FEATURES OF MODELLING THE EXTERNAL MAGNETIC FIELD OF ELECTROTECHNICAL COMPLEXES AND SYSTEMS BEFORE AND AFTER THEIR COMPENSATION

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Any electrotechnical equipment, including electrical installations (EIs), generates an alternating external magnetic field (EMF) during operation. This field adversely affects both the performance of low-current networks of computing systems, control, communication and monitoring equipment that are sensitive to electromagnetic interference, and the health of personnel. In the first case, the issue of ensuring electromagnetic compatibility (EMC) arises, which manifests itself in reduced reliability of electrotechnical systems, such as false tripping of power transmission lines caused by malfunctions of relay equipment, increased additional energy losses associated with the generation of eddy currents, and other effects. In the second case, the problem concerns environmental safety.

Different countries worldwide are attempting to solve the problem of reducing the EMF of EIs. Most commonly, this is addressed through structural solutions based on shielding, which is ineffective at industrial frequencies. For example, shielding applied by Legrand (France) made it possible to reduce the EMF level at mains frequency by a factor of 10. In Ukraine, a more promising approach is considered to be automatic compensation of EMF using parametric automatic compensation systems (ACS). Such systems provide automatic tracking of parameters that define the EMF and generate a compensating magnetic field by means of compensating electromagnets (CEs). For example, for an automatic circuit breaker (ACB), the compensation efficiency (the ratio of maximum EMF intensity before and after compensation) reaches about 70 units. However, inside the EI, where EMF compensation is particularly critical, such high results have not yet been achieved. Therefore, mathematical modelling of the variable three-phase EMF of EIs is considered appropriate, with the aim of determining the indicators of compensation efficiency.

The sources of EMF in EIs are spatial current-carrying loops, whereas the sources of the compensating EMF are CEs consisting of a coil with current and a ferromagnetic core. The core comprises two parts forming a spatial magnetic system. The alternating magnetic field generated by these sources is considered in the external region where current-carrying loops and magnetized ferromagnetic elements of sensitive equipment (e.g., low-current networks) are located. In general, the problem of calculating such EMF cannot be solved directly because initial data about the receivers are unavailable. However, under certain assumptions, a modelling formulation of the problem becomes possible. As a first approximation, the field is calculated only in the region external to the EI, specifically in the medium free of magnetized materials. Considering the complex spatial configuration of EI conductors and CE magnetic systems, the resulting EMF is assumed to be non-uniform and three-dimensional.

The EMF was treated as quasi-stationary, and its intensity at an arbitrary point *P* was determined based on the principle of superposition of fields from individual sources (current loops and concentrated CEs). The main EMF parameter is the magnetic field intensity, represented by the spatial vector *H*, whose magnitude and direction vary periodically.

The object of mathematical modelling is an automatic circuit breaker (ACB) equipped with a compensation unit (CU) for variable EMF (Fig. 1): 0 – geometric centre of the ACB (origin of the x, y, z coordinate system); 1 – ACB; 2 – CU; 3 – ACB terminals; 4, 5 – CU terminals for connecting the ACB and the external power circuit; *P* – observation plane used in the EMF modelling; *h*, h_P – distances from the origin to the planes of the power circuit of the ACB with CU and to the observation plane *P*, respectively.

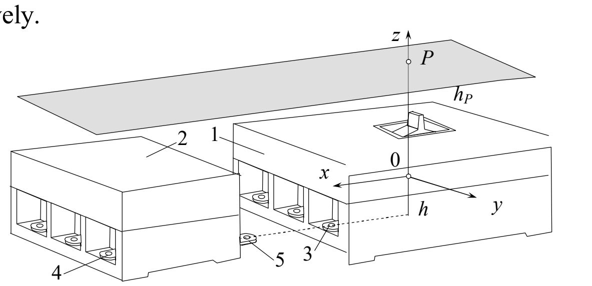

Fig. 1. Schematic representation of the ACB with CU

Figure 2 shows the power circuit scheme of the ACB with CU and the terminals K of the power circuit at the input of the ACB and the output of the CU. The loops are formed by the conductors of the *ACB* phases and the compensation unit. The directions of the phase currents $i_A(t)$, $i_B(t)$, and $i_C(t)$ follow standard convention. The CU contains two electromagnets, CE1 and CE2, in phases *A* and *C*. The CEs are represented by circuits $M_1(t)$ and $M_2(t)$.

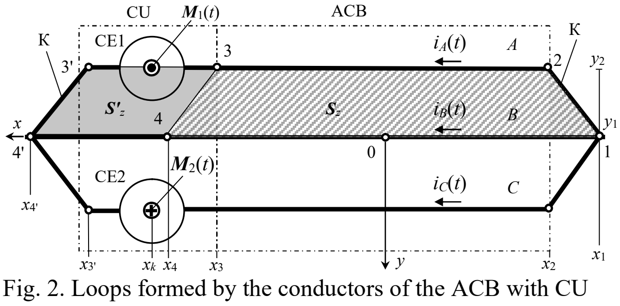

Fig. 2. Loops formed by the conductors of the ACB with CU

Computer modelling of the EMF of the three-pole ACB demonstrated specific features associated with the choice of direction for tracing loops carrying phase currents. The calculation of the magnetic field intensity vector and the magnetic moment of a loop with phase current must account for pulsating components.

The use of an external CE block for the ACB enables a reduction of EMF influence on microprocessor-based control units by 28 units along the x-axis and by 70 units along the z-axis, thereby preventing false triggering of relay protection devices.