Application Note No. 148

BFP405F RF Transistor as Low Cost, Low Current (2.5 mA) 3 to4 GHz UWB Tx Amplifier with 2.2 - 3.6 V Operation

RF & Protection Devices

Never stop thinking

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Application Note No. 148

Revision History: 2008-02-21, Rev. 1.2

Previous Version: 2005-8-07, Rev. 1.1

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

1 BFP405F RF Transistor as Low Cost, Low Current (2.5 mA) 3 to4 GHz UWB Tx Amplifier with 2.2 - 3.6 V Operation

Applications

- Ultra Wideband (UWB) applications in the 3 to 4 GHz frequency range.

Overview

The Infineon BFP405F SIEGET RF Transistor in TSFP-4 package is shown in a low-cost transmit amplifier circuit suitable for 3 to 4 GHz Ultra Wideband (UWB) applications. Current draw is X mA @ 2.2 V, 2 mA @ 2.9 V, and Y mA @ 3.6 V.

Target Specifications

Frequency 3 to 4 GHz, Gain > 6 dB min., OP_{1dB} = -1 dBm min., 2.2 V < V_{CC} < 3.6 V (2.9 V middle value).

Summary of Results

Table 1 Summary of Results, 2.2 V, 1.6 mA, T = 25 °C

Frequency MHz	dB [s11]²	dB [s21]²	dB [s12]²	dB [s22]²	NF^* dB	IIP_3 dBm	OIP_3 dBm	IP_{1dB} dBm	OP_{1dB} dBm
3000	6.6	13.8	18.9	8.3	---	---	---	---	---
3500	9.6	11.9	19.2	6.4	---	---	---	-19.7	-8.8
4000	7.3	10.6	19.1	10.1	---	---	---	---	---

Table 2 Summary of Results, 2.9 V, 2.5 mA, T = 25 °C

Frequency MHz	dB [s11]²	dB [s21]²	dB [s12]²	dB [s22]²	NF^* dB	IIP_3 dBm	OIP_3 dBm	IP_{1dB} dBm	OP_{1dB} dBm
3000	10.2	15.1	20.5	9.9	2.3	---	---	---	---
3500	12.0	13.1	20.7	7.3	1.9	---	---	-17.1	-5.0
4000	8.4	11.7	20.3	11.1	2.0	---	---	---	---

Table 3 Summary of Results, 3.6 V, 3.3 mA, T = 25 °C

Frequency MHz	dB [s11]²	dB [s21]²	dB [s12]²	dB [s22]²	NF^* dB	IIP_3 dBm	OIP_3 dBm	IP_{1dB} dBm	OP_{1dB} dBm
3000	13.3	15.6	21.6	10.7	---	---	---	---	---
3500	13.1	13.5	21.6	7.6	---	---	---	-4.5	+9.1
4000	8.8	12.2	21.0	11.4	---	---	---	---	---

* Note that 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

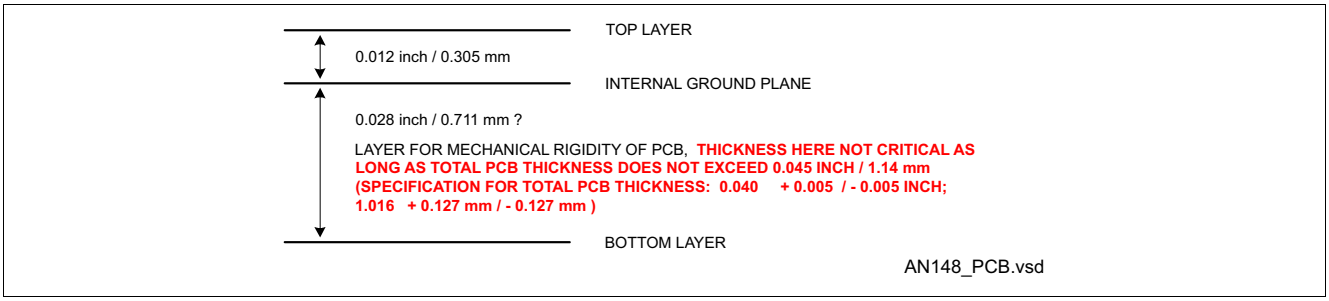


Figure 1 PCB - Cross Sectional Diagram

Schematic Diagram

Note “0402” case size passives are used.

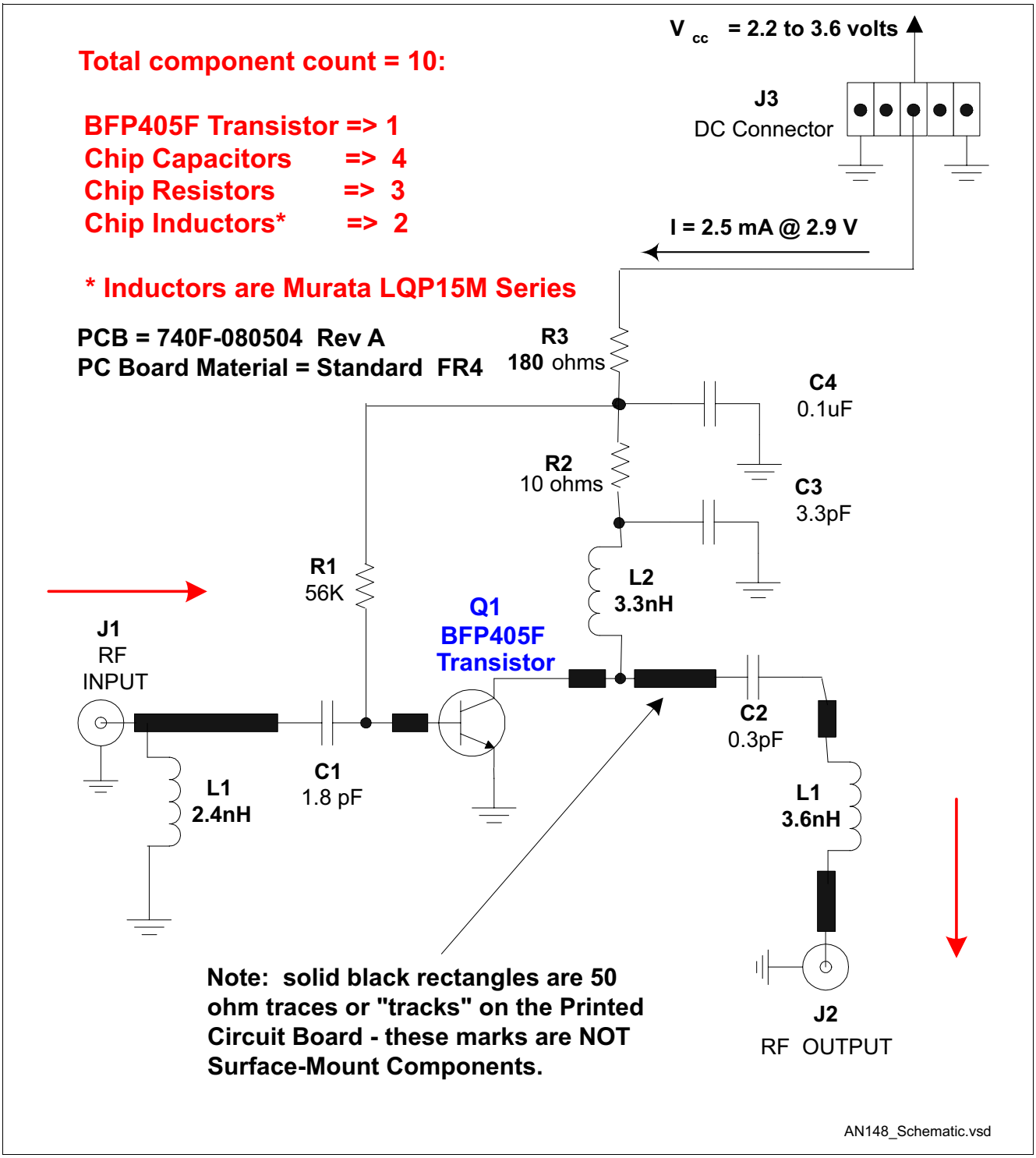


Figure 2 Schematic Diagram

Details on TSFP-4 Package (Thin Small Flat Pack)

Dimensions in Millimeters (mm).

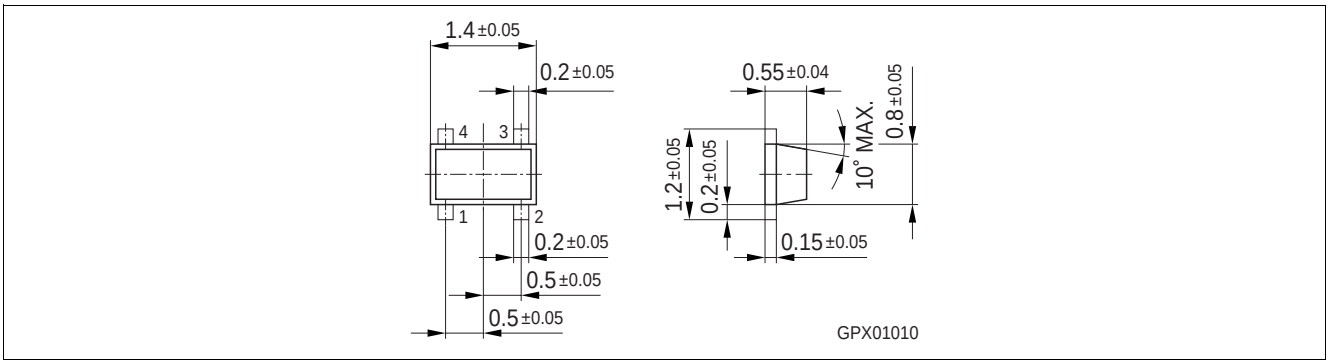


Figure 3 Package Details of TSFP-4

Recommended Soldering Footprint for TSFP-4 (dimensions in millimeters).

Device package is to be oriented as shown in above drawing (e.g. orient long package dimension horizontally on this footprint).

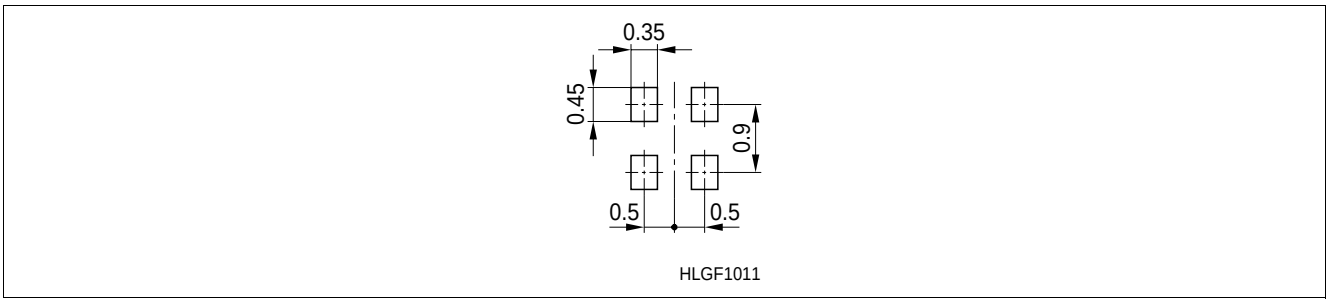


Figure 4 Package Footprint of TSFP-4

Noise Figure, Plot, 2.5 to 4.5 GHz. Center of Plot (x-axis) is 3.5 GHz.

Rohde & Schwarz FSEK3

08 Aug 2005

Noise Figure

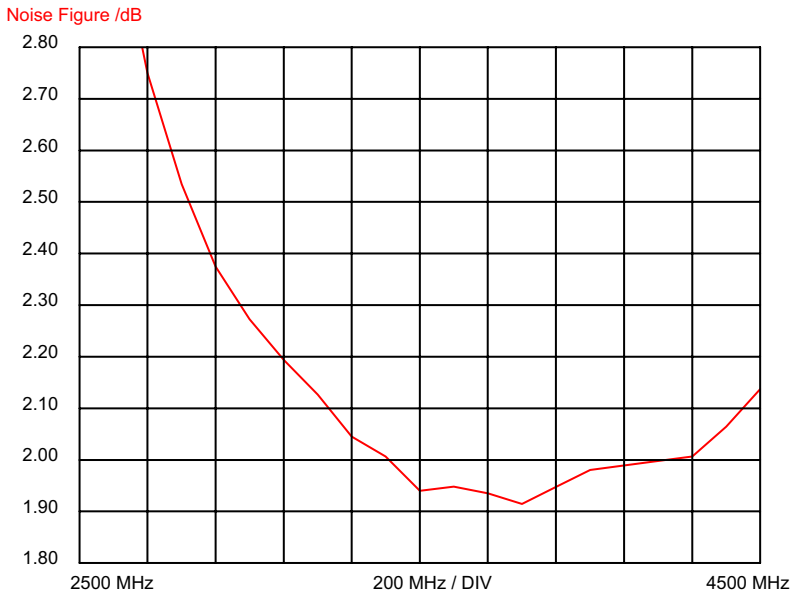
EUT Name:	BFP405F UWB Tx Amplifier, 3 to 4 GHz
Manufacturer:	Infineon Technologies AG
Operating Conditions:	V=2.9V, I=2.5mA, T = 25 C
Operator Name:	Gerard Wevers
Test Specification:	LWR SD00084 LNA P
Comment:	On PCB 740F-080504 Rev A 8 August 2005

Analyzer

RF Att:	0.00 dB	RBW :	1 MHz	Range:	40.00 dB
Ref Lvl:	-41.00 dBm	VBW :	100 Hz	Ref Lvl auto:	ON

Measurement

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



AN148_plot_nf.vsd

Figure 5 Noise Figure

Noise Figure, Tabular Data

From Rohde & Schwarz FSEK3 + FSEM30 + System Preamplifier
System Preamplifier = MITEQ SMC-02

Table 4 Noise Figure

Frequency	Noise Figure
2500 MHz	3.49 dB
2600 MHz	3.07 dB
2700 MHz	2.75 dB
2800 MHz	2.53 dB
2900 MHz	2.37 dB
3000 MHz	2.27 dB
3100 MHz	2.19 dB
3200 MHz	2.13 dB
3300 MHz	2.04 dB
3400 MHz	2.01 dB
3500 MHz	1.94 dB
3600 MHz	1.95 dB
3700 MHz	1.94 dB
3800 MHz	1.91 dB
3900 MHz	1.95 dB
4000 MHz	1.98 dB
4100 MHz	1.99 dB
4200 MHz	2.00 dB
4300 MHz	2.01 dB
4400 MHz	2.06 dB
4500 MHz	2.14 dB

Scanned Image of PC Board

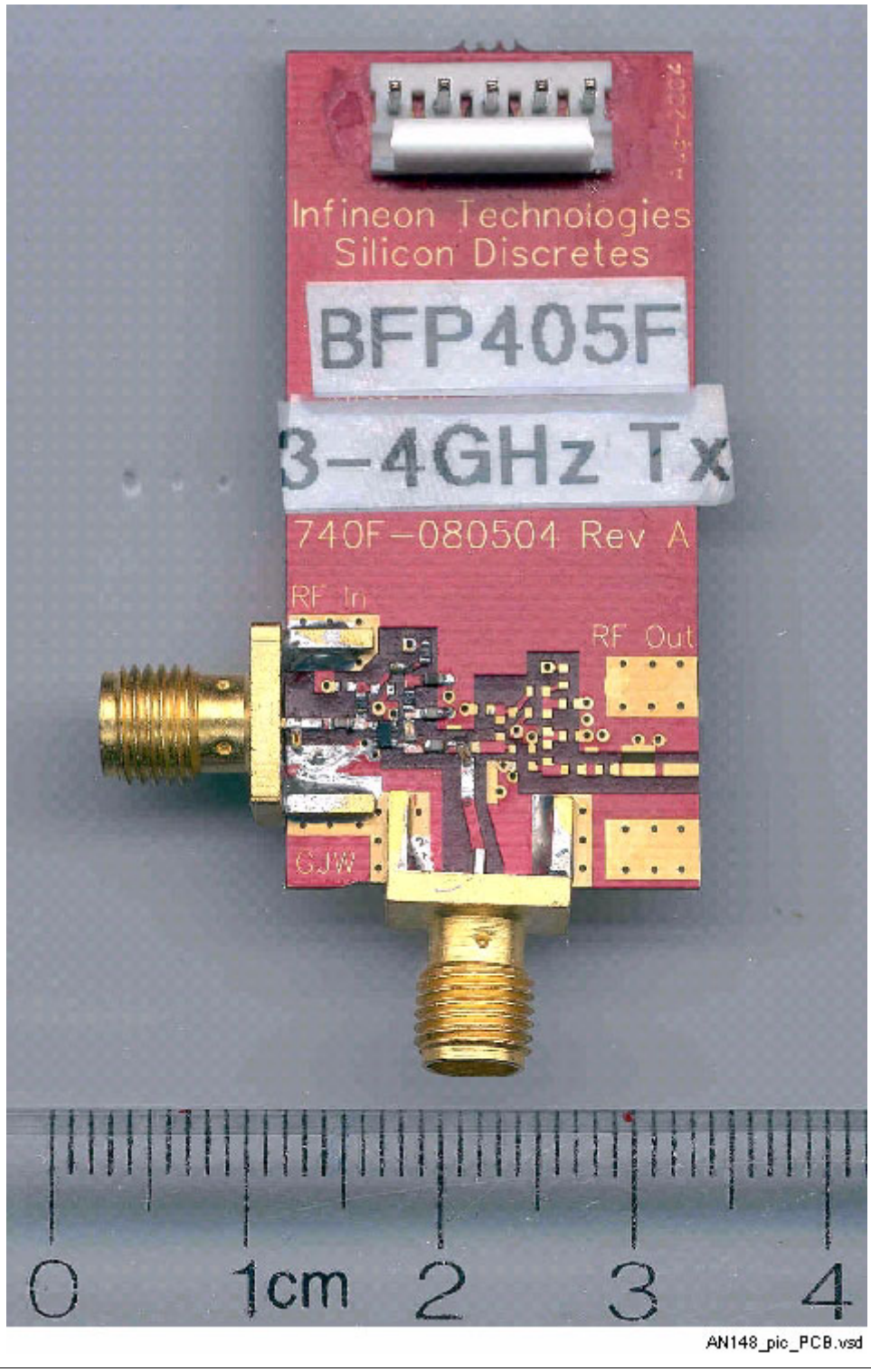


Figure 6 Image of PC Board

Scanned Image of PC Board, Close-In Shot.

Total PCB area used ≅ 45 mm². PCB Area may be reduced.

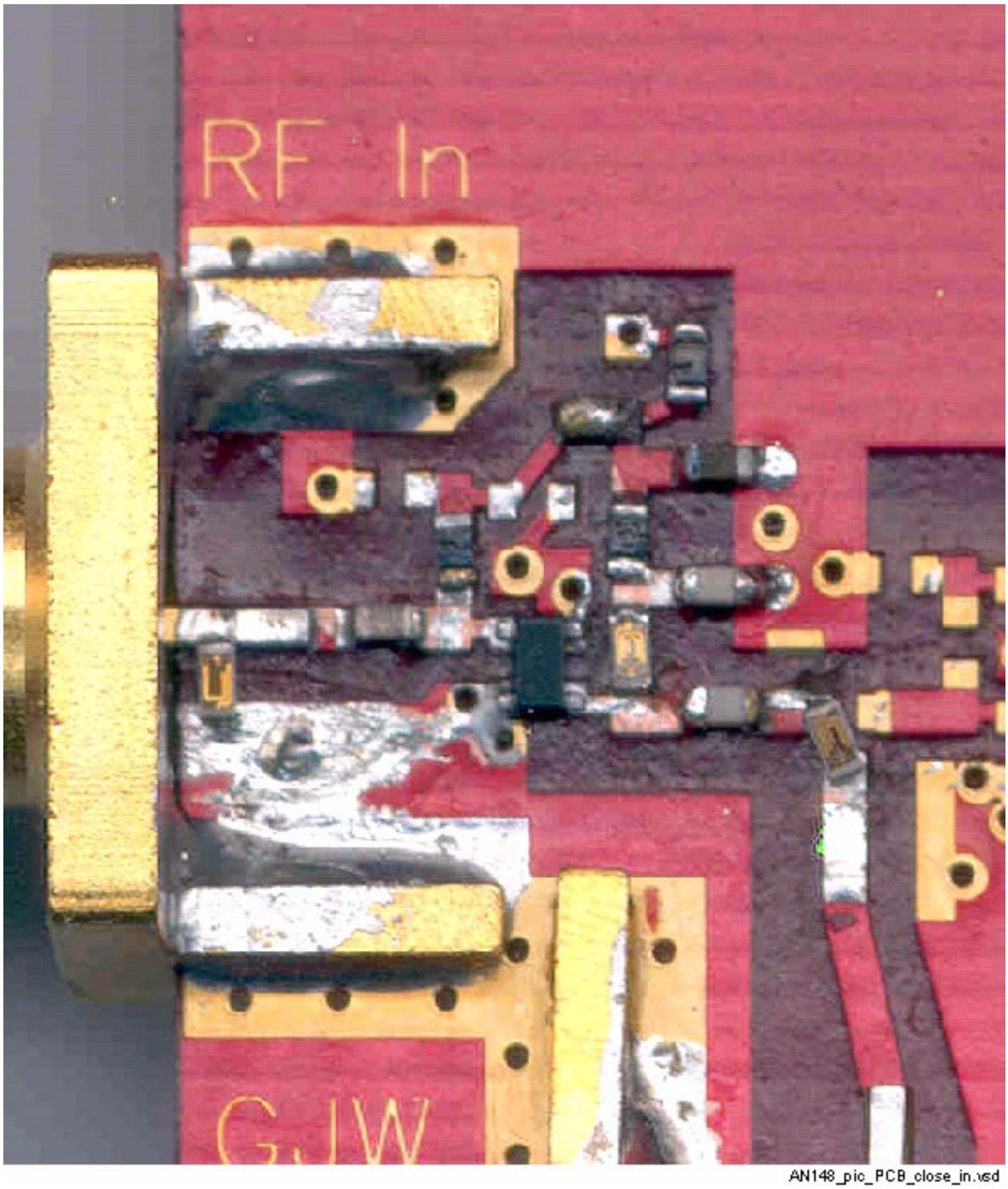


Figure 7 Image of PC Board, Close-In Shot

Gain Compression at 3.5 GHz, 2.2 Volts, 1.6 mA

Amplifier is checked for 1 dB compression point at V_{CC} = 2.2 V, I_C = 1.6 mA (with V_{CE} = 1.9 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} ≅ -8.8 dBm; Input P_{1dB} ≅ -8.8 dBm - (Gain - 1 dB) = -8.8 dBm - 10.9 dB = - 19.7 dBm

Table 5 Gain Compression at 3.5 GHz, 2.2 V, 1.6 mA

P_{OUT}, dBm	Gain, dB
-15.0	11.9
-14.0	11.9
-13.0	11.8
-12.0	11.7
-11.0	11.5
-10.0	11.3
-9.0	11.0
-8.0	10.5
-7.0	9.8
-6.0	8.3
-5.0	6.0
-4.0	3.4

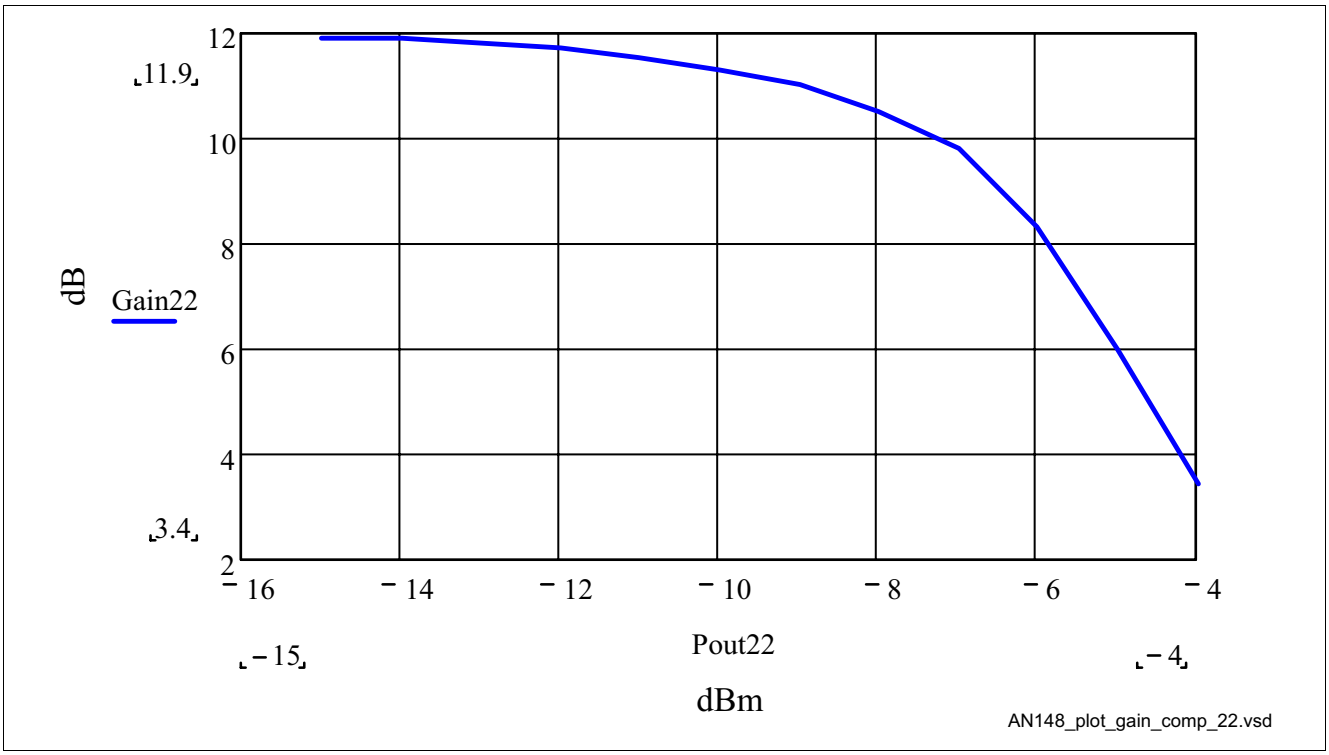


Figure 8 Plot of Gain Compression, 2.2 V, 1.6 mA, T = 25 °C

Gain Compression at 3.5 GHz, 2.9 V, 2.5 mA

Amplifier is checked for 1 dB compression point at V_{CC} = 2.9 V, I_C = 2.5 mA (with V_{CE} = 2.4 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} ≅ -5.0 dBm; Input P_{1dB} ≅ -5.0 dBm - (Gain - 1 dB) = -5.0 dBm - 12.1 dB = -17.1 dBm

Table 6 Gain Compression at 3.5 GHz, 2.9 V, 2.5 mA

P_{OUT}, dBm	Gain, dB
-15.0	13.1
-14.0	13.1
-13.0	13.1
-12.0	13.0
-11.0	13.0
-10.0	12.9
-9.0	12.8
-8.0	12.8
-7.0	12.6
-6.0	12.4
-5.0	12.1
-4.0	11.5
-3.0	10.3
-2.0	8.0

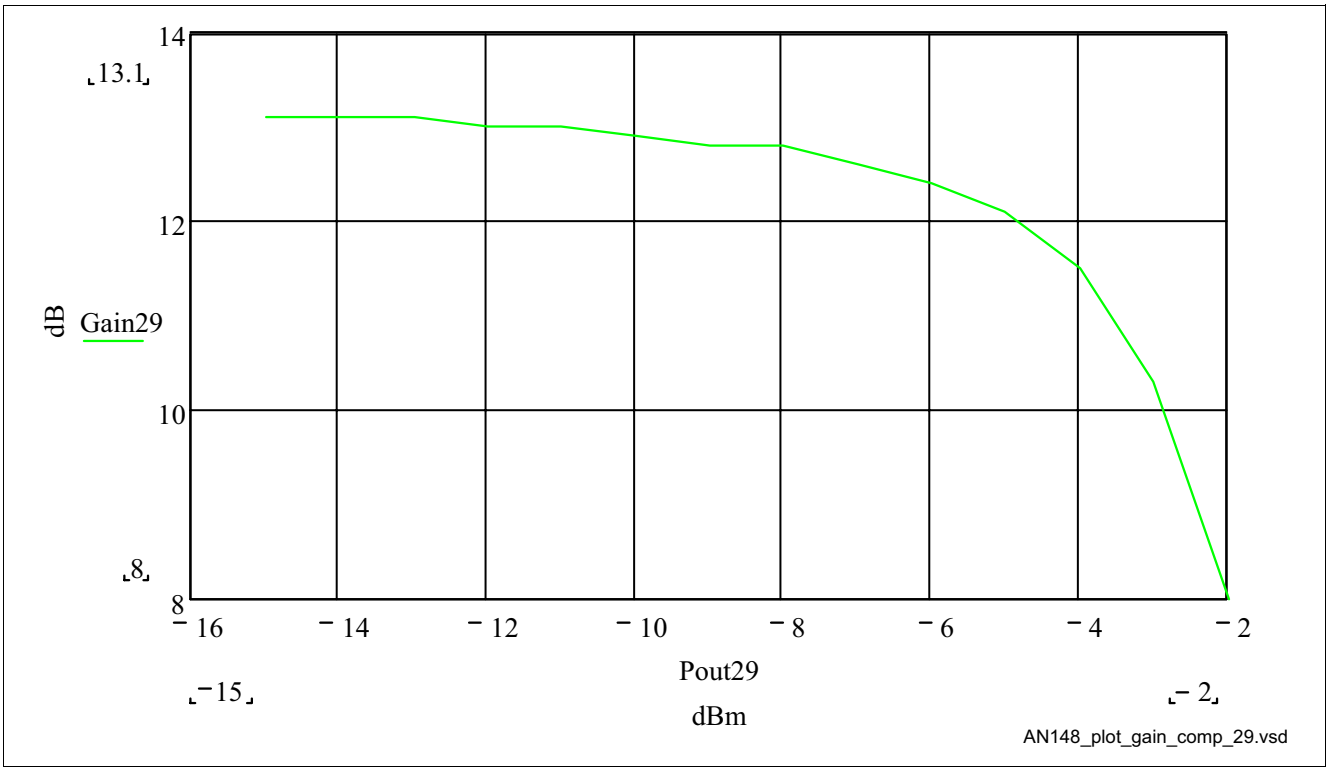


Figure 9 Plot of Gain Compression, 2.9 V, 2.5 mA, T = 25 °C

Gain Compression at 3.5 GHz, 3.6 V, 3.3 mA

Amplifier is checked for 1 dB compression point at V_{CC} = 3.6 V, I_C = 3.3 mA (with V_{CE} = 3.0 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} ≅ -.2 dBm; Input P_{1dB} ≅ -2.2 dBm -(Gain - 1 dB) = -2.2 dBm - 12.1 dB = -15.7 dBm

Table 7 Gain Compression at 3.5 GHz, 3.6 V, 3.3 mA

P_{OUT}, dBm	Gain, dB
-15.0	13.5
-14.0	13.5
-13.0	13.5
-12.0	13.5
-11.0	13.4
-10.0	13.4
-9.0	13.4
-8.0	13.3
-7.0	13.3
-6.0	13.2
-5.0	13.2
-4.0	13.0
-3.0	12.8
-2.0	12.4

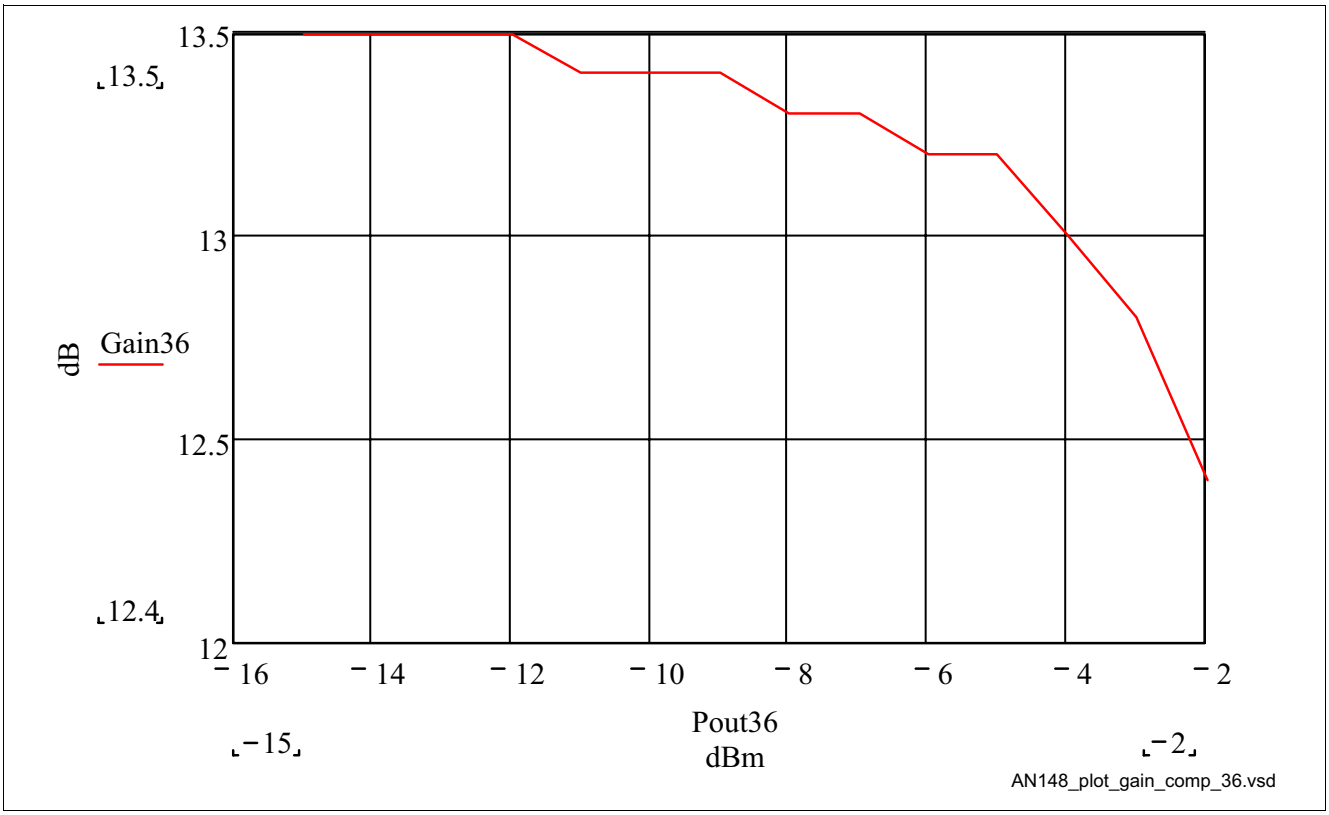


Figure 10 Plot of Gain Compression, 3.6 V, 3.3 mA, T = 25 °C

Stability, V_{CC} = 2.2 V, I = 1.6 mA

Rohde and Schwarz ZVC Network Analyzer calculates and plots Stabilty Factor "K" in real time, from 5 MHz to 8 GHz. Note K < 1 below 1.7 GHz and also dips slightly < 1 in 2.5 - 3.7 GHz range.

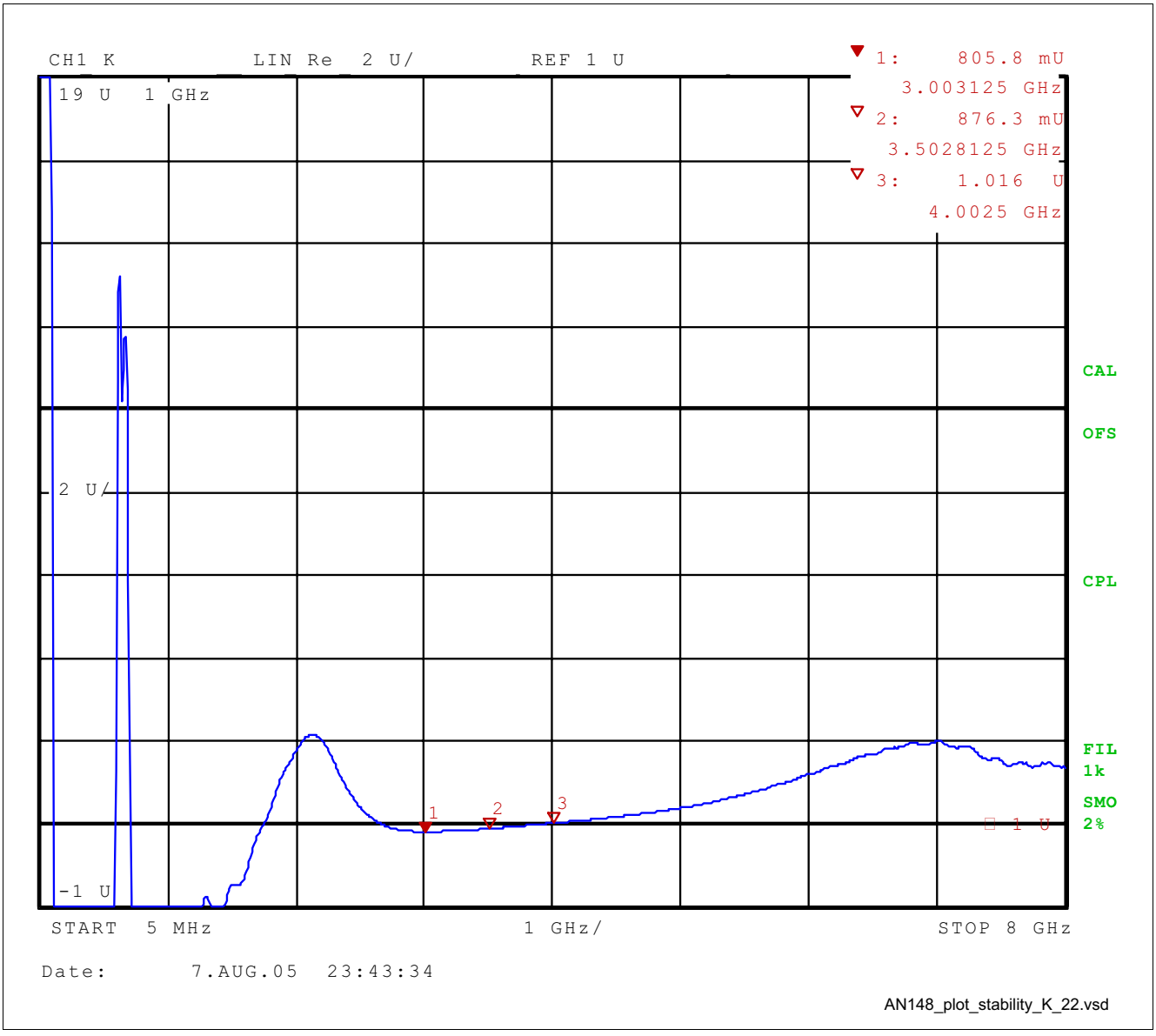


Figure 11 Plot of K(f), 2.2 V, 1.6 mA

Stability, V_{CC} = 2.9 V, I = 2.5 mA

Rohde and Schwarz ZVC Network Analyzer calculates and plots Stabilty Factor "K" in real time, from 5 MHz to 8 GHz. Note K < 1 below 1.7 GHz.

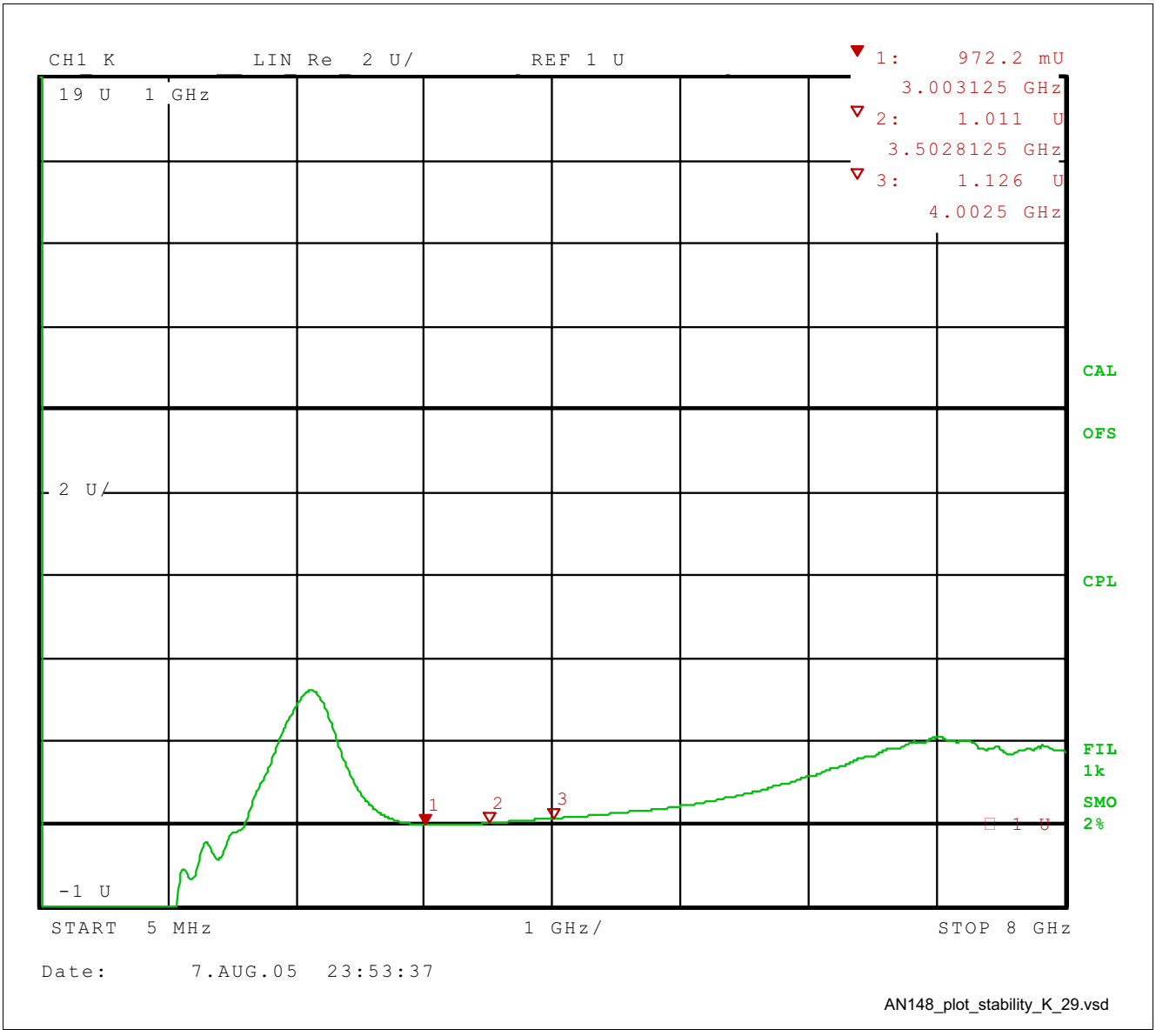


Figure 12 Plot of K(f), 2.9 V, 2.5 mA

Stability, V_{CC} = 3.6 V, I = 3.3 mA

Rohde and Schwarz ZVC Network Analyzer calculates and plots Stabilty Factor "K" in real time, from 5 MHz to 8 GHz. Note K < 1 below 1.5 GHz.

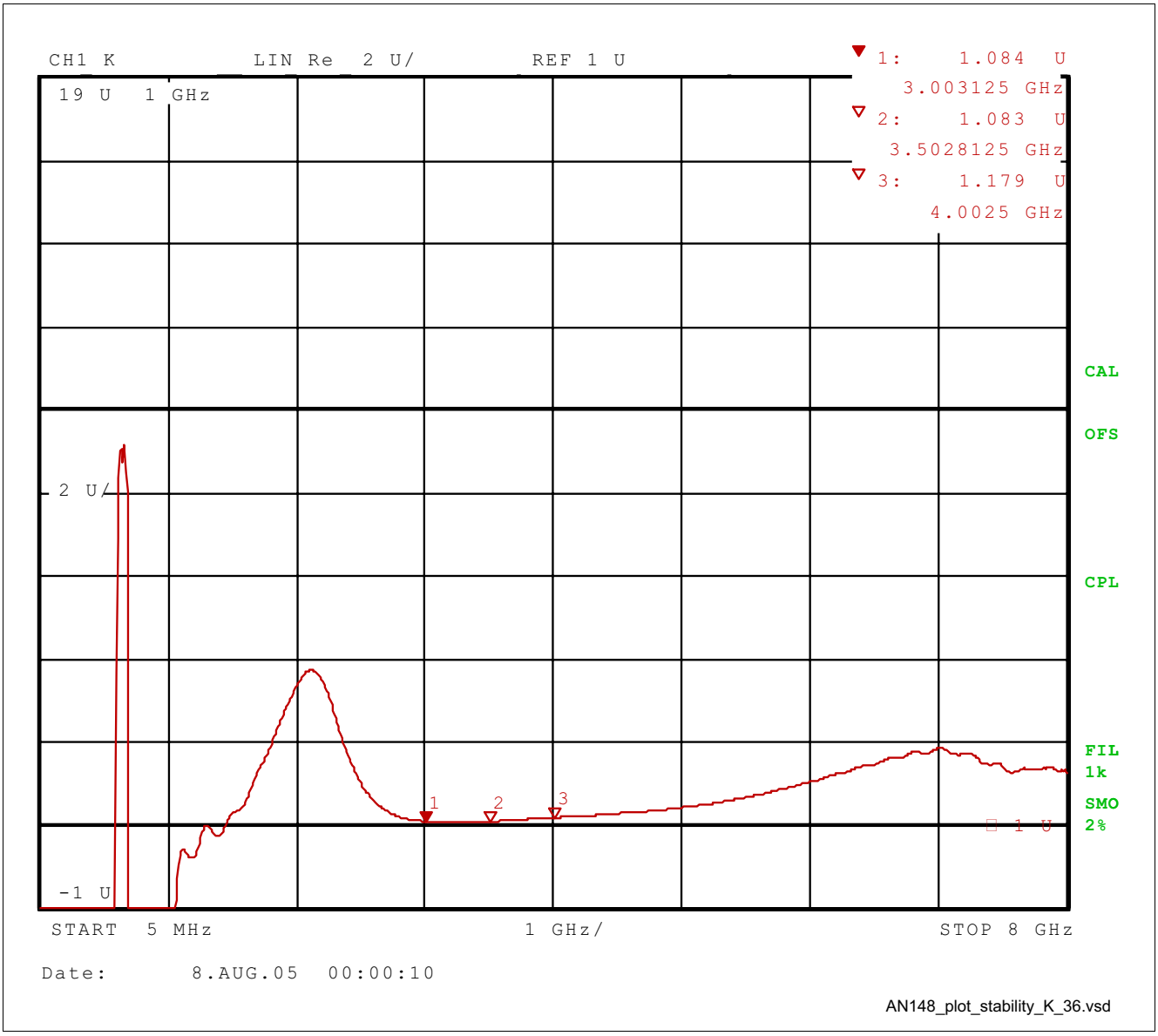


Figure 13 Plot of K(f), 3.6 V, 3.3 mA

Please Note - all plots are taken from Rohde and Schwarz ZVC Network Analyzer
T = 25 °C, source power ≈ -30 dBm.

Input Return Loss, Log Mag

5 MHz - 8 GHz Sweep

V_{CC} = 2.2 V, I = 1.6 mA

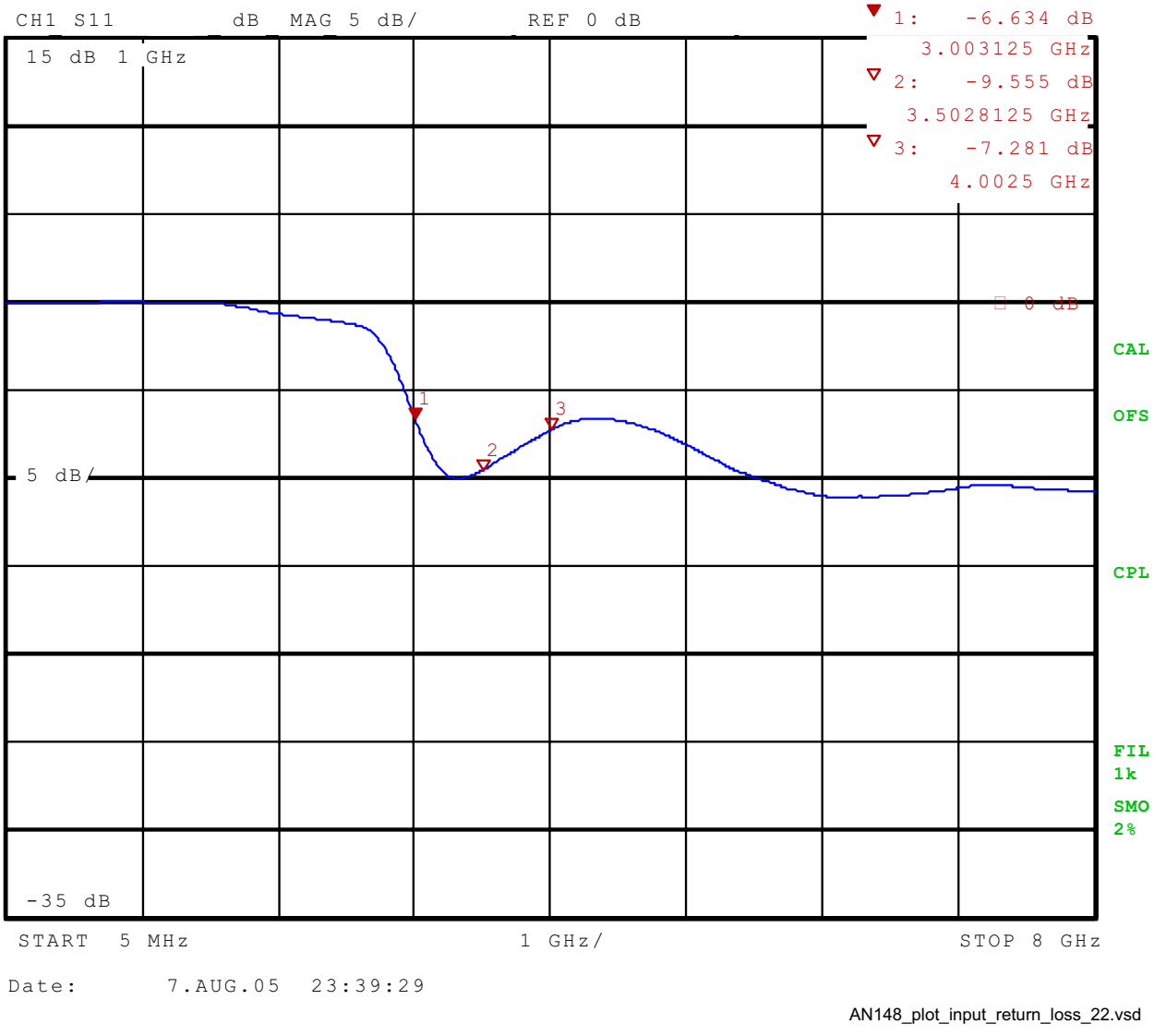


Figure 14 Plot of Input Return Loss, 2.2 V, 1.6 mA

Input Return Loss, Smith Chart

Reference Plane = Input SMA Connector on PC Board
5 MHz - 8 GHz Sweep
V_{CC} = 2.2 V, I = 1.6 mA

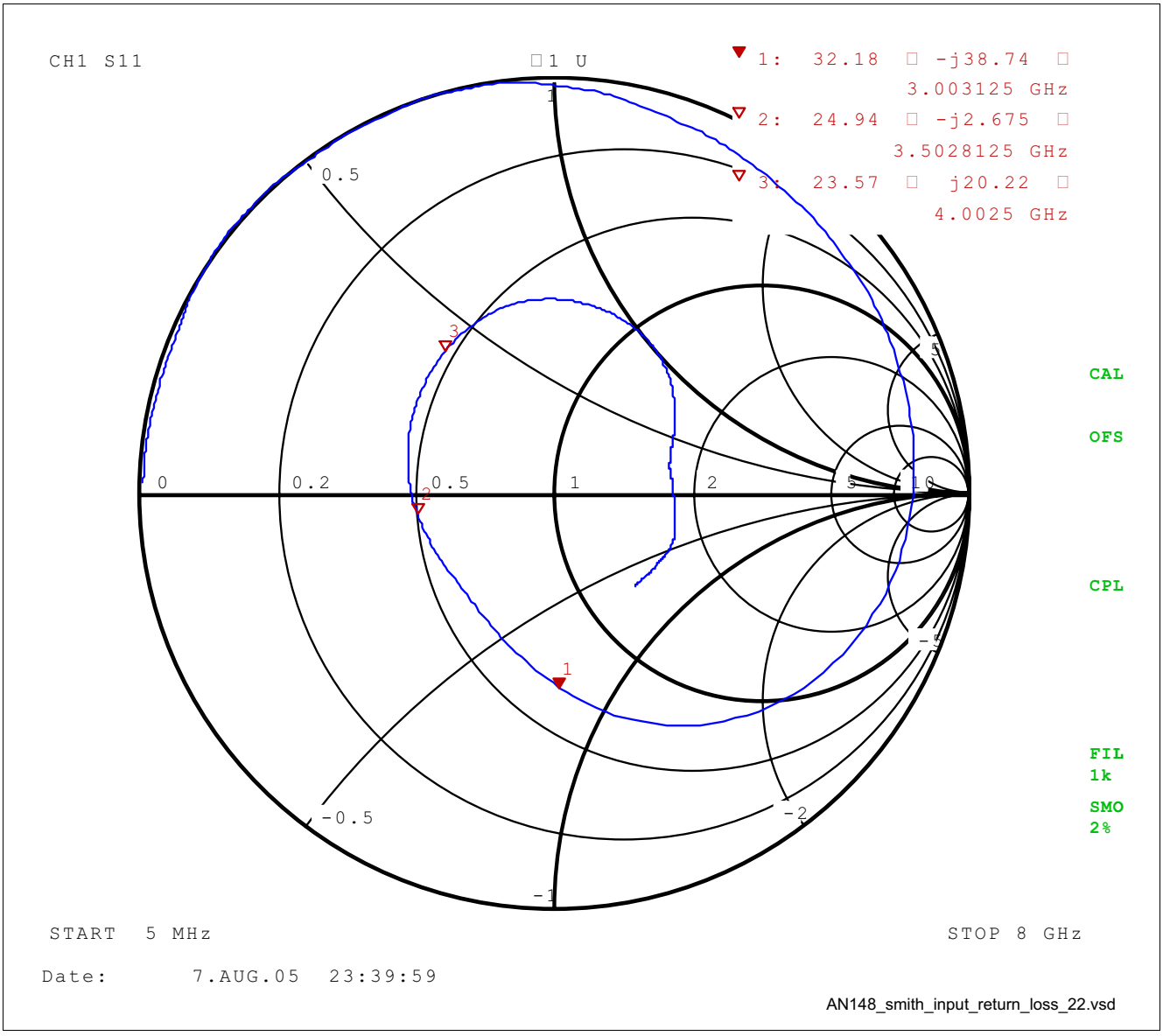


Figure 15 Smith Chart of Input Return Loss, 2.2 V, 1.6 mA

Forward Gain

5 MHz - 8 GHz Sweep

V_{CC} = 2.2 V, I = 1.6 mA

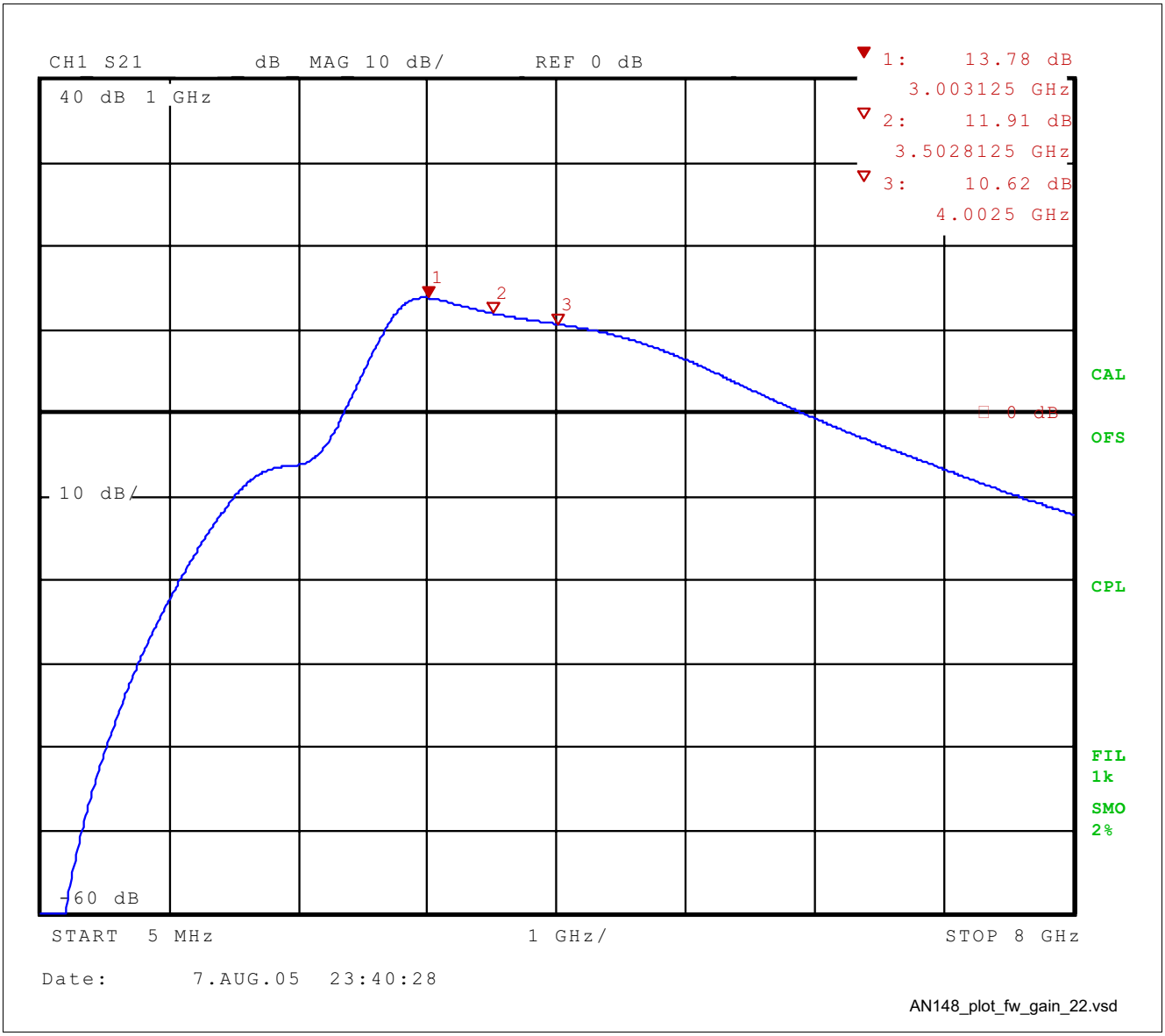


Figure 16 Plot of Forward Gain, 2.2 V, 1.6 mA

Reverse Isolation

5 MHz - 8 GHz

V_{CC} = 2.2 V, I = 1.6 mA

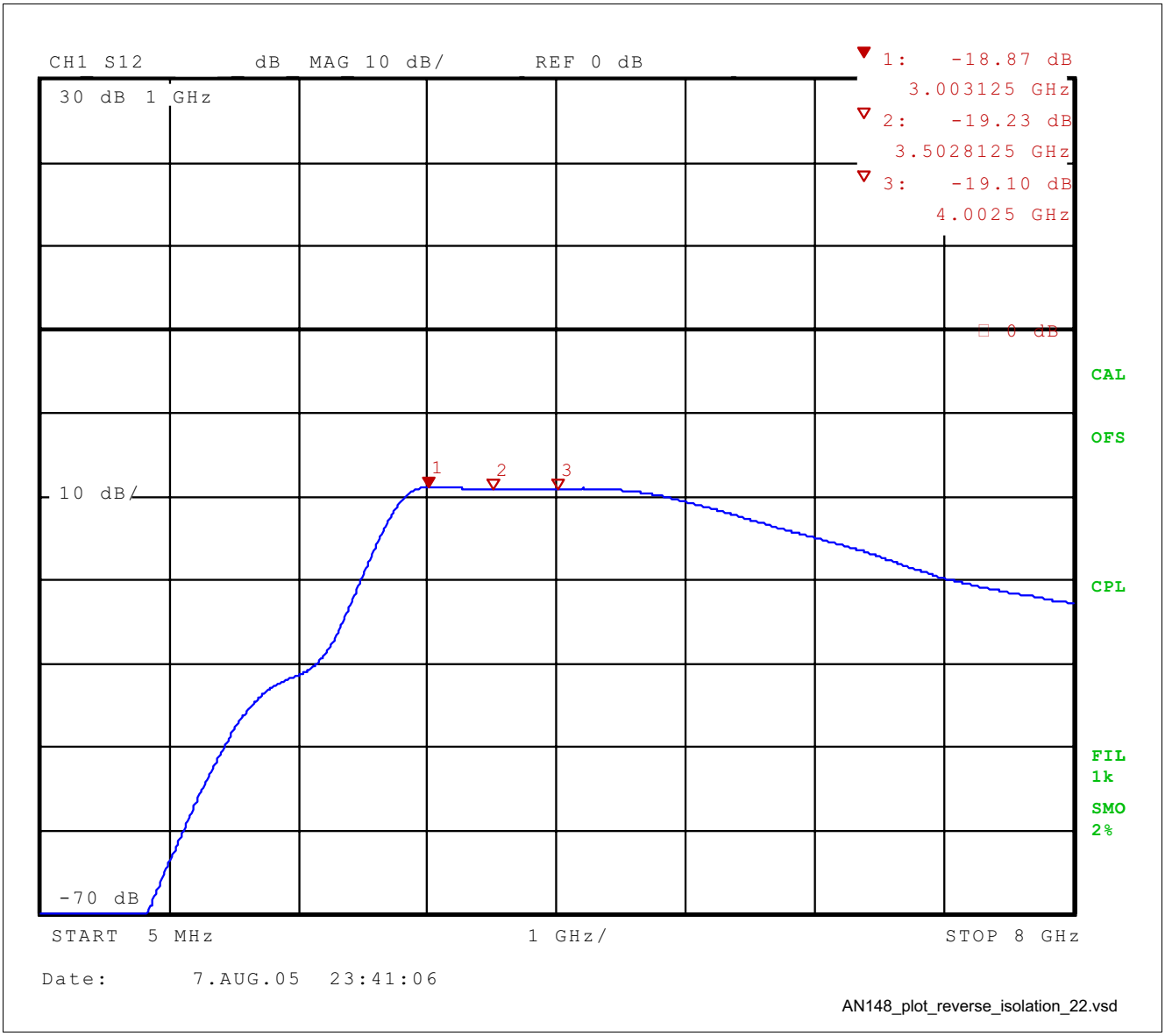


Figure 17 Plot of Reverse Isolation, 2.2 V, 1.6 mA

Output Return Loss, Log Mag

5 MHz - 8 GHz

V_{CC} = 2.2 V, I = 1.6 mA

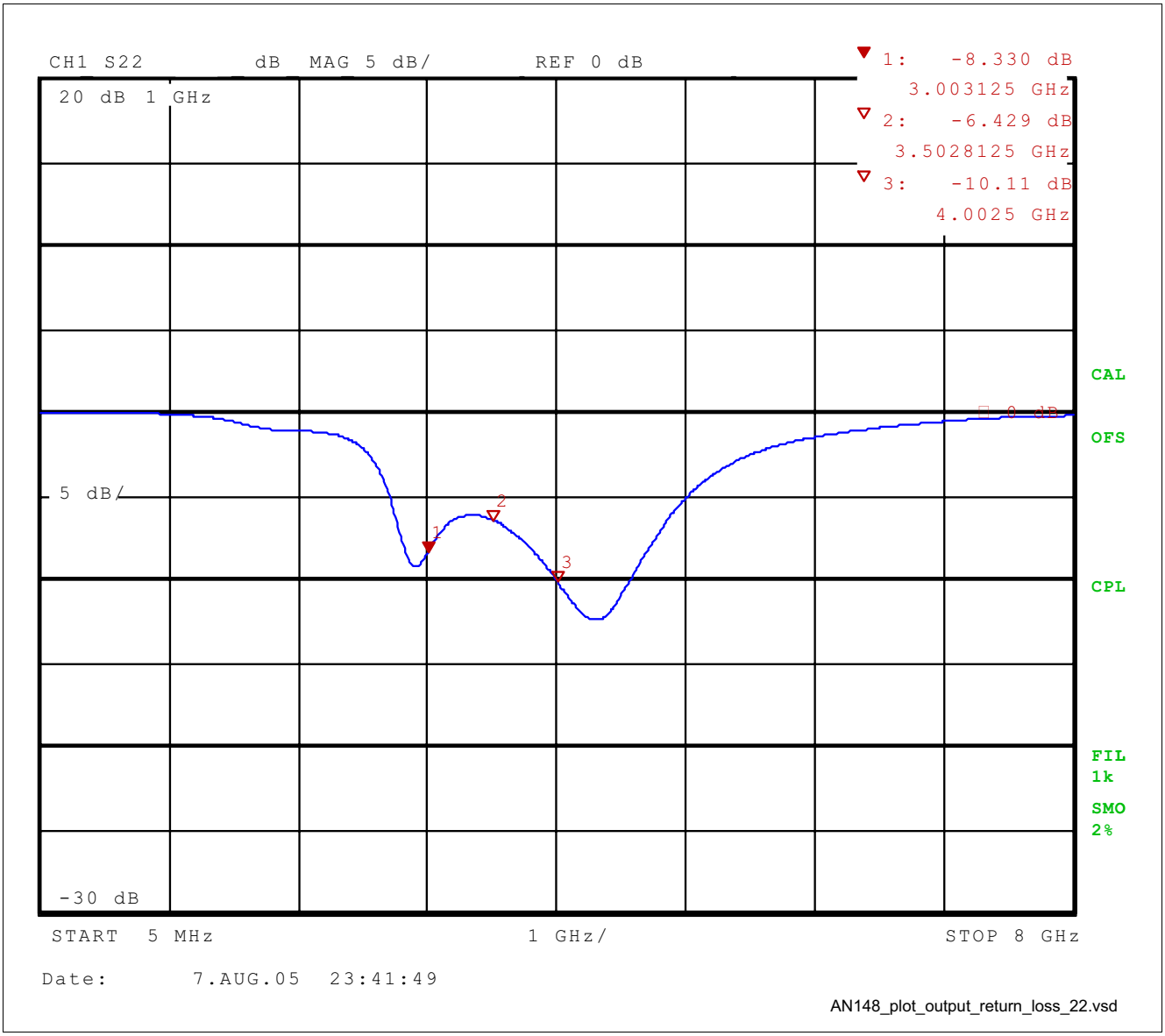


Figure 18 Plot of Output Return Loss, 2.2 V, 1.6 mA

Output Return Loss, Smith Chart

Reference Plane = Output SMA Connector on PC Board
5 MHz - 8 GHz Sweep
V_{CC} = 2.2 V, I = 1.6 mA

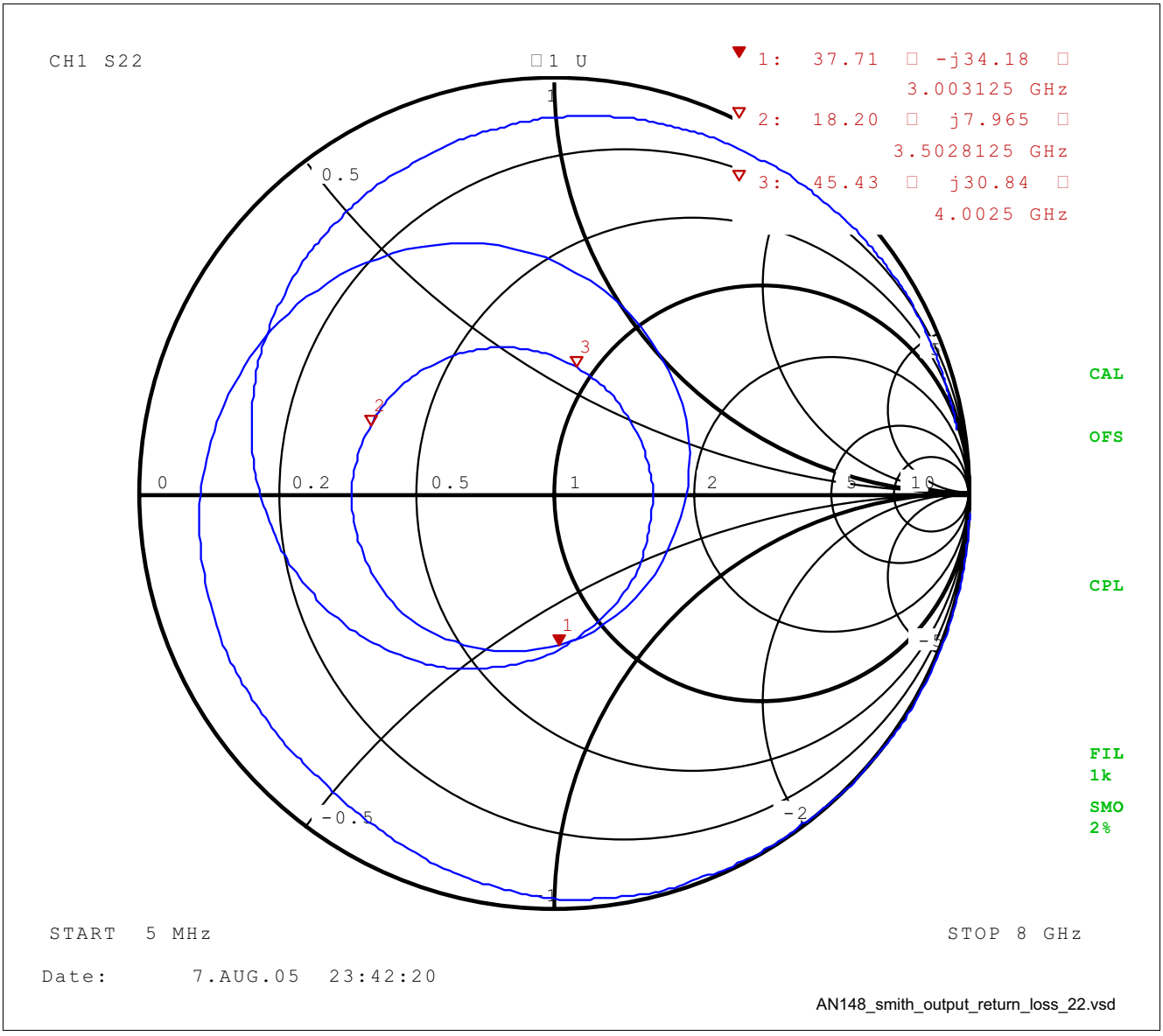


Figure 19 Smith Chart of Output Return Loss, 2.2 V, 1.6 mA

Input Return Loss, Log Mag

5 MHz - 8 GHz Sweep

V_{CC} = 2.9 V, I = 2.5 mA

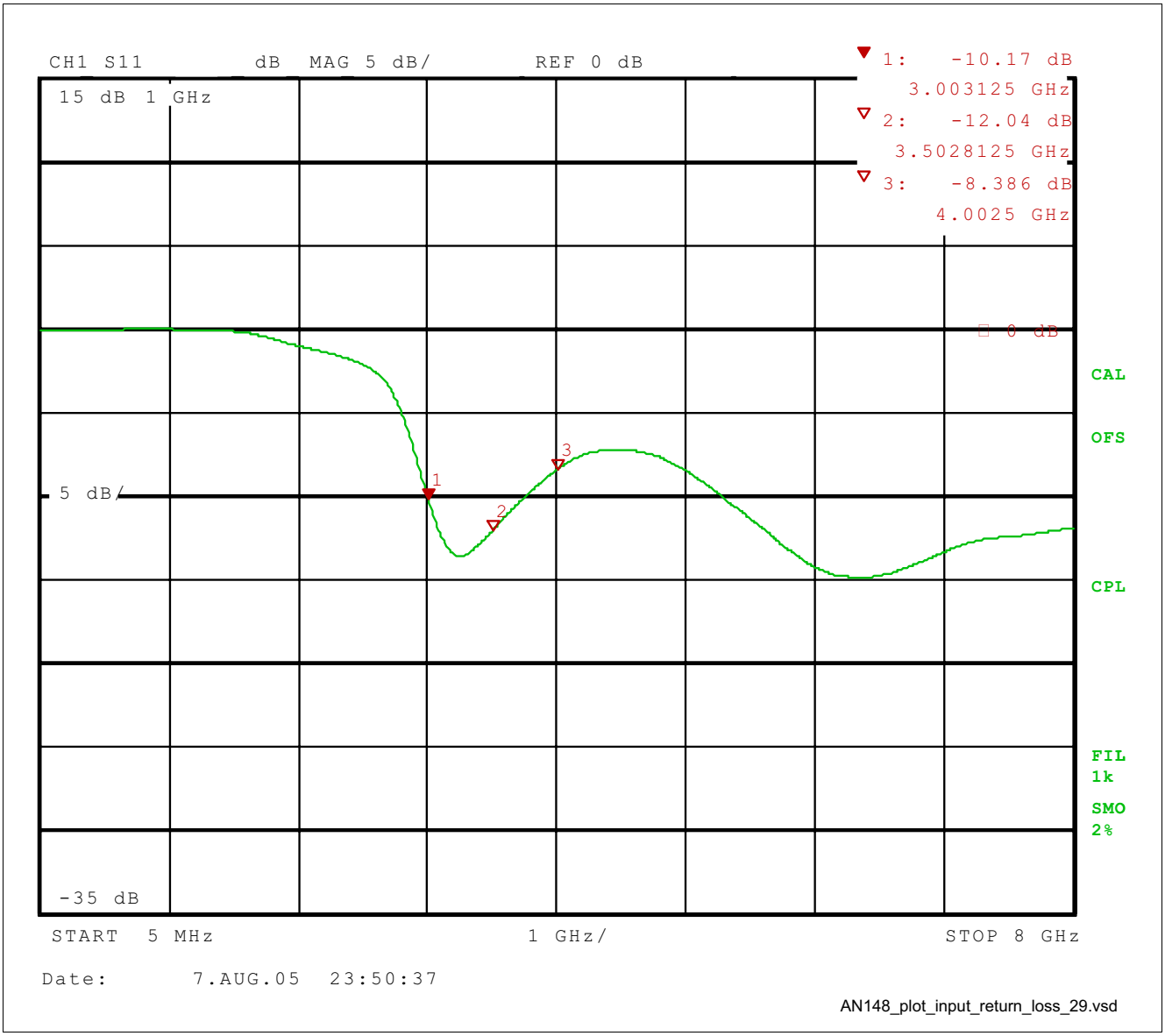


Figure 20 Plot of Input Return Loss, 2.9 V, 2.5 mA

Input Return Loss, Smith Chart

Reference Plane = Input SMA Connector on PC Board
5 MHz - 8 GHz Sweep
V_{CC} = 2.9 V, I = 2.5 mA

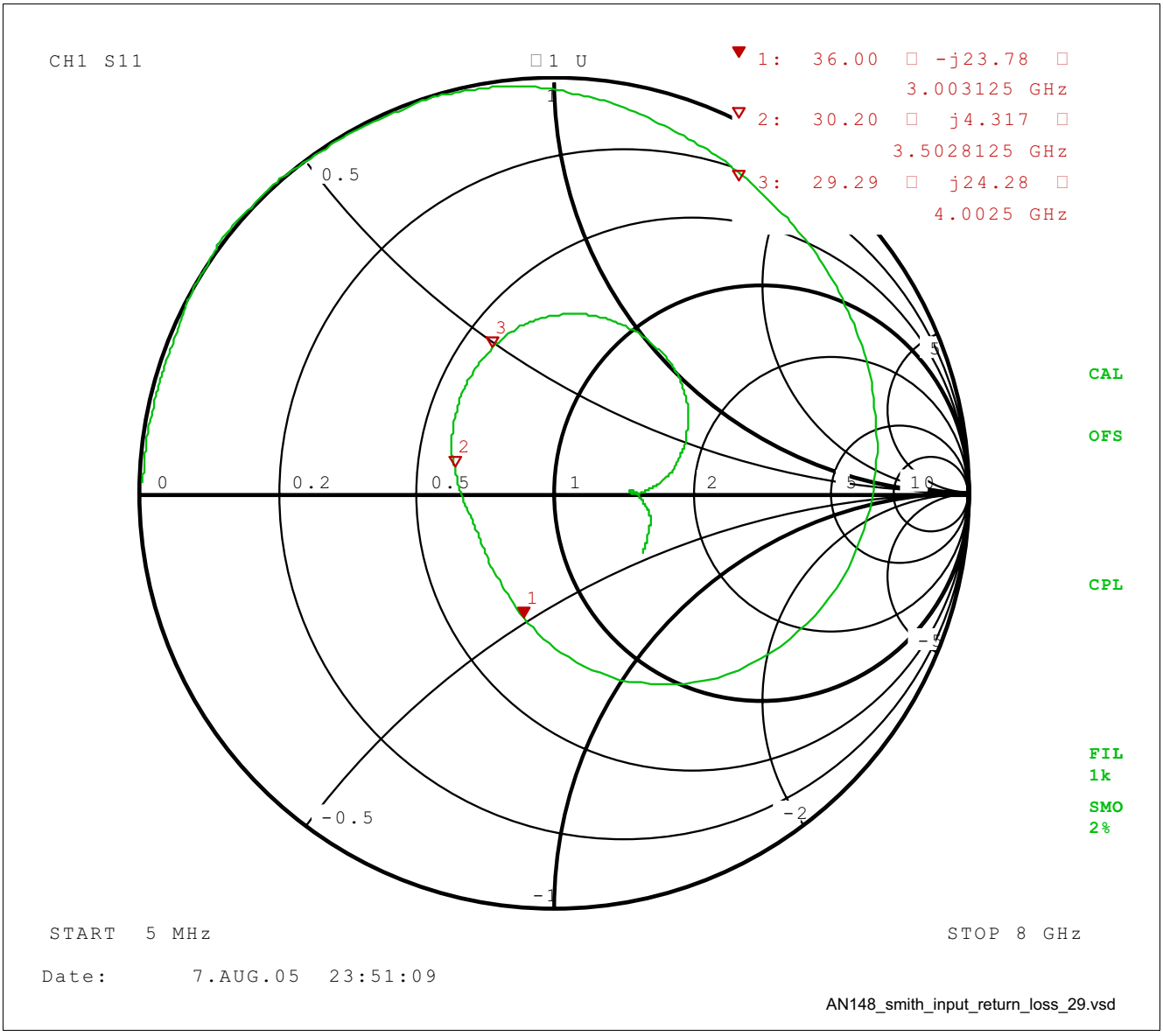


Figure 21 Smith Chart of Input Return Loss, 2.9 V, 2.5 mA

Forward Gain

5 MHz - 8 GHz Sweep

V_{CC} = 2.9 V, I = 2.5 mA

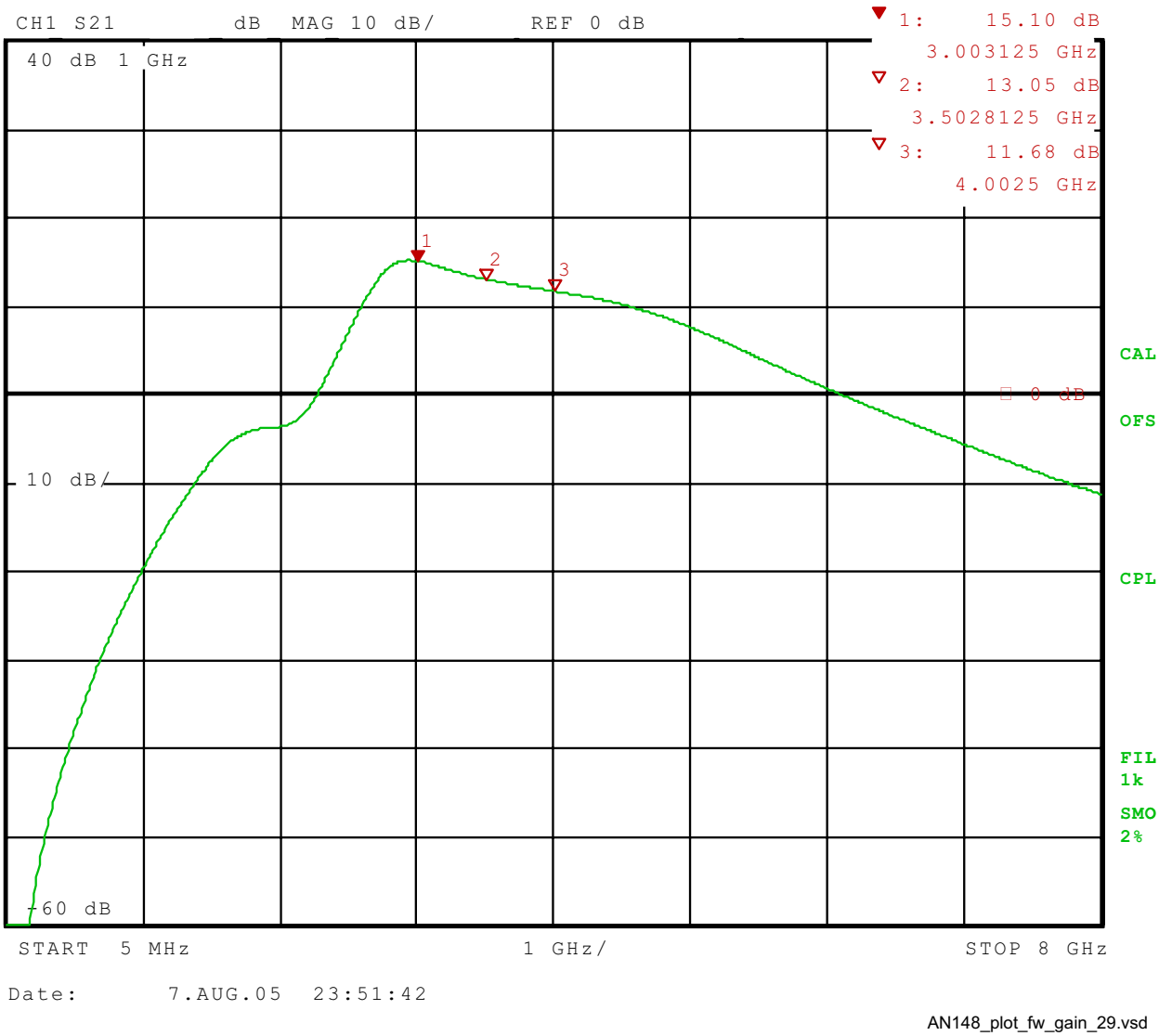


Figure 22 Plot of Forward Gain, 2.9 V, 2.5 mA

Reverse Isolation

5 MHz - 8 GHz

V_{CC} = 2.9 V, I = 2.5 mA

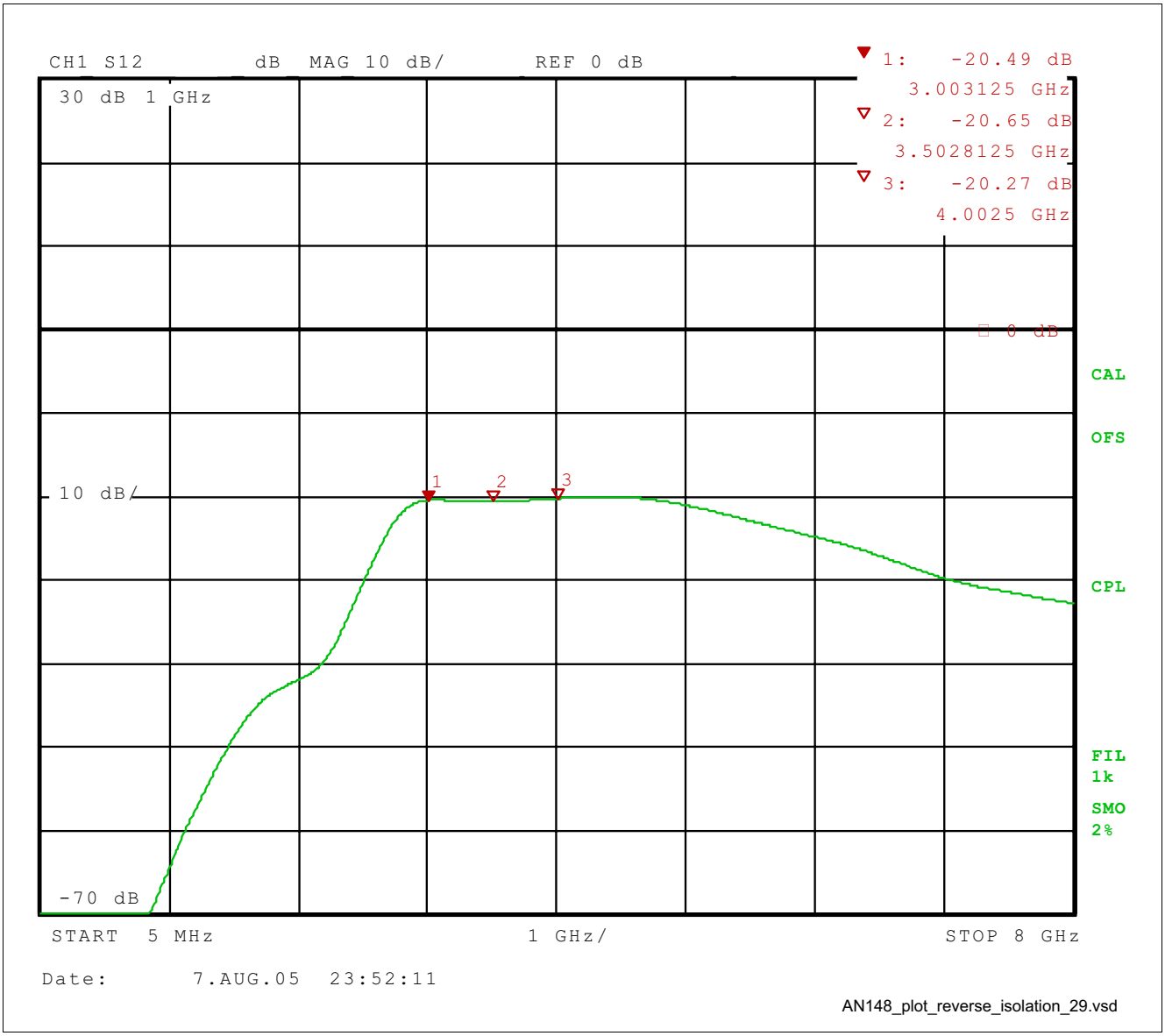


Figure 23 Plot of Reverse Isolation, 2.9 V, 2.5 mA

Output Return Loss, Log Mag

5 MHz - 8 GHz

V_{CC} = 2.9 V, I = 2.5 mA

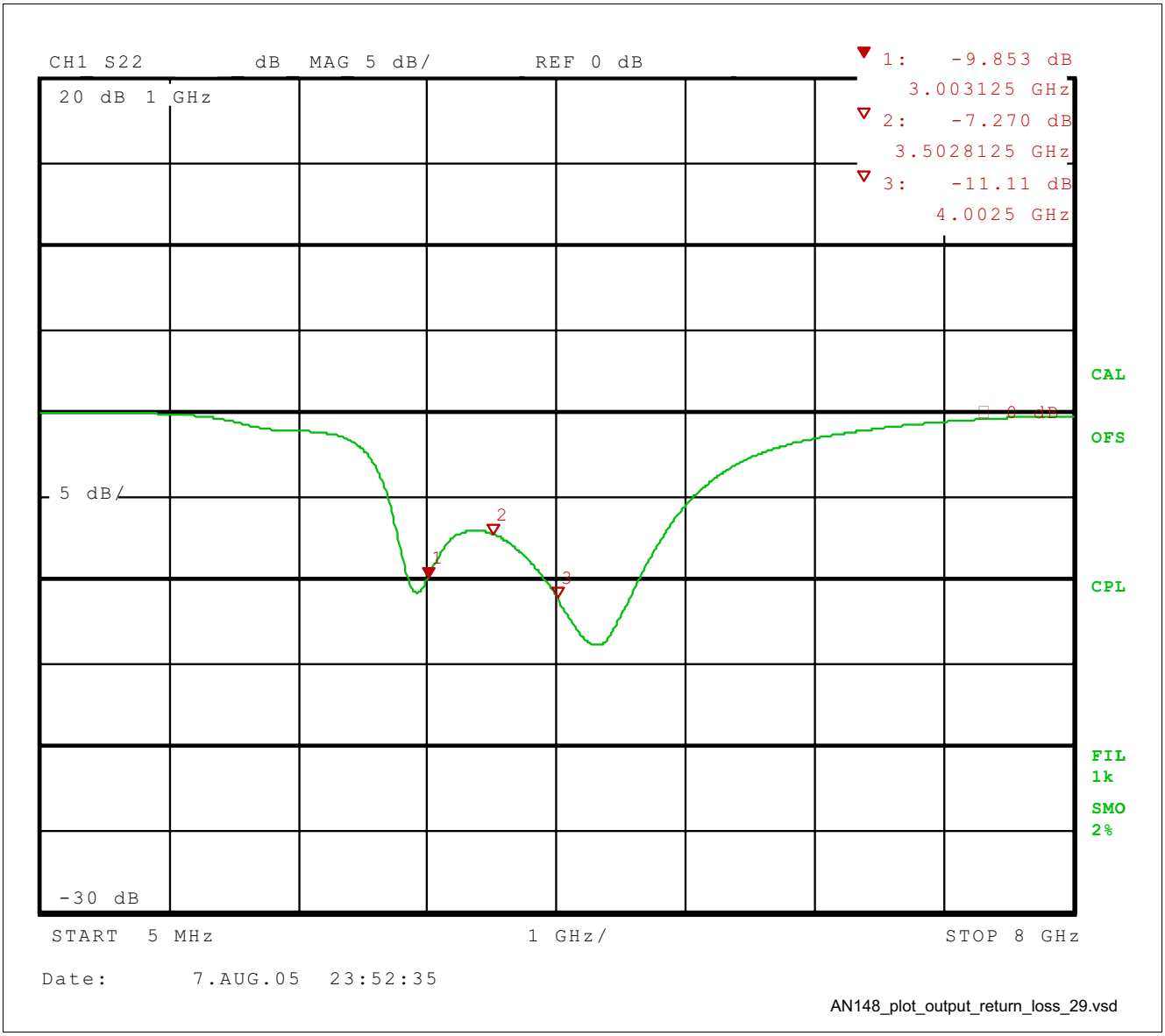


Figure 24 Plot of Output Return Loss, 2.9 V, 2.5 mA

Output Return Loss, Smith Chart

Reference Plane = Output SMA Connector on PC Board
5 MHz - 8 GHz Sweep
V_{CC} = 2.9 V, I = 2.5 mA

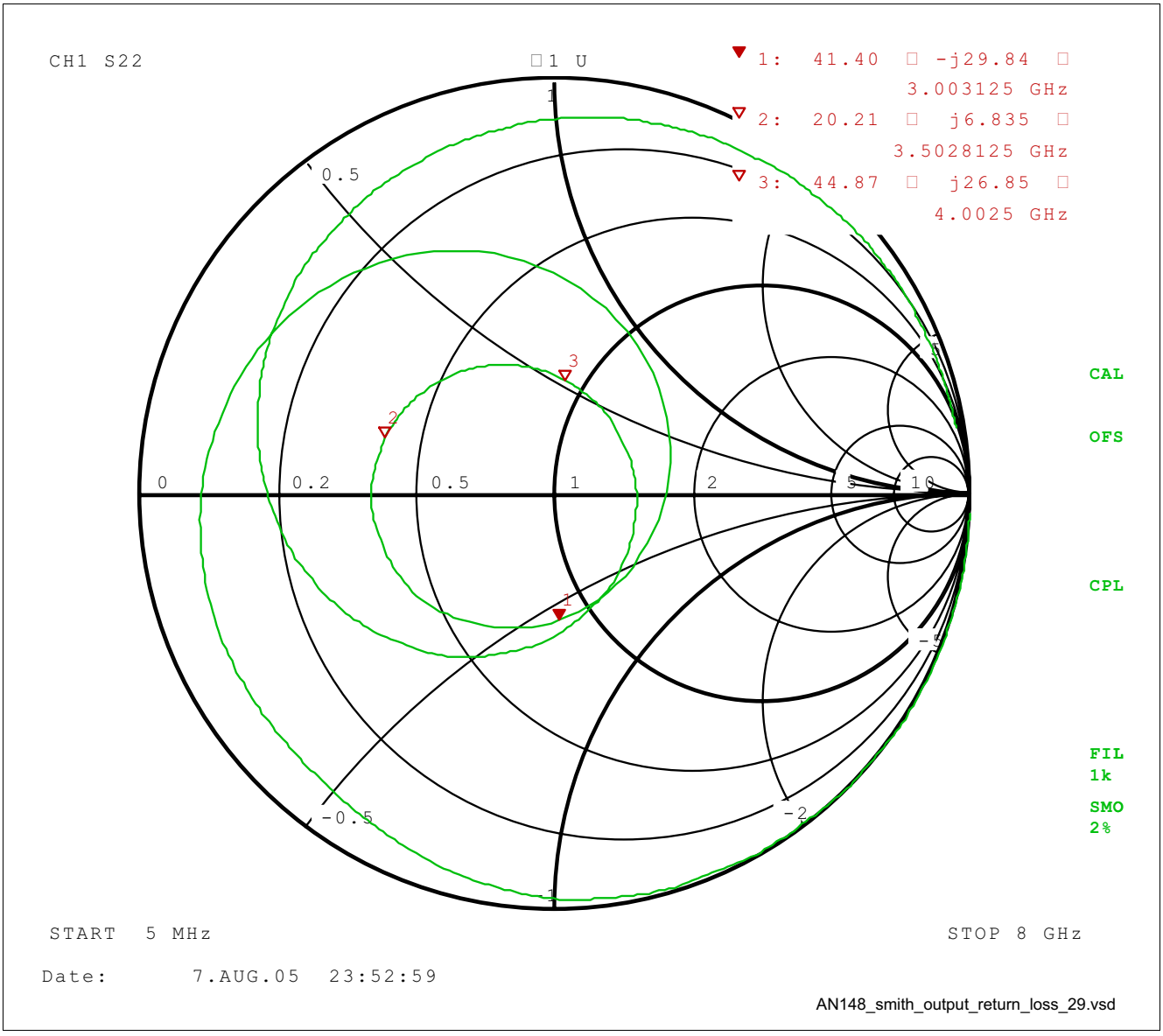


Figure 25 Smith Chart of Output Return Loss, 2.9 V, 2.5 mA

Input Return Loss, Log Mag

5 MHz - 8 GHz Sweep

V_{CC} = 3.6 V, I = 3.3 mA

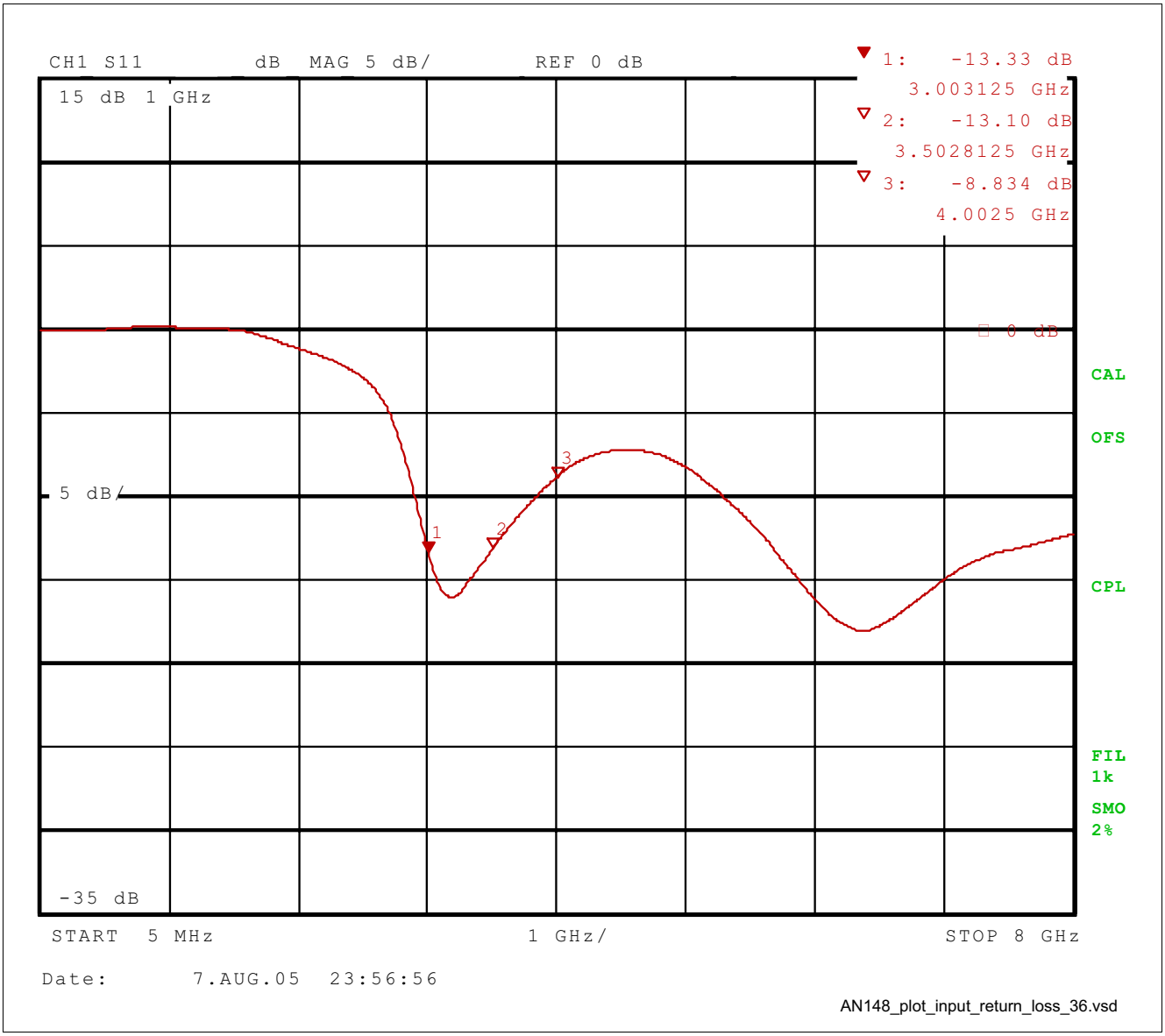


Figure 26 Plot of Input Return Loss, 3.6 V, 3.3 mA

Input Return Loss, Smith Chart

Reference Plane = Input SMA Connector on PC Board
5 MHz - 8 GHz Sweep
V_{CC} = 3.6 V, I = 3.3 mA

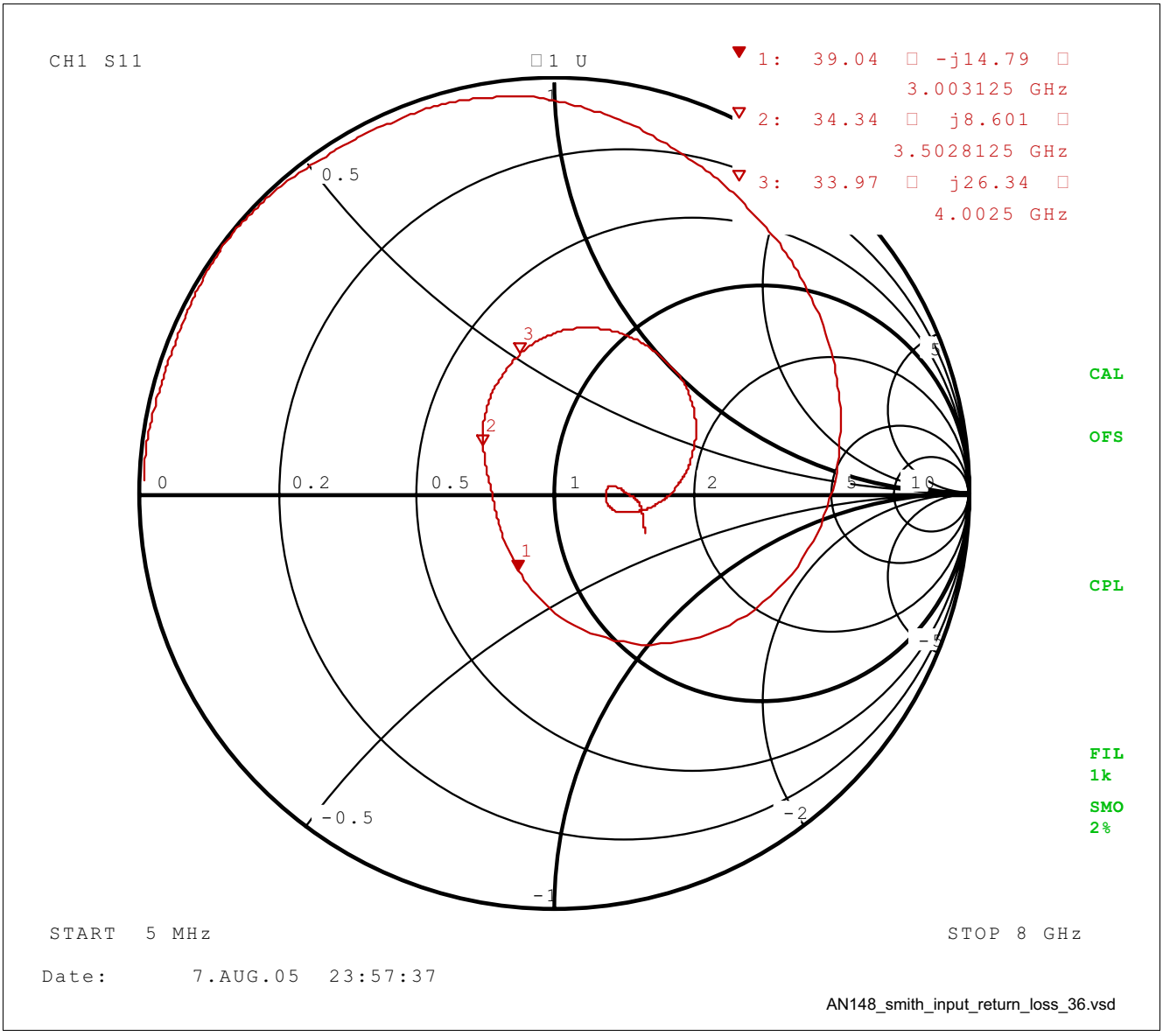


Figure 27 Smith Chart of Input Return Loss, 3.6 V, 3.3 mA

Forward Gain

5 MHz - 8 GHz Sweep

V_{CC} = 3.6 V, I = 3.3 mA

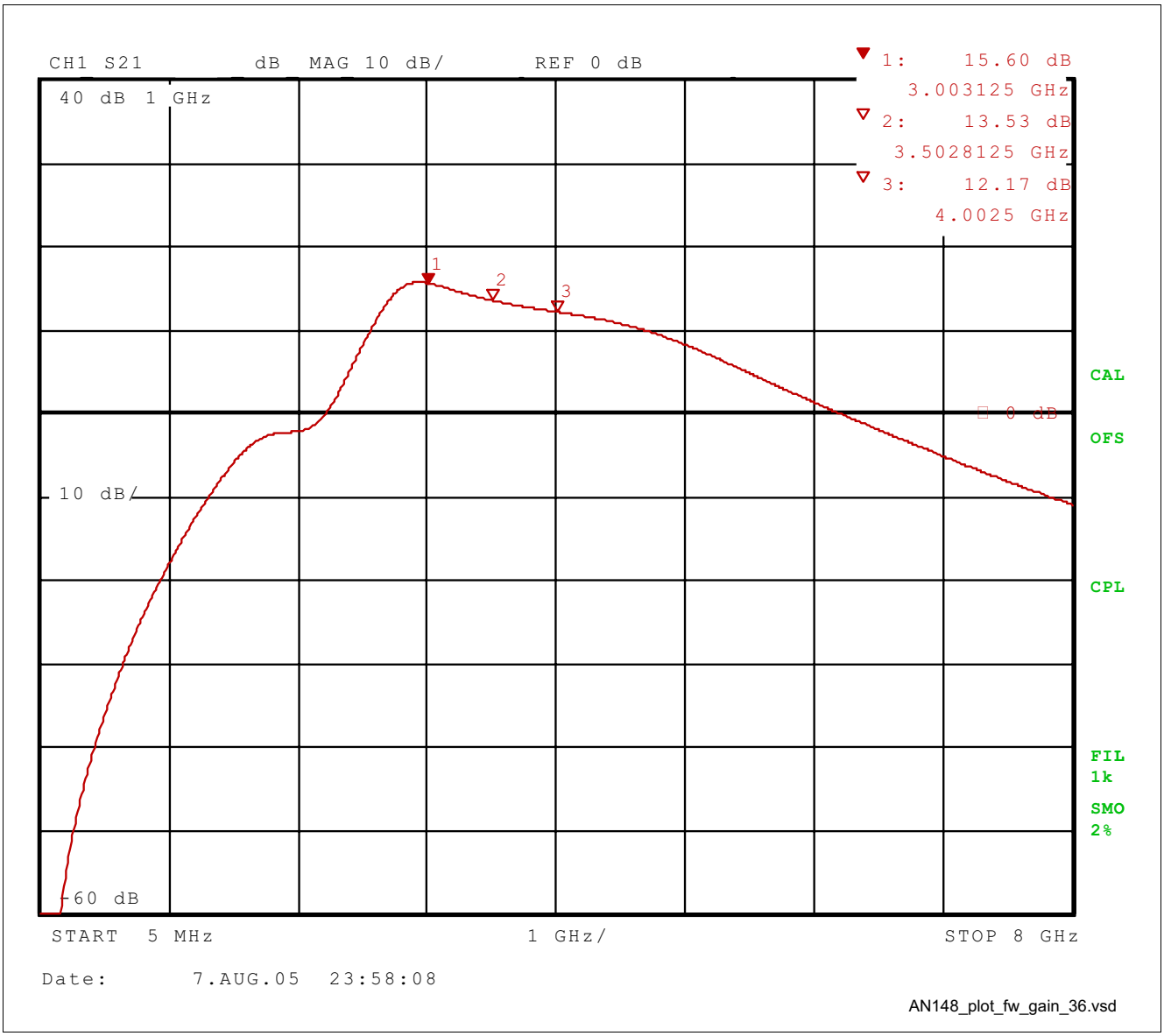


Figure 28 Plot of Forward Gain, 3.6 V, 3.3 mA

Reverse Isolation

5 MHz - 8 GHz

V_{CC} = 3.6 V, I = 3.3 mA

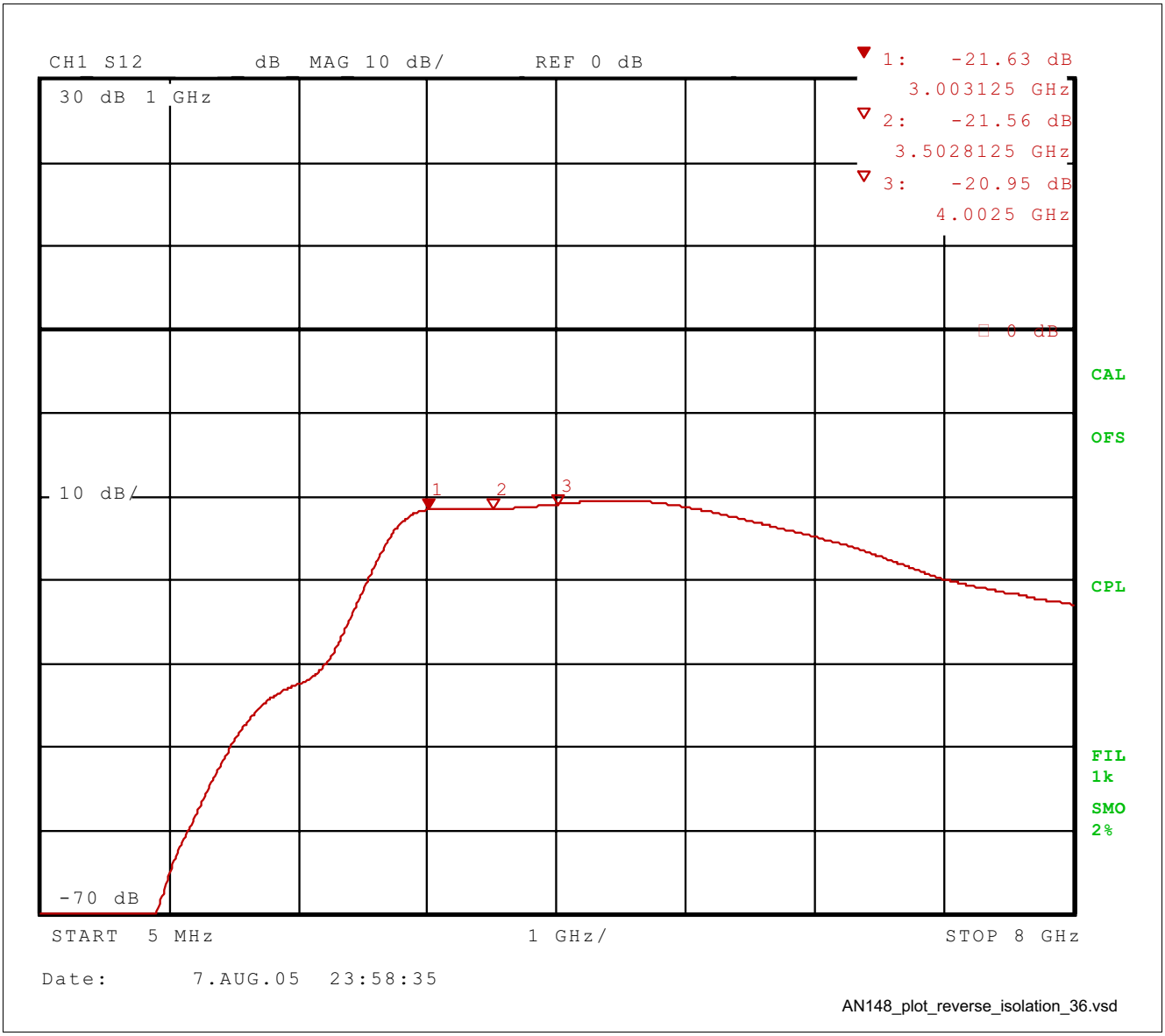


Figure 29 Plot of Reverse Isolation, 3.6 V, 3.3 mA

Output Return Loss, Log Mag

5 MHz - 8 GHz

V_{CC} = 3.6 V, I = 3.3 mA

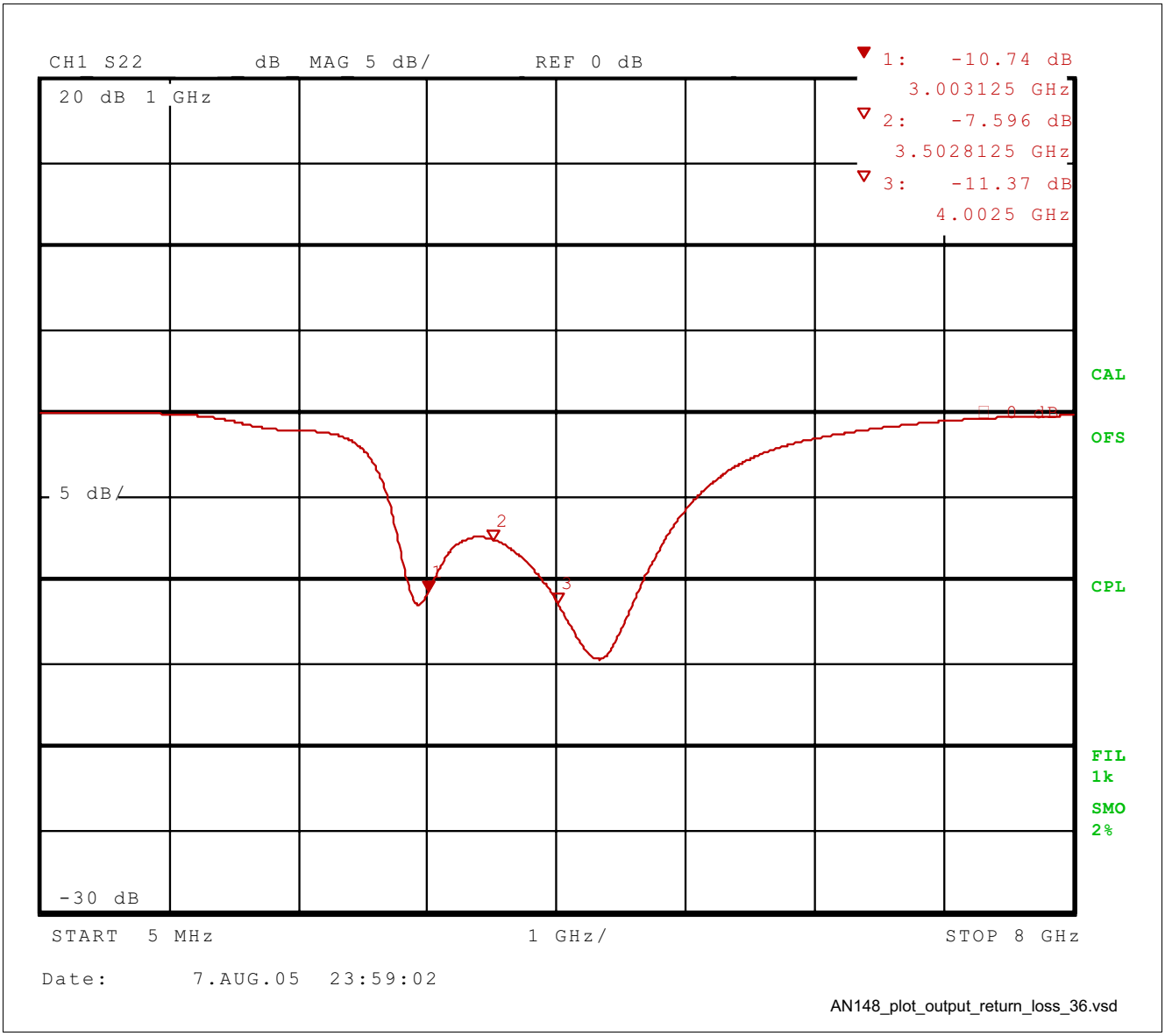


Figure 30 Plot of Output Return Loss, 3.6 V, 3.3 mA

Output Return Loss, Smith Chart

Reference Plane = Output SMA Connector on PC Board
5 MHz - 8 GHz Sweep
V_{CC} = 3.6 V, I = 3.3 mA

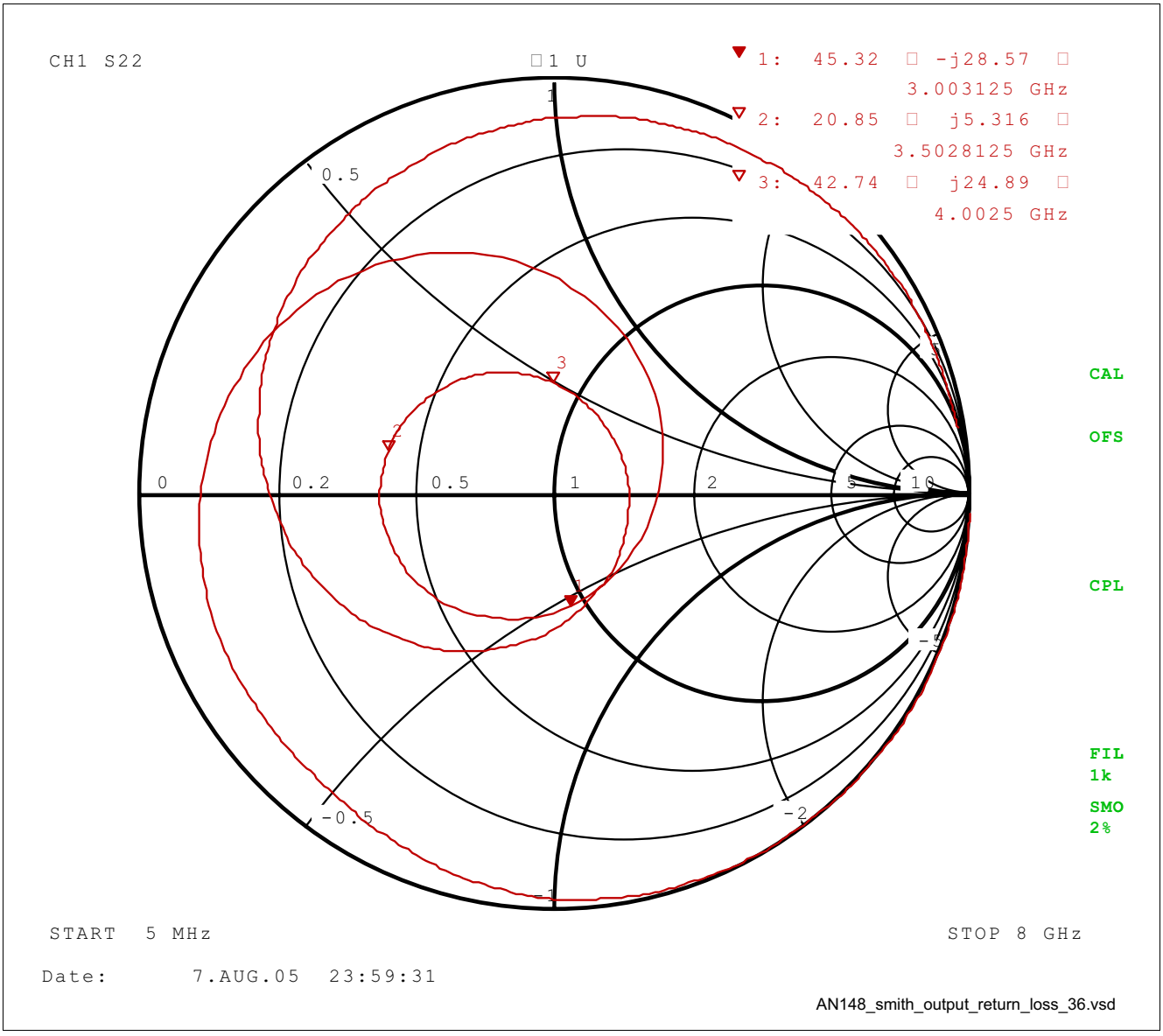


Figure 31 Smith Chart of Output Return Loss, 3.6 V, 3.3 mA