

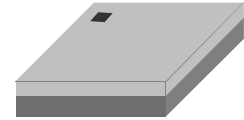
GPS Front-End Module

GENERAL DESCRIPTION

The NJG1168PCD is a front-end module (FEM) designed for GPS applications. Its ultra-low current consumption is particularly suitable for wearable devices. This FEM offers high gain, low noise figure, high linearity and very high out-band rejection characteristics brought by included high performance pre- SAW filter, low noise amplifier (LNA) and post- SAW filter.

This FEM offers very small mounting area by included two SAW filters, only two external components and very small package HFFP10-CD.

PACKAGE OUTLINE



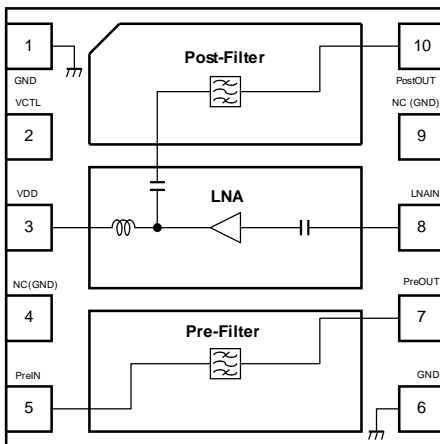
NJG1168PCD

FEATURES

- Low supply voltage 1.8 / 2.8V typ.
- Ultra-low current consumption 1.8 / 2.4mA typ. @ $V_{DD}=1.8 / 2.8V$, $V_{CTL}=1.8V$
0.1 μA typ. @ $V_{DD}=1.8 / 2.8V$, $V_{CTL}=0V$ (Stand-by mode)
- High gain 17.0 / 18.0dB typ. @ $V_{DD}=1.8 / 2.8V$, $V_{CTL}=1.8V$, $f=1575MHz$
- Low noise figure 1.70 / 1.65dB typ. @ $V_{DD}=1.8 / 2.8V$, $V_{CTL}=1.8V$, $f=1575MHz$
- High rejection 83.5dBc typ. @ $f=704$ to $915MHz$, relative to $1575MHz$
70.5dBc typ. @ $f=1710$ to $1980MHz$, relative to $1575MHz$
76.5dBc typ. @ $f=1526$ to $1536MHz$, 1627 to $1680MHz$,
relative to $1575MHz$
- Small package size HFFP10-CD: 2.5mmx2.5mm (typ.), $t=0.63mm$ (max.)
- RoHS compliant and Halogen Free, MSL1

PIN CONFIGURATION

(Top View)

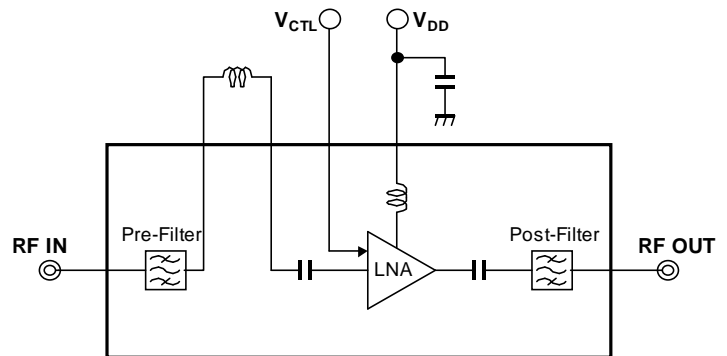


Pin connection

1. GND
2. VCTL
3. VDD
4. NC(GND)
5. PreIN
6. GND
7. PreOUT
8. LNAIN
9. NC(GND)
10. PostOUT

Exposed pad: GND

BLOCK DIAGRAM



TRUTH TABLE

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

| VCTL | 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} (inband) | $V_{DD}=2.8\text{V}$, $f=1575\text{MHz}$ | +15 | dBm |
| | P_{IN} (outband) | $V_{DD}=2.8\text{V}$, $f=50$ to 1460 , 1710 to 4000MHz | +27 | dBm |
| Power dissipation | P_D | 4-layer FR4 PCB with through-hole ($101.5 \times 114.5\text{mm}$), $T_j=100^{\circ}\text{C}$ | 510 | mW |
| Operating temperature | T_{opr} | | -40 to +85 | $^{\circ}\text{C}$ |
| Storage temperature | T_{stg} | | -40 to +100 | $^{\circ}\text{C}$ |

■ 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 Current 1 | I_{DD1} | RF OFF, $V_{DD}=2.8\text{V}$, $V_{CTL}=1.8\text{V}$ | - | 2.4 | 4.2 | mA |
| Supply Current 2 | I_{DD2} | RF OFF, $V_{DD}=1.8\text{V}$, $V_{CTL}=1.8\text{V}$ | - | 1.8 | 2.9 | mA |
| Supply Current 3 | I_{DD3} | RF OFF, $V_{DD}=2.8\text{V}$, $V_{CTL}=0\text{V}$ | - | 0.1 | 5.0 | μA |
| Supply Current 4 | I_{DD4} | RF OFF, $V_{DD}=1.8\text{V}$, $V_{CTL}=0\text{V}$ | - | 0.1 | 5.0 | μA |
| Control Current | I_{CTL} | $V_{CTL}=1.8\text{V}$ | - | 5.0 | 15.0 | μA |

■ ELECTRICAL CHARACTERISTICS 2 (RF)

General conditions: $V_{DD}=2.8V$, $V_{CTL}=1.8V$, $f_{RF}=1575MHz$, $T_a=+25^{\circ}C$, $Z_s=Z_l=50\Omega$, with application circuit

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|-----------------|---|------|-------|------|-------|
| Small Signal Gain1 | Gain1 | f=1575MHz, Exclude PCB, Connector Losses (0.19dB) | 14.5 | 18.0 | - | dB |
| Noise Figure1 | NF1 | f=1575MHz, Exclude PCB, Connector Losses (0.09dB) | - | 1.65 | 2.45 | dB |
| Input Power at 1dB Gain Compression Point 1 | P-1dB(IN)1 | f=1575MHz | - | -12.0 | - | dBm |
| Input 3rd Order Intercept Point 1 | IIP3_1 | f1=1575MHz, f2=f1+/-1MHz, Pin=-30dBm | - | +1.0 | - | dBm |
| Out of Band Input 2nd Order Intercept Point 1 | IIP2_OB1 | f1=824.6MHz at +15dBm, f2=2400MHz at +15dBm, fmeas=1575.4MHz | - | +85 | - | dBm |
| Out of Band Input 3rd Order Intercept Point 1 | IIP3_OB1 | f1=1712.7MHz at +15dBm, f2=1850MHz at +15dBm, fmeas=1575.4MHz | - | +55 | - | dBm |
| 700MHz 2nd Harmonics1 | 2fo1 | Input jammer tone: 787.76MHz at +15dBm Measure the harmonic tone at 1575.52MHz | - | -40 | - | dBm |
| Out-of-Band Input Power 1dB Compression 1 | P-1dB(IN)_OB1-1 | fjam=900MHz, fmeas=1575MHz at Pin=-40dBm | - | +24 | - | dBm |
| | P-1dB(IN)_OB1-2 | fjam=1710MHz, fmeas=1575MHz at Pin=-40dBm | - | +23 | - | dBm |
| Low Band Rejection 1 | BR_L1 | f=704 to 915MHz, relative to 1575MHz | - | 83.5 | - | dBc |
| High Band Rejection 1 | BR_H1 | f=1710 to 1980MHz, relative to 1575MHz | - | 73.5 | - | dBc |
| WLAN Band Rejection 1 | BR_W1 | f=2400 to 2500MHz, relative to 1575MHz | - | 70.5 | - | dBc |
| LS Rejection1 | BR_LS1 | f=1526 to 1536MHz, 1627 to 1680MHz, relative to 1575MHz | - | 76.5 | - | dBc |
| RF IN Return Loss1 | RLi1 | f=1575MHz | - | 5.5 | - | dB |
| RF OUT Return Loss1 | RLo1 | f=1575MHz | - | 20 | - | dB |

■ ELECTRICAL CHARACTERISTICS 3 (RF)

General conditions: $V_{DD}=1.8V$, $V_{CTL}=1.8V$, $f_{RF}=1575MHz$, $T_a=+25^{\circ}C$, $Z_s=Z_l=50\Omega$, with application circuit

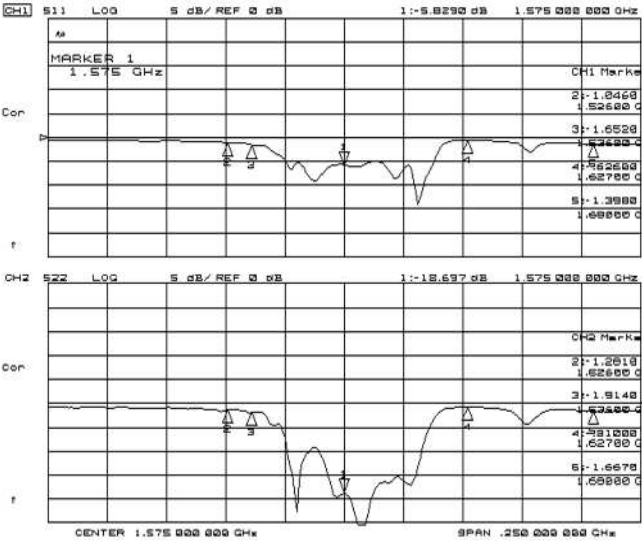
| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|--|------------------------|---|------|-------|------|-------|
| Small Signal Gain ² | Gain ² | f=1575MHz, Exclude PCB, Connector Losses (0.19dB) | 13.0 | 17.0 | - | dB |
| Noise Figure ² | NF ² | f=1575MHz, Exclude PCB, Connector Losses (0.09dB) | - | 1.70 | 2.50 | dB |
| Input Power at 1dB Gain Compression Point ² | P-1dB(IN) ² | f=1575MHz | - | -15.0 | - | dBm |
| Input 3rd Order Intercept Point ² | IIP3_2 | f1=1575MHz, f2=f1+/-1MHz, Pin=-30dBm | - | -4.0 | - | dBm |
| Out of Band Input 2nd Order Intercept Point ² | IIP2_OB2 | f1=824.6MHz at +15dBm, f2=2400MHz at +15dBm, fmeas=1575.4MHz | - | +85 | - | dBm |
| Out of Band Input 3rd Order Intercept Point ² | IIP3_OB2 | f1=1712.7MHz at +15dBm, f2=1850MHz at +15dBm, fmeas=1575.4MHz | - | +50 | - | dBm |
| 700MHz 2nd Harmonics ² | 2fo ² | Input jammer tone: 787.76MHz at +15dBm Measure the harmonic tone at 1575.52MHz | - | -40 | - | dBm |
| Out-of-Band Input Power 1dB Compression ² | P-1dB(IN)_OB2-1 | fjam=900MHz, fmeas=1575MHz at Pin=-40dBm | - | +24 | - | dBm |
| | P-1dB(IN)_OB2-2 | fjam=1710MHz, fmeas=1575MHz at Pin=-40dBm | - | +20 | - | dBm |
| Low Band Rejection ² | BR_L2 | f=704 to 915MHz, relative to 1575MHz | - | 83.5 | - | dBc |
| High Band Rejection ² | BR_H2 | f=1710 to 1980MHz, relative to 1575MHz | - | 73.5 | - | dBc |
| WLAN Band Rejection ² | BR_W2 | f=2400 to 2500MHz, relative to 1575MHz | - | 70.5 | - | dBc |
| LS Rejection ² | BR_LS2 | f=1526 to 1536MHz, 1627 to 1680MHz, relative to 1575MHz | - | 76.5 | - | dBc |
| RF IN Return Loss ² | RLi ² | f=1575MHz | - | 5.5 | - | dB |
| RF OUT Return Loss ² | RLo ² | f=1575MHz | - | 20 | - | dB |

■ TERMINAL INFORMATION

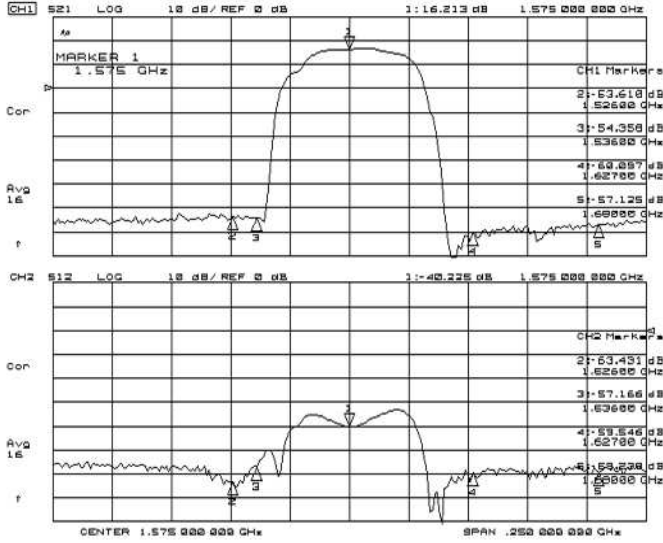
| No. | SYMBOL | DESCRIPTION |
|-------------|---------|--|
| 1 | GND | Ground terminal. This terminal should be connected to the ground plane as close as possible for excellent RF performance. |
| 2 | VCTL | Control voltage terminal. |
| 3 | VDD | Supply voltage terminal. Please connect bypass capacitor C1 with ground as close as possible. |
| 4 | NC(GND) | No connected terminal. This terminal is not connected with internal circuit. Please connect to the PCB ground Plane. |
| 5 | PreIN | RF input terminal. This terminal connects to input of pre-SAW filter. |
| 6 | GND | Ground terminal. This terminal should be connected to the ground plane as close as possible for excellent RF performance. |
| 7 | PreOUT | Pre-SAW filter output terminal. This terminal connects to LNAIN with L1. |
| 8 | LNAIN | RF input terminal. This terminal requires only a matching inductor L1, and does not require DC blocking capacitor because of integrated capacitor. |
| 9 | NC(GND) | No connected terminal. This terminal is not connected with internal circuit. Please connect to the PCB ground Plane. |
| 10 | PostOUT | RF output terminal. This terminal requires no DC blocking capacitor since this terminal has integrated SAW that also works as DC blocking capacitor in nature. |
| Exposed Pad | GND | Ground terminal. This terminal should be connected to the ground plane as close as possible for excellent RF performance. |

ELECTRICAL CHARACTERISTICS

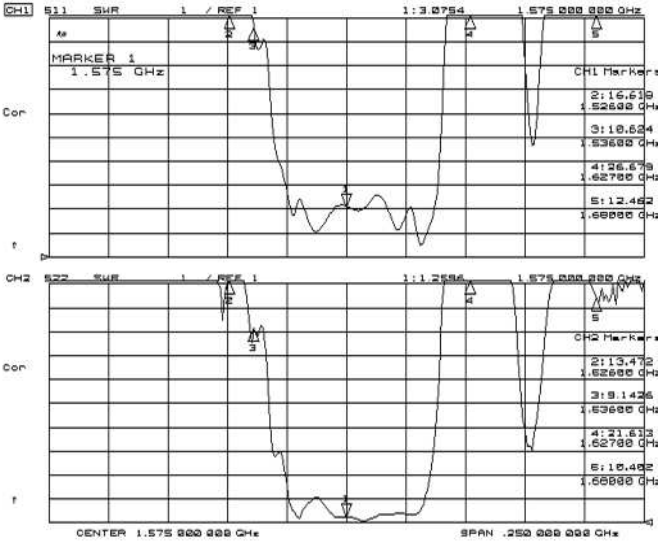
Conditions: $V_{DD}=2.8V$, $V_{CTL}=1.8V$, $T_a=25^{\circ}C$, $Z_s=Z_l=50\Omega$, with application circuit



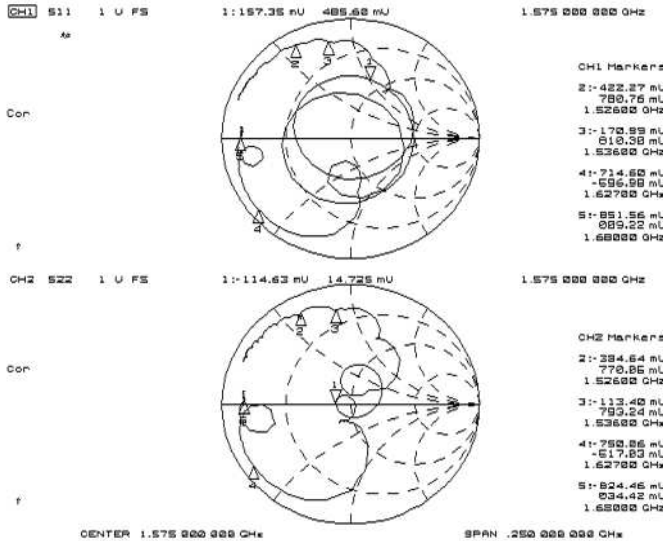
S11, S22



S21, S12



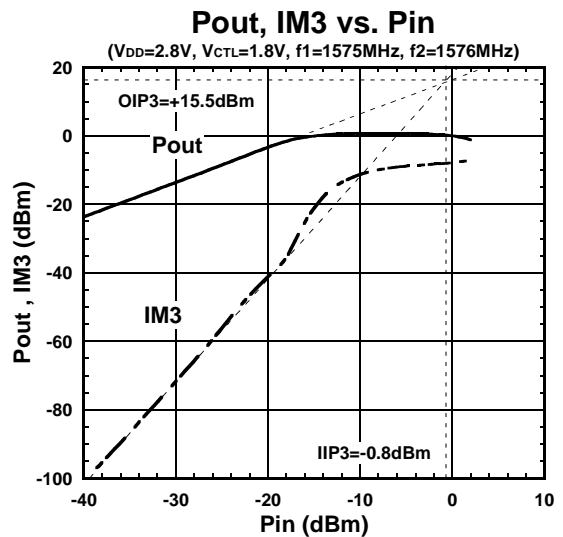
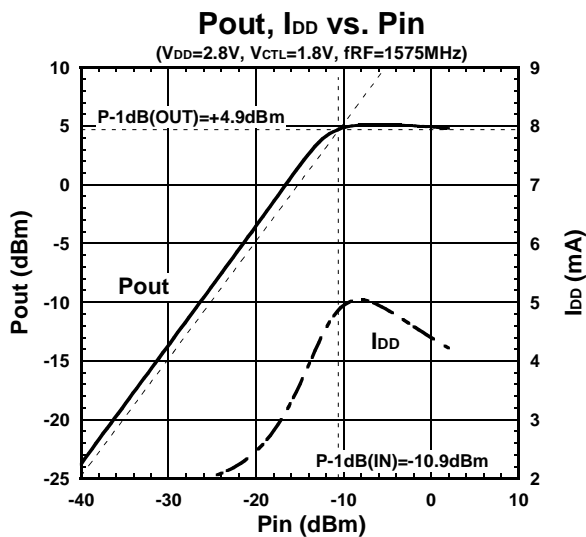
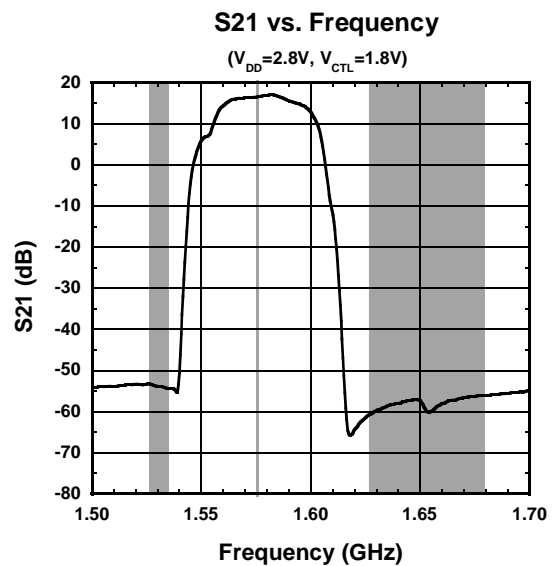
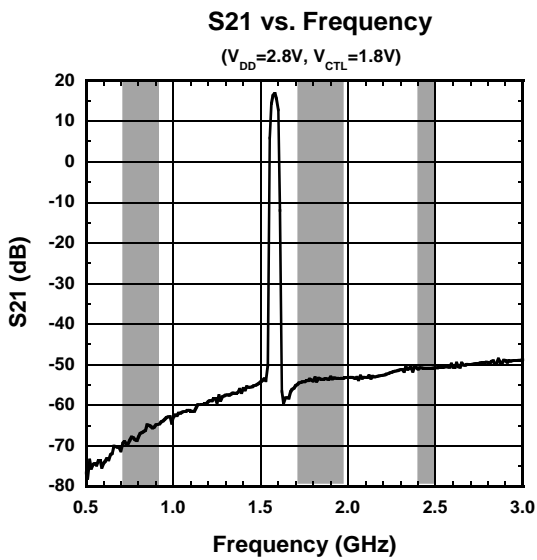
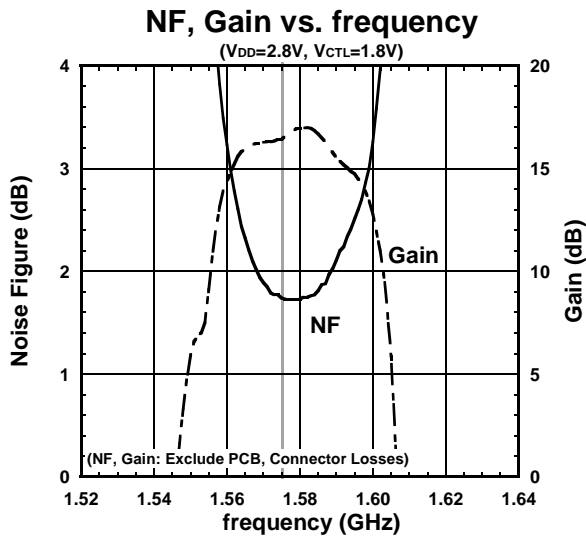
VSWR



Zin, Zout

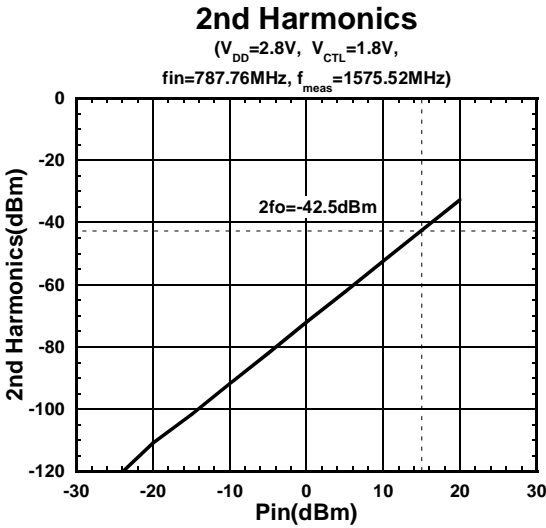
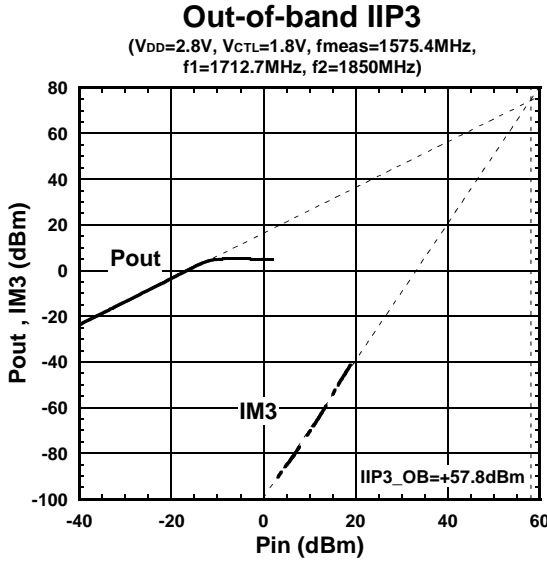
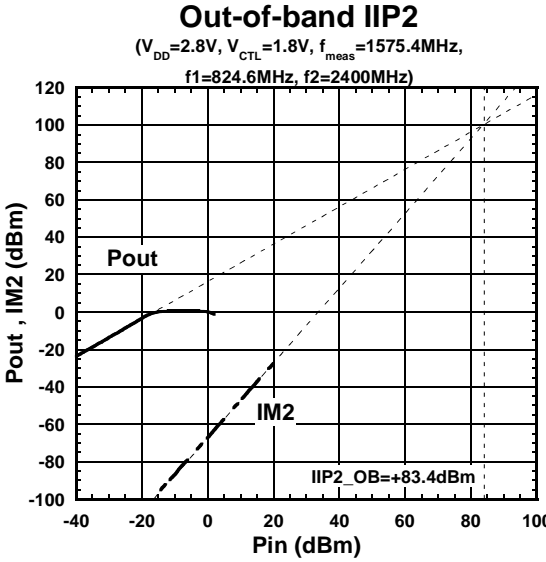
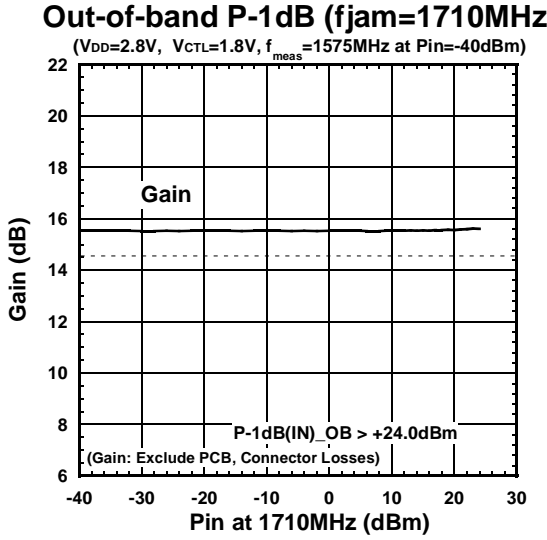
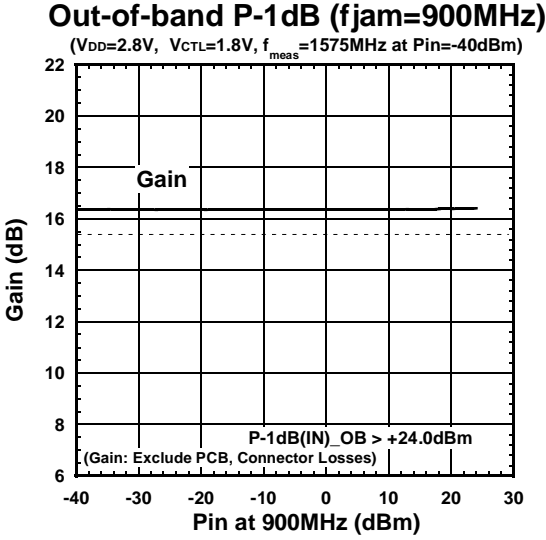
ELECTRICAL CHARACTERISTICS

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



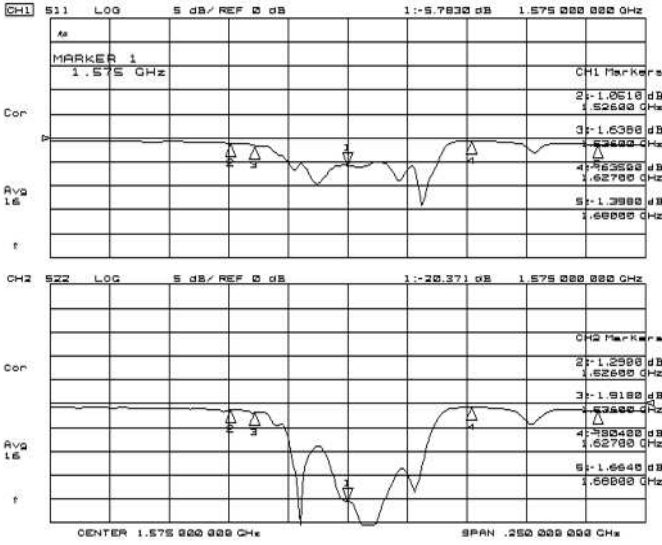
ELECTRICAL CHARACTERISTICS

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

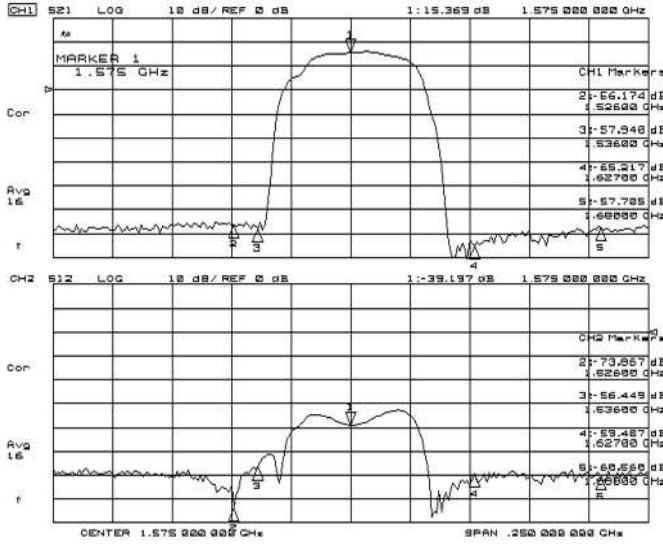


■ ELECTRICAL CHARACTERISTICS

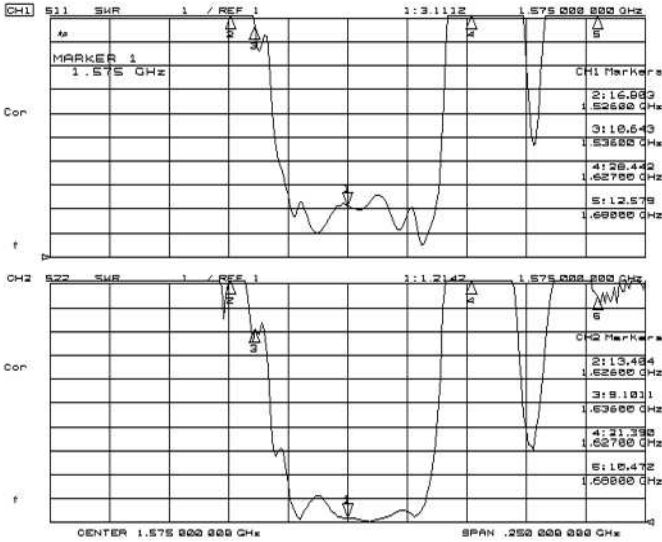
Conditions: $V_{DD}=1.8V$, $V_{CTL}=1.8V$, $T_a=25^\circ C$, $Z_s=Z_l=50\Omega$, with application circuit



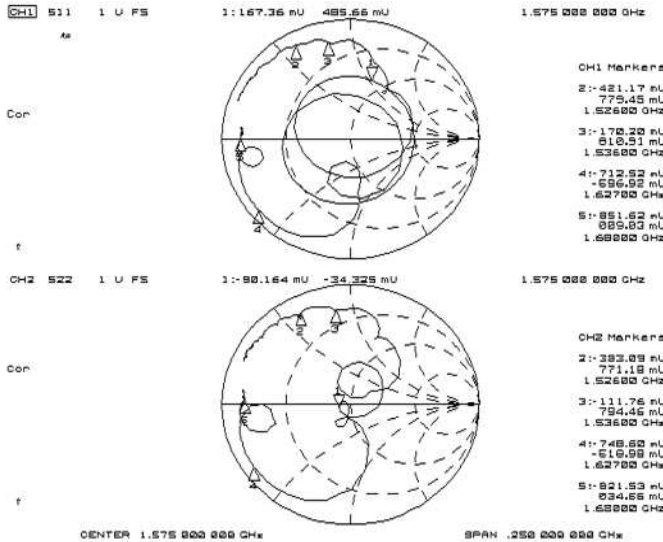
S11, S22



S21, S12



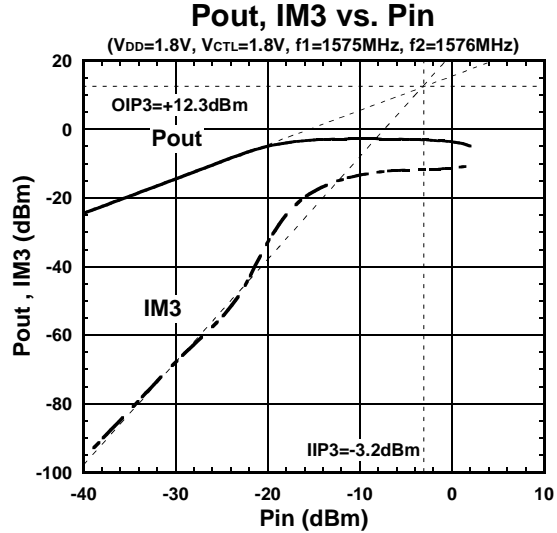
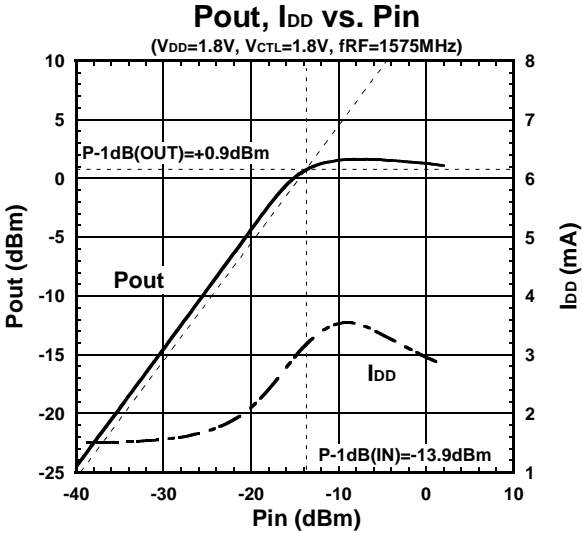
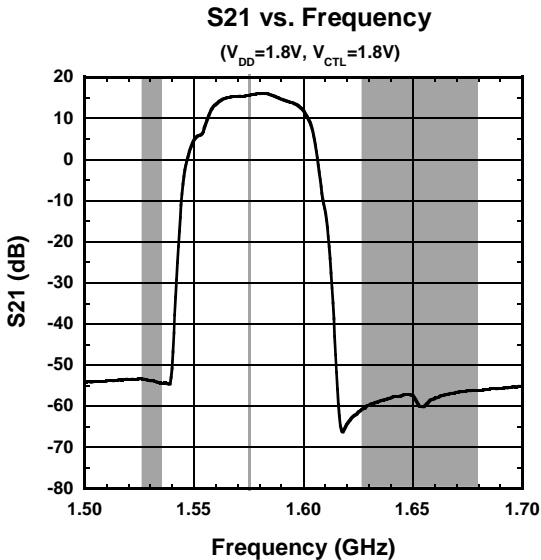
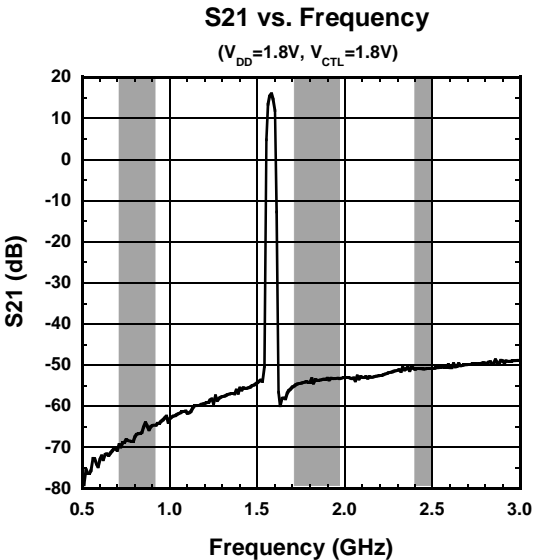
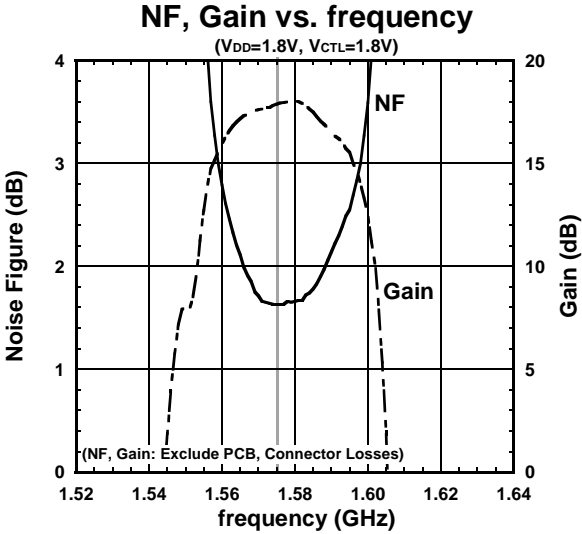
VSWR



Zin, Zout

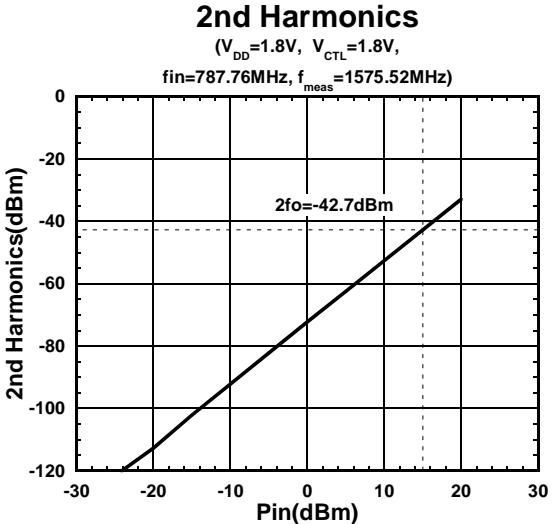
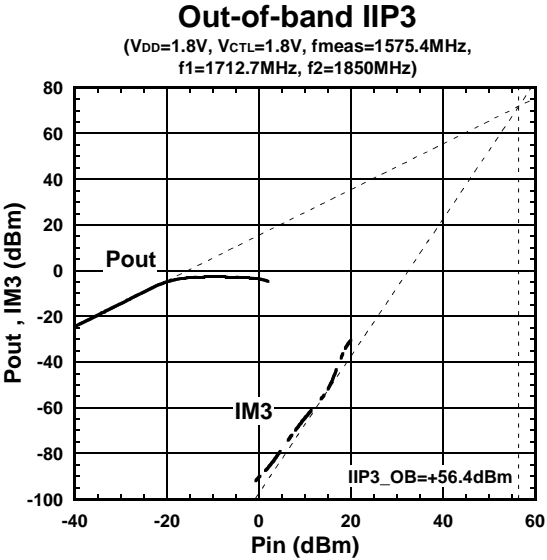
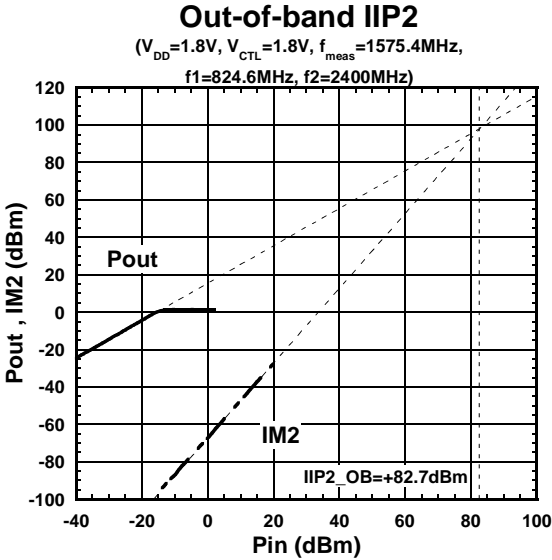
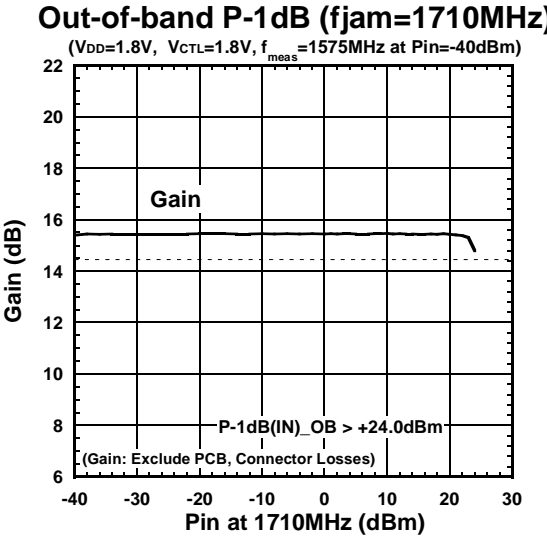
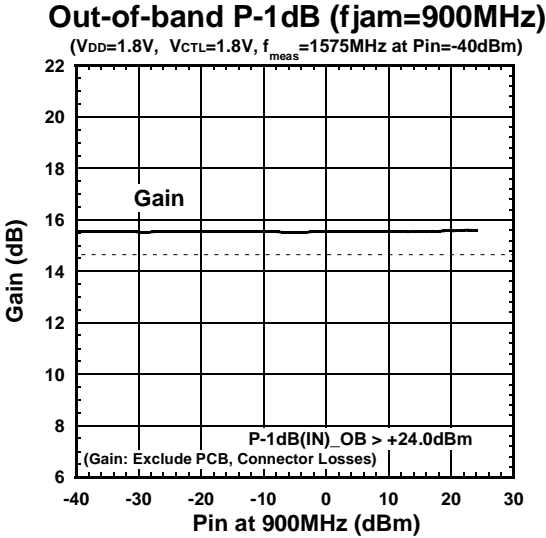
ELECTRICAL CHARACTERISTICS

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



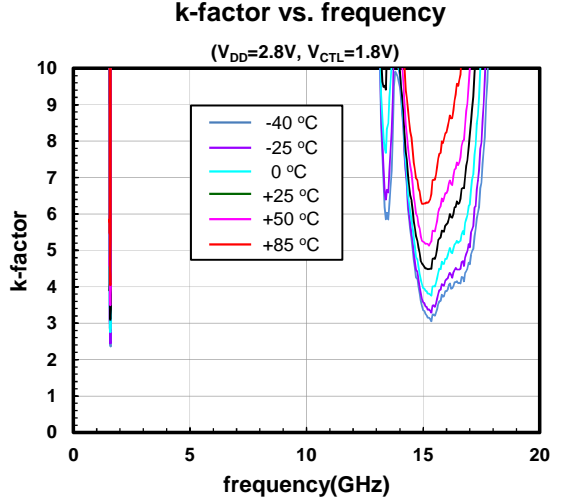
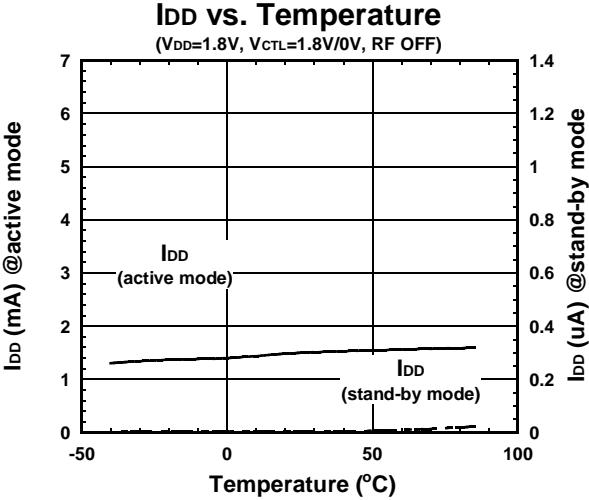
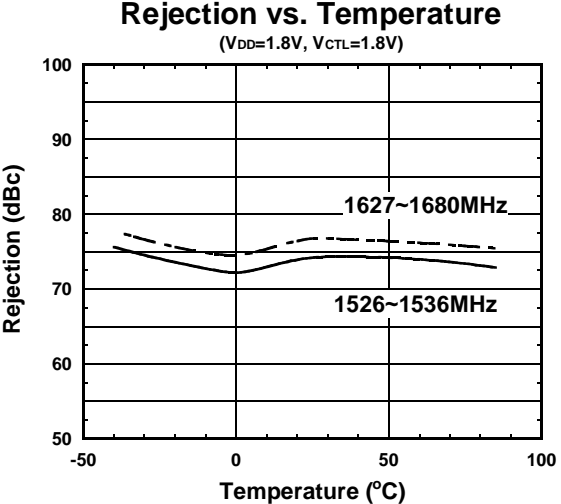
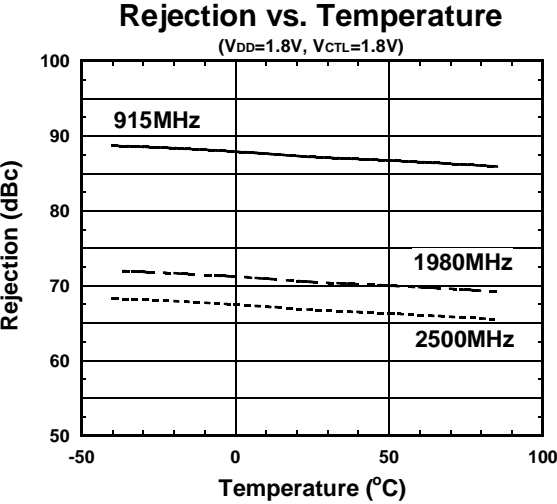
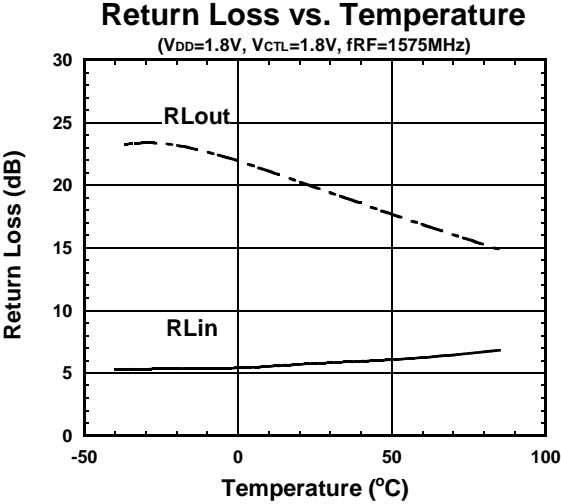
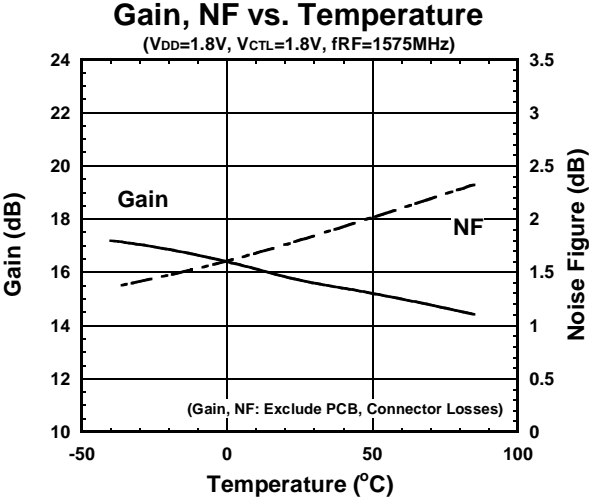
ELECTRICAL CHARACTERISTICS

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



ELECTRICAL CHARACTERISTICS

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

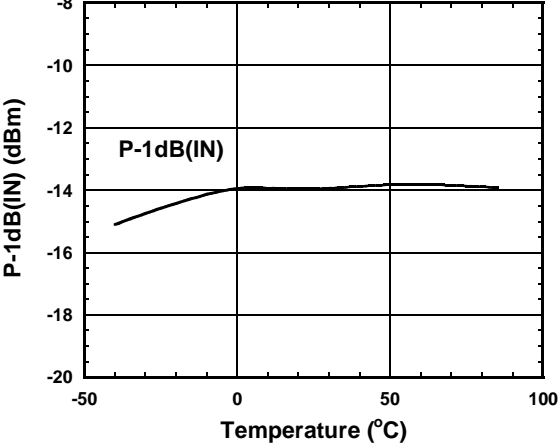


ELECTRICAL CHARACTERISTICS

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

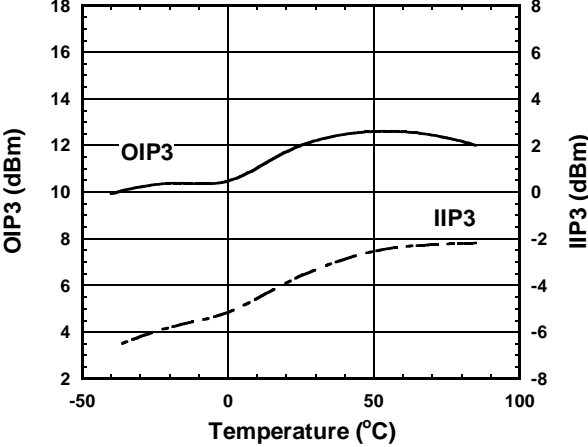
P-1dB(IN) vs. Temperature

($V_{DD}=1.8V$, $V_{CTL}=1.8V$, $f_{RF}=1575MHz$)



OIP3, IIP3 vs. Temperature

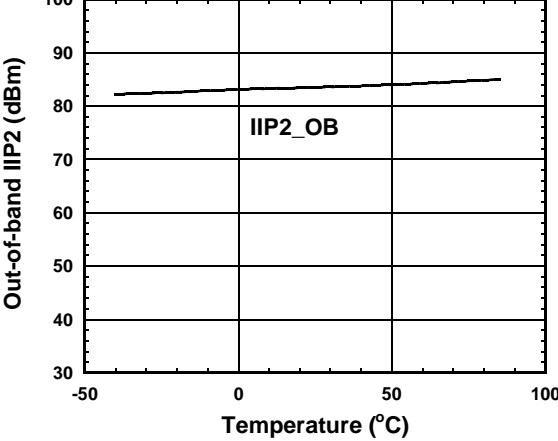
($V_{DD}=1.8V$, $V_{CTL}=1.8V$, $f_1=1575MHz$, $f_2=1576MHz$, $Pin=-30dBm$)



Out-of-band IIP2 vs. Temperature

($V_{DD}=1.8V$, $V_{CTL}=1.8V$, $f_{meas}=1575.4MHz$,

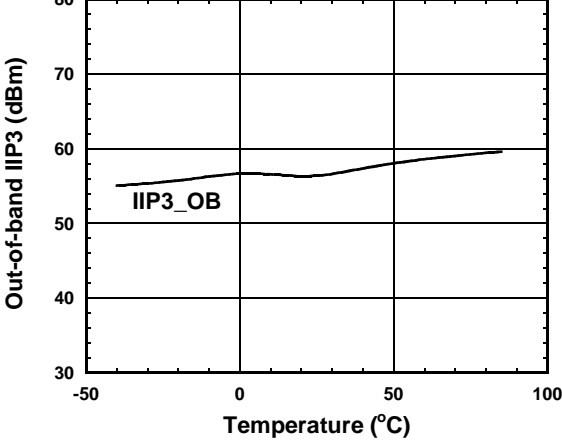
$f_1=824.6MHz$ at $Pin=+15dBm$, $f_2=2400MHz$ at $Pin=+15dBm$)



Out-of-band IIP3 vs. Temperature

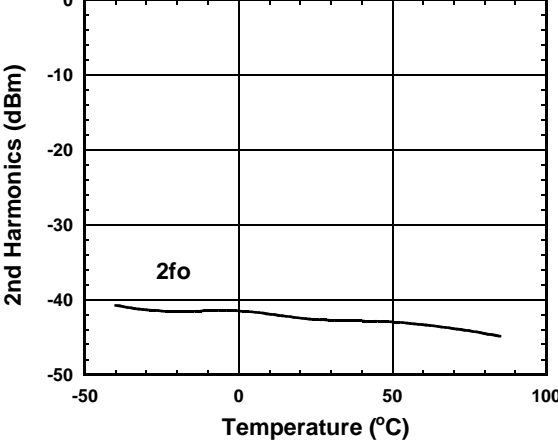
($V_{DD}=1.8V$, $V_{CTL}=1.8V$, $f_{meas}=1575MHz$,

$f_1=1713MHz$ at $Pin=+15dBm$, $f_2=1851MHz$ at $Pin=+15dBm$)



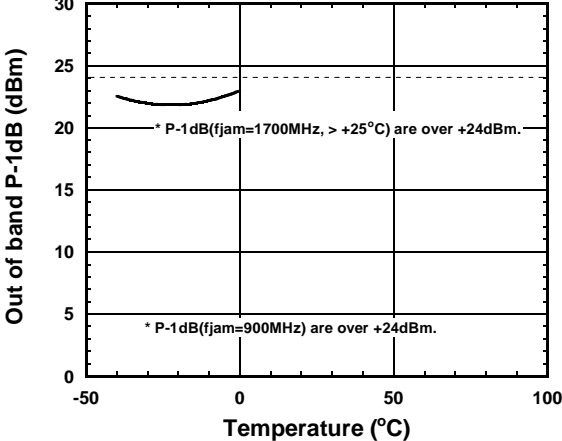
2nd Harmonics vs. Temperature

($V_{DD}=1.8V$, $V_{CTL}=1.8V$, $f_{RF}=787.76MHz$)



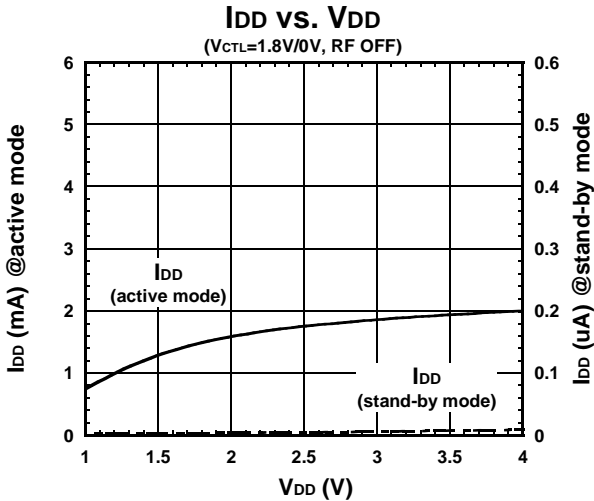
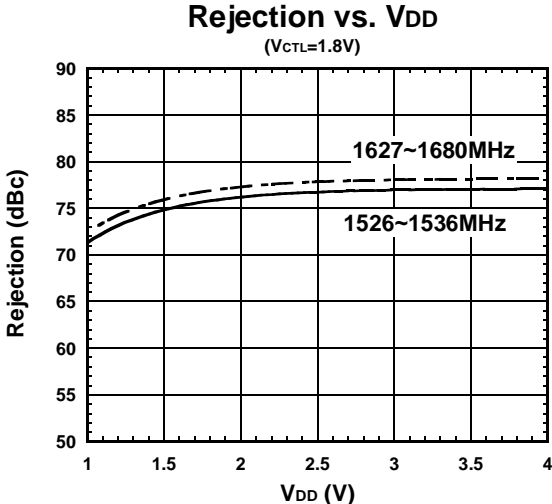
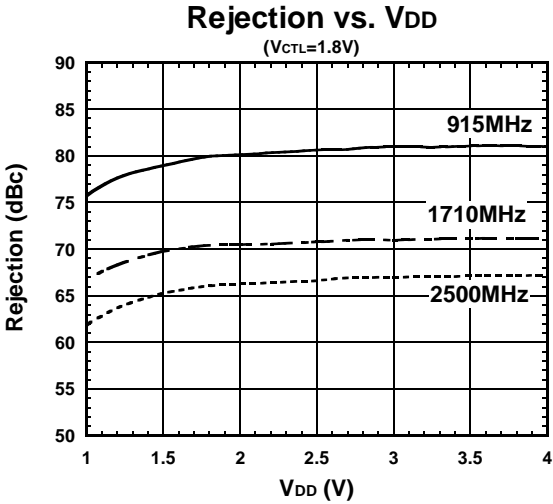
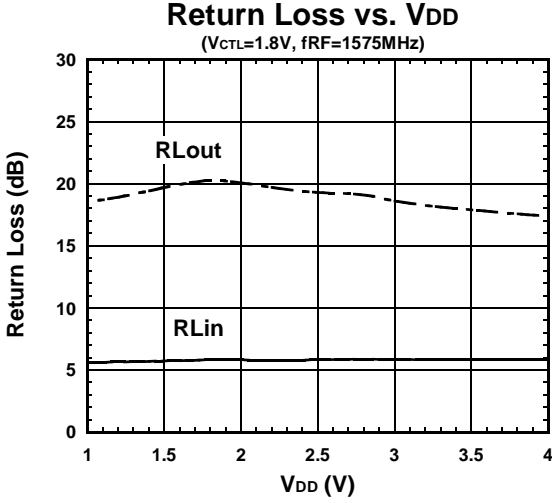
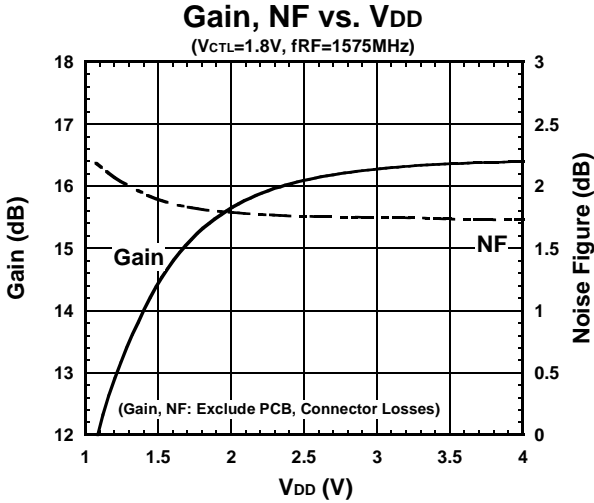
Out of band P-1dB vs. Temperature

($V_{DD}=1.8V$, $V_{CTL}=1.8V$, $f_{RF}=1575MHz$)



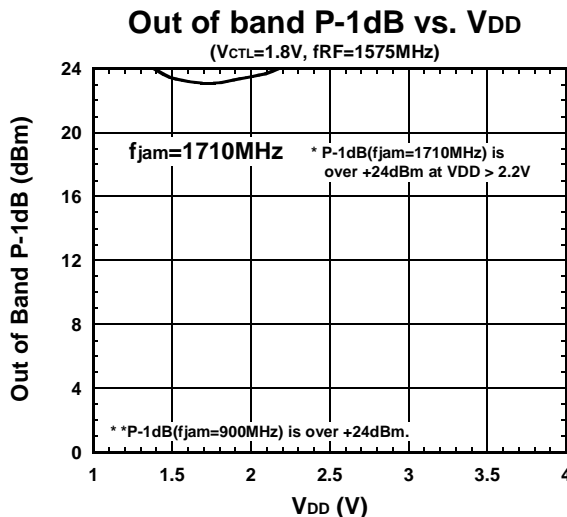
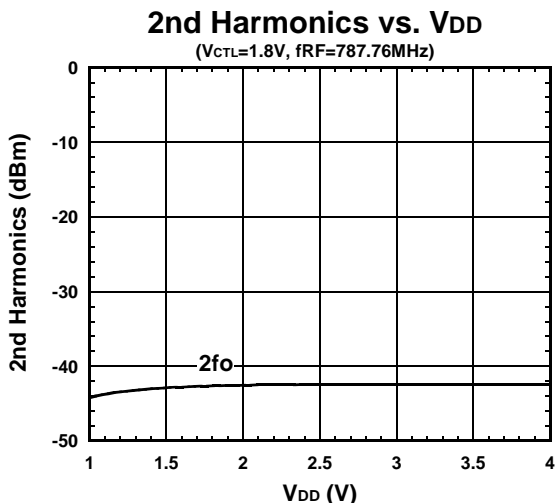
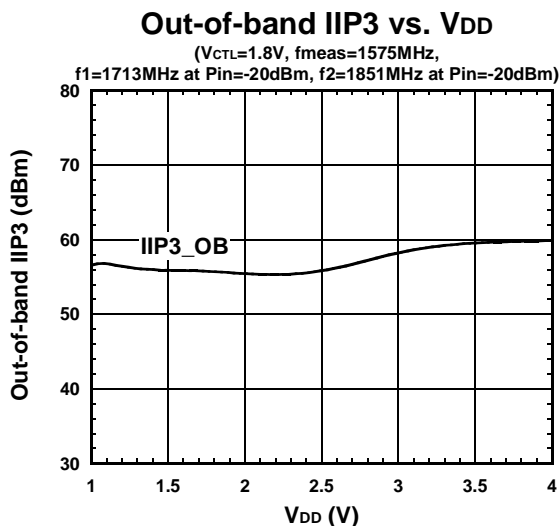
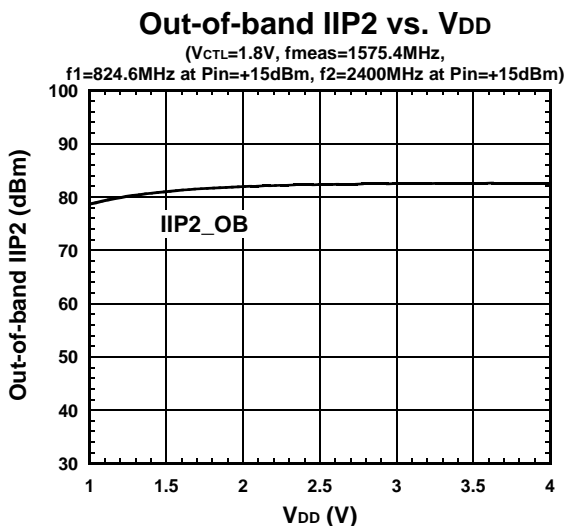
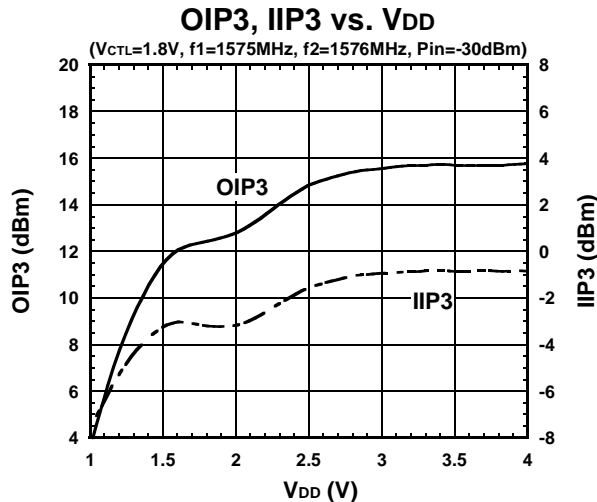
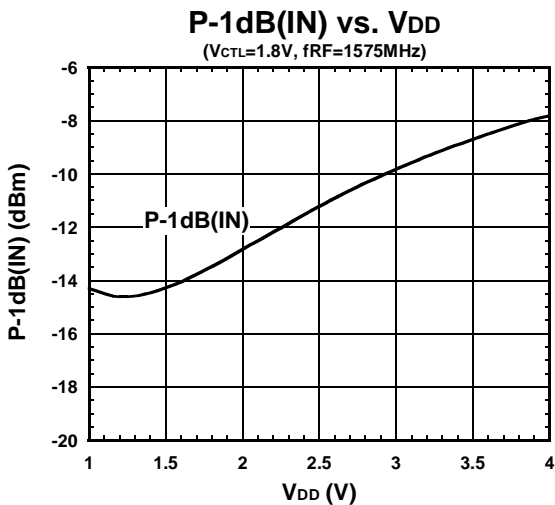
ELECTRICAL CHARACTERISTICS

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



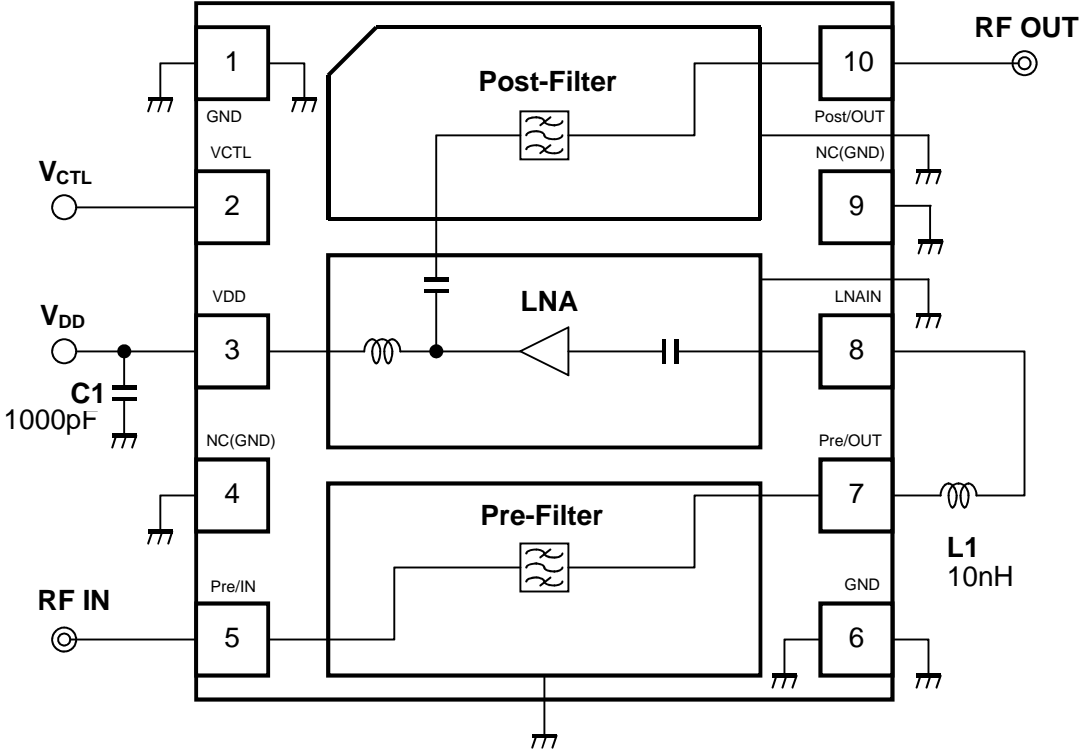
ELECTRICAL CHARACTERISTICS

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



APPLICATION CIRCUIT

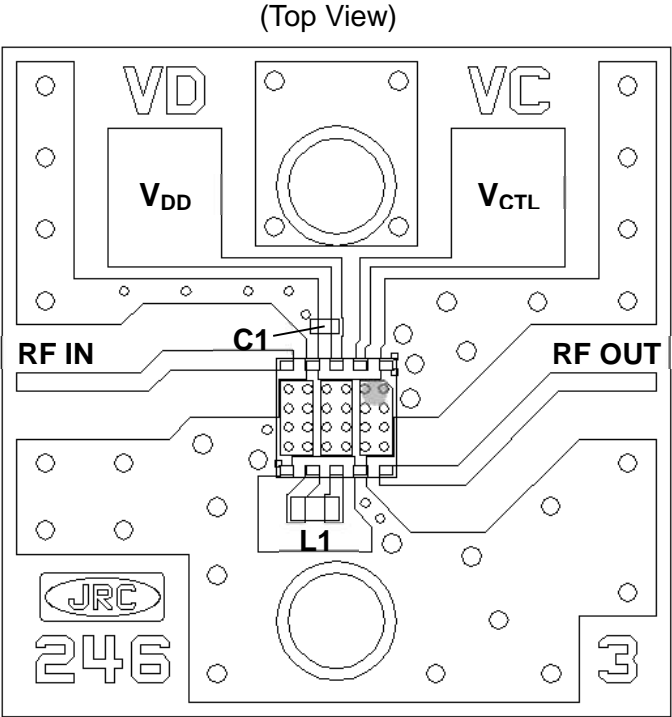
(Top View)



Parts list

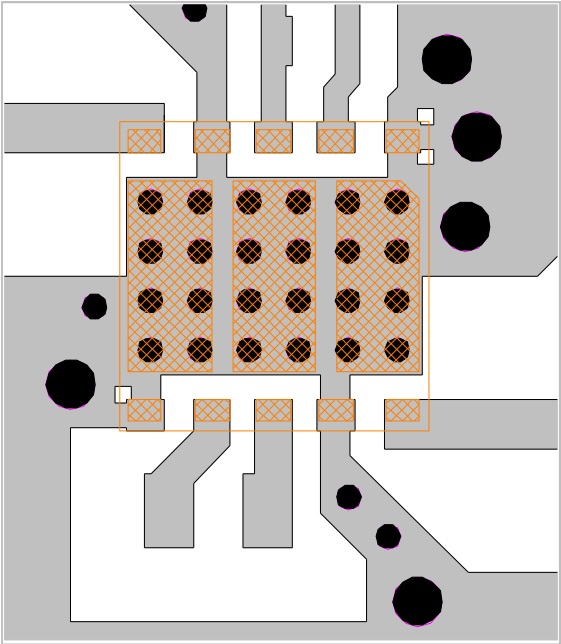
| Parts ID | Manufacture |
|----------|------------------------|
| L1 | LQW15A Series (MURATA) |
| C1 | GRM03 Series (MURATA) |





■ EVALUATION BOARD



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

<PCB LAYOUT GUIDELINE>



-  PCB
-  PKG Terminal
-  PKG Outline
-  GND Via Hole
Diameter $\phi=0.2\text{mm}, 0.4\text{mm}$

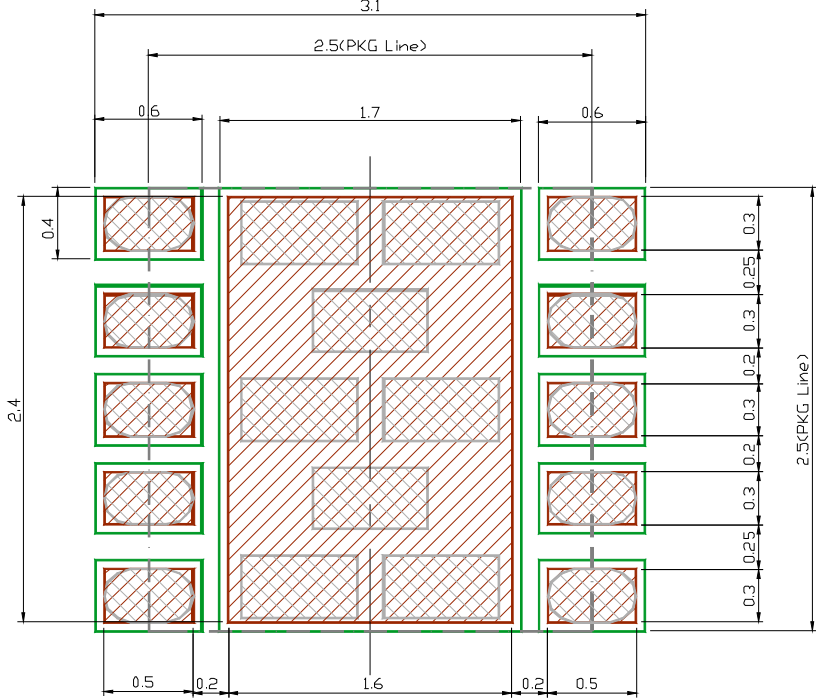
PRECAUTIONS

- Please layout ground pattern under this FEM in order not to couple with RFIN and RFOUT terminal.
- All external parts should be placed as close as possible to the FEM.
- 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 FEM.

RECOMMENDED FOOTPRINT PATTERN (HFFP10-CD PACKAGE) <Reference>

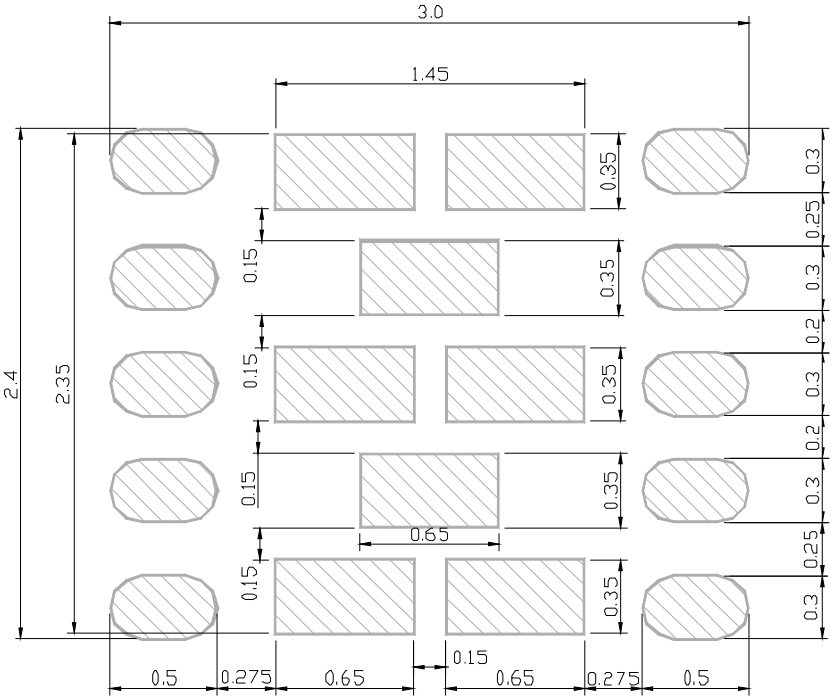
PKG : 2.5mm x 2.5mm

- : Land
- :Mask (Open area) *Metal mask thickness : 100μm
- :Resist(Open area)



Units : mm

Metal MASK Detail



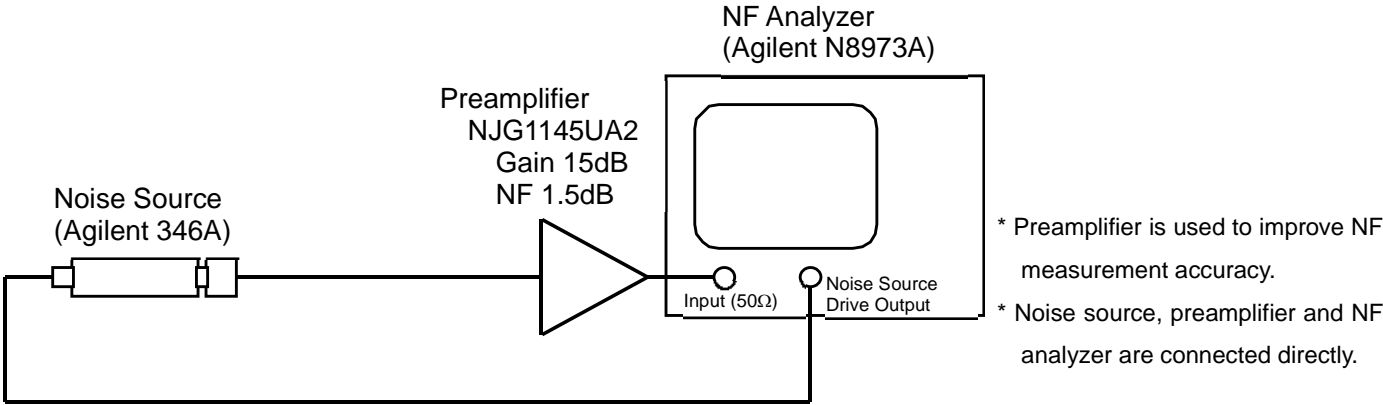
■ NOISE FIGURE MEASUREMENT BLOCK DIAGRAM

Measuring instruments

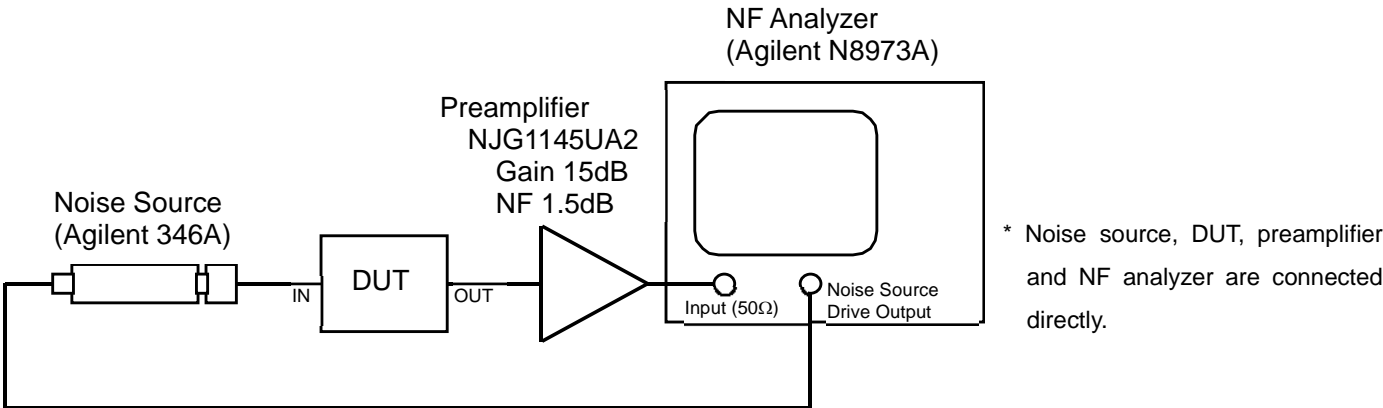
NF Analyzer : Agilent N8973A
Noise Source : Agilent 346A

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)



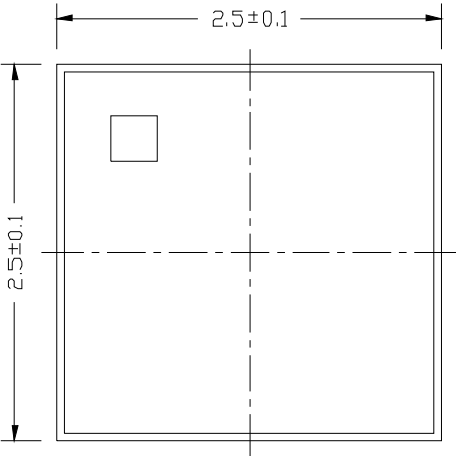
Calibration setup



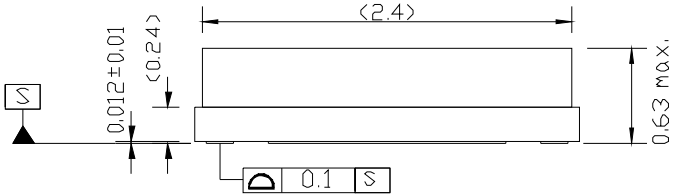
Measurement Setup

PACKAGE OUTLINE (HFFP10-CD)

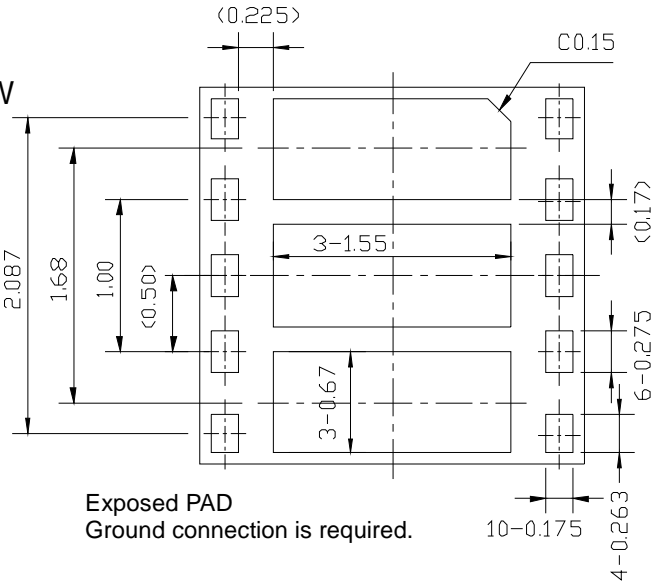
TOP VIEW



SIDE VIEW



BOTTOM VIEW



Package Size : 2.5±0.1mm
0.63mm max.
Electrode Dimensions clearance : ±0.05mm

Unit : mm
Substrate : Ceramic
Terminal treat : Au
Lid : SnAg/Kovar/Ni
Weight (typ.) : 18.00mg

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.

This product is hollow seal package type, and it is with the structure susceptible to stress from the outside. Therefore, note the following in relation to the contents, after conducting an evaluation, please use.
 1. After mounting this product, to implement the potting and transfer molding, please the confirmation of resistance to temperature changes and shrinkage stress involved in the molding.
 2. When mounted on the product, collet diameter please use more than 1mmφ. In addition, the value of static load is recommended mounting less than 5N.
 3. For dynamic load at the time of mounting, please use it after confirming in consideration of the contact area / speed / load.

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