Application Note No. 125

LNA for Satellite Digital Multimedia Broadcasting Applications using BFP640F SiGe Transistor

RF & Protection Devices

Never stop thinking

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Revision History: 2007-11-19, Rev. 1.2

Previous Version: 2004-09-08, Rev. 1.1

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

1 LNA for Satellite Digital Multimedia Broadcasting Applications using BFP640F SiGe Transistor

Overview

- BFP640F is investigated for use as an LNA for a 2630 - 2655 MHz Digital Multimedia Broadcasting ("DMB") application.
- Design Goals: Gain =15 dB, Noise Figure < 1.2 dB, Input / Output Return Loss 10 dB or better, current < 10 mA from a 1.8 V power supply, Output P_{1dB} > -5 dBm
- Printed Circuit Board used is Infineon Part Number 640F-021904 Rev A. Standard FR4 material is used in a three-layer PCB. Please refer to cross-sectional diagram.
- Low-cost, standard "0402" case-size SMT passive components are used throughout. Please refer to Schematic and Bill of Material. The LNA is unconditionally stable from 5 MHz to 6 GHz.
- Total PCB area used for the single LNA stage is approximately 35 mm². Total Parts count, including the BFP640F transistor, is 12.

Achieved ≅ 14 dB gain, 0.9 dB Noise Figure from 2400-2800 MHz from a 1.8 V supply, drawing 6.8 mA. Outstanding Input 3rd Order Intercept of +10.5 dBm. Note noise figure result does NOT "back out" FR4 PCB losses - if the PCB loss at LNA input were extracted, Noise Figure result would be approximately 0.2 dB lower. Amplifier is unconditionally stable from 5 MHz to 6 GHz.

PCB Cross - Section Diagram

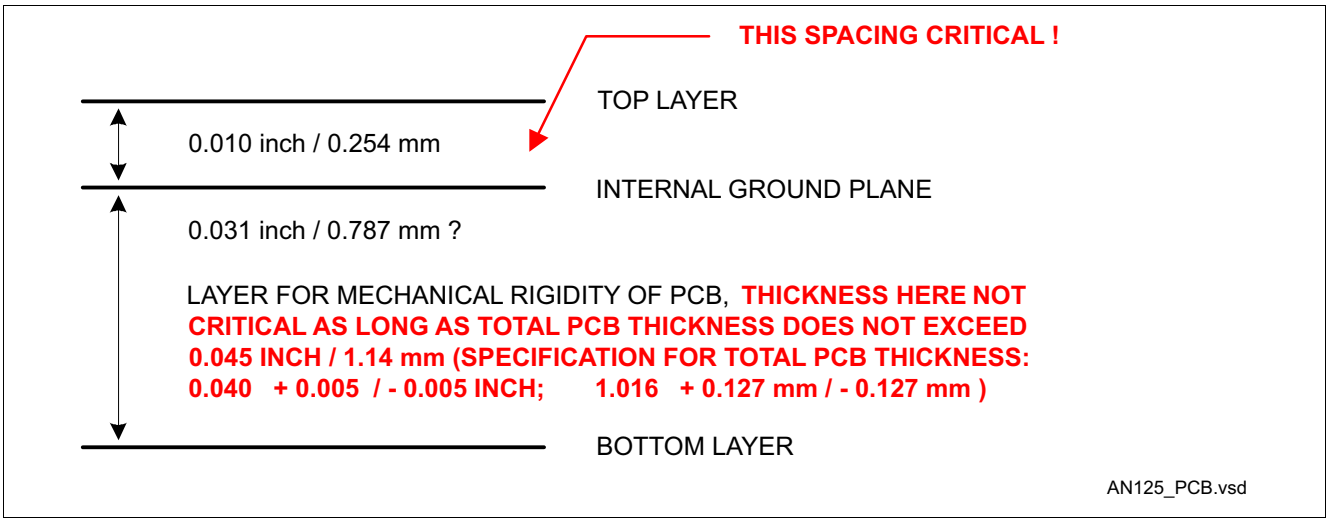

Figure 1 PCB - Cross Sectional Diagram

TSFP-4 Package Details (dimensions in millimeters)

Note maximum package height is 0.59 mm / 0.023 inch.

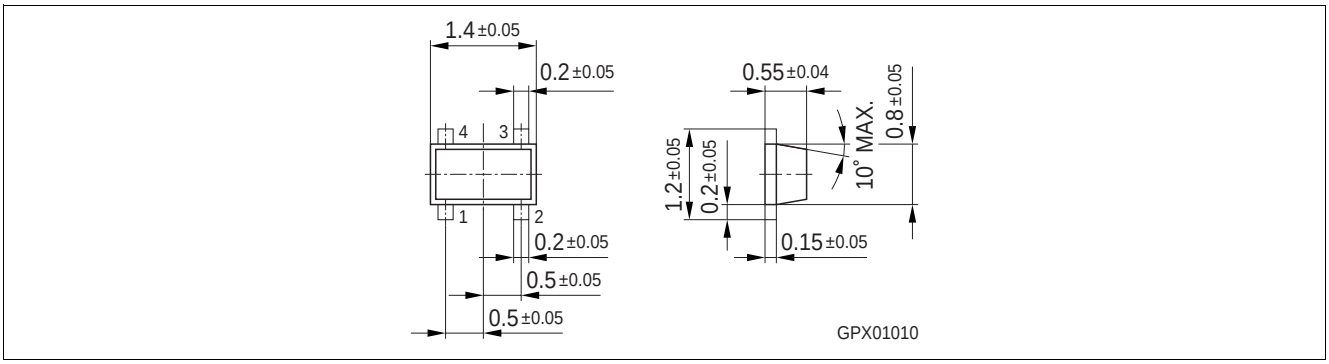

Figure 2 Package Details of TSFP-4

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).

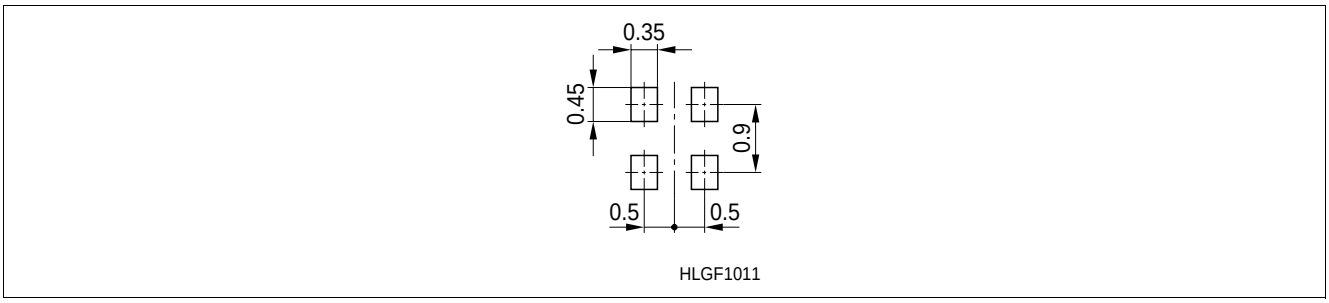

Figure 3 Package Footprint of TSFP-4

Summary of LNA Data

T = 25 °C, network analyzer source power = -25 dBm

Table 1 Summary of LNA Data

Parameter	Result	Comments
Frequency Range	2630 - 2655 MHz (can go wider)	
DC Current	6.8 mA	
DC Voltage, V_{CC}	1.8 V	
Collector-Emitter Voltage, V_{CE}	1.5 V	BFP640: V_{CEmax} = 4.0 V
Gain	14.2 dB @ 2630 MHz 14.2 dB @ 2642.5 MHz 14.1 dB @ 2655 MHz	
Noise Figure	0.9 dB @ 2630 MHz 0.9 dB @ 2642.5 MHz 0.9 dB @ 2655 MHz	See noise figure plot and tabular data, pages 6 and 7. (These values do NOT extract PCB losses, etc. resulting from FR4 board and passives used on PCB - these results are at input SMA connector)
Input P_{1dB}	-9.3 dBm @ 2640 MHz	See input power sweep vs. gain plot on page 11.
Output P_{1dB}	+3.9 dBm @ 2640 MHz	
Input 3rd Order Intercept	+10.5 dBm @ 2642.5 MHz	(For Test: Two tones, f_1=2642 MHz, f_2=2643 MHz, -18 dBm each tone). See plot on pages 16 - 17
Output 3rd Order Intercept	+24.7 dBm @ 2642.5 MHz	
Input Return Loss	12.8 dB @ 2630 MHz 12.9 dB @ 2642.5 MHz 13.0 dB @ 2655 MHz	
Output Return Loss	13.6 dB @ 2630 MHz 13.4 dB @ 2642.5 MHz 13.2 dB @ 2655 MHz	
Reverse Isolation	19.7 dB @ 2630 MHz 19.7 dB @ 2642.5 MHz 19.6 dB @ 2655 MHz	

Bill of Material

Table 2 Bill of Material

REFERENCE DESIGNATOR	VALUE	MANUFACTURER	CASE SIZE	FUNCTION
C1	8.2 pF	Various	0402	DC Blocking, Input.
C2	1.5 pF	Various	0402	DC Block, Output. Also Influences Output and Input Impedance Match
C3	0.1 µF	Various	0402	Decoupling, Low Frequency. Also improves Third-Order Interception
C4	8.2 pF	Various	0402	Decoupling (RF Short)
C5	5.6 pF	Various	0402	Decoupling (RF Short). Also has influence on stability.
C6	0.1 µF	Various	0402	Decoupling, Low Frequency
L1	10 nH	Murata LQG15H Series Low Cost Inductor	0402	RF Choke at Input
L2	3.6 nH	Murata LQP15M Series Inductor	0402	RF Choke + Impedance Match at Output
R1	10 Ω	Various	0402	Stability Improvement
R2	20 kΩ	Various	0402	Brings Bias Current / Voltage into Base of Transistor
R3	30 Ω	Various	0402	Provides some Negative Feedback for DC BIAS / DC Operation Point to Compensate for Variations in Transistor DC Current Gain, Temperature Variations, etc.
Q1	-	Infineon Technologies	TSFP-4	BFP640F B7HF SiGe Transistor
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

Schematic Diagram for 2.6 GHz BFP640F LNA

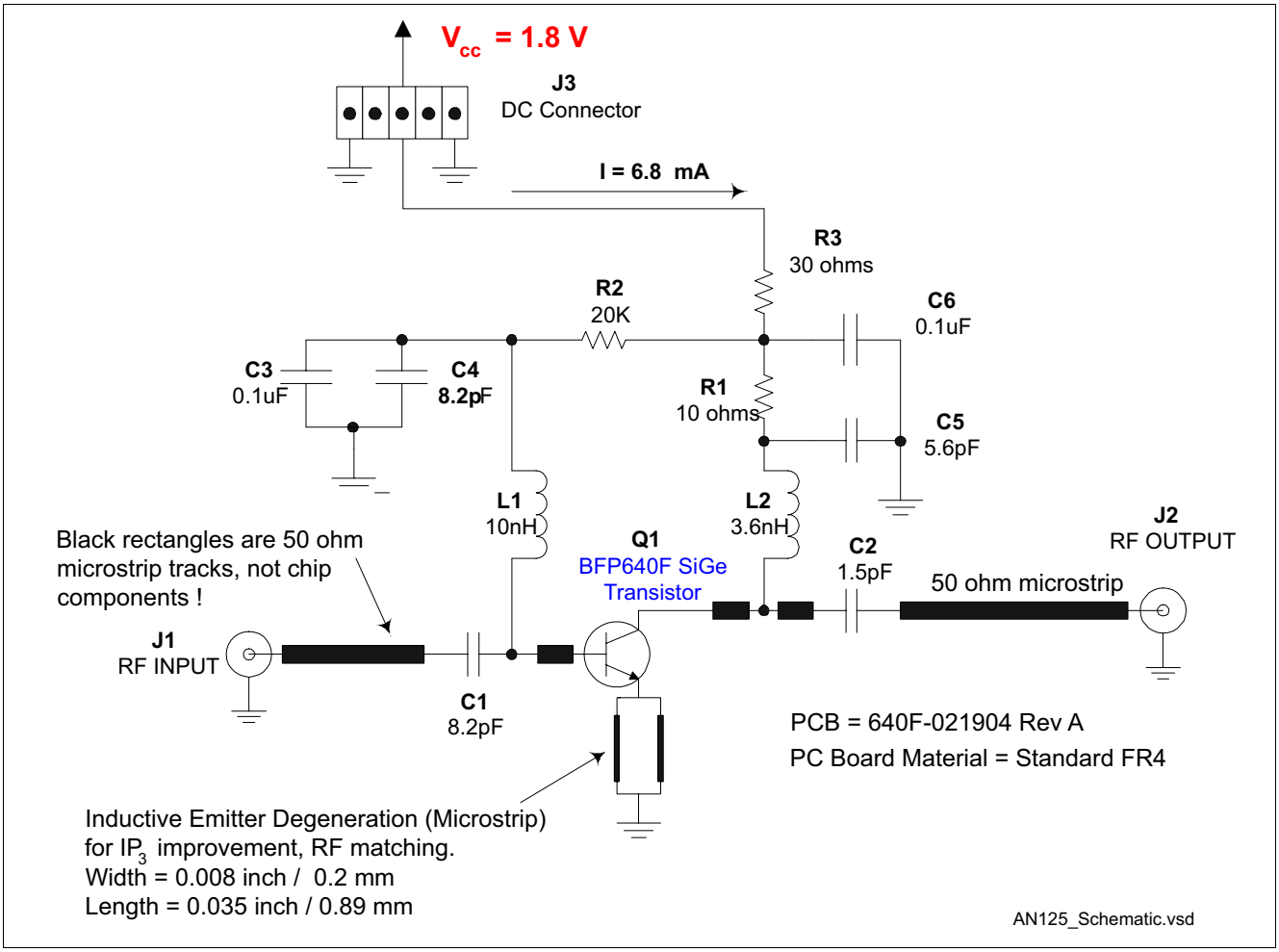

Figure 4 Schematic Diagram

Noise Figure, Plot. Center of Plot (x-axis) is 2642.5 MHz.

Rohde & Schwarz FSEK3 08 Sep 2004

BFP640F TSFP-4 Package -- LNA Noise Figure

EUT Name:	PCB = 640F-021904 Rev A
Manufacturer:	Infineon Technologies - Silicon Discretes Group GF32
Operating Conditions:	Vcc = 1.8 V, Ic = 6.8 mA
Operator Name:	Gerard Wevers
Test Specification:	2.6 GHz DMB-H Application (APAC)
Comment:	Vce = 1.5 volts

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

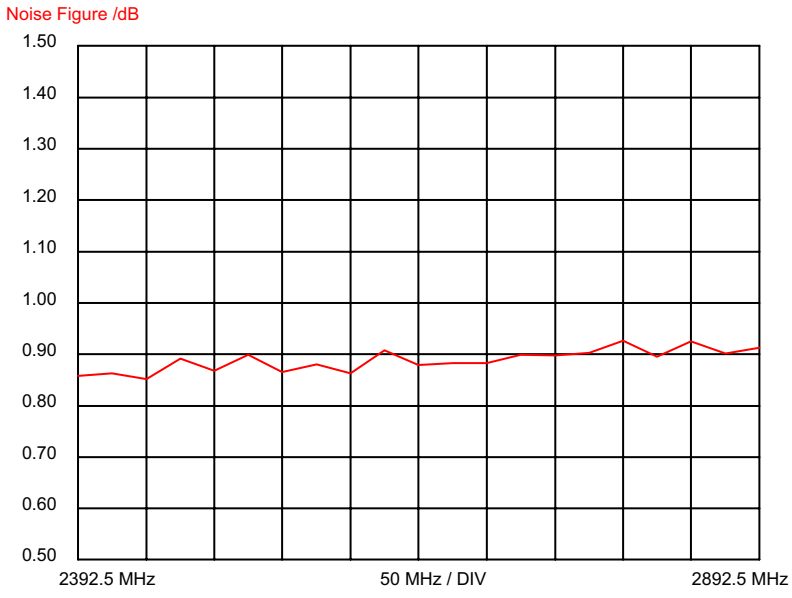

Figure 5 Noise Figure

Noise Figure, Tabular Data

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

Table 3 Noise Figure

Frequency	Noise Figure
2392.5 MHz	0.86 dB
2417.5 MHz	0.86 dB
2442.5 MHz	0.85 dB
2467.5 MHz	0.89 dB
2492.5 MHz	0.87 dB
2517.5 MHz	0.90 dB
2542.5 MHz	0.87 dB
2567.5 MHz	0.88 dB
2592.5 MHz	0.86 dB
2617.5 MHz	0.91 dB
2642.5 MHz	0.88 dB
2667.5 MHz	0.88 dB
2692.5 MHz	0.88 dB
2717.5 MHz	0.90 dB
2742.5 MHz	0.90 dB
2767.5 MHz	0.90 dB
2792.5 MHz	0.93 dB
2817.5 MHz	0.89 dB
2842.5 MHz	0.92 dB
2867.5 MHz	0.90 dB
2892.5 MHz	0.91 dB

Scanned Image of PC Board

Figure 6 Image of PC Board

Scanned Image of PC Board, Close-In Shot

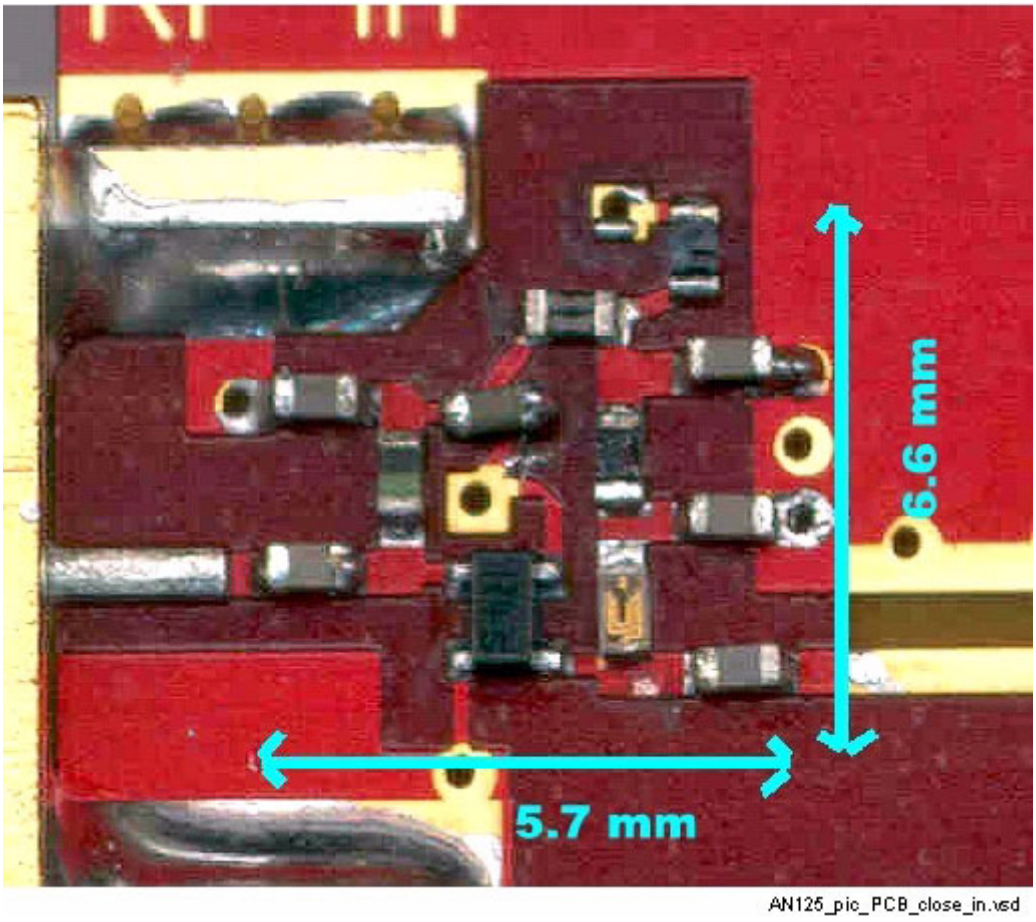

Figure 7 Image of PC Board, Close-In Shot

Stability Factor "K" and Stability Measure "B1"

Note that K > 1 and B_1 > 0, the amplifier is unconditionally stable. Measured LNA s-parameters were taken on a Network Analyzer & then imported into GENESYS simulation package, which calculates and plots K and B_1.

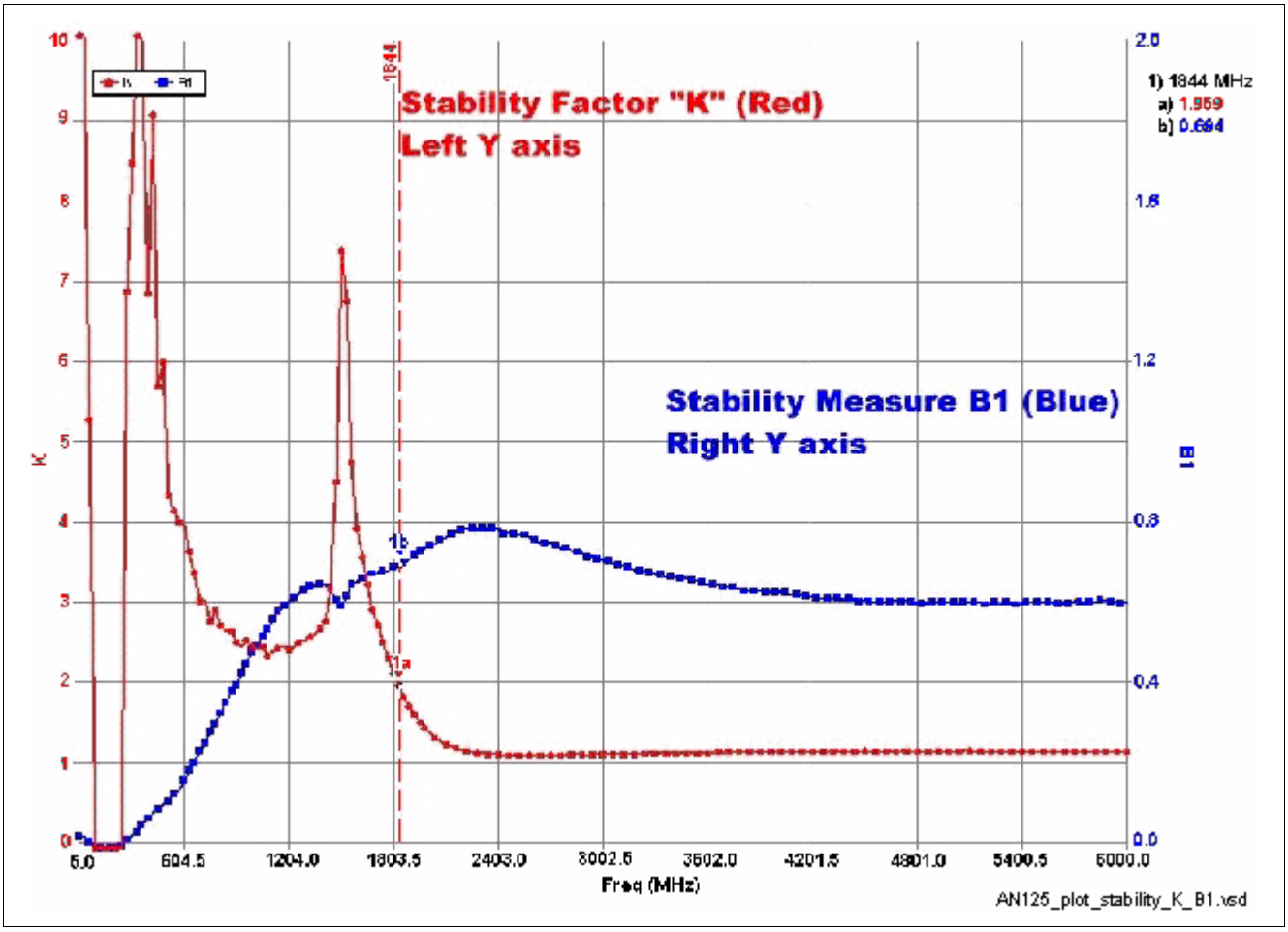

Figure 8 Plot of K(f) and B_1(f)

Power Sweep at 2640 MHz (CW)

Source Power (Input) swept from -35 to -7 dBm
Input P_{1dB} ≅ -9.3 dBm

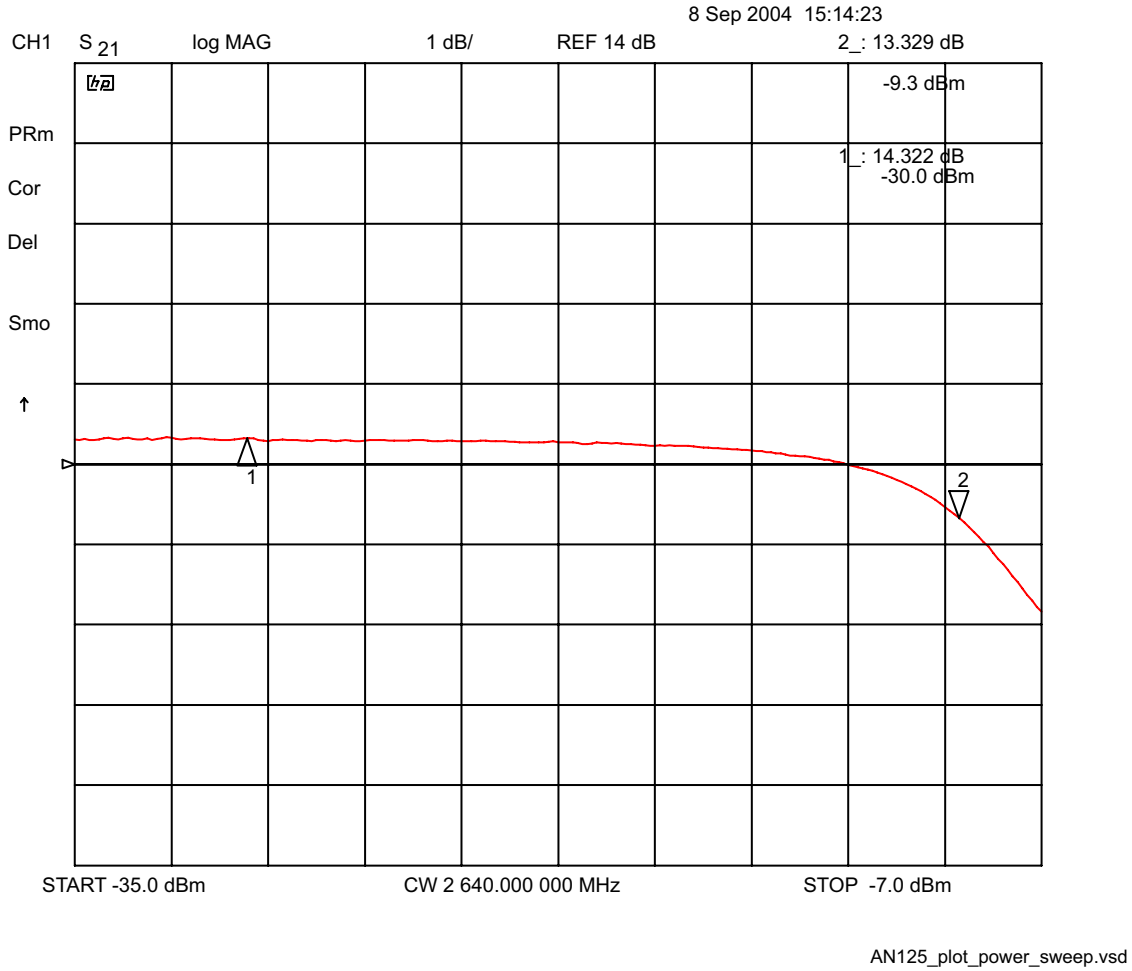

Figure 9 Plot of Power Sweep (@ 2640 MHz)

Input Return Loss, Log Mag, Wide Sweep

5 MHz - 6 GHz

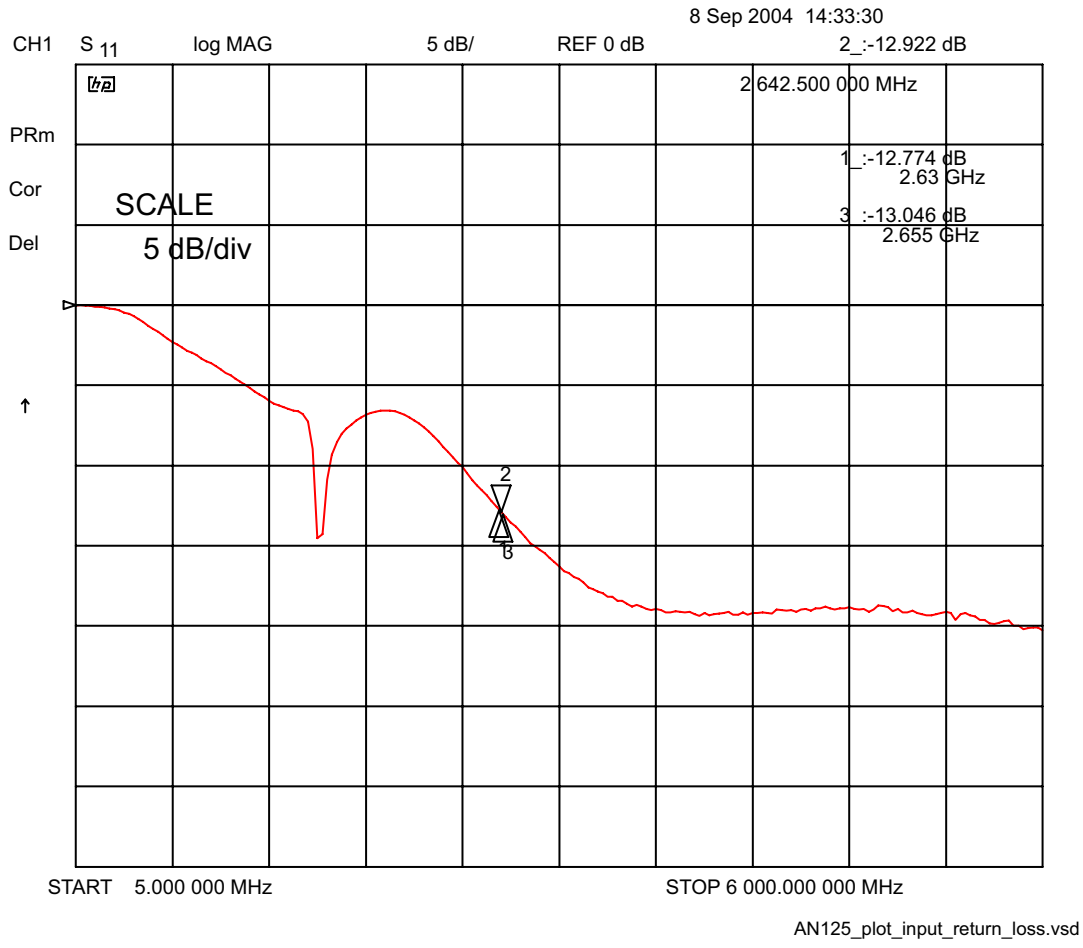

Figure 10 Plot of Input Return Loss, Wide Sweep

Forward Gain, Wide Sweep

5 MHz - 6 GHz

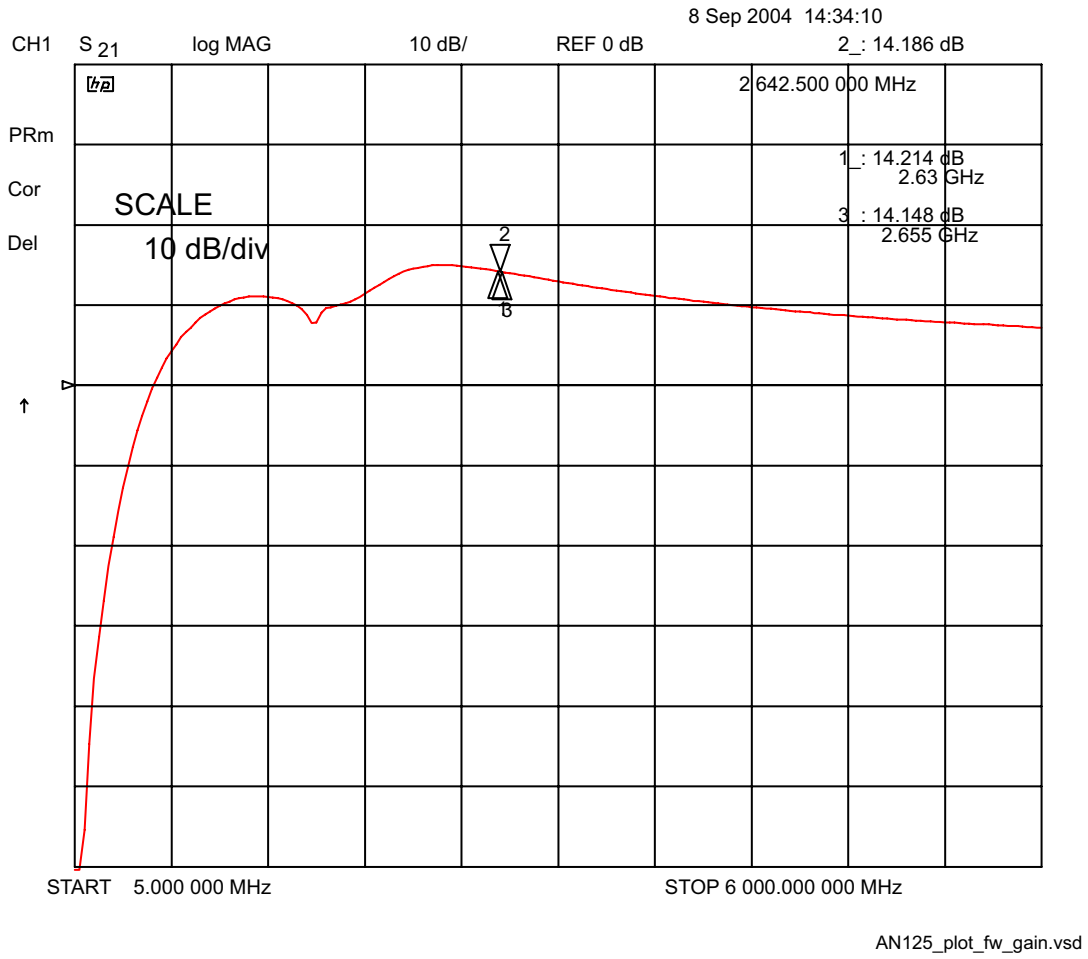

Figure 11 Plot of Forward Gain

Reverse Isolation, Wide Sweep

5 MHz - 6 GHz

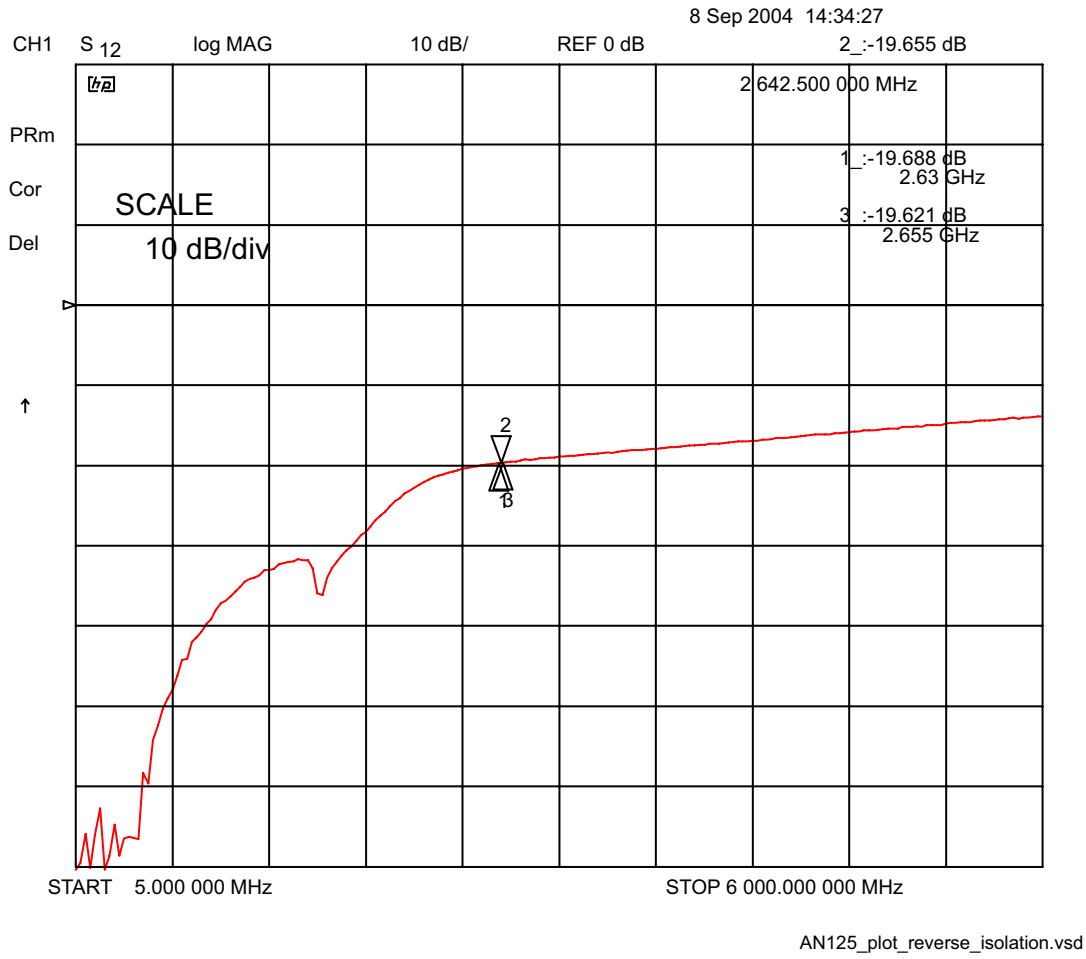

Figure 12 Plot of Reverse Isolation

Output Return Loss, Log Mag, Wide Sweep

5 MHz - 6 GHz

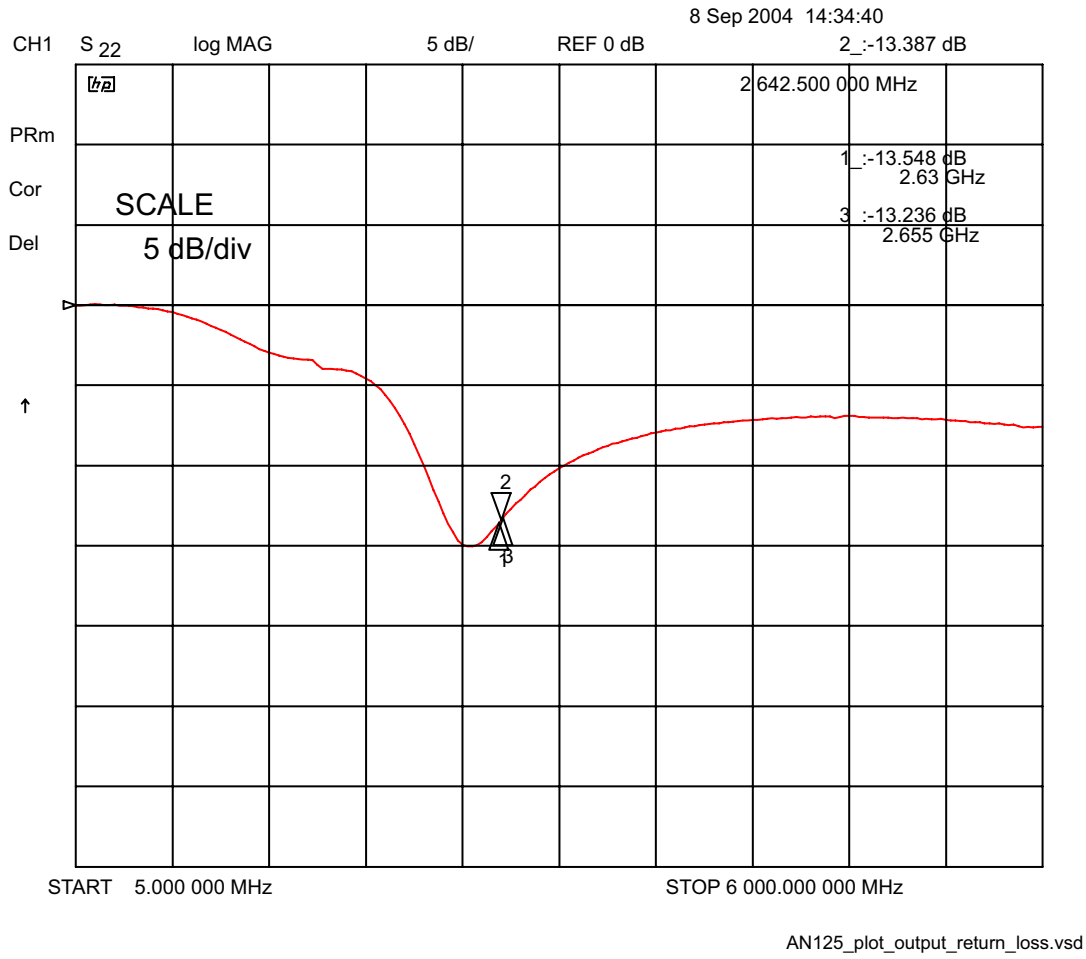

Figure 13 Plot of Output Return Loss

Input Stimulus for Amplifier Two-Tone Test

f_1 = 2642 MHz, f_2 = 2643 MHz, -18 dBm each tone.

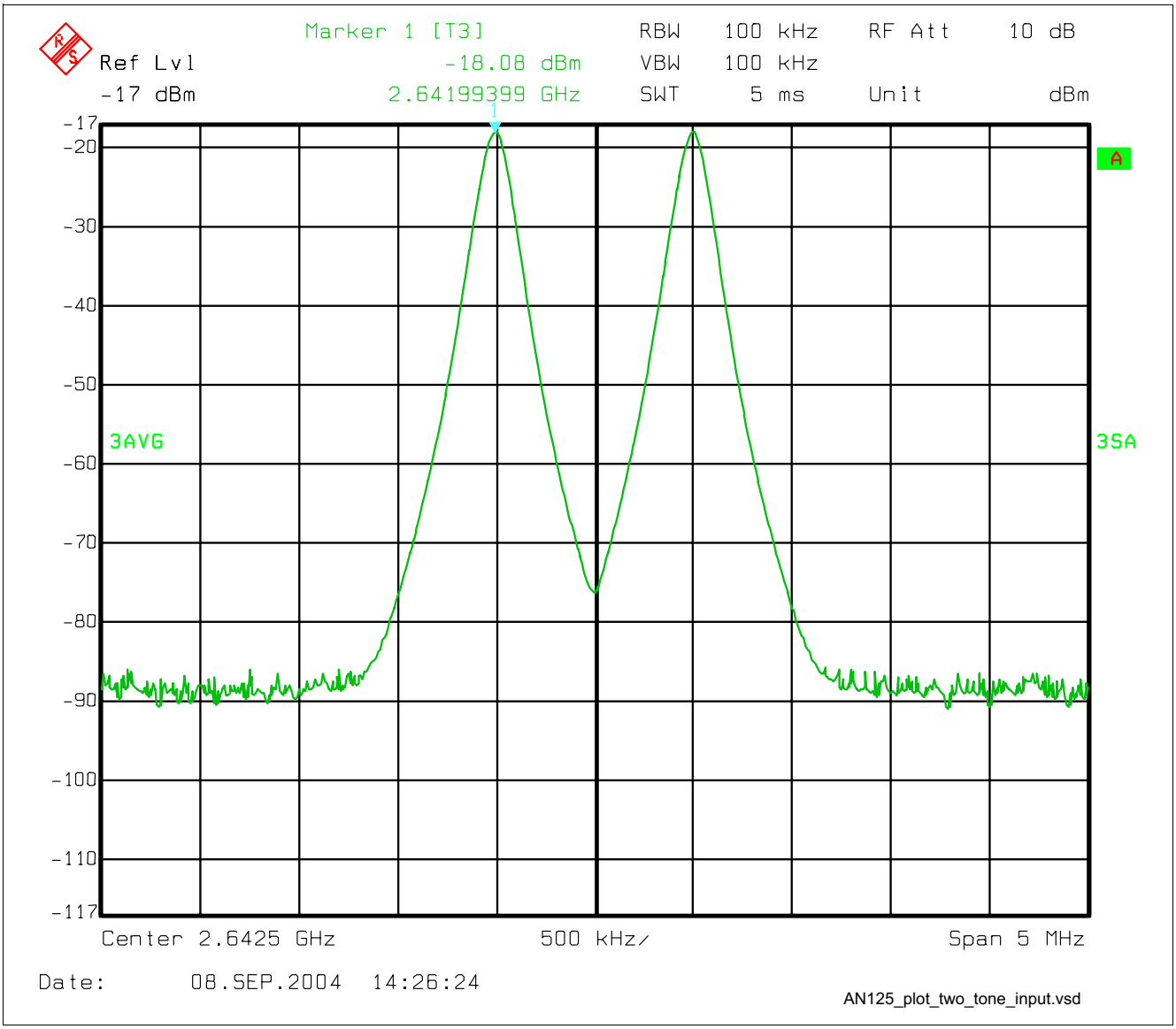

Figure 14 Tow-Tone Test, Input Stimulus

LNA Response to Two-Tone Test

Input IP_3 = -18 + (56.9/2) = +10.5 dBm
Output IP_3 = +10.5 dBm + 14.2 dB gain = + 24.7 dBm

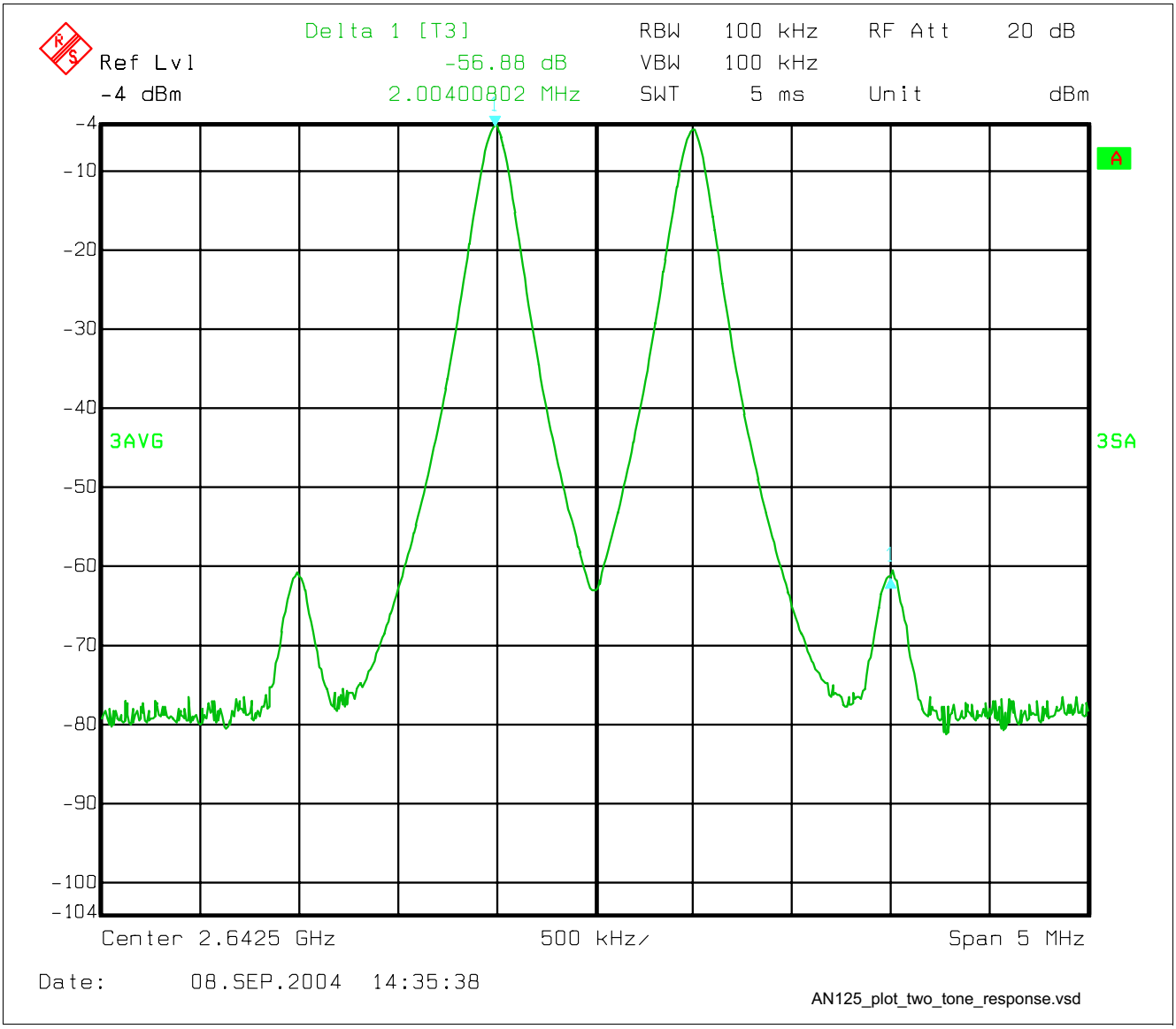

Figure 15 Tow-Tone Test, LNA Response