Simulation of Wind-solar Complementary Distribution Power Generation System Based on PSCAD

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Abstract

Toward to the situation that the overall model and simulation research of complementary power generation system is less recently, a new structure model of the wind-solar complementary distribution power generation system is proposed. According to the models of wind power generation and photovoltaic power generation, the PSCAD is used for building a three-phase photovoltaic grid-connected power generation system. Through the model, the systm performance is analyzed, and the correctness of the developed control element and the usability of the engineering simulation analysis are verified.

Keywords: Wind power generation, photovoltaic power generation, wind-solar complementary, PSCAD (power system computer aided design), distribution power generation.

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1 Introduction

Compared with other new energy sources, wind and solar energy development history is relatively early, which is relatively large and widely used for renewable energy. For some mid-latitude and hilly countries, wind and solar energy can be used to generate electricity together. Wind-light complementary can effectively solve the shortage of the single power generation system, reduce the oil, coal and other resources dependence, and solve the problem of environmental pollution, which plays an important role to the human sustainable development.

At present, domestic and foreign scholars in this field focus mainly on the large-scale grid power plants, the individual wind power generation and the individual solar photovoltaic power generation control. However, the research on the complementary power generation, especially on the overall modeling and simulation of the wind-solar complementary power generation system is less. The study on wind-solar complementary system chiefly concentrates in three aspects. Firstly, the optimization design of the system to improve the operation stability and power supply reliability of the whole wind-solar complementary system by establishing multi-objective function and designing intelligent optimization algorithm. Secondly, the research on MPPT control technology combined with DC/DC converter to realize the maximum power output, through the combination of hardware and software technology. The third is the research of energy storage, which focuses on the maintenance, charge and discharge control and capacity prediction of energy storage devices.

This study establishes the wind power generation system model, the photovoltaic electric power generation model, rectifier and inverter in PSCAD environment starting from the principle, working characteristic and circuit structure of wind-generated electricity and photovoltaic electric power generation, and studies the feasibility of implementing of the model systems.

2 PSCAD Model of Wind-Solar Complmentart Distribution Power Generation System

2.1 Wind Power Generation Subsystem Model

This research establishes the wind power-pumped storage system model, the photovoltaic system, rectifier and inverter in PSCAD environment starting from the principle, working characteristic and circuit structure of wind power generation and photovoltaic system, and studies the feasibility of implementing of the model systems.

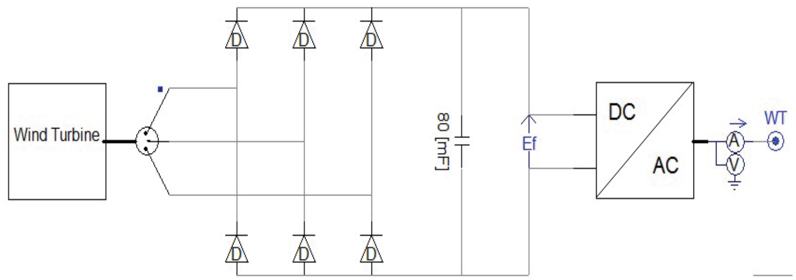

Figure 1 PSCAD simulation modeling of wind generator system.

The output of the wind-power turbine P_w can be expressed as:

$$P_\omega = \begin{cases} 0 & V_f \le V_{f\,\min} \\ aV_f^4 + bV_f^3 + cV_f^2 + dV_f + e & V_{f\,\min} < V_f < V_r \\ P_\varepsilon & V_r < V_f < V_{f\,\max} \\ 0 & V_f \ge V_{f\,\max} \end{cases} \tag{1}$$

In which, V_f-working winding speed, m/s; $V_{f\,\min}$-starting wind speed, m/s; $V_{f\,\max}$ – cut-off wind speed, m/s; V_r-rated wind speed, m/s; P_ε-rated output power, W/m.

The PSCAD simulation modeling of wind power generation system is shown in Figure 1.

2.2 Photovoltaic Generation Subsystem Model

The photovoltaic generation subsystem mainly embraces the photovoltaic array, blocking diode, Boosts booster chopper circuit and inverter circuit. The Photovoltaic cells output direct current, and do not need rectifying circuit. This model adopts an uncontrollable parallel network system. There is no need to add the accumulator in the following Figure 2. The voltage can be directly connected with the power network after the output of the inverter circuit.

The PV array adopts PV shading photovoltaic module, which can adjust the illumination intensity and temperature to simulate the real environment. And a group of blocking diodes is connected to the PV array to prevent current flow by using the characteristics of single guide. Because the voltage generated in the photovoltaic cells is very small (the voltage of single tiny piece of solar panels is about 0.07 V), a series Boost DC circuit is needed, and the inverter circuit is connected directly to the power grid or the AC load.

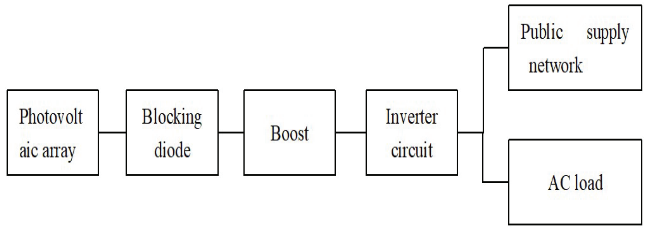

Figure 2 The flow chart of photovoltaic generation system.

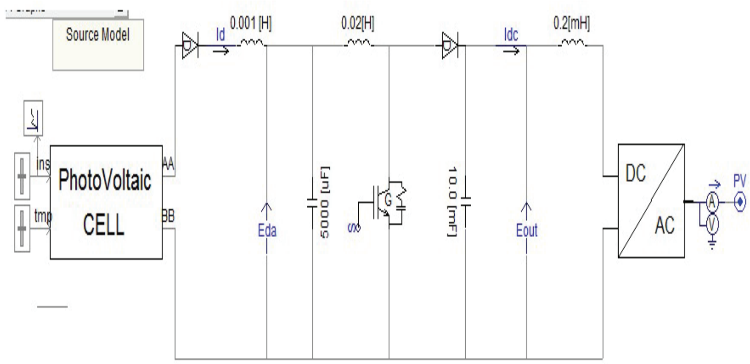

Figure 3 Photovoltaic generation system model on PSCAD.

The model of photovoltaic generation system on PSCAD is shown in Figure 3.

The overall PSCAD model of the wind-solar distribution hybrid power system is shown in Figure 4.

In the model, the three-phase uncontrollable rectifier circuit is used for the rectifier of wind power generation system. And a Boost Boost circuit is used to amplify the DC voltage, and the three-phase bridge voltage inverter is converted into a stable AC 220V power frequency voltage, which can ensure the normal operation of AC load or power network.

3 Simulation Analysis

3.1 Simulation Analysis of Wind Power System

The simulation time is set to 50 s, and the Figure 5 shows the input variation of wind speed and the output torque waves of the fan. The Figure 6 shows the output DC voltage waveform diagram of the rectifier circuit.

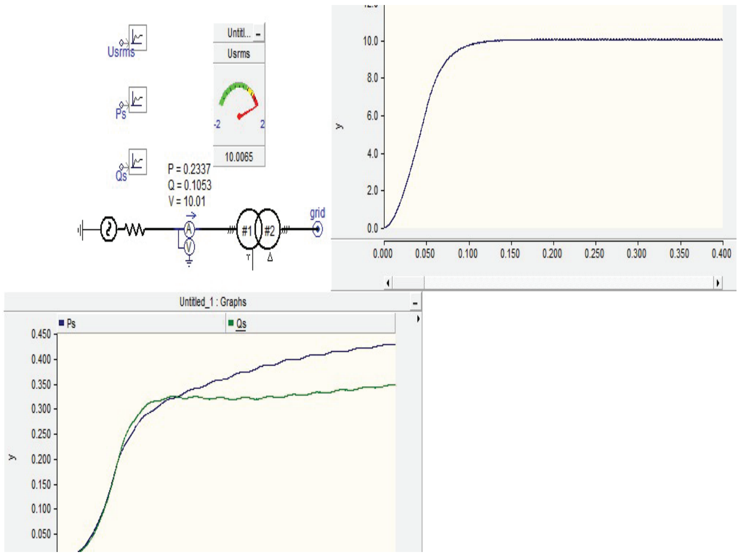

Figure 4 Model of the wind-solar distribution hybrid power system.

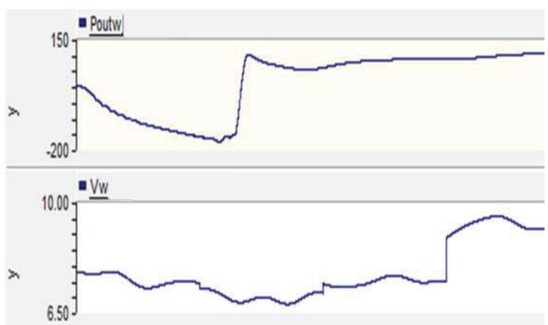

Figure 5 The input variation of wind speed and the output torque of the fan.

In Figure 5, the external input wind speed is not stable, and the wind speed varies from 6.5 m/s to 10 m/s to simulate the instability of wind energy. The force curve of the wind turbine was not stable at first, and after adjusting for a period of time, it could stabilize around 100 N. Also it can be seen in Figure 6 that the output voltage of Rectifier increases form 0 at beginning to the maximum value 1.3 V after 30 s. Then the voltage decrease slightly, and after one minute or so, the voltage is stable around 1V, which eventually achieve of the DC voltage output.

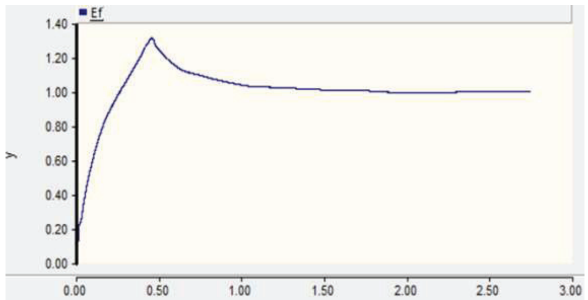

Figure 6 Output DC voltage of rectifier.

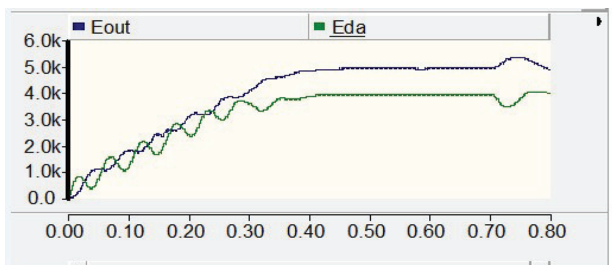

Figure 7 The DC voltage waveform on both sides of the booster circuit.

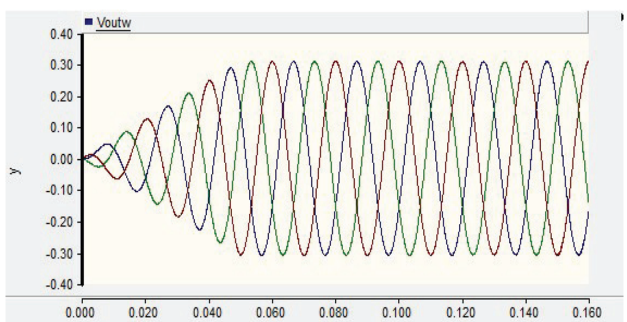

Figure 8 AC voltage waveform output of the inventer.

3.2 Simulation Analysis of Photovoltaic Generation Subsystem

The simulation time is set to 50s. Figure 7 shows the DC voltage waveform on both sides of the booster circuit, and Figure 8 shows the AC voltage waveform output of the inventer.

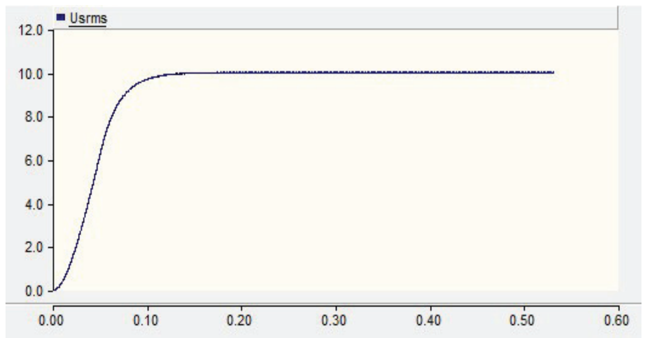

Figure 9 The effective value of the output voltage after the transformer.

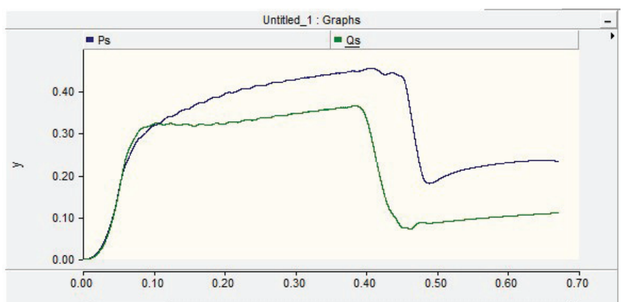

Figure 10 The active and reactive power of voltage after the transformer.

In Figure 9, the output and input voltage of the boost chopper circuit starts to rise from 0. After 30 s, the voltage is stable, and the output is about 1kV from the input voltage.

3.3 Simulation Results of Power Grid Side

Figure 9 shows the effective value of the output voltage after the transformer, and Figure 10 shows the active and reactive power of voltage after the transformer.

It can be seen from Figure 9 that the output three-phase voltage waveform, through the main bus-bar wind-light complementary system, is very stable, the value at about 300 V. And the effective value of the output voltage after the transformer is stable after 0.1 s and the value is about 10 kV. As shown is Figure 10, the active power increases sharply in the first 0.1 s, then slowly increases, and the maximum value is around 0.47 KW. And the value then drops sharply to the minimum value of 0.18 KW at about 0.47 s. The variation trend of reactive power is similar to that of active power. The simulation design of power generation system in this study is feasible.

4 Conclusions

This paper applies PSCAD to design and establish a set of complementary distributed generation system and simulate the model based on the structure of the system. Simulation results show that the system can simulation the characteristics of the photovoltaic systems and wind generation system, and the power generation system combined with the bus can convert input to 300 V AC output, and actually 10 kV after through transformer booster. This model can be used for the simulation study of three-phase photovoltaic grid-connected power generation system, which can provide a favorable basis for further researches.

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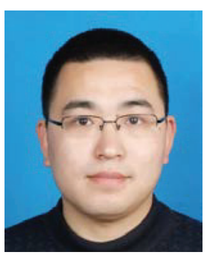

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