

STATCOM Control Research Based On Extension Theory

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Abstract. With the development of IGBT and GTO, more and more high-voltage and high-power devices applied in the power system. In terms of stability, harmonic, response speed, the superiority of STATCOM is more far than SVC. In order to make STATCOM play better results, the key is in controller design level. Through the introduction of advanced intelligent control method-extension control, extension control doesn't require to establish accurate mathematical model and has better control performance for the nonlinear system. In addition, it also can better improve power stability of the system. Compared with the effect of conventional PID control and the extension theory, based on the extension theory of STATCOM control has more advantages in power system.

Introduction

With the continuous growth of electricity load, as well as greater emphasis on security of the power system, the development of high-power electronic devices and flexible transmission system technology (FACTS) has become a hot topic of research. FACTS devices can effectively improve the transmission capacity and enhance system stability, improve reliability and security. As one of the most important members of the FACTS family, STATCOM is better than SVC in all aspects. To make STATCOM play a better results, the research of STATCOM control design level has very important significance. The traditional PID control for nonlinear systems exists flaw, the extension control method applied to the STATCOM control has a certain practical significance.

STATCOM Working Principle and Control Strategy

The basic structure of STATCOM is divided into two kinds: the voltage-bridge circuit and the current-bridge circuit. In practice, since the current-STATCOM operating efficiency is relatively low, so most of them are voltage type. [1] The voltage type circuit structure is adopted in this paper. The DC side of voltage-STATCOM uses capacitor as the energy storage component, the main circuit adopts three-phase voltage source bridge converting circuit, turns the DC voltage into AC voltage, and then connects to the grid by series reactors.

Based on the main circuit of STATCOM voltage bridge mainly have two kinds of structures, namely multiple structure and multilevel structure. In order to eliminate harmonic and fulfill the requirement of voltage and capacity, in this paper, the main circuit uses the four three-level 12-pulse GTO and four transformer [2].

As a dynamic reactive power compensation device, STATCOM achieves two main functions used in power system: to improve the system power factor and voltage regulation system. According to different functions and requirements, STATCOM control from the control strategy, there are three basic structure: open-loop control, closed-loop control, or a combination of the compound control. According to the control technology, including PID control, PID + PSS control, inverse system PI control, differential geometry control, nonlinear robust control, fuzzy control, Neural Network Control etc. According to the control of physical quantities, by the reactive current reference value adjusting STATCOM produce the required reactive current control method, can be divided into direct current control and indirect current control. [3]

By comparison, in this paper uses direct control. For the instantaneous value of the current waveform, direct current control strategy is to use the tracking type PWM control technology for feedback control, directly order currents occur. The direct current control method is shown in Figure 1 introducing d-q decomposition method. In this control method, based on reference value of the reactive component of the instantaneous current, or reactive component of the instantaneous current reference value is multiplied by lagging voltage of 90 degrees of sine wave and reactive current reference values, and then the reference values of instantaneous active current component are summed to obtain; According to the demand of STATCOM active energy, for correction of i_{qref} phase to get the total instantaneous current reference i_{ref} . Tracking type PWM control technology uses a triangle wave comparison method, also can use hysteresis comparison.

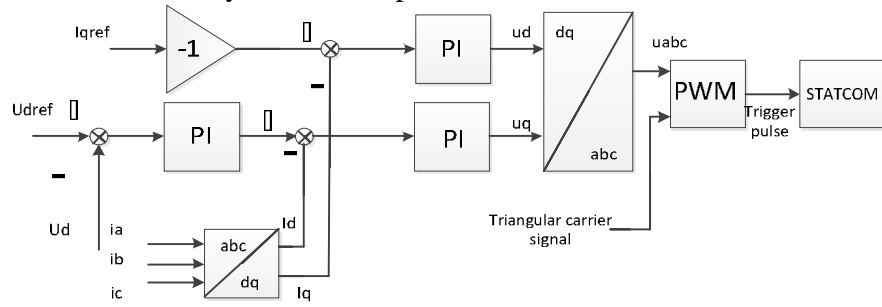


Fig.1 PWM technique using direct current control method

Extension Theory

To calculate the degree of association, we must set up a characteristic quantity of extension firstly. Then the feature state of extension is showed in figure 2:

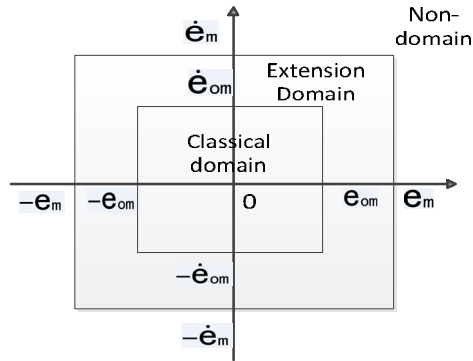


Fig.2 the feature state of extension

The origin of characteristic plane is (0,0). $M_0 = \sqrt{e_{om}^2 + e_m^2}$, $M_{-1} = \sqrt{e_m^2 + e_{om}^2}$. And then it defines correlation of an arbitrary point in the plane as follows:

$$K(s) = \begin{cases} 1 - |SS_0| / M_0 & S \in \text{Classical domain} \\ (M_0 - |SS_0|) / (M_{-1} - M_0) & S \notin \text{Classical domain} \end{cases} \quad (1)$$

Note: $|SS_0| = \sqrt{K_1 e^2 + K_2 e^2}$, K_1 , K_2 are decided by the characteristic patterns.[4]

Measurement mode is showed as followed:

$$\begin{aligned} M_1 &= \{s | K(s) \geq 0\} \\ M_2 &= \{s | -1 \leq K(s) \leq 0\} \\ M_3 &= \{s | K(s) \leq -1\} \end{aligned} \quad (2)$$

In order to overcome the control depends entirely on the state of the weighted feature vector[5,6], the control algorithm used in this paper are as follows:

1) For the measurement mode M_1 , the controller output remains unchanged, namely to maintain the value of the previous sampling time;

2) For the measurement mode M_2 , the controller output is:

$$u(t) = y(t) / k + K_{ci} K(s) (-\text{sgn}(e)) \quad (3)$$

Note: $u(t)$ --Output controller at the present time; $y(t)$ --the controlled sample values for the current time; K --Static gain; K_{ci} --Measure mode control coefficients of M_{2i} ; $K(s)$ --Correlation of feature status; $\text{sgn}(e)$ --Sign function of deviation, the method is as follows:

$$\text{sgn}(e) = \begin{cases} 1 & e > 0 \\ 0 & e = 0 \\ -1 & e < 0 \end{cases} \quad (4)$$

3) For the measurement mode M_3 , Controller outputs amplitude u_m

In summary, the basic extension controller output algorithm is as follows:

$$\begin{cases} u(t) = u(t-1) & K(s) \geq 0 \\ u(t) = y(t) / k + K_{ci} K(s) (-\text{sgn}(e)) + e & -1 \leq K(s) < 0 \\ u(t) = u_m & K(s) < -1 \end{cases} \quad (5)$$

Simulation Research

Main hookup of simulink is showed in Fig.4. The simulation model is established in MATLAB, the parameters as follows: STATCOM: $S=100\text{MVA}$; Voltage: 500KV ; System frequency: 60HZ ; Power line: $L_1=200\text{km}$, $L_2=75\text{km}$, $L_3=180\text{km}$; $V_{\text{base}}=500\text{KV}$; $S_{\text{base}}=100\text{MA}$.

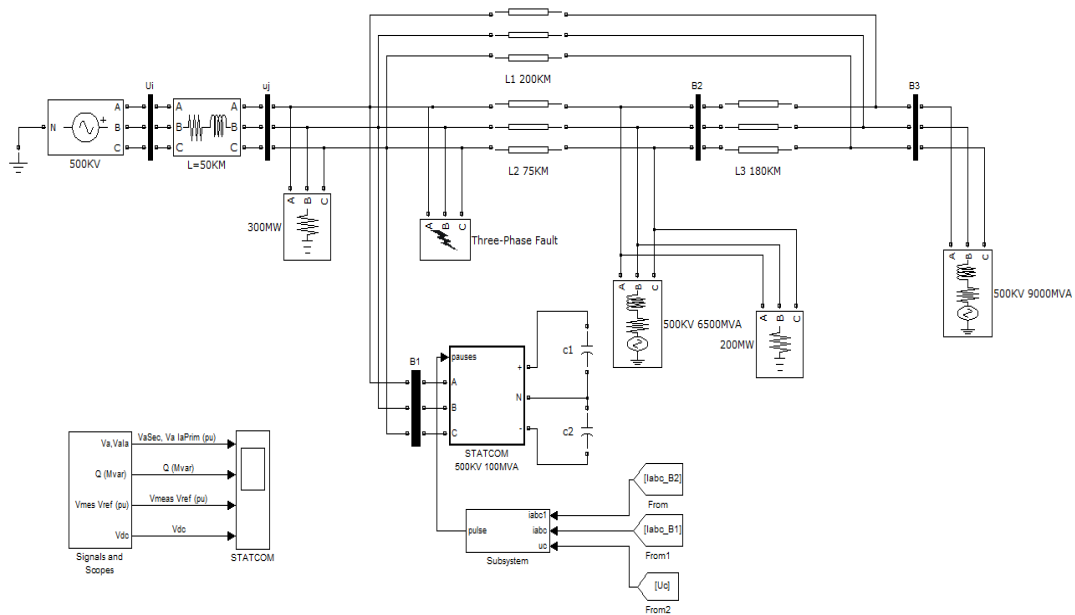


Fig.3 Main hookup of simulink

The text selects the most common and typical faults---single-phase short circuit.A phase short circuit occurs in the L2:

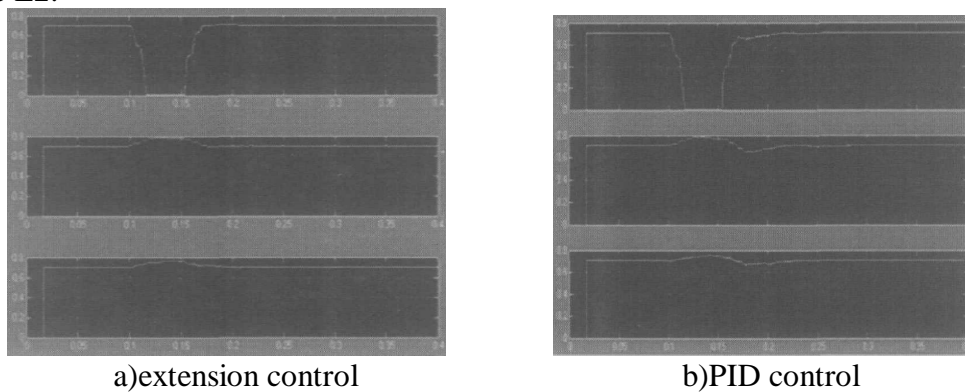


Fig.4 RMS voltage with two control methods

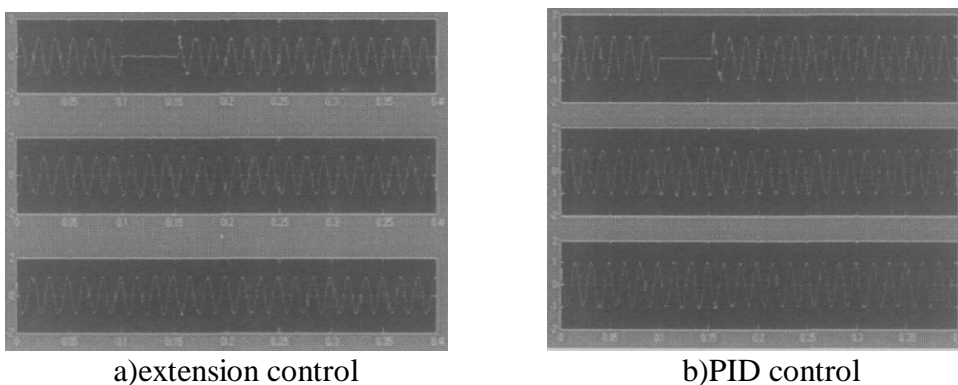
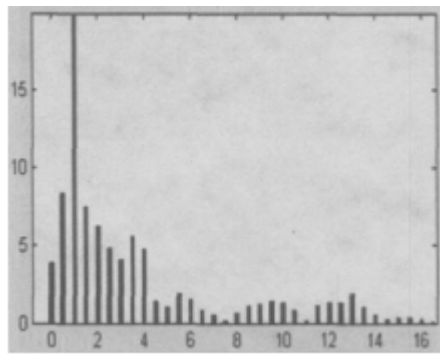
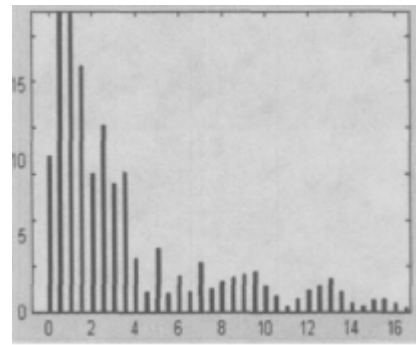


Fig.5 The instantaneous value of the voltage with two control methods



THD=13.29%

a)with harmonic suppression



THD=20.71%

b)without harmonic suppression

Fig.6 voltage harmonic of A phase

The simulation shows that A phase occurs short circuit, non-fault phase B, C phase voltage increases, PID control and the extension control for systems valid values in 60 ms and 30 ms returned to normal respectively after the elimination of short. Harmonic of extension control is less than PID.

Conclusion

According to the advantages of extension control technology, this paper puts forward optimal control mode based on extension theory for STATCOM. Then the third part sets up SIMULINK model and achieves satisfactory results. The result shows that compared with the classic PID control, based on the extension theory can obtain better control effect.

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