Application Note No. 116

BFR740L3 Ultra Low Noise SiGe:C RF Transistor as 2110 - 2170 MHz UMTS Low Noise Amplifier

RF & Protection Devices

Never stop thinking

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Application Note No. 116

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

Previous Version: 2005-10-11, Rev. 1.1	
Page	**Subjects (major changes since last revision)**
All	Change of layout

1 BFR740L3 Ultra Low Noise SiGe:C RF Transistor as 2110 - 2170 MHz UMTS Low Noise Amplifier

Applications

- UMTS LNA for Mobile Phone

Overview

- Infineon BFR740L3 Ultra Low Noise SiGe:C Transistor in reduced-height TSLP-3-8 package is shown in a low-cost, low-parts count, broadband resistive feedback LNA.
- Transistor package size is 1 x 0.6 x 0.39 mm (leadless, RoHS compliant package).
- Note that "0201" size passive components are used.
- Resistive feedback is used to provide for unconditional stability and to "broaden" the input and output match => provide better termination to duplexer and bandpass filter. The price paid with use of this feedback is a decrease in gain and a slight increase (≅ 0.1 to 0.2 dB) in noise figure.
- Amplifier is unconditionally stable (K>1) over 5 MHz - 8 GHz frequency range.
- ON / OFF or "enable" control can be implemented with a low-cost MOSFET switch or PNP transistor switch. Switch is not implemented in this PC board.

Summary of Results

Table 1 Summary of Results
(T = 25 °C, network analyzer source power = - 25 dBm, V_{CC} = 2.775 V, V_{CE} = 2.5 V, I_C = 6.5 mA)

Frequency MHz	dB[s11]²	dB[s21]²	dB[12]²	dB[22]²	NF 1) dB	IIP_3 dBm	OIP_3 dBm	IP_{1dB} dBm	OP_{1dB} dBm
2110	11.7	16.5	21.1	12.2	0.9				
2140	11.9	16.4	21.0	12.0	0.9	+4.7	+21.1	-15.2	+0.2
2170	12.0	16.3	21.5	11.7	0.9				

1) PCB loss is not extracted. If PCB loss were extracted, NF would be 0.1 to 0.2 dB lower.

Cross Sectional Diagram of PC Board

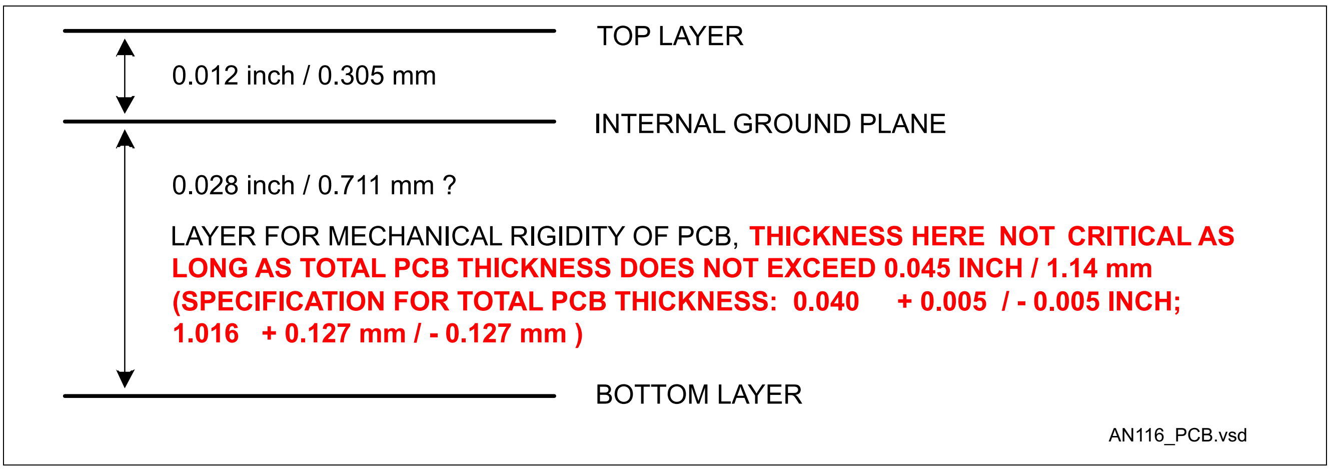
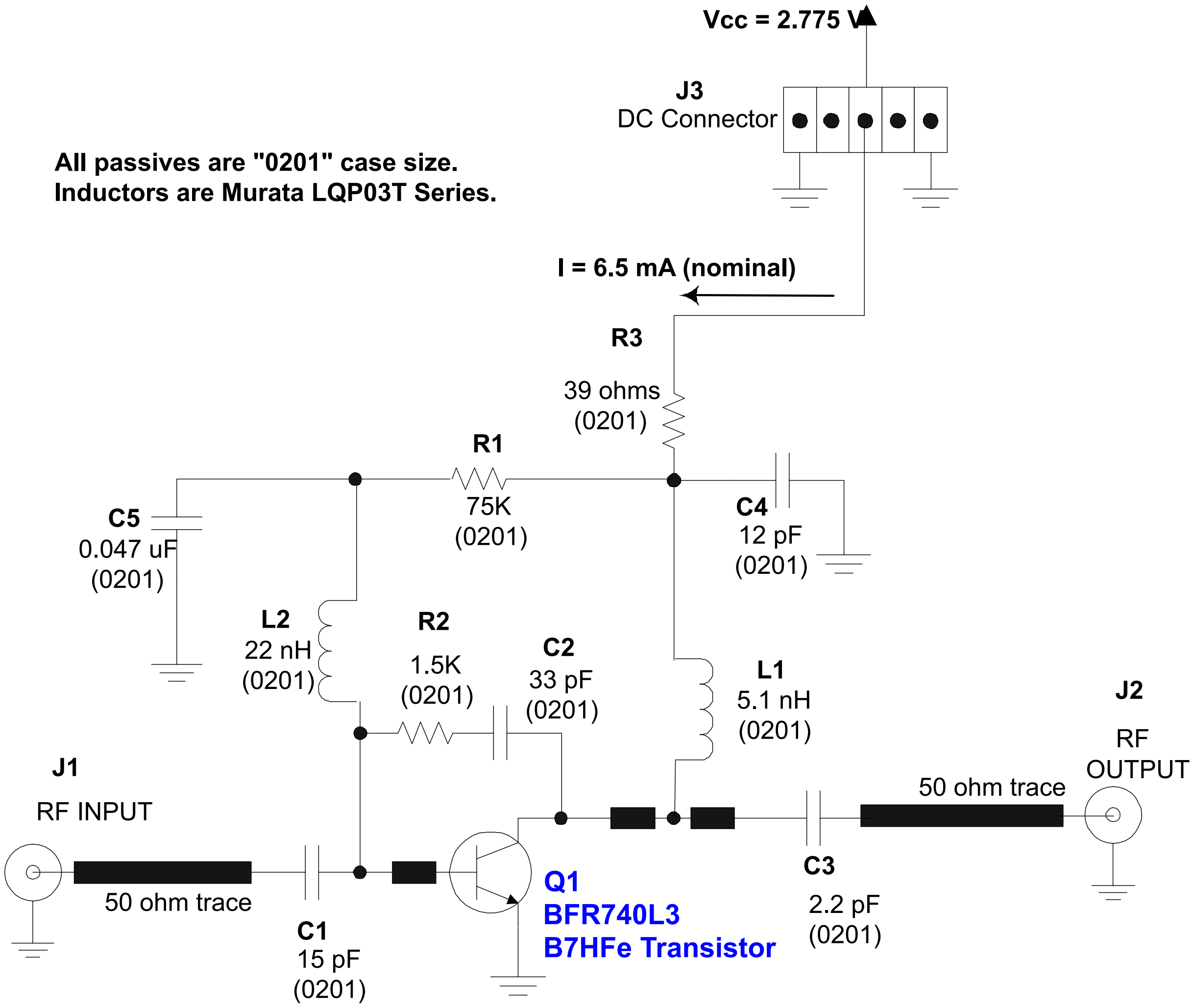


Figure 1 PCB - Cross Sectional Diagram

Schematic Diagram

Note: “0201” case size passives are used



BFR740L3 Wideband Feedback LNA

PCB = 740L3-081204 Rev A
PC Board Material = Standard FR4
Layer spacing (top RF to internal ground plane): 0.012 inch / 0.305 mm

Total Parts Count = 11, including RF transistor

BFR740L3 => 1
Capacitors => 5
Resistors => 3
Inductors => 2

AN116_Schematic.vsd

Figure 2 Schematic Diagram

Details on TSLP-3-8 Leadless Package, dimensions in millimeters (mm)

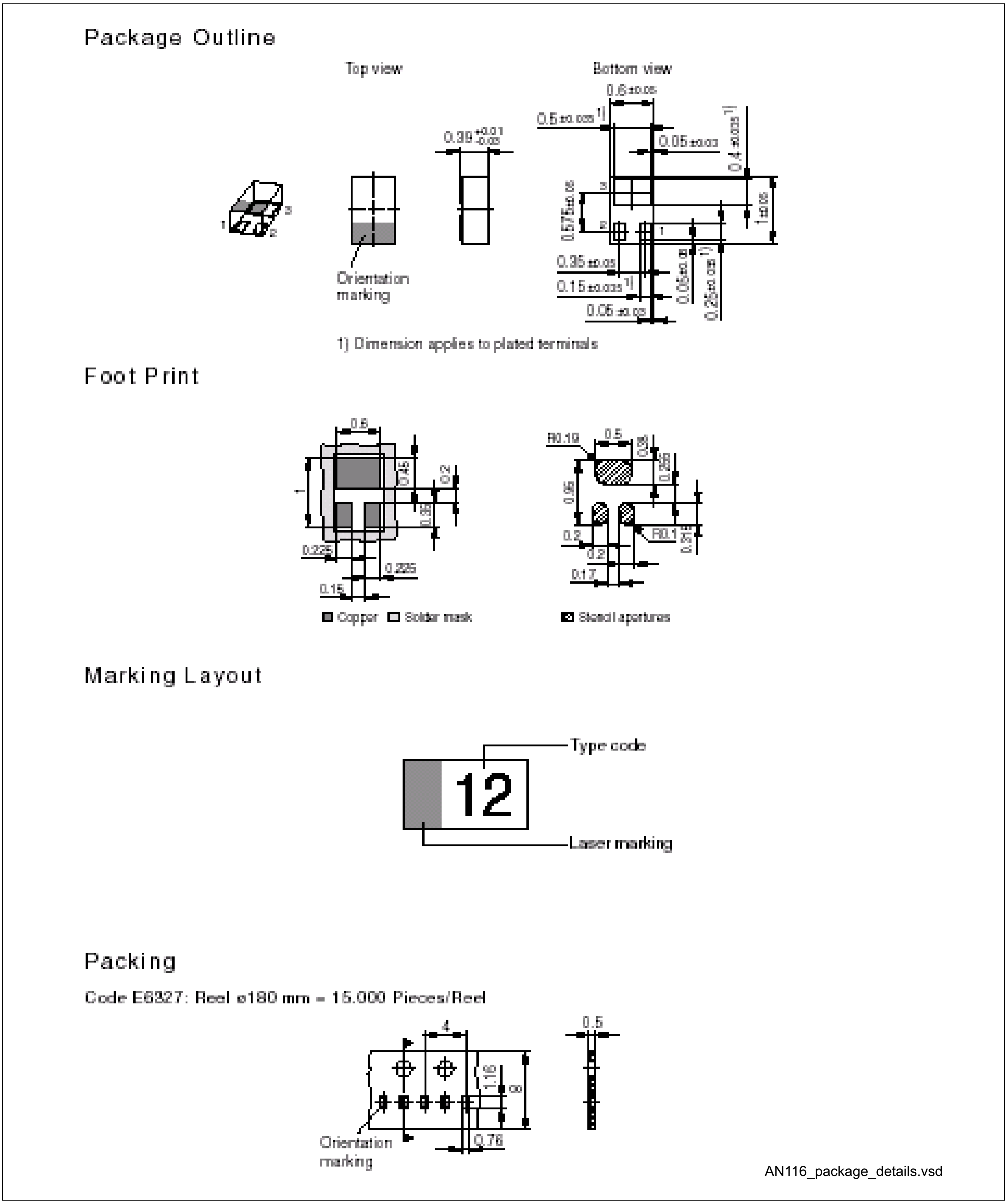


Figure 3 Details on TSLP-3-8 Leadless Package

Noise Figure, Plot, 1740 to 2540 MHz. Center of Plot (x-axis) is 2140 MHz.

Rohde & Schwarz FSEK3

11 Oct 2005

Noise Figure

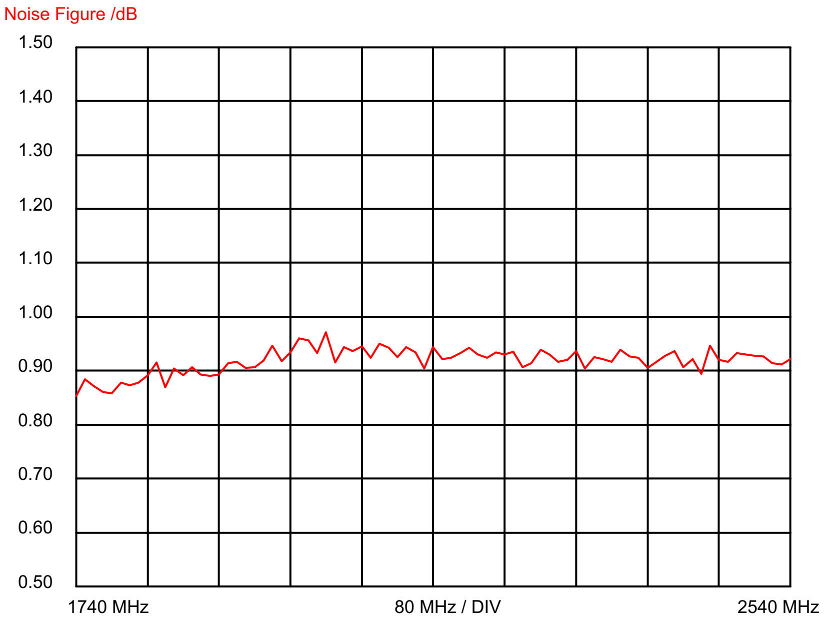
EUT Name:	BFR740L3 UMTS LNA 2110 - 2170 MHz
Manufacturer:	Infineon Technologies
Operating Conditions:	V=2.775 V, Vce = 2.5 V, I=6.5mA, T=25 C
Operator Name:	Gerard Wevers
Test Specification:	LWR SD 00094 LNA P
Comment:	on PCB 740L3-081204 Rev A 11 October 2005

Analyzer

RF Att:	0.00 dB	RBW :	1 MHz	Range:	40.00 dB
Ref Lvl:	-40.00 dBm	VBW :	100 Hz	Ref Lvl auto:	ON

Measurement

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



AN116_plot_nf.vsd

Figure 4 Noise Figure

Noise Figure, Tabular Data

From Rhode & Schwarz FSEK3 + FSEM30 + System PreAmp

Table 2 Noise Figure

Frequency	Noise Figure
1740 MHz	0.85 dB
1750 MHz	0.88 dB
1760 MHz	0.87 dB
1770 MHz	0.86 dB
1780 MHz	0.86 dB
1790 MHz	0.88 dB
1800 MHz	0.87 dB
1810 MHz	0.88 dB
1820 MHz	0.89 dB
1830 MHz	0.91 dB
1840 MHz	0.87 dB
1850 MHz	0.90 dB
1860 MHz	0.89 dB
1870 MHz	0.91 dB
1880 MHz	0.89 dB
1890 MHz	0.89 dB
1900 MHz	0.89 dB
1910 MHz	0.91 dB
1920 MHz	0.92 dB
1930 MHz	0.91 dB
1940 MHz	0.91 dB
1950 MHz	0.92 dB
1960 MHz	0.95 dB
1970 MHz	0.92 dB
1980 MHz	0.93 dB
1990 MHz	0.96 dB
2000 MHz	0.96 dB
2010 MHz	0.93 dB
2020 MHz	0.97 dB
2030 MHz	0.92 dB
2040 MHz	0.94 dB
2050 MHz	0.94 dB
2060 MHz	0.94 dB
2070 MHz	0.92 dB
2080 MHz	0.95 dB
2090 MHz	0.94 dB
2100 MHz	0.93 dB
2110 MHz	0.94 dB

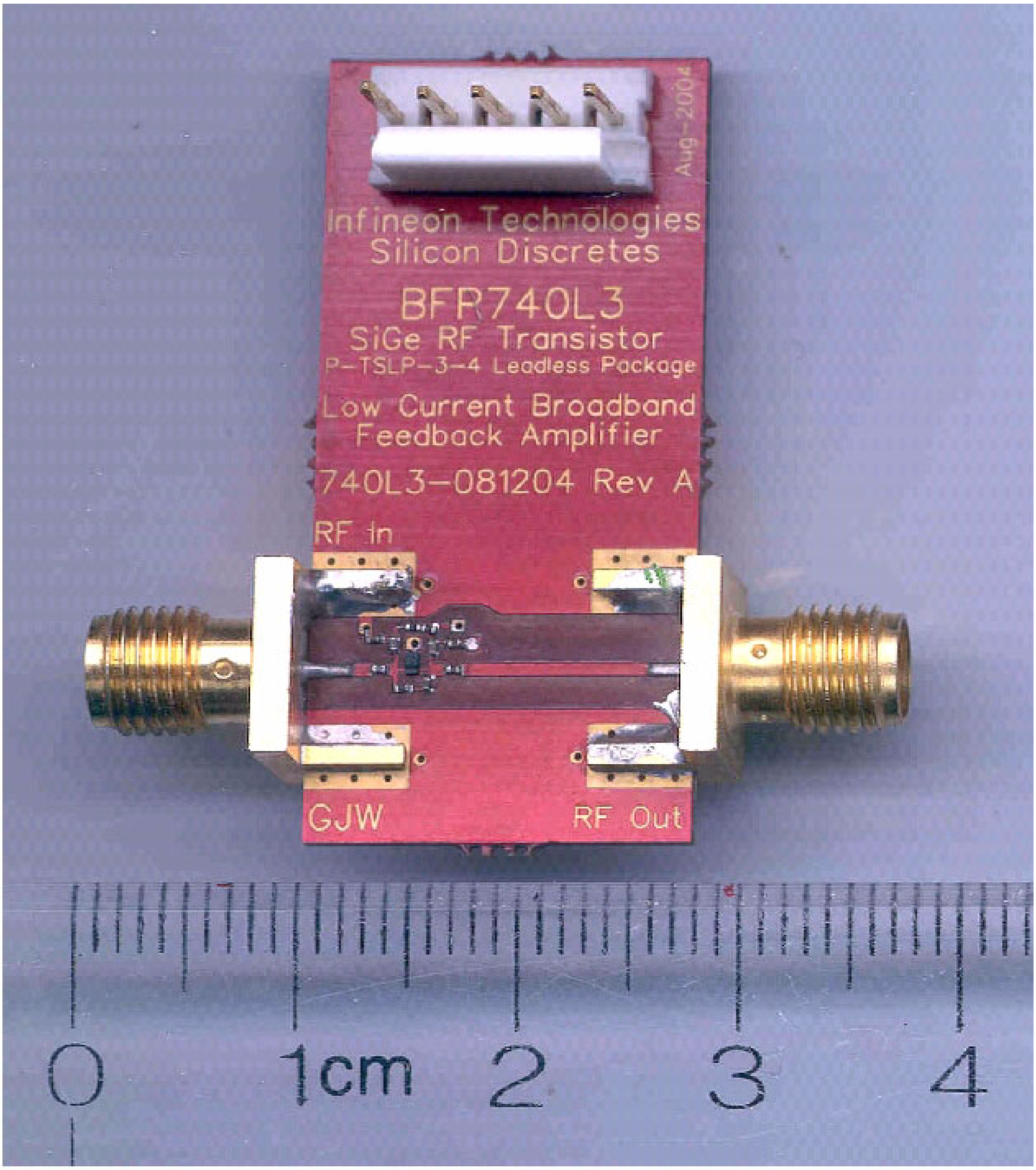
Table 2 Noise Figure (cont'd)

Frequency	Noise Figure
2120 MHz	0.93 dB
2130 MHz	0.90 dB
2140 MHz	0.94 dB
2150 MHz	0.92 dB
2160 MHz	0.92 dB
2170 MHz	0.93 dB
2180 MHz	0.94 dB
2190 MHz	0.93 dB
2200 MHz	0.92 dB
2210 MHz	0.93 dB
2220 MHz	0.93 dB
2230 MHz	0.94 dB
2240 MHz	0.91 dB
2250 MHz	0.91 dB
2260 MHz	0.94 dB
2270 MHz	0.93 dB
2280 MHz	0.92 dB
2290 MHz	0.92 dB
2300 MHz	0.94 dB
2310 MHz	0.90 dB
2320 MHz	0.92 dB
2330 MHz	0.92 dB
2340 MHz	0.92 dB
2350 MHz	0.94 dB
2360 MHz	0.93 dB
2370 MHz	0.92 dB
2380 MHz	0.91 dB
2390 MHz	0.92 dB
2400 MHz	0.93 dB
2410 MHz	0.94 dB
2420 MHz	0.91 dB
2430 MHz	0.92 dB
2440 MHz	0.89 dB
2450 MHz	0.95 dB
2460 MHz	0.92 dB
2470 MHz	0.92 dB
2480 MHz	0.93 dB
2490 MHz	0.93 dB
2500 MHz	0.93 dB
2510 MHz	0.93 dB
2520 MHz	0.91 dB

Table 2 Noise Figure (cont'd)

Frequency	Noise Figure
2530 MHz	0.91 dB
2540 MHz	0.92 dB

Scanned Image of PC Board



AN116_pic_PCB.vsd

Figure 5 Image of PC Board

Scanned Image of PC Board, Close-In Shot

Total PCB area used ≅ 15 mm²
PCB area may be reduced!

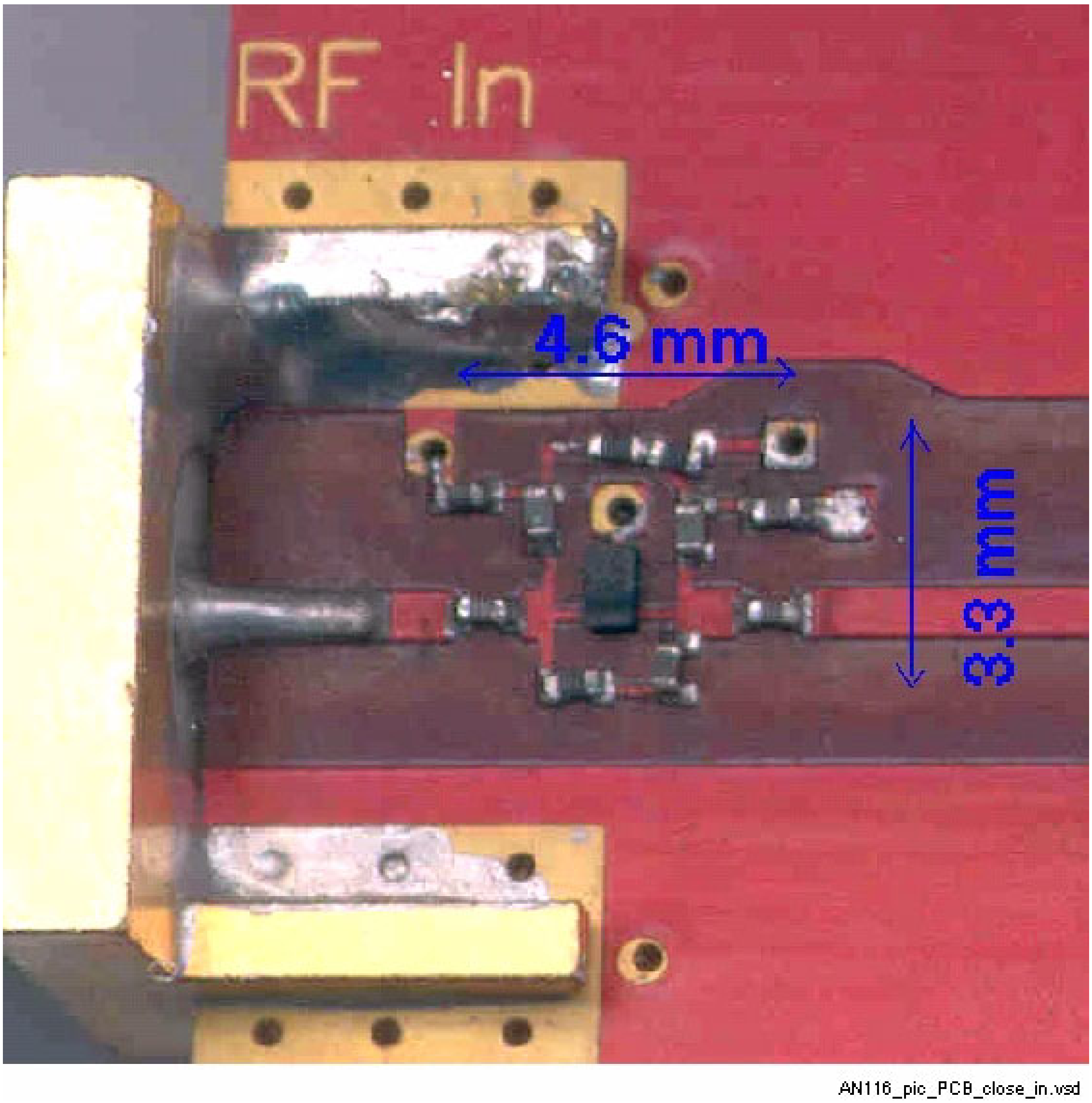


Figure 6 Image of PC Board, Close-In Shot

Gain Compression at 2140 MHz

Amplifier is checked for 1 dB compression point at V_{CC} = 2.775 V, I_C = 6.5 mA (with V_{CE} = 2.5 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} ≅ +0.2 dBm; Input P_{1dB} = +0.2 dBm - (Gain - 1 dB) = +0.2 dBm -15.4 dB = -15.2 dBm

Table 3 Gain Compression

P_{OUT}, dBm	Gain, dB
-10.0	16.4
-9.0	16.4
-8.0	16.4
-7.0	16.4
-6.0	16.3
-5.0	16.3
-4.0	16.2
-3.0	16.2
-2.0	16.1
-1.0	15.9
0.0	15.7
+1.0	15.3
+2.0	14.6

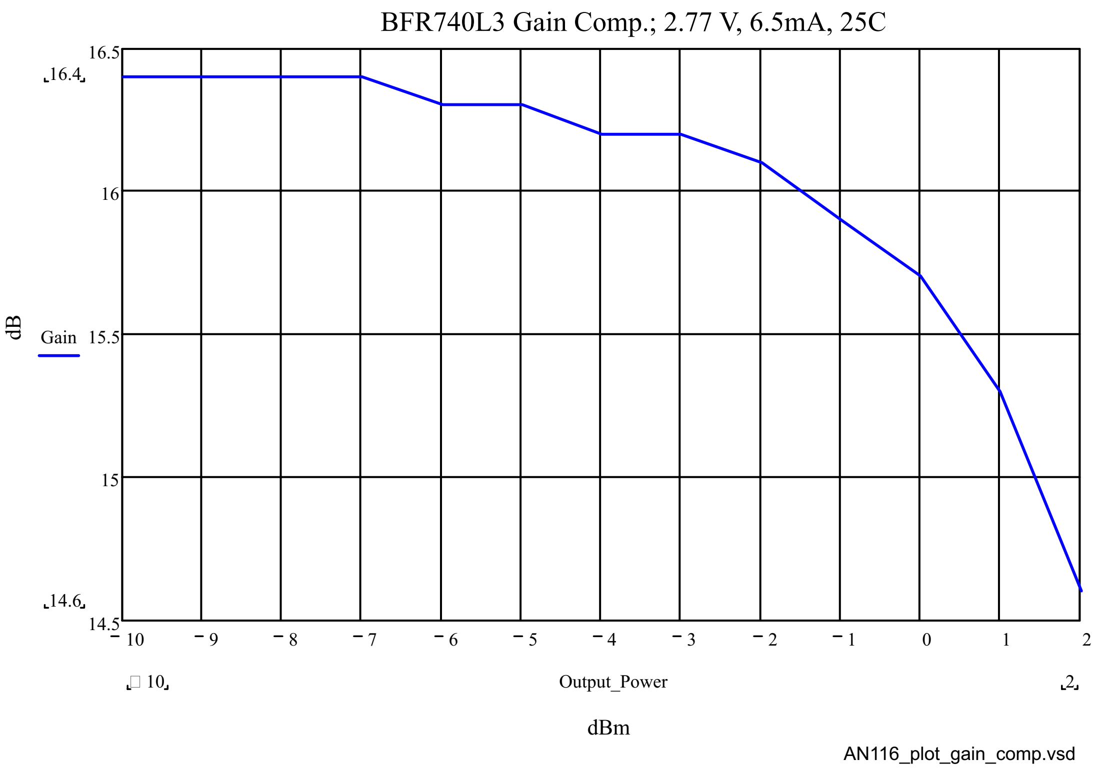


Figure 7 Gain Compression at 2140 MHz

Stability

Rohde and Schwarz ZVC Network Analyzer calculates and plots Stability Factor "K" in real time, from 5 MHz to 8 GHz.

Note K>1 from 5 MHz to 8 GHz. Amplifier is Unconditionally Stable over 5 MHz - 8 GHz frequency range

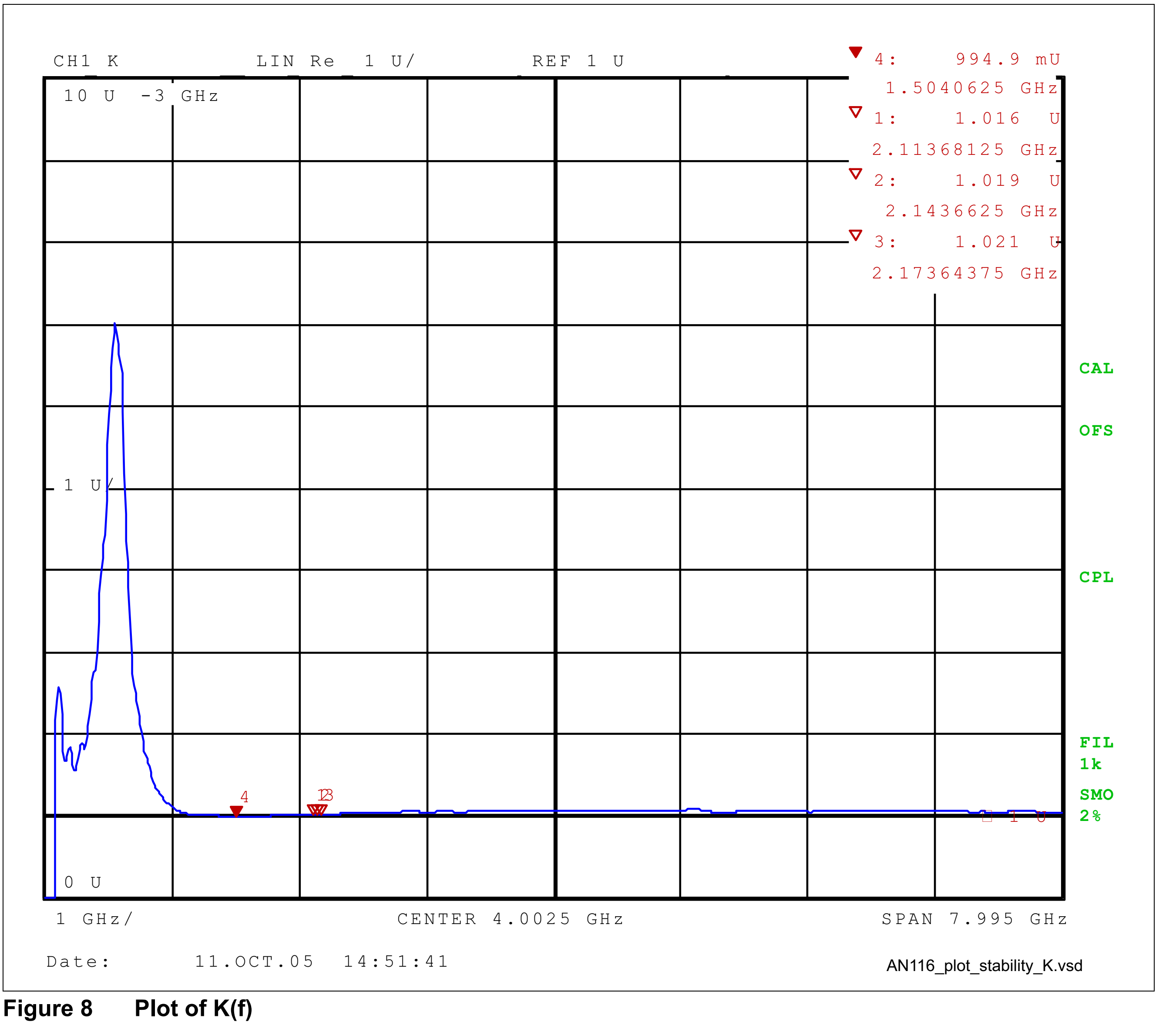


Figure 8 Plot of K(f)

Note: All plots are from Rhode and Schwarz ZVC Network Analyzer, T = 25 °C, Source Power ≅ -30 dBm, V_{CC} = 3.0 V, I = 6.5 mA

Input Return Loss, Log Mag

5 MHz to 8 GHz Sweep

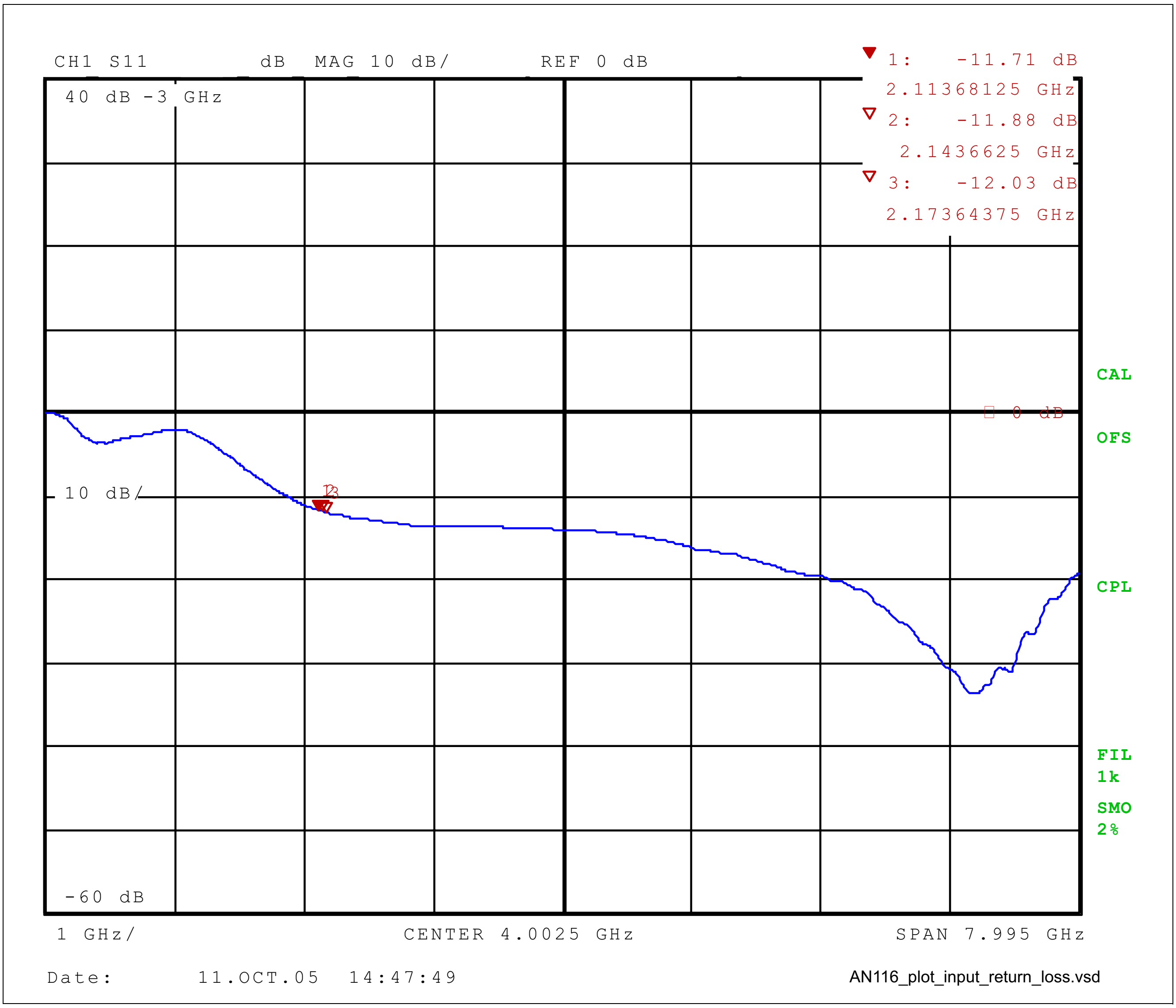


Figure 9 Plot of Input Return Loss

Input Return Loss, Smith Chart

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

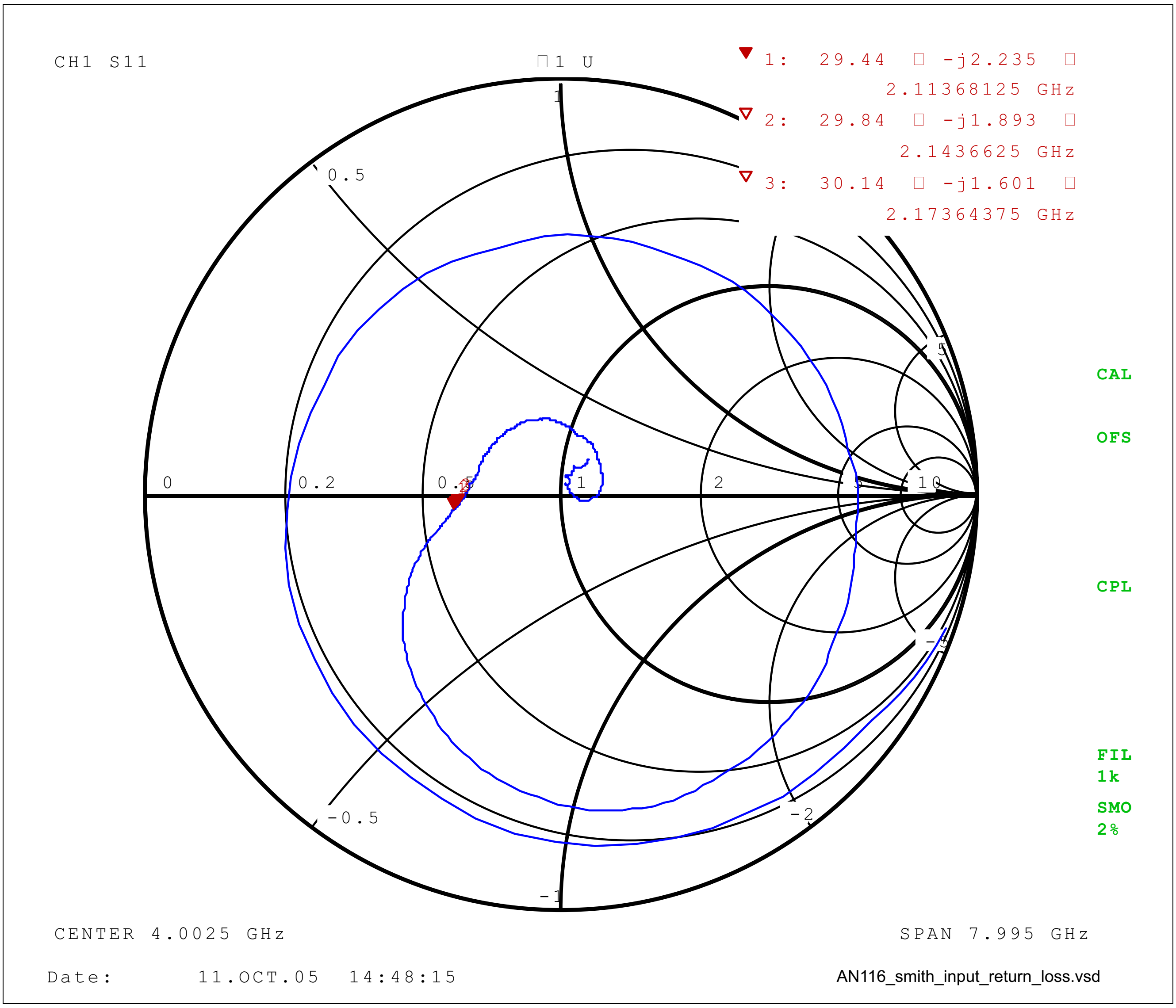


Figure 10 Smith Chart of Input Return Loss

Forward Gain

5 MHz to 8 GHz Sweep

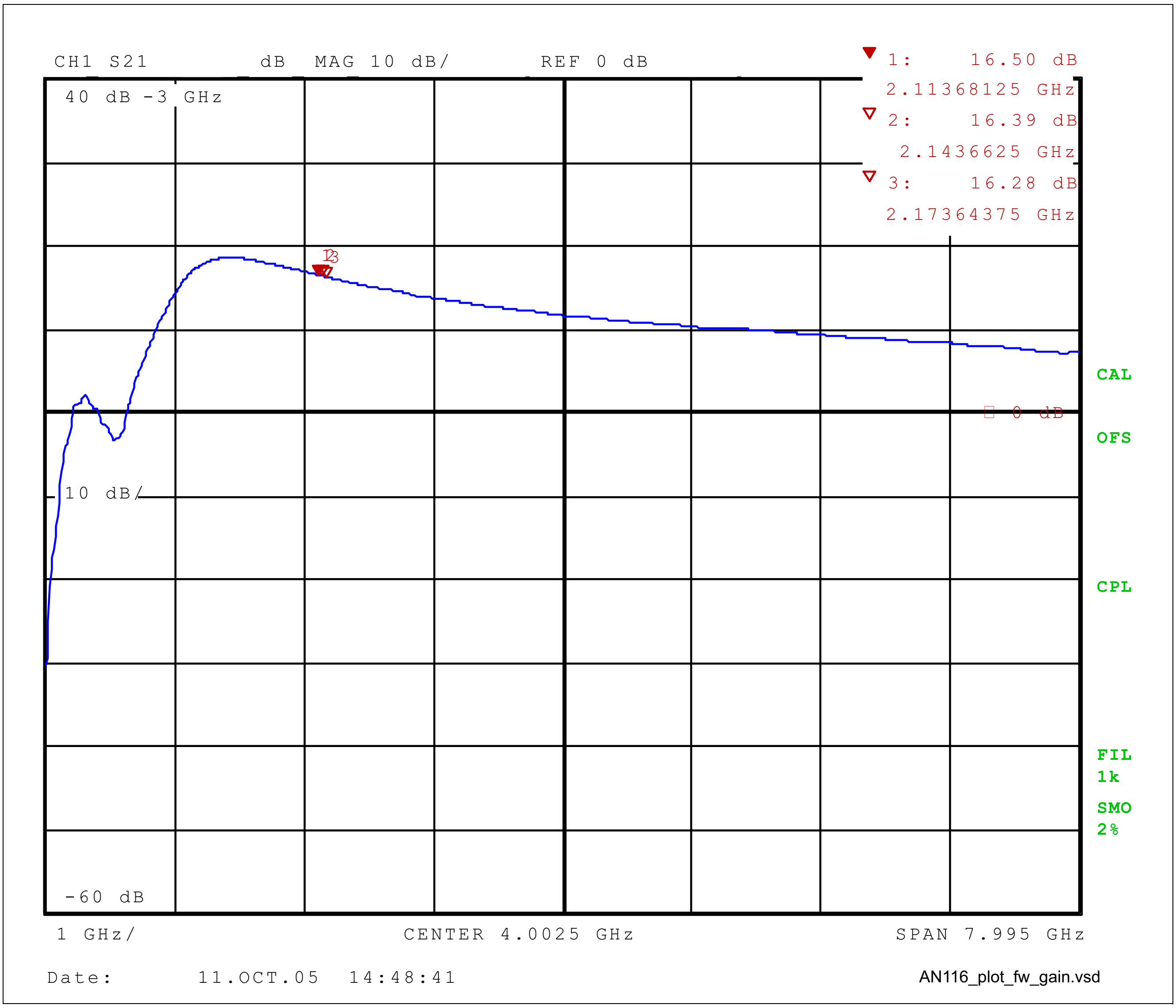


Figure 11 Plot of Forward Gain

Reverse Isolation

5 MHz to 8 GHz

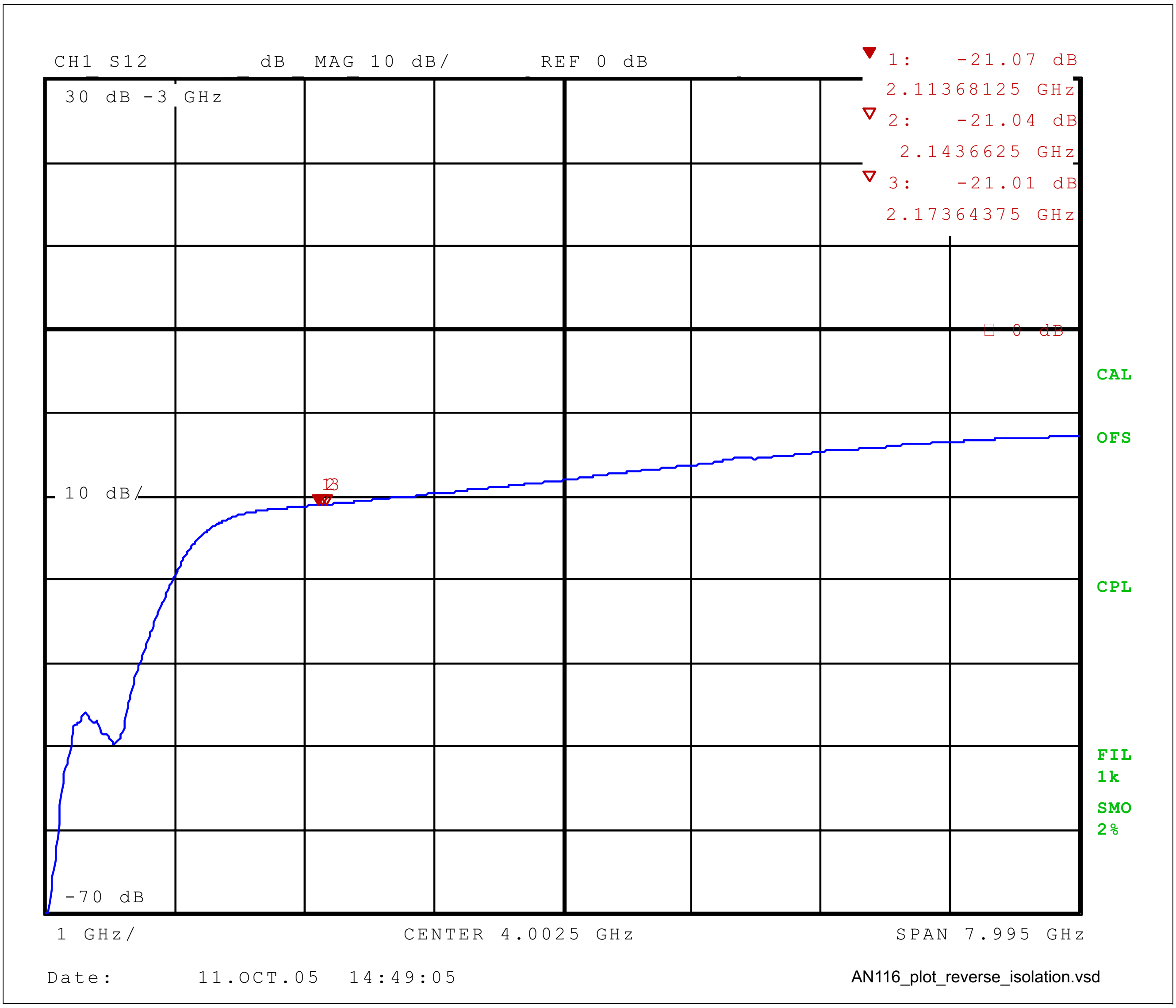


Figure 12 Plot of Reverse Isolation

Output Return Loss, Log Mag

5 MHz to 8 GHz

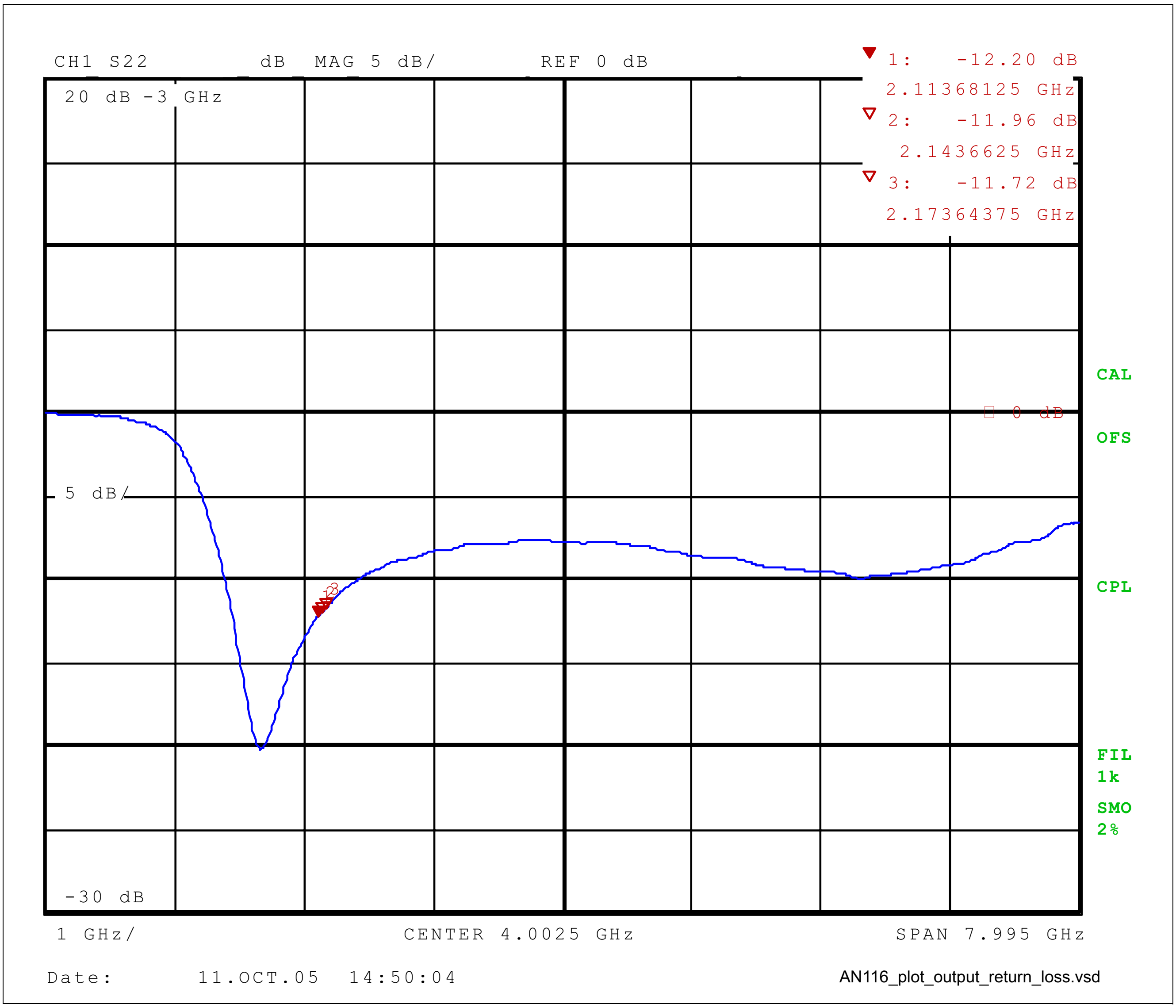


Figure 13 Plot of Output Return Loss

Output Return Loss, Smith Chart

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

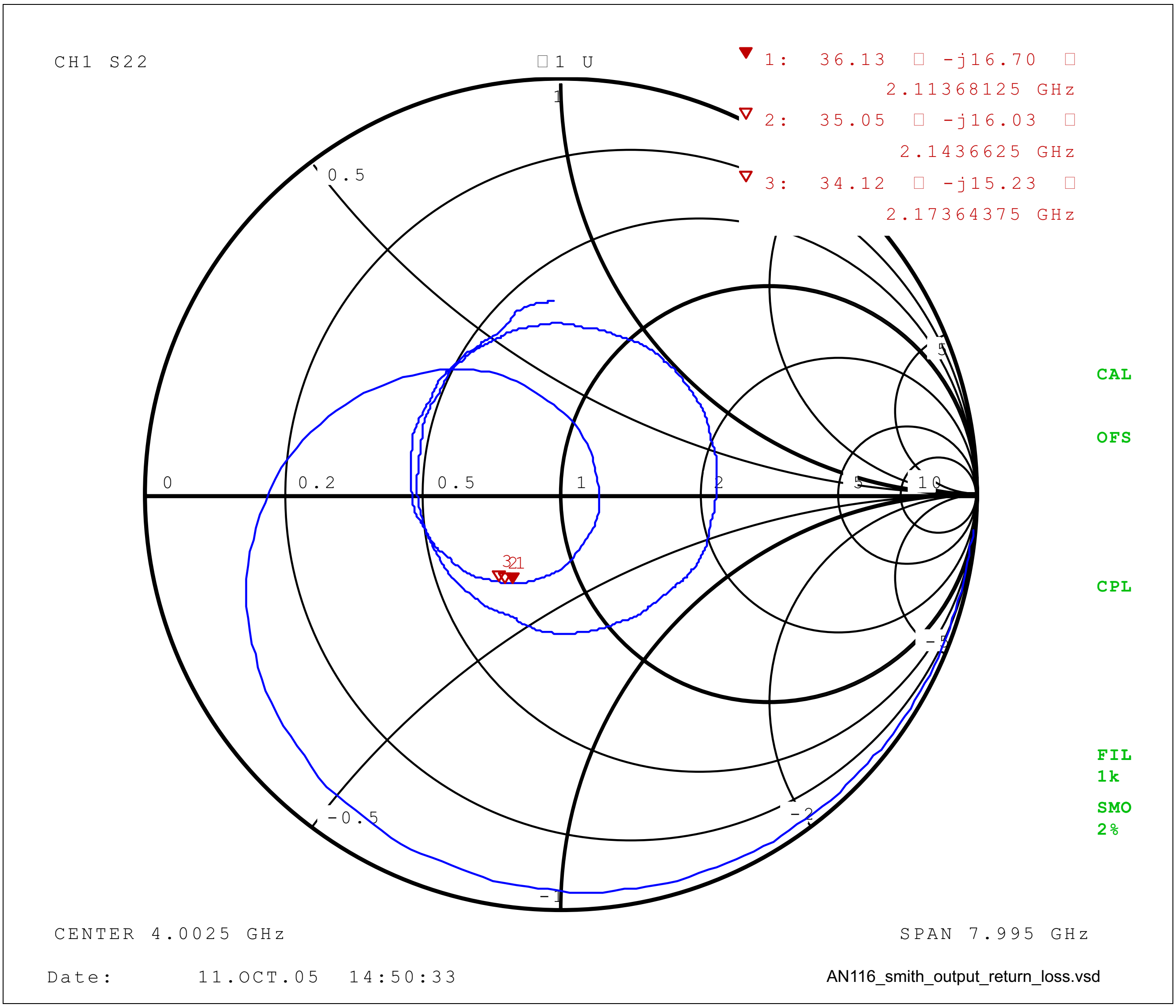


Figure 14 Smith Chart of Output Return Loss

Two-Tone Test, 2140 MHz

Input Stimulus for Amplifier Two-Tone Test
f_1 = 2140 MHz, f_2 = 2141 MHz, -25 dBm each tone
Input IP_3 = -25 + (59.3 / 2) = +4.7 dBm
Output IP_3 = +4.7 dBm + 16.4 dB gain = +21.1 dBm

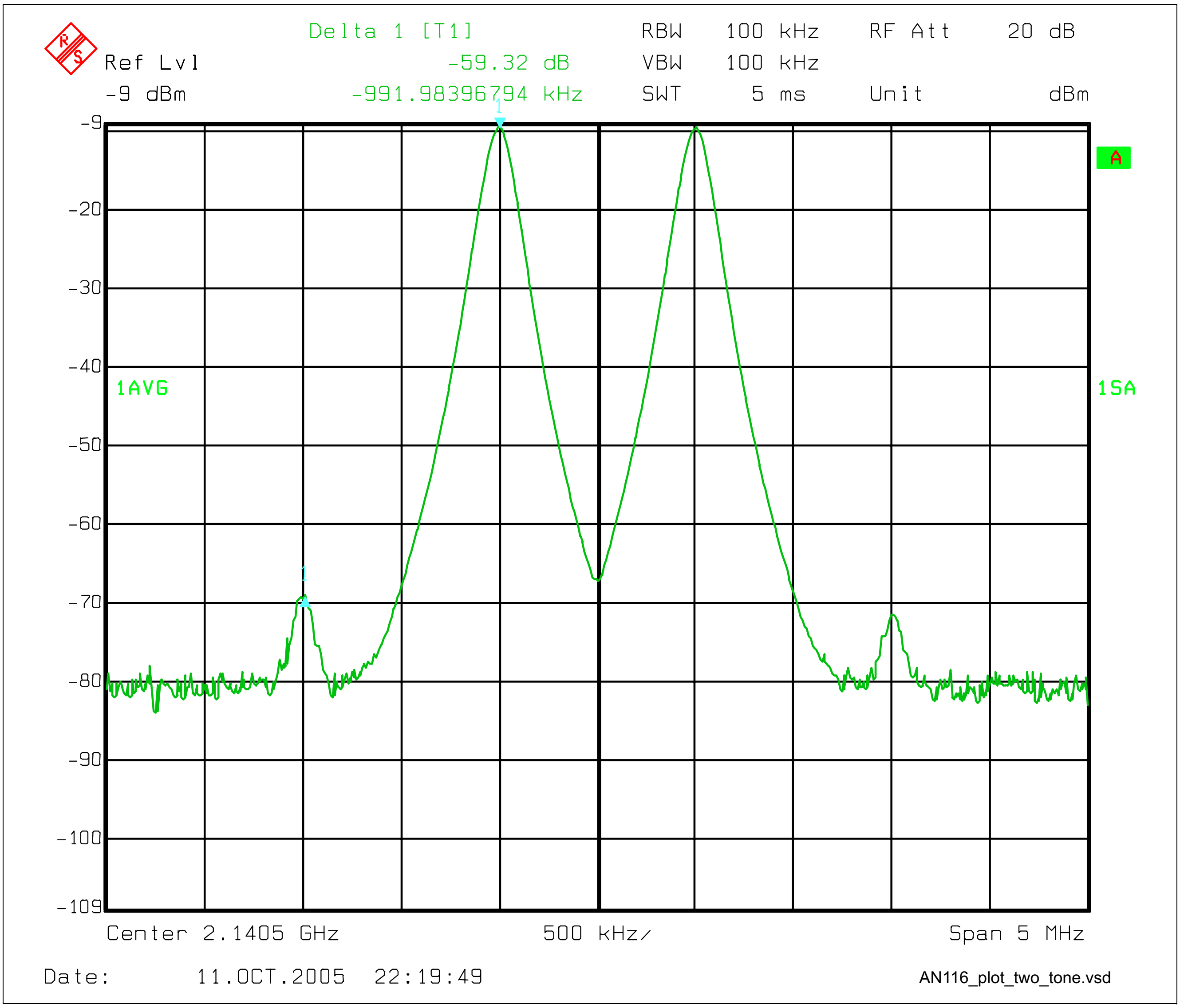


Figure 15 Tow-Tone Test