Generation of Voltage Sag Due to Underlying Causes Using MATLAB-Simulink

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***Abstract*—In this paper, we present a new method for designing and analyzing power disturbances using MATLAB Simulink, with a special focus on voltage sags [2]. PQ issues such as voltage drop are a major problem in power systems and cause poor power quality and financial loss. Our approach involves creating a complete test model in MATLAB Simulink that includes various systems and loads to create a drop test. We describe the simulation setup in detail, including modelling power supplies and generating power sag events using appropriate control strategies. Additionally, our analog voltage drop waveforms are extensively analyzed to ensure their accuracy and reliability. The program provides researchers and practitioners with important tools to study the impact of voltage sags on energy production and explore mitigation strategies. Experimental results demonstrate the effectiveness of our interventional energy production method and its practical applications in research and energy production.**

***Keywords*—Power Quality, MATLAB-based Simulink, Voltage Sag, Disturbance Generation.**

I. Introduction

In modern electrical power systems, ensuring high-quality power delivery to consumers is paramount for maintaining the reliable operation of various electrical and electronic devices. Power quality disturbances, such as voltage sags, pose significant challenges to achieving this goal. Voltage drop, also called a dip, is a brief reduction in the size of the RMS voltage [13]. It lasts from a fraction of a cycle to a few seconds. While voltage sags are transient phenomena, their effects can be disruptive, causing equipment malfunction, production downtime, and financial losses for industrial and commercial consumers.

Studying and mitigating negative power effects, such as voltage sags, are important tasks for power system engineers and scientists. Understanding voltage sags traits is essential [12]. Developing effective techniques is key to improving power systems' resilience and reliability [11].

This research paper focuses on power quality issues. It looks at voltage sags in particular. It uses MATLAB Simulink to study them. It is a powerful simulation platform. Academia and industry use it. It is for modelling and analyzing dynamic systems, including power systems. We will use MATLAB Simulink. It will let us simulate voltage sags. We will use it to study their impacts on power systems.

II. Causes of Voltage Sag

Voltage sag is a disturbance that mainly occurs in power quality. Voltage sag occurs due to various reasons like LG, LLG, LLLG faults, as well as from induction motor starting and transformer energization. We create the MATLAB model to generate the voltage by using MATLAB Simulink.

III. Simulation of Matlab Models

The line fault model, induction motor starting model, and transformer energization model are used to induced voltage sag. By these models, we add the load on the system and create voltage sag.

A. Line Fault Model

The model fault line has an 11 kV, 30 MVA, 50 Hz three-phase power feeder. It connects to a 200-kW resistive load and a 100 VAR inductive load. These loads are from an 11 kV/0.415 kV, 200 kVA delta/star transformer.[7] Voltage waveform and RMS measurement ranges are available for the 11 kV and 0.415 kV buses.

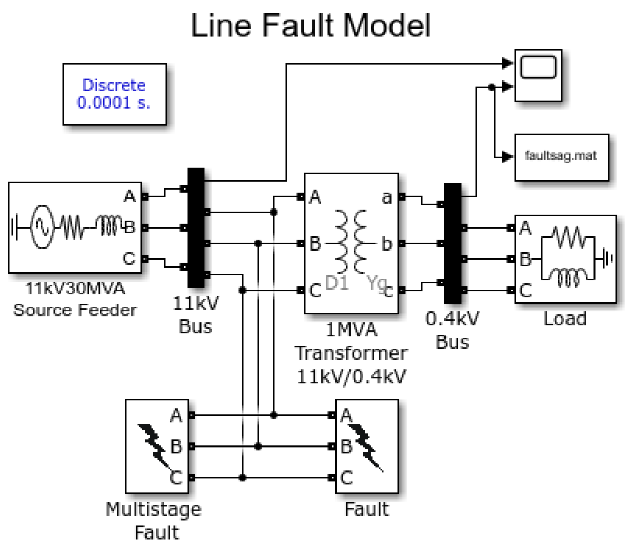

Fig. 1. Line Fault Model (LG, LLG, LLLG)

Fig.2 shows voltage sag waveform caused by a LG fault at 11 kV bus.

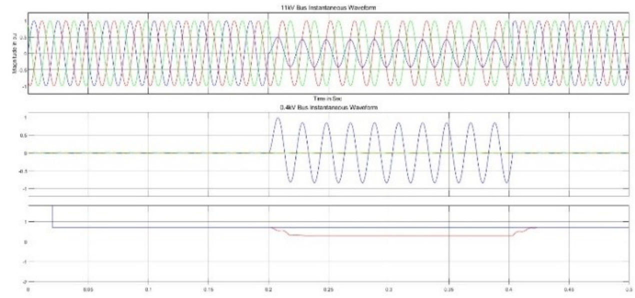

Fig. 2. 11 kV bus instantaneous waveform of LG Fault

Fig.3 shows voltage sag waveform caused by a LG fault at 0.415 kV bus.

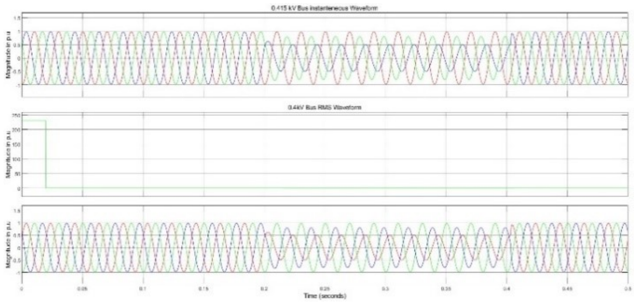

Fig. 3. 0.415 kV bus instantaneous waveform of LG Fault

Fig.4 shows voltage sag waveform caused by a LLG fault at 11 kV bus.

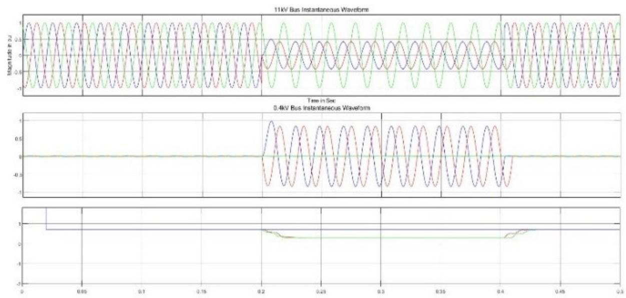

Fig. 4. 11 kV bus instantaneous waveform of LLG Fault.

Fig.5 shows a voltage sag waveform is induced by a LLG fault at 0.415 kV bus.

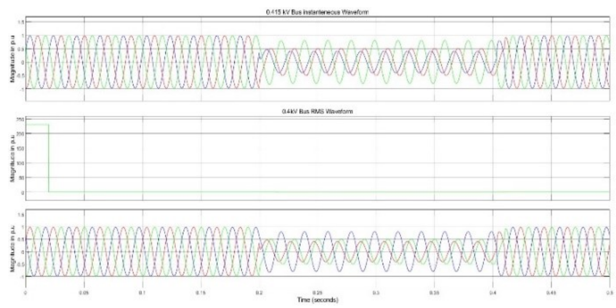

Fig. 5. 0.415 kV bus instantaneous waveform of LLG Fault

Fig.6 shows voltage sag waveform caused by a triple line to ground fault at 11 kV bus.

Fig.7 shows voltage sag waveform caused by a triple line to ground fault at 0.415 kV bus.

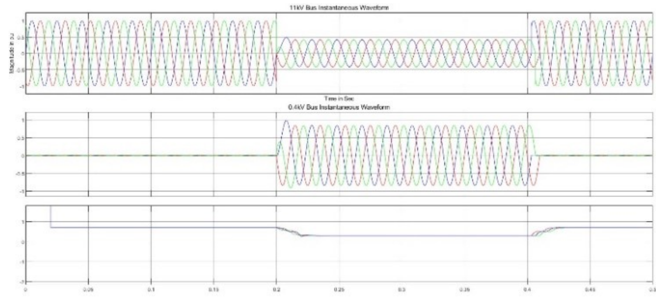

Fig. 6. 11 kV bus instantaneous waveform of LLLG Fault

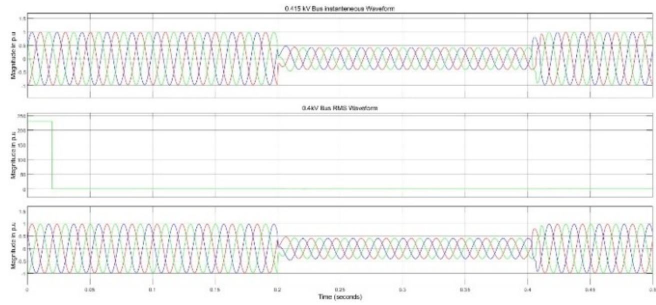

Fig. 7. 0.415 kV bus instantaneous waveform of LLLG Fault

B. *Induction Motor Starting Model*

The system's induction motor beginning is the primary cause of the voltage sag. As seen in picture 8, the MATLAB Simulink model is used to produce each of those events. 11 kV and 0.415 kV buses make up the system. At the 0.415 kV bus, the voltages and current are recorded and converted into each unit. The nominal value of the data is collected at a sampling frequency of 10 kHz. The induction motor's power rating determines how much of a voltage drop there will be. Voltage value is less than 15% of its stated value. The power rating (75 kW) of an induction motor determines how much of a voltage drop it will experience.

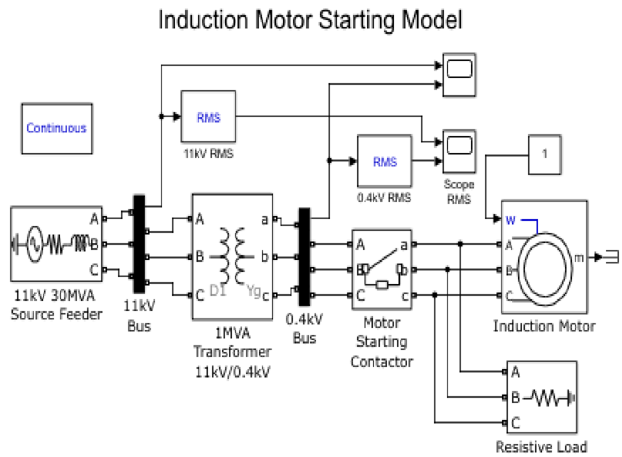

Fig. 8. Induction Motor Starting Model

Fig. 9 shows the waveform of an induction motor starting at an 11 kV bus. The magnitude of the voltage is less than 15% of its nominal value. The voltage drop in an induction motor depends on the power rating (75 KW) of the motor.

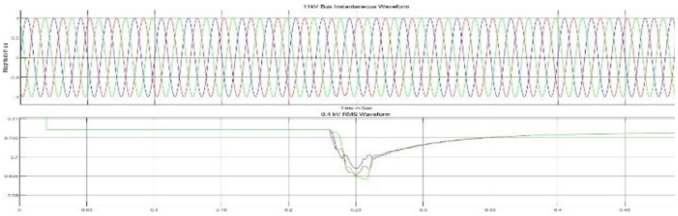

Fig. 9. 11 kV waveform of Induction Motor Starting Model

Fig. 10 shows the waveform caused by a induction motor starting at 0.415 kV bus. Value of the voltage less than 15% of its nominal value. The voltage drop in an induction motor depends on its power rating (75 KW).

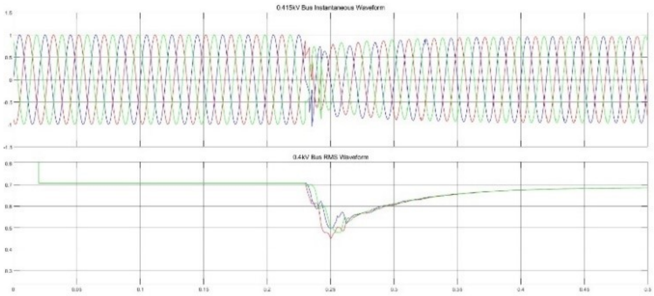

Fig. 10. 0.415 kV waveform of Induction Motor Starting Model

C. Transformer Energization Model

The figure shows the alternate excitation model that was made in Simulink. It is used to replicate the voltage drop brought on by the transformer's excitation's inrush current and core saturation. The structure features a three-phase block that is 11 kV, 30 MVA, 50 Hz, and is fed by a star/delta transformer that is 11 kV/0.415 kV, 200 KVA. Instantaneous waveform and root mean square (RMS) measurements are made using the 11 kV feeder bus. RMS readings were obtained from the feeder busbar at 0.415 kV. This model replicates the voltage drops that occur when a transformer is powered on. In order to replicate the voltage drop brought on by turning on the transformer, the three-phase circuit breaker was configured to close at 0.23 seconds and to go off at the beginning of the phase during the simulation [7].

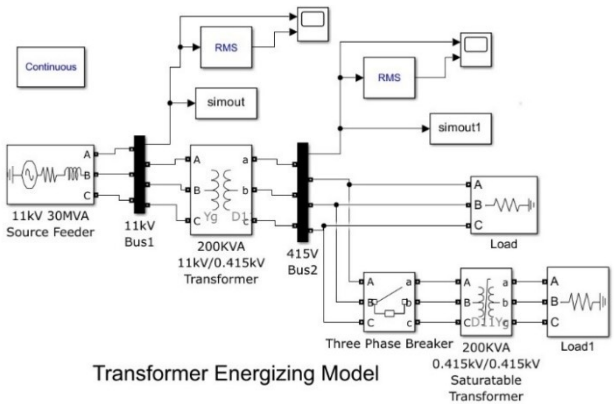

Fig.11. Transformer Energization Model

Fig. 12 shows the waveforms, voltage drops resulting from energizing a transformer at 11 kV bus.\

Fig. 13 shows the waveforms, voltage drops resulting from energizing a transformer at 0.415 kV bus.

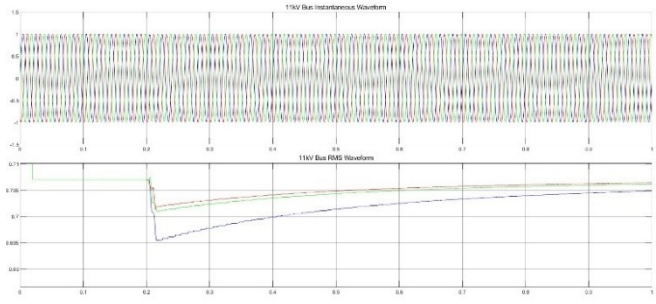

Fig. 12. 11 kV waveform of Transformer Energization Model

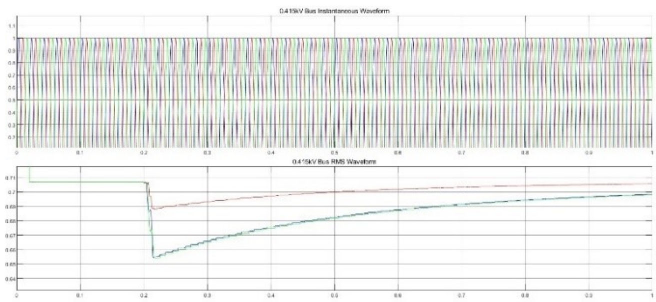

Fig. 13. 0.415 kV waveform of Transformer Energization Model

TABLE I. ESTIMATED PARAMETERS OF VOLTAGE SAG

Causes of Voltage Sag	Duration(sec) and Amplitude (p.u.)
LG Fault	T = 0.2 to 0.4 sec and amp = 0.8 pu
LLG Fault	T = 0.2 to 0.4 sec and amp = 0.75 pu
LLLG Fault	T = 0.2 to 0.4 sec and amp = 0.7 pu
Induction Motor Starting	T = 0.2 to 0.4 sec and amp = 0.6 pu
Transformer Energization	T = 0.2 to 0.4 sec and amp = 0.83 pu

IV. CONCLUSION

In conclusion, examining the causes of voltage drops using MATLAB Simulink provides a better understanding of this electrical phenomenon. Using simulation tools such as MATLAB Simulink, scientists and engineers can effectively model various scenarios and analyze the impact of factors such as faults, network switching effects, and voltage fluctuations. Through this process, it becomes clear that voltage drops can stem from multiple reasons, including short circuits, motor starting, and sudden changes in demand. Understanding these causes is important for designing robust power systems and implementing mitigation strategies to reduce the impact of voltage drops on equipment and performance.

Additionally, the ability to simulate voltage sag scenarios using MATLAB Simulink facilitates the development and testing of protective devices and control strategies aimed at improving power quality and increasing grid reliability. Overall, this approach provides a powerful tool for studying voltage drop phenomena and developing effective solutions for real-world applications.

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