Application Note No. 122

Infineon's BFP740F Ultra Low Noise RF Transistor in 2.33 GHz SDARS Low Noise Amplifier Application

RF & Protection Devices

Never stop thinking

Edition 2007-08-30

Published by
Infineon Technologies AG
81726 München, Germany

Application Note No. 122

Revision History: 2007-08-30, Rev. 1.2

Previous Version: 2007-02-14, Rev. 1.1	
Page	**Subjects (major changes since last revision)**
All	Change of layout

1 Infineon's BFP740F Ultra Low Noise RF Transistor in 2.33 GHz SDARS Low Noise Amplifier Application

Applications

- LNA stage for Satellite Digital Audio Radio Service "SDARS" active antennas, e.g. 2320 - 2332.5 MHz "SIRIUS" or 2332.5 - 234 MHz "XM Radio".

Overview

- The Infineon Technologies Silicon-Germanium-Carbon BFP740F HBT RF Transistor in TSFP-4 package is shown in a +3.0 V 2.33 GHz LNA application. Amplifier draws 8.9 mA. +5 V power supply can be used if bias resistor values are changed.
- Transistor package size is 1.4 x 1.2 x 0.55 mm including external leads (RoHS compliant package).

Specification Targets

Summary of Results

(T =25 °C, Network Analyzer Source Power = -30 dBm, V_{CC} = 3.0 V, V_{CE} = 2.6 V, I = 8.9 mA)

Table 1 Summary of Results

Frequency MHz	dB[s11]^2	dB[s21]^2	dB[s12]^2	dB[s22]^2	NF[1)] dB	IIP_3 dBm	OIP_3 dBm	IP_{1dB} dBm	OP_{1dB} dBm
2320	10.6	18.9	24.9	10.7	0.64	---	---	---	---
2332	10.8	18.8	24.8	10.4	0.65	+9.7	+28.5	-12.0	+5.8
2345	10.9	18.8	24.8	10.2	0.64	---	---	---	---

1) PCB loss is not extracted. If PCB loss were extracted, NF would be approximately 0.1 dB lower.

Cross Sectional Diagram of PC Board (standard FR4 material)

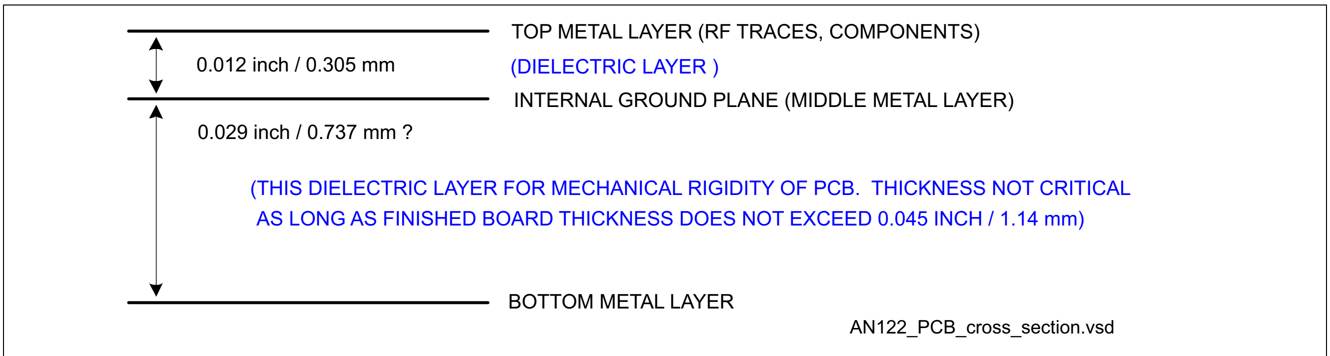

Figure 1 PCB Cross Section

Schematic Diagram

Total Parts Count = 11 pieces, including BFR740F Transistor.

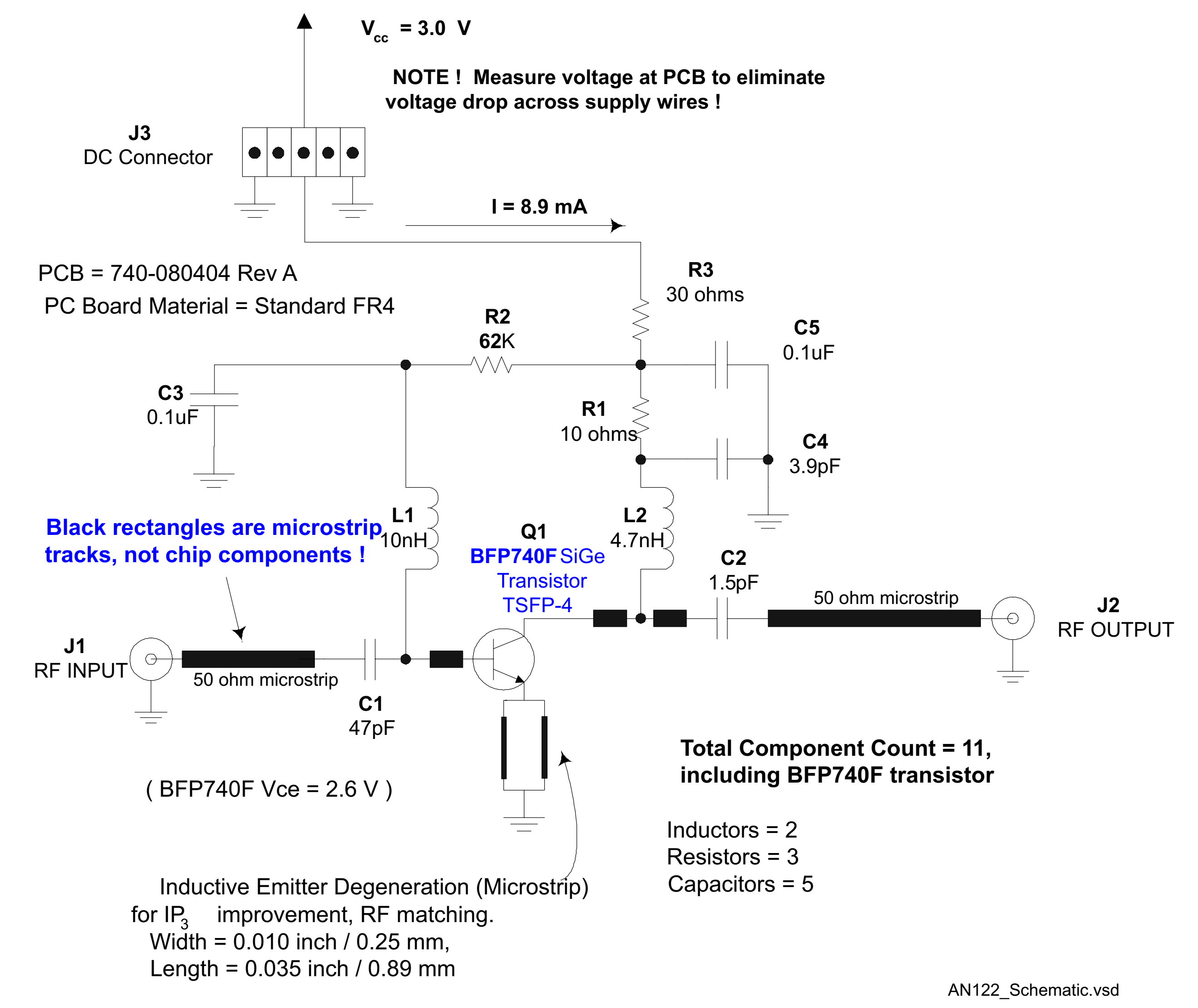

Figure 2 Schematic Diagram

Details on TSFP-4 Package. Dimensions in millimeters (mm)

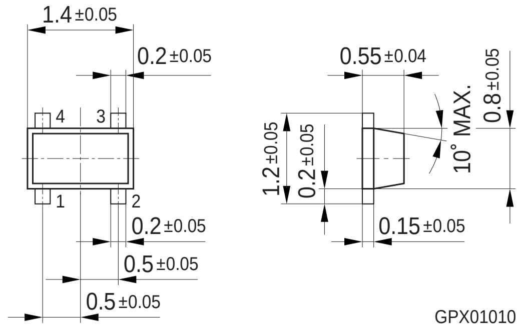

Figure 3 Package Outline TSLP-4

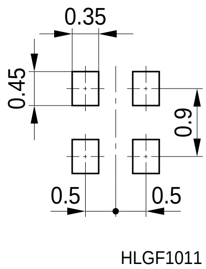

Figure 4 Footpint for TSLP-4

Noise Figure, Plot, 2132.5 to 2532.5 MHz. Center of Plot (x-axis) is 2332.5 MHz.

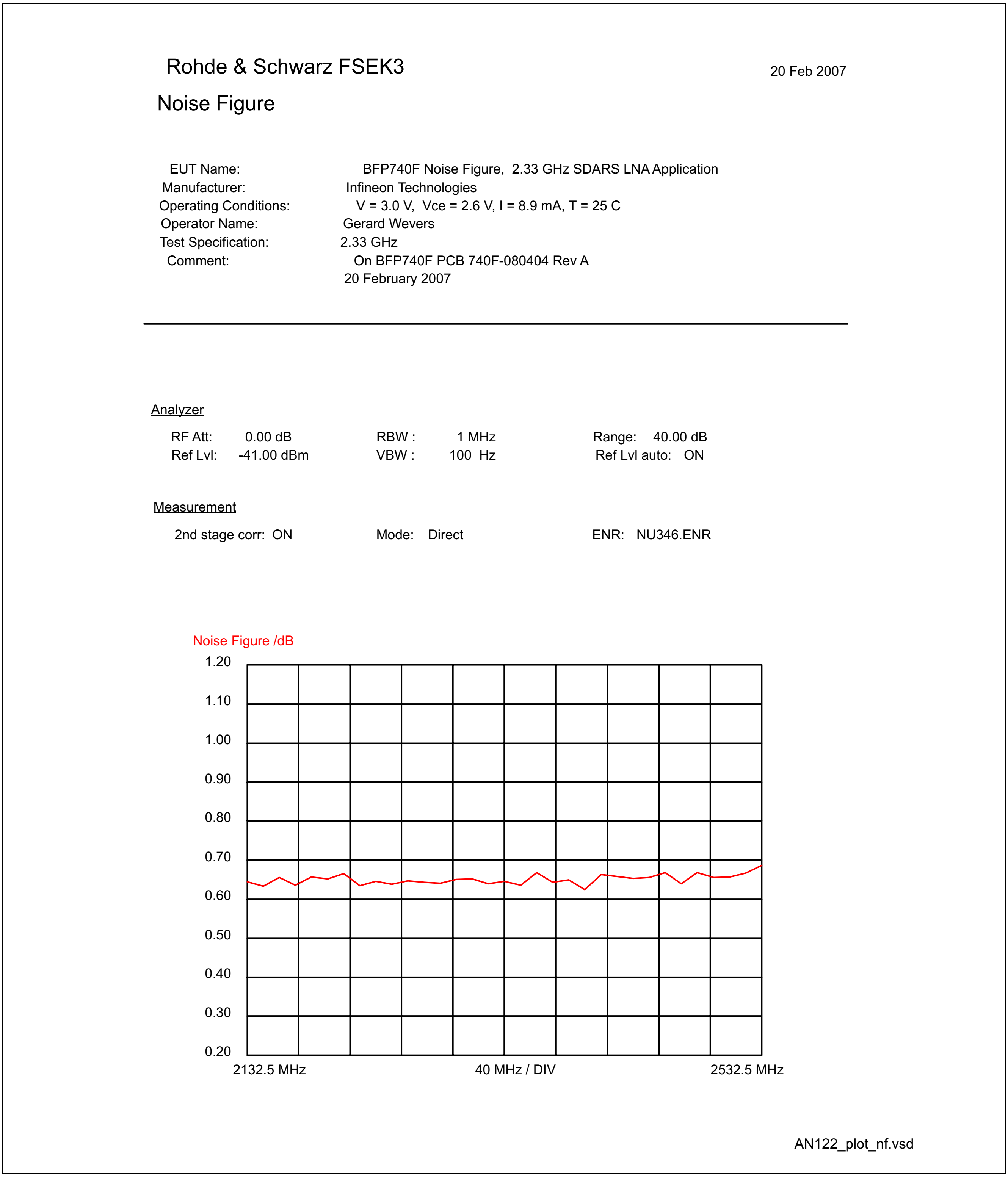

Figure 5 Plot of Noise Figure (2132.5 - 2532.5 MHz)

Noise Figure, Tabular Data

2 GHz - 4 GHz
From Rhode & Schwarz FSEK3+ FSEM30
System Preamplifier = MITEQ SMC-02

Table 2 Noise Figure

Frequency	Noise Figure	Temp
2132.5 MHz	0.64 dB	46.4 K
2145.0 MHz	0.63 dB	45.5 K
2157.5 MHz	0.65 dB	47.2 K
2170.0 MHz	0.64 dB	45.7 K
2182.5 MHz	0.66 dB	47.3 K
2195.0 MHz	0.65 dB	46.9 K
2207.7 MHz	0.67 dB	48.0 K
2220.0 MHz	0.63 dB	45.6 K
2232.5 MHz	0.64 dB	46.4 K
2245.0 MHz	0.64 dB	45.9 K
2257.5 MHz	0.65 dB	46.6 K
2270.0 MHz	0.64 dB	46.3 K
2282.5 MHz	0.64 dB	46.1 K
2295.0 MHz	0.65 dB	46.9 K
2307.5 MHz	0.65 dB	46.9 K
2320.0 MHz	0.64 dB	46.0 K
2332.5 MHz	0.65 dB	46.5 K
2345.0 MHz	0.64 dB	45.7 K
2357.5 MHz	0.67 dB	48.2 K
2370.0 MHz	0.64 dB	46.3 K
2382.5 MHz	0.65 dB	46.8 K
2395.0 MHz	0.62 dB	44.8 K
2407.5 MHz	0.66 dB	47.8 K
2420.0 MHz	0.66 dB	47.4 K
2432.5 MHz	0.65 dB	47.0 K
2445.0 MHz	0.66 dB	47.2 K
2457.5 MHz	0.67 dB	48.2 K
2470.0 MHz	0.64 dB	45.9 K
2482.5 MHz	0.67 dB	48.2 K
2495.0 MHz	0.65 dB	47.2 K
2507.5 MHz	0.66 dB	47.3 K
2520.0 MHz	0.67 dB	48.1 K
2532.5 MHz	0.69 dB	49.7 K

Scanned Image of PC Board

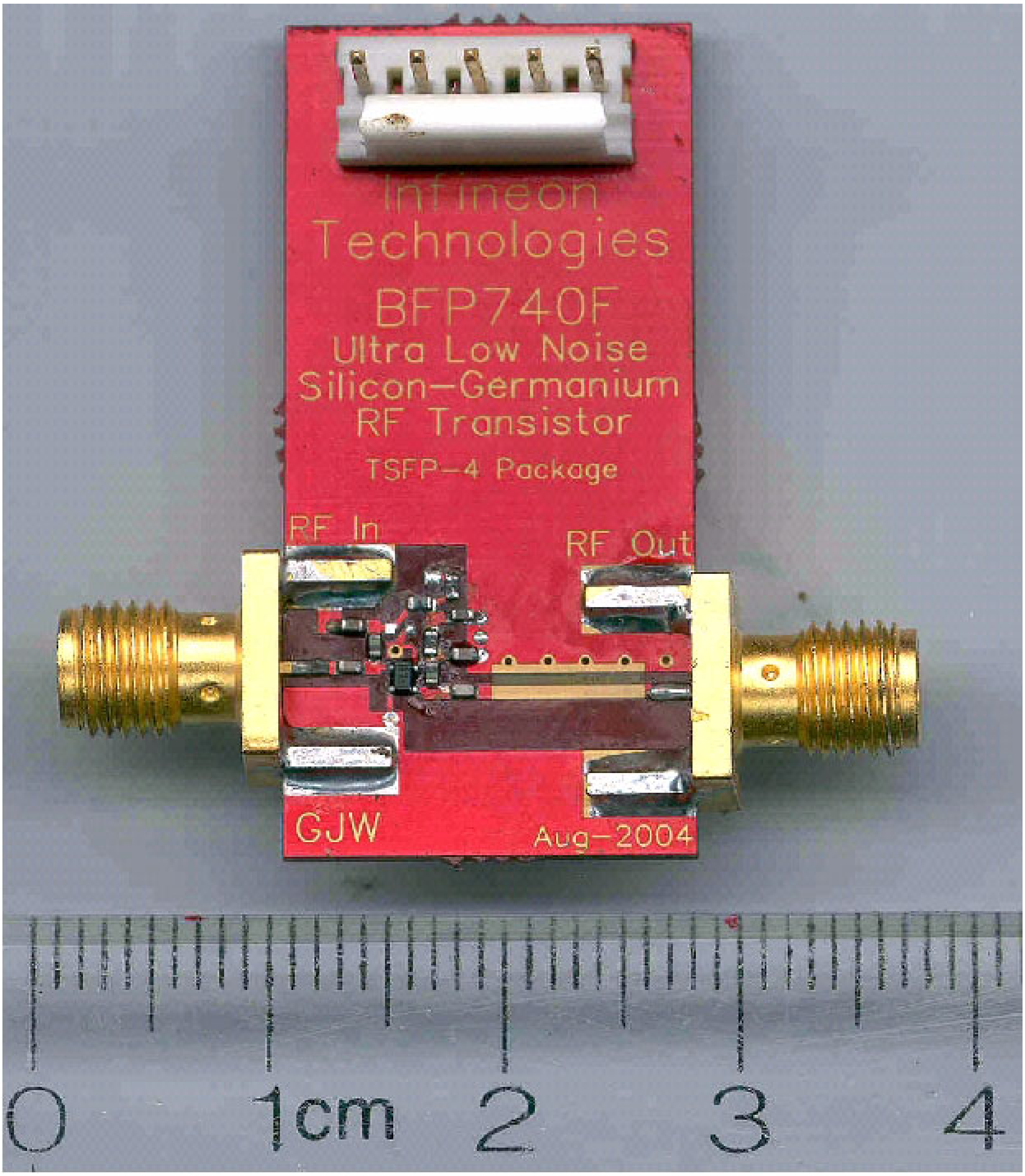

Figure 6 Image of PC Board

Scanned Image of PC Board, Close-In Shot

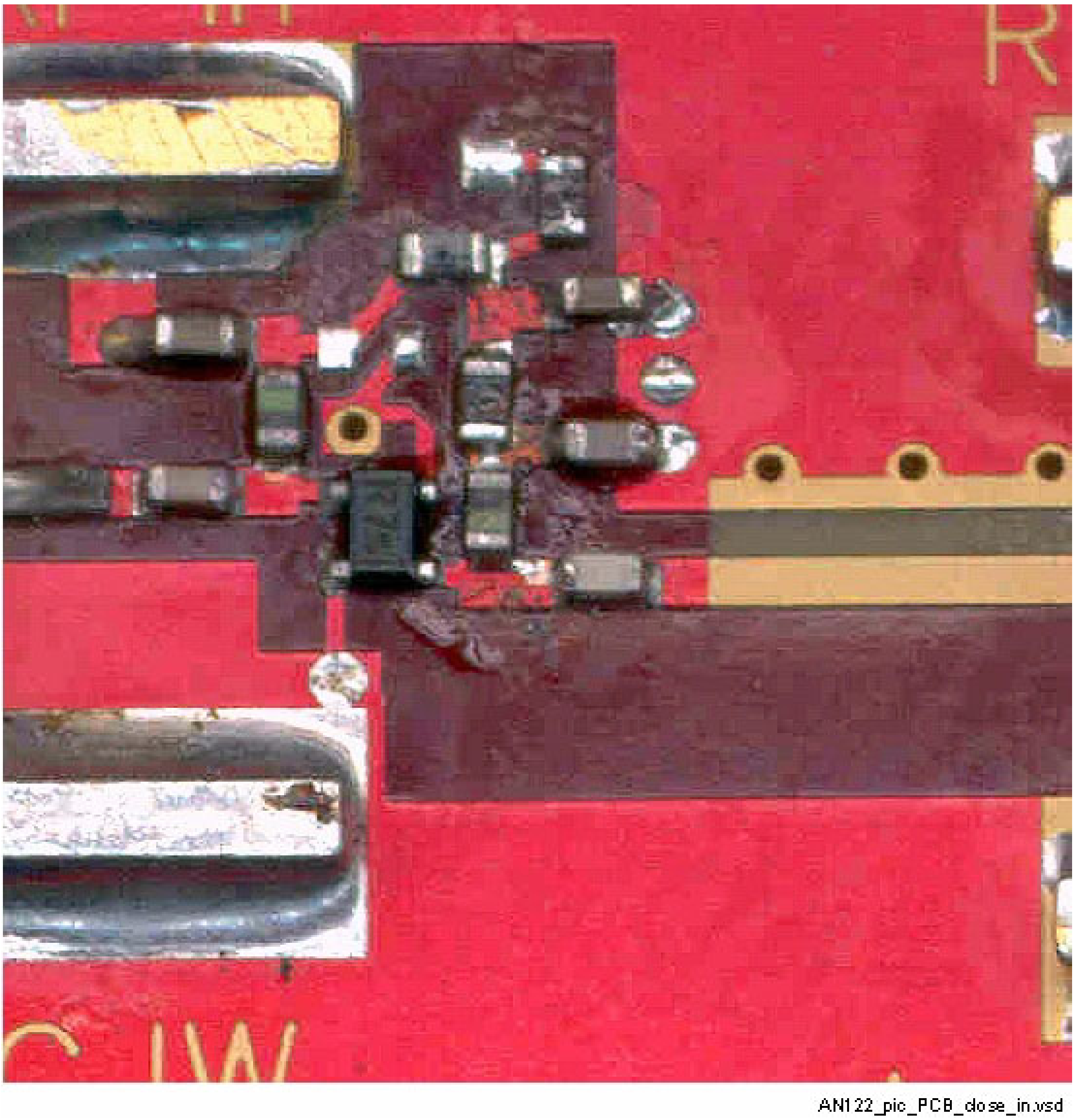

Figure 7 Image of PC Board, Close-In Shot

Gain Compression at 2332 MHz (curve x-axis is LNA output power)

Amplifier is checked for 1 dB compression point at V_{CC} = 3.0 V, I_C = 8.9 mA (with V_{CE} = 2.6 V). An Agilent power meter was used to ensure accurate power levels are measured (as opposed to using Vector Network Analyzer in "Power Sweep" mode).
Output $P_{1dB} \cong$ +5.8 dBm; Input P_{1dB} = +5.8 dBm - (Gain - 1 dB) = +5.8 dBm -17.8 dB = -12.0 dBm

Table 3 Gain Compression, Tabular Data

P_{OUT}, dBm	Gain, dB
-4.0	18.8
-3.0	18.8
-2.0	18.8
-1.0	18.8
0.0	18.8
+1.0	18.8
+2.0	18.7
+3.0	18.6
+4.0	18.5
+5.0	18.3
+6.0	18.6
+7.0	18.7

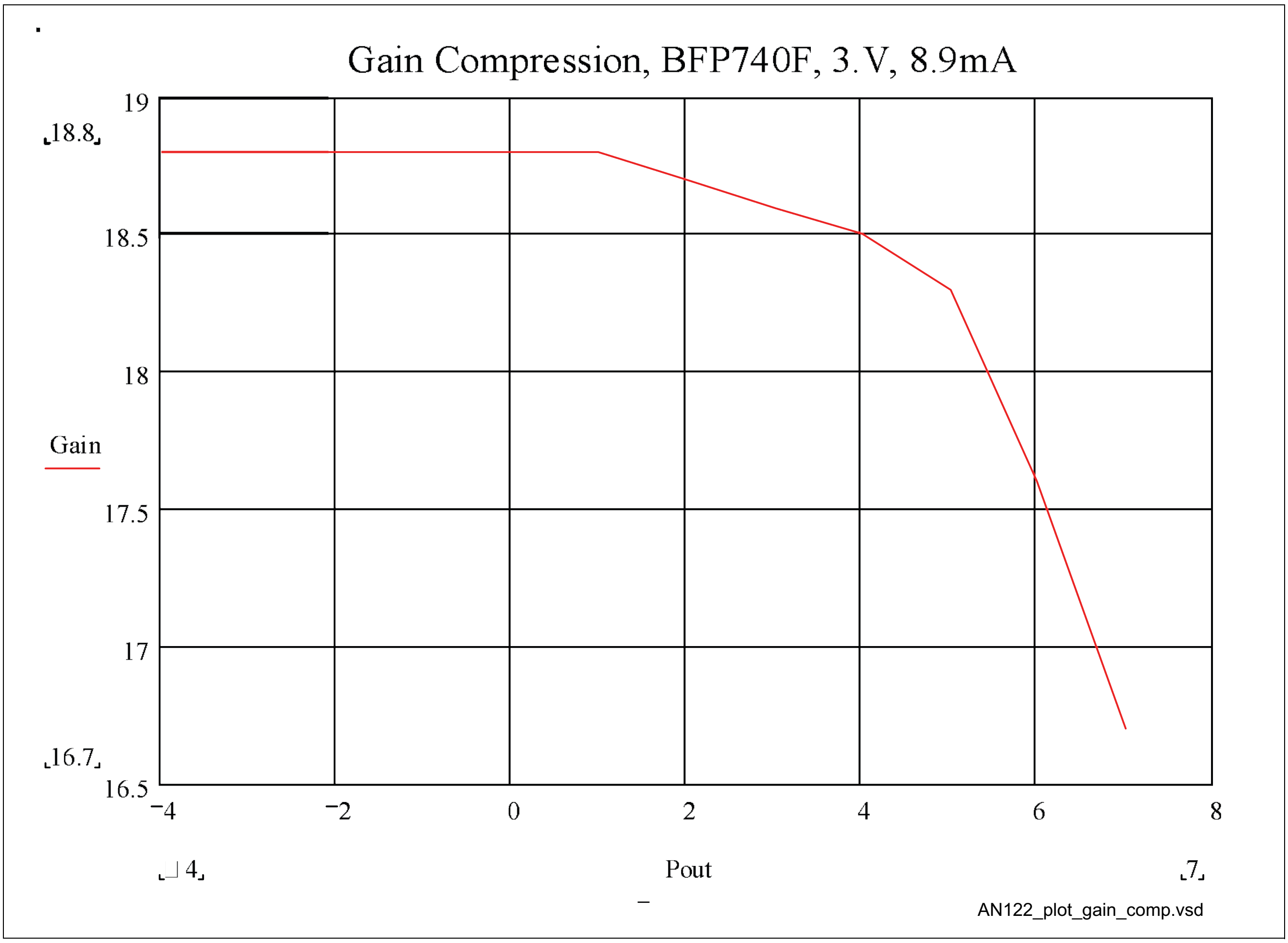

Figure 8 Plot of Gain Compression

PLEASE NOTE - All plots are from Rohde and Schwarz ZVC Network Analyzer, T = 25 °C, SOURCE POWER ≈ -30 dBm, V_{CC} = 3.0 V, I = 9.0 mA

Amplifier Stability

T = 25 °C, V_{CC} = 3.0 V, V_{CE} = 2.6 V, I = 8.9 mA

Stability Factor "K" shown below from "screen shot" taken from Rohde and Schwarz ZVC network analyzer. ZVC Vector Network Analyzer calculates and plots K in real time, from measured S parameters. Note, minimum K value is ~ 0.97 at 2.5 GHz, which is ≈ 1, for practical purposes; => amplifier is unconditionally stable over 5 MHz to 8 GHz ranges

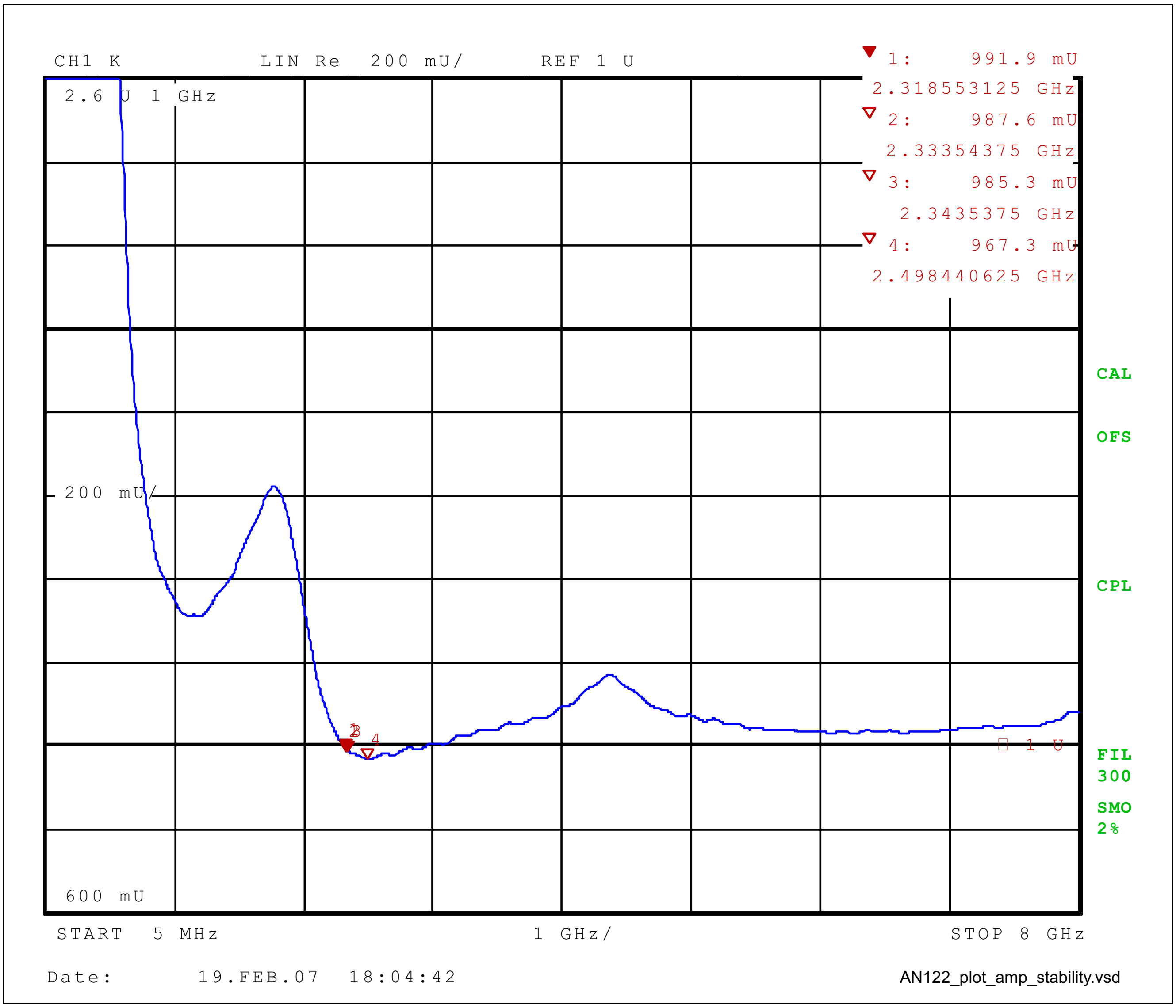

Figure 9 Stabilty Factor K(f)

Input Return Loss, Log Mag

5 MHz to 8 GHz Sweep

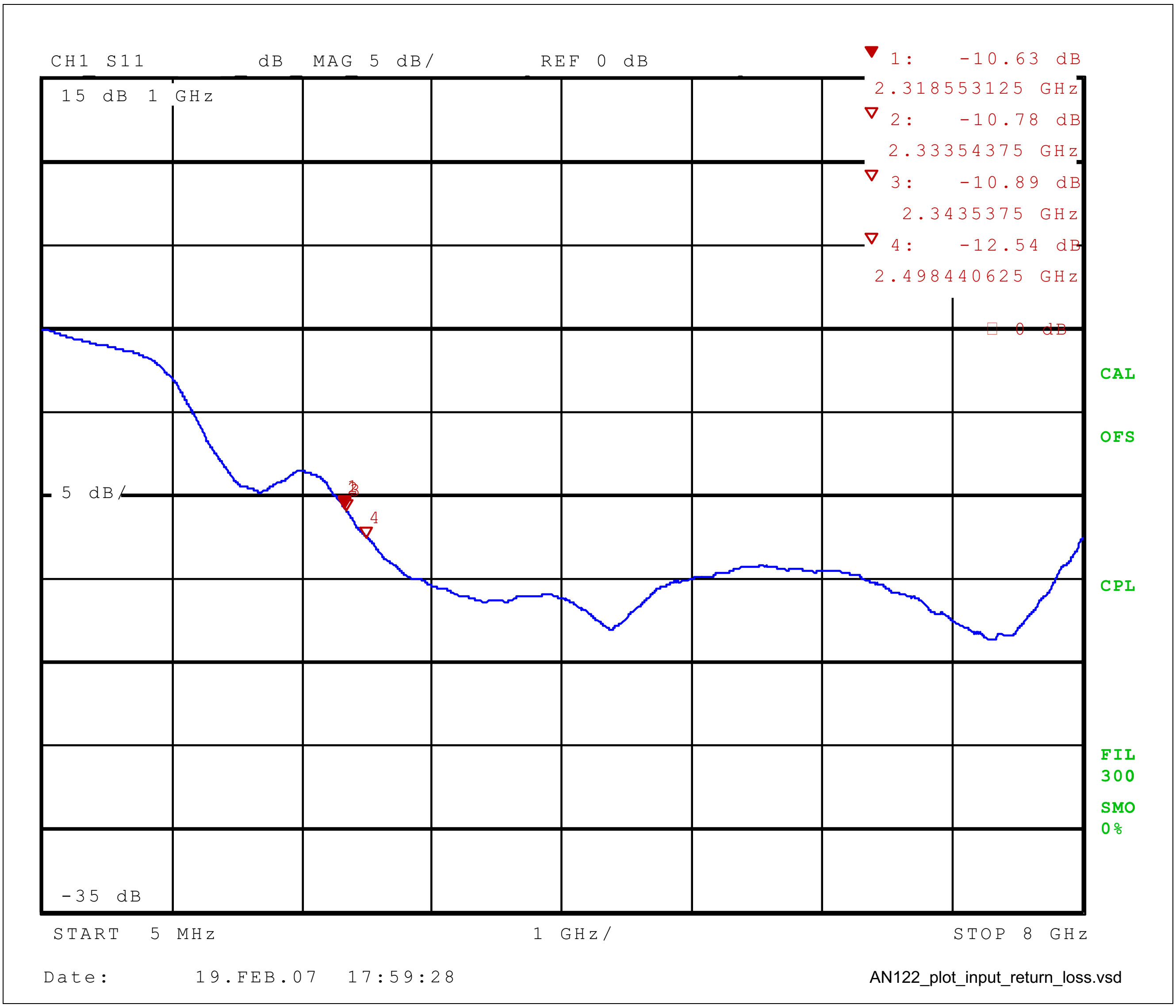

Figure 10 Plot of Input Return Loss (5 MHz - 8 GHz)

Input Return Loss, Smith Chart

Reference Plane = Input SMA Connector on PC Board
5 MHz to 8 GHz Sweep

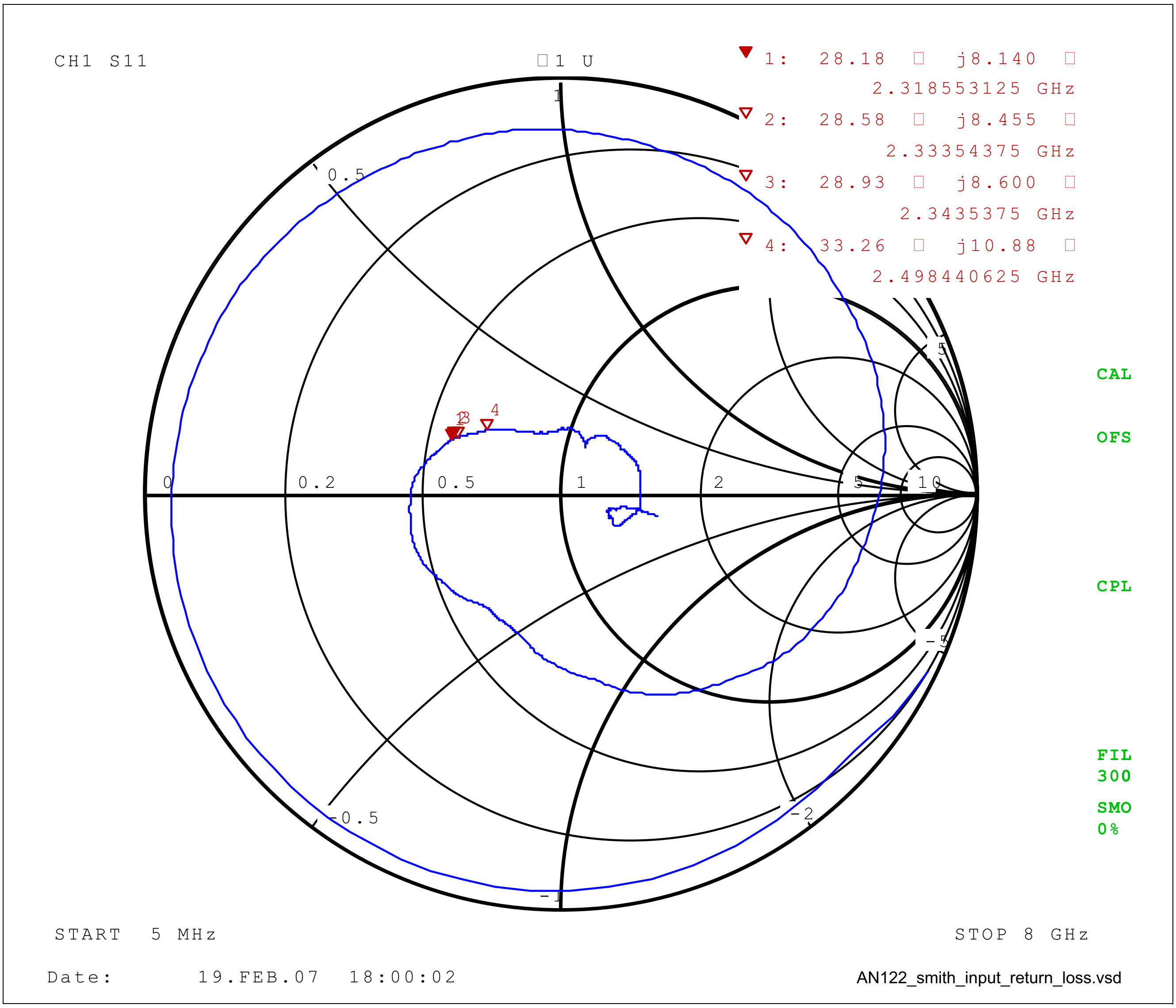

Figure 11 Smith Chart of Input Return Loss (5 MHz - 8 GHz)

Forward Gain

5 MHz to 8 GHz Sweep

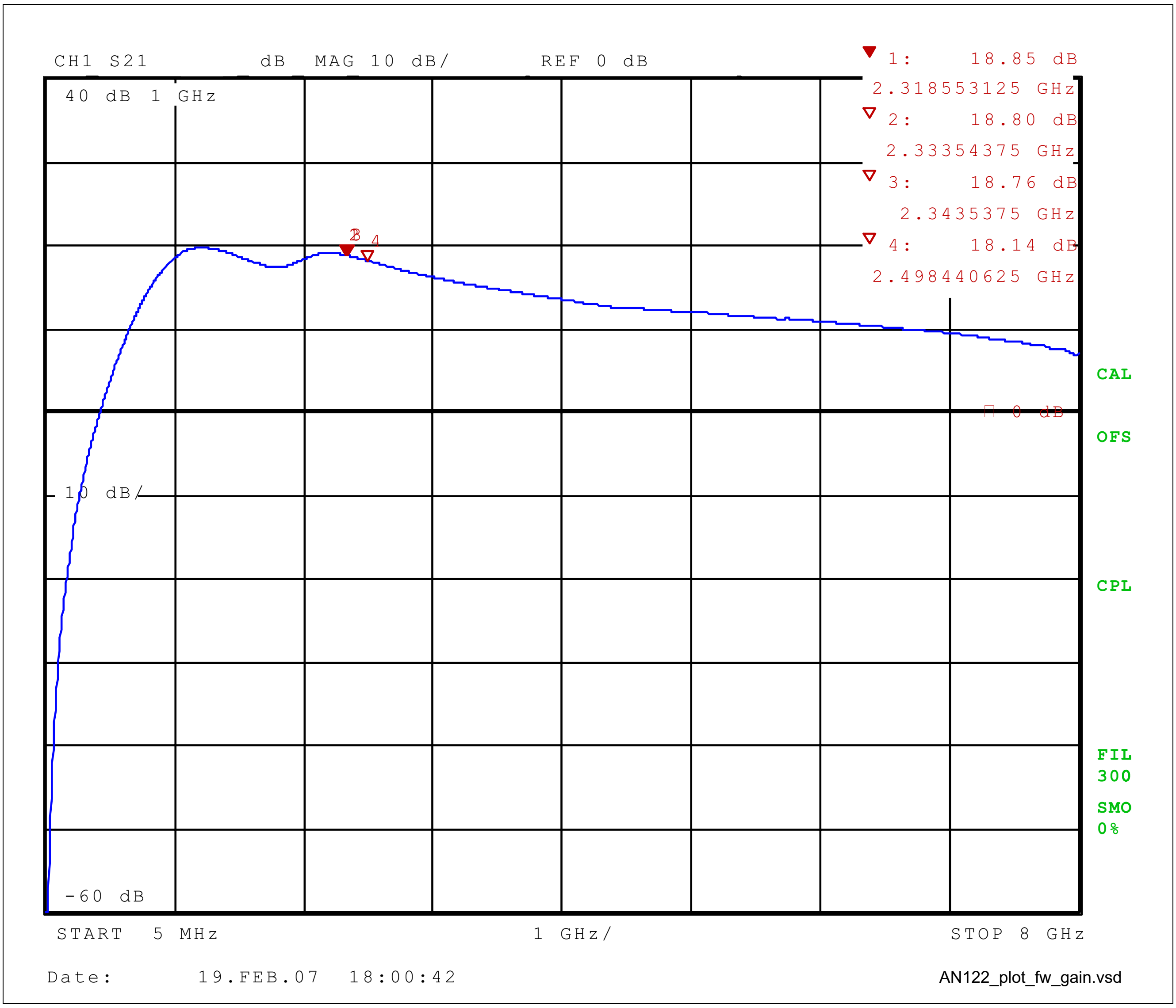

Figure 12 Plot of Forward Gain (5 MHz - 8 GHz)

Reverse Isolation

5 MHz to 8 GHz

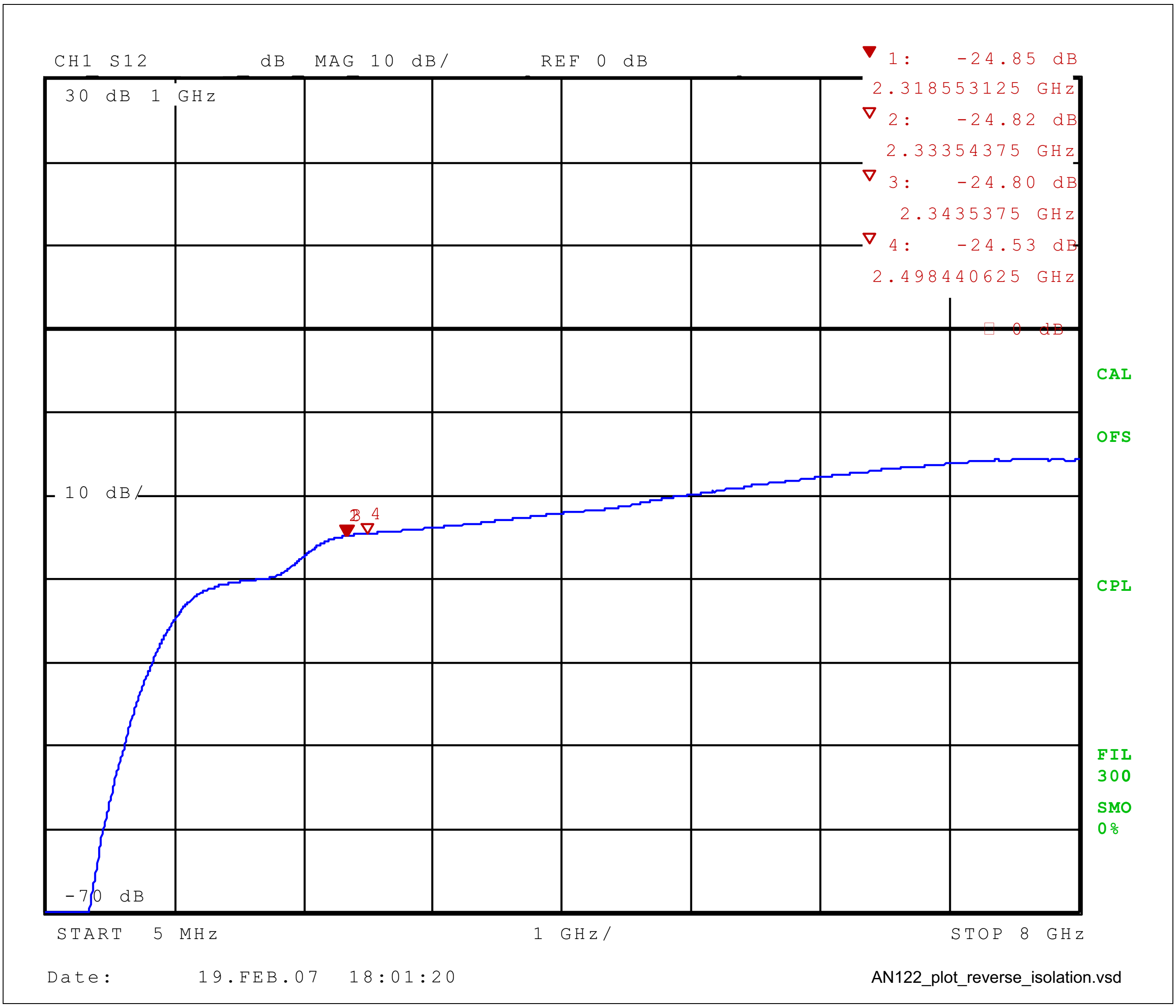

Figure 13 Plot of Reverse Isolation (5 MHz - 8 GHz)

Output Return Loss, Log Mag

5 MHz to 8 GHz

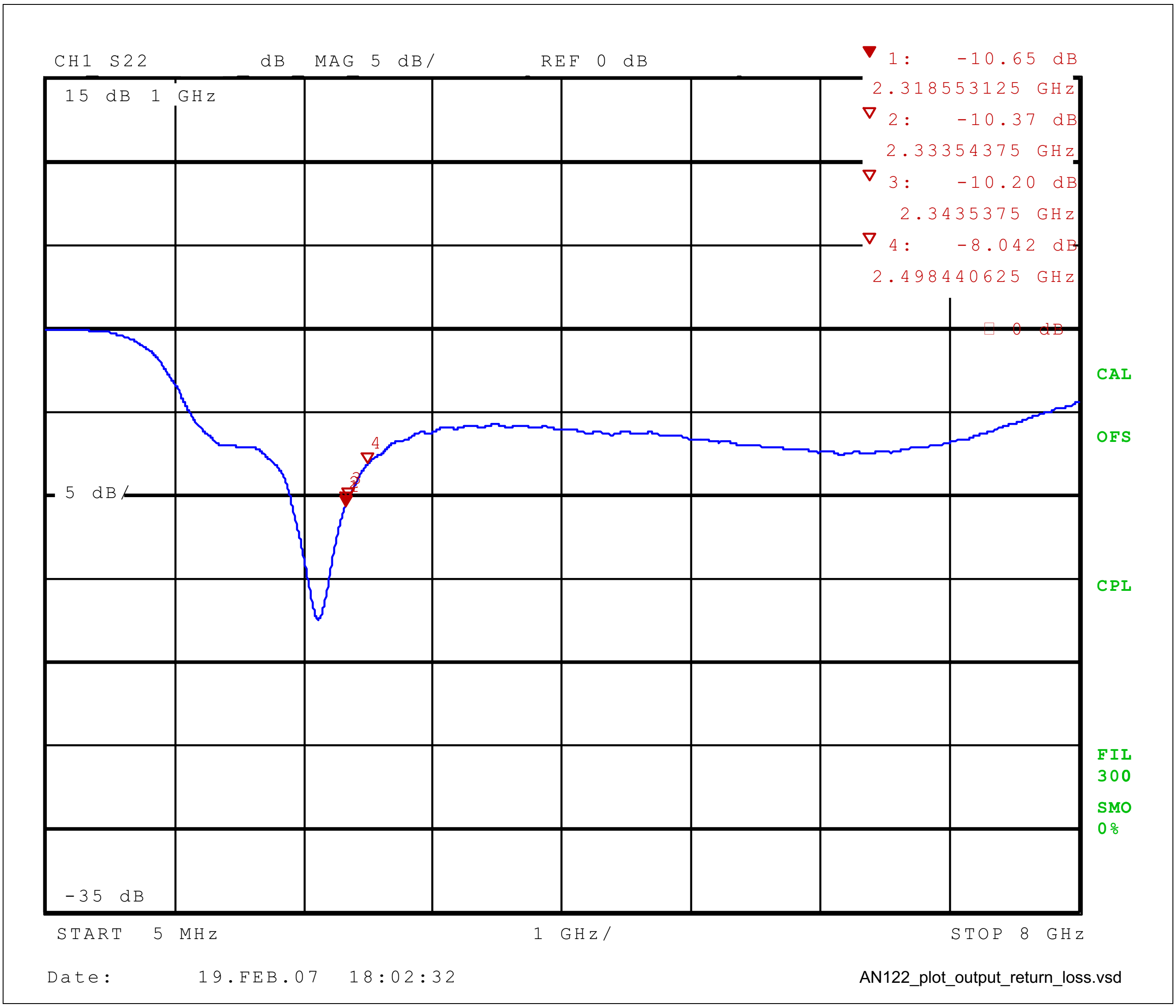

Figure 14 Plot of Output Return Loss (5 MHz - 8 GHz)

Output Return Loss, Smith Chart

Reference Plane = Output SMA Connector on PC Board
5 MHz to 8 GHz Sweep

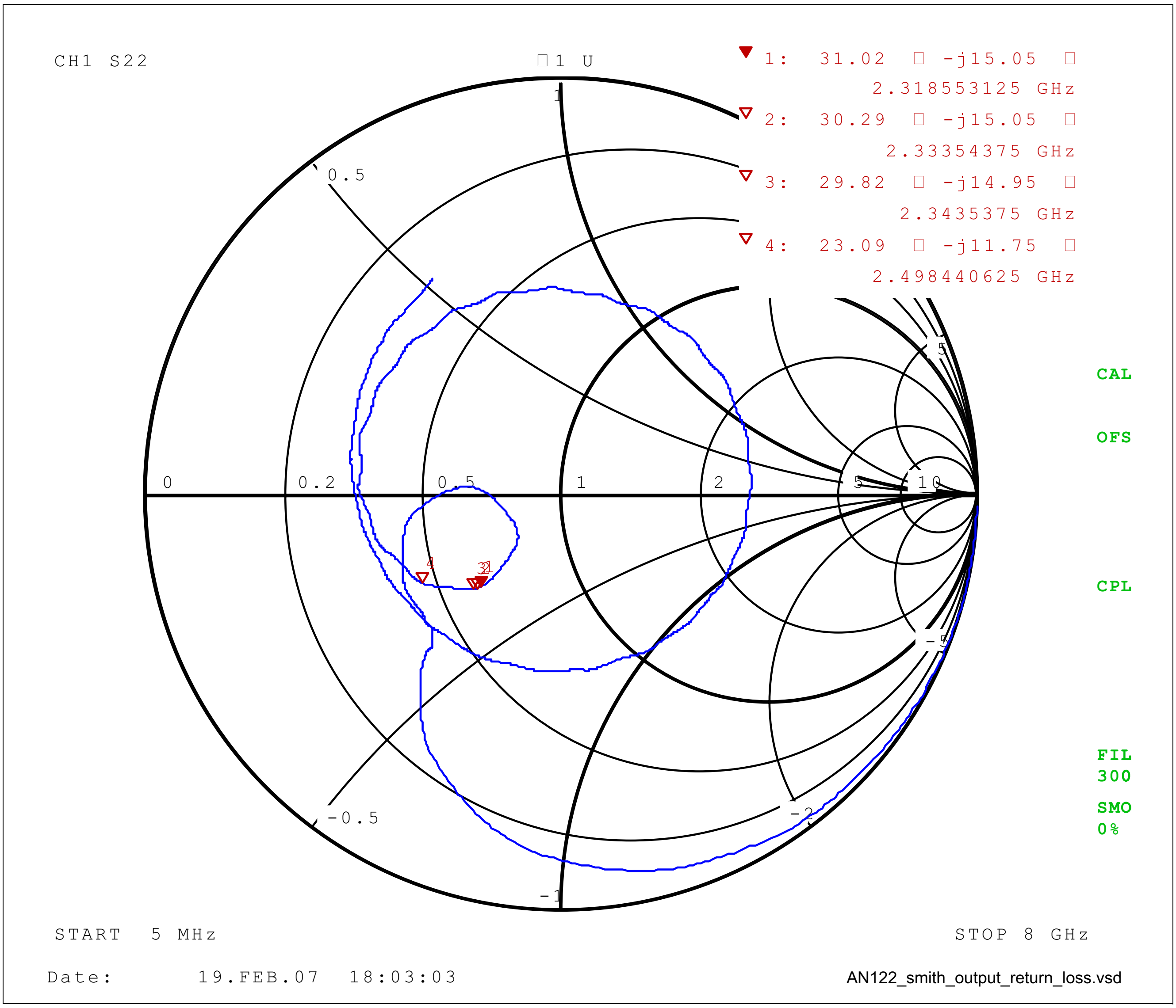

Figure 15 Smith Chart of Output Return Loss (5 MHz - 8 GHz)

Two-Tone Test, 2331.5 MHz

Input Stimulus for Amplifier Two-Tone Test:
f_1 = 2331 MHz, f_2 = 2332 MHz, -20 dB each tone
Input IP_3 = -20 + (59.3 / 2) = +9.7 dBm
Output IP_3 = +9.7 dBm + 18.8 dB gain = +28.5 dBm

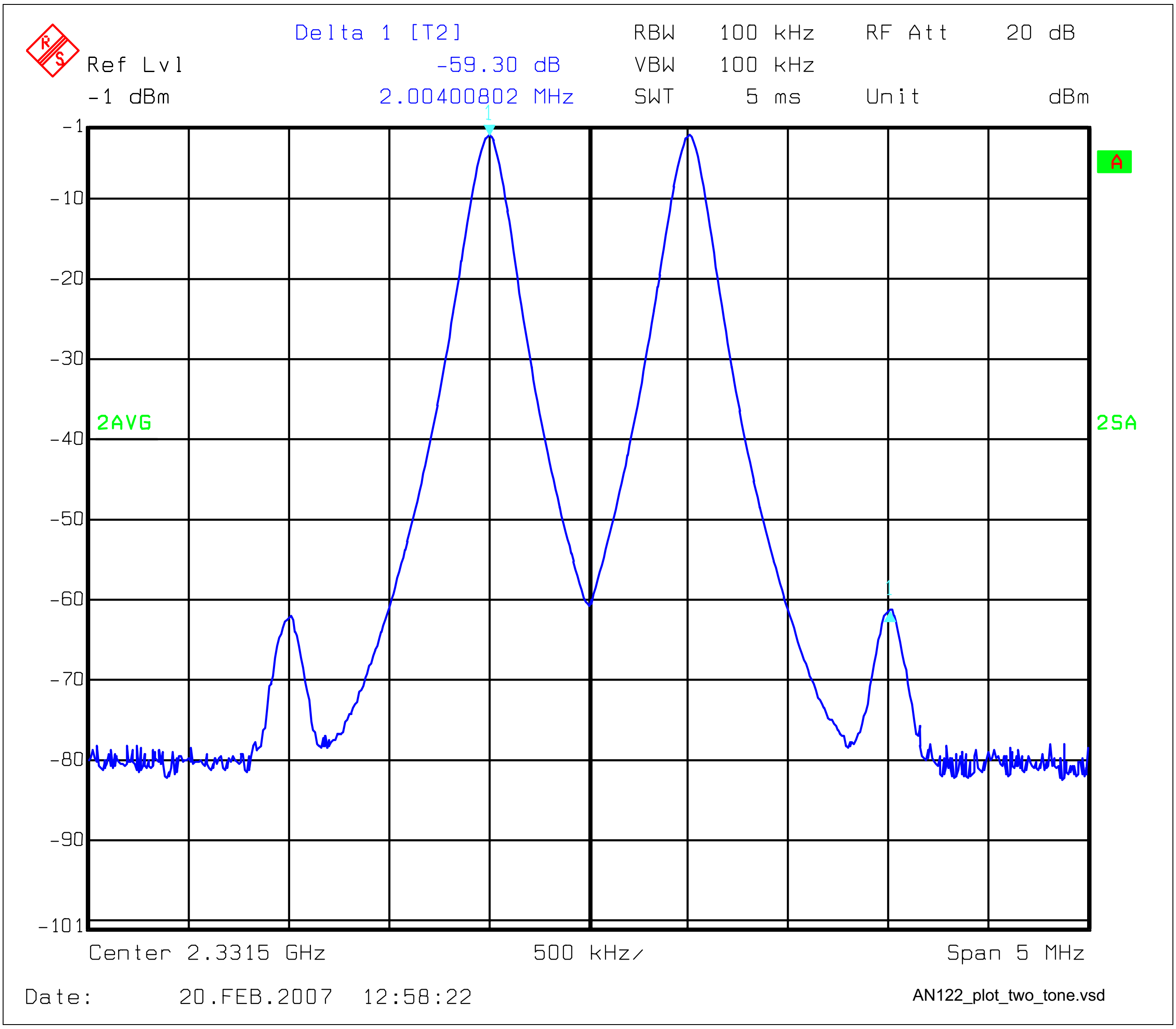

Figure 16 Tow-Tone Test @ 2331.5 MHz