

EE-490(c) - Lab in Electrical Energy Systems - Project 1

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Topic: Continuous PWM for Three-Phase Voltage Source Converters

Objectives of the project

Objectives of the project are:

- 1) **UNDERSTAND** the operating principles behind the continuous PWM schemes for a three-phase two-level voltage source inverter (VSI), considering the following PWM schemes: 1) Sinusoidal PWM, 2) 3rd harmonic injection PWM and 3) Min-Max signal injection PWM
- 2) **OFFLINE SIMULATIONS:** Implement, and develop a complete model for the PLECS offline simulations of the DC-AC voltage source inverter and investigate the performance of the selected PWM schemes considering DC voltage utilization, switching frequency impact on the output voltage, output current ripple, THD, impact of the dead time, overmodulation, etc. DC source will be used on the input (DC) side of the converter, and RL load on the output (AC) side of the converter.
- 3) **RT-HIL SIMULATIONS:** Program the modulator function on the DSP and validate experimentally, the correct operation of PWM schemes and performances on the PETS HIL (Fig.1) using real-time hardware in the loop simulations.
- 4) **EXPERIMENTAL VALIDATION:** Repeat all the experiments on the actual PETS (Fig.1)). The DC source of the PETS will be used to supply the converter, while the RL load will be connected at the converter terminals.



Fig. 1 PETS HIL (left) and actual PETS (right) that will be used for RT-HIL simulations and experimental investigations.

Background and methodology:

The goal of the projects offered in the EE-490(c) course is to provide practical experience with digital control for power electronics systems. Each project is relatively small in scope, but it allows for gradual learning through four steps:

- 1) **Theory:** Understanding certain concept that is of key relevance for the objectives of the project. Each project is therefore dealing with a well-defined topic.
- 2) **Modeling and Offline Simulations:** Developing models (hardware and software) and verifying theoretical concepts through offline simulations. PLECS software from PLEXIM is used for this.
- 3) **Real-Time Hardware-in-the-Loop Simulations:** This step requires programming of the Digital Signal Processor (DSP) from Texas Instruments in order to deploy relevant control algorithms on it. Model of the system to be controlled is developed on the RT-Box from PLEXIM (shown in Fig.1), and typically will be provided already on the RT-Box. In this way complete control algorithm can be verified in a safe manner. Programming of the DSP will be done using the Code Generation option from PLECS, avoiding need for prior knowledge in C-coding.
- 4) **Experimental Verification:** With control software developed in the previous step, experimental verification can be performed, using the same software, on the Power Electronics Teaching Setup (PETS).

Foreseen project steps

To carry out the **project** successfully, the following tasks are foreseen:

- 1) Getting familiar with the theory behind the project assignment, purpose and operating principles.
- 2) Getting familiar with PLECS which will be used for offline simulations.
- 3) Implementing the required models and/or controllers in PLECS for offline simulations and verification of correct operation. Collecting, analyzing and reporting the simulation results. Detailed goals and instructions will be provided during the project.
- 4) Getting familiar with PETS in order to be able to carry out experimental investigations.
- 5) Development of the required control software function which will be executed on the DSP.
- 6) Verification of the correct operation. Testing and collection of results.
- 7) Testing of the developed software function on the PETS. Collecting results
- 8) Documenting the work in the form of short technical report, continuously updated during the semester.
- 9) Presenting the work at the end of the semester.