



SIMULATION BASED STUDY OF LOAD FLOW ANALYSIS AND IMPLEMENTATION OF OVER CURRENT RELAY IN FIVE BUS SYSTEM

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ABSTRACT

Power flow analysis is an essential component of the power system's functioning and optimisation. One of the most effective power flow analysis methodologies produced in commercial software applications is the Newton Raphson (NR) approach. The Newton Raphson load flow solution methodology is comparably more reliable compared to other power flow techniques because, unlike other methods, it can address divergence-related instances. However, the NR technique has certain limitations. This approach has been known to fail in some ill-condition situations. The electrical distribution network is commonly classified as an ill-conditioned electrical network.

The occurrence of such problems while employing the NR technique in distribution networks drives study into various strategies to improve the dependability of the NR approach. In this study, the power flow of a small region with 5 busbars was calculated using NR in the MATLAB environment. The information from the case study was utilized as input for the system. The obtained data demonstrate that the voltage profiles of the 5 buses are within acceptable limits, implying the fact that there is no deviation in this situation utilizing the NR approach. The load flow solution might also be utilized to determine a suitable loss coefficient matrix.

INTRODUCTION

Load flow is a vital and essential tool for analysing any power system, and it is utilised both operationally and in the planning phases. Certain applications, notably those involving distribution automation and power system optimisation, need a repeating load flow solution. It is utilised to calculate the active and reactive power that's created in the technique's sections, and to calculate the electrical voltage's intensity and degree at each bus.

An evaluation of load flow provides important information about the current state of a network, including branch currents, active and reactive flow, bus voltages (both magnitudes and phase angle), and branch currents. These findings are essential for analysing the stability of the network's operation under stable state load levels. The load flow inspection aims to offer a thorough evaluation of conditions at each segment of the entire network in order to detect any anomalous conditions that might impair regular operation.

Load flow issues may be efficiently handled by a variety of simulators under a broad spectrum of scenarios. presently numerous simulation applications can be employed for estimating load strategies that are distinct from another, notably in computer algorithms, calculation methodologies, and network models. Typically, load flow issues are handled for one-phase only, when just several significant system parts and their specific features are considered, and the outcome is comprehensively documented in numerous papers.

BUS CLASSIFICATION

A node that links multiple lines, loads, and generations is called a bus. Each of the terminal or bus in the electrical network is connected by four quantities: voltage level, voltage phase angle, active or actual power, and reactive power in the case of a load flow problem. Only two of the four variables are given; the other two can be found by working through the equation. There are three categories of buses based on the quantity chosen.

The way in both of the four standards are stated determines the classification of buses.

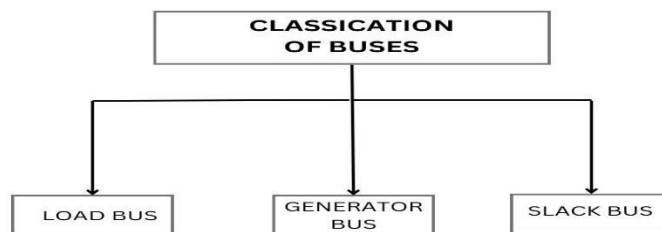


Figure: 1. Classification of Buses

- There is not a generator attached to the buses. At this bus, actual and reactive power are defined. It is wanted to determine voltage magnitude along with phase angle using load circulation equations. Simply P_d and Q_d must be specified of such a bus since the voltage at a load might fluctuate between the allowable range.
- **Generator Bus:** The voltage amplitude correlates to the generator's operating voltage, whereas the actual electrical output P_g belongs to its value. It is necessary to determine the reactive electrical power output Q_g and phase angle of the bus voltage.
- **Slack:** For a bus, it is assumed that the $|v|$ and voltage phases θ have been established, while the true and reactive powers P_g and Q_g are determined from the load flow equation.

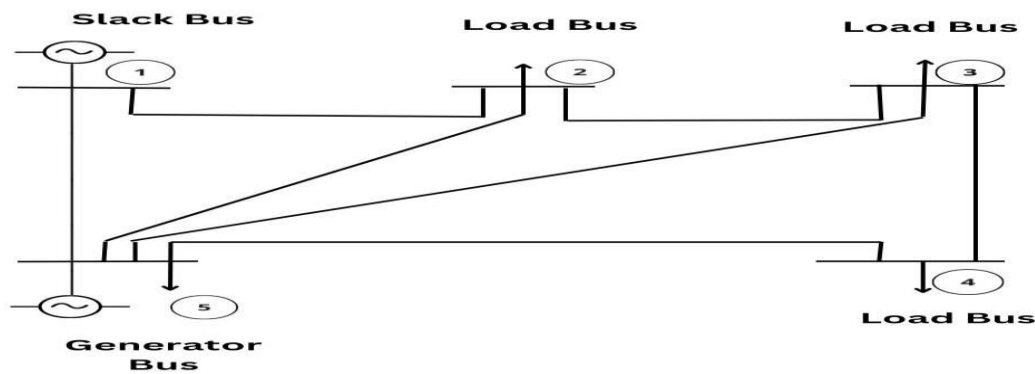


Figure: 2. 5 Bus System

OVERCURRENT RELAY

Overcurrent relay is a protective device, it works when the current is greater than a specified value and then trip circuit is send the command to circuit breaker. It must be provided protection to the equipment and remove short circuit. Overcurrent relays for electrical systems are one of the least complicated and most efficient techniques for electrical system safety. Overcurrent relays are the primary protection equipment for radial distribution networks.

To simulate the time-current curves of overcurrent relays in synchronisation, a variety of functions can be employed. Relay operating time qualities are generally nonlinear because relay time of operational T_{op} is a not linear function of its time multiplier setting (TMS) and relays take up current (I_p). The time characteristics become proportional for preset quantities of I_p , with variables α and n that depend on the relay qualities, as the parameters t and TMS may be connected in a linear equation. The relay's operating duration is established by

$$T_{op} = \frac{\alpha * TMS}{\left(\frac{I_f}{I_p}\right)^n - 1}$$

For IEC conventional time overcurrent qualities, α and n are constants.

METHODOLOGY

For load flow analysis, the Newton Raphson method was applied. For the analysis of load fluxes, this approach provides a quicker substitute. When compared to different approaches, it performs well in systems with high loads and needs an initial state. In order to provide voltage magnitude, phase angle, real power, and reactive power, load flow is constructed. One must have a solid grasp of Newton Raphson Load Flow ideas in order to build the tool.

Newton -Raphson Load Flow

Each process consists of 6 key phases. Every procedure involves multiple combinations.

Step 1. Evaluate the types of the Bus.

Slack, load, and generator buses are the three types of buses used in load flow study. The specified and unknown parameters for each type of bus are displayed in Table 1. Initially, it was assumed that the phase angles and voltage amplitudes for the load and slack buses were equal to $\delta_i=0.0$ and $|V_i| = 1.0$ p.u. Simultaneously, the generator bus P_i^{sch} and $|V_i|$ are determined using the initial phase angle zero, resulting in $\delta_i^{(0)} = 0.0$.

Table 1. Bus Classification

| Type of Buses | Unspecified Value | Specified Value |
|----------------------------|--------------------|--------------------|
| Swing Bus | P and Q | $ V $ and δ |
| Voltage Control (P, V) Bus | Q and δ | P and $ V $ |
| Load (P, Q) Bus | $ V $ and δ | P and Q |

Step 2. Design of Y_{bus} Matrix

Y_{bus} matrix is generated as below:

$$Y = \begin{bmatrix} Y_{11} & \dots & Y_{1j} \\ \vdots & \ddots & \vdots \\ Y_{ij} & \dots & Y_{jj} \end{bmatrix} \dots (1)$$

The diversity of bus in a power systems network determines the admittance matrix's size. An n-bus network can be used to create a (n×n) matrix.

Step 3. Separate real and imaginary parts

Reactive and real power at a given bus may be found using equations (2) and (3), which take the starting value and define the magnitude of the voltage and angle. Every cycle's commencement, k, is used to figure out the powers using the most recent predicted voltage magnitude and angle.

$$P_i^{calc(k)} = \sum_{j=1}^n |V_i| |V_j| |Y_{ij}| \cos(\theta_{ij} - \delta_i + \delta_j) \dots \dots \dots (2)$$

$$Q_i^{calc(k)} = - \sum_{j=1}^n |V_i| |V_j| |Y_{ij}| \sin(\theta_{ij} - \delta_i + \delta_j) \dots \dots \dots (3)$$

Step 4. Determining power imbalance

The starting point for P_i^{sch} is the stated P at the appropriate bus. Following iteration, the P_i^{sch} is earlier $P_i^{calc(k)}$.

$$\Delta P_i^{(k)} = P_i^{sch} - P_i^{calc(k)} \dots \dots \dots (4)$$

$$\Delta Q_i^{(k)} = Q_i^{sch} - Q_i^{calc(k)} \dots \dots \dots (5)$$

Step 5. Jacobian Structure.

The NR load flow technique may be expressed simply by the matrix expression shown in (6).

$$\begin{pmatrix} \Delta P \\ \Delta Q \end{pmatrix} = \begin{pmatrix} J_1 & J_2 \\ J_3 & J_4 \end{pmatrix} \begin{pmatrix} \Delta \delta \\ \Delta |V| \end{pmatrix} \dots \dots \dots (6)$$

The Jacobian matrix consists of the partial differential values of P and Q with regard to $|V|$ or δ .

The final step in the cycle is modifying the voltage magnitude and angle with the updated imbalance, as shown in (17) and (18).

$$\delta_i^{(k+1)} = \delta_i^{(k)} + \Delta\delta_i^{(k)} \dots \dots \dots (17)$$

$$|V_i^{(k+1)}| = |V_i^{(k)}| + \Delta|V_i^{(k)}| \dots \dots \dots (18)$$

The loop will end when the acceptable value for power discrepancy in equations (4) and (5) reaches 0.0001.

SOFTWARE APPLICATION

The GRAPHICAL USER INTERFACE recommends that user clone the whole project directory, which includes all software files that are stored on the hard disc. To activate the software, the user must open and run the project file in MATLAB. After getting the figure, the user can load the system and start the procedure. To test the software, you can use the IEEE5 Bus file or your own system specification. The input panel is where you must enter data for load flow analysis. It should provide the amount of bus systems, base MVA, iterations, accuracy, and method selection. After calculating voltages and line powers using one of three ways (NR Technique, GS Technique, or Fast Decoupled Technique).

RESULT

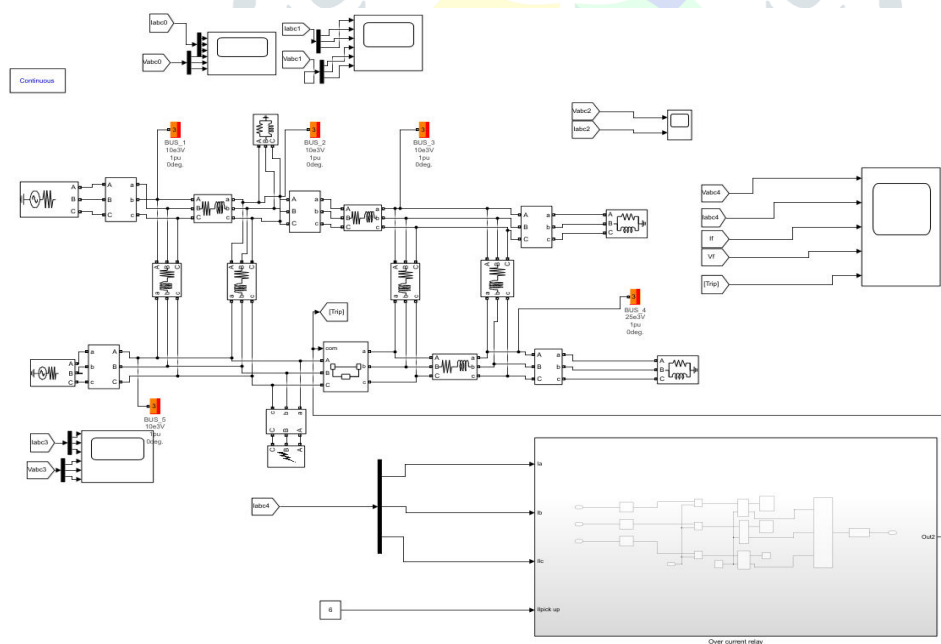


Figure 3. MATLAB /SIMULINK Model of Load Flow Analysis

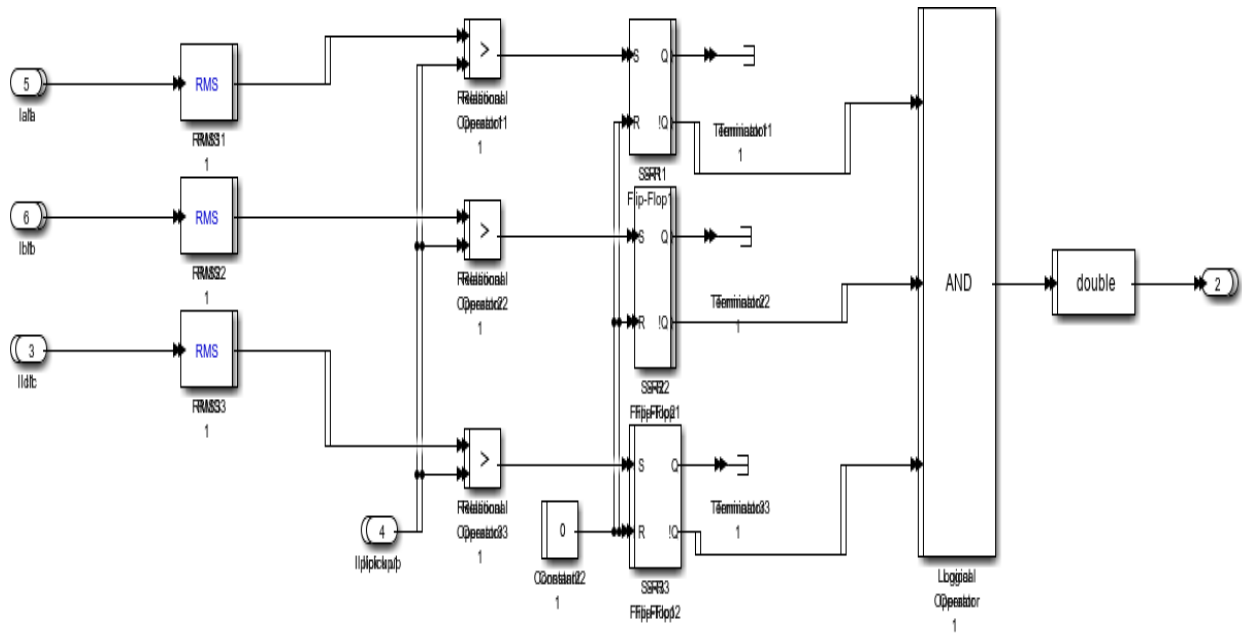


Figure: 4. MATLAB /SIMULINK MODEL of Overcurrent Relay

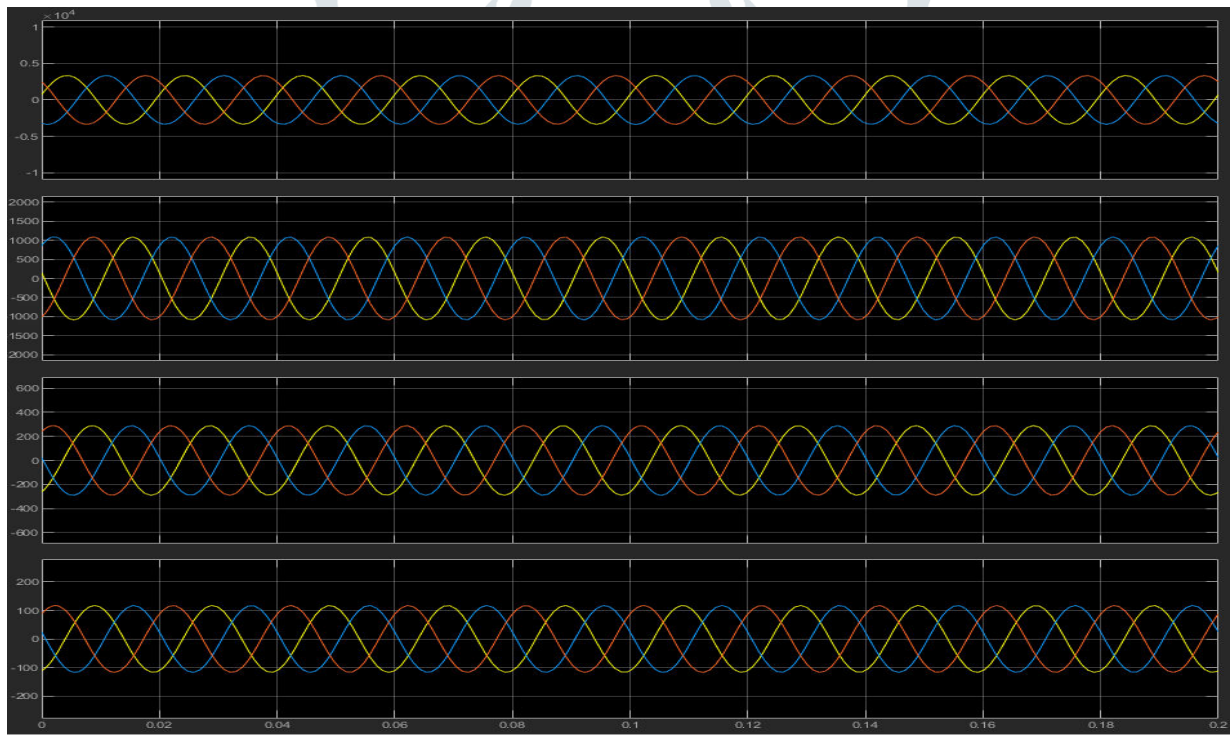


Figure: 5. During normal Condition

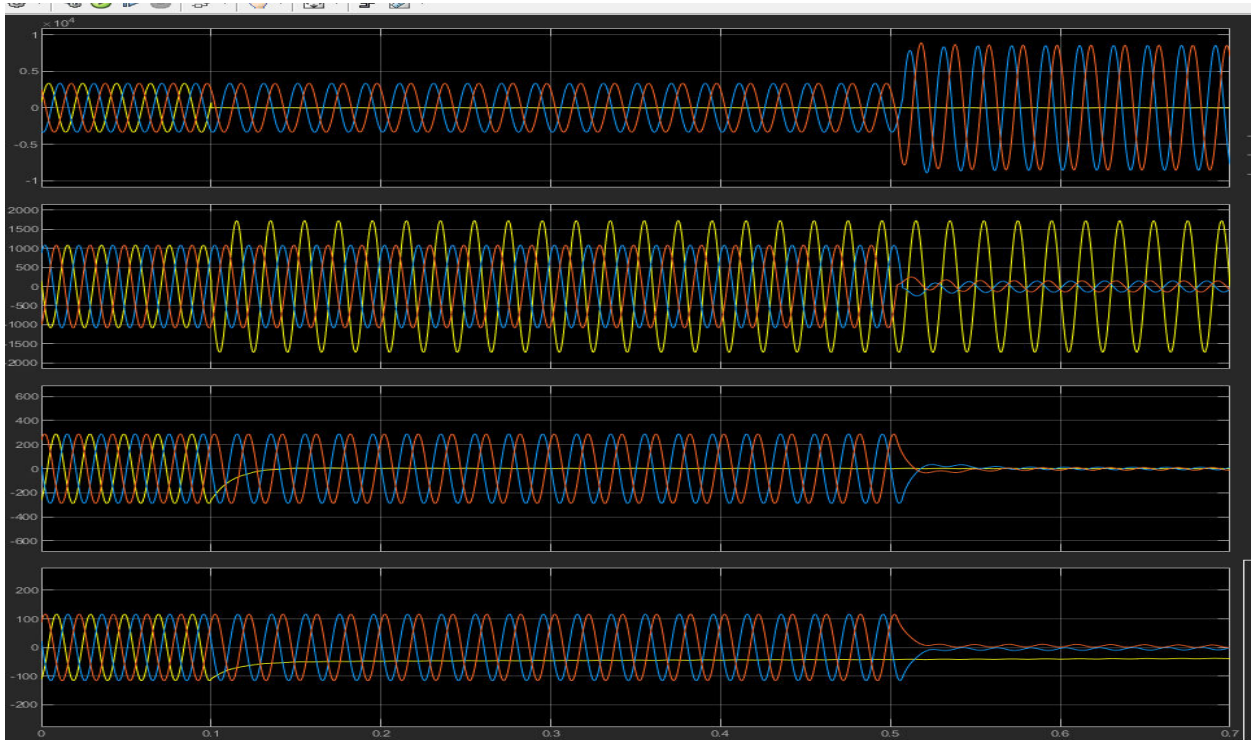


Figure :6. During Faulty Condition

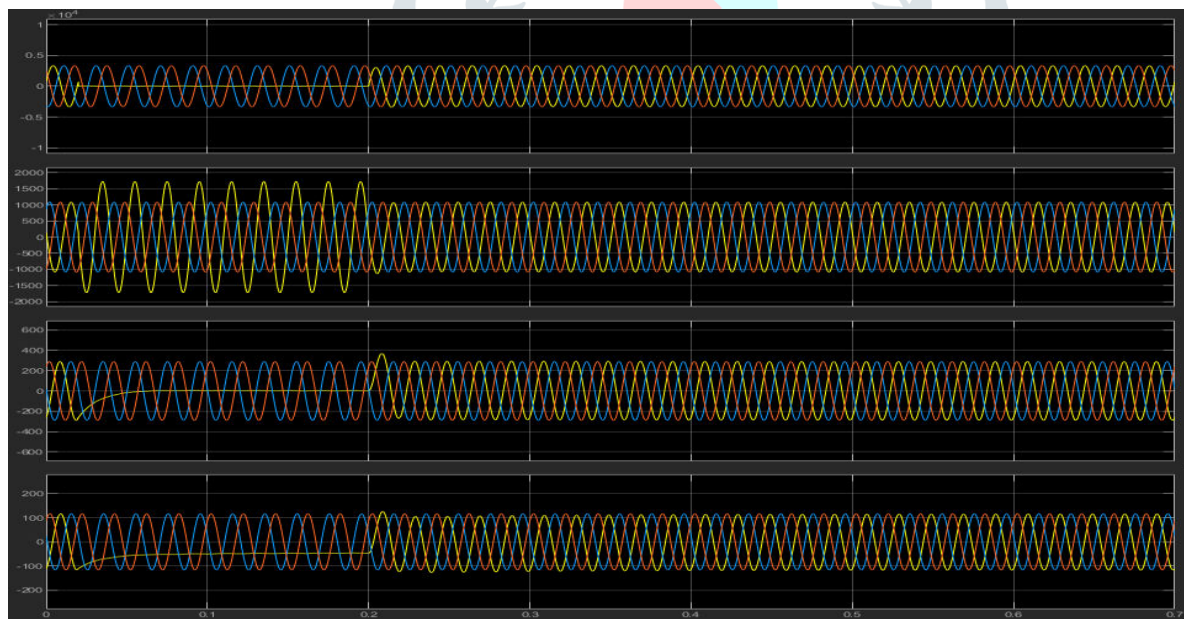


Figure:7. Condition after Overcurrent relay operate

CONCLUSION

The power flow study in this work, which includes estimations of power loss, load flow, voltage magnitude, and voltage angles, has significantly outperformed the power system. With MATLAB, the system may be simulated more quickly and with less effort. This study shows that the Newton Raphson method works better and is more effective than the Gauss-Seidel technique. Improvement and customisation lead to an increase in output accuracy. Bus information line information and a MATLAB modelling package may be used to precisely compute the load line losses in a given bus system with an increasing number of buses.

This article deals with the power flow programme, commonly known as the load flow issue. The load flow solution provides complex voltages across all buses as well as complicated power flows via the lines. This work describes the creation of a mechanism for including slack bus into the Jacobian for NR load flow modelling. The findings concur, confirming the method's accuracy. Though the NR approach has been widely used in the field of power systems, it fails to function well for systems with high R/X proportions. The implementation of the NR approach in such scenarios either leads in a substantial increase in the number of iterations necessary for the system to converge to the network's maximum power discrepancy.

The suggested technique is both resilient and efficient at processing actual networks under regular unsymmetrical operation conditions. The suggested approach is expected to be a valuable tool for unsymmetrical network analysis and is applicable to applications that include voltage quality evaluation and energy efficiency enhancement.

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