AN11148

BGU7003 1900 MHz to 2100 MHz LNA application

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Document information

Info	Content
Keywords	LNA, 1900 MHz to 2100 MHz, BGU7003, GSM, W-CDMA
Abstract	This application note provides circuit, layout, BOM and performance information for 1900 MHz to 2100 MHz LNA equipped with NXP Semiconductors BGU7003

Revision history

Rev	Date	Description
v.1	20120301	initial version

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1. Introduction

The BGU7003 is a wideband Silicon Germanium Amplifier MMIC intended for high speed, low noise applications. It is used for LNA applications up to 6 GHz such as GPS, satellite radio, cordless phone and China Mobile Multimedia Broadcasting (CMMB). The BGU7003 contains one RF stage and internal bias that is temperature stabilized. It also contains a power down function to shut down the amplifier with a logic signal on the enable pin.

The BGU7003 is ideal for use in portable electronic devices, such as mobile phones, Personal Digital Assistants (PDAs), Personal Navigation Devices (PNDs) etc.

The 1900 MHz to 2100 MHz LNA evaluation board (EVB) is designed to evaluate the performance of the BGU7003 applied as a GSM/W-CDMA LNA. In this document, the application diagram, board layout, bill of material, and some typical results are given.

Figure 1 shows the evaluation board

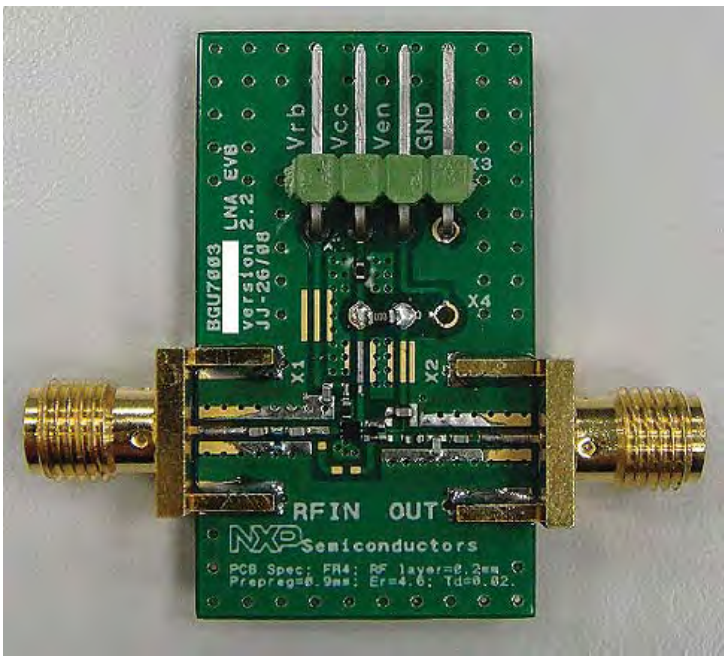

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Fig 1. BGU7003, 1900 MHz to 2100 MHz LNA evaluation board

2. General description

The BGU7003 design is a wideband Silicon Germanium (SiGe) transistor with internal bias circuit. This bias circuit is temperature stabilized, which keeps the current constant over temperature. The bias current for the RF stage can be set via an external bias resistor in order to give the designer flexibility in choosing the bias current. The MMIC is also supplied with a power down function that allows the designer to control the MMIC via a logic signal. This power down mode only consumes 0.4 µA. In Figure 2 the simplified internal circuit of the BGU7003 is given.

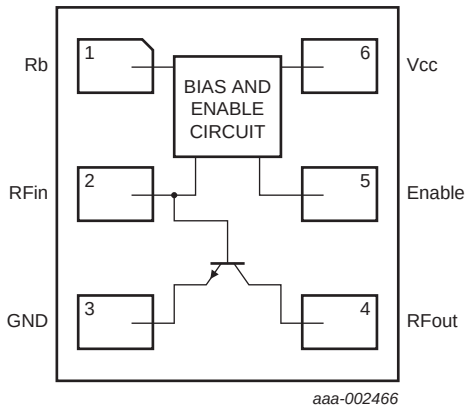


Fig 2. Simplified internal circuit of the BGU7003

The BGU7003 is not internally matched so for both input and output a matching circuit needs to be designed. The fact that no internal matching is available makes the product suitable for different application areas.

In the following Sections the BGU7003 is described applied as a 1900 MHz to 2100 MHz LNA.

3. Application board

The BGU7003 1900 MHz ~ 2100 MHz LNA EVB simplifies the evaluation of the BGU7003 wideband amplifier MMIC, for the GSM / W-CDMA application area. The EVB 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. The board is supplied with two SMA connectors for input and output connection to RF test equipment:

This document describes the EVBs functionality when operated from a 2.5 V DC supply voltage

3.1 Application circuit

The application diagram as supplied on the evaluation board is shown in Figure 3.

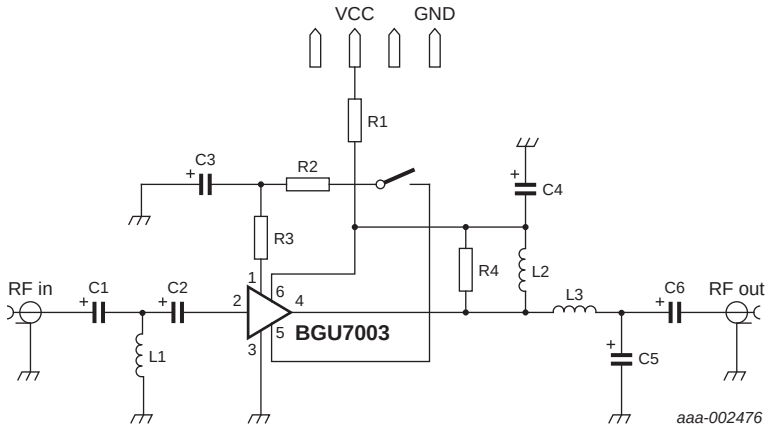


Fig 3. Evaluation board circuit diagram

3.2 Board layout

Figure 4 shows the board layout with components.

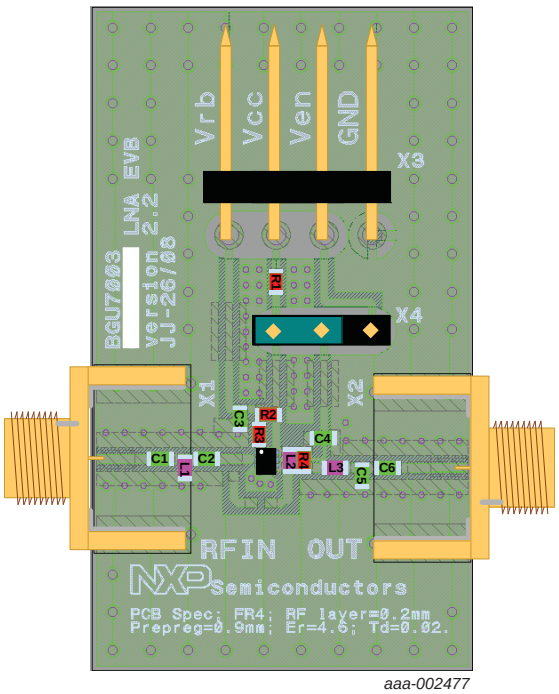


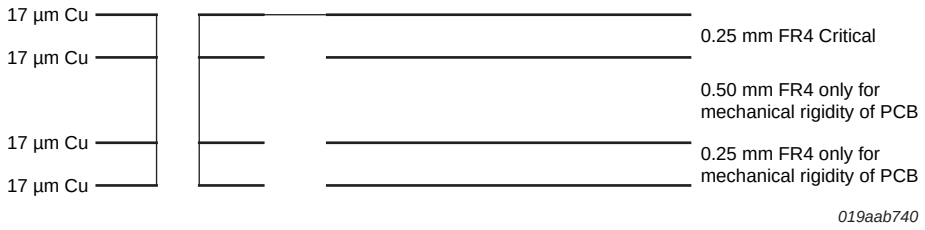
Fig 4. Component layout for the BUF690 2.33 GHz evaluation board

3.3 PCB layout

A good PCB Layout is an essential part of an RF circuit design. The EVB of the BGU7003 can serve as a guideline for laying out a board using either the BGU7003. Use controlled impedance lines for all high frequency inputs and outputs. Bypass supply voltage V_{CC} with decoupling capacitors, preferable located as close as possible to the device. For long bias

lines it may be necessary to add decoupling capacitors along the line further away from the device. Proper grounding of the GND pin is also essential for the performance. Either connect the GND pin directly to the ground plane or through vias, or do both.

The EVB is made of FR4 material using the stack shown in Figure 5



Material supplier Isola Duraver; ε_r = 4.6 to 4.9; Tδ = 0.02

Fig 5. Stack of PCB material

3.4 Bill of materials

Table 1. Bill of materials

Component	Description	Footprint	Value	Manufacturer	Comment
C1	capacitor	0402	10 pF	Murata GRM1555	input matching
C2, C6	capacitor	0402	100 pF	Murata GRM1555	DC blocking
C3, C4	capacitor	0402	0.1 µF	Murata GRM1555	LF decoupling
C5	capacitor	0402	1 pF	Murata GRM1555	output matching
L1	inductor	0402	4.3 nH	Murata/LQW15A; high Q, low Rs	input matching
L2	inductor	0402	18 nH	Murata/LQG15A; high Q, low Rs	DC bias
L3	inductor	0402	4.3 nH	Murata/LQG15A	output matching
R1, R2	resistor	0402	0 Ω	various	backup tune pads
R3	resistor	0402	3.9 kΩ	various	bias setting
R4	resistor	0402	120 Ω	various	stability
X1, X2	SMA RF connector	-	-	Johnson, End Launch SMA 142-0701-841	RF input/ RF output
X3	DC header	-	-	Molex, PCB header, Right angle, 1 row, 3 way, Part no: 90121-0763	bias connector

4. Required equipment

In order to measure the evaluation board the following are necessary:

- DC power supply up to 5 mA at 2.5 V (up to 15 V for bias Control)
- RF signal generator capable of generating an RF signal at the 1900 MHz to 2100 MHz operating frequency
- RF spectrum analyzer covering as a minimum the 1900 MHz to 2100 MHz operating frequency and some of the harmonics (up to 6 GHz should be sufficient). Optional: a version with the capability of measuring noise figure is convenient
- Amp meter to measure the supply current (optional)

- NetWork analyzer for measuring gain, return loss and reverse isolation
- Noise figure analyzer.

5. Connections and setup

The BFU690, 1900 MHz to 2100 MHz EVB is fully assembled and tested. To operate the EVB and test the device functions follow this step-by-step guide:

1. Connect the DC power supply to the V_{CC} and GND terminals and set to 2.5 V.
2. Connect the RF signal generator and the spectrum analyzer to the RF input and the RF output of the EVB respectively. Do not yet turn on the RF output of the signal generator. Set it to −30 dBm output power at 2000 MHz and set the spectrum analyzer to 2000 MHz center frequency with a reference level of 0 dBm.
3. Turn on the DC power supply and it should read approximately 5 mA.
4. Enable the RF output of the generator; the spectrum analyzer displays a tone of 2000 MHz at approximately −14 dBm.
5. In order to evaluate the board using different bias currents through RF stage of the MMIC, the voltage on Rb (VRb) can be connected to a separate power supply. This is enabling the control of the bias current.
6. To evaluate the enable function, the Ven terminal of the board can also be connected to a separate DC power supply that either gives a voltage >0.6 V (amplifier on) or <0.5 V amplifier off.
7. A NetWork Analyzer (NWA) can be used instead of a signal generator and spectrum analyzer in order to measure both gain and input and output return losses.
8. For noise figure evaluation use either a noise figure analyzer or a spectrum analyzer with noise option. The use of a 5 dB noise source, such as the Agilent 364A is recommended. When measuring the noise figure of the evaluation board, any kind of adaptors, cables etc, between the noise source and the EVB should be avoided, since this affects the noise performance.

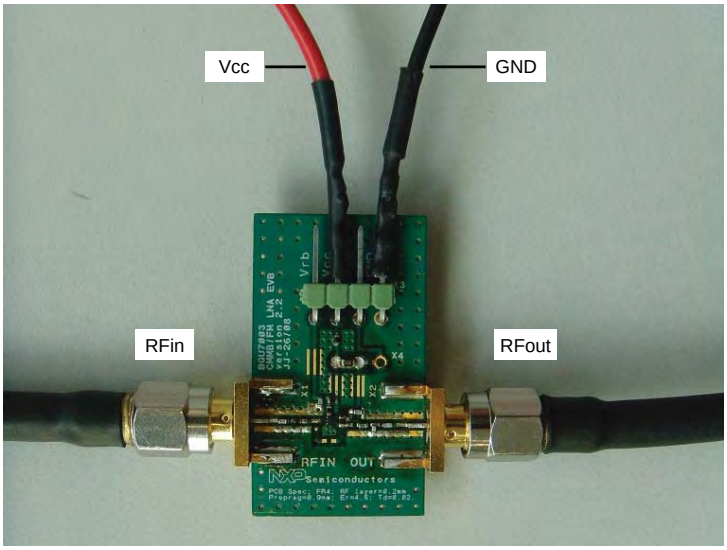


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Fig 6. Evaluation board showing its connections

6. Typical EVB results

Table 2. Typical results measured on the evaluation board

T = 25 °C; f = 2.33 GHz unless otherwise specified

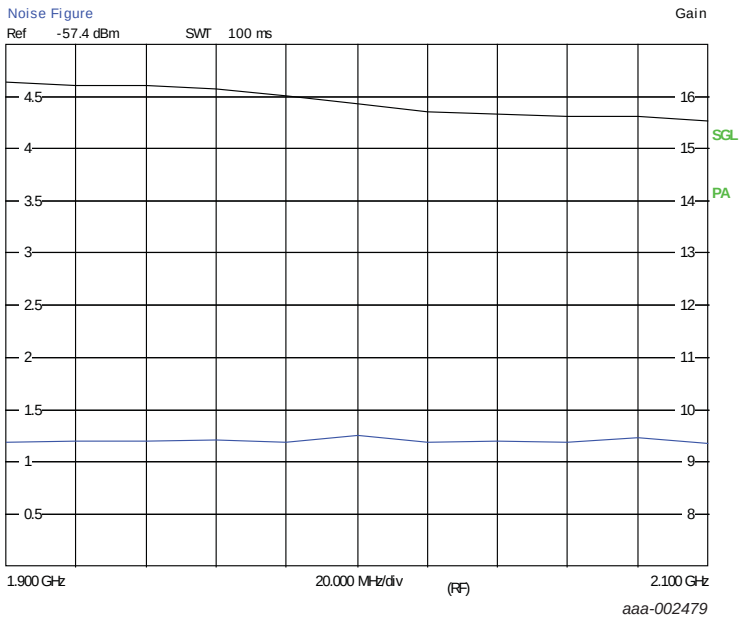
Symbol	Parameter	BGU7003 EVB	Unit
NF	noise figure	1.2[1]	dB
G_p	power gain	15.3[2]	dB
RL_{in}	input return loss	8.0[2]	dB
RL_{out}	output return loss	19.5[2]	dB
$\|s_{21}\|^2$	isolation	23.0[2]	dB
$P_{i(1dB)}$	input power at 1 dB gain compression	−18.1	dBm
$P_{L(1dB)}$	output power at 1 dB gain compression	−3.8	dBm
$IP3_I$	input third-order intercept point	−10.3[2][3]	dBm
$IP3_O$	output third-order intercept point	5.0[2][3]	dBm

[1] The NF and gain figures are measured at the SMA connectors of the EVB, so the connector and PCB losses are not subtracted. If subtracted the NF will improve by approximately 0.1 dB.

[2] Pin = −30 dBm.

[3] 2-Tone test with F1 =1999.5 MHz, F2 = 2000.5 MHz (spacing 1 MHz). Highest spurious recordings used for calculations.

6.1 Noise figure



1900 MHz to 2100 MHz.

Center of plot (x-axis) is 2000 MHz.

Fig 7. Noise figure and gain plot

Table 3. Noise figure tabular data

From Rohde & Schwarz FSU

Frequency list results			
RF (GHz)	**NF (dB)**	**Noise temp (K)**	**Gain (dB)**
1.900	1.192	91.588	16.278
1.920	1.198	92.109	16.212
1.940	1.197	91.992	16.212
1.960	1.214	93.552	16.153
1.980	1.184	90.882	16.021
2.020	1.248	96.557	15.846
2.000	1.182	90.728	15.712
2.040	1.198	92.149	15.650
2.060	1.182	90.738	15.605
2.080	1.234	95.262	15.614
2.100	1.175	90.113	15.534

6.2 Stability performance

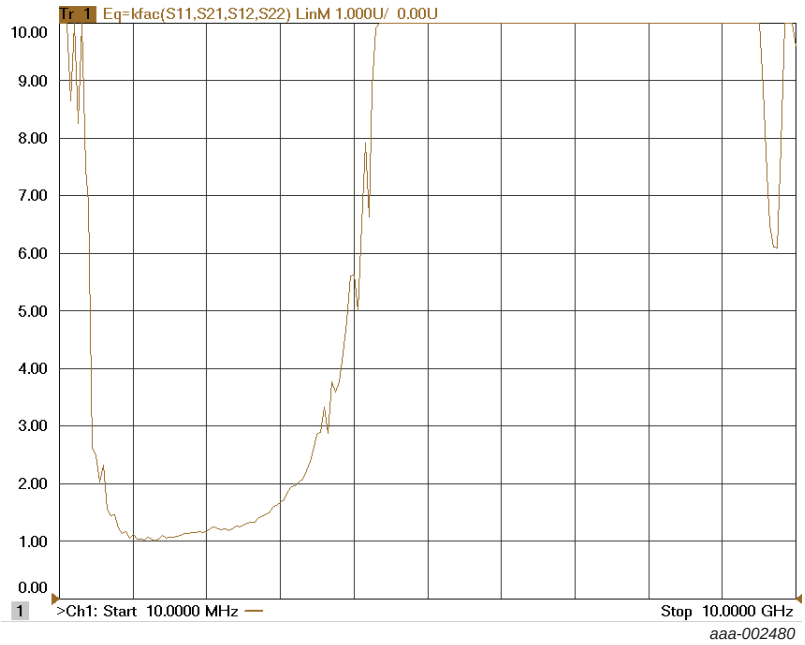
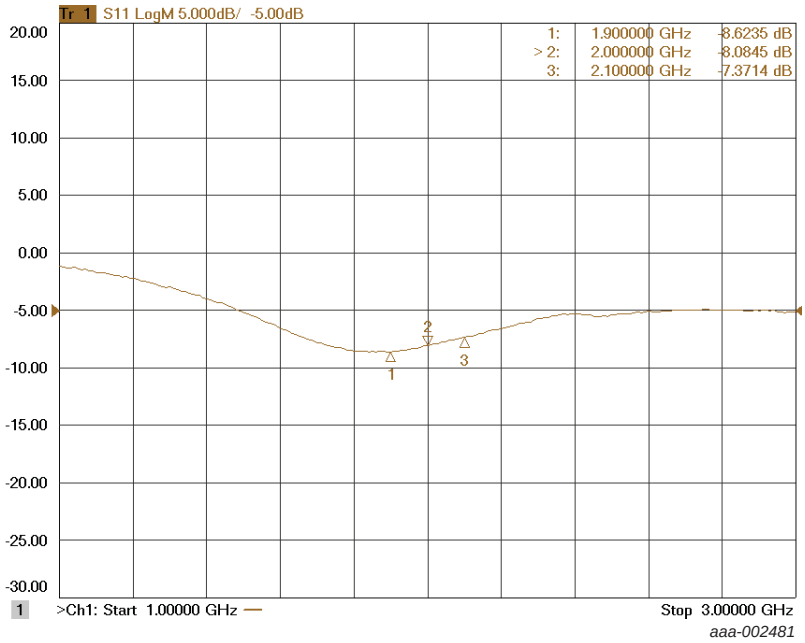


Fig 8. Stability performance plot

6.3 Input return losses

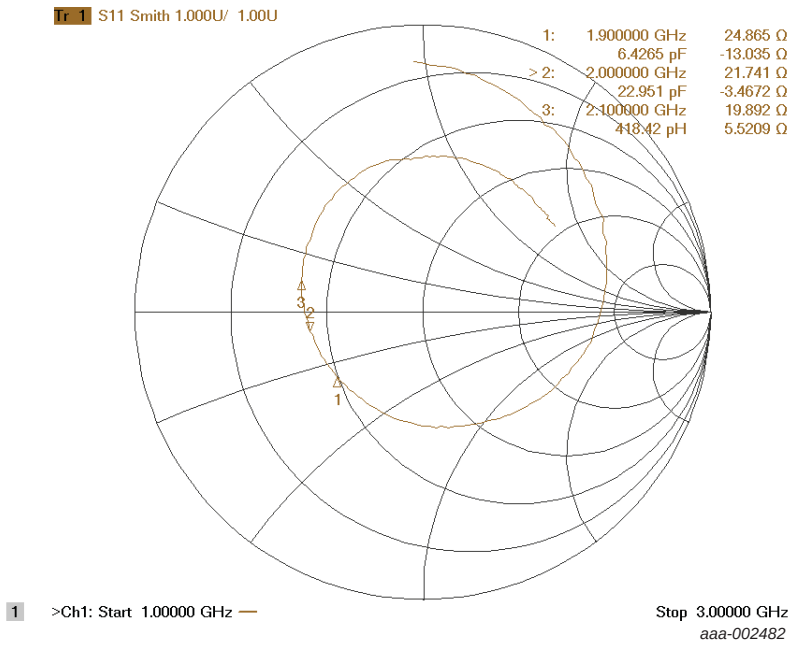
6.3.1 Log Mag



1 GHz to 3 GHz.

Fig 9. Input return loss plot

6.3.2 Smith chart

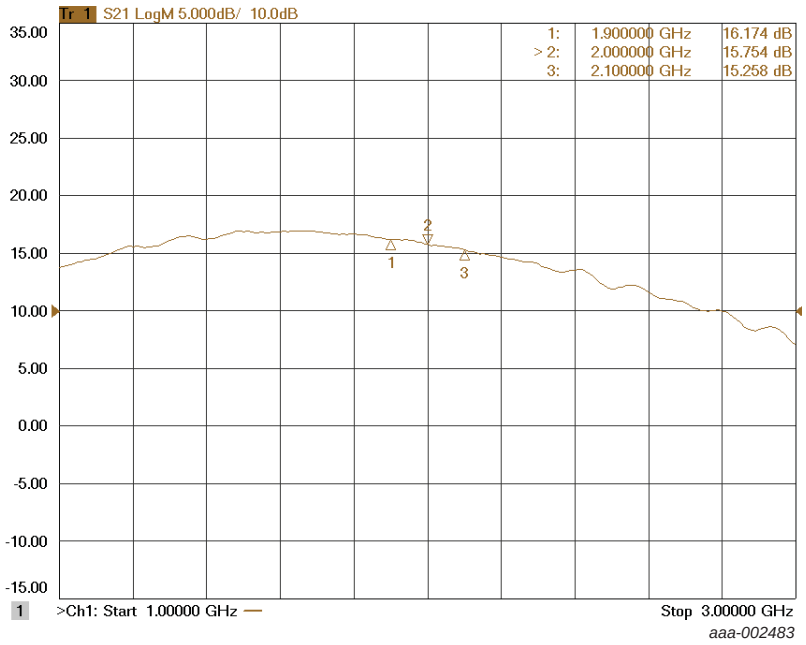


Reference plane = input SMA connector on PCB.

1 GHz to 3 GHz.

Fig 10. Smith chart of input return loss

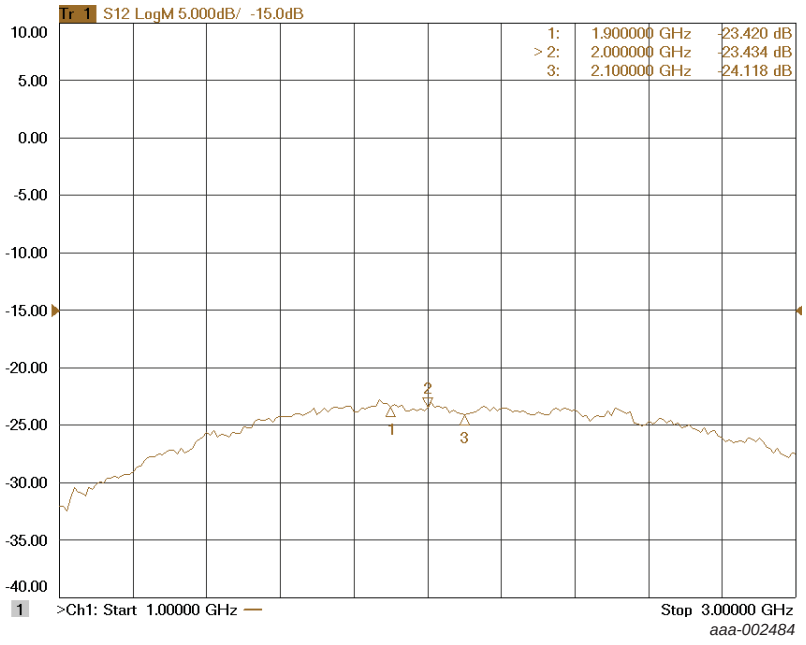
6.4 Forward gain, wide sweep



1 GHz to 3 GHz.

Fig 11. Forward gain plot

6.5 Reverse isolation

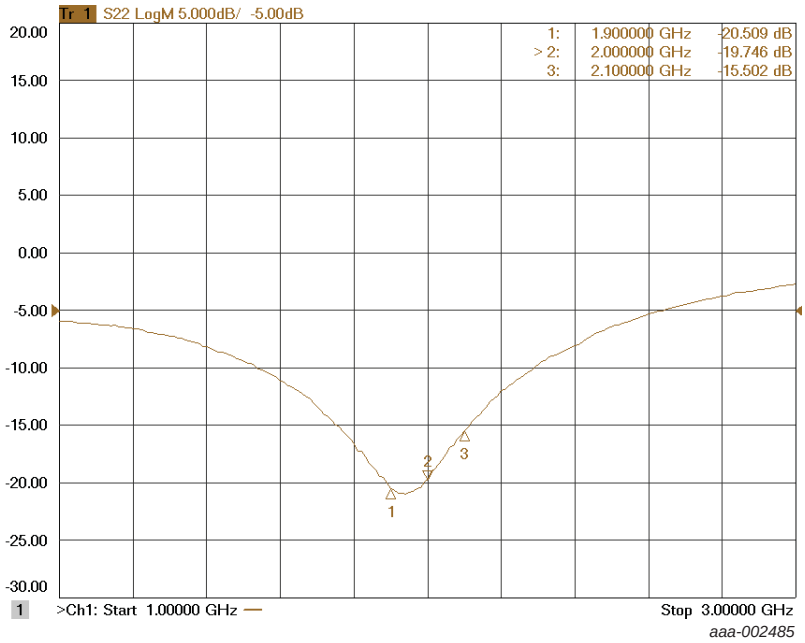


1 GHz to 3 GHz.

Fig 12. Reverse isolation plot

6.6 Output return losses

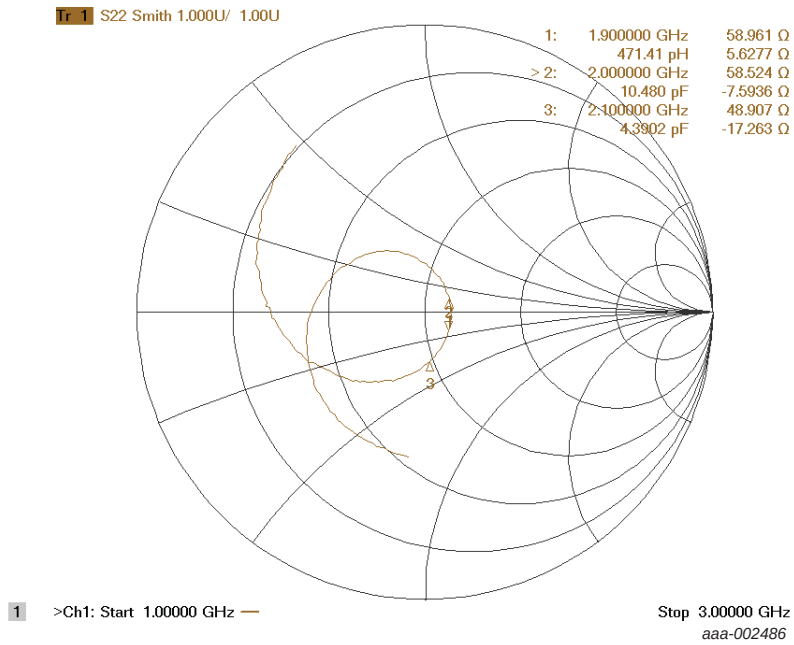
6.6.1 Log Mag



1 GHz to 3 GHz.

Fig 13. Output return loss plot

6.6.2 Smith chart



Reference plane = input SMA connector on PCB.

1 GHz to 3 GHz.

Fig 14. Smith chart of output return loss

7. Abbreviations

Table 4. Abbreviations

Acronym	Description
EVB	EValuation Board
GPS	Global Positioning System
LNA	Low Noise Amplifier
MMIC	Monolithic Microwave Integrated Circuit
NWA	NetWork Analyzer
RF	Radio Frequency

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