<u>Challenges of on-board narrow-pitch connections for microwave components</u>

Over the past several years IC devices have continually increased in performance relative to both speed and functionality. These changes have been accompanied by new package styles featuring higher I/O counts with decreased spacing and reduced interconnect feature size. All of these factors combined create more demanding requirements upon the sockets and adapters used for interconnection.

An IC connector is an electromechanical device that provides a pluggable interface between an IC package and a system circuit board or subassembly. This interface must be accomplished with maximum repeatability and minimal effect on signal integrity. Providing for a removable interface is a major reason for using a connector and may be required for ease of assembly, upgradeability, maintainability, and cost savings. In the field, a socket provides enhanced capability for maintenance, testing, replacement or upgrades, which may become a critical factor in product life cycle due to technology evolution and IC availability.

At GHz level operating frequencies and beyond it has become increasingly important to understand the scattering and reflection properties of traveling waves when an interconnection network is inserted within a transmission line between an IC device and the attaching PC Board. S-parameter measurements in terms of reflection coefficients and transmission gain have typically been accomplished via the use of network and signal analyzers coupled with the use of special test fixtures and probing devices. Based on these measurements, network analysis provides the appropriate S-parameters from which impedance values may be derived and directly correlated via the use of Smith Charts.

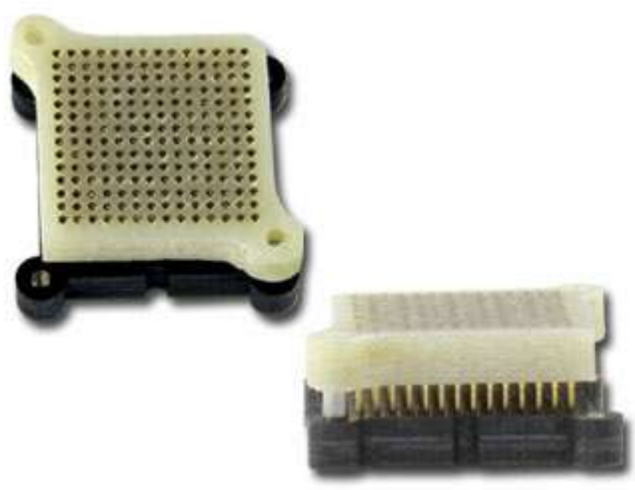

Figure 1: 0.5mm pitch array connector

For example, let us consider an oscillator. An oscillator always employs a sensitive amplifier whose output is fed back to the input in-phase. Thus, the signal regenerates and sustains itself. The oscillator selected for a particular application should be capable of supplying an output signal whose upper and lower frequency limits exceed those required by the application. To verify the functionality of an oscillator, it is better to plug (via connector) into an application board thereby eliminating solder/de-solder routine and avoid any damages to oscillator. Let's say, the oscillator selected for the particular application is 20GHz. In order to verify 20GHz functionality, the chosen connector has to accommodate 20GHz frequency without significant loss.

Figure 1 shows a typical connector in array configuration. The connector pin is a single piece integrated clip design and is made of heat-treated Beryllium Copper Alloy 172 with 30 micro inch of gold over 100 micro inch of Nickel finish. The socket pin is press-fit into the polyimide substrate directly. RF performance of the connector can be verified using the below methodology.

For G-S-G configurations, a signal pin surrounded by grounded pins is selected for the signal transmission. For G-S-S-G configurations, two adjacent pins are used 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 40 GHz.

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 HP8722C). The instrument was calibrated up to the end of the 0.022" diameter coax probes that are part of the test fixture. 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, capacitance data can be collected. When the DUT pins terminate in short circuit, inductance data can be determined.

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 (actual device to be tested or a flat plate with embedded coaxial probes). Measurements are performed for a corner pin of the contact array, a pin at the perimeter (edge) and a pin in the center (field).

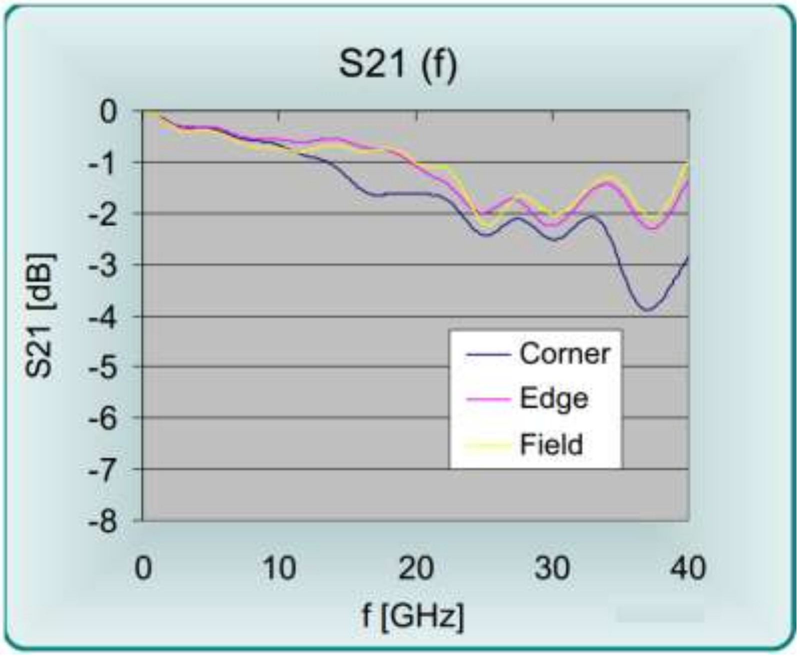

Figure 2: S-parameter data for Corner, Edge and Field array pins.

An insertion loss measurement is shown in figure 2 for the frequency range of 50 MHz to 40 GHz. Insertion loss is less than 1 dB to about 13.5, 19.7 and 20.1 GHz (corner, edge, field). The 3 dB point is not reached before 35.1, >40 and >40 GHz. Insertion loss of -1dB @ 20GHz is interpreted as 90% of signal pass through the interconnect medium and only 10% of signal is lost through the interconnect transition at 20GHz frequency. Also it can be noticed that only field array pins show -1dB@20GHz and the corner pins show -1dB@13.5GHz. This shows in addition to contact geometry, location of the contact pin plays significant role in RF performance. This is very critical for the test engineer as the specific pin functionality in the DUT is being verified at specific frequency.

A primary concern to anyone utilizing the high frequency devices is that the connector must provide a high electrical performance while meeting other mechanical requirements. The electrical path of the connector is a high priority performance issue with the physical length from the top connection point to the solder tail on the bottom of the connector along with physical geometry determines its capability to perform at specified frequency. This is the shortest connection length by far for interconnect pin sockets, therefore providing better transmission of high frequency signals.

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