30 kHz - 40 GHz GaAs MMIC Distributed Amplifier

Mimix BROADBAND™

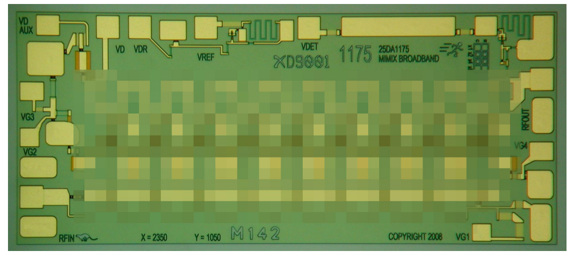
March 2009 - Rev 19-Mar-09

XD1008-BD

Features

- 15 dB Gain
- 22.5 dBm P1dB at 22 GHz
- 4.5 dB Noise Figure at 26 GHz
- Unconditional Stability over Temperature Range
- 100% On-Wafer RF, DC and Output Power Testing
- 100% Visual Inspection to MIL-STD-883 Method 2010

Chip Device Layout



General Description

Mimix Broadband's 30 kHz - 40 GHz GaAs MMIC distributed amplifier has a gain of 15 dB with a 4.5 dB noise figure at 26 GHz. 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 microwave, millimeter-wave, military, wideband and instrumentation applications.

Absolute Maximum Ratings[1]

Parameters/Conditions	Min.	Max.
Supply Voltage (Vd)		+10.0V
Supply Current (Id)		340 mA
Gate Bias Voltage (Vg1)	-9.5V	
Gate Current (Ig1)	-38 mA	+1 mA
Gate Bias Voltage (Vg2)	-3.5V	+4.0V
Gate Current (Ig2)	-20 mA	
CW Input Power (Pin)		17 dBm
Storage Temperature (Tstg)	-65 ºC	+165 ºC
Operating Temperature (Ta)	-55ºC	
Channel Temperature (Tch)		+150 ºC

(1) Absolute maximum ratings for continuous operation unless otherwise noted.

Bias Settings

Parameter	Units	Min.	Typ.	Max.	Function
Drain Current (Id), V=7V, VG1=-2.5V*, VG2=open circuit	mA		200		
Drain Current (Id), V=4V, VG1=-2.5V*, VG2=open circuit	mA		160		
Drain Voltage (Vd)	V	4	7		Supply drain current to device
Gate Bias (Vg1)	V				Adjusted to set drain current
Gate Bias (Vg2)	V				Adjusted for gain control

*approximate

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Electrical Characteristics for High Power Applications[1]
Vdd=7V, Idd(Q)=200 mA, Zin=Zo=50Ω

Parameter and Test Conditions	Units	Min.	Typ.	Max.
Small Signal Gain (S21)	dB		15	
Gain Flatness (ΔS21)	dB		+/-0.75	
Input Return Loss (S11)	dB		16	
Output Return Loss (S22)	dB		16	
Reverse Isolation (S12)	dB		28	
Output Power for 1 dB Compression (P1dB) @ 22 GHz	dBm		22	
Saturated RF Power (Psat) @ 22 GHz	dBm		24.5	
Output 3rd Order Intercept Point (OIP3) @ 22 GHz	dBm		27	
NF Noise Figure (NF) @ 26 GHz	dB		4.5	
NF Noise Figure (NF) @ 40 GHz	dB		6.5	

Electrical Characteristics[1]
Vdd=6V, Idd(Q)=187 mA, Zin=Zo=50Ω

Parameter and Test Conditions	Units	Min.	Typ.	Max.
Small Signal Gain (S21)	dB	14.0[2]	15.5	
Gain Flatness (ΔS21)	dB		+/-0.75	
Input Return Loss (S11)	dB		16	
Output Return Loss (S22)	dB		16	
Reverse Isolation (S12)	dB		28	
Output Power with 7 dB Input Power (Pout)	dBm	20[2]	22	
Output Power for 1 dB Compression (P1dB) @ 22 GHz	dBm		22.5	
Saturated RF Power (Psat) @ 22 GHz	dBm		24.5	
Output 3rd Order Intercept Point (OIP3) @ 22 GHz	dBm		27	
NF Noise Figure (NF) @ 26 GHz	dB		4.5	
NF Noise Figure (NF) @ 40 GHz	dB		6.5	

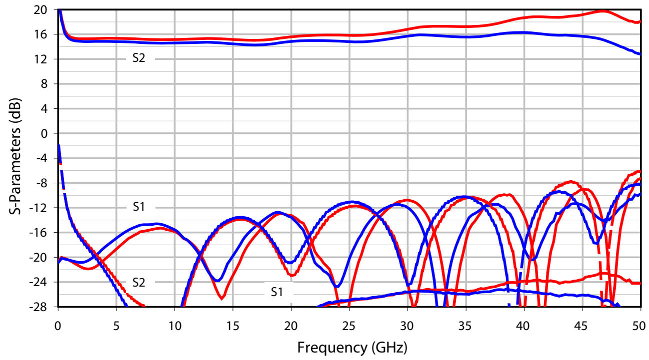
Electrical Characteristics for High Gain, Low Noise Applications[1]
Vdd=4V, Idd(Q)=160 mA, Zin=Zo=50Ω

Parameter and Test Conditions	Units	Min.	Typ.	Max.
Small Signal Gain (S21)	dB		16	
Gain Flatness (ΔS21)	dB		+/-0.75	
Input Return Loss (S11)	dB		16	
Output Return Loss (S22)	dB		16	
Reverse Isolation (S12)	dB		28	
Output Power for 1dB Compression (P1dB) @ 22 GHz	dBm		18	
Saturated RF Power (Psat) @ 22 GHz	dBm		22	
Output 3rd Order Intercept Point (OIP3) @ 22 GHz	dBm		30	
NF Noise Figure (NF) @ 26 GHz	dB		3.5	
NF Noise Figure (NF) @ 40 GHz	dB		5.5	

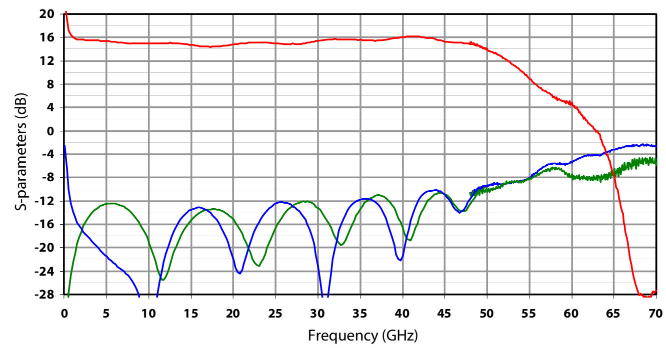
(1) Data measured in wafer form with backside temperature T = 25°C unless otherwise noted.
(2) 100% on-wafer RF test at 5, 25 and 40 GHz

Distributed Amplifier Measurements

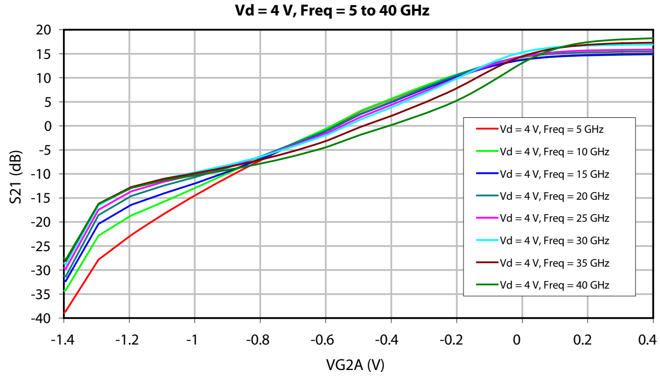
XD1008-BD: S-parameters (dB)
Blue = 7V_200mA, Red = 4V_160mA , VG2 = Open Circuit



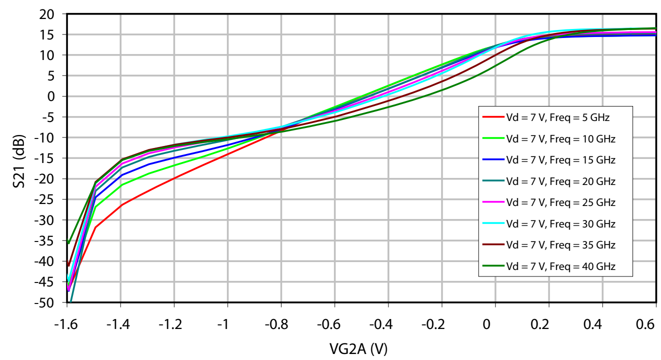
XD1008-BD S-parameters (dB)
at Bias 7 V_200 mA, Freq = 0 GHz - 70 GHz



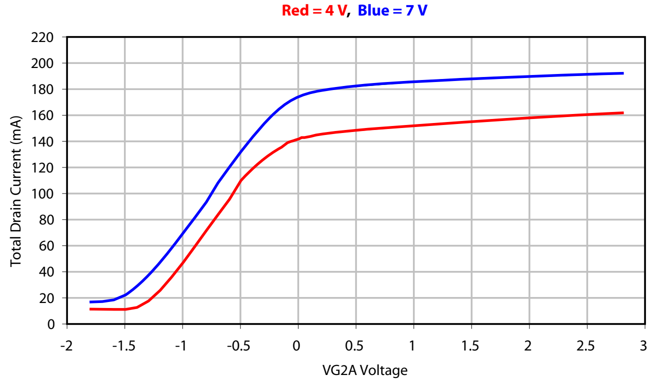
XD1008-BD: Gain Control (dB) vs VG2A Bias (V)
Vd = 4 V, Freq = 5 to 40 GHz



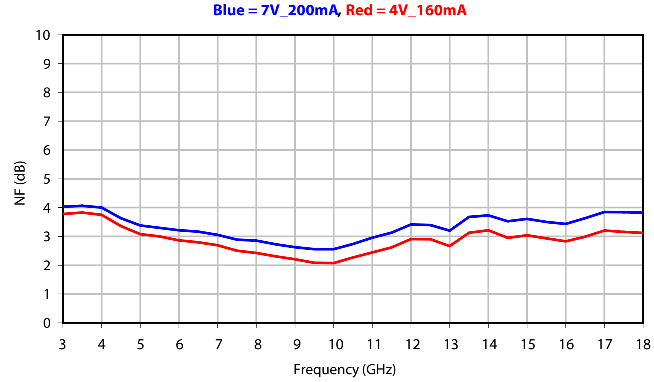
XD1008-BD: Gain Control (dB) vs VG2A Bias (V)
Vd = 7 V, Freq = 5 to 40 GHz



XD1008-BD: Total Drain Current (mA) vs VG2A (V)
Red = 4 V, Blue = 7 V

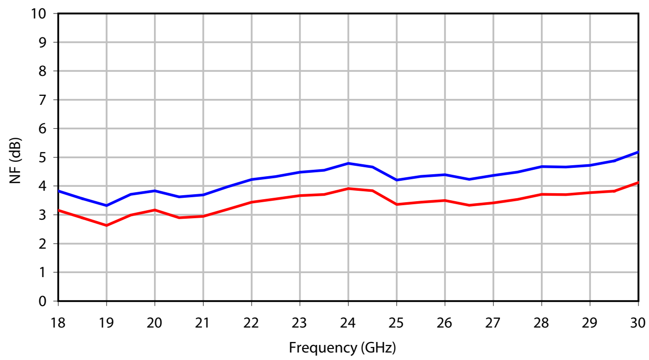


XD1008-BD: Noise Figure (dB) vs Frequency (GHz)
Blue = 7V_200mA, Red = 4V_160mA

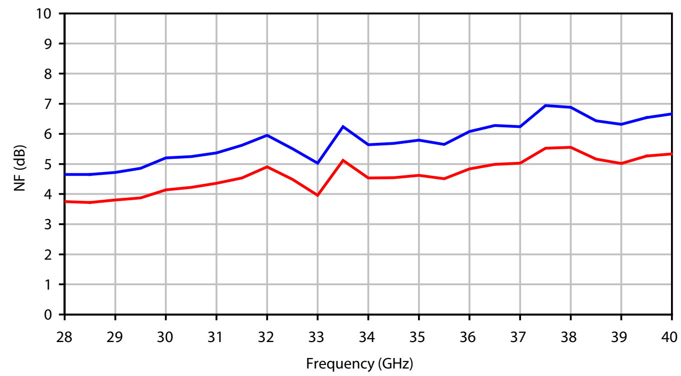


Distributed Amplifier Measurements (cont.)

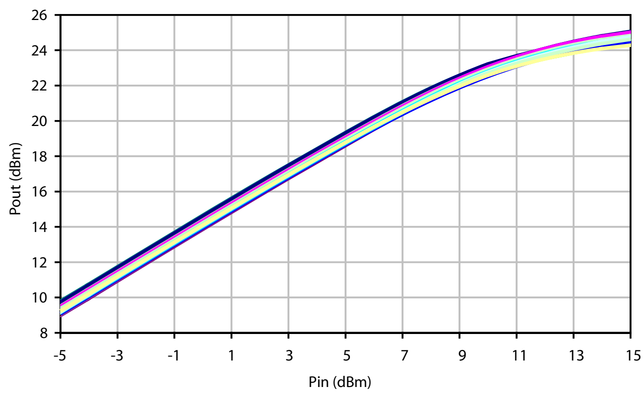
XD1008-BD: Noise Figure (dB) vs Frequency (GHz)
Blue = 7V_200mA, Red = 4V_160mA



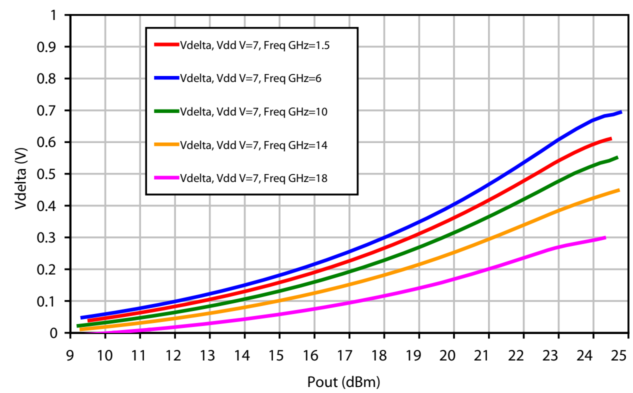
XD1008-BD: Noise Figure (dB) vs Frequency (GHz)
Blue = 7V_200mA , Red = 4V_160mA



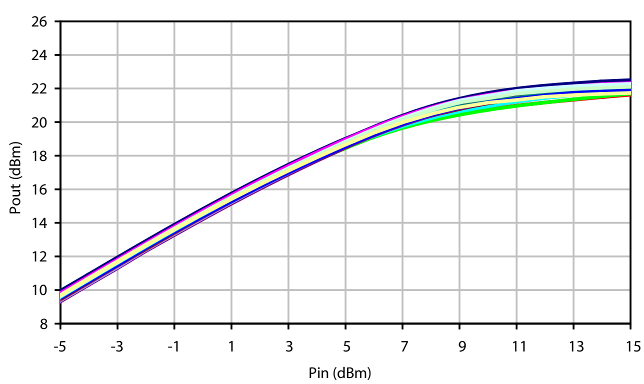
XD1008-BD: Pout (dBm) vs. Pin (dBm)
RF = 1.5 to 18 GHz, Vdd = 7 V, Idd = 200 mA



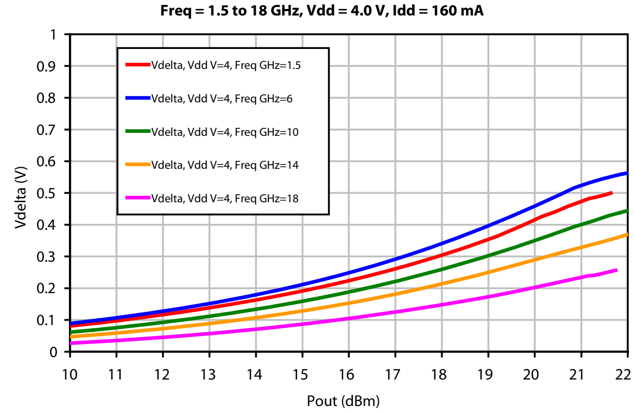
XD1008-BD: Vdelta (V) vs. Pout (dBm)
Freq = 1.5 to 18 GHz, Vdd = 7.0 V, Idd = 200 mA



XD1008-BD: Pout (dBm) vs. Pin (dBm)
RF = 1.5 to 18 GHz, Vdd = 4 V, Idd = 160 mA

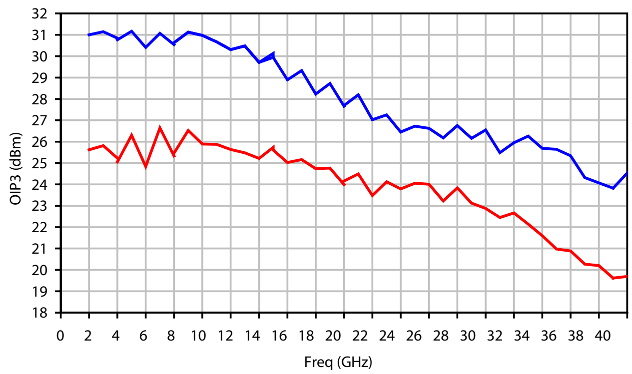


XD1008-BD: Vdelta (V) vs. Pout (dBm)
Freq = 1.5 to 18 GHz, Vdd = 4.0 V, Idd = 160 mA

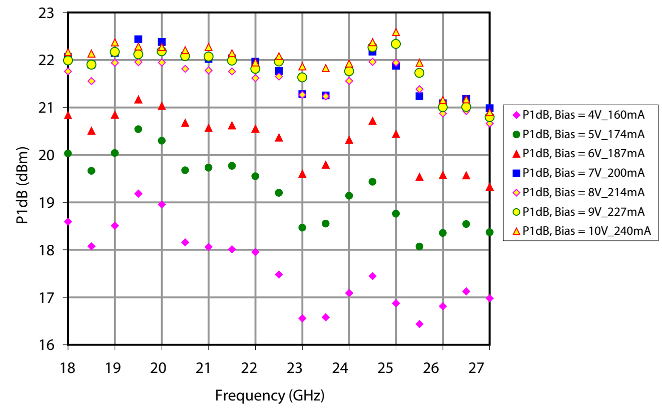


Distributed Amplifier Measurements (cont.)

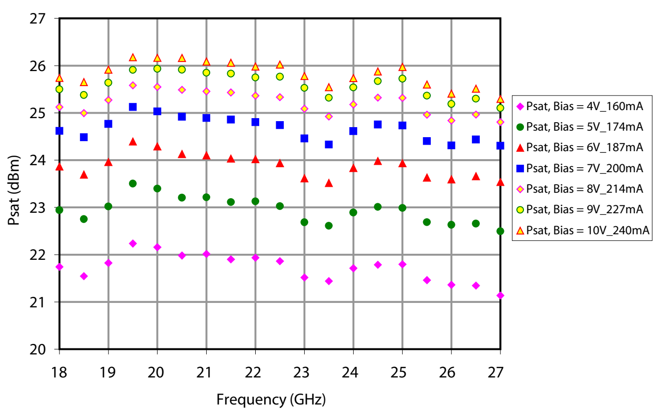
XD1008-BD: OIP3 (dBm) vs Freq (GHz)
Pin = 2 dBm, Blue = 7V_200mA , Red = 4V_160mA



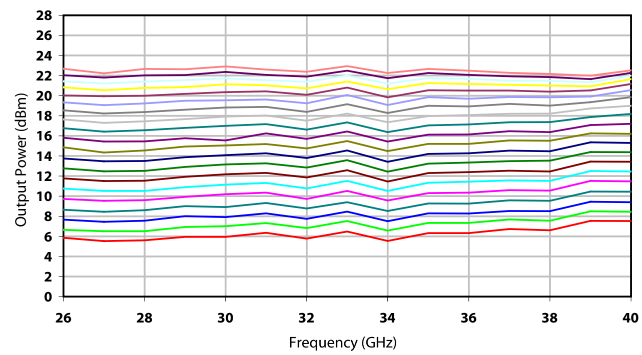
XD1008-BD: P1dB (dBm) vs Freq (GHz)



XD1008-BD: Psat (dBm) vs Freq (GHz)

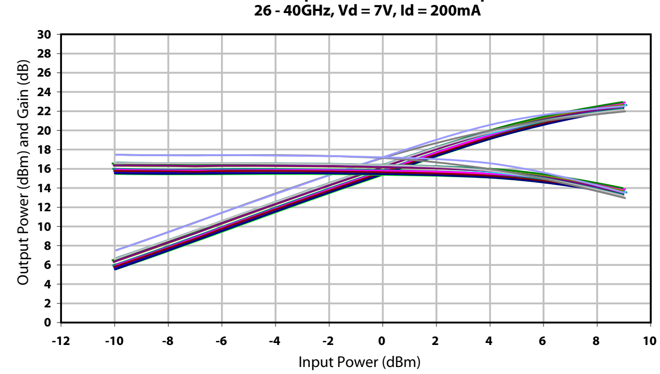


XD1008-BD: Output Power at Vd= 7V, Id = 200mA,
26-40 GHz with Pin -10 to +9 dBm



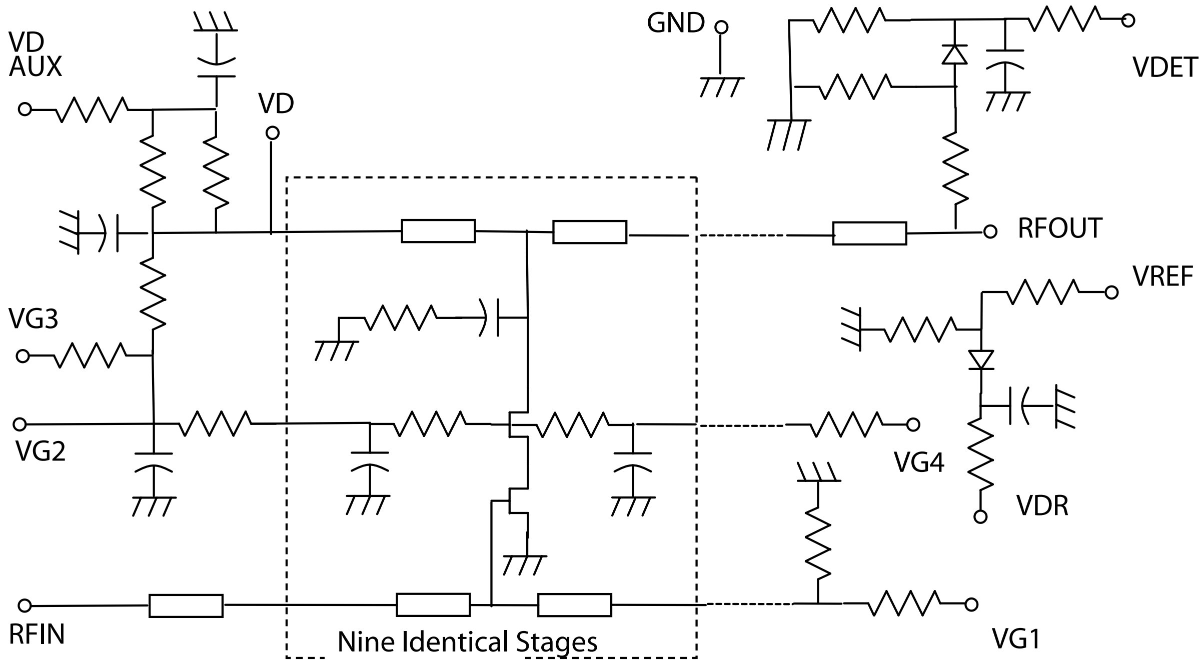
XD1008-BD: Output Power vs Input Power.
26 - 40 GHz, Vd = 7V, Id = 200mA

XD1008-BD: Output Power and Gain vs Input Power.
26 - 40GHz, Vd = 7V, Id = 200mA

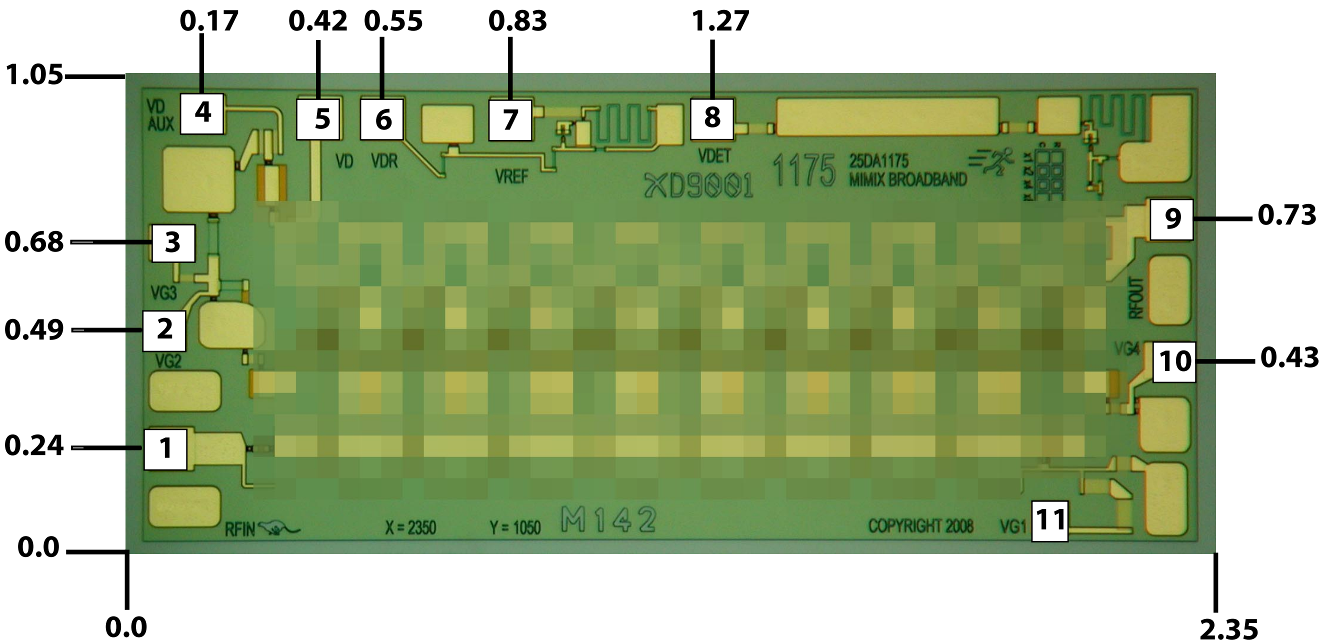


App Note [1] Biasing - The detector diode can be used to measure output power over a broad bandwidth. The detector diode is biased through the PA drain supply and the output voltage is measured at VDET with a high impedance voltage measurement device. A reference diode is also included which may be used to compensate for temperature and manufacturing process variation. The reference diode is biased through pin VDR with the same voltage as the PA drain supply and the voltage difference Vdelta = VDET – VREF is used to measure output power with temperature and manufacturing process compensation.

Biasing Schematic

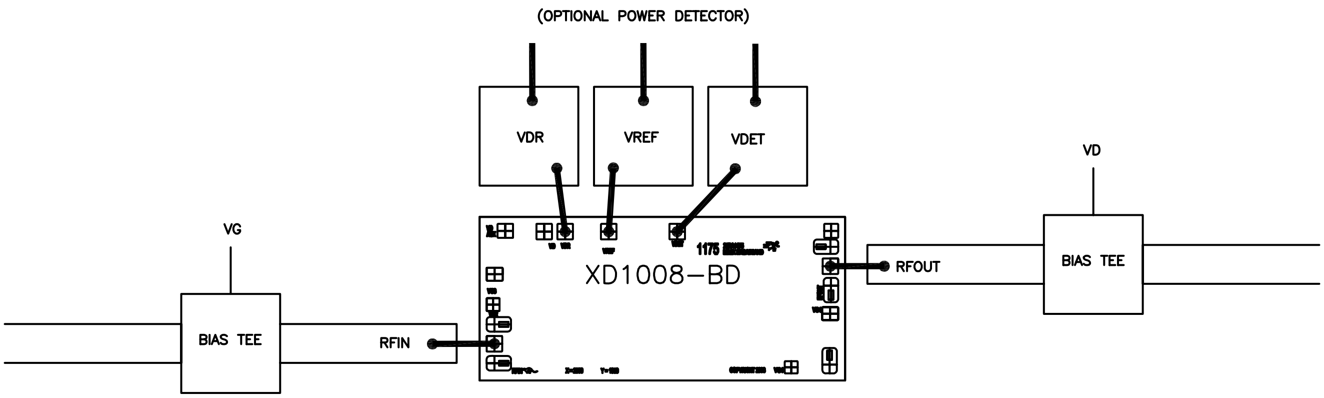


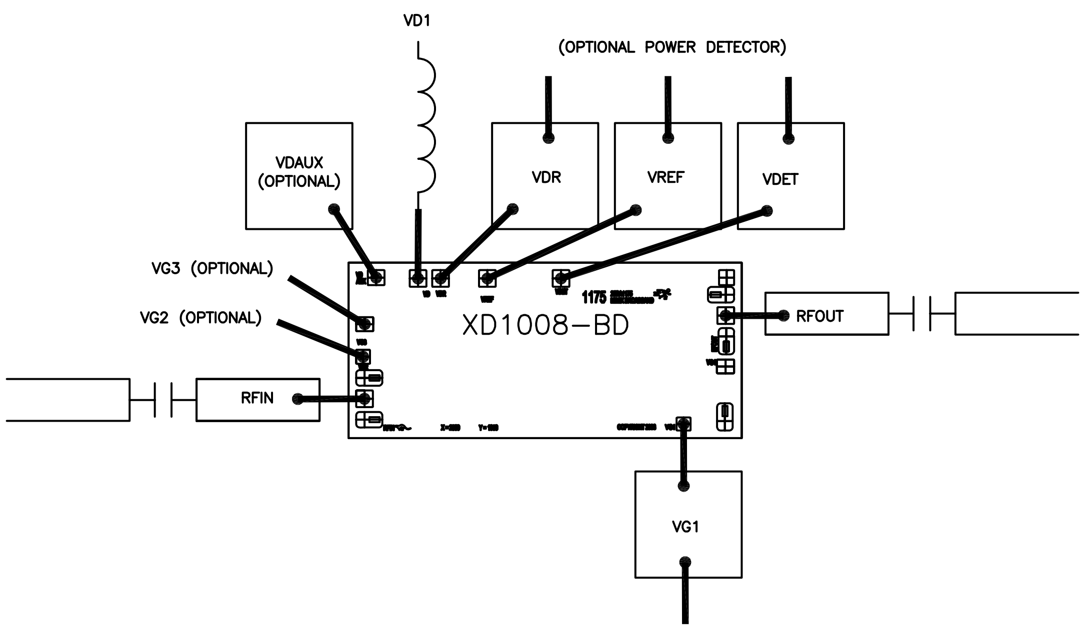
Layout Dimensions



Pin1 – RF IN
Pin2 – VG2, not connected for basic application, but can be used for gain control (VG2 = 2V to -2V)
Pin3 – VG3, not connected for basic application, can be used for gain peaking
Pin4 – VD Aux, not connected, but can be used for capacitive bypass for operation at frequencies lower than 2 GHz
Pin5 – VD – detector bias, the same as VD for the amplifier
Pin6 – VDR – bias voltage for reference diode (see application note)
Pin7 – VDREF – detector reference (see application note)
Pin8 – VDET – detector diode (see application note)
Pin9 – RFOUT
Pin10 – VG4, not connected
Pin11 – VG1, first gate bias typically bias at -2.5V to get -0.5V on the device.

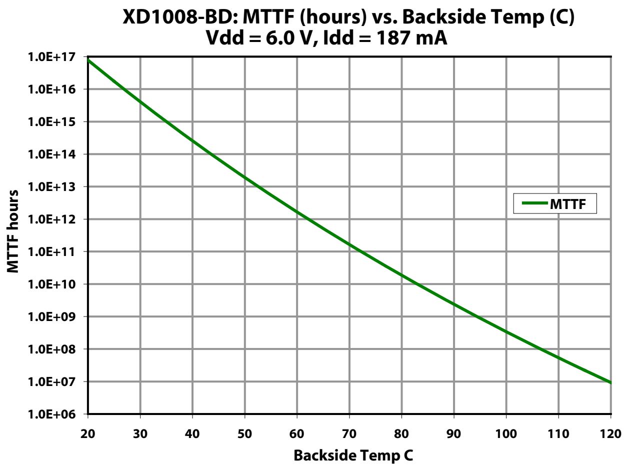
Bonding Diagram

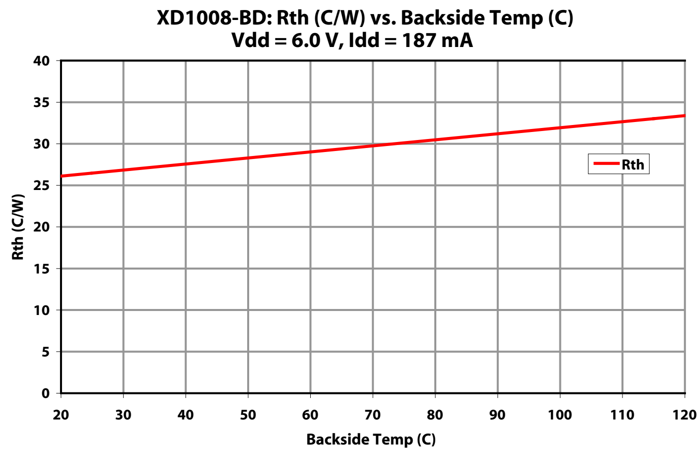


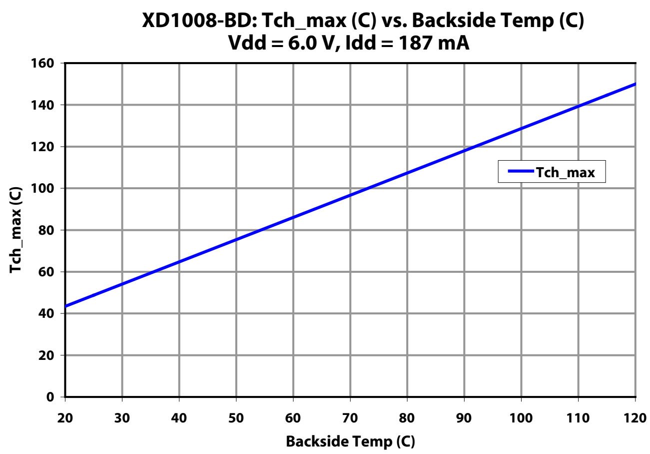


MTTF Graphs

These numbers were calculated based upon accelerated life test information received from the fabricating foundry and extensive thermal modeling/ finite element analysis done at Mimix Broadband. The values shown here are only to be used as a guideline against the end application requirements and only represent reliability information under one bias condition. Ultimately bias conditions and resulting power dissipation along with the practical aspects, i.e. thermal material stack-up, attach method of die placement are the key parts in determining overall reliability for a specific application, see previous pages. If the data shown below does not meet your reliability requirements or if the bias conditions are not within your operating limits please contact technical sales for additional information.







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 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 0.001^2 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 +/- 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.

Ordering Information

Part Number for Ordering	Description
XD1008-BD-000V	"V" - vacuum release gel paks
XD1008-BD-EV1	XD1008 die evaluation module

Note: Physical die may be labeled XD9001.

Caution: ESD Sensitive
Appropriate precautions in handling, packaging and testing devices must be observed.

Proper ESD procedures should be followed when handling this device.

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