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A REVIEW ON LINE TO LINE FAULT ANALYSIS DETECTION

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ABSTRACT

As we know that electricity losses during transmission and distribution are extremely high due to which many problems are faced such as varying voltage levels, change in the load current etc. This has been experienced due to the varying electrical consumption and power theft. Also these give rise to fault in power transmission line network and so it is necessary to implement fault detection system in transmission line network.

The fault detection system is implemented for three phase electrical distribution system. A practical prototype system can be implemented for fault detection in power system and also the system is successfully designed using 8-bit Microcontrollers which allows the detection of faults. Continuous monitoring of the three phase parameters such as voltage, current and energy consumed is done using data logging system on the PC screen through hyper terminal. There is a Master Slave communication using RS 485 protocol. Communication between Master and Microcontroller is done via RS 232. Comparison of energy units between Master and Slave is done. If difference between the Master and Slave energy units is found, wireless technology GSM (global system for mobile communication) is used to send SMS to a responsible person. Introduction of the mobile communication technology GSM and Microcontroller-based RTU (remote terminal unit) i.e. Master-Slave communication is provided in the paper. This RTU functions as fault detection when abnormality or emergency happens. Also wireless mobile communication technology i.e. GSM is used simultaneously to send message to a responsible person.

KEYWORDS: Distribution automation, fault location, protective relaying, short-circuit analysis.

1. INTRODUCTION

Electrical power system network consisting of several sources and loads helps in transfer of power from generating stations to consumers. Complexity in all the sectors of power system is increasing. Thus, for reliable operation of power system networks, proper identification of type and location of fault has become very much important. Two most frequently occurring faults in any power system network are line to ground (LG) and line to Line (LL) faults. A lot a research work is being carried out in the field of fault identification of power system networks. Elkalashy et al. [1] proposed a novel selectivity technique to detect the fault feeder in MV networks using the directionality of DWT detail coefficient of a residual current of each feeder. Wavelet transformation is used to analyze power system transients for identification of fault locations in double circuit transmission lines by Andanapalli et al. [2]. Dubeya et al. [3] proposed DWT and Independent component analysis (ICA) for detection of faulty negative sequence current in series compensated transmission line using Matlab or Simulink. Xie et al. [4] proposed a Wavelet transform based methods of measuring time and frequency information of high frequency transients produced by the faults on transmission lines for the purpose of locating the fault point. A relaying principle using Wavelet based artificial neural networks capable of classifying transients–including faults occurring on a protected line has been shown by Abdullah [5]. Devi et al. [6] has proposed a method of analysis of faults with different load conditions for localization, detection and classification of faults in transmission lines. Patel et al. proposed a novel technique or fault detection in high voltage transmission line using the wavelet transform during power swing condition [7, 8]. A method for

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identification of Line to Ground Fault in a standalone Wind Energy Conversion System using multi-resolution based DWT analysis has been proposed by Ray et al. [9]. Mishra et al. [10]proposed an improved method of transmission line fault classification using Wavelet Transform as well as impedance measurement and travelling wave theory. Chattopadhayay et al. [11] detected crawling of an induction motor by performing Wavelet decomposition of the stator current in Clarke Plane. Power Quality related different parameters have been assessed in Parke Plane by Chattopadhayay et al. [12]. Current Park Vector pattern approach is used for detection of electrical faults in an induction motor by S. Chattopadhyay et al. [13- 15].

2. LINE FAULT ANALYSIS

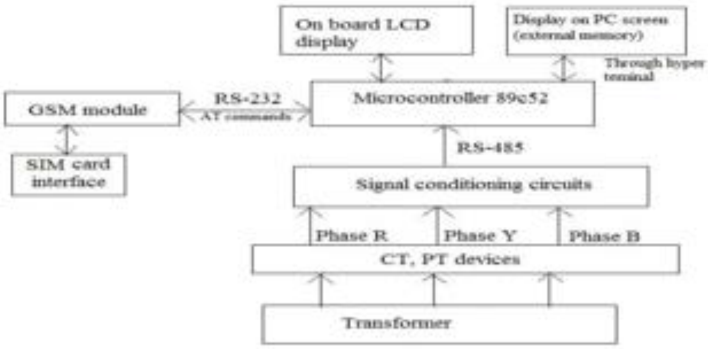

Figure 1. Block diagram line fault

Single line diagram of IEEE standard 9 bus system is shown below in Figure 1. The power system network consists of three generators, generator 1, 2 and 3 connected to bus 1, 2 and 3 respectively. It also has three load buses–Bus 5, 6 and 8.
Voltage and current rating of generator 1, 2 and 3 are 247.5

MW and 16.5 kV; 192 MVA and 18 kV; 126 MVA and 13.8
kV respectively. The rating of the load connected to bus 5, 6 and 7 are 125 MW and 50 MVAR; 90 MW and 30 MVAR; 100 MW and 35 MVAR respectively. Work presented here, attempts to identify type of fault as well as location of LG and LL fault DWT based statistical parameter analysis of the waveforms of outgoing currents from different generator buses in faulty conditions. The faults are made to occur at the load buses. However, the work may be extended to other type of faults taking place at other locations of the network also.

3. FAULT SIMULATION

DWT based statistical parameter analysis of the outgoing currents from the generator buses in healthy as well as faulty conditions have been performed to detect type of the fault and its location. LG and LL faults are made to occur in the load buses. Switching time of faults is set to 0.3-0.5 sec. The sampling frequency is taken to be 1000 Hz and total time of simulation is 0.8 sec. Very small total simulation time has been chosen to minimize the data size generated by the simulation software and computation time of the analysis process.

4. METHODOLOGY

DWT based decomposition of the generator bus outgoing currents are performed and approximate and detail coefficients and the process is carried out for both healthy and faulty conditions. Nine levels of decomposition of the current waveforms have been performed. After obtaining approximate and details coefficients in each level RMS, skewness and kurtosis values are computed. Hence, total six parameters are taken into account–skewness of approximate coefficient (Sa), skewness of detail coefficient (Sd), kurtosis of approximate coefficient (Ka), kurtosis of detail coefficient (Kd), RMS of approximate coefficient (RMSa) and RMS of detail coefficient (RMSd). In the entire DWT analysis, Daubechies4 (DB4) wavelet is considered as the mother wavelet. Each generator bus outgoing current is analyzed separately. Percentage deviation of all the above mentioned parameters are calculated from their corresponding healthy condition values are calculated using equation 1 shown below. So, in a healthy case the percentage deviations of the above mentioned parameters will be zero.

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$$\% \text{ Deviation} = \left| \frac{(\text{Healthy value}) - (\text{Faulty value})}{\text{Healthy value}} \right| \times 100 \quad (1)$$

Results and the corresponding observations are presented below for all three generator buses one by one.

Observation from generator Bus 1

Percentage deviations of Sa, Sd, Ka, Kd, RMSa and RMSd are calculated and shown in Table A.1–A.6 (Appendix). Data given in the earlier mentioned tables have been presented in the form of graphs in Figures 2-4.

From Figure 2(a) it has been noticed that when LG fault occurs at Bus 5, percentage deviation of Sa at 6^{th} level of decomposition is the greatest amongst all the parameters in all the levels. Figure 2(b) shows that for LL fault at Bus 5, greatest amount of percentage deviation occurs in RMSd at level 3

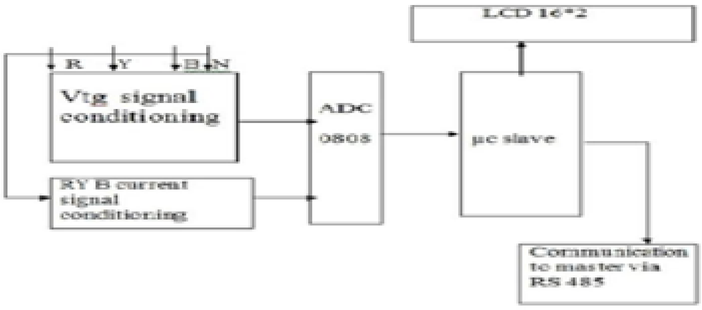
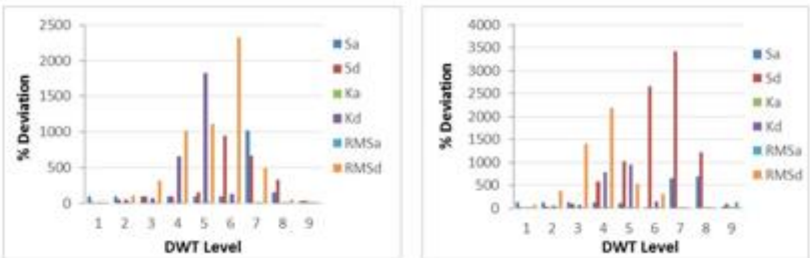


Figure 2. GEN SIGNAL for (a) LG fault at Bus 5 and (b) LL fault at Bus 5



3(a) 3(b)

Figure 3. Percentage Deviation of different parameters of GEN Bus 1 for (a) LG fault at Bus 6 and (b) LL fault at Bus

Observation from line fault detection

Percentage deviations of RMS, skewness and kurtosis of approximate and detail coefficients are calculated and shown in Table A.7–A.12 (Appendix). Data given in these tables have been presented in the form of graphs in Figures 5-7.

From Figure 5(a) it has been seen that greatest amount of percentage deviation takes place in Sd at level 6 when LG fault occurs at Bus 5. Whereas, Figure 5(b) shows that RMSd has the greatest amount of percentage deviation at level 3 when LL fault takes place at Bus 5.

Fault detection techniques are used to detect potential faults and search for the source of faults, which are convenient for fault recovery work. There are many research achievements recent years. In PSFQ [9] and GARUDA [10] techniques, packet loss is used as fault characteristic parameter, in which, communication protocol orders the destination node detect the lost pocket in the transmission process of the networks.

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By the feedback information, it determines if there has a fault. There exist a lot of redundant nodes in the network, who produce plentiful data, so individual packet loss is rarely detected, which is the shortcoming of this type of technique. In the paper [11-12], interruption, delay or lack of regular network traffic are also used as indications of faults. In the paper buffer occupancy level and channel loading conditions are used for detection, and there are a great deal of request and reply data, which will consume vast energy and lead to node premature death.

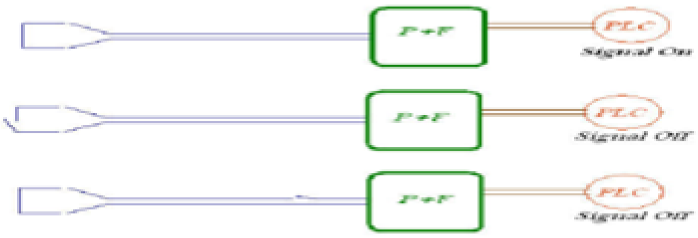

Figure 4. line fault signal transmission

5. SIMULINK ON MATLAB

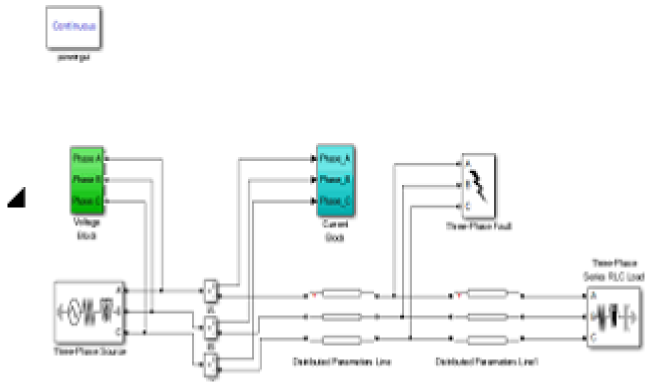

Figure 5. MATLAB based simulation link

Based upon the observations made in the previous section a simple rule set has been prepared which can be used for discriminating the fault type and identifying the fault location by monitoring the outgoing current of any generator bus. It is presented in the Table 1 shown below.

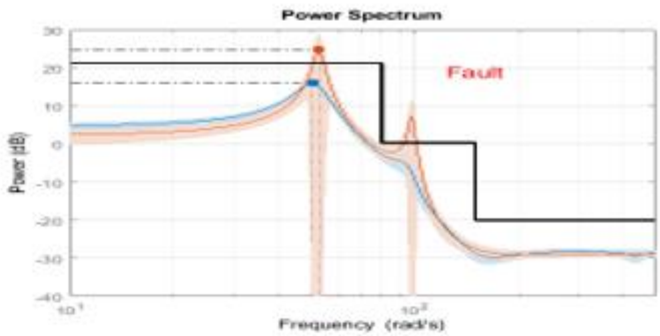

Figure 6. Fault condition Graphically present

Table 1. Rule set

Fault Type	Fault Location	Generator Bus used for observation					
		LINE- 1		LINE 2		LINE-3	
		Parameter with greatest % deviation	Level of occurrence	Parameter with greatest % deviation	Level of occurrence	Parameter with greatest % deviation	Level of occurrence
T. L.	Line 1	Sa	6	Sd	6	Sd	6
	Line 2	RMSd	6	Kd	5	Kd	5
	Line 3	Kd	5	Kd	4	Kd	4
T. L	Fault 1	RMSd	3	RMSd	3	RMSd	3
	Fault 2	Sd	7	RMSd	6	Sd	5
	Fault 3	Sd	5	Sa	7	Sa	6

6. FAULT PROBLEM AND VALIDATION

As real verification is practically impossible, the rule set presented in the previous section has been validated by simulating faults in IEEE standard 9 bus system. Three unknown cases are considered where the total time of simulation, fault duration time as well as the prefault condition of the loads have been varied. Results of the case studies have been given below in Table 2.

From Table 2 it has been observed that results in every case are very much optimistic.

7. SPECIFIC LINE FAULT DETECTION

The work presented here, shows a method of finding out fault type and location based upon a DWT based statistical parameter analysis of outgoing currents from the generator buses. Six different parameters are obtained for each generator bus outgoing currents in different conditions. Observation of the parameter having the greatest amount of percentage deviation from its corresponding healthy condition values and the level of occurrence reveals the type of fault and the location at which it takes place. A rule set has been prepared depending upon the observations and it has also been validated using three unknown cases where different simulation time, fault duration and load condition are used than that used for the analysis and preparation of the rule set. Results of the case studies have been found out to be very much satisfactory.

8. CONCLUSION

In the above work, LG and LL faults have been dealt with using DWT based statistical analysis of the outgoing currents from the generator buses and faults are considered at the load buses. Total six parameters are considered skewness of approximate coefficient, skewness of detail coefficient, kurtosis of approximate coefficient, kurtosis of detail coefficient, RMS of approximate coefficient and RMS of detail coefficient. IEEE standard 9 bus system has been utilized for this purpose. Using the method proposed here, type and location of a fault can be found out by monitoring the outgoing currents from the generator buses. Present work only considers two types of faults and fault locations to be the load buses. However, this work can be extended for other type of faults occurring at locations other than load buses.

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