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Multitest | ECT Interface Products

High Frequency Solutions for Wafer Level Package Test

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San Diego, CA USA

Drive Toward Final Test at Wafer Level

- **Wafer Level Packaging Offers Low Cost, High Frequency solution**
  - Eliminates second (package) test
  - Increased package pitch allows Pogo® pin architectures
  - Improved electrical performance compared to traditional packaging
- **Test Interface**
  - Often performance limiter for tests at high frequency
- **High-Frequency Testing at Wafer Level Can Be Challenging**
  - Successful solutions require signal integrity optimization
  - Optimization must include full test interface
  - Test hardware can be very costly

New High Frequency WLP Solution

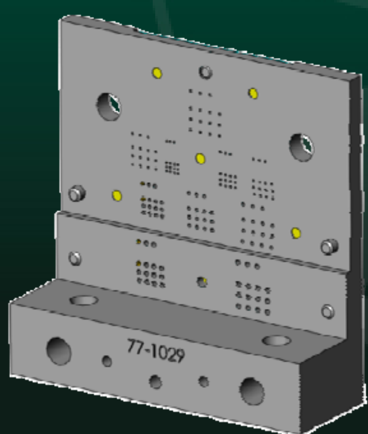
- **High-frequency Pogo Pin Solution Addresses Challenge**
  - PCB design guidelines for optimized signal integrity
  - Correct Pogo Pin for each specific application
  - Cost-effective
- **Turnkey Solution Specific to High-Speed WLP Test Market**
  - Design
  - Simulation
  - Fabrication
  - Assembly

Agenda

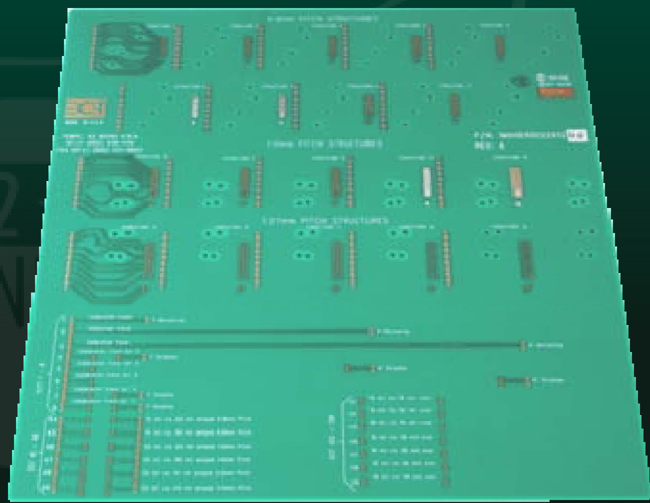
- **Simulation-Measurement Correlation**
  - Both PCB and contactor
  - Ensures maximum simulation accuracy
- **Frequency-Based PCB Design Guidelines**
  - Provides rules based on frequency
  - Avoids unnecessary overdesign and additional costs
- **Hardware Selector Tool**
  - Ensures performance specifications are met
  - Results based on application-specific variables
- **Example Application**

Simulation-Measurement Correlation

- **Simulation Proven Through Extensive Characterization**
  - Correlates simulation to measurement
  - Test hardware fabricated using Multitest manufacturing processes
  - Includes PCBs, contactors, and PCB/contactor interactions
  - Ensures simulation model accuracy



RF Characterization Contactor



RF Characterization PCB

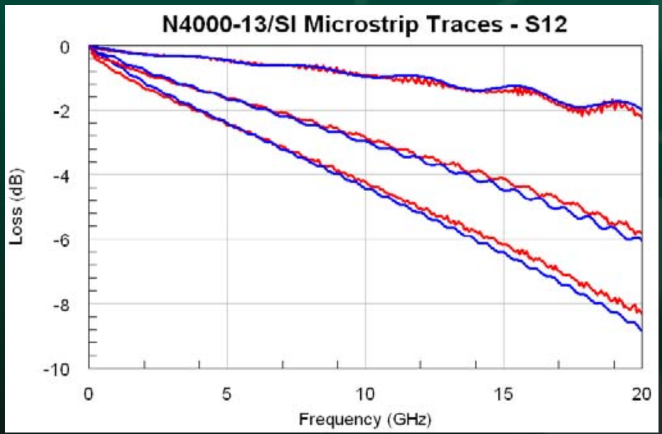
Correlation

PCB

- Microstrip traces
- 1”, 4”, 6”
- Nelco 4000-13/SI

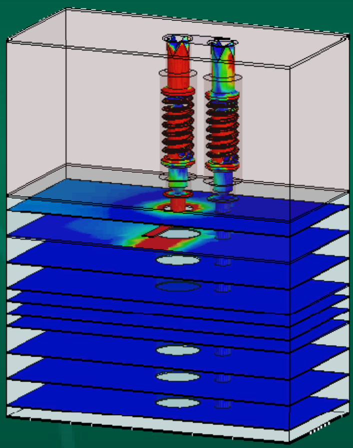
Contactor

- MER040
- 0.4mm pitch
- G-S-G Configuration

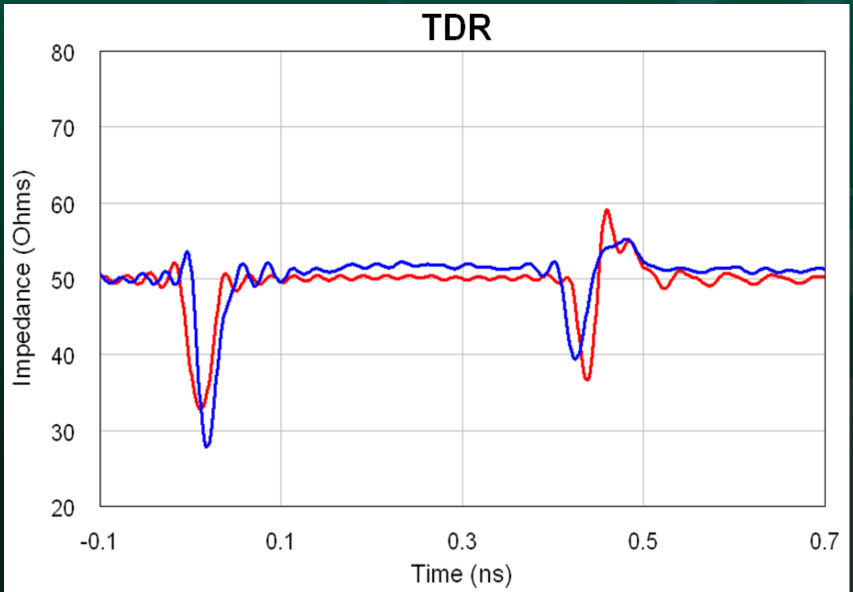


MEASUREMENT SIMULATION

System Correlation



- **Stripline Trace to BTM080 Contactor**
  – Includes via transition from PCB to contactor
- **Good Correlation out to 20GHz**



MEASUREMENT SIMULATION

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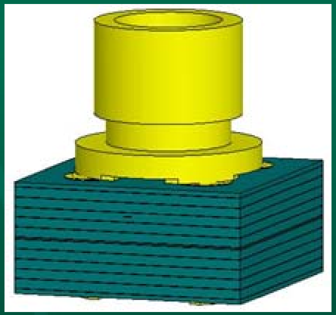
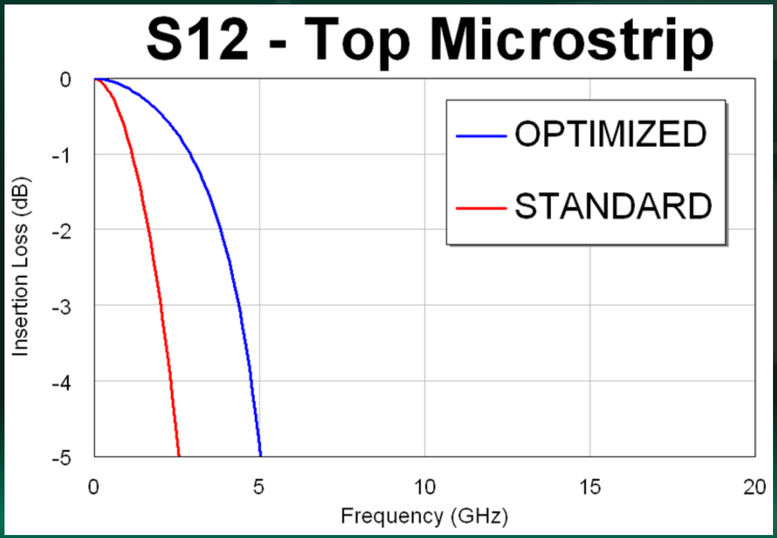
PCB Design Guidelines

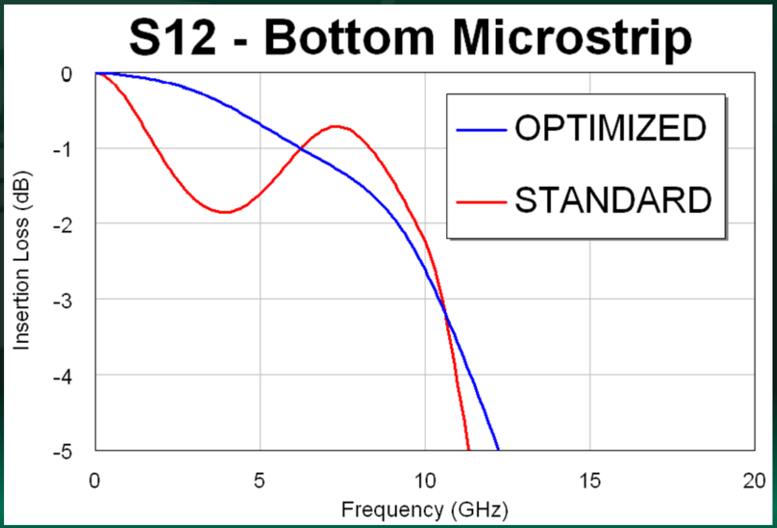
- **Design Rule Considerations**
  - Typically derived from ideal environment
  - Often do not relate to actual performance
  - Rules valid below 500 MHz do not apply above 1 GHz
- **Design Rules Improved Through Simulation**
  - Matched to application frequency
  - Ensures performance meets application requirements
  - Minimizes cost
- **Examples of Optimized Rules:**
  - Connector footprints, stub drilling, ground via optimization (shown)
  - Relay/component footprints, trace spacing, component locations, etc.

PCB Design Guidelines – Connector Footprint

- **Datasheet Specification:**
  - Bandwidth = 18.0 GHz
- **Simulation:**
  - Top microstrip -1dB: 1.2 GHz (Standard); 2.9 GHz (Optimized)
  - Bottom microstrip -1dB: 1.9 GHz (Standard); 6.2 GHz (Optimized)
- **Optimized Footprints Now Used as Design Standard**

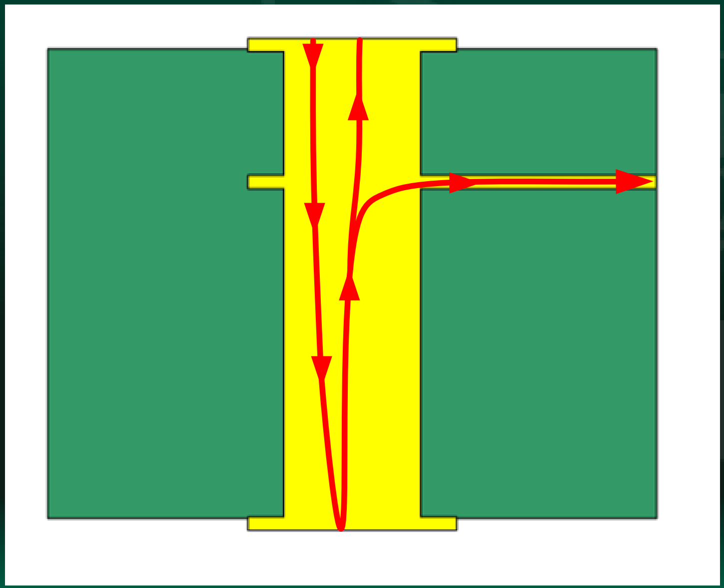


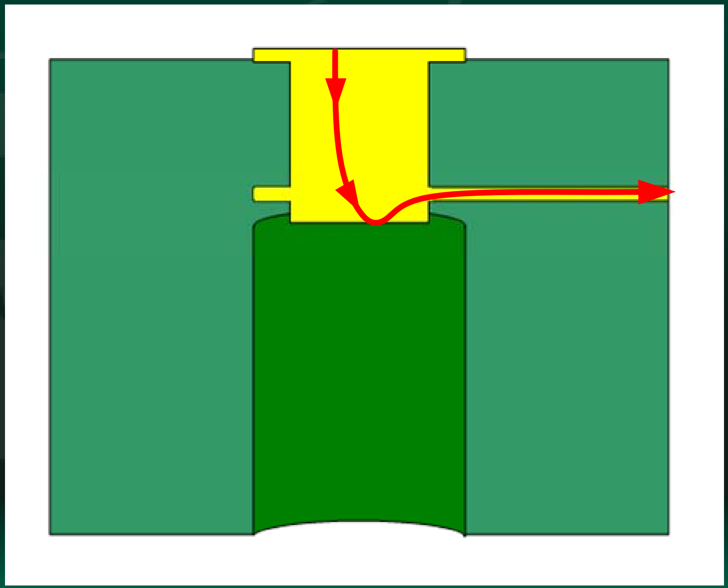




PCB Design Guidelines – Stub Drilling

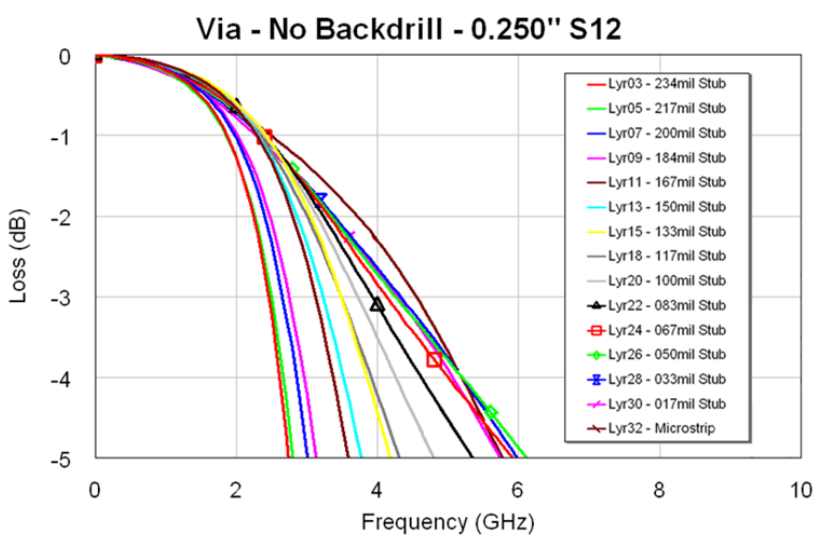
- **Stubs**
  - Create undesired noise in signal path
  - Creates signal reflections that limit bandwidth
- **Stub Drilling**
  - Removes undesired stubs from signal paths
  - Becomes increasingly important as frequencies increase





PCB Design Guidelines – Stub Drilling

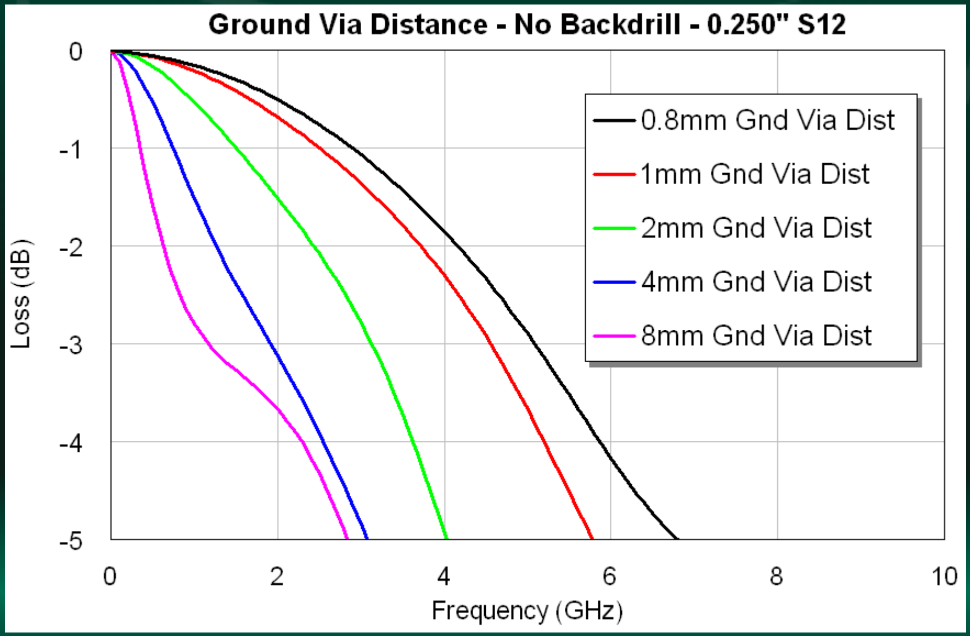
- **Stub Drilling - Rule of Thumb:**
  – Stub length must be less than ¼-wavelength of max frequency
- **Simulation Results:**
  – Stub drill required well below ¼-wavelength frequency
  – Required in GHz range
  – Much less dependent of signal layer than ¼-wave formula suggests



Backdrill Recommendations			
LYR	**Stub Len (mil)**	**¼-λ Equation**	**Bandwidth (-1dB)**
Lyr03	234	6.5 GHz	1.9 GHz
Lyr11	167	9.1 GHz	2.3 GHz
Lyr22	83	18.2 GHz	2.4 GHz
Lyr30	17	89.1 GHz	2.3 GHz

PCB Design Guidelines – Ground Via

- **Ground Via Proximity – Rule of Thumb:**
  – No standard design rules for ground via location
- **Simulation Results:**
  – Ground via location have significant impact on performance
  – Design rules created based on frequency



PCB Design Guidelines – Summary

- **Connector Manufacturer Specifications are not Accurate**
- **Quarter-Wavelength Stub Drill Approximation Insufficient**
- **Design Rules Require 3D Simulation**
  - Accounts for all necessary variables:
    - PCB Thickness
    - Signal Layer
    - Ground Via Proximity
    - Stub Length

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PCB Material & Contactor Selection

- **Factors impacting High Frequency Hardware Selection**
  - PCB material
  - Trace topology
  - Trace length
  - Device pitch
  - Signaling type – single-ended or differential
  - Ground-signal configuration – G-S, G-S-G, G-S-S-G
- **Multitest Hardware Selection Tool**
  - Accounts for all relevant variables

PCB Selection Parameters

- **Trace Topology**
  - Stripline (Internal) , Microstrip (External)
- **Trace Length**
  - 2”, 4”, 8”, 12”, 16”

Performance Matrix

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Pitch	GND	Trace	Length	PCB	Probe	Insertion Loss S12 -1dB	Insertion Loss S12 -3dB
0.5mm	GS	Stripline	02in	N4000-13	Btm050	2.9	7.0
0.5mm	GS	Stripline	04in	N4000-13	Btm050	1.5	5.0
0.5mm	GS	Stripline	08in	N4000-13	Btm050	0.6	2.7
0.5mm	GS	Stripline	12in	N4000-13	Btm050	0.3	1.7
0.5mm	GS	Stripline	16in	N4000-13	Btm050	0.2	1.2
0.5mm	GS	uStrip	02in	N4000-13	Btm050	3.8	8.4
0.5mm	GS	uStrip	04in	N4000-13	Btm050	2.3	6.4
0.5mm	GS	uStrip	08in	N4000-13	Btm050	1.0	3.9
0.5mm	GS	uStrip	12in	N4000-13	Btm050	0.6	2.6
0.5mm	GS	uStrip	16in	N4000-13	Btm050	0.4	1.9

Contactor Selection Parameters

- **Pitch**
  - 0.3mm, 0.4mm, 0.5mm
  - As pitch increases, impedance increases
- **Ground Configuration**
  - Signal Type
    - Single-ended (G-S, G-S-G) – one signal trace
    - Differential (G-S-S-G) – two signal traces
  - Number of adjacent grounds
    - G-S, G-S-G
    - As number of grounds increases, impedance decreases

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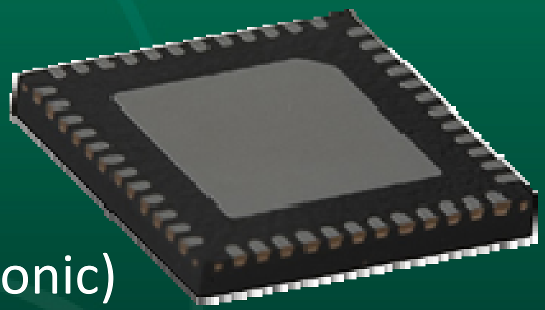
Application Example

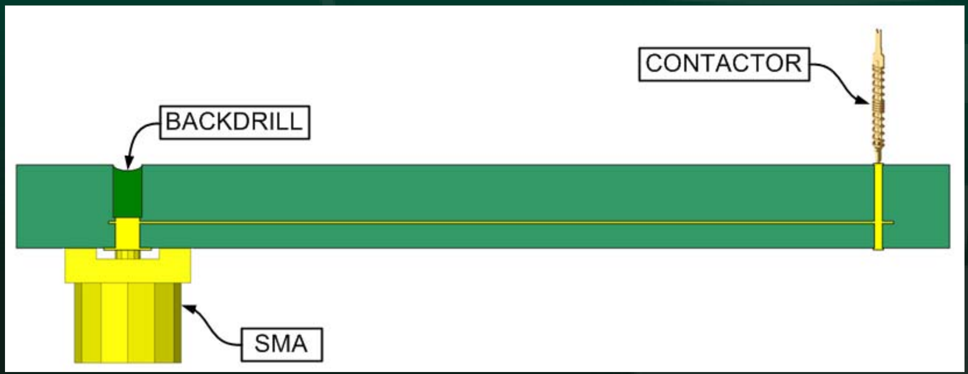
- **Example**
  - 48 QFN, 0.5 mm pitch, 7x7 mm
  - Application: Gigabit Ethernet Controller
  - 2.5 Gbit/s Differential PCI-express
    - Requires 3.75 GHz bandwidth (3^{rd} harmonic)



- **Goal – Meet Application Frequency Requirements**
  - Determine connector type
  - Determine if stub drill is required
  - Select optimal PCB material
  - Select optimal Pogo pin for contactor

Application Example – Connector Type

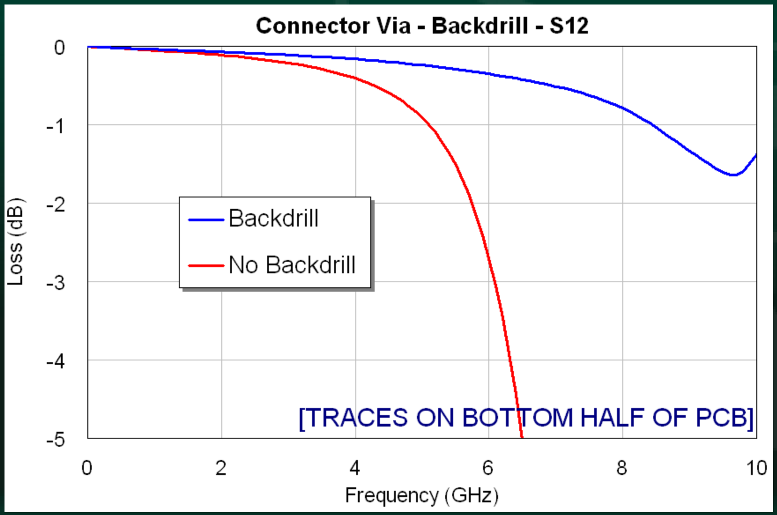
- **Requires 3.75 GHz bandwidth**
- **Connector choice**
  - Surface mount, right-angle, top-launch SMA connector
  - Allows for backdrill
  - Minimizes loss without use of high-cost connector

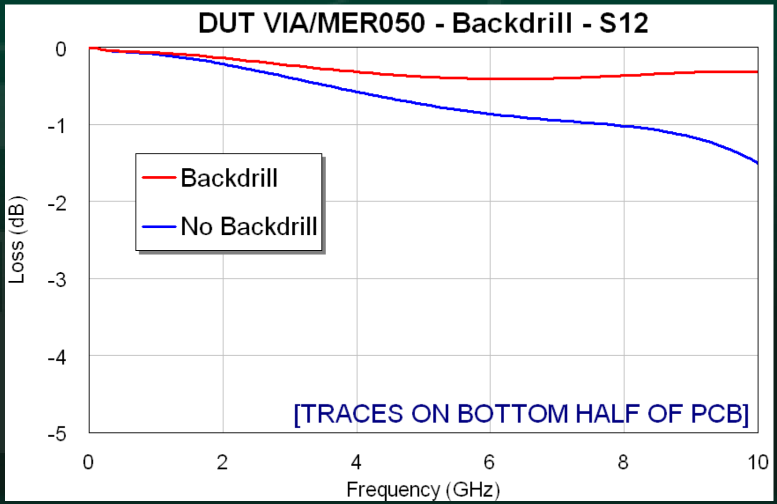


Connector Type	Loss @ 3.75GHz	Bandwidth (-1dB)
High-Cost Surface SMA	0.1dB	15.0 GHz
Med-Cost Surface SMA	0.1dB	11.1 GHz
Thru-Hole SMA	1.2dB	2.9 GHz

Application Example – Stub Drill

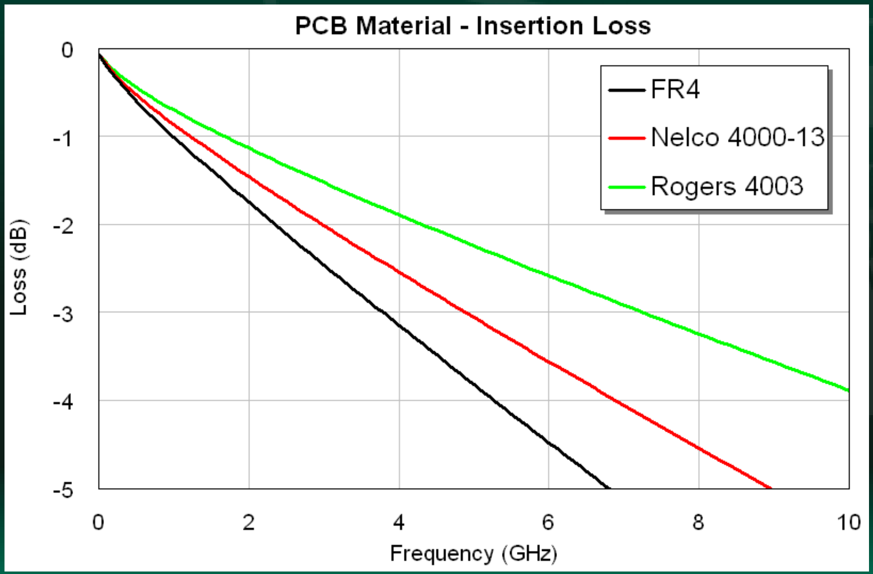
- **Stub Drill Not Necessary at DUT or at Connector**
- **Performance Stays Within Loss Budget (-3dB) Without Stub Drill**
- **Recommendation**
  – Use high-aspect ratio drilling at DUT
  – Eliminates the need for sequential lamination





Application Example – PCB Material

- **Majority of Loss Due to PCB Trace**
- **Recommendation – Nelco 4000-13**
  - Good high-speed material
  - Meets performance requirements without expense of exotic material



PCB Material	Loss @ 3.75GHz
FR4	2.8dB
Nelco 4000-13	2.1dB
Rogers 4003	1.6dB

Application Example – PCB & Contactor

- **Application Specifications**
  - 0.5mm
  - GSSG (Differential)
  - Stripline
  - 8” PCB Trace
- **Nelco 4000-13**
- **MER050 is best solution**
  - System Bandwidth (-3dB) is greater than 3.75GHz

Performance Matrix

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Pitch	GND	Trace	Length	PCB	Probe	Insertion Loss S12 -1dB	Insertion Loss S12 -3dB
0.3mm	GS	Stripline	02in	N4000-13	Btm050	2.9	7.0
0.4mm	GS	Stripline	04in	N4000-13	Btm050	1.5	5.0
0.5mm	GS	Stripline	08in	N4000-13	Btm050	0.6	2.7
0.5mm	GS	Stripline	12in	N4000-13	Btm050	0.3	1.7
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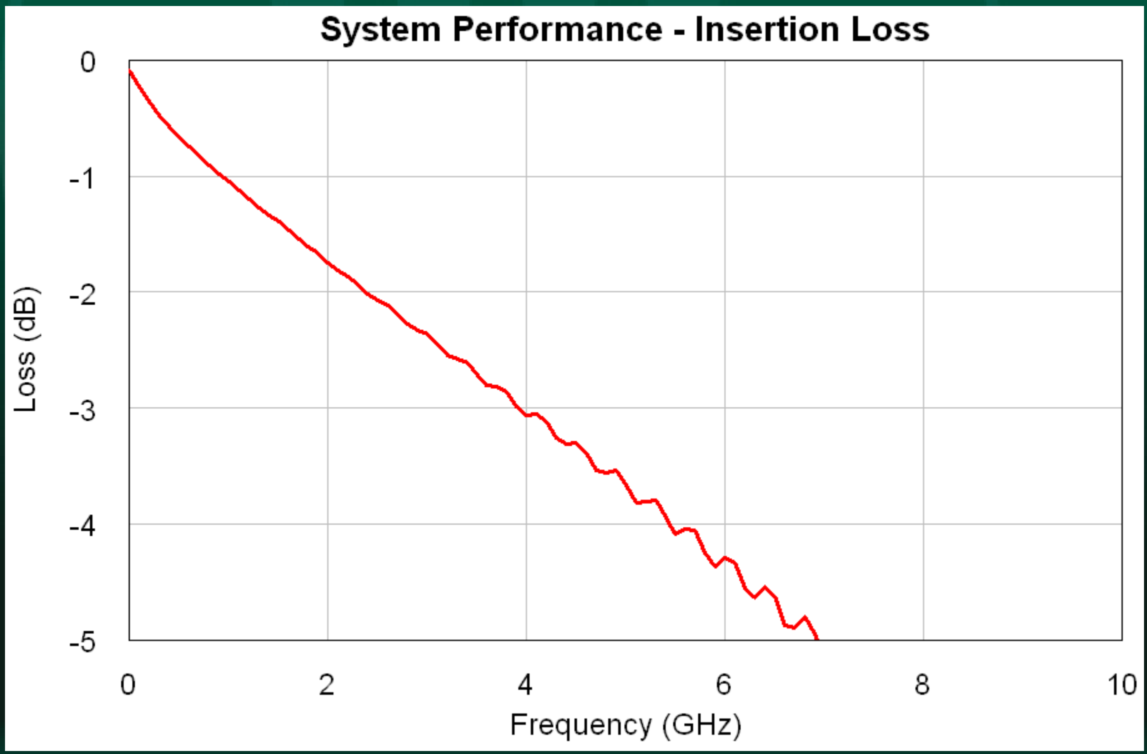
0.5mm	GS	uStrip	12in	N4000-13	Btm050	0.6	2.6
0.5mm	GS	uStrip	16in	N4000-13	Btm050	0.4	1.9
0.5mm	GSG	Stripline	02in	N4000-13	Btm050	3.9	12.2
0.5mm	GSG	Stripline	04in	N4000-13	Btm050	1.7	6.7
0.5mm	GSG	Stripline	08in	N4000-13	Btm050	0.6	3.0
0.5mm	GSG	Stripline	12in	N4000-13	Btm050	0.3	1.8
0.5mm	GSG	Stripline	16in	N4000-13	Btm050	0.2	1.2
0.5mm	GSG	uStrip	02in	N4000-13	Btm050	5.6	17.2
0.5mm	GSG	uStrip	04in	N4000-13	Btm050	2.7	9.4
0.5mm	GSG	uStrip	08in	N4000-13	Btm050	1.1	4.5
0.5mm	GSG	uStrip	12in	N4000-13	Btm050	0.6	2.8
0.5mm	GSG	uStrip	16in	N4000-13	Btm050	0.4	1.9
0.5mm	GSSG	Stripline	02in	N4000-13	Btm050	4.1	14.9
0.5mm	GSSG	Stripline	04in	N4000-13	Btm050	1.8	6.9
0.5mm	GSSG	Stripline	08in	N4000-13	Btm050	0.7	3.1
0.5mm	GSSG	Stripline	12in	N4000-13	Btm050	0.3	1.8

System Performance

- SMA Connector → 8” Stripline → MER050 Contactor
- System Bandwidth (-3dB): 3.9 GHz



Conclusion

- **A new WLP high frequency solution is available**
- **Multitest Solution Uses:**
  - Simulation and Characterization
  - PCB design recommendations based on high frequency 3D electromagnetic simulation
  - Hardware selection tool to fit the needs of each customer specific application