Reducing Simultaneous Switching Noise on Power Planes by Dissipative Edge Termination

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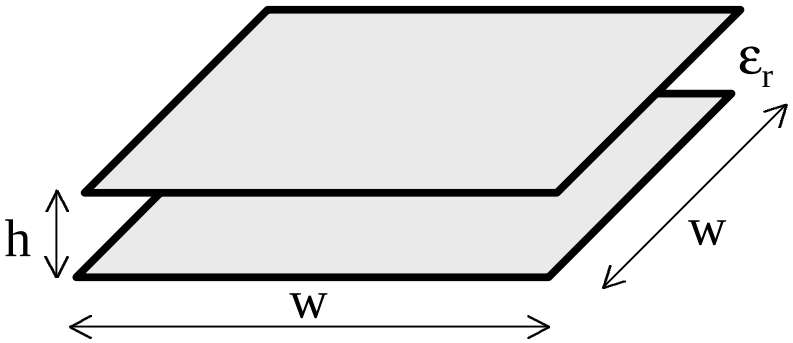
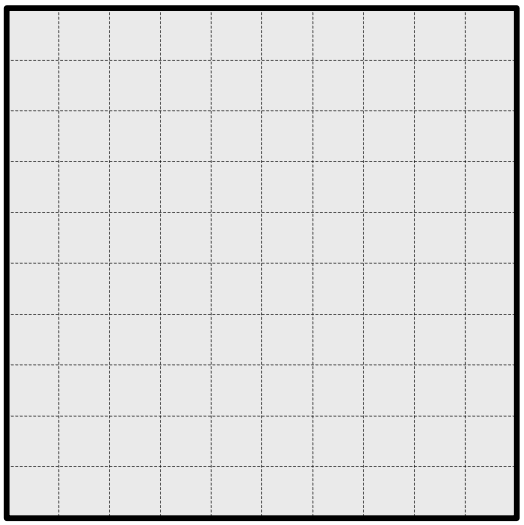
Plane Model



Equivalent circuit:
Transmission-line grid



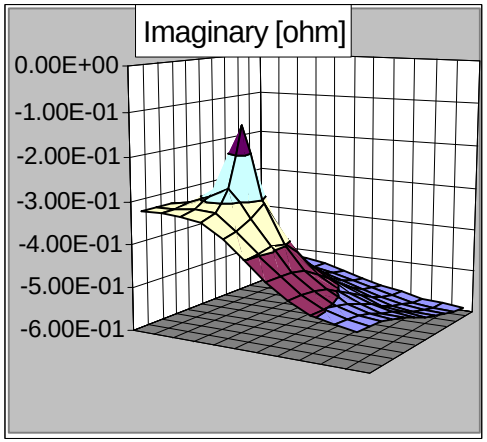
$$C_u = e_0 e_r \frac{w^2}{h}, \qquad t_{pd\_u} = \frac{w\sqrt{e_r}}{c}$$

$$Z_{0u} = \frac{t_{pd\_u}}{C_u} = 120p \frac{h}{w\sqrt{e_r}}, \qquad L_u = \frac{Z_0}{t_{pd\_u}} = m_0 h$$

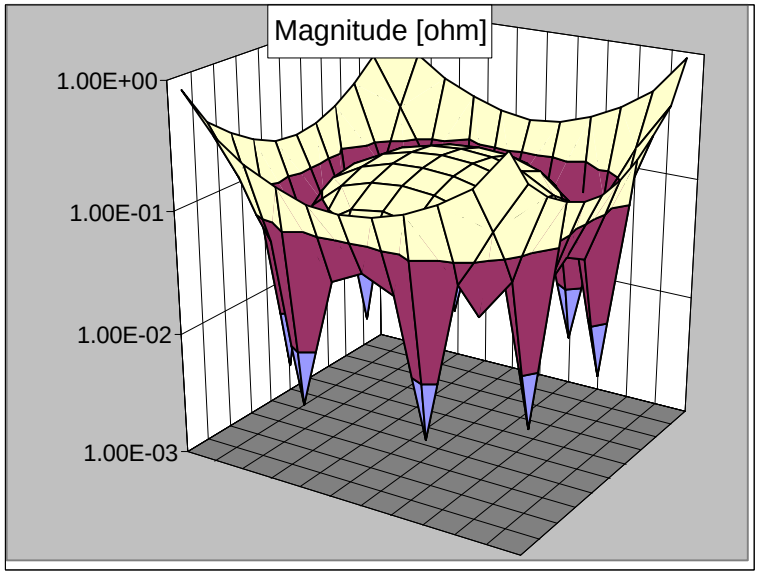
Impedances of Planes with Open Edge

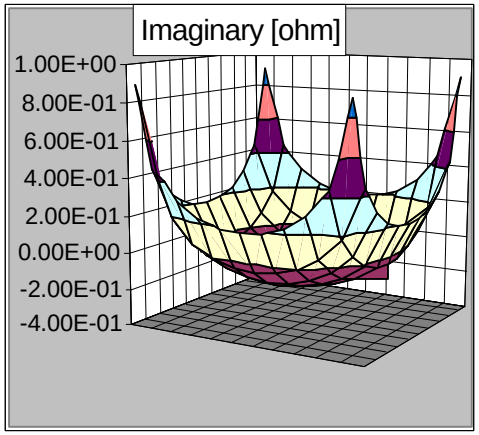
10”x10”x31mil FR4 planes at 100MHz

Transfer impedance from Node 4,4



Magnitude and imaginary self impedances

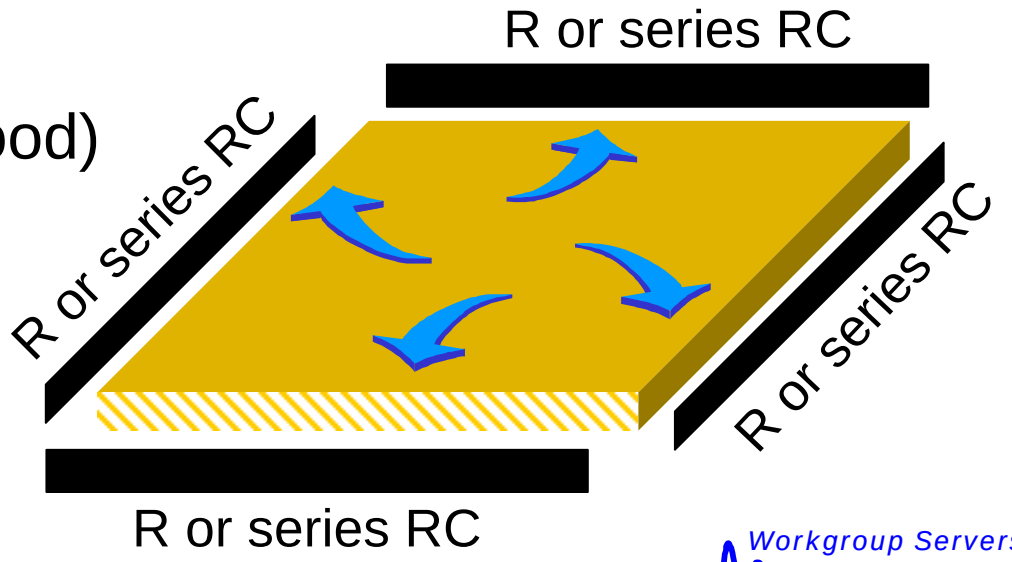




Dissipative Edge Termination (DET)

Resonances can be suppressed by

- series DC loss (no good)
- series AC loss
- parallel AC loss
- edge termination



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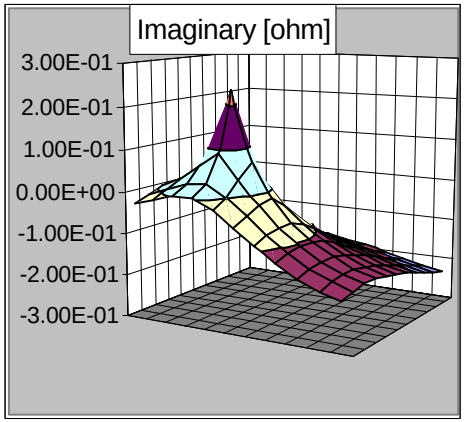

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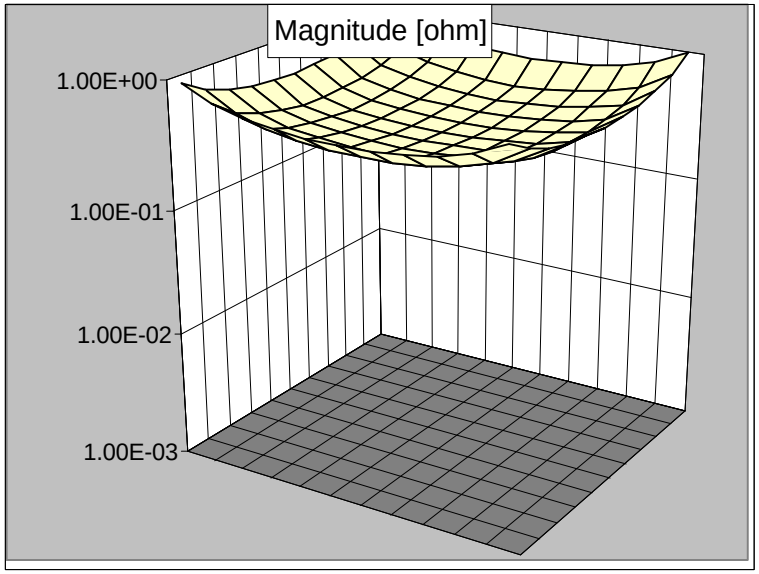
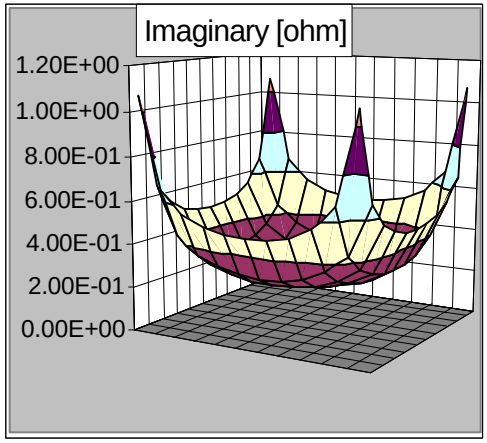
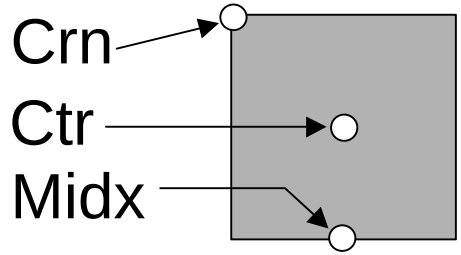
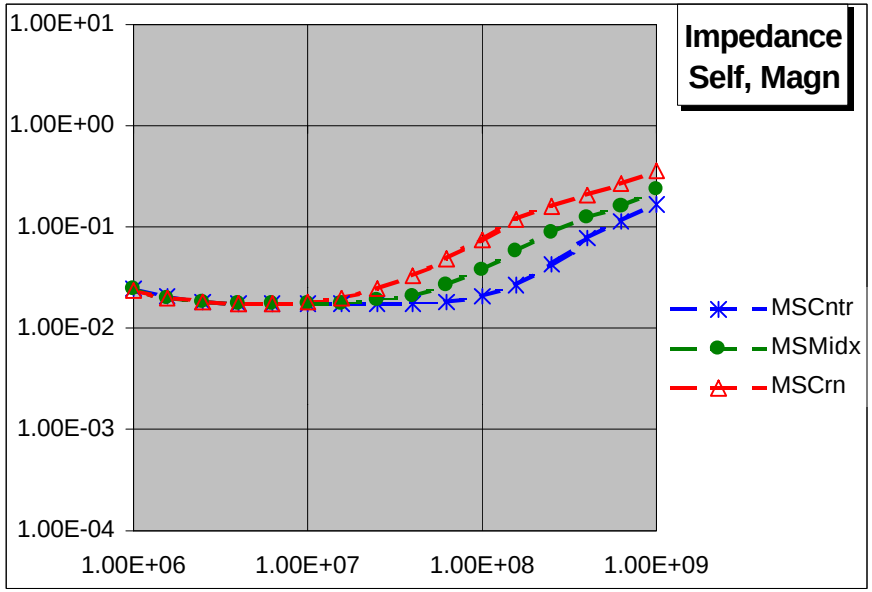


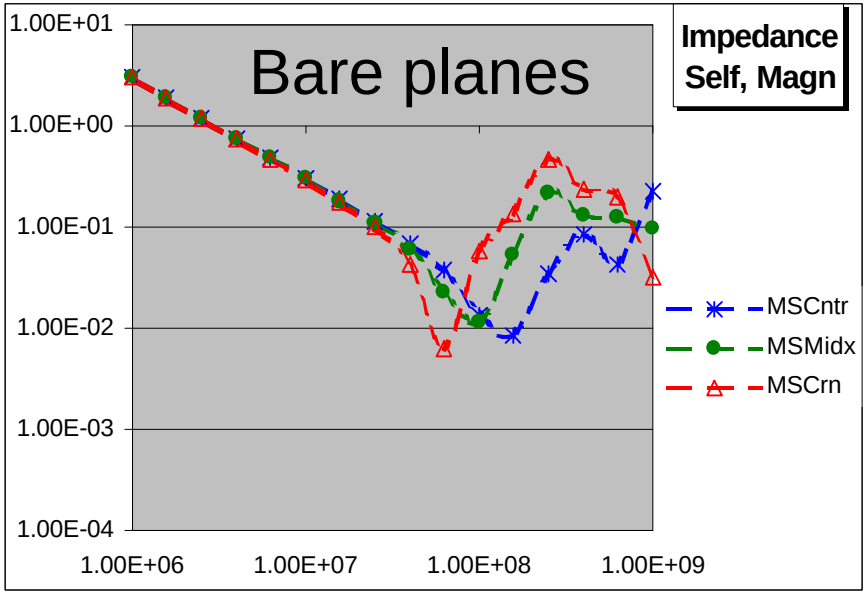


Open Edge vs. DET



Planes with DET

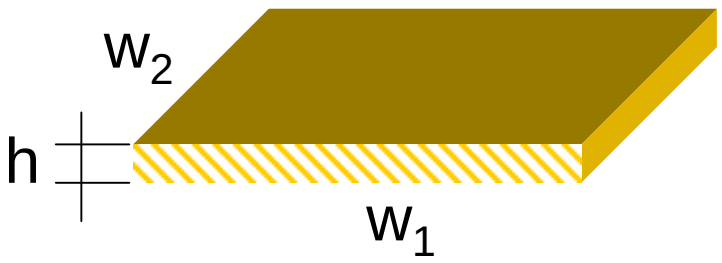




10”x10”x2mil FR4

DET at every inch

simulated with1 inch grid



DET Design Flow

Collect input data:

- Identify required impedance: Z, BW_t
- Identify plane dimensions {w_1, w_2, w=sqt(w_1*w_2)}, F_{res}, ε_r

Design DET:

- Calculate plane-pair height (and/or # of planes) from BW_t , ε_r, by rearranging: $Z < Z_{plane} = 120*\pi*h/\{w*\ sqt(\varepsilon_r)\}$
- Calculate component separation: $s < c/\{10*BW_t*sqt(\varepsilon_r)\}$
- Calculate R_t to match unit cell with size ‘s’
- Calculate C_t from $f_{res} < 1/\{2*\pi*R_t*C_t\}$

DET, Features

- Straightforward design methodology
- Smooth impedance profile
- Lower DM edge radiation
- Low component count
- Inner area of board is freed up
- Along edge easier to provide low-L connection
- Possible implementation with integrated passives
- Not sensitive to
  - component tolerances
  - placement tolerances

BUT...

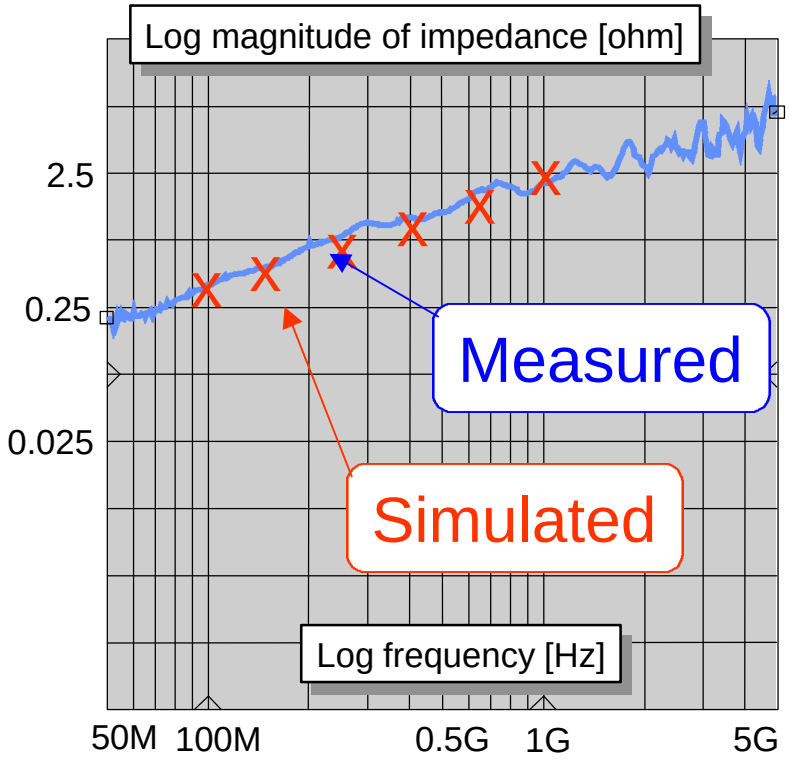
- DET in itself will not lower the impedance of planes
- Planes must be ‘good’ to start with
- Not just the peaks are reduced, but valleys are filled

Measured and Simulated Self Impedance

- 10” x 10” x 31mil FR4 with DET
- Measured with HP8720C VNA
- Simulated with 1-inch grid at center node:

Freq [Hz]	Zmagn[ohm]
1.00E+08	0.3143
1.58E+08	0.4413
2.51E+08	0.6574
3.98E+08	1.233
6.31E+08	1.744
1.00E+09	2.645

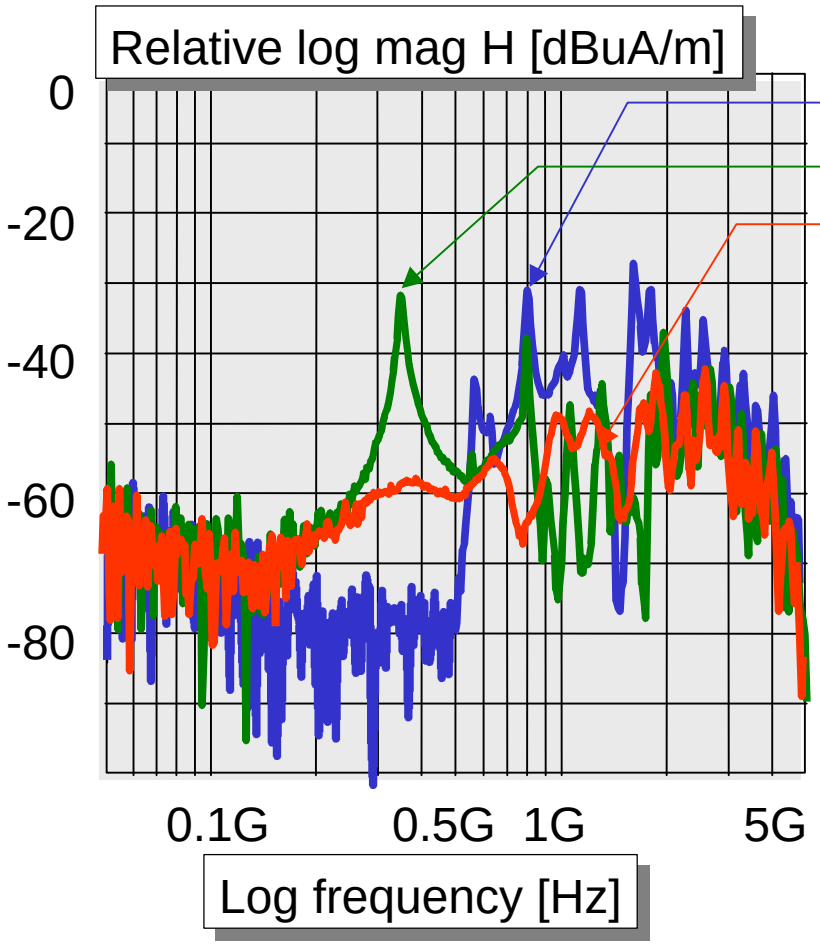
Self impedance at center node



Workgroup Servers

Board Design Technology

Measured H Field at Board Edge

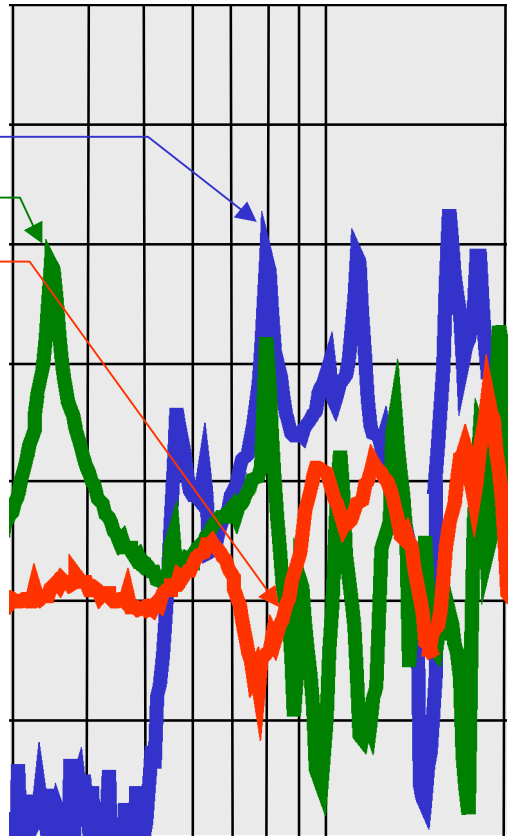


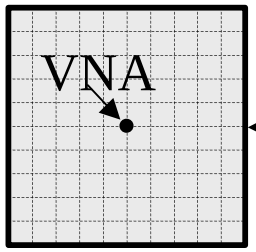
Open

Short

Terminated

Zoomed:





Probe

Workgroup Servers

Board Design

Technology

Conclusions

- Unterminated or short-terminated planes resonate
- Dissipative edge termination
  - reduces peaks in DM radiation
  - reduces peaks in self- and transfer impedances
- Bypass design is straightforward with DET