Test Report

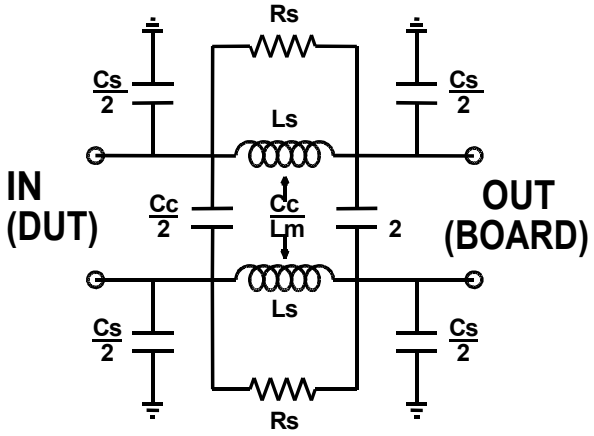
Report description:	RF Characterization IE SBT - 0.4mm Pitch array - Vespel SP-1 Body Material

Objective

The objective of this report is to evaluate the RF characteristics of IE SBT pins used for devices with 0.4mm pitch configured in different array patterns. Shunt capacitance and loop inductance are measured. Mutual capacitance and mutual inductance are extrapolated from simulation. Time domain reflection coefficient and frequency domain group delay characteristics quantify the signal delay. Fixture parasitics are minimized by direct measurement using 50Ω air coplanar probes. Test setup, conditions, and methodologies are described in the Appendix.

Results

Equivalent Circuit SPICE Compatible Model



Ls	**Loop Inductance**	**0.95nH**
Cs	**Shunt Capacitance**	**0.20pF**
Cc	**Mutual Capacitance****	**0.06pF**
Lm	**Mutual Inductance****	**0.11nH**
Rs	**Rskin (High-Frequency Loss)**	**1000Ω**

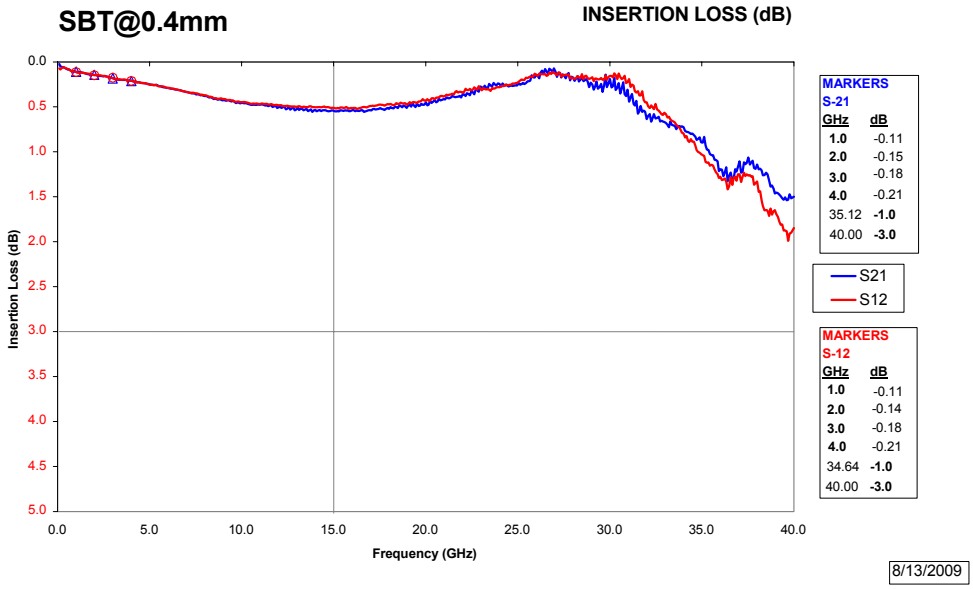
The crosstalk model is valid through 6GHz. 1GHz measured data is used to calculate derived values.

**These values are determined through curve-fit approximation, as these values cannot be directly measured

Bandwidth (One-way Through):

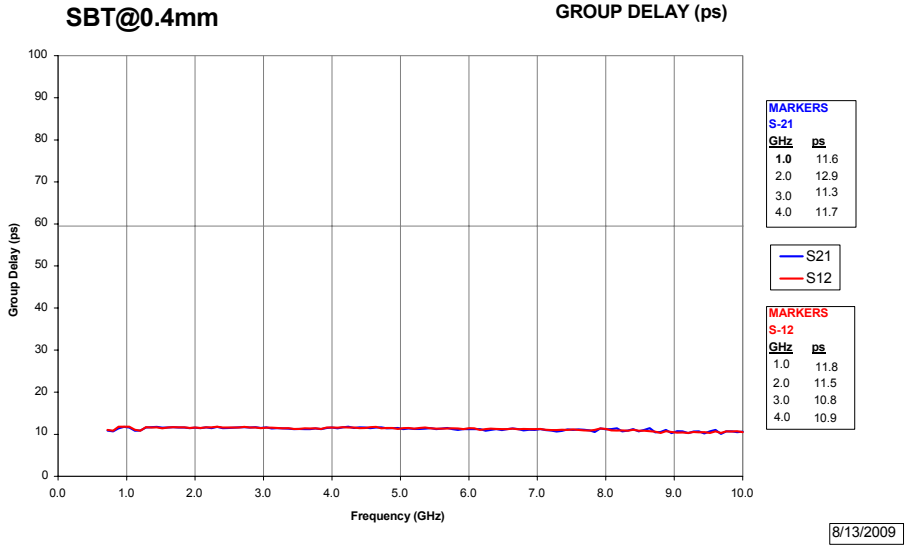
The bandwidth of the contactor is the insertion loss (S_{21}) from a direct one-way through measurement.

INSERTION LOSS (dB)	FREQUENCY (GHz)
1	**34.6 GHz**
3	**40+ GHz**



Group Delay:

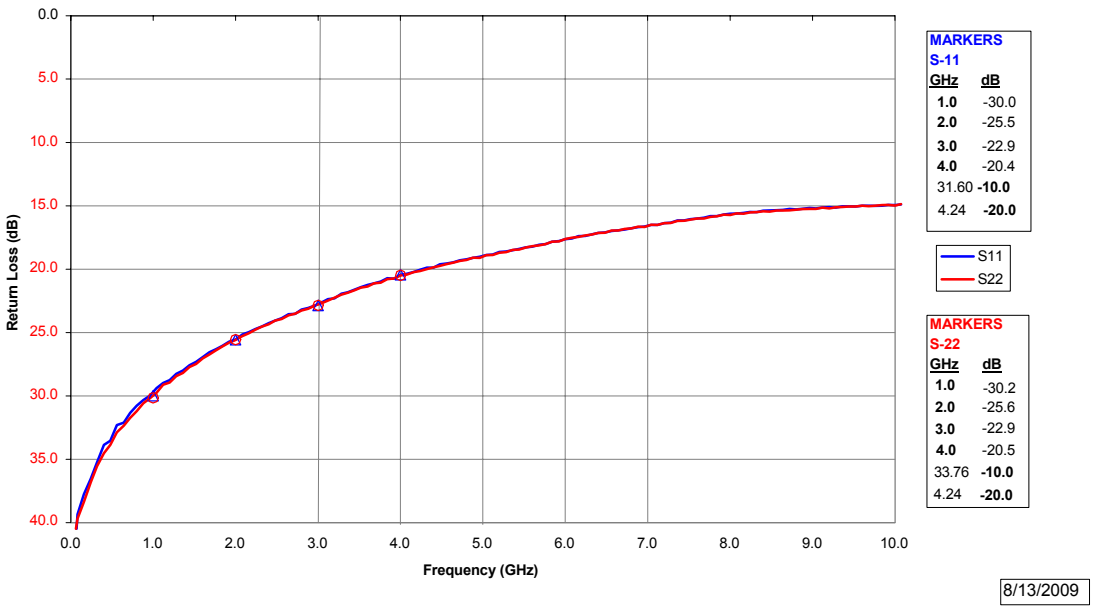
Group delay is a measure of the time it takes a signal to transmit through the device under test. Group delay indicates electrical length. Group delay is derived by differentiating the phase with respect to frequency.



Return Loss:

Return loss is the ratio of the reflected wave to the incident wave, expressed in dB. The -20dB return loss limit (10% reflection) is reached at **4.2 GHz**.

SBT@0.4mm **RETURN LOSS (dB)**



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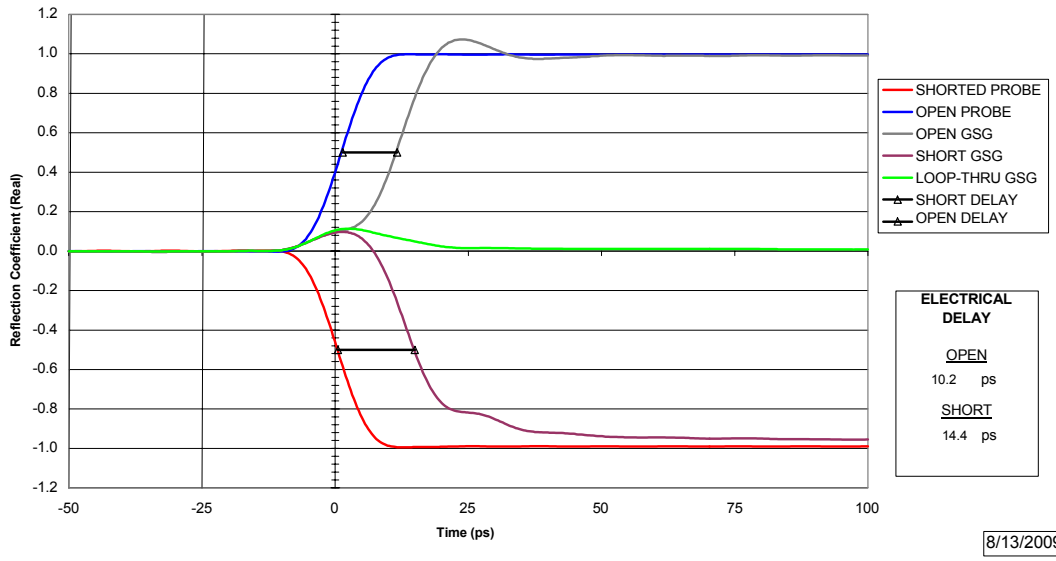
Time Domain Response and Electrical Delay:

Below is shown comparative Time Domain Responses from the open, short, and one-way through configurations. The electrical delay measured between the open port trace and the open contact trace is **10.2 picoseconds** (open circuit)**, 14.4 picoseconds** (short circuit)**.**

SBT@0.4mm **TIME DOMAIN (S_{11} REAL)**



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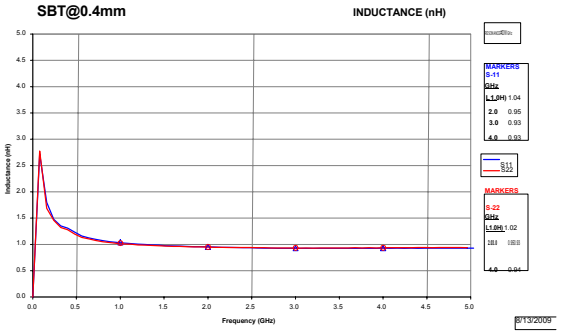
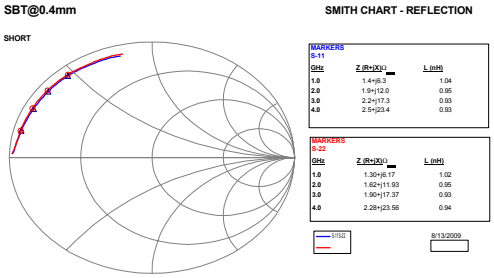
Loop Inductance:

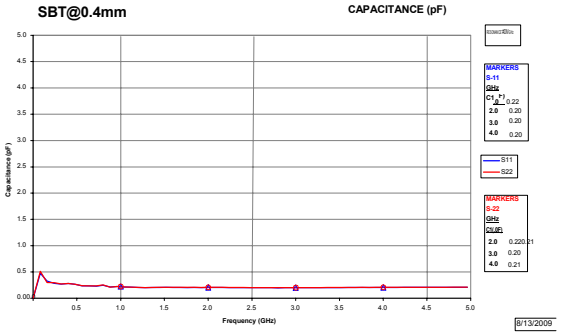
Loop inductance is derived from the short measurement, by measuring the imaginary component of S11 with respect to the frequency.

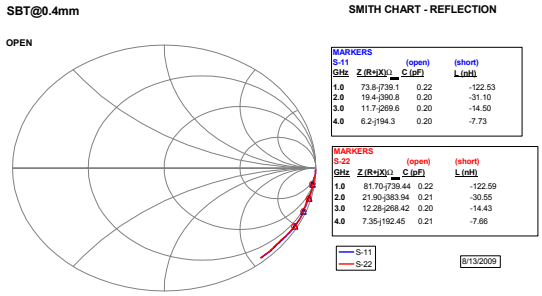




Shunt Capacitance:

Shunt Capacitance is derived from the open measurement, by measuring the imaginary component of S11 with respect to the frequency.



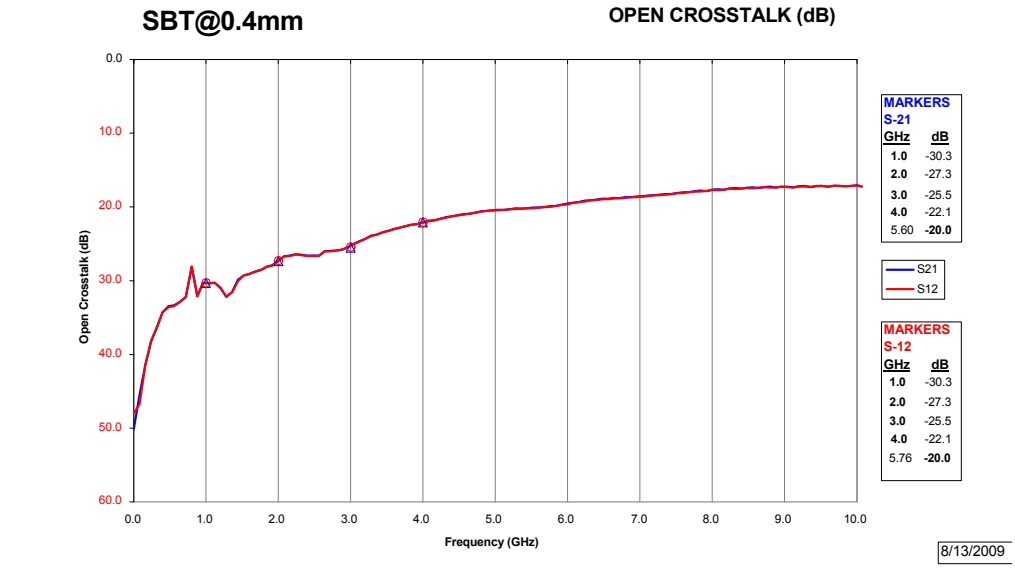


Contactor Crosstalk:

Contactor crosstalk is measured as the insertion loss (S_{21} and S_{12}) of a signal that is transmitted between 2 adjacent signal pins. Each signal pin has an adjacent ground on each side (GSG). The Appendix shows the configuration of source and victim pins. The -20dB crosstalk limit (10% voltage crosstalk) is reached at **5.6 GHz** (open circuit) and **4.3 GHz** (short circuit).

SPICE models for both measurements, which are used to extract coupling parameters, are shown in the Appendix.

Open Circuit Crosstalk:



Short Circuit Crosstalk:

Appendix 1 - Equipment List

Contactor:	Custom IE SBT pin with gold plated pogo pins. The contactor housing is designed so that all probes are preloaded to the specified test height.
Contactor Material	DuPont Vespel® SP-1. Dielectric constant, εr = 3.5; Loss Tangent = 0.007
Vector Network Analyzer:	1. Wiltron 360A, with time domain option installed 2. Wiltron 3611A S-Parameter Test Set, 66 MHz-40 GHz 3. Wiltron 360SS69 Synthesized Sweeper
Air Coplanar Probes:	GGB Industries PicoProbe®, model 40A-GSG, K connector interface
Calibration Substrate:	GGB Industries Model CS-10 Calibration Substrate with calibration coefficients for the HP8510 VNA
Test Port Extension Cables:	Gore PHASEFLEX Test Cable Assembly. Male-Female 2.92mm 24in cables; P/N EL0CQ0CP024.0.
Probing Station:	IE custom with mounting test block

Appendix 2 - Experimental Method

General Set-Up

1) The test contactor is cleaned per IE standard instructions.
2) The contactor is mounted to the test board such that contacts can be probed from above.
3) The test port extension cables and air coplanar probes are connected and mounted to the VNA and probing station per the manufacturers' recommended procedures.
4) The VNA is powered on per the manufacturers recommended procedures. The equipment is allowed at least ½ hour of temperature stabilization warm-up time.
5) The VNA is set for frequency domain to the frequency limits of interest. A full 2-port SOLT (Short, Open, Load, Thru) calibration is performed on the VNA using the Calibration substrate per the manufacturers recommended procedures. Calibration verification is done.

One-way Through Measurement (Insertion Loss and Impedance)

6) THROUGH measurements are required for insertion loss, return loss, and impedance extraction. See the Appendix for configuration details. The contactor is mounted vertically such that the probes are horizontal. The microwave probes on port1 and port2 engage directly to the device under test. The technique used is a direct through measurement. The contact probes are measured at proper test height as the test fixture is designed to pre-compress the probes for all through measurements.

Open Circuit Measurement (Crosstalk and Capacitance)

7) OPEN measurements are required for shunt and coupling capacitance extraction. See the Appendix for configuration details. The contactor is mounted to a bare PC board. No contact pins are shorted together whatsoever. The contactor and board are mounted on the probing station so that the VNA port 1 engages with the center left contact element and port 2 engages with the center right contact under test. The contact probes are engaged to proper test height.

Short Circuit Measurement (Crosstalk and Inductance)

8) SHORT circuit measurements are required for self and mutual inductance extraction. See the Appendix for configuration details. The contactor is mounted to a gold plated copper clad board. All contact pins are completely together. The contactor and board are mounted on the probing station so that the VNA port 1 engages with the center left contact element and port 2 engages with the center right contact under test. The contact probes are engaged to proper test height

General Data Sweep and Storage Procedure

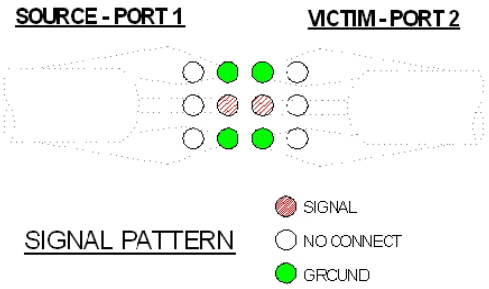
9) The VNA sweep is reset, and a full sweep is performed. Visual verification of the analysis is made on the VNA graphical display.
10) When the data is found to be accurate, the internal VNA data arrays are saved to disk. The format used is the "DATA-DATA' format. Time domain data is then also saved along with raw probe and/or raw PC board data for reference.
11) The raw VNA data is imported into IE proprietary analysis software for data extraction. 12)

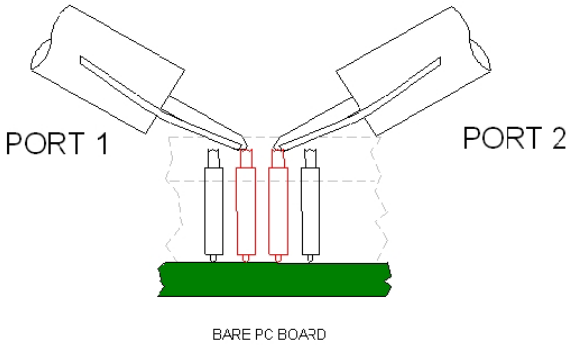
Mutual capacitance and mutual inductance are derived using IE best known methods.

(A curve-fit technique that converges upon measured cross-talk values.)

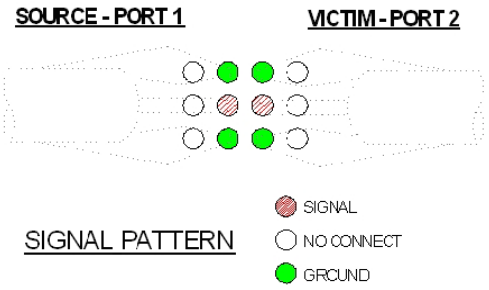
Appendix 3 - Probing Configuration

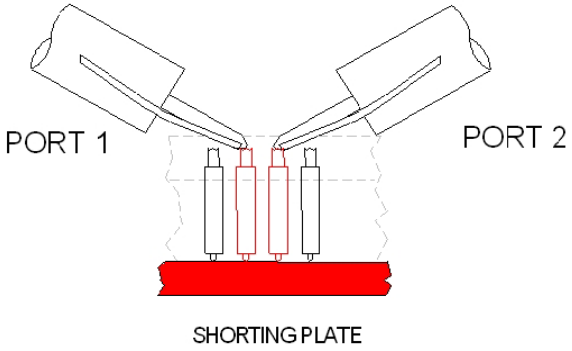
Open Circuit Crosstalk and Capacitance Measurement:



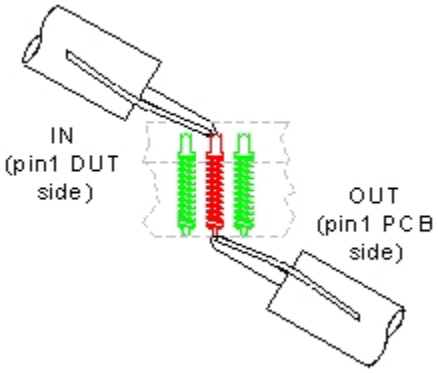


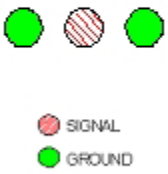
Short Circuit Crosstalk and Inductance Measurement:





One-way Through Measurement:

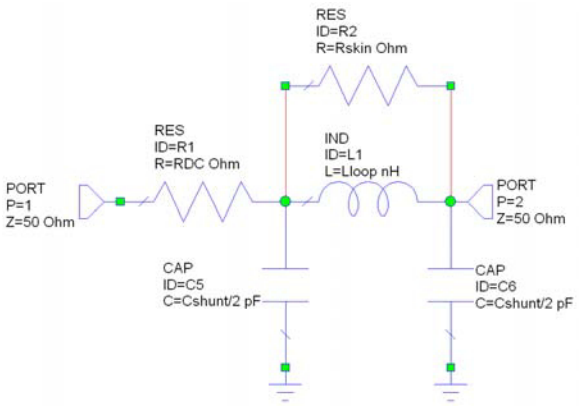




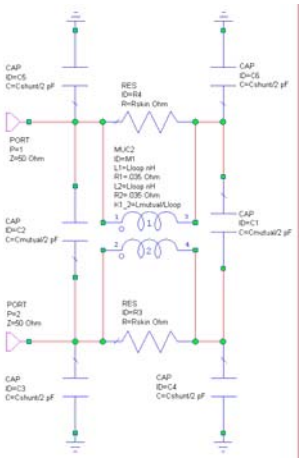
Appendix 4 - SPICE Models

The models shown below are used to extract coupling parameters. Measured values for Shunt Capacitance and Loop Inductance are used. R_{SKIN} and R_{DC} is a resistor models used to simulate high frequency losses, and DC contact resistance respectively. Both values were derived empirically. Mutual inductance and mutual capacitance are found using curve-fit methods to match measured crosstalk values.

One-way Through:



Open Crosstalk:



Short Crosstalk: