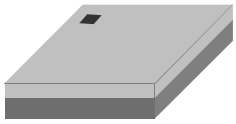
GPS Front-End Module

■ 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



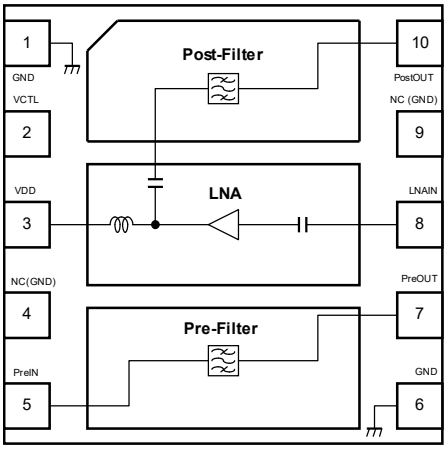
NJG1168PCD

■ 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
	0.1μA 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

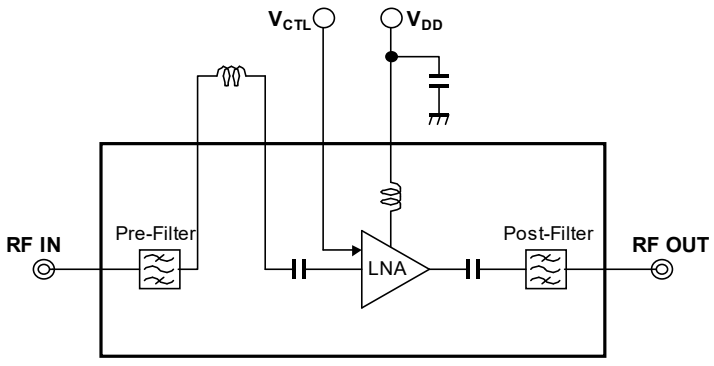
(Top View)



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°C, Z_s=Z_l=50Ω

PARAMETERS	SYMBOL	CONDITIONS	RATINGS	UNITS
Supply voltage	V_{DD}		5.0	V
Control voltage	V_{CTL}		5.0	V
Input power	P_{IN} (inband)	V_{DD}=2.8V, f=1575MHz	+15	dBm
	P_{IN} (outband)	V_{DD}=2.8V, f=50 to 1460, 1710 to 4000MHz	+27	dBm
Power dissipation	P_D	4-layer FR4 PCB with through-hole (101.5x114.5mm), T_j=100°C	510	mW
Operating temperature	T_{opr}		-40 to +85	°C
Storage temperature	T_{stg}		-40 to +100	°C

■ ELECTRICAL CHARACTERISTICS 1 (DC)

(General conditions: T_a=+25°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	$I_{DD}1$	RF OFF, V_{DD}=2.8V, V_{CTL}=1.8V	-	2.4	4.2	mA
Supply Current 2	$I_{DD}2$	RF OFF, V_{DD}=1.8V, V_{CTL}=1.8V	-	1.8	2.9	mA
Supply Current 3	$I_{DD}3$	RF OFF, V_{DD}=2.8V, V_{CTL}=0V	-	0.1	5.0	μA
Supply Current 4	$I_{DD}4$	RF OFF, V_{DD}=1.8V, V_{CTL}=0V	-	0.1	5.0	μA
Control Current	I_{CTL}	V_{CTL}=1.8V	-	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°C, Z_s=Z_l=50Ω, 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°C, Z_s=Z_l=50Ω, with application circuit

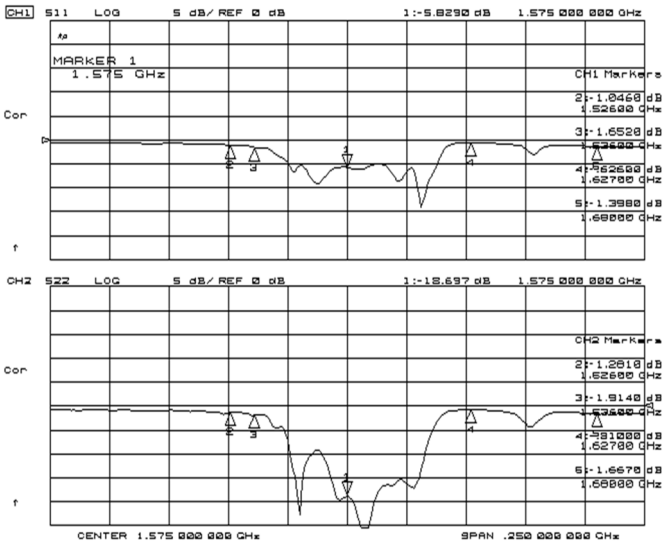
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Small Signal Gain2	Gain2	f=1575MHz, Exclude PCB, Connector Losses (0.19dB)	13.0	17.0	-	dB
Noise Figure2	NF2	f=1575MHz, Exclude PCB, Connector Losses (0.09dB)	-	1.70	2.50	dB
Input Power at 1dB Gain Compression Point 2	P-1dB(IN)2	f=1575MHz	-	-15.0	-	dBm
Input 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 Harmonics2	2fo2	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 Rejection2	BR_LS2	f=1526 to 1536MHz, 1627 to 1680MHz, relative to 1575MHz	-	76.5		dBc
RF IN Return Loss2	RLi2	f=1575MHz	-	5.5	-	dB
RF OUT Return Loss2	RLo2	f=1575MHz	-	20	-	dB

■ **TERMINAL INFORMATION**

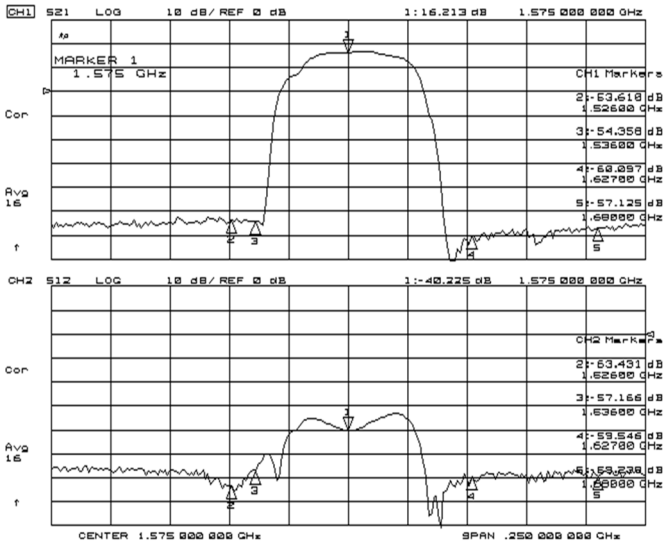
No.	SYMBOL	DESCRIPTION
1	GND	Ground terminal. This terminal should be connected to the ground plane as close as possible for excellent RF performance.
2	VCTL	Control voltage terminal.
3	VDD	Supply voltage terminal. Please connect bypass capacitor C1 with ground as close as possible.
4	NC(GND)	No connected 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

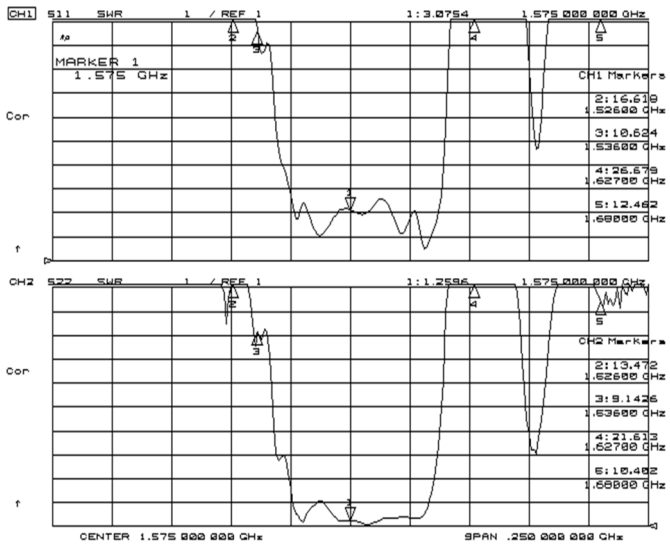
Conditions: V_{DD}=2.8V, V_{CTL}=1.8V, T_a=25°C, Z_s=Z_l=50Ω, with application circuit



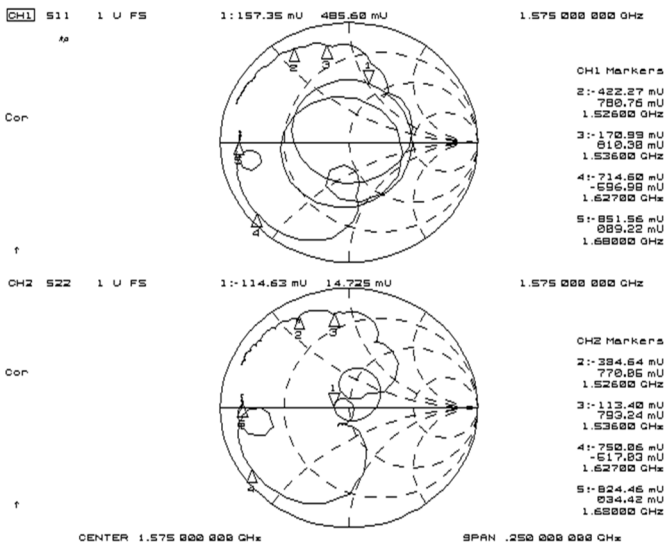
S11, S22



S21, S12



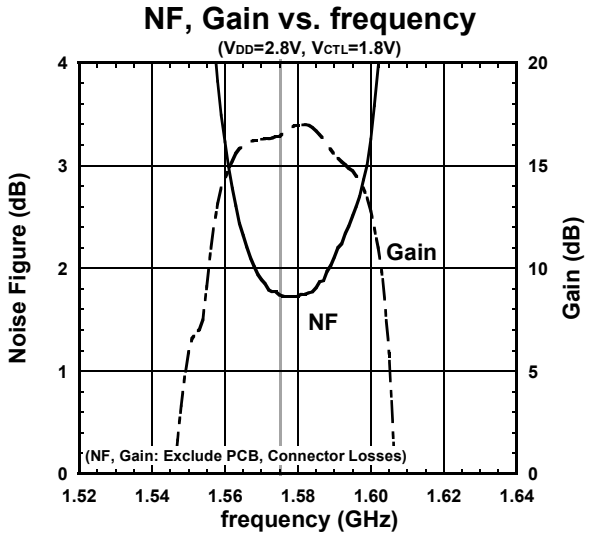
VSWR

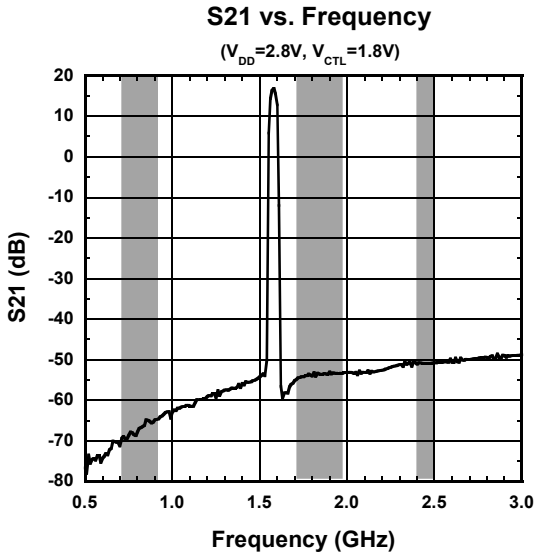


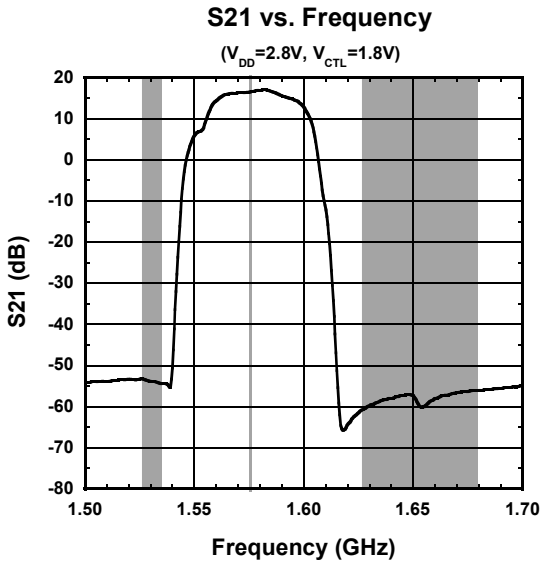
Zin, Zout

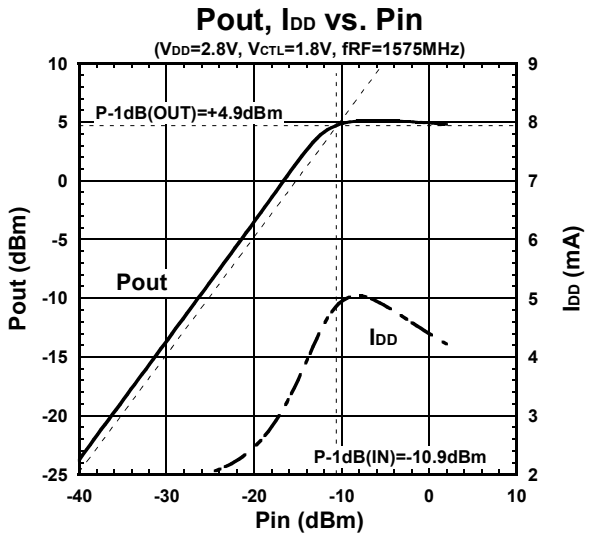
■ ELECTRICAL CHARACTERISTICS

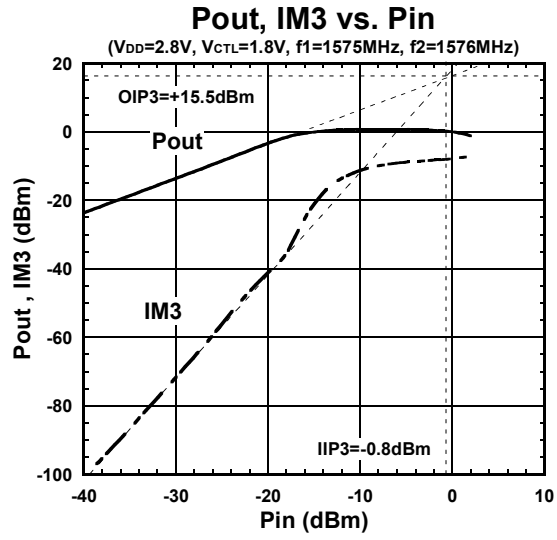
Conditions: V_{DD}=2.8V, V_{CTL}=1.8V, T_a=25°C, Z_s=Z_l=50Ω, with application circuit









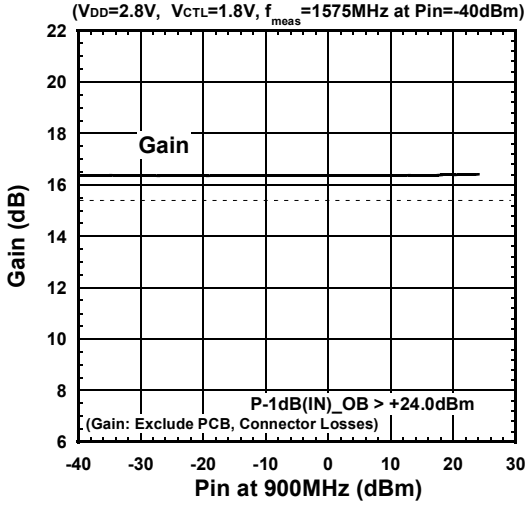


■ ELECTRICAL CHARACTERISTICS

Conditions: V_{DD}=2.8V, V_{CTL}=1.8V, T_a=25°C, Z_s=Z_l=50Ω, with application circuit

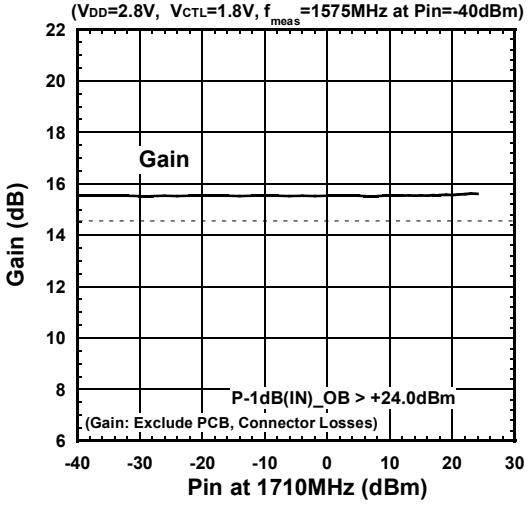
Out-of-band P-1dB (fjam=900MHz)

(V_{DD}=2.8V, V_{CTL}=1.8V, f_{meas}=1575MHz at Pin=-40dBm)



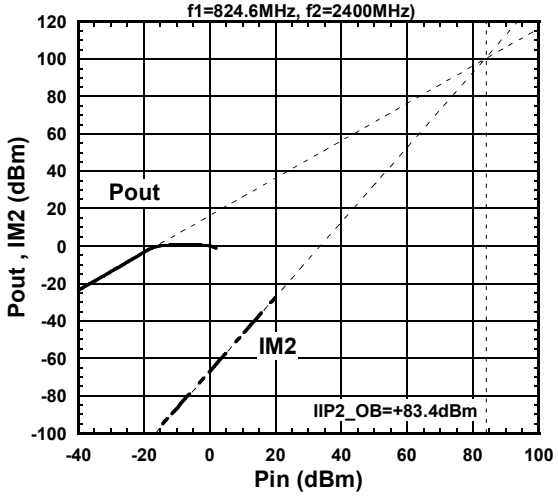
Out-of-band P-1dB (fjam=1710MHz)

(V_{DD}=2.8V, V_{CTL}=1.8V, f_{meas}=1575MHz at Pin=-40dBm)



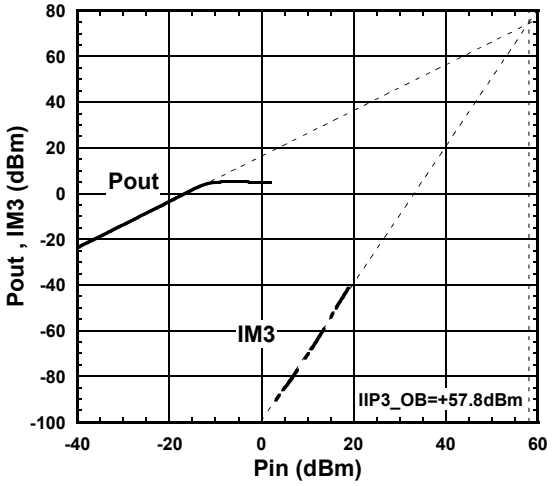
Out-of-band IIP2

(V_{DD}=2.8V, V_{CTL}=1.8V, f_{meas}=1575.4MHz, f1=824.6MHz, f2=2400MHz)



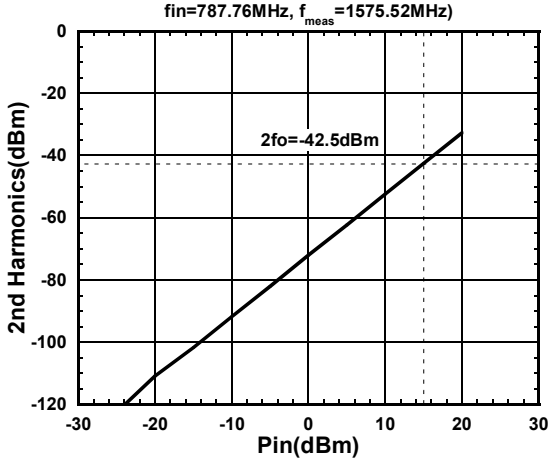
Out-of-band IIP3

(V_{DD}=2.8V, V_{CTL}=1.8V, fmeas=1575.4MHz, f1=1712.7MHz, f2=1850MHz)



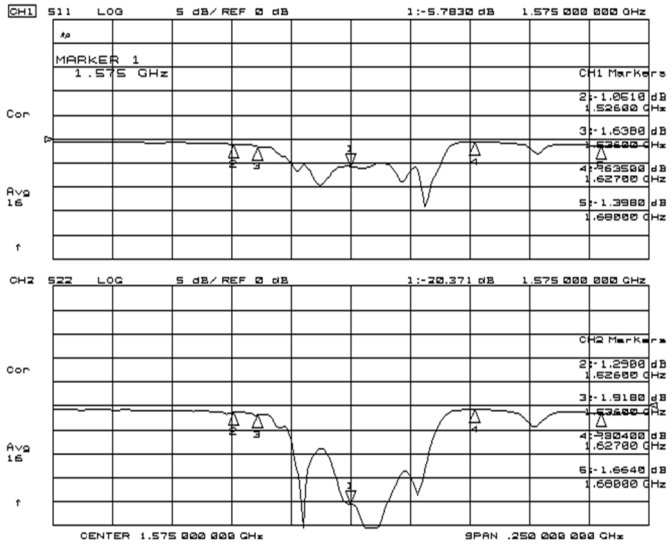
2nd Harmonics

(V_{DD}=2.8V, V_{CTL}=1.8V, fin=787.76MHz, f_{meas}=1575.52MHz)

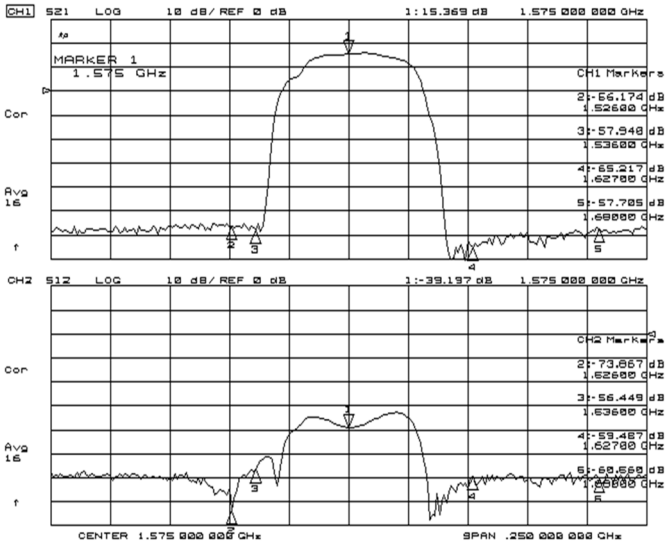


■ ELECTRICAL CHARACTERISTICS

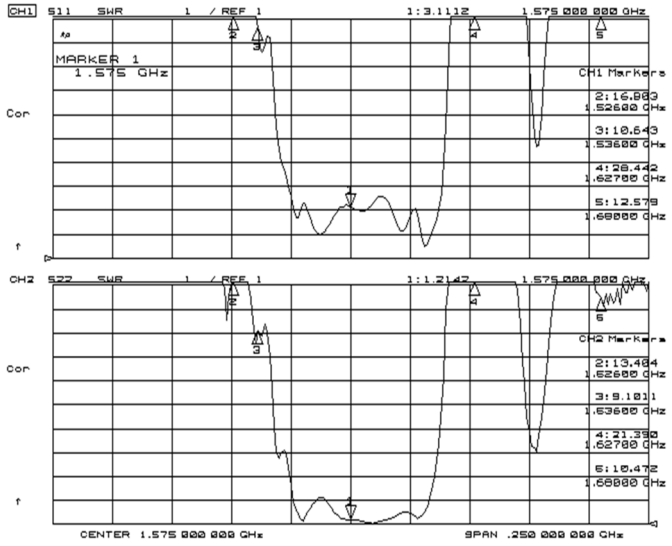
Conditions: V_{DD}=1.8V, V_{CTL}=1.8V, T_a=25°C, Z_s=Z_l=50Ω, with application circuit



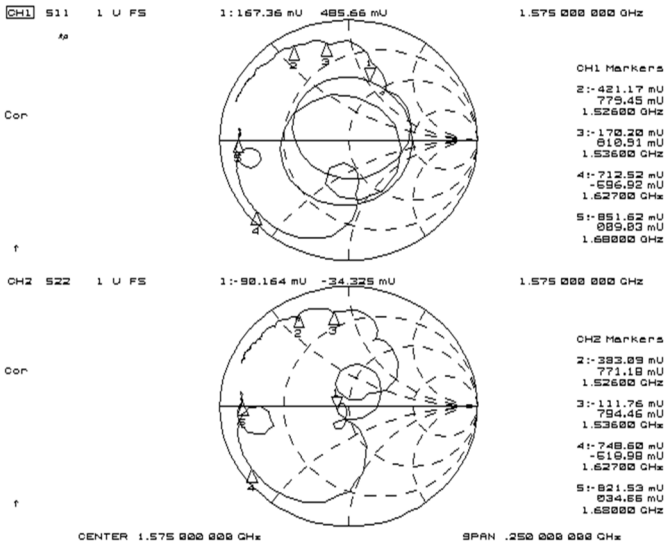
S11, S22



S21, S12



VSWR



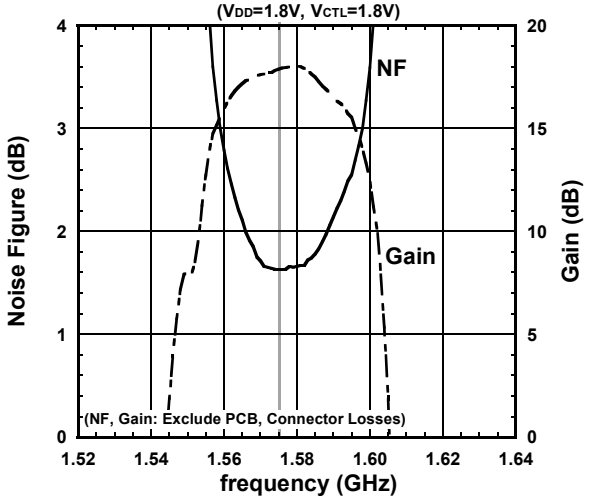
Zin, Zout

■ ELECTRICAL CHARACTERISTICS

Conditions: V_{DD}=1.8V, V_{CTL}=1.8V, T_a=25°C, Z_s=Z_l=50Ω, with application circuit

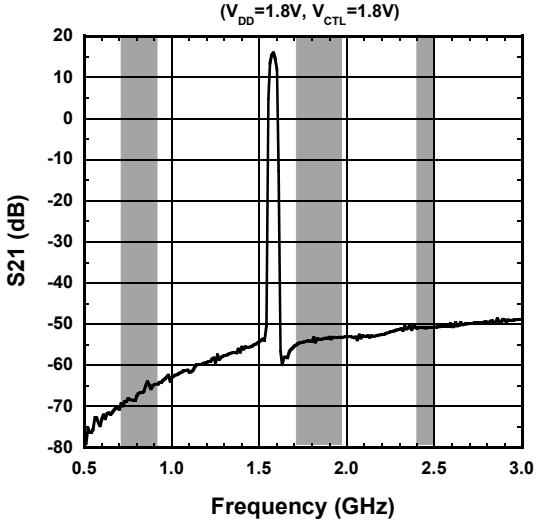
NF, Gain vs. frequency

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



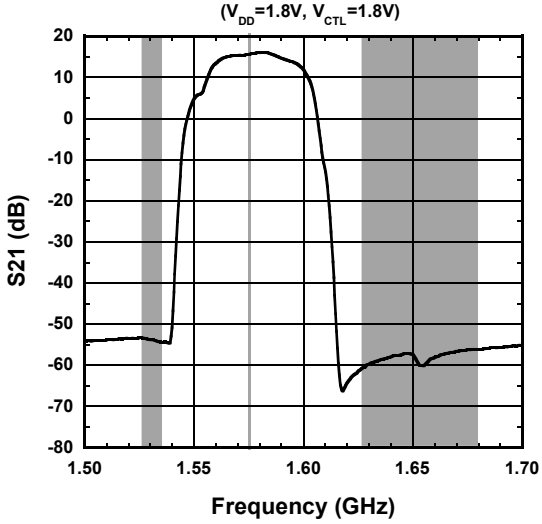
S21 vs. Frequency

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



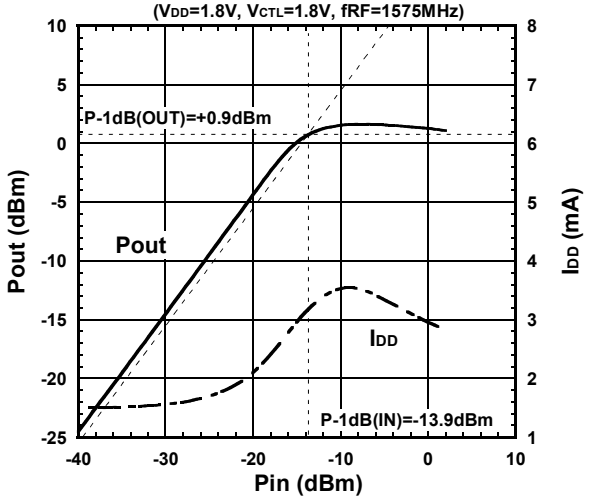
S21 vs. Frequency

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



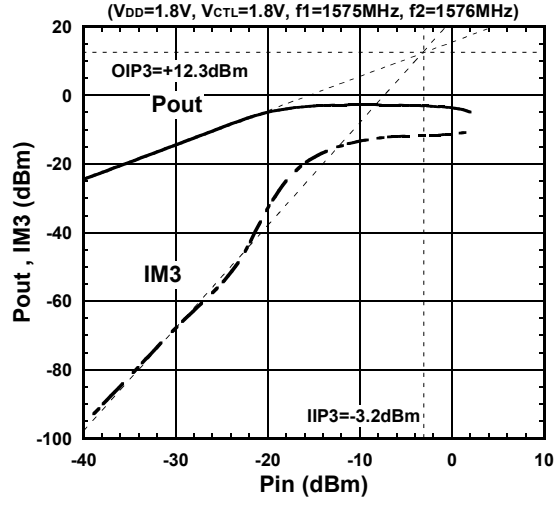
Pout, I_{DD} vs. Pin

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



Pout, IM3 vs. Pin

(V_{DD}=1.8V, V_{CTL}=1.8V, f1=1575MHz, f2=1576MHz)

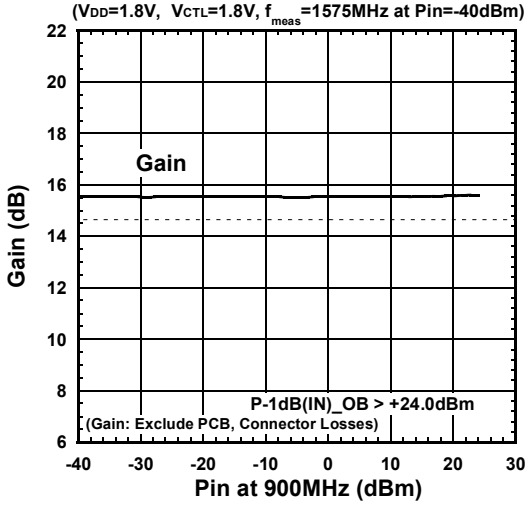


■ ELECTRICAL CHARACTERISTICS

Conditions: V_{DD}=1.8V, V_{CTL}=1.8V, T_a=25°C, Z_s=Z_l=50Ω, with application circuit

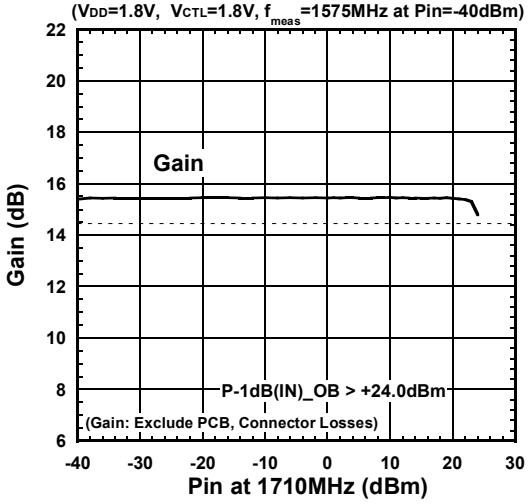
Out-of-band P-1dB (fjam=900MHz)

(V_{DD}=1.8V, V_{CTL}=1.8V, f_{meas}=1575MHz at Pin=-40dBm)



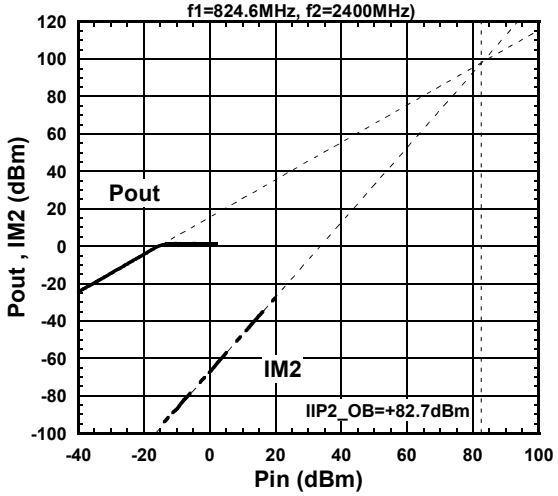
Out-of-band P-1dB (fjam=1710MHz)

(V_{DD}=1.8V, V_{CTL}=1.8V, f_{meas}=1575MHz at Pin=-40dBm)



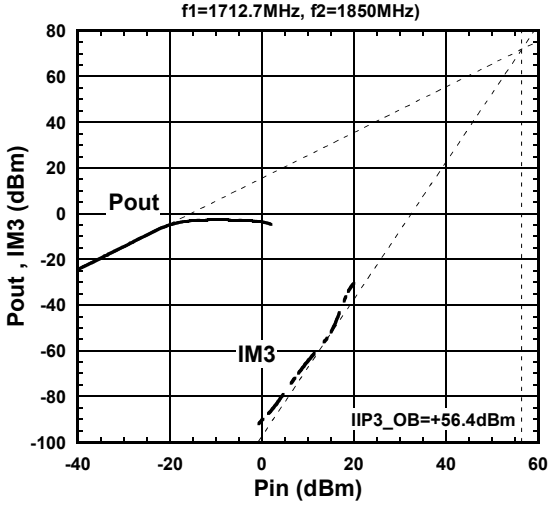
Out-of-band IIP2

(V_{DD}=1.8V, V_{CTL}=1.8V, f_{meas}=1575.4MHz, f1=824.6MHz, f2=2400MHz)



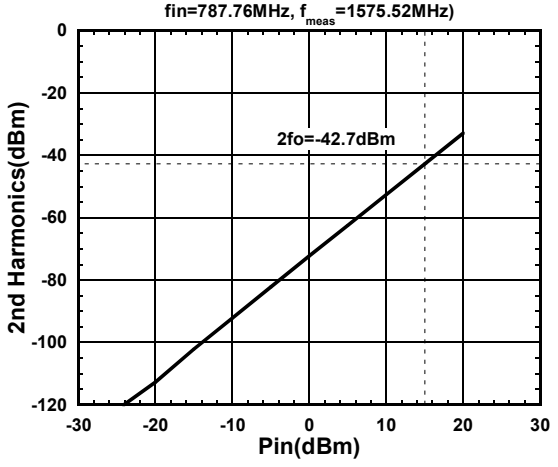
Out-of-band IIP3

(V_{DD}=1.8V, V_{CTL}=1.8V, fmeas=1575.4MHz, f1=1712.7MHz, f2=1850MHz)



2nd Harmonics

(V_{DD}=1.8V, V_{CTL}=1.8V, fin=787.76MHz, f_{meas}=1575.52MHz)

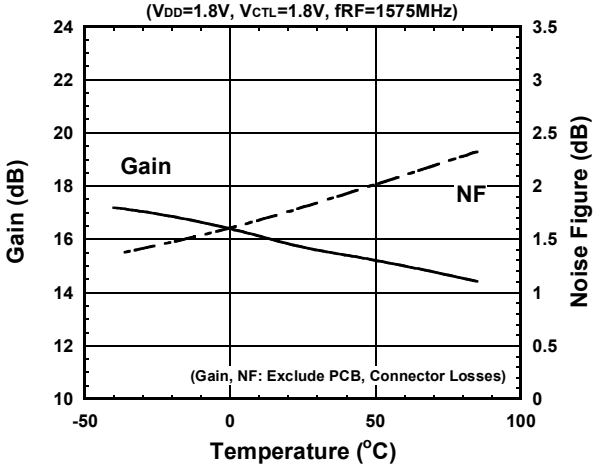


■ ELECTRICAL CHARACTERISTICS

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

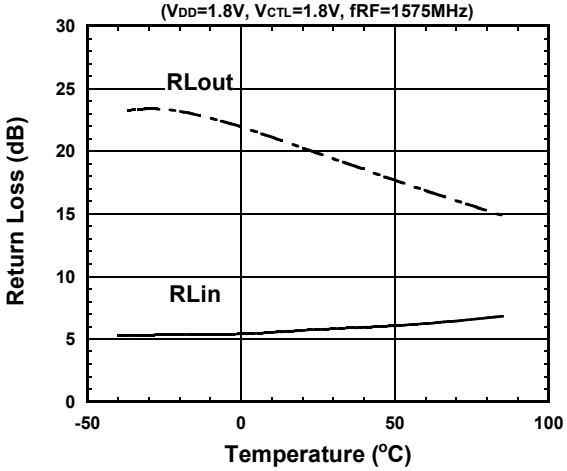
Gain, NF vs. Temperature

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



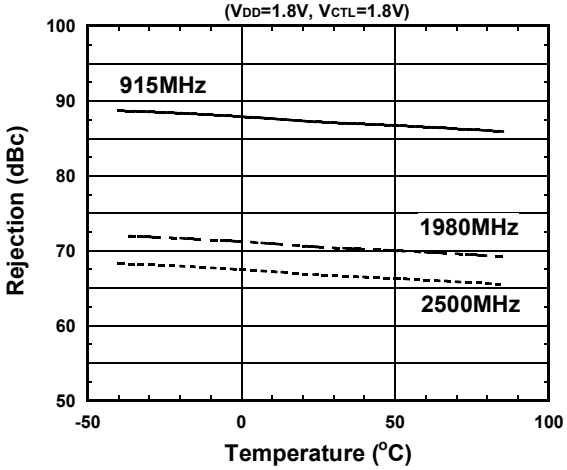
Return Loss vs. Temperature

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



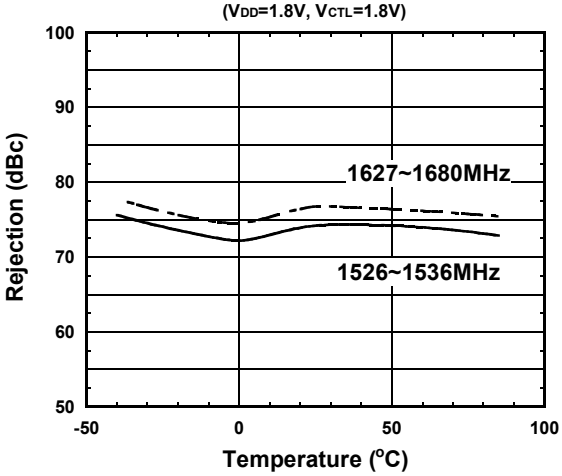
Rejection vs. Temperature

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



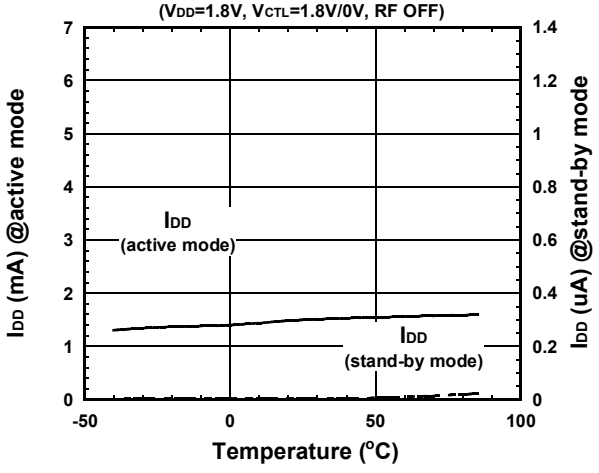
Rejection vs. Temperature

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



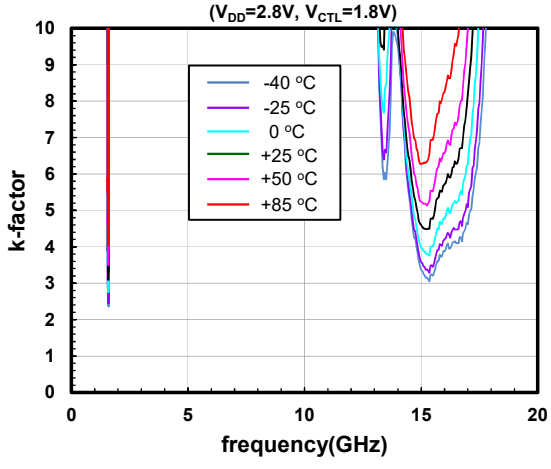
I_{DD} vs. Temperature

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



k-factor vs. frequency

(V_{DD}=2.8V, V_{CTL}=1.8V)

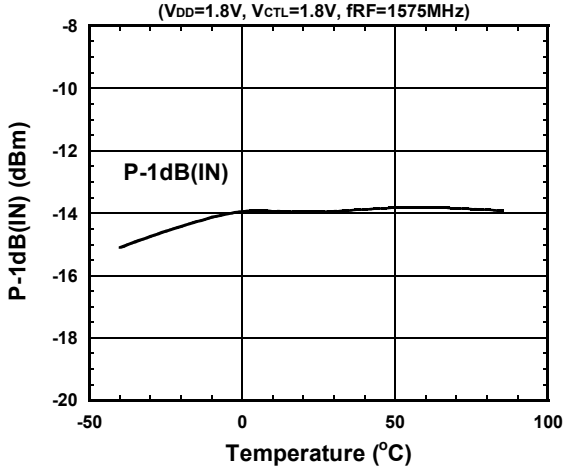


■ ELECTRICAL CHARACTERISTICS

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

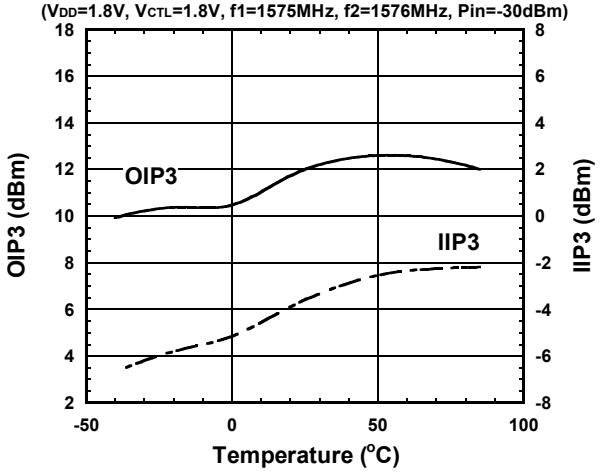
P-1dB(IN) vs. Temperature

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



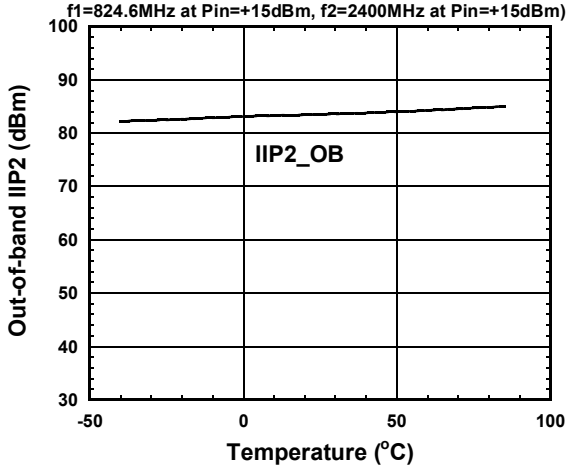
OIP3, IIP3 vs. Temperature

(V_{DD}=1.8V, V_{CTL}=1.8V, f1=1575MHz, f2=1576MHz, Pin=-30dBm)



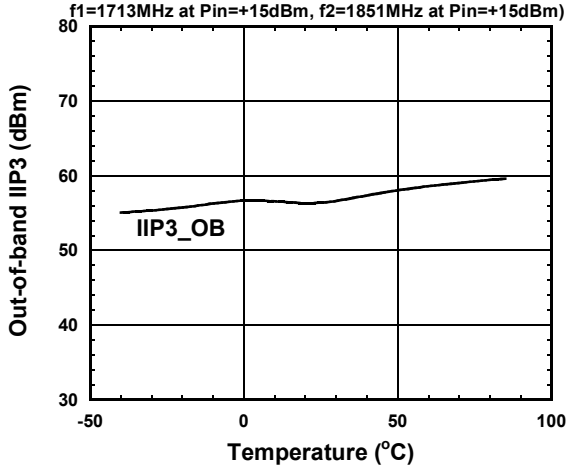
Out-of-band IIP2 vs. Temperature

(V_{DD}=1.8V, V_{CTL}=1.8V, fmeas=1575.4MHz, f1=824.6MHz at Pin=+15dBm, f2=2400MHz at Pin=+15dBm)



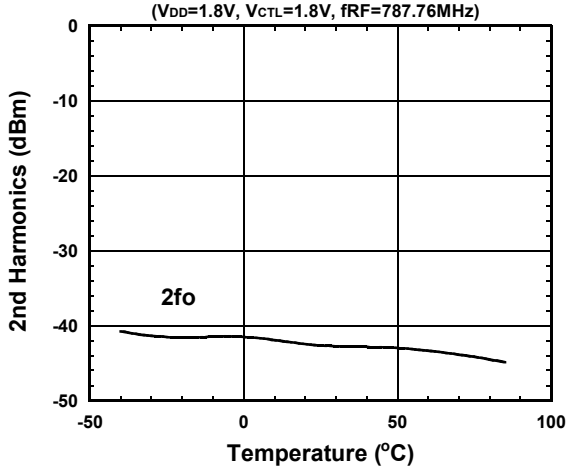
Out-of-band IIP3 vs. Temperature

(V_{DD}=1.8V, V_{CTL}=1.8V, fmeas=1575MHz, f1=1713MHz at Pin=+15dBm, f2=1851MHz at Pin=+15dBm)



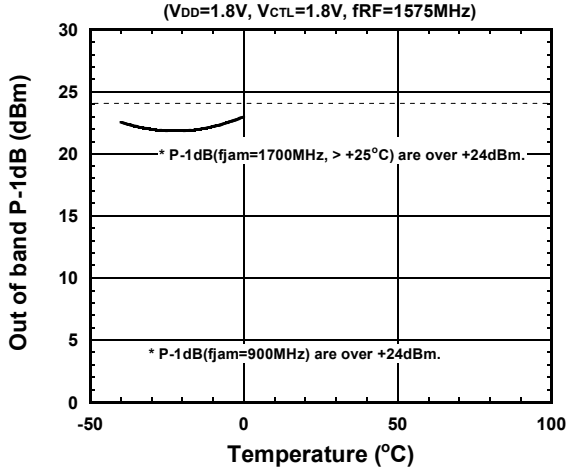
2nd Harmonics vs. Temperature

(V_{DD}=1.8V, V_{CTL}=1.8V, fRF=787.76MHz)



Out of band P-1dB vs. Temperature

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

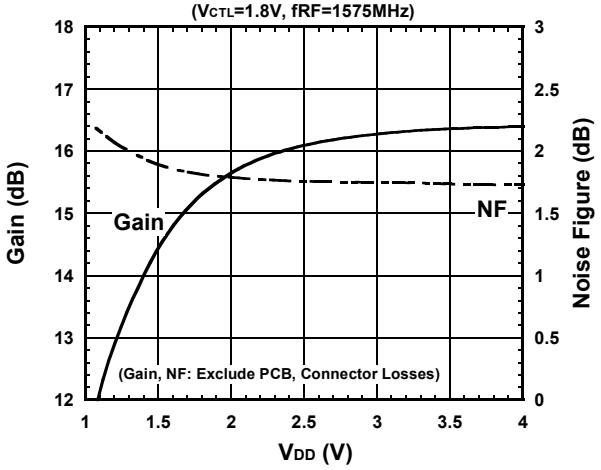


■ ELECTRICAL CHARACTERISTICS

Conditions: V_{CTL}=1.8V, T_a=25°C, Z_s=Z_l=50Ω, with application circuit

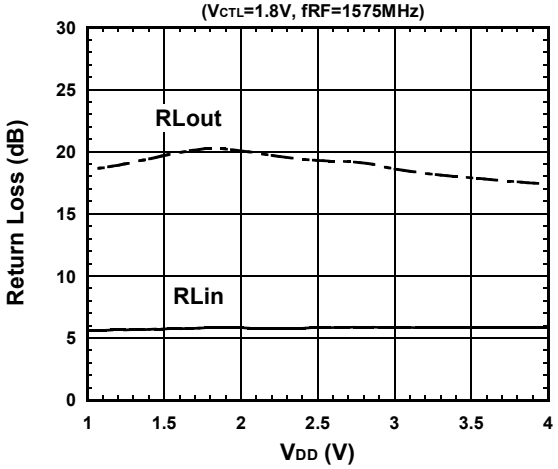
Gain, NF vs. VDD

(VCTL=1.8V, fRF=1575MHz)



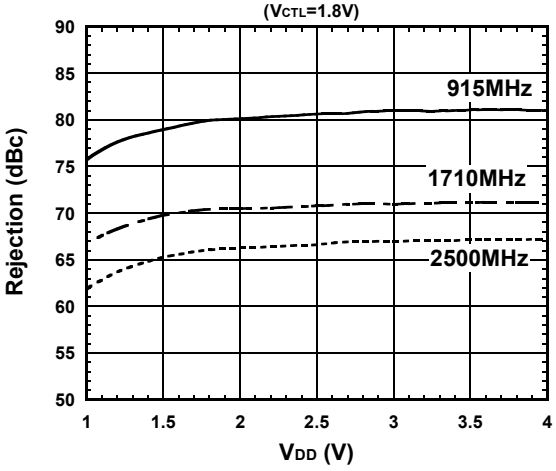
Return Loss vs. VDD

(VCTL=1.8V, fRF=1575MHz)



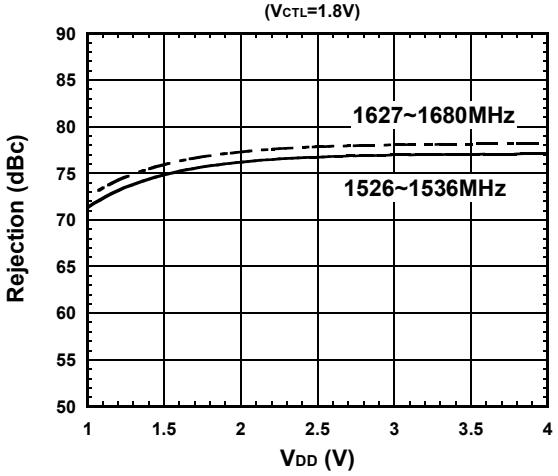
Rejection vs. VDD

(VCTL=1.8V)



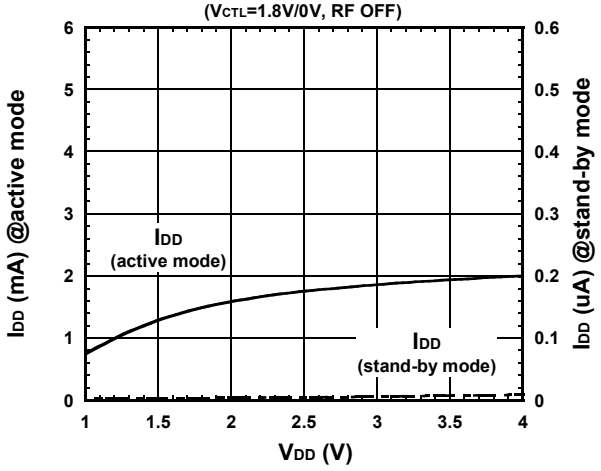
Rejection vs. VDD

(VCTL=1.8V)



IDD vs. VDD

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

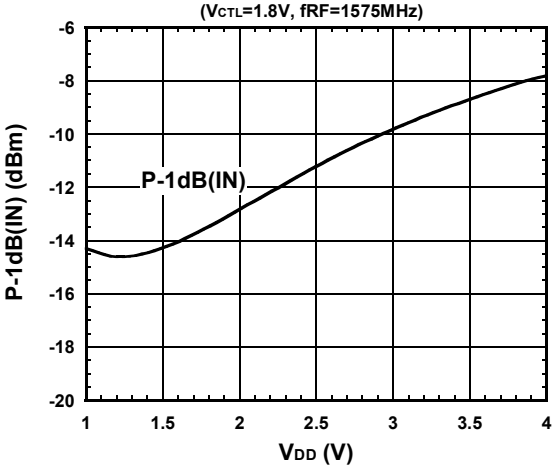


■ ELECTRICAL CHARACTERISTICS

Conditions: V_{CTL}=1.8V, T_a=25°C, Z_s=Z_l=50Ω, with application circuit

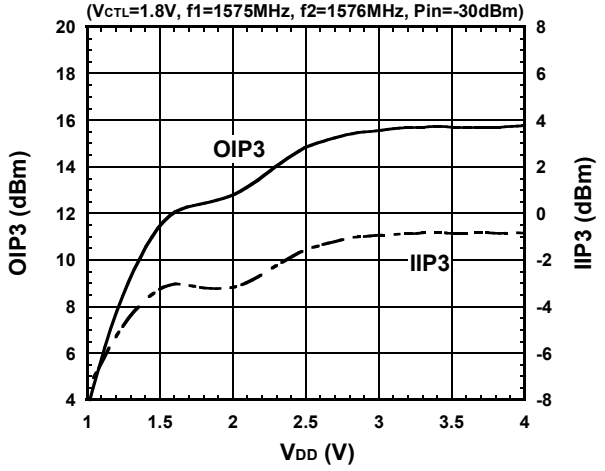
P-1dB(IN) vs. VDD

(VCTL=1.8V, fRF=1575MHz)



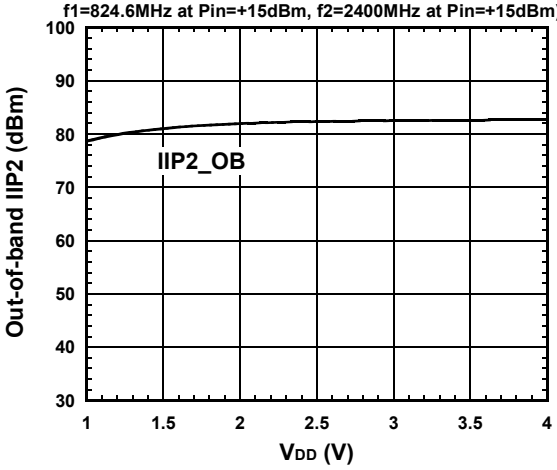
OIP3, IIP3 vs. VDD

(VCTL=1.8V, f1=1575MHz, f2=1576MHz, Pin=-30dBm)



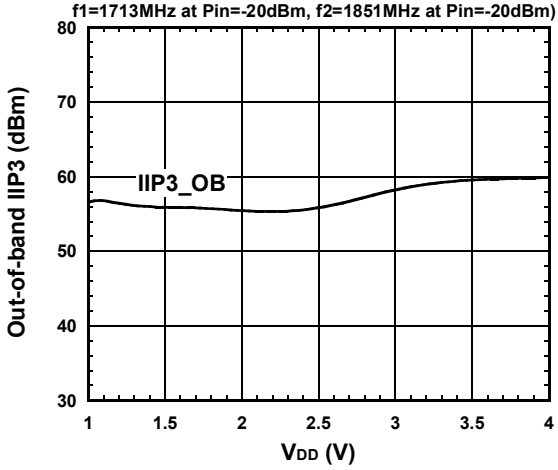
Out-of-band IIP2 vs. VDD

(VCTL=1.8V, fmeas=1575.4MHz,
f1=824.6MHz at Pin=+15dBm, f2=2400MHz at Pin=+15dBm)



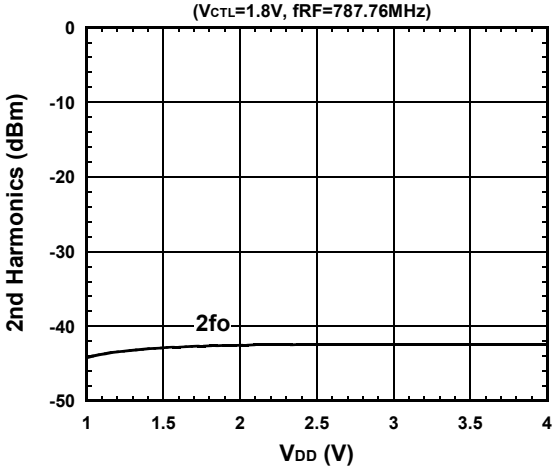
Out-of-band IIP3 vs. VDD

(VCTL=1.8V, fmeas=1575MHz,
f1=1713MHz at Pin=-20dBm, f2=1851MHz at Pin=-20dBm)



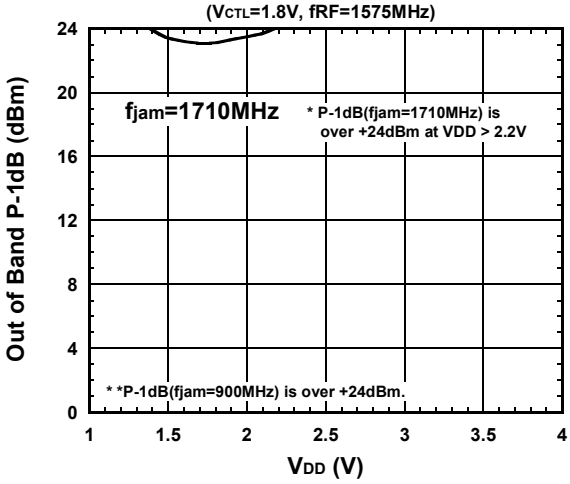
2nd Harmonics vs. VDD

(VCTL=1.8V, fRF=787.76MHz)



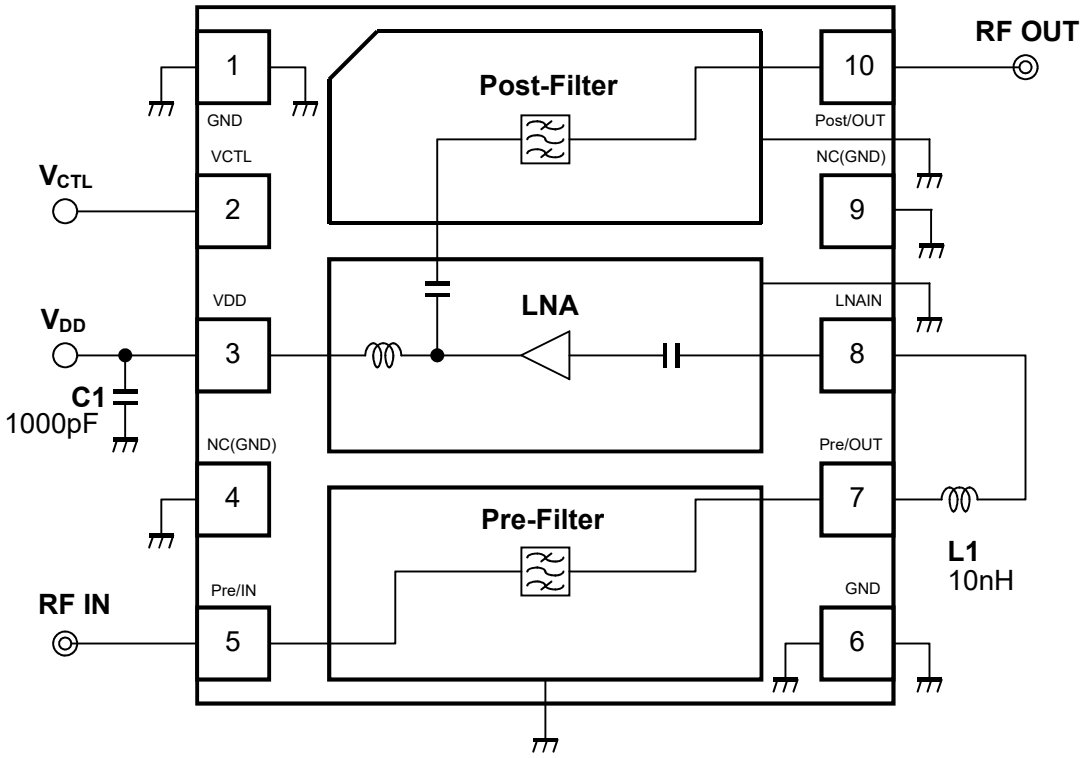
Out of band P-1dB vs. VDD

(VCTL=1.8V, fRF=1575MHz)



■ **APPLICATION CIRCUIT**

(Top View)

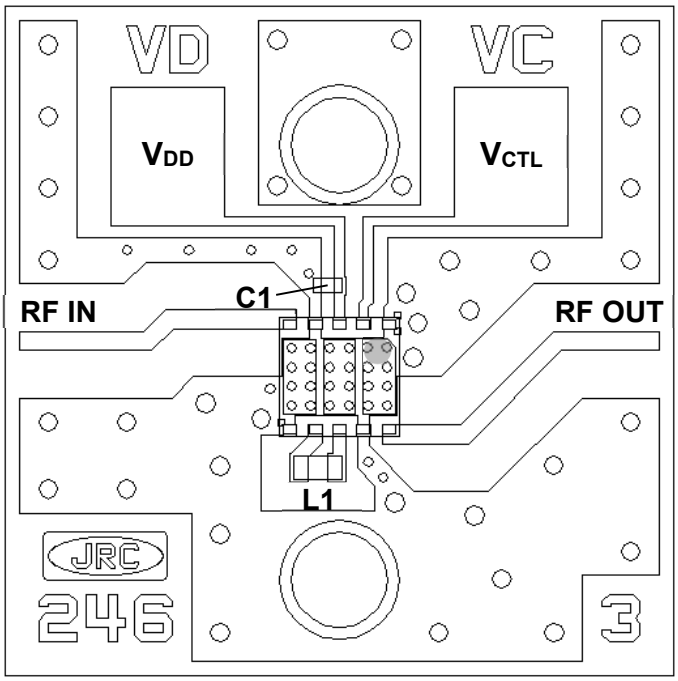


Parts list

Parts ID	Manufacture
L1	LQW15AN_00 Series (MURATA)
C1	GRM03 Series (MURATA)

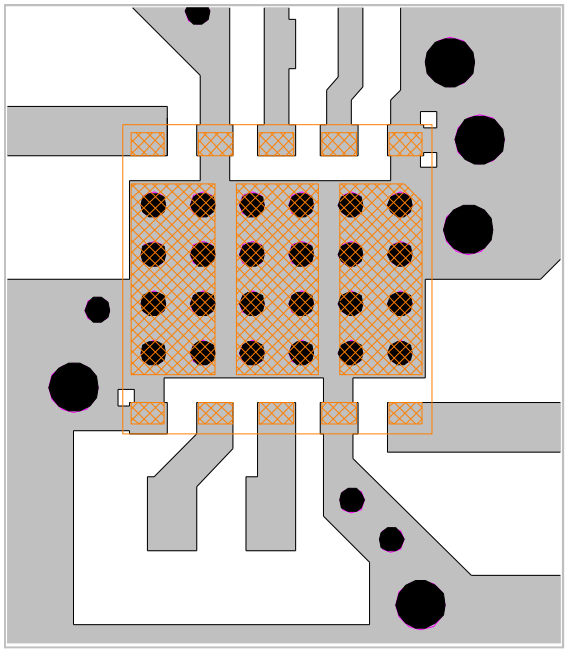
■ EVALUATION BORAD

(Top View)



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

<PCB LAYOUT GUIDELINE>



PCB
PKG Terminal
PKG Outline
GND Via Hole
Diameter ϕ= 0.2mm, 0.4mm

PRECAUTIONS

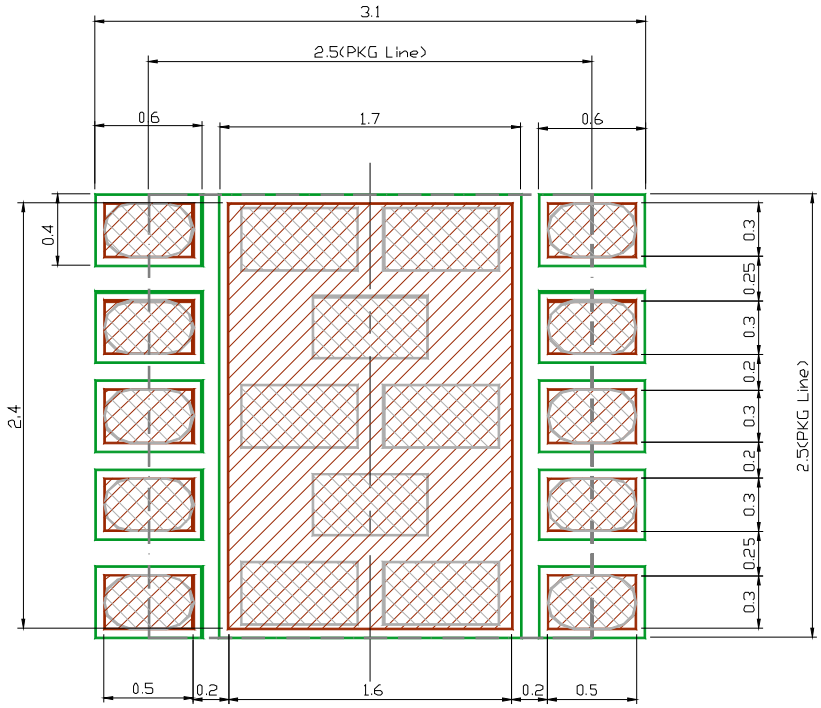
- Please layout ground pattern under this FEM in order not to couple with RFIN and RFOUT terminal.
- All external parts should be placed as close as possible to the FEM.
- For good RF performance, all GND terminals must be connected to PCB ground plane of substrate, and via-holes for GND should be placed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

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

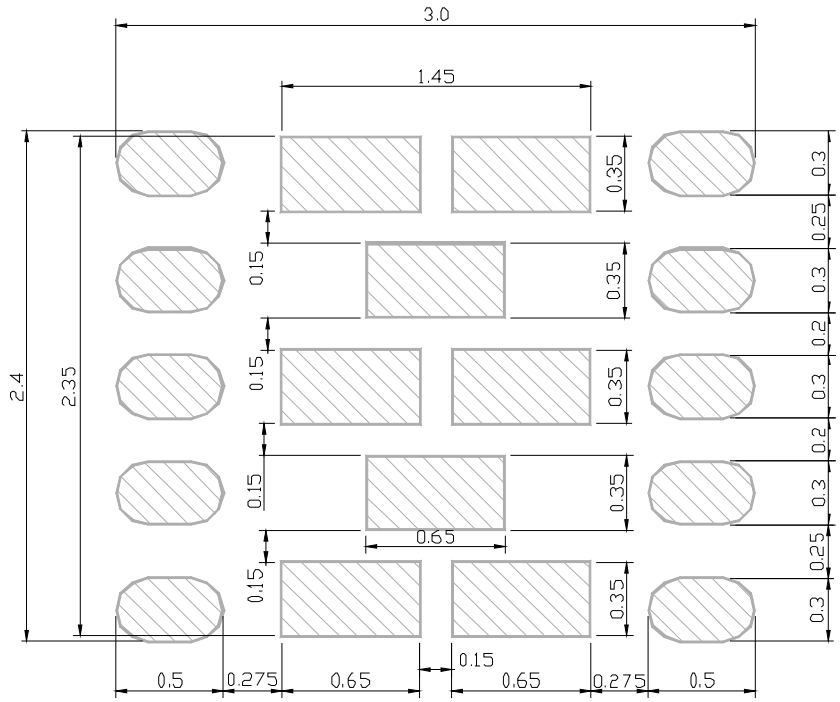
PKG : 2.5mm x 2.5mm

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

Units : mm



Metal MASK Detail



■ NOISE FIGURE MEASUREMENT BLOCK DIAGRAM

Measuring instruments

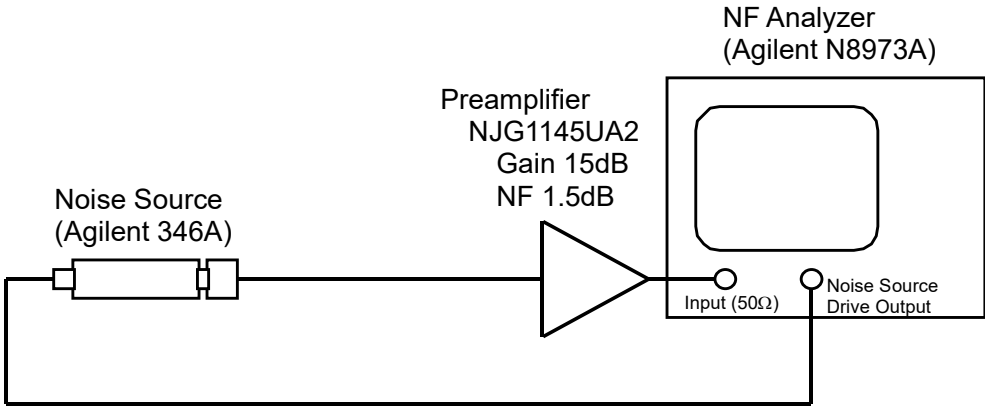
NF Analyzer : Agilent N8973A
Noise Source : Agilent 346A

Setting the NF analyzer

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

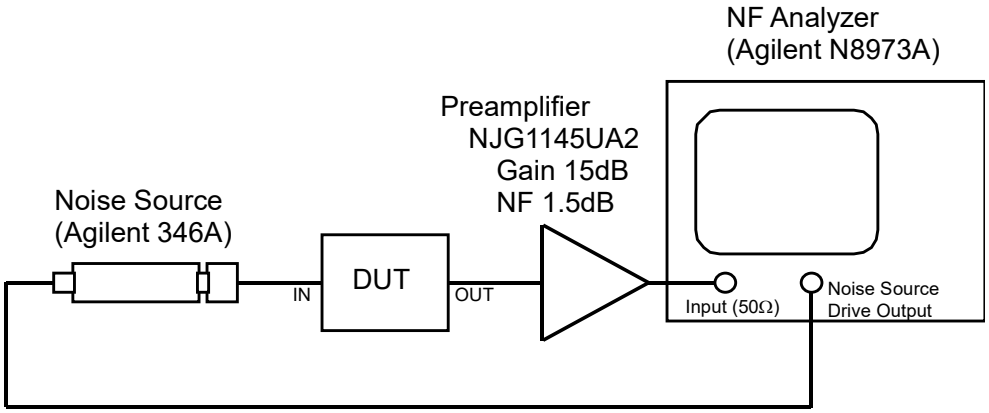
Mode setup form
- Sideband : LSB

Averages : 16
Average mode : Point
Bandwidth : 4MHz
Loss comp : off
Tcold : setting the temperature of noise source (303.15K)



* Preamplifier is used to improve NF measurement accuracy.
* Noise source, preamplifier and NF analyzer are connected directly.

Calibration setup

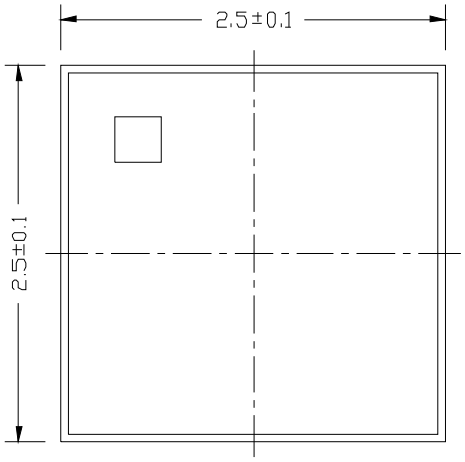


* Noise source, DUT, preamplifier and NF analyzer are connected directly.

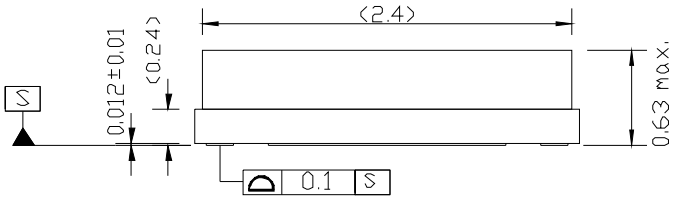
Measurement Setup

■ PACKAGE OUTLINE (HFFP10-CD)

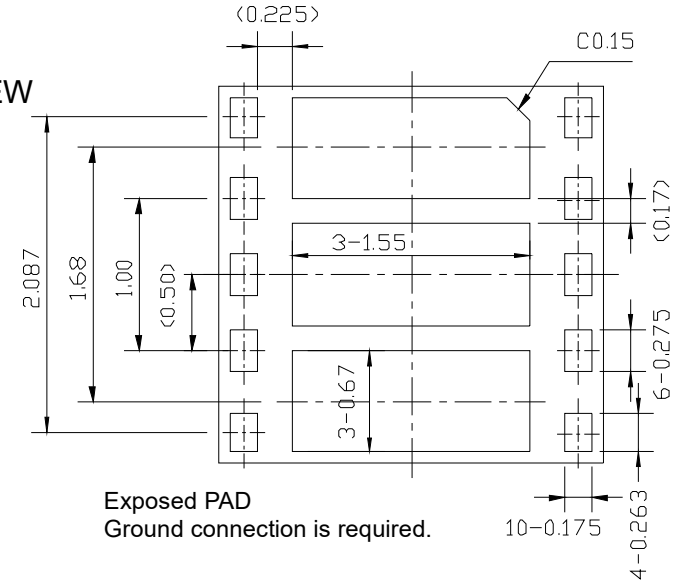
TOP VIEW



SIDE VIEW



BOTTOM VIEW



Exposed PAD
Ground connection is required.

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.

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 electronic device 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. 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.
12. Front end module 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.
    12-1. 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.
    12-2. 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.
    12-3. For dynamic load at the time of mounting. please use it after confirming in consideration of the contact area /speed /load.
13. Please contact our sales representatives should you have any questions or comments concerning the products or the technical information.