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Electromagnetic Solutions

Effect of microstrip line width on losses per unit length

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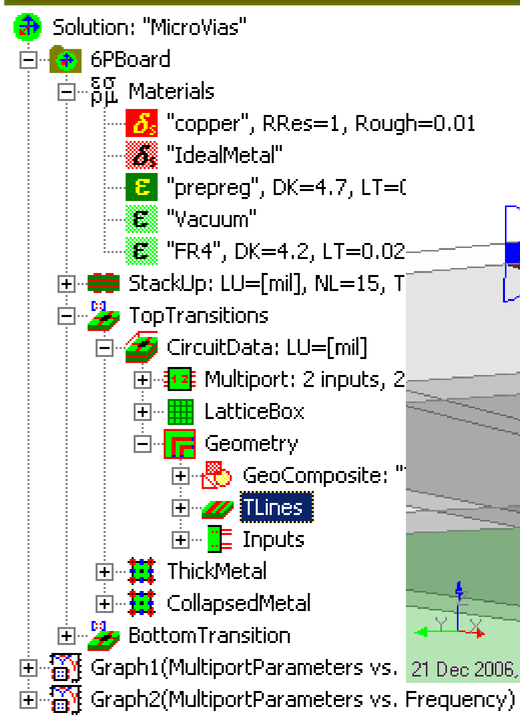

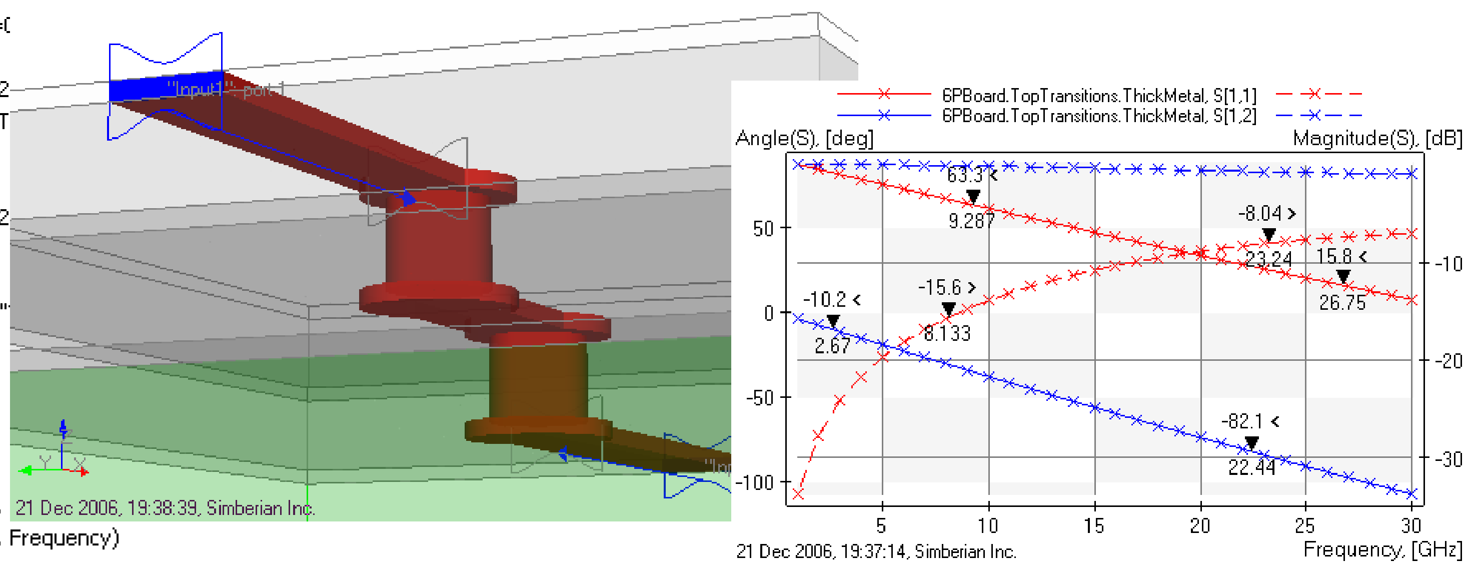

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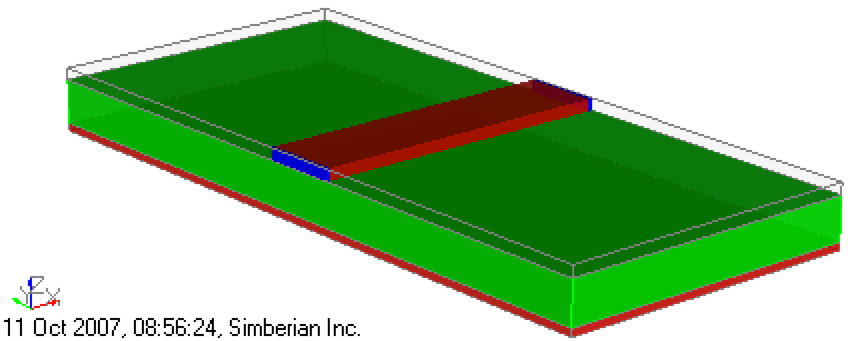
Goal

- Investigate effect of trace width on losses of single and differential microstrip lines in frequency range from 1 GHz to 20 GHz with 3D full-wave solver Simbeor 2007
  - Estimate attenuation per unit length for 50-Ohm single and 100-Ohm differential lines with different trace width
  - Take into account skin, edge, proximity effects and conductor surface roughness
  - Use causal wideband dielectric model for polarization losses

Single microstrip lines



Common parameters:

Trace conductor thickness 1.2 mil, plane thickness 0.77 mil

Dielectric DK=4.1, loss tangent 0.01 at 1 GHz, wideband Debye polarization model

Conductor is copper with resistivity 1.724e-8 Ohm-meter

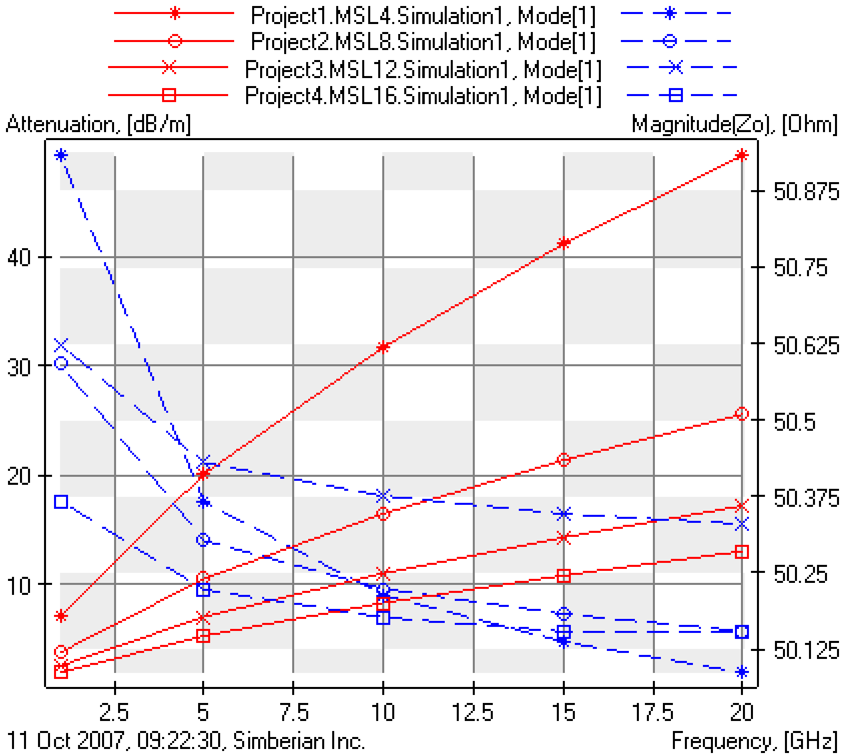
Roughness is 1 um for all conductor surfaces

Configurations under study (all are approximately 50-Ohm lines):

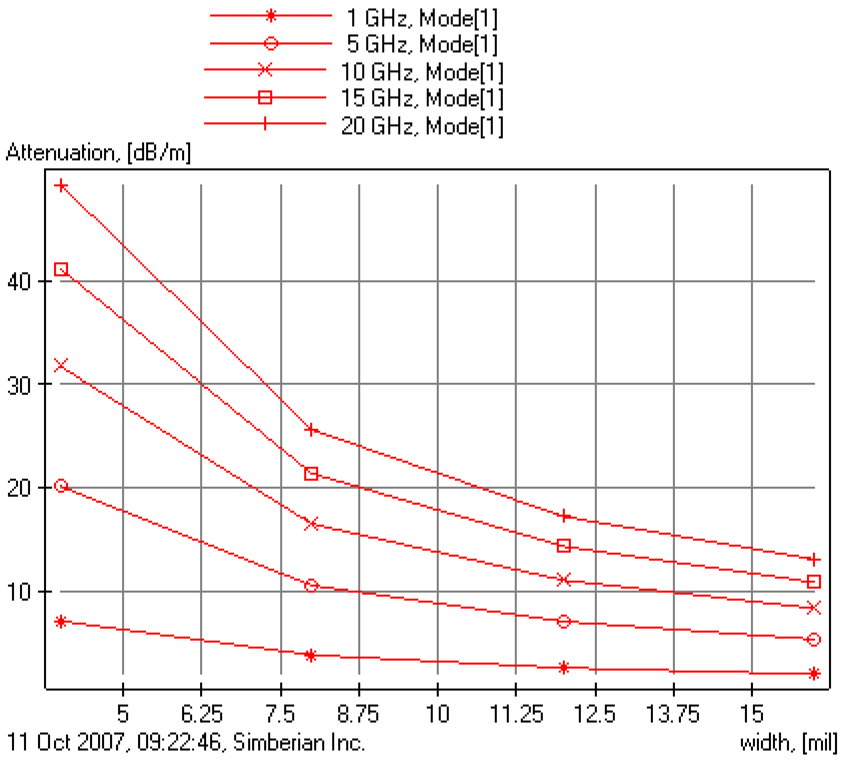
- MSL4: trace width 4 mil, substrate thickness 2.3 mil
- MSL8: trace width 8 mil, substrate thickness 4.4 mil
- MSL12: trace width 12 mil, substrate thickness 6.5 mil
- MSL16: trace width 16 mil, substrate thickness 8.5 mil

Conductor loss only (no dielectric loss)

Attenuation [dB/m] and magnitude of characteristic impedance as functions of frequency



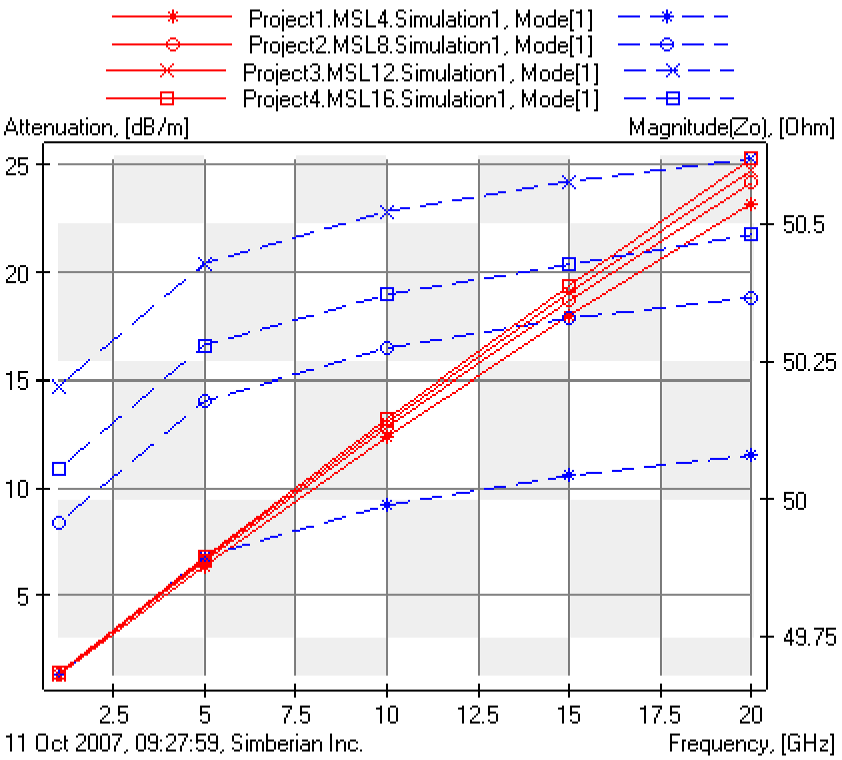
Attenuation [dB/m] as a function of strip width (substrate thickness changes to have 50-Ohm line)



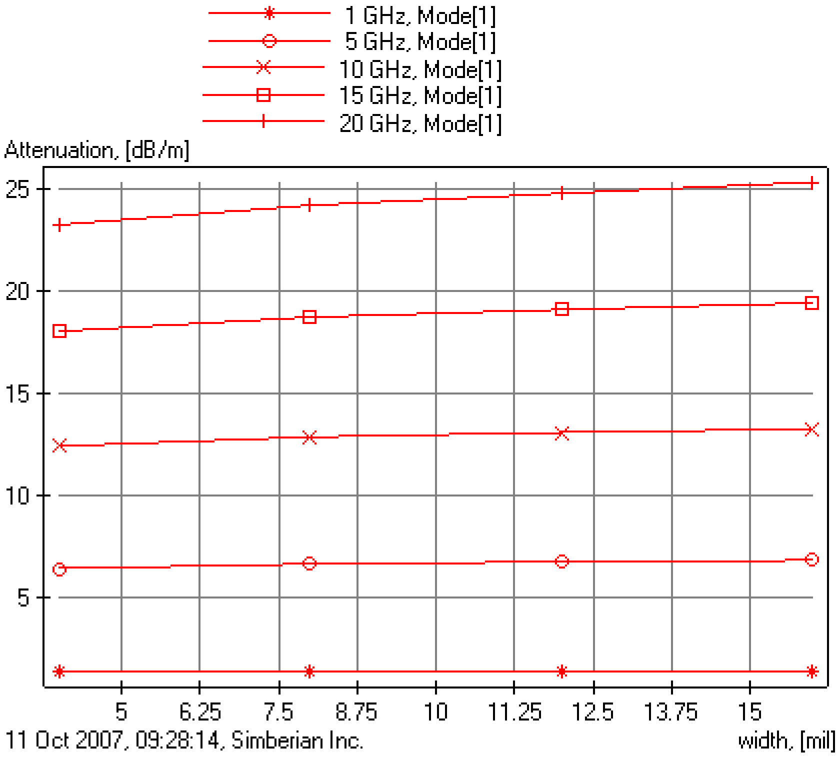
Microstrip with 16-mil trace on 8.5 mil substrate has about 3.7 times smaller losses at all frequencies than the line with 4-mil trace on 2.3 mil substrate

Dielectric loss only (no conductor loss)

Attenuation [dB/m] and magnitude of characteristic impedance as functions of frequency



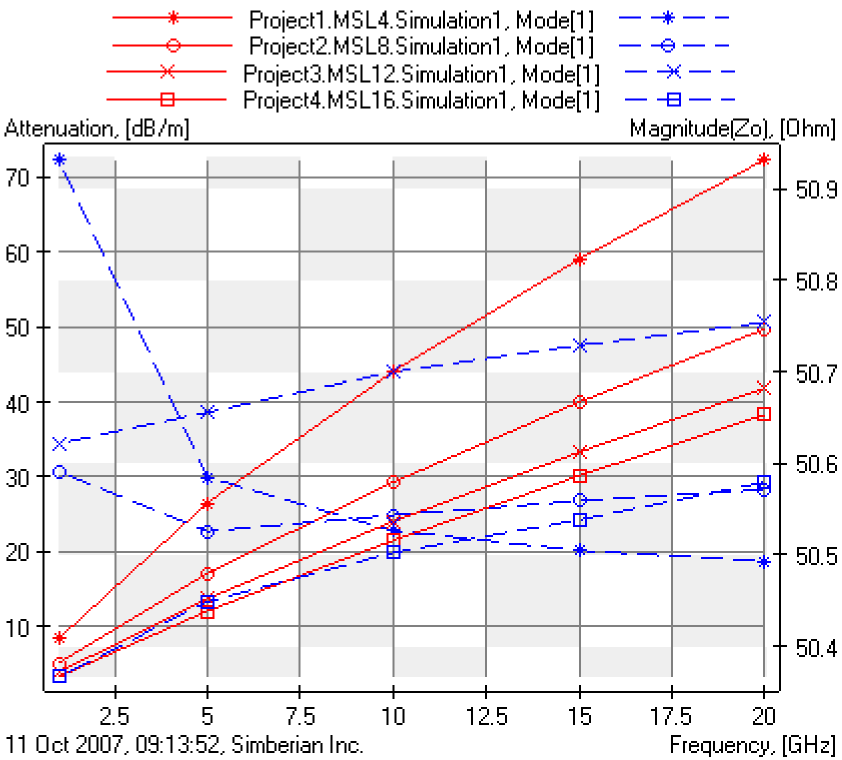
Attenuation [dB/m] as a function of strip width (substrate thickness changes to have 50-Ohm line)



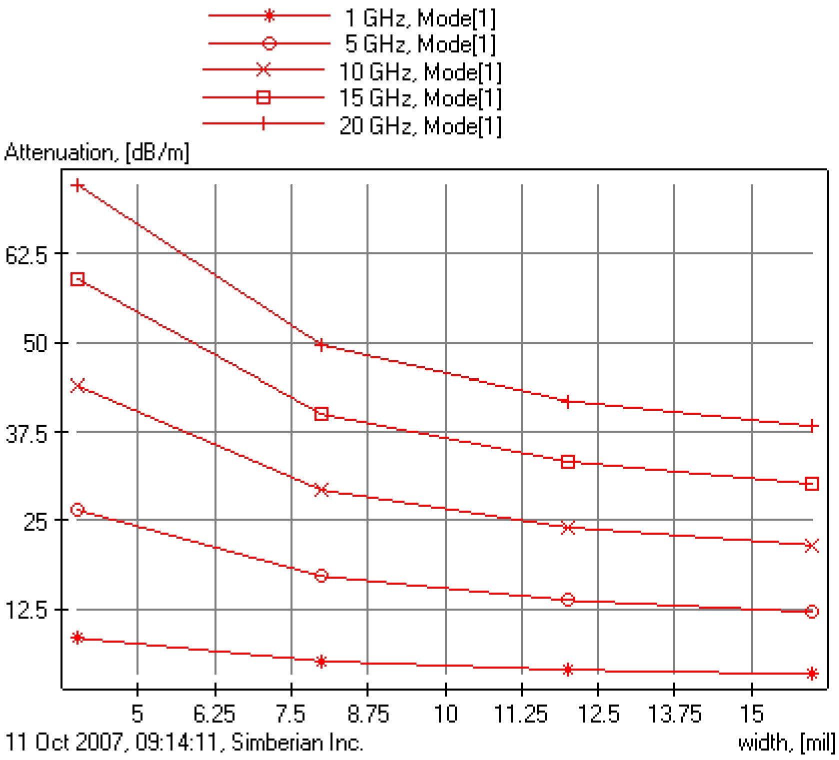
Microstrip with 16-mil trace on 8.5 mil substrate has slightly larger losses than the line with 4-mil trace on 2.3 mil substrate

Total losses (dielectric and conductor)

Attenuation [dB/m] and magnitude of characteristic impedance as functions of frequency

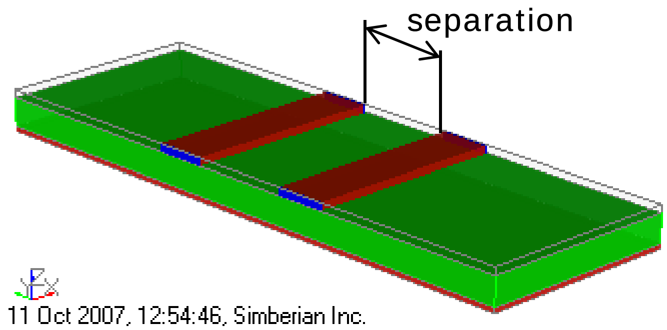


Attenuation [dB/m] as a function of strip width (substrate thickness changes to have 50-Ohm line)



Microstrip with 16-mil trace on 8.5 mil substrate has about 2.54 times smaller losses at 1 GHz and 1.9 times smaller losses at 20 GHz than the line with 4-mil trace on 2.3 mil substrate

Differential microstrip lines (loose coupling)



Common parameters:

Trace conductor thickness 1.2 mil, plane thickness 0.77 mil

Dielectric DK=4.1, loss tangent 0.01 at 1 GHz, wideband Debye polarization model

Conductor is copper with resistivity 1.724e-8 Ohm-meter

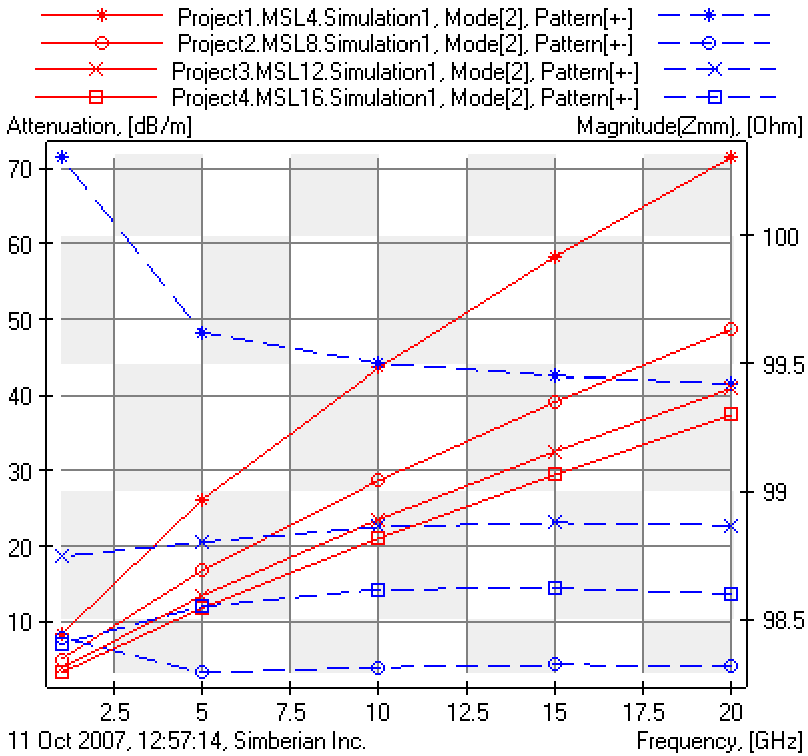
Roughness is 1 um for all conductor surfaces

Configurations under study (all are approximately 100-Ohm lines):

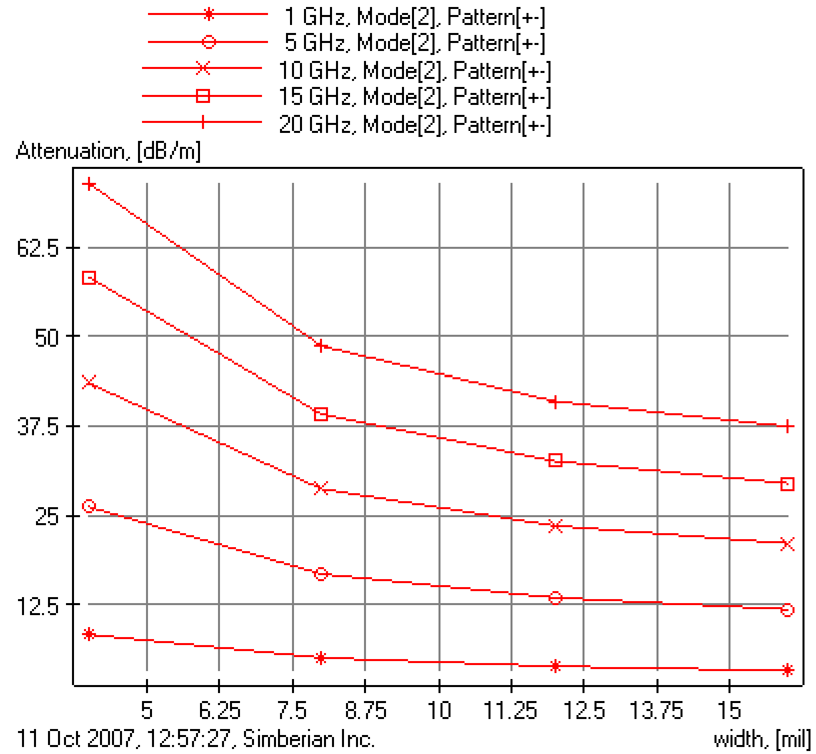
- MSL4: trace width 4 mil, separation 8 mil, substrate thickness 2.3 mil
- MSL8: trace width 8 mil, separation 16 mil, substrate thickness 4.4 mil
- MSL12: trace width 12 mil, separation 24 mil, substrate thickness 6.5 mil
- MSL16: trace width 16 mil, separation 32 mil, substrate thickness 8.5 mil

Total losses for differential mode (loose coupling)

Attenuation [dB/m] and magnitude of characteristic impedance as functions of frequency for differential mode

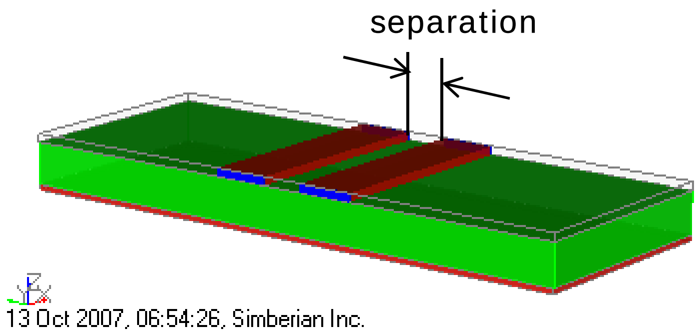


Attenuation [dB/m] of differential mode as a function of strip width (substrate thickness and separation changes to have 100-Ohm line)



Line MSL16 with 16-mil traces has about 2.55 times smaller losses at 1 GHz and only 1.9 times smaller losses at 20 GHz than the line MSL4 with 4-mil traces. Similar to single-ended microstrip.

Differential microstrip lines (tight coupling)



Common parameters:

Trace conductor thickness 1.2 mil, plane thickness 0.77 mil

Dielectric DK=4.1, loss tangent 0.01 at 1 GHz, wideband Debye polarization model

Conductor is copper with resistivity 1.724e-8 Ohm-meter

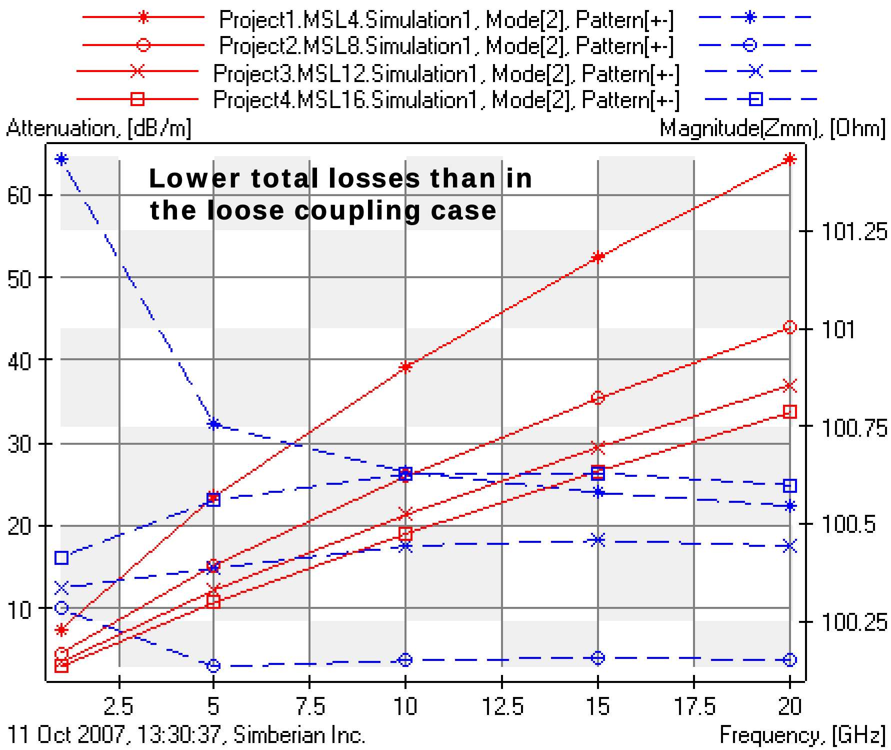
Roughness is 1 um for all conductor surfaces

Configurations under study (all are approximately 100-Ohm lines):

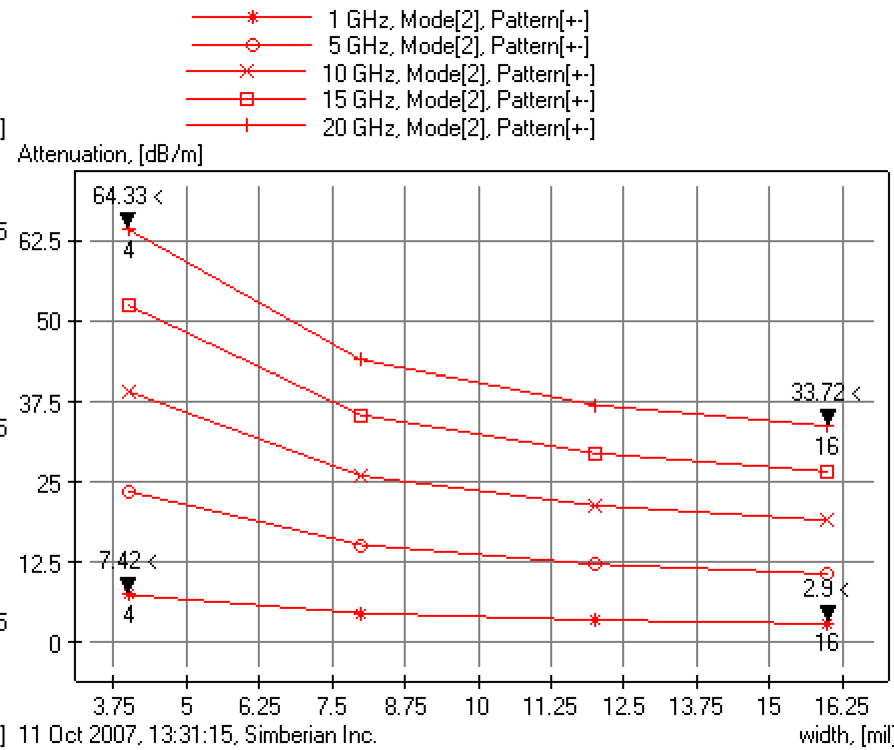
- MSL4: trace width 4 mil, separation 4 mil, substrate thickness 3 mil
- MSL8: trace width 8 mil, separation 6 mil, substrate thickness 6 mil
- MSL12: trace width 12 mil, separation 9 mil, substrate thickness 8.5 mil
- MSL16: trace width 16 mil, separation 12 mil, substrate thickness 11 mil

Total losses for differential mode (tight coupling)

Attenuation [dB/m] and magnitude of characteristic impedance as functions of frequency for differential mode



Attenuation [dB/m] of differential mode as a function of strip width (substrate thickness and separation changes to have 100-Ohm line)



Line MSL16 with 16-mil traces has about 2.55 times smaller losses at 1 GHz and only 1.9 times smaller losses at 20 GHz than the line MSL4 with 4-mil traces.
Similar to single-ended microstrip and to loosely coupled cases.

Conclusion

- Microstrip lines with wider traces have smaller loses
  - Increase of width 2 times can reduce losses about 2 times for almost lossless dielectrics
  - The higher dielectric losses the smaller the loss reduction
  - Single-ended and differential lines show the same loss reduction for wider traces
- Conductor and dielectric loss effects are not separable in general and only 3D full-wave analysis with longitudinal field components can produce reliable results for frequencies above 1 GHz

Solutions and contact

- Solution files are available for download from the simberian web site
  - http://www.simberian.com/AppNotes/Solutions/LossesInMicrostripLine_2007_06.zip
- Send questions and comments to
  - General: info@simberian.com
  - Sales: sales@simberian.com
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