PO.068

Lifetime Prediction of Power Electronics in Wind Energy Plants

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Abstract

While predicted maintenance for drive trains and mechanical parts is already a state-of-the-art procedure to reduce downtimes, this procedure is currently not available for power electronics. Experience of wind farm operators shows that downtimes due to damages in power electronics start dominating failure statistics. On top, damages in power electronics along with damages of the generator lead to higher downtimes caused by gear boxes. In this work the development of a lifetime prediction model for power semiconductor devices as main contributor to power electronics failures is described. In parallel, measurements at the laboratories of the IALB are performed to stress the power switches of the main converter in a climate chamber and a load cycling set-up. The presented material is part of the project "WEA-Retrofit", funded by the German Federal Ministry of Economic Affairs and Energy under grant 0325758A-D.

Fig. 1: Measurement System developed at IALB

Objectives

The long term goal is a livelong prediction of the health status of the power devices based on de facto occurred, measured and analysed stress of the main converter of the wind energy plant. The learning objectives are a prediction model for estimating the remaining lifetime of the power electronics of wind energy plants and establishing a database of long-time high resolution data recordings of commercially used wind energy plants.

Methods

The required field-data will be recorded over years in an active, commercial wind farm in northern Germany between Bremen and Hamburg. Seven measurement units and special electronic systems, developed by the IALB at the University of Bremen, are used to measure and analyse the stress of the power electronics of seven wind energy plants with high resolution 24 hours a day and 365 days a year. In a first stage, started in April 2016, high resolution raw data is recorded 24/7 without data compression. In the next stage, starting in summer 2016, the measurements will be triggered by selected stress-events. The characterisation of these events is part of the project. The huge amount of data is recorded and processed by a combination of DSP, FPGA and high-end IPC devices. One of the built up measurement systems is shown in Fig. 1. Currently, the flexible and modular system allows sampling of up to seven channels simultaneously with 16 Bit @ 50 kHz or up to 18 channels if lower frequency is sufficient. An extension board with a FPGA, connected to a fast RAM, with seven channels with 12 Bit @ 10 MHz, was added for real-time signal analysis and data compression. Also four channels for humidity and temperature measurements are available. All raw data is transferred to the IPC and stored together with a timestamp. Fig. 2 shows a measurement-snippet of the grid currents under fluctuating wind conditions, i.e. partial load. After data evaluation the focus will be on the development of an online lifetime prediction model (Fig. 3) for the switching devices that will be integrated in the measurement system for first field-tests. The model is supposed to estimate the health status of the switches with respect to the thermal-mechanical and electro-chemical degradation, respectively. The presented model-based approach stays in contrast to efforts of measuring electrical key parameters of the semiconductor directly within the circuit environment, like investigated in the HiReS project (grant 0325261A/B). An approach, analogue to the presented here is described in [1]. It is focusing on a method to describe characteristic load-cycles to stimulate offshore environmental conditions in a lab-based load-cycle test-setup. In contrast to the presented approach it takes into account the thermo-mechanical stress of the semiconductors only.

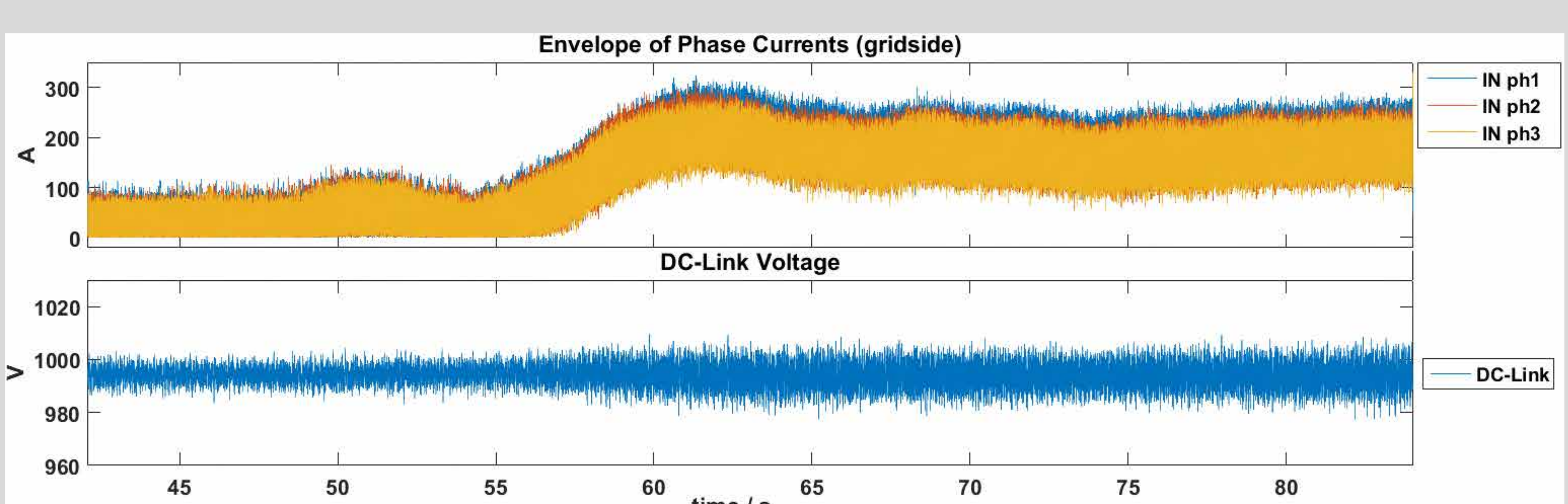

Fig. 2: Measurement-Snippet; wind fluctuation is directly passed to the grid via the converter

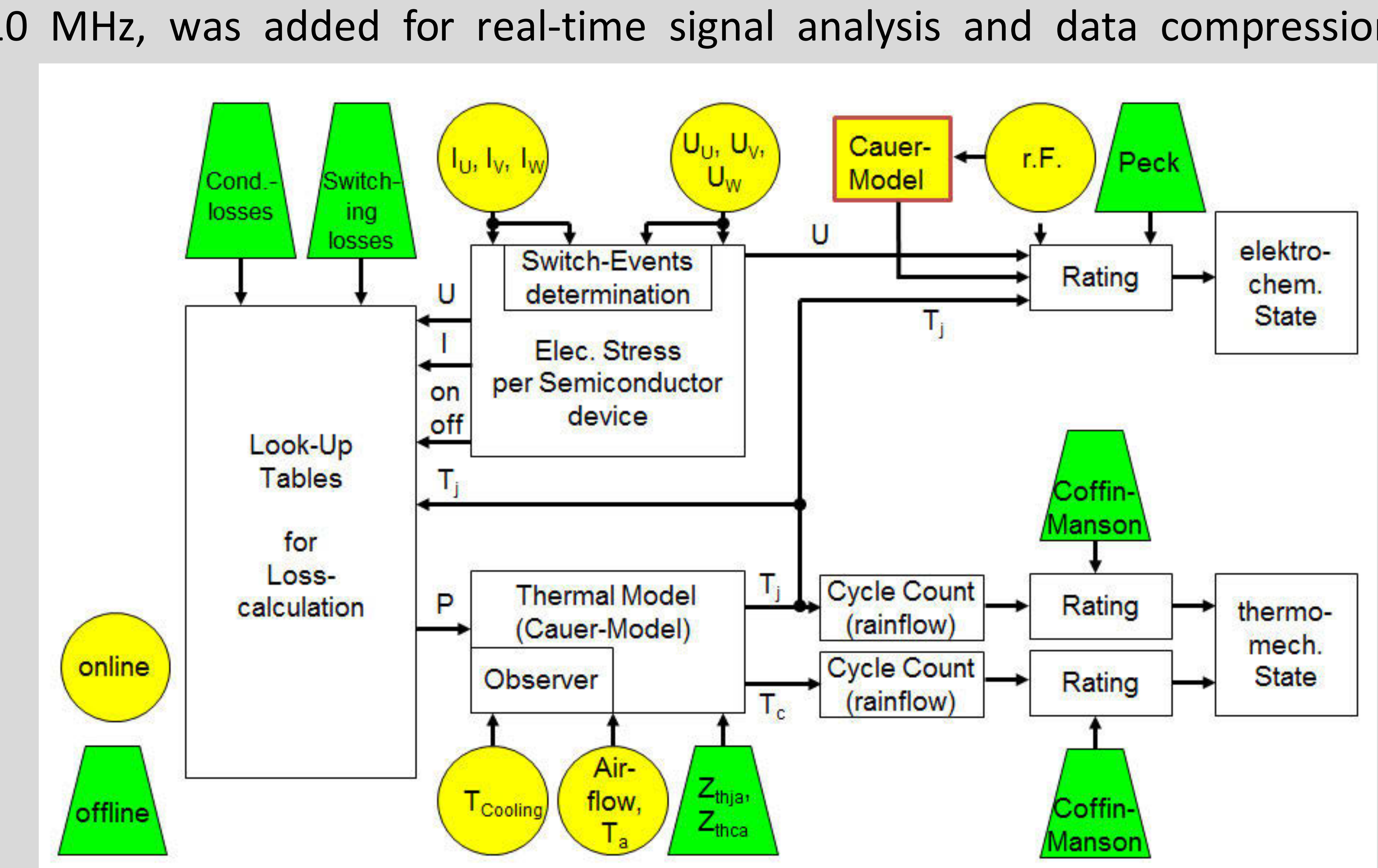

Fig. 3: Model-based estimation of the remaining lifetime of the power switches

Conclusions

A flexible measurement system for long term synchronised data recording of power electronic signals is presented. It is used to determine the stress of the power electronics on-line. After cause and effect analysis of transients imposed by the grid the data is used to predict the remaining lifetime of the power electronics in a model-based approach.

References

[1] Bohländer M.:"Lastwechseltestbasierte Lebensdauer-analysemethoden für Leistungshalbleiter in Offshore-Windenergieanlagen, ISBN 978-3-944640-01-3