IDENTIFICATION AND CLASSIFICATION OF HIGH IMPEDANCE FAULTS ON 33 KV POWER DISTRIBUTION LINE USING ANFIS MODEL

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ABSTRACT

High impedance fault occurs when an energized conductor makes contact with a quasi-insulating object such as concrete, asphalt, structure, or falls to the ground. The consequence of these previously undetectable faults is that they represent a serious public safety hazard as well as a risk of arcing ignition of fires. A high impedance fault is characterized by having impedance sufficiently high that it is not detected by conventional or traditional over-current protection devices, such as fuses and over-current relays. This paper presents the development of an intelligent model for the identification and classification of HIFs on a 33 kV distribution line using ANFIS. The study was conducted on the 33 kV Uyo-Ikot Ekpene power distribution line. The case study power distribution system was modeled using MATLAB software. HIFs were introduced at various locations along the distribution line. The data obtained from the MATLAB/Simulink simulated fault using discrete wavelet transform (DWT) were used to train the ANFIS model for detection and classification of the HIFs occurrence in the system. The results of the HIF detection and classification show that the success and discrimination rate of FIS are 72 % and 89 % respectively whereas that of ANFIS 100 % and 98.9 % respectively.

Keywords: High impedance fault, identification, classification, power distribution line, ANFIS model.

INTRODUCTION

Over time, standard fortification arrangements have been reliably used to identify and safeguard low impedance faults in power networks in which a small resistance restricts the fault current. However, once the resistance of the fault path is quite high to the extent that the fault current cannot be simply identified, this is referred to as high impedance fault (HIF) (Vijayachandran and Mathew, 2013; Sirisha & Babu 2016). Additional conspicuous behaviour of high impedance faults is their demonstration of indiscriminate behaviour with unbalanced and wide variations in current values. The fault current waveforms are full of harmonics and possess much frequency components because of arcing. (Stoupis et al., 2004; Akorede and Katende, 2010). Records have shown that most of fire outbreaks caused by electrical faults are owed to arc type, hot neutral intermittent faults (Zamanan et al., 2007; Lima et al., 2018).

Due to the severe devastations emanating from high impedance faults since 1970, this area of study and research has been seen as being inevitable if utility companies are to remain in business (Tengdin et al., 1996) with optimism of discovering some features in current waveform that will make everyday detection achievable. This study has brought about the development of many techniques of identifying high impedance faults (Gomes et al., 2018). The most famous identifying method involves the alteration of over-current defensive devices (IEEE PES, 1989), but this method has brought about many unpredicted service disturbances since the magnitude of the electric current from the high impedance fault cannot be distinguished from different non-fault happenings in the power system. A particular type of earth relay was modeled and developed for identifying abnormal earth currents. The main disadvantage of this device is its inconsistency for heavily uneven loads (Carr, 1981).

In recent times, artificial neural network knowledge has been used to identify high impedance fault detection through signals generated from Electromagnetic Transient Programme (EMTP) (Ebron et al., 1990). Moreover, due to variations in the harmonic contents in the feeder content, some algorithms were proposed. Some of these include: third harmonic current method (Uriarte, 2003), fractal technique (Mamishev et al., 1999), the nearest neighbour rule approach (Lai et al., 2006), the decision tree-based method (Sheng and Rovnyak, 2004) and the wavelet transform based algorithm (Akorede and Katende, 2010). Obviously, all these methods could advance fault identification, however, each method has its shortcomings. Nevertheless, viewing from signal processing perspective, high impedance fault produced signals are seen to exhibit time-varying features. It was on the basis of this, that signal processing method using wavelet transform technique was used in identifying high impedance faults (Akorede and Katende, 2010; Kim and Sowah, 2015).

Simulation of the distribution system

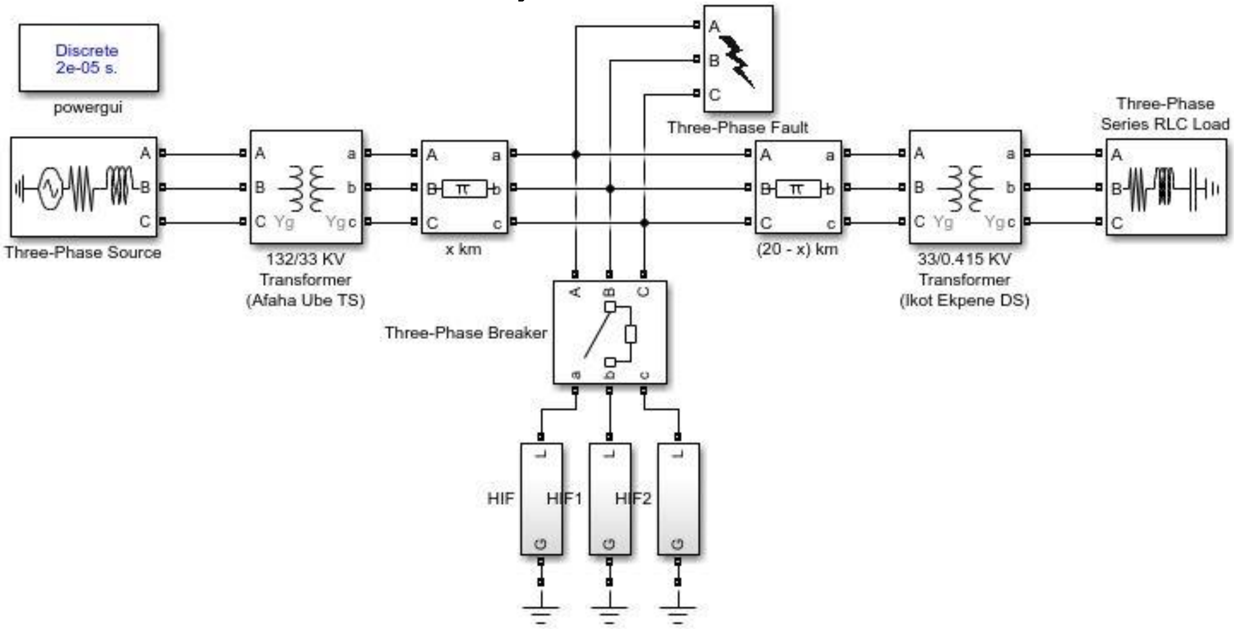

Figure 1: HIF model in MATLAB of the 33 kV line

HIF ANFIS Based Detection and Classification

This part presents the procedure to identify the HIFs in the medium voltage distribution system, as well as separating them from other faults in the system.

Firstly, three phase current signal obtained using MATLAB simulation of the medium voltage distribution system as analyzed using DWT to get the data for training. The input to the ANFIS identifier/ classifier model are standard deviation values of each phase of three phase system obtained by DWT analysis of fault current signal obtained by MATLAB simulation of the distribution system. The output of the ANFIS is the type of fault that occurs in the system.

Secondly, for effective classification, the ANFIS is trained to classify the fault in the system.The result includes the DWT waveforms for normal case, phase 'A' HIF, phase 'AB' HIF, phase 'ABC' HIF shown in Figure 2, Figure 3, Figure 4 and Figure 5 respectively.

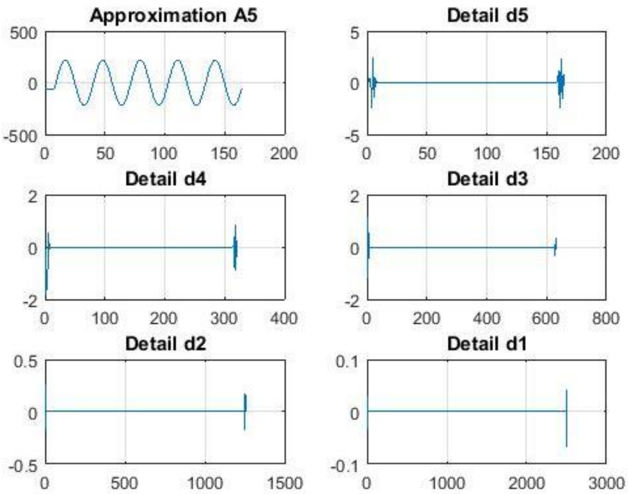

Figure 2: DWT Waveform of the normal case

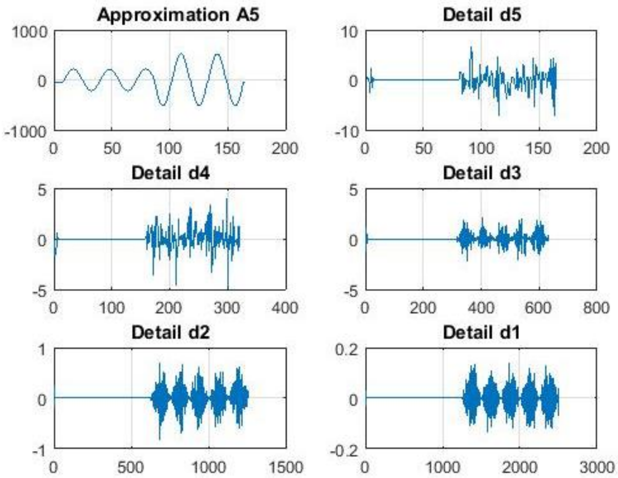

Figure 3: DWT waveform of phase 'A' HIF

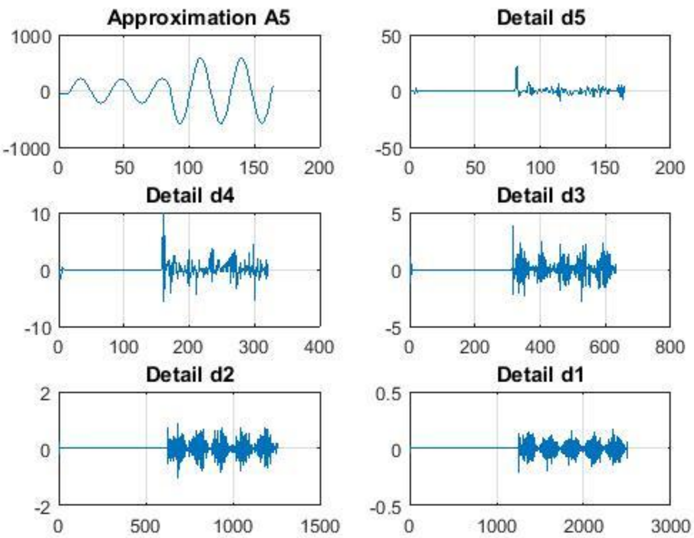

Figure 4: DWT Waveform of phase 'AB' HIF

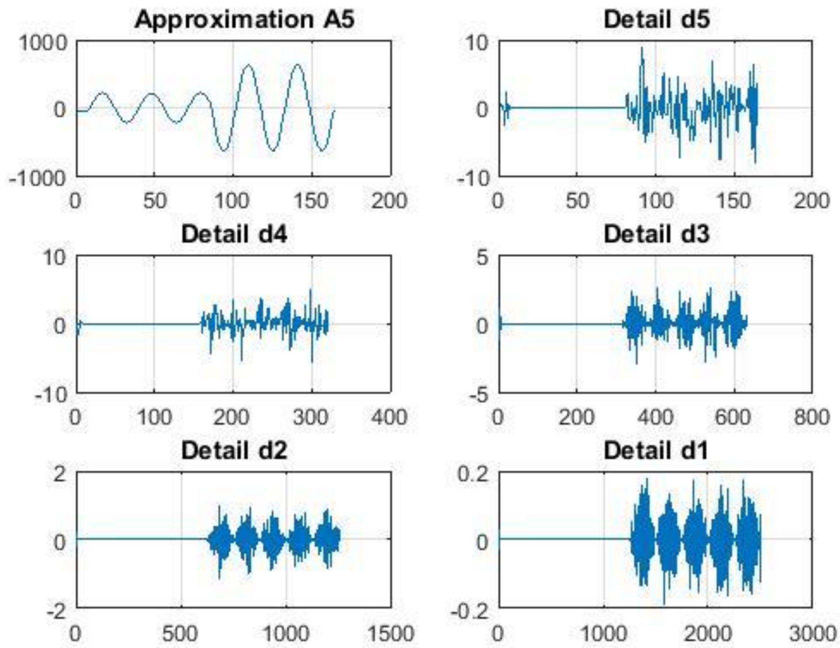

Figure 5: DWT Waveform of phase 'ABC' HIF

ANFIS Detector and Classifier

This section presents the intelligent approach of detecting HIFs and classifying the different types of faults in the medium voltage distribution system.

ANFIS is an intelligent adaptive data learning approach in which fuzzy inference system is optimized via the ANN training.

It maps the input and output through the input and output member function. From the input and output data, ANFIS adjusts the membership function using least the membership function using least square method or back propagation descent method for linear and non – linear system (reference).

Twenty seven rules are framed for the fault type fuzzy membership function as shown in Figure 6.

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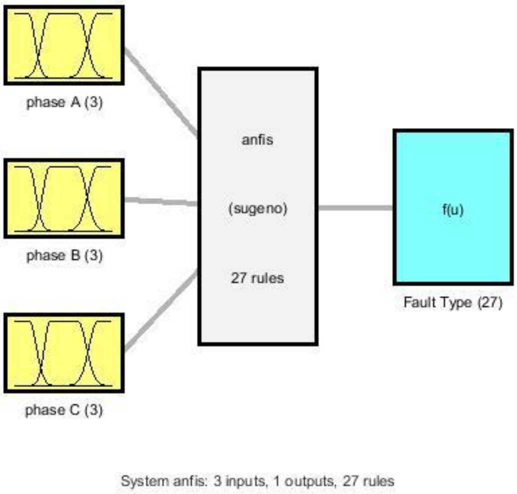

Figure 6: Membership function structure for fault detection and classification

The 5 layers in the ANFIS structure are input layer, fuzzification layer, rule layer, defuzzification layer and output layer respectively. The inputs to the ANFIS detection model are SD value of each phase of the three phase system obtained by DWT analysis of fault current signal. The ANFIS fault detector and classifier structure consists of three neurons in the input layer and three triangular membership functions for each input. It has a constant single membership functions for the output. The output of ANFIS is the type of fault that occurs in the system.

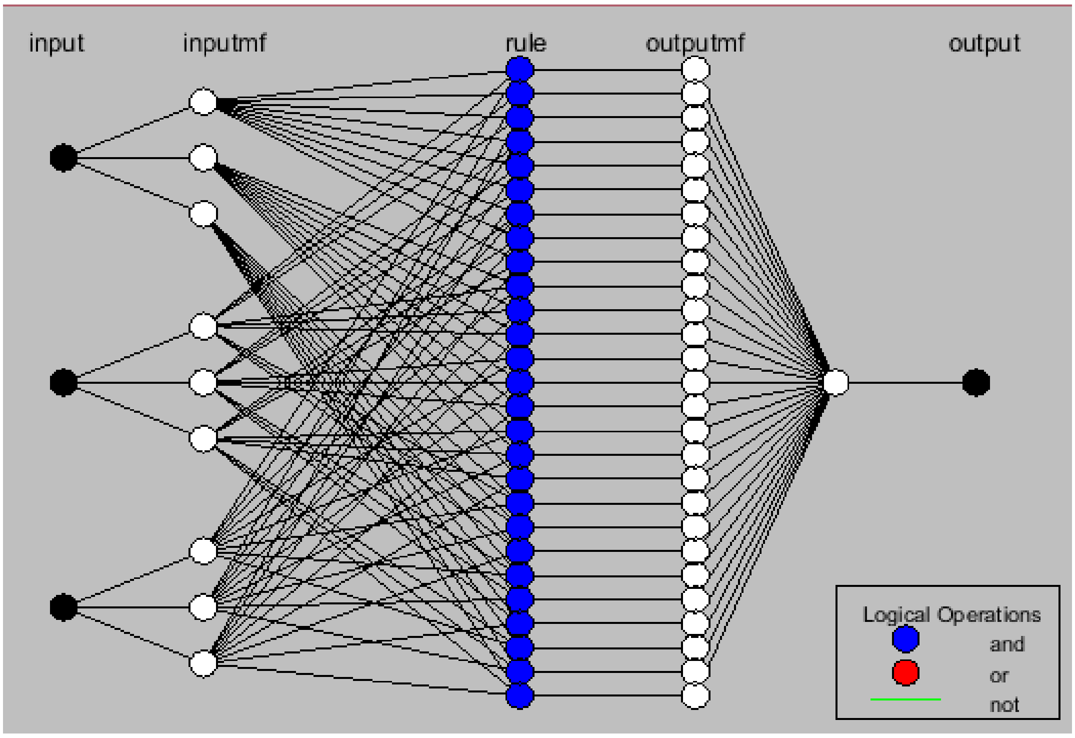

Figure.7: ANFIS structure for detection and classification

SUMMARY

The research describes a very reliable method of identifying and classifying high impedance faults on a medium voltage distribution system which begins from the secondary side of the 132/ 33 kV transformer located in Afaha Ube transmission station and terminates at the primary side of the 33/ 11 kV transformer located in Ikot Ekpene injection substation. The case study distribution system was modeled using MATLAB/ Simulink. Discrete wavelet transform (DWT) was used to extract data which was used to train the ANFIS to detect and classify HIFs from other faults and the Fuzzy inference system (FIS) was as well trained for detection and classification of high impedance faults along the case study distribution system. It was evidently observed that ANFIS has more ability to identify and classify high impedance faults in the system more than fuzzy inference system (FIS).

CONCLUSION

Performance evaluation was conducted on the developed model, that is, ANFIS with FIS and the results from the two systems were compared. The results show clearly that ANFIS performs better in detection and classification of high impedance faults than FIS. The work has achieved the overall objective which is to develop a model with enhanced performance in identification and classification of HIFs on the 33kV power distribution line.

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