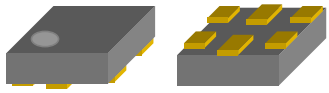
GNSS LOW NOISE AMPLIFIER GaAs MMIC

■ GENERAL DESCRIPTION

The NJG1143UA2 is a low noise amplifier GaAs MMIC designed for GNSS (Global navigation Satellite Systems).

The NJG1143UA2 is featured very small size, low noise figure, high gain and low current consumption. The NJG1143UA2 operates from 1.5V to 3.6V single voltage between -40 and 105°C, has stand-by mode to save the supply current, and requires only three external components. The NJG1143UA2 has an on-chip ESD protection. The NJG1143UA2 is available in a very small, lead-free, halogen-free, 1.0mm x 1.0mm x 0.37 mm, 6-pin EPFFP6-A2 package.

■ PACKAGE OUTLINE



NJG1143UA2

■ APPLICATION

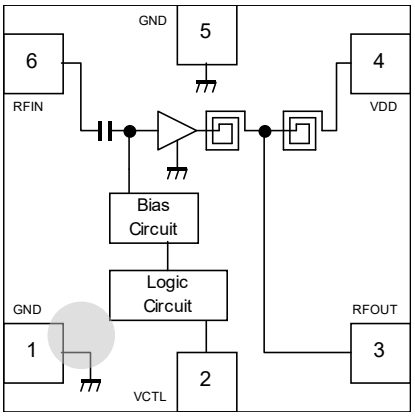
GNSS applications like GPS, Galileo, GLONASS and COMPASS

■ FEATURES

● Low supply voltage	+2.85V typ.	(+1.5V to +3.6V)
● Low control voltage	+1.8V typ.	(+1.5V to +3.6V)
● Low current consumption	4.0mA typ.	@V_{DD}=2.85V, V_{CTL}=1.8V
	7μA typ.	@V_{DD}=2.85V, V_{CTL}=0V, Stand-by mode
● High gain	20.0dB typ.	@V_{DD}=2.85V, V_{CTL}=1.8V, f=1575MHz
● Low noise figure	0.70dB typ.	@V_{DD}=2.85V, V_{CTL}=1.8V, f=1575MHz
● Input power at 1dB gain compression point	-16.5dBm typ.	@V_{DD}=2.85V, V_{CTL}=1.8V, f=1575MHz
● High input IP3	-2.0dBm typ.	@V_{DD}=2.85V, V_{CTL}=1.8V, f=1575+1575.1MHz
● Stand-by function		
● Small package size	EPFFP-A2	(Package size: 1.0mmx1.0mmx0.37mm typ.)
● Integrated ESD protection circuit		
● Lead-free and halogen-free, MSL1		

■ PIN CONFIGURATION

(Top View)



Pin Connection
1. GND
2. VCTL
3. RFOUT
4. VDD
5. GND
6. RFIN

■ TRUTH TABLE

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

VCTL	LNA Mode
H	Active mode
L	Stand-by mode

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

■ ABSOLUTE MAXIMUM RATINGS

T_a=+25°C, Z_s=Z_l=50Ω

PARAMETERS	SYMBOL	CONDITIONS	RATINGS	UNITS
Supply voltage	V_{DD}		5.0	V
Control voltage	V_{CTL}		5.0	V
Input power	P_{IN}	V_{DD}=2.85V	+15	dBm
Power dissipation	P_D	4-layer FR4 PCB with through-hole (101.5mmx114.5mm), T_j=150°C	590	mW
Operating temperature	T_{opr}		-40 to +105	°C
Storage temperature	T_{stg}		-55 to +150	°C

■ ELECTRICAL CHARACTERISTICS 1 (DC)

(General conditions: T_a=+25°C, Z_s=Z_l=50Ω)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
Supply Voltage	V_{DD}	VDD Terminal	1.5	-	3.6	V
Control Voltage (High)	$V_{CTL(H)}$	VCTL Terminal	1.5	1.8	3.6	V
Control Voltage (Low)	$V_{CTL(L)}$	VCTL Terminal	0	0	0.3	V
Supply Current 1	I_{DD1}	Active mode VDD Terminal V_{DD}=2.85V, V_{CTL}=1.8V	-	4.0	6.5	mA
Supply Current 2	I_{DD2}	Active mode VDD Terminal V_{DD}=1.8V, V_{CTL}=1.8V	-	3.0	4.7	mA
Supply Current 3	I_{DD3}	Stand-by mode VDD Terminal V_{DD}=2.85V, V_{CTL}=0V	-	7.0	15.0	μA
Supply Current 4	I_{DD4}	Stand-by mode VDD Terminal V_{DD}=1.8V, V_{CTL}=0V	-	4.0	10.0	μA
Control Current	I_{CTL}	V_{CTL}=1.8V, VCTL Terminal	-	5.0	12.0	μA

■ **ELECTRICAL CHARACTERISTICS 2 (RF, V_{DD}=2.85V)**

(General conditions: V_{DD}=2.85V, V_{CTL}=1.8V, Freq=1.575GHz,T_a=+25°C, Z_s=Z_l=50Ω, with application circuit)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
Small Signal Gain 1	Gain1		17.5	20.0	22.0	dB
Noise Figure 1	NF1	Exclude PCB and connector Losses (0.08dB)	-	0.70	0.95	dB
Input Power at 1dB Gain Compression Point 1	P-1dB(IN)_1		-19.0	-16.5	-	dBm
Input 3rd Order Intercept Point 1	IIP3_1	2 tone, 100k spacing Pin=-34dBm	-6.0	-2.0	-	dBm
RF Input Port VSWR 1	$VSWR_i1$		-	1.5	2.0	
RF Output Port VSWR 1	$VSWR_o1$			1.5	2.0	

■ **ELECTRICAL CHARACTERISTICS 3 (RF, V_{DD}=1.8V)**

(General conditions: V_{DD}=1.8V, V_{CTL}=1.8V, Freq=1.575GHz,T_a=+25°C, Z_s=Z_l=50Ω, with application circuit)

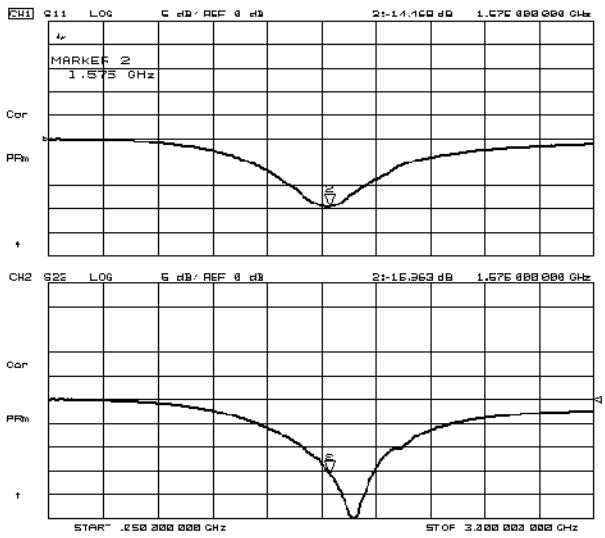
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
Small Signal Gain 2	Gain2		16.5	19.0	21.0	dB
Noise Figure 2	NF2	Exclude PCB and connector Losses (0.08dB)	-	0.75	1.10	dB
Input Power at 1dB Gain Compression Point 2	P-1dB(IN)_2		-22.0	-19.5	-	dBm
Input 3rd Order Intercept Point 2	IIP3_2	2 tone, 100k spacing Pin=-34dBm	-10.0	-6.0	-	dBm
RF Input Port VSWR 2	$VSWR_i2$		-	1.5	2.3	
RF Output Port VSWR 2	$VSWR_o2$			1.3	1.7	

■ TERMINAL INFORMATION

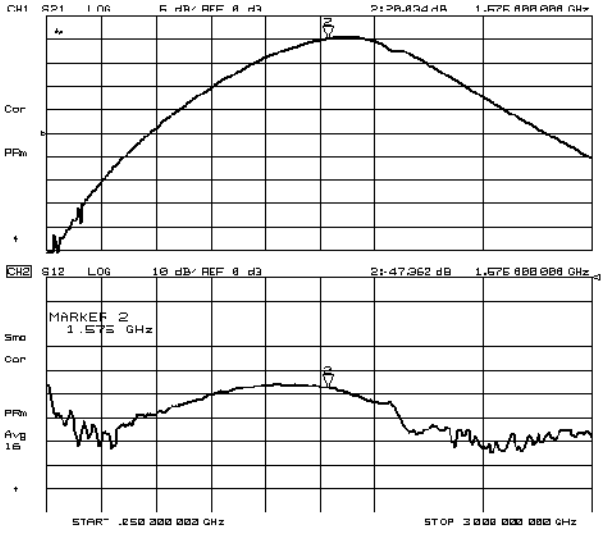
No.	SYMBOL	DESCRIPTION
1	GND	Ground terminal. These terminals should be connected to the ground plane as close as possible for excellent RF performance.
2	VCTL	Control voltage terminal. Inputting a logic-high, the LNA turn at LNA active mode. Inputting a logic-low, the LNA turn at stand-by mode.
3	RFOUT	RF output terminal. Requires an external capacitor C1. The capacitor C1 is not only a matching component, but also a DC blocking capacitor.
4	VDD	Supply voltage terminal. Bypass to ground with capacitor C2 as close as possible to the IC.
5	GND	Ground terminal. These terminals should be connected to the ground plane as close as possible for excellent RF performance.
6	RFIN	RF input terminal. Requires a matching inductor L1. Integrated a DC blocking capacitor.

■ ELECTRICAL CHARACTERRISTICS

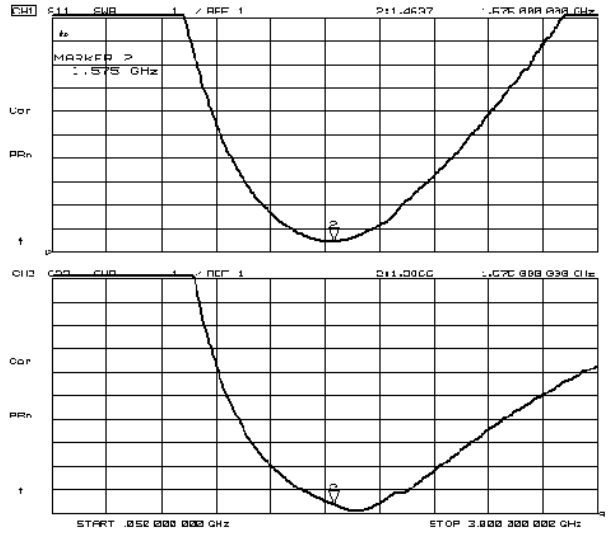
Conditions: V_{DD}=2.85V, V_{CTL}=1.8V, Ta=+25°C, Zs=Zl=50Ω, with application circuit



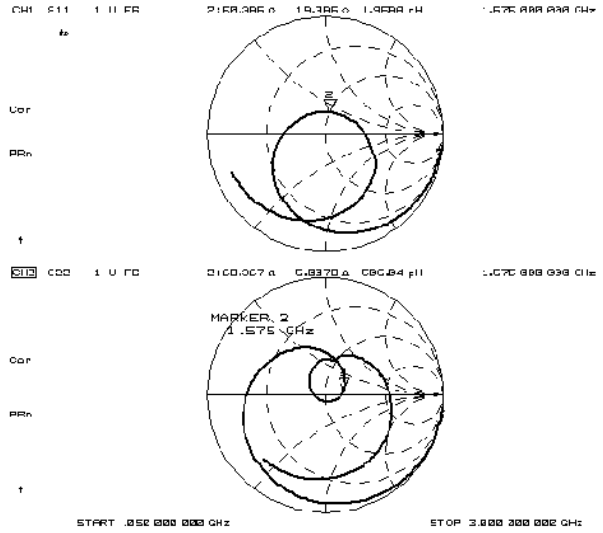
S11, S22



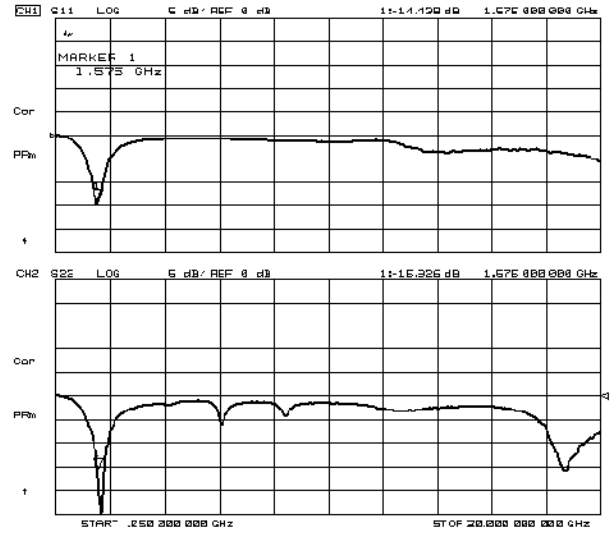
S21, S12



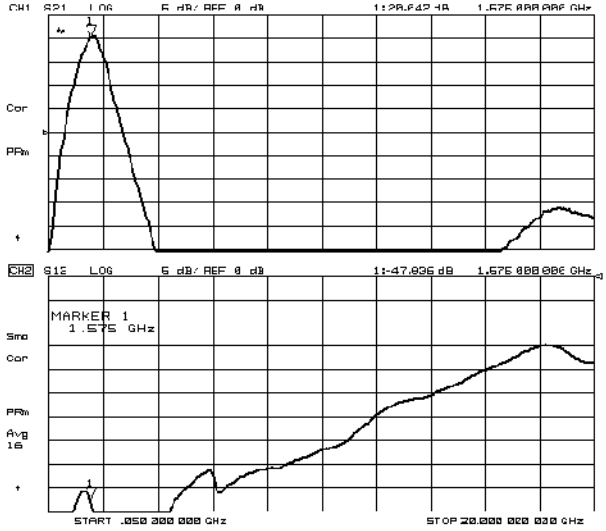
VSWR



Zin, Zout



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



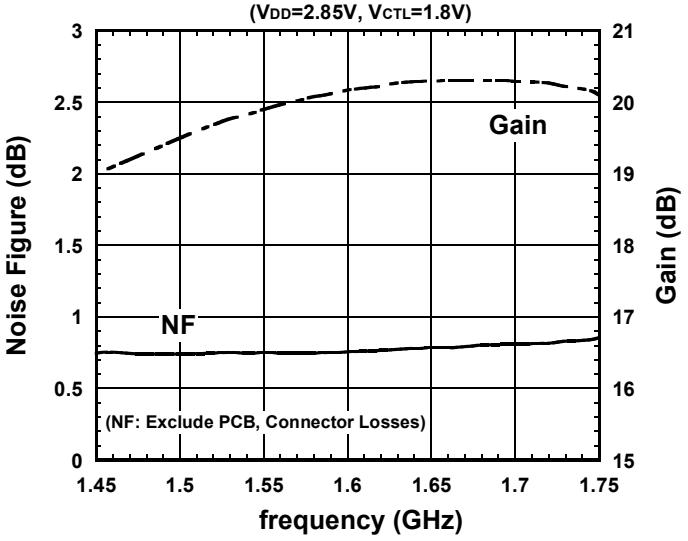
S21, S12 (f=50MHz~20GHz)

■ ELECTRICAL CHARACTERRISTICS

Conditions: V_{DD}=2.85V, V_{CTL}=1.8V, Ta=+25°C, Zs=Zl=50Ω, with application circuit

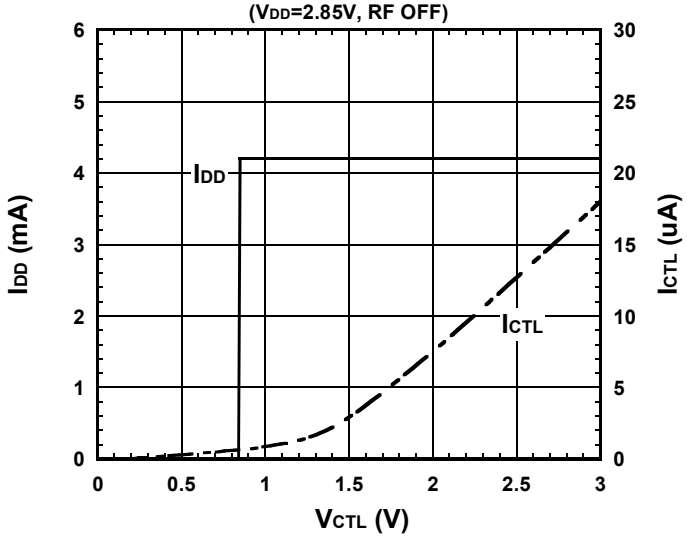
NF, Gain vs. frequency

(V_{DD}=2.85V, V_{CTL}=1.8V)



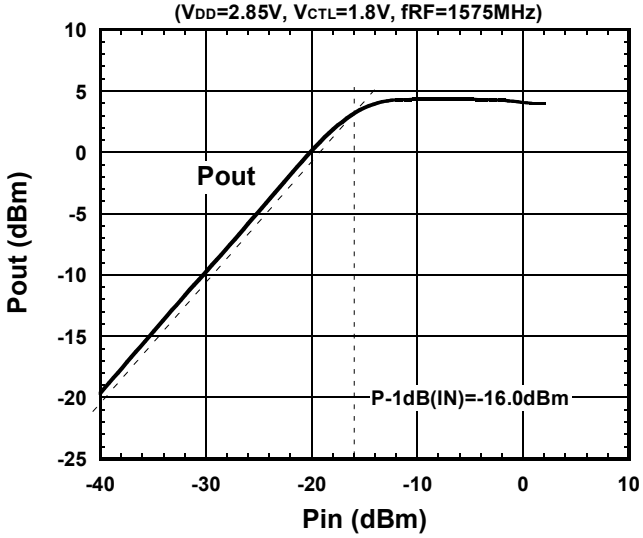
IDD, ICTL vs. VCTL

(V_{DD}=2.85V, RF OFF)



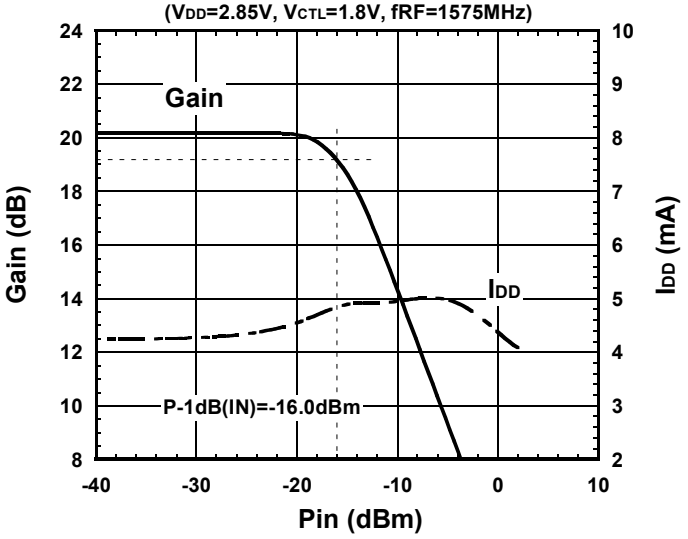
Pout vs. Pin

(V_{DD}=2.85V, V_{CTL}=1.8V, fRF=1575MHz)



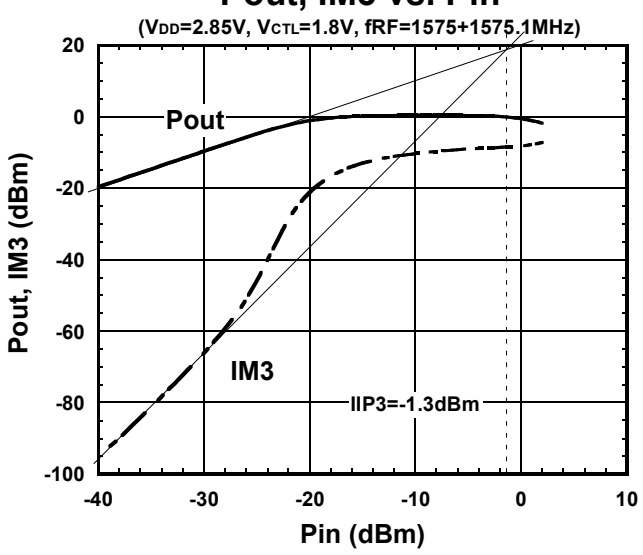
Gain, IDD vs. Pin

(V_{DD}=2.85V, V_{CTL}=1.8V, fRF=1575MHz)



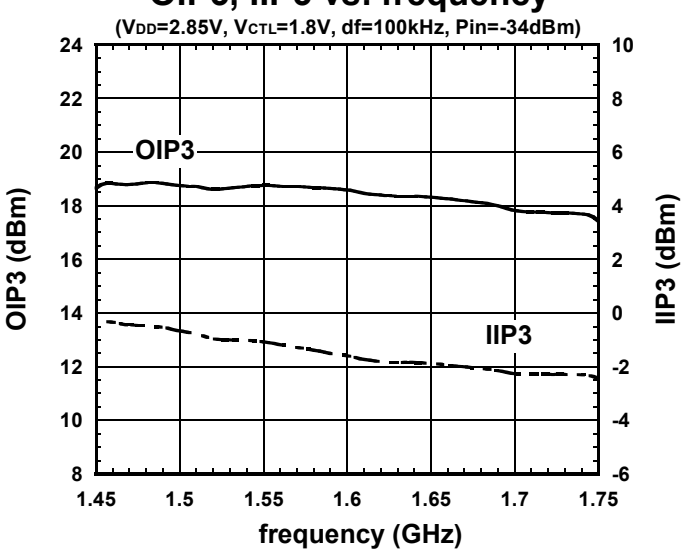
Pout, IM3 vs. Pin

(V_{DD}=2.85V, V_{CTL}=1.8V, fRF=1575+1575.1MHz)



OIP3, IIP3 vs. frequency

(V_{DD}=2.85V, V_{CTL}=1.8V, df=100kHz, Pin=-34dBm)

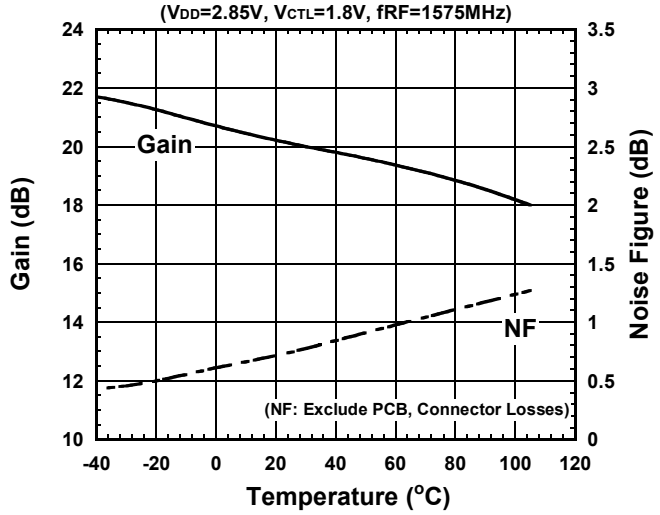


■ ELECTRICAL CHARACTERRISTICS

Conditions: V_{DD}=2.85V, V_{CTL}=1.8V, Ta=+25°C, Zs=Zl=50Ω, with application circuit

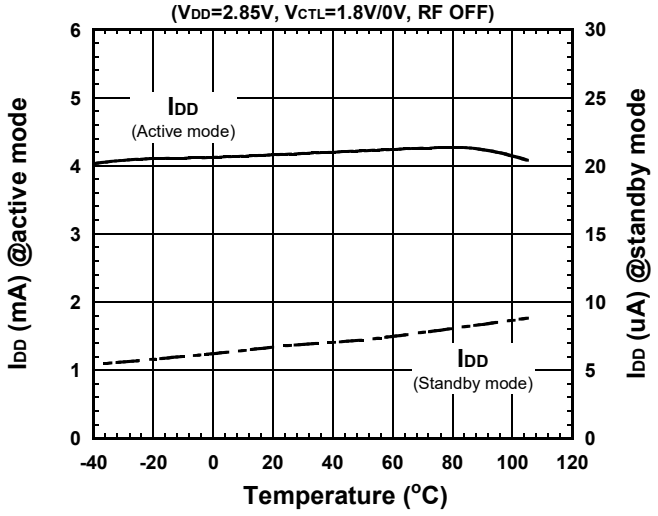
Gain, NF vs. Temperature

(V_{DD}=2.85V, V_{CTL}=1.8V, fRF=1575MHz)



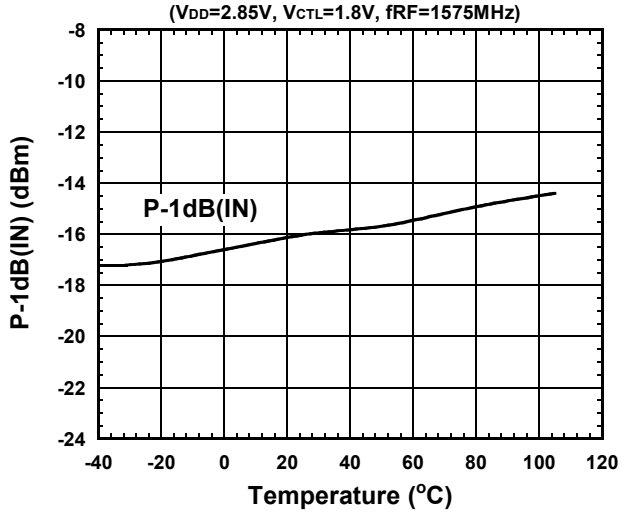
I_{DD} vs. Temperature

(V_{DD}=2.85V, V_{CTL}=1.8V/0V, RF OFF)



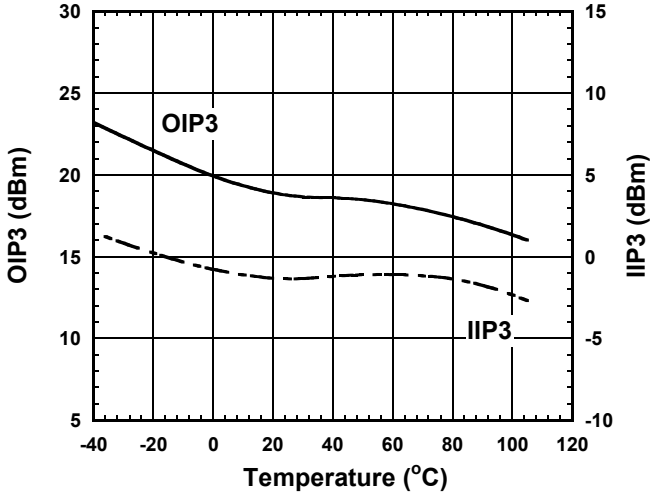
P-1dB(IN) vs. Temperature

(V_{DD}=2.85V, V_{CTL}=1.8V, fRF=1575MHz)



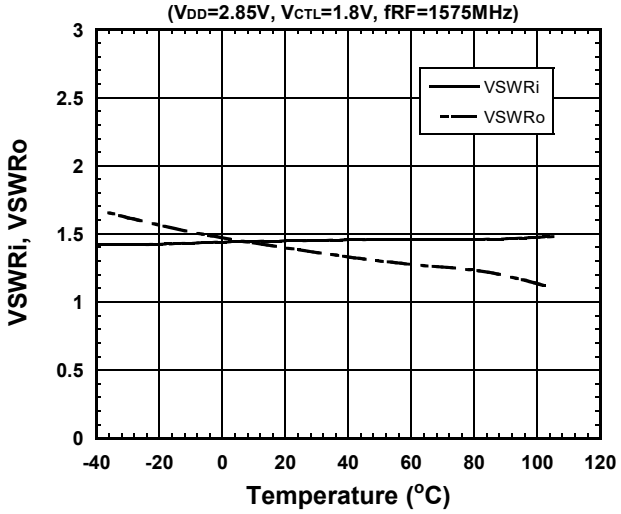
OIP3, IIP3 vs. Temperature

(V_{DD}=2.85V, V_{CTL}=1.8V, fRF=1575+1575.1MHz, Pin=-34dBm)



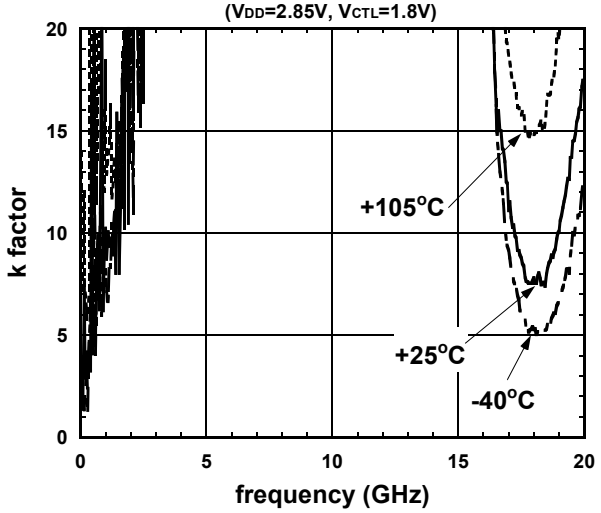
VSWR vs. Temperature

(V_{DD}=2.85V, V_{CTL}=1.8V, fRF=1575MHz)



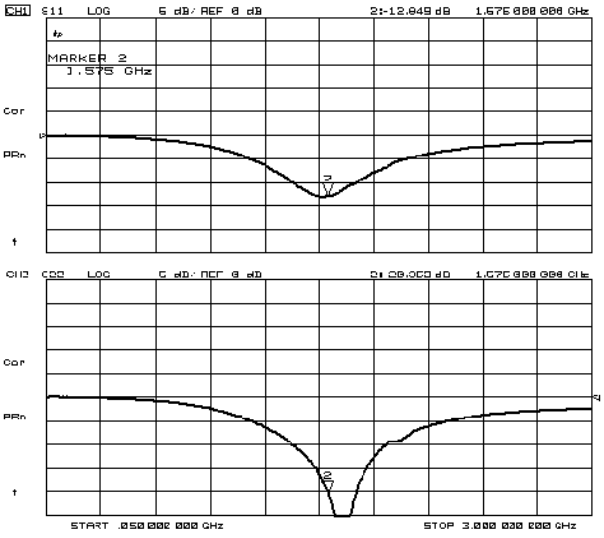
k factor vs. frequency

(V_{DD}=2.85V, V_{CTL}=1.8V)

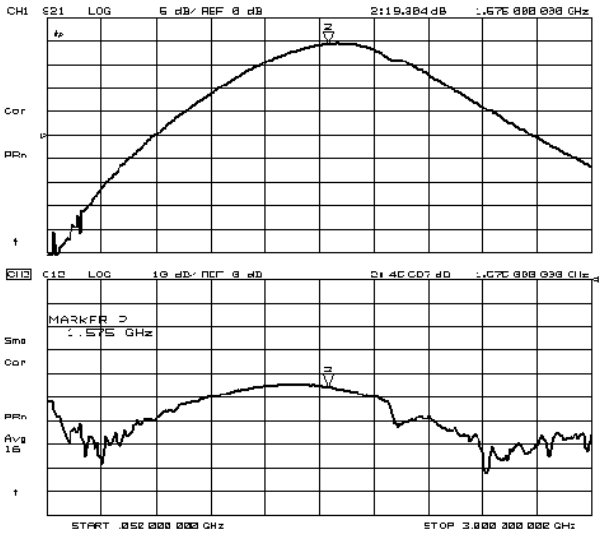


■ ELECTRICAL CHARACTERRISTICS

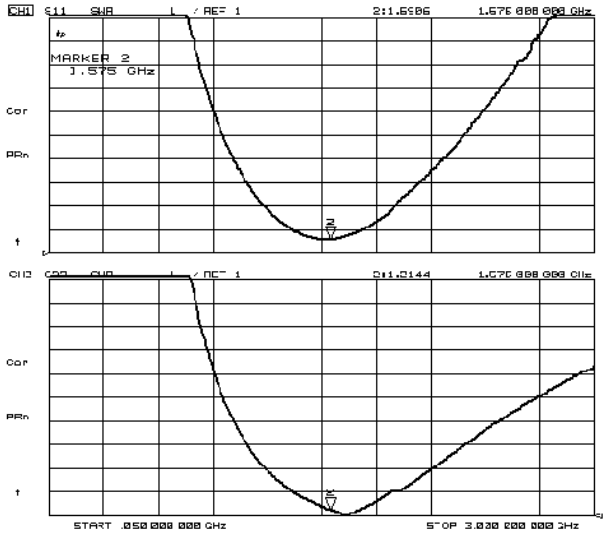
Conditions: V_{DD}=1.8V, V_{CTL}=1.8V, Ta=+25ºC, Zs=Zl=50Ω, with application circuit



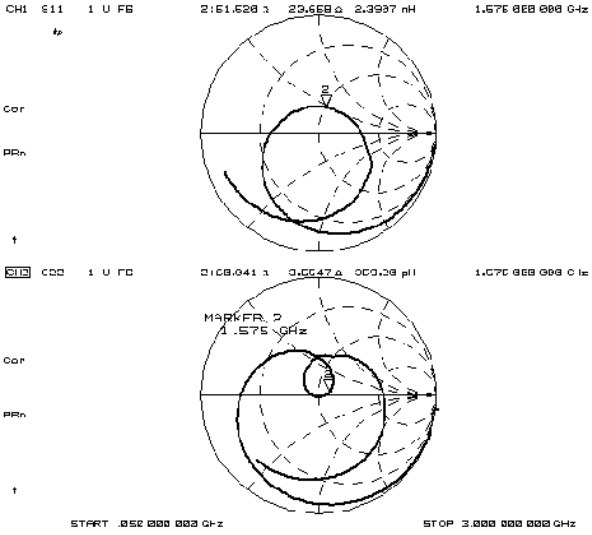
S11, S22



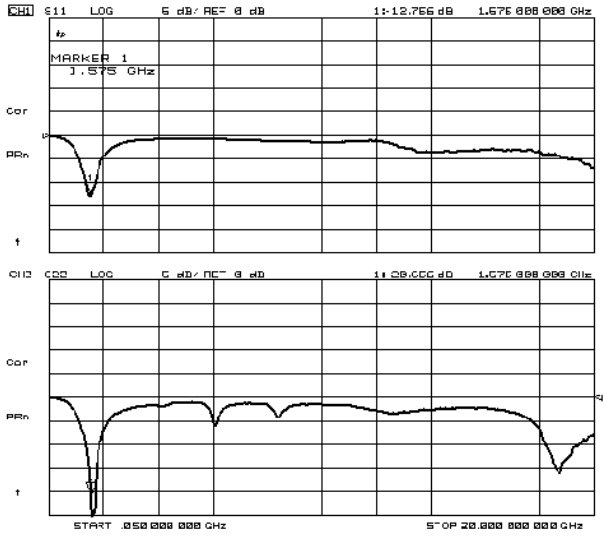
S21, S12



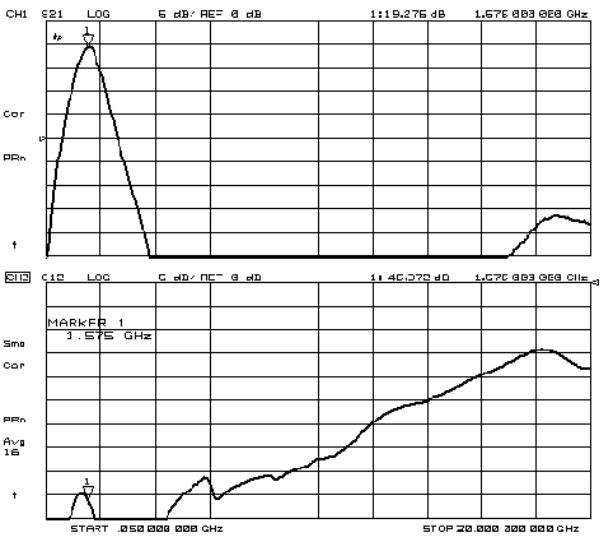
VSWR



Zin, Zout



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



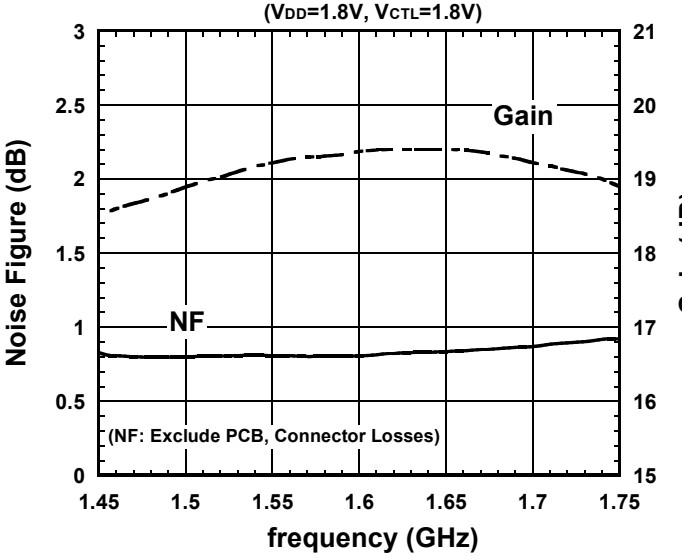
S21, S12 (f=50MHz~20GHz)

■ ELECTRICAL CHARACTERRISTICS

Conditions: V_{DD}=1.8V, V_{CTL}=1.8V, Ta=+25°C, Zs=Zl=50Ω, with application circuit

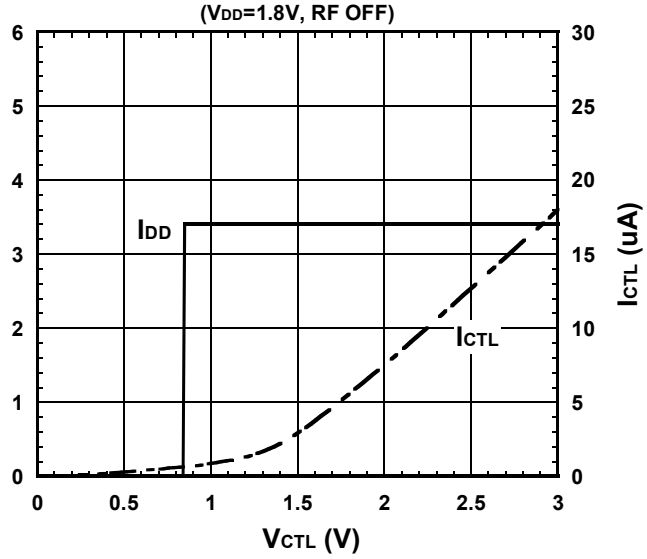
NF, Gain vs. frequency

(V_{DD}=1.8V, V_{CTL}=1.8V)



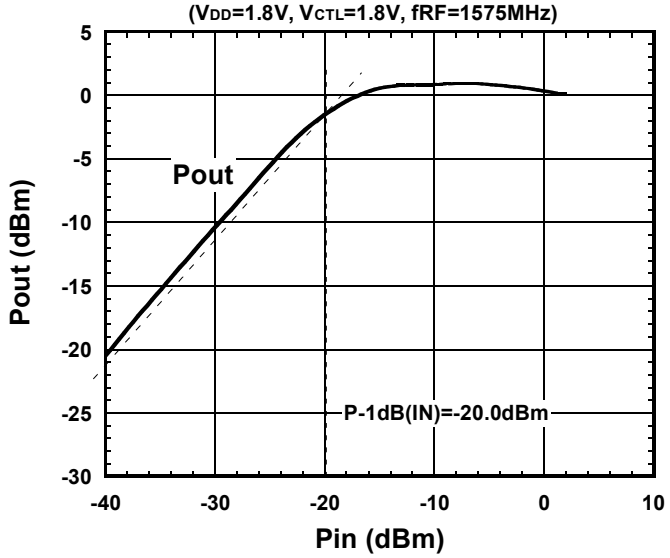
I_{DD}, I_{CTL} vs. V_{CTL}

(V_{DD}=1.8V, RF OFF)



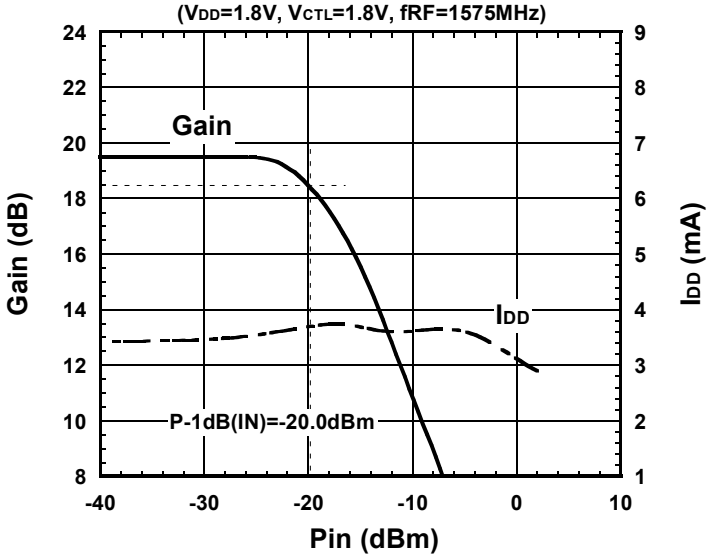
Pout vs. Pin

(V_{DD}=1.8V, V_{CTL}=1.8V, fRF=1575MHz)



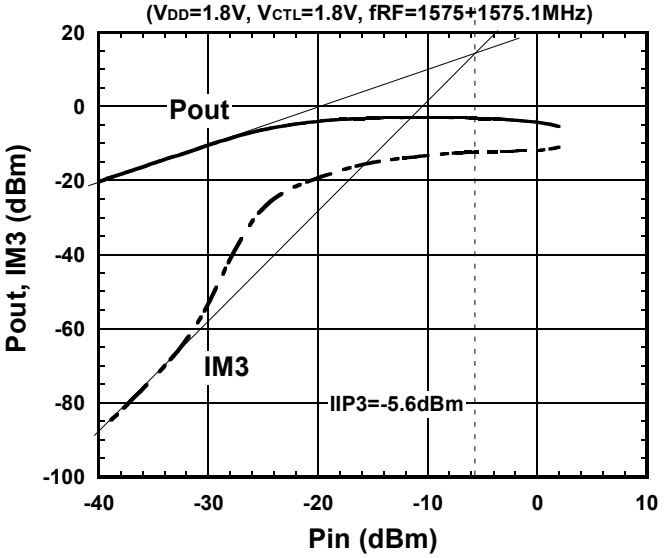
Gain, I_{DD} vs. Pin

(V_{DD}=1.8V, V_{CTL}=1.8V, fRF=1575MHz)



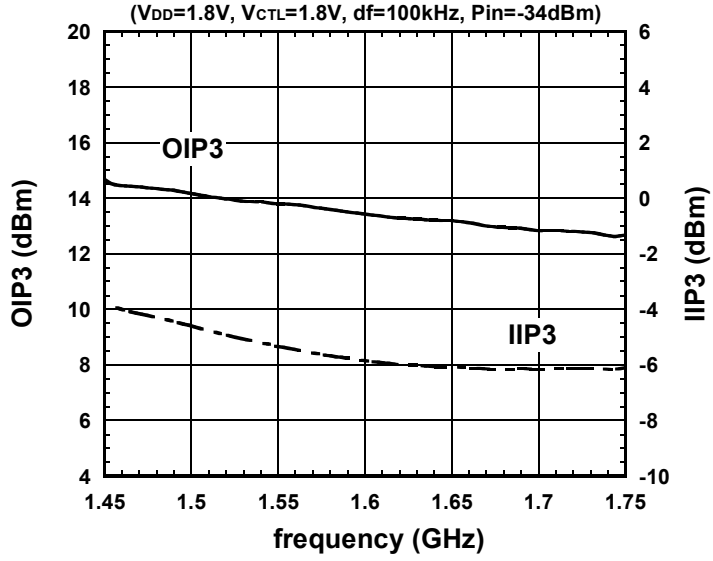
Pout, IM3 vs. Pin

(V_{DD}=1.8V, V_{CTL}=1.8V, fRF=1575+1575.1MHz)



OIP3, IIP3 vs. frequency

(V_{DD}=1.8V, V_{CTL}=1.8V, df=100kHz, Pin=-34dBm)

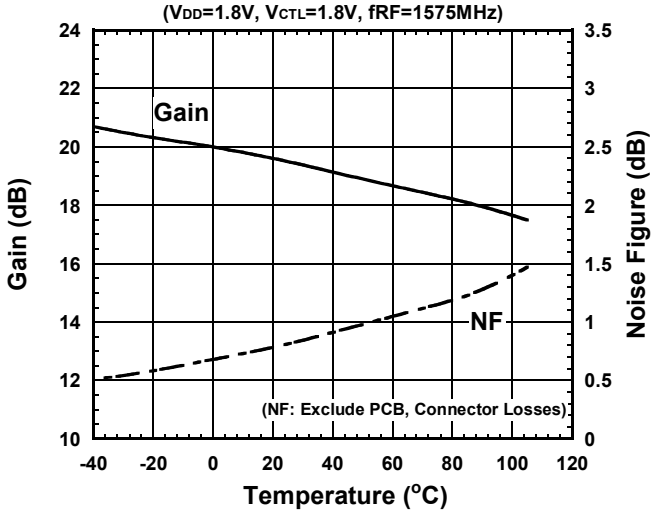


■ ELECTRICAL CHARACTERRISTICS

Conditions: V_{DD}=1.8V, V_{CTL}=1.8V, Zs=Zl=50Ω, with application circuit

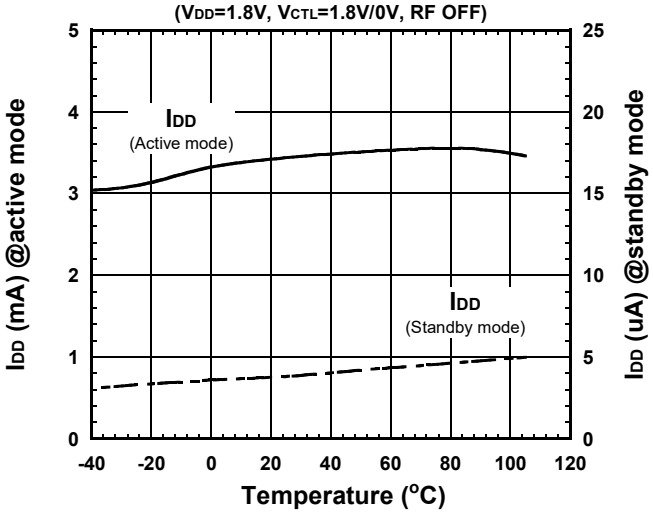
Gain, NF vs. Temperature

(V_{DD}=1.8V, V_{CTL}=1.8V, fRF=1575MHz)



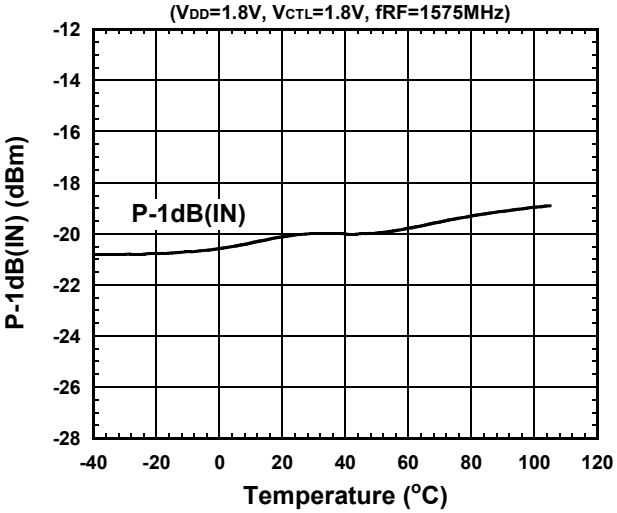
IDD vs. Temperature

(V_{DD}=1.8V, V_{CTL}=1.8V/0V, RF OFF)



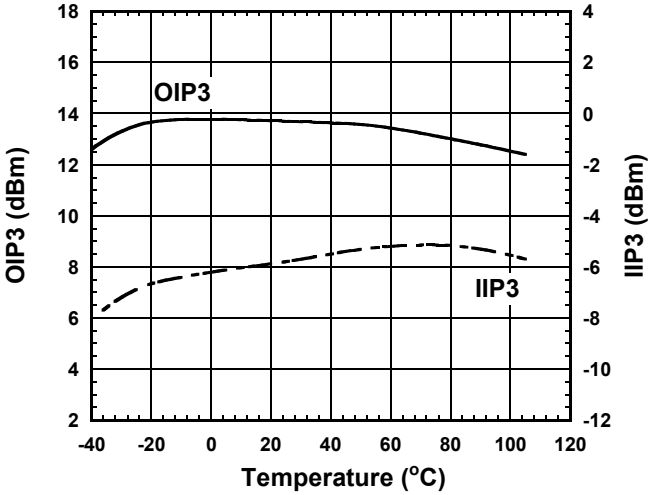
P-1dB(IN) vs. Temperature

(V_{DD}=1.8V, V_{CTL}=1.8V, fRF=1575MHz)



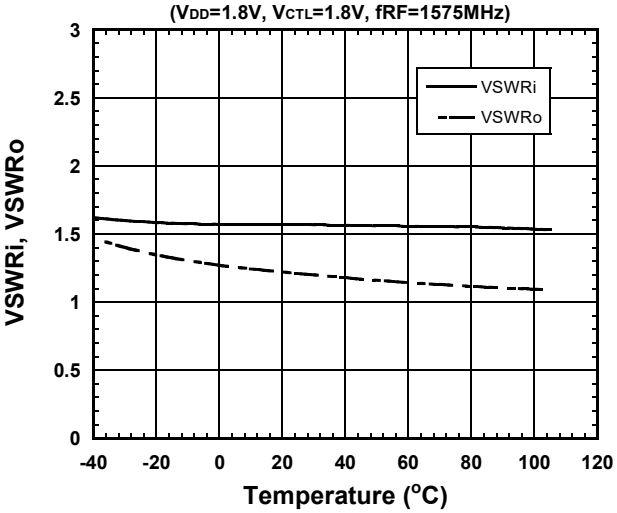
OIP3, IIP3 vs. Temperature

(V_{DD}=1.8V, V_{CTL}=1.8V, fRF=1575+1575.1MHz, Pin=-34dBm)



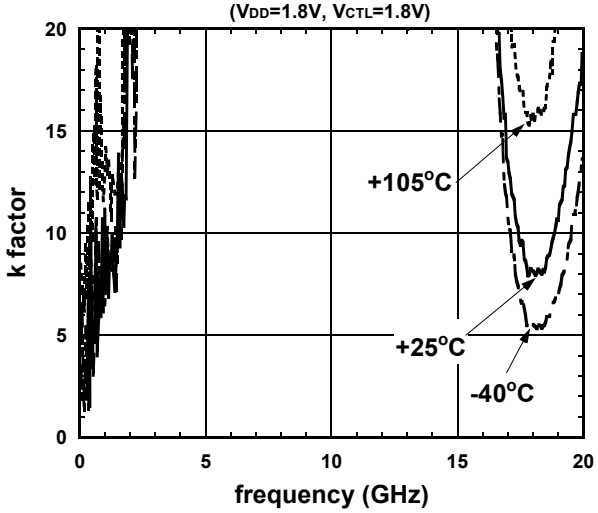
VSWR vs. Temperature

(V_{DD}=1.8V, V_{CTL}=1.8V, fRF=1575MHz)



k factor vs. frequency

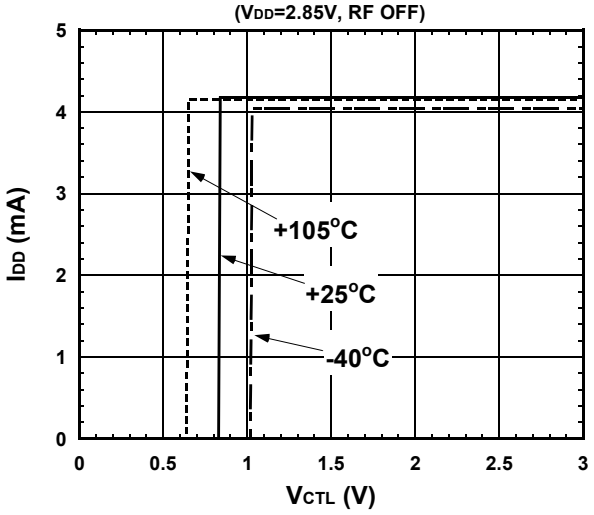
(V_{DD}=1.8V, V_{CTL}=1.8V)



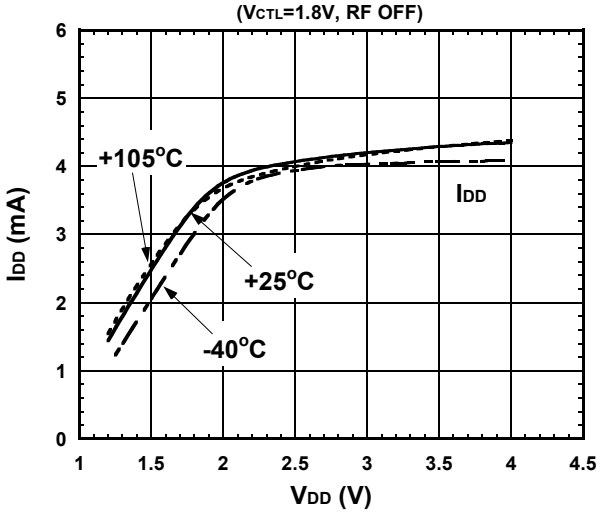
■ ELECTRICAL CHARACTERRISTICS

Conditions: RF OFF, Zs=Zl=50Ω, with application circuit

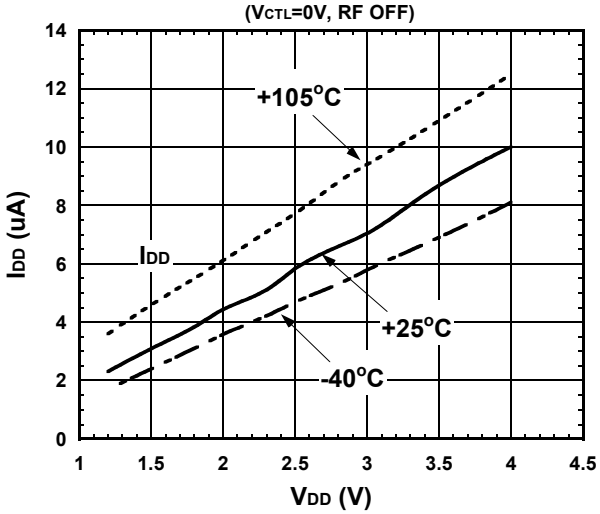
IDD vs. VCTL
(VDD=2.85V, RF OFF)



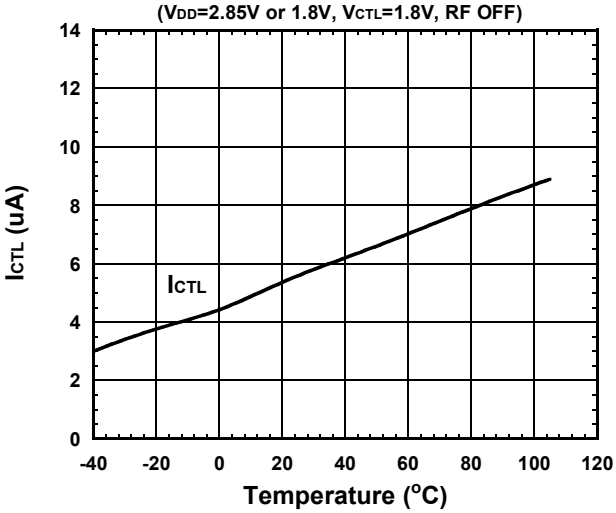
IDD vs. VDD
(VCTL=1.8V, RF OFF)



IDD vs. VDD
(VCTL=0V, RF OFF)



ICTL vs. Temperature
(VDD=2.85V or 1.8V, VCTL=1.8V, RF OFF)

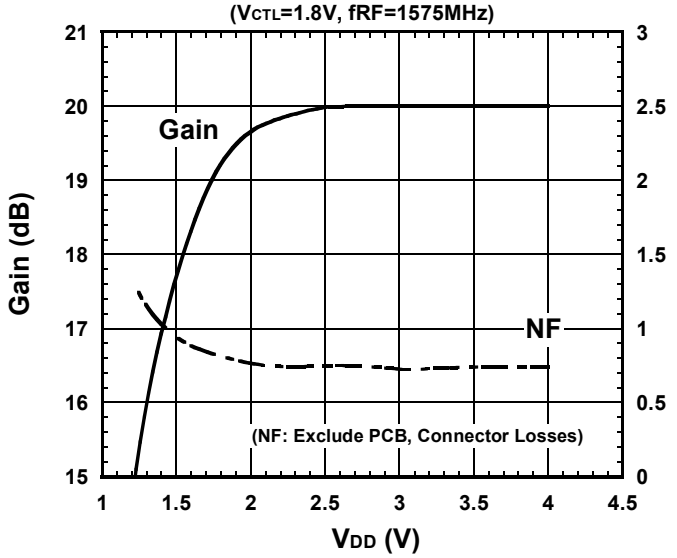


■ ELECTRICAL CHARACTERRISTICS

Condition: V_{CTL}=1.8V, Ta=+25°C, Zs=Zl=50Ω, with application circuit

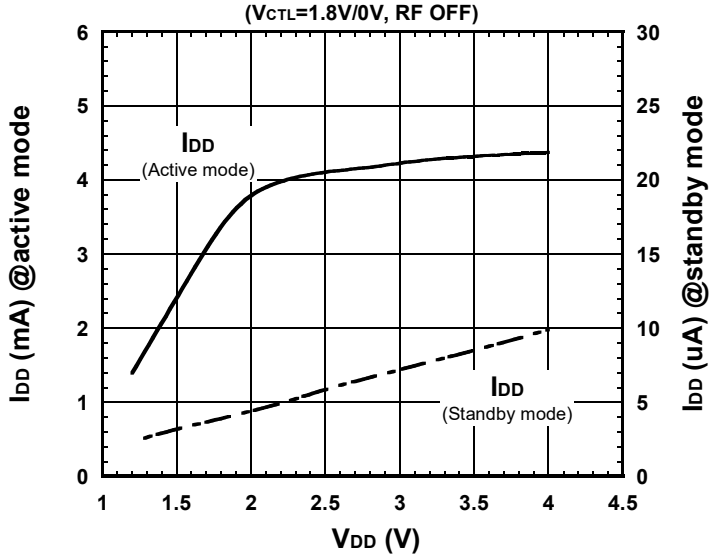
Gain, NF vs. VDD

(VCTL=1.8V, fRF=1575MHz)



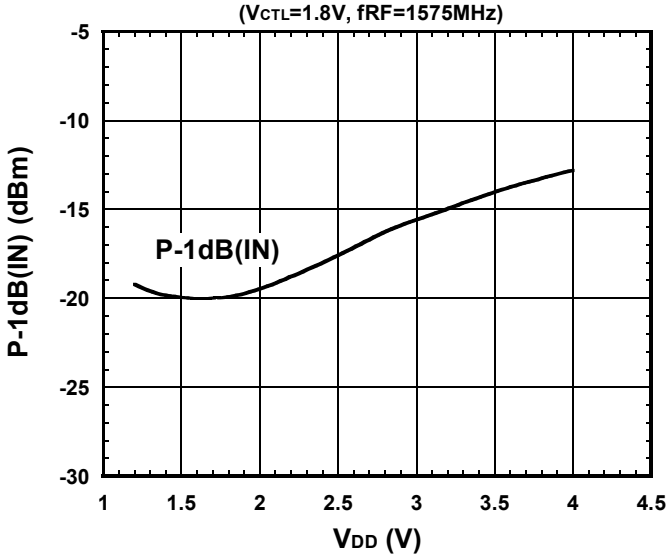
IDD vs. VDD

(VCTL=1.8V/0V, RF OFF)



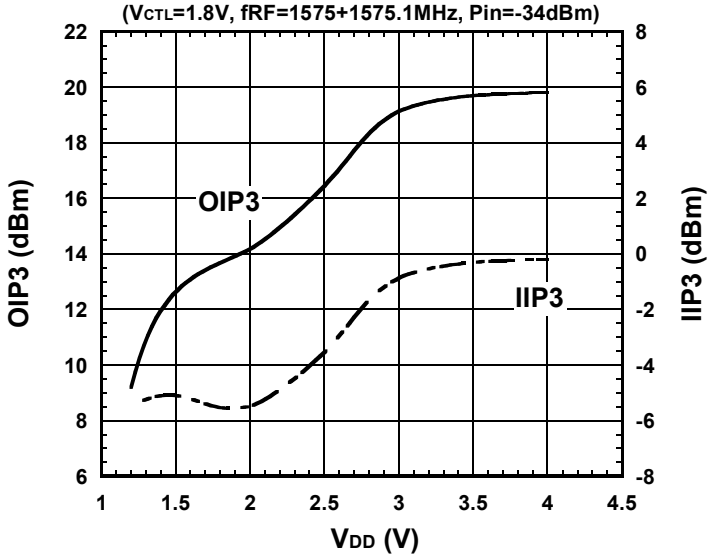
P-1dB(IN) vs. VDD

(VCTL=1.8V, fRF=1575MHz)



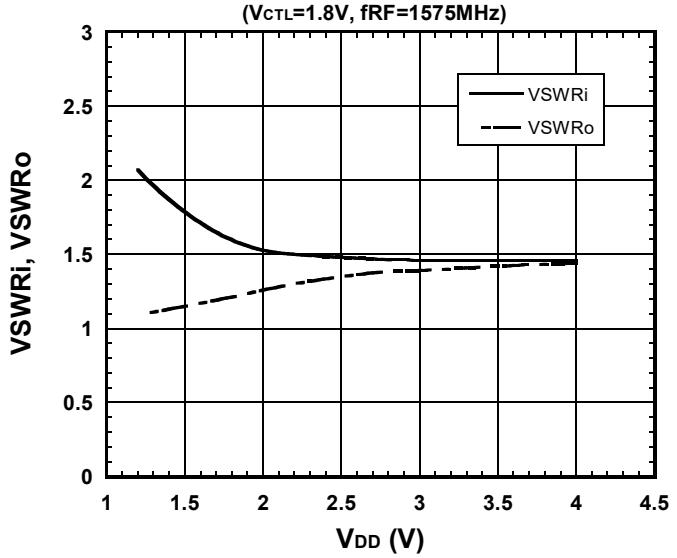
OIP3, IIP3 vs. VDD

(VCTL=1.8V, fRF=1575+1575.1MHz, Pin=-34dBm)



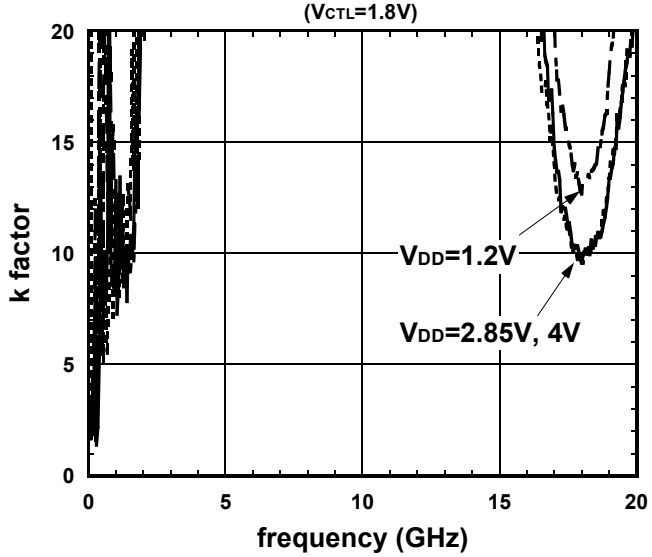
VSWR vs. VDD

(VCTL=1.8V, fRF=1575MHz)

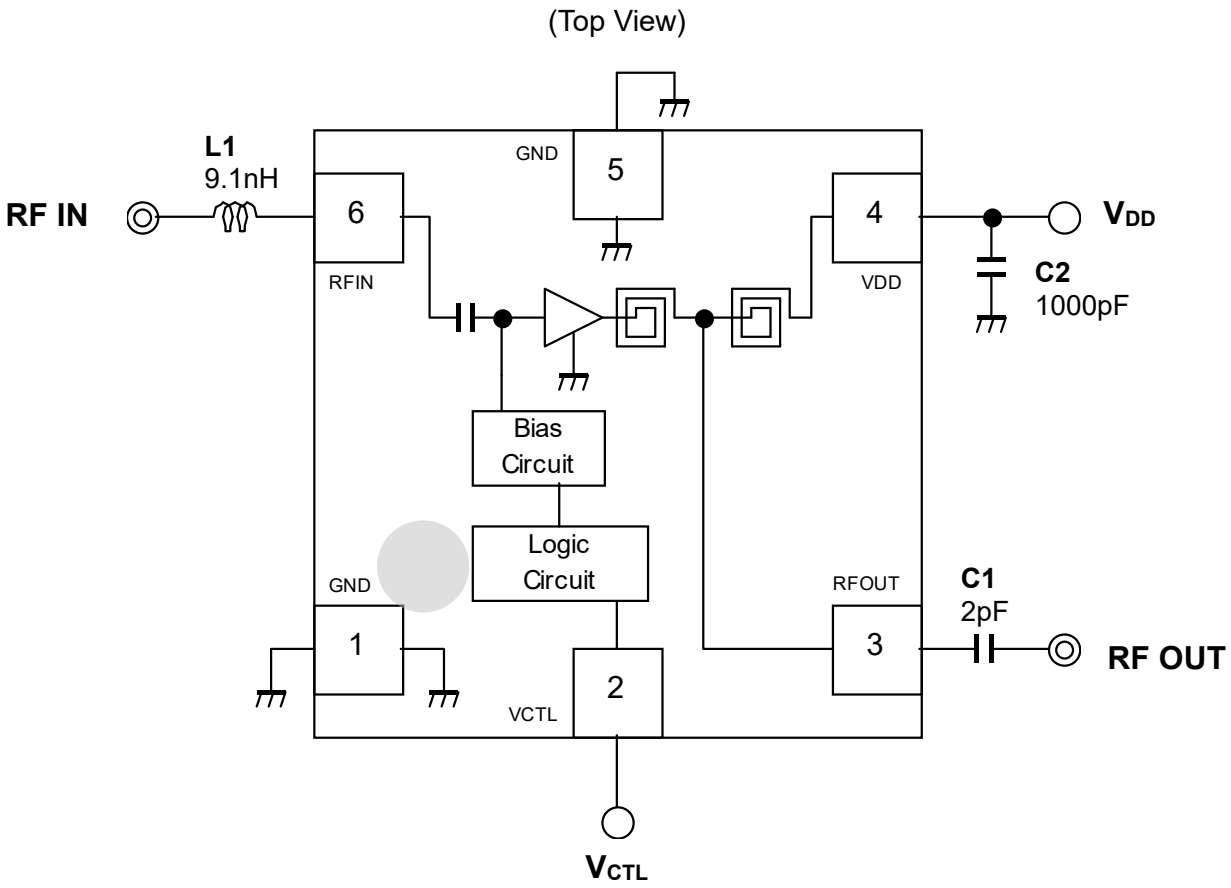


k factor vs. frequency

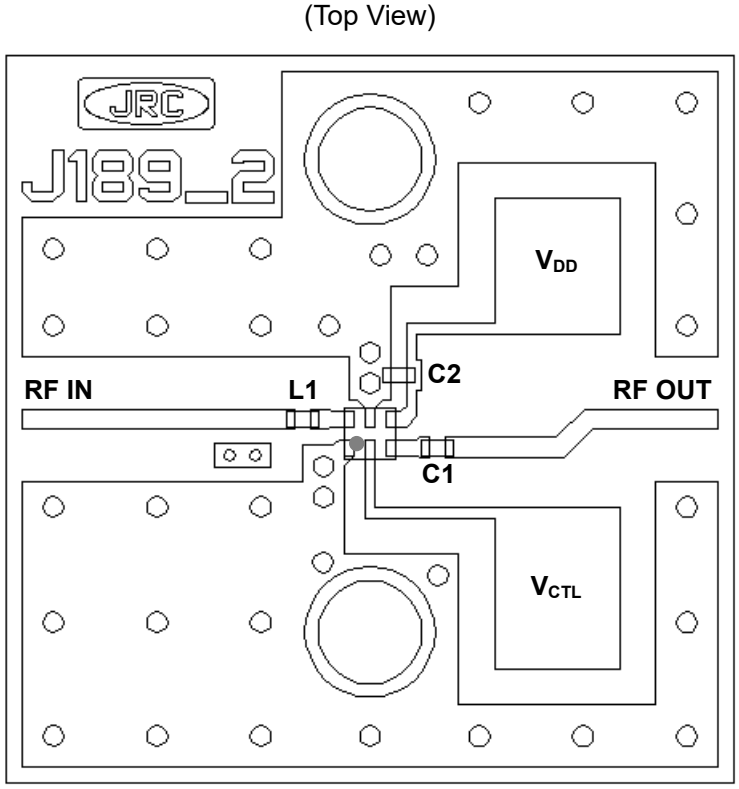
(VCTL=1.8V)



■ APPLICATION CIRCUIT



■ TEST PCB LAYOUT



Parts list

Parts ID	Manufacture
L1	LQP03T_02 Series (MURATA)
C1, C2	GRM03 Series (MURATA)

PCB
Substrate: FR-4
Thickness: 0.2mm
Microstrip line width: 0.4mm (Z_0=50Ω)
Size: 14.0mm x 14.0mm

■ NOISE FIGURE MEASUREMENT CONDITONS

Measuring instruments

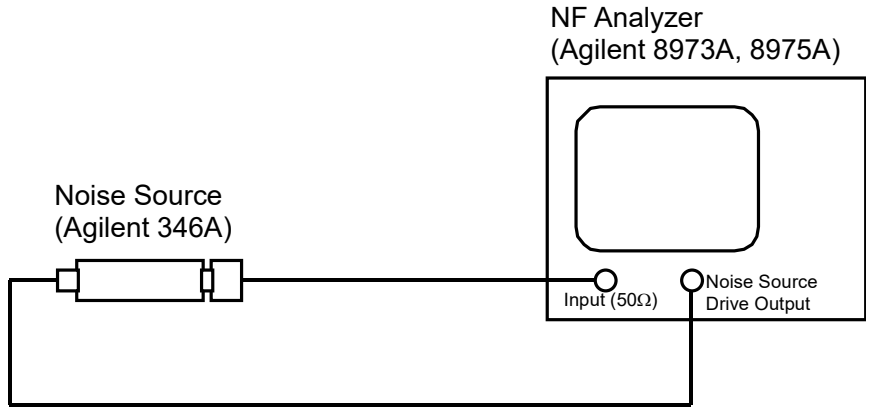
NF Analyzer : Agilent 8973A, 8975A
Noise Source : Agilent 346A

Setting the NF analyzer

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

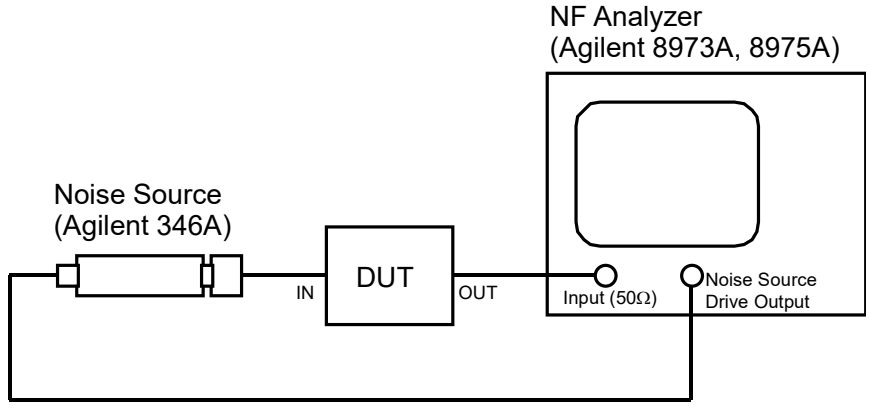
Mode setup form
- Sideband : LSB

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.

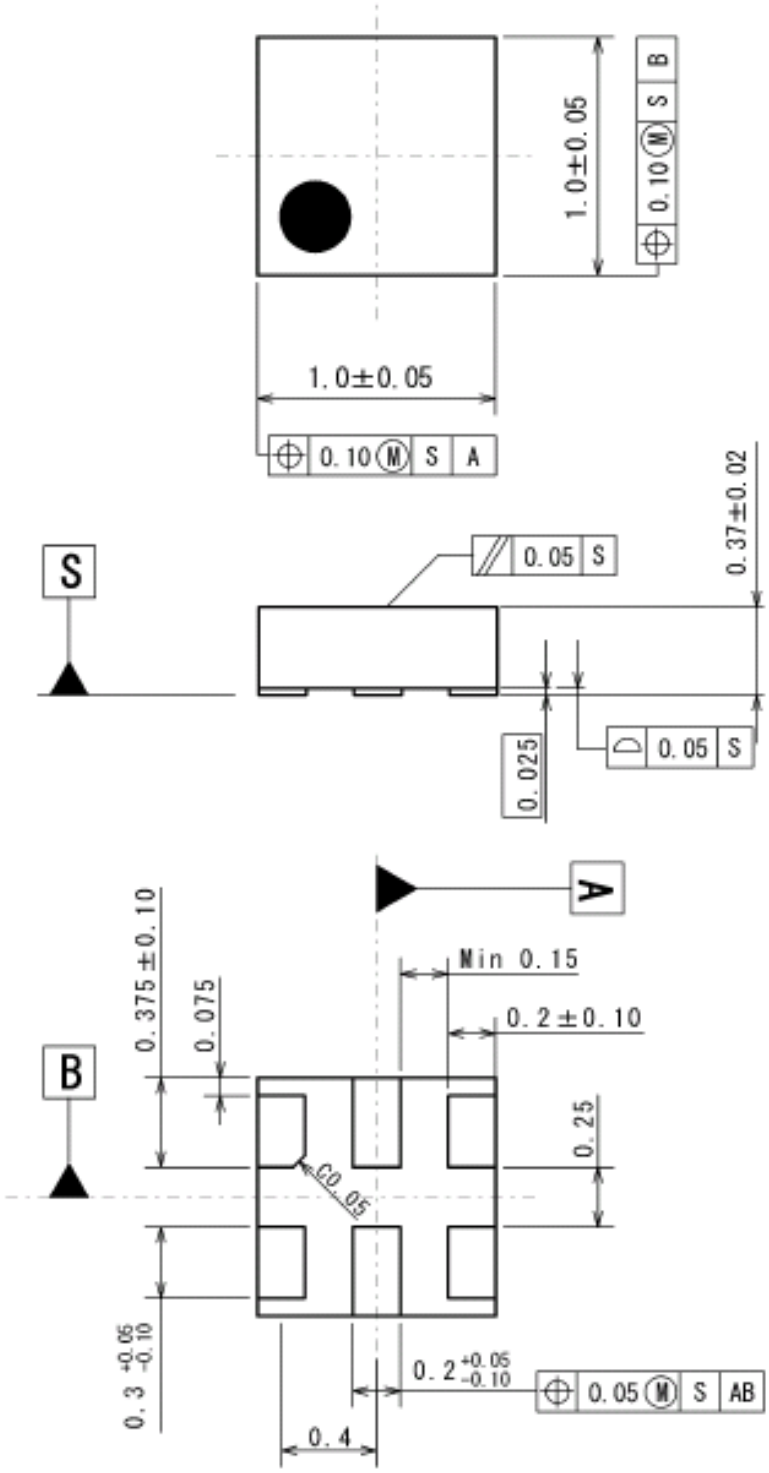
Calibration Setup



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

Measurement Setup

■ PACKAGE OUTLINE (EPFFP6-A2)



Unit	: mm
Substrate	: FR4
Terminal treat	: Au
Molding material	: Epoxy resin
Weight (typ.)	: 0.855mg

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.

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    - Power Generator Control Equipment (nuclear, steam, hydraulic, etc.)
    - Life Maintenance Medical Equipment
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    - Vehicle Control Equipment (automotive, airplane, railroad, ship, etc.)
    - Various Safety Devices
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    - Combustion equipment

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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.
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