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Analysis of Electrical Faults Detection Techniques: Case of 132kv Transmission Network AFAM Station

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Abstract- Researchers compared three cutting-edge and innovative methods for identifying, classifying, and locating faults on Nigeria's 132kv transmission network. The trio consists of fuzzy logic, artificial neural networks, and an adaptive neuro-fuzzy inference system (ANFIS). To perform the comparative analysis, a MATLAB/SIMULINK model of the transmission system under consideration was built, and simulations were run for various fault types and locations. Over five different fault distances, eleven different types of faults were simulated.

Indexed Terms- fault detection, fault Analysis, Electric Fault, Fault

I. INTRODUCTION

Fault detection and mitigation are critical for determining the kind and frequency of failures. This aids in the implementation of a failure mitigation and prevention plan for efficient power distribution to end customers. The electrical power system is made up of a variety of complicated dynamic and interacting parts that are always vulnerable to disruption or electrical faults (Staszewski, & Rebizant, 2018). The usage of high-capacity electrical producing power plants and the grid concept, i.e. synchronized electrical power plants and geographically displaced grids, necessitates fault detection and protection equipment operation in the shortest time possible to keep the power system stable (Cadini, et al., 2017). Faults in electrical power transmission lines are meant to be recognized, classified, and repaired as quickly as feasible. A good fault detection system detects, classifies, and clears problems on electrical lines in an effective, reliable, rapid, and secure manner. An electrical power system is a complicated system made up of a large number of interconnected electrical components whose main purpose is to allow electrical power generated at different places to reach customers. Any electrical power system may be broken down into three phases: generation, transmission, and distribution (Yang & Jiang, 2017). Single line to ground faults (AG, BG, and CG), line to line faults (AB, AC, BC), double line to ground faults (ABG, ACG, and BCG), and three phase faults (ABC) are the four primary kinds of faults. A, B, and C represent the Red, Blue, and Yellow phases on the network, respectively. Fault is simply defined as a series of unfavorable but unavoidable events that can disrupt the power system's stable operation when the system's insulation fails at any point. Furthermore, transitory faults, which are generally resolved by de-energizing and re-energizing the line, can inflict small damage to electrical networks, which might later develop into permanent problems as line load grows. In this example, fault location enables the network operator to locate weak places on the network caused by transient faults and dispatch maintenance people to reinforce the system during routine preventative maintenance.

II. STATEMENT OF PROBLEMS

Moreover, with the gradual shift from the conventional electric grid system to the concepts of the smart grid system, the need to develop and incorporate an intelligent fault monitoring system that is capable of detecting faults on transmission lines with high accuracy cannot be overemphasized. The transmission of electric power and its protection is a challenge for engineers in Nigeria due to the long distance of the networks. Therefore, transmission line faults should be discovered and located as fast and accurately as possible for fault removal and system recovery.

III. RELATED WORKS

Fault detection can be classed as either signal model detection (periodic signals, stochastic signals, non-stationary signals) or model-based method detection (Abdullah & Butler, 2018). Signal model-based fault detection approaches are particularly useful for identifying machine vibration, imbalance or bearing defects, knocking, and other phenomena in which the measured signals of processes exhibit harmonic, stochastic, or both types of oscillations. Model-based fault detection methods collect information on possible changes caused by faults by looking at the link between several measured variables. These relationships are usually analytical in nature, taking the form of process model equations, but they can also be causal. The classification approach (without structural knowledge) and the inference method (with structural knowledge) are the two fault diagnosis methods (Poudel & Malla, 2017). Idoniboyeobu et al. (2018) used the Improved Resonant Fault Current Limiting (RFCL) Protection Scheme to explore the fault assessment and mitigation of the 132KV Transmission Line in Nigeria. To mitigate the impact of three-phase short-circuit failures in a power system sub-transmission network, this study presented an enhanced Resonant Fault Current Limiting (RFCL) protection method. For automating the procedure of estimating the required reactor value that must be in resonant circuit to restrict the short-circuit current values to allowable values, the model employed an interpolator-extrapolator technique based on a Resonant Fault Current Limiter (RFCL). Short-circuit fault simulations on the three phases of the transmission line (Phase A-C) were done in the MATLAB-SIMULINK environment using the created model. The values used to program a functional interpolator-extrapolator in MATLAB were obtained by varying the resonant inductance (reactor) parameter of the RFCL circuit for each of the phases to obtain permissible short-circuit current levels and the values used to program a functional interpolator-extrapolator in MATLAB; the resonant values were typically set to values of inductance equal to 0.001H, 0.01H, and from 0.1H to At low values of the resonant inductor, simulation results revealed the occurrence of extremely high short-circuit current levels. According to the simulation results, the RFCL strategy is indeed highly important in reducing short circuit current levels during a fault and can protect the circuit breaker mechanism in the investigated power system sub-transmission system. Furthermore, higher inductance values result in faster fault clearing times; however, clearance times begin to converge at inductance levels of 0.1H and above.

Power system fault can be shunted, series, or a combination of both types, with a shunt fault giving a current flow between two or more phases, or a series fault providing a current flow between two or more phases, or a fault to earth (Ogboh and Madueme, 2015). . Series faults are characterized by a rise in voltage and frequency in the faulted phases, as well as a decrease in current.

Table 1.1 Type of Fault and Occurrence

Fault category	Design	Occurrence (%)	Simplicity
Line ground	L-G	75-85%	Very low
Line-line	L-L	8-15%	Low
Double line ground	L-L-G	5-10%	Moderate
Three phase	3Ψ	2-5%	Very high

(Arghandeh *et al.*, 2016).

IV. MATERIALS AND METHOD

A thorough examination of the methods for detecting, classifying, and locating faults in transmission lines and distribution systems, with a selection of important practical applications will be presented in this study. The Afam – Port Harcourt main, Z2 132 KV transmission line will be used in the analysis of electrical fault detection. Faults that will be compared in the study can be classified broadly into four different categories namely:

i. Line to ground faults
ii. Line to line faults
iii. Double-line to ground faults
iv. Three-phase faults

Simulations will be performed on the power transmission line model with real and generated line parameters and obtained graphical results for both parameters. The two versions of parameters will be used to train and simulate the various network architecture selected for each stage of the detection.

A. Short Transmission Lines

Short Transmission Line is defined as a transmission line with a length of less than 80 kilometers (50 miles). The shunt capacitance of this sort of line is ignored for small lengths, and other factors such as electrical resistance and inductance of these short lines are lumped together, resulting in the equivalent circuit.

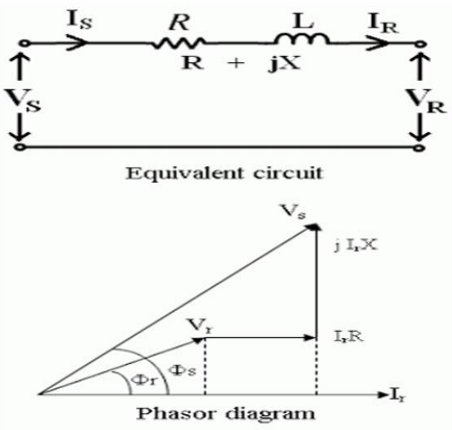

Figure 1.1: Phasor Diagram and Equivalent Circuit

B. Long Transmission Lines

Long T/Line refers to transmission lines that are longer than 240 kilometres (150 miles). Calculations for circuit parameters (ABCD parameters) of such a power transmission are not as straightforward as they were for a short or medium transmission line.

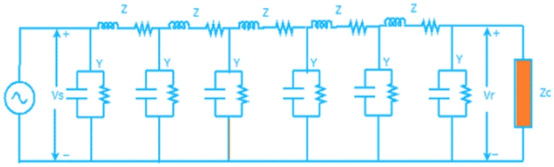

Figure 1.2: Long Transmission Line Model

C. Nominal T Representation of Medium Transmission Lines

The lumped shunt admittance is placed in the middle of the nominal T model of a medium transmission line, while the net series impedance is divided into two equal halves and placed on either side of the shunt admittance. The resulting circuit resembles the capital T sign, and is thus known as the notional T network of a medium-length transmission line, as seen in the diagram below.

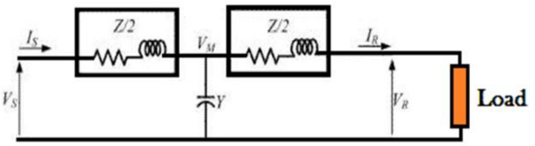

Figure 1.3: Nominal T representation of a medium transmission line

The supply and receiving end voltages are represented by Vs and Vr, respectively, and

I_s is the current flowing through the supply end.

I_r is the current flowing through the receiving end of the circuit.

Let M represent the node at the circuit's midpoint, and Vm represent the drop at M.

When we apply KVL to the network above, we get

$$\frac{V_s - V_m}{Z/2} = Y V_M + \frac{V_m - V_R}{Z/2}$$

or

$$V_M + \frac{2(V_s + V_R)}{YZ/4} \text{`} \tag{1.1}$$

And the receiving end current

or

$$I_R = \frac{2(V_m + V_R)}{Z/2} \text{`} \tag{1.2}$$

Now substituting V_m from equation (3.9) to (3.10) we get,

or

$$I_R = \frac{[(2V_s + V_R)/YZ + 4] - V_R}{Z/2} \text{`} \tag{1.3}$$

Rearranging the above equation:

$$Vs = \left(\frac{Y}{2}Z + 1\right)V_R + Z\left(\frac{Y}{4}Z + 1\right)I_R \text{`} \tag{1.4}$$

The sending end's current is now,

$$I_s = YV_M + I_R \text{`} \tag{1.5}$$

We get by substituting the value of VM into equation (3.13):

$$I_S = Y\, V_R + \left(\frac{Y}{2}Z + 1\right)I_R \text{`} \tag{1.6}$$

When comparing equations (3.12) and (3.14) to the typical ABCD parameter equations, we get:

$$V_S = AV_R + BI_R$$

$$I_S = CV_R + DI_R$$

The parameters of a medium transmission line's T network are

$$A = \left(\frac{Y}{2} Z + 1 \right)$$

$$B = Z\left(\frac{Y}{4} Z + 1 \right)\Omega$$

$$C = Y \ mho$$

$$D = \left(\frac{Y}{2} Z + 1 \right)$$

CONCLUSION

Transmission lines are the most important part of the distribution system because they transfer the bulk of the power from the generating station to the load center. They have been a target for fault detection and location since the development of distribution and transmission systems. The results of this study will allow transmission line fault detection, classification, and location to be handled more quickly and accurately by a robust fault detection technique. An open path for disconnecting the part where this incident occurred without delay is also provided, and with this, it provides a safe way to the system from any damages, since the magnitude of the fault current is known at any given time.

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