

SHE-PWM HYBRID MULTILEVEL INVERTER WITH DC-DC BUCK CONVERTER FOR STATCOM APPLICATIONS

CH. Hemanth, Mr. G. Madhu Sagar Babu

Sri Vasavi Engineering College, Pedatadepalli, Tadepalligudem, Andhra Pradesh, India

ABSTRACT

This paper presents a Selective Harmonic Elimination-PWM technology (SHE-PWM) for transformer less static synchronous compensator (STATCOM) system employing Hybrid multilevel inverter configuration. In this method variable DC voltage is used and the lower order harmonics are eliminated, without affecting the structure of the inverter. This method gives constant switching angle, so it reduces the number of steps required for offline calculation. The proposed method optimizes the DC-DC converter topology for high efficiency with high voltage capacity. In this paper a Buck converter is used. Current and voltage closed loop controllers are used to meet reactive power demand under varying load condition. The mat lab simulink shows the output result.

Key Words— Hybrid multilevel inverter, MSHE-PWM, STATCOM, reactive power (VAR) compensation.

1. INTRODUCTION

The reactive power compensation is an important factor in power network. The large penetration of renewable sources, which are intrinsically uncertain and highly variable by nature as an effective means of power generation has arisen new challenges to power networks. Nonlinear loads such as single phase ac tractions systems make the network to operate under undesired conditions [i.e., distorted, uncontrolled reactive power (VAR)], restricting the maximum active power transfer and significant unbalance enforcement. During these conditions the compensation is needed. Due to the advancement in FACTS devices the compensation is made simple. There are many devices are available to compensate the reactive power .In all among FACTS controllers the STATCOM system has better compensating capability than other controllers. It is a shunt compensation device. STATCOM can absorb or release reactive power instantaneously by adjusting the amplitude and phase of voltage/current on the AC side. In this work the STATCOM system is considered. In this project a STATCOM system is used along with the multilevel inverter. This increases the efficiency of compensation. It can provide reactive power compensation without the dependence on the ac system voltage. By controlling the reactive power, a STATCOM can stabilize the power system, increase the maximum active power flow and regulate the line voltages.

2. SELECTIVE HARMONIC ELIMINATION -PWM METHOD

There are many popular methods are used to reduce the harmonics in order to get an effective results. The popular methods for high switching frequency are Sinusoidal PWM and Space Vector PWM. For low switching frequency methods are space vector modulation and selective harmonic elimination. The SPWM technique has disadvantage that it cannot completely eliminate the low order harmonics. Due to this it cause loss and high filter requirement is needed. In Space Vector Modulation technique cannot be applied for unbalanced DC voltages. SHE PWM technique uses many mathematical methods to eliminate specific harmonics. The popular Selective Harmonic Elimination method is also called fundamental switching frequency based on harmonic elimination Theory.

The STATCOM output voltage waveform is described by Fourier series (1) and the optimal switching angles and the dc voltage levels are obtained by solving the following objective Function

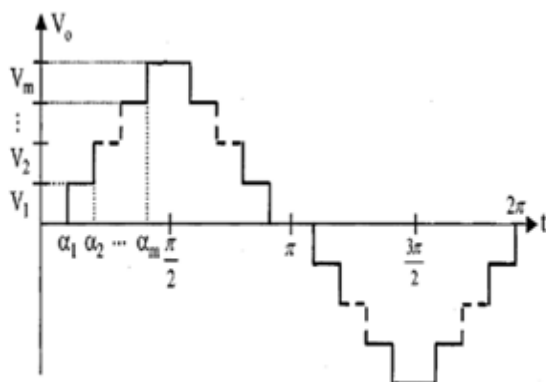
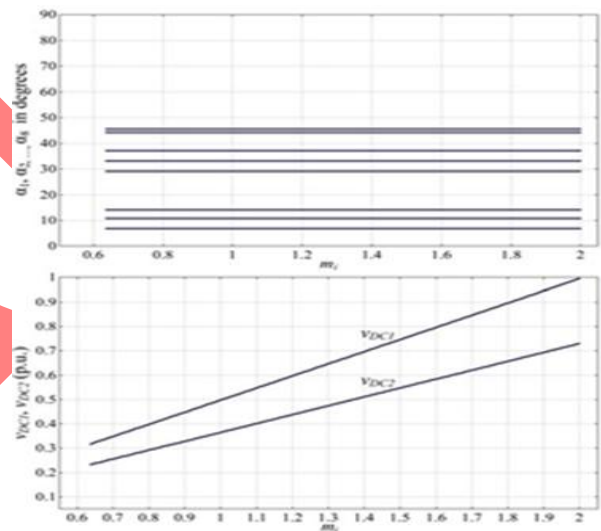


Fig. Generalized stepped voltage waveform.



$$\left(v_{DC1} \sum_{l=1}^{N_1} (-1)^{l+1} \cos(\alpha_l) + v_{DC2} \sum_{l=N_1+1}^{N_1+N_2} (-1)^l \cos(\alpha_l) \right) = \frac{m_l \times \pi}{4}$$

$$\left(v_{DC1} \sum_{l=1}^{N_1} (-1)^{l+1} \cos(5\alpha_l) + v_{DC2} \sum_{l=N_1+1}^{N_1+N_2} (-1)^l \cos(5\alpha_l) \right) = 0$$

$$\left(v_{DC1} \sum_{l=1}^{N_1} (-1)^{l+1} \cos(n\alpha_l) + v_{DC2} \sum_{l=N_1+1}^{N_1+N_2} (-1)^l \cos(n\alpha_l) \right) = 0$$

(1)

$$\alpha_1=7.43^0 \quad \alpha_2=10.92^0 \quad \alpha_3=13.91^0 \quad \alpha_4=29.41^0$$

$$\alpha_5=32.27^0 \quad \alpha_6=38.67^0 \quad \alpha_7=44.67^0 \quad \alpha_8=47.99^0$$

3. HYBRID MULTILEVEL INVERTER

Several new multi-level topologies, based on a combination of two basic topologies and classified as hybrid topologies, have recently been proposed. Hybrid multilevel topologies promise significant improvements for medium voltage and high power industrial drives. Each power module of a hybrid multi-level can be operated at distinctive DC voltage and switching frequency. These topologies minimize total harmonic distortion (THD) of output voltage without increasing the number of power devices. In other words, hybrid topologies increase convert ratings as well as level numbers of while reducing switching frequency. By adding or subtracting various power sources- such as capacitors or inductors, hybrid topologies are able to generate-different voltage levels with the same amount of components. More popular hybrid topologies are NPC-CHB and FC-CHB.

4. BLOCK DIAGRAM OF STATCOM WITH PROPOSED CONTROL SCHEME

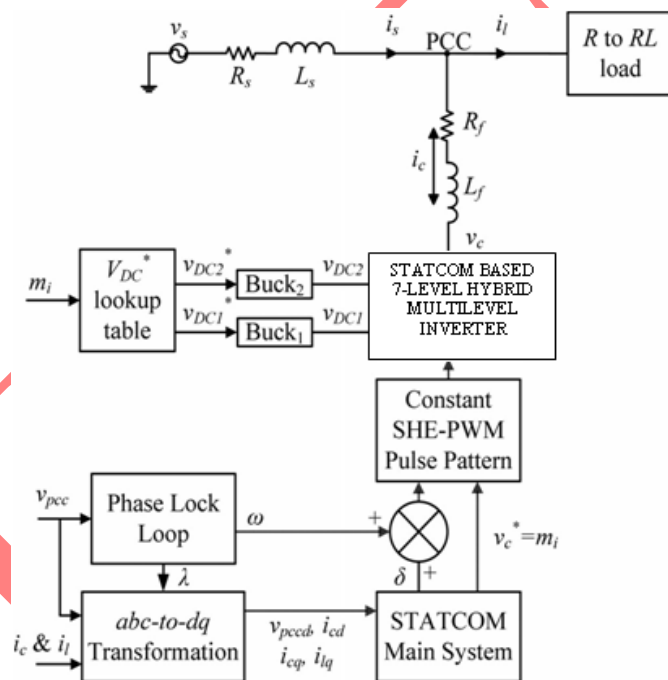
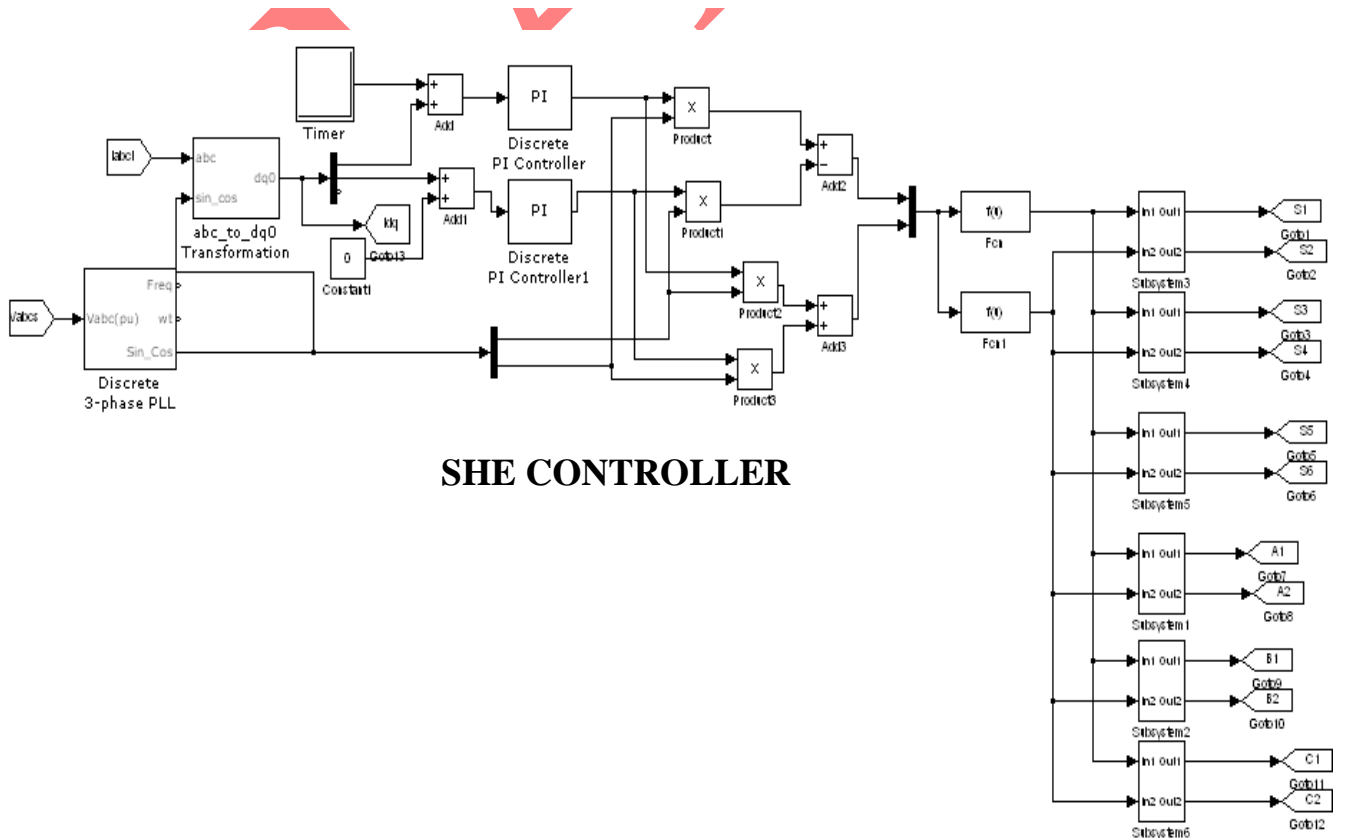
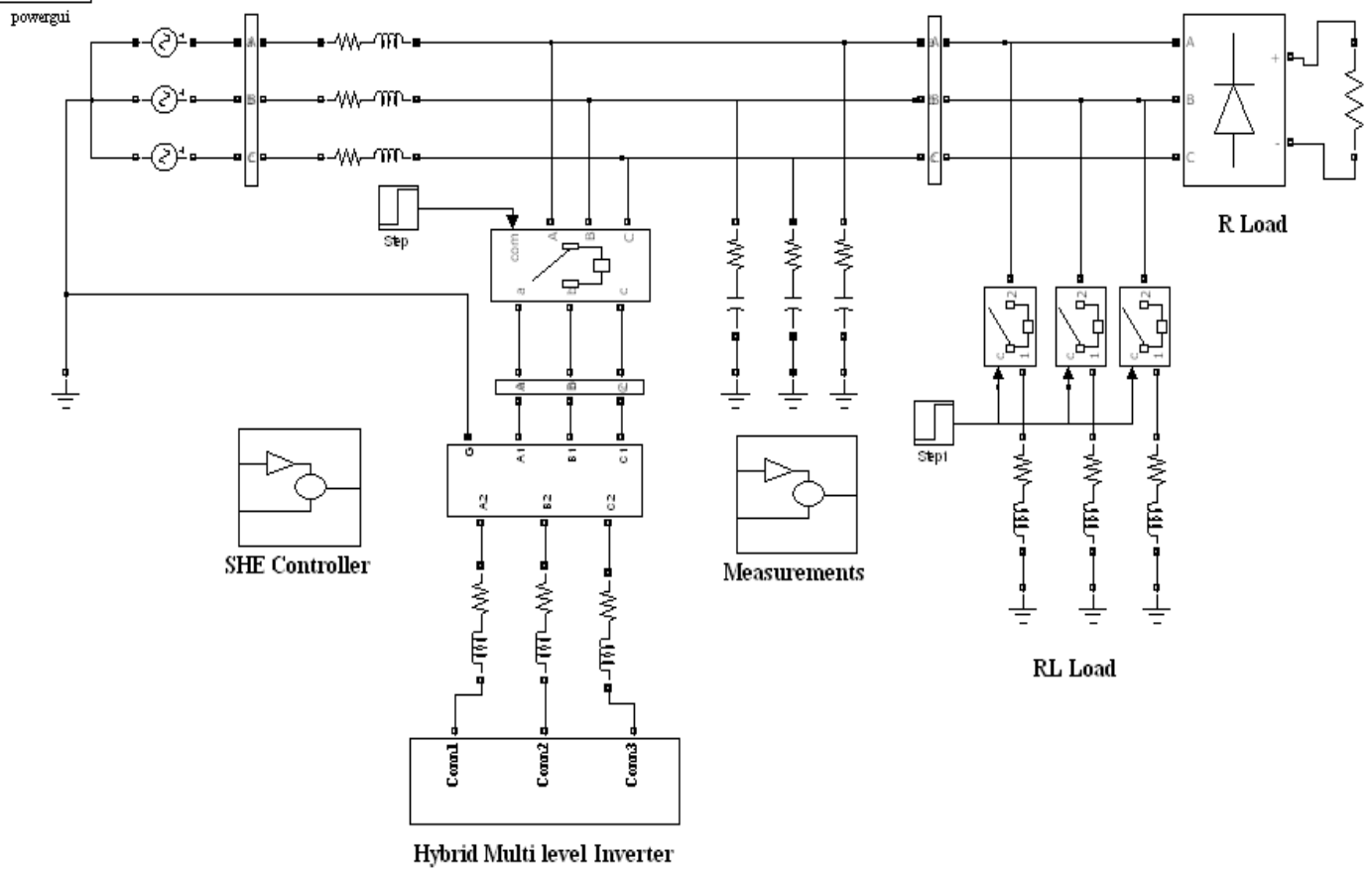


Figure shows the single-line block diagram of the STATCOM system based on the proposed seven levels SHE-PWM inverter along with the associated control schemes. The STATCOM is shunted to the power system via coupling inductor Z_f at the PCC. The proposed method relies on the availability of the variable dc-voltage levels which can be easily obtained by advanced dc-dc converters. With the rapid growth in semiconductor devices industry and advanced materials such as nano crystalline soft magnetic core that offers high saturation flux density (more than 1.2 T) and high relative permeability (over 10 000 at 100 kHz), leading to an extremely low core loss.

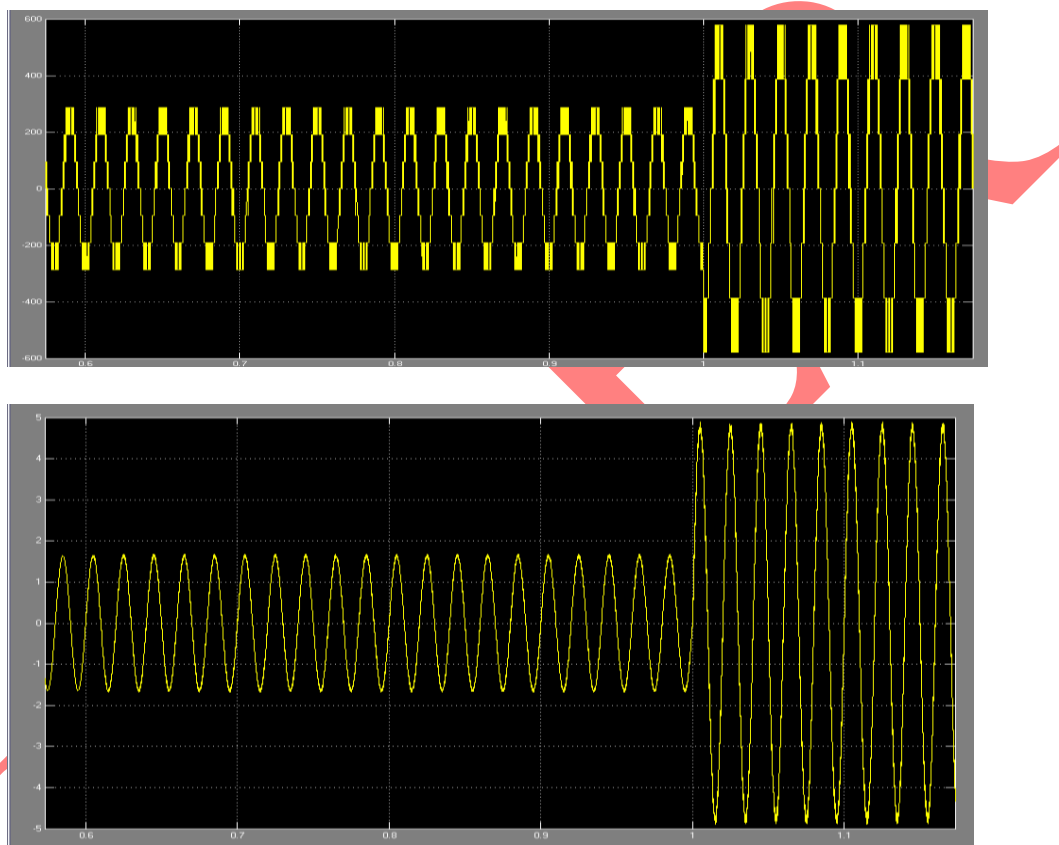
5. SIMULATION CIRCUIT

Discrete,
Ts = 5e-005 s.



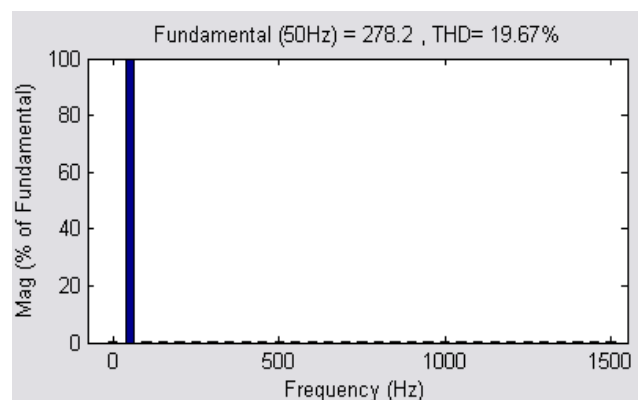
6. SIMULATION RESULTS

The implementation of the proposed line to- neutral MSHE–PWM voltage waveform produced by the STATCOM system can be observed that the intended low order non triplen harmonics (i.e., fifth, seventh, eleventh, thirteenth, seventeenth, nineteenth, twenty-third, twenty-fifth, and twenty-ninth) which were meant to be eliminated. The proposed MSHE–PWM switching method possesses eight switching angles per quarter cycle (i.e., 32 switching angles per one cycle) that make the effective switching frequency of the inverter equals to 1.6 kHz (i.e., 32×50 Hz).



STATCOM VOLTAGE AND CURRENT

FFT ANALYSIS OF STATCOM VOLTAGE USING SHE PWM TECHNIQUE



7. CONCLUSION

A Multilevel Selective Harmonic PWM Control method in STATCOM system is presented in this paper. The performance of the control method is verified through MATLAB simulink. The lower order harmonics are eliminated in this control method. Variable dc-voltage sources were obtained through a simple dc-dc converter, where the advancement and the rapid development in power semiconductor devices promised high efficiency dc-dc conversion systems. Although only buck converter was considered in this paper. This also increases the system performance.

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