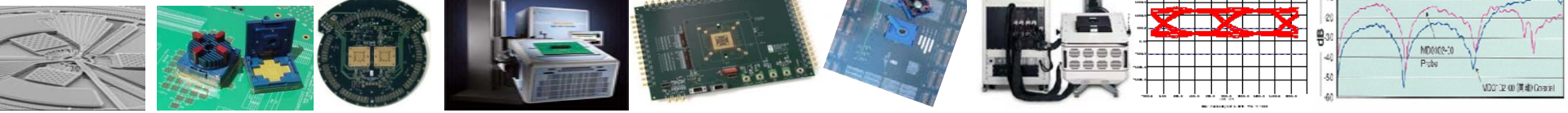

Unused Socket Pins- what to do with them during test and in final use

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Problem

- Use of standard interconnect patterns can lead to the presence of unused socket pins, and device as well as PCB N/Cs
- Electromagnetic coupling between pins alters performance on used connections depending on how unused pins are treated
- Crosstalk via unused pins may not be readily recognized and accounted for
- Unused pins plus unused lines can become conduits of additional low frequency noise

Objective

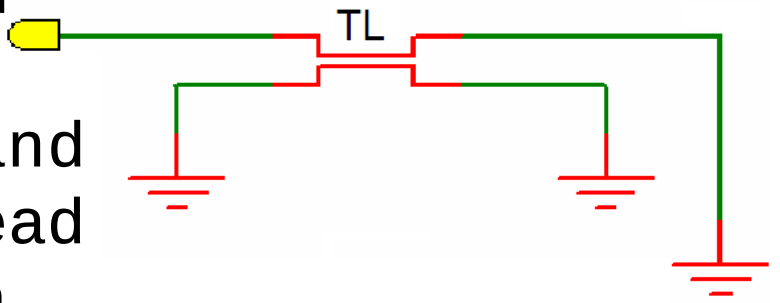
- Examine socket performance as a function of unused pins and grounding conditions
- Identify favorable arrangements
- Point out unexpected behavior
- Look at real life results

Approach

- Explore several different connection scenarios
- Compare results for shorted, open circuited and terminated unused pins
- Engage computer simulations to demonstrate impact of coupling
  - SPICE circuit simulator
  - ANSYS HFSS field modeler
- Complement with some measured data

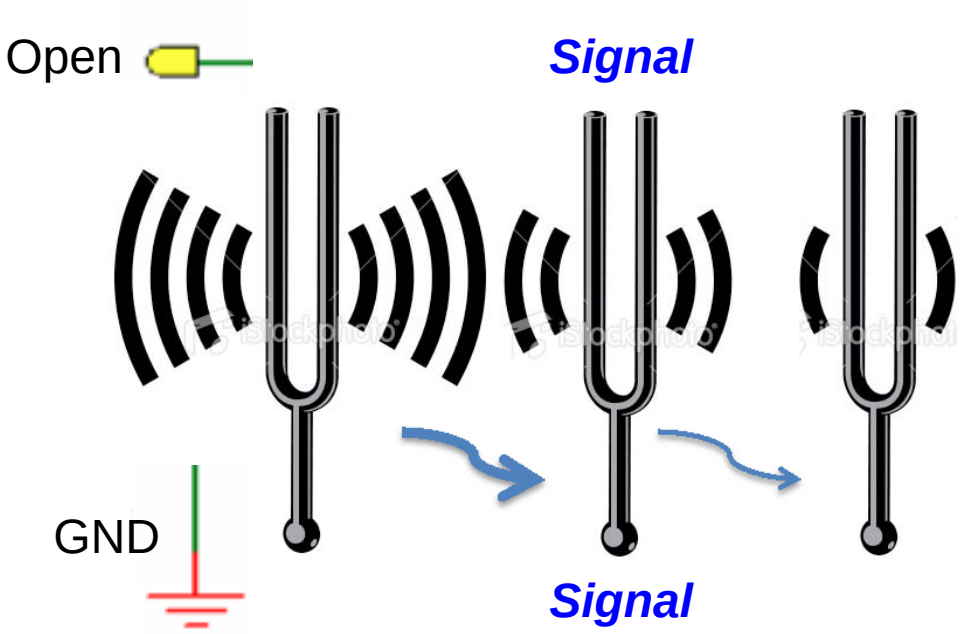
Issue

Transmission line, open on one end, shorted on the other is a quarter-wavelength transformer that transforms the short circuit into and open circuit. This situation can lead to resonances in the signal path.



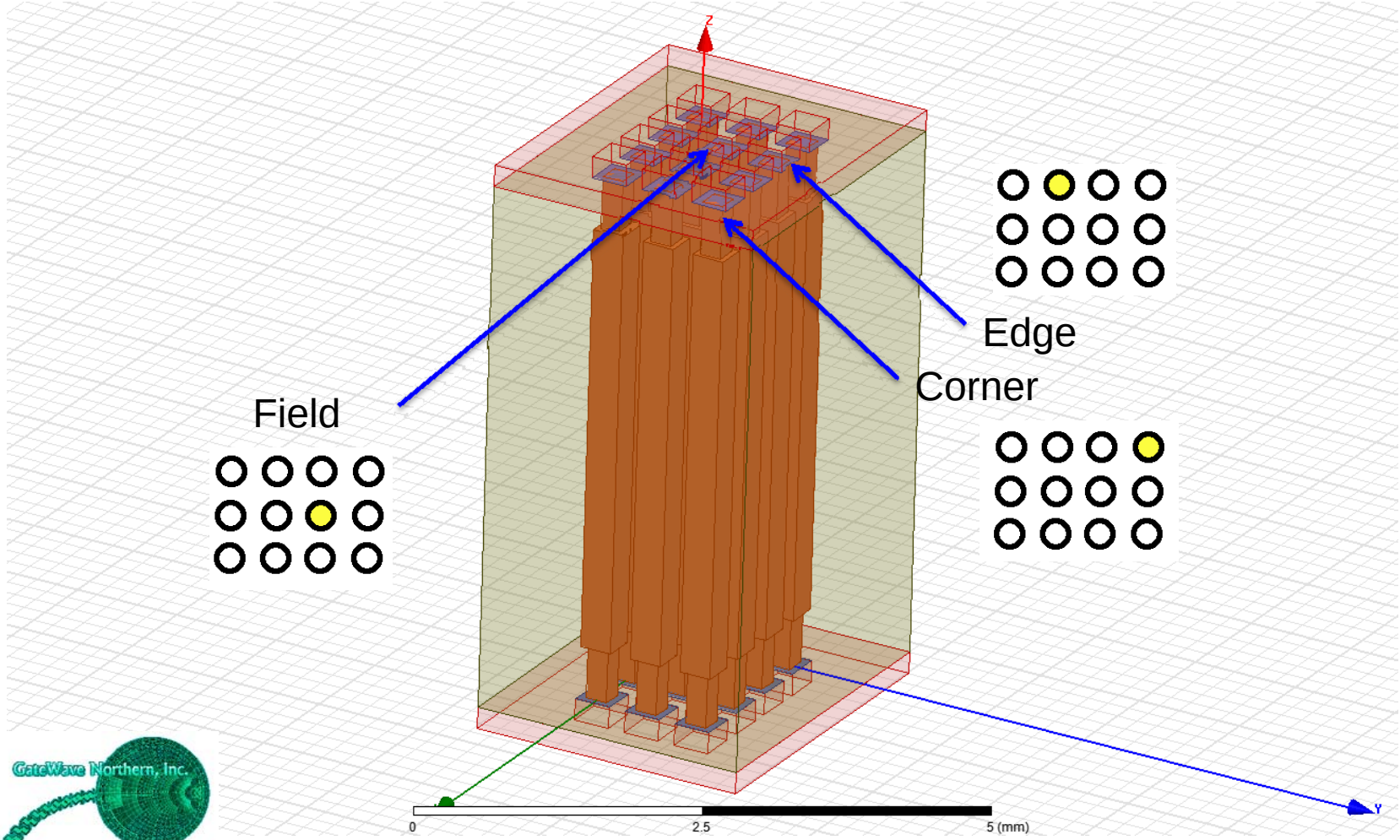
Helmholtz resonator

Issue



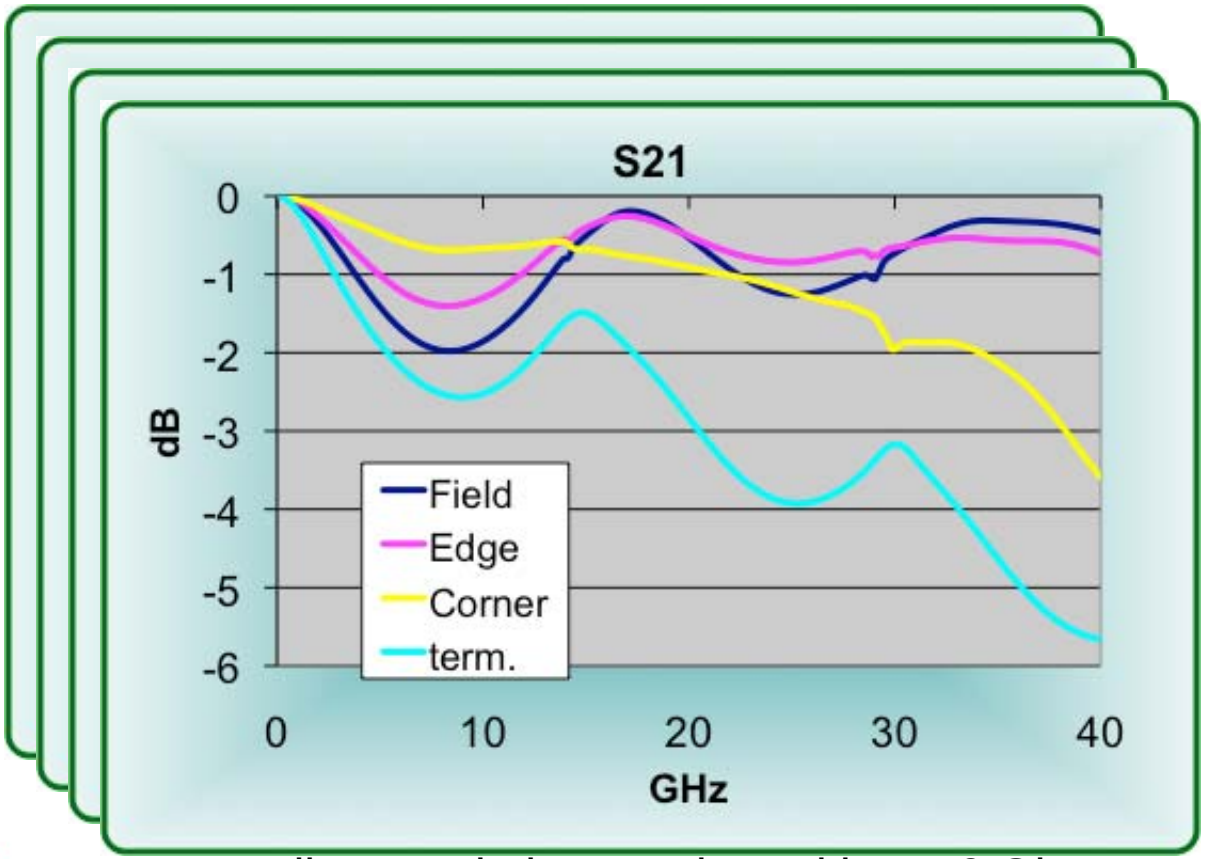
A resonance on a pin/line can affect adjacent pins via electromagnetic coupling

Model



Insertion loss, test configuration

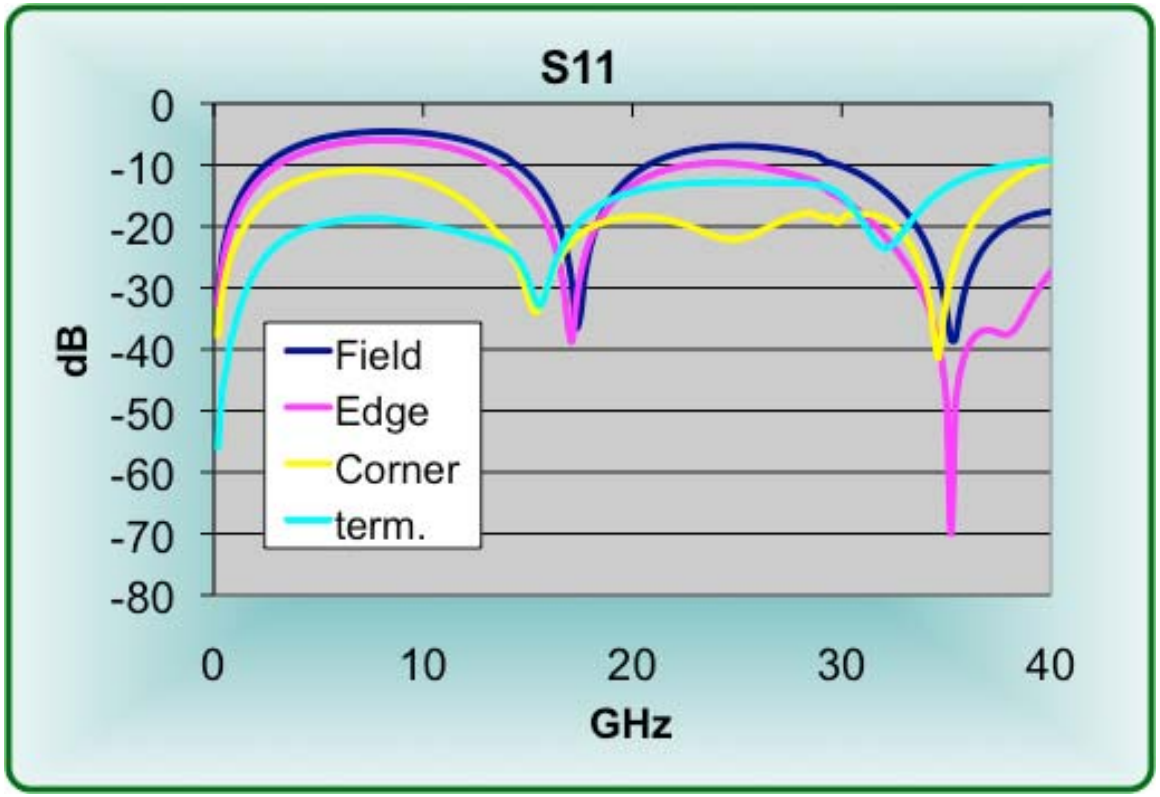
Best performer is the 'corner' configuration since its impedance Z_o is closest to 50 Ohms



Worst performer is the 'term.' configuration since coupling results in energy being diverted to other pins

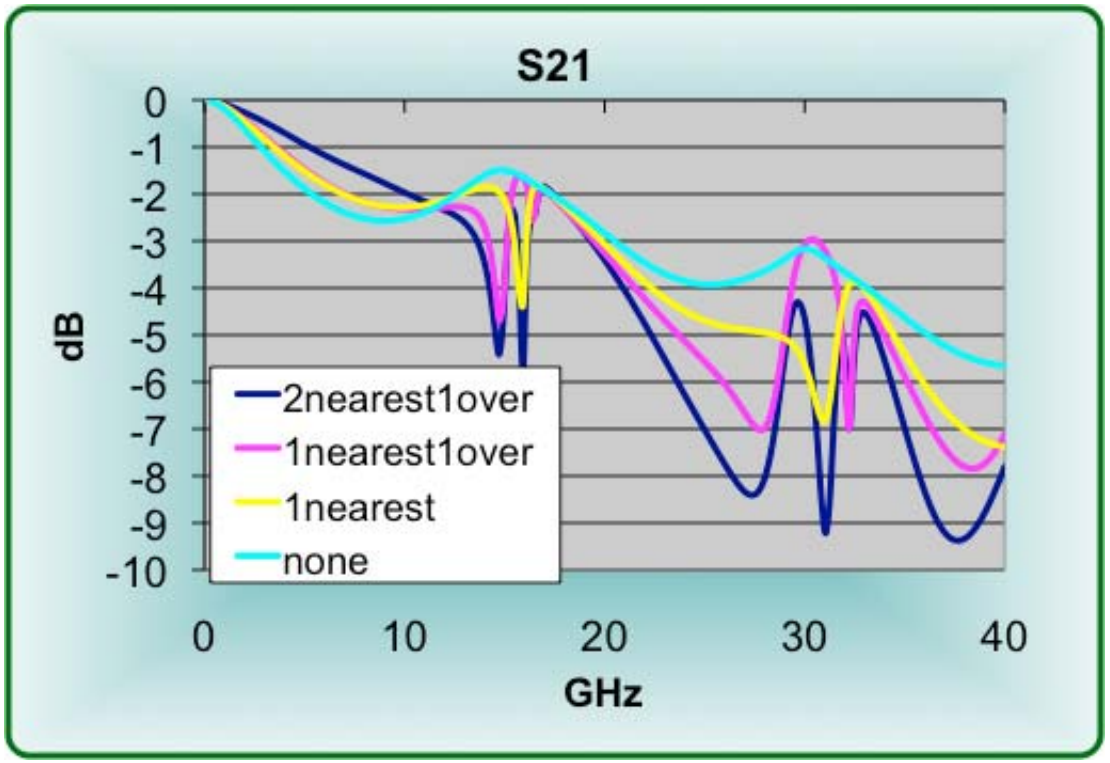
term. = all unused pins terminated into 50 Ohms
otherwise = all unused pins grounded

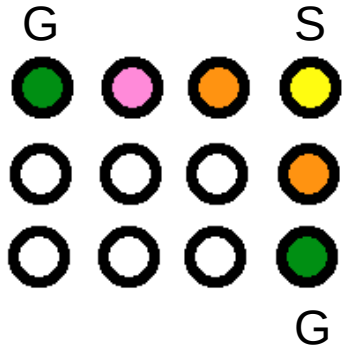
Return loss, test configuration



term. = all unused pins terminated into 50 Ohms
otherwise = all unused pins grounded

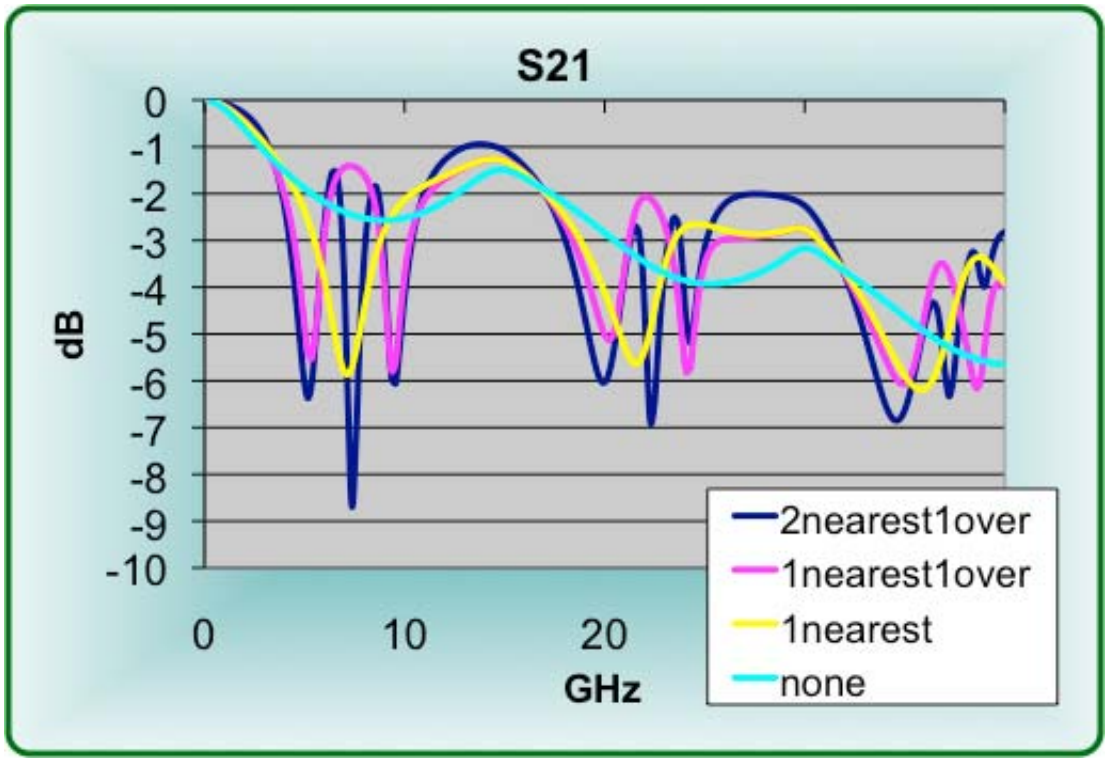
Insertion loss
open adjacent pins

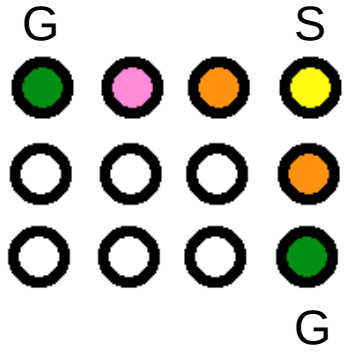




all other pins terminated into 50 Ohms

Insertion loss short/open adjacent pins

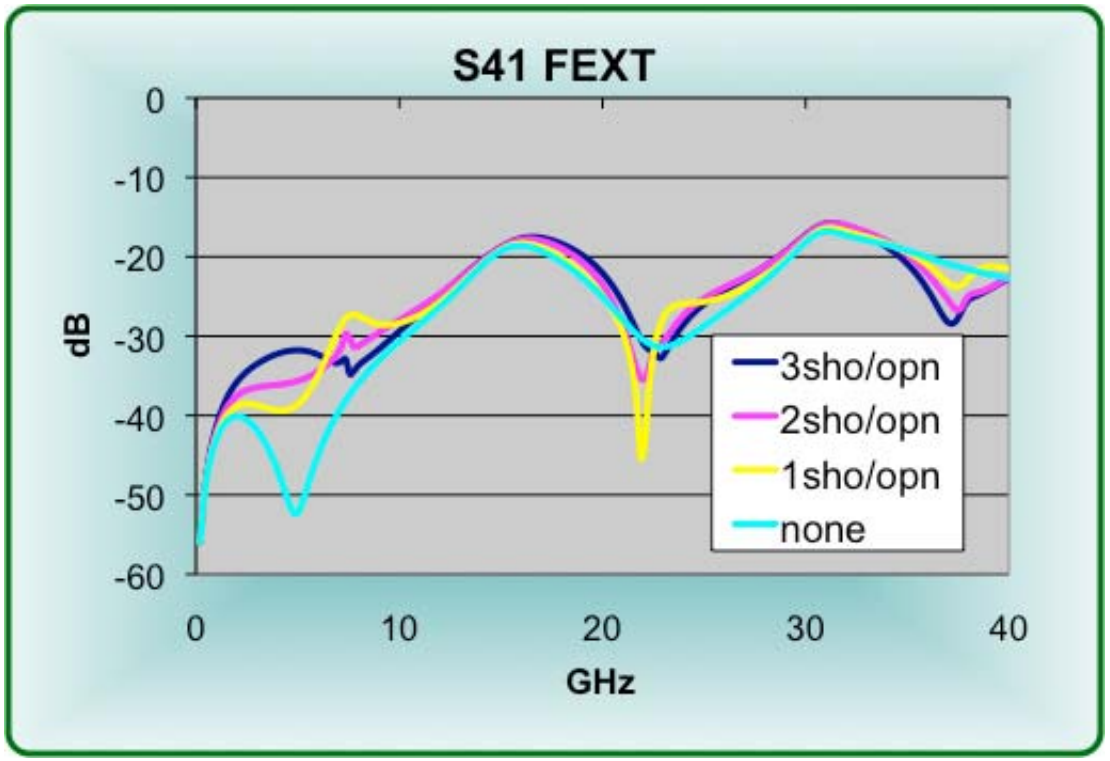


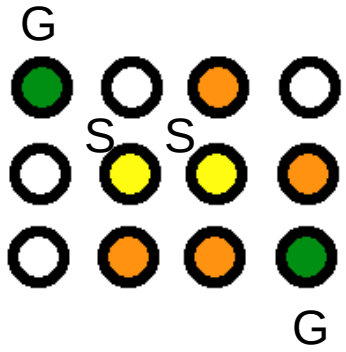


Sho/Opn on alternating sides (PCB/DUT)

all other pins terminated into 50 Ohms

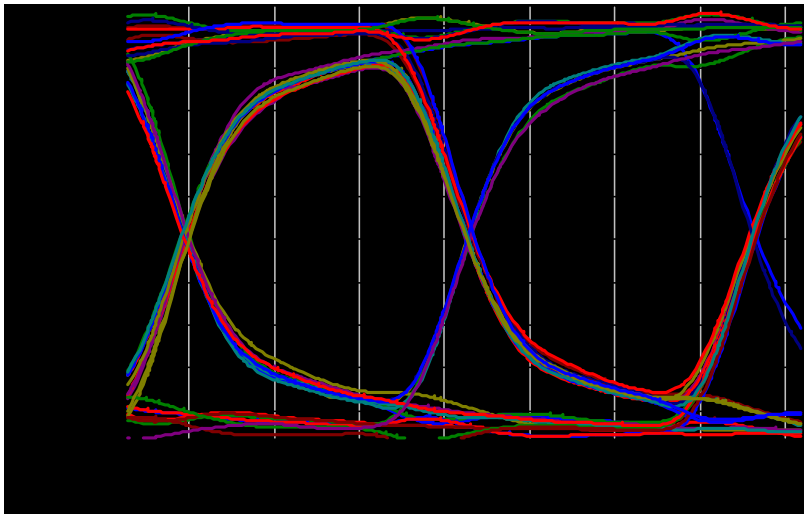
Crosstalk, FEXT short/open adjacent pins

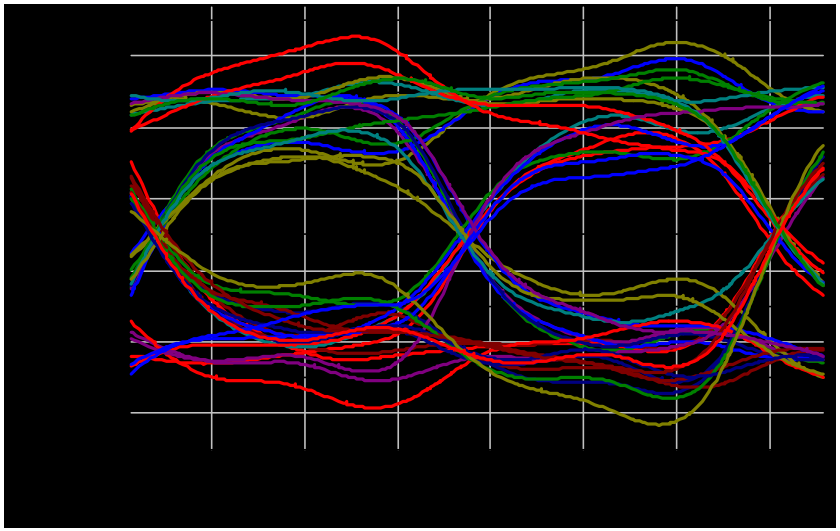




all unused pins terminated into 50 Ohms

Eye diagram with open/short resonance





no resonance or clock not at f_{res}

with resonance

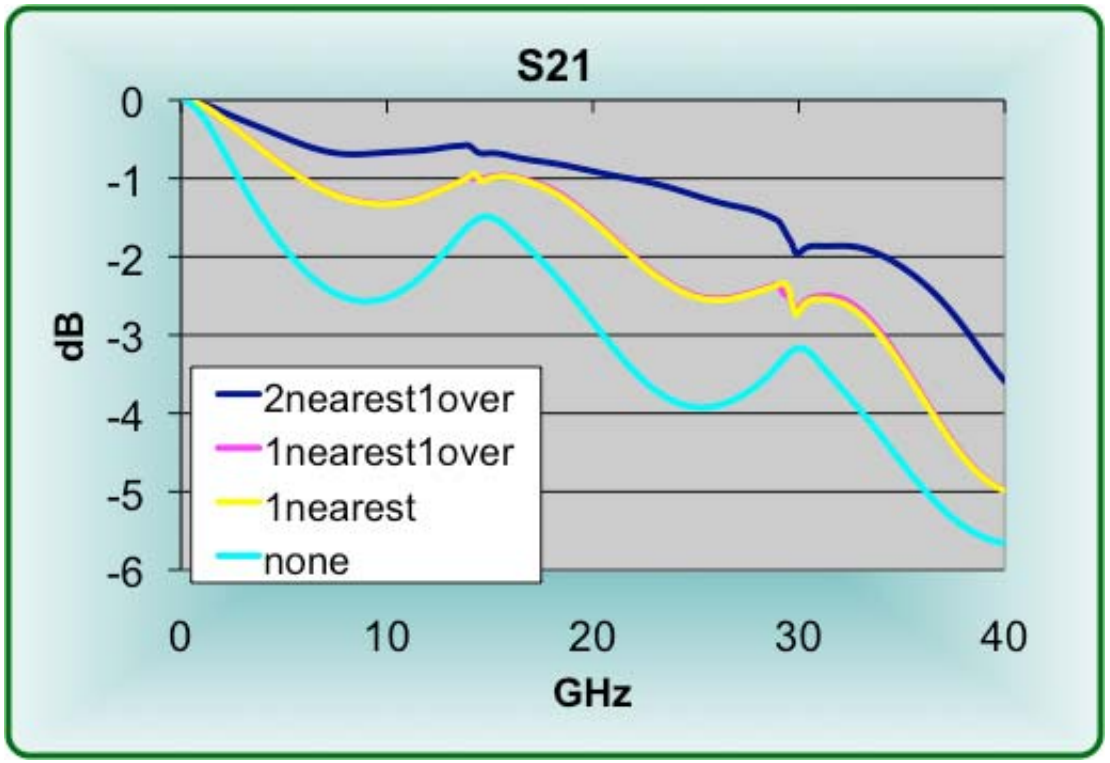
Noticeable degradation of a load board eye diagram (6Gbps) from a 3 GHz resonance

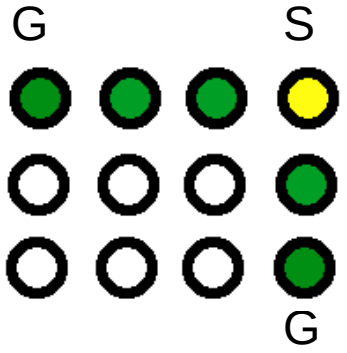
Possible solutions

Options: (N/C's are frequently open at the DUT)

a) open at PCB and DUT
b) terminated at PCB and DUT
c) terminated at PCB and open at DUT
d) shorted to GND at PCB and open at DUT
e) shorted to GND at PCB and DUT
f) no pin

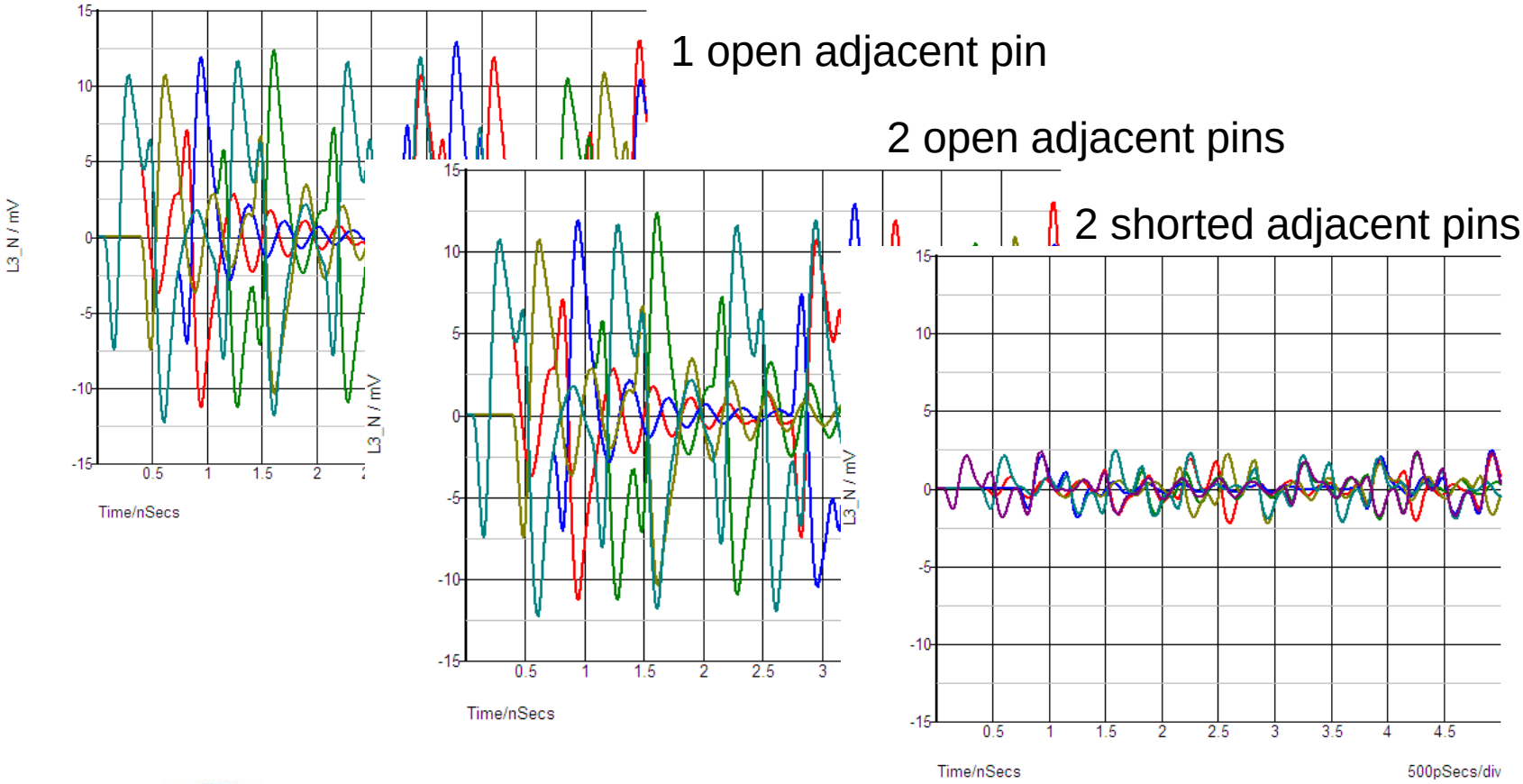
Insertion loss short/short adjacent pins





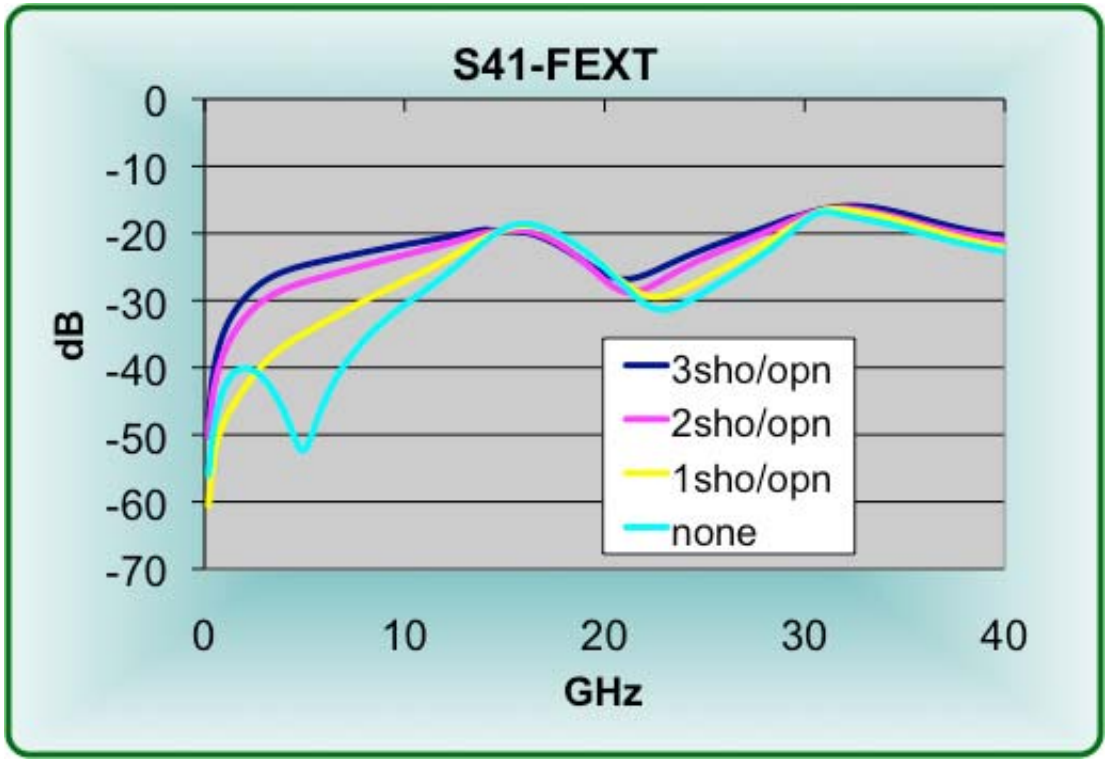
all other pins terminated into 50 Ohms

Noise due to AC current in an adjacent power line



Current in power connection is assumed to be 100mA/200ps RT PRBS

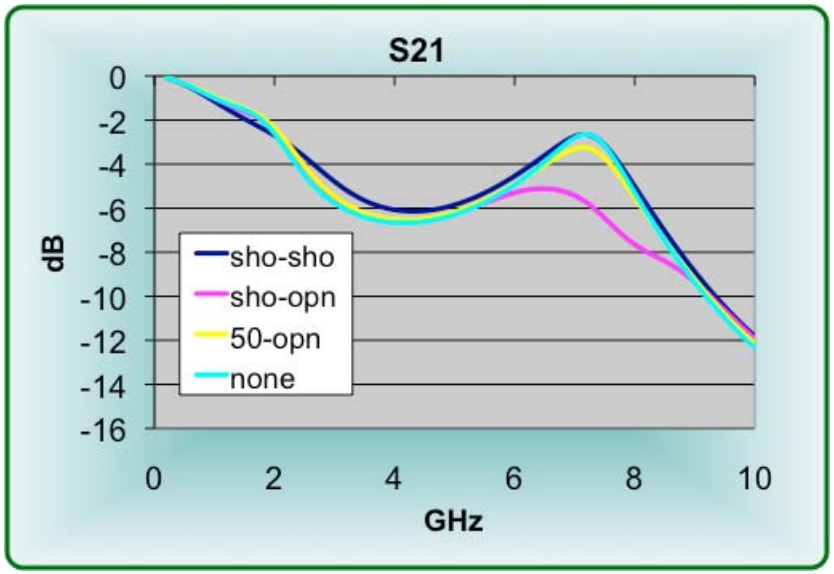
Crosstalk, FEXT short/short adjacent pins



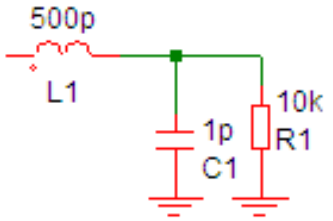
Unfortunately the sho/sho arrangement adversely affects forward crosstalk in this case

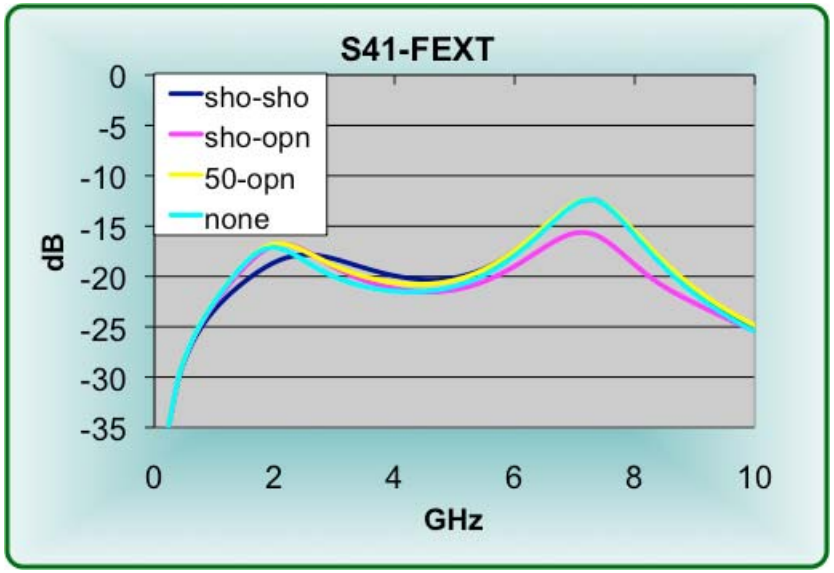
unused pins terminated into 50 Ohms

RC termination on device (DUT) side



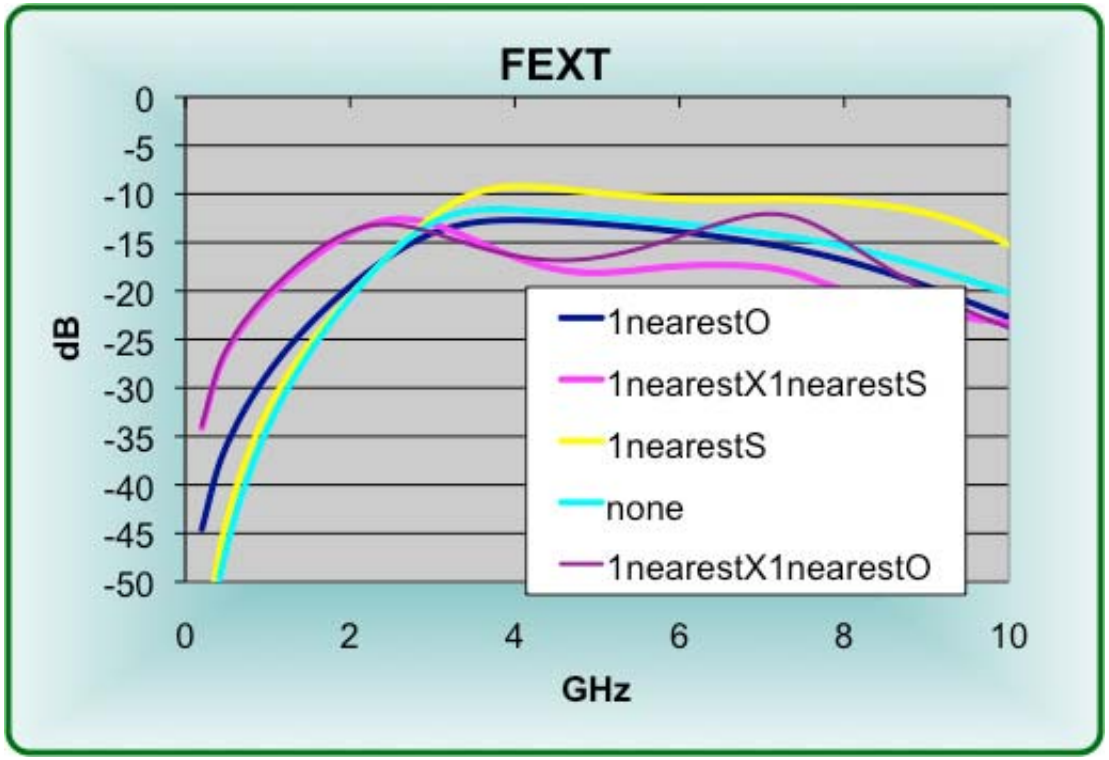
Example:

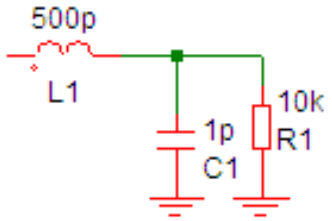




Signal pins terminate in 10k Ohms / 1 pF
with a 0.5 nH series L (package)

Crosstalk, signal line different adjacent pin configs

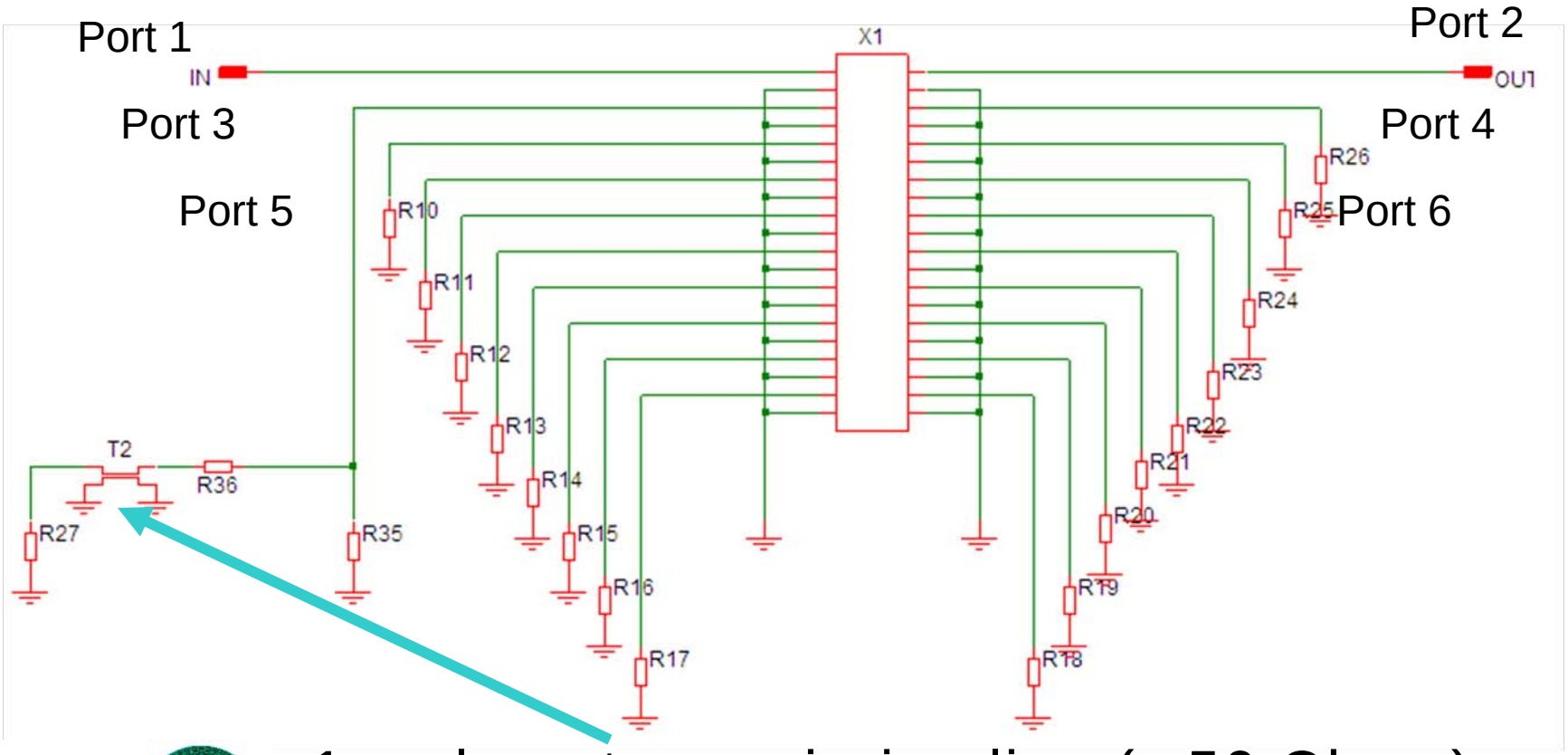




Low end crosstalk is adversely affected by configuration

All used signal pins terminated into 50 Ohms on PCB side, unused pins grounded/open as indicated

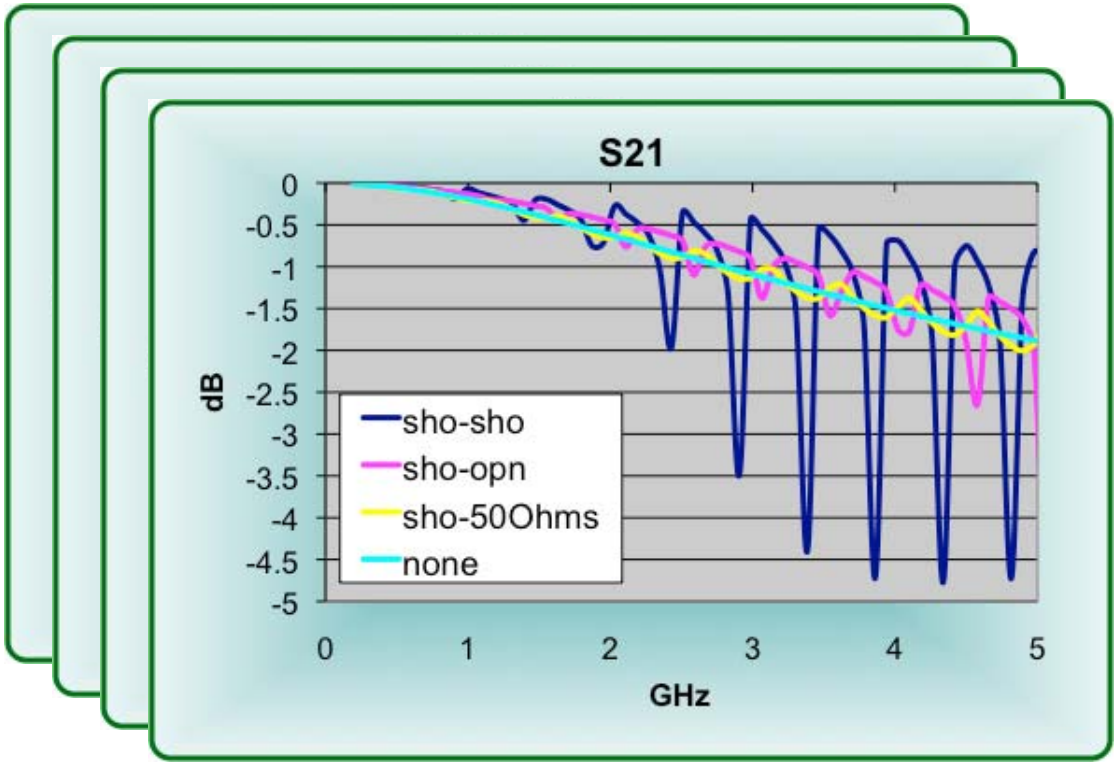
Model for DC, unused or ‘don’t care’ lines



1 ns long transmission line (~50 Ohms)

Insertion loss for coupled line scenario

Best performer is the terminated configuration (none)

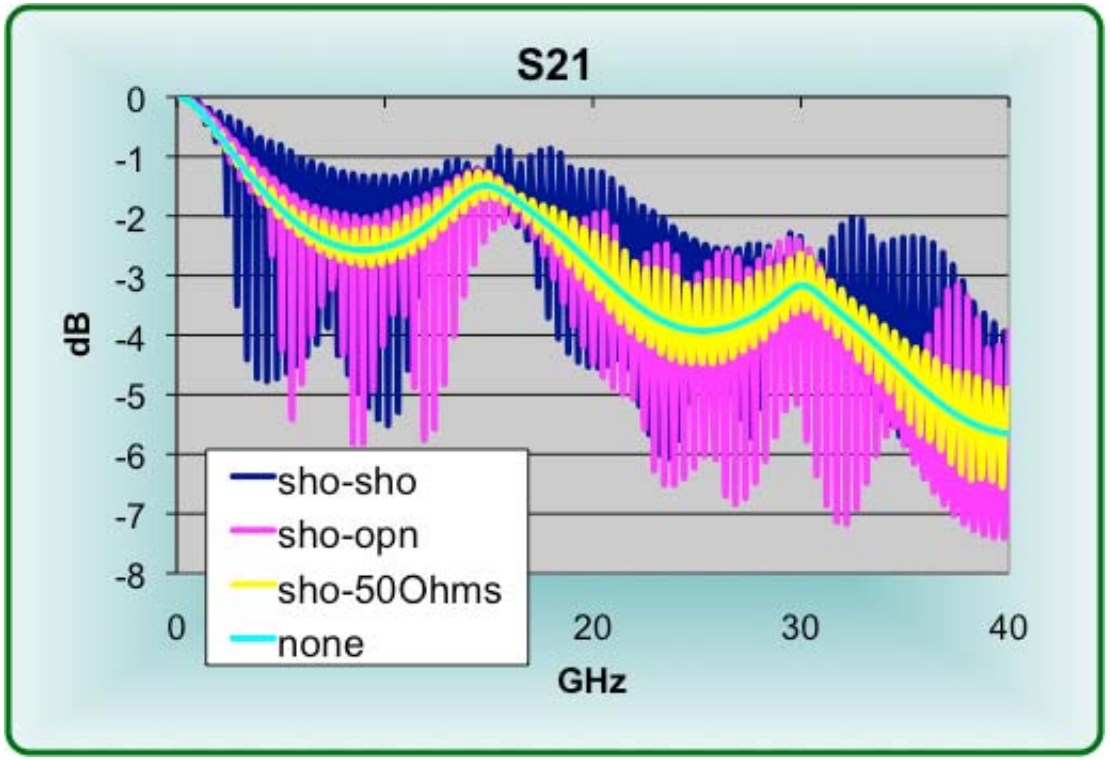


Worst performer is the 2x short configuration

all unused pins terminated into 50 Ohms coupled line as indicated

Insertion loss for coupled line scenario

Best performer is the terminated configuration (none)

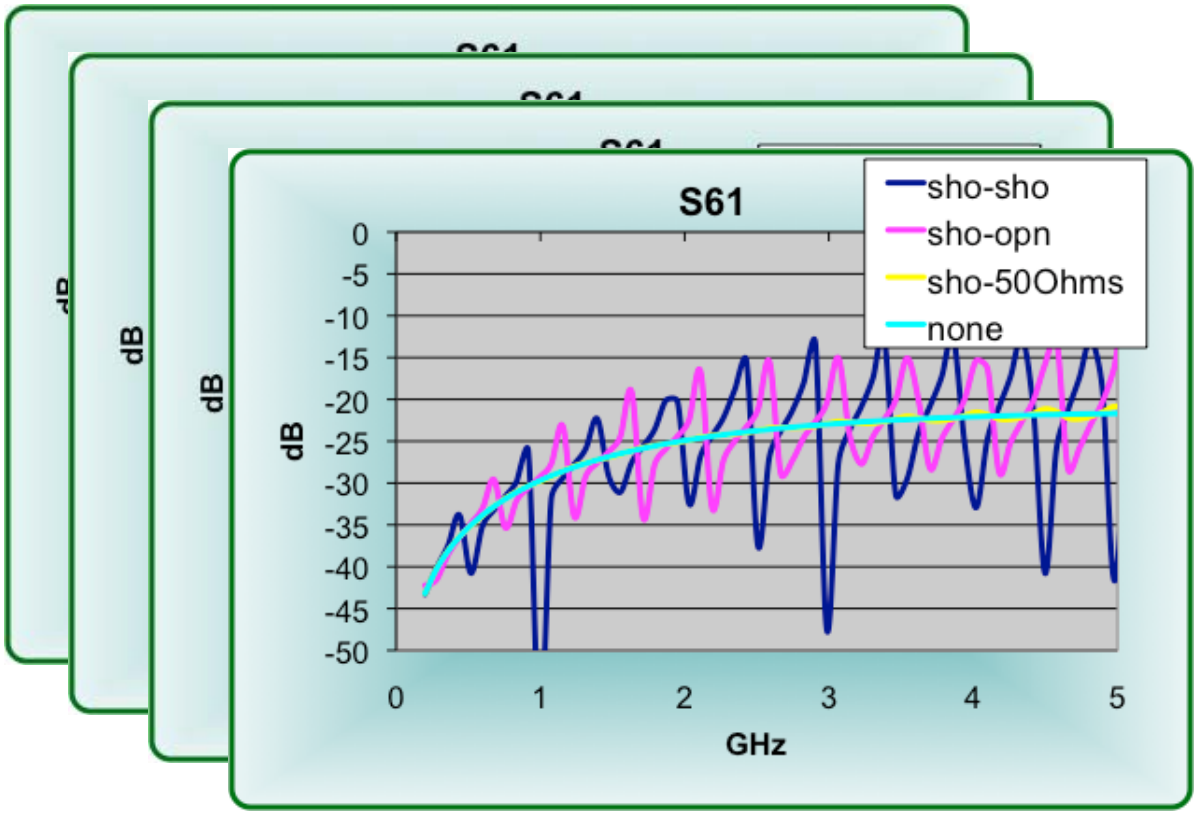


Worst performer is the 2x short configuration

Expanded frequency range shows periodicity of transmission line resonances at multiple frequencies of fundamental resonance

Crosstalk to far side line

Best performer is the terminated configuration (none)

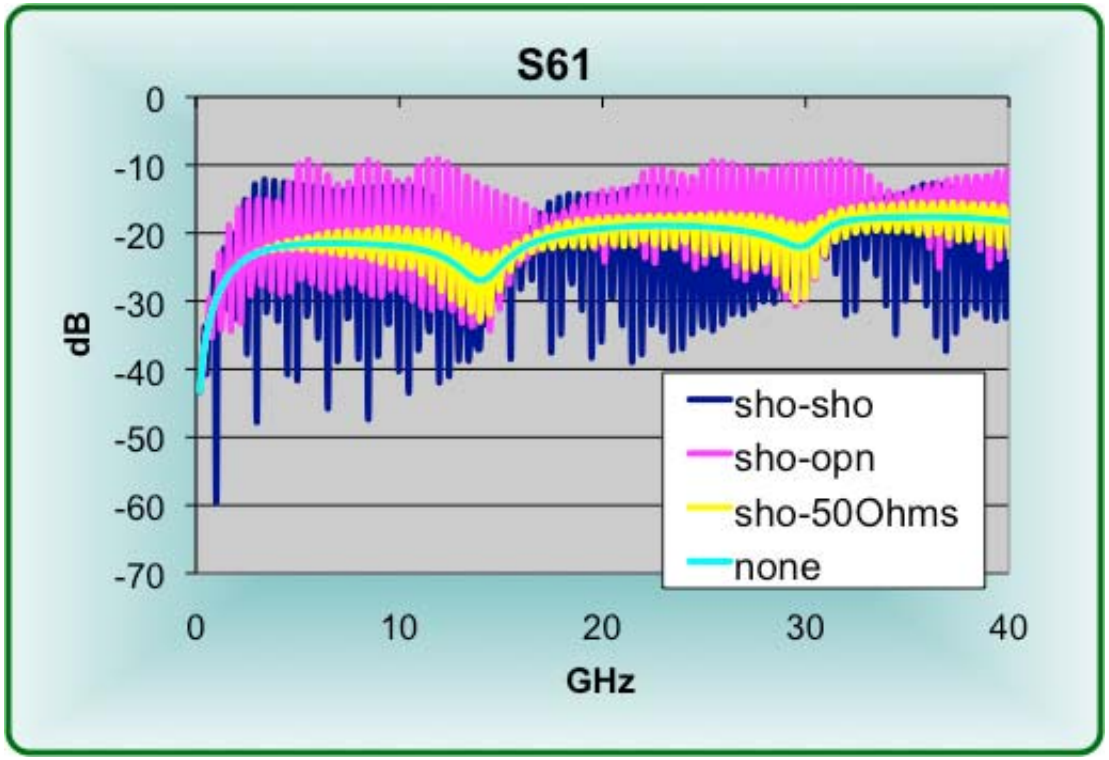


Worst performer is the 2x short configuration

all unused pins terminated into 50 Ohms coupled line as indicated

Crosstalk to far side line

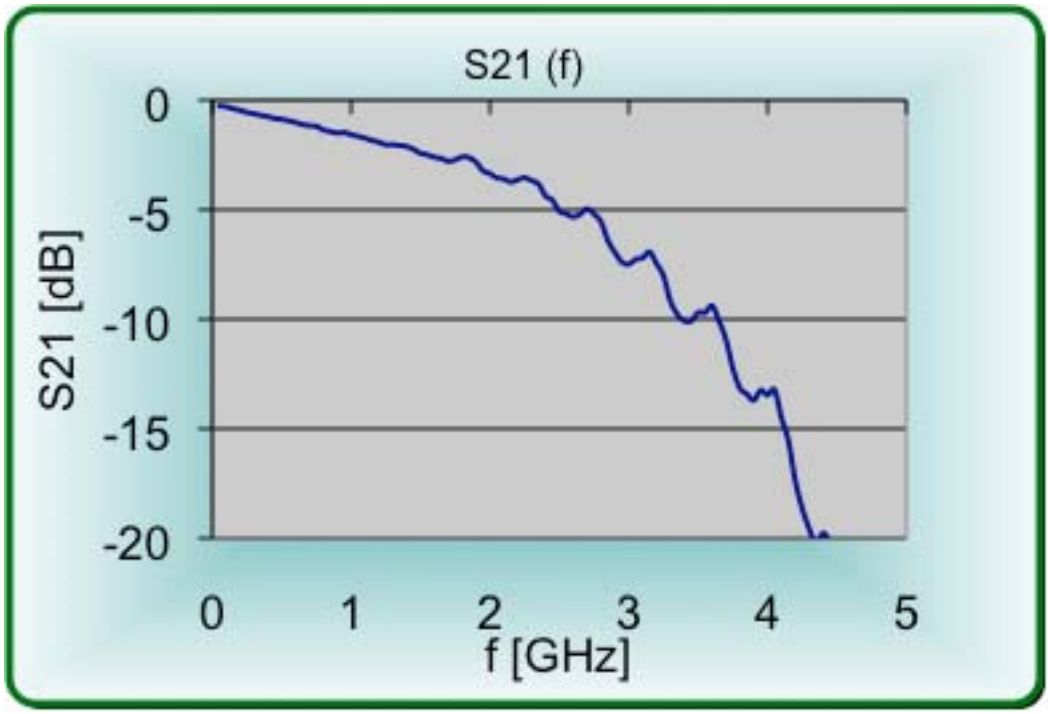
Best performer is the terminated configuration (none)



Worst performer is the 2x short configuration

Expanded frequency range shows periodicity of transmission line resonances at multiple frequencies of fundamental resonance

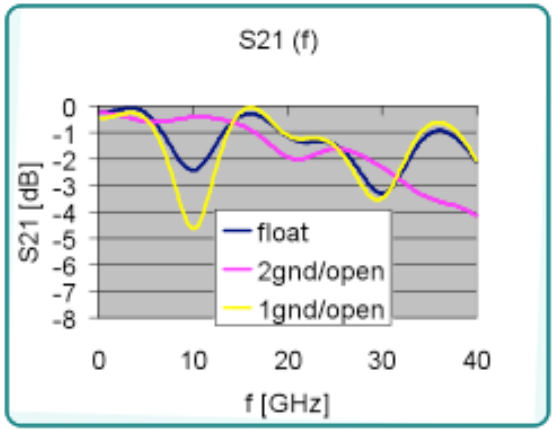
Measured insertion loss S21 of a load board

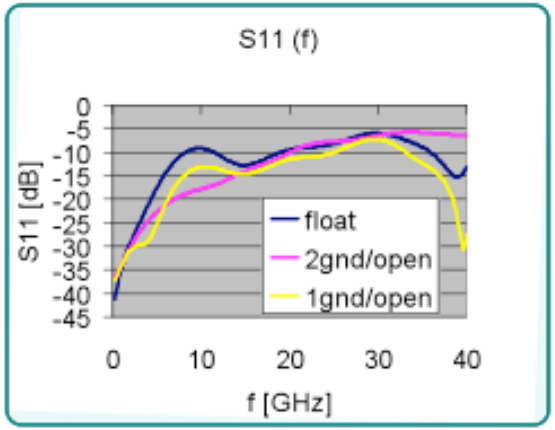


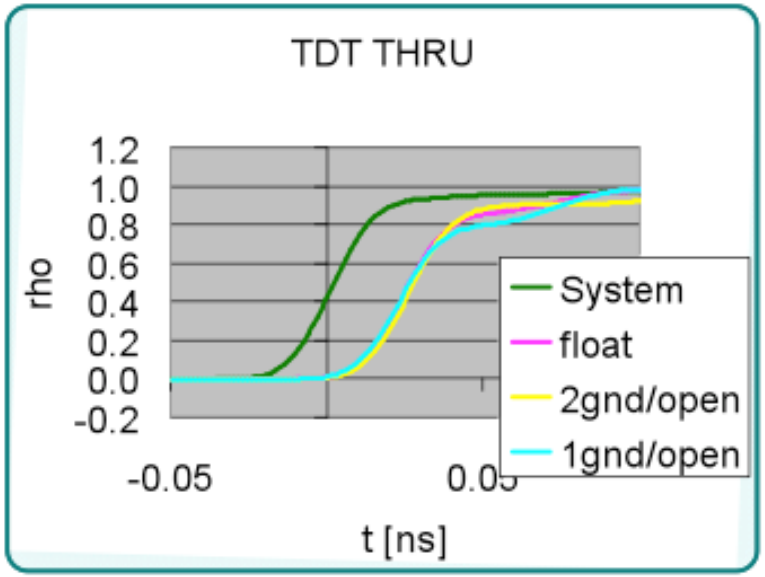
Ripple is due to coupling to adjacent lines that are not terminated in their characteristic impedance Z_o

X-talk will be adversely affected at these frequencies

Measured performance, different adjacent pin configs







Conclusion

- Unused pins must be treated with care.
- Generalizations do not appear readily possible. Improvements in transmission may adversely result in additional crosstalk, etc.
- When shorting unused pins results must be properly understood as crosstalk may worsen if the DUT side is not also properly grounded.
- Power connections may further complicate the picture, depending on location and nature of bypass capacitors.