International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 05 Issue: 06 | June - 2021 ISSN: 2582-3930

Simulation of Power Quality Disturbances using MATLAB/SIMULINK

Nagulapati Kiran[1]

[1]*EEE Department, ANITS*

---***---

Abstract - This paper presents a comprehensive set of MATLAB/SIMULINK models used to simulate various power quality disturbances. The various reasons for power quality disturbances are distribution line fault, inductor motor starting, transformer energizing, Capacitor bank switching, Lightening Impulse, Single-phase Non-Linear Load, Three phase Non-Linear Load and Electric Arc Furnace. The Line fault model and Induction motor starting model are presented in this paper showing various power quality disturbances and waveforms for power quality analysis research.

Key Words: Power Quality, Voltage sag, Line fault model, Induction motor starting model, MATLAB/SIMULINK.

1.INTRODUCTION *(Size 11, Times New roman)*

Power quality in an important branch of power system engineering. It plays an important role to ensure the quality of power being delivered to industry consumer. The emergence of smart grids further distinguishes the importance of power quality. Power quality disturbances are categorized into voltage sag, voltage swell, transient, harmonic, voltage notch, flicker and phase angle jump. A single power quality event such as voltage sag caused by a fault in transmission or distribution level may cost the industries up to millions of losses. Power Quality research is the study of various phenomenon that cause power quality disturbance to occur and the development of mitigation strategy. To develop the right mitigation strategy for power quality problem, root cause of phenomenon must be fully understood. With the advancement of computer technology, software development, simulation of power quality disturbance is possible. This allows researchers to model and simulate a given power system to trace, analyze and understand root cause of power quality disturbance. It provides an insight of how power quality disturbance propagates from source and through the entire power network. There are many power system simulation tools such as PSCAD/EMTDC, ATP/EMTP, MATLAB with Power systems Toolbox, Power System Analysis Toolbox, SIMULINK with SimPowerSystems Blockset. In this paper, MATLAB/SIMULINK is chosen as simulation platform.

2. Modelling Approach

The simulation models were developed using MATLAB/SIMULINK with SimPowerSystems. Various power quality disturbances are simulated and observed how these disturbances distort the power system sinusoidal waveform.

Line Fault Model

The line fault model developed in SIMULINK is shown in Figure 1. The line fault model is used to simulate voltage sag caused by line fault. The line fault model consists of 11 kV, 30 MVA, 50 Hz, three-phase source feeding 11 kV/0.4 kV, 1 MVA delta/wye transformers to a 10kW resistive and 100kVAR inductive load.

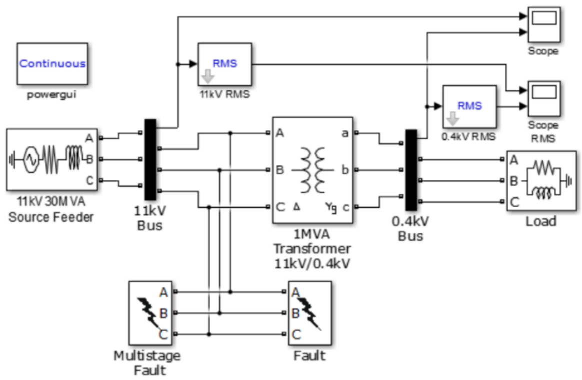

Fig. 1: Line fault Simulink model

This fault model is capable of simulating various line faults including single line to ground, double line to ground, line to line, three-phase fault and multistage. Figure-2 shows voltage sag waveforms caused by line-to-line fault between A and B phases at 11kV feeder. It can be observed that 11kV bus experiences two voltage sags at phase A and Phase B with different sag magnitude. This is due to high resistance between two faulted lines.

In power quality studies, voltage sag waveform magnitude is commonly presented in RMS waveform. Figure 3 shows RMS analysis of line-to-line voltage sag waveforms in Figure 2. The sag magnitudes can be visualized clearly. The slight

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 05 Issue: 06 | June - 2021 ISSN: 2582-3930

oscillation occurs at pre- and post-sag and swell, which is due to phase shift during fault.

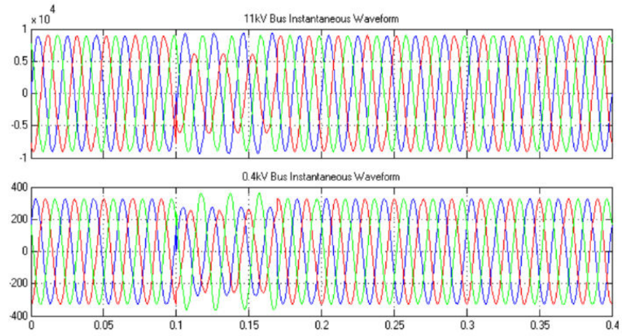

Fig. 2: Voltage sag caused by line-to-line fault at 11kV line

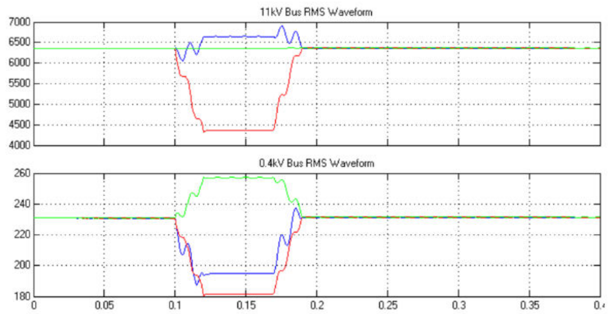

Fig. 2: Voltage sag in RMS waveform

This fault model is capable of simulating multi-stage line faults. The multistage voltage sag is typically due to multiple faults protecting relay mechanisms that are not synchronous with each other, thus changing power system impedance and network configuration leading to multiple stages of voltage sag. Figure 4 shows multistage voltage sag instantaneous waveforms caused by double line to ground fault. Figure 5 shows RMS waveform of multistage voltage sag to better visualize the multistage voltage sag.

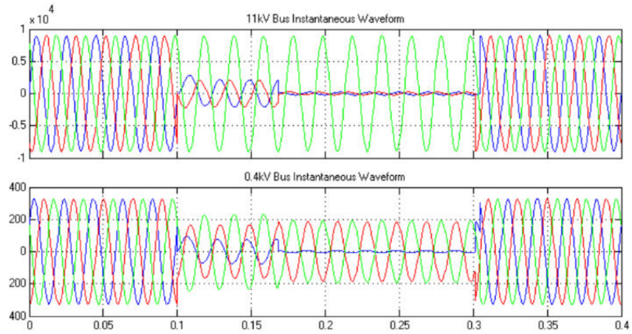

Fig. 4: Multistage Voltage sag caused by double line to ground fault at 11 kV line.

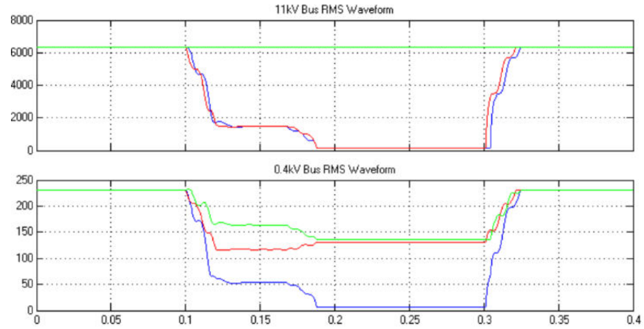

Fig. 5: Multistage Voltage sag caused in RMS waveform.

Induction Motor Starting Model

The induction motor starting model is used to simulate voltage sag caused by starting a high-power industry induction motor. Figure 6 shows the induction motor starting model developed in Simulink. The model consists of 11 kV, 30 MVA, 50 Hz three-phase source feeder block feeding through 11kV/0.4kV, 1 MVA delta/wye transformers, a three-phase breaker as motor starting contactor, a three-phase induction motor and 10kW resistive load.

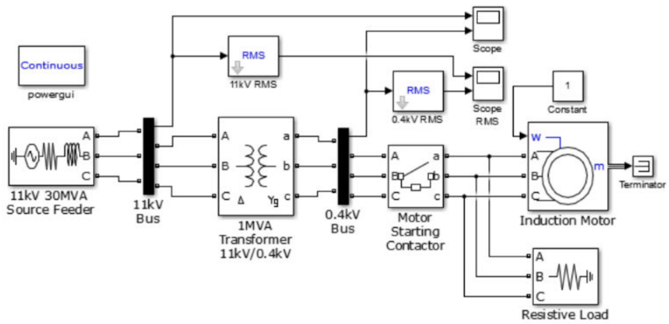

Fig. 6: Induction motor starting Simulink model

Figure 7 shows a three-phase voltage sag instantaneous waveform caused by 100 hp induction motor starting upon closing of motor starting contactor at 0.1 sec. The speed of induction motor during starting is set at 1 rad/sec using constant block. Three-phase induction motor starting voltage sag is balanced and has a shallow drop up to 15% from its nominal magnitude. The sag magnitude of induction motor is dependent on induction motor power rating. The voltage sag pattern can be visualized clearly in RMS waveform as shown in figure 8.

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 05 Issue: 06 | June - 2021 ISSN: 2582-3930

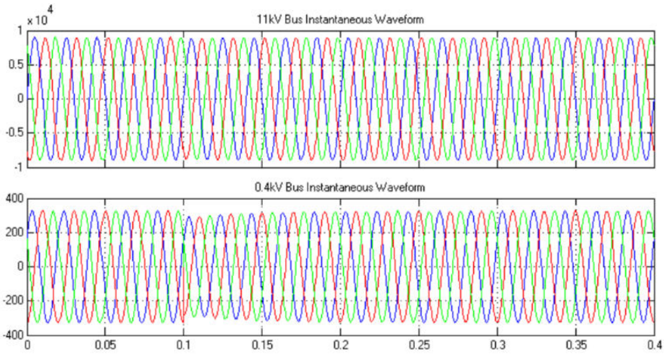

Fig.7: Voltage sag waveform caused by starting of 100 HP induction motor

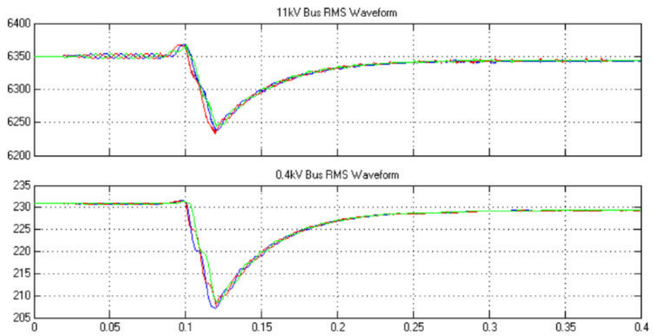

Fig.8: Voltage sag RMS waveform caused by starting of 100 HP induction motor

3. CONCLUSIONS

The simulation approach provides researcher the flexibility to create power system models to simulate power quality disturbance by connecting various blocks in simulation environment. This paper only presents simulation models that are capable to simulate power quality disturbance including voltage sag due to fault and induction motor starting. The same can also be shown using voltage sag due to transformer energizing, capacitor bank switching, Lighting impulse, single phase and three phase nonlinear load and electric arc furnace.

REFERENCES

[1] 1. S.R.K Kanaesalingam, V.R Rama Chandra murthy, "*Intelligent driven power quality monitoring using psedomeasurement technique",* International Conference on Power Quality, September 15-17, 2009.

[2] Patne N R, "Stochastic Estimation of Voltage Sag due to Faults in Power systems using PSCAD/EMTDC Software," *Journal of Electric Power Quality and Utilization*, vol-13, pp. 59–63, 2007.

[3] Bollen M.H.J, "Understanding Power Quality Problems-Voltage Sag and Interruptions," *IEEE Press Series on Power Engineering*, Piscataway, NJ, 2000.

[4] Sean Elphick, "Large Scale Pro-active Power Quality Monitoring," *IEEE Transactions on Power Delivery*, vol. 32, Issue:2, pp. 881-889, May. 2016.

[5] E.A. Mertens, "Evaluation and Trends of Power Quality Indices in Distribution System," in International Conference on Power Quality and Utilization, October 9-11, 2007.

[6] Konstantin Suslov, "Assessment of impact of power supply on Power Quality," in *Electronics and Automation Control Conference,* March 15-17, 2019.