

ENERGY SAVING THROUGH POWER QUALITY IMPROVEMENT

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Abstract –

In an industrial environment more number of motor load are operated through power electronic control device. As a characteristic of power electronic controller, the non linear in the load will deteriorated power quality in the system which may lead to increase in power losses. With the development of power electronic controller using multilevel switching device it is possible to improve the power quality. This paper present analysis of improvement in the power supply and power quality compensation feeding to a nonlinear load in industrial environment. Exhaustive simulation research are presented to verify the performance analysis.

Keywords -Multilevel inverter, cascaded H-bridge, THD, VSI

I. INTRODUCTION

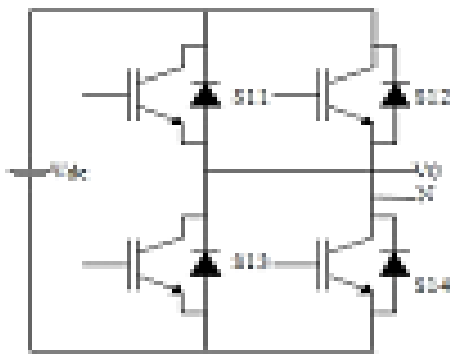


Fig. 1. Multilevel inverter topologies: three-level CHB-MLI.

The preliminary studies on multilevel inverters (MLI) have been performed using three-level inverters. In recent years, multilevel inverters have gained much attention due to their various advantages such as lower common mode voltage, lower voltage stress on power switches, lower dv/dt ratio to supply lower harmonic contents in output voltage and current. Comparing two inverter topologies at the same power ratings, MLIs also have the advantages that the harmonic components of line-to-line voltages fed to load are reduced owing to its switching frequencies. The most common MLI topologies classified into three types are neutral/diode clamped MLI (DC-MLI), flying capacitor MLI (FC-MLI), and cascaded H-Bridge MLI (CHB-MLI).

II. INVERTER TOPOLOGIES

The major multilevel inverter structures applied to industrial applications is the cascaded H-bridge inverter with separate DC sources. In addition to this, many hybrid multilevel inverters have been developed by using these basic types mentioned above. Among the three types of multilevel inverters, the cascade inverter has the least components for a given number of levels. Cascade multilevel inverters consists of a series of H-bridge cells to synthesize a desired voltage from several separate DC sources. All these properties of cascade inverters allow using various pulse width modulation (PWM) strategies to control the inverter accurately.

A Cascaded H-Bridge multilevel inverter

An alternative multilevel inverter topology with less power devices requirement compared to previously mentioned topologies is known as cascaded H-bridge multilevel inverter (CHB-MLI) and the topology is based on the series connection of H-bridges with separate DC sources. Since the output terminals of the H-bridges are connected in series, the DC sources must be isolated from each other. The resulting AC output voltage is synthesized by the addition of the voltages generated by different H-bridge cells. Each single phase H-bridge generates three voltage levels as $+V_{dc}$, 0 & $-V_{dc}$ by connecting the DC source to the AC output by different combinations of four switches S_{a1} , S_{a2} , S_{a1}^1 and S_{a2}^1 as seen in first cell of fig. 1. For the seven level CHB-MLI, three separate DC sources per phase and generates an

output voltage with seven levels. To obtain $+V_{dc}$, S_{a1} and S_{a21} switches are turned on, whereas $-V_{dc}$ level can be obtained by turning on the S_{a2} and S_{a1}^1 . The output voltage will be 0 by turning S_{a1} and S_{a2} switches or S_{a1}^1 and S_{a2} switches. If m is assumed as the number of modules connected in series, then the number of output levels n in each phase is given by equation (1). The switching states of a CHB-MLI can be determined by using equation (2)

$$n = 2m + 1 \tag{1}$$

$$sw = 3^n \tag{2}$$

The first leg phase voltage (V_{an}) is constituted by multiplying V_{a1} and V_{a2} values of series connected H-bridge cells and will generate a stepped waveform.

III. CARRIER BASED DISPOSITION PWM METHOD

Carrier based disposition PWM methods were first proposed by Carrara et al[2]. For an n -level inverter, $n-1$ carriers with the same frequency f_c and the same amplitude A_c are disposed such that the bands they occupy are contiguous. The reference waveform has maximum amplitude A_m , a frequency f_m , and its zero centered in the middle of the carrier set. The reference is continuously compared with each of the carrier signals. If the reference is greater than a carrier signal, then the IGBT corresponding to that carrier is switched on and if the reference is less than a carrier signal, then the IGBT corresponding to that carrier is switched off [3]. Previous works on PWM techniques shows that disposition technique for diode clamped and PSCPWM for cascaded inverter five rises to same harmonic profile for the same number of total switch transition. Hence these techniques can be efficiently applied for Cascaded Multilevel Inverter.

Carrier Disposition method arrange $N-1$ carrier waveform of same amplitude and frequency in continuous bands to fully occupy the linear modulation range of the inverter. The reference or modulating wave is positioned at the center of the carrier set, and continuously compared with the carriers to obtain the necessary gating pulses [3].

In multilevel inverters, the amplitude modulation index (m_a) is the ratio of reference amplitude (R_a) to carrier amplitude (C_a).

$$M.I. = R_a / (m-1)C_a \tag{3}$$

The frequency ratio (R_f) is ratio of carrier frequency (f_c) to reference frequency (f_r).

$$R_f = F_c / F_r.$$

IV. CONTROL METHOD

The main objective of this control method is to control the phase angle of the inverter output with respect to the changes in the system reactive power. The quantities obtained from above algorithms are used to calculate the system reactive power and phase angle (α). The measured reactive power is then compared with reference value to produce error signal, which is then passed through a PI controller to obtain the required phase angle α . Pulses required for the inverter are generated from SWPM block. By controlling the phase angle α of inverter output voltage, the DC capacitor voltage can be changed. Thus, the amplitude of the inverter output voltage can be controlled. Schematic representation of the control circuit as shown in fig (3).

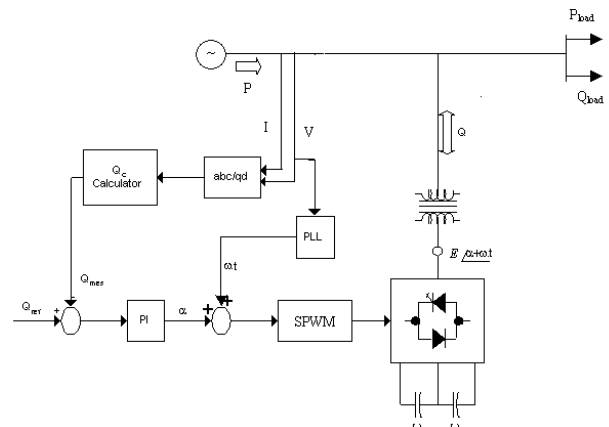


Fig 2: Schematic Representation of the Control Circuit

SIMULATION RESULTS

The following are the results for above mentioned values of the model parameters

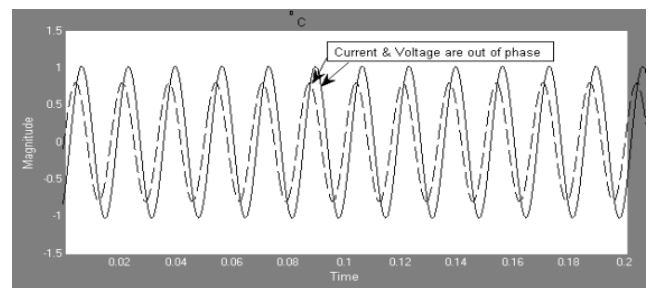


Fig 3 Phase current and voltage waveform of uncompensated system

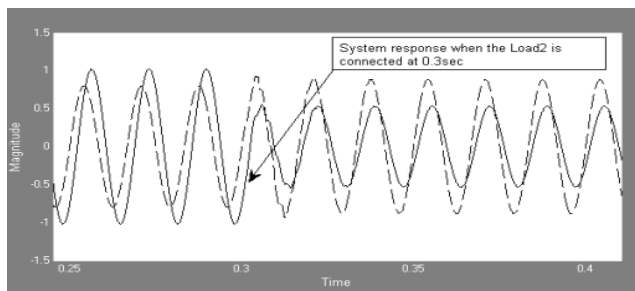


Fig 4 Phase Voltage and Current Waveform for Uncompensated System for change in the Load

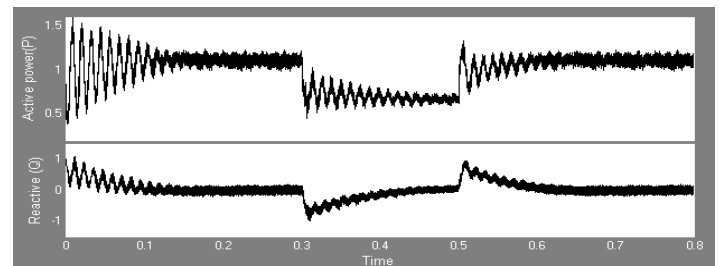


Fig 8 Active and Reactive power flow in Transmission system using multilevel inverter

V. CONCLUSION

In order to enhance the power flow capability in a transmission system a multilevel inverter is developed .The performance of the multilevel inverter is verified using conventional PI controller for different loading condition. It is found that the multilevel inverter bring the power factor to the unity thereby enhancing the power transfer capability by supplying or absorbing controllable amount of reactive power by using a simple PI controller.

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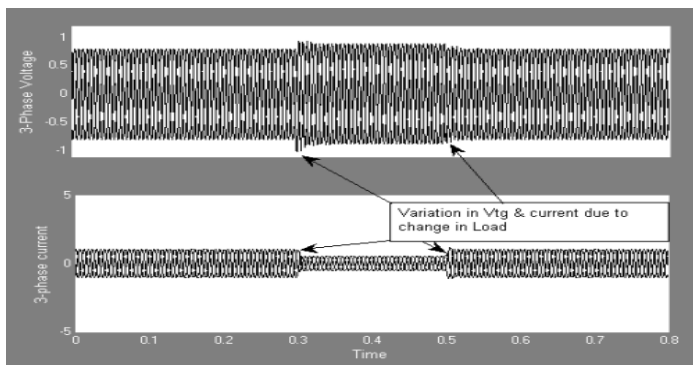


Fig 5 3 phase Voltage and Current Waveform for Uncompensated System

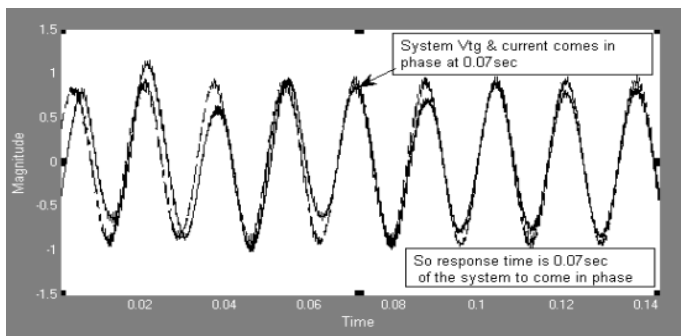


Fig 6 Phase Current and Voltage waveform using multilevel inverter

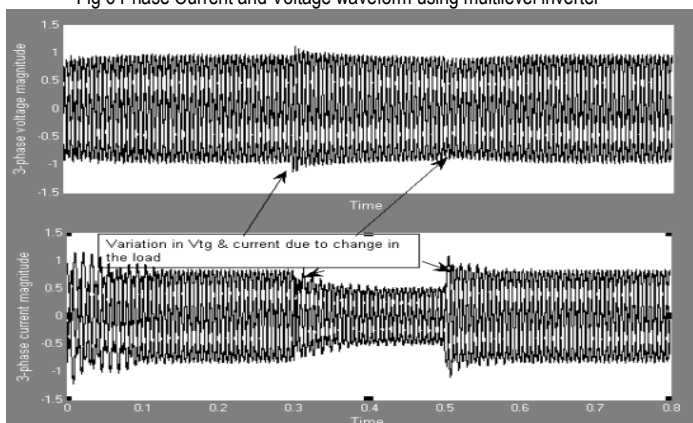


Fig 7 3-phase current and voltage waveform using multilevel inverter