

## GNSS LOW NOISE AMPLIFIER

### ■ GENERAL DESCRIPTION

The NJG1150UA2 is a low noise amplifier GaAs MMIC designed for GNSS (Global Navigation Satellite Systems).

The NJG1150UA2 is featured low noise figure and low distortion, and operates from 1.5V to 3.3V single voltage. The NJG1150UA2 has stand-by mode to save the supply current, has the on-chip ESD protection devices.

The NJG1150UA2 achieves very small mounting area by only two external components and very small package that is lead-free and halogen-free 6-pin EPFFP6-A2 package.

### ■ PACKAGE OUTLINE



NJG1150UA2

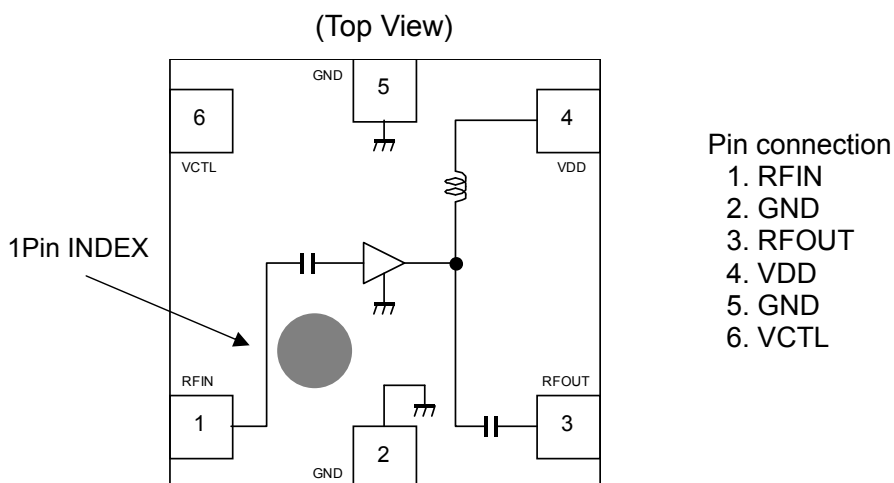
### ■ APPLICATIONS

GNSS applications, like GPS, Galileo, GLONASS and COMPASS.

### ■ FEATURES

- Low supply voltage 1.8/ 2.8V typ.
- Low current consumption 4.2 / 4.9mA typ. @ $V_{DD}=1.8/ 2.8V$ ,  $V_{CTL}=1.8V$   
0.1 $\mu$ A typ. @ $V_{DD}=1.8/ 2.8V$ ,  $V_{CTL}=0V$  (Stand-by mode)
- High gain 16.0dB typ. @ $V_{DD}=1.8/ 2.8V$ ,  $V_{CTL}=1.8V$ ,  $f=1575MHz$
- Low noise figure 0.6dB typ. @ $V_{DD}=1.8/ 2.8V$ ,  $V_{CTL}=1.8V$ ,  $f=1575MHz$
- High input IP3 -1 / +1dBm typ. @ $V_{DD}=1.8/ 2.8V$ ,  $V_{CTL}=1.8V$ ,  $f=1575+1575.1MHz$
- High out of band input IP3 +5 / +6dBm typ. @ $V_{DD}=1.8/ 2.8V$ ,  $V_{CTL}=1.8V$ ,  $f=1712.7+1850MHz$
- Small package EPFFP6-A2 (Package size: 1.0mmx1.0mmx0.37mm typ.)
- RoHS compliant and Halogen Free
- MSL1

### ■ PIN CONFIGURATION



### ■ 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

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

| PARAMETERS            | SYMBOL    | CONDITIONS                                                                     | RATINGS  | UNITS              |
|-----------------------|-----------|--------------------------------------------------------------------------------|----------|--------------------|
| Supply voltage        | $V_{DD}$  |                                                                                | 5.0      | V                  |
| Control voltage       | $V_{CTL}$ |                                                                                | 5.0      | V                  |
| Input power           | $P_{IN}$  | $V_{DD}=2.8\text{V}$                                                           | +15      | dBm                |
| Power dissipation     | $P_D$     | 4-layer FR4 PCB with through-hole (101.5mmx114.5mm), $T_j=150^{\circ}\text{C}$ | 590      | mW                 |
| Operating temperature | $T_{opr}$ |                                                                                | -40~+85  | $^{\circ}\text{C}$ |
| Storage temperature   | $T_{stg}$ |                                                                                | -55~+150 | $^{\circ}\text{C}$ |

## ■ ELECTRICAL CHARACTERISTICS 1 (DC)

General conditions:  $T_a=+25^{\circ}\text{C}$

| PARAMETER              | SYMBOL       | CONDITIONS                                                | MIN | TYP | MAX  | UNITS         |
|------------------------|--------------|-----------------------------------------------------------|-----|-----|------|---------------|
| Supply Voltage         | $V_{DD}$     |                                                           | 1.5 | -   | 3.3  | V             |
| Control Voltage (High) | $V_{CTL(H)}$ |                                                           | 1.5 | 1.8 | 3.3  | V             |
| Control Voltage (Low)  | $V_{CTL(L)}$ |                                                           | 0   | 0   | 0.3  | V             |
| Supply Current1        | $I_{DD1}$    | Active mode, $V_{DD}=2.8\text{V}$ , $V_{CTL}=1.8\text{V}$ | -   | 4.9 | 8.0  | mA            |
| Supply Current2        | $I_{DD2}$    | Active mode, $V_{DD}=1.8\text{V}$ , $V_{CTL}=1.8\text{V}$ | -   | 4.2 | 7.0  | mA            |
| Supply Current3        | $I_{DD3}$    | Stand-by mode, $V_{DD}=2.8\text{V}$ , $V_{CTL}=0\text{V}$ | -   | 0.1 | 3.0  | $\mu\text{A}$ |
| Supply Current4        | $I_{DD4}$    | Stand-by mode, $V_{DD}=1.8\text{V}$ , $V_{CTL}=0\text{V}$ | -   | 0.1 | 3.0  | $\mu\text{A}$ |
| Control Current        | $I_{CTL}$    | $V_{CTL}=1.8\text{V}$                                     | -   | 5.0 | 12.0 | $\mu\text{A}$ |

## ■ ELECTRICAL CHARACTERISTICS 2 (RF)

General conditions:  $V_{DD}=2.8V$ ,  $V_{CTL}=1.8V$ ,  $f_{RF}=1555\sim 1610MHz$ ,  $T_a=+25^{\circ}C$ ,  $Z_s=Z_l=50\Omega$ , with application circuit1

| PARAMETER                                    | SYMBOL           | CONDITIONS                                                                              | MIN   | TYP   | MAX  | UNITS |
|----------------------------------------------|------------------|-----------------------------------------------------------------------------------------|-------|-------|------|-------|
| Small Signal Gain1                           | Gain1            | Exclude PCB and connector Losses (0.17dB)                                               | 14.5  | 16.0  | 17.0 | dB    |
| Noise Figure1                                | NF1              | Exclude PCB and connector Losses (0.08dB)                                               | -     | 0.6   | 0.9  | dB    |
| Input Power at 1dB Gain Compression Point1   | $P_{-1dB}$ (IN)1 |                                                                                         | -12.0 | -7.0  | -    | dBm   |
| Input 3rd Order Intercept Point1             | IIP3_1           | $f_1=f_{RF}$ , $f_2=f_1\pm 1MHz$ ,<br>Pin=-30dBm                                        | -1.0  | +1.0  | -    | dBm   |
| Out of Band Input 3rd Order Intercept Point1 | IIP3_OB1         | $f_1=1712.7MHz$ Pin =-20dBm,<br>$f_2=1850MHz$ Pin =-65dBm                               | +2.0  | +6.0  | -    | dBm   |
| 700MHz Harmonic1                             | 2fo1             | Input jammer tone:<br>787.76MHz at -25dBm<br>Measure the harmonic tone<br>at 1575.52MHz | -     | -45.0 | -    | dBm   |
| RF IN VSWR1                                  | VSWRi1           |                                                                                         | -     | 1.9   | 2.4  | -     |
| RF OUT VSWR1                                 | VSWRo1           |                                                                                         | -     | 1.8   | 2.3  | -     |

## ■ ELECTRICAL CHARACTERISTICS 3 (RF)

General conditions:  $V_{DD}=1.8V$ ,  $V_{CTL}=1.8V$ ,  $f_{RF}=1555\sim 1610MHz$ ,  $T_a=+25^{\circ}C$ ,  $Z_s=Z_l=50\Omega$ , with application circuit2

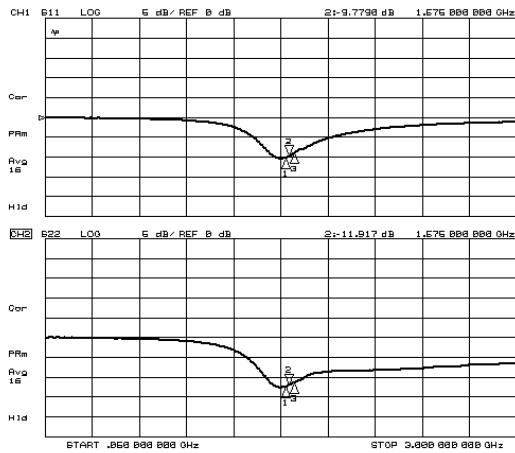
| PARAMETER                                    | SYMBOL           | CONDITIONS                                                                              | MIN   | TYP   | MAX  | UNITS |
|----------------------------------------------|------------------|-----------------------------------------------------------------------------------------|-------|-------|------|-------|
| Small Signal Gain2                           | Gain2            | Exclude PCB and connector Losses (0.17dB)                                               | 14.0  | 16.0  | 17.0 | dB    |
| Noise Figure2                                | NF2              | Exclude PCB and connector Losses (0.08dB)                                               | -     | 0.6   | 0.95 | dB    |
| Input Power at 1dB Gain Compression Point2   | $P_{-1dB}$ (IN)2 |                                                                                         | -14.0 | -9.0  | -    | dBm   |
| Input 3rd Order Intercept Point2             | IIP3_2           | $f_1=f_{RF}$ , $f_2=f_1\pm 1MHz$ ,<br>Pin=-30dBm                                        | -6.0  | -1.0  | -    | dBm   |
| Out of Band Input 3rd Order Intercept Point2 | IIP3_OB2         | $f_1=1712.7MHz$ Pin =-20dBm,<br>$f_2=1850MHz$ Pin =-65dBm                               | -1.0  | +5.0  | -    | dBm   |
| 700MHz Harmonic2                             | 2fo2             | Input jammer tone:<br>787.76MHz at -25dBm<br>Measure the harmonic tone<br>at 1575.52MHz | -     | -45.0 | -    | dBm   |
| RF IN VSWR2                                  | VSWRi2           |                                                                                         | -     | 1.9   | 2.6  | -     |
| RF OUT VSWR2                                 | VSWRo2           |                                                                                         | -     | 1.8   | 2.5  | -     |

## ■ TERMINAL INFORMATION

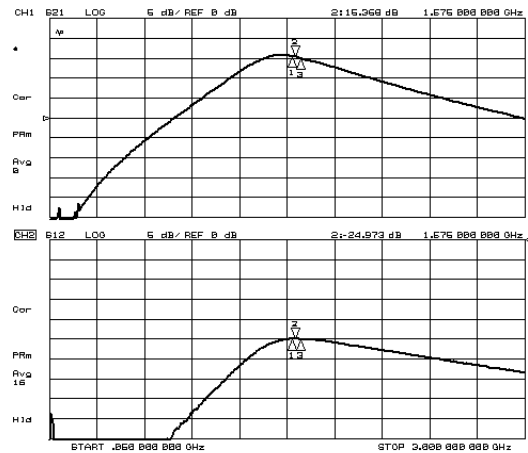
| No. | SYMBOL | DESCRIPTION                                                                                                                                             |
|-----|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | RFIN   | RF input terminal. This terminal requires only a matching inductor L1, and does not require DC blocking capacitor.                                      |
| 2   | GND    | Ground terminal. This terminal should be connected to the ground plane as close as possible for excellent RF performance.                               |
| 3   | RFOUT  | RF output terminal. This terminal requires no DC blocking capacitor since this IC has internal output matching circuit including DC blocking capacitor. |
| 4   | VDD    | Supply voltage terminal. Please connect bypass capacitor C1 with ground as close as possible.                                                           |
| 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.                                                                                                                               |

## ELECTRICAL CHARACTERISTICS

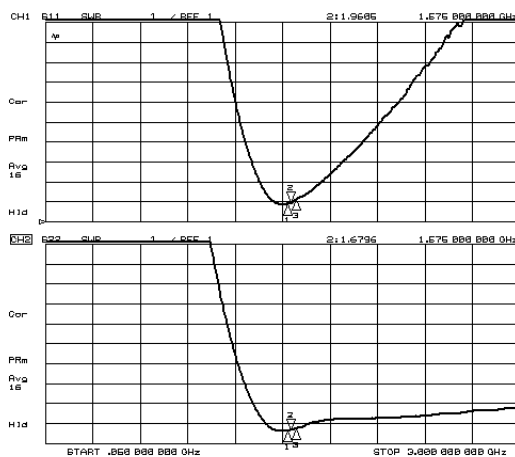
Conditions:  $V_{DD}=2.8V$ ,  $V_{CTL}=1.8V$ ,  $T_a=25^{\circ}C$ ,  $Z_s=Z_l=50\Omega$ , with application circuit1



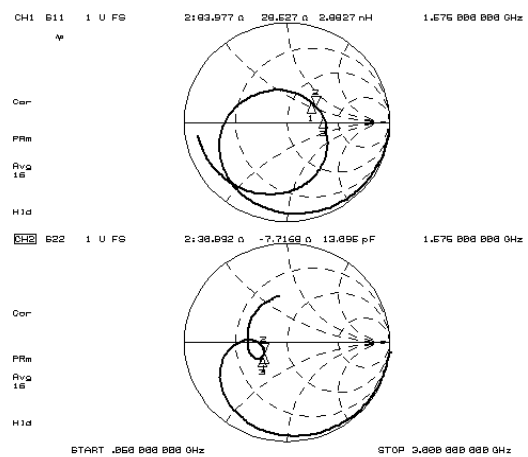
S11, S22



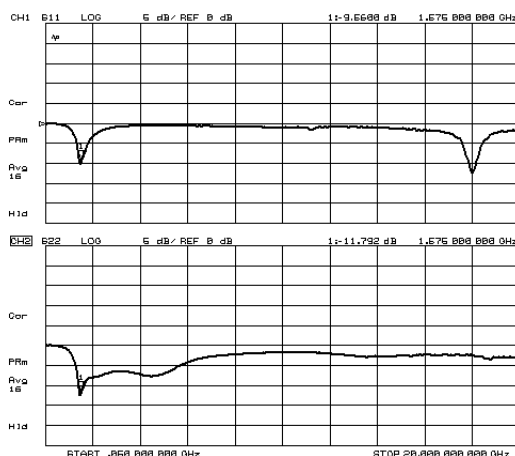
S21, S12



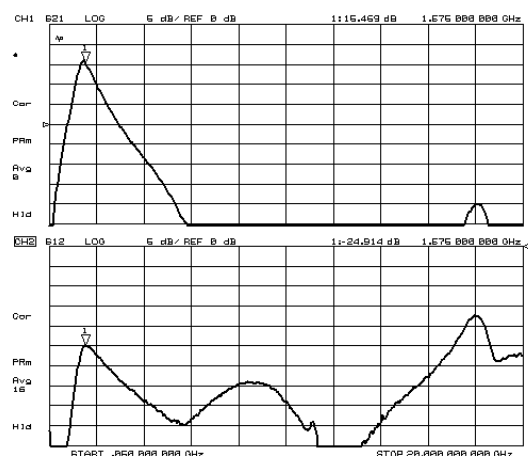
VSWRi, VSWRo



Zin, Zout



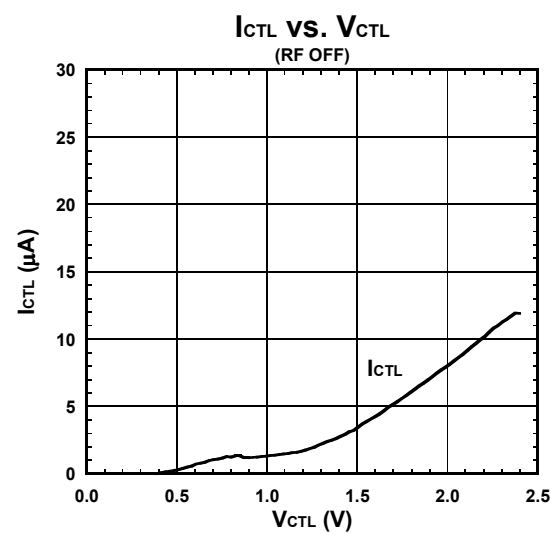
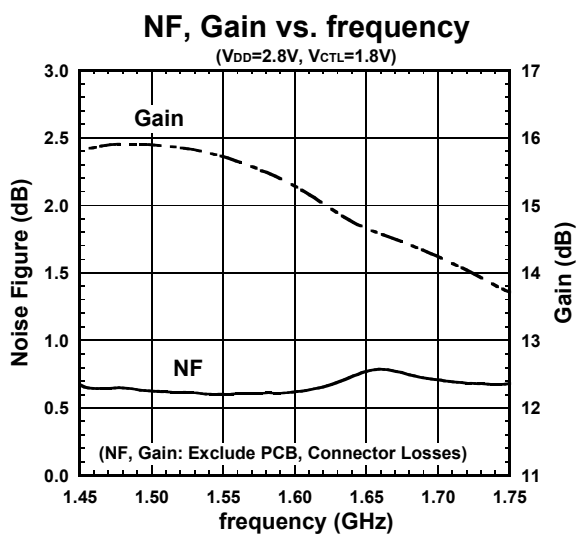
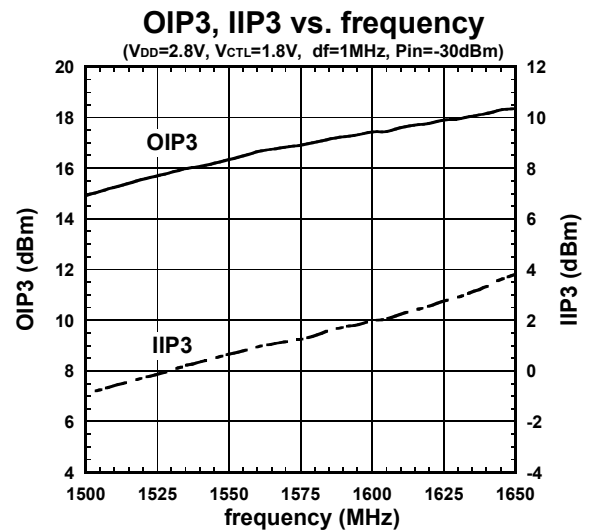
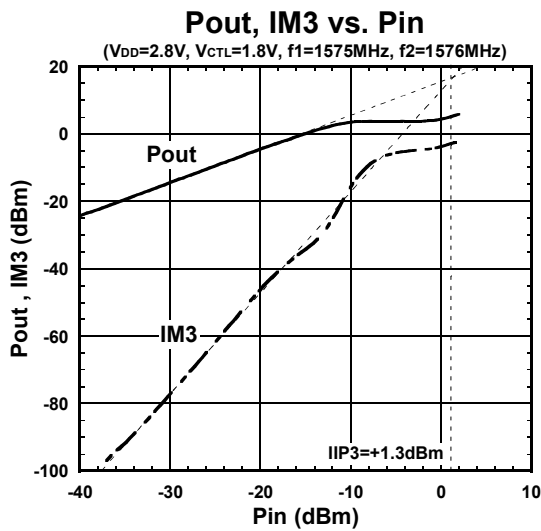
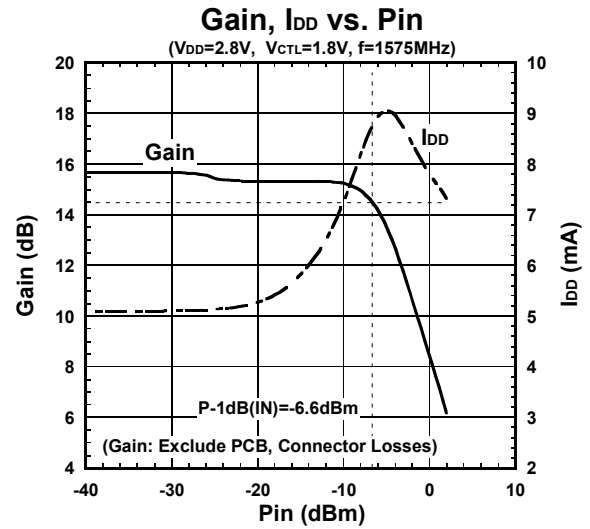
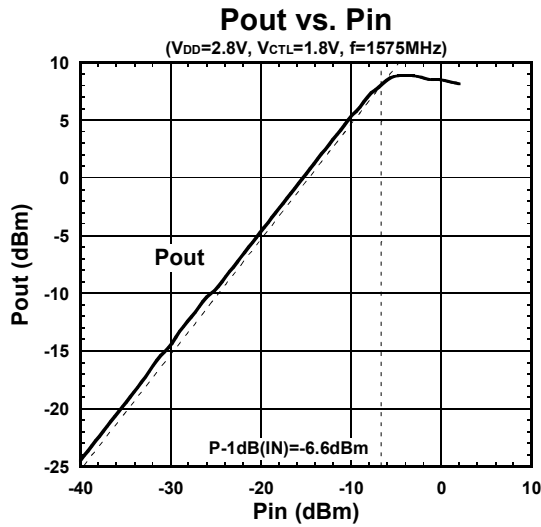
S11, S22 (50M~20GHz)



S21, S12 (50M~20GHz)

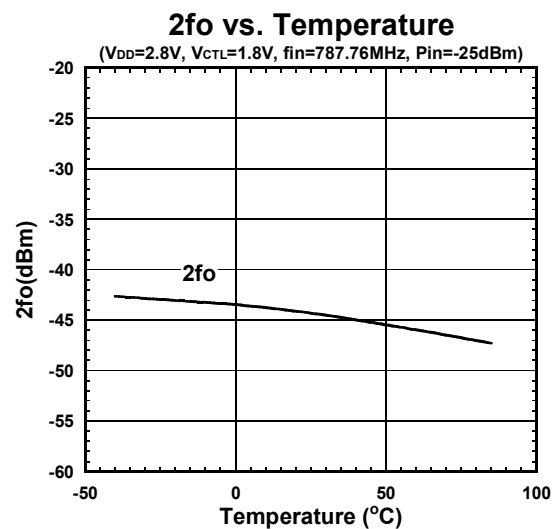
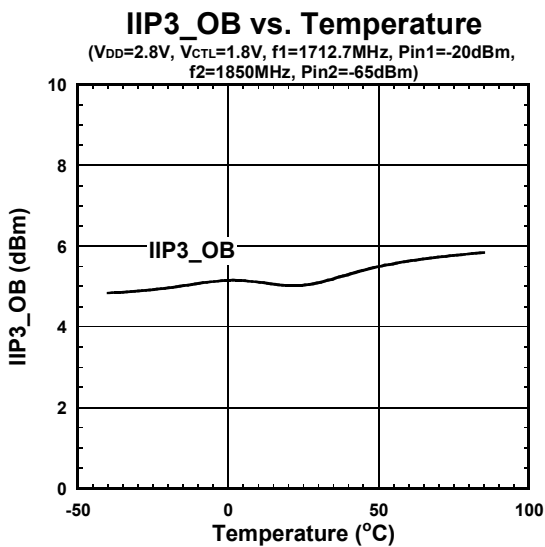
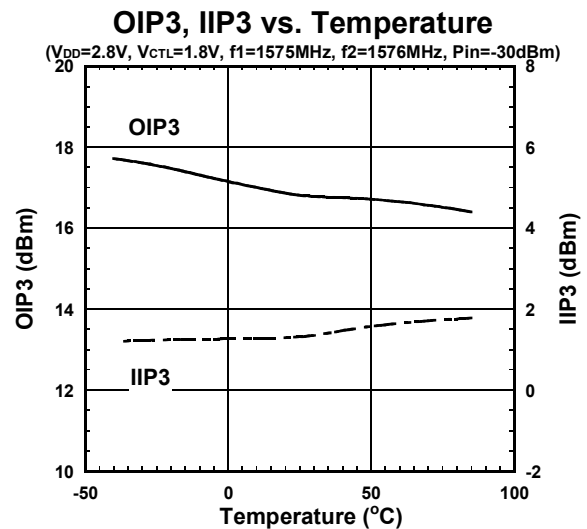
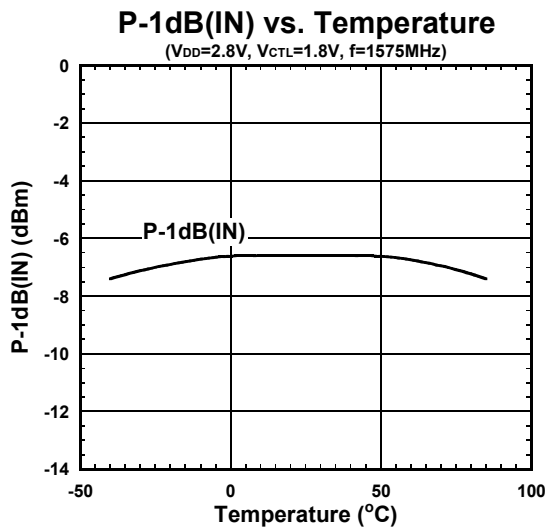
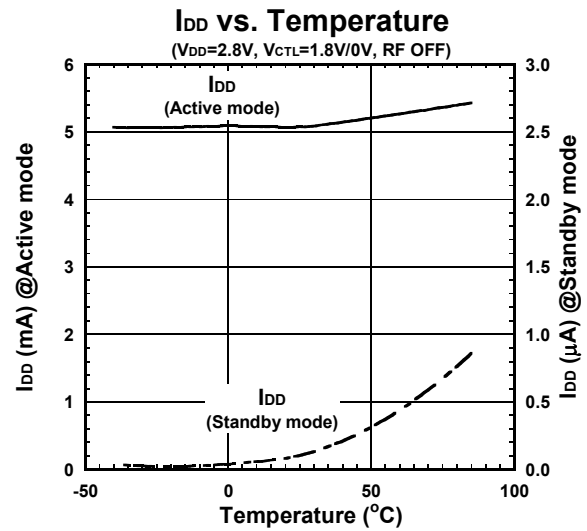
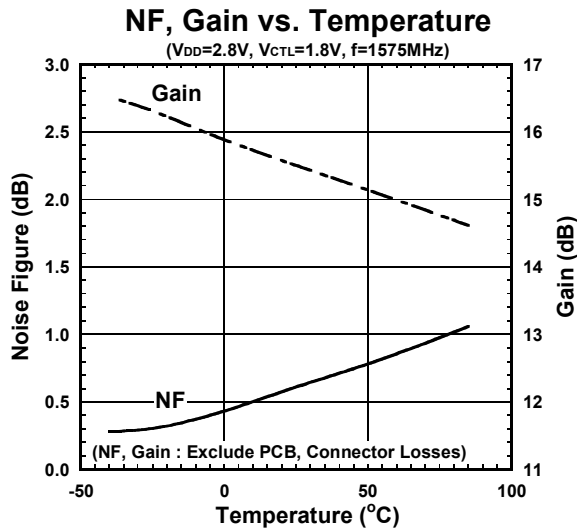
## ELECTRICAL CHARACTERISTICS

Conditions:  $V_{DD}=2.8V$ ,  $V_{CTL}=1.8V$ ,  $T_a=25^{\circ}C$ ,  $Z_s=Z_l=50\Omega$ , with application circuit1



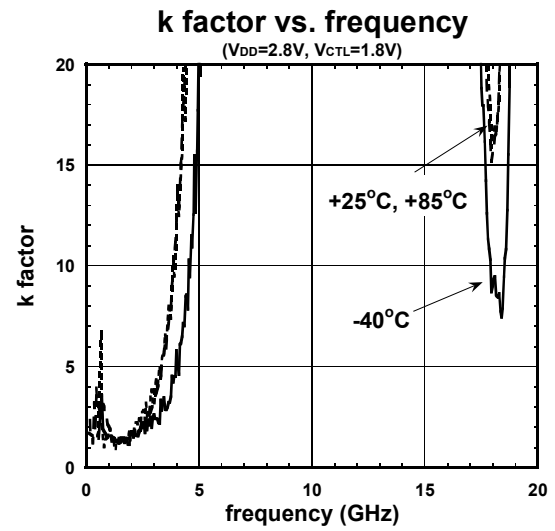
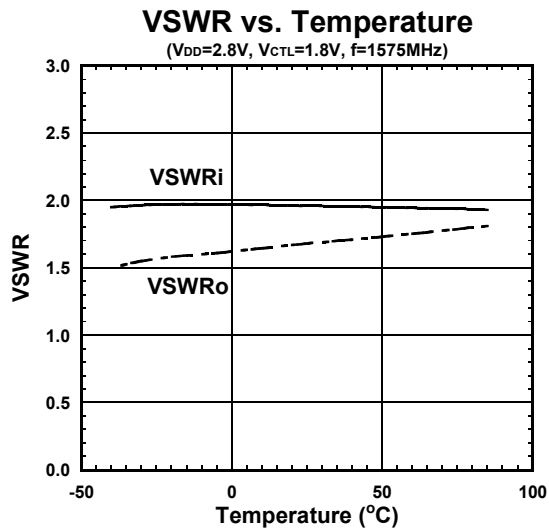
## ELECTRICAL CHARACTERISTICS

Conditions:  $V_{DD}=2.8V$ ,  $V_{CTL}=1.8V$ ,  $Z_s=Z_l=50\Omega$ , with application circuit1



## ■ ELECTRICAL CHARACTERISTICS

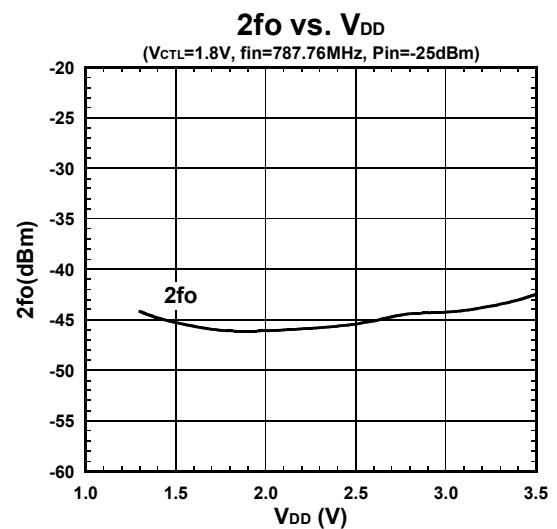
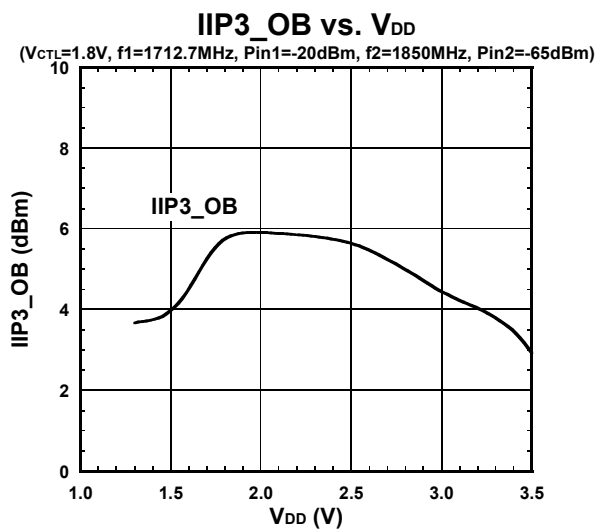
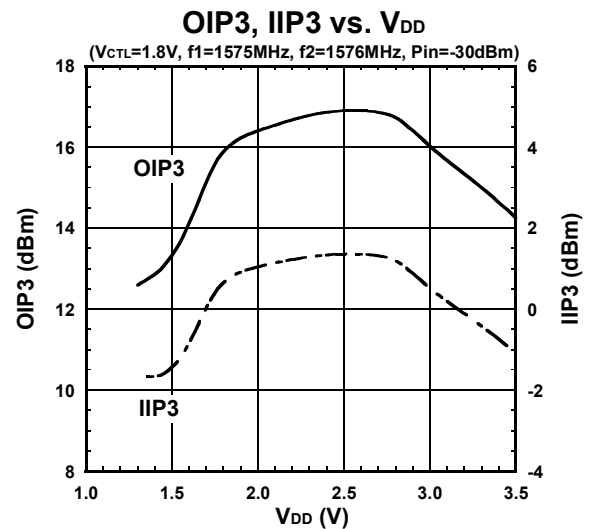
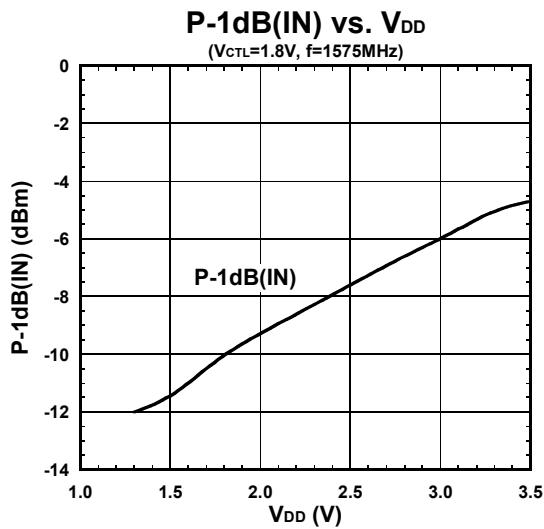
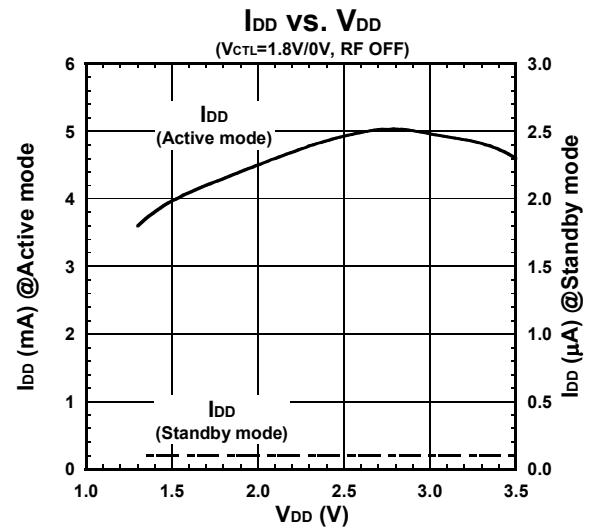
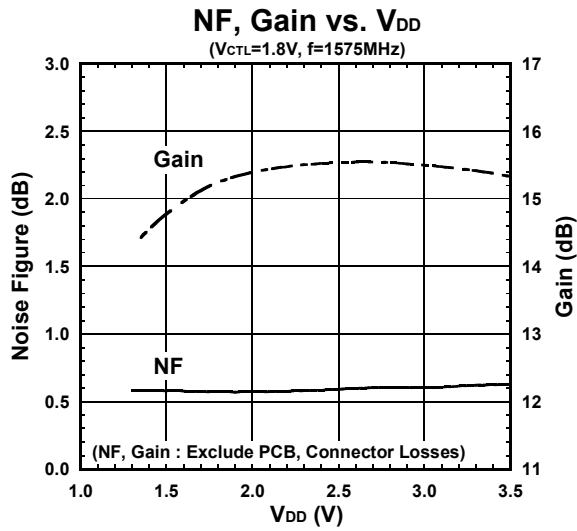
Conditions:  $V_{DD}=2.8V$ ,  $V_{CTL}=1.8V$ ,  $Z_s=Z_l=50\Omega$ , with application circuit1





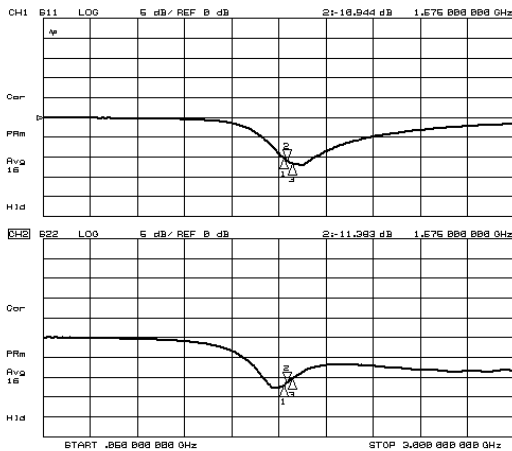
## ELECTRICAL CHARACTERISTICS

Conditions:  $V_{CTL}=1.8V$ ,  $T_a=25^{\circ}C$ ,  $Z_s=Z_l=50\Omega$ , with application circuit1

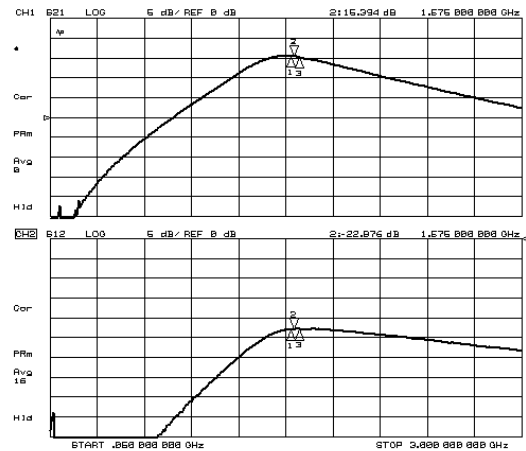


## ELECTRICAL CHARACTERISTICS

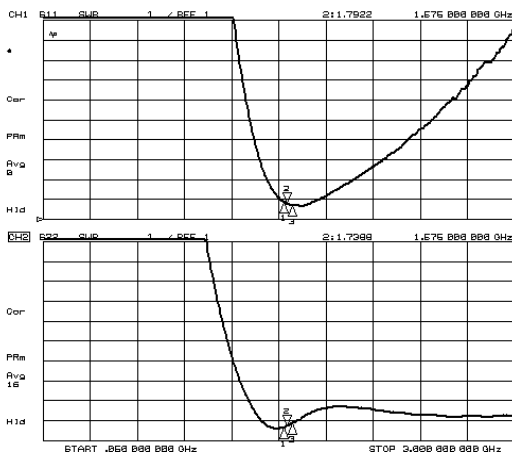
Conditions:  $V_{DD}=1.8V$ ,  $V_{CTL}=1.8V$ ,  $T_a=25^{\circ}C$ ,  $Z_s=Z_l=50\Omega$ , with application circuit2



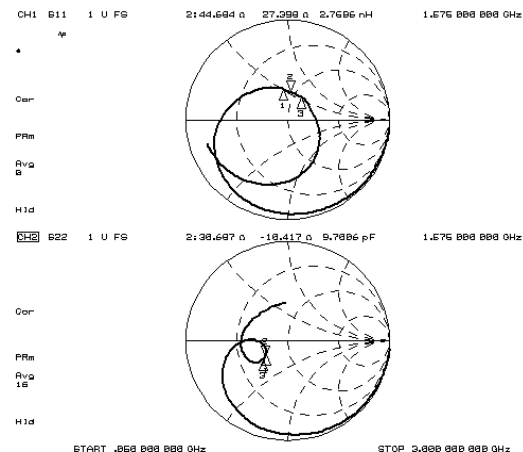
S11, S22



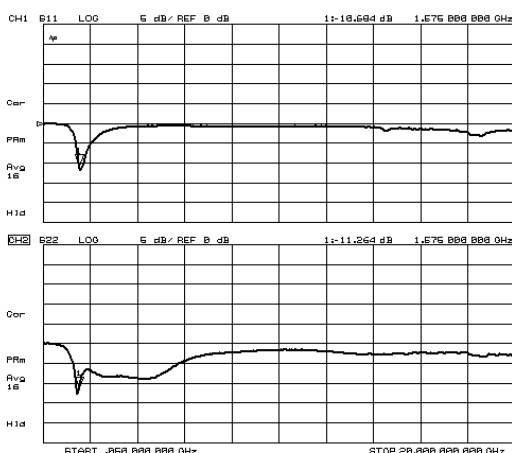
S21, S12



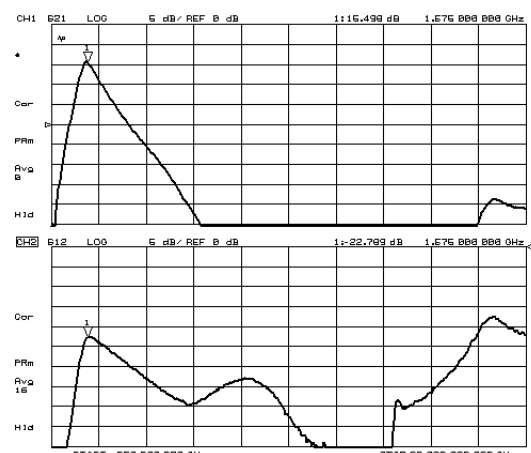
VSWRi, VSWRo



Zin, Zout



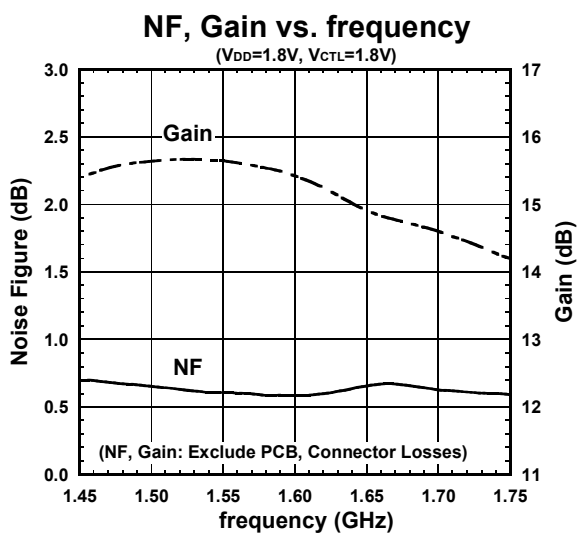
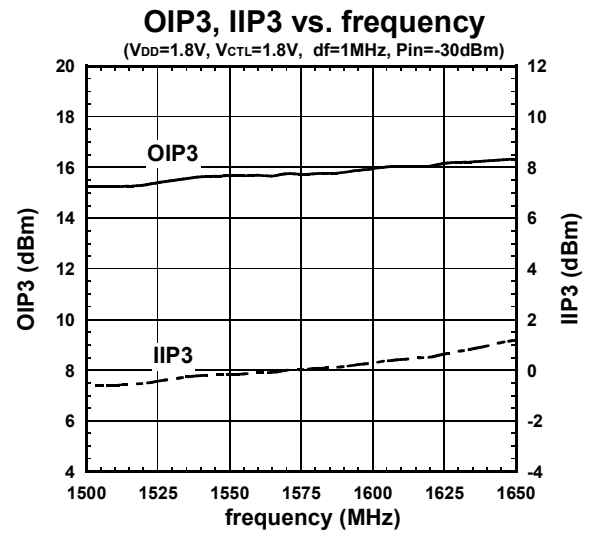
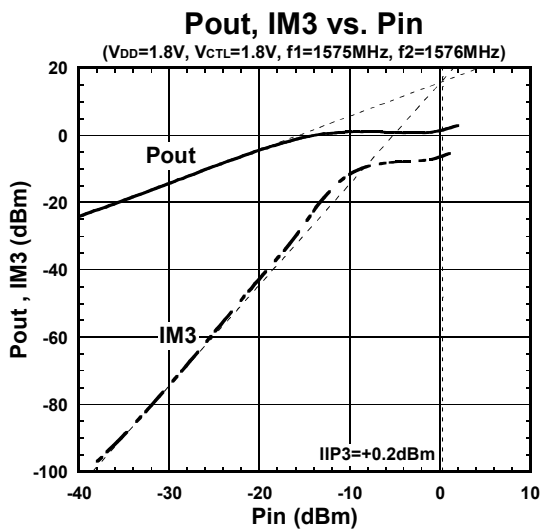
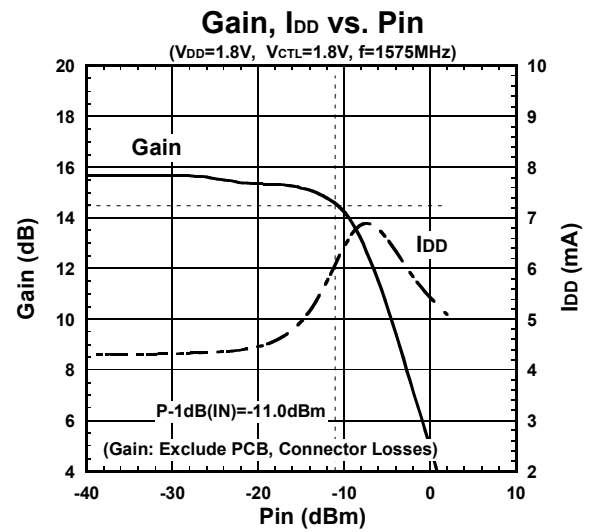
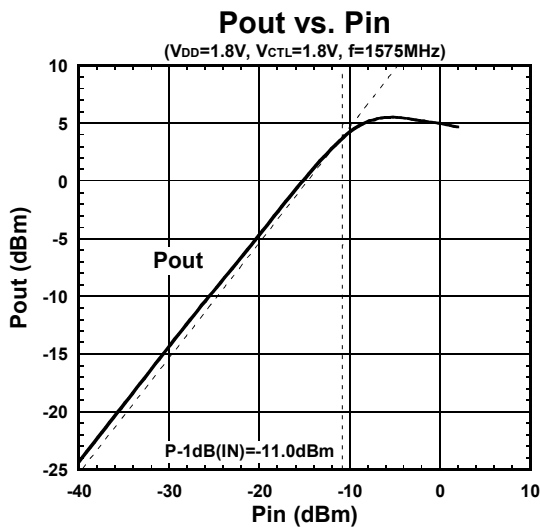
S11, S22 (50M~20GHz)



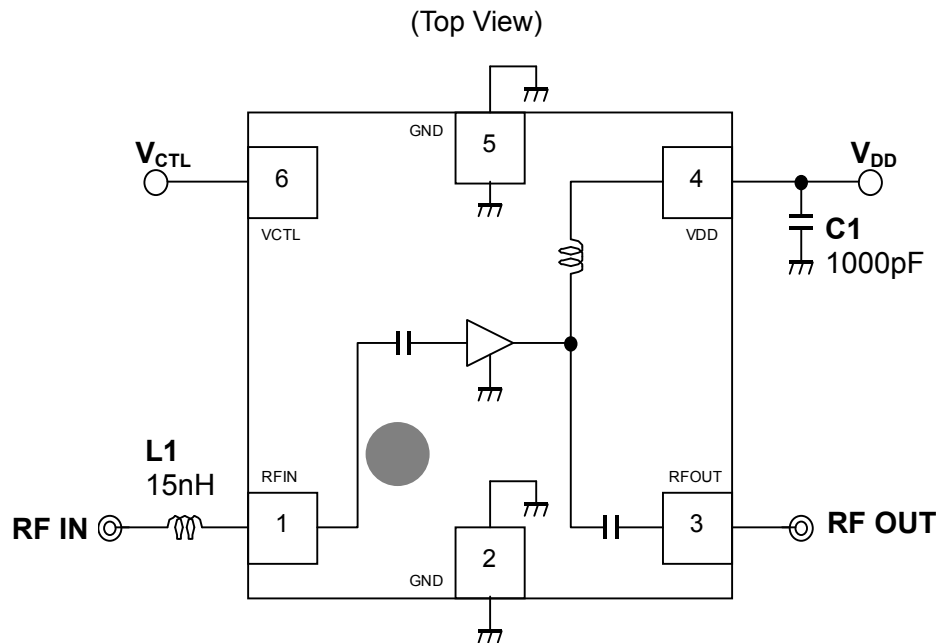
S21, S12 (50M~20GHz)

## ELECTRICAL CHARACTERISTICS

Conditions:  $V_{DD}=1.8V$ ,  $V_{CTL}=1.8V$ ,  $T_a=25^{\circ}C$ ,  $Z_s=Z_L=50\Omega$ , with application circuit2



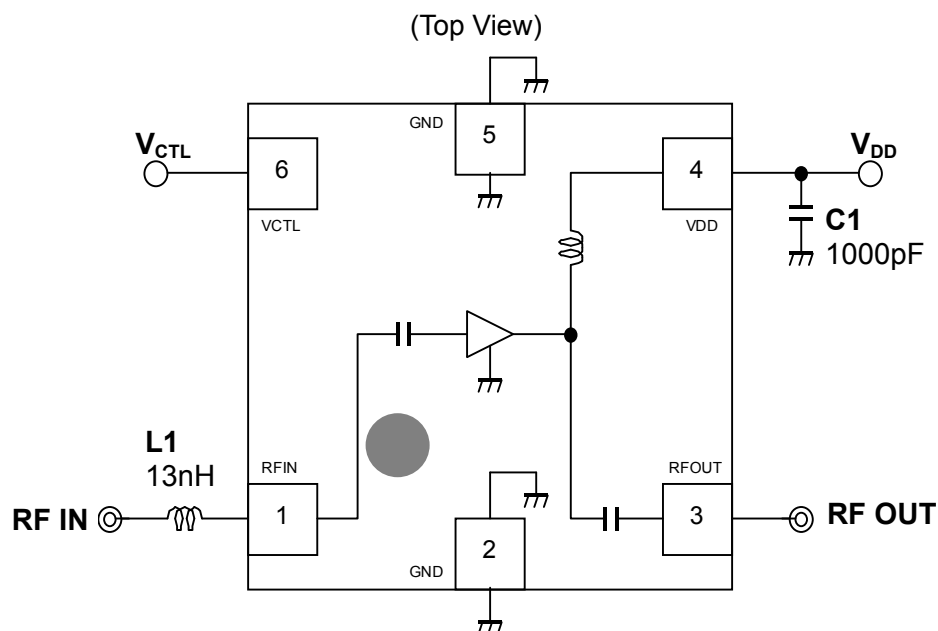
## ■ APPLICATION CIRCUIT1 ( $V_{DD}=2.8V$ )



Parts list

| Parts ID | Manufacture            |
|----------|------------------------|
| L1       | LQW15A Series (MURATA) |
| C1       | GRM03 Series (MURATA)  |

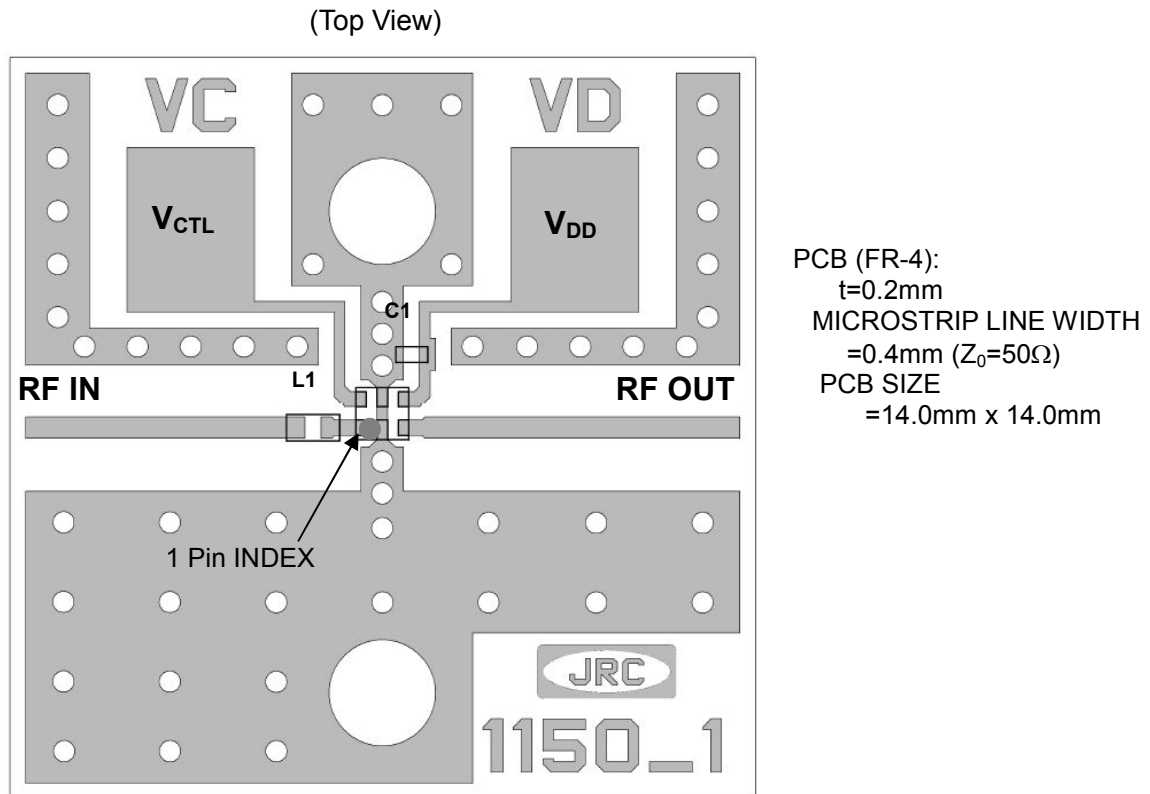
## ■ APPLICATION CIRCUIT2 ( $V_{DD}=1.8V$ )



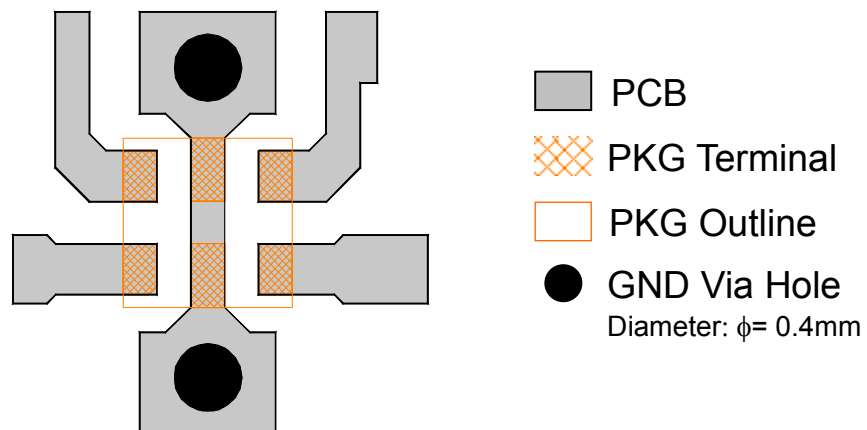
Parts list

| Parts ID | Manufacture            |
|----------|------------------------|
| L1       | LQW15A Series (MURATA) |
| C1       | GRM03 Series (MURATA)  |

## ■ EVALUATION BOARD



## <PCB LAYOUT GUIDELINE>



## PRECAUTIONS

- Please layout ground pattern under this IC in order not to couple with terminal RFIN and RFOUT.
- All external parts should be placed as close as possible to the IC.
- For good RF performance, all GND terminals must be connected to PCB ground plane of substrate, and via-holes for GND should be placed near the IC.

## ■ RECOMMENDED FOOTPRINT PATTERN (EPFFP6-A2 PACKAGE Reference)

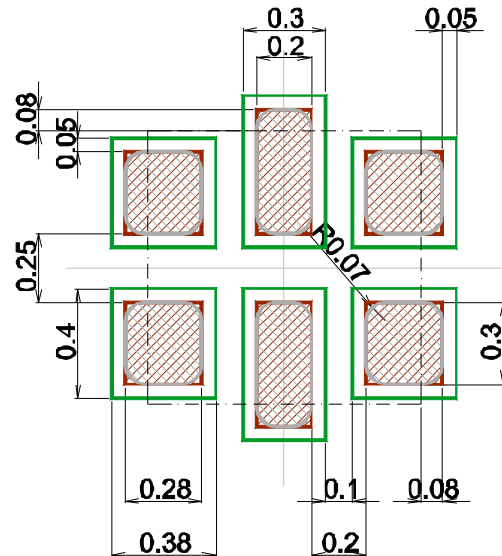
 : Land

 : Mask (Open area) \*Metal mask thickness: 100um

 : Resist (Open area)

Package: 1.0 x 1.0mm

Pin pitch: 0.4mm



## APPLICATION NOTE FOR SMALLER MOUNTING AREA (using MLG0603P Series inductor)

This application note shows an example in order to achieve smaller mounting area using smaller size external inductor L1. MLG0603P (TDK-EPC) Series inductor is used for this application. The example of electrical characteristics are shown as follows:

### ■ ELECTRICAL CHARACTERISTICS 4 (DC)

General conditions:  $T_a=+25^{\circ}\text{C}$

| PARAMETER              | SYMBOL       | CONDITIONS                                                   | MEASURED DATA | UNITS         |
|------------------------|--------------|--------------------------------------------------------------|---------------|---------------|
| Supply Voltage         | $V_{DD}$     |                                                              | 2.8 / 1.8     | V             |
| Control Voltage (High) | $V_{CTL(H)}$ |                                                              | 1.8           | V             |
| Control Voltage (Low)  | $V_{CTL(L)}$ |                                                              | 0             | V             |
| Supply Current1        | $I_{DD1}$    | Active mode,<br>$V_{DD}=2.8\text{V}$ , $V_{CTL}=1.8\text{V}$ | 5.04          | mA            |
| Supply Current2        | $I_{DD2}$    | Active mode,<br>$V_{DD}=1.8\text{V}$ , $V_{CTL}=1.8\text{V}$ | 4.33          | mA            |
| Supply Current3        | $I_{DD3}$    | Stand-by mode,<br>$V_{DD}=2.8\text{V}$ , $V_{CTL}=0\text{V}$ | 0.1           | $\mu\text{A}$ |
| Supply Current4        | $I_{DD4}$    | Stand-by mode,<br>$V_{DD}=1.8\text{V}$ , $V_{CTL}=0\text{V}$ | 0.1           | $\mu\text{A}$ |
| Control Current        | $I_{CTL}$    | $V_{CTL}=1.8\text{V}$                                        | 6.0           | $\mu\text{A}$ |

### ■ ELECTRICAL CHARACTERISTICS 5 (RF)

General conditions:  $V_{DD}=2.8\text{V}$ ,  $V_{CTL}=1.8\text{V}$ ,  $f_{RF}=1555\sim 1610\text{MHz}$ ,  $T_a=+25^{\circ}\text{C}$ ,  $Z_s=Z_l=50\Omega$ , with application circuit3

| PARAMETER                                    | SYMBOL           | CONDITIONS                                                                                             | MEASURED DATA | UNITS |
|----------------------------------------------|------------------|--------------------------------------------------------------------------------------------------------|---------------|-------|
| Small Signal Gain5                           | Gain5            | Exclude PCB and connector Losses                                                                       | 15.3~15.7     | dB    |
| Noise Figure5                                | NF5              | Exclude PCB and connector Losses                                                                       | 0.80~0.84     | dB    |
| Input Power at 1dB Gain Compression Point5   | $P_{-1dB}$ (IN)5 |                                                                                                        | -8.6~-6.6     | dBm   |
| Input 3rd Order Intercept Point5             | IIP3_5           | $f_1=f_{RF}$ , $f_2=f_1\pm 1\text{MHz}$ ,<br>$\text{Pin}=-30\text{dBm}$                                | +0.2~+1.5     | dBm   |
| Out of Band Input 3rd Order Intercept Point5 | IIP3_OB5         | $f_1=1712.7\text{MHz}$ $\text{Pin}=-20\text{dBm}$ ,<br>$f_2=1850\text{MHz}$ $\text{Pin}=-65\text{dBm}$ | +4.3          | dBm   |
| 700MHz Harmonic5                             | 2fo5             | Input jammer tone:<br>787.76MHz at $-25\text{dBm}$<br>Measure the harmonic tone at 1575.52MHz          | -44.8         | dBm   |
| RF IN VSWR5                                  | VSWRi5           |                                                                                                        | 1.54~1.60     | -     |
| RF OUT VSWR5                                 | VSWRo5           |                                                                                                        | 1.54~1.69     | -     |

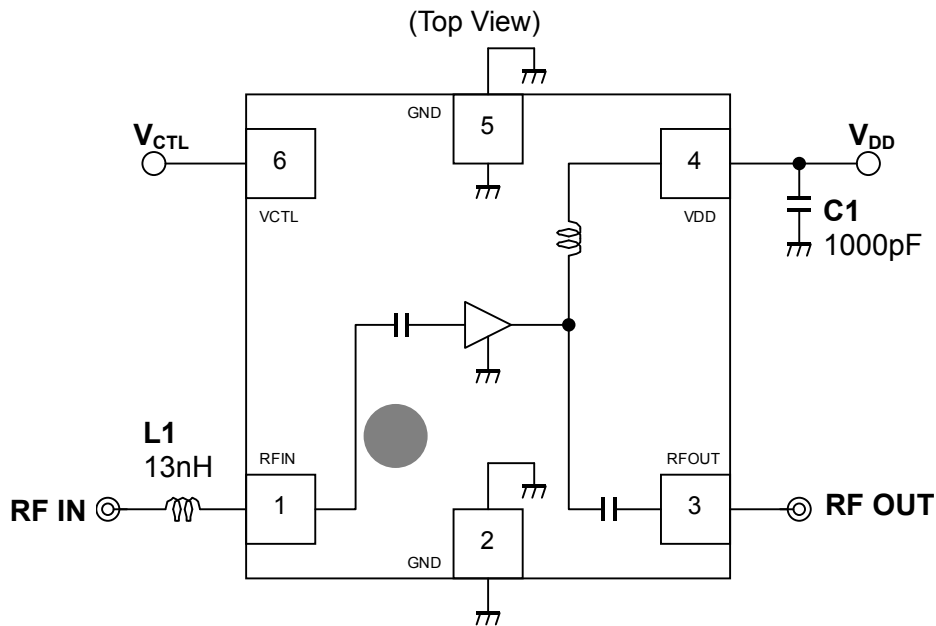
## ■ ELECTRICAL CHARACTERISTICS 6 (RF)

General conditions:  $V_{DD}=1.8V$ ,  $V_{CTL}=1.8V$ ,  $f_{RF}=1555\sim1610MHz$ ,  $T_a=+25^{\circ}C$ ,  $Z_s=Z_l=50\Omega$ , with application circuit3

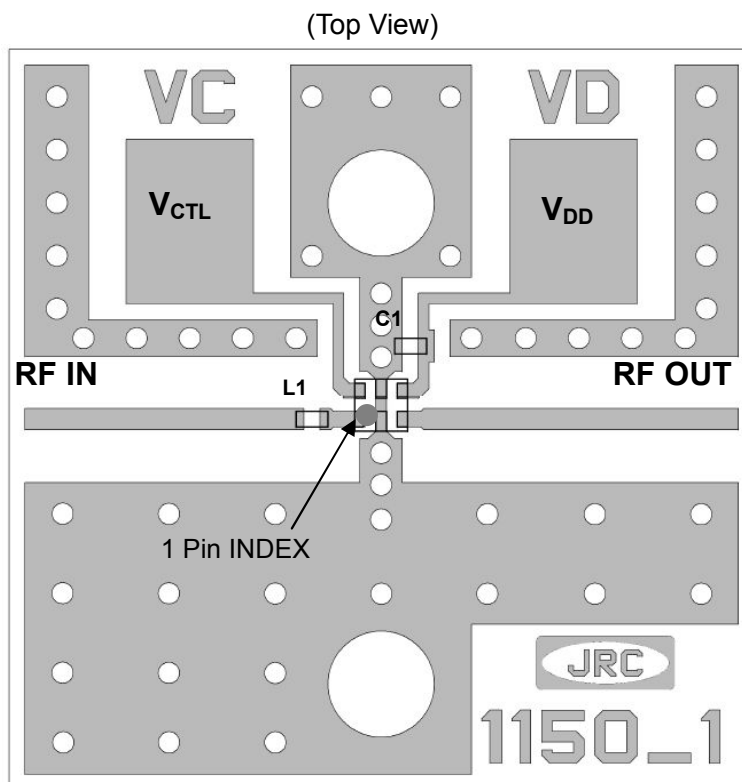
| PARAMETER                                    | SYMBOL           | CONDITIONS                                                                              | MEASURED DATA | UNITS |
|----------------------------------------------|------------------|-----------------------------------------------------------------------------------------|---------------|-------|
| Small Signal Gain6                           | Gain6            | Exclude PCB and connector Losses                                                        | 14.9~15.4     | dB    |
| Noise Figure6                                | NF6              | Exclude PCB and connector Losses                                                        | 0.77~0.83     | dB    |
| Input Power at 1dB Gain Compression Point6   | $P_{-1dB}$ (IN)6 |                                                                                         | -10.5 ~ -10.0 | dBm   |
| Input 3rd Order Intercept Point6             | IIP3_6           | $f_1=f_{RF}$ , $f_2=f_1\pm 1MHz$ ,<br>$P_{in}=-30dBm$                                   | +0.5 ~ +1.2   | dBm   |
| Out of Band Input 3rd Order Intercept Point6 | IIP3_OB6         | $f_1=1712.7MHz$ $P_{in}=-20dBm$ ,<br>$f_2=1850MHz$ $P_{in}=-65dBm$                      | +5.8          | dBm   |
| 700MHz Harmonic6                             | 2fo6             | Input jammer tone:<br>787.76MHz at -25dBm<br>Measure the harmonic tone<br>at 1575.52MHz | -45.5         | dBm   |
| RF IN VSWR6                                  | VSWRi6           |                                                                                         | 1.67~1.78     | -     |
| RF OUT VSWR6                                 | VSWRo6           |                                                                                         | 1.87~2.11     | -     |



## ■ APPLICATION CIRCUIT3 (Using MLG0603P Series inductor)



## ■ EVALUATION BOARD (Using MLG0603P Series)



PCB (FR-4):  
 $t=0.2\text{mm}$   
 MICROSTRIP LINE WIDTH  
 $=0.4\text{mm}$  ( $Z_0=50\Omega$ )  
 PCB SIZE  
 $=14.0\text{mm} \times 14.0\text{mm}$

## ■ NOISE FIGURE MEASUREMENT BLOCK DIAGRAM

### Measuring instruments

NF Analyzer : Agilent N8973A  
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)

