Wide Band Low Noise Amplifier with Auto Gain Control Function

■ FEATURES

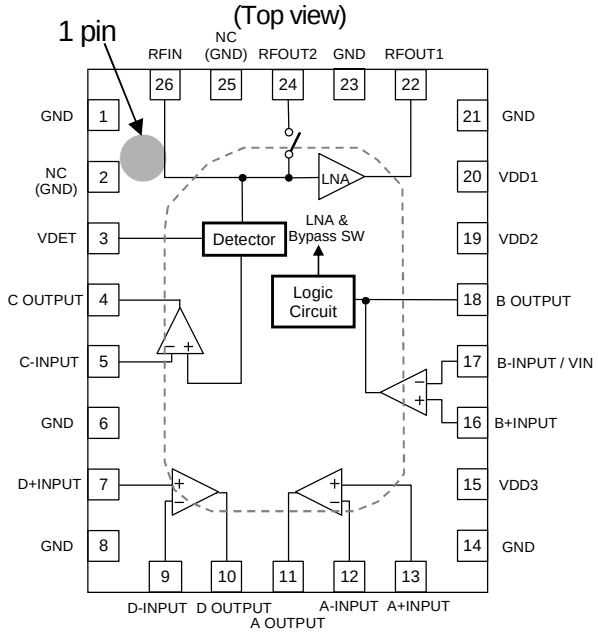
- High gain 18 dB typ. @ 40 to 780 MHz
- Low noise figure 0.9 dB typ. @ 174 to 780 MHz
- Auto gain control (AGC) function with hysteresis
- Integrated signal detector with thermal compensation
- Package size 3.4 x 2.6 mm^2, 26-pin
- RoHS compliant and Halogen Free, MSL1

■ APPLICATION

- Digital TV, DAB, FM, terrestrial broadcast applications
- Active antenna, digital video recorder, set top box, tuner module applications

■ BLOCK DIAGRAM (EQFN26-HH)

(Top view)



■ GENERAL DESCRIPTION

The NJG1740MHH is a wideband low noise amplifier with AGC function for DAB, DTV and FM applications.

This LNA has LNA mode and bypass mode switched by AGC function which features temperature compensation and hysteresis performance to avoid excessively frequent switching (chattering). AGC function is suitable for active antennas whose gain can't be controlled externally.

Its integrated ESD protection circuits bring high ESD tolerance.

The small and thin EQFN26-HH package is adopted.

■ PIN CONFIGURATION

PIN NO.	SYMBOL	DESCRIPTION
1	GND	Ground
2	NC(GND)	No Connection
3	VDET	Detector signal output
4	C OUTPUT	Output C
5	C -INPUT	Inverting input C
6	GND	Ground
7	D +INPUT	Noninverting input D
8	GND	Ground
9	D -INPUT	Inverting input D
10	D OUTPUT	Output D
11	A OUTPUT	Output A
12	A -INPUT	Inverting input A
13	A +INPUT	Noninverting input A
14	GND	Ground
15	VDD3	Power supply 3
16	B +INPUT	Noninverting input B
17	B –INPUT / VIN	Inverting input B / Manual inspection
18	B OUTPUT	Output B
19	VDD2	Power supply 2
20	VDD1	Power supply 1
21	GND	Ground
22	RFOUT1	RF output 1 (LNA mode)
23	GND	Ground
24	RFOUT2	RF output 2 (bypass mode)
25	NC(GND)	No Connection
26	RFIN	RF input
Exposed pad	GND	Ground

■ MARK INFORMATION

NJG1740 MHH (TE1)
| | |
Part number Package Taping form

■ ORDERING INFORMATION

PART NUMBER	PACKAGE OUTLINE	RoHS	HALOGEN-FREE	TERMINAL FINISH	MARKING	WEIGHT (mg)	MOQ (pcs.)
NJG1740MHH	EQFN26-HH	Yes	Yes	Sn-Bi	1740	1.89	1,500

■ ABSOLUTE MAXIMUM RATINGS

T_a = 25°C, Z_s = Z_l = 50 Ω

PARAMETER	SYMBOL	RATINGS	UNIT
Supply voltage	V_{DD}	6.0	V
Inspection voltage	Vin (1)	V_{DD} + 0.3	V
Input power	P_{IN}	+15 (2)	dBm
Power dissipation	P_D	2200 (3)	mW
Operating temperature	T_{opr}	-40 to +105	°C
Storage temperature	T_{stg}	-55 to +150	°C

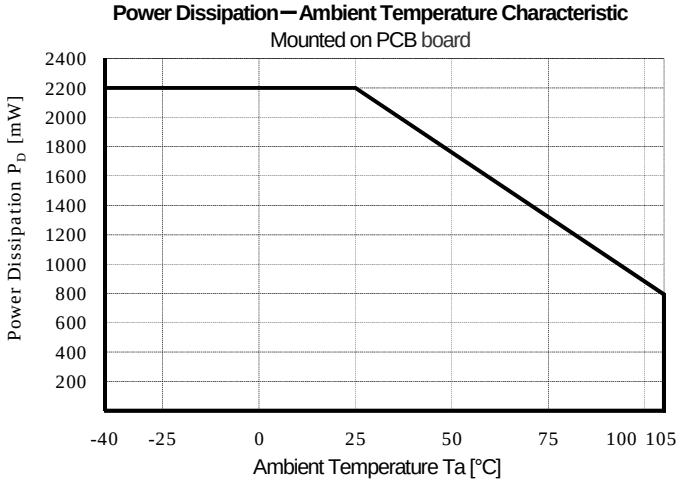
(1): Vin is only applied to select manually LNA active mode or bypass mode for inspection. Please refer APPLICATION CIRCUIT for detail.

(2): V_{DD} =5 V

(3): Mounted on four-layer FR4 PCB with through-hole (114.5 × 101.5 mm), T_j = 150°C

■ POWER DISSIPATION VS.AMBIENT TEMPERATURE

Please, refer to the following Power Dissipation and Ambient Temperature.
(Please note the surface mount package has a small maximum rating of Power Dissipation [P_D],
a special attention should be paid in designing of thermal radiation.)



■ ELECTRICAL CHARACTERISTICS 1 (DC CHARACTERISTICS)

T_a = 25°C, with application circuit

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Supply voltage	V_{DD}		4.7	5.0	5.5	V
Operating current 1	$I_{DD}1$	LNA active mode	-	40	100	mA
Operating current 2	$I_{DD}2$	Bypass mode	-	10	20	mA

■ ELECTRICAL CHARACTERISTICS 2 (LNA active mode)

V_{DD} = 5V, freq = 40 to 780 MHz, T_a = 25°C, Z_s = Z_l = 50 Ω, with application circuit

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Small signal gain	Gain	Exclude PCB & connector losses (Note1)	15.0	18.0	21.0	dB
Noise figure1_1	NF1_1	freq = 40 to 174 MHz, exclude PCB & connector losses (Note2)	-	1.2	2.0	dB
Noise figure 1_2	NF1_2	freq = 174 to 780 MHz, exclude PCB & connector losses (Note2)	-	0.9	1.3	dB
3rd order intermodulation distortion1	IM3_1	f1 = freq, f2 = freq + 100 kHz Pin = -60 dBm	-	-	-105	dBm
Input 3rd order intercept point1	IIP3_1	f1 = freq, f2 = freq + 100 kHz Pin = -45 dBm (Note 3)	-15	-5.0	-	dBm
RFIN port return loss1	RLi1		4.5	7.5	-	dB
RFOUT port return loss 1	RLo1		8.0	14.0	-	dB

■ ELECTRICAL CHARACTERISTICS 3 (Bypass mode)

V_{DD} = 5V, freq = 40 to 780 MHz, T_a = 25°C, Z_s = Z_l = 50Ω, with application circuit

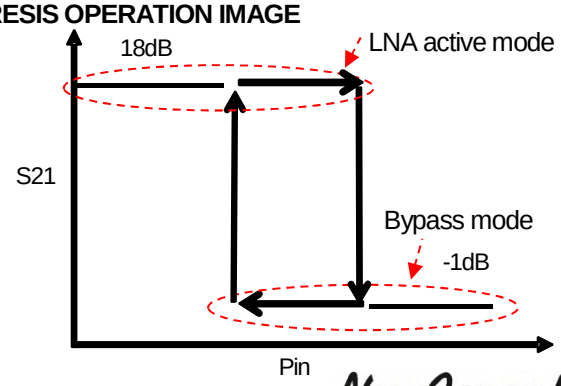
PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Insertion loss	Loss	Exclude PCB & connector losses (Note1)	-	1.0	3.0	dB
3rd order intermodulation distortion 2_1	IM3_2_1	f1 = 40 to 68 MHz, f2 = freq + 100 kHz, Pin = -34 dBm	-	-115	-100	dBm
3rd order intermodulation distortion 2_2	IM3_2_2	f1 = 68 to 240 MHz, f2 = freq + 100 kHz, Pin = -34 dBm	-	-105	-90	dBm
3rd order intermodulation distortion 2_3	IM3_2_3	f1 = 240 to 780 MHz, f2 = freq + 100 kHz, Pin = -34 dBm	-	-95	-80	dBm
Input 3rd order intercept point 2_1	IIP3_2_1	f1 = 40 to 68 MHz, f2 = freq + 100 kHz, Pin = -34 dBm (Note 3)	-2.0	+6.0	-	dBm
Input 3rd order intercept point 2_2	IIP3_2_2	f1 = 68 to 240 MHz, f2 = freq + 100 kHz, Pin = -34 dBm (Note 3)	-7.5	+1.0	-	dBm
Input 3rd order intercept point 2_3	IIP3_2_3	f1 = 240 to 780 MHz, f2 = freq + 100 kHz, Pin = -34 dBm (Note 3)	-12.5	-4.0	-	dBm
RFIN port return loss 2	RLi2		7.5	14.0	-	dB
RFOUT port return loss 2	RLo2		7.5	14.0	-	dB

(Note1) Input and output PCB, connector losses: 0.01 dB (40 MHz), 0.03 dB (174 MHz), 0.09 dB (620 MHz), 0.11 dB (780 MHz)

(Note2) Input PCB and connector losses: 0.01 dB (40 MHz), 0.02 dB (174 MHz), 0.04 dB (620 MHz), 0.05 dB (780 MHz)

(Note3) IIP3 = OIP3-Gain, OIP3 = (3*Pout-IM3)/2

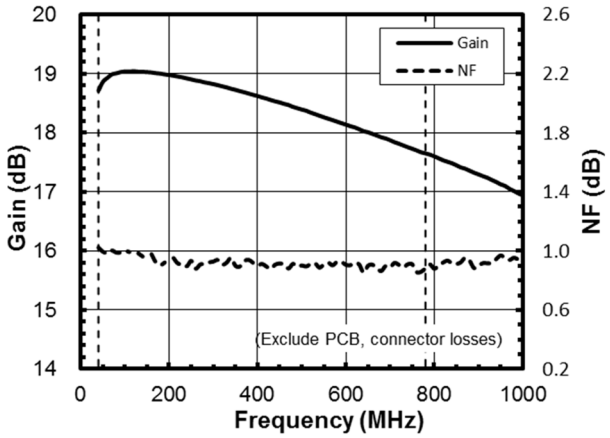
■ HYSTERESIS OPERATION IMAGE



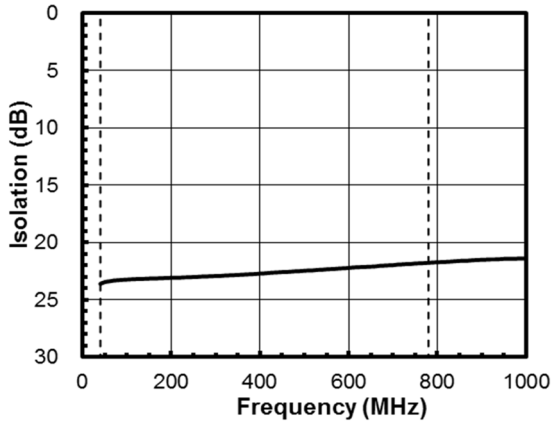
■ ELECTRICAL CHARACTERISTICS (LNA active mode)

General condition: V_{DD} = 5.0 V, T_a = 25°C, Z_S = Z_l = 50 Ω, with application circuit

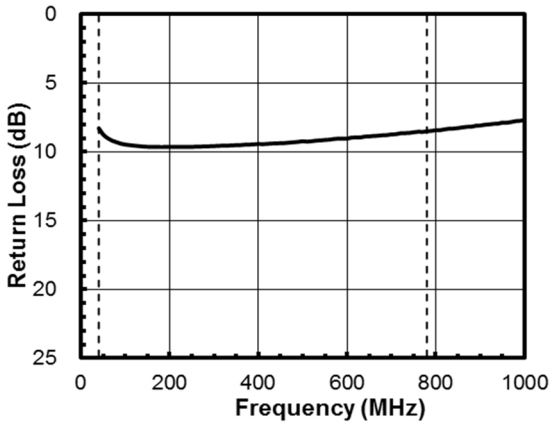
Gain, NF vs. Frequency



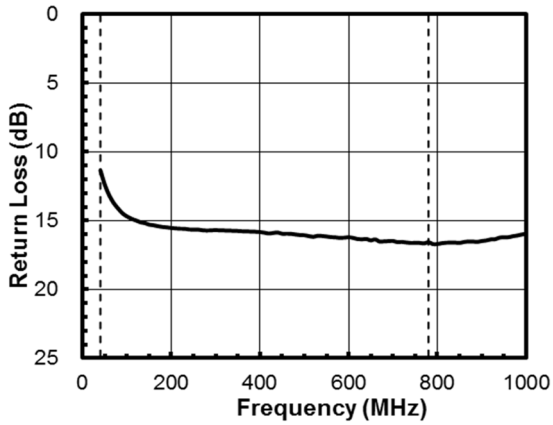
Reverse Isolation vs. Frequency



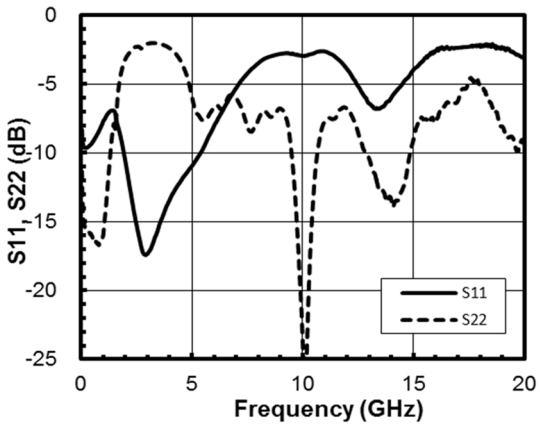
RFIN Return Loss vs. Frequency



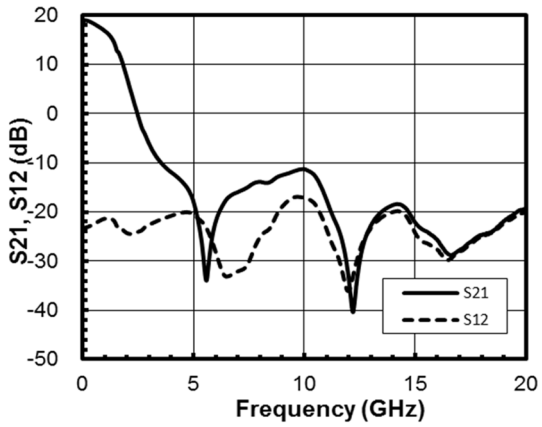
RFOUT Return Loss vs. Frequency



S11, S22 vs. Frequency

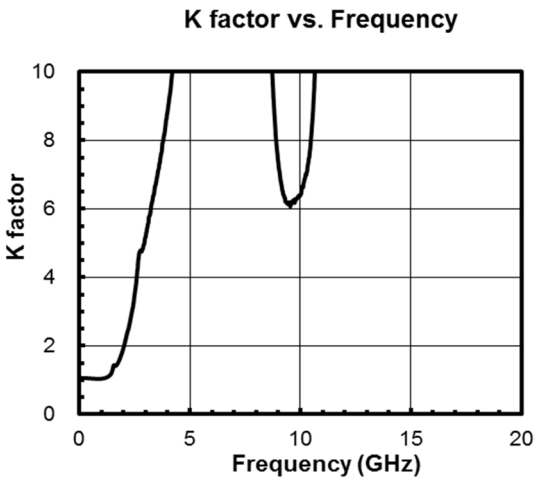


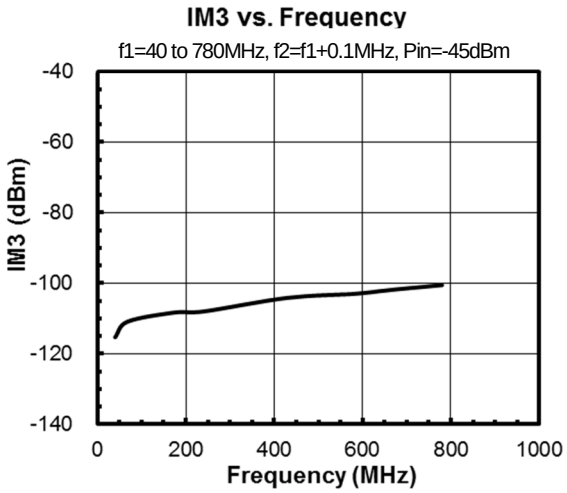
S21, S12 vs. Frequency

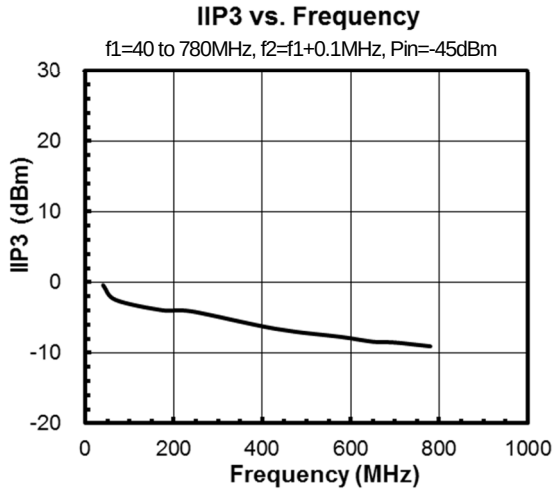


■ ELECTRICAL CHARACTERISTICS (LNA active mode)

General condition: V_{DD} = 5.0 V, T_a = 25°C, Z_S = Z_l = 50 Ω, with application circuit



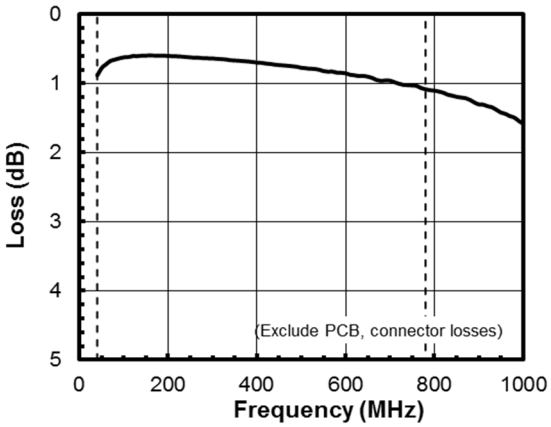




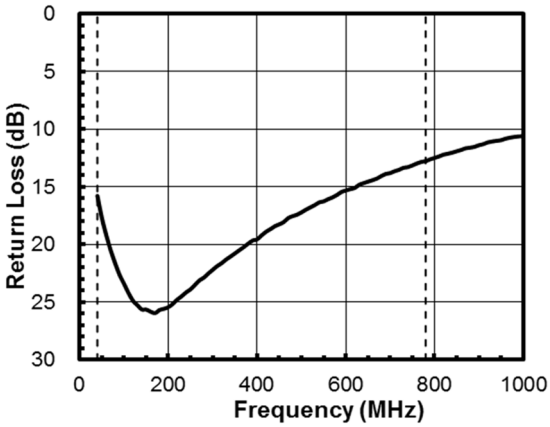
■ ELECTRICAL CHARACTERISTICS (Bypass mode)

General condition: V_{DD} = 5.0 V, T_a = 25°C, Z_S = Z_I = 50 Ω, with application circuit

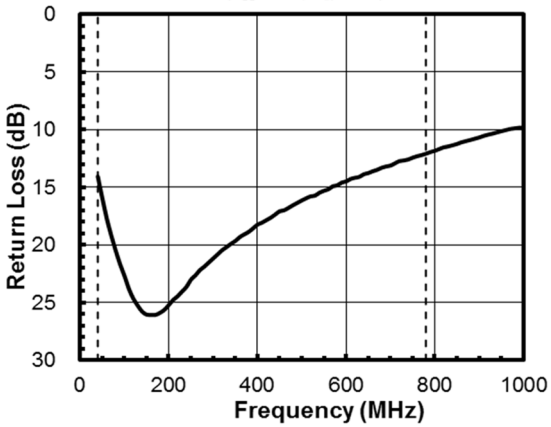
Loss vs. Frequency



RFIN Return Loss vs. Frequency

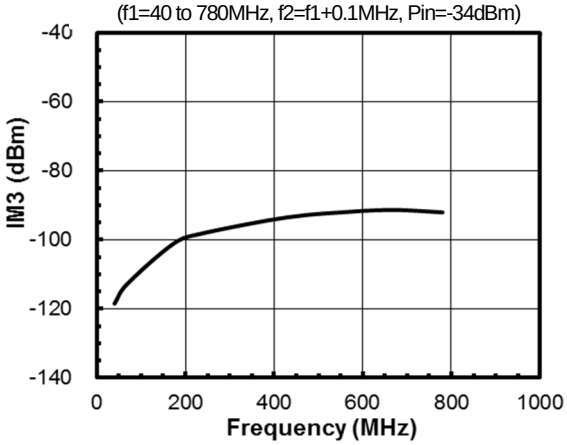


RFOUT Return Loss vs. Frequency



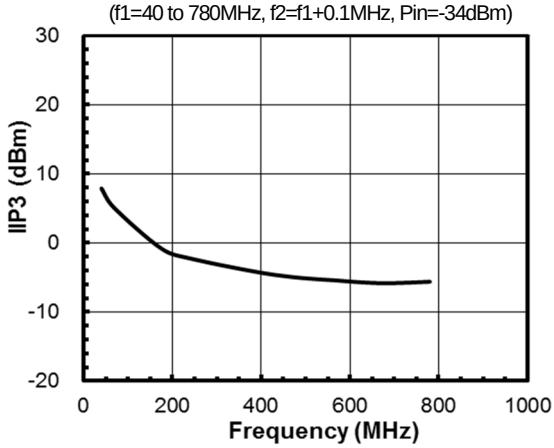
IM3 vs. Frequency

(f1=40 to 780MHz, f2=f1+0.1MHz, Pin=-34dBm)



IIP3 vs. Frequency

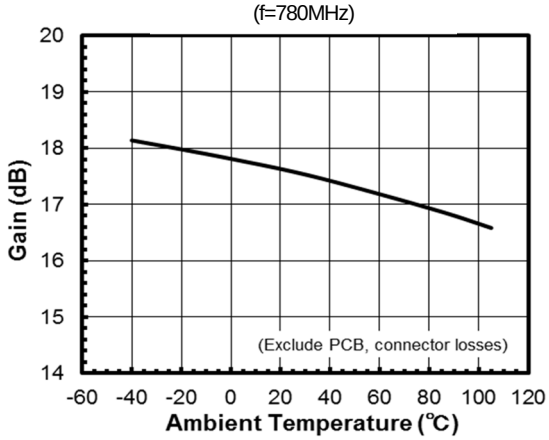
(f1=40 to 780MHz, f2=f1+0.1MHz, Pin=-34dBm)



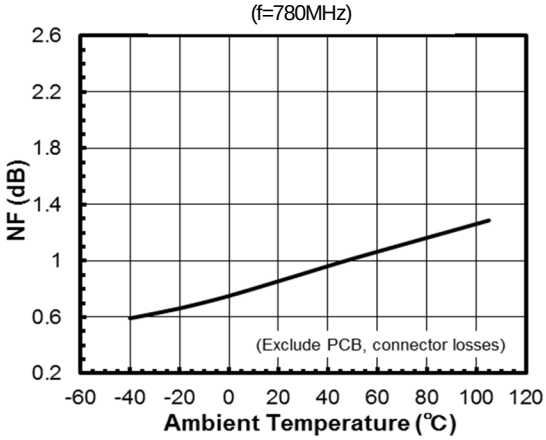
■ ELECTRICAL CHARACTERISTICS (LNA active mode)

General condition: V_{DD} = 5.0 V, Z_S = Z_L = 50 Ω, with application circuit

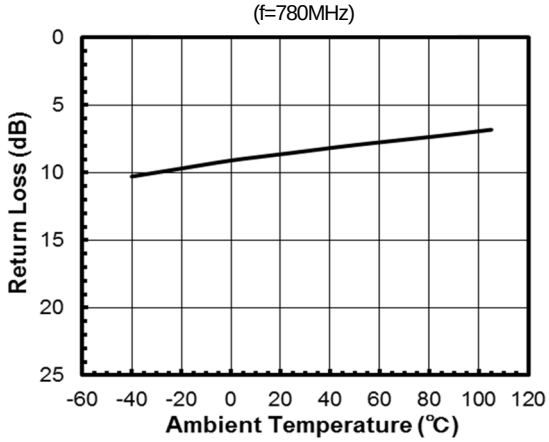
Gain vs. Ambient Temperature
(f=780MHz)



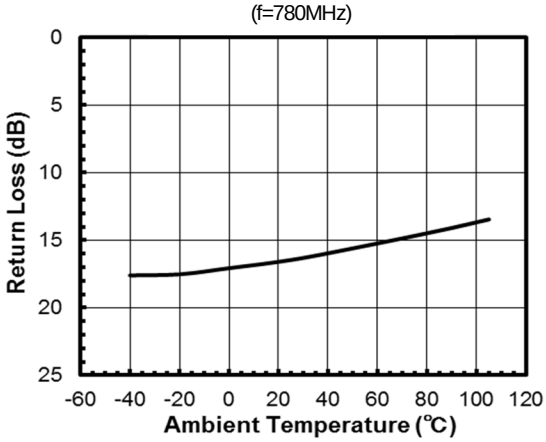
NF vs. Ambient Temperature
(f=780MHz)



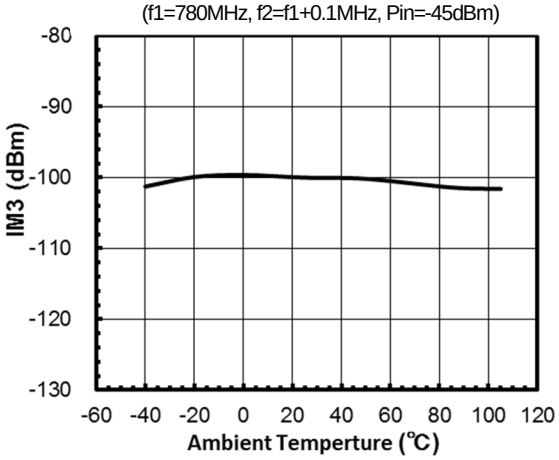
RFIN Return Loss vs. Ambient Temperature
(f=780MHz)



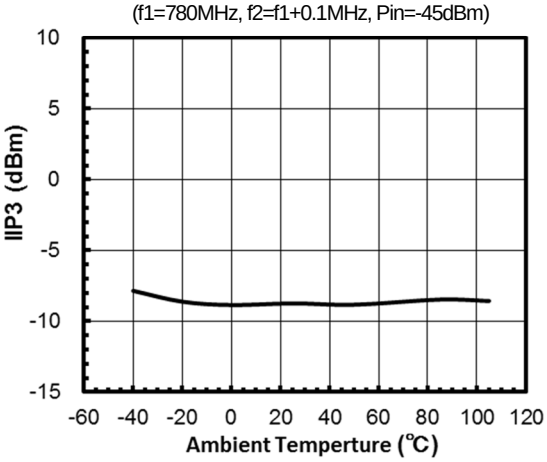
RFOUT Return Loss vs. Ambient Temperature
(f=780MHz)



IM3 vs. Ambient Temperture
(f1=780MHz, f2=f1+0.1MHz, Pin=-45dBm)



IIP3 vs. Ambient Temperture
(f1=780MHz, f2=f1+0.1MHz, Pin=-45dBm)

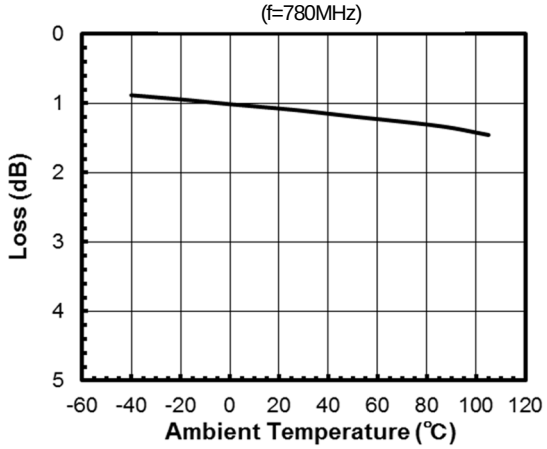


■ ELECTRICAL CHARACTERISTICS (Bypass mode)

General condition: V_{DD} = 5.0 V, Z_S = Z_I = 50 Ω, with application circuit

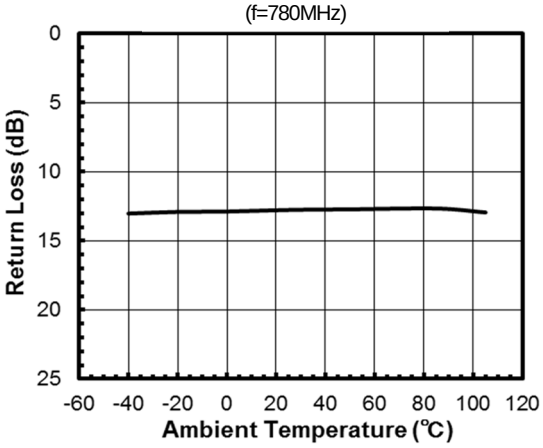
Loss vs. Ambient Temperature

(f=780MHz)



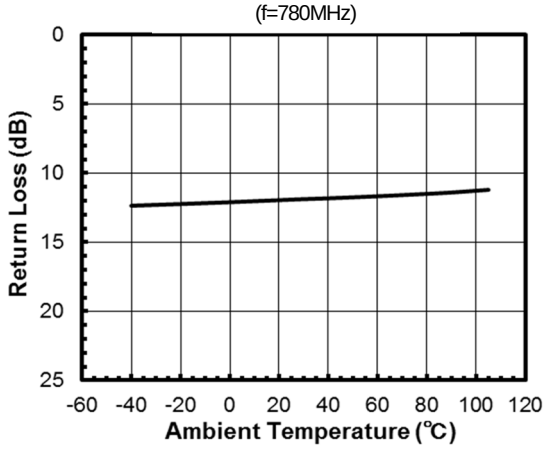
RFIN Return Loss vs. Ambient Temperature

(f=780MHz)



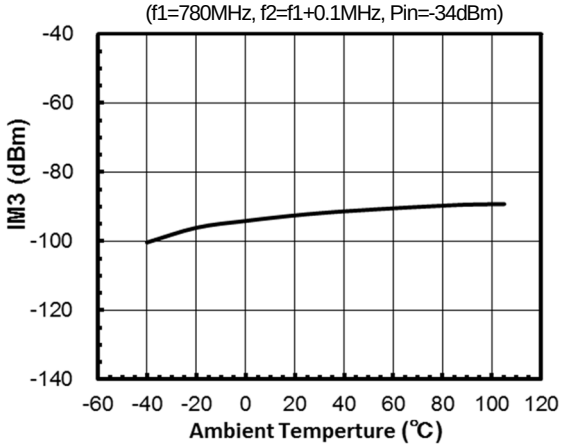
RFOUT Return Loss vs. Ambient Temperature

(f=780MHz)



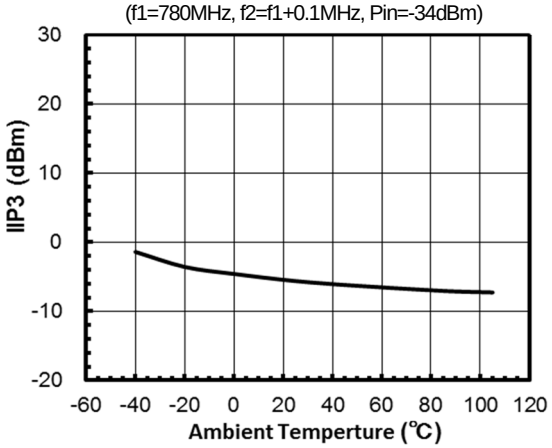
IM3 vs. Ambient Temperture

(f1=780MHz, f2=f1+0.1MHz, Pin=-34dBm)



IIP3 vs. Ambient Temperture

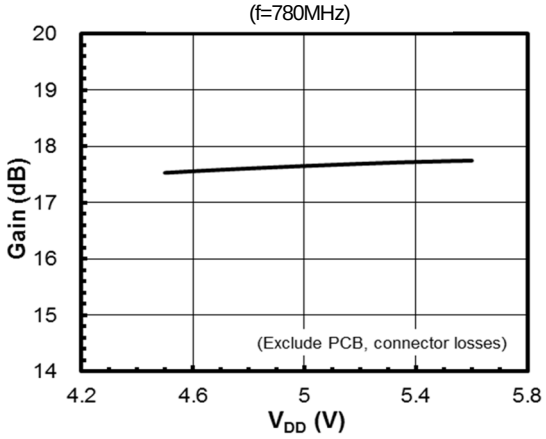
(f1=780MHz, f2=f1+0.1MHz, Pin=-34dBm)



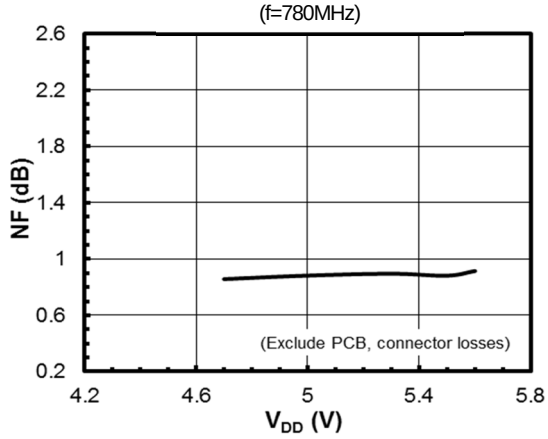
■ ELECTRICAL CHARACTERISTICS (LNA active mode)

General condition: T_a = 25°C, Z_s = Z_l = 50 Ω, with application circuit

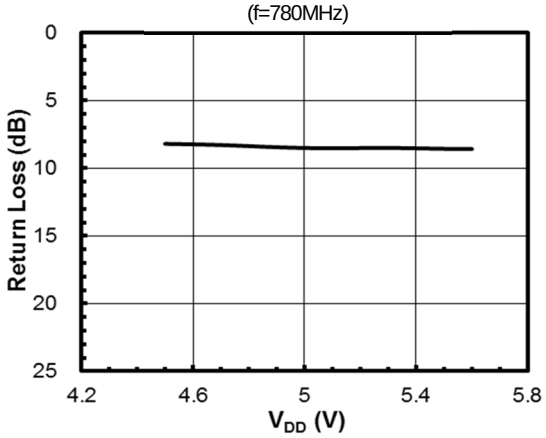
Gain vs. V_{DD}
(f=780MHz)



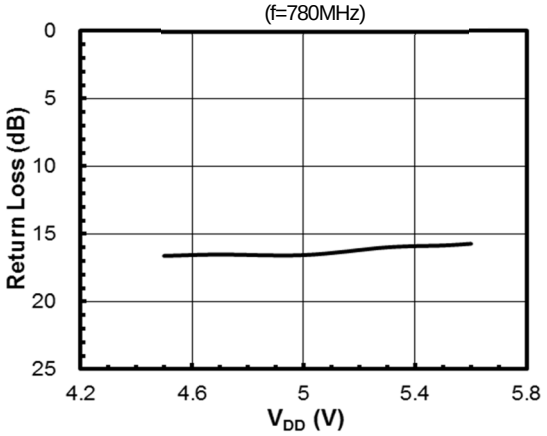
NF vs. V_{DD}
(f=780MHz)



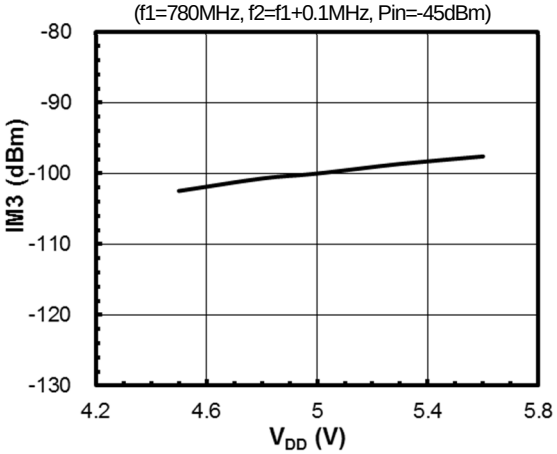
RFIN Return Loss vs. V_{DD}
(f=780MHz)



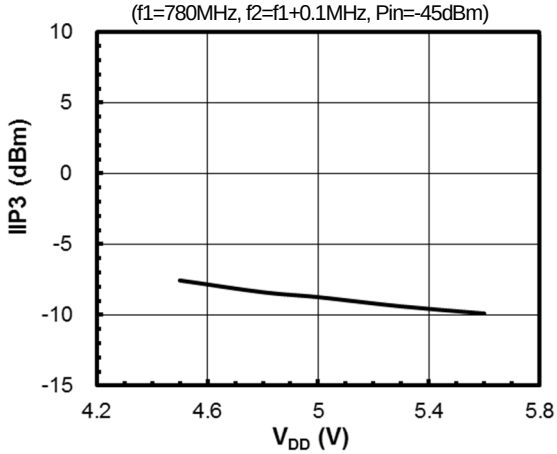
RFOUT Return Loss vs. V_{DD}
(f=780MHz)



IM3 vs. V_{DD}
(f1=780MHz, f2=f1+0.1MHz, Pin=-45dBm)



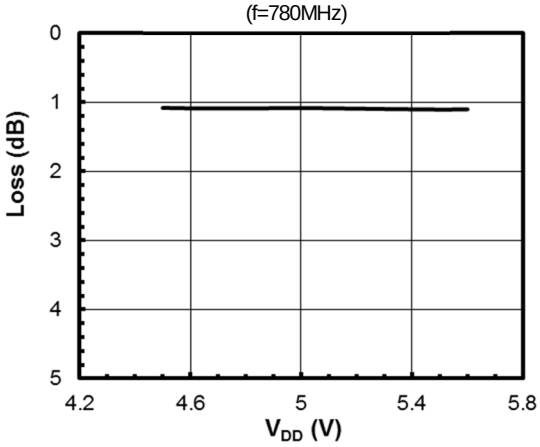
IIP3 vs. V_{DD}
(f1=780MHz, f2=f1+0.1MHz, Pin=-45dBm)



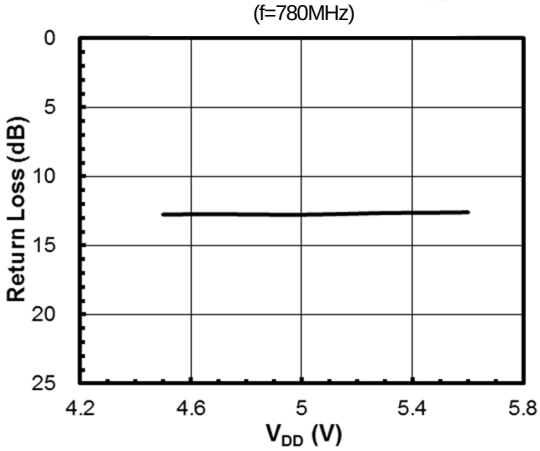
■ ELECTRICAL CHARACTERISTICS (Bypass mode)

General condition: T_a = 25°C, Z_s = Z_l = 50 Ω, with application circuit

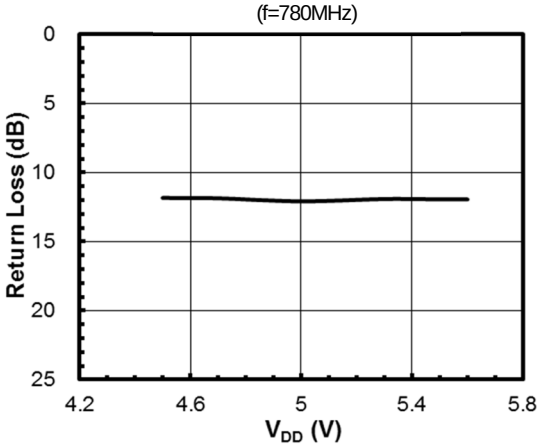
Loss vs. V_{DD}
(f=780MHz)



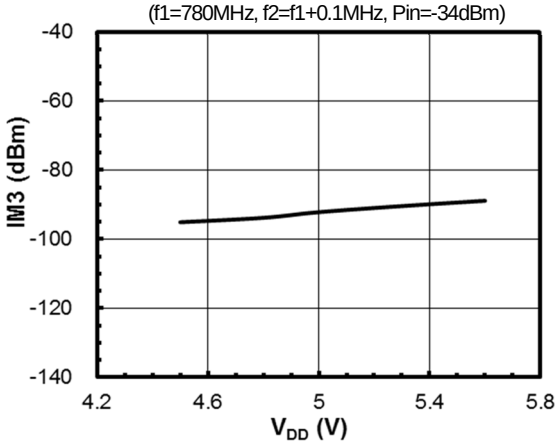
RFIN Return Loss vs. V_{DD}
(f=780MHz)



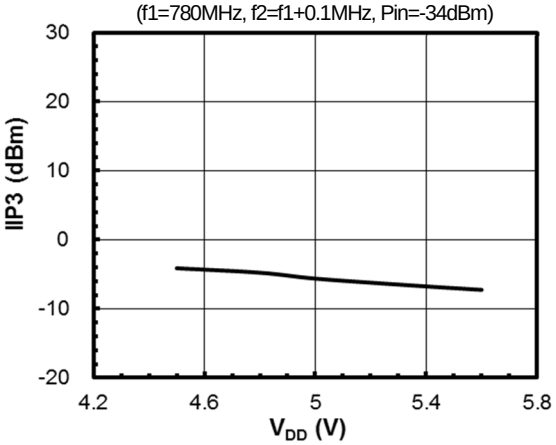
RFOUT Return Loss vs. V_{DD}
(f=780MHz)



IM3 vs. V_{DD}
(f1=780MHz, f2=f1+0.1MHz, Pin=-34dBm)



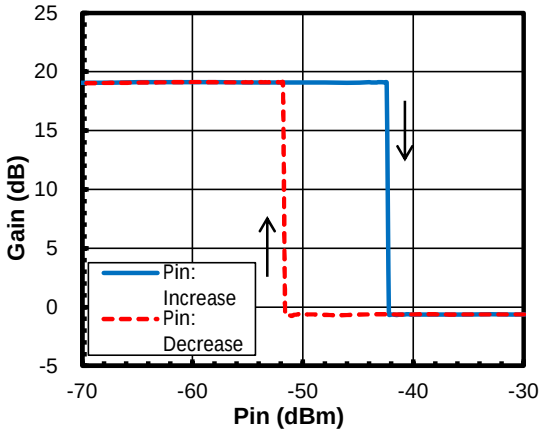
IIP3 vs. V_{DD}
(f1=780MHz, f2=f1+0.1MHz, Pin=-34dBm)



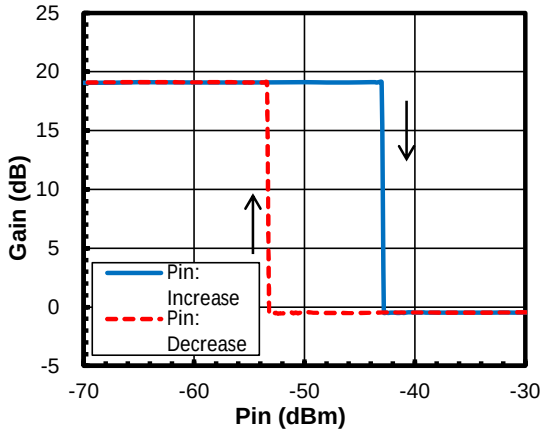
■ ELECTRICAL CHARACTERISTICS (Auto gain control)

General condition: V_{DD} = 5.0V, T_a = 25°C, Z_S = Z_l = 50 Ω, with application circuit

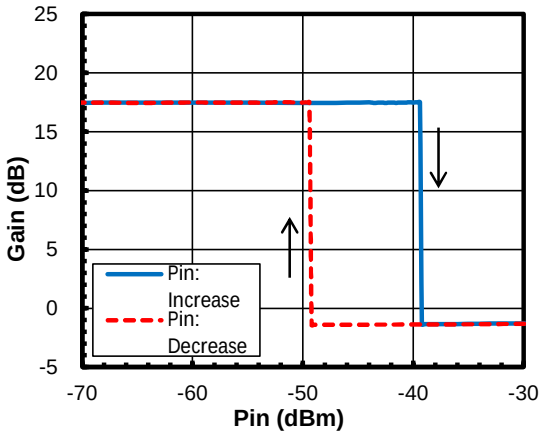
Gain vs. Pin
(V_{DD}=5.0V, f=40MHz)



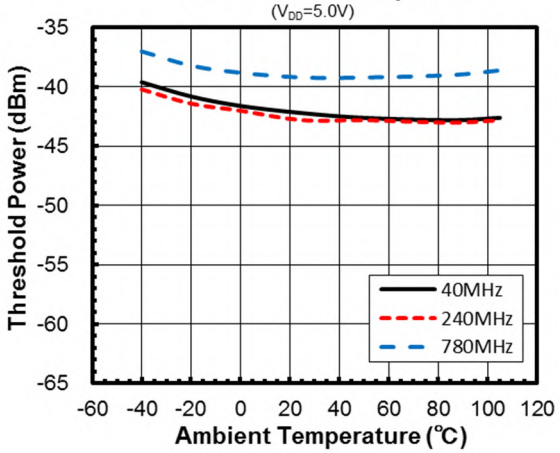
Gain vs. Pin
(V_{DD}=5.0V, f=240MHz)



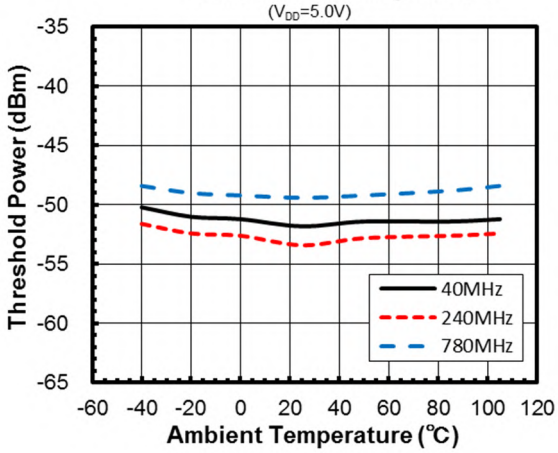
Gain vs. Pin
(V_{DD}=5.0V, f=780MHz)



Threshold Power of LNA to Bypass mode
vs. Ambient Temperature
(V_{DD}=5.0V)

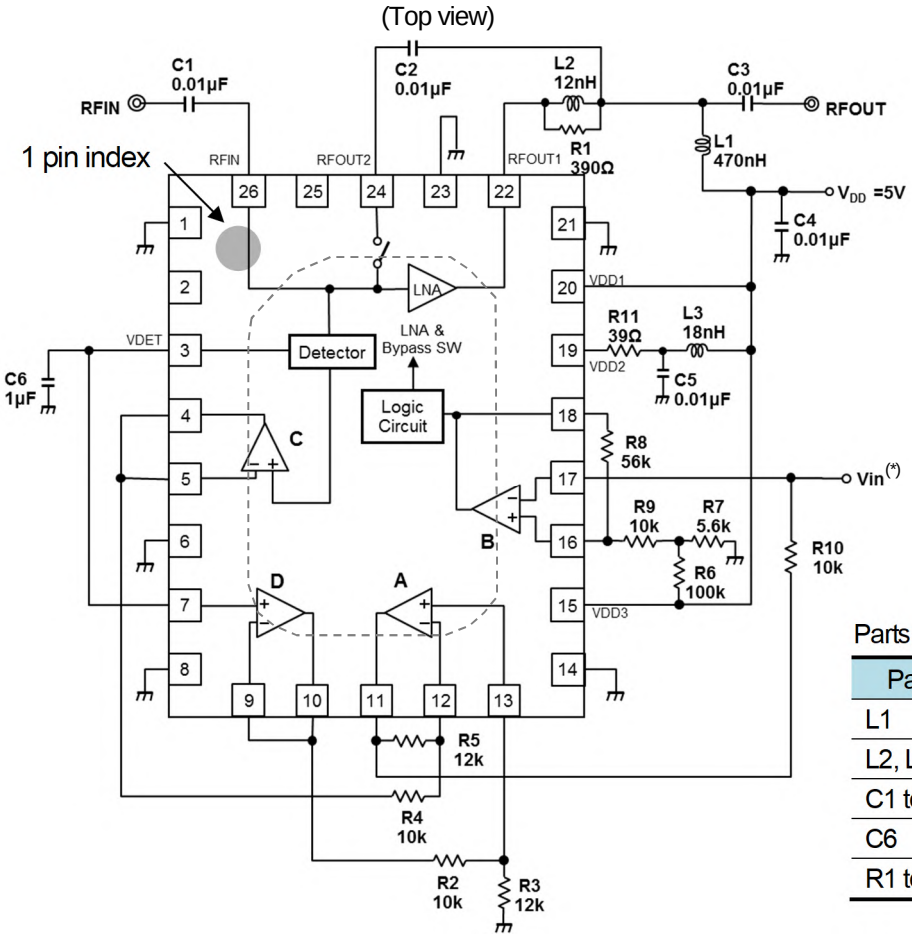


Threshold Power of Bypass to LNA mode
vs. Ambient Temperature
(V_{DD}=5.0V)



■ APPLICATION CIRCUIT

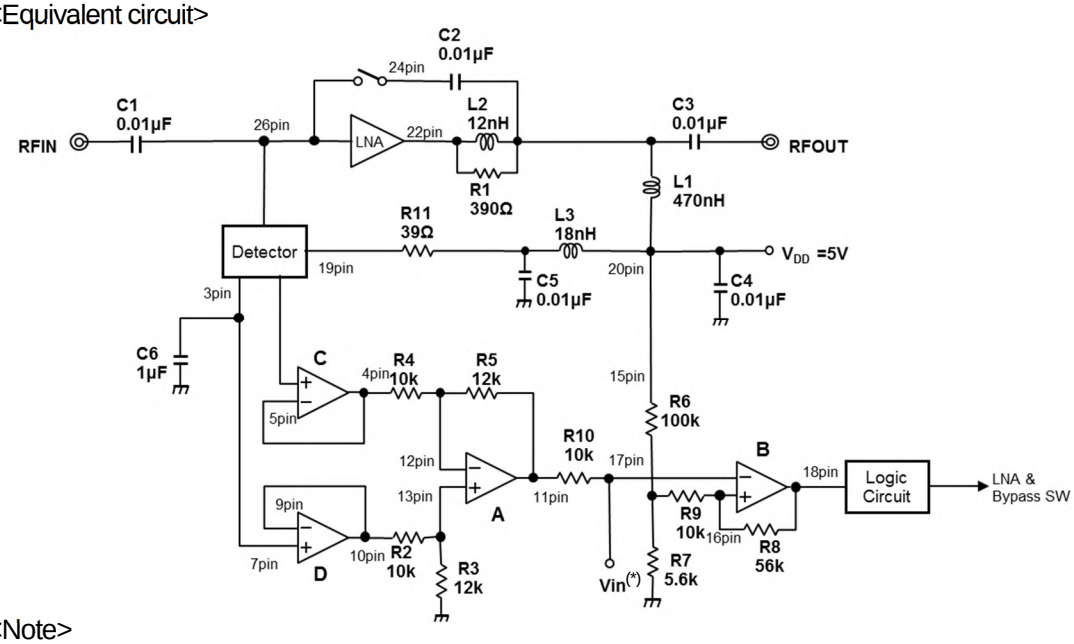
(Top view)



Parts list

Part ID	Notes
L1	TAIYO-YUDEN HK1608 series
L2, L3	TAIYO-YUDEN HK1005 series
C1 to C5	MURATA GRM15 series
C6	MURATA GRM18 series
R1 to R11	KOA RK73H series

<Equivalent circuit>



<Note>

*Regarding Vin, please keep open normally and not applying voltage externally when auto gain control function is used.

Applying voltage to Vin is only used to select manually and inspect performance of LNA active mode or bypass mode as below:

Vin = 0V → LNA active mode

Vin = 5V → Bypass mode

■NF MEASUREMENT BLOCK DIAGRAM

Measuring instruments

NF Analyzer : Keysight 8975A

Noise Source : Keysight 346A

Setting the NF analyzer

Measurement mode form

Device under test : Amplifier

System downconverter : off

Mode setup form

Sideband : LSB

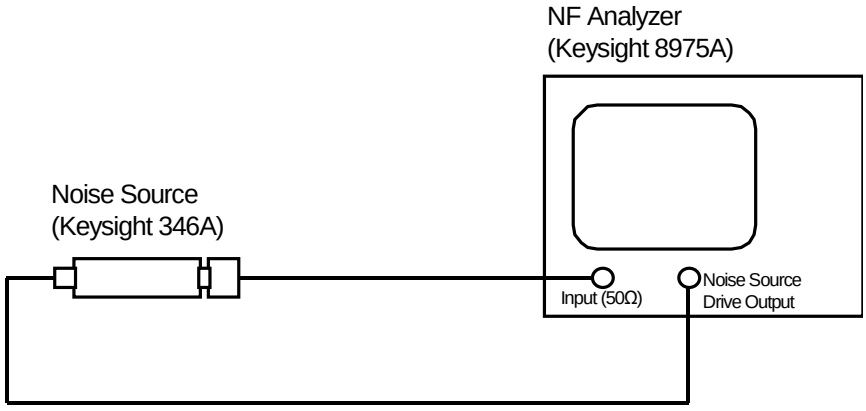
Averages : 4

Average mode : Point

Bandwidth : 4 MHz

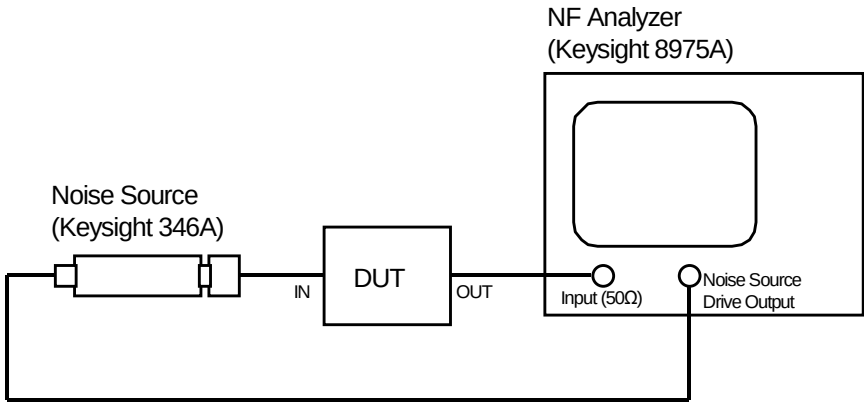
Loss comp : off

Tcold : setting the temperature of noise source (303 K)



* Noise source and NF analyzer are connected directly.

Calibration Setup

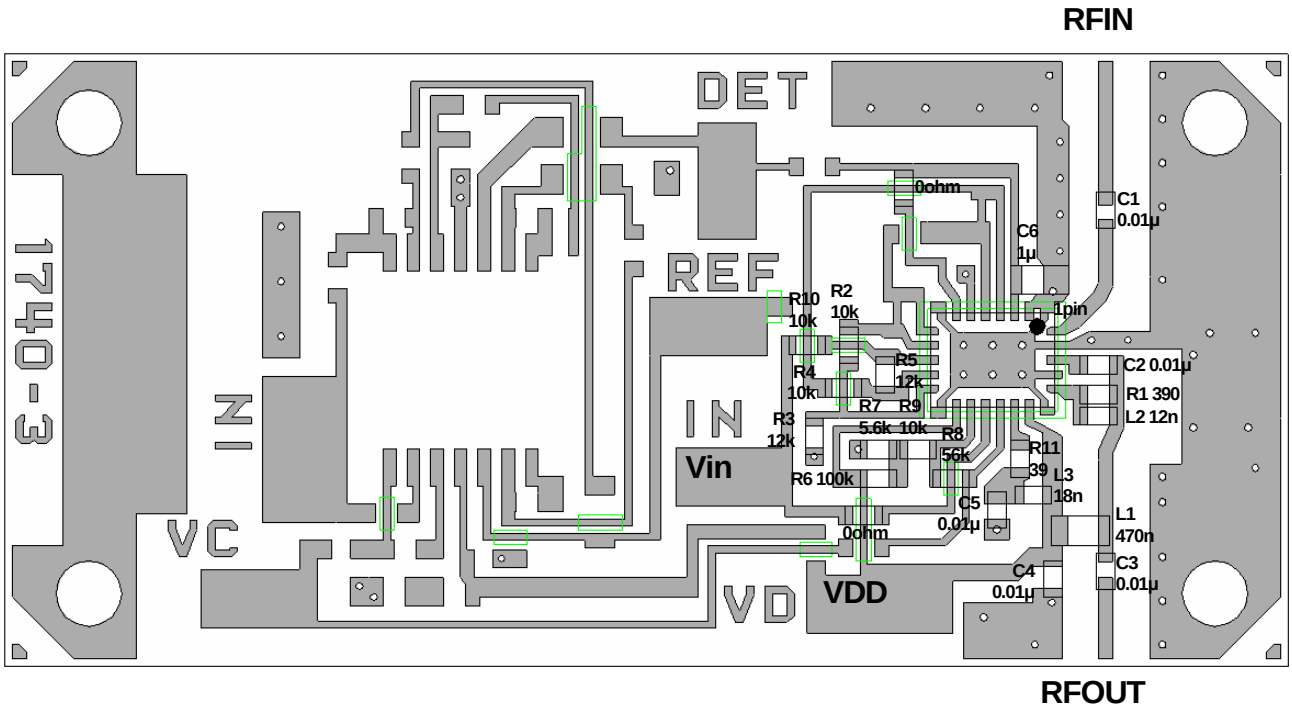


* Noise source and DUT, DUT and NF analyzer are connected directly.

Measurement Setup

■ EVALUATION BOARD

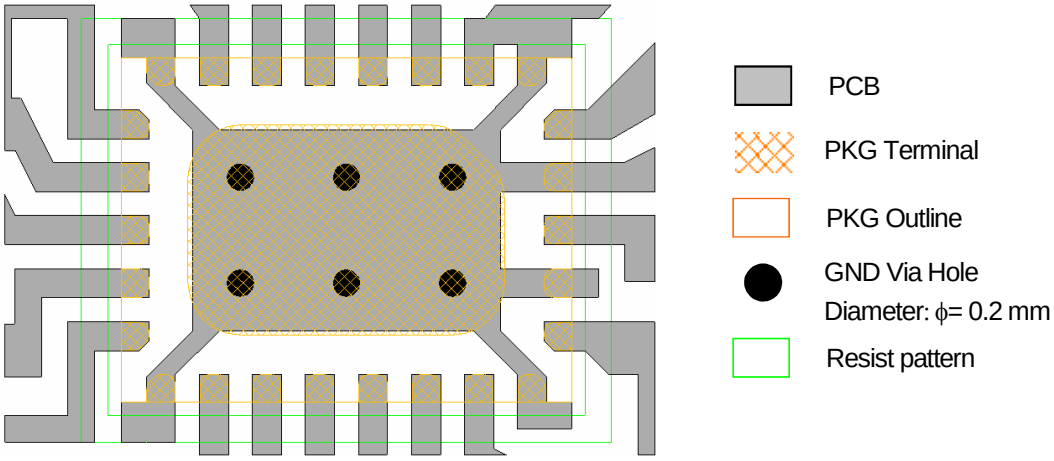
(Top View)



PCB Information

Substrate:	FR-4
Thickness:	0.2 mm
Micro strip line width:	0.4 mm (Z_0 = 50 Ω)
Size:	35.2 mm x 16.8 mm

<PCB LAYOUT GUIDELINE>



PRECAUTIONS

- 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.
- In order not to couple with terminal RFIN and RFOUT, please layout ground pattern between both terminals.

■ RECOMMENDED FOOTPRINT PATTERN (EQFN26-HH)

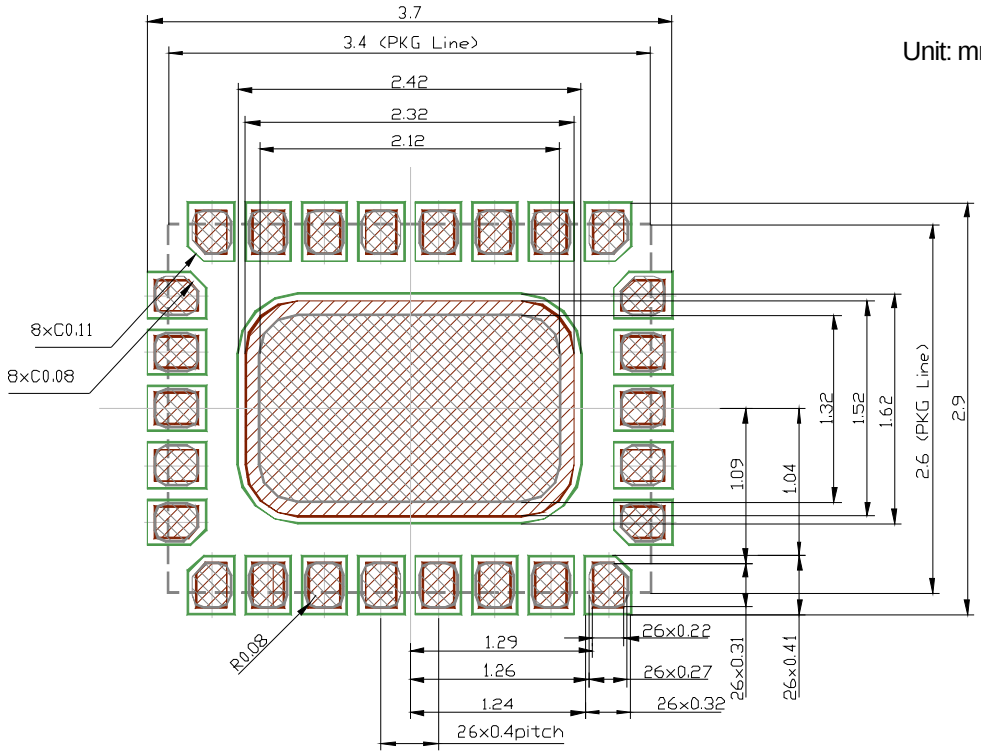
: Land

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

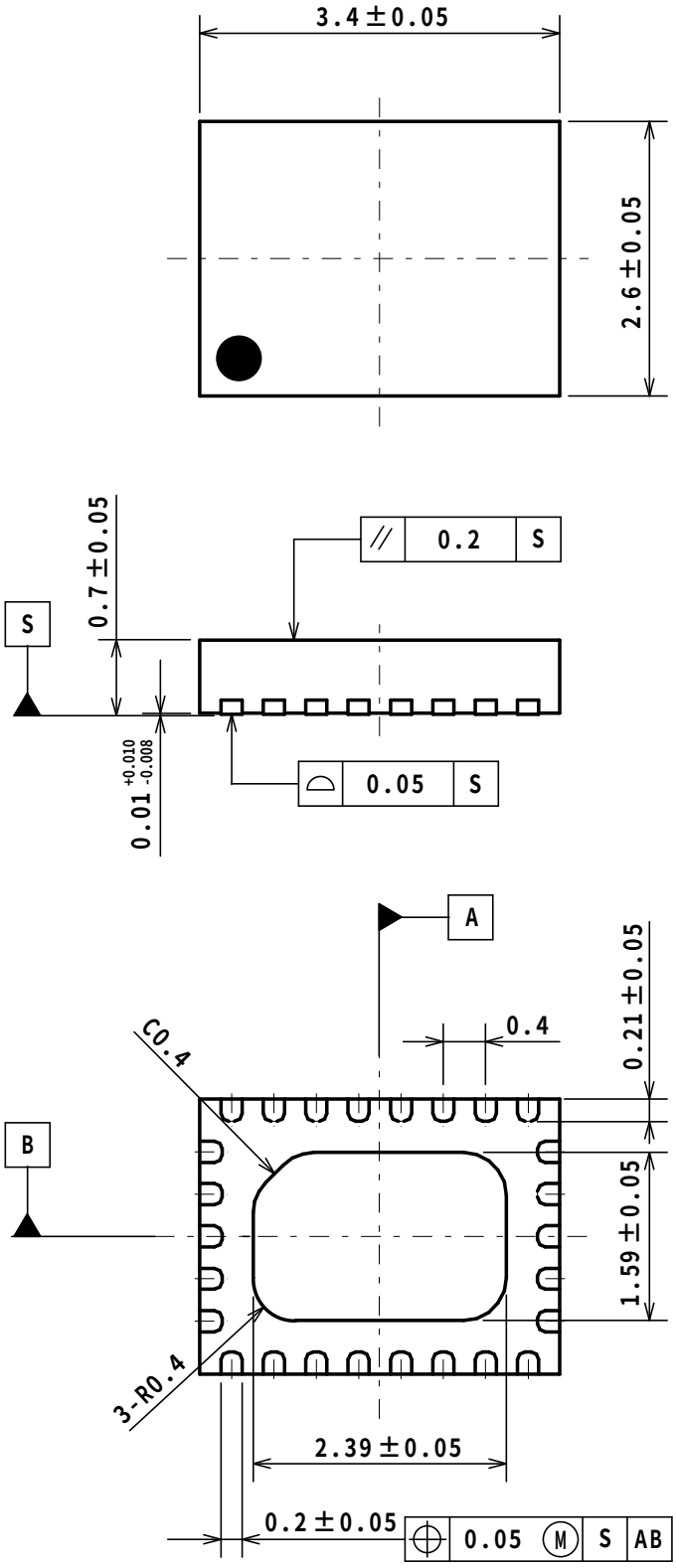
: Resist (Open area)

PKG: 3.4 mm x 2.6 mm
Pin pitch: 0.4 mm

Unit: mm



■ PACKAGE OUTLINE (EQFN26-HH)

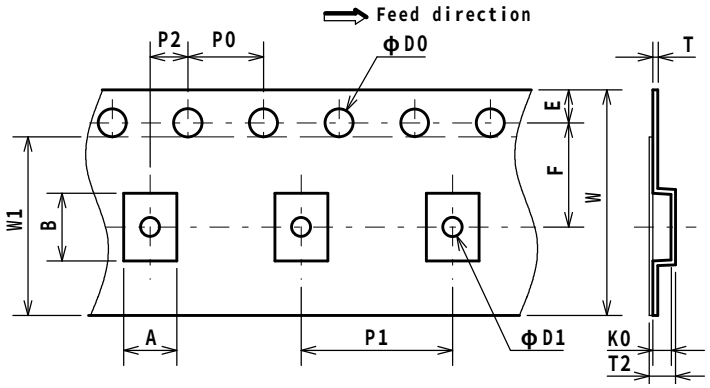


Units	: mm
Board	: Cu
Terminal treat	: SnBi
Molding material	: Epoxy resin
Weight	: 1.89 mg

■ PACKING SPECIFICATION (EQFN26-HH)

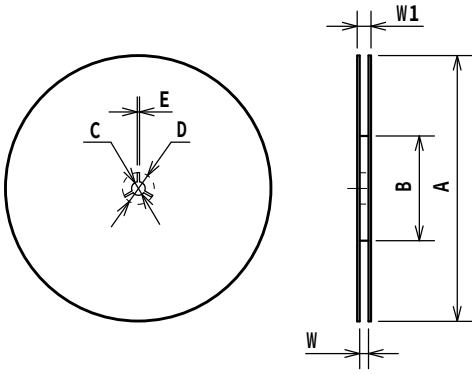
Unit: mm

TAPING DIMENSIONS



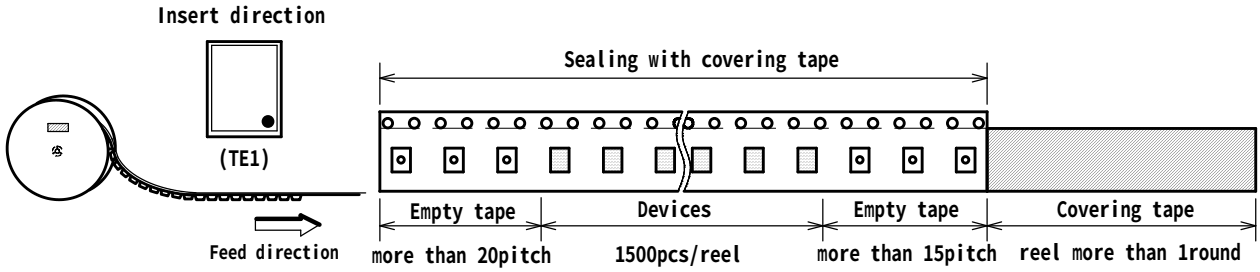
SYMBOL	DIMENSION	REMARKS
A	2.8±0.05	BOTTOM DIMENSION
B	3.6±0.05	BOTTOM DIMENSION
D0	$1.5^{+0.1}_{0}$	
D1	$1.0^{+0.1}_{0}$	
E	1.75±0.1	
F	5.5±0.05	
P0	4.0±0.1	
P1	8.0±0.1	
P2	2.0±0.05	
T	0.25±0.05	
T2	1.2	
K0	0.85±0.05	
W	$12.0^{+0.3}_{-0.1}$	
W1	9.5	THICKNESS 0.1max

REEL DIMENSIONS

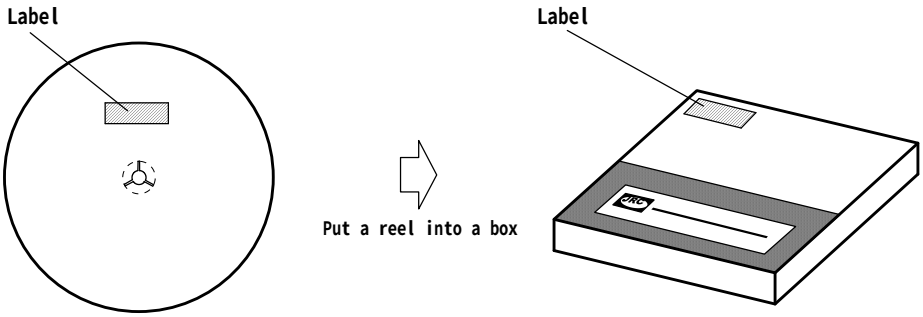


SYMBOL	DIMENSION
A	$\Phi 180^{0}_{-3}$
B	$\Phi 60^{+1}_{0}$
C	Φ 13±0.2
D	Φ 21±0.8
E	2±0.5
W	$13^{+1.0}_{0}$
W1	15.4±1.0

TAPING STATE



PACKING STATE



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