Electromagnetic Coupling into Enclosures and unto Circuit Board Element

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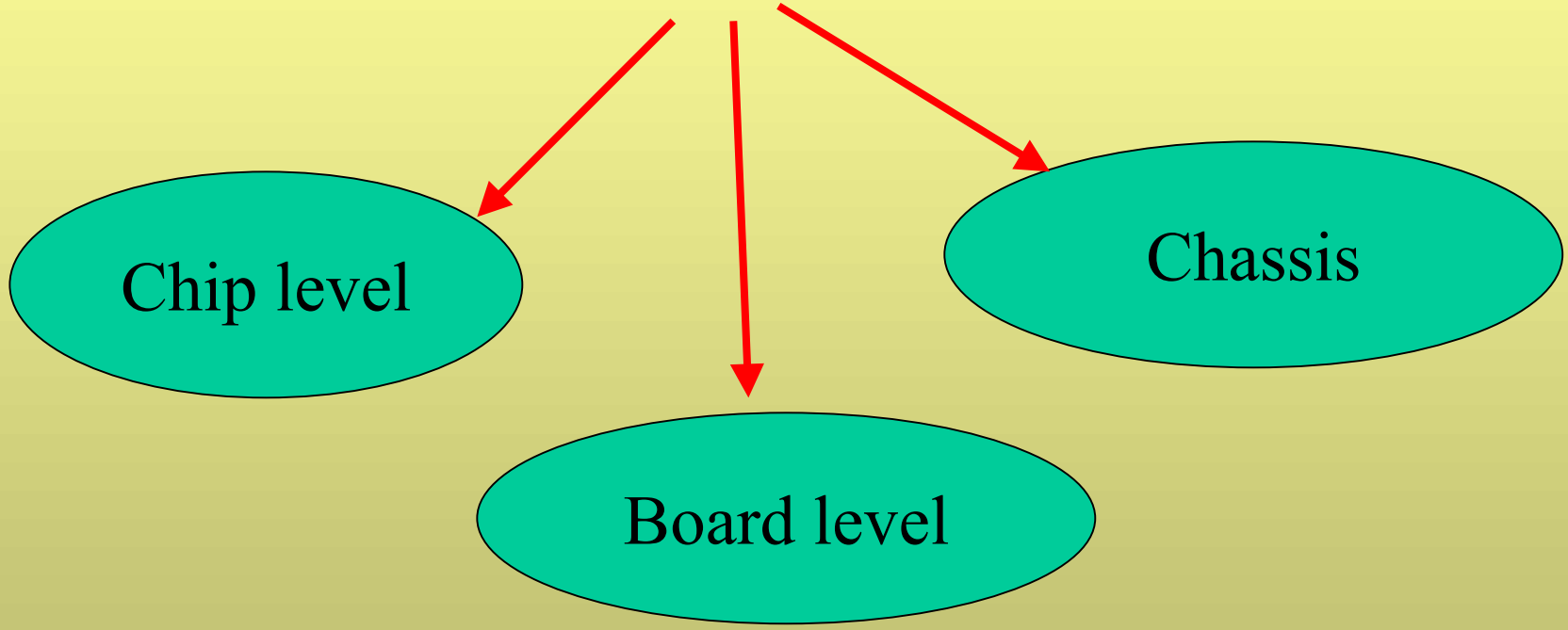
SCHOOL OF ENGINEERING

Outline

- Understand electromagnetic coupling into enclosures
- Develop techniques to minimize coupling
- Understand coupling unto printed-circuit boards elements
- Develop techniques to minimize coupling or confine coupling to non-critical paths or components
- Develop numerical algorithms to predict coupling unto wire harness
- Validation through measurements

EM Understanding, Analysis and Containment



EMC Design/Control Concepts

- Shielding and Grounding
- Filtering and non-linear protective devices
- Reflection and matching
- Coupling path reduction (conducted emissions)
- Ground/reference planes
- Signal Integrity
- Signal processing techniques
- Cable routing

Shielding

Definition

Minimize amount of electromagnetic energy which penetrates from the external environment to the circuit

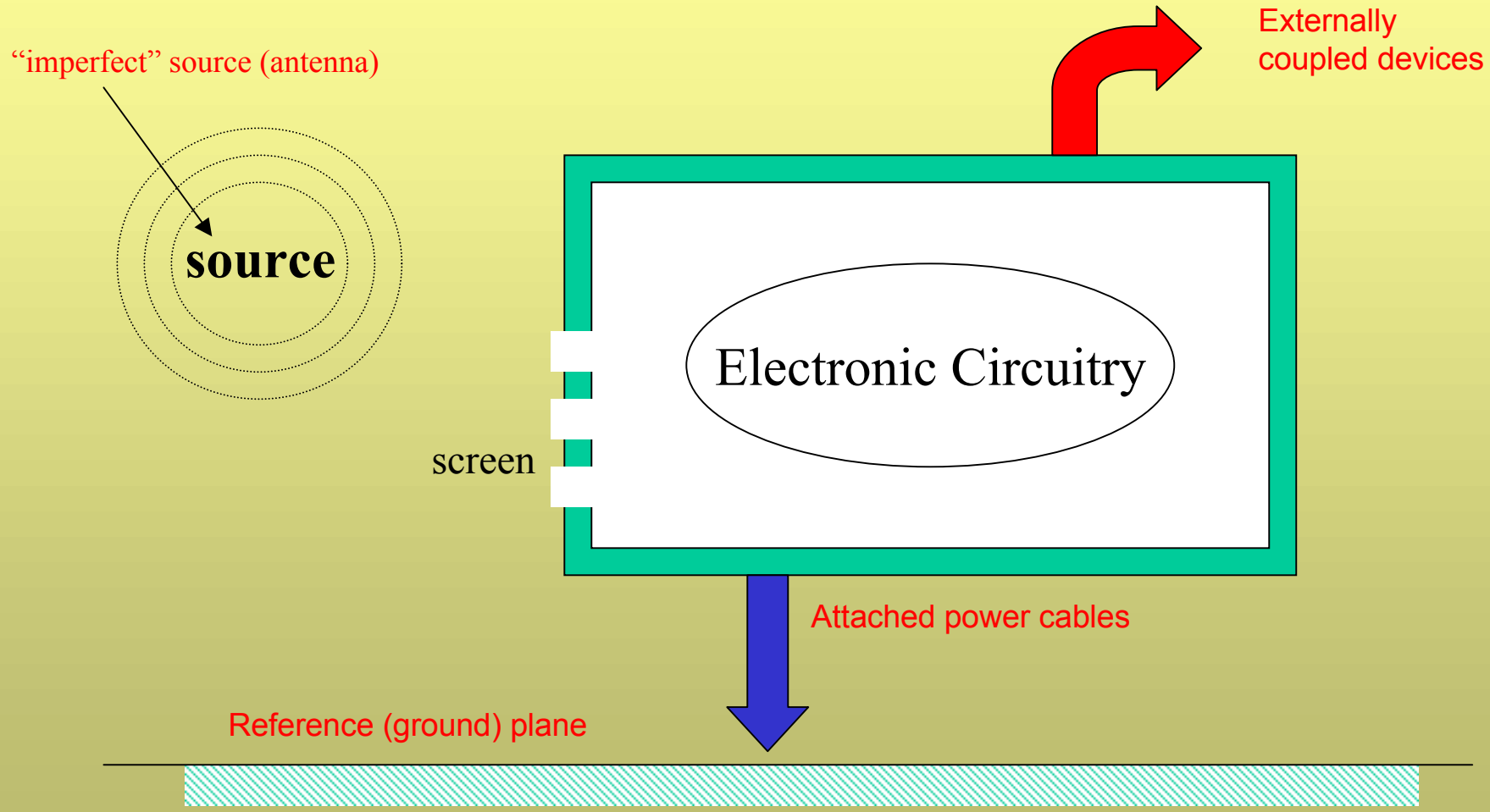
or

Influence how much energy generated by a circuit escapes to the external or adjacent environment

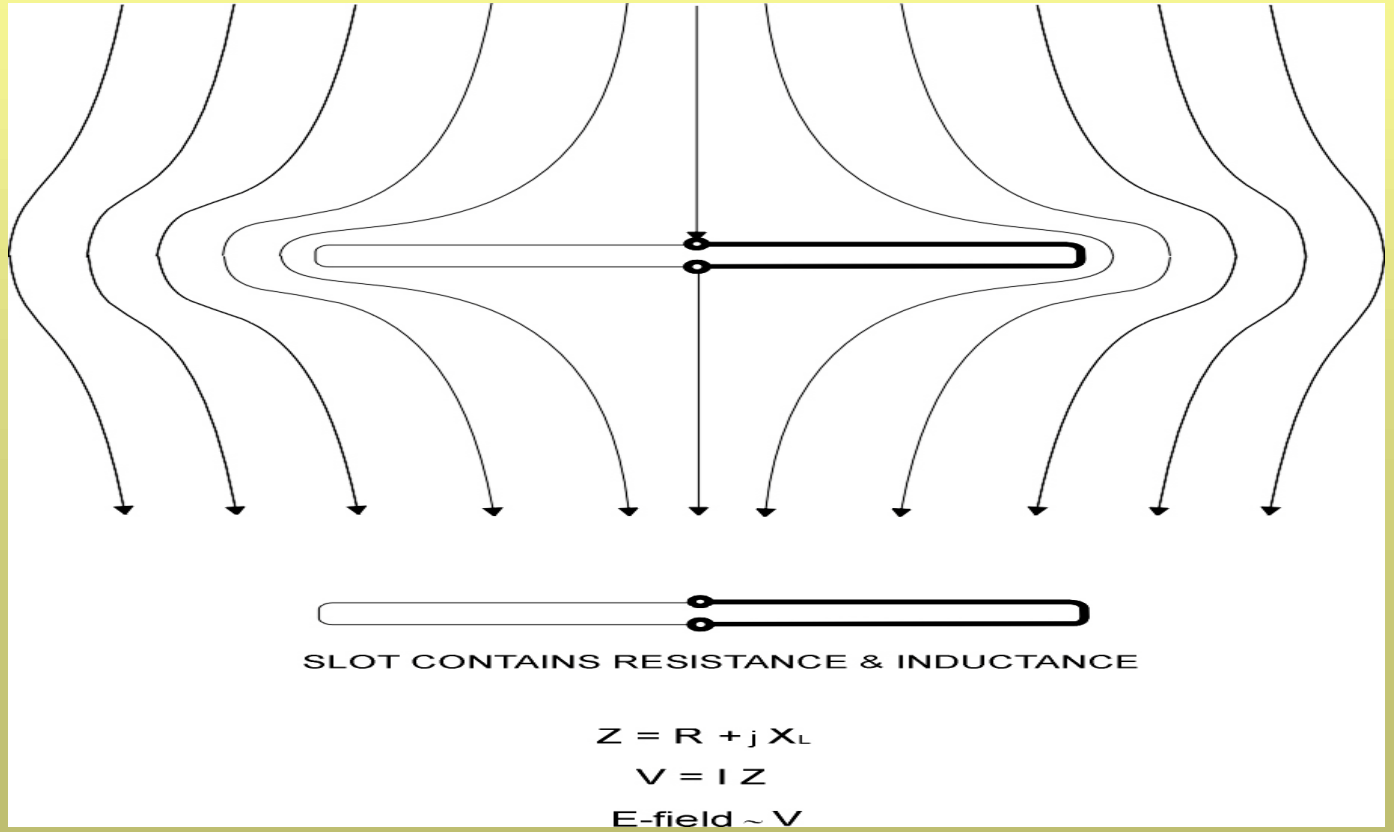
Whether source is inside or outside, shielding properties remain the same (electromagnetic reciprocity)

In practical scenarios, reciprocity still holds but needs very careful interpretation

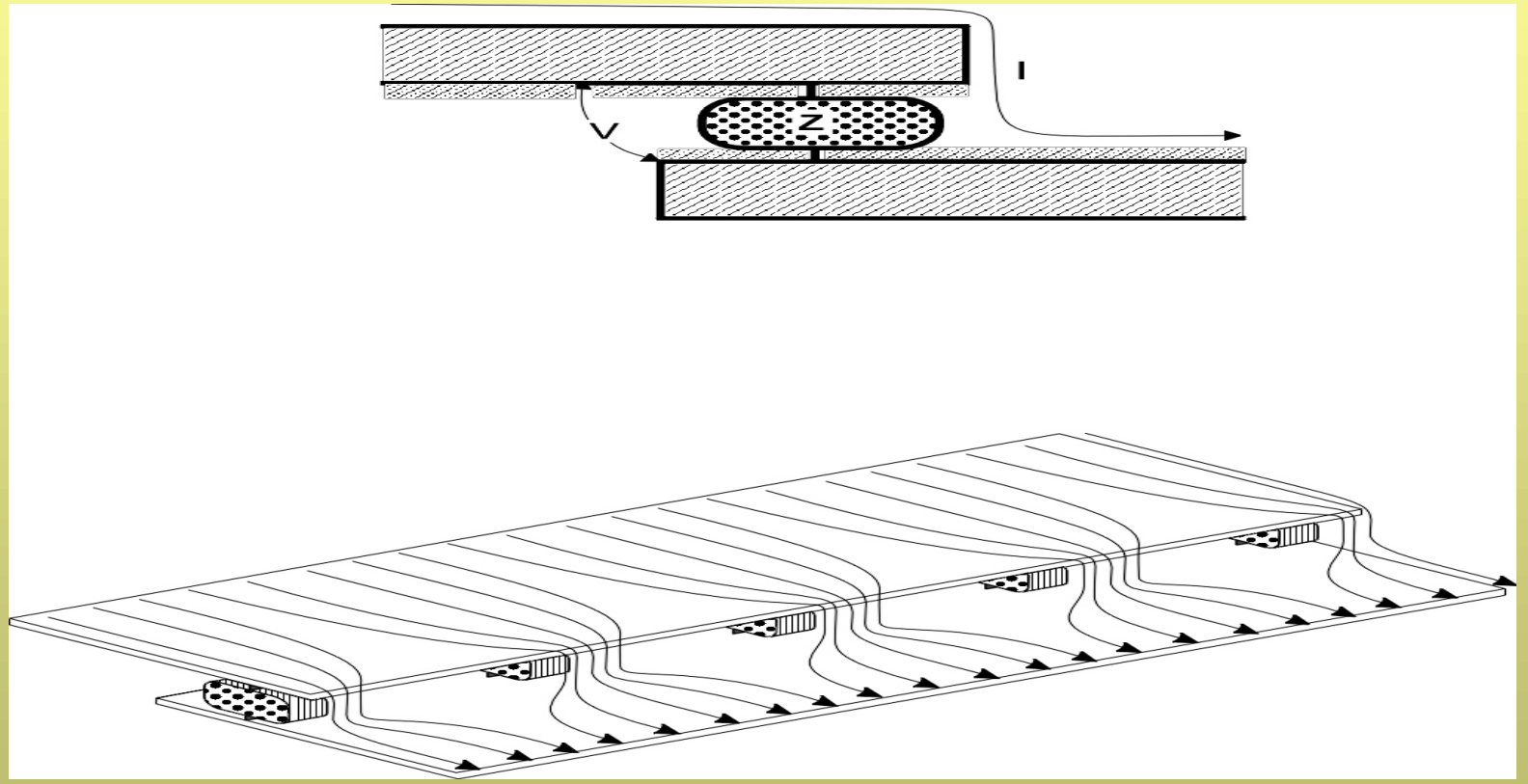
Understanding
Energy Penetration Mechanism



Understanding Behavior of Currents Near Apertures. Why do Apertures Radiate?



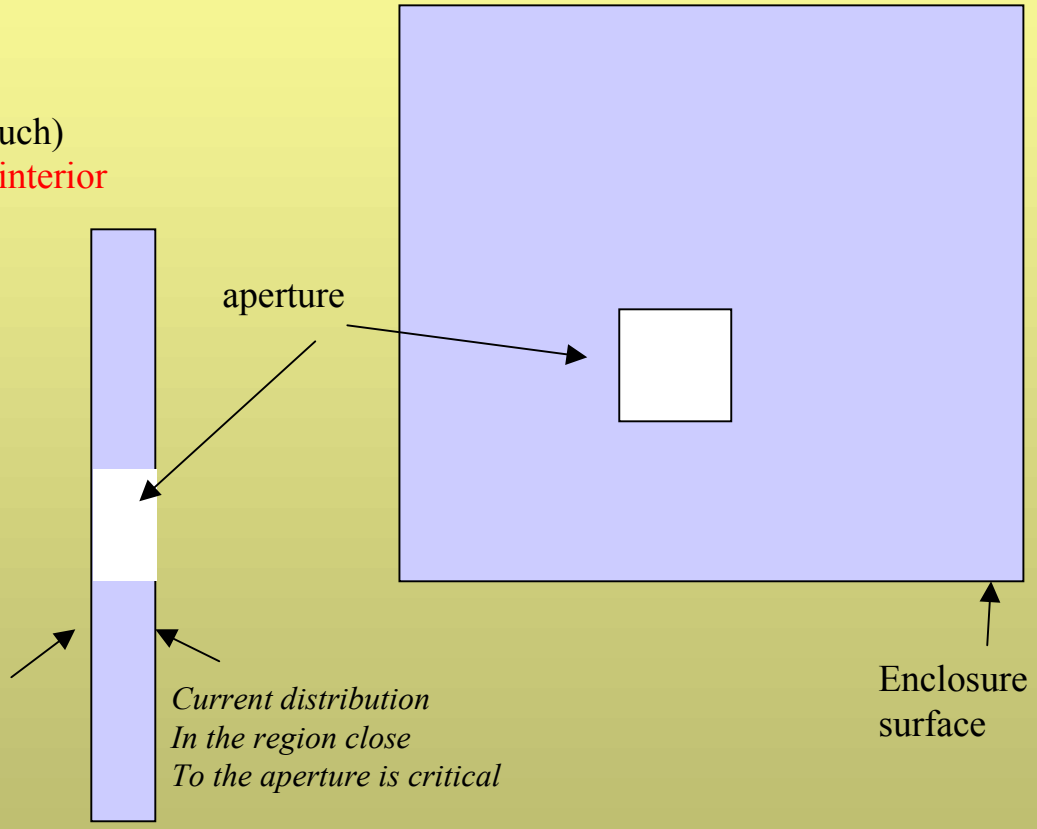
How and Why do Joints Radiate?



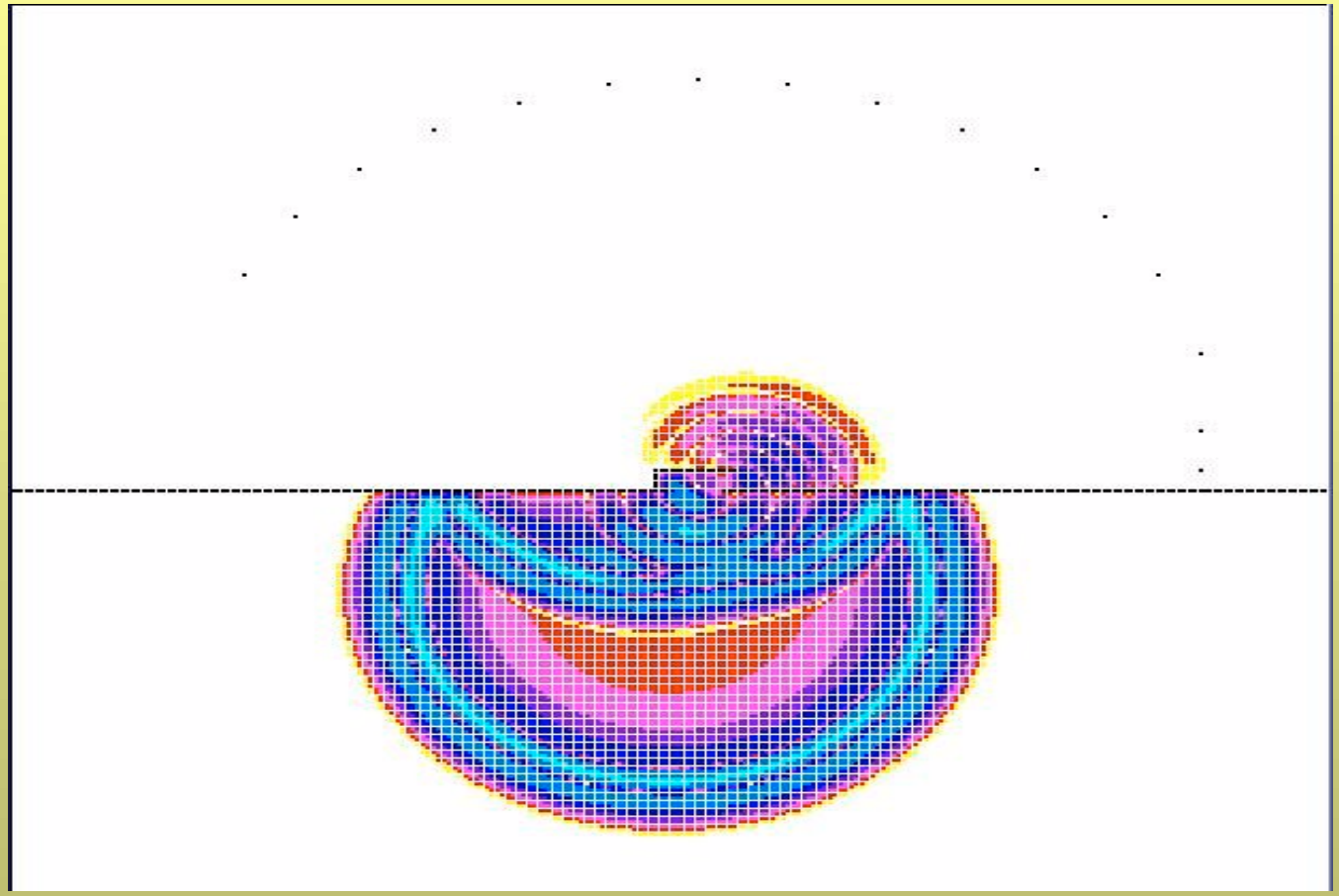
Fundamental Studies of Radiation:
Radiation through Single Aperture

Radiation through aperture depends on
- Size of aperture (cannot control much)
- Current distribution pattern to the interior and exterior of aperture

Reduction of radiation through:
- Aperture rim material
- Aperture shape



Novel Material Numerical Modeling to predict effect on current distribution



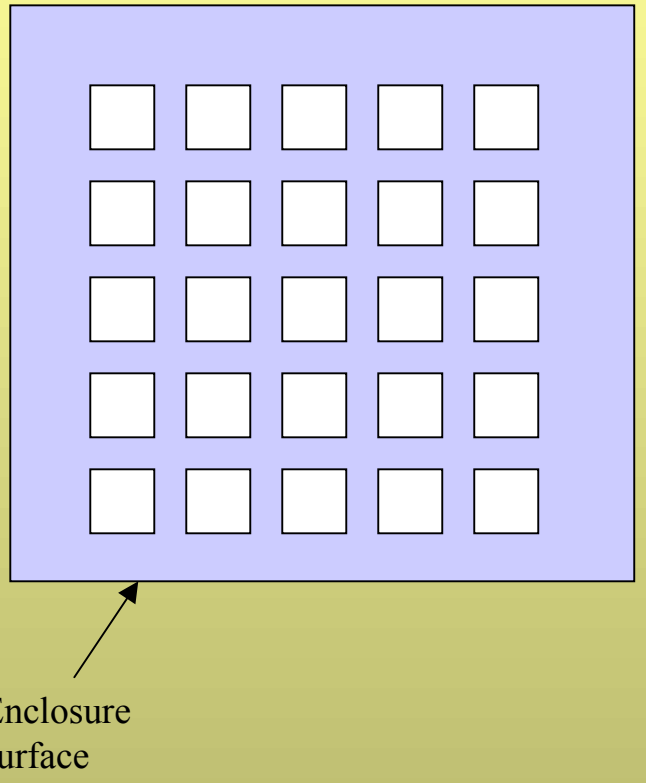
Radiation through Multiple Apertures

Radiation through aperture depends on

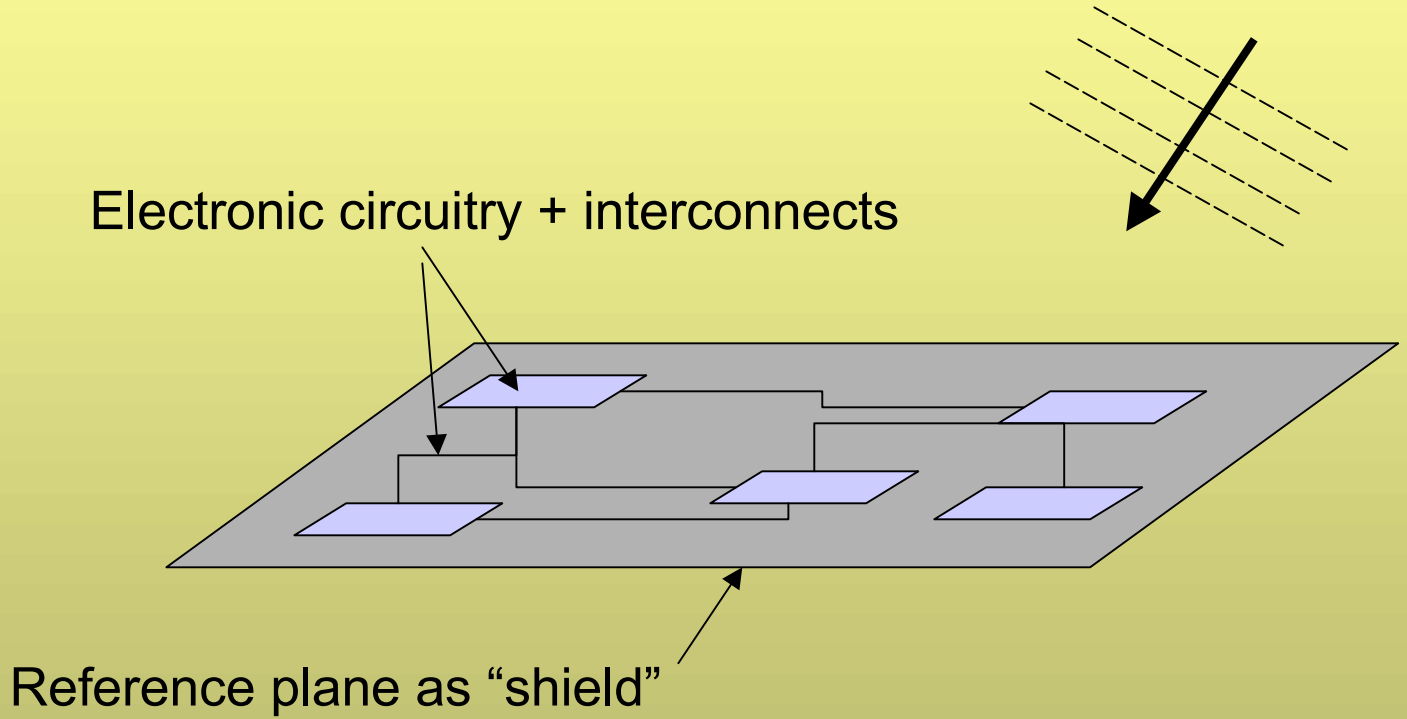
- Size of aperture (cannot control much)
- Current distribution pattern to the interior and exterior of aperture
3. Geometrical pattern of aperture array

Reduction of radiation through:

- Genetic Algorithm optimization (Selection of population through measurements)
- Current control material in the close proximity of apertures

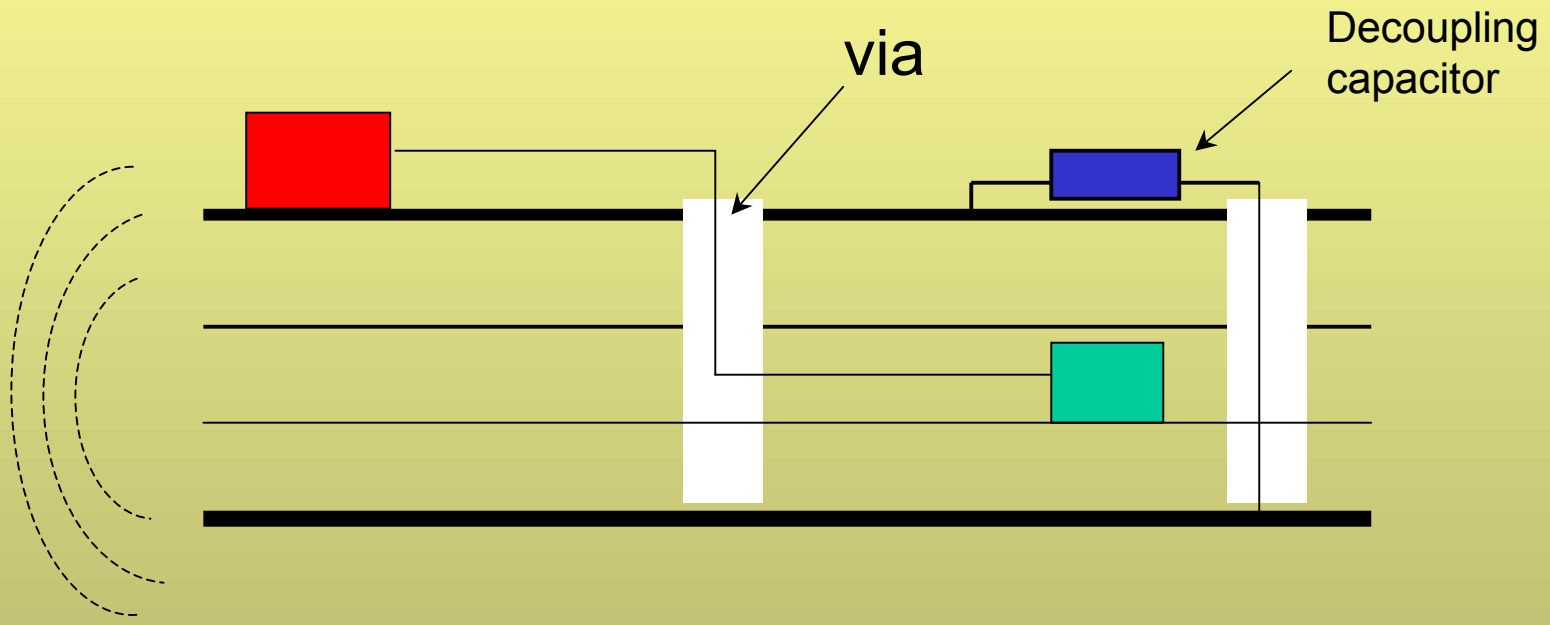


Generalized Shielding Concepts (Shielding without enclosures)



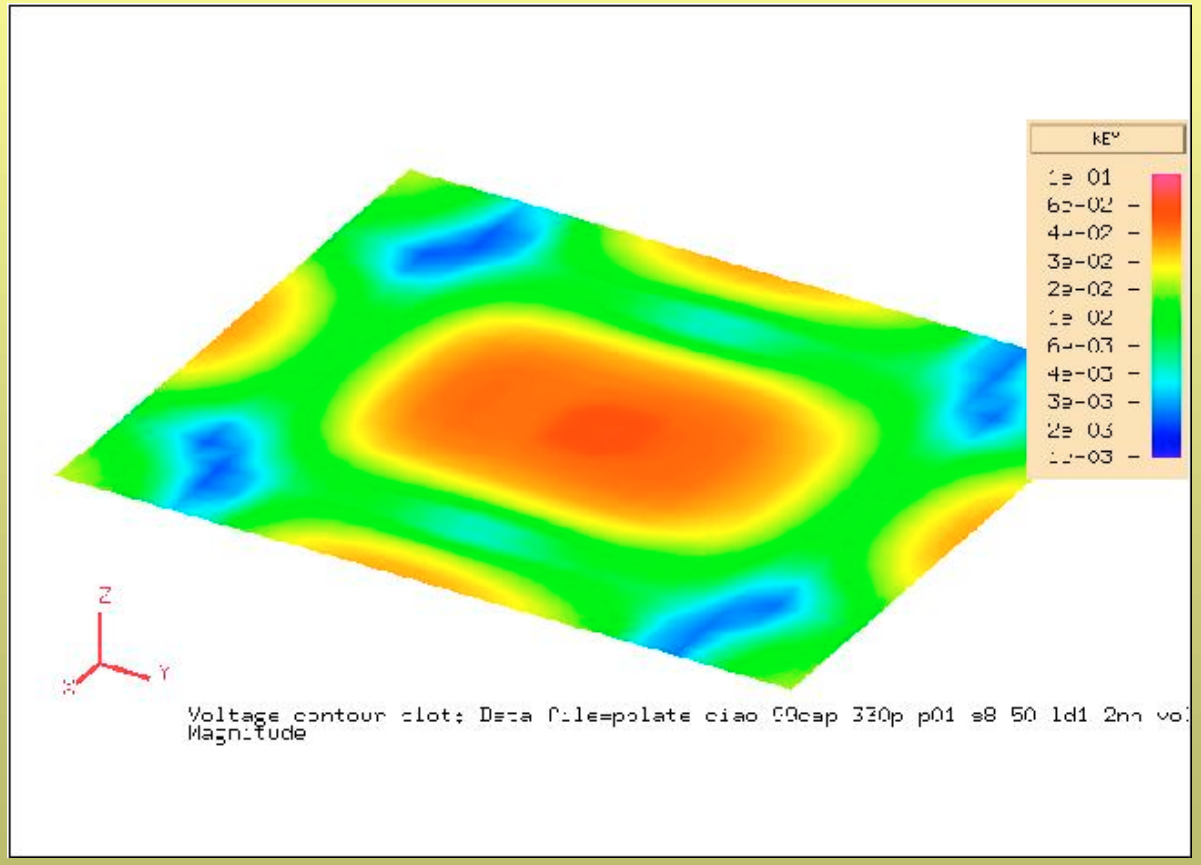
Circuit might be covered (shielded) with a RADOME
(as in the examples of wire/printed antennas…)

“Shielding” without Enclosures
Decoupling Capacitors



Board-Edge
Radiation

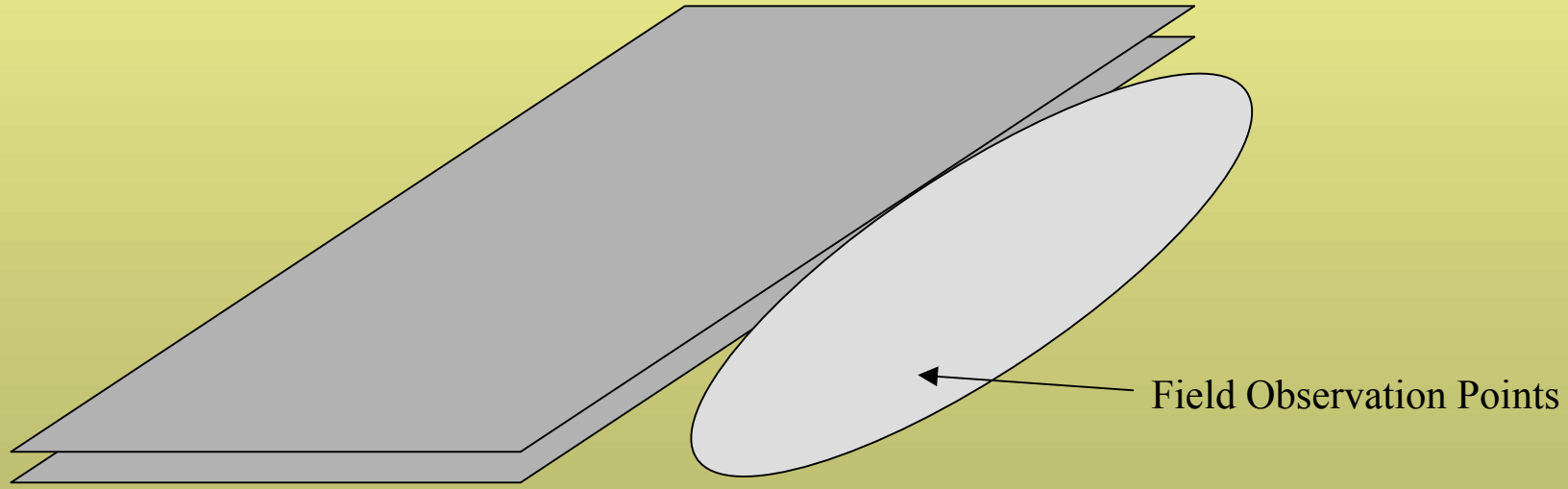
Voltage Distribution @ 950 MHz
.01uF and 330pF Case (Source in Center)



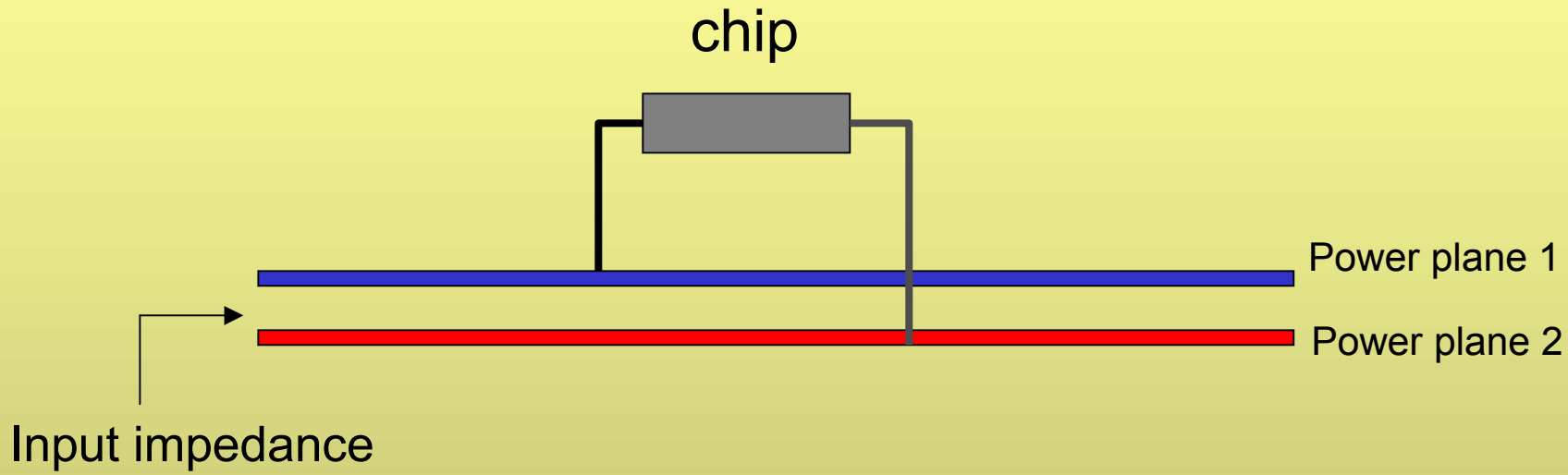
Unintentional Signals Emissions

Power Plane Switching Noise

- Circuits susceptible to radiation are also susceptible to coupling
- Develop effective near-edge design guidelines

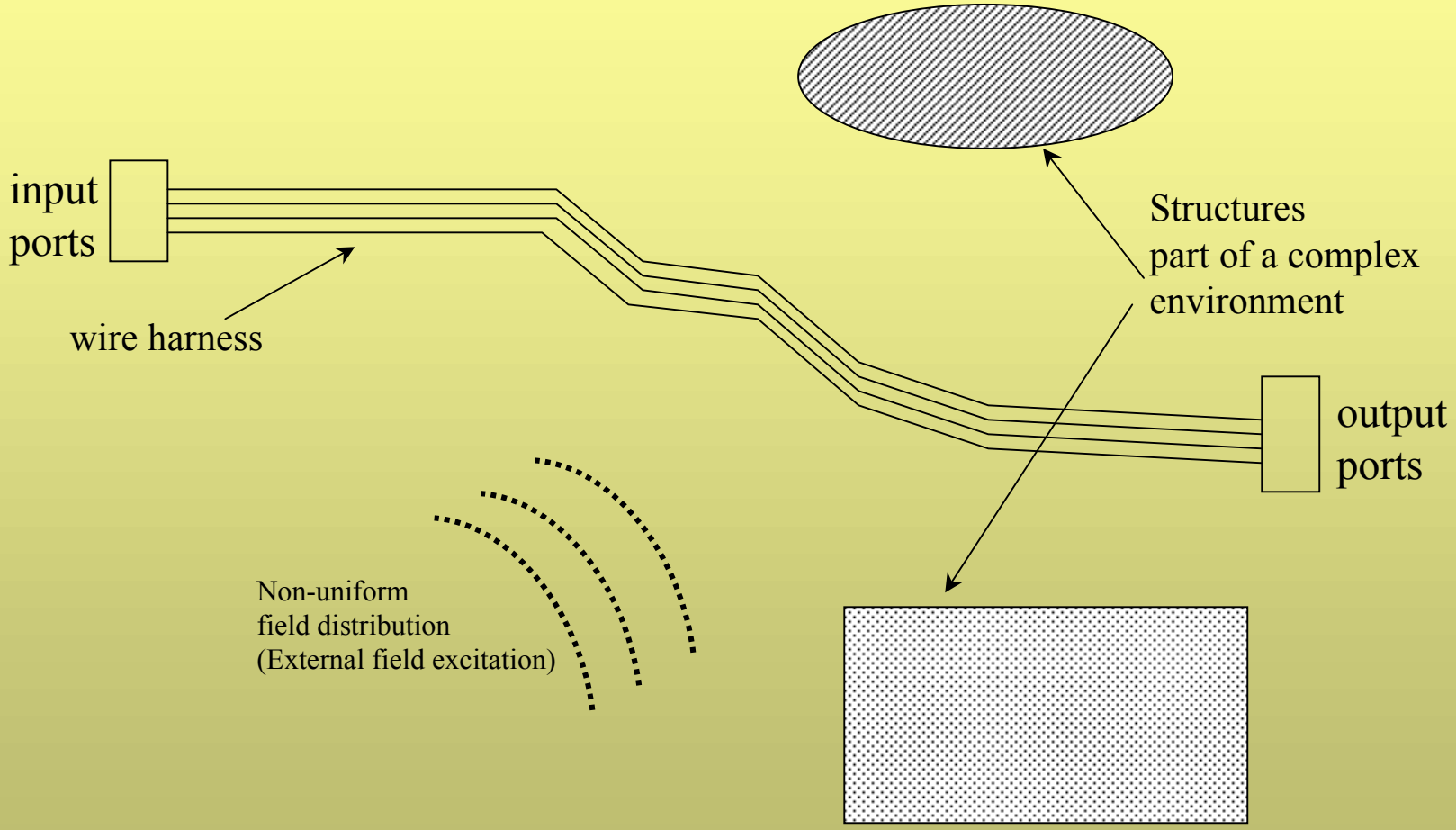


Power-Planes Approach

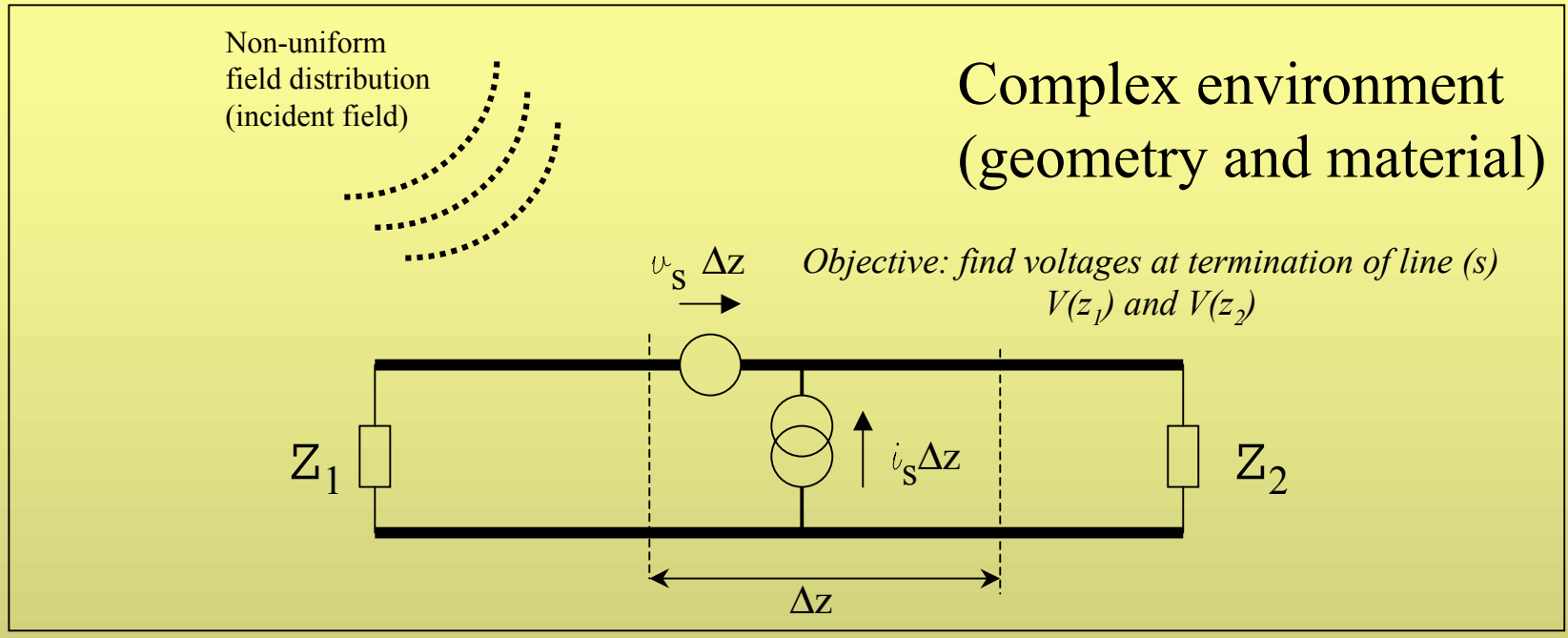


Embedded capacitance
- capacitors
- material
- Lossy material
- ?

Coupling unto Wire Harness



Problem Description



Solution Approach

- Develop Numerical Algorithms to Predict Coupling in heterogeneous environment
2. Design experiments to validate numerical models

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