

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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Revision History: 2008-04-04, Rev. 1.2

Previous Version: 2001-01-10, Rev. 1.1

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

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

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 $B_1 > 0$ 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 3 rd Order Intercept	+4.3 dBm @ 1575.42 MHz
Output 3 rd 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

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Schematic Diagram

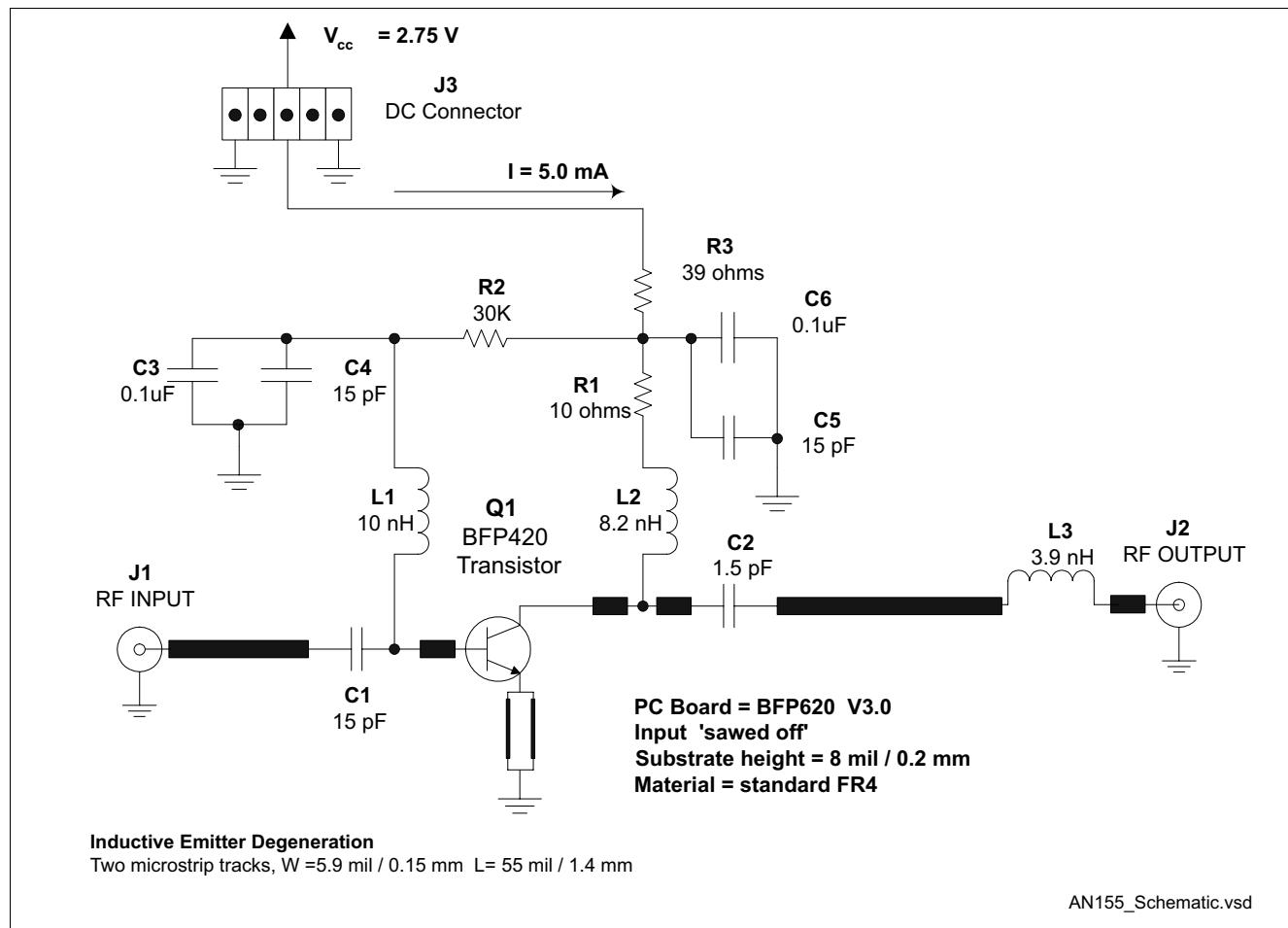


Figure 1 Schematic Diagram

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

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 $S_{12} \neq 0$.
C3	0.1 μ F	Various	0402	Low frequency ground at base (Input 3 rd Order Intercept improvement).
C4	15 pF	Various	0402	RF bypass / RF block
C5	15 pF	Various	0402	RF bypass / RF block
C6	0.1 μ F	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 k Ω	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

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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:
Manufacturer:
Operating Conditions:
Operator Name:
Test Specification:
Comment:

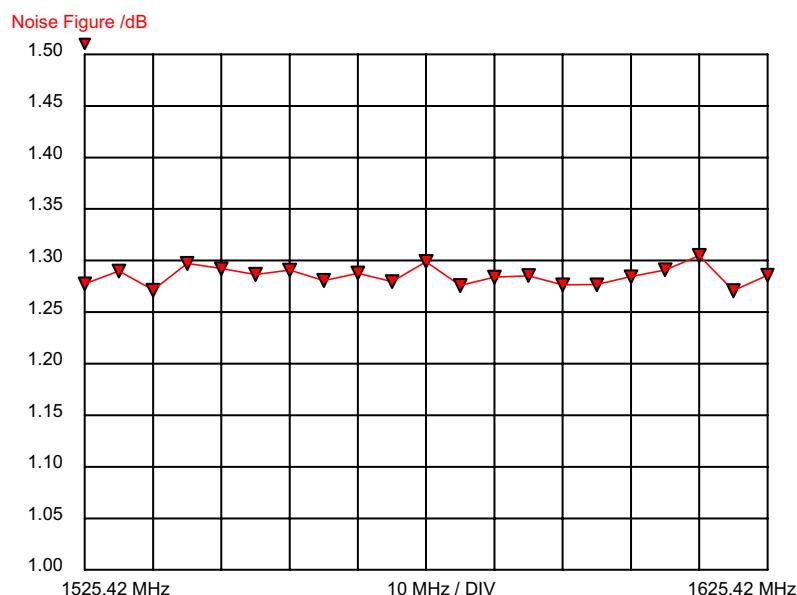
PCB = BFP620 V3.0
Infineon
V=2.75V, I=5mA, Vce = 2.5 volts
Gerard Wevers
David Vessal

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

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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

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Stability Factors K and B₁

For unconditional stability, $K > 1$ and $B_1 > 0$. (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 .

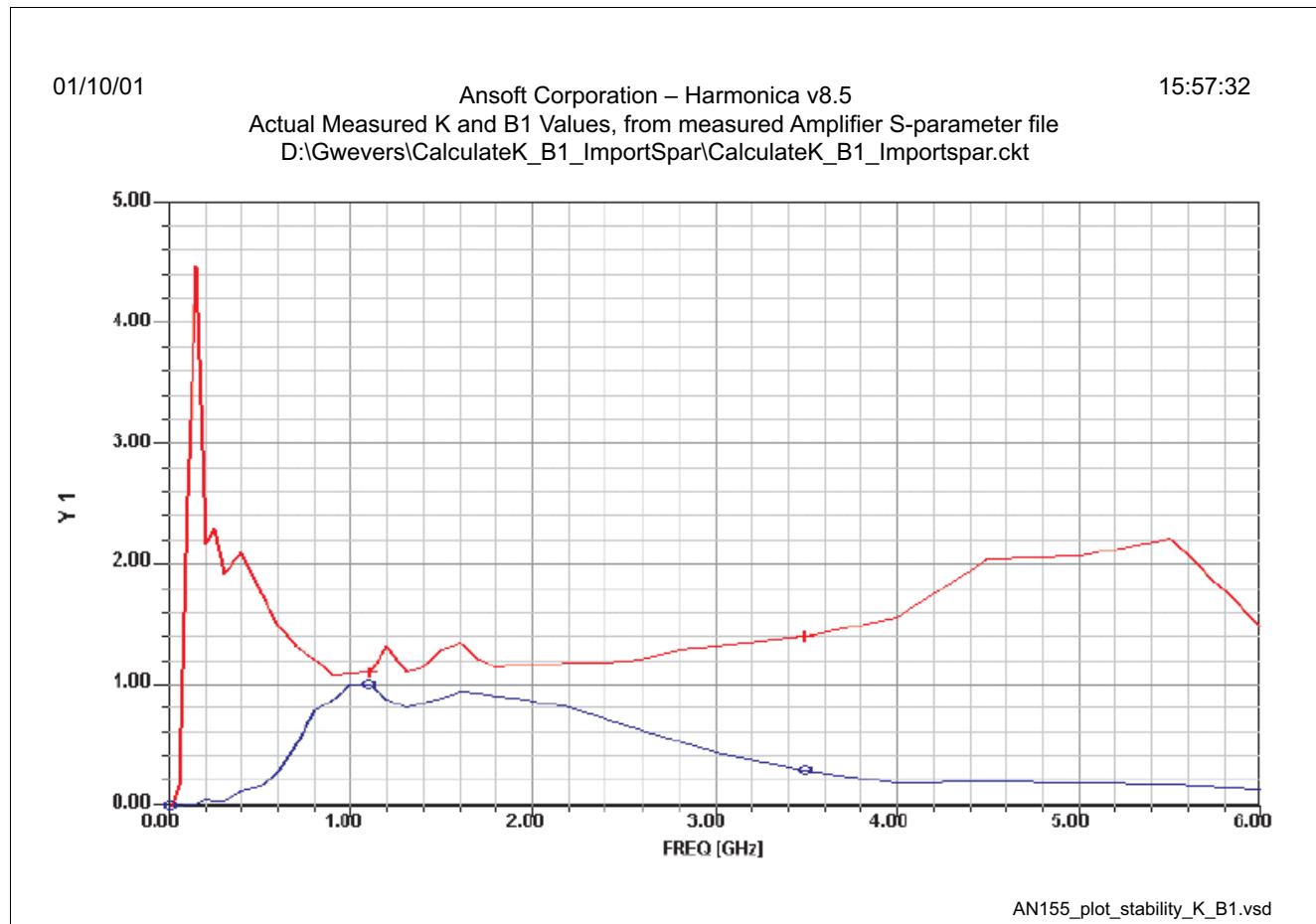


Figure 3 Plot of $K(f)$ and $B_1(f)$

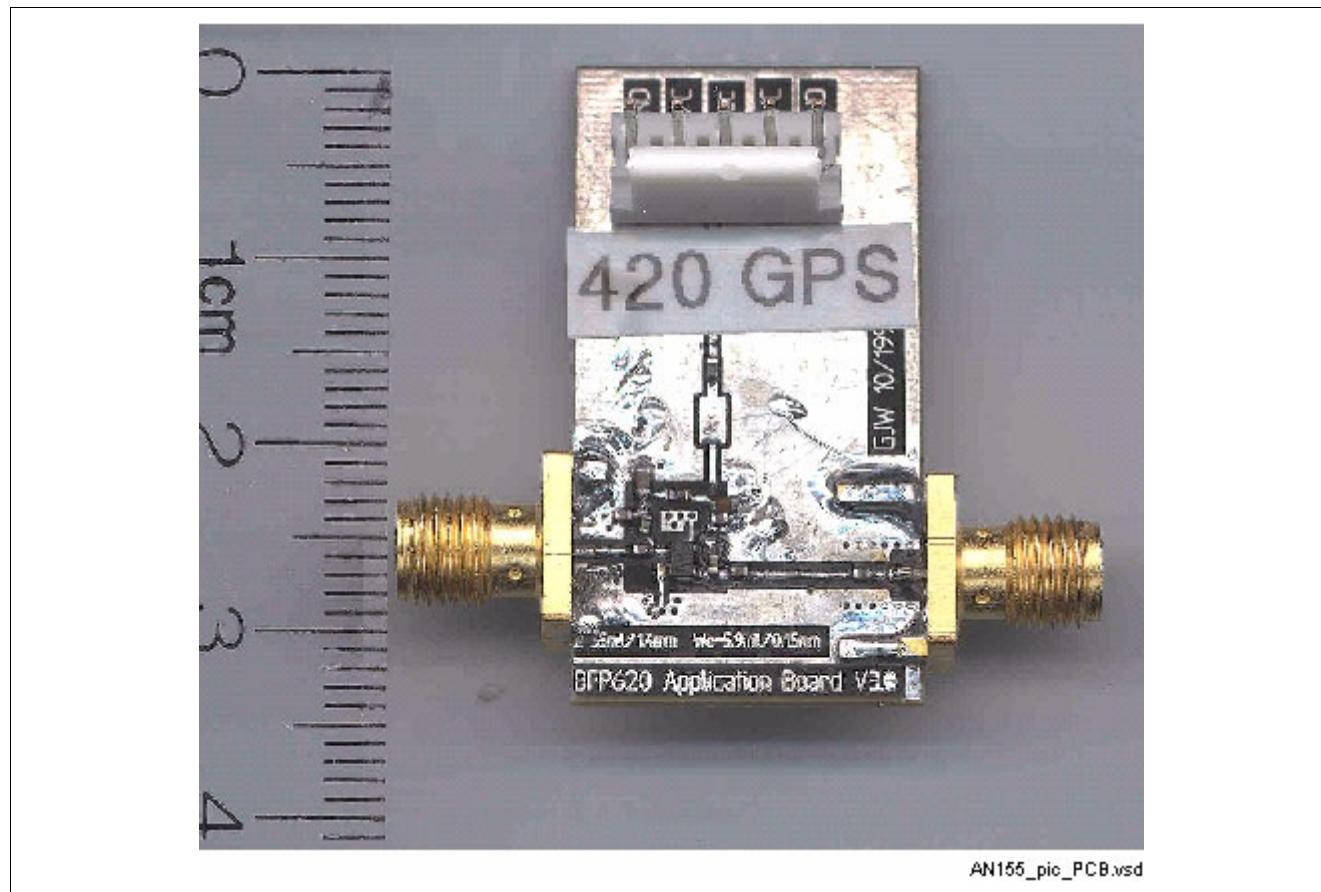
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LNA Gain Compression at 1575.42 MHz

Input $P_{1\text{dB}} \approx -15.9 \text{ dBm}$

Output $P_{1\text{dB}} \approx -2.7 \text{ dBm}$
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

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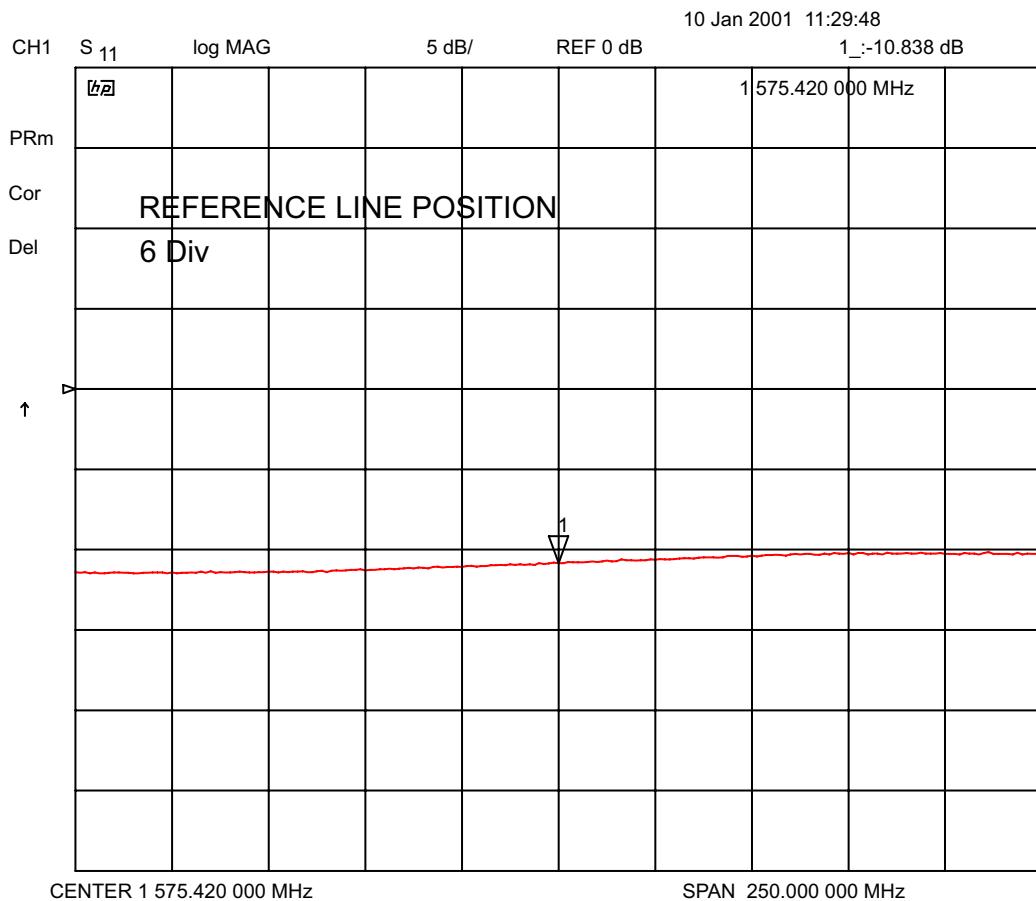
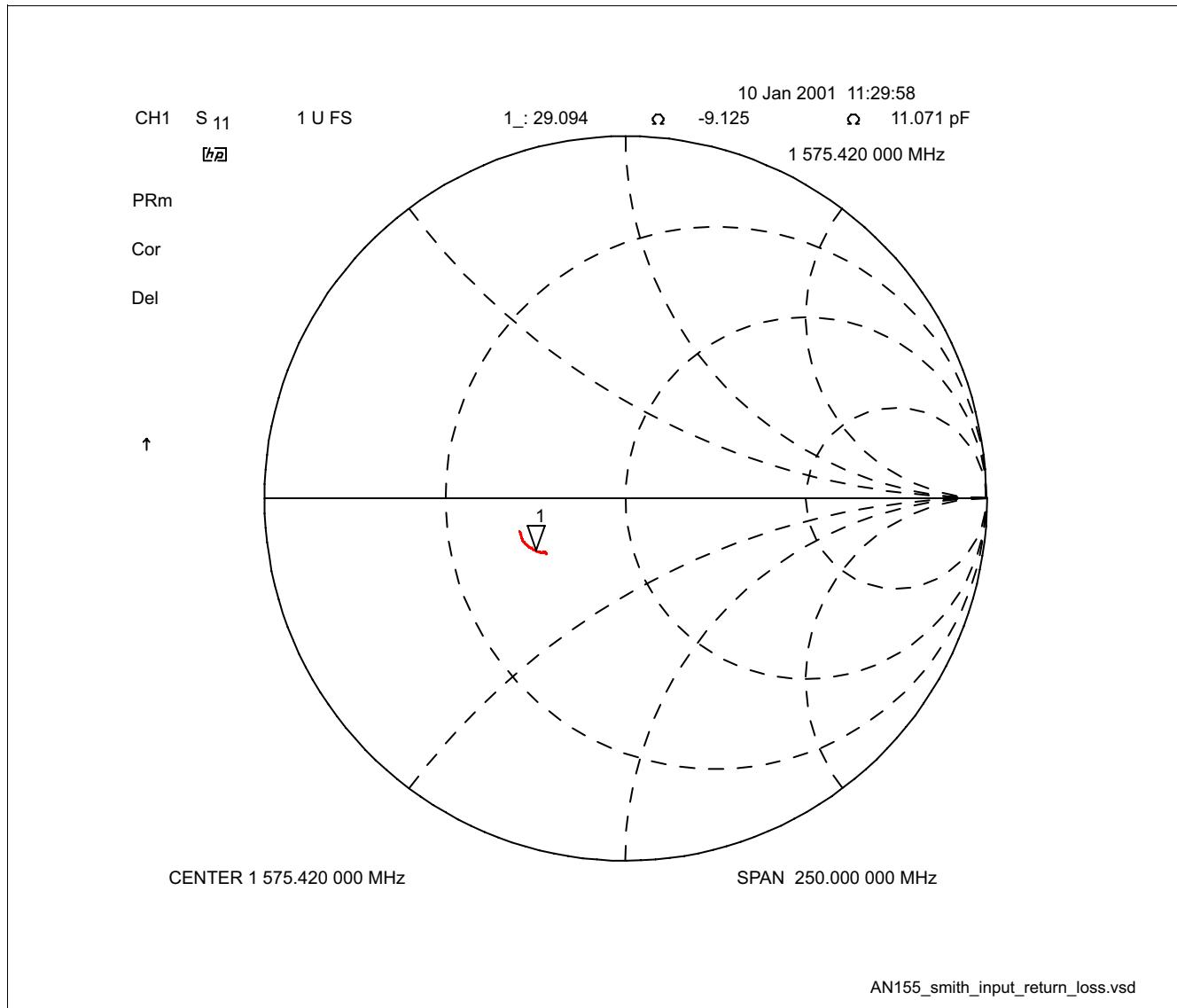


Figure 5 Plot of Input Return Loss

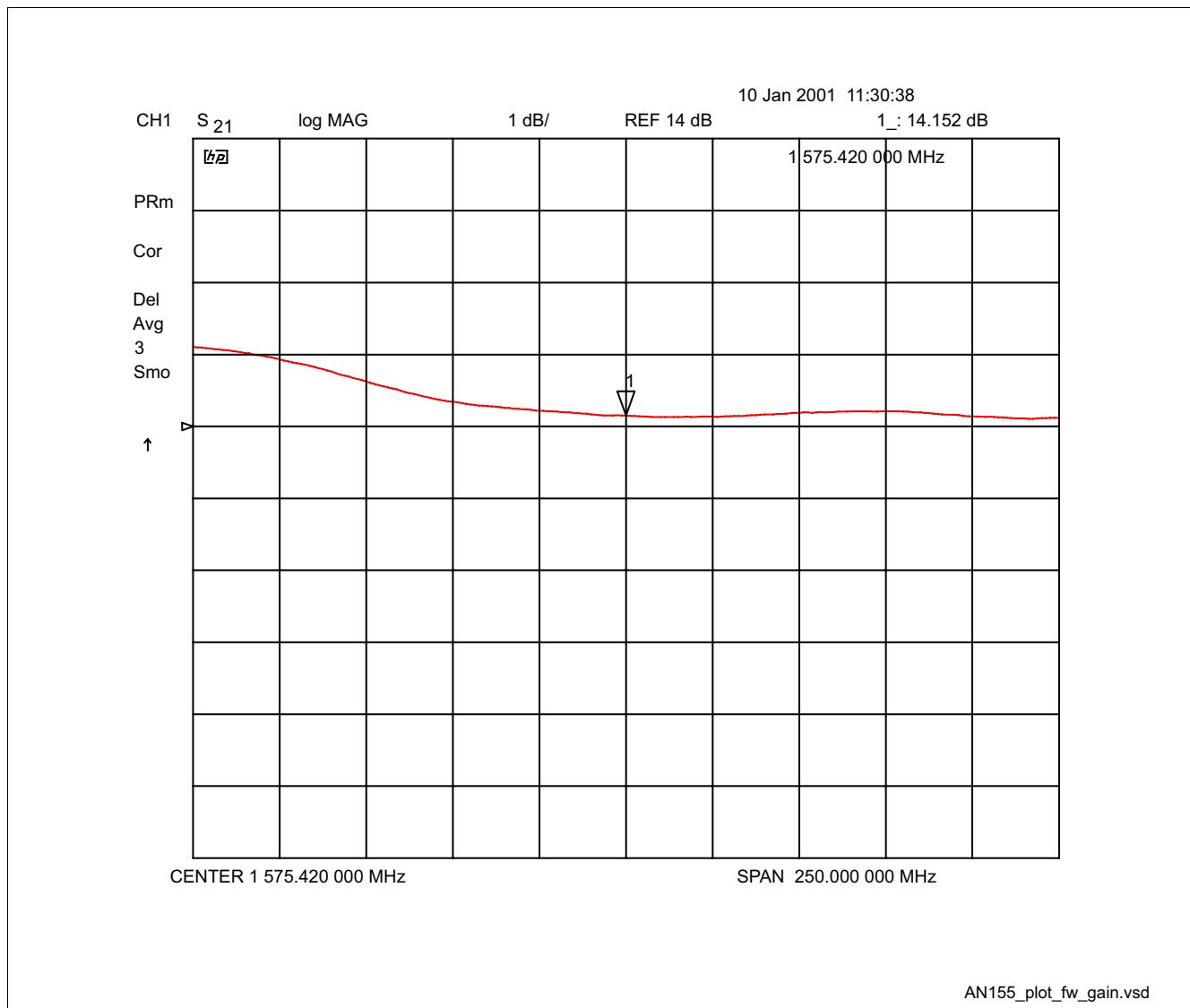
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Input Return Loss, Smith Chart

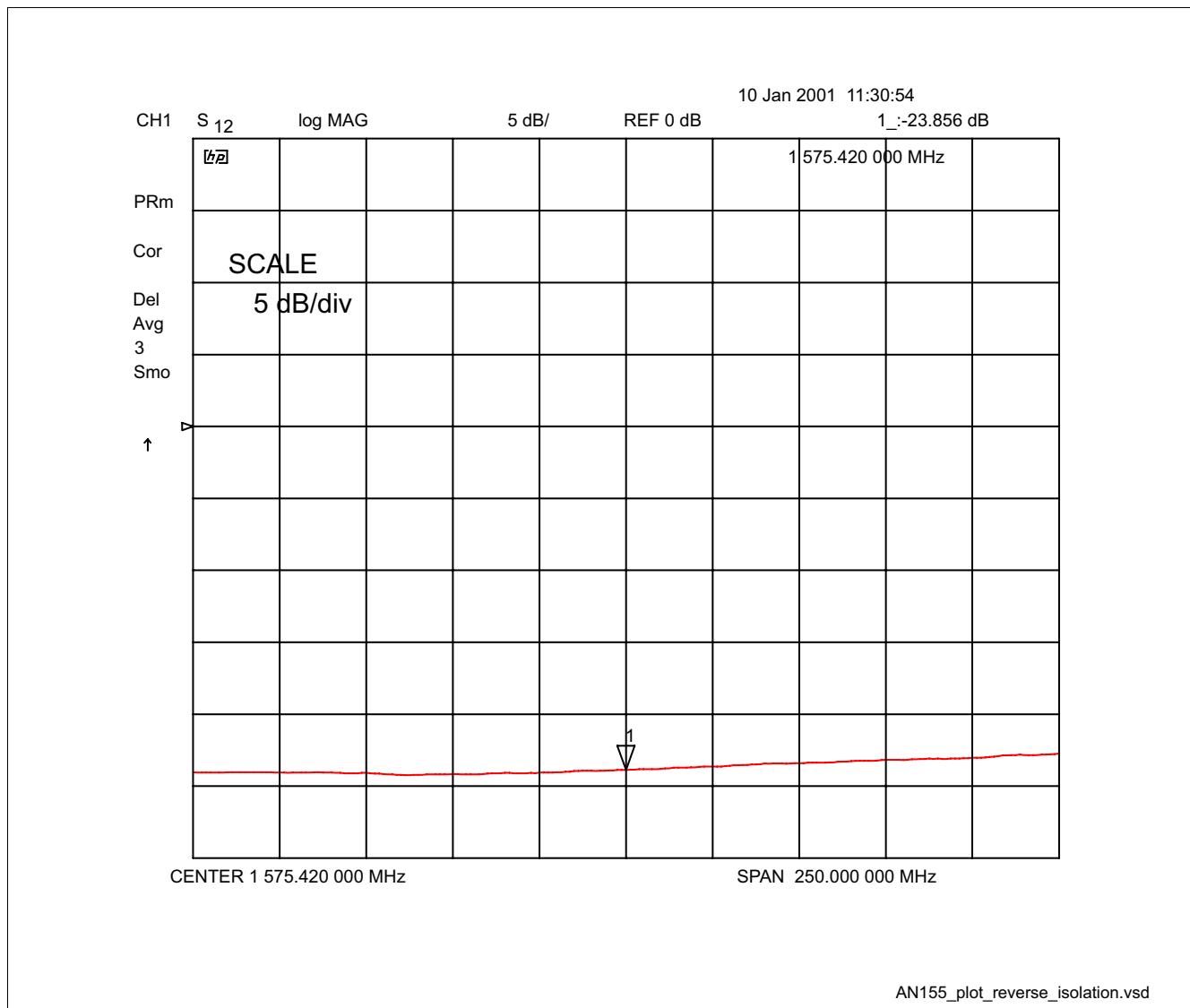
Reference Plane = PCB RF Output Connector


Figure 6 Smith Chart of Input Return Loss

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Forward Gain

Figure 7 Plot of Forward Gain

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Reverse Isolation

Figure 8 Plot of Reverse Isolation

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Output Return Loss, Log Mag

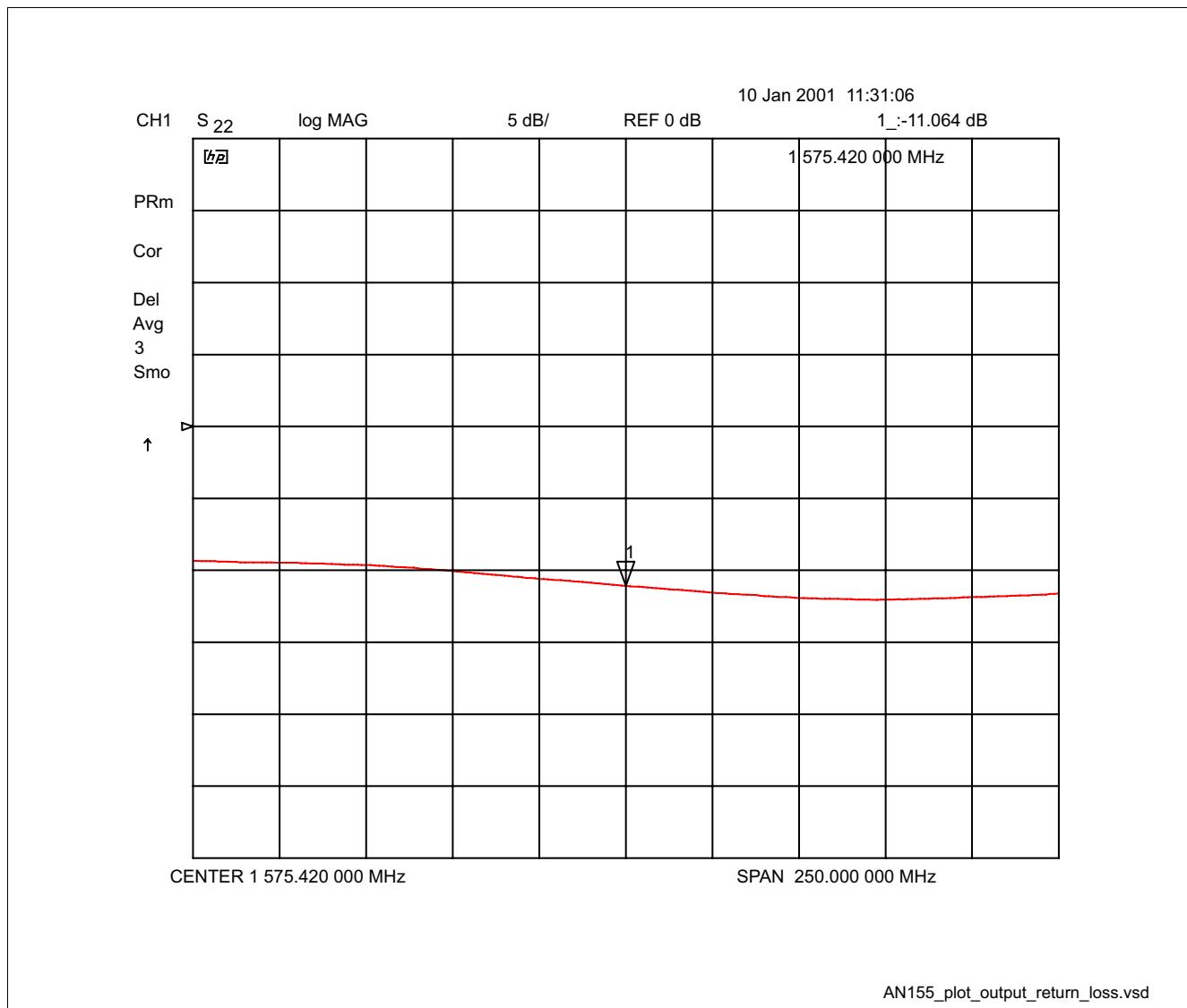
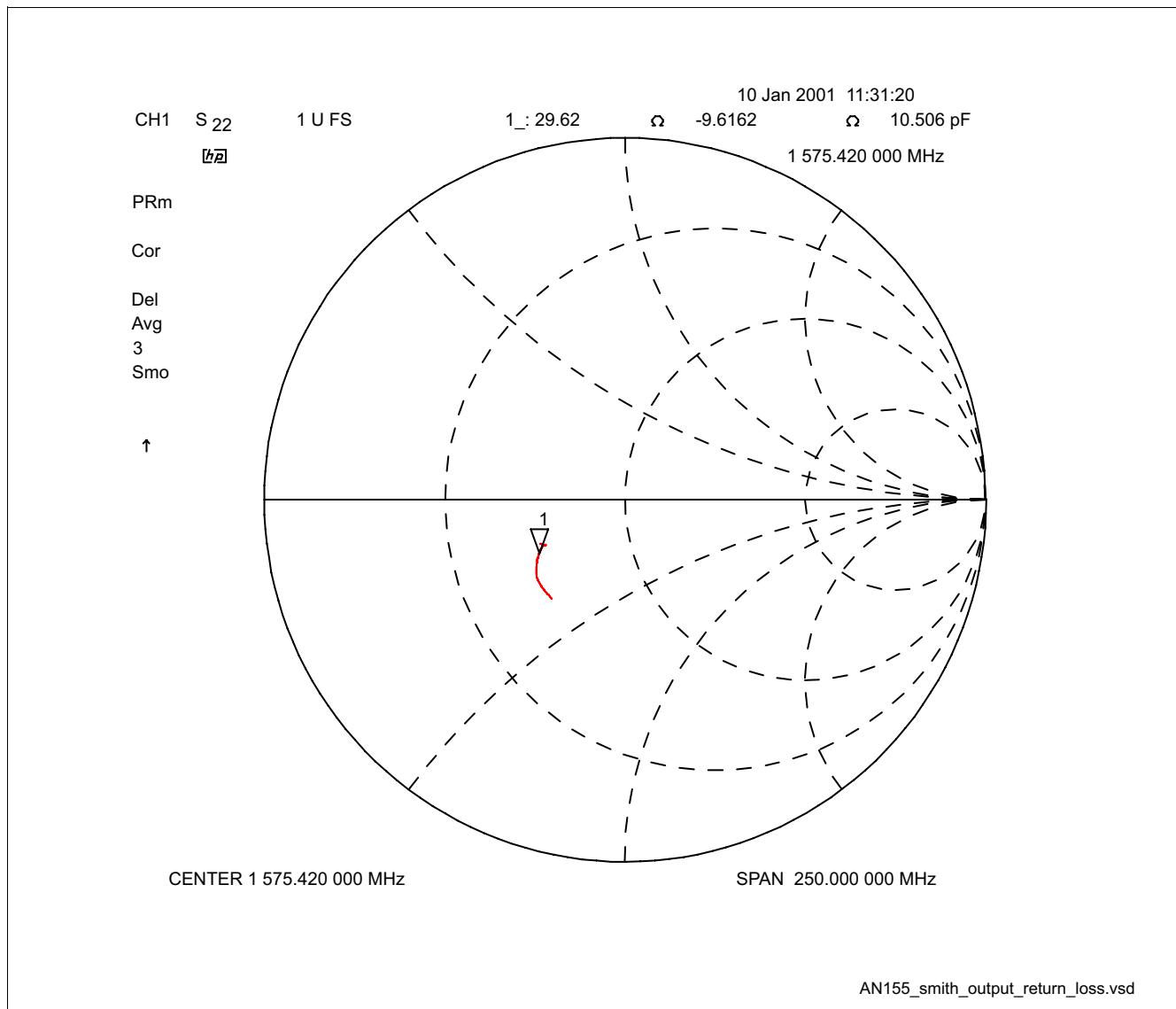


Figure 9 Plot of Output Return Loss

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Output Return Loss, Smith Chart

Reference Plane = PCB RF Output Connector

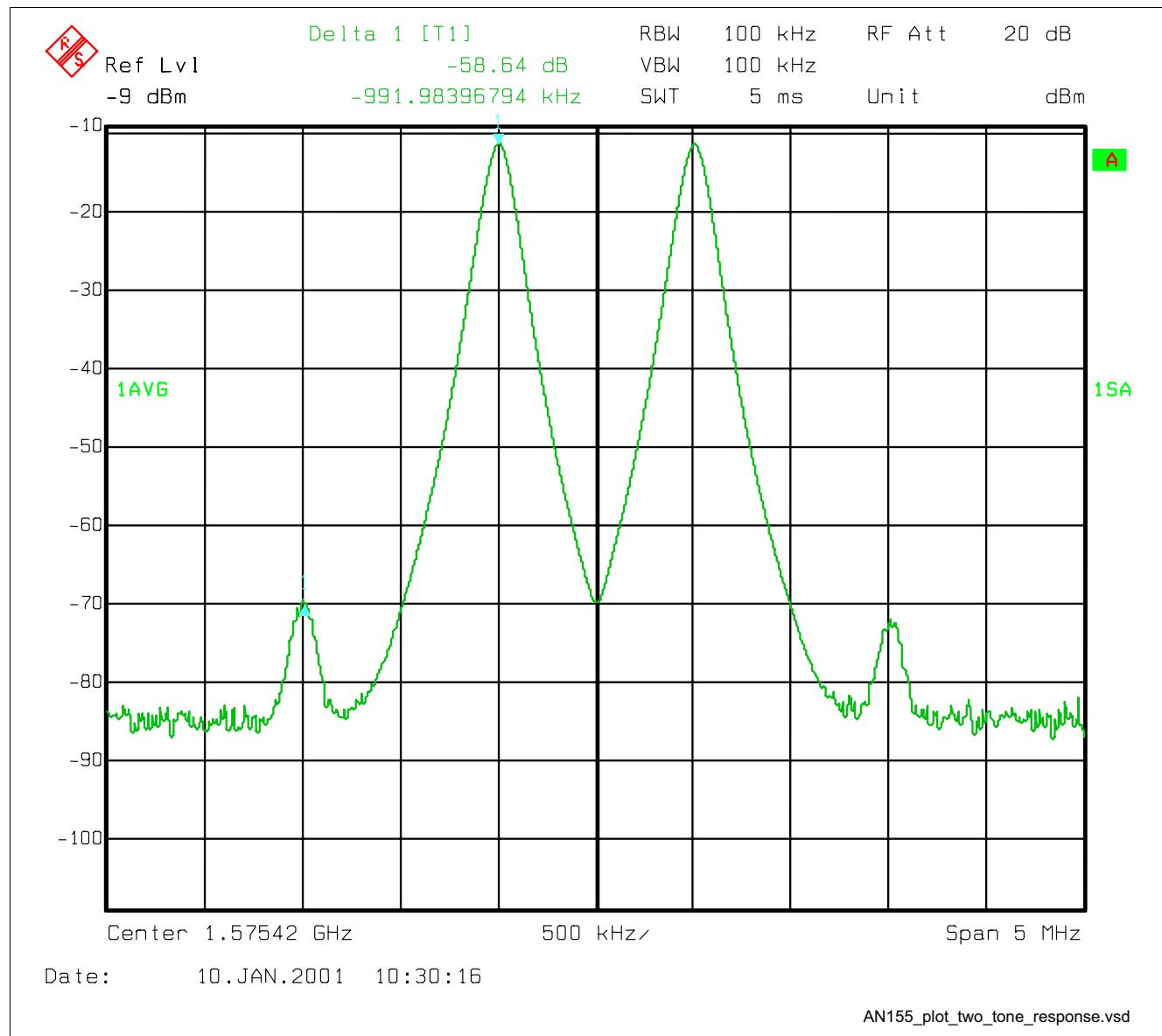

Figure 10 Smith Chart of Output Return Loss

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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 Two-Tone Test, LNA response