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EE-490(c) - Lab in Power Electronics - Project 12

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Topic: **Unipolar and Bipolar PWM for Full-Bridge Converters**

<u>Objectives of the project</u>

Objectives of the project are:

1) **UNDERSTAND** the operating principles behind the PWM for single-phase systems, namely the full-bridge converter and Unipolar and Bipolar PWM schemes.
2) **OFFLINE SIMULATIONS**: Select, implement, and develop a complete model of the PLECS offline simulations of the DC-DC full-bridge converter using two PWM schemes. Select, implement, and develop a complete model of for the PLECS offline simulations of a DC-AC full-bridge converter using two PWM schemes. Investigate the performance of the Unipolar and Bipolar PWM for both considered converter types (DC-DC and DC-AC), considering DC voltage utilization, output frequency, current ripple, THD, impact of the dead-time, overmodulation, etc. A DC source will be used on the input (DC) side of the converter, and an RL load on the output (DC or AC) side of the converter.
3) **RT-HIL SIMULATIONS:** Program the modulator function on the DSP for the RT-HIL (Fig.1) testing and validate results obtained from the offline simulations.
4) **EXPERIMENTAL VALIDATION:** Use already developed DSP code and validate experimentally correct operation of both PWM schemes and performances on the 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.

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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 concepts that are 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. A 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 safely. Programming of the DSP will be done using the Code Generation option from PLECS, avoiding the need for prior knowledge in C-coding.
4) **Experimental Verification:** With the 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 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 a short technical report, continuously updated during the semester.
9) Presenting/demonstrating the work at the end of the semester.