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Load Flow Analysis of 132 kV substation using ETAP Software

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Abstract-Power is essentially required for the development of any country. To maintain the generation of electric power at adequate level the power has to be transmitted in proper form and quality to the consumer. This research paper deals with the simulation of 132 kV substation in Electrical Transient Analyzer Program (ETAP) with detailed load flow analysis and also to overcome the problem of an under voltage. The results are based on actual data received from 132 kV substation.

Index Terms-Capacitor bank placement, demand and Losses, Load Flow Analysis using ETAP software, need of Load Flow Analysis, reactive power transmission, surmount the problem of an under voltage, voltage profile.

1 INTRODUCTION

Load flow analysis using software is accurate and gives highly reliable results. This research makes effective use of Electrical Transient Analyzer Program (ETAP) to carry out load flow analysis of 132 kV substation[1],[2]. The actual ratings of Power Transformers, Circuit Breakers, Current Transformers, Potential Transformers and Isolating switches are taken and modelled accordingly in ETAP. This 132 kV substation is located in Punjab State Transmission Corporation Limited (PSTCL) which comprises of 2 Power Transformers, 13 Circuit Breakers, 13 Current Transformers, 3 Potential Transformers and 6 Isolating switches [3].

The major cause of almost all the major power system disturbance is under voltage. Reactive power (Vars) cannot be transmitted very far especially under heavy load conditions so it must be generated close to the point of consumption. This is because the difference in voltage causes reactive power (Vars) to flow and voltages on a power system are only +/- 5 percent of nominal and this small voltage difference does not cause substantial reactive power (Vars) to flow over long distances. So if that reactive power (Vars) is not available at the load centre, the voltage level go down. Chronic under voltages can cause excess wear and tear on certain devices like motor as they will tend to run overly hot if the voltage is low[4].

The single line diagram of the substation is simulated in ETAP based upon actual data and it is seen that at both the 11 kV feeder buses there is under voltage. To overcome the under voltage at both the 11 kV feeder buses capacitor bank of suitable ratings are placed in shunt.

Section 2 is the details of the components. Section 3 is the simulation of single line diagram of 132 kV substation in ETAP based upon practical data. Section 4 is the Load Flow Analysis of the substation. Section 5 contains the Alert summary report generated after load flow analysis. Section 6 is the load flow analysis of the substation with an improvement to surmount the problem of under voltage. Section 7 is the ratiocination of this research work.

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2 DETAILS OF COMPONENTS

TABLE 1

Component	Type	Rating	
		Minimum	Maximum
Power Transformer	Transformer 1	10 MVA	12.5 MVA
	Transformer 2	16 MVA	20 MVA
Circuit Breaker	CB 1-4	145kV/1600A	
	CB 5-12	12kV/630A	
	CB 13	12kv/1250A	
Current Transformer		Primary	Secondary
	CT 1,3	600A	1A
	CT 2	75A	1A
	CT 4	200A	1A
	CT 5,6	400A	5A
	CT 7	900A	5A
	CT 8-12	400A	5A
	CT 13	1200A	5A
Potential Transformer	PT 1	132 kV	110 V
	PT 2,3	11 kV	110V
Isolating Switches	SW 1-6	132 kV/1600A	
Feeders	Load 1	250A	
	Load 2	400A	
	Load 3	200A	
	Load 4	270A	
	Load 5	310A	
	Load 6	280A	
	Load 7	20A	

3 SIMULATION OF 132 kV SUBSTATION IN ETAP

Fig. 1 shows the Power Grid which supplies power to the 132 kV Bus 1. Transformer 1 and Transformer 2 supply power to Bus 4 and Bus 3 respectively. Five feeders are emanating from Bus 3 and two feeders are emanating from Bus 4.

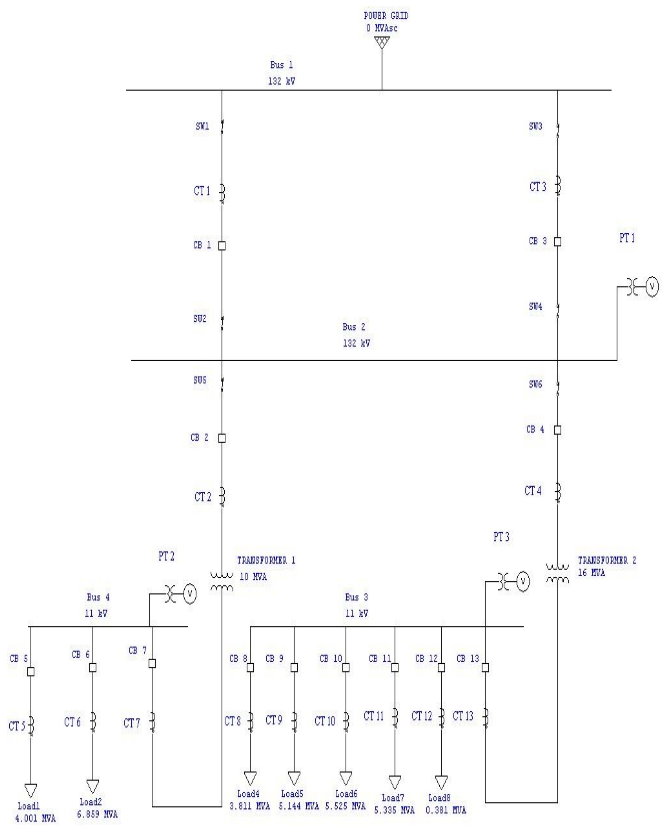

Fig. 1. Simulated diagram of 132 kV substation using ETAP

4 LOAD FLOW ANALYSIS

Fig. 2 shows the Load Flow Analysis of the 132 kV substation carried out using ETAP in which Newton-Raphson method [5],[6] is used and it is observed that at the Bus 3 and Bus 4 there is under voltage which can be clearly seen from Fig. 2 (a) showing the sectional view of the feeders. At Bus 3 the voltage level is 94.01% and at bus 4 the voltage level is 94.78%.

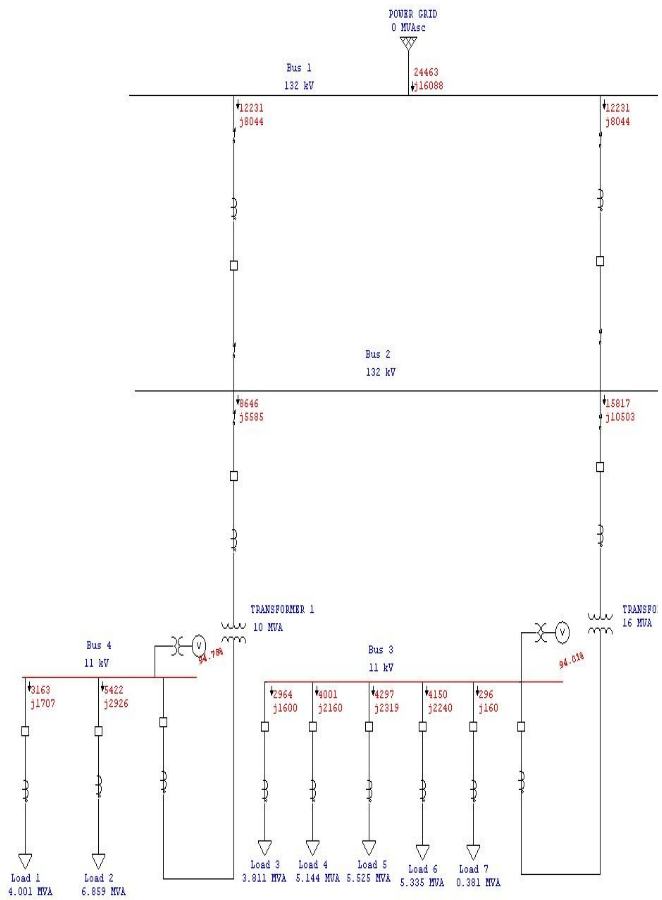

Fig. 2. Load Flow Analysis of 132 kV substation

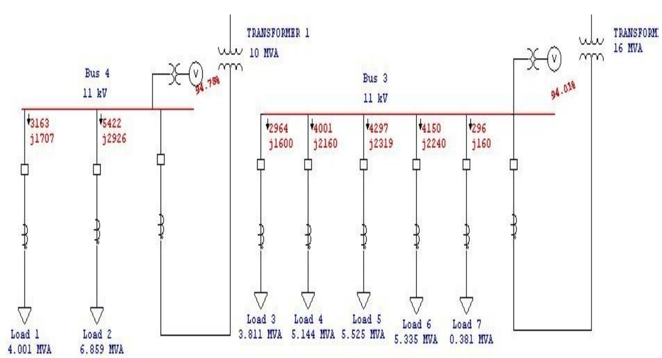

Fig. 2(a). Sectional View of the Feeders

TABLE 2 shows that the real power on swing bus i.e. BUS 1 is 24.463 MW and the reactive power is 16.088 Mvar and the power factor is 83.6% which is very low.

TABLE 2

Monitoring Points	kV	MW	Mvar	%PF
BUS 1*	132	24.463	16.088	83.6
BUS 3	11	17.772	9.593	83.3
BUS 4	11	9.557	5.158	84

* Swing Bus

TABLE 3 shows the Demand and Losses summary report which tells us about the total demand of the system and also about the losses that occurs in a system.

TABLE 3

Type	MW	Mvar	MVA	%PF
Swing Bus	24.463	16.088	29.279	83.6(lag)
Total Demand	24.463	16.088	29.279	83.6(lag)
Total Static Load	24.293	13.112	27.605	88(lag)
Apparent Losses	0.17	2.976		
Transformer 1	61.4*	951.5*		
Transformer 2	108.9*	2024.9*		

*KW *Kvar

5 ETAP ALERTS DURING LOAD FLOW ANALYSIS

TABLE 4 After carrying out load flow analysis using ETAP an alert summary report is generated which tells us which part of the system needs immediate attention and it can be clearly seen from the Table 4 that the Bus 3 and Bus 4 are operating at an under voltage.

TABLE 4

Device ID	Condition	Rating	Operating	%Operating
Bus 3	Under Voltage	11 kV	10.342 kV	94.01
Bus 4	Under Voltage	11 kV	10.425 kV	94.78

6 LOAD FLOW ANALYSIS WITH AN IMPROVEMENT TO OVERCOME THE PROBLEM OF UNDER VOLTAGE

Fig. 3 The simulation of the 132 kV substation is carried out in ETAP by placing the capacitor banks in shunt with the feeders. The rating of capacitor bank 1 is 4.4 Mvar and that of capacitor bank 2 is 8.2 Mvar. Fig. 3(a) shows the load flow analysis of the substation. From Fig. 3(b) which shows the sectional view of the feeders it can be clearly seen that the operating voltage of Bus 3 has improved from 94.01% (Fig. 2(a)) to 98.23% and that of Bus 4 from 94.78% (Fig. 2(a)) to 98.43%.

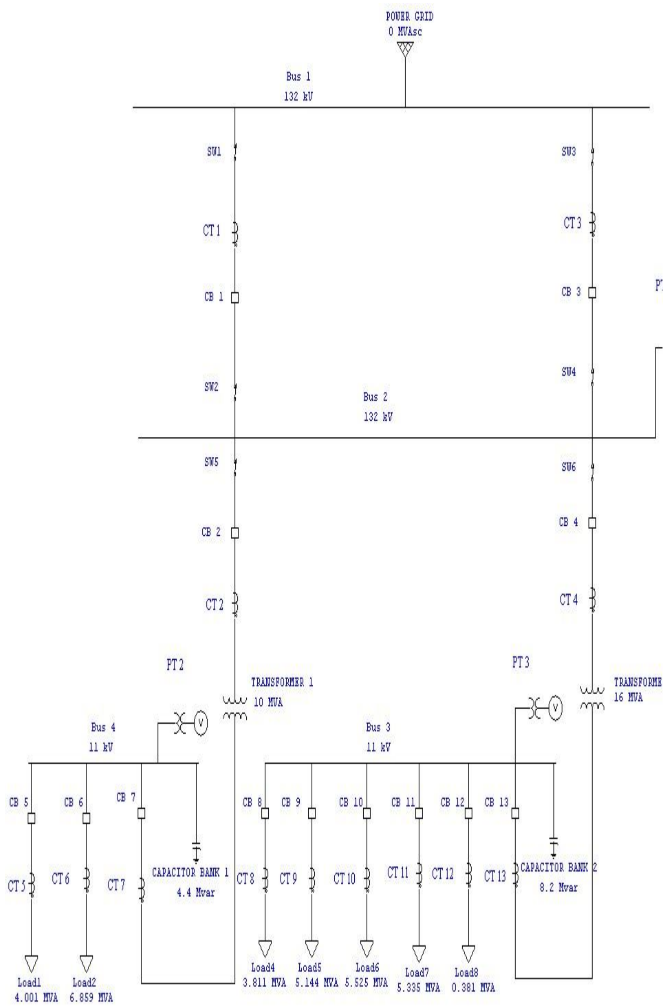

Fig. 3. Simulated diagram of 132 kV substation using ETAP

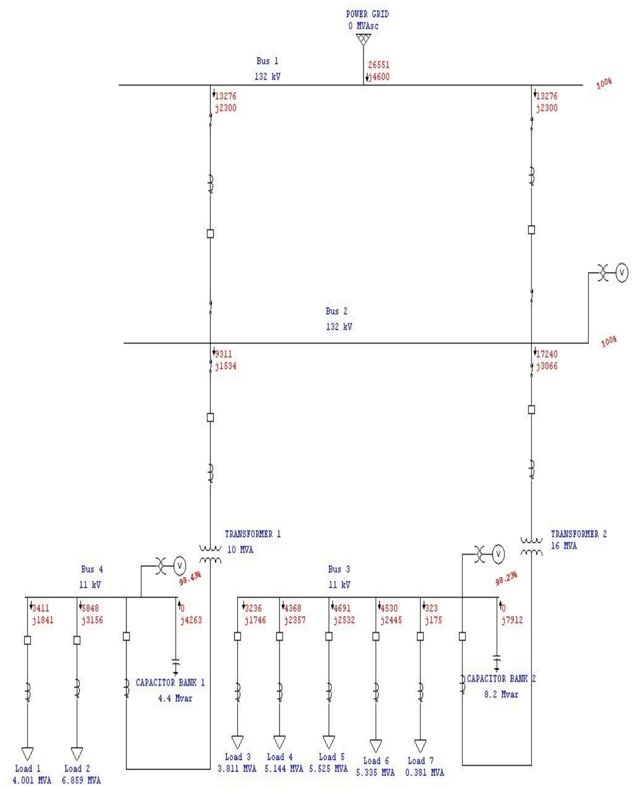

Fig. 3(a). Load Flow Analysis of 132 kV substation

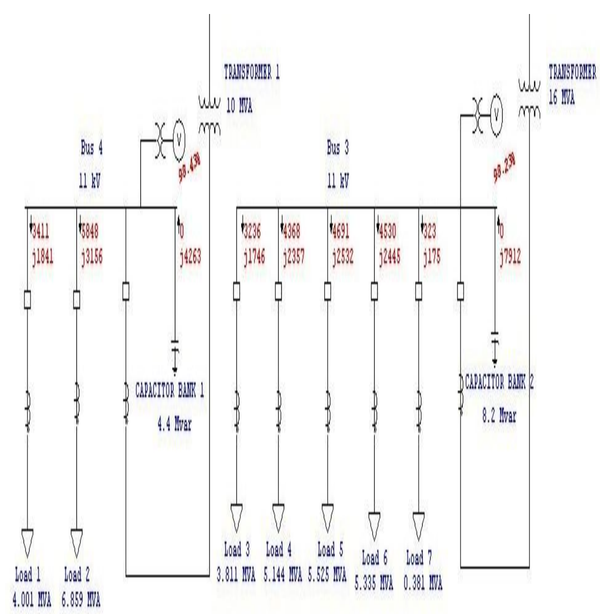

Fig. 3(b). Sectional view of the Feeders

TABLE 5 shows the load flow results and by comparing it with TABLE 2 it can be clearly seen that there is an improvement in the power factor.

TABLE 5

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

TABLE 6

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	51.6*	799.7*		
Transformer 2	92.6*	1722.3*		
	*KW	*Kvar		

By comparing TABLE 7 to TABLE 4 it can clearly be seen that the problem of an under voltage at both the buses is surmounted by the placement of capacitor banks in shunt to the feeders.

TABLE 7

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

7 CONCLUSIONS

In this paper Load Flow study using ETAP software is carried out with an approach to overcome the problem of an under voltage. Load Flow Studies using ETAP software is an excellent tool for system planning. A number of operating procedures can be analyzed such as the loss of generator, a transmission line, a transformer or a load. Load flow studies can be used to determine the optimum size and location ofcapacitors to surmount the problem of an under voltage. Also, they are useful in determining the system voltages under conditions of suddenly applied or disconnected loads. Load flow studies determine if system voltages remain within specified limits under various contingency conditions, and whether equipment such as transformers and conductors are overloaded. Load-flow studies are often used to identify the need for additional generation, capacitive, or inductive VAR support, or the placement of capacitors and/or reactors to maintain system voltages within specified limits.

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