

**Master Thesis Proposal**  
**Development of an Online Frequency Coupling Matrix Measurement  
Method for Power Converters**

**Context:**

Owing to renewable based power generation, a new stability phenomenon called as Harmonic stability or Super-Synchronous stability has emerged. With power converters and their fast wideband control, it is not only the 50 Hz component that contributes towards instability but also the super synchronous range of frequencies (frequencies above 50 Hz up to half the switching frequency of power converters). To assess the stability, the measurement of wideband impedance is required.

In this context, a Wideband-frequency Impedance Measurement (WFZ) device was developed. The device injects a band-limited white noise signal in its duty cycle, thereby perturbing the injected current. Depending on the device under test (DUT), which could be a linear passive impedance branch or an active power converter, the voltage at the point of common coupling is perturbed. This perturbation data is used to compute the impedance. Previously, the impedance calculation was considered only in the linear sense i.e., the coupling between frequencies were ignored. Recently, an approach called as Frequency Coupling Matrix (FCM) was proposed wherein the coupling between frequencies can be considered. Thus, the electrical quantities such as impedances or admittances which were conventionally modelled as transfer functions can be modelled as an FCM which considers the first order non-linearity.

The goal of this thesis is to develop an online FCM measurement method for measuring the wideband impedances of power converters considering the coupling between frequencies. The thesis should aim to develop a recursive method whereby the measured FCM in the previous time step can be used to update the FCM with new measurement data. The developed recursive method needs to be applied for the existing WFZ device model and perform measurements of power converters.

**Your Tasks:**

In this context, the required task for this thesis will be:

- Literature survey wideband impedance measurement techniques and FCM measurement techniques
- Development of an online recursive FCM estimation method for power converters
- Application of the online recursive FCM method for the WFZ device
- Measurement of FCM models for power converters with different operational modes
- Validation and uncertainty analysis of FCM models
- Depending on availability of time, the student can work on the development of an impedance-based stability criterion based on FCM models

- Thesis documentation

The student will receive an introduction to wideband impedance measurement (WFZ) device concepts and a Simulink model of the WFZ device to quickly start with the required tasks. The details of the tasks and time plan will be discussed in the first meeting. During the work, the student will be supervised and supported by research associates of the institute. Supervision will be offered in English.

**Your Profile:**

- Good knowledge in power systems and control of power electronics
- MATLAB / SIMULINK is a prerequisite skill
- Good proficiency in English

This thesis should be written in English. Students with background in electrical engineering and control engineering are encouraged to apply. If you have any questions or concern, please do not hesitate to contact us.

**Contact:**

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