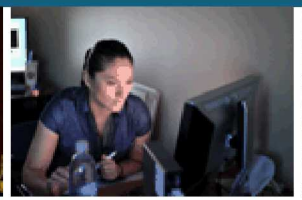
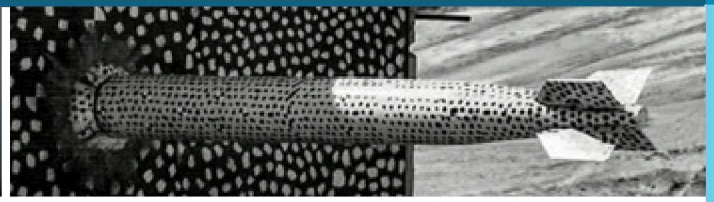
SAND2019-7096PE

Testing mutual inductance between PTLs





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Rupert Lewis

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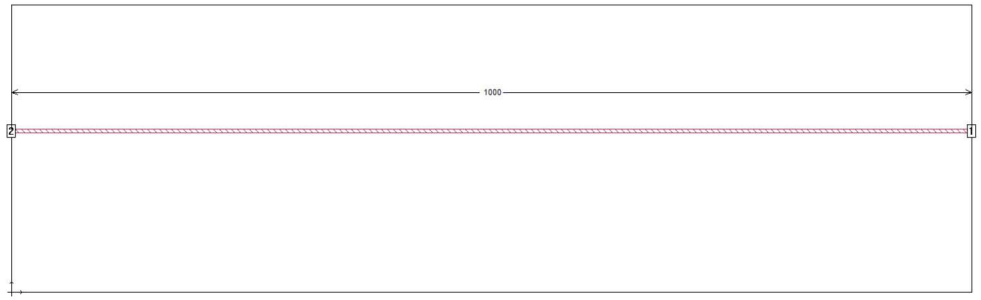
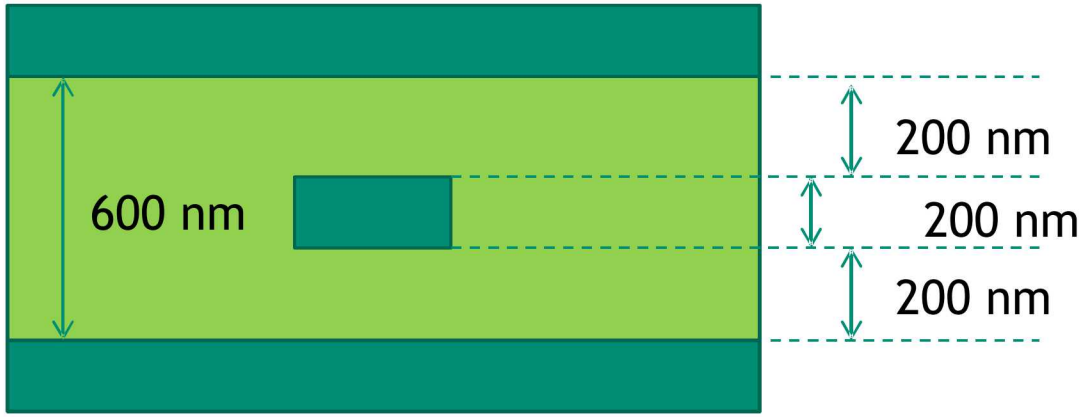
Basic check of a microstrip transmission line: 1 mm line between ground planes.

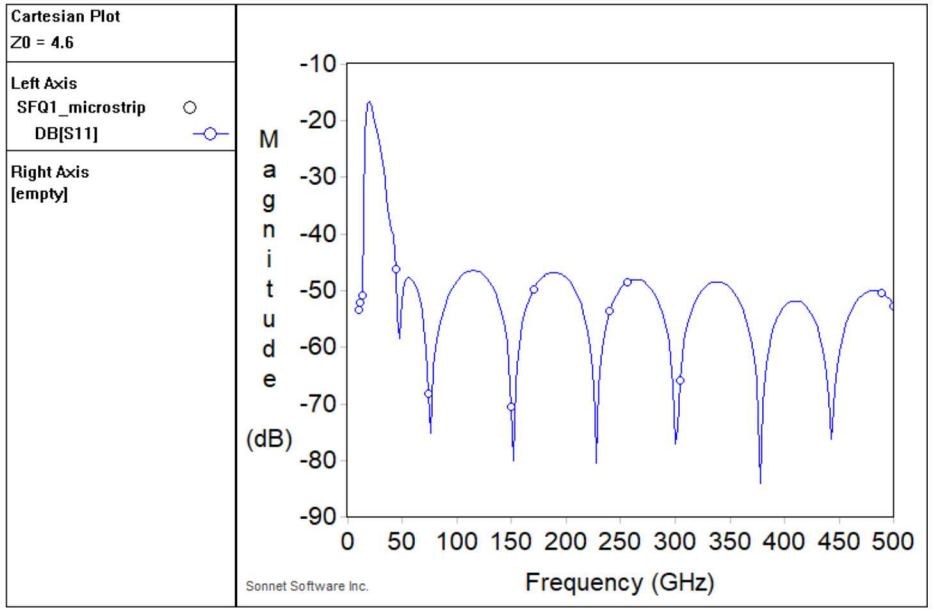


4.6 ohm ports, 4 um wide line, 200nm thick. This is lossless, but not superconducting.

Geometry: Section view of line

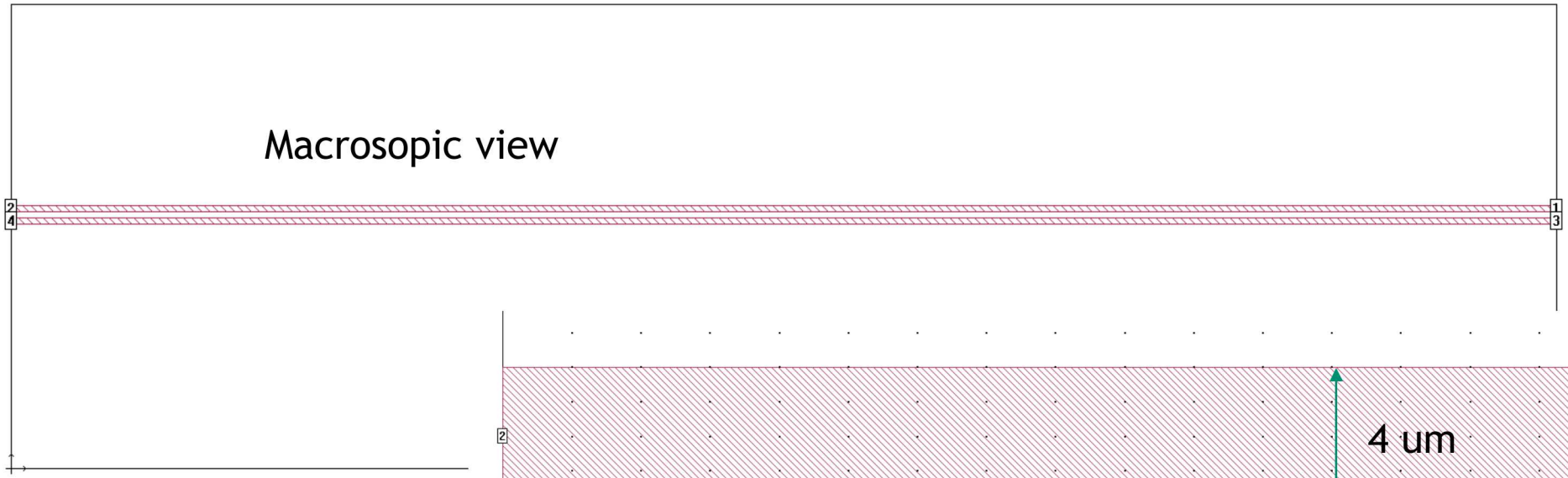


Reflection coefficient is low! Good match.

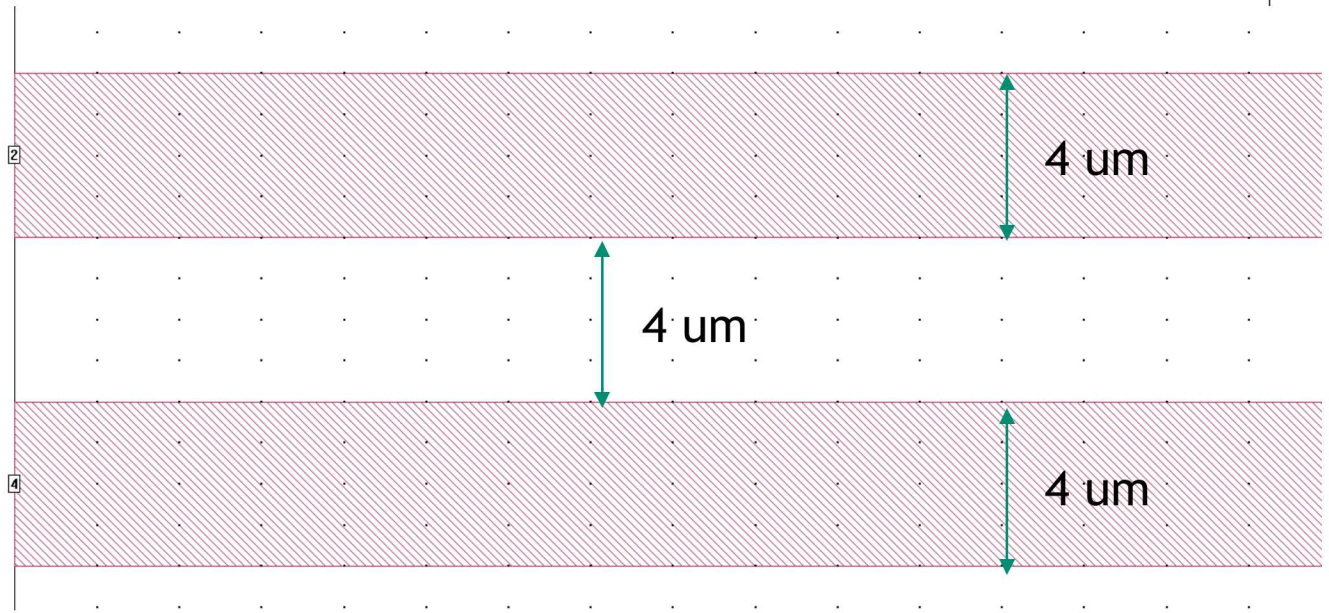


Caveat: metal films modeled as lossless, no surface reactance here

Add a parallel line for parasitic coupling: pitch is 2 line widths



Zoom in

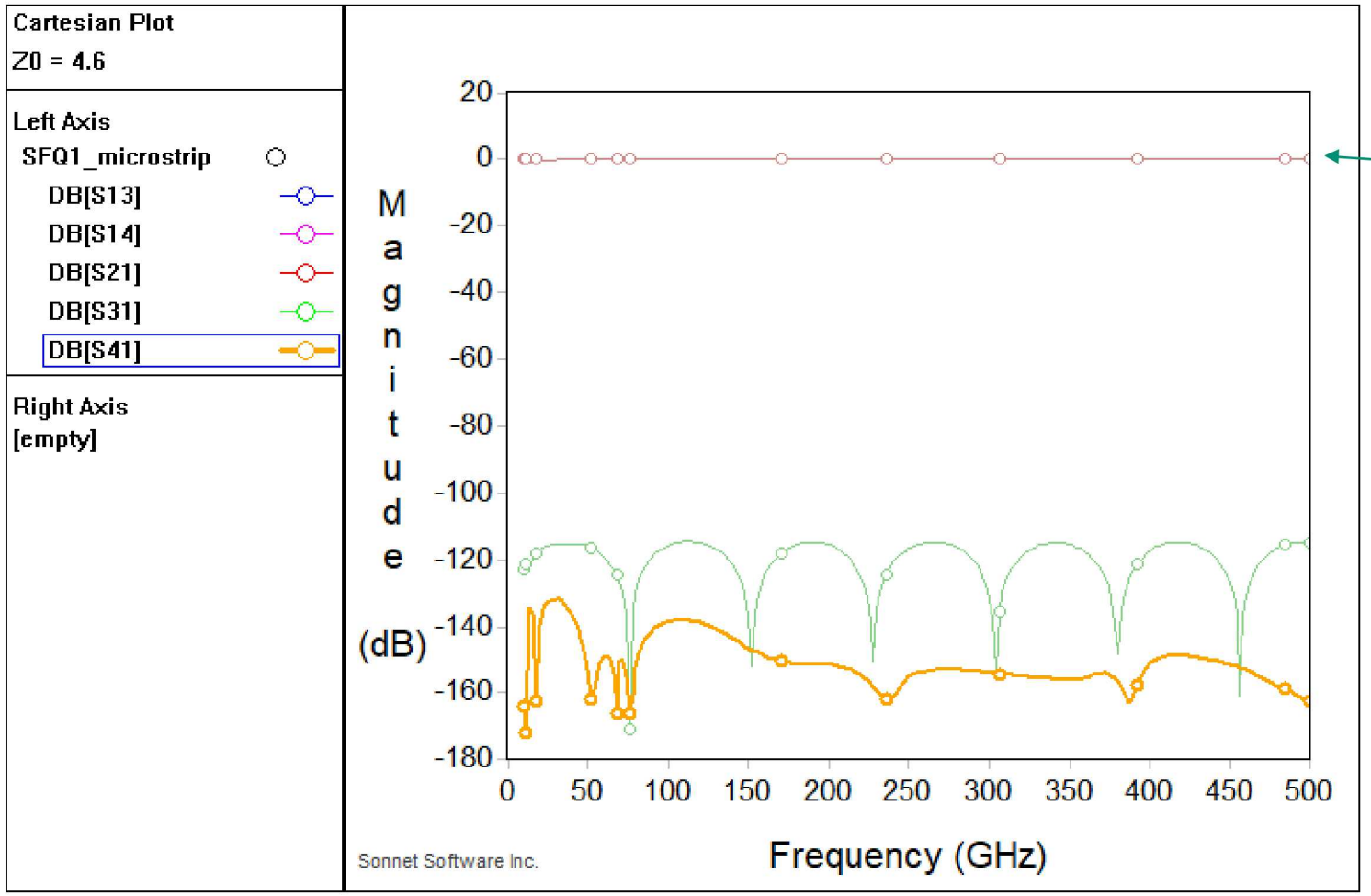


Zoom in.

Dots are:2 um in x
1 um in y

Lines are: 4 um wide,
4 um apart

Transmission S parameters for previous slide



S21 (port 1 to 2)

S31 (from 1 to 3)

S41 (from 1 to 4)

No significant coupling, max coupled power is 12 orders of magnitude down.

How to interpret slide 6:

Plots show LogMag of Power transmitted (P = energy/time)

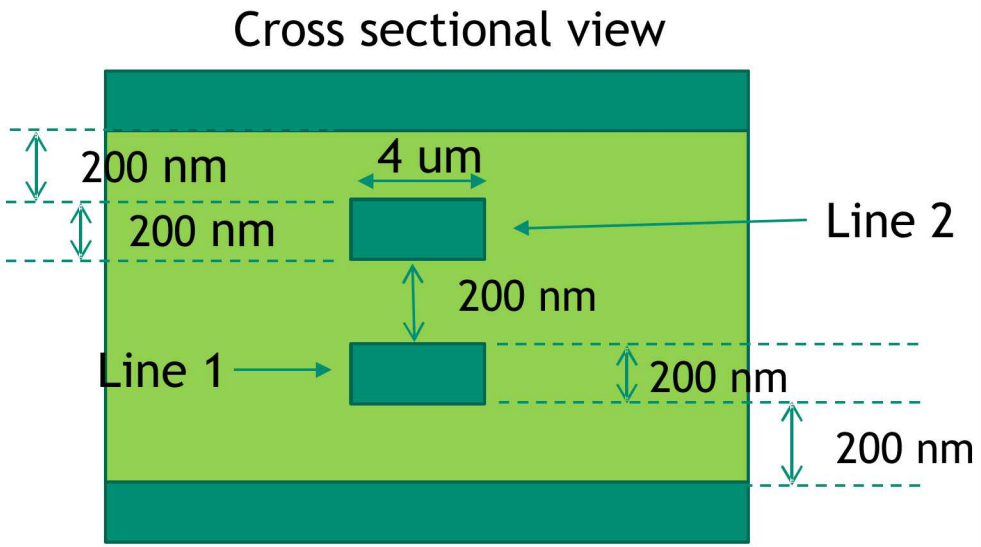
Very little power is coupled into the parallel line at 4 um spacing

- Coupled power is 1e-12 approx. (-120 dB)
- Coupled current is 1e-6 ($P = I^2 R$)

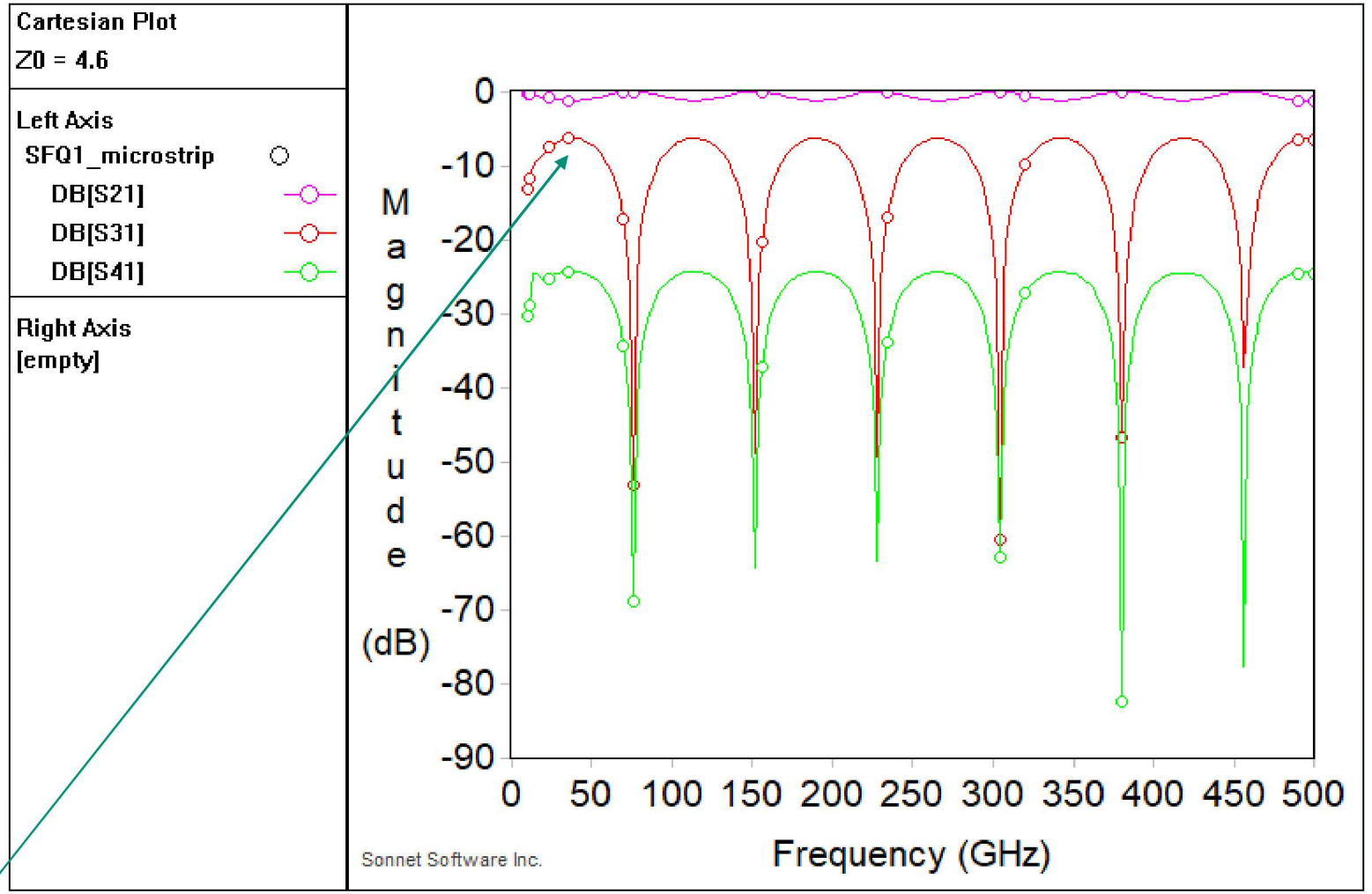
This lateral coupling can be ignored for 1 mm length wires

- Couplings grow linearly (with length) in the abcense of resonant effects (standing waves)

Change the arrangement of the lines for maximum coupling (stack vertically)

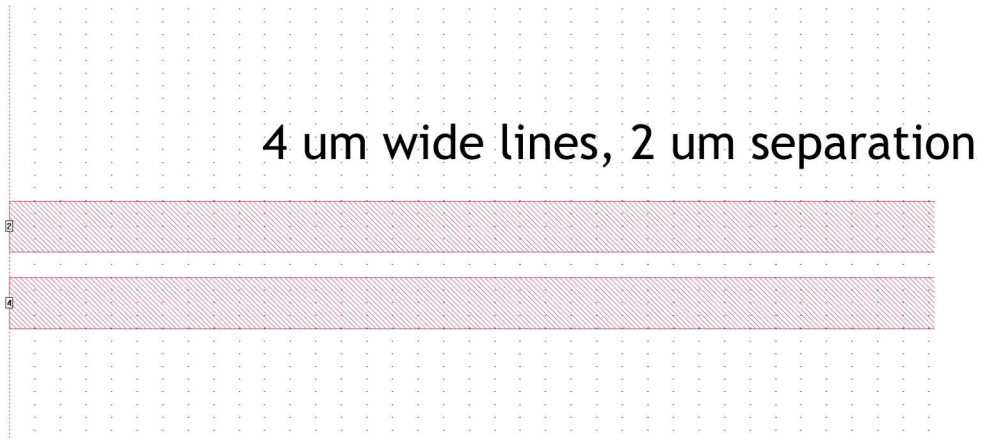


Vertical spacings are 200 nm between each layer
Lines are 1 mm long, terminated with 4.6 ohm ports



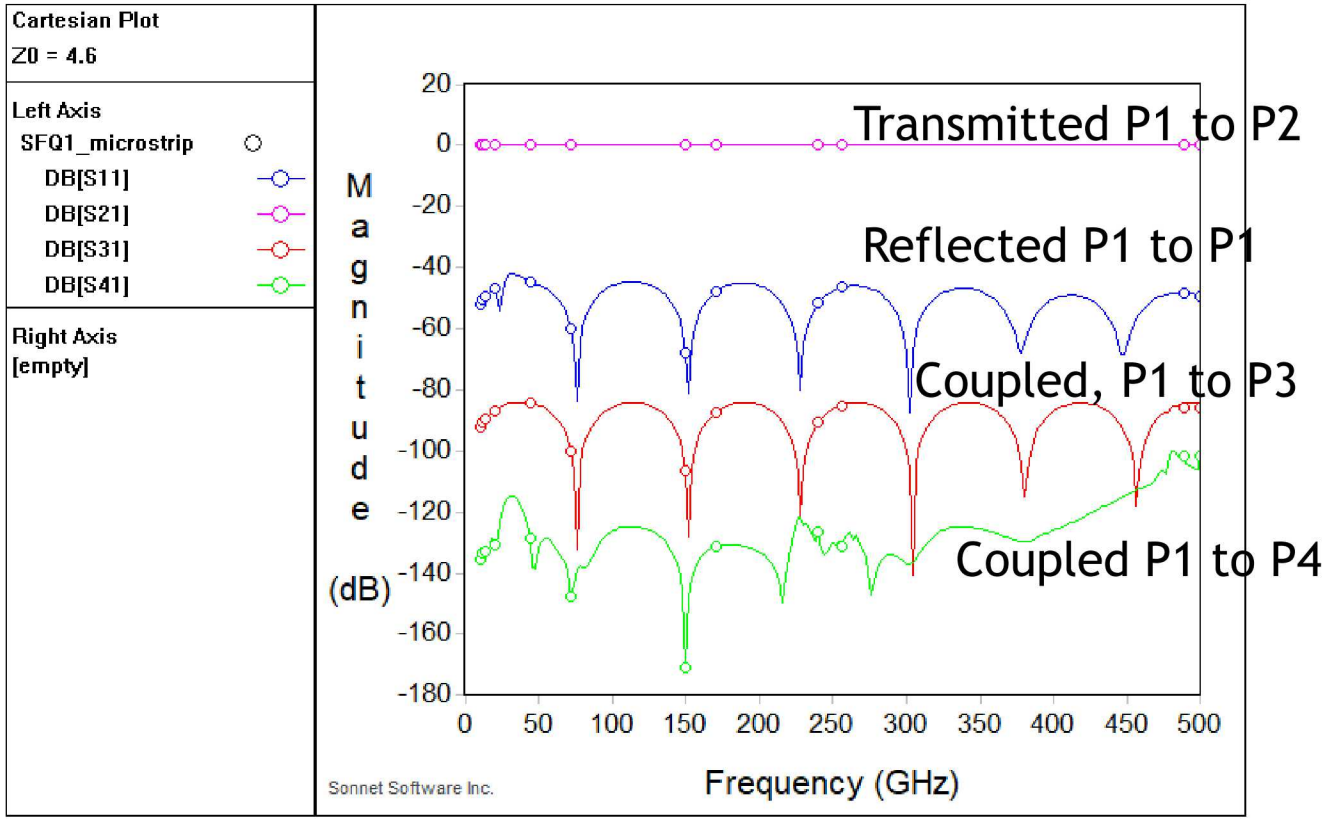
Couples ~ ¼ of the power into the second line!

Two strip lines, 2 um apart. Gnd above/below

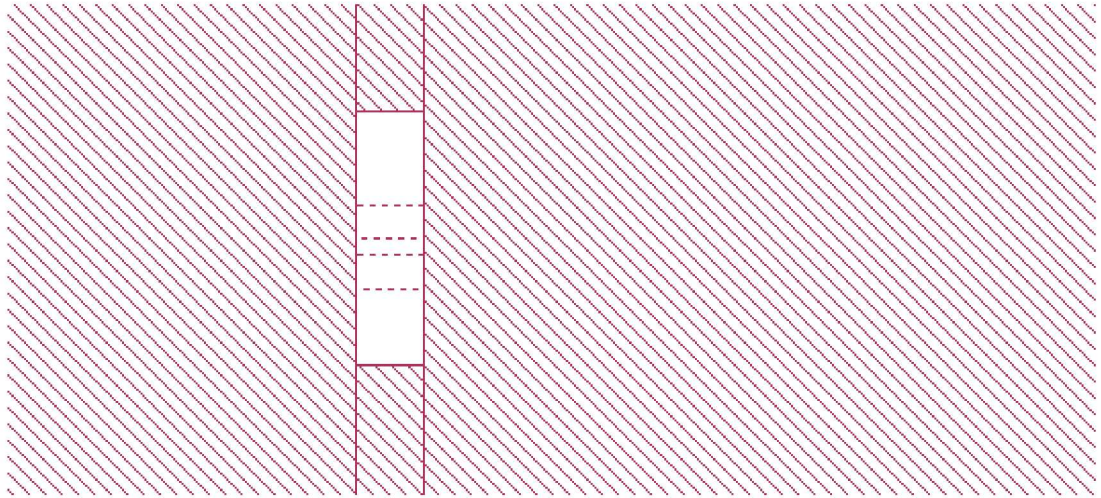


As previously, these are 1 mm lines between ground planes, ports are 4.6 Ohms to provide good match. This is similar to Hypres PTL designs (pitch is tighter though).

Even at 2 um spacing between lines, coupling is minimal! (-80 dB) for 1 mm lengths.

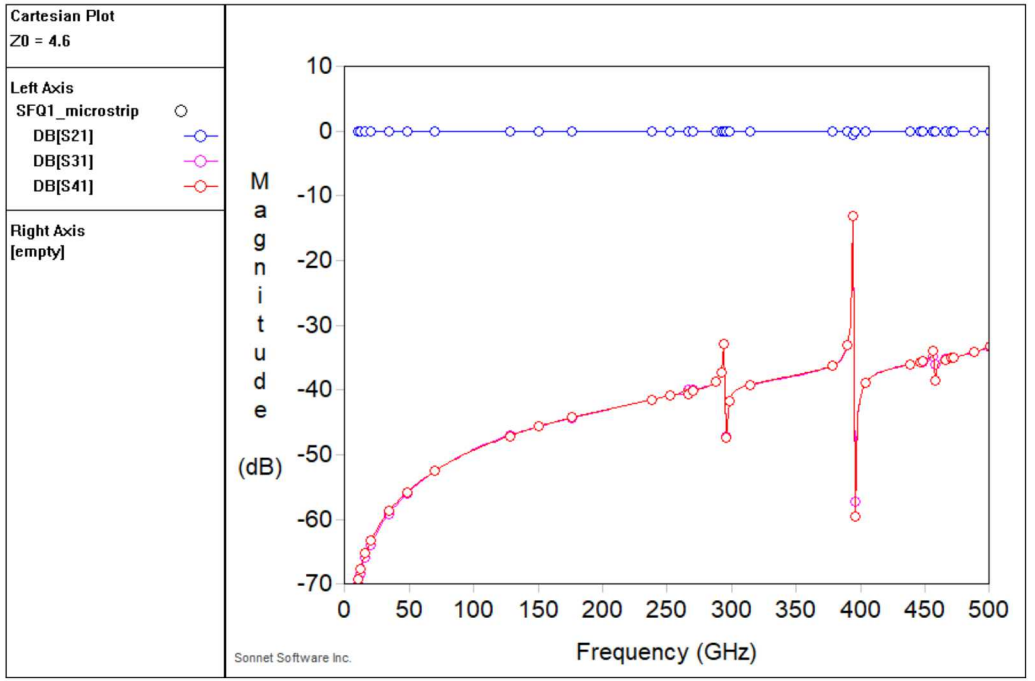


Parallel strip lines passing under a cut in the ground plane (simulates a single moat)



There are frequencies where this case is much worse than the pervious case (slide 8). Note resonances at 300 GHz, 400 GHz.

But in general, coupling is still weak (~ -40 dB).



Summary

Lateral coupling with pitch at twice line-width doesn't couple

- Decreasing pitch to 1.5 x width coupling is still weak
- Exceptions are heavily moated structures with moats passing under/over both lines

Vertically spaced lines couple strongly—good for mutual inductances, bad for wiring layers

Standing waves—due to vias up/down may complicate—no detailed analysis yet.

Although this treatment is not superconducting, we don't expect full SC treatment will enhance lateral couplings much. It will enhance the vertical coupling.