# Load Flow Analysis of A 3-Bus or 5-Bus Power System Using ETAP

**Prof. Vishal V. Mehtre, Prathmesh Pawar, Kartik Jadhav.**

**How to Cite this Article**:

Pawar, P. & Jadhav, K. (2026). Load Flow Analysis of A 3-Bus or 5-Bus Power System Using ETAP. International Journal of Creative and Open Research in Engineering and Management, <i>02</i>(05). https://doi.org/10.55041/ijcope.v2i5.377



https://doi.org/10.55041/ijcope.v2i5.377

## Abstract

Load flow analysis is the most critical investigation done on an electric power system to determine the operation condition of the system at steady state. This paper involves the analysis of a 3-Bus and 5-Bus power system model using the ETAP software. This research work is based on the analysis of voltage magnitude, active power flow, reactive power flow, transformer loading, and transmission line analysis at different operating conditions. Buses, Transformers, Loads, Generators and Transmission lines are created in ETAP software to form the electrical network. The load flow analysis of the model is done by using the Newton-Raphson approach due to its fast convergence and higher accuracy. Several operating scenarios including the Normal Operating Condition, Transformer Overload, and Increased Load conditions were studied, and the results indicate that although the system works efficiently at normal operating conditions, it will face voltage drop, transformer overload, and power loss when loading increases.

Keywords: Load Flow Analysis, ETAP, Power System, Bus System, Voltage Profile, Transformer Loading, Power Flow.

## 1.Introduction:

Electricity forms part of the most crucial necessities required for any industrial, commercial, and residential use. The current electrical power systems are becoming increasingly larger and interdependent due to the ever-growing need for electrical power. With the rising complexity and magnitude of the power systems, it is vital to carry out a thorough analysis of the system to guarantee its safe, efficient, and reliable operation. Load flow analysis constitutes an indispensable study that forms part of the power system engineering discipline. The study is important in determining the magnitude of the voltage, voltage angles, active power flow, reactive power flow, and power losses in the transmission lines. The results obtained from load flow studies are useful for:

1. Power System Planning.
2. Voltage Control.
3. Transformer Loading Analysis.
4. Stability Improvement.
5. Fault Analysis Preparation
6. Expansion of Transmission Network

Previously, load flow studies were done manually through mathematics. But manual studies are extremely complex and time-consuming when considering large power systems. Thus, sophisticated software packages are currently in extensive use for power system studies.

ETAP is one of the most commonly used software packages in the field of electrical engineering for studying and analyzing power systems. The ETAP software offers a graphical interface that helps engineers analyze their electrical systems efficiently. For the completion of this project, the creation of a power system is planned in ETAP software. Various components like generators, transformers, transmission lines, buses, and loads will be linked to form a network. Load flow analysis of the system will be done under normal and overloaded conditions.

**2.Methodology:**

In this study, a 3-Bus or 5-Bus power system design and analysis have been undertaken. Load flow analysis has been performed by using ETAP Software. In order to design an electrical power system, firstly, a single line diagram is created by utilizing various electrical components that are available in the ETAP library. These components include buses, transformers, generators, transmission lines, and loads. After designing the network, rating details of each of the electrical components like voltage levels, transformer ratings, and load values are inputted to the software. All the components are then correctly connected with each other.

After designing the system, load flow analysis option in ETAP software has been chosen for analyzing the electrical power system design. Newton Raphson algorithm is selected for simulation due to its faster convergence properties. Various types of analysis like normal load condition analysis, transformer overload condition analysis, and increased load condition analysis are undertaken during the simulation process. While conducting this analysis, all parameters related to bus voltage, power flow, transformer loading, and power loss are considered carefully. The outcomes of the analysis are studied to understand the behavior and performance of the power system for various loads. Variations in voltage, transformer overload, and system losses are identified based on the simulation outcomes. Finally, the observations are documented using tables, graphs, and screenshots from ETAP to explain the process of load flow analysis and its performance.

**3.LOAD FLOW STUDY:**

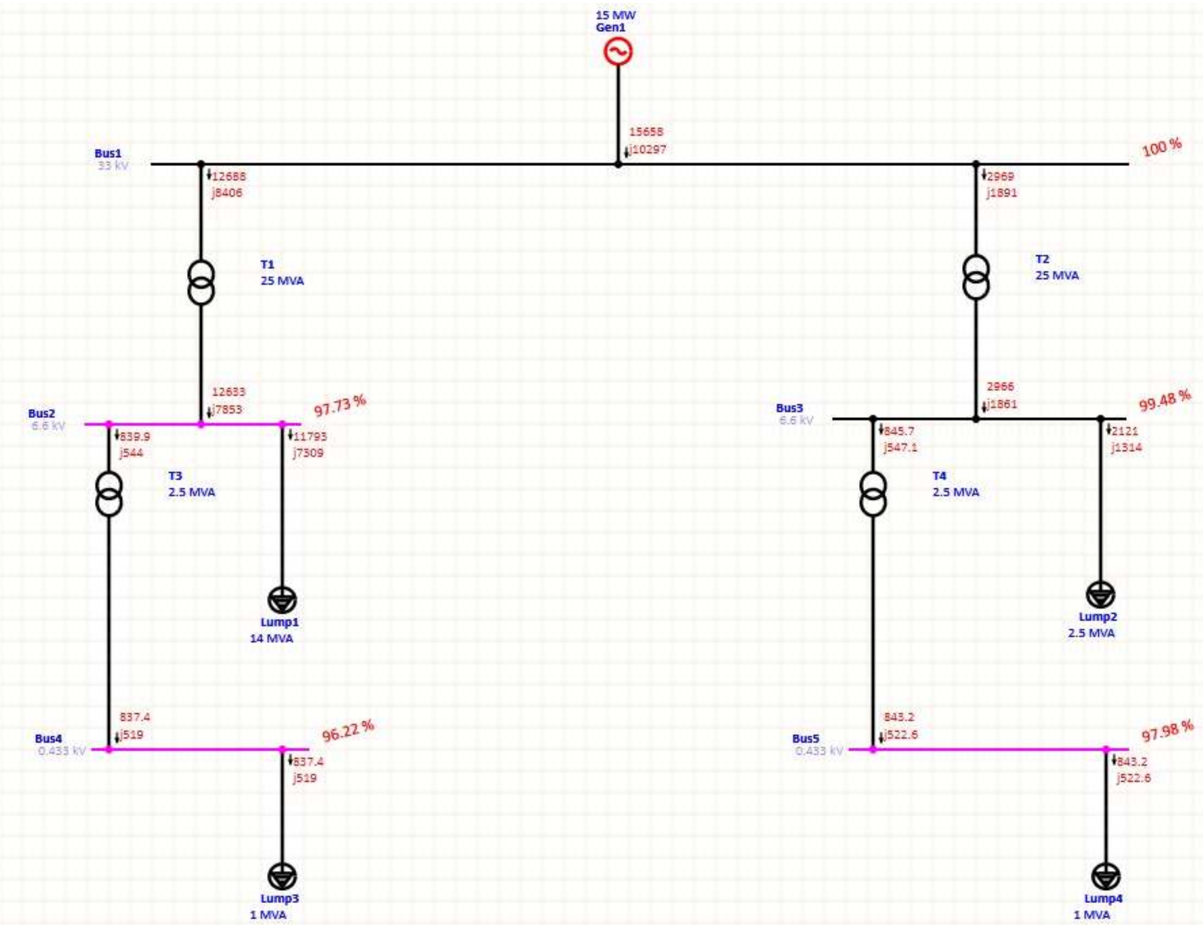
Load Flow Study or Power Flow Analysis is one of the major studies that is done on electrical power systems. It involves the determination of the working condition of a power system under steady-state operation. The analysis determines the voltage magnitude, voltage phase angle, active power flow, reactive power flow, and power loss in different buses of the power system.

The primary aim of power flow study is to understand the flow of electrical energy from the power station to load buses by means of the transmission line and transformers. This is important for ensuring voltage stability and power loss minimization within the electrical system.

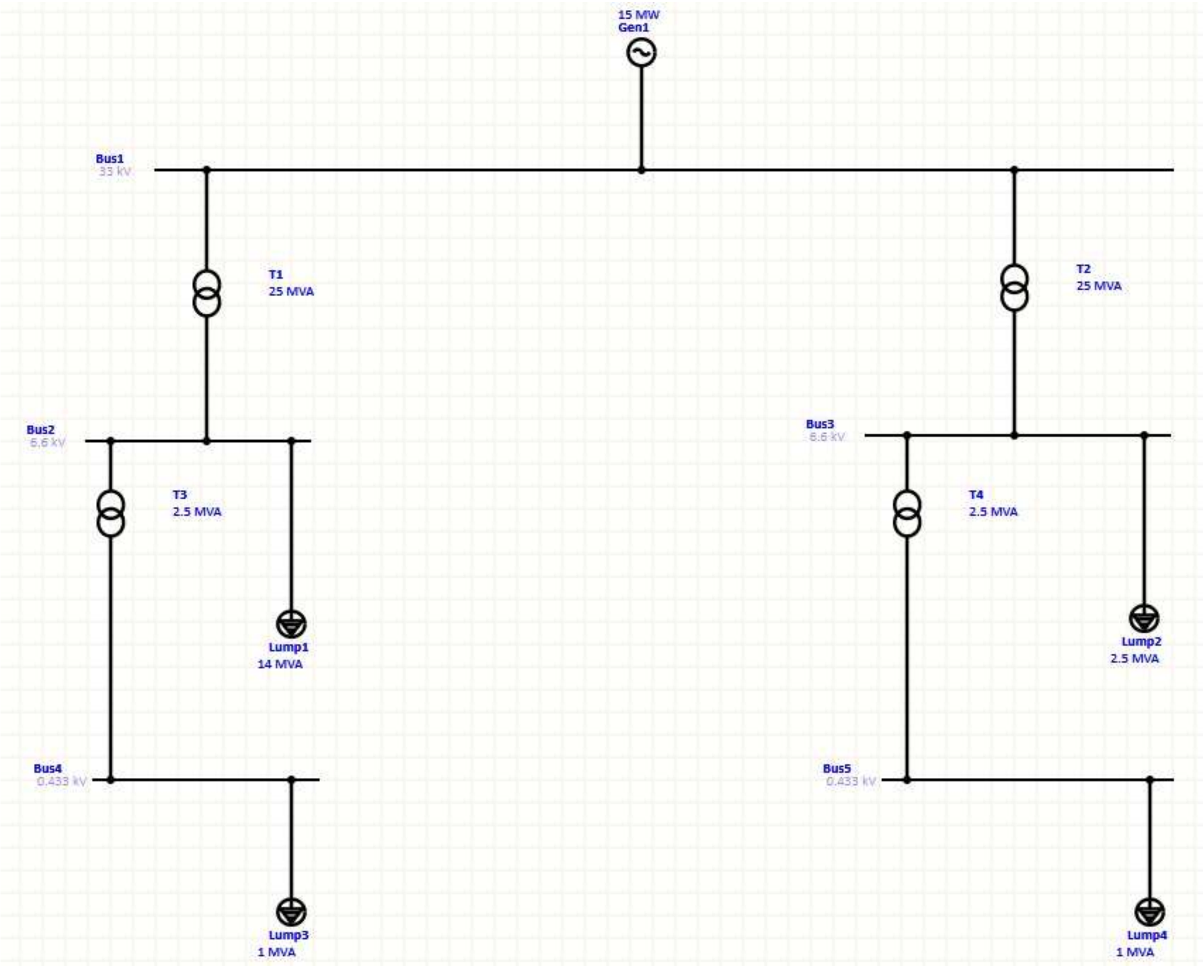
Power flow analysis plays an important role since it enables engineers to conduct performance analysis of the electrical system before its implementation. This study is common in power generation plants, substations, industries, and transmission networks. As today's electric networks become more complex and extensive, the regulation of voltage levels becomes increasingly complicated. The study of load flows allows us to better understand how the electric network works and operates under different conditions.

## 4.ETAP SIMULATION AND ANALYSIS:




| Components | Ratings / Voltages | Buses to which they are connected | Additional Information |
|---|---|---|---|
| Bus1 | 33 kV | Top Main Bus | Main Supply Bus |
| Gen1 | 15 MW | Bus1 | Currents: i1568, j10297 |
| T1 | 25 MW | Bus1-Bus2 | Current: i2633, j7853 |
| Bus2 | 6.6 kV | Left Side | Voltage Level:97.73% |
| T3 | 2.5 MVA | Bus-2 Bus-4 | Current: i837.4, j519 |
| Bus4 | 0.433 kV | Bottom Left | Voltage Level: 96.22% |
| Lump1 | 14 MVA | Bus2 | Currents: i11793, j7309 |
| Lump3 | 1 MVA | Bus4 | Currents:i837.4, j519 |
| T2 | 25 MVA | Bus1-Bus3 | Currents: i2966, j1861 |
| Bus3 | 6.6 Kv | Right Side | Voltage Level: 99.48% |
| T4 | 2.5 MVA | Bus3-Bus5 | Current: i843.2, j522.6 |
| Bus5 | 0.433kV | Bottom Right | Voltage Level: 97.98% |
| Lump2 | 2.5 MVA | Bus3 | Current: i1321,j1314 |
| Lump4 | 1 MVA | Bus5 | Current: i843.2, j522.6 |




| Component | Voltage/Rating | Connection Bus | Types |
|---|---|---|---|
| Bus1 | 33kV | Main Bus | HT Bus |
| Gen1 | 15 MW | Bus1 | Generator |
| T1 | 25 MVA | Bus1-Bus2 | Power Transformer |
| Bus2 | 6.6kV | Left Section | MV Bus |
| T3 | 2.5 MVA | Bus2-Bus4 | Distribution Transformer |
| Bus4 | 0.433kV | Bottom Left | LV Bus |
| Lump1 | 14 MVA | Bus2 | Load |
| Lump3 | 1 MVA | Bus4 | Load |
| T2 | 25 MVA | Bus1-Bus3 | Power Transformer |
| Bus3 | 6.6kV | Right Side | MV Bus |
| T4 | 2.5 MVA | Bus3-Bus5 | Distribution Transformer |
| Bus5 | 0.433 MVA | Lower Right | LV Bus |
| Lump2 | 2.5 MVA | Bus3 | Load |
| Lump4 | 1 MVA | Bus5 | Load |

## 5.Conclusion:

In this regard, this project was able to successfully carry out the analysis of load flow on the 3-Bus or 5-Bus system through the ETAP Software. All components including buses, transformers, transmission lines, generators, and loads made up the electrical network. Various operating conditions were studied including normal loading, transformer overloading, and increased load conditions to find out how the power system behaved.

From the analysis carried out, it was discovered that the power system worked efficiently under normal conditions with proper voltages and safe transformer loading. However, under the overloaded and increase loading conditions, voltage drops at various buses were recorded and unsafe transformer loading recorded. It also appeared that the power system loses a lot of power under overload condition.

This project helped to understand the significance of load flow analysis in the effective operation of electrical power systems. Moreover, the ETAP Software makes it easy and accurate for engineers to carry out the analysis of electrical networks.

Consequently, load flow analysis is an essential component of the operation and performance of power systems. This study therefore concludes that ETAP is an excellent tool for analyzing electrical networks.

**6.Futher Scope:**

The current project deals with load flow analysis of 3-bus or 5-bus power system analysis using ETAP software under varying operating conditions. Future research could include carrying out power system analysis of larger and complex systems using ETAP Software. Apart from that, other studies including short-circuit analysis, transient stability analysis, relay coordination, harmonic analysis and protection system analysis can also be carried out using ETAP software.

Future research could include incorporating various renewable energy resources including solar power generation plants and wind farms into electrical networks to study their effects on system performance. Smart grid technology and real-time monitoring technology could also be incorporated in future researches to have improved efficiency of operation. Optimisation techniques can be applied in future projects to reduce transmission losses, improve voltage stability and increase reliability.

In future research projects, various load flow analysis techniques including Fast Decoupled Load Flow and Gauss-Seidel method can be compared with the Newton Raphson technique to study their performances. The project can also be extended to the field of industrial application of electrical networks for advanced and practical analysis of power systems.

**7.References:**

1. Authors: J. J. Grainger and W. D. Stevenson; Book: Power System Analysis; Publisher: McGraw-Hill Education.

2. Author: Hadi Saadat; Book: Power System Analysis; Publisher: Tata McGraw-Hill Publishing Company Limited.

3. Authors: Chakrabarti and S. Halder; Book: Power System Analysis: Operation and Control; Publisher: PHI Learning.

4. URL: http://www.etap.com/

5. Electrical Engineering journals covering topics on power system studies and voltage stability analysis.

6. Techincal manuals and simulation guides for ETAP load flow analysis.

7. Author: P. Kundur; Book: Power System Stability and Control; Publisher: McGraw-Hill Publication.

8. Author: C. L. W