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Research Paper

TRANSMISSION LINE FAULT DETECTION USING WAVELET IN MATLAB

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***Abstract*—This project explores the application of a Buck-Boost Converter for managing wind energy, specifically aimed at addressing the issue of voltage variations in the output from wind turbines. The objective is to ensure a consistent output voltage during electricity generation, thereby improving the reliability of wind power supply. While there have been notable advancements in wind technology, further enhancements are necessary to optimize power control under diverse loading conditions. The use of a single power MOSFET with a low on-resistance (RDS-ON) is shown to significantly enhance the efficiency of the proposed converter design. This study includes a detailed technical overview, mathematical analysis, and a comparative review of similar systems found in existing literature. A laboratory setup was conducted with a load power rating of 100W at a switching frequency of 50 kHz to validate the performance of the converter. By integrating the Buck-Boost Converter across the DC link, we can maintain a stable voltage supply, which is crucial for consistent electricity distribution under varying environmental conditions. Simulation results were conducted using MATLAB/SIMULINK.**

key words: Wind Energy, Buck Converter, Boost Converter

I. INTRODUCTION

Transmission lines are critical components of electrical power systems because they enable the flow of electricity from production stations to distribution networks and end customers. The stable and reliable operation of these lines is critical to ensuring system integrity. However, transmission lines are extremely vulnerable to defects caused by environmental conditions, equipment failures, and external disturbances. These defects can cause power outages, voltage fluctuations, and significant damage to power system components, resulting in economic losses for millions of customers. As a result, reliable and early fault detection is an essential component of power system protection in order to avoid long-term damage and provide an uninterrupted power supply.

Challenges in Traditional Fault Detection Methods

Conventional fault detection methods rely heavily on time- and frequency-domain analytical techniques. These methods, while useful in some situations, have substantial limits when dealing with transient events like short-circuit faults and ground faults. Time-domain approaches assess voltage and current signals directly, but they struggle to distinguish between typical disturbances and errors. Frequency-domain approaches, such as the Fourier Transform (FT), provide insights into a signal's frequency components but do not identify errors in the temporal domain.

The main disadvantage of Fourier-based approaches is their inability to give simultaneous time and frequency resolutions. Transmission line failures frequently cause abrupt changes in the system that require accurate identification. The Fourier Transform, which analyzes signals as a whole, cannot efficiently capture localized transitory disruptions. To solve these issues, the Wavelet Transform (WT) has arisen as a sophisticated signal processing tool capable of efficiently detecting defects by providing a time-frequency representation of the signal.

Wavelet Transform for Fault Detection

The Wavelet Transform (WT) is a mathematical tool that breaks down signals into distinct frequency bands, providing both time-domain and frequency-domain information. Unlike typical Fourier methods, WT does multi-resolution analysis, making it extremely effective for detecting and analyzing transitory occurrences. The essential idea behind WT is to split a signal into shifted and scaled versions of a base function known as the mother wavelet.

In the context of fault detection, WT enables the identification of sudden changes in power system signals that indicate transmission line defects. Signal decomposition into distinct frequency levels enables the isolation of fault-induced disruptions, making it easier to examine system irregularities.
Objectives of the project

Discrete Wavelet Transform (DWT) for Transmission Line Fault Detection

Among the different wavelet approaches, the Discrete Wavelet Transform (DWT) is very beneficial for fault detection in power systems. DWT breaks down a signal into approximation and detailed coefficients, where:

- Approximate coefficients, which comprise low-frequency components, depict the signal's steady-state nature.
- Detailed coefficients detect high-frequency components, emphasizing transient disturbances and fault occurrences.

Transmission line failures generally cause high-frequency transients in the system. These fault-induced disturbances can be successfully separated by evaluating the DWT's detailed coefficients. The choice of mother wavelet, such as Daubechies (db4), Haar, or Symlets, is critical in improving fault detection accuracy.

Use of Wavelet Transform in Power Systems

Wavelet Transform is used to detect faults in power systems other than transmission lines. It is commonly used to detect disturbances in distribution networks, transformers, circuit breakers, and busbars. WT's time-frequency localization property makes it an excellent tool for monitoring harmonics, voltage sags, and transient faults in electrical grids.

The Wavelet Transform is useful for real-time monitoring and assessment of voltage and current waveforms in transmission line protection applications. It allows power system operators to take corrective actions swiftly, preventing cascading failures and improving grid reliability.

1.1 Objectives of the paper

This project aims to develop an efficient and accurate fault detection system for power transmission networks using wavelet transform in MATLAB. By applying Discrete Wavelet Transform (DWT), the system analyzes current and voltage signals to detect and classify faults in real time. This method enhances fault identification accuracy, enabling quick fault isolation and improving system stability. The approach minimizes outages, reduces equipment damage, and enhances the overall reliability of the power system. The MATLAB-based simulation provides a robust platform for testing and validating the effectiveness of wavelet-based fault detection techniques, ensuring a reliable and efficient power transmission network.

II. METHODOLOGY

The fault detection process begins with the modeling of a transmission line in MATLAB/Simulink, incorporating voltage and current measurement blocks. The recorded signals are then subjected to Discrete Wavelet Transform (DWT) to extract time-frequency characteristics. By analyzing wavelet coefficients, sudden variations caused by faults are detected. A thresholding mechanism is employed to differentiate normal operation from faulty conditions. Once a fault is identified, it is classified based on phase involvement and severity, enabling rapid fault isolation and protection system activation.A schematic diagram of the converter's operation is shown in Figure 3.1, highlighting the PWM control mechanism that adjusts the duty cycle for efficient energy conversion. The advantage of using a buck-boost converter lies in its ability to both step-up and step-down the voltage, which is crucial in applications like wind energy where the input voltage is highly variable.

The proposed method involves real-time acquisition of voltage and current signals from the transmission line. Using MATLAB, these signals are processed through the wavelet transform, which effectively captures transient disturbances. The norm of the decomposed wavelet coefficients is computed for each phase, and the phase with the maximum deviation is identified. A predefined threshold is used to determinewhethera fault has occurred. If the norm exceeds the threshold, the system logs the fault and identifies its location and type. This method enhances the accuracy and speed of fault detection in high-voltage power networks.

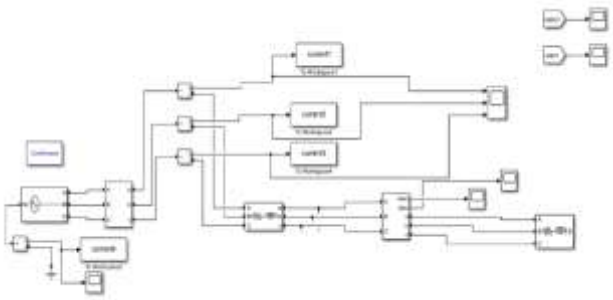


Fig.2.1: Transmission line without fault

The methodology starts with signal extraction from the transmission line, where MATLAB/Simulink is used for fault modeling and simulation. Wavelet Transform (WT) is applied to decompose these signals into different frequency bands, allowing detection of transient disturbances. A mathematical norm is calculated from the wavelet coefficients to determine fault magnitude. Based on a pre-set threshold, the system differentiates between normal and faulty conditions. If a fault is detected, the involved phase is identified, and the information is sent for corrective action. This approach improves system reliability and minimizes downtime by enabling early fault detection.

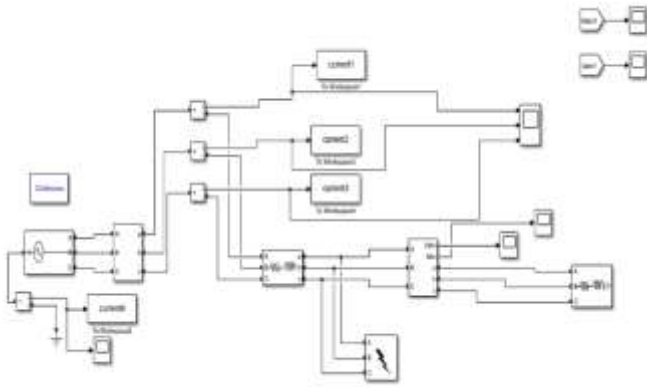


Fig.2.2: Transmission line with faul

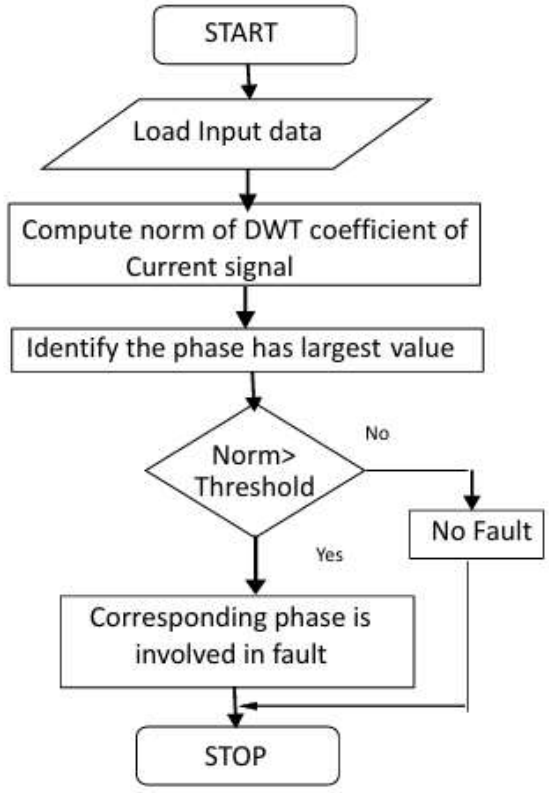


Fig.2.3: Flow chart

The flowchart depicts a technique for detecting problems in a transmission line using the Discrete Wavelet Transform (DWT). It starts by initializing the system, then loads input data, which comprises of voltage and current signals collected from the transmission line. These signals are examined using wavelet transform techniques to identify key information. Specifically, the norm of the current signal's DWT coefficient is determined, which aids in recognizing signal changes caused by suspected problems.

Once the norm is computed, the system decides which phase has the highest value, as defects usually cause large disruptions in a certain phase. The discovered phase's norm is then compared to a predetermined threshold. If the norm exceeds the threshold, the system determines that the relevant phase is engaged in a fault. If the norm remains below the threshold, it indicates that no fault occurred. Based on this analysis, the system either confirms the presence of a defect in a certain phase or determines that the transmission line is operating normally.

The method ensures that problems are discovered efficiently and accurately by evaluating signal transients. The wavelet transform is an effective approach for capturing high-frequency disruptions caused by faults, making the detection procedure more reliable. Using a mathematical thresholding method, the system reduces false detections while ensuring accurate defect identification. When the fault classification is done, the process comes to an end. This methodology is very effective for real-time monitoring and protection of transmission lines, which helps to preserve power system stability and prevent future damage.

III. RESULT& ANALYSIS

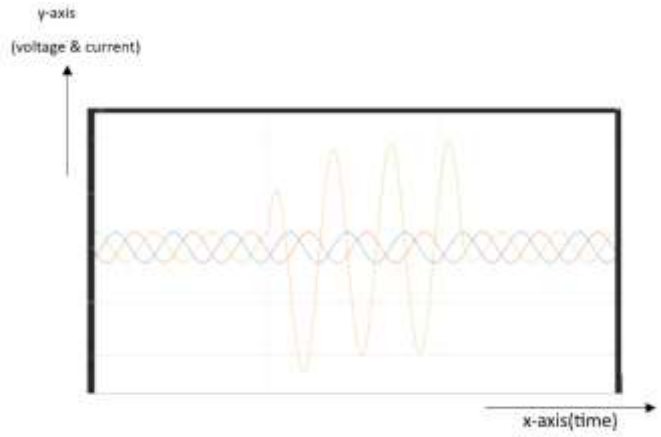


Fig.3.1: Phase A and ground fault

To simulate the transmission line fault detection, wstart by opening the simulation model and manually introducing a fault into the system. Next, we access and run the code, which directs us back to the simulation model. From there, we can observe the resulting waveforms to confirm the occurrence of the fault within the system. The figures3.1 shows the phase Y and ground fault. When the Phase Y and ground fault occurs the Y phase current spikes at high level.

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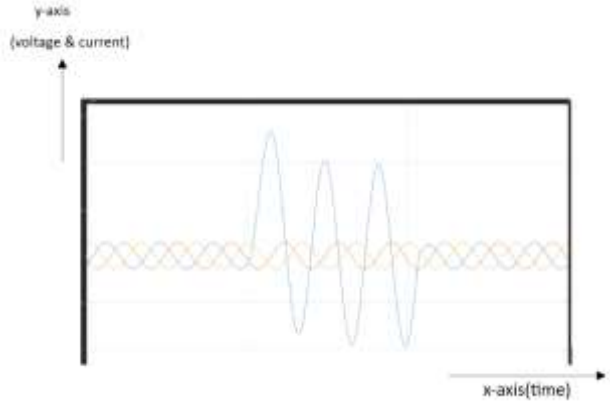


Fig.3.2: Phase B and ground fault

The figures3.2 shows the phase B and ground fault. When the Phase B and ground fault occurs the B phase current spikes at high level

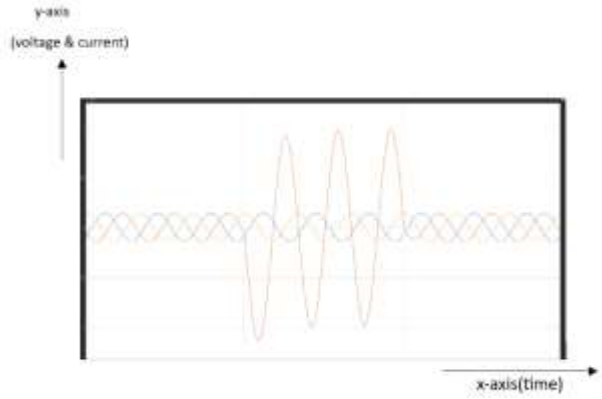


Fig.3.3: Phase B and ground fault

The figures3.3 shows the phase R and ground fault. When the Phase R and ground fault occurs the R phase current spikes at high level

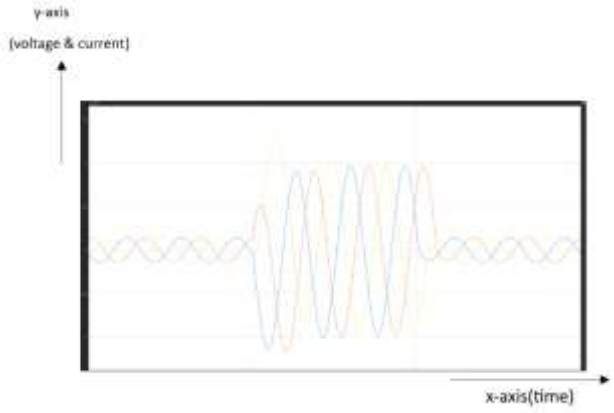


Fig.3.4: Three phasefault

The figure 3.4 shows the Three phase fault. When the Three phase fault occurs the three phases current spikes at high level

Table.3.1:Coefficient values

Type of fault	Max coefficient of phase Y current	Max coefficient of phase B current	Max coefficient of phase R current	Max coefficient of ground current
Three phase to ground fault	919.8271	976.9918	728.7967	0.0143
Three phase fault	767.3107	700.1110	792.7979	385.1788
Double line to ground fault(AB-G)	1.0282e+03	708.8546	131.5798	720.2410
Double line to ground fault(AC-G)	881.2649	128.1626	888.0458	500.0681
Double line to ground fault(BC-G)	132.3731	666.6001	794.8711	321.8262
Line to line fault(A-B)	502.8042	527.8540	114.1036	0.0051
Line to line fault(A-C)	372.9172	99.4121	488.2035	0.0136
Line to line fault(B-C)	115.7232	594.5955	735.5252	0.0104
Single line to ground fault(A-G)	1.0397e+03	97.2940	121.5884	671.5323
Single line to ground fault(B-G)	124.9663	639.3719	85.0469	910.1870
Single line to ground fault(C-G)	131.0642	131.0646	786.2072	839.8093
System without fault	72.1093	132.0854	115.7165	1.1268e-09

IV. CONCLUSION

This project implemented wavelet-based analysis for transmission line fault detection using MATLAB. By applying the Discrete Wavelet Transform (DWT) to voltage and current signals, we analyzed signal behavior and identified transient anomalies. The wavelet coefficients provided detailed insights into energy variations, enhancing real-time signal interpretation. Through simulations, we demonstrated the effectiveness of wavelet analysis in monitoring transmission line conditions. This study lays a strong foundation for improving power system reliability and safety. Future work can incorporate fault classification, enabling fully automated detection systems and further advancing fault monitoring and protection in power transmission networks.

V. FUTURE SCOPE

The future scope of transmission line fault detection using wavelet analysis in MATLAB includes several promising developments. Advanced wavelet-based algorithms could be integrated with artificial intelligence and machine learning to enhance fault classification accuracy. Real-time implementation of these methods could be further explored to provide faster response times in fault detection. Additionally, hybrid approaches combining wavelet transforms with other signal processing techniques may improve fault identification under complex conditions, such as in multi-line faults or during fluctuating power loads. As smart grids evolve, wavelet-based fault detection systems can play a critical role in enhancing grid resilience and reliability.Further research could also focus on adapting these methods for renewable energy sources and microgrid systems, where fault dynamics differ from traditional power systems

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