AN11481

2.62 ~ 2.69GHz LNA by using BGU7003

Rev. 1 — 3 Dec 2013 Application note

Document information

Info	Content
Keywords	LNA, 2.62 ~ 2.69GHz, BGU7003, LTE
Abstract	The document provides circuit, layout, BOM and performance information for 2.62 ~ 2.69GHz LNA equipped with NXP Semiconductors BGU7003.

Revision history

Rev	Date	Description
1.0	20131203	Initial draft

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1. Introduction

The BGU7003 is wideband Silicon Germanium Amplifier MMIC for high speed, low noise applications. It can be used mainly for LNA applications up to 6 GHz like GPS, Satellite radio, Cordless Phone, CMMB (China Mobile Multimedia Broadcasting). 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 by means of 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 2.62 ~ 2.69GHz LNA evaluation board (EVB) is designed to evaluate the performance of the BGU7003 applied as a LTE LNA. In this document, the application diagram, board layout, bill of material, and some typical results are given.

Figure 1 shows the evaluation board.

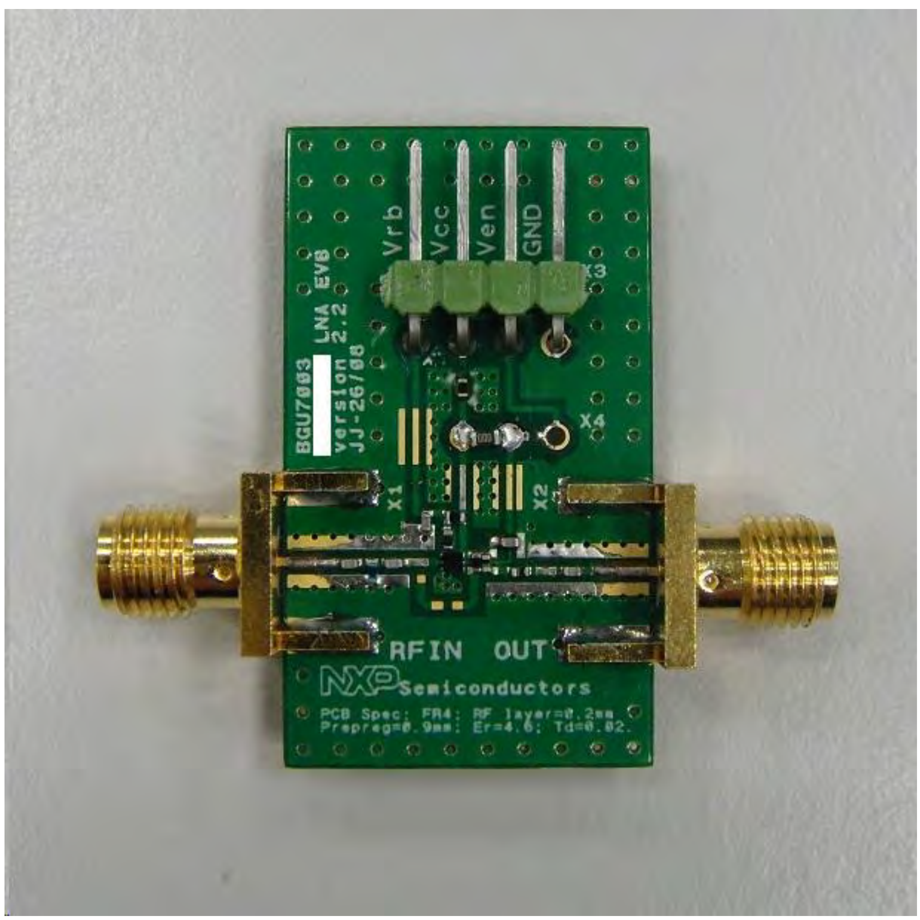


Fig 1. BGU7003 2.62 ~ 2.69GHz LNA evaluation board.

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 resister 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.

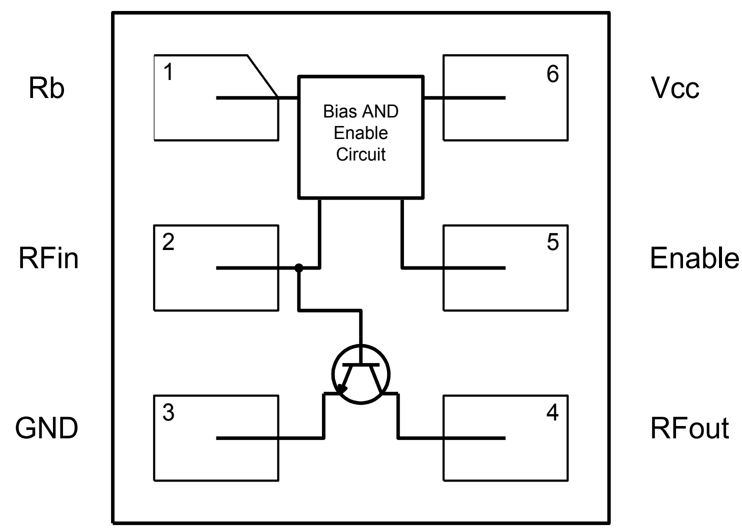


Fig 2. Simplified internal circuit of the BGU7003

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 next paragraphs the BGU7003 applied as a 2.62GHz to 2.69GMHz LNA is described.

3. Application Board.

The BGU7003 2.62 ~ 2.69GHz LNA EVB simplifies the evaluation of the BGU7003 wideband amplifier MMIC, for the LTE 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 2.8V Vdc supply voltage.

3.1 Application Circuit

In figure 3 the application diagram as supplied on the evaluation board is given.

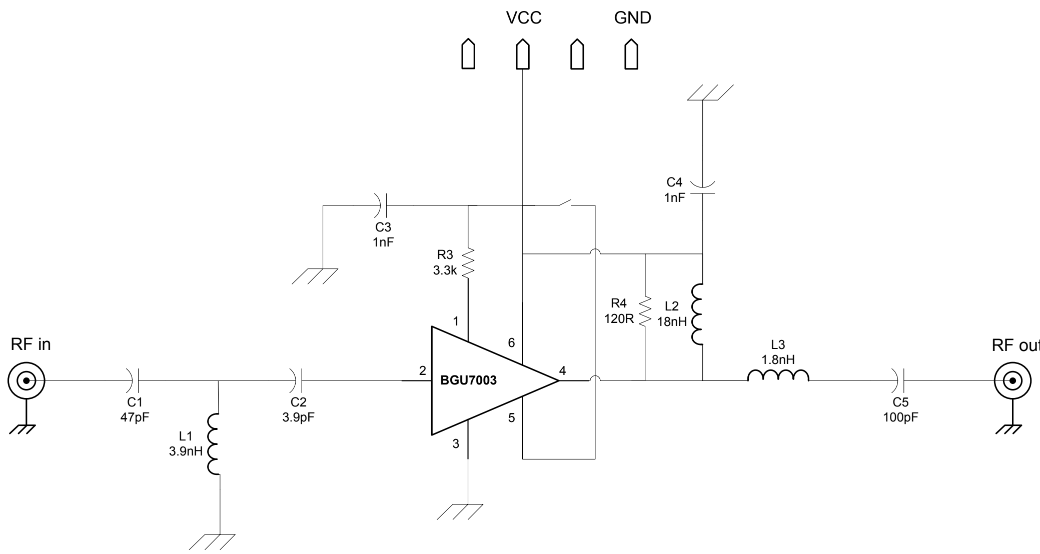


Fig 3. Circuit diagram of the evaluation board

3.2 Board Layout

Figure 4 shows the board layout with the component

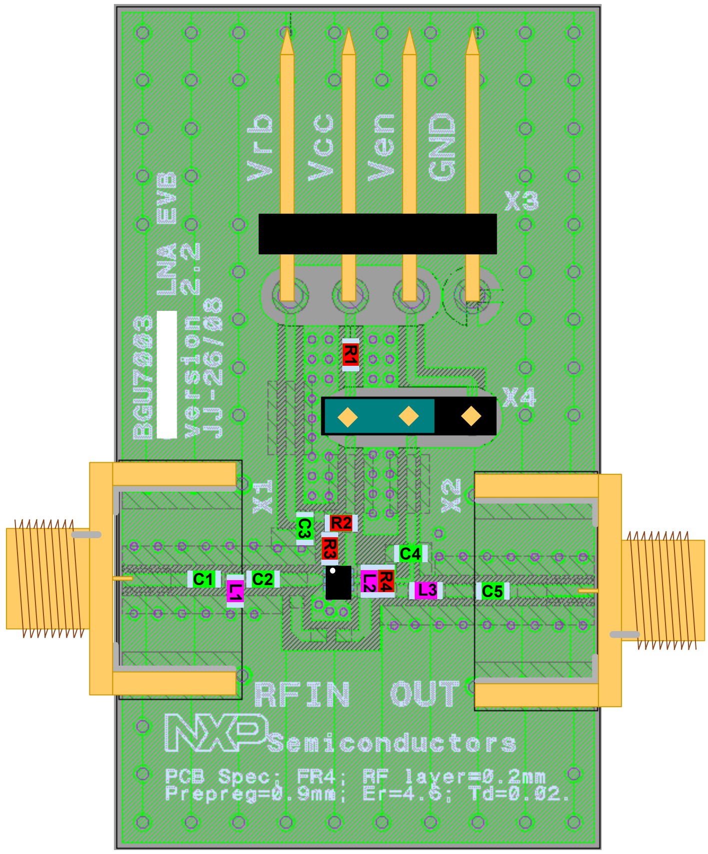


Fig 4. Printed circuit board of the BGF7003 2.62 ~ 2.69GHz evaluation board

3.3

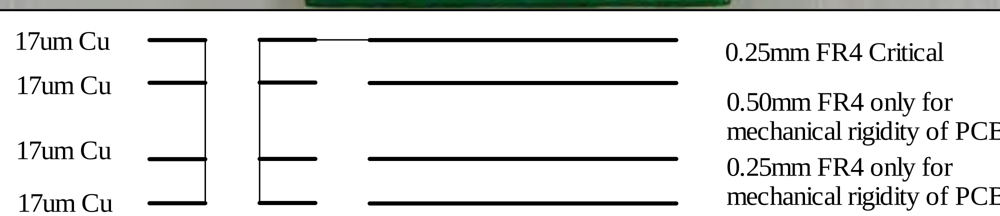


Fig 5. Stack of the PCB material

Material supplier is ISOLA DURAVER; Er= 4.6-4.9: Tδ=0.02

3.4 Bill of materials

Table 1. Bill of materials

Designator	Description	Footprint	Value	Supplier Name/type	Comment
C1	Capacitor	0402	47 pF	MurataGRM1555	Input matching
C2	Capacitor	0402	3.9 pF	MurataGRM1555	Input matching
C3	Capacitor	0402	1 nF	MurataGRM1555	LF Decoupling
C4	Capacitor	0402	1 nF	MurataGRM1555	Output matching
C5	Capacitor	0402	100 pF	MurataGRM1555	DC Blocking
L1	Inductor	0402	3.9 nH	Murata/LQW15A High Q low Rs	Input matching
L2	Inductor	0402	18 nH	Murata/LQG15A	DC Bias
L3	Inductor	0402	1.8 nH	Murata/LQG15A	Output matching
R1, R2	Resistor	0402	0 Ω	Various	Backup tune pads
R3	Resistor	0402	3.3 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 90121-0763	Bias connector

4. Required Equipment

In order to measure the evaluation board the following equipment or equivalent is suggested.

- ✓ DC Power Supply up to 10mA at 2.8V (up to 15 V for bias Control)
- ✓ RF Signal generator capable of generating an RF signal at the operating frequency of 2620MHz to 2690MHz.
- ✓ RF spectrum analyzer that covers at least the operating frequency of 2620MHz to 2690MHz as well as a few of the harmonics, (up to 10 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 BGU7003, 2620MHz to 2690MHz EVB is fully assembled and tested. Please follow the steps below for a step-by-step guide to operate the EVB and testing the device functions.

1. Connect the DC power supply set to 2.8V to the V_{CC} and GND terminals.
2. Connect the RF signal generator and the Spectrum Analyzer; to the RF input and the RF output of the EVB respectively. Do not turn on the RF output of the Signal generator yet, set it to -30dBm output power at 2650MHz, set the spectrum analyzer on 2650MHz center frequency and a reference level of 0dBm.
3. Turn on the DC power supply and it should read approximately 6.6mA.
4. Enable the RF output of the generator; the Spectrum analyzer displays a tone of 2650MHz at around –15dBm.
5. In order to evaluate the board on different bias currents through RF stage of the MMIC the Voltage on Rb (V_{Rb}) can be connected to a separate power supply. This is enabling the control of the bias current.
6. To evaluate the enable function the V_{en} terminal of the board can also be connected to a separate DC power supply that either gives a voltage >0.6V (amplifier on) or <0.5V amplifier off.
7. Instead of using a signal generator and spectrum analyzer one can also use a Network Analyzer (NVA) in order to measure Gain as well as in- and output return loss
8. For Noise figure evaluation, either a Noise-figure analyzer or a spectrum analyzer with noise option can be used. The use of a 5 dB noise source, like 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.

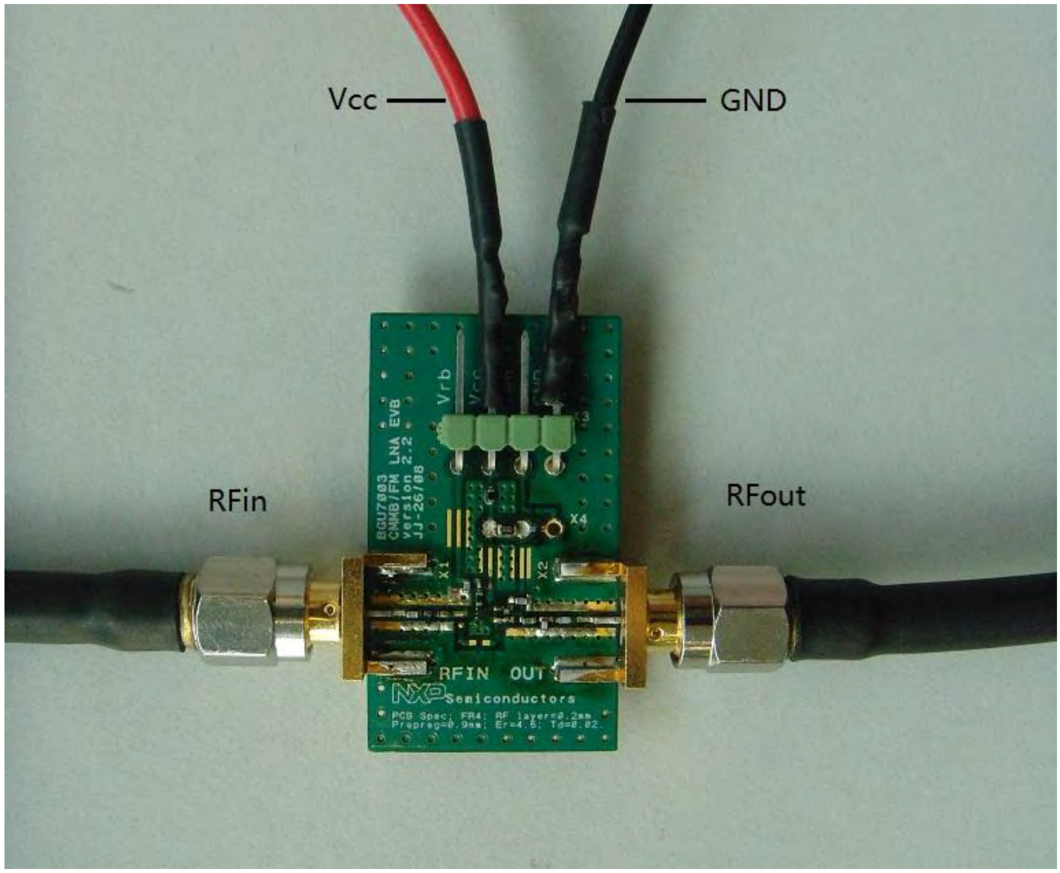


Fig 6. Evaluation board including its connections.

6. Typical EVB Results

Table 2. Typical measurement results measured on the evaluation board.

Temp=25 ℃, frequency is 2650MHz unless otherwise specified.

Parameter	Symbol	BGU7003 EVB	Unit	Comment
Supply Voltage	Vcc	2.8	V	
Supply Current	Icc	6.6	mA	
Noise Figure	NF	1.3	dB	[1]
Power Gain	Gp	14.4	dB	[2]
Input Return Loss	IRL	8.0	dB	[2]
Output Return Loss	ORL	10.6	dB	[2]
Reverse Isolation		23.3	dB	[2]
Input 1dB Gain Compression	IP1dB	-15	dBm	
Output 1dB Gain Compression	OP1dB	-0.6	dBm	
Input third order intercept point	IIP3	-6	dBm	[2] [3]
Output third order intercept point	OIP3	8.4	dBm	[2] [3]

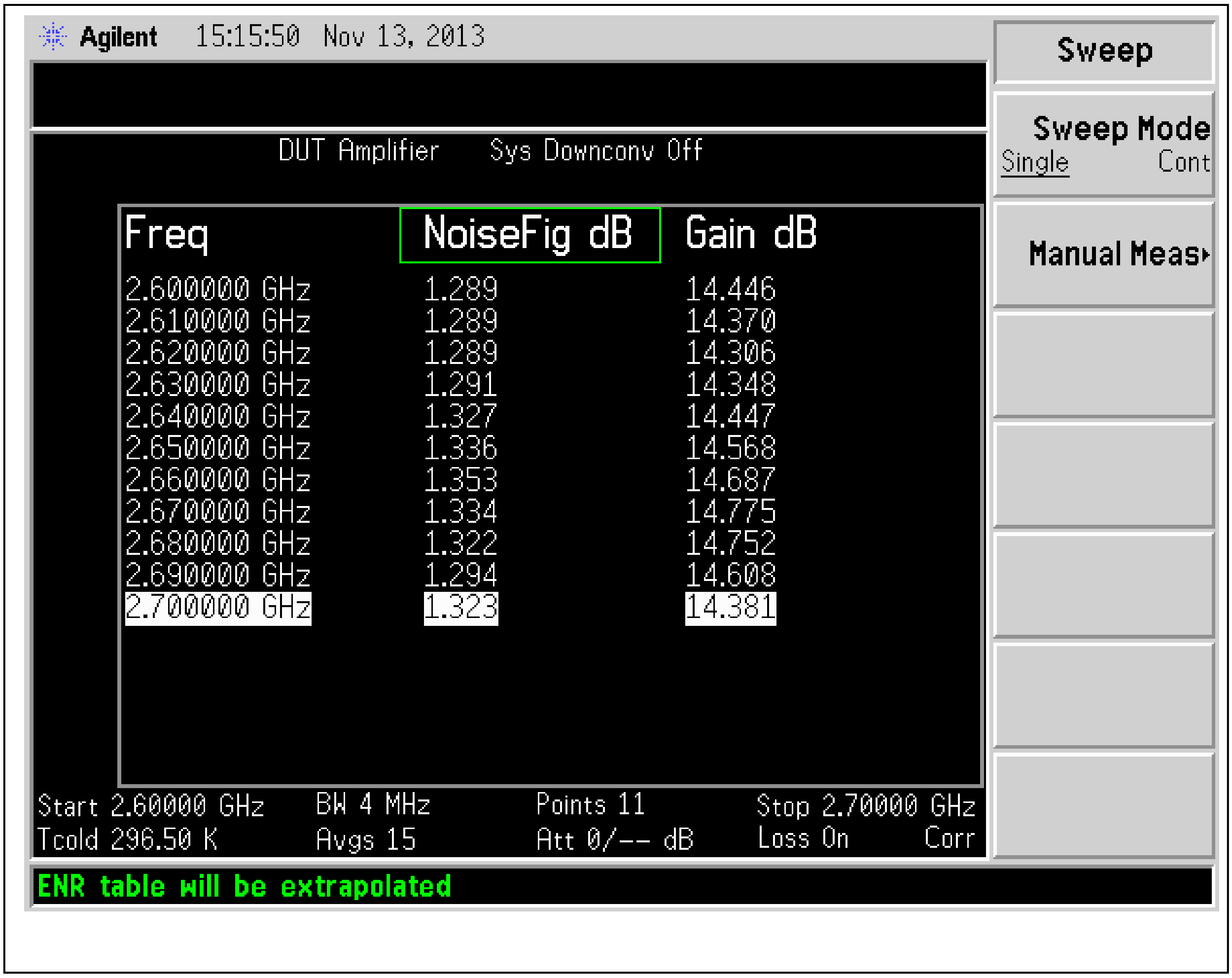
[1] The NF and Gain figures are being measured at the SMA connectors of the EVB, so the losses of the connectors and the PCB should be subtracted. The loss will be approximately 0.15 dB.

[2] Pin= - 30dBm

[3] 2-Tone test with F1=2649.5MHz, F2=2650.5MHz (Spacing 1MHz). Highest spurious used for calculations.

Noise Figure, Tabular Data

From Agilent N8975A



Freq	NoiseFig dB	Gain dB
2.600000 GHz	1.289	14.446
2.610000 GHz	1.289	14.370
2.620000 GHz	1.289	14.306
2.630000 GHz	1.291	14.348
2.640000 GHz	1.327	14.447
2.650000 GHz	1.336	14.568
2.660000 GHz	1.353	14.687
2.670000 GHz	1.334	14.775
2.680000 GHz	1.322	14.752
2.690000 GHz	1.294	14.608
2.700000 GHz	1.323	14.381

Table 3. Table of Noise Figure.

K - Factor, Lin Mag

10 MHz – 10 GHz

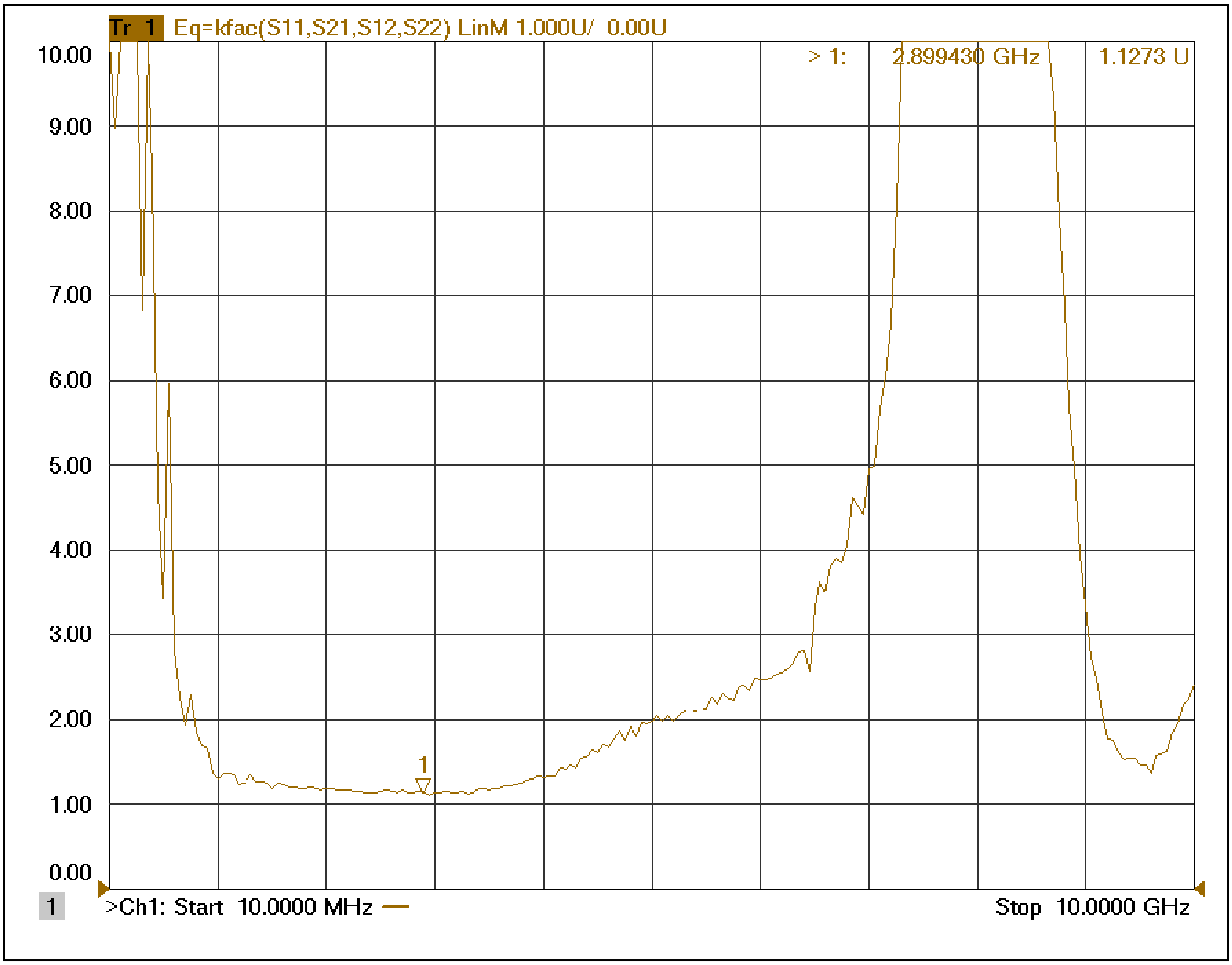


Fig 7. Plot of Stability Performance.

Iutput Return Loss, Log Mag

1GHz – 4GHz

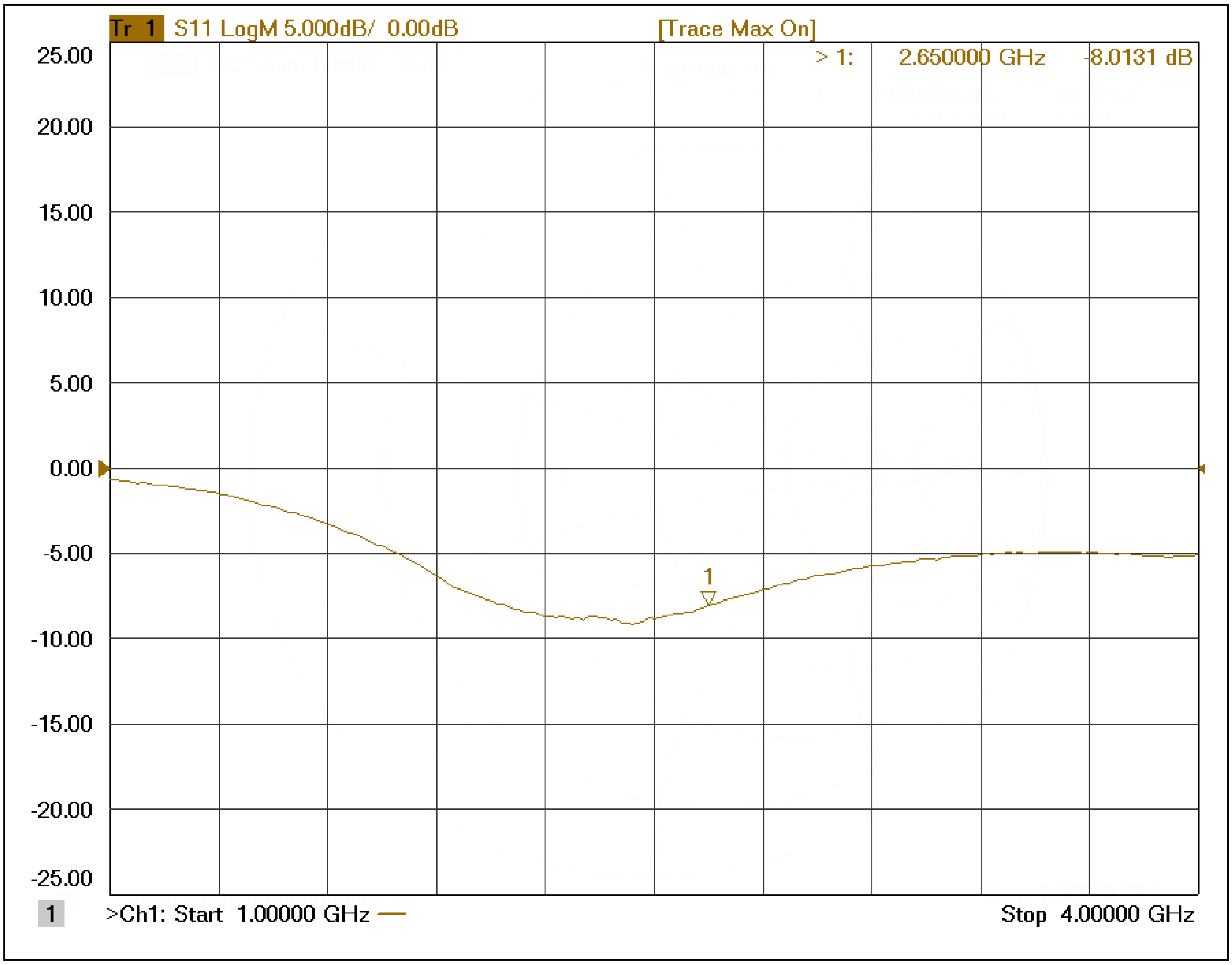


Fig 8. Plot of Iutput Return Loss.

Input Return Loss, Smith Chart

Reference Plane = Input SMA Connector on PC Board

1GHz – 3GHz

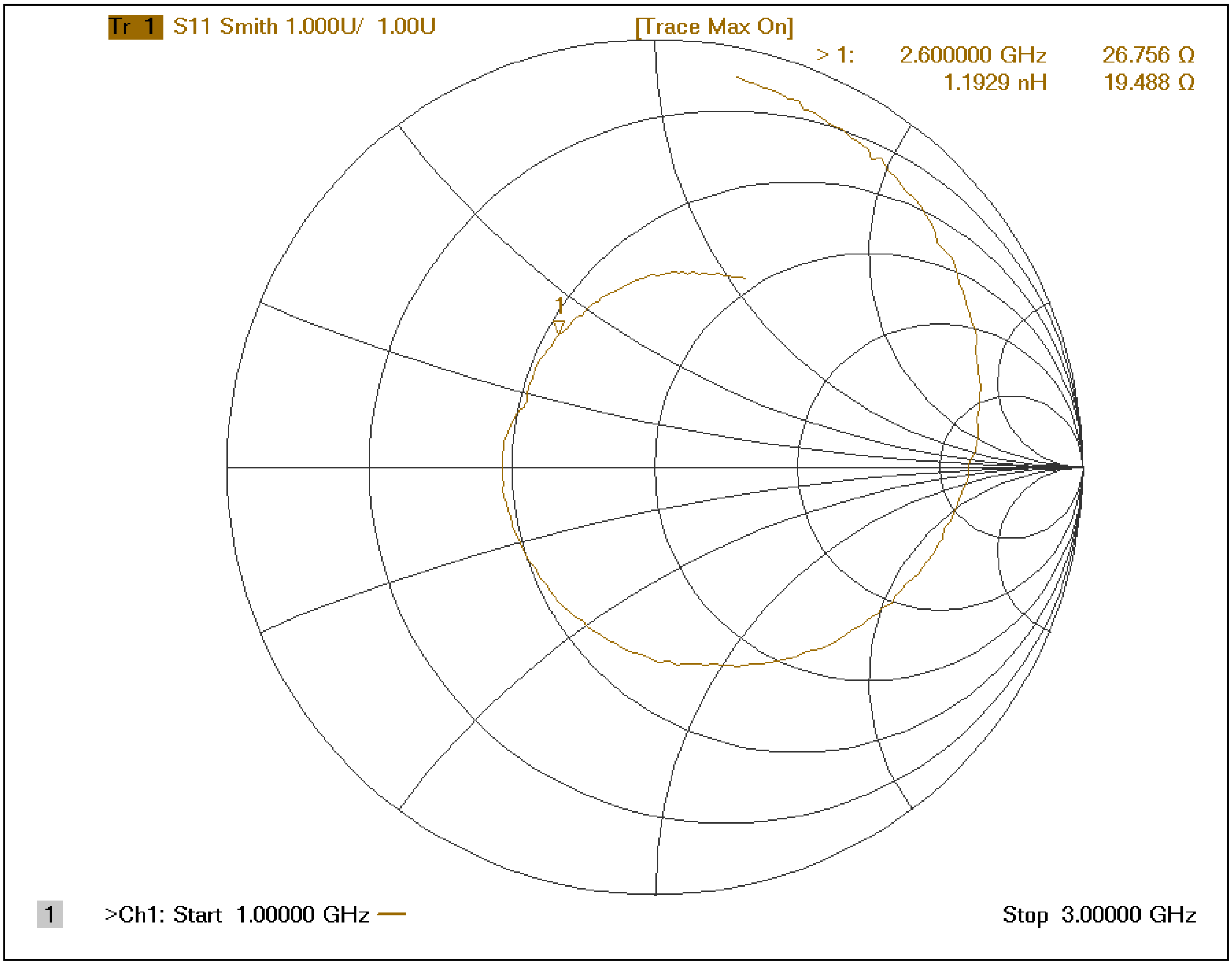


Fig 9. Smith Chart of Input Return Loss.

Forward Gain, Wide Sweep

1GHz – 4GHz

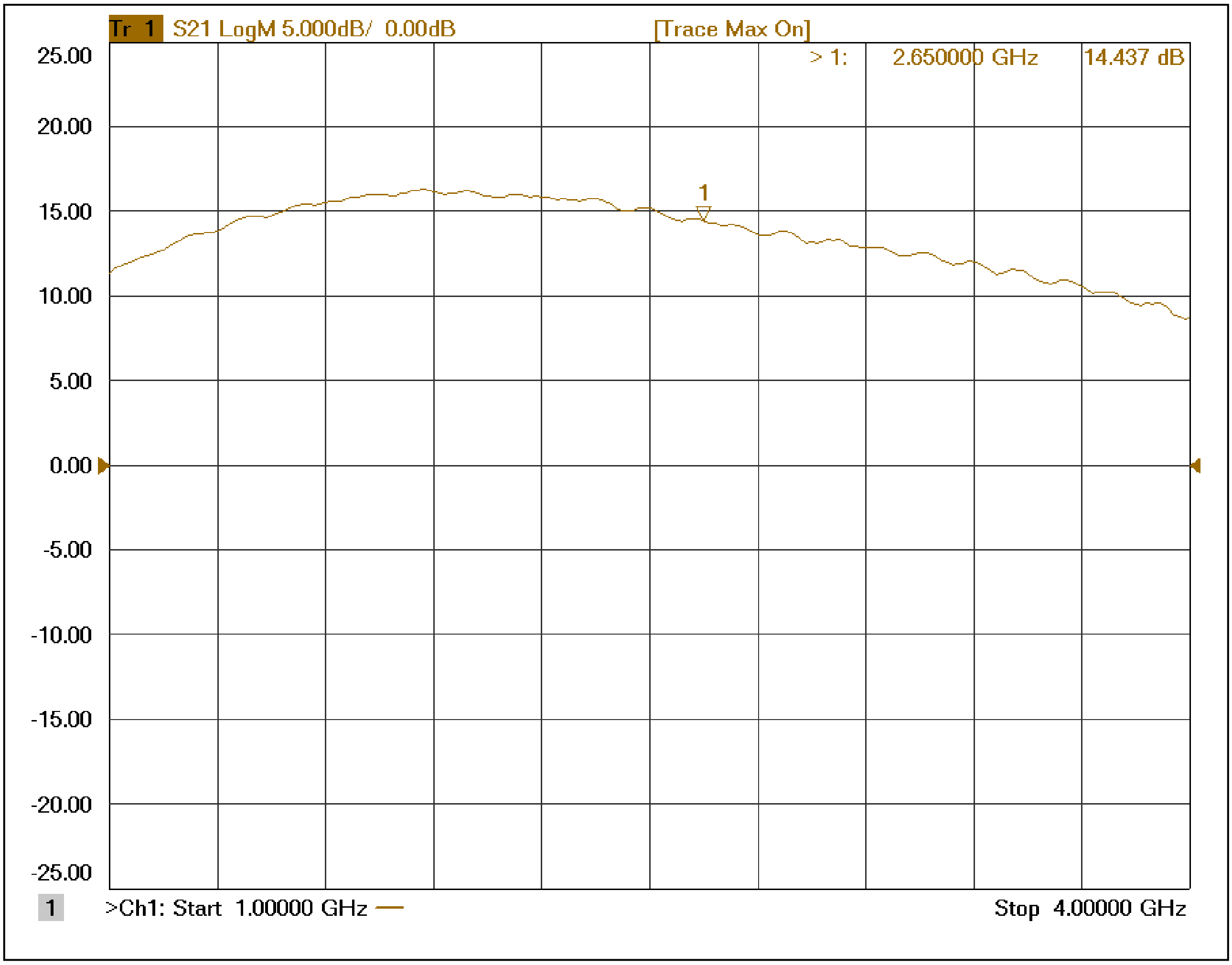


Fig 10. Plot of Forward Gain.

Reverse Isolation

1GHz – 4GHz

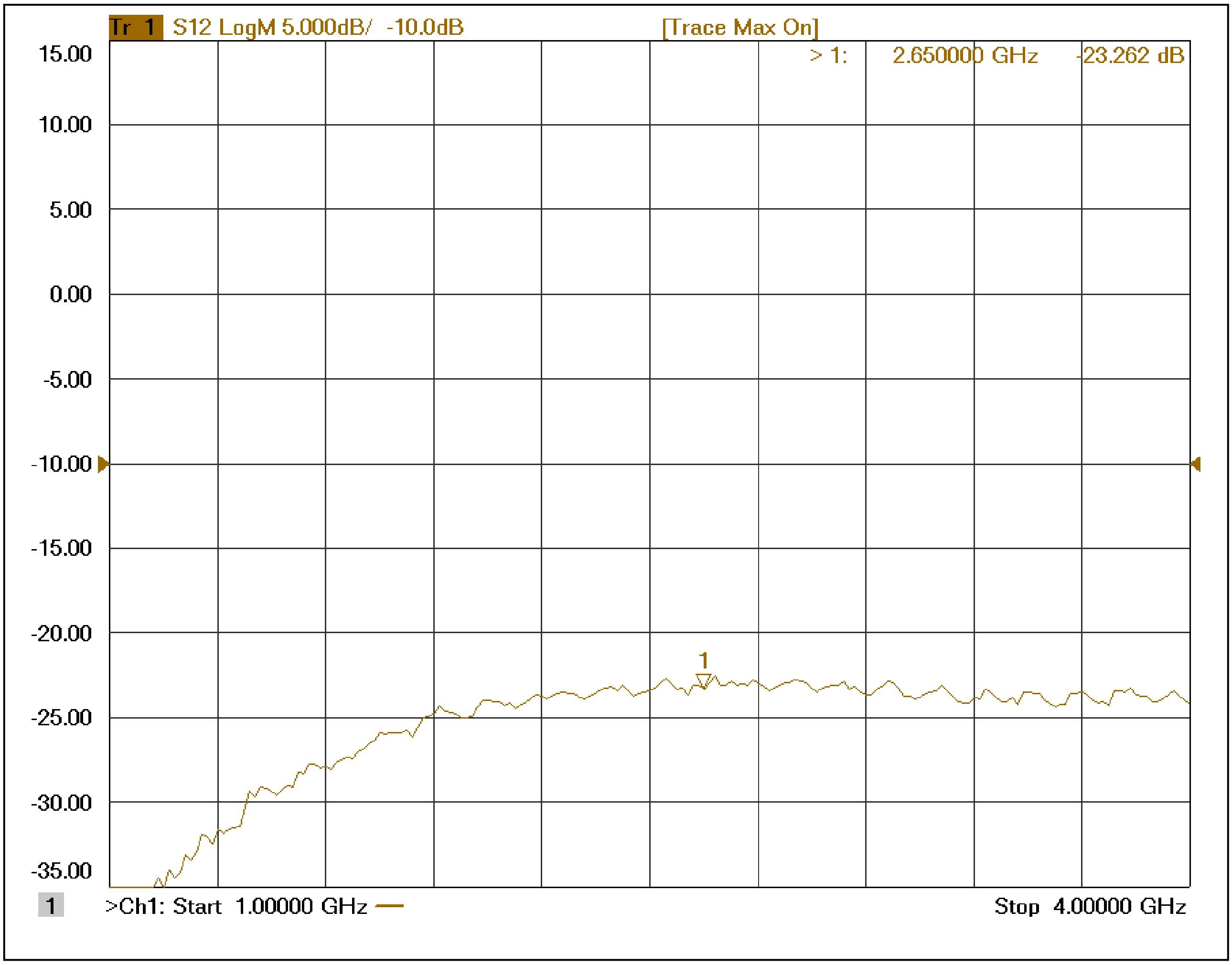


Fig 11. Plot of Reverse Isolation.

Output Return Loss, Log Mag

1GHz – 4GHz

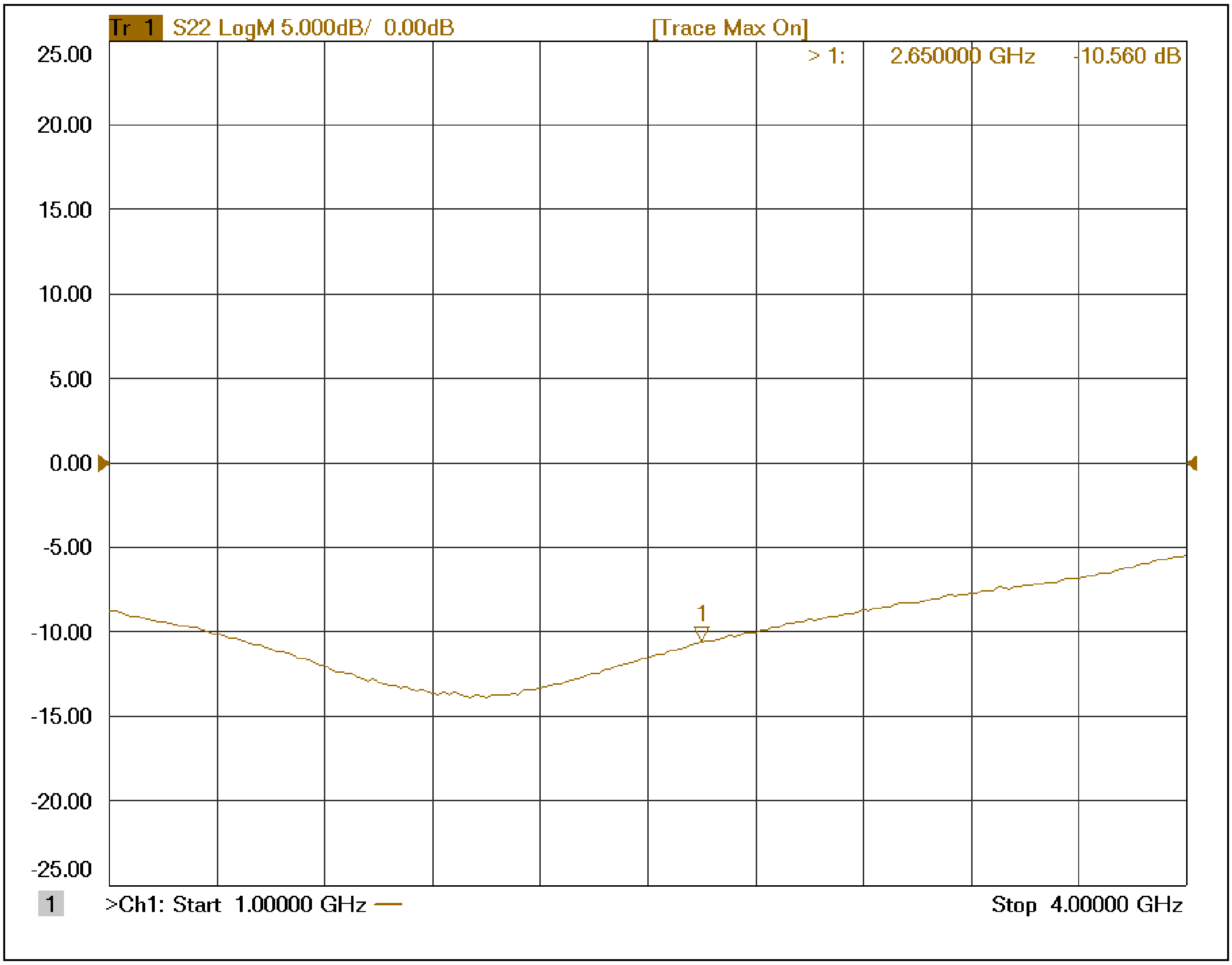


Fig 12. Plot of Output Return Loss.

Output Return Loss, Smith Chart

Reference Plane = Input SMA Connector on PC Board

1GHz – 3GHz

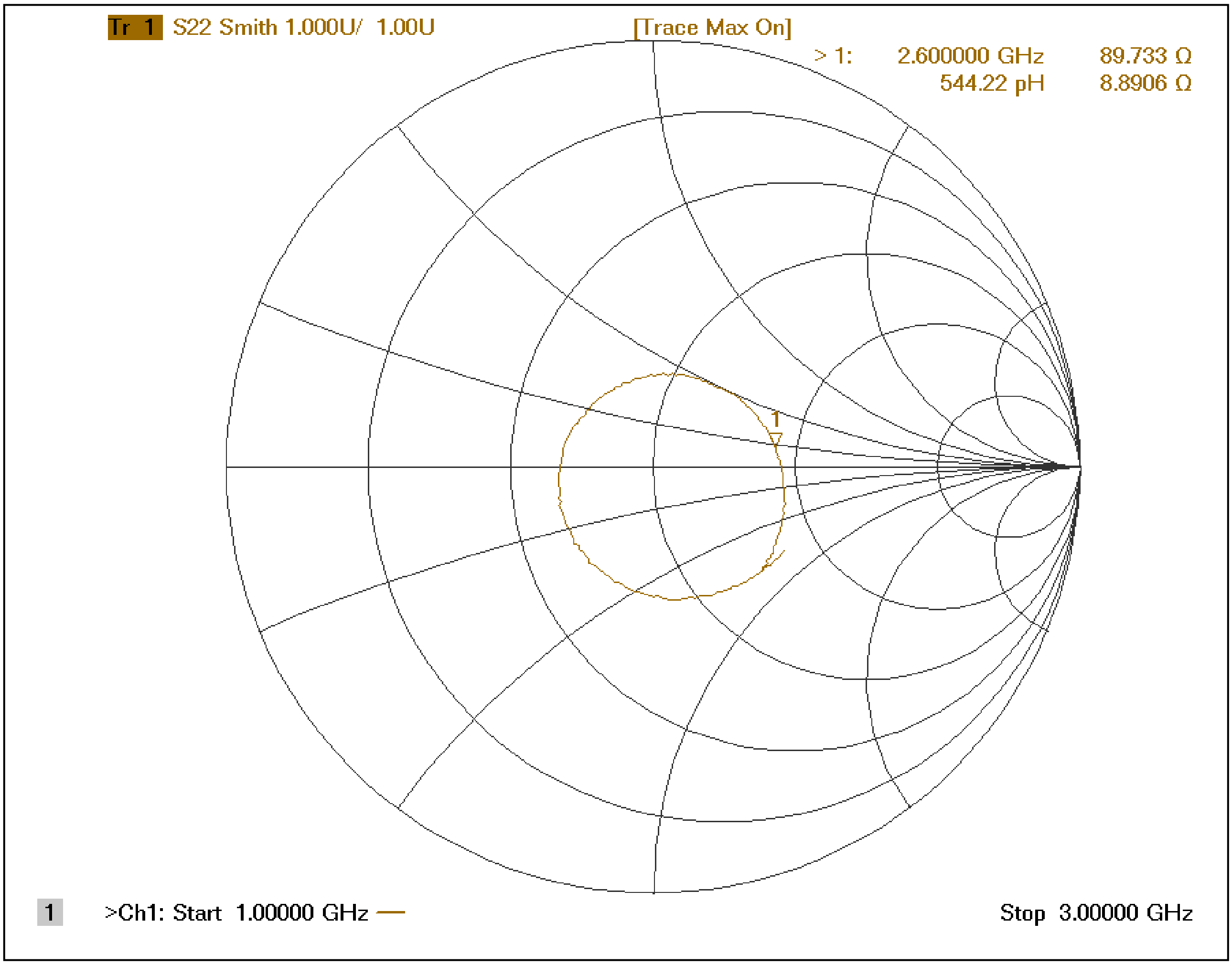


Fig 13. Smith Chart of Output Return Loss.

P1dB, Linearity

2.65GHz

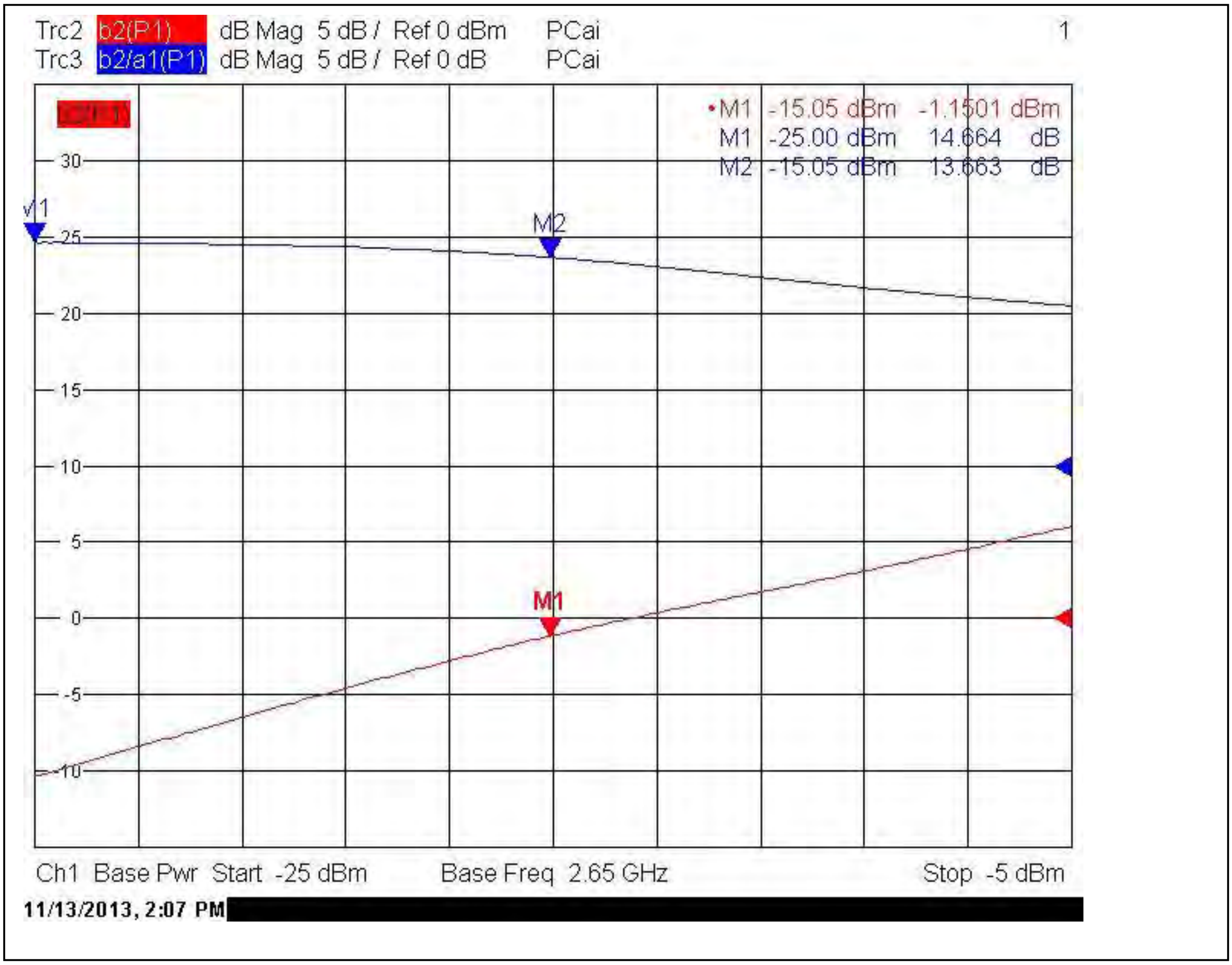


Fig 14. P1dB, Linearity

Output Return Loss, Smith Chart

OIP3, Linearity

Pin= - 30dBm

2-Tone test with F1=2649.5MHz, F2=2650.5MHz (Spacing 1MHz).

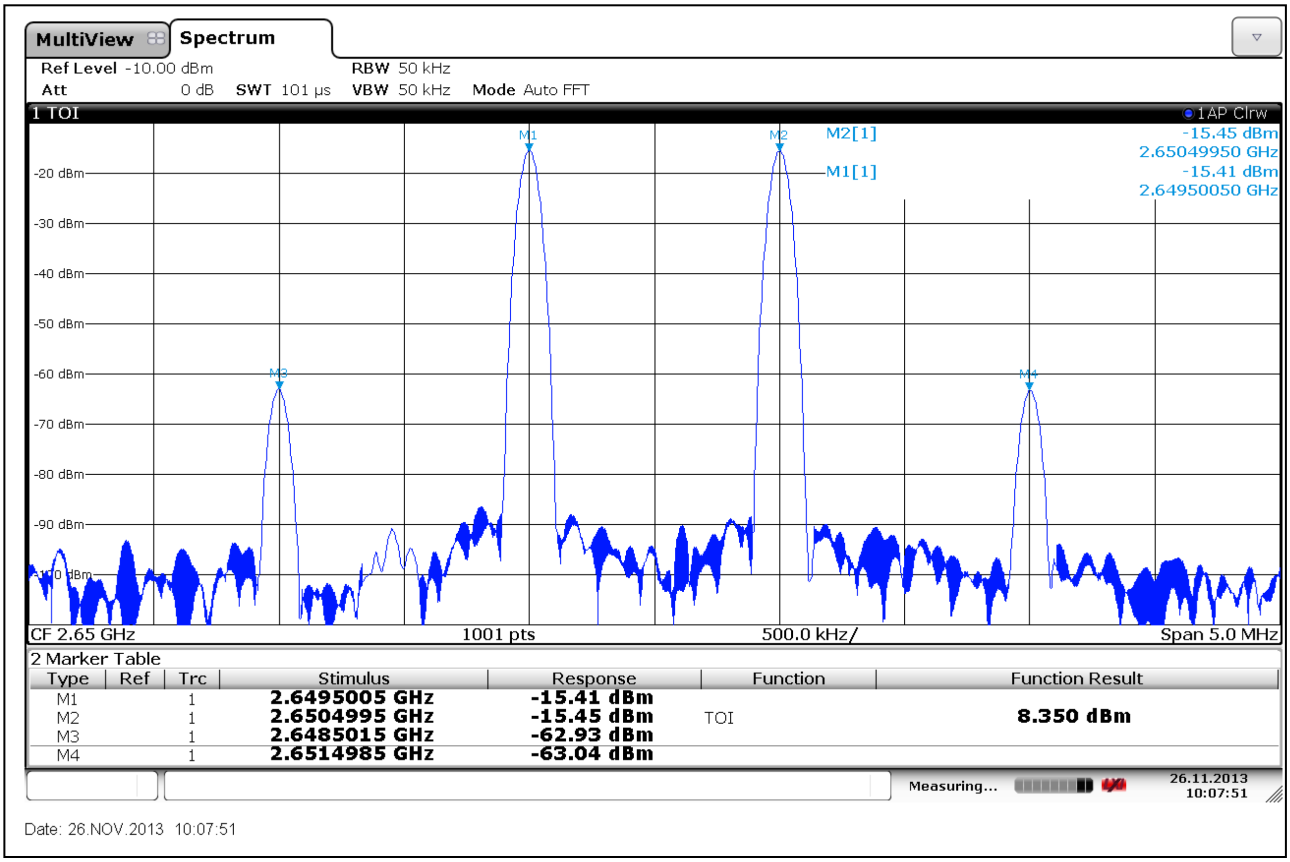


Fig 15. OIP3, Linearity.

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