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XXXVI Cycle

Application of a Novel Adaptive control approach for Power Converter Applications

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Research context and motivation

- With the integration of Renewable energy resources and Electric Vehicles (EVs) in the modern grid, the study of power electronic devices has become a necessity also in the field of power systems.
- The dynamics of power electronic devices can be characterized by nonlinear, fast switching models belonging to a class of variable structure systems. To derive proper control strategies for these systems, it is of utmost importance that we consider the hard nonlinearities of the converter topologies that these systems are composed of.
- Our aim is to introduce the use of novel control strategies that can be used not only for modelling and regulation of power converter topologies but also for devising the optimal control strategies for the integration of power electronic based devices in the microgrid.

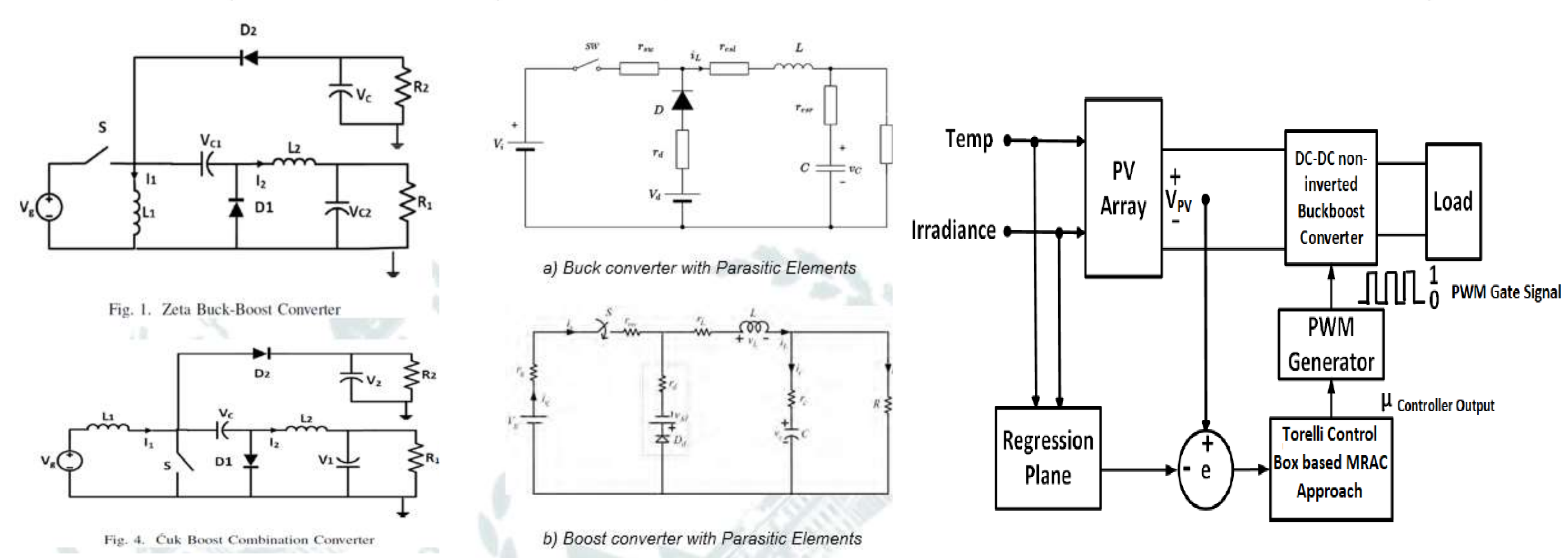


Fig. 1: Use of TCB approach for (a) Modelling of ZBB and CBC converter topologies (b) Regulation of Buck and Boost converter topologies with nonlinearities (c) For MPPT of Buck-Boost converter based MPPT

Addressed research questions/problems

- The aim is to present an alternative approach for the modelling and control of both DC-DC converter topologies and DC-AC converter topologies under different grid-connected applications.
- The traditional linear control approaches suffer when it comes to regulation of DC-DC converter topologies due to the variable nonlinear structure of these systems. For other nonlinear control techniques, the design of the controller can get significantly more challenging as the systems get complex or when we take model nonlinearities into account.
- A particular aim of the study is to provide a novel approach for the regulation of 3 phase Voltage Source Inverters. This study of inverters is done in two primary contexts:

i. As a part of Grid Forming Control strategy based on Renewable energy Resources i.e. PhotoVoltaic arrays or wind turbine systems connected with the grid

ii. As a study of an Electric Vehicle Charging station for Vehicle to Buildings (V2B) / Vehicle to Grid (V2G) purposes or an Electric Vehicle for Vehicle to Home (V2H) purposes.

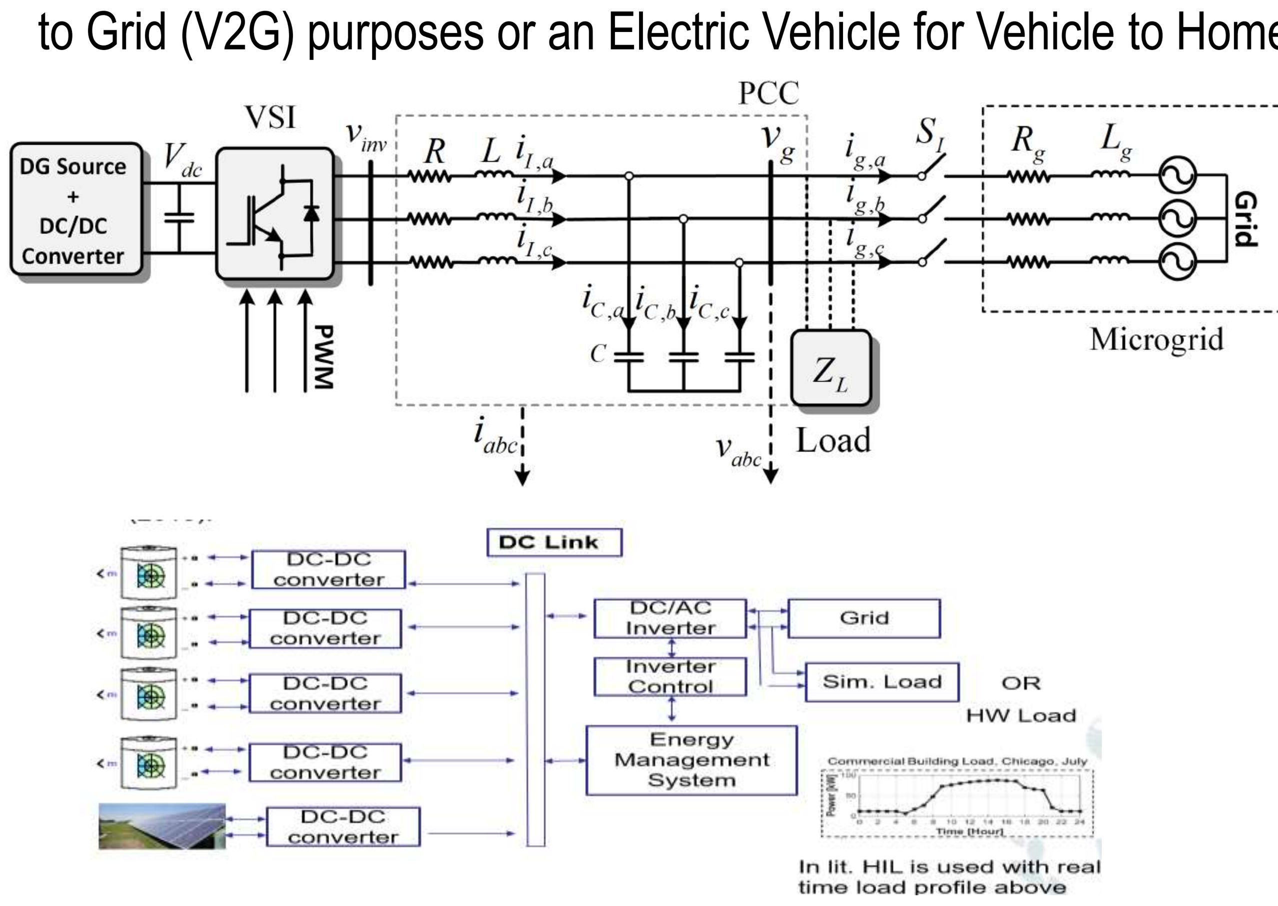


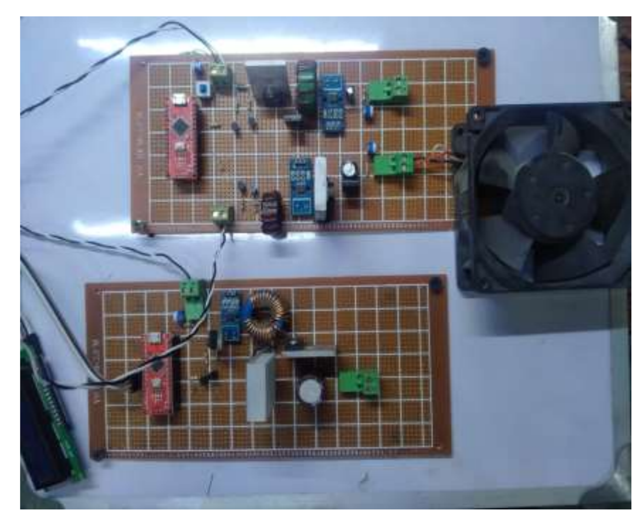
Fig. 3: An overview of simulations already prepared in Simulink (a) Grid-Forming inverter (b) Simulation of V2G based Electric Vehicle Charging Station

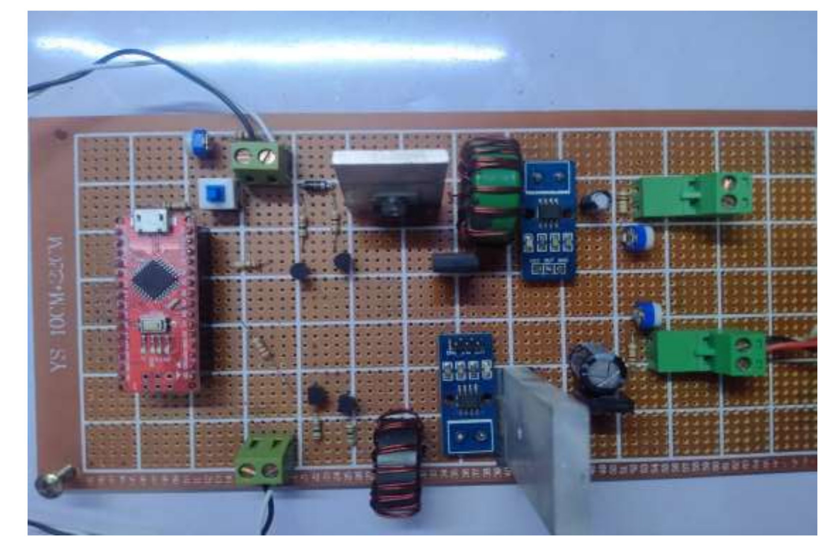
Submitted and published works

- Qureshi, Muhammad Ahmed, et al. "Application of Artificial Dynamics to Represent Non-isolated Single-Input Multiple-Output DC-DC Converters with Averaged Models." 2021 56th International Universities Power Engineering Conference (UPEC). IEEE.
- Qureshi, Muhammad Ahmed, et al. " Application of a Novel Adaptive Control Approach for the Regulation of Power Converters" 2022 57th International Universities Power Engineering Conference (UPEC). IEEE.

Novel contributions

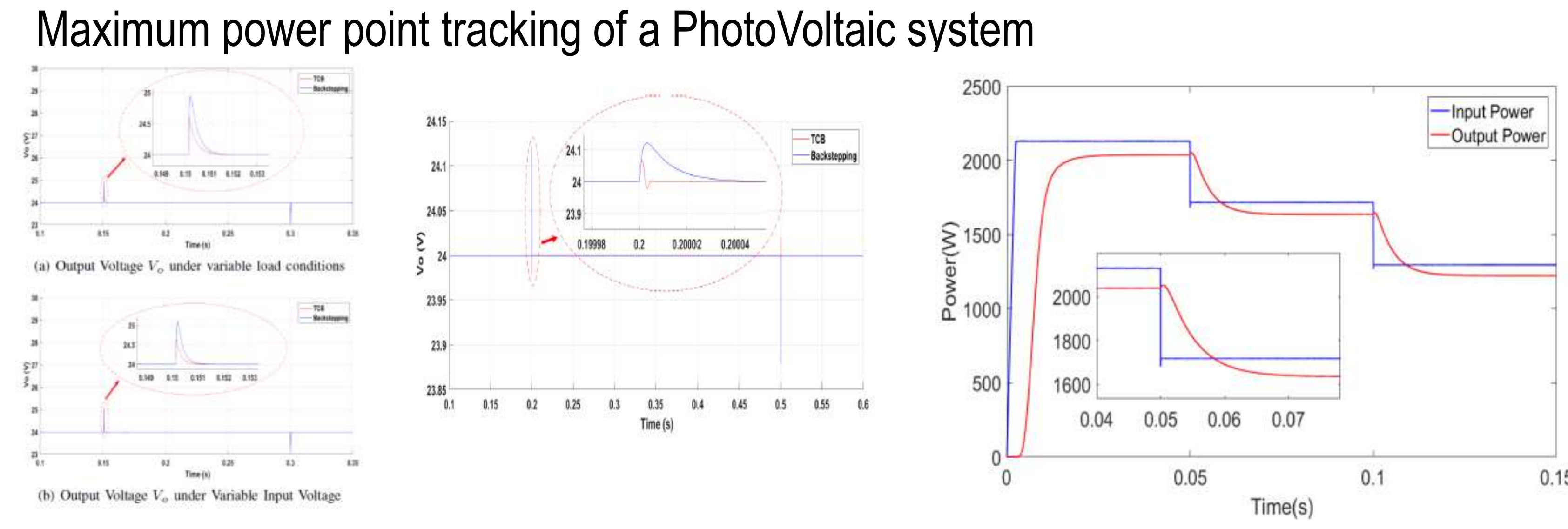
- The implementation of a novel modified reference adaptive control Approach for various power converter applications including, but not limited to, their integration with the Grid.
- The proper verification of this control approach through practical implementation of the converter topologies.using Power Hardware in the loop setup.





Adopted methodologies

- We have approached this entire process methodologically. Our initial step was to introduce a novel modelling approach for switched DC-DC converter topologies whose dynamics are governed by Differential Algebraic Equations instead of Ordinary differential Equations. Results published in [1]
- The 2nd step was the introduction of the novel Lyapunov based approach for regulation of different DC-DC converter topologies assuming ideal conditions. Results published in [2]
- The next step, the results of which has already been compiled, is the simulation of the above converters taking into account hard nonlinearities. Furthermore, we have used the Lyapunov approach for a practical application for DC-DC converter topologies, namely the Maximum power point tracking of a PhotoVoltaic system



- The next phase of our research was to do a practical implementation of these converter circuits, and verify the results of our control approach by its implementation in digital controllers.

Future work

- The inverter based circuits will be further tested for grid-forming purposes and V2G applications using Hardware in the loop simulations.
- In the immediate future, we need to complete the *practical* implementation of our converters. The circuits have been built but we still need the implementation of the controller in Arduino.
- We still need to devise a proper controller for a 3 phase bidirectional inverter that can be a used as prototype for our Grid-Forming and Electric Vehicle applications.
- The next steps will be their implementation of our controller and our circuits in Power Hardware in the loop in the Energy Center Lab.

List of attended classes

- 01LGSRV– Characterization and planning of small-scale multigeneration systems (17/09/2021, 25 hours)
- 01DOARV – Electrical demand management (23/09/2022, 25)
- 02ITTRV Generators and photovoltaic systems (12/4/2021,25)
- 01LEVRV Power system economics (14/7/2021,16)
- 01VPORW Statistical Methods with application to Climate Variability and Change Assessments (10/6/2022,20)
- 01QFFRV Innovative techniques for optimization (26/2/2021, 20)
- 01DOCRV The Hitchhiker's Guide to the Academic Galaxy (16/6/2022,20)
- 01QORRV Writing Scientific Papers in English (24/3/2022,15)