Equivalent modeling of a direct-drive wind farm based on the measured data

Wenfan Li,Xuxuan Chen,Man Li

School of information science and engineering, Wuhan University of Science and Technology, Wuhan, China

Abstract: In view of the difference between the wind speed and the actual wind speed in the example, the wind farm with fifteen direct-drive permanent magnet synchronous motors draws the recorded wind speed data on the coordinates of time and wind speed by linear regression to group the change trend.Secondly, the detailed model of wind farm is built in PSCAD, and the multi-machine equivalent model of wind farm is built by the control current source replacing the permanent magnet synchronous motor and the control part.Finally, the simulation analysis shows that the equivalent model reduces the simulation time and accurately reflects the dynamic and transient properties of the wind farm.

I. Main Structure

This paper presents a multi-machine equivalent modeling method based on the measured data, and the specific model is shown in Figure 1.Then, the measured wind velocity was simulated using the Will distribution, as shown in Equation (1).Parameters were selected and the wind speed modeling was completed, as shown in Figure 2.Change wind speed, wind motor component group and establish a multi-machine equivalent model based on wind speed change trend as shown in Figures 3.Finally, we compare the simulation results of the detailed model with the equivalent model.

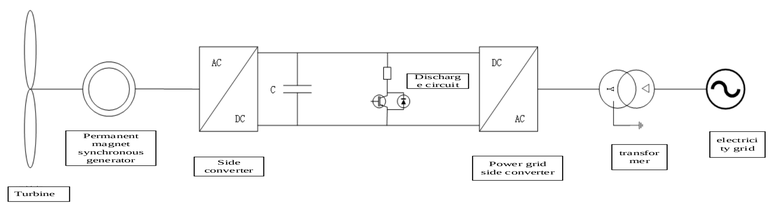


Fig. 1. Structure of the wind turbine unit

II. Derivation of mathematical model and establishment of physical model

The wind turbine dynamic simulation research requires establish wind speed model.The wind speed w (t) of the simulated actual effect on the wind turbine is :

$$\upsilon_w(t) = \upsilon_{Bw}(t) + \upsilon_{Rw}(t) + \upsilon_{Gw}(t) + \upsilon_{Nw}(t) \quad (1)$$

$$\upsilon_{Bw}(t) = A\cdot\Gamma(1+1/K) \quad \upsilon_{NW} = 2\sum_{i=1}^{N}(S_v(\omega_i)\Delta\omega)^{\frac{1}{2}}\cos(\omega_i t+\phi_i)$$

$$\upsilon_{Rw}(t) = \begin{cases} 0 & 0<t<t_s, t\ge t_e+t_r \\ \upsilon_{R\max} & t_e<t<t_e+t_r \\ \upsilon_{Ramp} & t_s<t<t_e \end{cases} \quad \upsilon_{Gw} = \begin{cases} 0 & t<T_{1G} \\ \upsilon_{COS}T_{1G}<t<T_{2G} \\ 0 & t>t_{2G} \end{cases}$$

Tab.1. Values of the random wind parameters

parameter	Model 1	Model 2
K_N	0.004	0.004
F	600	200
μ	2	0
△ω	0.5	2
N	100	50

Fig. 2. No.12 Actual wind speed and simulated wind speed

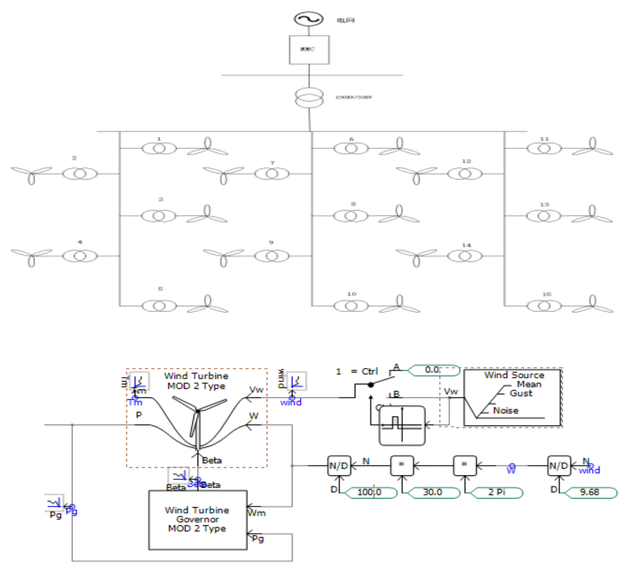
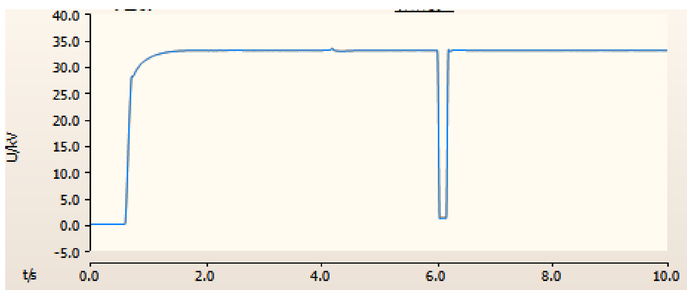
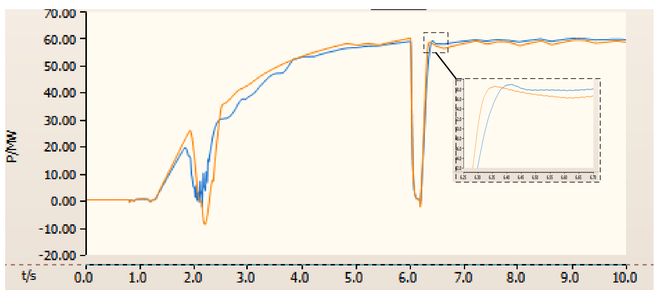


Fig. 3. multi-machine equivalent model

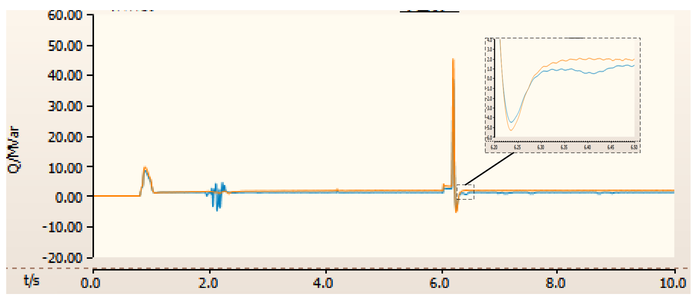
III. Simulation and Analysis



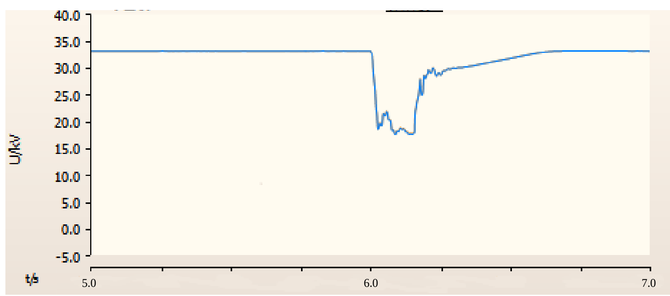
(a)Three-phase short-circuit voltage change



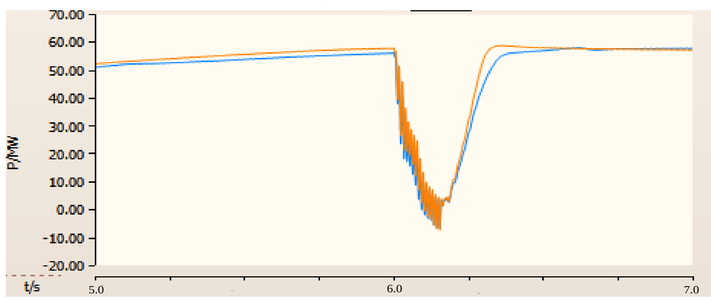
(b) Change in the active power of the three-phase short-circuit



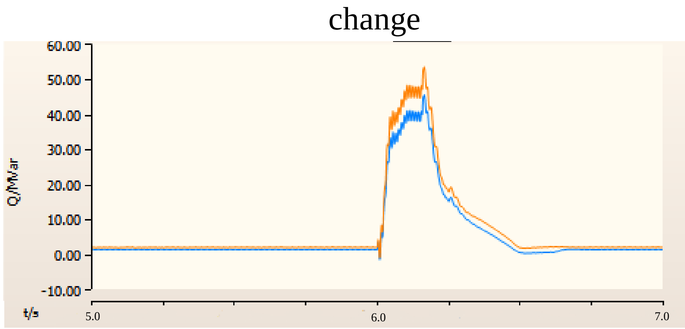
(c) Changes in the three-phase short-circuit reactive power



(d) Single-phase short-circuit voltage change



(e) Changes in active power for a single-phase short-circuit



(f)Changes in single-phase short-circuit reactive power

Fig. 5. Simulation results

IV. Conclusions

The simulation results of the detailed model and equivalent model in wind farm and power grid failure show that the change of active power, reactive power and voltage approach under the equivalent trend of wind speed, that is, the modeling method proposed in this paper can accurately reflect the dynamic characteristics of wind farm and outlets, and solve the modeling problem of the value of wind farm under the actual variable wind speed.The detailed model running time is 82 times the equivalent model running time, which greatly reduces the simulation time.

However, there are many deficiencies: 1. Failure to analyze the correlation between the same wind speed trends; 2. Failure to properly control the current source will amplify the shock when the system is unstable.3. failed to dig deeper into the wind farm grid.