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DETERMINATION OF PERFORMANCE INDICATORS OF PRESENT WIND TURBINE SIMULATORS

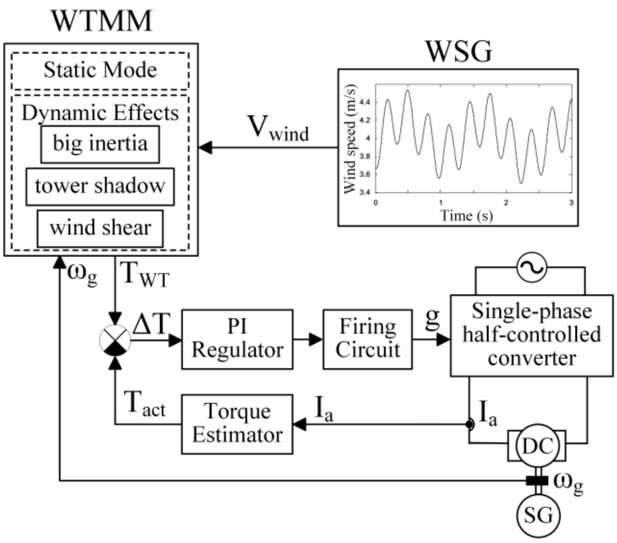
Introduction

In the context of the rapid development of modern wind power, the development of wind turbine simulators (WTS) is topical. WTS are software and hardware complexes capable of reproducing the operation modes of wind turbines (WT) relative to the generator shaft of a wind power plant (WPP). The use of such complexes makes it possible to check and research an electrical equipment (EE) of wind power plants in a short time in the conditions of manufacturing enterprises without connection to real wind turbines.

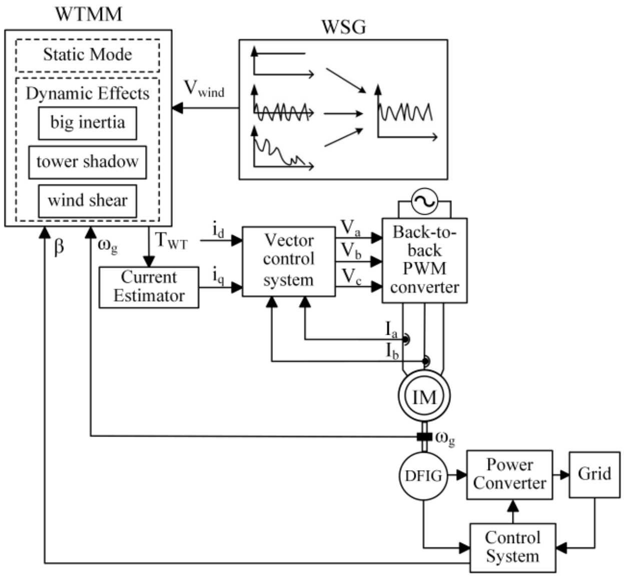
Given the variety of approaches to WTS's design [1], as well as the growing requirements for the energy efficiency of the electric drive, the issues of rational choice of the structure of the simulator for the most effective work are relevant. The primary task is to determine the performance indicators of work and application of wind turbine systems.

The main part of research

Thus, present WTS are built on the basis of automated electric drives (ED) of a direct current (Figure 1a) or alternating current (Fig. 1b). Figure 1 depicts a WTS based on a DC motor that drives a synchronous generator (SG) [2] and a WTS based on an induction motor (IM), which drives a double-fed induction generator (DFIG)) [3].



a)



b)

Figure 1 – WTS based on a DC motor (a) and IM (b)

Conditionally, two systems can be distinguished in the WTS structure: software-control system (SCS), which is based on the mathematical model of the wind turbine mathematical model (WTMM), and electromechanical system (EMS), which, based on the reference signal from the SCS, reproduces on the oscillator shaft the characteristics of the real WT.

The WTS are built on the principle of an automatic control system for the electromagnetic moment (*T*) of an electrical machine. The torque reference signal (T_{WT}) is generated by a WTMM block designed for a WT with fixed blades (β = const) [2] or with aerodynamic control of blades (β = var) [3]. The development of WTMM takes into account the static and dynamic modes of WT operation and the dynamic effects that occur when a real wind turbine is in operation. Obviously, taking into account dynamic effects determines the adequacy of the process of simulating a real wind turbine. The input parameters of the WTMM block are the actual angular velocity value obtained from the sensor on the generator shaft (ω_g) and the wind speed value (V_{wind}) that is generated by the wind speed generator (WSG) in various ways. At the same time, the use of only one way of setting the wind speed in the SCS (for example, only software simulation) limits the use of the WTS in the study of EE, for example, for the prediction of the generation of electricity by a wind turbine at a specific location.

The difference between the set torque value of the wind turbine (T_{WT}) and the calculated torque value (T_{act}) is used to generate control signals in the gate valve control system of the power semiconductor converter (PSC), which controls the motor to reproduce the wind turbine state parameters (T, ω_g) relative to the EE generator shaft WPP. It is obvious that the PSC schemes should be reliable, energy efficient and must be able to realize all modes of operation of WT (start, acceleration, braking). Thus, the use of a single-phase half-controlled converter in [2] makes it possible to simplify the EMS and the corresponding control algorithms. However, it does not allow realizing the recuperation of the braking energy into the power supply network and simulating some starting and braking modes of the WTS operation due to the impossibility of realizing a controlled reverse of the motor current. The back-to-back PWM converter used in [3] allows realizing energy-efficient energy recuperation in the power supply network and realizing imitation of all possible operating modes of WT, but it has a high cost, complex structure and large computational complexity of the control algorithms.

It should be borne in mind that in order to assess the adequacy of the process of simulating the behavior of wind turbines, it is necessary that the generating system be similar to the real electrical equipment of the wind power plant.

Conclusions

Thus, as indicators of the effectiveness of wind turbine systems, the following requirements for operation and technical and economic indicators are defined:

1) the simulation of all operating modes of wind turbines using selected electromechanical system;
2) the energy efficiency of the system;
3) the cost of the system;
4) the simplicity and reliability of power converter and control algorithms;
5) the similarity of generating system to electrical equipment of wind energy conversion systems;
6) the accounting of dynamic effects in software-control system (big inertia effect, tower shadow effect, wind shear effect, elasticity of the drive train);
7) flexibility of wind speed setting.

Literature:

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