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# Power System Analysis and Optimization of a Micro-grid using ETAP.

Mohit Jambu
Department of Core Engineering, Gulzar Group of Institutions, Khanna.

,Kulwinder Singh
Department of Core Engineering, Gulzar Group of Institutions, Khanna

Jagdeep Singh
Department of Core Engineering, Gulzar Group of Institutions, Khanna

**Abstract -** The growth of smaller generating systems, such as micro turbines, wind turbines, solar PV systems, etc., has formed new options for onsite power generation, also known as distributed energy resources (DER), which is placed at the user's location. By combining these resources into a micro-grid, the great potential of DER to independently address consumer needs and utility needs may be realized. Power system engineering must include power system studies and analysis. This study examines an Electrical Transient Analyzer Programmed (ETAP) simulation of the Micro Grid. This research focuses on the in-depth analyses utilizing the most recent software, ETAP, which produces output reports that are useful for implementing a Micro-grid system and conducts numerical computations of huge integrated power systems with amazing speed. Off-line monitoring of a big power system is accomplished using this programme, which comprises current flowing in every branch, power factor, active and reactive power flow, short circuit analysis, harmonic distortion, etc. based on the data that has been collected and taken from a real Micro-grid that has been used in ETAP for off-line observing and analysis.

**Keywords**-Micro-grids, Power system analysis, Energy storage systems, Wind turbines, Distributed energy resources (DERs), Solar photovoltaics

## I. INTRODUCTION

The increasing demand for electric power necessitates not only the construction of additional generating locations but also the reform of existing power grids. Load flow studies, such as those conducted with the Electrical Transient Analyzer Program (ETAP), play a crucial role in achieving this goal by providing accurate and reliable outcomes. ETAP offers a comprehensive set of Electrical Design tools, containing transient stability, transfer coordination, load flow analysis, and more [Vishal et al., (2015)].

The rise in energy consumption is anticipated to accompany population growth, urbanization, and economic development [Czumbil et al., (2017)]. Developing countries like India face challenges in meeting electricity demands due to a lack of proportional increase in electricity generation. This shortfall can be attributed, in part, to deficiencies in the field of analysis [ Khan et al., (2009)]. Voltage instability is a significant issue in power systems, as it hinders the transmission of reactive power over long distances, necessitating local generation near the point of consumption. Deviations between rated voltage and actual voltage can also lead to low voltage, which is dangerous and can cause machinery like motors to overheat [Mozina et al., (2007)].

Electrical engineers have been using various software tools for power system studies, and computer-based software has emerged as a powerful tool for conducting research in electrical engineering. This project focuses on the practical application of ETAP for modeling and simulating a robust electrical power system, particularly the power distribution from the 132kV grid in Punjab [Brown et al., (1990]. The project comprises the single line schematic as well as the actual ratings of the 132kV grid's isolating switches, circuit breakers, potential transformers, power transformers, and current transformers.

### Details of components

The power grid system under consideration consists of 9 buses, which include 2 power t/f, 2 potential t/f, 51 current t/f, 51 circuit breakers, 9 feeders operating at 11KV, and 16 isolating switches. All the data presented in the tables is real-time info collected directly from the local grid station.

Table 1. Data and rating of all apparatuses

| **Component** | **Type** | **Rating** | |
|---|---|---|---|
| **Power Transformer** | T1(2-winding) | 40MVA | |
| | T2(2-winding) | 40MVA | |
| **CT** | CT 1-3 | 600A | 1A |
| | CT 4 | 75 | 1A |
| | CT 5-11 | 900 | 5A |
| | Remaining 41 CTs | 1200 | 5A |
| **PT** | PT- 1 | 132KV | 110 V |
| | PT- 2 | 11 KV | 110 V |
| **Isolating switches** | SW 1-16 | 132KV/1600Amp | |
| **CB** | | RATED CURRENT | NORMAL CURRENT |
| | KHN 81-84 | 145kV/1600A | |
| | KHN71-74 | 12kV/630V | |
| | CB'S WITH FEEDER | 12kV/1250A | |

Table 2 Showing Connected Bus-bars

| **Feeders** | **11KVoutgoing** | **Load amp** |
|---|---|---|
| | Load 1 | 248A |
| | Load 2 | 396A |
| | Load 3 | 210A |
| | Load 4 | 250A |
| | Load 5 | 300A |
| | Load 6 | 270A |
| | Load 7 | 18A |

The Figure 1 below shows single line diagram of 132kV substationconventional in ETAP. The grid has 4 incoming supplies connected to 2 bus bars each of evaluation 132kV. Further, power transformers that scale down 132kV to 11kV for distribution are used to connect these bus bars to feeders. There are two capacitor banks fitted, each with a 7.3 MVAR rating.

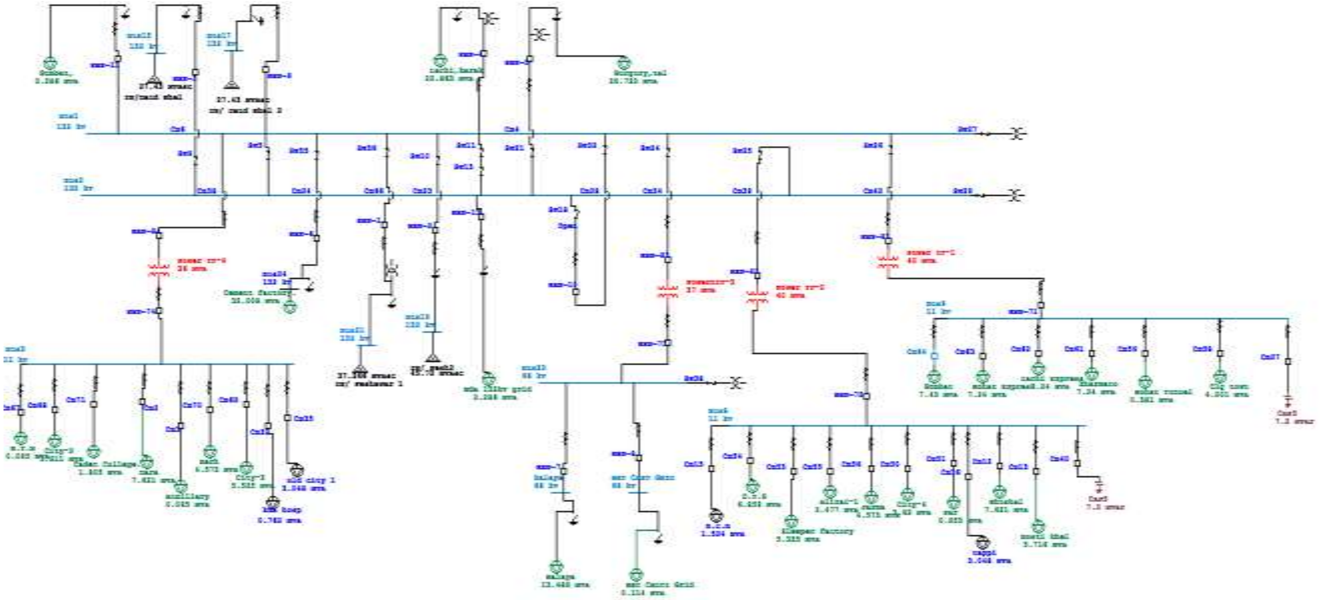

Figure 1. Single line diagram of 132kv grid in etap

## II. SIMULATION IN ETAP

The Figure 2 below shows replicated diagram of 132kV grid in ETAP. After simulation ETAP alerts shows that bus no 4, 6, 7 are in under energy which are load busses in which bus no 3 is in critical situation and power transformer TF-4 is overloaded.

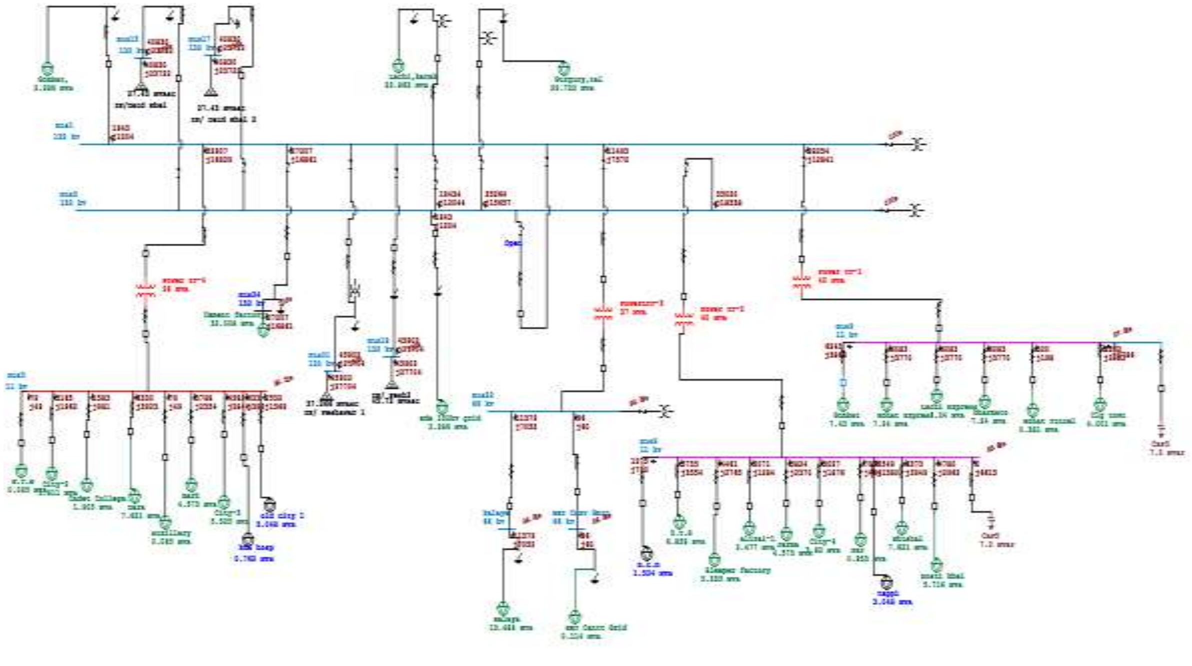

Figure 2. Simulated diagram of 132/11kv grid in etap before adding capacitor bank.

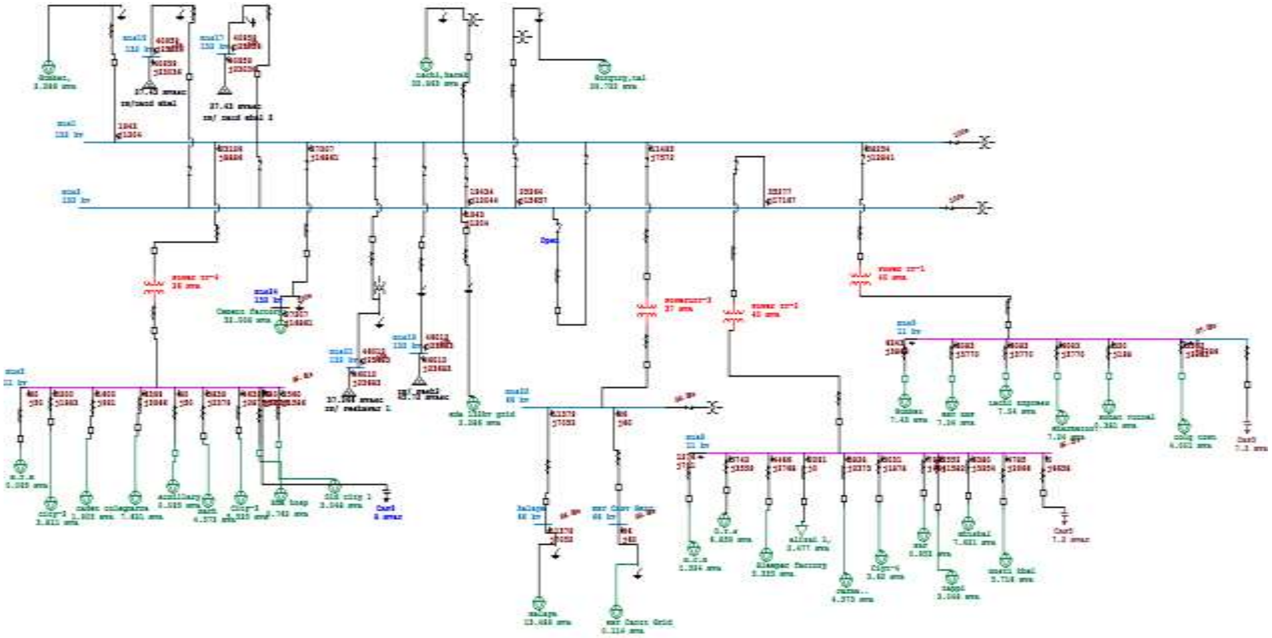

Figure 3. simulated diagram of 132/11kv grid in etap after adding capacitor bank.

**Total incoming supply**

The table below shows the dissimilar incoming supplies to the grid station.

Table 3. Total incoming supply to the selected 132kv grid

| TYPE | RATING | RATED KV | MW | MVAR | %PF |
|---|---|---|---|---|---|
| **Bus 1** | **132** | **132** | **24.463** | **16.088** | **83.6** |
| **Bus 2** | **11** | **11** | **17.773** | **9.593** | **83.3** |
| **Bus 3** | **11** | **11** | **9.557** | **5.158** | **84** |

**Load flow analysis**

In ETAP, a 132 KV substation load flow assessment using several numerical techniques has been performed. Table 4 provides a summary of the system's total generation, total demand, and losses prior to the addition of a capacitor bank.

Summary of generation, demand, and loss data prior to the adoption of the capacitor ban Parameters

| Type | MW | MVAR | MVA | %pf |
|---|---|---|---|---|
| **Swing Bus** | **24.460** | **16.070** | **29.270** | **83.4** |
| **Total Demand** | **24.593** | **16.091** | **29.269** | **83.4** |
| **Total Static Load** | **24.310** | **13.116** | **27.599** | **87** |
| **App Losses** | **0.17** | **2.967** | | |
| **T/F 1** | **61.6kW** | **949.5Kvar** | | |
| **T/F 2** | **107.90kW** | **2022.6Kvar** | | |

**Load flow analysis cautions by etap**

Following the deployment of load flow analysis, ready information that identifies the minimal or critical state of various system components can be observed. The critical and minimal cautions reports are shown in the tables below. Buses with an operational condition of less than 95% that are under voltage are placed in the critical condition, whereas buses with an operational condition of more than 95% that are under voltage are placed in the marginal alert report category. Bus numbers 3 and 8 are clearly under-voltage, as shown in Table 4. 46

**Etap alerts by putting load**

The table below details the under voltage warning for buses 3 and 4 only in each of the two buses.

Table 5.critical alerts in which bus no 3&4are in under voltage (critical situation).

| Device id | Condition | Rating | Operating | %operating | Phase type |
|---|---|---|---|---|---|
| Bus 3 | Under Voltage | 11kV | 10.278kV | 93.4 | 3-Phase |
| Bus 4 | Under Voltage | 11kV | 10.378kV | 93.4 | 3-Phase |

**Addition of capacitor bank to overcome the problem of under voltage**.

A capacitor bank of 8 MVAR is linked in shunt with feeders to address the under voltage issue. Following the generation of these ETAP warnings, table 9 displays the minimal ETAP alerts, showing that bus number 3 have improved from 94.1% to 96.9% and bus number 8 has improved from 95.5 to 96.2. Busses are still under-voltaged, but none are in a life-threatening situation.
Following the capacitor bank's connection, table 8 presents a summary of the overall generation, demand, and losses. When table 2 and table 7 are compared to one another, there is a difference. It is undeniably demonstrated that apparent losses are decreased.

TABLE 5 shows the results of the load flow, and when compared to TABLE 2, it is clear that the power factor has improved.

table 6

| Monitoring Points | kV | MW | Mvar | %PF |
|---|---|---|---|---|
| BUS 1* | 132 | 26.551 | 4.6 | 98.5 |
| BUS 3 | 11 | 17.148 | 1.344 | 98.6 |
| BUS 4 | 11 | 9.259 | 0.735 | 98.7 |

*Swing Bus

TABLE 7 shows the Demand and Losses summary report and the losses are far less as compared to the losses shown in TABLE 3.

table 7

| Type | MW | Mvar | MVA | %PF |
|---|---|---|---|---|
| Swing Bus | 26.551 | 4.6 | 26.947 | 98.53(lag) |
| Total Demand | 26.551 | 4.6 | 26.947 | 98.53(lag) |
| Total Static Load | 26.407 | 2.078 | 26.489 | 99.3(lag) |
| Apparent Losses | 0.144 | 2.522 | | |
| Transformer 1 | 51.6kW | 799.7kVar | | |
| Transformer 2 | 92.6kW | 1722.3kVar | | |

By comparing TABLE 7 to TABLE 4, it can be seen that the placement of capacitor banks in shunt to the effluents has eliminated the issue of an undervoltage at both motorcars.

table 8

| Device ID | Condition | Rating | Operating | %Operating |
|---|---|---|---|---|
| Bus 3 | Not at Under Voltage | 11 kV | 10.805 kV | 98.23 |
| Bus 4 | Not at Under Voltage | 11 kV | 10.827 kV | 98.43 |

## III. CONCLUSIONS

In order to solve the undervoltage issue, a load flow study using the ETAP program is conducted in this article. System planning is greatly aided by load flow studies performed with ETAP software. Many operational processes can be deconstructed in a manner like to that of a transmission line, a motor, or a load. The best size and placement of capacitors can be determined via load flow studies in order to solve the under voltage issue. Additionally, they are helpful in identifying the system voltages when loads are applied or disconnected quickly.Studies of load influx assess whether overfilled equipment such as mills and operators are present and whether system voltages remain within predetermined limits under varied contingency scenarios. It is common practice to utilize load-inflow studies to determine whether new generation, capacitive or inductive VAR support, or the placement of capacitors and/or reactors is required to keep system voltages within predetermined bounds, is necessary.

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