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Analysis of Three-Phase Transmission Line Fault Using Matlab/Simulink

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ABSTRACT
Faults affect the reliability of the power systemnetwork. The frequency and degree of faults determine the downtime (outage time) of a power system network. The more frequent fault occurs, the less reliable the power system is. To ensure a high degree of reliability and provide quality service at a reduced cost to consumers, protection, and control of fault are required. Successful protection and regulation of faults in the power system demand adequate knowledge and analysis of faults. This research work deals with the analysis of faults in transmission lines using MATLAB/SIMULINK. In this research a 300KM transmission line model was developed, faults simulated and analyzed such as 1L-G, 2L-G, and 3L-G faults) during the simulation study of the various faults, the FFT tool was used to analyze the harmonic content of the various faults. The effect of faults was observed and discussed. A discrete powergui with sampling time Ts=5e-05s was used for the simulation study under various fault conditions.

KEYWORDS: Transmission Line Faults, Matlab/Simulink,FFT Tool.

I. INTRODUCTION:

Transmission lines conveyed bulk power from the power generating station to consumers through the distribution lines, it does this at a high voltage to reduce losses along the transmission line. Transmission lines normally experience various faults abnormalities.

A fault in any power system network circuit is any failure that interferes with the proper flow of electric current. This can be unexpected creation of conducting path, says short circuit fault and interruption to the flow of electric current says open-circuit fault [1].When faultcurrent flows in a power system network, the short circuit electric current will become typically high say about six to ten times more than the proper or standard full load electric current in such power systemcircuit [4, 5]. Typical Faults in an electric Power System circuit is said to take place when conductors or any two transmission lines comes in contact with each other or earth includes; Single -line- ground fault, Double -line- ground fault, Three -line- ground fault, and line- to line faults. These faults can are also referred to as short circuit faults, which are common to a transmission line. There such power transmissionsystem must be protected from the flow of heavy short-circuit currents, which can affect the safety of personnel and cause permanent damage to major equipment by disconnecting the faulty section of the system [2,6,7]. The safe disconnection can be guaranteed if the current does not exceed the capacity of the circuit protecting equipment.

Professionally in such situation these abnormal current flows needs to be mathematically evaluated and its obtained results compared with the ratings of the various protective devise such as circuit breakers as a routine practice aim at enhancing preventive maintenance of the system.Depending on the location, the nature, the time involve and as well as the system network condition grounding, short circuits can results to

i. Interference of electromagnetic discharge with conductors found within such vicinity.
ii. Thermal or mechanical stress (that is, damage effect on equipment, personnel danger).

The transmission line has resistance R, inductance L, capacitanceC, and shunt or leakage conductance G. These parameters along with the load and the transmission line determine the performance of the power transmission line system. The term performance means the sending-end voltage, sending-end currents, sending end power factor, power loss in the line, efficiency of the transmission line, regulate and limit of power flow during efficiency and transmission, regulation and limits of power during steady-state and transient condition [3, 6,7].When a fault occurs in

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transmission lines, it affects the availability and continuity of operations of the power system.

This is because when faults occur and it's not cleared immediately it causes power outages which may result in interruption of service. In addition, when faultis experienced or takes place, it endangers the life of personnel and equipment. This research work is aimed at analysing faults on a power system transmission lines in order to recommend the proper selection of protective devices to enable utility companies to provide services to consumers with the required safety of personnel and equipment at an affordable cost.

II. FAULTS IN TRANSMISSION LINE

In an electric power system circuit or network, fault is any abnormal flow of electric current. E.g., a short circuit fault is a fault in which the current flows throng the wrong path, not originally design for the normalload. Also open-circuit fault takes if an electric circuit is interrupted by some failures or mishap [4, 5].In three-phase power system, faults may involve one or more phases and ground or may take place only between phases.In a poly-phase power system circuit, fault may affect all phases throughout and equally which is referred to as symmetrical fault"[4, 5]. In other words If some phases are affected, the resulting fault in such a system is known as asymmetrical fault, this type of fault is always complicated to analyze or mathematically evaluated. The analysis of these types of faults is often simplified by using methods such as symmetrical components [5].

The commonly known typeof faults in typical electrical power systeminclude,Symmetrical (or Balanced Faults) fault and Unsymmetrical faults (or unbalanced fault)

2.1. Symmetrical Faults

These are severe faults that takes place but not frequently in the power transmission systems. These are also known as balanced faults. A common example of this type of fault is when all the three conductors of a typical three-phase power transmission line are simultaneously brought to an unintentional connection(short-circuit) condition, which is commonly known as L-L-L-L- Ground Fault. [6, 12, 13].

2.2. Unsymmetrical faults

These are faults that results to unbalanced currentswith unequal displacement in the line when they occurred. There are mainly three types namely,Line to Ground (L-G), Line to Line (L-L), and Double-Line – to - Ground (LL-G) Faults[6, 12, 13].

III. METHODOLOGY

MATLAB/SIMULINK is a computer digital software tool for high-performance computation and visualization. Its analysis reliability, capability, flexibilityand powerful graphic makes MATLAB/SIMULINK a highly acceptable and utilized software package for engineers and scientists. MATLAB is an acronym which mean Matrix Laboratory. It's a high-performance computer package with multiple accurate and reliable in-build mathematical functions. These functions provide a solution to a wide range of mathematical problems such as Matrix algebra, Complex arithmetic, Linear systems, Differential equations, Signal processing, Optimization, Son-linear systems, and other scientific computations [7].

In other to analyze the transmission line fault, the following model circuit arrangement was used as it can be seen in figure (2). Two 200 MVA, 11Kv, 50Hz, three Phase sources are connected to a network of 300Km transmission lines. The power transmission line system is split into two, 150Km each, connected between buses B1, B2, and B3, and protected by circuit breakers CB1 and CB2. A 150MVA, 11/132Kv transformer feeds an 11Kv, 100MW load. Universal transformer blocks are used to model the two transformers. With the fault tool blocks, the various fault was created at time 0.2 seconds, in which the different fault current and voltage waveform results were observed on a scope which is contained in the data acquisition block. A discrete powergui with sampling time Ts=5e-05s was used for the simulation study under various fault conditions. During the simulation, the Fast Fourier Transform (FFT) of the voltage spectrum was carried out at different faults study conditions, where various fault harmonic content was analyzed. In this research work, the following faults were considered for the simulation study, 1L-G fault, 2L-G fault, and 3L-G fault.

The FFT tool allows the computation of fundamental components of voltage and current while the simulation is running, it enables the observation of harmonic components. FFT tool of powergui displays various levels of the frequency spectrum of voltage and current waveforms. The signal is stored with time variables generated by the scope block. The signal is then sampled at a fixed step and consequently satisfies the FFT tool requirements. Analysis was achieved by setting the parameters specifying the analyzed signal, the time window, and the frequency range.

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3.1. CONCEPTUAL SIMULATION MODEL

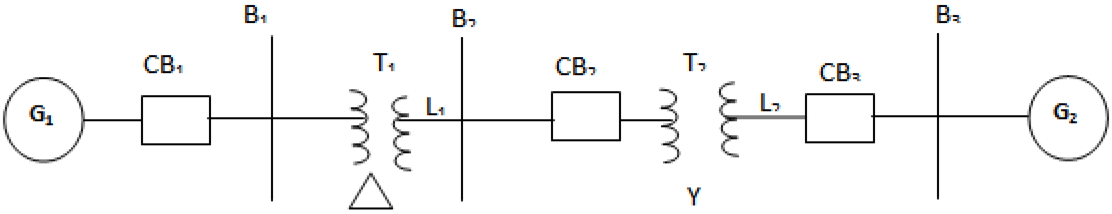

FIGURE 1: One Line Diagram of the Conceptual Transmission Line Model

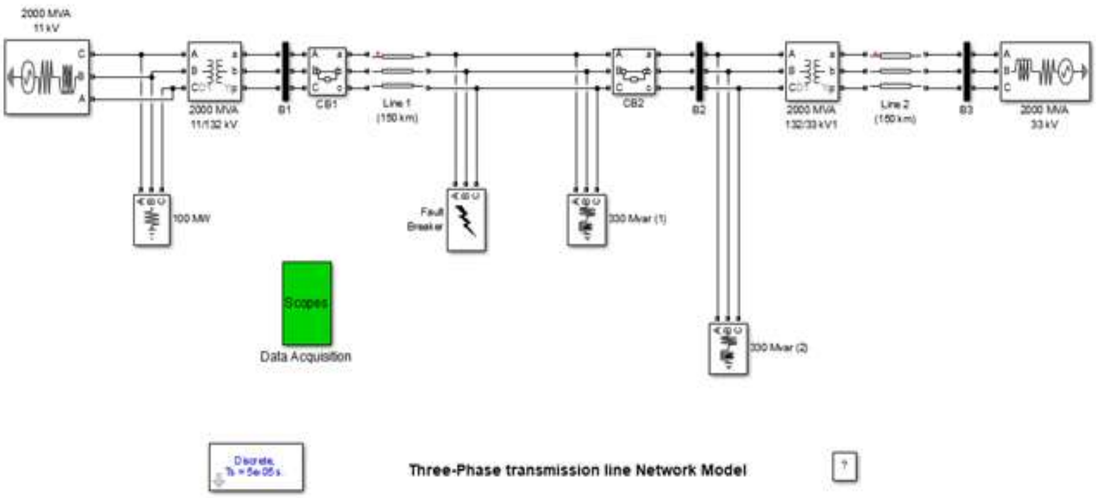

FIGURE 2. Transmission Line Model for Fault Analysis.

SIMULATION ANALYSIS RESULTS

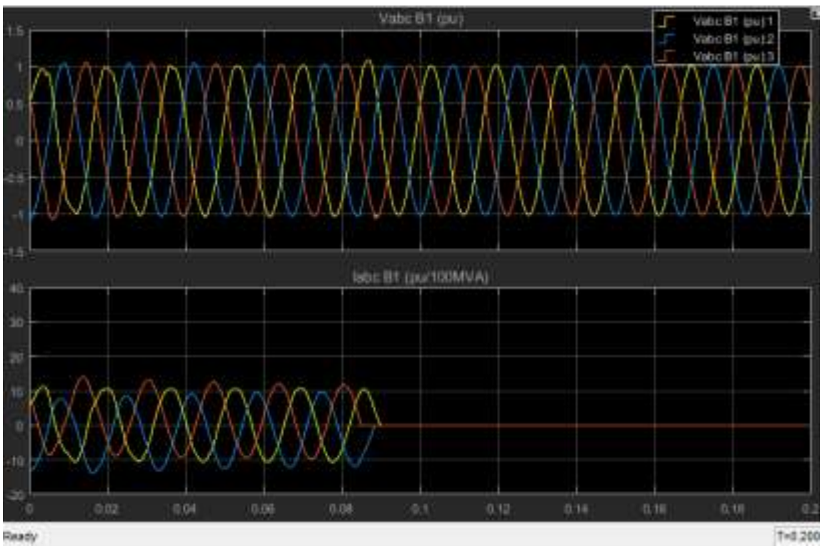

FIGURE 3: Voltage and Current Waveform when has not occurred on either Phase A, B, or C.

Figure (3) shows the waveform of voltage and current when there is no fault on the transmission line. It can be observed that the voltage waveform maintains a continuous sinusoidal signal waveform from time = 0 seconds to Time = 0.2 seconds without any change in the behaviour of the voltage waveform. This indicates that fault has not occurred on either phase of the transmission line. The magnitude of the voltage was maintained at approximately 1.2p.u.
The magnitude of the current was maintained at approximately 10.2p.u from Time = 0 to Time = 0.1 second.

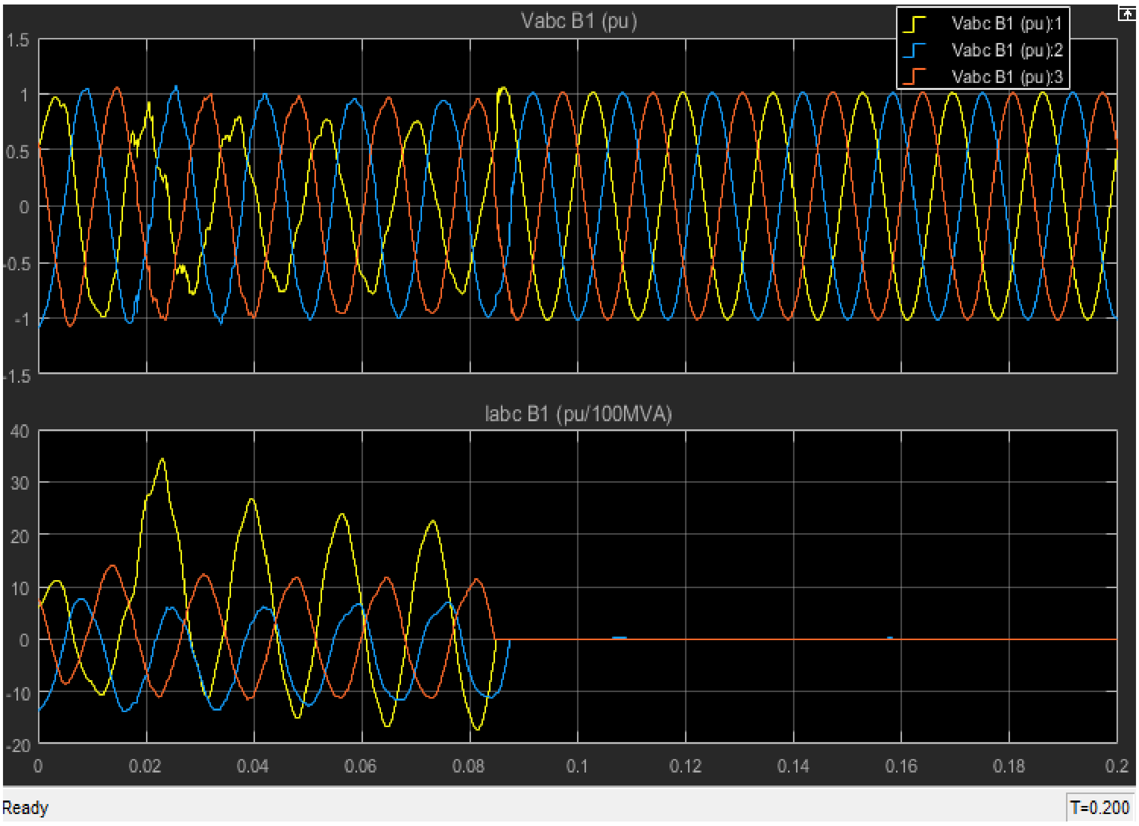

Figure 4: Waveform of Voltage and Current of Phase A, (1L-G) to Ground Fault.

Figure (4) shows the waveform of voltage and current when fault occur between Phase A and the ground at Time = 0 to Time = 0.02 second, A sinusoidal waveform was observed for both current and voltage, before there was an intercepting fault occurrence on phase A, during this period of fault occurrence, there was a distortion in the waveform of the voltage and current, as it can be seenin figure 4. The circuit breaker then senses and trip to isolate the healthy lines from the faulted line. After the protective operation by the circuit breaker, the voltage sinusoidal waveform was then restored between Time = 0.1 to Time = 0.2 seconds.

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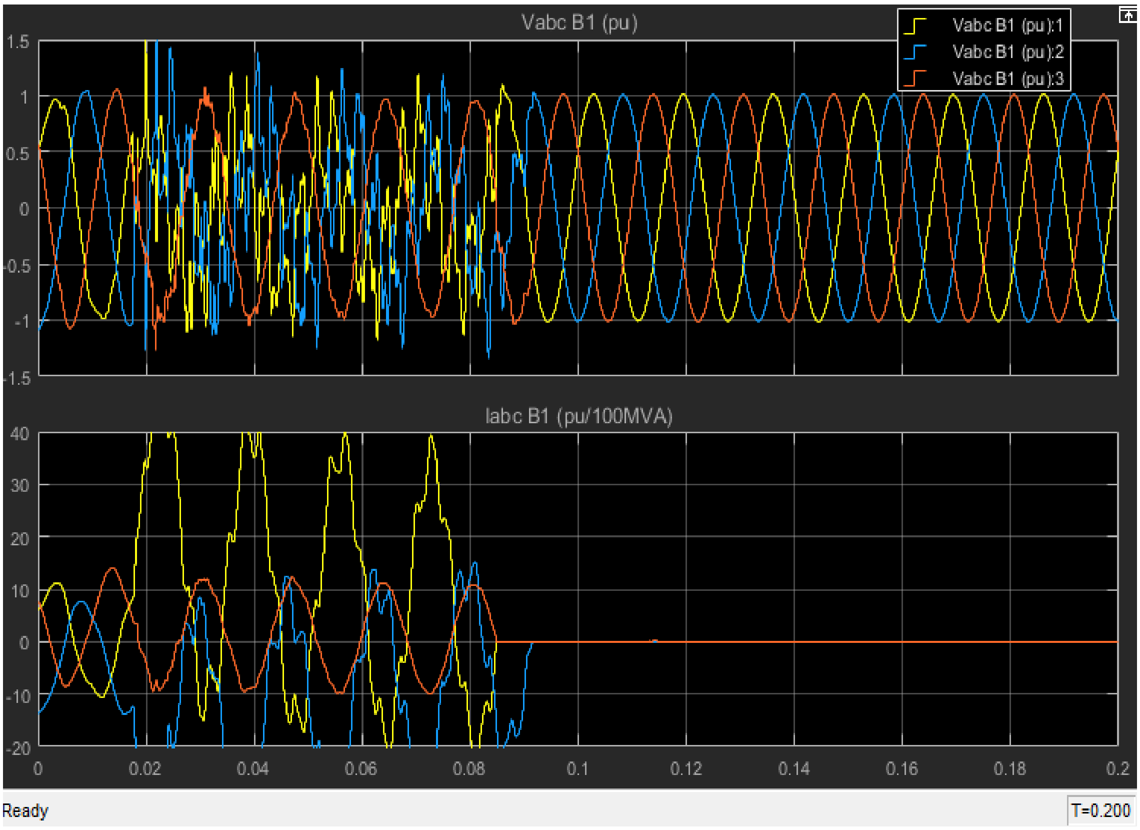

FIGURE 5:Waveform of voltage and current of phase A and B. (2L-G) to Ground Fault.

Figure (5) shows the waveform of voltage and current when there is double-line-to-ground fault occurrence on phase A and B within Time = 0.02 to Time = 0.1 seconds, within this interval of time there was a distortion in the waveform signal on both voltage and current signals, indicating the effect of the resulting fault that occurs on the lines. The circuit breaker sense and isolated the healthy part of the line from the faulted part of the lines, and there was a restored sinusoidal waveform between Time = 0.1 to Time = 0.2 seconds.

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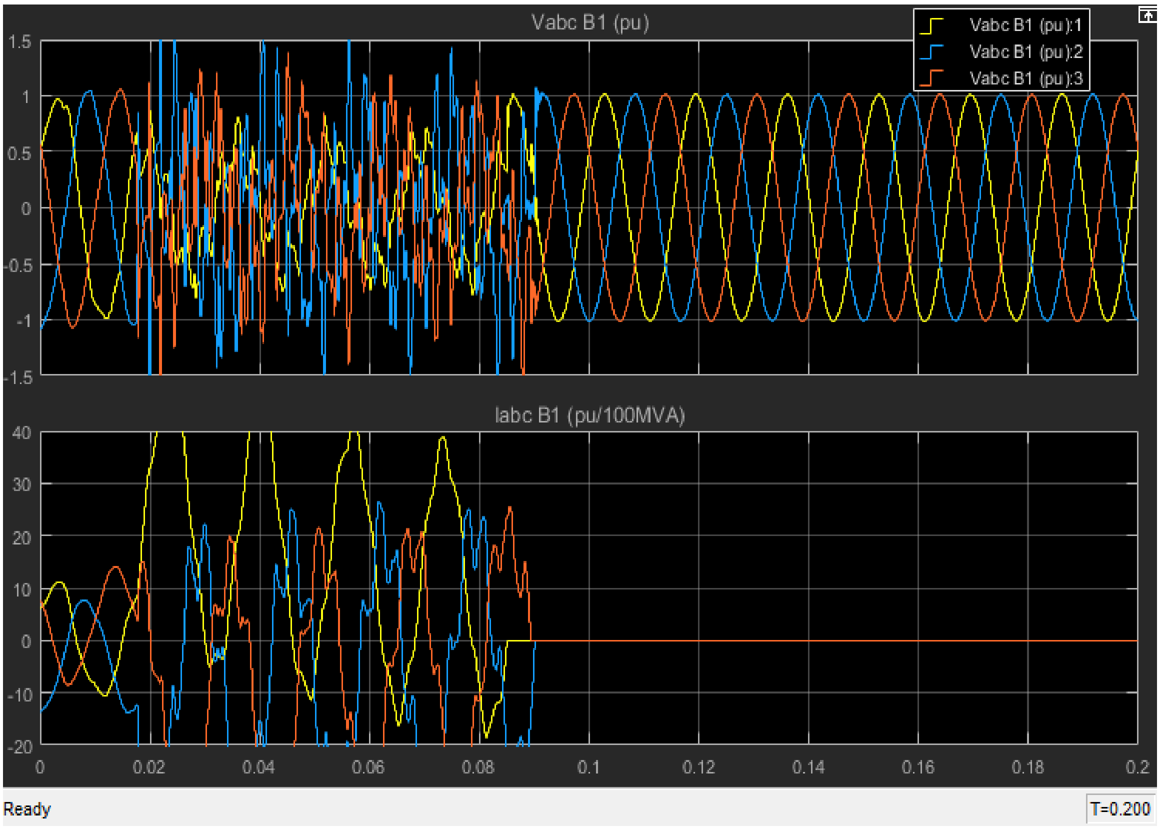

Figure 6:Waveform of voltage and current of phase A, B, and C (3L-G) to ground fault.

Figure (6) shows a three (3) phase-to-ground fault it could be observed that at initial time = 0. To 0.2 seconds, there was a sinusoidal waveform, which indicates that no fault has occurred yet on the lines. But between Time = 0.20 to Time = 0.1 seconds, the sinusoidal waveform was distorted showing that there was fault occurrence on the lines on both the voltage and current waveform signal. The circuit breaker cleared the fault, thereby isolating the faulted lines from the healthy parts of the lines, restoring a sinusoidal waveform signal of the line between Time = 0.1 to Time = 0.2 seconds.

3.2.FAST FOURIER TRANSFORM (FFT) ANALYSIS OF THE VOLTAGE SPECTRUM

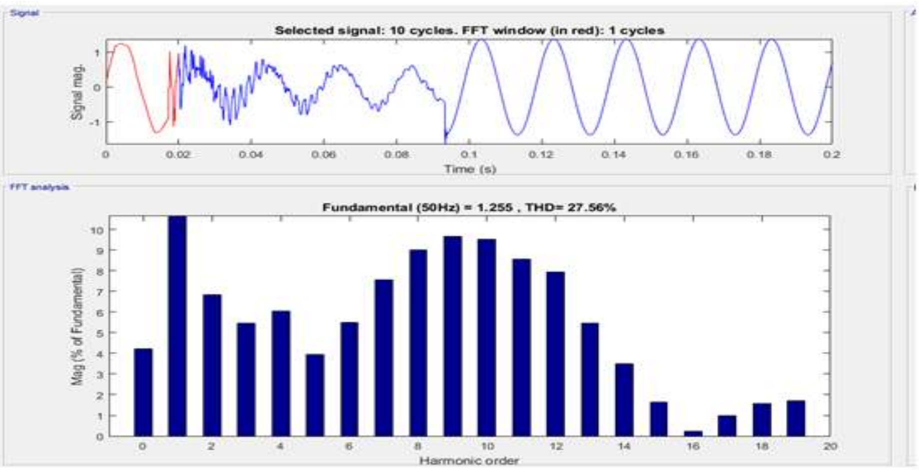

FIGURE 7: 1L-G Fault Voltage (Va) FFT Analysis.

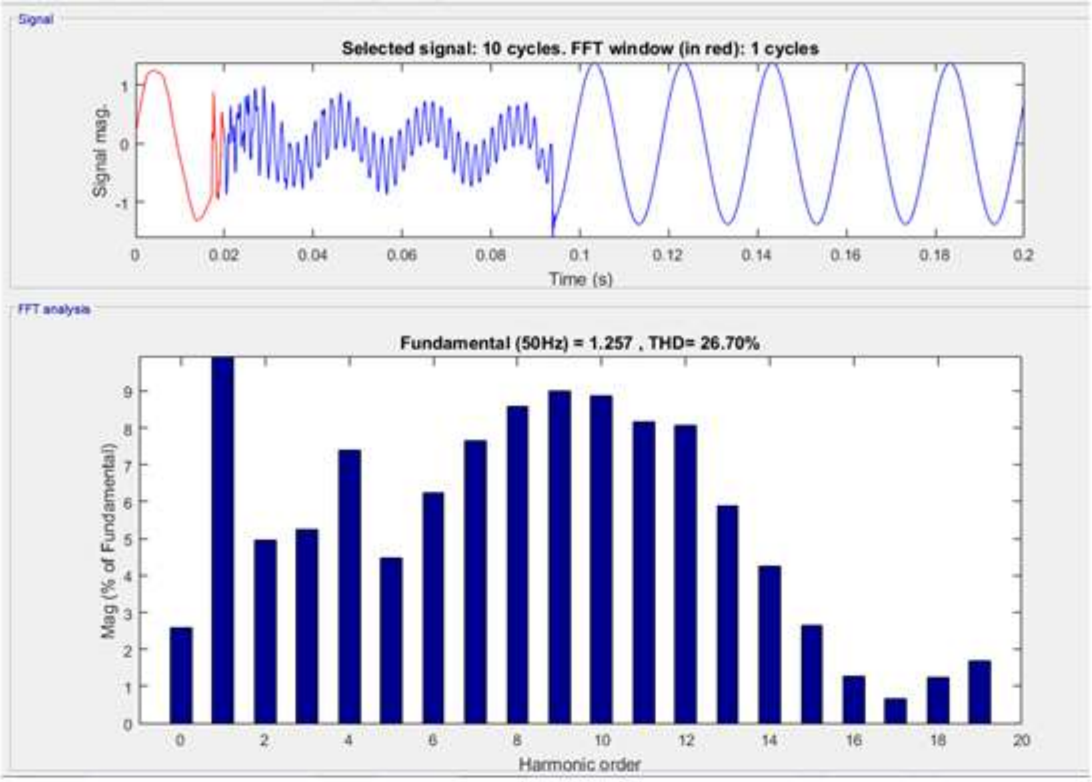

FIGURE 8: 2L-G Fault Voltage (Vab) FFT Analysis.

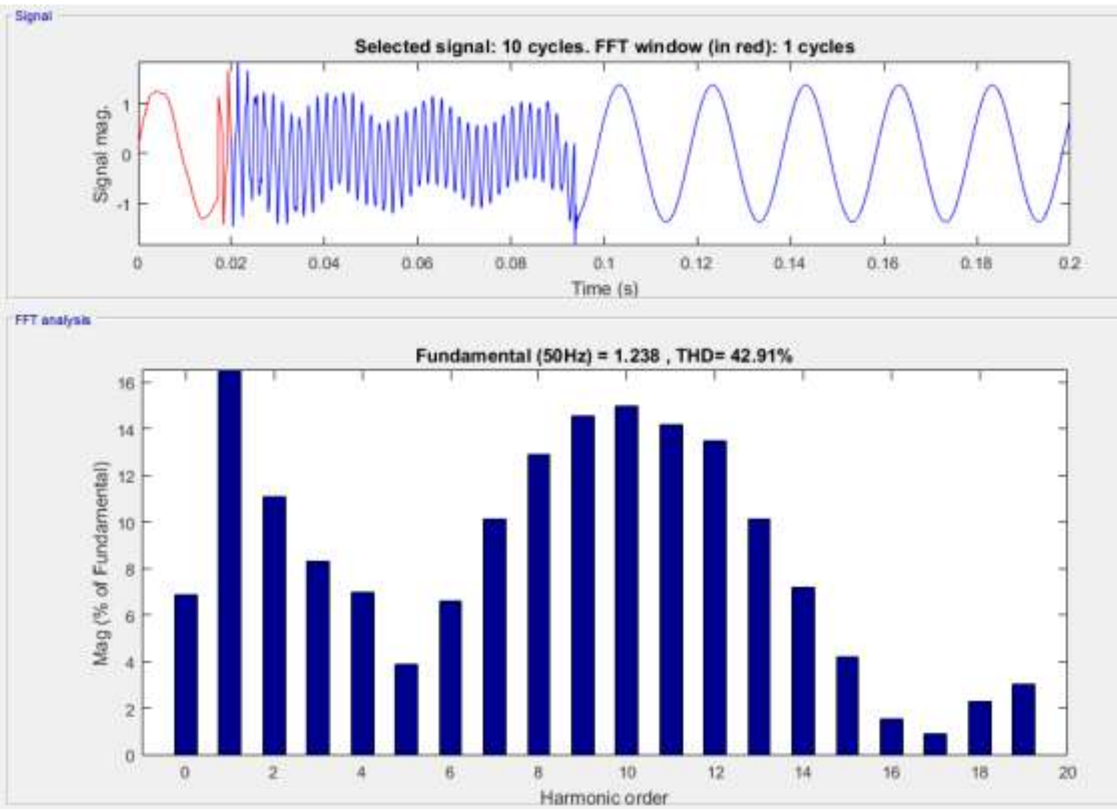

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FIGURE 9:3L-G Voltage (Vac) Fault FFT Analysis

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IV. CONCLUSION

Simulation andanalysis of three-phase electric transmission line fault to achieve results of the transmission line system parameter is possible and convenient through the use of MATLAB software. In this research work, the transmission power system was modelled to show the Variations of voltage and current when a single-line-ground fault, double-line-ground fault and a three-line-ground fault occurs in the transmission line. To complete the task of isolating faulted parts of the power system, to maintain the continuity in power supply, fault analysis need to be carried out in every location under various fault conditions, its priority is to determine the appropriate protection scheme by determining the fault currents and voltages. In other words, the analysis of faults leads to optimum protection settings which can be analysed to select suitable circuit breaker rating and type of relays.

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