FAULT MONITORING IN SYSTEM USING SIMULINK

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Abstract - The goal of this study is to create a simulation model using MATLAB that can be used to examine different kinds of three-phase faults in electrical transmission line systems. Single line-to-ground, double line-to-ground, and line-to-line faults—all of which are frequent in long-distance power transmission networks—as well as symmetrical (triple line-to-ground) faults are included in the study. The changes in system characteristics, such voltage and current, under various fault scenarios are investigated through simulation. The results of this study advance our knowledge of fault behavior and offer a useful tool for MATLAB-based fault analysis and system protection studies.

Key Words: *Line to line fault, Line to ground fault, Double line to ground fault, symmetrical and asymmetrical faults, MATLAB software*

1. INTRODUCTION

The stability and dependability of the electrical energy supply are crucial in contemporary power systems. However, a variety of disruptions and unusual operating situations are constantly present in power systems, which might result in malfunctions. When the current and voltage in a circuit diverge from their typical levels because of insulation failure, short circuiting, or an unforeseen connection of live conductors to the ground or one another, this is known as a fault. If not dealt with quickly and efficiently, such incidents can seriously harm electrical equipment, disrupt the power supply, and even jeopardize the stability and safety of the system.

Electrical power system design, operation, and protection all depend heavily on fault analysis. It offers important details about the size of fault currents, voltage dips, and the system's transient behavior when it is faulted. In order to ensure that faults are identified and fixed as quickly as possible, this type of analysis is essential for figuring out the specifications and settings of protective devices like relays, circuit breakers, and fuses. Accurate fault analysis also helps with stability studies, equipment sizing, and the creation of backup plans to improve system reliability.

Symmetrical and asymmetrical faults are the two primary categories into which defects in a three-phase power system are often divided. Balanced fault currents and voltages are indicative of symmetrical faults, which have an equal impact on all three phases. Conversely, asymmetrical faults cause unbalanced system conditions and include one or two phases. Single-line-to-ground, line-to-line, double-line-to-ground, and three-phase faults are the fault types that are most frequently researched. Asymmetrical faults are more common and complex, necessitating in-depth analytical and simulation-based research, whereas symmetrical faults are less common but usually more severe.

Power systems failure analysis and simulation have made extensive use of computational tools such as MATLAB/Simulink in recent years. Because these technologies allow for accurate modeling of transmission lines, generators, transformers, and loads, engineers may analyze system performance under various fault situations. Through their insights into fault current magnitudes, voltage profiles, and system stability during disturbances, the simulated results help build efficient protection strategies.

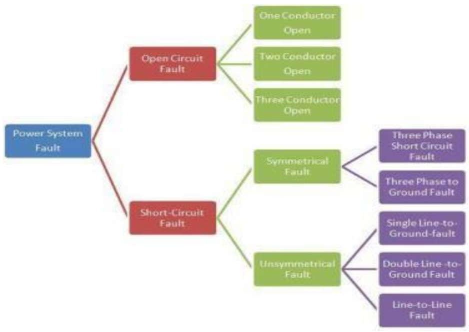
All things considered, fault analysis is an essential part of power system engineering that increases operational dependability, promotes the design of protective mechanisms, and ensures the safety of personnel and equipment. In order to keep electrical networks functional and intact under real-world operating situations, it is essential to have a thorough understanding of failure behavior and how it impacts the system.

2. TYPES OF FAULTS IN POWER SYSTEM

Power system faults are primarily divided into two categories:

- Asymmetrical Fault
- Symmetrical Fault.

The picture below illustrates the various kinds of power system faults.



2.1 Asymmetrical Fault

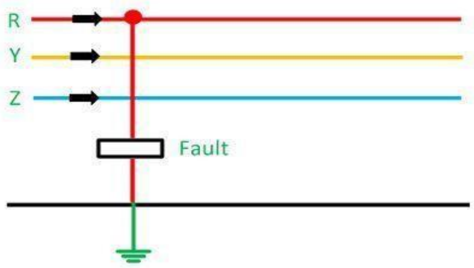
When an electrical power system encounters an unbalanced disturbance that results in unequal current flow in all three phases, the fault state is referred to as an asymmetric fault. Asymmetric faults, such as single line-to-ground, line-to- line, or double line-to-ground failures, introduce voltage and current imbalance that can significantly impact system stability, equipment performance, and power quality. In contrast, symmetrical faults impact all phases equally. These issues are more prevalent in real-world applications and are frequently brought on by conductor degradation, insulation failure, or unintentional contact with grounded items. Maintaining dependable power system performance requires accurate asymmetric fault detection, analysis, and mitigation.

Typically, methods like symmetrical component analysis are employed to make the investigation of these defects easier and to create protective schemes that guarantee quick system recovery and fault isolation.

2.1.1 Types Of Asymmetrical Fault

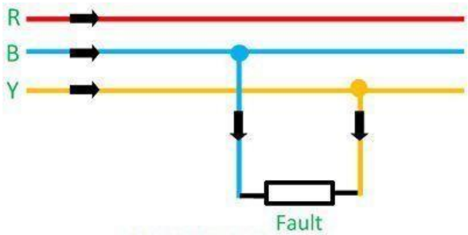
It is mainly divided into three categories. They're:

- ***Single line -to- ground (L-G) Fault*** **-** When one conductor hits the neutral conductor or falls to the ground, a single line of ground fault happens. Single line-to-ground faults account for 70–80% of power system faults.



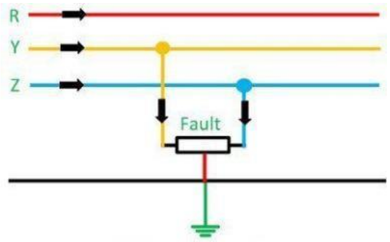
Single line-to-ground (L-G) fault

- ***Line -to- line (L-L) fault*** **–** When two wires short circuit, a line-to-line fault happens. The strong winds are the main cause of this kind of issue. The line conductors may come into contact with one another because to the strong wind, resulting in a short circuit. Between 15 and 20 percent of defects are of this type.



Line-to- line(L-L) fault

- ***Double line -to- ground (L-L-G) fault*** **–** In a double line-to-ground fault, the ground and the two lines make touch with one another. These kinds of problems are over 10% likely to occur.



Double line -to- ground fault

2.2 Symmetrical Fault

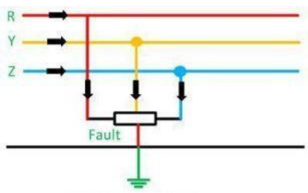
An electrical failure in a power system is said to be symmetrical if it affects all three circuit phases equally, resulting in balanced fault currents flowing through each line. The most common cause of this situation is a three-phase short circuit, which is regarded as the most serious but is also the most straightforward to mathematically analyze due to its symmetry. In spite of the fault, the system remains balanced because the fault currents in a symmetrical fault are the same size and are displaced by 120 degrees. Symmetrical component analysis is used by power system engineers to determine these currents and create protection devices that can swiftly isolate the fault, reducing damage and guaranteeing system stability.

Understanding symmetrical faults is essential for creating dependable and secure electrical networks, even if they are less frequent in real-world applications than unsymmetrical ones.

2.2.1 Types Of Symmetrical Fault

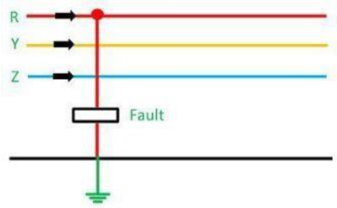
The two subcategories of symmetrical faults are three- phase line-to-ground fault and line-to-line-to-line fault.

- ***Line – line – line (L-L-L) fault*** **-** These faults are balanced, meaning that the system maintains its symmetry even after the fault has occurred. Although the L-L-L fault is the most severe and involves the biggest current, it happens infrequently. This high current is utilized to calculate the circuit breaker's rating.



Three line to ground (L-L-L) fault

- ***Three phase line -to- ground (L-L-L-G) fault -*** All three phases of the system are included in the three-phase line to ground fault. The L-L-L-G fault happens between the system's ground and the three phases. This kind of issue is almost two to three percent likely to occur.



Three phase line -to- ground (L-L-L-G) fault

3. CAUSES OF ELECTRICAL FAULTS

There are many reasons why electrical failures occur, but they are mostly caused by anomalous situations in electrical systems that interfere with normal current flow. Among the main reasons are:

- Overstressing, aging, moisture, filth, vibrations, or corrosive vapors can all cause insulation to fail, causing the insulation between conductors or to ground.
- Short circuits, which can lead to overheating, equipment damage, or fire when an unauthorized low resistance channel results in excessive current flow.
- Overvoltage circumstances that result in insulation failure and excessive current can be caused by electrical resonance, switching surges, lightning surges, or industrially produced voltages.
- Broken conductors that result in open circuits or ground faults because of aging, mechanical stress, or physical damage
- Dust or contaminant buildup on insulators weakens the insulation.

Therefore, insulation failure, conduction path failure, environmental effects, equipment failures, and human mistake compromising system safety and dependability are the root causes of electrical defects.

4. CIRCUIT AND DESCRIPTION

Fig. 1 shows how a simulation model made with the MATLAB software to exercise the Sim Power System is used to enforce the simulation of various faults. It is composed of a single three-phase source and a single three-phase motor with two windings. Additionally, a transmission line connects one R-L cargo and one three-phase VI dimension. For the purpose of measuring voltage and current faults, three-phase faults occur between the motor line and the three-phase VI dimension. A compass is connected in order to measure the voltage and current waveforms. Additionally, One Step is used to determine who's The step function is among MATLAB's most useful tools for control design.

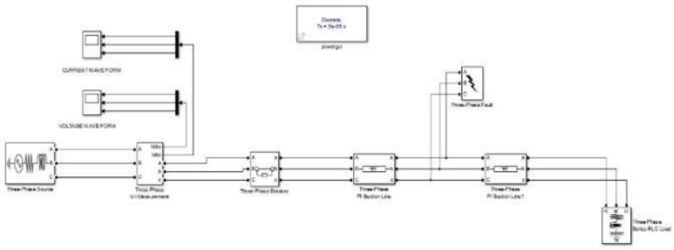


Fig -1: Representation of Transmission line model for Fault monitoring

5. SIMULATION RESULTS

5.1 Cause of Asymmetrical Fault on current and voltage –

5.1.1 (S-L-G) Fault -

In Figures 5.1.1(a) and 5.1.1(b), the voltage and current waveforms depict a single-line to ground fault in the system.

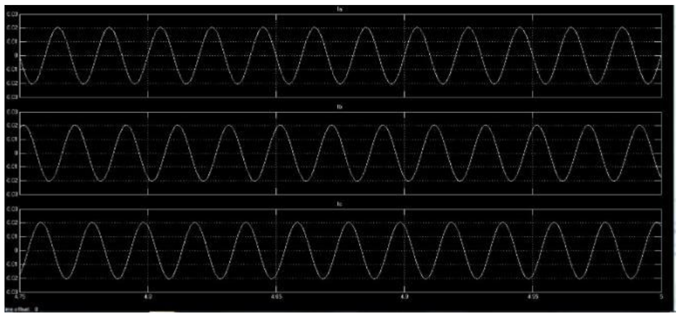


Fig 5.1.1(a) : Current Waveform

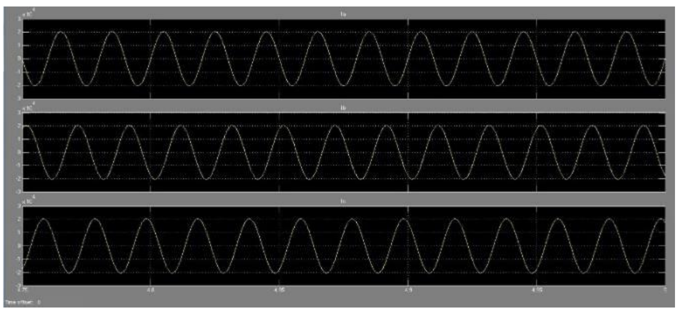


Fig 5.1.1(b) Voltage Waveform

5.1.2 Line-to-line (L-L) Fault

In Figures 5.1.2(a) and 5.1.2(b), the voltage and current waveforms depict a line-to-line fault in the system.

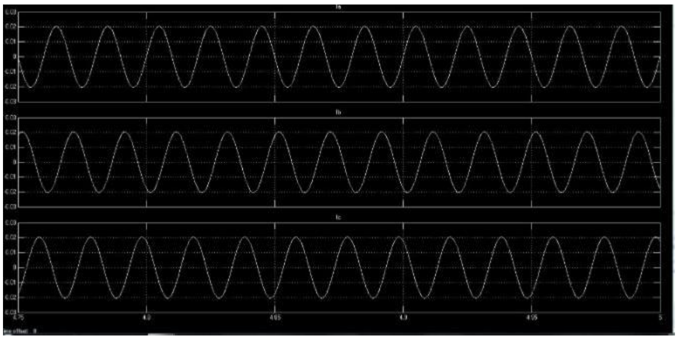


Fig 5.1.2(a) Current Waveform

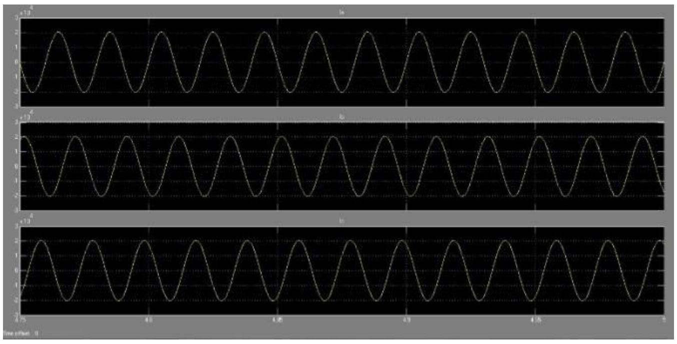


Fig 5.1.2Voltage Waveform

5.1.3 Double line-to – ground (L-L-G) FAULT

In Figures 5.1.3(a) and 5.1.3(b), the voltage and current waveforms depict a double line to ground fault in the system.

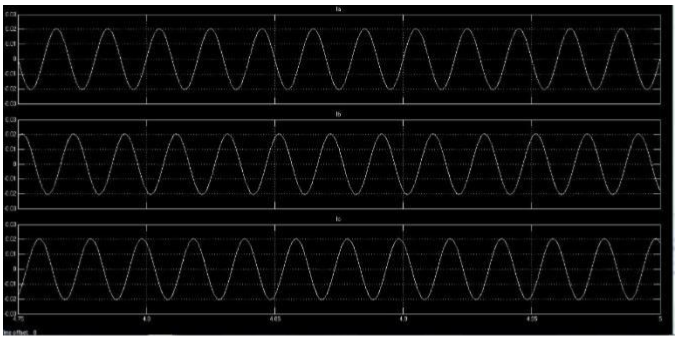


Fig 5.1.3(a) Current Waveform

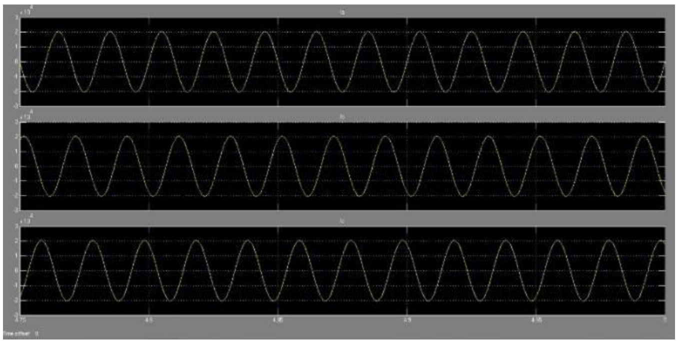


Fig 5.1.3(b) Voltage Waveform

5.2 Causes of symmetrical fault on current and. voltage –

5.2.1 Line -to- line (L-L-L) Fault

In Figures 5.2.1(a) and 5.2.1(b), the voltage and current waveforms depict a line -line -line to ground fault in the system.

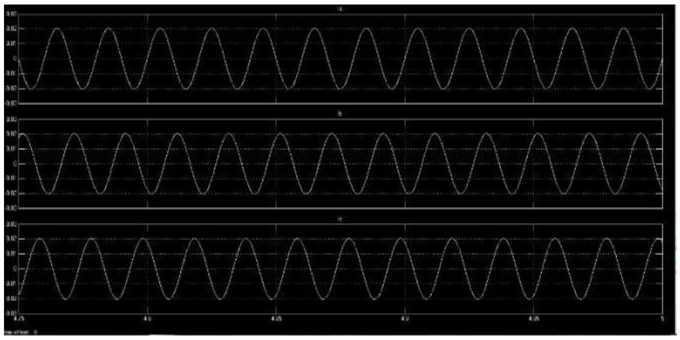


Fig 5.2.1(a) Current Waveform

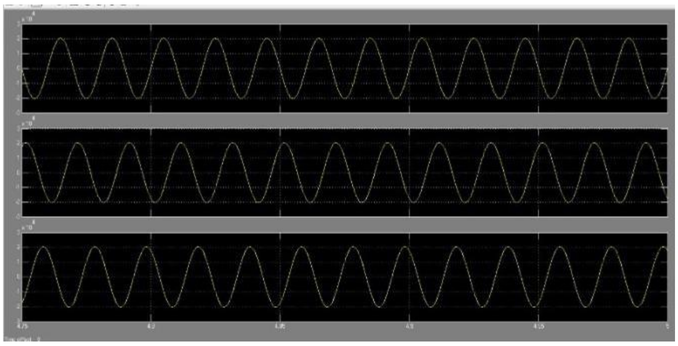


Fig 5.2.1(b) Voltage Waveform

5.2.2 Three phase line- to- ground (L-L-L-G) Fault

In Figures 5.2.2(a) and 5.2.2(b), the voltage and current waveforms depict a Three phase line to ground fault in the system.

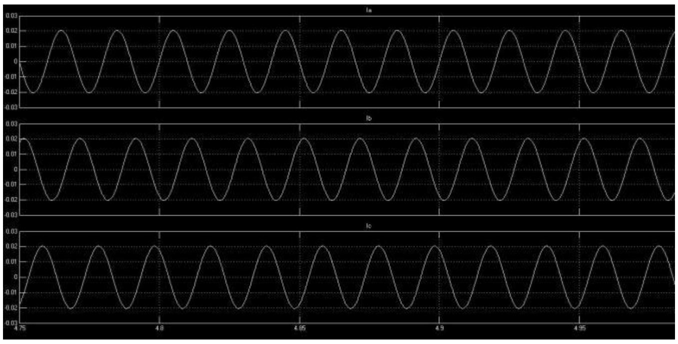


Fig 5.2.2 (a) Current Waveform

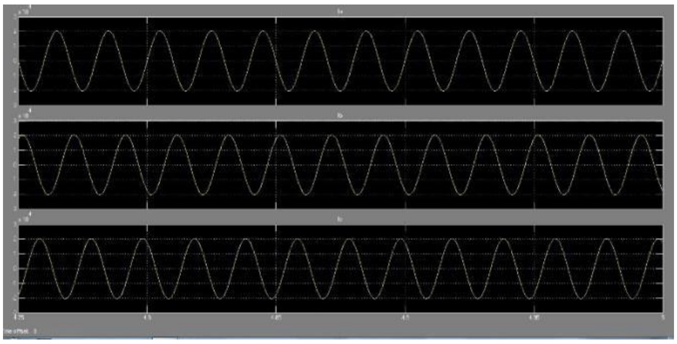


Fig 5.2.2(b) Voltage Waveform

6. CONCLUSIONS

In conclusion, a thorough grasp of fault monitoring and analysis in power transmission systems is provided by the extensive simulation study carried out using MATLAB/Simulink. Simulink's capacity to predict and assess the effects of different symmetrical and asymmetrical defects on system performance is clearly demonstrated by the study. Through the simulation of several fault circumstances, including single line-to-ground, double line-to-ground, line-to-line, and three-phase faults, the study demonstrates the unique characteristics of voltage and current waveforms both during and following a fault.

The simulation outputs' oscillations, abrupt voltage dips, and current surges emphasize how crucial it is to identify faults accurately and implement mitigation plans in a timely manner in order to preserve the power system's stability and safety. The study also indicates how MATLAB/Simulink can serve as a dependable platform for testing preventive strategies and validating theoretical concepts of power system functioning under faulty conditions. Additionally, the study confirms that using simulation to monitor defects helps determine their type and severity as well as their impact on load-side performance, equipment safety, and overall power quality. It emphasizes how important it is to create automatic and intelligent fault detection systems that can function in real time so that malfunctioning areas may be isolated more quickly and regular operations can resume. The results of the simulation demonstrate that ongoing monitoring can lower maintenance costs, stop cascade failures, and improve the reliability of contemporary electrical networks.

Engineers can forecast system reactions under various fault situations and create more robust grid systems that can tolerate dynamic disturbances by combining sophisticated modeling, waveform analysis, and fault diagnostics within Simulink. The development of smarter, more effective, and fault-tolerant power infrastructures that guarantee a steady and uninterrupted supply of electricity while reducing operational risks and boosting the dependability of the entire power system network is ultimately made possible by this simulation-based study.

7. REFERENCES

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