Project II Report

PRJ5PW_Gr.1

Project Proposal

High frequency travelling wave fault location methods

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1 Introduction

This project is designed to investigate different approaches for detecting fault location in transmission lines using high frequency travelling waves. Fault location is one of the main aspects of creating and maintaining distribution networks. Storms, vegetation, aerial animals (birds), as well as system breakdowns and lighting strikes can contribute to creation of faults in a transmission line. This can lead to interruption of businesses and infrastructure and cause fires. The goal of this project is to design a method for detecting the location of transmission line fault with travelling waves.

2 Methods and Techniques

There are two main methods associated with high frequency travelling wave fault location techniques: Single-ended and double-ended.

2.1 Single-ended

Single-ended fault location uses a locator only on one bus at one end of the transmission line. When a fault triggers in a transmission line, two surge waves in form of voltage and current propagate in opposite directions along the lines (Figure 1).

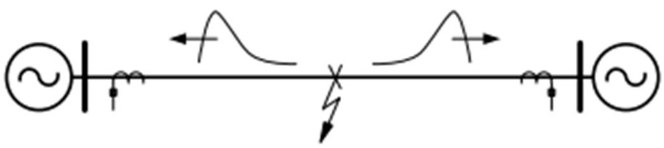

Figure 1: Propagation of travelling waves at the fault location [1]

As the first wave travels back to the sending end of the bus, the second wave travels forward to the far end of the line and reflects back to the bus.

The propagated voltage and current waves can be represented as:

$$u(x,t) = u_1\left(t - \frac{x}{v}\right) + u_2\left(t + \frac{x}{v}\right) \quad (1)$$

$$i(x,t) = \frac{1}{Z_0}u_1\left(t - \frac{x}{v}\right) + \frac{1}{Z_0}u_2\left(t + \frac{x}{v}\right) \quad (2)$$

Where Z_0 is the characteristic impedance of the line, x is the distance the wave travelled from the fault distance, v is the speed of propagation, u_1 is the forward wave and u_2 is the backward wave.

By timing the waves to reach the locator, the distance can be found as:

$$d = \frac{v(t_b - t_f)}{2} \tag{3}$$

The propagating speed can be found as:

$$v = \sqrt{\frac{1}{L'C'}} \tag{4}$$

Where L' and C' are inductance and capacitance of the transmission line respectively per unit length.

2.2 Double-ended

The double-ended approach uses to locators at each end of the transmission line. Each end of the line is equipped with a traveling wave processing unit. Figure 2 shows the working principle of an early implementation of the approach.

Once the TW reaches the master terminal it starts an electronic counter. Once the wave reaches the remote terminal sends a signal via communication channels to the master terminal to stop the counter. In this case the delay in communications should be accounted for.

The distance to the fault can be determined as:

$$d = \frac{l - v\tau(t_{Timer} - t_{Channel})}{2} \tag{5}$$

Where l is the length of the transmission line, τ is the sampling rate, t_{timer} is the time counted by the terminal and $t_{channel}$ is the delay due to the communication channels.

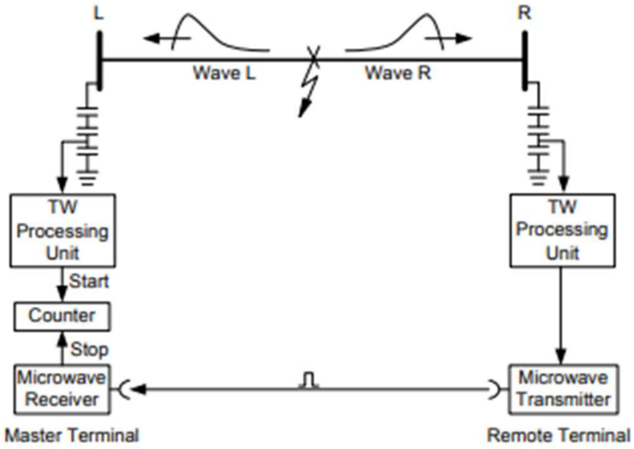

Figure 2: Working principle of double-ended fault detection approach [2]

In modern days, the devices capturing the TW are using a common time reference. Figure 3 shows the principle of operation using a common time reference.

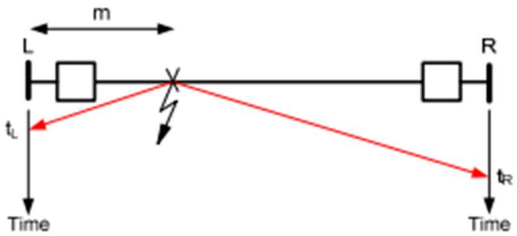

Figure 3: Fault locating principle of operation using a common time reference [2]

From the figure above, the distance to fault can be calculated as:

$$d = \frac{l + v(t_L - t_R)}{2} \tag{6}$$

2.3 Simulation

A simulation should be built to test the methods for detecting fault location.

The flowchart of the simulation process can be seen in Figure 4. A Clarke Transformation should be implemented first in order to ease calculations on an unbalanced three-phase system. Then, A sampling rate should be chosen. As can be seen from Equation 5, sampling rate can influence the error of the calculations. A Wavelet Transform is performed as it provides signal analysis both in time and frequency domain. This helps information about changes in frequency.

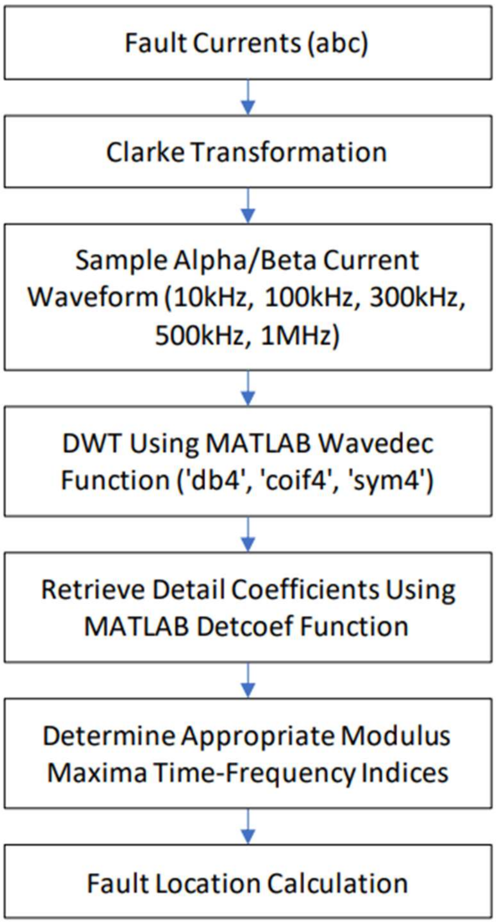

Figure 4: Flowchart of Fault Location Signal Processing Using Discrete Wavelet [5]

3 Project Requirement

- MATLAB/Simulink
- Research papers and scientific articles related to the topic
- Access to library

4 Resources

Table 1: Resources

Resource	Cost
MATLAB/SIMULINK	€ 2,100
Computer	€ 600

5 Risk Management

Table 2: Risks

Risk	Probability	Seriousness
Missing Deadline	5	10
Fatigue	3	4
Computer Malfunction	3	9

6 Timeline

Table 3: Timeline of the project divided into weeks

	Completed	Oct				Nov				Dec				Jan			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Planning	Yes																
Research	60%																
Proposal	70%																
Simulations	15%																
Final Presentation	0%																
Final Report	0%																

7 Workbook

A workbook was set up on GitHub for the supervisor to follow. It can be accessed with https://github.com/AyazAhmadov/PRJ5

References

[1] Reza Sirjani, “A Comparative Study of Different Traveling Wave Fault Location Techniques”, Karlstad University, Karlstad, Sweden, 2018

[2] Edmund O. Schweitzer, “Locating Faults by the Traveling Waves They Launch”, 67th Annual Conference for Protective Relay Engineers, 2014

[3] M.K. Ngwenyama, “Traveling Wave Fault Location Detection Technique for High Voltage Transmission Lines”, Tshwane University of Technology, 2021

[4] Mohammad Abdul Baseer , “Travelling waves for finding the fault location in transmission lines”, Journal Electrical and Electronic Engineering, 2013

[5] Wesley Fluty, “Fault Location Techniques Using the Traveling Wave Method and The Discrete Wavelet Transform”, University of Kentucky, 2019