ETAP Based Power System Analysis of a 6 MW Biomass Power Plant

Dipesh B. Pardeshi, Anupama Deshpande

Abstract*: To meet needs of electricity in rural India, there is an alternative option to be searched as the traditional ways and present approach which is renewable energy based and decentralized. While considering for options in the renewable energy sector for this purpose, such as bio-energy technologies are being explored. This work basically is intended to minimize the problems and difficulties involved in the generation of power by biomass combustion technique. The work behind this paper is to conduct a power system analysis of a 6 MW biomass power plant to calculate an impinging force advantageously placed distributed or embedded generation on distribution systems using an iterative power system simulation tools as regards the load flows, short circuit or fault studies, relative protective relay co-ordinations. This paper is based on modeling of single line diagram and simulates it through Electrical Transient Analyzer Program (ETAP) software. This work is investigated and resolved the problem to build the required confidence that a high penetration of biomass power plant connected to the grid is both realistic and secure.

Keywords: Biomass, ETAP, Load Flow Analysis, Short Circuit Analysis.

I. INTRODUCTION

Generation of power is the indication of economic, social, future growth and industrial development of country. It is obvious that alternative source of energy is necessary which is renewable and few of the advantages of renewable energy sources being – they are renewable, clean, available freely in nature, least by products, no hazardous effects and do not contribute to greenhouse and global warming effects.

In the naturally occurring energy sources category, biological action by living microorganism (biomass) can be used as substitute for fossil fuels due to large availability in India, especially in rural part. Also there is more waste land available on which no useful crops are taken. Different biomass energy related crops like strass grass and others can be grown in this land. For economic and social development of rural part, there is need of eminence, consistent minimum priced energy. Even though in the state of Maharashtra, state government is trying to provide electrical energy to farmers with lowest cost, but unable to provide supply a full day due to unavailability. With the availability of Land, human power and water, till there is problems persist for improving low quality of life and environmental degradation due to unavailability of supply.

Revised Manuscript Received on June 22, 2020.

Dipesh B. Pardeshi, Ph.D. Scholar, Department of Electrical Engineering, Shri Jagdishprasad Jhabarmal Tibrewala University, *{JJTU}*, Jhunjhunu, Rajasthan, India.

Dr. Anupama Deshpande, Associate Professor, Department of Electrical Engineering, Shri Jagdishprasad Jhabarmal Tibrewala University, *{JJTU}*, Jhunjhunu, Rajasthan, India.

As per the Ministry of Power (MOP), Govt. of India approximations, about 8% power shortfall is prevalent in the country. This has worried the availability of power in rural areas. There are about 74% of villages which have been electrified but still about 154,230 villages are un-electrified. Even in the so called grid linked villages the quality and availability of power is poor. In India, major power generation is by burning of coal i.e. thermal power plants which is placed adjacent to the availability of coal area (fuel) and second by using flow of water i.e. hydro-electric power plants which requires naturally available sites. For generation of power, the deportation of coal at load center is difficult as well as costly task and required to overcome lot of hurdles. As there is huge power loss in transmission and distribution network and it is approximately 30 to 40% which is very large as compared to other developing countries. While scrutinizing the generation performance during the current years, it has been observed that power utilities are countenancing the problem of fuel supply and deficiencies, loss of generation in consequence of transmission restraints, no/ low schedules and high coal (fuel) cost etc. Therefore this opens up a gigantic prospective for development of power generation plants at distribution level systems and the need to search for renewable energy based options in a sustainable way to meet the demand of energy in rural area. Under Distributed Generation (DG) or embedded generation concept, we are generating energy at load center by using different renewable energy generation techniques depending on availability of bulk amount of raw material. DG technologies are used one of the best option to overcome the problem of load shedding by increasing power generation to meet our own demand of energy and can satisfy demand in grid parallel mode. Typically electricity generating stations are located away from the load center and electricity generated is transmitted through the transmission network to the load center, which regularly requires huge investment in infrastructure and up-gradation of existing networks. To reach generated power to end user by using transmission and distribution networks costs as approximately about 30% of the cost of delivered energy. DG technologies put a stop to the need for a costly transmission network and its necessary up-gradation required in future to handle large power and minimize transmission and distribution losses. As compared to convention power plants, a newly developed distributed generation station using biomass and utilizing stream varies from 1 to 3 years depending on which technology is adopted. This paper basically is intended to reduce the problems and difficulties involved in the generation of power by biomass combustion technique.

The objective of this project is to study the power system analysis of 6 MW biomass power plant and find out different faults, problems arising in this embedded generation system. The method thought will be based on modeling of a single line diagram and simulate it through ETAP software.

A power system analysis of electrical network allows performing to determine short circuit-fault levels, balance load studies, load flow analysis, industrial simulation, arc-flash hazards evaluation, equipment evaluation, harmonic Analysis, verification of protection schemes and settings and ultimately ensure that electrical network and infrastructure is safe and secure with the help of different tools available in ETAP software. Equipment ratings must be capable of handling fault situation to withstand fault current and be capable of providing protection to equipment and minimizing damage of expensive equipment and infrastructure. This paper is come up to analyze the power system network by using ETAP software with the help of one line diagram model. This diagram is implemented in ETAP software to perform load flow study, short circuit and protective relay coordination studies. This is going to help in future to find out different faults, problems and solve them easily without too much affecting the power generation and find out future potential expansion.

II. LOAD FLOW ANALYSIS

Load flow analysis is the most important calculation part in the analysis of power system. Various important stages like designing, planning and power system operations demand load flow analysis to study steady state stability of power system under different constraints and to analyze the effect of change in the ratings of equipment. Load flow calculations are done with the aid of proven numerical method based computer programs with high rate of convergence and speed. The statement of load flow problem is to gain the knowledge of four parameters, magnitude of voltage, phase angle of voltage, active power and reactive power at each and every bus in power system satisfying operational constraints. Every time two parameters will be known and remaining two are to be obtained with the help of two iterative load flow equations.

Load flow analysis of the power system under different operational constraints assures that system is properly planned and designed to perform satisfactorily. Few applications of load flow analysis to obtain,

- Component or circuit loadings
- Steady-state bus voltages
- Reactive power flows
- Transformer tap settings
- System losses
- Generator exciter/regulator voltage set points
- Performance under emergency conditions

Modern power systems are complex and have many paths or branches over which power can flow forming series, parallel paths or their combinations. Power flow in these networks divides among the branches until a balance is reached in accordance with Kirchoff's laws.

Computer methods of load flow analysis are of two types—offline (static) or real time (dynamic). Static method is most common. Supervisory Control and Data Acquisition (SCADA) systems utilize dynamic method of load flow analysis with real time data from various buses. These systems are basically used for optimal generation, voltage control, load dispatch, operation losses, and control of power flow over interconnecting lines.

As load flow analysis deals with power system analysis under steady state and balanced conditions, single phase model with positive sequence values of the components and variables are sufficient. Load flow analysis with three phase system model with separate AC/DC load flow software programs can be done but not generally required for simple commercial power systems.

For a specified load demand and available generation, power system state can be determined by loaf flow analysis. It gives steady state solution assuming that the state is constant for a short period. But in actual, power flow, load demand and voltage at a bus never remains constant and varies by a small value due to changes in different types of loads, switching, and moreover turbine speed never remains constant. Practically, such small changes in load, speed, voltages, power flows are neglected and assumed to be constant for analyzing the steady state of power system. Since the load demand and power flows over the lines continues to change during different time period of a day, between weekdays and weekends, over atmospheric conditions or festival related variations, it becomes necessary to get load flow analysis with various conditions of power system like peak, off-peak, or intermediate load. These possible results can be used to find most suitable operational environment like as setting of different operating and control devices for example reactive power control, excitation control, power system stabilizers etc which and cope up with these changes and will take care of uncertainty of events for maintain the power system reliability. As the load is continuously growing over geographical regions, new substations and feeders and associated devices are continuously getting added or upgraded, load flow analysis helps in determining the effectiveness and adverse effects of these expansions or future expansion requirements to maintain the state of the power system. Load flow analysis is the basic study platform to undertake other different power system studied such as large motor starting analysis, power quality analysis, fault analysis, protection system design, and stability analysis. It provides steady state model of the power system for these studies.

A. Load Flow Problem / Power Flow Equations

The complex power injected by the source into the i^{th} bus of power system is

$S_i = P_i + jQ_i = V_i I_i^*$ $\qquad$ $i = 1, 2, \ldots\ldots., n.$

Where, Vi is the voltage at the i^{th} bus w.r.t ground and Ii is the source current injected into the bus.

The load flow problem is handled more conveniently by use of Ii rather than I_i^*.

$P_i - j\,Q_i = V_i^* I_i$ $\qquad$ $i = 1, 2, \ldots\ldots., n.$

Form the nodal current equations, total current entering i^{th} bus of the n bus system is

$$I_i = Y_{i1}V_1 + Y_{i2}V_2 + \ldots\ldots + Y_{ij}V_j + \ldots. + Y_{in}V_n = \sum_{k=1}^{n} Y_{ik}V_k$$

given by,

$$\therefore P_i - jQ_i = V_i^* \sum_{k=1}^{n} Y_{ik} V_k \ldots\ldots i = 1,2,\ldots n$$

Equating real and imaginary parts,

$$Pi(real \quad power) = \operatorname{Re}\{V_i^* \sum_{k=1}^{n} Y_{ik} V_k\}$$

$$Qi(reactive \quad power) = -\operatorname{Im}\{V_i^* \sum_{k=1}^{n} Y_{ik} V_k\}$$

In polar form,

$$V_i = |V_i| e^{j\delta^i}$$

$$Yik = |Y_{ik}| e^{j\theta ik}$$

Real and reactive powers can be expressed as,

$$Pi(real \quad power) = |V_i|^* \sum_{k=1}^{n} |Y_{ik}||V_k| \cos(Qik + \delta k - \delta i) \ldots\ldots (1)$$

$$Qi(reactive \quad power) = -|Vi| \sum_{k=1}^{n} |Y_{ik}||V_k| \sin(Qik + \delta k - \delta i) \ldots.i = 1,2\ldots n \ldots\ldots (2)$$

Above equations represent 2n power flow equations at n buses of a power system (n for Pi and n for Qi). Pi, Qi, |Vi| and δi to be defined at each and every bus thus total 4n variables are defined for n number of buses. Equation (1) and (2) can be solved for 2n variables if the remaining 2n variables are specified.

Practical consideration allows a power system analyst to fix a priori two variables at each bus. The solution for the remaining 2n bus variables is difficult by the fact that equations (1) and (2) are non-linear algebraic equations (bus voltages are involved in product form and sine and cosine terms are present). Solution can only be obtained by iteration numerical techniques. Equations (1) and (2) are referred as static load flow equations.

B. Practical Constraints

Static load flow equations have practical significance. Specified practical limits are dictated by specifications of power system hardware and operating constraints described below.

i. Voltage magnitude |Vi| must satisfy the inequality $|Vi|min \leq |Vi| \leq |Vi|max$. The power system equipment is designed to operate at fixed voltages will allowable variations of (±5-10%) of the rated values.

ii. This inequality constraint limits the maximum permissible power angle of transmission line connecting buses i and k and is imposed by consideration of system stability. $|\delta i - \delta k| \leq |\delta i - \delta k| \max$

iii. Owing to physical limitations of P and or Q generation sources P_{Gi} and Q_{Gi} are constrained $P_{Gi}Min \leq P_{Gi} \leq P_{Gi}Max$ $Q_{Gi}Min \leq Q_{Gi} \leq Q_{Gi}Max$

Total generation must equal to total load demand plus losses

$$\sum_i PGi >= \sum_i PDi + PL$$

$$\sum_i QGi >= \sum_i QDi + QL$$

PL and QL are the system real and reactive power loss.

C. Methods of load flow solution

A large number of methods using both Y bus and Z bus are available. The expected advantages of an ideal meth of load flow analysis are,

1. High speed (fast convergence).
2. Minimal storage.
3. Simplicity and east of programming.
4. Reliability for ill conditioned system such as system having junctions of very high and low series impedances, long series capacitance, series and shunt compensation. These factors affect the convergence.

No single load flow method satisfied all these requirements. Practically all these advantages are not possible with a single method and are also not necessarily required in every system analysis. A compromised is to be made in the choice of a particular method. The buses are numbered as follows,

i = 1,	Slack bus
i = 2, 3, …. m	PV buses
i = 1, m+1, m+2, ……, n	PQ buses

Iterative methods used for load flow analysis are,

1. Gauss-seidal method.
2. Newton-Raphson method.
3. Fast decoupled method.

The Newton-Raphson method is more complex than Gauss-seidal method but it is reliable and more powerful technique for solving load flow problems.

III. ELECTRICAL TRANSIENT ANALYZER PROGRAM (ETAP)

Electrical Transient Analyzer Program (ETAP) is the foremost-integrated database for electrical systems allowing us to have multiple representations of a power system for different analysis and design purpose. The project aims to provide the basic understanding of the load flow studies and use of Electrical Transient Analyzer Program (ETAP) application software as a successful and accurate tool to conduct load flow study of complex electrical power systems within minimum time period.

The ETAP program operation resembles real electrical system operation as close as possible. For example for opening or closing circuit breaker operation, out of service operation of an element or branch, or to change the status of operation of a motor, the inactive element and respective part of the system is indicated in gray on the single-line diagram.

With power station it is possible graphically to build one-line diagrams and underground raceway systems and perform load flow, short-circuit, harmonic, motor starting, transient stability, protective device co-ordination and cable de-rating studies of electrical system.

Power station contains built-in libraries for the following circuit elements: cable, cable fire protection, motor (nameplate, model, and characteristic load), low voltage circuit breakers, high voltage circuit breakers and fuse.

Righting on library folder in project view and selecting "create" can also create new libraries.

The load flow study in power system relates the electrical performance and power flows (real and reactive) for specified conditions when system is working under steady state. Load flow analysis also gives information of the loads and losses in the lines and over the transformers and bus voltages for performance evaluation of power system.

ETAP is a fully graphical electrical power system analysis program that runs on Microsoft Windows 2000, XP, and operating systems. In addition to the standard offline simulation modules, ETAP can utilize real-time operating data for advanced monitoring, real-time simulation, optimization, and high- speed intelligent load shedding.

ETAP is a powerful tool for power system engineers to study the vast area of power systems by means of one application software with many interface views like AC and DC networks, cable systems, earth grid, GIS, panels, relay coordination/design, and control system diagrams.

ETAP allows to handle directly with the help of visual one-line diagrams, underground cable raceway systems, three-dimensional cable systems, advanced time-current coordination and selectivity plots, geographic information system schematics (GIS), as well as three-dimensional ground grid systems.

Following analysis supports are provided by ETAP from the single line diagram of the power system:

1. Load Flow Analysis
2. Unbalanced Load Flow Analysis
3. IEC Short-Circuit Analysis
4. Motor Acceleration Analysis
5. Harmonic Analysis
6. Transient Stability Analysis
7. Star - Protective Device Coordination
8. Optimal Power Flow Analysis
9. Reliability Assessment Analysis
10. Optimal Capacitor Placement
11. DC Load Flow Analysis
12. DC Short-Circuit Analysis
13. Battery Sizing and Discharge Calculations
14. Underground Cable Raceway Systems
15. Ground Grid Systems Studies
16. Cable Pulling Systems

The ETAP Program calculates the bus voltages; branch power factors, currents and power flow throughout the electrical system. The program supports the slack, voltage controlled, and uncontrolled buses with many load points and power source connections. It handles both radial and loop systems. The load flow tool bar will appear on the screen when load flow study mode is selected. The various icons in load flow tool bar are 1) run load flow studies 2) update cable load current 3) load flow display options 4) view load flow output report. For performing load flow study run load flow study icon is clicked. Selecting the update cable load current icon will transfer cable load current data from previously run load flow study. Load flow display option is clicked to edit the results look. View load flow icon is clicked to display the contents of last output report.

Load flow study case editor: clicking on the study case button from load flow tool bar accesses. It consists of solution control variables, loading conditions and variety of options for output reports.

A. System Representation

Single line diagrams of practical power systems can be complex. A simple method to represent and visualize with necessary information is required to understand it. The system single-line diagram serves this purpose. The single-line diagram contains symbolic model of generators, loads, transformers, buses, lines, cables, breakers, reactors, capacitors etc. along with their ratings and locations. It is necessary to show equipment parameters as well as their relationship to each other. Buses may be named, numbered, or both. Interconnecting lines are usually shown with their impedance values entered or cross-referenced with tables of values. Equipment associated with a bus is shown connected to that bus.

Transformers are shown between two buses with the primary connected to one bus and the secondary to the other. Information to convey an off-nominal turns ratio should be given when applicable.

B. *Input Data*

The system information shown on the single-line diagram, defines the system configuration and the location and size of loads, generation and equipment. It is represented into a listed data which represents mathematical model of that power system equipment and the way equipment are interconnected. The preparation of this data file is the foundation of all load flow analysis as well as other analysis requiring the network model such as short-circuits and stability analysis. It is therefore essential that the data preparation be performed in a consistent and thorough manner. Data values must be as accurate as possible. Rounding off or not including enough decimal places in certain parameters can lead to erroneous results. Influential parameters must not be ignored.

IV. RESULS AND DISCUSSION

A 6 MW biomass power plant i.e. M/S Armstrong Energy Private Ltd, Nashik, Maharashtra, India is selected for the practical case study. The required information is collected from the power plant and substation in-charge.

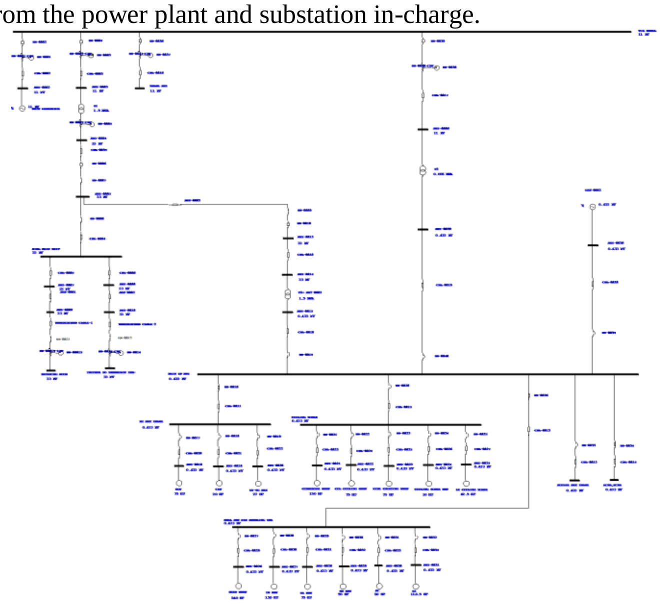

Fig.1. Single Line Diagram (SLD) of power plant.

The data accumulated is as follows:

- Engineered data includes its protective contrivances details, percentage impedance etc.
- Feeder line currents, line voltages, active power, reactive power etc.
- Transformer data includes HV and LV side voltages and currents, percentage impedance etc.
- Generator data includes its protective devices details, percentage impedance etc.
- Transmission line data includes length of the line, positive sequence resistance and reactance, zero sequence resistance and reactance.
- Cables data includes length of the cables, types etc.
- In Plant loads etc.

After accumulation of all compulsory data, one line diagram model is constructed in ETAP application software. Then all the obligatory inputs are provided for the simulation.

Load flow analysis is carried out on the model and results are given below.

LOAD FLOW REPORT

Bus	Voltage			Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
ACDB,DCDB	0.433	94.648	-2.8	0	0	0	0	MAIN LV BUS	0.000	0.000	0.0	0.0	
BOILER AUX SPARE	0.433	94.648	-2.8	0	0	0	0	MAIN LV BUS	0.000	0.000	0.0	0.0	
* BUS-0002	11.000	100.000	0.0	0.738	0.566	0	0	VCB PANEL	0.738	0.566	48.8	79.4	
BUS-0003	11.000	99.991	0.0	0	0	0	0	VCB PANEL	-0.725	-0.568	48.3	78.7	
								BUS-0004	0.725	0.568	48.3	78.7	
BUS-0004	33.000	97.416	-1.4	0	0	0	0	BUS-0005	0.720	0.536	16.1	80.2	
								BUS-0003	-0.720	-0.536	16.1	80.2	
BUS-0005	33.000	97.414	-1.4	0	0	0	0	BUS-0004	-0.720	-0.536	16.1	80.2	
								RING MAIN UNIT	0.000	0.000	0.0	0.0	
								BUS-0013	0.720	0.536	16.1	80.2	
BUS-0006	11.000	99.996	0.0	0	0	0	0	VCB PANEL	-0.013	0.002	0.7	-98.7	
								BUS-0039	0.013	-0.002	0.7	-98.7	
BUS-0007	33.000	97.414	-1.4	0	0	0	0	RING MAIN UNIT	0.000	0.000	0.0	0.0	
								BUS-0009	0.000	0.000	0.0	0.0	
BUS-0008	33.000	97.414	-1.4	0	0	0	0	RING MAIN UNIT	0.000	0.000	0.0	0.0	
								BUS-0010	0.000	0.000	0.0	0.0	
BUS-0009	33.000	97.414	-1.4	0	0	0	0	BUS-0007	0.000	0.000	0.0	0.0	
BUS-0010	33.000	97.414	-1.4	0	0	0	0	BUS-0008	0.000	0.000	0.0	0.0	
BUS-0013	33.000	97.411	-1.4	0	0	0	0	BUS-0014	0.720	0.536	16.1	80.2	
								BUS-0005	-0.720	-0.536	16.1	80.2	
BUS-0014	33.000	97.410	-1.4	0	0	0	0	BUS-0013	-0.720	-0.536	16.1	80.2	
								BUS-0015	0.720	0.536	16.1	80.2	
BUS-0015	0.433	94.872	-2.9	0	0	0	0	MAIN LV BUS	0.714	0.504	1228.2	81.7	
								BUS-0014	-0.714	-0.504	1228.2	81.7	
BUS-0018	0.433	92.696	-2.1	0	0	0.060	0.045	TG AUX SPARE	-0.060	-0.045	108.1	80.0	
BUS-0019	0.433	93.379	-2.4	0	0	0.016	0.012	TG AUX SPARE	-0.016	-0.012	28.6	80.0	
BUS-0020	0.433	93.208	-2.3	0	0	0.022	0.016	TG AUX SPARE	-0.022	-0.016	38.7	80.0	
BUS-0021	0.433	88.687	-1.5	0	0	0.120	0.090	COOLING TOWER	-0.120	-0.090	226.0	80.0	
BUS-0022	0.433	88.687	-1.5	0	0	0.060	0.045	COOLING TOWER	-0.060	-0.045	113.0	80.0	
BUS-0023	0.433	88.687	-1.5	0	0	0.060	0.045	COOLING TOWER	-0.060	-0.045	113.0	80.0	
BUS-0024	0.433	89.146	-1.7	0	0	0.024	0.018	COOLING TOWER	-0.024	-0.018	45.0	80.0	
BUS-0025	0.433	88.825	-1.5	0	0	0.034	0.026	COOLING TOWER	-0.034	-0.026	63.9	80.0	
BUS-0026	0.433	93.139	-2.4	0	0	0.192	0.144	FUEL AND ASH HANDLING SPA	-0.192	-0.144	344.4	80.0	
BUS-0027	0.433	93.139	-2.4	0	0	0.096	0.072	FUEL AND ASH HANDLING SPA	-0.096	-0.072	172.2	80.0	
BUS-0028	0.433	93.000	-2.3	0	0	0.060	0.045	FUEL AND ASH HANDLING SPA	-0.060	-0.045	107.8	80.0	
BUS-0029	0.433	92.945	-2.2	0	0	0.040	0.030	FUEL AND ASH HANDLING SPA	-0.040	-0.030	71.9	80.0	
BUS-0030	0.433	93.681	-2.5	0	0	0.016	0.012	FUEL AND ASH HANDLING SPA	-0.016	-0.012	28.5	80.0	
BUS-0031	0.433	93.152	-2.4	0	0	0.095	0.071	FUEL AND ASH HANDLING SPA	-0.095	-0.071	170.0	80.0	
BUS-0036	0.433	94.704	-2.8	0.212	0.182	0	0	MAIN LV BUS	0.212	0.182	392.8	75.9	
BUS-0039	0.433	94.907	-2.8	0	0	0	0	MAIN LV BUS	0.012	-0.003	17.3	-97.7	
								BUS-0006	-0.012	0.003	17.3	-97.7	
COOLING TOWER	0.433	89.907	-2.0	0	0	0	0	MAIN LV BUS	-0.305	-0.224	561.0	80.5	
								BUS-0021	0.123	0.090	226.0	80.5	
								BUS-0022	0.061	0.045	113.0	80.5	
								BUS-0023	0.061	0.045	113.0	80.5	
								BUS-0024	0.024	0.018	45.0	80.4	
								BUS-0025	0.035	0.026	63.9	80.5	
FUEL AND ASH HANDLING SPA	0.433	94.163	-2.7	0	0	0	0	MAIN LV BUS	-0.508	-0.376	894.8	80.4	
								BUS-0026	0.196	0.145	344.4	80.4	
								BUS-0027	0.098	0.072	172.2	80.4	
								BUS-0028	0.061	0.045	107.8	80.5	
								BUS-0029	0.041	0.030	71.9	80.5	
								BUS-0030	0.016	0.012	28.5	80.2	
								BUS-0031	0.097	0.071	170.0	80.4	
MAIN LV BUS	0.433	94.648	-2.8	0	0	0	0	TG AUX SPARE	0.101	0.074	175.5	80.7	
								BOILER AUX SPARE	0.000	0.000	0.0	0.0	
								FUEL AND ASH HANDLING SPA	0.511	0.377	894.8	80.5	
								ACDB,DCDB	0.000	0.000	0.0	0.0	
								COOLING TOWER	0.324	0.232	561.0	81.4	
								BUS-0015	-0.712	-0.503	1228.2	81.7	
								BUS-0039	-0.012	0.003	17.3	-97.7	
								BUS-0036	-0.212	-0.182	392.8	75.9	
RING MAIN UNIT	33.000	97.414	-1.4	0	0	0	0	BUS-0005	0.000	0.000	0.0	0.0	
								BUS-0007	0.000	0.000	0.0	0.0	
								BUS-0008	0.000	0.000	0.0	0.0	
SPARE BUS	11.000	99.996	0.0	0	0	0	0	VCB PANEL	0.000	0.000	0.0	0.0	
TG AUX SPARE	0.433	93.863	-2.6	0	0	0	0	MAIN LV BUS	-0.099	-0.073	175.5	80.4	
								BUS-0018	0.061	0.045	108.1	80.5	
								BUS-0019	0.016	0.012	28.6	80.2	
								BUS-0020	0.022	0.016	38.7	80.3	
VCB PANEL	11.000	99.996	0.0	0	0	0	0	BUS-0002	-0.738	-0.566	48.8	79.4	

Fig. 2. Load flow analysis report of power plant generated in ETAP.

A. Short Circuit Study

Generally electrical power systems consists of several types of different ranges instruments like generators, Power transformer, potential transformers, current transformers, circuit breakers, relays and protection equipment etc. connected to various load centers which creates widely complex network. Because of complexity of network, after taking all precaution and due care, failure in network and occurring of faults cannot be avoided as some are occurring due to natural accidents or some are because of human nature. The practicability of designing, developing and working a system with zero breakdowns is not realistic, cost-effectively unwarrantable.

Under Short Circuit study, we evaluate breakdowns levels of insulation and it may leads to following things once at a time,

- Unsymmetrical current waveforms
- The magnitude of overload current may damage assets
- The magnitude of voltage swell or the transients in voltage waveform may reduce the reliability of system
- The voltage sag or swell due to the fault affects performance of dynamic machines.
- Uncertainty of supply system may damage the human being.

Faults coming under short circuit categories cannot be prohibited, but there is always possibility to make an attempt to take the edge off their potentially harmful possessions. To avoid probable short circuit incidences, due care should be taken at the time of designing of system. If a short circuit occurs, however extenuating its effects consists of

a) Reducing the magnitude of the unwanted fault currents
b) Segregating the minimum possible segment of the system in the region of the failure in order to retain service to the rest of the system.

For finding out short circuit faults exact location, majority of protective equipment and related systems are required in trustworthy manners.

System which is capable in handling all types of fault currents at all voltage levels and isolating the faulty area required huge capital investment for equipment.

It's a major cause for analyzed the short circuit studies, as follows,

- Verification of the adequacy of existing interrupting equipment. The same type of studies will form the basis for the selection of the interrupting equipment for system planning purposes.
- Tenacity of the system protective contrivance settings, which is done primarily by quantities characterizing the system under fault conditions. These quantities withal referred to as "protection handles", typically include phase and sequence currents or voltages and rates of changes of system currents or voltages.
- Resoluteness of the effects of the fault currents on sundry system components such as cables, lines, bus-ways, transformers, and reactors during the time the fault persists.
- Thermal and mechanical stresses from the resulting fault currents should always be compared with the corresponding short-term, conventionally first-cycle, withstand capabilities of the system equipment. Assessment of the effect that different kinds of short circuits of varying astringency may have on the overall system voltage profile.

These studies will identify areas in the system for which faults can result in unacceptably widespread voltage depressions. Conceptualization, design and refinement of system layout, neutral grounding, and substation grounding.

Short circuit analysis results are given below,

Short-Circuit Summary Report

3-Phase, LG, LL, LLG Fault Currents

Bus		3-Phase Fault			Line-to-Ground Fault				Line-to-Line Fault				*Line-to-Line-to-Ground			
ID	kV	I"k	ip	Ik	I"k	ip	Ib	Ik	I"k	ip	Ib	Ik	I"k	ip	Ib	Ik
ACDB,DCDB	0.433	26.626	57.631	18.599	28.290	61.232	28.290	28.290	22.423	48.533	22.423	22.423	28.565	61.827	28.565	28.565
BOILER AUX SPARE	0.433	26.626	57.631	18.599	28.290	61.232	28.290	28.290	22.423	48.533	22.423	22.423	28.565	61.827	28.565	28.565
BUS-0002	11.000	3.105	7.897	0.155	2.986	7.593	2.986	2.986	2.680	6.815	2.680	2.680	3.057	7.774	3.057	3.057
BUS-0003	11.000	3.097	7.841	2.936	2.973	7.527	2.973	2.973	2.673	6.767	2.673	2.673	3.045	7.709	3.045	3.045
BUS-0004	33.000	0.458	1.069	0.382	0.466	1.087	0.466	0.466	0.391	0.913	0.391	0.391	0.465	1.086	0.465	0.465
BUS-0005	33.000	0.458	1.068	0.382	0.466	1.087	0.466	0.466	0.391	0.913	0.391	0.391	0.465	1.086	0.465	0.465
BUS-0006	11.000	3.094	7.819	2.934	2.969	7.505	2.969	2.969	2.670	6.748	2.670	2.670	3.041	7.687	3.041	3.041
BUS-0007	33.000	0.458	1.068	0.382	0.466	1.087	0.466	0.466	0.391	0.913	0.391	0.391	0.465	1.086	0.465	0.465
BUS-0008	33.000	0.458	1.068	0.382	0.466	1.087	0.466	0.466	0.391	0.913	0.391	0.391	0.465	1.086	0.465	0.465
BUS-0009	33.000	0.411	0.910	0.349	0.384	0.850	0.384	0.384	0.352	0.779	0.352	0.352	0.399	0.883	0.399	0.399
BUS-0010	33.000	0.411	0.910	0.349	0.384	0.850	0.384	0.384	0.352	0.779	0.352	0.352	0.399	0.883	0.399	0.399
BUS-0013	33.000	0.458	1.068	0.382	0.465	1.086	0.465	0.465	0.391	0.913	0.391	0.391	0.465	1.085	0.465	0.465
BUS-0014	33.000	0.458	1.068	0.381	0.465	1.085	0.465	0.465	0.391	0.913	0.391	0.391	0.465	1.085	0.465	0.465
BUS-0015	0.433	27.727	63.219	19.294	30.716	70.035	30.716	30.716	23.341	53.218	23.341	23.341	29.997	68.395	29.997	29.997
BUS-0018	0.433	5.699	8.507	5.236	4.718	7.042	4.718	4.718	4.901	7.316	4.901	4.901	5.551	8.286	5.551	5.551
BUS-0019	0.433	4.012	5.796	3.836	3.337	4.821	3.337	3.337	3.457	4.995	3.457	3.457	3.836	5.542	3.836	3.836
BUS-0020	0.433	4.027	5.831	3.836	3.343	4.840	3.343	3.343	3.467	5.021	3.467	3.467	3.856	5.583	3.856	3.856
BUS-0021	0.433	7.635	12.605	5.880	5.791	9.561	5.791	5.791	6.456	10.659	6.456	6.456	7.247	11.965	7.247	7.247
BUS-0022	0.433	5.367	8.288	4.408	4.147	6.403	4.147	4.147	4.569	7.055	4.569	4.569	5.064	7.820	5.064	5.064
BUS-0023	0.433	5.367	8.288	4.408	4.147	6.403	4.147	4.147	4.569	7.055	4.569	4.569	5.064	7.820	5.064	5.064
BUS-0024	0.433	3.886	5.695	3.386	3.068	4.496	3.068	3.068	3.318	4.864	3.318	3.318	3.631	5.321	3.631	3.631
BUS-0025	0.433	3.920	5.827	3.386	3.079	4.578	3.079	3.079	3.340	4.965	3.340	3.340	3.669	5.454	3.669	3.669
BUS-0026	0.433	17.940	29.311	13.703	16.044	26.213	16.044	16.044	15.252	24.919	15.252	15.252	18.614	30.412	18.614	18.614
BUS-0027	0.433	11.969	18.159	10.094	10.206	15.483	10.206	10.206	10.256	15.560	10.256	10.256	11.944	18.120	11.944	11.944
BUS-0028	0.433	7.410	10.930	6.719	6.195	9.138	6.195	6.195	6.379	9.409	6.379	6.379	7.263	10.713	7.263	7.263
BUS-0029	0.433	4.898	7.155	4.600	4.073	5.949	4.073	4.073	4.225	6.171	4.225	4.225	4.755	6.945	4.755	4.755
BUS-0030	0.433	4.813	6.947	4.600	4.028	5.814	4.028	4.028	4.152	5.994	4.152	4.152	4.624	6.674	4.624	4.624
BUS-0031	0.433	11.963	18.136	10.094	10.202	15.467	10.202	10.202	10.252	15.541	10.252	10.252	11.936	18.095	11.936	11.936
BUS-0036	0.433	27.175	60.874	14.207	29.133	65.260	29.133	29.133	22.873	51.237	22.873	22.873	29.168	65.339	29.168	29.168
BUS-0039	0.433	6.547	9.444	6.309	5.621	8.108	5.621	5.621	5.664	8.170	5.664	5.664	6.356	9.169	6.356	6.356
COOLING TOWER	0.433	11.648	19.988	8.461	8.858	15.199	8.858	8.858	9.790	16.800	9.790	9.790	11.052	18.965	11.052	11.052
FUEL AND ASH HANDLING SPA	0.433	26.436	55.424	18.215	27.433	57.515	27.433	27.433	22.233	46.612	22.233	22.233	28.679	60.128	28.679	28.679
MAIN LV BUS	0.433	27.723	62.983	19.105	30.124	68.437	30.124	30.124	23.311	52.959	23.311	23.311	29.991	68.136	29.991	29.991
RING MAIN UNIT	33.000	0.458	1.068	0.382	0.466	1.087	0.466	0.466	0.391	0.913	0.391	0.391	0.465	1.086	0.465	0.465
SPARE BUS	11.000	3.100	7.863	2.939	2.978	7.553	2.978	2.978	2.675	6.786	2.675	2.675	3.049	7.735	3.049	3.049
TG AUX SPARE	0.433	15.055	22.890	12.415	13.351	20.300	13.351	13.351	12.859	19.552	12.859	12.859	15.360	23.354	15.360	15.360
VCB PANEL	11.000	3.102	7.872	2.941	2.980	7.563	2.980	2.980	2.676	6.793	2.676	2.676	3.051	7.745	3.051	3.051

Fig. 3. Short circuit analysis report of power plant generated in ETAP.

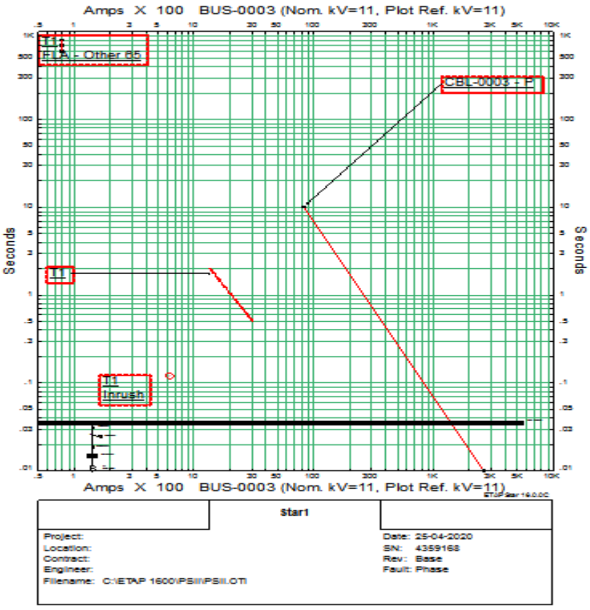

Fig. 4. Time versus current characteristics for transformer T1.

Fig. 4 shows time-current characteristics plotted on log-log scale graphs along with respective portion of one line diagram model which are observed on the power system during running load flow analysis. On TCC, different blocks are shown in figures which contain details of relay setting required for protective relay co-ordination and figures are self-explanatory.

Data block on TCC shows manufacturer type of equipment, its function and probable tap, time delay, and instantaneous settings recommended

In this model initially steady state conditions defined for network to analyze the power system.

V. CONCLUSION.

The load flow solution provides a means to study systems under real or hypothetical conditions. The solution results should be evaluated and analyzed with respect to optimum present and future operation. This leads to a diagnosis of the system as it exists. The analysis can also point the way to improved operation and provide a meaningful basis for future system planning. To make the system healthy from the abnormalities in the power system, so we take precaution for the voltage control devices, also to meet the future expansion and present deficiencies. The Single line diagram developed a load flow model which is source for a number of other types of studies such as arc flash analysis, stability, reliability, DC system analysis, equipment evaluation, failed equipment evaluation, transient motor starting and harmonic analysis of plant or sub-connected network.

REFERENCES

1. A. Panyosam, B. R. Oswald, "Modified Newton Raphson Load Flow Analysis for Integrated AC/DC Power System", *Institute of Electric Power Systems, University of Hannover, Germany*.
2. Grainger, J.; Stevenson, W., "*Power System Analysis*", New York McGraw-Hill.
3. Hadi Saadat, "*Power System Analysis*", Tata McGraw Hill, 2001..
4. IEEE Brown Book: IEEE Std. 399:1997 "IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis", *Power Systems Engineering Committee of the Industrial and Commercial Power Systems* Department of the IEEE Industry Applications Society.
5. Jignesh S. Patel Manish N. Sinha. " Power System Transient Stability Analysis Using ETAP Software", *National Conference on Recent Trends in Engineering & Technology*, B. V. M. Engineering College, V. V. Nagar, Gujarat, India, 13-14 May 2011.
6. Rohit Kapahi "Load Flow Analysis of 132 kV substation using ETAP Software", *International Journal of Scientific and Engineering Research*, Volume 4, Issue 2, February-2013 ISSN 2229-5518.
7. ETAP 16.0.0 Documentation and help files.
8. Sunil S. Rao, "Switchgear and Protection", Dhanpat Rai Publications.

AUTHORS PROFILE

Mr. Dipesh B. Pardeshi is a Research Scholar at Shri JJT University, Rajasthan. He received Bachelor degree in Electrical Engineering from Government College of Engineering, Karad, Maharashtra in the year 1999 and received Master degree in the stream of Electrical Power Systems at Government College of Engineering, Aurangabad. Currently working as a Associate Professor in Sanjivani College of Engineering, Kopargaon, Maharashtra and his areas of interest includes Electrical Power Systems, Renewable Energy, Distributed Generation, Smart Grid & Electrical machines".

Prof. Dr. Mrs. Anupama A. Deshpande was born and brought up in Hyderabad, Andhra Pradesh in 1947. She had completed her B.E. (Electrical) in 1967 from Govt. College of Engineering, Aurangabad and was First Lady Engineer of Marathwada University. She had received M.E. (Instrumentation) from Shri Guru Gobindsingh (SGGS) College of Engineering in Nanded, affiliated to Shri Ramanand Teerth University (SRTU) Nanded in 1997. Ph.D. completion from Interdisciplinary Department of Systems and Control, IIT Bombay in 2006. She worked in Maharashtra State Electricity Board at Aurangabad and Pune, Kaycee Industries at Bombay and various Colleges in Bombay and retired as Principal of Atharva College of Engineering in Mumbai in 2017. At present teaching and guiding Ph.D. scholars of Shri Jagadish Prasad, Jhabarmal Tibrewala University near Jhunjhunu of Rajasthan. She is Life Member of ISTE and IETE Institutions.