Design and Analysis of Load Flow and Fault Studies for an Industrial Power Plant

Ananya C[1*], Dr. E. Latha Mercy[2]

[1] Department of Electrical and Electronics Engineering, Government College of Technology, Coimbatore, India

[2] Department of Electrical and Electronics Engineering, Government College of Technology, Coimbatore, India

DOI: https://doi.org/10.51244/IJRSI.2026.1305000027

Received: 01 May 2026; Accepted: 05 May 2026; Published: 22 May 2026

ABSTRACT

In order to assess the steady state performance and dependability of the system, this project uses ETAP (version 19.0.1) software to offer load flow and fault studies of the industrial plant. The substation provides power to the facility (220/33 kV). This bus is connected to two transformers that feed Zone-I with a 25 MVA, 220/33 kV unit, and 60 MVA. A balanced load distribution and steady operation under typical circumstances are confirmed by the load flow simulation results, which show that all bus voltages stay within ±10% of their nominal values. The fault studies mimic single line-to-ground and three-phase faults at different bus locations in order to examine how the system responds to anomalous circumstances. Examined are the ensuing fault currents and bus voltages, especially during the sub-transient phase.

Keywords: ETAP, Load flow analysis, Short-circuit analysis, Power system protection, Industrial power systems.

INTRODUCTION

Load flow analysis and fault studies is a crucial aspect of power system planning, operation and control. It provides the steady state solution for the power system network. The Newton Raphson method is widely regarded as the most dependable and successful load flow method due to its higher accuracy and faster convergence. ETAP 19.0.1 is widely used for Load flow analysis and fault studies due to its ease of use and speed.

The program's operation closely resembles that of a real electrical system. By analysing load flow under various operating conditions using ETAP, power system engineers can evaluate the system response to different disturbances and plan for future system expansion. They involve numerical analysis of the flow of electric power in a power system under steady-state conditions, calculating voltage magnitude and phase angle at each bus, real and reactive power flows in transmission lines.

The primary objectives of load flow studies are to determine voltage levels, calculate power flows, identify potential issues such as overloads and under voltages and optimise system operation. Fault analysis determines how a system responds to abnormal conditions such as symmetrical and unsymmetrical fault.

Objectives of the Paper

i To create an accurate model of the Industrial plant using ETAP [Electrical Transient Analyzer Program] 19.1.0.

ii To investigate the steady state power flow using the Newton Raphson method. This paper presents the details for assessing the voltage profile within its nominal range.

iii To conduct a short circuit study for the loads connected to the industry by collecting all relevant load data and analysing both symmetrical and unsymmetrical faults.

Study on Load Flow

Load flow analysis is an important aspect in the study of electrical power networks. It contains critical information on the steady state operation of a power network. The analysis is crucial for system planning and operational research, allowing engineers to determine voltage levels at different buses.

- Assess power flow across transmission cables.
- Identify overloaded equipment.
- Optimize network operations for economic dispatch and stability.

Without reliable Load flow analysis power system operators cannot make educated judgments on network layout or the integration of new generation and load centres.

Analysis on Fault Studies

A short circuit or fault happens when the systems insulation fails or a conducting object contacts a live point. Fault analysis in power systems involves identifying, calculating and mitigating the effects of faults to ensure system reliability and safety. It occurs due to a low resistance connection between phase conductors or to ground. They are further divided into symmetrical and unsymmetrical faults based on the balance of fault currents [1].

Types of Faults

Various types of faults can occur in the system. Figure 1.2 represents the different types of faults in power system studies.

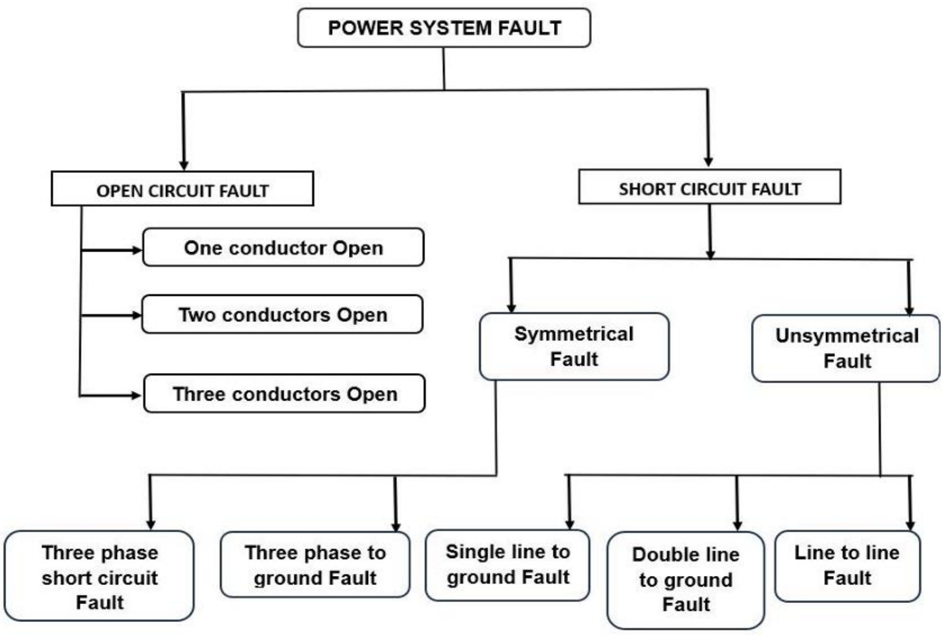

Figure 1.2 Different types of faults in power system studies.

Short Circuit Fault

A short circuit problem arises when there is an unintentional low resistance channel between two locations in an electrical circuit, allowing electricity to bypass the load. When conductors, like wires make contact directly with

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI Volume XIII Issue V May 2026

each other or conductive materials, they form a connection. As a result, excessive current flows through the circuit, often exceeding the systems safe limit. This can cause overheating, component damage, fires and system failure.

1. Symmetrical Faults in Power Systems
2. Unsymmetrical Faults in Power Systems

Block Diagram of the Industrial Plant

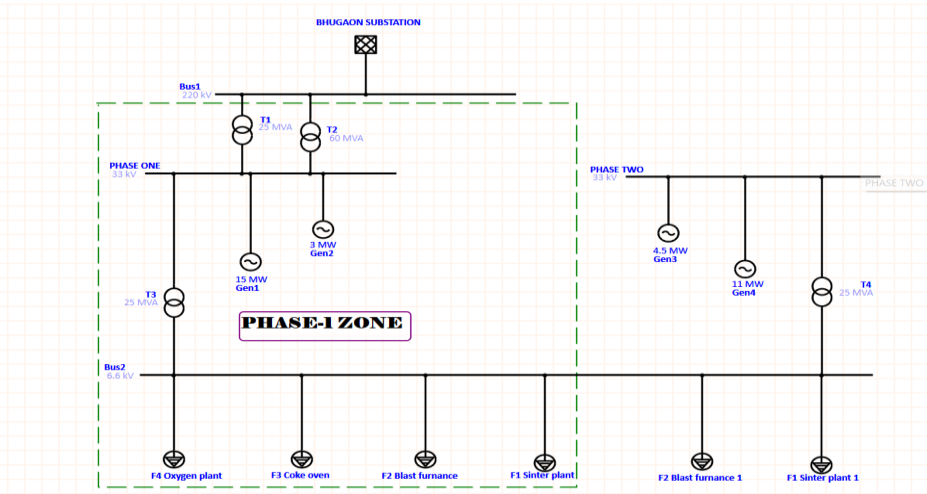

Figure 1.3 Block diagram of the industrial plant

Figure 1.3 illustrates the block diagram of the industrial plant which receives power from the Substation, which feeds a 220/33 kV switchyard. From this switchyard, two outgoing transformers operate: one transformer rated at 25 MVA, 220/33 kV is connected to Zone-I and another transformer rated at 60 MVA. Two generators, rated at 15 MW and 3 MW, are connected to Zone-I.

Modelling of the Industrial Plant

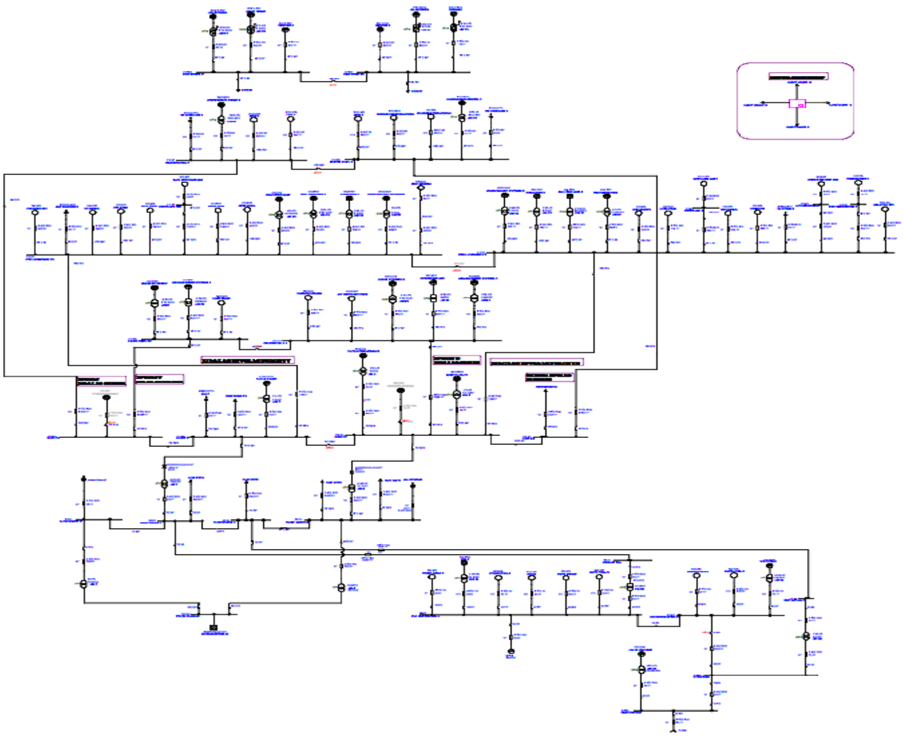

Figure 1.4 Modelling of zone-I

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI Volume XIII Issue V May 2026

The Figure 1.4 is the detailed modelling of Plant Zone-I which are modelled using ETAP 19.1.0 software. It includes a many inner plants with various voltage ranges, like mentioned at the block diagram.

Simulation Results for Load Flow Analysis

As per the standard of load flow analysis, the system maintains its nominal tolerance of ±10% of its range. The load flow analysis results are provided in the Figure 1.5 which specify the voltage of all buses in zones I.

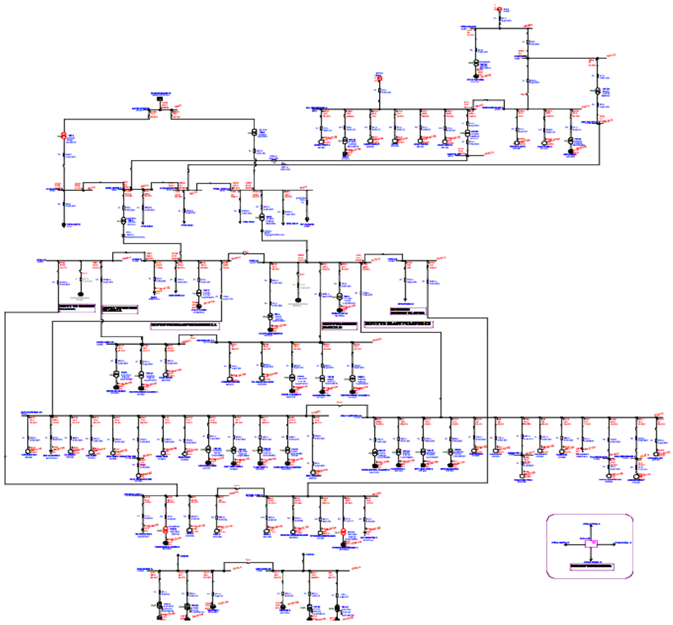

Figure 1.5 Load flow analysis results of zone-I

Simulation Results for Fault Studies

From the voltage profile obtained through the load flow analysis, fault studies are subsequently performed using the data from the plant. Based on the results of the earlier simulation, the short-circuit current at the grid and the impedance values of the generators are incorporated into the system model. Using this information, various fault conditions are simulated to analyze the system response. The fault analysis includes both three-phase (symmetrical) and single line-to ground (L–G) (unsymmetrical) faults. The results for the symmetrical fault for the zones I are illustrated in Figure 1.6. And the results for the unsymmetrical fault are illustrated in Figure 1.7.

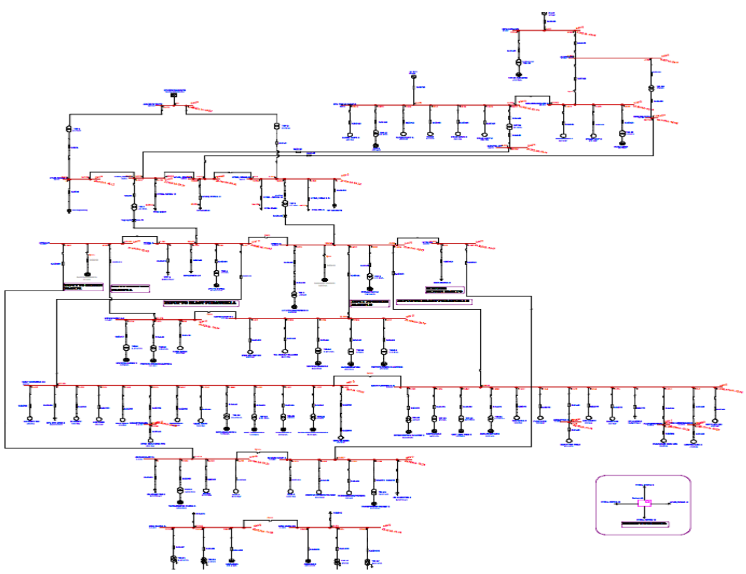

Figure 1.6 Symmetrical fault for the zones I

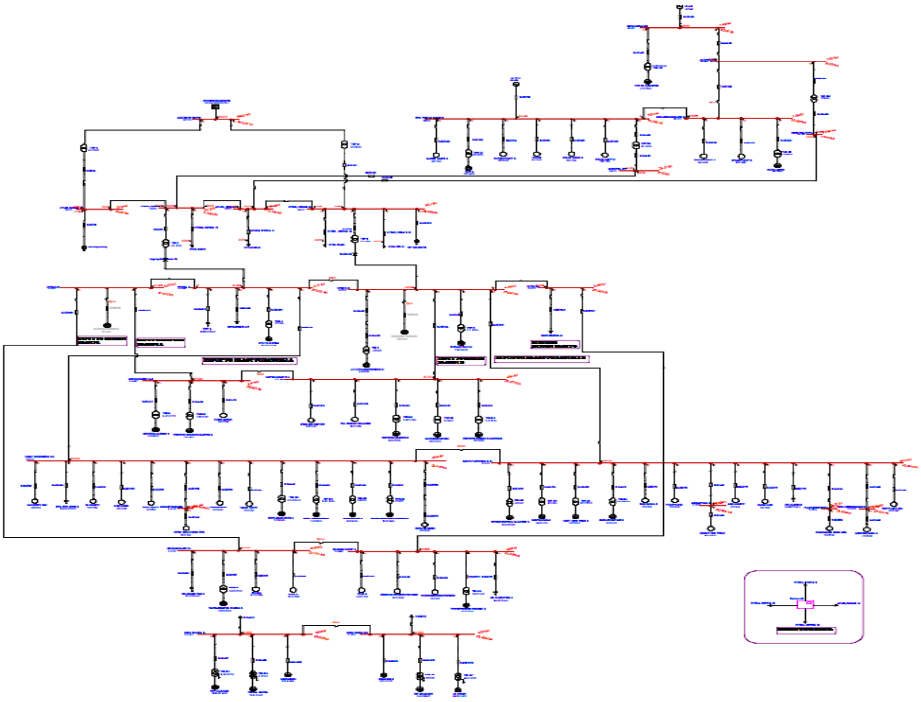

Figure 1.7 Unsymmetrical fault for the zone-I

CONCLUSION

The Plant has a total power capacity of 38 MW and receives its main power supply from the nearby Substation. The entire electrical network of the industrial plant has been modelled and simulated using ETAP (19.1.0) software.

The results indicated that the voltage profiles of all buses are within permissible limits, confirming the systems stable operating condition during the load flow analysis. Furthermore, Fault studies are then performed utilizing plant data and the voltage profile acquired from the load flow study. Using this information, various failure conditions are simulated to analyse the system's response. The fault analysis covers both three phase (symmetrical) and single line-to-ground (unsymmetrical) faults. As a result, the fault currents at various buses in Phase-1 Zone are obtained and these values assist in determining the appropriate circuit breaker interrupting capacity and support effective protection coordination of the electrical distribution system.

REFERENCES

1. Vishal V, Ishwar, April 24, “Load Flow Analysis of Power System in ETAP”, IJIREEICE, ISSN (O) 2321-2004, Vol. 12, Issue 4, pp. 64-69.
2. Vishal V, Utkarsh Chaurasia, 2020 “Load Flow Analysis of 66 kV substation using ETAP Software”, JUNE 2022, IRE, Vol. 5, Issue 12, ISSN:2456-8880, pp. 208-211.
3. Igbogidi O. N. and Dahunsi, A. A. 2024, “Modern Trend of Power flow Analysis in Power System”, American Journal of Engineering Research (AJER), e-ISSN: 2320-0847 p ISSN: 2320-0936, Vol. 12, Issue 4, pp.53 582024.
4. Ukut, Uwem Isong1, Okpura, Nseobong2 March-2023, “The IEEE 33 Bus Distribution System Power flow Analysis Using Newton Raphson Method”, Journal of Multidisciplinary Engineering Science and Technology, Journal of Multidisciplinary Engineering Science and Technology (JMEST), ISSN: 2458-9403, Vol. 10 Issue-3, pp. 16039-16047.
5. Muhammad Bilal, Prof. Dr. M. Naeem Arbab, Muhammad Zubair, November 2019, “Using ETAP Power flow Analysis of 132/11kv Kohat Substation: A Case Study”, Global scientific journal (GSJ), ISSN 2320-9186, Volume 7, Issue 11, 1041-1046.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI Volume XIII Issue V May 2026

AUTHORS' INFORMATION

Ananya C- Postgraduate scholar in Power Systems Engineering at Government College of Technology, Coimbatore. She received her Bachelor of Engineering degree in Electrical and Electronics Engineering from Dr. N.G.P Institute of Technology, Coimbatore, in 2024. Her research interests include power system analysis and industrial power system studies. She has worked on load flow and short circuit analysis for industrial electrical networks. Her current research focuses on improving reliability and efficiency in power system operation and planning.

Dr E. Latha Mercy- Professor and HoD of Electrical & Electronics Engineering is with the Government College of Technology, Coimbatore, TamilNadu. She completed her Doctoral degree from Anna University in 2011, Masters in Applied Electronics in Government College of Technology, Coimbatore from Bharathiyar University in 1999 and Bachelor of Engineering in Electrical Engineering at Thiagarajar College of Engineering from Madurai Kamaraj University, Madurai in 1988. She has more than 37 years of teaching experience in various Government Engineering Colleges under Directorate of Technical Education, Tamilnadu. She is a life member of ISTE. Having 50+ Journal publications, 36+ Conference Publications, attended 100+ FDPs/STTPs/Workshops/Webinars and organized 15+ FDPs. Received few institutional academic awards. Recognized research supervisor under Anna University.