MICROPROCESSOR PROTECTION OF SYNCHRONOUS GENERATORS AT POWER PLANTS

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Abstract: *The application of microprocessor relay protection devices in electric power engineering, particularly for the protection of synchronous generators at power plants, is examined. These devices are characterized by increased service reliability, small size and weight, low electricity consumption, cost-effectiveness, and stability of power system modes. Synchronous generators impose limitations on power system modes when the designated overload of the synchronous generator may lead to undesirable consequences. This is manifested in operation through increased current and heating factor, increased stator heating and stress due to changes in phase angles, and increased voltage.*

To prevent such dangerous modes, it is recommended to use microprocessor-based transverse differential protection. This is used in combination with differential current cutoff, which activates protection during internal short circuits with high currents. In this case, it is possible to implement programmed changes in the polarity of input signals during maintenance, adjustment, and monitoring of current circuit integrity.

Keywords: *synchronous generator, asymmetric modes, microprocessor protection, differential protection, short circuits, current transformer.*

Microprocessor-based protection systems for synchronous generators in power plants

In the current energy sector, microprocessor-based protection systems are used to ensure the normal functioning of electrical equipment. These systems are characterized by increased reliability, compact size and low weight, low power consumption, the ability to implement and apply complex digital methods for processing measured input signals over minimal time intervals, and the capacity to determine optimal triggering characteristics for digital relays.

Electrical energy in power plants is generated by synchronous generators. Therefore, relay protection for these generators is a crucial tool for eliminating faults and ensuring the normal operation of electrical equipment.

Let us consider the asymmetrical modes that occur in the power system when the generator becomes overloaded with negative-sequence currents, which create a rotating magnetic field opposite to the rotor's rotation. Rotor current overload occurs due to a malfunction in the excitation system of the synchronous generator, causing increased oscillations in stator current and voltage, which in turn leads to changes in the generator's rotational speed and voltage increase.

To prevent such dangerous modes in synchronous generators, differential protection can be used, which also prevents dual ground faults, one occurring in the generator and the other in the network. Differential protection is implemented based on current differences arising at the output of current transformers, which are installed on the line and neutral terminals of the synchronous generator (Fig. 1).

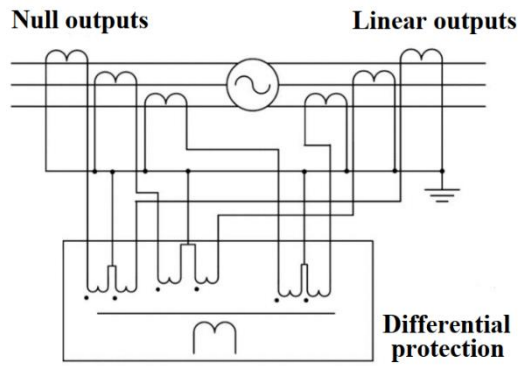


Fig. 1. Current circuits of the generator's longitudinal differential protection

Differential protection is implemented by comparing the magnitude and phases of currents at the beginning and end of the stator phase winding. These currents differ slightly from zero due to the different characteristics of the magnetization process of current transformers and are called unbalance currents during a short circuit.

To correct the improper operation of differential protection, an additional current called the restraining current can be used. If the external short-circuit current is greater than the operating current of the differential relay, the relay does not operate. If the internal short-circuit current exceeds the restraining current, the differential protection activates (Fig. 2). The operation condition has the following form:

$$I_{Д} > k_{Т} \cdot I_{Т},$$

Where I_d is the differential operating current of the differential relay; k_r is the restraint coefficient; I_r is the restraining current.

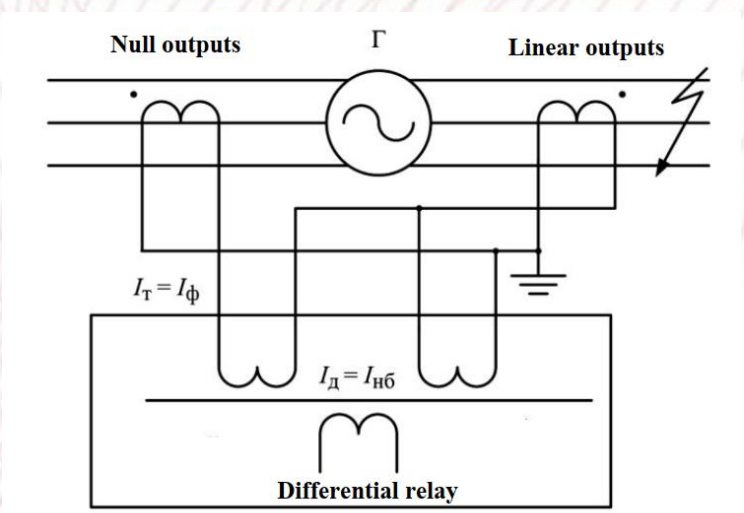


Fig. 2. Differential relay with restraint, shown for one phase

In modern microprocessor-based differential protection devices for synchronous generators at power plants, the operating characteristic shown in Figure 3 is used.

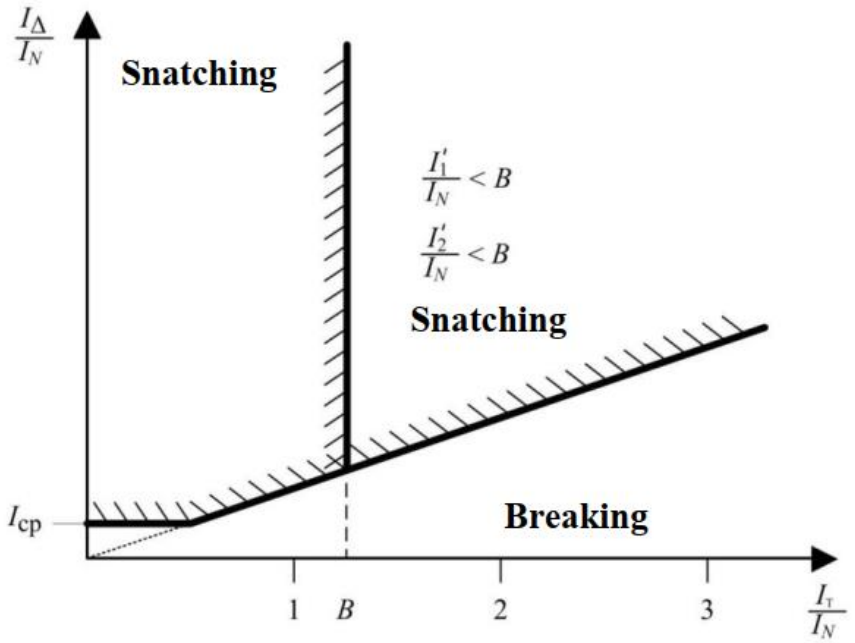


Fig.3. Operating characteristic of the microprocessor-based differential generator protection

The restraining current can be defined as:

$$I_T = \sqrt{(I_1' * I_2')cos\alpha}, \text{ for } \cos\alpha > 0 \text{ (through fault)}$$

$I_т = 0$, for $\cos\alpha \leq 0$ (internal fault),

Where α is the angle between the phase currents flowing from the line and neutral terminals; I_d - differential current; I_N - rated current; I'_1, I'_2 - phase currents from the line and neutral terminals of the synchronous generator. $I_т$ - restraining current; B - the break point of the operating characteristic, on the sloped section of the characteristic, ensuring the stability of the protection's operation during through faults with current transformer saturation at a restraining current greater than B.

The microprocessor-based differential current protection set includes a differential instantaneous overcurrent element that operates during internal faults with high currents.

The functional diagram of the microprocessor-based differential current protection has the following form:

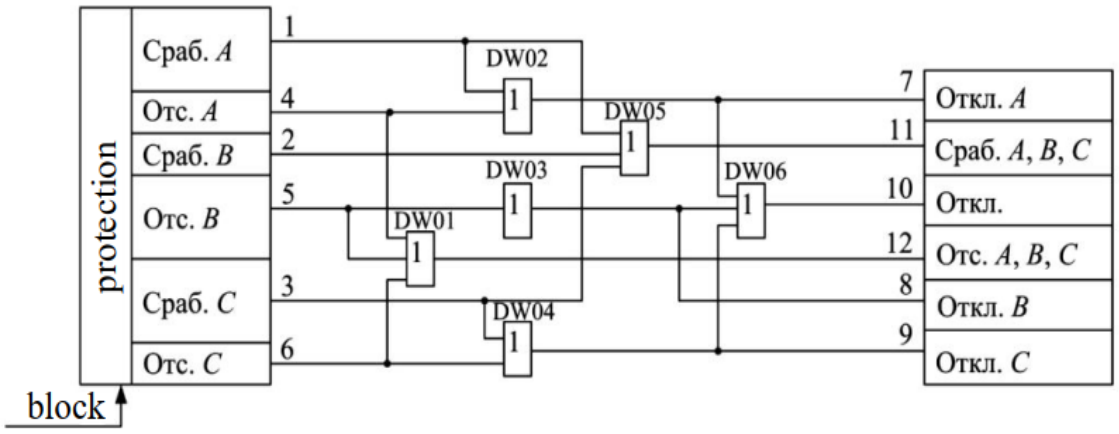


Figure 4. Functional logic diagram of the microprocessor-based differential protection of a synchronous generator

There is also the possibility of applying a software-based polarity reversal of input currents, which is useful during maintenance, commissioning,

and startup of the differential protection, as well as for monitoring the integrity of current circuits.

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