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EE-490(c) - Lab in Power Electronics - Project 4

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Topic: **Three-phase Phase Locked Loop (PLL)**

Objectives of the project

Objectives of the project are:

1) **UNDERSTAND** the operating principles behind the PLL for three-phase systems (400V, 50Hz).
2) **OFFLINE SIMULATIONS:** Select, implement, and develop complete models of the PLL for the PLECS offline simulations. Investigate the performance of the PLL in relation to key relevant parameters available for the PLL tuning. Investigate the performance of the PLL in relation to grid voltage variations, frequency variations, and phase variations. Typically, these are introduced through step changes of these parameters in the model of a three-phase AC supply and will be defined by TAs. Observe and validate the limitations of the simple three-phase PLL during unbalanced grid conditions.
3) **RT-HIL SIMULATIONS:** Program the PLL function on the DSP and validate experimentally the correct operation 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). Variable AC source will be used to emulate the AC grid during the testing.

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.