An Intelligent Approach to High Impedance Fault Detection

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Abstract

In this poster, High Impedance Fault (HIF) is detected in Primary Distribution Network (PDN) using an Adaptive-Neuro Fuzzy Inference System (ANFIS) model. The detection of HIF in PDN is quite challenging because of its characteristic features (low fault current magnitude amongst others) and its delayed or non-detection causes devastating scenarios such as electric shock, wildfire, electrocution, system malfunctioning and power losses. This poster proposes an Intelligent approach in a simulated study. Simulink toolbox in MATLAB software was used to model a typical 33kV distribution network (DN) and accurate detection of HIF in the DN was achieved using fault current signal data to train the ANFIS model. The modeled network was simulated for normal and fault conditions. The results show that the ANFIS model was able to detect HIF using binary codes 0 for normal condition or 1 for fault condition on one or more phases.

Introduction

High Impedance Fault (HIF) is a general name for a group of power system disturbances that do not generate sufficient fault current required to trip the over current protection relays due to high grounding impedance [1].

HIF occurs when an electrical conductors comes in unintentional contact with a highly resistive medium, resulting in a fault current lower than what can be detected by the over current protective devices as in figures 1 and 3 [2].

Figure 1: A Typical HIF Scene [2]

Problem Definition

One of the biggest challenges in the distribution network (DN) is HIF [2].The difficulty in detecting HIF exists due to the high resistive value of the contact medium or surface. This causes the fault current magnitude to be lower than what can be detected by conventional protective devices; hence the over-current relay will not operate when HIF occurs. This exposes lives and properties to risk of electrocution and fire respectively as shown in figures 1 and 2 [2].

Figure 2: Scene of a recent fire incident in Nigeria caused by HIF

Aim of the Study

The aim of this study is to at develop an intelligent technique for HIF detection in PDN using an ANFIS model

Case Study Network

A section of 33kV distribution network of ohiya-Umudike, in Abia State, Nigeria shown in figure 4 is used as a case study. It was modelled using Simulink toolbox in MATLAB software. A sectional view of the Simulink Model is shown in figure 5.

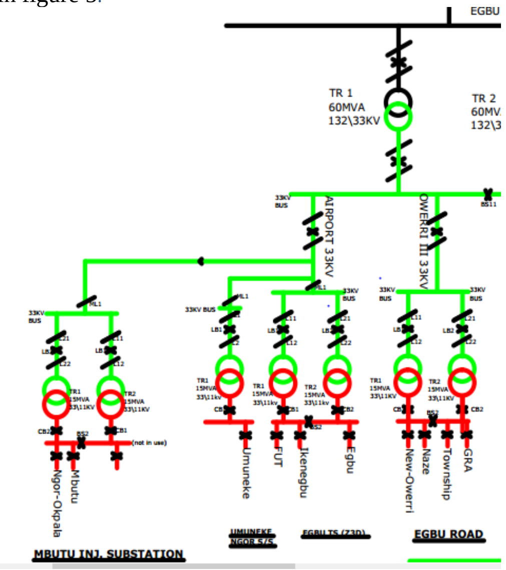

Figure 4: A typical Distribution Schematic Diagram

SIMULINK Model of Network (sectional View)

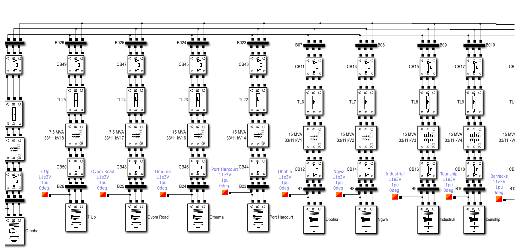

Figure 5: SIMULINK Model of a section of the case study network

Results and Discussion

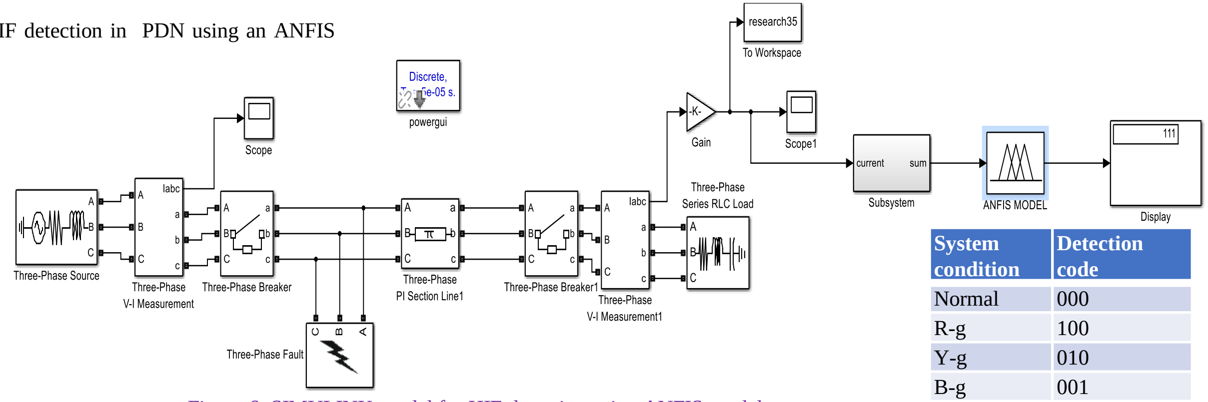

Figure 6: SIMULINK model for HIF detection using ANFIS model

Figure 6 shows the developed Simulink model for HIF detection using ANFIS model. At normal condition, 000 is seen on the display but at fault condition, the faulted phases will be indicated by 1.

A fault on the three phases will be detected when 111 is seen on the display as in figure 6.

System condition	Detection code
Normal	000
R-g	100
Y-g	010
B-g	001
RY-g	110
RB-g	101
YB-g	011
RYB-g	111

Table 1: The detection codes for normal and fault condition .

When there is no HIF in the network, the current signal is as shown in figure 7.

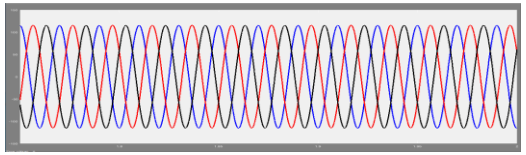

Figure 7: Current signal during normal operating condition

When there is a single phase fault on the red phase, the current signal is as shown in figure 8.

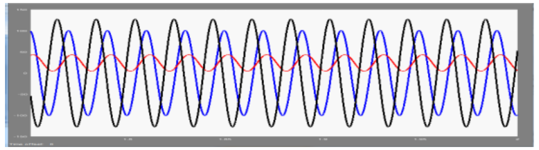

Figure 8: Current Signal during single-phase fault on the red phase

Figure 3: Downed conductor on a High Impedance Surface [2]

Conclusion

The developed ANFIS model was able to detect HIF as seen on the display of figure 6. Also, Table 1, shows the detection codes that will be seen on the display according to the condition of the network (when the network is at normal condition 000 is displayed but for fault conditions, what is seen on the display depends on the affected phase(s). A fault on any phase is indicated by 1 on the display. These intelligent models are embedded on the circuitry of protective devices or used to program relaying systems.

References

1. Aljohani, A., & Habiballah, I. (2020). High-Impedance Fault Diagnosis: A Review. *Energies*, *13*(23), 6447.

2. Ghaderi, A., Ginn III, H. L., & Mohammadpour, H. A. (2017). High impedance fault detection: A review. *Electric power systems research*, *143*, 376-388.