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Design and simulation of printed inductors for inductive wireless power charging applications

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Abstract — *Winding coils are key elements in the design and the implementation of an effective wireless power charging platform for wireless devices such as mobile phones, smart phones and tablet computers. Planar winding inductors are low-cost, ready to integrate with the electronics and fully compatible with a general printed circuit board (PCB) manufacturing process. This paper addresses the design and the simulation of the planar winding inductors in order to overcome some drawbacks of such structures concerning mainly the quality factor and the resistive/thermal losses.*

PLANAR INDUCTIVE ANTENNAS

➢Simulation technique

FEKO: MoM-VEP, MoM-GF, MoM-FEM

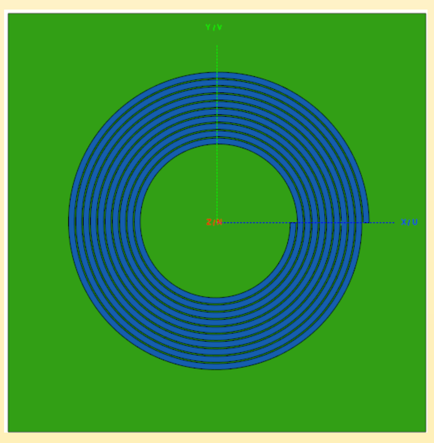
ANSYS HFSS: FEM 2D or 3D

- ✓ coupling effects, PCB impact and ferrite layers can be taken into account
- ✓ Inductive antennas (IAs) manufactured on a multilayer PCB (2 to 8 layers) can be simulated
- ✓ circuital and electromagnetic quantities can be computed directly
- ✓ other antennas such as NFC or GSM antennas can be further added and simulated using the same software

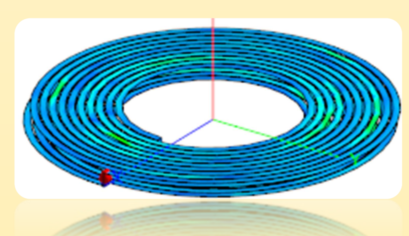
- ✓ the simulation time can be excessive. Nevertheless this drawback was overcome by using a cluster

➢Correlation

❑Benchmark structure (BS)

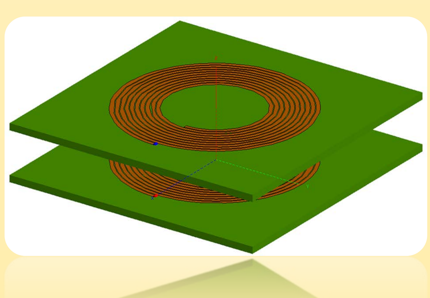


manufactured on a square FR4 PCB (60 mm wide, substrate thickness h=1.6 mm) consists of a hollow spiral with following geometrical parameters:
- •metallization thickness t=35µm
- •inner radius Ir=10.5mm
- •outer radius Or=21.85mm
- •turns n=10
- •cooper strip width w=0.85mm
- •gap between strips g=0.2 mm

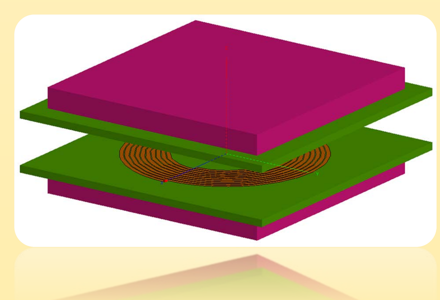


It's a two layers structure with two identical hollow spirals located on top and on bottom side of the PCB.

❑Face to face configuration



❑Face to face configuration with a shielding ferrite layer placed outside



A square ferrite L7H (52 mm wide, thickness hf=3 mm, gap between ferrite and PCB: gf=1mm) from TDK

❑Experimental and simulation (BS)

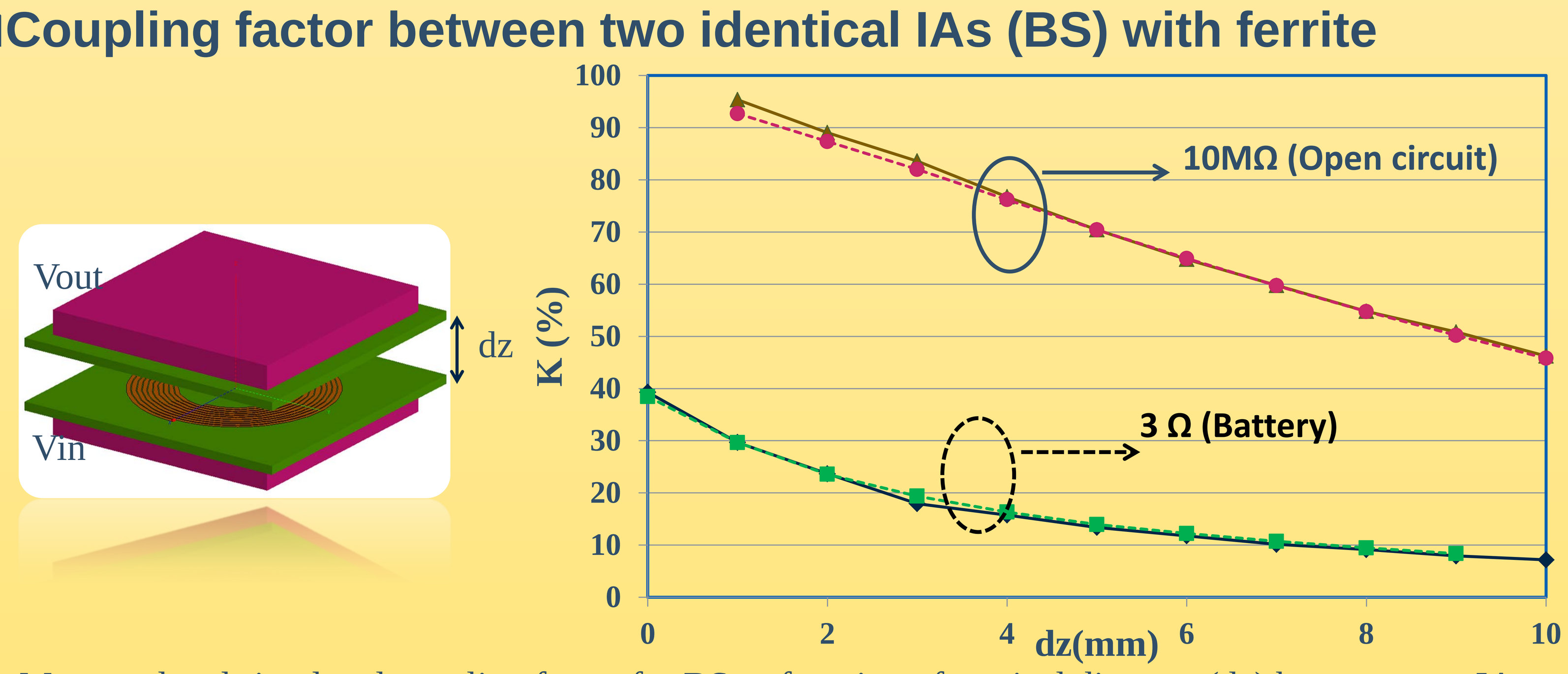
	Simulation				
Without ferrite	FEKO-VEP	FEKO-FEM	FEKO-GF	HFSS FEM	Measurement
Re(Zin) Ω	1.212	1.289	1.149	1.278	1.28
Im(Zin) Ω	10.36	11.71	9.98	10.4	10.02
With ferrite					
Re(Zin) Ω	1.22	1.37	NC*	1.45	1.33
Im(Zin) Ω	16.87	15.83	NC*	16.85	16.31

From input impedance (Zin) values reported in Table I, useful quantities (inductance: L, quality factor: Q or thermal losses, etc.) can be derived.

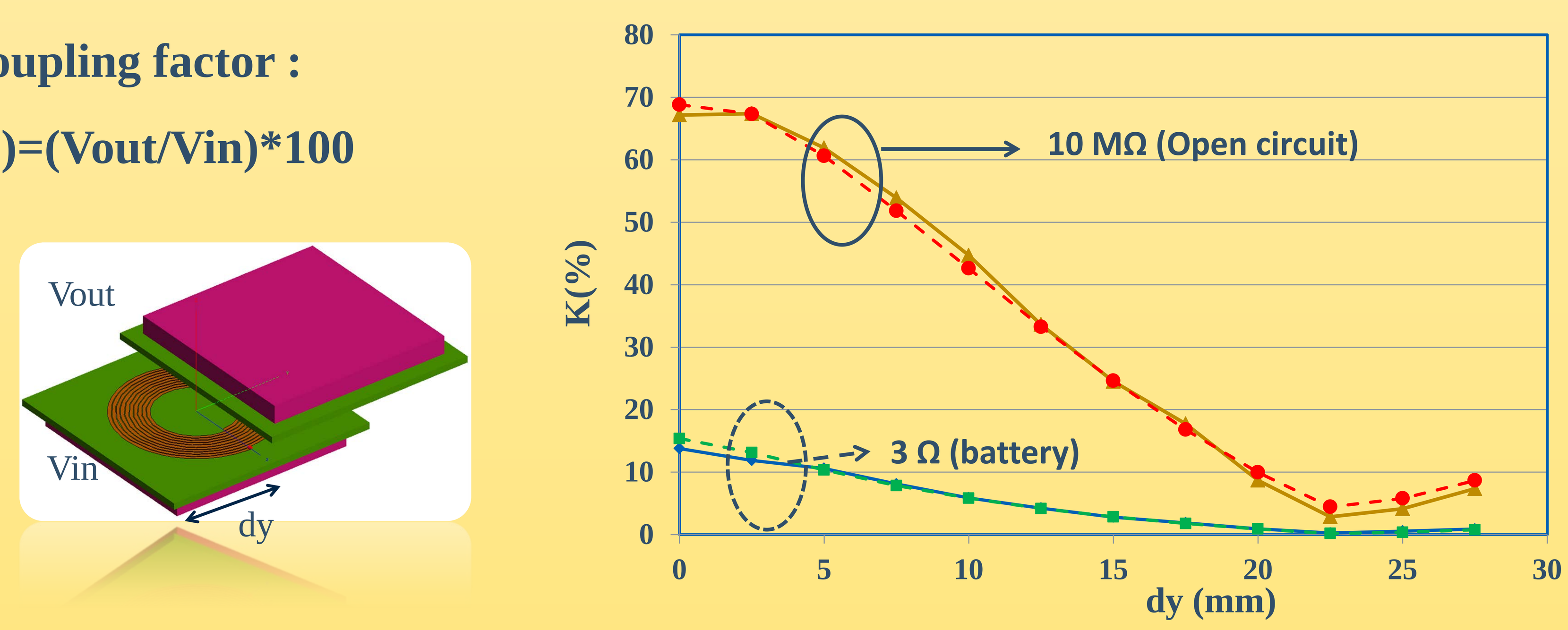
❑Coupling factor between two identical IAs (BS) with ferrite

Coupling factor :

$$K(\%)=(Vout/Vin)*100$$



Measured and simulated coupling factor for BS as function of vertical distance (dz) between two IAs surrounded by ferrite . Measurement (continuous line) with 3Ω load (diamond marker) or with 10MΩ load (triangle marker). Simulation (FEKO, dotted line) with 3Ω load (square marker) or with 10MΩ load (circular marker)



Measured and simulated coupling factor for BS as function of horizontal misalignment (dy) between two IAs surrounding by ferrite (dz=5 mm). Measurement (continuous line) with 3Ω load (diamond marker) or with 10MΩ load (triangle marker). Simulation (FEKO, dotted line) with 3Ω load (square marker) or with 10MΩ load (circular marker)

Conclusion — *The use of full wave electromagnetic simulation in order to predict IAs performances of was demonstrated by correlating numerical (FEKO simulation) and experimental results. Based on electromagnetic simulation design guidelines were derived. Minimize wire length (metallic trace), keep inductance and quality factor as high as possible (by increasing the number of turns and by reducing the gap between metallic strips within manufacturing tolerances) are the key points to design an effective IA for an efficient wireless power charging system at low frequencies (in the range of 110 kHz)*

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