Load Flow and Short Circuit Study of 220 kV Substation

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Abstract— Short Circuit Analysis provides the information required to determine if the interrupting capacities of the power system components are adequate enough to protect your power system. Load flow is basic requirement to conduct the short circuit analysis of any system. The load flow gives us the sinusoidal steady state of the entire system - voltages, real and reactive power generated and absorbed and line losses. In this study, we have carried short circuit study of 220 kV substation system using ETAP software. From the ETAP generated report, load flow and short circuit system are studied.

Key words: ETAP Software, Load Flow, Short Circuit, 220 kV Substations

I. Introduction

From load flow studies we can obtain the voltage magnitudes and angles at each bus in the steady state. This is rather important as the magnitudes of the bus voltages are required to be held within a specified limit. Once the bus voltage magnitudes and their angles are computed using the load flow, the real and reactive power flow through each line can be computed. Also based on the difference between power flow in the sending and receiving ends, the losses in a particular line can also be computed. Furthermore, from the line flow we can also determine the over and under load conditions.

Short Circuit analysis is required to ensure that existing and new equipment ratings are adequate to withstand the available short circuit energy available at each point in the electrical system. No substation equipment can be installed without knowledge of the complete short circuit values for the entire power distribution system. The short circuit calculations must be maintained and periodically updated to protect the equipment laid in the substation.

II. Importance

Load flow studies are one of the most important aspects of power system planning and operation. The load flow gives us the sinusoidal steady state of the entire system - voltages, real and reactive power generated and absorbed and line losses. Since the load is a static quantity and it is the power that flows through transmission lines.

A Short Circuit Analysis will help to ensure that personnel and equipment are protected by establishing proper interrupting ratings of protective devices (circuit breaker and fuses). If an electrical fault exceeds the interrupting rating of the protective device, the consequences can be devastating. It can be a serious threat to human life and is capable of causing injury, extensive equipment damage, and costly downtime.

On large systems, short circuit analysis is required to determine both the switchgear ratings and the relay settings.

A. System Information:

To conduct load flow and short circuit study, here we have taken 220 kV network consists 8 nos. of feeders (X-1 to X-8) and 2 nos. of Load (X-9 & X-10). The related information about kV rating and respective load are mentioned in table 1 & 2.

1) System Data:

Sr. No.	Bus ID	kV rating	Name of Bus
1	220 kV	220	220 kV Bus-I
2	220 kV	220	220 kV Bus-II
3	Bus 1	220	X-1 station side
4	Bus 2	220	X-2 station side
5	Bus 3	220	X-3 station side
6	Bus 4	220	X-4 station side
7	Bus 5	220	X-5station side
8	Bus 6	220	X-6 station side
9	Bus 7	220	X-7 station side
10	Bus 8	220	X-8 station side
11	Bus 9	220	X-9 station side
12	Bus 10	220	X-10 station side

Table 1: System Data

2) Load Data:

Sr. No.	Station	MW/MVA
1	X - 1	0.1
2	X - 1	6.66
3	X - 1	0.1
4	X - 1	7.164
5	X - 1	28.768
6	X - 1	77.17
7	X - 1	7.97
8	X - 1	7.97
9	X - 1	50.07
10	X - 1	201

Table 2: Load Data

From the above data considered to conduct the load flow and short circuit analysis of substation system.

The single line diagram prepared as per diagram 1.

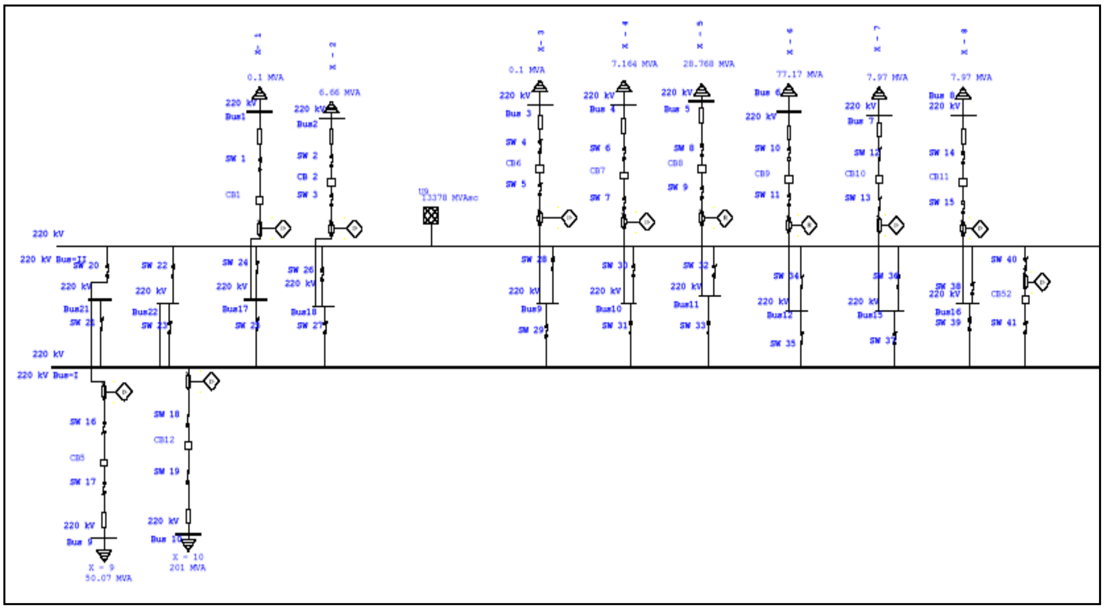

Diagram.1: Single Line Diagram of 220 kV Substation

The load flow study provides information about current, voltage, bus power flow of transformer, circuit breakers, and other information.

III. Load Flow and Short Circuit Analysis of System

A. Load Flow Analysis of System:

For planning and operation of electrical system load flow study plays an important role.

The load flow analysis gives the current, voltage and power flow of line, bus, transformer, circuit breakers and other equipments. The load flow standard output report generated by ETAP enlists all input parameters like bus input parameters, line/cable parameters and transformer parameters. The load flow results exhibits loads, bus voltages, generation and power flow as per diagram-2.

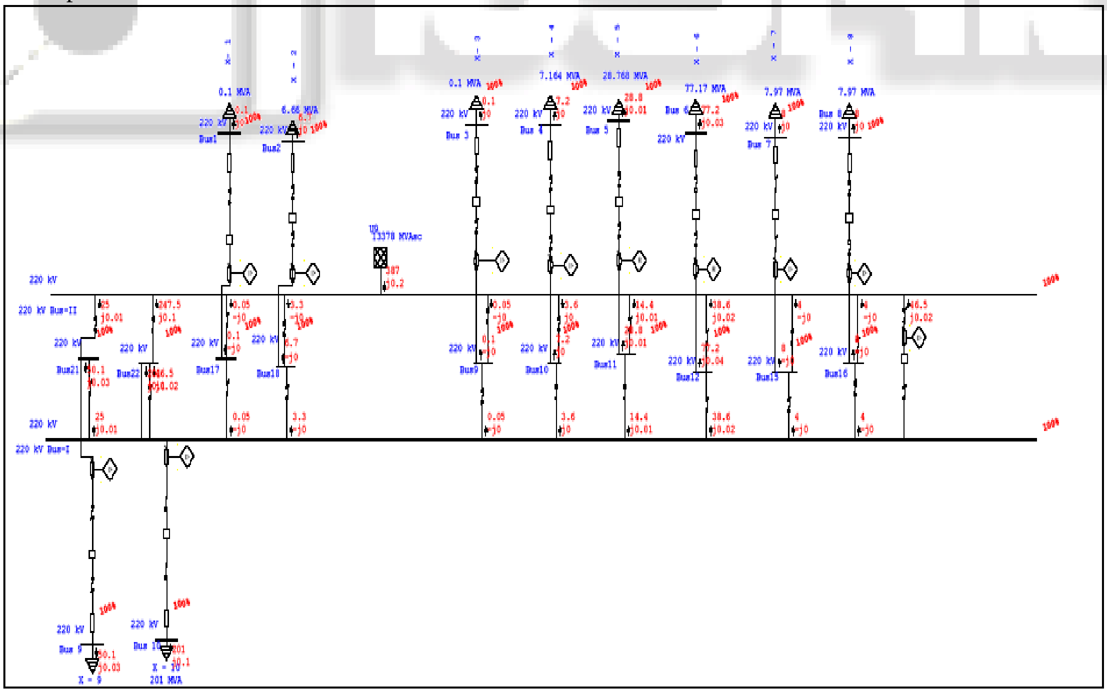

Diagram 2: Load Flow Single Line Diagram Generated In ETAP

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Location:		Date:	05-19-2015
Contract:		SN:	12345678
Engineer:	Study Case: LF	Revision:	Base
Filename: IJSRD		Config.:	Normal

SUMMARY OF TOTAL GENERATION , LOADING & DEMAND

	MW	Mvar	MVA	% PF
Source (Swing Buses):	386.967	0.191	386.967	100.00 Lagging
Source (Non-Swing Buses):	0.000	0.000	0.000	
Total Demand:	386.967	0.191	386.967	100.00 Lagging
Total Motor Load:	0.000	0.000	0.000	
Total Static Load:	386.963	0.174	386.963	100.00 Lagging
Total Constant I Load:	0.000	0.000	0.000	
Total Generic Load:	0.000	0.000	0.000	
Apparent Losses:	0.005	0.017		
System Mismatch:	0.000	0.000		

Number of Iterations: 2

Fig. 1: Load Flow Report Generated in ETAP

Based on the load flow study, report has been generated in the ETAP which provides details about total active, apparent and reactive power having total demand and total generation exhibits system losses. Short circuit carried after completion of load flow study.

B. Short Circuit Analysis of System:

Short circuit report of power system tends to be more complex due to mixture of load which contributes to fault current. In a typical modern industrial system the basic sources of fault currents are the utility, the in-plant generation and synchronous and induction motors. These sources contribute additional exponentially decaying currents which make fault current magnitudes at various locations time dependent. The short-circuit results short circuit level of different buses as per diagram-3.

ETAP is capable to generate the report for 3 phases, LLL, LG, LLG faults. Here summary of 3 phase, LG, LL and double line to ground faults can be created and according to that report generated [2]. The report of short-circuits is presented as per fig-2.

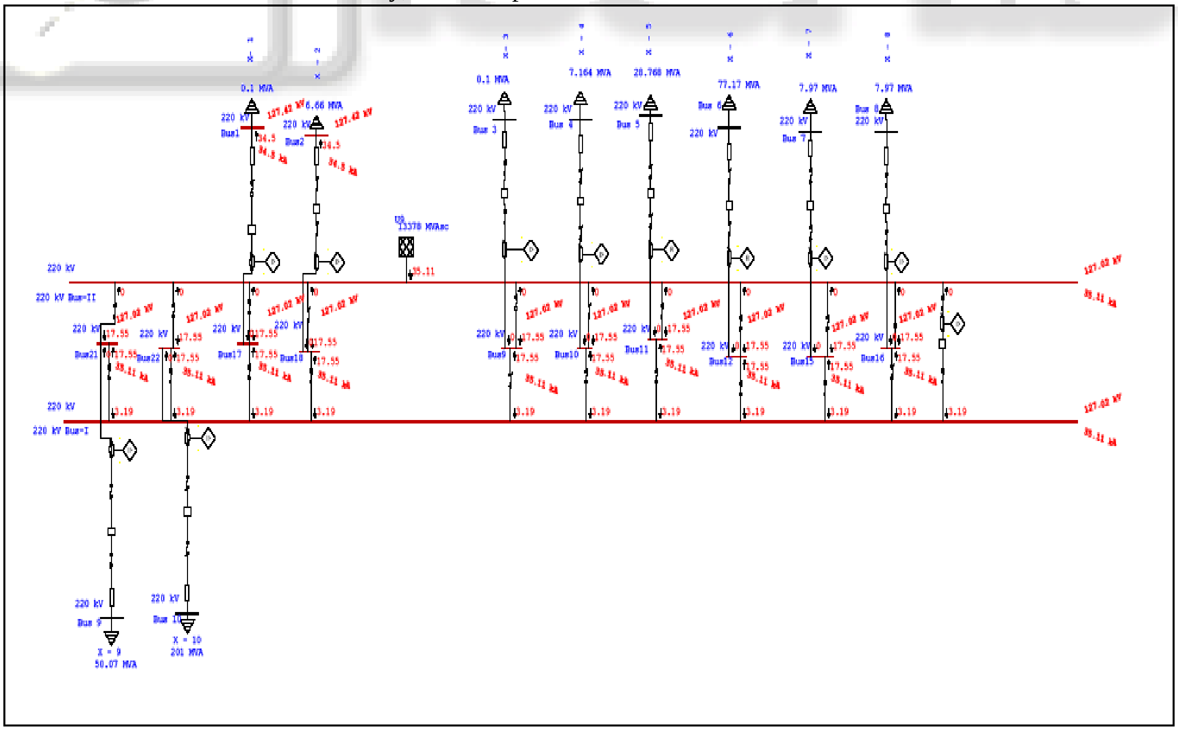

Diagram 3: Short Circuit Single Line Diagram Generated in ETAP

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Location: | | Date: 05-19-2015
Contract: | | SN: 12345678
Engineer: | Study Case: SC | Revision: Base
Filename: IJSRD | | Config.: Normal

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
220 kV Bus-I	220.000	35.109	92.525	35.109	35.109	92.525	35.109	35.109	30.405	80.129	30.405	30.405	35.109	92.525	35.109	35.109
220 kV Bus-II	220.000	35.109	92.525	35.109	35.109	92.525	35.109	35.109	30.405	80.129	30.405	30.405	35.109	92.525	35.109	35.109
Bus1	220.000	34.765	91.447	34.765	34.503	90.757	34.503	34.503	30.108	79.196	30.108	30.108	34.657	91.164	34.657	34.657
Bus2	220.000	34.765	91.447	34.765	34.503	90.757	34.503	34.503	30.108	79.196	30.108	30.108	34.657	91.164	34.657	34.657
Bus9	220.000	35.109	92.525	35.109	35.109	92.525	35.109	35.109	30.405	80.129	30.405	30.405	35.109	92.525	35.109	35.109
Bus10	220.000	35.109	92.525	35.109	35.109	92.525	35.109	35.109	30.405	80.129	30.405	30.405	35.109	92.525	35.109	35.109
Bus11	220.000	35.109	92.525	35.109	35.109	92.525	35.109	35.109	30.405	80.129	30.405	30.405	35.109	92.525	35.109	35.109
Bus12	220.000	35.109	92.525	35.109	35.109	92.525	35.109	35.109	30.405	80.129	30.405	30.405	35.109	92.525	35.109	35.109
Bus15	220.000	35.109	92.525	35.109	35.109	92.525	35.109	35.109	30.405	80.129	30.405	30.405	35.109	92.525	35.109	35.109
Bus16	220.000	35.109	92.525	35.109	35.109	92.525	35.109	35.109	30.405	80.129	30.405	30.405	35.109	92.525	35.109	35.109
Bus17	220.000	35.109	92.525	35.109	35.109	92.525	35.109	35.109	30.405	80.129	30.405	30.405	35.109	92.525	35.109	35.109
Bus18	220.000	35.109	92.525	35.109	35.109	92.525	35.109	35.109	30.405	80.129	30.405	30.405	35.109	92.525	35.109	35.109
Bus21	220.000	35.109	92.525	35.109	35.109	92.525	35.109	35.109	30.405	80.129	30.405	30.405	35.109	92.525	35.109	35.109
Bus22	220.000	35.109	92.525	35.109	35.109	92.525	35.109	35.109	30.405	80.129	30.405	30.405	35.109	92.525	35.109	35.109

All fault currents are in rms kA. Current ip is calculated using Method C.

* LLG fault current is the larger of the two faulted line currents.

Fig. 2: Short Circuit Report Generated in ETAP

IV. CONCLUSION

From the above load flow study carried out for 220 kV substation, there is no overloading observed on different buses. Calculation of short circuit current currents for selected 220 kV system tend to be more complex because of the mixture of sources contributing currents to the fault. From the short circuit study, it is concluded that no device is overstressed. ETAP is very useful tool to conduct load flow as well as short circuit study. The load flow and short circuit study is the basic requirement to perform relay coordination.

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