MMIC DIE

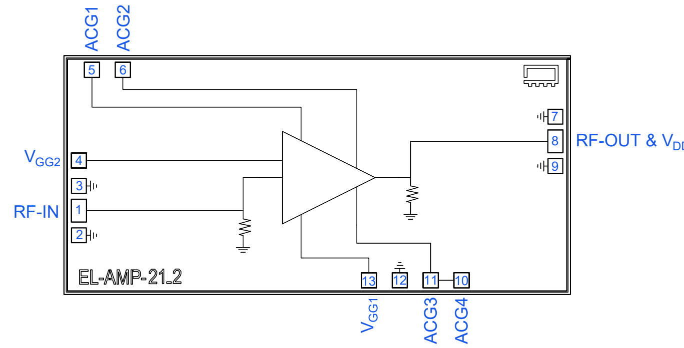
Medium Power Amplifier AVA-223MP-D+

50Ω 100 kHz to 22 GHz Wideband Amplifier

THE BIG DEAL

- Wide Bandwidth 100 kHz to 22 GHz
- High Saturated Output Power, Typ. +27.7 dBm
- High OIP3, Typ. +37.9 dBm
- Low Noise Figure, Typ. 3.1 dB
- Positive Gain Slope from 4 to 22 GHz

FUNCTIONAL DIAGRAM



SEE ORDERING INFORMATION ON THE LAST PAGE

APPLICATIONS

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

PRODUCT OVERVIEW

Mini-Circuits' AVA-223MP-D+ is a wideband, high dynamic range, MMIC amplifier fabricated on a GaAs pHEMT process with high output power and broadband gain. Operating from 100 kHz to 22 GHz, this amplifier features typical +25.9 dBm P1dB, +27.7 dBm P_{SAT}, 3.1 dB NF, and +37.9 dBm OIP3. This device is matched to 50Ω and measures only 3.28 x 1.55 mm.

KEY FEATURES

Features	Advantages
Wide Bandwidth: 100 kHz to 22 GHz	Supports a variety of broadband and narrowband applications without the need to reconfigure circuitry.
High Dynamic Range - Noise Figure: 3.1 dB - Output IP3: +37.9 dBm - Output P1dB: +25.9 dBm	Low noise figure, high IP3 and high P1dB make this ideal for use in high dynamic range receivers.
Positive Gain Slope from 4 to 22 GHz	Positive gain slope acts as equalization to counteract loss from other components in the signal chain as frequency increases.
Unpackaged Die	Suitable for chip and wire hybrid assemblies.

Mini-Circuits
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ELECTRICAL SPECIFICATIONS[1] AT +25°C, V_{DD} = +10 V, V_{GG2} = +3.5 V, AND Z_O = 50Ω UNLESS NOTED OTHERWISE

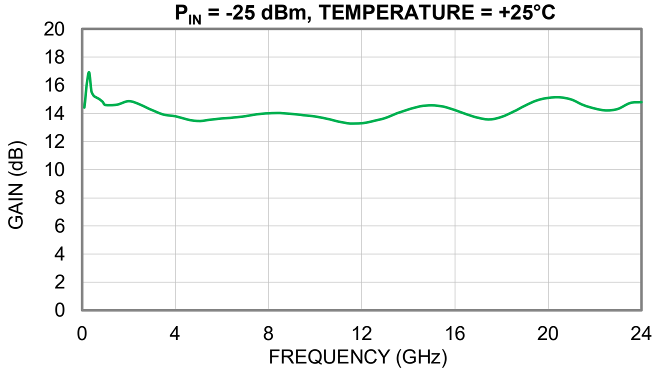
Parameter	Condition (GHz)	Min.	Typ.	Max.	Units
Frequency Range		0.0001		22	GHz
Gain	0.1[2]		16.1		dB
	5		13.4		
	10		13.7		
	15		14.5		
	22		14.5		
Input Return Loss	0.1[2]		20		dB
	5		18		
	10		17		
	15		19		
	22		14		
Output Return Loss	0.1[2]		20		dB
	5		19		
	10		17		
	15		20		
	22		12		
Isolation	0.1-22		41.4		dB
Output Power at 1 dB Compression (P1dB)	0.1[2]		+26.2		dBm
	5		+27.0		
	10		+25.9		
	15		+25.4		
	22		+23.2		
Output Power at Saturation (P_{SAT})[3]	0.1[2]		+27.1		dBm
	5		+29.6		
	10		+27.7		
	15		+28.4		
	22		+25.4		
Output Third-Order Intercept (OIP3) (P_{OUT} = +16 dBm/Tone)	0.1[2]		+38.4		dBm
	5		+41.0		
	10		+37.9		
	15		+37.5		
	22		+30.1		
Noise Figure	0.1		5.3		dB
	5		3.2		
	10		3.1		
	15		3.2		
	22		4.4		
Device Operating Voltage (V_{DD})		+9	+10	+11	V
Gate Voltage (V_{GG1})		-2.0	-0.8	-0.6	V
Gate Voltage (V_{GG2})[4]		+3.25	+3.5	+3.75	V
Device Operating Current (I_{DD})[5]		250	300		mA
Gate Current (I_{GG1})			0.2		mA
Gate Current (I_{GG2})			1.4		mA
Device Current Variation vs. Temperature[6]			-157.7		µA/°C
Device Current Variation vs. Voltage[7]			+0.8		µA/mV

1. Tested on Mini-Circuits Die Characterization Test Board. See Figure 3. Loss de-embedded to the RF input and output wire bonds of the device.
2. Tested on AVA-223MP-D+ Modified Die Application Circuit. See Figure 4. Loss de-embedded to the RF input and output wire bonds of the device.
3. Defined as output power at which change is 0.1 per 1 dB change in input power.
4. V_{GG2} should be set to +3.5 V for optimal performance. It is not recommended to operate V_{GG2} outside of the specified range.
5. Current at P_{IN} = -25 dBm. Increases to 380 mA at P_{SAT}.
6. (Current at +85°C - Current at -45°C)/(+85°C - -45°C)
7. (Current at +11 V - Current at +9 V)/(+11 V - +9 V)

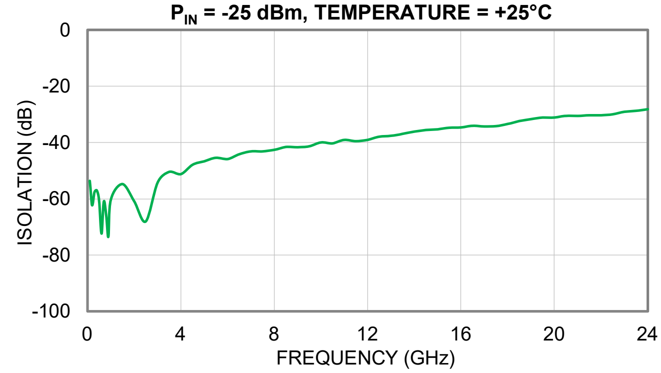
TYPICAL PERFORMANCE GRAPHS

Note: Data was taken at V_{DD} = +10 V and V_{GG2} = +3.5 V. At +25°C, V_{GG1} has been adjusted to achieve I_{DD} = 300 mA. For over voltage and temperature data, see AVA-223MP+.

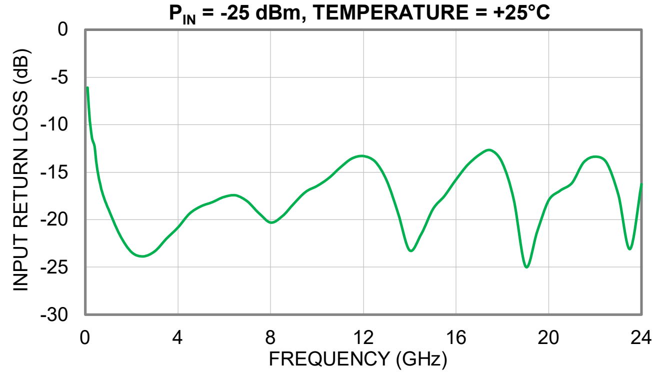
GAIN vs. FREQUENCY
P_{IN} = -25 dBm, TEMPERATURE = +25°C



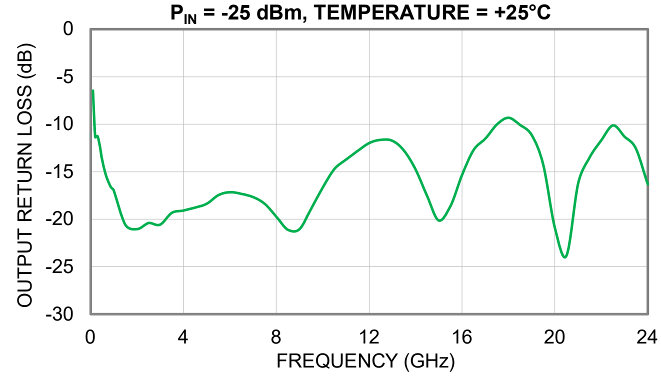
ISOLATION vs. FREQUENCY
P_{IN} = -25 dBm, TEMPERATURE = +25°C



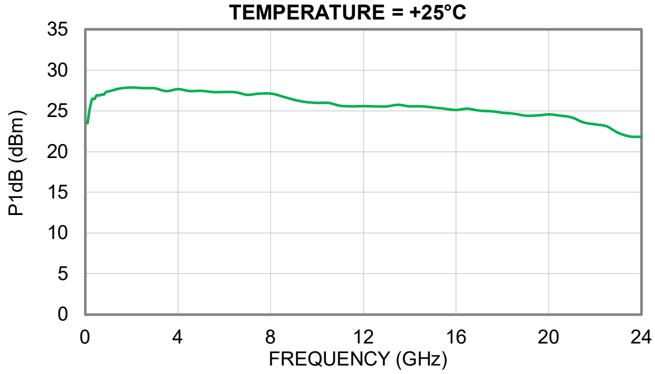
INPUT RETURN LOSS vs. FREQUENCY
P_{IN} = -25 dBm, TEMPERATURE = +25°C



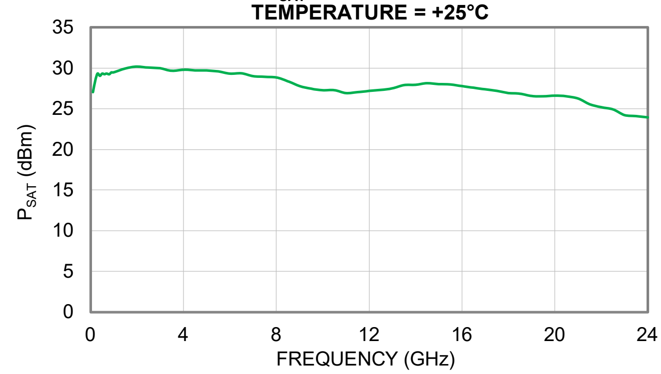
OUTPUT RETURN LOSS vs. FREQUENCY
P_{IN} = -25 dBm, TEMPERATURE = +25°C



P1dB vs. FREQUENCY
TEMPERATURE = +25°C

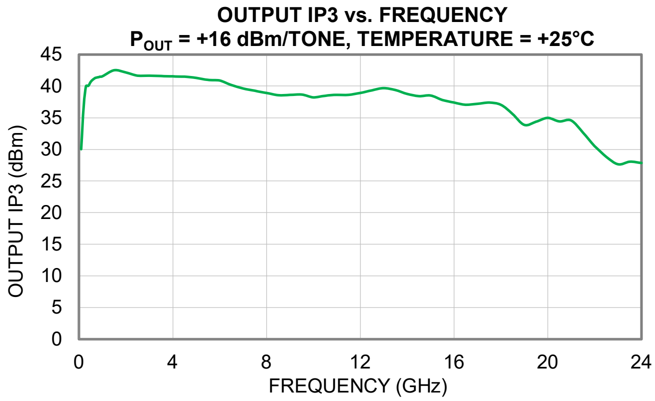


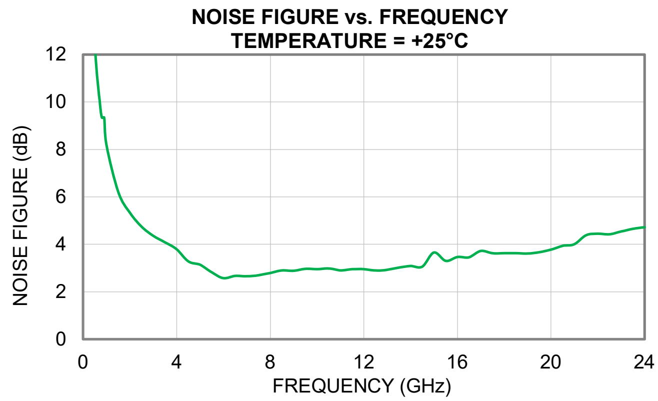
P_{SAT} vs. FREQUENCY
TEMPERATURE = +25°C



TYPICAL PERFORMANCE GRAPHS

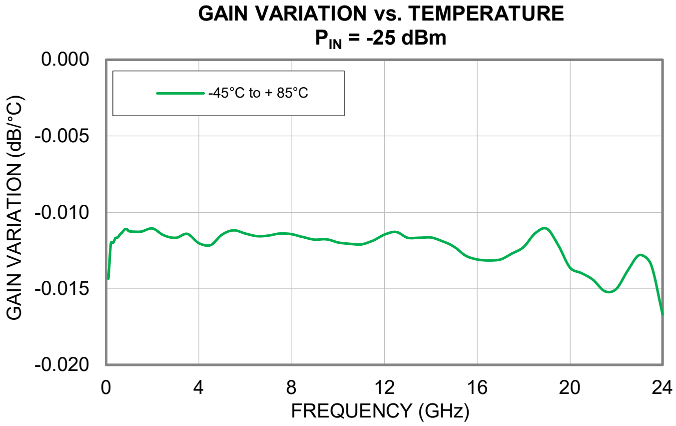
Note: Data was taken at V_{DD} = +10 V and V_{GG2} = +3.5 V. At +25°C, V_{GG1} has been adjusted to achieve I_{DD} = 300 mA. For over voltage and temperature data, see AVA-223MP+.

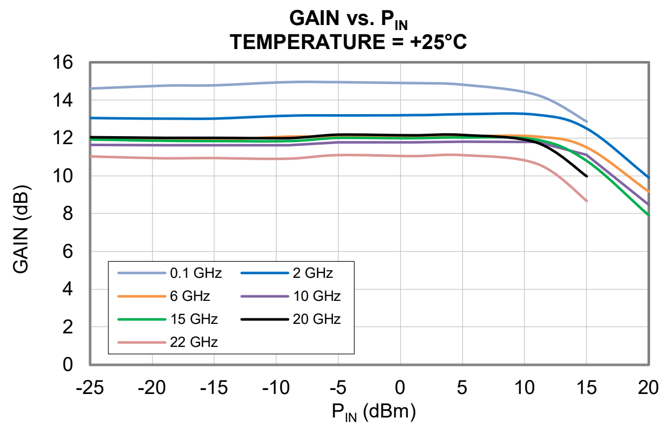


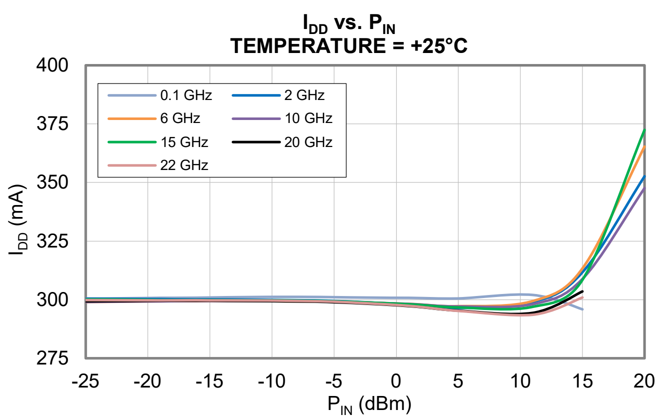


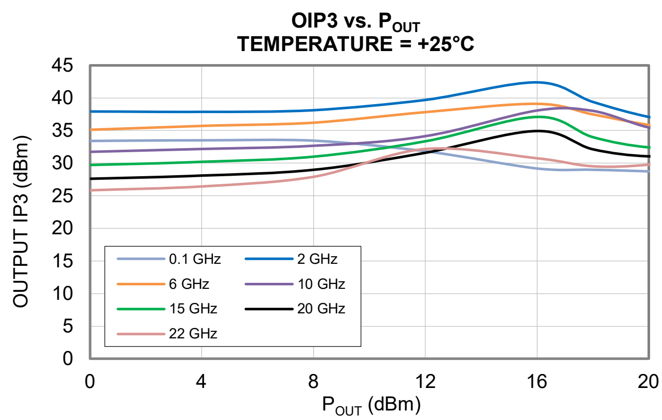
TYPICAL PERFORMANCE GRAPHS

Note: All data taken in this section represents the Die attached in a 5x5mm 32-Lead QFN-style package and measured on Mini-Circuits Characterization Test Board TB-AVA-223MPC+. Data was taken at V_{DD} = +10 V and V_{GG2} = +3.5 V. At +25°C, V_{GG1} has been adjusted to achieve I_{DD} = 300 mA.





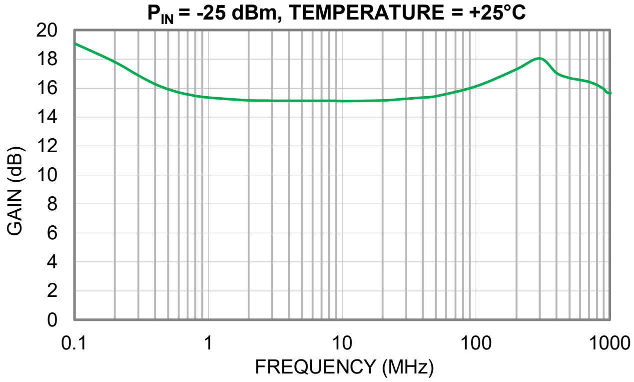




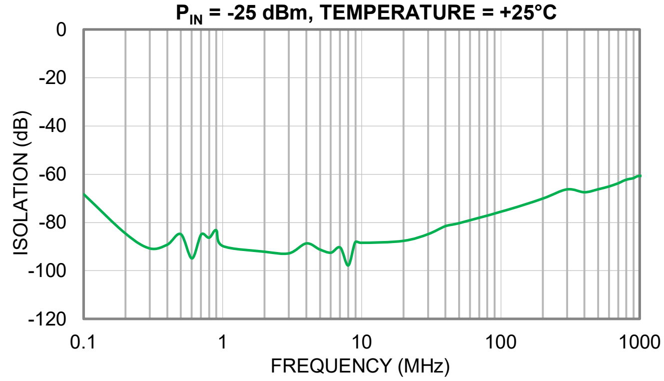
TYPICAL PERFORMANCE GRAPHS

Note: All data taken in this section represents the die measured on modified Mini-Circuits Die Characterization Test Board using external bias tee (Figure 4). Data was taken at V_{DD} = +10 V and V_{GG2} = +3.5 V. At +25°C, V_{GG1} has been adjusted to achieve I_{DD} = 300 mA.

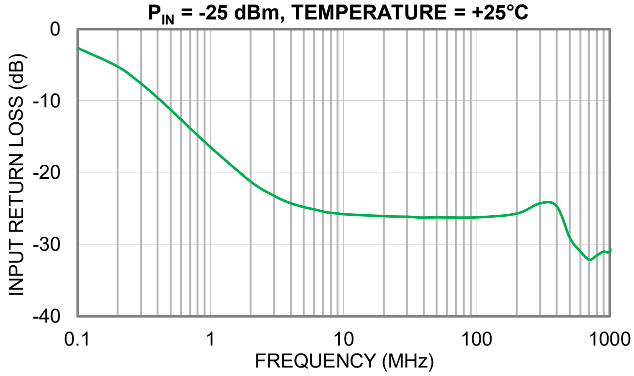
GAIN vs. FREQUENCY
P_{IN} = -25 dBm, TEMPERATURE = +25°C



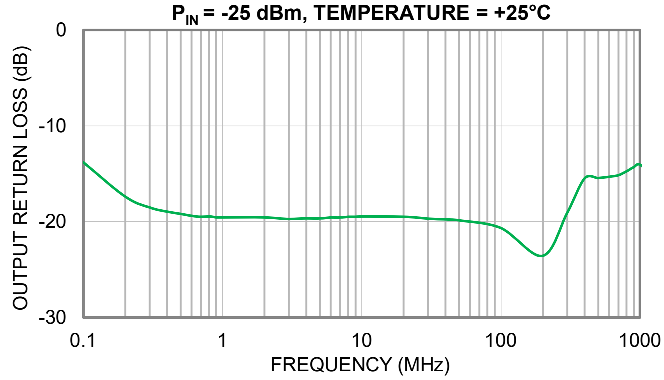
ISOLATION vs. FREQUENCY
P_{IN} = -25 dBm, TEMPERATURE = +25°C



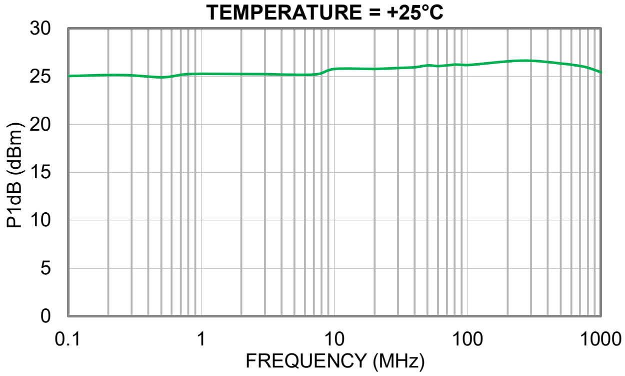
INPUT RETURN LOSS vs. FREQUENCY
P_{IN} = -25 dBm, TEMPERATURE = +25°C



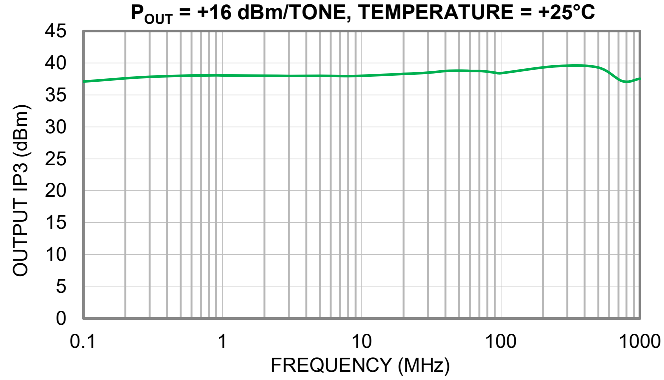
OUTPUT RETURN LOSS vs. FREQUENCY
P_{IN} = -25 dBm, TEMPERATURE = +25°C



P1dB vs. FREQUENCY
TEMPERATURE = +25°C



OUTPUT IP3 vs. FREQUENCY
P_{OUT} = +16 dBm/TONE, TEMPERATURE = +25°C



ABSOLUTE MAXIMUM RATINGS[8]

Parameter	Ratings
Operating Temperature[9]	-45°C to +85°C
Storage Temperature[10]	-65°C to +150°C
Total Power Dissipation	6.38 W
Junction Temperature[11]	+175°C
Input Power (CW), V_{DD} = +10 V	+22 dBm
DC Voltage on RF-OUT & V_{DD}	+14 V
DC Voltage on RF-IN	+6 V
DC Gate Voltage on V_{GG1}	-3 V < V_{GG1} < 0 V
DC Gate Voltage on V_{GG2}	+5 V
DC Drain Current I_{DD}	500 mA
DC Gate Current I_{GG1}	1 mA
DC Gate Current I_{GG2}	10 mA

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

THERMAL RESISTANCE

Parameter	Ratings
Thermal Resistance (Θ_{JC})[12]	14.1°C/W

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

ESD RATING[13]

	Class	Voltage Range	Reference Standard
HBM	1B	500 V < 1000 V	ANSI/ESDA/JEDEC JS-001-2023
CDM	C3	> 1000 V	ANSI/ESDA/JEDEC JS-002-2022

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

13. ESD measured in 5x5 mm 32-Lead QFN-style package.

FUNCTIONAL DIAGRAM

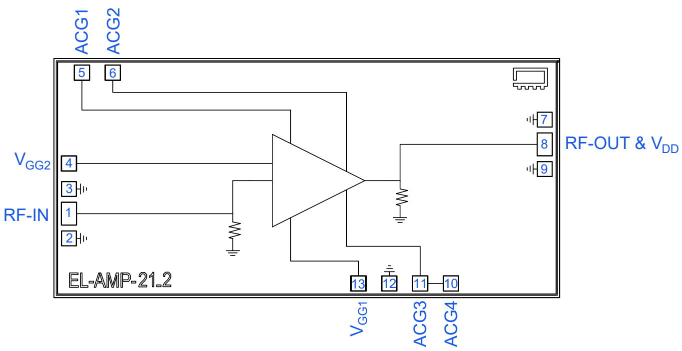


Figure 1. AVA-223MP-D+ Functional Diagram

PAD DESCRIPTION

Function	Pad Number	Description (Refer to Fig 3)
RF-IN	1	RF-IN pad connects to RF Input port.
RF-OUT & V_{DD}	8	RF-OUT & V_{DD} pad connects to RF-Output port and voltage input port, V_{DD}.
V_{GG1}	13	DC Input pad connects to voltage input port, V_{GG1}.
V_{GG2}	4	DC Input pad connects to voltage input port, V_{GG2}.
ACG1	5	ACG1 pad connects to AC ground port 1.
ACG2	6	ACG2 pad connects to AC ground port 2.
ACG3	11	ACG3 pad connects to AC ground port 3. ACG3 pad connected to ACG4 on die.
ACG4	10	ACG4 pad connects to AC ground port 4. ACG4 pad connected to ACG3 on die.
GND	2, 3, 7, 9, 12, & Bottom of Die	Connected to die backside through vias. Bond wires to ground are optional.

DIE OUTLINE: inches [mm], Typical

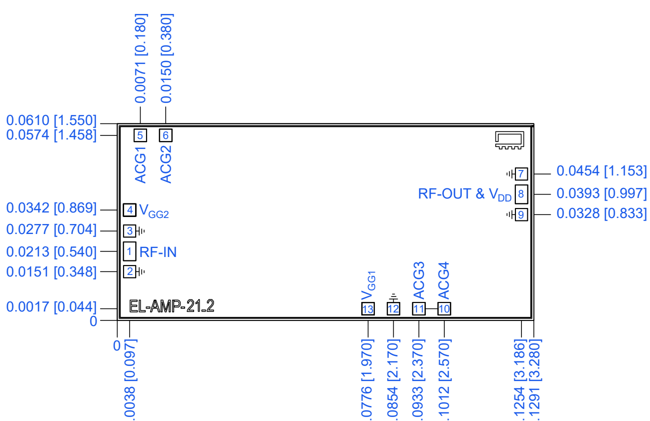


Figure 2. AVA-223MP-D+ Die Outline

DIMENSIONS: inches [mm], Typical

Die Size	0.1291 x 0.0610 [3.280 x 1.550]
Die Thickness	0.0040 [0.100]
Bond Pad Sizes:	
Pads 1, 8	0.0039 x 0.0059 [0.100 x 0.150]
Pads 2-7, 9-13	0.0039 x 0.0039 [0.100 x 0.100]
Plating (Pads & Bottom of Die)	Gold

EVALUATION BOARD

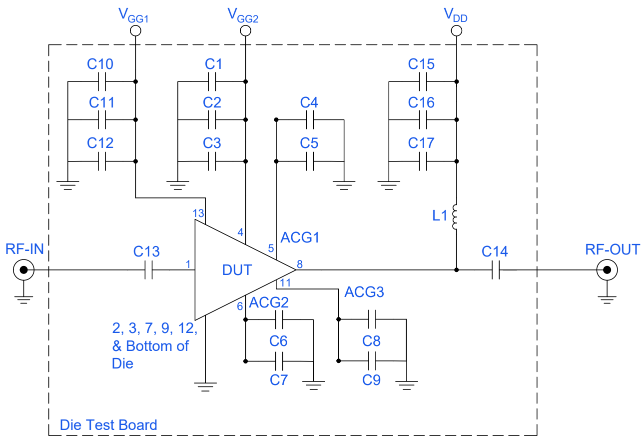


Figure 3. AVA-223MP-D+ Evaluation and Application Circuit

Electrical Parameters and Conditions
Gain, Return Loss, Output Power at 1 dB Compression (P1dB), Output Power at Saturation (P_{SAT}), Output IP3 (OIP3), and Noise Figure measured using N5245B 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, +16 dBm/Tone at output.

Note: ACG3 and ACG4 are connected internally and can be bonded to interchangeably as needed.

Power ON/Power OFF Sequence[14]
Caution: Permanent damage to the device will occur if the Power ON and Power OFF sequences are not followed.

POWER ON:
1) Set V_{GG1} = -2 V. Apply V_{GG1}.
2) Set V_{GG2} = +3.5 V. Apply V_{GG2}.
3) Set V_{DD} = +10 V. Apply V_{DD}.
4) Increase V_{GG1} to obtain the desired I_{DD} as shown in specification table.
5) Apply RF Signal.

POWER OFF:
1) Turn off RF Signal.
2) Adjust V_{GG1} to -2 V.
3) Turn off V_{DD}.
4) Turn off V_{GG2}.
5) Turn off V_{GG1}.

14. V_{GG2} may be derived from V_{DD} using a resistive divider, zener diode, or equivalent circuit. If V_{GG2} is derived from V_{DD}, it may be applied simultaneously with V_{DD}.

Component	Value	Size	Part Number	Manufacturer
C5, C6, C8, C12	100 pF	0.022 x 0.022 in	MA4M3100	MACOM
C3, C17	100 pF	0603	GRM1885C1H101GA01D	Murata
C2, C4, C9, C11, C16	0.01 µF	0402	GRM155R71E103KA01D	Murata
C13, C14	30 pF	0201	P21BN300M5S	DLI
C1, C7, C10, C15	4.7 µF	1812	C4532X7S2A475K230KB	TDK Corp
L1	0.22 µH	0.2 x 0.15 in	CCM19T40-002	Piconics

EVALUATION AND APPLICATION CIRCUIT

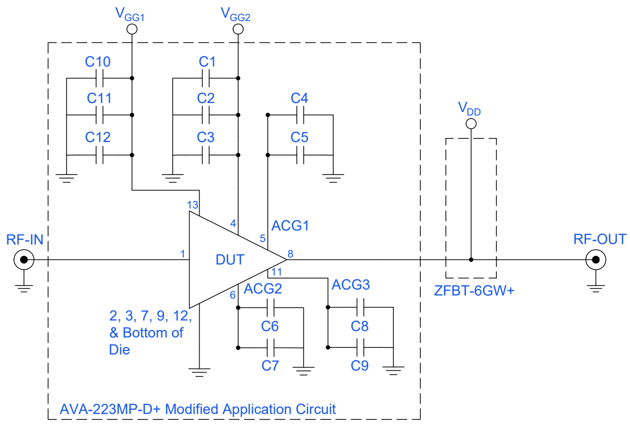


Figure 4. AVA-223MP-D+ Low Frequency Evaluation and Application Circuit

Electrical Parameters and Conditions
Gain and Return Loss measured using P5022A Vector Network Analyzer.

Output Power at 1 dB Compression (P1dB) measured using Mini-Circuits' PWR-4GHS Power Sensor.

Output IP3 (OIP3) measured using MXA N9020A Signal Analyzer.

Conditions:
1. Gain and Return Loss: P_{IN} = -25 dBm
2. Output IP3 (OIP3): Two tones, spaced 1 MHz apart, +16 dBm/tone at output.

Component	Value	Size	Part Number	Manufacturer
C5, C6, C8, C12	100 pF	0.022 x 0.022 in	MA4M3100	MACOM
C3	100 pF	0603	GRM1885C1H101GA01D	Murata
C2, C4, C9, C11	0.01 µF	0402	GRM155R71E103KA01D	Murata
C1, C7, C10	4.7 µF	1812	C4532X7S2A475K230KB	TDK Corp

ASSEMBLY DIAGRAM

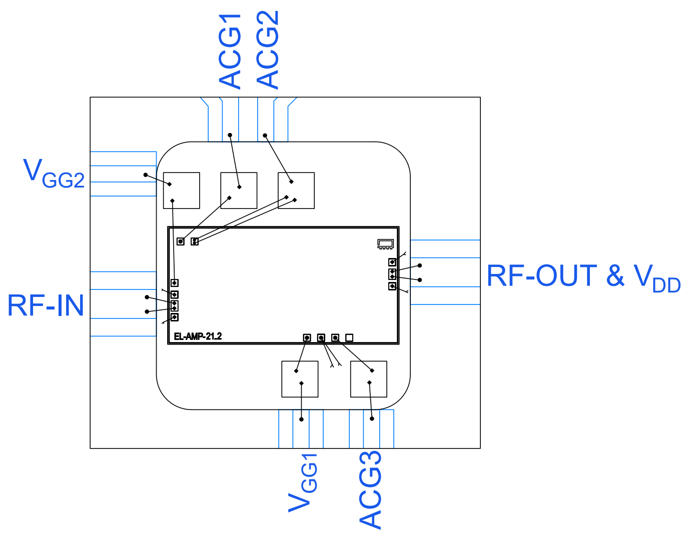


Figure 5. AVA-223MP-D+ Assembly Diagram

- Bond wire diameter: 1 mil
- Bond wire lengths from die pad to PCB at RF-IN & RF-OUT & V_{DD}: 20 mils ± 2 mils
- Bond wire lengths from die pad to capacitor near V_{GG1}: 22 mils ± 2 mils
- Bond wire lengths from die pad to capacitor near V_{GG2}: 48 mils ± 2 mils
- Bond wire lengths from die pad to capacitor near ACG1: 35 mils ± 2 mils
- Bond wire lengths from die pad to capacitor near ACG2: 52 mils ± 2 mils
- Bond wire lengths from die pad to capacitor near ACG3: 22 mils ± 2 mils
- Typical gap from die edge to PCB edge: 3 mils
- PCB thickness and material: 8 mils Rogers 4003 (Thickness: 1 oz copper on each side). Die is mounted in a cut-out of the PCB, directly onto the brass baseplate using high thermal conductivity silver-sintering epoxy.

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 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 ATROX Sintering 800HT5 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.

ADDITIONAL DETAILED INFORMATION IS AVAILABLE ON OUR DASHBOARD CLICK HERE

Performance Data & Graphs	Data Graphs S-Parameter (S2P Files) Data Set (.zip file)	
Case Style	Die	
RoHS Status	Compliant	
Die Ordering and Packaging Information	Quantity, Package	Model No.
	Gel - Pak: 5, 10, or 50 KGD*	AVA-223MP-DG+
	Medium†, Partial wafer: KGD*<464	AVA-223MP-DP+
	Full wafer†	AVA-223MP-DF+
	†Available upon request contact sales representative. Refer to AN-60-067	
Die Marking	EL-AMP-21_2	
Environmental Ratings	ENV80	

* 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 high degree of confidence that die are capable of meeting typical RF electrical parameters specified by Mini-Circuits.