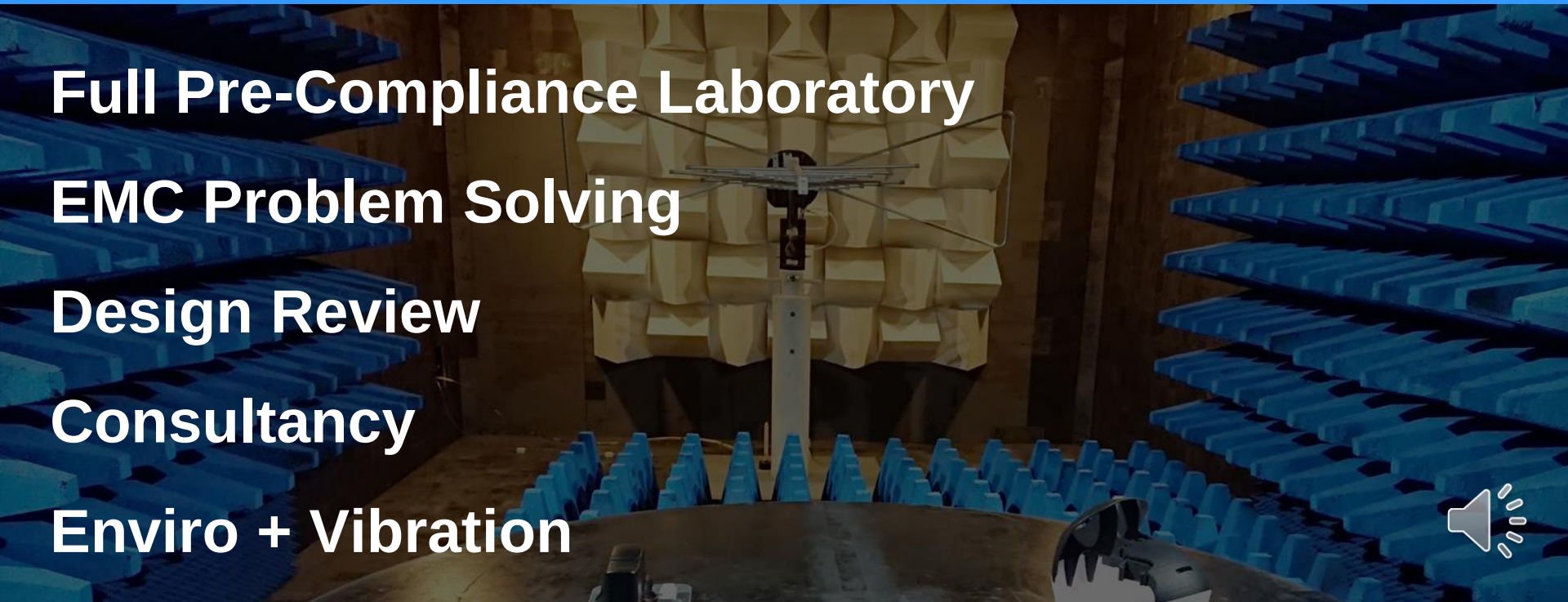
We need to talk about GROUND

Follow this link to watch on YouTube

James Pawson - Unit 3 Compliance

@ Rohde & Schwarz “Demystifying EMC” 2020

Unit 3 Compliance



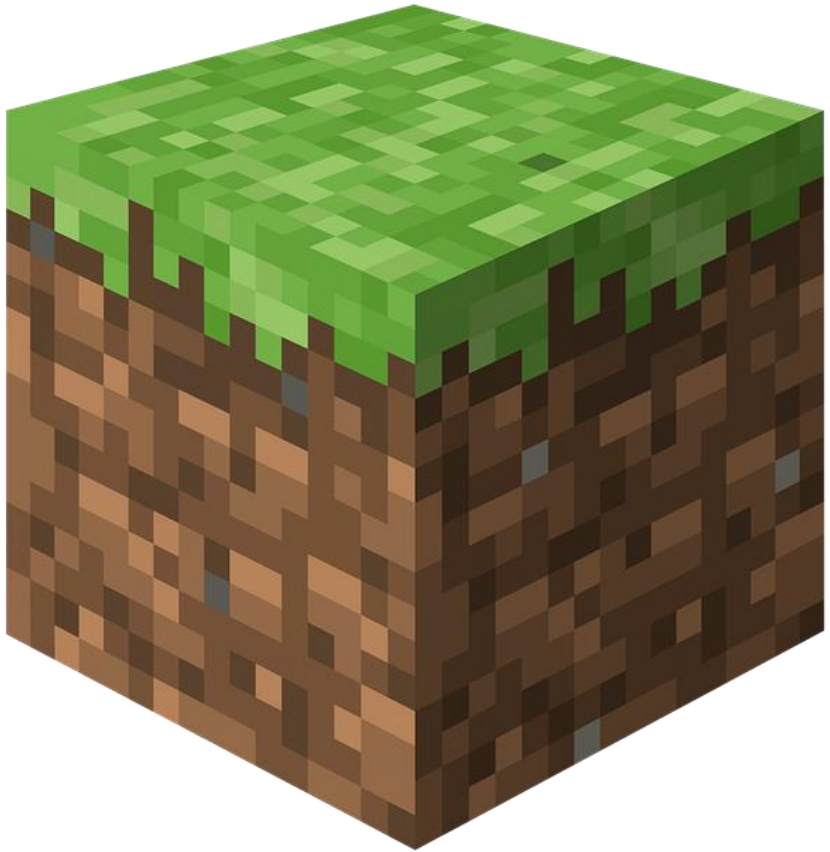
Full Pre-Compliance Laboratory

EMC Problem Solving

Design Review

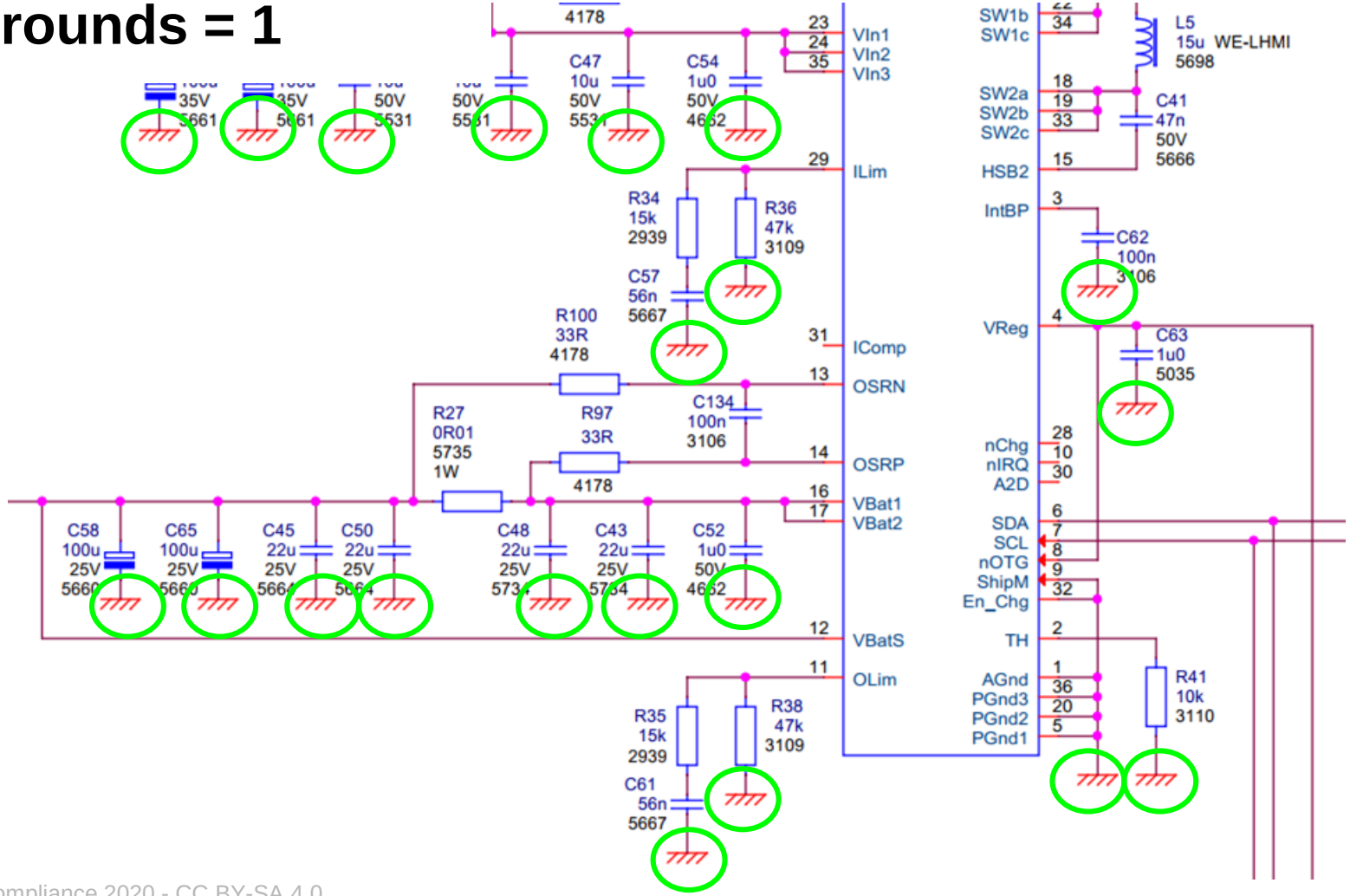
Consultancy

Enviro + Vibration

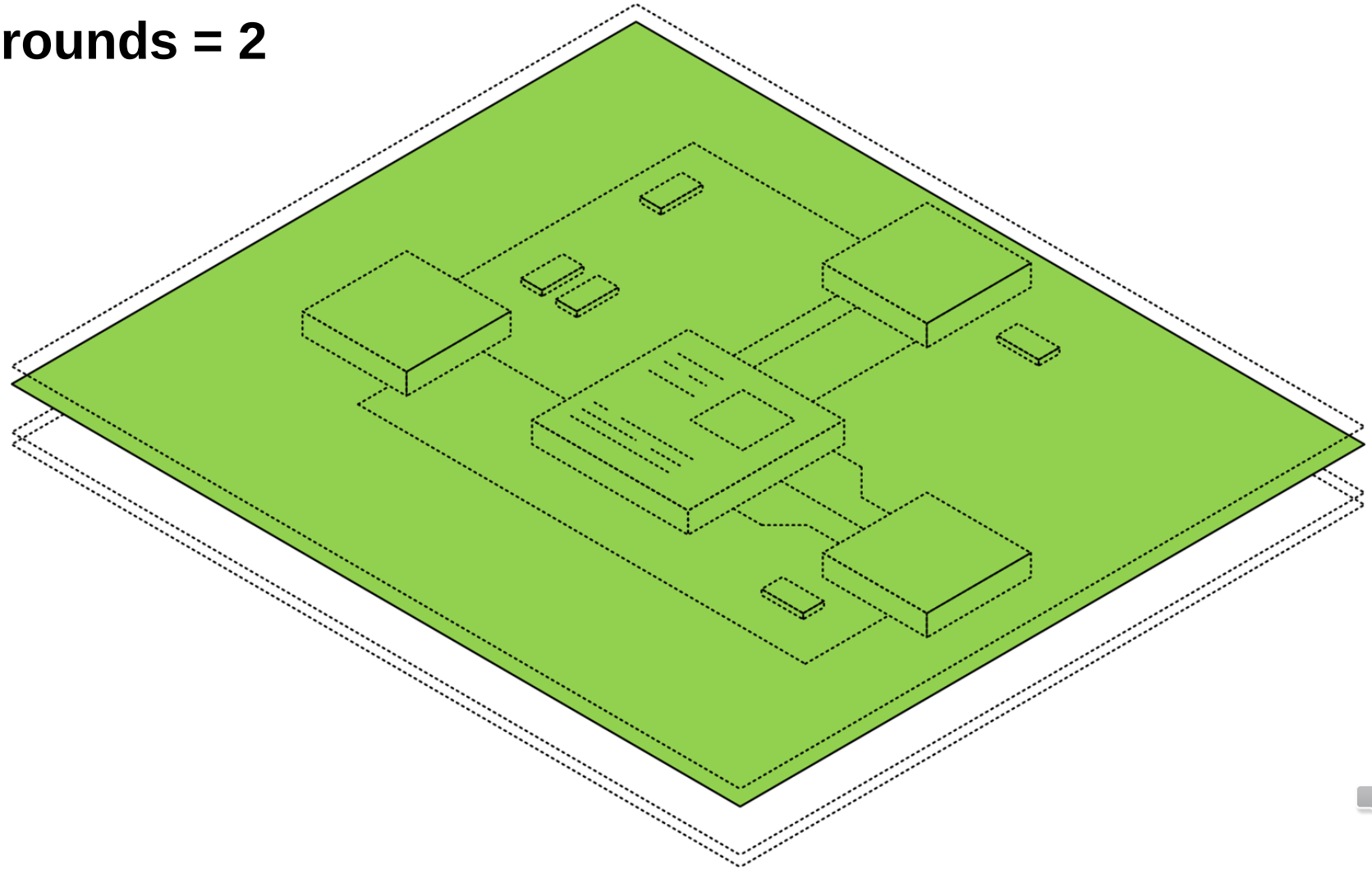


A lack of clarity

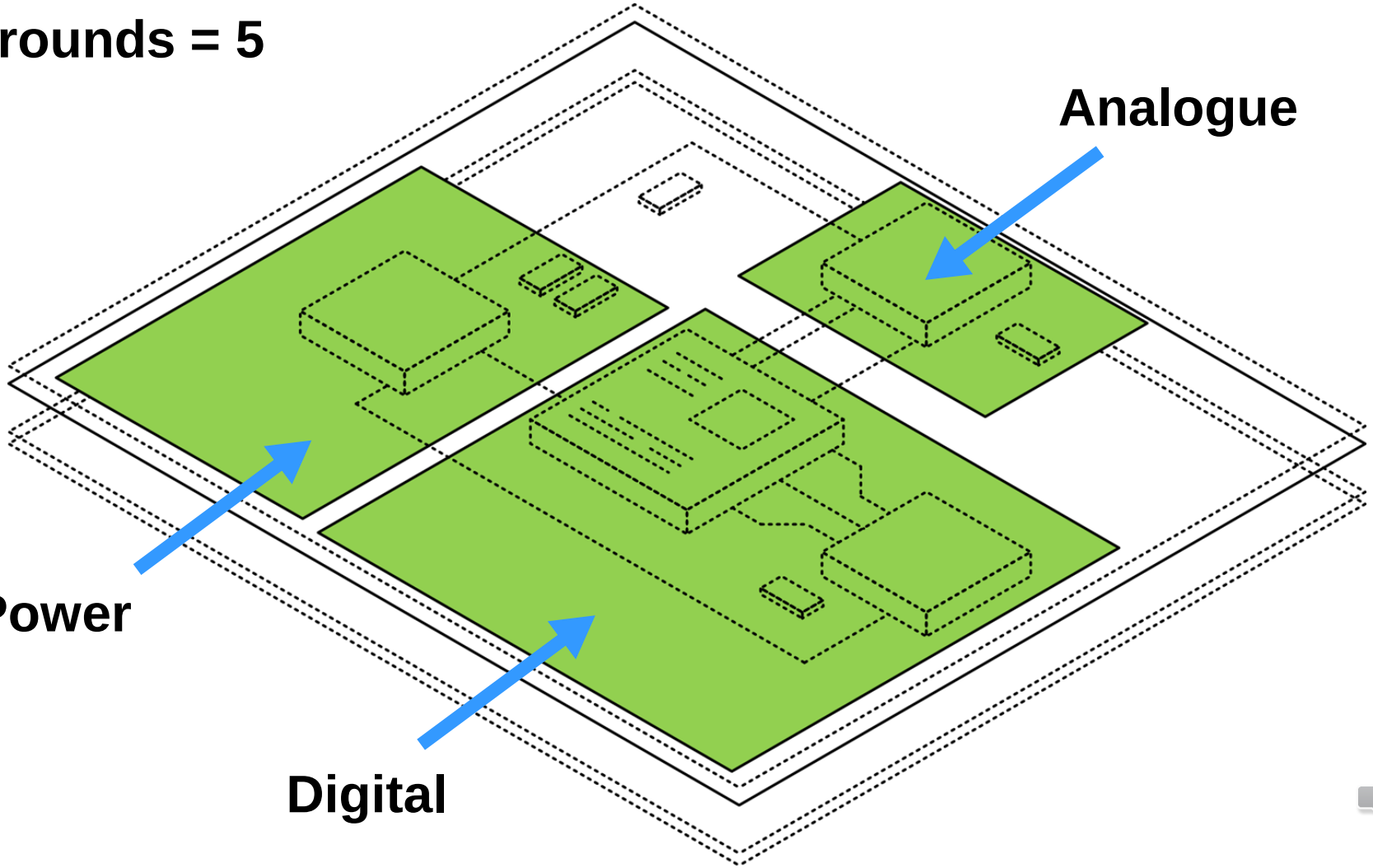
Grounds = 1



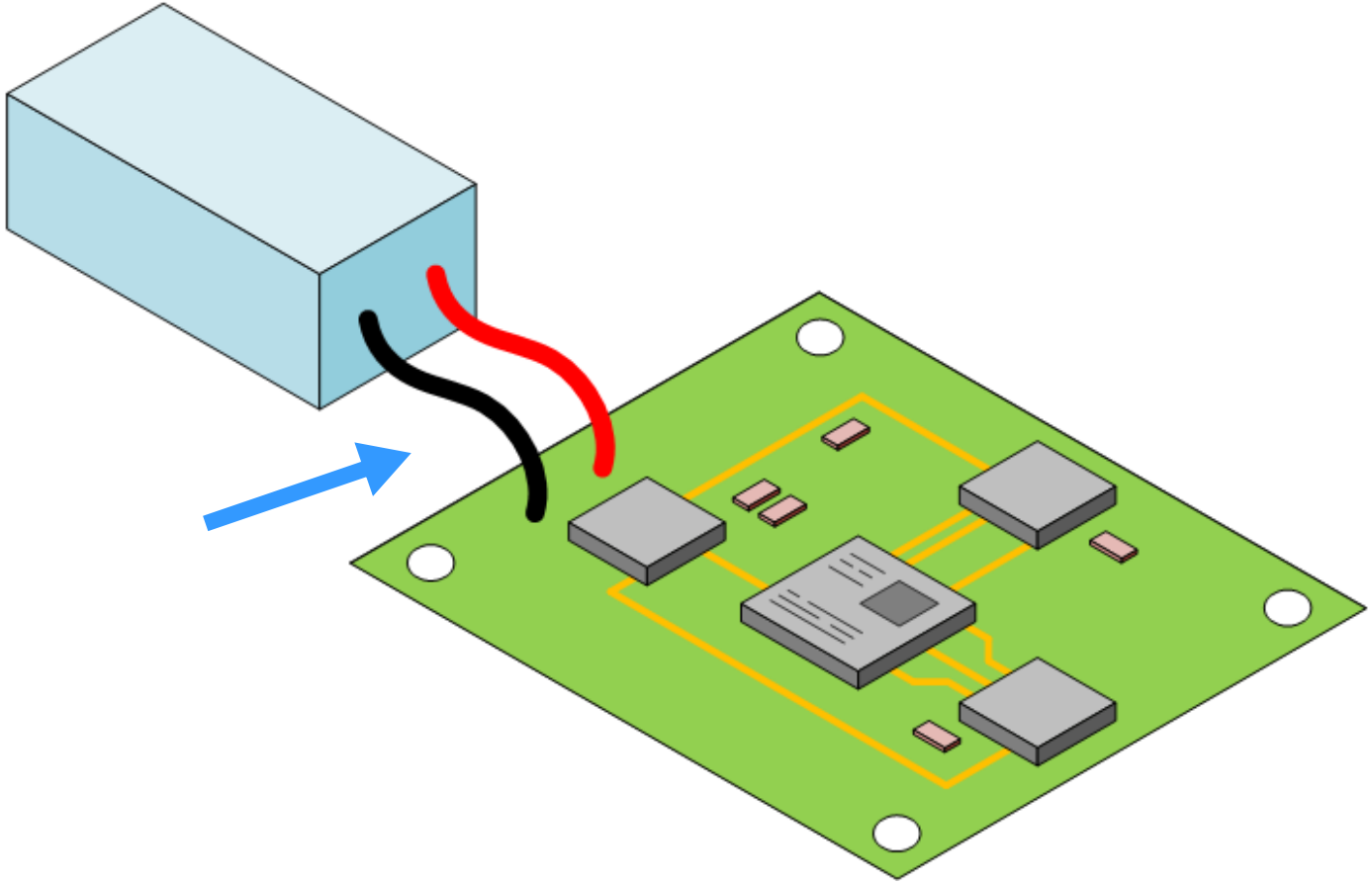
Grounds = 2



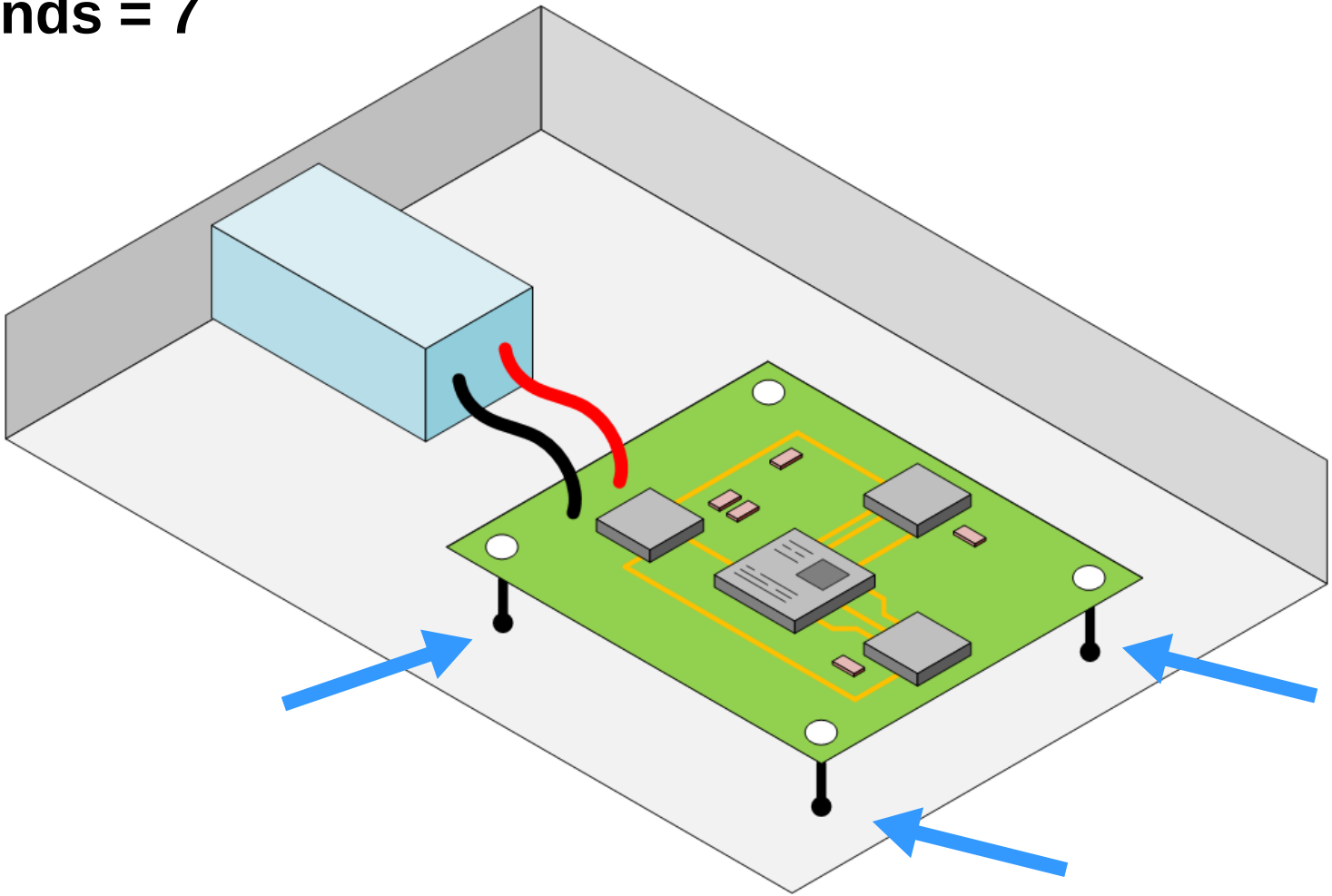
Grounds = 5



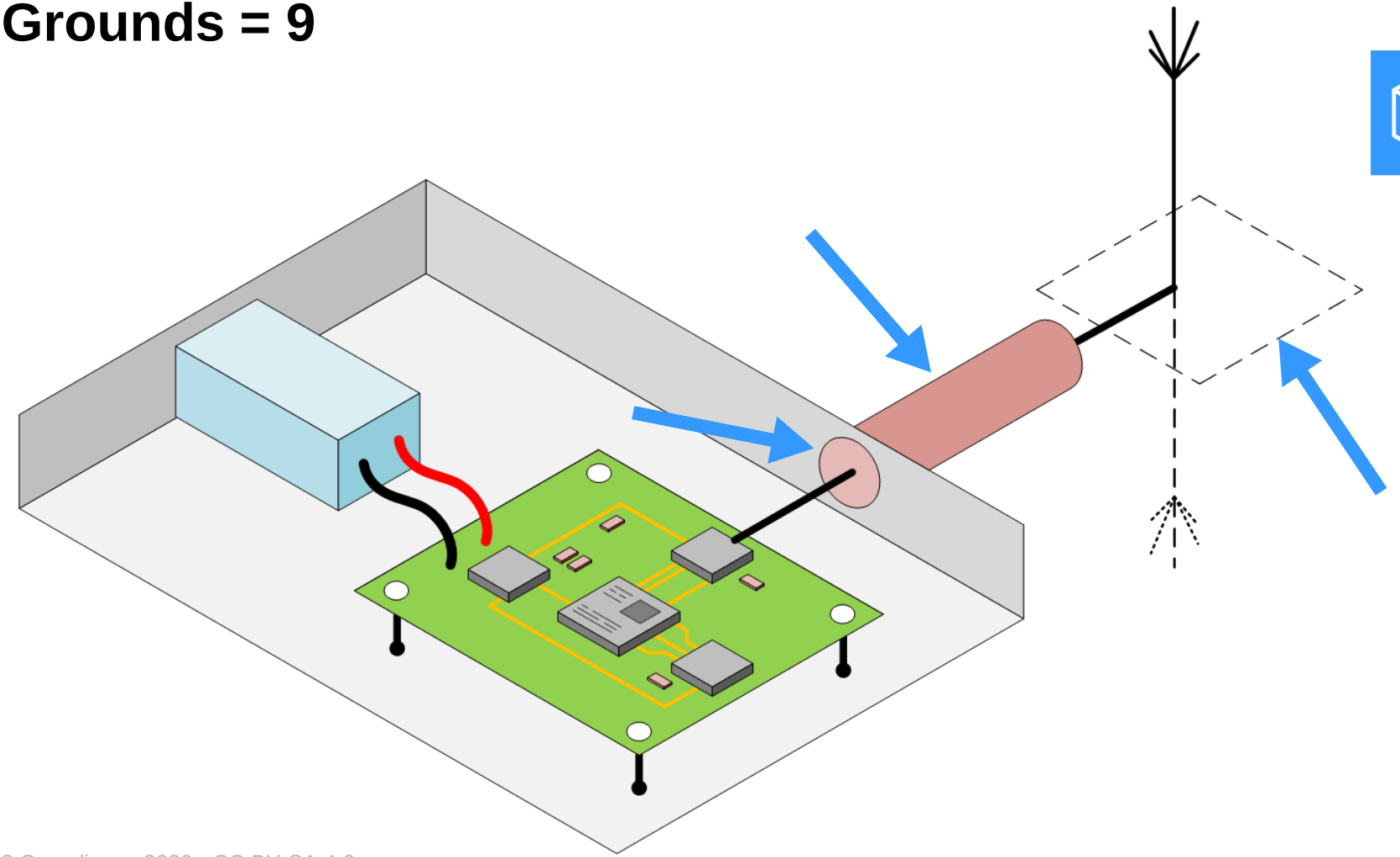
Grounds = 6



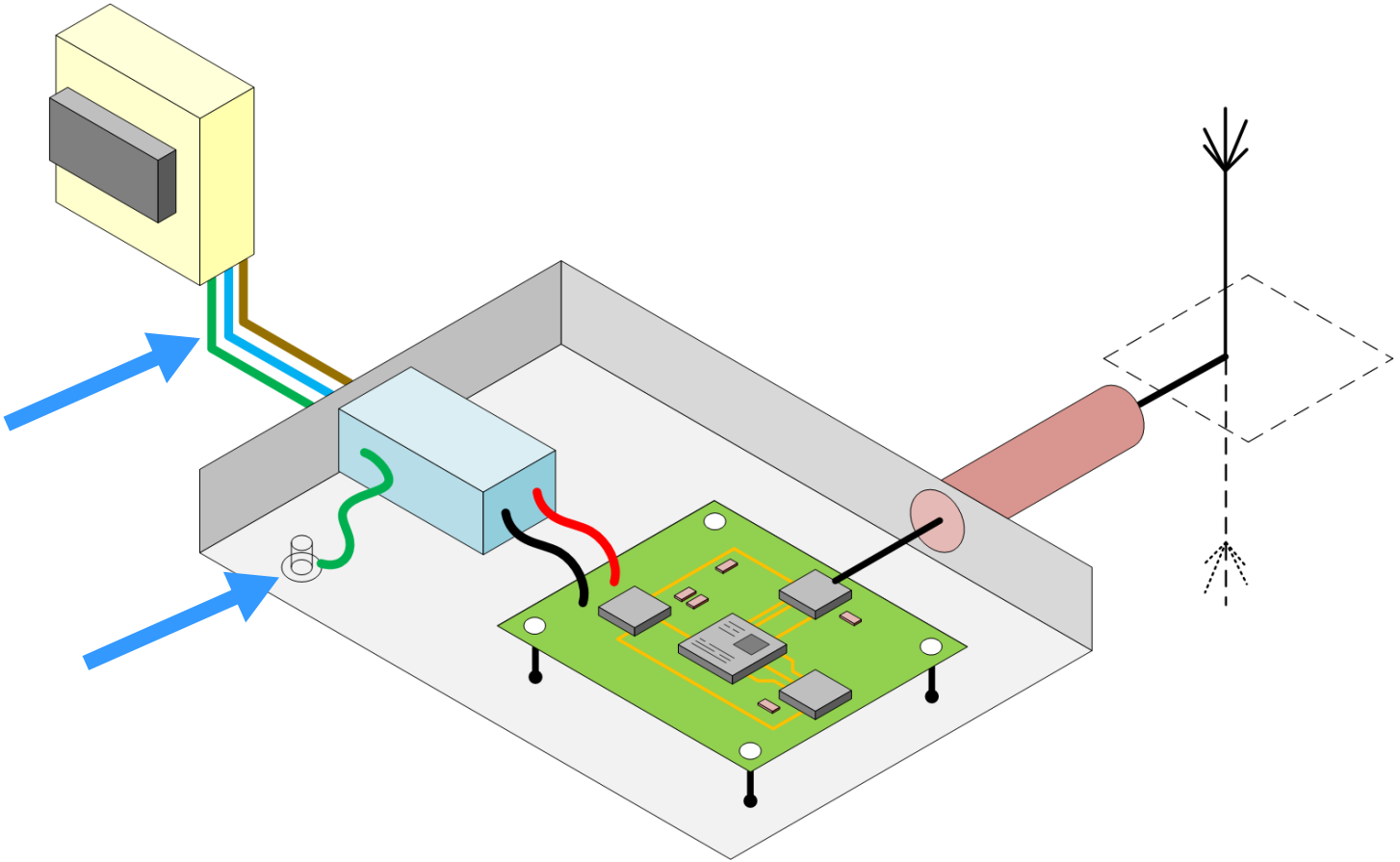
Grounds = 7



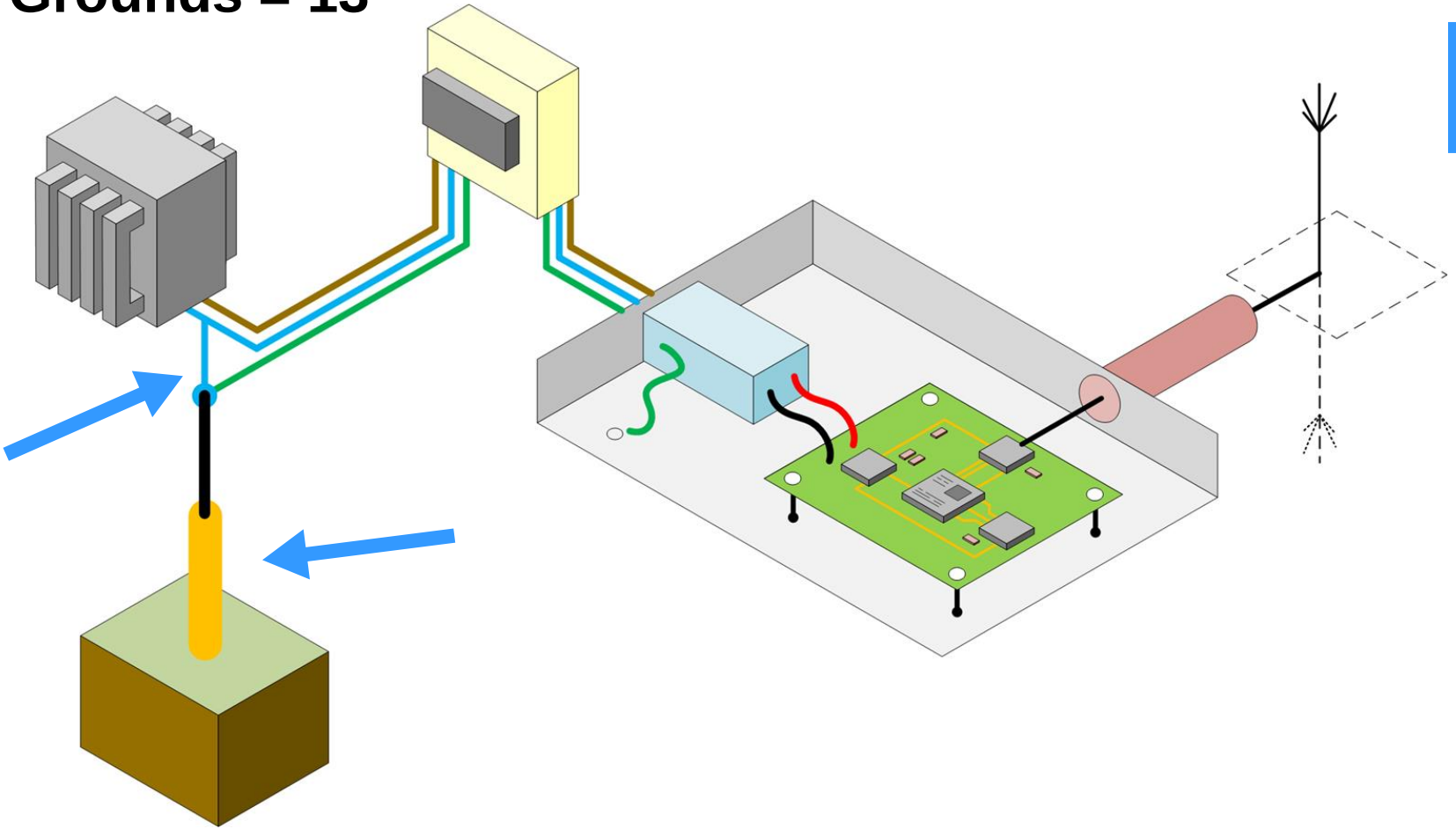
Grounds = 9



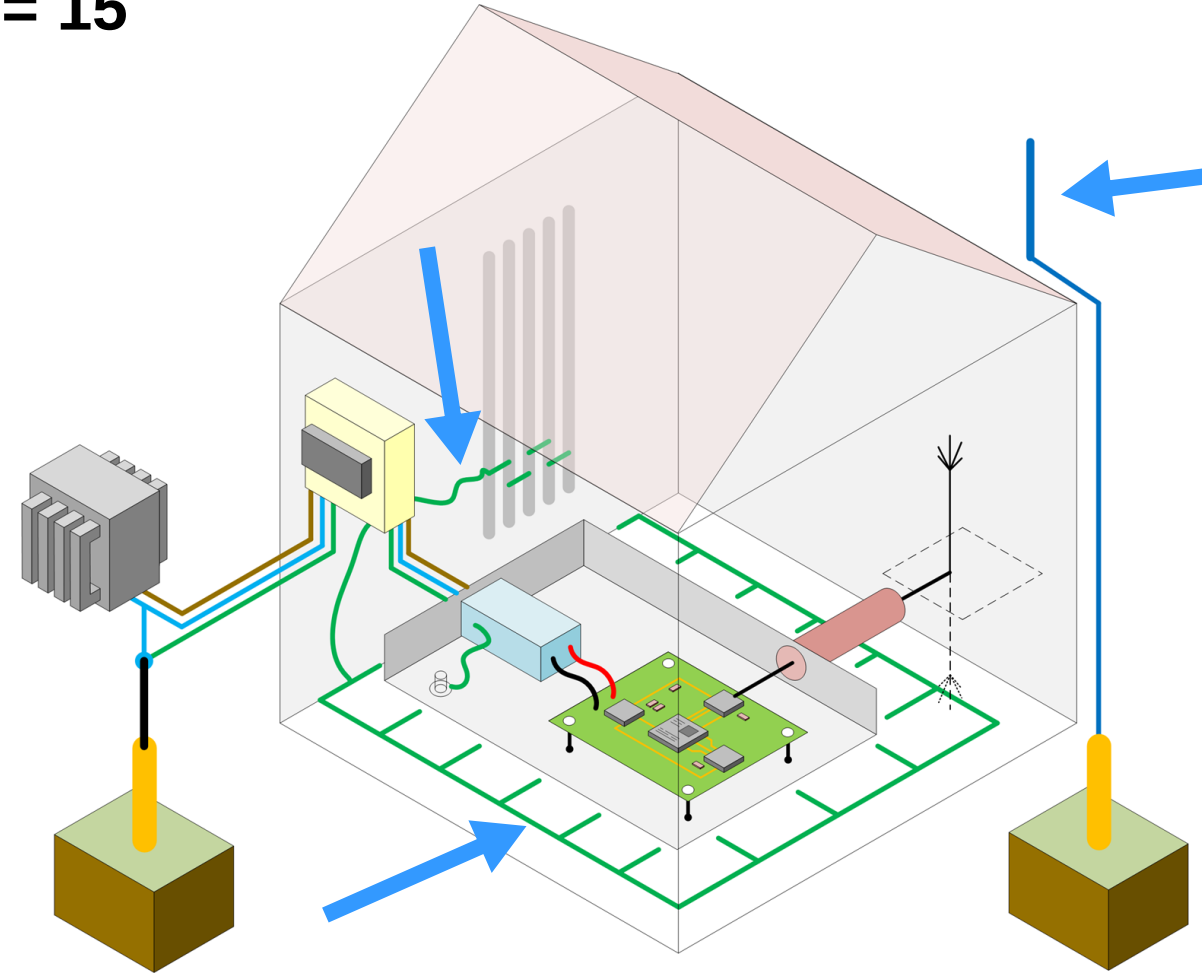
Grounds = 11

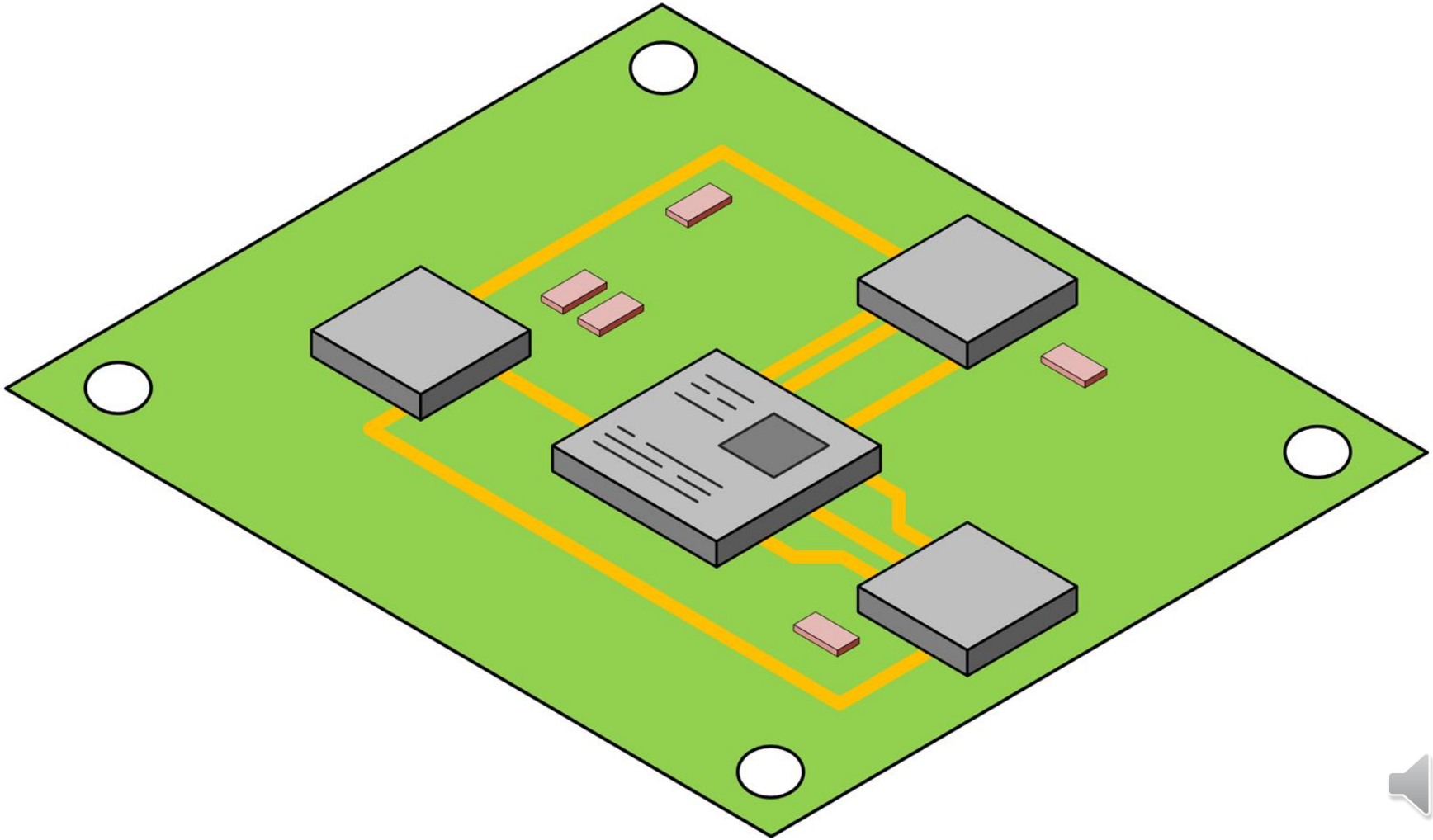


Grounds = 13



Grounds = 15



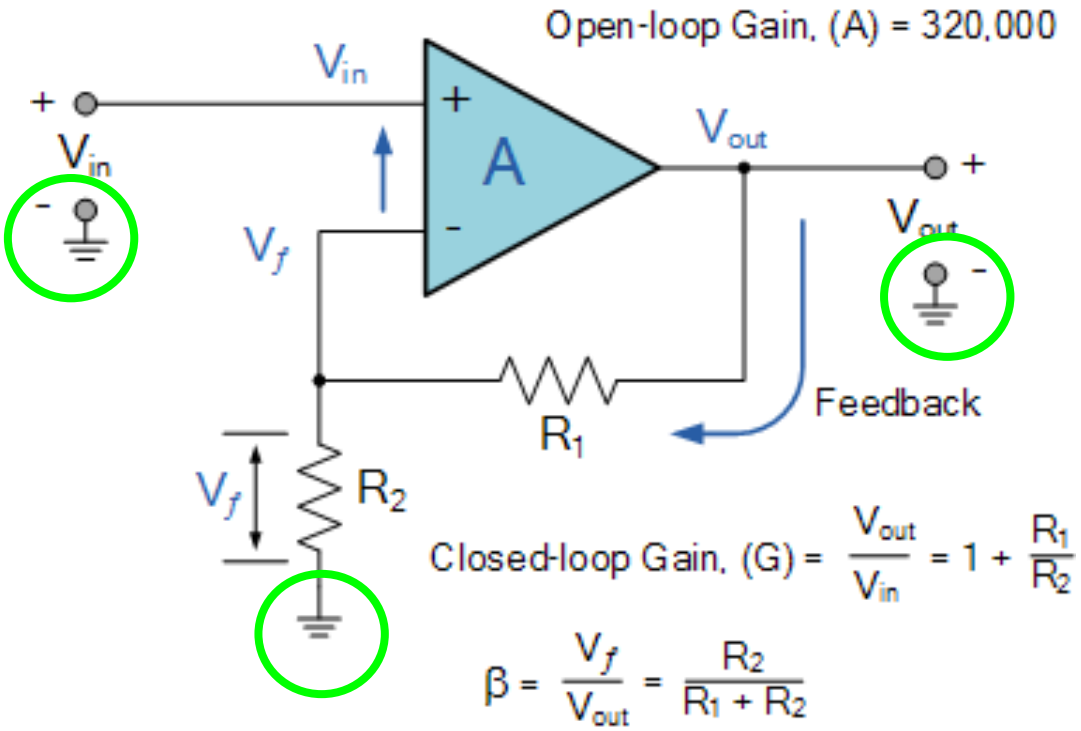


Taxonomy of ground

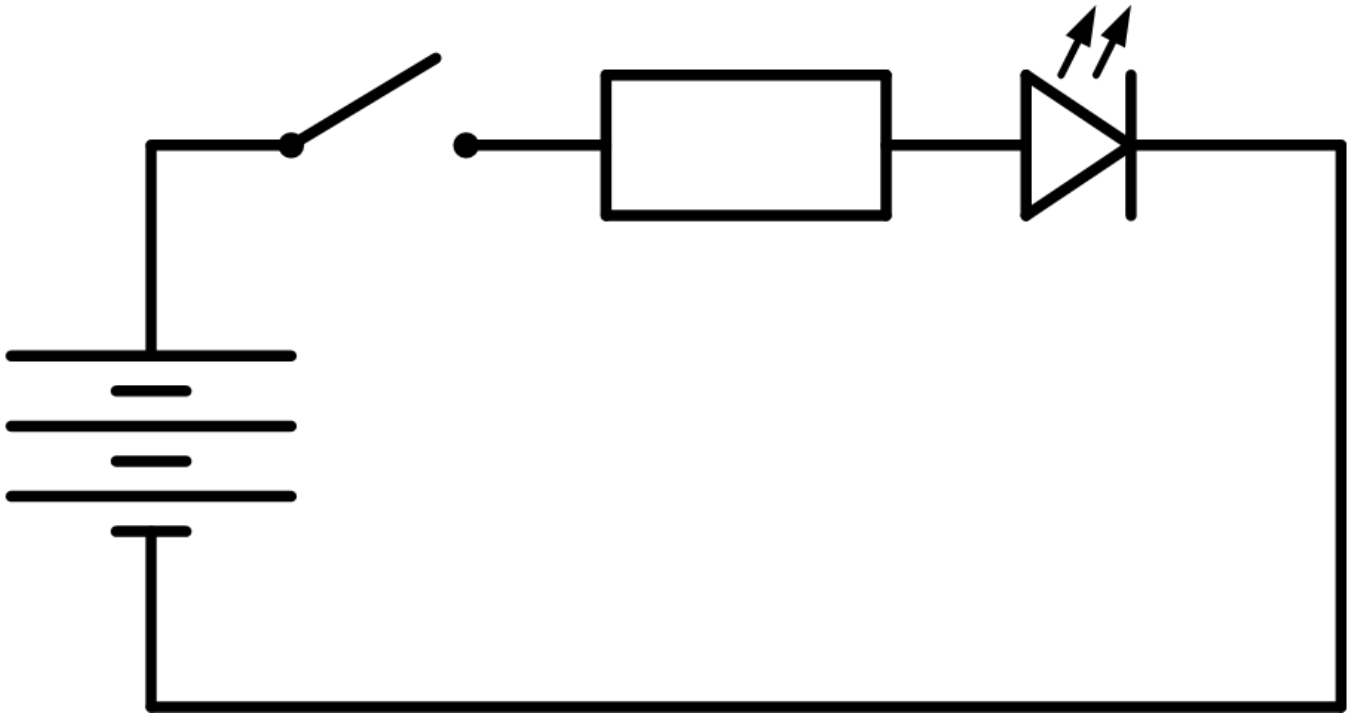
(from an EMC perspective)

1) Does it normally carry current?

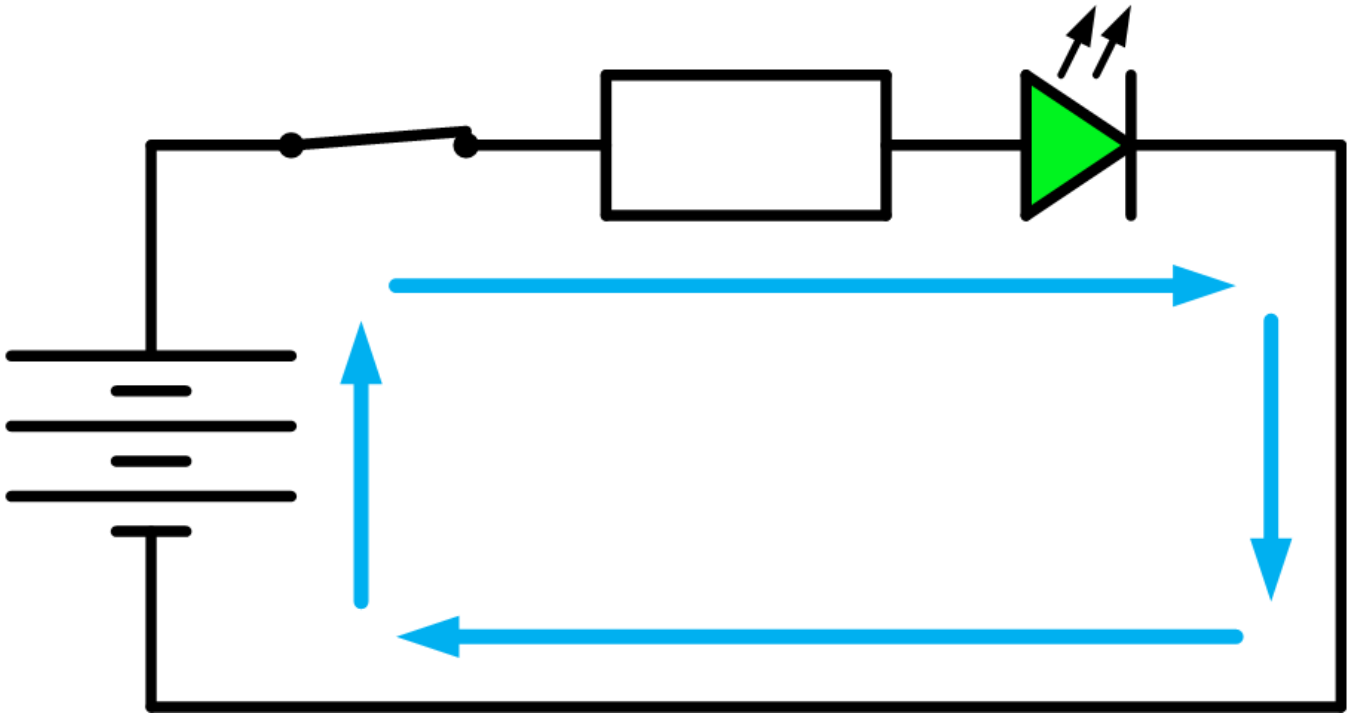
Ground as an equipotential



What happens when we close the switch?



Signal ground current



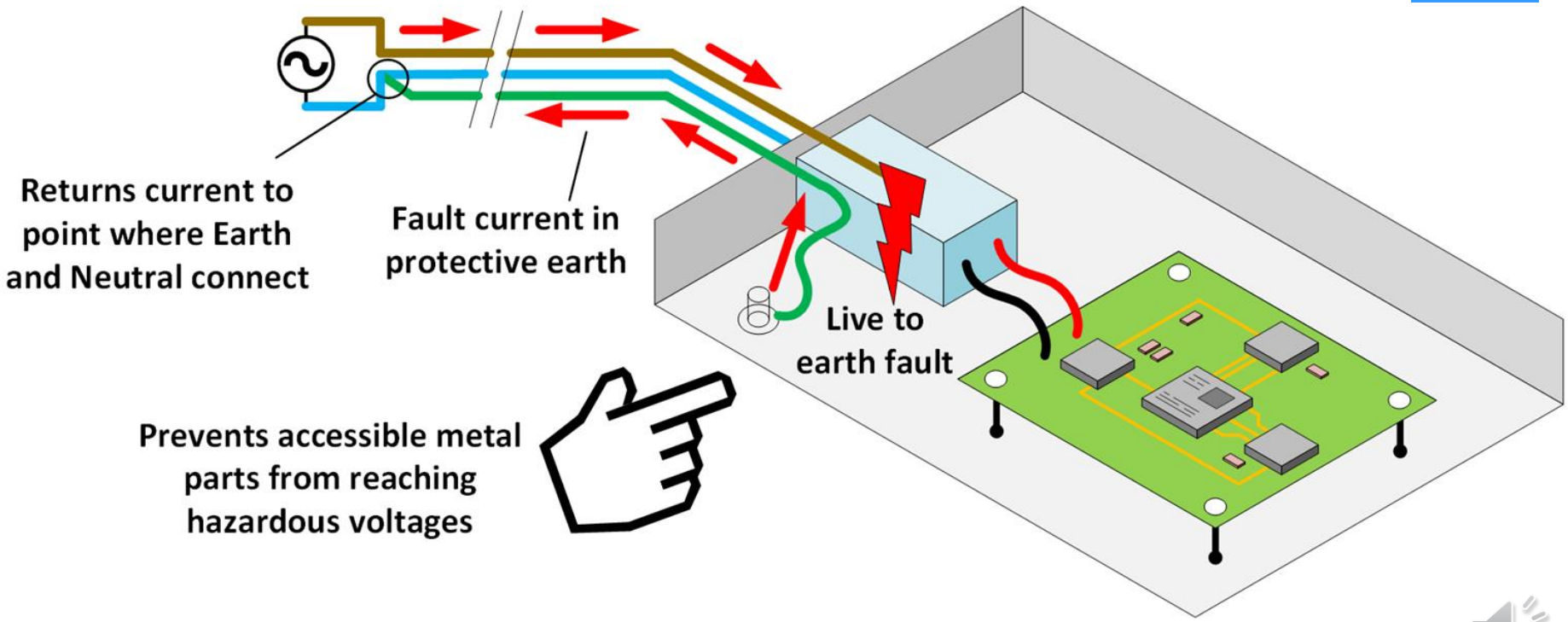
Ground is not a sink

Ground is not a sink

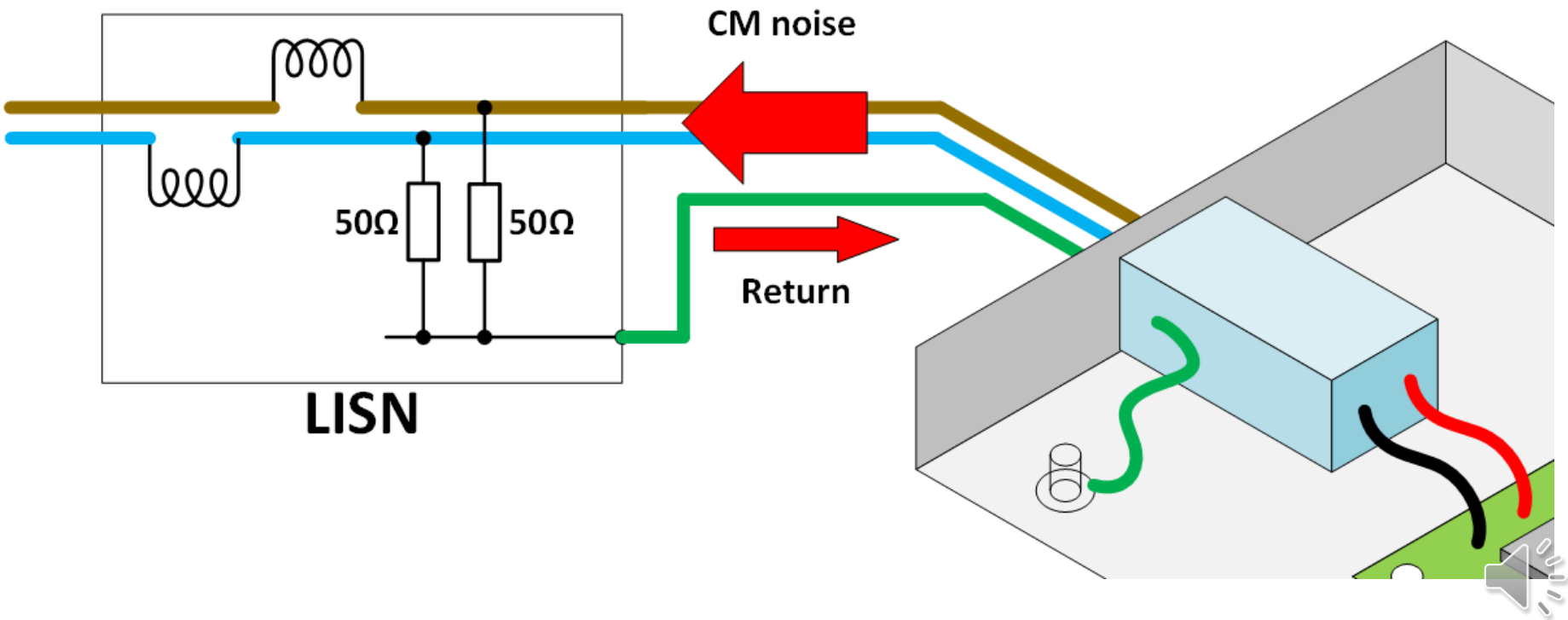
oh hai

we come back

Safety ground current? No.

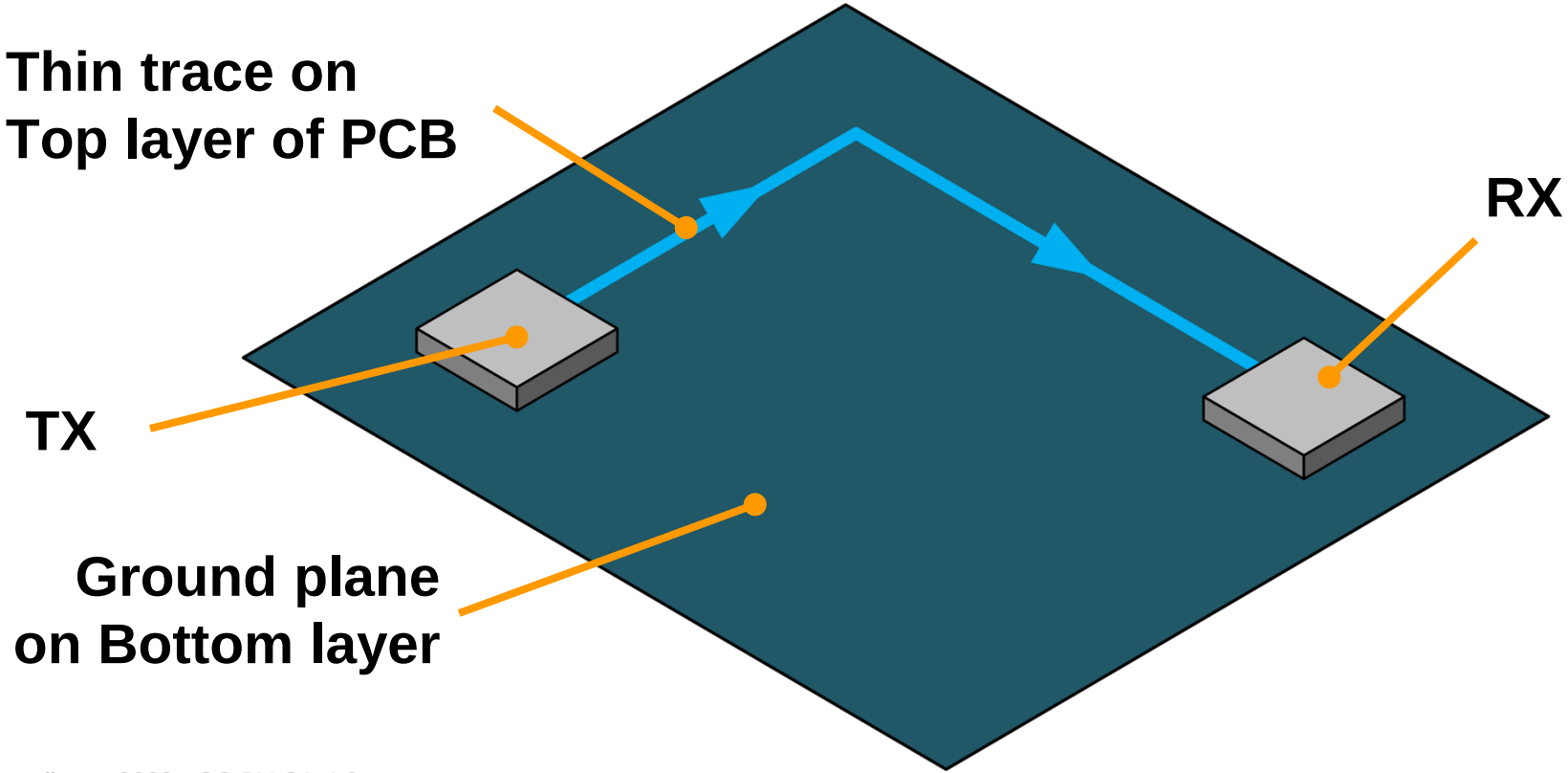


Safety ground current? Yes.

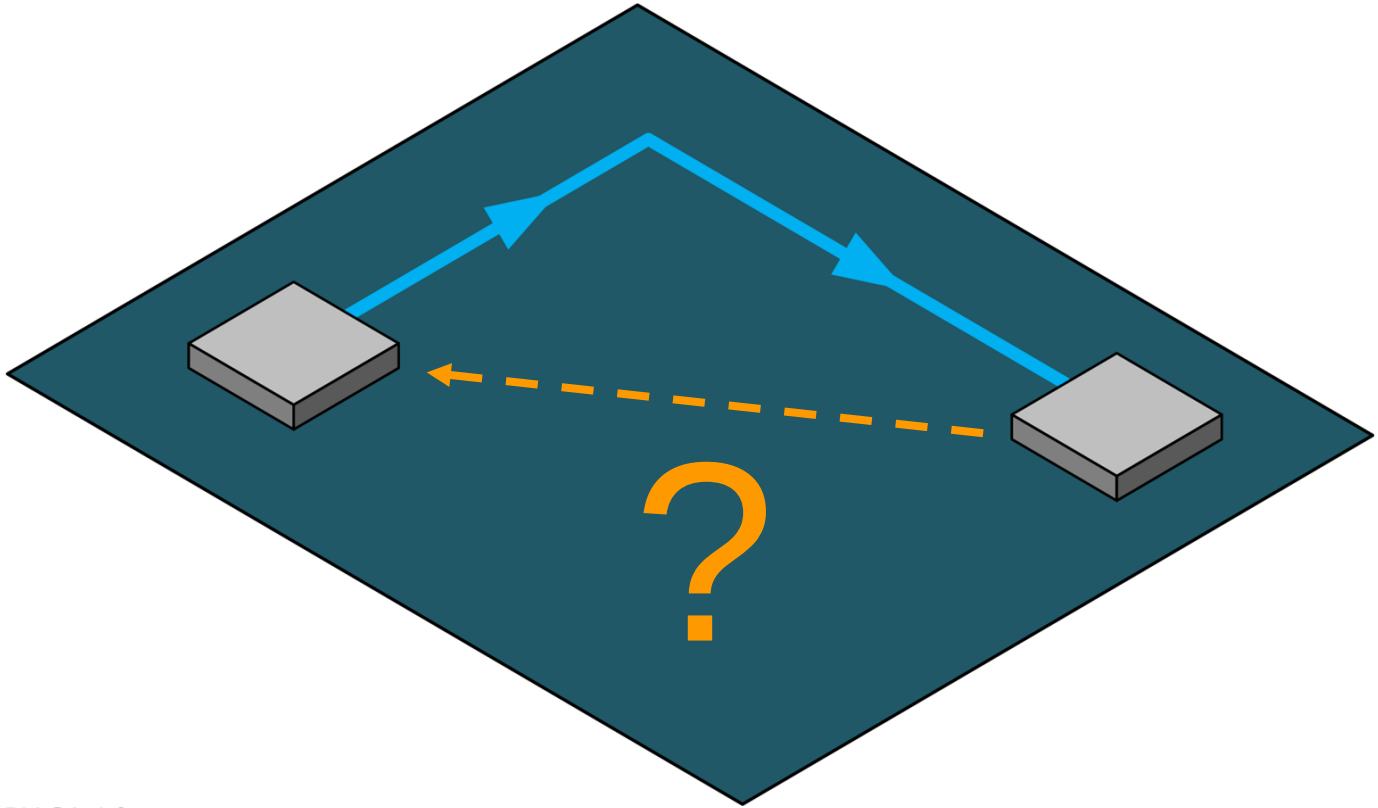


2) What is the frequency of this current?

Current Flow Example

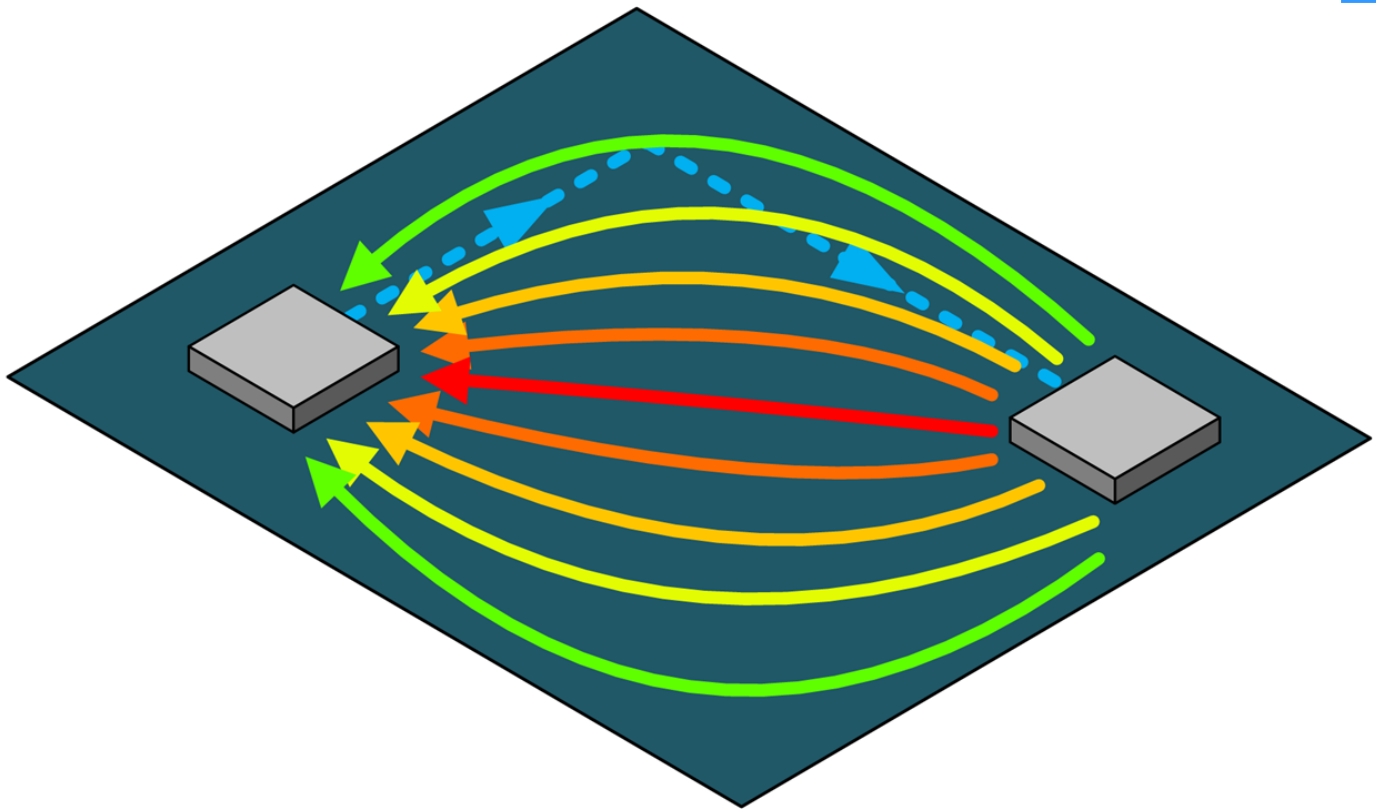


Current Flow Example



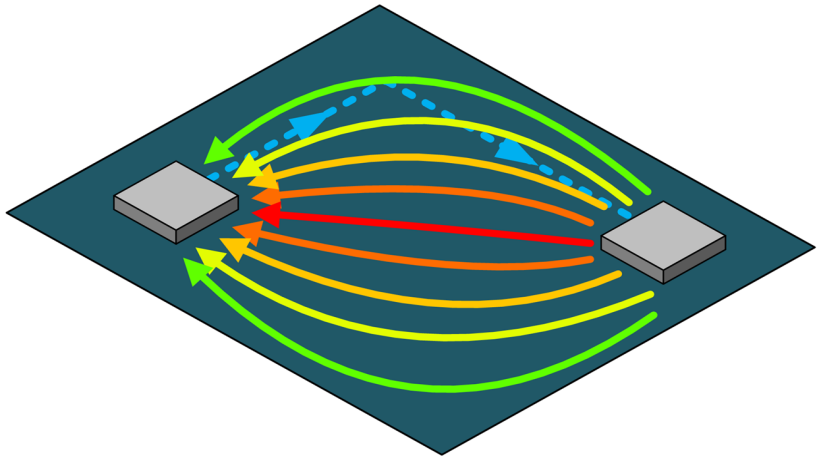
DC Current Flow

DC



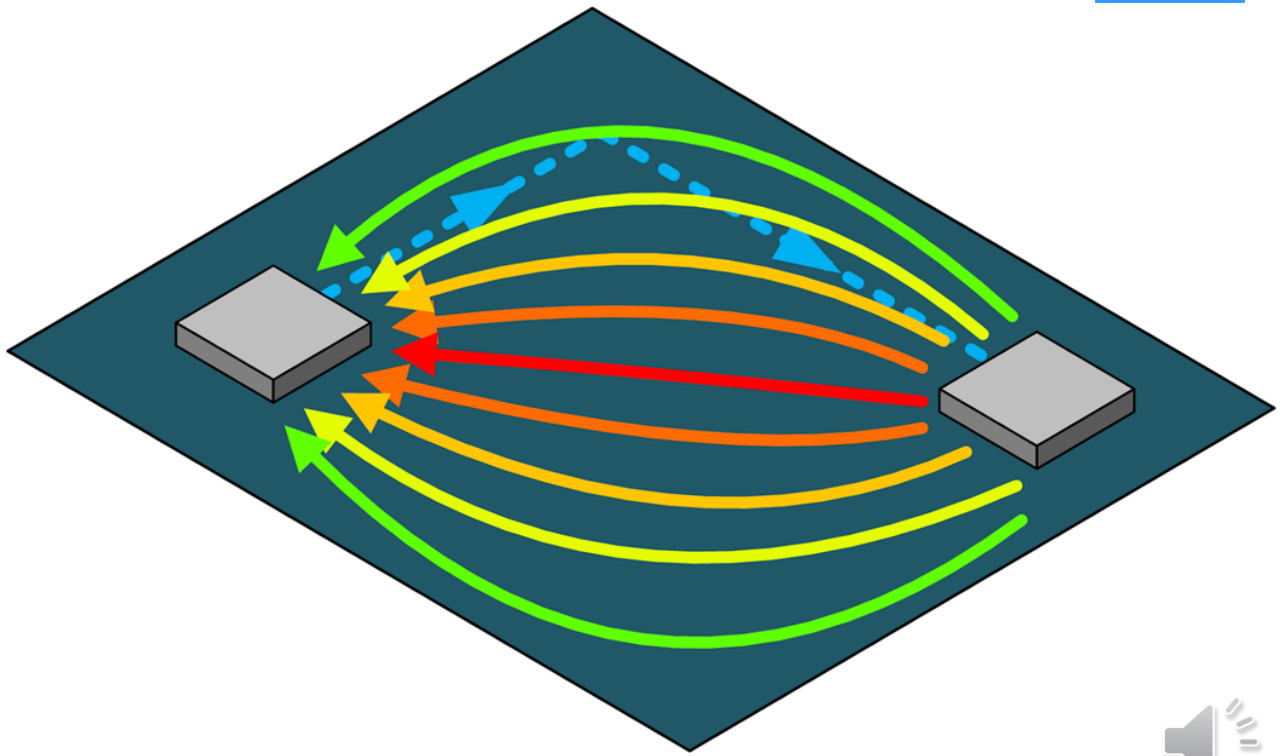
$$R = (\rho \ell) / xsa$$

DC



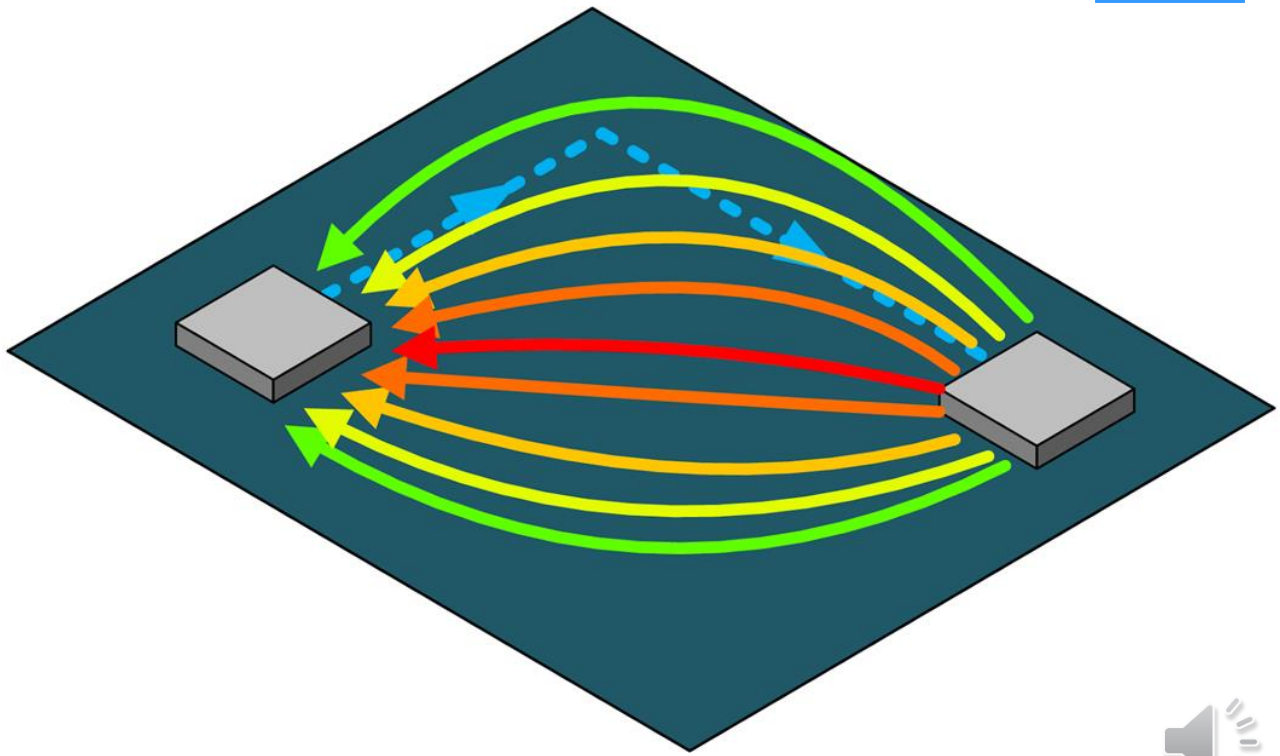
High Frequency Current Flow

50 Hz



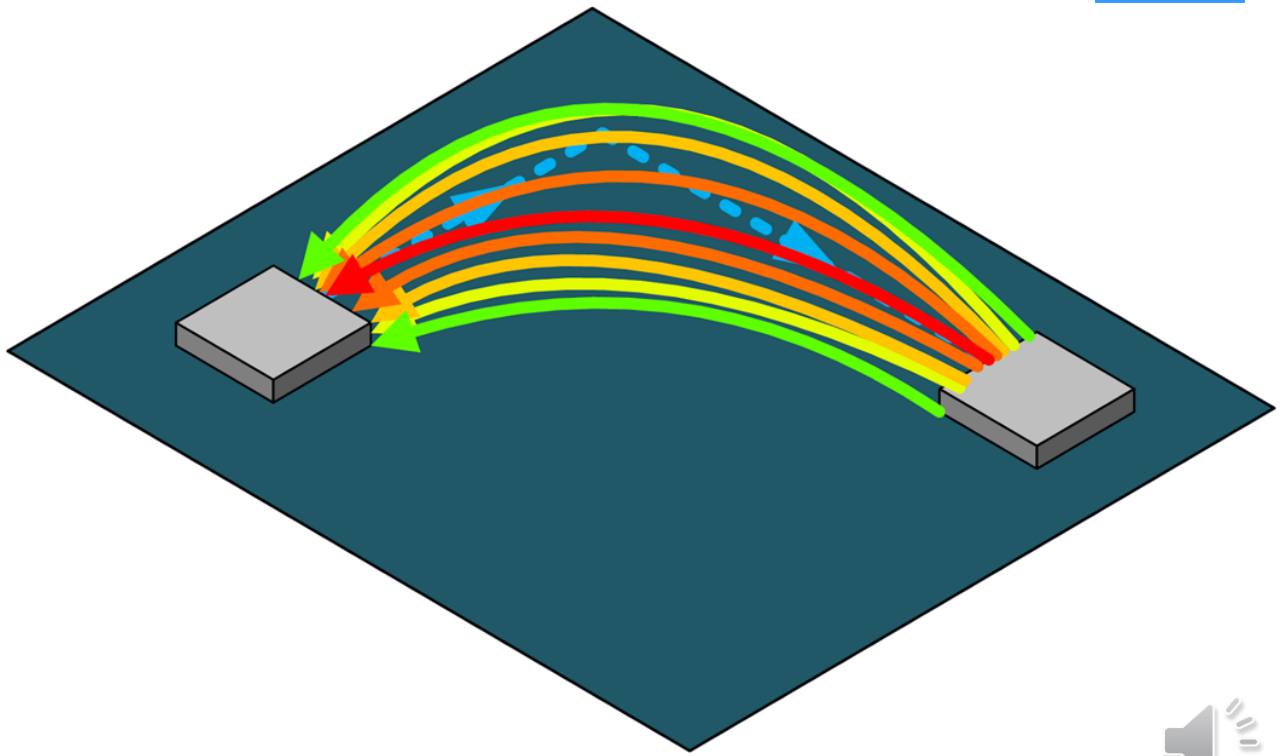
High Frequency Current Flow

500 Hz



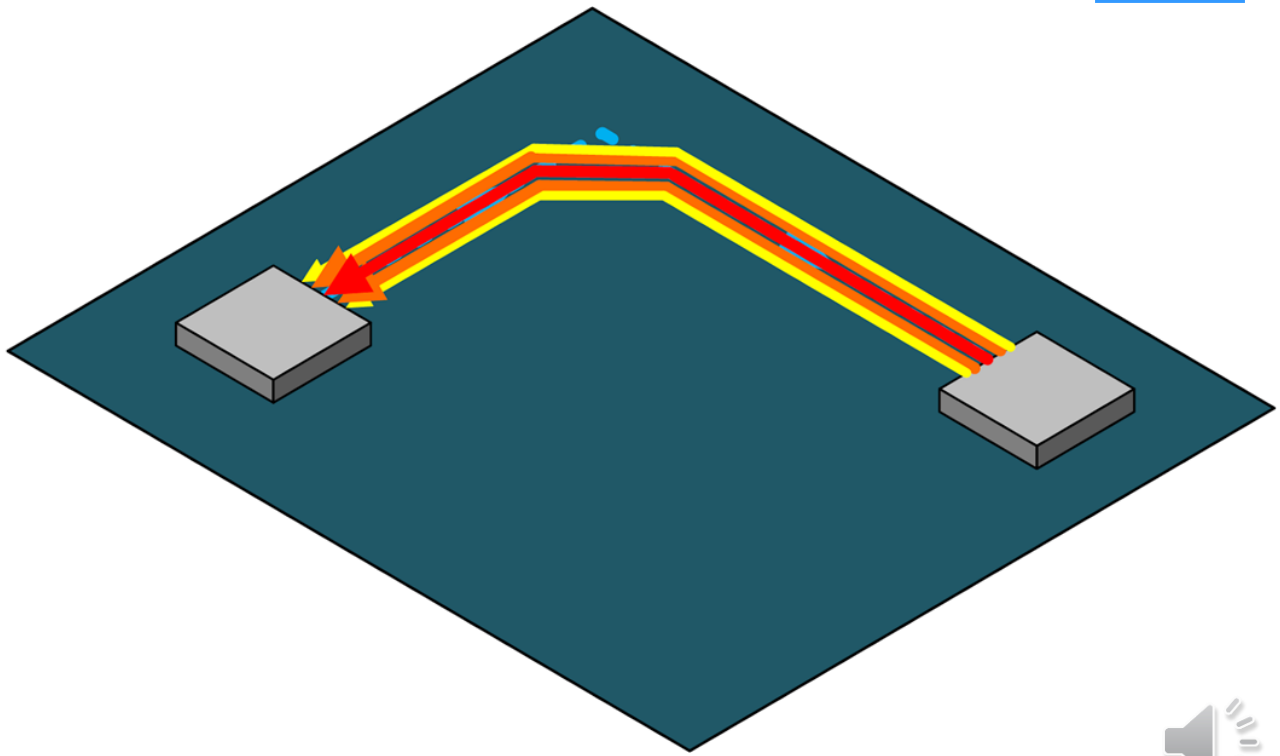
High Frequency Current Flow

5 kHz



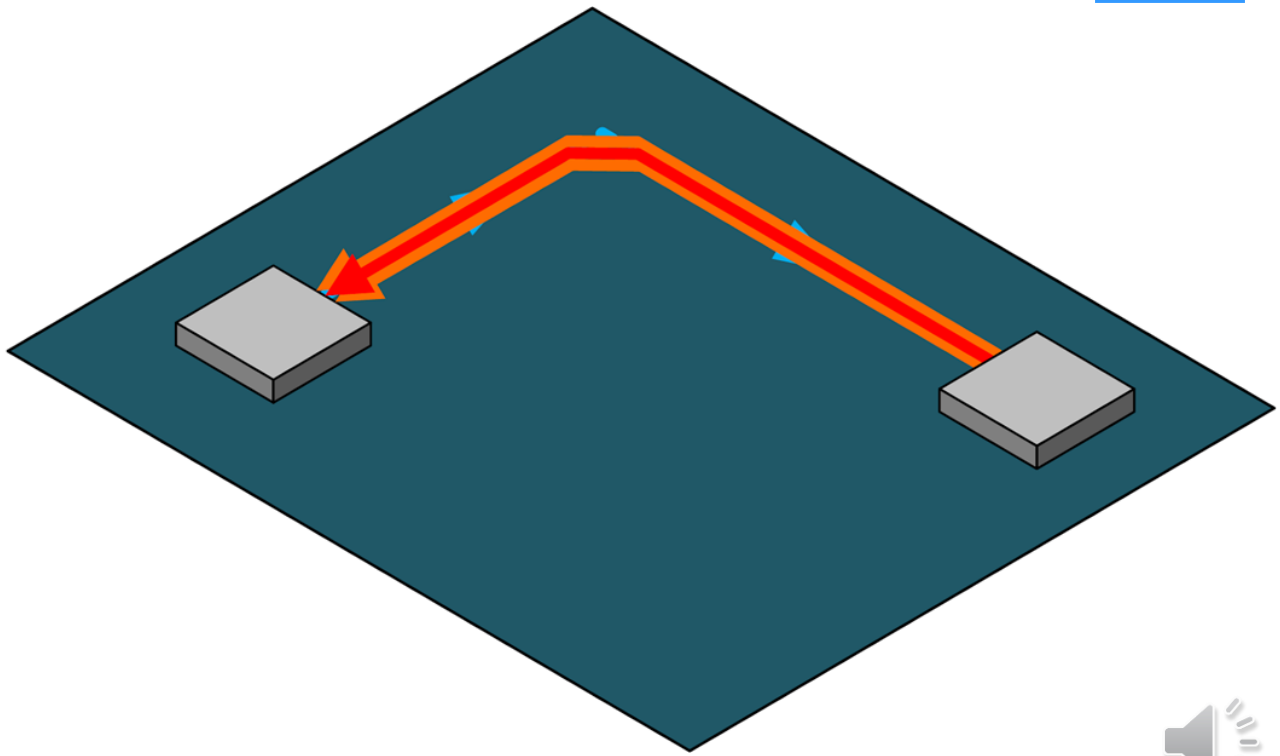
High Frequency Current Flow

50 kHz



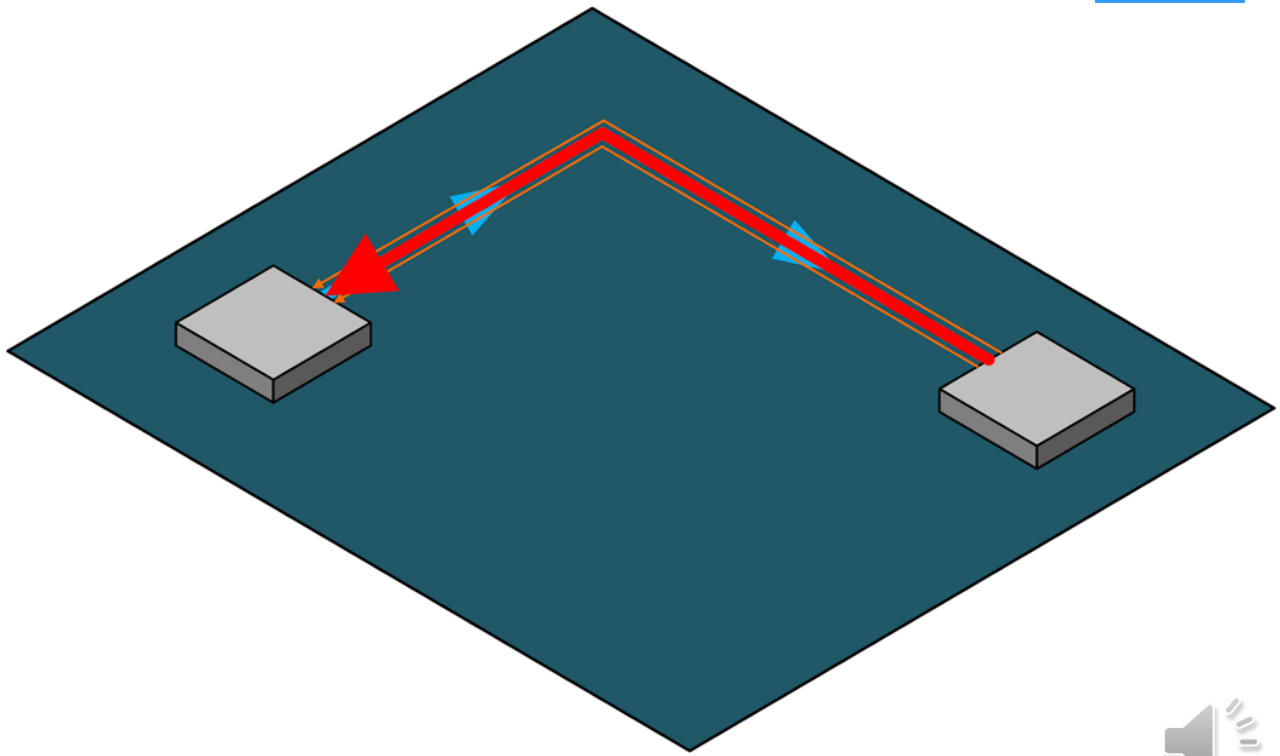
High Frequency Current Flow

500 kHz



High Frequency Current Flow

5 MHz



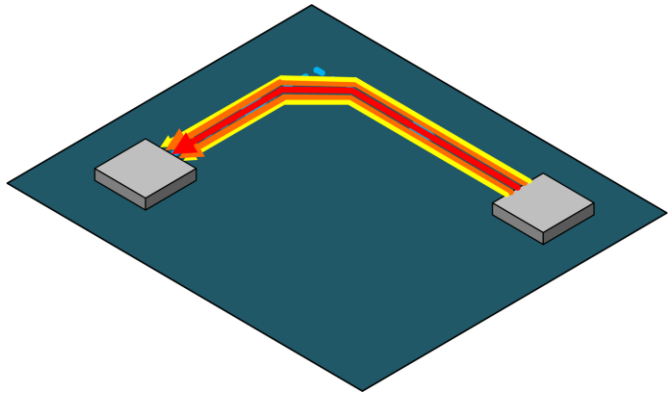
$$R = (\rho \ell) / xsa$$

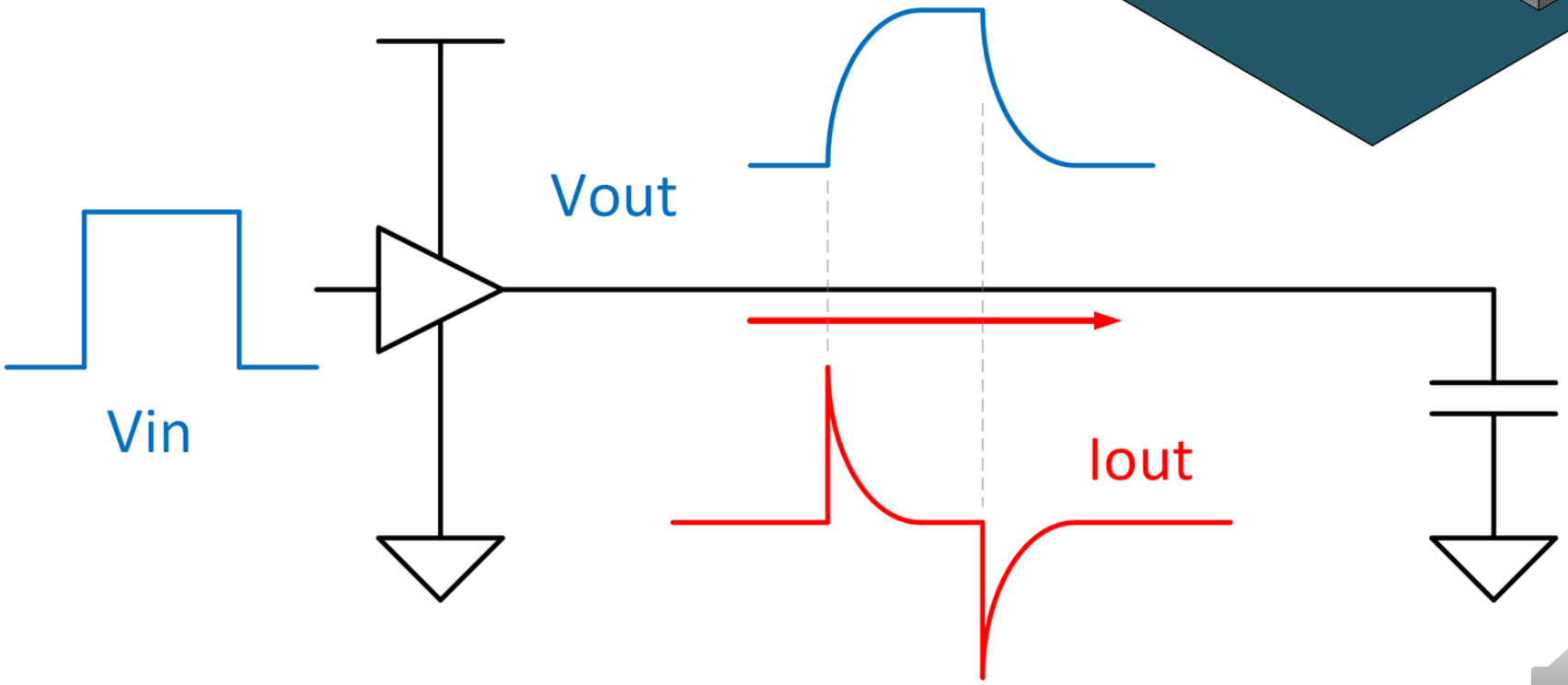
~~$R = (\rho \ell) / xsa$~~

$$\text{Impedance, } Z_L = 2 \pi f L$$

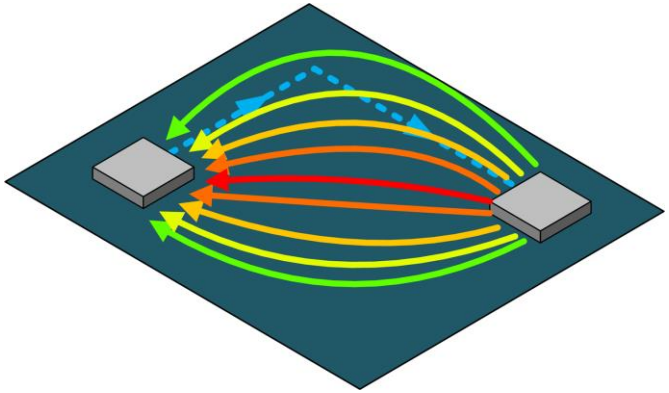
$$L = (\mu N^2 A) / \ell$$

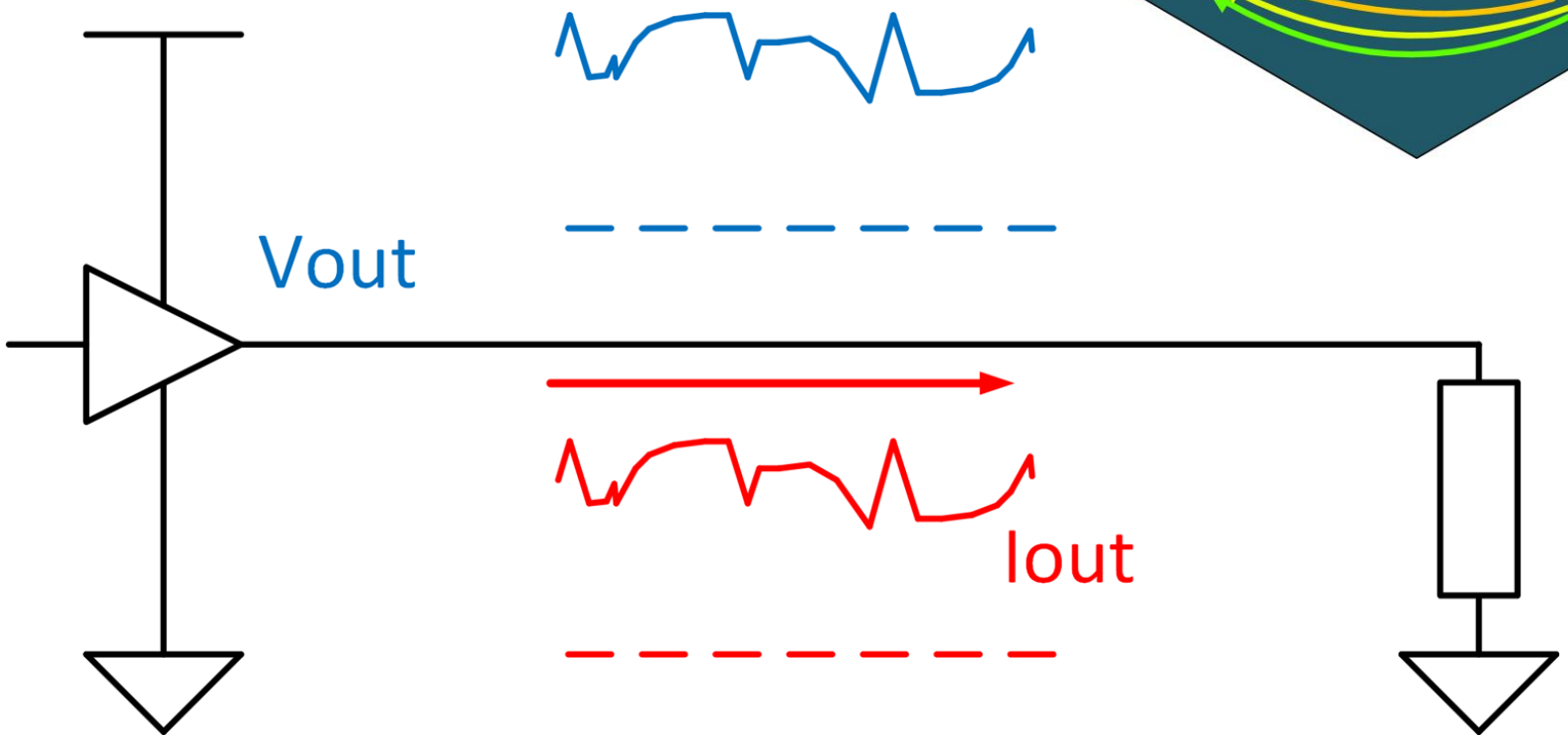
Digital Logic Current





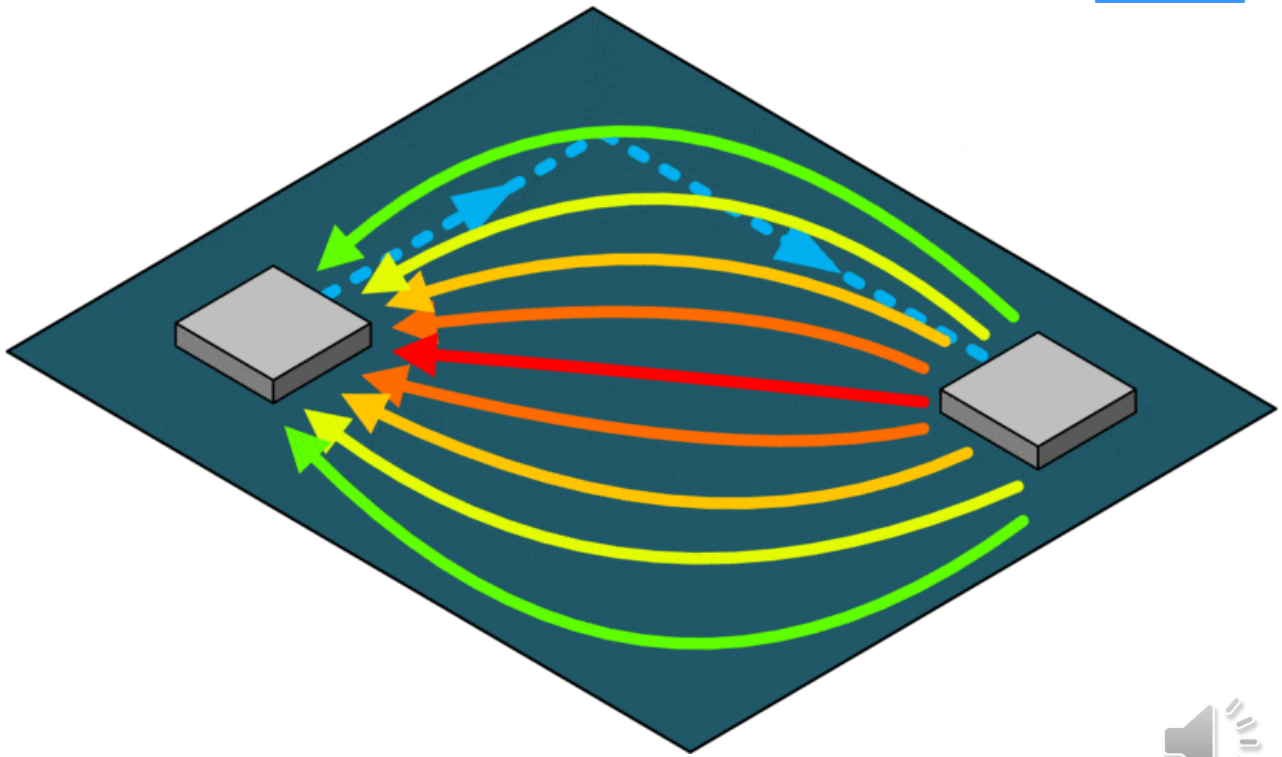
Analogue Power Current





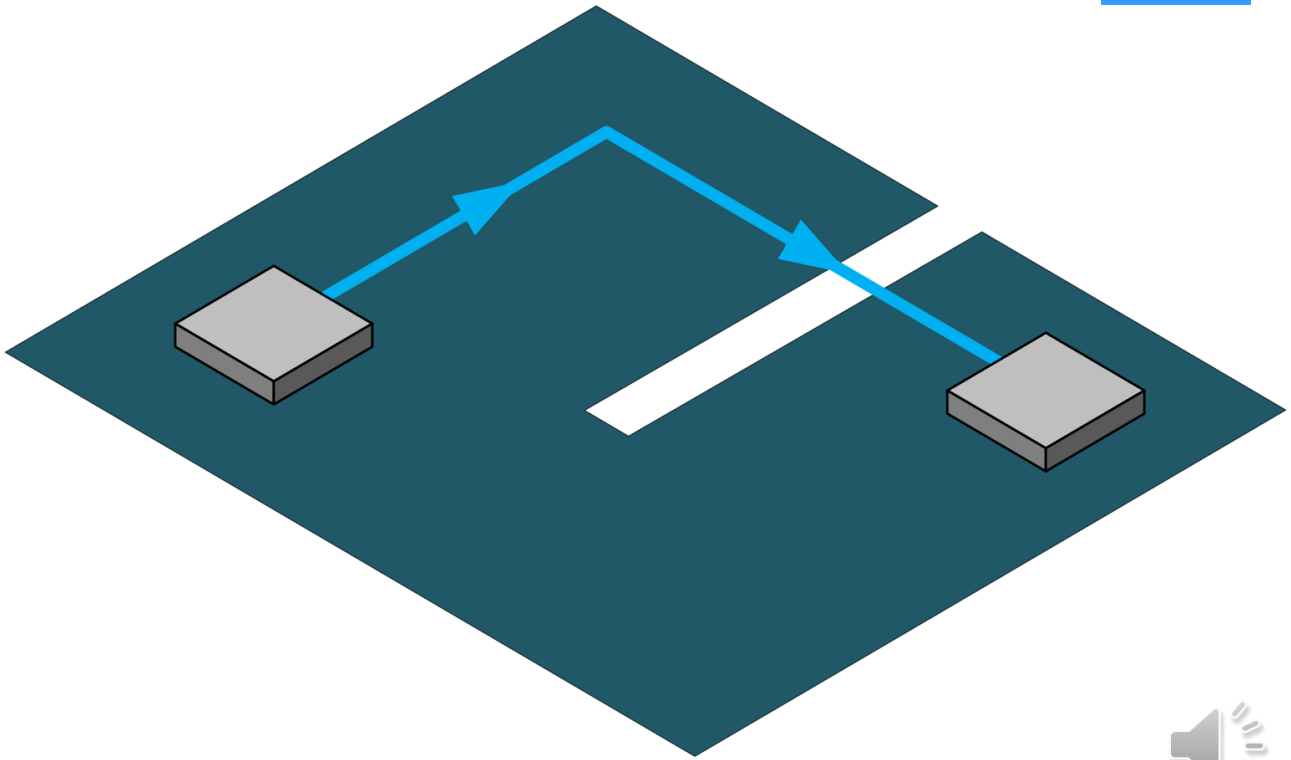
High frequency current flow

DC



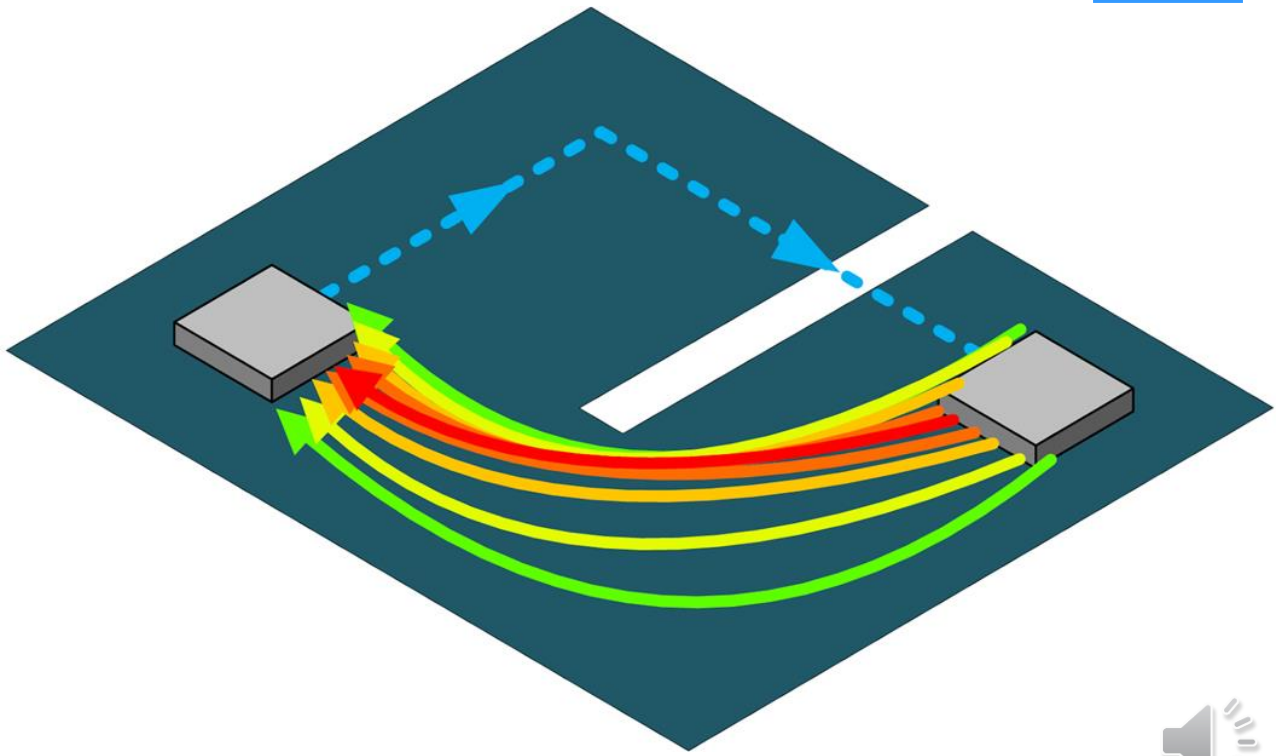
So what?

Implications of non ideal ground?



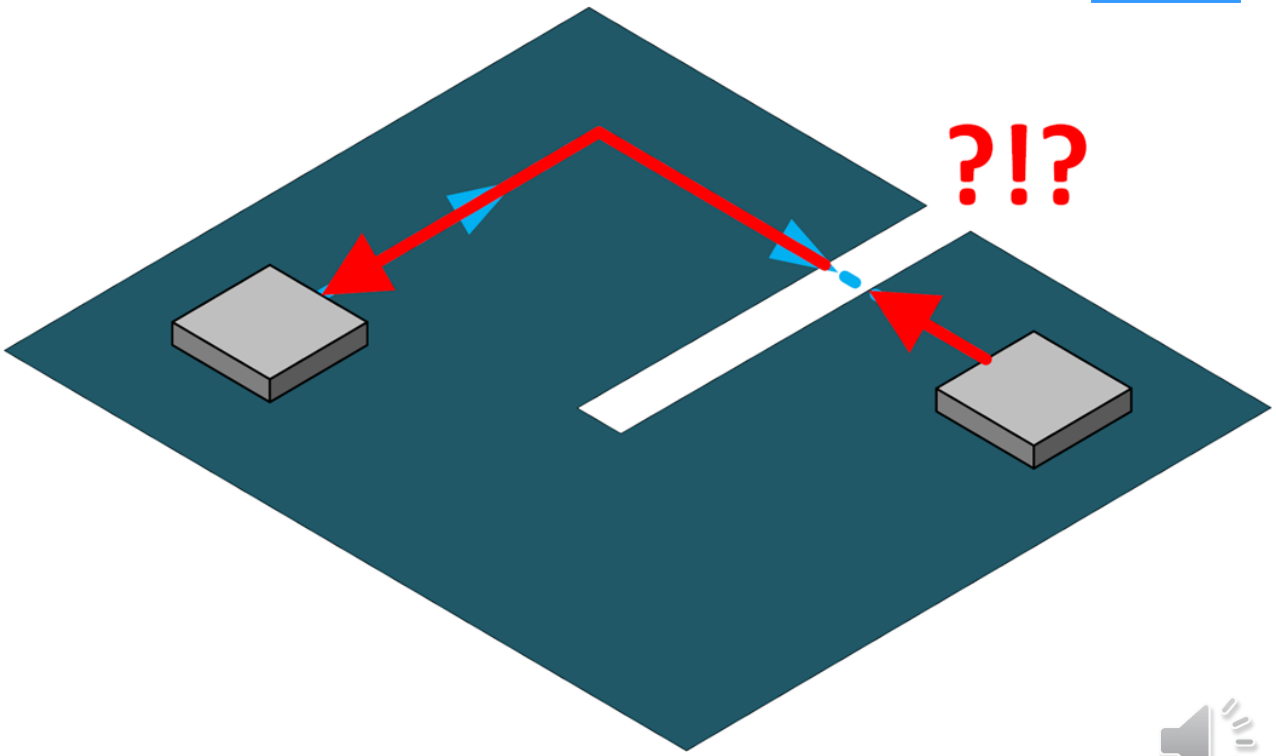
Implications of non ideal ground?

DC

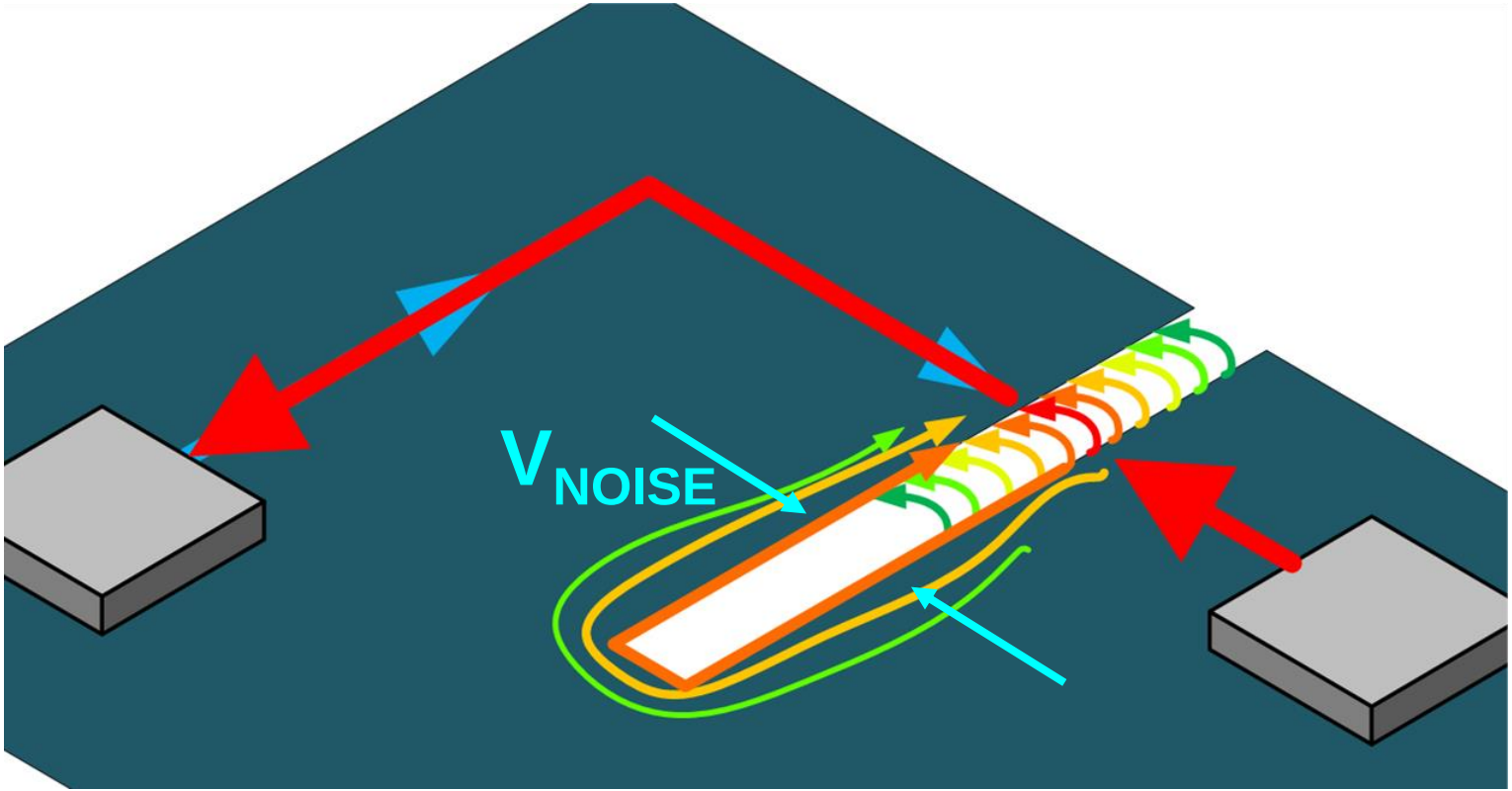


Implications of non ideal ground?

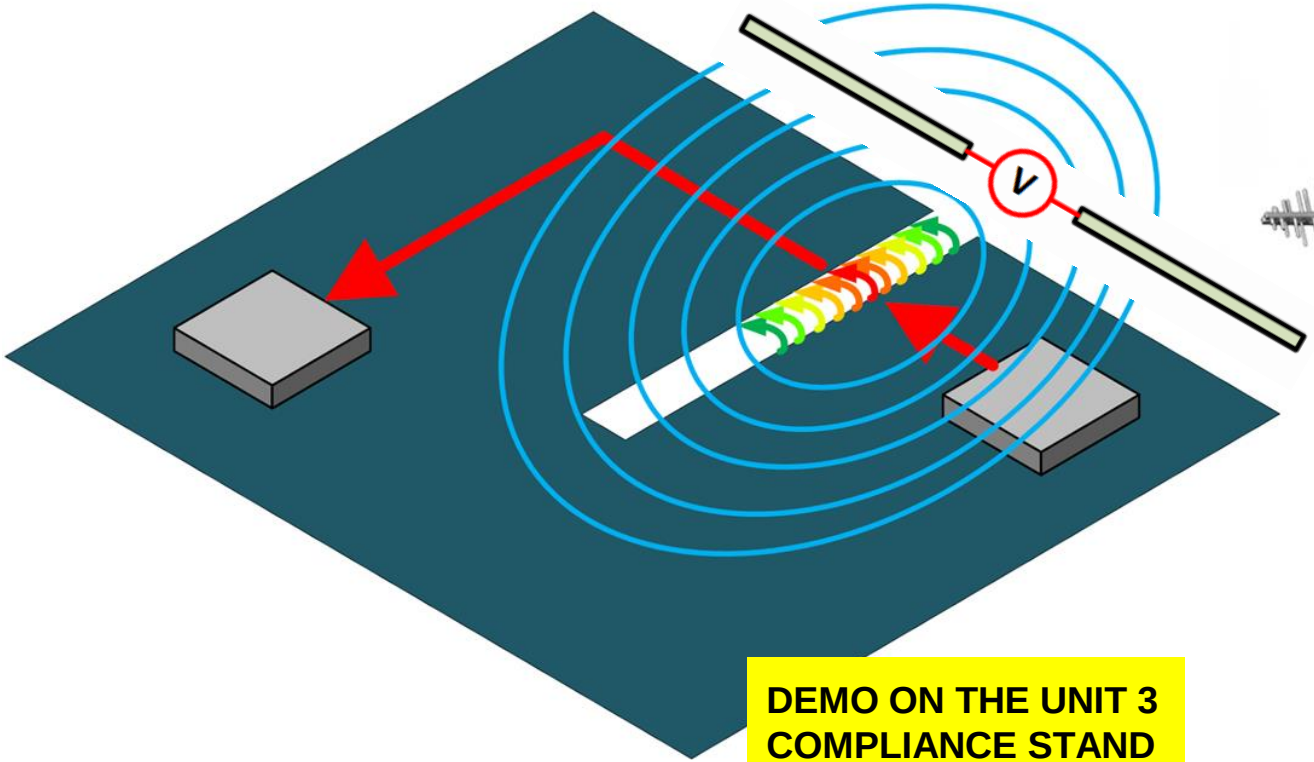
5 MHz

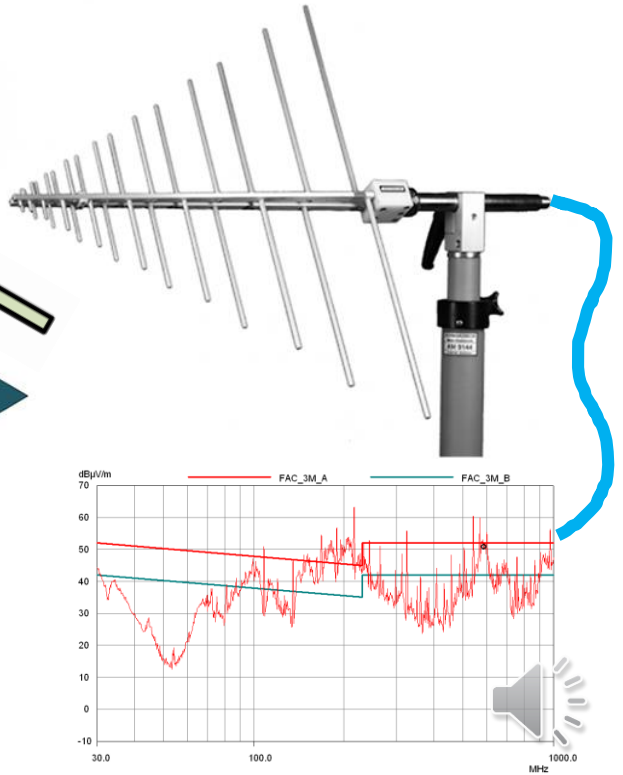


Implications of non ideal ground?



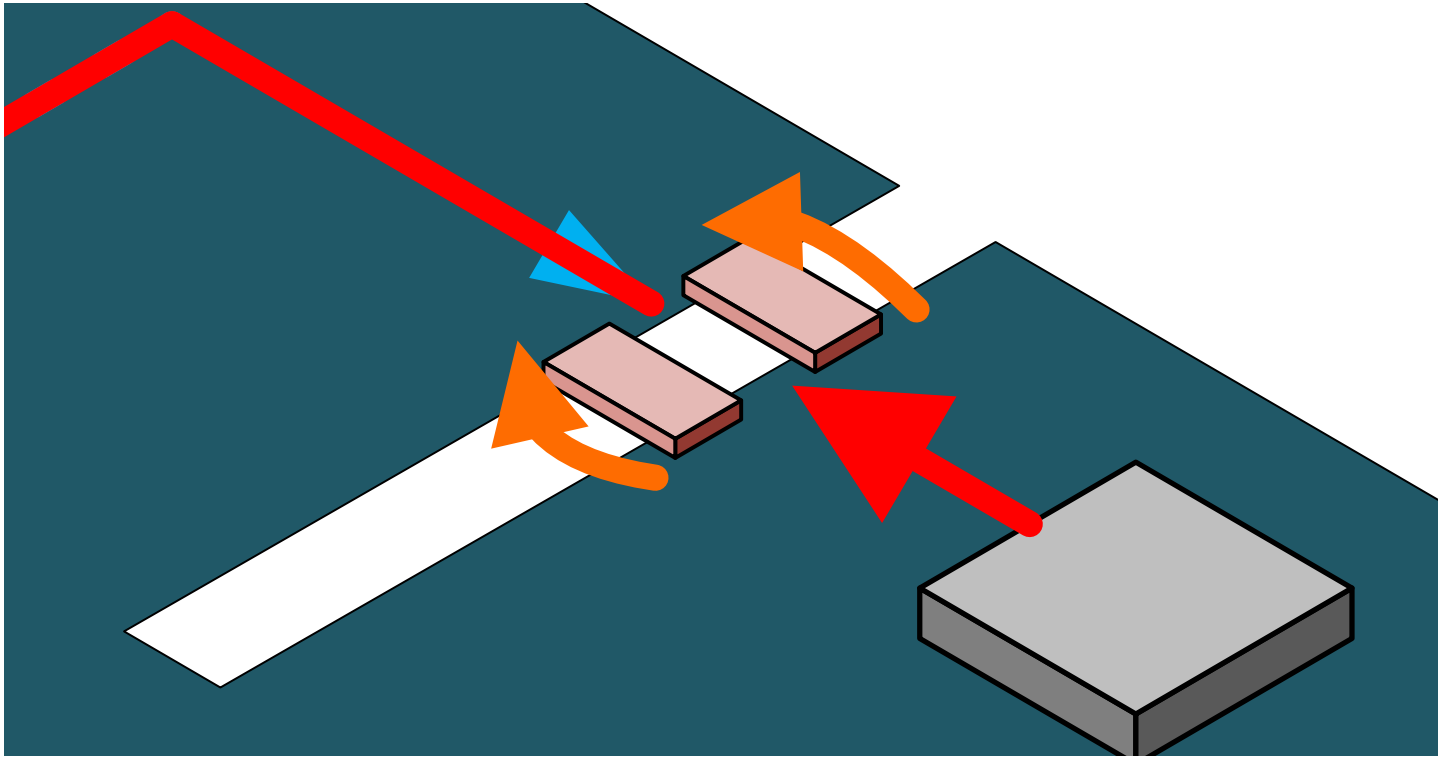
Implications of non ideal ground?



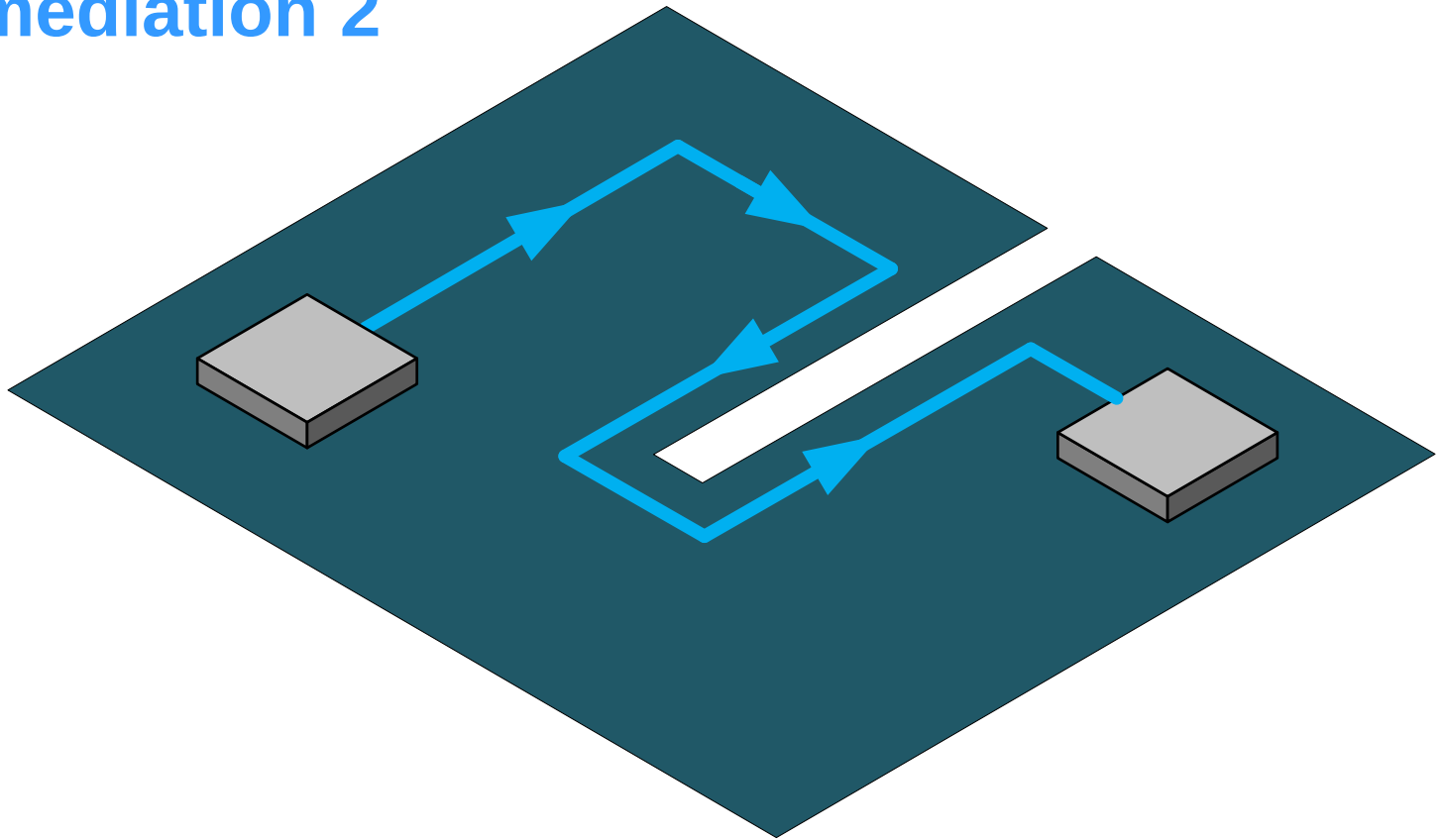


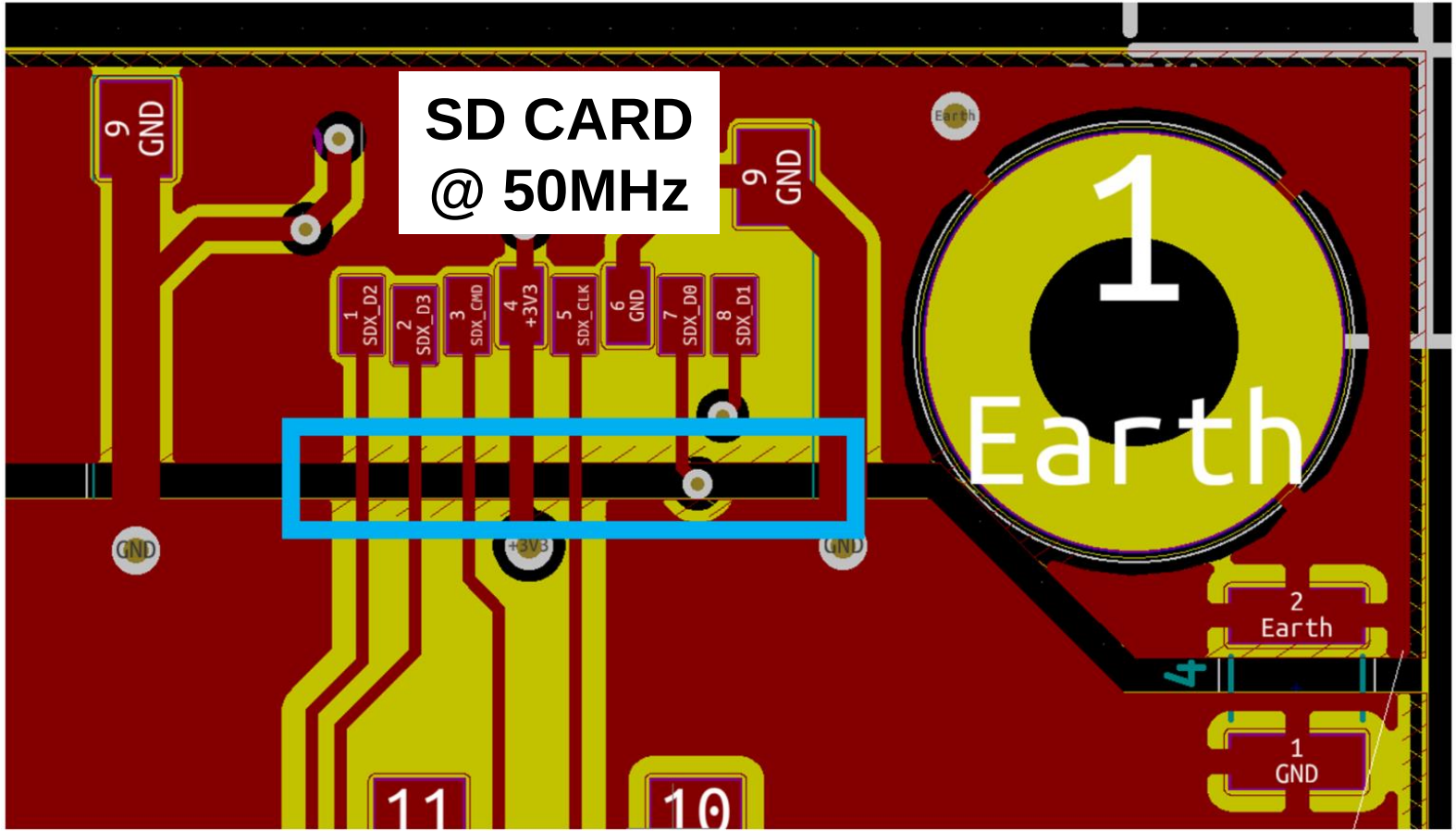
DEMO ON THE UNIT 3 COMPLIANCE STAND

Remediation 1

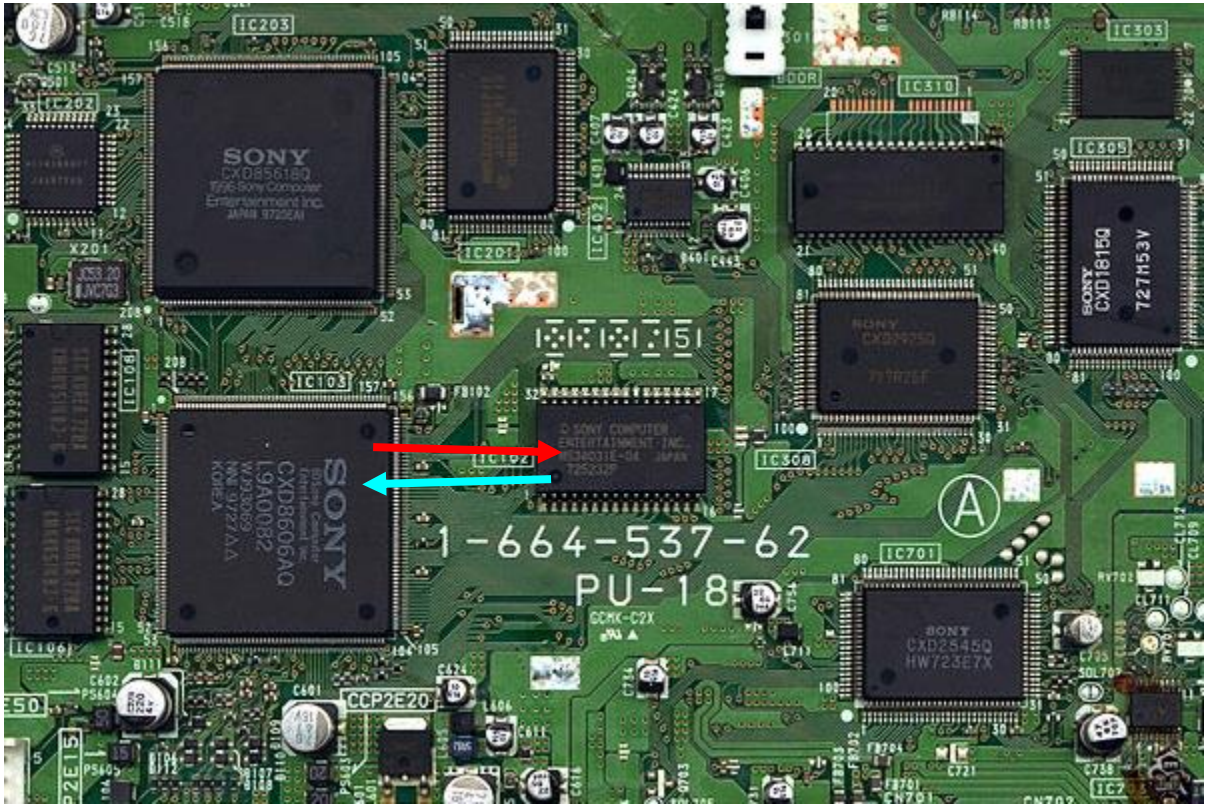


Remediation 2

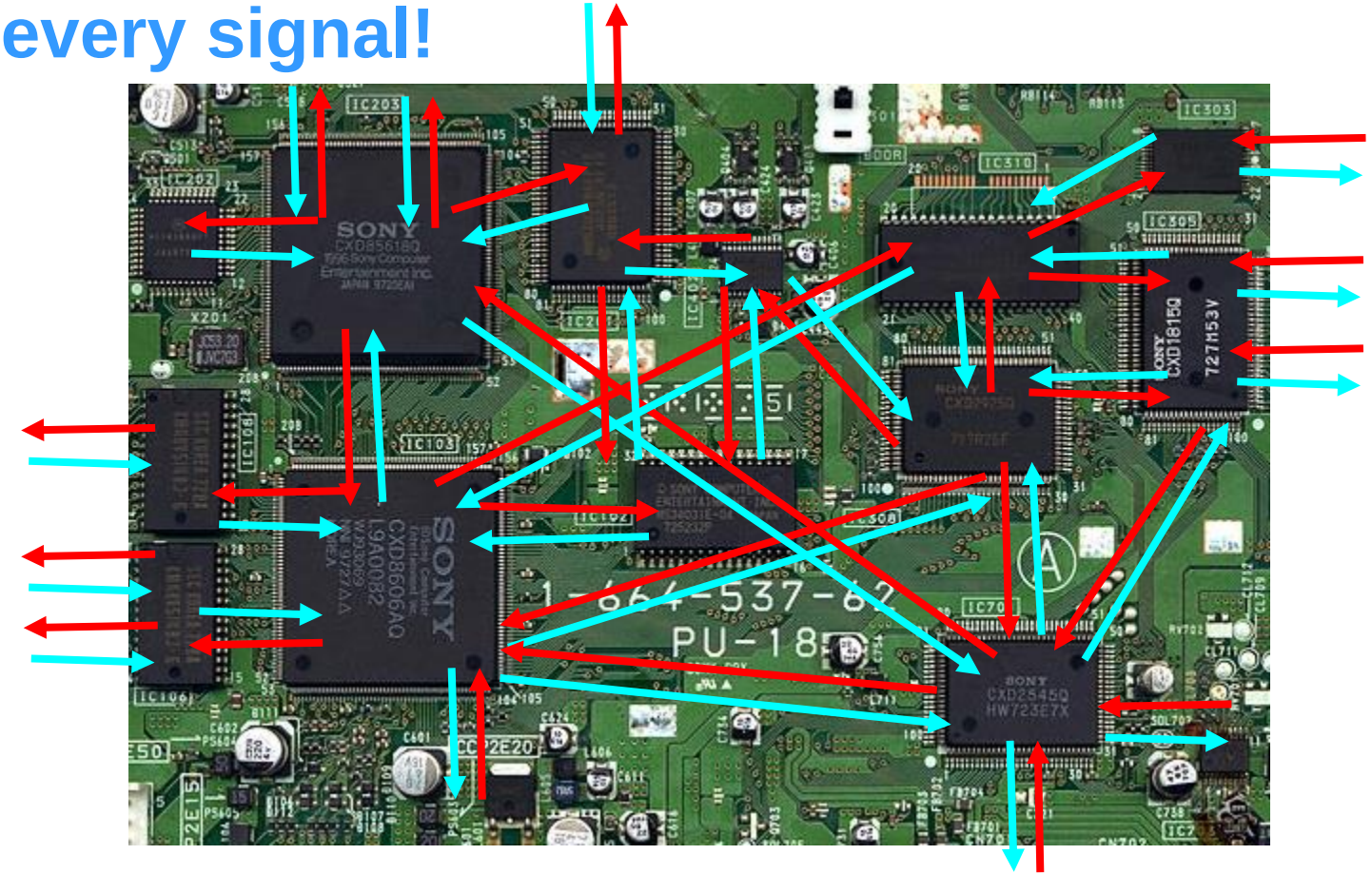


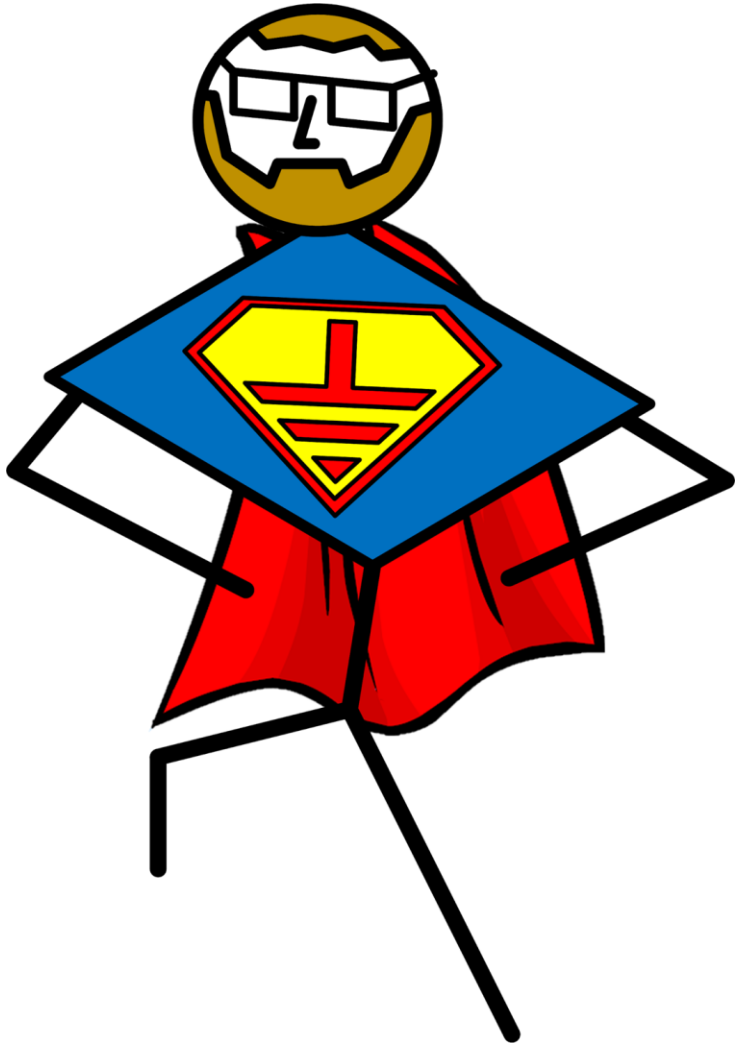


A good return for every signal



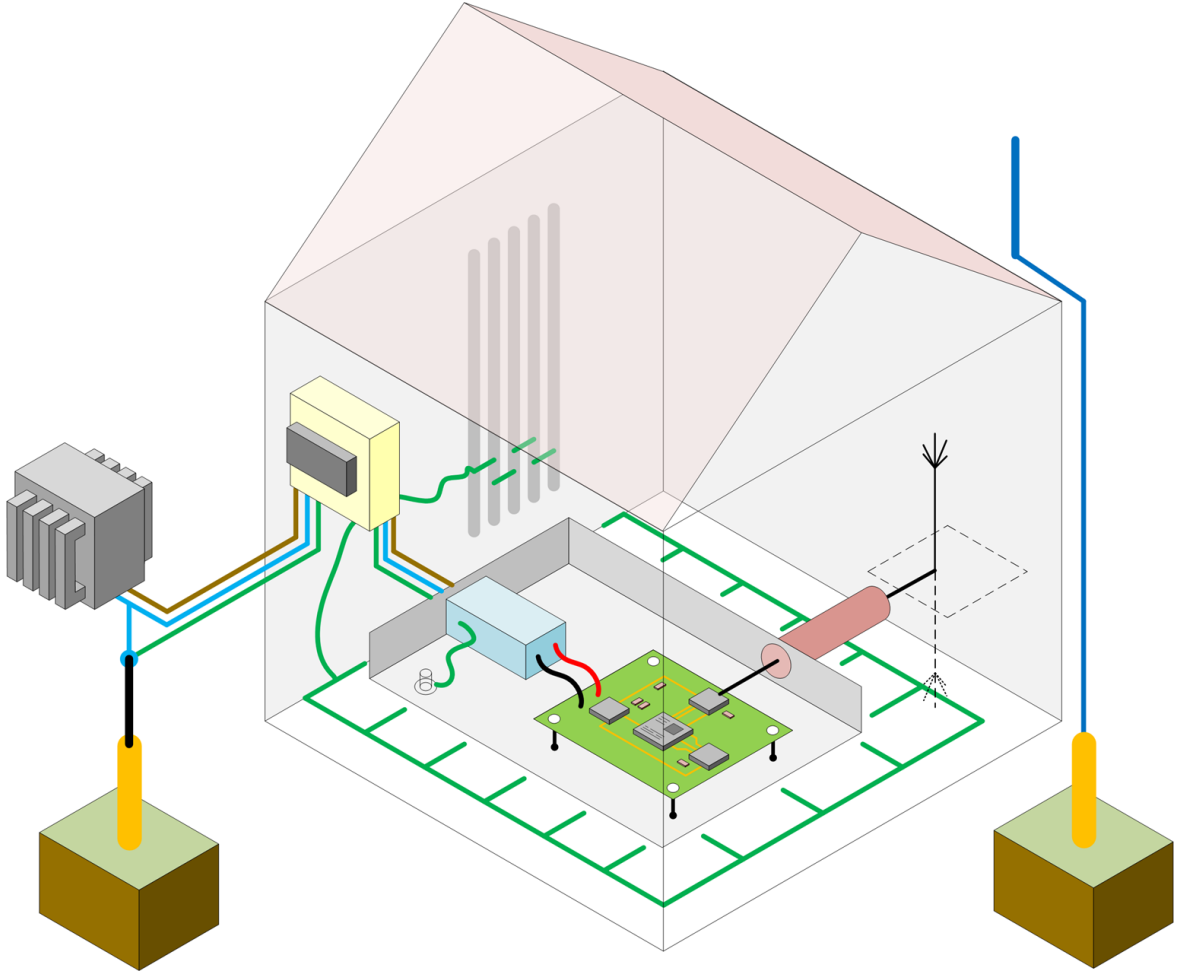
For every signal!





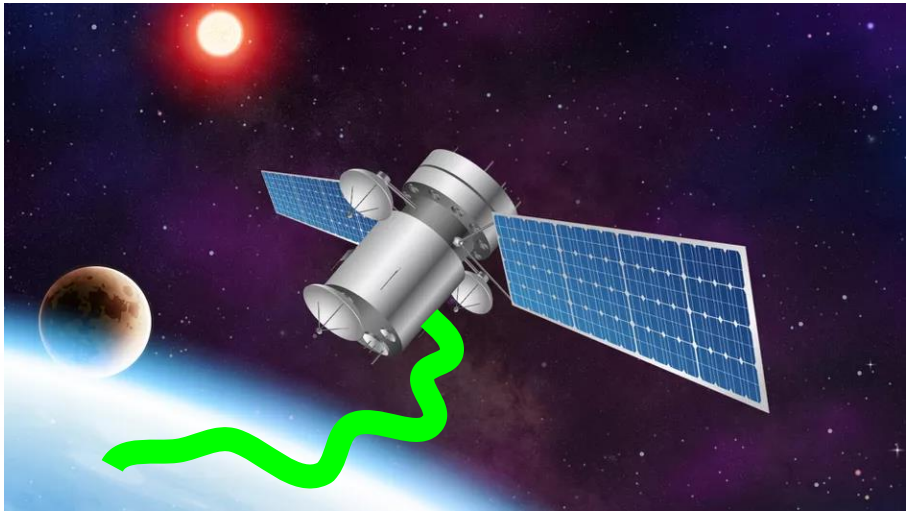
Time to bust some EMC myths

“Could we just connect it to a quiet ground / to earth to see what happens?”



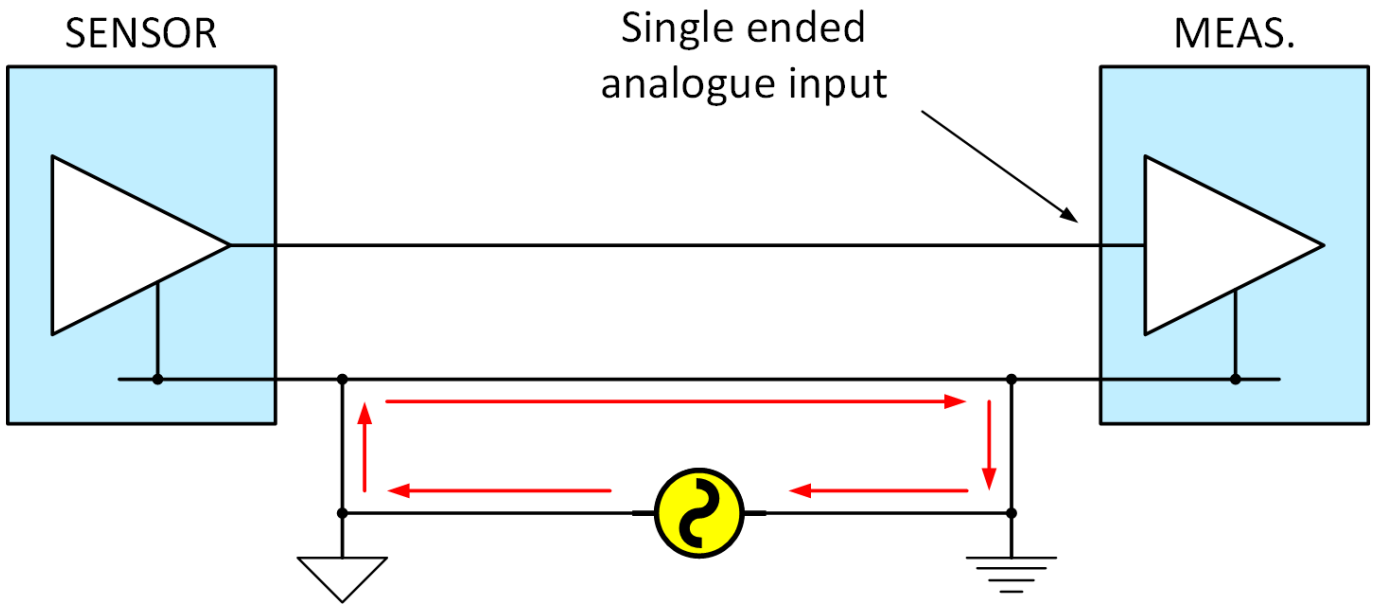
Where is this “quiet” ground?

Where is this “quiet” ground?

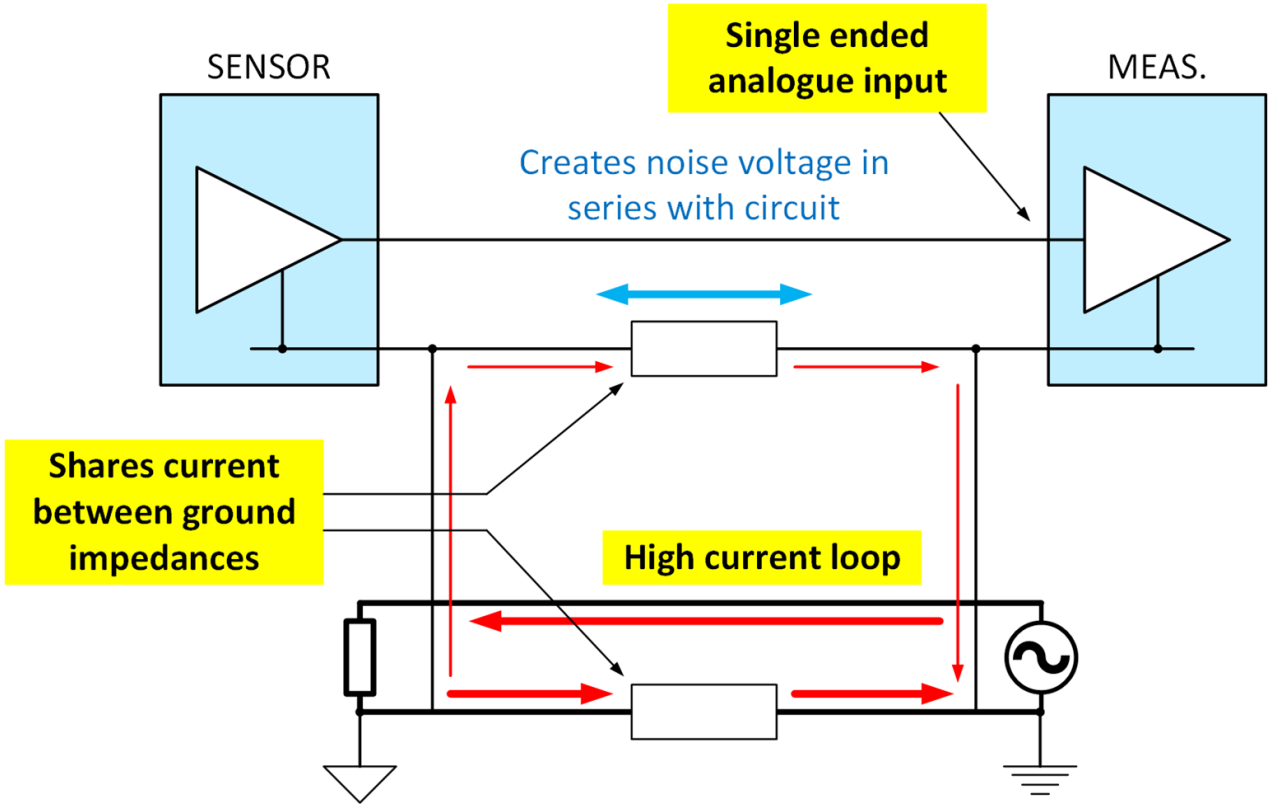


“I’m trying to avoid creating a ground loop”

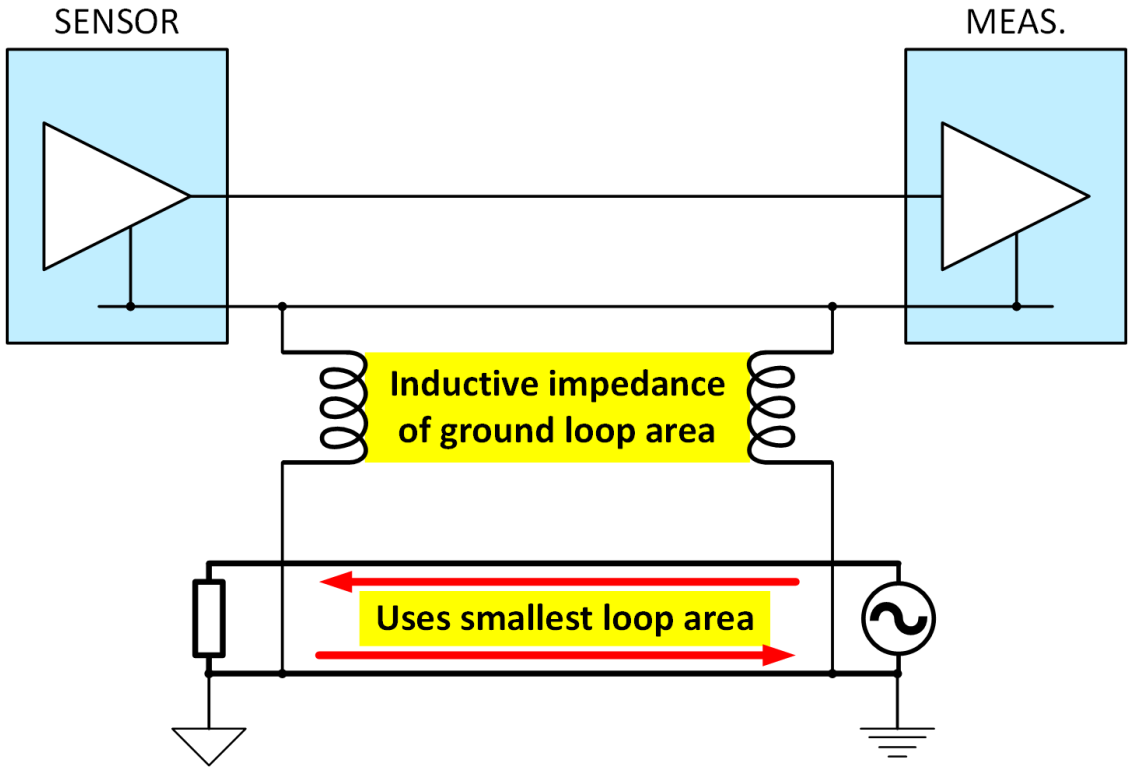
Ground Loop



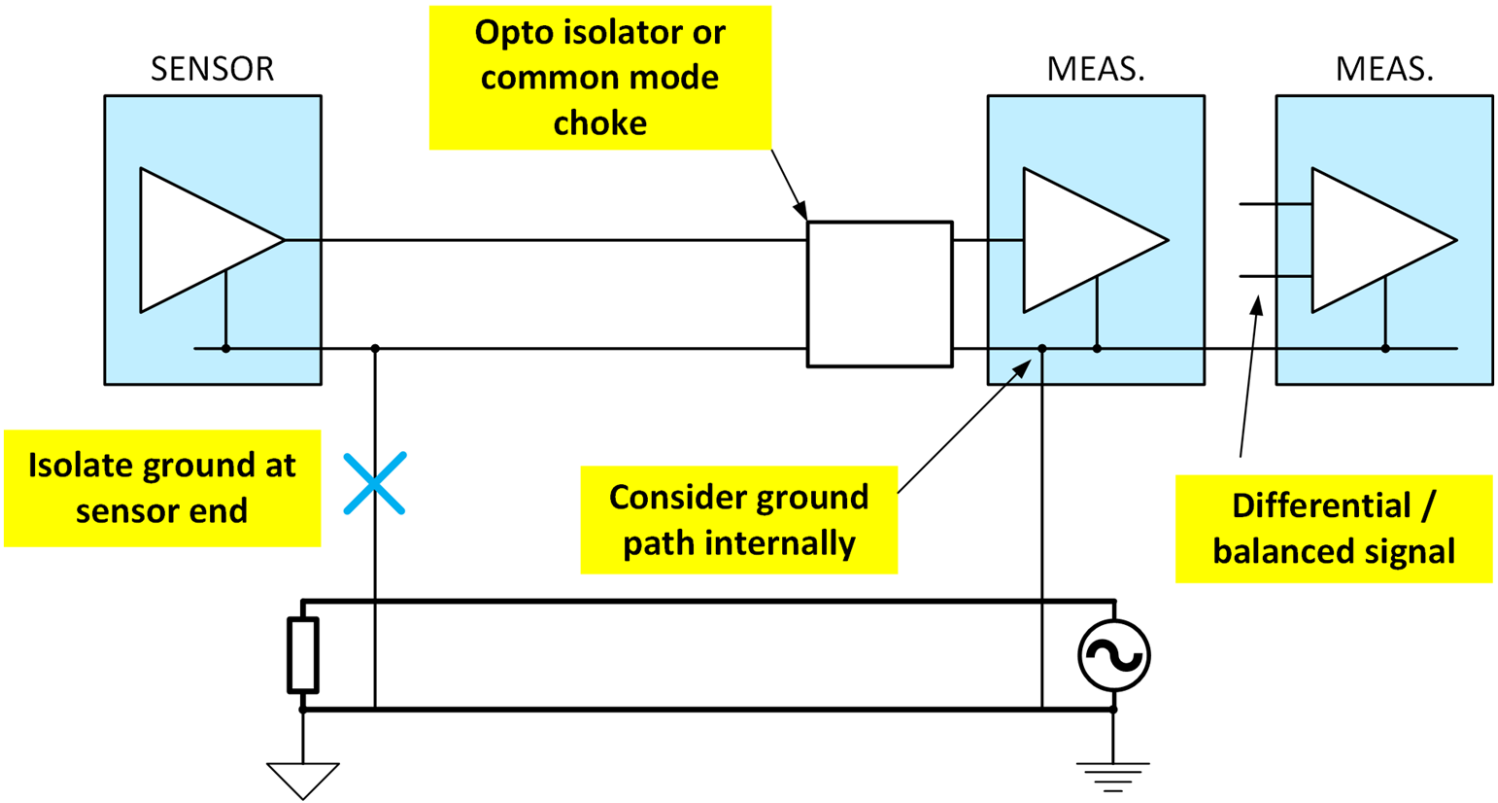
Typical LF Ground Loop



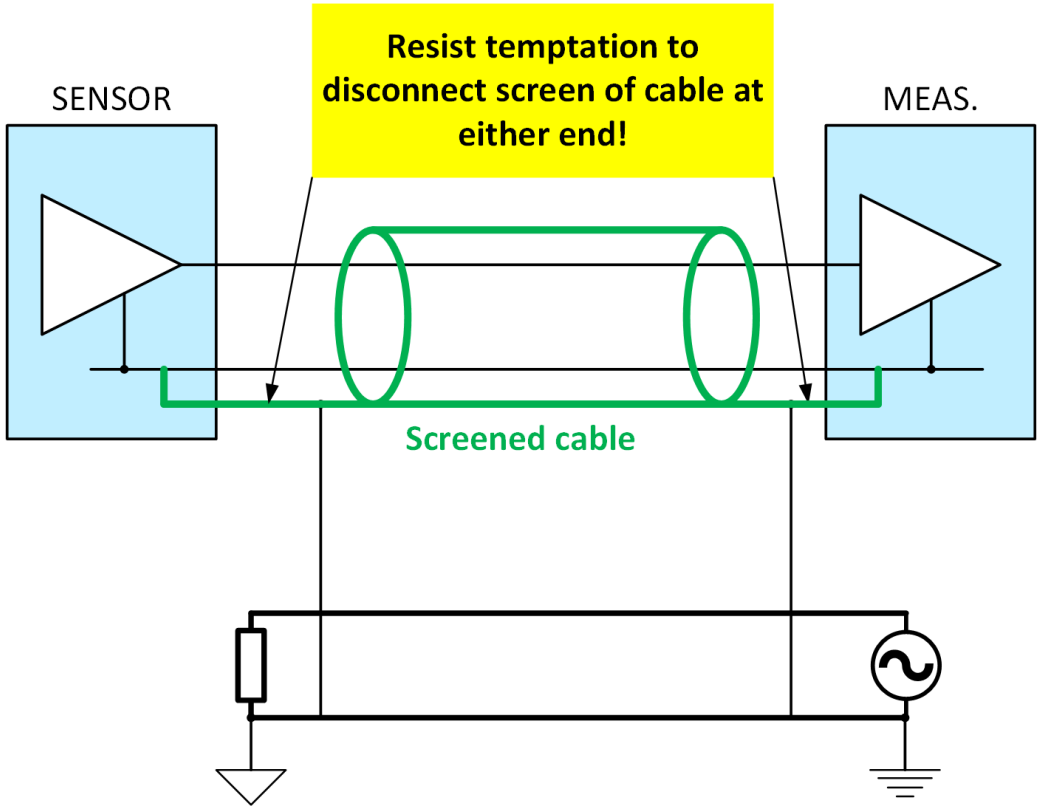
HF Ground Loop = Insignificant



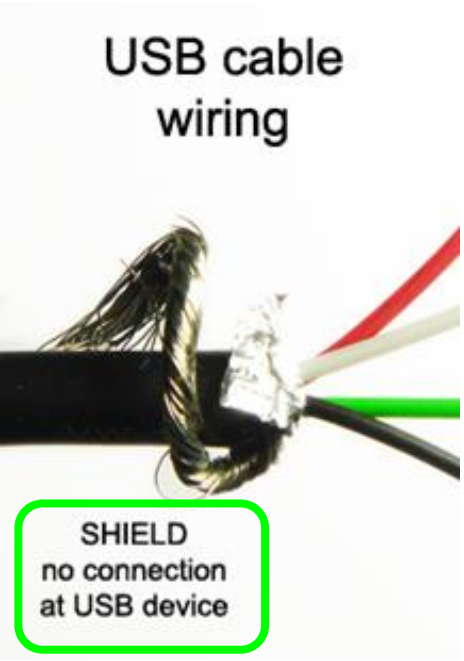
Fixing LF Ground Loops

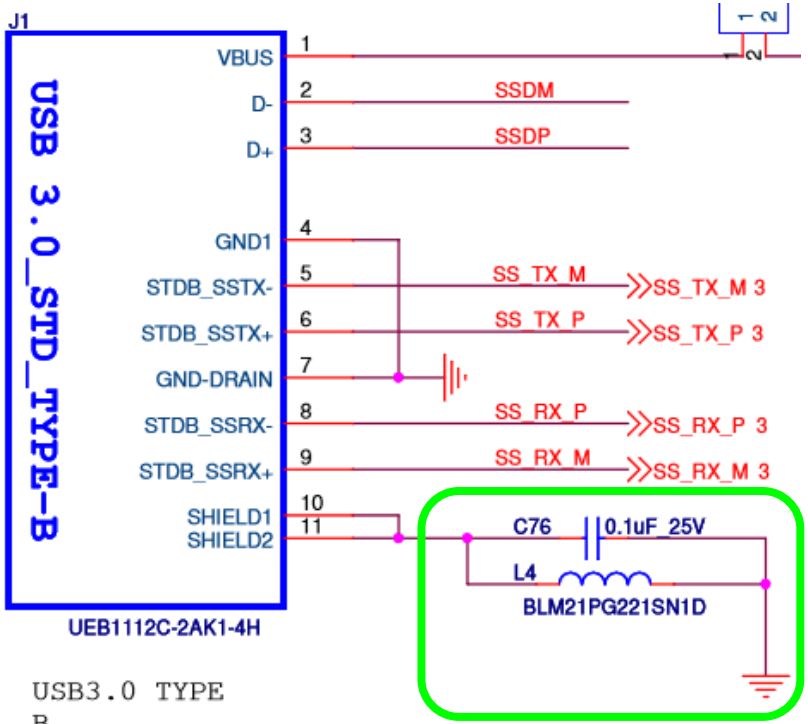


When “Ground Loops” Bite

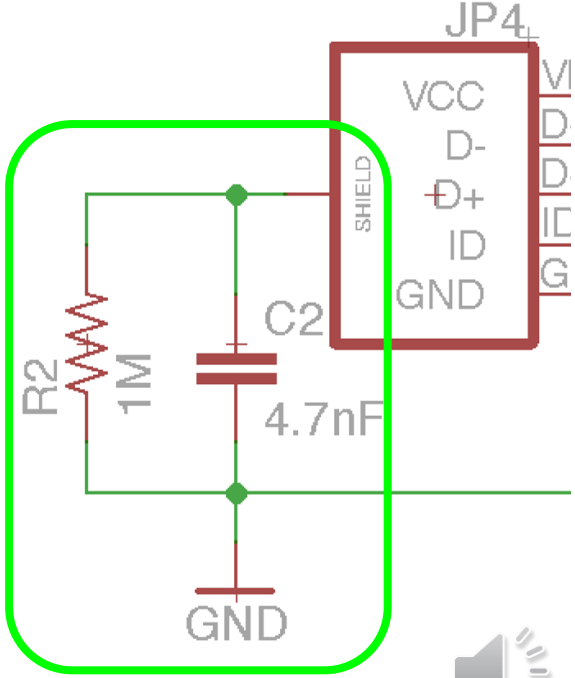


“I’ve put a capacitor / ferrite bead / resistor in series with my cable shield”

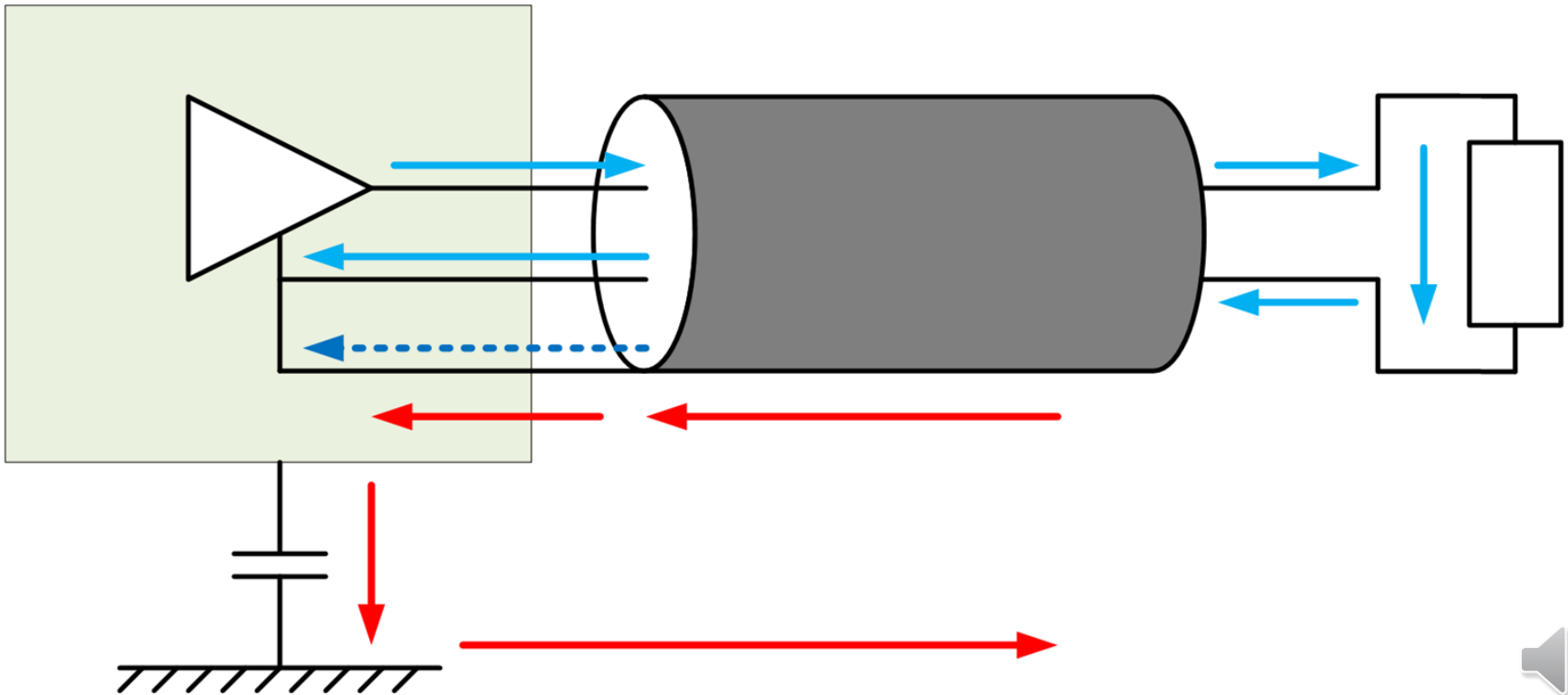




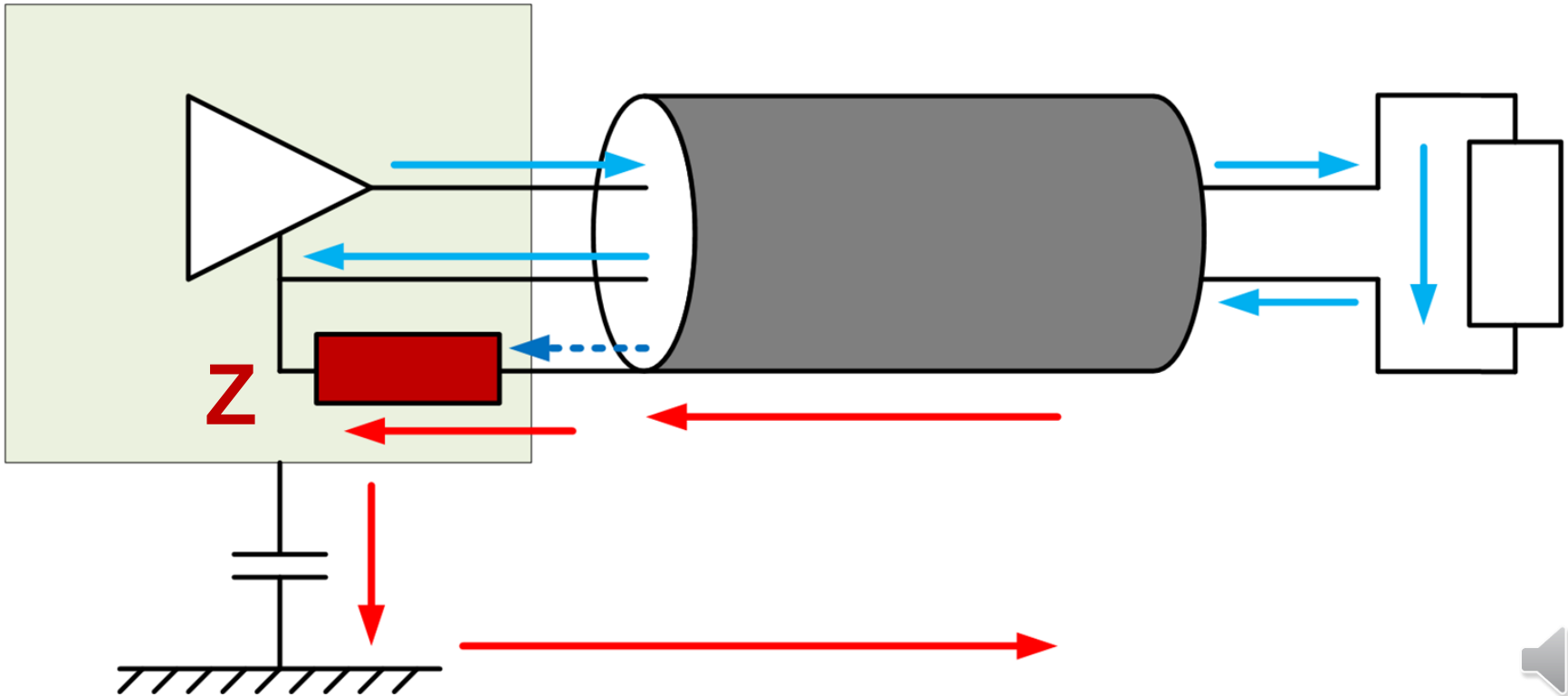
USB3.0 TYPE
B



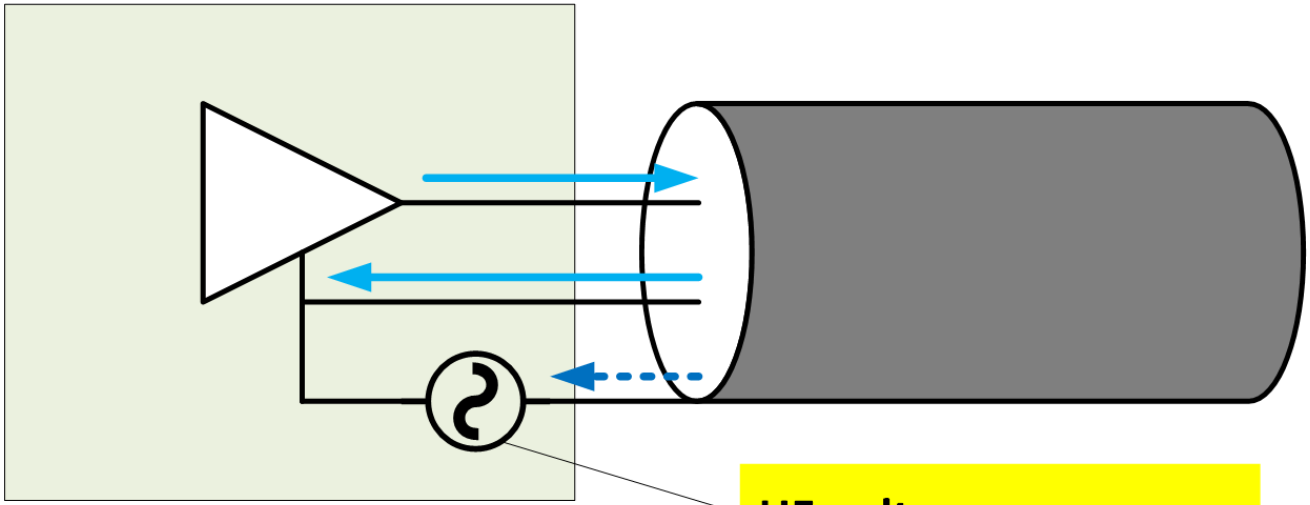
Cable Shield Ground Currents



Additional Impedance



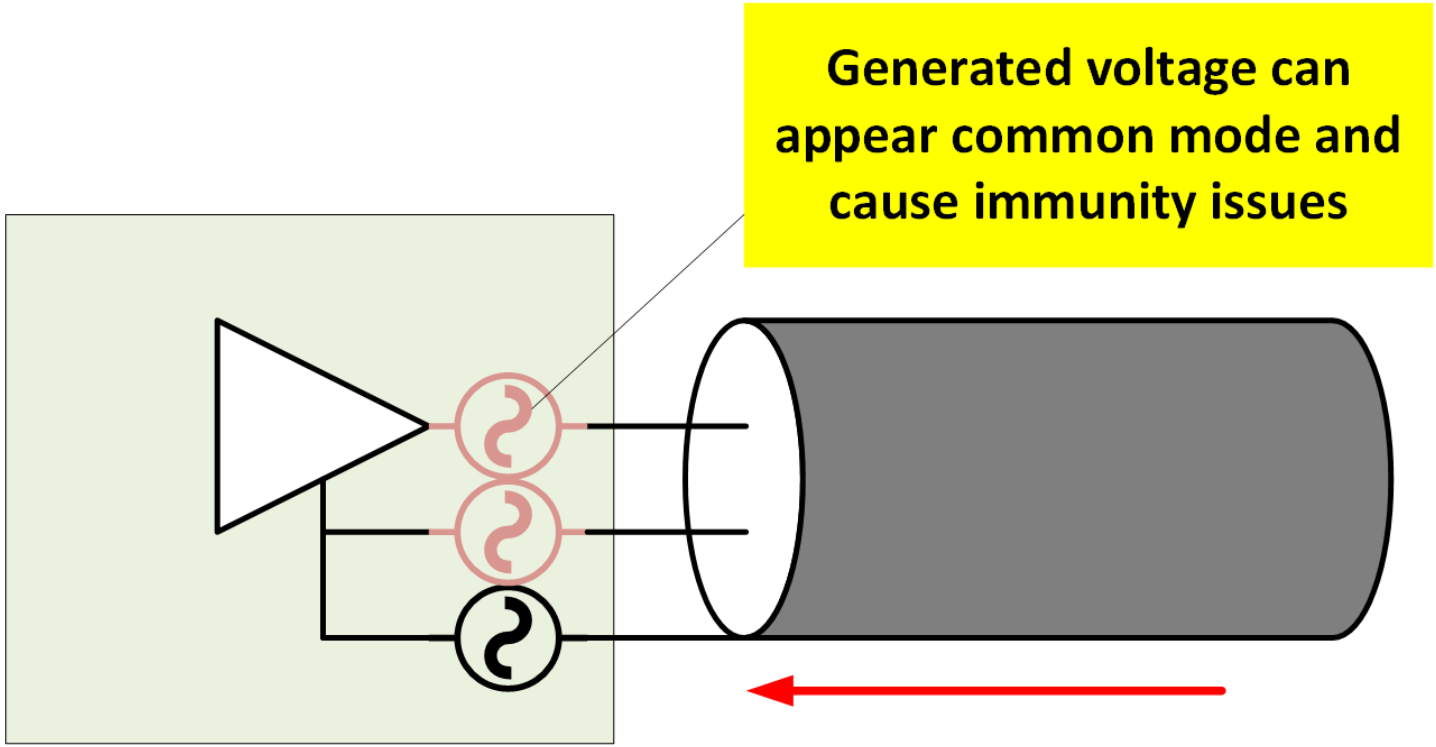
Bad For Emissions



HF voltage appears on shield of cable = radiated emissions

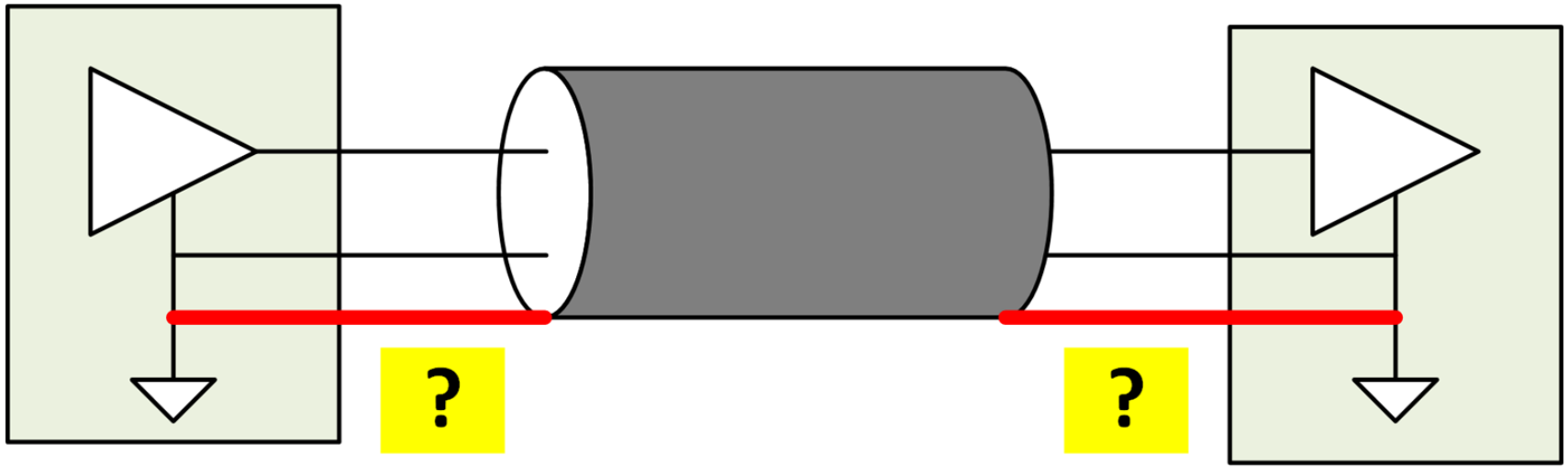
= dipole antenna

Bad For Immunity



“I’ve only connected the cable shield at one end.”

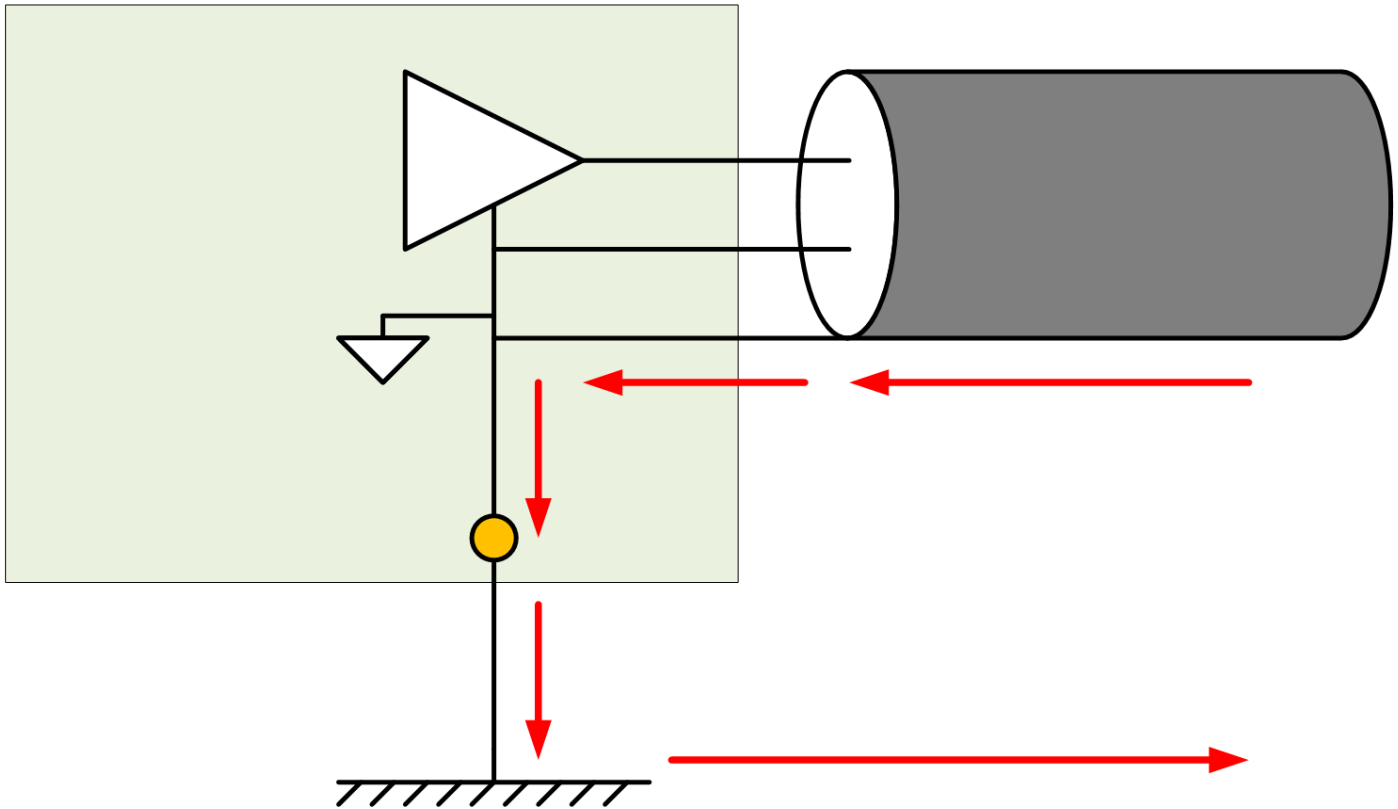
Which end to connect the shield?



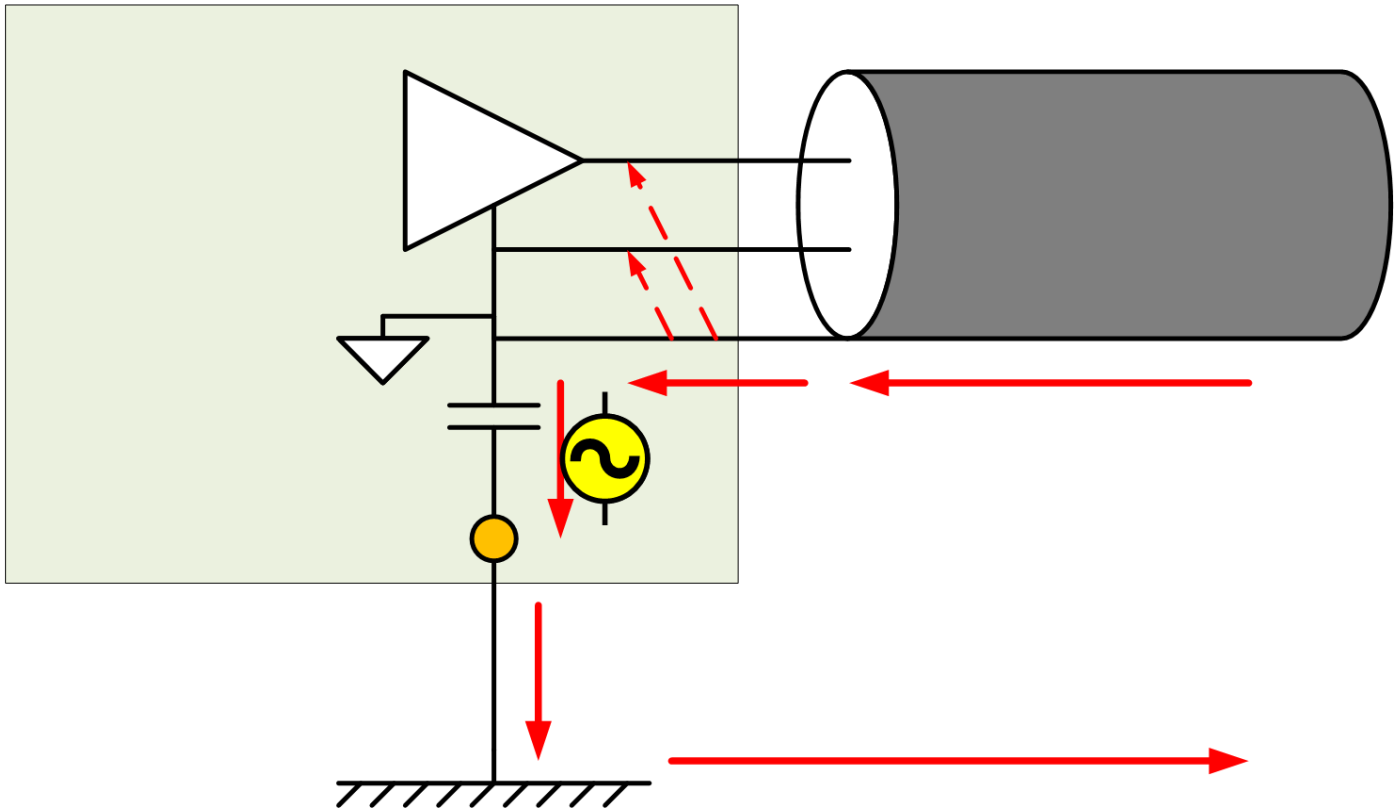
Ans: both

“The mounting holes are floating and not connected to the ground plane”

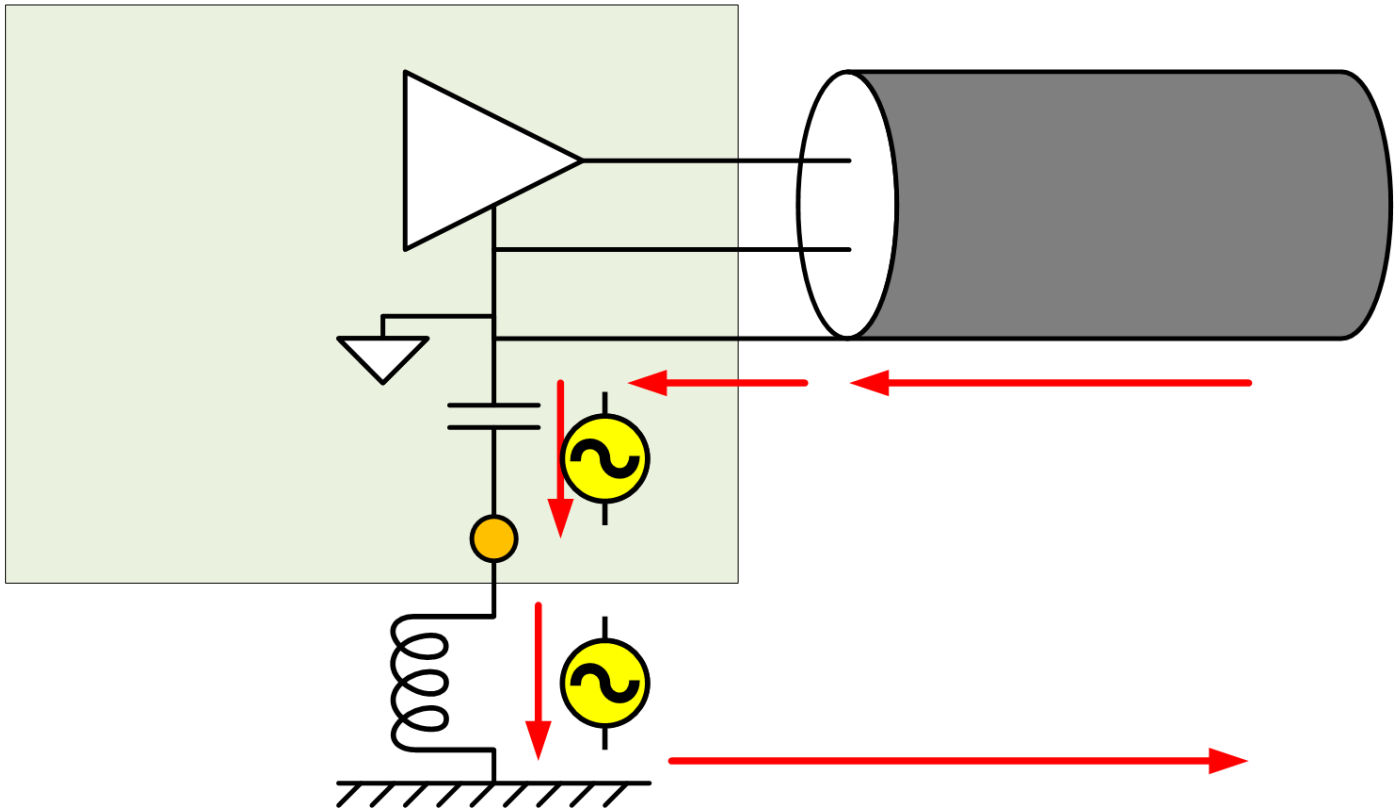
Metal Chassis Mounting Hole Currents



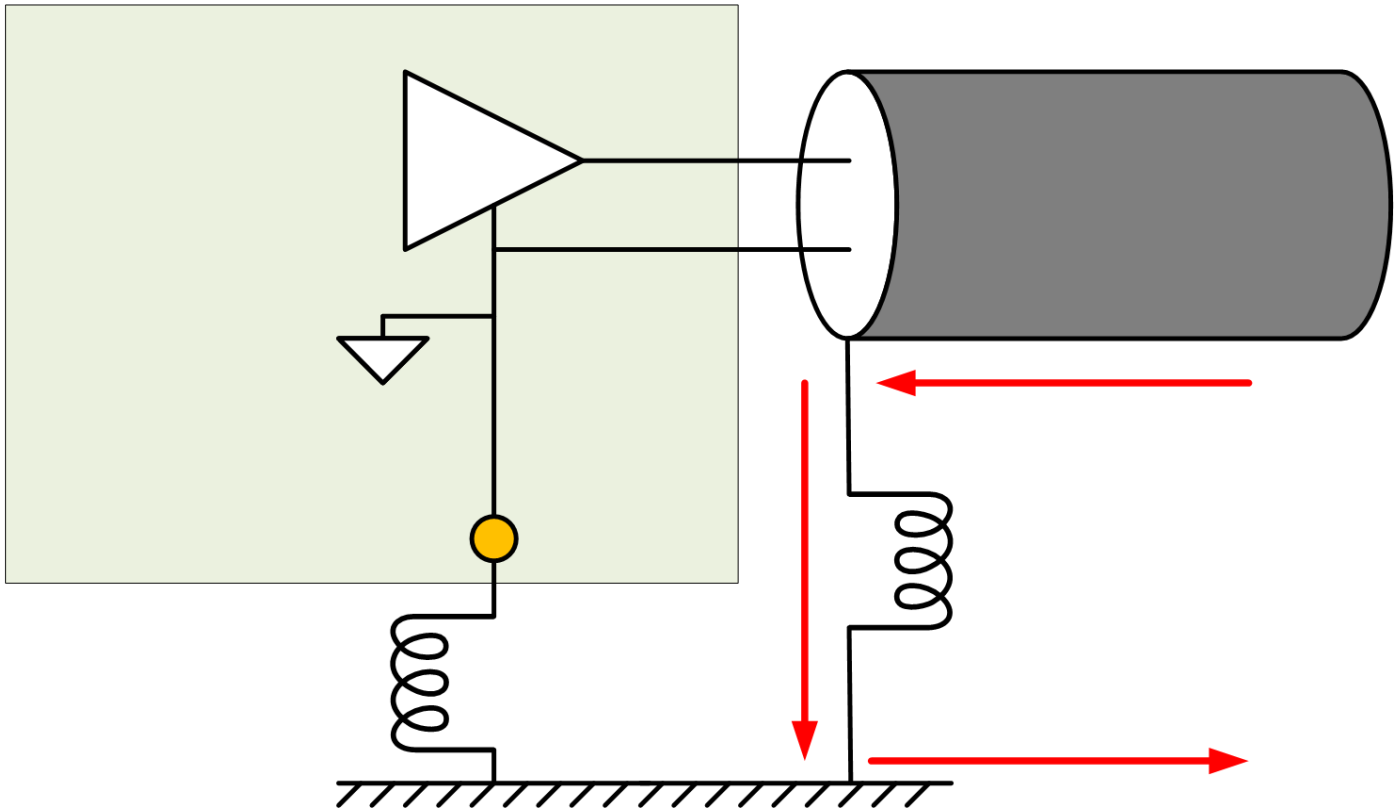
Removed Direct Connection



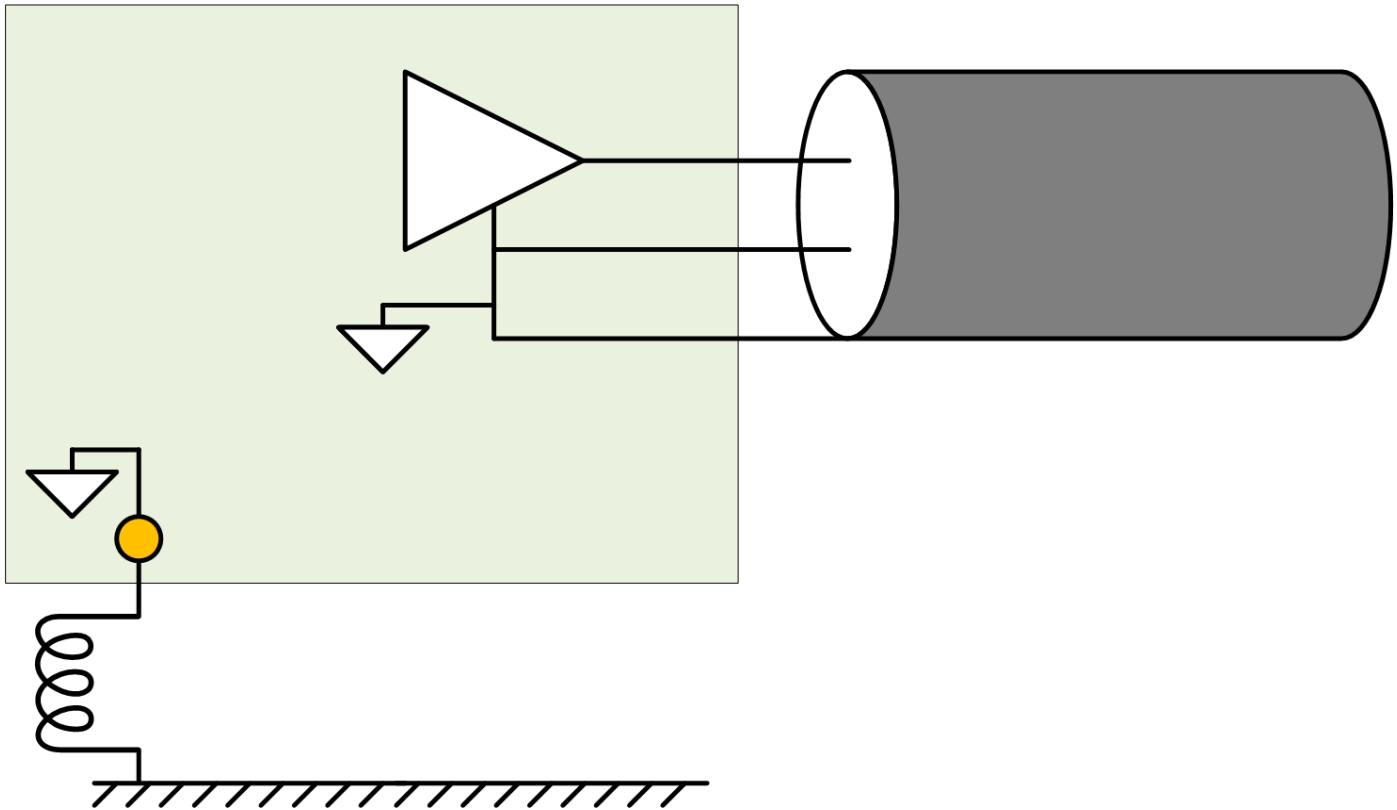
Existing Chassis Bond



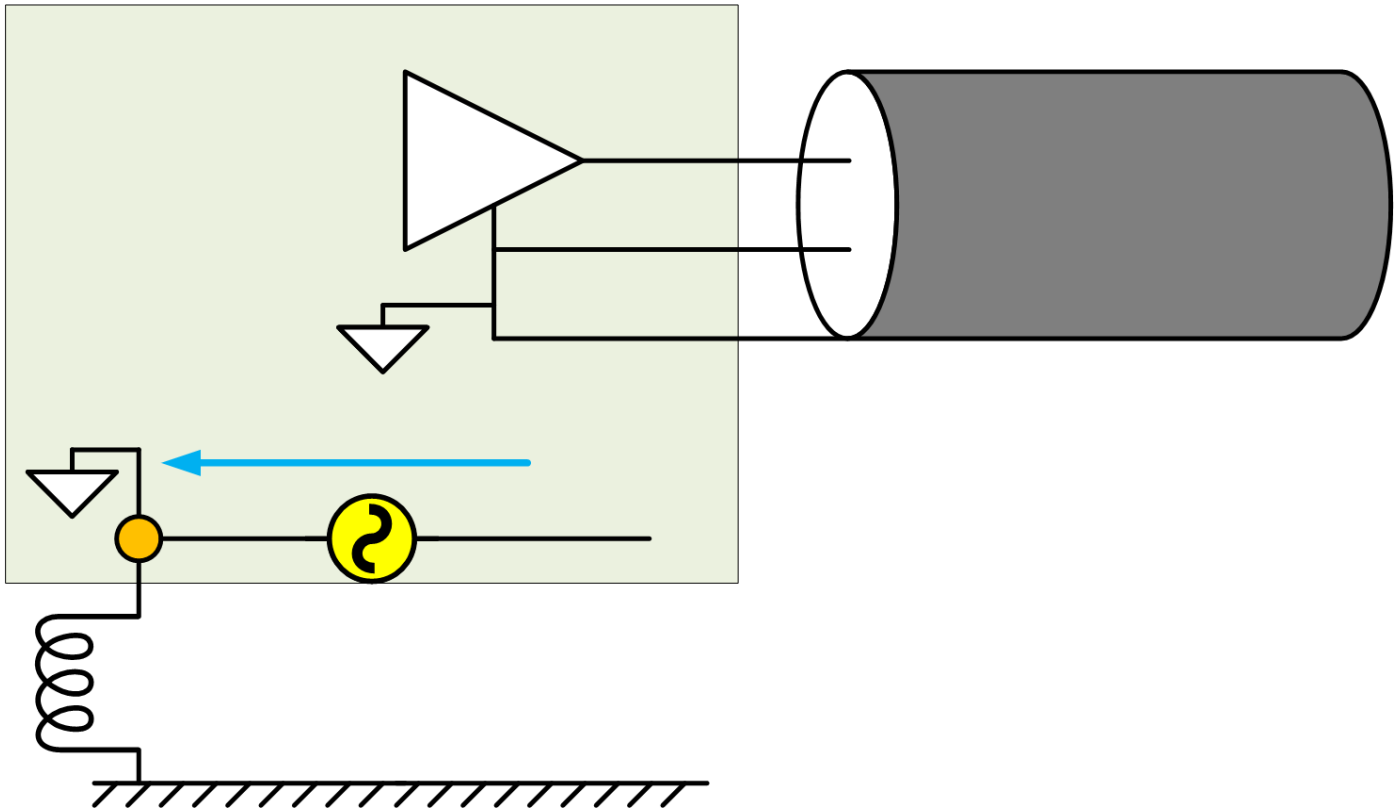
Importance of Connecting Cable Shield



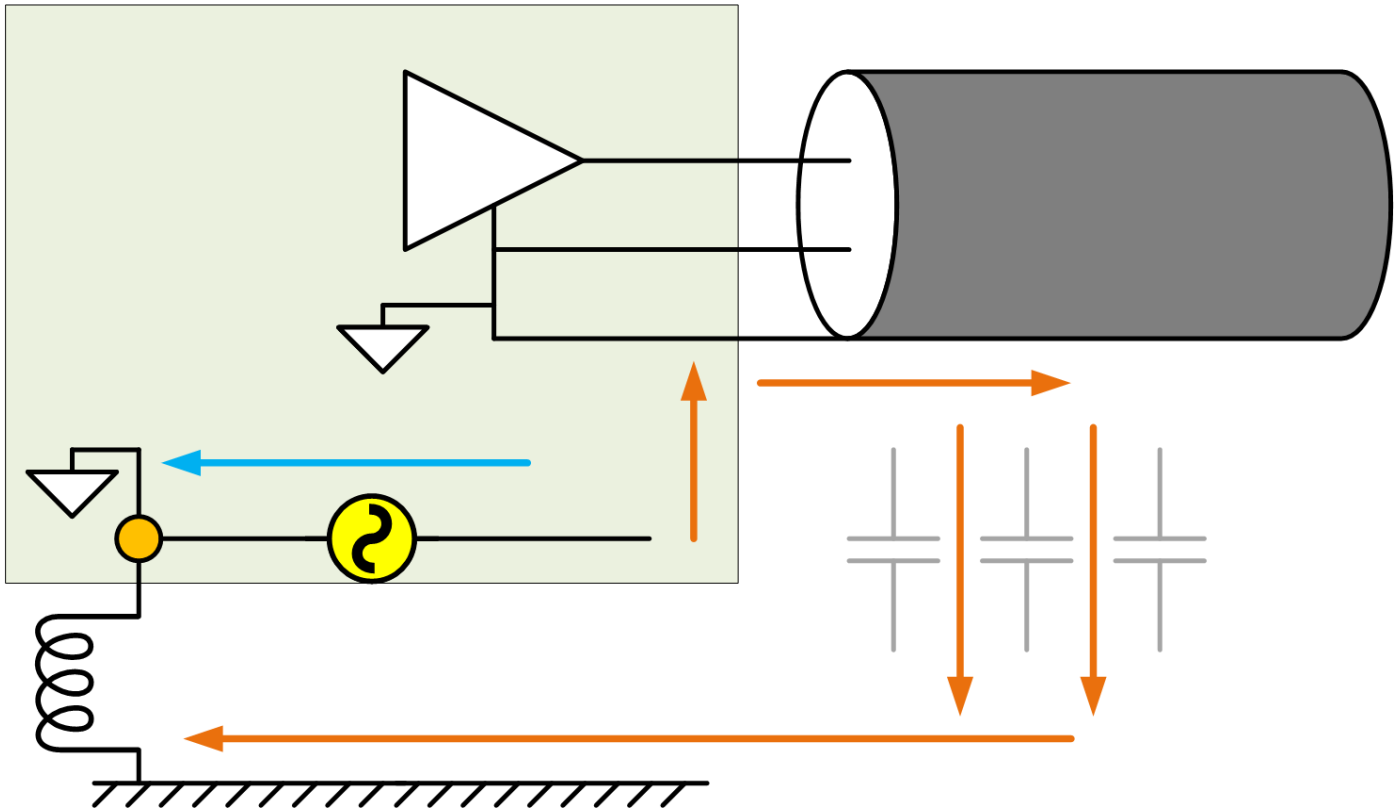
Location of Mounting Hole



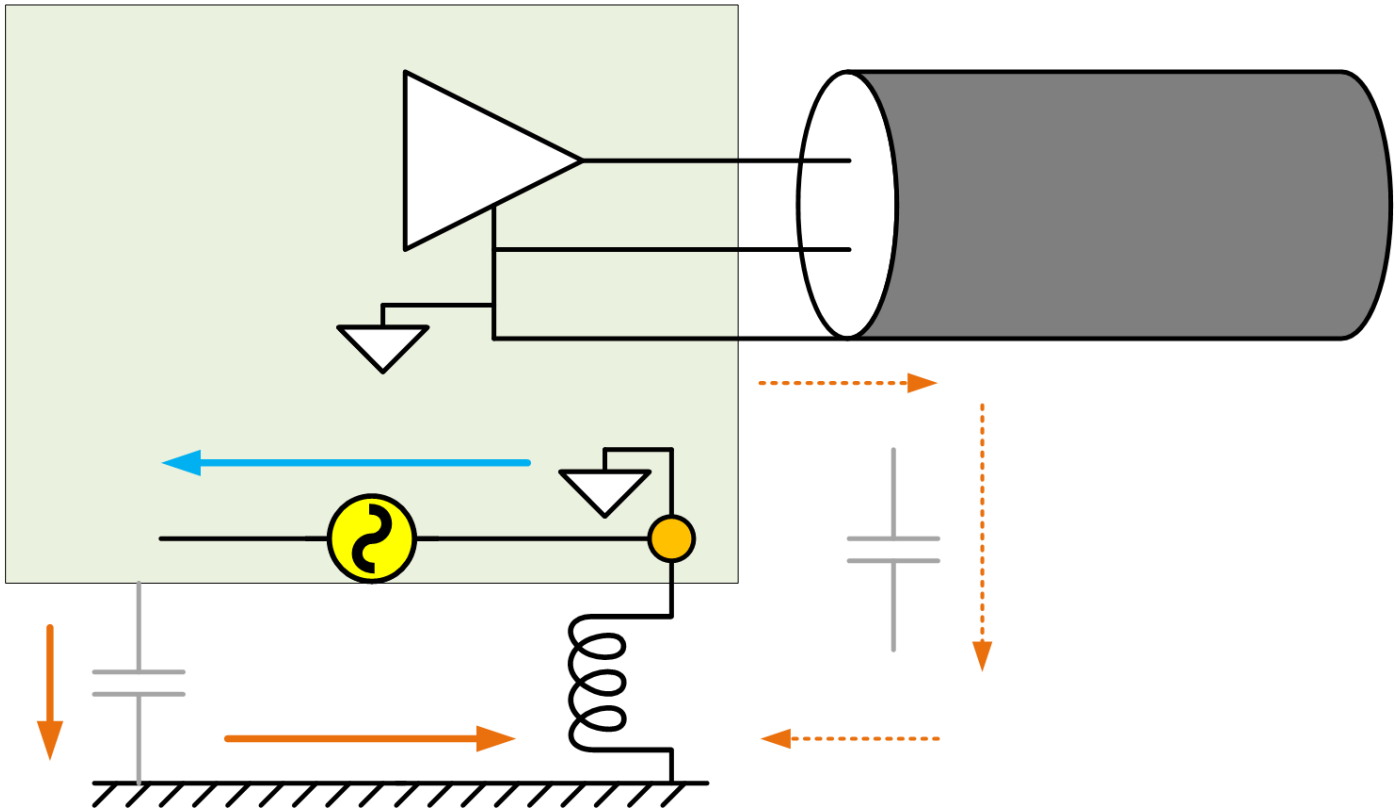
Location of Mounting Hole



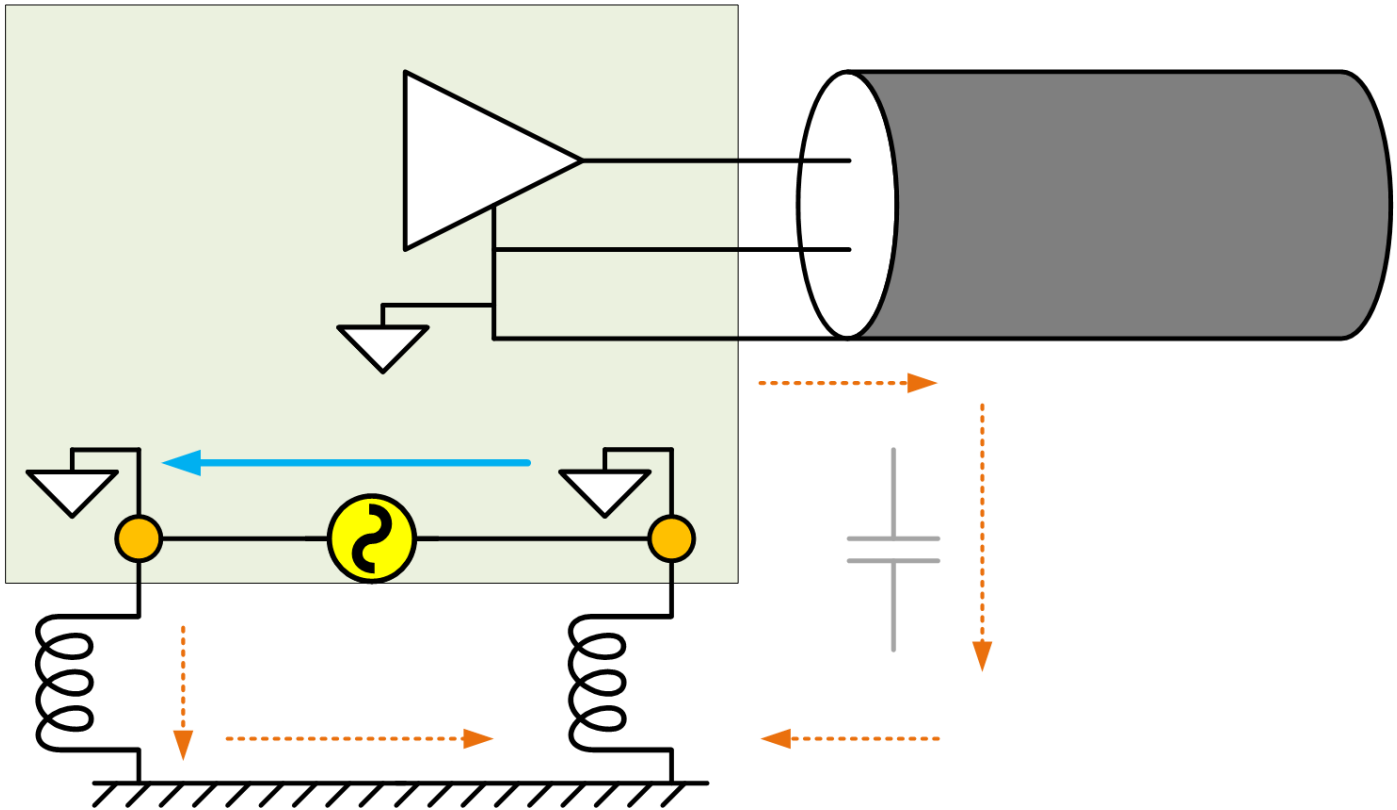
Location of Mounting Hole



Location of Mounting Hole

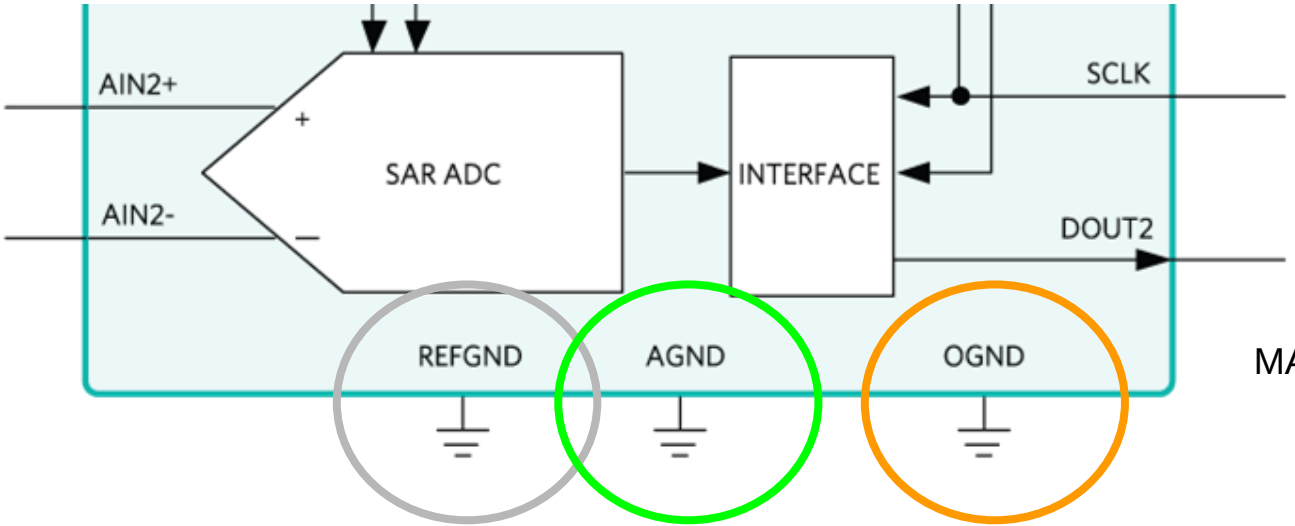


Location of Mounting Hole



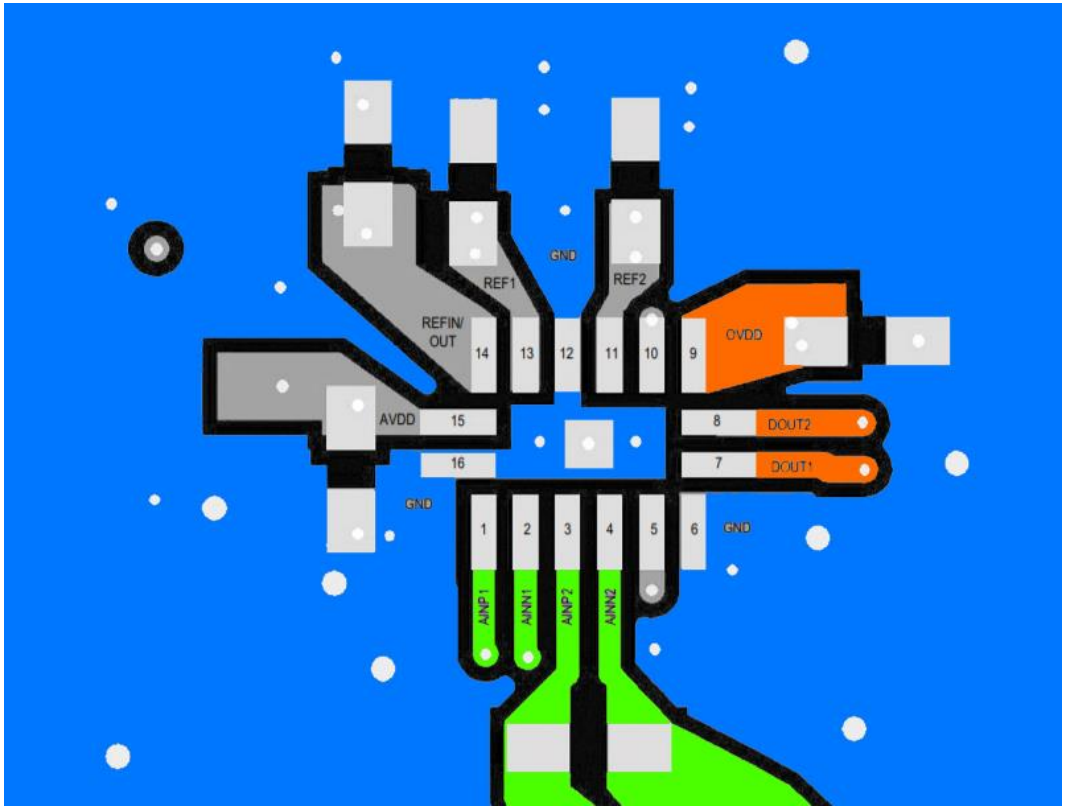
“I need to provide a separate analogue ground plane”

Separate grounds on IC datasheets



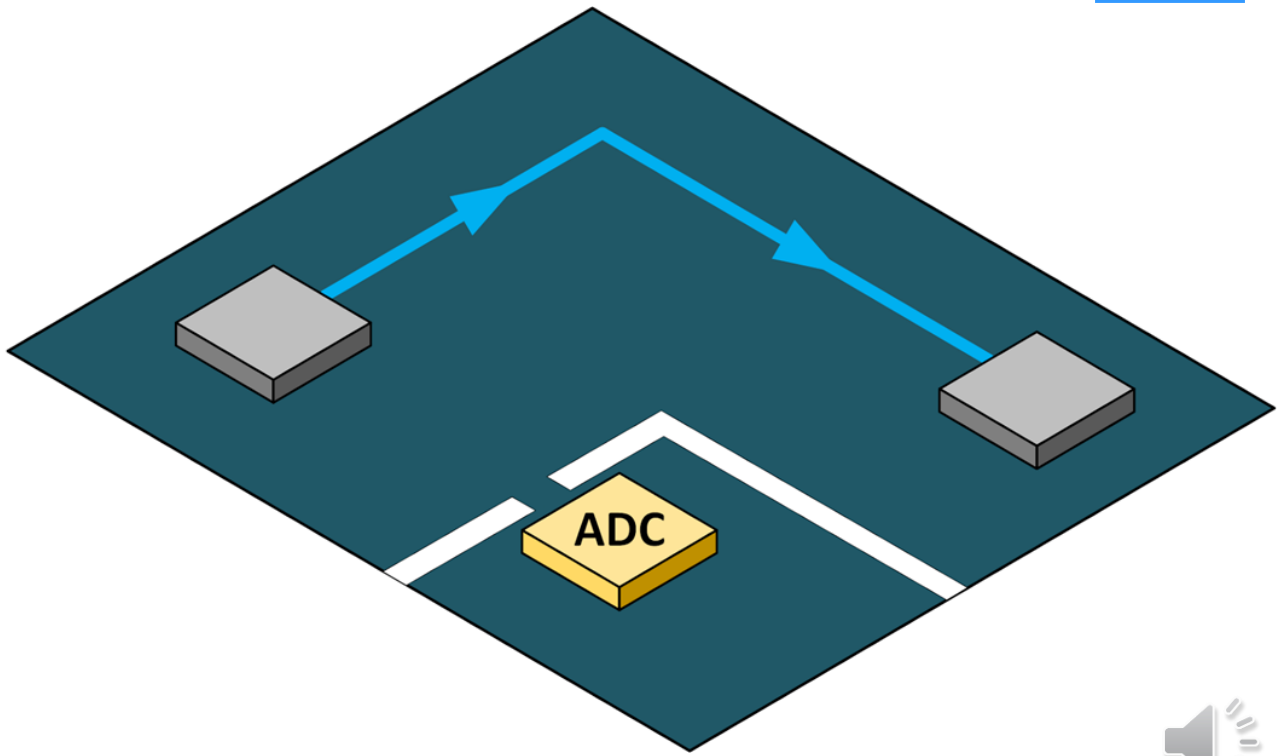
MAX11192

Separate grounds on IC datasheets



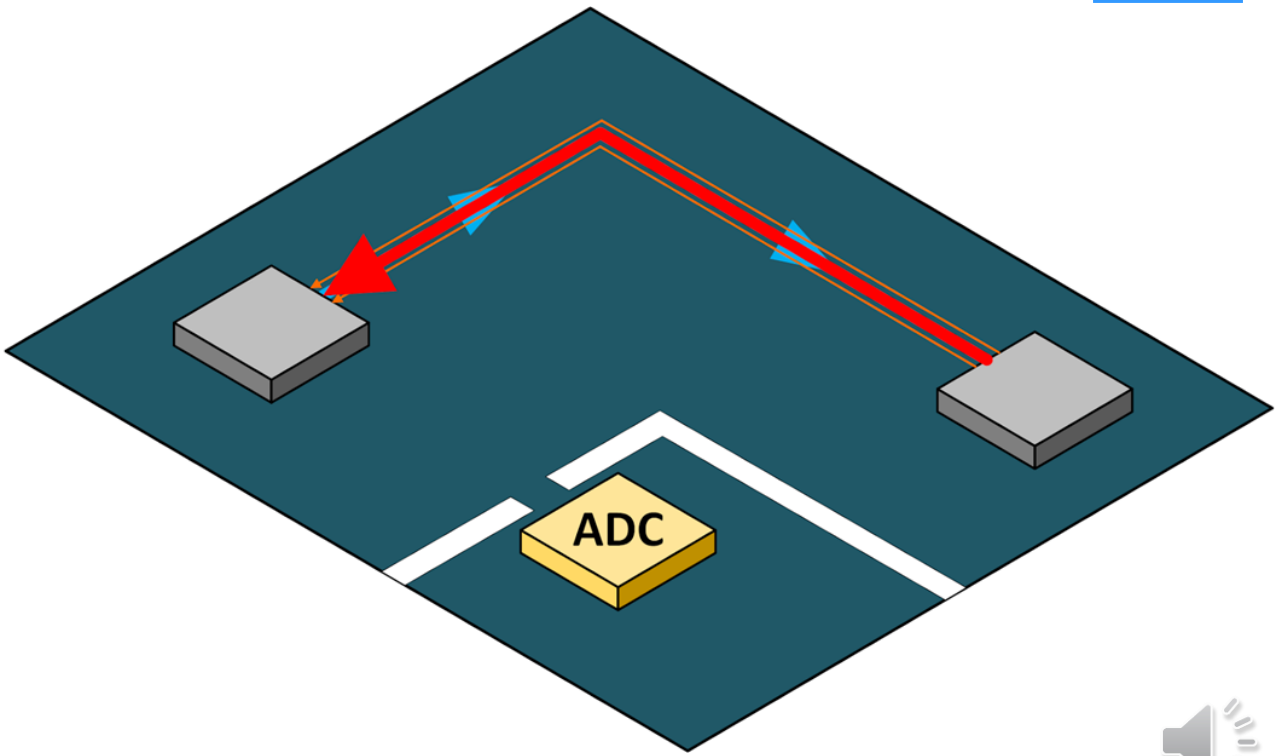
MAX11192

Different analogue and digital grounds?



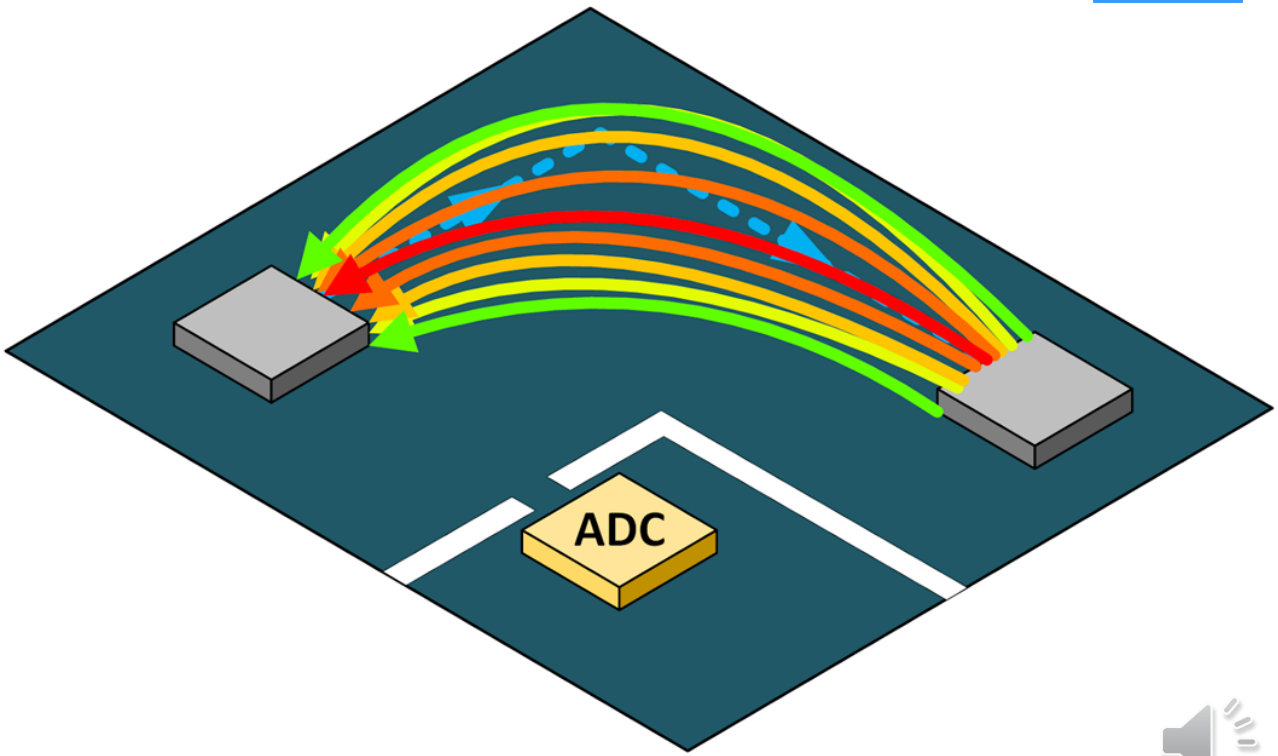
Different analogue and digital grounds?

5 MHz



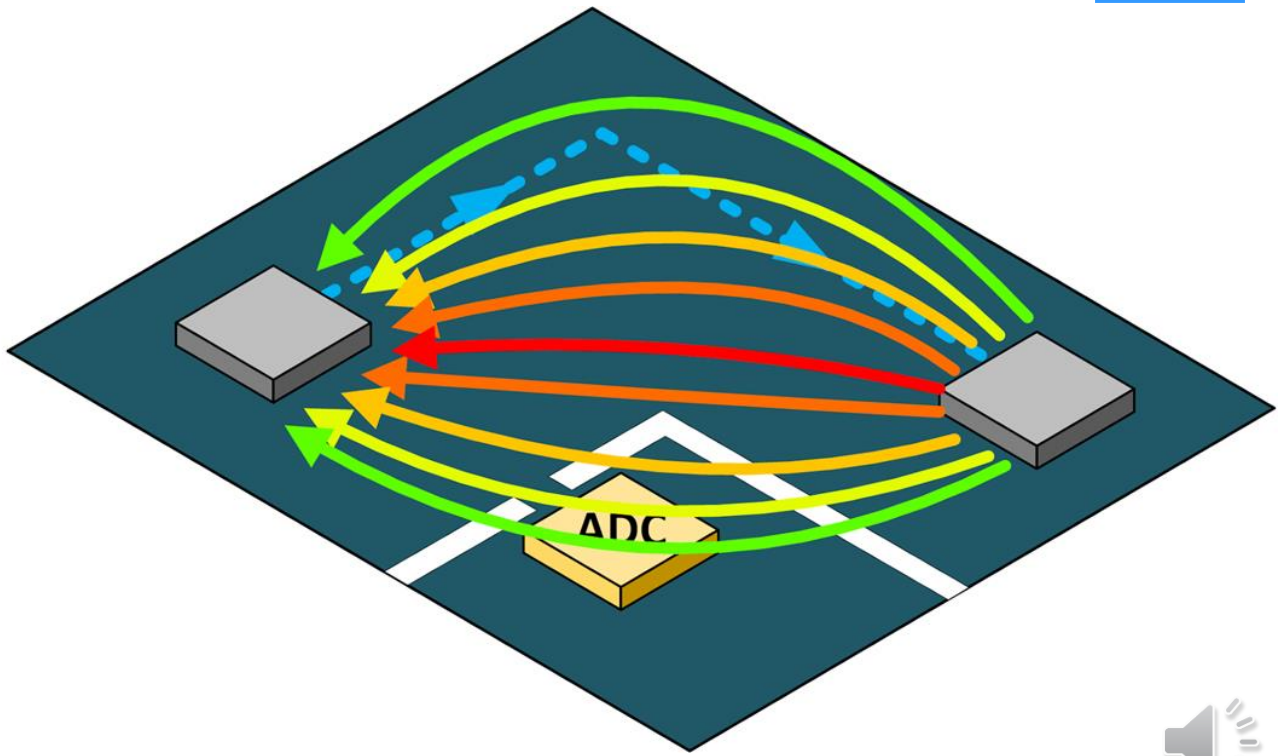
Different analogue and digital grounds?

5 kHz



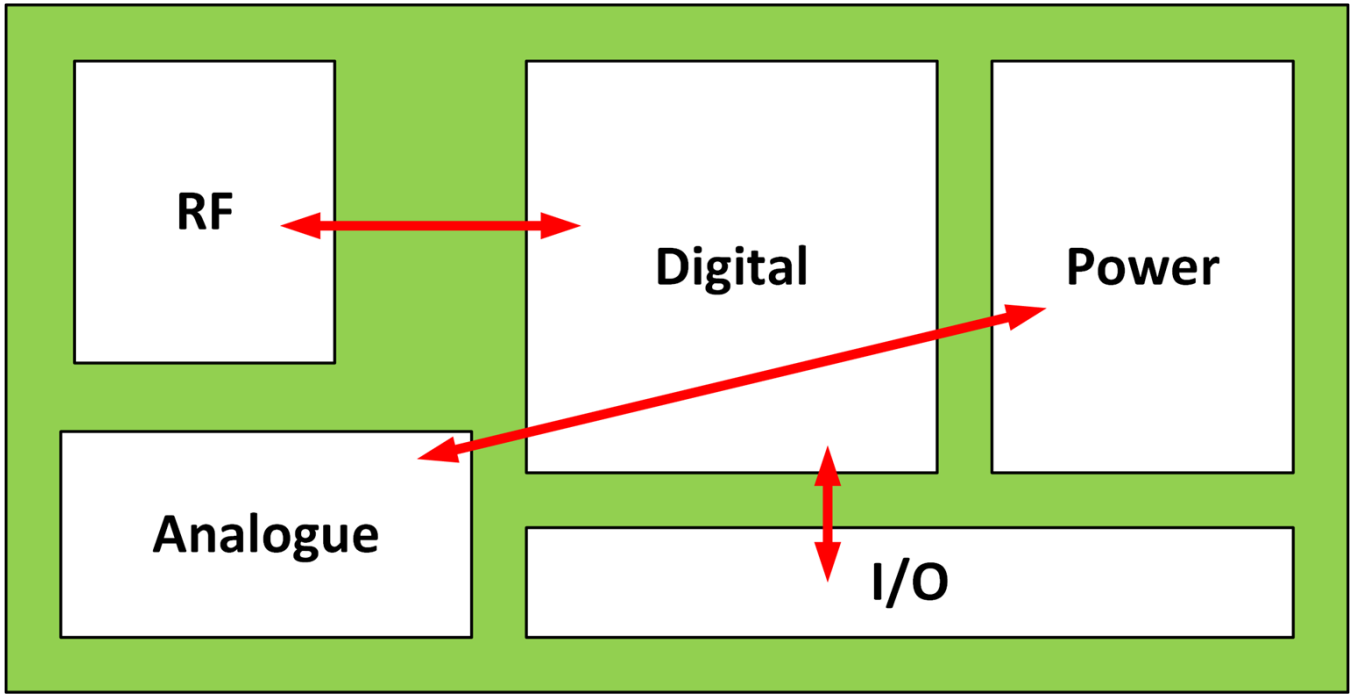
Different analogue and digital grounds?

500 Hz

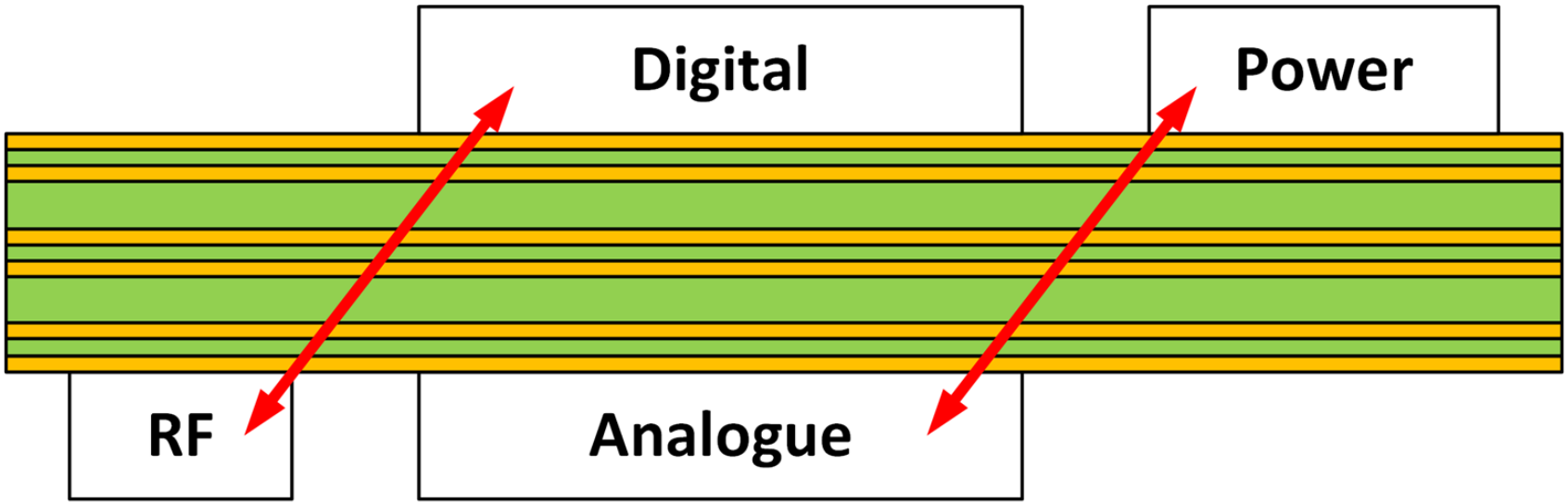


This is a system design problem, not an EMC problem.

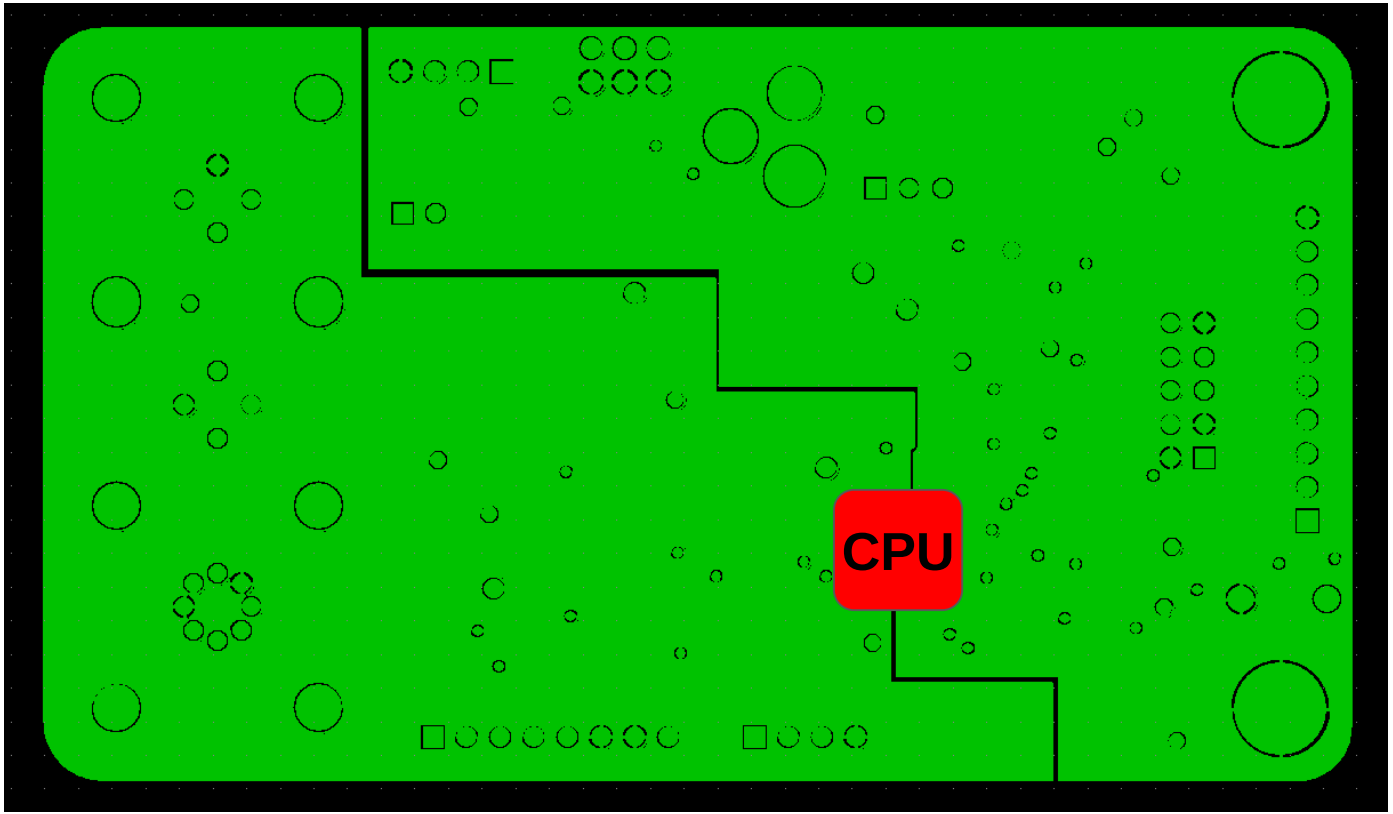
Design Partitioning



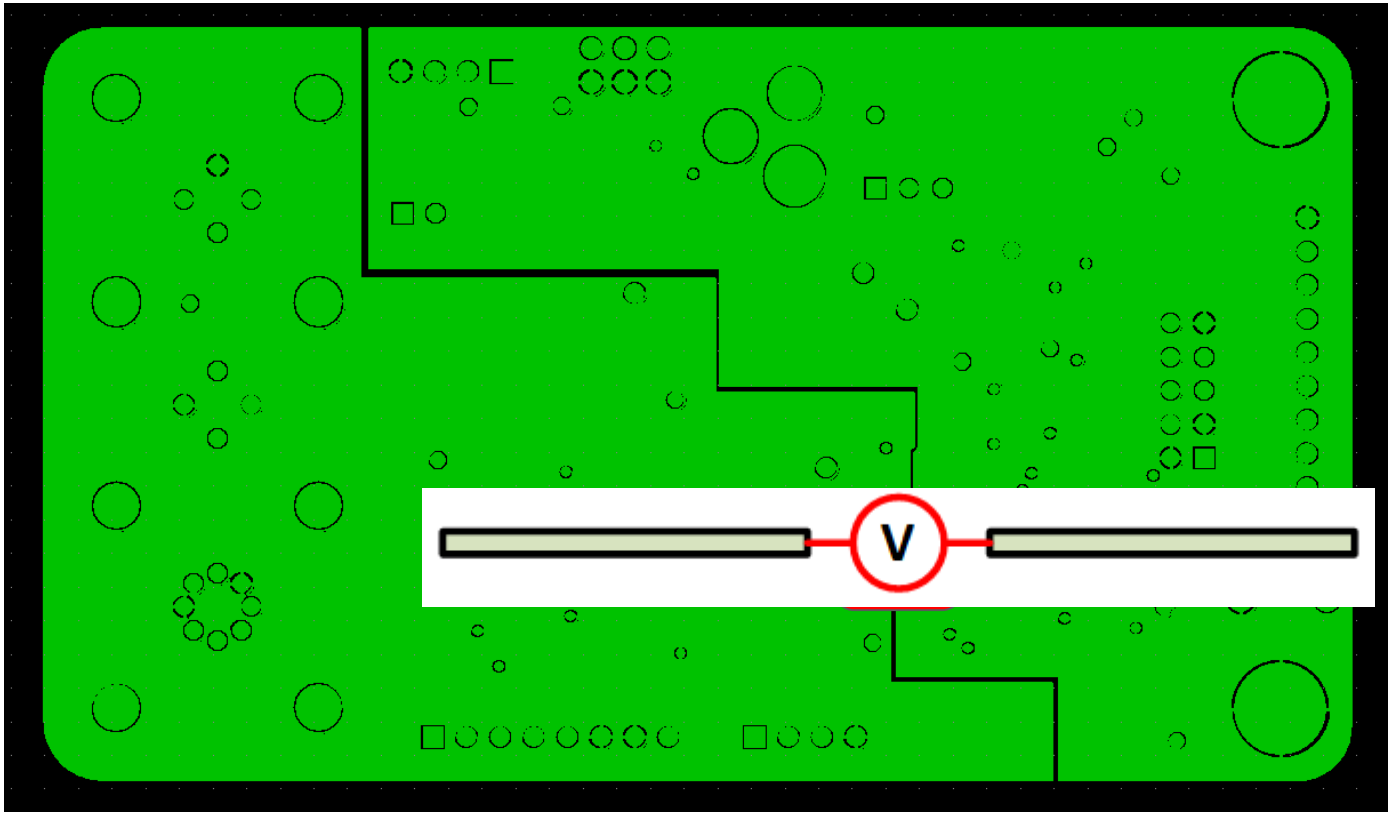
Vertical Partitioning



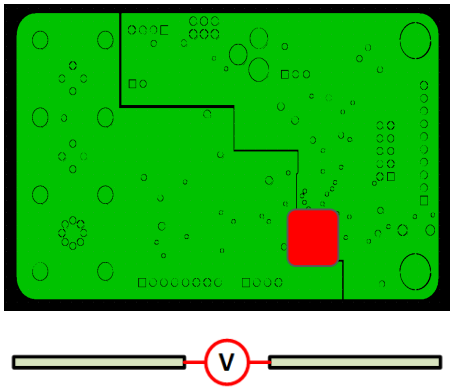
Splitting Grounds

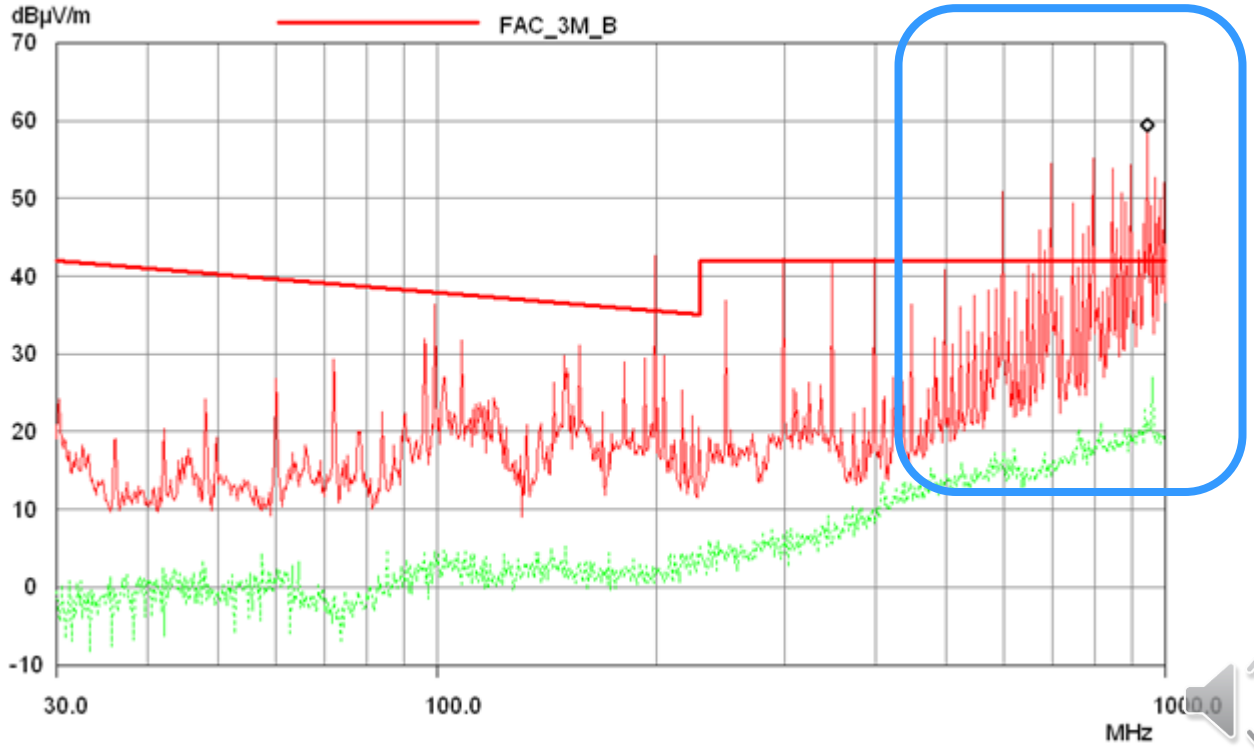


Splitting Grounds



Splitting Grounds





Q: What do you call an engineer who splits a ground plane?

A: A customer

Back down to earth.

Ground vs power as reference planes in PCBs

Shielding

Decoupling

Resonance in ground

ΔI noise and ground bounce

Did not cover :(

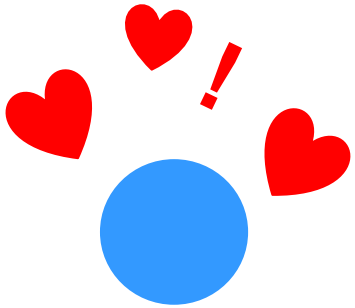
Ground maps

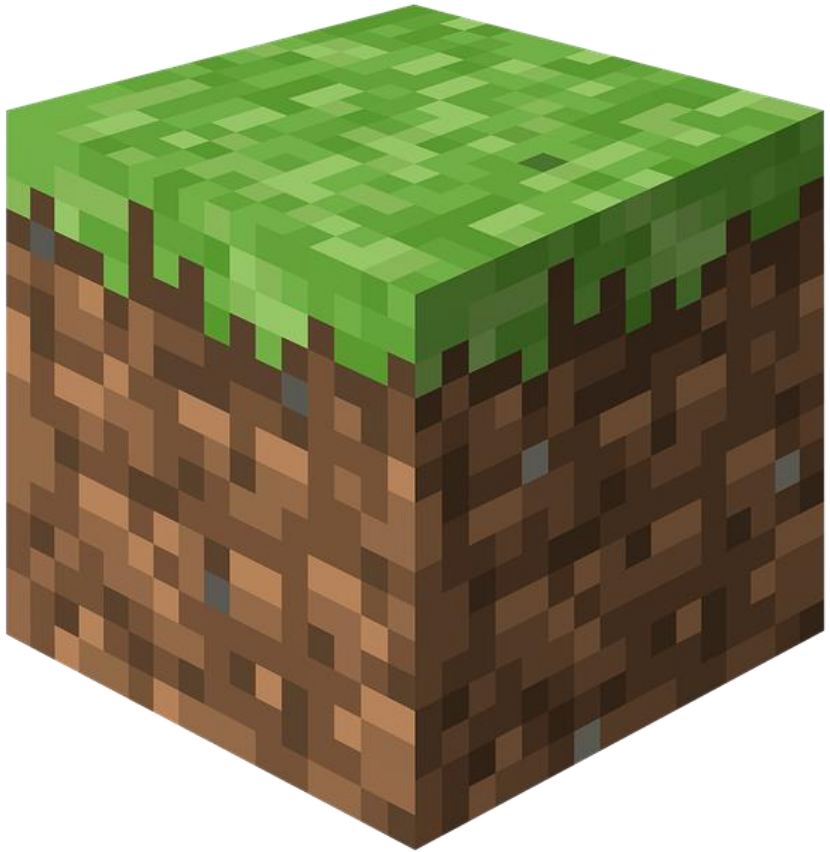
Hybrid grounds

Grounding in larger systems

PCB stackups

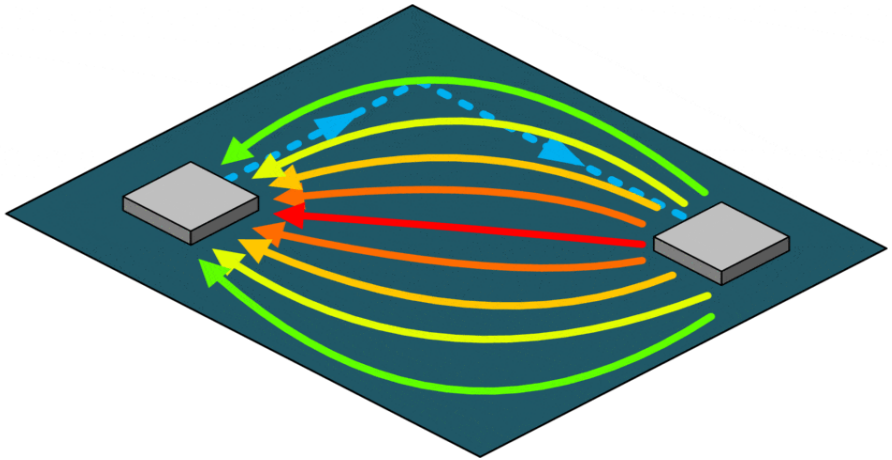
...and more





Where does the current flow?

DC



Ambiguity

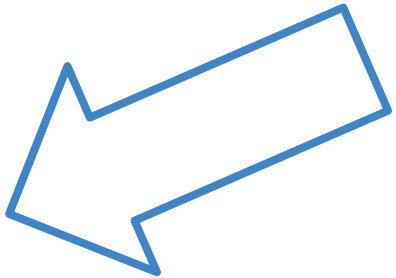
“Protective Earth”

“DC negative”

“Bond” or “connect x to y”

“PCB ground”

Connect on LinkedIn



@ James Pawson

Thanks :)

Questions?

Come and have a chat > exhibition area

hello @ unit3compliance.co.uk

@ James Pawson