# Computation of Intra- and Inter- Winding Capacitances in a High Frequency Coaxial Transformer with Faraday Shield

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# Computation of Intra- and Inter-Capacitances in High Frequency Coaxial Transformer with Faraday Shield

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**Abstract —The placement and thickness of the Faraday shield in a high-frequency coaxial transformer (HFCT) has to be optimized as it has a significant influence on the intra- and inter-capacitances. This paper presents the parasitic capacitance matrix of a HFCT with and without a shield calculated by the Finite Element method. A capacitance formula is developed for the high frequency equivalent circuit. The simulation results demonstrate that the insertion loss caused by the shield can be neglected, and the intra-capacitance is almost reduced to zero if the shield is grounded properly. The calculated inter-capacitance of the HFCT is in good agreement with the experimental result. An optimized winding arrangement is used to minimize the power loss in the HFCT.**

## I. Introduction

The inter-winding capacitance couples high frequency (HF) noise from the primary winding to the secondary winding, which may cause serious common mode HF noise problems [1]. The effect of the parasitic capacitances cannot be neglected if the operating frequencies are above 100 kHz. The problem of coupling noise is commonly addressed by introducing a grounded Faraday shield between the primary and secondary windings. This paper investigates the winding arrangement of a novel HFCT [2] to minimize the winding loss and the shield effects on noise attenuation.

## II. Computation of Intra- and Inter-Capacitances

The typical HFCT (600W and 500kHz) used as an isolation transformer for a solar PV system application consists of a primary winding, secondary winding, and Faraday shield threaded through four identical magnetic cores. Six turn coils are used for both the inner and outer windings with a 30 degree spatial phase shift between the inner and outer circumferential layers. Each coil comprises litz wire with 7 strands. The HFCT structure, high frequency equivalent circuit model, and cross section of HFCT are shown in Fig. 1(a)-(c). The intra- and inter- capacitance parameters can be obtained from the distributed parasitic capacitances in the HFCT as shown in Fig.1 (d). Parasitic capacitances can be calculated using the Finite Element method (FEM). Based on the theory of the capacitance of multi-conductors system, charges on multi-conductors are obtained from the following FEM system matrix equations: $\{Q\}=[S]\{V\}$, where $[S]$ is the global coefficient matrix. For an $n$ conductor system, the lumped capacitor matrix C[$n$] is obtained, where $c_{ii}$ represents the capacitance of the $i^{th}$ conductor to ground, and $c_{ij}$ represents the capacitance of the $i^{th}$ conductor to the $j^{th}$ conductor. A formula has been derived to calculate the intra- and inter- capacitances of a HF transformer.

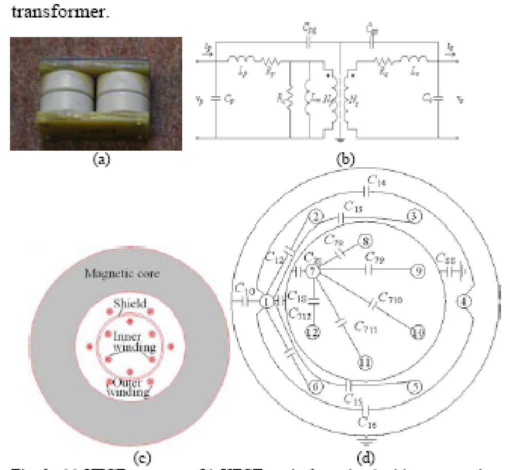


Fig. 1 (a) HFCT structure, (b) HFCT equivalent circuit, (c) cross section of HFCT, (d) parasitic capacitances of HFCT.

The coupling capacitance between the primary and secondary windings with the grounded Faraday shield was reduced significantly from 19.96pF (without shield, experimental result is 20.9pF) to 0.08pF, while $C_p$ increased from 7.67pF to 24.67pF and $C_s$ increased from 3.55pF to 22.50pF respectively where $C_{pg}$ and $C_{gs}$ were added to the primary and secondary sides through the ground.

## III. Conclusion

The inter- and intra-winding capacitances for a HFCT have been determined numerically and are in good agreement with the experimental values. With a grounded shield, the inter-capacitance is almost equal to zero and the intra-capacitances in the primary and secondary windings increase. An optimized winding arrangement was used to minimize the power loss.

## IV. References

[1] Laszlo Tihanyi, *Electromagnetic Compatibility in Power Electronics*, IEEE Press, 1995.

[2] J. Lu and F. Dawson, "Analysis of Eddy Current Distribution in High Frequency Coaxial Transformer with Faraday Shield," *IEEE Trans. On Magnetics*, vol. 42, no. 10, Oct. 2006. pp. 3171-3173.