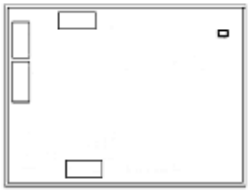
Ultra High Dynamic Range

Monolithic Amplifier Die

PHA-101-D+

50Ω 0.05 to 1.5 GHz



The Big Deal

- Ultra High IP3
- Broadband High Dynamic Range without external Matching Components

Product Overview

PHA-101-D+ (RoHS compliant) is an advanced wideband amplifier die fabricated using E-PHEMT technology and offers extremely high dynamic range over a broad frequency and with low noise figure. In addition, the PHA-101-D+ has good input and output return loss over a broad frequency range without the need for external matching components. Moreover, the PHA-101-D+ has demonstrated excellent reliability and has low thermal resistance.

Key Features

Feature	Advantages
Broad Band: 0.05 to 1.5 GHz	Broadband covering primary wireless communications bands: Cellular, PCS, LTE
Extremely High IP3 Versus DC power Consumption 45 dBm typical at 0.9 GHz	The PHA-101-D+ matches industry leading IP3 performance relative to device size and power consumption. The combination of the design and E-PHEMT Structure provides enhanced linearity over a broad frequency range as evidence in the IP3 being typically 20 dB above the P 1dB point. This feature makes this amplifier ideal for use in: • Driver amplifiers for complex waveform up converter paths • Drivers in linearized transmit systems • Secondary amplifiers in ultra High Dynamic range receivers
No External Matching Components Required	Mini-Circuits PHA-101-D+ provides Input and Output Return Loss of 9.9-12.5 dB up to 1.5 GHz without the need for any external matching components
Unpackaged die	Enables the user to integrate the amplifier directly into hybrids.

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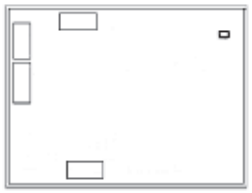
PHA-101-D+

50Ω 0.05 to 1.5 GHz



Product Features

- High IP3, 45 dBm typ. at 0.9 GHz
- Gain, 15.2 dB typ. at 0.9 GHz
- High Pout, P1dB 26 dBm typ. at 0.9 GHz
- Low noise figure, 4.0 dB at 0.9 GHz
- No external matching components required

+RoHS Compliant

The +Suffix identifies RoHS Compliance. See our web site for RoHS Compliance methodologies and qualifications

Ordering Information: Refer to Last Page

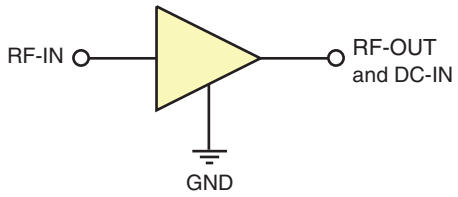
Typical Applications

- Base station infrastructure
- CATV
- LTE

General Description

PHA-101-D+ (RoHS compliant) is an advanced wideband amplifier fabricated using E-PHEMT technology and offers extremely high dynamic range over a broad frequency range and with low noise figure. In addition, the PHA-101-D+ has good input and output return loss over a broad frequency range without the need for external matching components and has low thermal resistance.

Simplified Schematic and Pad description



Pad	Description
RF IN	RF input pad. This pad requires the use of an external DC blocking capacitor chosen for the frequency of operation.
RF-OUT and DC-IN	RF output and bias pad. DC voltage is present on this pad; therefore a DC blocking capacitor is necessary for proper operation. An RF choke is needed to feed DC bias without loss of RF signal due to the bias connection.
GND	Connections to ground. Bottom of die.

Note: 1. Bond Pad material - Gold
2. Bottom of Die - Gold plated

Electrical Specifications[1] at 25°C, 50 ohms, unless noted

Parameter	Condition (MHz)	Vd=9V[1]			Units
		Min.	Typ.	Max.	
Frequency range		0.05		1.5	GHz
Gain	50		15.3		dB
	450		15.5		
	900		15.2		
	1500		15.0		
Input return loss	50		10.7		dB
	450		11.4		
	900		10.7		
	1500		9.5		
Output return loss	50		13.2		dB
	450		10.7		
	900		10.2		
	1500		8.9		
Reverse isolation			20.5		dB
Output power @1dB compression	50		25.3		dBm
	450		26.2		
	900		25.8		
	1500		25.4		
Output IP3[2]	50		47.0		dBm
	450		44.3		
	900		45.0		
	1500		43.8		
Noise figure	50		4.1		dB
	450		3.9		
	900		4.0		
	1500		4.2		
Device operating voltage			9.0		V
Device operating current			182	220	mA
Device current variation vs. temperature[3]			-4		µA/°C
Device current variation vs voltage			0.024		mA/mV
Thermal Resistance, junction-to-ground lead at 85°C stage temperature			20		°C/W

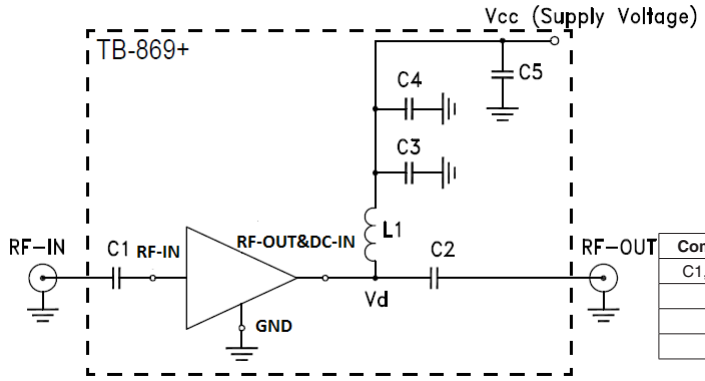
1. Measured on Mini-Circuits Characterization test board. Die packaged in SOT-89 Package and soldered on TB-869+.
2. Tested at Pout=8dBm / tone.
3. (Current at 85°C — Current at -45°C)/130

Absolute Maximum Ratings[4]

Parameter	Ratings
Operating Temperature (ground lead)	-40°C to 85°C
Operating Current at 9V	360 mA
Power Dissipation	3.25 W
Input Power (CW)	+24 dBm (5 minutes max.) +20 dBm (continuous)
DC Voltage at RF-OUT & DC-IN Pad	11 V

4. Permanent damage may occur if any of these limits are exceeded.
Electrical maximum ratings are not intended for continuous normal operation.

Characterization Test Circuit



Component	Value	Size	Part Number	Manufacturer
C1, C2, C3	150 pF	0603	GRM1885C1H151JA01D	Murata
C4	0.01 µF	0603	GRM188R71H103KA01D	Murata
C5	10 µF	1206	GRM31CR61H106KA12L	Murata
L1	390 nH	0505	0805CS-391XJEC	Coilcraft

Fig 1. Block Diagram of Test Circuit used for characterization. Die packaged in SOT-89 Package and soldered on TB-869+. Gain, Return loss, Output power at 1dB compression (P1 dB) , output IP3 (OIP3) and Noise figure measured using Agilent's N5242A PNA-X microwave network analyzer.

Conditions:
1. Gain and Return loss: Pin= -25dBm
2. Output IP3 (OIP3): Two tones, spaced 1 MHz apart, 8 dBm/tone at output.

Die Layout

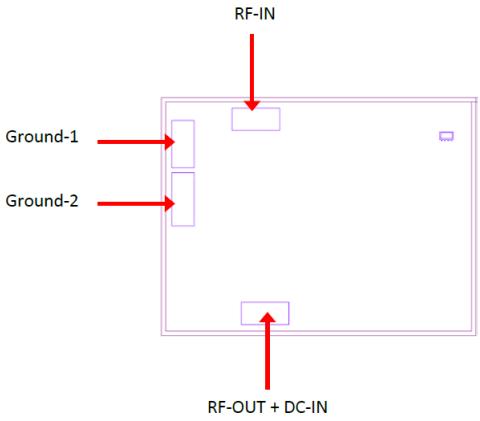


Fig 2. Die Layout

Bonding Pad Position

(Dimensions in µm, Typical)

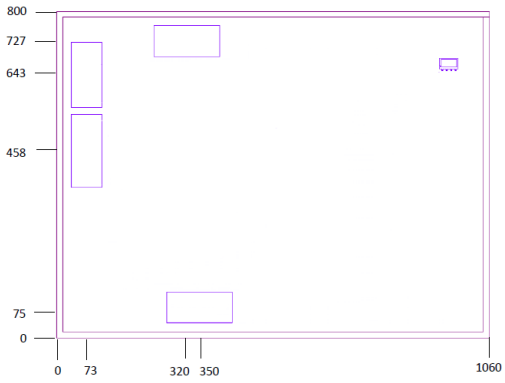


Fig 3. Bonding Pad Positions

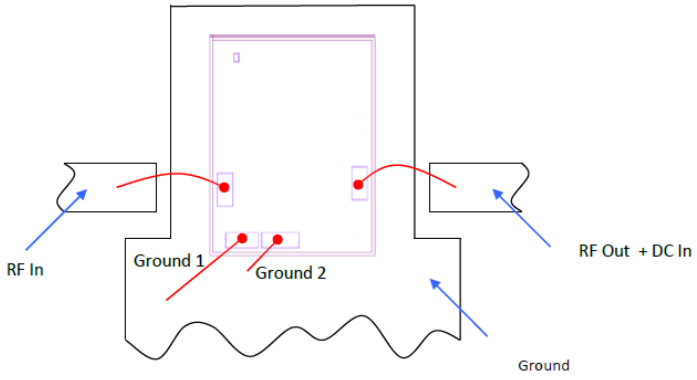
Critical Dimensions

Parameter	Values
Die Thickness, µm	100
Die Width, µm	1060
Die Length, µm	800
Bond Pad Size, µm	75 x 150

Assembly and Handling Procedure

1. Storage
   Dice should be stored in a dry nitrogen purged desiccators or equivalent.
2. ESD
   MMIC E-PHEMT amplifier dice are susceptible to electrostatic and mechanical damage. Die are supplied in antistatic protected material, which should be opened in clean room conditions at an appropriately grounded anti-static workstation. Devices need careful handling using correctly designed collets, vacuum pickup tips or sharp antistatic tweezers to deter ESD damage to dice.
3. Die Attach
   The die mounting surface must be clean and flat. Using conductive silver filled epoxy, recommended epoxies are DieMat DM6030HK-PT/H579 or Ablestik 84-1LMISR4. Apply sufficient epoxy to meet required epoxy bond line thickness, epoxy fillet height and epoxy coverage around total die periphery. Parts shall be cured in a nitrogen filled atmosphere per manufacturer's cure condition. It is recommended to use antistatic die pick up tools only.
4. Wire Bonding
   Bond pad openings in the surface passivation above the bond pads are provided to allow wire bonding to the dice gold bond pads. Thermosonic bonding is used with minimized ultrasonic content. Bond force, time, ultrasonic power and temperature are all critical parameters. Suggested wire is pure gold, 1 mil diameter. Bonds must be made from the bond pads on the die to the package or substrate. All bond wires should be kept as short as low as reasonable to minimize performance degradation due to undesirable series inductance.

Assembly Diagram



Recommended Wire Length, Typical

Wire	Wire Length (mm)	Wire Loop Height (mm)
RF In	1.90	0.50
RF-Out + DC In	1.65	0.50
Ground 1	1.15	0.50
Ground 2	0.35	0.15

Additional Detailed Technical Information

additional information is available on our dash board.

Performance Data	Data Table	
	Swept Graphs	
	S-Parameter (S2P Files) Data Set with and without port extension(.zip file)	
Case Style	Die	
Die Ordering and packaging information	Quantity, Package	Model No.
	Small, Gel - Pak: 5,10,50,100 KGD*	PHA-101-DG+
	Medium†, Partial wafer: KGD*<1625	PHA-101-DP+
	Large†, Full Wafer	PHA-101-DF+
	†*Available upon request contact sales representative*	
	Refer to AN-60-067	
Environmental Ratings	ENV80	

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

ESD Rating**

Human Body Model (HBM): Class 1A (250 to <500V) in accordance with ANSI/ESD STM 5.1 - 2001

** Tested in industry standard SOT-89 package.

Additional Notes

A. Performance and quality attributes and conditions not expressly stated in this specification document are intended to be excluded and do not form a part of this specification document.

B. Electrical specifications and performance data contained in this specification document are based on Mini-Circuit's applicable established test performance criteria and measurement instructions.

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MMIC Amplifier Die PHA-101+

Typical Performance Data

NOTE: Use PDF Bookmarks to view DATA at required conditions

Definitions:
Input Return Loss = -S11 (dB)
Gain(Power Gain) = S21 (dB)
Reverse Isolation = -S12 (dB)
Output Return Loss = -S22 (dB)

TEST CONDITIONS: Vd = 9V, Id = 190.68 mA @ Temperature = +25degC

FREQ	Gain	Isolation	Input Return Loss	Output Return Loss	Stability		IP-3 Output	1dB Comp. Output	Noise Figure
(MHz)	(dB)	(dB)	(dB)	(dB)	K	Measure	(dBm)	(dBm)	(dB)
50	15.27	20.39	11.33	14.18	1.13	0.67	48.57	25.93	4.12
100	15.49	20.63	12.58	12.60	1.14	0.63	45.82	26.49	4.04
150	15.51	20.74	12.56	12.06	1.14	0.63	45.50	26.41	3.98
200	15.52	20.77	12.55	11.88	1.14	0.62	45.27	26.63	3.89
250	15.51	20.81	12.52	11.78	1.14	0.62	44.99	26.48	4.01
300	15.50	20.85	12.47	11.71	1.15	0.63	44.46	26.66	4.04
350	15.48	20.82	12.45	11.63	1.14	0.62	43.54	26.67	4.10
400	15.46	20.84	12.39	11.58	1.15	0.63	43.35	26.45	4.08
450	15.44	20.84	12.33	11.52	1.15	0.63	42.92	26.55	4.08
500	15.42	20.87	12.26	11.43	1.15	0.63	42.77	26.47	4.12
550	15.40	20.91	12.17	11.36	1.15	0.63	42.68	26.58	4.09
600	15.38	20.89	12.16	11.31	1.15	0.63	42.55	26.39	4.10
650	15.36	20.89	12.04	11.25	1.15	0.63	42.78	26.40	4.09
700	15.33	20.93	12.00	11.22	1.16	0.63	43.22	26.53	4.10
750	15.32	20.92	11.90	11.12	1.16	0.63	43.07	26.57	4.05
800	15.30	20.97	11.81	11.02	1.16	0.64	43.31	26.55	4.03
850	15.28	20.99	11.74	10.96	1.16	0.64	43.68	26.64	4.02
1000	15.21	21.07	11.42	10.63	1.16	0.64	44.91	26.60	4.14
1050	15.20	21.10	11.27	10.49	1.17	0.64	44.91	26.52	4.12
1100	15.18	21.14	11.20	10.39	1.17	0.64	45.25	26.57	4.12
1150	15.15	21.17	11.08	10.26	1.17	0.64	45.14	26.71	4.18
1200	15.13	21.23	10.99	10.12	1.17	0.64	46.20	26.48	4.20
1250	15.11	21.28	10.87	10.01	1.18	0.65	46.47	26.54	4.15
1300	15.08	21.36	10.74	9.83	1.18	0.65	46.16	26.23	4.20
1350	15.04	21.42	10.68	9.70	1.18	0.65	47.37	26.34	4.20
1400	15.05	21.45	10.53	9.64	1.18	0.65	46.77	26.14	4.21
1450	15.04	21.53	10.38	9.50	1.19	0.65	46.13	26.14	4.23
1500	15.02	21.54	10.28	9.37	1.19	0.65	44.94	26.19	4.20
1550	14.99	21.66	10.15	9.24	1.19	0.65	43.39	26.07	4.26
1600	14.97	21.71	10.09	9.10	1.20	0.65	43.61	25.97	4.28
1650	14.94	21.78	9.93	8.94	1.20	0.65	44.29	25.99	4.29
1700	14.90	21.89	9.83	8.81	1.21	0.66	42.39	25.70	4.23
1750	14.87	22.02	9.75	8.70	1.22	0.66	41.46	25.76	4.36
1800	14.81	22.13	9.61	8.57	1.23	0.67	41.62	25.63	4.32
1850	14.76	22.21	9.56	8.42	1.23	0.67	41.39	25.52	4.52
1900	14.70	22.38	9.39	8.28	1.25	0.67	41.32	25.48	4.44
1950	14.62	22.53	9.30	8.13	1.26	0.68	41.07	25.42	4.47
2000	14.50	22.71	9.23	8.00	1.28	0.69	40.75	25.27	4.50

Note: Test data of die packaged in industry standard SOT-89 Package

Typical Performance Data

Definitions:
Input Return Loss = -S11 (dB)
Gain(Power Gain) = S21 (dB)
Reverse Isolation = -S12 (dB)
Output Return Loss = -S22 (dB)

TEST CONDITIONS: Vd = 8.5V, Id =177.90 mA @ Temperature = +25degC

FREQ	Gain	Isolation	Input Return Loss	Output Return Loss	Stability		IP-3 Output	1dB Comp. Output	Noise Figure
(MHz)	(dB)	(dB)	(dB)	(dB)	K	Measure	(dBm)	(dBm)	(dB)
50	15.25	20.62	11.33	14.22	1.15	0.69	48.81	25.41	4.02
100	15.47	20.66	12.53	12.62	1.14	0.63	45.09	25.95	3.98
150	15.49	20.75	12.53	12.07	1.14	0.63	45.04	25.86	3.89
200	15.50	20.77	12.50	11.87	1.14	0.63	44.50	26.09	3.84
250	15.49	20.83	12.47	11.77	1.15	0.63	43.32	25.94	3.95
300	15.47	20.81	12.41	11.68	1.14	0.63	43.46	26.14	3.96
350	15.46	20.85	12.40	11.62	1.15	0.63	41.84	26.13	4.03
400	15.43	20.86	12.32	11.57	1.15	0.63	41.74	25.91	4.04
450	15.42	20.88	12.29	11.53	1.15	0.63	41.61	26.01	4.04
500	15.40	20.88	12.22	11.44	1.15	0.63	41.10	25.95	4.04
550	15.38	20.87	12.12	11.37	1.15	0.63	41.94	26.06	4.03
600	15.36	20.90	12.11	11.33	1.15	0.63	41.82	25.85	4.03
650	15.33	20.91	12.01	11.28	1.16	0.63	42.24	25.85	4.02
700	15.31	20.91	11.97	11.22	1.16	0.63	42.61	26.02	4.03
750	15.30	20.92	11.87	11.14	1.16	0.64	42.80	26.05	4.00
800	15.27	20.95	11.76	11.05	1.16	0.64	43.31	26.04	3.94
850	15.26	20.96	11.71	10.97	1.16	0.64	44.23	26.13	3.97
1000	15.19	21.06	11.38	10.65	1.17	0.64	46.07	26.05	4.09
1050	15.17	21.10	11.24	10.51	1.17	0.64	46.35	26.00	4.11
1100	15.15	21.14	11.15	10.39	1.17	0.64	47.37	26.03	4.06
1150	15.13	21.19	11.05	10.27	1.17	0.65	45.95	26.17	4.10
1200	15.10	21.24	10.95	10.13	1.18	0.65	46.58	25.94	4.11
1250	15.08	21.31	10.83	10.01	1.18	0.65	45.71	26.03	4.10
1300	15.05	21.36	10.70	9.83	1.18	0.65	44.62	25.73	4.15
1350	15.01	21.42	10.64	9.70	1.19	0.65	44.92	25.84	4.17
1400	15.02	21.46	10.47	9.64	1.19	0.65	44.68	25.64	4.15
1450	15.01	21.50	10.34	9.50	1.19	0.65	44.13	25.66	4.14
1500	14.99	21.56	10.24	9.37	1.19	0.65	43.45	25.69	4.14
1550	14.95	21.66	10.11	9.24	1.20	0.66	41.94	25.60	4.21
1600	14.93	21.76	10.06	9.12	1.20	0.66	41.71	25.51	4.20
1650	14.90	21.83	9.89	8.95	1.21	0.66	42.36	25.52	4.22
1700	14.86	21.92	9.80	8.81	1.21	0.66	41.21	25.23	4.23
1750	14.83	22.04	9.72	8.71	1.22	0.67	40.45	25.30	4.31
1800	14.77	22.17	9.58	8.58	1.23	0.67	40.30	25.17	4.26
1850	14.72	22.27	9.53	8.44	1.24	0.67	40.19	25.06	4.44
1900	14.65	22.42	9.36	8.29	1.25	0.68	40.27	25.01	4.34
1950	14.57	22.58	9.28	8.15	1.27	0.68	39.87	24.96	4.40
2000	14.45	22.73	9.22	8.03	1.29	0.69	39.83	24.82	4.45

Note: Test data of die packaged in industry standard SOT-89 Package

Typical Performance Data

Definitions:
Input Return Loss = -S11 (dB)
Gain(Power Gain) = S21 (dB)
Reverse Isolation = -S12 (dB)
Output Return Loss = -S22 (dB)

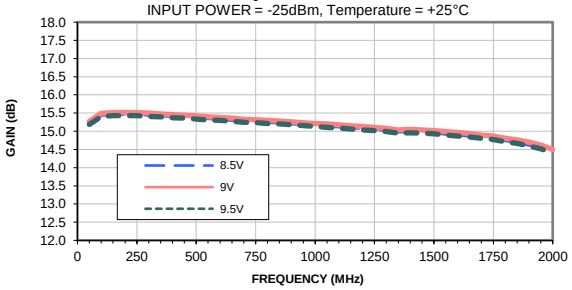
TEST CONDITIONS: Vd = 9.5V, Id = 202.27 mA @ Temperature = +25degC

FREQ	Gain	Isolation	Input Return Loss	Output Return Loss	Stability		IP-3 Output	1dB Comp. Output	Noise Figure
(MHz)	(dB)	(dB)	(dB)	(dB)	K	Measure	(dBm)	(dBm)	(dB)
50	15.19	20.38	11.36	14.12	1.14	0.67	44.16	26.43	4.37
100	15.41	20.62	12.60	12.52	1.14	0.63	44.18	26.99	4.30
150	15.43	20.72	12.59	11.98	1.14	0.63	44.34	26.91	4.22
200	15.43	20.79	12.55	11.78	1.15	0.63	43.98	27.11	4.15
250	15.43	20.78	12.53	11.66	1.15	0.63	43.44	26.97	4.25
300	15.41	20.81	12.49	11.59	1.15	0.63	42.89	27.11	4.30
350	15.40	20.81	12.46	11.53	1.15	0.63	42.50	27.17	4.33
400	15.37	20.82	12.39	11.47	1.15	0.63	42.34	26.93	4.33
450	15.36	20.83	12.34	11.42	1.15	0.63	42.12	27.01	4.33
500	15.34	20.88	12.29	11.35	1.16	0.63	42.17	26.96	4.39
550	15.31	20.84	12.19	11.26	1.15	0.63	41.90	27.05	4.36
600	15.30	20.88	12.18	11.21	1.16	0.63	42.00	26.85	4.33
650	15.27	20.90	12.07	11.17	1.16	0.63	41.93	26.87	4.35
700	15.25	20.91	12.04	11.12	1.16	0.64	42.07	27.03	4.33
750	15.24	20.94	11.94	11.01	1.16	0.64	42.08	27.06	4.28
800	15.21	20.94	11.83	10.93	1.16	0.64	42.01	27.02	4.26
850	15.20	20.96	11.78	10.86	1.16	0.64	42.24	27.11	4.29
1000	15.13	21.05	11.43	10.53	1.17	0.64	42.94	27.07	4.37
1050	15.11	21.10	11.30	10.39	1.17	0.64	42.74	27.00	4.37
1100	15.09	21.10	11.23	10.28	1.17	0.64	42.94	27.04	4.38
1150	15.06	21.14	11.10	10.15	1.17	0.64	42.71	27.17	4.44
1200	15.04	21.23	11.00	10.01	1.18	0.65	43.03	26.96	4.42
1250	15.02	21.25	10.88	9.89	1.18	0.64	43.27	27.00	4.43
1300	14.99	21.32	10.75	9.72	1.18	0.65	43.24	26.69	4.47
1350	14.95	21.41	10.68	9.60	1.19	0.65	43.95	26.78	4.47
1400	14.96	21.45	10.52	9.53	1.19	0.65	44.00	26.57	4.46
1450	14.95	21.49	10.38	9.39	1.19	0.65	43.42	26.58	4.48
1500	14.93	21.54	10.27	9.26	1.19	0.65	43.18	26.61	4.46
1550	14.90	21.63	10.14	9.13	1.20	0.65	42.48	26.49	4.51
1600	14.87	21.68	10.08	8.99	1.20	0.65	43.05	26.41	4.50
1650	14.84	21.78	9.91	8.82	1.20	0.65	43.16	26.41	4.56
1700	14.81	21.88	9.81	8.69	1.21	0.66	41.62	26.11	4.51
1750	14.77	21.97	9.73	8.58	1.22	0.66	40.99	26.18	4.63
1800	14.71	22.12	9.59	8.45	1.23	0.67	41.35	26.04	4.61
1850	14.67	22.24	9.54	8.31	1.24	0.67	41.32	25.94	4.77
1900	14.60	22.39	9.36	8.17	1.25	0.67	40.98	25.90	4.68
1950	14.52	22.54	9.28	8.01	1.26	0.68	41.01	25.84	4.74
2000	14.41	22.70	9.23	7.90	1.29	0.69	40.53	25.66	4.77

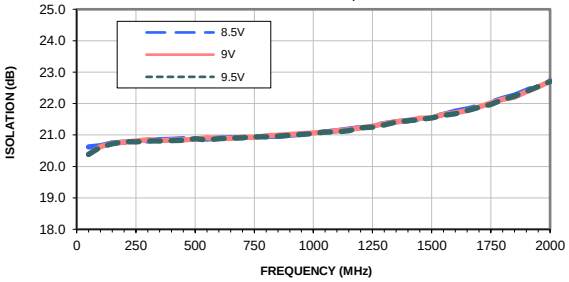
Note: Test data of die packaged in industry standard SOT-89 Package

Typical Performance Curves

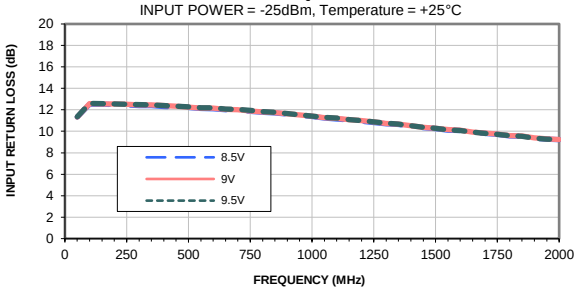
GAIN vs. FREQUENCY & DEVICE VOLTAGE
INPUT POWER = -25dBm, Temperature = +25°C



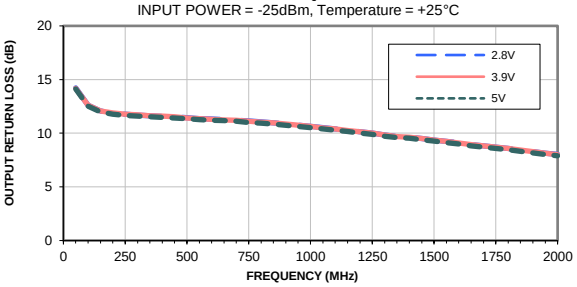
ISOLATION vs. FREQUENCY & DEVICE VOLTAGE
INPUT POWER = -25dBm, Temperature = +25°C



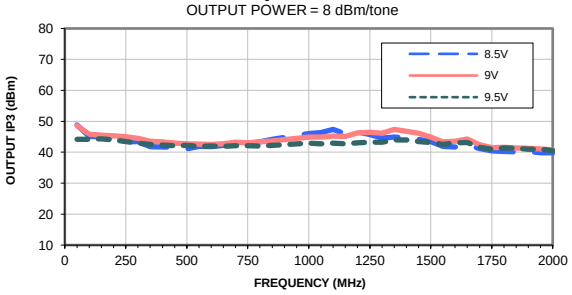
INPUT RETURN LOSS vs. FREQUENCY & DEVICE VOLTAGE
INPUT POWER = -25dBm, Temperature = +25°C



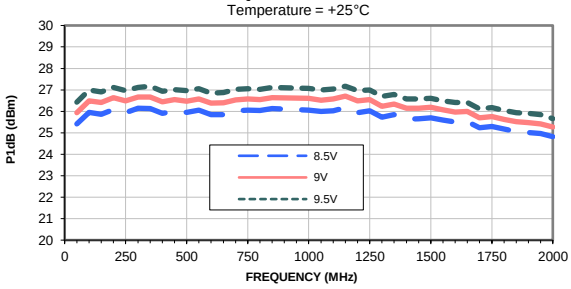
OUTPUT RETURN LOSS vs. FREQUENCY & DEVICE VOLTAGE
INPUT POWER = -25dBm, Temperature = +25°C



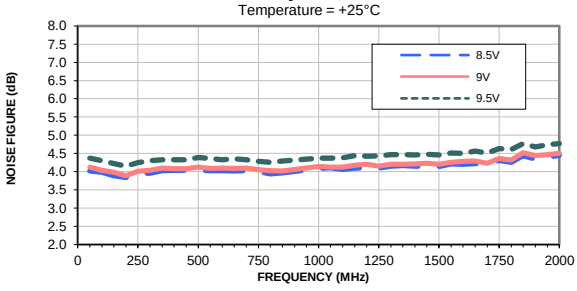
OUTPUT IP3 vs. FREQUENCY & DEVICE VOLTAGE
OUTPUT POWER = 8 dBm/tone



P1dB vs. FREQUENCY & DEVICE VOLTAGE
Temperature = +25°C



NOISE FIGURE vs. FREQUENCY & DEVICE VOLTAGE
Temperature = +25°C



Note: Test data of die packaged in industry standard SOT-89 Package

Mini-Circuits

Environmental Specifications **ENV08T1**

All Mini-Circuits products are manufactured under exacting quality assurance and control standards, and are capable of meeting published specifications after being subjected to any or all of the following physical and environmental test.

Specification	Test/Inspection Condition	Reference/Spec
Operating Temperature	-40° to 85° C or -45° to 85° C or -55° to 105° C or -40° to 105° C or -40° to 95° C Ambient Environment	Individual Model Data Sheet
Storage Temperature	-55° to 100° C or -65° to 150° Ambient Environment	Individual Model Data Sheet
HTOL	1000 hours at 125°C	MIL-STD-883, Method 1005, Condition B
Thermal Shock	-55° to 100°C, 100 cycles	MIL-STD-202, Method 107, Condition A-3, except +100°C
Mechanical Shock	1.5Kg, 0.5 ms, 5 shock pulses, Y1 direction only	MIL-STD-883, Method 2002, Condition B, except Y1 direction only
Vibration (Variable Frequency)	50g peak	MIL-STD-883, Method 2007, Condition B
Autoclave	15 psig, 100% RH, 121°C, 96 hours	JESD22-A102, Condition C
HAST	130°C, 85% RH, 96 hours	JESD22-A110
Solderability	10X Magnification	J-STD-002, Para 4.2.5, Test S, 95% Coverage
Solder Reflow Heat	Sn-Pb Eutetic Process: 240°C peak Pb-Free Process: 260°C peak	J-STD-020, Table 4-1, 4-2 and 5-2; Figure 5-1
Moisture Sensitivity: Level 1	Bake at 125°C for 24 hours Soak at 85°C/85% RH for 168 hours, Reflow 3 cycles at 260°C peak	J-STD-020

All Mini-Circuits products are manufactured under exacting quality assurance and control standards, and are capable of meeting published specifications after being subjected to any or all of the following physical and environmental test.

Specification	Test/Inspection Condition	Reference/Spec
Marking Resistance to Solvents	Isopropyl alcohol + mineral spirits at 25°C; terpene defluxer at 25°C; distilled water + proylene glycol monomethyl ether + monoethanolamine at 63°C to 70°C	MIL-STD-202, Method 215