

Interpretation of the Properties of the Spectra of Electromagnetic Radiation Emitted from High-Voltage Equipment

N. V. Kinsht and N. N. Petrun'ko

Received April 4, 2012

Abstract—The analysis of spectra of intrinsic electromagnetic radiation (EMR) emitted from high-voltage equipment makes it possible to obtain information from which the intensity of discharge processes that occur in the insulation can be determined. The purpose is to identify indicators that characterize the internal technical condition of a component of the equipment. Radiation emitted from external sources should be filtered out from the overall picture of recorded EMR. The spectra of EMR emitted from various units of the equipment are individual ones, but for similar units of the equipment they have similar structure and similar general properties. Examples of actual spectra of EMR are given. The most probable interferences are analyzed. The principles of signal selection are discussed. The special features of interpreting the dependence of amplitudes of natural frequencies of a spectrum on the time are examined. The possibilities for determining natural frequencies of a component of the equipment are shown.

DOI: 10.1134/S0040601512140066

Statement of the problem. The apparent charge as a characteristic of the partial discharges. The operation of the high-voltage power equipment is accompanied by partial discharges. From the viewpoint of formal mathematics, the processes of partial discharges, i.e., currents, charges, voltages, and attendant electromagnetic radiation (EMR), are nonstationary random processes. It is obvious, however, that there is an explicitly expressed information component in them [1, 2].

It is customary to evaluate partial discharges by means of so-called apparent charge. The latter is held to be one of the major normative parameters and has been included in both national and international standards. It is used for calibration of measurements, and other parameters that determine the quality of the insulation, and as far as partial discharges are concerned, are associated with an apparent charge. Therefore, numerical values of an apparent charge are used actively in evaluating the technical condition of the high-voltage equipment. The method of evaluating a partial discharge based on the concept of an apparent charge was formulated more than 70 years ago (Scanavi, 1955; Koske, 1939).

The practice of operation of important power equipment demonstrated that methods based on measuring an apparent charge do not ensure identification of faulty equipment at the early stage of deterioration of its technical condition, and in some cases, they may provide false estimates of the latter, resulting in severe accidents. The main problem is that reliable principles of interpreting the information obtained, which would provide the possibility to reliably predict changes in the technical condition of the insulation are lacking.

One of the most important uncertainty factors that is not taken into account in current methods and normative documents is the problem of the number of actual defects in the insulation. In essence, the apparent charge is a characteristic of a single event of the partial discharge, but there are difficulties associated with interpretation of single discharges. The same pattern of distribution of a host of these partial discharges depending on the phase of operating voltage may correspond to significantly different technical conditions of a transformer. For example, if a set of these partial discharges is uniformly distributed over the entire volume of the transformer, such a situation does not excite apprehension. But, when all partial discharges are localized in a small volume, rapid deterioration of the insulation in this volume occurs, an evolving discharge is known to be more dangerous, and the probability of equipment failure is much higher. The detailed analysis shows [3] that uncertainty factors incorporated into the traditional model of partial discharge, when the notion of apparent charge serves as the basis for evaluating the technical condition of the equipment, in total comprise several orders of magnitude. It seems likely that the model of partial discharge based on the concept of “apparent charge” has already exhausted itself.

Spectrum of electromagnetic radiation as primary information about discharge processes. The method of the evaluation of the technical condition of the transformer equipment on the basis of monitoring of EMR near a component of the equipment, which has received wide acceptance, seems to hold promise. Its special feature is the fact that EMR is an objective electrophysical characteristic, whereas an apparent charge is a fictitious indicator that depends on meth-