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Distance Relay Setting for One Zone of Transmission Line

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A B S T R A C T

The objective of this work is to determine the fault location for one zone. Impedance relays constitute a vital component of power systems, specifically within the real value of transmission system, which was accomplished through the utilization of MATLAB/SIMULINK. The sim power system toolbox was employed to enable the intricate modeling of the distance relay, transmission line, and fault simulation. Within the modeling phase, the specific fault type chosen was single line to ground (SLG), Line-to-Line, while the protection scheme was established as the impedance type distance characteristic. This technique represents an interactive simulation environment that facilitates the design and evaluation of relaying algorithms. Moreover, the fundamental principles governing digital distance relays, as well as several pertinent filtering techniques, are meticulously elucidated within the confines of this paper. In order to enhance the user experience and ensure ease of interaction, thereby augmenting the functionality of the developed model. It is important to note that distance or impedance relays constitute a vital component of power systems, specifically within the realm of transmission systems. Finaly, it has been concluded that the fault impedance became less than the set value and a trip signal sent with short time to the circuit breaker.

1. Introduction

Distance protection constitutes an essential protective strategy that is most commonly utilized in transmission lines, playing a vital role in ensuring the reliable operation of power systems. This protection scheme can operate solely based on local measurements, without the need for communication with the other line terminal, which greatly simplifies its implementation in numerical relays[1]. The fundamental principle behind distance protection is the calculation of fault impedance using the local measurements of voltage and current, which is then compared to a predetermined impedance threshold in order to determine whether the fault lies within its operating region[2]. The distance to the fault is deduced from the observed impedance value, as the length of the transmission line is directly related to the distance, thereby validating the designation "distance protection"[3]. Protection systems, encompassing various protective relays, occupy a position of paramount importance in power systems, as they are entrusted with the task of safeguarding the transmission of electrical energy[4]. The manifestation of short circuit anomalies, which can transpire in numerous locations within electrical power systems, can be attributed to diverse factors, including strikes of lightning, wind of high speed, weight of ice, earth quakes, fires, explosions, trees of falling, objects of flying, animals, humans, hardware failure, hardware aging, incorrect hardware usage, incorrect operations, and improper switching actions. Consequently, protection relays are strategically positioned at points of different and components of the system of power to ensure rapid and protection of selective [5]. Among the various types of protective relays, distance protection relays are highly favored for the protection of transmission lines, and although their primary application lies in the protection of lines, they are also extensively employed as back-up protection for transformers, bus-bars, and distant of lines. The relays have undergone precise modifications in order to operate in alignment with the impedance properties of a transmission line through the analysis of voltage and current measurements[6]. The distance at which The fault connected relay the determination of the impedance value is achieved through measurement, as the short circuit impedance exhibits a certain rate of decrease When it approaches the line feed point, thereby enabling the identification of the location of fault [7]. The proficiency to precisely ascertain the location of faults within transmission lines. represents a crucial advantage employed in the protection of system, the growing intricacy of power transmission systems has considerably enhanced the significance of conducting fault location investigation studies in recent times. When the fault location can be ascertained or estimated with a high degree of precision, the fault can be promptly repaired, leading to a multitude of benefits, such as reduced customer complaints, minimized downtime, lower operating costs, preserved revenue, and enhanced system stability[8-11].

2. Principle of Operation

The single line diagram of power system with protection unit is shown in Figure.1

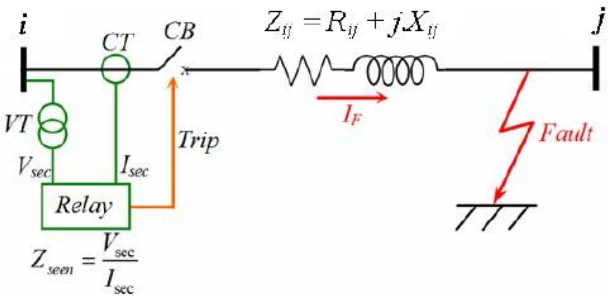

FIGURE.1 Single line with protection unit

The working principle of the distance relay is inherently straightforward, as it is primarily based on the fundamental concept of impedance, which is the ratio of voltage to current. To facilitate its operation, the present relay is furnished with a potential transformer which provides the required voltage and a current transformer, the entire circuit is connected in series. It is important to note that a distance relay is typically employed for the protection of transmission lines, as it effectively measures the impedance from the side of installation to the location of any fault that may occur. Consequently, this relay is able to respond to any changes in the ratio of the current and voltage that it measures. Within the relay of distance, the operation is contingent upon the aforementioned ratio of V/I, the expression of impedance. Essentially, the relay will initiate its operation when the impedance, quantified by the ratio V/I, falls below a predetermined value. Furthermore, distance relays encompass a range of types, including impedance, reactance, and admittance relays, each of which serves specific purposes in relation to protection. In the present scenario, the V/I ratio surpasses the reach point, signifying that the relay's reach extends beyond the fault location. It is important to delineate the reach of a relay, which denotes the distance between the relaying point and the fault point. Additionally, it is worth mentioning that the voltage present on the primary voltage transformer (VT), can be calculated through a series of intricate calculations.

$$V_T = \frac{E * Z_f}{Z_s + Z_f} \qquad (1)$$

Where V_T : Primary Voltage Transformer

E : Voltage Source

Z_f : Fault Impedace

Z_s : Source Impedance

And Fault current is given as

$$I_f = \frac{E_a}{Z_s + Z_f} \qquad (2)$$

Where, I_f : Fault Current

The following relationship (equation 3) is used to measure the impedance and the relay performs a comparison between the secondary quantities of voltage and current, with the aim of evaluating their respective values and potentially determining any discrepancies or inconsistencies that may exist between them.

$$Z_m = \frac{Z_f * C_T}{P_T} \qquad (3)$$

Where , Z_m : Measured Impedance

C_T :Current Transformer

P_T :Voltage Transformer

3. Fault Kinds :

In the overall context of transmission networks, it can be observed that there exist two distinct categories with regards to faults that may arise, namely balanced faults, which are also known as symmetrical faults, and unbalanced faults, which are referred to as unsymmetrical faults. It is essential to understand that these faults can be further categorized as either series faults or shunt faults[12].These kinds of faults are known to occur when there is an opening in the conductor and there are unbalanced series impedance conditions present in the line. One instance of such a malfunction occurs when the system encounters one or two malfunctioning lines, or when there is an introduction of impedance in one or two lines. In a practical context, or to phrase it differently, in real-life situations, this malfunction occurs when the circuit breaker takes charge of the lines without opening all three phases, thereby enabling the opening of one or two phases while keeping the other closed. Series malfunctions can be categorized based on the observed rise in voltage and frequency, accompanied by a decline in current in the affected phases[13]. Shunt faults, which include power conductors, a connection to ground, or a direct short circuit between conductors, represent the predominant category of faults that occur within electrical power systems. These shunt faults are responsible for the escalation of current and the decline of voltage and frequency[14]. Approximately seventy percent of fault incidents are attributed to line to ground faults, as indicated in reference . This particular type of fault arises when one of the phases in any given transmission line establishes a connection with the ground [15].When two different phases come into contact with each other, typically as a result of cyclones or powerful winds, a situation known as phase-to-phase contact occurs. It has been observed that approximately 15% of transmission faults can be attributed to line-to-line faults. This finding is supported by the research conducted in reference [16] .

4. Method of adjusting distance relay

Knowing the power system transmission lines current topology and the generation level , the proposed setting scheme for one zone distance relay to determine the fault location is depended on the impedance

5. protection Zone

The power equipment is encompassed by the protection zone. In the event of a fault transpiring within any of the zones, solely the circuit breaker corresponding to that specific zone will be triggered [17]. The ensuing circuit diagram will illustrate the protection scheme for zone A . The Figure.2 represents the modeling circuit of transmission line with protection circuit at one zone.

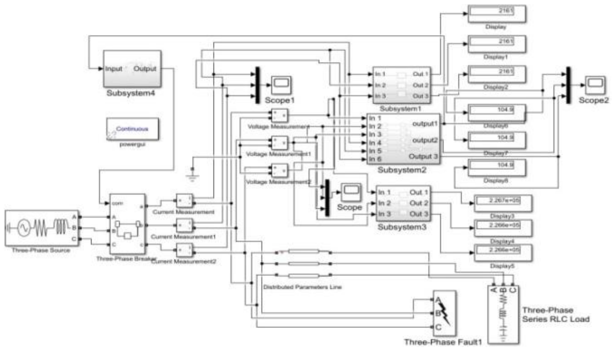

Figure.2. Matlab Simulation of the proposed Circuit

The given circuit model comprises of four distinct subsystems. The first subsystem is responsible for measuring the average value of current. In the second subsystem, the average value of impedance is determined. Similarly, the third subsystem focuses on measuring the average value of voltage. Finally, the fourth subsystem is dedicated to the design of a relay circuit that activates whenever the impedance falls below a predetermined threshold of (1). The assessment of the average values of these parameters can be accomplished by utilizing the RMS and MEAN VALUE blocks.

In the second subsystem, the average impedance is determined by dividing the average voltage by the average current in the respective phases. In the fourth subsystem, a relay is devised in such a way that it detects any decrease in impedance below a predetermined value on the fault line. As a result, the relay circuit identifies the fault and sends a signal to the circuit breaker to disconnect the line. In subsystem 2, the mean impedances of the three phases are calculated as depicted in Figure.3.

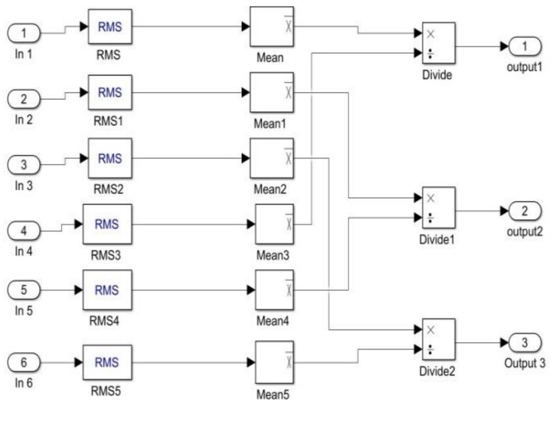

Figure.3 Logical calculation of impedance

The power system model parameters and the relay model settings are used in the following Table1 :

Table.1. Transmission Line Parameters

No.	Parameters	Value
1	Length Line (L)	20 km
2	Voltage (V)	400 kV
3	Frequency	50 Hz
4	Resistance Line	0.02083 Ω/km
5	Inductance Line	0.8984 mH / km
6	Capacitance Line	0.0129µF / km

Table.2. Data of Relay setting parameters

Zone	Setting	Values (Ω)	Time setting
Zone1	80% TL	103.9	Instantaneous

At first and before the fault is applied, normal voltages, currents and impedances will appear in the transmission line Now, The waveform of the phase Voltage before fault will show in the Figure.4

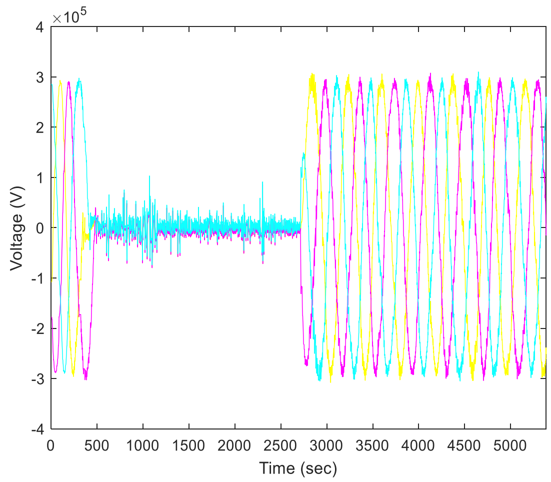

Figure.4 Phase voltage before fault

The waveform of the phase voltage after fault will show in the Figure.5

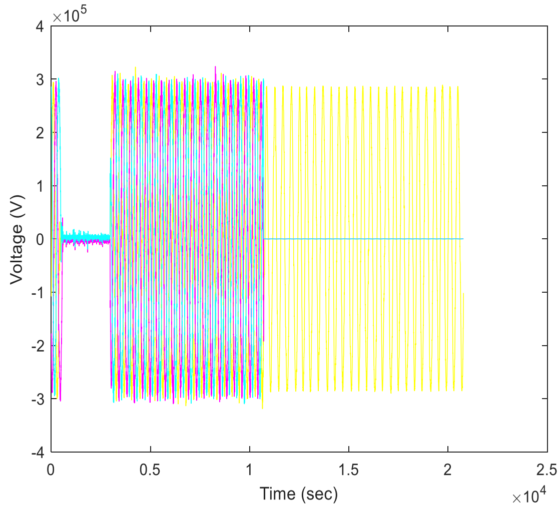

Figure.5 Phase voltage after fault

The waveform of the phase current before fault will show in the Figure.6

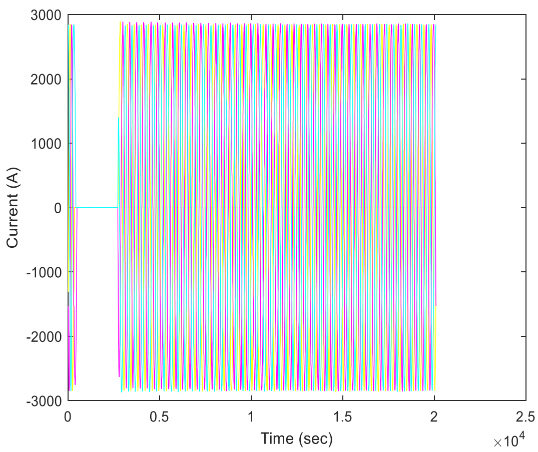

Figure.6 Phase current before fault

The waveform of the phase current after fault will show in the Figure.7

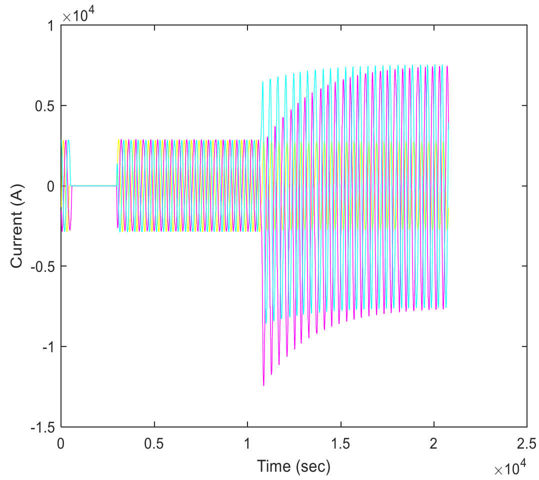

Figure.7 Phase current after fault

The waveform of impedance when the fault is applied to phase A as will show in the Figure.8

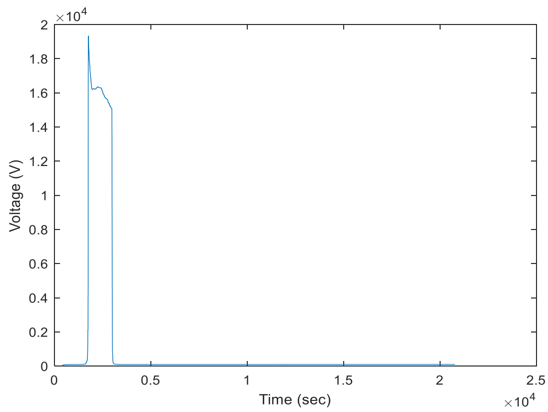

Figure.8. Impedance waveform when fault is at Phase A

5.1 Impedance Relay of Operation :

Impedance Relay work when the impedance will be change and they are recognized by the relay and give trip to the (C.B) in order to open the line, will show the impedance relay when the fault is not applied.

5.2 Impedance Relay Modeling :

Figure .9 illustrate the circuit diagram model of both the impedance relay and the zone protection scheme in our discussion.

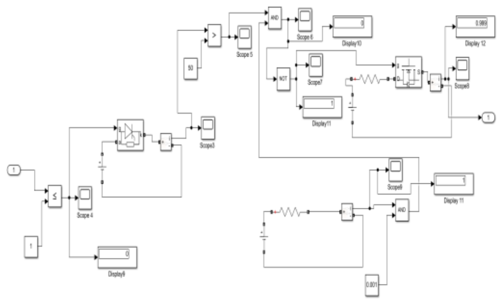

Figure.9 Relay Circuit diagram

From the above figure of the electronic circuit the relational operator is used to compare the first input is the impedance of phase (A) It will be implemented with a constant say (1) Whenever a fault occurs in phase A, the impedance will be reduced dramatically and close to zero. the relational operator will give signal as output '1' this signal will turn on the thyristor in the next circuit. A current will be generated in the next closed circuit due to the thyristor being switched on by the signal generated by the relational operator . The measurement of the current will be conducted by means of a current transformer (C.T), whereby the resultant value will subsequently be compared with a low constant through the utilization of a relational operator. This comparison process aims to generate an output that is characterized by a logic high or '1'. The aforementioned logic high signal, in conjunction with a constant high signal, is then supplied to an AND gate, resulting in the production of an output that assumes a logic high state. Subsequently, this logic high signal is connected to a NOT gate, which subsequently yields an output that assumes a logic low state or '0'. Based on the elucidation provided above, it can be concluded that in the absence of any faults within the line, the NOT gate will exhibit a logic high state or '1', thereby enabling the mosfet to close the circuit and facilitate the conduction of a certain level of current. The measurement of the current in a circuit is accomplished by employing a current transformer, which is capable of delivering an accurate measurement of the current value. This measured value is subsequently transmitted to the circuit breaker, thereby enabling it to perform its fundamental function of closing the line. In the event of a fault occurring within the system, an interesting phenomenon takes place. The NOT gate, which is an integral part of the circuit, generates a logical output of '0'. This particular output is of great significance, as it causes the mosfet to cease its conduction. Consequently, the current transformer is unable to provide any current value to the circuit breaker, resulting in the opening of the three phase transmission line. This operational process highlights the vital role played by the impedance relay, which is specifically designed to actuate in the presence of a fault.

6. Conclusion

From the waveforms it is concluded the voltage reaches zero and large currents, on the order of 500 amps, flow through the line. To safeguard against this fault, a relay circuit is created and a circuit breaker is included in the transmission system. The impedance values are measured at different moments: prior to the occurrence of the fault, at the moment the fault occurs, and after the line is isolated. It is determined that during fault conditions, the circuit breaker is activated and the impedance values are decreased. A simulink model is constructed for the distance zone protection scheme. The logic circuit for the operation of the relay is derived from the observed impedance waveforms. Based on this model, it is deduced that the specific zone where the fault takes place can be identified.

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