Application Note No. 155

BFP420 as a Low-Cost LNA for Global Positioning L1 Band (1575.42 MHz)

RF & Protection Devices

Never stop thinking

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Page	**Subjects (major changes since last revision)**
All	Small changes in figure descriptions

1 BFP420 as a Low-Cost LNA for Global Positioning L1 Band (1575.42 MHz)

Overview

- Demo of BFP420 LNA for GPS L1 frequency. PC board used is BFP620 V 3.0 with sawed-off input. Note this PCB has inductive emitter degeneration (short microstrip tracks between device emitter leads and ground plane) which is useful for 1) improving stability 2) input / output match and 3) improving amplifier compression point. Note approximately 1 to 2 dB additional gain could be had if best possible emitter grounding were used (e.g. no degeneration) were used.
- Test Conditions: V_{CC} = 2.75 V, V_{CE} = 2.5 V, total current = 5 mA, T = 25 °C, network analyzer source power = -30 dBm
- Amplifier is unconditionally stable (e.g. K > 1 and B1 > 0 over 100 MHz - 6 GHz range).

Summary of Data

Table 1 Summary of Data

Parameter	Result / Value
Frequency Range	1575.42 MHz (GPS L1 frequency)
DC Current	5.0 mA
DC Voltage, V_{CC}	2.75 V
Collector-Emitter Voltage, V_{CE}	2.5 V
Input P_{1dB}	≈ -15.9 dBm @ 1575.42 MHz
Output P_{1dB}	≈ -2.7 dBm @ 1575.42 MHz
Input 3rd Order Intercept	+4.3 dBm @ 1575.42 MHz
Output 3rd Order Intercept	+18.5 dBm @ 1575.42 MHz
Noise Figure	+1.3 dBm @ 1575.42 MHz
Gain	+14.2 dBm @ 1575.42 MHz
Input return loss	+10.8 dBm @ 1575.42 MHz
Output return loss	+11.1 dBm @ 1575.42 MHz
Reverse isolation	+23.9 dBm @ 1575.42 MHz

Schematic Diagram

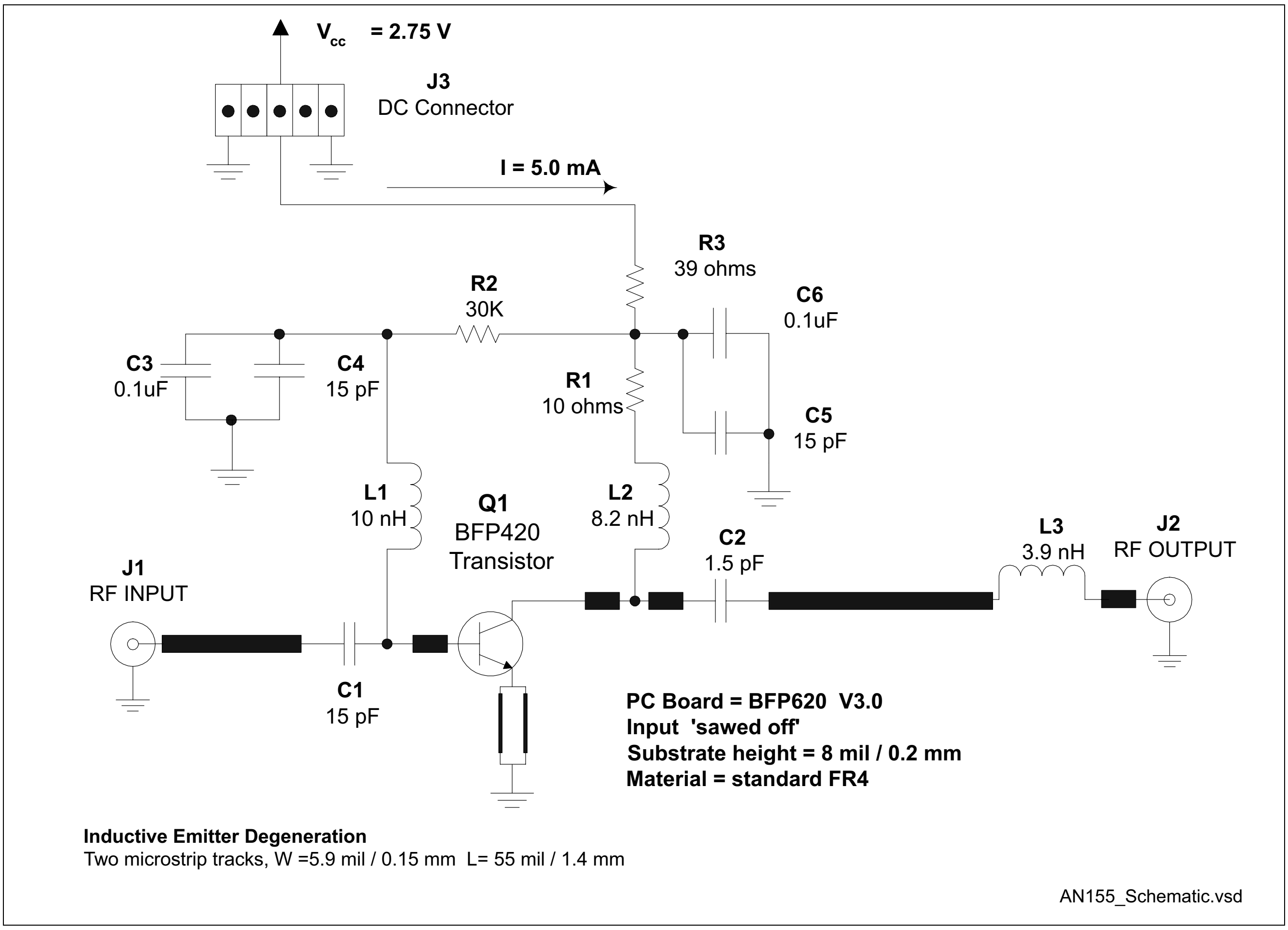


Figure 1 Schematic Diagram

Bill of Material

Table 2 Bill of Material

Reference Designator	Value	Manufacturer	Case Size	Function
C1	15 pF	Various	0402	DC blocking, input
C2	1.5 pF	Various	0402	DC block, output. Influences input match since S12 $\neq$ 0.
C3	0.1 μF	Various	0402	Low frequency ground at base (Input 3rd Order Intercept improvement).
C4	15 pF	Various	0402	RF bypass / RF block
C5	15 pF	Various	0402	RF bypass / RF block
C6	0.1 μF	Various	0402	Bypass / block, some IP_3 improvement.
L1	10 nH	Murata LQG10A low cost inductor	0402	RF choke to DC bias on base, input matching.
L2	6.2 nH	Murata LQG10A low cost inductor	0402	Output RF match, DC feed to collector.
L3	3.9 nH	Murata LQG10A low cost inductor	0402	Output match.
R1	10 Ω	Various	0402	Improves stability, output matching.
R2	30 kΩ	Various	0402	DC bias for base.
R3	39 Ω	Various	0402	Drop supply voltage.
Q1	-	Infineon Technologies	SOT343	BFP420 Si Bipolar, f_T = 25 GHz
J1, J2	-	Johnson 142-0701-841	-	RF input / output connectors
J3	-	AMP 5 pin header MTA-100 series 640456-5 (standard pin plating) or 641215-5 (gold plated pins)	-	DC connector Pins 1, 5 = ground Pin 3 = V_{CC} Pins 2, 4 = no connection

Noise Figure, Plot. Center of Plot (x-axis) is 1575.42 MHz.

Rohde and Schwarz FSEK3 V2.00

10 Jan 2001

BFP420 set up as GPS L1 LNA

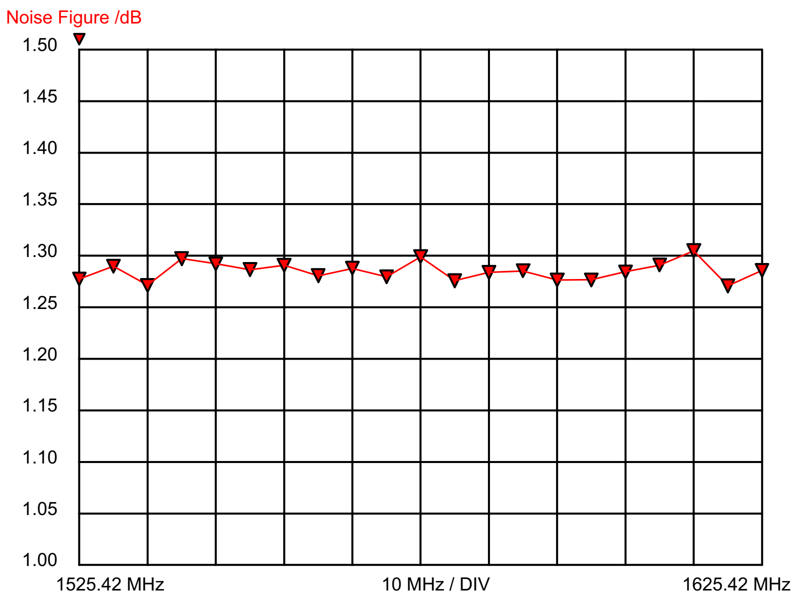
EUT Name:	PCB = BFP620 V3.0
Manufacturer:	Infineon
Operating Conditions:	V=2.75V, I=5mA, Vce = 2.5 volts
Operator Name:	Gerard Wevers
Test Specification:	David Vessal
Comment:	

Analyzer

RF Att:	0.00 dB	RBW :	1 MHz	Range:	30.00 dB
Ref Lvl:	-57.00 dBm	VBW :	100 Hz	Ref Lvl auto:	ON

Measurement

2nd stage corr: ON	Mode: Direct	ENR: HP346A.ENR



AN155_plot_nf.vsd

Figure 2 Noise Figure

Noise Figure, Tabular Data

Table 3 Noise Figure

Frequency	Noise Figure
1525.42 MHz	1.28 dB
1530.42 MHz	1.29 dB
1535.42 MHz	1.27 dB
1540.42 MHz	1.30 dB
1545.42 MHz	1.29 dB
1550.42 MHz	1.29 dB
1555.42 MHz	1.29 dB
1560.42 MHz	1.28 dB
1565.42 MHz	1.29 dB
1570.42 MHz	1.28 dB
1575.42 MHz	1.30 dB
1580.42 MHz	1.28 dB
1585.42 MHz	1.28 dB
1590.42 MHz	1.29 dB
1595.42 MHz	1.28 dB
1600.42 MHz	1.28 dB
1605.42 MHz	1.28 dB
1610.42 MHz	1.29 dB
1615.42 MHz	1.30 dB
1620.42 MHz	1.27 dB
1625.42 MHz	1.29 dB

Stability Factors K and B_1

For unconditional stability, K > 1 and B1 > 0. (For plot, actual measured LNA s-parameters are imported into the Ansoft Serenade design environment; the software calculates and plots K and B_1).

Note red trace is K, blue trace is B_1.

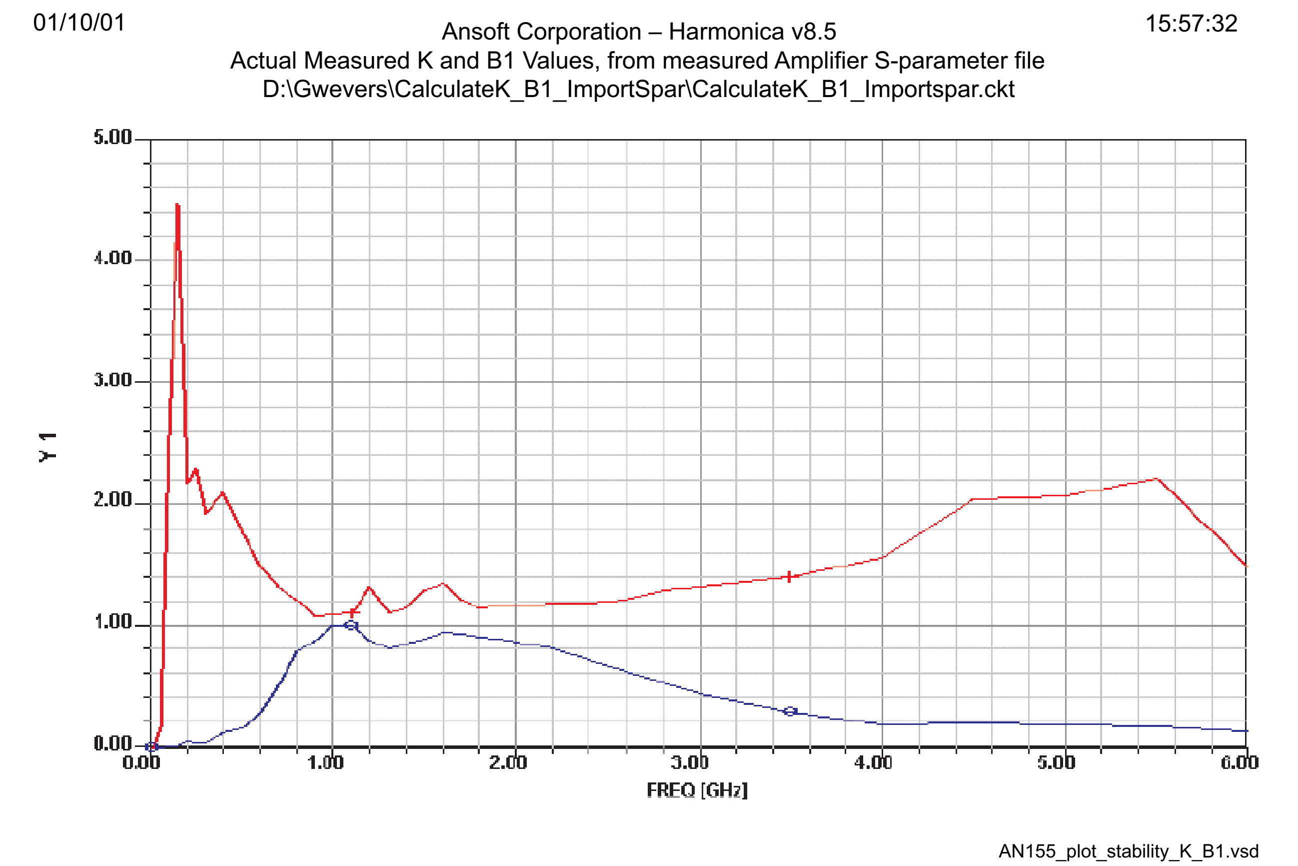


Figure 3 **Plot of K(f) and B_1(f)**

LNA Gain Compression at 1575.42 MHz

Input $P_{1dB} \cong$ -15.9 dBm
Output $P_{1dB} \cong$ -2.7 dBm

Table 4 Gain Compression at 1575.42 MHz

Input Power, dBm	Output Power, dBm	Gain, dB
-28	-13.8	14.2
-26	-11.8	14.2
-24	-9.9	14.1
-22	-7.9	14.1
-20	-6.1	13.9
-18	-4.2	13.8
-16	-2.7	13.3
-14	-1.5	12.5
-12	-0.5	11.5

Scanned Image of PCB, top of board

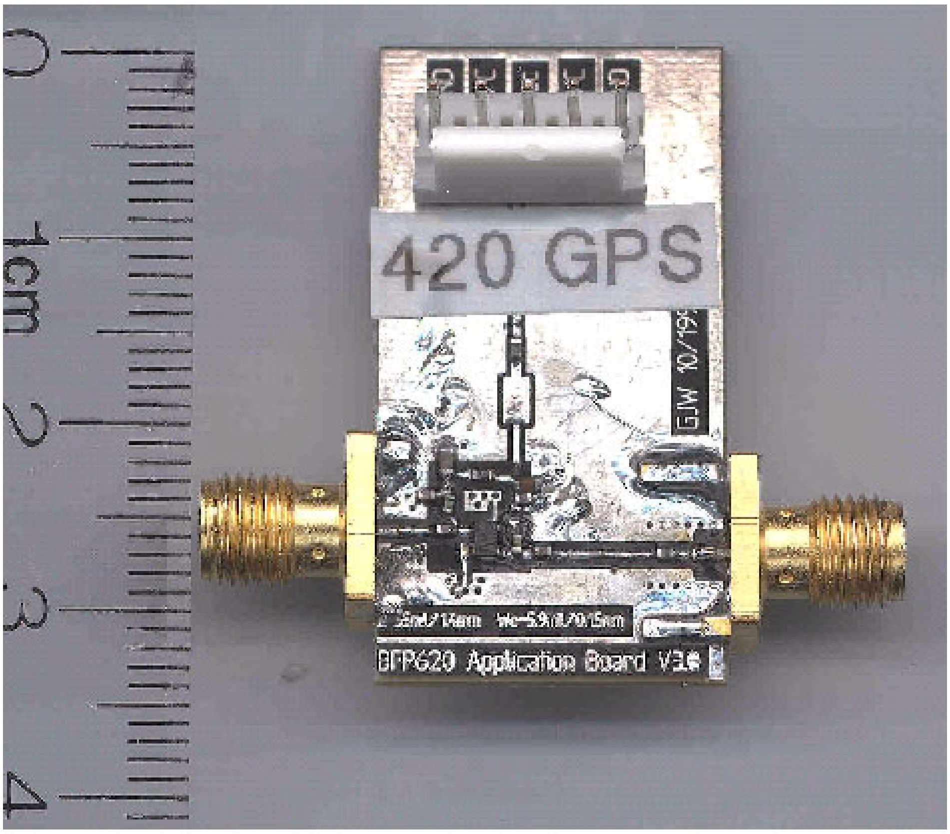


Figure 4 Image of PC Board

Input Return Loss, Log Mag

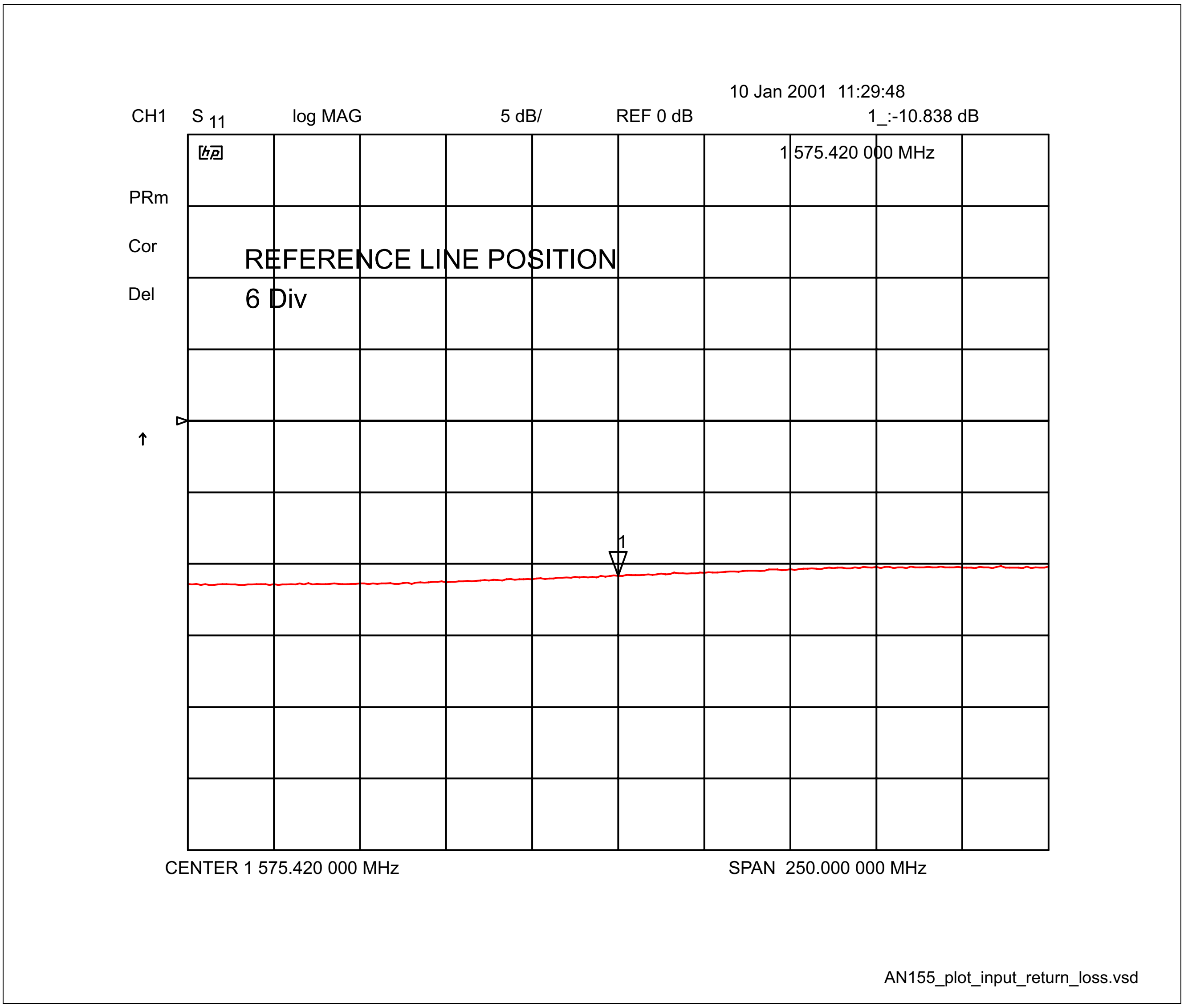


Figure 5 Plot of Input Return Loss

Input Return Loss, Smith Chart

Reference Plane = PCB RF Output Connector

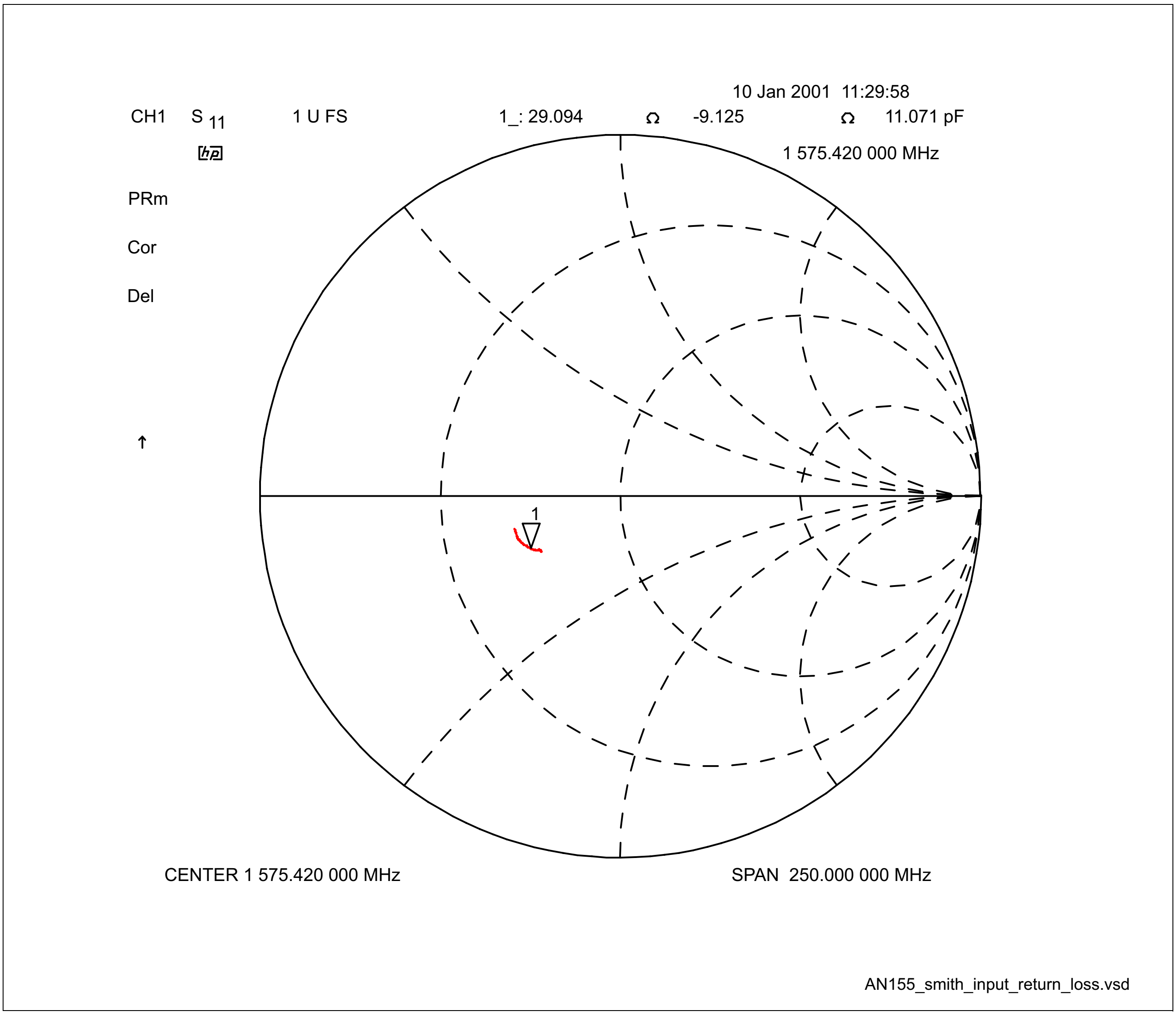


Figure 6 Smith Chart of Input Return Loss

Forward Gain

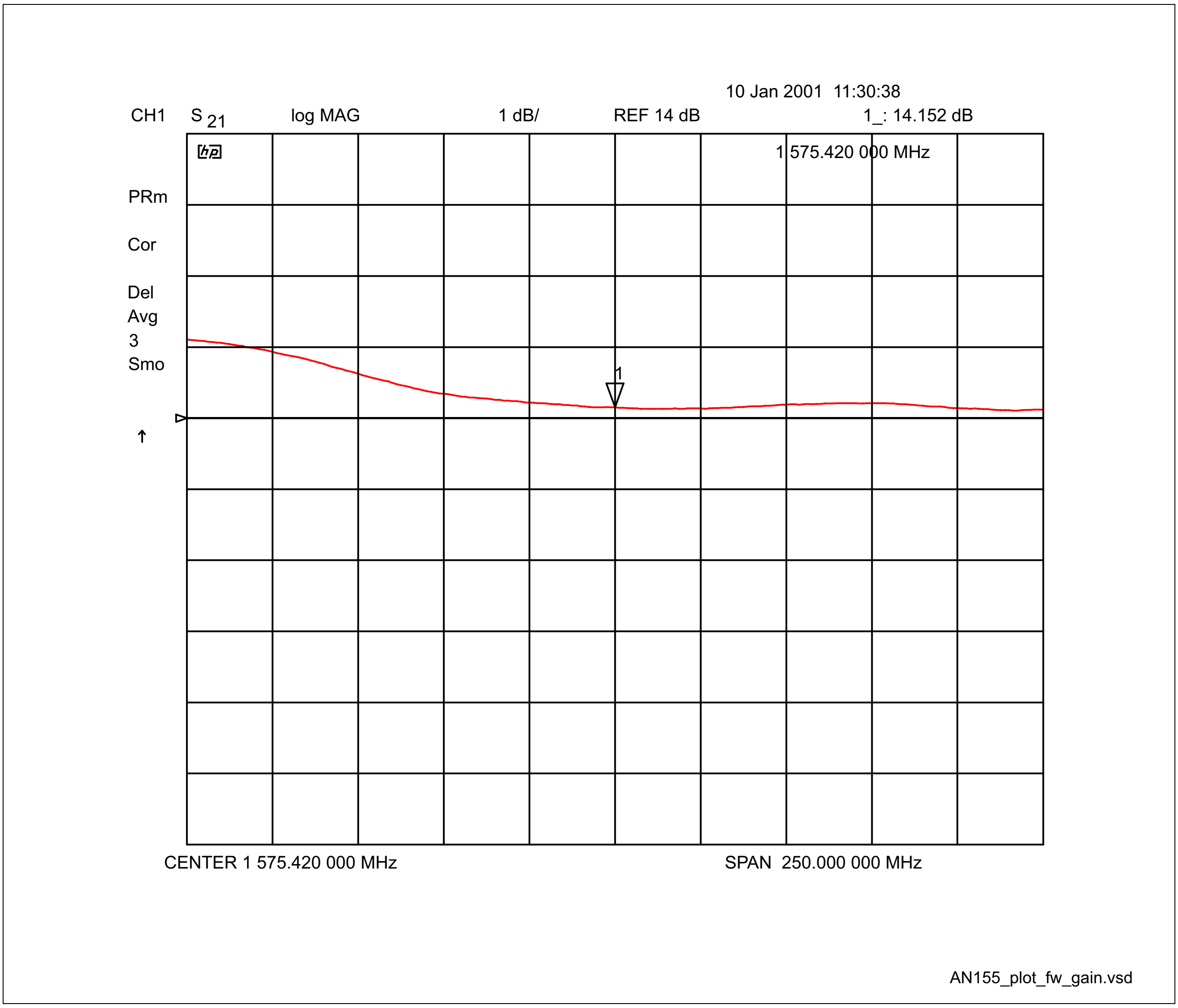


Figure 7 Plot of Forward Gain

Reverse Isolation

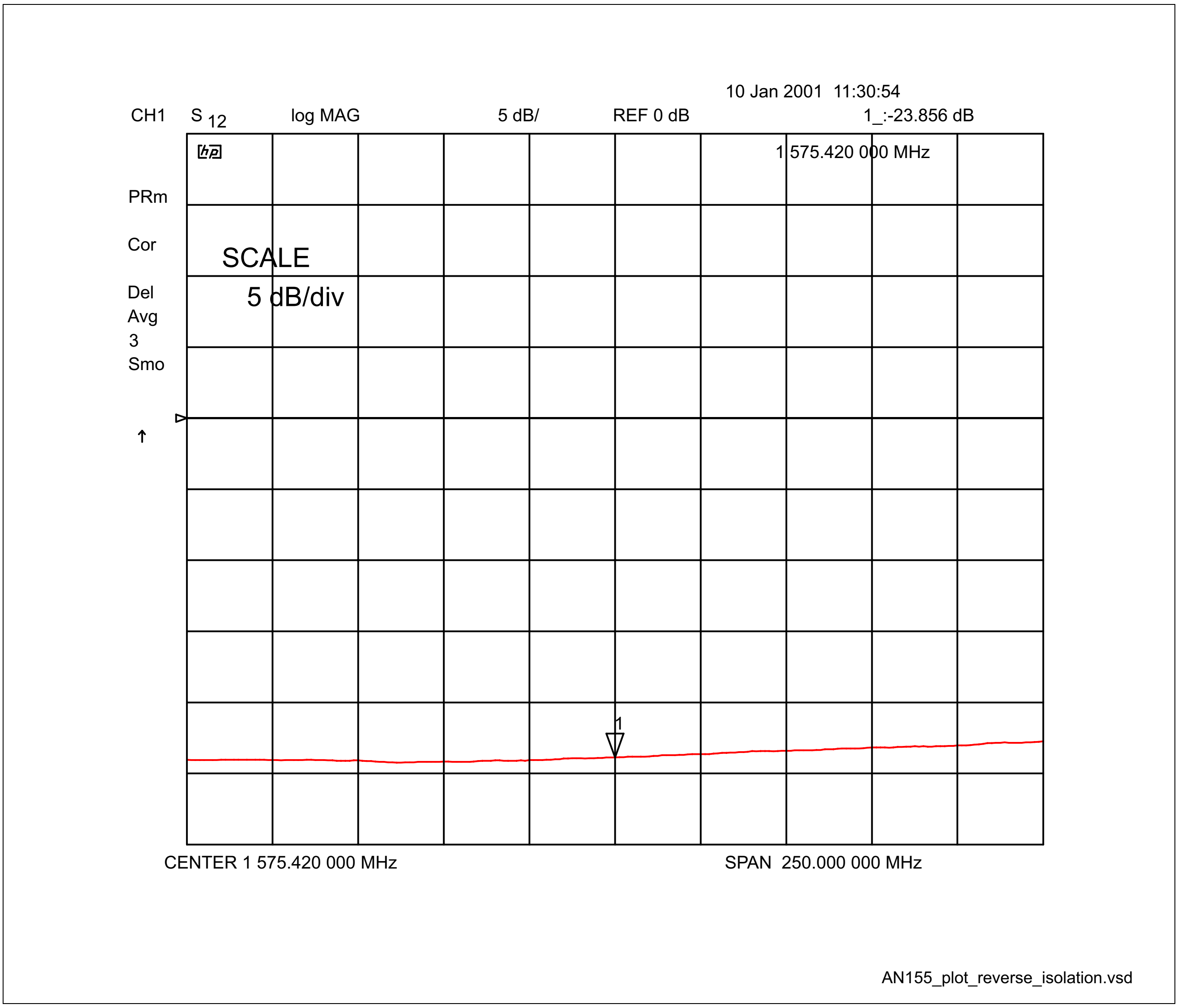


Figure 8 Plot of Reverse Isolation

Output Return Loss, Log Mag

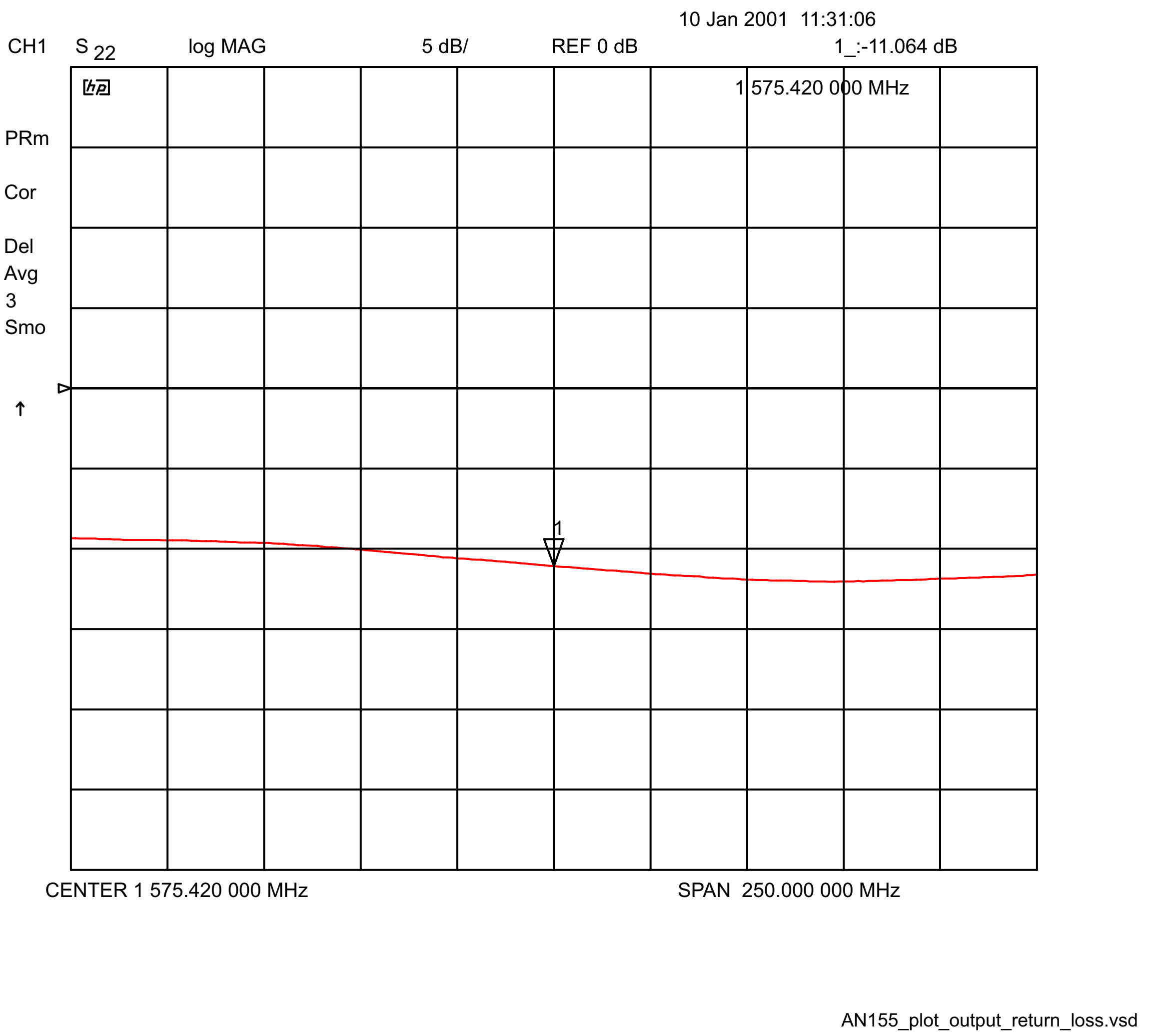


Figure 9 Plot of Output Return Loss

Output Return Loss, Smith Chart

Reference Plane = PCB RF Output Connector

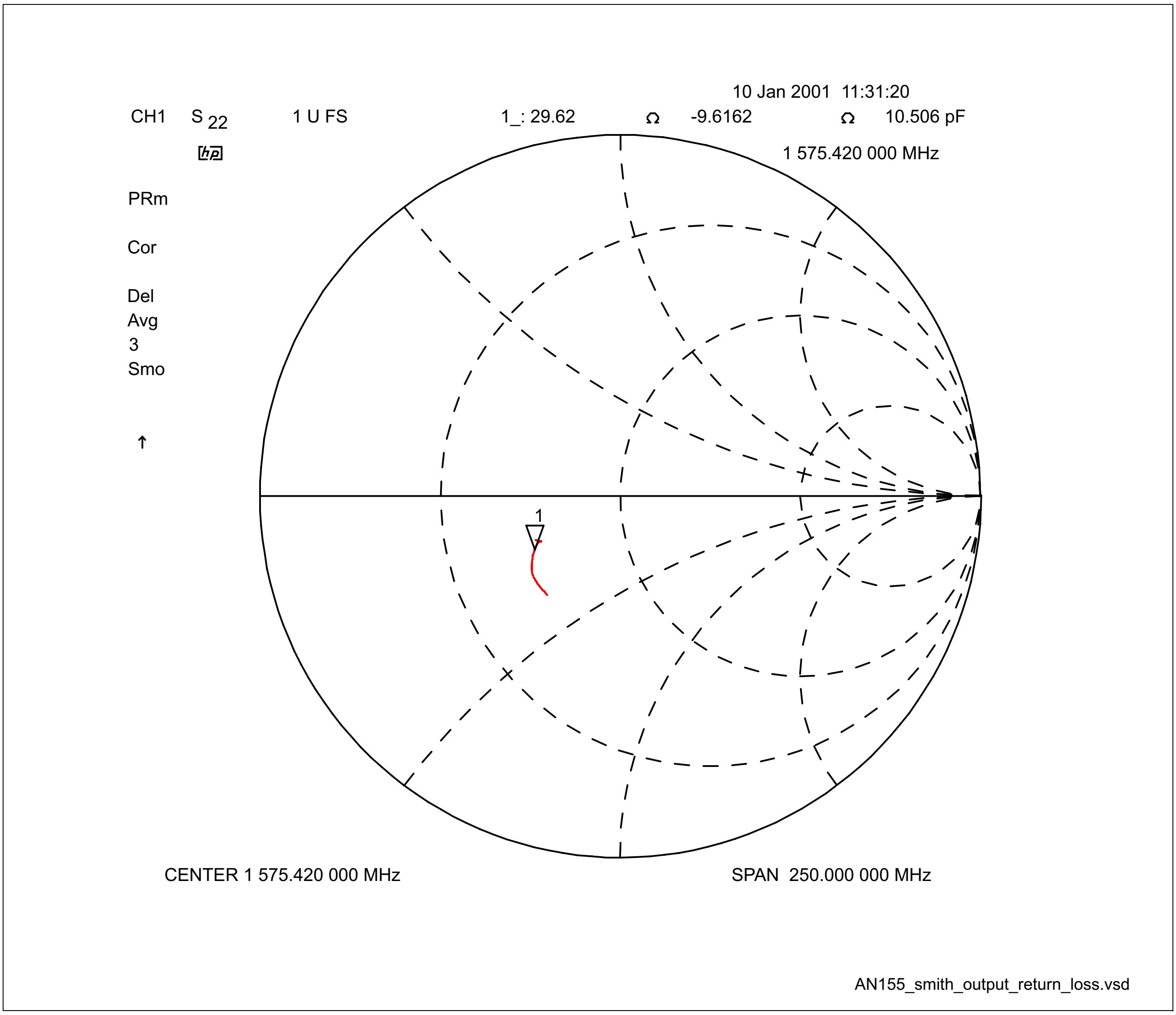


Figure 10 Smith Chart of Output Return Loss

Two-Tone Test

Output Response of Amplifier to Two-Tone 3rd Order Intercept Test.

Two Tones: f_1 = 1574.920 MHz, f_2 = 1575.920 MHz, -25 dBm each tone, tone spacing = 1 MHz.

Input IP_3 = -25 + (58.2 / 2) = +4.3 dBm

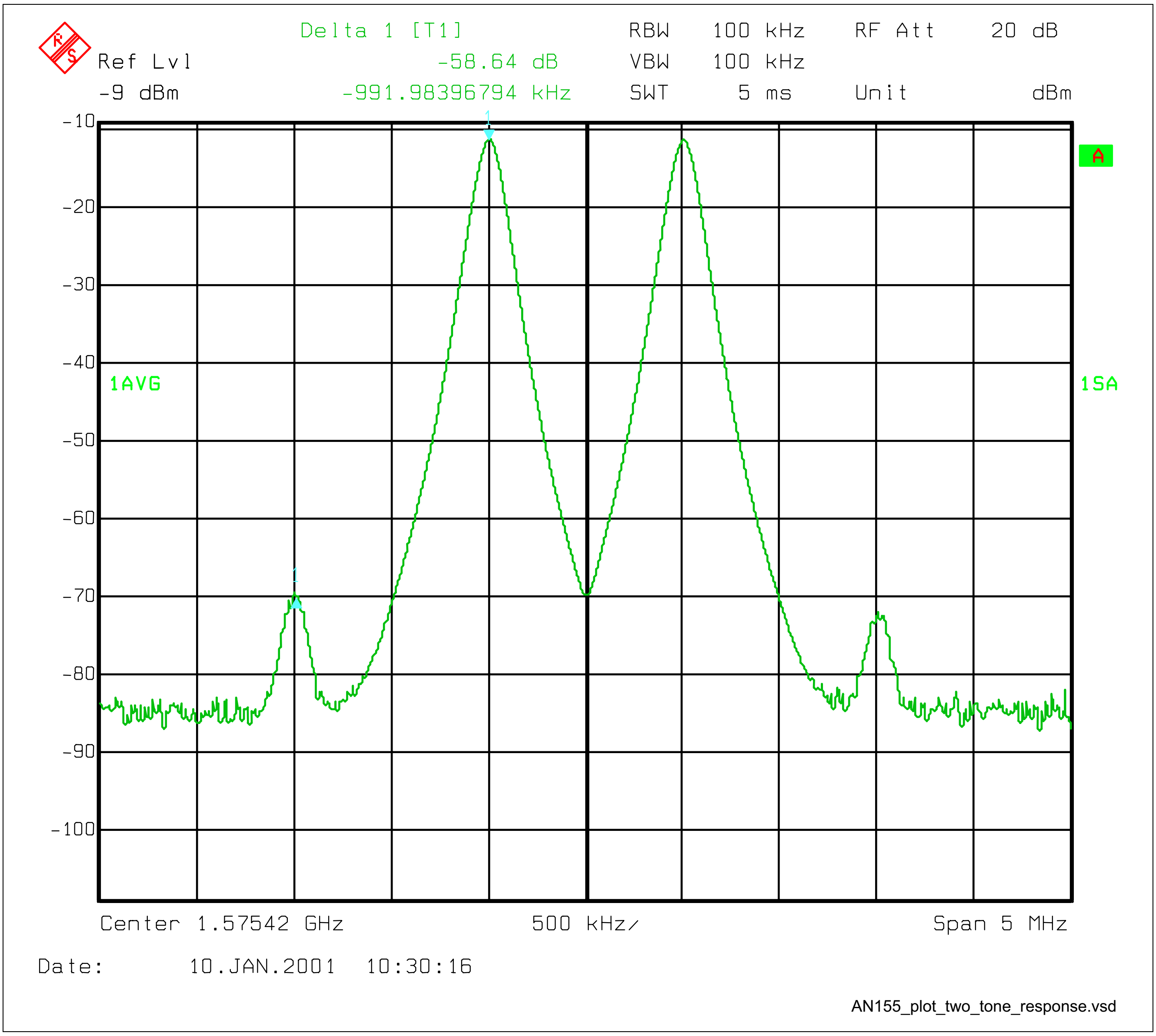


Figure 11 Plot of Tow-Tone Test, LNA response