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Three Phase Transmission lines fault Detection, Classification and Location

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Abstract: ***Power transmission is a major issue in Electrical Engineering after Power generation. Fault in transmission lines is common and major problem to deal with in this stream. This paper presents a technique to detect the location of the different faults on a transmission lines for quick and reliable operation of protection schemes. The simulation is developed in MATLAB to generate the fundamental component of the transient voltage and current. MATLAB software is used to simulate different operating and fault conditions on high voltage transmission line, namely single phase to ground fault, line to line fault, double line to ground and three phase short circuit. Effects of variations in the fault resistance (Rf), distance to fault (Lf) have been studied broadly on the voltage, current and its relation to impedance of the system which creates the logic for detection, classification and location of faults.***

Keywords: Transmission Line faults, Transmission Line Protection, Detecting and Locating faults in overhead transmission lines, Fault Analysis in transmission line.

1. Introduction

Fault location and distance estimation is very important issue in power system engineering in order to clear fault quickly and restore power supply as soon as possible with minimum interruption. This is necessary for reliable operation of power equipment and satisfaction of customer. There are 11 possible faults in a three phase transmission line, namely AG, BG, CG, AB, AC, BC, ABG, ACG, BCG, ABC and ABCG. These fault types are categorized into five different types of faults:

1. LG faults – AG, BG, CG
2. LL faults – AB, AC, BC
3. LLG faults – ABG, ACG, BCG
4. LLL faults – ABC
5. LLLG faults – ABCG

Faults occurrence can be easily detected with abrupt decrease in impedance of the line due to high current during fault. Next problem is its classification that is the type of fault which has occurred. Out of these five the LLL and LLLG faults are symmetrical faults and are indistinguishable. The voltage and current values changes abruptly during the fault and also phase imbalance occurs. The method requires continuous inspection of the line impedance values in each phase. The phase with abrupt decrease in impedance denotes that the phase is faulty. The ground is involved in fault or not can be easily distinguished with a zero sequence analyzer. Zero sequence current flows in case of ground fault. This paper proposes line impedance monitoring based fault detecting and locating algorithm. For this purpose, 220KV, 200km, 50Hz transmission line is simulated using power system BLOCKSET of MATLAB.

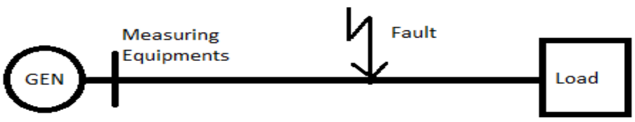


Figure 1: Simple Power System Network.

2. Basic idea of the method used

The arrangement of relay system for fault analysis is depicted in the Fig.2. The fundamental component of voltage and current of each phase is continuously fed to the relay which gives the impedance value in each phase. When fault occurs in the system, impedance gets abrupt decrease due to short circuit path for current. This change of value is detected and the faulty phases are identified with the help of relay using logic controlled devices. As the change in value is large and occurs only in those phases in which fault occurs, hence identification of faulty phases becomes easier and the respective phases can be isolated from the system using circuit breaker.

For this purpose, 220KV, 50Hz three phase transmission line is simulated using power system BLOCKSET of MATLAB. All possible faults with various values of fault resistance and locations are simulated which provides the set point value for current and impedance to detect the fault and identify the phases. To distinguish whether ground is involved in the fault or not we use a Zero Sequence Analyzer which gives a respectable value only when ground is involved in fault. Simulink model used is shown in Fig. 3. The three phase fault block makes it possible to simulate all possible faults at any inception angle. The voltage and current block are subsystem blocks which consists of all measuring equipments required for the relay operation.

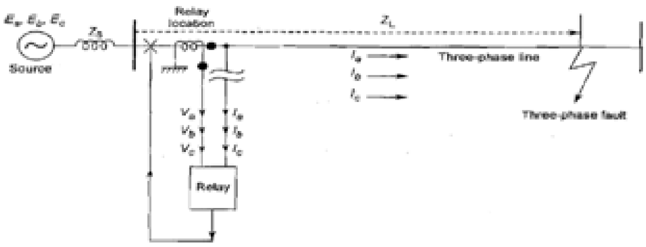


Figure 2: Single line diagram of a three phase transmission line under study.

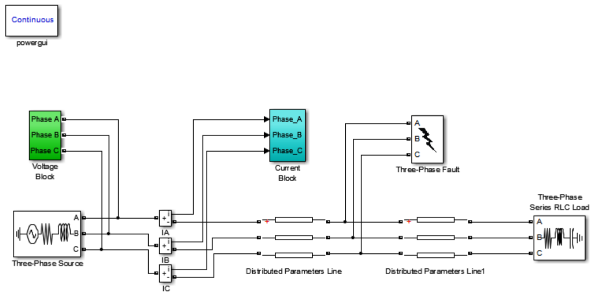


Figure 3: Power system model in Simulink under study

The impedance drops from range of thousands to hundreds and current increases from range of hundreds to thousands during fault condition depending on the fault resistance and distance to fault. These values also changes due change of load. High load currents can be a problem for the single-ended fault location algorithms and must be taken into consideration. Proper set point must be selected for proper differentiation between fault and overload.

3. Algorithm

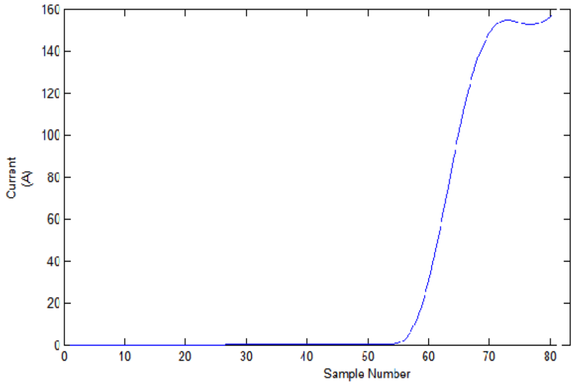
3.1 Algorithm to detect and classify fault

As shown in the fig.4 we have the plots of fundamental values of current in all the three phases and also of Zero sequence analyzer simulated during a fault. We find huge peak in zero sequence analyzer, value ranging in range of 150 A (under normal condition value is near to zero). This high value confirms Ground is involved in fault. The value of current in phase B and C is within normal current values (below 160A – 190 A), so Phase B and C are not involved in fault. Current in Phase A rises extremely and hence involved in fault. Therefore type of fault is AG.

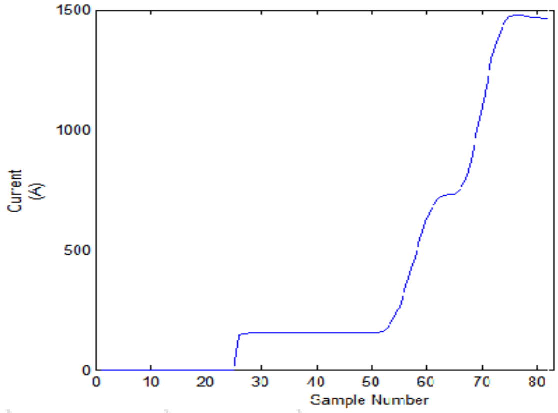
Thus, whenever a huge current beyond 200 A flows in any phase that phase is classified as faulty. Ground is faulty or not is determined if the zero sequence current value is beyond 35 A. The set points are for system where nominal value of current in each phase is 160 A. A gap of 40 A is kept to distinguish between overload condition and fault. These set points can be similarly adjusted for any other system as well. Thus as the relay classifies the fault, trip signals can be sent from relay to the respective phases involved in the fault.

3.2 Algorithm to locate the fault

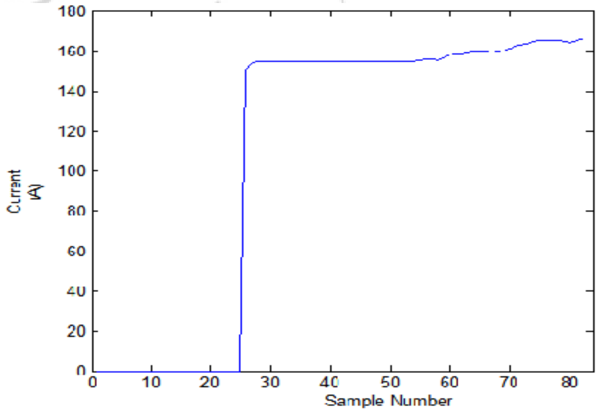
The next work is locating the fault, for this we made some observations. Line impedance not only changes with the fault resistance but also with the location of the fault. The plot obtained using Simulink by creating LG and LLG fault with various fault resistance and location is shown in Fig.5. The plots obtained from simulation shows that line impedance increases with increase in fault location and with increase in fault resistance. We have a database of fault line impedance at various fault location and with various fault resistance values. If suppose a fault occurs and is identified as LG fault and line impedance measured by the relay is



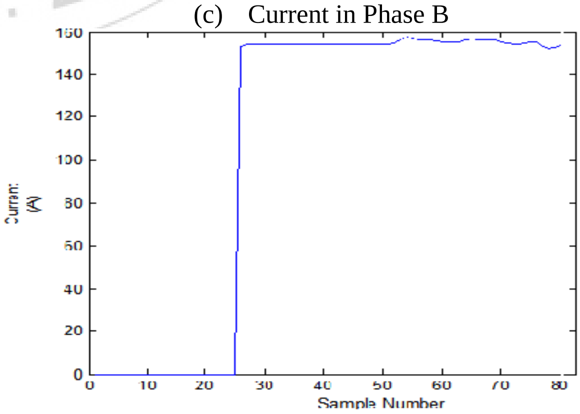
(a) Zero Sequence Current



(b) Current in phase A



(c) Current in Phase B

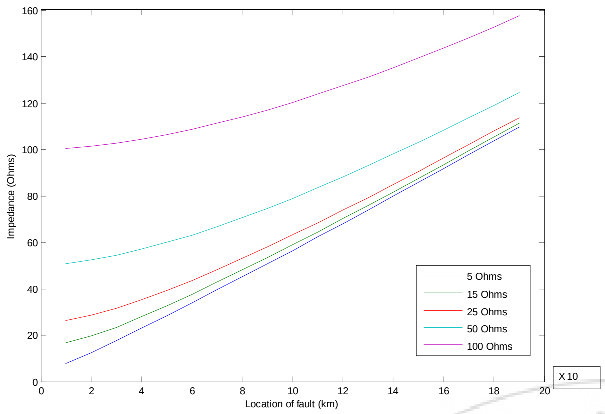


(d) Current in Phase C

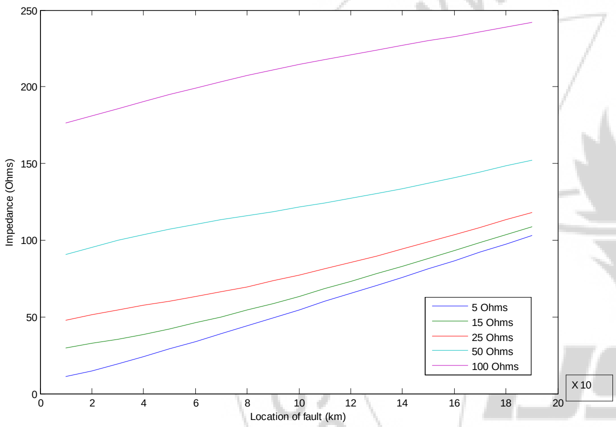
Figure 4: Plot of fundamental value of current in all the three phases and zero sequence analyzer (from SIMULINK)

124Ω (example from the model simulated, value can be referred from the plot) it is obvious that fault resistance is of

100 ohms or 50 ohms. To increase accuracy, measurements will be done from the remote end also and the location with respect to line impedance value can be matched up which will then give location of fault. This can be done using any of the soft computing techniques like fuzzy logic or ANN (Artificial Neural Network).



(a) Fault type: LG



(b) Fault type: LL

Figure 5: Plot for change of line impedance with change in fault location with different fault resistance (obtained from SIMULINK) for (a) LLG fault and (b) LL fault.

4. Test Result of the Fault Detector and Classifier

After setting up the logic, the line impedance based fault detector and classifier is tested for different faults types created at different location and at different inception angles. The response of the fault classifier is shown in the Table I. For example fault AG is created at inception time = 0.04sec (at fault inception angle 0 degrees) with fault resistance of 100 ohms. After the occurrence of fault the currents in respective phases will change. The plot of fundamental value of currents in all phases under this fault condition is shown in fig. 4. Fault occurs at T= 0.04sec so the fault occurs at sample number 49 (49 X 0.000833sec = 0.040817sec), where 0.000833sec = sampling time. Since the set point is 200 A for the given system to consider fault in phase so from fig. 4(b) fault is detected at sample number 54 (T= 54 X 0.000833 = 0.044982sec).

The time of operation of line impedance based fault detector and classifier can be calculated as follows:
Fault occurred at sample no. 49
Fault inception time = 49 X 0.000833 = 0.040817sec.
Fault detected at sample no. 54
Fault detected at time= 54 X 0.000833 = 0.044982sec.
Time of operation = Fault detection time – Fault inception time = 0.044982-0.040817= 0.004165 sec.
The system frequency is 50 Hz. To complete one cycle it takes 0.02 sec. From above calculation it is clear that the time in which the relay operates is about one fifth of the time period of the system (0.02 sec).

The testing data set has been created considering different fault scenarios and the test results of line impedance based Detector and Classifier are given in Table I. For healthy condition (no fault condition) the output of fault detector and classifier should be zero and for faulty condition it should be one in the corresponding faulty phases. From the Table I it is clear that after the occurrence of fault the output of the corresponding phases go high.

Table 1: Test results.

Fault Type	Fault Location (Distance from the relay in km)	Fault inceptio-n angle (in degrees)	Fault Resist-ance in Ohms	Output of the line impedance based detector and classifier			
				Phase A	*Phase B*	*Phase C*	*Ground G*
No fault	-	-	-	0	0	0	0
AG	100	0	100	1	0	0	1
AB	50	90	25	1	1	0	0
ACG	150	90	100	1	0	1	1
BG	20	50	25	0	1	0	1
ABC	50	50	100	1	1	1	0

5. Conclusion

The impedance-based fault detection, classification and location methods compares most often pre-known line parameters to the impedance measured in the case of fault. Using this method with pre-known set of values with any soft computing technique detects, classifies and provides probable fault location without any of the bridge methods. Test results indicate that the speed and selectivity of the approach are quite robust and provide adequate performance for a three phase transmission line.

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Author Profile

Raunak Kumar is pursuing his B.Tech in Electrical Engineering from National Institute of Technology, Raipur and presently is in his third year (2012 -2016 expected). His schooling has been done from Saint Joseph's School and Adwaita Mission completing it in 2010 and 2012 respectively. During his B.Tech he has worked upon many projects like RF controlled Robofish and Hexapod. He had led the technical team of Technocracy, Technical Committee of NIT Raipur where he organized many events for the Aavartan 2013 & 14. His robotics projects where displayed to faculties of college during the science fair Vigyaan at NIT Raipur. He is currently working to design an Amphibian robot.