

## 1.5/1.9GHz BAND MIXER GaAs MMIC

### ■GENERAL DESCRIPTION

NJG1556KB2 is a mixer GaAs MMIC features low distortion, high conversion gain and low noise figure.

NJG1556KB2 includes a mixer and a local amplifier, and ideally suitable for 1.5GHz or 1.9GHz band digital mobile phone handsets.

An ultra small & ultra thin FLP6-B2 package is adopted.

### ■PACKAGE OUTLINE

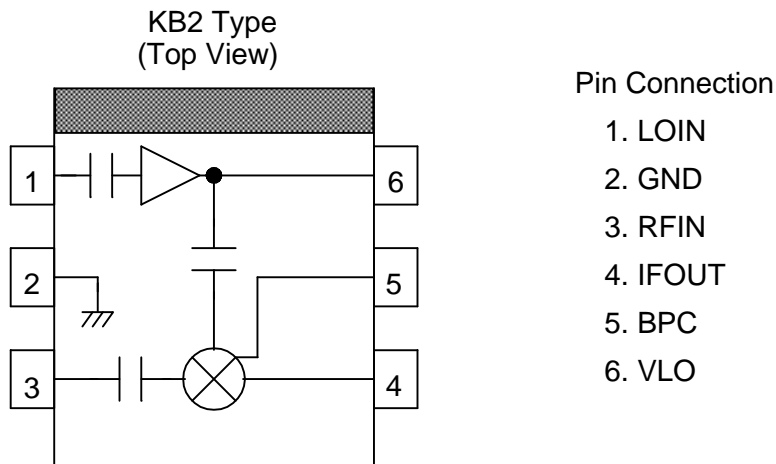


NJG1556KB2

### ■FEATURES

- |                                   |  |   |
|-----------------------------------|--|---|
| ●Low voltage operation            | +2.7V  |   |
| ●High conversion gain             | 10dB typ.                                    | @ $f_{RF}=1489\text{MHz}$ , $P_{LO}=-15\text{dBm}$          |
|                                   | 12.5dB typ.                                  | @ $f_{RF}=1960\text{MHz}$ , $P_{LO}=-10\text{dBm}$          |
| ●High Input IP3                   | -1.0dBm typ.                                 | @ $f_{RF}=1489.0+1489.1\text{MHz}$ , $P_{LO}=-15\text{dBm}$ |
|                                   | -0.5dBm typ.                                 | @ $f_{RF}=1960.0+1960.1\text{MHz}$ , $P_{LO}=-10\text{dBm}$ |
| ●Low noise figure                 | 7.0dB typ.                                   | @ $f_{RF}=1489\text{MHz}$ , $P_{LO}=-15\text{dBm}$          |
|                                   | 6.5dB typ.                                   | @ $f_{RF}=1960\text{MHz}$ , $P_{LO}=-10\text{dBm}$          |
| ●Ultra small & ultra thin package | FLP6-B2 (Mount Size: 2.0mm x 2.1mm x 0.75mm) |   |

### ■PIN CONFIGURATION



NOTE: The portion above shows orientation mark printed on the package surface.

NOTE: Please note that any information on this catalog will be subject to change.

# NJG1556KB2

## ■ABSOLUTE MAXIMUM RATINGS

( $T_a=25^{\circ}\text{C}$ ,  $Z_s=Z_l=50\Omega$ )

PARAMETERS	SYMBOL	CONDITIONS	RATINGS	UNITS
Mixer Supply Voltage	$V_{\text{MIX}}$		5	V
Local Amplifier Supply Voltage	$V_{\text{LO}}$		5	V
Mixer RF Input Power	$P_{\text{RFIN}}$	$V_{\text{MIX}}=2.7\text{V}, V_{\text{LO}}=2.7\text{V}$	+10	dBm
Mixer LO Input Power	$P_{\text{LOIN}}$	$V_{\text{MIX}}=2.7\text{V}, V_{\text{LO}}=2.7\text{V}$	+10	dBm
Power Dissipation	$P_{\text{D}}$		450	mW
Operating Temperature	$T_{\text{opr}}$		-40~+85	$^{\circ}\text{C}$
Storage Temperature	$T_{\text{stg}}$		-55~+125	$^{\circ}\text{C}$

## ■ELECTRICAL CHARACTERISTICS 1 (DC CHARACTERISTICS)

( $T_a=25^{\circ}\text{C}$ )

PARAMETERS	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Mixer Supply Voltage	$V_{\text{MIX}}$		2.5	2.7	4.5	V
Local Amplifier Supply Voltage	$V_{\text{LO}}$		2.5	2.7	4.5	V
Mixer Current	$I_{\text{MIX}}$	$P_{\text{RF}}=\text{OFF}, P_{\text{LO}}=\text{OFF}$	-	5.0	6.3	mA
Local Amplifier Current	$I_{\text{LO}}$	$P_{\text{RF}}=\text{OFF}, P_{\text{LO}}=\text{OFF}$	-	1.0	1.5	mA

## ■ELECTRICAL CHARACTERISTICS 2 (AC CHARACTERISTICS PDC 1.5GHz BAND)

GENERAL CONDITIONS:  $T_a=25^{\circ}\text{C}$ ,  $V_{\text{MIX}}=2.7\text{V}$ ,  $V_{\text{LO}}=2.7\text{V}$ ,  $f_{\text{RF}}=1489\text{MHz}$ ,  $f_{\text{LO}}=1619\text{MHz}$

$P_{\text{RF}}=-30\text{dBm}$ ,  $P_{\text{LO}}=-15\text{dBm}$ ,  $Z_s=Z_l=50\Omega$ , with test circuit 1

PARAMETERS	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Operating Frequency	freq1		1470	1489	1510	MHz
Conversion Gain	Gc1		8.0	10.0	-	dB
Input 3rd Order Intercept point	IIP3_1	$f_{\text{RF}}=1489.0\text{MHz}+1489.1\text{MHz}$	-4.0	-1.0	-	dBm
Noise Figure	NF1		-	7.0	8.5	dB
LO to RF Isolation	ISL1	IF OUT Port: $50\Omega$ term.	-	2.0	-	dB

## ■ELECTRICAL CHARACTERISTICS 3 (AC CHARACTERISTICS PCS 1.9GHz BAND)

GENERAL CONDITIONS:  $T_a=25^{\circ}\text{C}$ ,  $V_{\text{MIX}}=2.7\text{V}$ ,  $V_{\text{LO}}=2.7\text{V}$ ,  $f_{\text{RF}}=1960\text{MHz}$ ,  $f_{\text{LO}}=2090\text{MHz}$

$P_{\text{RF}}=-30\text{dBm}$ ,  $P_{\text{LO}}=-10\text{dBm}$ ,  $Z_s=Z_l=50\Omega$ , with test circuit 2

PARAMETERS	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Operating Frequency	freq2		1920	1960	2000	MHz
Conversion Gain	Gc2		10.0	12.5	-	dB
Input 3rd Order Intercept point	IIP3_2	$f_{\text{RF}}=1900.0\text{MHz}+1900.1\text{MHz}$	-3.0	-0.5	-	dBm
Noise Figure	NF2		-	6.5	8.0	dB
LO to RF Isolation	ISL2	IF OUT Port: $50\Omega$ term.	-	7.0	-	dB

## ■ TERMINAL INFORMATION

PIN No.	SYMBOL	DESCRIPTIONS
1	LOIN	Local power input terminal of local amplifier. External matching circuit is required.
2	GND	Ground terminal (0V).
3	RFIN	RF input terminal of mixer. External matching circuit is required.
4	IFOUT	IF signal output terminal for mixer external matching circuit is required. Please connect mixer power supply through choke inductor (L7) as shown in test circuit.
5	BPC	Optional bypass capacitor terminal for mixer. Please connect optimum capacitor if need for tuning Gc or IP3.
6	VLO	Local amplifier supply terminal. Please place R1 & L5 close to this terminal as shown in test circuit.

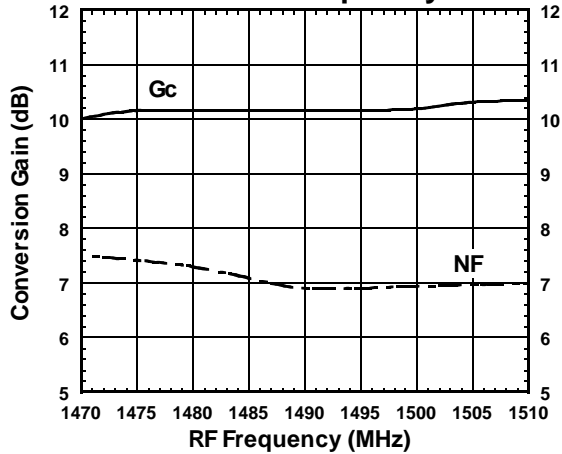
### NOTE:

- 1) Ground terminal (2pin) should be connected with ground plane by multiple via holes for good grounding.

# NJG1556KB2

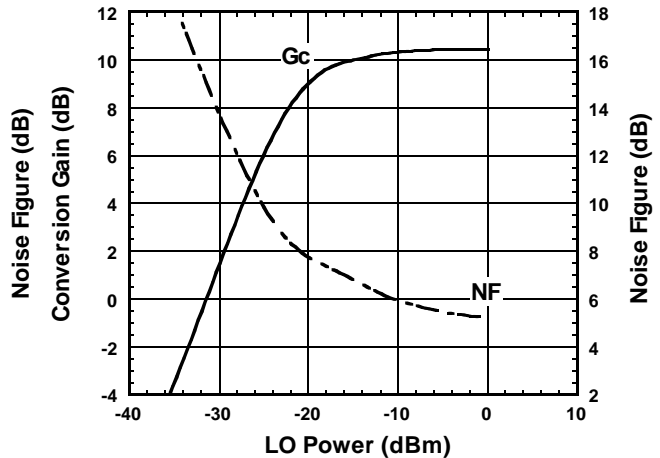
## ■ TYPICAL CHARACTERISTICS (PDC 1.5GHz BAND)

**Conversion Gain , Noise Figure vs. RF Frequency**



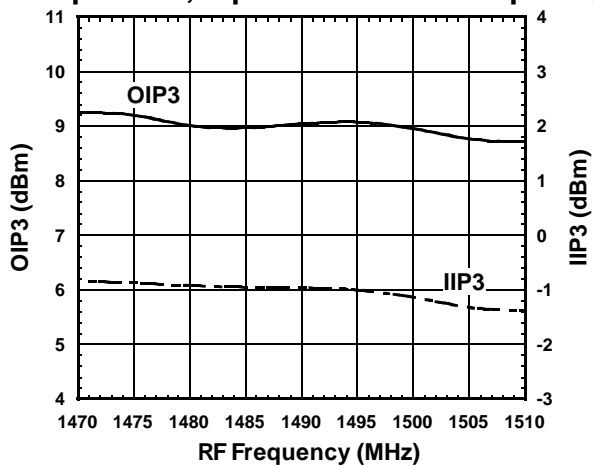
Condition  
 $f_{IF}=130\text{MHz}$   
 $f_{RF}=1470\sim 1510\text{MHz}$ ,  $P_{RF}=-30\text{dBm}$   
 $f_{LO}=1600\sim 1640\text{MHz}$ ,  $P_{LO}=-15\text{dBm}$   
 $V_{MIX}=V_{LO}=2.7\text{V}$

**Conversion Gain , Noise Figure vs. LO Power**



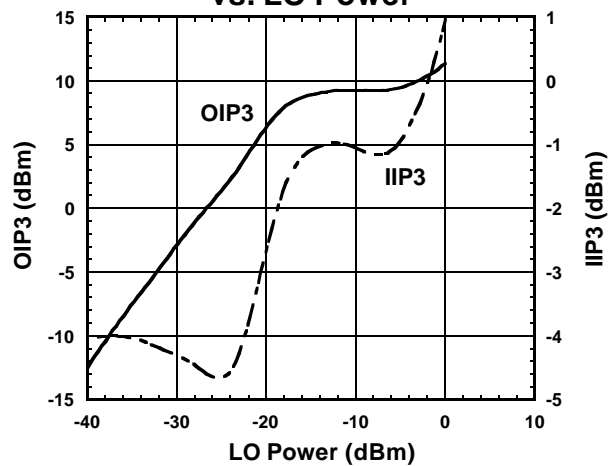
Condition  
 $f_{IF}=130\text{MHz}$   
 $f_{RF}=1489\text{MHz}$ ,  $P_{RF}=-30\text{dBm}$   
 $f_{LO}=1619\text{MHz}$   
 $V_{MIX}=V_{LO}=2.7\text{V}$

**Output IP3 , Input IP3 vs. RF Frequency**



Condition  
 $f_{IF}=130\text{MHz}$   
 $f_{RF1}=1470\sim 1510\text{MHz}$ ,  $P_{RF}=-30\text{dBm}$   
 $f_{RF2}=f_{RF1}+100\text{kHz}$   
 $f_{LO}=1600\sim 1640\text{MHz}$ ,  $P_{LO}=-15\text{dBm}$   
 $V_{MIX}=V_{LO}=2.7\text{V}$

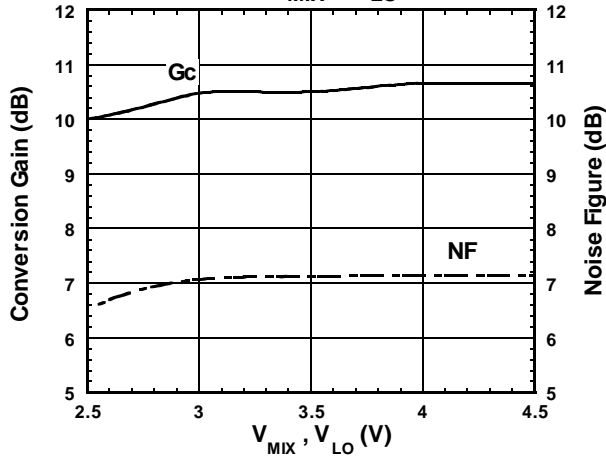
**Output IP3 , Input IP3 vs. LO Power**



Condition  
 $f_{IF}=130\text{MHz}$   
 $f_{RF}=1489.0+1489.1\text{MHz}$   
 $P_{RF}=-30\text{dBm}$   
 $f_{LO}=1619\text{MHz}$   
 $V_{MIX}=V_{LO}=2.7\text{V}$   
 $OIP3 = \frac{3XIF-IM3}{2}$   
 $IIP3 = OIP3 - Gc$

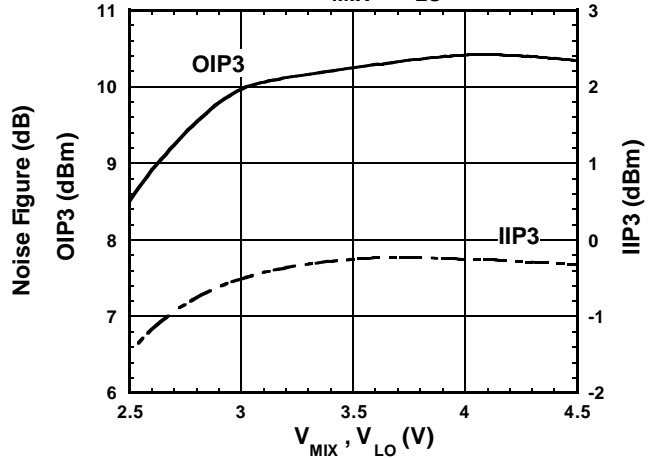
## ■ TYPICAL CHARACTERISTICS (Continued)

**Conversion Gain , Noise Figure  
vs.  $V_{MIX}$  ,  $V_{LO}$**



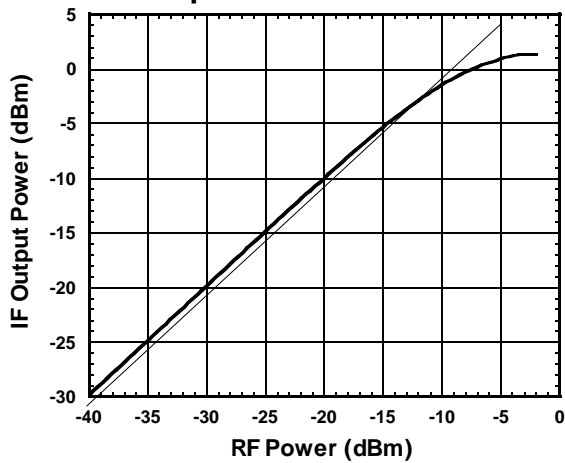
Condition  
 $f_{IF}=130\text{MHz}$   
 $f_{RF}=1489\text{MHz}$ ,  $P_{RF}=-30\text{dBm}$   
 $f_{LO}=1619\text{MHz}$ ,  $P_{LO}=-15\text{dBm}$

**Output IP3 , Input IP3  
vs.  $V_{MIX}$  ,  $V_{LO}$**



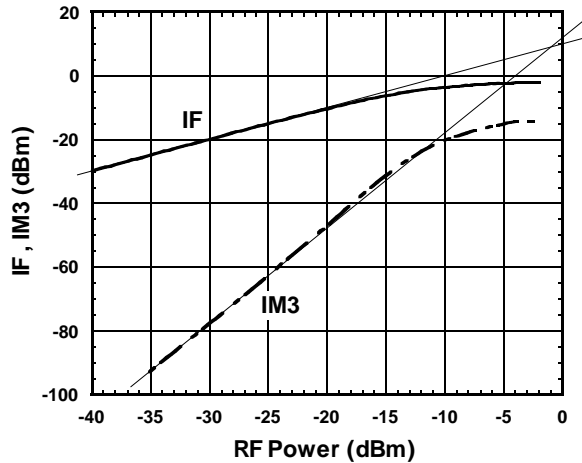
Condition  
 $f_{IF}=130\text{MHz}$   
 $f_{RF}=1489.0+1489.1\text{MHz}$ ,  $P_{RF}=-30\text{dBm}$   
 $f_{LO}=1619\text{MHz}$ ,  $P_{LO}=-15\text{dBm}$   
 $OIP3 = \frac{3X_{IF}-IM3}{2}$   
 $IIP3 = OIP3 - G_c$

**IF Output Power vs. RF Power**



Condition  
 $f_{IF}=130\text{MHz}$   
 $f_{RF}=1489\text{MHz}$   
 $f_{LO}=1619\text{MHz}$ ,  $P_{LO}=-15\text{dBm}$   
 $V_{MIX}=V_{LO}=2.7\text{V}$

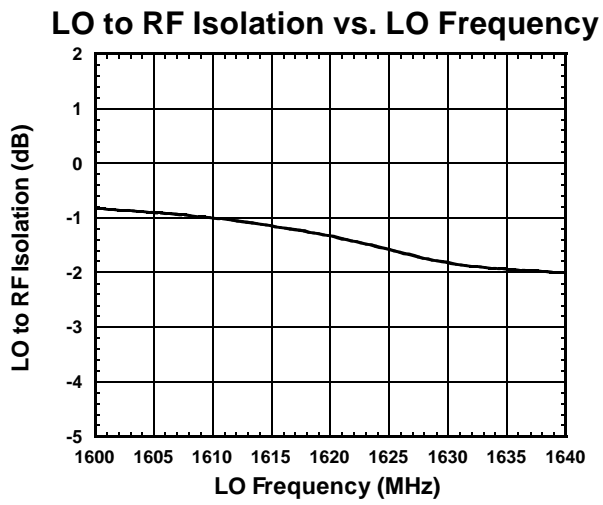
**IF , IM3 vs. RF Power**



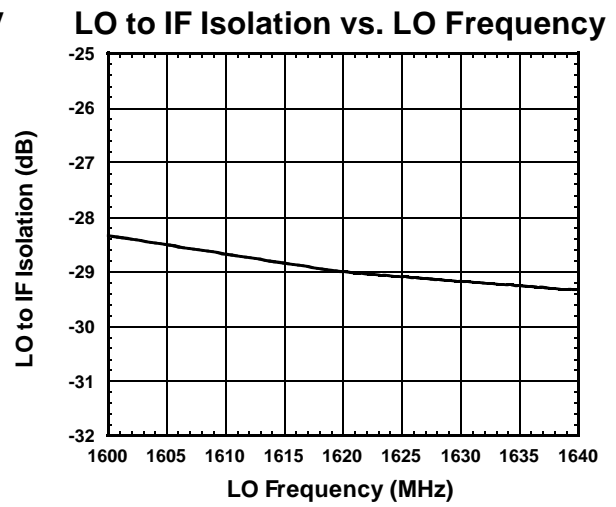
Condition  
 $f_{IF}=130\text{MHz}$   
 $f_{RF}=1489.0+1489.1\text{MHz}$   
 $f_{LO}=1619\text{MHz}$ ,  $P_{LO}=-15\text{dBm}$   
 $V_{MIX}=V_{LO}=2.7\text{V}$

# NJG1556KB2

## ■ TYPICAL CHARACTERISTICS (Continued)



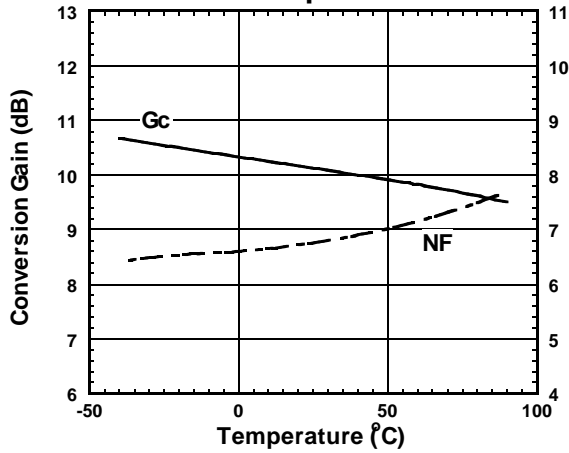
Condition  
 $f_{LO}=1600\sim 1640\text{MHz}$   
 $P_{LO}=-15\text{dBm}$   
 $V_{MIX}=V_{LO}=2.7\text{V}$   
IF OUT Port:  $50\Omega$ term.



Condition  
 $f_{LO}=1600\sim 1640\text{MHz}$   
 $P_{LO}=-15\text{dBm}$   
 $V_{MIX}=V_{LO}=2.7\text{V}$   
RF IN Port:  $50\Omega$ term.

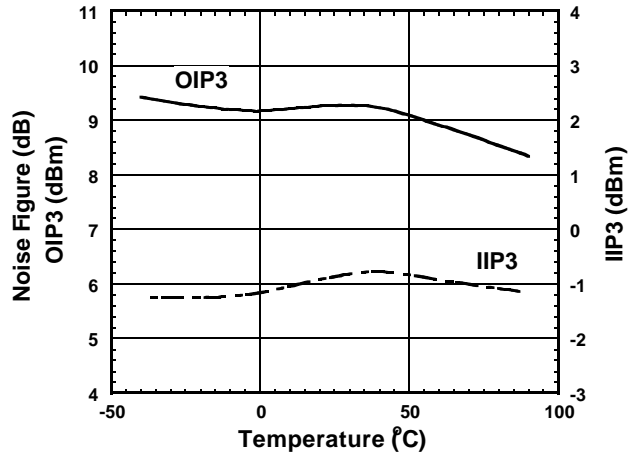
## ■ TYPICAL CHARACTERISTICS (Continued)

### Conversion Gain , Noise Figure vs. Temperature



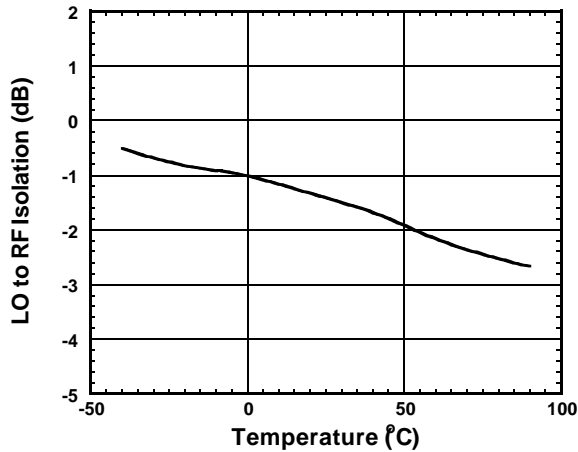
Condition  
 $f_{IF}=130\text{MHz}$   
 $f_{RF}=1489\text{MHz}$ ,  $P_{RF}=-30\text{dBm}$   
 $f_{LO}=1619\text{MHz}$ ,  $P_{LO}=-15\text{dBm}$   
 $V_{MIX}=V_{LO}=2.7\text{V}$

### Output IP3 , Input IP3 vs. Temperature



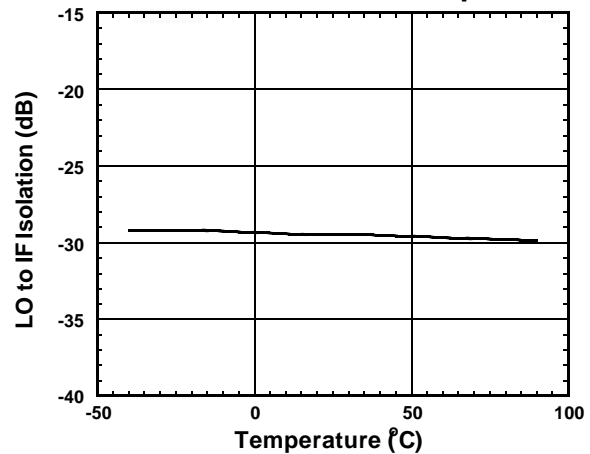
Condition  
 $f_{IF}=130\text{MHz}$   
 $f_{RF}=1489.0+1489.1\text{MHz}$        $OIP3 = \frac{3XIF-IM3}{2}$   
 $P_{RF}=-30\text{dBm}$   
 $f_{LO}=1619\text{MHz}$ ,  $P_{LO}=-15\text{dBm}$        $IIP3=OIP3-Gc$   
 $V_{MIX}=V_{LO}=2.7\text{V}$

### LO to RF Isolation vs. Temperature



Condition  
 $f_{LO}=1619\text{MHz}$   
 $P_{LO}=-15\text{dBm}$   
 $V_{MIX}=V_{LO}=2.7\text{V}$   
 IF OUT Port:  $50\Omega$ term.

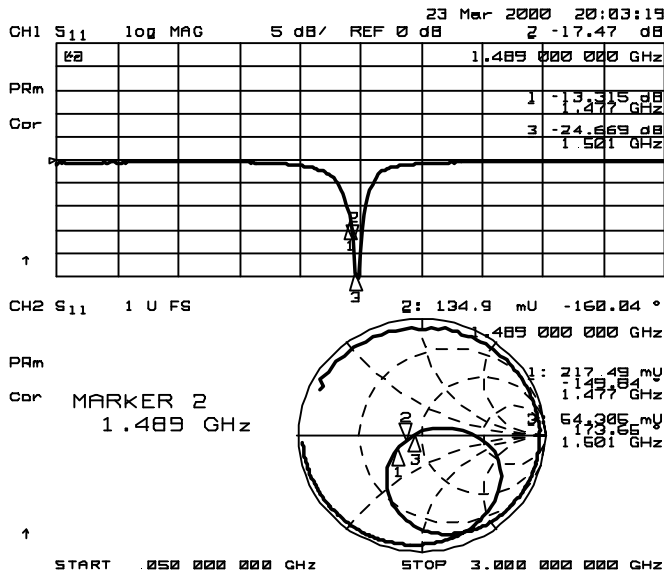
### LO to IF Isolation vs. Temperature



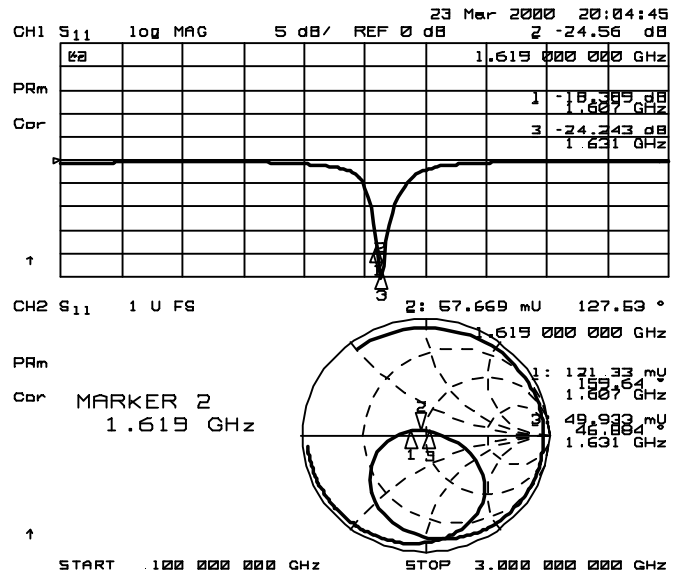
Condition  
 $f_{LO}=1619\text{MHz}$   
 $P_{LO}=-15\text{dBm}$   
 $V_{MIX}=V_{LO}=2.7\text{V}$   
 RF IN Port:  $50\Omega$ term.

# NJG1556KB2

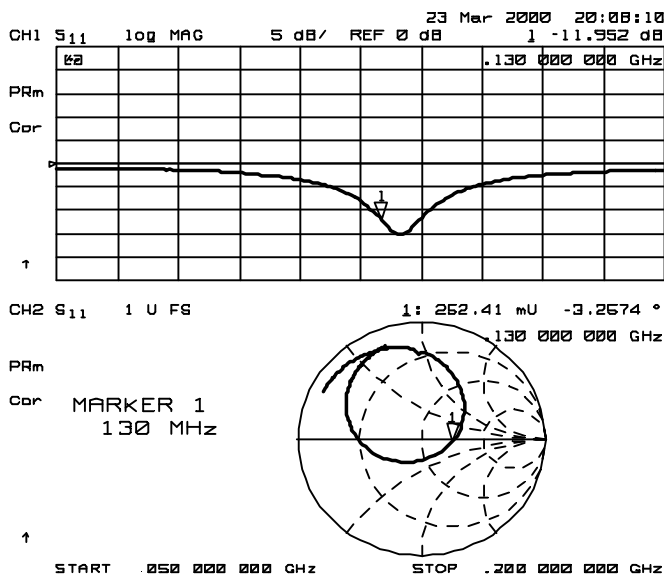
## TYPICAL CHARACTERISTICS (Continued)



RF IN Port Impedance  
(LOCAL IN Port, IF OUT Port: 50Ω term.)



LOCAL IN Port Impedance  
(RF IN Port, IF OUT Port: 50Ω term.)

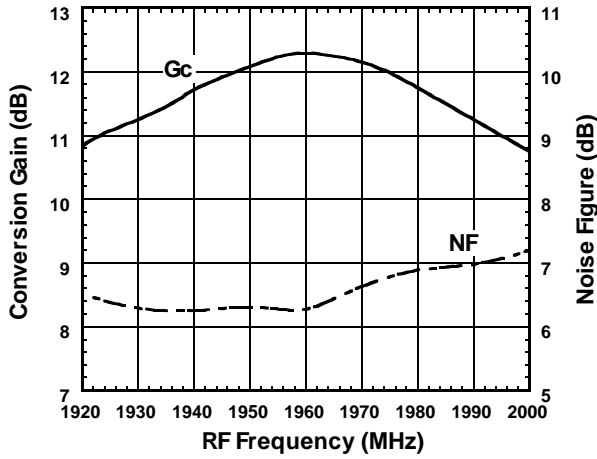


IF OUT Port Impedance  
(RF IN Port, LOCAL IN Port: 50Ω term.)



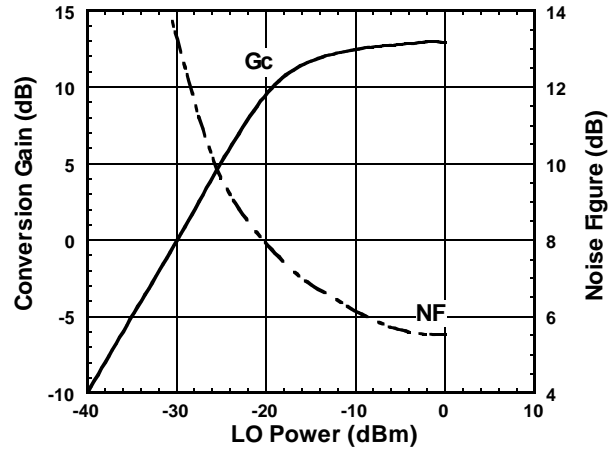
## ■ TYPICAL CHARACTERISTICS (PCS 1.9GHz BAND)

### Conversion Gain , Noise Figure vs. RF Frequency



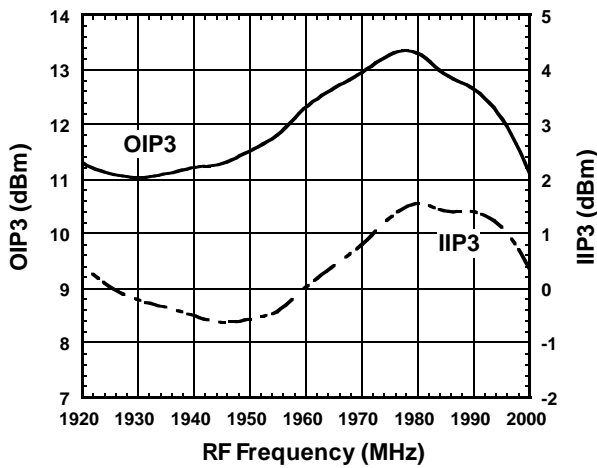
Condition  
 $f_{IF}=130\text{MHz}$   
 $f_{RF}=1920\sim 2000\text{MHz}$ ,  $P_{RF}=-30\text{dBm}$   
 $f_{LO}=2050\sim 2130\text{MHz}$ ,  $P_{LO}=-10\text{dBm}$   
 $V_{MIX}=V_{LO}=2.7\text{V}$

### Conversion Gain , Noise Figure vs. LO Power



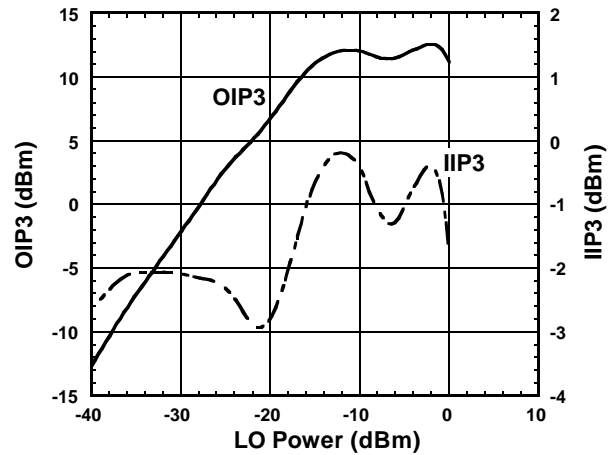
Condition  
 $f_{IF}=130\text{MHz}$   
 $f_{RF}=1960\text{MHz}$ ,  $P_{RF}=-30\text{dBm}$   
 $f_{LO}=2090\text{MHz}$   
 $V_{MIX}=V_{LO}=2.7\text{V}$

### Output IP3 , Input IP3 vs. RF Frequency



Condition  
 $f_{IF}=130\text{MHz}$   
 $f_{RF1}=1920\sim 2000\text{MHz}$ ,  $P_{RF}=-30\text{dBm}$   
 $f_{RF2}=f_{RF1}+100\text{kHz}$   
 $f_{LO}=2050\sim 2130\text{MHz}$ ,  $P_{LO}=-10\text{dBm}$   
 $V_{MIX}=V_{LO}=2.7\text{V}$

### Output IP3 , Input IP3 vs. LO Power



Condition  
 $f_{IF}=130\text{MHz}$   
 $f_{RF}=1960.0+1960.1\text{MHz}$   
 $P_{RF}=-30\text{dBm}$   
 $f_{LO}=2090\text{MHz}$   
 $V_{MIX}=V_{LO}=2.7\text{V}$

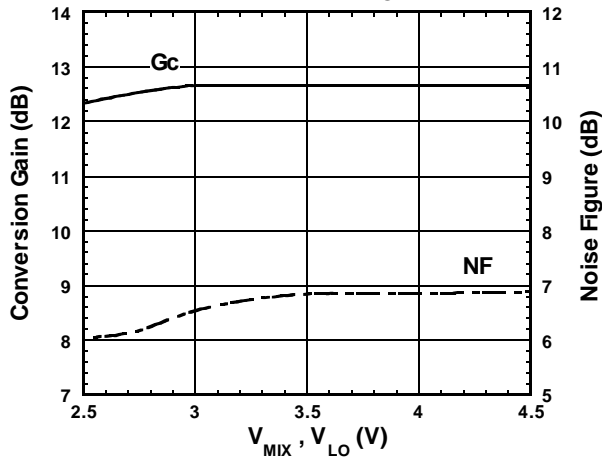
$$OIP3 = \frac{3XIF - IM3}{2}$$

$$IIP3 = OIP3 - Gc$$

# NJG1556KB2

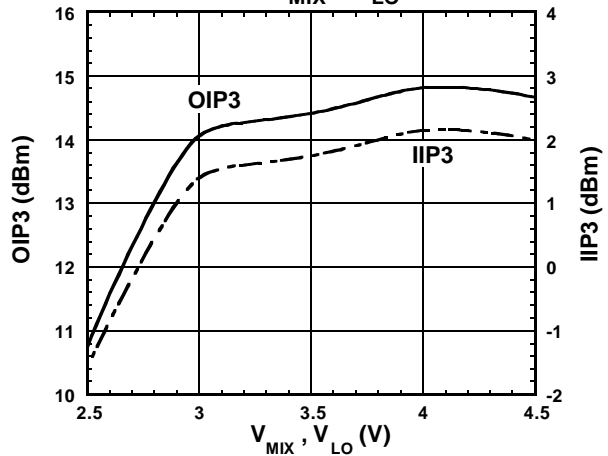
## ■ TYPICAL CHARACTERISTICS (Continued)

**Conversion Gain, Noise Figure**  
vs.  $V_{MIX}$ ,  $V_{LO}$



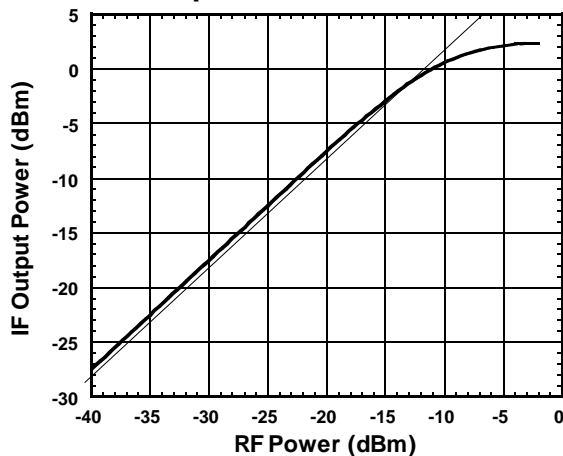
Condition  
 $f_{IF}=130\text{MHz}$   
 $f_{RF}=1960\text{MHz}$ ,  $P_{RF}=-30\text{dBm}$   
 $f_{LO}=2090\text{MHz}$ ,  $P_{LO}=-10\text{dBm}$

**Output IP3, Input IP3**  
vs.  $V_{MIX}$ ,  $V_{LO}$



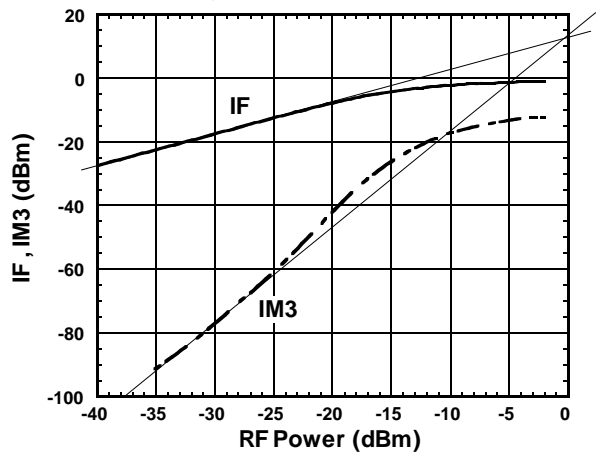
Condition  
 $f_{IF}=130\text{MHz}$   
 $f_{RF}=1960.0+1960.1\text{MHz}$ ,  $P_{RF}=-30\text{dBm}$   
 $f_{LO}=2090\text{MHz}$ ,  $P_{LO}=-10\text{dBm}$   
 $OIP3 = \frac{3 \times IIP3 - IM3}{2}$   
 $IIP3 = OIP3 - Gc$

**IF Output Power vs. RF Power**



Condition  
 $f_{IF}=130\text{MHz}$   
 $f_{RF}=1960\text{MHz}$   
 $f_{LO}=2090\text{MHz}$ ,  $P_{LO}=-10\text{dBm}$   
 $V_{MIX}=V_{LO}=2.7\text{V}$

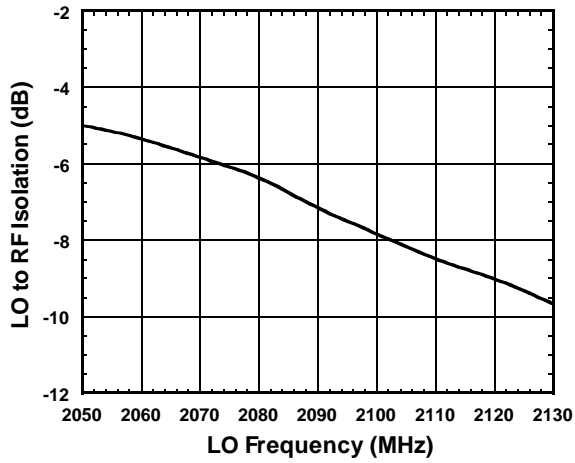
**IF, IM3 vs. RF Power**



Condition  
 $f_{IF}=130\text{MHz}$   
 $f_{RF}=1960.0+1960.1\text{MHz}$   
 $f_{LO}=2090\text{MHz}$ ,  $P_{LO}=-10\text{dBm}$   
 $V_{MIX}=V_{LO}=2.7\text{V}$

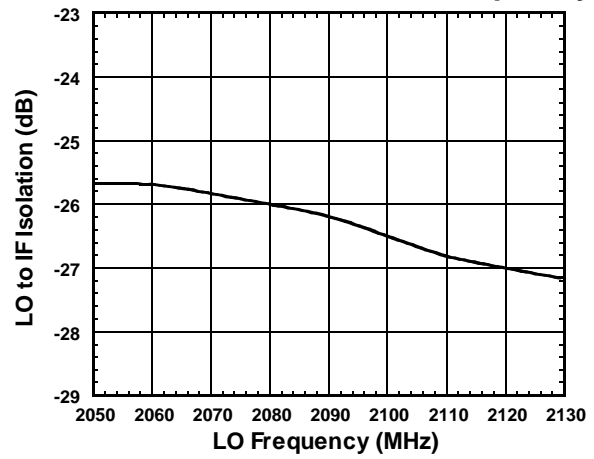
## ■ TYPICAL CHARACTERISTICS (Continued)

### LO to RF Isolation vs. LO Frequency



Condition  
 $f_{LO}=2050\sim 2130\text{MHz}$   
 $P_{LO}=-10\text{dBm}$   
 $V_{MIX}=V_{LO}=2.7\text{V}$   
 IF OUT Port:  $50\Omega$ term.

### LO to IF Isolation vs. LO Frequency

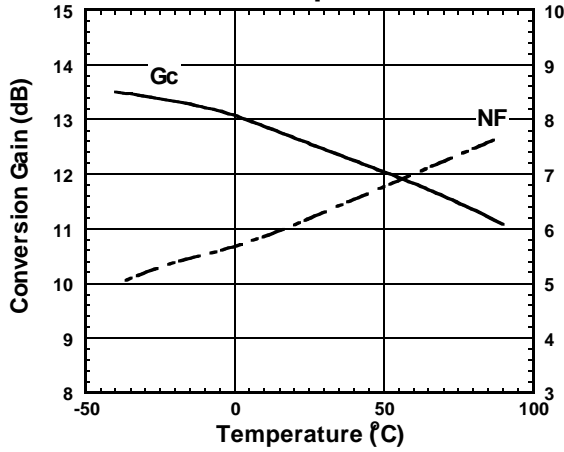


Condition  
 $f_{LO}=2050\sim 2130\text{MHz}$   
 $P_{LO}=-10\text{dBm}$   
 $V_{MIX}=V_{LO}=2.7\text{V}$   
 RF IN Port:  $50\Omega$ term.

# NJG1556KB2

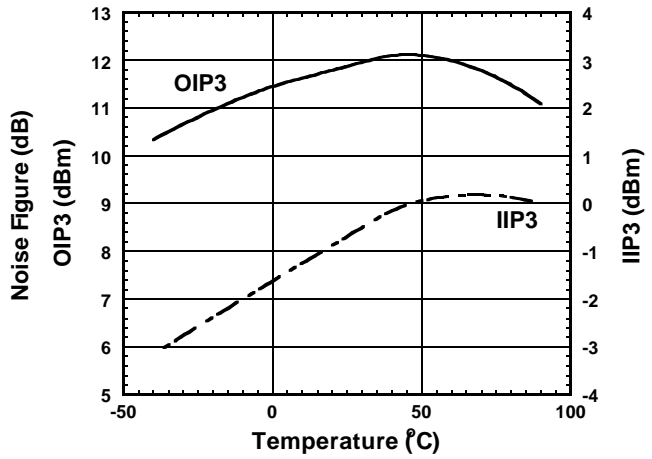
## ■ TYPICAL CHARACTERISTICS (Continued)

**Conversion Gain , Noise Figure vs. Temperature**



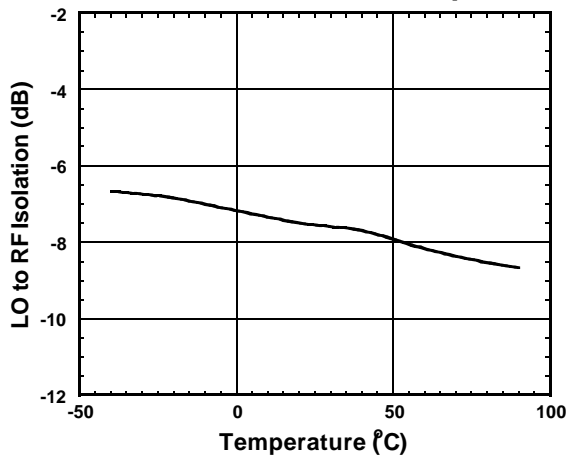
Condition  
 $f_{IF}=130\text{MHz}$   
 $f_{RF}=1960\text{MHz}$ ,  $P_{RF}=-30\text{dBm}$   
 $f_{LO}=2090\text{MHz}$ ,  $P_{LO}=-10\text{dBm}$   
 $V_{MIX}=V_{LO}=2.7\text{V}$

**Output IP3 , Input IP3 vs. Temperature**



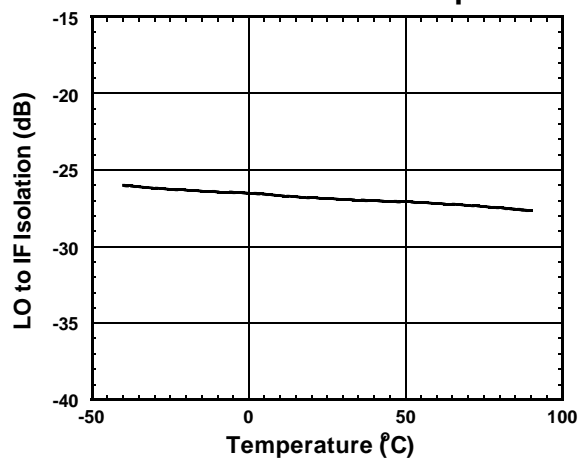
Condition  
 $f_{IF}=130\text{MHz}$   
 $f_{RF}=1960.0+1960.1\text{MHz}$       $OIP3=\frac{3XIF-IM3}{2}$   
 $P_{RF}=-30\text{dBm}$   
 $f_{LO}=2090\text{MHz}$ ,  $P_{LO}=-10\text{dBm}$       $IIP3=OIP3-Gc$   
 $V_{MIX}=V_{LO}=2.7\text{V}$

**LO to RF Isolation vs. Temperature**



Condition  
 $f_{LO}=2090\text{MHz}$   
 $P_{LO}=-10\text{dBm}$   
 $V_{MIX}=V_{LO}=2.7\text{V}$   
 IF OUT Port:  $50\Omega$ term.

**LO to IF Isolation vs. Temperature**

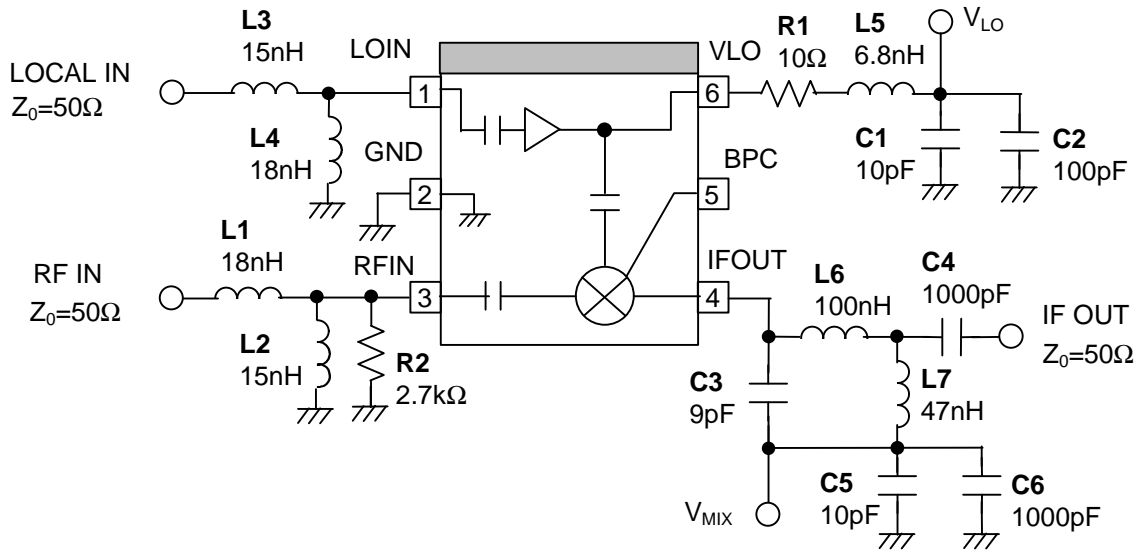


Condition  
 $f_{LO}=2090\text{MHz}$   
 $P_{LO}=-10\text{dBm}$   
 $V_{MIX}=V_{LO}=2.7\text{V}$   
 RF IN Port:  $50\Omega$ term.



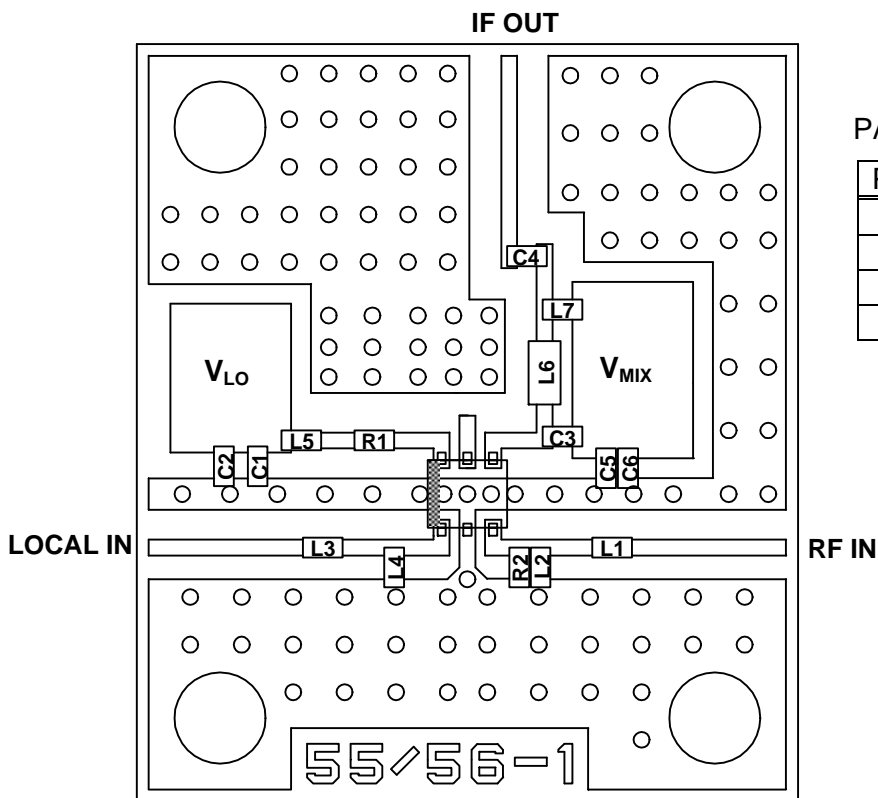
# NJG1556KB2

## APPLICATION CIRCUIT 1 (PDC 1.5GHz BAND)



## RECOMMENDED PCB DESIGN 1 (PDC 1.5GHz BAND)

(Top View)



### PARTS LIST

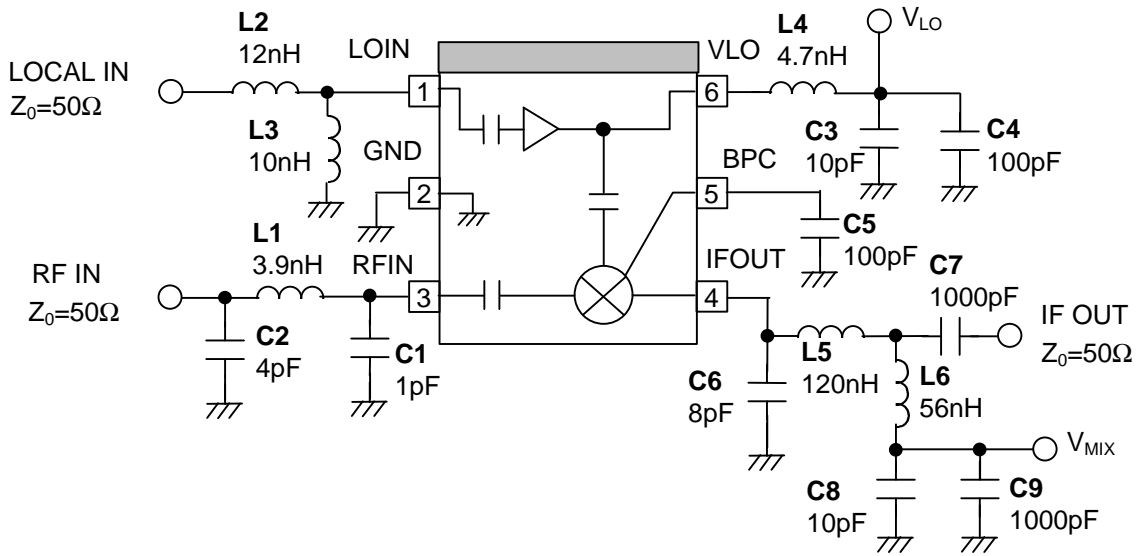
PARTS ID	COMMENT
L1~L5,L7	TAIYO-YUDEN(HK1005)
L6	TAIYO-YUDEN(HK1608)
C1~C6	MURATA(GRM36)
R1,R2	1005 Size

PCB (FR-4), t=0.2mm  
 STRIP LINE WIDTH  
 =0.4mm ( $Z_0=50\Omega$ )  
 PCB SIZE  
 =16.7X19.1mm

### PRECAUTIONS

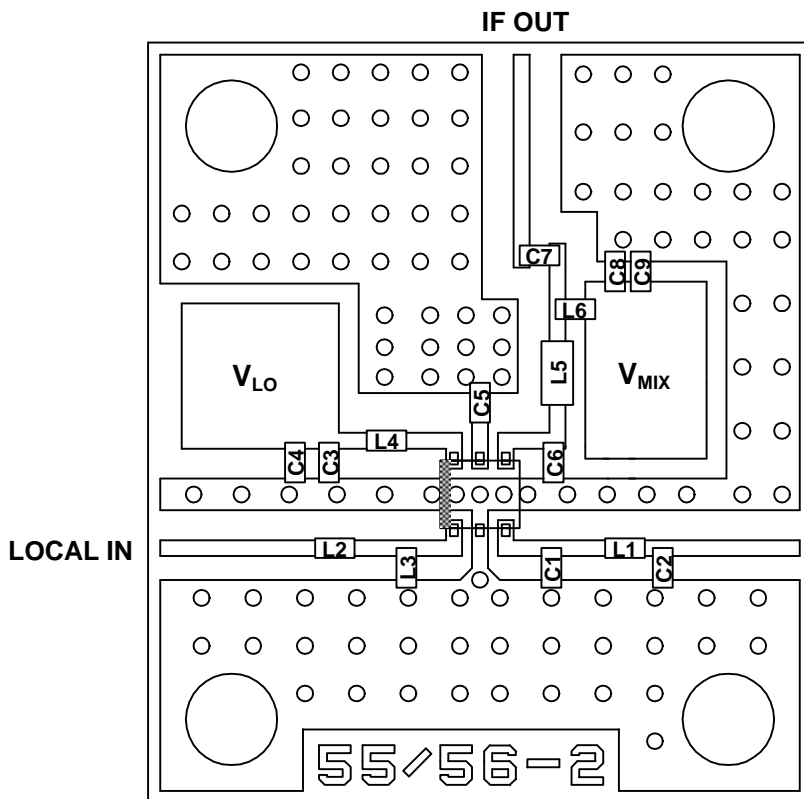
- [1] Please locate L5 and R1 close to VLO terminal (6).
- [2] Please locate C1 and C2 close to L5.
- [3] Please locate C5 and C6 close to C3.

## APPLICATION CIRCUIT 2 (PCS 1.9GHz BAND)



## RECOMMENDED PCB DESIGN 2 (PCS 1.9GHz BAND)

(Top View)



### PARTS LIST

PARTS ID	COMMENT
L1~L4,L6	TAIYO-YUDEN(HK1005)
L5	TAIYO-YUDEN(HK1608)
C1~C9	MURATA(GRM36)

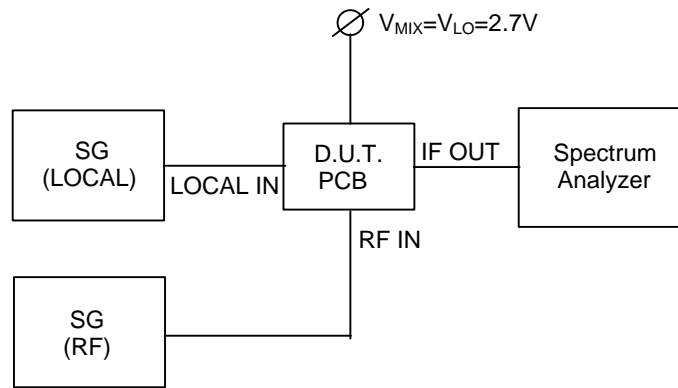
PCB (FR-4), t=0.2mm  
 STRIP LINE WIDTH  
 =0.4mm ( $Z_0=50\Omega$ )  
 PCB SIZE  
 =16.7X19.1mm

### PRECAUTIONS

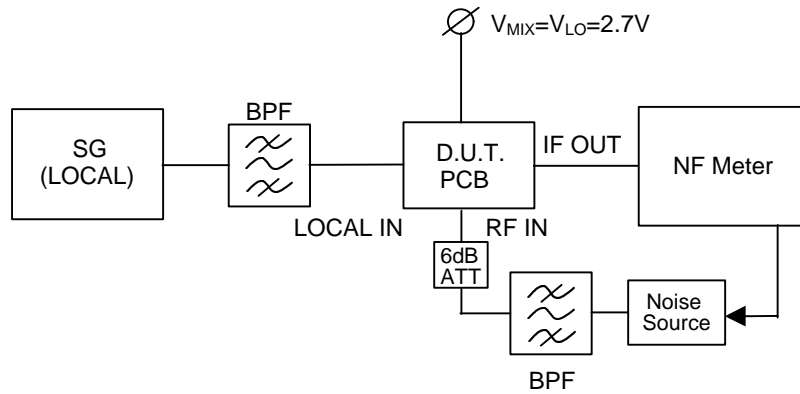
- [1] Please locate L4 close to VLO terminal (6).
- [2] Please locate C5 close to BPC terminal (5).
- [3] Please locate C3 and C4 close to L4.
- [4] Please locate C8 and C9 close to L6.

# NJG1556KB2

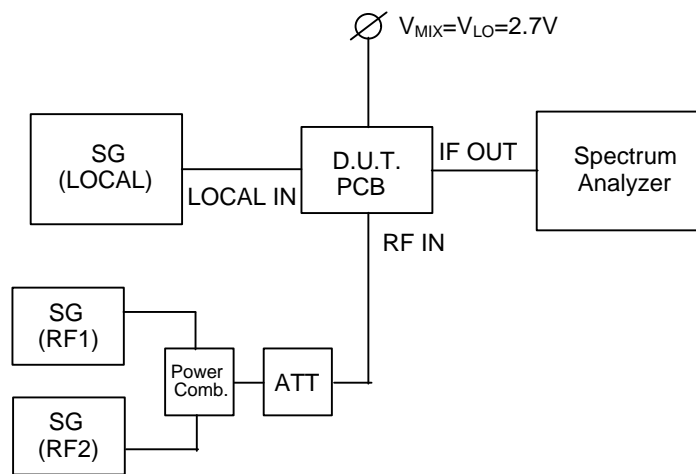
## MEASURING BLOCK DIAGRAM



Conversion Gain Measuring Block Diagram



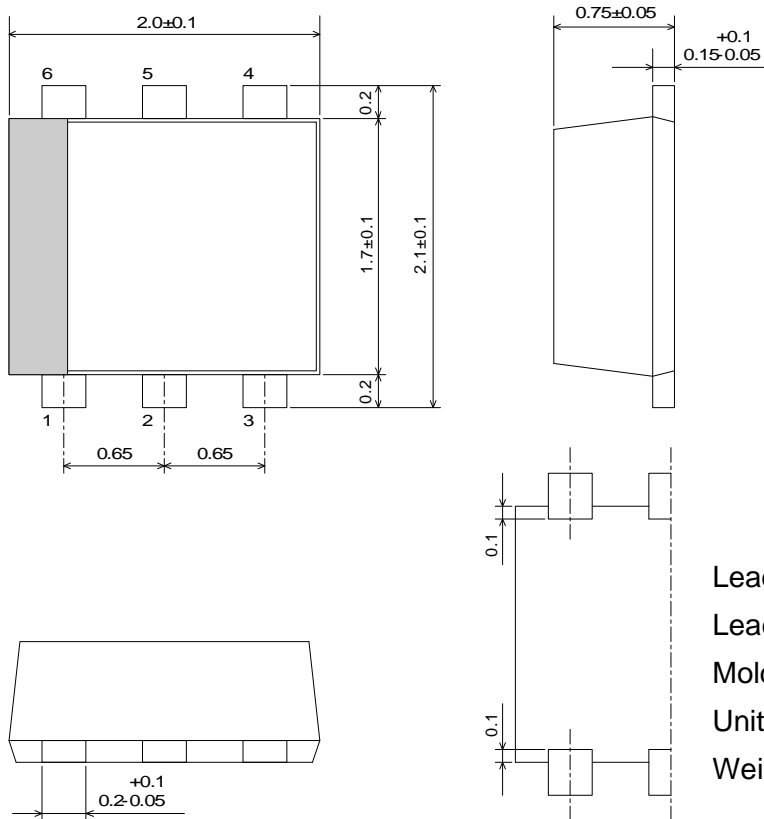
Noise Figure Measuring Block Diagram



OIP3, IIP3 Measuring Block Diagram



## PACKAGE OUTLINE (FLP6-B2)



Lead material	: Copper
Lead surface finish	: Solder plating
Molding material	: Epoxy resin
Unit	: mm
Weight	: 6.5mg

### Cautions on using this product

This product contains Gallium-Arsenide (GaAs) which is a harmful material.

- Do NOT eat or put into mouth.
- Do NOT dispose in fire or break up this product.
- Do NOT chemically make gas or powder with this product.
- To waste this product, please obey the relating law of your country.

### [CAUTION]

The specifications on this databook are only given for information, without any guarantee as regards either mistakes or omissions. The application circuits in this databook are described only to show representative usages of the product and not intended for the guarantee or permission of any right including the industrial rights.

This product may be damaged with electric static discharge (ESD) or spike voltage. Please handle with care to avoid these damages.

Компания «Океан Электроники» предлагает заключение долгосрочных отношений при поставках импортных электронных компонентов на взаимовыгодных условиях!

Наши преимущества:

- Поставка оригинальных импортных электронных компонентов напрямую с производств Америки, Европы и Азии, а так же с крупнейших складов мира;
- Широкая линейка поставок активных и пассивных импортных электронных компонентов (более 30 млн. наименований);
- Поставка сложных, дефицитных, либо снятых с производства позиций;
- Оперативные сроки поставки под заказ (от 5 рабочих дней);
- Экспресс доставка в любую точку России;
- Помощь Конструкторского Отдела и консультации квалифицированных инженеров;
- Техническая поддержка проекта, помощь в подборе аналогов, поставка прототипов;
- Поставка электронных компонентов под контролем ВП;
- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001;
- При необходимости вся продукция военного и аэрокосмического назначения проходит испытания и сертификацию в лаборатории (по согласованию с заказчиком);
- Поставка специализированных компонентов военного и аэрокосмического уровня качества (Xilinx, Altera, Analog Devices, Intersil, Interpoint, Microsemi, Actel, Aeroflex, Peregrine, VPT, Syfer, Eurofarad, Texas Instruments, MS Kennedy, Miteq, Cobham, E2V, MA-COM, Hittite, Mini-Circuits, General Dynamics и др.);

Компания «Океан Электроники» является официальным дистрибьютором и эксклюзивным представителем в России одного из крупнейших производителей разъемов военного и аэрокосмического назначения «JONHON», а так же официальным дистрибьютором и эксклюзивным представителем в России производителя высокотехнологичных и надежных решений для передачи СВЧ сигналов «FORSTAR».



## JONHON

«JONHON» (основан в 1970 г.)

Разъемы специального, военного и аэрокосмического назначения:

(Применяются в военной, авиационной, аэрокосмической, морской, железнодорожной, горно- и нефтедобывающей отраслях промышленности)

«FORSTAR» (основан в 1998 г.)

ВЧ соединители, коаксиальные кабели, кабельные сборки и микроволновые компоненты:

(Применяются в телекоммуникациях гражданского и специального назначения, в средствах связи, РЛС, а так же военной, авиационной и аэрокосмической отраслях промышленности).



Телефон: 8 (812) 309-75-97 (многоканальный)

Факс: 8 (812) 320-03-32

Электронная почта: [ocean@oceanchips.ru](mailto:ocean@oceanchips.ru)

Web: <http://oceanchips.ru/>

Адрес: 198099, г. Санкт-Петербург, ул. Калинина, д. 2, корп. 4, лит. А