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Analysis and design of pulse frequency modulation dielectric barrier discharge for low power applications

Key words: Dielectric barrier discharge, Rectifier-compensated first harmonic approximation, Parasitic capacitance, Power converter design

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Motivation

- Use a linear equivalent model to learn how the transformer parasitic capacitance influences the performance of dielectric barrier discharge (DBD) and give a simple design method of the transformer parameters.

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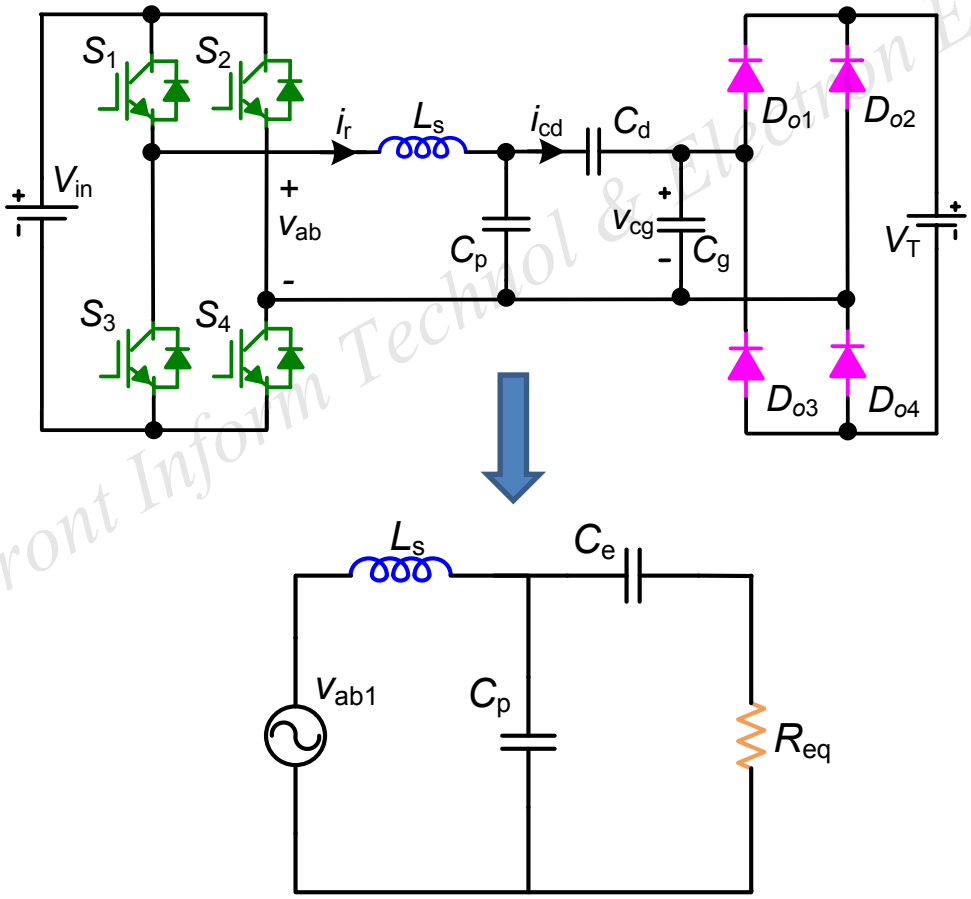
Method

- Use of rectifier-compensated first harmonic approximation (RCFHA) to linearize the equivalent model for easier analysis and more accurate result
- Derivation of equations for simple parameters design according to the analysis, considering the transformer parasitic capacitance

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Circuit analysis (I)

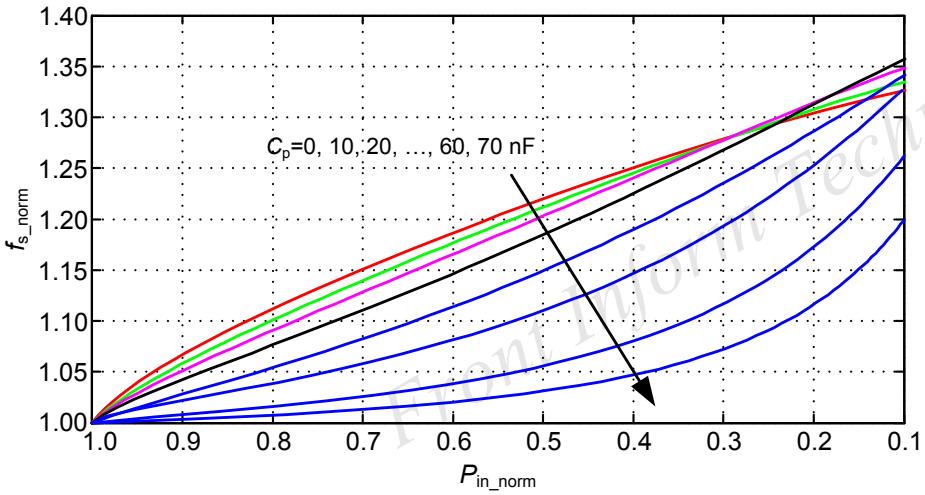
Linearization of the DBD equivalent model by RCFHA:

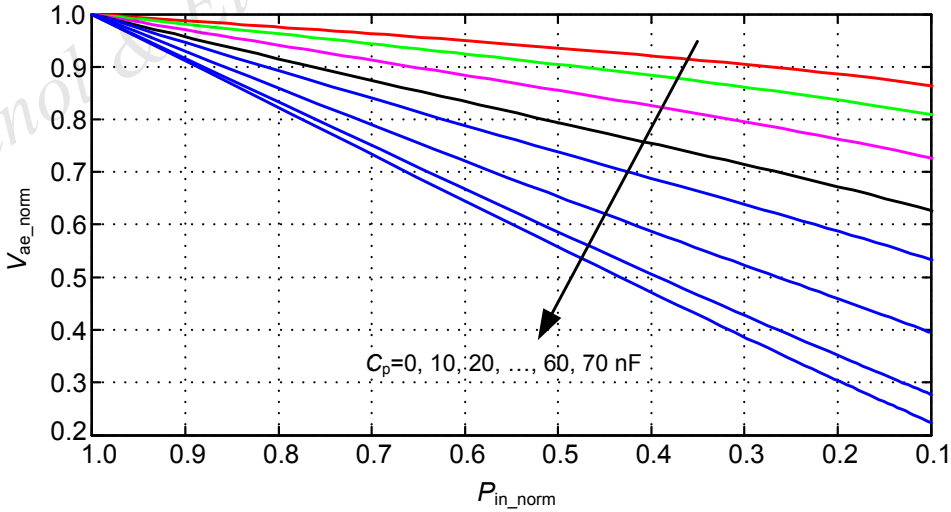


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Circuit analysis (II)

Learn the impact of the transformer parasitic capacitance on the performance of the converter:





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Design method

Presentation of the simple design procedure:

Step 1: select transformer ratio (n) and parasitic capacitance (C_p).

Step 2: calculate the transformer leakage inductance (L_s).

Step 3: calculate current stress.

Step 4: check the tolerance of C_p and L_s.

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Major results

Table 5 Simulation, calculation, and experimental results in rated conditions

Parameter	Value		
	Simulation with C_p	Calculation	Experiments
P_{in} (W)	26.6	27.3	26.8
I_r (A)	1.91	1.98	2.05
f_s (kHz)	19.0	19.0	18.1
t_{pe} (μs)	4.03	3.91	4.00
V_{ae} (kV)	7.86	8.03	7.76

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Table 6 Calculation and experimental results at variant frequencies

t_{pe} (μs)	P_{in} (W)		f_s (kHz)		I_r (A)		V_{ae} (kV)	
	Cal.	Exp.	Cal.	Exp.	Cal.	Exp.	Cal.	Exp.
6	23.3	23.0	19.6	18.7	1.92	1.95	7.75	7.80
8	15.4	15.3	20.7	19.6	1.81	1.75	7.36	6.80
10	4.59	4.53	21.8	20.7	1.57	1.65	6.17	6.00

Cal.: calculation result; Exp.: experimental result