DOUBLE WINDING TRANSFORMER ARTIFICIAL INTELLIGENCE VOLTAGE REGULATION COMPENSATION ALGORITHM

Zhong Sheng

HAIKOU HAINAN Power Grid Company Power Transmission and Distribution Overhaul Branch, Haikou, Hainan
491928938@qq.com

Abstract: To solve the current double-winding transformer voltage regulation effect is not good, and so on, put forward the double-winding transformer artificial intelligence voltage regulation compensation algorithm. Based on double winding transformer voltage regulation control method and the configuration parameters optimization, reasonable setting standards regulating parameters of artificial intelligence, in order to guarantee the accuracy of the pressure regulating compensation, combined with the optimization allocation algorithm of artificial intelligence pressure regulating compensation standard parameters setting, so as to complete the double winding transformer voltage regulation compensation algorithm of artificial intelligence research. Finally, it is proved by the experiment that the algorithm of artificial intelligence voltage regulation compensation of double-winding transformer can restrain voltage harmonics effectively and guarantee the voltage regulation compensation effect of artificial intelligence of transformer.

1. Introduction

In recent years, with the continuous development of industry, all kinds of electric appliances emerge at the historic moment. The advantage of electric energy is more and more obvious and its function is more and more important. Too high or too low voltage of power system will increase the active power loss of power supply and reduce the operating efficiency. The traditional voltage regulation compensation methods include: increasing or decreasing voltage for voltage regulation, such as the use of generator, static compensator, regulator, shunt capacitor, shunt transformer, etc. Changing the distribution of active power and voltage to adjust voltage, such as using load regulator, changing transformer tap, etc. Voltage regulation is carried out by changing network parameters, such as installing series capacitors, stopping and switching parallel transformers, etc. [1]. But traditional methods often lack of power system voltage will cause the loss of power supply system power factor, active load case same current increase, increases heat loss caused by power supply equipment, line loss increases, and the excess voltage will cause power system voltage rise, also can make the transformer, motor excitation loss increase insulation damage, reduce its service life. Therefore, double winding transformer voltage balance is a must solve the problem. To solve the above problems, an artificial intelligence voltage regulation compensation algorithm for double-winding transformer is proposed [2]. The experimental results show that the algorithm can effectively adjust the voltage balance of the double-winding transformer and protect the electrical equipment.
2. Double winding transformer voltage regulation compensation algorithm of artificial intelligence

2.1 Voltage regulating control of double-winding transformer

In the power system, there are a variety of reactive power supply and reactive load, which are the main source of voltage in the power grid. The reactive power supply includes synchronous generator, synchronous camera and synchronous motor. In the power supply system, synchronous generator is the only source of electricity. However, the synchronous generator generates voltage at the same time of active power, which is the most basic source of voltage at the beginning of the transmission. Synchronous generators have a large installed capacity and can supply most of the voltage in the power grid. The synchronous tuner is a special component designed to provide reactive power compensation. Synchronous motors not only provide voltage, but also convert electrical energy into mechanical energy during operation to complete the specified work. Reactive load includes asynchronous motor, transformer, rectifier and power line [3]. Asynchronous motors are the main load of the power grid and the main source of voltage at the load end. Due to its basic characteristics of inductance, the transformer will also generate a certain voltage in operation, especially in the case of multi-stage transformer [4]. Due to the characteristic of resistance and distributed capacitance of power line, voltage and power loss will be produced. In recent years, with the promotion of power electronic rectifier device, it not only reduces energy consumption, but also sends a large amount of voltage to the power grid, affecting the normal operation of the power grid. If the voltage required at a certain point in the grid cannot be compensated timely and effectively, various problems will arise in the power system and electrical equipment, among which the most troublesome problems are power loss, harmonic and voltage instability [5].

The double-winding transformer artificial intelligence voltage regulation compensation algorithm can compensate the voltage in the power network and control the voltage fluctuation, so as to improve the quality of electric energy and reduce the loss of electric energy in the transmission line by reducing the reactive current. The principle is to change the magnitude of dc excitation current by changing the trigger Angle of thyristor, and then change the saturation degree of the core, so as to adjust the voltage. The double-winding transformer has the advantages of convenient control, low cost, smooth voltage regulation, and the ability to prevent over voltage, which improves the transmission capacity and stability of the transmission system [6]. The double-winding transformer is mainly composed of controllable magnetic saturation transformer, capacitor, thyristor pulse trigger control circuit and DSP control circuit. Through parallel operation of controllable transformer and capacitor bank, reactive power can be coordinated and adjusted, which is more flexible and convenient than the current methods of synchronous tuner and pure capacitor bank to compensate reactive power, and the compensation effect is also better. The double-winding transformer takes the controllable magnetic saturation transformer as the main component, and is composed of the capacitor, the related thyristor pulse trigger control circuit and the DSP control circuit [7]. Its working principle is shown in figure 1 below.

![Figure 1 double winding transformer voltage regulation works](image-url)
In the double-winding transformer, the two side core columns play the role of magnetic conductivity in operation and are used to form the magnetic field loop. The middle two core pillars are covered with four windings externally. The lower part of the upper winding and the upper part of the lower winding of each core pillar are provided with taps. The turn-to-turn ratio of taps is \( k = \frac{N_2}{N_A} \), \( N_A = N_1 + N_2 \). On each column, the next two taps indirectly have opposite polarity thyristors VT1, VT2, and the middle cross connection points at both ends of a secondary diode VD. The tapped interwinding is the control winding, and the other windings are the working windings. Among them, the relay diode VD, thyristor VT1 and VT2, the trigger control circuit constitute the control part of the controllable transformer \([8]\). By controlling the conduction Angle of thyristor, the DC flux of transformer core can be controlled, and the inductance of transformer can be smoothly adjusted, so as to achieve the purpose of voltage regulation and compensation.

2.2 Voltage regulating compensation algorithm for double-winding transformer

Traditional voltage regulation compensation can only realize the regulation of fixed value, but not smooth regulation. In practical application, the traditional method mainly plays the role of current limiting, because the current flowing through inductance cannot be mutated. The double winding transformer has an iron core in the transformer coil, which greatly increases the magnetic permeability in the transformer coil. However, the magnetization curve of the core is not linear, but nonlinear. When the current reaches a certain value, the core is close to saturation \([9]\). Of course, its working principle is opposite to the linear section of the core magnetization curve obtained by the traditional method, which belongs to the nonlinear section. The nonlinear relation of the magnetization curve of ferromagnetic materials is used to change the magnetic saturation of the transformer core through dc, so as to achieve the purpose of smoothing the transformer reactance value. The inductance of the ac working winding is changed by changing the current of the dc control winding of the transformer. The magnetic saturation of the transformer core changes along the magnetic saturation curve of the core under dc bias. Its reactance value is defined as:

\[ X_L = \omega N^2 A \mu_0 / L \]  

(1)

\( \omega \) represents the angular frequency; \( N \) represents the number of winding turns; \( A \) represents the cross-sectional area of the core column; \( \mu_0 \) represents the iron core permeability and air permeability; \( L \) is the magnetic circuit length.

The magnetic flux of the core is composed of the linear addition of the ac magnetic flux generated by the working winding and the dc magnetic flux generated by the control winding, as follows:

\[ \phi (\omega t) = \pm \phi_A + \phi_c (\omega t) \]  

(2)

Where, and respectively represent the dc magnetic flux and the alternating magnetic flux in the linear region when dc bias is not added. When the dc magnetic flux is on the positive half axis of the magnetic flux curve, it is taken as positive, and when it is on the negative half axis, it is taken as negative. When the ground dc current in the control winding is zero, \( = 0 \), and the ac magnetic flux changes alternately as an alternating variable. If the dc current in the control winding is increased, part of the dc component will enter the nonlinear region of the magnetization curve, thus causing magnetic saturation of the core. The value of dc bias directly affects the value of magnetic saturation. Then the total compensation capacity of the three phases can be calculated by the following formula:

\[ Q_C = P \tan \phi_1 - \tan \phi_2 \]  

(3)

Among them,

- The unit of \( Q_C \) is kvar;
- \( P \) is the total active power of the three-phase calculation load, kW;
- and are respectively the power factor Angle before compensation and the compensation power factor Angle after compensation.
Through the calculation of the three-phase total compensation capacity, the double-winding transformer in the actual operation process to increase the control winding dc current to increase the dc component, to achieve intelligent voltage regulation compensation. With these formulas, the structural parameters of the double-winding transformer can be better determined when it is designed, so that its performance can be optimized.

2.3 Realization of voltage regulating compensation of double-winding transformer

The design of the control system affects the control precision and the reaction speed, which plays an important role in the performance of the whole voltage automatic compensation. Traditional power capacitors, power transformers and static voltage compensators are the main static voltage compensation devices. They are all passive, and there are some active static voltage compensation devices [10]. There are many kinds of controllable magnetic saturation transformers. The simplest magnetic saturation transformer is of turn-regulating type, which adjusts the reactance value by adjusting the number of turns. There is another way to change the value of reactance by changing the magnetoresistance of the magnetic circuit. It changes the value of reactance by adjusting the size of adjustable air gap in the magnetic circuit. This method has low accuracy. There is also a two-way thyristor series in the main circuit control circuit current conduction time method to change the inductance, although ensure smooth regulation, but the thyristor requirements are higher. The last type of saturation transformer is a saturation transformer with external dc bias, which can change the reactance value by controlling the working current of the dc winding. Therefore, the hardware circuit of the control system should be effective, reliable and anti-interference, and the software design should be stable, efficient and optimized. Double-winding transformer artificial intelligence voltage regulation compensation process is shown in the figure below.

![Figure 2 artificial intelligence voltage regulation compensation method](image)

Based on DSP, the control flow of magnetically controlled voltage regulating reactive power automatic compensation device is as follows. Firstly, the voltage and current signals of the compensated circuit are collected, and the current and voltage transformers are used. Then, the signals are processed, and the reactive power factor, active power, reactive power and compensated reactive power of the compensated circuit are obtained from the instantaneous power calculation formula. The information is input into the DSP, and the PWM pulse is adjusted by the DSP, so as to adjust the trigger delay Angle of the thyristor according to the data in the data sheet, and change the working state of the controllable magnetic saturation transformer, so as to achieve the purpose of compensating the reactive power. In this way, reactive power compensation can be carried out quickly and voltage can be adjusted dynamically, and reactive power regulation can be realized at the same time. The specific operation flow of the algorithm is shown in the figure below.
voltage compensation
Start of program

Signal acquisition (MCR side)

Calculation of System Voltage and Power

Power factor = \text{pset}?

The equivalent susceptance of the system is calculated and converted to the MCR side of the cutter.

MCR trigger angle calculation

Thyristor Triggering of Controllable Reactor

Figure 3 double winding transformer regulating compensation process

The basic flow of the above voltage regulation compensation algorithm can be summarized as follows: firstly, collect the voltage and current of the compensated circuit, calculate the system's reactive power and reactive power factor through calculation, and calculate the system's equivalent susceptance to calculate the system's compensable susceptance. The compensation admittance is converted to the thyristor side, and the trigger Angle 1 of the thyristor can be obtained. By collecting the voltage signal on the thyristor side, we can obtain its synchronization signal, which is combined with the on-off compensation requirement to obtain the required trigger pulse. Since the trigger delay Angle of the thyristor depends on the difference between the reactive power that needs to be compensated theoretically and the reactive power output of the actual input capacitor, the two can be continuously coordinated to make the actual voltage of the system reach the set value.

3. Analysis of experimental results

With the simulation analysis of electric power system has become one of the important applications of computer technology, to verify the feasibility of the double winding transformer voltage regulation compensation algorithm of artificial intelligence, in computer simulation environment, compared to the traditional pressure regulating voltage stability experiment, the effect of compensation method in the experimental process, to ensure accuracy, combined with double winding transformer device, to set parameters of the two groups, compared to observe the result of the experiment, the concrete below parameter Settings.

| Project          | Parameter value |
|------------------|-----------------|
| Initial voltage  | 220V            |

Table 1 experimental parameter Settings
Transformer turns 200
Transformer power factor 0.67
Line resistance 36Ω
Initial current 10A

The experimental simulation of the method is carried out by combining the above parameters, and the results obtained by comparison with the traditional method are shown in the following figure.

![Figure 4. The simulation results](image)

The bigger the harmonic wave is, the worse the compensation effect will be. It can be observed from the above test results that the voltage regulating characteristic of the double-winding transformer is the relationship between the effective value of the transformer voltage and the operating time under the action of the sinusoidal power supply. The working current of the magnetic saturation transformer varies with alpha at the rated working state. The control characteristics of the transformer are nearly stable. It can be seen from the simulation results that the volt-ampere characteristics of the transformer can be approximately linear, which can effectively avoid resonance. When $\alpha=0$, the reactance of the transformer is at the maximum value. As time goes on, the voltage of the transformer gradually tends to be stable. This indicates that the transformer has the same volt-ampere characteristic as the common transformer when it maintains constant value in the process of voltage regulation compensation. This method is in accordance with the volt-ampere characteristics, and can effectively adjust the voltage compensation of the double-winding transformer to meet the research requirements.

4. Conclusion

In recent years, with the continuous development of industry, a variety of electrical appliances came into being, electricity is in the form of ac transmission, electrical equipment voltage balance has become a problem must be solved. The traditional voltage compensation method is easy to cause the insulation damage due to the increase of excitation loss. Based on the analysis of the traditional method, the artificial intelligence voltage regulation compensation algorithm for the double-winding transformer is proposed.

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