Distribution System Fault Analysis Using MATLAB/SIMULINK

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ABSTRACT

In this paper, the impacts of various faults in the distribution network system (DNS) have been analyzed. Modelling and simulation is done using MATLAB/Simulink software package. The proposed model is simple and it can be used by power engineers as a platform. The designed model is used to study various common faults in distribution network at different points. The waveform display due to the various faults gives us an idea of hazardousness of the respective fault. The response of the system after introducing protective device is also observed.

Keywords: Fault analysis, MATLAB/Simulink, Distribution system, Modelling and simulation.

1 Introduction

The overall sustainable economic growth of a state mostly dependent on the reliability and quality of the electric power supply [1]. Distribution network connects the bulk sources to the customer's sources. The distribution lines which can be single phase or three phase are generally connected in radial network. It is projected that 80% of the customer disruptions happens due to the faults in distribution system [2] [3]. Due to the huge population growth in India, most distribution system is unplanned radial network which makes it very prone to faults. In radial network distribution system, when fault occurs more customers are affected as power flow is unidirectional [4]. Being positioned over a huge geographical area, the faults in the distribution network is caused by lightning, storms, rain, insulation failure, short circuits, overloading etc. [5]. Whenever a fault is detected in distribution line, it is very essential to detect the fault as soon as possible to maintain the system reliability [6].

2 Distribution System Faults

Faults are the unexpected change in the circuit parameters. The hazardousness of faults mainly depend on the amplitude of fault current which in turn rely upon location and type of the fault. The duration of faults are also significant while assessing the consequences of the fault. To prevent the injury and damage of the people and property faults must be cleared fast. In broad the faults are classified into two categories: series and shunt fault [7] [8].

2.1 Series Faults

Series faults are basically unbalance in the system. If one or two phase opens while the third phase remains in the circuit, then these type of faults are called series faults. Joint failures of the cables and overhead lines is the common cause of these faults. Series faults leads to the abnormal increase in voltages. Series faults can be tolerated for longer duration than shunt faults.

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2.2 Shunt Faults

These faults are the most common and severe kind of fault in the distribution system. Shunt faults are the irregular linkage of a lower impedance between two points of different potential. These faults are also called short circuit faults. It causes due to failure of insulation between overhead conductors or between phase conductors with ground or both. In three phase power system there are 10 possible types of shunt faults. These 10 faults can be categorized in four groups.

(a) Single - phase - to - ground faults
(b) Two - Phase - to - ground faults
(c) Phase - to - phase faults
(d) Three - phase faults

(a) Single phase to ground fault

There are three possibilities of phase to ground faults which are shown in *Figure 1* – (i) Phase R-G fault, (ii) Phase B-G fault and (iii) Phase Y-G fault

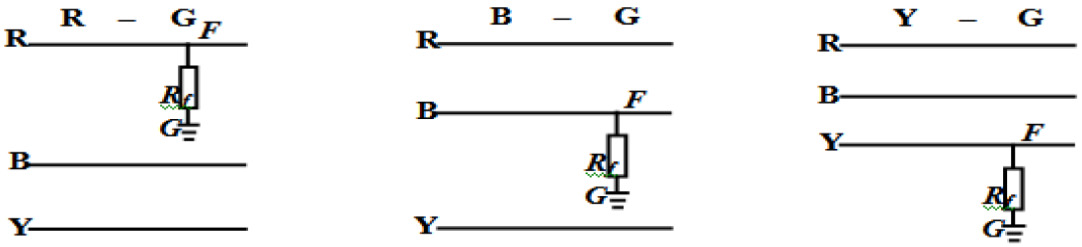

Figure 1: single phase to ground faults in three phase line

(b) Two phase to ground fault

There are also three types of two phase to ground faults which are shown in *Figure 2* – (i) phase R and B to Ground fault, (ii) phase B and Y to Ground fault and (iii) phase Y and R to Ground fault.

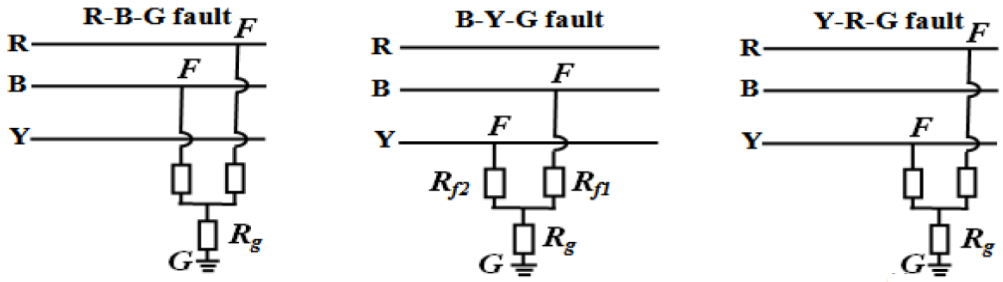

Figure 2: two phase to ground faults in three phase line

(c) Phase to phase fault

This fault occurs when two phase gets shorted. There are also three possibilities which are shown in *Figure 3*- (i) phase R to phase B fault, (ii) phase B to phase Y fault and (iii) phase Y to phase R fault.

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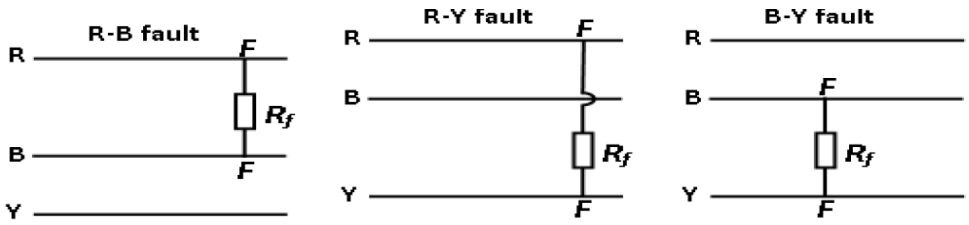

Figure 3: phase to phase fault in three phase lines

(d) Three phase fault

These faults are also called symmetrical or balanced fault. Here all the three phases are short circuited. These faults can be with or without ground which can be seen in *Figure 4*.

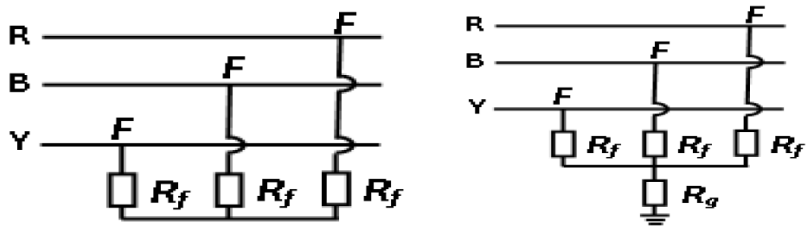

Figure 4: three phase faults.

3 Methodology

The tool *MATLAB* is used for simulation of the model. The name *MATLAB* imply Matrix Laboratory, which is an efficient software tool for computing high speed numerical data. Analysis capability, reliability and flexibility, powerful graphics brands *MATLAB* a leading software for technical academics. It offers several reliable and precise mathematical built in functions [5] [9].

Simulink is a *MATLAB* based graphical programming environment for modelling and simulation and it is used for both linear and nonlinear systems. Modelling can be done within continuous time, discrete time or both. For modelling purpose in Simulink, there is a graphical interference named GUI which is useful in designing models as well as block diagrams [10]. A standard distribution system is modelled with standard parameters as shown below.

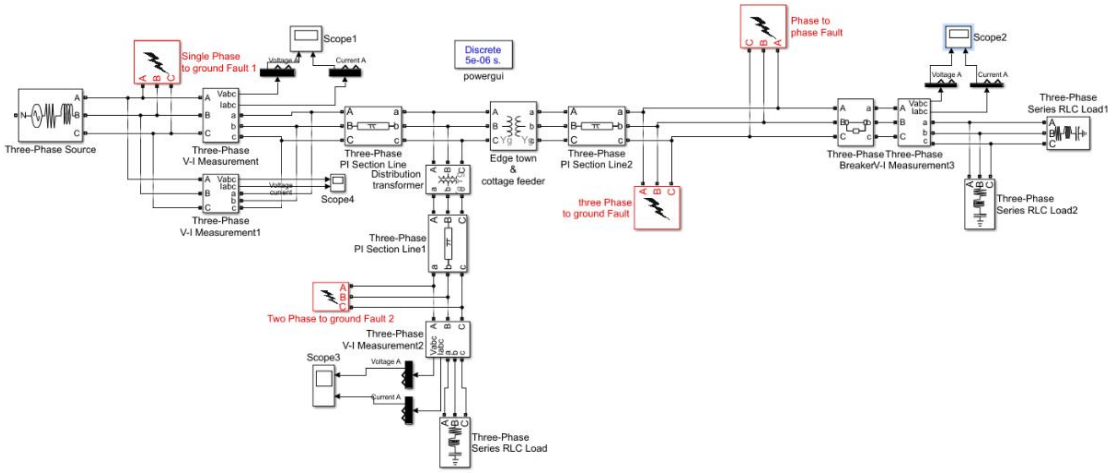

Figure 5: MATLAB Simulink model for Distribution system with different Faults

4 Simulating faults in Simulink MATLAB

Modelling of the distribution system is done in a toolbox of MATLAB called Sim Power Systems. For fault measurement at any point of a line, two blocks are modelled with every line. One block have the distance equal to the distance of the fault location to the beginning of the line. Another one have the distance equal to the total line distance after omitting the fault distance [11]. Loads are coupled at the nodes to reproduce a realistic scene. Though the electric lines have both sequential and parallel admittance but as the lines are short so parallel admittance is neglected. Simulation is done by taking faults at different position of the distribution lines. At different. The voltage and current waveform of simulated faults as shown below are:

a) L-G fault

b) L-L-G fault

c) L-L-L-G fault

d) L-L fault

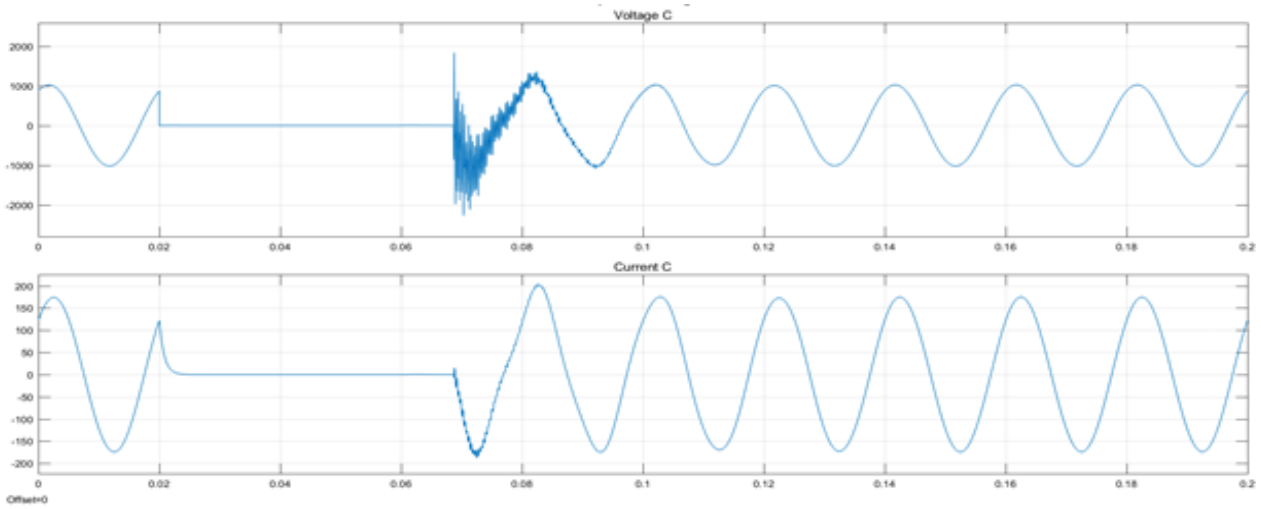

Figure 6: Single phase to ground fault

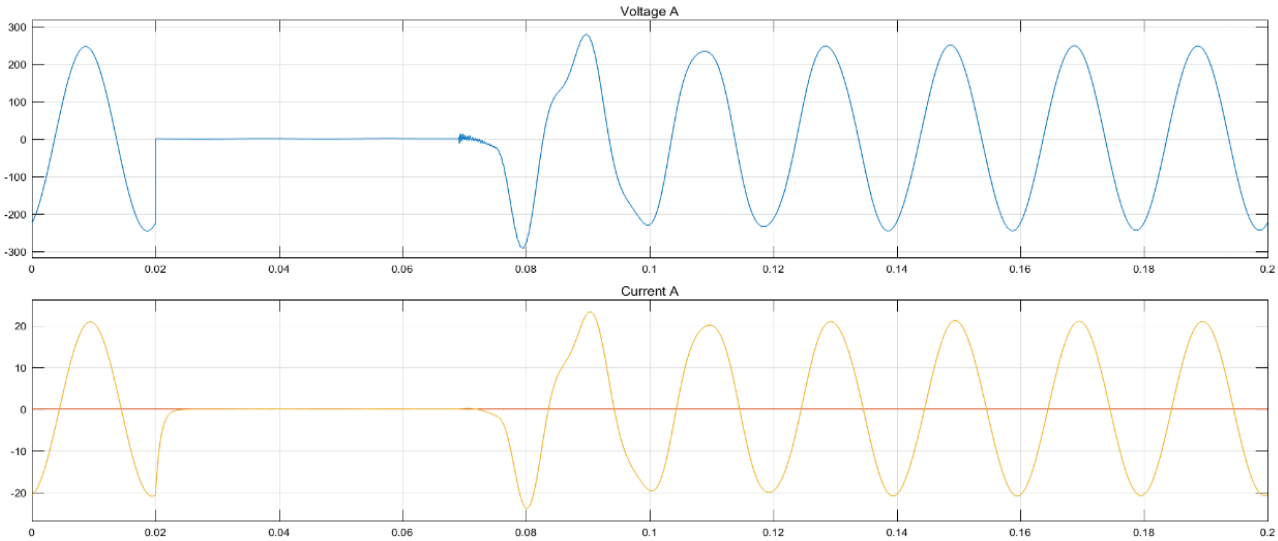

Figure 7: Double phase to ground fault

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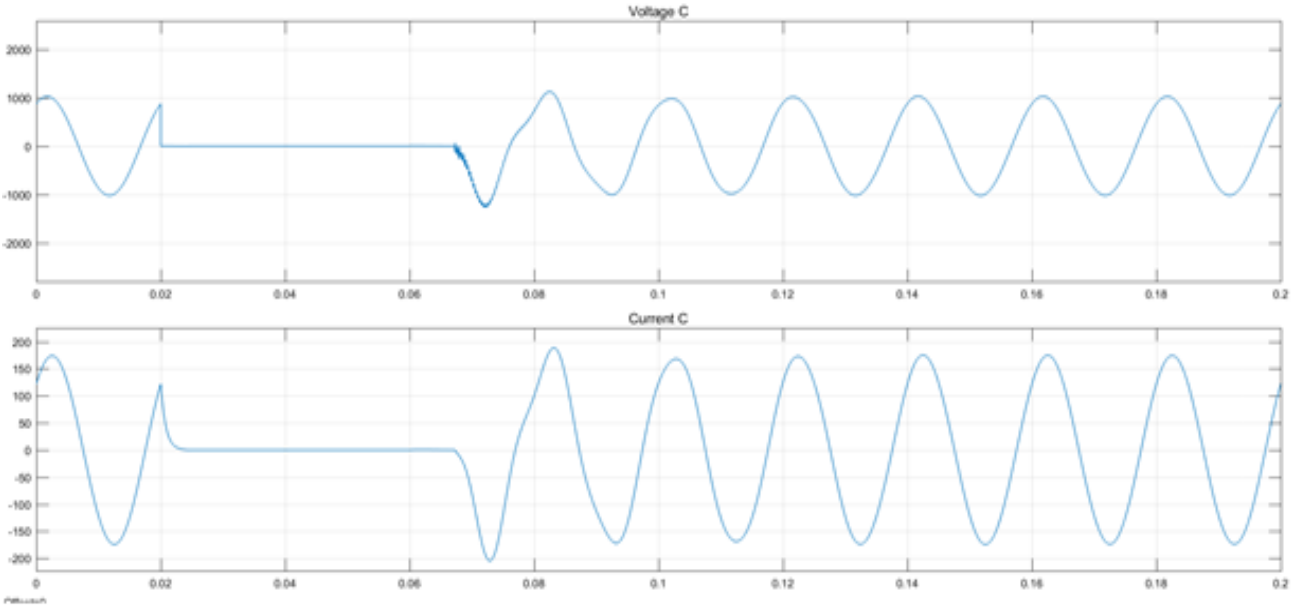

Figure 8: Three phase to ground fault

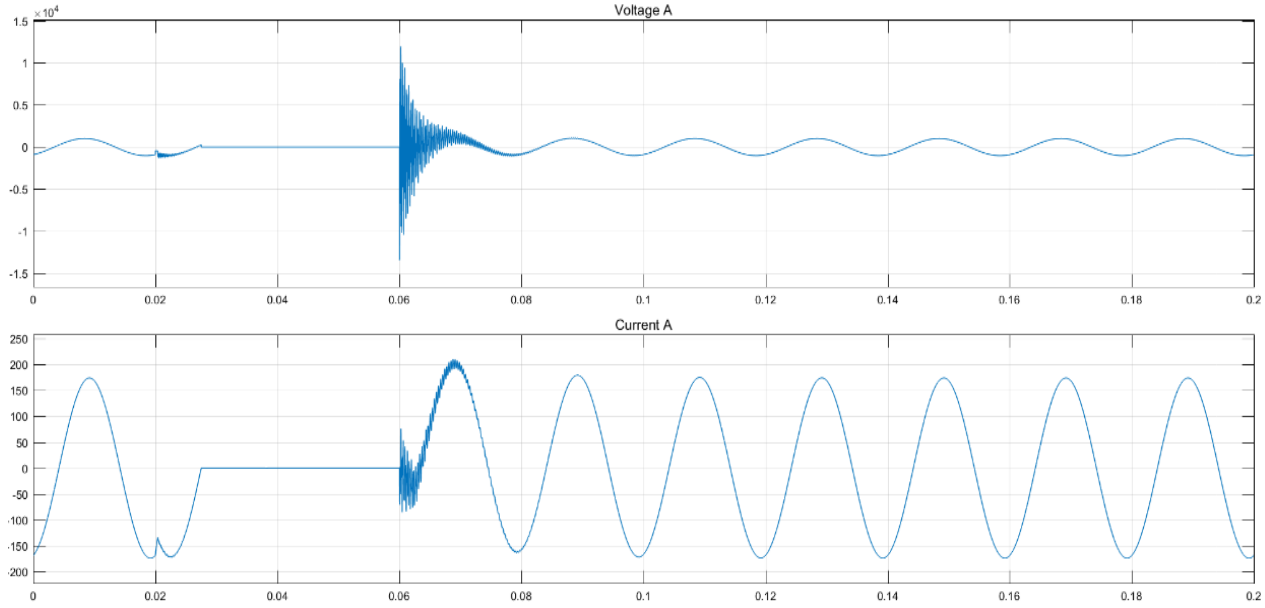

Figure 9: Phase to phase fault

The results of the graph after adding single phase to ground fault, two phase to ground fault and three phase to ground fault is shown above. It is seen that Single phase to Ground fault gives highest harmonics and three phase fault gives lowest harmonics. Double phase to ground fault also gives low harmonics whereas phase to phase fault gives high harmonics.

So for minimizing the over current due to fault we design a overcurrent relay using S-R flip-flop.

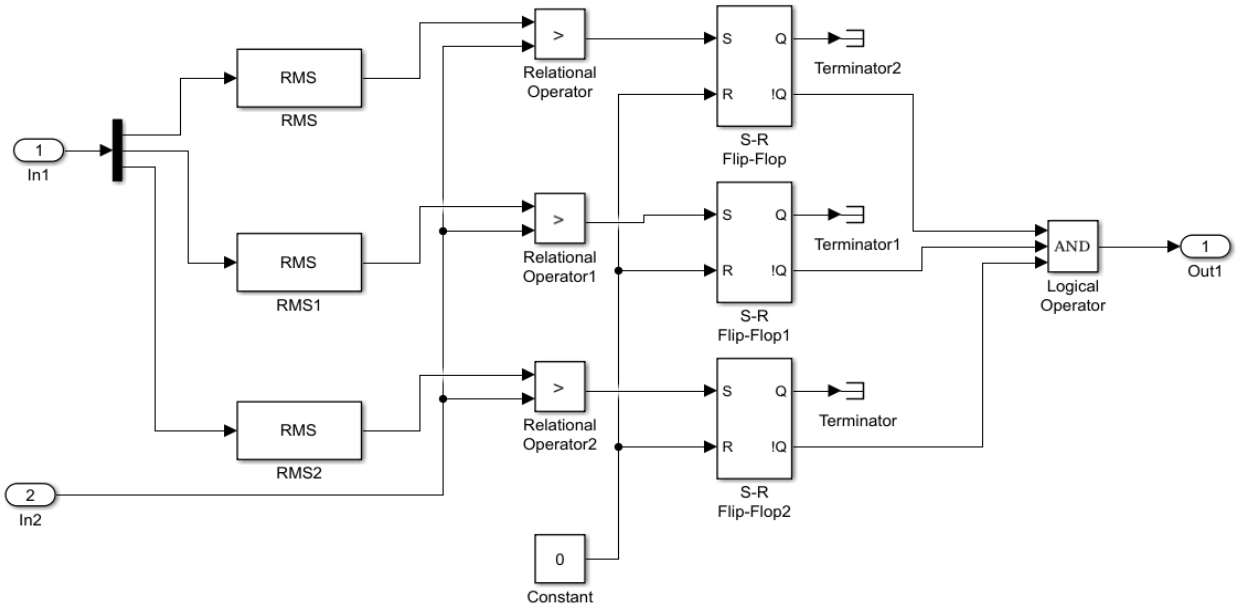

Figure 10: modeling of overcurrent relay

And putting this relay subsystem to the three phase circuit breaker we clearly see in *Figure 11*, that the transient current decreases significantly for single phase to ground fault whereas transient effect was maximum for that fault.

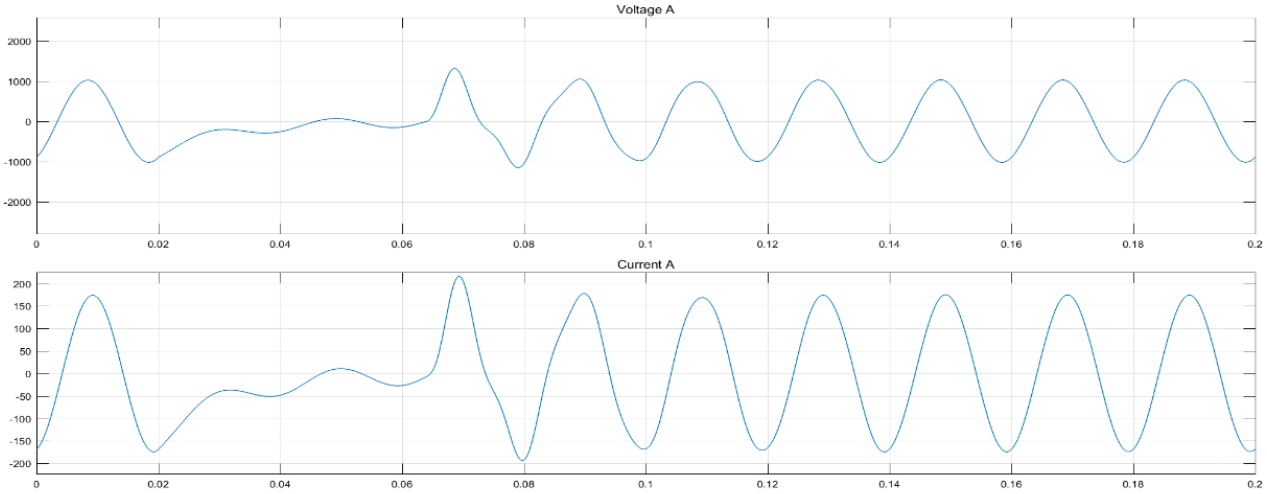

Figure 11: current and voltage waveform after introduction of relay and circuit breaker

5 Conclusions

In this paper distribution system is modelled in MATLAB/Simulink and response of the system to fault s at different points are analysed. Introducing a overcurrent relay with a circuit breaker can decrease the harmonics significantly which can be seen above. Flexibility of MATLAB provide us to simulate the faults of various magnitude at different position and reliability indices(SAIDI, SAIFI, CAIDI, ASAI etc.) in each cases can be evaluated with the help of the graph and input data.

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