AN11072

BGU7003 400 MHz and 900 MHz application

Rev. 1 — 7 December 2011 Application note

Document information

Info	Content
Keywords	BGU7003, LNA, E-metering.
Abstract	This document provides circuit, layout, BOM and tested performance for 400 MHz and 900 MHz band LNA for E-metering applications based on the BGU7003.

Revision history

Rev	Date	Description
v.1	20111207	initial version

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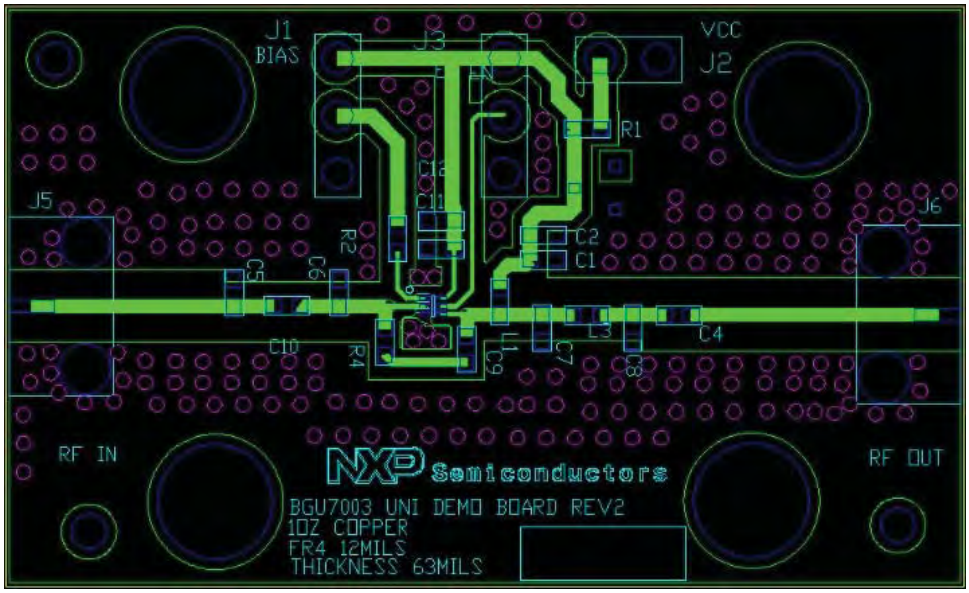
1. Introduction

The BGU7003 is a wideband low noise amplifier in a plastic, leadless 6 pin extremely thin small outline SOT891 package. It can be used for various LNA applications up to 6 GHz such as GPS, satellite radio, cordless phone and E-metering.

The BGU7003 contains 1 RF stage and an internal bias that is temperature stabilized. It also contains an enable function to shut down the amplifier with a logic signal on the enable pin.

The BGU7003 is ideal for use where size and low power are most critical. Typical usages are mobile phones, Personal Digital Assistants (PDA), Personal Navigation Devices (PND), E-metering and remote controllers.



aaa-000915

Fig 1. BGU7003 EVB demo board

2. General description

This universal LNA evaluation board (EVB) is optimized to evaluate the performance of the BGU7003 in an E-metering application.

This document details circuit simulations and results in Agilent ADS, and provides information on the application schematic, board layout and the bill of materials. Typical test results are also shown.

3. Typical design requirement of E-metering LNA

Low Noise Figure is important to improve meter reading sensitivity where blockage and fading could occur. The following is a list of typical design requirements:

- Operating frequency band: 400 MHz to 450 MHz and 900 MHz to 950 MHz
- Operating voltage: 3.3 V to 3.7 V
- Current draw: 5 mA
- Noise figure: < 1.2 dB
- Gain: > 15 dB
- In-band gain flatness: 2 dB (+/-1 dB)
- Return loss: input > 10 dB, Output > 10 dB
- Reverse isolation: > 23 dB

4. Application circuit simulation

4.1 BGU7003 400 MHz band LNA simulation

Assumptions:

- 50 Ω termination at source and load
- Device is modeled as a small signal s-parameter file at 2.5 V with 5 mA bias condition
- 3.7 V supply voltage

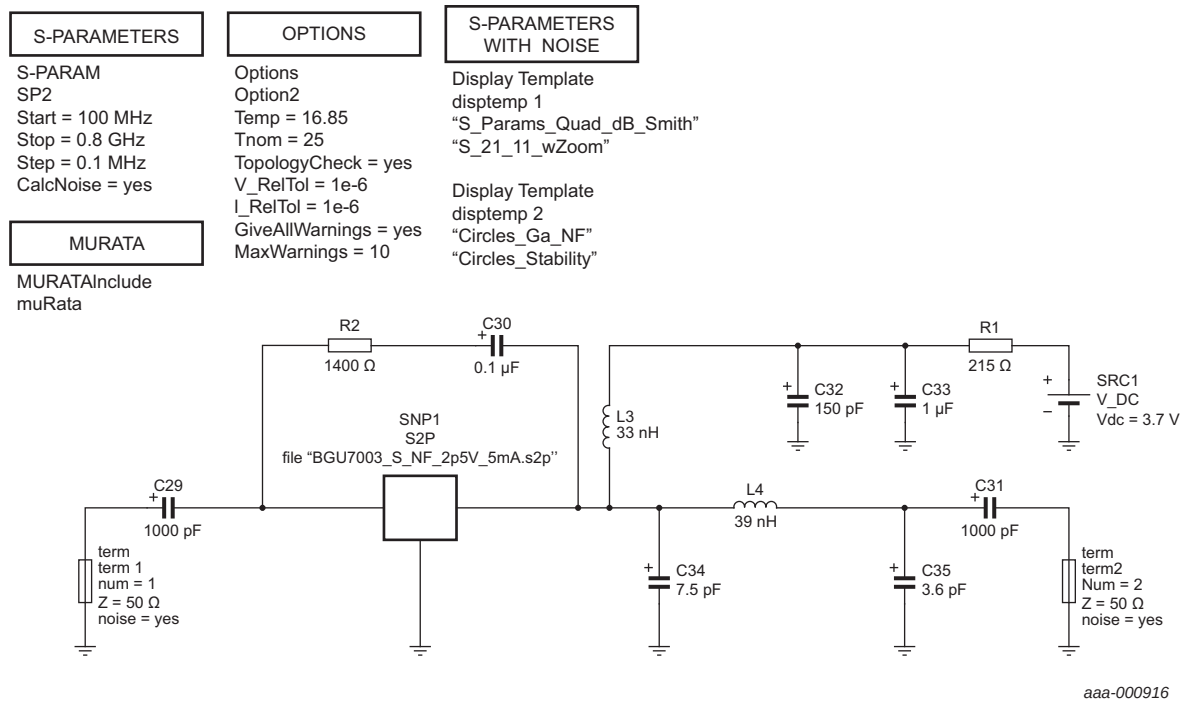


Fig 2. BGU7003 400 MHz band LNA simulation: circuit diagram

4.2 BGU7003 400 MHz band LNA simulation results

4.2.1 Input and output match in the 400 MHz Band

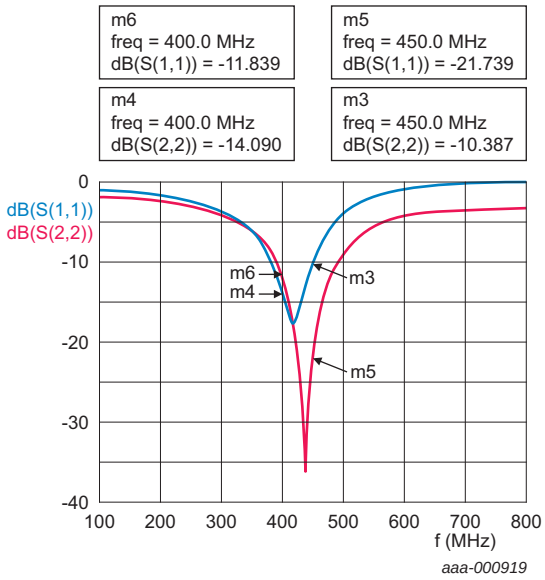


Fig 3. BGU7003 400 MHz band LNA simulation: input and output match

4.2.2 Gain and gain flatness in 400 MHz band

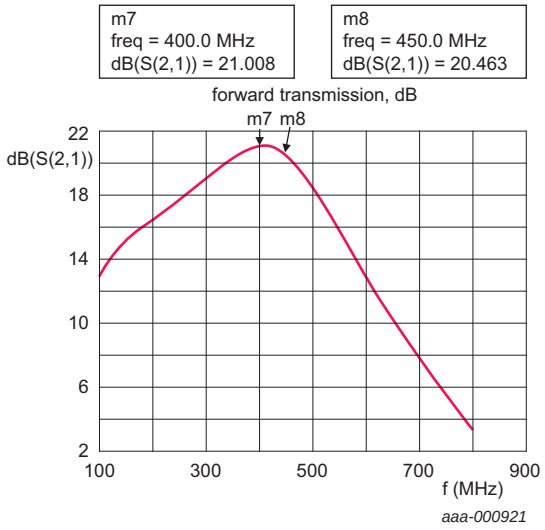


Fig 4. BGU7003 400 MHz band LNA simulation: gain and gain Flatness

4.2.3 Noise figure in 400 MHz band

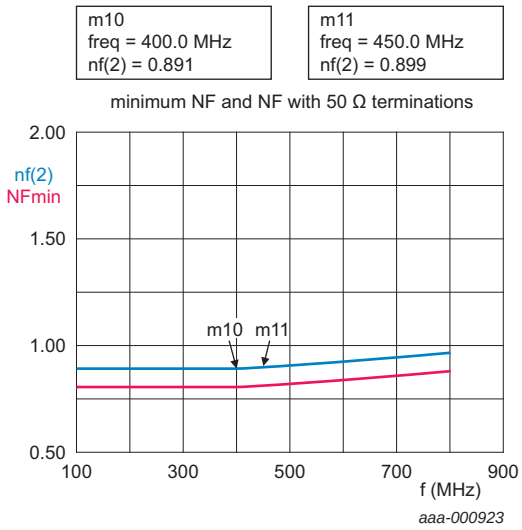


Fig 5. BGU7003 400 MHz band LNA simulation: noise figure

4.2.4 Stability

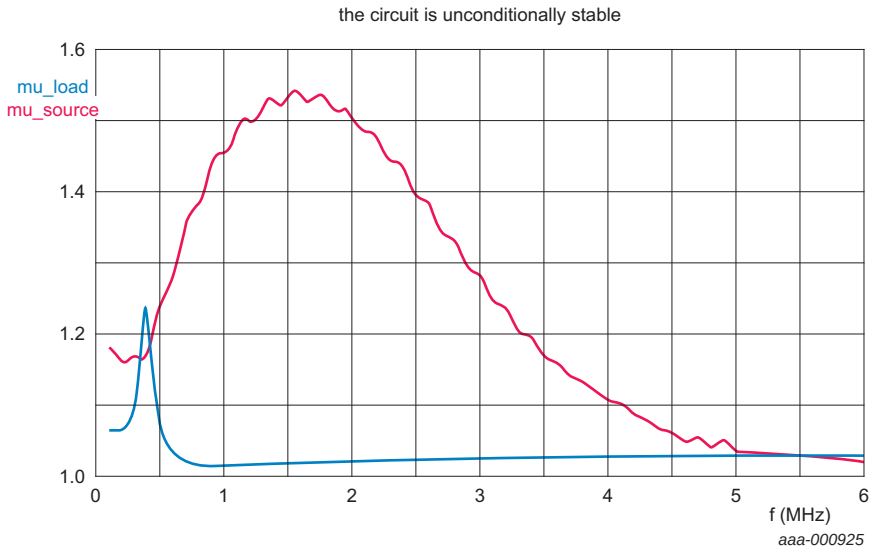


Fig 6. BGU7003 400 MHz band LNA simulation: stability

4.3 BGU7003 900 MHz band LNA simulation

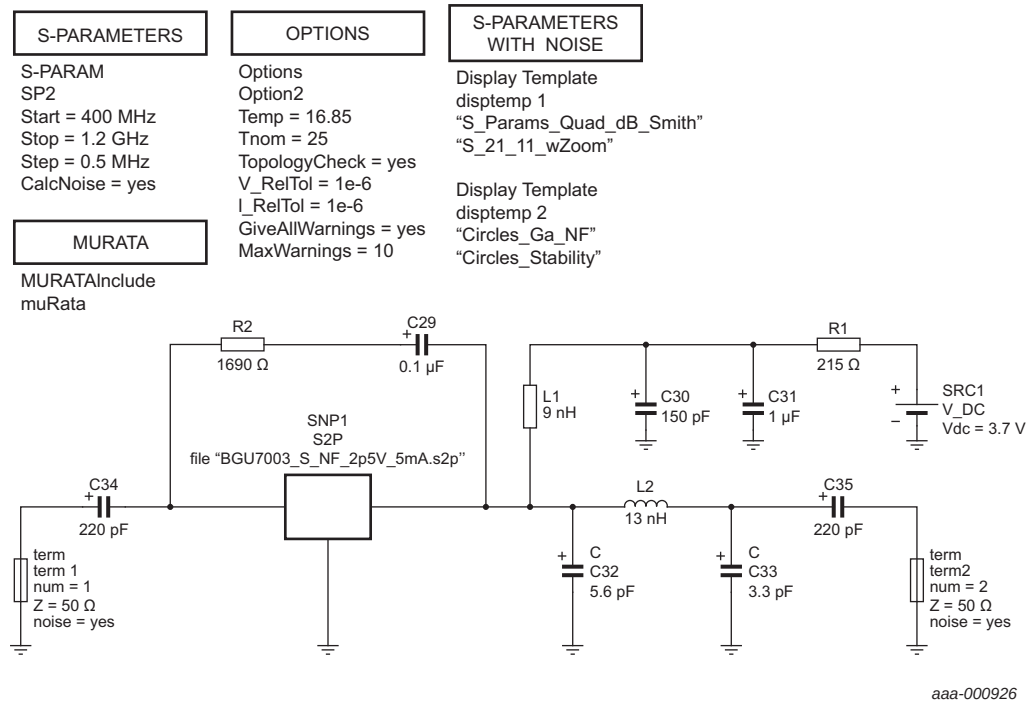


Fig 7. BGU7003 900 MHz band LNA simulation: circuit

4.4 BGU7003 900 MHz band LNA simulation results

4.4.1 Input and output match in the 900 MHz Band

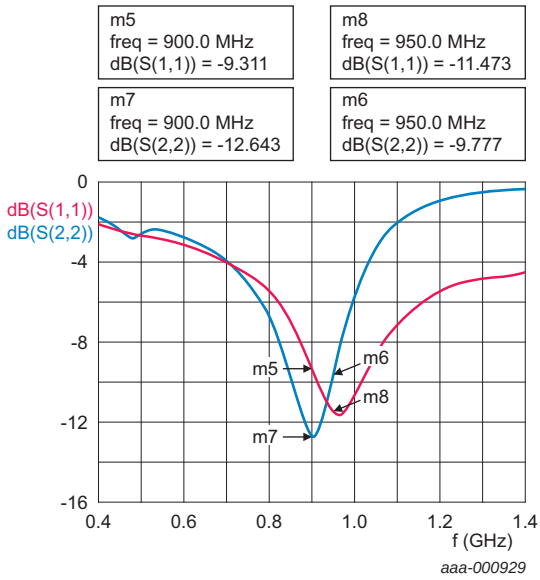


Fig 8. BGU7003 900 MHz band LNA simulation: input and output match

4.4.2 Gain and gain flatness in 900 MHz band

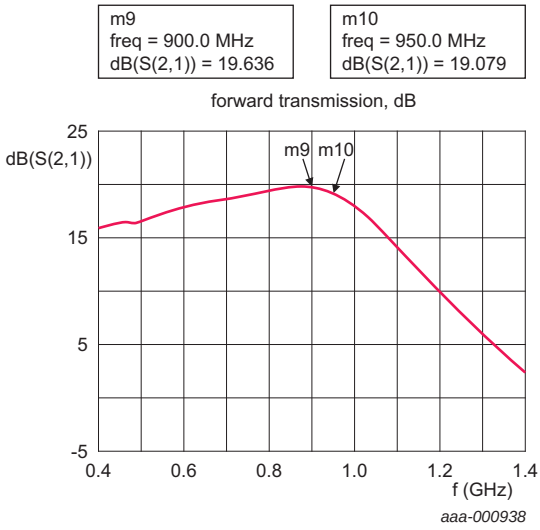


Fig 9. BGU7003 900 MHz band LNA simulation: gain and gain Flatness

4.4.3 Noise figure in 900 MHz band

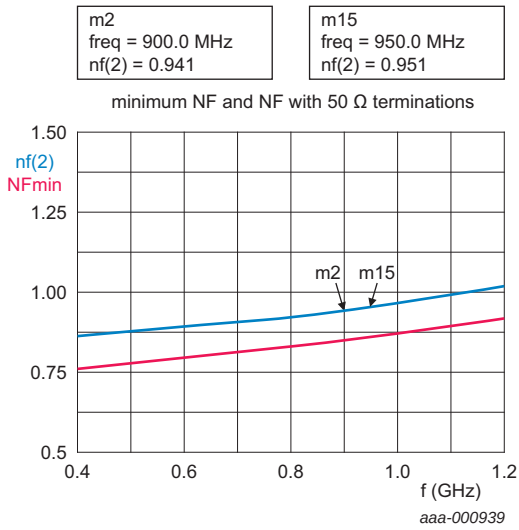


Fig 10. BGU7003 900 MHz band LNA simulation: noise figure

4.4.4 Stability

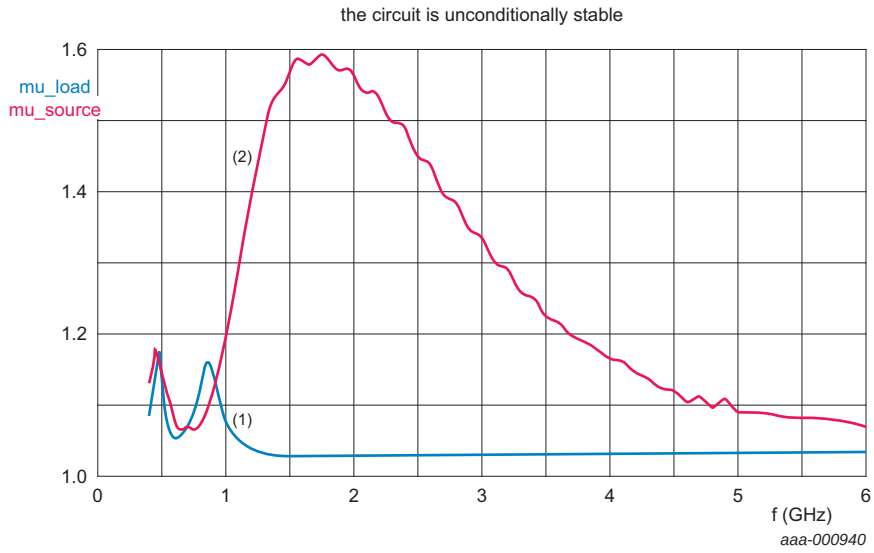


Fig 11. BGU7003 900 MHz band LNA simulation: stability

5. Application boards

The BGU7003 400 MHz and 900 MHz band LNA evaluation board simplifies the evaluation of the BGU7003 in the E-metering application area. The evaluation board enables testing of the device performance and requires no additional support circuitry. The board is fully assembled with the BGU7003 IC, including input- and output matching, to optimize the performance.

A simple feedback path is added to improve its in-band gain flatness as well as improving stability.

The board is supplied with two SMA connectors for input and output connection to RF test equipment.

The BGU7003 is designed to operate at 2.5 V with optimal performance, and not to exceed 2.85 V. When it is used with varying supply voltages (3.3 V to 3.7 V for E-metering), the enable function is not used and LNA is always on. An enable pin jumper is installed, which avoids the voltage on the VCC, VEN and RF output pin exceeding 2.85 V.

In this application, the supply voltage is set to 3.7 V which is reduced to 2.5 V by a 215 Ω voltage dropping resistor.

5.1 Application circuit schematic (400 MHz band)

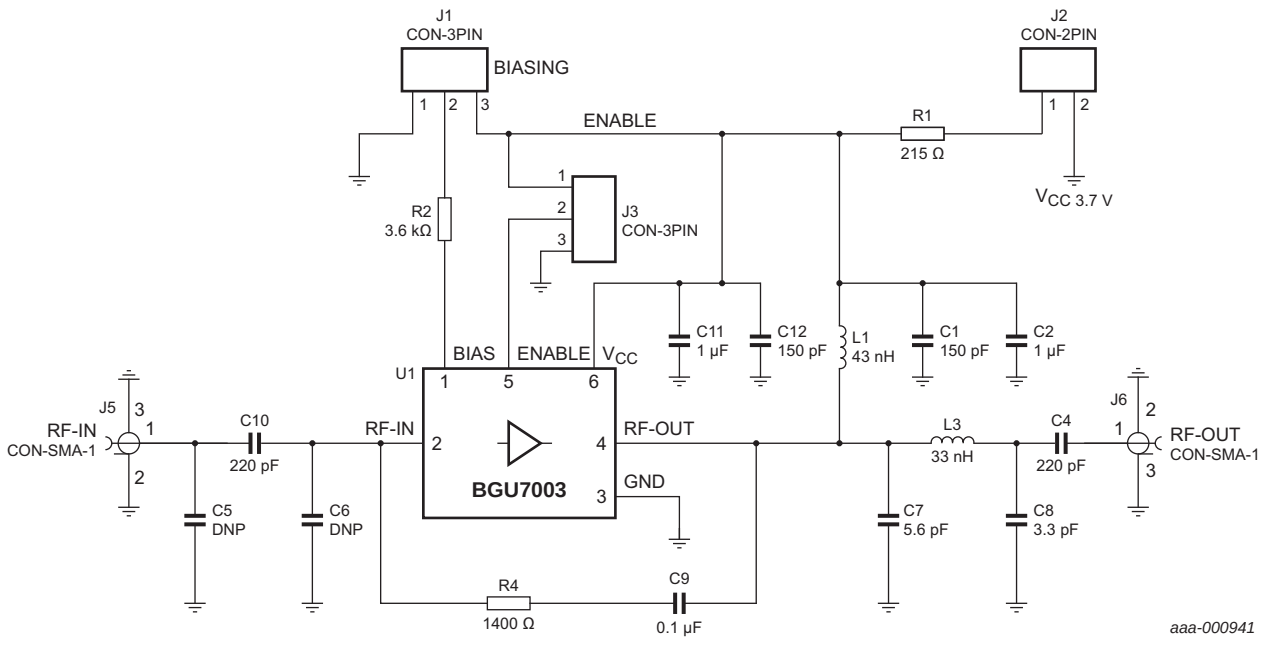


Fig 12. BGU7003 400 MHz band LNA: schematic

5.2 Application board Bill Of Materials BOM (400 MHz band)

Table 1. BGU7003 400 MHz band LNA EVB parts List

Item	Quantity	Part reference	Part number	Vendor	Value
1	2	C1	GRM1555C1H151JA01	Murata	150 pF
		C12	GRM1555C1H151JA01	Murata	150 pF
2	2	C2	GRM155F50J105ZE01	Murata	1 μF
		C11	GRM155F50J105ZE01	Murata	1 μF
3	2	C4	GRM1555C1H221JA01	Murata	220 pF
		C10	GRM1555C1H221JA01	Murata	220 pF
4	2	C5	<tbd>	Murata	DNP
		C6	<tbd>	Murata	DNP
5	1	C7	GRM1555C1H5R6DZ01	Murata	5.6 pF
6	1	C8	GRM1555C1H3R3CZ01D	Murata	3.3 pF
7	1	C9	GRM155R71C104KA88	Murata	0.1 μF
8	2	J1	90120-0763	Molex	CON-3PIN
		J3	90120-0763	Molex	CON-3PIN
9	1	J2	90120-0762	Molex	CON-2PIN
10	2	J5	901-10110	Amphenol	CON-SMA-1
		J6	901-10110	Amphenol	CON-SMA-1
11	1	L1	0603CS-43NX_L	Coilcraft	43 nH
12	1	L3	LQW15AN33NJ00D	Murata	33 nH
13	1	R1	ERJ-2RKF2150X	Panasonic - ECG	215 Ω
14	1	R2	ERJ-2RKF3901X	Panasonic - ECG	3.9 kΩ
15	1	R4	ERJ-2RKF1401X	Panasonic - ECG	1400
16	1	U1	BGU7003	NXP	BGU7003

5.3 Typical application board test result (400 MHz band)

5.3.1 S-parameter gain and match

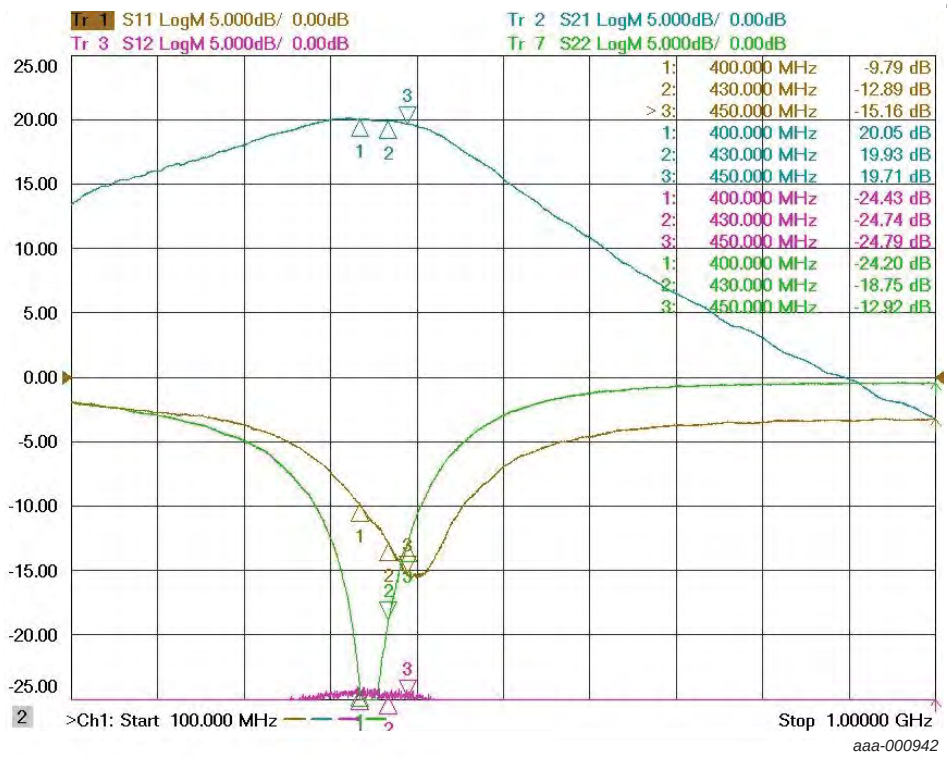


Fig 13. BGU7003 400 MHz band LNA demo board: S-parameter

5.3.2 P1dB

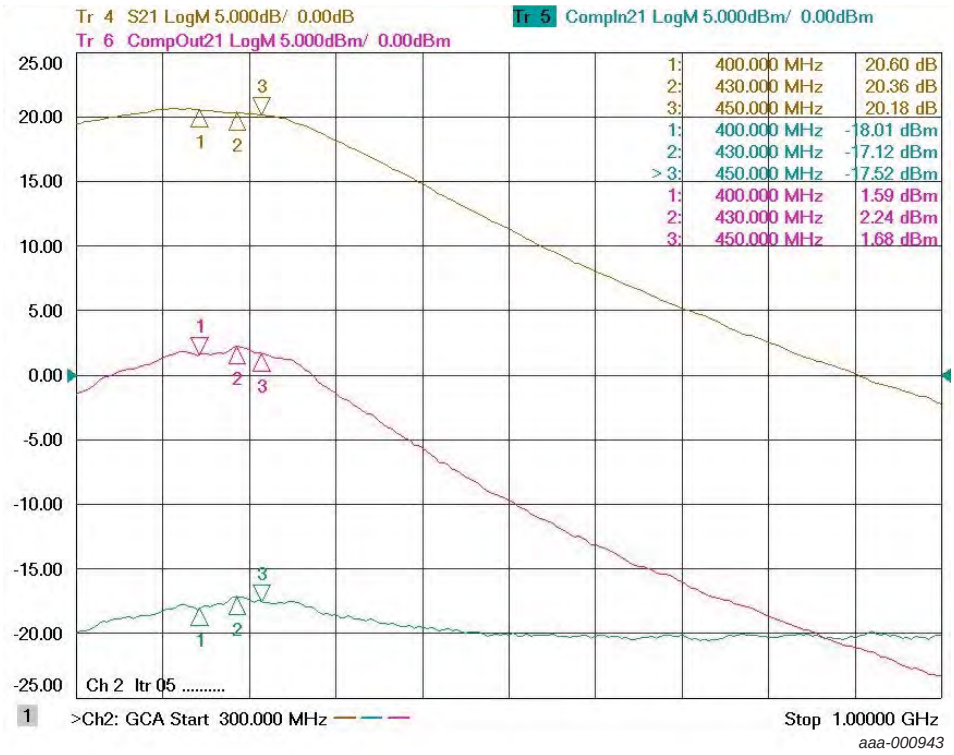


Fig 14. BGU7003 400 MHz band LNA demo board: P1dB

5.3.3 Linearity/IP3

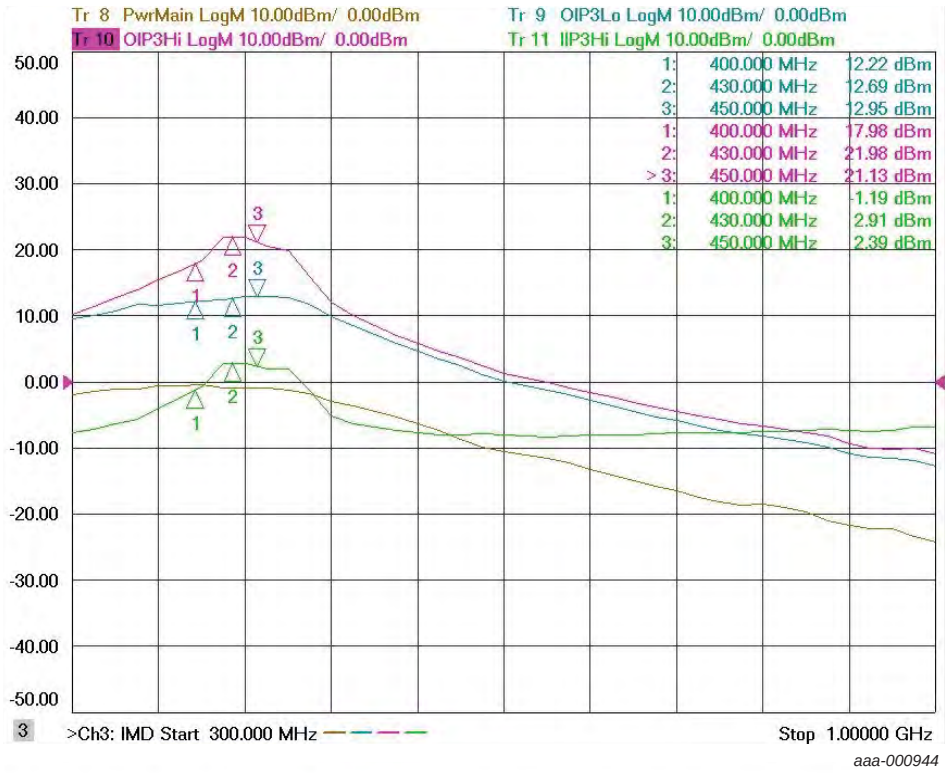


Fig 15. BGU7003 400 MHz band LNA demo board: IP3

5.3.4 Stability

K-factor

Fig 16. BGU7003 400 MHz band LNA demo board: stability

5.3.5 Noise figure measurement

A 6 dB pad is inserted between the noise source and RF input to improve the NF measurement accuracy.

A 0.1 dB loss from connector to package pin is de-embedded at both input and output.

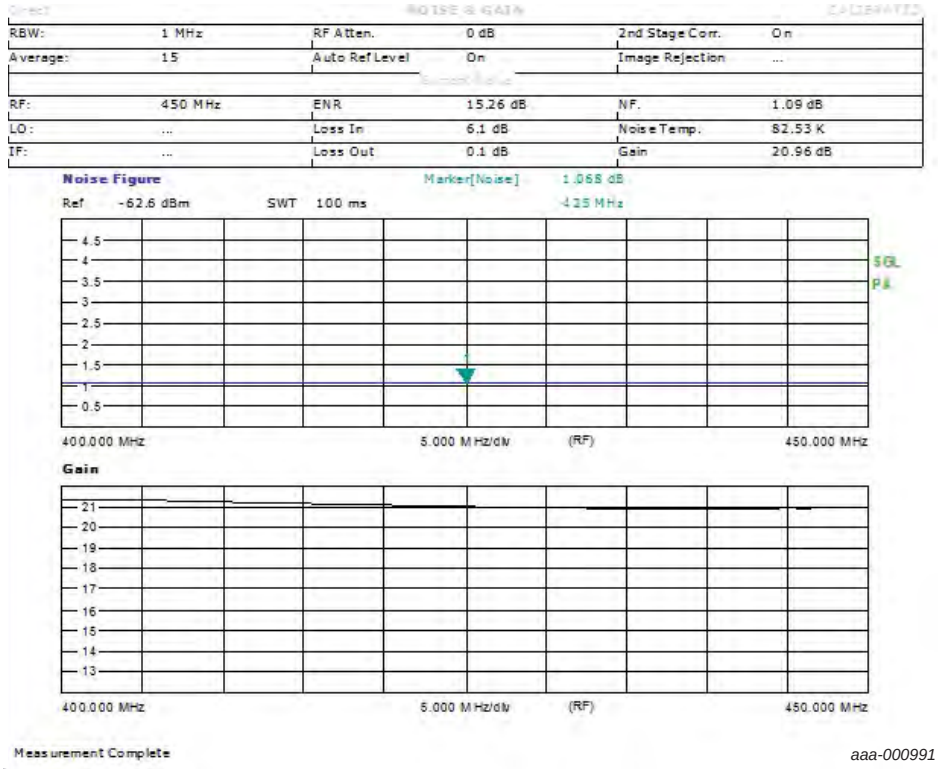


Fig 17. BGU7003 400 MHz band LNA demo board: noise figure

5.3.6 Summary of typical evaluation board test results

Table 2. Typical results measured on the 400 MHz band evaluation board

Operating frequency 400 MHz to 450 MHz, testing at 425 MHz unless otherwise specified, Temp = 25 °C

Symbol	Description	Conditions	Value	Unit
V_{CC}	supply voltage	-	3.7	V
I_{CC}	supply current	-	5	mA
NF	noise figure	-	1.06	dB
G_p	power gain	400 MHz	20.06	dB
		425 MHz	19.93	dB
		450 MHz	19.70	dB
ΔG_p	power gain variation	-	0.35	dB
RL_{in}	input return loss	-	12.89	dB
RL_{out}	output return loss	-	18.75	dB
$\alpha_{isol(r)}$	reverse isolation	-	24.70	dB
$P_{i(1dB)}$	input power at 1 dB gain compression	-	−17.12	dBm
$P_{L(1dB)}$	output power at 1 dB gain compression	-	2.24	dBm
$IP3_I$	input third-order intercept point	-	2.91	dBm
$IP3_O$	output third-order intercept point	-	21.98	dBm
K	Rollett stability factor	0 to 26 GHz	>1	-

5.4 Application circuit schematic (900 MHz band)

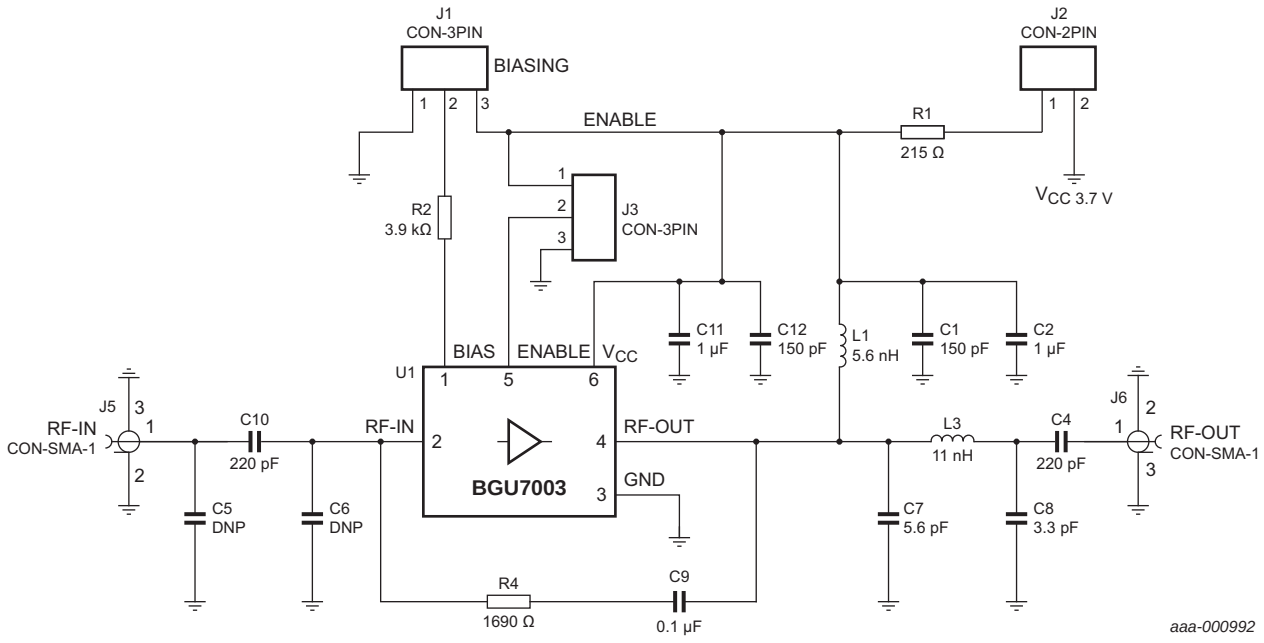


Fig 18. BGU7003 900 MHz band LNA: schematic

5.5 Application board Bill Of Materials BOM (900 MHz band)

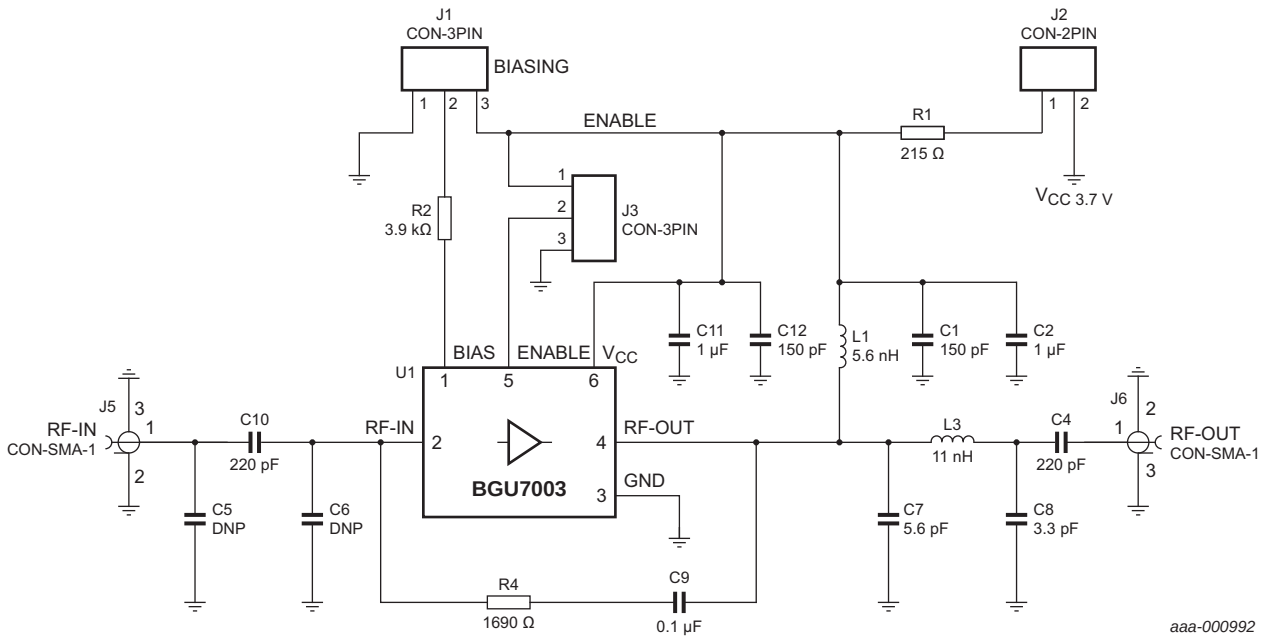


Fig 19. BGU7003 900 MHz band LNA: schematic

Table 3. BGU7003 900 MHz band LNA EVB parts List

Item	Quantity	Part reference	Part number	Vendor	Value
1	2	C1	GRM1555C1H151JA01	Murata	150 pF
		C12	GRM1555C1H151JA01	Murata	150 pF
2	2	C2	GRM155F50J105ZE01	Murata	1 µF
		C11	GRM155F50J105ZE01	Murata	1 µF
3	2	C4	GRM1555C1H221JA01	Murata	220 pF
		C10	GRM1555C1H221JA01	Murata	220 pF
4	2	C5	<tbd>	Murata	DNP
		C6	<tbd>	Murata	DNP
5	1	C7	GRM1555C1H5R6DZ01	Murata	5.6 pF
6	1	C8	GRM1555C1H3R3CZ01D	Murata	3.3 pF
7	1	C9	GRM155R71C104KA88	Murata	0.1 µF
8	2	J1	90120-0763	Molex	CON-3PIN
		J3	90120-0763	Molex	CON-3PIN
9	1	J2	90120-0762	Molex	CON-2PIN
10	2	J5	901-10110	Amphenol	CON-SMA-1
		J6	901-10110	Amphenol	CON-SMA-1
11	1	L1	0603CS-5N6X_L	Coilcraft	5.6 nH
12	1	L3	0603CS-11NX_L	Coilcraft	11 nH
13	1	R1	ERJ-2RKF2150X	Panasonic - ECG	215 Ω

Table 3. BGU7003 900 MHz band LNA EVB parts List *...continued*

Item	Quantity	Part reference	Part number	Vendor	Value
14	1	R2	ERJ-2RKF3901X	Panasonic - ECG	3.9 kΩ
15	1	R4	ERJ-2RKF1691X	Panasonic - ECG	1690
16	1	U1	BGU7003	NXP	BGU7003

5.6 Typical application board test result (900 MHz band)

5.6.1 S-parameter gain and match

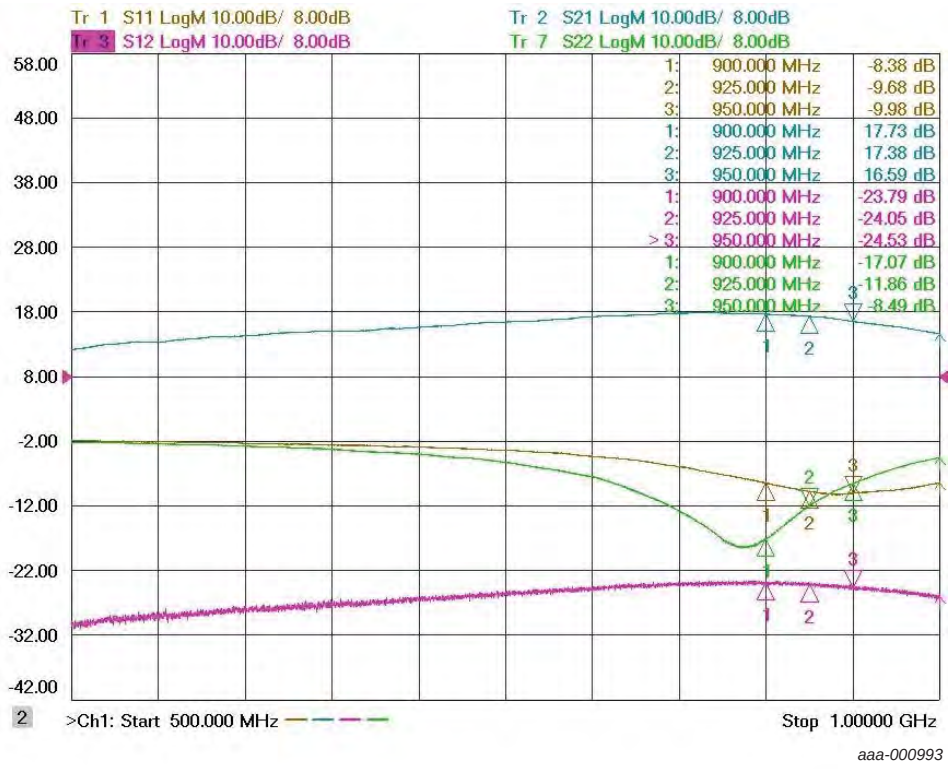


Fig 20. BGU7003 900 MHz band LNA demo board: S-parameter

5.6.2 P1dB

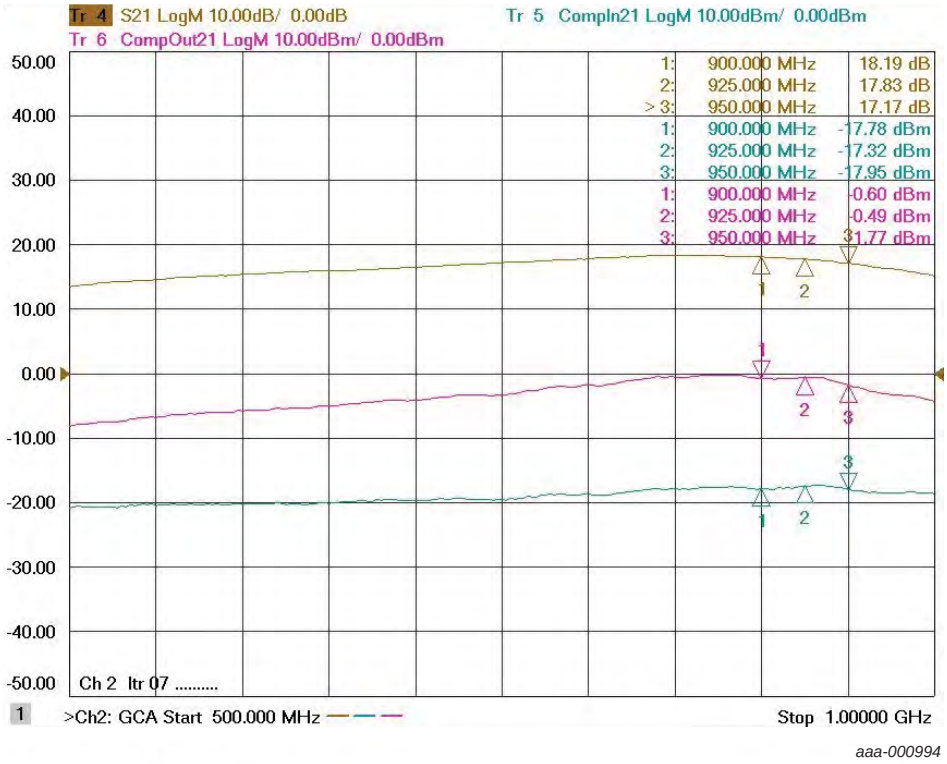


Fig 21. BGU7003 900 MHz band LNA demo board: P1dB

5.6.3 Linearity/IP3

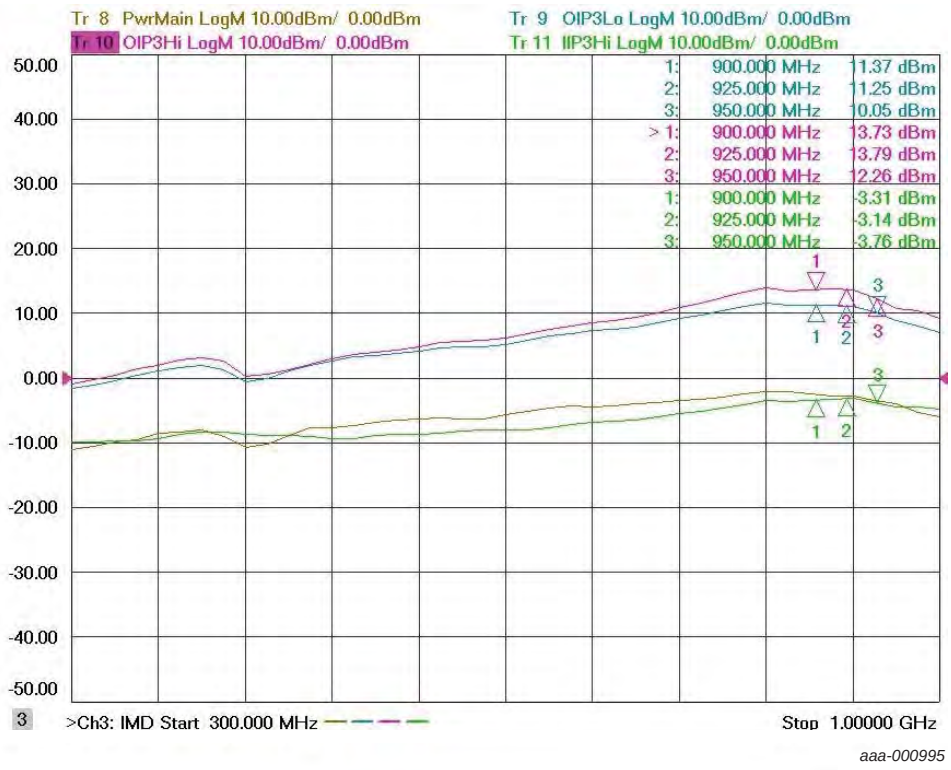


Fig 22. BGU7003 900 MHz band LNA demo board: IP3

5.6.4 Stability

K-factor

Fig 23. BGU7003 900 MHz band LNA demo board: stability

5.6.5 Noise figure measurement

A 6 dB pad is inserted between the noise source and RF input to improve the NF measurement accuracy.

A 0.1 dB loss from connector to package pin is de-embedded at both input and output.

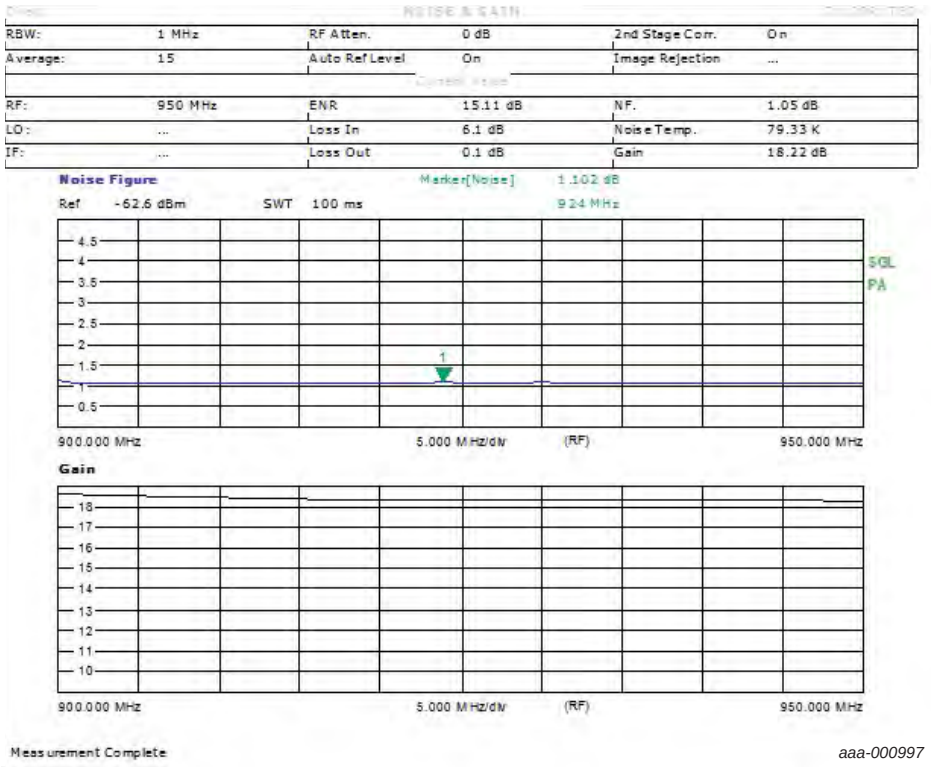


Fig 24. BGU7003 900 MHz band LNA demo board: noise figure

5.6.6 Summary of typical evaluation board test results

Table 4. Typical results measured on the 400 MHz band evaluation board

Operating frequency 900 MHz to 950 MHz, testing at 925 MHz unless otherwise specified, Temp = 25 °C

Symbol	Description	Conditions	Value	Unit
V_{CC}	supply voltage	-	3.7	V
I_{CC}	supply current	-	5	mA
NF	noise factor	-	1.10	dB
G_p	power gain	900 MHz	17.73	dB
		925 MHz	17.38	dB
		950 MHz	16.59	dB
ΔG_p	power gain variation	-	1.14	dB
RL_{in}	input return loss	-	9.68	dB
RL_{out}	output return loss	-	11.86	dB
$\alpha_{isol(r)}$	reverse isolation	-	21.05	dB
$P_{i(1dB)}$	input power at 1 dB gain compression	-	−17.32	dBm
$P_{L(1dB)}$	output power at 1 dB gain compression	-	−0.49	dBm
$IP3_I$	input third-order intercept point	-	−3.14	dBm
$IP3_O$	output third-order intercept point	-	13.79	dBm
K	Rollett stability factor	0 to 26 GHz	>1	-

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