Study on Transmission Line and Associated Varying Parameters, Devices and Control Algorithms

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Abstract: **The transmission line is the most important part of the electricity network. The need for electricity and its affiliations have increased exponentially in modern times and the main task of a transmission line is to transmit electricity from the area of origin to the distribution network. The explosion between limited production and huge demands placed more emphasis on reducing power losses. Losses like transmission loss and also conjecture factors as like as physical losses to various technical losses, another reason is that reactive power and voltage difference in the long distance transmission line are of great importance. In essence, fault analysis is a very important topic in network technology in order to eliminate errors in a short time and restore the electrical network as quickly as possible with minimal interruptions. However, detecting errors that interrupt the transmission line is in itself a difficult task to look for errors and improve system reliability. The transmission line is vulnerable to all parameters that connect the entire electrical network. A review of the transmission and associated equipment was described in this study. And it explains the classification and fault detection scheme. This document provides an overview of transmission line failure detection.**

Keywords: **fault current, transmission line, transformer, current transformer.**

I. INTRODUCTION

Current transformers (CT) play an important role in the protection and measurement functions of a power supply system. The correct selection of current transformers leads to the correct functioning of the protection and measurement devices. Magnetic saturation of the current transformer core causes unwanted problems with the protection devices, therefore it is necessary to design a current transformer to activate the protection devices during the first fault cycles without its core being saturated.

The transmission line is one of the most important components of an electrical power system. Since these transmission lines cover important areas, they are often subject to errors. Furthermore, power systems are being developed and, in parallel with this expansion, stability problems arise in their operations. Using precise troubleshooting solutions can speed up troubleshooting and minimize recovery time for the defective line. In this way, the stability of the fuel system and the quality of the energy are improved.

Most fault detection algorithms use the fundamental frequency phases of voltage and current. Another category of fault detection algorithms uses the components of the mobile waves [1]-[2] generated by the fault. Fundamental frequency algorithms are cheaper and less complex to implement because they do not require special sensors or devices with a high sampling rate. In this case, the actual sensors and devices with sampling frequency (eg those used for protection or monitoring) can be used [3]. Fault finding algorithms that use the fundamental voltage and current frequency phases are divided into two main categories: one-end and two-end data algorithms.

One-end data algorithms are based on estimating apparent impedance from the measurement point (for example, one end of the line) using the voltage and current phases of the fault regime [5]. To obtain the location of the fault, this apparent impedance is compared with the total impedance of the line. To improve the location of the error, data error algorithms are used for the final data in addition to the voltage and current phases before the error.

One-end data algorithms are inexpensive and very easy to implement, which is why fault finding using voltage and current phases at one end has become standard in most digital relays. On the other hand, the accuracy of these algorithms is affected by many sources of error, such as the DC components of the error current. [3]- [4].

II. LITERATURE REVIEW

Peyman Soleiman Nezhad et al. [5] this article proposes a new differential protection scheme for pilot transmission lines. The concept of differential impedance (Z diff) is introduced using the synchronous voltages and currents of the two lines of the line. The proposed scheme is able to quickly distinguish between internal and external errors, even in the worst operating conditions. Dependence on the capacitive mains load current and on the source force are common problems with conventional pilot protection methods, which have been eliminated in the proposed scheme.

Justyna Herlender et al. [6] this article deals with the analysis of the differential impedance protection when locating faults on the power transmission line. Differential impedance is calculated based on voltage and current measurements on both ends of the cable. It allows the formulation of an effective protection algorithm. In addition, the presented differential impedance protection can determine the location of the fault for inspection and repair.

K. V. Babu et al. [7] this article offers an overview of developments in digital relays to protect transmission lines. For a modern power supply system, the high-speed selective elimination of faults on high voltage transmission lines is of paramount importance. This study shows effective and promising implementations for the detection, classification and location of faults in the protection of power transmission lines. Work in this area promotes IT relays, digital communication technologies and other technical developments to avoid cascade failures and enable safer and more reliable power systems.

Gabriel Benmouyal et al. [8] This article examines the different trajectories of the current relationship according to the emergency conditions: type of element (phase or sequence), line load, line length, level of resistance to failures, degree of saturation of the current transformer (CT)) , if applicable, presence of an open stem or similar conditions.

Marian Dragomir et al. [9] This article presents two transmission line fault location algorithms that use line parameters to estimate the distance to the fault. The first algorithm uses only the measurements at one end of the line and the positive and zero sequence parameters of the line, while the second uses the measurements at both ends of the line and only the positive sequence parameters of the line. The algorithms were tested with a transmission network transposed into MATLAB. First, a baseline has been established for troubleshooting, where the above algorithms estimate the locations of the faults using the exact parameters of the line.

III. Transmission Line

Transmission lines are an integral part of the energy distribution system because they represent the means for transferring energy between production and load. Transmission lines operate at voltage levels from 69 kV to 765 kV and are ideally tightly connected for reliable operation. Factors such as the unregulated market environment, the economy, the Right of passage, and environmental requirements have prompted utilities to manage transmission lines close to their operating limits. Any errors that are not quickly identified and isolated will result in a system-wide error that will result in widespread failures in a very tight system operating near its limits. Transmission protection systems are used to identify the location of faults and isolate only the defective section. The main challenge for the protection of the transmission line is to reliably detect and isolate faults that endanger the safety of the system.

Fig. 1 Transmission line [10]

IV. Line Current Differential Relays

General concepts Differential protection is basically simple. Gustav Kirchhoff's first law states that the sum of the currents entering and leaving a node is zero. We implement this principle with differential relays to protect transmission lines, bus sections, power transformers and generators. Of course, a relay 87 does not measure primary currents. Compensation may be required for differences in size and phase angle induced by CTs and elements of the power system [10]. In IEC 61850-9-2 transmission line or process bus applications, the simple principle 87 is further complicated by the processing, communication and alignment of the distributed digital signal. A generic relay 87, with these complicated functions, is shown in the figure 2.

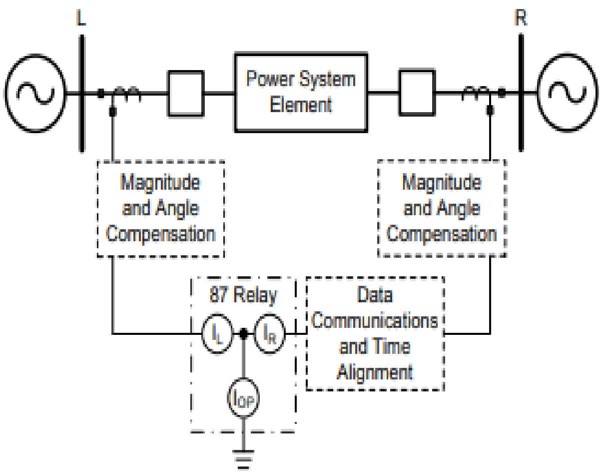

Fig. 2. Functional Current Differential Relay [11]

For normal power flow or for external faults, we expect that the current I_L is nearly equal in magnitude and opposite in phase angle from I_R after compensation, data communications, and time alignment. The difference current, IOP, is the pharos sum of I_L and I_R. IOP should be nearly zero under these ideal conditions.

V. CURRENT TRANSFORMER

The main requirement is that the current ratio is constant. The primary winding is connected in series with the load and carries the load current to be measured. The winding is connected to the relay or to the dosing unit. The secondary current of the relay, as well as the load resistance and the winding impedance, form the load on the transformer. The primary current contains two components [12].

a) Secondary current which is transformed and is in inverse ratio of the turns ratio.

b) Exciting current to magnetise the core and supply eddy and hysteresis losses and is not transformed. Amount of exciting current depends upon core material and burden requirement.

The ratio error is given by the following expression.

$$\% \text{ error } = \frac{K_a I_s - I_p \times 100}{I_p}$$

Ka = Rated transformation ratio

Is = Actual secondary current

Ip = Actual primary current

Since the relay time in modern protection relays has been reduced to a few milliseconds, more attention should be paid to the transient response of the current and voltage transformers. To avoid saturation of the current transformer cores during transient currents, larger cores and air spaces are introduced into the current transformers for quick protection relays. The standard specifications specified by IEC, IEEE and IS cover various aspects of current transformers, e.g. General Requirements, specifications, tests, applications, terms and definitions. The main criterion for selecting the current transformer ratio is almost always the maximum load current. In other words, the secondary current of the current transformer must not exceed the direct current of the relay applied to the maximum load currents. This is especially true of phase relays where the load current flows through the relays. This criterion applies indirectly to the earthing relays, although they do not receive current, since they are generally connected to the same set of current transformers as the phase relays.

VI. FAULT DETECTION AND CLASSIFICATION SCHEME

The proposed method for detecting and classifying errors compares the change of direction of the instantaneous power on both ends of the transmission line using a synchronized scan measurement. The method uses raw data measurements extracted from the data examples without the need for pointer calculations. The method was assessed using both the current differential and the differential real power values. Active power use showed greater accuracy as it was less affected by the presence of noise or higher frequencies in current difference measurements.

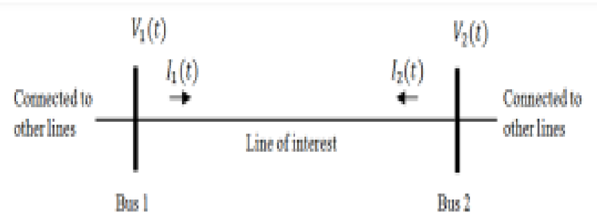

Fig. 3 line of interest

In Fig. 3, $v_1(t)$, $l_1(t)$ and $v_2(t)$, $l_2(t)$ represent voltage and current measured at two ends (Bus 1 and Bus 2) of the line at instance t, respectively. Instantaneous powers can be calculated at both ends using following formulas:

$$P_1(t) = V_1(t) \times I_1(t)$$

$$P_2(t) = V_2(t) \times I_2(t)$$

The unique feature of instantaneous power measurements from both ends under fault condition makes the detection and classification of faults possible without using any thresholds. $P_1(t)$ and $p_2(t)$ phase angles are opposite to each other during the normal condition. However, during a fault, the faulty phases will be almost in phase with each other. It should be noted that, even after the fault inception, the phase opposition is maintained in phases that do not experience a faulted condition. Representing this feature mathematically can be done using a signum function defined as:

$$\text{sgn}(x) = \begin{cases} -1, & x < 0 \\ 0, & x = 0 \\ 1, & x > 0 \end{cases}$$

VII. SERIES COMPENSATION

Series compensated transmission lines use series capacitors to cancel some of the inductive reactance of the transmission line. The power transmission capacity of the line can therefore be improved by compensation. Serial compensation has been applied mainly to long transmission lines and to other places where transmission distances are long and where large power transmissions over such distances are required [13]. Modern HV and EHV transmission lines are compensated in series to improve electrical system performance, improve transmission capacity, improve current flow and voltage regulation and reduce capital investment [14]. Performance along the series-compensated transmission line is often explained using the system shown in Figure 4 [15].

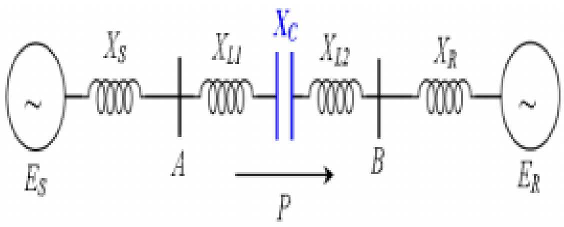

Fig. 4 Transmission line with series compensation

The active power P transferred by the compensated transmission lines are computed as
p = ((Es*Er)/Xt-Xc)*sin(δ)

VIII. CONCLUSION

In this study, the transmission line and associated parameters are described. Also the fault detection and classification scheme is described. The work can be focused on reducing transmission line faults, improve its detection and removal it. In order to improve the quality of the current, i.e. to make the performance cleaner, the compensated circuit is considered connected in the transmission line which could be any FACTS devices or any filtering unit. The performance of transmission line can be improved by using these devices. The study has also seen importance of SFCL (Superfluous fault current limiters) in the line and its affects. The further work may be focused on any of these devices so as to enhance the performance by utilizing AI technique.

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