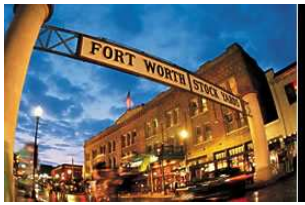
Karlsruhe Institute of Technology

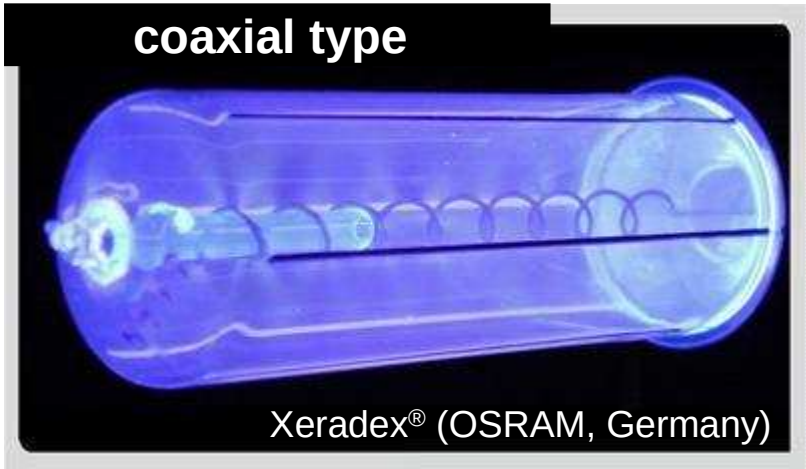


Universal Resonant Topology for High Frequency Pulsed Operation of Dielectric Barrier Light Sources

Michael Meisser, Rainer Kling, Wolfgang Heering

Light Technology Institute (LTI), Department of Electrical Engineering and Information Technology

Dielectric Barrier Discharge Lamps - DBD



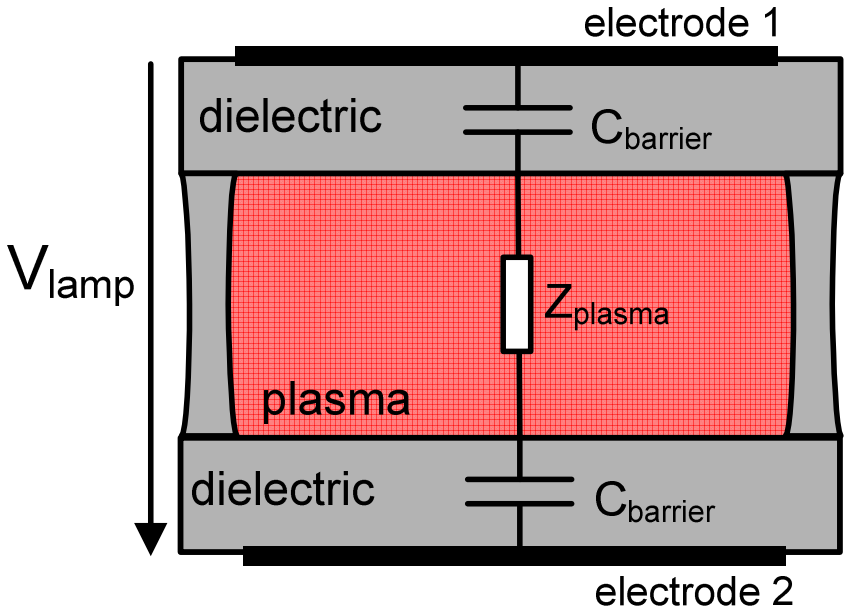
features:

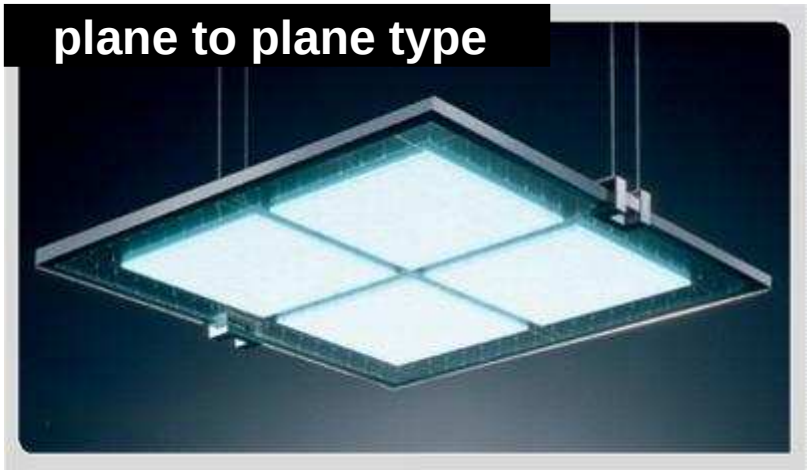
- instant-on, no run-up
- long lifetime
- areal radiation
- various wavelengths
- mercury free

applications:

- ultraviolet light source:
  - surface modification,
  - lacquer curing
- visible light source:
  - scanner and copying machines e.g. XeFI™ (OSRAM, Germany)
  - ambient lighting

Dielectric Barrier Discharge Lamps – Set-up





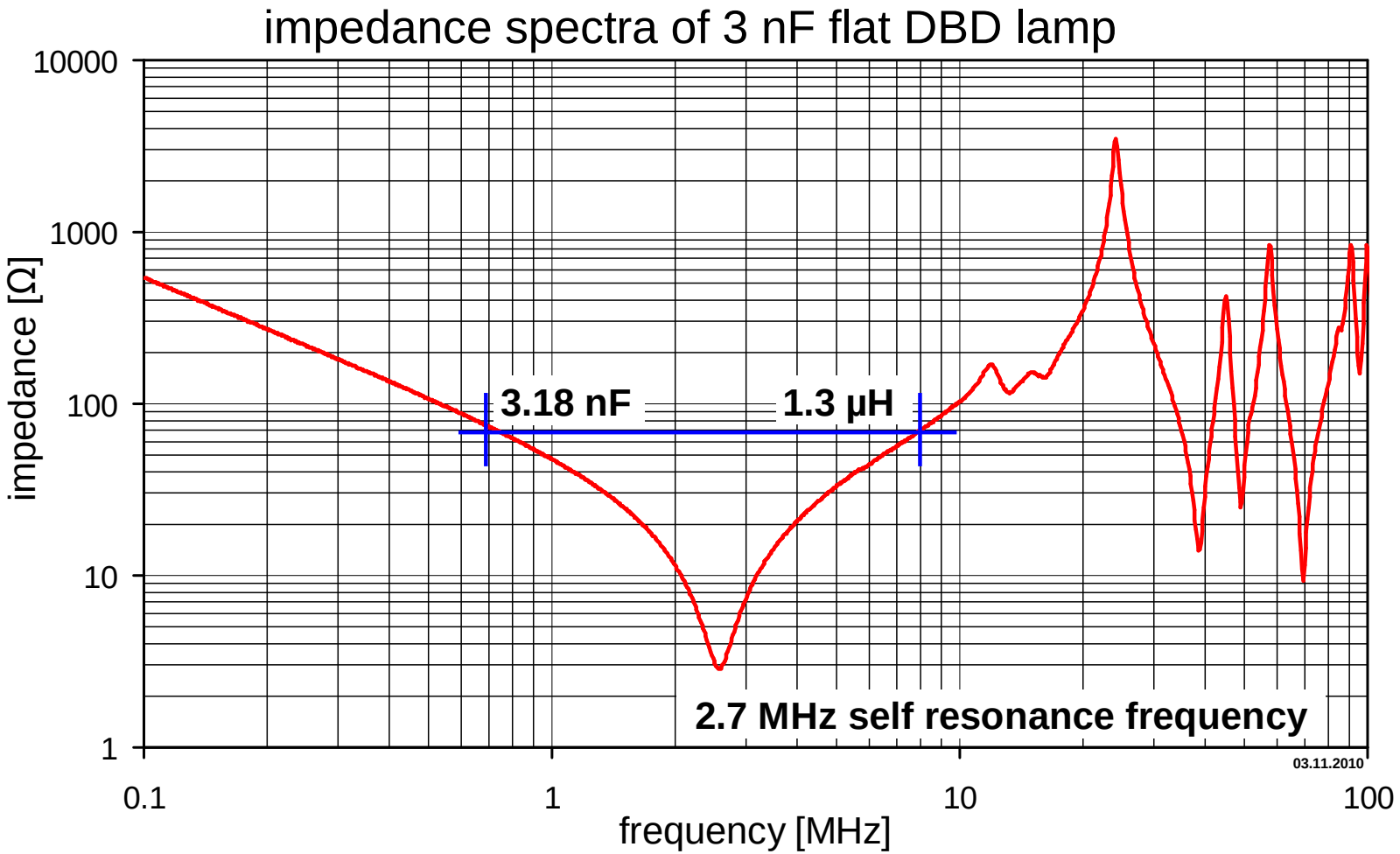
electrical characterization:

- low power factor – capacitive load
- dirac-like power consumption

operation requirements of DBD:

- high AC voltage amplitude
- high frequency pulsed operation
- idle time between pulses

DBD lamp parasitics



- significant series inductance
- LCR resonant circuit

Requirements to Driving Circuit

high electrical efficiency

high pulse frequency

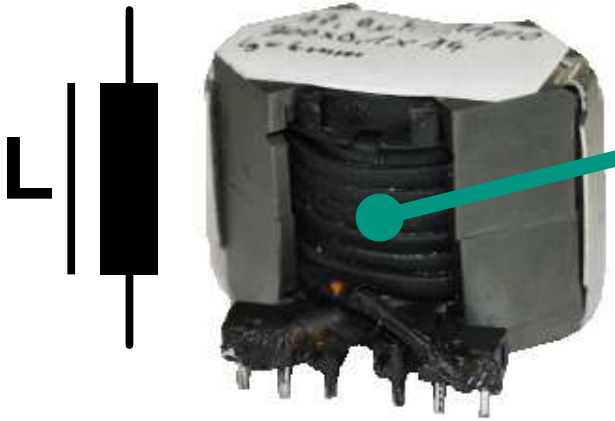
energy recovery

low input voltage

high output peak voltage

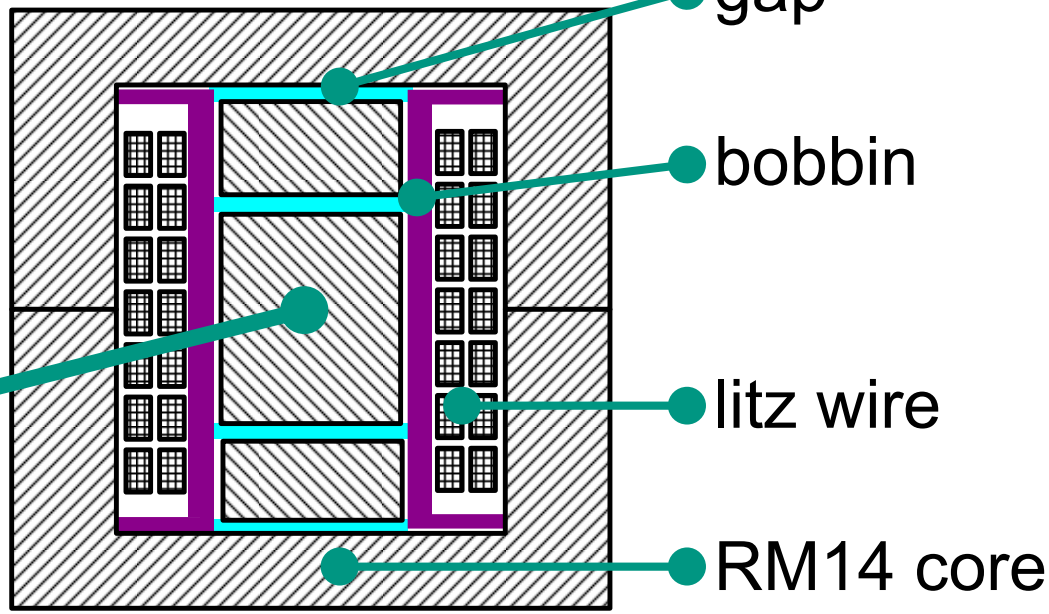
Combination of Precharge and Resonance

precharge



high energy inductor

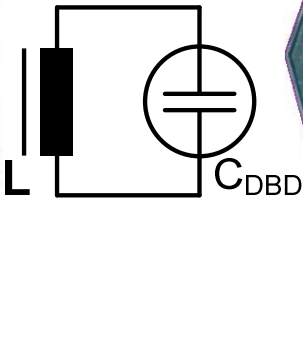
E_L > 7 mJ



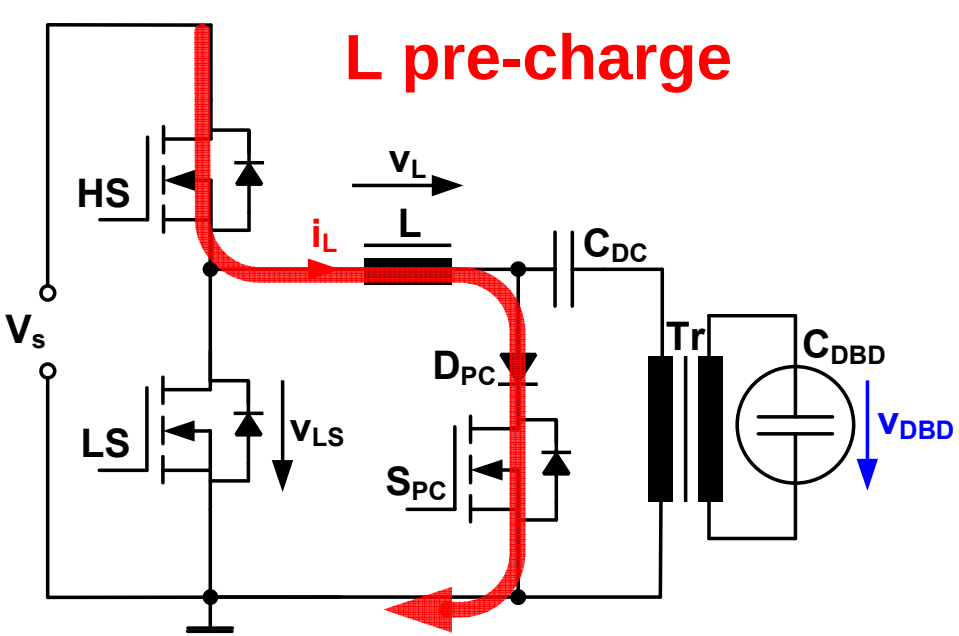
Combination of Precharge and Resonance

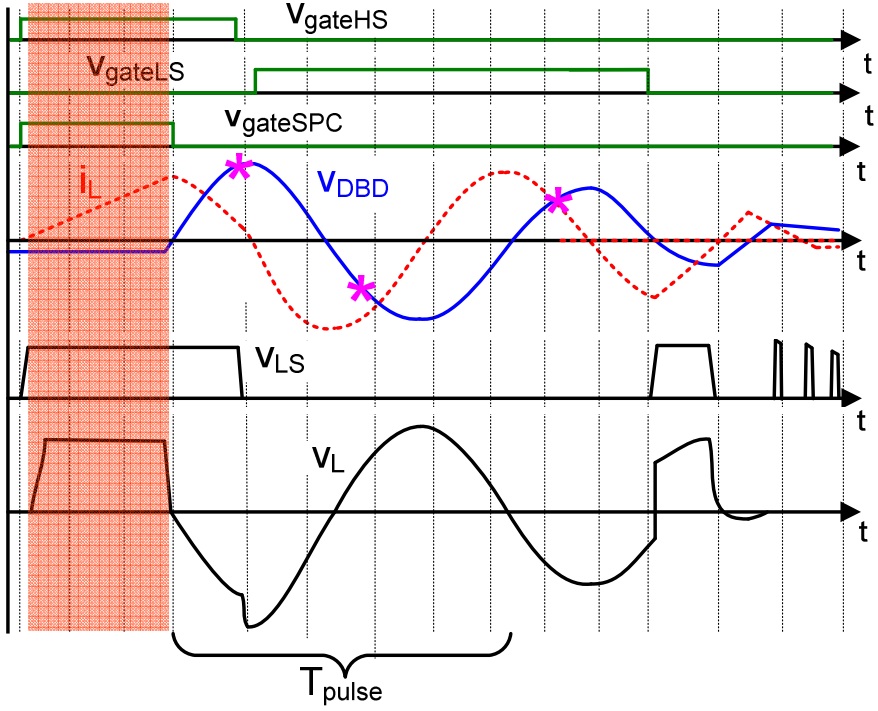
precharge

resonance



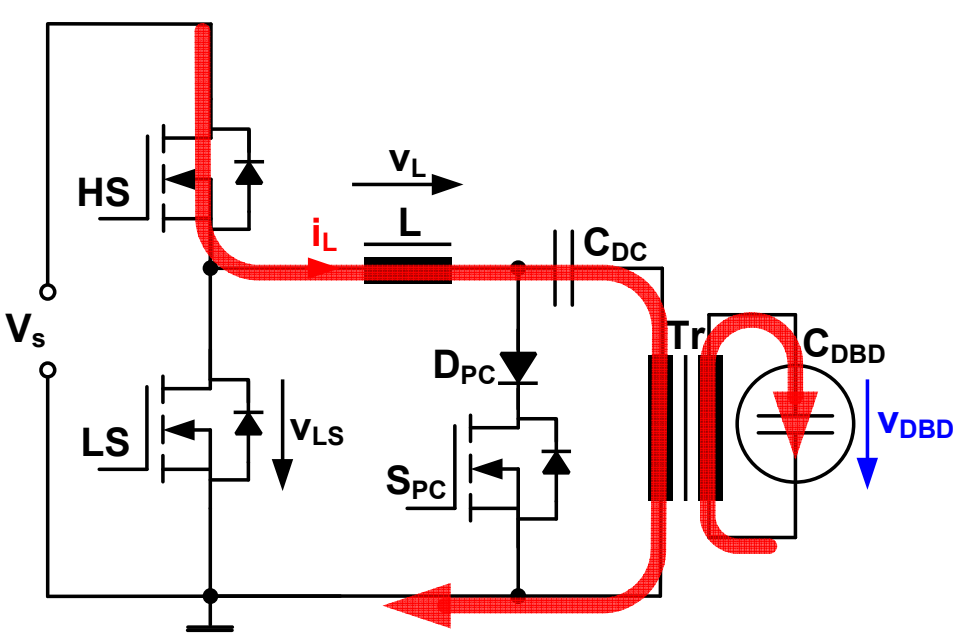
Schematic and Operation Mode of the Universal Sinusoidal Pulse Topology

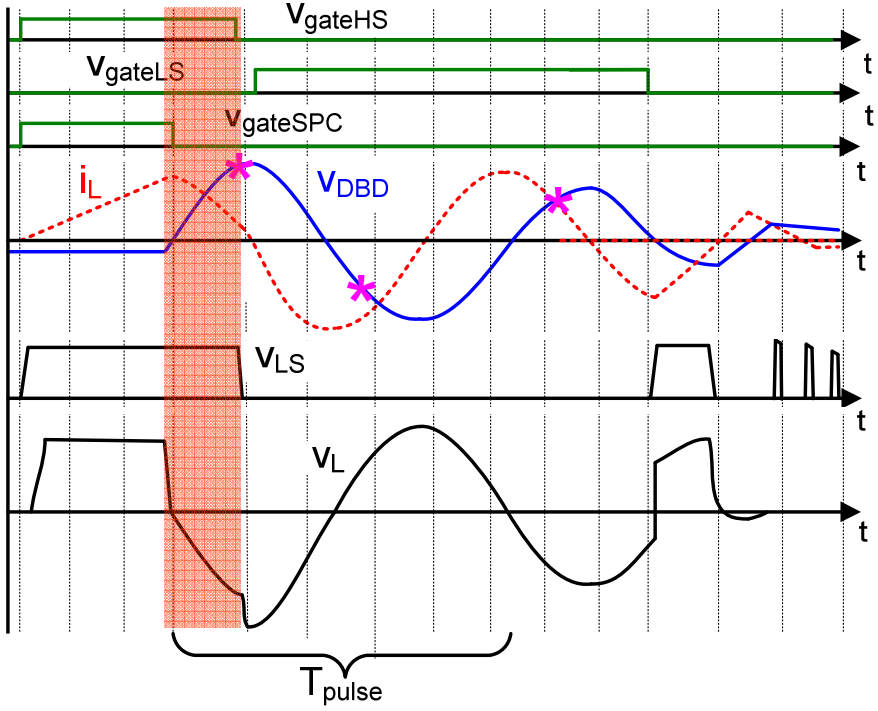




- universal: ability to adjust to different loads and different input voltages

Schematic and Operation Mode of the Universal Sinusoidal Pulse Topology





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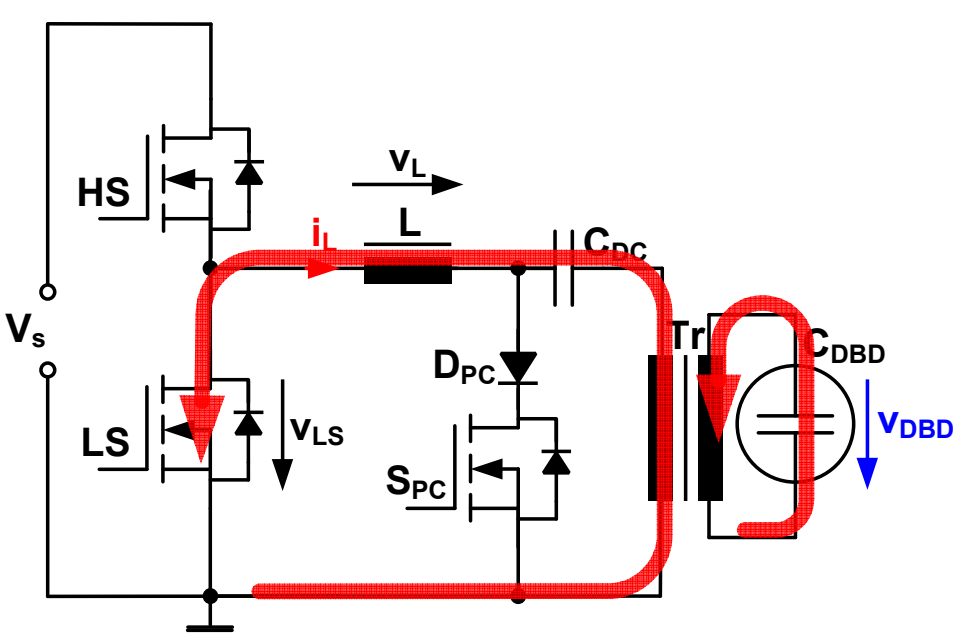

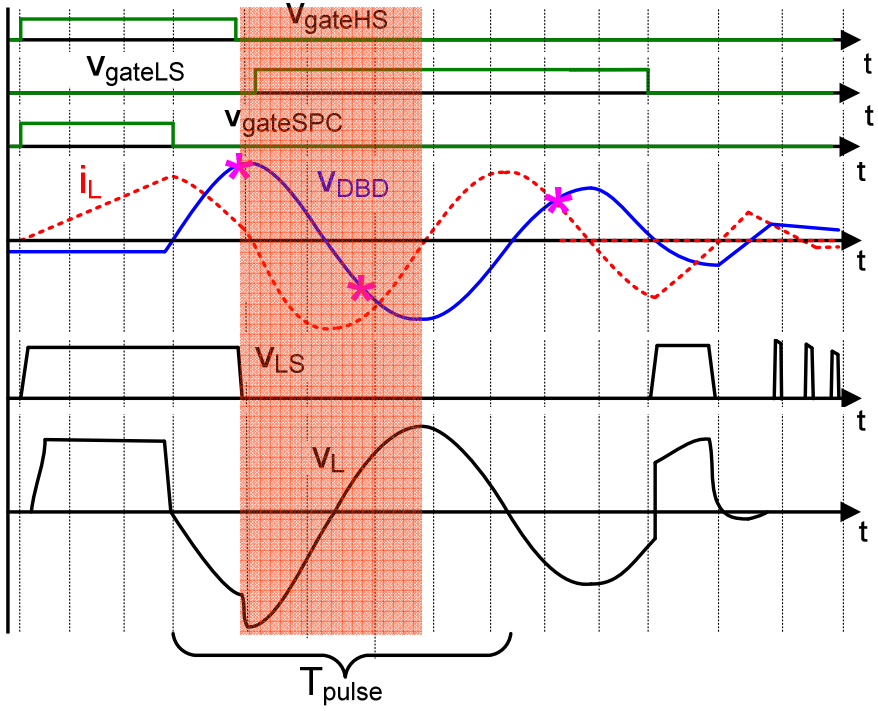

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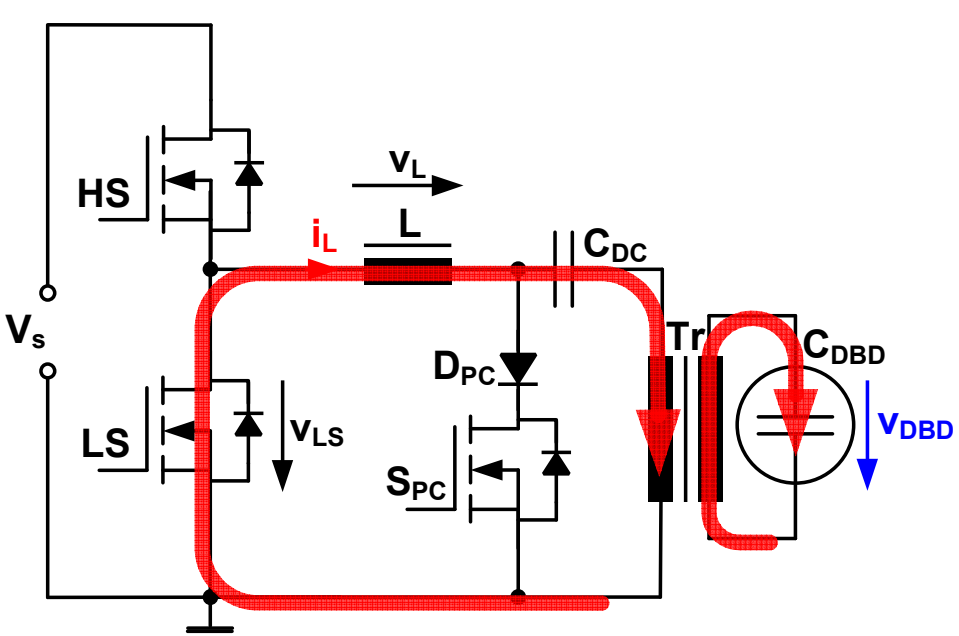
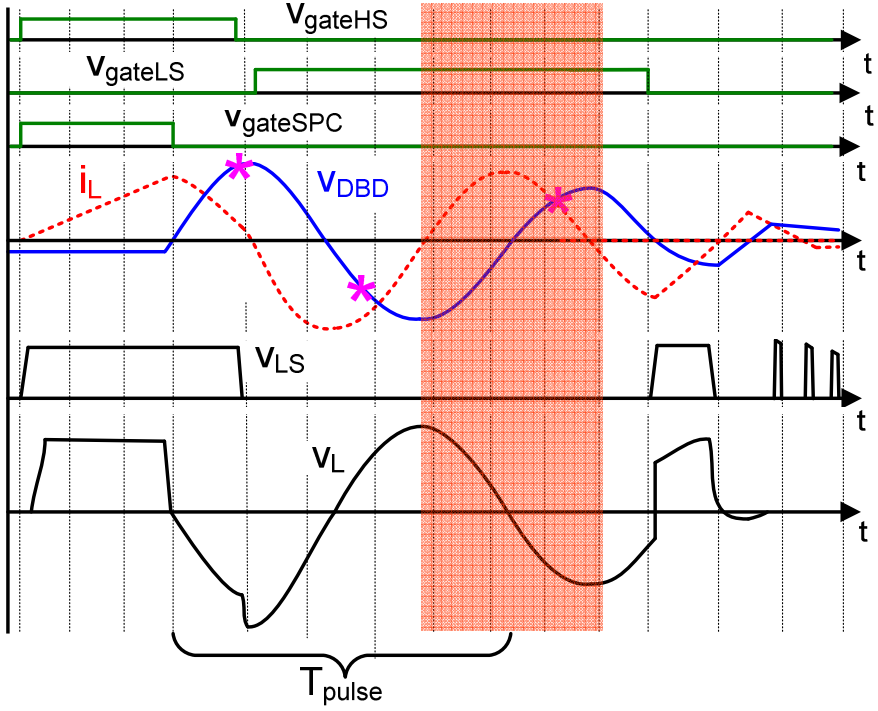
Schematic and Operation Mode of the Universal Sinusoidal Pulse Topology





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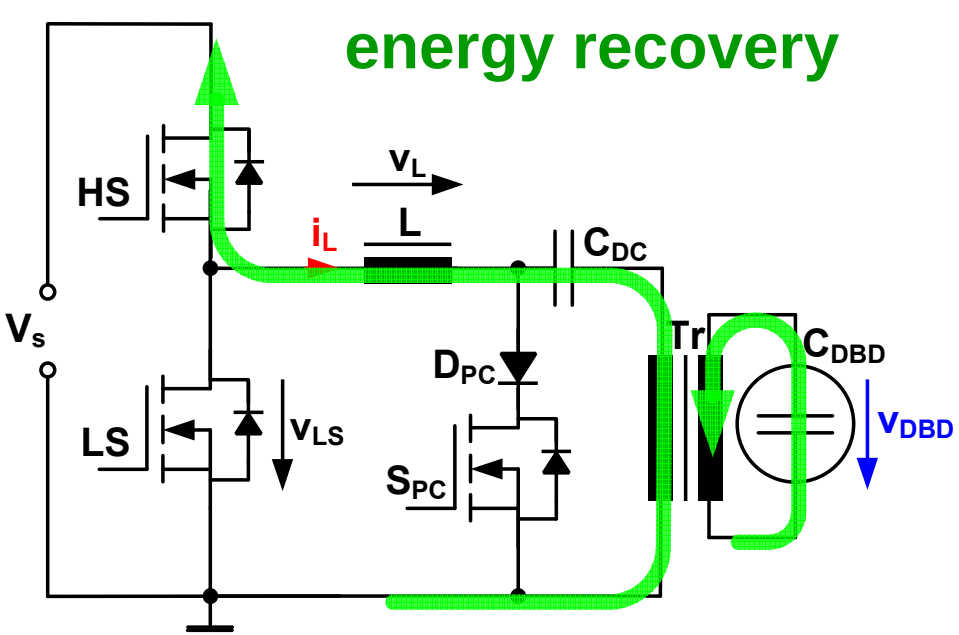
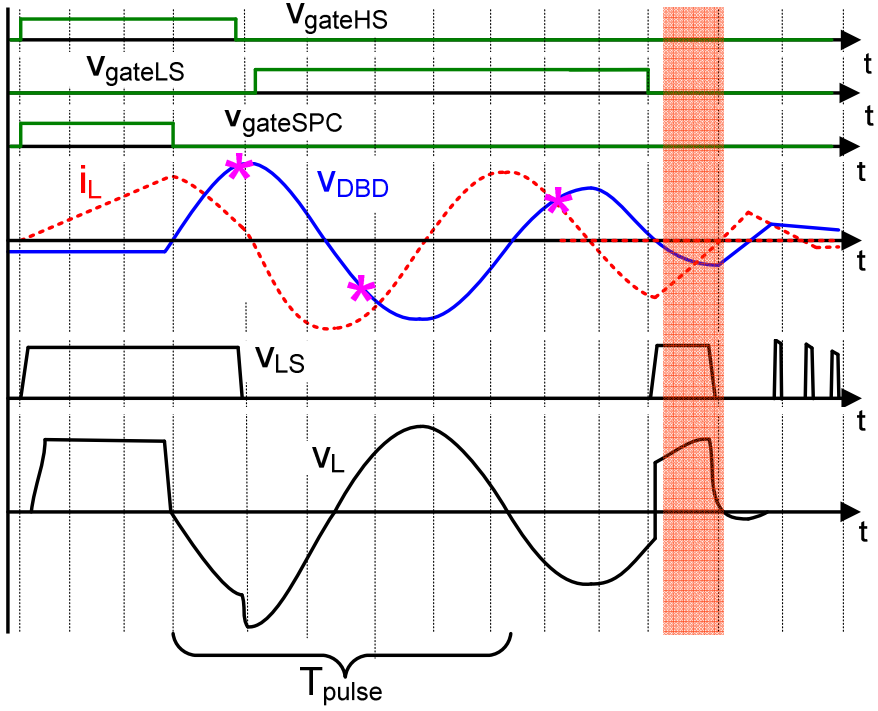
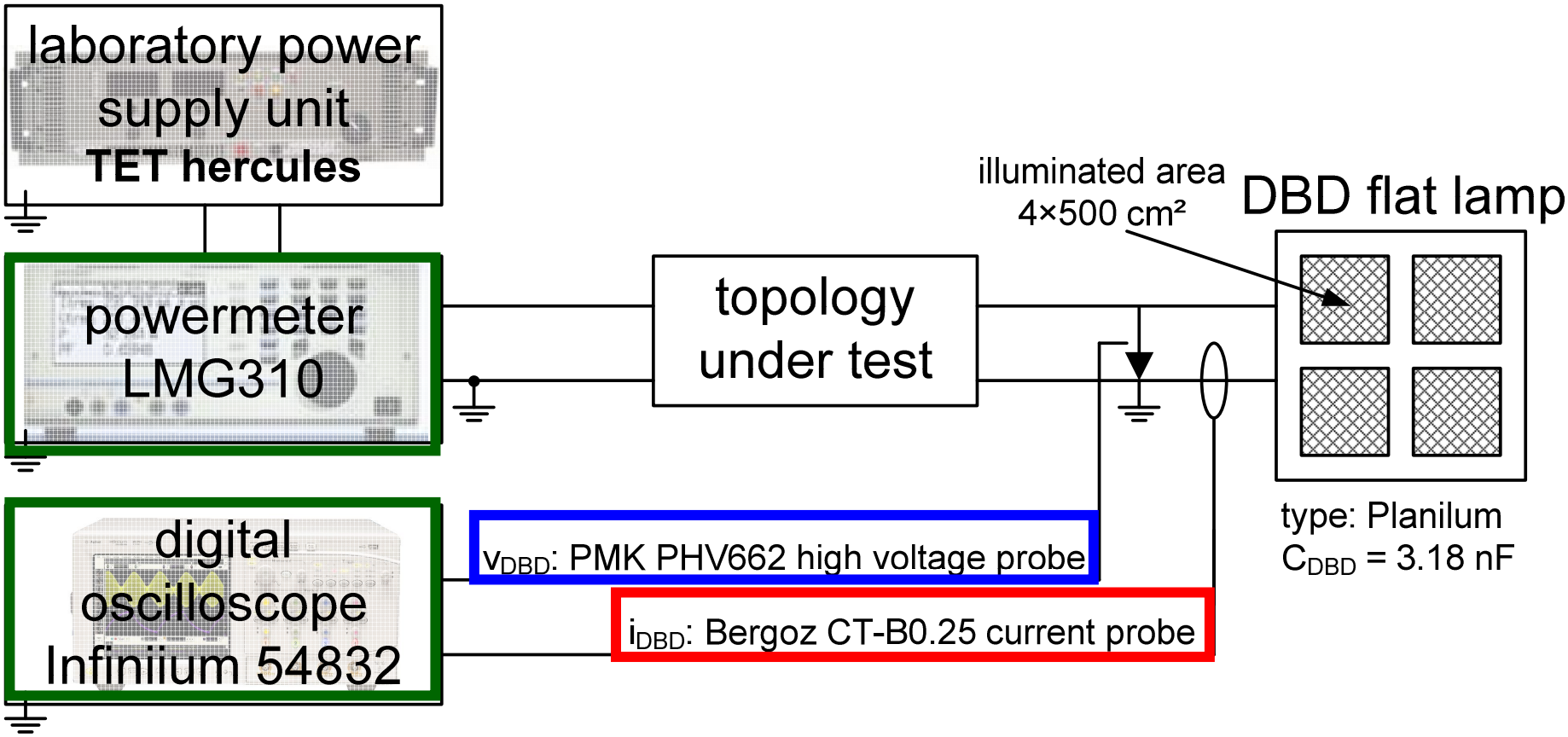


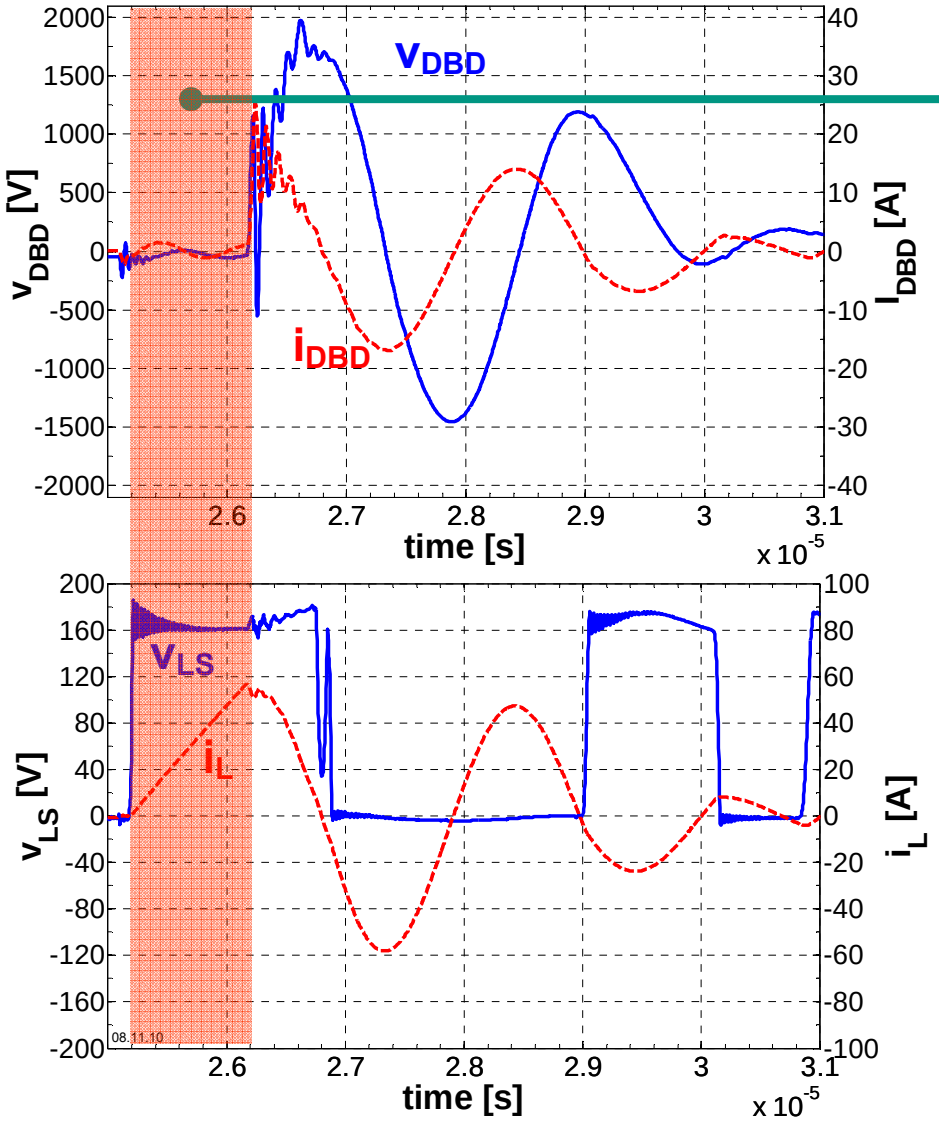


- universal: ability to adjust to different loads and different input voltages

Experimental Set-up



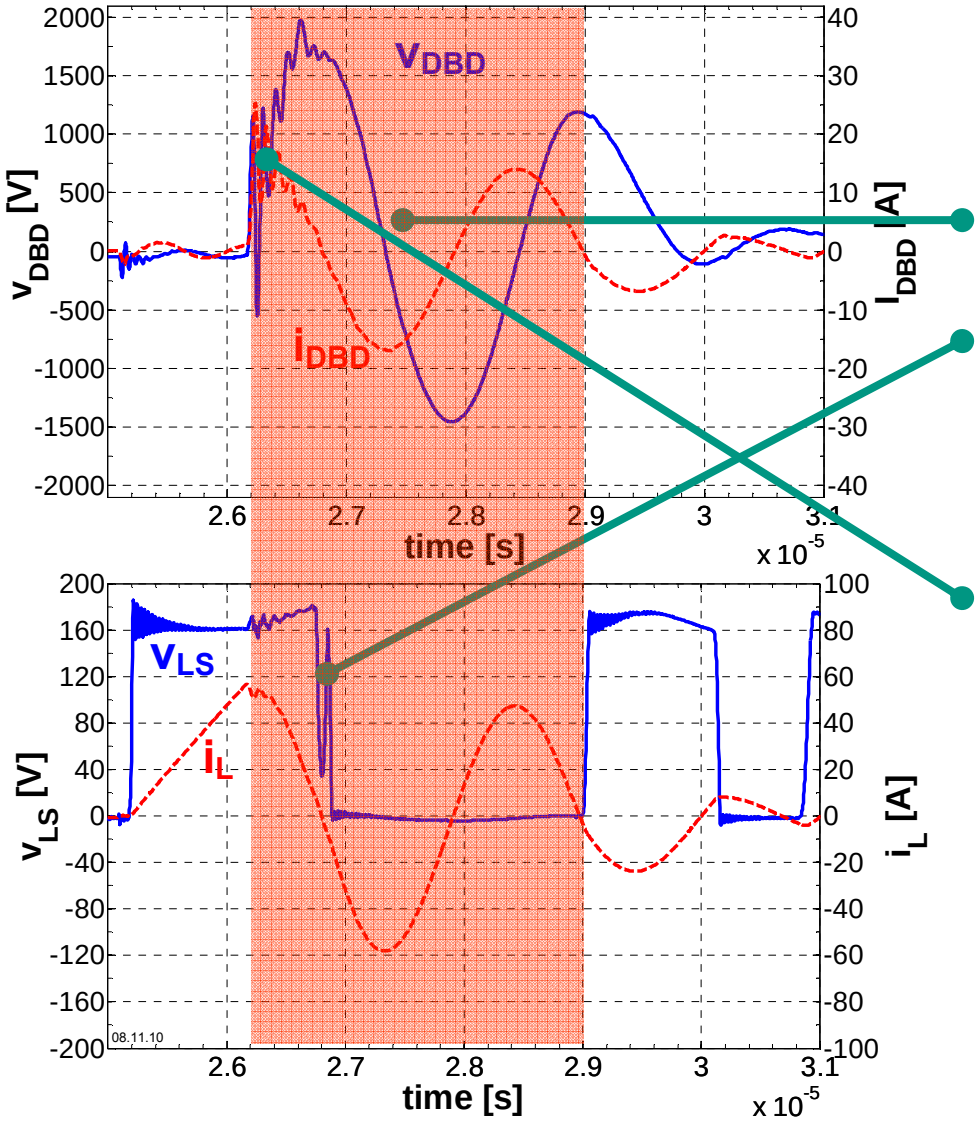
Experimental Results



- inductor precharge

- parameters:
  - V_S = 175 V,
  - T_{rep} = 50 µs, f_{pulse} = 440 kHz
  - η = 67.5 %, η_{th} = 77.8 %

Experimental Results



- inductor precharge
- pulse shaping resonance
- missed ZVS-condition
- energy recovery
- parasitic resonance
- parameters:
  - V_S = 175 V,
  - T_{rep} = 50 µs, f_{pulse} = 440 kHz
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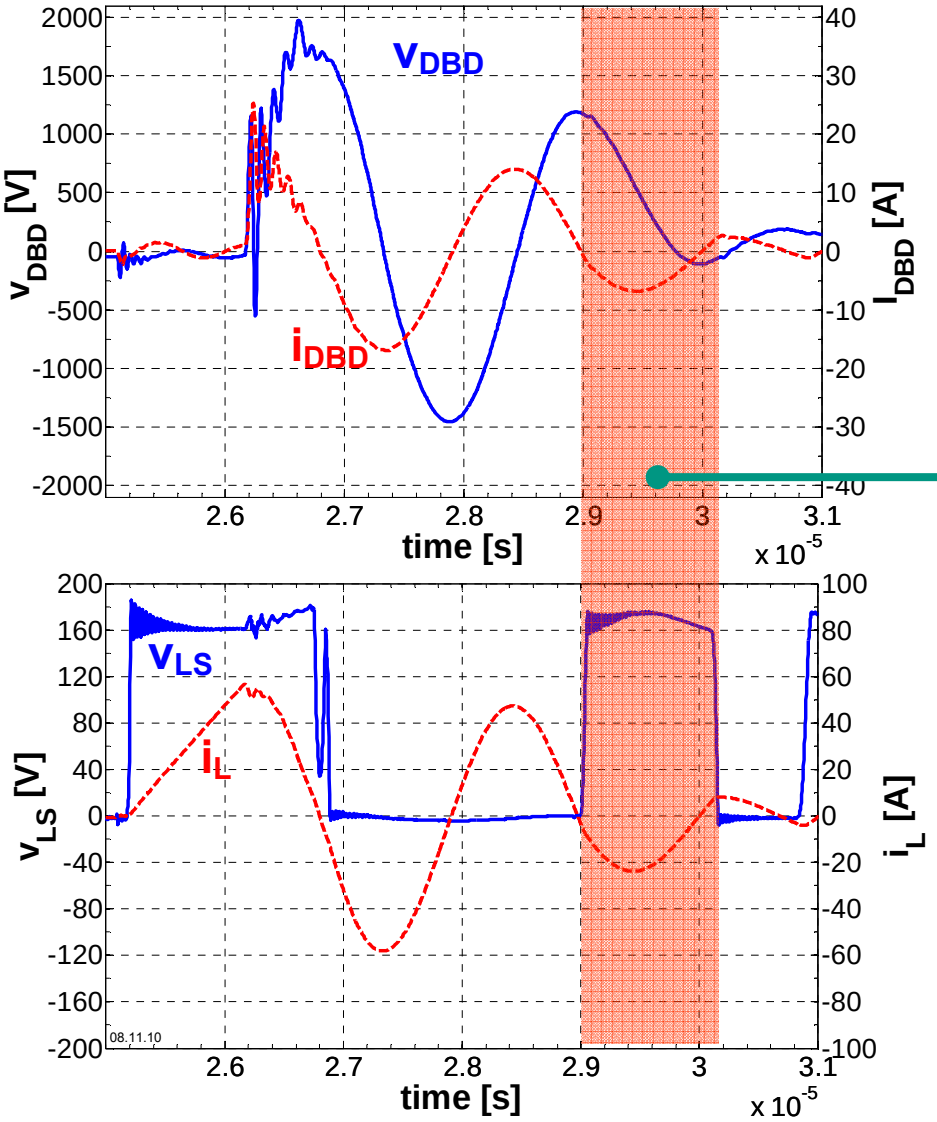
Experimental Results



- inductor precharge
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- parameters:
  - V_S = 175 V,
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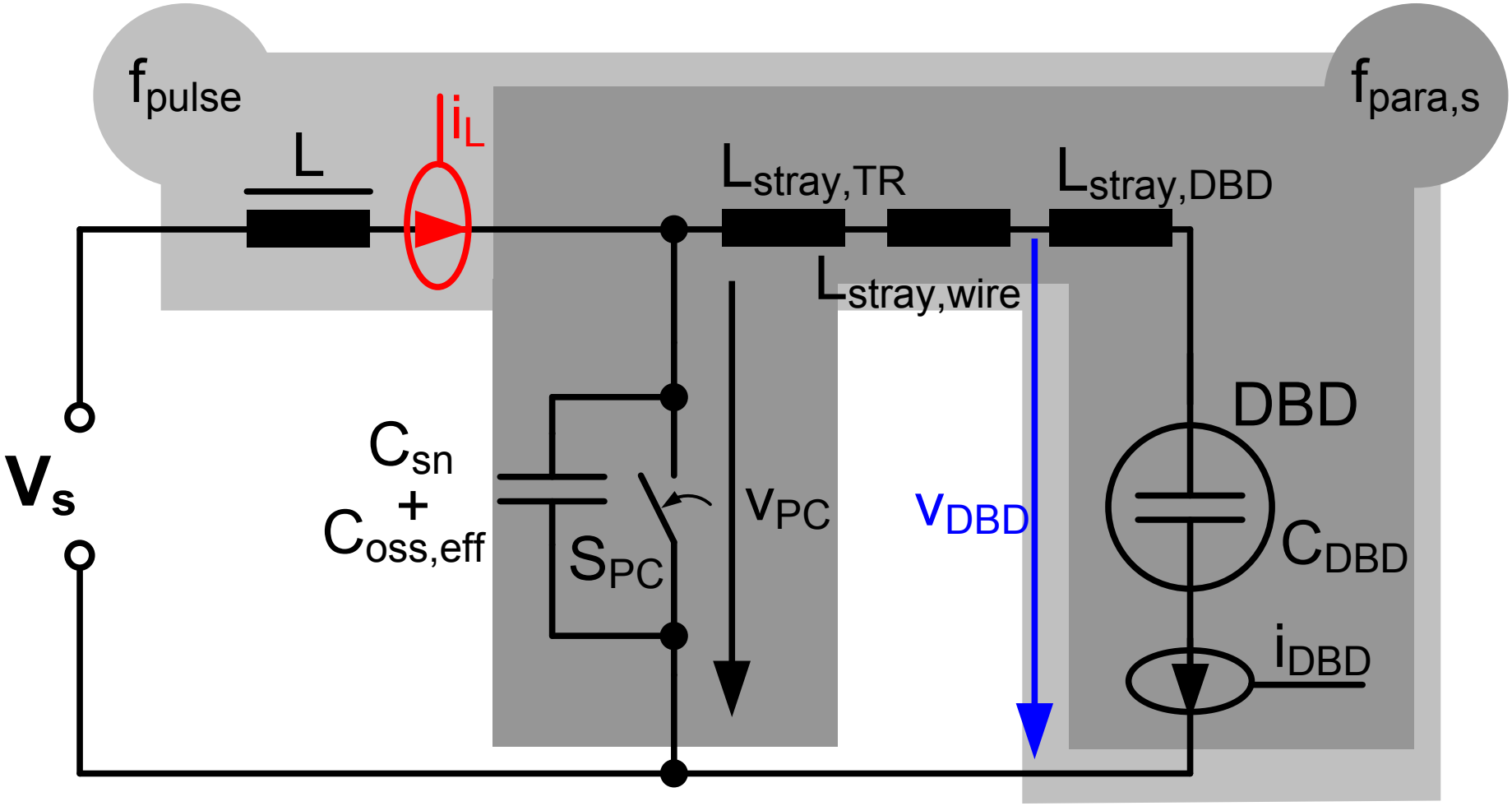
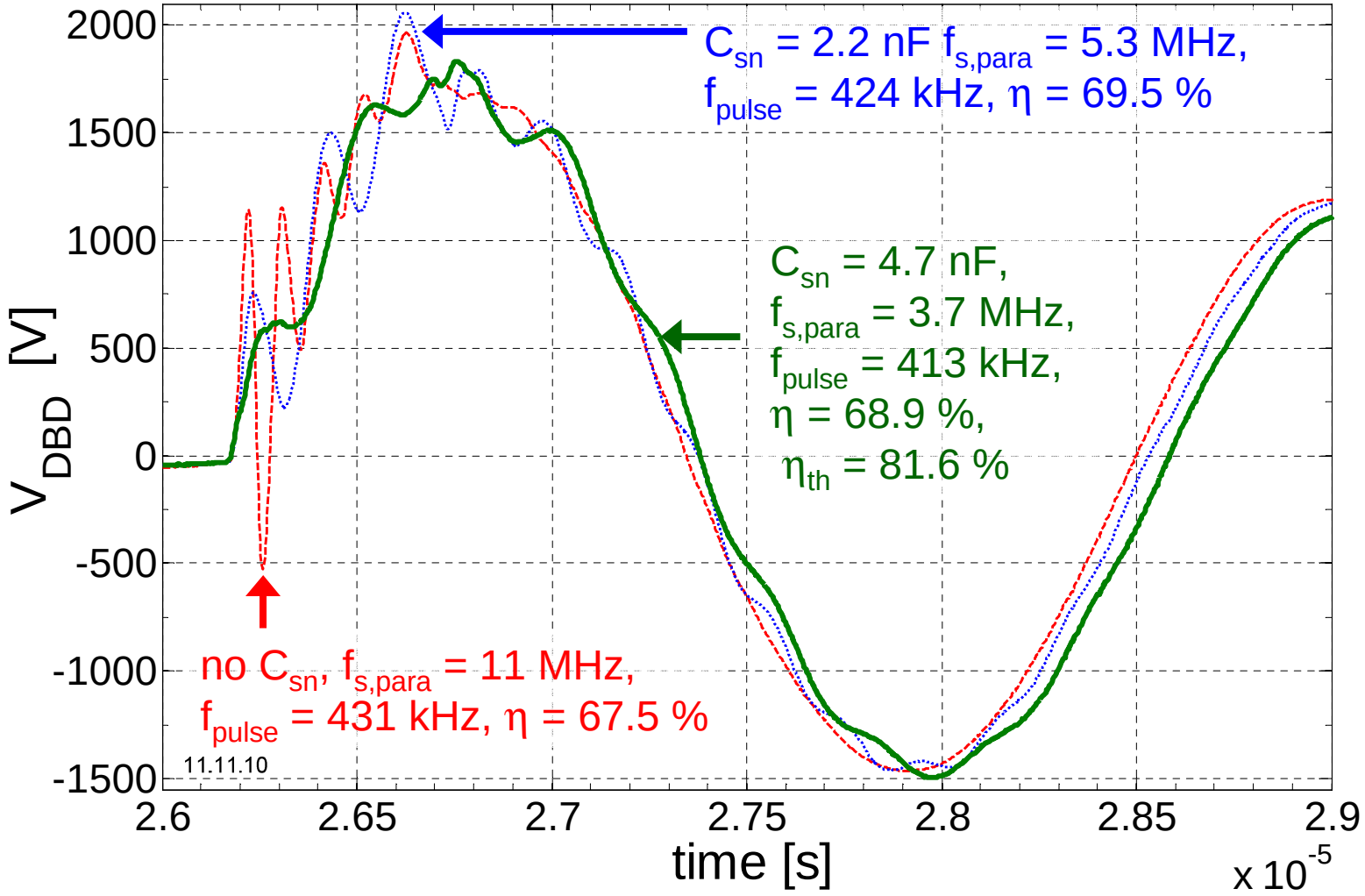
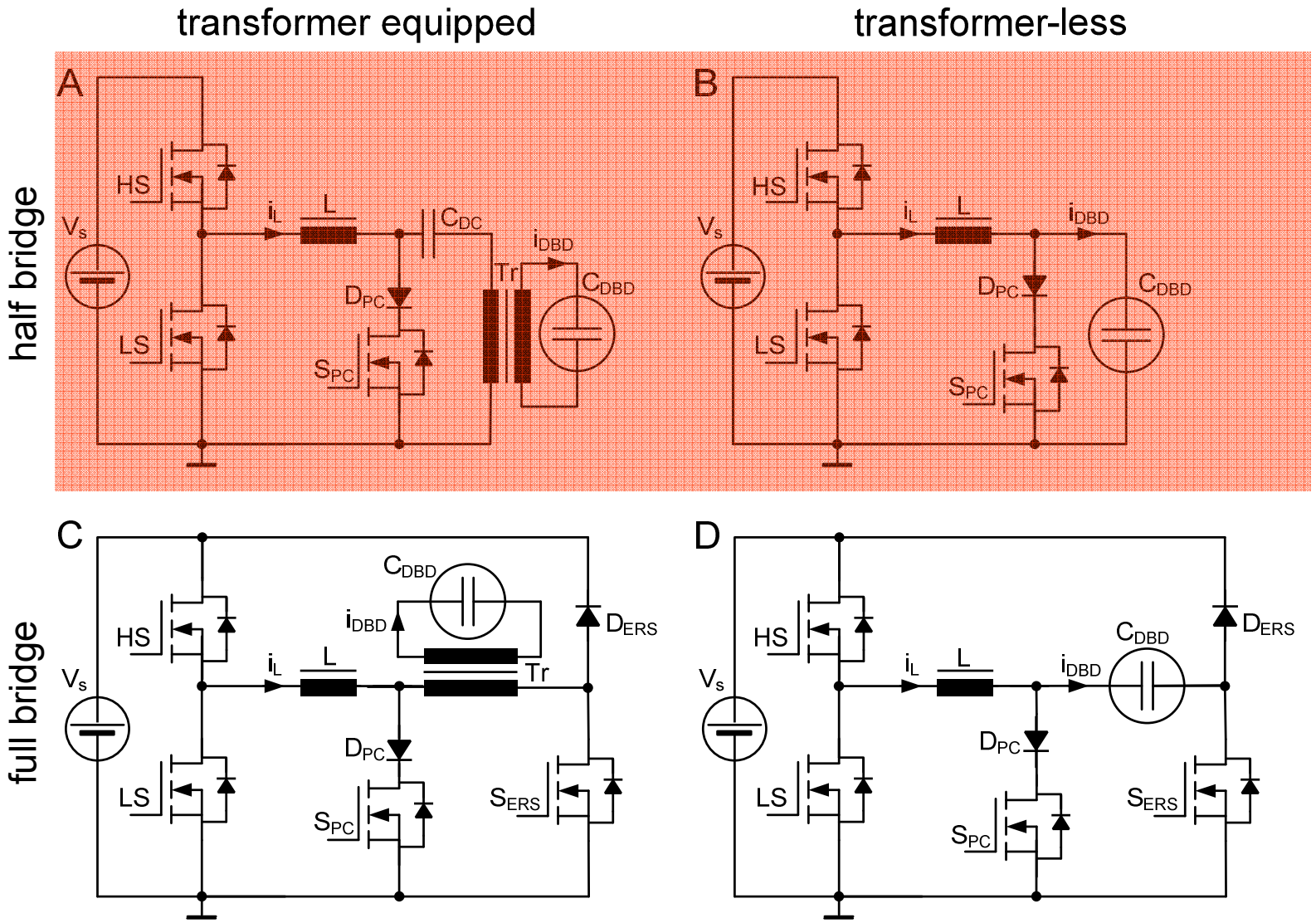
Parasitic Resonance: Electric Equivalent Circuit



Managing Voltage Overshoot



Topology Variations



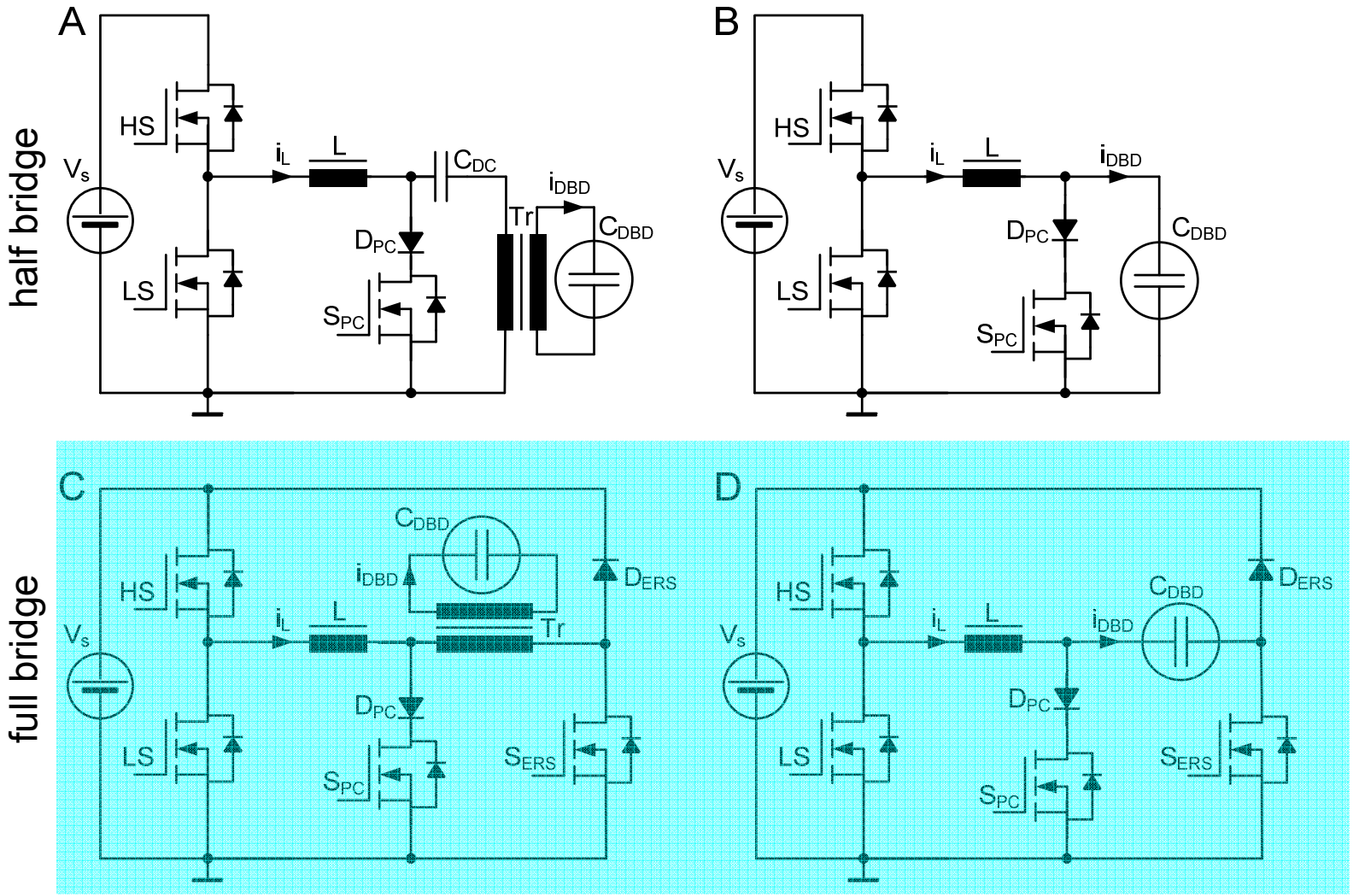
Topology Variations

transformer equipped

transformer-less

half bridge

full bridge



Topology Variations

transformer equipped

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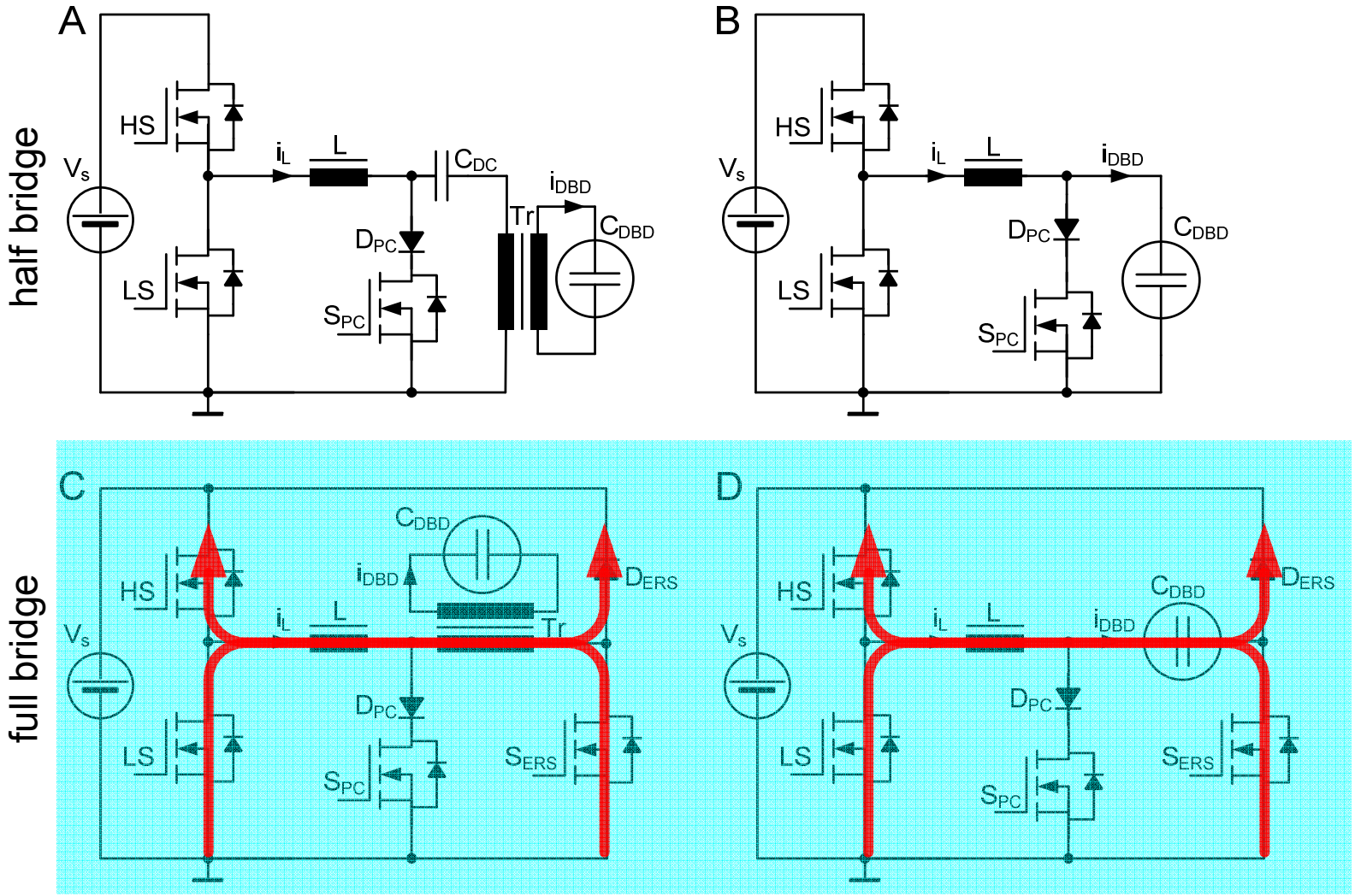
half bridge

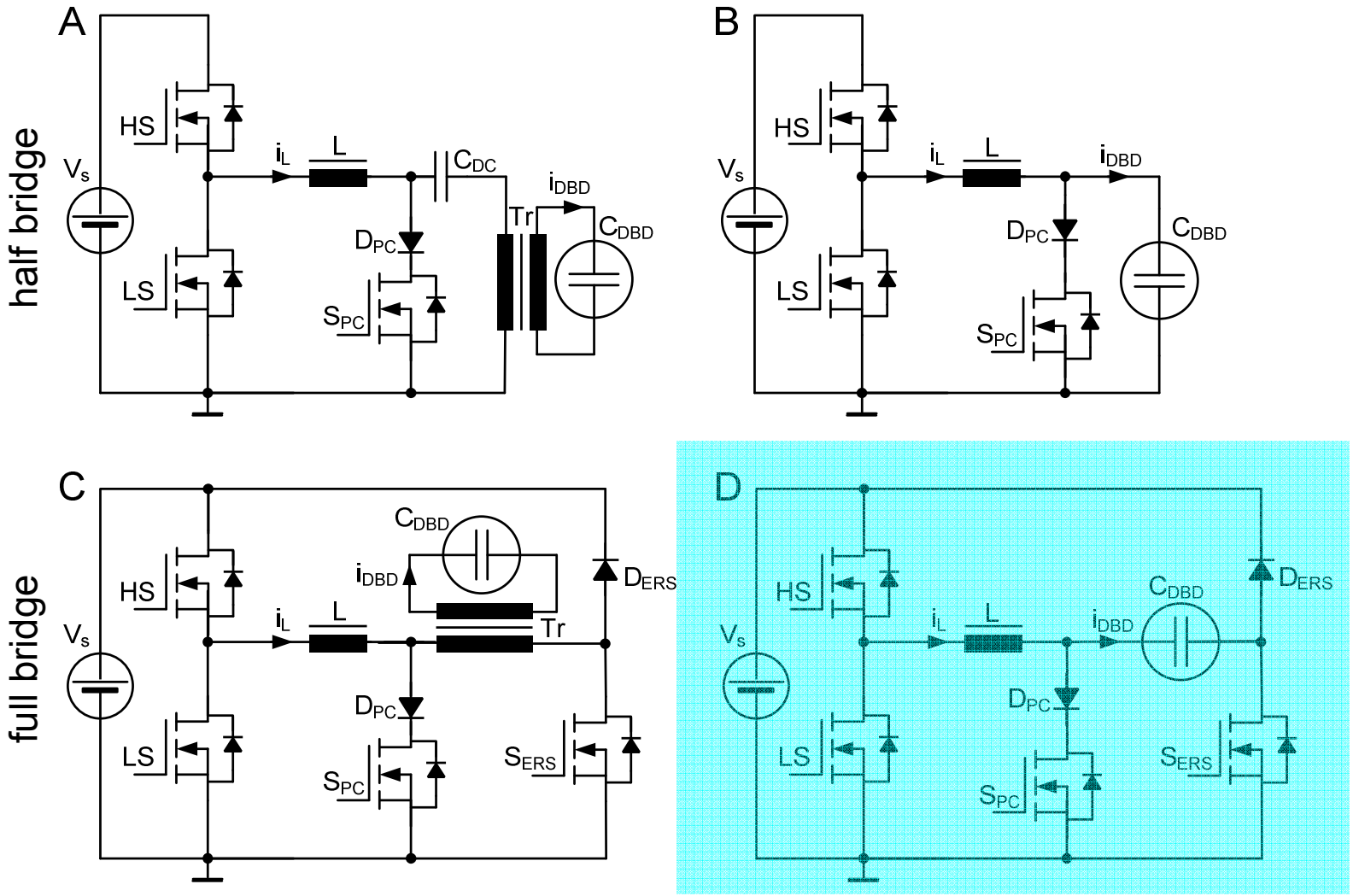
full bridge



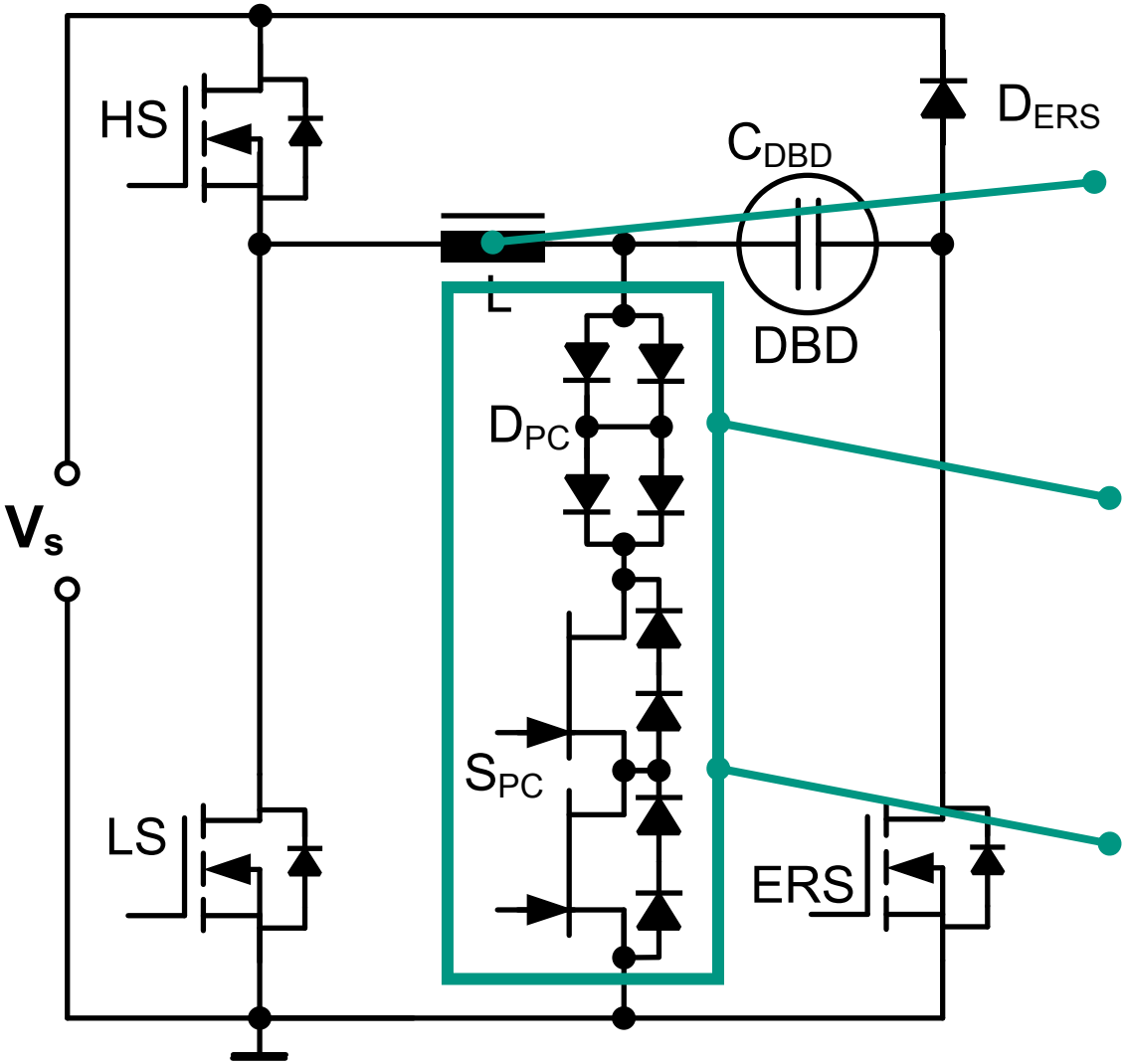
Topology Variations

transformer equipped

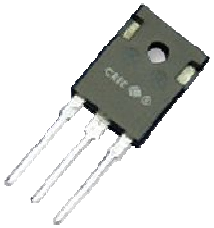
transformer-less



Transformer-less Full Bridge: Schematic

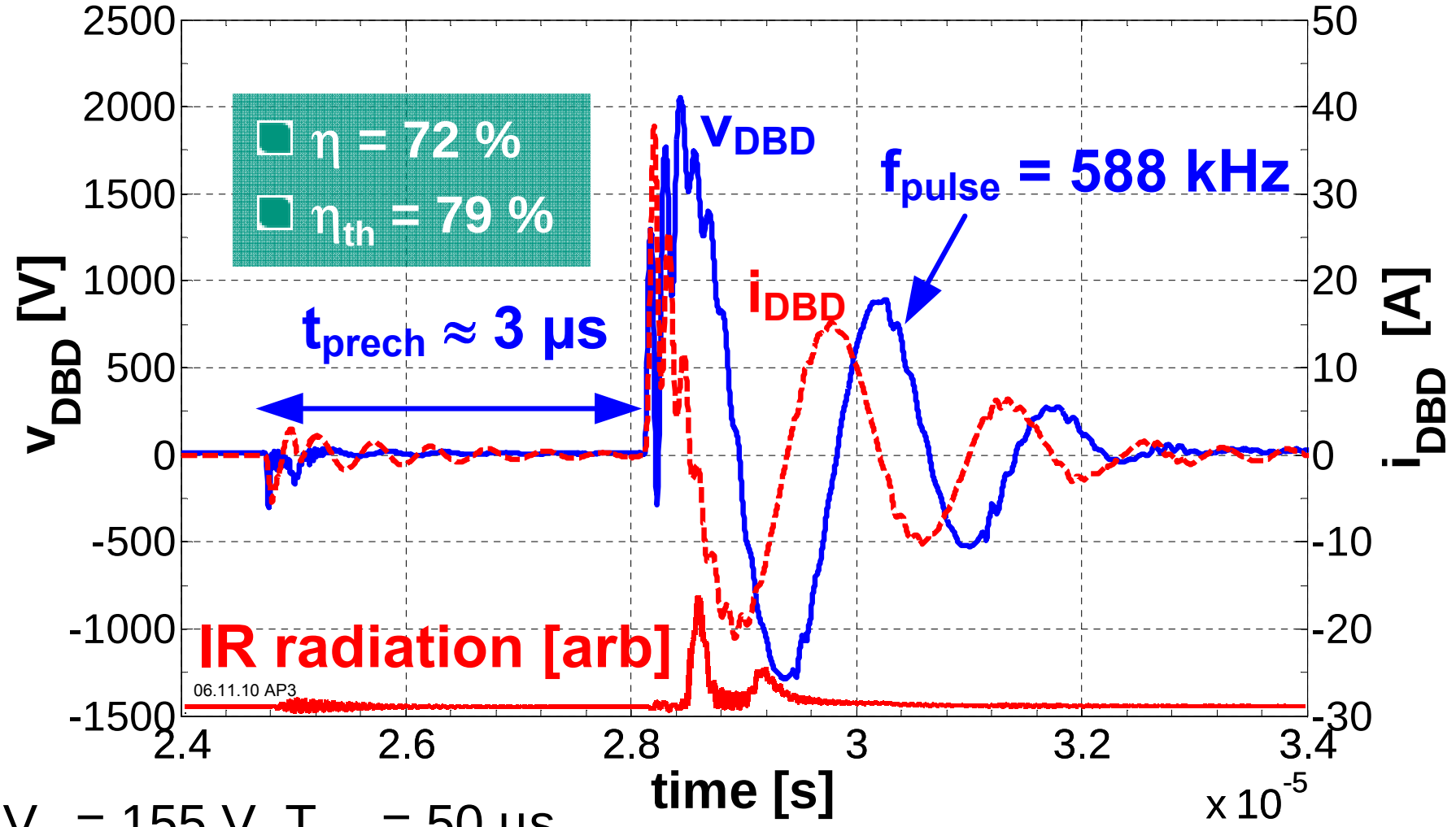


- inductor 18 µH, enhanced winding isolation
- 4x SiC SBD Cree



- 2x SiC JFET Semisouth SJEP120R63 anti-parallel 2x 1N4007

Experimental Results

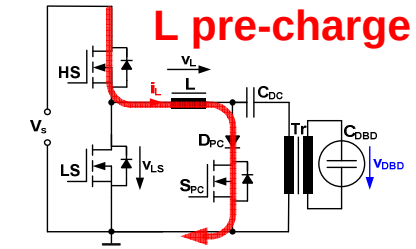


V_S = 155 V, T_{rep} = 50 µs

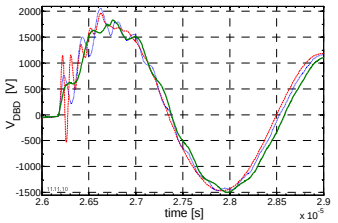
To Conclude

- DBD light sources require high frequency pulsed operation

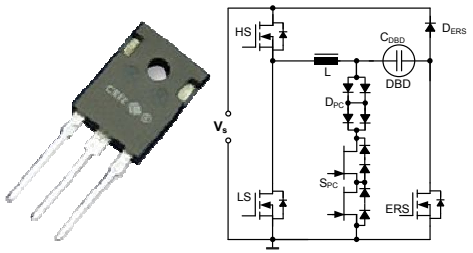
- Operation mode of New Universal Sinusoidal Pulse Topology was presented



- Voltage overshoot reduced by snubber capacitor efficiency **> 75 %**



- Silicon Carbide switches used to drive DBD with transformerless topology variation efficiency **~ 75 %**



Question and Answer Part

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