Ironwood Electronics

SG-7000 series 0.5mm thick elastomer

0.40 mm pitch

Measurement and Model Results

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Table of Contents

Objective

The objective of these measurements is to determine the RF performance of a SG-7000 series 0.5mm thick elastomer in a 0.40 mm pitch array. For G-S-G configurations, a signal pin surrounded by grounded pins is selected for the signal transmission. For the G-S-S-G configuration, two adjacent pins are used for signal and all other pins are grounded. Measurements in both frequency and time domain form the basis for the evaluation. Parameters to be determined are pin capacitance and inductance of the signal pin, the mutual parameters, the propagation delay and the attenuation to a maximum frequency of 40 GHz.

Methodology

Capacitance and inductance for the equivalent circuits were determined through a combination of measurements in time and frequency domain. Frequency domain measurements were acquired with a network analyzer (Agilent 8722). The instrument was calibrated up to the end of the 0.022" diameter coax probes that are part of the test fixturing. The device under test (DUT) was then mounted to the fixture and the response measured from one side of the contact array. When the DUT pins terminate in an open circuit, a capacitance measurement results. When a short circuit compression plate is used, inductance can be determined.

Time domain measurements are obtained via Fourier transform from VNA tests. These measurements reveal the type of discontinuities at the interfaces plus contacts and establish bounds for risetime and clock speeds.

Test procedures

To establish capacitance of the signal pin with respect to the rest of the array, a return loss calibration is performed. Phase angle information for S11 is selected and displayed. When the array is connected, a change of phase angle with frequency can be observed. It is recorded and will be used for determining the pin capacitance.

The self-inductance of a pin is found in the same way, except the contact array is compressed by a metal plate instead of an insulator. Thus a short circuit at the far end of the pin array results. Again, the analyzer is calibrated and S11 is recorded. The inductance of the connection can be derived from this measurement.

Setup

Testing was performed with a test setup that consists of a brass plate that contains the coaxial probes. The DUT is aligned and mounted to that plate. The opposite termination is also a metal plate with coaxial probes, albeit in the physical shape of an actual device to be tested or a flat plate with embedded coaxial probes.

Figs. 1 and 2 show a typical arrangement base plate and DUT probe:

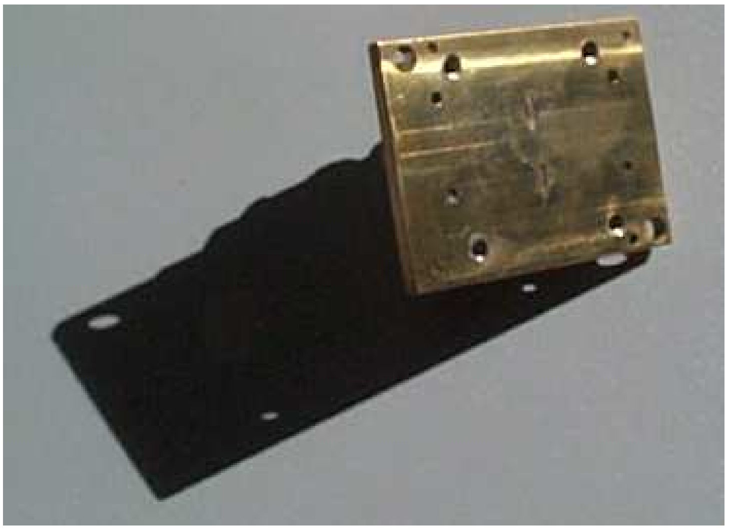


Figure 1 base plate example

Figure 2 DUT plate

The contact housing and base plate as well as the DUT plate are then mounted in a test fixture as shown below in Fig. 3:

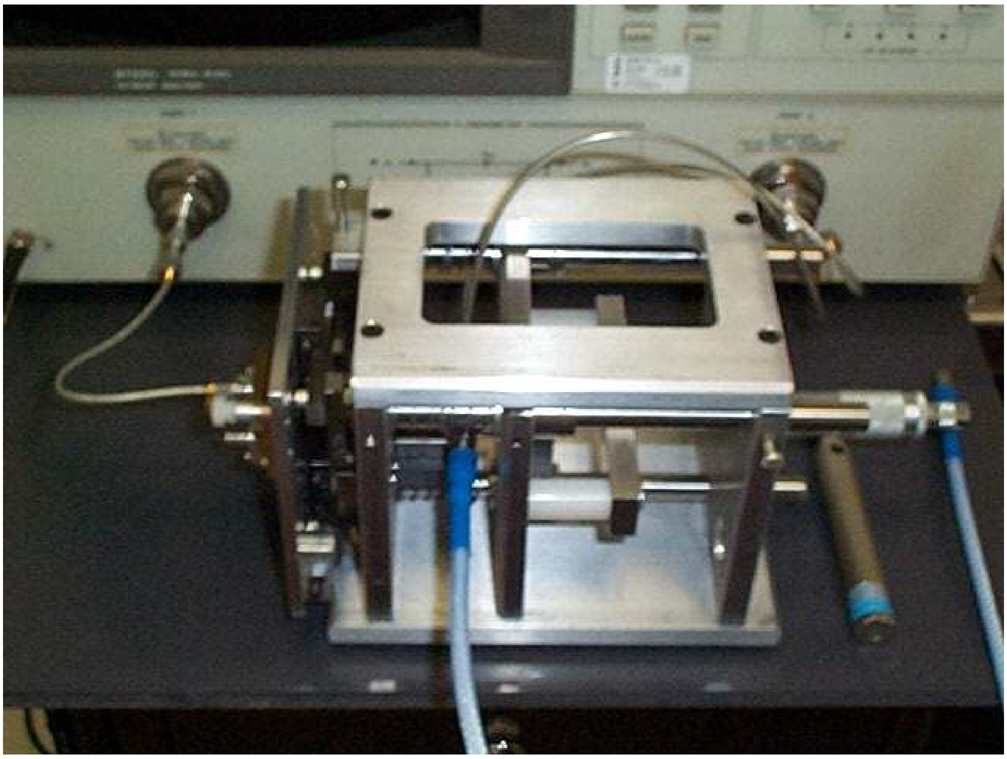
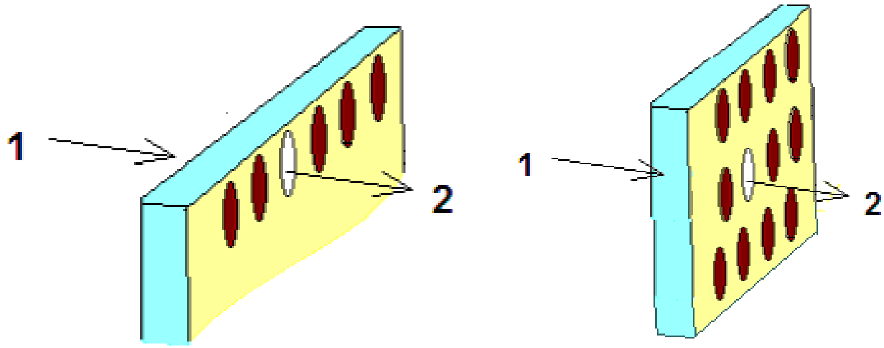


Figure 3 Test fixture

This fixture provides for independent X,Y and Z control of the components relative to each other. X, Y and angular alignment is established once at the beginning of a test series and then kept constant. Z (depth) alignment is measured via micrometer and is established according to specifications for the particular DUT.

Connections to the VNA are made with high quality coaxial cables with K connectors.

For G-S-G and G-S-S-G measurements, the ports are named as follows:



Single row DUTs

Multi-row DUTS

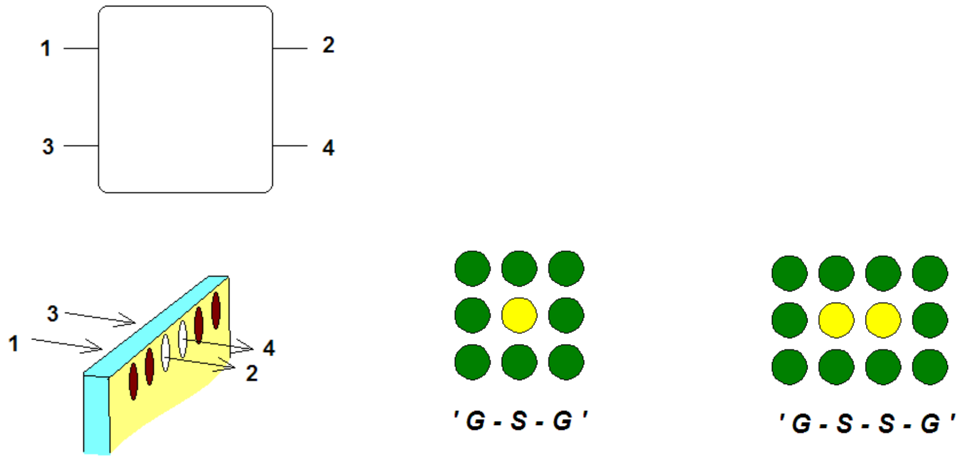


Figure 4 Ports for the G-S-G and G-S-S-G measurements

Signals are routed though two adjacent connections (light areas), unused connections are grounded (dark areas).

Measurements G-S-G

Time domain

The time domain measurements will be presented first. TDR reflection measurements are shown below:

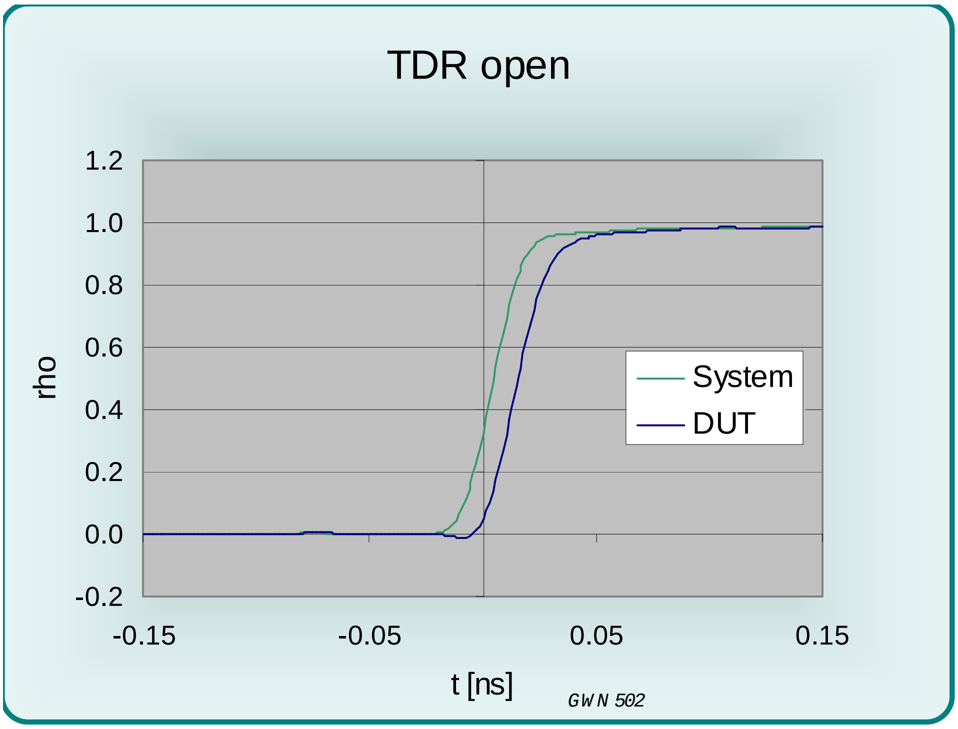


Figure 5 TDR signal from an OPEN circuited contact

The reflected signal from the contact array (right trace) shows only a small deviation in shape from the original waveform (left trace). The risetime is about 30.0 ps and is almost the same as that of the system with the open probe (27.0 ps). Electrical open circuit pin length is about 5.2 ps (one way).

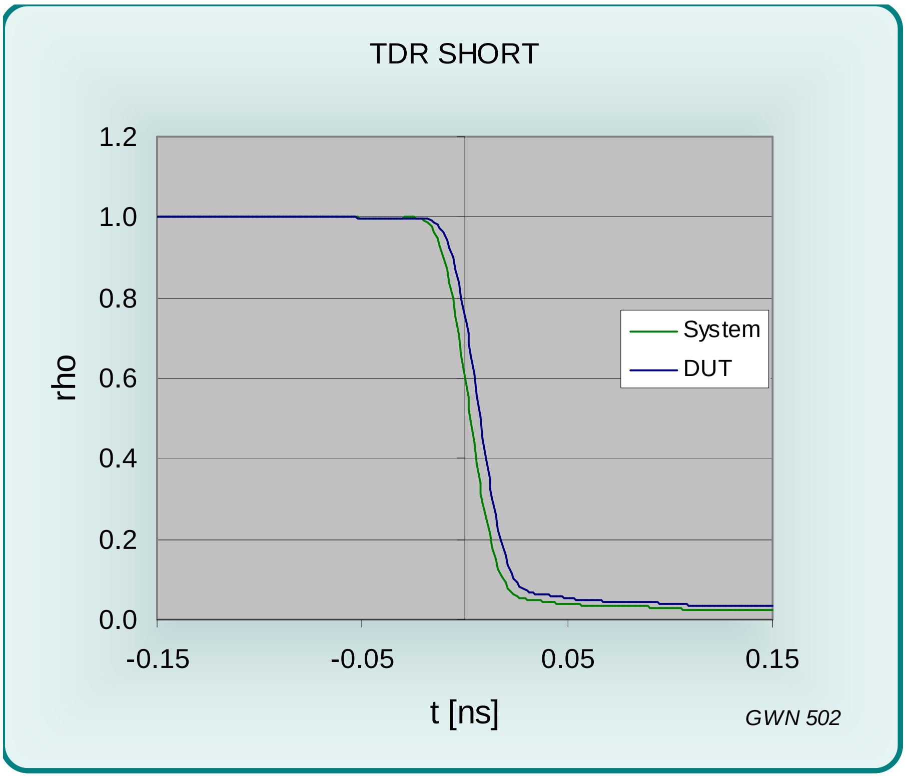


Figure 6 TDR signal from a SHORT circuited contact

For the short circuited contact array the fall time is about 28.5 ps. There is no increase over the system risetime of 28.5 ps caused by the contact impedance levels.

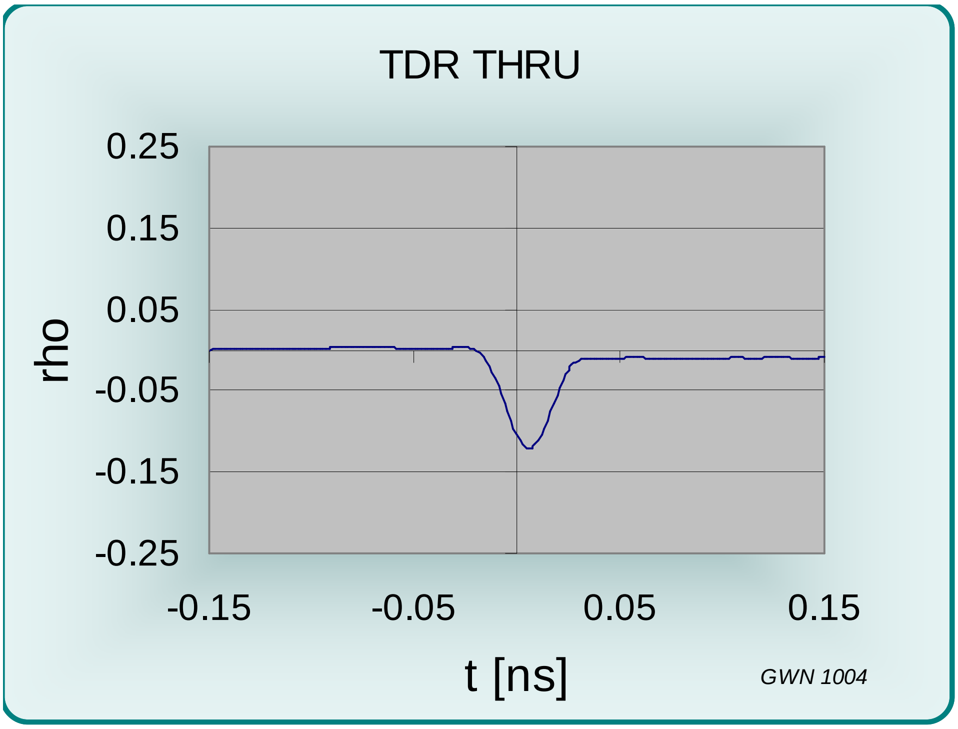


Figure 7 TDR measurement into a 50 Ohm probe

The thru TDR response shows primarily no significant perturbation to the signal. The peak corresponds to an impedance of 50.5 Ohms and is almost the same as 50 Ohms. The dip below the 0 line goes to 39.2 Ohms.

The TDT performance for a step propagating through the contact arrangement was also recorded:

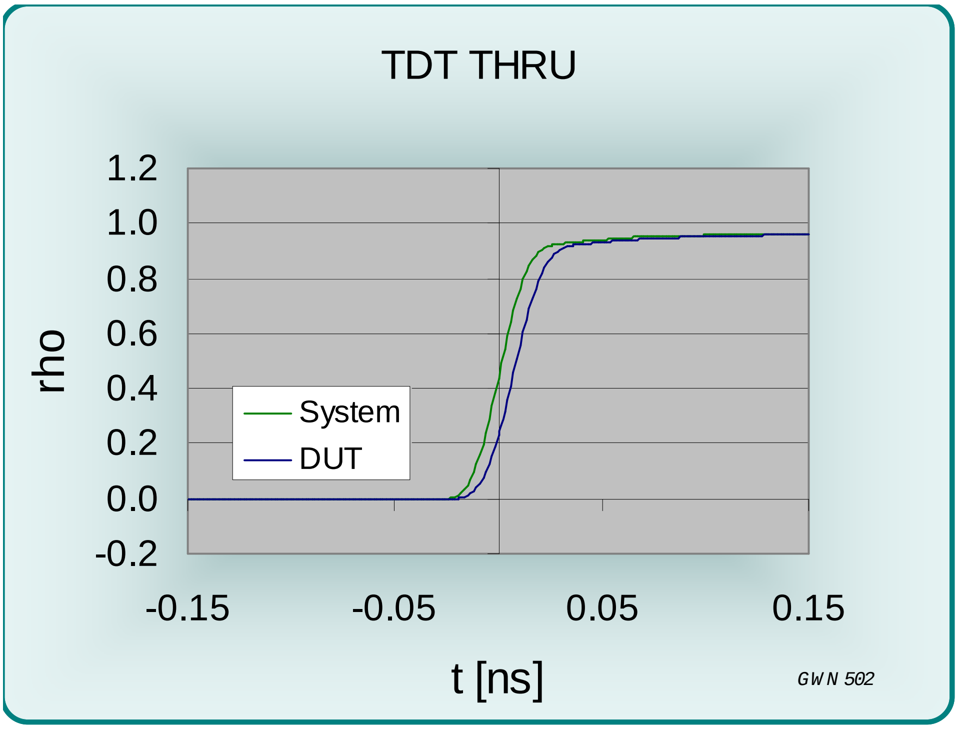


Figure 8 TDT measurement

The TDT measurements for transmission show almost the same risetime from the pin array (10-90% RT = 31.5 ps, the system risetime is 28.5 ps). The added delay at the 50% point is 7.5 ps. There is a small plateau because of the low impedance level. If the 20%-80% values are extracted, the risetime is only 19.5 ps vs. 19.5 ps system risetime.

Frequency domain

Network analyzer reflection measurements for a single sided drive of the signal pin with all other pins open circuited at the opposite end were performed to determine the pin capacitance. The analyzer was calibrated to the end of the probe and the phase of S11 was measured. From the curve the capacitance of the signal contact to ground can be determined (see Fig. 10).

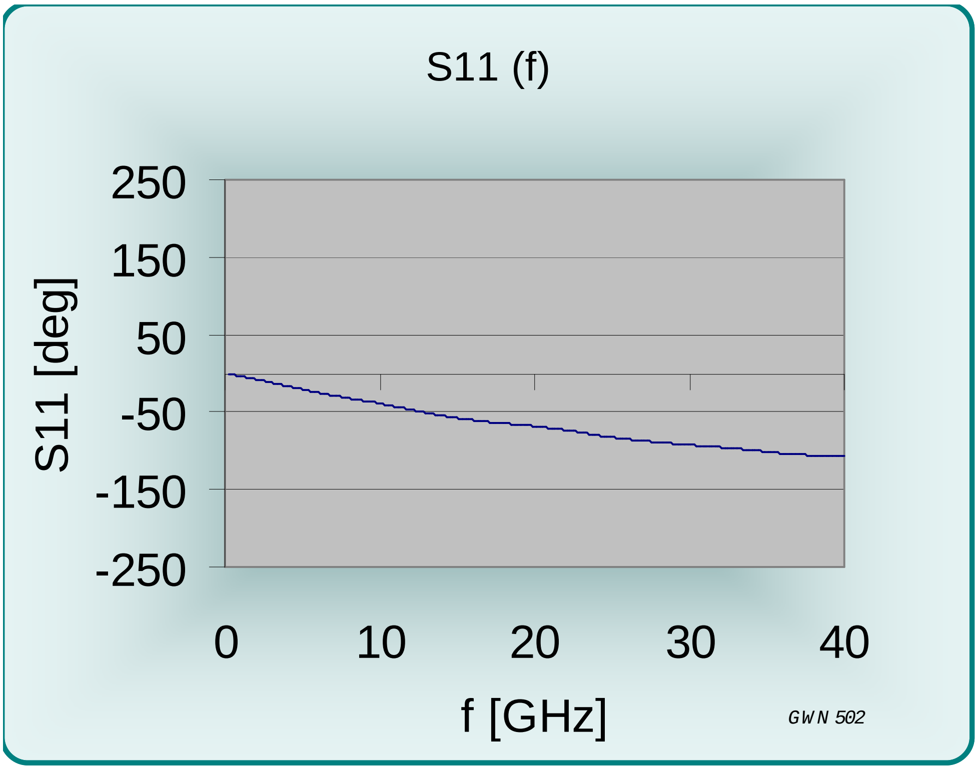


Figure 9 S11 phase (f) for the open circuited signal pin

There are no aberrations in the response.

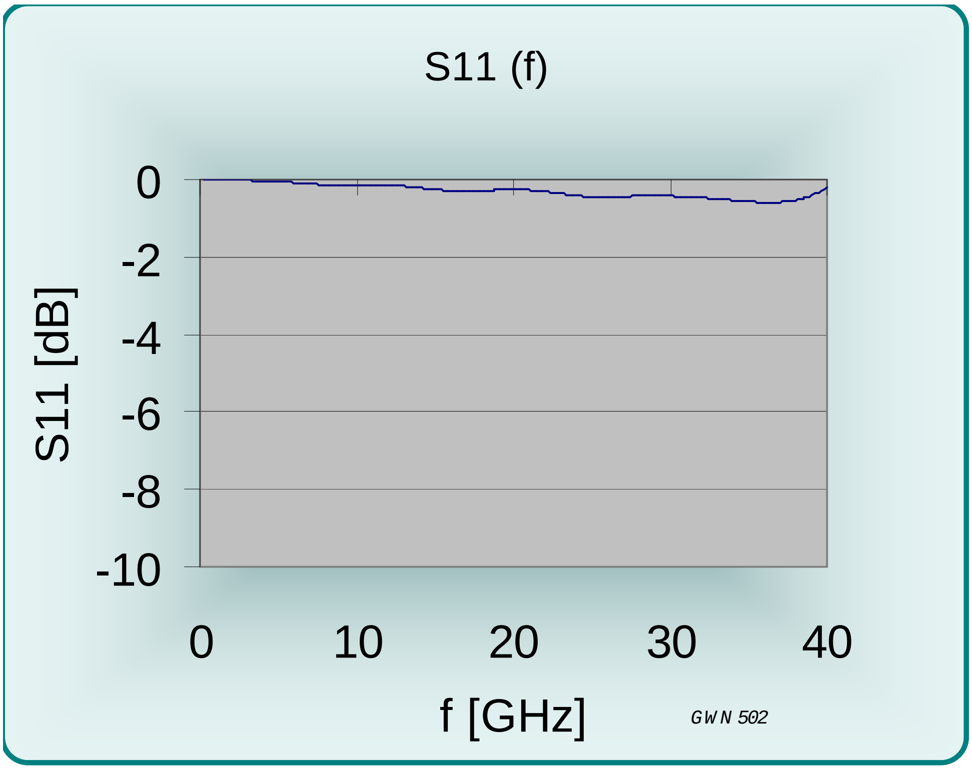


Figure 10 S11 magnitude (f) for the open circuited signal pin

While ideally the magnitude of S11 should be unity (0 dB), minimal loss and radiation in the contact array are likely contributors to S11 (return loss) for the open circuited pins at elevated frequencies.

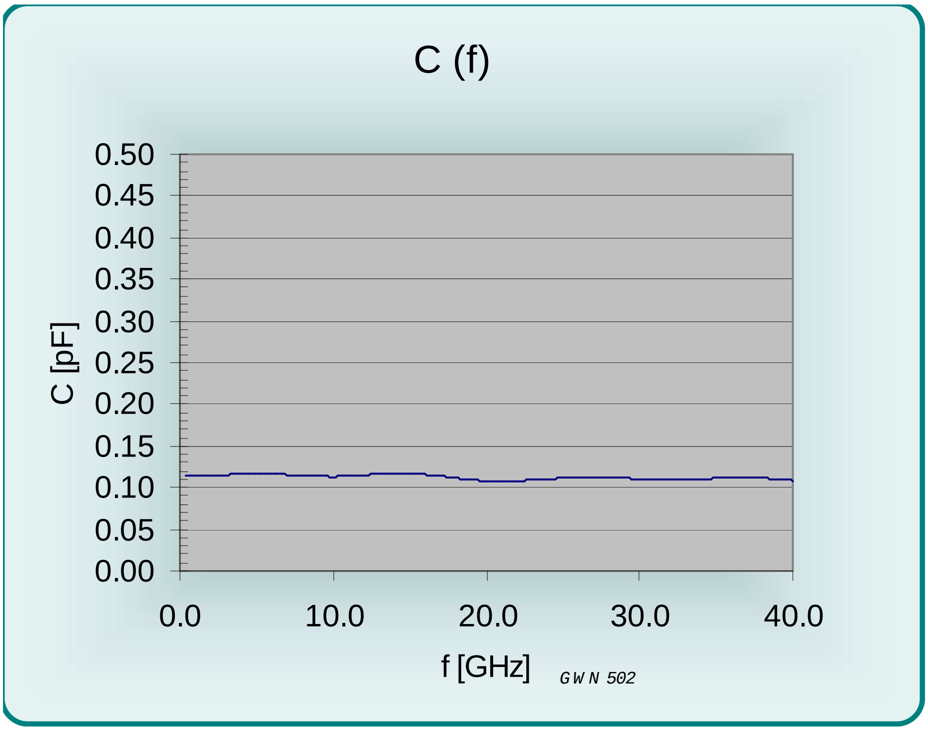


Figure 11 C(f) for the open circuited signal pin

Capacitance is 0.11 pF at low frequencies.

The Smith chart measurement for the open circuit shows no resonances. A small amount of loss is present. The Smith chart covers frequencies to 40 GHz.

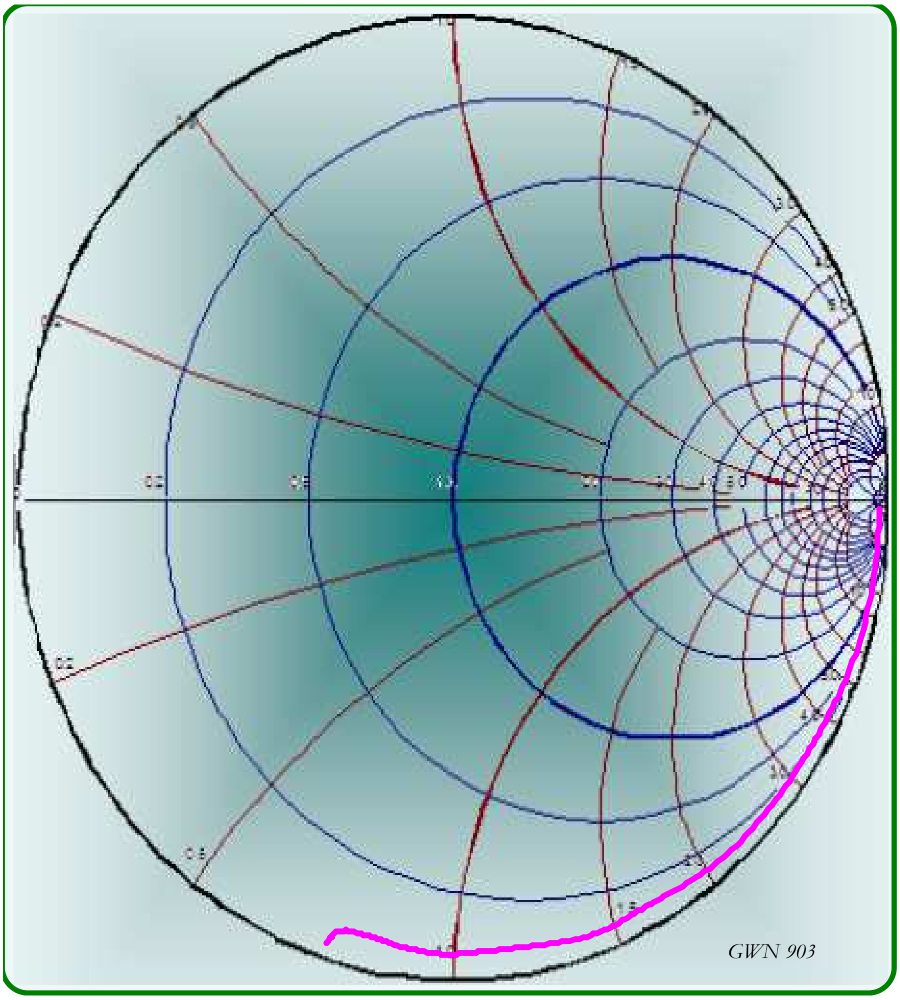


Figure 12 Reflections from the open circuited contacts

To extract pin inductance, the same types of measurements were performed with a shorted pin array. Shown below is the change in reflections from the shorted contact array. Calibration was established with a short placed at the end of the coax probe.

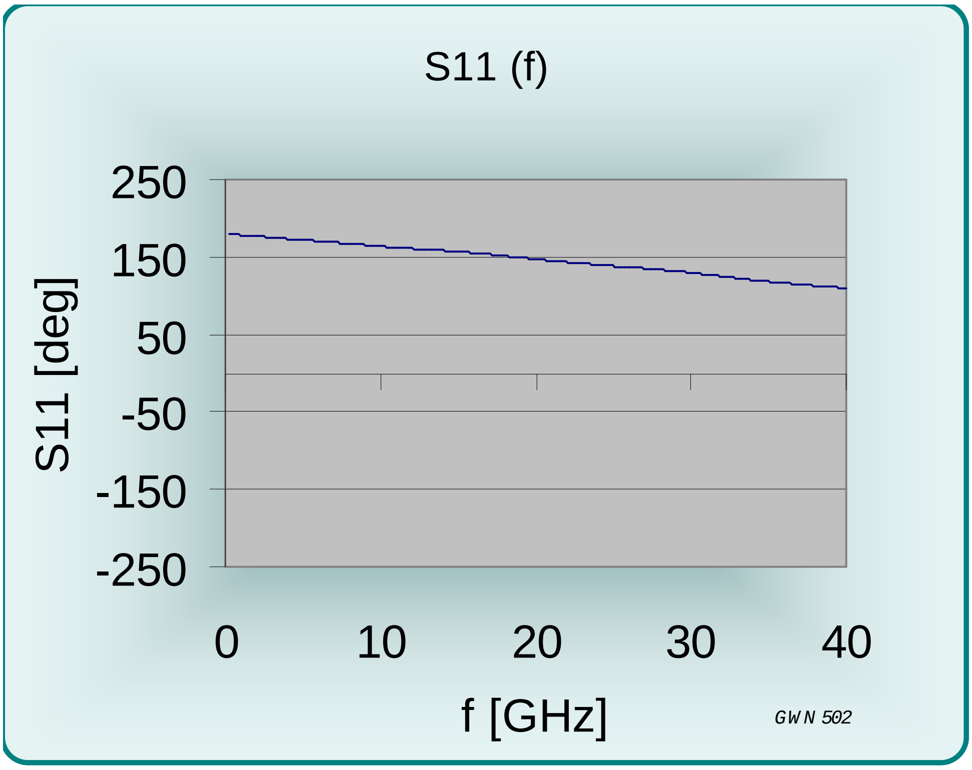


Figure 13 S11 phase (f) for the short circuited case

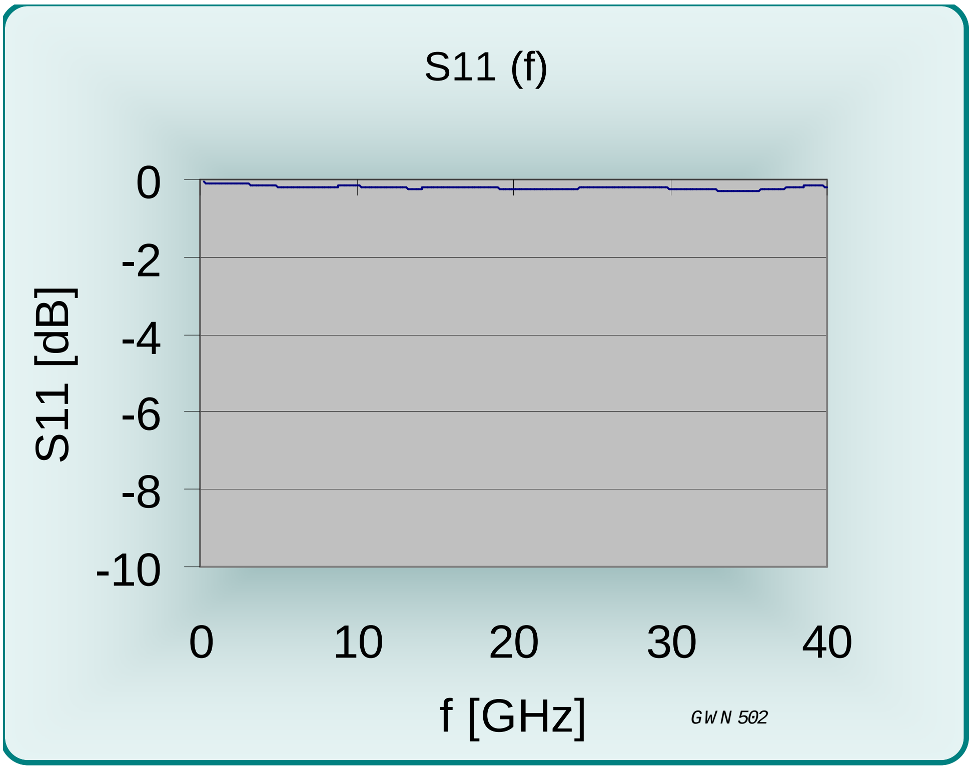


Figure 14 S11 magnitude (f) for the short circuited case

A small S11 return loss exists, likely the result of minimal loss and radiation.

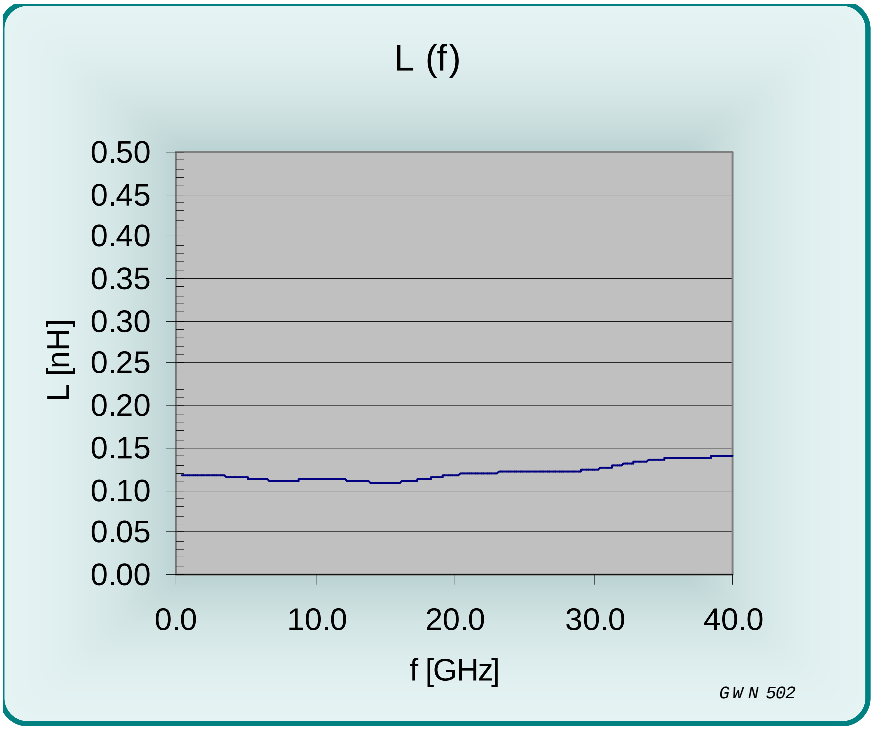


Figure 15 L(f) for the contact

The phase change corresponds to an inductance of 0.12 nH at low frequencies. Toward 30 GHz inductance increases. At these frequencies, the transmission line nature of the arrangement must be taken into account.

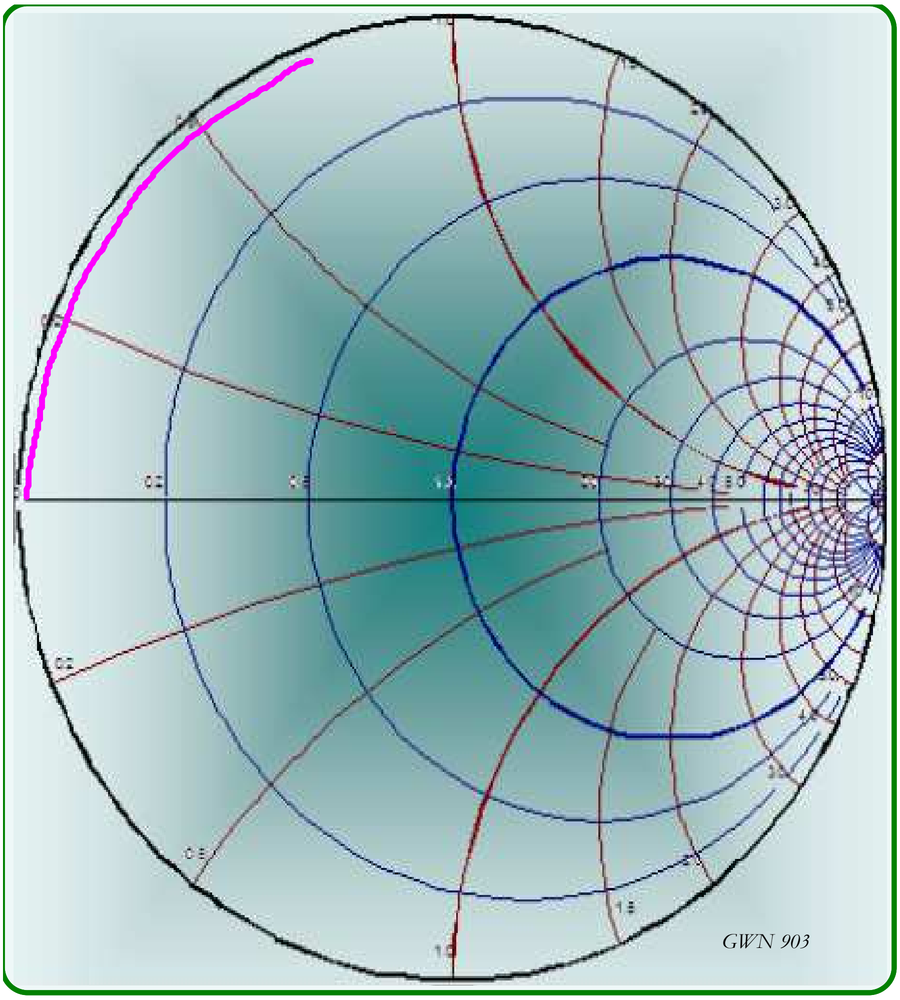


Figure 16 Short circuit response in the Smith chart

Only a small amount of loss is noticeable in the Smith chart for the short circuit condition. The Smith chart covers frequencies to 40 GHz.

An insertion loss measurement is shown below for the frequency range of 50 MHz to 40 GHz:

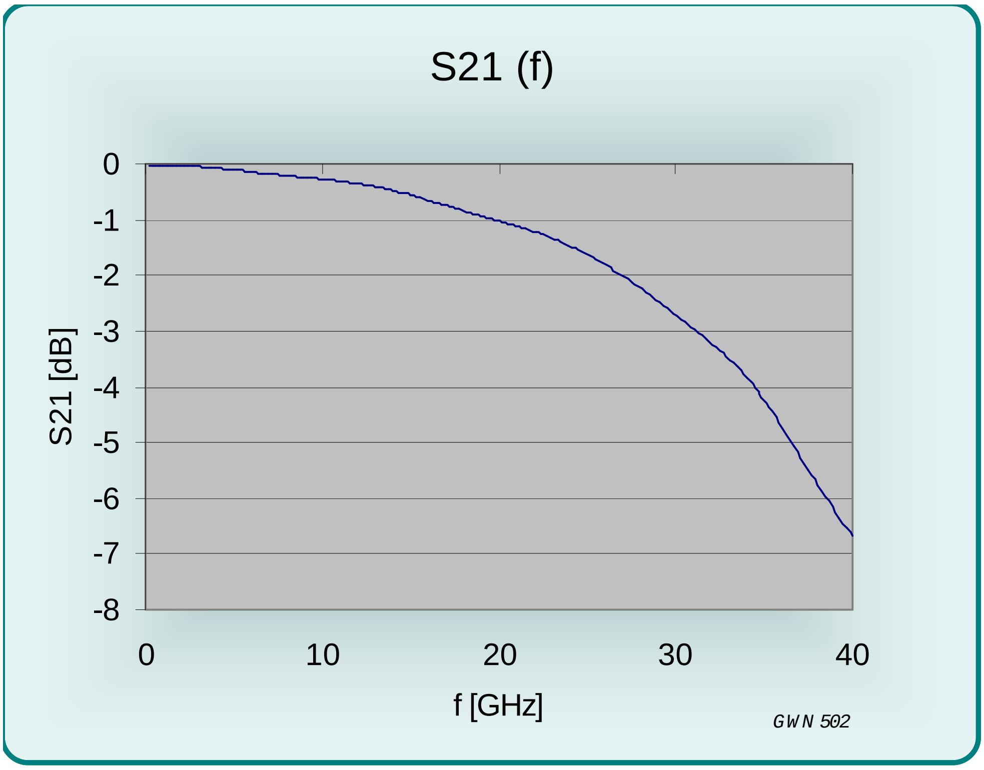


Figure 17 Insertion loss S21 (f)

Insertion loss is less than 1 dB to about 19.7 GHz. The 3 dB point is not reached before 31.1 GHz.

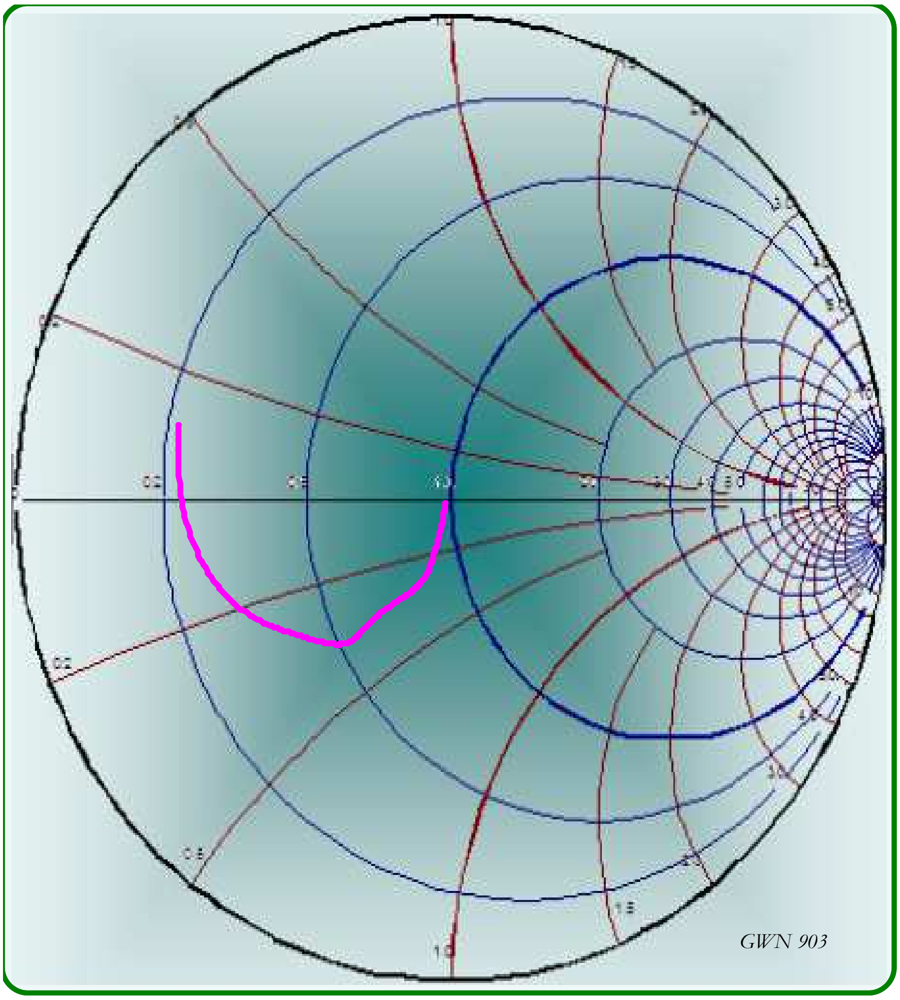


Figure 18 Smith chart for the thru measurement into a 50 Ohm probe

The Smith chart for the thru measurements shows reactive components toward higher frequencies. The Smith chart covers frequencies to 40 GHz.

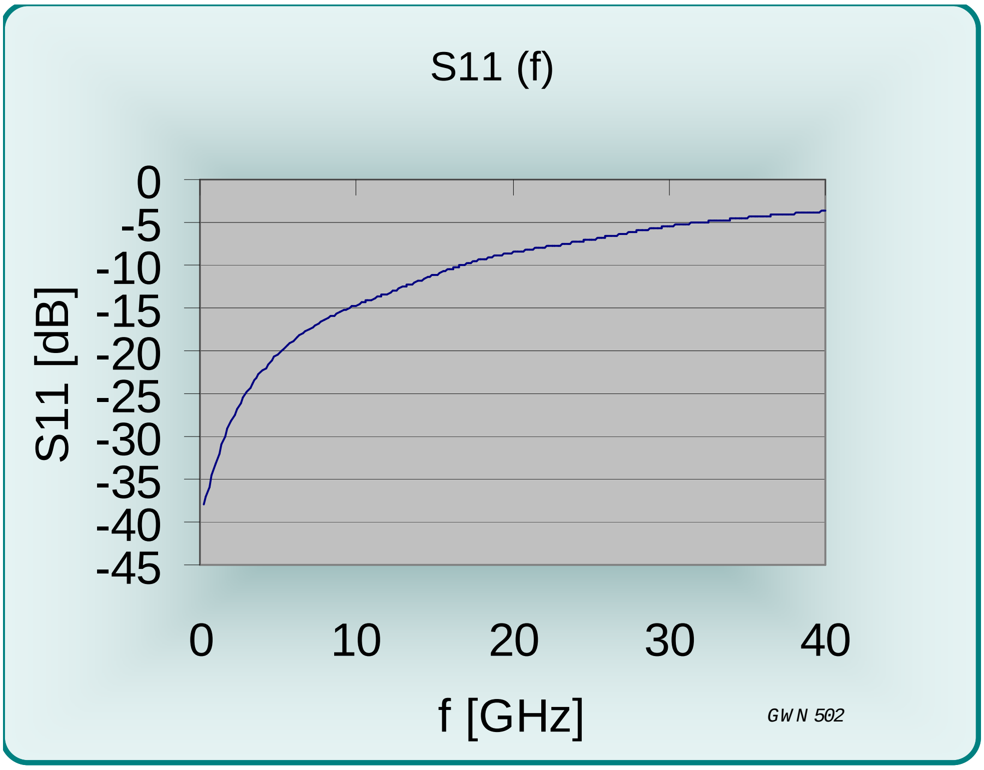


Figure 19 S11 magnitude (f) for the thru measurement into a 50 Ohm probe

The value of the return loss reaches -20 dB at a frequency of 5.2 GHz and -10 dB not before 16.7 GHz.

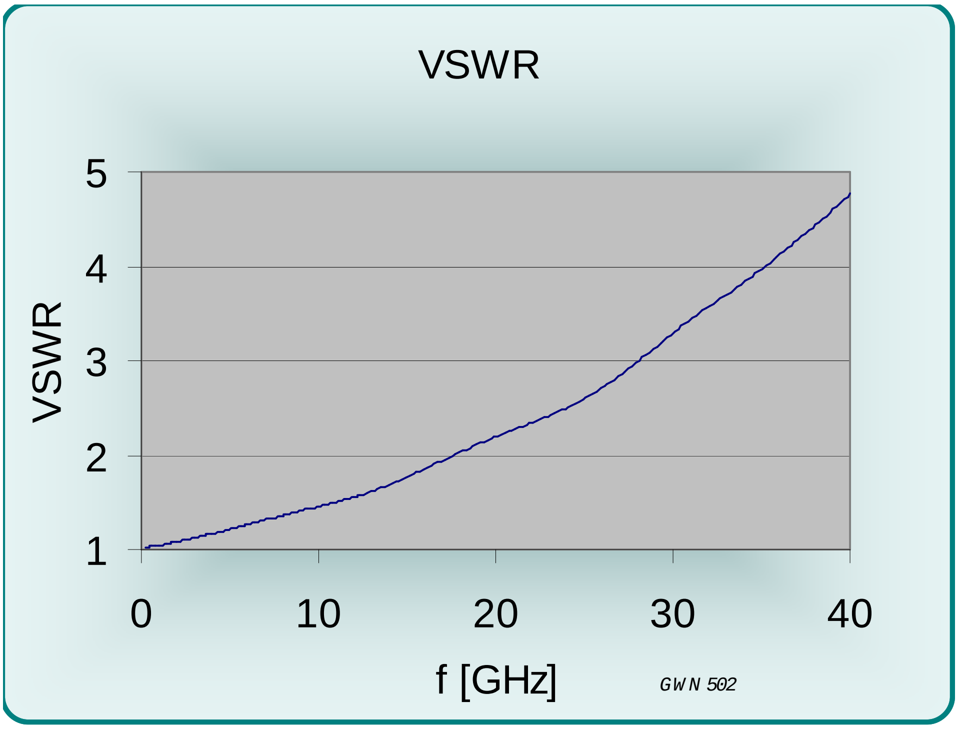


Figure 20 Standing wave ratio VSWR (f) [1 / div.]

The VSWR remains below 2 : 1 to a frequency of 17.5 GHz.

Crosstalk was measured in the G-S-S-G configuration by feeding the signal pin and monitoring the response on an adjacent pin. Measurement results can be found in the section on the G-S-S-G configuration.

The mutual capacitance and inductance values will be extracted from G-S-S-G models and are also listed in that section.

Measurements G-S-S-G

Time domain

G-S-S-G time domain measurements will be presented first. A TDR reflection measurement is shown in Fig. 21 for the thru case at port 1 to port 2:

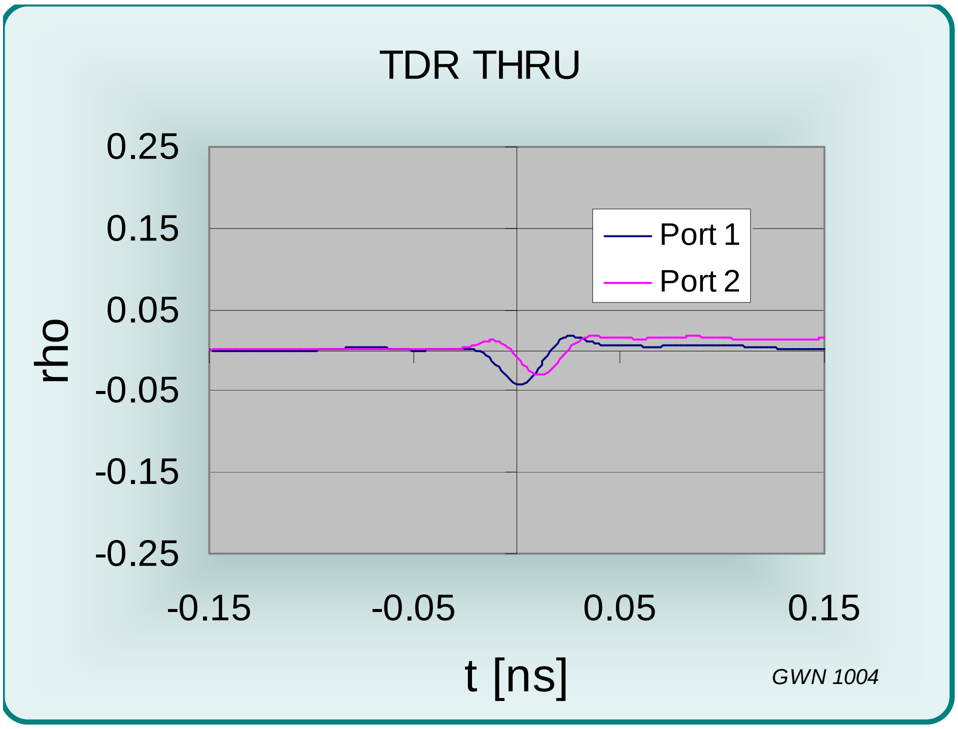


Figure 21 TDR through DUT into a terminated probe

The thru TDR measurement from port 1 to port 2 shows both capacitive and inductive responses. The low peak corresponds to a transmission line impedance of 46.0 Ohms. This is almost the same as the system impedance and higher than in the G-S-G case due to the fact that the connection adjacent to the signal pin is not grounded.

The TDT performance for a step propagating through the G-S-S-G pin arrangement was also recorded:

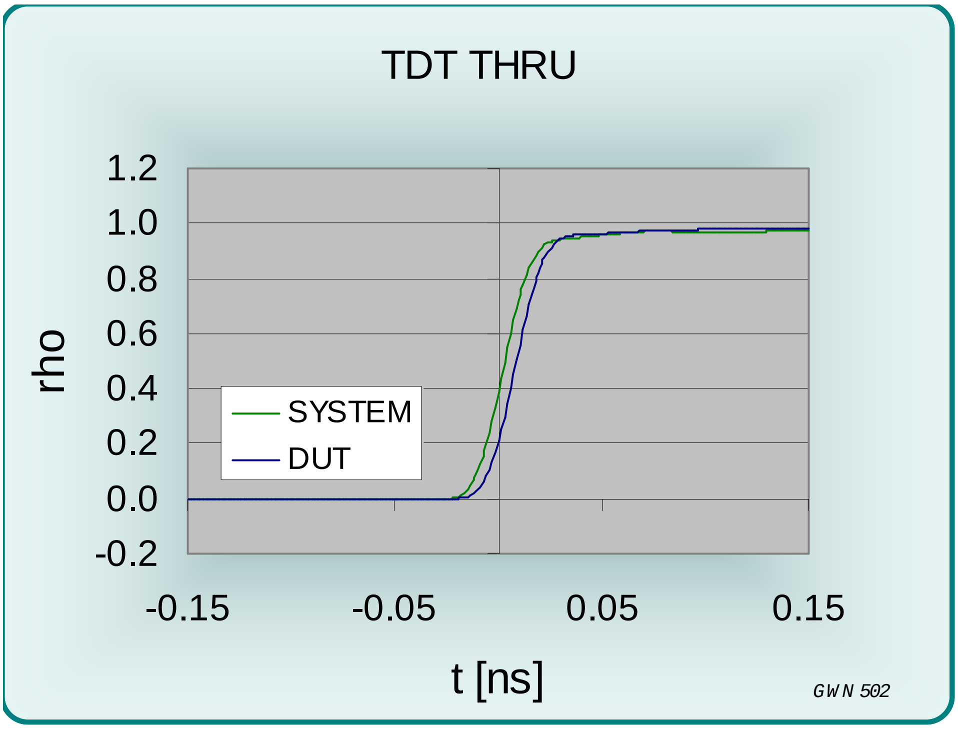


Figure 22 TDT measurement

The TDT measurements for transmission shows almost the same risetime from the pin array (10-90% RT = 28.5 ps) as the system risetime (27.0 ps). The added delay at the 50% point is 6.0 ps. The 20%-80% values are 18.0 ps and 18.0 ps, respectively.

Frequency domain

Network analyzer reflection measurements for the G-S-S-G case were taken with all except the pins under consideration terminated into 50 Ohms (ports 1-4). As a result, the scattering parameters shown below were recorded for reflection and transmission through the contact array.

First, an insertion loss measurement is shown for port 1 to port 2.

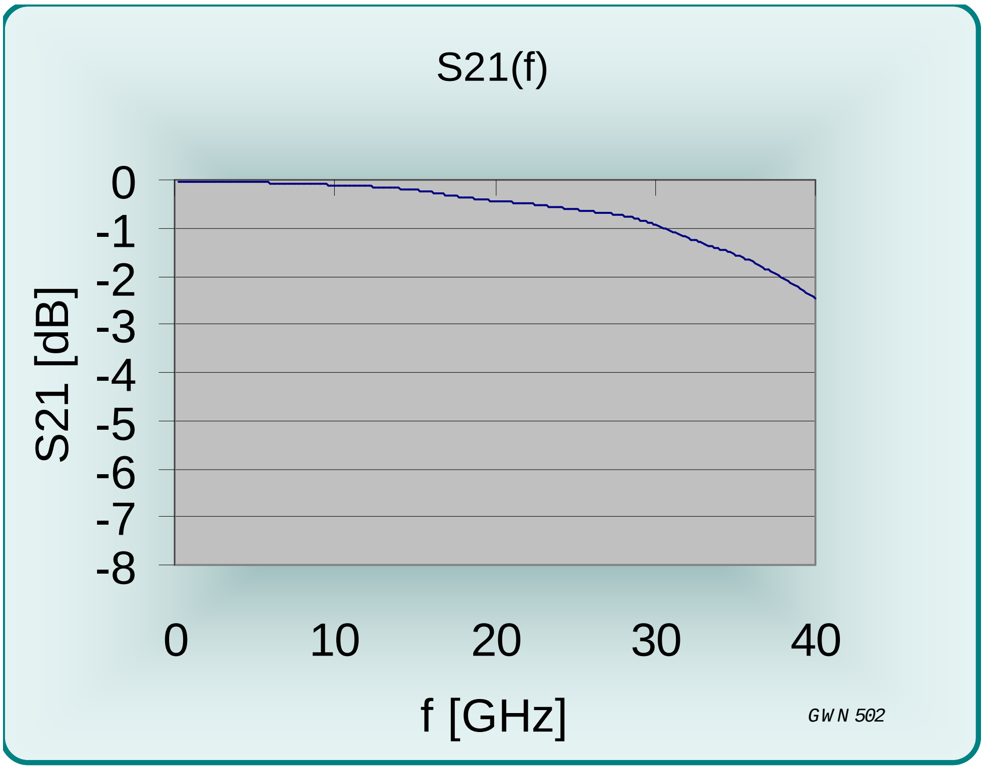


Figure 23 Insertion loss S21 (f) and S12 (f)

Insertion loss is less than 1 dB to about 30.5 GHz. The 3 dB point is not reached before 40.0 GHz.

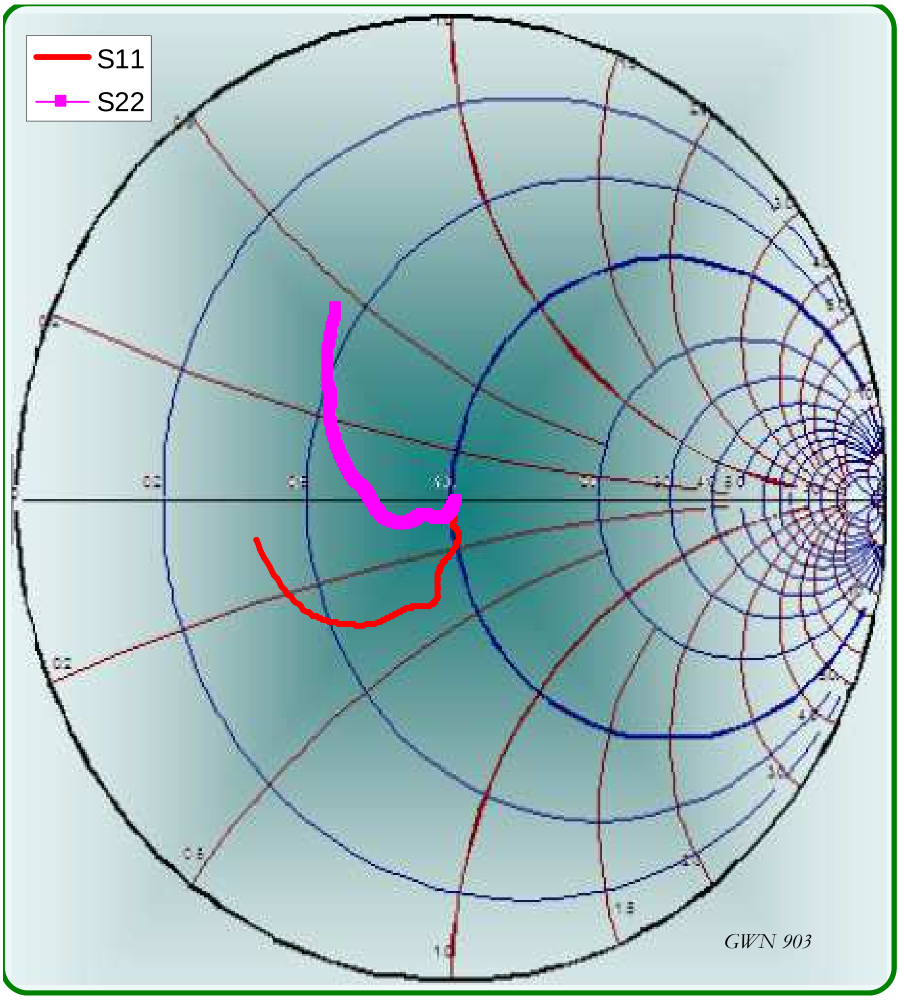


Figure 24 Smith chart for the thru measurement into a 50 Ohm probe

The Smith chart for the thru measurements shows a good match with some reactive components. The Smith chart covers frequencies to 40 GHz.

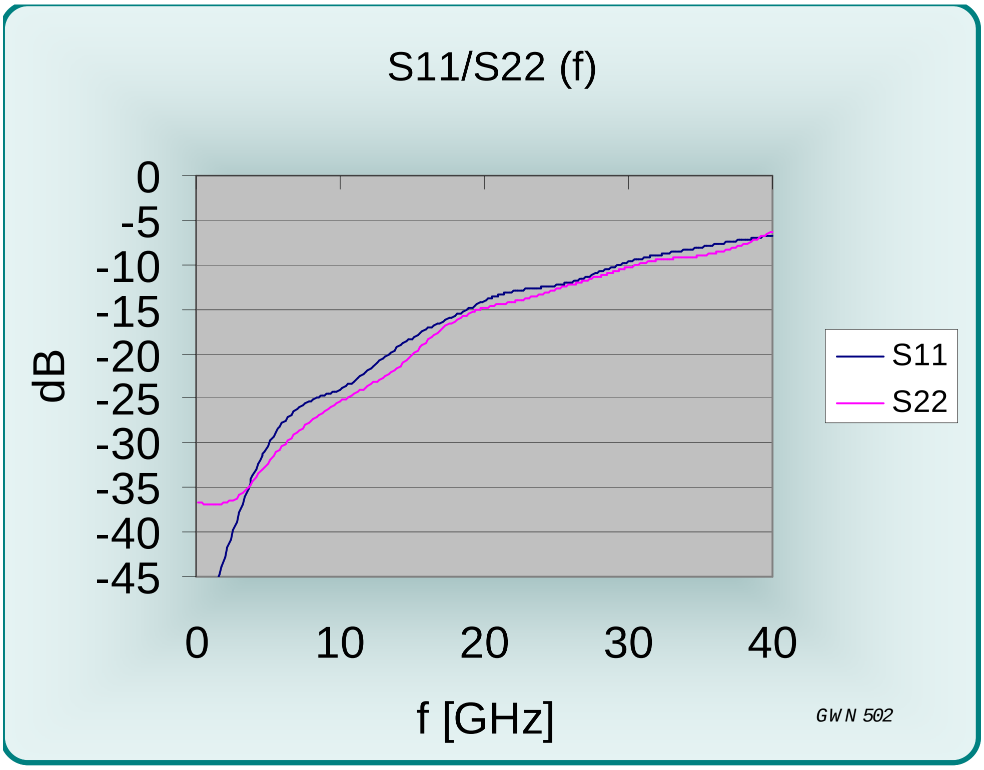


Figure 25 S11 magnitude (f) for the thru measurements into a 50 Ohm probe

The value of the return loss for the thru measurement reaches -20 dB at 13.3 GHz (S11) and 14.9 GHz (S22). It exceeds -10 dB beyond 29.3 GHz and 30.5 GHz, respectively.

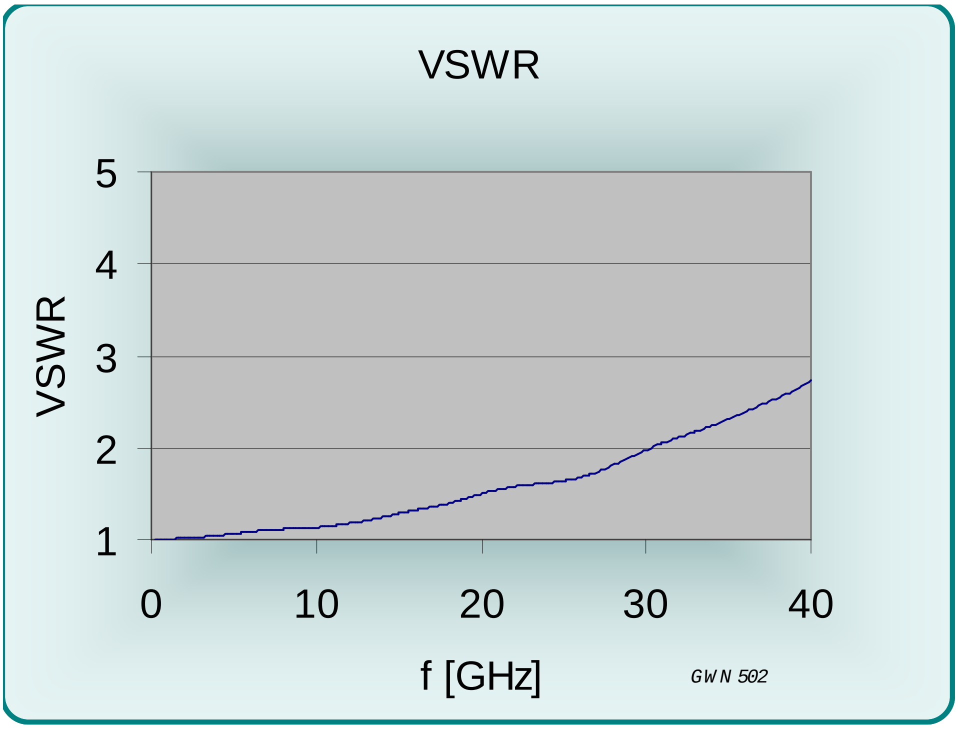


Figure 26 Standing wave ratio VSWR (f) [1 / div.]

The VSWR remains below 2 : 1 to a frequency of 30.3 GHz.

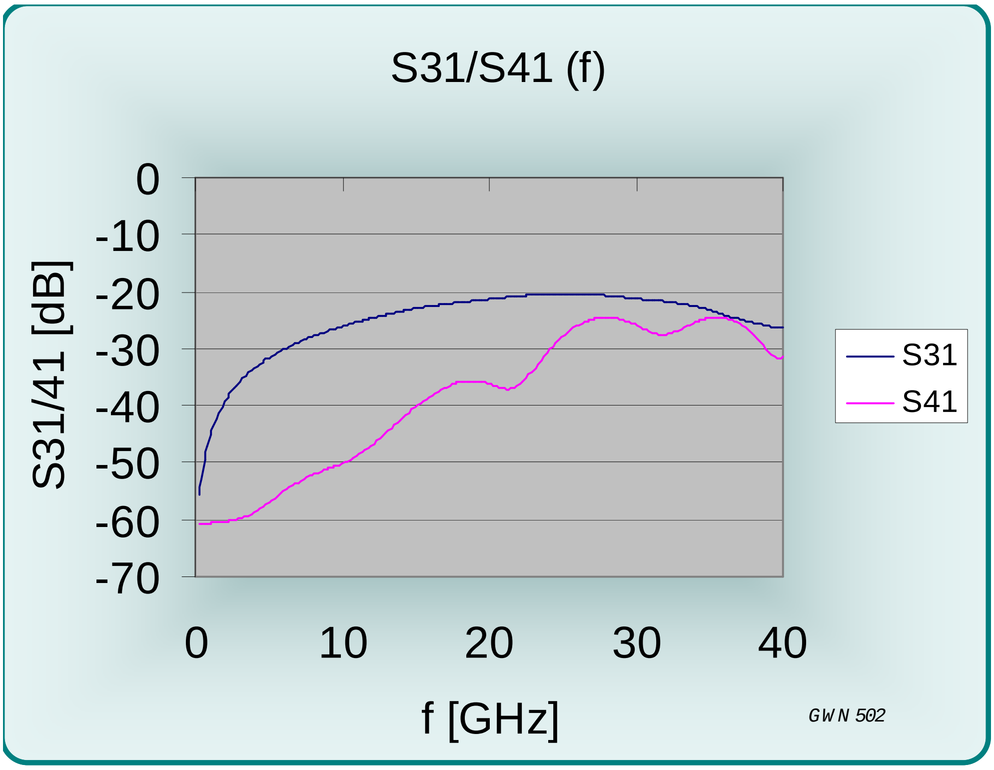


Figure 27 Crosstalk as a function of frequency

The graph shows forward crosstalk from port 1 to port 4 (S41) and backward crosstalk from port 1 to the adjacent terminal (port 3, S31). The -20 dB point is reached at 40.0 GHz (S41). Not before 40.0 GHz (S41) does the level of signal reach -10 dB.

For the purpose of model development the open circuit and short circuit backward crosstalk S31 is also recorded. It is shown below for the different sites. Model development results in a mutual capacitance of 0.025 pF and a mutual inductance of 0.02 nH.

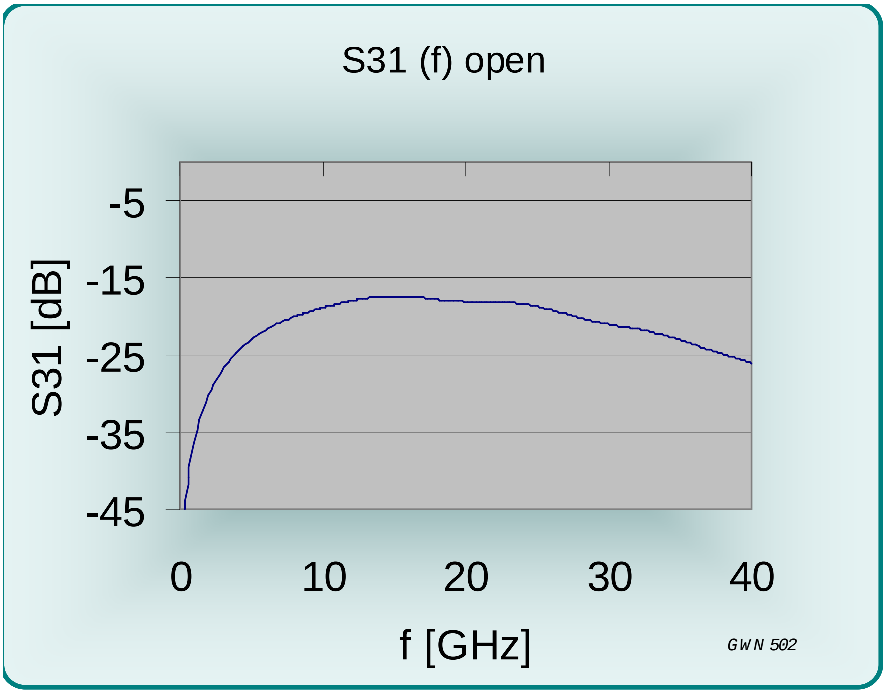


Figure 28 Open circuit crosstalk from port 1 to port 3

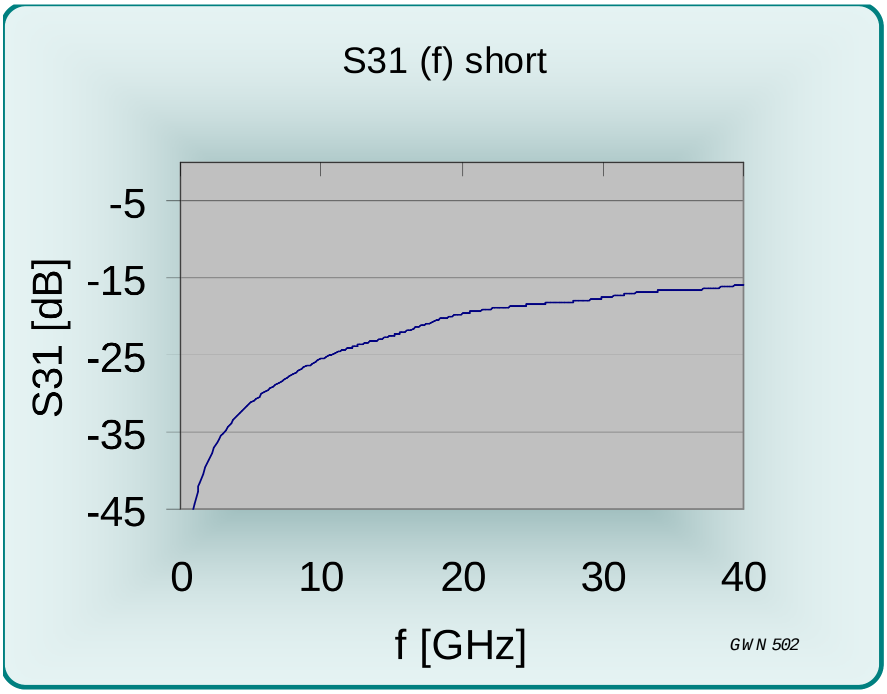


Figure 29 Short circuit crosstalk from port 1 to port 3

Ironwood Electronics

SG-7000 series 0.5mm thick elastomer

0.40 mm pitch

Parameter	Value
Inductance	0.118 nH
Mutual Inductance	0.025 nH
Capacitance to Ground*	0.229 pF
Mutual Capacitance	0.025 pF
S21 (insertion loss) @ -1dB, GSG	19.7 GHz
S21 (insertion loss) @ -1dB, GSSG	30.5 GHz
S11 (return loss) @ -20 dB, GSG	5.2 GHz
S11 (return loss) @-20 dB, GSSG	13.3 GHz
Crosstalk at -20dB	40.0 GHz
Impedance, GSG	39.2 Ω
Impedance, GSSG	46.0 Ω