FRENETIC
PARASITIC CAPACITANCE IN PLANAR TRANSFORMERS

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FEEL IT

The use of planar transformers throughout the industry is growing fast due to their advantages as low profile, higher efficiency, manufacturing repeatability and reduced electromagnetic interferences. One of the characteristics of planar transformers is the possibility of obtaining a very good coupling between windings, but the drawback is the increment of the parasitic capacitance. Consequently, obtaining the value before manufacturing the transformer is crucial for avoiding potential problems.

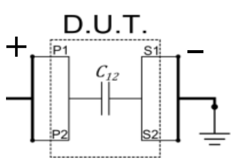
EXAMPLE OF HOW FRENETIC AI HANDLES THIS PARASITIC CAPACITANCE

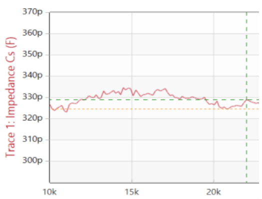
In this app note we are going to prove the effectiveness of Frenetic AI calculating the parasitic capacitance comparing Frenetic estimation with the theoretically calculated using different models and real measurements. As an example, we will use a 2 layers PCB on primary and two layers PCB on secondary transformer.

Laboratory measurements:

The values needed are obtained, with a measurement from the equipment Bode 100 and processing this data with the equations that follow.

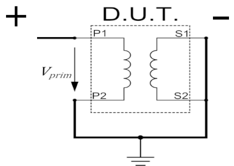
Interwindig capacitance





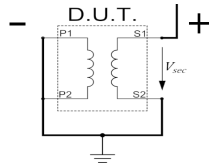
Primary Interwinding Capacitance

$$L_{C1} = L_{l1} + \frac{L_{MAG_1}\cdot n^2 L_{l2}}{L_{MAG_1} + n^2 L_{l2}} \qquad C1 = \frac{1}{\omega^2 L_{C1}}$$



Secondary Interwinding Capacitance

$$L_{C2} = L_{l2} + \frac{L_{MAG_1}\cdot L_{l1}}{n^2\cdot(L_{MAG_1} + L_{l1})} \qquad C2 = \frac{1}{\omega^2 L_{C2}}$$



Where:
- L_{MAG}: Magnetizing inductance
- Ll: Leakage inductance
- n: Number of turns
- ω: Angular frequency

Classic models:

The theoretical models from (Ziwei Ouyang, Ole C.Thomsen, Majid Pahlevaninezhad, Djilali Hamza, Amish Servansing) are used for a theoretical estimation of the parasitic capacitance.

$$C_0 = \varepsilon_r \cdot \varepsilon_0 \cdot \frac{S}{h_\Delta}$$

$$C_d = \frac{(n+1)(2n+1)}{6n} C_o$$

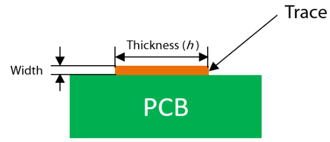
Parallel connection

$$C'_d = \frac{4(m-1)}{m^2} C_d$$

$$C_d = (n/4)\cdot C_o$$

Series connection

Where:
- S : overlapping surface area of the layers
- ε_0 : permittivity of free air space
- ε_r : permittivity of the material
- h_Δ : distances between the layers
- n : number of turns
- m : number of layers
- C_0 : capacitance between two plates
- C_d : capacitance of the same winding
- C'_d : capacitance in all layers



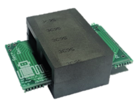
SOLUTIONS OBTAINED

Case of study:

-Primary:(type A)
- Turns = 8
- Layers =2
- Thickness = 2oz
- Area = 0.0064

-Secondary:(type B)
- Turns = 1
- Layers = 2
- Thickness = 2oz
- Area = 0.0064

Material = FR4



Frenetic AI found variables that were not considered in other models that affect in the calculation of the capacitance, and use them to obtain a solution really close to the reality and also in a short time.

Results	Measured	Classic	Frenetic AI
Operating frequency	200 kHz	200 kHz	200 kHz
Interwinding capacitance	324 pF	465 pF ±30%	320 pF ±2.3%
Primary capacitance	437 pF	581 pF ±24%	414 pF ±4.3%
Secondary capacitance	445 pF	611 pF ±27%	439 pF ±2.5%
Total Capacitance	1206 pF	1657 pF ±27%	1173 pF ±3.8%

% of error

CONCLUSIONS

In planar technology the PCB windings implementation causes higher parasitic capacitance than other technologies. The capacitance affects to the resonance frequency and operation of the transformer, limiting the operating region of the transformer, therefore, obtaining a very accurate estimation will avoid future problems.

Try Frenetic

SP Control Technologies
www.spcontroltechnologies.com

Miguel Ángel Carmona
miguel.carmona@spfrenetic.com