Case Study of Power Factor Effect on 220 KV and 66 KV Transmission Lines from VAJAMANGALA 220/66/11 KV Station

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Abstract— This paper presents the analysis of power factor effect on 66 KV transmission lines (SFC-1, SFC-2, FTS, FTS-3) from Vajamangala 220/66/11 station based on 2014 yearly data. Power factor plays an important role in the electrical power system, especially in the transmission and distribution side. Power factor is low in some-months of the year in these four 66 kV transmission lines. Especially power factor is poor in SFC-1 line, almost throughout the year 2014. So this line is a major concern. The distance of SFC-1 and SFC-2 lines from Shivanasamudra generating station to Vajamangala 220/66/11 station is approximately 50 KMs. Power factor in these transmission lines reduces drastically in an unusual way during sometimes in a year 2014. Optimum solution is obtained through proper analysis based on 2014 yearly collected data from the Karnataka Power Transmission and Corporation Limited (KPTCL).

Key words: Transmission lines, Power factor, Generating station, KPTCL

I. INTRODUCTION

Nowadays, transmission-level voltages are usually considered to be 110 kV and above. Lower voltages, such as 33 kV and 66 kV, are usually considered sub transmission voltages, but are occasionally used on long lines with light loads. Voltages less than 33 kV are usually used for distribution purposes. Voltages above 220 kV are considered extra high voltage and require different designs compared to equipment used at lower voltages.

The power factor of an AC electrical power system is defined as the ratio of the real power flowing to the load to the apparent power in the circuit. It is a dimensionless number between -1 and +1.

A high power factor is generally desirable in a transmission system to reduce transmission losses and improve voltage regulation at the load.

Low power factor results in large KVA rating, greater conductor size, large copper losses, poor voltage regulation, reduced handling capacity of system, reduced transmission efficiency.

A power factor of one or "unity power factor" is the goal of any electric utility company since if the power factor is less than one, they have to supply more current to the user for a given amount of power use. In so doing, they incur more line losses. Capacitors have the opposite effect and can compensate for the inductive motor windings. Some Industrial sites will have large banks of capacitors strictly for the purpose of correcting the power factor back toward one to save on utility charges.

In an electric power system, a load with a low power factor draws more current than a load with a high power factor for the same amount of useful power transferred. The higher currents increase the energy lost in the distribution system, and require larger wires and other equipment. Because of the costs of larger equipment and wasted energy, electrical utilities will usually charge a higher cost to industrial or commercial customers where there is a low power factor.

High voltage capacitor banks are used at substations, long transmission lines and at points in HV networks suitable for maintaining reactive power balance. Capacitors reduce network losses and voltage drop and transmission of reactive power is avoided. This means considerable annual savings. Proper location of capacitor banks is the most important criteria. Nowadays, switching capacitors are usually used for power factor problems as load varies throughout the day or a week.

II. PROBLEM DESCRIPTION

Figure.1 shows the single line diagram of 220 kV receiving station, vajamangala. From the two buses 66 KV Bus A and 66 KV Bus B, the 66 KV transmission lines are tapped as shown in figure1. Here SFC-2(Bannur-Kirgavalu), SFC-1(Meghalapura), D.K.Maiden-Jyothinagara/FTS, Devanoor/FTS-3 are the 66 KV lines as shown in the figure1.Also 220 KV bus A and 220KV bus B, the 220 KV Hootgaly and T.K.Halli lines are tapped as shown in figure 1. This figure shows the clear picture of 220 kV Hootgally and T.K.Halli lines.

Figure 2 shows the single line diagram of 66 KV lines from vajamangala 220/66/11 KV station. Four 66 KV transmission lines such as SFC-1 (Meghalapura), SFC-2 (Bannur-Kirgavalu), FTS (D.K.Maidan-Jyothinagara), FTS-3 (Devanoor) transmission lines are received in a vajamangala 220/66/11 KV station. LIS (Lift Irrigation Scheme), Bannur and Kirgavalu substations are connected to the SFC-2 66 KV line. On similar words, B.G.Pura, Meghalapura and T.N.Pura substations are connected to the SFC-1 line. These 2 lines are taken from SFC 66 kV bus.Jyothinagara and D.K. maidan are connected to the FTS line, also Devanoor(mys) is connected to FTS-3 line. Both these lines are taken to the FTS 66 kV bus, to this Hootgally 66 kV line is directly connected as shown in figure 2. Figure 2 consists of only 66 kV and 11 kV lines (220 kV line is not shown).

Power factor is low in some-months of the year in SFC-1(Meghalapura), SFC-2(Bannur-Kirgavalu), D.K.Maidan-Jyothinagara(FTS), Devanoor(FTS-3) 66 KV transmission lines. Especially power factor is poor in SFC-1and SFC-2 lines, almost throughout the year 2014. So this line is a major concern.

Power factor is poor such that power factor reduces drastically in an unusual way during sometimes in a year 2014 in one or more transmission lines which are directly connected to Vajamangala 220/66/11 KV station. Even 220 kV Hootgally line also has a power factor problem along with those 66 kV lines. This is the headache to the KPTCL people. So it is necessary to analyze the 2014 yearly data of all stations to overcome the above mentioned problem. So that it is easy to analyze the power factor problem in all 66 kV and 220 kV lines along with loads and interconnected transformers between them. Thus proper analysis results in the optimal solution to the above mentioned problem.

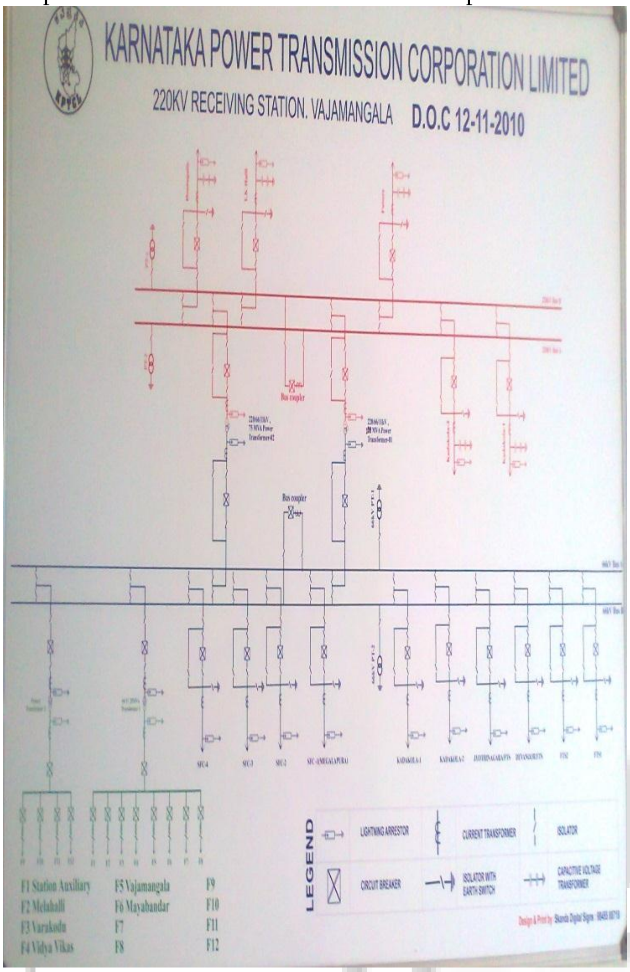

Fig. 1 : Single Line Diagram Of 220kv Receiving Station, Vajamangala.

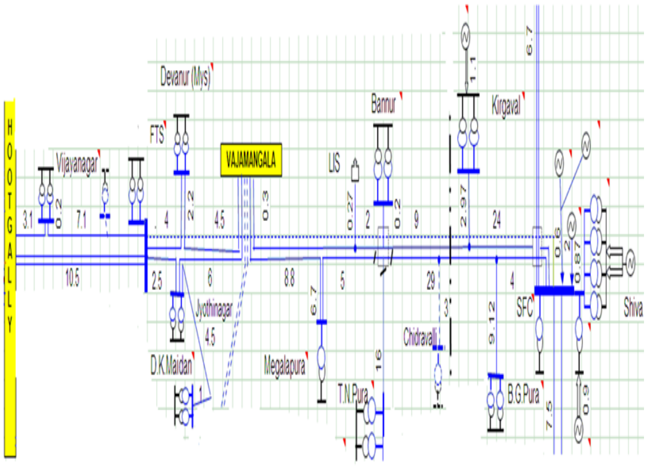

Fig. 2: Single Line Diagram Of 66 Kv Lines From Vajamangala 220/66/11 Kv Station.

III. PROBLEM FORMULATION

Line Names	**Hours**	**1**	**2**
	Weather	Clear	Clear
220 kV BAYS/LINES			
220 kV HOOTGALLY (2-7)	AMPS	115.06	114.06
	MW	-46.12	-43.42
	MVAR	7.12	6.13
	PF	-0.98	-0.99
220 kV T.K.HALLI (2-6)	AMPS	74.23	76.45
	MW	25.6	26.99
	MVAR	8.9	9.71
	PF	0.95	0.94
220kV BUS COUPLER (2-3)	AMPS	85.91	88.91
	MW	22	33.23
	MVAR	-2	-1.06
	PF	1	1
66 kV LINES			
SFC-2 (BANNUR-KIRGAVALU) (6-6)	AMPS	66.2	65.74
	MW	2	1.52
	MVAR	7.5	6.81
	PF	0.22	0.21
SFC-1 (MEGHALAPURA) (6-7)	AMPS	48.2	42.02
	MW	0.85	0.75
	MVAR	3.15	4.14
	PF	0.2	0.16
D.K.MAIDAN - JYOTHINAGAR/F.T.S (6-12)	AMPS	175.2	170.21
	MW	5	4.52
	MVAR	-25.2	-18.2
	PF	0.35	0.24
DEVANOOR/FTS - 3 (6-14)	AMPS	118.95	117.95
	MW	9.15	8.18
	MVAR	-10.13	-10.13
	PF	0.55	0.63

Table 1: Analysis Of Power Factor Effect At 220 Kv And 66 Kv Lines Based On Real Time Data Of November 26, 2014.

Table 1 shows the analysis of power factor effect on 66 kV lines in the month of November on 30th of 2014. 220kV lines are shown to know the direction of MVAR power during the low power factor period. Power factor is poor in SFC-1, SFC-2 and FTS lines. Almost all the year of 2014, the power factor has lot of variations in these lines.

IV. REAL TIME DATA ANALYSIS AND DISCUSSION

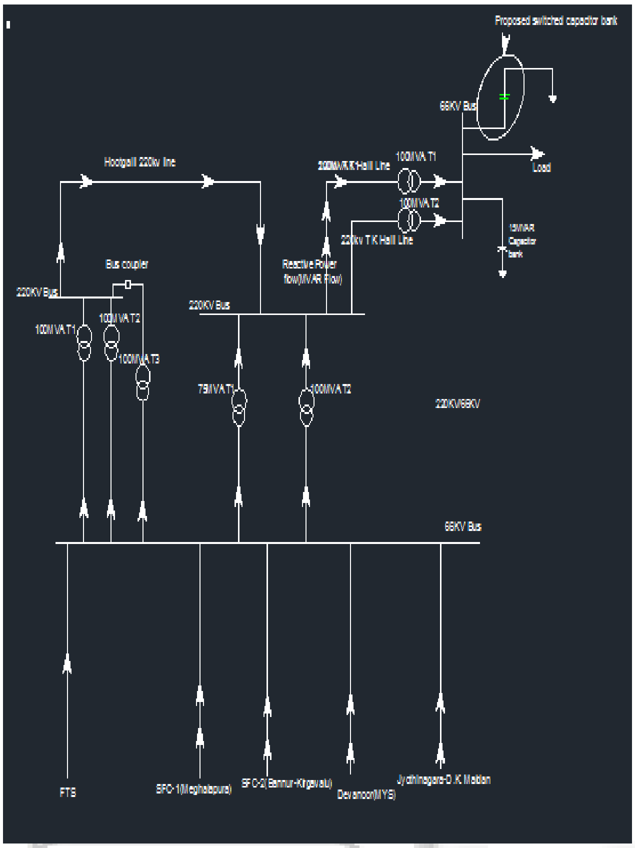

Fig. 3: Flow of Reactive Power With Arrows In 66 Kv And 220 KV Lines.

Vajamangala 220/66/11 kV station incorporated with SCADA (Supervisory Control and Data Acquisition) system comes under Mysore jurisdiction of Karnataka state in India.

The 2014 yearly data of this station is properly analyzed to know the power factor problem in different months in all the 66 kV lines. Figure 3 shows the flow of reactive power (MVAR power) with arrows in the 66 kV and 220 kV lines along with transformers. 66kV/220kV three step up transformers of 100 MVA are used in the Hootgally side and one of 75 MVA and other of 100 MVA are used at the Vajamangala side .

The reactive power flow in these 66 kV lines plays a vital role in the data analysis. When the power factor is low in any two or three lines sometimes in all four lines, reactive power flows towards the 66 kV bus at that instant of time. When we further analyzed the data with L.T. side and H.T. side of transformers, the reactive power flow from 66 kV buses to the 220 kV main Bus as shown in figure 3. Even in the Hootgally 220 kV line, the power flow is towards 220 kV main Bus.

Thus the analysis states that all the reactive power is flowing towards the 220 kV Bus from all the lines whenever there is poor or low power factor in these lines. From that 220 kV Bus, the reactive power (MVAR power) is flowing into the T.K.Halli 220 kV line. One year complete data analysis confirmed that all the lines supply reactive power to the T.K.Halli line. So that it is inferred that all the reactive power is consumed by the T.K.Halli 220 kV line. This reactive power is consumed by the continuously varying loads which are connected through the 220/66/11 kV transformers.

V. SOLUTION

Already 15 MVAR capacitor bank is in charge at the 66 kV T.K.Halli Bus. But which is not sufficient for the varying loads connected through this bus. So that T.K.Halli 220/66/11 kV substation needs a proper compensation.

As loads are varying in nature, it is better to go for switched capacitors rather than fixed shunt capacitors to overcome the power factor problem. So that loads reflect us that there is a requirement of reactive power injectors. Usually government agencies like KPTCL will always go for use of shunt capacitors banks for the power factor problem either at the local banks or in the HT networks.

Thus switched capacitor of 10 MVAR is required at the T.K.Halli. This proposed switched capacitor bank to the KPTCL at 66 kV bank of T.K.Halli substation is the optimal solution to the power factor problem as shown in figure 3. Finally power factor correction can be done with 10 MVAR switched capacitor bank.

Bannur and Kirgavalu stations have no any local compensation units. So they also require local compensation at the banks. Thus according to KPTCL standards, 2.9 MVAR shunt capacitor banks should be installed as a part of local compensation network.

VI. CONCLUSION

In this paper, switched capacitor of 10 MVAR is proposed at T.K.Halli along with two 2.9 MVAR fixed shunt capacitor banks at Bannur and Kirgavalu for the power factor problem in 66 kV SFC-1, SFC-2, FTS, FTS-3 lines. As per government regulations, they are compensated with 2.9 MVAR capacitor banks as a part of local compensation. Presently switching capacitor is necessarily required by the T.K.Halli line. After proper analysis of 2014 yearly data of all the stations connected to the power factor problem, an optimal solution is finally obtained. Thus power factor correction and reactive power management should be done with a most economical and practical approach. In one word, this paper is the most helpful guide to the KPTCL.

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