# Resume

**Motivation**

The evolution of modern power electronics is of main concern in the modern economy. Many applications starting of from automotive and continuing with industrial and renewable energy require step-up or step-down converters respectively, with a higher/lower conversion ratio.

In a DC-DC converter the input voltage is converted to an output voltage having larger or smaller amplitude, opposite or, the same and isolated or nonisolated polarity, with respect to the input side. Classical DC-DC converters are unable to provide very high step-up or step-down conversion ratios. On the other side, utilization of transformers to achieve higher/lower conversion ratios comes with a decrease in efficiency.

Boris Axelrod, Yefim Berkovich and Adrian Ioinovici [[1](#BAx03)]-[[2](#BAx04)][[3](#Axe05)][[4](#Bor08)][[5](#Axe06)][[6](#ADR13)], propose several simple switching structures, consisting by either two capacitors and two-three diodes (C-switching), or two inductors and two-three diodes (L-switching) that can be inserted in classical converters in order to get new converter topologies. The new structures have a very large step-up or step-down conversion ratio compared to the classical converters.

The multiphase converter is a circuit where the same “n”- converter topology are connected in parallel both at the input and at the output, at a common input and output capacitor of the converter, forming the different phases that are controlled with phase shift.

One basic goal of this study is to try to extend the existing knowledge and techniques obtained from classical multiphase converters to the hybrid multiphase converters.

**Thesis outline**

In this work, different hybrid multiphase DC-DC converter topologies are proposed, analytically studied, digitally simulated and validated through practical experiments. The dissertation consists of 5 chapters and is organized as follows.

**Chapter 1** was thought as a general introduction to DC-DC converters. Different structures of DC-DC converters for renewable energy systems encountered in the literature are presented by the author through a comprehensive literature survey.

The survey was done via a classification of these DC-DC converters in three classes: classical converters, bidirectional converters and association of converters.

A special focus was made on the parallel and multiphase converters that are the subject of the thesis.

**Chapter 2** presents the L and C-switching structures proposed by Boris Axelrod, Yefim Berkovich and Adrian Ioinovici. These structures are inserted in classical and bidirectional converters resulting in new hybrid structures. The possible hybrid structures are presented in , and the new conversion ratios are presented in .

A comparative analysis of the hybrid converters is performed by the author. Such an analysis is very important before making a choice for a hybrid converter.

Different hybrid DC-DC converter topologies, with switched capacitor or switched inductor cells inserted in the classical or bidirectional converters are studied and simulated. From this study a synthesizing method for multiphase hybrid converters is proposed.

A method for increasing the efficiency, reducing the size through reducing the numbers of inductors in the hybrid L-converter without affecting the circuit operation and the dc voltage transfer function, is also proposed.

In eleven new multiphase converters with hybrid structures that are possible to be implemented are proposed by the author.

In **Chapter 3** one hybrid step-up structure has been chosen due to its advantages and a complete description with an analytical study, operating modes, waveforms, and design parameters is provided. A method for improving the drawbacks of the circuit is also described and compared with the help of digital simulation.

The digital simulation results are validated by experimental results obtained from a laboratory prototype.

In **Chapter 4** the hybrid step-up structure that was analyzed in Chapter 3, is used to build multiphase converter. A two-phase hybrid Boost L-converter is designed.

The new converter is analytically studied, the operating modes are presented, together with the main waveforms and design parameters. Experimental results validated the simulation and theoretical analyses for these types of converters. An analysis and a comparation between single phase structures and two-phase structures are also performed. The main features of the multiphase converters are evaluated at the end of this chapter.

The thesis ends with **Chapter 5**, that summarizes the conclusions, original contributions of the author and possible future work.

**Thesis objectives**

* to perform a review of the main DC-DC converters used for renewable energy systems developed in the literature;
* to analyse and compare the switching cells structures;
* to analyse and compare the hybrid converters;
* to present the main methods and rules (synthesizing method) to generate new multiphase hybrid converters;
* to propose a new class of multiphase DC-DC converter topologies based on hybrid structures;
* to study both analytically and through digital simulation the proposed converters;
* to build and test laboratory prototypes in order to practically validate the theoretical results and simulations.

Theoretical concepts developed throughout the chapters are supported and validated by simulations as a preliminary phase.

Single phase hybrid Boost L-converter and two-phase hybrid Boost L-converter are compared through experimental results obtained from a laboratory prototype. The laboratory prototypes were built at the University of Applied Science Wilhelmshaven, in the Power Electronic laboratory, number L122a.

For experimental results and efficiency calculation of the converters the following technical equipment was used:

* LeCroy waverunner LT354M Oscilloscope;
* LeCroy AP015 Current Probe;
* Universal Waveform Generator Wavetek 40 MHz;
* Electronic Load EA-EL 9160-100;
* Multichannel Precision Power Meter Electronic Systems ZES ZIMMER LMG 450.

For text editing, design and simulation media the author used the following tools:

* for text editing: Microsoft Office Word 2007;
* for calculations and graphics: Mathcad Prime 2.0, Matlab R2011a and Microsoft Office Excel 2007;
* for circuit simulation program: CASPOC package, Saber Simulator;
* for schematic and layout design: EAGLE PCB design software.