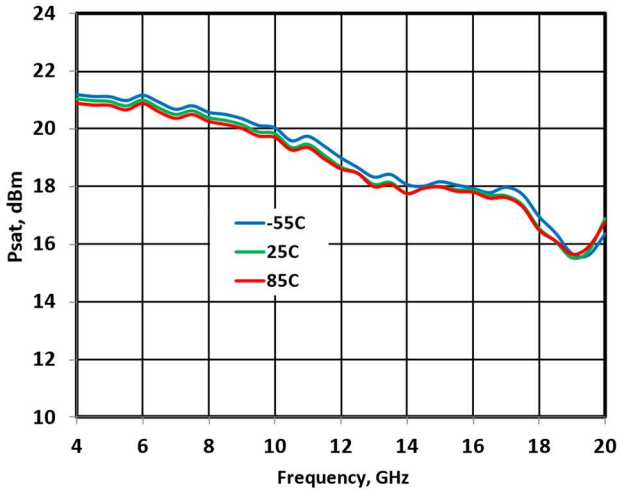


Figure 21 - Psat vs. Temperature @ 6V/150mA

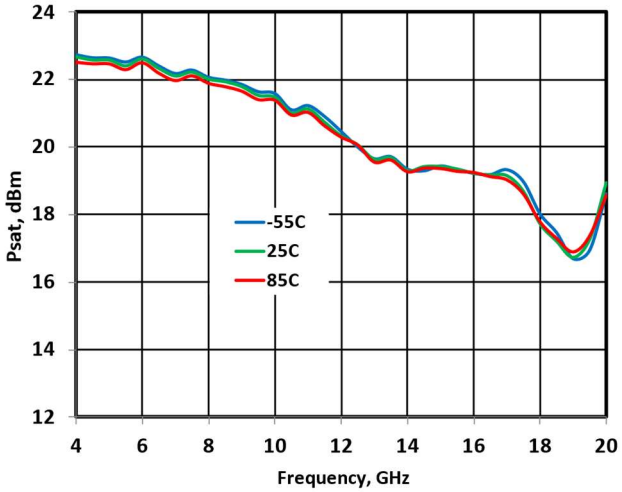


Figure 22 - Psat vs. Temperature @ 7V/180mA

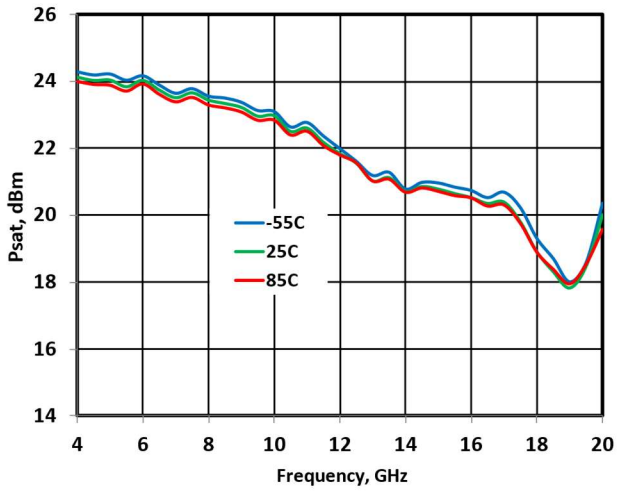


Figure 23 - OIP3 vs. Temperature @ 5V/120mA

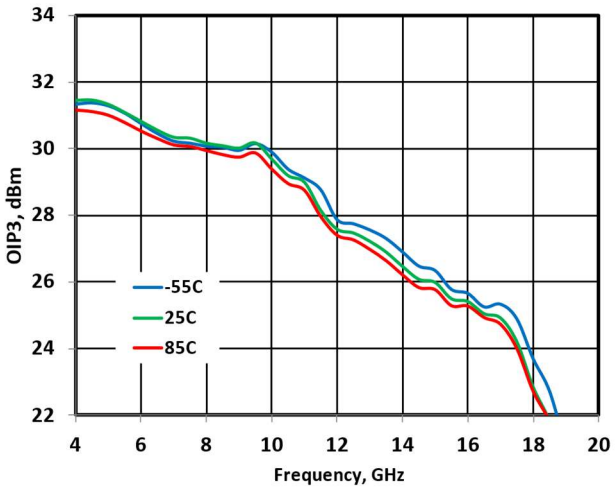


Figure 24 - OIP3 vs. Temperature @ 6V/150mA

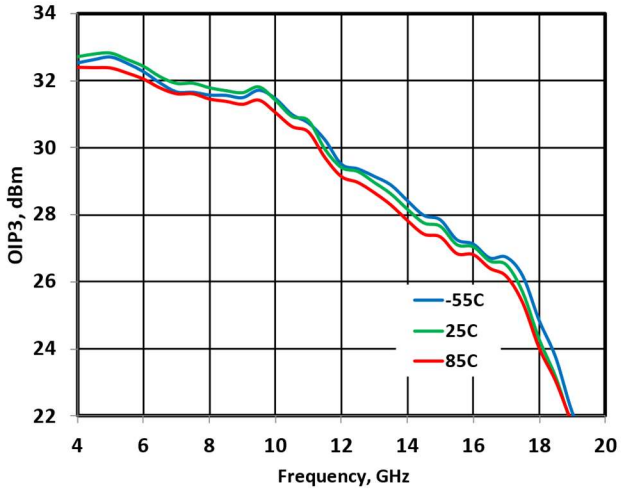


Figure 25 - OIP3 vs. Temperature @ 7V/180mA

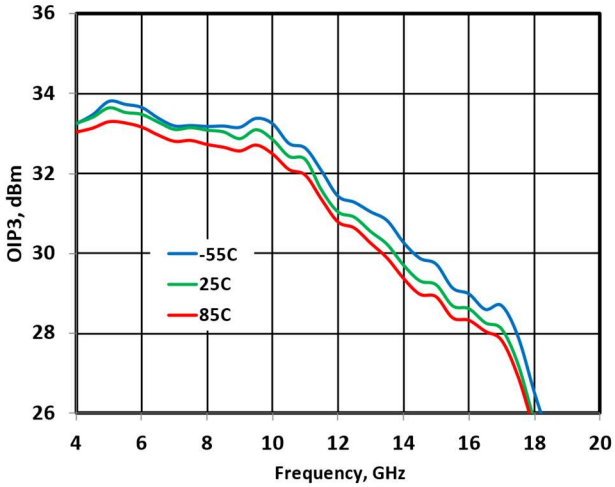


Figure 26 - OIP2(low) vs. Temperature @ 5V/120mA

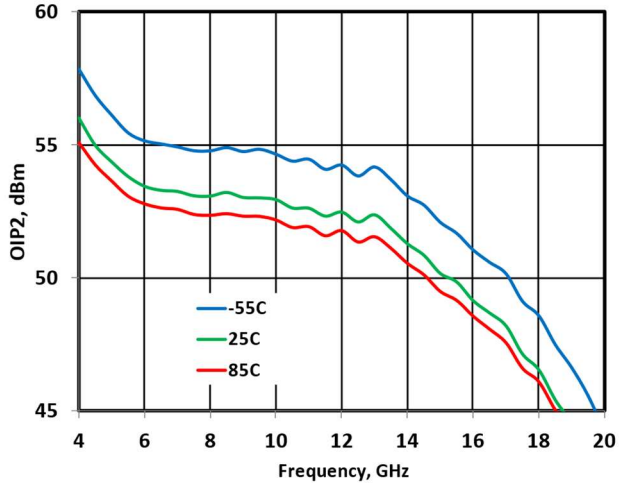


Figure 27 - OIP2(low) vs. Temperature @ 6V/150mA

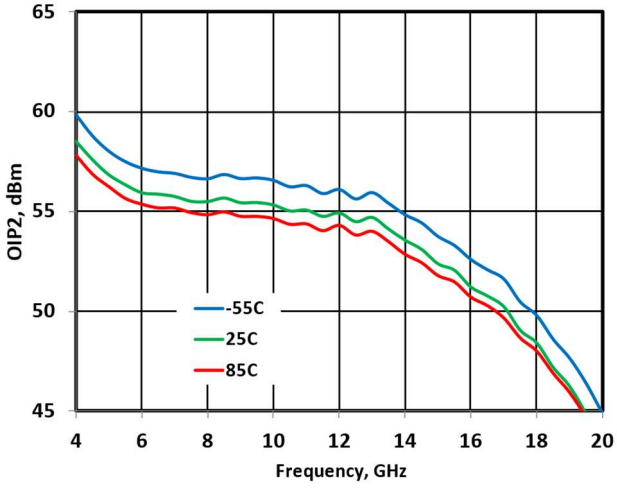


Figure 28 - OIP2(low) vs. Temperature @ 7V/180mA

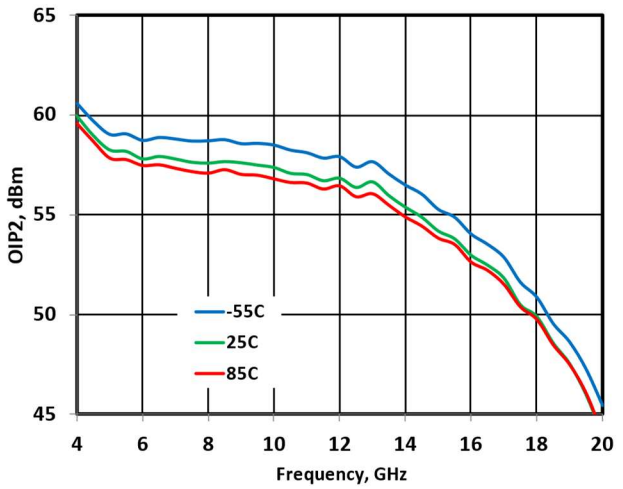


Figure 29 - IM3 vs. Temperature @ 5V/120mA, 10dBm(per tone)

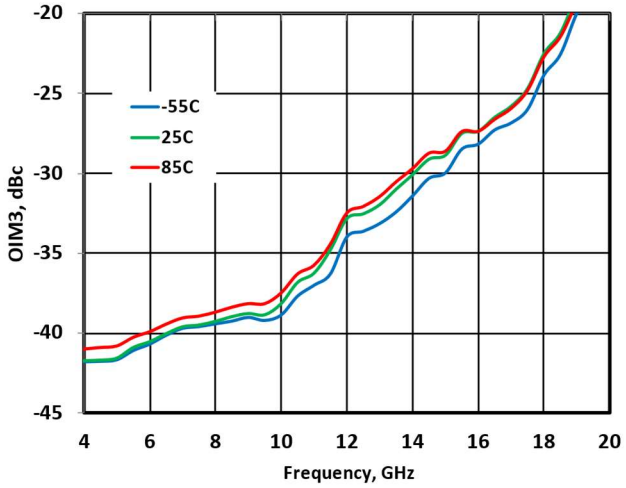


Figure 30 - IM3 vs. Temperature @ 6V/150mA, 10dBm(per tone)

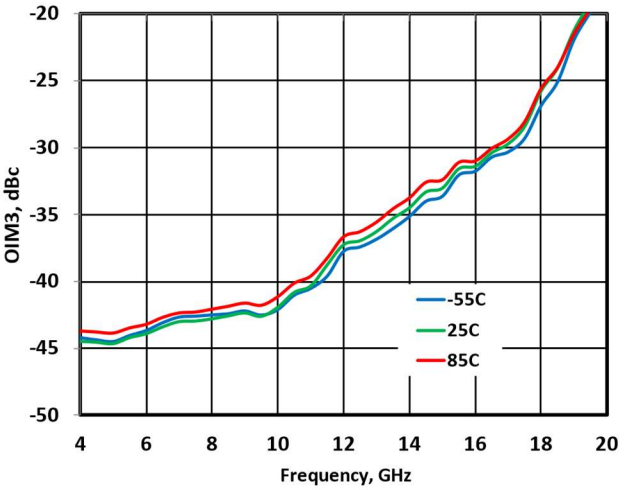
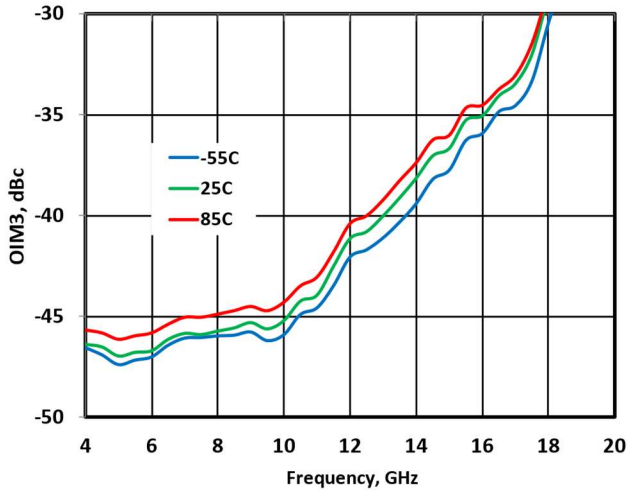


Figure 31 - IM3 vs. Temperature @ 7V/180mA, 10dBm(per tone)



1.3.2 Typical Performances vs. Bias

The following graphs show the typical performance curves of the MMA047AA device at 25 °C vs. Bias conditions, measurements performed using application circuit shown on Figure 71 -below.

Figure 32 - Gain vs . V_{DD} @ 120mA

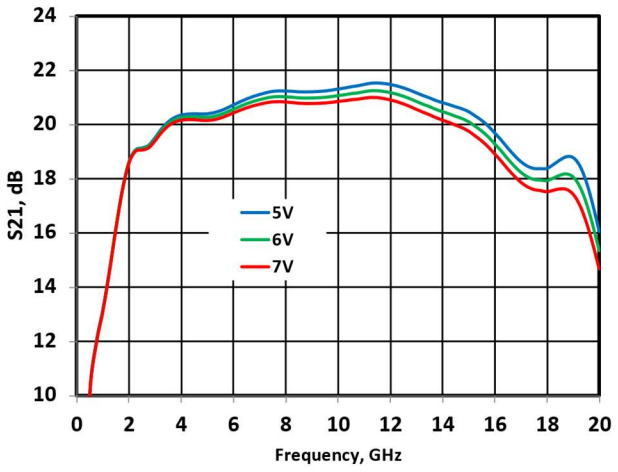


Figure 33 - Gain v s. V_{DD} @ 150mA

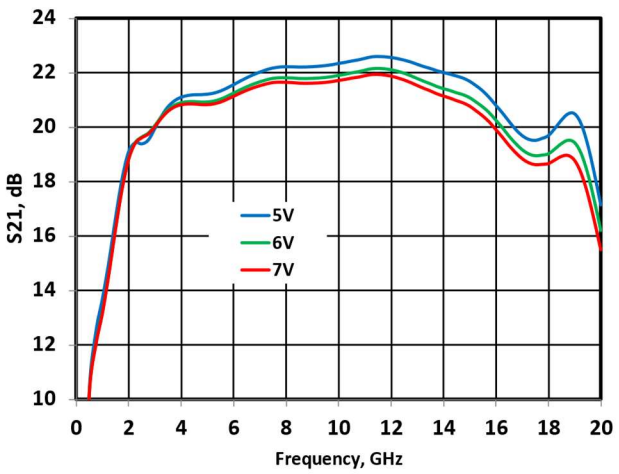


Figure 34 - Gain vs. V_{DD} @ 180mA

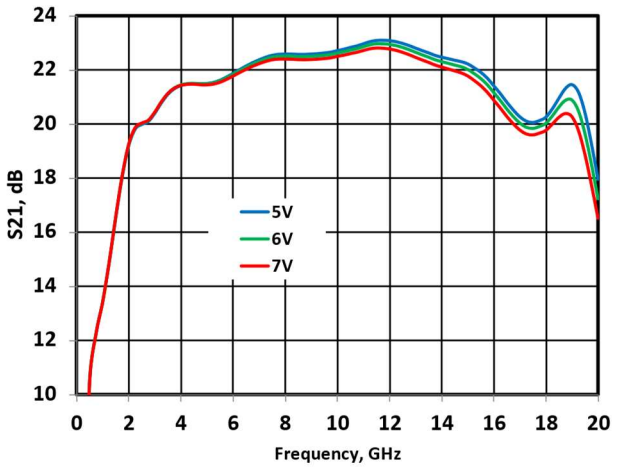


Figure 35 - N F vs. V_{DD} @ 120mA

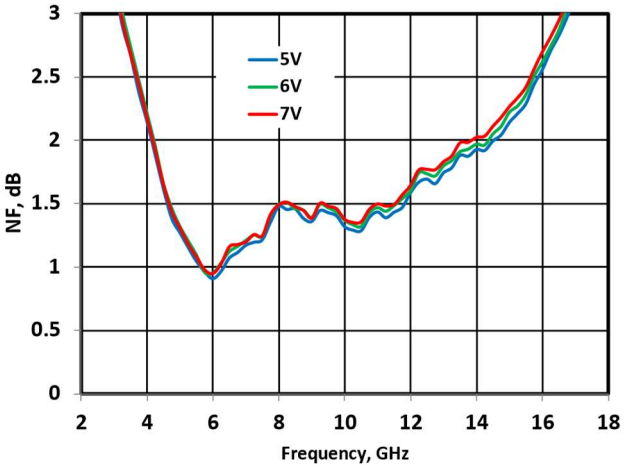


Figure 36 - NF vs. V_{DD} @ 150mA

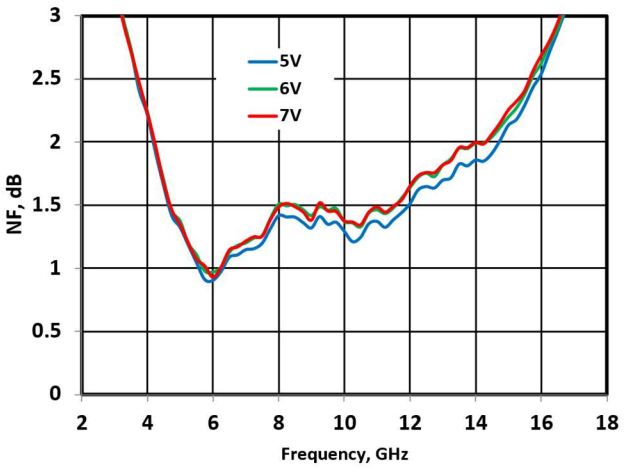


Figure 37 - NF vs. V_{DD} @ 180mA

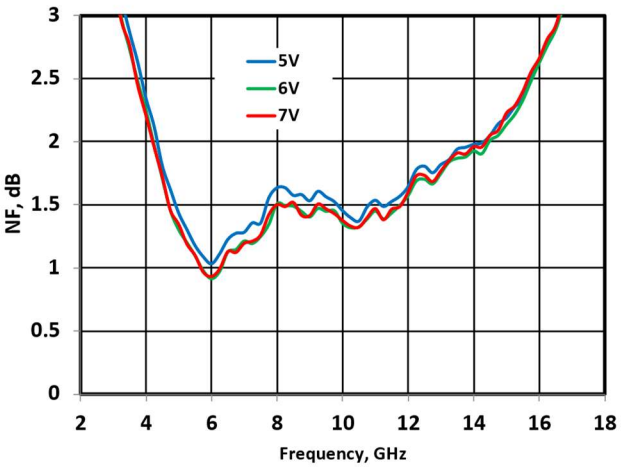


Figure 38 - P1dB vs. V_{DD} @ 120mA

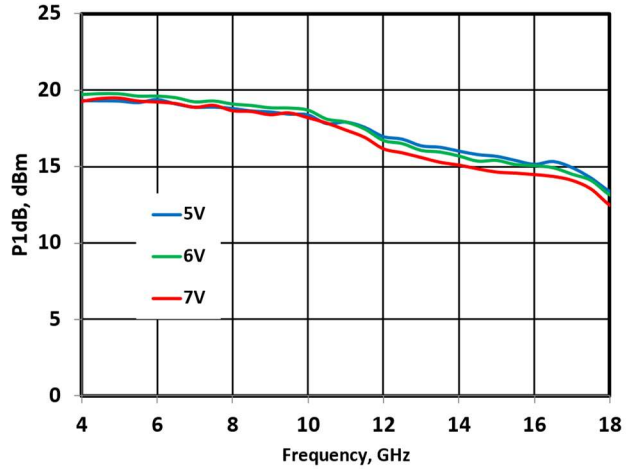


Figure 39 - P1dB vs. V_{DD} @ 150mA

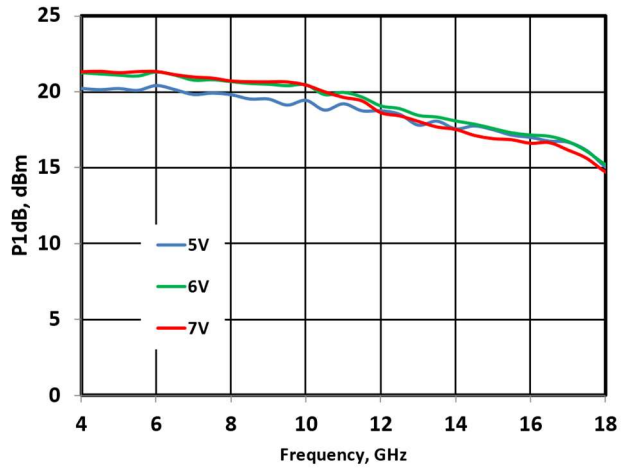


Figure 40 - P1dB vs. V_{DD} @ 180mA

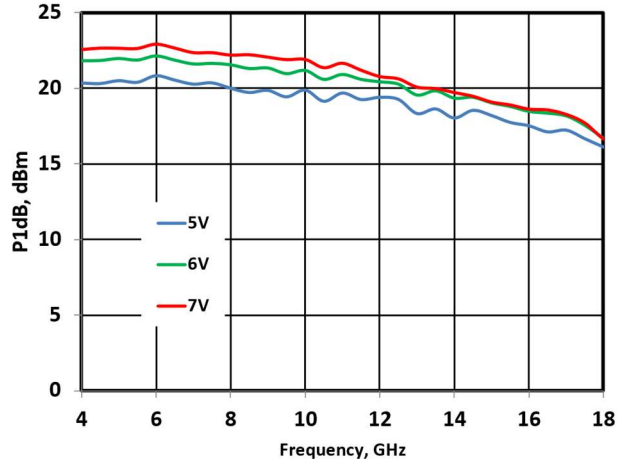


Figure 41 - OIP3 vs. V_{DD} @ 120mA

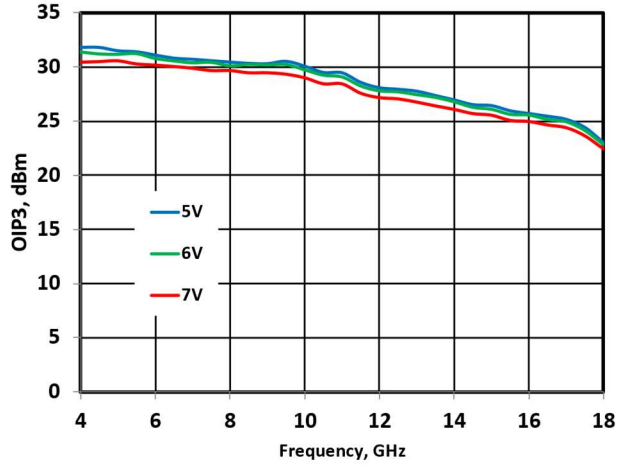


Figure 42 - OIP3 vs. V_{DD} @ 150mA

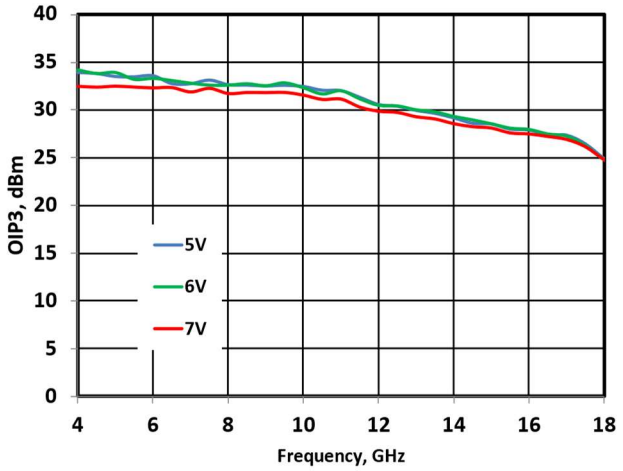


Figure 43 - OIP3 vs. V_{DD} @ 180mA

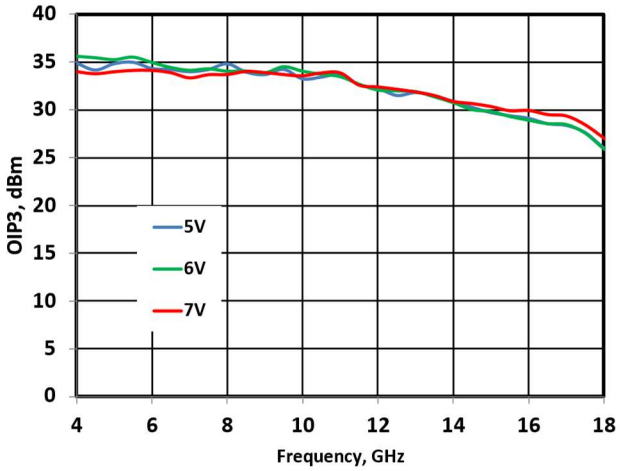


Figure 44 - OIP2 Low at Δ=10MHz vs. V_{DD} @ 120mA

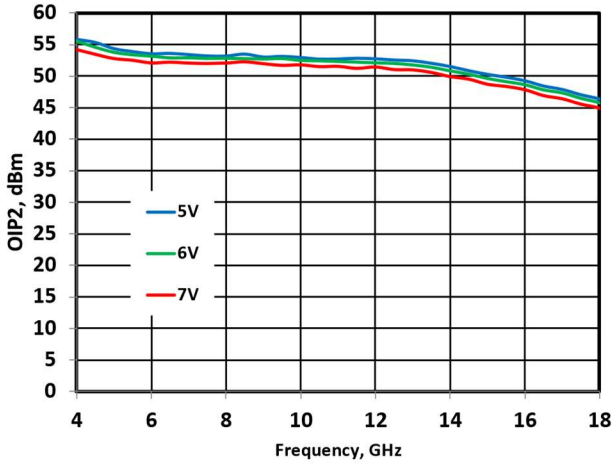


Figure 45 - OIP2 Low at Δ=10MHz vs. V_{DD} @ 150mA

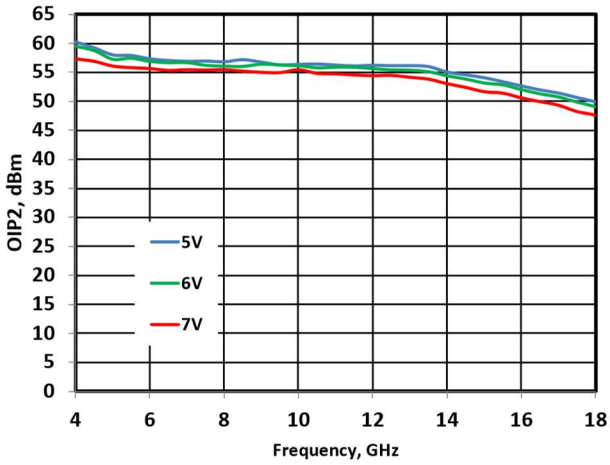


Figure 46 - OIP2 Low at Δ=10MHz vs. V_{DD} @ 180mA

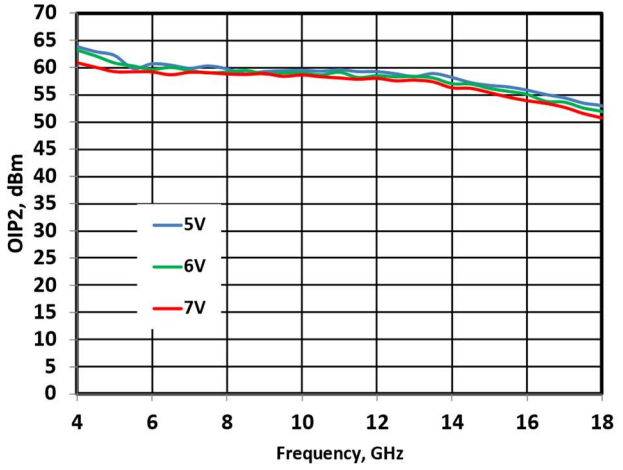


Figure 47 - IM3 vs. V_{DD} @ 120mA, 10dBm(per tone)

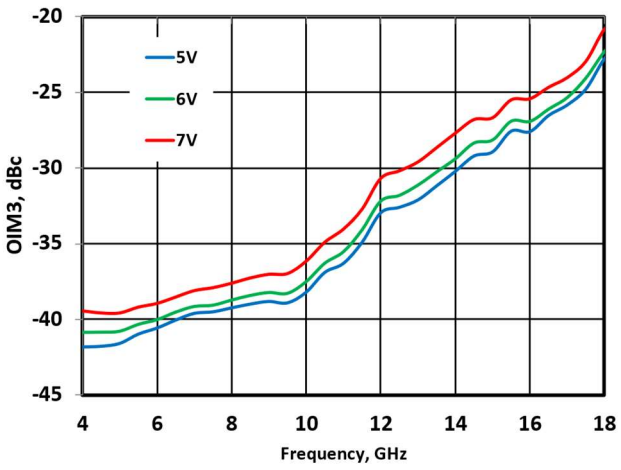


Figure 48 - IM3 vs. V_{DD} @ 150mA, 10dBm(per tone)

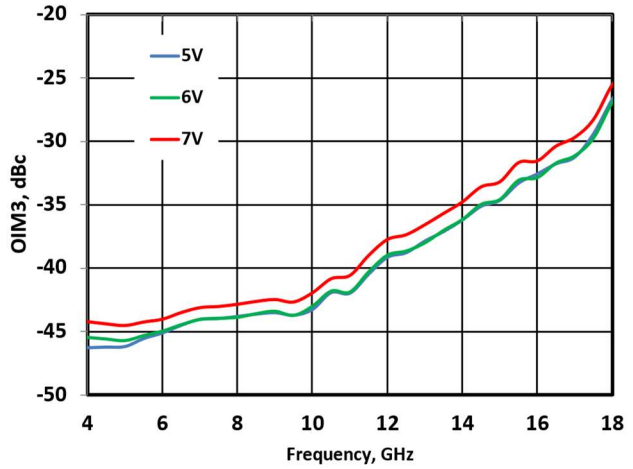
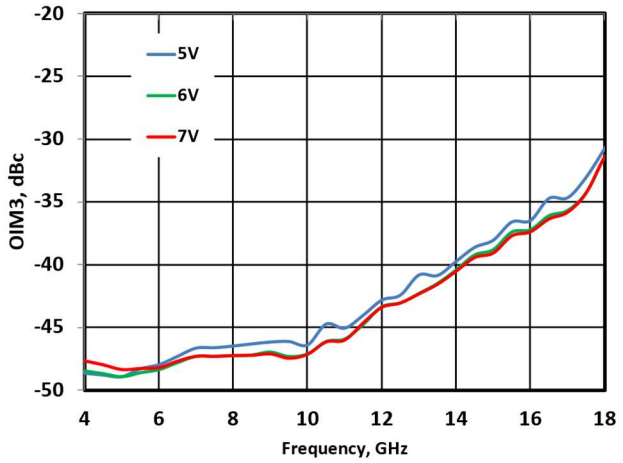


Figure 49 - IM3 vs. V_{DD} @ 180mA, 10dBm(per tone)



1.3.3 Typical Performances vs. Output Power

The following graphs show the typical performance curves of the MMA047AA device at 25 °C vs. Output Power conditions, measurements performed using application circuit shown on Figure 71 -below.

Figure 50 - IM2 vs. Power @ 5V/120mA

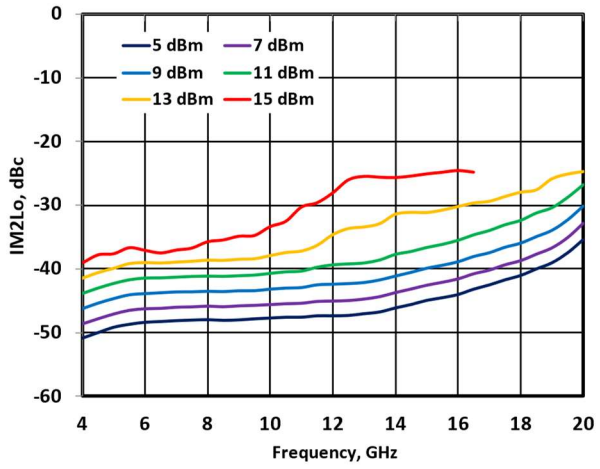


Figure 51 - IM2 vs. Power @ 6V/150mA

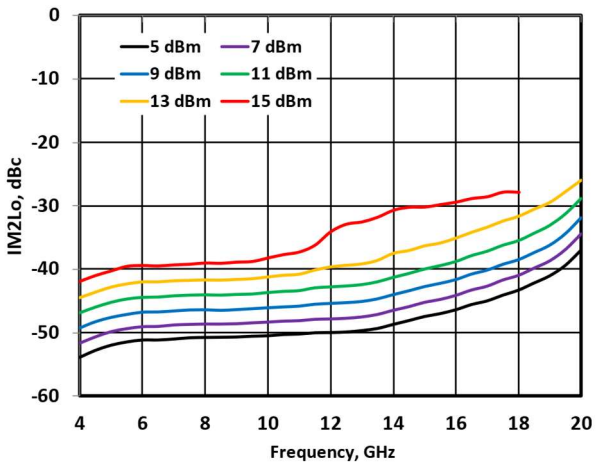


Figure 52 - IM2 vs. Power @ 7V/180mA

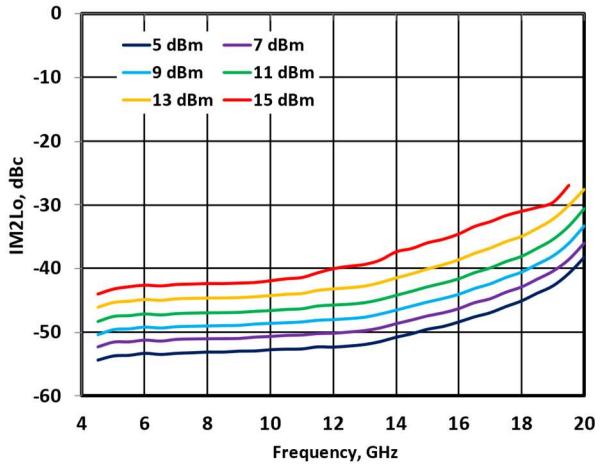


Figure 53 - IM3 vs. Power @ 5V/120mA

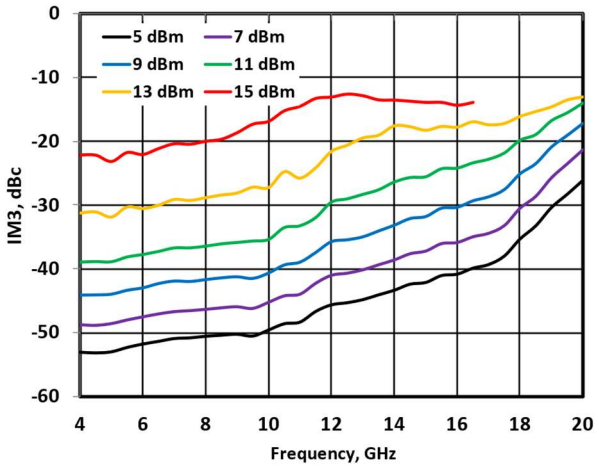


Figure 54 - IM3 vs. Power @ 6V/150mA

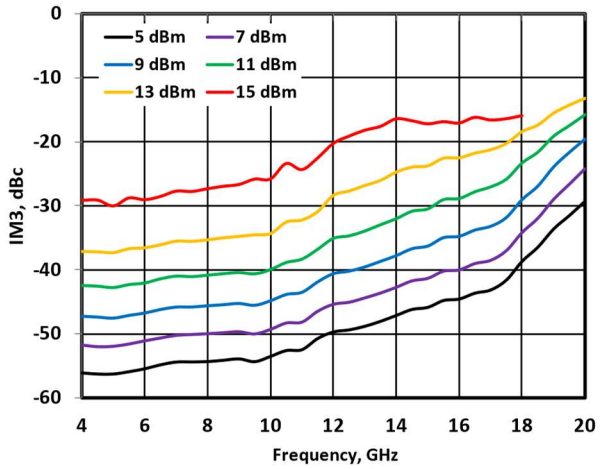


Figure 55 - IM3 vs. Power @ 7V/180mA

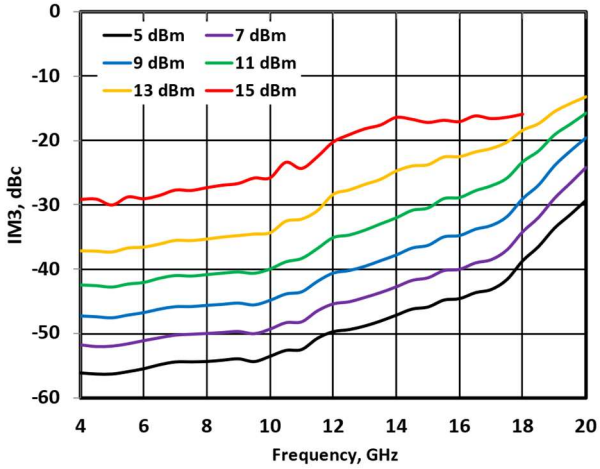


Figure 56 - 2-nd Harmonic vs. Power @ 5V/120mA

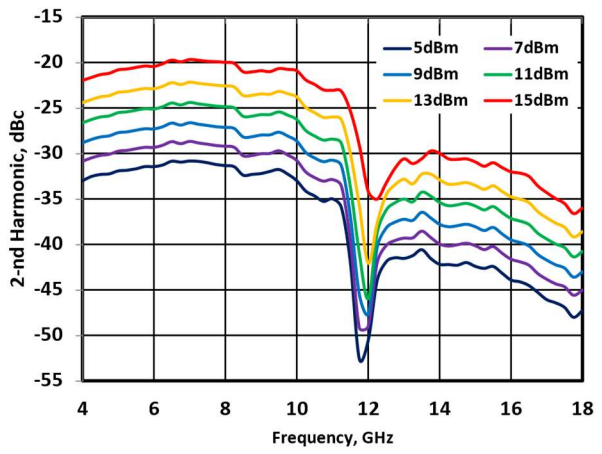


Figure 57 - 2-nd Harmonic vs. Power @ 6V/150mA

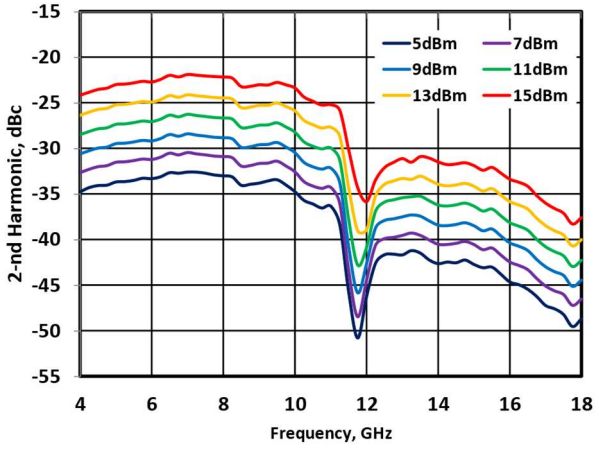
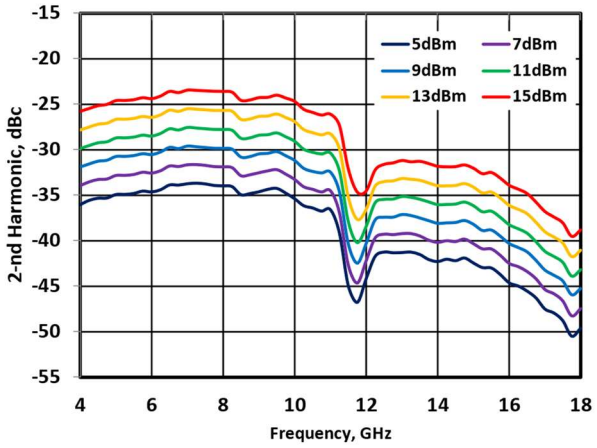


Figure 58 - 2-nd Harmonic vs. Power @ 7V/180mA



1.3.4 Typical Performances For Applications Circuit with PIN Diode (Figure 72 -)

The following graphs show the typical performance curves of the MMA047AA device at 25 °C, measurements performed using application circuit shown on Figure 72 -below.

Figure 59 - S21 @ 7V/180mA

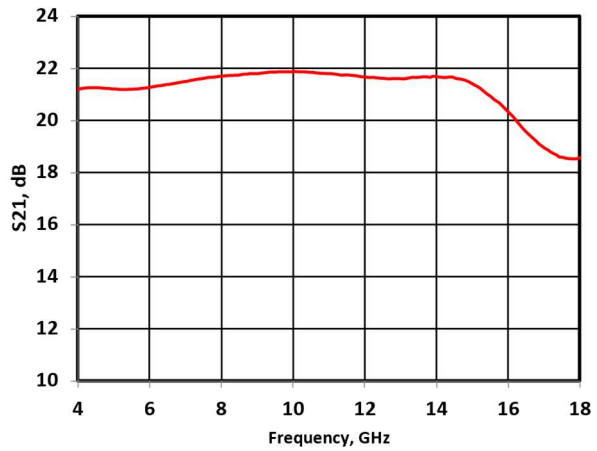


Figure 60 - S11, S22 @ 7V/180mA

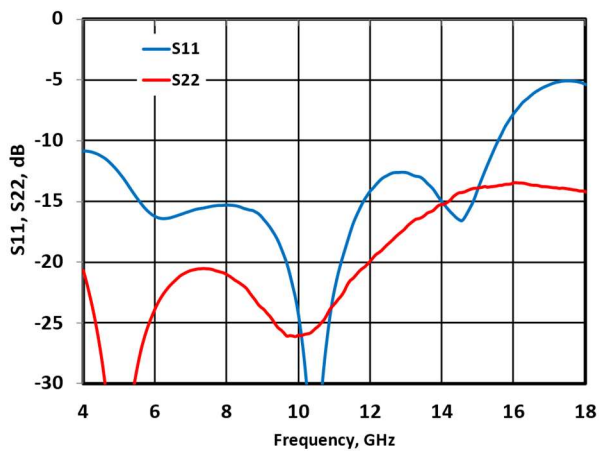


Figure 61 - S12 @ 7V/180mA

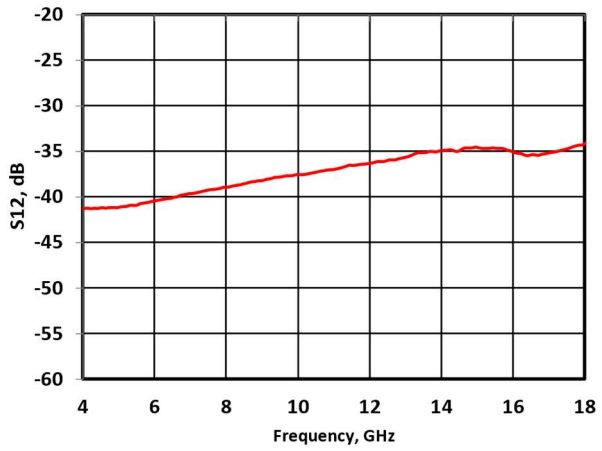


Figure 62 - NF @ 7V/180mA

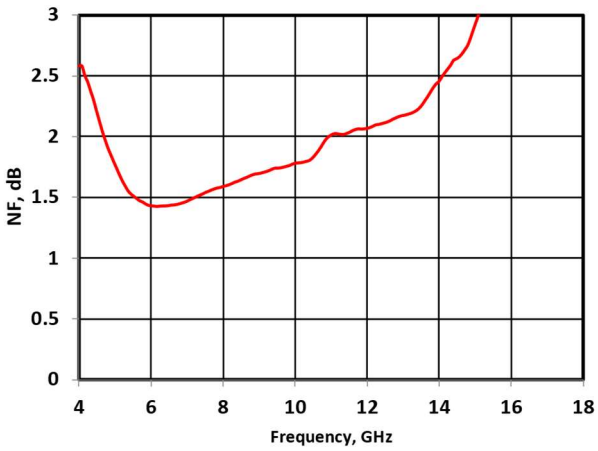
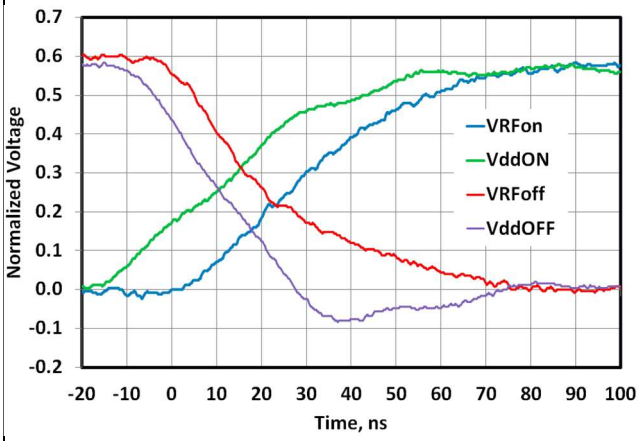


Figure 63 - Hot switching responses



1.3.5 Typical Performances for Applications Circuit with SLC Capacitance (Figure 73 -)

The following graphs show the typical performance curves of the MMA047AA device at 25 °C, measurements performed using application circuit shown on Figure 73 -below.

Figure 64 - S21 @ 7V/180mA

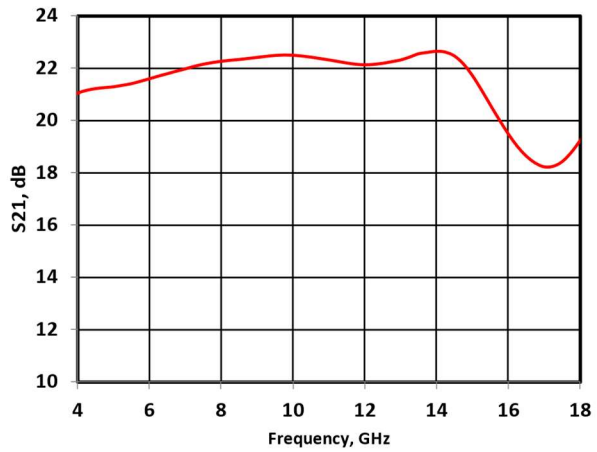


Figure 65 - S11, S22 @ 7V/180mA

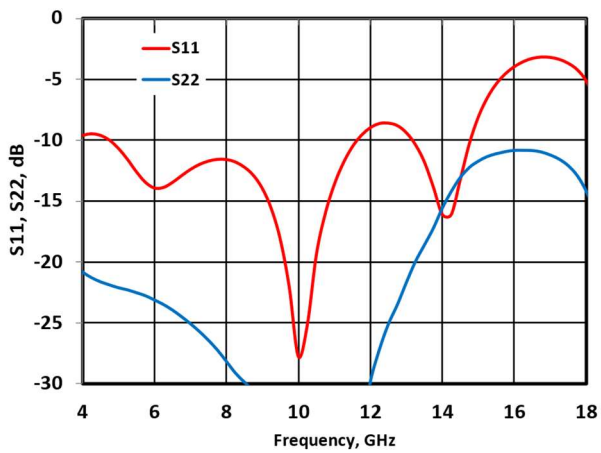


Figure 66 - S12 @ 7V/180mA

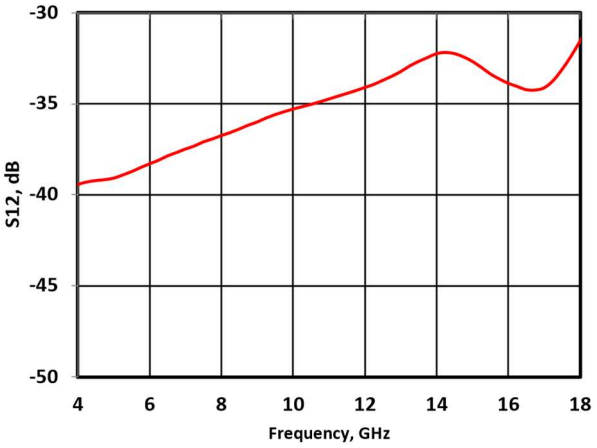
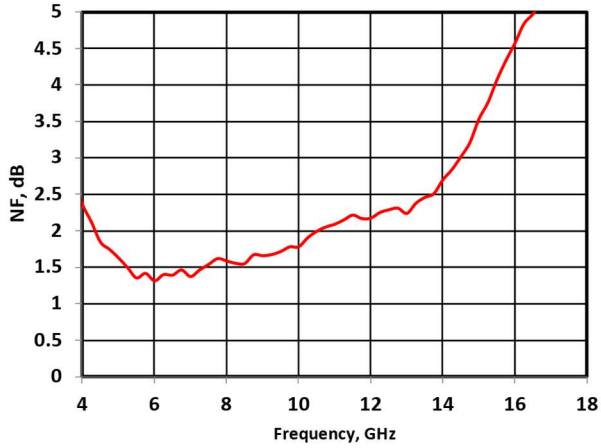


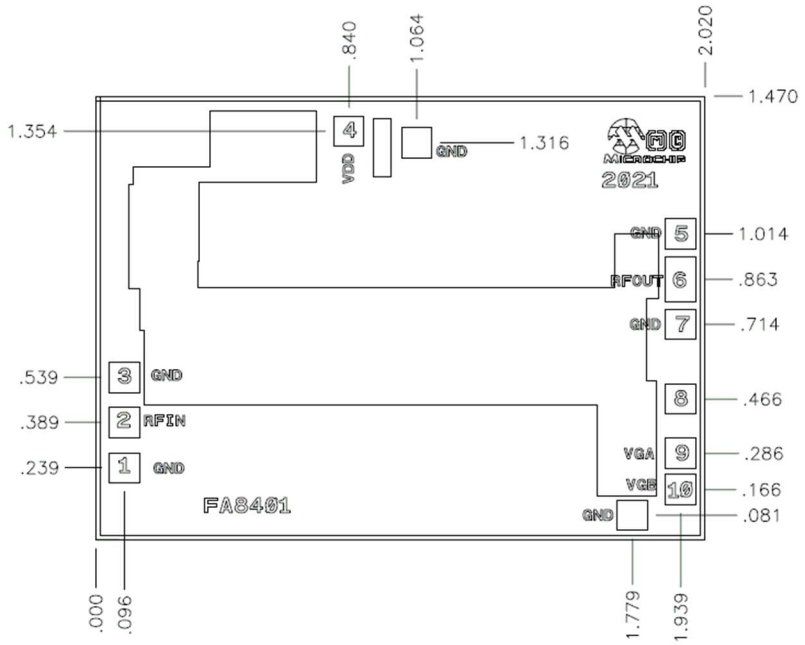
Figure 67 - NF @ 7V/180mA



1.4. Die Specifications

The following illustration shows the chip outline of the MMA041AA device. Dimensions are in millimeters and are relative to the zero datum locations shown in the drawing. The minimum bond pad size is 0.1 mm × 0.1 mm. Both the bond pad surface and the backside metal have 3 µm thick gold. The die thickness is 0.1 mm. The backside is the DC/RF ground. The airbridge keep-out polygon region is shown inside.

PAD NO.	DESCRIPTION	PAD SIZE
1	GND	0.1x0.1
2	RFIN	0.1x0.1
3	GND	0.1x0.1
4	VDD	0.1x0.1
5	GND	0.1x0.1
6	RFOUT	0.1x0.149
7	GND	0.1x0.1
8	VSB	0.1x0.1
9	VGA	0.1x0.1
10	VGB	0.1x0.1



or additional packaging information, contact your Microchip sales representative.

Figure 68 - Die Outline Drawing (mm)

Table 3 - I/O Description

Pad Number	Pad Name	Pad Description
2	RF_{IN}	This pad is DC-short and matched to 50 Ohm.
6	RF_{OUT}	This pad is DC-decoupled and matched to 50 Ohm.
4	V_{DD}	V_{DD} pad for Bias Supply; external bypass capacitor is required to further reduce noise impact from Bias Line
8	V_{SB}	Ground or connect external resistor to change I_{DD}
9, 10	V_{GA}, V_{GB}	Recommended connection to ground. Access to gate 1 DC (not recommended)
1,3,5, 7	Ground	Ground connections used for die test purposes; DC/RF Ground is using Die Backside metal

2. Application Circuits

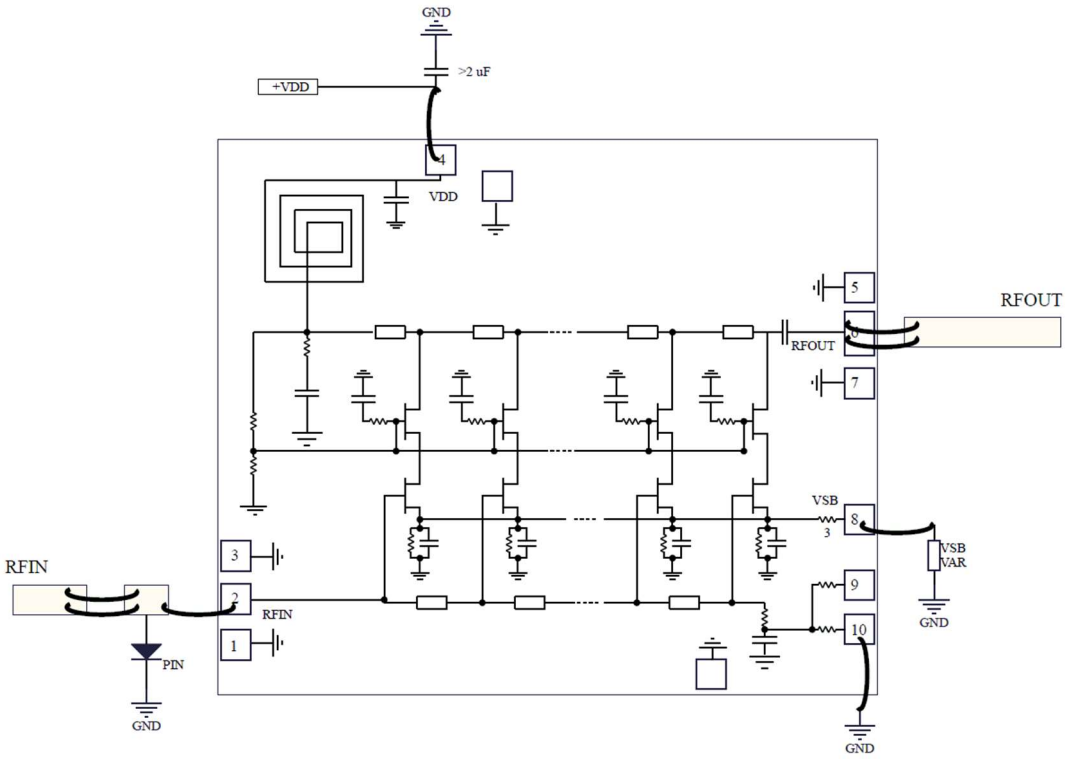


Figure 69 - Application Circuit: Schematic

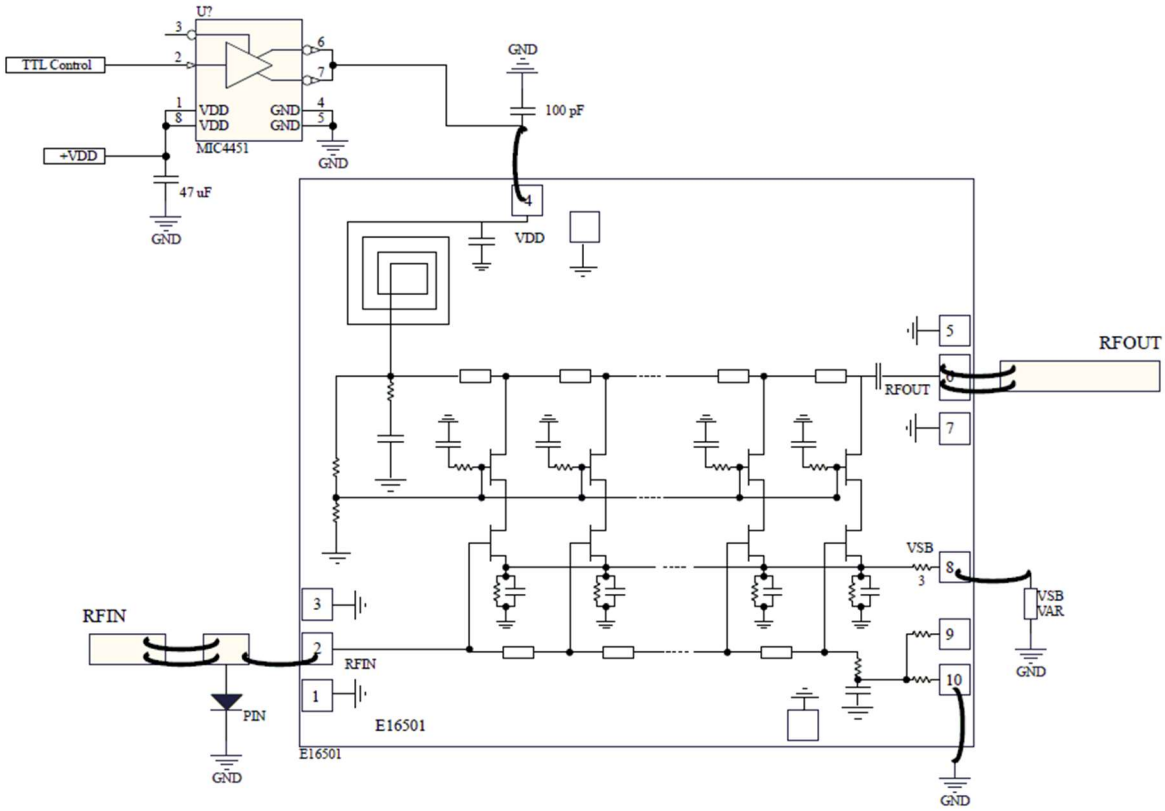


Figure 70 - Applications Circuit for Switching Operation using Microchip MIC4451 Driver

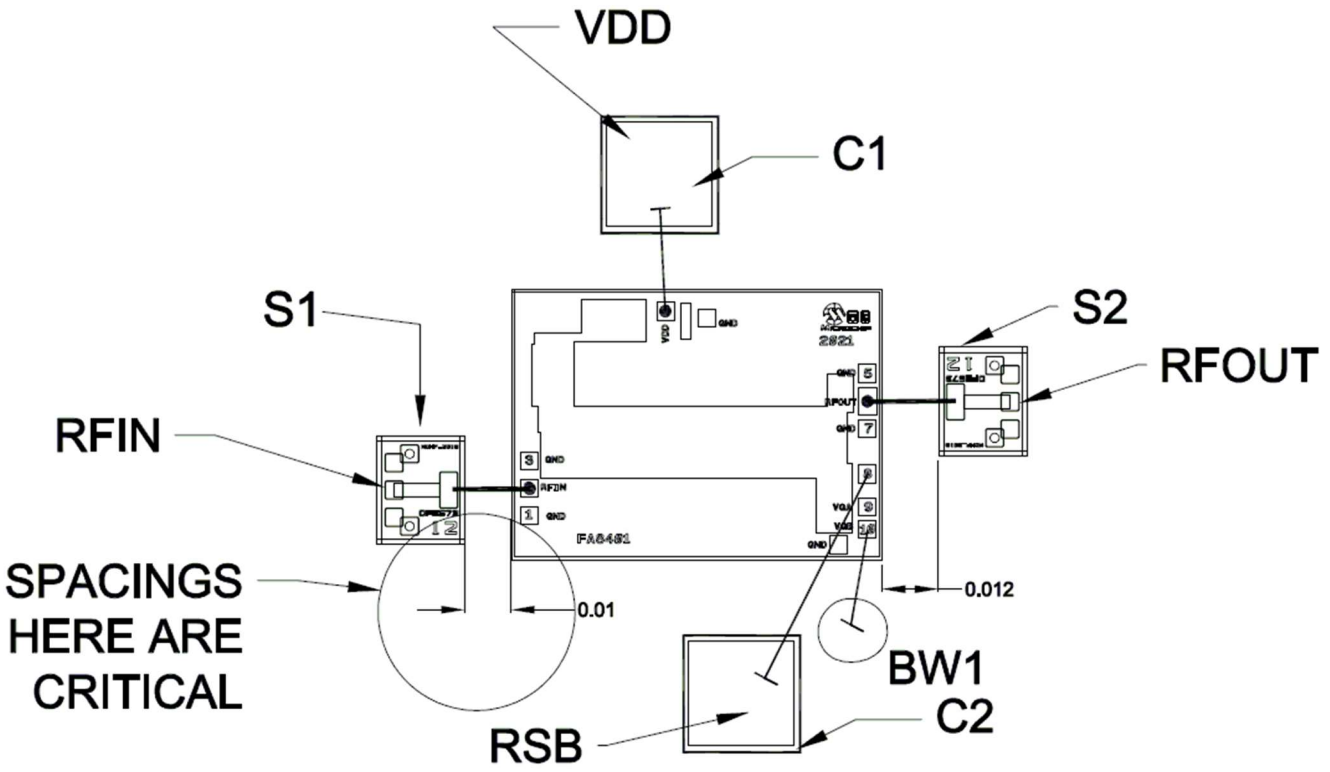


Figure 71 - Die Test Circuits: Assembly Drawing

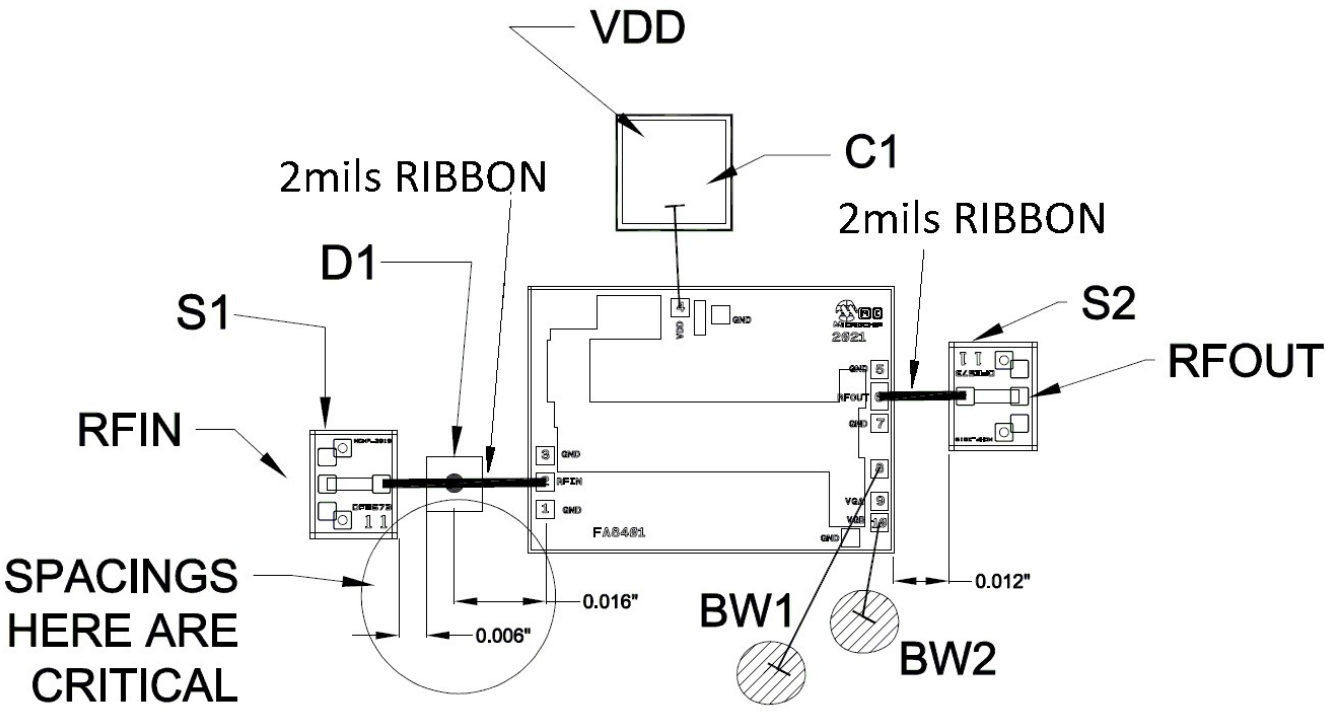


Figure 72 - Applications Assembly with Complimentary External PIN diode (D1)

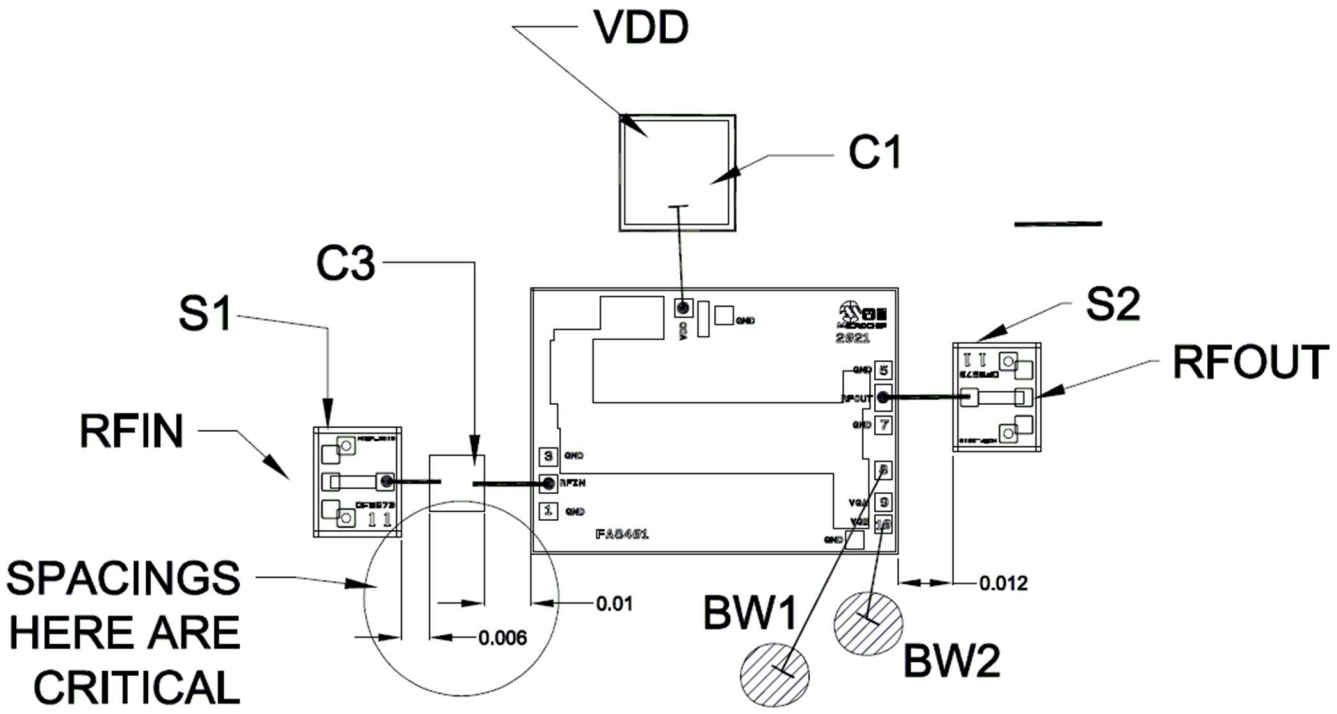


Figure 73 - Applications Assembly with Cap C3 to substitute PIN Diode D1 on Figure 72 -

Table 4 – List of Material for Figures 71-73

Reference	Part Number	Description
FA8401	MMA047AA	MMA047AA Amplifier Die
D1	LP4D03T43G	PIN Diode Chip (Anode pad) (Ask Microchip Sales Dep.)
C1, C2	160U02A102MT4W	Johnson Dielectric, Cer.Cap 1nF
C3	D10CDR15**	SLC Cap 0.15pF (Knowles)
S1, S2	E57311, E57312	Probe Launchers

Table 5 – R_{SB} Values vs Drain Current at 5, 6, 7V

R_{SB} (Ohm)	I_{DD}(mA) at 5V	I_{DD}(mA) at 6V	I_{DD}(mA) at 7V
0	173	179	185
2	140	145	150
3	131	136	140
4	128	133	138
5	125	129	134
6	123	127	131
7	119	123	127
8	116	120	124
9	114	119	123
10	112	117	121
11	110	114	117
12	109	113	117
13	107	111	114
14	106	110	114
15	105	109	113
16	105	108	112
17	103	107	111
18	103	107	110

3. 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.

4. Ordering Information

For additional ordering information, contact your Microchip sales representative.

Part Number	Package
MMA047AA	Die

4.1. Packing Information

Standard Format
Gel Pack
50 Pieces per Pack

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