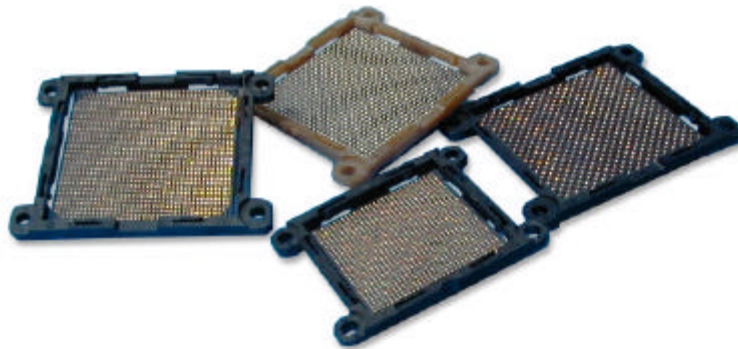




**cLGA<sup>®</sup> Socket**  
**Electrical Characterization Report**  
**0.05-5.05 GHz**



**Final Report**  
**Revision A1**  
**January 7, 2002**

**Testing Performed and Reported by:**

***Giga Test Labs***

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## Results Summary

A 1 millimeter centerline InterCon cLGA<sup>®</sup> socket was measured to determine its high-speed electrical performance and electrical characteristics.

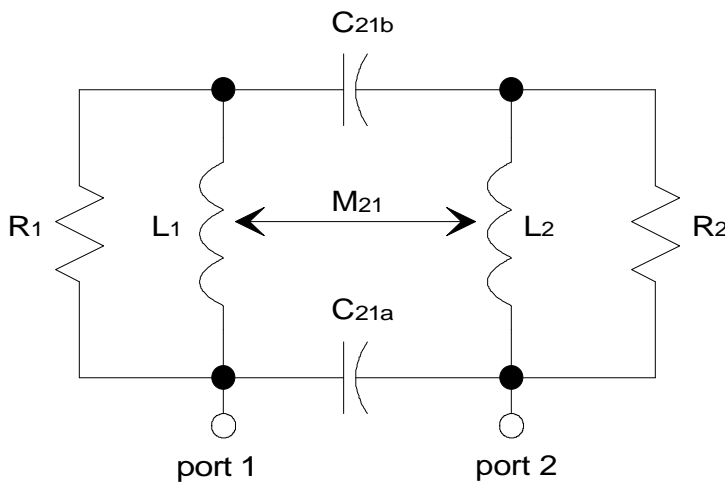
The loop-thru bandwidth of the socket was determined at several signal-to-ground ratios, as shown in Table 1:

Signal to Ground ratio	1 dB BW (GHz)
2:1	7.3
1:1	8.8
1:2	12.5
1:3	13.1
1:5	16.2

**Table 1 –  
S:G Ratio vs.  
1 dB Bandwidth**

The 1 dB bandwidth values shown above included the via lengths in the upper and lower test boards. The boards are shown in Figure 4.

An equivalent circuit model for the 1 millimeter centerline socket was also developed. The model is valid from DC to 5.05 GHz, and is shown in Figure 1:



**Figure 1 –  
Equivalent Circuit  
Model**

**Where:**

**L<sub>1</sub>, L<sub>2</sub>** are pin self-inductance (+/- 0.05 nH)

**M<sub>21</sub>** is mutual inductance between adjacent pins (+/- 0.01 nH)

**R<sub>1</sub>, R<sub>2</sub>** are the shunt-resistance of inductors L<sub>1</sub> and L<sub>2</sub>, used to model high-frequency loss due to skin effect and dielectric loss

**C<sub>21a</sub>** is the mutual-capacitance between adjacent pins (PCB side)

**C<sub>21b</sub>** is the mutual-capacitance between adjacent pins (LGA side)

For this model, the following values were determined, shown in Table 2:

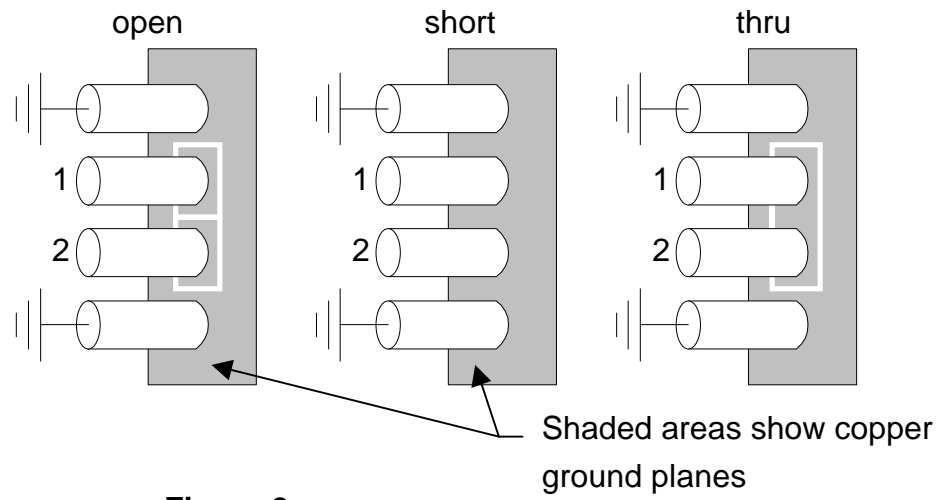
<b>Pins</b>	<b>L<sub>1</sub> &amp; L<sub>2</sub> (nH)</b>	<b>M<sub>21</sub> (nH)</b>	<b>R<sub>1</sub> &amp; R<sub>2</sub> (Ω)</b>	<b>C<sub>21a</sub> (pF)</b>	<b>C<sub>21b</sub> (pF)</b>
Field adjacent	0.73	0.07	1000	0.011	0.012
Edge	0.72	0.06	1000	0.015	0.018
Corner	0.80	0.07	1000	0.015	0.017
Field diagonal	0.73	0.01	1000	0.001	0.001

**Table 2 –  
Element Values**

A SPICE model is available upon request.

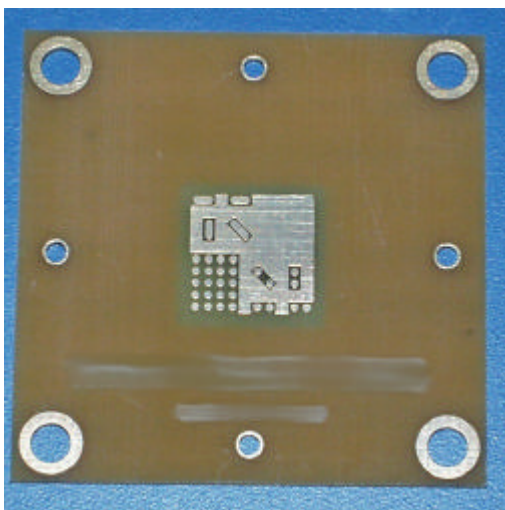
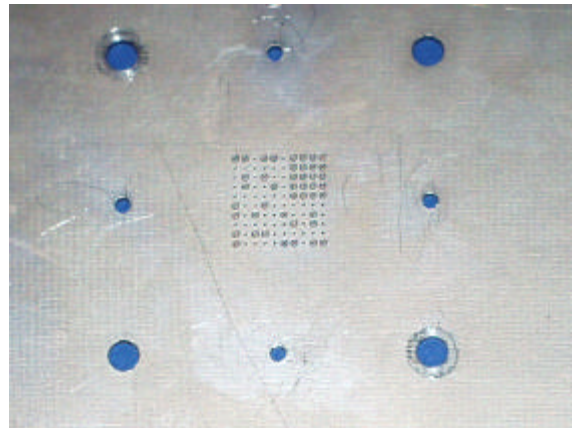
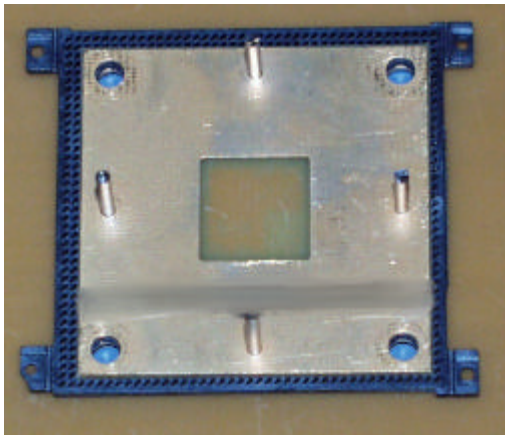
**Methodology**

The LGA socket was mounted onto a custom PCB, designed to exhibit low parasitics and allow the use of coplanar probes. A second PCB (called a surrogate package) with measurement standard patterns was mounted above each socket. This allows pins to be measured under three conditions: open, shorted and thru (see Figure 2).



**Figure 2-  
Measurement Configurations**

Pictures of the fixture and surrogate package are shown in Figure 3.



**Figure 3 –  
Assembled test fixture  
(above left), test board  
(above right), and  
surrogate package (left)**

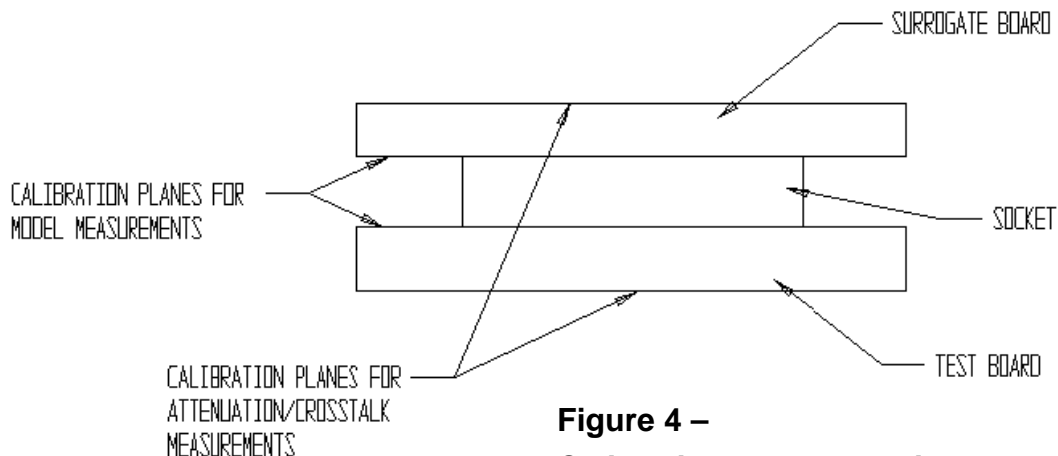
Agilent ADS 1.5 (Advanced Design System) software was used to extract an equivalent-circuit model, which is SPICE compatible.

### Measurement system

All measurements were taken using a high-frequency measurement system. This consists of a Hewlett-Packard 8510C network analyzer & GGB Picoprobes™ 450 m pitch. The HP 8510C network analyzer is a frequency domain instrument. The measurements are taken as scattering parameters (a.k.a. s-parameters). The HP8510C has great calibration capabilities, which make it the most accurate high-frequency instrument available. For this work the short-open-load-thru (SOLT) calibration was used. The GGB Picoprobes provide a high-quality 50 Ω path from the network analyzer and cables to the DUT. After the SOLT calibration, the measurement reference plane will be located at the probe tips.

### Equivalent-circuit model

Figure 2 shows the topology used to model the LGA socket. By de-embedding the response of the fixture and surrogate, the reference plane for the model is shifted to the top and bottom surfaces of the socket. Figure 4 shows the locations of the reference planes for the model, and also for the bandwidth/attenuation measurements shown in Table 1. The equivalent circuit model for the socket is shown in Figure 1.



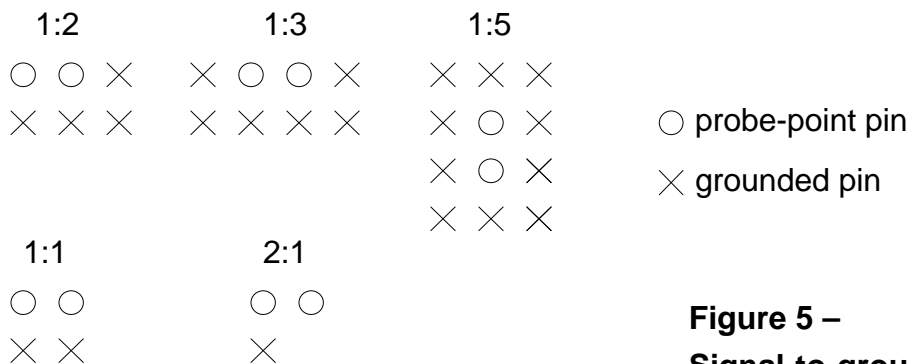
**Figure 4 –  
Calibration Plane Locations**

## Element values

Element values for the equivalent circuit model shown in Figure 1 are shown in Table 2. The 1mm LGA socket model is valid from DC to 5.05 GHz. The measured and modeled transmission response agrees within 0.1 dB. Models were extracted for four types of pins: field adjacent pins, field diagonal pins, edge pins and corner pins.

## Bandwidth Measurements

Bandwidth values were determined for several signal-to-ground ratios, as shown in Figure 5. Bandwidth values at a 1 dB loss for these signal-to-ground ratios are shown in Table 1.



**Figure 5 –  
Signal-to-ground ratio  
footprints**

The bandwidths at these signal-to-ground ratios were determined from a loop-thru measurement on two adjacent pins, indicated as ‘probe-point pins’ in Figure 5. The calibration planes used for these measurements were on the outer sides of the test boards, as shown in Figure 4. This calibration plane location means that test board thickness and test board via lengths were included in the bandwidth/attenuation measurements.

The bandwidth measurements for all signal-to-ground ratios in Figure 5 are shown in Table 1. The measured data and conceptual diagrams for these

different ratios studied are found in the appendix. The model bandwidth is DC to 5.05 GHz, which will easily accommodate signals with 200 picosecond edges.



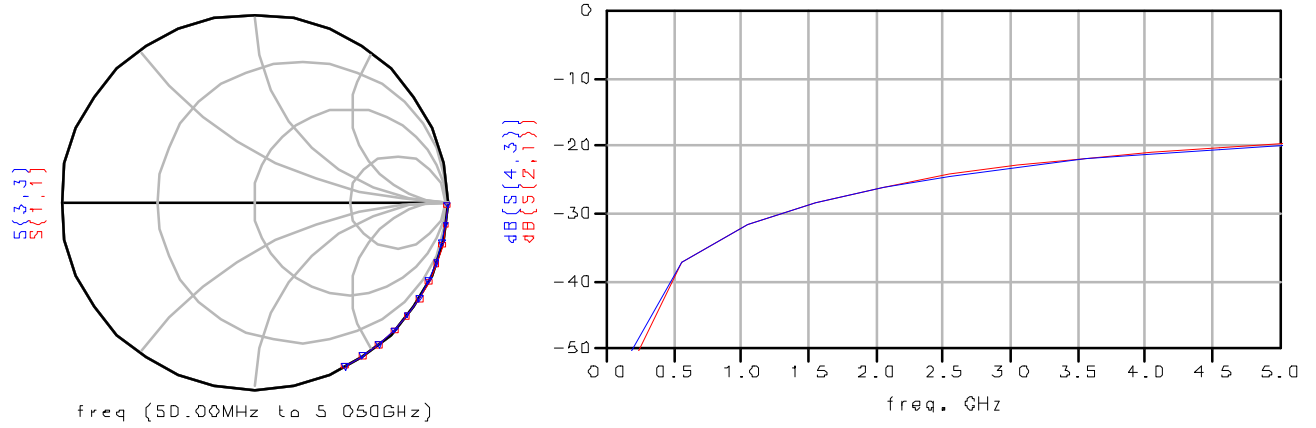
## Appendix

The appendix shows the measured and simulated output data.

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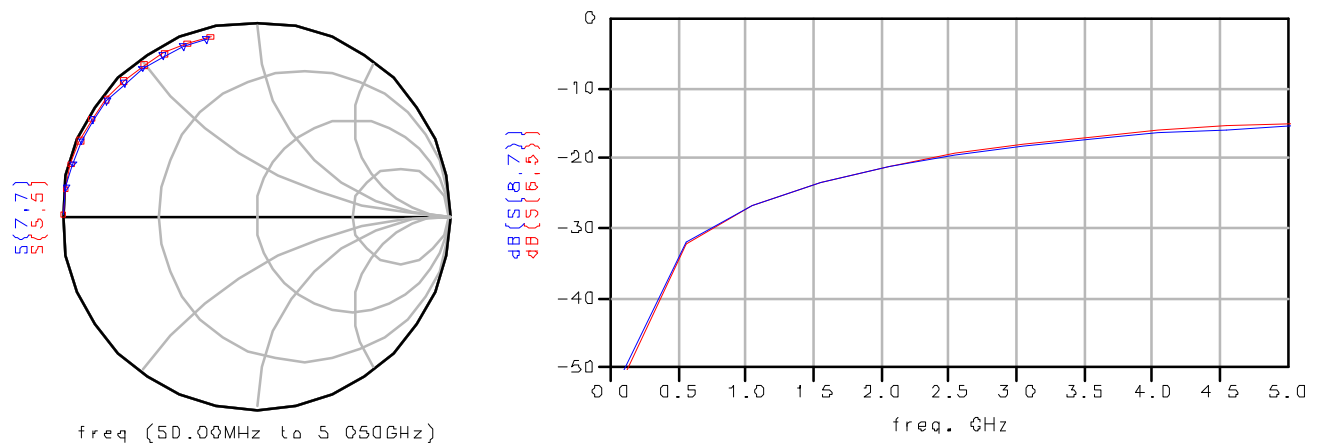
### Adjacent Open Response (1:5 S/G ratio)

Measured response (blue) versus Simulated response (red)



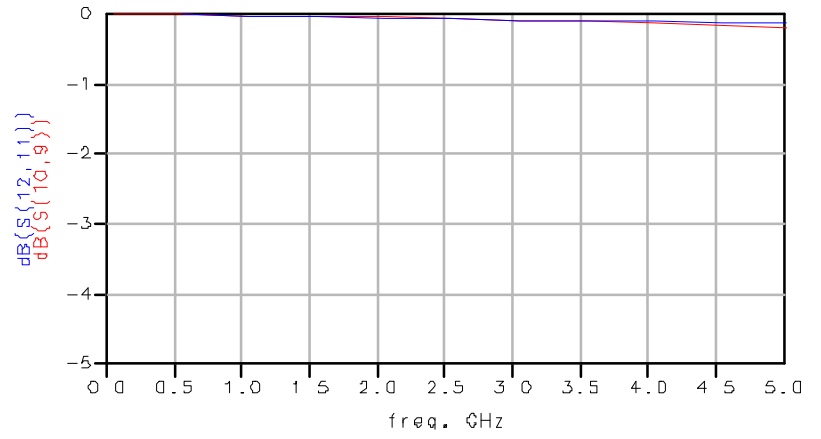
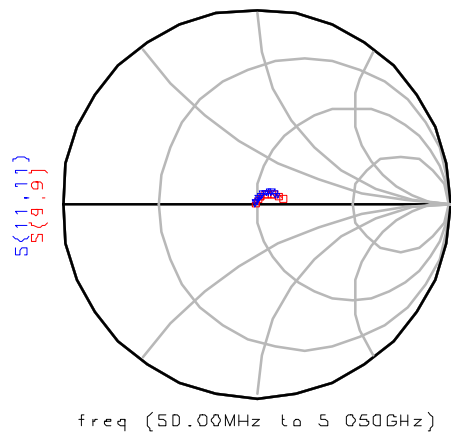
### Adjacent Short Response (1:5 S/G ratio)

Measured response (blue) versus Simulated response (red)

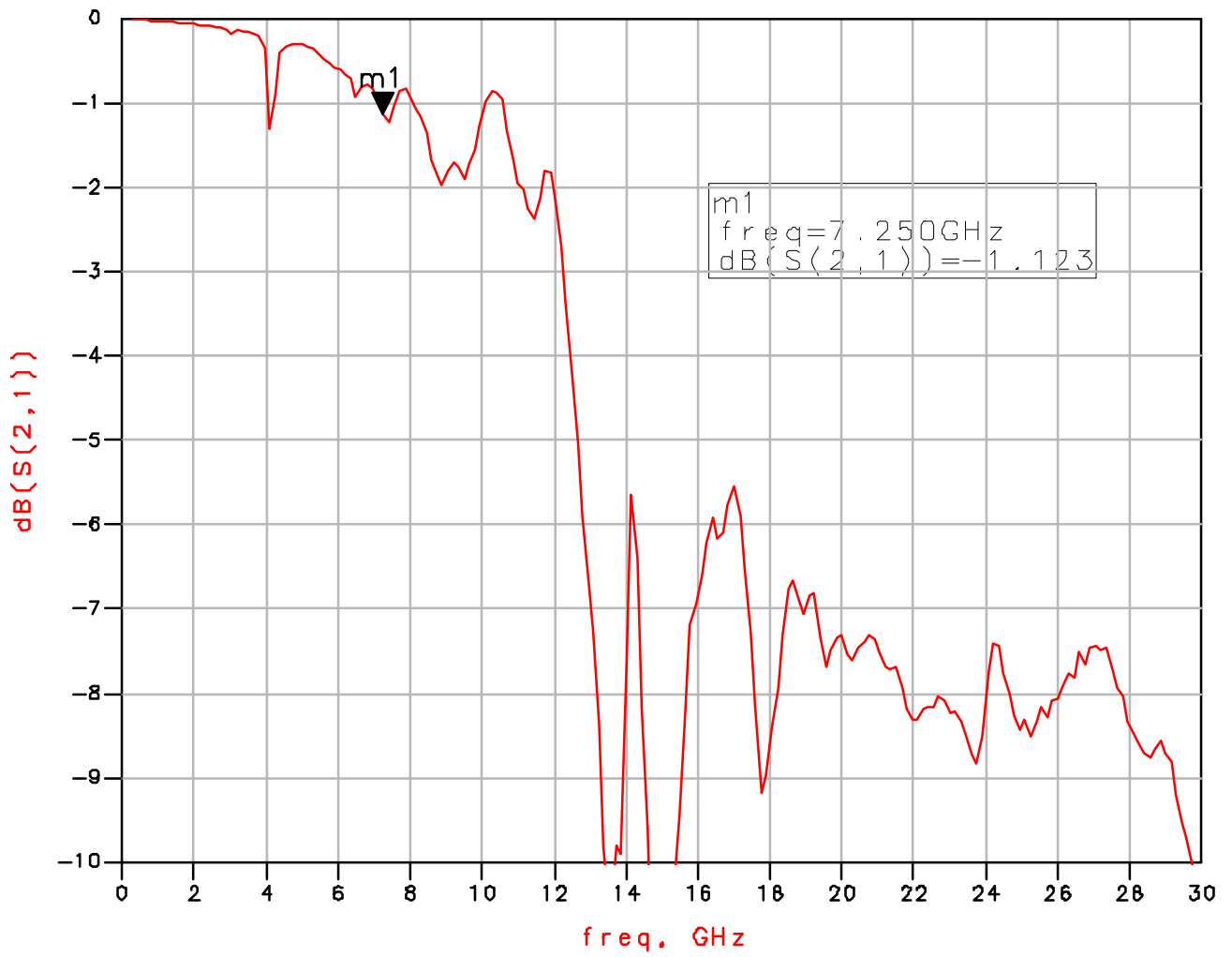


# Adjacent Loop-Thru response (1:5 S/G ratio)

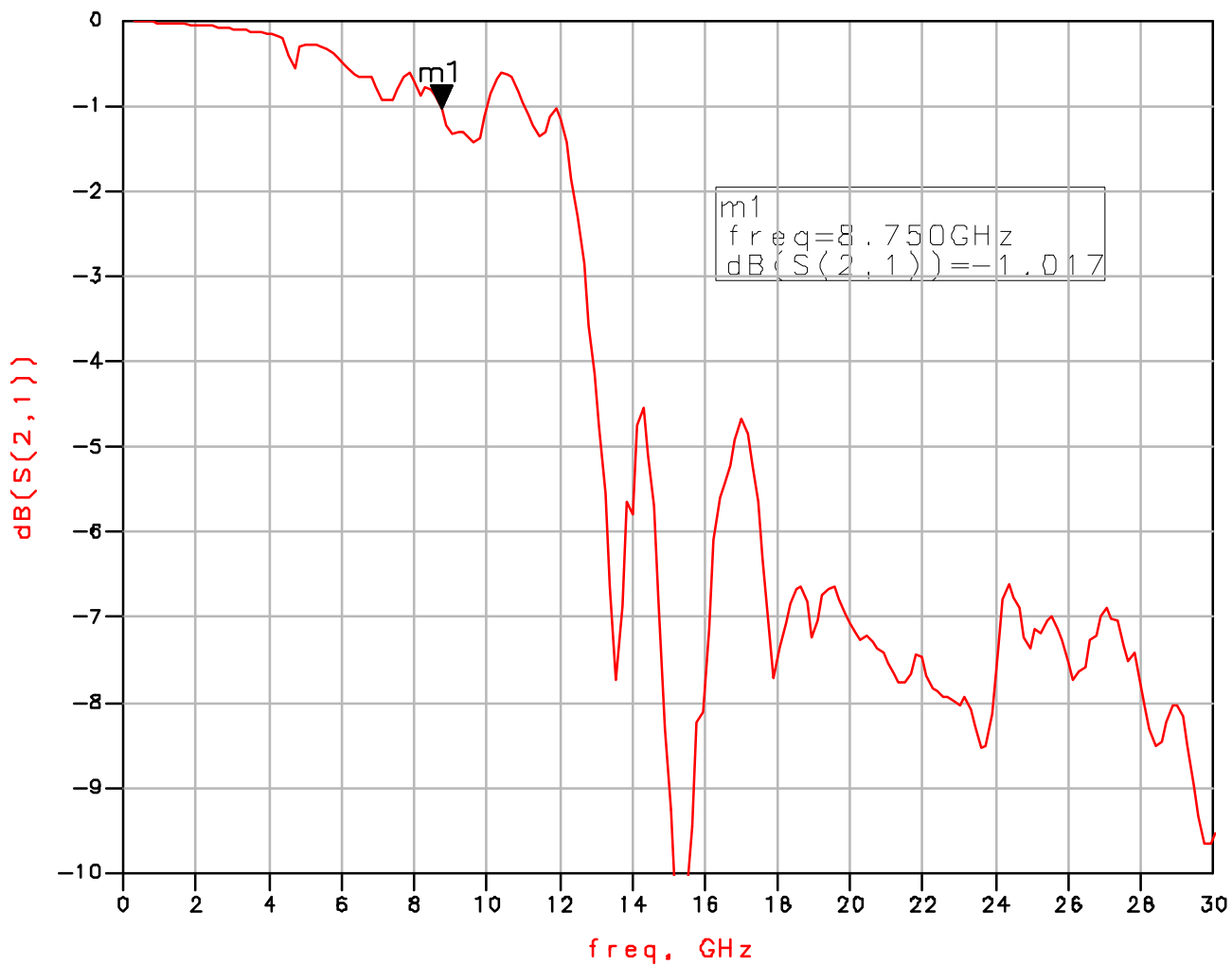
Measured response (blue) versus Simulated response (red)



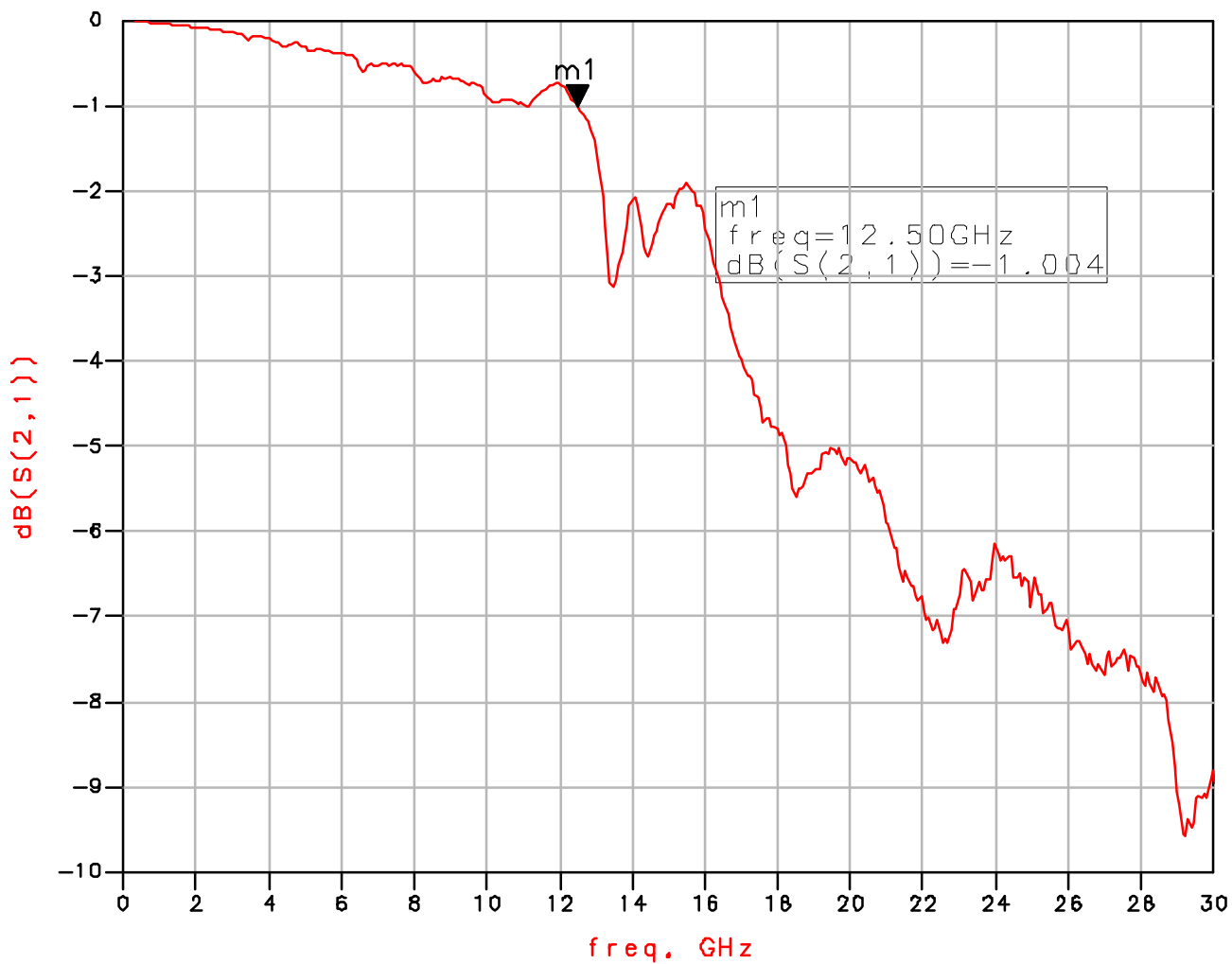
# Loop-Thru Bandwidth Measurement for 2:1 S/G ratio



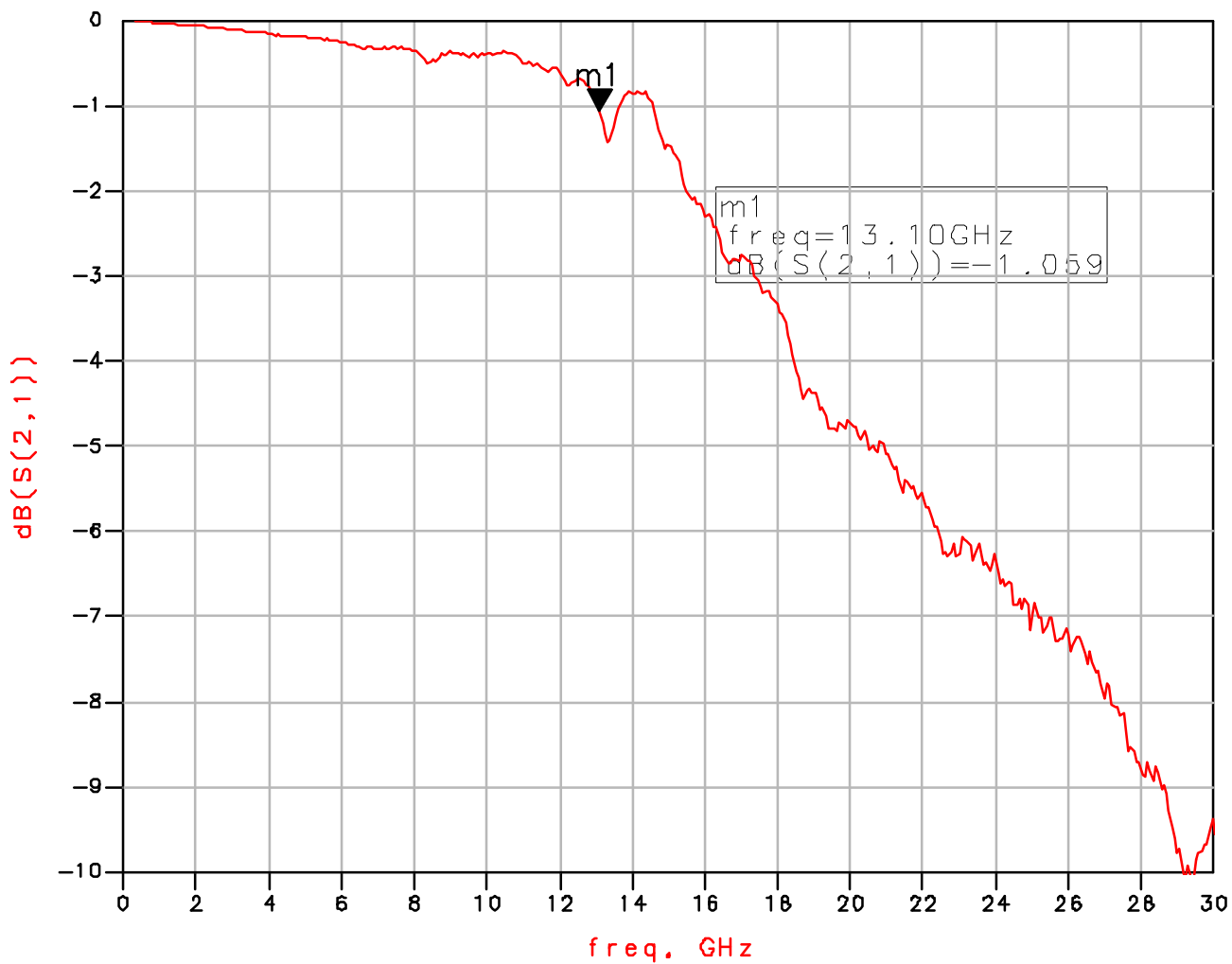
# Loop-Thru Bandwidth Measurement for 1:1 S/G ratio



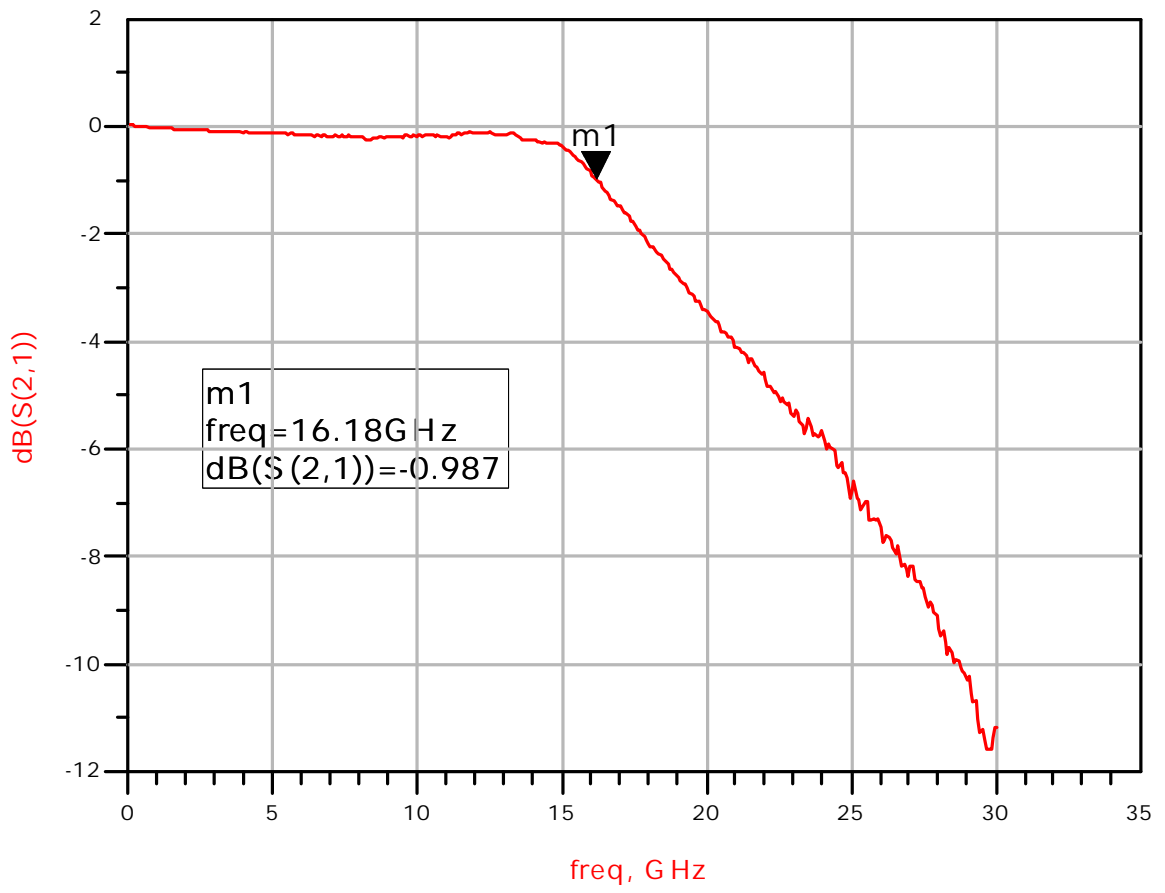
# Loop-Thru Bandwidth Measurement for 1:2 S/G ratio



# Loop-Thru Bandwidth Measurement for 1:3 S/G ratio



# Loop-Thru Bandwidth Measurement for 1:5 S/G ratio





## Revisions:

<b>Revision</b>	<b>Date</b>	<b>Description</b>
A	1/2/02	Released
A1	1/7/02	Added notes to Figure 2; added tolerances to values under Table 1; added revision table