Application of Capacitor Bank and FACTS Devices in Traction System with Their Comparative Study

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Abstract—One of the major load on grid is railway which causes voltage instability in the system It is studied that these controllers significantly increase the voltage level of traction system.

In India most common means of transportation is railway. Most of the railway line is electrified, which increases the demand for electricity. Arrivals and departure of locomotive at substation are dynamic load. The single phase fault on OHE line is most severe fault,due to this voltage drop occur at OHE and three phase supply line also, result of this is inefficient operation of motor in loco.

The paper shows the comparative study of capacitor bank, SVC and STATCOM.. In this paper, improvement in traction system over capacitor bank by using SVC and STATCOM has been studied.

IndexTerms—traction substation, OHE, loco, SVC, STATCOM

I. INTRODUCTION

Railway is a largest means of transportation in India because it offers low transportation cost and most important it is free from pollution Railway works under the Indian railway which is a state-owned organization of the Ministry of railway. Electrification is most important up gradation of Indian railway. But this increases the consumption electricity. There is most important to study traction system and its effect on power system .

Indian railway traction system uses 1.5 kV DC around Bombay and 25Kv ac is used in rest of the country. The supply for traction system is taken from state utility which is three phase source at 132/220 kV. The Indian traction OHE takes 25 kV supply, so only two phases are taken and step down to single phase 25 kV through transformer which is placed at traction substation. This 25kV is fed to the OHE from feeder then to the loco via pantograph which is kept at the roof of loco. When there are severalloco at substation operating at a time then there is voltage drop at OHE. Because of this, inefficient operation of motor takes place as large amount of current is drawn from line.

To reduce the tariff it is required to reduce the losses and improve system performance. The compensation scheme such as Capacitor, SVC and STATCOM can be used to overcome the problem in traction system.

II. TRACTIONSYSTEMIN INDIA

The detailed traction system can be described by dividing it into three sections such as three phase supply system, traction substation and locomotive system which is described as follows:

A. Three phase supply system

The generated power from generating station is transmitted to the grid substation via three phase distribution system. The three phase distribution system is at voltage level of 220 KV or 132 KV from normal. But the available three phase voltage has to be step down to 25 kv. The step down transformer is connected to any of two phases of normal three phase lines to step down the 220/132 Kv to 25kv. For balancing of the load on the power system, the OHE contact wires are supplied from A-B, B-C, C-A at regular intervals (about 40-60Km) at traction substation To avoid the short circuit between the phase's neutral section or dead zone is provided between two consecutive sections which is powered from two different set of phases.

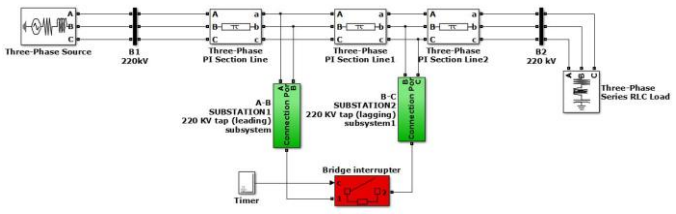


Fig. 1Typical Feeding Arrangement of 25 KV Traction System of Indian Railway

B.Traction substation

At traction substation 220/132 kV is step down to 25 kV through single phase transformer.The traction substation not only consists of transformer but also various protective devices. It includes lightning arrestor, circuit breaker, transformer protection etc. This 25 kv is then supplied to the feeder then to the OHE line.

Fig.2.Arrangement of Traction Substation

C. Locomotive Subsystem

The AC or DC drives are used for loco.The traction motors used are DC series motor, three phase induction motor. But new locos are come up with three phase induction motor. The induction traction motor has many advantages over dc series motor like high power at low speed, absence of commutator, VVVF control and regenerative breaking system. In today's scenario WAP7 and WAG9 are the passenger and goods loco which are mostly used. It consists of transformer, DC link in between line converter and motor converter. The specification given below is from WAP7 manual.

Table 1.Specificatio of WAP7 AC locomotive

	specification
Traction transformer	25kV – 1269V
DC link	2800V
Traction motor	3 phase squirrel cage induction motor1283/2484 rpm
Power output	Max 5100 kW (6000 hP) (1 motor 850kW)

III. FACTS FOR TRACTION SYSTEM

A. SVC

SVC is a shunt connected device used to control to provide rapid and variable reactive

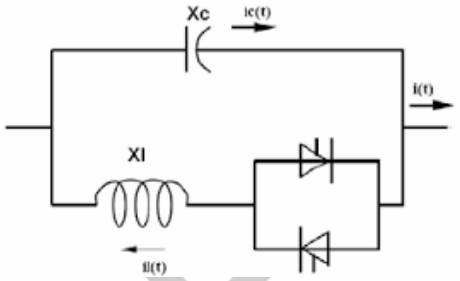


Fig.3.Block diagram of SVC

It consists of fixed capacitor i.e., var generator and a thyristor controlled reactor which acts as variable var absorbing and supplying according to the firing angle of the thyristor. SVC can inject or absorb variable amount of reactive power to the system.

B.STATCOM

It is also a shunt connected device like SVC. It consists of coupling transformer and voltage source converter (VSC).The operating principle of STACOM is based on controlling the genet=rated voltage by VSC to control the reactive power.

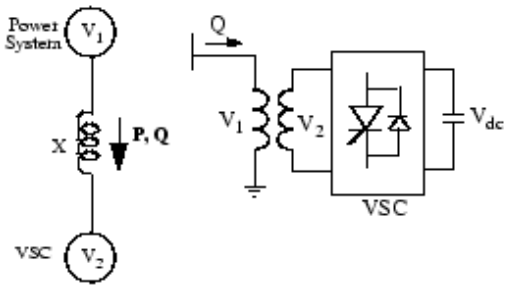


Fig.4 Block diagram of STATCOM

IV. CASE STUDY: TRACTION SUBSTATION

A case study is carried out to investigate the superiority ofSVC and STATCOM over capacitor bank. Traction substation which is at Kalmeshwar is studied. It is equipped with capacitor bank to improve the voltage profile which wascontinuously degraded.

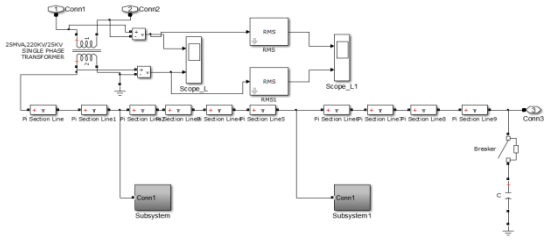


Fig.5. Traction Substation with capacitor bank

After that the capacitor bank is replaced with SVC to study the behavior of SVC in same condition.

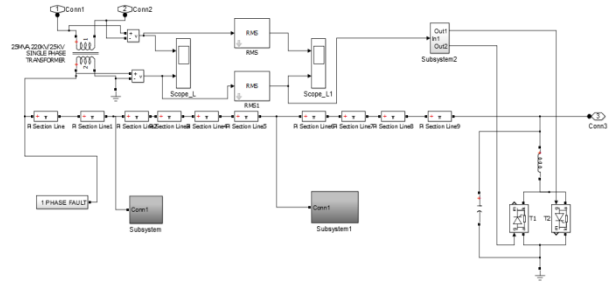


Fig.6.Traction Substation with SVC

After that the capacitor bank SVC is replaced with STATCOM to study the comparison of SVC and STATCOM .

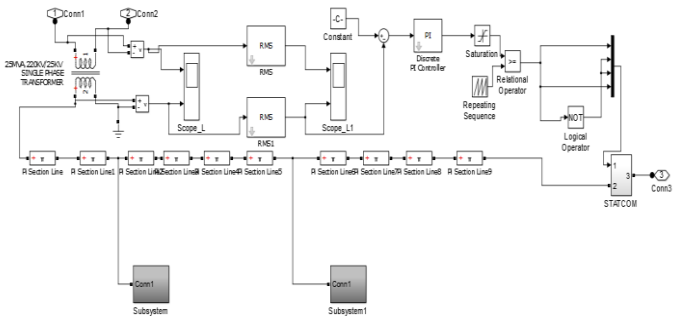


Fig.7. Traction Substation with STATCOM

The case studied:

1. When fault occur on line for short duration of two second. In this condition system is studied and effect of fault on line analyzed by simulating the model.

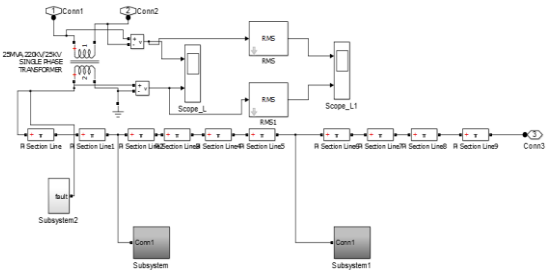
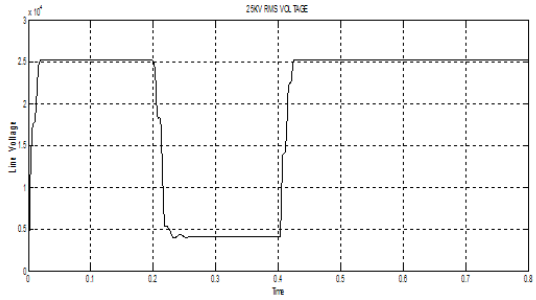


Fig.8. MATLAB model of traction substation with fault

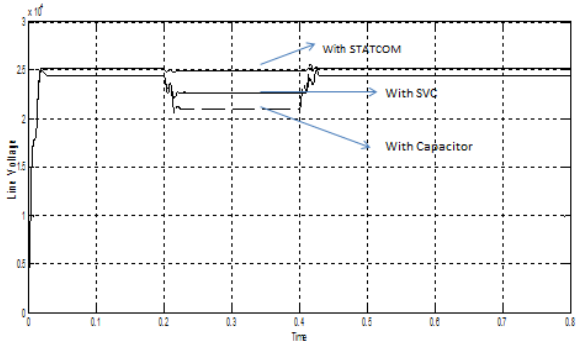
V. SIMULATION RESULT

Case 1 : fault on Line



When transient fault occur on line, there is significant drop in voltage. This drop not only harms the traction system but also to the three phase supply system. Therefore it is necessary to remove this fault and make system healthy.

Comparison of Capacitor, SVC and STATCOM during Fault:



VI. CONCLUSION

As there is large load on traction system FACTS controller enhances the power transfer capability of existing line there by reduces the cost for new transmission line installation. From above simulation result it can be concluded that during low voltage drop SVC and STATCOM provide dynamic voltage support for high power traction system and prevents it from harmful voltage sag.STATCOM, not only controls, but internally generates capacitive and inductive reactive power.STATCOM is more superior then SVC than capacitor bank.

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