Topic: O&M & logistics

Lifetime prediction of power electronics in wind energy plants

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Introduction

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. The required field-data will be recorded over years in an active, commercial wind park. 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 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 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 presented material is part of the project “WEA-Retrofit”, funded by the German Federal Ministry of Economic Affairs and Energy under grant 0325758A-D.

Approach

The necessary data is gathered in long term field-measurements in a wind farm in northern Germany between Bremen and Hamburg. 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. This measurement system is developed and manufactured by the IALB at the University of Bremen (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 sampling frequency is appropriate. An extension board with a FPGA, connected to 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 data is transferred to the IPC and stored together with a timestamp. After data evaluation the focus will be on the development of an online lifetime

prediction model (Fig. 2) 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.

Conclusion

A flexible measurement system for long term data recording and processing is presented. All measurement systems can be synchronised by a cable link if installed close to each other or by GPS if the units are placed in larger distance, e.g. in plants in a wind farm. The recorded data is needed to analyse the stress of power electronics of wind energy plants connected to the grid. Stress of the power electronics in this case is unknown up to now and has to be determined for the predictive model. One goal will be the cause and effect analysis of transients imposed by the grid as well as power oscillations within the wind park itself. Correlations of measured voltages and currents with meteorological data, like lightning, will be done in a separate work package.

Objectives

The learning objectives are a lifelong 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.

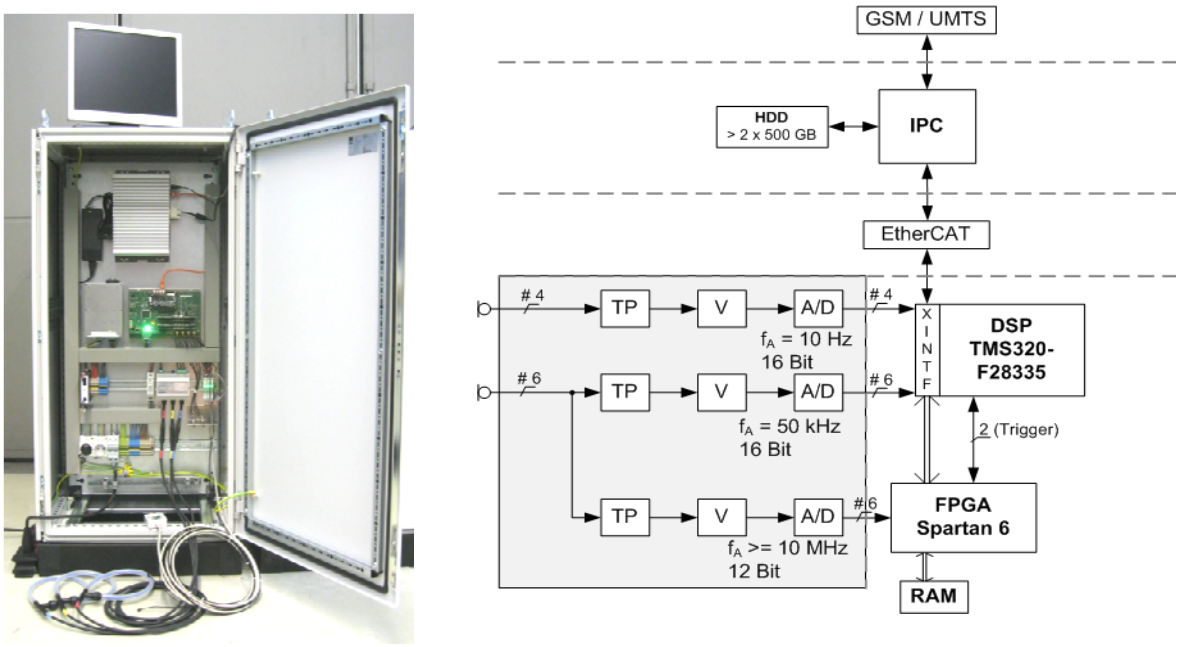

Fig. 1: Measurement Device, photograph and principle block diagram

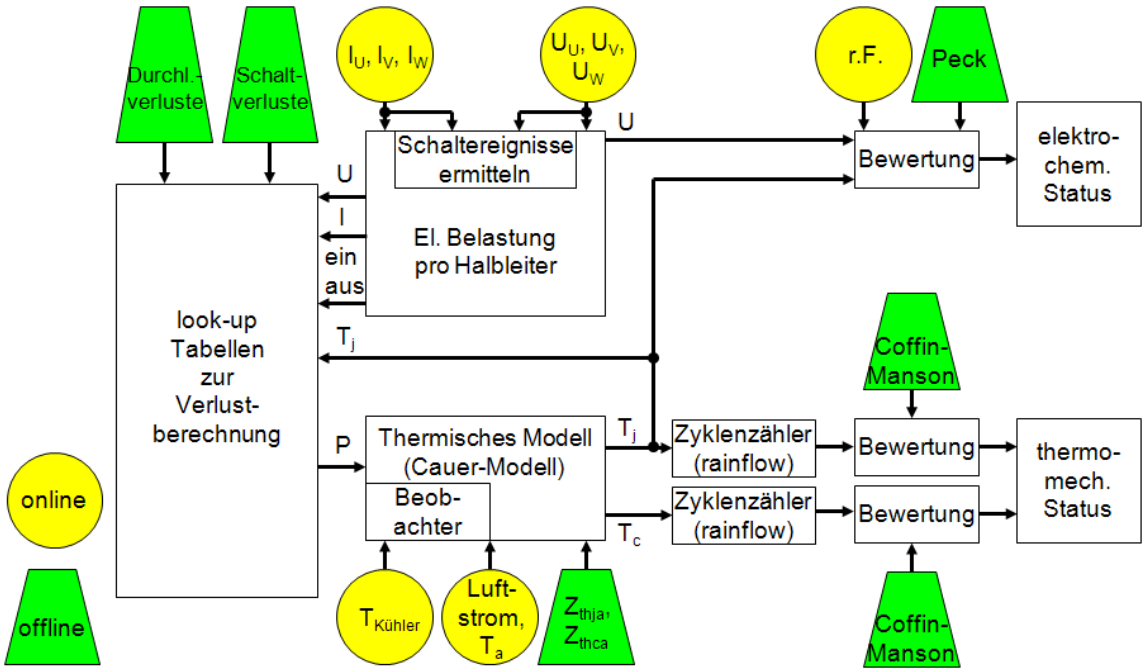

Fig. 2: Prediction model for estimating the remaining lifetime of the power electronics