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Power Quality Improvement through 84 Pulse Voltage Source Converter

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ABSTRACT
Flexible Alternating Current Transmission System (FACTS) devices is a system composed of static equipment used for the AC transmission of electrical energy. The device have been proposed for dynamic control voltage, impedance, and phase angle in high voltage AC lines. It refers to a family of power electronics-based devices able to enhance AC system controllability and stability and to increase power transfer capability. The application of this technology has opened new and better opportunities for an appropriate transmission and distribution control. The injection principle used in this proposal to be considered as a reasonable solution to the sinusoidal synthetization due to the reduced number of required switches. The injection transformer is one of the most important elements in this configuration, which has a wide range of turns ratio variation. The conventional PI controllers applied to maintain the output voltage of the Stat Com around nominal conditions exhibit poor performance under severe disturbances, where the error signal jumps with big steps in magnitude. The strategy followed in this research, employs the error and errors variation to break down the control action into smaller sections that can be selected according to simple rules. Simulation results evidence the proposals suitability validating each part of the device.

Key words: Power Quality, Pulse Voltage, Transmission System

INTRODUCTION

Now Strong efforts have been made in order to reach minimum harmonic distortion in the VSCs output voltage. A strategy to build an 84-pulse equivalent output voltage waveform, which employs a twelve-pulse along with an eight-level reinjection converter is presented in. however, the cost for this is 26 extra switch devices and 7 DC voltage sources (capacitors). This array makes the large chain of capacitors. Multi-level Voltage Reinjection (MLVR) is another option to generate 84 pulses, which requires the use of 5 additional DC voltage sources and 12 switches, as opposed to the conventional 12-pulse converter. It may be easily utilized to attain more levels on the reinjection schemes. The reinjection principle used, makes this proposal to be considered as an affordable solution to the sinusoidal synthetization due to the reduced number of switches needed. The reinjection transformer is one of the most important elements in this configuration, and it can have a wide turn ratios variation without leading out the special application standards.

This project describes 84-pulse voltage-source converter (VSC), assembled by combining a 12- pulse VSC in conjunction with an asymmetric single-phase seven-level converter. The phase- locked-loop strategy used ensures the determination of the systems frequency and phase angle of the fundamental positive sequence voltage of the controlled AC bus. The amount of switches and capacitors employed on the implementation, and the wide turn ratio allowed to the reinjection transformer, constitute an attractive array in terms of cost and reduced output voltage distortion and notching. The voltage magnitude in some buses may be controlled through sophisticated and versatile devices such as the Stat Com, which is the smaller and most cost effective FACTS device in many applications and is a power reactive source. By regulation of the Stat Coms output voltage magnitude, the reactive power exchange between the Stat Com and the transmission system can be controlled. This project describes how the assembling of an 84 pulse Voltage Source Converter (VSC) is obtained, and emphasizes its development through MATLAB simulations. Because of the low Total Harmonic Distortion (THD) that this VSC produces allows us to use on stringent applications or in the reactive power compensation and the power quality improvement.

The efforts performed all over the world to improve the power quality have originated several power conditioners, which by them selves contribute to power degradation due to switching of these miconductor devices, and harmonic effects generated in the converters. Thus, bug elements have been used as a filters, pursuing to have appropriate power quality with low extra noise. Because of that, this technology has not been probed in stringent applications such as hospitals or airports, which are two of the environments to consider. The series and shunt power systems compensation are used with the purpose of improving the operating Conditions. Respect to the voltage, the compensation has the purpose of handling reactive power to maintain the voltages close to their nominal values, reduce line currents, and reduce system losses. The voltage magnitude in some busses may be controlled through sophisticated and versatile devices suchas the STATCOM. This project describes a strategy to generate the84-pulseVSC, assembled with the combination of one 12-pulse converter with a seven-level converter, as well as one reinjection transformer to attain the required performance. The extra components are: 8switches, 4DC voltage sources, and 4 diodes for the seven-level converter. Are injection transformer is needed, which is able to work properly within a wide range of its turn ratio. This constitutes as attractive array in terms of costs.

OPERATION OF SEVEN LEVEL INVERTER

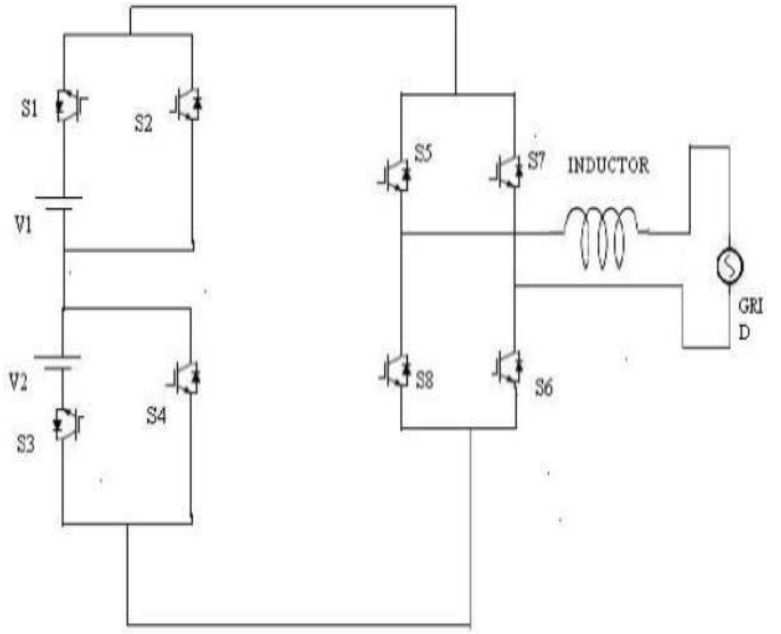


Fig. 1 Single phase seven level inverter

It is a single phase seven level inverter with less power elements for grid connection. It has 8 switches and works on fundamental frequency. Compared to 6 level, 7 level inverter reduces the switching losses, complexity, control circuit and phase requirement. In this we are using PWM technique, it has two identical triangular carrier signals with an offset equivalent to the reference amplitude of the reference signal used to generate PWM signal for two switches. Multi -level inverter has two main advantages compared with the H bridge inverter, i.e. the higher voltage capability and reduced harmonic content in the output waveform due to multiple DC level.

The switching sequence of the seven level output voltage produced in the proposed inverter explain below

- The +1.5 V dc output voltage produced by using the switches are S3, S5 and S6 are ON position in the proposed inverter.
- The +V dc output voltage produced by using switches are S3, S2 and S5 are ON position in the proposed inverter.
- The +0.5 V dc output voltage produced by using switches are S1, S4, S5 and S6 are ON positioning the proposed inverter.
- The 0 volts voltage produced by using switches are S5and S6 are ON position in the proposed inverter.
- The -0.5 V dc voltage produced by using switches areS1, S4, S7, S8 are ON position in the proposed inverter.
- The –V dc voltage produced by using switches are S2, S3, S7 and S8 are ON position in the proposed inverter.

ANGLE’S CONTROL CIRCUIT

Majorly reactive power exchange between the AC system and the compensator is controlled by varying the fundamental component magnitude of the inverter voltage, above and below the AC system level. The compensator control is achieved by small variations in the semiconductor devices switching angle, so that the fundamental component of thevoltage generated by the inverter is forced to lag or lead the AC system voltage by a few degrees. This causes active power to flow into or out of the inverter, modifying the value of the DC capacitor voltage, and consequently the magnitude of the inverter terminal voltage, and the resultant reactive power. The angles control blockdiagram is described for a PI controller. The inputs are theline-to- line voltages of the controlled AC bus prior to the coupling transformer. The reference voltage VREF is chosen as the RMS value for a pure sinusoidal three phase signal, which is √1.5 times the peak of the line voltage. This value is compared to the filtered RMS Stat Com voltage output (VRMS) multiplied by the coupling transformers turn ratio; it may contain an oscillating component. The output signal δ corresponds to the displacement angle of the generated multi pulse voltage, with respect to the controlled AC bus voltage (primary voltage of the converter transformer). The low-pass-filter (LPF) is tuned to remove the characteristic harmonic content in the multi pulse configuration; for the twelve-pulse it begins with the 11th harmonic. The PIcontroller has a limiting factor by dividing the error signal by the reference voltage VREF in order to have the δ signalwith a maximum value of -1 when the Stat Com output is equal to zero. In the following chapter special attention is paid to the fuzzy segmented PI controller.

84 PULSE STATCOM

A static synchronous compensator (STATCOM), also known as a "static synchronous condenser" ("STATCON”). It is a member of the FACTS family of devices. The reactive power at the terminals of the STATCOM depends on the amplitude of the voltage source. For example, if the terminal voltage of the VSC is higher than the AC voltage at the point of connection, the STATCOM generates reactive current; on the other hand, when the amplitude of the voltage source is lower than theAC voltage, it absorbs reactive power. The response time of a STATCOM is shorter than that of an SVC (static voltage compensator), mainly due to the fast switching times provided by the IGBTs of the voltage source converter. It generates a three-phase voltage, synchronized with the transmission voltage, from a DC energy source and it is connected to the Electrical Power System (EPS) by a coupling transformer. The regulation on the magnitude of the Stat Com s output voltage, gives rise to the reactive power exchange between the Stat Com and the transmission system. The Stat Com's basic structure consists of a transformer, a three-phase Voltage Source Converter (VSC). It generates a three- phase voltage, synchronized with the transmission voltage, from a DC energy source, and it is connected to the Electrical Power System (EPS) by a coupling transformer. The regulation on the magnitude of the Stat Com's output voltage, gives rise to the reactive power exchange between the Stat Com and the transmission system. The Stat Com's basic structure illustrated in below figure, which consists of a step- down transformer, a three-phase voltage source converter (VSC) and a DC capacitor or a battery. In thiswe are focusing on the internal structure of the proposed VSC to get a low THD output voltage. There are two modes of operation for a STATCOM, inductive mode and the capacitive mode. The STATCOM regards an inductive reactance connected at its terminal when the convertor voltage is higher then the transmission line voltage. Hence, from the systems point of view, it regards STATCOM as a capacitive reactance and the STATCOM is considered to be operating in a capacitive mode. Similarly, when the system voltage is higher than the converter voltage, the system regards an inductive reactance connected at its terminal. Hence, the STATCOM regards the system as a capacitive reactance and the STATCOM is considered to be operating in an inductive mode. This dual mode capability enables theSTATCOM to provide inductive compensation as well as capacitive compensation to a system. Inductive compensation of the STATCOM makes it unique. This inductive compensation is to provide inductive reactance when overcompensation due to capacitors banks occurs. This happens during the night, when a typical inductive load is about Page 45 20% of the full load, and the capacitor banks along the transmission line provide with excessive capacitive reactance due to the lower load. Basically the control system for a STATCOM consists of a current control and a voltage control.

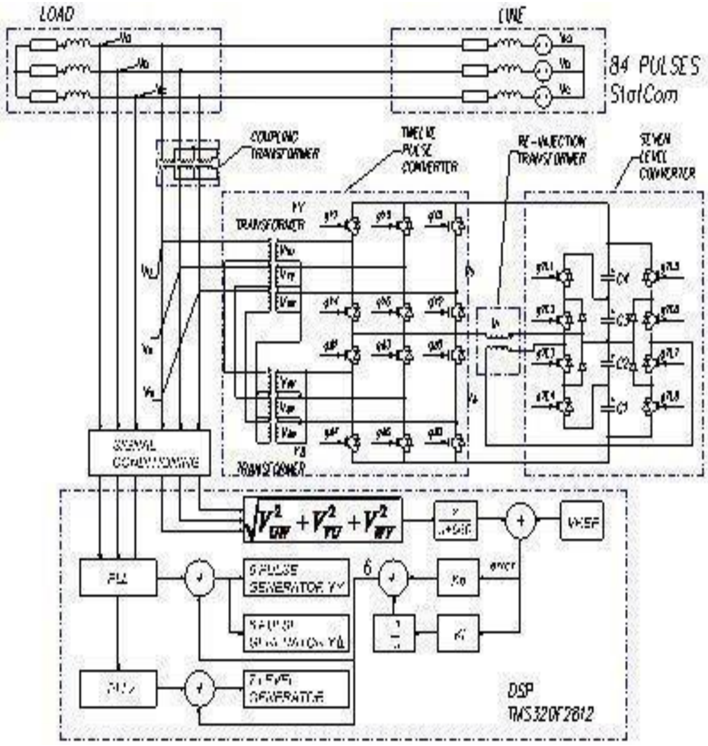


Fig. 2 Pulse statcom structure

SIMMULATION RESULTS OF PULSE CONVERTER

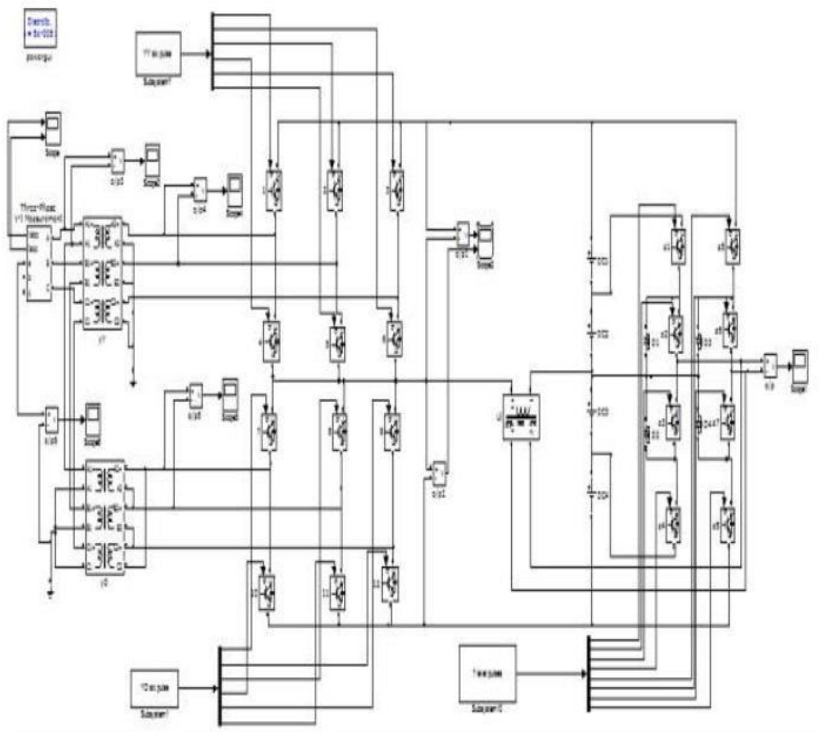


Fig. 3 Simulation diagram of 84-Pulses Converter for Open Loop System

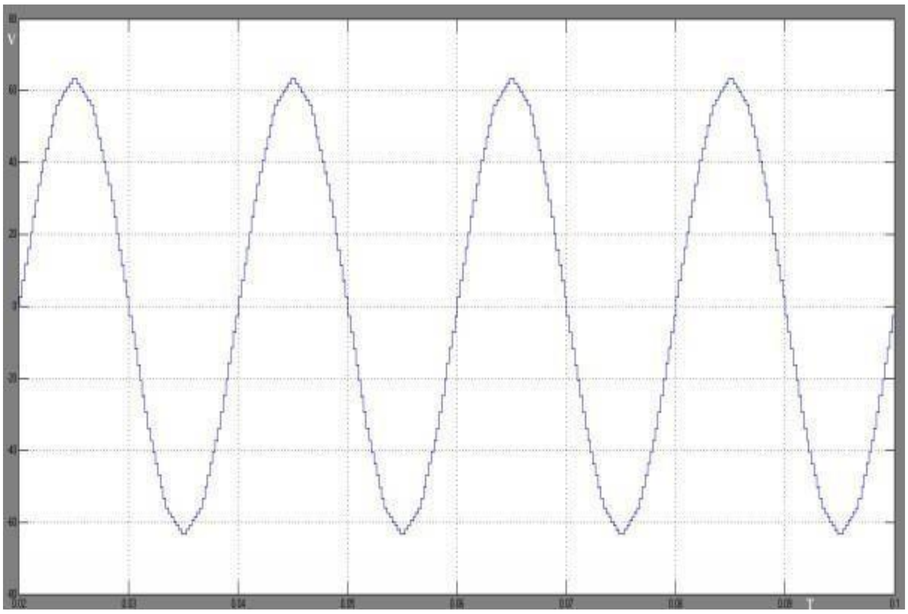


Fig. 4 Simulated Output of 84 Pulse Converter for Open Loop System

The simulated output for 84 pulse converter for open loop system is shown in fig 4. Here total 84 pulses are obtained in each cycle. The total time period for each cycle is Page 69 0.02 seconds and frequency is 50 Hz. The total rms voltage is 62V. The total simulation time is 0.1 seconds.

The simulated output of 84 pulse converter for closed loop system is shown in fig 5. Here on X axis time is taken and on Y axis voltage is taken. The total time period is 0.02 sec per cycle and frequency is 50 Hz. The total rms voltage is 62V. The total simulation time taken to run is 0.1 seconds.

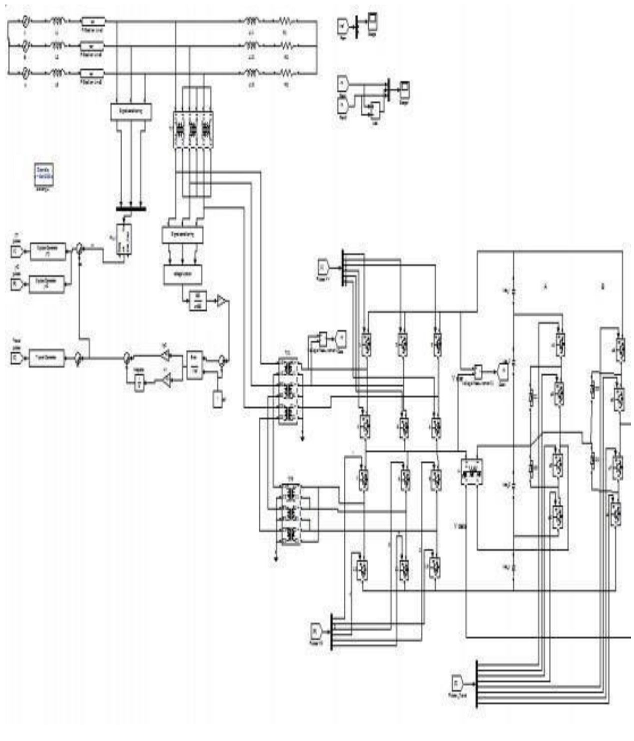
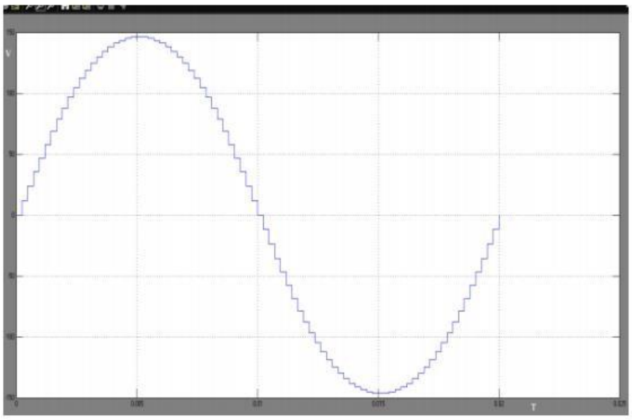


Fig. 5 84-Pulse Converter for Closed Loop System



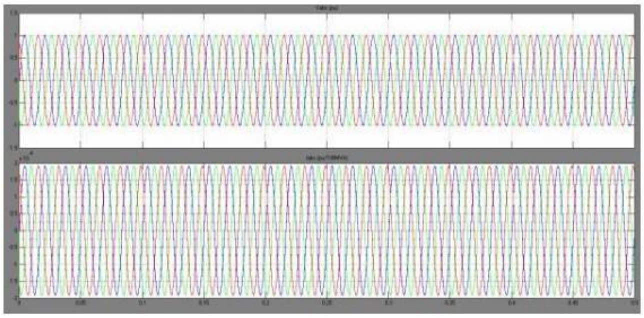


Fig. 6 Simulated Output of 84 Pulse Converter for Open Loop System

Total harmonic distortion is a ratio of sum of all harmonic components to the fundamental frequency. The THD of a signal is a measurement of the harmonic distortion. As number of pulses increases the total THD decreases, so by using 84 pulses the total THD decreases i.e, 2.358% The below figures 6 a) and b) shows the Total Harmonic Distortion of an Open Loop System and Closed Loop Systems respectively. The following table shows the THD for different pulses.

Table-1 %THD comparison

Number of Pulses	THD (%)
12	15.22
24	7.38
48	3.8
60	3.159
84	2.358

CONCLUSSION

This This project presents a study about one of the most used VSC-based FACTS device, the Stat Com. A novel strategy to generate higher pulse number by combining one twelve pulse converter with a seven level converter, in order to attain the overall 84-pulses VSC performance with the corresponding high quality voltage wave, has been presented. The associated seven level converter is built through the combination of two three level topologies with asymmetric gate pattern inverters. The explanation of the control stages is described. Through simulations, the suitability of the proposal is demonstrated. The reinjection principle, mainly applicable with Total Harmonic Distortion reduction purpose, has been demonstrated utilizing the harmonics calculation. With this low THD, the inverter is able to be used in special applications. The proposition allows savings in the total amount of employed switches along with a small quantity of capacitors to prevent problems of system unbalance. The segmented PI controller introduced, gives a fast and appropriate response when used for connecting the Stat Com to the system on common under disturbed conditions.

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