GigaTest Labs

ELECTRICAL PERFORMANCE

of

PCB MATERIALS

for

TEST TOOLING APPLICATIONS

by Tom Strouth

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Outline

- Problem Definition
- Typical Probe Card Construction
- Electrical Properties of Materials
- Analysis of Typical Signal Line
- Frequency Domain Results
- Time Domain Results
- Conclusions

Problem Definition

What PCB materials will meet the electrical performance needs for my high speed Digital or Wireless test tooling requirement?

Other Critical Criteria

- Multi-layer PCB fabrication
- Copper clad metalization
- Meets mechanical requirements
- Stable at high temperatures

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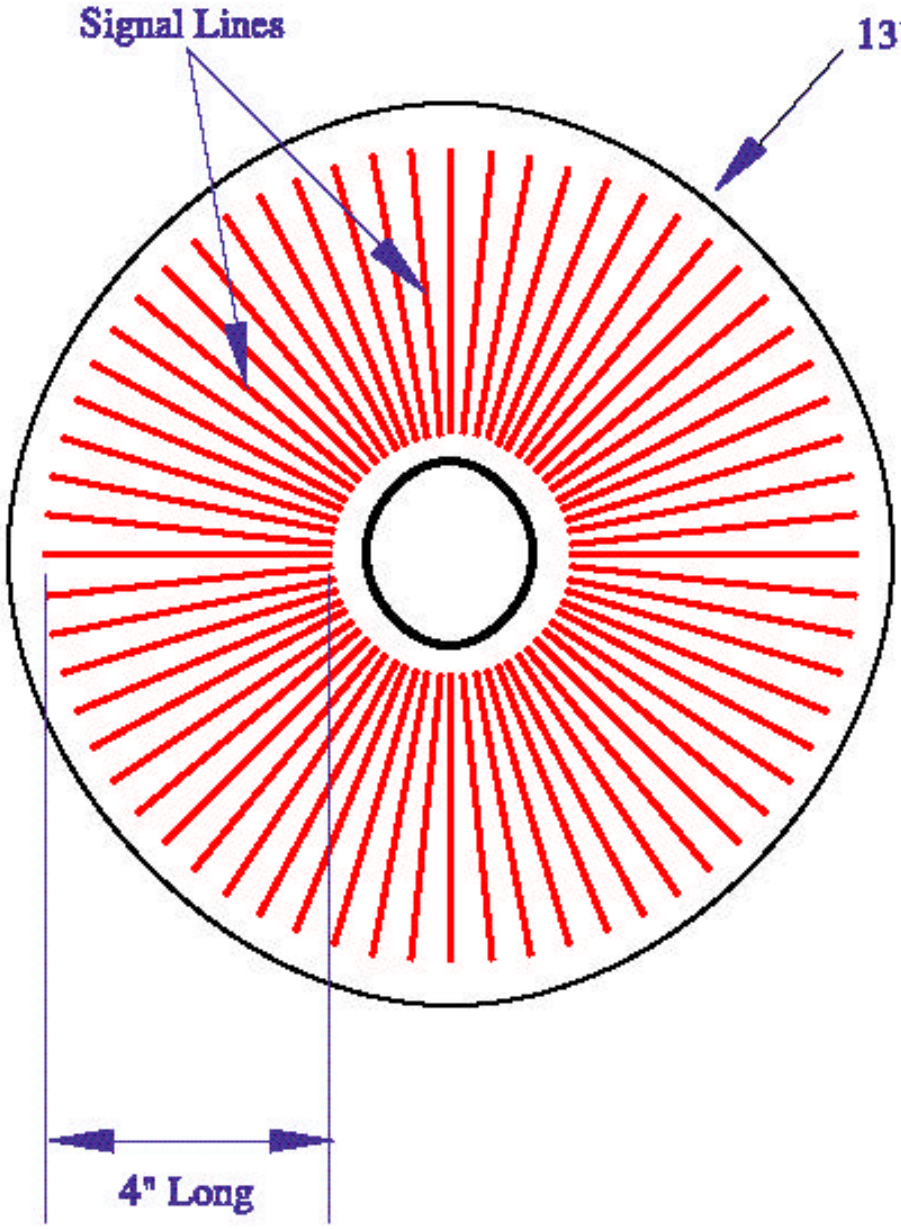
Typical Probe Card Construction



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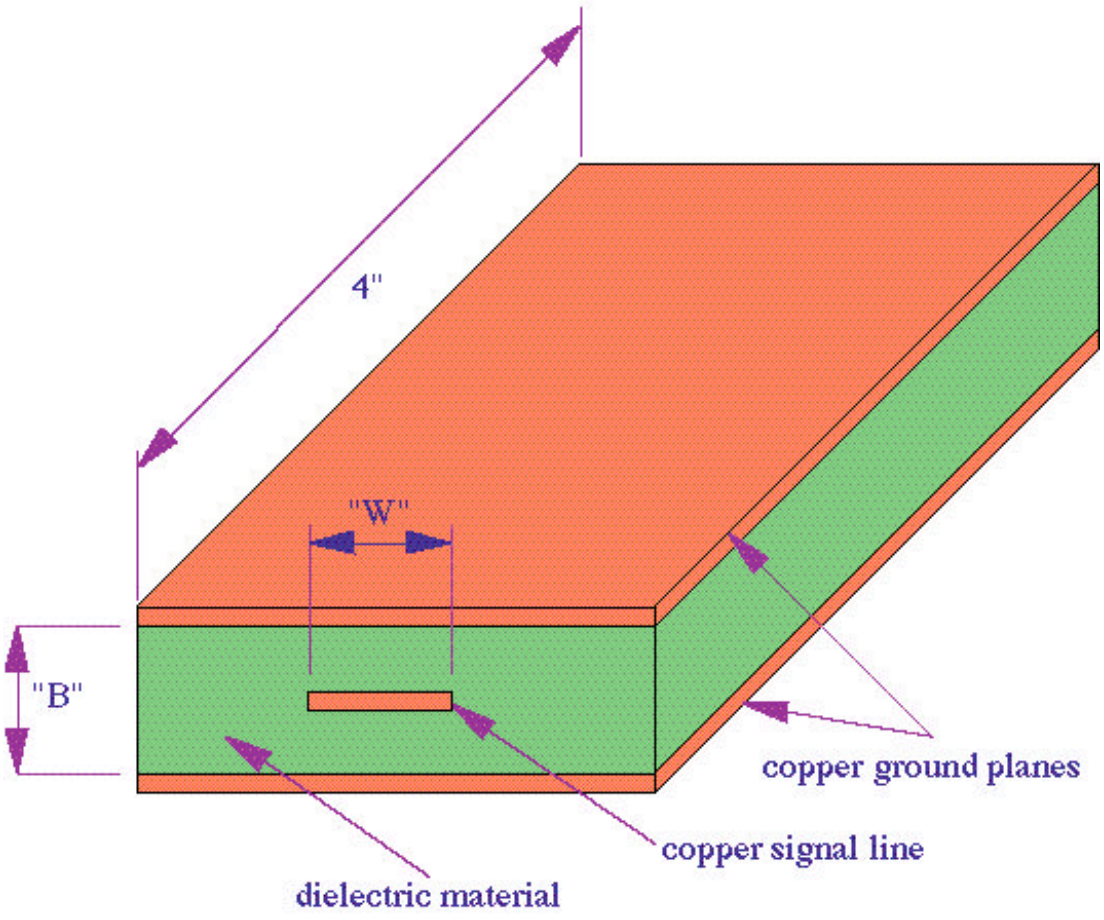
Signal Line Analysis
Test Vehicle

Stripline Transmission Line



"B" = 0.040 inches

"W" = signal line width

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Electrical Properties of PCB Materials

Material	Dielectric Constant	Dissipation Factor
FR4	4.6	0.030
Polyimide Glass	4.0	0.020
Polyimide Film (Flex)	3.5	0.050
Cyanate Ester	3.5	0.005
Bismaleimide Triazine (BT)	4.2	0.020
GETEK®	3.9	0.010
Duroid®	2.3	0.001

Analysis Methodology

- HP MDS (Microwave Design System) Electrical Performance Computer Simulation Tools

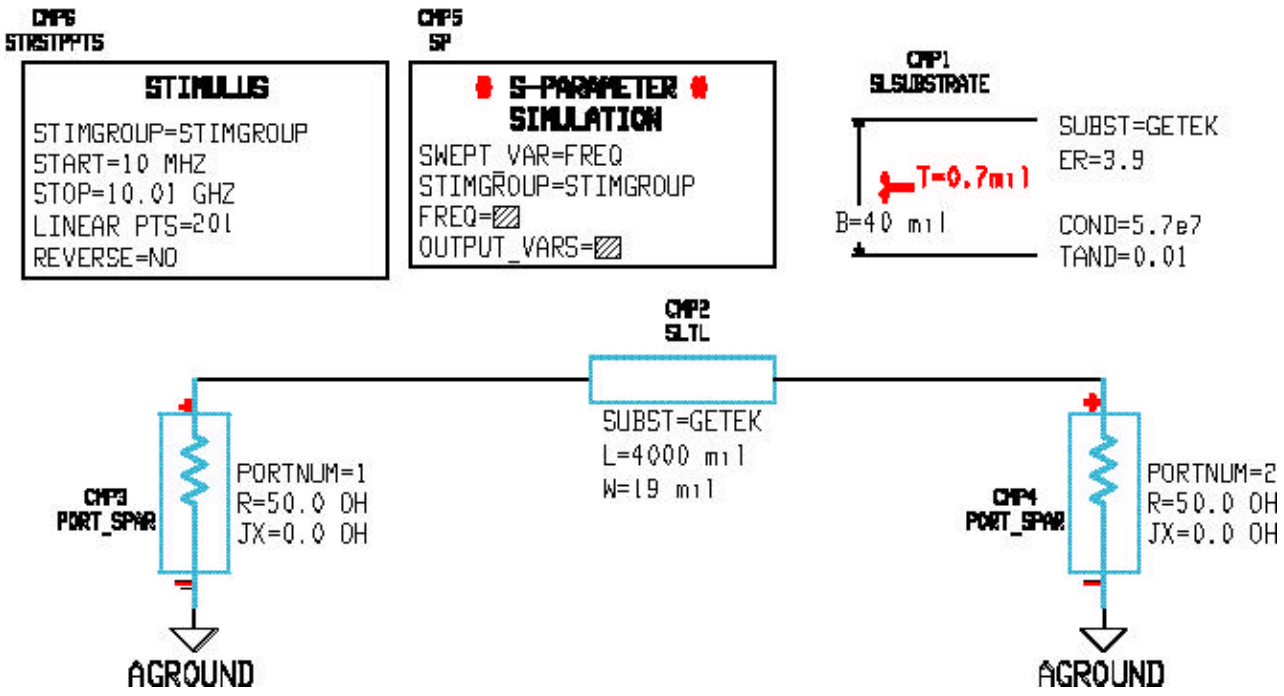
  (Transmission line models include frequency dependent parameters like dielectric losses and skin effect)

- Verification of model accuracy through s-parameter measurements
- Use “Dynamic Convolution” technique and HP Impulse tools for Time Domain analysis
- Keep Ground Plane spacing constant (“B”), adjust signal line width (“W”) for 50ž characteristic impedance
- Define Bandwidth as -3 dB loss frequency
- Metalization in all cases is 1 oz copper

Frequency Domain Circuit

Electrical Performance of PCB Materials

MDS Frequency Domain Circuit Simulation



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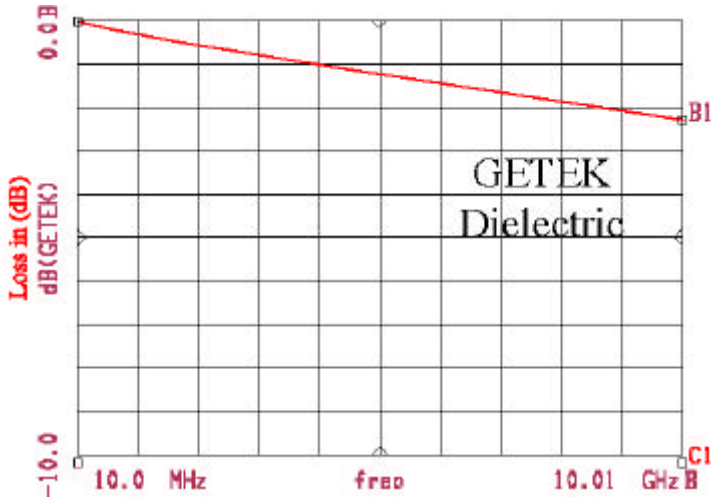
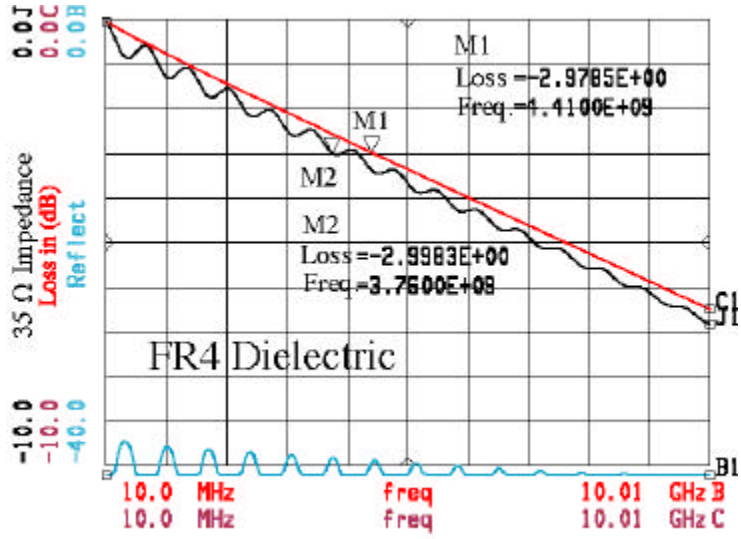
Frequency Domain Results

Electrical Performance of PCB Materials

MDS Frequency Domain Simulation





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Frequency Domain Results

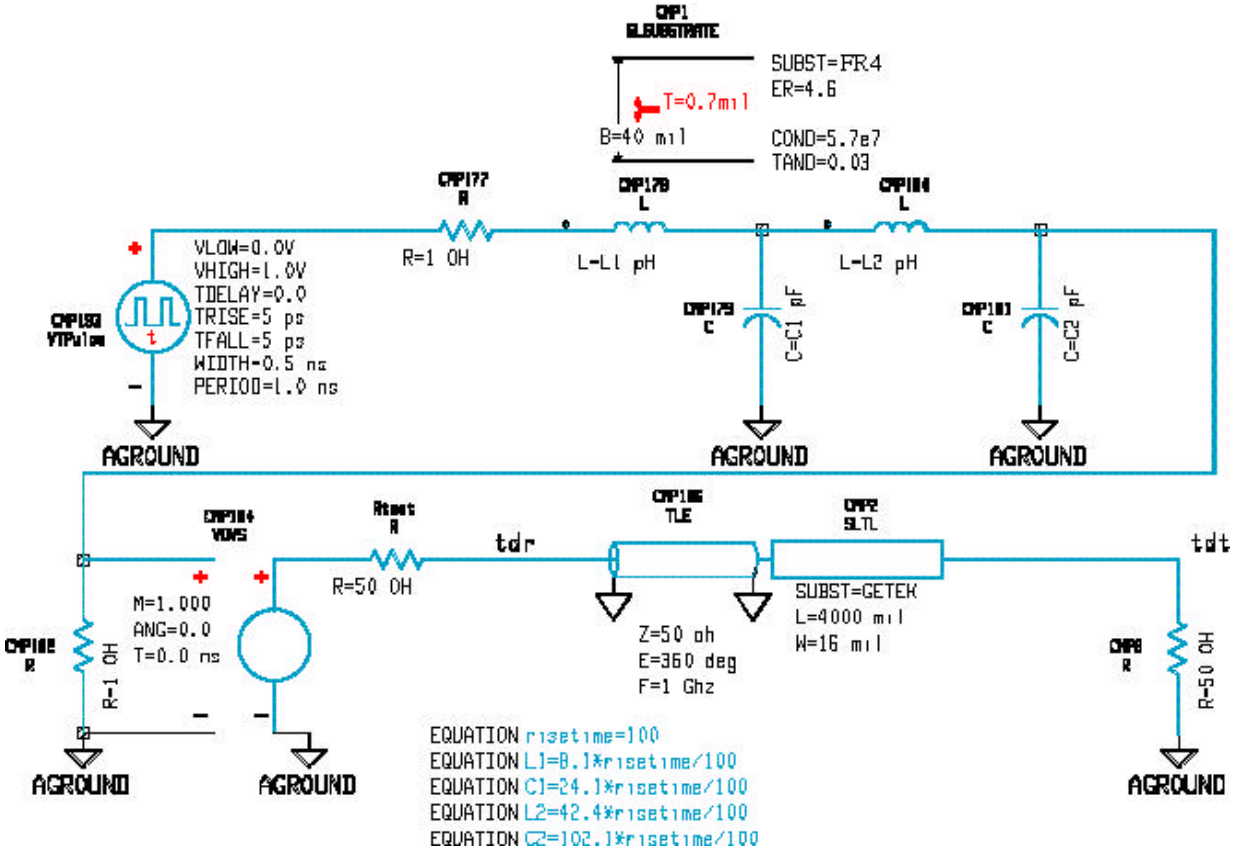
Based on 4 inch long 50ž signal line

Material	-1dB Bandwidth (GHz)	-3dB Bandwidth (GHz)
FR4	1.4	4.5
Polyimide Glass	2.2	7.0
Polyimide Film (Flex)	1.0	3.2
Cyanate Ester	7.4	>10
Bismaleimide Triazine (BT)	2.0	6.9
GETEK®	4.0	>10
Duroid®	>10	>10

Time Domain Circuit

Electrical Performance of PCB Materials

MDS Time Domain Circuit Simulation



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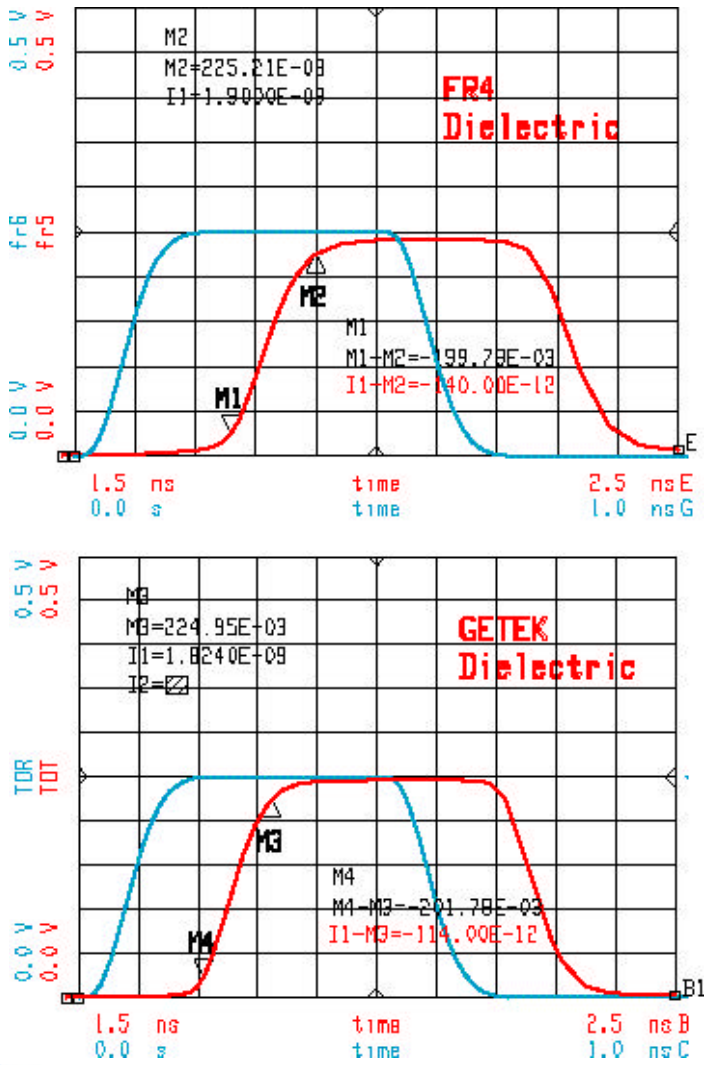
Time Domain Results

Electrical Performance of PCB Materials

MDS Time Domain Simulation



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Time Domain Results

Output Rise Time (ps)
Based on 4 inch long 50ž signal line

Material	500 MHz Data (t_r in = 200 ps)	1 GHz Data Data (t_r in = 100 ps)
FR4	245	140
Polyimide Glass	235	124
Polyimide Film (Flex)	260	160
Cyanate Ester	210	105
Bismaleimide Triazine (BT)	225	126
GETEK®	225	114
Duroid®	200	104

Conclusions

- Common low cost PCB materials do not limit signal line electrical performance in most probe card applications.
- Impedance control of ± 10% for high speed signal lines is sufficient for most test tooling applications.