Actuator and Sensor Fault Diagnosis for Wind Energy Conversion Systems

A THESIS

submitted by

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(by Research)

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"Time and space are the myths. ".

– Anonymous

I dedicate this thesis to my family, friends and teachers.

Declaration

I hereby declare that the entire work embodied in this thesis is the result of the investigations carried out by me in the **School of Computing and Electrical Engineering, Indian Institute of Technology Mandi**, under the supervision of **Dr. Tushar Jain**. This work has not been submitted elsewhere for any degree or diploma. In keeping with the general practice, due acknowledgments have been made wherever the work described is based on finding of other investigators. In addition, I certify that no part of this work will, in future, be used for submission in my name, for the award of any other degree at any university.

Place: Mandi **Bindu Sharan**

Date:

Thesis Certificate

This is to certify that the thesis titled **"Actuator and Sensor Fault Diagnosis for Wind Energy Conversion Systems"**, submitted by **Bindu Sharan**, at the Indian Institute of Technology Mandi for the award of Master of Science (by research) is a bonafide record of the research work carried out by her under my supervision. The content of this thesis, in full or in parts, have not been submitted to any other institute or university for the award of any degree or diploma.

Dr. Tushar Jain
(Guide)

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ABSTRACT

Renewable energy resources are of paramount importance while setting up power generation policies. The production of power, from wind through a wind energy conversion system (WECS), i.e., variable speed wind turbines (WT), plays a significant role in achieving the energy targets worldwide. Under the event of actuator and sensor faults or malfunctions in WT, an expertly designed control scheme may result in unsatisfactory performance or even instability of the overall system. Hence, determining the size and location of these faults quickly and precisely helps in avoiding possibly fault propagation in an interconnected system. This is considered as a critical and significant problem for reliable power generation and transmission. To address this issue, fault detection and diagnosis (FDD) schemes for wind turbines, namely at system- and component- level, are developed in this thesis.

At system-level, a complete FDD module to address actuator and sensor faults is developed using an unknown-input-residual generator and a suitably designed estimation filter to extract complete information of the fault. The effectiveness of the developed FDD method is demonstrated on a FAST (Fatigue, Aerodynamics, Structures, and Turbulence)-coded benchmark WT simulator designed by the U.S. National Renewable Energy Laboratorys (NREL) National Wind Turbine Center under the MATLAB® environment.

For the component level fault detection and diagnosis, a 3-phase uncontrolled bridge rectifier, which is a part of the power conditioning unit, used in WECS is considered for the unbalance input and opencircuited faults. Three fault diagnosis algorithms have been developed using a signal-based method, where the magnitude and phase of the fundamental component along with other harmonic components of the rectified DC voltage play a significant role. The novelty of the proposed scheme lies in the identification of an exact location of OC diode(s) and unbalance phase, which is established by introducing a set of specifically designed resistances.

The effectiveness of the proposed scheme is successfully demonstrated through MATLAB® simulations and on developed prototype hardware of the variable power fed power 3-phase uncontrolled rectifier.

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