A CURE FOR INTRA-PAIR SKEW IN HIGH SPEED DIFFERENTIAL SIGNALS

DesignCon 2015

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UBM

Speaker

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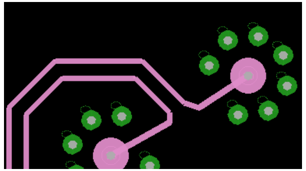
Effects of Intra-pair Skew

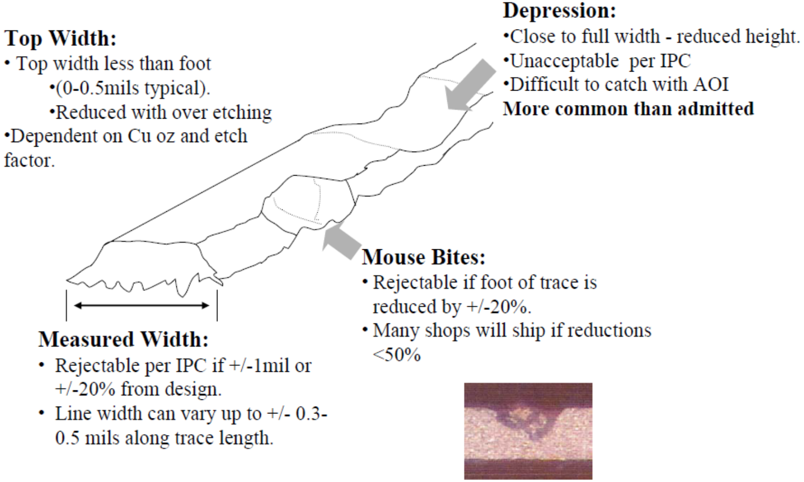
- Mode Conversion (increased Common Mode)
  - Increased generation of EMI
  - Increased susceptibility to EMI
  - Less energy in differential signal reaching RX

Causes of Intra-pair Skew

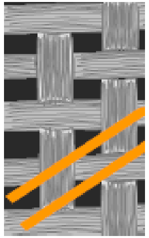
- Component and PCB layout asymmetries



- Manufacturing variability



- PCB Laminate Weave



Fiber Weave Effect

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No Common Mode → No Skew

Zero common mode

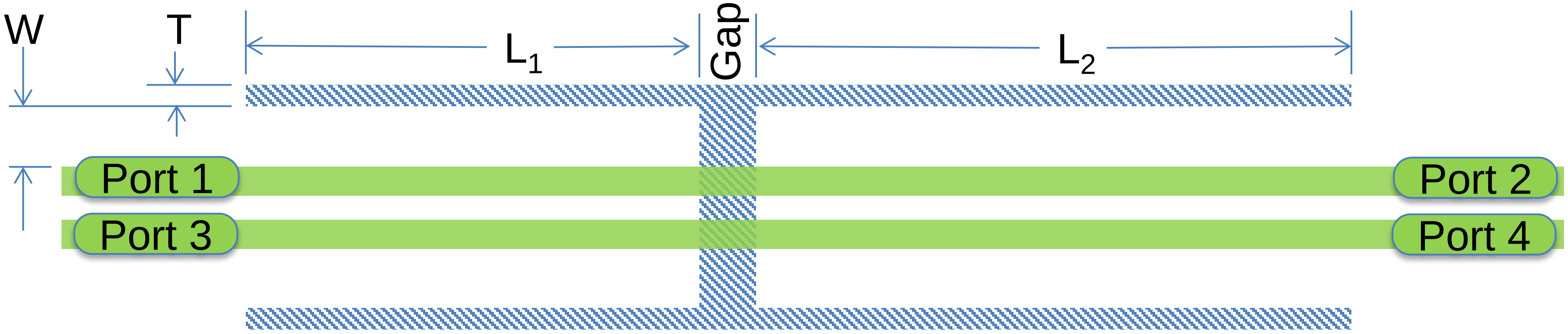
→ $V_{pos}(t) + V_{neg}(t) = 0$

→ $V_{pos}(t) = -V_{neg}(t)$

→ when Vpos = 0, Vneg = 0 as well

→ Zero skew

Common Mode Block: Ground Plane Cuts

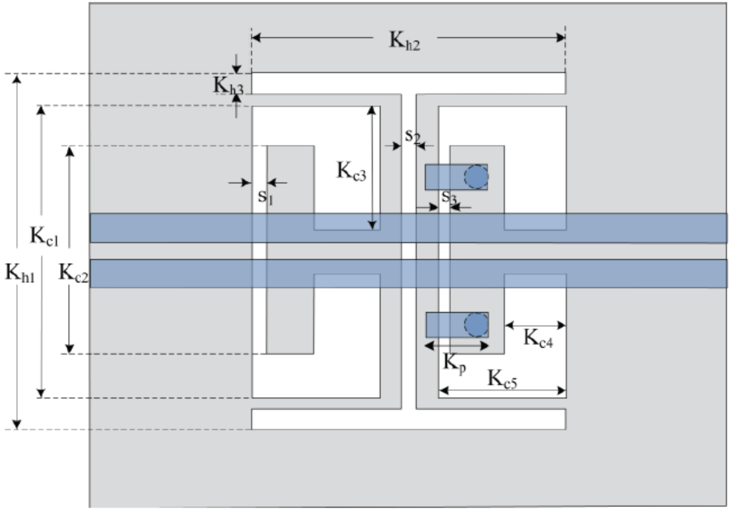


- Cuts in ground planes above and below strip line pair
- W & Gap 2 to 3 times dielectric thickness
- L sets block center frequency (~Nyquist)
  - $L_{1,2} \sim \lambda/4 = [300\text{ mm/ns}] / [4 * \mathrm{sqrt}(\varepsilon_r) * f_{Nyquist}]$ (~ 150 mils @ $f_{Nyquist}$ = 10 GHz)
  - Stagger $L_{1,2}$ for wider stop band (e.g., L_1 = 130 mils & L_2 = 170 mils)
- This was developed heuristically – no pretense of optimality

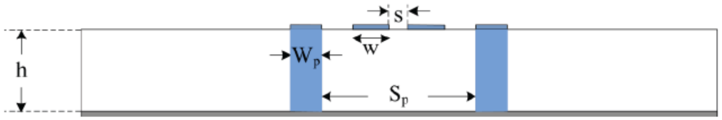
Common Mode Block: Alternatives

An alternative, somewhat more complex design

[Yangyang Pang, Zhenghe Feng,
"*A compact common-mode filter for GHz differential signals using defected ground structure and shorted microstrip stubs*,"
2012 International Conference on Microwave and Millimeter Wave Technology (ICMMT),
Volume: 4, Publication Year: 2012 , Page(s): 1 – 4]

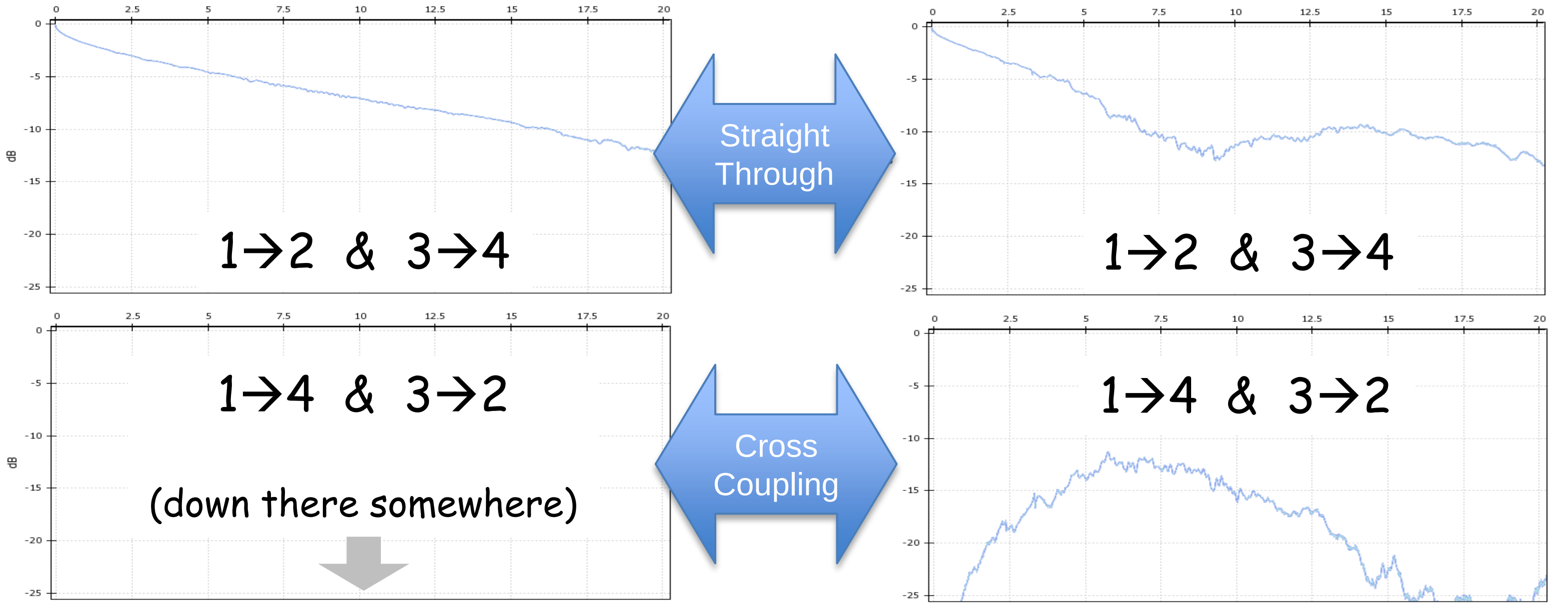


(a)



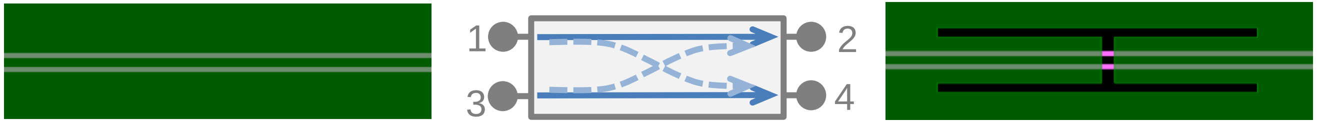
(b)

Single-ended Cross-coupling

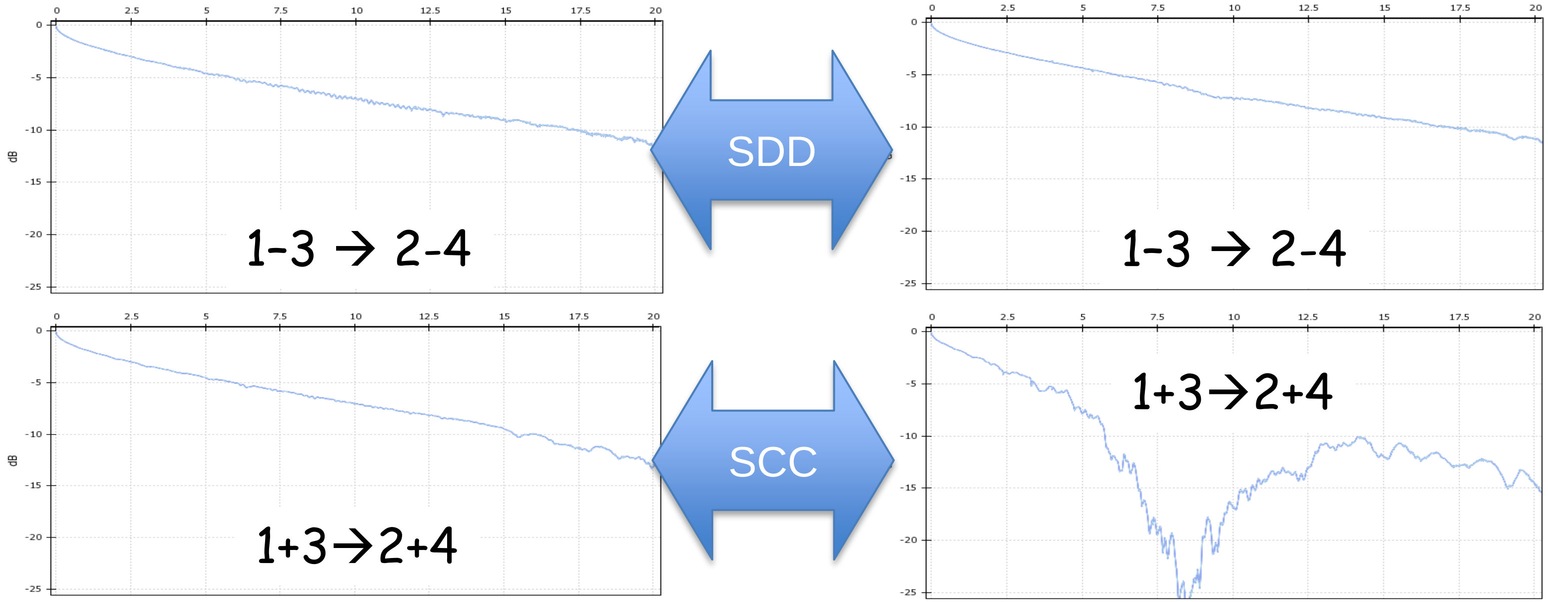


no GND Cutout

with GND Cutout

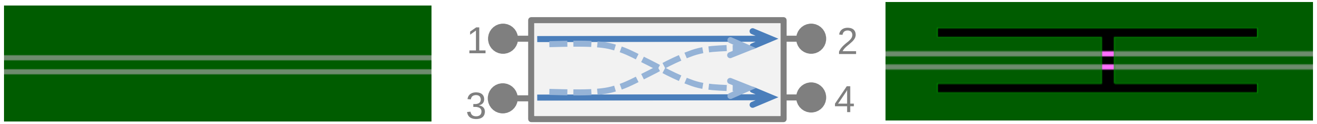


SDD & SCC



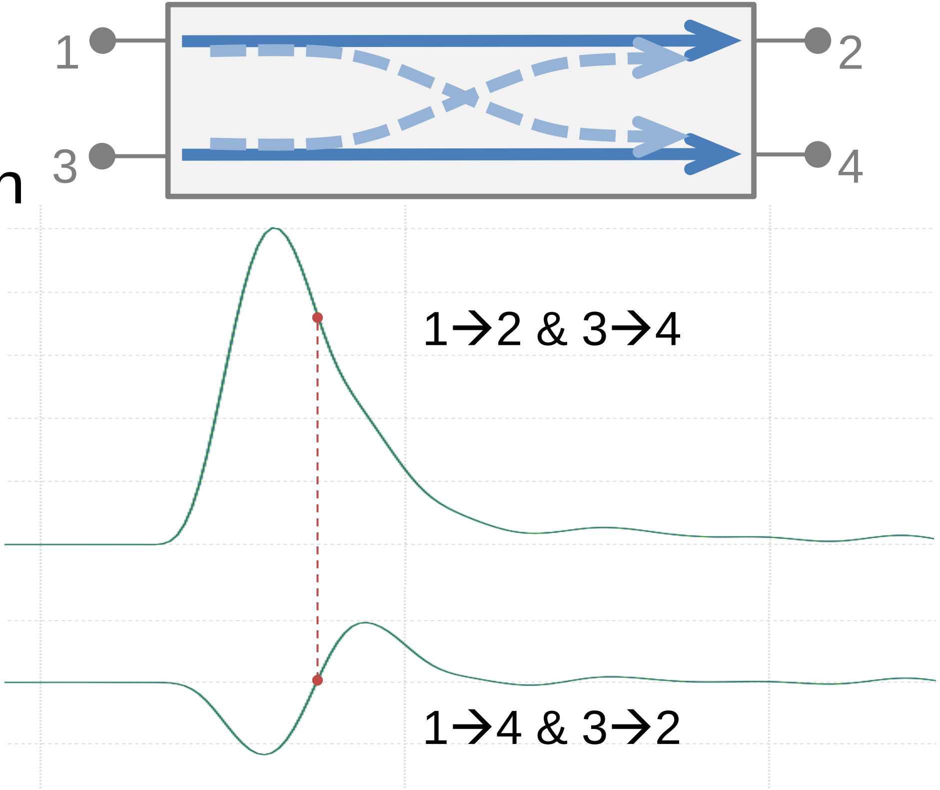
no GND Cutout

with GND Cutout



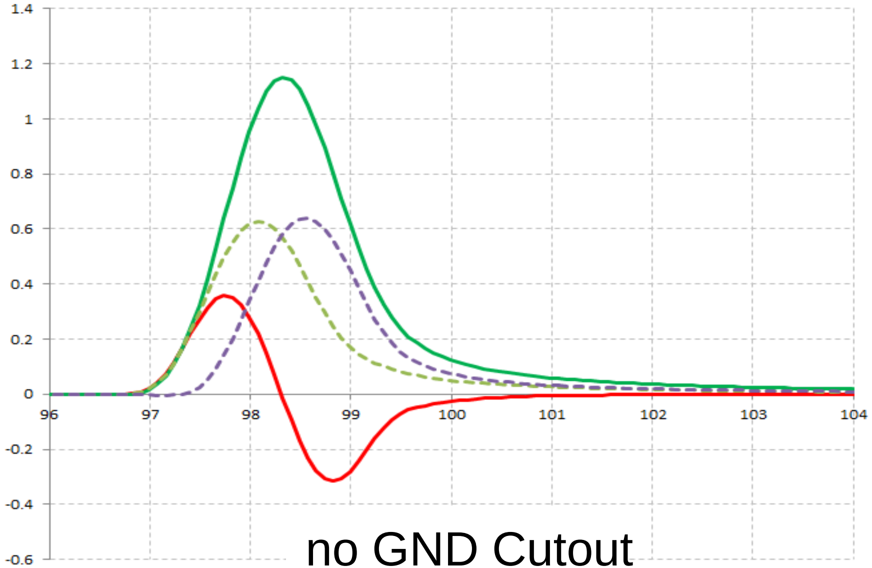
Differential Pulse Response

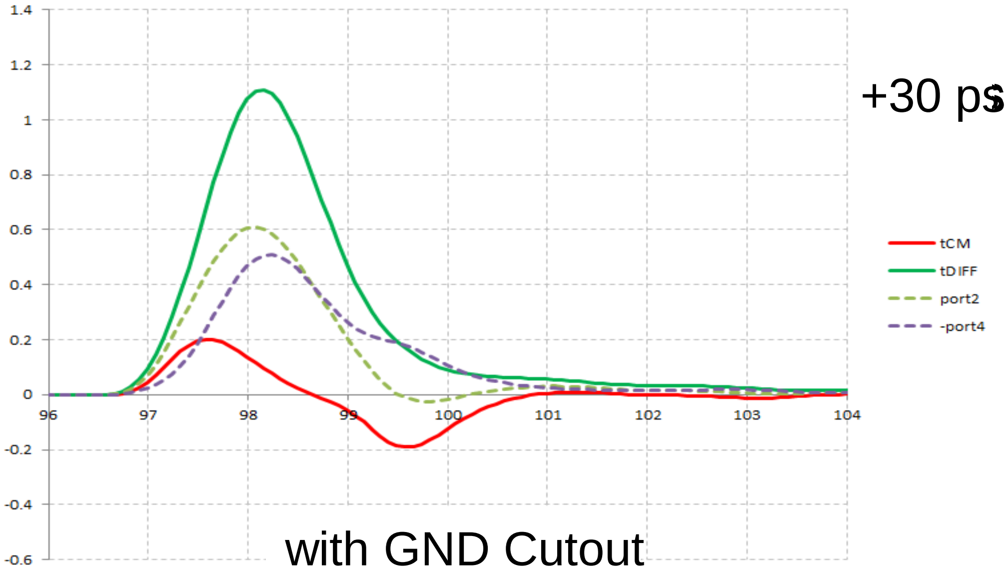
- Coupling…
  - … delays effect of faster path
  - … accelerates effect of slower path
  - … minimizes common mode pulse response
  - … has negligible effect on differential pulse response



Effect of GND Cutouts on Skew

16.7 Gb/s Pulse Response thru 6 inches of Megtron 6 strip line

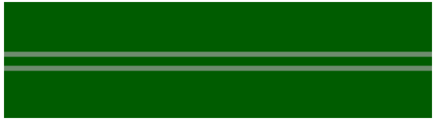


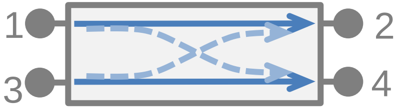


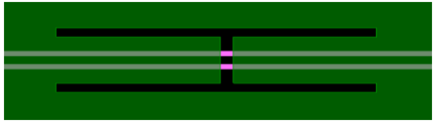
+30 ps

no GND Cutout

with GND Cutout







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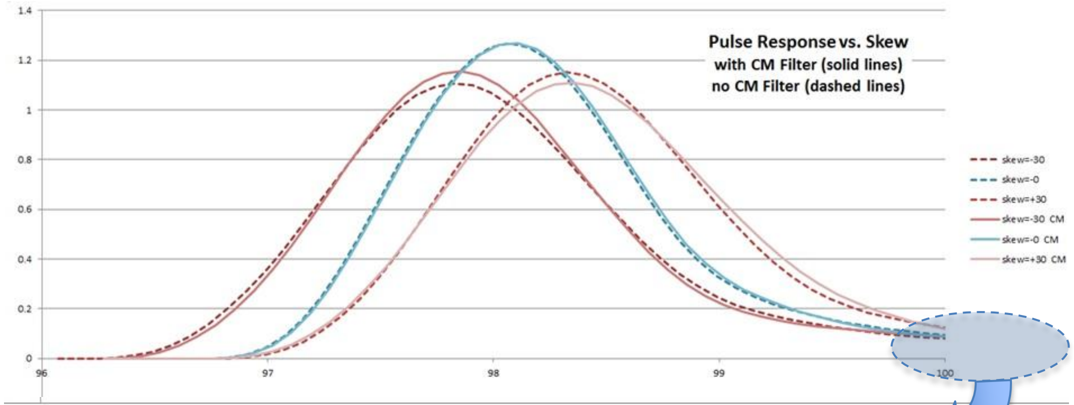
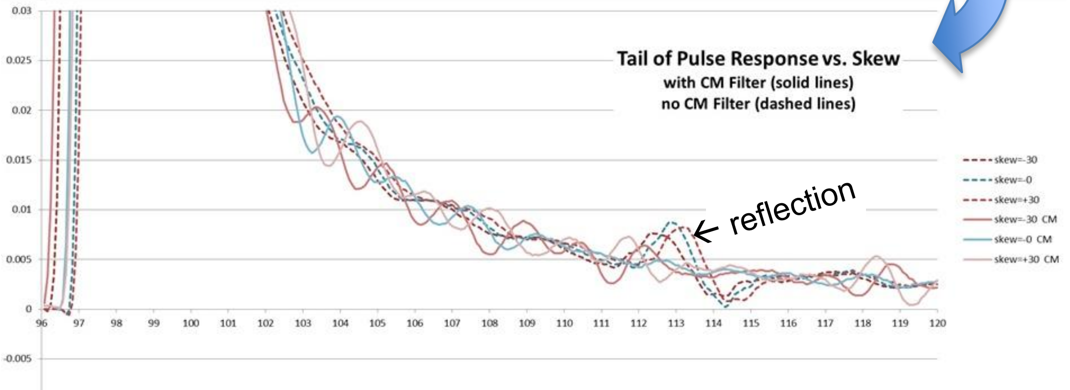
Differential Pulse Response vs. Skew

- Differential pulse responses with & without CM filter nearly identical



- Low level ripple in pulse response with CM filter
  - …but smaller than a minor reflection in response without CM filter



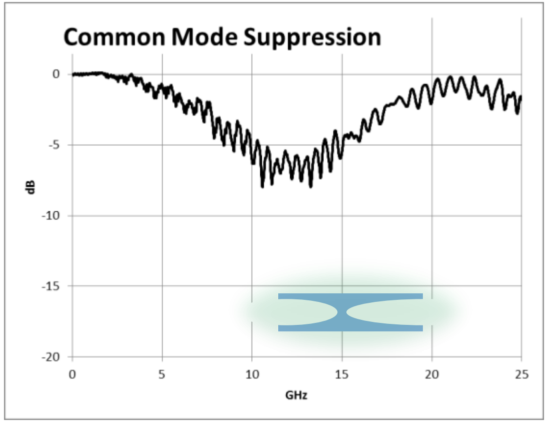
GND Cutout Geometries

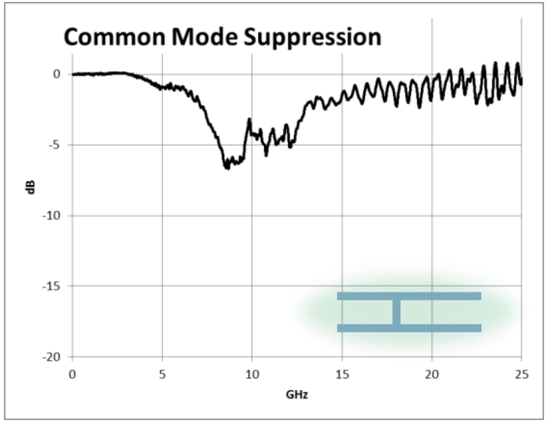
Common Mode Suppression:

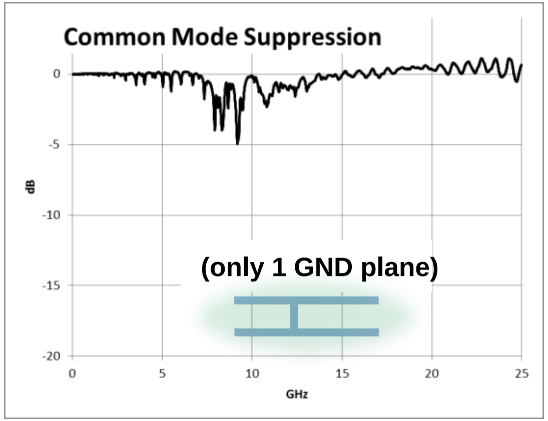
Common Mode Insertion Loss / Differential Insertion Loss

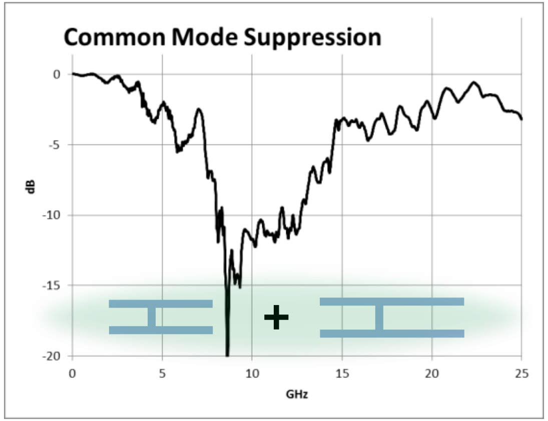
=

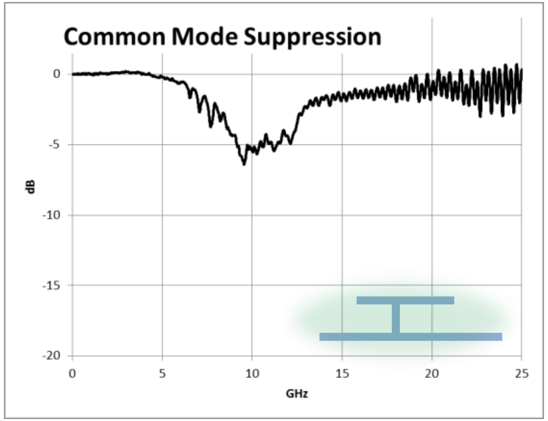
SCC21 (dB) – SDD21 (dB)





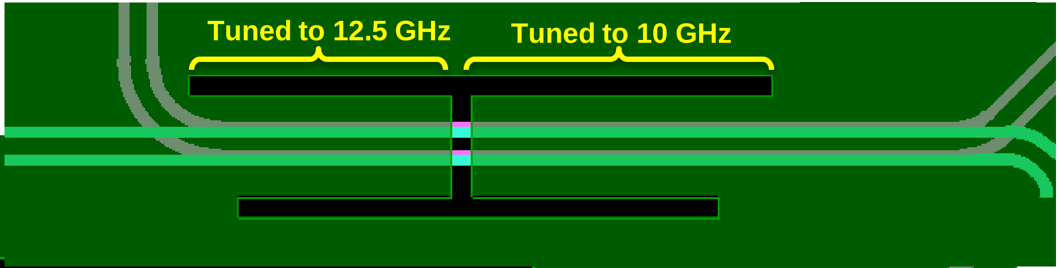


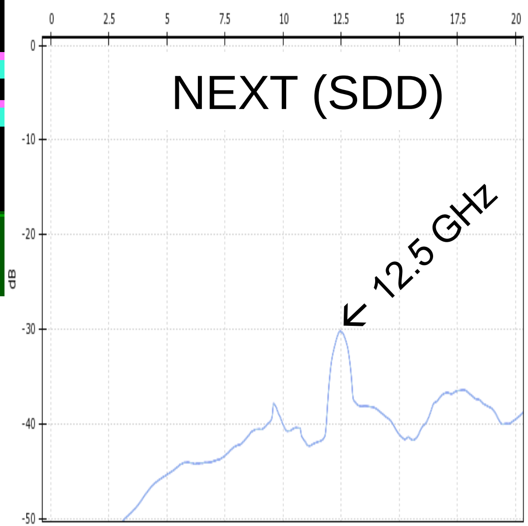


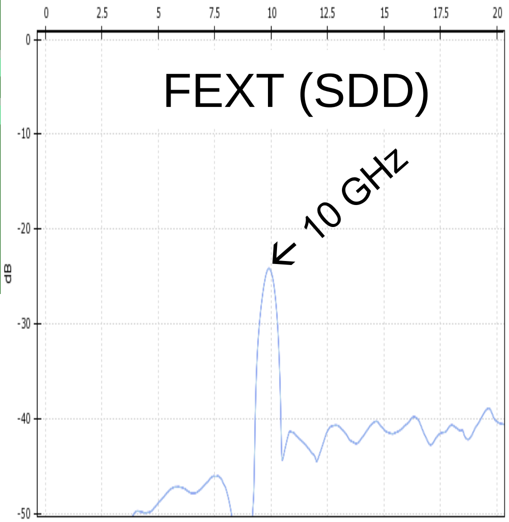


Isn't this a Slot Antenna?

- Differential pairs on opposite sides of GND cutout
- Some energy leaks thru from pair to pair, although most unbalanced energy is reflected back to transmitter
- Probably best to avoid using this technique with:
  - parallel traces on adjacent planes
  - cutouts in external GND planes
  - microstrip traces

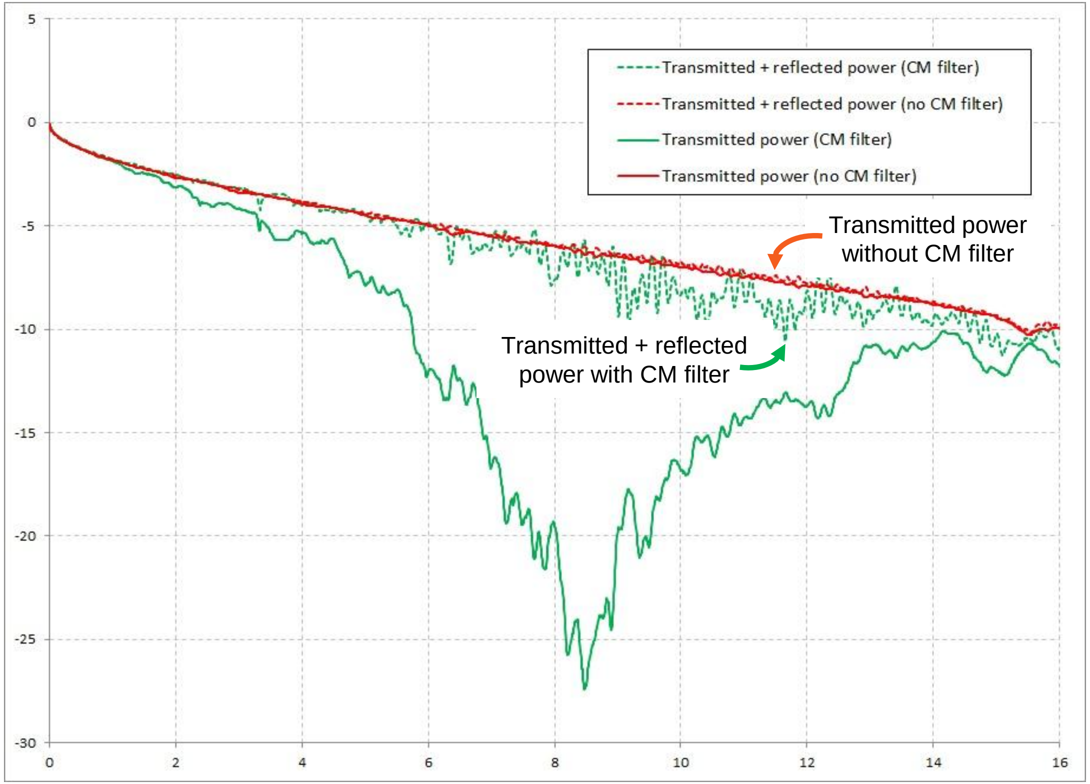






Where Does the Power Go ?

- Transmitted common mode power + power reflected back to transmitter by CM filter almost equal to transmitted power without CM filter



Take Aways

- Skew is a growing problem at higher data rates
- Minimizing common mode also minimizes skew
- "Defected ground planes" can be effective common mode band reject filters ☺
- Be careful not to make accidental antennas ☹

THANK YOU

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