LOAD FLOW ANALYSIS OF132/11KV SUBSTATION USING ETAP: A CASE STUDY

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ABSTRACT

In the operation and design planning for the power system, the most significant and beneficial approach for the investigation of problems relating to power systems can be done by means of load flow analysis or design power flow. In light of a predefined structured power system and transmission system, the load flow analysis provides steady state characteristic data for voltage phase angles and its magnitude, the flow of reactive power in the transmission lines, losses in the system, generation and consumption of reactive power in the bus bar load. In this paper, an endeavor has been made to explore power flow in the 132kV grid by utilizing ETAP. The data is collected from Kohat 132KV substation over a period of one year, specifically in summer and winter peak loads.

KEYWORDS: Power flow analysis, ETAP, single line diagram.

INTRODUCTION

As the need for electric power is exceedingly expanding day by day, therefore this increasing demand ought not only to overcome by building more generating stations but also to redesign the current power grids. For this reason, load flow studies can play indispensable part. Load flow or power flow studies can be performed by using Electrical Transient Analyzer Program (ETAP) which gives precise and reliable outcomes[1][2].ETAP provides a package of complete set of Electrical Design programming tools which consists of transient steadiness, transfer coordination, burden stream, transient steadiness, transfer coordination, link capacity, and numerous more ETAP [3].

It is predicted that consumption of energy will rise as the population raises by which urbanization intensifies and financial system will grow too[4].In developing countries like Pakistan, where the generation of electricity is not increasing in the same proportion as the demand of the country, which in term leads to short fall of electric power. In spite of the lack of electric power, the main reason for the energy shortfall is the deficiency in the field of analysis[5].In power system, under voltage is the main problem causes disturbance in power system, the reactive power cannot be send over the long separations in case of heavy loads, so that should be generated near the point of utilization. This is the fact that any change in voltage causes the flow of reactive power (VARS), and furthermore on power system there is a little contrast in the rated voltage and actual voltage, which usually does not cause reactive power (VARS) to stream over long distances. In that particular scenario, the reactive power is absent at the point of load which tends the voltage to go down. Low voltage are dangerous and can cause serious disintegration in specific machines like a motor as they are forced to run excessively hot if the voltage is low[6]. Power system studies are done by electrical engineers from many years for utilizing distinctive programming tools. The recently powerful Computer-based software is emerged as a cause of eminent research in the field of electrical engineering. For the analysis and examination of mighty electrical power systems, which comprises of power distribution flowing from the 132kV grid, this project features the viable utilization of Electrical Transient Analyzer Program (ETAP).[7][8][9].For modeling and simulation in ETAP, the single line diagram and real ratings of power transformers, current transformers, circuit breakers, potential transformers and isolating switches are taken from 132kV grid situated in Kohat Pakistan.

RESULTS AND DISCUSSION

DETAILS OF COMPONENTS

The power grid system has 14 buses, 4 power transformers, 6 potential transformers, 51 current transformers,51 circuit breakers,19 feeders of 11KV and 16 isolating switches. All the data is real time and collected from local grid station of Kohat.

The table below shows the rating of all the components which is collected from the Kohat substation and whiles the next table in the sequence illustrates the load on the different feeders.

Component	**Type**	**Rating**	**Primary**	**Secondary**
Power Transformer	T1(2-winding)	40MVA	132KV	11KV
	T2(2-winding)	40MVA	132KV	11KV
	T3(2-winding)	37MVA	132KV	66KV
	T4(2-winding)	26MVA	132KV	11KV
Current	CT 1-3		1200	5A

Transformers	CT 4	1600	5A
	CT 5-11	300	5A
	Remaining 41 CTs	600	5A
Potential Transformers	PT- 5	132KV	120 KV
	PT- 6	66 KV	120 KV
Isolating switches	SW 1-16	132KV/1250Amp	
Circuit breaker		RATED CURRENT	NORMAL CURRENT
	KHN 81-84	40KA	3120A
	KHN71-74	25KA	2500A
	CB'S WITH FEEDER	25KA	2500A
	REMANING CB'S		400A

Table 1. Data and rating of all components

LOAD ON 11 KV FEEDERS IN WINTER AND SUMMER			
		In Feb 2016	**In May 2016**
Feeders	**11KVoutgoing**	**Load amp**	**Load amp**
	Gumbat	360	390
	Kohat Express	400	380
	Kharmato	400	380
	College town	140	210
	Cadet college	110	100
	Kohat tunnel	20	20
	City 1	220	160
	O.T.S	120	360
	Barh	280	240
	Alizai-1	200	130
	City 2	280	200
	City 3	280	290
	K.T.M	5	5
	B.C.M	40	80
	Lachi Express	380	380
	Jarma	440	240

The Figure 1 below shows single line diagram of 132kV grid modeled in ETAP. The substation has 4 incoming supplies connected to two bus bars each is rated 132kV. Further these bus bars are connected to feeders through power transformers by which 132kV is stepped down to 11kV for distribution. Two capacitor banks are installed each having rating of 7.2 MVAR.

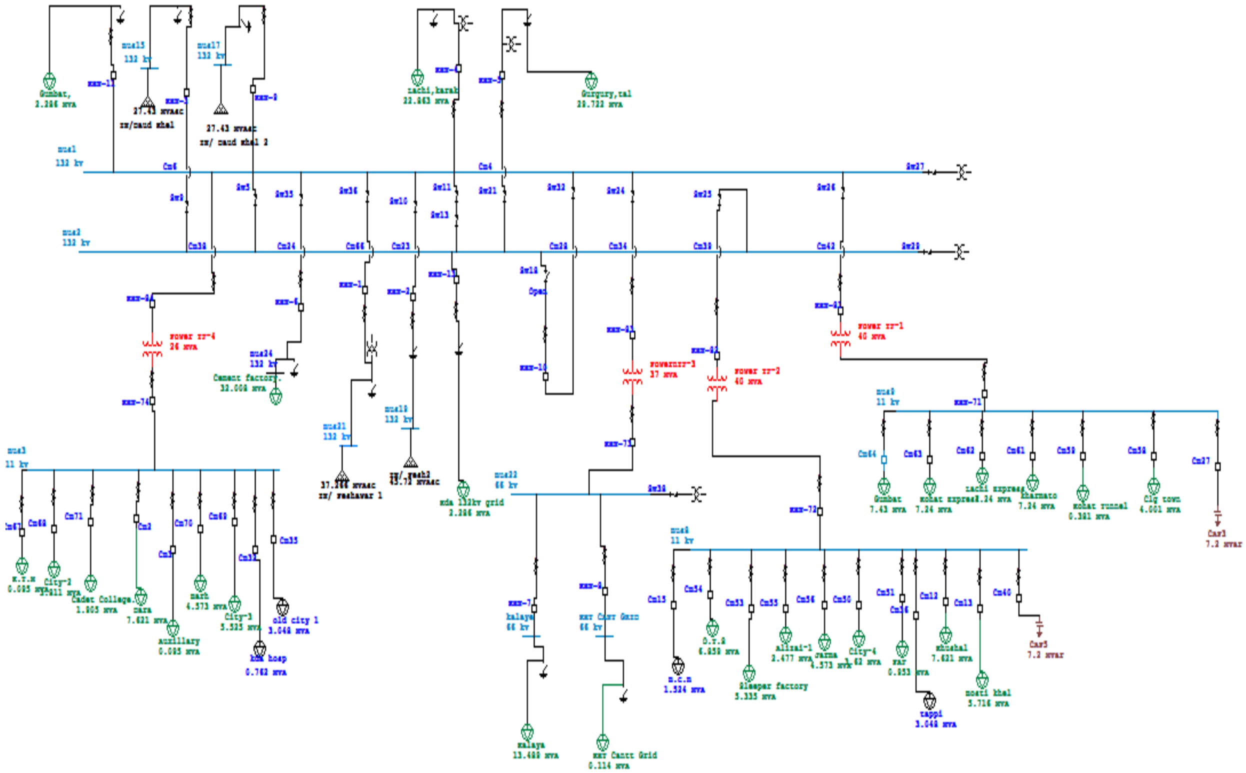

Figure 1. Single line diagram of 132kv grid in etap

SIMULATION IN ETAP

The Figure 2 below shows simulated diagram of 132kV grid in ETAP. After simulation ETAP alerts shows that bus no 3, 8, 9 are in under voltage which are load busses in which bus no 3 is in critical situation and power transformer TF-4 is overloaded.

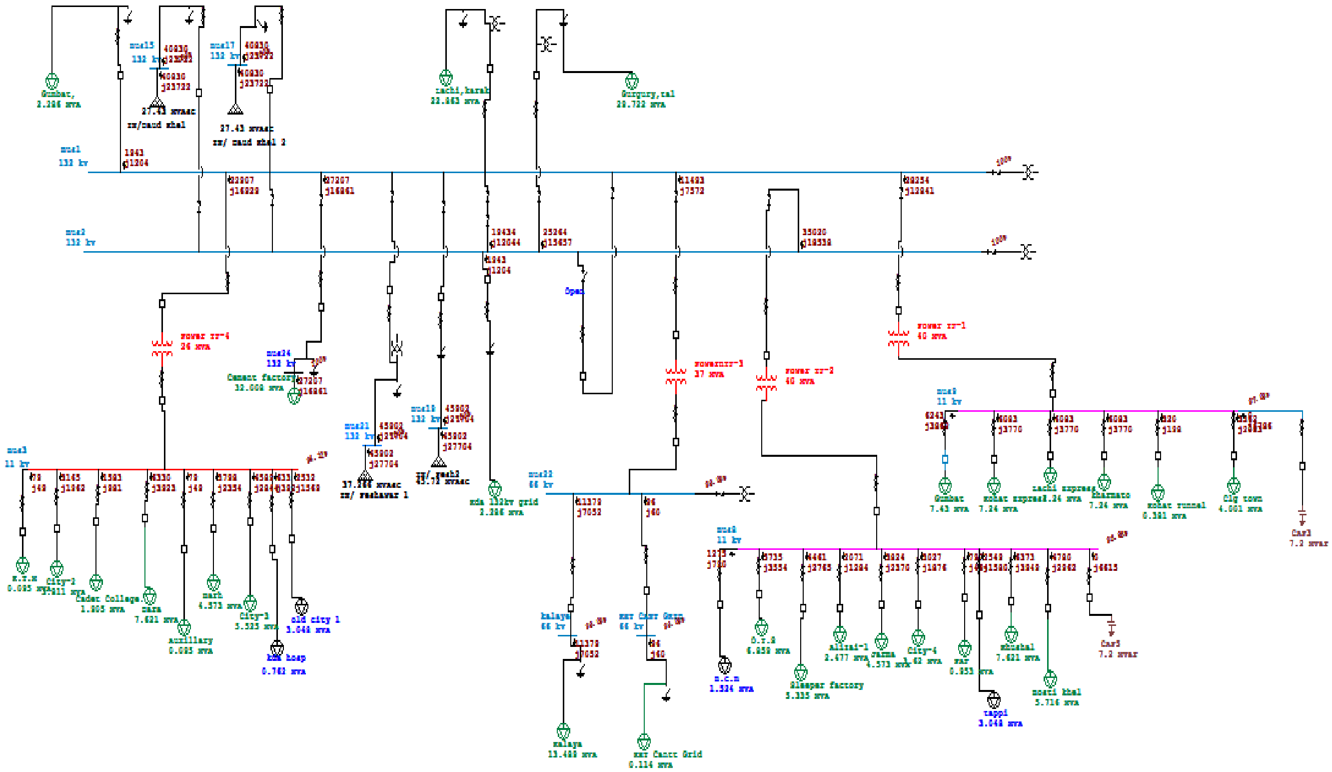

Figure 2. Simulated diagram of 132/11kv grid in etap before adding capacitor bank.

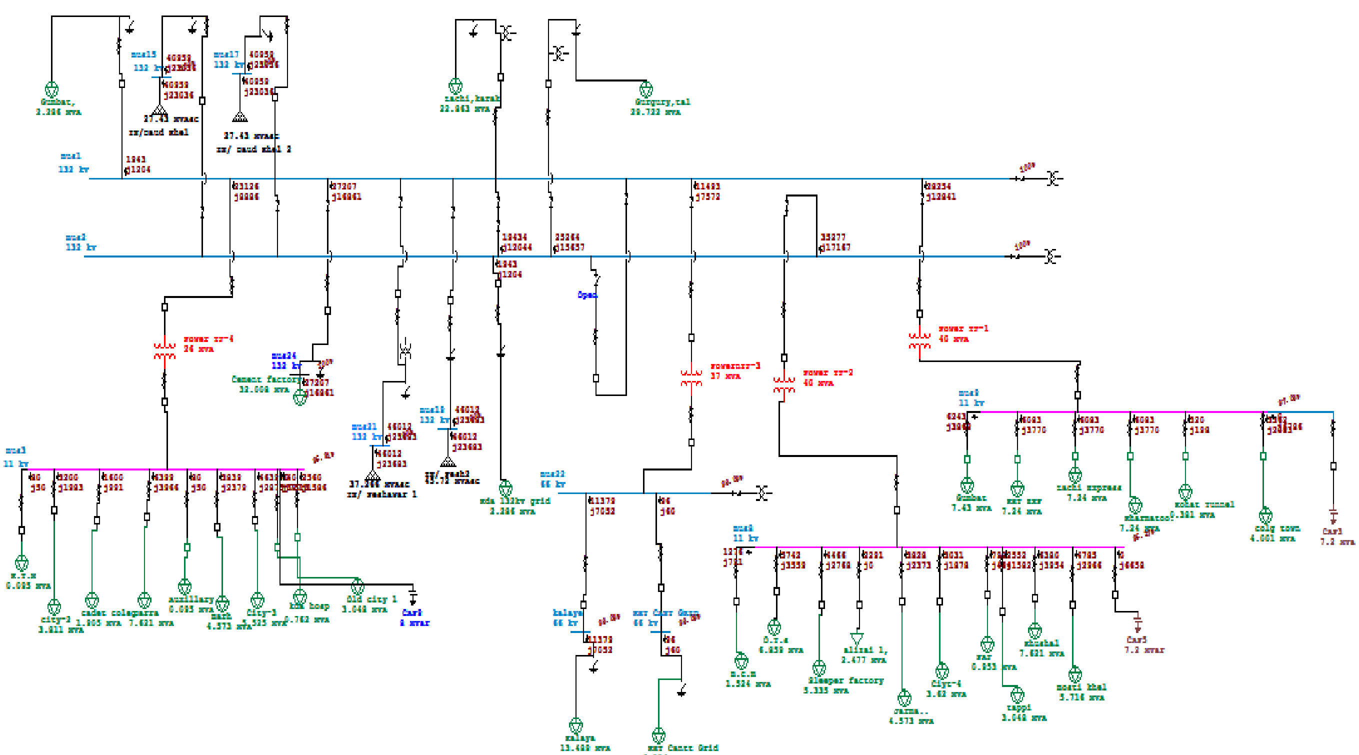

FIGURE 3. SIMULATED DIAGRAM OF 132/11KV GRID IN ETAP AFTER ADDING CAPACITOR BANK.

Total incoming supply

The table below shows the different incoming supplies to the grid station.

Table 2. Total incoming supply to the selected 132kv grid

ID	TYPE	RATING	RATED KV	MW	MVAR	AMP	%PF
IN/ DAUD KHEL 2	Power grid	27.43 MVA	132	40.959	23.036	205.5	87.16
IN/ PESH2	Power grid	45.72 MVA	132	45.902	27.704	234.5	85.61
IN/ PESH1	Power grid	37.266MVA	132	45.902	27.704	234.5	85.61
IN/ DAUD KHEL 1	Power grid	27.43 MVA	132	40.959	23.036	205.5	87.16

LOAD FLOW ANALYSIS

A 132 KV substation load flow analysis has been performed in ETAP which applies different numerical methods. The below table 3 shows the summary report of total generation, total demand and losses in the system before adding capacitor bank.

Table 3. Summary report of total generation, demand and losses before adding capacitor ban

Parameters	MW	MVAR	MVA	%pf
Swing	173.721	101.48	206.609	86.16
Total demand	173.721	101.48	206.609	86.16
Apparent losses	0.341	8.893	---	---

LOAD FLOW ANALYSIS CAUTIONS BY ETAP

After performing load flow analysis, a ready report can be seen that demonstrates the critical or marginal situation of various parts of the system. Here tables show the critical and marginal cautions reports, the busses that are in under voltage and their operational condition is under 95% are put in the critical circumstance while others having the operating condition greater than 95% and are in under voltage condition and placed marginal alert report. Table 4 plainly indicates bus no 3 and 8 are in under voltage condition.

ETAP ALERTS BY PUTTING LOAD OF FEB. 2016

The table below indicates the caution of under voltage in the two buses merely bus no 3 and 8 respectively.

Table 4.critical alerts in which bus no 3&8 are in under voltage (critical situation).

Device id	Type	Condition	Rating	Unit	Operating	%operating	Phase type
Bus 3	Bus	Under voltage	11.000	KV	10.378	94.3	3-phase
Bus 8	Bus	under voltage	11.000	kV	10.402	94.6	3-phase

This table below indicates the marginal alerts before the addition of capacitor bank

Table 5. Marginal view of bus 9 which is in under voltage and a power transformer tf-2&tf-4 are overloaded.

Device Id	Type	Condition	Rating	Operating	%Operating	Phase Type
Bus 9	Bus	under voltage	11 kV	10.616	96.5	3-phase
TF-2	Transformer	overload	40 MVA	38.85	97.1	3-phase
Tf-4	Transformer	overloaded	26 MVA	25.901	99.6	3-phase

ETAP ALERTS BY PUTTING LOAD OF MAY 2016

The Table 6below shows ETAP critical alerts when the capacitor bank was not added.

Table 6. Under voltage bus no 3 and overloaded power transformer tf-4.

Device id	**Type**	**Condition**	**Rating**	**Unit**	**Operating**	**%operating**	**Phase type**
Bus 3	Bus	Under voltage	11.0	KV	10.354	94.1	3-phase
Tf-4	Power transformer	Overloaded	26.0	MVA	26.810	103.1	3-phase

Table 7 Demonstrates ETAP marginal alerts before adding capacitor bank.

Device id	Type	Condition	Rating	Unit	Operating	%operating	Phase type
Bus 8	Bus	Under voltage	11.000	KV	10.544	95.9	3-phase
Bus 9	Bus	under voltage	11.000	KV	10.679	97.1	3-phase

ADDITION OF CAPACITOR BANK TO OVERCOME THE PROBLEM OF UNDER VOLTAGE.

To solve the trouble caused by under voltage, capacitor bank of 8 MVAR is connected in shunt with feeders. After this ETAP alerts are generated, table 9 showing ETAP marginal alerts in which bus no 3 has improved from 94.1% to 96.9%.,bus no 8 has improved from 95.5 to 96.2. Still busses are in under voltage but no busses are in critical situation.

After connecting the capacitor bank, the summary report oftotal generation, demand and losses are shown in table 8 as follows. A difference can be seen by comparison made in between table 2 & 8 respectively. It is clearly shown that apparent losses are reduced.

Table 8 Summary Reports of Total Generation, Demand and Losses after Adding Capacitor Bank

Parameters	MW	MVAR	MVA	%pf
Swing	173.94	93.437	205.461	87.89
Total demand	173.94	93.437	205.461	87.89
Apparent losses	0.313	8.21	---	---

After the addition of capacitor bank the following results are being obtained as shown in table 9.

Table 9. Etap marginal alerts in which under voltage busses are shown that are improved after addition of 8mvar capacitor bank.

Device id	Type	Condition	Rating	Unit	Operating	%operating	Phase type
Bus 3	Bus	Under voltage	11.0	KV	10.66	96.9	3-phase
Bus 8	Bus	Under voltage	11.0	KV	10.578	96.2	3-phase
Bus 9	Bus	Under	11.0	KV	10.67997.1		3-phase

	voltage

CONCLUSION

The load-flow study is vital for monetary scheduling depth provisioning and also arranging its future expansion. The principle outcomes acquired from power flow studies are nodal voltages, phase angles, system transmission losses and the real and reactive power streaming in each line.

Load flow Investigation was directed on 132 kV grid utilizing ETAP. Over-loaded transformer and under voltage buses are identified. The up gradation of substations, Static capacitor banks for reactive power compensation will be viable for buses in under voltage and furthermore for the improvement of power factor.

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