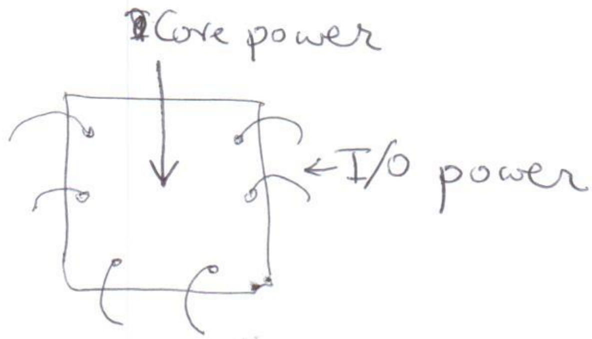
E8 : 262 Lecture 16

Power Integrity : AC analysis

Core power vs. I/O power



Core power – power supply to core circuits

I/O power – power supply to I/O circuits

Target Impedance :-

$$Z_T = \frac{V_{dd} \times \text{ripple}}{50\% \text{ of } I_{max}}$$

e.g. ripple = 5% of 5V V_{dd}

$I_{max} = 1$

$Z_T = 0.5\Omega$

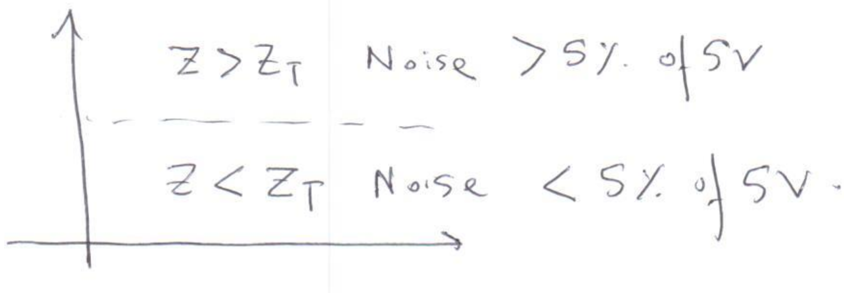


Table 1.1 of Ref.

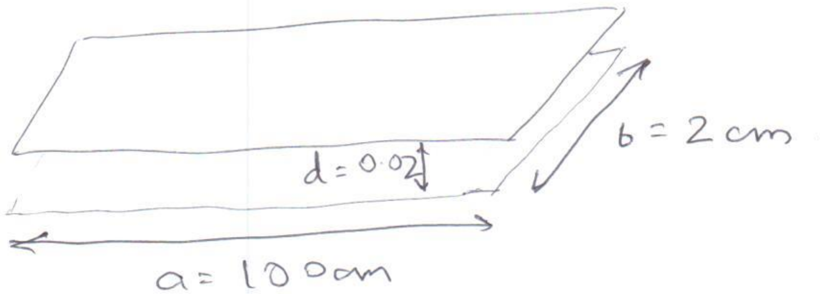
	V	Power	Current	Z target	F(MHz)
1990	5	5	1	250	16
2002	1.2	180	150	0.4	1200

Components of a PDN

- VRM (Voltage regulator module)
- Decoupling Capacitors
- PG planes
- On chip PDN grids

Modeling Power ground planes

(a) Transmission line models



$$C = \frac{\epsilon_0 b}{d} = 8.854 \text{ pF/cm}$$

$$l = \frac{\mu d}{b} = 0.125 \text{ nH/cm}$$

$$Z_0 = \sqrt{\frac{L}{C}} = 3.757 \,\Omega$$

$$T_d = a\sqrt{LC} = 3.33 \text{ ns/cm}$$

$$Z_{in} = Z_0 \left[\frac{Z_L + jZ_0 \tan\beta a}{Z_0 + jZ_L \tan\beta a} \right]$$

$$Z_L = \infty$$

For $a = \frac{\lambda}{4}$ resonance $Z_{in} = 0$.

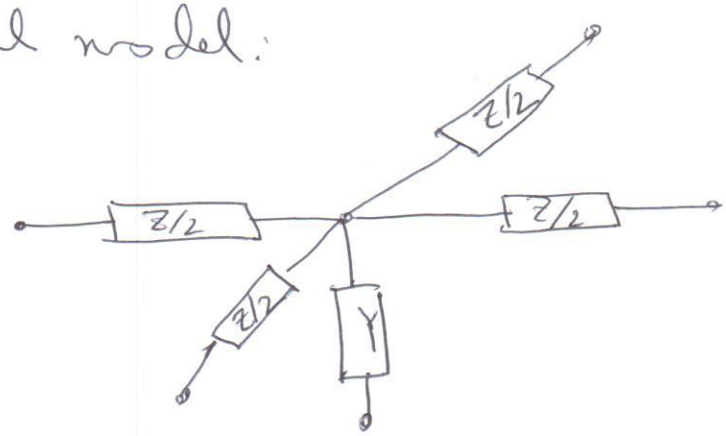
$a = \frac{\lambda}{2}$ anti-resonance $Z_{in} = \infty$

(b) Multilayered Finite Difference Method (MFDM) — Ref:- Engin et al. IEEE Trans on EMC pp. 441 - 448

eqⁿ: $\left(\nabla_T^2 + k^2\right) u = -j\omega \mu d J_z$

Unit cell model for a plane pair:-

T unit cell model:



$Z = R + j\omega L$

$Y = G + j\omega C$

$C = \frac{\epsilon h^2}{d}$.

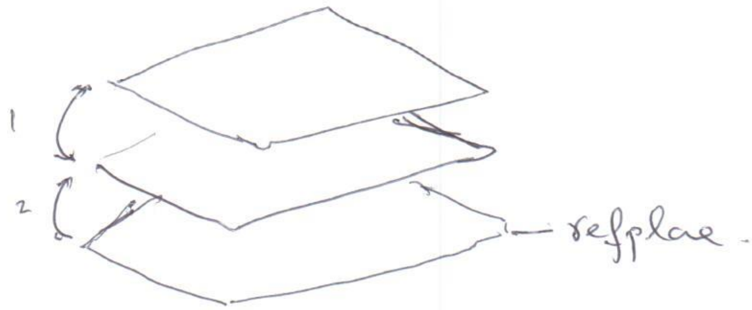
h : cellsize
d = plane distance.

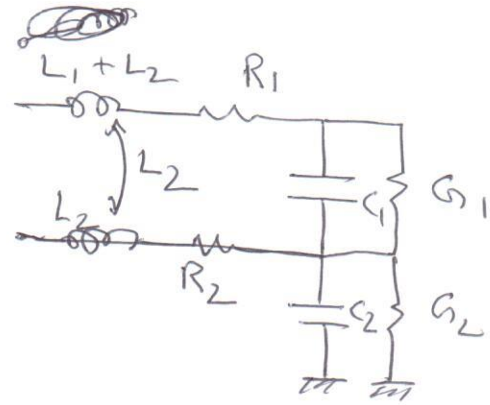
$L = \mu d$

$R = \frac{2}{\sigma t} + 2\sqrt{\frac{j\omega \mu}{\sigma}}$

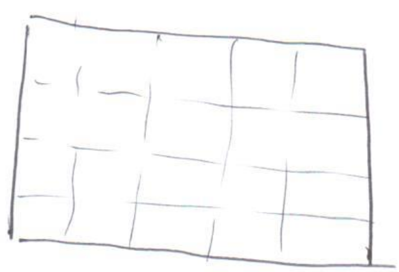
$G = \omega C \tan\delta$

Multi planar structures





Implementation:-



(a) discretization.

(b) identify ref. plane.

(c) stamp R, L, C, G.

(d) solve as MNA.

Drawbacks :-

(a) Horizontal coupling: fringe and gap.
(b) Ref plane identification.

Extension to non-uniform meshing

Mosin et al. ISQED 2010.

"Efficient Hierarchical discretization of off-chip power delivery Network geom. for 2.5D Electrical analysis.