Journal of Chemical and Pharmaceutical Sciences ISSN: 0974-2115

# Design and implementation of a Statcom for railway applications

**T.Iswariya*, V.Vennila**
P.G Scholar, Jeppiaar Engineering College, Chennai
***Corresponding author:Email:iswariyaishu06@gmail.com**

## ABSTRACT

In this study, with the rapid development of high speed and high power railway system in power quality such as the negative Sequence current and harmonic current can be caused more. These papers propose a HBRPC which consists of two half bridge converters connected by two capacitors in series. Compared with the conventional Rpc, the HBRPC requires a two pair of power switch legs and two capacitors. For completing the same Function of RPC, half of the power switches can be reduced in the proposed methods, it can reduce the hardware complexity and cost is lower. A double loop control is proposed for HBRPC to keep the dc-link voltage stable and achieve the dynamic tracking of the current reference signals. The voltage control has been balanced and is proposed to eliminate the two capacitor voltage errors and the normal operation of HBRPC has been maintained.

**Keywords**: HBRPC; RPC; double loop; STATCOM.

## INTRODUCTION

The voltage related power quality problems, such as sags and swells, voltage dips, harmonic distortions due to nonlinear loads and voltage unbalancing in electrical power distribution systems, have been a major concern for the voltage-sensitive loads. Load voltage regulation using VSC for different grid-connected applications has been recently attempted in. With the increased use of power-electronics devices in the consumer products, the loads are becoming voltage sensitive and nonlinear in nature. Depending upon the applications, these loads are connected to the distribution system having varying voltage and power levels. In addition, the radial feeders of the distribution system to which these loads are connected have varying length and short circuit current levels. This depends upon the location of the load, distribution system size, and its voltage and volt-ampere ratings. This leads to the wide variations in the Thevenin's equivalent feeder impedance looking from the load side. If the load is connected at the end of the long feeder and has small short-circuited current value, it is called a weak ac supply system. There has been a variety of control strategies proposed for load voltage control using the aforementioned two devices. For DSTATCOM, this includes reactive power compensation and voltage-control mode operation of DSTATCOM. For DVR, it includes open loop and closed-loop load voltage-control methods the closed-loop voltage-control mode operation of the two devices is considered best from the point of view of precise and fast control against sudden variations in the supply voltage and the load in a common control strategy has been proposed for the shunt and series compensator.

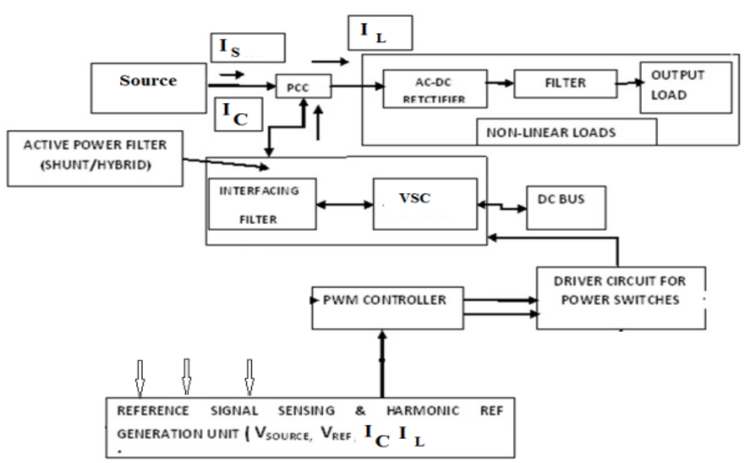


**Figure.1.Functional diagram of DSTATCOM**

**Shunt and Series Compensators based on VSC:** The single-phase equivalent of a radial distribution system. The feeder and load of the distribution and respectively. The source is considered to be the starting point of the radial feeder. The point of common coupling (PCC), represented by point P, is a particular bus of the feeder to which a nonlinear load is connected. Inductance and resistance represent the Thevenin's equivalent feeder impedance. Restoring the load bus voltage at point L under the conditions of sags and swells in the source is an essential requirement for the sensitive loads. In addition, it is required to control this voltage against distortions due to the nonlinear load.

A VSC-based generalized structure of the compensator used in a single-phase distribution system. Two types of compensators have been considered in this paper for load voltage control of the distribution system. In case the compensator is shunt type (i.e., DSTATCOM), the terminals P, L, and are joined together and is grounded. In case, the compensator is series type (i.e., DVR), the terminal is connected to L and is connected to P. The compensator consists of a VSC that is interfaced to the distribution system. The voltage represents the net dc link voltage across the VSC.

**Power Quality Issues:** Power quality is simply the interaction between the electrical power and electrical requirement. If electrical requirement are operates correctly and reliability does not damaged or stressed, and if the electrical power is of good quality. If the electrical requirement and malfunctions are unreliable or is damaged. There are various types of power quality issues and power problems each can cause the various effects. Power Quality problem can be further classified in to two types,

(A) Amplitude disturbances

(B) Wave shape disturbances

Amplitude disturbances can be further classified into two categories,

(A.1) Periodic

(A.2) Transient

Wave shape disturbances can also be classified into two categories,

(B.1) Current

(B.2) Voltage

A brief description of each can be provided and the relevant power quality indicator is defined.

**Principles and Operation of STATCOM:** STATCOM is used to control the reactive power. It provides the desired reactive power generation and absorption by means of electronic processing of the voltage and current waveforms in a voltage-source converter. A single-line STATCOM power circuit, where a VSC is connected to a utility bus through magnetic coupling, STATCOM is an adjustable voltage source behind a reactance meaning that capacitor banks and shunt reactors are does not need reactive power generation and absorption, thereby giving a STATCOM a design will be compact, low noise and magnetic impact is low. The amplitude of the 3-phase output voltage can be varied by exchange of the reactive power between the converter and the ac system. That if ,above the utility bus voltage if the amplitude of the output voltage is increased, then a current flows through the reactance from the converter to the ac system and the converter generates capacitive reactive power for the ac system. And below the utility bus voltage if the amplitude of the output voltage decreased, then the current flows from the ac system to the converter and if the convertor absorbs inductive-reactive power from the ac system. If the ac system voltage equals to the output voltage, than the reactive-power becomes zero, in which floating case is otherwise called STATCOM. It can provide the desired reactive power by exchanging the instantaneous reactive power among the phases of the ac system. The converter can generates and absorbs the reactive power can be understood by considering the relationship between the converter input and output powers. The converter switches connect the dc input circuit directly to the ac output circuit. Thus power at the ac output terminals must always be equal dc input terminals.

The reactive power of a STATCOM is produced by means of power-electronic equipment of the voltage-source-converter type. The Voltage source converter may be a 2- level or 3-level type, it can be depending on the output power and voltage. The STATCOM can be formed by using the number of VSCs it can be combined in a multi pulse connection.

Journal of Chemical and Pharmaceutical Sciences ISSN: 0974-2115

**Synchronous link between STATCOM and Grid:** Two ac sources of same frequency connected through an interconnecting link. Voltage source inverter based STATCOM is also a synchronous link with IGBT VSI and grid being ac sources.

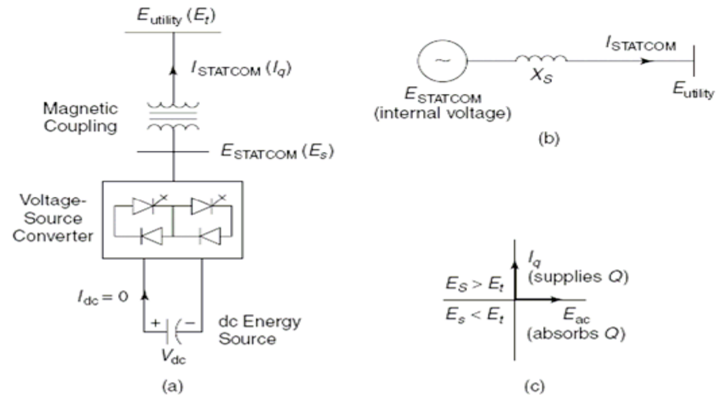


**Figure.2.Design of the STATCOM**

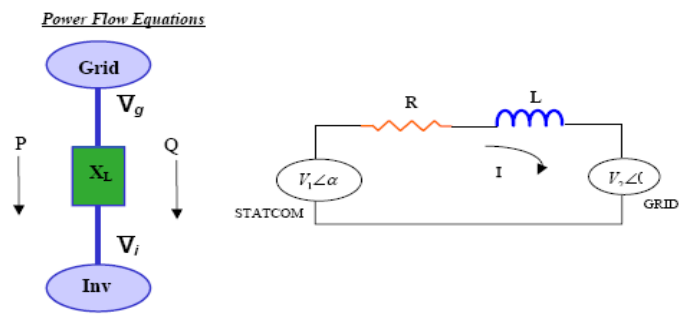


**Figure.3.Synchronous link Between STATCOM and Grid**

**Real and Reactive Power Equations:**

$$\text{Active power (P)} = \frac{V_1^2}{Z}\cos\theta - \frac{V_1V_2}{Z}\left(\cos(\alpha+\theta)\right)$$

$$\text{Reactive power(Q)} = \frac{V_1^2}{Z}\sin\theta - \frac{V_1V_2}{Z}\left(\sin(\alpha+\theta)\right)$$

In the case of STATCOM, since the impedance of the interconnecting choke is purely inductive

$$P = \frac{V_1V_2}{Z}\sin\alpha$$

Then

$$Q = \frac{V_1}{Z}[V_1 - V_2\cos\boldsymbol{\alpha}]$$

Since the impedance value of the coupling choke will be very small, it doesn't have any effect on the power transfer between STATCOM and Grid. Normally the phase difference between grid voltage and inverter voltage will be very small, since small change in δ can make big change in power flow from grid to STATCOM or vice versa. If δ is small, then sinδ can be approximated to δ. Therefore the active power transfer is directly proportional to phase angle between grid and converter, i.e. sourcing and sinking active power based on the angle between grid and converter. The cosδ is approximated to 1, since δ is very small. Therefore the reactive power is directly proportional to difference between amplitude of grid voltage and converter voltage, i.e. sourcing and sinking reactive power based on the amplitude difference of grid voltage and converter voltage. By making δ as small, the sourcing and sinking of active and reactive can be decoupled and given as a reference to converter.

**Conventional half-bridge Railway power conditioner (HBRPC):**

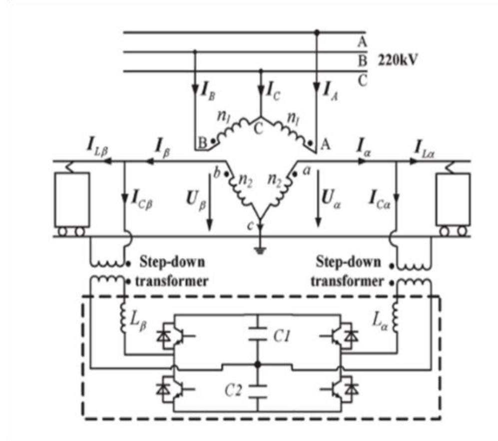


**Figure.4.Circuit diagram for HBRPC**

**Modes of operations:** When the supply current i> 0, the circuit have two operating modes
**MODE1:** Charging Mode

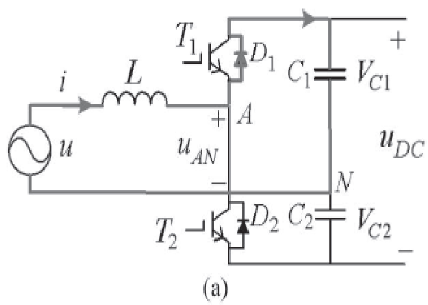


**Figure.5. Charging Mode**

D1 is conducted, and M = 1. This is called the charging mode of the dc-link capacitor.
**Mode 2:** Discharging Mode
T2 is conducted, and M = 0. This is called the discharging mode of the dc-link capacitor.

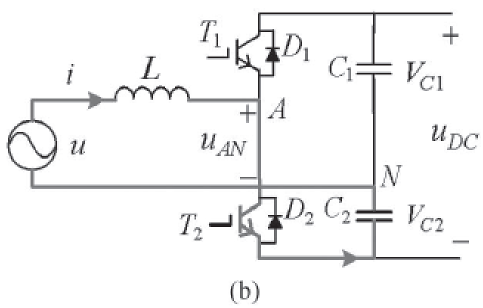


**Figure.6.Discharging Mode**

When the supply current i< 0, the circuit have two operating modes.
**Mode 3:** Discharging Mode
T1 is conducted, the capacitor C1 is discharging, and |i| starts to increase.

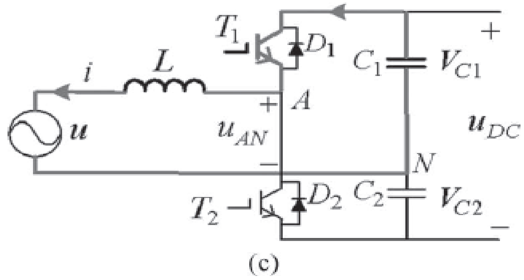


**Figure.7.Discharging Mode**

**Mode4:** Charging Mode

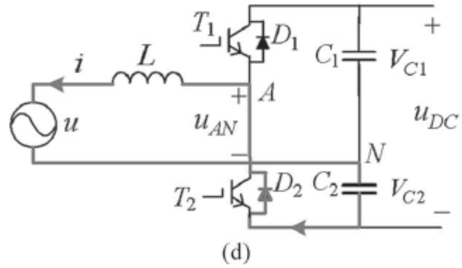


**Figure.8.Charging Mode**

D2 is conducted, the capacitor C2 is charging, and |i| starts to decrease.

**Simulation results and analysis:** MATLAB/SIMULINK is highly user interactive tool. The control algorithm discussed simulation / MATLAB software. A three phase linear and nonlinear load fed from three-phase supply to be taken as load since most of the drives and UPS using 6-pulse converters to convert AC into DC power. The 5th and 7th order harmonics are predominant harmonic present in the six pulse converter. The rating of STATCOM is finalized based on the harmonic demand of the load. The STATCOM is connected in parallel with grid and DVR is connected in series with the source and load. The load current and load voltage is sensed in all three phases and calculated the amount of harmonic demand of the load and voltage variations in load i.e. due to sag and swell. These extracted reference signals (currents and voltages) are given as a reference signal to STATCOM and DVR switches. The equivalent and opposite of the harmonic current load current to be supplied by the shunt active filter to make the grid as pure and harmonic free. Simulation system parameters and specifications are a nominal frequency 50hz, Nominal grid voltage 415 V +10% -15% and the rated Dc Bus voltage is 800-1000V, interface filter inductance per phase is 2mH, sourceimpedance0.001Ω,0.25mH,DcBuscapacitance2400uF, Switching frequency20kHz,Time constant for current controller 100us,Time constant for DC bus controller 100ms.

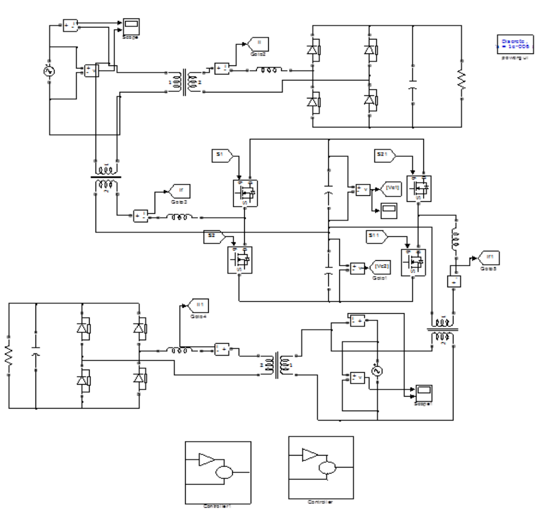

**Figure.9.Proposed half bridge railway power conditioner**

Journal of Chemical and Pharmaceutical Sciences ISSN: 0974-2115

In figure 9 the power conditioner is essentially the two back to back half bridge converters, and one converter can be dealt with rectification to absorb energy and charge the dc-link capacitors while the other can be treated with inversion to release energy and discharge the dc-link capacitors, then a dynamical energy balance can be achieved.

**Source voltage and current waveform:**

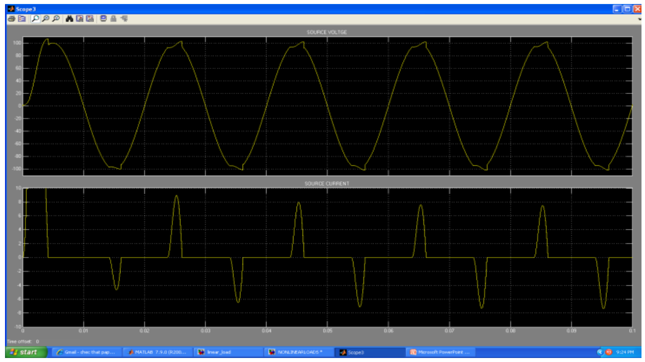

**Figure.10. Output voltage and current waveform**

The formula to find out THD in % if the measurement data is in volt (V) is,

$$THD(\%) = \left[\frac{\sqrt{V_2^2 + V_3^2 + V_4^2 + \cdots + V_n^2}}{V_1}\right] \times 100 \quad \ldots\ldots\ldots..Equation.1$$

Where, $V_n$ is the RMS value of the voltage and n is the harmonic order.

The formula to find out THD in % if the measurement data is in ampere (A) is,

$$HD(\%) = \left[\frac{\sqrt{I_2^2 + I_3^2 + I_4^2 + \cdots + I_n^2}}{I_1}\right] \times 100 \quad \ldots\ldots\ldots..Equation.2$$

Where, $I_n$ is the RMS value of the current and n is the harmonic order.

**CONCLUSION**

A real-time reference detection method for NSC and harmonic currents under V/V traction system has been presented. The hysteresis control is adopted to achieve fast tracking of the current reference and improve the dynamical compensation performance. Finally, simulation and experiment results have confirmed that the proposed system has a good effect on NSC compensation and harmonic current suppression. Even though the half-bridge converter has some drawbacks, the proposed HBRPC provides a new attempt for managing the power quality of railway system.Simulation of the module layout successfully carried out using MATLAB/ SIMULINK.

**REFERENCES**

A.Badin and I. Barbi, Unity power factor isolated three-phase rectifier with split DC-bus based on the Scott transformer," IEEE Trans. Power Electron., 23(3), 2008, 1278–1287.

J. Wang, C. Fu, and Y. Zhang, SVC control system based on instantaneous reactive power theory and fuzzy PID, IEEE Trans. Ind. Electron., 55(4), 2008, 1658–1665.

K. Fujii, K. Kunomura, K. Yoshida, and A. Suzuki, STATCOM applying flat-packaged igbts connected in series, IEEE Trans. Power Electron., 20(5), 2005, 1125–1132.

Z. Guiping, C. Jianye, and L. Xiaoyu, Compensation for the negative sequence currents of electric railway based on SVC, Proc. 3rd IEEE Conf. Ind. Electron. Appl., 2008, 1958–1963.

Z. Zhang, B. Wu, J. Kang, and L. Luo, A multi-purpose balanced transformer for railway traction applications, IEEE Trans. Power Del., 24(2), 2009, 711–718.