

OPEN-PHASE OPERATING MODES IN POWER SYSTEMS

One of the types of malfunction during operations in power systems is the open-phase operation modes which arise during the breakdowns of the wires of overhead power transmission lines, incomplete phase commutations, broken contacts, and for other reasons. Such modes are not always provided with relay protection. The asymmetric modes that arise during the breakdowns of overhead line wires are not always accompanied by high emergency currents sufficient for the operation of relay protection. So, for overhead lines with a two-way power supply in accordance with the EIC [1], differential-phase high-frequency protection is used as the primary, three-stage distance protection and four-stage zero-sequence protection is used as backup protection.

Experience of operation [2] – [6] shows that in complex electric networks at wire breakage of transmission lines there are operating modes that lead to non-selective operation of relay protection and excessive power cuts. Such cases were repeatedly found in the networks of the Dnipro power system, which are documented, reviewed and analyzed in special reports.

Damage analysis on 150 kV transmission lines shows that more than 60% of stable emergency shut-downs occur on single-phase faults and breakdowns of one phase of the transmission line [6]. For power lines with one-way power these accidents are accompanied by a long shutdowns of consumers. As a rule, in case of breakdowns, all phases of the line remain disconnected during the entire time of searching for damages and repairs. Meanwhile, the operation of transition line in two-phases mode under a pre-composed instruction allows, in most cases, to significantly shorten the duration of the power supply breakdown and the emergency failure of electricity to consumers. In addition to the emergency operation of transition line in two-phases mode, open-phase loading mode can be provided, for example, during phase repair of power lines or ice phase melting.

The main reasons for the occurrence of open-phase modes of electrical equipment are the breakdowns of wires, the failure to turn-off or turn-on individual phases of switches with single phase control and so on.

In the case of a wire breakdown of the overhead line without a short-circuit, the relay protection devices of this line can come into action if, after the breakage, the zero-sequence current and the zero-sequence power will exceed the protection settings values. These values are determined by the level of the load current of the previous mode.

Currents of the negative and zero sequence are largely depend on the operating mode of the transmission lines before the damage and triggered by the basic differential-phase protection fault detectors. These currents are usually insufficient to start-up the trip circuits and are not always sufficient for the start-up of the transmitter chains.

The use of adaptive algorithms of microprocessor Smart Grid systems allows to increase the sensitivity of relay protection in open-phase modes, to reduce the number of excessive power cuts, and also to shorten the duration of interruption of power supply (SAIDI, SAIFI, CAIDI) and emergency failure of electricity to consumers.