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Fault Tolerant Control Design for a Tidal Current Turbine Generation System

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ABSTRACT

Tidal energy is renewable and also highly predictable; however, access for maintenance operations on devices is limited and very expensive. The immense forces impacting on tidal current turbines (TCT) may cause component failures which have the potential to result in loss of power generation. Fault tolerant control offers the potential for the TCT to continue operating in the event of failures in components such as tidal velocity sensors. This paper presents a fault tolerant control methodology for maximum power point tracking in the event of a tidal velocity sensor failure with simulation results demonstrating the capability of the technique.

KEY WORDS: Fault tolerant control; tidal current turbine; robustness; P&O; PMSG; MPPT

INTRODUCTION

Renewable energy is making a greater contribution than ever in supplying global energy demand. Due to the predictability and capacity of the tidal currents, the position of tidal energy in the renewable energy mix has significantly increased with tidal current energy starting to make contribution (Benbouzid et al., 2011).

Tidal current turbines capture energy from tidal currents using technology which is very similar to the wind turbine capture of energy from moving air (Clarke et al., 2006). The water density is significantly higher than that of the air, so tidal current turbines operate at lower speeds but higher torques compared with wind turbines. In tidal current turbine systems, there is the potential for certain faults to cause failure of the whole system because the devices are subjected to large forces from strong tidal currents. Such failures would generally require retrieval of the device to carry out maintenance on shore but the time window to access a device is limited both by the weather and the tidal currents themselves (Sousounis et al., 2016). In order to reduce the maintenance time and increase the energy capture, fault tolerant control is essential in tidal current turbine systems.

Fig. 1 shows the percentage breakdown of failures that occurred during the period 2000-2004 in Swedish wind power plants, from this figure it can be seen that the sensor faults accounted for 14.1%, faults in electric systems 17.5% and faults in control system 12.9%. These are the most common faults that might occur in the electrical side of the system (Amirat et al., 2009). The electrical control system of a tidal current turbine is sufficiently similar to that of the wind turbine for the fault data of wind turbines to be considered as a reference for tidal current turbines.

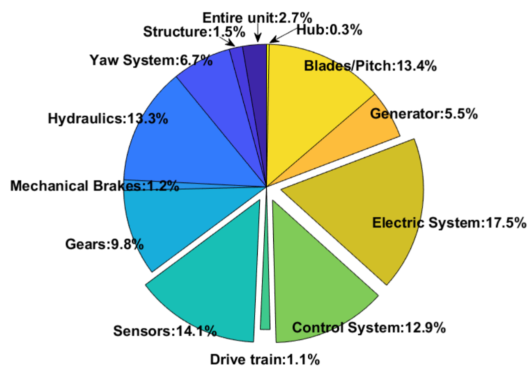

Fig. 1 Occurrence (%) of failures for Swedish wind power plants between 2000-2004.

In this paper, the sensor faults on the electrical side will be briefly introduced, as well as some corresponding potential solutions. The fault that this paper focuses on is the tidal current speed sensor fault. Generally, the sensor faults that occur in tidal current turbine systems are tidal current speed sensor faults and generator rotor speed faults. The tidal current speed sensors are often lost or damaged due to the underwater environment and strong tidal currents (Pham et al., 2017). Rotor speed sensors are generally installed on the rotor shaft; the accuracy of this kind of mechanical sensor will be influenced by environment factors, such as humidity, temperature and vibration, all of which will be significant in the underwater turbines and will potentially cause problems with the speed readings (Pham et al., 2015).

This paper will present a basic control structure for a tidal current turbine generation system with a Permanent Magnet Synchronous Generator (PMSG), the control of the tidal current turbine system is achieved by