

# Efficient Fault Detection in Power Transmission: A Review of Three-Phase Line Fault Detection with Hybrid Energy using MATLAB

Sagar Chaudhari<sup>1,\*</sup>, Varad Gurav<sup>1</sup>, Chinmay Upasani<sup>1</sup>, Suraj Ghule<sup>1</sup>, Sharad S. Patil<sup>2</sup>

## Abstract

*In urban regions, the density of power demand has significantly increased recently. Large-scale subterranean power cable installations are beginning to take the place of overhead transmission lines everywhere in the world because of environmental concerns in highly populated areas. The present project's primary objective is to use MATLAB to create a simulation model that includes 3ph symmetrical and unsymmetrical defects. Some have proven to be effective in detecting errors while the system is operating. With a few exceptions there hasn't been much research on fault location methods for line-selection devices in industrial systems that aren't grounded, including those running at 35 kV and lower. This document describes how to handle MATLAB programming, which is used to create gearbox line models and reenact various problems using tool compartments. Numerous types of defects have been analysed, and the results show up in the simulation output. Examples of these include control, voltage, and current, as well as the positive, negative, and zero grouping parts of the voltage and current output. Consequently, utility is being requested to improve the precision of fault location and fault section discrimination in integrated transmission lines.*

**Keywords:** Fault detection, 3 phase transmission line, solar and wind energy, matlab simulation

## INTRODUCTION

Many related technologies are needed to operate mixed transmission lines (lines having parts of subsurface and above wire) with high accuracy and efficiency. The characteristics of overhead wires, which can differ significantly from those of underground cables, constitute the foundation of today's protection algorithms. The fault location technique designed for overhead lines alone cannot be applied directly to underground cables since zero impedance varies with the complexity of the underground cable (where joint boxes, groundings, and crossholdings are located).

Except for a small number of publications that calculate the underground cable impedance using the travelling wave approach, studies addressing fault location for integrated transmission lines are not frequently published. There are numerous techniques for locating faults in transmission lines in systems with a strong grounding. Certain ones have demonstrated efficacy in identifying malfunctions while the system is functioning. Except for a few line-selection devices, not much study has been done on fault location techniques in industrial systems that are not directly grounded, such as those operating at 35 kV and below. The steady-state zero-sequence current in the non-directly grounded system is not directly correlated with the fault point's location. Due to the positioning

### \*Author for Correspondence

Sagar Chaudhari  
E-mail: [sagarc532000@gmail.com](mailto:sagarc532000@gmail.com)

<sup>1</sup>Student, Department of Electrical Engineering, NBN Singhad College of Engineering, Pune, Maharashtra, India.

<sup>2</sup>Assistant Professor, Department of Electrical Engineering, NBN Singhad College of Engineering, Pune, Maharashtra, India.

Received Date: October 24, 2023

Accepted Date: December 21, 2023

Published Date: January 10, 2024

**Citation:** Sagar Chaudhari, Varad Gurav, Chinmay Upasani, Suraj Ghule, Sharad S. Patil. Efficient Fault Detection in Power Transmission: A Review of Three-Phase Line Fault Detection with Hybrid Energy using MATLAB. International Journal of Electrical Power and Machine Systems. 2023; 1(1): 42–47p.

of faults on transmission lines, high-speed fault clearing and improved transient stability are now requirements for modern extra-high voltage power systems. Accurate fault location leads to faster maintenance and power supply restoration, especially for persistent failures. Techniques for identifying power system failures can be broadly divided into two groups: those that use the high frequency contents of the transient fault signals, and those that rely on the power frequency components.

## LITERATURE SURVEY

An artificial neural network (ANN) technique is used by Akhikpemelo et al to detect faults in a 132kV transmission line system [1].

Khoker et al described a current-based algorithm for the identification and classification of transmission line faults with solar energy that used complex features assessed by the application of discrete wavelet transform (DWT) and Hilbert transform (HT). The study investigated several defects, including those involving all three phases and ground (LLLG), line to ground (LG), double line (LL), and double line with ground (LLG) [2].

Ekici et al examined many regressions techniques' performance on a hybrid power system [8]. Mampilly and Sheeba proposed a new fault travelling wave-based hybrid line location technique [9]. Wang et al presented a novel deep learning (DL) approach to perform real-time automatic fault detection and classification of a photovoltaic (PV) system: a hybrid model-based combination architecture [10]. Alrifayy et al conducted a thorough evaluation study on a 250-kW grid-connected PV system to ascertain the performance of the suggested fault model [11]. They examined both symmetrical and asymmetrical faults that affect all phases and ground faults, including single, phase-to-phase, phase-to-phase, and three-phase-to-ground faults. Elnozahy et al discussed the use of Artificial Neural Network (ANN) algorithms for fault detection, classification, and quick fault site determination [13]. The system can precisely identify the position of the defect, classify the type of fault, and assess if a fault is there or not. Hamidi et al proposed a travelling wave-based fault location technique for hybrid three-terminal transmission systems, which comprise an onshore overhead line and offshore cables. These kinds of networks are used to connect offshore wind farms [13]. A novel method for locating a defect on a multi-terminal transmission line was described in the research of Brahma et al. [14] Liao et al suggested a potential approach for estimating the fault location optimally, which can minimise the effects of measurement errors, detect and identify inaccurate measurement data, and so improve fault location accuracy [15].

## PNN (Perceptron Neural Network)

A lemma theorem, a tested theory improves the qualifying of the TSVD outcomes, leading to a more substantial and ideal outcome. This is the reason it is also called a "helping theorem" or an "auxiliary theorem." It consists of two modules for fault analysis of power systems:

### *Defect classification (ii) Detection*

It merges the truncated singular value decomposition (TSVD) with the Recurrent Perceptron Neural Network (RPNN) derived from the human urbanisation algorithm (HUA). Matrix decomposition, or TSVD, classifies the result as fast or slow.

Rajesh et al proposed a hybrid approach to forecast and categorise transmission line issues in power systems termed as TSVD-HUARPNN methodology [3].

The creation of a dataset containing both normal and abnormal transmission line parameters for the power system using TSVD is the first step in the proposed system. The HUA-based RPNN algorithm evaluates the extracted dataset to categories the fault analysis that takes place in the transmission system. The transmission line fault predicted and classified using the TSVD-HUARPNN algorithm. The accuracy of the system is boosted since the suggested TSVD-HUARPNN system assures a system with reduced complexity for fault detection and classification. By then, MATLAB/Simulink has activated the suggested model, and its performance has been compared to the models that already exist. This technique achieves a performance of 99.77% with noise at 20 dB [3].

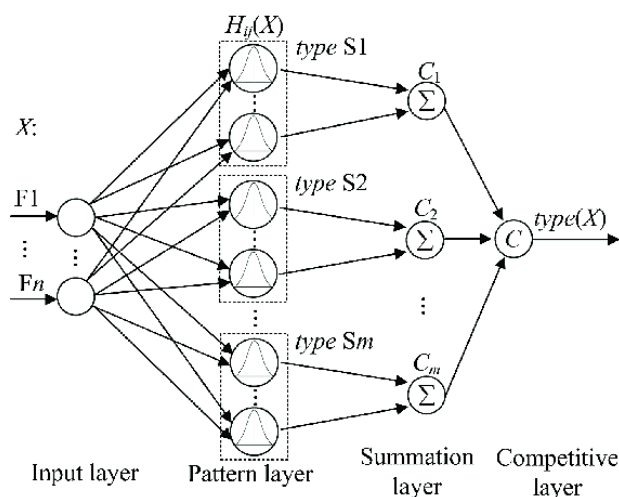
### Hybrid Transmission Lines

Because the travelling propagation of waves frequencies in hybrid transmission networks vary and it is difficult to distinguish between the initial travelling wavelength front and the resulting reflected wave fronts, the standard travelling-wave-based fault location algorithm for single overhead lines is not adequate. The random nature of submarine cable defects combined with the unpredictability of maritime weather makes maintenance of these lines exceedingly challenging. Precisely locating faults in underwater cables is crucial for hybrid transmission networks. A whole waveform, a novel representation of a travelling wave in 3D subspace, is provided by Deng F et al [4]. The three-dimensional absolute grey incidence degree was used to assess both qualitatively and quantitatively the correlation and difference of the entire waveform at distinct fault spots, based on the travelling wave's transmission properties and its refraction and reflection mechanism. It was revealed that the single end measured entire waveforms and the fault locations corresponded exactly. A hybrid transmission line fault location algorithm based on single-ended travelling waves was suggested. A multi-scale travelling wave panorama waveform with a distinct physical meaning was used to test the suggested technique. It is not necessary to know the initial travelling wave front arrival times, their subsequent reflection waveforms, or their modal component velocities. MATLAB is used for post-fault analysis while PSCAD/EMTDC is used for transient simulation.

### Series Compensators in AC Transmission Systems

These days, an efficient and cost-effective way to boost transmission capacity and enhance the system's short- and long-term stability is to employ series compensators in AC transmission systems, particularly in lengthy transmission lines. with the goal of giving consumers with critical loads better services and the growing competition brought about by the privatization of the energy sector. It has prompted the advancement of fault location techniques for transmission and distribution networks in terms of speed and dependability. It could be challenging to find the problem. Locating in series compensated lines using series equipment can be done in several ways. In the context of series compensated lines with a thyristor-controlled capacitor compensator present, a novel hybrid scheme algorithm (TCSC) is presented in study [5].

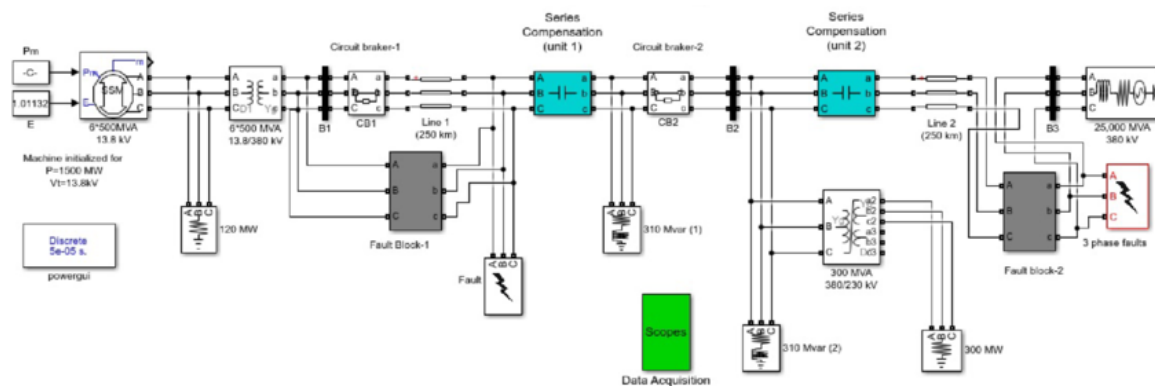
It demonstrated that, to avoid relay operation malfunction, the suggested method improved accuracy while also accelerating the process of locating faults in series compensated transmission lines as shown in Figure 1. The stability and security of electrical power systems depend heavily on the effective and dependable operation of power transmission lines. On the other hand, transmission line problems may result in equipment damage as well as power supply interruptions. Thus, it is crucial to design efficient fault detection systems to guarantee the uninterrupted operation of electricity grids.



**Figure 1.** The perceptron neural network.

## Transmission Lines

Transmission lines (TLs) are crucial to power system engineering, and one of their main objectives is to transfer generated electricity to different distribution units. A power plant's clients and the plant are connected by transmission lines. Because transmission lines are situated in open areas, faults frequently arise in them. Transmission lines can develop a variety of problems, and it's important to identify and fix these faults as soon as possible. For the power system to continue operating normally, gearbox line problems must be quickly identified and repaired as depicted in Figure 2. Techniques like the Empirical Mode Decomposition (EMD) and Discrete Wavelet Transform (DWT) are employed in fault diagnosis and detection to overcome these disturbances. Due to its ability to extract data in both the temporal and frequency domains concurrently, DWT is used to dissect fault transients [9]. The transmission line voltages are broken down into intrinsic mode functions (IMFs) using an EMD. The grid-connected power system generates four different kinds of failure signals.



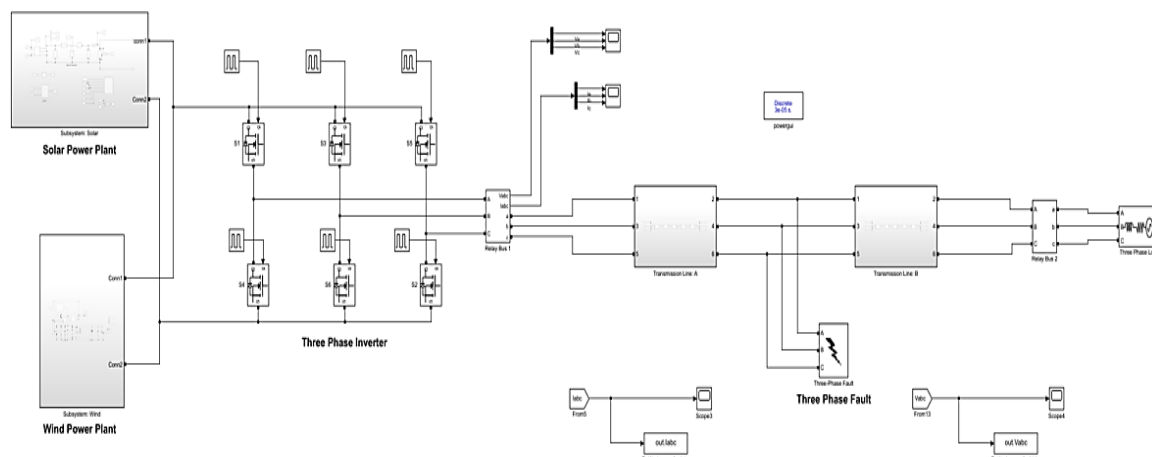
**Figure 2.** Three phase transmission line fault detection with hybrid energy by MATLAB.

## Fault Detection

An increasing likelihood of system faults occurring is one of the effects of power systems becoming more sophisticated. Quick and accurate estimation of the fault section is necessary since a swift restoration of the power system improves service reliability and lowers power outages. Transmission lines are crucial components of electricity systems that can malfunction for a variety of reasons, leading to unplanned outages. Selecting the best FD approach requires a suitable examination of the many FD methods that are proposed by several research works and published in technical literature. Therefore, effective fault detection, classification, and localization (FDL) methods for transmission lines are crucial to ensuring the dependability and safety of a power system. Therefore, it is always necessary to improve appropriate strategies for fault detection and classification (FD) in power transmission systems to boost system efficiency and prevent significant damage. Selecting the best FD approach requires a suitable examination of the many FD methods that are proposed by several research works and published in technical literature. An increasing likelihood of system faults occurring is one of the effects of power systems becoming more sophisticated. Quick and accurate estimation of the fault section is necessary since a swift restoration of the power system improves service reliability and lowers power outages. Transmission lines are crucial components of electricity systems that can malfunction for a variety of reasons, leading to unplanned outages. Therefore, effective fault detection, classification, and localization (FDL) methods for transmission lines are crucial to ensuring the dependability and safety of a power system. Therefore, it is always necessary to improve appropriate strategies for fault detection and classification (FD) in power transmission systems to boost system efficiency and prevent significant damage.

Tîrnovan et al provided an overview of the techniques used for FD in gearbox systems by analysing the technical literature and provide a summary of the key techniques [6]. They introduced a wave velocity-insensitive fault location technique for hybrid three-terminal HVDC transmission lines based on enhanced LMD [6]. The use of FD in gear box systems is required to lessen the effects of travelling wave velocity, wave head recognition, LMD (Local Mean Decomposition) end effect, and mode mixing

on location accuracy. Furthermore, it is more accurate than LMD when utilising the double-ended location method with wave velocity computation, the wavelet packet location methodology, and the CSI (Cubic Spline Interpolation) algorithm [7].



**Figure 3.** Transmission line fault detection with hybrid energy.

*Modelling the Transmission Line:* Using MATLAB, model the three-phase transmission line as the initial stage in building the fault detection system. This entails utilising the proper mathematical models to represent the line properties, such as capacitance, inductance, and resistance as shown in Figure 3.

*Fault Simulation:* Fault conditions must be simulated after the gearbox model has been created. Tools for simulating many kinds of faults, including open-circuit and short-circuit faults that might happen in transmission lines, are available in MATLAB. Developing a fault detection algorithm that can precisely identify the presence and location of faults in the transmission line is the next stage. This approach may be based on various signal processing techniques, artificial neural networks, or wavelet transforms.

*Hybrid Energy Integration:* We can incorporate hybrid energy sources, like solar or wind turbines, into the fault detection system to increase its dependability. It will be ensured that the defect detection system keeps working even when there are power interruptions.

*Testing and Validation:* Simulated fault scenarios must be used to test and validate the fault detection system after it has been created and built in MATLAB. To guarantee that the system operates accurately under a range of operational situations, this phase is essential.

## CONCLUSION

MATLAB software makes it convenient to simulate and analyse a three-phase fault to determine the transmission line parameter. This research proposes a fault analysis system simulation for three-phase transmission lines. Transmission line faults such as Single Line to Ground and Double Line faults are also simulated. This system makes it possible to rethink the power system's bus system considering its findings. The use of MATLAB in the design of a fault detection system for a three-phase transmission line with hybrid energy provides a solid and dependable method for guaranteeing the security and stability of power networks. The technology can contribute to reducing downtime and guaranteeing the effective operation of electrical power systems by precisely identifying and localising issues. Hybrid energy source integration also improves the system's resilience, which makes it a great option for contemporary power transmission networks.

## REFERENCES

1. Akhikpemelo A, Evbogbai MJ, Okundamiya MS. Fault detection on a 132kV transmission line using artificial neural network. *Int. Rev. Electr. Eng.* 2019 Jun 30;14(3):220–5.

2. Khoker MZ, Mahela OP, Ahmad G. A current based hybrid algorithm using discrete wavelet transform and Hilbert transform for detection and classification of power system faults in the presence of solar energy. In 2020 IEEE International Students' Conference on Electrical, Electronics and Computer Science (SCEECS) 2020 Feb 22 (pp. 1–6). IEEE.
3. Rajesh P, Kannan R, Vishnupriyan J, Rajani B. Optimally detecting and classifying the transmission line fault in power system using hybrid technique. ISA transactions. 2022 Nov 1; 130:253–64.
4. Deng F, Zeng X, Tang X, Li Z, Zu Y, Mei L. Travelling-wave-based fault location algorithm for hybrid transmission lines using three-dimensional absolute grey incidence degree. International Journal of Electrical Power & Energy Systems. 2020 Jan 1; 114:105306.
5. Silveira EG, Paula HR, Rocha SA, Pereira CS. Hybrid fault diagnosis algorithms for transmission lines. Electrical Engineering. 2018 Sep; 100:1689–99.
6. Tîrnovan RA, Cristea M. Advanced techniques for fault detection and classification in electrical power transmission systems: An overview. In 2019 8th International Conference on Modern Power Systems (MPS) 2019 May 21 (pp. 1–10). IEEE.
7. Gao S, Xu Z, Song G, Shao M, Jiang Y. Fault location of hybrid three-terminal HVDC transmission line based on improved LMD. Electric Power Systems Research. 2021 Dec 1; 201:107550.
8. Ekici S, Unal F, Ozleyen U. Comparison of different regression models to estimate fault location on hybrid power systems. IET Generation, Transmission & Distribution. 2019 Oct; 13(20): 4756–65.
9. MAMPILLY BJ, SHEEBA V. Transmission Lines Fault Detection using Empirical Mode Decomposition in a Grid-Connected Power System. In 2020 International Conference on Power Electronics and Renewable Energy Applications (PEREA) 2020 Nov 27 (pp. 1–6). IEEE.
10. Wang L, Liu H, Dai LV, Liu Y. Novel method for identifying fault location of mixed lines. Energies. 2018 Jun 12; 11(6):1529.
11. Alrifaey M, Lim WH, Ang CK, Natarajan E, Solihin MI, Juhari MR, Tiang SS. Hybrid deep learning model for fault detection and classification of grid-connected photovoltaic system. IEEE Access. 2022 Jan 4; 10:13852–69.
12. Elnozahy A, Sayed K, Bahyeldin M. Artificial neural network-based fault classification and location for transmission lines. In 2019 IEEE Conference on Power Electronics and Renewable Energy (CPERE) 2019 Oct 23 (pp. 140–144). IEEE.
13. Hamidi RJ, Livani H. A travelling wave-based fault location method for hybrid three-terminal circuits. In 2015 IEEE Power & Energy Society General Meeting 2015 Jul 26 (pp. 1–5). IEEE.
14. M. Brahma, Fault location scheme for a multiterminal transmission line using synchronized voltage measurements, IEEE Trans. Power Del., vol. 20, no. 2, pp. 1325–1331, Apr. 2005.
15. Liao and M. Kezunovic, Optimal estimate of transmission line fault location considering measurement errors, IEEE Trans. Power Del. vol. 22, no. 3, pp. 1335–1341, Jul. 2007.