WIDE BAND LOW NOISE AMPLIFIER GaAs MMIC

■ GENERAL DESCRIPTION

The NJG1146KG1 is a fully matched wide band low noise amplifier GaAs MMIC for terrestrial application.

To achieve wide dynamic range, the NJG1146KG1 offers high gain mode and low gain mode. Selecting high gain mode for weak signals, the NJG1146KG1 helps improve receiver sensitivity through high gain and low noise figure. Selecting low gain mode for strong signals, it bypasses LNA circuit to offer higher linearity.

A small and ultra-thin package of ESON6-G1 is adopted.

■ PACKAGE OUTLINE

NJG1146KG1

■ APPLICATIONS

Terrestrial application from 40MHz to 900MHz
Digital TV, Set-top box and Broadband CATV applications

■ FEATURES

- Operating frequency 40MHz to 900MHz
- Operating voltage 5.0V typ.
- Package size ESON6-G1 (Package size: 1.6mm x 1.6mm x 0.397mm typ.)

[High gain mode]

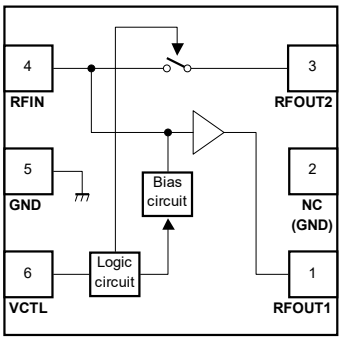
- Operating current 60mA typ.
- Gain 12.0dB typ.
- Noise figure 2.2dB typ.
- IM2 52.0dB typ.
- IM3 80.0dB typ.

[Low gain mode]

- Low current consumption 30μA typ.
- Gain(Low loss) -1.0dB typ.

■ PIN CONFIGURATION

(Top View)



Pin Connection

1. RFOUT1
2. NC(GND)
3. RFOUT2
4. RFIN
5. GND
6. VCTL

*Exposed PAD: GND

■ TRUTH TABLE

"H"=$V_{CTL(H)}$, "L"=$V_{CTL(L)}$

V_{CTL}	LNA ON	Bypass	LNA mode
H	ON	OFF	High Gain mode
L	OFF	ON	Low Gain mode

Note: Specifications and description listed in this datasheet are subject to change without notice.

■ ABSOLUTE MAXIMUM RATINGS

Ta=+25°C, Z_s=Z_l=50Ω

PARAMETER	SYMBOL	CONDITIONS	RATINGS	UNITS
Drain voltage	V_{DD}		6.0	V
Control voltage	V_{CTL}		6.0	V
Input power	P_{IN}	V_{DD}=5.0V	+10	dBm
Power dissipation	P_D	4-layer FR4 PCB with through-hole (101.5x114.5mm), T_j=150°C	1200	mW
Operating temperature	T_{opr}		-40 to +85	°C
Storage temperature	T_{stg}		-55 to +150	°C

■ ELECTRICAL CHARACTERISTICS1 (DC CHARACTERISTICS)

V_{DD}=5.0V, Ta=+25°C, with application circuit

PARAMETERS	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Operating voltage	V_{DD}		2.4	5.0	5.5	V
Control voltage (High)	$V_{CTL(H)}$		1.3	1.8	5.5	V
Control voltage (Low)	$V_{CTL(L)}$		0.0	0.0	0.5	V
Operating current1	$I_{DD}1$	RF OFF, V_{CTL}=1.8V	-	60	80	mA
Operating current2	$I_{DD}2$	RF OFF, V_{CTL}=0V	-	30	50	μA
Control current	I_{CTL}	RF OFF, V_{CTL}=1.8V	-	6	12	μA

■ **ELECTRICAL CHARACTERISTICS2** (High Gain mode)

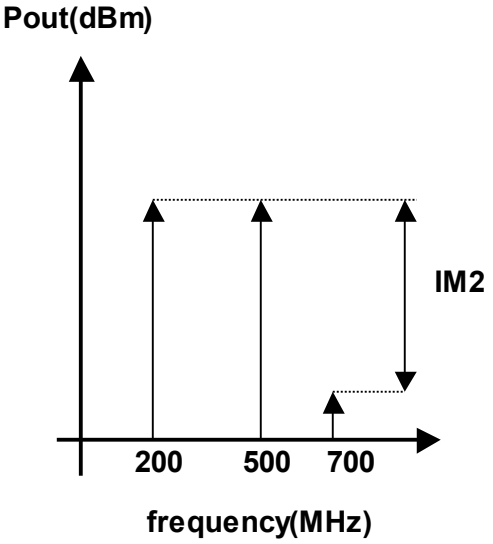
V_{DD}=5.0V, V_{CTL}=1.8V, freq=40 to 900MHz, Ta=+25°C, Z_S=Z_l=50Ω, with application circuit

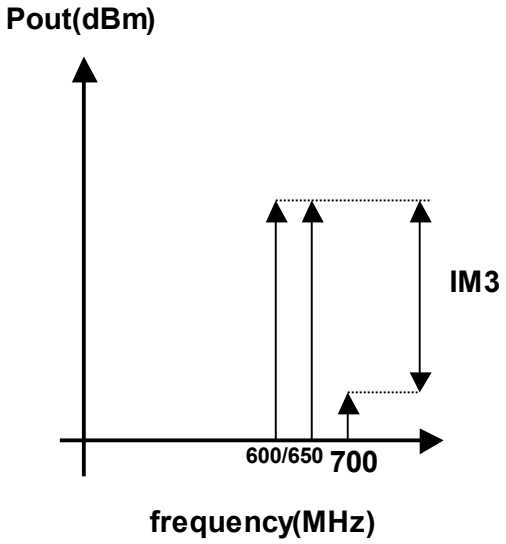
PARAMETERS	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Small signal gain1	Gain1	Exclude PCB & connector losses *1	9.0	12.0	14.0	dB
Noise figure1_1	NF1_1	freq=40 to 80MHz, Exclude PCB & connector losses *2	-	2.5	4.0	dB
Noise figure1_2	NF1_2	freq=80 to 900MHz, Exclude PCB & connector losses *2	-	2.2	3.0	dB
Input power at 1dB gain compression point1	$P_{-1dB(IN)}$1		+0.0	+6.0	-	dBm
Input 3rd order intercept point1	IIP3_1	f1=freq, f2=freq+100kHz, P_{IN}=-12dBm	+16.0	+22.0	-	dBm
2nd order intermodulation distortion1	IM2_1	f1=200MHz, f2=500MHz, fmeas=700MHz, P_{IN}1=P_{IN}2=-15dBm *3	42.0	52.0	-	dB
3rd order intermodulation distortion1	IM3_1	f1=600MHz, f2=650MHz, fmeas=700MHz, P_{IN}1=P_{IN}2=-15dBm *3	55.0	80.0	-	dB
Isolation	ISL1	S12	-	-17.0	-13.0	dB
RF IN Return loss1	RLi1		7.0	10.0	-	dB
RF OUT Return loss1	RLo1		7.0	10.0	-	dB

*1 Input & output PCB and connector losses: 0.014dB(40MHz), 0.088dB(620MHz), 0.121dB(900MHz)

*2 Input PCB and connector losses: 0.007dB(40MHz), 0.011dB(80MHz), 0.044dB(620MHz), 0.060dB(900MHz)

*3 Definitions of IM2 and IM3.





■ **ELECTRICAL CHARACTERISTICS3** (High Gain mode)

V_{DD}=5.0V, V_{CTL}=1.8V, freq=40 to 900MHz, Ta=+25°C, Z_S=Z_l=75Ω, with application circuit

PARAMETERS	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Small signal gain75	Gain75	Exclude PCB & connector losses *1	-	12.0	-	dB
Composite Second Order	CSO	74channels *4, CW P_{IN}=+15dBmV fmeas=295.25MHz,	-	-56	-	dBc
Composite Triple Beat	CTB	74channels *4, CW P_{IN}=+15dBmV fmeas=295.25±1.25MHz,	-	-81	-	dBc
Cross Modulation	XMOD	74channels *4, Modulation P_{IN}=+15dBmV fmeas=295.25±15.75kHz,	-	-80	-	dBc
RF IN Return loss75	RLi75		-	15	-	dB
RF OUT Return loss75	RLo75		-	15	-	dB

*1 Input & output PCB and connector losses: 0.014dB(40MHz), 0.088dB(620MHz), 0.121dB(900MHz)

*4 74channels: ch1 to C63(91.25 to 463.25MHz 6MHz step) and U13 to U25(471.25 to 543.25MHz 6MHz step) except ch7(189.25MHz), C28(253.25MHz)

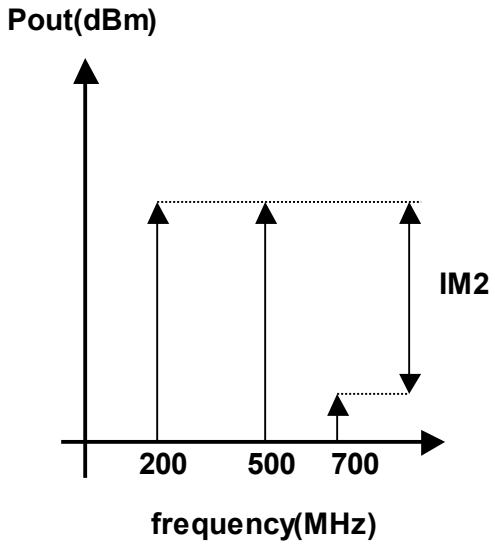
■ **ELECTRICAL CHARACTERISTICS4** (Low Gain mode)

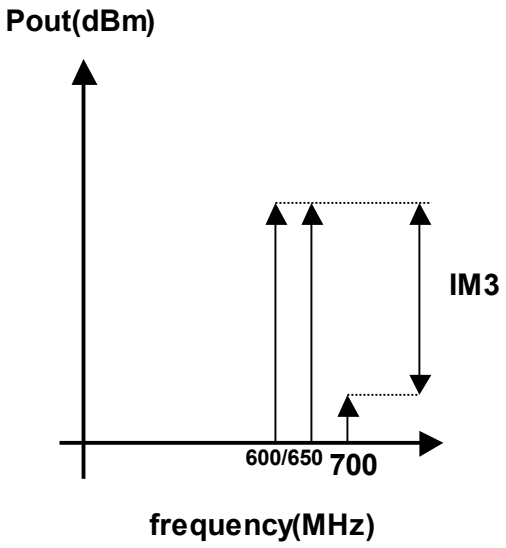
V_{DD}=5.0V, V_{CTL}=0V, freq=40 to 900MHz, Ta=+25°C, Z_S=Z_l=50Ω, with application circuit

PARAMETERS	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Small signal gain2	Gain2	Exclude PCB & connector losses *1	-2.5	-1.0	-	dB
Input power at 1dB gain compression point2	$P_{-1dB(IN)}2$		+10.0	+16.0	-	dBm
Input 3rd order intercept point2	IIP3_2	f1=freq, f2=freq+100kHz, P_{IN}=-2dBm	+25.0	+33.0	-	dBm
2nd order intermodulation distortion1	IM2_2	f1=200MHz, f2=500MHz, fmeas=700MHz, $P_{IN}1$=$P_{IN}2$=0dBm *3	40.0	60.0	-	dB
3rd order intermodulation distortion1	IM3_2	f1=600MHz, f2=650MHz, fmeas=700MHz, $P_{IN}1$=$P_{IN}2$=0dBm *3	48.0	70.0	-	dB
RF IN Return loss2	RLi2		8.0	15.0	-	dB
RF OUT Return loss2	RLo2		8.0	15.0	-	dB

*1 Input & output PCB and connector losses: 0.014dB(40MHz), 0.088dB(620MHz), 0.121dB(900MHz)

*3 Definitions of IM2 and IM3.





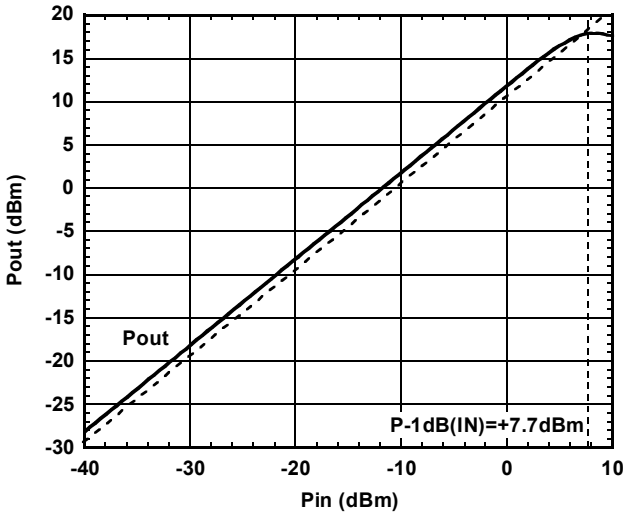
■ TERMINAL INFORMATION

No.	SYMBOL	DESCRIPTION
1	RFOUT1	At the High gain mode, RF output terminal. This terminal doubles as the drain terminal of the LNA. Please connect this terminal to the power supply(VDD) via inductor(L1).
2	NC(GND)	No connected terminal. This terminal is not connected with internal circuit.
3	RFOUT2	At the Low gain mode, RF output terminal. Please connect this terminal with RFOUT1 terminal through DC blocking capacitor(C2) shown in the application circuit.
4	RFIN	RF input terminal. External capacitor C1 is required to block the DC bias voltage of internal circuit.
5	GND	Ground terminal. This terminal should be connected to the ground plane as close as possible for excellent RF performance.
6	VCTL	Control voltage terminal.
Exposed Pad	GND	Ground terminal. Please connect Exposed Pad with GND by using the plated through holes.

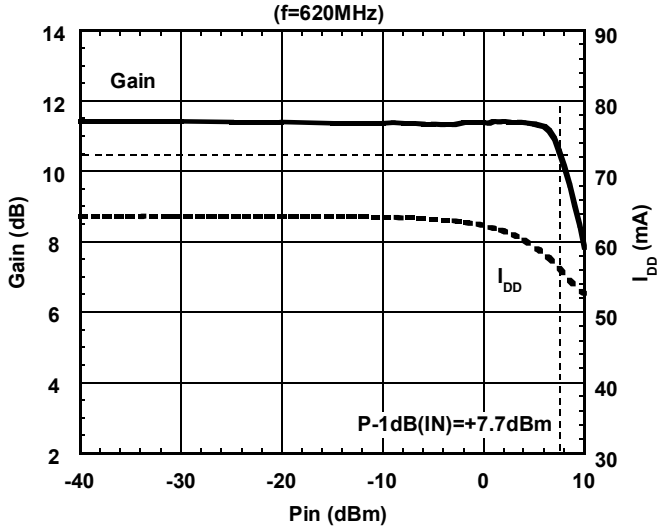
■ ELECTRICAL CHARACTERISTICS (High Gain mode)

Conditions: V_{DD}=5.0V, V_{CTL}=1.8V, Ta=25°C, Z_s=Z_l=50Ω, with application circuit

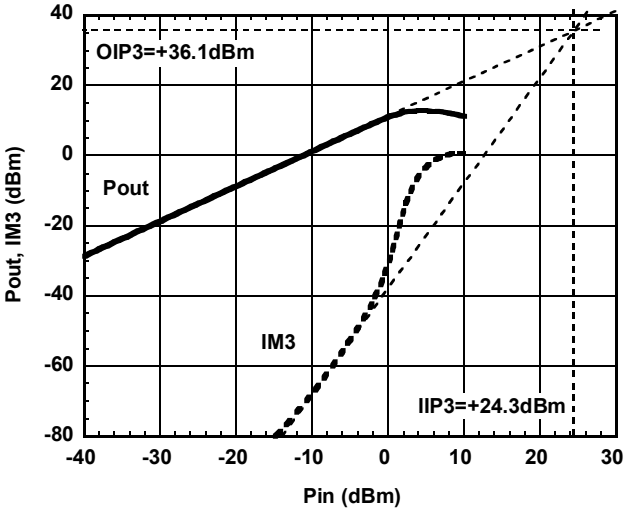
Pout vs. Pin
(f=620MHz)



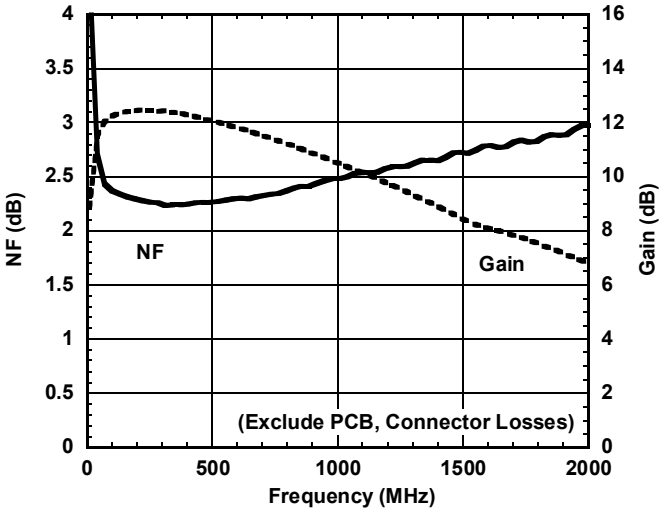
Gain, I_{DD} vs. Pin
(f=620MHz)



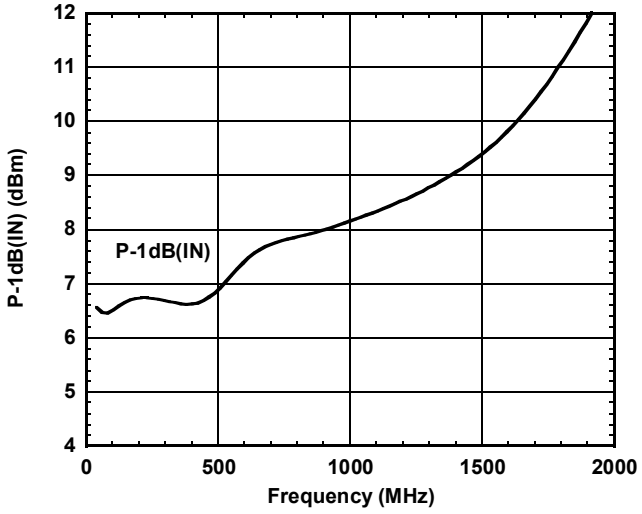
Pout, IM3 vs. Pin
(f1=620MHz, f2=620.1MHz)



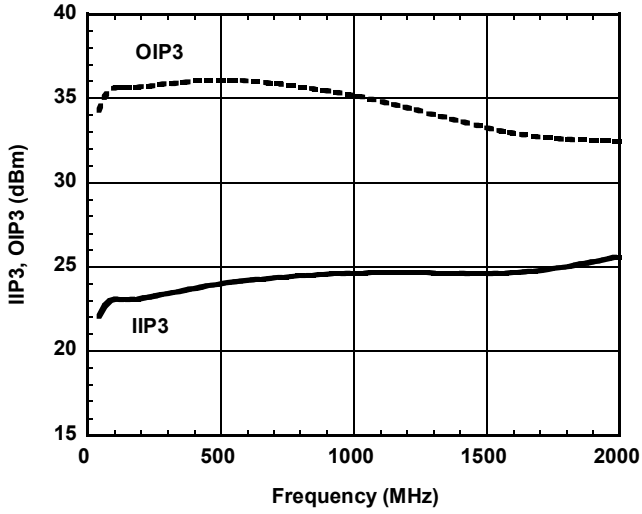
NF, Gain vs. Frequency



P-1dB(IN) vs. Frequency

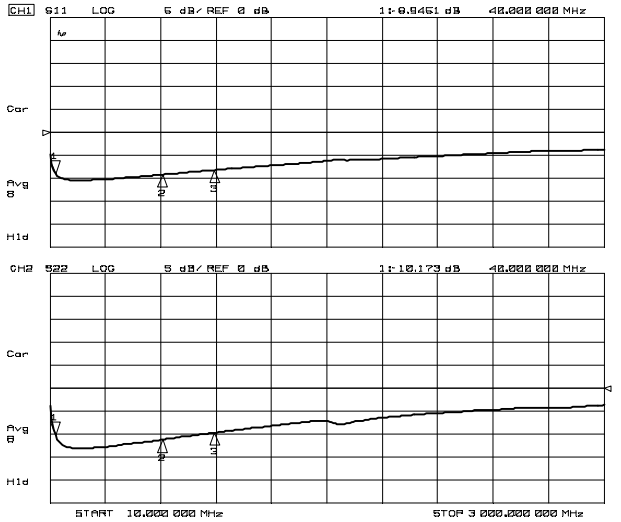


IIP3, OIP3 vs. Frequency
(f1=Frequency, f2=f1+100kHz, Pin=-12dBm)

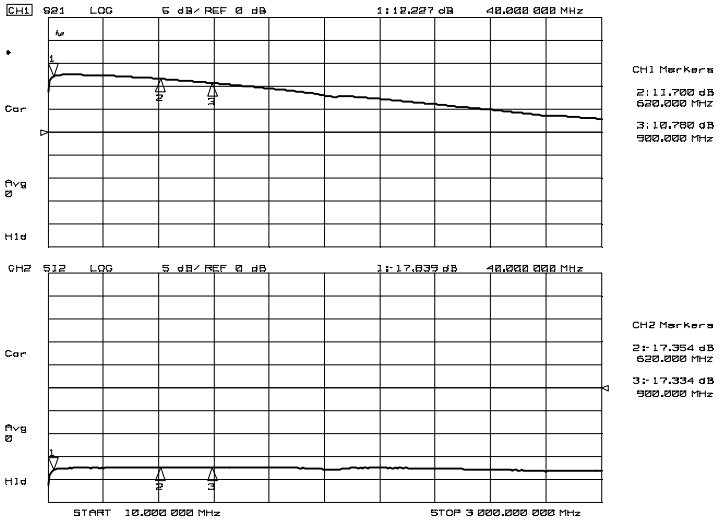


■ ELECTRICAL CHARACTERISTICS (High Gain mode)

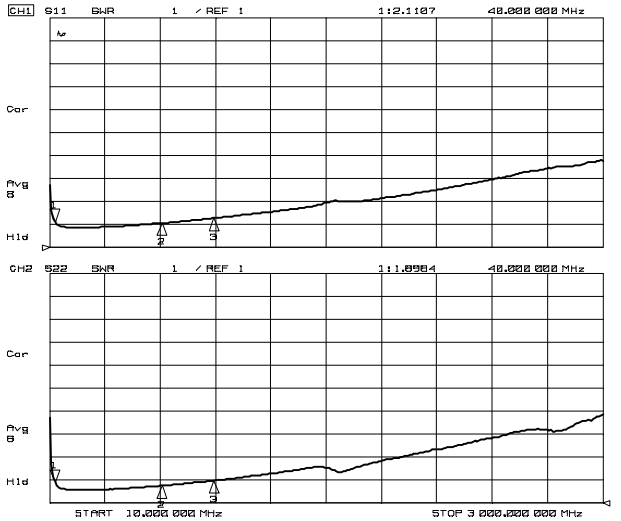
Conditions: V_{DD}=5.0V, V_{CTL}=1.8V, Ta=25°C, Z_s=Z_l=50Ω, with application circuit



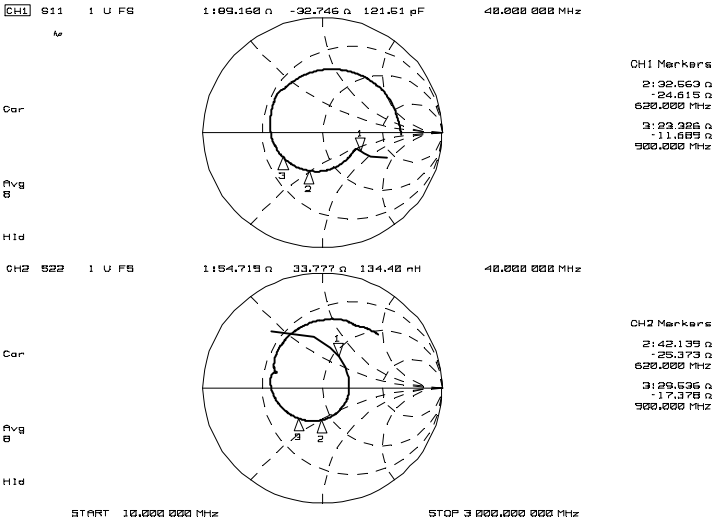
S11, S22 (f=10MHz to 3GHz)



S21, S12 (f=10MHz to 3GHz)



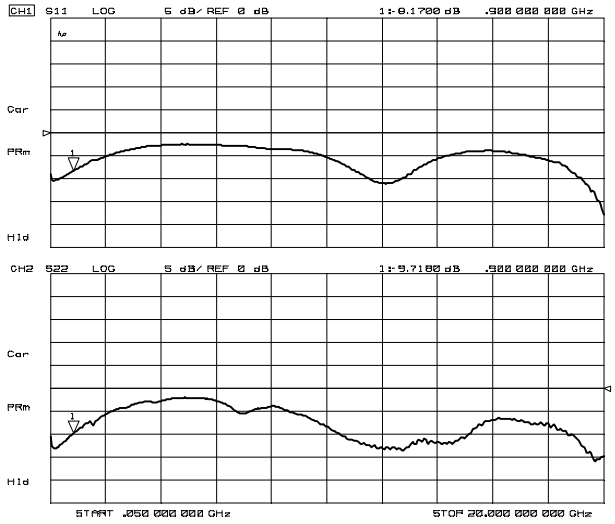
VSWR (f=10MHz to 3GHz)



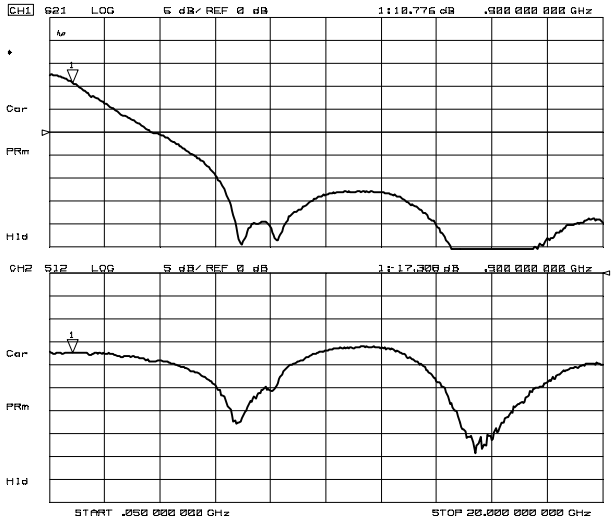
Zin, Zout (f=10MHz to 3GHz)

■ ELECTRICAL CHARACTERISTICS (High Gain mode)

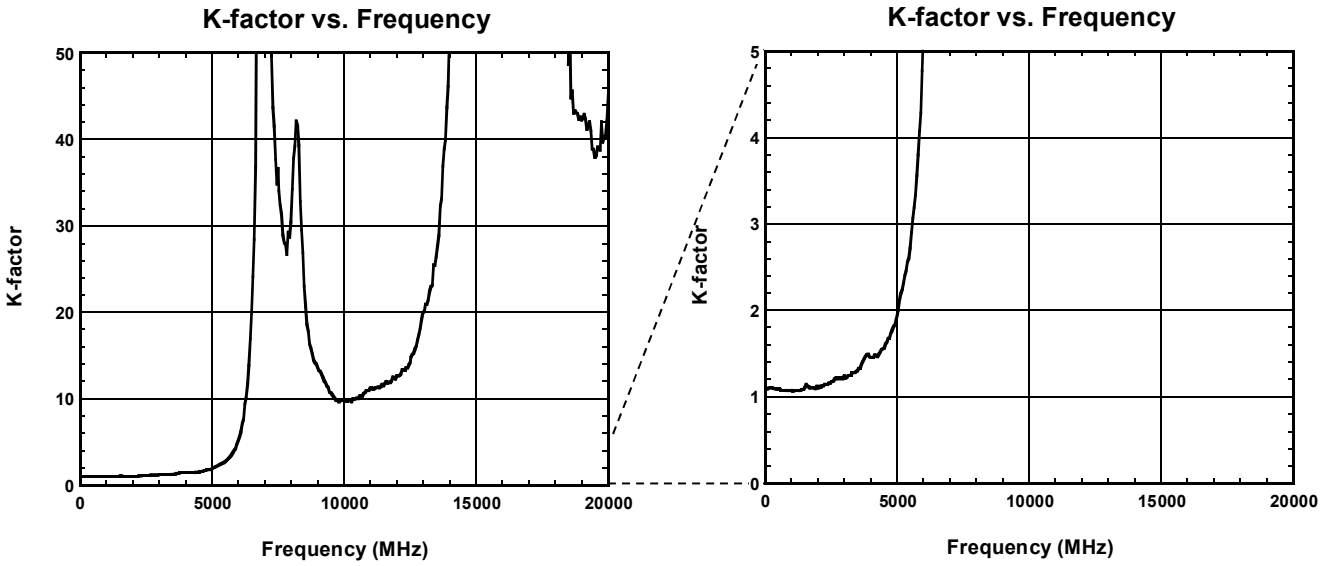
Conditions: V_{DD}=5.0V, V_{CTL}=1.8V, Ta=25°C, Z_s=Z_l=50Ω, with application circuit



S11, S22 (f=50MHz to 20GHz)



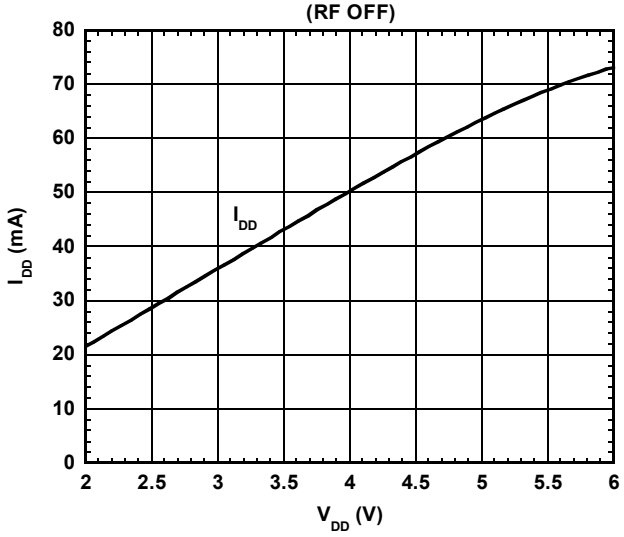
S21, S12 (f=50MHz to 20GHz)



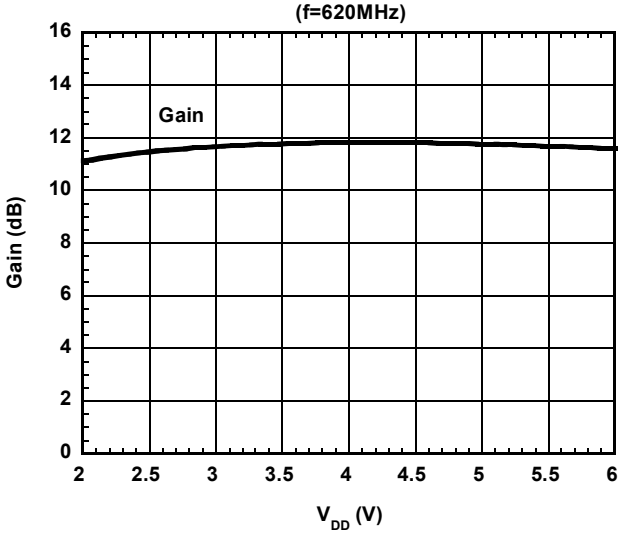
■ ELECTRICAL CHARACTERISTICS (High Gain mode)

Conditions: V_{CTL}=1.8V, Ta=25°C, Z_s=Z_l=50Ω, with application circuit

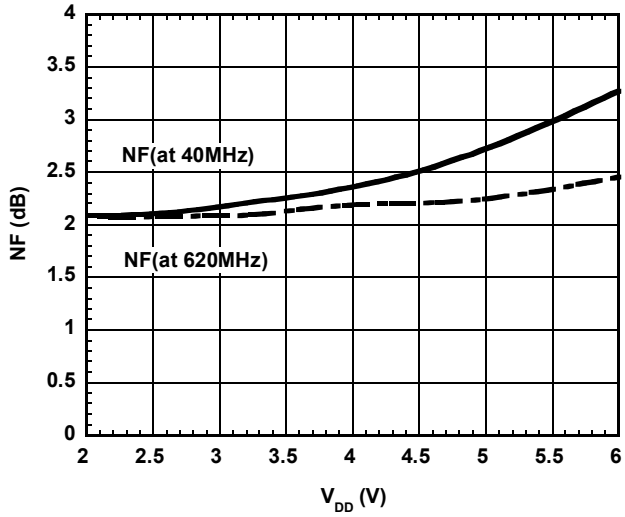
I_{DD} vs. V_{DD} (RF OFF)



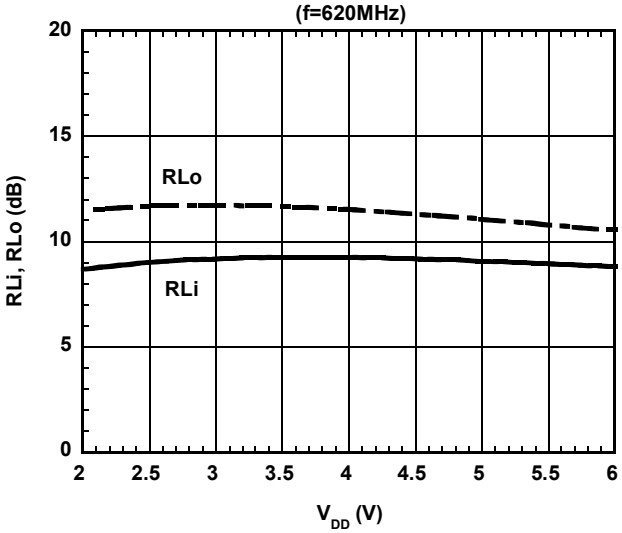
Gain vs. V_{DD} (f=620MHz)



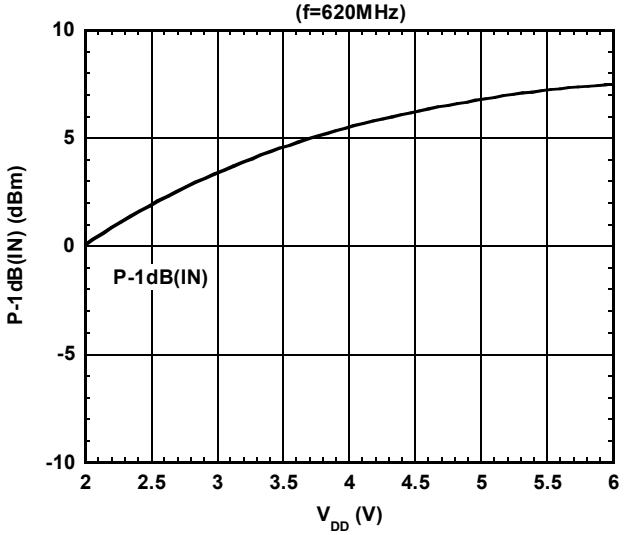
NF vs. V_{DD}



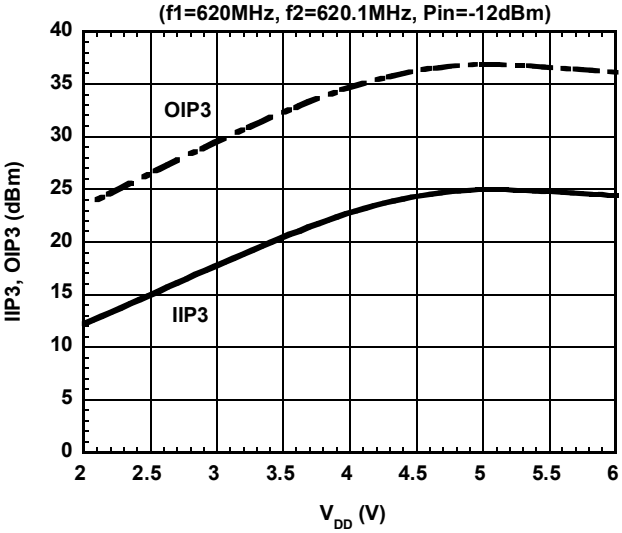
RLi, RLo vs. V_{DD} (f=620MHz)



P-1dB(IN) vs. V_{DD} (f=620MHz)



IIP3, OIP3 vs. V_{DD} (f1=620MHz, f2=620.1MHz, Pin=-12dBm)

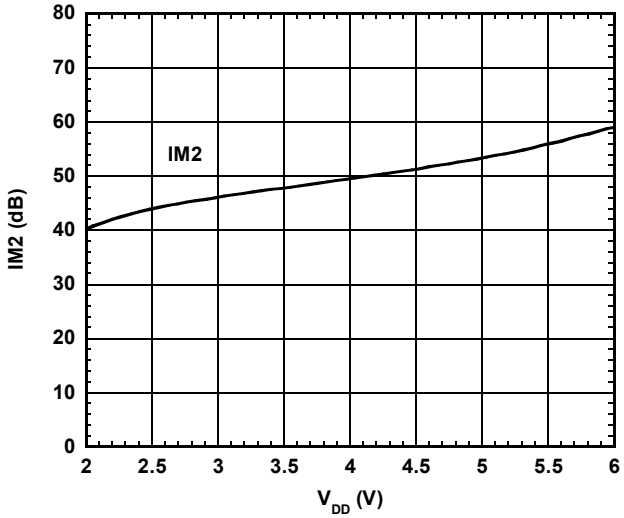


■ ELECTRICAL CHARACTERISTICS (High Gain mode)

Conditions: V_{CTL}=1.8V, Ta=25°C, Z_s=Z_l=50Ω, with application circuit

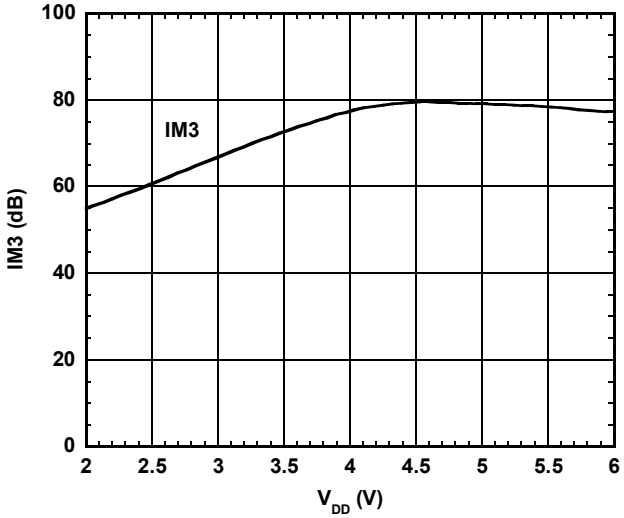
IM2 vs. V_{DD}

(f1=200MHz, f2=500MHz, fmeas=700MHz, Pin1=Pin2=-15dBm)

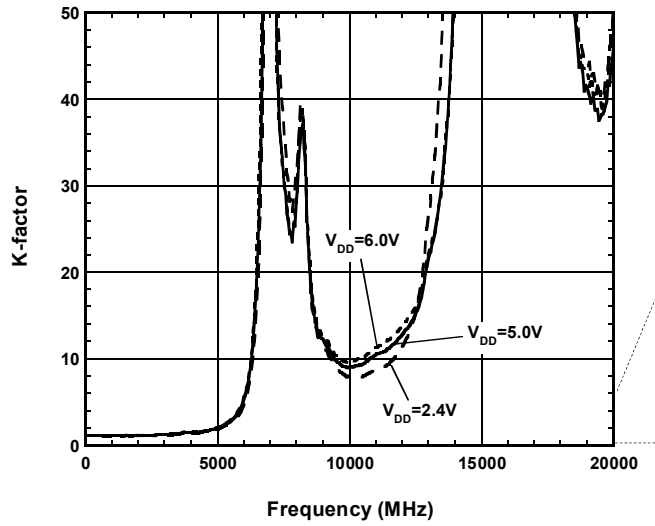


IM3 vs. V_{DD}

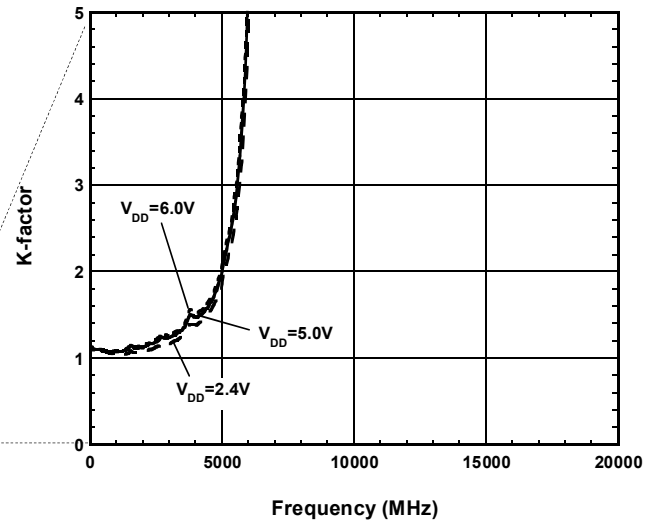
(f1=600MHz, f2=650MHz, fmeas=700MHz, Pin1=Pin2=-15dBm)



K-factor vs. Frequency



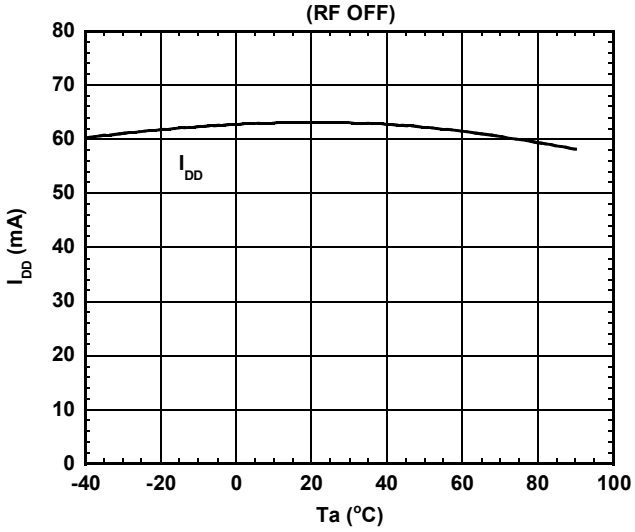
K-factor vs. Frequency



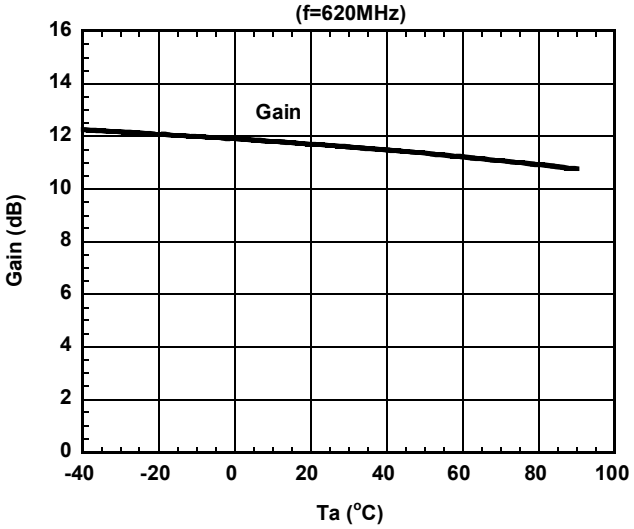
■ ELECTRICAL CHARACTERISTICS (High Gain mode)

Conditions: V_{DD}=5.0V, V_{CTL}=1.8V, Z_s=Z_l=50Ω, with application circuit

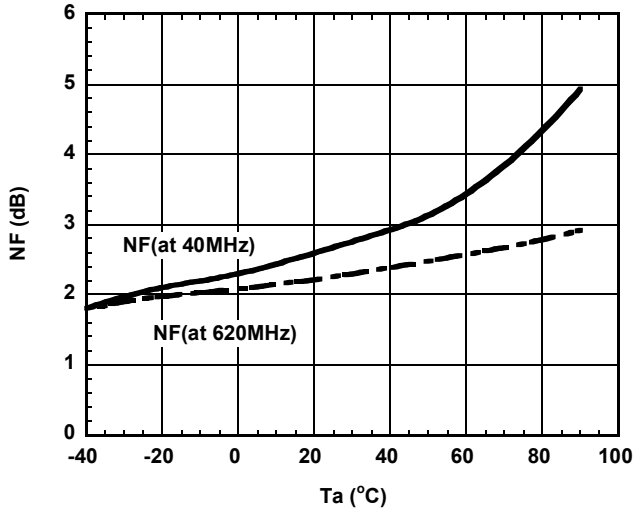
I_{DD} vs. Ta
(RF OFF)



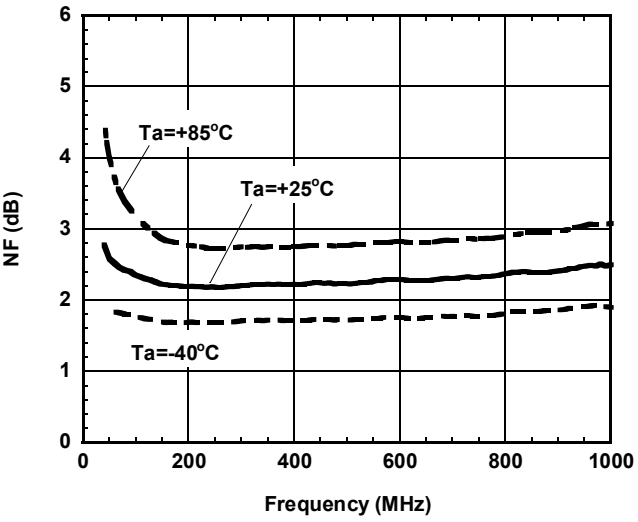
Gain vs. Ta
(f=620MHz)



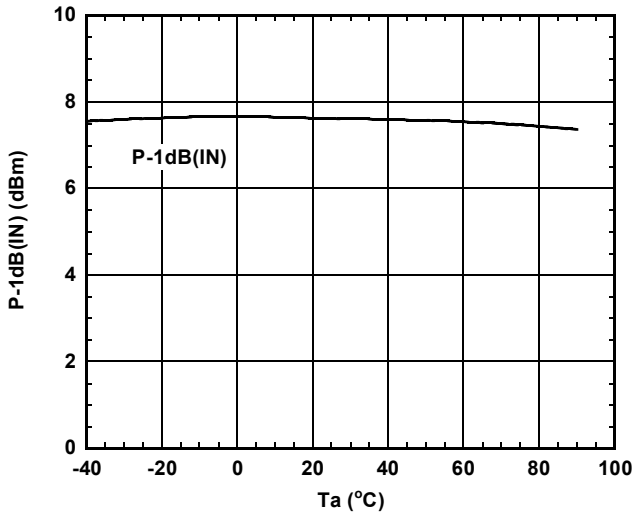
NF vs. Ta



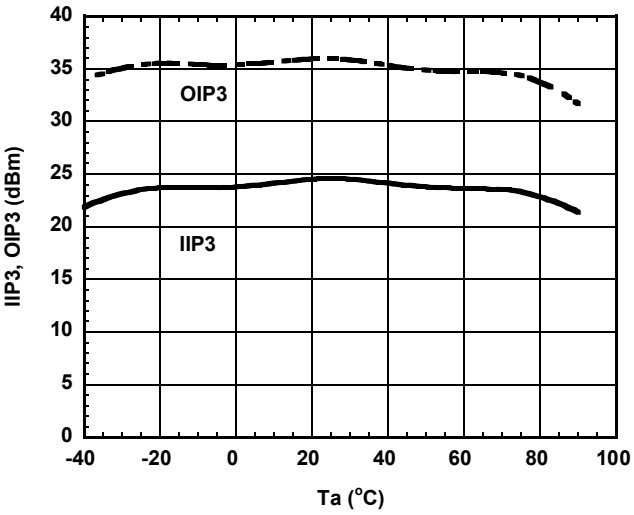
NF vs. Frequency



P-1dB(IN) vs. Ta
(f=620MHz)



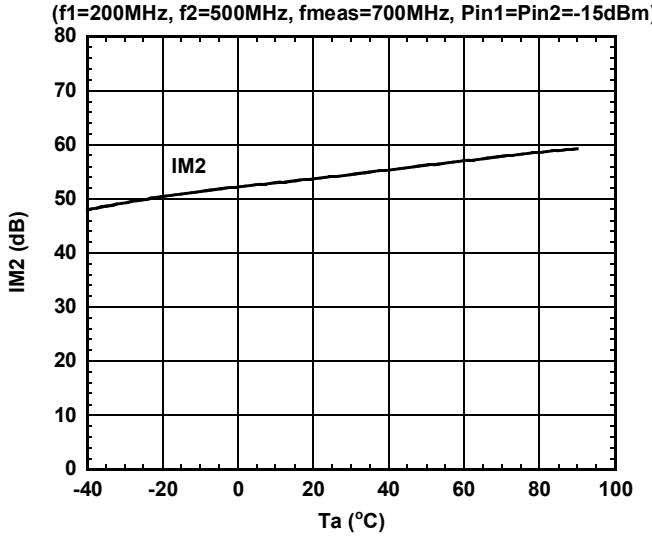
IIP3, OIP3 vs. Ta
(f1=620MHz, f2=620.1MHz, Pin=-12dBm)



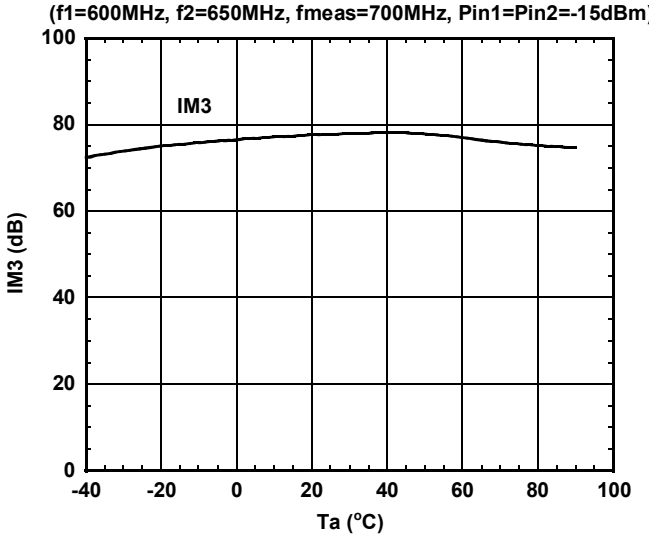
■ ELECTRICAL CHARACTERISTICS (High Gain mode)

Conditions: V_{DD}=5.0V, V_{CTL}=1.8V, Z_s=Z_l=50Ω, with application circuit

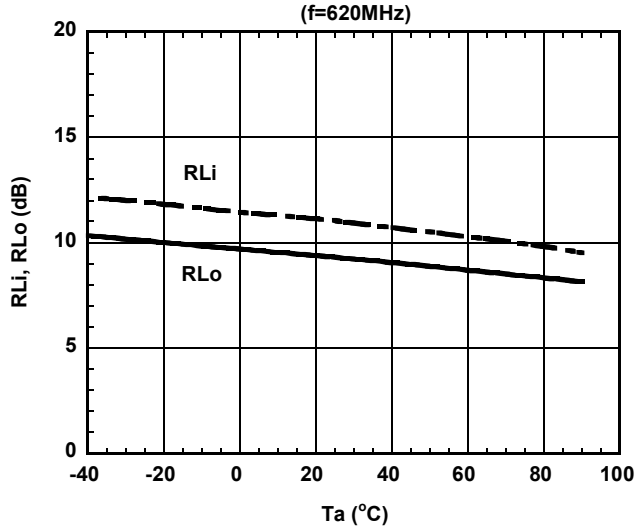
IM2 vs. Ta
(f1=200MHz, f2=500MHz, fmeas=700MHz, Pin1=Pin2=-15dBm)



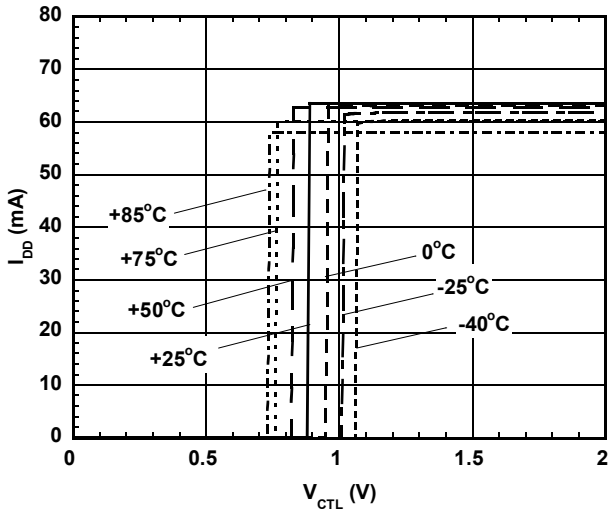
IM3 vs. Ta
(f1=600MHz, f2=650MHz, fmeas=700MHz, Pin1=Pin2=-15dBm)



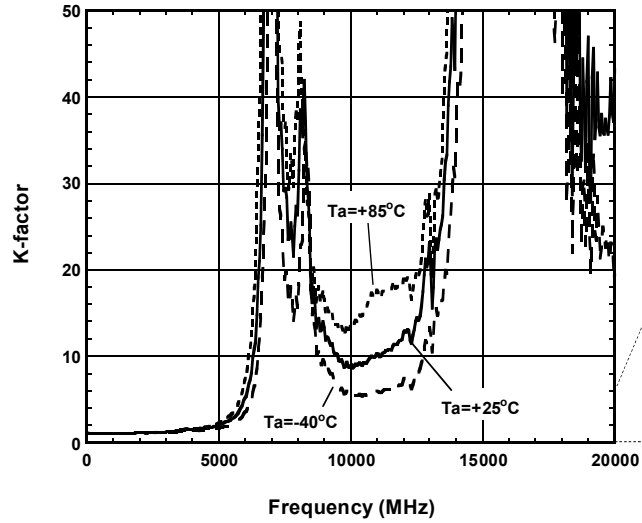
RLi, RLo vs. Ta
(f=620MHz)



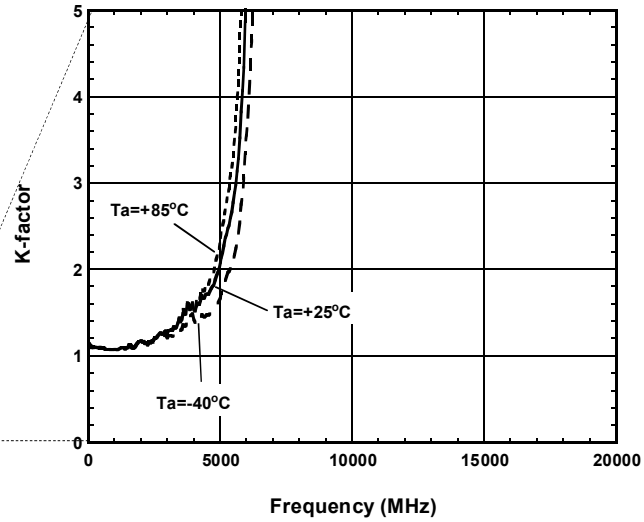
I_{DD} vs. V_{CTL}



K-factor vs. Frequency



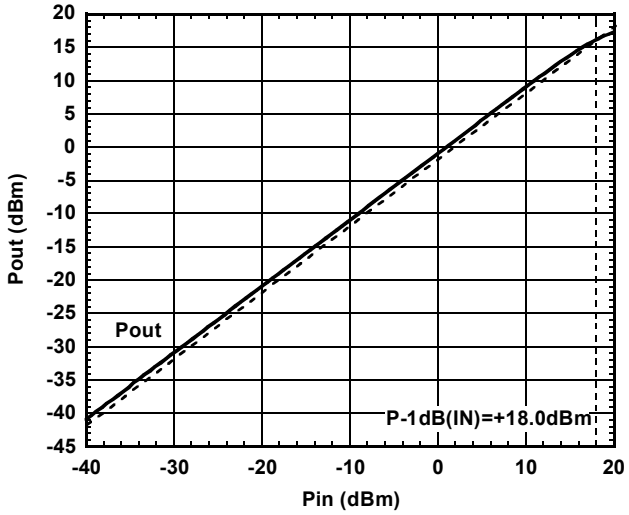
K-factor vs. Frequency



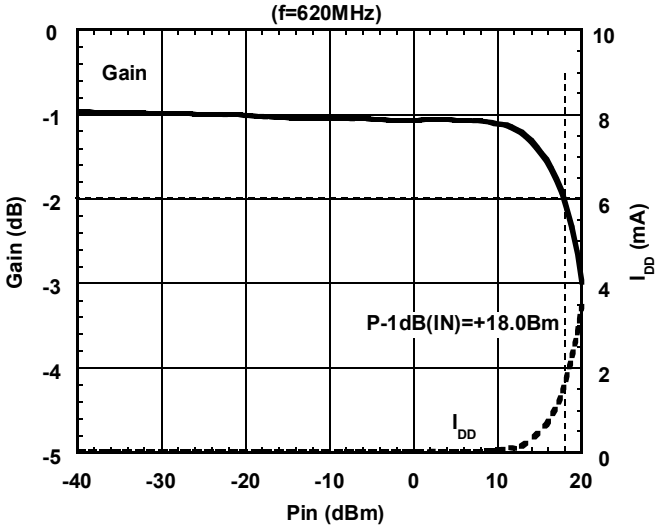
■ ELECTRICAL CHARACTERISTICS (Low Gain mode)

Conditions: V_{DD}=5.0V, V_{CTL}=0V, Ta=25°C, Z_s=Z_l=50Ω, with application circuit

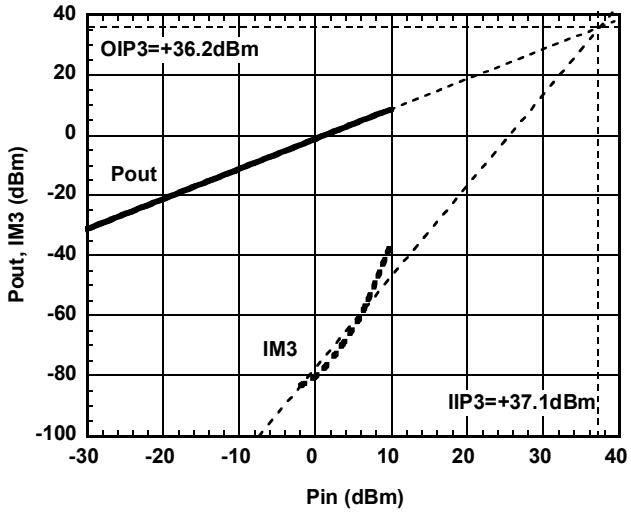
Pout vs. Pin
(f=620MHz)



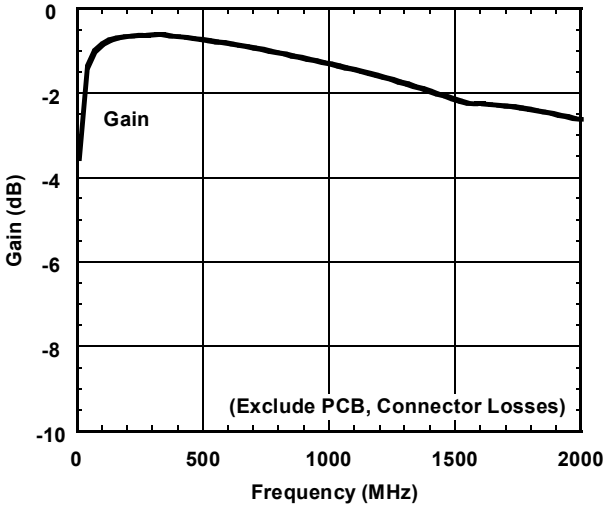
Gain, I_{DD} vs. Pin
(f=620MHz)



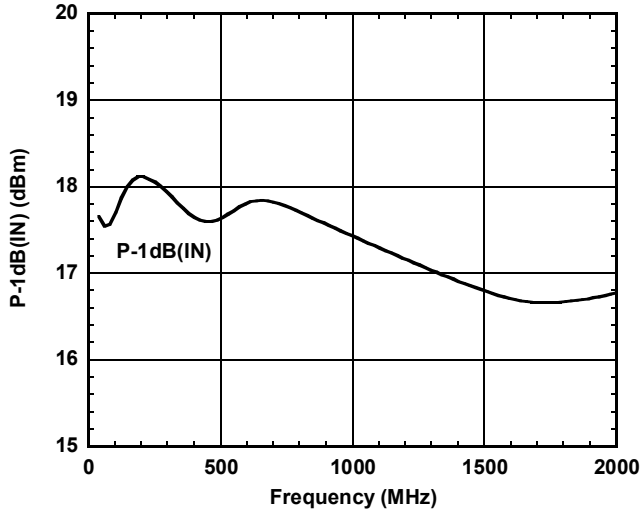
Pout, IM3 vs. Pin
(f1=620MHz, f2=620.1MHz)



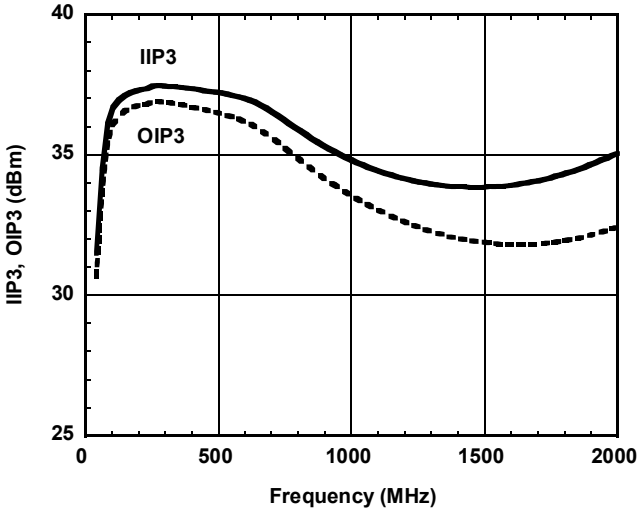
Gain vs. Frequency



P-1dB(IN) vs. Frequency

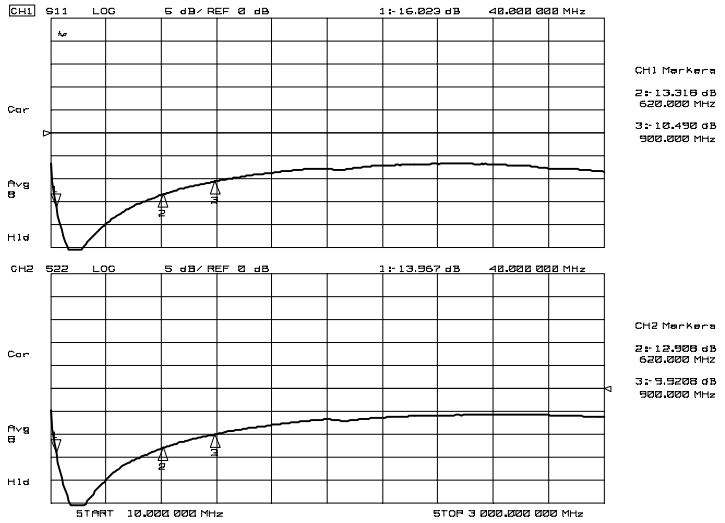


IIP3, OIP3 vs. Frequency
(f1=Frequency , f2=f1+100kHz, Pin=-2dBm)

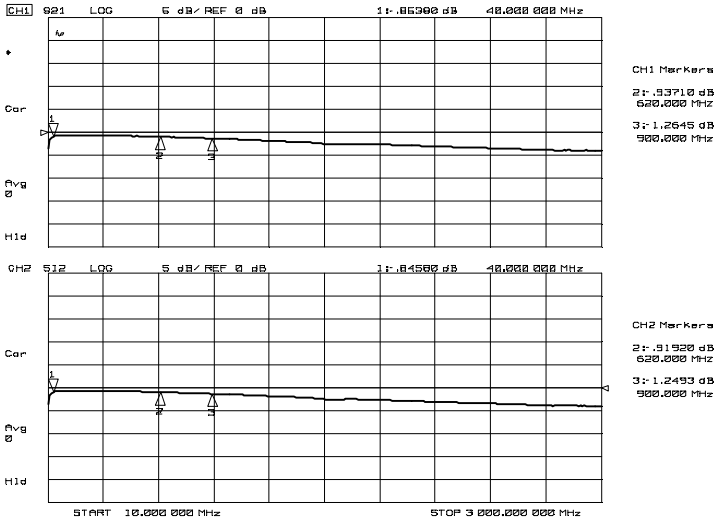


■ ELECTRICAL CHARACTERISTICS (Low Gain mode)

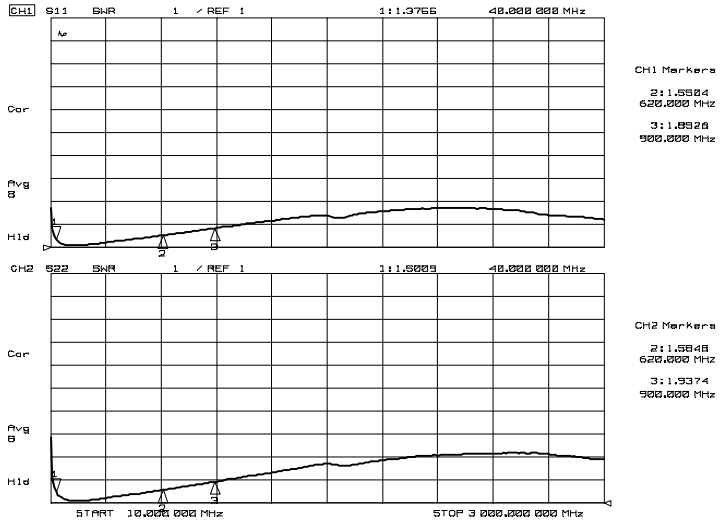
Conditions: V_{DD}=5.0V, V_{CTL}=0V, Ta=25°C, Z_s=Z_l=50Ω, with application circuit



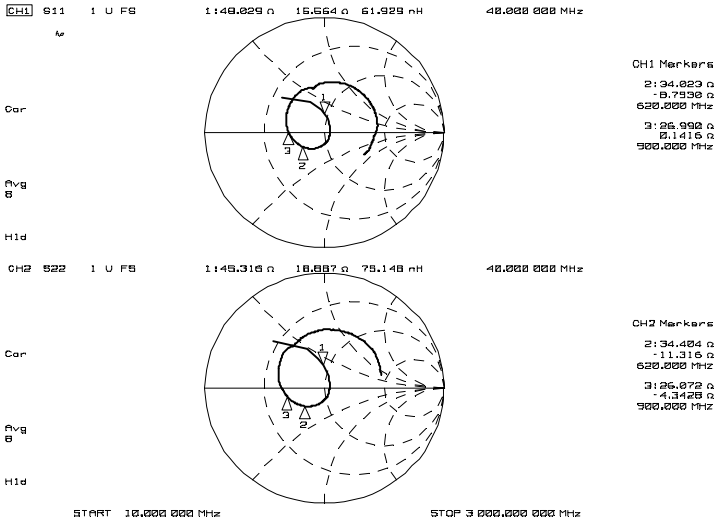
S11, S22 (f=10MHz to 3GHz)



S21, S12 (f=10MHz to 3GHz)



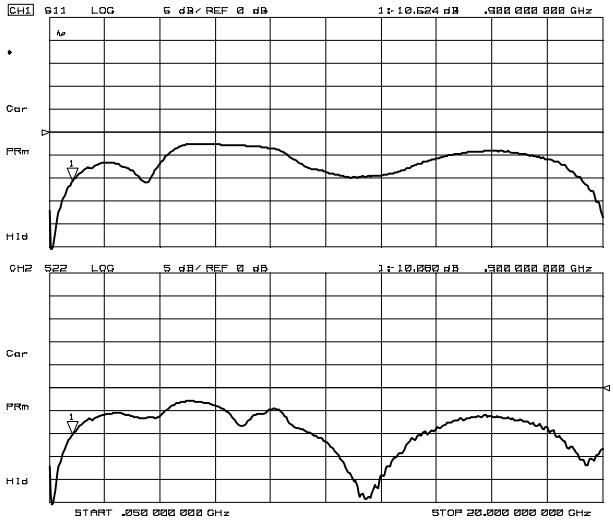
VSWR (f=10MHz to 3GHz)



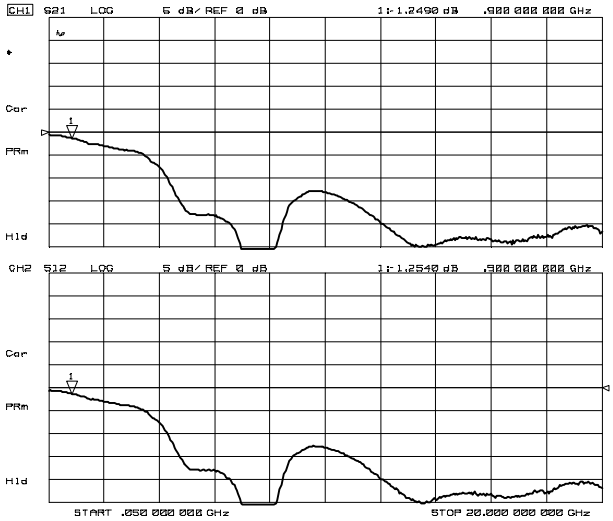
Zin, Zout (f=10MHz to 3GHz)

■ ELECTRICAL CHARACTERISTICS (Low Gain mode)

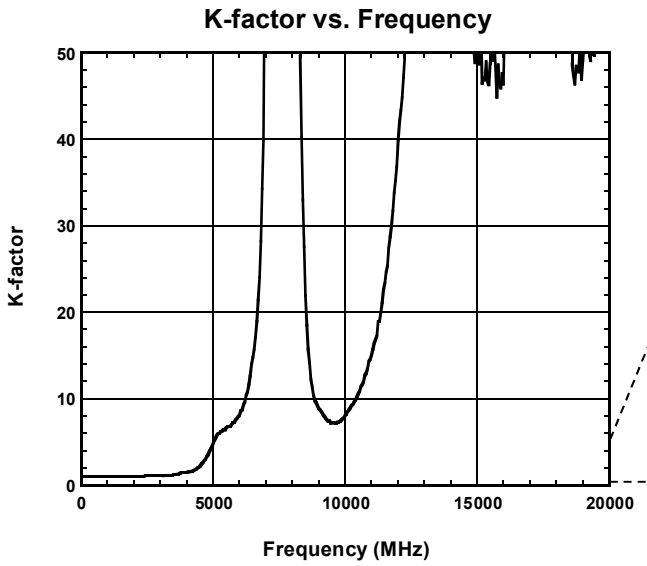
Conditions: V_{DD}=5.0V, V_{CTL}=0V, Ta=25°C, Z_s=Z_l=50Ω, with application circuit

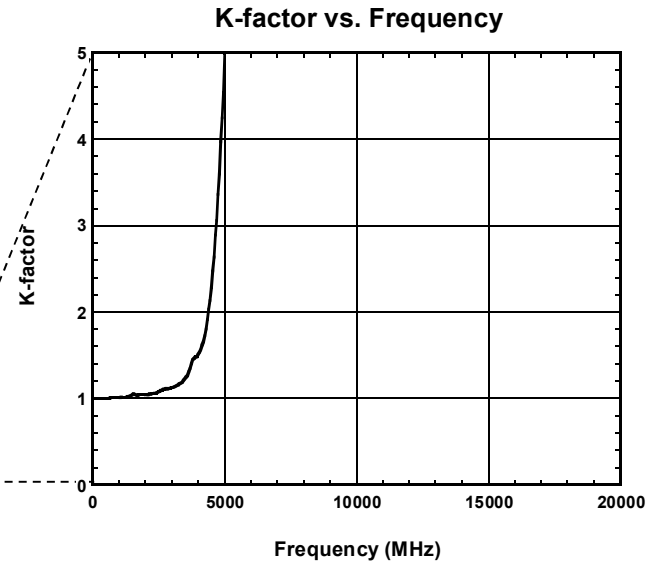


S11, S22 (f=50MHz to 20GHz)



S21, S12 (f=50MHz to 20GHz)

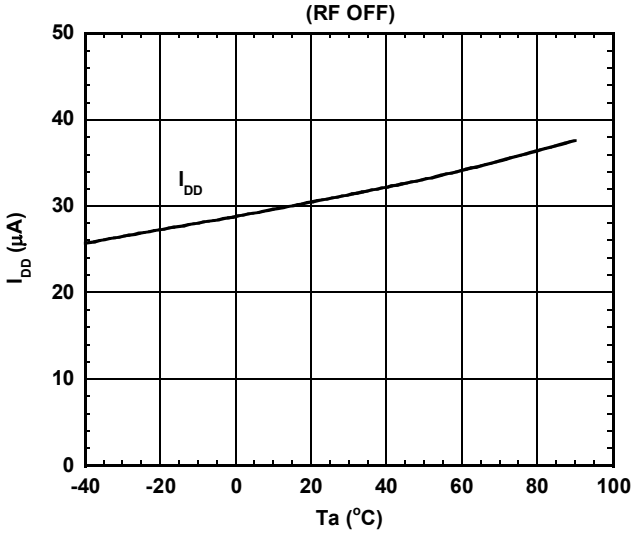




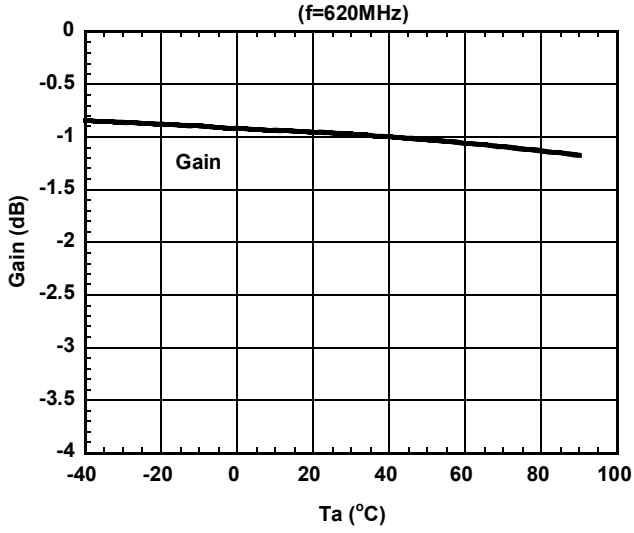
■ ELECTRICAL CHARACTERISTICS (Low Gain mode)

Conditions: V_{DD}=5.0V, V_{CTL}=0V, Z_s=Z_l=50Ω, with application circuit

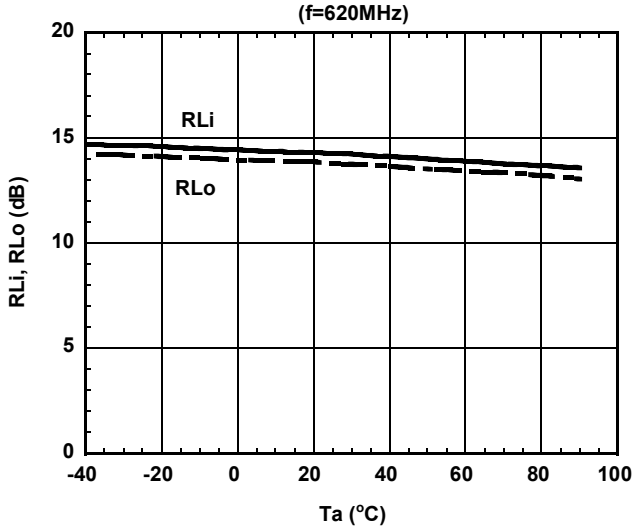
I_{DD} vs. Ta
(RF OFF)



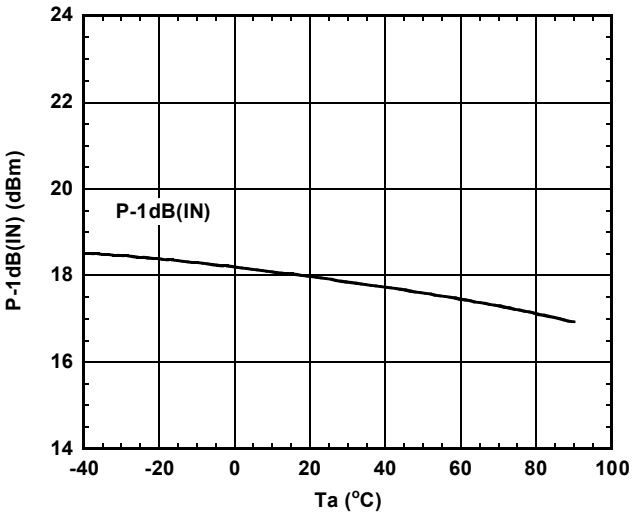
Gain vs. Ta
(f=620MHz)



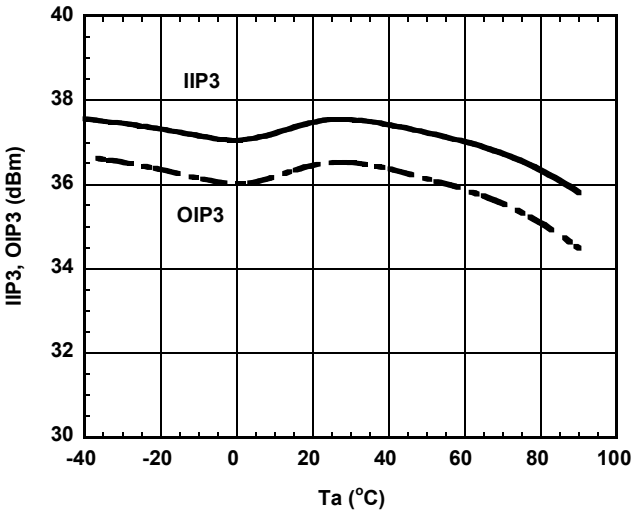
RLi, RLo vs. Ta
(f=620MHz)



P-1dB(IN) vs. Ta
(f=620MHz)

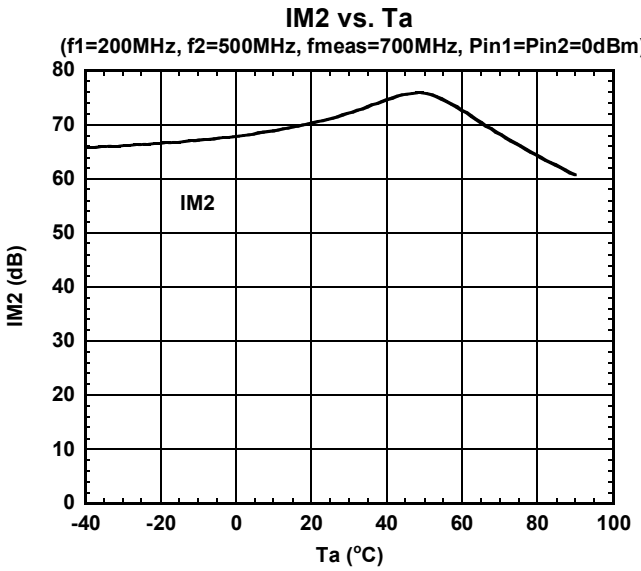


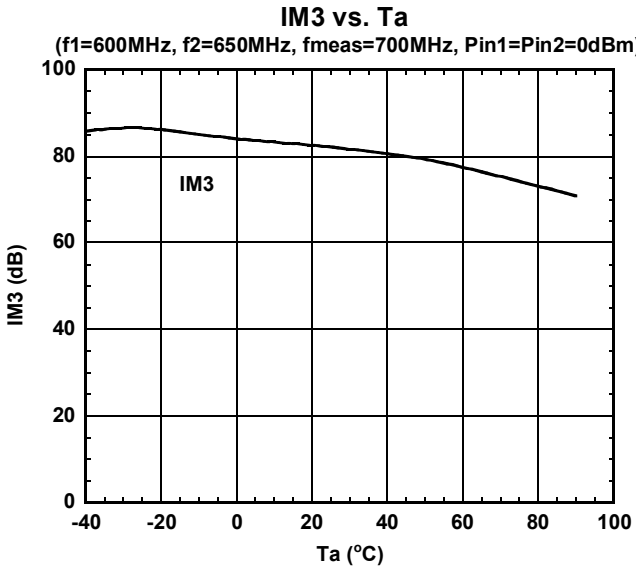
IIP3, OIP3 vs. Ta
(f1=620MHz, f2=620.1MHz, Pin=-2dBm)

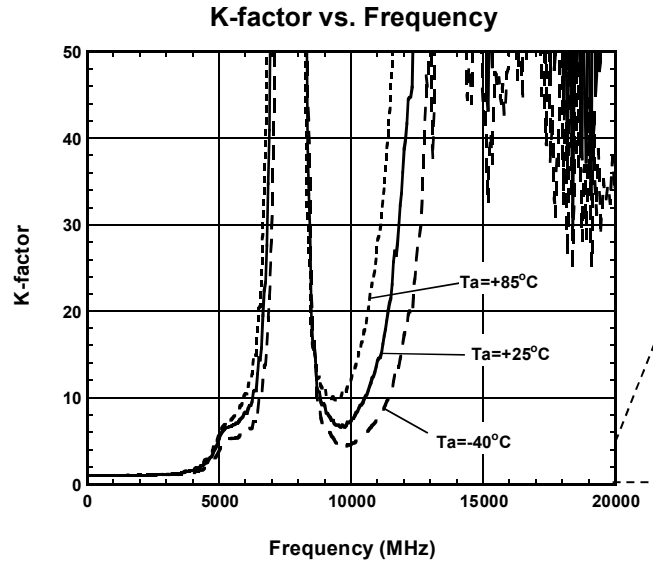


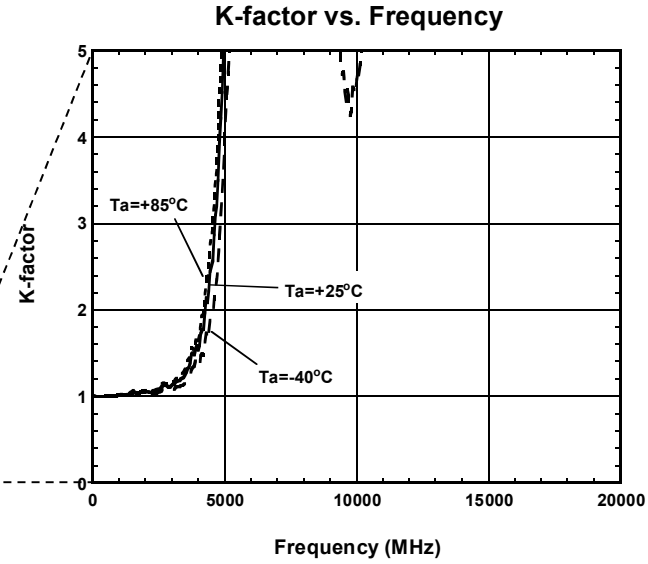
■ ELECTRICAL CHARACTERISTICS (Low Gain mode)

Conditions: V_{DD}=5.0V, V_{CTL}=0V, Z_s=Z_l=50Ω, with application circuit

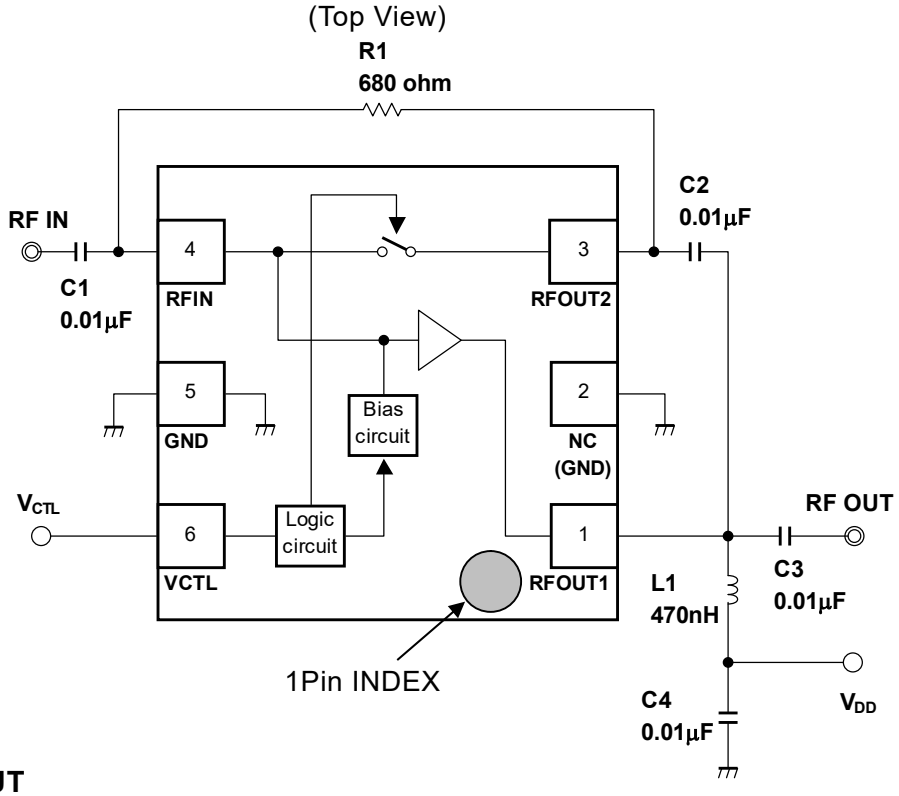




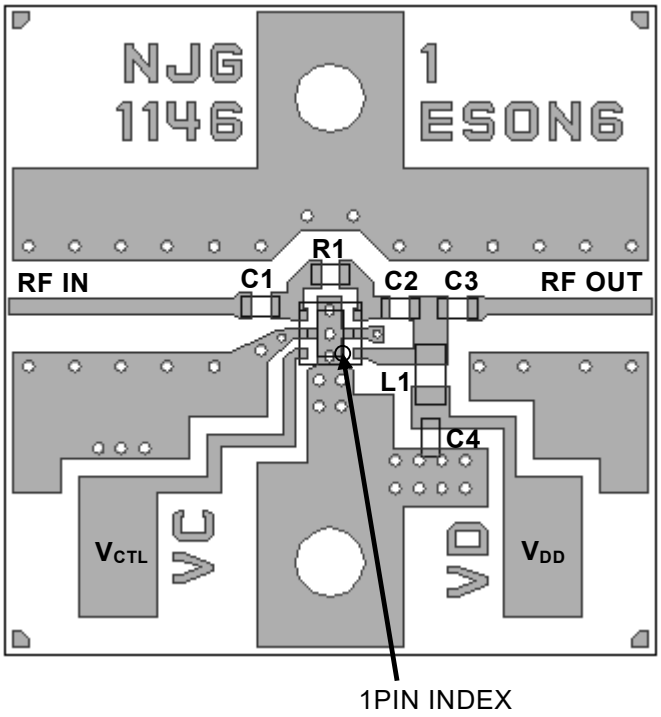




■ APPLICATION CIRCUIT



■ TEST PCB LAYOUT



PARTS LIST

Parts ID.	Manufacturer
L1	TAIYO-YUDEN HK1608 Series
C1 to C4	MURATA GRM15 Series
R1	KOA RK73B Series

PCB (FR-4):
t=0.2mm
MICROSTRIP LINE WIDTH
=0.40mm (Z_0=50Ω)
PCB SIZE=16.8mm x 16.8mm

PRECAUTIONS

- C1 to C3 are DC-Blocking capacitors, and L1 is a DC-feed inductor, and C4 is a bypass capacitor.
- Please connect Exposed Pad with GND by using the plated through hole.
- In order not to couple with terminal RFIN and RFOUT, please layout ground pattern under the IC.
- All external parts are placed as close as possible to the IC.

■ MEASUREMENT BLOCK DIAGRAM

Measuring instruments

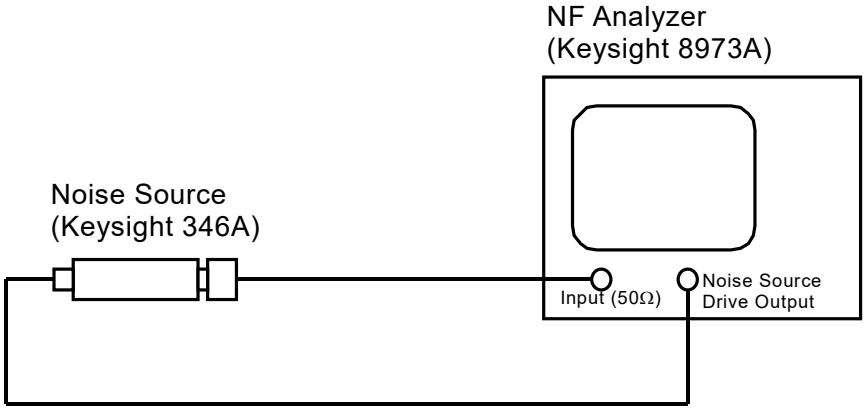
NF Analyzer : Keysight 8973A
Noise Source : Keysight 346A

Setting the NF analyzer

Measurement mode form
- Device under test : Amplifier
- System downconverter : off

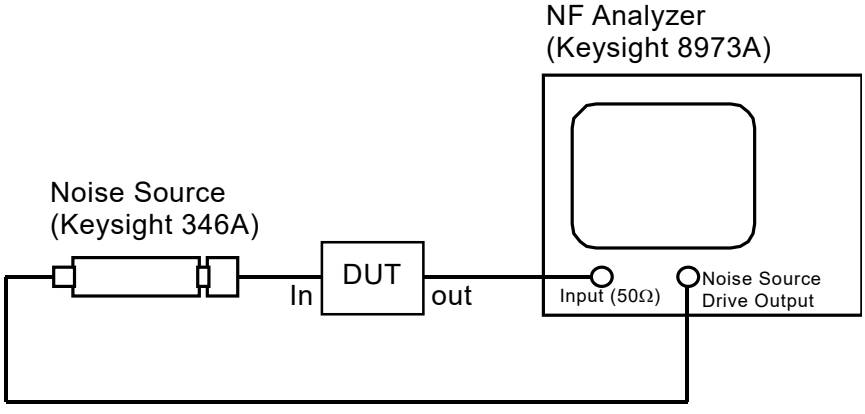
Mode setup form
- Sideband : LSB

Averages : 16
Average mode : Point
Bandwidth : 4MHz
Loss comp : off
Tcold : setting the temperature of noise source (303.15K)



* Noise source and NF analyzer are connected directly.

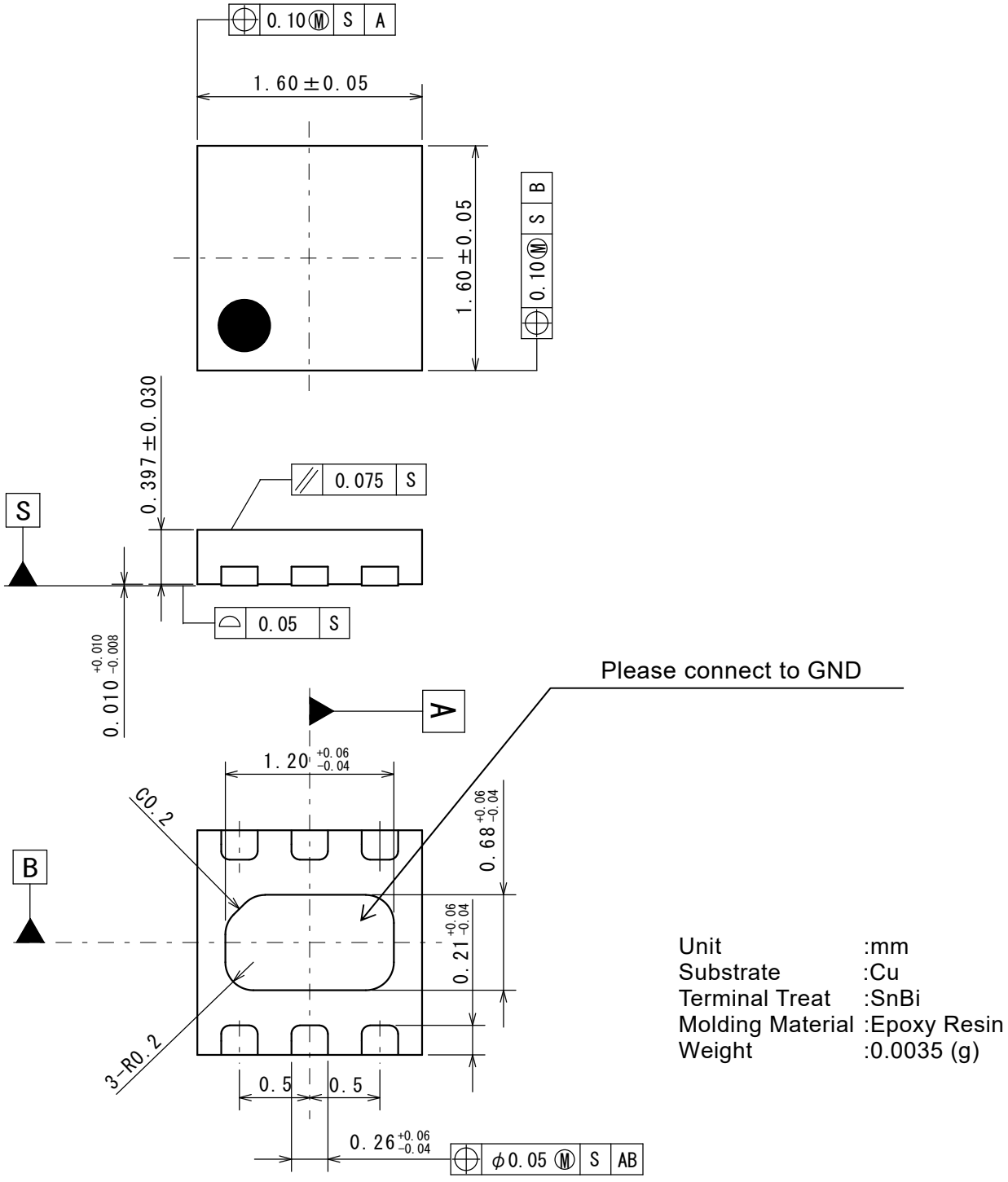
Calibration Setup



* Noise source and DUT, DUT and NF analyzer are connected directly.

Measurement Setup

■ PACKAGE OUTLINE (ESON6-G1)



Unit :mm
Substrate :Cu
Terminal Treat :SnBi
Molding Material :Epoxy Resin
Weight :0.0035 (g)

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.

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

1. The products and the product specifications described in this document are subject to change or discontinuation of production without notice for reasons such as improvement. Therefore, before deciding to use the products, please refer to our sales representatives for the latest information thereon.
2. The materials in this document may not be copied or otherwise reproduced in whole or in part without the prior written consent of us.
3. This product and any technical information relating thereto are subject to complementary export controls (so-called KNOW controls) under the Foreign Exchange and Foreign Trade Law, and related politics ministerial ordinance of the law. (Note that the complementary export controls are inapplicable to any application-specific products, except rockets and pilotless aircraft, that are insusceptible to design or program changes.) Accordingly, when exporting or carrying abroad this product, follow the Foreign Exchange and Foreign Trade Control Law and its related regulations with respect to the complementary export controls.
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    - Aerospace Equipment
    - Equipment Used in the Deep Sea
    - Power Generator Control Equipment (nuclear, steam, hydraulic, etc.)
    - Life Maintenance Medical Equipment
    - Fire Alarms / Intruder Detectors
    - Vehicle Control Equipment (automotive, airplane, railroad, ship, etc.)
    - Various Safety Devices
    - Traffic control system
    - Combustion equipment

    In case your company desires to use this product for any applications other than general electronic equipment mentioned above, make sure to contact our company in advance. Note that the important requirements mentioned in this section are not applicable to cases where operation requirements such as application conditions are confirmed by our company in writing after consultation with your company.
6. We are making our continuous effort to improve the quality and reliability of our products, but semiconductor products are likely to fail with certain probability. In order to prevent any injury to persons or damages to property resulting from such failure, customers should be careful enough to incorporate safety measures in their design, such as redundancy feature, fire containment feature and fail-safe feature. We do not assume any liability or responsibility for any loss or damage arising from misuse or inappropriate use of the products.
7. The products have been designed and tested to function within controlled environmental conditions. Do not use products under conditions that deviate from methods or applications specified in this datasheet. Failure to employ the products in the proper applications can lead to deterioration, destruction or failure of the products. We shall not be responsible for any bodily injury, fires or accident, property damage or any consequential damages resulting from misuse or misapplication of the products.
8. Quality Warranty
    8-1. Quality Warranty Period
    In the case of a product purchased through an authorized distributor or directly from us, the warranty period for this product shall be one (1) year after delivery to your company. For defective products that occurred during this period, we will take the quality warranty measures described in section 8-2. However, if there is an agreement on the warranty period in the basic transaction agreement, quality assurance agreement, delivery specifications, etc., it shall be followed.
    8-2. Quality Warranty Remedies
    When it has been proved defective due to manufacturing factors as a result of defect analysis by us, we will either deliver a substitute for the defective product or refund the purchase price of the defective product.
    Note that such delivery or refund is sole and exclusive remedies to your company for the defective product.
    8-3. Remedies after Quality Warranty Period
    With respect to any defect of this product found after the quality warranty period, the defect will be analyzed by us. On the basis of the defect analysis results, the scope and amounts of damage shall be determined by mutual agreement of both parties. Then we will deal with upper limit in Section 8-2. This provision is not intended to limit any legal rights of your company.
9. Anti-radiation design is not implemented in the products described in this document.
10. The X-ray exposure can influence functions and characteristics of the products. Confirm the product functions and characteristics in the evaluation stage.
11. WLCSP products should be used in light shielded environments. The light exposure can influence functions and characteristics of the products under operation or storage.
12. Warning for handling Gallium and Arsenic (GaAs) products (Applying to GaAs MMIC, Photo Reflector). These products use Gallium (Ga) and Arsenic (As) which are specified as poisonous chemicals by law. For the prevention of a hazard, do not burn, destroy, or process chemically to make them as gas or power. When the product is disposed of, please follow the related regulation and do not mix this with general industrial waste or household waste.
13. Please contact our sales representatives should you have any questions or comments concerning the products or the technical information.

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