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Design of Electric-Take Ring for Microcomputer Relay Protection Device

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Abstract. A miniaturized electric-taking ring used in microcomputer relay protection device is designed in this paper, which can obtain electric energy from the measured circuit and provide stable power supply for the protection device. The test results show that the ring is suitable for microcomputer relay protection device, low cost, safe and stable, and solves the difficult problem of equipment power supply in box environments.

1. Introduction

At present, with the advancement of intelligent electric network, relay protection devices are more and more widely used in power network. However, in some special working environments, the power network can not provide working power for relay protection devices. Therefore, many power supplies are switch cabinet solar panels, but this power supply is easy to be affected by the external environment [1]. Based on this problem, a relay protection device electric-taking which can obtain electric energy from the measured circuit is designed.

2. Electric-take method of relay protection device in special environment

There are three main ways to obtain electricity from relay protection devices in the box environment such as switch cabinet without power supply at home and abroad: Potential Transformer, Current Transformer and Photovoltaic Solar Panel.

2.1. Power supply mode of potential transformer

The power supply mode of the Potential transformer refers to the installation of a dedicated PT at the position where the microcomputer relay protection device is installed. The PT converts the voltage of 10KV or higher into a low voltage alternating current of 220V or 100V. The relay protection device of the microcomputer uses the low voltage output of the PT as the low voltage output of the PT. A type of power supply for working power[2]. However, this power supply method has many disadvantages. Because the installation of the PT requires a dedicated bracket mechanism and installation space, in the cabinet such as the switch cabinet, the space for installing the special bracket is difficult to



guarantee. Finally, the increase of PT will increase the hidden danger of system ground fault and reduce the safety performance of the system.

2.2. Power supply mode of current transformer

The way of power supply mode of current transformer means changing the secondary side of the current transformer to a semi-open state, connecting the filter circuit at the break [3], and using this output energy as the working power of the microcomputer relay protection device. There is no need to install a special mounting mechanism, and the space occupied is small.

2.3. Power supply mode of photovoltaic solar panel

Solar panels are a kind of power supply equipment that converts light energy directly into electrical energy. It is a new type of power supply developed recently. This form is widely used in remote mountainous areas or in the supply of these independent electrical devices. This kind of power supply is clean and pollution-free, and there is no insulation problem to be considered by the voltage transformer. However, this power supply method can only supply power during the day, and the solar panel power supply is greatly affected by the weather.

Combining the above three power supply methods, we finally chose a current transformer power supply method that has a wide application range and is relatively easy to implement.

3. Design of electric-take ring

In order to ensure that the relay protection device in the cabinet environment such as the switch cabinet and substation without power supply can stably obtain the working power supply, in summary, the electric-take ring uses the current transformer to obtain the electric energy from the circuit under test.

3.1. Brief introduction to the principle of electric-take ring

The electric-take ring is designed according to the principle of electromagnetic induction. When the current changes in the line, the magnetic field strength around it will change. Because the line passes through the center of the iron core, the magnetic flux of the iron core will change. Therefore, an induced electromotive force is generated in the wire of the iron core. The energy collection structure is shown in Figure 1.

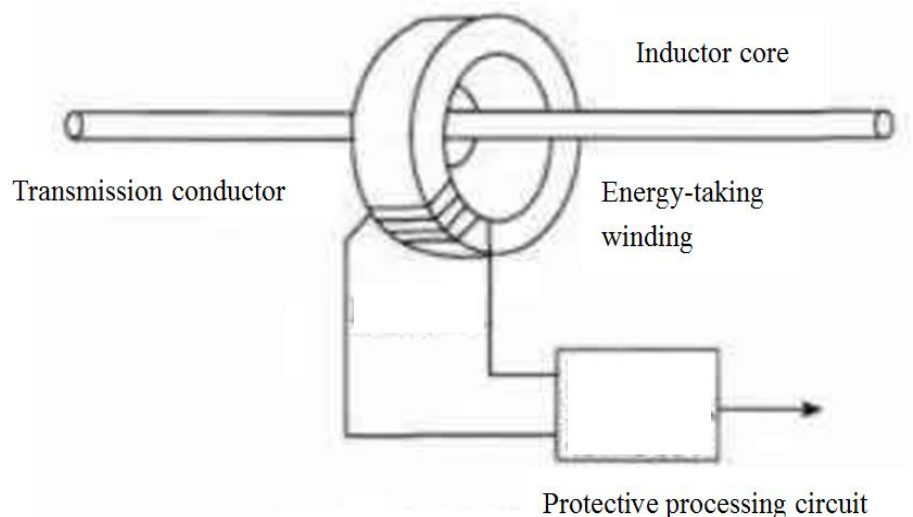


Figure 1 Schematic diagram of induction energy acquisition structure

3.2. Design requirements for the electric-take ring of the relay protection device

Electric-take ring to obtain the electric energy from the circuit under test requires attention to the complexity of the circuit under test. When the fault occurs, the current in the circuit may be several

times or even several times of the normal current, or may be several times smaller than the normal current. In this complicated situation, the power supply mode is required to provide a stable working power for the device. When a fault occurs, the electrical energy that needs to be vented will be large, and it will not have any influence on the relay protection device to ensure normal operation of other functional circuits. When the fault current is detected and the relay protection device performs protection action, the electromagnetic release device, the energy storage capacitance in the drive circuit of the electromagnetic trip unit will release the electric energy, and the power supply module needs to charge the storage capacitor in a short time.

The electric energy obtained from the secondary side current transformer of the circuit under test is converted into a direct current by respective rectifying circuits, and the current source is converted into a voltage source by charging the capacitor. Since the system power supply requires a stable voltage source, it is necessary to ensure the stability of the voltage source by means of a bleeder voltage regulator circuit. The obtained 24V power supply will be used for the conversion of the storage capacitor and the DC power supply (+5V power supply) in the electromagnetic trip unit drive circuit to ensure the normal operation of the equipment. The electric-take ring block diagram as shown in Figure 2.

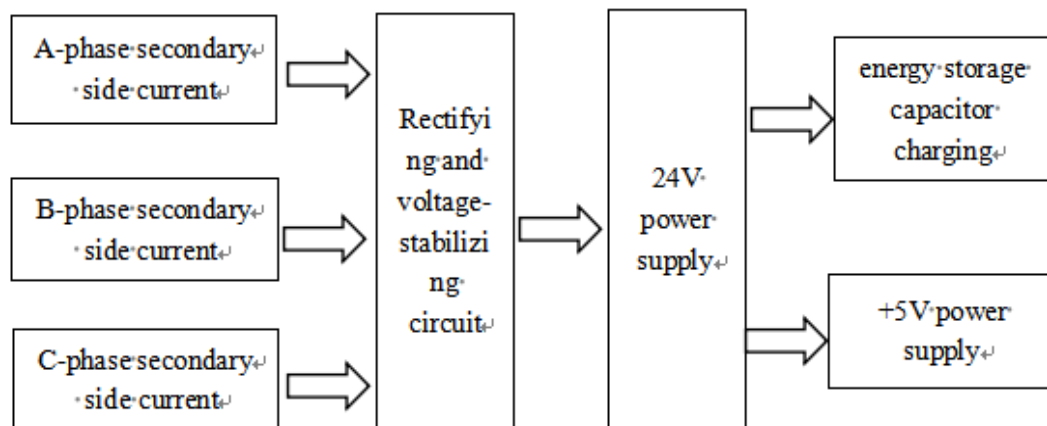


Figure 2 Electric-take ring frame diagram

3.3. Circuit design of electric-take ring for relay protection device

According to the design requirements of the electric-take ring, the electric-take ring circuit is divided into a rectifier circuit, a filter circuit and a bleeder voltage regulator circuit. The rectifier circuit obtains the alternating current from the circuit under test and converts it into a direct current. The filter circuit eliminates harmonics and smoothes the waveform. The bleeder regulator circuit discharges excess power obtained from the circuit under test maintain the stability of the output voltage of the electric-take ring module [4]. The change of its current under the action of induction coil, rectifier circuit and filter circuit is shown in Figure 3:

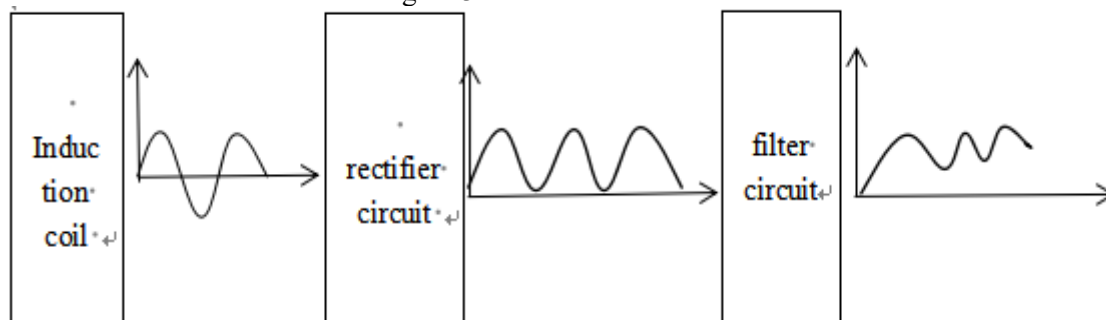


Figure 3 Schematic diagram of current waveform change

3.3.1. Selection and design of rectifier circuit

The main function of the rectifier circuit is to pass the input AC current through a series of electronic components to output a DC current. The commonly used rectifier circuits include half-wave rectifier, bridge rectifier and so on. The bridge rectifier circuit is composed of two pairs of diodes in series. Compared with the half-wave rectifier circuit, it has a higher utilization ratio. Compared with the full-wave rectifier circuit, it solves the problem that its diodes need to bear a large reverse voltage, because two diodes are shared on one bridge arm. Therefore, a bridge rectifier circuit is selected.

3.3.2. Selection and design of filter circuit

Since the waveform output from the rectifier circuit generally has large harmonics and cannot be supplied to the subsequent devices, the function of the filter circuit is also needed to make the waveform containing large harmonics become smoother and eliminate its harmonic components. The effect of the inductive filter circuit is proportional to the L value, but the average value of the output power is smaller, which is smaller than the average value of the output of the rectifier circuit. The performance of the LC filter is similar to that of the inductive filter circuit, and the LC π type filter circuit has a large average value of the output value, which is a significant advantage. Therefore, the LC π type filter circuit is selected.

3.3.3. Design of bleeder voltage regulator circuit

The bleeder regulator circuit uses a controllable precision regulator source TL431 and a bidirectional thyristor BTA26-600B as the core of the control circuit. When the Vref pin voltage of the controllable precision regulator reaches 2.5V, the cathode and anode are turned on. Due to the conduction of the controllable precision voltage regulator, the thyristor is turned on, so that the AC current obtained from the current transformer no longer charges the capacitor, so that the voltage value of the capacitor will not continue to rise. When the sine wave of the alternating current crosses the zero point, the thyristor automatically turns off and charges the capacitor again. This constant charging and discharging method can provide a stable power supply for subsequent circuits.

4. Test and Application

4.1. Test of electric-take ring

The electric-take ring is used to provide working power for the relay protection device. The electric-take ring module can stably output +24V power supply, and the output voltage ripple rate is less than 5% to ensure stable operation of the device. Figure 4 shows the physical diagram of the electric-take ring module. The test results of the electric-take ring module are as shown in Table 1.



Figure 4 Physical drawing of electric-take ring module

Table 1 test results of electric-take ring module

Input current value(A)	Output voltage value(V)	Ripple rate
0.4	23.84	2.2%
1.0	24.22	1.5%
1.5	24.31	1.3%
2.0	24.38	1.7%
3.0]	24.35	1.8%

As shown in the above table, the electric-take ring module can stably output +24V power supply under different current input conditions, and the ripple ratio is less than 5%. Meet the power supply design requirements.

4.2. Microcomputer relay protection device test for electric-take ring power supply

The electric-take ring is installed in the microcomputer relay protection device, and the ZX-1600 microcomputer relay protection tester is used to test the protection function when the electric-take ring is used for powering the device. The protection function test takes the time-limited speed current protection as an example. Test whether the set protection current value can meet the actual requirements. As shown in Figure 5, it is a microcomputer relay protection device with a power-take ring; as shown in Table 2, it is the actual operating current value of the time-limited current quick-break protection trip.

Table 2 actual tripping current value

set value(A)	actual tripping current value(A)				
	1	2	3	4	5
1.000	1.001	1.003	1.001	1.002	1.004
1.500	1.502	1.501	1.503	1.504	1.502
2.000	2.001	2.003	2.002	2.001	2.003
2.500	2.502	2.501	2.503	2.503	2.501
3.000	3.001	3.003	3.002	3.002	3.001



Figure 5 microcomputer relay protection device with electric-take ring

As shown in the above table, the fault current error is within 0.005A, and the protection function of the microcomputer relay device can be successfully realized by using the electric-take ring.

5. Summary

The electric-take ring has a unique electric-take mode and design concept. When the line is energized, the power supply can be stabilized, and the shortage of solar power and PT power is overcome. The electric-take ring based on the current transformer design has been installed in the microcomputer relay protection device, and is applied to the environment of switch cabinet, and substation of power grid of Anhui province in a small scale. Through the use of the situation, the electric-take ring work performance is stable, the quality is reliable,, fully meets the power demand of the microcomputer relay protection device, and reduces the maintenance and repair work, and meets the predetermined design requirements..

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