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# Modeling and Analysis of Multi Level Voltage Source Inverter Based Statcom for Improving Power Quality

\*P.UPENDRA KUMAR, \*\*J.ANAND KUMAR, \*\*K.MANO HAR, \*\*T.M.MANO HAR

\*\*CH.S.K.CHAITANYA

\*Associate.Professor, Dept.of EEE, Lendi Inst.Of Engg. & Technology, Vizianagaram, Andhra Pradesh, India

\*\*UG Students, Dept.of EEE, Lendi Inst.Of Engg. & Technology, Vizianagaram, Andhra Pradesh, India

*Abstract: The development of power electronic devices implements the use of FACTS (Flexible alternating current transmission system) devices they are widely used for improving power quality and reactive power compensation of high voltage ac transmission lines. Switching frequency is restricted to line frequency (since the reactive power is injected into existing power system). This paper focuses on reducing harmonics for better output. There are several power conditioners, which by themselves contribute to power degradation due to switching of the power semiconductor devices and harmonic effects generated in the converters. Thus filters are used to reduce the harmonics but is of low efficient way. FACTS controllers are widely used to improve not only the power quality, but also provide dynamic control of the power transfer parameters of transmission voltage, line impedance and phase angle for improving stability.. In this study, two levels and three level VSI based STATCOM are connected to the ac distribution [1] system is proposed using. MATLAB / Sim power system (SPS) toolbox and the results are presented to show the effectiveness of the proposed control strategy.*

**Key terms:** Voltage, Phase Angle, FACTS, Multilevel Converter, Power Quality, STATCOM.

## I. INTRODUCTION

As the complexity in modern power system increases to meet the required load demand which leads to effect of poor power quality. The causes for the power quality problems are generally complex and difficult to detect. Technically speaking, the ideal AC line supply by the utility system should be a pure sine wave of fundamental frequency (50/60Hz). The lack of quality power can cause loss of production, damage of equipment or appliances [2]. Thus it is important to improve the power quality. This project investigates that the power electronic based FACTS devices like STATCOM can be effectively utilized to improve the quality of power supplied to the customers [5]. The aim of the project is to implement two level and three level VSI based STATCOM to compare various results using MATLAB/Simulink. Simpower systems tool box.

## II. POWER QUALITY PROBLEM AND THEIR REMEDIES

Power electronics has two faces in power distribution, that consists of controllable industrial and domestic equipment to match the appliance with the power supply and that helps to solve the power quality problems created by the controllers [2]. Modern semiconductor switching devices are being utilized in a wide range of applications in a.c distribution networks, particularly in domestic and industrial loads. The power electronics devices offer economical and reliable solutions for better manage and to control the use of electric energy. Accordingly, the various conventional compensation schemes are available like UPFC, SVC, TCSC and STATCOM and etc [6].

## III. THEORETICAL ANALYSIS

Power quality and reliability costs the industries with large amounts due to mainly sags and short-term interruptions, distorted and unwanted voltage wave forms, too. And the main concern for the consumer's electricity was the reliability of supply. Here we define the reliability as the continuity of supply. As shown in fig.1, the problem of distribution lines is divided into two major categories. First group is power quality, second is power reliability. First group consists of harmonic distortions, impulses and swells. Second group consists of voltage sags and outages. Voltage sags is much more serious and can cause a large amount of damage. If exceeds a few cycle, motors, robots, servo drives and machine tools cannot maintain control of process.

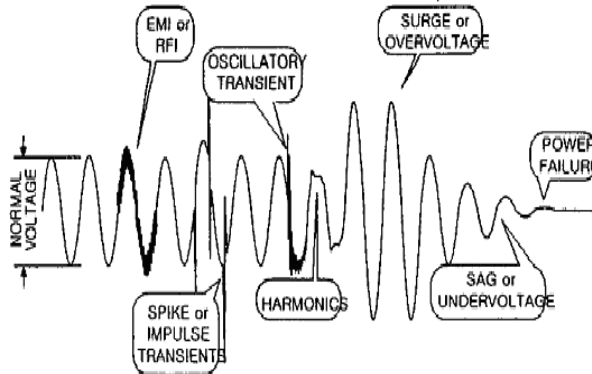


Fig 1 Power quality and reliability

#### IV. MULTI-LEVEL INVERTERS

The figure 2 shows a multi-level inverter which is an extension of single and three phase inverters. Here, four IGBT circuits are connected in three different legs and the diodes are connected in parallel to each legs in opposite direction. Also, the loads are connected between two IGBT circuits for each leg as shown in figure. Advantages of using multi-level inverters instead of single and three phase inverters are as follows

- Also, since the output contains multiple d.c levels multi-level inverters have higher capability of reducing the harmonics.
- Multi-level inverters can be used for higher voltage levels

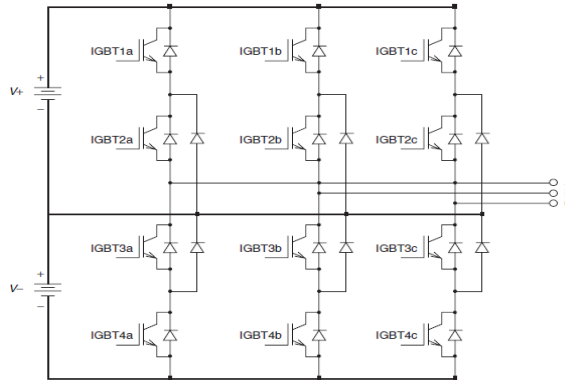


Fig 2 Multi-Level Inverter

#### V. TWO LEVEL AND THREE LEVEL VSI BASED STATCOM

As explained earlier, one of the most important aspects of a system is the reduction of harmonics that are present in the system. In case of an inverter, it is very important to remove from ac output. The harmonics present in a dc to ac inverter are very much obvious compared to the harmonics that can be present in an ac/dc converter. This is because of the output of dc to ac inverter being ac. As the output of dc to ac inverters is alternating, it is very important to produce sinusoidal output waveforms. In order to produce such sinusoidal waveforms multilevel inverters are used as the output contains multiple d.c levels and also the cost of expensive filters are reduced [6].

#### VI. TOTAL HARMONIC DISTORTION

The harmonic content in the output is measured by total harmonic distortion (or distortion factor), which is defined as the ratio of the rms value of the harmonics (above fundamental) to the rms value of the fundamental component, times 100%. [4]

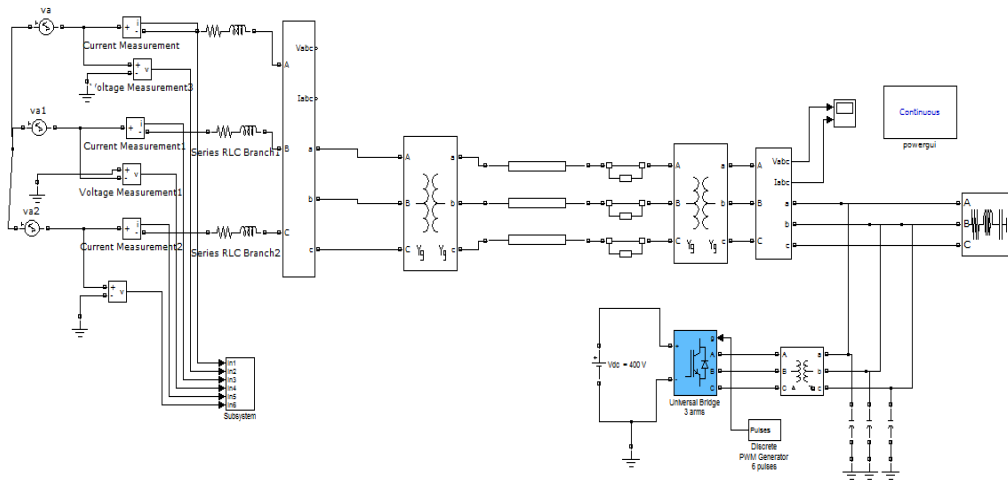
$$THD = \frac{\sqrt{\sum_{k=2}^{\infty} v_{krms}^2}}{V_{1rms}} \dots\dots\dots 6.1$$

The power factor of the system is affected with THD and hence if THD is controlled power factor of the system is controlled.

In this paper The Total Harmonic Distortion is calculated when two level and three level VSI based STATCOM are connected to A.C distribution system.

**Two level VSI based STATCOM are connected to A.C distribution system.**

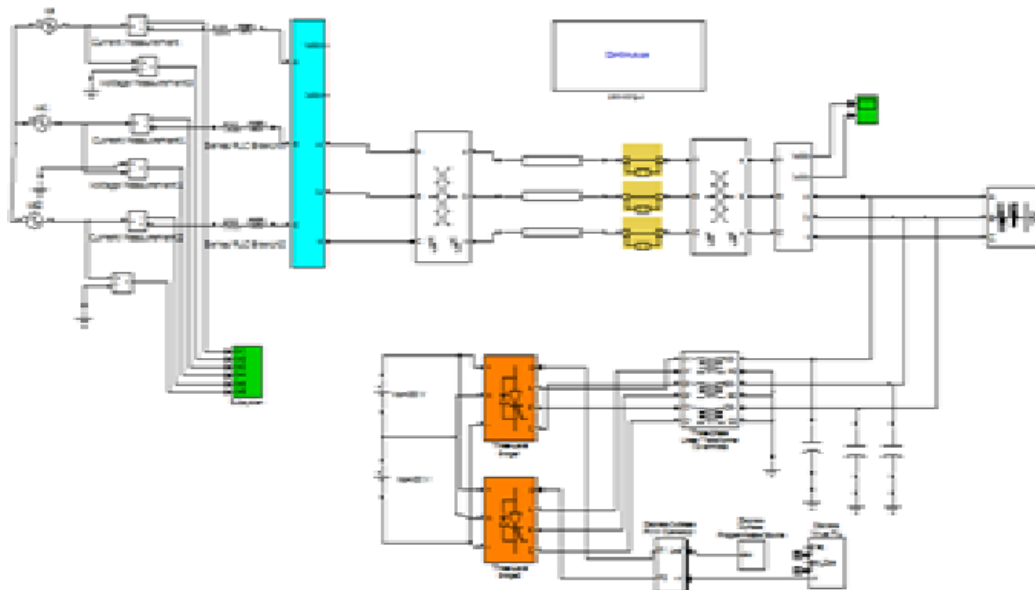
In our proposed system two level VSI based STARCOM is connected to a.c. distribution system having a load of 1KW parallel RLC branch. From the fig 3 RLC load is connected to the ac distribution system. In order to improve the power quality i.e. to reduce the total harmonic distortion two level VSI based STATCOM is connected to the ac distribution system at load side. Input to load can be provided by three phase ac voltage source followed by voltage measurement block and distribution line parameters and circuit breaker illustrated as follows



**Fig 3 Two level VSI based STATCOM connected to the AC distribution system**

**Three Level VSI Based STATCOM Connected To the Ac Distribution System**

In the proposed system three level VSI based STATCOM is connected to a.c. distribution system having a load of 1KW parallel RLC branch. The system consists of two three-phase three-level PWM voltage source inverters connected in twin configuration. The inverter is controlled in open loop. Pulses are generated by the 3-Phase PWM Generator block



Three level VSI based STATCOM

**Fig 4 Three level VSI based STATCOM connected to the AC distribution system**



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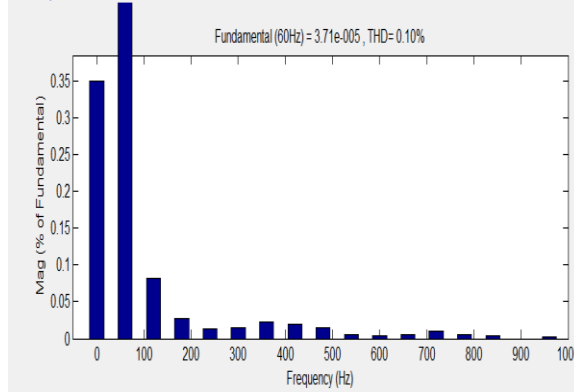
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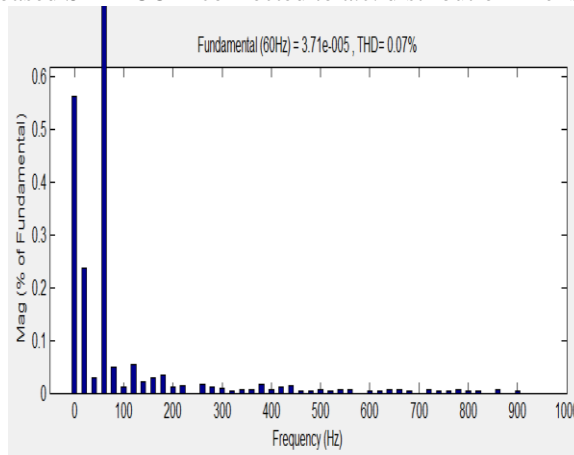
### VIII. RESULTS

The harmonic content when capacitors are connected to a.c. distribution line are obtained as follow



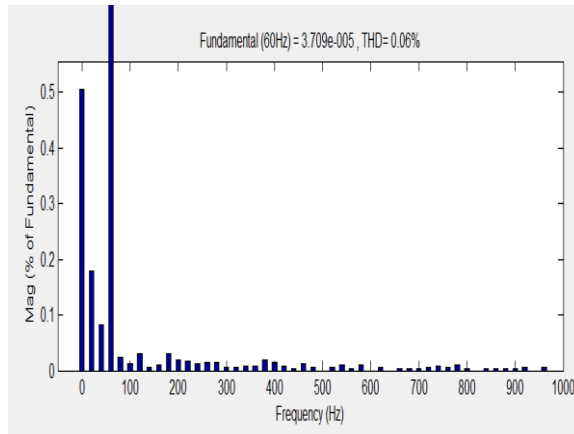
**Fig 5 THD when capacitors connected to A.C. distribution line**

From the fig 5 result the harmonic content when capacitors are connected across the line is **0.10%** for a load of 1000 watt parallel RLC load. To improve the power quality harmonic content is to be reduced. The harmonic content when two level VSI based STATCOM connected to a.c. distribution line is as shown



**Fig 6 THD when two level VSI based STATCOM connected to A.C. distribution line**

From the fig 6 the harmonic content is reduced to **0.07%**. Hence when compared to above case the harmonic content is reduced and hence power quality is improved. The harmonic content when three level VSI based STATCOM connected to a.c. distribution line is as shown. As the number of levels increases the harmonic content is to be decreased.



**Fig 7 THD when three level VSI based STATCOM connected to A.C. distribution line**



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From the fig 7 the harmonic content is reduced to **0.06%**. Hence when compared to above case the harmonic content is reduced and hence power quality is improved. Hence from the above discussions the power quality is improved when three level VSI based STATCOM connected to a.c. distribution

**COMPARISON OF ABOVE PERFORMANCES**

	% THD
when capacitors connected to A.C. distribution line	0.10
when two level VSI based STATCOM connected to A.C. distribution line	0.07
when three level VSI based STATCOM connected to A.C. distribution line	0.06

**IX. CONCLUSION**

Among all FACTS controllers, the shunt controllers are in terms of cost-effectiveness and they have a wide range of problem-solving abilities from transmission to distribution levels. For decades, it has been recognized that the transmittable power flowing through transmission lines could of good power quality. The voltage profile along the transmission line could be controlled by an appropriate amount of compensated reactive power By Employing advanced power electronic devices, switching power converters have been able to operate at higher switching frequencies and to provide a faster response. This makes the voltage source converter (VSC) an important part in the FACTS controllers. The STATCOM basically circulates power with the connected network instead of directly deriving reactive power from the energy storage Components. Hence the reactive components used in the STATCOM, can be much smaller than those in the SVC. The proposed model is feasible and will be helpful to improve the power quality. Electronic circuit described in the paper can be used to obtain the required voltage and keep the low THD. In the present paper, we have observed that application of the three-level converter provides quality compensation compared with that of the two-level converter.

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**AUTHOR BIOGRAPHY**

\*P.Upendra Kumar Completed M.Tech from JNTU. Presently working as Associate professor in electrical and electronics engineering, LENDI institute of Eng. & Tech., Andhra Pradesh, India. His areas of interests are Power systems, Power electronics and Control systems. He published many papers in various reputed national and international journals and conferences.

\*\*J.Anandkumar graduate in electrical and electronics engineering, LENDI institute of Eng. & Tech., Andhra Pradesh, India.

\*\*K.M.manohar graduate in electrical and electronics engineering, LENDI institute of Eng. & Tech., Andhra Pradesh, India.

\*\*T.M.Manohar graduate in electrical and electronics engineering, LENDI institute of Eng. & Tech., Andhra Pradesh, India.

\*\*CH.S.K.Chaitanya graduate in electrical and electronics engineering, LENDI institute of Eng. & Tech., Andhra Pradesh, India.