Ironwood Electronics

SMP Contact System
1.04mm Compressed Contact Length
0.5mm Pitch QFN Socket

AC Measurements and Model Results

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Objective

The objective of these measurements is to determine the RF performance of a Phoenix Test Arrays ***S200/C200*** 0.5mm QFN socket. The QFN socket is composed of a flexible array of contacts (Contact Set), a flexible silicone matrix selectively populated with conductive columns (Silmat), and aligning and actuating mechanisms. A signal pin surrounded by grounded pins is selected for the signal transmission configuration. 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 propagation delay, and the attenuation in the frequency range from 50 MHz to 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 (HP8722C). The instrument was calibrated up to the end of the 0.020" diameter coax probe. The probe was then connected to the fixture and the response measured from one side of the array. When the pins terminate into 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 digital system 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 QFN socket pin array is compressed using 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 pin can be derived from this measurement.

Setup

Testing was performed with a test setup that consists of two Au plated brass plates with holes for the coaxial probes. One plate is mounted on the PCB side of the QFN socket, the other on the DUT side. Holes in the blocks receive semi-rigid coaxial cables. Fig. 1 shows the site for which testing was performed:

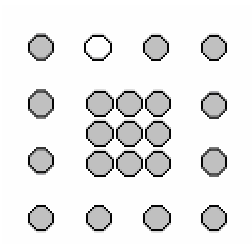

Fig. 1 QFN socket test arrangement

All contacts except the one under test are grounded. Crosstalk is measured to the adjacent pin, which is not grounded under those conditions.

The QFN socket is held in fixture similar to the one shown in Fig. 2:

Fig. 2: Example of Socket Mounting Plates

This fixture is part of a setup with stereo zoom microscope and probe manipulators. Connections to the VNA are made with high quality coaxial cables with SMA 3.5 or K connectors.

Measurements

Time domain

The time domain measurements will be presented first because of their significance for digital signal integrity. TDR reflection measurements are shown in Figs. 3 to 5.

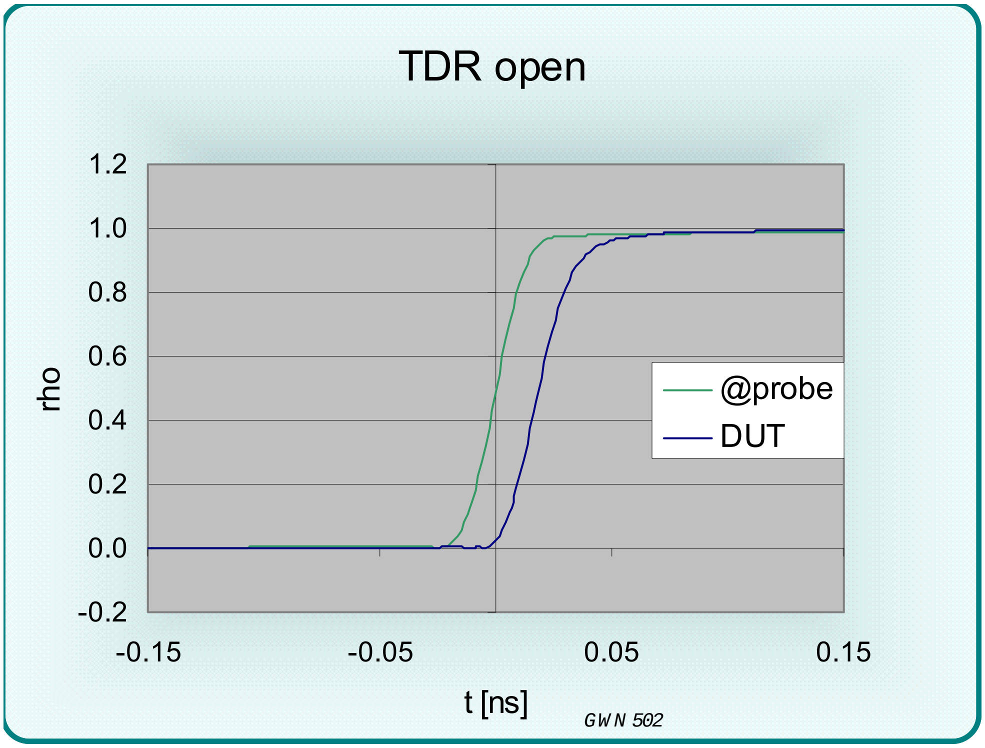

Fig. 3 TDR signal from an OPEN circuited QFN socket

The reflected signals from the QFN socket (rightmost trace) shows only a small deviation in shape from the original waveform (leftmost trace). The risetime of about 31.5 ps is only slightly larger than that of the system with the open probe (25.5 ps). Impedance is close to 50 Ohms. Electrical pin length is about 9.0 ps one way.

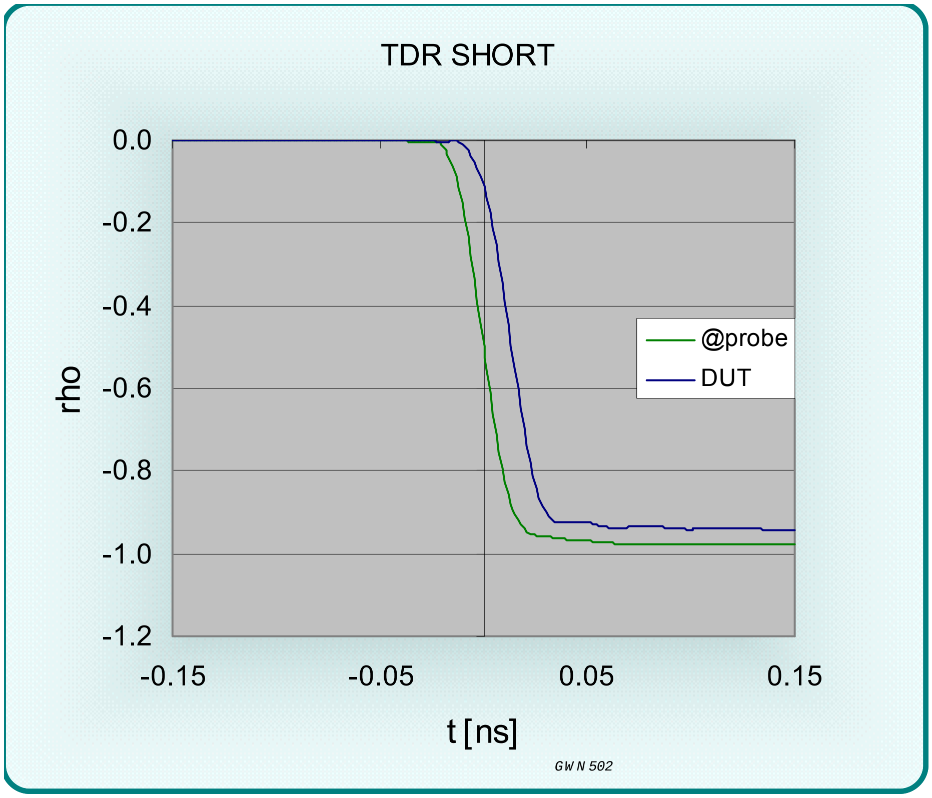

Fig. 4 TDR signal from SHORT at probe plus SHORT inclusive socket

For the short circuited QFN socket the fall time is about 27.0 ps. This is very close the system risetime of 25.5 ps.

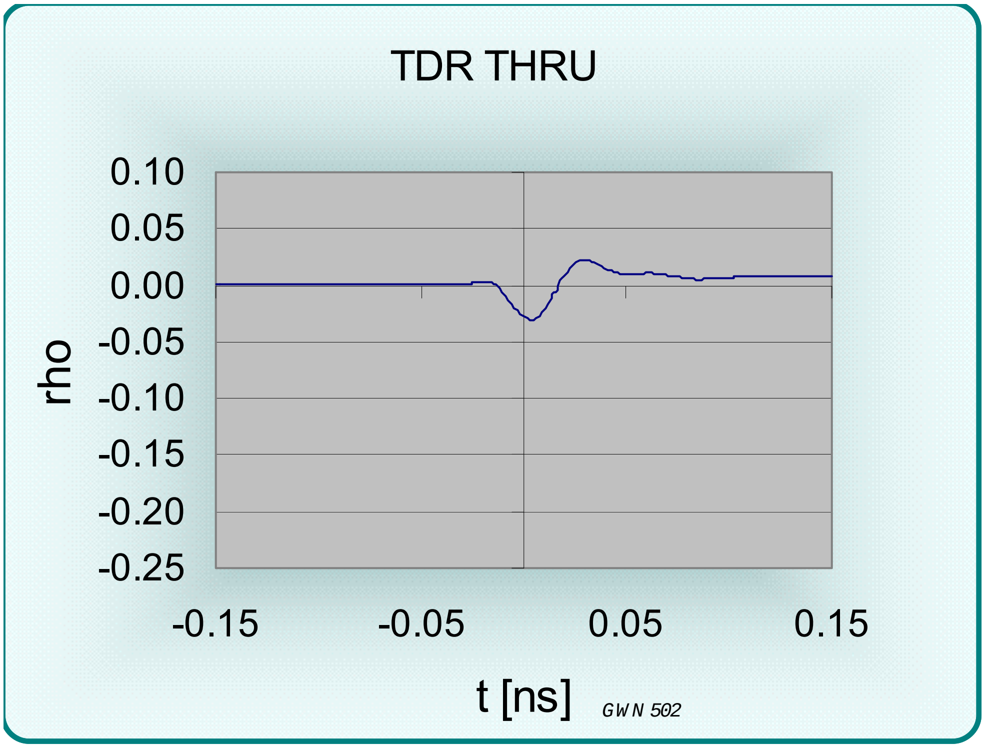

Fig. 5 TDR measurement into a 50 Ohm probe

The thru TDR response shows both inductive and capacitive response. The dip recorded corresponds to a transmission line impedance of 47.0 Ohms; the peak reaches 52 Ohms.

The TDT performance for a step propagating through the socket was also recorded (see Fig. 6).

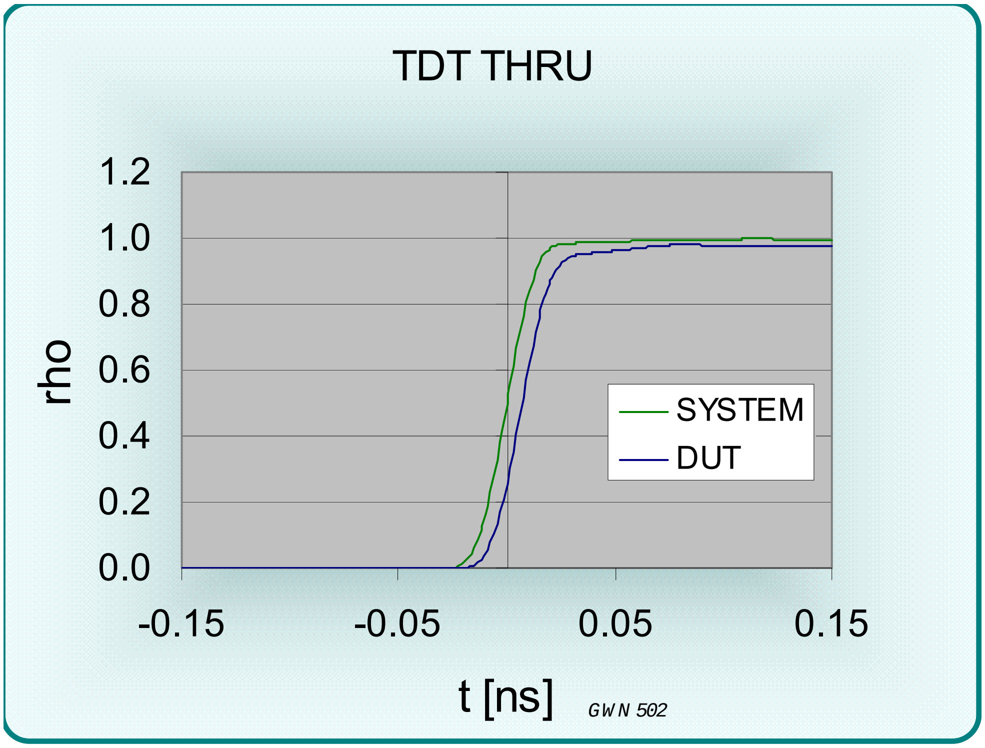

Fig. 6 TDT measurement

The TDT measurements for transmission show a negligible contribution to risetime from the socket (10-90% RT = 27.0 ps, the system risetime is 25.5 ps). The added delay at the 50% point is 7.5 ps.

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 recorded (Fig. 7). From the curve the capacitance of the signal pin to ground can be determined (see Fig. 8).

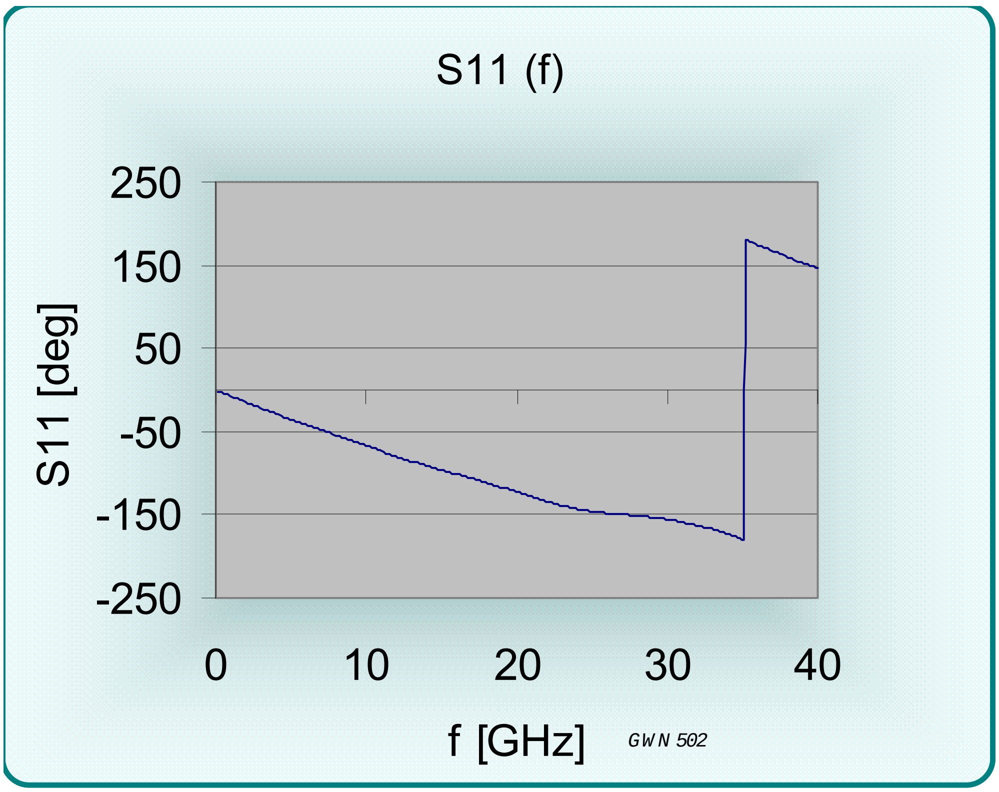

Fig. 7A: S11 phase vs. (f) for the open circuited signal pin

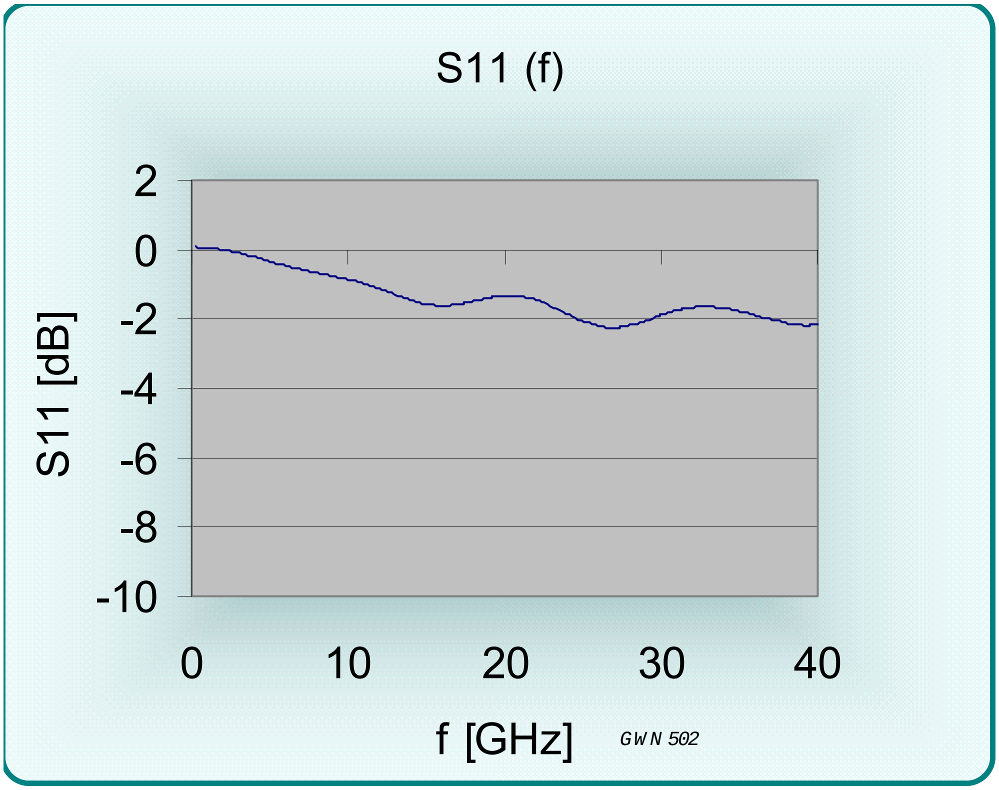

Fig. 7B: S11 magnitude vs. (f) for the open circuited signal pin

While ideally the magnitude of **S11** should be unity (0 dB), loss, radiation and resonances in the array are likely contributors to noticeable return loss for the open circuited pins.

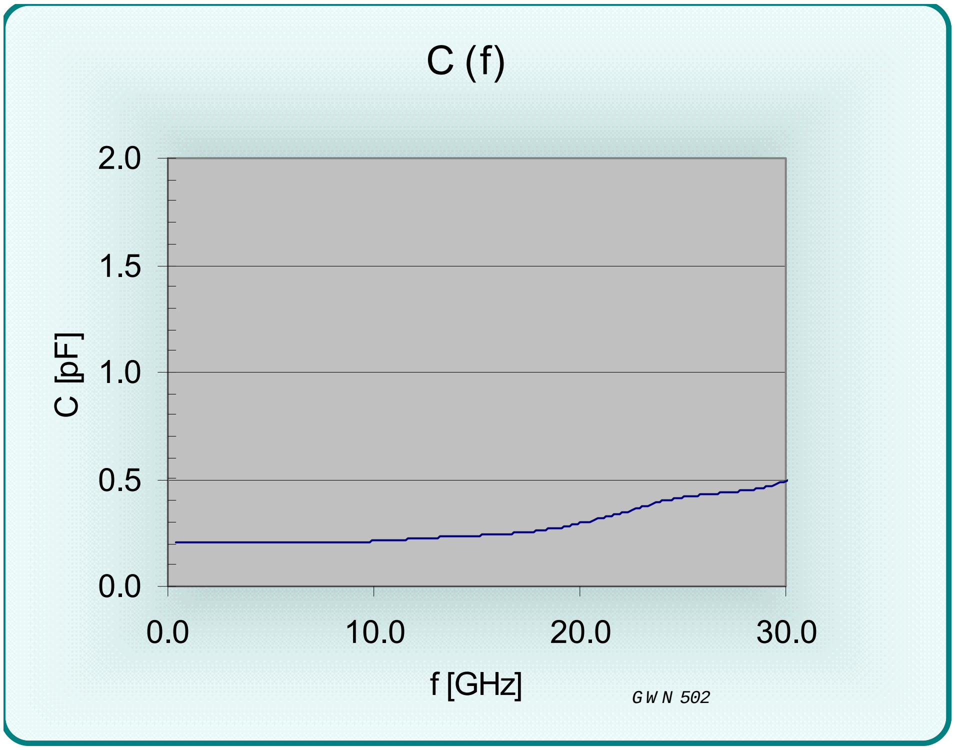

Fig. 8: C(pF) vs. f(GHz) for the open circuited signal pin

Capacitance is about 0.20 pF at low frequencies. The rise in capacitance toward 30 GHz is due to the fact that the contacts form a transmission line with a length that has become a noticeable fraction of the signal wavelength. The lumped element representation of the transmission environment as a capacitor begins to become invalid at these frequencies and so does the mathematical calculation of capacitance from the measured parameters. This merely means the model is not valid anymore. As is evident from time domain and insertion loss measurements this does not imply that the socket does not perform at these frequencies.

The Smith chart measurement for the open circuit shows no significant resonances:

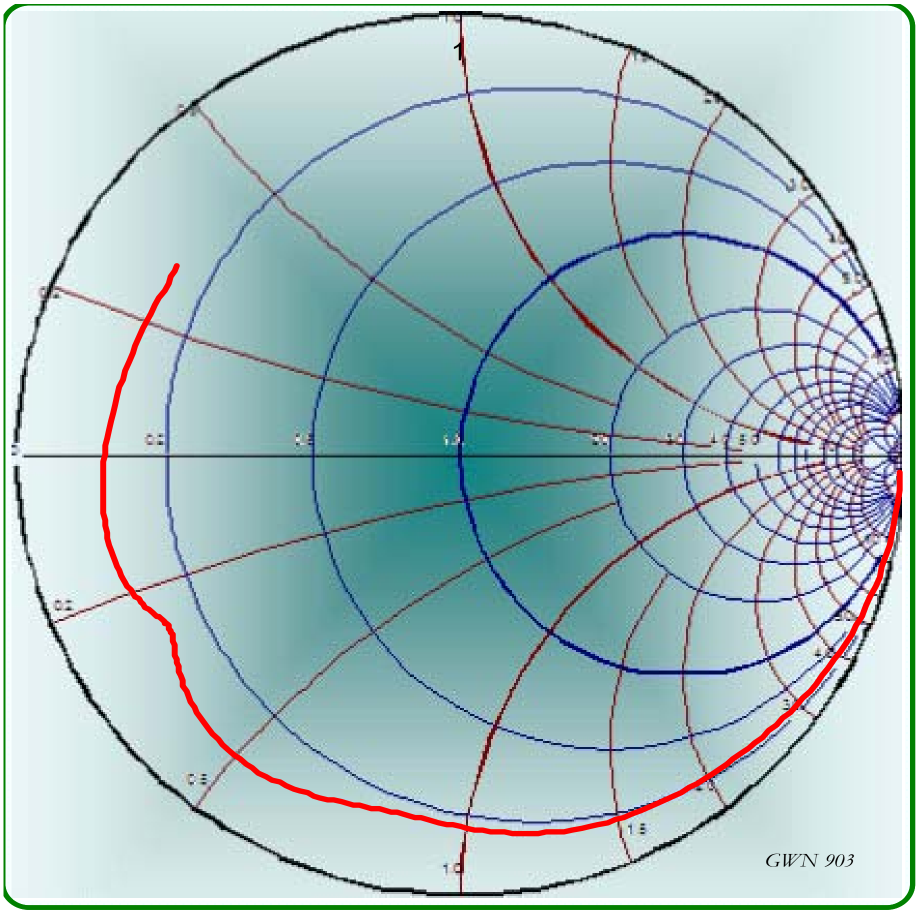

Fig. 9: Reflections from the open circuited QFN socket

To extract the contactor inductance, the same types of measurements were performed with a shorted pin array. Fig. 10 shows the change in reflections from the QFN socket. Calibration was established with a short placed at the end of the feed coax.