MMIC DIE

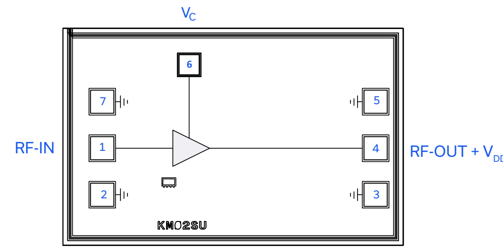
Variable Gain Amplifier PVGA-123-D+

50Ω 0.4 to 12 GHz

THE BIG DEAL

- Wide Bandwidth 0.4 to 12 GHz
- High OIP3 Typ. +30 dBm
- Single Positive Supply +6V
- Adjustable Gain Range Typ. 16 dB

FUNCTIONAL DIAGRAM



SEE ORDERING INFORMATION ON THE LAST PAGE

APPLICATIONS

- Radar, EW, and ECM Defense Systems
- 5G MIMO and Back Haul Radio Systems
- Test and Measurement Equipment

PRODUCT OVERVIEW

The PVGA-123-D+ is a GaAs pHEMT high performance variable gain amplifier operating from 0.4 to 12 GHz. The amplifier provides 16 dB Gain, +30 dBm OIP3 and +22 dBm P1dB with 17 dB typical return loss while operating from +6V and 77 mA DC power. The amplifier gain is voltage adjustable over a 16 dB dynamic range while maintaining excellent input IP3. The amplifier is ideal for use in very wideband ECM, Test and Measurement and Back Haul Radio systems

KEY FEATURES

Features	Advantages
Wideband: 0.4 to 12 GHz • 16 dB Typ. Gain at 6 GHz • 13 dB Typ. Gain at 12 GHz	Suitable for wide bandwidth defense and test and measurement application as well as narrow band performance driven applications
High P1dB & OIP3 • +22 dBm Typ. P1dB • +30 dBm Typ. OIP3	Suitable as a driver amplifier in receiver/transmitter chains
Adjustable Gain, 16 dB	Enables temperature compensation and power control for transmit and receive signal chains
Unpackaged Die	Enables integration into hybrid chip and wire assemblies

REV. OR
ECO-018346
PVGA-123-D+
MCL NY
230626

ELECTRICAL SPECIFICATIONS[1] AT 25°C, V_C = +5V, UNLESS NOTED OTHERWISE

Parameter	Condition (GHz)	V_{DD} = +6V			V_{DD} = +5V			Units
		Min.	Typ.	Max.	Min.	Typ.	Max.	
Frequency Range		0.4		12	0.4		12	GHz
Gain	0.4		16.8			16.6		dB
	4		16.7			16.4		
	6		16.1			15.8		
	8		15.2			14.9		
	12		13.1			12.9		
Output Power at 1 dB Compression (P1dB)	0.4		+21.0			+19.3		dBm
	4		+20.7			+18.8		
	6		+19.8			+18.0		
	8		+19.4			+17.9		
	12		+19.1			+17.2		
Output Power at 3 dB Compression (P3dB)[2]	0.4		+22.0			+20.1		dBm
	4		+21.7			+19.9		
	6		+21.1			+19.0		
	8		+20.9			+18.8		
	12		+19.9			+18.3		
Output Third-Order Intercept (P_{OUT} = -5 dBm/Tone)	0.4		+27			+27		dBm
	4		+33			+33		
	6		+30			+29		
	8		+29			+28		
	12		+30			+27		
Input Return Loss	0.4		18			19		dB
	4		14			14		
	6		13			14		
	8		11			11		
	12		9			9		
Output Return Loss	0.4		18			19		dB
	4		14			14		
	6		12			12		
	8		12			12		
	12		15			15		
Isolation	0.4		26			26		dB
	4		27			27		
	6		29			29		
	8		30			29		
	12		29			29		
Noise Figure	0.4		5.4			5.5		dB
	4		4.4			4.4		
	6		4.5			4.5		
	8		4.5			4.5		
	12		4.7			4.7		
Device Operating (V_{DD})			+6			+5		V
Device Operating Current (I_{DD})[3]			77			72		mA
DC Current Variation vs. Temperature[4]			26.9			42.5		µA/°C
DC Current Variation vs. Voltage[5]		0.005						mA/mV

1. Electrical specifications are measured by soldering the die on Mini-Circuits Die Characterization Test Board. Board loss is de-embedded to the device.
2. Defined as Output Power in which gain is compressed 3dB.
3. Current at P_{IN} = -25 dBm.
4. ((Current at +85°C - Current at -45°C))/(+130°C).
5. ((Current at +6V in mA)- (Current at +5V mA))/((+6V - +5V)*1000)

ELECTRICAL SPECIFICATIONS[6] OVER VARIOUS V_C AT 25°C, V_{DD} = +6V, UNLESS NOTED OTHERWISE

Parameter	Frequency (GHz)	Control Voltage, V_C						Units
		+0.8V	+1V	+2V	+3V	+4V	+5V	
DC Current, Typ.	-	8	14	30	43	59	77	mA
Gain, Typ.	0.4	6.9	8.4	11.2	14.6	16.1	16.8	dB
	4	5.7	7.8	11.1	14.5	16.0	16.7	
	6	2.7	5.6	9.6	13.5	15.2	16.1	
	8	0.1	3.5	8.2	12.4	14.3	15.2	
	12	-2.7	1.2	6.5	10.7	12.3	13.1	
Isolation, Typ.	0.4	19	19	21	23	25	26	dB
	4	20	20	22	25	26	27	
	6	23	22	24	26	28	29	
	8	25	24	25	27	29	30	
	12	26	25	25	27	29	29	
Input Return Loss, Typ.	0.4	8	10	16	28	21	18	dB
	4	13	16	27	20	16	14	
	6	10	12	15	15	14	13	
	8	9	9	10	11	11	11	
	9	8	8	8	9	9	9	
Output Return Loss, Typ.	0.4	6	6	10	21	26	18	dB
	4	7	9	12	18	16	14	
	6	5	6	8	11	12	12	
	8	4	5	6	9	11	12	
	12	5	6	8	12	14	15	
Output Power at 1 dB Compression (P1dB), Typ.	0.4	+21.7	+21.8	+22.1	+21.8	+21.2	+21.0	dBm
	4	+21.6	+21.7	+21.6	+21.3	+21.0	+20.7	
	6	+21.0	+21.1	+20.9	+20.5	+20.1	+19.8	
	8	+20.6	+20.8	+21.0	+20.5	+19.8	+19.4	
	12	+20.8	+21.3	+21.3	+19.3	+19.1	+19.1	
Output Power at 3 dB Compression (P3dB)[7], Typ.	0.4	+21.7	+21.7	+22.1	+22.3	+22.3	+22.0	dBm
	4	+21.6	+21.6	+21.8	+21.8	+21.8	+21.7	
	6	+20.9	+21.0	+21.3	+21.2	+21.2	+21.1	
	8	+20.5	+20.7	+21.1	+21.2	+21.0	+20.9	
	12	+20.8	+21.0	+21.4	+19.9	+19.9	+19.9	
Output Third-Order Intercept, Typ. (P_{OUT} = -5 dBm/Tone)	0.4	+11	+12	+12	+20	+25	+27	dBm
	4	+12	+14	+14	+25	+31	+33	
	6	+10	+16	+13	+24	+28	+30	
	8	+9	+16	+12	+23	+27	+29	
	12	+8	+12	+13	+22	+26	+30	
Noise Figure, Typ.	0.4	8.6	8.7	7.2	6.0	5.6	5.4	dB
	4	5.6	5.3	5.0	4.5	4.4	4.4	
	6	6.0	5.4	5.0	4.5	4.5	4.5	
	8	6.8	5.7	5.1	4.5	4.5	4.5	
	12	8.6	7.0	5.4	4.8	4.6	4.7	

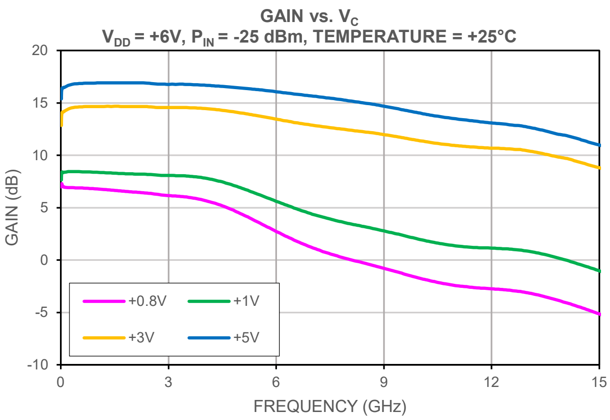
6. Electrical specifications are measured by soldering the die on Mini-Circuits Die Characterization Test Board. Board loss is de-embedded to the device.
7. Defined as Output Power at which gain is compressed by 3dB.

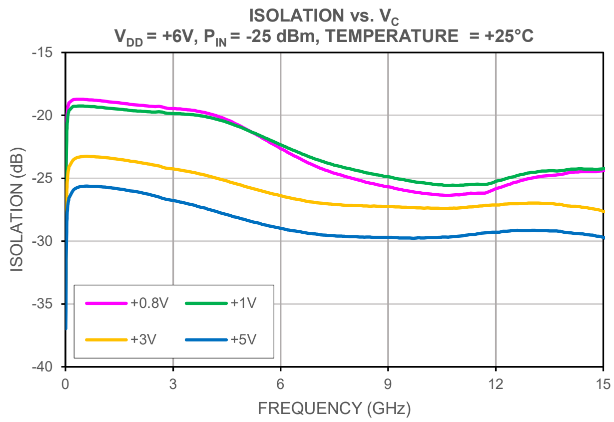
ELECTRICAL SPECIFICATIONS[8] OVER VARIOUS V_C AT 25°C, V_{DD} = +5V, UNLESS NOTED OTHERWISE

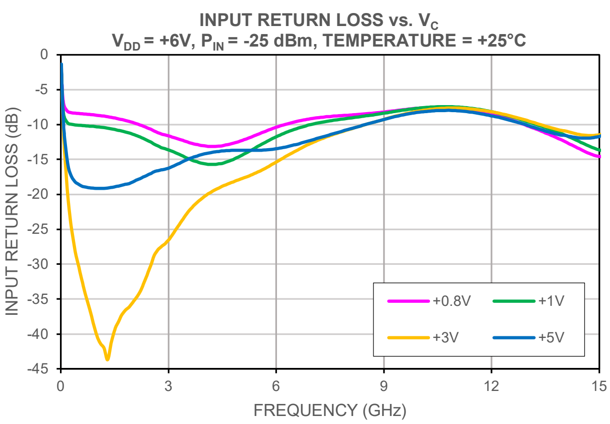
Parameter	Frequency (GHz)	Control Voltage, V_C						Units
		+0.8V	+1V	+2V	+3V	+4V	+5V	
DC Current, Typ.	-	7	13	29	41	55	72	mA
Gain, Typ.	0.4	6.5	8.3	10.7	14.1	15.8	16.6	dB
	4	5.1	7.7	10.5	13.9	15.6	16.4	
	6	2.0	5.4	8.9	12.8	14.8	15.8	
	8	-0.7	3.3	7.5	11.8	13.9	14.9	
	12	-3.6	0.9	5.8	10.1	12.0	12.9	
Isolation, Typ.	0.4	19	19	21	23	25	26	dB
	4	20	20	22	24	26	27	
	6	23	22	24	26	28	29	
	8	25	24	25	27	28	29	
	12	26	25	25	27	28	29	
Input Return Loss, Typ.	0.4	8	10	16	27	23	19	dB
	4	13	16	25	22	16	14	
	6	10	12	15	16	14	14	
	8	9	9	10	11	11	11	
	12	9	8	8	8	9	9	
Output Return Loss, Typ.	0.4	5	6	9	18	31	19	dB
	4	7	9	11	17	16	14	
	6	5	6	7	10	12	12	
	8	4	5	6	9	11	12	
	12	5	6	8	11	14	15	
Output Power at 1 dB Compression (P1dB), Typ.	0.4	+19.3	+19.6	+20.0	+19.8	+19.0	+19.3	dBm
	4	+19.5	+19.7	+19.8	+19.3	+18.7	+18.8	
	6	+19.1	+19.3	+18.6	+18.3	+17.9	+18.0	
	8	+19.1	+19.2	+19.1	+18.4	+17.6	+17.9	
	12	+19.8	+20.1	+19.6	+17.5	+17.2	+17.2	
Output Power at 3 dB Compression (P3dB)[9], Typ.	0.4	+19.3	+19.4	+20.0	+20.3	+20.3	+20.1	dBm
	4	+19.5	+19.5	+19.9	+20.1	+20.1	+19.9	
	6	+19.1	+19.1	+19.5	+19.3	+19.1	+19.0	
	8	+19.0	+19.1	+19.4	+19.4	+19.1	+18.9	
	12	+19.8	+20.0	+18.2	+18.1	+18.1	+18.3	
Output Third-Order Intercept, Typ. (P_{OUT} = -5 dBm/Tone)	0.4	+11	+13	+11	+18	+24	+27	dBm
	4	+11	+14	+13	+22	+32	+33	
	6	+9	+16	+12	+22	+28	+29	
	8	+8	+18	+11	+21	+26	+28	
	12	+8	+13	+12	+20	+25	+27	
Noise Figure, Typ.	0.4	8.8	8.8	7.4	6.1	5.7	5.5	dB
	4	5.7	5.3	5.1	4.5	4.4	4.4	
	6	6.2	5.4	5.1	4.6	4.5	4.5	
	8	7.1	5.8	5.2	4.6	4.5	4.5	
	12	9.4	7.0	5.5	4.9	4.8	4.7	

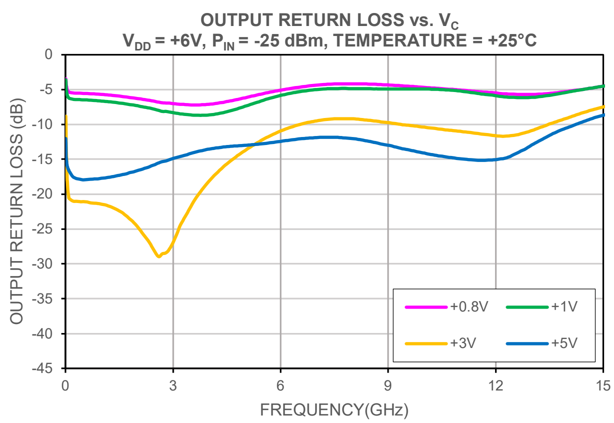
8. Electrical specifications are measured by soldering the die on Mini-Circuits Die Characterization Test Board. Board loss is de-embedded to the device.
9. Defined as Output Power at which gain is compressed 3dB.

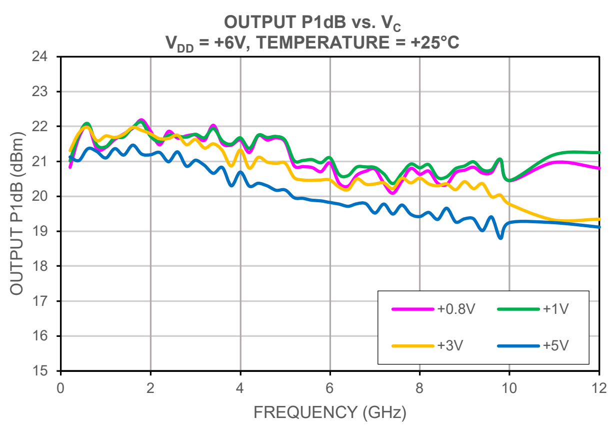
TYPICAL PERFORMANCE GRAPHS

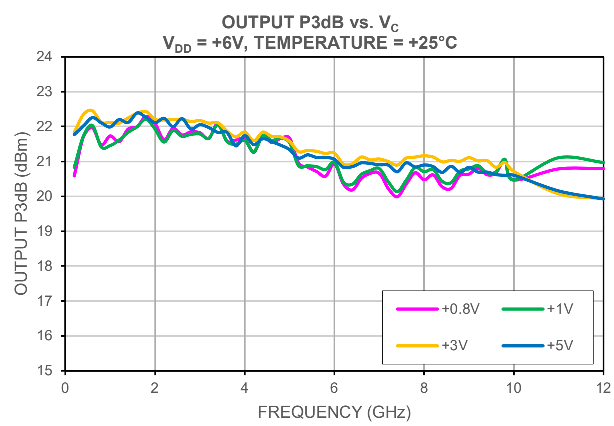






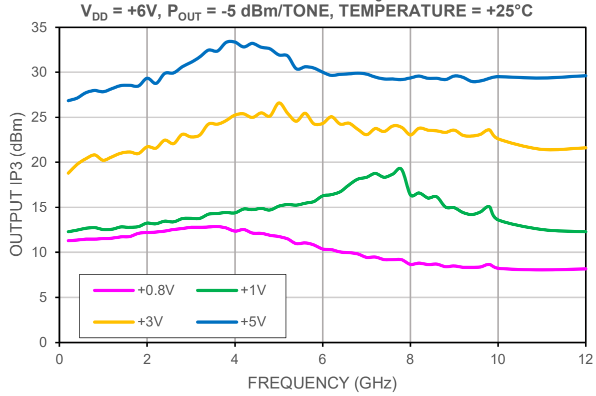




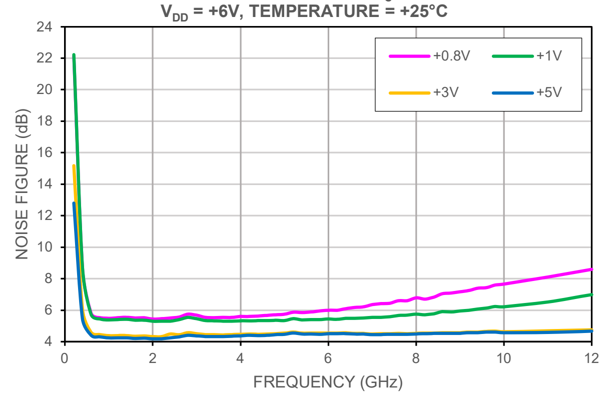


TYPICAL PERFORMANCE GRAPHS

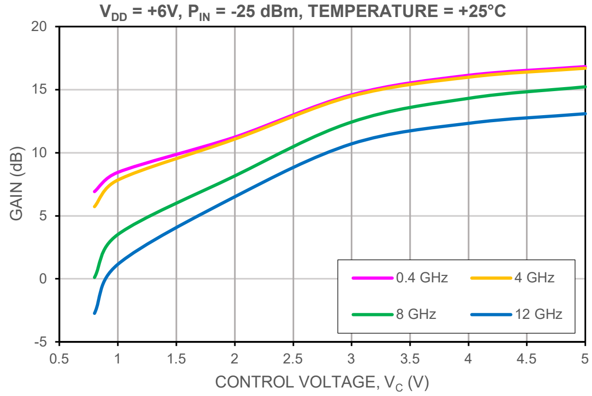
OUTPUT IP3 vs. V_C
V_{DD} = +6V, P_{OUT} = -5 dBm/TONE, TEMPERATURE = +25°C



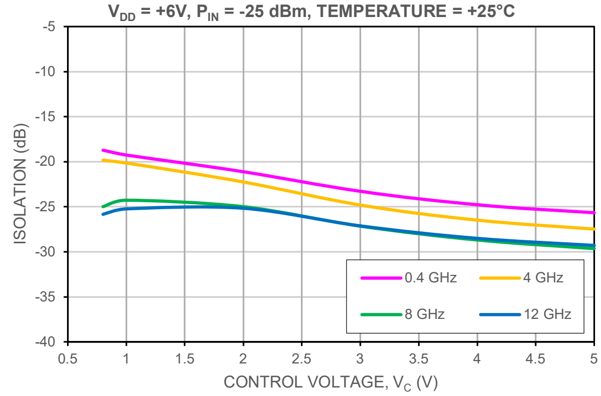
NOISE FIGURE vs. V_C
V_{DD} = +6V, TEMPERATURE = +25°C



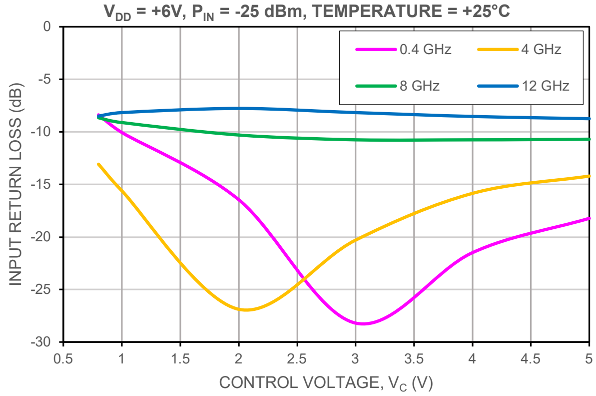
GAIN vs. FREQUENCY
V_{DD} = +6V, P_{IN} = -25 dBm, TEMPERATURE = +25°C



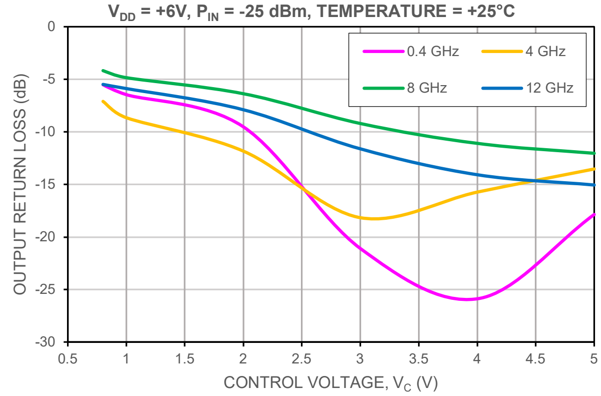
ISOLATION vs. FREQUENCY
V_{DD} = +6V, P_{IN} = -25 dBm, TEMPERATURE = +25°C



INPUT RETURN LOSS vs. FREQUENCY
V_{DD} = +6V, P_{IN} = -25 dBm, TEMPERATURE = +25°C

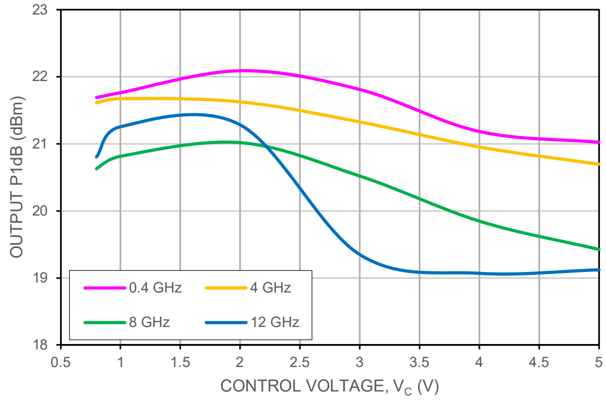


OUTPUT RETURN LOSS vs. FREQUENCY
V_{DD} = +6V, P_{IN} = -25 dBm, TEMPERATURE = +25°C

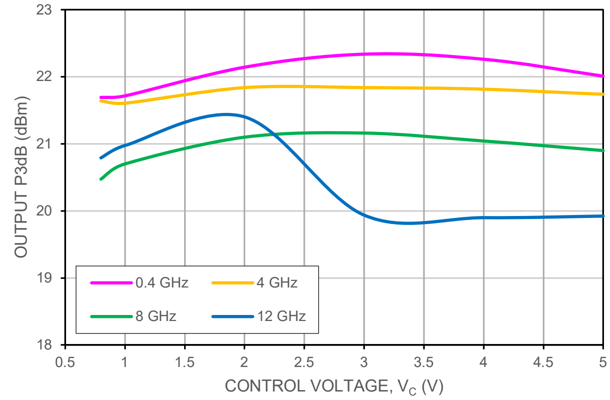


TYPICAL PERFORMANCE GRAPHS

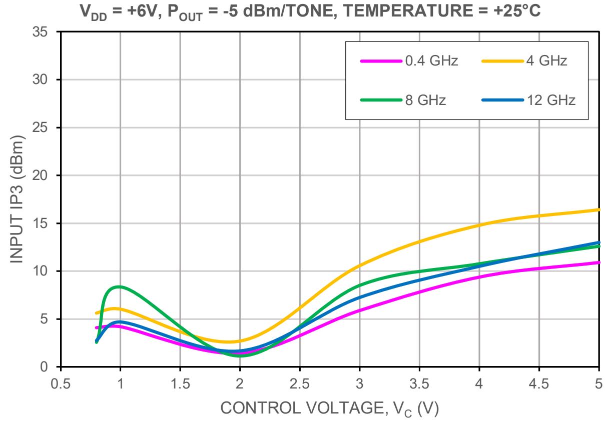
OUTPUT P1dB vs. FREQUENCY
V_{DD} = +6V, TEMPERATURE = +25°C



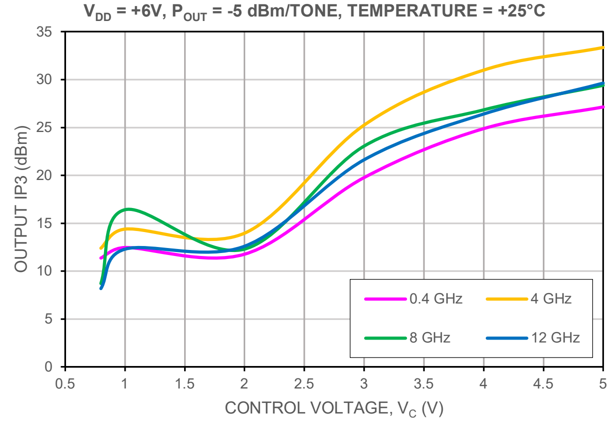
OUTPUT P3dB vs. FREQUENCY
V_{DD} = +6V, TEMPERATURE = +25°C



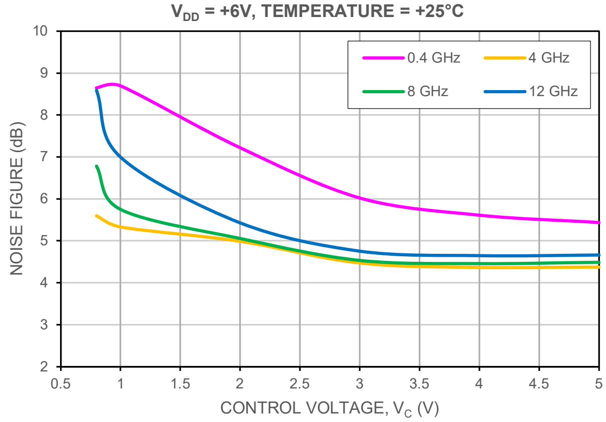
INPUT IP3 vs. FREQUENCY
V_{DD} = +6V, P_{OUT} = -5 dBm/TONE, TEMPERATURE = +25°C



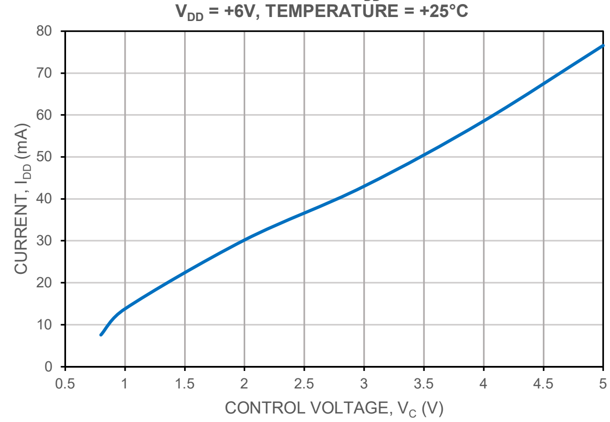
OUTPUT IP3 vs. FREQUENCY
V_{DD} = +6V, P_{OUT} = -5 dBm/TONE, TEMPERATURE = +25°C



NOISE FIGURE vs. FREQUENCY
V_{DD} = +6V, TEMPERATURE = +25°C

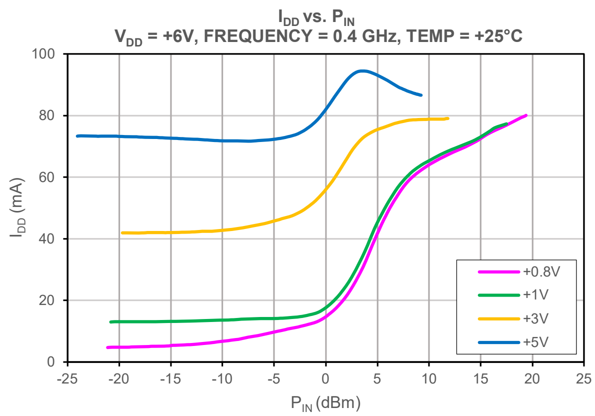


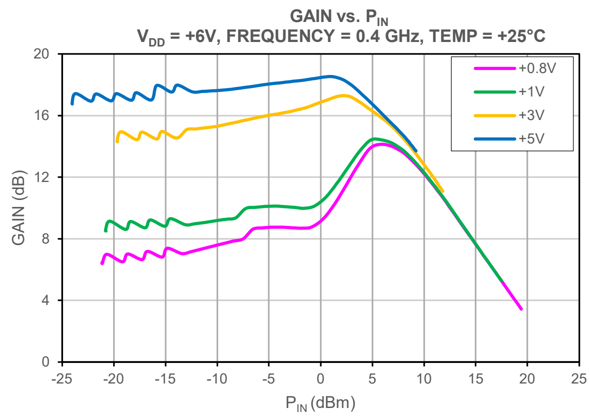
CURRENT, I_{DD}
V_{DD} = +6V, TEMPERATURE = +25°C

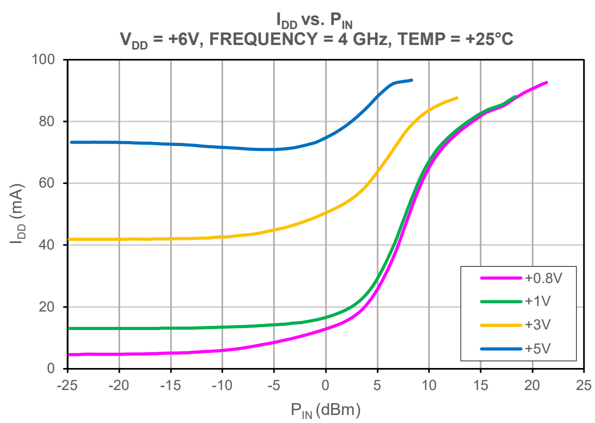


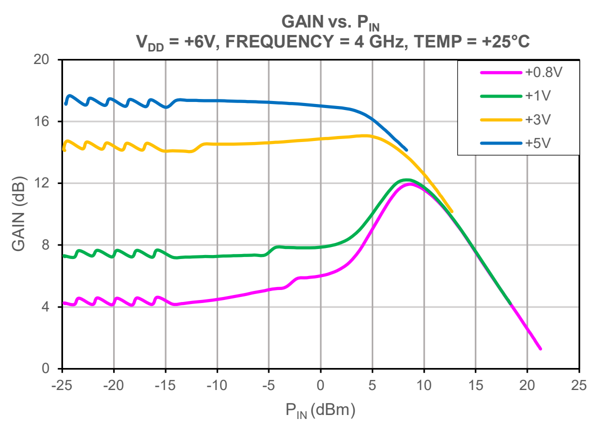
TYPICAL PERFORMANCE GRAPHS

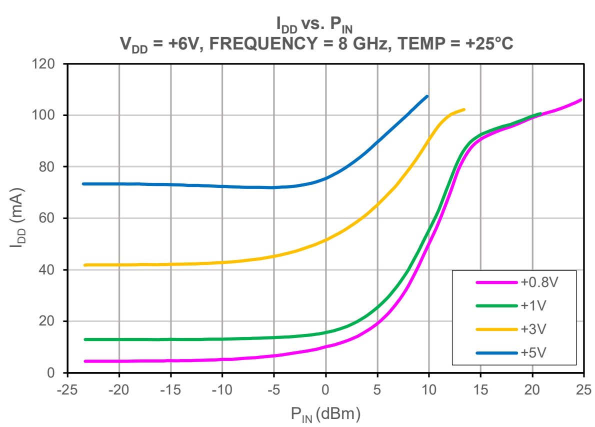
Note: All data on this page represents the Die attached in a 3x3mm 12-Lead QFN style package and measured on Mini-Circuits Characterization Test Board TB-PVGA-123C+.

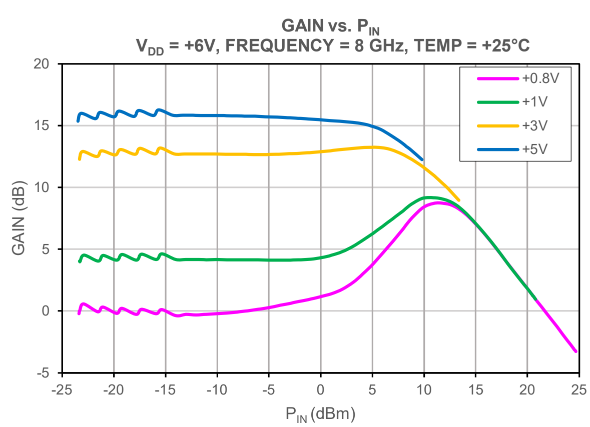






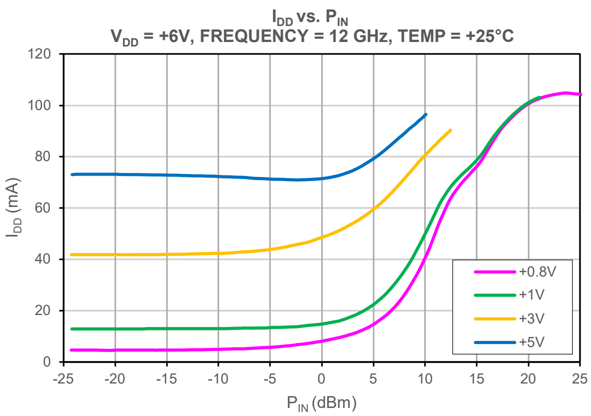


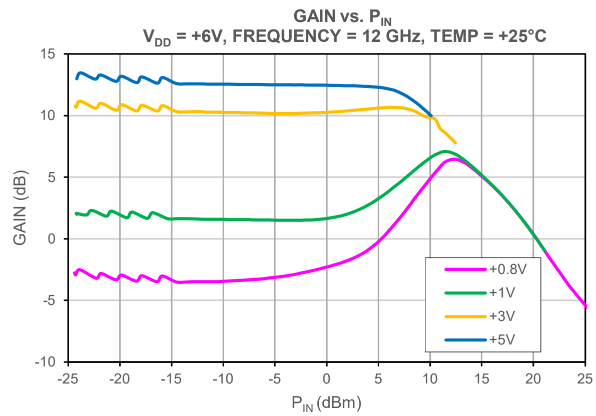




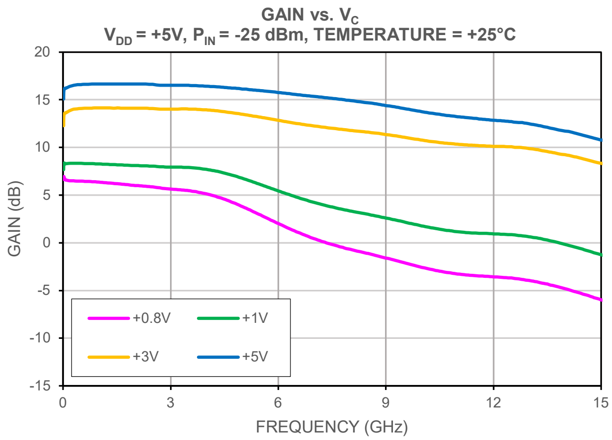
TYPICAL PERFORMANCE GRAPHS

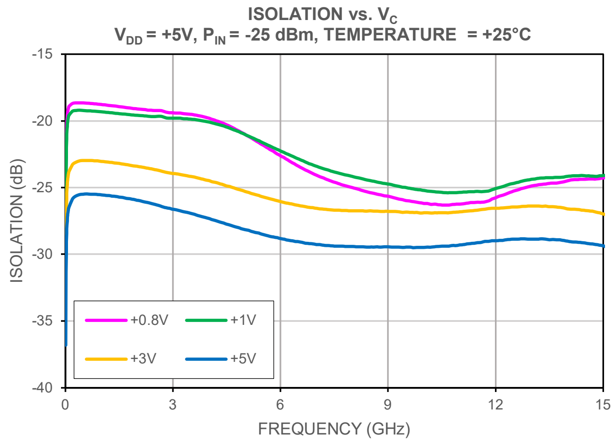
Note: All data on this page represents the Die attached in a 3x3mm 12-Lead QFN style package and measured on Mini-Circuits Characterization Test Board TB-PVGA-123C+.

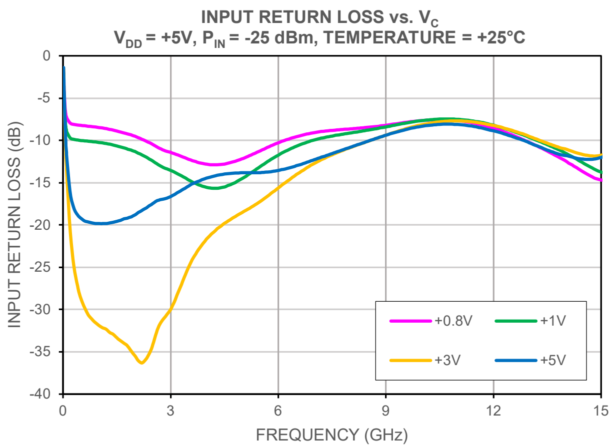


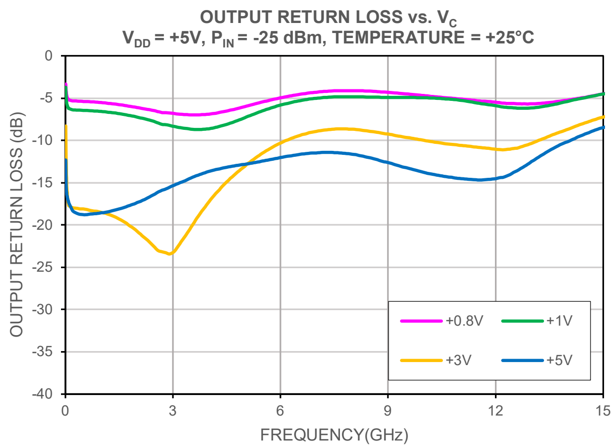


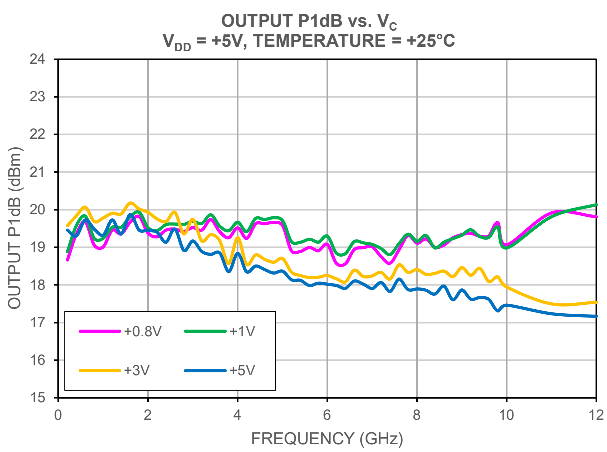
TYPICAL PERFORMANCE GRAPHS

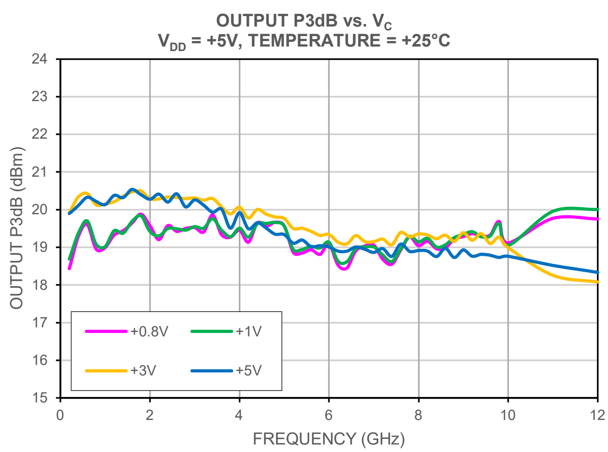




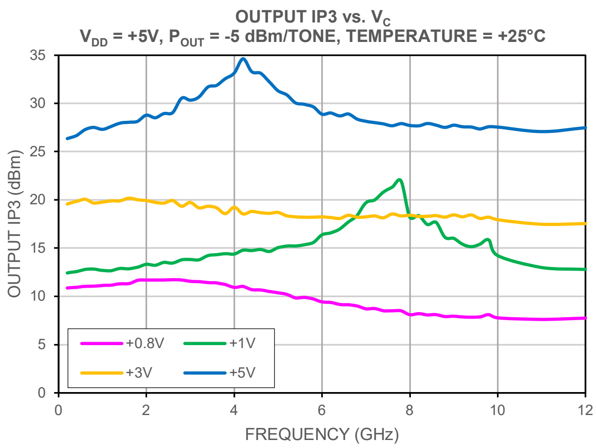


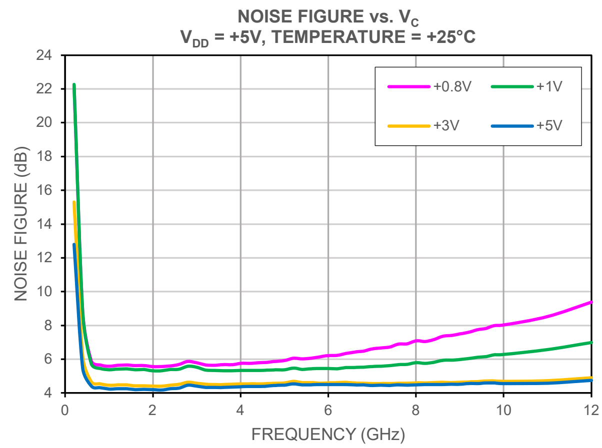


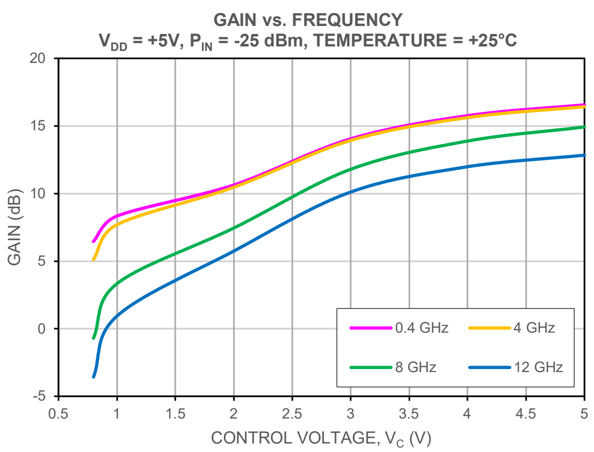


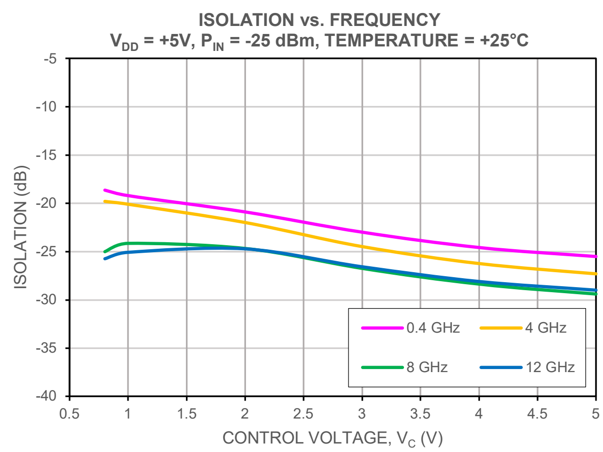


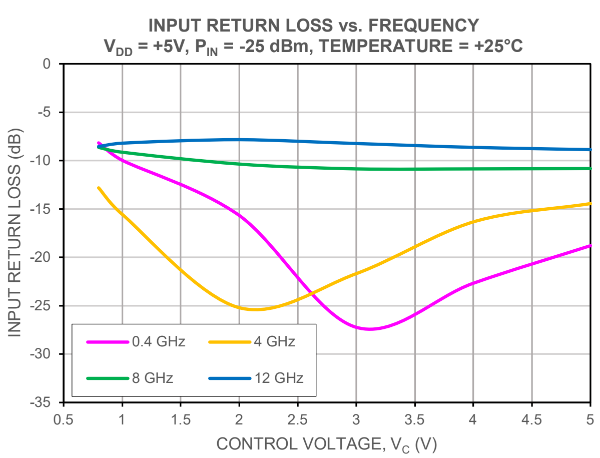
TYPICAL PERFORMANCE GRAPHS

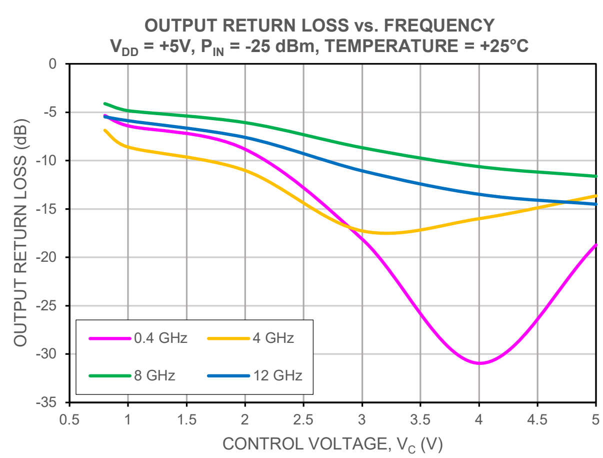




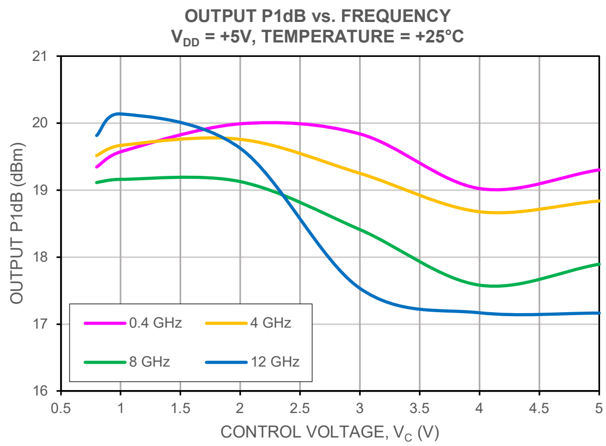


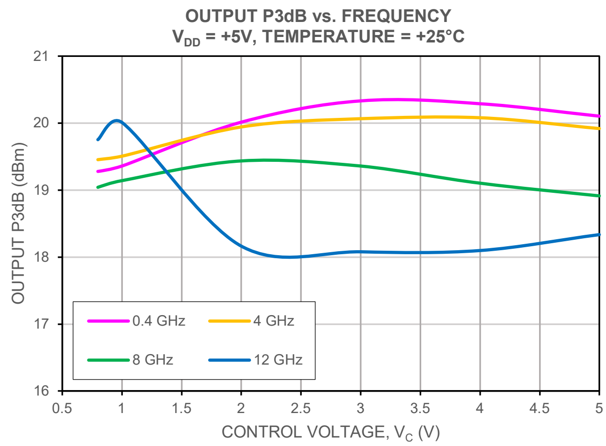


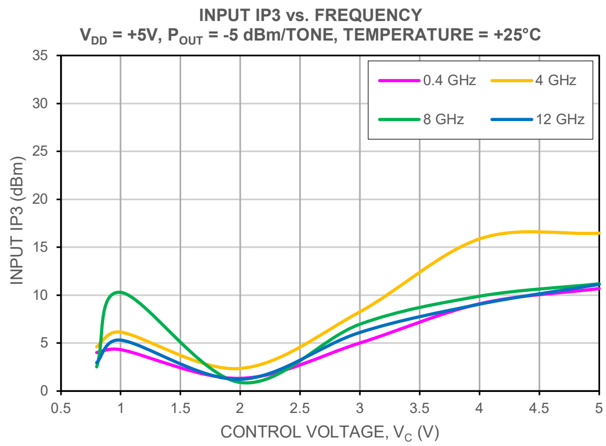


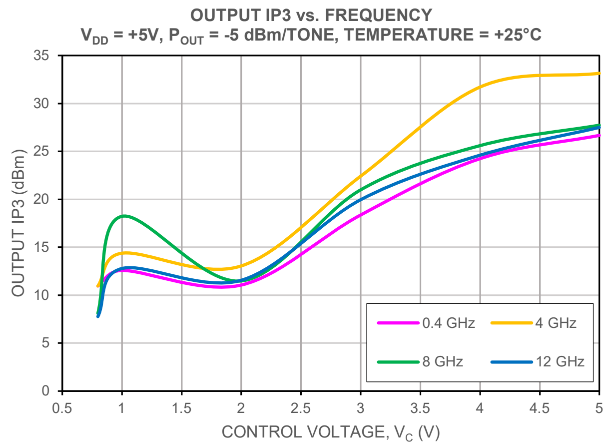


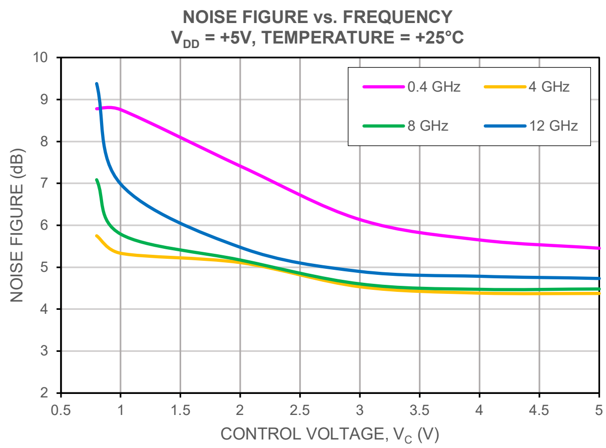
TYPICAL PERFORMANCE GRAPHS

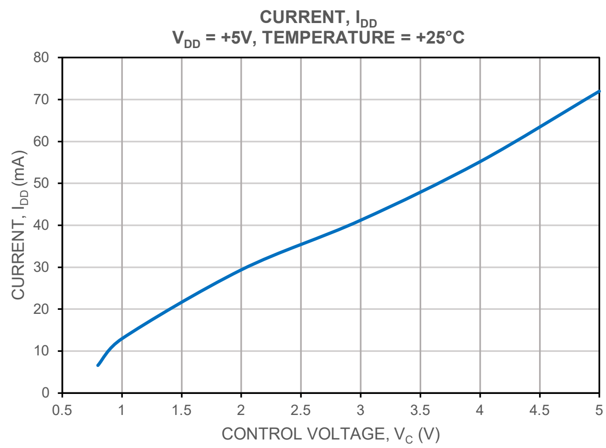






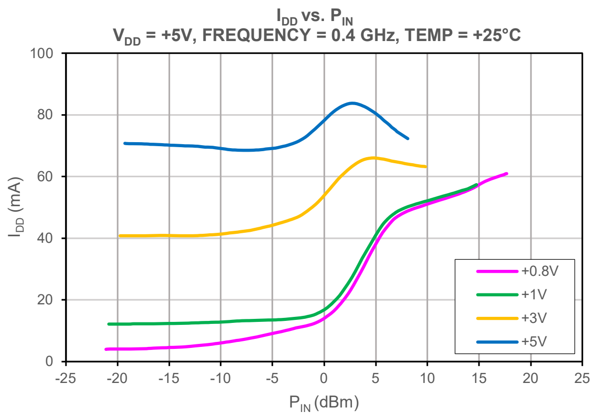


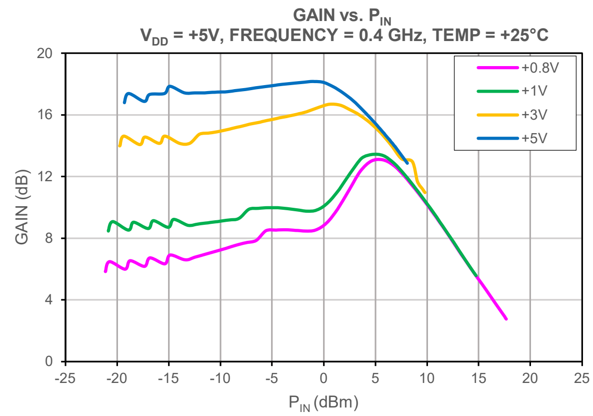


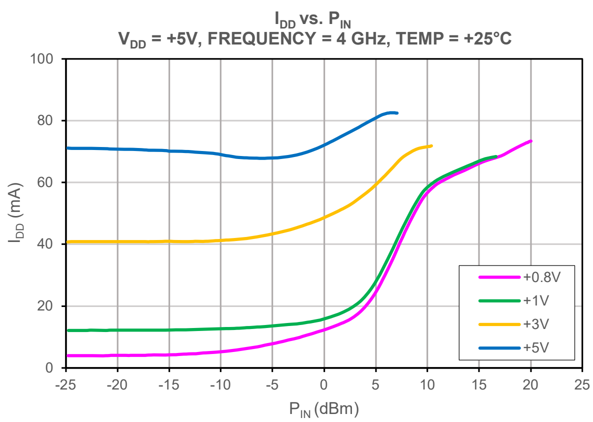


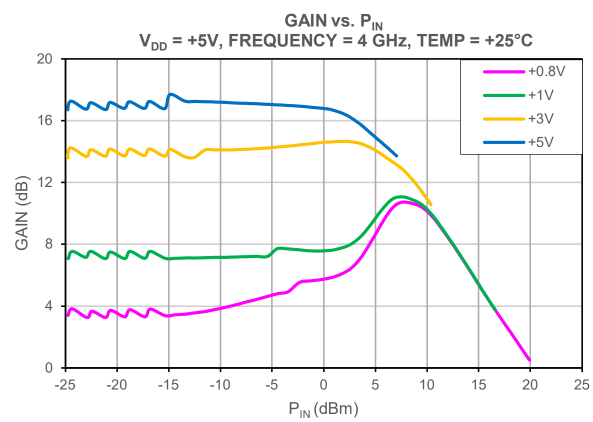
TYPICAL PERFORMANCE GRAPHS

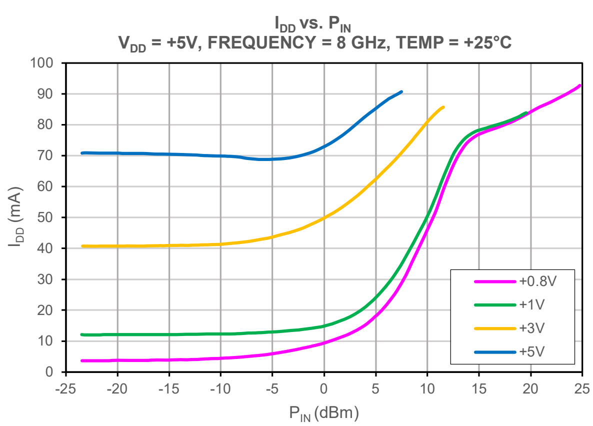
Note: All data on this page represents the Die attached in a 3x3mm 12-Lead QFN style package and measured on Mini-Circuits Characterization Test Board TB-PVGA-123C+.

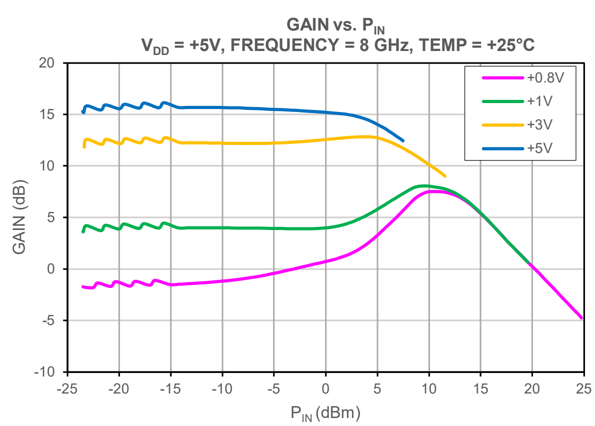






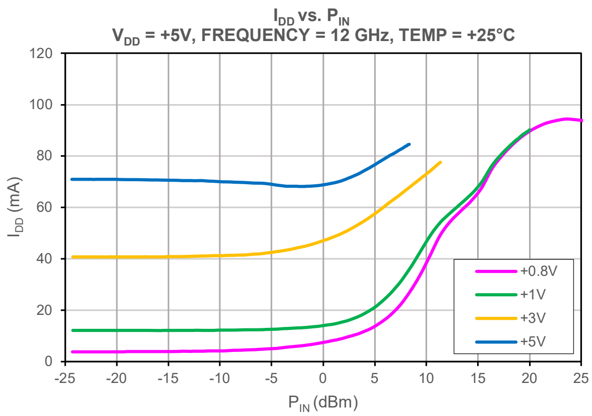


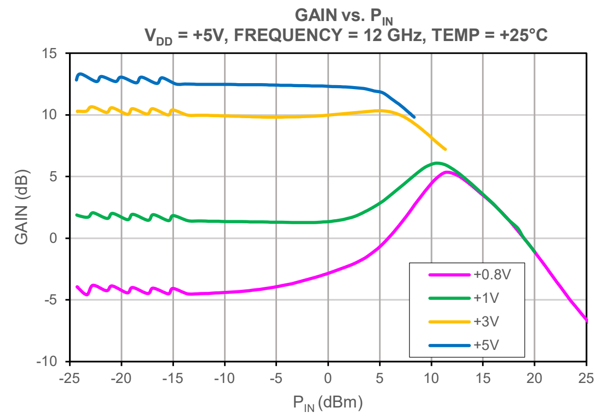




TYPICAL PERFORMANCE GRAPHS

Note: All data on this page represents the Die attached in a 3x3mm 12-Lead QFN style package and measured on Mini-Circuits Characterization Test Board TB-PVGA-123C+.





ABSOLUTE MAXIMUM RATINGS[10]

Parameter	Ratings
Operating Temperature	-45°C to +85°C
Storage Temperature[11]	+20°C to +35°C
Junction Temperature[12]	+175°C
Total Power Dissipation	1.5 W
RF Input Power (CW), V_{DD} = +6V, V_C = +5V	+23 dBm
DC Voltage at V_{DD} Pad	+10.5V
DC Voltage at V_C Pad	+10.5V

10. Permanent damage may occur if these limits are exceeded.
11. For die shipped in Gel-Pak see ENV-80 (limited by packaging).
12. Peak temperature on top of Die.

THERMAL RESISTANCE

Parameter	Ratings
Thermal Resistance (Θ_{jc})[13]	53.2 °C/W

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

ESD RATING[14]

	Class	Voltage Range	Reference Standard
HBM	1A	250 to <500V	ANSI/ESDA/JEDEC JS-001-2017
CDM	C3	250 to <500V	JESD22-C101F

ESD HANDLING PRECAUTION: This device is designed to be Class 1A 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

14. Tested in 3x3mm 12-lead QFN-Style Package

FUNCTIONAL DIAGRAM

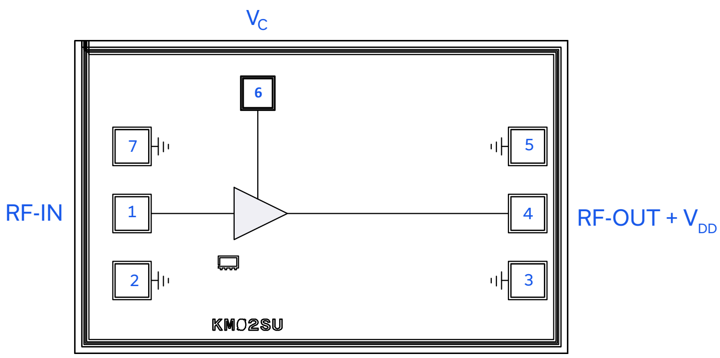


Figure 1. PVGA-123-D+ Functional Diagram

PAD DESCRIPTION

Function	Pad #	Application Description (Refer to Figure 1)
RF-IN	1	RF-IN Pad connects to RF-Input port.
RF-OUT + V_{DD}	4	RF-OUT + DC Pad connects to RF-Output and DC port.
V_C	6	DC Input Pad connects to control voltage input port V_C.
GND	2, 3, 5, 7	Connects to ground.

DIE OUTLINE: inches [mm], Typical

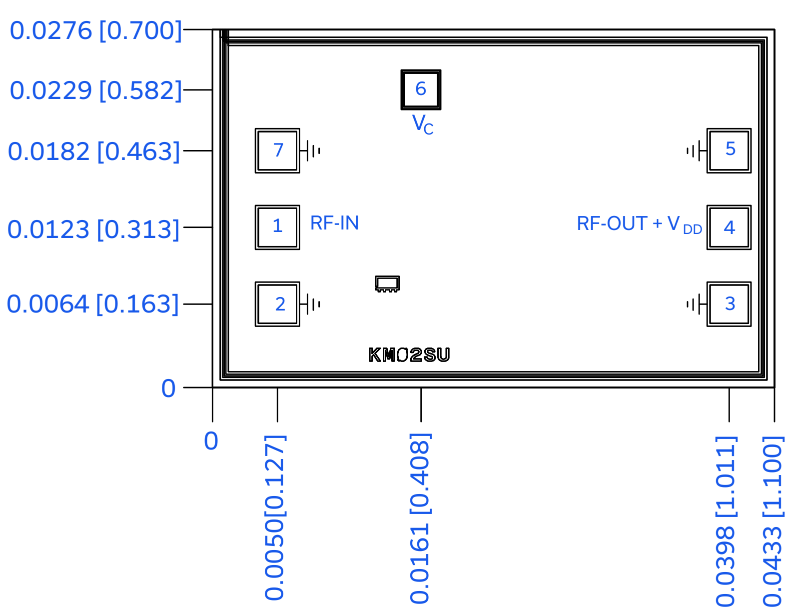


Figure 2. PVGA-123-D+ Die Outline

DIMENSIONS: inches [mm], Typical

Die Size	0.0433 x 0.0276 [1.100 x 0.700]
Die Thickness	0.0040 [0.100]
Bond Pad Sizes:	
Pad 6	0.0026 x 0.0026 [0.065 x 0.065]
Pads 1, 2, 3, 4, 5, & 7	0.0030 x0.0030 [0.075 x 0.075]
Plating (Pads & Bottom of Die)	Gold

CHARACTERIZATION AND APPLICATION CIRCUIT

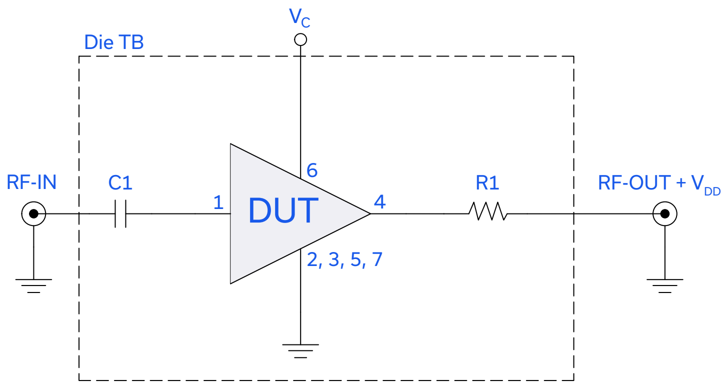


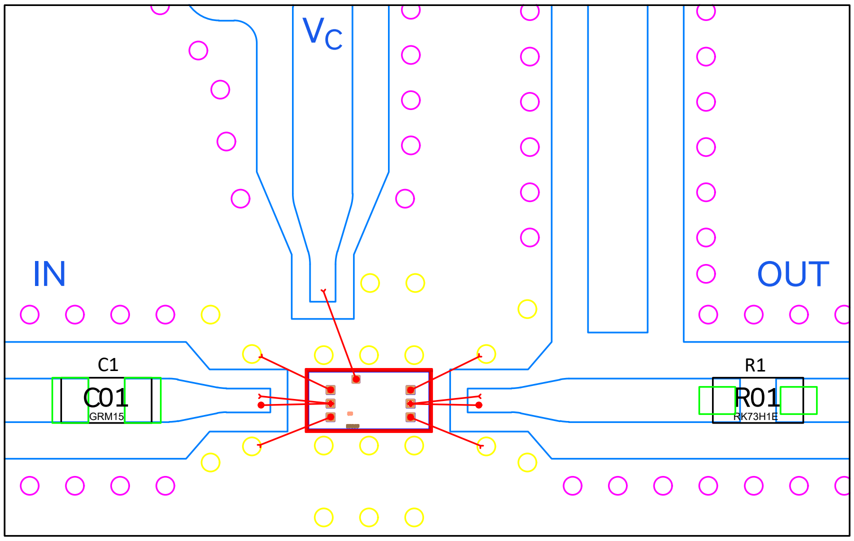
Figure 3. DUT attached to Mini-Circuits die Characterization Test Board.

Electrical Parameters and Conditions
Gain, Return Loss, Output Power at 1dB Compression (P1dB), Output IP3 (OIP3) and Noise Figure measured using N5245A PNA-X microwave network analyzer.

Conditions:
1. Gain and Return loss: P_{IN}= -25 dBm
2. Output IP3 (OIP3): Two tones, spaced 1 MHz apart, -5 dBm/tone at output.

Component	Value	Size	Part Number	Manufacturer
C1	100pF	0402	GRM1555C1H101JA01J	Murata
R1	0 Ω	0402	RK73Z1ETTP	KOA Speer

ASSEMBLY DIAGRAM



Note:
C1 : 100pF Capacitor
R1 : 0 Ohm Resistor

Figure 4. PVGA-123-D+ Assembly Diagram.

Refer to the table in Figure 3 for more details on the passive components.

- Bond wire diameter: 1 mil
- Bond wire lengths from Die Pad to PCB at RF-IN & RF-OUT ports: 30 ± 2 mils
- Typical Gap from Die edge to PCB edge: 3 mils
- PCB thickness and material: 10 mil RO4350B (Thickness : 1 oz copper on each side).

ASSEMBLY AND HANDLING PROCEDURE

1. Storage
   Die should be stored in a dry nitrogen purged desiccator or equivalent.
2. ESD Precautions
   MMIC pHEMT amplifier die are susceptible to electrostatic and mechanical damage. Die are supplied in anti-static protected material, which should be opened only in clean room conditions at an appropriately grounded anti-static workstation.
3. Die Handling and Attachment
   Devices require careful handling using tools appropriate for manipulating semiconductor chips. It is recommended to handle the chips along the edges with a custom designed collet. The surface of the chips have exposed air bridges and should not be touched with a vacuum collet, tweezers or fingers.
   The die mounting surface must be clean and flat. Using conductive silver-filled epoxy, apply sufficient adhesive to meet the required bond line thickness, fillet height and coverage around the total periphery of the device. The recommended epoxy is Ablestik 84-1 LMISR4 or equivalent. Parts should be cured in a nitrogen-filled atmosphere per manufacturer's recommended cure profile.
4. Wire Bonding
   Openings in the surface passivation above the gold bond pads are provided to allow wire bonding to the die. Thermosonic bonding is recommended with minimized ultrasonic content. Bond force, time, ultrasonic power and temperature are all critical parameters. The suggested interconnect is pure gold, 1 mil diameter wire. Bonds are recommended to be made from the bond pads on the die to the package or substrate. All bond wire length and bond wire height should be kept as short as possible, unless specified by design, to minimize performance degradation due to undesirable series inductance.

Variable Gain Amplifier PVGA-123-D+

50Ω 0.4 to 12 GHz

ADDITIONAL DETAILED INFORMATION IS AVAILABLE ON OUR DASH BOARD CLICK HERE

Performance Data	Table Graphs S-Parameter (S2P Files) Data Set (.zip file)	
Case Style	Die	
RoHs Status	Compliant	
Die Ordering and Packaging Information	Quantity, Package	Model No.
	Gel-Pak: 5, 10, 50, 100 KGD*	PVGA-123-DG+
	Medium†, Partial wafer: KGD*<1692	PVGA-123-DP+
	Full wafer†	PVGA-123-DF+
	†Available upon request contact sales representative. Refer to AN-60-067	
Die Marking	KM02SU	
Environmental Ratings	ENV-80	

* Known Good Die ("KGD") means that the die in question have been subjected to Mini-Circuits DC test performance criteria and measurement instructions and that the parametric data of such die fall within a predefined range. While DC testing is not definitive, it does provide a higher degree of confidence that die are capable of meeting typical RF electrical parameters specified by Mini-Circuits.