SHORT CIRCUIT ANALYSIS OF 220/132 KV SUBSTATION BY USING ETAP

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ABSTRACT

Modern power system is different from older system. The character of load is drastically changed now days. As most of the load is controlled and operated by using digital electronics controller. It is also important to focus on protection of the modern power system. For healthy operation of electrical power generation, transmission and distribution, it is important that system should be balanced and fault current should be in design limits. This paper deals with the simulation of 220/132 kV substation fault current calculation. The analysis is done by using advance software Electrical Transient Analyzer Program (ETAP) with detailed short circuit analysis. All the data used for analysis is real time and collected from 220/132 KV substation under M.S.E.T.C.L.

Keywords: ETAP, Fault studies using ETAP, Fault Studies on Software, Short Circuit Analysis using ETAP, Substation Fault Analysis.

I. INTRODUCTION

Recent advances in engineering sciences have brought a revolution in the field of electrical engineering after the development of powerful computer based software. This research work high- lights the effective use of Electrical Transient Analyzer Program (ETAP) software for Short Circuit Studies. Transmission networks of present power systems are becoming progressively more stressed because of increasing demand and limitations on building new lines. One of the consequences of such a stressed system is the risk of losing stability following a disturbance. Transients occur due to various disturbances like sudden change in the load, switching of the power electronics devices and capacitor banks, loss of the synchronous generators. The short circuit fault can occurs due to any reason. In electrical devices unintentional short circuits are usually caused when a wire's insulation breaks down, or when another conducting material is introduced, allowing charge to flow along a different path than the one intended. In mains circuits, short circuits may occur between two phases, between a phase and neutral or between a phase and earth (ground). Such short circuits are likely to result in a very high current and therefore quickly trigger an over current protection device. However, it is possible for short circuits to arise between neutral and earth conductors, and between two conductors of the same phase. Such short circuits can be dangerous, particularly as they may not immediately result in a large current and are therefore less likely to be detected. Possible effects include unexpected energisation of a circuit presumed to be isolated. A short circuit fault current can, within milliseconds, be thousands of times larger than the normal operating current of the system. Damage from short circuits can be reduced or prevented by employing fuses, circuit

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breakers, or other overload protection, which disconnect the power in reaction to excessive current. Overload protection must be chosen according to the current rating of the circuit.

In this work there are out Short circuit analysis of 220 kV substation. The actual ratings of Power Transformers, Circuit Breakers, Current Transformers, Potential Transformers and Isolating switches are taken and modeled accordingly in ETAP. This 220 kV substation is located in Maharashtra State Electricity Transmission Corporation Limited (MSETCL) which comprises of 4 Power Transformers, 25 Circuit Breakers, 21 Current Transformers, 4 Potential Transformers and 55 Isolating switches.

II. ABOUT ETAP

ETAP is Electrical Transient Analyzer Program. This software provides engineers, operators, and managers a platform for continuous functionality from modeling to operation. ETAP's model-driven architecture enables 'Faster than Real-Time' operations - where data and analytics meet to provide predictive behavior, preemptive action, and situational intelligence to the owner-operator. ETAP offers a suite of fully integrated electrical engineering software solutions including arc flash, load flow, short circuit, transient stability, relay coordination, cable capacity, optimal power flow, and more. Its modular functionality can be customized to fit the needs of any company, from small to large power systems. Here we are focusing on load flow studies of 220 kV/132 kV/33 kV substation.

III. DETAILS OF COMPONENTS

COMPONENT	**TYPE**	**RATINGS**	
Power Transformer	Transformer 1	50 MVA	
	Transformer 2	25 MVA	
	Transformer 3	150 MVA	
	Transformer 4	100 MVA	
Circuit Breaker	CB 1-11	33kV/1600A	
	CB 12-19	145kV/3150A	
	CB 20-25	245kV/3150A	
Current Transformer		Primary	Secondary
	CT 1-3	800A	1A
	CT 4-11	200A	1A
	CT 12-18	800A	1A
	CT 19-22	400A	1A

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	PT 1	220kV	120V
Potential Transformer	PT 2,3	33kV	120V
	PT 4	132kv	120V
	SW 1-20,45,47,49	33kV/1500A	
	SW 21-37,50	132kV/1250A	
Isolating Switches	SW 38-44,46-48	220kV/1000A	
	SW 51-55	220kV/1000A	
	Load 1	175A	
	Load 2	262.4A	
	Load 3	175A	
Feeders	Load 4	140A	
	Load 5	209.9A	
	Load 6	122.5A	
	Load 7	157.5A	
	Load 8	140A	
	Load 9	349.9A	
	Load 10	306.2.A	
Feeders	Load 11	43.74	
	Load 12,13,14	0A (FUTURE)	

IV. SHORT CIRCUIT SIMULATION OF 220 kV SUBSTATION IN ETAP

Fig. 1 shows the Power Grid which supplies power to the 220 kV Bus 6 and Bus 7. Transformer 1 and Transformer 2 are 220kV/33kV supply power to Bus 1 and Bus 2 respectively. Four feeders are emanating from Bus 1 and four feeders are emanating from Bus 2. On the other side Transformer 3 and Transformer 4 is 220kV/132kV supply power to Bus 4 and Bus 5 respectively. Three feeders are emanating from Bus 4 and three feeders are emanating from Bus 5.

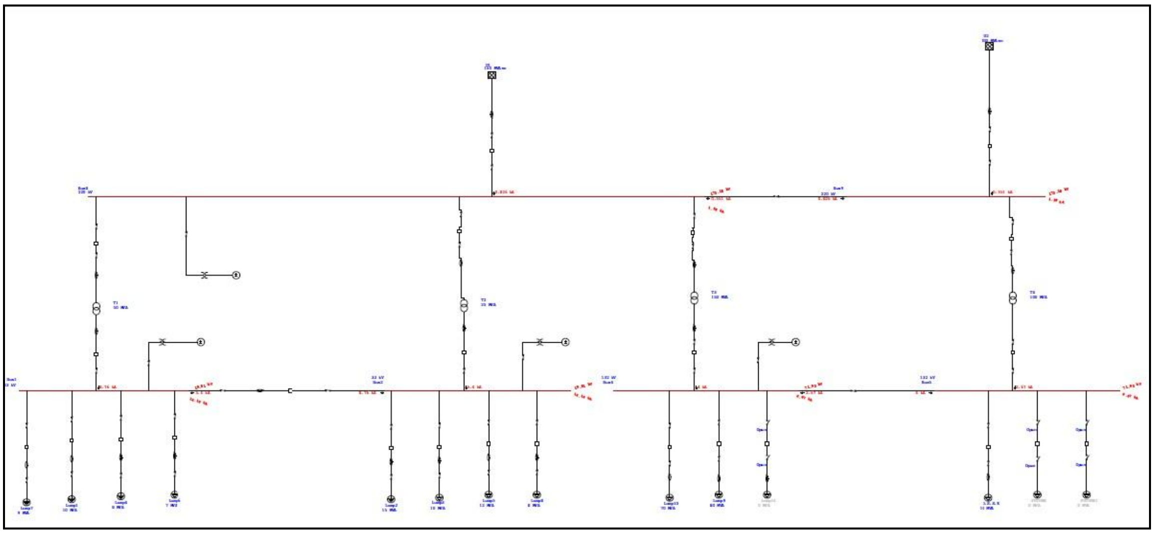

Fig.1. Simulated diagram of 220 kV substation using ETAP

V. SHORT CIRCUIT ANALYSES

Fig. 2 shows the sectional view of short circuit current flow Analysis of the 220kV substation carried out using ETAP. It is observed that at the Bus 4 and Bus 5 there is fault at that bus which can be clearly seen from Fig. 2 showing the sectional view of the feeders. At Bus 4 and Bus 5 the current is 6.67kA. That is when 3 phase short circuit happened on this bus the fault current will flow from them is 6.67kA. Both the buses are connected with the help of tie breaker. The voltage level of 132 kV bus is decreased to 71.93 kV. This short circuit is done with reference of IEC60909. The manual calculation of this fault current is time consuming, but as ETAP software work on the both standards either ANSI or IEC the results are more accurate and according to standard which we consider for analysis. Similarly from fig 3 it is observed that at the Bus 1 and Bus 2 there is under voltage which can be clearly seen from the sectional view of the feeders. At Bus 1 and Bus 2 the voltage level shown in red color indicating 19.81 kV and the fault current is 14.16 kA. These values give us the components rating which can be used to design condition as well as current condition of the protection system for the substations.

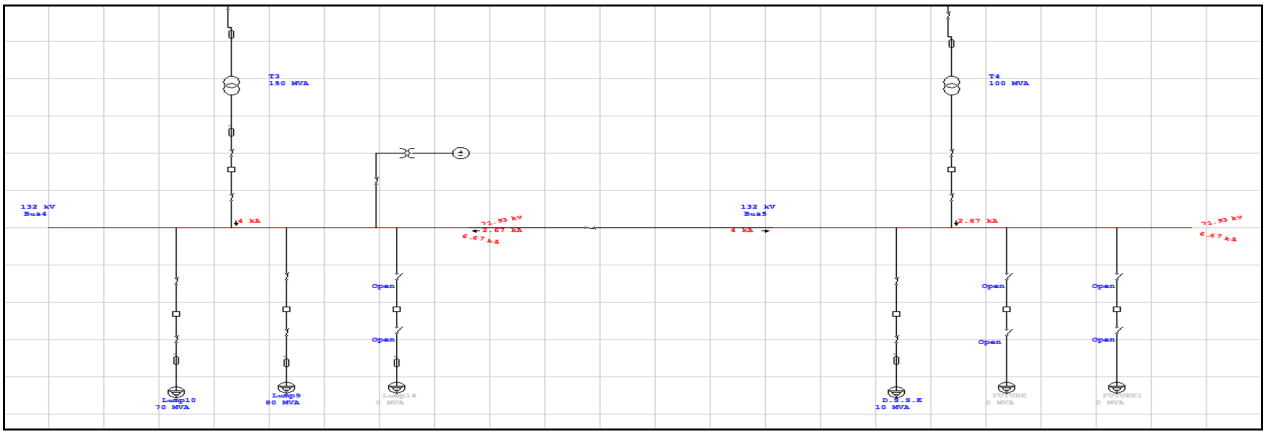

Fig -2 Sectional view of Substation

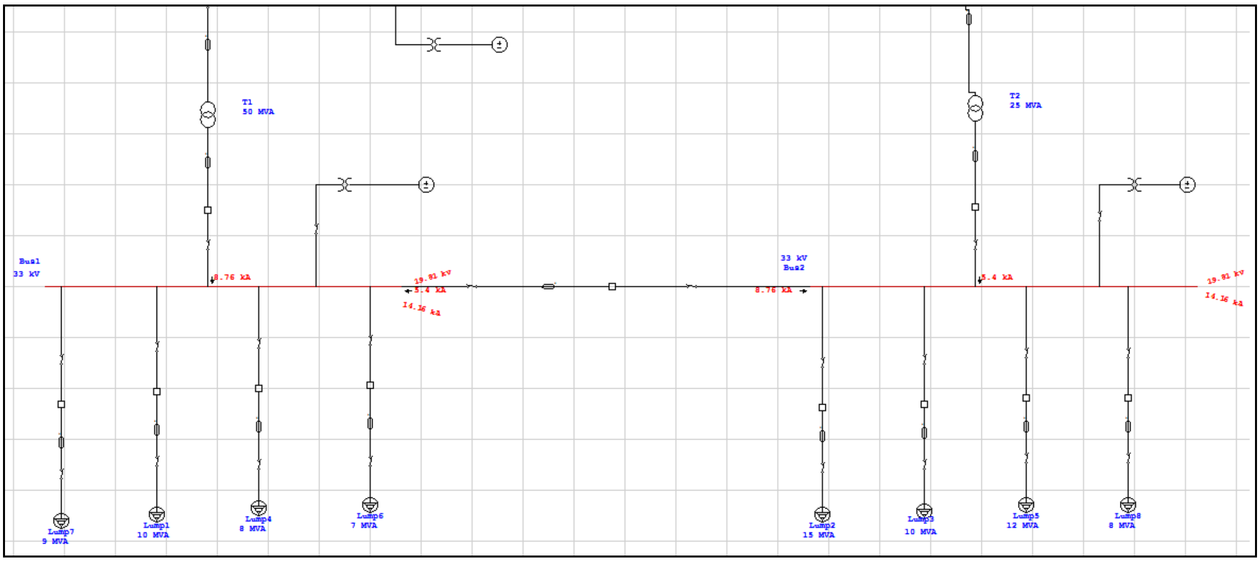

Fig -3 Sectional view of Substation

VI. GENERAL DESCRIPTION OF CALCULATION METHODOLOGY

In IEC short-circuit calculations; an equivalent voltage source at the fault location replaces all voltage sources. A voltage factor c is applied to adjust the value of the equivalent voltage source for minimum and maximum current calculations. All machines are represented by their internal impedances. Transformer taps can be set at either the nominal position or at an operating position, and different schemes are available to correct transformer impedance and system voltages if off-nominal tap setting exists. System impedances are assumed to be balanced 3-phase, and the method of symmetrical components is used for unbalanced fault calculations. Zero sequence capacitances of transmission lines, cables and shunt admittances can be considered for unbalanced fault calculations (LG and LLG) if the option in the study case is selected to include branch Y and static load. This means that the capacitances of static loads and branches are considered based on IEC 60909-0 2001. Calculations consider electrical distance from the fault location to synchronous generators. For a far-from-generator fault, calculations assume that the steady-state value of the short-circuit current is equal to the initial symmetrical short-circuit current and only the DC component decays to zero. However, for a near-to-generator fault, calculations count for decaying in both AC and DC components. The equivalent R/X ratios determine the rates of decay of both components, and different values are taken for generators and loads near the fault.

VII. FORMULAS AND EQUATIONS

The short circuit current for a circuit in which the pre-load current can be ignored is:

$$i(t) = i_{ac}(t) \; + \; i_{dc}(t) = \frac{\sqrt{2} \cdot V}{Z} \left[\sin(\omega \cdot t + \alpha - \theta) - \sin(\alpha - \theta) \cdot e^{-\frac{t}{T}} \right] \; A. \tag{1}$$

Where,

$$i_{ac}(t) = \frac{\sqrt{2} \cdot V}{Z} \cdot \sin(\omega \cdot t + \alpha - \theta) \;\; A, \;\; i_{dc}(t) = -\frac{\sqrt{2} \cdot V}{Z} \cdot \sin(\alpha - \theta) \cdot e^{-\frac{t}{T}} \;\; A, \tag{2}$$

$$Z = |R + j \cdot \omega \cdot L| = \sqrt{R^2 + X^2} \ \ \Omega, \ \ \theta = \arctan\left(\frac{\omega \cdot L}{R}\right) = \arctan\left(\frac{X}{R}\right) \text{ and} \tag{3}$$

ϴ= impedance angle

α= initial phase displacement (or offset) angle of the source voltage, v (t)

The time constant, T, for the circuit is given by,

$$T = \frac{L}{R} = \frac{X}{\omega \cdot R} = \frac{X}{2 \cdot \pi \cdot f \cdot R} s. \tag{4}$$

For a three phase fault, L and R are the positive sequence inductance and resistance of the system. For an earth fault, L and R are derived from

$Z_{TOT} = R_{TOT} + jX_{TOT} = Z_1 + Z_2 + Z_0$.

The maximum possible offset occurs when, $\alpha - \Theta = \pm 90$ i.e.

$$i(t) = \frac{\sqrt{2} \cdot V}{Z}\left[\sin(\omega \cdot t + 90°) - e^{-\frac{t}{T}}\right] \text{ or } \ i(t) = \frac{\sqrt{2} \cdot V}{Z}\left[\sin(\omega \cdot t - 90°) + e^{-\frac{t}{T}}\right] A. \tag{5}$$

The asymmetrical R.M.S. equivalent of the transient current, $I_{R.M.S.}$, is given by,

$$I_{r.m.s.}(t) = I_{AC}\sqrt{1 + 2 \cdot e^{\frac{-4 \cdot \pi \cdot f \cdot t}{X/R}}} = K(t) \cdot I_{AC} \ \ A. \ \ \text{Where } \ K(t) = \sqrt{1 + 2 \cdot e^{\frac{-4 \cdot \pi \cdot f \cdot t}{X/R}}} . \tag{6}$$

K is called the asymmetry factor. The asymmetrical r.m.s. fault current varies from $\sqrt{3} \cdot I_{AC}$ when t = 0 to I_{AC} when t is large where I_{AC} = Init Sym RMS. Note that the asymmetrical rms current does not form part of IEC60909. The peak current, I_p, as per IEC 60909 is given by

$$I_p = \sqrt{2} \cdot I_k'' \cdot \left(1.02 + 0.98 \cdot e^{\frac{-3 \cdot R}{X}}\right). \tag{7}$$

The limit for both is when X/R approaches giving $i_{p(max)}$ =2* 2*Ik" or $i_{p(max)}$ = 2*2* I_{AC}.

VIII. SIMULATION RESULT OF FAULTS AT VARIOUS BUSES

8.1 Faults at Bus 1 and Bus 2

FAULT	**3 – Phase**	**L – G**	**L – L**	**L – L – G**
Initial Symmetrical Current (kA, rms)	14.954	14.162	12.951	14.763
Peak Current (kA),	37.980	35.969	32.892	37.494
Breaking Current (kA, rms, symm)		14.162	12.951	14.736
Steady State Current (kA, rms)	3.260	14.162	12.951	14.763

Table 2 Fault Current at Bus 1&2

8.2 Faults at Bus 4 and Bus 5

FAULT	3 – Phase	L – G	L – L	L – L – G
Initial Symmetrical Current (kA, rms)	5.728	6.666	4.961	6.463
Peak Current (kA),	14.384	16.739	12.457	16.230
Breaking Current (kA, rms, symm)		6.666	4.961	6.463
Steady State Current (kA, rms)	0.985	6.666	4.961	6.463

Table 3 Fault Current at Bus 4&5

8.3 Faults at Bus 8 and Bus 9

FAULT	3 – Phase	L – G	L – L	L – L – G
Initial Symmetrical Current (kA, rms)	3.056	1.377	2.646	2.689
Peak Current (kA),	7.798	3.514	6.753	6.862
Breaking Current (kA, rms, symm)		1.377	2.646	2.698
Steady State Current (kA, rms)	0.656	1.377	2.646	2.689

Table 4 Fault Current at Bus 8&9

IX. REFERENCE FOR RELAY CO-ORDINATION

Relay co-ordination plays an important role in the protection of power system. For proper protection, proper co-ordination of relays with appropriate relay settings is to be done. Relay settings are done in such a way that proper co-ordination is achieved along various series network. However the review of Co-ordination is always essential since various additions / deletion of feeders and equipments will occur after the initial commissioning of plants. As power can be received from generators of captive power plant, the analysis becomes complex. So this study can be a base reference for relay as well as circuit breaker ratings and plug setting of the protective devices.

X. CONCLUSIONS

Short circuit studies are important for planning future expansion of power systems as well as in determining the best operation of protective systems. In this paper design analysis of 220/132 kV substation using ETAP software is carried out with an approach to calculate short circuit current of complex substation. Short circuit Studies using ETAP software is an excellent tool for system planning and its protection. A number of operating procedures is analyzed such as line to line fault, line to ground fault, line-line to ground fault and three phase fault. This can be used to determine the optimum size and location of relays and circuit breaker. Also, it is useful in determining the system voltages under conditions of different faults.

REFERENCES

[1] Kiran Natkar, Naveen Kumar, "Design Analysis of 220/132 KV Substation Using ETAP", ISSN: 2395-0072, Volume: 02 Issue: 03 (June-2015)

[2] ETAP Operations Technology, Inc., Available: http://www.etap.com.

[3] P. Kundar, "Power System Stability and Control". New York: McGraw-Hill, 1994.

[4] P.K. Iyambo, R. Tzonova, "Transient Stability Analysis of the IEEE 14- Bus Electrical Power System", IEEE Conf. 2007.

[5] P. M. Anderson and A. A. Fouad, "Power System Control and Stability". New York: IEEE Press,1994.

[6] Rana A. Jabbar Khan, Muhammad Junaid, Muhammad Mansoor Asgher, "Analysis and Monitoring of 132 grid using ETAP software".

[7] Hadi Saadat (2002) "Power System Analysis", Edition , Tata Mc Graw Hill.