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Implementation of Symmetrical and Unsymmetrical Fault in Power System Network Using Matlab

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Abstract: The main goal of this study is to provide a MATLAB-based simulation model for three-phase symmetrical and unsymmetrical faults. This paper shows how to deal with MATLAB programming in which a transmission line model is created and various challenges are acted out using a toolbox. Fault analysis for many types of faults has been performed, and the resultant effects may be seen in simulation output such as voltage, current, and control, as well as the positive, negative, and zero grouping parts of voltage and current output as waveforms.
Keywords: MATLAB Simulations of L-L faults, Single Line to Ground faults, and 2L-G Double Line to Ground faults.

I. INTRODUCTION

Currently, power requests are increasing step by step, resulting in the need to transmit more power by increasing the transmission line limit from one location to the next. However, a few failures in the system occur during transmissions, such as the Line-To-Line fault (L-L), single line to ground fault (L-G), and 2L-G fault (two-fold line to ground). These flaws have an impact on the power framework types of gear that are connected to it. Controlling and monitoring of power systems is now necessary due to the continual expansion of the Power System Network. The benefits of using an advanced data communications strategy are clear. [1-26] When various forms of faults occur in a power system, assessment of bus voltage and RMS line current is feasible during the transmission line fault diagnosis process. The phrases bus voltage and RMS current of a line are quite crucial while consulting with the power system. In a three-phase power system, there are primarily two types of defects: three-phase balancing faults and unbalance faults on the transmission line, such as a double line to ground faults, line to ground faults, and double line faults. The transmission line fault analysis aids in the selection and development of a better protective system. The circuit has been installed to ensure the transmission line's safety.

The rating of breakers is determined by the triple line fault.

The reason for this is that, in comparison to other fault currents, the triple line fault current is quite high. As a result, transmission line fault investigation may be readily carried out using MATLAB simulation on a computer. The primary goal of this research is to investigate the general fault types of transmission line balance and unbalance faults in the power system. Additionally, using MATLAB [27], execute the analysis and acquire the results of various parameters (voltage, current, power, and so on) from simulation on those types of faults. The approach combines frequency information in dynamical models and provides approximation non-linear models that are well adapted for the study and simulation of unbalance faults in power systems[28].

Saturation is included in the transformer display. The parameters were derived from reasonable or exploratory guesses. When voltage returns, sags might cause transformer saturation, according to the study [29]. This causes an inrush current to be generated, similar to the inrush current formed during transformer energization.

The study points out that the voltage recovery moment can only take discrete values because the fault clearing is only supplied if there are regular current zeros. The time it takes for the voltage to recover is comparable to the time it takes for a defect to clear. A solitary point-on-wave of voltage recovery can be described for phase to phase faults and single-phase faults [30]. The recovery for two-phase to the ground and three-phase faults, on the other hand, occurs in stages. Establishing and ground fault security are essential issues in the petrochemical sector [31].

For the first, it is vital to have the appropriate framework in place for the specific framework application, and it is also critical to have the best possible protection from a ground fault.

A. Methodology MATLAB

Math-Works built the Lattice research facility, a multi-world view numerical registration environment, and a fourth-generation programming dialect. MATLAB allows grid controls, Interfacing with projects written in multiple dialects, charting capacities and information, executing calculations, ensuring UIs, and plotting capabilities and information. Although MATLAB is primarily intended for numerical computations, The MuPAD's standard processing capacities are used to register a discretionary tool compartment. Simulink, a separate package, contains a graphical multi-space reconstruction and a model-based design for a dynamic and installed framework. Clients of MATLAB come from a variety of backgrounds, including design, science, and finance. MATLAB is widely used in academic and research institutions, as well as mechanical ventures. MATLAB also provides an appealing domain with many dependable and exact inherent capabilities. To exhibit electrical, mechanical, and control systems, the MATLAB family collaborates with Simulink programming[32]. The Math-Works, Inc. produced this result. MATLAB began as a tool for performing framework science, but it has now evolved into a versatile processing framework capable of dealing with virtually any specific problem. MATLAB is capable of controlling and transforming large structures and can be used in a variety of numerical applications. SIMULINK, a tool that is commonly used in the analysis and combination of modern systems [33], can extend MATLAB's capabilities.

1) *MATLAB Standards:* When MATLAB/SIMULINK was compared to EMTP/ATP, it was discovered that MATLAB/SIMULINK is superior for power system simulations. The following items condense their most important differences in insurance framework simulations. [34]
2) The EMTP/ATP is specialized programming for simulating control framework transient issues, though MATLAB/SIMULINK can also be used to simulate power system faults and calculate defensive relays. SIMULINK, which is now part of MATLAB, may also be used to analyze and design power systems. Simulation of power systems has grown in importance during the last four decades. A recently issued IEEE paper discussing several approaches to presenting defensive transfers and related power systems reveal a variety of possible programming devices that could be used for this purpose. However, instead of MATLAB/SIMULINK programming, it is difficult to integrate modeling and simulation to demonstrate specific defense transference ideas that go beyond the product's original level of detail. SIMULINK support is included in the MATLAB programming bundle. PSB stands for Power System Block Set, and it's used to make customized display libraries for teaching protective relaying concepts.
3) While ATP/EMTP is designed to quickly and efficiently replicate the physical procedures of transmission lines and transformers, MATLAB/SIMULINK offers greater possibilities in power electronics, signal processing, and control.
4) With MATLAB/SIMULINK, clients can easily create new relay models, whereas EMTP/ATP has no such restriction.
5) MATLAB/SIMULINK envelopes are preferred over EMTP/ATP of pc plot, plot XY, and other realistic capacity devices.

B. Matlab Toolbox Elements

The components of the MATLAB toolbox that are used in the analysis of power systems encourage future programming amendments and extensions. This is critical for investigations that are interested in developing and testing novel technologies for various power system applications. It supplies a way to efficiently prepare information records is commonly recognized organizations for systems that are established, and the outcomes created by one application can be easily employed either entirely or partially by another application supported by the bundle.

The MATLAB/SIMULINK toolbox contains the following items:

1) Mat Power Tool Storage
2) Voltage Stability Toolkit and
3) Power System Analysis Toolkit.

Dispersed assets library, Electric drives library, and Adaptable Air conditioning transmission library are examples of application libraries. A.C.'s current source, A.C. furthermore, D.C. voltage source, Controlled voltage and current source, Three-phase programmable voltage source, Three-phase source, and Battery are included in the Electrical Sources assemble. Single-phase models RLC branches and loads, linear and saturable transformers, shared inductances, n-area lines, MOV sort surge arrester, circuit breaker, and n-phase distributed parameter line display are all included in the Components collection. The client can surely include more mind-boggling components developed from the main PSB building parts and partner a dialogue box by utilizing SIMULINK's covering office. This method was used to create a three-phase library, which is also available. Basic semiconductor devices are found in the Power Electronics category. Except for the Diode, every component in this assembly has a SIMULINK gating control input and a SIMULINK output that returns switch current and voltage.

The Mat Power Tool Kit is a collection of tools for describing power stream and optimal power stream issues. This bundle is designed to provide the best possible performance while keeping the code simple to understand and modify. The Power System Analysis Tool collection is for electric power systems. Control and investigation. Control stream, never-ending power stream, optimum power stream, tiny flag security investigation, and time area reproduction are all included. Stability of voltage Tool storage solves voltage security problems and provides information for power system planning, operation, and control. Control squares, discrete control pieces, discrete estimations, and phasor libraries are among the other libraries available.

a) *Block Libraries:* In the SIMULINK environment, the PSB is a realistic device that allows you to develop schematics and recreate force frameworks. The SIMULINK environment is used to communicate with basic segments and networks present in electrical power systems. It includes an electrical model library that includes RLC branches and loads, transformers, lines, surge arresters, electric machines, control devices, and so on. Snap and drag tactics into SIMULINK windows can be used to create outlines. To enter parameters, the Power system Block set uses the same artwork and intelligent dialogue boxes as normal SIMULINK pieces. Simplified and detailed models of synchronous machines, asynchronous machines, a permanent magnet synchronous machine, a model of a hydraulic turbine governor, and an excitation system can be found in the Machines groups. Every machine block has a SIMULINK output that returns inside factor estimations. A straightforward tool for setting introduction conditions is included in the PSB graphical interface (Powergui). This enables reproduction under initial conditions or the start of recreation in a lasting state. A heap stream computational motor enables the installation of three-stage circuits with synchronous and asynchronous machines, allowing the recreation to start in a persistent state. Simulink scopes linked to estimation piece yields in the PSB library can be used to visualize reproduction outcomes. This estimation block serves as a link between the electrical components and the SIMULINK blocks. To convert electrical signals into SIMULINK signals, the voltage and current estimation blocks can be used at certain points in the circuit.

II. FAULTS IN THE TRANSMISSION LINE

As previously stated, two types of faults can occur in a three-phase transmission line of a power system: balance faults (also known as symmetrical faults) and unbalance faults (also known as unsymmetrical faults). However, this study focuses on the asymmetrical fault, which typically occurs between two or three conductors in a three-phase system or between conductor and ground at some point. Unsymmetrical faults can be classified into three basic categories based on this:-

1) Single Line to Ground Fault.
2) Double Line to a Ground fault.
3) Double Line fault.

The single line to ground fault occurs most frequently in three-phase systems, followed by the L-L fault, 2L-G fault, and three-phase fault. These types of faults can arise during electrical storms, resulting in insulator flashover and ultimately affecting the power grid. In order to explore and analyze the unsymmetrical fault in MATLAB, a network of positive, negative, and zero sequences must be developed. In this study, we examine the voltage and current of buses in positive, negative, and zero sequences under various fault conditions. We also look at the active and reactive power, as well as the system's RMS bus current and voltage, under various fault conditions.

A. *Protective Relay*

The relay, which is a device that treks the circuit breakers when the information voltage and current indicators relate to the fault circumstances intended for the relay function, is one of the most critical elements of a power protection system.

When all is said and done, relays can be classified into the following classes:

1) *Directional Relays:* They respond to a difference in phase angle between two relay contributions.
2) *Differential Relays:* They respond to the magnitude of the logarithmic sum of the information sources.
3) *Size Relays:* These relays are triggered by the magnitude of the input amount.
4) *Pilot Relays:* These relays respond to information flags received from a remote location.
5) *Remove Relays*: They are affected by the ratio of two information phasor signals. Over the years, relay technology has progressed, and the following generational classification has been established:
6) *Electromechanical Relays:* This is the first relay generation. They work on the electromechanical conversion principle. They're tough and unaffected by electromagnetic interference. However, current technological improvements have rendered them obsolete in most domains.

7) *Solid State Relay:* These use transistors, op-amps, and other electronic components. They are more flexible than electromechanical relays, with a self-check feature, consume less power, and have better dynamic performance. They were also smaller, necessitating less panel area.
8) *Numerical Relays:* The operation of these relays entails an Analog to Digital conversion of currents and voltages obtained from CTs and VTs and fed to the DSP or microprocessor. The protection algorithms are then applied to these signals, and the necessary decisions are made. The following are some of the benefits of using a Numerical Relay:

a) Extreme adaptability.
b) A wide range of capabilities.
c) The ability to self-check and communicate.
d) Has the ability to adjust

III. POWER SYSTEM NETWORK CIRCUIT MODEL FOR THREE-PHASE FAULTS

The GUI is used to implement the model created in MATLAB using the Sim Power Systems® Tool. Any power system network may be simulated with ease using this powerful data simulation model, and fault analysis can be carried out. [33-43].

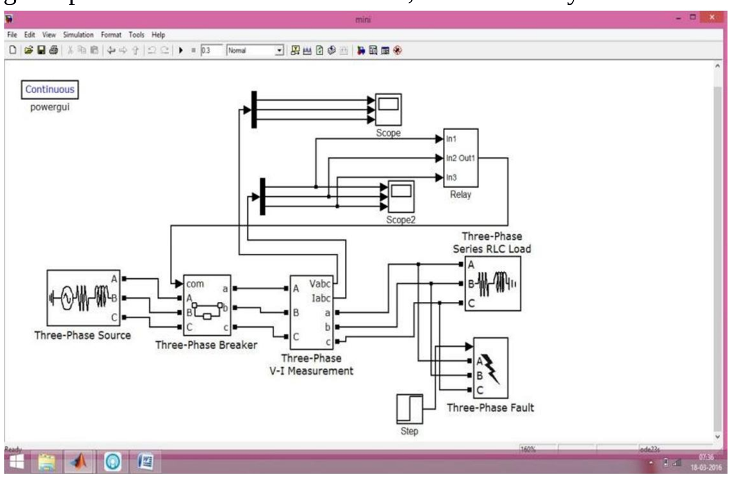

Fig 1: The Distribution Model

A. Step-by-Step Guide to Creating a Circuit Model

1) Start
2) Open the model file (.mdl/.slx) and run it.
3) Explain the terms CT and PT.
4) Determine the number of samples, phrases, and sampling time (frequency)
5) Establish operating times for faults and circuit breakers.
6) Define the system voltage as well as the line lengths.
7) Allocate RAM for the three phases' current and voltage data.
8) Check the maximum and minimum current and voltage values in each phase, and if abs(min)>max, abs(min)=max.
9) Change the matrix to an array and normalize the maximum current and voltage to 32767.
10) Divide current and voltage data by phase into separate instructions.
11) Initialize the buffer to determine the travel duration
12) Create a user-defined Current and Voltage waveform
13) Perform the test and obtain the relay's trip status and journey time.
14) Save the plots you've created.
15) Create a report by building a new Excel server and sending data from MATLAB to Excel.
16) Save the report as a pdf after converting the file.
17) End

In a Matlab environment, Figure 2 depicts the relay circuit sub-system for the suggested three-phase model.

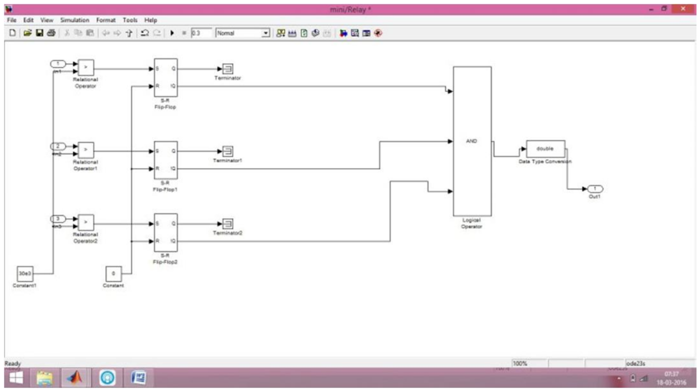

Figure 2: shows the relay subsystem.

B. Simulation Outcomes

The Distribution system model is used in this scenario to simulate a Three-Phase To Ground Fault. The simulation is run for 1 second to make the waveforms more visible. 10 kHz is assumed to be the sampling frequency. The system voltage is 33 kV, and the line length is 10 kilometers, with a fault occurring at 5 kilometers. As illustrated in Figure 3, the fault starts at 0.2 seconds and ends at 0.7 seconds. For other test scenarios, these parameters were also kept constant. The current and voltage waveforms for the provided requirements are shown in Figures 3 and 4. When these signals are injected into the relay, the relay trips after 47.51 milliseconds and the status of its coil is displayed in the simulated results. The trip status of a self-reset relay returns to 0 when the fault is cleared, whereas the trip status of a manual reset relay remains 1 until the reset button is manually pressed. To view the charts, the proposed MATLAB model can be run standalone or on the GUI.

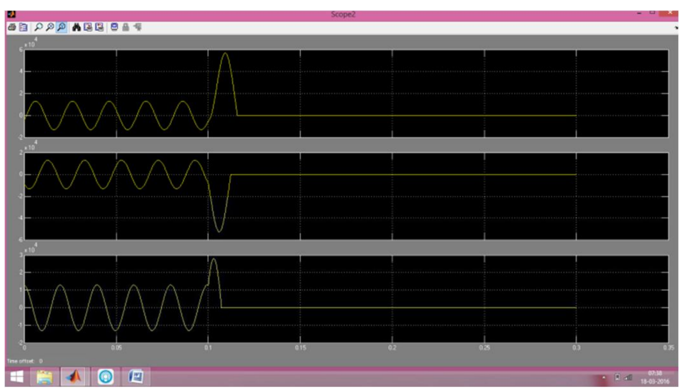

Figure 3: Waveform of three-phase fault current.

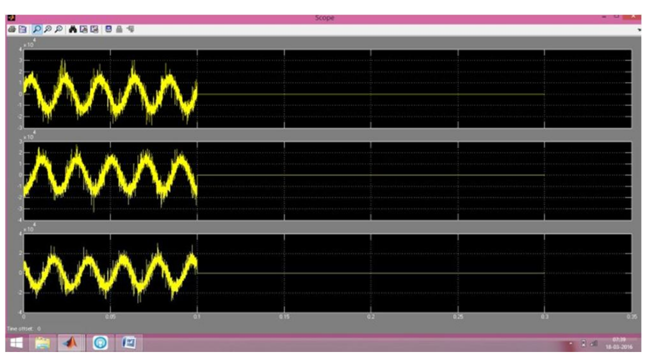

Figure 4: Waveform of three-phase fault voltage.

Simulating unsymmetrical faults such as Double Line to Ground fault, Line to Line fault, and Single Line to Ground fault is part of the suggested study work.

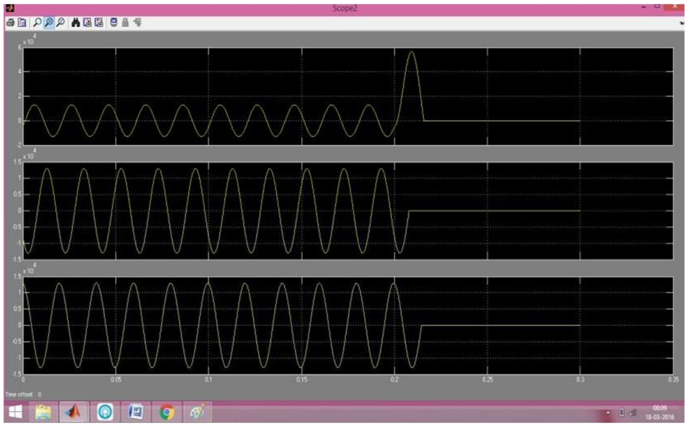

Figure 5: the simulation results of the current waveform for the induced double line to ground fault are shown.

IV. CONCLUSION

The use of MATLAB software allows for the modeling and analysis of three-phase faults in order to provide transmission line parameter data. This paper proposes a simulation of a three-phase transmission line fault analysis system. Transmission line faults such as a single line to ground faults, double line faults, and so on are also simulated. This system paves the way for the power system's bus system to be redesigned. according to the outcomes The proposed method has the potential to be implemented for larger power networks that are geographically separated.

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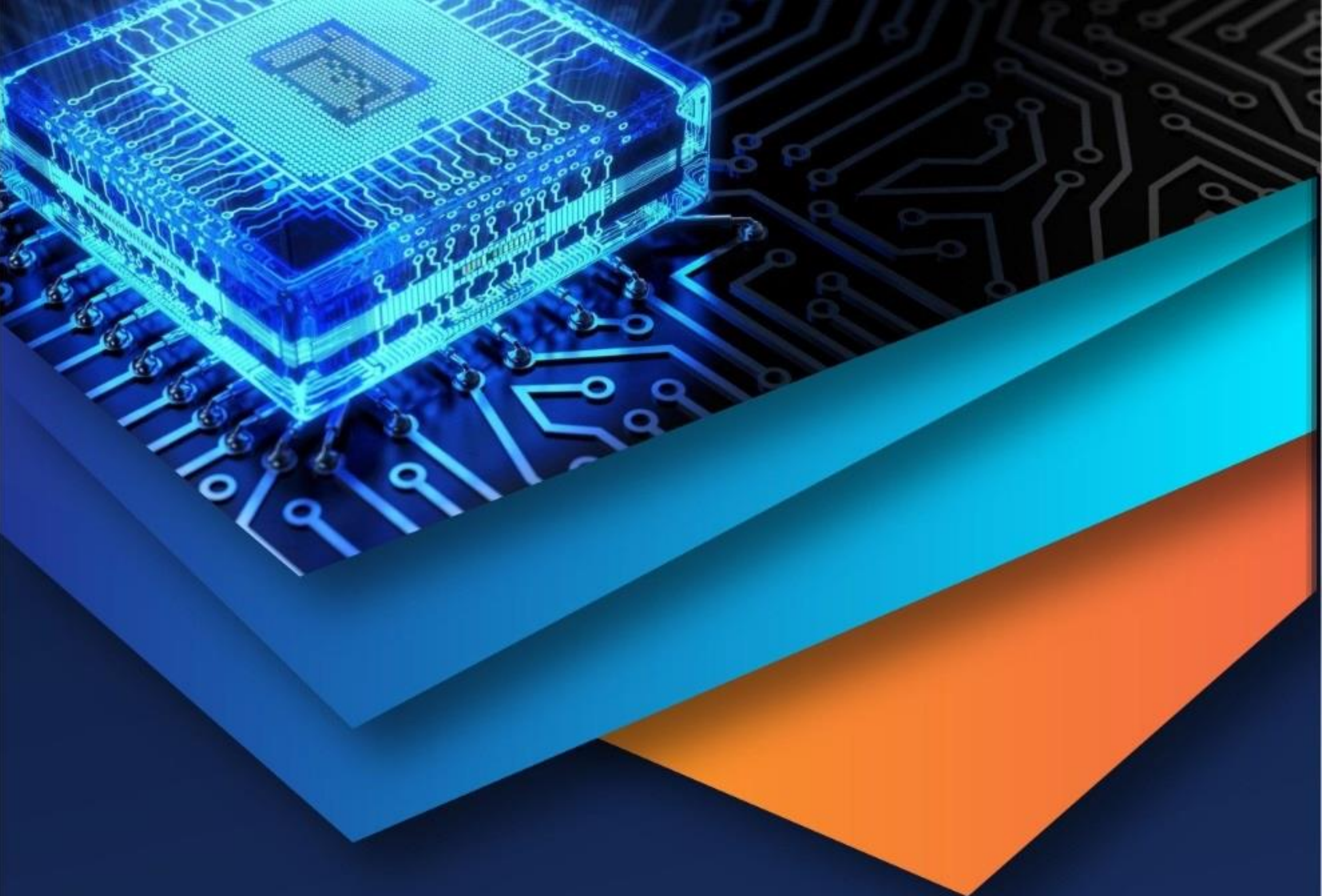

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