Diode turn-off event equivalent circuit analysis for PSFB converters

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Project Type:	Bachelor Semester Project	Section:	SEL
Official Start Date:	16.2.2026		
Submission of Final Report:	TBD		
Presentations at Group Meeting:	TBD		
Delivery of project results:	Analysis Scripts, Simulation Files, Final Report, Final Presentation		

Context, Background, and Motivation:

The Phase Shifted Full Bridge (PSFB) is a promising DC/DC converter topology for future renewable energy applications [1]. Nonetheless, rectifiers of these converters suffer from inherent overvoltage issues arising from two distinct phenomena – diode reverse recovery, and parasitic resonance between the diode junction capacitance and transformer leakage inductance. Although this presents an obstacle in high output voltage applications, simple passive circuitry can be used to alleviate the mentioned detrimental occurrences – distributed RC snubbers (also ensuring voltage balancing in series connected devices) [2] and the output RCD clamp [3]. Despite the complexity of the dynamics governing the converter behavior, the effects of the protective circuitry can be analyzed through simplified equivalent circuits allowing the use of analytical models instead of time-consuming and computationally demanding simulations.

Project Objectives:

Complex optimization problems benefit from models that execute quickly. This is particularly relevant when the design parameter sweeping range is wide. Modeling the PSFB diode turn-off behavior (when the problematic overvoltage occurs) by means of simple equivalent circuits enables the evaluation of the protective circuitry performance in a manner consistent with this concept. Depending on the used technology (diodes and their number, transformer, electrical connections etc.), different mechanisms (reverse recovery, parasitic resonance or both coupled) dominate the converter behavior. Therefore, the effects of the protective circuit (RC snubbers and RCD clamp) will be analyzed both separately and together with the ultimate goal of modeling all possible scenarios analytically while taking into account the diode reverse recovery and the parasitic elements of the circuit; and being able to do so for arbitrary converter specifications.

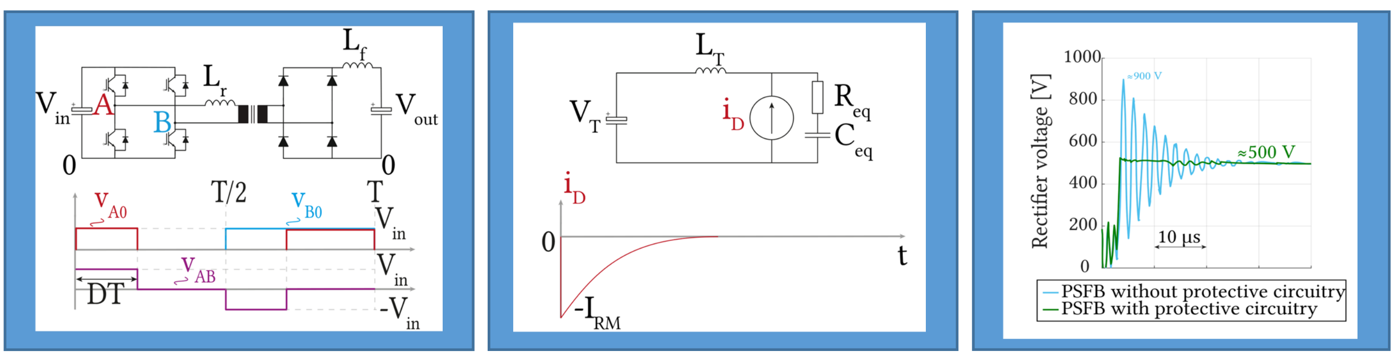

Figure 1. *Left: Simplified* PSFB converter topology (no protective circuitry shown). *Center: Example of the eq. turn-off circuit assuming RC snubbers only and diode reverse recovery-driven overvoltage. Right: Experimental waveforms showing the rectifier voltage with and without protective circuitry in a PSFB converter*

The selected student will take part in the analysis of the equivalent circuit models as well as validation of each result through time domain simulation of the full converter operation. The project activities include:

- Understanding the principles of equivalent circuit derivation and diode reverse recovery model employment
- Analytical solving of several equivalent circuit cases (see Figure 1 for reference)
- Verification of derived analytical models by comparison with time domain simulations
- Quantitative analysis of different snubber effects on the converter performance (potential for contribution)

The specified project tasks will be executed sequentially in agreement with the project supervisor. Activities do not include the derivation of own equivalent circuits, but require the understanding of provided ones for a successful completion. The project results will be documented in a final report and presented through a semester-end student presentation.

Prerequisite knowledge:

- Electrical circuits
- Knowledge of MATLAB and Simulink/PLECS
- Introductory understanding of semiconductor devices
- Basic understanding of power conversion concepts

Available equipment:

- PC with installed software (use of own PC is allowed)

Methodology and foreseen steps of the project:

- Familiarization with the theoretical concepts
- Simulation
- Model derivation/solving
- Validation
- Analysis
- Report
- Presentation

Student gain:

- Amelioration of converter modeling skills
- Understanding of parasitic effects in converter operation
- Understanding of passive overvoltage protective circuitry
- Enhancing analysis methodology

References:

[1] S. Subotic, R. Burkart, T. Gradinger and D. Dujic, "Comparative Analysis of Unidirectional High Step-Up Converters for Medium-Voltage Applications," *PCIM Europe 2024; International Exhibition and Conference for Power Electronics, Intelligent Motion, Renewable Energy and Energy Management*, Nürnberg, Germany, 2024, pp. 274-283, doi: 10.30420/566262033.

[2] Dynex Semiconductor. (n.d.). *AN6481 – RC Snubber Design for Dynex Thyristors and Diodes*. Available at: https://www.dynexsemi.com/Portals/0/PDF/DNX_AN6481.pdf

[3] Song-Yi Lin and Chern-Lin Chen, "Analysis and design for RCD clamped snubber used in output rectifier of phase-shift full-bridge ZVS converters," in *IEEE Transactions on Industrial Electronics*, vol. 45, no. 2, pp. 358-359, April 1998, doi: 10.1109/41.681236