

**Description of a project for a Master thesis at the Institute ie<sup>3</sup>**

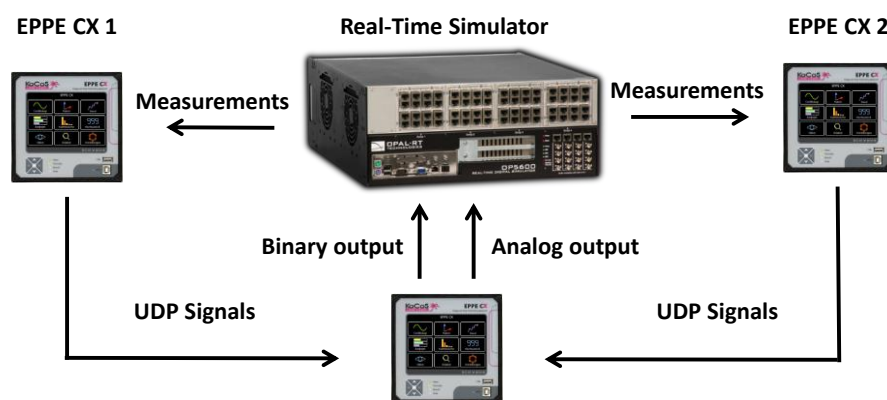
*M.Sc Thesis: Implementation of learning algorithms for a voltage regulation algorithm and validation using a Hardware-in-the-Loop Simulator*

**Background and motivation of the thesis:**

The influence of Renewable Energy Resources (RES) on the electrical grid has increased tremendously over the past few decades. The non-uniform behaviour of RES and varying loads introduce new operating conditions and complexities in the electrical grid. Power system operators face an enormous challenge of maintaining their power quality despite these complexities. One of the major problems is the maintenance of the voltage within acceptable limits. The institute ie<sup>3</sup> focusses extensively on protection and control of electrical power systems. The research includes areas such as implementation and testing of smart grid functions on field devices and on a real-time simulator (RTS).

The hardware devices used is called the KoCoS EPPE CX. It is a power quality measurement device on which multiple smart grid and protection functionalities are already implemented as part of the project i-Automate. A voltage regulation algorithm has already been implemented on the EPPE CX device and applied to the CIGRE low voltage benchmark network. It is practical for any system to use the information from its previous problems and learn from them. The objective of this thesis is to implement learning algorithms for the existing voltage regulation algorithm on the hardware device. Training data will be provided by the network operator and suitable data sets for the learning algorithms have to be developed. The response of the system voltage to different operating conditions and disturbances such as load changes, RES infeed changes and fault conditions will be given as training data. Multiple scenarios are to be developed to train the system.

The implementation of a learning algorithm for a distribution grid voltage regulation is a relatively new topic of research in the smart grid community. The whole work will be unique on the national and international scale and will serve academic as well as industrial research. The test setup is given in the figure:



*Figure: Overview of workflow*

Tentative work plan:

The learning algorithm has to be implemented on the hardware device. The usage of learning algorithms to the hardware devices in C++ would enable the devices to predict suitable scenarios and solutions in cases of future faults. In case of communication or power failure, this learning algorithm will help system restoration. For the verification and validation, suitable test processes are to be developed in open loop and/or closed loop simulation environments with the RTS. The student has the flexibility of choosing the type and extent of the learning algorithm required for the implementation.

This work is recommended to be structured in the following way:

- Literature review of state-of-the-art learning algorithm possibilities
- Determination of required learning algorithms for voltage regulation
- Deploying the learning algorithms on to the hardware device
- Validation of the learning algorithms using the RTS
- Development of scenarios in case of other faults and communication failure
- Writing the Master's Thesis. The thesis can be written beside the development of the work or it can be left at the end. The choice is left to the student.

The profile of the student:

The thesis is suitable for a student with background in electrical engineering, computer science, automation engineering and has interest in new smart grid technologies. Experience in programming is highly beneficial. Previous knowledge of power systems/smart grids is not required. The theme is open to several possibilities and can be modified to match the wishes and requirements of the student. After completing the thesis, the student is expected to have a good understanding of learning algorithms, voltage regulation and smart grids. The student has the advantage of familiarizing with the RTS, the advanced technology available only at select research institutes.

- Die Arbeit kann auf Englisch oder auf Deutsch geschrieben werden

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