Method of automatic fault location in 6-35 kV electrical networks

https://doi.org/10.31713/MCIT.2023.079

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Abstract— **The paper analyses the known means of fault location in electrical networks, identifies their disadvantages and proposes its own method of solving this problem. The model of electric network is built and investigated by MATLAB.**

Keywords — power grids; single-phase ground fault; fault location; modelling.

I. Introduction

The electric power system, as a control object, combines numerous elements of different levels of complexity: power plants, power transmission lines, substations, transformers, automation and relay protection devices, etc. All elements of the system are interconnected by complex links [1]. All elements of the system are interconnected by complex links [1]. At the same time, the system acquires difficulties related to optimisation of its operation modes, sensitivity to damages, complexity of repair works, etc.

Faults in the power grid are random and unpredictable. Therefore, they lead to disruption of power supply regimes and under-delivery of electricity to end consumers. The losses of the power supply company depend on how quickly the damaged section of the network is repaired.

The time during which a damaged network section is de-energised is determined by the duration of fault location and the duration of repair. For this reason, it is important to optimise the fault location process.

II. Analysis of latest researches and publications

Devices for fault location began to appear in power systems in the early 1960s. Prior to that, fault location was determined by bypassing, bypassing, and sometimes by helicopter overflight of the line route. This work requires a lot of time and money, as the lines are up to hundreds of kilometres long, and the line route often runs through difficult terrain. In addition, the fault location is sometimes poorly visible even in close proximity. It is even more difficult to determine the fault location in the case of a self-recovering fault, where the line remains in operation after automatic reclosing. The information about such damages is useful for repair services, because usually after them there is a weakened place on overhead lines, which can lead to an accident in the future. All this has led to the widespread use of fault location methods and tools [2]. However, they are usually limited to short-circuit location. At present, most substations of 110 kV and above are equipped with fault location devices. In PJSC "Kirovogradoblenergo" 150 kV substations are equipped with "Rekon-07BS" devices, which record the transient process during a short circuit, and based on the analysis of emergency parameters with an accuracy of 50-150 m via telemechanics channel indicate to the on-duty dispatcher the place of damage. The data are given from my own experience in a power distribution company. It was not possible to find any documented data with an assessment of the accuracy of fault location.

6-35 kV networks have an isolated neutral operating mode. If we consider this mode of neutral operation from the point of view of fault location, it should be noted that there is no dependence of the single-phase earth fault current on the distance to the fault location. And since this principle is the basis for the operation of fault location devices, an automated method of detection of single-phase earth faults has not been developed at present [3]. Substation duty personnel can only obtain information about the number of the feeder on which the single-phase earth fault occurred. This process can occur in two ways:

1) with the help of the "Altra-32" device, which automatically detects the damaged branch line by analysing the zero sequence currents of each feeder and the zero sequence voltage at the substation busbars;

2) by alternately disconnecting each connection and observing the zero sequence voltage. This paper is devoted to the development of methods for fault location in single-phase earth faults in networks with isolated neutral, as the least developed area of fault location.

III. Formulation of research objectives

The purpose of this publication is to develop an automatic method of fault location in 6-35 kV insulated-neutral power grids with single-phase earth fault.

IV. Statement of the main material

The authors of the publication propose a frequency method for determining the location of a single-phase earth fault in a network with isolated neutral, which is based on analysing the harmonic composition of the transient current during a single-phase earth fault. Namely on the observation of the change of the resonant frequency of the network during a single-phase earth fault.

For this purpose, a 35 kV network model was built and studied in MATLAB Simulink environment (Fig.1). It consists of a block of step-down transformer "TDTN-63000/150/35/10" on the supply side of the lines; a block of lines (U-shaped substitution diagram) "Pi Section Line"; a block of step-down transformer "TRDNS-25000/35/10" on the receiving side of the line under study; an equivalent line "Equivalent Line", which takes into account the influence of lines that are on the same busbars with the line under study; Equivalent Load", by means of which the influence of transformers and loads of the 35 kV network connected to the busbars of the substation under study is taken into account; "Impedance Measurement" block, by means of which the change of impedance of the part of the network shown in the figure is studied depending on the distance to the fault location, and therefore the change of its own resonant frequency.

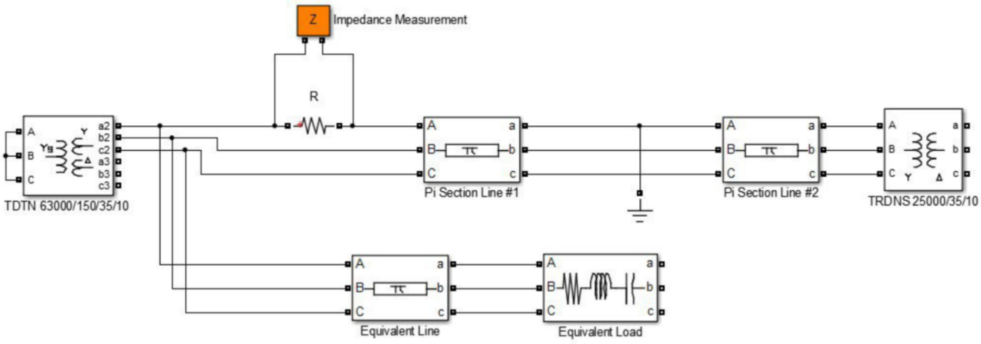

Figure 1. Model of part of 35 kV network in MATLAB Simulink environment, single-phase earth fault on phase A

The conducted studies have shown that the resonance frequency depends on the distance from the supply substation to the fault location (Fig. 2). In the figure, the resonance frequencies are indicated by local minima of the function $z = F(f)$, where z is the input impedance of the network, f is the frequency.

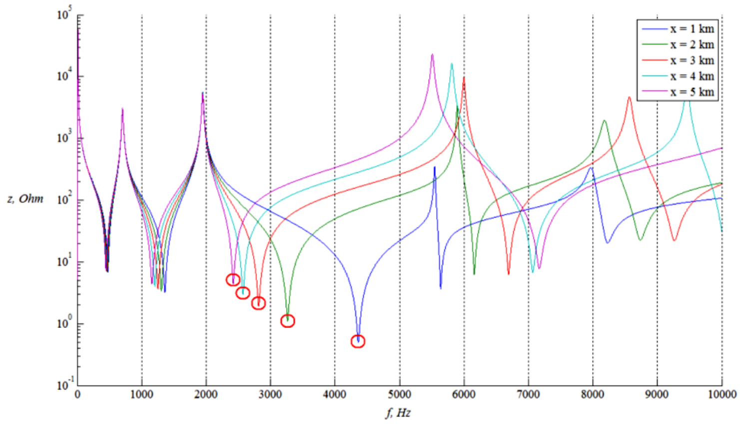

Figure 2. Displacement of the mains resonant frequency (highlighted with red markers) at different distance x to the single-phase earth fault location

V. Conclusions and Prospects for Further Research

The conducted research has shown the existence of a promising way to solve the problem of automating the process of fault location in 6-35 kV networks.

The direction of further research is to determine the function $f=F(L)$ of the change of resonant frequency f from the distance to the place of single-phase earth fault L. This will make it possible, having fixed the frequency of higher harmonics during transients from the device developed in the future and automatically determine the distance to the fault location.

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