

# 20.0-40.0 GHz GaAs MMIC Low Noise Amplifier

April 2005 - Rev 01-Apr-05

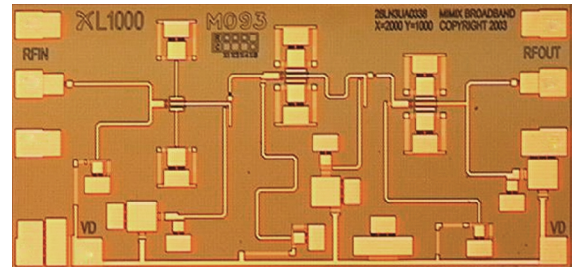
## Features

- ✕ Self Bias Architecture
- ✕ Small Size
- ✕ 3.0 or 5.0 V Operation
- ✕ 20.0 dB Small Signal Gain
- ✕ 2.0 dB Noise Figure
- ✕ +9.0 dBm P1dB Compression Point
- ✕ 100% On-Wafer RF, DC and Noise Figure Testing
- ✕ 100% Visual Inspection to MIL-STD-883 Method 2010

## General Description

Mimix Broadband's three stage 20.0-40.0 GHz GaAs MMIC low noise amplifier has a small signal gain of 20.0 dB with a noise figure of 2.0 dB across the band. This MMIC uses Mimix Broadband's 0.15  $\mu\text{m}$  GaAs PHEMT device model technology, and is based upon electron beam lithography to ensure high repeatability and uniformity. The chip has surface passivation to protect and provide a rugged part with backside via holes and gold metallization to allow either a conductive epoxy or eutectic solder die attach process. This device is well suited for Millimeter-wave Point-to-Point Radio, LMDS, SATCOM and VSAT applications.

## Chip Device Layout



## Absolute Maximum Ratings

Supply Voltage (Vd)	+7.0 VDC
Supply Current (Id)	70 mA
Input Power (Pin)	+12 dBm
Storage Temperature (Tstg)	-65 to +165 °C
Operating Temperature (Ta)	-55 to MTTF Table <sup>1</sup>
Channel Temperature (Tch)	MTTF Table <sup>1</sup>

(1) Channel temperature affects a device's MTTF. It is recommended to keep channel temperature as low as possible for maximum life.

## Electrical Characteristics (Ambient Temperature T = 25 °C)

Parameter	Units	Min.	Typ.	Max.
Frequency Range (f)	GHz	20.0	-	40.0
Input Return Loss (S11) <sup>2</sup> @ 22.0-36.0 GHz	dB	6.0	12.0	-
Output Return Loss (S22) <sup>2</sup> @ 22.0-36.0 GHz	dB	4.0	10.0	-
Small Signal Gain (S21) <sup>2</sup>	dB	12.0	20.0	-
Gain Flatness ( $\Delta S21$ )	dB	-	+/-4.0	-
Reverse Isolation (S12) <sup>2</sup>	dB	30.0	45.0	-
Noise Figure (NF) <sup>2</sup> @ 24.0-40.0 GHz	dB	-	2.0	-
Output Power for 1 dB Compression (P1dB)	dBm	-	+9.0	-
Output Third Order Intercept Point (OIP3)	dBm	-	+16.0	-
Drain Bias Voltage (Vd)	VDC	-	+3.0	+5.0
Supply Current (Id) (Vd=3.0V or 5.0V)	mA	-	35	50

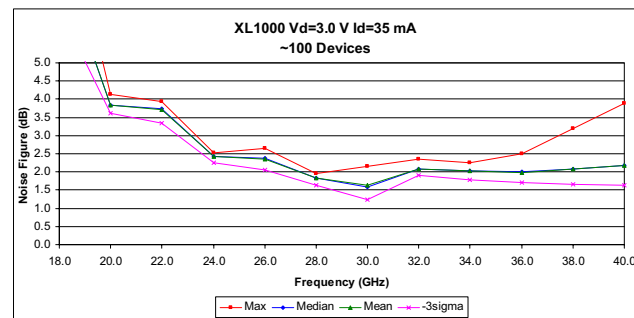
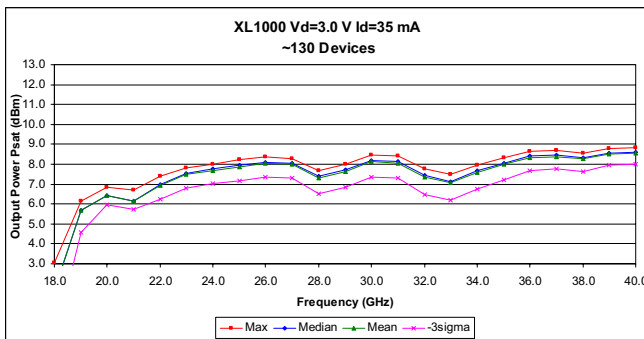
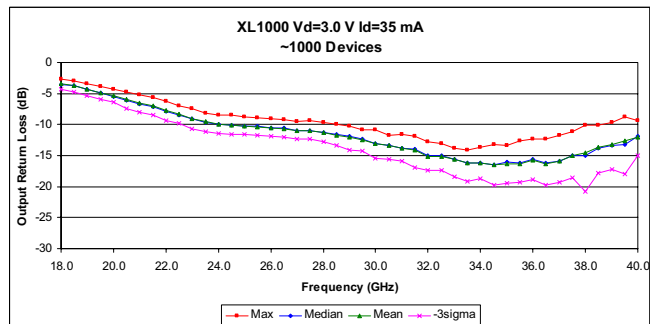
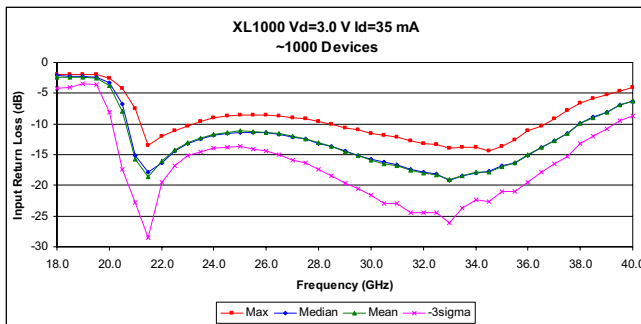
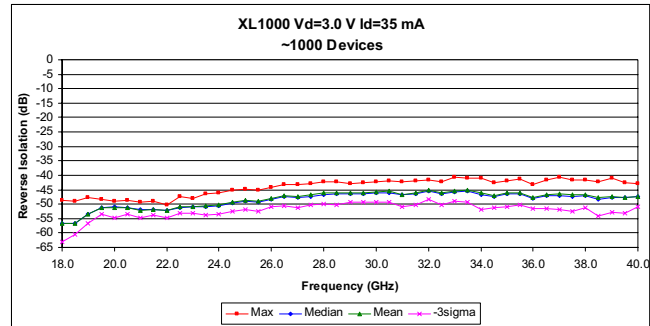
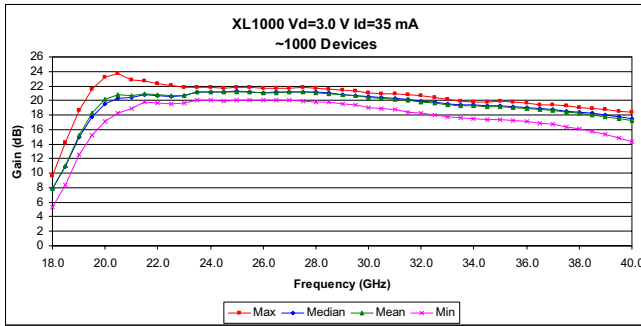
(2) Unless otherwise indicated min/max over 20.0-40.0 GHz and biased at Vd=5V, Id=50mA.

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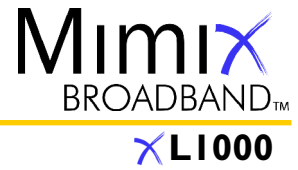


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## Low Noise Amplifier Measurements

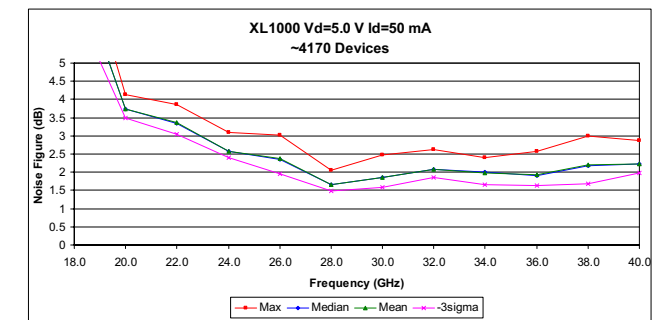
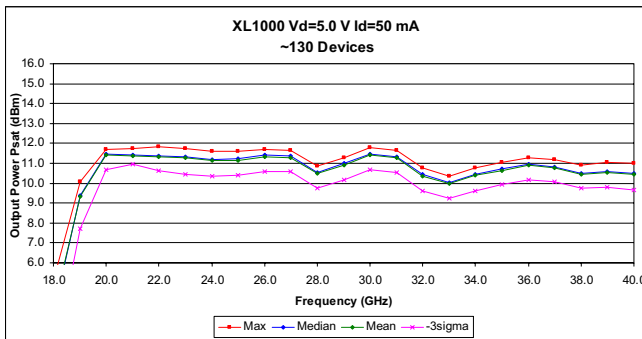
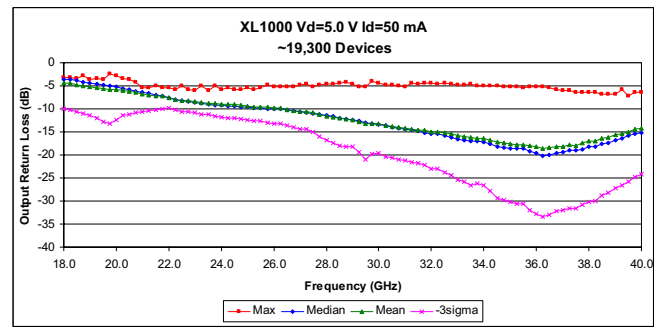
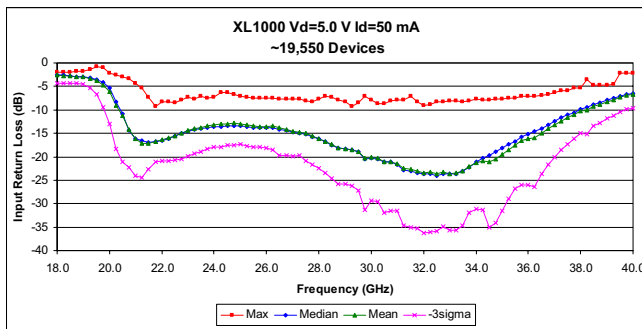
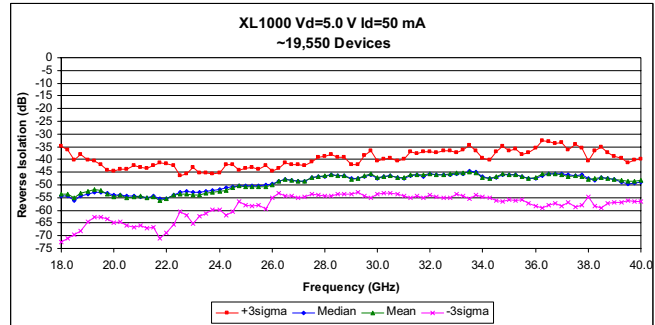
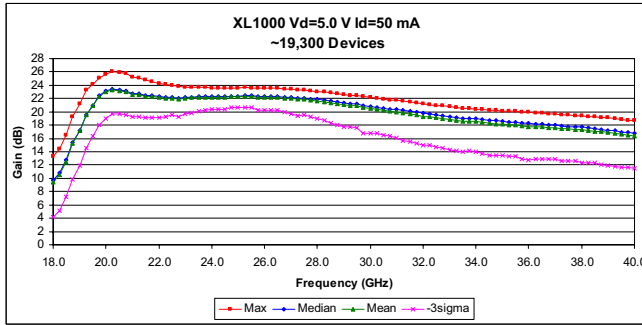


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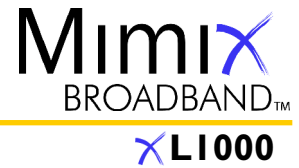


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## Low Noise Amplifier Measurements (cont.)



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## S-Parameters

Typical S-Parameter Data for XL1000  
Vd=3 V Id=35 mA

Frequency (GHz)	S11 Mag dB	Ang °	S21 Mag dB	Ang°	S12 Mag dB	Ang°	S22 Mag dB	Ang°
18	-2.200	-172.1	7.284	32.8	-54.177	165.1	-3.618	-121.8
19	-2.399	133.1	16.781	-9.0	-51.411	126.6	-4.679	-56.4
20	-7.105	25.6	22.182	-93.5	-53.098	51.8	-5.369	8.5
21	-16.496	-158.8	21.456	-167.2	-53.707	-1.3	-6.741	51.4
22	-13.705	125.9	20.991	153.4	-52.904	-40.7	-7.966	105.7
23	-12.473	86.8	20.832	122.1	-50.363	-74.6	-9.227	173.6
24	-12.081	52.9	20.926	89.4	-48.447	-102.1	-10.152	-144.8
25	-12.038	27.4	21.015	60.0	-47.146	-129.2	-10.567	-88.5
26	-12.956	8.6	20.987	31.1	-46.486	-143.7	-10.909	-28.7
27	-14.269	-9.2	20.854	1.8	-45.888	-165.1	-11.395	18.1
28	-15.397	-25.1	20.628	-24.1	-43.938	-165.8	-12.052	82.0
29	-17.700	-32.6	20.224	-49.5	-44.948	153.4	-13.273	153.0
30	-19.336	-41.1	19.788	-72.8	-44.741	139.6	-14.044	-136.2
31	-20.634	-59.7	19.509	-95.9	-44.813	132.0	-14.985	-68.6
32	-21.606	-86.6	19.002	-118.9	-43.798	122.4	-16.398	-14.9
33	-21.541	-110.7	18.582	-139.4	-43.461	113.9	-17.350	54.3
34	-18.765	-126.6	18.293	-158.0	-43.458	86.6	-17.210	142.7
35	-15.442	-152.7	17.991	173.3	-44.577	85.5	-17.880	-158.5
36	-12.610	-169.7	17.705	159.0	-46.372	68.5	-17.598	-113.4
37	-10.623	173.2	17.369	139.1	-44.693	57.7	-16.893	-45.5
38	-7.853	163.4	16.982	115.8	-45.551	24.5	-14.959	3.2
39	-6.345	152.6	16.304	94.6	-45.794	8.7	-14.213	68.5
40	-4.936	139.4	15.469	73.2	-47.691	-18.2	-13.011	135.0

Typical S-Parameter Data for XL1000  
Vd=5 V Id=50 mA

Frequency (GHz)	S11 Mag dB	Ang °	S21 Mag dB	Ang°	S12 Mag dB	Ang°	S22 Mag dB	Ang°
18	-2.600	-172.8	9.028	27.5	-54.509	165.0	-3.453	-122.3
19	-3.409	126.2	18.842	-17.5	-53.271	124.2	-4.345	-56.8
20	-10.078	-1.0	24.224	-105.0	-57.935	67.3	-4.854	6.6
21	-15.538	-156.2	23.310	-172.1	-56.605	10.8	-6.249	49.5
22	-14.868	130.9	22.707	147.5	-56.413	-32.4	-7.361	104.0
23	-14.383	87.3	22.544	115.5	-53.163	-72.0	-8.568	174.2
24	-14.351	48.6	22.572	82.3	-51.183	-99.4	-9.431	-142.6
25	-14.446	19.7	22.613	52.2	-49.459	-126.2	-9.959	-84.0
26	-15.816	-0.4	22.458	22.4	-48.784	-139.9	-10.403	-22.0
27	-17.560	-20.7	22.178	-7.4	-48.461	-159.9	-11.048	27.4
28	-19.092	-41.7	21.859	-33.7	-45.980	-171.2	-11.936	93.6
29	-22.798	-51.1	21.171	-59.0	-47.457	161.5	-12.946	167.7
30	-26.012	-68.9	20.570	-82.0	-47.358	149.7	-13.737	-119.1
31	-26.152	-108.3	20.086	-104.4	-46.965	146.1	-14.992	-48.2
32	-24.241	-147.9	19.426	-126.9	-45.662	138.2	-16.501	12.0
33	-21.954	-166.9	18.909	-147.0	-45.317	129.7	-17.747	87.3
34	-19.416	-169.0	18.548	-164.7	-45.776	102.9	-17.865	164.5
35	-15.716	172.5	18.136	173.7	-46.026	108.2	-19.936	-128.8
36	-13.036	167.1	17.783	154.8	-48.076	98.6	-21.248	-65.2
37	-11.444	161.2	17.463	136.3	-45.494	86.8	-21.347	-1.9
38	-8.718	151.7	17.153	114.6	-47.150	57.3	-19.655	33.6
39	-7.306	145.2	16.619	94.8	-47.596	48.1	-19.338	92.3
40	-5.717	135.2	15.988	74.1	-49.537	28.4	-17.564	151.6

Mimix Broadband, Inc., 10795 Rockley Rd., Houston, Texas 77099  
Tel: 281.988.4600 Fax: 281.988.4615 mimixbroadband.com

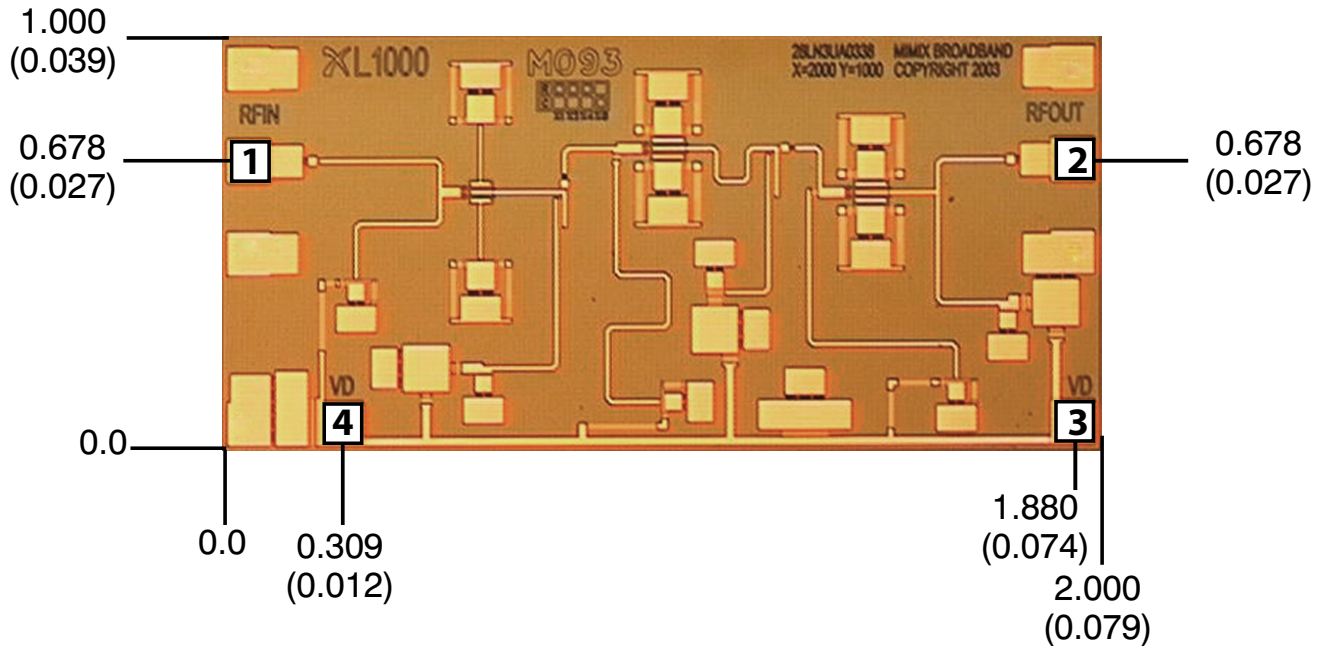
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## Mechanical Drawing

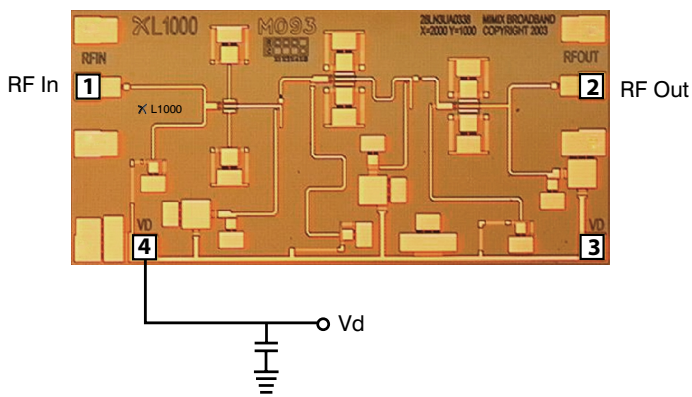


(Note: Engineering designator is 28LN3UA0338)

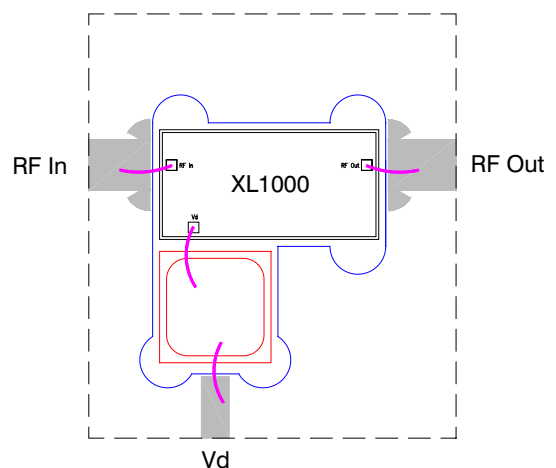
Units: millimeters (inches) Bond pad dimensions are shown to center of bond pad.  
 Thickness: 0.110 +/- 0.010 (0.0043 +/- 0.0004), Backside is ground, Bond Pad/Backside Metallization: Gold  
 All Bond Pads are 0.100 x 0.100 (0.004 x 0.004).  
 Bond pad centers are approximately 0.109 (0.004) from the edge of the chip.  
 Dicing tolerance: +/- 0.005 (+/- 0.0002). Approximate weight: 1.239 mg.

Bond Pad #1 (RF In)    Bond Pad #2 (RF Out)    Bond Pad #3 (Vd)    Bond Pad #4 (Vd)

## Bias Arrangement



Bypass Capacitors - See App Note [2]



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**App Note [1] Biasing** - As shown in the bonding diagram, this device operates using a self-biased architecture and only requires one drain bias. Bias is nominally  $V_d=3V, I_d=35mA$  or  $V_d=5V, I_d=50mA$ .

**App Note [2] Bias Arrangement** - Each DC pad ( $V_d$ ) needs to have DC bypass capacitance ( $\sim 100-200$  pF) as close to the device as possible. Additional DC bypass capacitance ( $\sim 0.01$  uF) is also recommended.

## MTTF Tables

These numbers were calculated based on accelerated life test information and thermal model analysis received from the fabricating foundry.

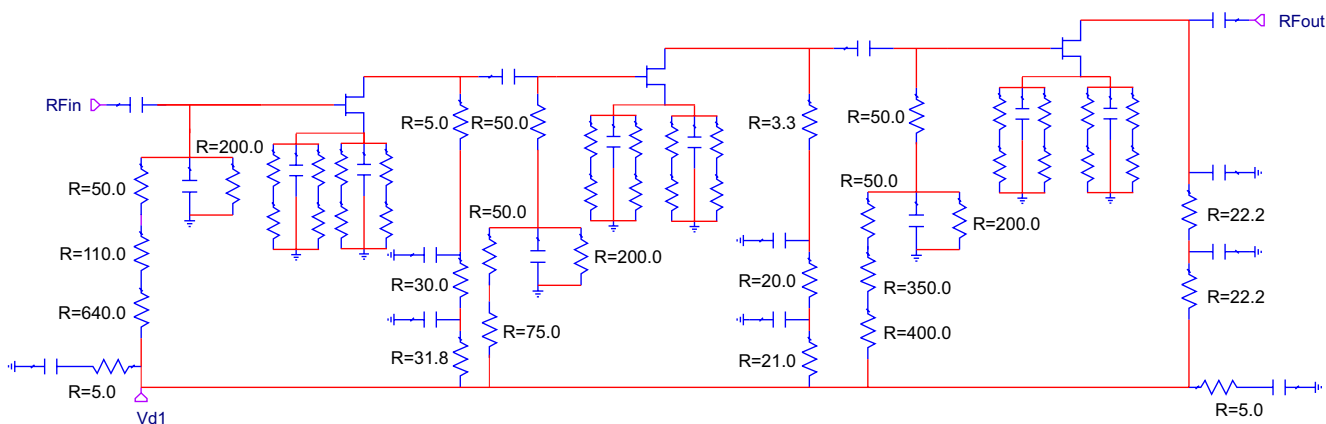
Backplate Temperature	Channel Temperature	Rth	MTTF Hours	FITs
55 deg Celsius	72.2 deg Celsius	164.0° C/W	2.52E+11	3.96E-03
75 deg Celsius	93.6 deg Celsius	176.7° C/W	1.53E+10	6.52E-02
95 deg Celsius	114.7 deg Celsius	188.0° C/W	1.29E+09	7.76E-01

**Bias Conditions:**  $V_d=3.0V$  and  $I_d=35.0$  mA

Backplate Temperature	Channel Temperature	Rth	MTTF Hours	FITs
55 deg Celsius	98.9 deg Celsius	175.8° C/W	8.24E+09	1.21E-01
75 deg Celsius	122.1 deg Celsius	188.4° C/W	5.99E+08	1.67E+00
95 deg Celsius	145.0 deg Celsius	199.9° C/W	6.00E+07	1.67E+01

**Bias Conditions:**  $V_d=5.0V$  and  $I_d=50$  mA

## Device Schematic





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## Handling and Assembly Information

**CAUTION!** - Mimix Broadband MMIC Products contain gallium arsenide (GaAs) which can be hazardous to the human body and the environment. For safety, observe the following procedures:

- *Do not ingest.*
- *Do not alter the form of this product into a gas, powder, or liquid through burning, crushing, or chemical processing as these by-products are dangerous to the human body if inhaled, ingested, or swallowed.*
- *Observe government laws and company regulations when discarding this product. This product must be discarded in accordance with methods specified by applicable hazardous waste procedures.*

**Life Support Policy** - Mimix Broadband's products are not authorized for use as critical components in life support devices or systems without the express written approval of the President and General Counsel of Mimix Broadband. As used herein: (1) Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user. (2) A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

**ESD** - Gallium Arsenide (GaAs) devices are susceptible to electrostatic and mechanical damage. Die are supplied in antistatic containers, which should be opened in cleanroom conditions at an appropriately grounded anti-static workstation. Devices need careful handling using correctly designed collets, vacuum pickups or, with care, sharp tweezers.

**Die Attachment** - GaAs Products from Mimix Broadband are 0.100 mm (0.004") thick and have vias through to the backside to enable grounding to the circuit. Microstrip substrates should be brought as close to the die as possible. The mounting surface should be clean and flat. If using conductive epoxy, recommended epoxies are Ablestick 84-1LMI or 84-1LMIT cured in a nitrogen atmosphere per manufacturer's cure schedule. Apply epoxy sparingly to avoid getting any on to the top surface of the die. An epoxy fillet should be visible around the total die periphery. If eutectic mounting is preferred, then a fluxless gold-tin (AuSn) preform, approximately 0.001<sup>2</sup> thick, placed between the die and the attachment surface should be used. A die bonder that utilizes a heated collet and provides scrubbing action to ensure total wetting to prevent void formation in a nitrogen atmosphere is recommended. The gold-tin eutectic (80% Au 20% Sn) has a melting point of approximately 280°C (Note: Gold Germanium should be avoided). The work station temperature should be 310°C ± 10°C. Exposure to these extreme temperatures should be kept to minimum. The collet should be heated, and the die pre-heated to avoid excessive thermal shock. Avoidance of air bridges and force impact are critical during placement.

**Wire Bonding** - Windows in the surface passivation above the bond pads are provided to allow wire bonding to the die's gold bond pads. The recommended wire bonding procedure uses 0.076 mm x 0.013 mm (0.003" x 0.0005") 99.99% pure gold ribbon with 0.5-2% elongation to minimize RF port bond inductance. Gold 0.025 mm (0.001") diameter wedge or ball bonds are acceptable for DC Bias connections. Aluminum wire should be avoided. Thermo-compression bonding is recommended though thermosonic bonding may be used providing the ultrasonic content of the bond is minimized. Bond force, time and ultrasonics are all critical parameters. Bonds should be made from the bond pads on the die to the package or substrate. All bonds should be as short as possible.