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Research on the wind power's ability in supplying electrical energy for 6kV grid of underground mines in Quang Ninh, Vietnam

Nghiên cứu khả năng kết nối điện gió với lưới 6kV các mỏ hầm lò Quảng Ninh Việt Nam

Research paper

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Quang Ninh province, Vietnam has a rich wind power resources. This type of energy will be soon utilized for generating power to supply all industrial sites including mining corporations. Because of geological characteristics, wind power stations are located near the 6kV grid of mining areas, therefore it needs to make the analysis about the connection ability of wind power generators to the grids. The paper presents the connection model of a wind turbine and 6kV grids. Based on this model, the simulations of system's possible operating mode are implemented. The conclusions about the suitable operating modes of wind turbine are pointed out to give the operators and grid managers a general observation for the possibility of connecting a wind turbine to 6kV grid

Tỉnh Quảng Ninh là một trong những địa phương giàu tiềm năng về năng lượng gió. Theo phân tích, loại năng lượng này sẽ sớm được đưa vào cung cấp điện năng cho các khu công nghiệp trong đó có các công ty than. Do đặc thù địa lý, các trạm phát phong năng được đặt khá gần các lưới điện 6kV của mỏ, vì thế cần tiến hành phân tích khả năng kết nối trực tiếp các máy phát điện gió với lưới điện này. Bài báo giới thiệu mô hình kết nối máy phát điện gió với lưới 6kV. Các mô phỏng về các chế độ vận hành có thể có của lưới cũng được thực hiện. Các kết luận về chế độ vận hành thích hợp của tua bin gió được đúc rút để giúp người vận hành, các nhà quản lý lưới điện có được cái nhìn tổng quan về khả năng kết nối tua bin gió với lưới điện 6kV.

Keywords: wind power, 6kV grid, simulation model, DFIG

1. Introduction

Renewable energy, in general, and wind energy, in specific have a great advantage over the fossil-sourced energy. The potential of wind energy in Vietnam was estimated about 513,360 MW, equivalent to approximately six times higher than the predicted capacity of the electricity sector by 2020 [7]. Quang Ninh province with costal character has promising wind power resources. Base on the investigation of EVN and WB the total capacity of wind power is over 7MW (at wind speed of 65m/s) [1], [7]. The power generated by wind turbines must be either transmitted for long distance or supplied the local load. Because of geological character, 6kV grids of underground mines which are big capacity local loads are located quite near the wind power station (Ha Long and Van Don). Therefore, it needs to make a research of connecting wind power turbine to the grids for better operation as well as ensure the stability of the whole system

2. Models and the simulation of possible connection

2.1 The connection models of wind turbine and 6kV grid

2.1.1 Introduction of wind turbine model

There are a lot of wind turbine models: inland model, island model, … In operation, all models consist of two conversion procedures: One is the conversion from wind kinetic energy into mechanical energy, others is the conversion from mechanical energy into electrical energy [4], [5].

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The model utilizing in this research is a wind turbine with a doubly fed induction generator (DFIG). Its motor is wire wound one with its stator is connected to the grid directly, while its rotor is connected to the grid by power converter. The detail of the model is shown in figure 1 [8].

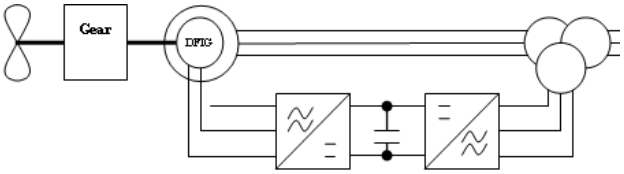

Figure 1. The model of wind generating system with Double Fed Induction Generator

As operation of a DFIG, both rotor and stator can generate power, the total generating power injected into grids is rotor's power and stator's one. The direction of powers is shown in figure 2 and 3.

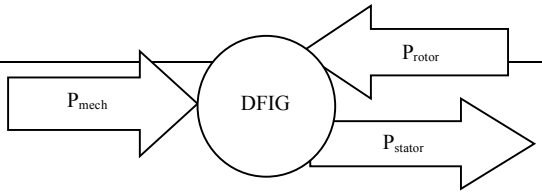

Figure 2: The direction of power in DIFG when $\omega<\omega_0$

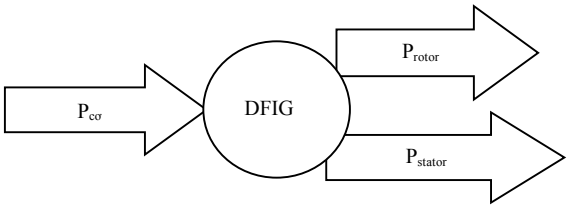

Figure 3: The direction of power in DIFG when $\omega>\omega_0$

Total power injected into grid is calculated by the formula (1) [2], [4], [8]:

$$P_{total} = P_{stator} + P_{rotor} \quad (1)$$

The single diagram of this structure is presented in figure 5 [3].

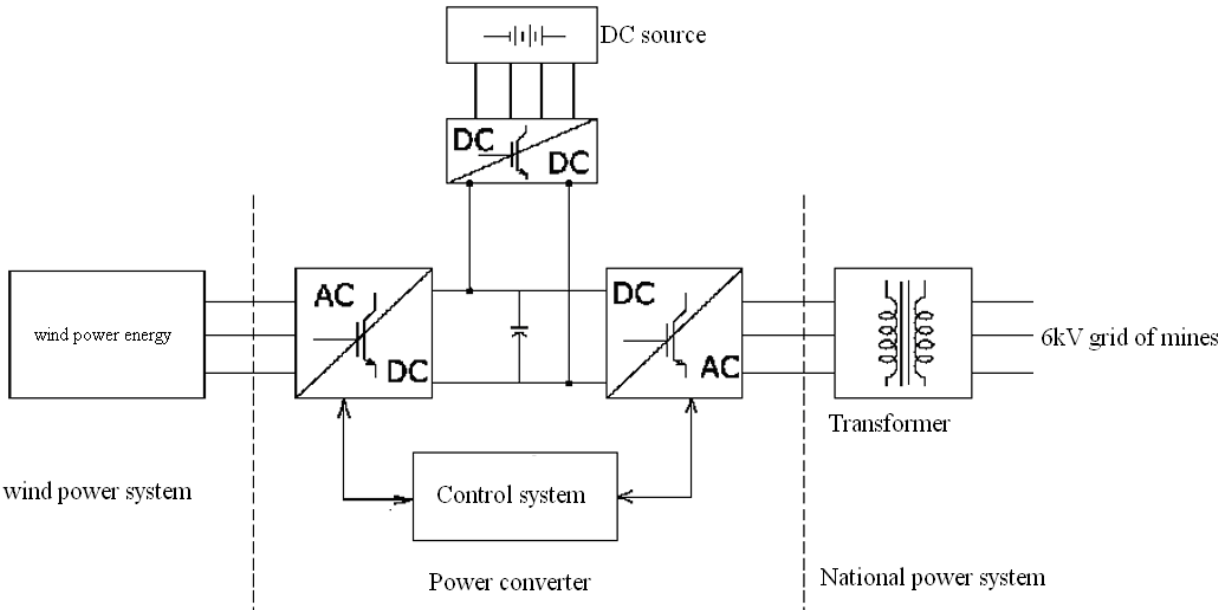

Figure 4. The connection diagram of wind power system and national power system.

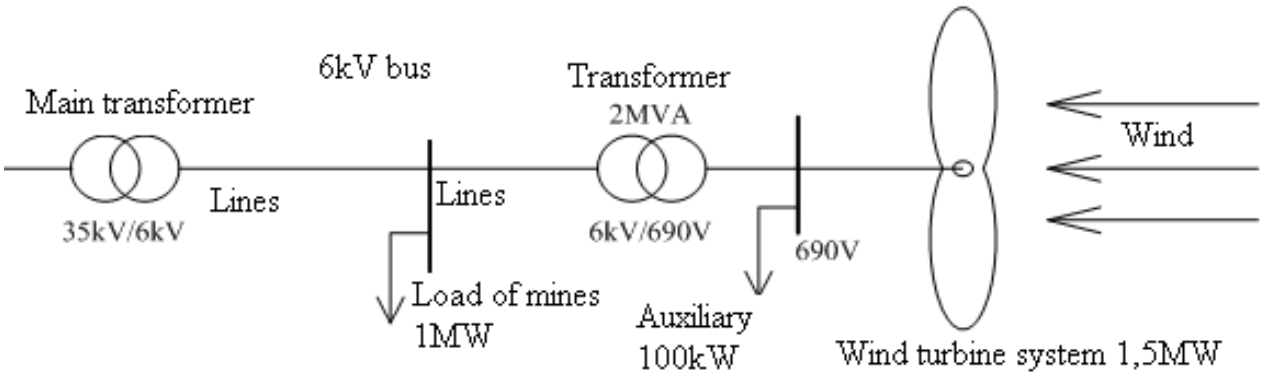

Figure 5. Single line diagram of system

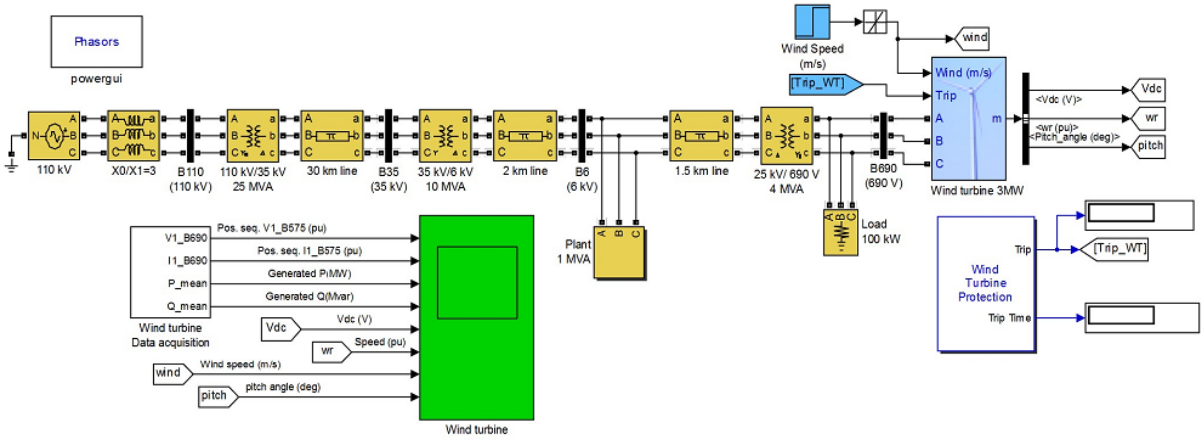

Figure 6. Simulation model of grid on figure 5

2.1.2 Simulation model

The simulation model is shown in figure 6. It contains: a wind power system having 1,5MW capacity (DIFG), a 6kV grid including lines and 6/0,69kV transformer, loads connected into bus number 6.

The diagram is simulated in 50s, the frequency of the system is 50Hz. The out put response of DIFG is shown in figure 7.

In figure 7, the simulation is implemented with the following data: From 0 to 5s wind speed is lower than 7m/s, turbine speed is about 0,7pu. The power of wind power system is 0,5MW. As wind speed is changed, the current is about 0,2 pu, dc voltage on bus B6 is unchanged 1pu. From 5 to 18s, the speed of wind is come up to the stable value-14m/s, the turbine velocity increases to 1,25pu, but the out-put power and the current of system are also increased, reactive power is decreased.

2.2 The simulation results

2.2.1 Normal operation mode

After 20s, the capacity of wind power reaches to 3MW, reactive power Q is 0,25 MVAr. As wind speed is over setting value, the control system will adjust the pitch angle to ensure the stability of rotor's rotating speed.

2.2.2 Abnormal operation mode

The analysis is implemented with the following abnormal operation modes: earth fault on 6kV grid, phase to phase short circuited, and 3 phase short circuited. The figure 8 shows the system and abnormal operation mode.

The response of the whole system is shown in figure 9, the impact of earth fault on wind power system is temporary, the recloser located in 6kV feeder can recover the pre-situation of system.

Similarly, the simulation of other abnormal mode is presented in figure 10.

The simulation results in figures 10 and 11 show that when short circuited happen, the wind turbine is disconnected from system. At this moment the system needs to start up some backup power system such as UPS to energize the mining system.

When the out-put power of wind turbine is zero, the controller also control the pitch angle of the wings to get better performance of rotating speed for avoiding the mechanical damage.

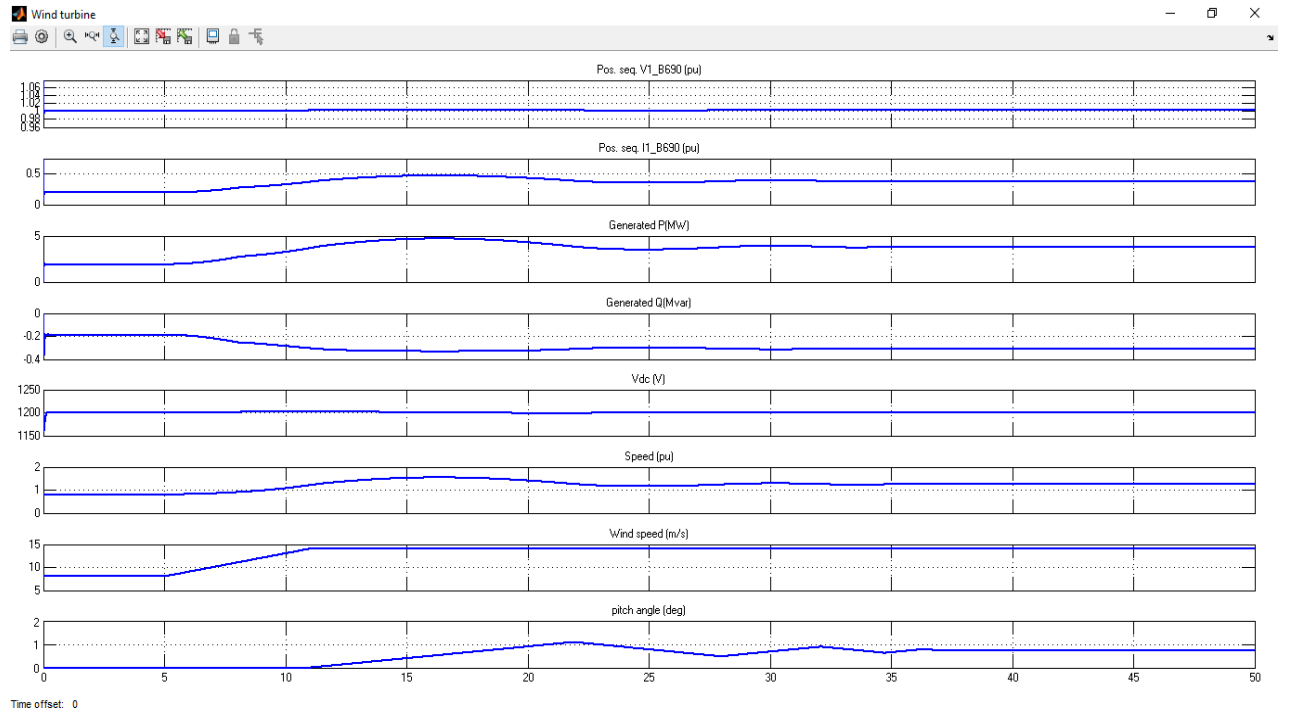

Figure 7. Output response of DIFG

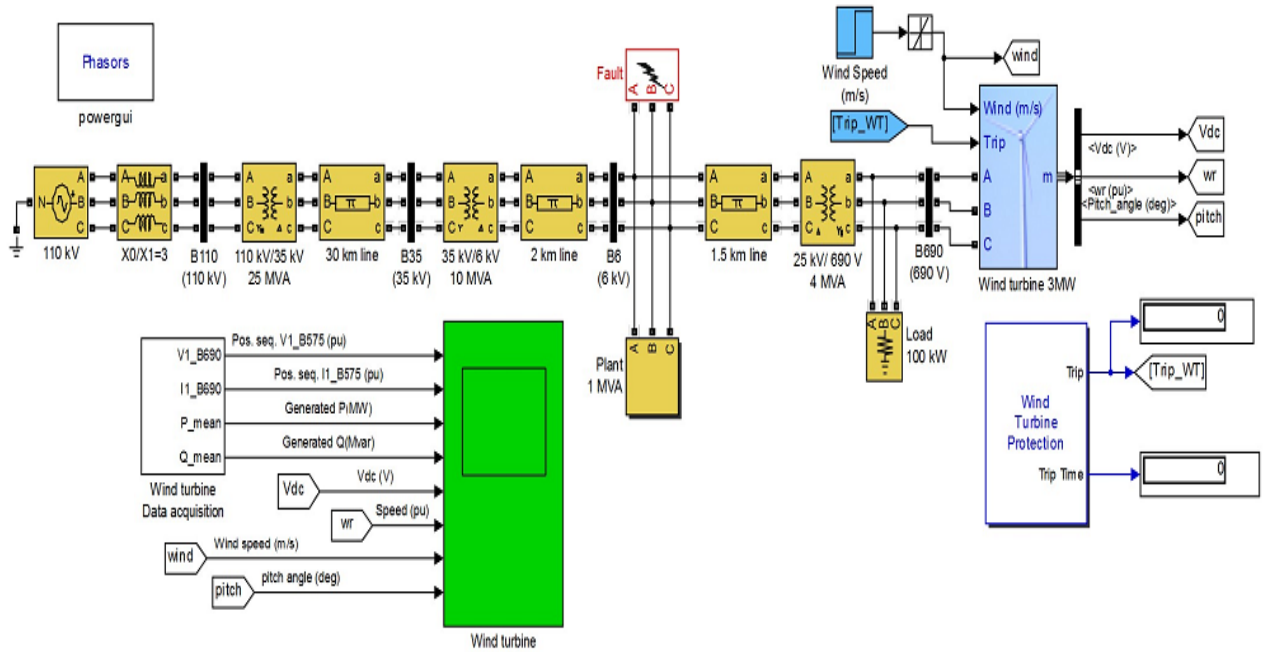

Figure 8. The simulation diagram of abnormal mode

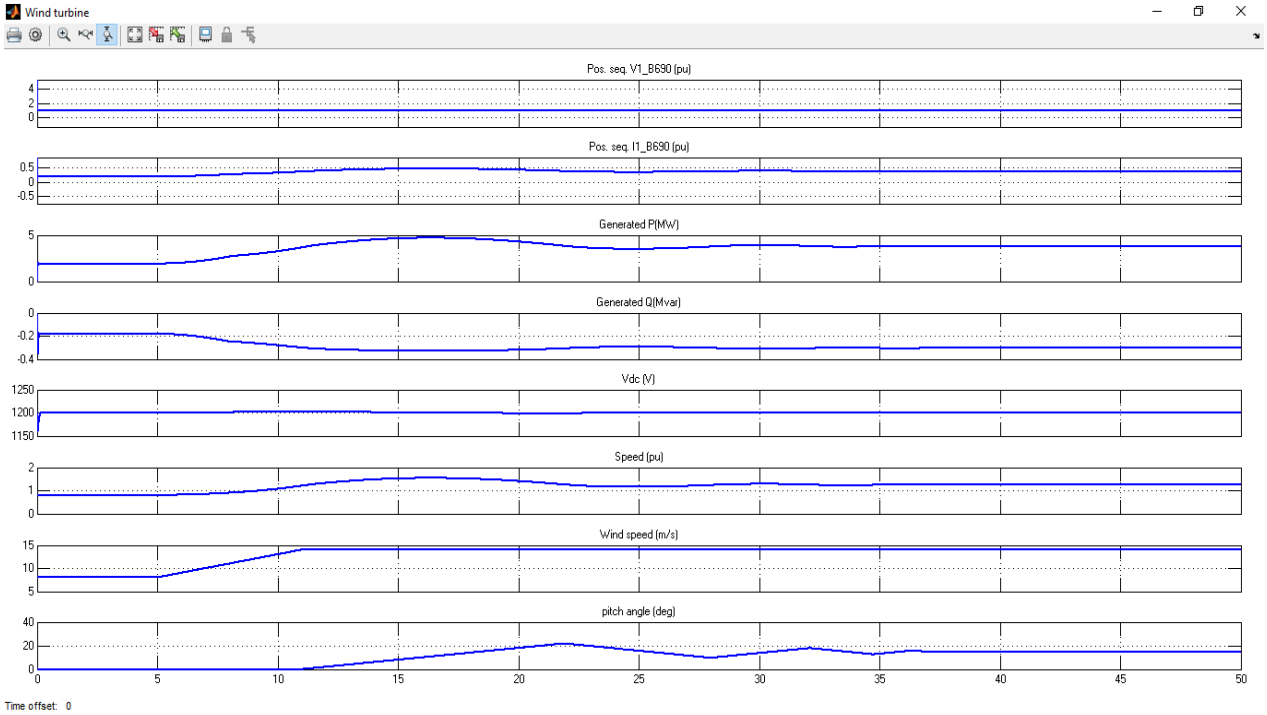

Figure 9. The response of wind power system when 6kV grid is earthed fault

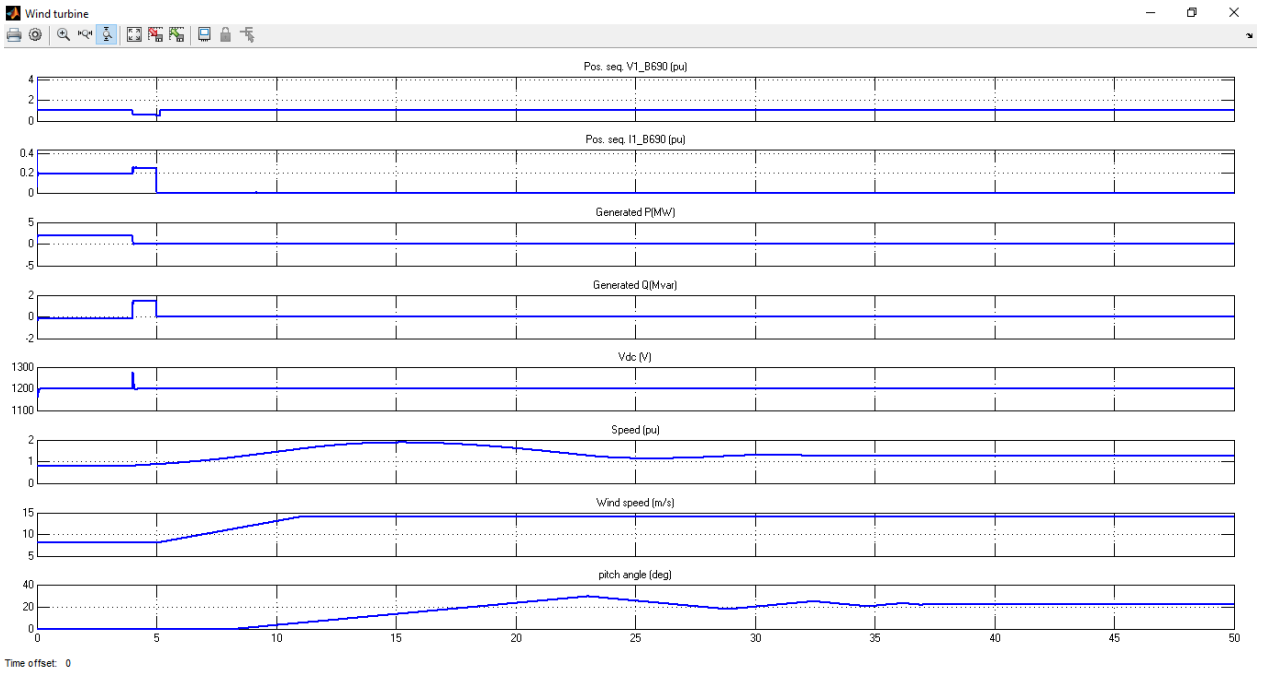

Figure 10. The response of wind power system when 6kV grid is phase to phase short circuited

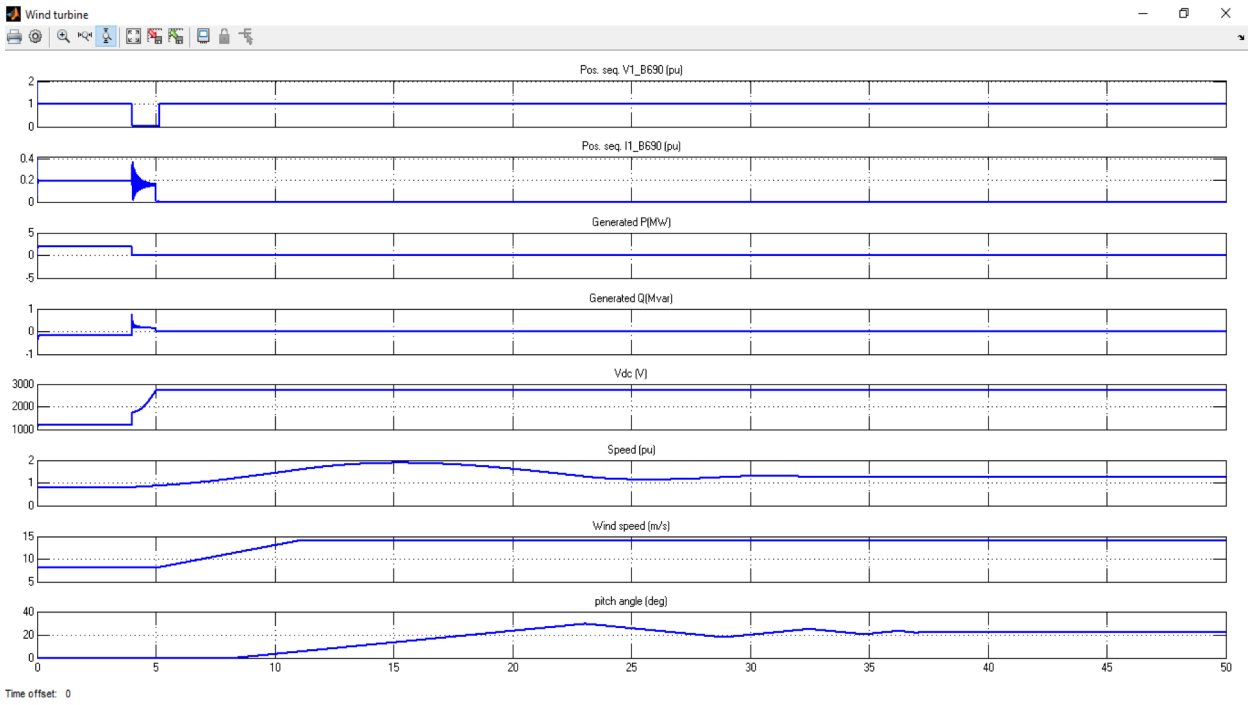

Figure 11. The response of wind power system when 6kV grid is 3-phase short circuited

3. Conclusion

The simulations in figures 7, 9, 10 and 11 show that:

+ The changing of wind speed will affect to the response of power injecting into system;
+ The operation of wind turbine controlled by a programmable controller is suitable for supplying the big capacity load of mines;
+ By adjusting the pitch angle, the wind power system have a good response to the vary of wind speed;

+ In abnormal operation, wind turbine cannot work under stressed situation, its system must be disconnected from grid to protect the turbine from mechanical damage.

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