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Load Flow Study of GCT Powerhouse using ETAP

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Abstract

Load flow is one of the most significant aspects to consider while studying and analyzing power system functioning. A comprehensive study of load flow analysis at the Government College of Technology (GCT) powerhouse is offered in this research. The Electrical Transient Analyzer Program (ETAP) software is used to construct a case study of modelling and simulation of the actual power distribution network (Version: 19.1). A comparison of common load flow approaches for power distribution is also offered. This evaluation provides and compares numerical and practical approaches such as Adaptive Newton-Raphson, Newton-Raphson, and Fast Decoupled. The study is an analysis of high voltage substations to loads utilizing ETAP software. The capabilities and usefulness of load flow evaluation are proved by applying ETAP simulation findings to the actual distributed power system of GCT, Coimbatore. ETAP makes easy the conversion of traditional to a smart grid.

Keywords: Load Flow, Electrical Transient Analyzer Program (ETAP), Adaptive Newton Raphson, GCT Powerhouse

1. Introduction

According to IEEE Standard 399 [1], the load consumption at all buses of a known electric power system configuration and the power production at each generator, as well as the power flow in each line and transformer of the interconnecting network, as well as the voltage magnitude and phase angle at each bus can be determined. Load flow studies are the most prevalent type of power system analysis computation. In planning studies, they are used to identify if and when certain aspects may become overloaded. Major investment choices

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begin with load flow analysis-based reinforcement techniques. Load flow analysis is used in operational studies, to guarantee that each generator operates at its optimal operating point, that demand is fulfilled without overloading facilities, and that maintenance plans may be carried out without undermining the security of the system.

The voltage profile of the system is significant data discovered from the power movement. Large reactive flows will result from V's wide variations throughout the system, which will raise real power losses and, in the worst instances, raise the risk of voltage failure. It is a standard practice to place capacitor banks in order to provide reactive correction to the load when a specific bus has an unacceptable low voltage. Studies of load movement replicate the operational circumstances that can actually be felt when using the device. In order to analyse load flow, it is necessary to model the network and individual parts of the electricity system. The load flow equations are then developed and solved numerically.

2. GCT POWERHOUSE

A. About GCT Powerhouse

The block diagram of GCT powerhouse is shown in Fig.1

It receives power supply from Tamil Nadu Electricity Board [TNEB]. Total demand of GCT is approximately 400 kW. It has two 500 kVA transformers, among them only one is operated at a time and another one is spare. The typical transformer is shown in Fig. 2, and the name plate details is given in Fig. 3. Transformer data is shown in Table I.

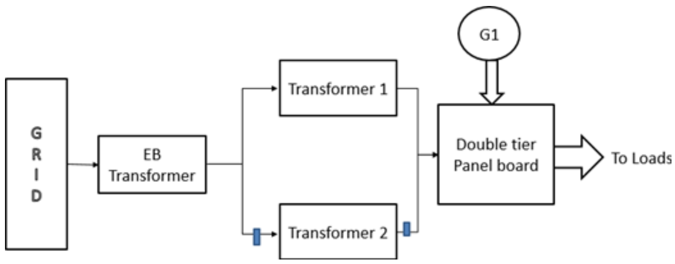

Figure 1. Block diagram representation of GCT powerhouse

Figure 2. Typical transformer in GCT powerhouse

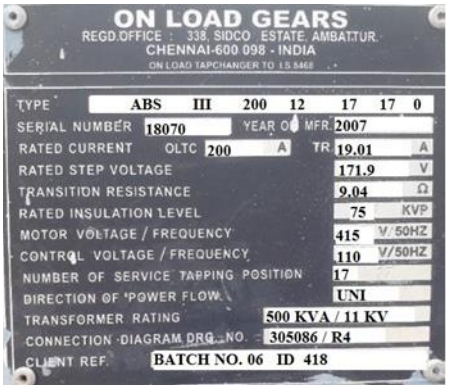

Figure 3. Name plate details of transformer

Table 1. Transformer Data

From bus	To bus	Circuit	Resistance (%)	Reactance (%)	Transformer identifier	Transformer KVA	%Z	X/R	R/X	Tap (kV)
1	15	1	2.219	3.328	T1	500	4	1.5	0.667	11/0.415
1	15	1	2.219	3.328	T2	500	4	1.5	0.667	11/0.415

The connection from transformer and the switchgears are given through 3c x 400 sq.mm underground cables. It also has a double tier panel board which permits to connect the transformers and generators without any short circuit.

A 380 kVA AC generator set is also present which is operated by diesel in case of power shut down. The capacity of the diesel tank is 500 liters. The generator in GCT is shown in Fig. 4, the name plate details of the generator is shown in Fig. 5 and the generator data is shown in Table II. A 50 kVA capacitor bank is present for power factor correction and it is automatically operated whenever there is a decrease in power factor. It is shown in Fig. 6. There are two automatic tap changers for transformer with the maximum number of 16 tapings, one for each transformer. The tap changer is shown in Fig. 7.

Figure 4. Diesel generator in GCT

Figure 5. Name plate details of diesel generator

Figure 6. A 50 kVA capacitor bank

Figure 7. Tap changing transformer in powerhouse

Table 2. Generator Data

Unit ID	Real Power (kW)	Excitation Voltage (V)	Generator identifier	Generator KVA	Speed (RPM)	% PF	% Eff	MVAR Upper Limit
1	304	38	G2	380	1500	80	95	200.2

B. Different loads in GCT

The different loads that are connected to the GCT powerhouse through the switchgears are as follows.

- Main Building
- Rudra Building
- Amaravathy Hostels
- Boys Hostel
- Auditorium
- Industrial Biotechnology
- EIE Department
- CSE Department

- ECE Department
- Auditorium
- Science Block
- Mechanical Engineering
- Pillar Box 1 (Civil laboratories)
- Pillar Box 2 (Electrical Machines lab)
- Pillar Box 3 (Other parts of GCT)

These loads are connected at different voltage levels depending upon the total load consumption by different loads. In the above loads, pillar box is a distribution box that distributes load to some specific areas. Here, heat engines laboratory and electrical machines laboratory are connected by pillar box I, whereas fitting shop, lathe shop, carpentry and special machines laboratory are connected by pillar box II. Among these loads, the motor consisting of loads are modelled in ETAP as per the data collected from each department and workshop.

3. Simulation Tool

The Electrical Transient Analyzer Program (ETAP) is a software program used by power system engineers to construct an "electrical digital twin" and analyze electrical power system dynamics, transients, and security.

Load flow study in this work is simulated using ETAP. With the collected load data from the GCT, they are modelled and inputs are given to it.

4. Simulation and Results

A. Standards for conducting Load Flow Study

- “IEEE Std 399-1997 - IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis”.

- “IEEE Std 3002.2-2018 - IEEE Recommended Practice for Conducting Load-Flow Studies and Analysis of Industrial and Commercial Power Systems”.

B. ETAP modelling GCT powerhouse

GCT is supplied with the voltage level of 11kV from the national grid. The powerhouse of GCT is exactly modelled in the ETAP software with the load details collected. In this, the higher capacity motor loads are modelled separately and the remaining loads such as lower capacity and lighting loads are modelled as lumped load. Each load system is modelled by the bus bar connected with the main powerhouse bus bar with the help of the cables of suitable ratings. From the powerhouse bus bar, it is connected to the distribution box with the cable and from the box the loads are further connected with the help of cables.

C. kW and kVA ratings of the load

The load kilo watts and kVA ratings of each load in GCT is represented in Table 3.

Table 3. Kw AND KVA Ratings

S.No	Load	kW	kVA
1	Main Building	39.4	43.8
2	Rudra Block	50.0	55.6
3	Auditorium	5.6	6.2
4	Box 1	13.0	14.4
5	Box 2	13.0	14.4
6	Box 3	11.0	12.2
7	CSE Department	15.0	16.7
8	ECE Department	28.0	31.1
9	EIE Department	30.0	33.3
10	Amaravathi hostels	28.0	31.1
11	Boys hostels	30.0	33.3
12	Science Block	15.0	16.7
13	Autonomous Block	7.0	7.8
14	IBT Department	18.0	20.0
15	Mechanical Block	26.0	28.9
	Total	**329**	**365.6**

D. Load flow methods in ETAP

There are three methods available in ETAP software and they are shown in Fig.8. Among them, Adaptive Newton Raphson method is used for load flow estimation in this work. On comparing with the Newton Raphson method, the Adaptive Newton Raphson method is more precise with lesser number of iterations and so the complexity is reduced.

Figure 8. Load flow methods available in ETAP

5. Simulation

The load flow is performed by ETAP using the Adaptive Newton Raphson method. The simulation model of GCT distribution system using ETAP is shown in Fig. 9. The simulation model of GCT distribution system after running load flow analysis using ETAP is shown in Fig. 10. The ETAP will generate a summary upon performing the load flow study.

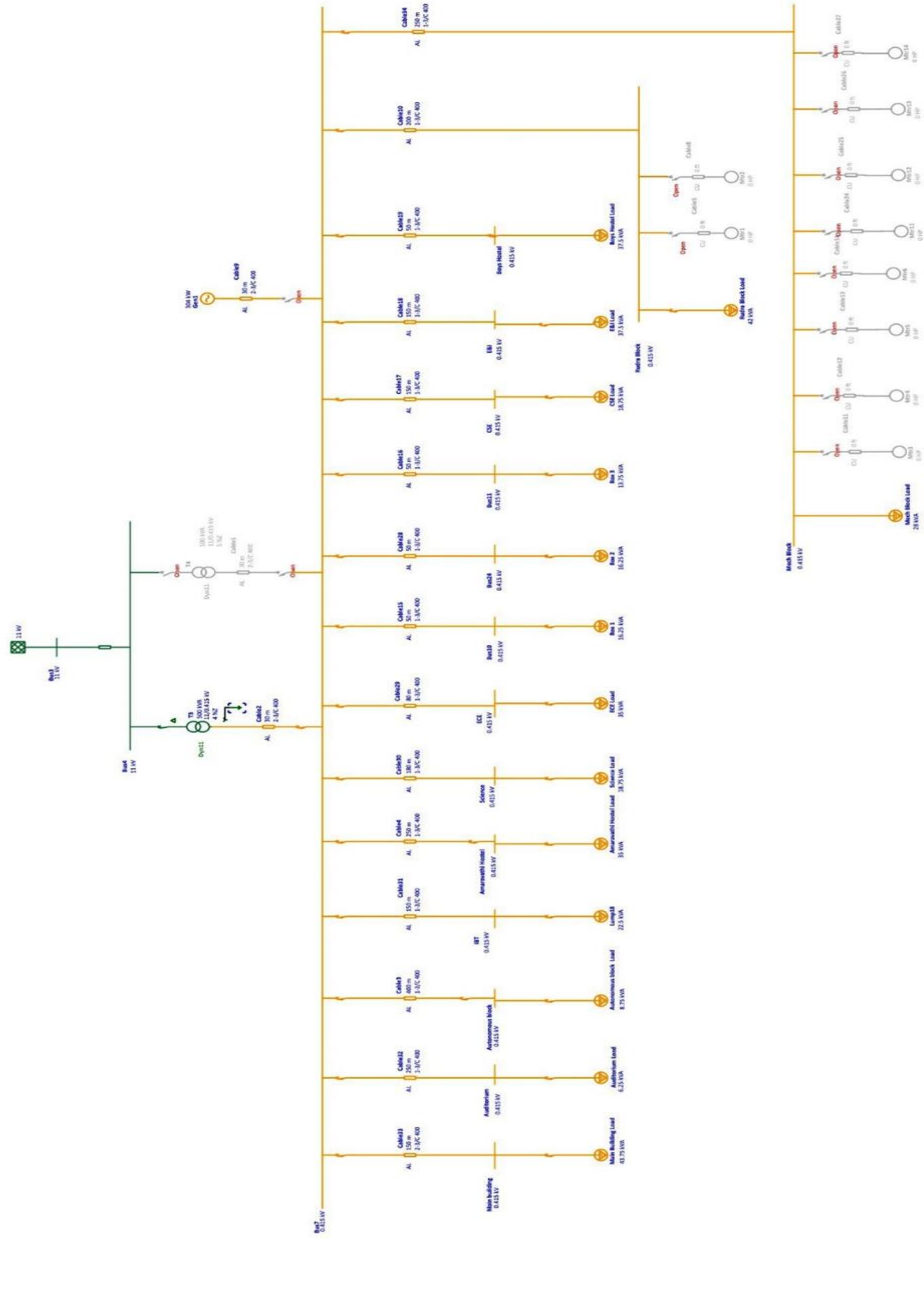

Figure 9. ETAP simulated model of GCT powerhouse distribution system

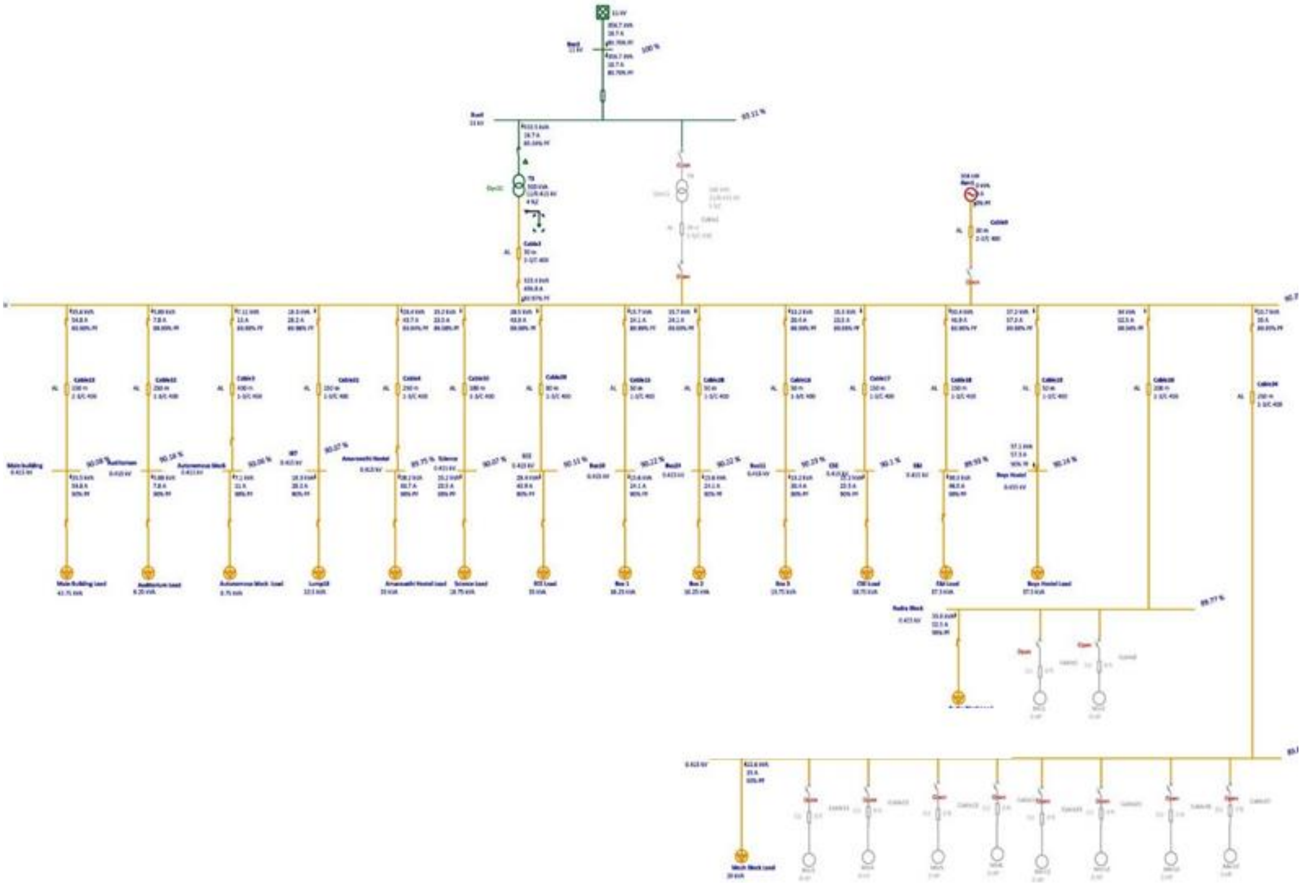

Figure 10. ETAP simulated model of GCT powerhouse distribution system after load flow

6. Conclusion and Future Scope

A. Conclusion

The Load Flow study here is performed by using Adaptive Newton Raphson method in ETAP. It helps in determining bus voltages, branch power factors, currents, power flow analysis, voltage drop calculations, demand evaluation, power factor, losses, correction, and power flows across the electrical system. These results are generated as a report which can be downloaded. The main advantage of this method is the lesser number of iterations, so that the reduction of the complexity of the network is achieved, and this method is more accurate than other methods. The load demand received by GCT from TNEB is 400 kW. In that, up to 370 kW is consumed as of now.

B. Future scope

A detailed modelling can be done for the Machines lab, Mechanical lab, and Civil lab of GCT by collecting the motor load data from each department. Short circuit study and motor starting study can be performed for GCT powerhouse using ETAP software.

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