# Application Note No. 158

## The BFP420 Transistor as a Low-Cost 900 MHz ISM Band Power Amplifier

RF & Protection Devices

Never stop thinking

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**Application Note No. 158**

**Revision History: 2008-02-27, Rev. 1.2**

**Previous Version: 2000-04-12, Rev. 1.1**

| Page | Subjects (major changes since last revision) |
|---|---|
| All | Small changes in figure descriptions |
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# 1 The BFP420 Transistor as a Low-Cost 900 MHz ISM Band Power Amplifier

**Overview**

- The BFP420 is shown in a 902 - 928 MHz Class A Power Amplifier for a cordless phone application. The PC Board used is the BFP620 V3.0 PCB with "sawed-off" inputs and outputs. Low cost components are used (e.g. Murata LQG10A chip inductors) and effort was made to minimize external parts count - a total of 10 external SMT components were used, not including a jumper or DC and RF connectors.
- Test Conditions: $V_{CC}$ = 3.0 V, $I$ = 33.1 mA, $V_{CE}$ = 2.8 V, $T$ = 25 °C.
- Comments: Inductive emitter degeneration is used to reduce excess gain and improve linearity. Two microstripline inductors are used, between each device ground lead and PCB ground plane. Amplifier is shy on 1 dB compression point. BFP420 maximum safe continuous current = 35 mA. Improvement in $P_{1dB}$ and DC efficiency could be achieved with Class AB bias to amplifier, provided modulation format being used is constant-envelope (e.g. modulation format tolerant of mild levels of PA distortion).

**Summary of Data**

**Table 1 Summary of Data**

| **Parameter** | **Result / Value**<br>**869 MHz** |
|---|---|
| Frequency Range | 902 - 928 MHz |
| DC Current | 33.1 mA |
| DC Voltage, $V_{CC}$ | 3.0 V |
| Input $P_{1dB}$ | ≈ -6.7 dBm @ 915 MHz |
| Output $P_{1dB}$ | ≈ +13.0 dBm @ 902 MHz<br>≈ +13.1 dBm @ 915 MHz<br>≈ +13.1 dBm @ 928 MHz |
| Input 3rd Order Intercept | +5.0 dBm @ 915 MHz |
| Output 3rd Order Intercept | +25.8 dBm @ 915 MHz |
| Noise Figure | 2.50 dB @ 902 MHz<br>2.50 dB @ 915 MHz<br>2.53 dB @ 928 MHz |
| Gain | 20.7 dB @ 902 MHz<br>20.8 dB @ 915 MHz<br>20.8 dB @ 928 MHz |
| Input return loss | 16.5 dB @ 902 MHz<br>16.1 dB @ 915 MHz<br>15.7 dB @ 928 MHz |
| Output return loss | 19.2 dB @ 902 MHz<br>21.0 dB @ 915 MHz<br>20.4 dB @ 928 MHz |
| Reverse isolation | 28.6 dB @ 902 MHz<br>27.5 dB @ 915 MHz<br>27.3 dB @ 928 MHz |

## Schematic Diagram

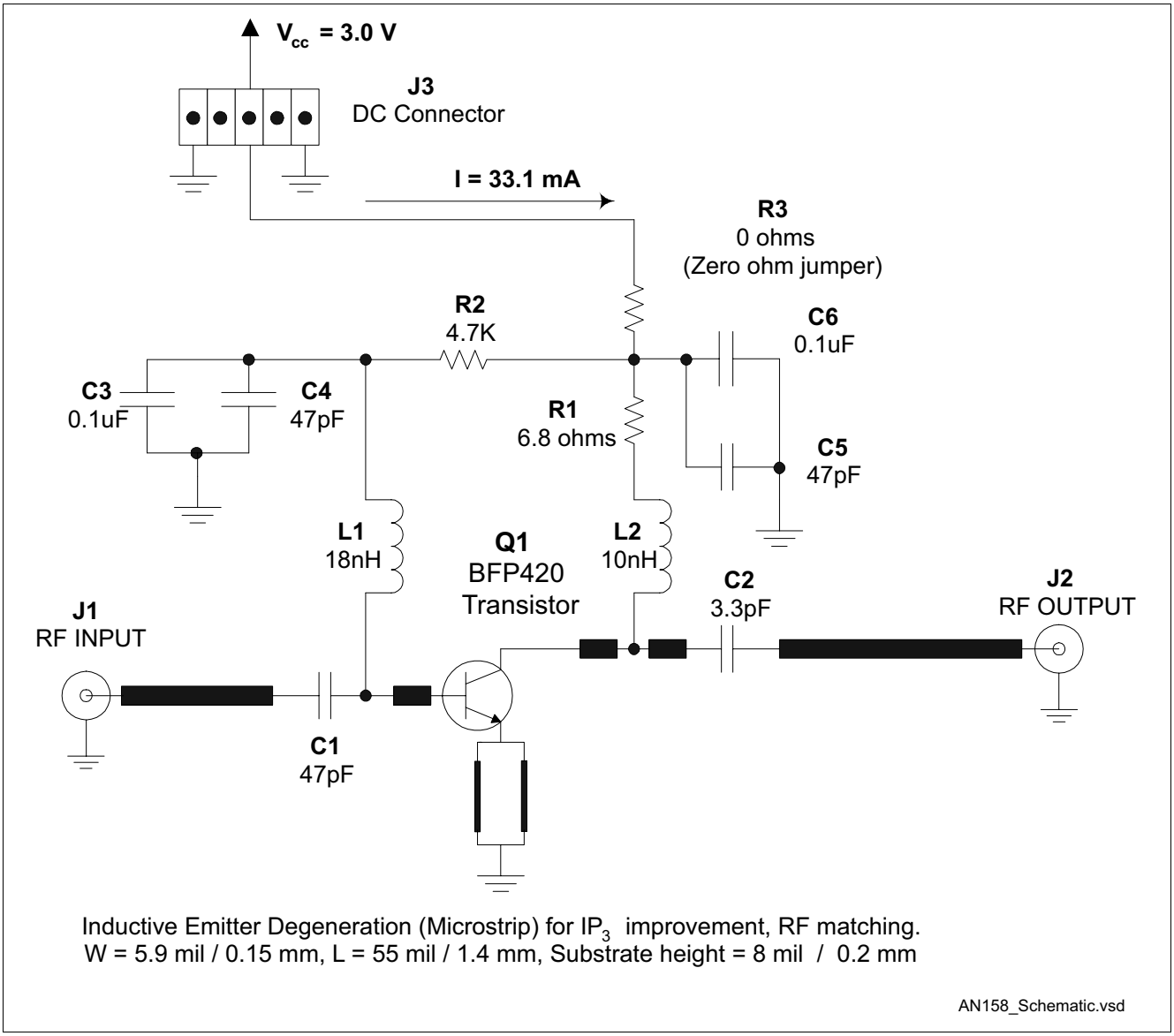



**Figure 1 Schematic Diagram**

## Bill of Material

**Table 2 Bill of Material**

| Reference Designator | Value | Manufacturer | Case Size | Function |
|---|---|---|---|---|
| C1 | 47 pF | Various | 0402 | Input DC block |
| C2 | 3.3 pF | Various | 0402 | Output DC block, output RF matching. |
| C3 | 0.1 µF | Various | 0402 | Low frequency ground at base (Input 3rd Order Intercept improvement). |
| C4 | 47 pF | Various | 0402 | RF bypass / RF block |
| C5 | 47 pF | Various | 0402 | RF bypass / RF block |
| C6 | 0.1 µF | Various | 0603 | Bypass / block |
| L1 | 18 nH | Murata LQG10A | 0402 | RF choke to DC bias on base, input matching. |
| L2 | 10 nH | Murata LQG10A | 0402 | Output RF match, DC feed to collector. |
| R1 | 6.8 Ω | Various | 0402 | Stability, output matching. |
| R2 | 4.7 kΩ | Various | 0402 | DC bias for base. |
| R3 | 0 Ω | Various | 0603 | Just a jumper. |
| Q1 | - | Infineon Technologies | SOT343 | BFP420 transistor, $f_T$ = 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<br><br>Pins 1, 5 = ground<br>Pin 3 = $V_{CC}$<br>Pins 2, 4 = no connection |

**Noise Figure, Plot. Center of Plot (x-axis) is 915 MHz.**

Rohde and Schwarz FSEK3 V2.00

13 Apr 2000

BFP420 Noise Figure

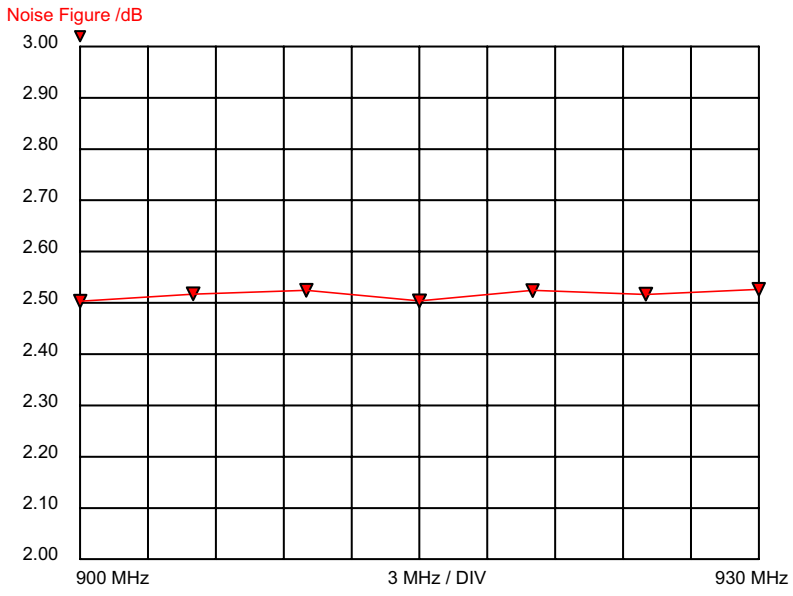
| | |
|---|---|
| EUT Name: | 900 MHz ISM Band Cordless Phone PA |
| Manufacturer: | Infineon |
| Operating Conditions: | V=3.0V, I=33.1mA, T=25C, Vce=2.8V |
| Operator Name: | Gerard Wevers |
| Test Specification: | Norm G. / Lawrence C. |
| Comment: | LWR # 00331 PA P |
| | PCB = BFP620 App. Board V3.0, Sawed Off Input / Output |

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 |




AN158_plot_nf.vsd

**Figure 2 Noise Figure**

### Noise Figure, Tabular Data

**Table 3 Noise Figure**

| Frequency | Noise Figure |
|---|---|
| 900 MHz | 2.50 dB |
| 905 MHz | 2.52 dB |
| 910 MHz | 2.52 dB |
| 915 MHz | 2.50 dB |
| 920 MHz | 2.52 dB |
| 925 MHz | 2.52 dB |
| 930 MHz | 2.53 dB |

### Amplifier Gain Compression at 902, 915 and 928 MHz

Input $P_{1dB}$ ≅ -6.7 dBm @ 915 MHz
Output $P_{1dB}$ ≅ +13.1 dBm @ 915 MHz

**Table 4 Gain Compression Test, $T$ = 25 °C**

| Output Power, dBm | Gain @ 902 MHz, dB | Gain @ 915 MHz, dB | Gain @ 928 MHz, dB |
|---|---|---|---|
| +5 | 20.7 | 20.8 | 20.8 |
| +6 | 20.7 | 20.8 | 20.8 |
| +7 | 20.7 | 20.8 | 20.8 |
| +8 | 20.7 | 20.8 | 20.7 |
| +9 | 20.6 | 20.7 | 20.7 |
| +10 | 20.5 | 20.6 | 20.6 |
| +11 | 20.4 | 20.5 | 20.5 |
| +12 | 20.2 | 20.2 | 20.2 |
| +13 | 19.7 | 19.9 | 19.9 |
| +14 | 18.8 | 19.2 | 19.3 |
| +15 | 16.1 | 17.0 | 17.4 |

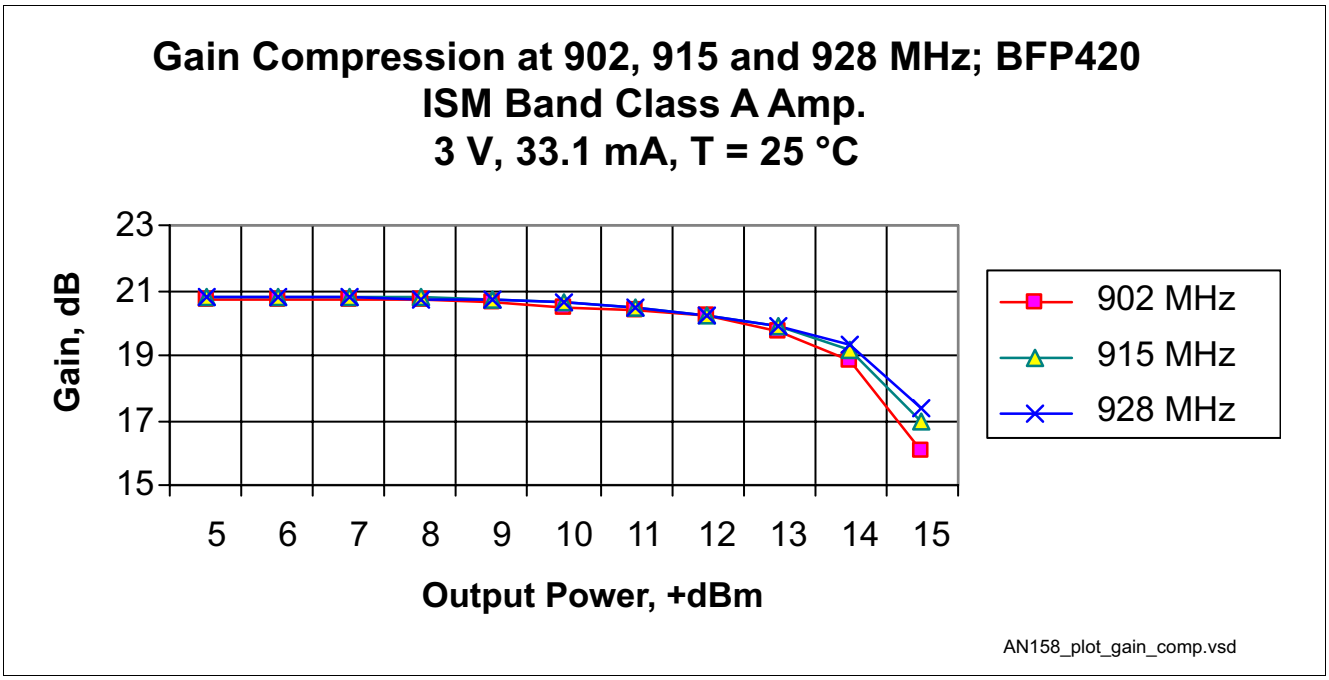



**Figure 3 Plot of Gain Compression**

### Stability Factors K and $B_1$

Measured s-parameter file from actual PCB is imported into Ansoft Harmonica V8.0, which then calculates K and $B_1$. For unconditional stability, K > 1 AND $B_1$ > 0.

Note red trace is K, blue trace is $B_1$.

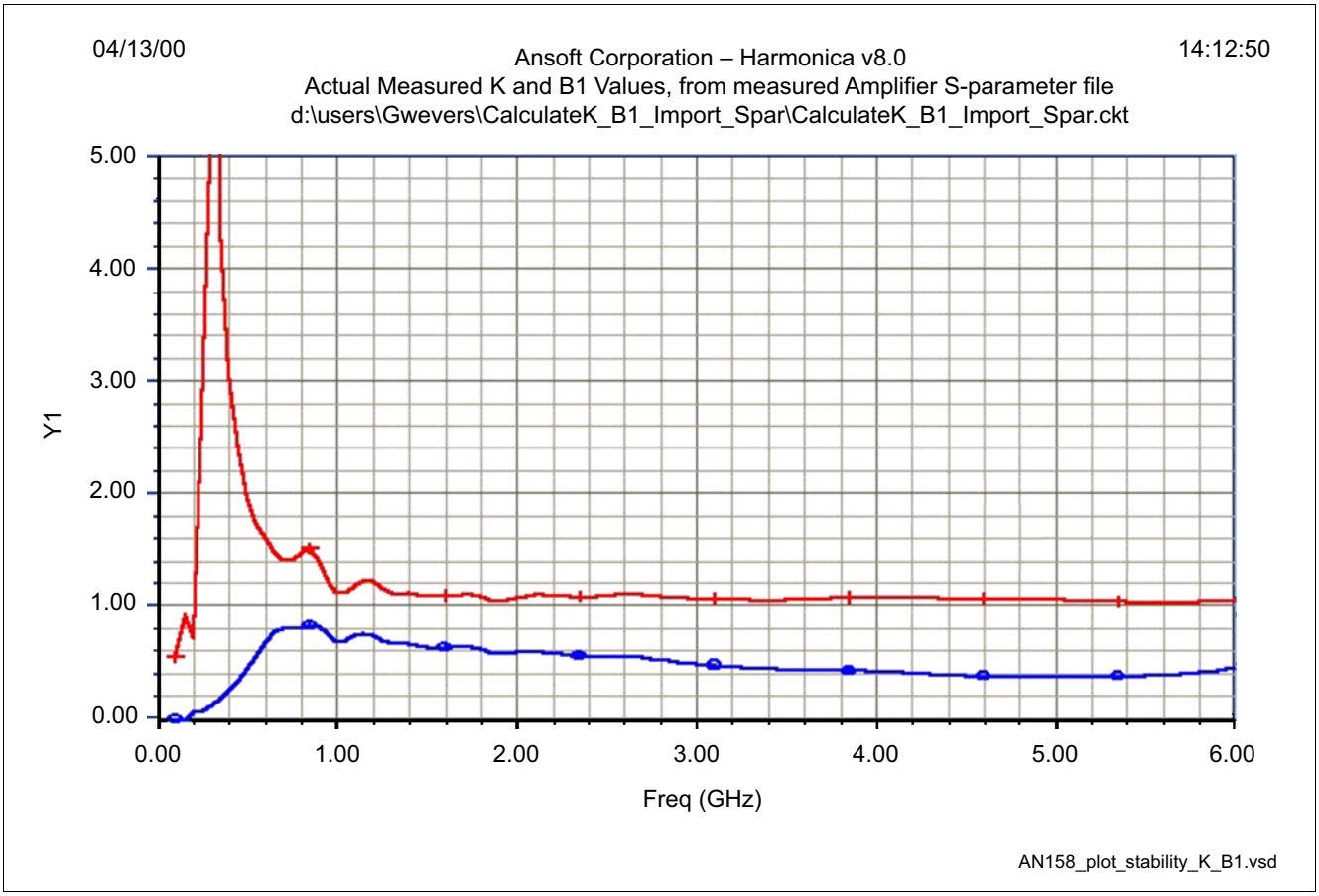



**Figure 4 Plot of K(f) and $B_1$(f)**

**Scanned Image of PCB**

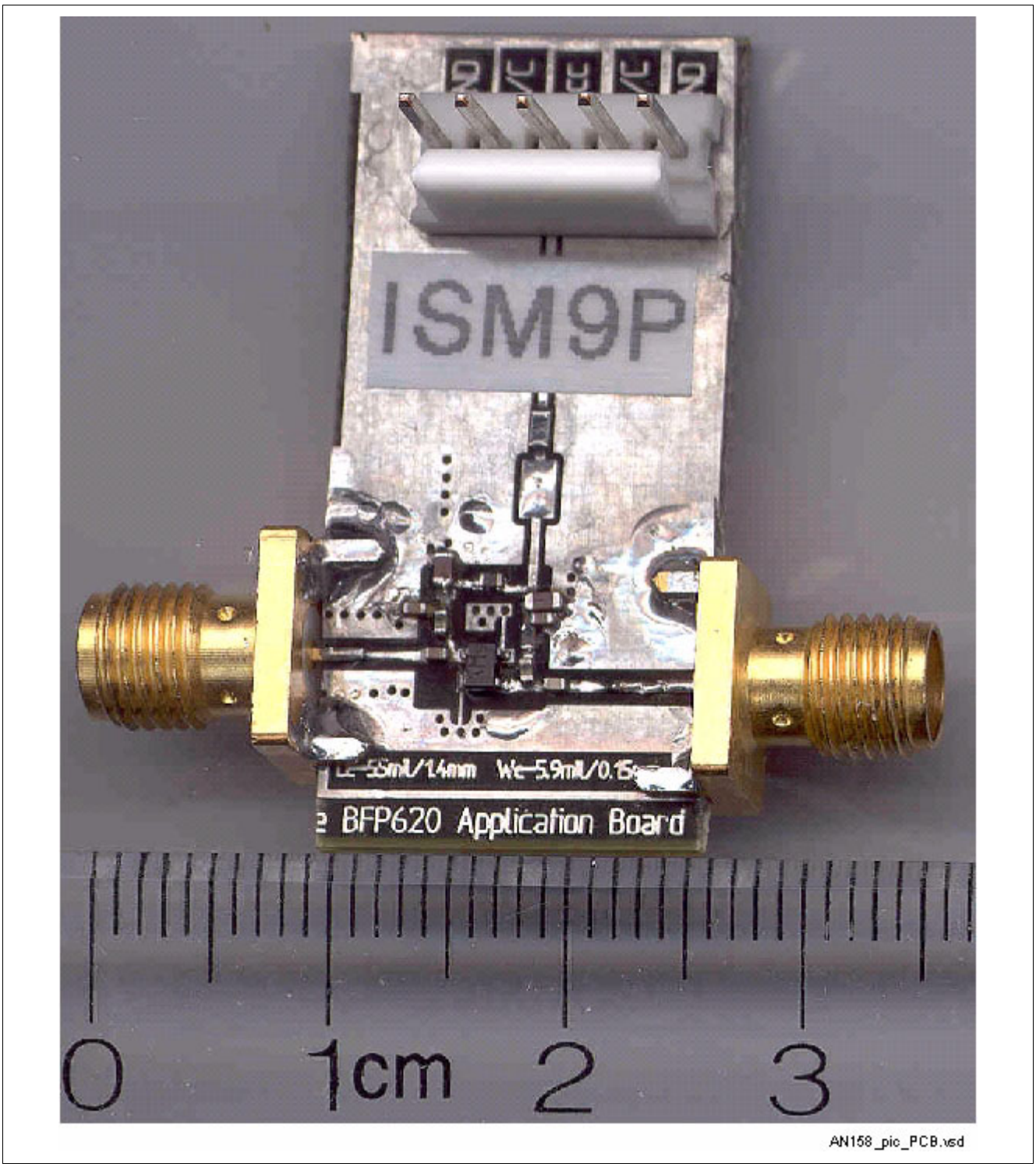



**Figure 5 Image of PC Board**

**Input Return Loss, Log Mag**

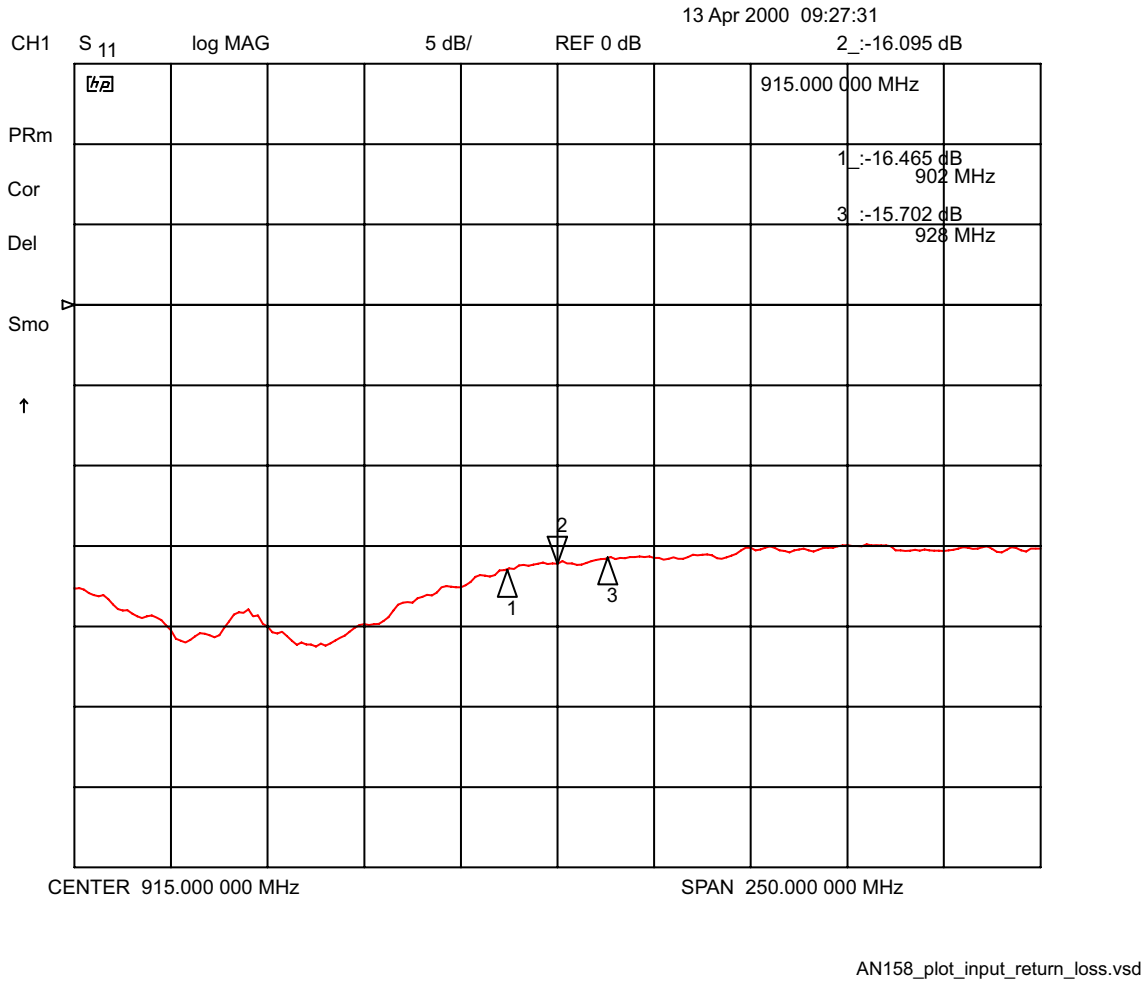



**Figure 6 Plot of Input Return Loss**

**Input Return Loss, Smith Chart**

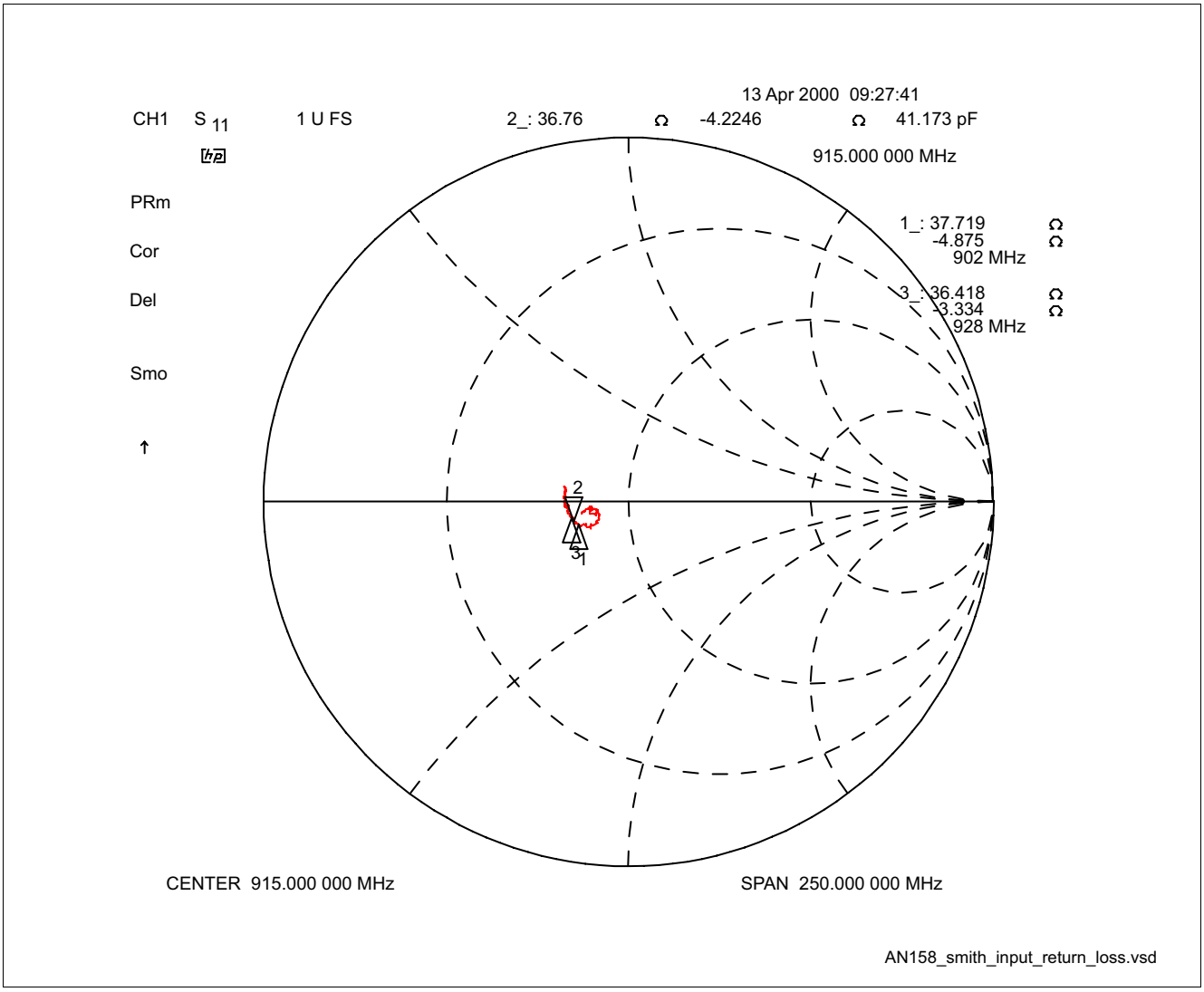



**Figure 7 Smith Chart of Input Return Loss**

**Forward Gain**

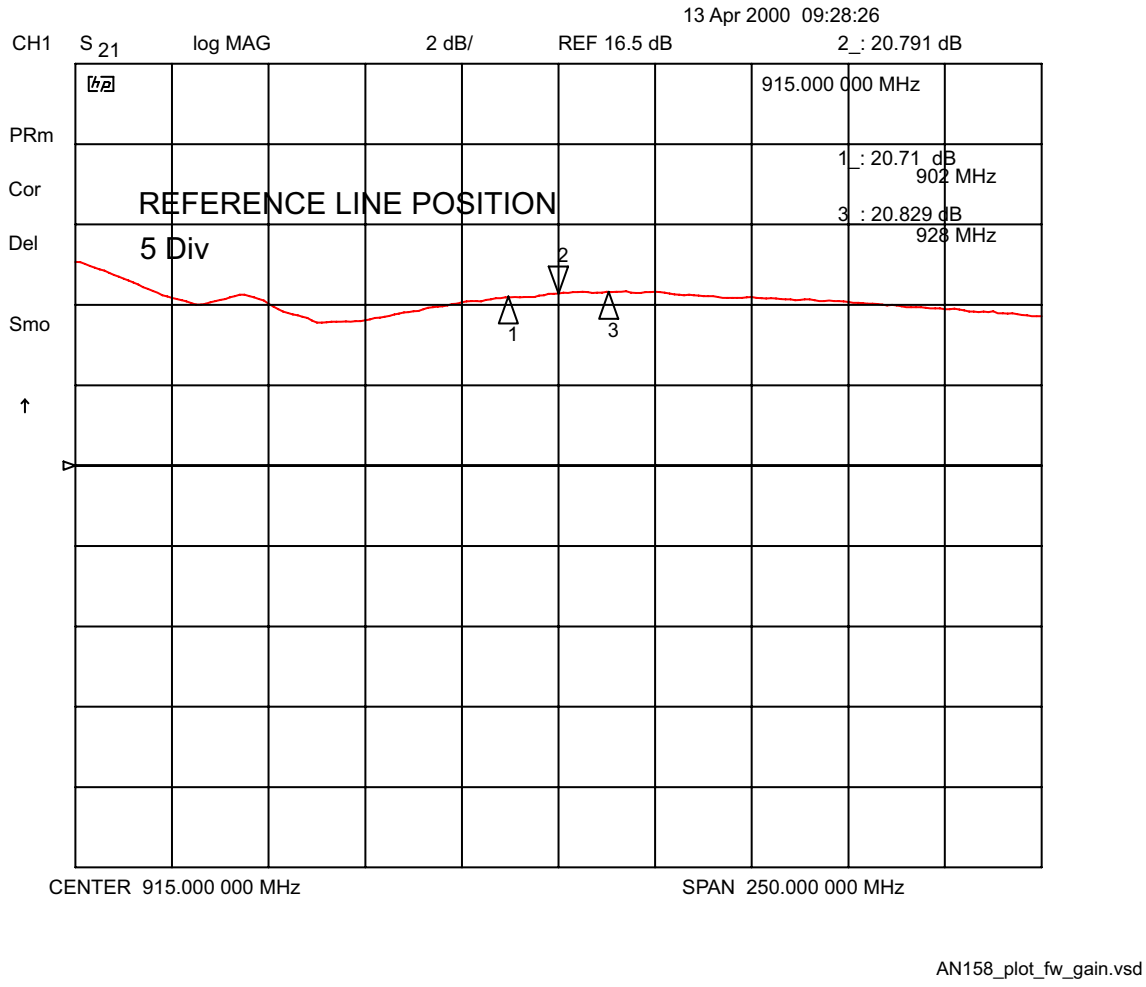



**Figure 8 Plot of Forward Gain**

**Forward Gain, Wide Span**

30 kHz - 6 GHz

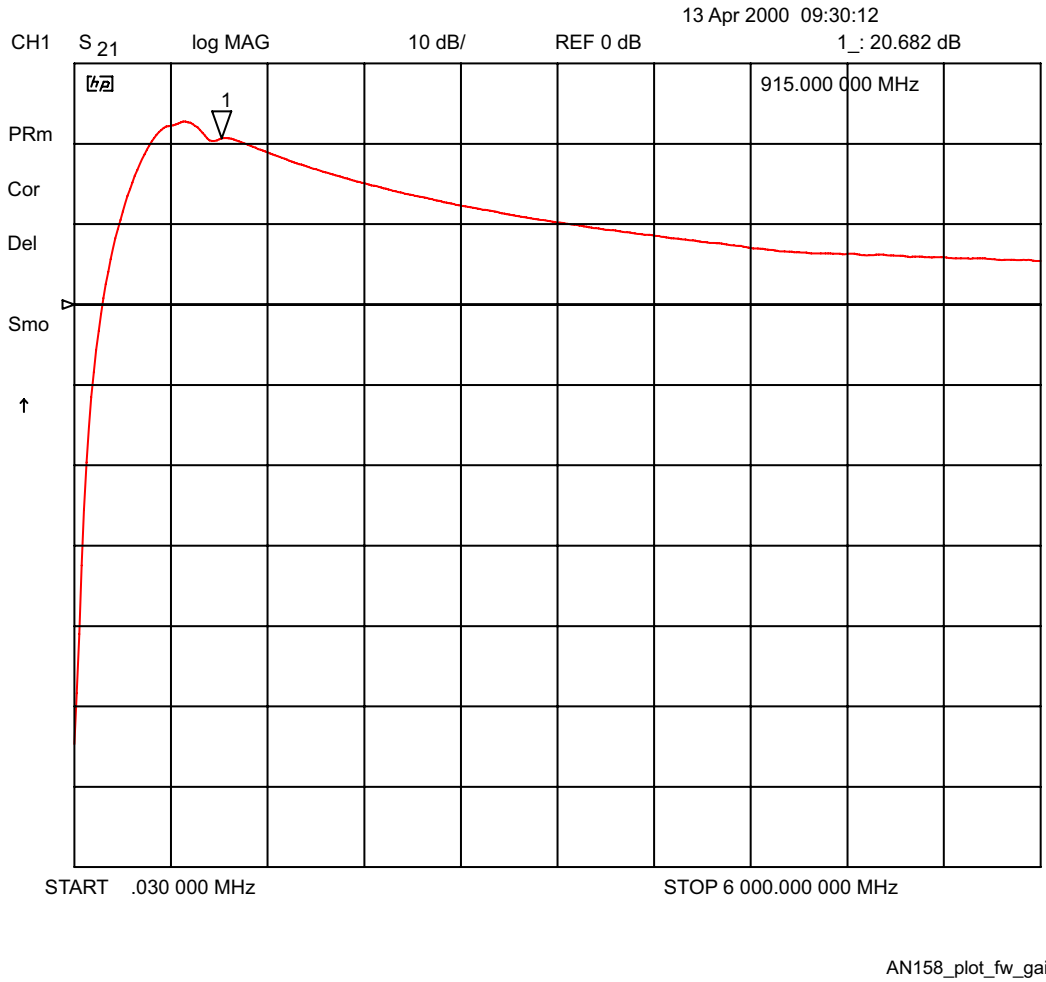



**Figure 9 Plot of Forward Gain, Wide Span**

## Reverse Isolation

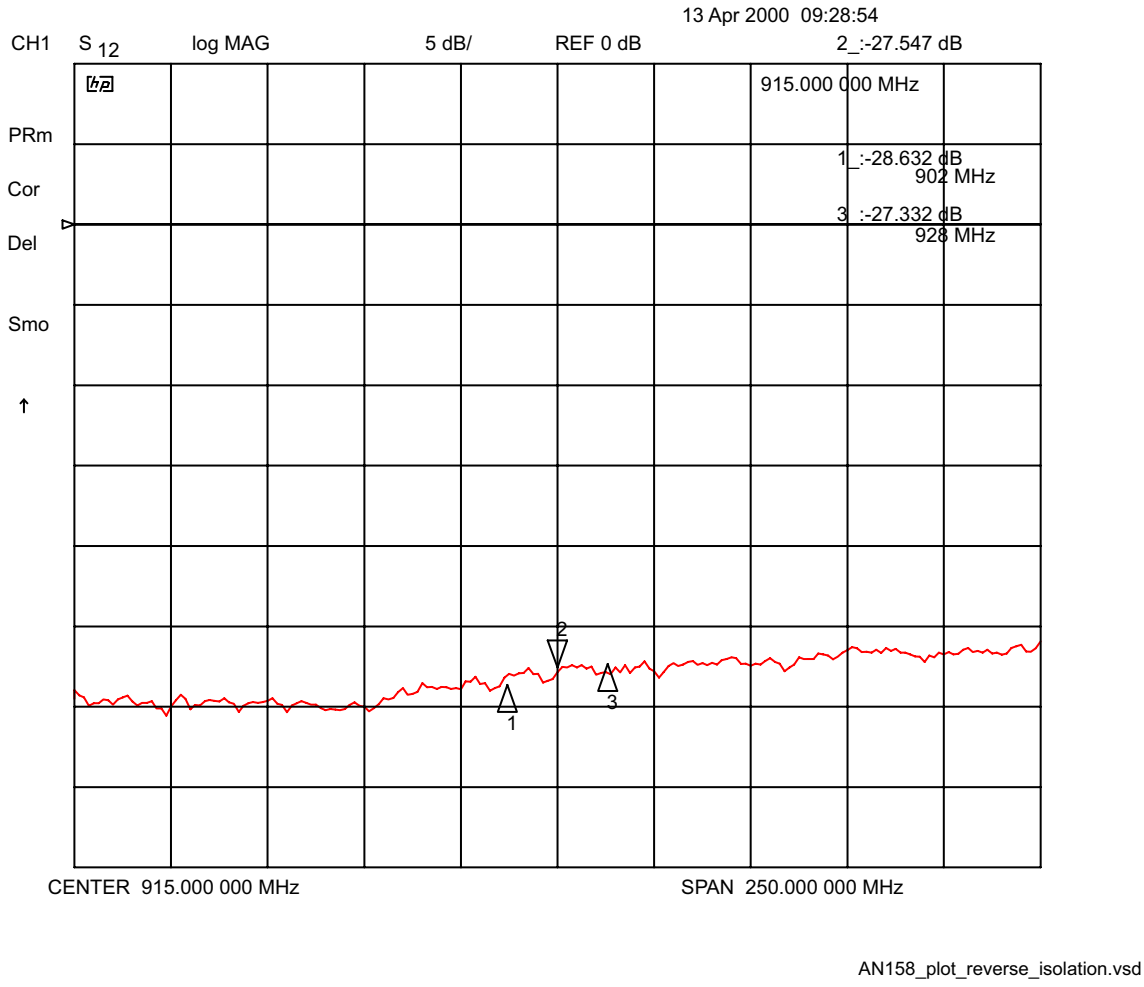



**Figure 10 Plot of Reverse Isolation**

**Output Return Loss, Log Mag**

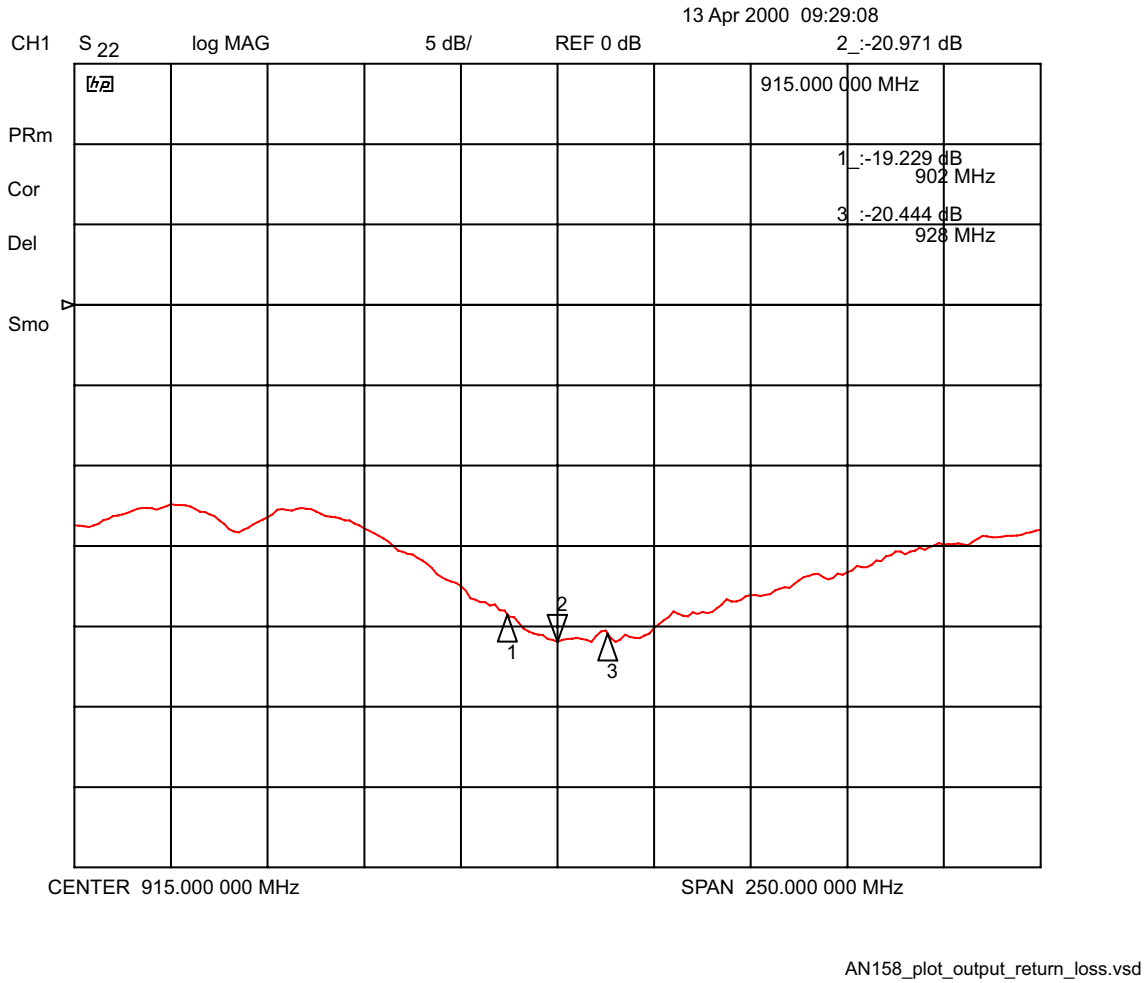



**Figure 11 Plot of Output Return Loss**

**Output Return Loss, Smith Chart**

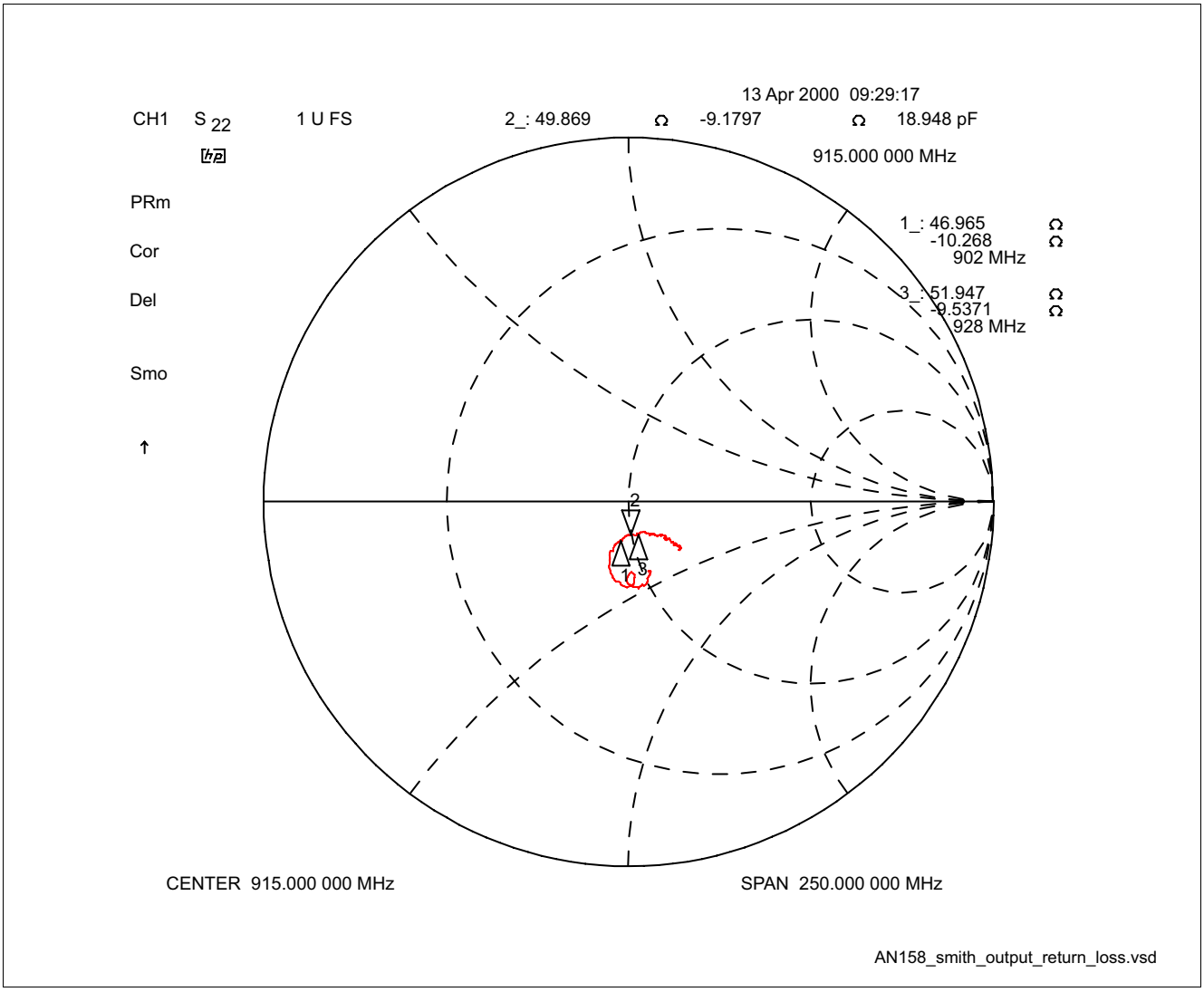



**Figure 12 Smith Chart of Output Return Loss**

### Two-Tone Test

Output Response of Amplifier to Two-Tone 3rd Order Intercept Test, mid-band (915 MHz). Two tones, -20 dBm each tone, tone spacing = 1 MHz.

Input $IP_3$ = -20 + (50.0 / 2) = +5.0 dBm

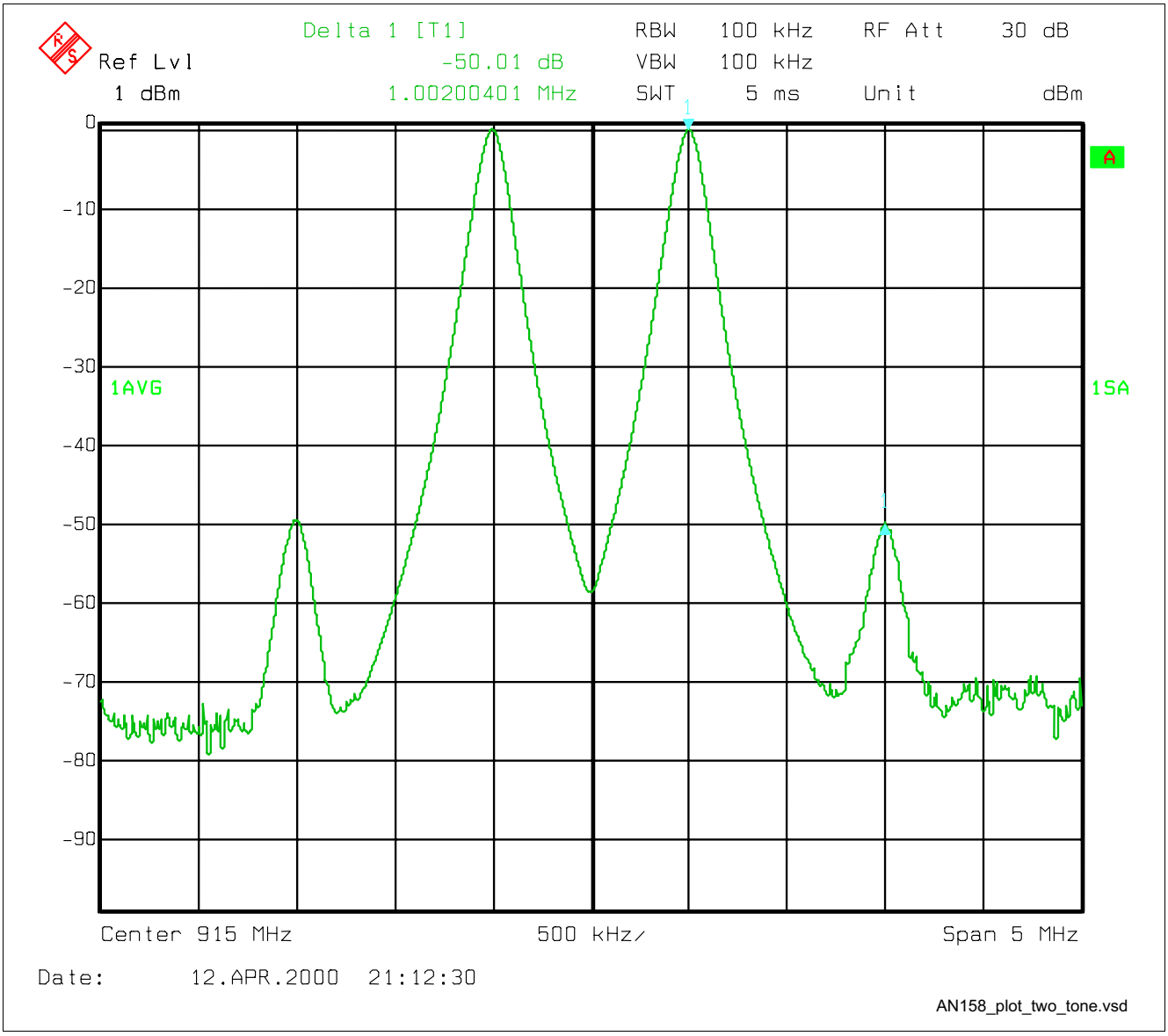



**Figure 13 Plot of Tow-Tone Test, LNA response**