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Investigation of Circuit Breaker Switching Transients for Shunt Capacitor Using Matlab/Simulink

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ABSTRACT

It is common practice to install shunt capacitors to improve the power factor and voltage profile at all voltage levels in the power system. Almost all type of load including domestic user's appliances are inductive. Due to low water level agricultural load are also increasing. All these conditions lead to poor power factor and large amount of reactive power flows through the transmission line and voltage drop occurs. Hence, in several areas low voltage pockets are created. To improve this low power factor, adequate compensation is to be provided at load end point. Due to increasing load/consumers it is very difficult to insist every consumer to provide compensating device. Ultimately power transmission companies have decided to provide the capacitor bank at the feeding substation at various voltage levels such as 11KV, 33KV and EHV levels also. And now a day it is well accepted practice to install a capacitor bank at the feeding substation for improving the power factor of the system. The major problem with the capacitor bank is the interrupter failure i.e. the failure of circuit breaker employed for its switching. It is reported by power distribution and transmission companies that breaker failure occurs before its specified number of operation. In order to understand this problem, I thought of taking a topic of dissertation work, which relates to the failure of circuit breaker employed for capacitor switching.

Keywords: Inrush Current, Capacitor Bank, Shunt Capacitor Switching.

I. INTRODUCTION

It is common practice to install shunt capacitors to improve the power factor and voltage profile at all voltage levels in the power system. Due to low water level agricultural load are increasing. All these conditions lead to poor power factor and large amount of reactive power flows through the transmission line and voltage drop occurs. The major problem with the capacitor bank is the interrupter failure i.e the failure of circuit breaker employed for its switching. It is reported by power distribution and transmission companies that breaker failure occurs before its specified number of operation. Various reasons for failure of breaker can be broadly categorized as below.

1. Less effective medium in interrupting chamber
2. Deterioration of circuit breaker contacts due to frequent switching operation of capacitor bank
3. Effect of capacitor bank charging in-rush current which can be of very high magnitude.
4. Out-rush current due to fault on supply bus or very to bus.
5. Effect of restricking voltage (over voltage).
6. Effect of L-C Resonance

All these effects are to be studied and simulate these conditions by developing soft computing model.

III. AIM

Simulation of capacitor bank switching actions of a shunt capacitor bank connected to 3 phase power supply through extra high voltage circuit breaker with all standard specifications of normal circuit breaker and to establish that normal specification circuit breaker is not adequate for capacitive load switching.

IV. OBJECTIVES

1. To study and differentiate between inductive load switching and capacitor bank switching.

2. To study the behaviour of circuit breaker during capacitor bank switching and switching during fault by developing soft computing model.
3. To establish that normal specification circuit breaker is not adequate for capacitive load switching.

V. METHODOLOGY

The methodology proposed for this dissertation work is given as below.
It is proposed to consider 132KV level substation as a model substation, having 132 KV bus and accordingly it is proposed to design in soft model. Bus is connected to 2 Nos. of 132 /11KV 25 MVA transformers and 2 Nos. of 132 KV lines eminating from bus having 150 Amps load on each line with PF 0.80. Each transformer is drawing 43-44 amps HV side current with 0.80PF. For improvement in power factor, 20 MVAR shunt capacitor bank is connected to bus. All the circuit breakers connected for lines, transformers and capacitor bank have same name plate details as below.

BREAKER SPECIFICATION

1. Normal voltage-145KV(Max)
2. Normal current-1600Amps.
3. Lightning Impulse withstand voltage-650KV.
4. Short circuit Breaking current-31.5Amps/sec.
5. Line charging Breaking current-50Amps.
6. Operating sequence-0.035-CO-3Min-CO.
7. First pole to clear factor-1.3.
8. Power Frequency withstand voltage-275KV
9. DC component-51%.
10. Making capacity-80KA.

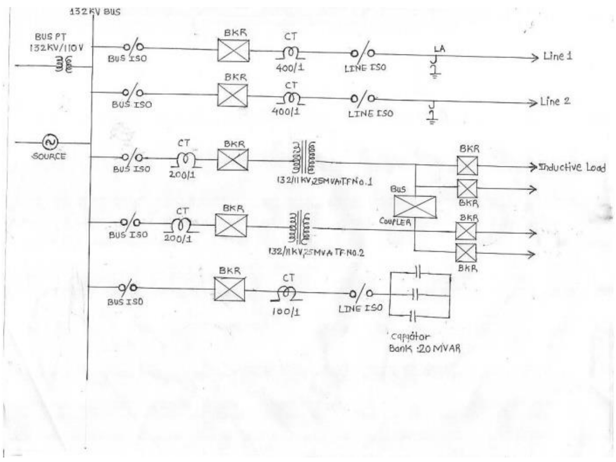
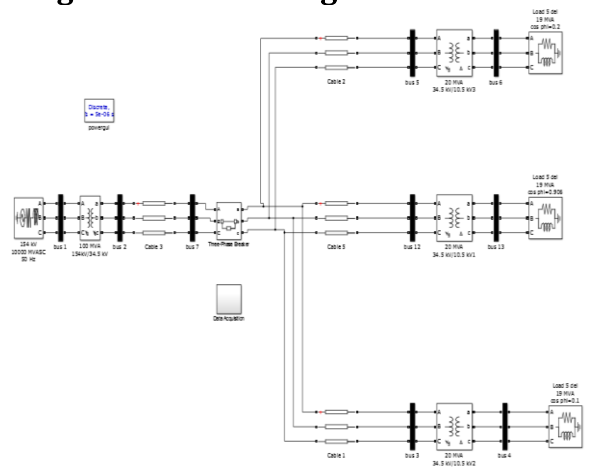
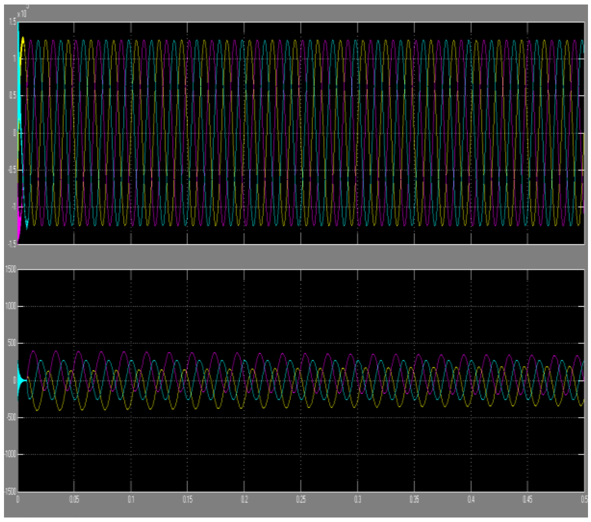


Figure 1 : Single Line Diagram of Proposed 132/11 Kv Model Substation

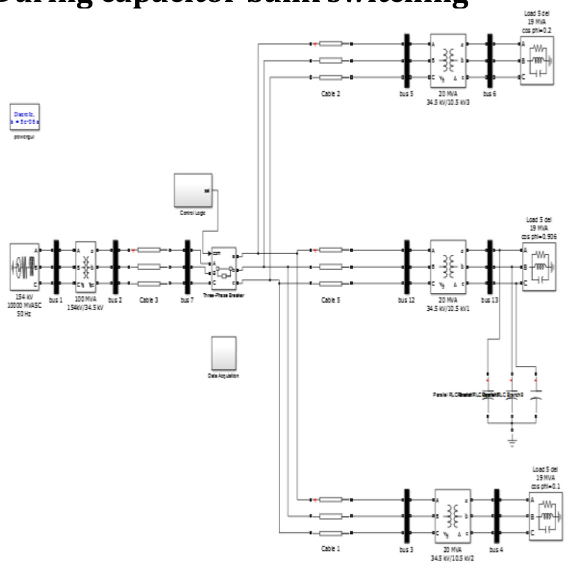
VI. RESULTS AND DISCUSSION

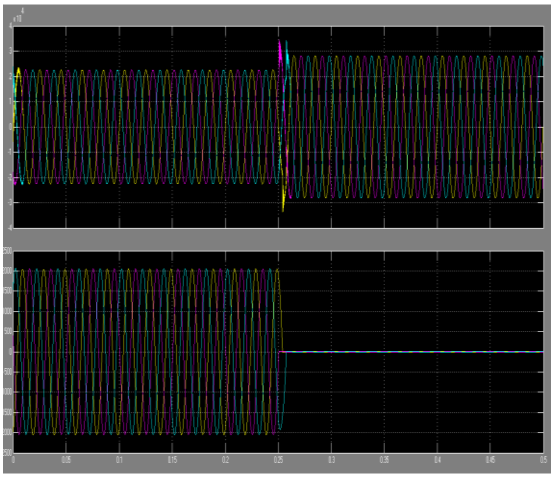
During normal switching



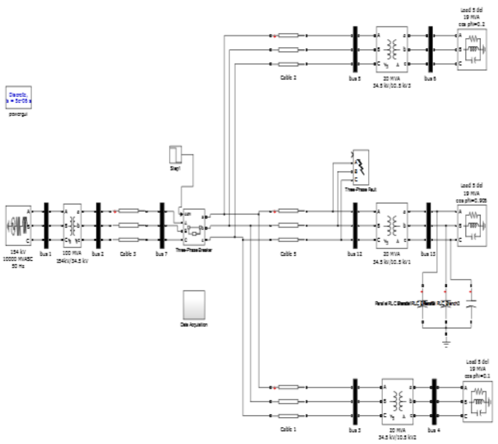


During capacitor bank switching





Switching during fault



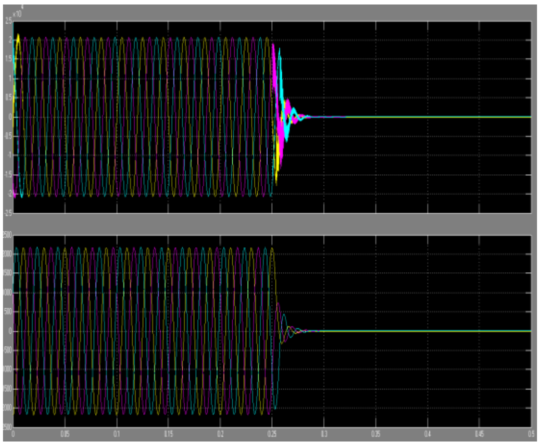


TABLE I
TABLE SHOWING RESULTS OF RESPECTIVE OPERATING CONDITIONS

Sr. No.	**Operating Condition**	**Normal voltage**	**Load**	**Magnitude (% DC component)**	**Power Factor**	**Capacity of capacitor bank to installed (Mvar)**	**Remark**
1	Normal Condition	154 KV/ 54KV	19MVA	-	0.2	-	-
2	Capacitor Bank Charge	154 KV/ 54KV	19MVA	71%	0.9	20	Breaker failed
3	Fault Condition	154 KV/ 54KV	19MVA	87%	0.9	20	Breaker failed

VII. CONCLUSION

Providing capacitor bank to power feeding sub-station is beneficial and also increases transformer MVA efficiency. But, majority of capacitor banks are non operative due to problems in switching circuit breaker. if adequate switching device is provided which can sustain all the stresses of capacitive switching then all the capacitor banks can be made operative and stresses on power system can be reduced to much extent.

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