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Preset Performance Theory Based Station Control Strategy of Wind Farm for Frequency Stability

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I. INTRODUCTION

An energy system dominated by new energy will be formed in China under the background of peak carbon - carbon neutral goals. It is predicted that renewable generator units will gradually become the main power supply. However, under conventional control strategies, renewable energy sources have no inertia and primary frequency support capabilities. The lack of the fast frequency response resources will bring severe challenges to the safety of the power grid operation. In the future, it is bound to require renewable energy sources to participate in frequency stability control, in order to maintain frequency stability of high proportion renewable energy power systems. There are rotating elements in wind turbines, so that the wind farm have the ability to quickly adjust power downwards and upwards. Therefore, it is of great significance to develop the frequency stability control ability of wind farms.

This paper reinterprets frequency stability from the perspective of preset performance control, and proposes a novel power control strategy for wind farms. This strategy gives the guidance of when and how much wind power is required to be injected into power system for frequency stability control. The advantage of the proposed strategy is that it only takes the frequency variety as the input variable, which makes it convenient for realizing the local control of the station. Finally, the correctness and validity of the proposed strategy is verified in MATLAB Simulink platform..

II. SYSTEM MODEL

This paper focuses on studying the active power control strategy of wind farms in power system frequency stability control. So the system is aggregated and equivalent to the single-machine single-wind farm constant load model as Fig. 1 shows below.

The equations of state can be listed as:

$$\begin{cases} \dfrac{d\delta_1}{dt} = \Delta\omega \\ T_J\dfrac{d\Delta\omega}{dt} = \Delta P_{M1} - \Delta P_{E1} - D_1\Delta\omega \end{cases}$$

The real-time balance of electromagnetic power is the system network constrain: $\Delta P_{E1} = \Delta P_L - \Delta P_{E2}$

Using $-\Delta P_L$ as the disturbance input, and the change of wind farm power put into the system as a control variable, the system control structure is shown as Fig. 2

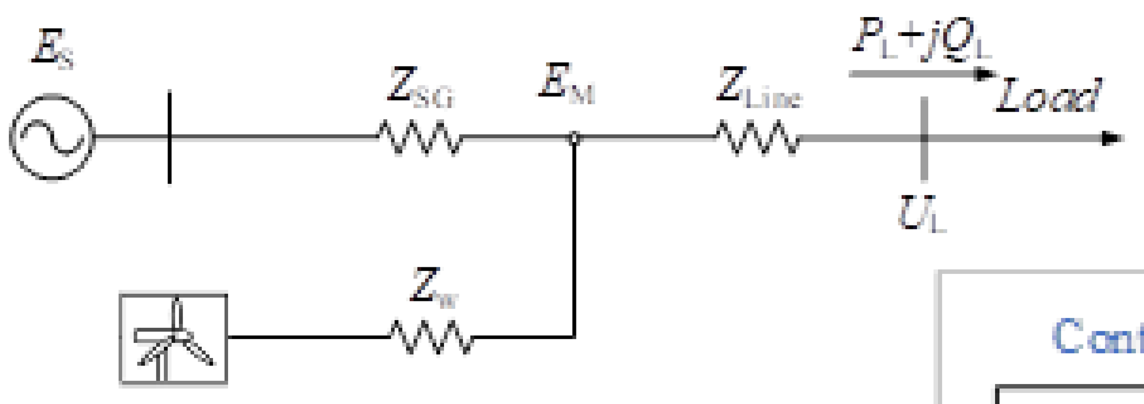

Fig.1 Simplified system model

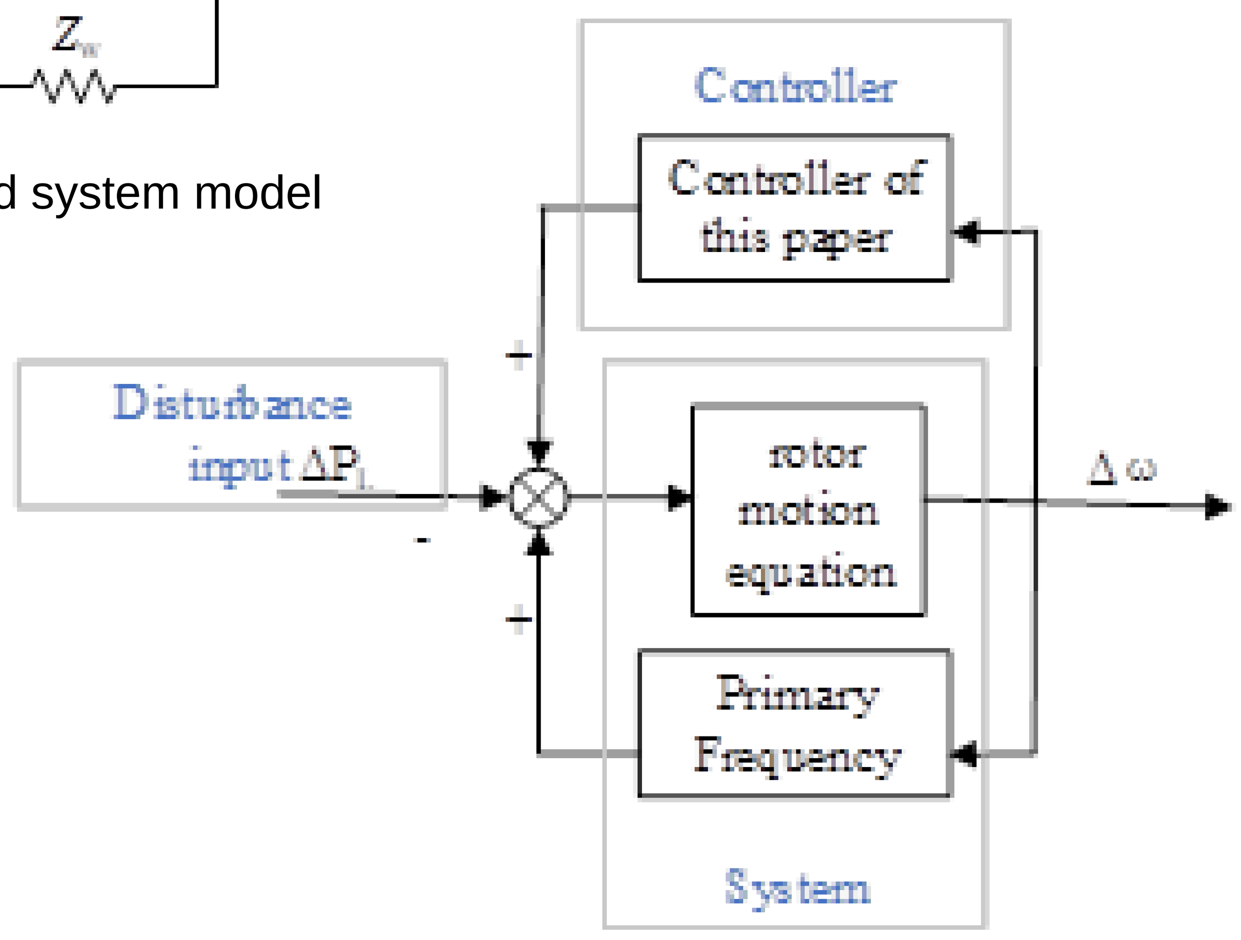

Fig. 2 System control structure diagram.

III. THE PROPOSED CONTROL STRATEGY

The preset performance function:

$$\phi(t) = (0.024 - 0.01)e^{-\gamma t} + 0.01$$

The tracking error is

$$\lambda(t) = \Delta\omega(t)$$

So the frequency stability control goal can be achieved through inequality:

$$-\phi < \lambda < \phi$$

In order to make it easier to achieve the above control objective, the inequality constraint is transformed into equality constraint. Introduce the error transformation formula in the following form:

$$\lambda(t) = \phi(t)l(\varepsilon)$$

where ε is the new conversion error, and $l(\varepsilon)$ has the following properties:

1) Smooth, reversible, strictly increasing;

2) Satisfy $-1 < l(\varepsilon) < 1$.

Substituting λ with ε, the system conversion error equation can be obtained as:

$$\dot{\varepsilon} = r(f + gu_1 + w) + v$$

The output after error conversion is $z = \varepsilon$.

Controller designed:

$$u_1 = -\frac{1}{gr}\left(\left(\frac{r}{2\beta}\right)^2 + 1\right)\cdot\varepsilon - \frac{f}{g} - \frac{v}{gr}$$

IV. SIMULATION

The effectiveness of the proposed strategy is compered with droop control and verified in MATLAB Simulink platform.

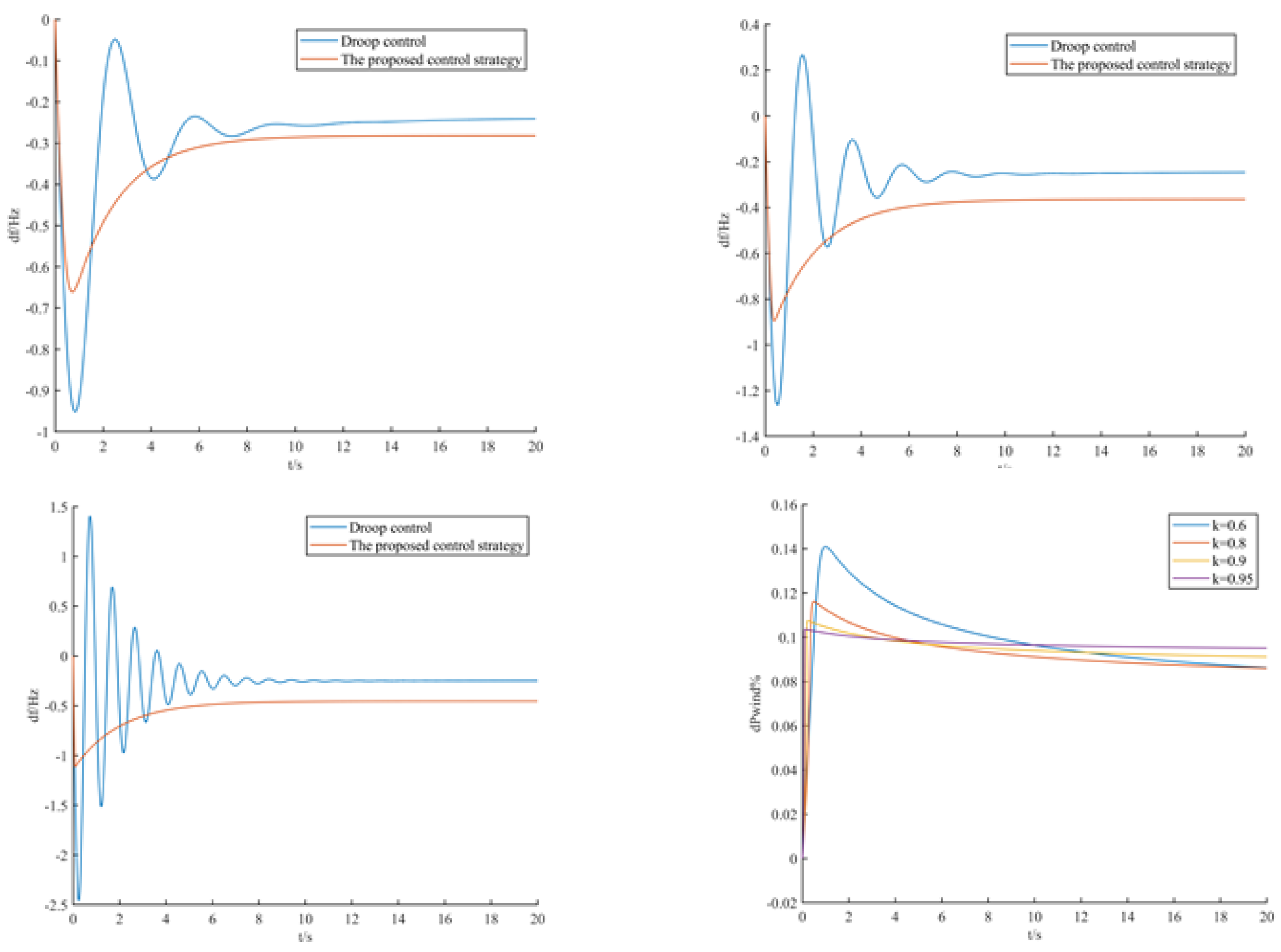

Fig. 3 System frequency comparison.
(a) k=0.6, (b) k=0.8, (c) k=0.95, (d) change rate of wind power

V. CONCLUSION

This paper reinterprets frequency stability issues from the perspective of preset performance control, and proposes a novel power control strategy for the wind farm. This strategy answers the question of when and how much wind power is required to be injected into power system for frequency stability control. The advantage of the proposed strategy is that it only takes the frequency variety as the input variable, which makes it convenient for realizing the local control of the station.

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