

# 500-6000 MHz Dual, Ultra Low Noise, High IP3 Amplifier

Mimix  
BROADBAND™

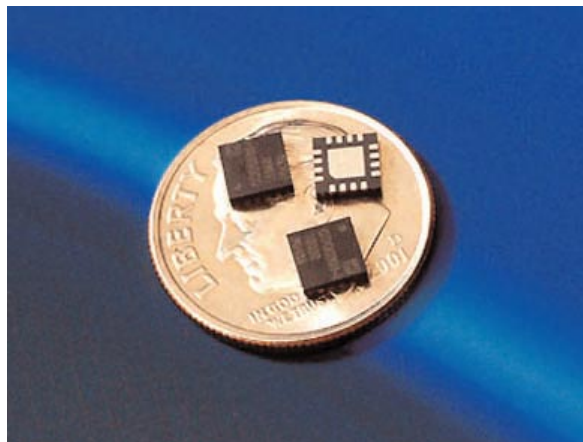
May 2006 - Rev 24-May-06

CDQ0303-QS

RoHS

## Features

- ✕ Matched Pair of Transistors for Optimum Balanced Amplifier Design
- ✕ AlGaAs/InGaAs/AlGaAs Pseudomorphic High Electron Mobility Transistor (pHEMT)
- ✕ High Gain:
  - 25 dB @ 900 MHz
  - 21 dB @ 1900 MHz
- ✕ Low Noise Figure:
  - 0.6 dB @ 900 MHz
  - 0.7 dB @ 1900 MHz
- ✕ 17 dBm P1dB at 2 GHz
- ✕ 33 dBm OIP3 at 2 GHz
- ✕ 600 $\mu$ m Gate Width: 50 $\Omega$  Output Impedance
- ✕ Excellent Uniformity
- ✕ Ultra Compact Surface-Mount QFN Package
- ✕ 10 Year MTBF Lifetime
- ✕ RoHS-Compliant Construction



## Applications

- ✕ Low Noise Amplifiers and Oscillators Operating over the RF and Microwave Frequency Ranges
- ✕ Cellular/PCS/GSM/W-CDMA
- ✕ Mobile Handsets, Base Station Receivers and Tower-Mount Amplifiers
- ✕ WiMAX WLAN, LEO, GEO, WLL/RLL, GPS and MMDS Applications
- ✕ General Purpose Discrete pHEMT for Other Ultra Low-Noise and Medium Power Applications

## Description

The CDQ0303-QS is a dual, ultra low-noise amplifier combining high gain, state-of-the-art noise figure and high IP3. Utilizing Mimix's distinctive in-house GaAs fabrication advantage and matched pair technology, co-located matched transistor die are assembled in the 4mm x 4mm QFN package. The low-cost, surface-mount, 16 terminal, plastic package is also lead-free.

Packaging a matched pair of ultra low-noise devices in a single package makes the CDQ0303-QS an ideal product for balanced amplifier implementation. It is intended for many applications operating in the 900 MHz to 2400 MHz

## Typical Specifications (50 $\Omega$ System)

Parameter	900 MHz	1900 MHz	2400 MHz	Units
S21 Gain	23.5	20.0	16.0	dB
S11 Input Return Loss	-3.0	-4.0	-3.0	dB
S22 Output Return Loss	-3.5	-4.5	-7.0	dB
Output IP3	31.8	32.5	32.7	dBm
Output P1 dB	16.5	16.0	16.0	dBm
Noise Figure	0.55	0.72	0.89	dB
Operating Current Range	50	50	50	mA
Supply Voltage	3.0	3.0	3.0	V

Note: Typical specifications represents performance for each side of the matched pair of transistors in the recommended application circuit board (see page 15). It is anticipated that the pair will be used in a balanced circuit configuration, hence the matches are optimized for best noise figure and OIP3 performance.

frequency range. It can also be used in a dual-band configuration where a single transistor is used for each band.

Mimix's high performance packaged pHEMTs are ideal for use in all applications where low-noise figure, high gain, medium power and good intercept is required. The CDQ0303-QS is the perfect solution for the first or second stage of a base station LNA due to the excellent combination of low-noise figure and linearity. It is also well suited as a medium power driver stage in pole-top amplifiers and other transmit functions, particularly as the low thermal resistance allows extended power dissipation when voltage and current are adjusted for increased power and linearity.

# 500-6000 MHz Dual, Ultra Low Noise, High IP3 Amplifier

Mimix  
BROADBAND™

May 2006 - Rev 24-May-06

CDQ0303-OS  
XRoHS

## Electrical Characteristics

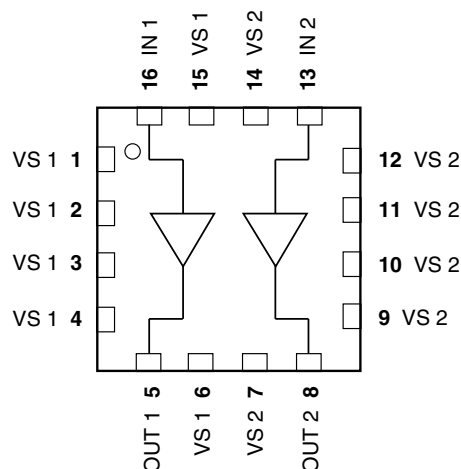
Ta=25°C, Typical device RF parameters measured in test system.

Parameters	Test Conditions	Min	Typ	Max	Units
Operating Frequency		500		3000	MHz
DC Supply Voltage	Vdd Only		3		V
Saturated Drain Current (Per Device)	Vds=4.5V, Vgs=0V	120	165	200	mA
Idd (Per Device)	Vgg=-0.65 nom		60		mA
Transconductance (Per Device)	Vds=4.5V, Gm=Idss/Vp	190	250		mmho
Associated Gain <sup>1</sup>	f=900 MHz Vd=3V, Ids=50 mA f=1900 MHz Vd=3V, Ids=50 mA	23 18	25 20		dB dB
Noise Figure <sup>1</sup>	f=900 MHz Vd=3V, Ids=50 mA f=1900 MHz Vd=3V, Ids=50 mA		0.6 0.7		dB dB
Output Third Order Intercept Point <sup>1</sup>	f=900 MHz Vd=3V, Ids=50 mA f=1950 MHz Vd=3V, Ids=50 mA		29 29		dBm dBm
Isolation (Between IN1 and IN2)	f=900 MHz Vd=3V, Ids=50 mA f=1950 MHz Vd=3V, Ids=50 mA		34 29		dB dB
Input Overdrive Tolerance Level	Returns to full operation after 1 min.			17	dBm
ESD (ESD precautions should be followed)	ESD (HBM) for (All I/Os)	600			V

Notes:

1. Measured in Celeritek Evaluation Board (No circuit de-embedding used). See page 15.

## Functional Block Diagram



## Pin Out Detail

Pin	Function	Description
16	IN 1	Amplifier 1 RF Input
13	IN 2	Amplifier 2 RF Input
5	OUT 1	Amplifier 1 RF Output
8	OUT 2	Amplifier 2 RF Output
1, 2, 3, 4	VS 1	Amplifier 1 Source Connection
9, 10, 11, 12	VS 2	Amplifier 2 Source Connection
6, 7, 14, 15	GND	Main Heat-Sinking Connection

## Absolute Maximum Ratings<sup>1</sup>

Parameter	Rating	Parameter	Rating	Parameter	Rating
Drain-Source Voltage <sup>2</sup>	+5.5 V	Drain Current <sup>2</sup>	Idss <sup>3</sup> A	Channel Temperature	+175°C
Gate-Source Voltage <sup>2</sup>	-5.0 V	Total Pwr Dissipation	1.12 W	Storage Temperature	-65°C to +160°C
Gate-Drain Voltage <sup>2</sup>	-5.0 V	RF Input Power	17 dBm	Thermal Resistance	70°C/W

Notes:

1. Operation of this device above any one of these parameters may cause permanent damage

2. Assumes DC quiescent conditions. RF OFF.

3. Vgs=0V

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

Page 2 of 14

Characteristic Data and Specifications are subject to change without notice. ©2006 Mimix Broadband, Inc.  
Export of this item may require appropriate export licensing from the U.S. Government. In purchasing these parts, U.S. Domestic customers accept their obligation to be compliant with U.S. Export Laws.

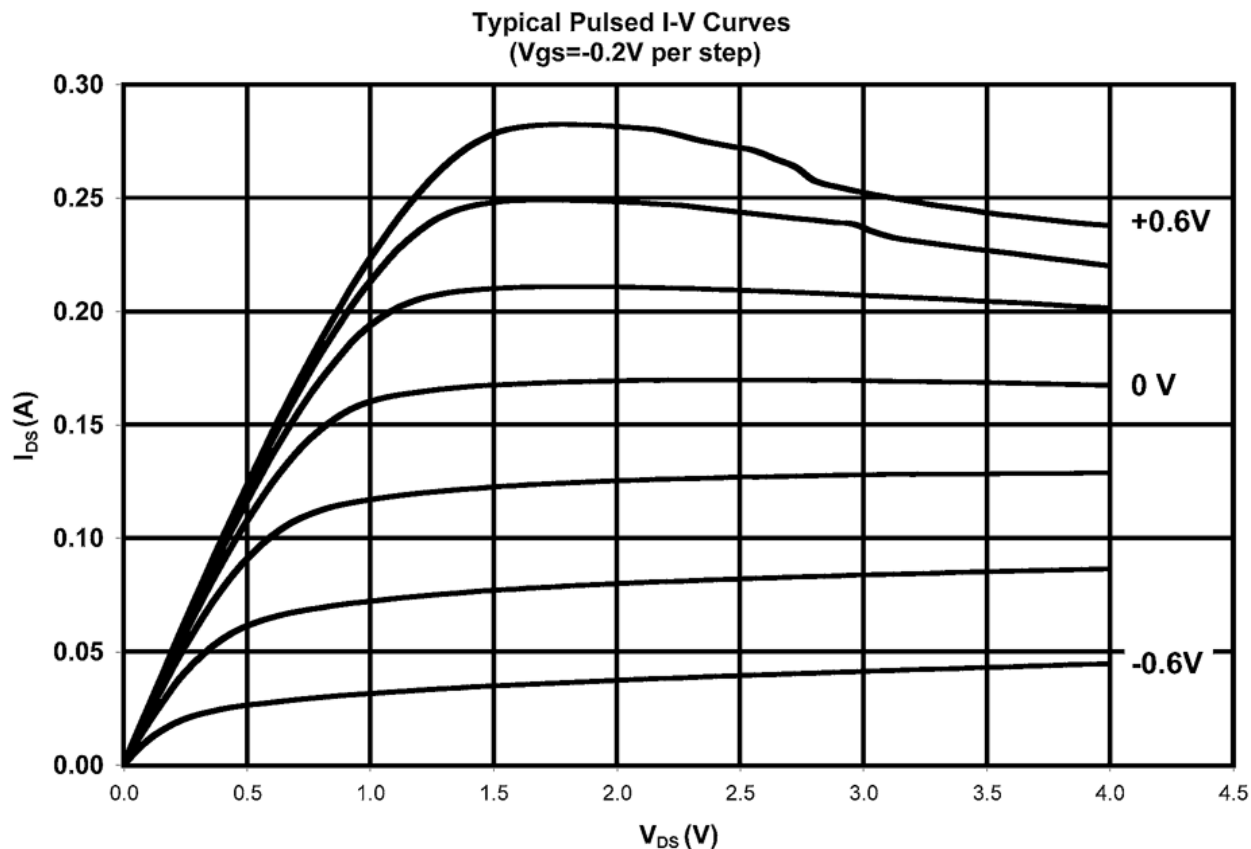
# 500-6000 MHz Dual, Ultra Low Noise, High IP3 Amplifier

May 2006 - Rev 24-May-06

Mimix  
BROADBAND™

CDQ0303-OS  
RoHS

## Typical Pulsed I-V Performance



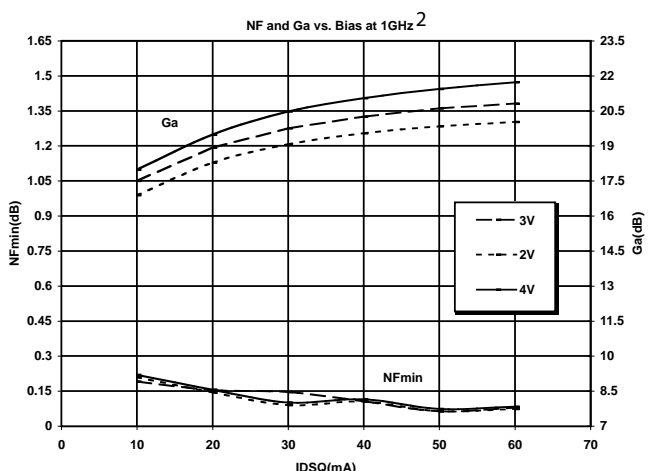
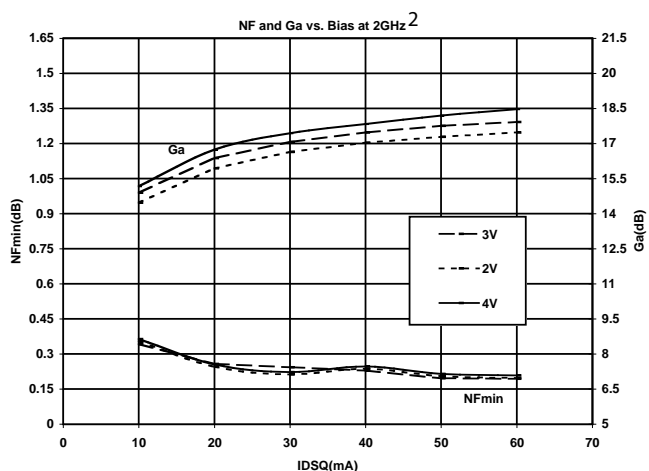
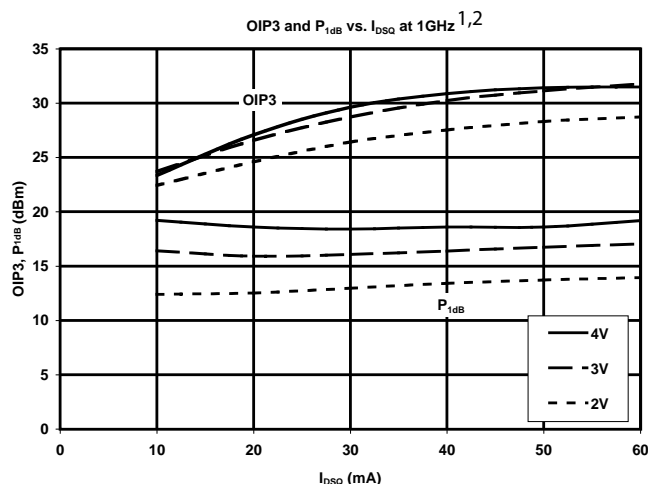
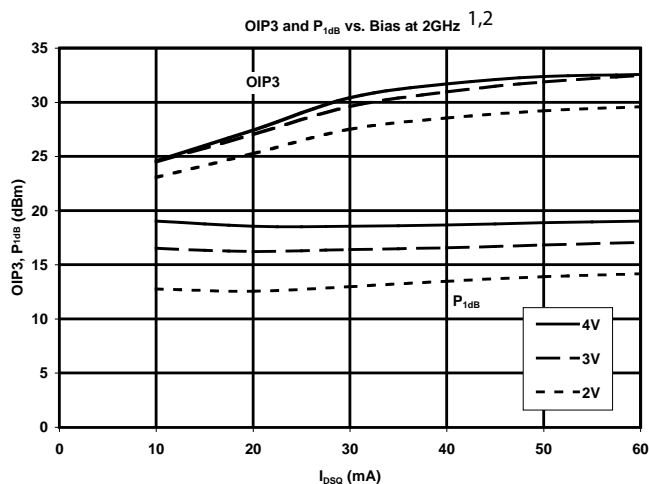
# 500-6000 MHz Dual, Ultra Low Noise, High IP3 Amplifier

Mimix  
BROADBAND™

May 2006 - Rev 24-May-06

CDQ0303-OS  
RoHS

## Typical Performance



### Notes:

1. P<sub>1dB</sub> and OIP3 measurements are performed with passive biasing. Idsq is set with zero RF drive applied. As P<sub>1dB</sub> is approached the drain current may increase or decrease depending on frequency and DC bias point. At lower values of Idsq the device is running in a Class AB mode and current tends to rise as P<sub>1dB</sub> is approached. As an example, at a V<sub>ds</sub> = 3.0V and Idsq = 10 mA, Id increases to 30 mA as P<sub>1dB</sub> of 16.5 is approached. This rise in current is no longer present as Idsq approaches 60 mA.

2. Measurements made on a fixed tuned test system set for optimum noise match. Circuit losses have been de-embedded for the actual measurements.

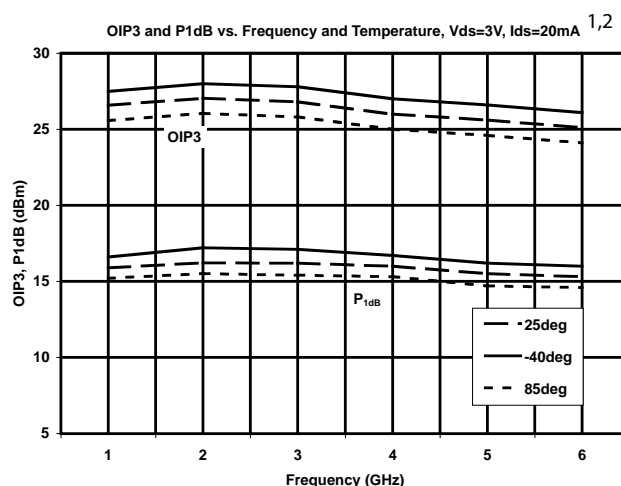
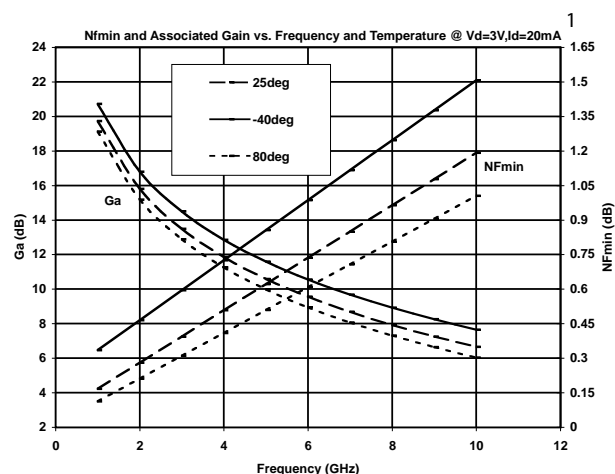
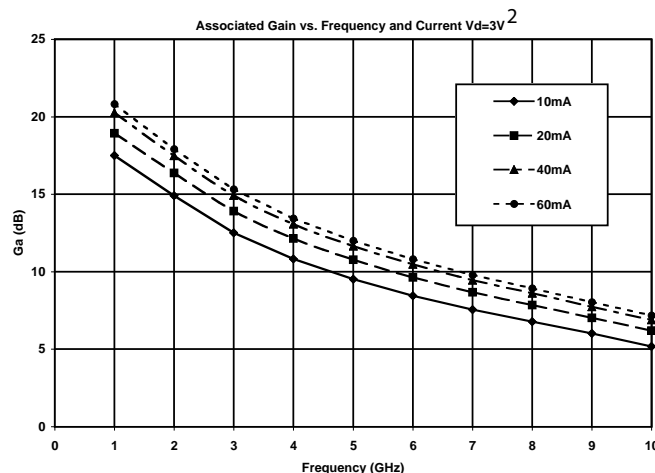
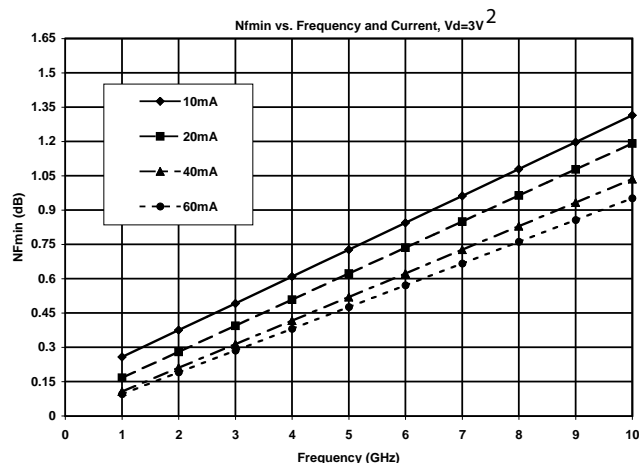
# 500-6000 MHz Dual, Ultra Low Noise, High IP3 Amplifier

Mimix  
BROADBAND™

May 2006 - Rev 24-May-06

CDQ0303-OS  
RoHS

## Typical Performance



### Notes:

1. P1dB and OIP3 measurements are performed with passive biasing.  $I_{dsq}$  is set with zero RF drive applied. As P1dB is approached, the drain current may increase or decrease depending on frequency and DC bias point. At lower values of  $I_{dsq}$  the device is running in a Class AB mode and current tends to rise as P1dB is approached. As an example, at a  $V_{ds} = 3.0V$  and  $I_{dsq} = 10 mA$ ,  $I_d$  increases to 30 mA as P1dB of 16.5 is approached. This rise in current is no longer present as  $I_{dsq}$  approaches 60 mA.

2. Measurements made on a fixed tuned test system set for optimum noise match. Circuit losses have been de-embedded for the actual measurements.

# 500-6000 MHz Dual, Ultra Low Noise, High IP3 Amplifier

**Mimix**  
BROADBAND™

May 2006 - Rev 24-May-06

**CDQ0303-QS**

**RoHS**

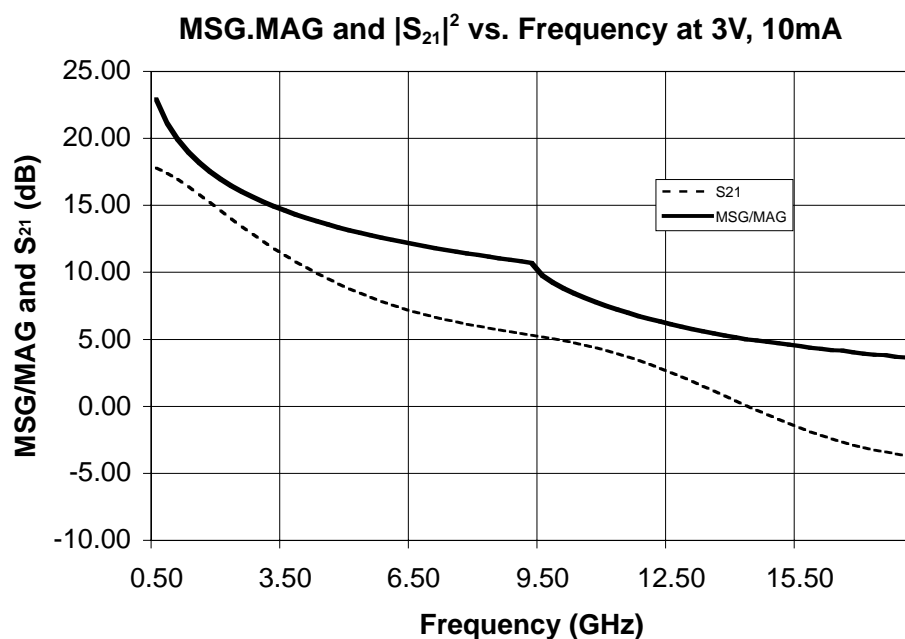
## Typical Noise Parameters

S-Parameter Data Files are available on-line at: [www.mimixbroadband.com](http://www.mimixbroadband.com)

### CDQ0303-QS Typical Noise Parameters

(V<sub>ds</sub> = +3.0V, I<sub>ds</sub> = 10 mA)

Freq. GHz	NFmin db	Gamma Opt Mag.	Opt Ang.	Rn	Ga db
1.0	0.19	0.83	30.97	0.44	17.51
2.0	0.34	0.74	56.07	0.41	14.90
3.0	0.49	0.66	77.32	0.52	12.51
4.0	0.64	0.57	96.15	0.69	10.82
5.0	0.78	0.50	114.83	0.26	9.52
6.0	0.92	0.44	135.28	0.11	8.45
7.0	1.04	0.38	159.59	0.07	7.55
8.0	1.14	0.37	-173.41	0.08	6.78
9.0	1.23	0.40	-149.74	0.13	6.01
10.0	1.29	0.46	-133.22	0.23	5.18



# 500-6000 MHz Dual, Ultra Low Noise, High IP3 Amplifier

Mimix  
BROADBAND™

May 2006 - Rev 24-May-06

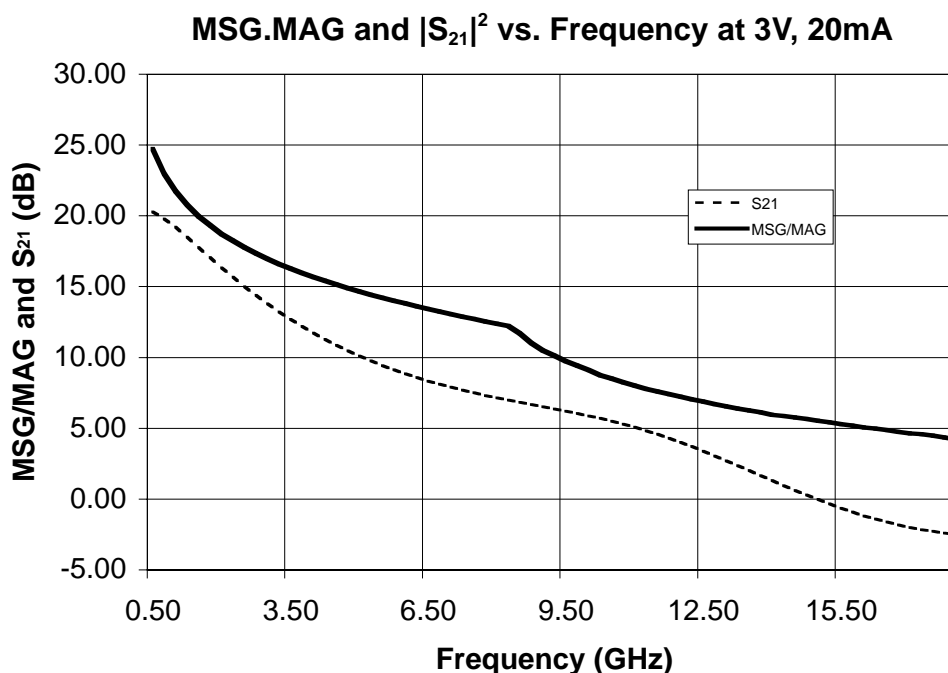
CDQ0303-OS  
RoHS

## Typical Noise Parameters

S-Parameter Data Files are available on-line at: [www.mimixbroadband.com](http://www.mimixbroadband.com)

### CDQ0303-QS Typical Noise Parameters (V<sub>ds</sub> = +3.0V, I<sub>ds</sub> = 20 mA)

Freq. GHz	NFmin db	Gamma Opt Mag.	Ang.	Rn	Ga db
1.0	0.15	0.83	22.26	0.23	18.93
2.0	0.26	0.72	59.00	0.24	16.38
3.0	0.38	0.59	88.09	0.40	13.92
4.0	0.50	0.49	112.62	0.33	12.14
5.0	0.63	0.40	135.17	0.10	10.78
6.0	0.76	0.33	157.85	0.06	9.64
7.0	0.88	0.29	-178.05	0.07	8.67
8.0	1.00	0.29	-157.41	0.08	7.85
9.0	1.10	0.34	-145.46	0.10	7.02
10.0	1.21	0.41	-142.31	0.12	6.19



# 500-6000 MHz Dual, Ultra Low Noise, High IP3 Amplifier

**Mimix**  
BROADBAND™

May 2006 - Rev 24-May-06

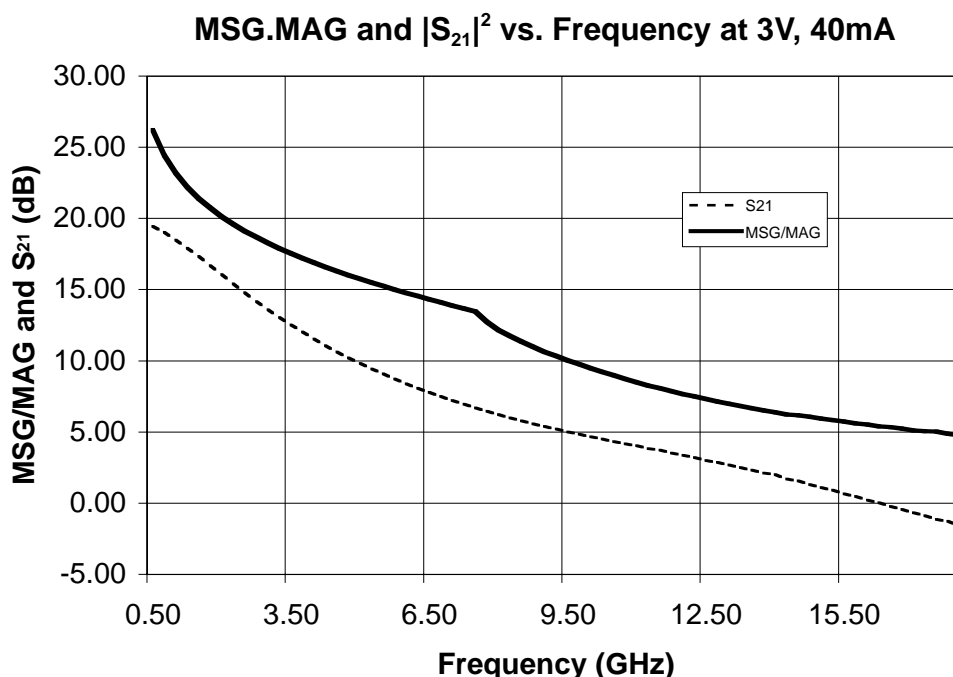
**CDQ0303-OS**  
RoHS

## Typical Noise Parameters

S-Parameter Data Files are available on-line at: [www.mimixbroadband.com](http://www.mimixbroadband.com)

### CDQ0303-QS Typical Noise Parameters (V<sub>ds</sub> = +3.0V, I<sub>ds</sub> = 40 mA)

Freq. GHz	NFmin db	Gamma Opt Mag.	Ang.	Rn	Ga db
1.0	0.11	0.74	23.04	0.19	20.26
2.0	0.23	0.64	61.25	0.24	17.47
3.0	0.35	0.54	91.67	0.41	14.92
4.0	0.49	0.44	117.82	0.29	13.07
5.0	0.62	0.36	142.70	0.10	11.65
6.0	0.74	0.29	169.14	0.07	10.47
7.0	0.85	0.26	-162.52	0.07	9.46
8.0	0.96	0.28	-139.75	0.09	8.60
9.0	1.06	0.33	-127.62	0.13	7.73
10.0	1.14	0.40	-124.24	0.17	6.89





# 500-6000 MHz Dual, Ultra Low Noise, High IP3 Amplifier

**Mimix**  
BROADBAND™

May 2006 - Rev 24-May-06

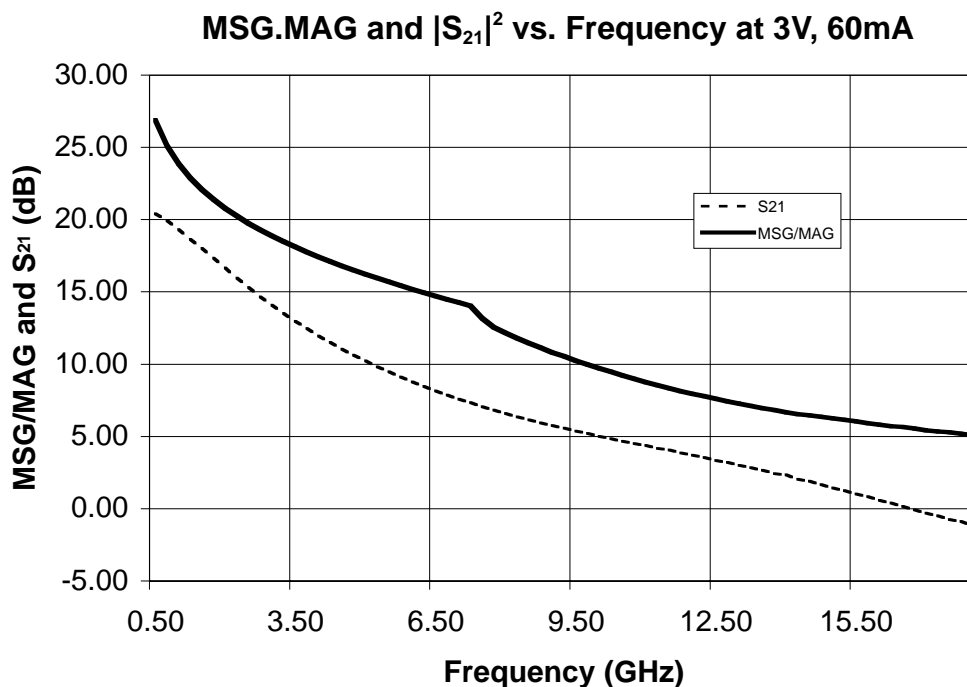
**CDQ0303-OS**  
XRoHS

## Typical Noise Parameters

S-Parameter Data Files are available on-line at: [www.mimixbroadband.com](http://www.mimixbroadband.com)

### CDQ0303-QS Typical Noise Parameters (V<sub>ds</sub> = +3.0V, I<sub>ds</sub> = 60 mA)

Freq. GHz	NFmin db	Gamma Opt Mag.	Ang.	Rn	Ga db
1.0	0.08	0.83	36.63	0.18	20.82
2.0	0.19	0.70	71.35	0.23	17.92
3.0	0.33	0.58	99.28	0.46	15.32
4.0	0.46	0.47	123.90	0.26	13.44
5.0	0.61	0.39	147.46	0.10	12.00
6.0	0.73	0.32	172.31	0.07	10.81
7.0	0.83	0.30	-162.17	0.08	9.79
8.0	0.94	0.32	-141.96	0.10	8.91
9.0	1.02	0.39	-131.18	0.14	8.04
10.0	1.10	0.47	-128.00	0.17	7.17



# 500-6000 MHz Dual, Ultra Low Noise, High IP3 Amplifier

Mimix  
BROADBAND™

May 2006 - Rev 24-May-06

CDQ0303-OS  
RoHS

**Considerations When Designing for Optimum Noise Figure Using Noise Parameters** - For any two-port network, the noise figure gives a measure of the amount of noise added to a signal transmitted through that network. In this datasheet we have given the NFmin and the corresponding optimum source resistance values for the device under various bias conditions. NFmin represents the true minimum noise figure when the device is presented with an impedance matching network that transforms the source impedance typically 50 ohms to that optimum noise matching impedance referred to as  $G_{opt}$ . All stability considerations still apply, of course. If the calculated Rollet stability factor (K) is less than 1, then the source and load reflection coefficients must be carefully chosen. For an accurate graphical depiction of the unstable regions, it is best to draw stability circles.

In practice the impedance that minimizes the noise figure is different from the impedance that minimizes the return loss. Matching techniques such as inductive feedback will be used to bring the noise match closer to this gain match. An additional inherent danger of this technique is the increased instability of the design at higher frequencies. As the frequency increases the amount of feedback to the devices source up to an oscillation level. This issue can be reduced by carefully choosing the input and output matching topology so that the transducer gain is limited at the frequency of potential oscillation. Design of a high pass / low pass matching network on the input and output is one solution that addresses this problem. Careful simulation is essential using the wideband s-parameters provided and can only be achieved through careful modeling of all components utilized in the design, including:

1. Accurate high frequency models for all surface mount components used.
2. Accurate models of the board characteristics including loss tangents and metal thickness.
3. Use of Via holes and via pads instead of perfect grounds where used.

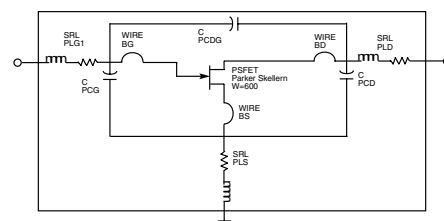
In any case if the reflection coefficient of the chosen matching network is other than  $G_{opt}$ , then the noise figure of the device will be greater than NFmin. The losses of the matching circuits are also non-zero and it must be considered that the noise figure of the completed amplifier is equal to the noise figure of the device plus the losses of the matching network preceding the device.

The losses of the matching networks are related to the Q of the components and associated printed circuit board loss. In general larger gate width devices will typically have a lower  $G_{opt}$  as compared to smaller gate width devices. Matching to higher impedance devices requires very hi-Q components in order to minimize circuit losses. The main reason for using smaller gate width devices is the trade-off of current consumption and optimum noise performance. The CDQ0303-QS is a 600um gate width device has a minimum noise figure of 0.08 dB and a  $G_{opt}$  of Mag 0.83, Ang 36.63, making it significantly easier to match than competitive devices. Associated gain  $G_a$  is 20.82 dB.

**Device Non-Linear Model** - Mimix develops its own non-linear model based on its own internal device characterization. The model is verified in different simulators and compared to the original data from which it was extracted.

## Die Model - Gate Width = 600 $\mu$ m, Optimized for 0.1 GHz to 26.0 GHz

Cgs	1.04 pF	Rg	0.29	Cpd	0.08 pF
Cdg	0.07 pF	Ls	0.04 nH	PCG	0.195 pF
Cds	0.1 pF	Ld	0.1 nH	PCD	0.21 pF
Gm	303 mS	Lg	0.05 nH	PLS	0.085 nH
Ri	2.2 Ohm	BG	5 mil Gold wire (1 mil dia)	PLG	0.525 nH
Tau	0.06 ps	BD	5 mil Gold wire (1 mil dia)	PLD	0.55 nH
Rs	1.28	BS	3 mil Gold wire (1 mil dia)	PCDG	0.005 pF
Rd	1.35	Cpg	0.10 pF		



The PSFET is a Mimix implementation of the Parker Skellern large signal model. The model is available as an ADS project file on-line at: [www.mimixbroadband.com](http://www.mimixbroadband.com)

## Typical Reflow Profiles

Reflow Profile	SnPb	Pb Free
Ramp Up Rate	3-4 °C/sec	3-4 °C/sec
Activation Time and Temperature	60-120 sec @ 140-160 °C	60-180 sec @ 170-200 °C
Time Above Melting Point	60-150 sec	60-150 sec
Max Peak Temperature	240 °C	265 °C
Time Within 5 °C of Peak	10-20 sec	10-20 sec
Ramp Down Rate	4-6 °C/sec	4-6 °C/sec

Mimix Broadband, Inc., 10795 Rockley Rd., Houston, Texas 77099  
Tel: 281.988.4600 Fax: 281.988.4615 [mimixbroadband.com](http://mimixbroadband.com)

Page 10 of 14

Characteristic Data and Specifications are subject to change without notice. ©2006 Mimix Broadband, Inc.  
Export of this item may require appropriate export licensing from the U.S. Government. In purchasing these parts, U.S. Domestic customers accept their obligation to be compliant with U.S. Export Laws.

# 500-6000 MHz Dual, Ultra Low Noise, High IP3 Amplifier

**Mimix**  
BROADBAND™

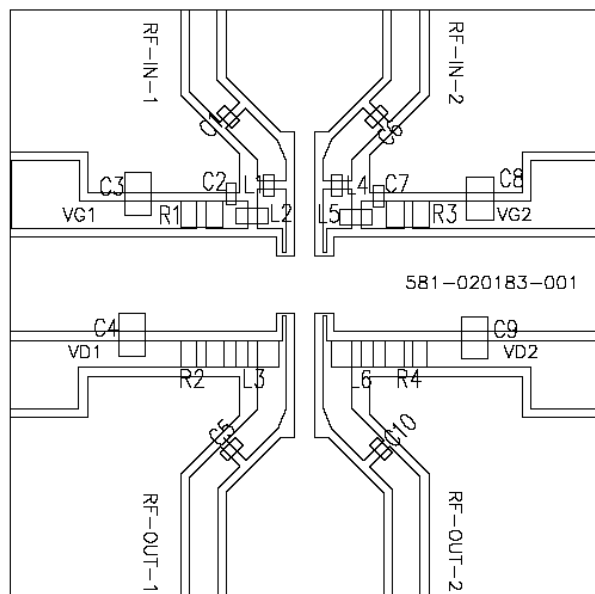
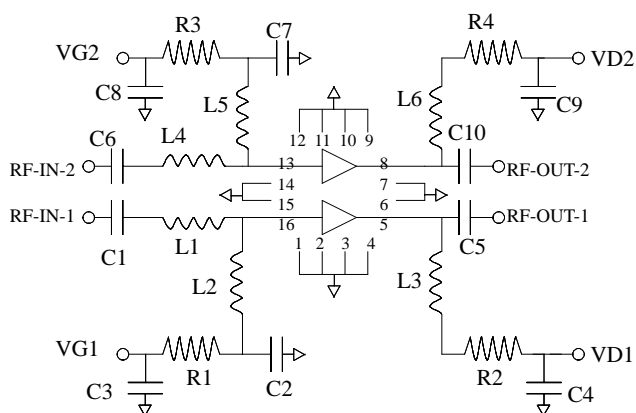
May 2006 - Rev 24-May-06

**CDQ0303-OS**  
RoHS

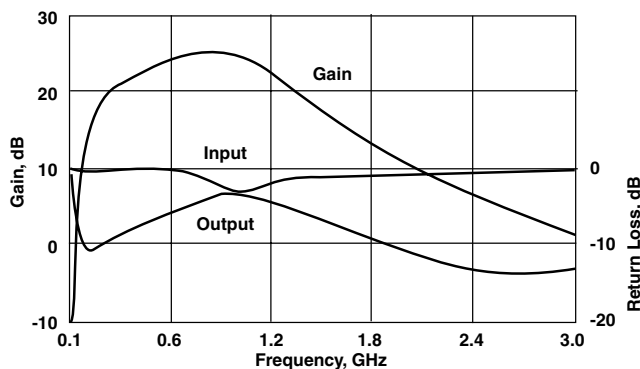
## Application Circuit - 900 MHz

Typical Specifications (50 $\Omega$  System)

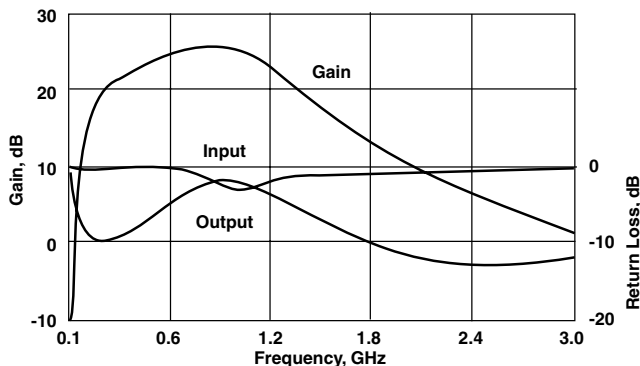
Frequency	900 MHz
S21 Gain	23.5 dB
S11 Input Return Loss	-3.0 dB
S22 Output Return Loss	-3.5 dB
Output IP3	31.8 dBm
Output P1 dB	16.5 dBm
Noise Figure	0.55 dB
Operating Current Range	50 mA
Supply Voltage	3.0 V



S-Parameters vs Frequency



S-Parameters vs Frequency



Ref Designator	Value	Description	Size
C1, C5, C6, C10	100 pF	0402, 10%	0402
C3, C4, C8, C9	1000 pF	MCH185A101JK	0805
C2, C7	5600 PF	0402, 10%	0402
R1, R3	300 Ohm	0805, 1/8W, 1%	0805
R2, R4	18 Ohm	0805, 1/8W, 1%	0805
L1, L4	10 nH	Coil Craft 0402, 10%	0402
L2, L3, L5, L6	47 nH	Coil Craft 0603, 10%	0603

It is important to add via holes under the part in order to achieve good RF grounding.

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

Page 11 of 14

Characteristic Data and Specifications are subject to change without notice. ©2006 Mimix Broadband, Inc.  
Export of this item may require appropriate export licensing from the U.S. Government. In purchasing these parts, U.S. Domestic customers accept their obligation to be compliant with U.S. Export Laws.

# 500-6000 MHz Dual, Ultra Low Noise, High IP3 Amplifier

**Mimix**  
BROADBAND™

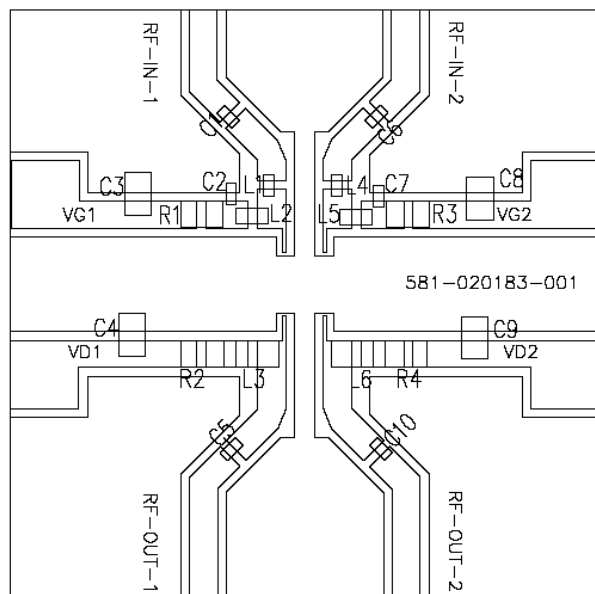
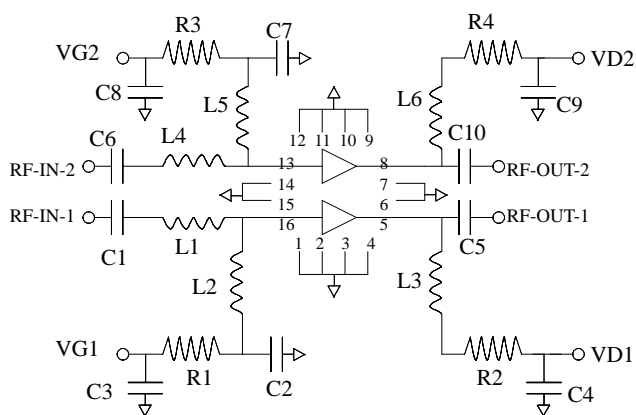
May 2006 - Rev 24-May-06

**CDQ0303-OS**  
RoHS

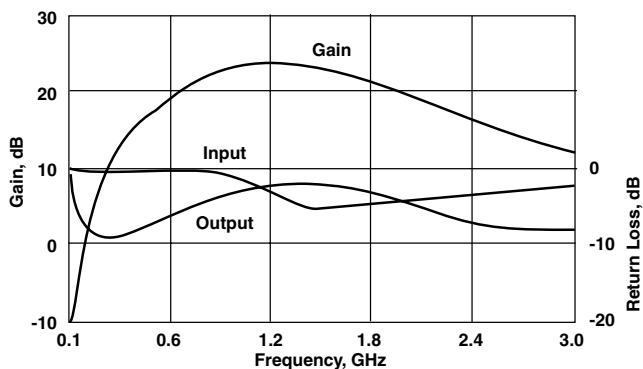
## Application Circuit - 1900 MHz

Typical Specifications (50 $\Omega$  System)

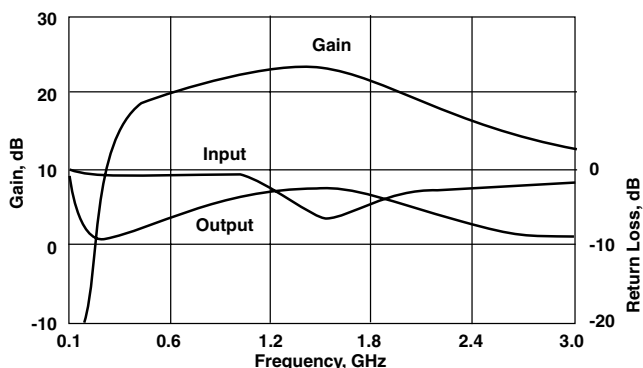
Frequency	1900 MHz
S21 Gain	20.0 dB
S11 Input Return Loss	-4.0 dB
S22 Output Return Loss	-4.5 dB
Output IP3	32.5 dBm
Output P1 dB	16.0 dBm
Noise Figure	0.72 dB
Operating Current Range	50 mA
Supply Voltage	3.0 V



S-Parameters vs Frequency



S-Parameters vs Frequency



Ref Designator	Value	Description	Size
C1, C5, C6, C10	100 pF	0402, 10%	0402
C3, C4, C8, C9	1000 pF	MCH185A101JK	0805
C2, C7	0.01 uF	0402, 10%	0402
R1, R3	300 Ohm	0805, 1/8W, 1%	0805
R2, R4	18 Ohm	0805, 1/8W, 1%	0805
L1, L4	2.7 nH	Coil Craft 0402, 10%	0402
L2, L5	6.8 nH	Coil Craft 0603, 10%	0603
L3, L6	47 nH	Coil Craft 0603, 10%	0603

It is important to add via holes under the part in order to achieve good RF grounding.

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

Page 12 of 14

Characteristic Data and Specifications are subject to change without notice. ©2006 Mimix Broadband, Inc.  
Export of this item may require appropriate export licensing from the U.S. Government. In purchasing these parts, U.S. Domestic customers accept their obligation to be compliant with U.S. Export Laws.

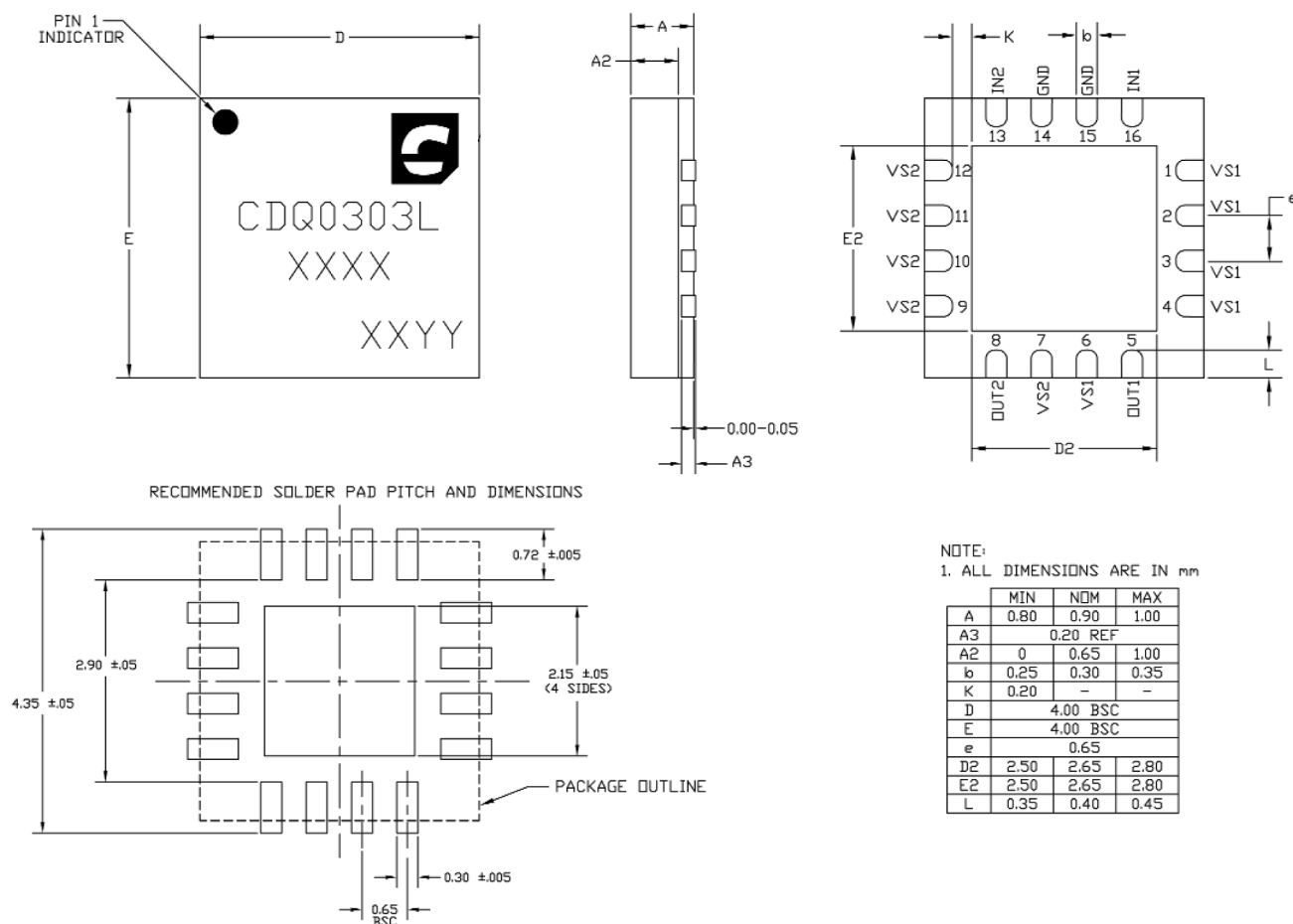
# 500-6000 MHz Dual, Ultra Low Noise, High IP3 Amplifier

**Mimix**  
BROADBAND™

May 2006 - Rev 24-May-06

**CDQ0303-OS**  
RoHS

## Physical Dimensions - QS Package (QFN)



# 500-6000 MHz Dual, Ultra Low Noise, High IP3 Amplifier

Mimix  
BROADBAND™

May 2006 - Rev 24-May-06

CDQ0303-OS  
X RoHS

**Mimix Lead-Free RoHS Compliant Program** - Mimix has an active program in place to meet customer and governmental requirements for eliminating lead (Pb) and other environmentally hazardous materials from our products. All Mimix RoHS compliant components are form, fit and functional replacements for their non-RoHS equivalents. Lead plating of our RoHS compliant parts is 100% matt tin (Sn) over copper alloy and is backwards compatible with current standard SnPb low-temperature reflow processes as well as higher temperature (260°C reflow) "Pb Free" processes.

**Part Numbering Designator** - For Mimix/Celeritek lead-free products, the letter "G" will be used in the part number for Matte Tin finished RoHS compliant components and "L" will be used in the part number of NiPdAu finished RoHS Compliant components in the second position of the part number suffix, as shown below:

Example A: CXX1234-XX-0G00 = component bulk quantity Matte Tin finished RoHS compliant parts

Example B: CXX1234-XX-0L0T = component in tape and reel NiPdAu finished RoHS parts

For those customers not making the change at this time, Mimix/Celeritek will maintain production of current configurations. For questions and comments e-mail: [ourearth@mimixbroadband.com](mailto:ourearth@mimixbroadband.com).



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

## Ordering Information

### Part Number for Ordering

CDQ0303-QS-0G00

CDQ0303-QS-0G0T

PB-CDQ0303-QS-00A0

PB-CDQ0303-QS-00B0

### Package

Matte Tin finished RoHS compliant QFN4X4 16L surface mount package in bulk quantity

Matte Tin finished RoHS compliant QFN4X4 16L surface mount package in tape and reel

Evaluation Board with SMA connectors for CDQ0303-QS matched at 900 MHz

Evaluation Board with SMA connectors for CDQ0303-QS matched at 1900 MHz

We also offer the plastic package with SnPb (Tin-lead) or NiPdAu plating. Please contact your regional sales manager regarding different plating types.