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A real time testing system for wind turbine controller with xPC target machine

Jianzhong Zhang *, Ming Cheng

School of Electrical Engineering, Southeast University, Nanjing, China

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ABSTRACT

A cheap hardware-in-the-loop testing system for wind turbine controller is built based on MATLAB xPC. A wind-power generation model is constructed in the Matlab/Simulink of host machine, where the code is generated by real-time workshop and downloaded to the target machine. Then the virtual wind power generation system may be controlled by the physical controller, and the effectiveness and performance of the controller can be validated. By composing the drivers for xPC device, the selection of I/O devices for the testing system is flexible. A friendly interface of the testing system is established by combination of xPC and virtual reality toolbox. A testing system for wind power generation system with friend interface may be established by the described method.

Introduction

With the increasing concerns on environment and energy issues, the development and utilization of renewable energy become the focus of governments and experts all over the world. Among all kinds of renewable energy, wind energy is one of the most important ones and has been seen rapid development in worldwide area. In china, the total installed capacity of wind turbine has been over 62 GW since 2011. With the rapid growth of installed capacity of wind turbine, more and more efforts are put on the research of wind power generation related technologies by leading countries, in order to cope with the developing trend of wind turbines that unit capacity is increasing continuously, variable-speed and variable-pitch becomes popular and more offshore wind farms are planed [1,2].

The controller is the core component of wind turbines, whose performance is directly related to the quality of wind turbines. Then it is very critical to use an effective and reliable testing method for the controller of wind turbines. Simple mathematical simulation is non-real time, and it is hard to model the complex characteristics of some actual systems.

Traditionally two testing methods are used for wind turbine controller. One method is building full-size wind turbine in certain site. The testing results will be believable because of the actual situation. However, wind speed is a stochastic process and it is impossible to control in natural. In this case the performance testing of the controller would spend a long time and cost much money. Since wind speed and direction are determined by external factors, some experiments under extreme conditions such as wind turbulence are quite difficult and dangerous. Another widely used method is building wind turbine simulator, where a motor simulates the operations of the wind turbine and drags wind power generator to generate electricity [3–6]. This method greatly reduces the cost and is easy to use. It is also possible in certain extent to simulate the wind turbine output in different wind aerodynamic situations. However, the wind turbine simulator usually only outputs the rotational speed and torque of the wind turbine under different wind conditions, while ignoring many other operation status, such as vibration, tower and blade shaking. Therefore the actual situation may have certain deviations with simulated one.

With the fast development of computer technology, the real time semi-physical simulation for wind turbine research is possible by introducing hardwares to the digital simulation systems [7–14]. This paper presented a hardware-in-the-loop testing system for wind power generation based on xPC. Matlab/Simulink xPC can provide a relatively inexpensive hardware in the loop testing method [15–18]. The real time testing system under the environment of Simulink xPC has the physical controller of the wind turbine and the virtual wind power generation system. The physical controller controls the virtual wind power generation system by through PCI data acquisition card on computer motherboard.

* Corresponding author.
E-mail addresses: jiz@seu.edu.cn (J. Zhang), mcheng@seu.edu.cn (M. Cheng).

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The real time testing system not only has more flexibility in adjusting and improving the simulation environment, but also greatly reduces the verification cost of the controller.

This paper is organized as follows. Section 'xPC technology' introduces the xPC technology, include the xPC target, device driver and virtual reality. Section 'Configurations' discusses the configuration of the proposed testing system. The experiments are carried out and the results are put forward in Section 'Experiments'. At last the conclusions are given in Section 'Conclusions'.

xPC technology

xPC target machine

xPC may convert the simulation model constructed in Matlab/Simulink into xPC real time kernel code by through real-time workshop, and then download the real time kernel code into the xPC target machine. Because the xPC uses computer's micro kernel and hardware, where the micro kernel is not based on DOS or Windows, an ideal cost-effective and real time xPC target machine is achieved. The micro kernel is a high performance processor and can be adjusted to the state of minimum cost and optimum performance. Here the sampling rate reaches 100 kHz. The target PC machine, using the standard PC hardware and data acquisition card, becomes a real time rapid prototype machine by xPC technology. In this way, not only the simulation model will be running on the xPC target machine, but also low-cost real time simulation is achieved due to the high response speed. Furthermore, the model parameters may be adjusted during the execution of a program through management device of the xPC target machine. If the monitor is deployed for the xPC target machine, various state information and signals can be observed on the xPC target machine by Target Scope function. Users can also use user-defined interface to access these data and signals.

The xPC configuration method is as follows: Firstly starts Matlab software on the host machine and generates the real time kernel code for communication environment between host and target machines. This real time kernel code is usually output to the floppy drive by default. Considering the floppy drive is not the standard configuration for the computer now, a real time kernel floppy readable *.img file can be generated by RamDiskNT software and then the real time kernel code will be read in the target machine by virtual floppy. The real time kernel of xPC can be run in any PC machine, which is used to run the model built in Simulink. By calling VC or Watcom compiler, the simulation model will be built into xPC target code. Downloading the code to the xPC target machine via Ethernet or RS232, then the model built in Simulink may run on the xPC target machine. The xPC has rich drivers for I/O device, and allows users to write their own drivers for extended I/O device meanwhile. In order to realize the hardware in the loop simulation, the users can also develop their own graphical interfaces to access data and signals. The data can be exchanged between the host and target machine, then the parameters can be dynamically adjusted. The xPC operating principle is shown in Fig. 1.

Device driver programming

In real time simulations the xPC target machine, as a prototype machine, usually need to transfer and feedback signal with the

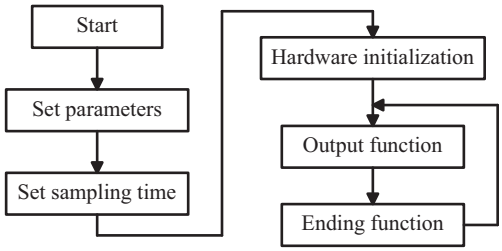

Fig. 2. Flow chart of device driver programming.

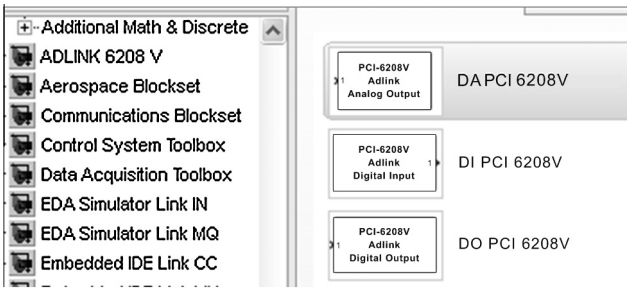

Fig. 3. I/O device driver modules.

Fig. 4. Model of virtual wind turbine.

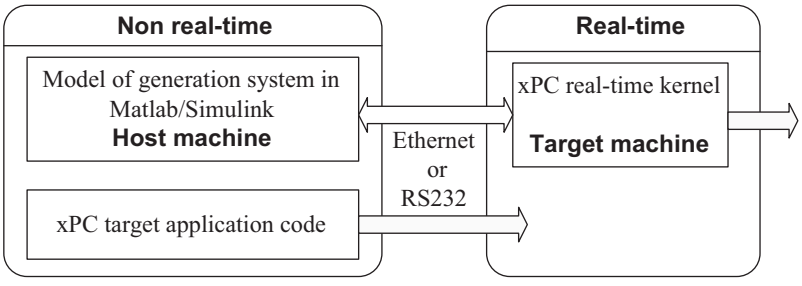

Fig. 1. xPC operating principle.