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Calculation Technique of Operating Currents and the Offset of Magnetically Controlled Contacts Protection from Interference Effect

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Abstract

The effective methods of current work calculation of magnetic hermetically sealed contacts (hercons) and methods of turning out protection on the hercons from the interference influence is listed. The method of current work calculation of the hercons, disposed at a safety distance from the bus-bars is simple and sufficiently exact for the practical use. The analysis shows that the tuning out on the hercons from the ground current and in neighbour plants can be realised by the choice of proper position the magnetic contacts under the bus-bars of the plant.

Complex protectors of electric system with magnetically controlled contacts (MCC) combining the functions of a measuring transducer with those of a current realy, are most often used in low-voltage network systems. Here MCC is located directly on the bus-line or near it, for high-voltage plants MCC are installed at a safety distance from the bus-lines [1]. At that the bus-line of the electricity generating plant is treated as an infinitely thin and long conductor with current. When placing the MCC at a safety distance from the current conducting bus-line in high-voltage electricity generating plants one should always observe the condition $h / h_b > 2,5$ (h – distance from the center of the current distributor to the point, in which the field density is established; h_b – the height of the bus-line).

If MCC is at the distance h from the conductor (figure 1) and L = 0, then (irrespective of other phases' currents influence):

$$B_o = \mu_0 \frac{I_o}{2\pi h} \cos\alpha , \tag{1}$$

where I_o – the minimal value of the current in the conductor;

B_o – the minimal value of the magnetic field induction under which MCC responds;

μ_0 – magnetic conductivity of the air;

α – the angle between the horizontal plane and the longitudinal axis of MCC.

If the same MCC is in the center of the coil axe of solenoid with $l >> r_c$, then, applying Biot-Savart-Laplace law, we can get:

$$B_o = \mu_0 \frac{\omega I_{cc}}{1_c} = \mu_0 \frac{F_o}{1_c} \quad , \tag{2}$$

where I_{cc} – minimal value of current in the coil, under which MCC, placed in this field, responds;

F_o – minimal value of magnetomotive force, under which MCC responds;

l_c and r_c – length and radius of solenoid, in which magnetomotive force is estimated.

Equating (1) and (2), we get

$$I_o = 2\pi \frac{F_o h}{l_c \cos\alpha} \quad . \tag{3}$$

The formula (3) can be used for calculating I_o in electricity generating plants of direct and single-phase alternating currents [2].

Magnetically controlled contacts of protectors can be influenced by interference – magnetic fields, created by telluric currents, the currents in the neighboring electricity generating plants (figure 1). To exclude false response of MCC in the line protector L1 from interference it is necessary to meet the condition:

$$B_o \geq C_{OFF} B_{LG}; \; B_{LG} = B_{L1} + B_{L2} + B_{L3} \quad , \tag{4}$$

where B_o – the value of the magnetic field induction, under which МГК responses;

B_{L1}+B_{L2}+B_{L3} – longitudinal components of the magnetic fields, created respectively by the currents L1 under the peak load conditions, by the currents L2 and by telluric currents;

C_{OFF} – the offset coefficient, taking into account the calculation uncertainty and the error of the protector ($К_{OF} > 1$).

Let $C_{OFF}B_{LI} / B_O = C_1$.

Then from (4):

$$B_o(1 - C_1) \;\geq\; C_{OFF}(B_{L2} + B_{L3}). \tag{5}$$

All kinds of the mentioned interference will simultaneously influence the MCC under ground short circuit in nets with a grounded neutral. Other kinds of interference are calculated additionally. The magnetic field induction components B_G и B_{L1} will produce maximum influence under ground short circuit of the phase A of the line L2 located at the minimal possible from phase C of the line L1 distance D (figure 1), considering that the current in the earth is concentrated under the MCC.

In dispatch devices the currents under ground short circuit go mostly along grounding electrodes and are closed through earthed neutrals of transformers. The main influence on MCC will be rendered by the currents, going along the horizontal grounding electrodes. It is considered that they conduct not more than 0,5 $I^{(1)}_{sc}$ ($I^{(1)}_{sc}$ – single-phase short circuit current).

Consequently:

$$B_g = \mu_0 \frac{0{,}5 I^{(1)}sc}{2\pi h_g} \cos\alpha, \;\; B_{L2} = \mu_0 \frac{I^{(1)}sc\left(h\cos\alpha - D\sin\alpha\right)}{2\pi\left(h^2 + D^2\right)},$$

where h_g – distance form MCC to grounding electrodes.

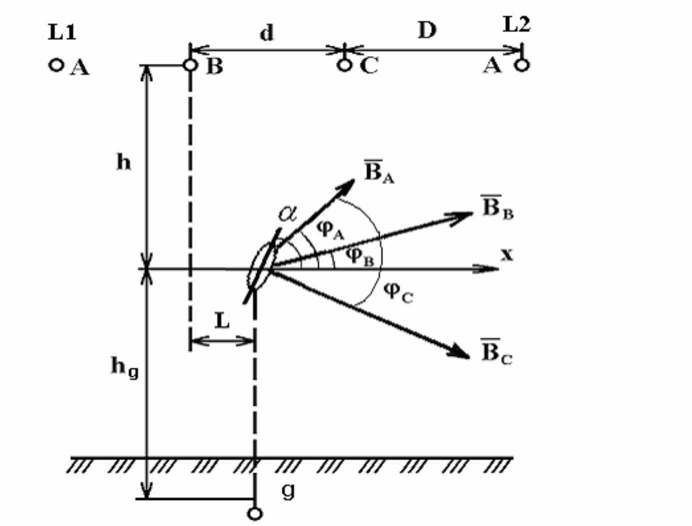

Fig. 1. Magnetically controlled contact between electricity generating plant bus-lines

Substituting the obtained expressions in (5), after the conversion we will get:

$$\frac{\sin^2\alpha_1 + 0{,}5h/h_g}{\sin\alpha_1\cos\alpha_1} > \operatorname{tg}\alpha \geq \frac{\sin^2\alpha_1 + 0{,}5h/h_g - C_4}{\sin\alpha_1\cos\alpha_1}, \qquad (6)$$

where $\alpha_1 = \operatorname{arctg}(h/D)$,

$$C_4 = \frac{1-C_1}{C_g C_{OFF}}, \quad C_G = I^{(1)}{}_{sc}/I_o .$$

The use of MCC in various types of protectors depends on its sensitivity, and the latter is determined by the value H_o and the coordinates of MCC.

In electrical networks with a grounded neutral with $h = h_{pos}$, where h_{pos} – is a minimal distance from MCC to the bus-lines permitted by the accidence prevention techniques in cases with inter-phase КЗ $I_{o.\,min} \approx I^{(1)}{}_{o.\,min}$, and in the network with insulated neutral $I_{o.\,min} \approx I^{(2)}{}_{o.\,min}$.

References

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