

# Parasitic capacitances in DBD transformerless power supply: an issue?

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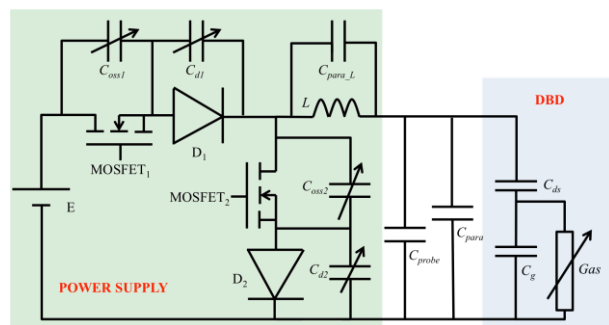
From an electrical point of view, cold plasmas are complex loads to control. This is because, for ignition, high voltages are required, and once established at atmospheric pressure, the plasma can easily go into the arc regime (thermal plasma). In Dielectric Barrier Discharge (DBD) setups, at least one dielectric is placed between the two metal electrodes that supply the gas. The capacitive character of the dielectric barriers limits the current and therefore prevents it from going into the arc regime. This property makes the DBD particularly appealing in various applications that require the use of plasmas with low temperatures: UV excimer lamps, thin film deposition and surface treatment, controls of flows and disinfection. Furthermore, to ignite the discharge at atmospheric pressure, the applied voltage usually reaches several kilovolts. This high alternating voltage is traditionally obtained via amplification using a step-up transformer. Unfortunately, the parasitic elements of the transformer (leakage inductance, inter-turn and inter-winding parasitic capacitance) specific to the physical structure of this equipment limit the power transfer: parasitic capacitance has generally low values but often are of the same order of magnitude as those of the DBD. It is parallel to the DBD, so it diverts a significant proportion of the current transferred to the DBD device. It slows down the voltage rise and delays the ignition of the discharge. Thus, the plasma remains *OFF* during a higher percentage of the operating period. During this *OFF* time, the excited species created by the previous discharge disappear. In some processes the decrease of the number of these species change the behavior of the discharge. As a matter of fact, the main consequences of the parasitic capacitance of the transformers concern the functioning of the discharge and not the energetic efficiency of the system.

Improving these performances incited us to investigate power supplies for DBD without transformer. The solution is to directly connect a high-voltage inverter to the DBD. This involves using high-voltage switches. To our knowledge, only theoretical developments have been proposed to date [1], because high-voltage switches have only been available for a few years. In this study, several switch solutions are evaluated and tested experimentally:

- 10kV SiC power DMOSFETs designed by CREE
- Low voltage (1700 V) power MOSFET in series
- High voltage power MOSFET in series

Using these devices, an innovative transformerless pulsed-current source topology (*Figure 1*) is proposed and will be detailed. We will analyze all the parasitic capacitances presented in *Figure 1* and highlight their impact on

the quality of the power transfer. In the proposed topology, the largest parasitic capacitances (switches) are isolated from the DBD by an inductance. So they do not affect the *OFF* time and the behavior of the discharge. However, they can produce some oscillations when all the switches are open. This is not a real problem but should be noticed.



**Figure 1:** Power supply and DBD electrical model with parasitic capacitance (arrows indicate the variability)

The main issue is in fact related to the efficiency of the supply: indeed, parasitic capacitances of the switches ( $C_{oss}$ ) hold a high voltage and so a high energy before switching ( $1/2 \cdot C_{oss} \cdot V_{MOS}^2$ ). This energy is integrally dissipated in the MOSFET at turn *ON*. These losses depend only on the voltage sustained by the switch (for a given  $C_{oss}$  value). When the converter transmits high power, these losses are acceptable; however, when the power injected into the DBD decreases, the efficiency of the converter decreases significantly. For low power, the best way is to decrease the global capacitance of the switches. 10kV switches are currently designed for high current application (switch currents up to 10A): their parasitic capacitances are high ( $C_{oss}=150 \text{ pF}$ ). Thus, the only solution is the use of series connected MOSFETs. It allows naturally to decrease the equivalent capacitance but requires an accurate voltage balance.

The design of high voltage converter without transformer is not an obvious process. We highlight the main negative effects caused by the parasitic capacitances on the DBD and on the converter, and we propose a set of solutions in order to reduce these issues.

## References

- [1] El-Deib A, Dawson F, Zissis G. Transformer-less current controlled driver for a dielectric barrier discharge lamp using HV silicon carbide (SiC) switching devices *Energy Conversion Congress and Exposition (ECCE IEEE)*, pp.1124-1131, 17-22 Sept. 2011.

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Areas and application fields:

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	Plasmas and liquids
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