

# 5GHz BAND LOW NOISE AMPLIFIER GaAs MMIC

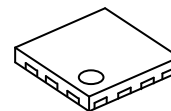
## ■ GENERAL DESCRIPTION

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

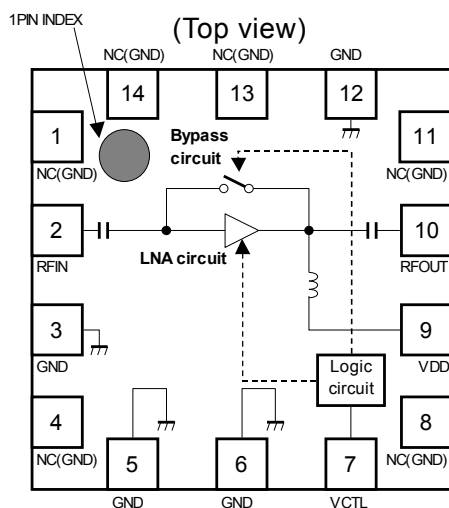
5GHz Band application from 4.9GHz to 5.95GHz

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)  
5 $\mu A$  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

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

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

## ■ ELECTRICAL CHARACTERISTICS 1 (DC CHARACTERISTICS)

$V_{DD}=3.3\text{V}$ ,  $T_a=+25^{\circ}\text{C}$ ,  $Z_s=Z_l=50\Omega$

| 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     | $I_{DD1}$    | RF OFF, $V_{CTL}=1.8\text{V}$ | -   | 7.0 | 11.0 | mA            |
| Operating current2     | $I_{DD2}$    | RF OFF, $V_{CTL}=0\text{V}$   | -   | 5   | 9    | $\mu\text{A}$ |
| Control current        | $I_{CTL}$    | RF OFF, $V_{CTL}=1.8\text{V}$ | -   | 6   | 10   | $\mu\text{A}$ |

## ■ ELECTRICAL CHARACTERISTICS 2 (LNA mode)

$V_{DD}=3.3V$ ,  $V_{CTL}=1.8V$ ,  $freq=4900\sim 5950MHz$ ,  $T_a=+25^{\circ}C$ ,  $Z_s=Z_l=50\Omega$ , 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<br>Tx frequency: f2=1710MHz, 1940MHz, 2170MHz<br>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)

$V_{DD}=3.3V$ ,  $V_{CTL}=0V$ ,  $freq=4900\sim 5950MHz$ ,  $T_a=+25^{\circ}C$ ,  $Z_s=Z_l=50\Omega$ , 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    |

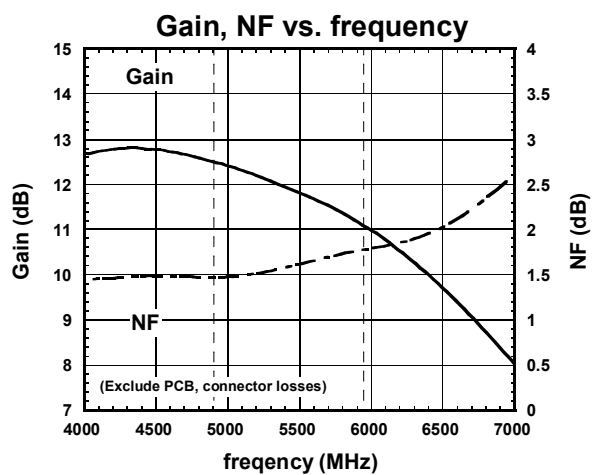
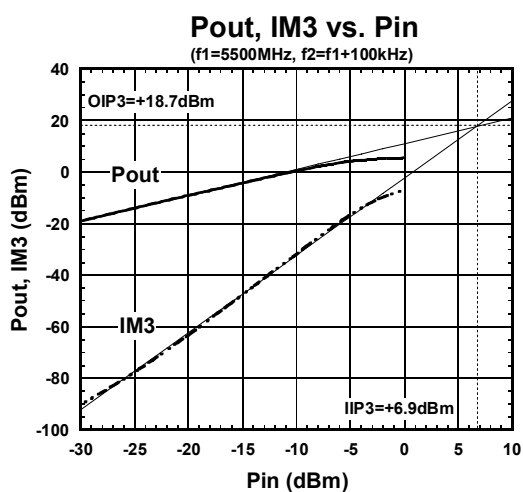
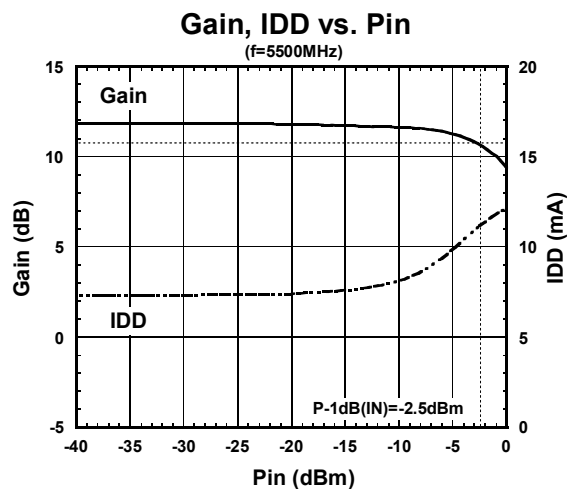
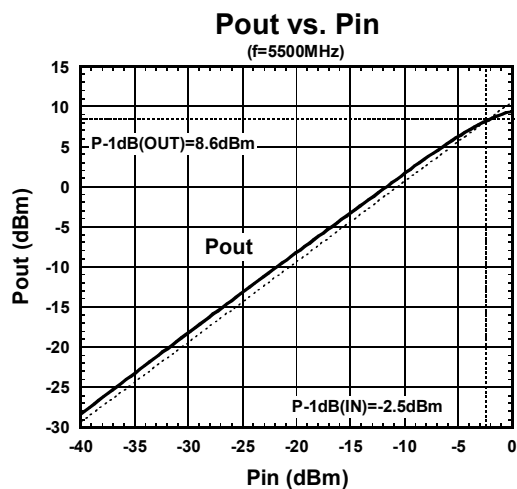
\*1 Input & output PCB and connector losses: 0.58dB (5500MHz)

## ■ TERMINAL INFORMATION

| No.                    | SYMBOL  | DESCRIPTION                                                                                                                                                                    |
|------------------------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1, 4, 8, 11,<br>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:  $V_{DD}=3.3V$ ,  $V_{CTL}=1.8V$ ,  $T_a=25^{\circ}C$ ,  $Z_s=Z_L=50\Omega$ , with application circuit

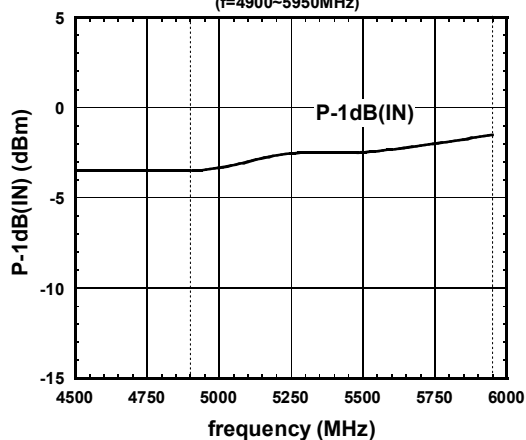


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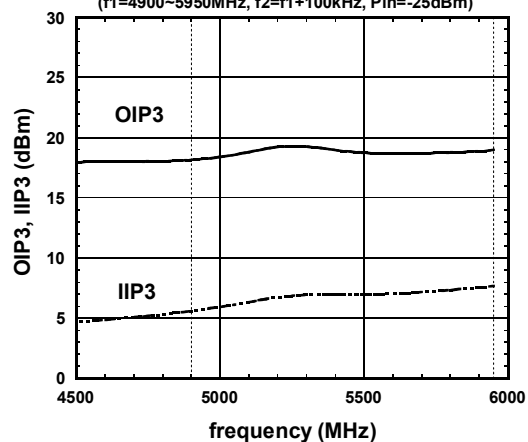
**P-1dB(IN) vs. frequency**

(f=4900~5950MHz)



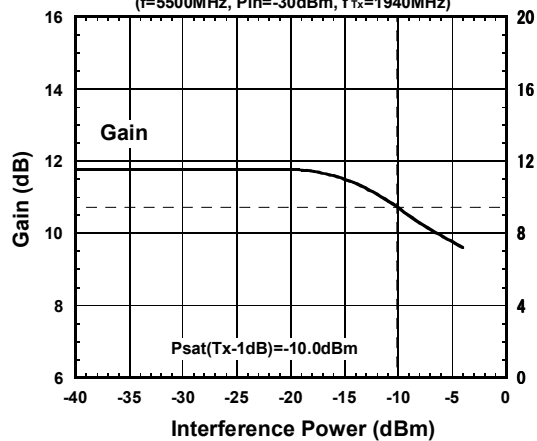
**OIP3, IIP3 vs. frequency**

(f1=4900~5950MHz, f2=f1+100kHz, Pin=-25dBm)



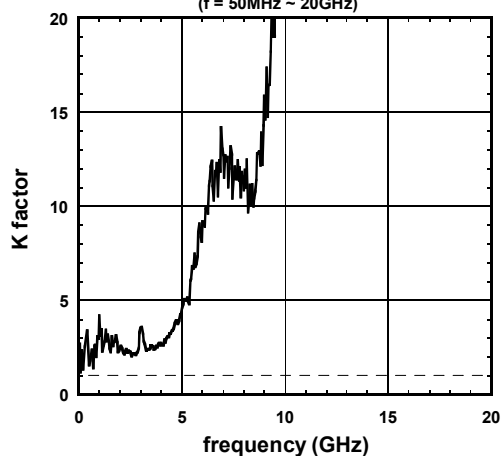
**Gain vs. Interference Power**

(f=5500MHz, Pin=-30dBm, fTx=1940MHz)



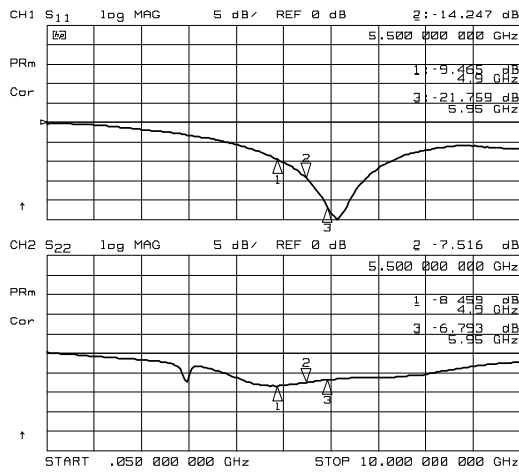
**K factor vs. frequency**

(f = 50MHz ~ 20GHz)

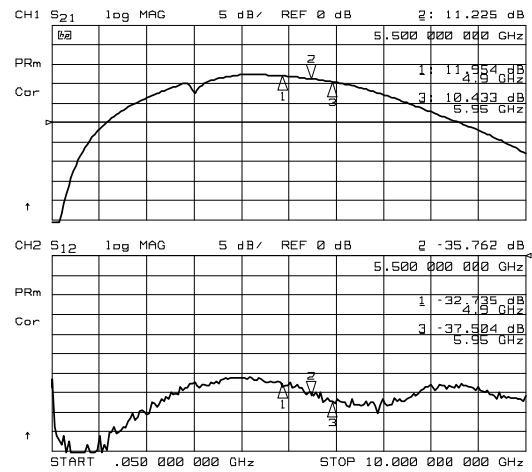


## ELECTRICAL CHARACTERISTICS (LNA mode)

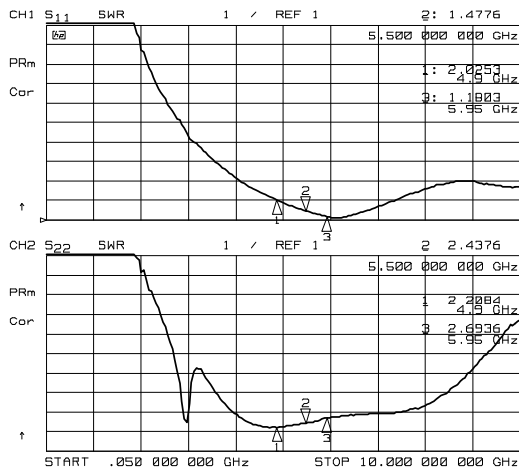
Conditions:  $V_{DD}=3.3V$ ,  $V_{CTL}=1.8V$ ,  $T_a=25^\circ C$ ,  $Z_s=Z_L=50\Omega$ , with application circuit



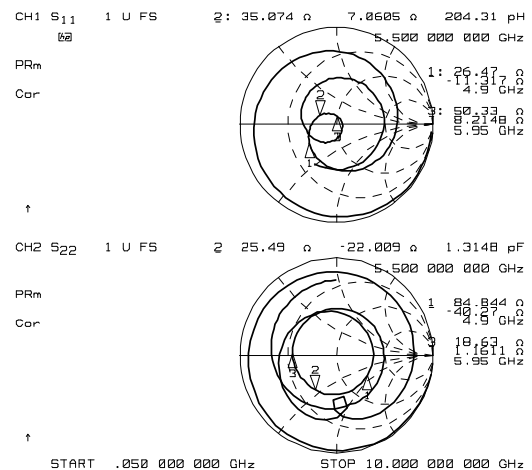
S11, S22 (0.05~10GHz)



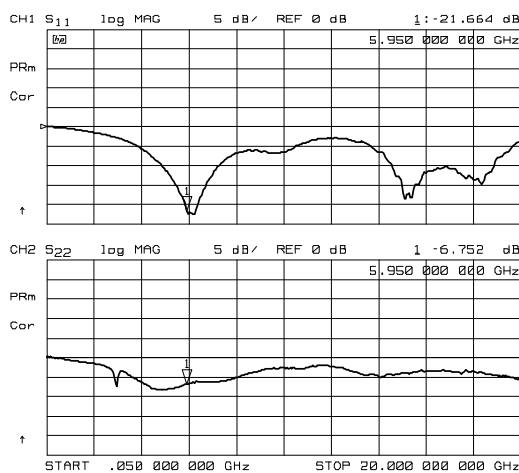
S21, S12 (0.05~10GHz)



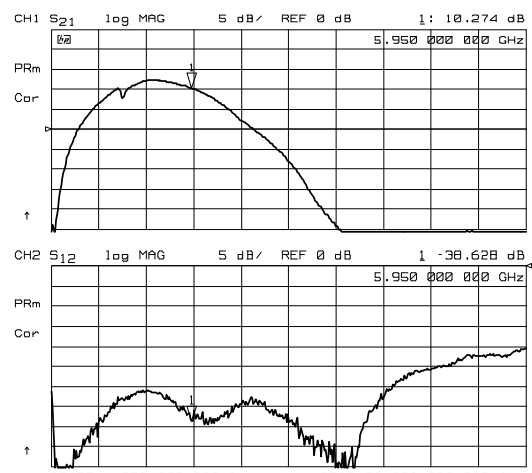
VSWRi, VSWRo (0.05~10GHz)



Zin, Zout (0.05~10GHz)



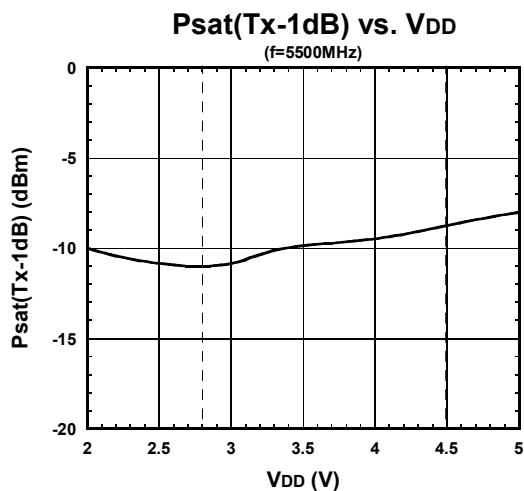
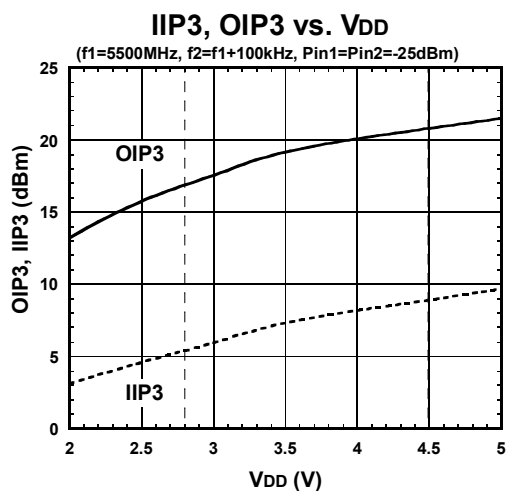
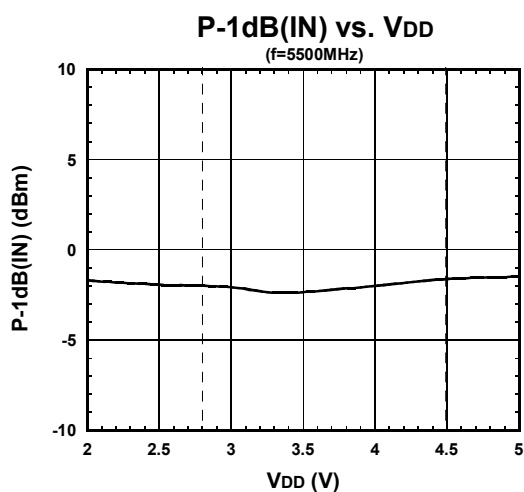
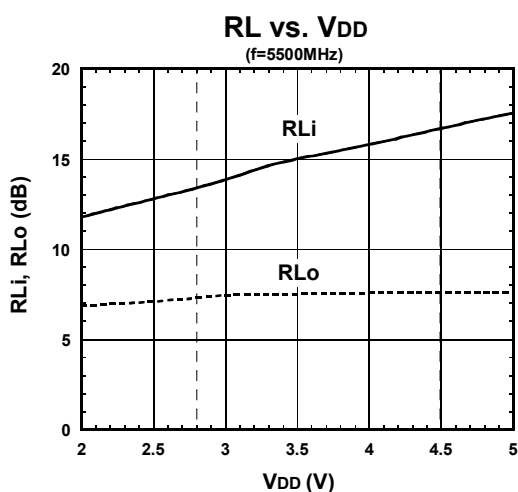
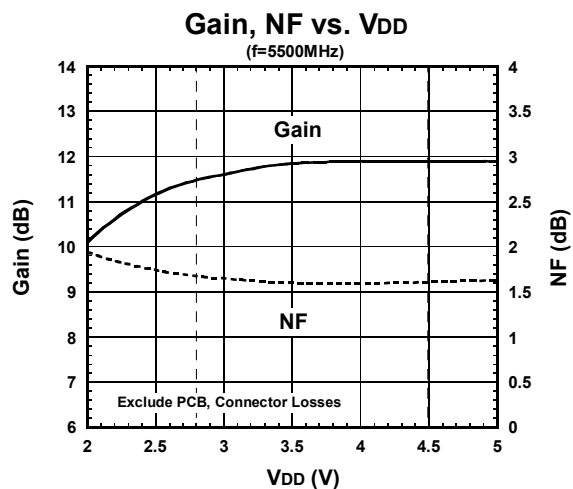
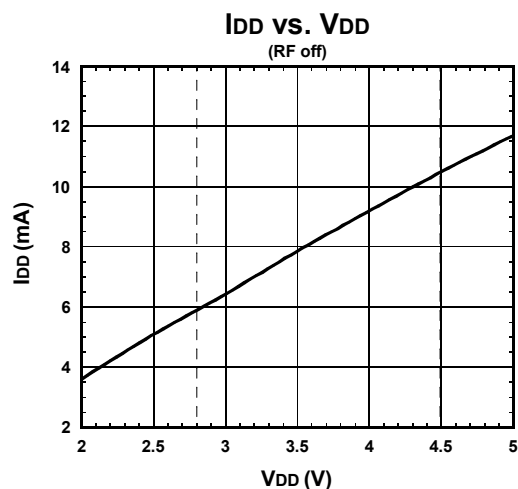
S11, S22 (0.05~20GHz)



S21, S12 (0.05~20GHz)

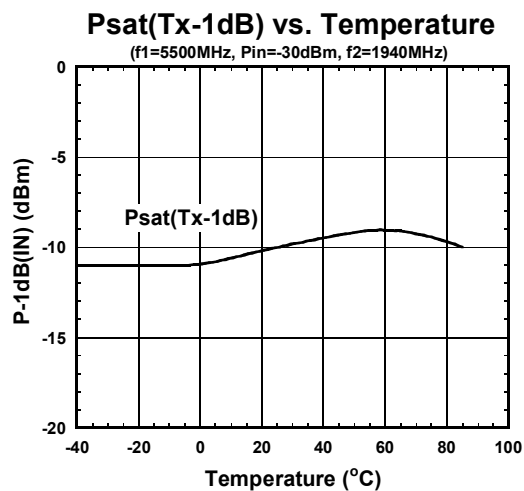
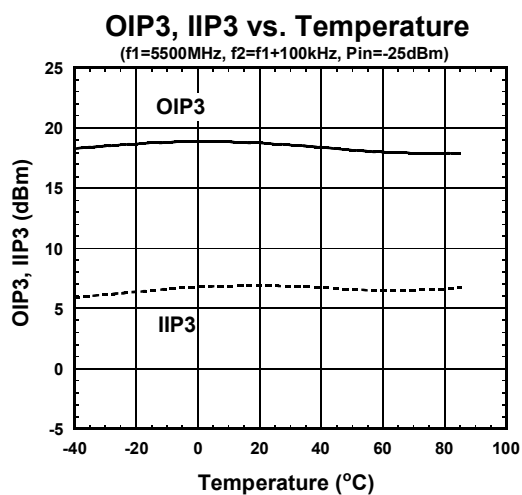
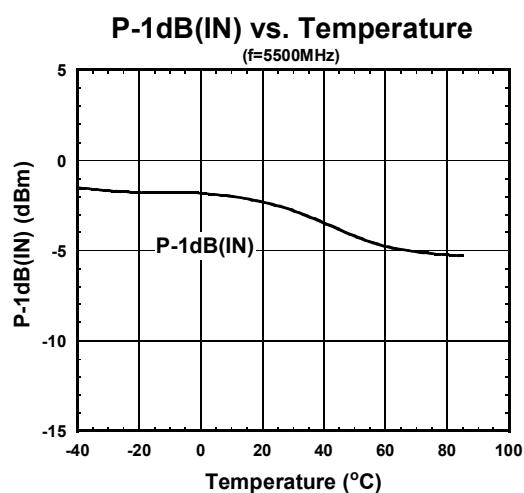
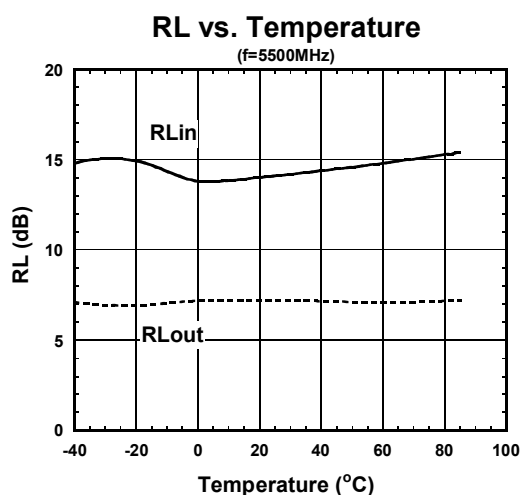
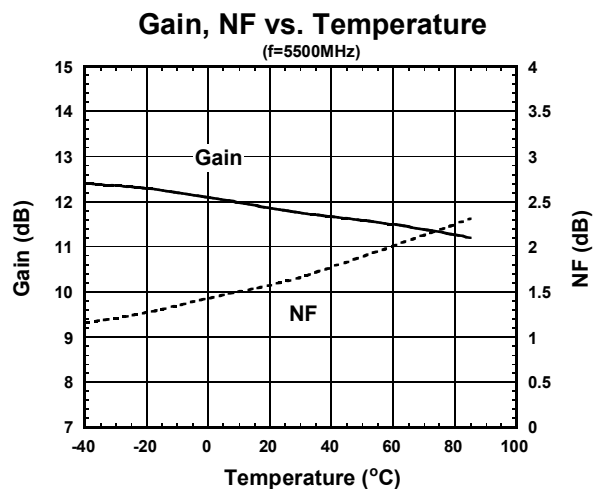
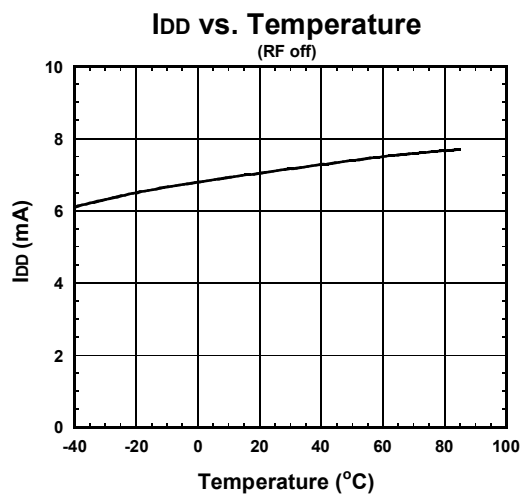
## ■ ELECTRICAL CHARACTERISTICS (LNA mode)

Conditions:  $V_{CTL}=1.8V$ ,  $T_a=25^{\circ}C$ ,  $Z_s=Z_L=50\Omega$ , with application circuit



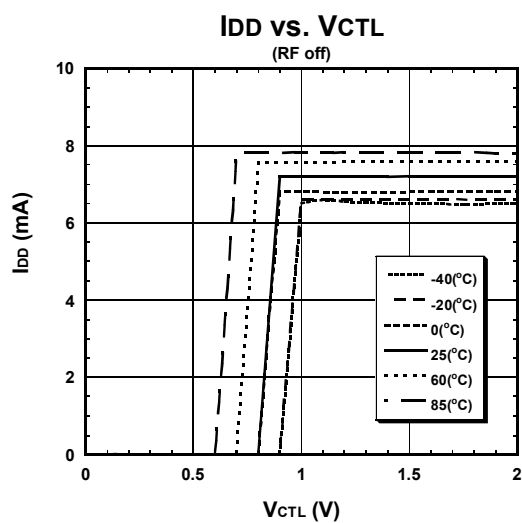
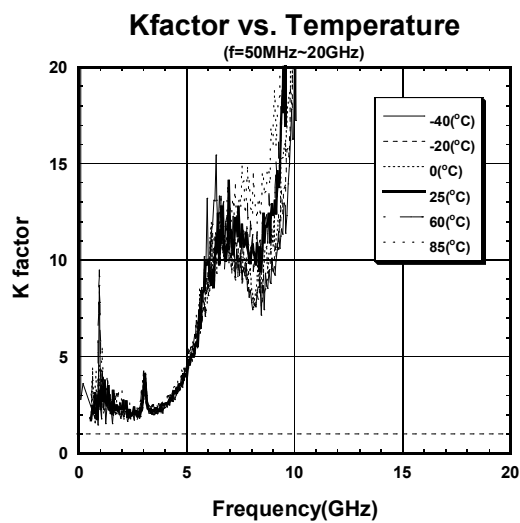
## ■ ELECTRICAL CHARACTERISTICS (LNA mode)

Conditions:  $V_{DD}=3.3V$ ,  $V_{CTL}=1.8V$ ,  $Z_s=Z_L=50\Omega$ , with application circuit



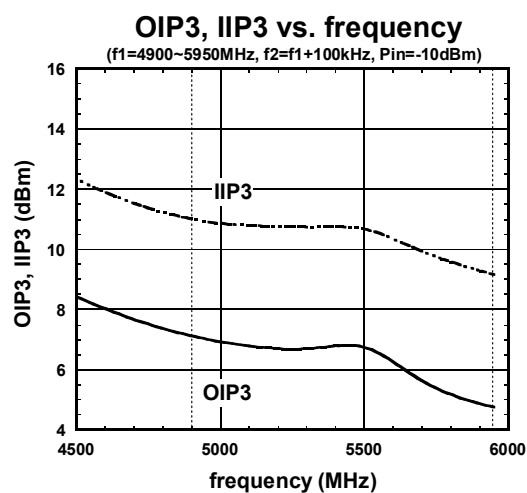
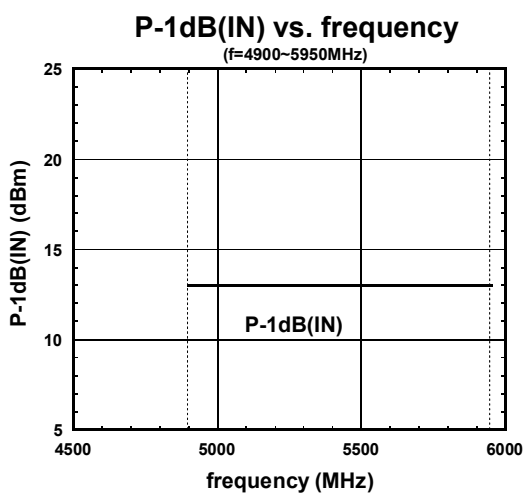
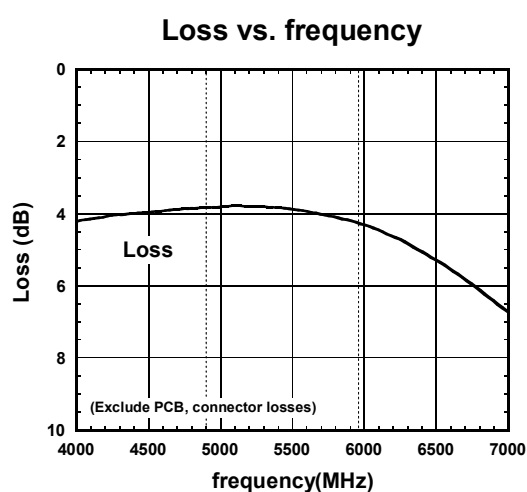
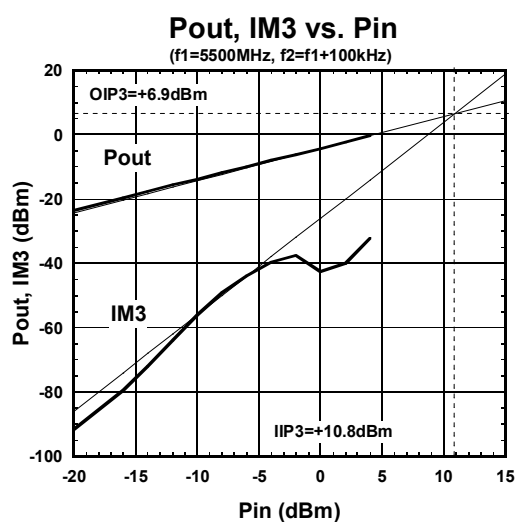
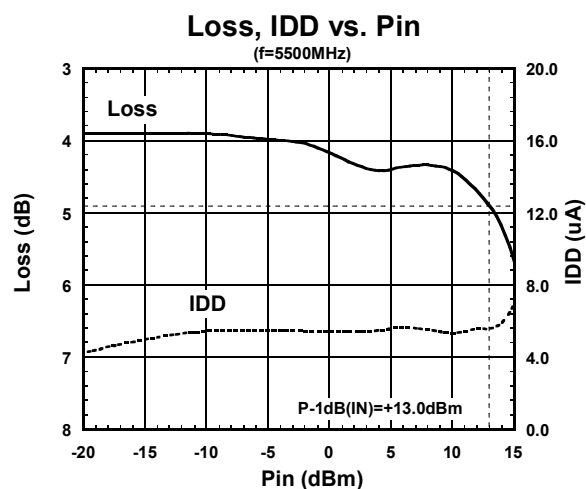
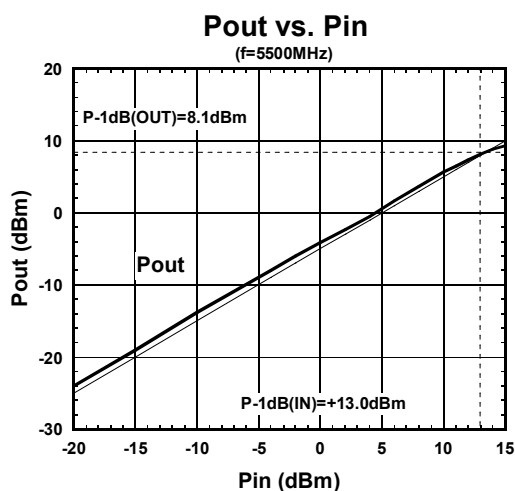
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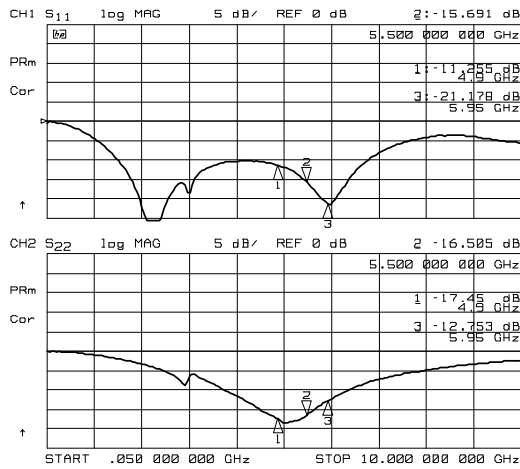
## ■ ELECTRICAL CHARACTERISTICS (Bypass mode)

Conditions:  $V_{DD}=3.3V$ ,  $V_{CTL}=0V$ ,  $T_a=25^{\circ}C$ ,  $Z_s=Z_L=50\Omega$ , with application circuit

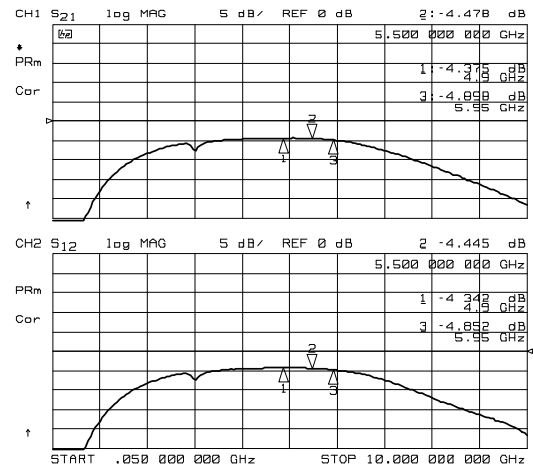


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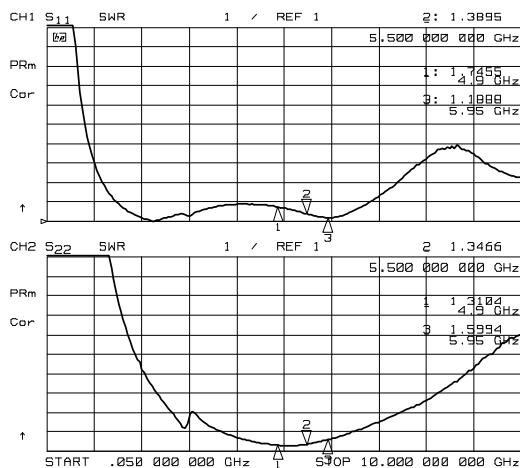
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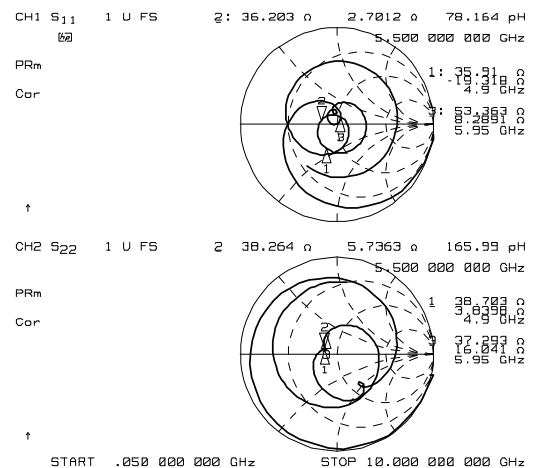
S11, S22 (0.05~10GHz)



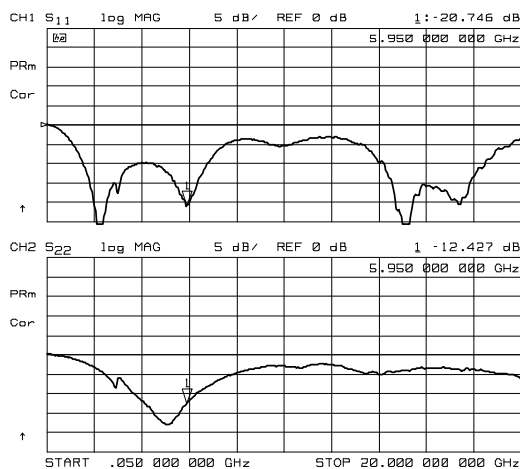
S21, S12 (0.05~10GHz)



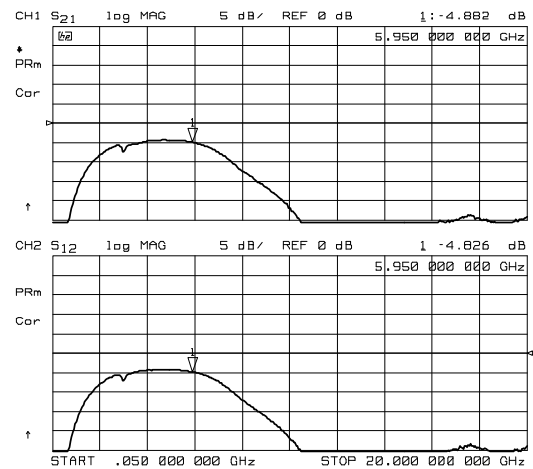
VSWRi, VSWRo (0.05~10GHz)



Zin, Zout (0.05~10GHz)



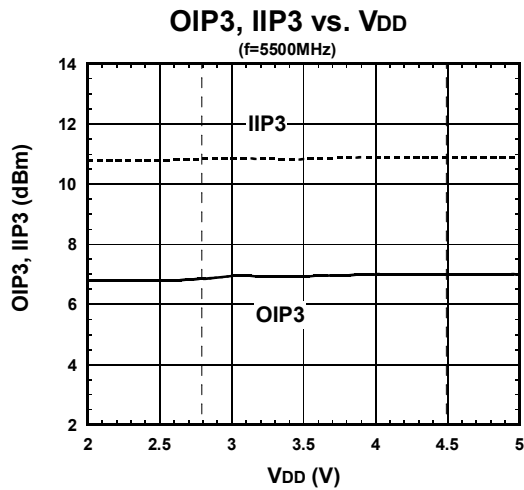
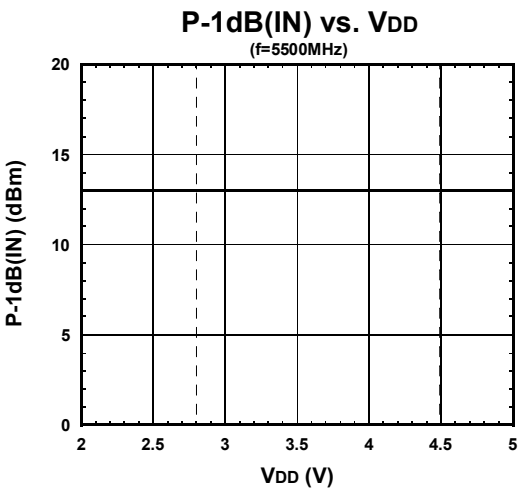
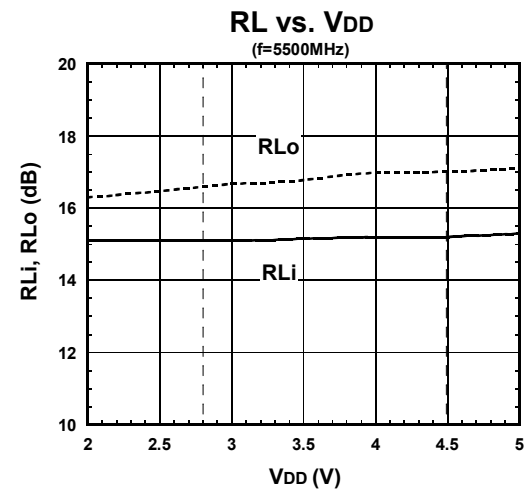
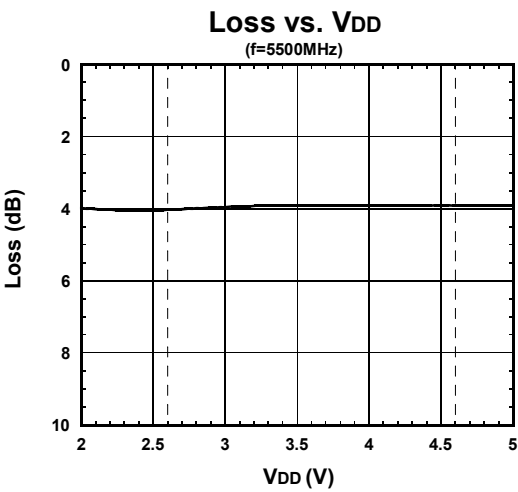
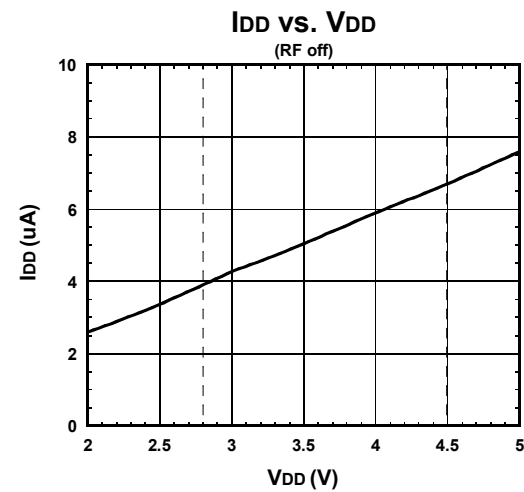
S11, S22 (0.05~20GHz)



S21, S12 (0.05~20GHz)

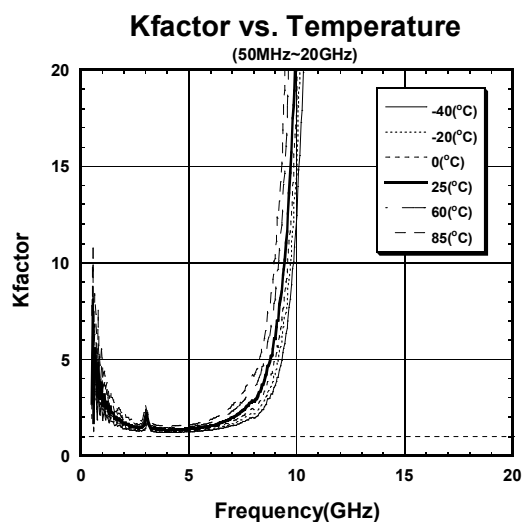
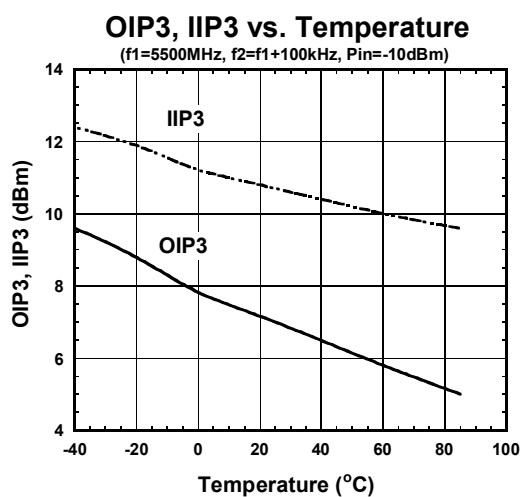
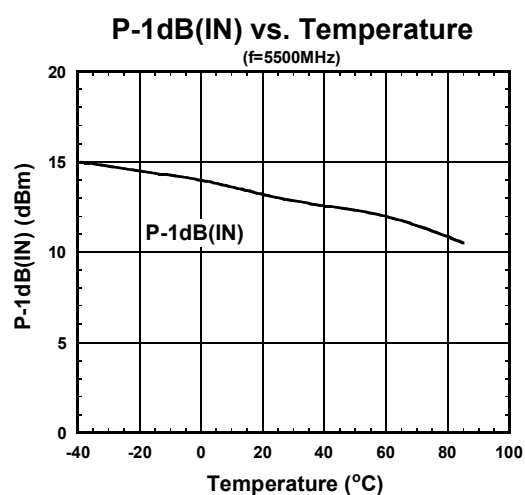
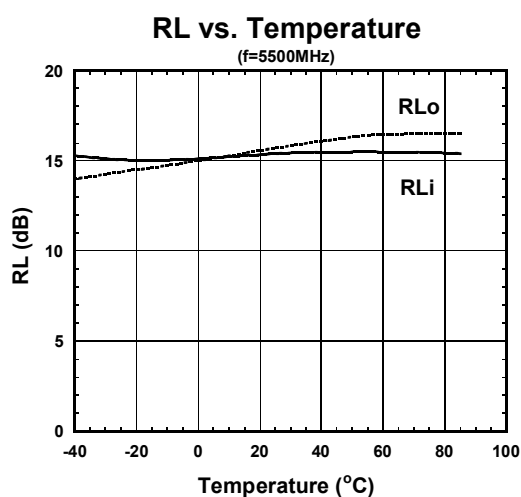
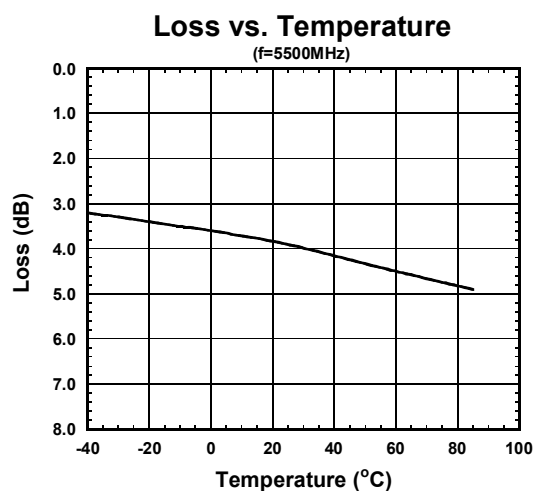
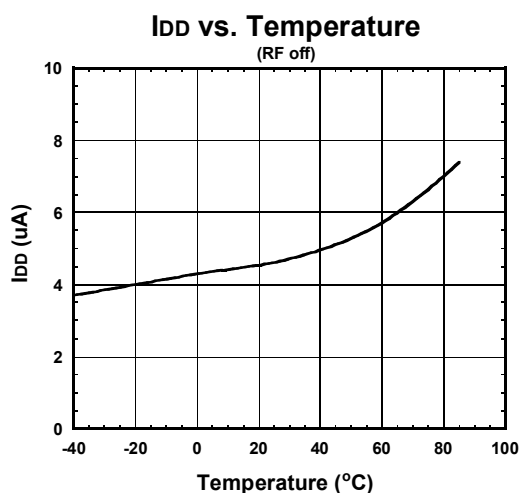
■ ELECTRICAL CHARACTERISTICS (Bypass mode)

Conditions:  $V_{CTL}=0V$ ,  $T_a=25^{\circ}C$ ,  $Z_s=Z_L=50\Omega$ , with application circuit

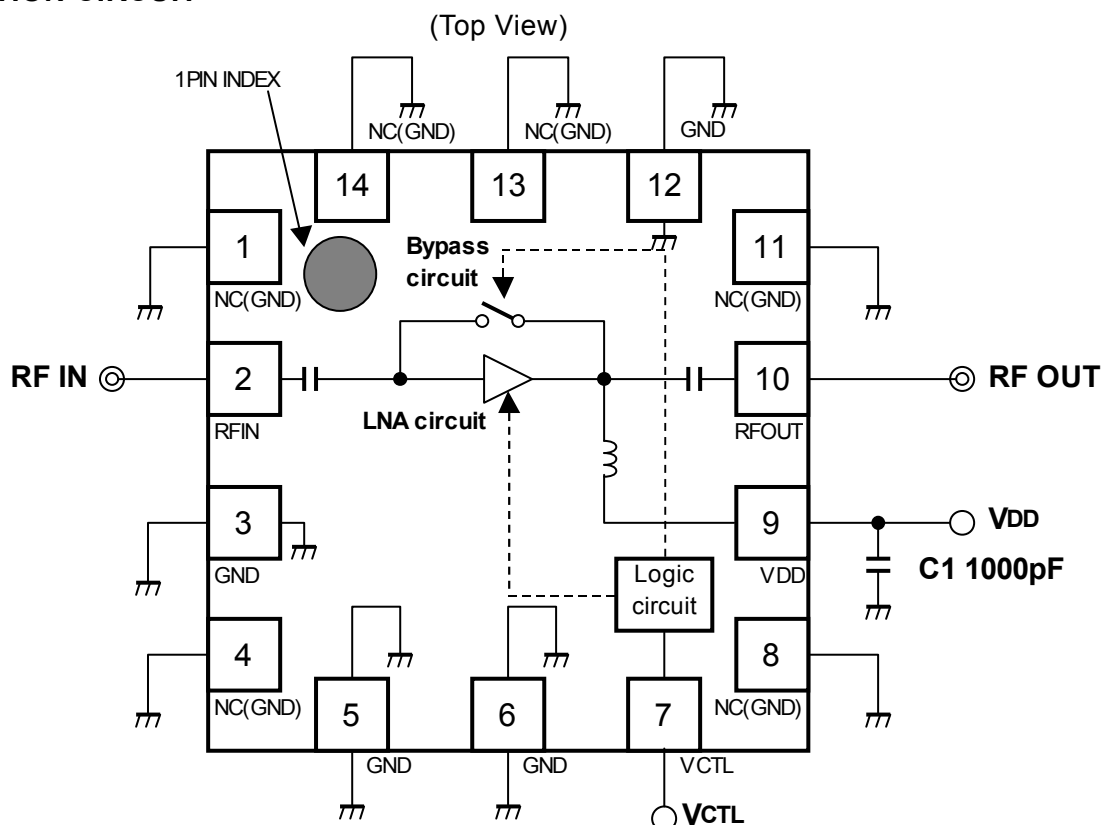


## ■ ELECTRICAL CHARACTERISTICS (Bypass mode)

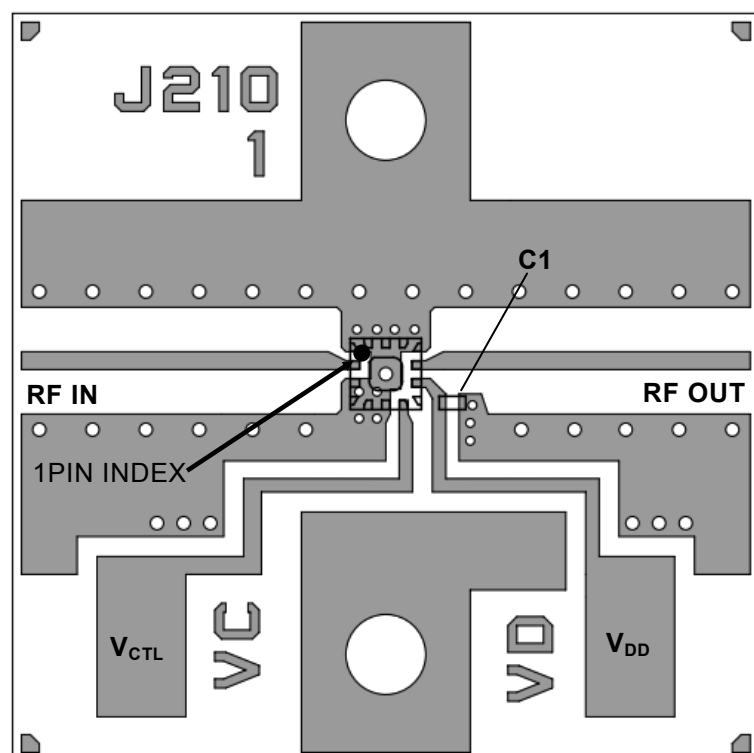
Conditions:  $V_{DD}=3.3V$ ,  $V_{CTL}=1.8V$ ,  $Z_s=Z_L=50\Omega$ , with application circuit



## 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 ( $Z_0=50\Omega$ )

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  |

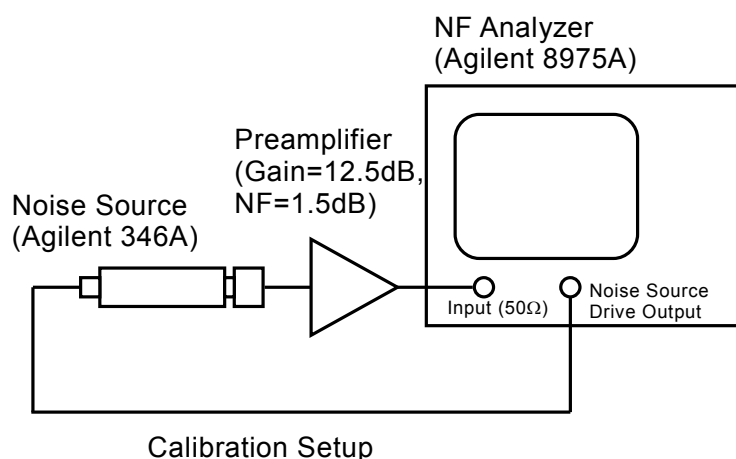
### Setting the NF analyzer

Measurement mode form

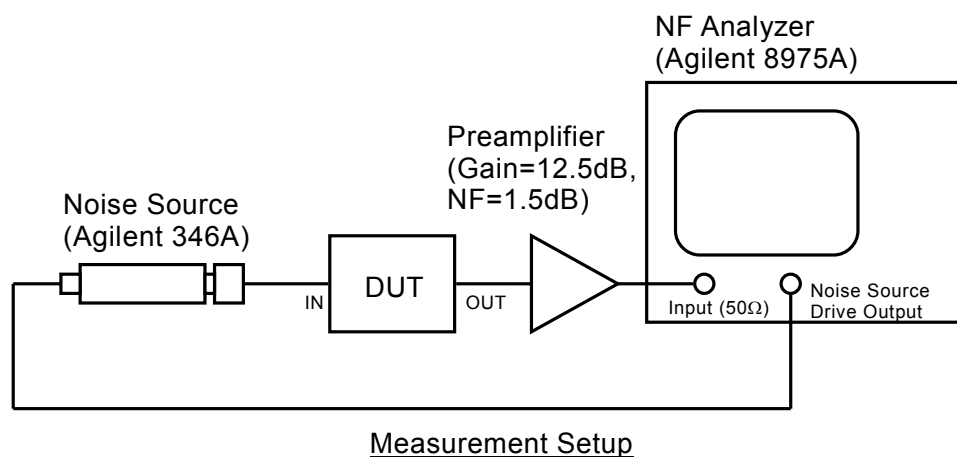
|                      |             |
|----------------------|-------------|
| Device under test    | : Amplifier |
| System downconverter | : off       |

Mode setup form

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

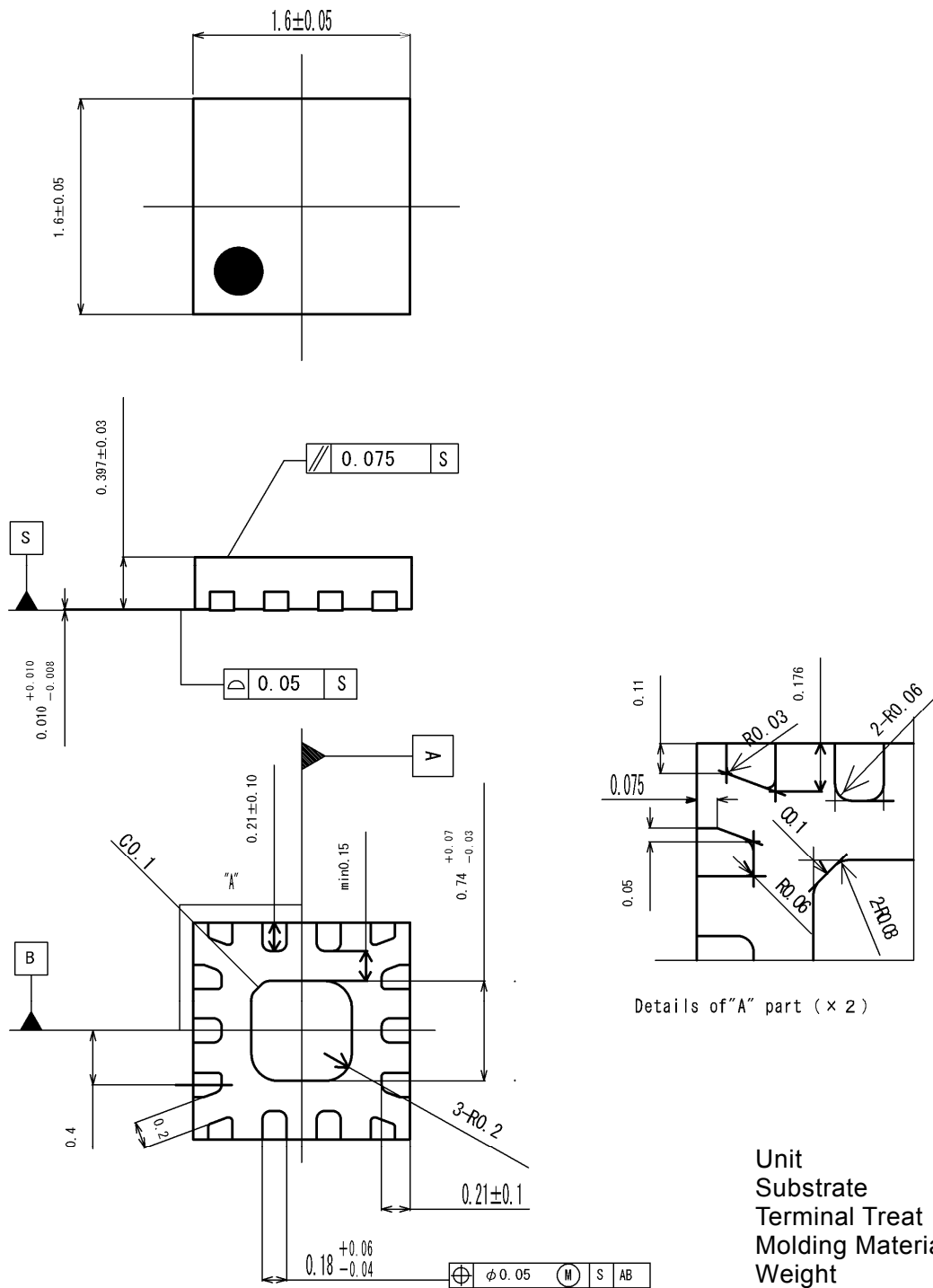


\* Noise source, the preamplifier, and NF analyzer are connected directly.



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

## ■ PACKAGE OUTLINE (ESON14-D7)



|                  |               |
|------------------|---------------|
| 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.

### [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.

# Mouser Electronics

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- Поставка электронных компонентов под контролем ВП;
- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001;
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ВЧ соединители, коаксиальные кабели,  
кабельные сборки и микроволновые компоненты:

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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