International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue-17
December 2017

Implementation of Space Vector Pwm for the Hybrid D-Statcom

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ABSTRACT *This paper presents the comprehensive reviews for mitigation of the harmonic problems in the power supply which is caused by the non-linear characteristic based loads. The presence of harmonics leads to transformer heating, electromagnetic interference and solid state device mal-functioning. Hence keeping in view of the above concern, research has been carried out to mitigate harmonics. The most popular and best modulation method used among Pulse Width Modulation (PWM) technique is Space Vector Modulation (SVM) method as it generates low total harmonic distortion (THD). This paper also represents the current status of mitigation of power quality problems by FACTS controllers. The authors strongly believe that the literature survey will be very much useful to the researchers for finding out the relevant references in the field of power quality problems mitigated by FACTS controllers.*

Keywords: Flexible Alternating Current Transmission Systems (FACTS), Space vector pulse width modulation (SVPWM), Static Synchronous Compensator (STATCOM), Total Harmonic Distortion (THD), Voltage Source Inverter (VSI).

I. INTRODUCTION

Space Vector Modulation was first introduced by the German researchers in the mid of 1980s. This technique showed several advantages over the traditional pulse width modulation (PWM) technique. SVM technique can maximize the output voltage and also reduce the switching number at the same carrier frequency of the PWM method. A number of pulse width modulation (PWM) schemes are used to obtain variable voltage and frequency supply. The most widely used PWM schemes for three-phase voltage source inverters are carrierbased sinusoidal PWM and space vector PWM (SVPWM). There is an increasing trend of using space vector PWM (SVPWM) because of their easier digital realization and better DC bus utilization [1-3]. Moreover, it gives a higher output voltage for the same DC bus voltage, lower switching losses, and better harmonic performance in comparison to carrier based

sinusoidal pulse width modulation [4]. In SVM technique, the combined effect of three phases is considered as one vector. Firstly, three phases are converted into two phases for simplicity [5]. Here space vectors are expressed as any time varying quantities which always sum to zero and are separated by 120° are expressed as space vectors. Facts device is an effective solution for regulation of voltage and compensation of reactive power. The most common configuration of the solid state device consists of voltage source inverter and DC voltage source. By injecting a variable magnitude current at the point ofcommon coupling PCC, which is almost in quadrature with the line voltage, a Statcom can insert reactive power into a power system resulting in either unity power factor (UPF) or by voltage regulation to the required value.

II. SPACE VECTOR PULSE WIDTH MODULATION (SVPWM): BASIC SYSTEM CONFIGURATION As we know that at high power levels, low switching frequencies of solid- state devices resulting in poor power quality or decreased power quality leads to a distortions which is present in both current and voltage waveforms. This SVPWM control methodology with series Active Power Filter can be used to compensate the Power Quality distortions. This modulation technique aims to derive the pulse width for active vectors for each sampling interval which helps to contribute in Line-to-Line voltages. The performance of this technique will be superior when the optimal sequence is within the interval of sampling. SVPWM algorithm helps to manage in the reactive power flow which results in power factor to be in unity. It also have been studied both under steady- state and transient conditions at the point of common coupling, the supply current is in phase with the voltage. The Reactive power can be control by extracting the quadrature component of load current then injecting the corresponding compensating current at transmission side. It can also be controlled by developing soft computing technique which is adaptive in nature, insensitive to the variation of parameter and it does not require any mathematical model of the system to be designed and then comparing it with the methodology which leads to significant reduction in switching frequency which can be considered as an advantage in high power application with space vector modulation technique. Fig 1 shows the basic space vector with eight switching states and space vector voltage.

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p-ISSN: 2348-795X
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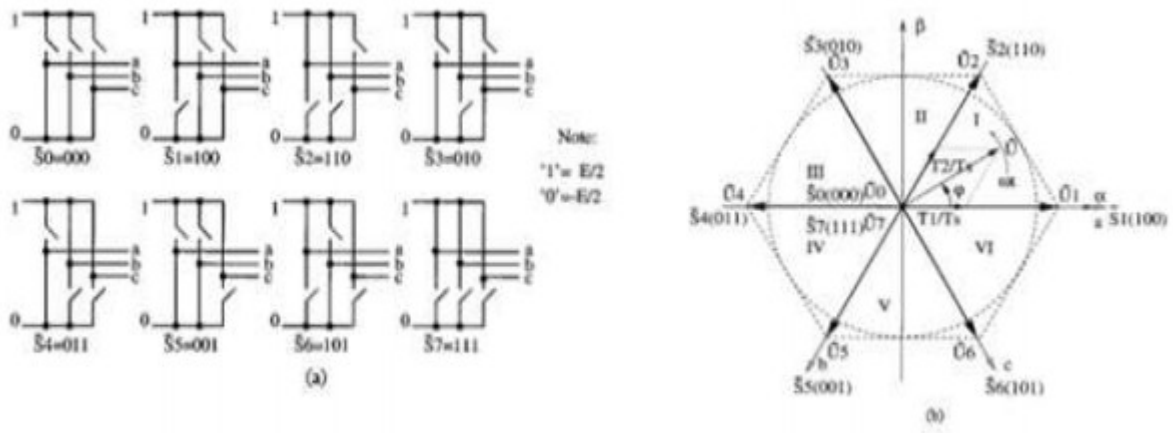

Fig. 1 Space Vectors (a) Eight Switching States (b) Voltage Vector Space

III. LITERATURE REVIEWS The literature reviews by various researchers has been presented with different modulation techniques. The objective of the literature survey starts with the use of non-linear loads with the location of harmonics emerging at high power level. The main reason of harmonic for both current and voltage are because of the transmission system used in various power electronic devices such as Cyclo-converters, chopper, rectifiers and all other nonlinear equipments.In 2007 Ahmed M. Massoud and et al proposed and described about space vector modulation scheme of two level and extended upto five level inverter with a capacitor voltage control technique. For current controller, predictive current was being used. Five-level phase shift SVM and Hybrid SVM were used as PWM Techniques. Also for a higher number of levels, this capacitor balancing technique can be used. Instead of using cycle by cycle rotation of PWM signals, cycles of rotation can be generalized for n-level inverter. In IEEE Transactions on Power Electronics, another researcher Maria Isabel and et al in 2007 described that a comparative analysis of four control strategies for shunt Active Power Filters installed in three-phase four wire system with harmonic distortion has been provided. This strategy is the most sensitive to distortion and imbalance in the voltages at the PCC. With zero sequence voltage components, this aim is not achieved in case of three phase four-wire systems. In 2007 S. Filizadeh, A. Mehrizi-sani, and P.L. Wilson stated that for the whole range of operation of modulation with different switching strategies, this model is capable of generating firing pulse including the conventional, bus-clamped and

minimum loss SVM. They also stated that loss factors of conventional and minimum-loss SVM methods are almost identical and lowest. Sinusoidal PWM method has intermediate switching losses, but its WTHD is significantly higher. Again the research has been carried out in 2009 by R. Arulmozhiyal and K. Baskaran in presented in the paper simulation results for speed control of induction motor with fuzzy logic control has been implemented. It have been proved that for same operation condition, fuzzy logic control gives better simulation results as compared to PI controller for induction motor drives. The motor speed maintained constant at varying load. Also the motor was working properly at lower speed levels. With this continuing year other researcher Jose A. Restrepo and et al also designed a new optimum space vector technique for power control and stated that switching strategy based optimum rectifier space vector voltage for DPC have shown the better alternative than the traditional table based DPC algorithm. The results have been simulated and experimented and it provides less current ripple, faster tracking response, low harmonic injection, constant switching response, and robustness. Due to parameter mismatching there is an undesirable cross coupling between active and reactive power commands in experimental implementation. The instantaneous response is limited by the control cycle period with this algorithm. In 2011 Bindeshwar Singh and et al also stated in the paper presented a comprehensive survey on mitigation of power quality problems like shortage of reactive power, poor voltage, low power factor, due to sudden change in field excitation voltage and current harmonics, sudden increase in load, sudden fault occurring in the system are solved by FACTS controller such as STATCOM and DSTATCOM. Again in 2011, other researcher J. Mohan and Dr. B.V. Manikandan described in the paper that sequence of vectors is similar for all group of rectifiers as they all have same neutral point connection at input and output point to determine the gating pulses, it is important to verify the characteristics of the semi-conductor arrangement. For the initiation of analysis of new converter topology, this semiconductor switching arrangement may be used. In this proposed SVM technique, it is important to determine the sector to be imposed from input voltage reference which reduced the number of switching commutation with number of switches and improves the total converter efficiency. In 2011 Xiangsheng Li and et al described a simplified implementation of 3-D SVPWM for three-phase four leg converters is

being presented with two DPWM methods are proposed. By both simulation and experimentalresult, an improved algorithm have been verified with following characteristics such as calculating duration times of three switching vectors and improved means of selecting needed tetrahedron. This is one of the unified control method with improved SVPWM algorithm. In this proposed algorithm, in order to obtain the on time of the upper switch, there is no need to determine the tetrahedron or to calculate durations of three vectors. In next year 2012, researcher Archana M. Kadam and et al presented the modeling of DSTATCOM. By inserting DSTATCOM in the distribution line, mitigation of voltage sag can be done. Also THD can be reduced by adding LCL passive filter to D-STATCOM which improves the power quality of the system. It has been concluded that at the transmission level, DSTATCOM is similar to a STATCOM and its control scheme should be such that in addition to complete reactive power compensation, voltage regulation and power factor correction are also checked for achieving improved power quality levels at distribution line. In 2012 J. Sompal and VenuGopalaRaoMannam developed a control methodology using a discrete PWM and SVPWM for Active Power Filter is proposed which require a few sensors and simple in sensors that is able to compensate the harmonics and unbalanced loads. The proposed algorithm is able to reduce the complexity of the control circuitry. Under non-linear condition, this harmonic spectrum shows better reduction of harmonics. SVPWM is used for simulation study of two level inverter which generates less harmonic distortion in three phase VSI. With the same year Y. Satyanarayana and Dr. A. Srujana presented that there is no need to change control parameters in fuzzy based system as the reference speed changes. But it does not work with conventional PI controller. It has been obtained from the simulation result that for the same operation condition, fuzzy based system shows better result as compared to PI controller based system mainly at the region when motor works at low speed. X. Wang and et al proposed in 2012 for a matrix converter under abnormal condition, a modified SVM strategy is used in which the instantaneous vector magnitude of output and input voltage is used to calculate the modulation index and input current phase angle. Thus, according to the distortion of the input voltage in time, duty cycles of switch states can be adjusted. For both normal and abnormal input voltage conditions, this strategy is used for the output voltages with reference. With increasing year space vector

technique advanced in reducing harmonics and various researcher Anjana Manuel and Jebin Francis presented a project in 2013 for SVPWM inverter- fed AC motor drives, reviewed Direct Torque Control strategies can be used. A viable field oriented control can be represented by this DTC strategy which is being divided into two group that operates with Space vector Modulators: hysteresis- based switching table DTC and constant switching frequency schemes. Later scheme improve the drive performance with reduced torque and flux pulsations. J. Wang and et al presented in 2013 that SVM can be separately applied to rectification and inversion stages of the model, before all the switching states and duty ratios are converted and combined to produce the final gating signals. This paper also proposes two switching patterns for the output pulses, and has demonstrated the better waveform quality brought it. In 2013 KedarPatil stated that different voltage control techniques produced a range of harmonics on output voltage. Also from the simulation results, it has been observed that in reducing the Lower order harmonics, Sine PWM is more effective as compared to hysteresis band PWM with low switching losses. By comparison ofdifferent PWM techniques, power quality has been improved by giving higher output voltage, good linearity in voltage and low harmonics contents in output voltage especially in low frequency region. A comparative study is presented by K. Mounika and B. KiranBabu in 2013 compared both the technique and found that there is a tremendous decrease in lower order harmonics (LOH) in SVPWM. And also there is better utilization of DC bus as compared with SPWM by about 15%. SVPWM proved to be a better technique as compared to SPWM. The analysis of space vector PWM has been carried out by P. Chaturvedi and A. Dubey in 2013 developed a matlab simulation and examined the performance of three phase squirrel cage induction motor which is fed by a three phase IGBT inverter connected to a DC Link Voltage source. By constant V/Hz block, speed control of the motor is performed. By set point of the speed, magnitude and frequency of the stator voltages is governed. In 2013 power quality problems by facts controller by Radha A. Krishna and CH. Kasi Rama Krishna Reddy stated that flexible alternating current transmission system (FACTS) is a recent development in electrical power system which gives remarkable influences on steady state variables. Control of interrelated parameters can be achieved that rule the operation of the transmission system with serial impedance, derivation impedance, the current, the voltage,

the phase angle, and the muffling of oscillations to different frequencies under nominal frequency. Power quality problem by sinusoidal pulse width modulation in 2014 by researcher DarakhshanMajid and et al stated the model of space vector PWM based neutral-point clamped rectifier model has been investigated and the result has been experimentally validated. Both at the line side and load side, the converter operation gives good power quality like sinusoidal source current at nearly unity power factor, reduced line current THD and reduced rippled DC bus voltage. This system gives tremendous applications in various applications used in industries. With the help of Facts Controller, power quality problems can be mitigated and researcher Rajeev Kumar Chauhan and J.P. Pandey in 2014 presented that mitigation techniques has been reviewed using FACTS devices for various Power Quality issues such as voltage sag or dip, very short and long interruption, voltage spike, voltage swells, etc. power system have been badly affected by this PQ issues and various problems arises like breakdown of information technology equipment or may be stoppage of all equipment, circuit breakers trip without being overloaded, automated systems stop for no apparent reason, electronic systems work in one location but not in other location. Here, proper changes in perspective of PQ have been intended which is useful and helpful in understanding the mitigation techniques using Facts Devices.

IV. CONCLUSION In today‟s modern world, nonlinear loads are frequently used in our power system which is the major source of power quality issues. This paper focuses on various research studies and literature surveys based on the space vector pulse width modulation technique used to compensate variation in voltage such as sag, swell, etc. It can also mitigate voltage dips and over-voltages, compensate reactive power of the load, unbalance in currents, and can compensate unbalance in load voltages. In future, researcher must focus on the cost-effective mitigation techniques that can be developed to simultaneously mitigate multiple power quality problems.

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