## *Research Field: Control and Automation Systems*

*Development of resilient and dynamic control algorithms to counter cyber-physical events and communication failures on a distribution grid automation platform*

There is an enormous increase in the number of decentralized energy generation in the past few years, which leads to the need of sophisticated automation schemes for the power system in consideration. Power Systems (PS) are progressively reliant on Information and Communication Technologies (ICT). While ICT facilitates grid services essential for the safe and secure operation of power systems, it also introduces the risk of disturbances spreading further due to the interconnected nature of these two systems. With the extensive amount of distributed energy resources, the control algorithms play a pivotal role in modern-day power systems. State estimation is crucial within the energy management system, supporting numerous monitoring, management, and control functions. If state estimation fails, situational awareness is compromised, negatively affecting grid operations. Hence, it's critical to continuously monitor state estimation performance, particularly in the face of various disturbances, to uphold grid reliability.

Institute ie³ has various research projects dealing with implementing protection and smart grid functions in a measurement device and testing it using a real-time simulator (RTS). While all control functions have been tested and validated individually, their reliability and resilience against communication failures have not been clearly researched. To successfully achieve this task, resilient algorithms are to be implemented to identify alternate control strategies during data unavailability or cyber-attacks. In principle, robust control algorithms have to be created with various use cases, i.e., what happens to the control algorithms when a measurement value is missing during an exactly observable grid? The candidate has to research methods and formulate ideas as to what constitutes a robust algorithm that can proactively react to data and cyber-physical problems. The whole setup has to be experimentally verified in the laboratory using real-time simulations. The work has to concentrate on the effect of three different types of ICT errors: Delayed data, data loss and data corruption on the control algorithms. While previous attempts [1],[2],[3] are made to investigate the effects of the three types of erros on power systems, their impact on the control algorithms have not been investigated yet.

As part of this thesis, the characteristics of robust control algorithms must be defined using literature analysis. Various use-cases for power system applications during communication failure or cyber-attacks must be determined and countermeasures are to be implemented in the existing framework available at institute ie³. To verify the functionality of the implementation, tests using a real-time simulator existing at the ie³ lab shall be carried out.

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

- Literature review and understanding of the already implemented algorithms
- Determination of improvements and optimizing the existing implementation with respect to data unavailability, identifying and countermeasures for bad data
- Determination of priorities according to importance for various use cases
- Extending the existing control algorithm to a more robust and resilient one to counter data unavailability and cyber-attacks
- Implementation and validation of the co-ordination algorithm on the RTS
- Analysis of the implementation and drawing of conclusions & and recommendations
- Documentation of the thesis

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