C4 - Power system technical performance
PS1 / Improving power system technical performance through the use of advanced methods, models and tools

Methods and technology for electromagnetic environment and electromagnetic compatibility study at power engineering objects

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The analysis of local and system failures resulted in power outage of more than 300 MW showed that correct performance of relay protection and automation (PACS) systems and, in turn, power system performance reliability depends, in many situations, on electromagnetic compatibility within power substations and plants. Most dangerous disturbances for PACS are electromagnetic interferences due to switching operations or faults in HV or EHV mains and due to lightning strokes to lightning protection system of object.

When electromagnetic compatibility for PACS is provided power system performance improves as a result of lower number and severity of failures. Statistical data confirms this thesis for Moscow and Moscow region power system, which is the largest power system in Russia.

Method was developed to calculate electromagnetic environment as well as computer programs to implement this method. The method is applied in designing of newly constructed or re-constructed objects in order to choose measures to provide equipment EMC during operation. Before re-construction of operating object, electromagnetic environment parameters are determined within the object by means of calculation and experimental method. Before object put into operation electromagnetic environment parameters are defined experimentally. This experimental method includes full-scale and simulation experiments.

Electromagnetic environment parameters were calculated at designing stage of 750/500 kV substation. When construction finished and before substation was put into operation experiments were conducted to simulate transients in 500 kV and 750 kV switchgear mains due to earth faults and disconnector switching, special generators having been used. Effective method was also implemented to perform full-scale transient simulation in HV mains connected according to normal scheme while PACS was installed and connected to auxiliary circuits. In those experiments, low voltage of hundreds of volts was applied to mains. Then required switching operations and artificial earth faults in mains were performed and interferences in auxiliary circuits were measured. Values measured were then recalculated linearly to mains nominal voltage. After that artificial short circuit experiments were performed. Nominal voltage was applied to switchgear while special conductors were installed between 750 kV phase conductor and earth within switchgear and at overhead line. During full-scale and simulation experiments currents and voltages were measured in primary and auxiliary circuits. After substation put into operation impulse interferences were measured in auxiliary circuits when 500 kV and 750 kV circuit breaker and disconnector switching operations were performed. 0.4 kV unshielded

power supply cables for circuit breaker and disconnector drives suffered 15 kV and higher impulse interferences at 750 kV switchgear and more than 6 kV at 500 kV switchgear. This resulted in 0.4 kV earth faults occurred in drive cabinets at switchgear. At the same time, interferences in 0.4 kV main switchboard were not registered.

Full-scale mains transient simulations were performed in GIS of 110 kV, 220 kV and 500 kV, high-frequency current component frequency response having been determined.

Electromagnetic disturbances from lightning were defined by simulation using high-current and low-current impulse generators. Voltages induced in auxiliary cables were defined by means of lightning current simulation using long vertical conductor discharge.

Data obtained in full-scale and simulation experiments were compared with each other and with calculation results. Good agreement was received, auxiliary circuit interference frequency response varied not more than 15%.

Based on investigations performed cost effective measures were developed to improve electromagnetic environment within substation. For example, surge arresters were installed in drive cabinets having voltage protection level of 1.5 kV. Measurements confirmed that arresters limited interference level and eliminated earth faults in 0.4 kV mains.