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P- Q Control Using Cascaded Two-Level Inverter-Based Multilevel Power Flow Controller in a Distribution Level

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Abstract:
This paper discuss with power quality improvement of system by reducing the Total harmonic distortion (THD) in the grid current. In this system static compensator (STATCOM) is used to injecting currents by regulating dc link voltages in the system which consists of two standard inverters are associated in cascaded to obtain eleven level output. In present system dc link voltages are controlled by PI controller. By this method, when the fault occurrence in the system then time response of PI controller will be slow, Overshoot problems are raised. To rectify this problem, PID and fuzzy controller are using. By using PID and fuzzy controller, dc link voltages are synchronized and a dq reference frame theory is used in this system for Statcom to recompense the current harmonics. The case study has been performed using MATLAB-Simulink software.

Keywords:
STATCOM (Static Compensator), Cascaded Multi level Inverters, Fuzzy.

I. INTRODUCTION:

Modern trends in the world many generating stations and number of load centers are interconnected through long power transmission, grid and distribution networks. Although the power generation is reliable, the standard of power isn't continuously thus reliable. Power distribution system should offer with an uninterrupted power supply to reach to customer requirement like required supply voltage and frequency.

Power Quality problem is outlined as drawback in voltage, current or resulting in frequency deviations that lead to failure of Load. Traditionally passive components like RLC elements are used on the line for injecting voltages and filtering the current harmonics in the line. But by using these components line weight & cost will increase, efficiency of the system output will decrease and leakage currents will be high. To resolve these problems flexible Ac transmission systems (FACTS) are look as interested concept. Facts have many devices like series compensators, shunt compensators and both series and shunt compensators. In series compensator only voltages can inject into the line, by shunt current can inject and voltage can control and by series-shunt compensators both voltages and current can inject into the line.

In this paper analyzing is done on one of the shunt compensator STATCOM device [1]. The STATCOM can operate as both rectifier and inverter mode. At the time of inverter mode of operation it is injecting the voltages in the line but usually the output of inverter is square wave form when it is compared to sinusoidal waveform the Total Harmonic Distortion is more. In order to get near to sinusoidal waveform a multilevel inverters are proposed. In this topology cascaded connection of H-bridge inverters based on multilevel STATCOM is proposed to improve the power quality and reducing harmonics in the system [2]. The dc link voltages of inverters are regulated by PID and fuzzy logic controller, their performance is investigated. This paper is described as follows: section 1 describes introduction, section2&3 about operation and control strategy of STATCOM, section4 describes about fuzzy

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logic controller, section5 about results and comparison, finally section6 for conclusion.

Operation of Static Synchronous Compensator (STATCOM):

STATCOM is a static synchronous condenser which can provide variable reactive power and regulation of bus voltages. The equivalent circuit of STATCOM is shown in below figure1 the magnitude of variable source voltage is controlled by adjusting field current. The phase angle difference between source voltage and bus voltage is assumed to be zero [3]. By varying supply voltage magnitude E, reactive power supplied by the static condenser is varied.Whenever supply voltage is equal to bus voltage then output of reactive power is zero. When the supply voltage magnitude is greater than bus voltage then STATCOM is operated as capacitive mode. When it is less than the bus voltage then it is acts as Inductive mode of operation.

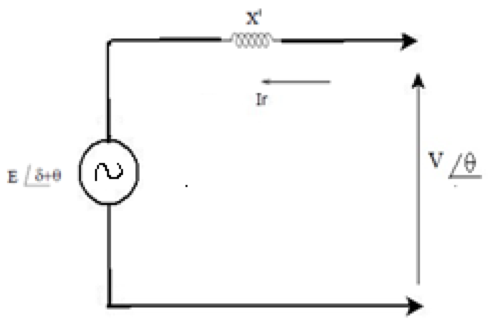


Fig1: equivalent circuit of STATCOM

STATCOM also provides higher reactive power sustain at low AC voltages than SVC, because the reactive power of STATCOM decreases linearly with the AC voltage. STATCOM would play major role in power system stability, reactive power compensation, loss deduction, voltage regulation, voltage balancing and power quality and stability enhancement.

Cascaded Two-Level Inverter-Based Multilevel STATCOM

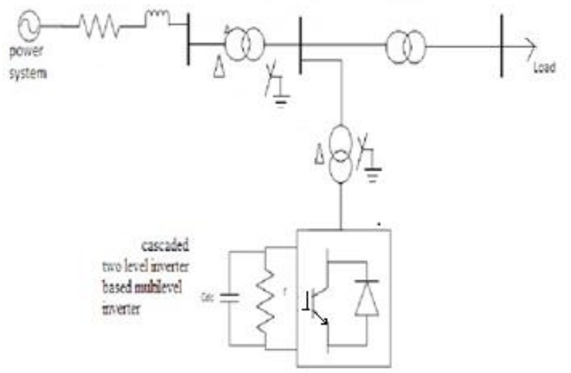
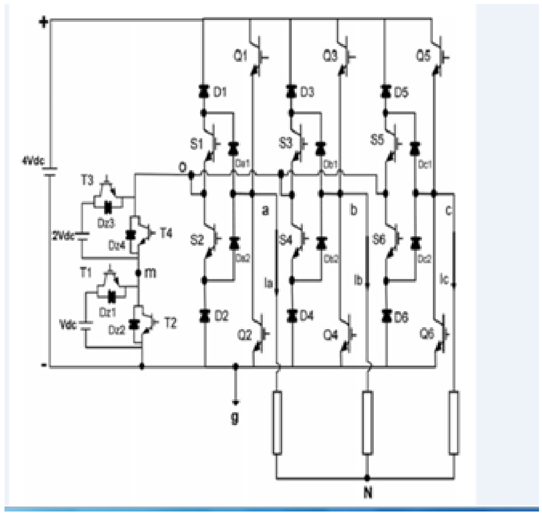


Fig2: power system STATCOM model

The cascaded two level inverter with multi level STATCOM as shown figure [4]. The two standard inverters are connected, one on low voltage side of transformer and another on high voltage side connected to grid.



v_a,v_b.v_c are source side voltages referred to Low voltage side of transformer, L_a,L_b,L_c are leakage inductance of transformer,e_{a1},e_{a2},e_{a3} and e_{b1},e_{b2},e_{b3} are the load side voltages of inverter 1 and inverter2[5].

Proposed Control Strategy of STATCOM:

The control diagram m as shown in below figure3: consists of phase locked loop (PLL) the usage of PLL is to measure the exact angle between the each phase even though fault occurs in the line and also the control diagram consists of current controller, voltage controller, and Dc link voltage regulator. The source voltage is connected to PLL to generate the synchronous reference frame (sinwt,coswt) for abc to dq transformation. The load side current is given to the abc-dq transformation block converts three phase stationary reference frame to two phase rotational reference frame after the transformation is given to low pas filter to remove the small ripples. The ripple free id ref and iq ref is given to the gain block for amplifying purpose. The Vdc1 is compared with Vdc2 by an error block from this it is given to the Pid + fuzzy controller for voltage regulation purpose. If the controller is not present the capacitor voltages will be unequal this results to produce the negative currents. The output of controller generates a reference wave form this reference waveform is compared with the triangular waveforms to get five level operation of a statcom.

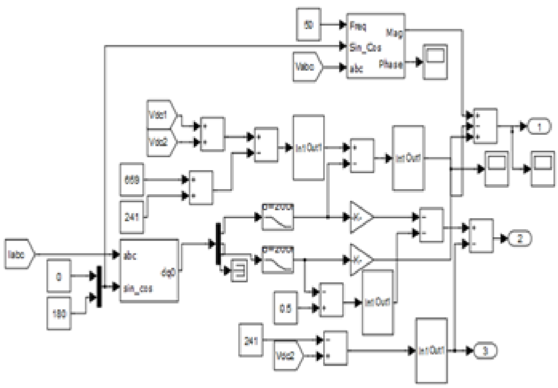


Fig4: Control system of STATCOM

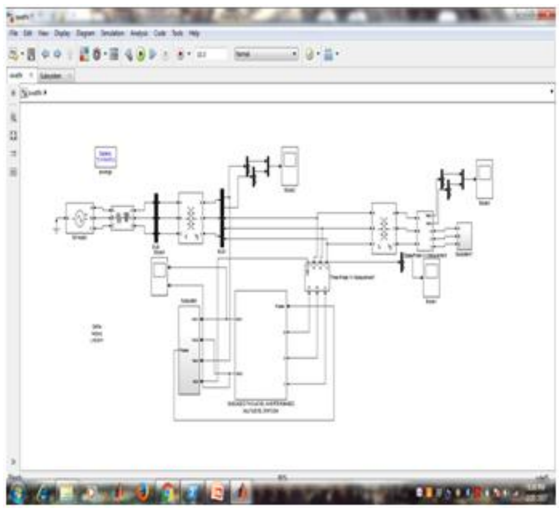
Multilevel Inverter:

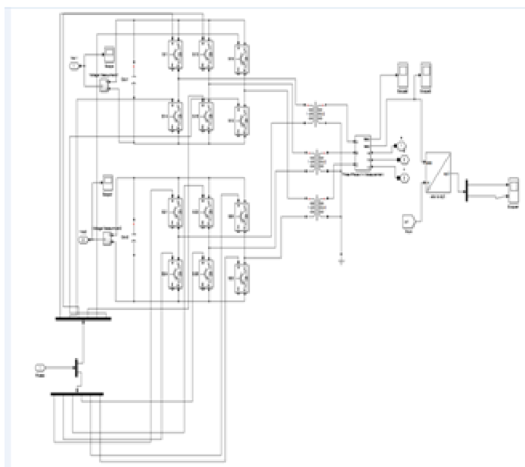
Now a day's many industrial applications have begun to require high power. Some appliances in the industries however require medium or low power for their operation. Using a high power source for all industrial loads may prove beneficial to some motors requiring high power, while it may damage the other loads. Some medium voltage motor drives and utility applications require medium voltage. The multi level inverter has been introduced since 1975 as alternative in high power and medium voltage situations.

The Multi level inverter is like an inverter and it is used for industrial applications as alternative in high power and medium voltage situations.

VI. SIMULATION RESULTS:

The simulation is carried out with three phase four wire system with non-linear load. Here the diode rectifier is used as non-linear load. The comparisons are done for PI controller and FUZZY controller. The THD value is high because of pi controller in this circuit.





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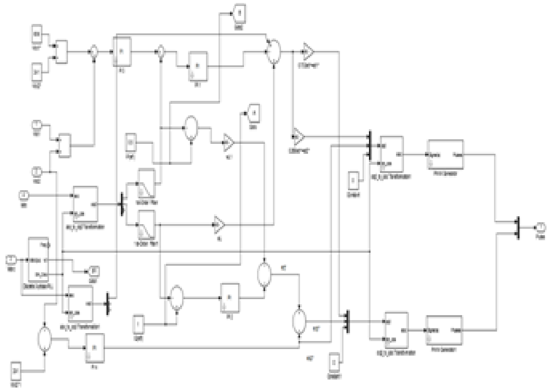
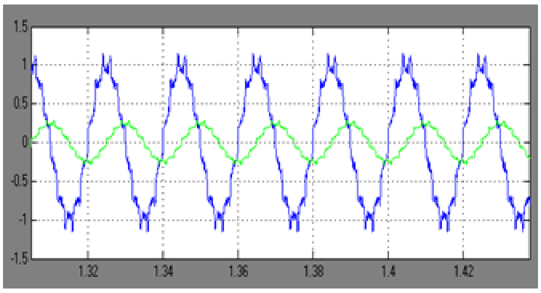
Controller action:

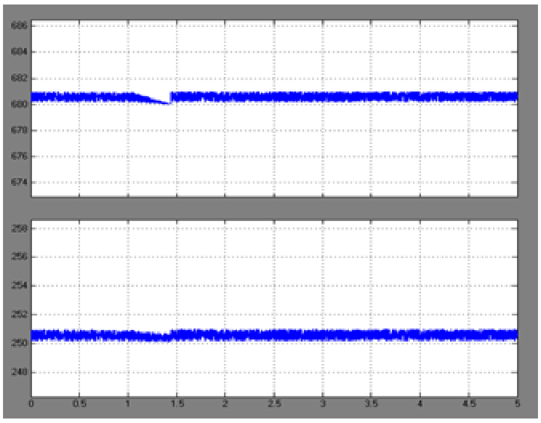


OUTPUTS WAVEFORMS:

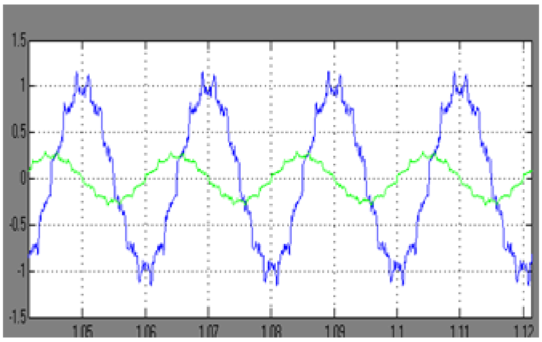
a) Lagging condition:



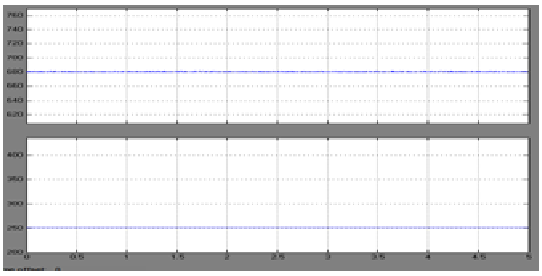
DC link voltages:



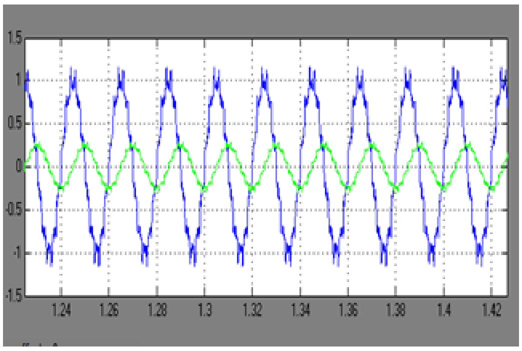
b) Leading condition:



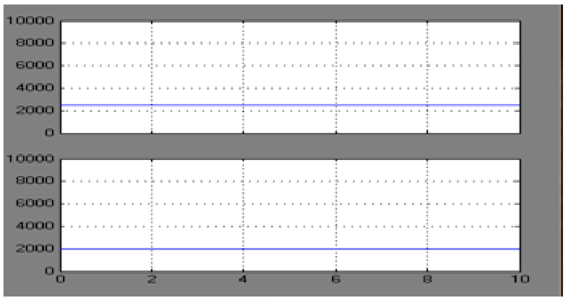
Dc link voltages



Voltages and currents:



Controlled Active and reactive powers to load



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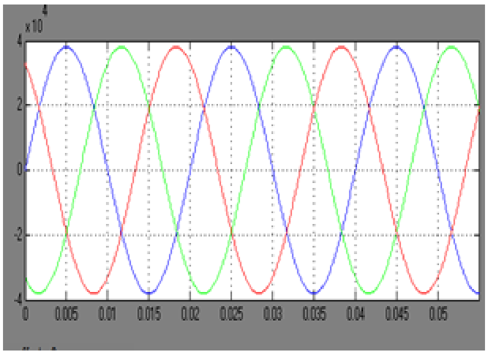
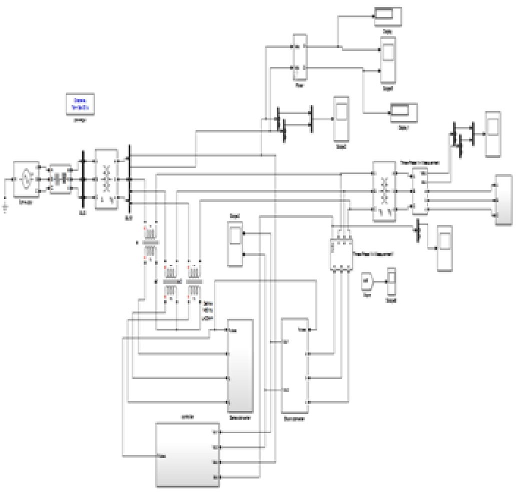
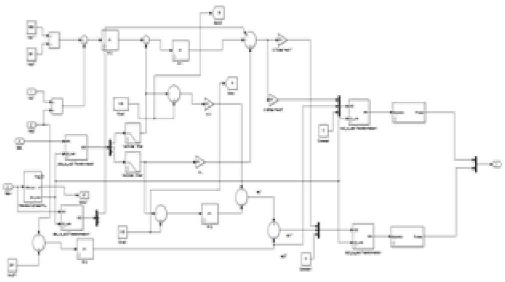
Source voltage:

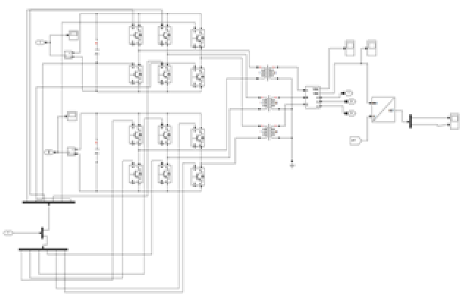


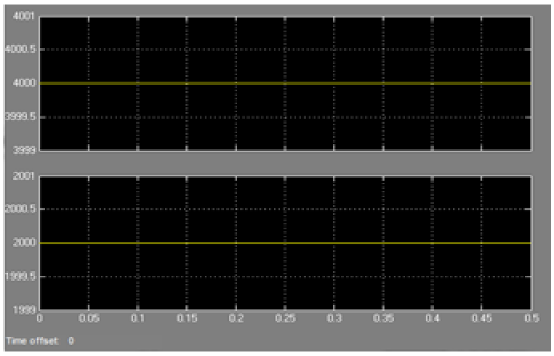
EXTENSION SIMULINK

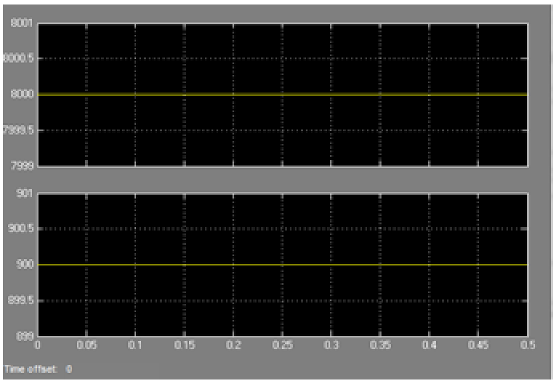


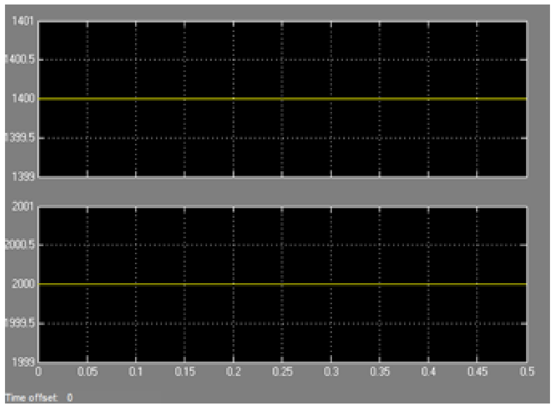
SUSYSTEM CIRCUITS











CONCLUSION:

DC -link voltage balance is one of the major issues in cascaded inverter-based STATCOMs. In this paper, a simple var compensating scheme is proposed for a cascaded two-level inverter-based multilevel inverter. The scheme ensures regulation of dc-link voltages of inverters at asymmetrical levels and reactive power compensation. The performance of the scheme is validated by simulation and experimentations under balanced and unbalanced voltage conditions.

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Further, the cause for instability when there is a change in reference current is investigated. The dynamic model is developed and transfer functions are derived. System behavior is analyzed for various operating conditions. From the analysis, it is inferred that the system is a non minimum phase type, that is, poles of the transfer function always lie on the left half of the s-plane. However, zeros shift to the right half of the s-plane for certain operating conditions. For such a system, oscillatory instability for high controller gains exists.

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