# 5GHz BAND LOW NOISE AMPLIFIER GaAs MMIC

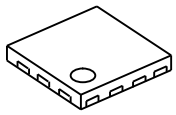
## ■ GENERAL DESCRIPTION

NJG1148MD7 is a 5GHz band low noise amplifier GaAs MMIC designed for wireless LAN, wireless image transmission and Intelligent Transport System.

The NJG1148MD7 has a LNA pass-through function to select high gain mode or low gain mode by low control voltage operation. Within the wide dynamic range from 4.9~5.95GHz, the NJG1148MD7 achieves low noise figure and high linearity with fewer external components. The ESD protection circuits are integrated into the MMIC. They achieve high ESD protection voltage.

A small and ultra-thin package of EQFN14-D7 is adopted.

## ■ PACKAGE OUTLINE



NJG1148MD7

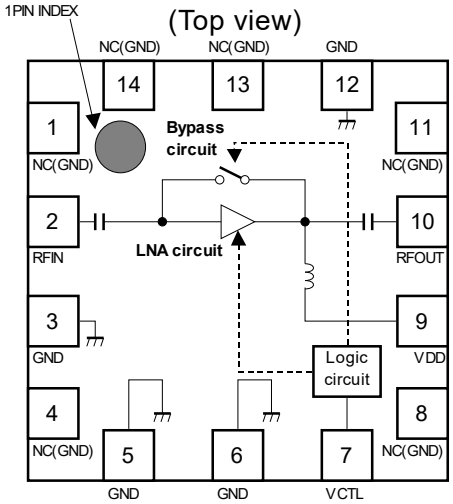
## ■ APPLICATIONS

5GHz Band application from 4.9GHz to 5.95GHz
Wireless LAN, wireless image transmission and Intelligent transport System applications

## ■ FEATURES

| | |
|---|---|
| ● Operating voltage | 3.3V |
| ● Low current consumption | 7.0mA typ. @$V_{DD}$=3.3V, $V_{CTL}$=1.8V (LNA mode) |
| | 5μA typ. @$V_{DD}$=3.3V, $V_{CTL}$=0V (Bypass mode) |
| ● High Gain | 12.5dB typ. @$V_{DD}$=3.3V, $V_{CTL}$=1.8V (LNA mode) |
| ● Low Noise figure | 1.5dB typ. @$V_{DD}$=3.3V, $V_{CTL}$=1.8V (LNA mode) |
| ● High IIP3 | +5.0dBm typ. @$V_{DD}$=3.3V, $V_{CTL}$=1.8V (LNA mode) |
| ● Low Insertion Loss | 5.0dB typ. @$V_{DD}$=3.3V, $V_{CTL}$=0V (Bypass mode) |
| ● Few external components | 1pc (Bypass Capacitor) |
| ● Small package size | EQFN14-D7 (Package size: 1.6mm x 1.6mm x 0.397mm typ.) |
| ● Pb free, Halogen free | |

## ■ PIN CONFIGURATION




Pin Connection

| | |
|---|---|
| 1. NC (GND) | 8. NC (GND) |
| 2. RFIN | 9. VDD |
| 3. GND | 10. RFOUT |
| 4. NC (GND) | 11. NC (GND) |
| 5. GND | 12. GND |
| 6. GND | 13. NC (GND) |
| 7. VCTL | 14. NC (GND) |

## ■ TRUTH TABLE

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

| $V_{CTL}$ | LNA Circuit | Bypass Circuit | Operating mode |
|---|---|---|---|
| H | ON | OFF | LNA mode |
| L | OFF | ON | Bypass 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

| PARAMETER | SYMBOL | CONDITIONS | RATINGS | UNITS |
|---|---|---|---|---|
| Drain voltage | $V_{DD}$ | | 5.0 | V |
| Control voltage | $V_{CTL}$ | | 5.0 | V |
| Input power | $P_{in}$ | $V_{DD}$=3.3V | +15 | dBm |
| Power dissipation | $P_D$ | 4-layer FR4 PCB with through-hole (76.2x114.3mm), $T_j$=150°C | 1300 | mW |
| Operating temperature | $T_{opr}$ | | -40~+85 | °C |
| Storage temperature | $T_{stg}$ | | -55~+150 | °C |

## ■ ELECTRICAL CHARACTERISTICS 1 (DC CHARACTERISTICS)

$V_{DD}$=3.3V, $T_a$=+25°C, $Z_s$=$Z_l$=50Ω

| PARAMETERS | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Operating voltage | $V_{DD}$ | | 2.7 | 3.3 | 4.5 | V |
| Control voltage (High) | $V_{CTL(H)}$ | | 1.6 | 1.8 | 4.5 | V |
| Control voltage (Low) | $V_{CTL(L)}$ | | 0 | 0 | 0.4 | V |
| Operating current1 | $I_{DD}1$ | RF OFF, $V_{CTL}$=1.8V | - | 7.0 | 11.0 | mA |
| Operating current2 | $I_{DD}2$ | RF OFF, $V_{CTL}$=0V | - | 5 | 9 | μA |
| Control current | $I_{CTL}$ | RF OFF, $V_{CTL}$=1.8V | - | 6 | 10 | μA |

■ **ELECTRICAL CHARACTERISTICS 2** (LNA mode)

$V_{DD}$=3.3V, $V_{CTL}$=1.8V, freq=4900~5950MHz, $T_a$=+25°C, $Z_s$=$Z_l$=50Ω, with application circuit

| PARAMETERS | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Small signal gain | Gain | Exclude PCB & connector losses *1 | 9.5 | 12.5 | 16.0 | dB |
| Noise figure | NF | Exclude PCB & connector losses *2 | - | 1.5 | 2.2 | dB |
| Input power at 1dB gain compression point1 | P-1dB (IN)1 | | -12.0 | -5.0 | - | dBm |
| Input 3rd order intercept point1 | IIP3_1 | f1=freq, f2=freq+100kHz, $P_{IN}$=-25dBm | 0.0 | +5.0 | - | dBm |
| Input Tx Power at 1dB Gain Compression Point | Psat (Tx-1dB) | Fundamental frequency: f1=5500MHz, Pin=-30dBm Tx frequency: f2=1710MHz, 1940MHz, 2170MHz Input Tx Power at 1dB fundamental Gain compression point | -17.0 | -8.0 | - | dBm |
| Isolation | ISL | | - | 35.0 | - | dB |
| RF IN Return loss1 | RLi1 | | 8.0 | 12.0 | - | dB |
| RF OUT Return loss1 | RLo1 | | 5.0 | 12.0 | - | dB |

*1 Input & output PCB and connector losses: 0.58dB (5500MHz)

*2 Input PCB and connector losses: 0.29dB (5500MHz)

■ **ELECTRICAL CHARACTERISTICS 3** (Bypass mode)

$V_{DD}$=3.3V, $V_{CTL}$=0V, freq=4900~5950MHz, $T_a$=+25°C, $Z_s$=$Z_l$=50Ω, with application circuit

| PARAMETERS | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Insertion Loss | Loss | Exclude PCB & connector losses *1 | - | 5.0 | 7.0 | dB |
| Input power at 1dB gain compression point2 | P-1dB (IN)2 | | -1.0 | +10.0 | - | dBm |
| Input 3rd order intercept point2 | IIP3_2 | f1=freq, f2=freq+100kHz, $P_{IN}$=-10dBm | +3.0 | +10.0 | - | dBm |
| RF IN Return loss2 | RLi2 | | 7.0 | 12.0 | - | dB |
| RF OUT Return loss2 | RLo2 | | 8.0 | 12.0 | - | dB |

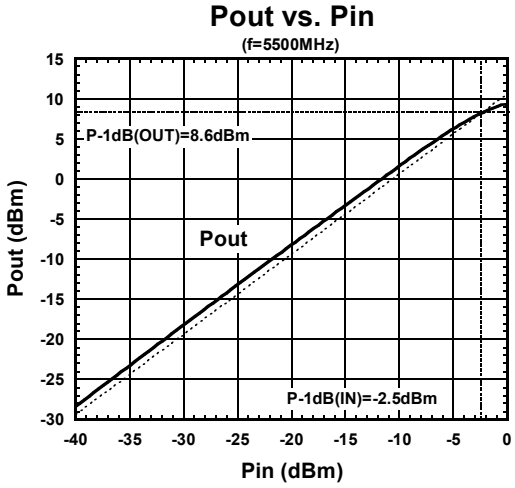
*1 Input & output PCB and connector losses: 0.58dB (5500MHz)

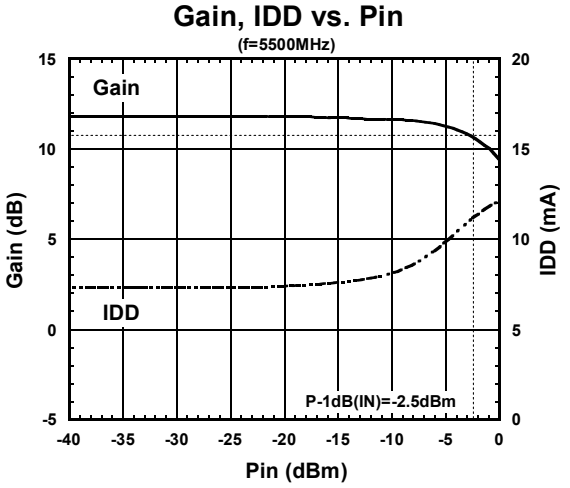
## ■ TERMINAL INFORMATION

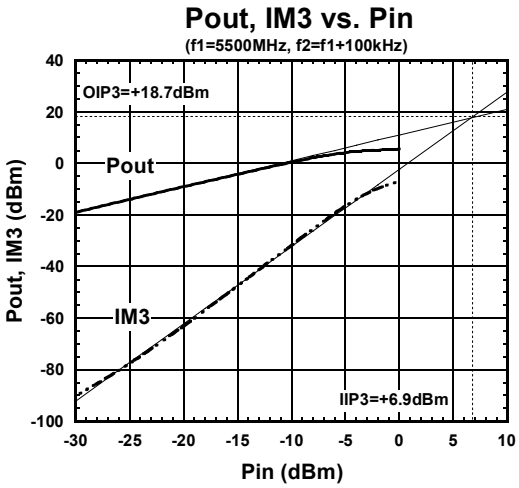
| No. | SYMBOL | DESCRIPTION |
|---|---|---|
| 1, 4, 8, 11, 13, 14 | NC(GND) | No connected terminal. This terminal is not connected with internal circuit. Please connect this terminal with ground place as close as possible for excellent RF performance. |
| 2 | RFIN | RF input terminal. This IC integrates an input DC blocking capacitor. |
| 3, 5, 6, 12 | GND | Ground terminal. This terminal should be connected to the ground plane as close as possible for excellent RF performance. |
| 7 | VCTL | Control voltage terminal. |
| 9 | VDD | Supply voltage terminal for LNA and logic circuit. Bypass to ground with capacitor C1 as close as possible to the IC. |
| 10 | RFOUT | RF output terminal. This IC integrates an input DC blocking capacitor. |

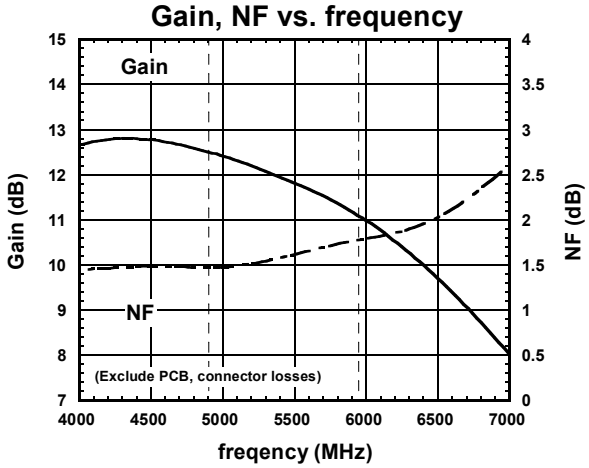
## ■ ELECTRICAL CHARACTERISTICS (LNA mode)

Conditions: $V_{DD}$=3.3V, $V_{CTL}$=1.8V, Ta=25°C, Zs=Zl=50Ω, with application circuit



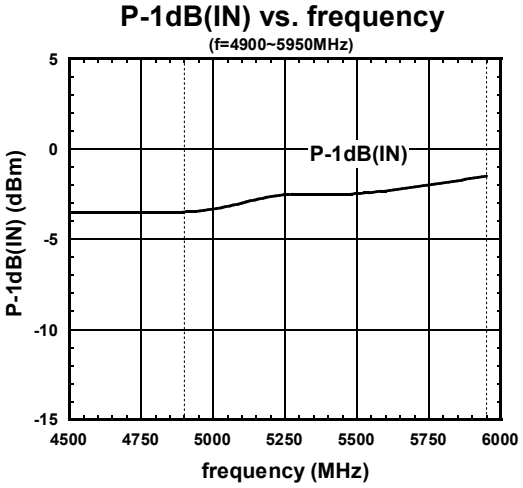



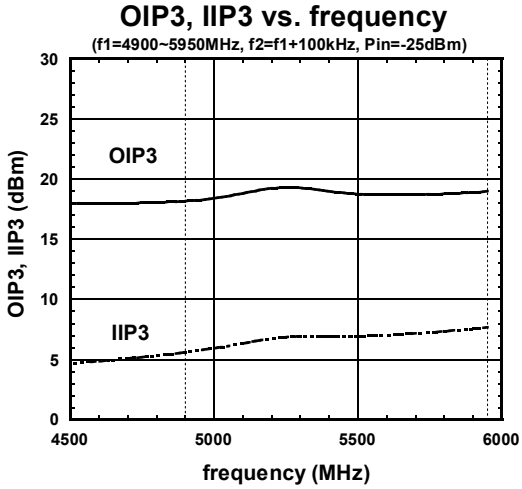



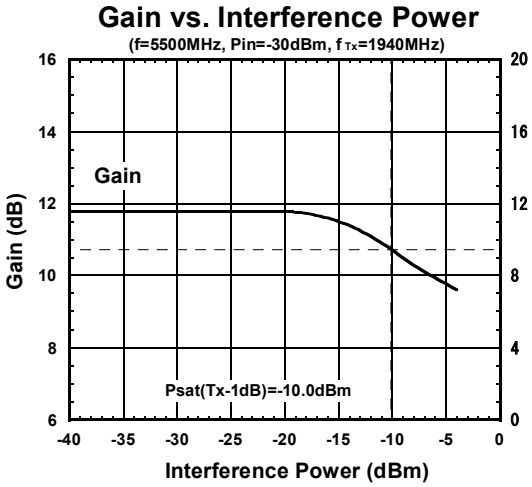



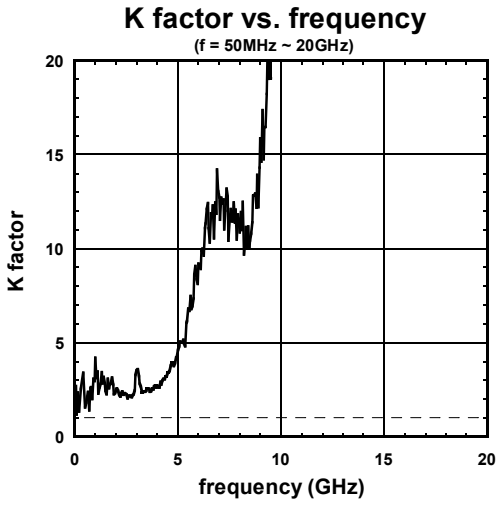
## ■ ELECTRICAL CHARACTERISTICS (LNA mode)

Conditions: $V_{DD}$=3.3V, $V_{CTL}$=1.8V, Ta=25°C, Zs=Zl=50Ω, with application circuit



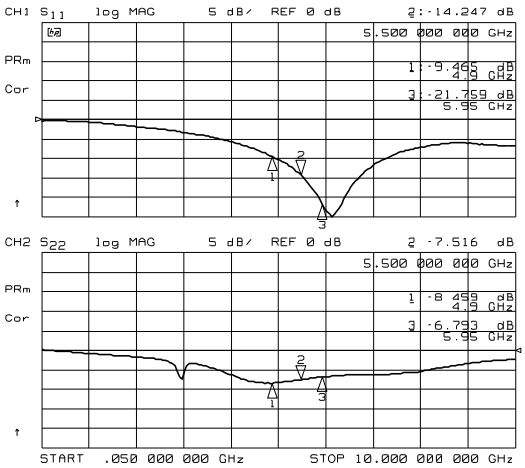



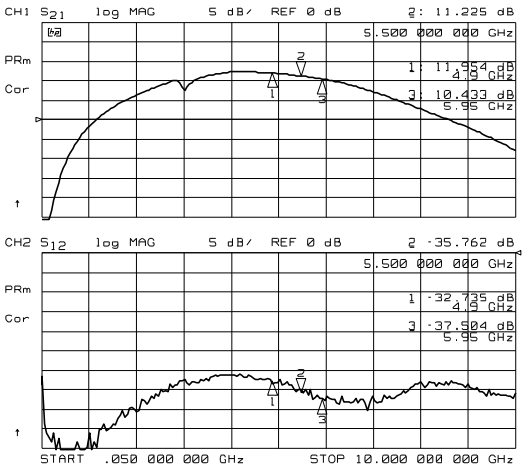



## ■ ELECTRICAL CHARACTERISTICS (LNA mode)

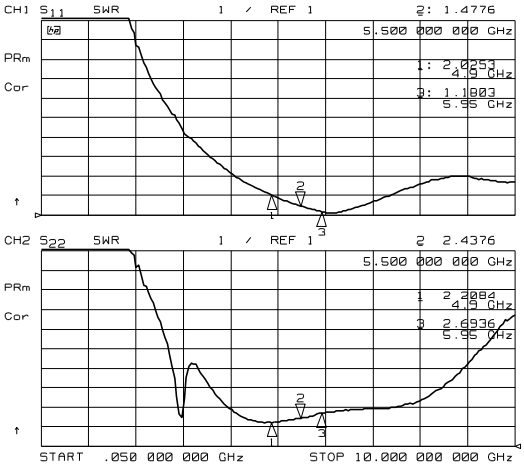
Conditions: $V_{DD}$=3.3V, $V_{CTL}$=1.8V, Ta=25°C, Zs=Zl=50Ω, with application circuit



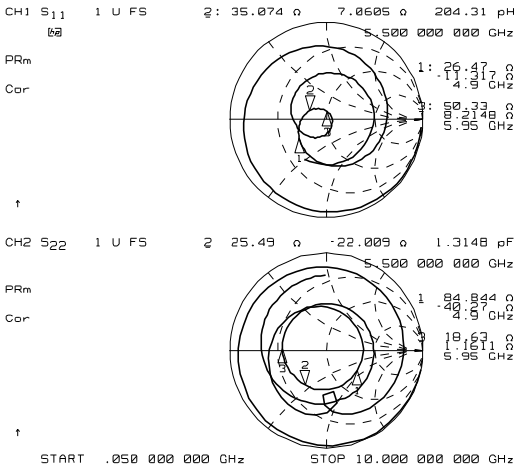

S11, S22 (0.05~10GHz)



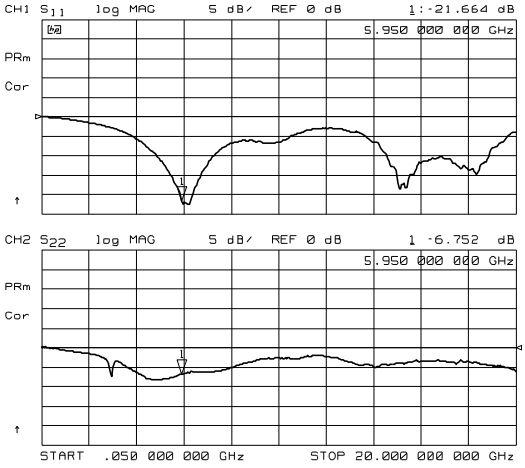

S21, S12 (0.05~10GHz)



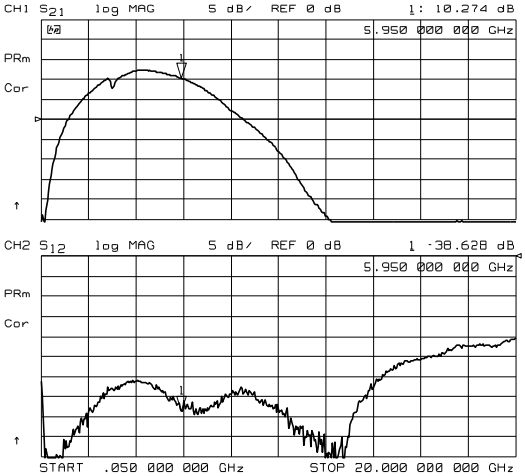

VSWRi, VSWRo (0.05~10GHz)




Zin, Zout (0.05~10GHz)



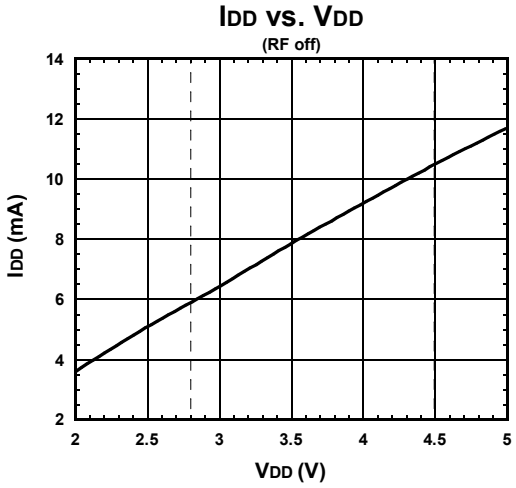

S11, S22 (0.05~20GHz)

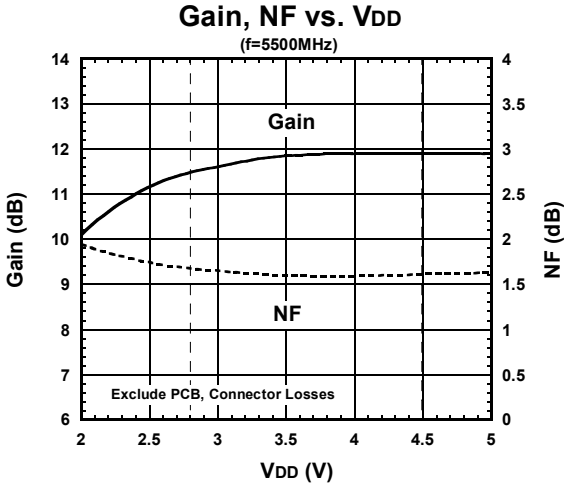


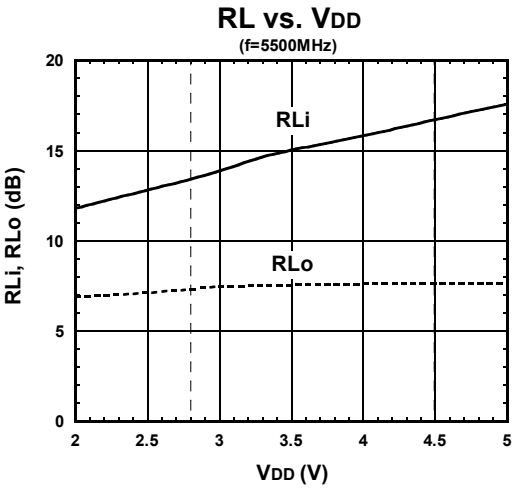

S21, S12 (0.05~20GHz)

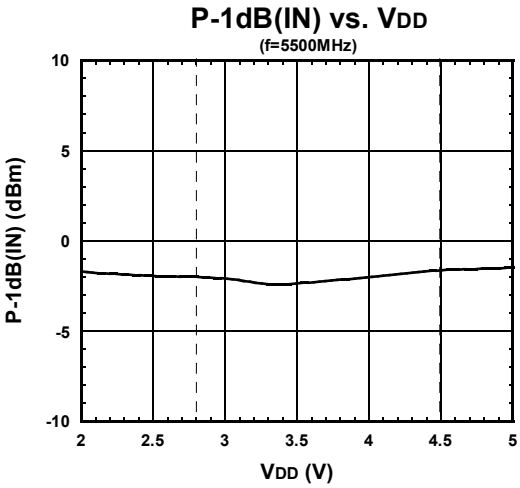
## ■ ELECTRICAL CHARACTERISTICS (LNA mode)

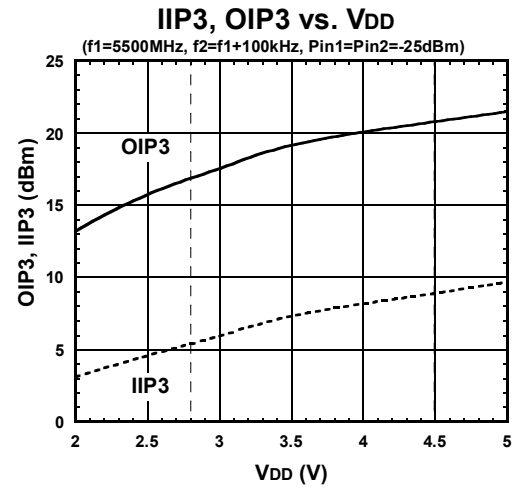
Conditions: $V_{CTL}$=1.8V, Ta=25°C, Zs=Zl=50Ω, with application circuit

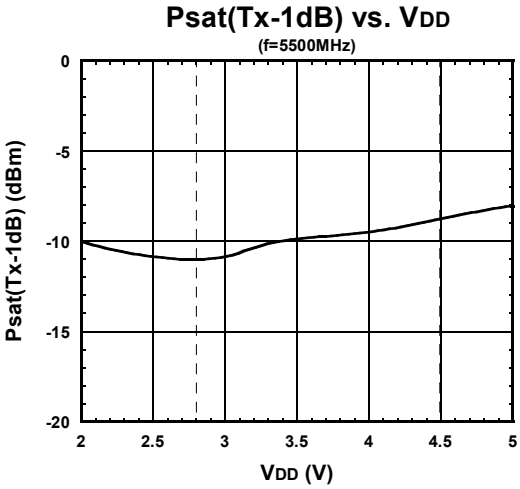


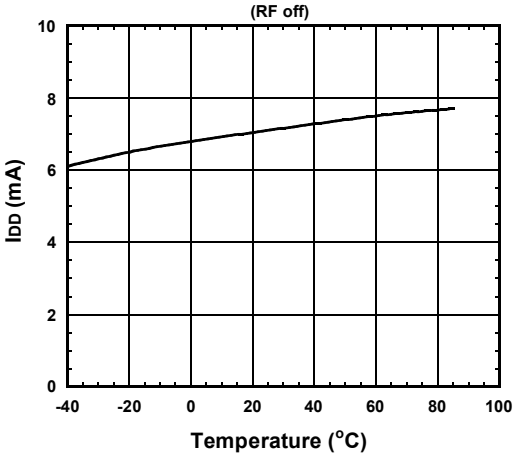



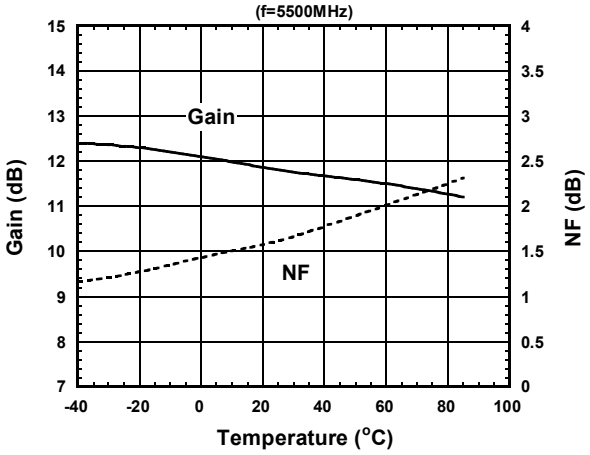
## ■ ELECTRICAL CHARACTERISTICS (LNA mode)

Conditions: $V_{DD}$=3.3V, $V_{CTL}$=1.8V, Zs=Zl=50Ω, with application circuit

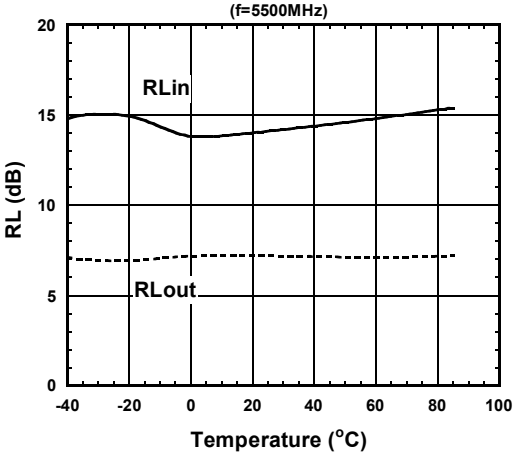
**IDD vs. Temperature**



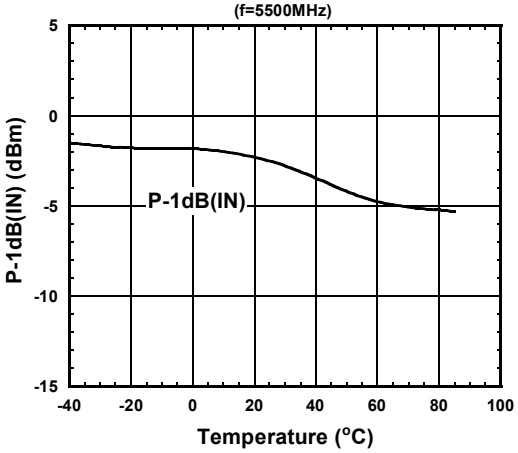

**Gain, NF vs. Temperature**



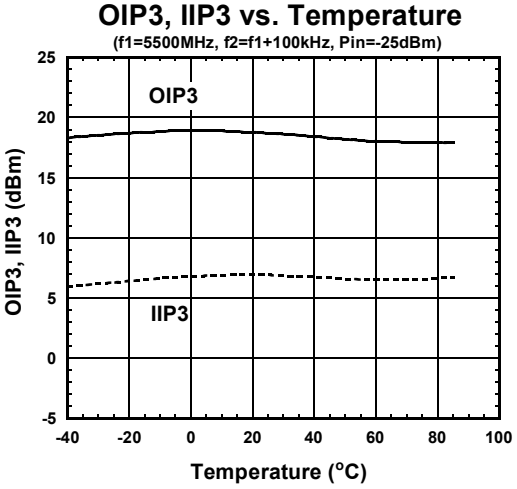

**RL vs. Temperature**



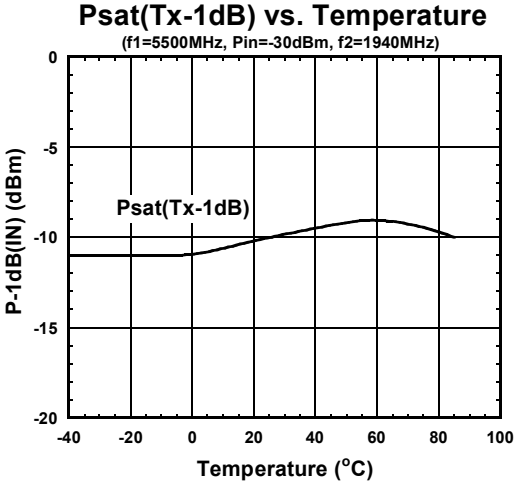

**P-1dB(IN) vs. Temperature**




**OIP3, IIP3 vs. Temperature**

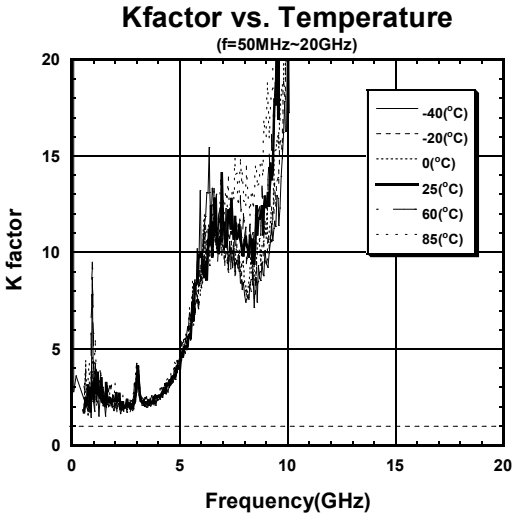


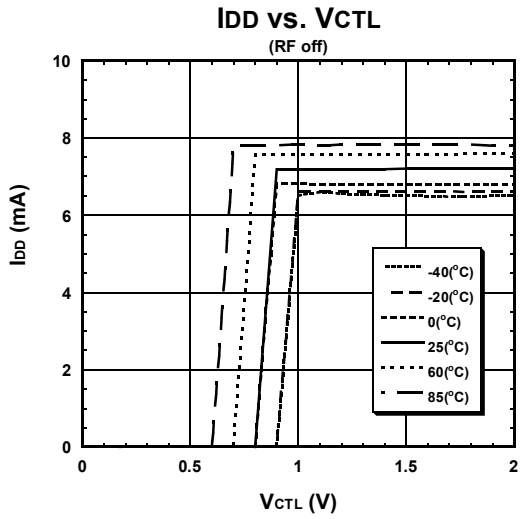

**Psat(Tx-1dB) vs. Temperature**



## ■ ELECTRICAL CHARACTERISTICS (LNA mode)

Conditions: $V_{DD}$=3.3V, $V_{CTL}$=1.8V, Zs=Zl=50Ω, with application circuit

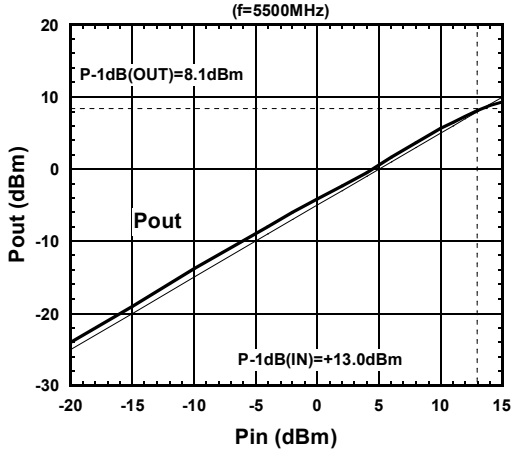


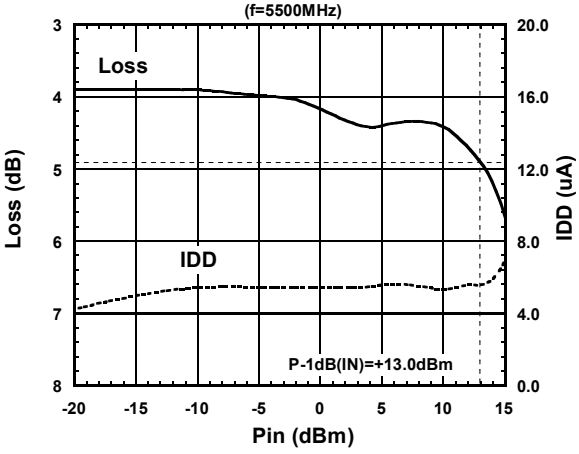
## ■ ELECTRICAL CHARACTERISTICS (Bypass mode)

Conditions: $V_{DD}$=3.3V, $V_{CTL}$=0V, Ta=25°C, Zs=Zl=50Ω, with application circuit

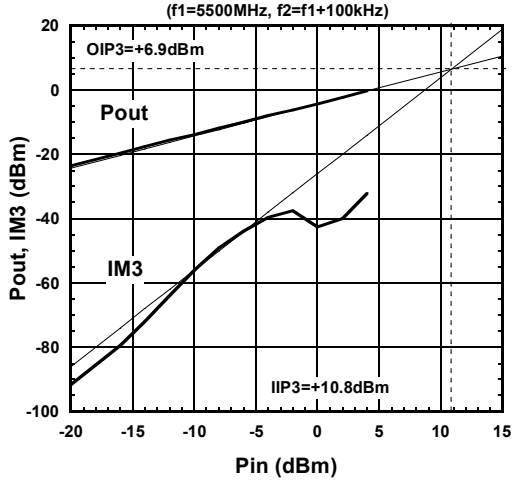
**Pout vs. Pin**



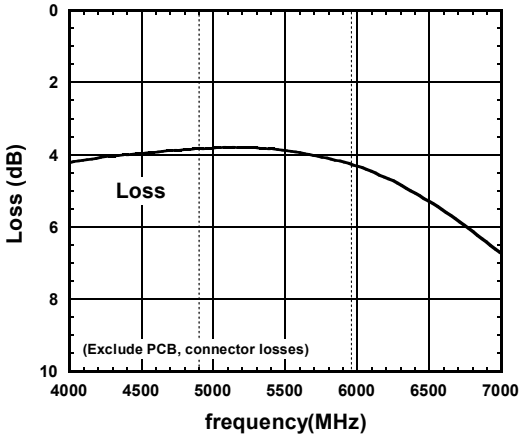

**Loss, IDD vs. Pin**



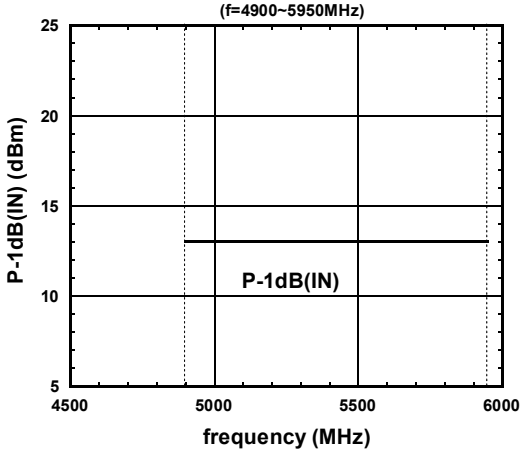

**Pout, IM3 vs. Pin**



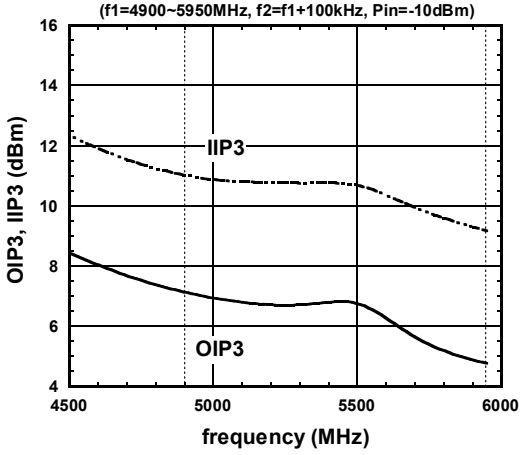

**Loss vs. frequency**




**P-1dB(IN) vs. frequency**

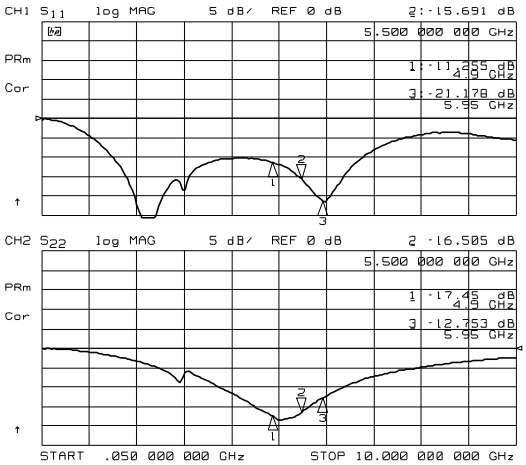



**OIP3, IIP3 vs. frequency**

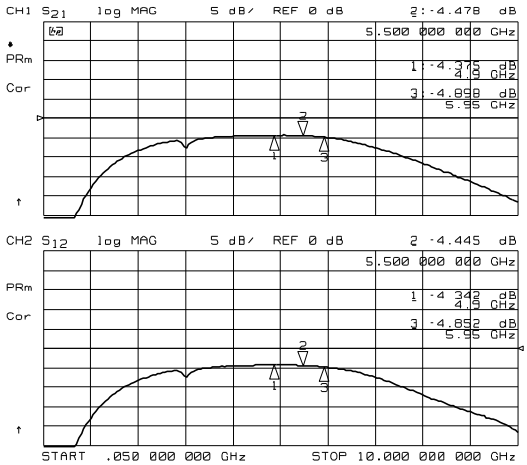


## ■ ELECTRICAL CHARACTERISTICS (Bypass mode)

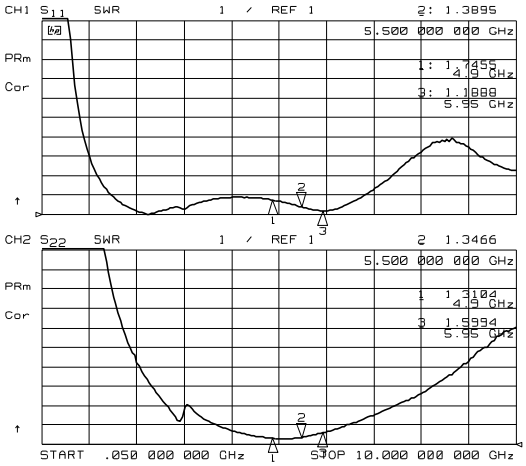
Conditions: $V_{DD}$=3.3V, $V_{CTL}$=0V, Ta=25ºC, Zs=Zl=50Ω, with application circuit



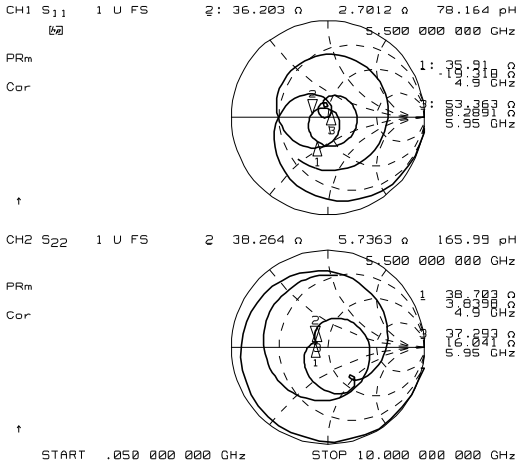

S11, S22 (0.05~10GHz)



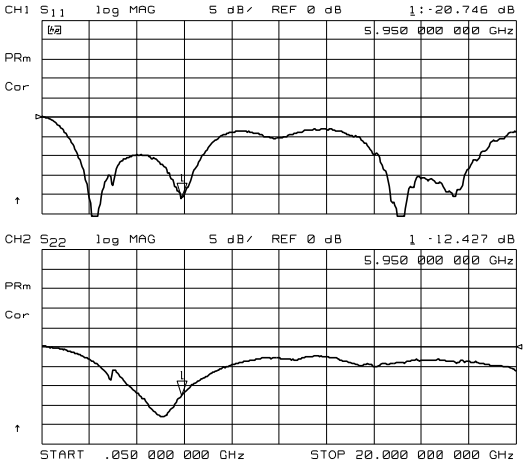

S21, S12 (0.05~10GHz)



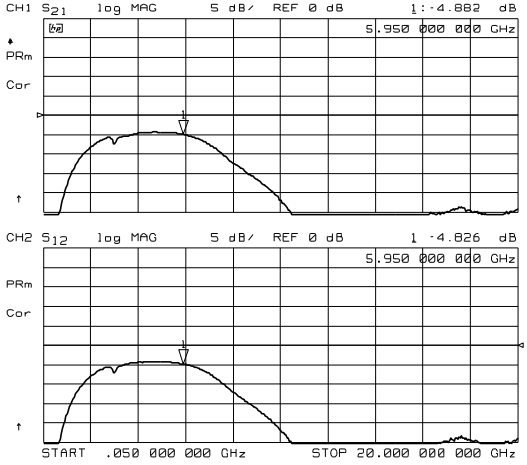

VSWRi, VSWRo (0.05~10GHz)




Zin, Zout (0.05~10GHz)



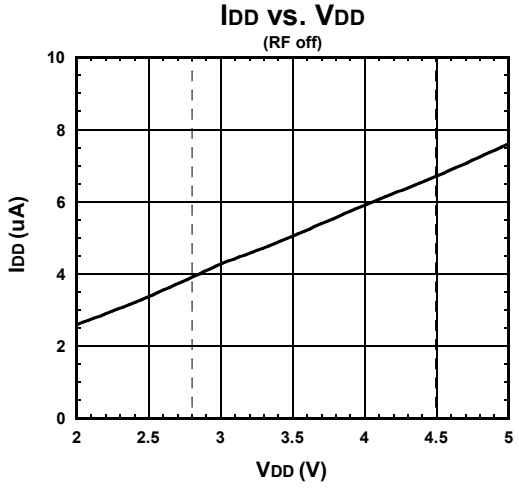

S11, S22 (0.05~20GHz)

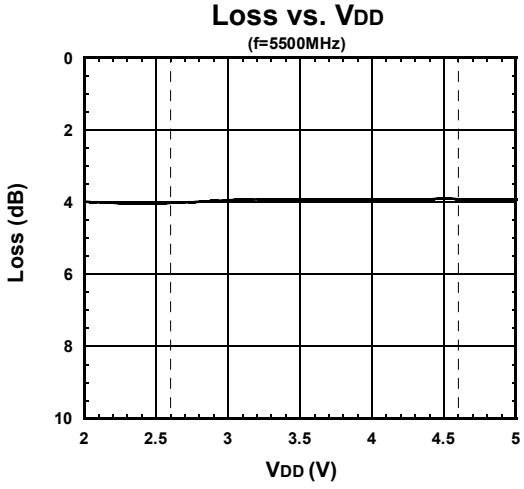


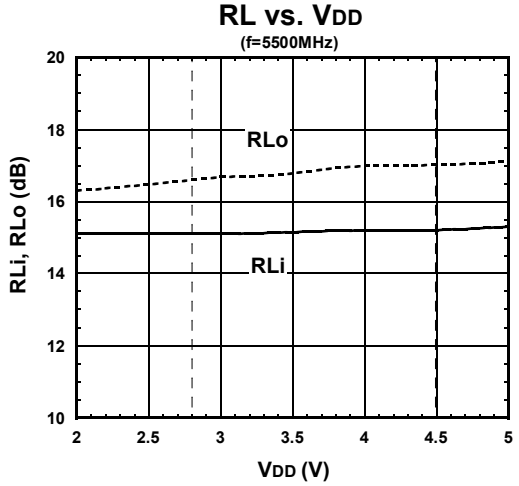

S21, S12 (0.05~20GHz)

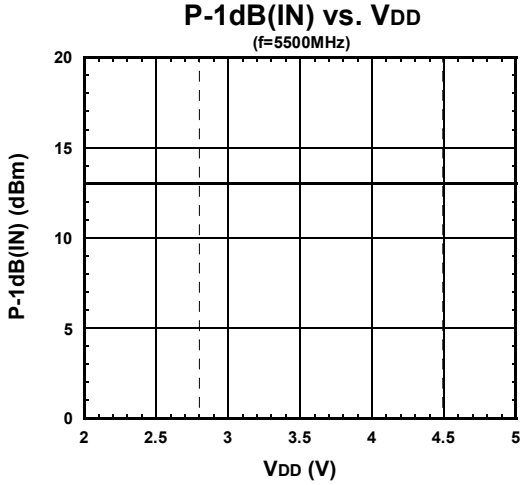
## ■ ELECTRICAL CHARACTERISTICS (Bypass mode)

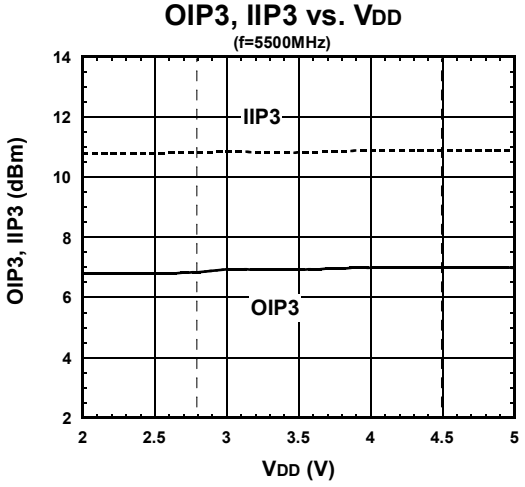
Conditions: $V_{CTL}$=0V, Ta=25°C, Zs=Zl=50Ω, with application circuit



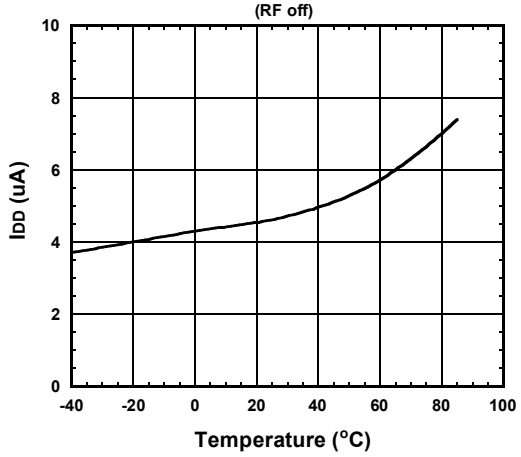



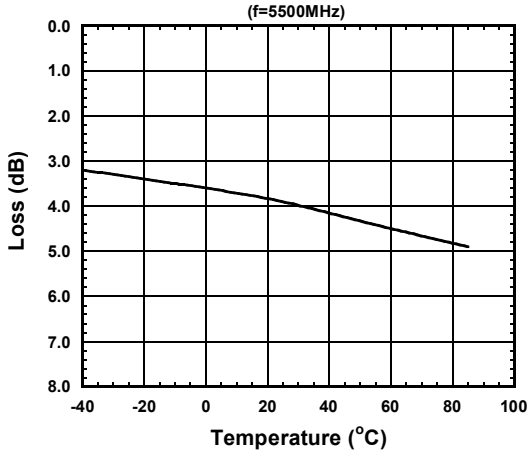
## ■ ELECTRICAL CHARACTERISTICS (Bypass mode)

Conditions: $V_{DD}$=3.3V, $V_{CTL}$=1.8V, Zs=Zl=50Ω, with application circuit

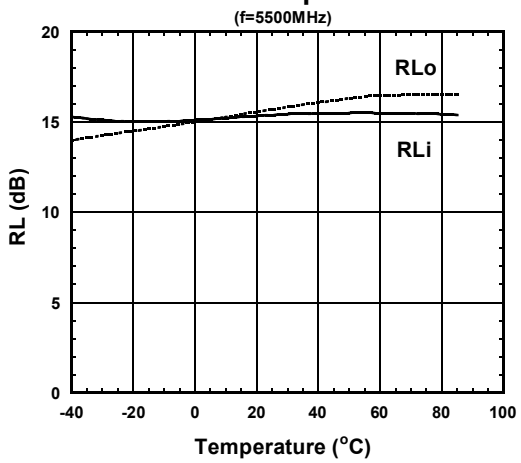
**IDD vs. Temperature**



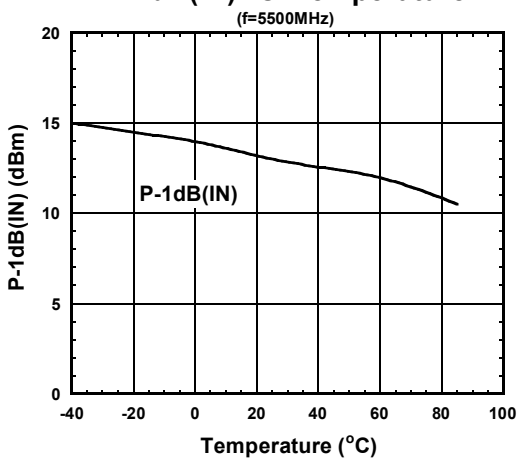

**Loss vs. Temperature**



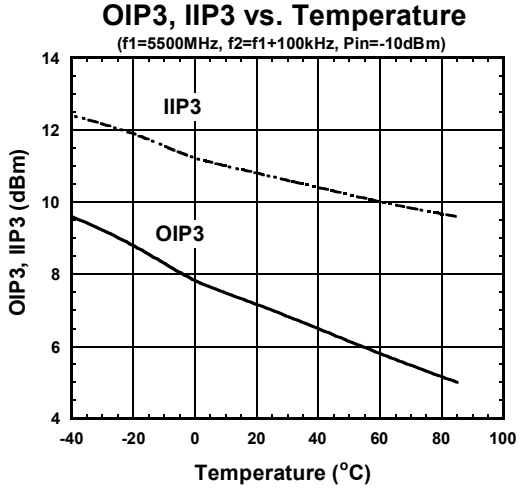

**RL vs. Temperature**



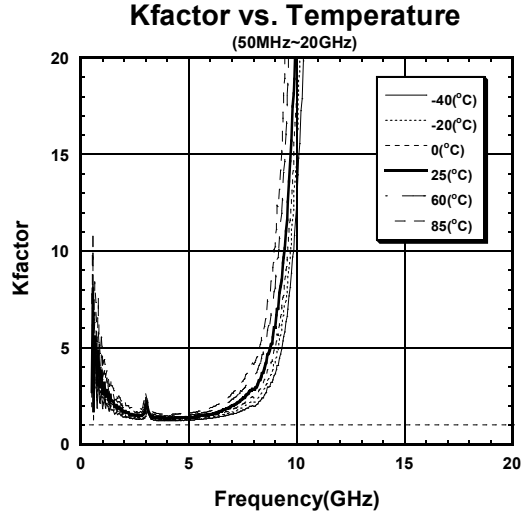

**P-1dB(IN) vs. Temperature**



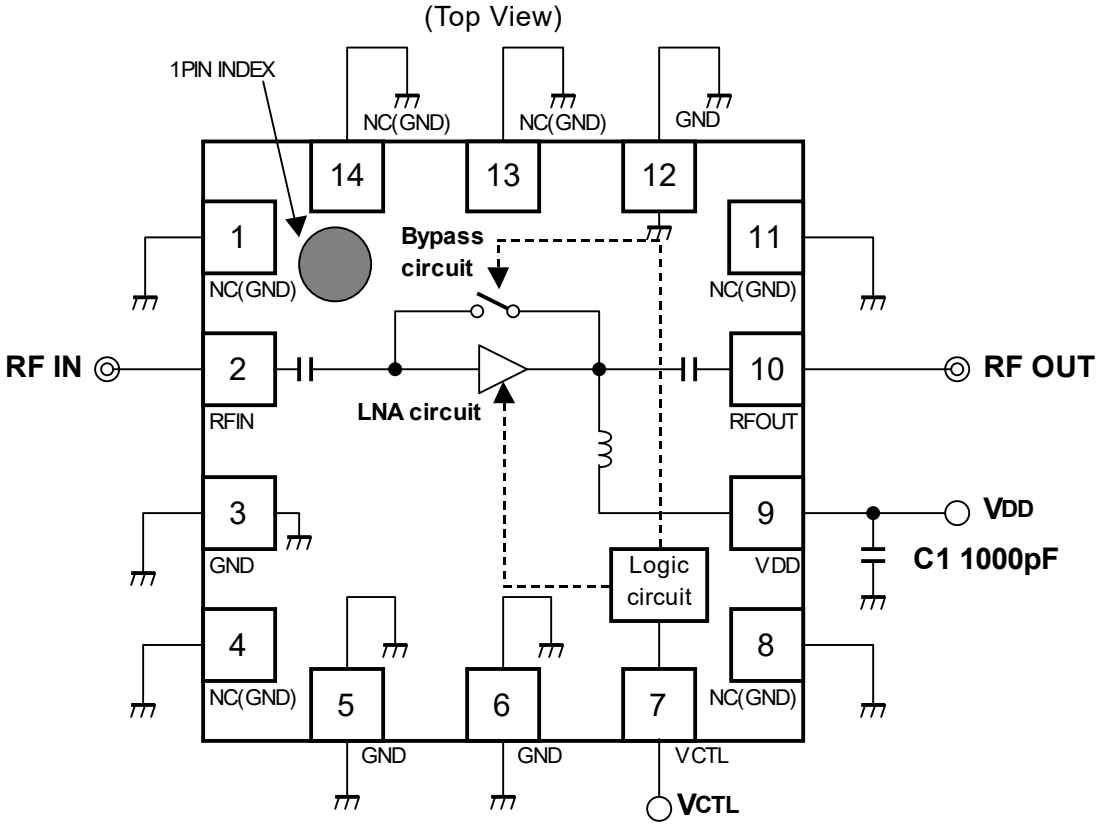

**OIP3, IIP3 vs. Temperature**



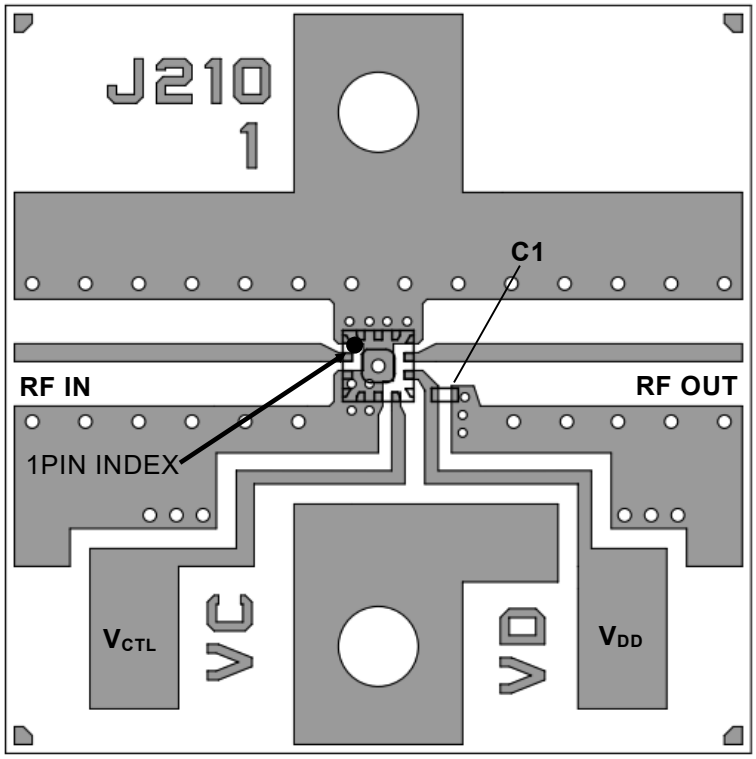

**Kfactor vs. Temperature**



## ■ APPLICATION CIRCUIT




## ■ TEST PCB LAYOUT




PARTS LIST

| Parts ID | Manufacturer |
|---|---|
| C1 | MURATA<br>GRM03 Series |

PCB

Substrate: FR4

Thickness: 0.2mm

MICROSTRIP LINE WIDTH

: 0.40mm ($Z_0$=50Ω)

PCB SIZE: 17.0mm x 17.0mm

**PRECAUTIONS**

- Bypass capacitor C1 is placed as close as possible to the IC.
- In order not to couple with terminal RFIN and RFOUT, please layout ground pattern under the IC.
- All GND terminals must be connected to PCB ground place in order to reduce the inductance as soon as possible.

## ■ MEASUREMENT BLOCK DIAGRAM

**Measuring instruments**

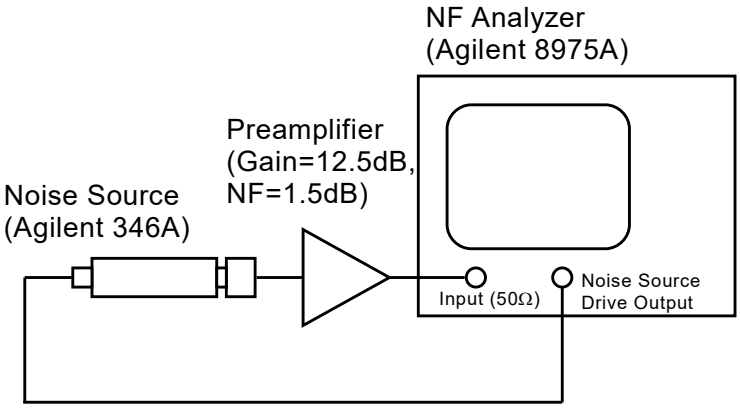
NF Analyzer : Agilent 8975A
Noise Source : Agilent 346A

**Setting the NF analyzer**

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

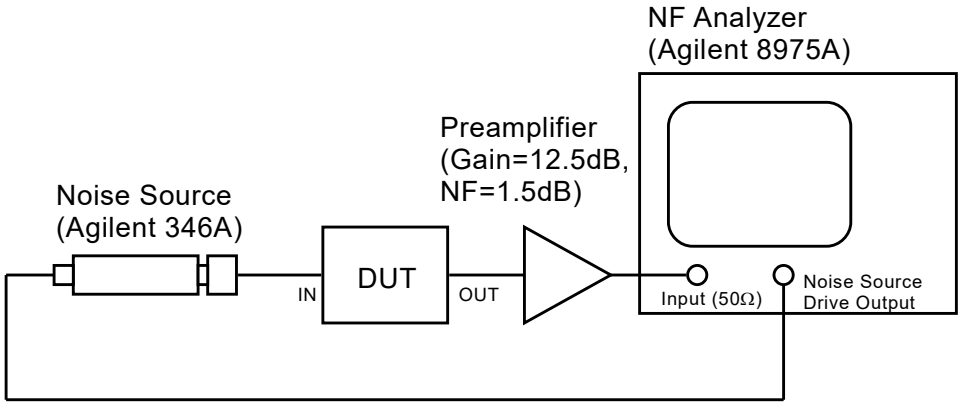
Mode setup form
- Sideband : LSB

Averages : 16
Average mode : Point
Bandwidth : 4MHz
Loss comp : off
Tcold : setting the temperature of noise source (300K)




* Noise sauce, the preamplifier, and NF analyzer are connected directly.

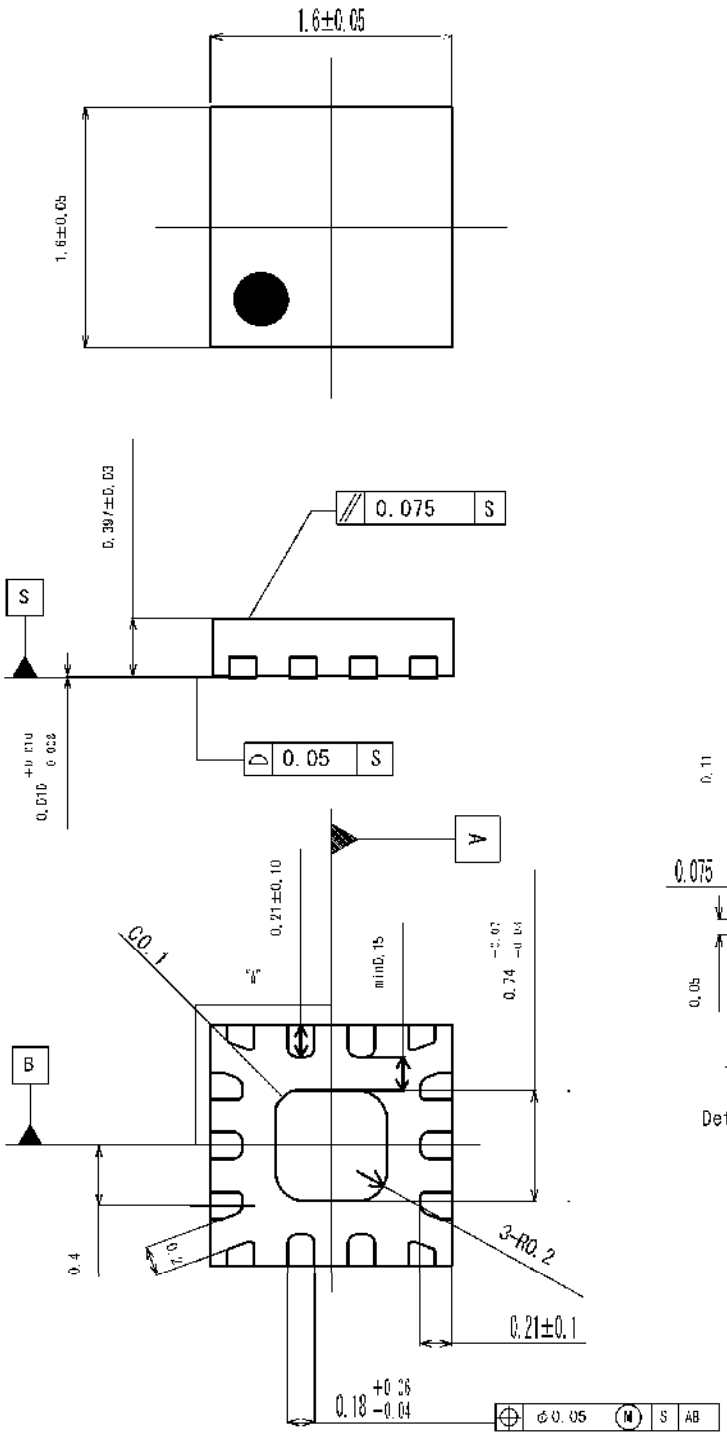
Calibration Setup

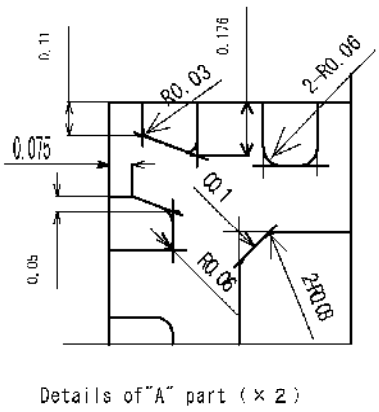



* Noise sauce, DUT, the preamplifier, and NF analyzer are connected directly.

Measurement Setup

## ■ PACKAGE OUTLINE (ESON14-D7)




Details of"A" part (×2)

| | |
|---|---|
| Unit | : mm |
| Substrate | : Cu |
| Terminal Treat | : SnBi |
| Molding Material | : Epoxy Resin |
| Weight | : 3.4mg |

**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.
4. The technical information described in this document shows typical characteristics and example application circuits for the products. The release of such information is not to be construed as a warranty of or a grant of license under our or any third party's intellectual property rights or any other rights.
5. The products listed in this document are intended and designed for use as general electronic components in standard applications (office equipment, telecommunication equipment, measuring instruments, consumer electronic products, amusement equipment etc.). Those customers intending to use a product in an application requiring extreme quality and reliability, for example, in a highly specific application where the failure or misoperation of the product could result in human injury or death should first contact us.
    - 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.

NISSHINBO

**Nisshinbo Micro Devices Inc.**

**Official website**
**https://www.nisshinbo-microdevices.co.jp/en/**

**Purchase information**
**https://www.nisshinbo-microdevices.co.jp/en/buy/**