17.0-35.0 GHz GaAs MMIC Low Noise Amplifier

March 2005 - Rev 01-Mar-05

XL1001

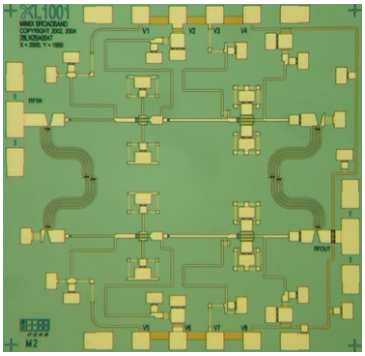
Features

- Balanced Design
- Excellent Input/Output Match
- Self-biased Architecture
- 14.0 dB Small Signal Gain
- 2.5 dB Noise Figure
- 100% On-Wafer RF, DC and Noise Figure Testing
- 100% Visual Inspection to MIL-STD-883 Method 2010

General Description

Mimix Broadband's two stage balanced 17.0-35.0 GHz GaAs MMIC low noise amplifier has a small signal gain of 14.0 dB with a noise figure of 2.5 dB across the band. This MMIC uses Mimix Broadband's 0.15 μm 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)	+6.0 VDC
Supply Current (Id)	85 mA
Input Power (Pin)	+15.0 dBm
Storage Temperature (Tstg)	-65 to +165 °C
Operating Temperature (Ta)	-55 to MTTF Table[1]
Channel Temperature (Tch)	MTTF Table[1]

(1) Channel temperature affects a device's MTBF. 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	17.0	-	35.0
Input Return Loss (S11)[3]	dB	8.0	10.0	-
Output Return Loss (S22)[3]	dB	15.0	18.0	-
Small Signal Gain (S21)[3]	dB	12.0	14.0	-
Gain Flatness (ΔS21)	dB	-	+/-1.5	-
Reverse Isolation (S12)[3]	dB	25.0	30.0	-
Noise Figure (NF) @ 21.0-35.0 GHz[3]	dB	-	2.5	3.5
Output Power for 1 dB Compression (P1dB)	dBm	-	+4.0[2]	-
Output Third Order Intercept Point (OIP3)	dBm	-	+16.0[2]	-
Drain Bias Voltage (V5)	VDC	-	+5.0	+5.5
Supply Current (Id)	mA	-	55	65

(2) See plots for additional information.
(3) Unless otherwise indicated min/max over 17.0-35.0 GHz and biased at Vd=5V, Id=55mA.

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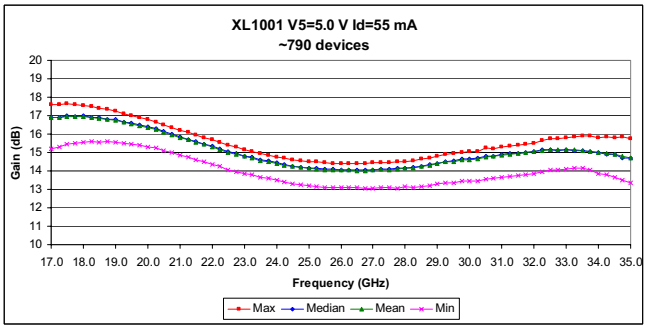
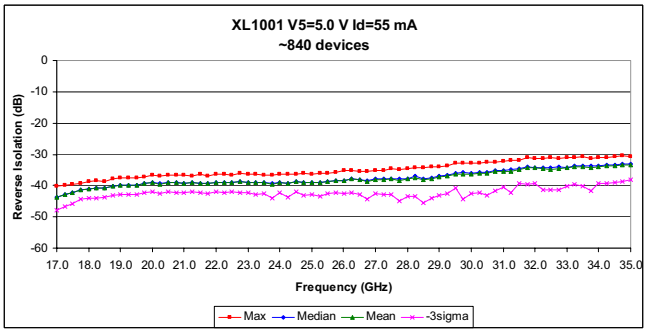
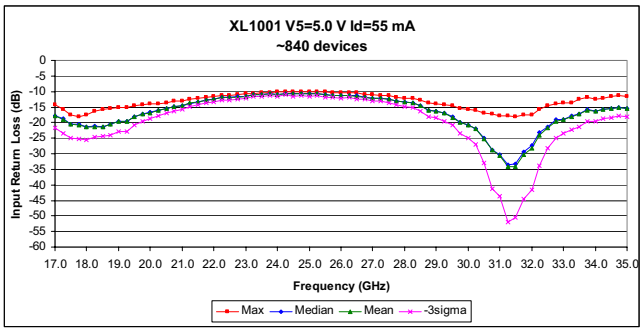
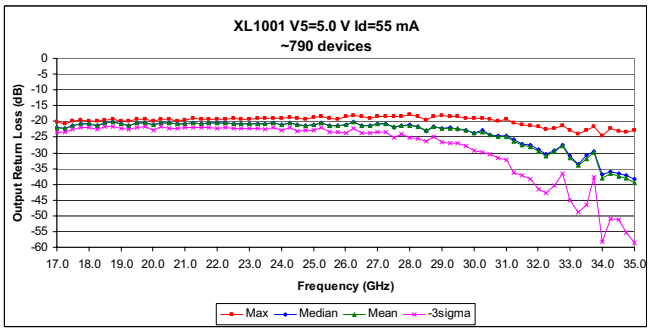
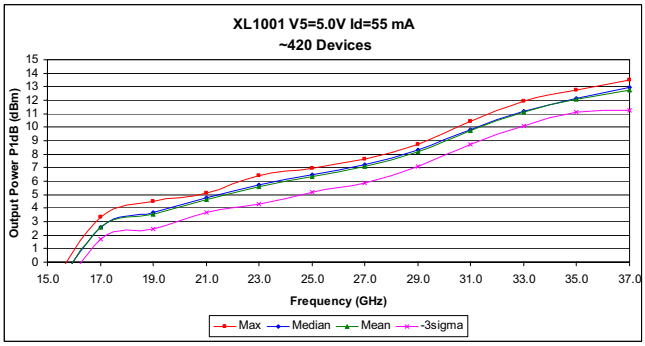
Low Noise Amplifier Measurements

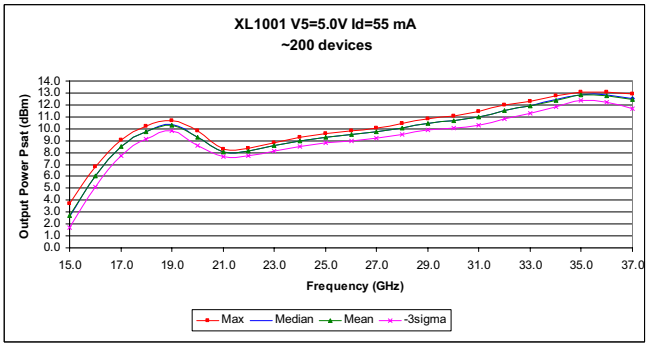


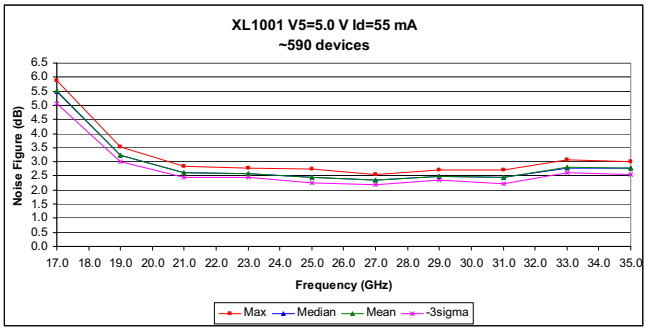












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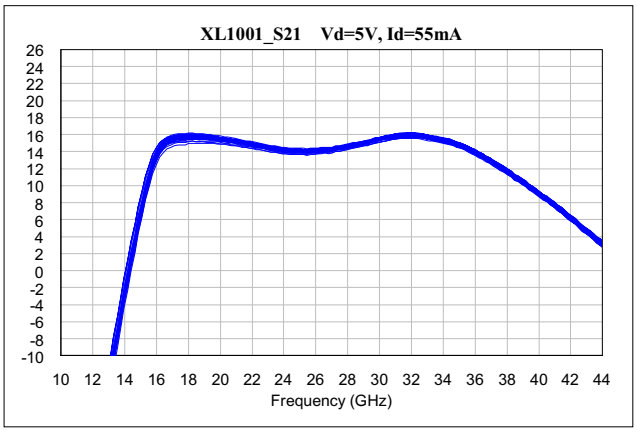
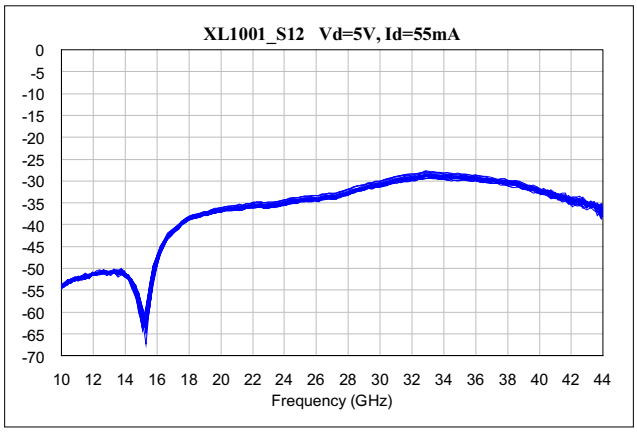
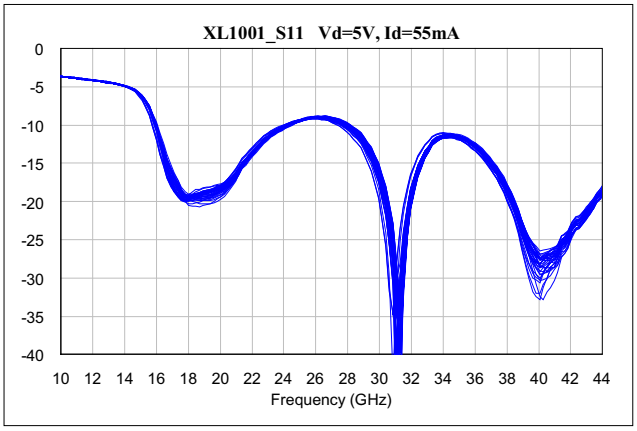
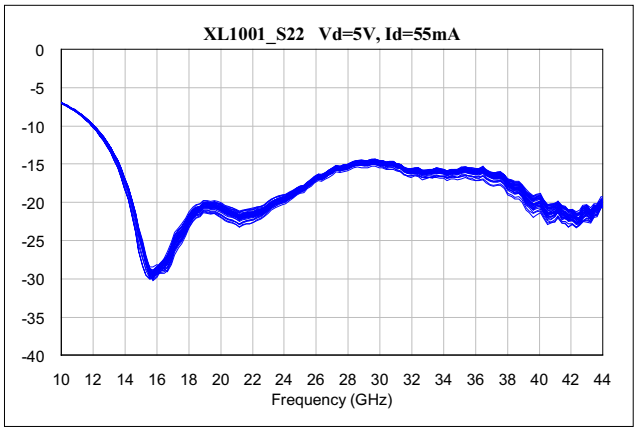
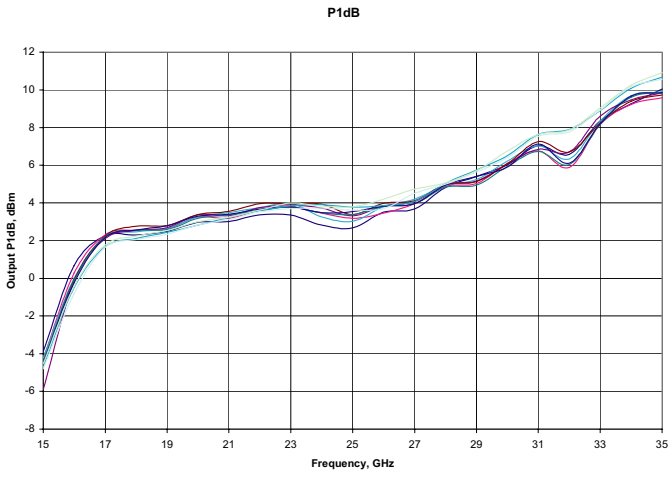
Low Noise Amplifier Measurements (cont.)

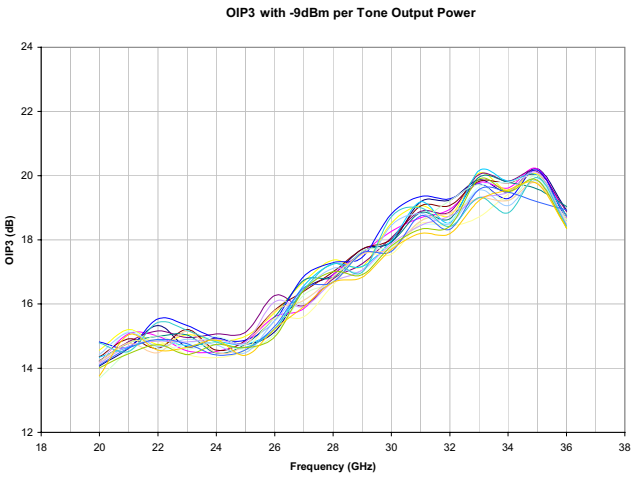












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S-Parameters

Typical S-Parameter Data for XL1001
Vd=5 V Id=55 mA

Frequency (GHz)	S11 Mag dB	S11 Phase Ang°	S12 Mag dB	S12 Phase Ang°	S21 Mag dB	S21 Phase Ang°	S22 Mag dB	S22 Phase Ang°
17.00	-16.99632238	139.375	-43.50135231	-165.0034	16.83518948	27.56314	-21.5662562	-145.8288
17.25	-18.22034734	143.7155	-42.92199881	-169.7041	16.87423756	14.29959	-21.98967927	138.5046
17.50	-19.46130647	149.3745	-42.16608471	171.3443	16.91162905	2.342399	-21.17645409	66.65816
17.75	-20.021277	157.7866	-41.41931548	169.1783	16.8988471	-8.969337	-20.68817633	-12.65336
18.00	-20.5230626	162.5519	-41.0283522	161.3903	16.88168555	-19.82675	-20.92767435	-91.32869
18.25	-20.79350858	164.0144	-40.86274857	154.5895	16.86207475	-29.9521	-21.2424634	-163.5413
18.50	-21.03547412	-162.5143	-40.65611208	147.2125	16.79916016	-39.65725	-20.63942484	122.3871
18.75	-20.33289145	-162.3319	-40.27985003	143.6475	16.76593352	-49.02252	-20.32237051	44.88822
19.00	-19.74821093	-160.1269	-39.83071713	135.4723	16.70160593	-58.0738	-21.10196596	-32.11696
19.25	-19.65833757	-154.13	-39.84003258	128.3112	16.59635708	-66.92716	-21.26399727	-100.6937
19.50	-18.73569262	-150.6178	-39.78948973	122.8059	16.51201293	-75.31522	-20.49368522	-172.2169
19.75	-18.00112021	-150.1321	-39.41944586	118.6622	16.41252149	-83.79314	-20.48053642	108.4545
20.00	-17.74030982	-151.6351	-38.77541743	110.17	16.28421084	-91.99918	-21.32987518	37.22786
20.25	-16.93611612	-148.0286	-39.47690025	106.6602	16.18789062	-99.39564	-20.47033864	-28.80878
20.50	-16.10189145	-150.2199	-38.99334211	100.1368	16.01093249	-107.1319	-20.55188264	-105.1162
20.75	-15.44496195	-152.6892	-39.11710705	95.17268	15.89582057	-114.2677	-20.87478241	-173.5728
21.00	-15.15035958	-152.6458	-38.97990051	89.70592	15.75055192	-121.0448	-20.69244786	117.0107
21.25	-14.28884065	-154.1784	-38.99408887	84.93417	15.62364162	-127.988	-20.42563027	44.79455
21.50	-13.78632457	-156.4666	-39.10445783	77.69951	15.48422452	-134.3429	-20.64844027	-24.99466
21.75	-13.23082096	-160.9358	-39.3666839	76.60333	15.35980691	-140.9036	-20.54756792	-94.38763
22.00	-13.06341343	-163.3492	-38.99868222	72.40802	15.23031773	-147.1864	-20.49483591	-165.9165
22.25	-12.48264971	-166.3888	-39.0143968	66.88152	15.08773149	-153.3092	-20.55487864	119.6442
22.50	-12.41050427	-171.106	-38.7624762	64.31834	14.92882621	-159.323	-20.60855069	49.67002
22.75	-12.24980855	-174.3592	-38.83696132	57.54897	14.83073257	-165.0063	-20.82143463	-20.85219
23.00	-11.9718369	-175.001	-38.93113547	52.16542	14.70156851	-170.5581	-20.81131829	-91.58767
23.25	-11.66130252	175.2349	-39.14947041	47.88209	14.61513456	-175.7427	-20.71323343	-160.4042
23.50	-11.49396311	172.3154	-38.98983022	45.34269	14.47697596	176.1237	-20.74020992	125.1164
23.75	-11.48111131	168.6437	-39.58993981	39.8782	14.40450984	172.2124	-20.58346134	50.20322
24.00	-11.51126177	165.6087	-38.74658715	36.2598	14.31530097	167.1249	-20.88243468	-13.83082
24.25	-11.3781628	162.0349	-39.30852919	31.82264	14.22519482	162.113	-20.52650526	-86.85399
24.50	-11.42159635	157.3341	-38.73287765	30.08148	14.12218561	157.1459	-20.75361152	-157.3243
24.75	-11.56625992	153.5069	-39.05590664	25.36871	14.08745853	152.1462	-21.31832968	130.1578
25.00	-11.7053422	151.03	-38.76663499	20.64142	14.03423715	147.1736	-20.85328522	62.67803
25.25	-11.72581082	146.5571	-39.04292712	16.35048	13.99406027	141.9767	-20.55219882	-11.75971
25.50	-11.77209413	141.1745	-38.71074182	14.35935	13.9292971	137.3834	-21.13117115	-83.11944
25.75	-12.10894283	137.015	-38.47292867	12.05855	13.93028124	132.8367	-21.43840093	-143.6926
26.00	-12.05120986	133.794	-38.42338621	4.893866	13.91800938	128.0229	-20.79462492	142.8679
26.25	-12.05645099	130.3703	-37.93613334	-0.4999815	13.90974609	122.9593	-20.41180145	64.02857
26.50	-12.05617331	124.3654	-38.07985536	-8.52309	13.90164737	118.2524	-21.12542644	-7.409314
26.75	-12.365988	119.5065	-38.6077536	-9.877016	13.87603731	113.8509	-21.51735636	-72.2129
27.00	-12.54280318	117.7405	-38.14147693	-13.96298	13.89372036	108.7928	-20.63852043	-142.2001
27.25	-12.66435174	111.5445	-37.99840456	-15.54111	13.95917696	104.4438	-20.97351704	142.6847
27.50	-12.89454563	106.4406	-37.74363624	-24.01004	13.94595398	99.4355	-21.61922984	69.12561
27.75	-13.44494988	101.562	-38.26118951	-27.72787	13.95486967	94.4838	-21.52438538	-0.617398
28.00	-13.64633488	99.64151	-37.77805157	-31.18327	14.00059914	90.20975	-20.88353898	-74.6953
28.25	-13.97494046	93.37321	-37.4684142	-36.28835	14.02320469	85.2106	-21.93021107	-143.286
28.50	-14.57713942	86.10413	-38.15045095	-42.24523	14.0865178	80.39879	-23.03158417	145.0658
28.75	-15.92177677	82.08988	-37.90431875	-40.72722	14.17701466	75.86873	-21.75429554	78.67702
29.00	-16.18821722	80.52306	-37.26253959	-46.18079	14.25079338	70.56535	-21.94554671	8.958519
29.25	-16.93184208	74.4507	-36.87451043	-51.09059	14.3350981	65.59789	-22.43376476	-60.07335
29.50	-18.02002281	68.77728	-36.05356609	-55.22031	14.36570353	60.5971	-22.17912903	-131.3199
29.75	-19.42241819	64.24228	-36.45846149	-64.88429	14.44879615	55.63038	-23.02114882	156.2451
30.00	-20.35240685	62.60468	-36.32763539	-67.67895	14.46990794	50.69379	-23.60769064	81.19078
30.25	-21.51572677	52.23897	-36.09157141	-72.65342	14.50271084	45.04929	-23.51767644	6.943614
30.50	-24.59757337	45.28998	-36.26154295	-76.77634	14.64352708	39.93787	-23.75469054	-57.03593
30.75	-27.63243773	56.27588	-35.53240597	-82.27695	14.62710647	34.54861	-24.69917254	-130.9978
31.00	-29.24539992	63.35837	-35.45069025	-85.27858	14.71629116	29.25891	-24.21826248	153.7268
31.25	-33.05100599	54.67377	-35.37890716	-90.68305	14.76855133	24.22786	-26.17949275	80.85181
31.50	-32.2255574	21.32345	-34.64439929	-94.05429	14.79127288	18.37123	-26.94499982	7.64232
31.75	-29.56508463	32.74833	-34.36608485	-103.5716	14.82711707	13.00255	-27.7948772	-68.73909
32.00	-27.42100673	-46.63418	-34.31455605	-111.0306	14.89051797	7.676987	-28.6015573	-130.3359
32.25	-23.6327812	-133.8798	-34.69492154	-115.8281	14.98209216	2.029904	-30.19862906	-15.98623
32.50	-20.78925535	164.9067	-34.75988301	-118.7765	14.98811582	-3.867283	-27.85849305	99.83913
32.75	-19.35152131	163.758	-34.42111704	-123.5373	14.97073653	-9.858306	-27.3709995	24.32363
33.00	-18.45373034	157.7206	-34.31834637	-127.1059	14.98076929	-15.39653	-30.38654094	-58.65744
33.25	-17.9166638	156.2775	-33.91199138	-132.3549	14.96913564	-21.054	-32.97929522	-105.3385
33.50	-16.68176243	149.6813	-34.03444441	-140.2881	14.95144826	-27.27283	-28.93613812	-131.3147
33.75	-16.01296201	141.8956	-34.18343182	-144.8102	14.90443987	-32.92151	-29.09335104	97.72387
34.00	-15.87056003	135.5129	-34.02519154	-146.5383	14.76367179	-39.00824	-35.43483674	-3.238748
34.25	-15.75794954	131.1042	-33.73531567	-151.229	14.78396807	-44.87165	-35.34884601	8.814638
34.50	-14.95362452	126.3466	-33.80475691	-155.8534	14.66771797	-50.65154	-35.46898768	-82.0274
34.75	-14.99746978	117.2361	-33.34660119	-159.9445	14.59668203	-57.21058	-36.63339404	105.3629
35.00	-15.0933962	111.014	-33.34259783	-164.4034	14.46929951	-62.64054	-39.20296741	-59.73188

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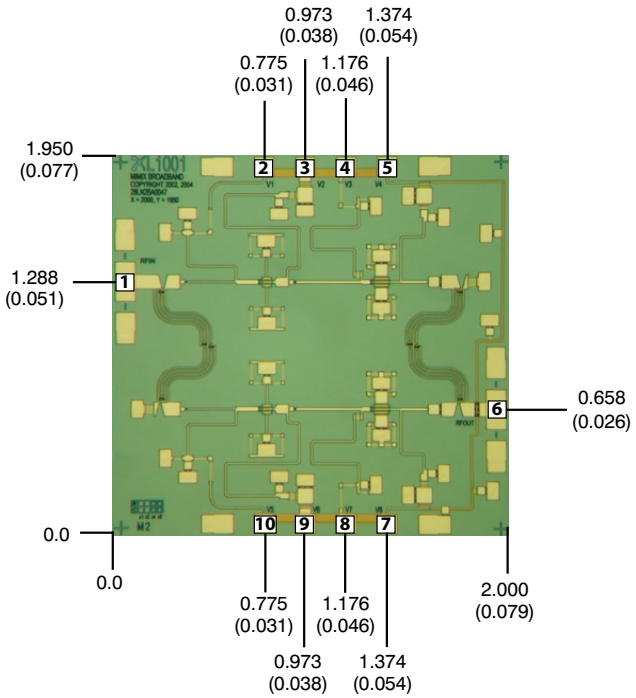
Mechanical Drawing

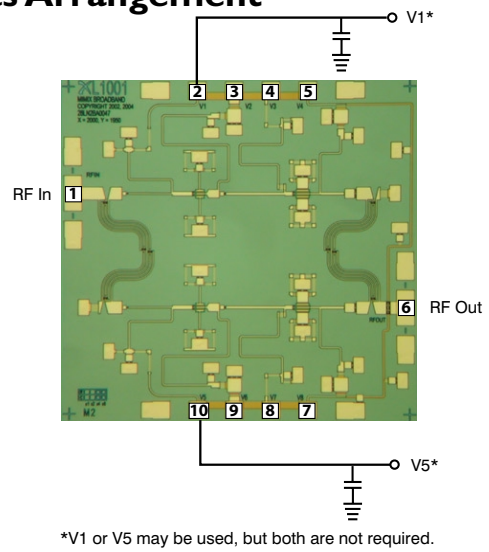


(Note: Engineering designator is 28LN2BA0047)

Units: millimeters (inches) Bond pad dimensions are shown to center of bond pad.
Thickness: 0.115 +/- 0.010 (0.0045 +/- 0.0004), Backside is ground, Bond Pad/Backside Metallization: Gold
All DC Bond Pads are 0.100 x 0.100 (0.004 x 0.004). All RF Bond Pads are 0.100 x 0.200 (0.004 x 0.008)
Bond pad centers are approximately 0.109 (0.004) from the edge of the chip.
Dicing tolerance: +/- 0.005 (+/- 0.0002). Approximate weight: 2.416 mg.

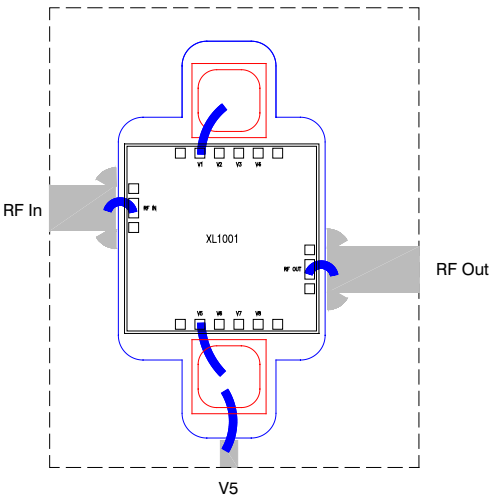
Bond Pad #1 (RF In)
Bond Pad #2 (V1)
Bond Pad #3 (V2)
Bond Pad #4 (V3)
Bond Pad #5 (V4)
Bond Pad #6 (RF Out)
Bond Pad #7 (V8)
Bond Pad #8 (V7)
Bond Pad #9 (V6)
Bond Pad #10 (V5)

Bias Arrangement



*V1 or V5 may be used, but both are not required.

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 a single bias voltage. All DC pads (V1 through V8) are tied together on-chip. Even though V1 or V5 are shown as main connections, any of the eight DC pads may be used to bias the device. Bias is nominally V1 or V5=5V, Id=55mA.

App Note [2] Bias Arrangement - The DC pad at the top (V1) should be connected to one DC bypass capacitor (~100-200 pf) and the DC pad at the bottom (V5) should be connected using another DC bypass capacitor (~100-200 pf). Additional DC bypass capacitance (~0.01 µf) is also recommended. Capacitance should be as close to the device as possible.

MTTF Table

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	89.4 deg Celsius	149.6° C/W	1.98E+10	5.04E-02
75 deg Celsius	111.9 deg Celsius	160.7° C/W	1.35E+09	7.39E-01
95 deg Celsius	134.2 deg Celsius	170.6° C/W	1.28E+08	7.84E+00

Bias Conditions: V1 or V5=5.0V, Id=55 mA

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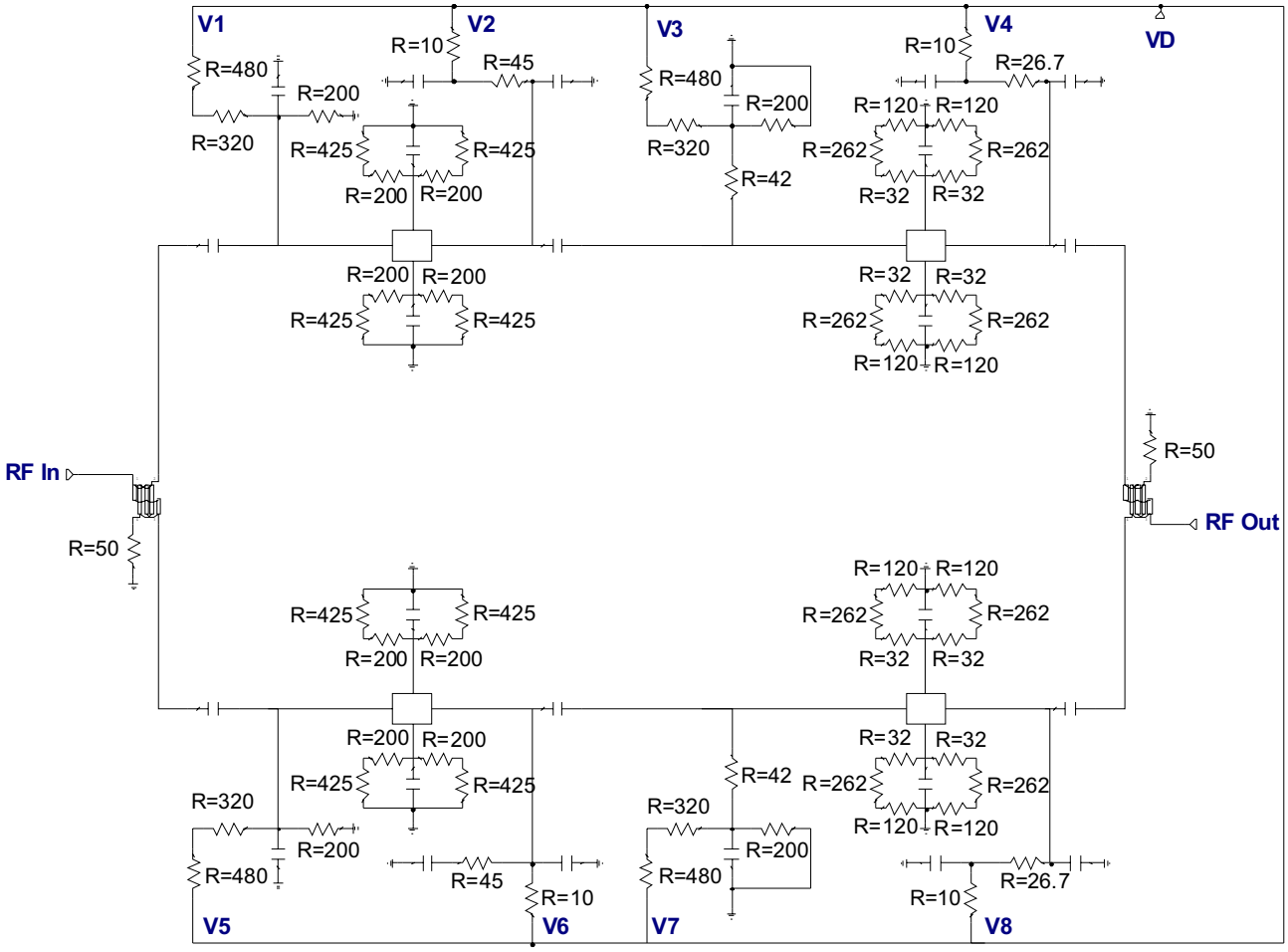
Device Schematic



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 0.001^2 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 $\pm$ 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.

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