

# 37.0-42.0 GHz GaAs MMIC Power Amplifier

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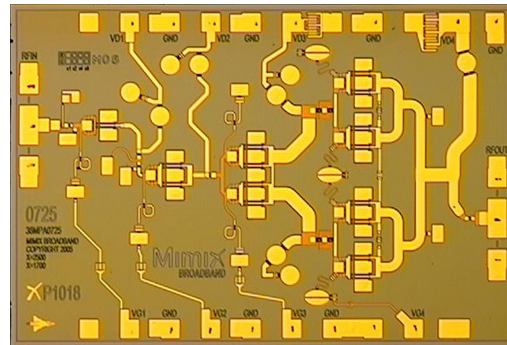
## Features

- X Excellent Transmit Output Stage
- X Output Power Adjust
- X 26.0 dB Small Signal Gain
- X +25.0 dBm P1dB Compression Point
- X 100% On-Wafer RF, DC and Output Power Testing
- X 100% Visual Inspection to MIL-STD-883 Method 2010

## General Description

Mimix Broadband's four stage 37.0-42.0 GHz GaAs MMIC power amplifier has a small signal gain of 26.0 dB with a +25.0 dBm P1dB output compression point. This MMIC uses Mimix Broadband's 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 (Id1,2,3,4)	45,80,165,325 mA
Gate Bias Voltage (Vg)	+0.3 VDC
Input Power (Pin)	TBD
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)

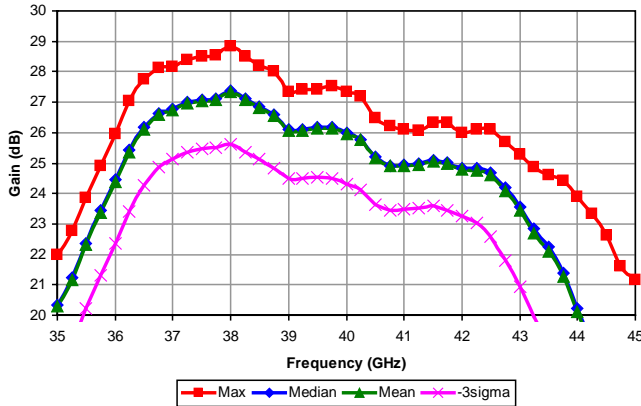
Parameter	Units	Min.	Typ.	Max.
Frequency Range (f)	GHz	37.0	-	42.0
Input Return Loss (S11)	dB	-	9.0	-
Output Return Loss (S22)	dB	-	10.0	-
Small Signal Gain (S21)	dB	-	26.0	-
Gain Flatness ( $\Delta$ S21)	dB	-	+/-1.5	-
Reverse Isolation (S12)	dB	-	45.0	-
Output Power for 1dB Compression (P1dB) <sup>2</sup>	dBm	-	+25.0	-
Drain Bias Voltage (Vd1,2,3,4)	VDC	-	+5.0	+5.5
Gate Bias Voltage (Vg1,2,3,4)	VDC	-1.0	-0.7	0.0
Supply Current (Id1) (Vd=5.0V, Vg=-0.7V Typical)	mA	-	35	40
Supply Current (Id2) (Vd=5.0V, Vg=-0.7V Typical)	mA	-	60	70
Supply Current (Id3) (Vd=5.0V, Vg=-0.7V Typical)	mA	-	125	150
Supply Current (Id4) (Vd=5.0V, Vg=-0.7V Typical)	mA	-	245	295

(2) Measured using constant current.

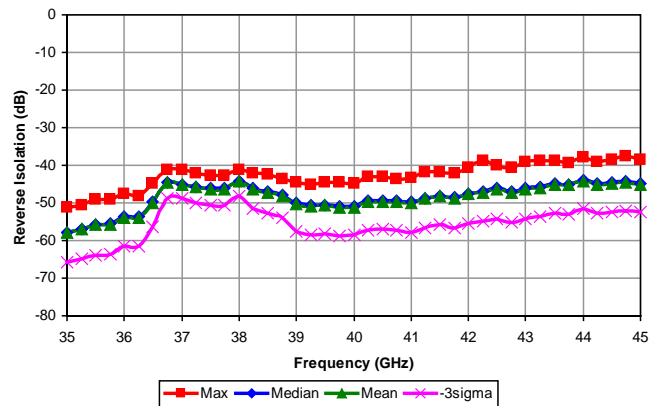
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## Power Amplifier Measurements

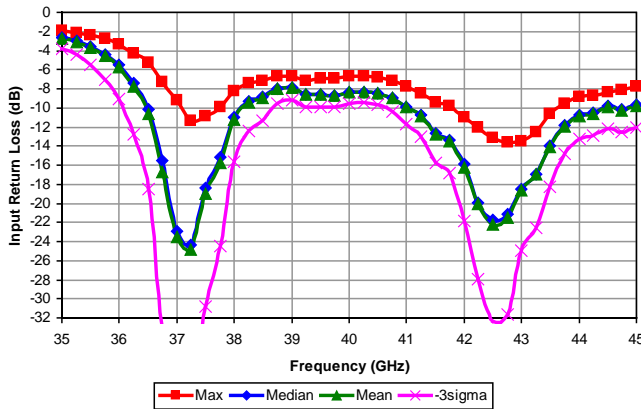
XP1018 Vd1,2,3,4=5.0 V Id1=35 mA, Id2=60 mA, Id3=125 mA, Id4=245 mA, ~2500 Devices



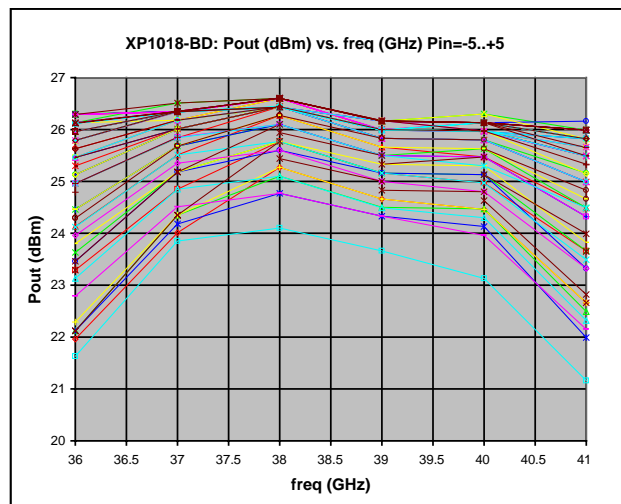
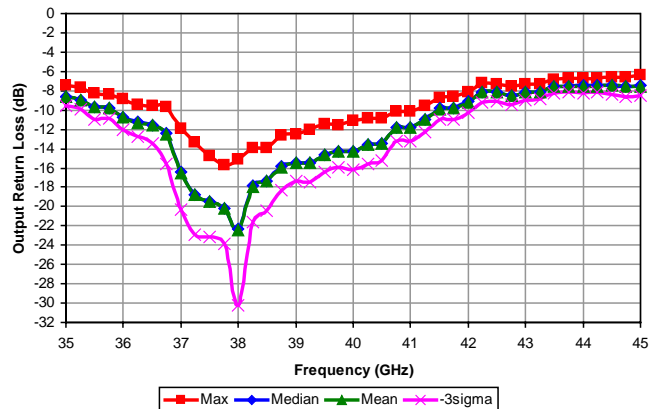
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## Typical S-Parameter Data

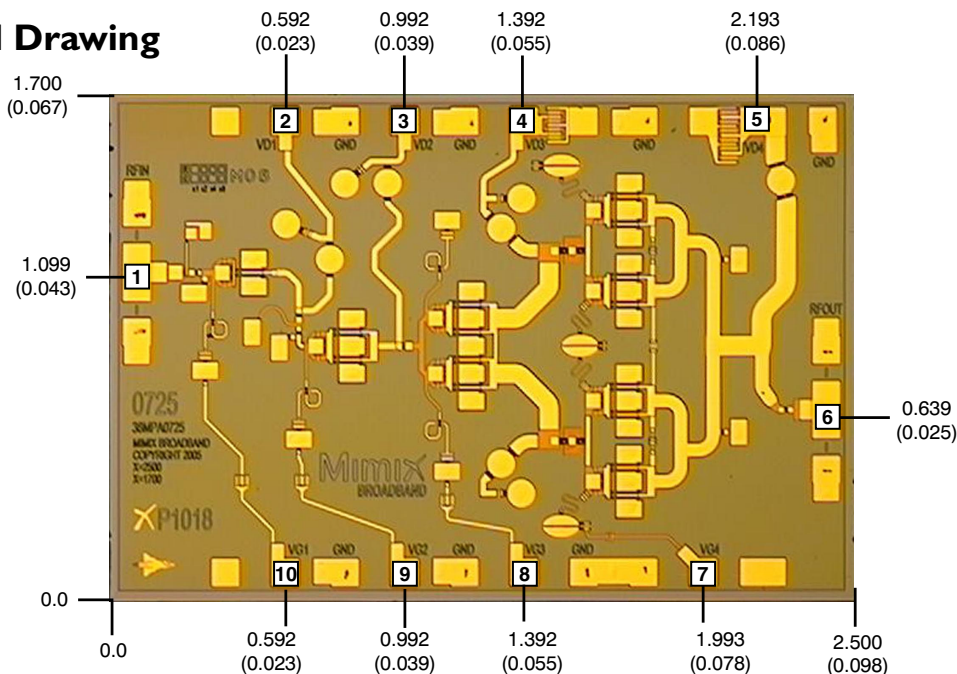
Vd=5.0 V Id1=35 mA, Id2=60 mA, Id3=125 mA, Id4=245 mA

Frequency (GHz)	S11 (Mag)	S11 (Ang)	S21 (Mag)	S21 (Ang)	S12 (Mag)	S12 (Ang)	S22 (Mag)	S22 (Ang)
30.0	0.940	166.72	0.973	126.18	0.0016	125.63	0.793	-116.09
31.0	0.918	160.79	1.439	93.29	0.0014	103.26	0.737	-127.95
32.0	0.895	154.19	2.174	57.85	0.0027	90.17	0.685	-141.44
33.0	0.865	146.15	3.330	18.79	0.0015	31.96	0.605	-155.99
34.0	0.799	134.26	5.328	-23.67	0.0009	-9.64	0.518	-171.42
35.0	0.668	116.35	8.807	-73.36	0.0006	-96.69	0.436	169.08
36.0	0.392	89.70	13.998	-133.53	0.0019	107.67	0.310	147.17
37.0	0.056	-139.88	17.870	154.86	0.0028	134.73	0.239	119.47
38.0	0.361	-163.89	17.691	87.55	0.0027	57.83	0.179	106.28
39.0	0.431	172.55	16.144	29.35	0.0019	35.08	0.178	73.00
40.0	0.390	158.03	15.076	-23.67	0.0023	49.33	0.203	42.37
41.0	0.294	155.03	15.492	-78.70	0.0026	27.34	0.248	0.33
42.0	0.215	170.09	16.183	-139.23	0.0029	4.03	0.326	-40.82
43.0	0.235	-171.97	15.015	152.39	0.0015	-20.71	0.355	-80.28
44.0	0.318	-166.98	11.838	80.99	0.0031	-9.65	0.361	-113.60
45.0	0.372	-177.71	8.093	13.07	0.0029	-57.16	0.355	-134.54
46.0	0.357	153.74	5.027	-52.46	0.0016	-84.71	0.407	-155.94
47.0	0.208	110.14	2.823	-114.47	0.0006	-129.77	0.450	-176.19
48.0	0.167	-13.13	1.439	-174.53	0.0008	-49.86	0.526	165.42
49.0	0.372	-58.88	0.680	134.81	0.0008	-83.22	0.591	147.23
50.0	0.534	-86.46	0.311	88.80	0.0013	-113.98	0.637	131.07

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## Mechanical Drawing



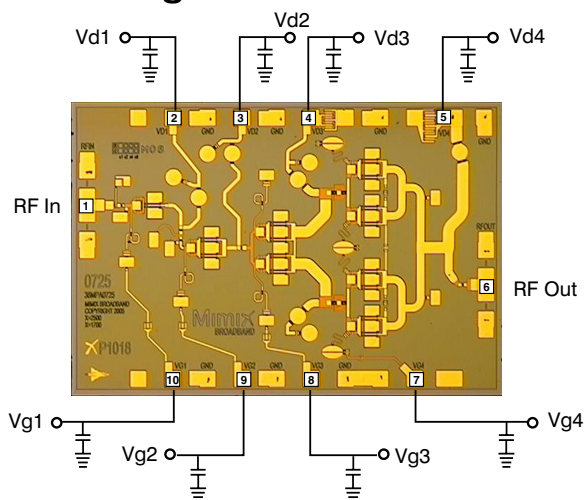
(Note: Engineering designator is 38MPA0725)

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 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: 2.241 mg.

Bond Pad #1 (RF In)	Bond Pad #5 (Vd4)	Bond Pad #8 (Vg3)
Bond Pad #2 (Vd1)	Bond Pad #6 (RF Out)	Bond Pad #9 (Vg2)
Bond Pad #3 (Vd2)	Bond Pad #7 (Vg4)	Bond Pad #10 (Vg1)
Bond Pad #4 (Vd3)		

## Bias Arrangement

Bypass Capacitors - See App Note [2]



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

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**App Note [1] Biasing** - It is recommended to separately bias each amplifier stage Vd1 through Vd4 at Vd(1,2,3,4)=5.0V with Id1=35mA, Id2=60mA, Id3=125mA and Id4=245mA. Separate biasing is recommended if the amplifier is to be used at high levels of saturation, where gate rectification will alter the effective gate control voltage. For non-critical applications it is possible to parallel all stages and adjust the common gate voltage for a total drain current Id(total)=465 mA. It is also recommended to use active biasing to keep the currents constant as the RF power and temperature vary; this gives the most reproducible results. Depending on the supply voltage available and the power dissipation constraints, the bias circuit may be a single transistor or a low power operational amplifier, with a low value resistor in series with the drain supply used to sense the current. The gate of the pHEMT is controlled to maintain correct drain current and thus drain voltage. The typical gate voltage needed to do this is -0.7V. Typically the gate is protected with Silicon diodes to limit the applied voltage. Also, make sure to sequence the applied voltage to ensure negative gate bias is available before applying the positive drain supply.

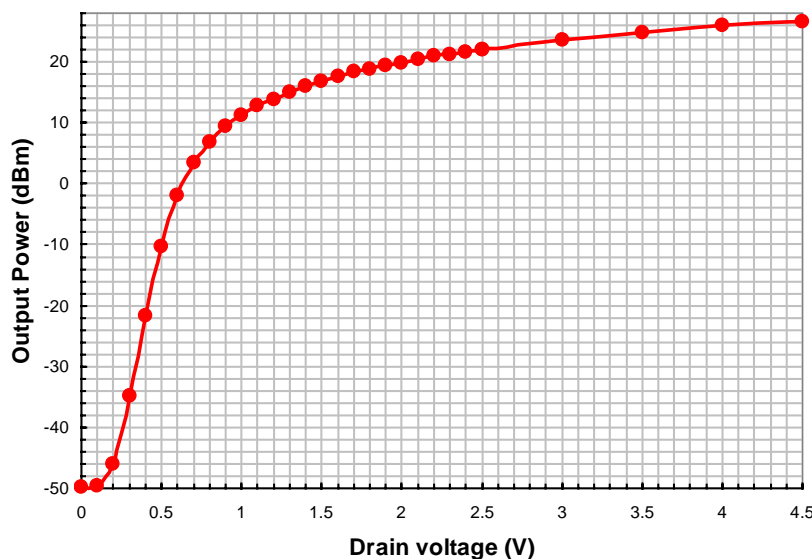
## App Note [2] Bias Arrangement -

For Parallel Stage Bias (Recommended for general applications) -- The same as Individual Stage Bias but all the drain or gate pad DC bypass capacitors (~100-200 pF) can be combined. Additional DC bypass capacitance (~0.01 uF) is also recommended to all DC or combination (if gate or drains are tied together) of DC bias pads.

For Individual Stage Bias (Recommended for saturated applications) -- Each DC pad (Vd1,2,3,4 and Vg1,2,3,4) needs to have DC bypass capacitance (~100-200 pF) as close to the device as possible. Additional DC bypass capacitance (~0.01 uF) is also recommended.

**App Note [3] Output Power Adjust Using Gate Control** - This device has a very useful additional feature. The output power can be adjusted by lowering the individual or combined gate voltages towards pinch off without sacrificing much in the way of Input/Output 3rd Order Intercept Point. Improvements to the IIP3/OIP3 data shown here while attenuating the gain are also possible with individual gate control. Data here has been taken using combined gate control (all gates changed together) to lower the device's output power. The results are shown below. Additionally, the accompanying graphs show the level and linearity of the typical attenuation achievable as the gate is adjusted at various levels until pinch-off.

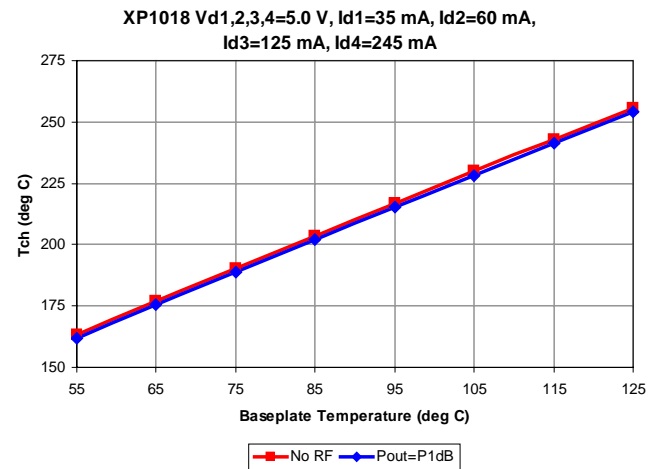
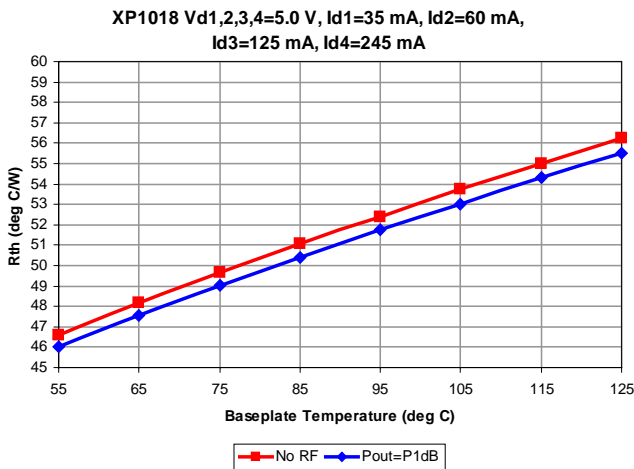
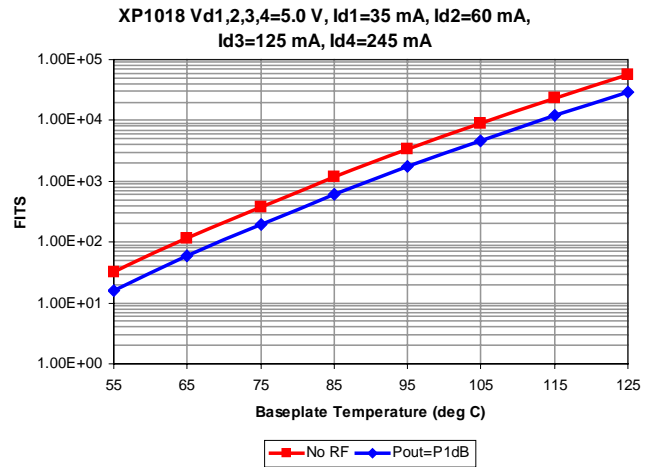
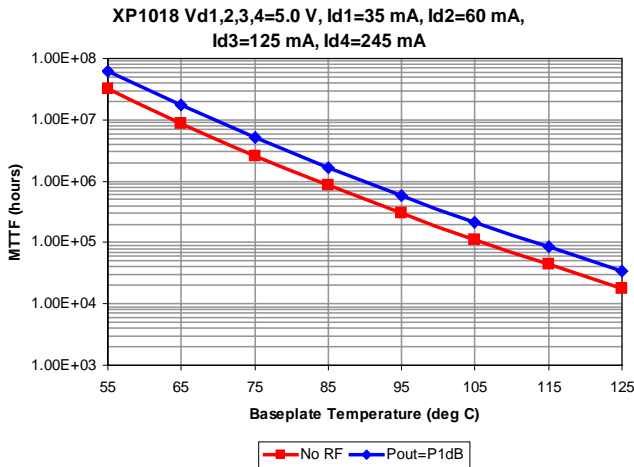
XP1018-BD: Pout vs. Vd @ 40 GHz and Pin=+5dBm



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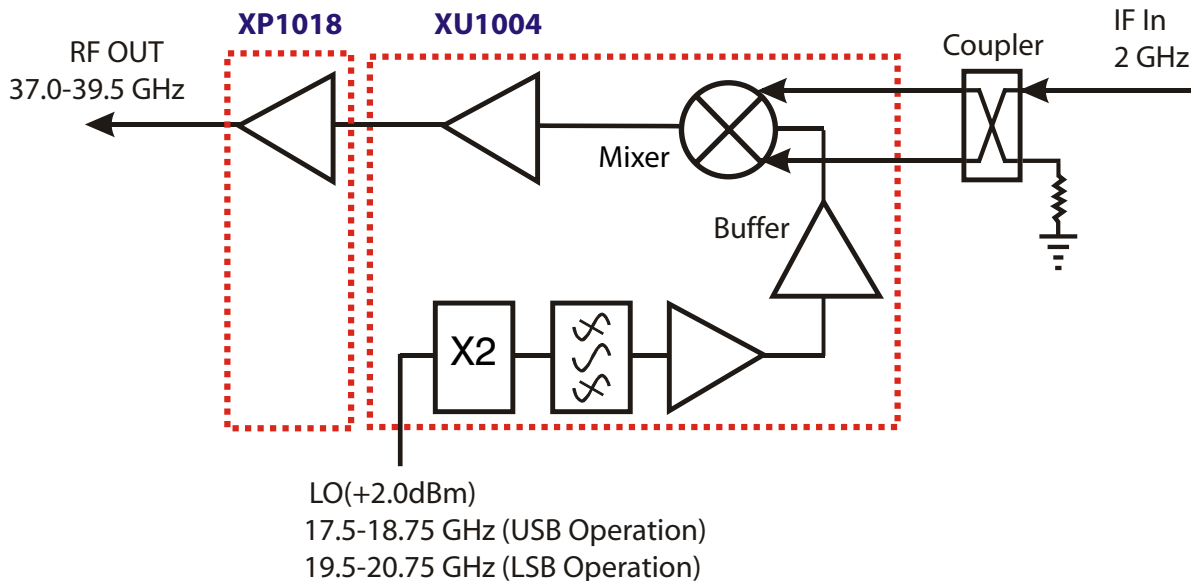
## MTTF Graphs



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## Typical Application



### Mimix Broadband MMIC-based 37.0-42.0 GHz Transmitter Block Diagram

(Changing LO and IF frequencies as required allows design to operate as high as 42 GHz)

Mimix Broadband's 35.0-45.0 GHz XU1004 GaAs MMIC Transmitter can be used in saturated radio applications and linear modulation schemes up to 128 QAM. The receiver can be used in upper and lower sideband applications from 37.0-42.0 GHz.



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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 antistatic workstation. Devices need careful handling using correctly designed collets, vacuum pickups or, with care, sharp tweezers.

**Die Attachment** - GaAs Products from Mimix Broadband are 0.076 mm (0.003") 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 Tanaka TS3332LD, Die Mat DM6030HK or DM6030HK-Pt 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. For additional information please see the Mimix "Epoxy Specifications for Bare Die" application note. If eutectic mounting is preferred, then a fluxless gold-tin (AuSn) preform, approximately 0.001" 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.

Part Number for Ordering	Description
XP1018-BD-000X	Where "X" is RoHS compliant die packed in "V" - vacuum release gel packs or "W" - waffle trays
XP1018-BD-EV1	XP1018-BD evaluation module