

Shielding Low Frequency Magnetic Fields

OMICRON 12th Power Analysis & Design Symposium



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Organized by,



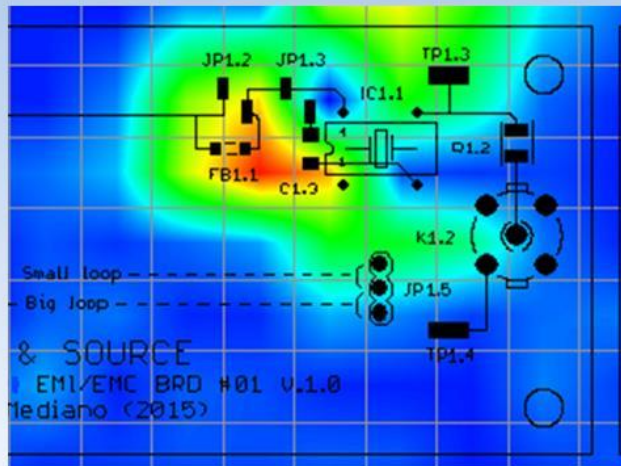
2022

March 15th, 2023



A High Frequency Lab for

design, diagnostic,
troubleshooting and
training



Interferences (EMI)
Electromagnetic Compatibility (EMC)
Signal Integrity (SI)
Radiofrequency (RF)

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About the speaker ...

Prof. **Arturo Mediano**

Teaching Professor in EMI/EMC/RF/SI

I3A, University of Zaragoza (SPAIN)

Arturo Mediano is the founder of The HF-Magic Lab®, a specialized laboratory for design, diagnostic, troubleshooting, and training in the EMI/EMC, Signal Integrity, and RF fields at I3A (University of Zaragoza).

He received his M.Sc. (1990) and his Ph. D. (1997) in Electrical Engineering from the University of Zaragoza (Spain), where he has held a teaching professorship in EMI/EMC/RF/SI since 1992.

For more than 30 years Arturo has been involved in R&D projects with many companies in the EMI/EMC, Signal Integrity and RF fields for communications, industry, medical, and scientific applications. He regularly shares his knowledge and expertise with students and engineers in teaching courses and seminars.



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Outline ...

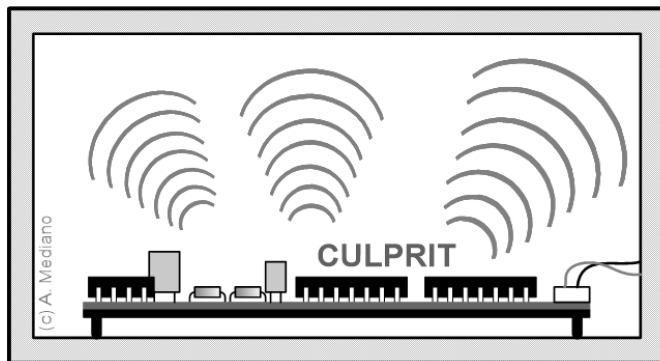


- Reviewing (briefly) the **theory of shielding**
- **Electric and magnetic fields** in shielding
- What is “**low frequency**” in shielding
- **Common techniques to solve** this problem.
- **Demos**

Shielding: motivation

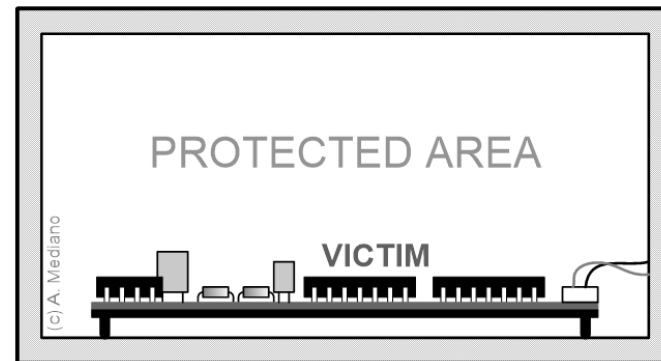
EMISSION

PROTECTED AREA



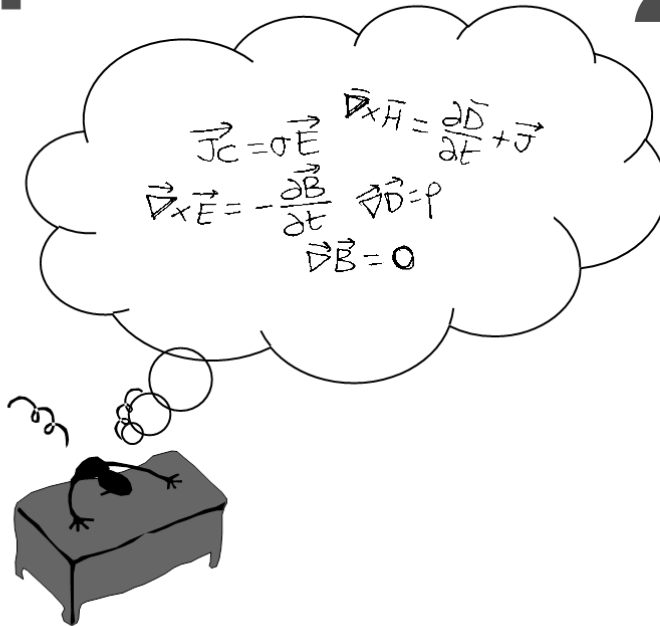
IMMUNITY

PROTECTED AREA



Shielding: theory paths

1 MAXWELL



2 SCHELKUNOFF

$$SE_{dB} = \underbrace{R_{dB}}_{\text{Reflection}} + \underbrace{A_{dB}}_{\text{Absorption}}$$

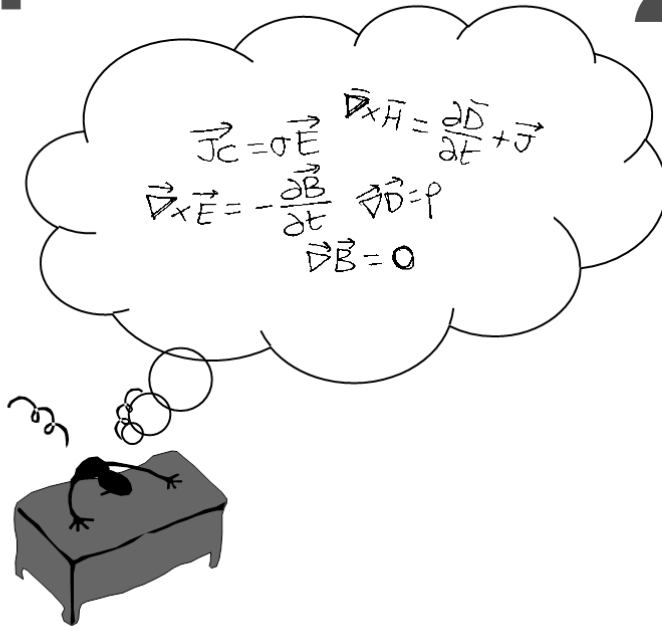
“De-matching impedances”

“Dissipation in material”



Shielding: theory paths

1 MAXWELL



2 SCHELKUNOFF

$$SE_{dB} = \underbrace{R_{dB}}_{\text{Reflection}} + \underbrace{A_{dB}}_{\text{Absorption}}$$

“De-matching impedances”

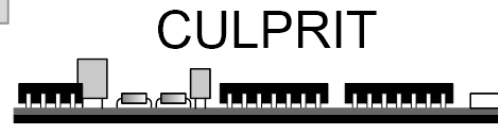
“Dissipation in material”



Shielding: effectiveness

$$SE_{E_{dB}} = 20 \text{ LOG } \frac{E_{\text{without}}}{E_{\text{with}}}$$

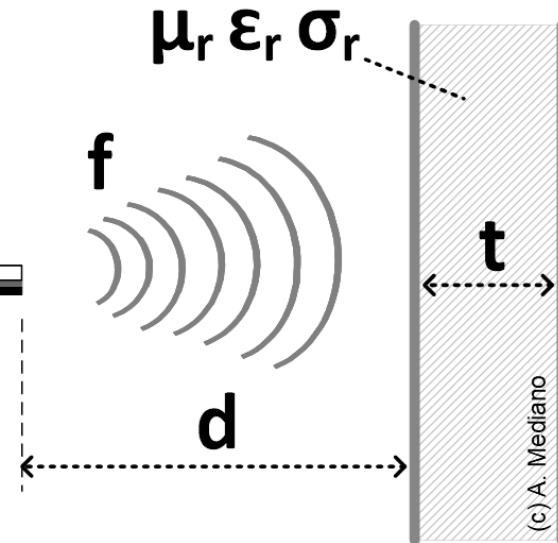
$$SE_{H_{dB}} = 20 \text{ LOG } \frac{H_{\text{without}}}{H_{\text{with}}}$$



$$SE_{dB} = R_{dB} + A_{dB} + B_{dB}$$

KEY ELEMENTS:

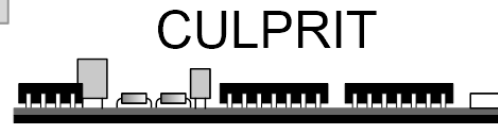
- 1) Efficiency of material
- 2) Leakage because slots/apertures
- 3) I/O cables



Shielding: effectiveness

$$SE_{E_{dB}} = 20 \text{ LOG } \frac{E_{\text{without}}}{E_{\text{with}}}$$

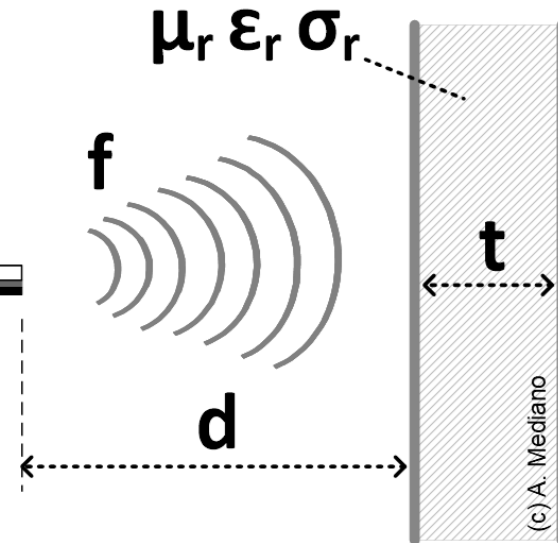
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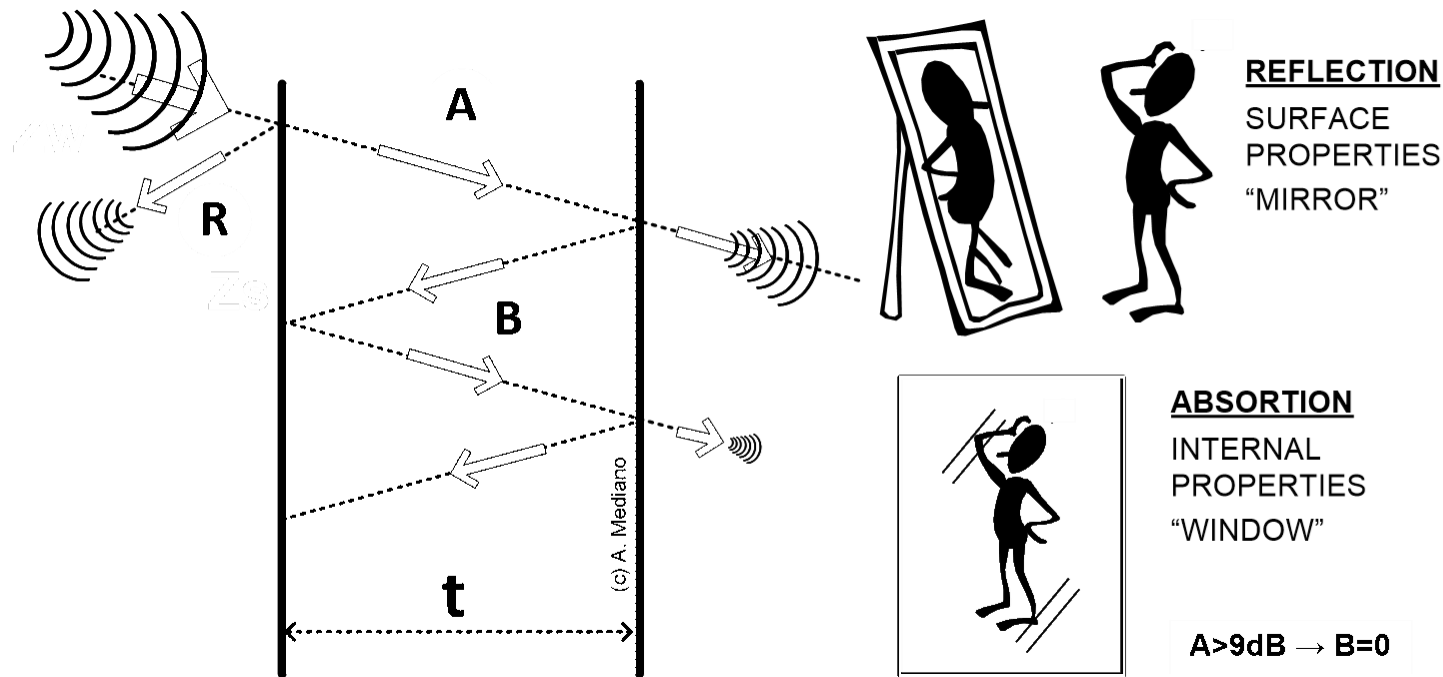
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KEY ELEMENTS:

- 1) Efficiency of material
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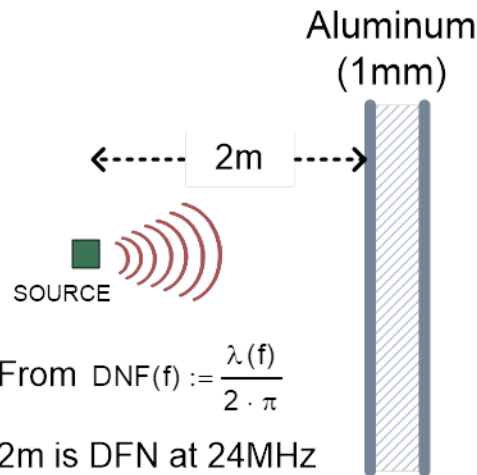
Shielding: understanding the picture ...



Shielding: absorption + reflection

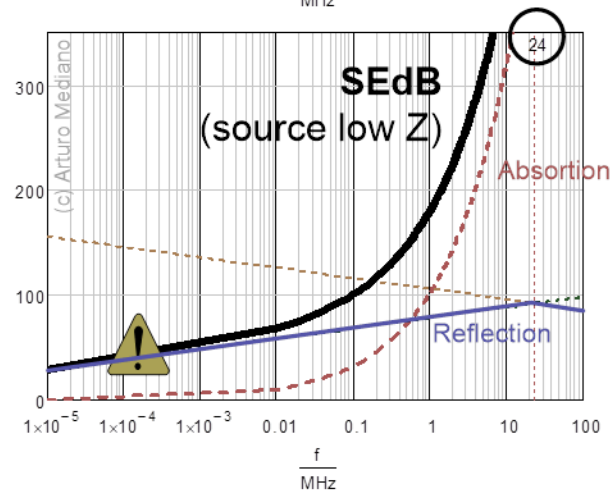
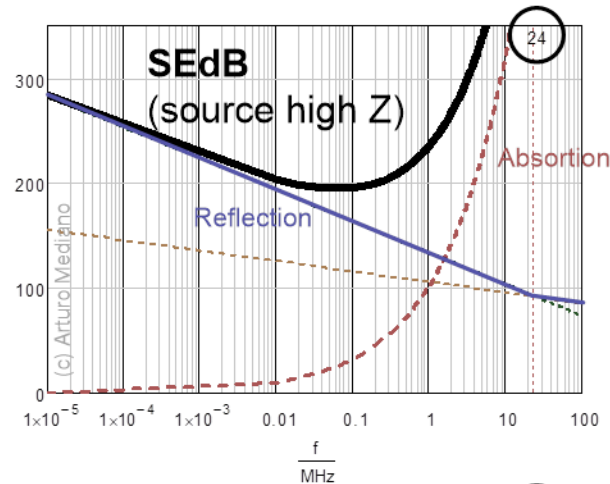
COMPLETE EXAMPLE

$$SdB = RdB + AdB$$



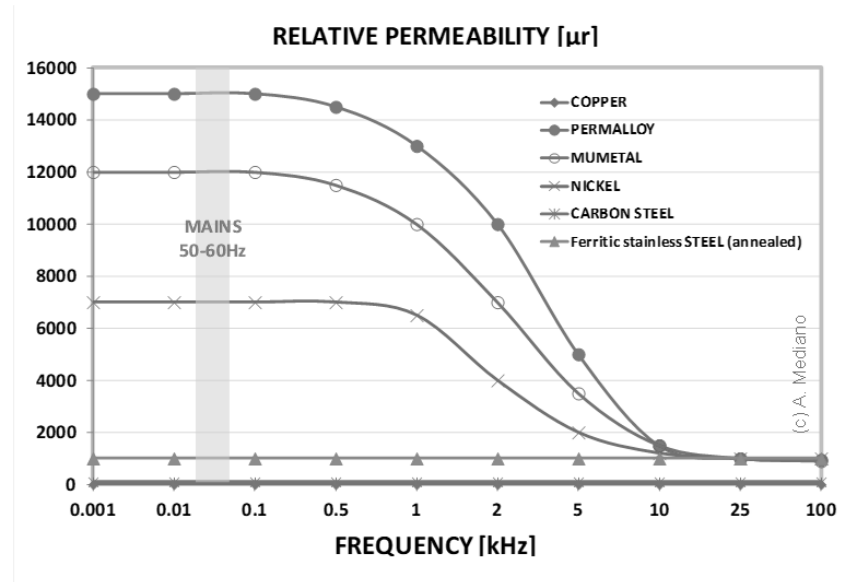
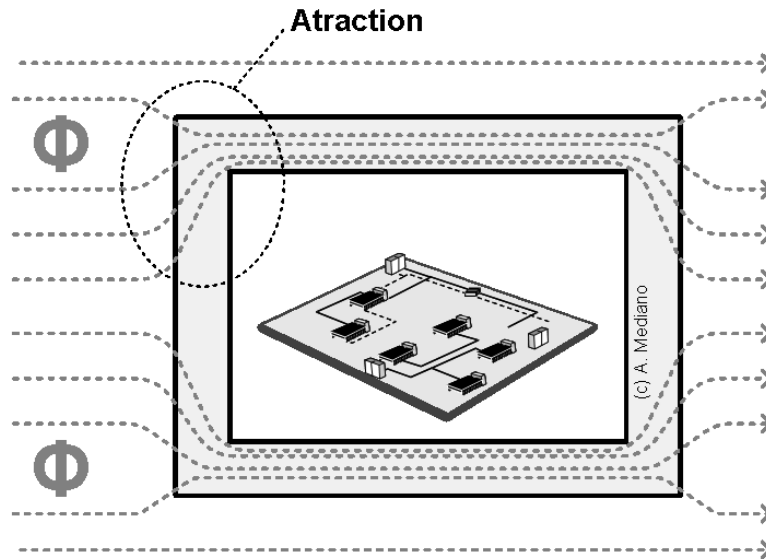
$$\text{From } DNF(f) := \frac{\lambda(f)}{2 \cdot \pi}$$

2m is DFN at 24MHz



Shielding: low frequency H field

High permeability μ_r = Concentration of magnetic field lines far from victim



NOTES:

- 1.- $\mu \uparrow @ f \downarrow$
- 2.- Be careful with SATURATION.
- 3.- Sensitivity to mechanical manipulation.
- 4.- High COST.



Demo

THANK YOU!



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