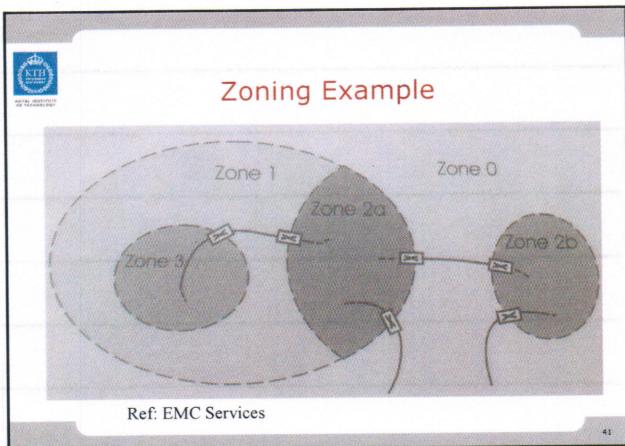
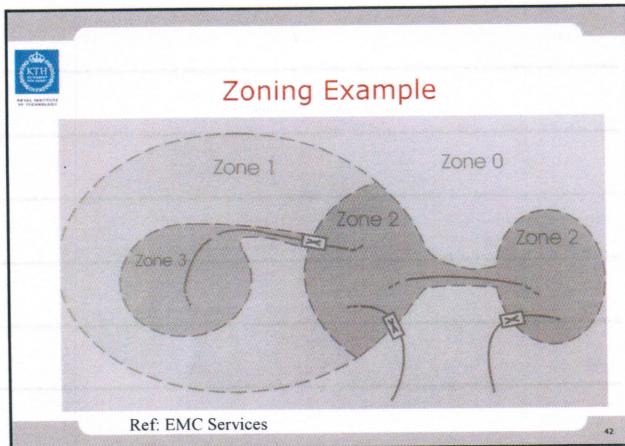


= Filter



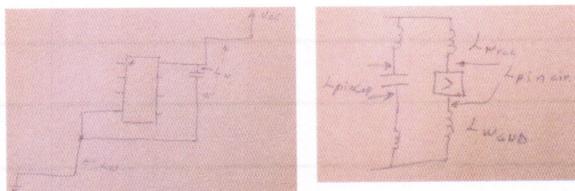
dots of filters => Expense



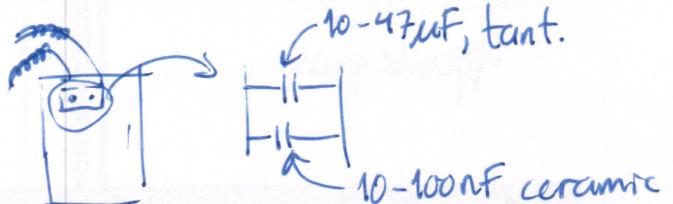


PCB power

Very important part of the board.
Wires => inductance approx 1nH/mm
Example, power lines



34



If you try to draw a lot of current, inductance in wires will cause a voltage drop. Big cap prevents this.



Capacitors for input

Always put capacitor on input of power at PCB
Could be $10-100 \mu\text{F}$ + a small 10nF

35



Designing electronics for EMC

- Zoning
- PCB layout
- Power plane
- Partitioning
- Decoupling

36

The image contains three hand-drawn diagrams on a pink background:

- Top Left Diagram:** A rectangle divided into four quadrants by a horizontal and vertical line. A red arrow labeled "Signal" points from the top-left quadrant to the bottom-right quadrant. A blue arrow labeled "return path" points from the bottom-right quadrant back to the top-left quadrant.
- Top Right Diagram:** A rectangle containing a central cross-shaped connection point. Four red lines extend from this center point to the four edges of the rectangle, representing a star-grounded power plane layout.
- Bottom Diagram:** A rectangle divided into four quadrants. A central cross-shaped connection point is shown. Red lines represent signal traces connecting the center to the top and left edges. A blue arrow labeled "return path" points from the bottom edge back to the center. A blue arrow labeled "Loop" points from the center to the right edge, indicating a looped return path.

Antenna in loop

A photograph of a Multilayer PCB. The board features two parallel traces running horizontally across the center. Above the top trace, the word "signal" is handwritten above it. Below the bottom trace, the word "signal" is handwritten above it. To the right of the top trace, the label "VCC" is written. To the right of the bottom trace, the label "GND" is written. The board has a light brown or tan color, characteristic of FR-4 material.

 Becomes a dipole antenna



Signal traces

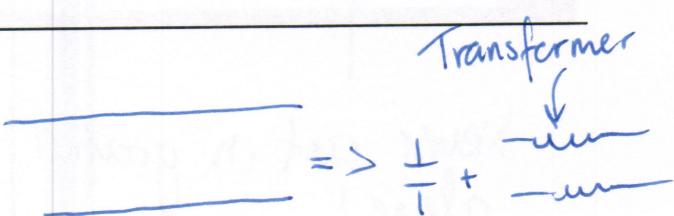
- Keep short, length depending on frequencies on signal
- Sharp edges can give reflections and radiation.
- Home made boards will be easier to solder if wires and pads are as big as possible.

Better





Shouldn't mix adjacent signal types.





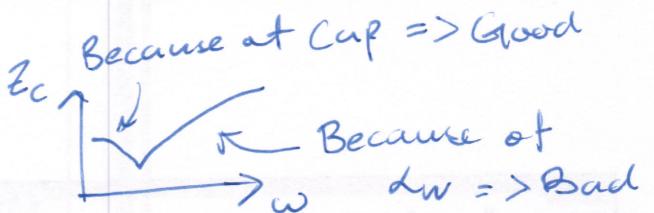
Impedance in wires

The inductance for a wire on a PCB could be something like

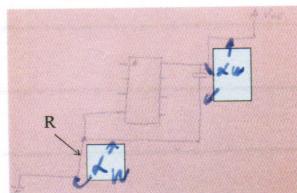
<http://www.eeweb.com/toolbox/broadside-trace-inductance/>

So 10 cm of wire $\sim 1\mu\text{H}$
at 1 MHz $\Rightarrow \omega L = 6.8\Omega$

22



Wire ground



What happens at DC?
And AC?

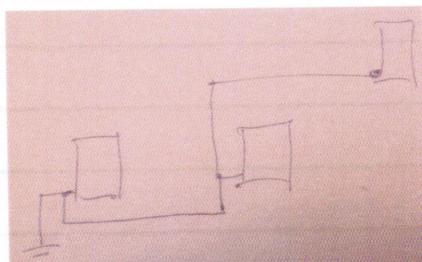
23

Not referring to same
ground on high freq.



PCB power

Never this way!



24

Common Mode current in a cable

- Lower Common Mode impedance results in higher Common Mode current. Grounding is thus not always desirable

Source: EMC services

Even higher I_{CM}

Common impedance coupling or CM to DM conversion

$Z_w \ll R_{IN}; Z_w \ll R_{OUT}; Z_w \gg Z_g$

$$U_{AB} = U_{DM} = I \cdot Z_w; \text{ Interference contribution: } U_{DM} = \frac{U_{CM} \cdot R_{IN}}{R_{OUT} + R_{IN}}$$

CM = Common mode
DM = Differential mode

Note: The output port is also exposed to disturbance

Source: EMC services

$$R_{in} = 1M\Omega \quad R_{out} = 1k\Omega$$

$$U_{CM} = 0.1V$$

$$U_{DM} = \frac{0.1 \cdot 1M}{1k + 1M} \approx 0.1V$$

Avoid common impedance coupling

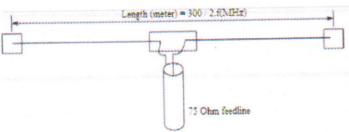
- Use dedicated common voltage and 0 V return for communicating modules
- Floating sensors
- Floating loads

Source: EMC services



Antennas

Dipole antenna

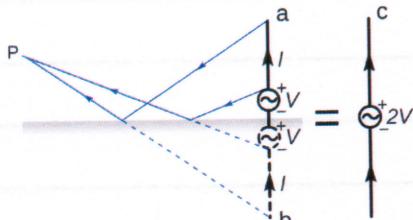


Length (meter) = $300 / 2.5 \text{ MHz}$

10



Rod antenna



11



Loop antenna



12



Electro Static Discharge ESD

Several discharge are performed:

4 kV in contact with the box

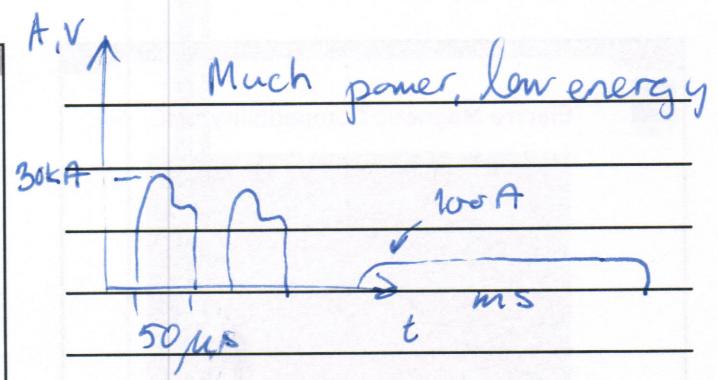
8 kV with a specified airgap



Electro Magnetic Pulse EMP

Nuclear explosions

Lightning



$500 MJ \approx 12 l$ petrol



The big drill



Source (culprit)
Interference emission
from a source



Victim have some immunity
against disturbance

6
