

Simulation Analysis of Multi level Inverter for Solar Power Applications

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Abstract – Due to the increasing demand on the renewable energy sources, grid connected inverter systems are becoming more and more important than ever before. For grid - connected operation, the inverter should to generate a pure sinusoidal output voltage and low total harmonic distortion (THD). This paper presents This paper presents a New Multi-Level Inverter Topology based on a H-Bridge structure with four switches connected to the Dc-Link. PWM method which requires only one carrier signal we used. The switching sequence is based on balance on the capacitor voltage is also considered. An "active power factor corrector" (active PFC) is a power electronics system that changes the wave shape of current drawn by a load to improve the power factor has been discussed. The purpose is to make the load circuitry that is power factor corrected appear purely resistive (apparent power equal to real power).

Keywords - Mli, PWM, Reactive power, THD

I. INTRODUCTION

Multilevel Power Converters

Numerous industrial applications have begun to require higher power apparatus in recent years. Some medium voltage motor drives and utility applications require medium voltage and megawatt power level. For a medium voltage grid, it is troublesome to connect only one power semiconductor switch directly. As a result, a multilevel power converter structure has been introduced as an alternative in high power and medium voltage situations. A multilevel converter not only achieves high power ratings, but also enables the use of renewable energy sources. Renewable energy sources such as photovoltaic, wind, and fuel cells can be easily interfaced to a multilevel converter system for a high power application.

The concept of multilevel converters has been introduced since 1975. The term multilevel began with the three-level converter. Subsequently, several

multilevel converter topologies have been developed. However, the elementary concept of a multilevel converter to achieve higher power is to use a series of power semiconductor switches with several lower voltage dc sources to perform the power conversion by synthesizing a staircase voltage waveform. Capacitors, batteries, and renewable energy voltage sources can be used as the multiple dc voltage sources. however, the rated voltage of the power semiconductor switches depends only upon the rating of the dc voltage sources to which they are connected.

II. EXISTING SYSTEM

In existing system a SPWM approach was presented to deal with the uneven power transferring characteristics of the conventional SPWM modulation technique. This technique proved to be successful due to the irradiance profile and the use of capacitors to smooth the voltage fluctuation. The system was driven at 2 kHz because of speed constrains of the control platform, which required bulk filter components. Number of devices of the proposed multi-level inverter is lower than that of the conventional multi-level inverters

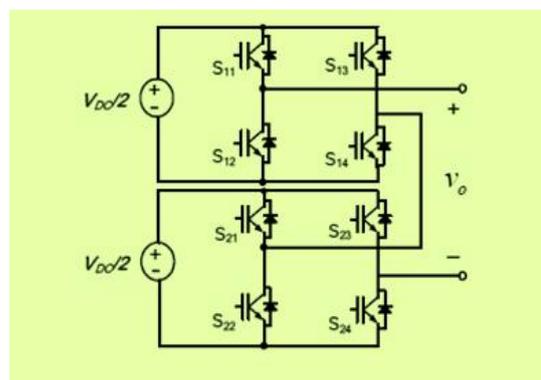


Fig.1 : Cascade topology of multi level inverter

III. PROPOSED MULTI-LEVEL INVERTER FOR ACTIVE AND REACTIVE POWER CONTROL

As shown in Fig 2, the proposed MLI is composed of two dc-link capacitors (C_1 , C_2) and four switching devices (T_{A+} , T_{A-} , T_{B+} , T_{B-}) comprising a H-bridge, and four active switches (T_{P+} , T_{P-} , T_{N+} , T_{N-}) located between dc-link and H-bridge. The voltage across the switching devices in the dc-link (T_{P+} , T_{P-} , T_{N+} , T_{N-}) is $V_{DC}/2$ and operated at a switching frequency. Whereas, voltage across the switching devices in the H-bridge (T_{A+} , T_{A-} , T_{B+} , T_{B-}) is V_{DC} and the switches (T_{A+} , T_{A-} , T_{B+} , T_{B-}) are switched at a frequency of the fundamental component of the output voltage (e.g. 50 or 60 Hz). Thus, the dc-link switches (T_{P+} , T_{P-} , T_{N+} , T_{N-}) and the H bridge switches (T_{A+} , T_{A-} , T_{B+} , T_{B-}) can be strategically selected based on the rated power of the inverter system in order to reduce system cost and increase efficiency. Table I shows the output voltage according to the switching states.

IV. OPERATING MODES AND PROPOSED PWM STRATEGY

The output voltage of the proposed MLI shown in Fig. 2 has five levels (V_{DC} , $V_{DC}/2$, 0, $-V_{DC}/2$, $-V_{DC}$) according to the switching states of the inverter. There are four operation modes depending on the instantaneous value of the reference voltage, V_{ref} and the maximum value of the carrier signal, V_c . Table II shows the possible inverter output voltage level according to the operating mode.

In case of the N-level NPC type multi-level inverter, N-1 triangular carrier signals with the same frequency and amplitude are used so that they fully occupy contiguous bands over the range $+V_{DC}$ to $-V_{DC}$. A single sinusoidal reference is compared with each carrier signal to determine the output voltage for the inverter. Three dispositions of the carrier signal are considered to generate the PWM signal.

- 1) Phase disposition (PD); where all carriers are in phase.
- 2) Alternative phase opposition disposition (APOD); where each carrier is phase shifted by 180 degree from its adjacent carrier.
- 3) Phase opposition disposition (POD); where the carriers above zero voltage are 180 degree out of phase with those below zero voltage.

The reference signal and the carrier signal arrangements for PD modulation, POD modulation, and APOD modulation. A new PWM strategy based on POD

modulation which requires only a single carrier signal ($v_{carrier}$) is proposed and the detailed PWM strategy is depicted in Fig 1. If the reference signal is positive, then the switch pair (T_{A+} , T_{B-}) are turned on, and if it is negative, then the switch pair (T_{A-} , T_{B+}) are turned on. Thus the switches composing the H bridge inverter turned on and turned off once during the period of the reference signal. The voltage across the switch at blocking state is V_{DC} . The switches (T_{P-} , T_{N+}) are operated complementally to the switches (T_{P+} , T_{N-}). The generation of the PWM signal for dc-link switches (T_{P+} , T_{N-}) can be explained as follows.

Mode 1: a signal subtracted from the reference signal by V_c is compared with the carrier signal. If $v_{ref} - V_c > v_{carrier}$, then all switches T_{P+} and T_{N-} are turned on. If $v_{ref} - V_c < v_{carrier}$, then the switch T_{P+} or T_{N-} is turned off alternately.

Mode 2: the reference signal is directly compared with a carrier signal. If $v_{ref} > v_{carrier}$, then the switch T_{P+} or T_{N-} is turned on alternately. If $v_{ref} < v_{carrier}$, then all switches T_{P+} and T_{N-} are turned off.

Mode 3: $-v_{ref}$ is directly compared with a carrier signal. If $-v_{ref} > v_{carrier}$, then the switch T_{P+} or T_{N-} is turned on alternately. If $-v_{ref} < v_{carrier}$, then all switches T_{P+} and T_{N-} are turned off.

Mode 4: a signal subtracted from $-v_{ref}$ by V_c is compared with the carrier signal. If $-v_{ref} - V_c > v_{carrier}$, then all switches T_{P+} and T_{N-} are turned on. If $-v_{ref} - V_c < v_{carrier}$, then the switch T_{P+} or T_{N-} is turned off alternately. Only one carrier signal is used to generate eight PWM signals in the proposed PWM method. Thus it is quite simple.

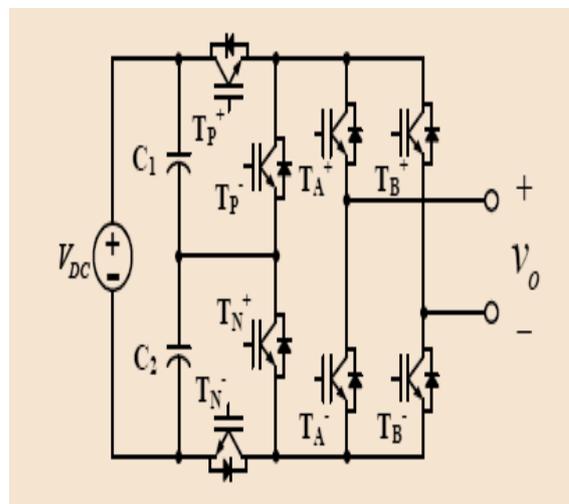


Fig. 2 : Proposed single-phase multi-level inverter topology

V. DEVICES

The electronic semiconductor device act as a switching device in the power electronic converters. In general, the characteristics of the device are utilized in such a way that it acts as a short circuit when closed. In addition to an ideal switch also consumes less power to switch from one state to other.

Semiconductor is defined as the material whose conductivity depends on the energy (light, heat, etc.) falling on it. They don't conduct at absolute zero temperature. But as the temperature increases, the current conducted by the semi conductor increases as it gets energy in the form of heat. The increase in current is propotional to the temperature rise. Semiconductor switches are diodes, SCR, MOSFET, IGBT, BJT, TRIAC etc.,The insulated-gate bipolar transistor or IGBT

The insulated-gate bipolar transistor or IGBT is a three-terminal power semiconductor device noted for high efficiency and fast switching. It switches electric power in many modern appliances: electric cars, variable speed refrigerators, air-conditioners, and even stereo systems with digital amplifiers Since it is designed to rapidly turn on and off, amplifiers that use it often synthesize complex waveforms with pulse width modulation and low-pass filters.

Device structure

An IGBT cell is constructed similarly to a n-channel vertical construction power MOSFET except the n+ drain is replaced with a p+ collector layer, thus forming a cross section of a typical IGBT showing internal connection of MOSFET and bipolar device

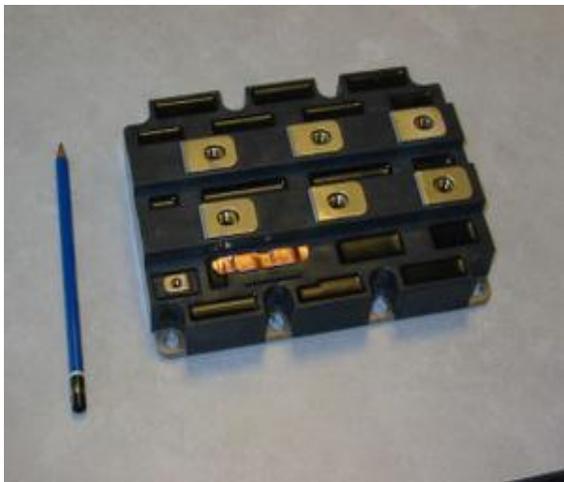


Fig. 3 : IGBT

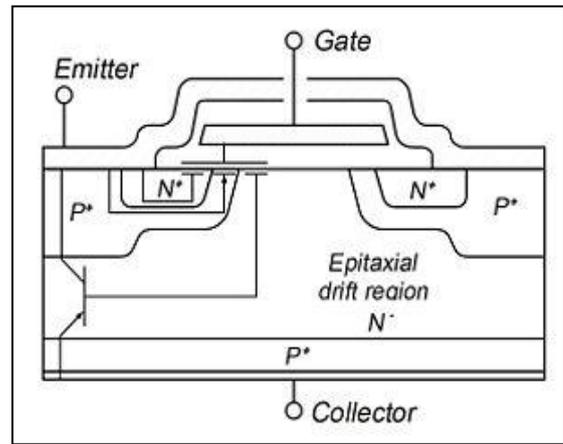


Fig. 4 : MOSFET

VI. SIMULATION RESULTS

The proposed 5-level inverter is tested to verify the operating principle of the proposed MLI. The LC filter is inserted between the output of the inverter and the load. Electrical specifications of the proposed inverter are summarized in Table III. Fig. 7 and 8 show simulation waveforms of the proposed inverter in 5-level. Fig. 7 shows the waveforms of the inverter output voltage, load voltage and the load current when the power factor becomes unity. Fig. 8 shows the waveforms of the inverter output voltage, load voltage and the load current during the lagging power factor

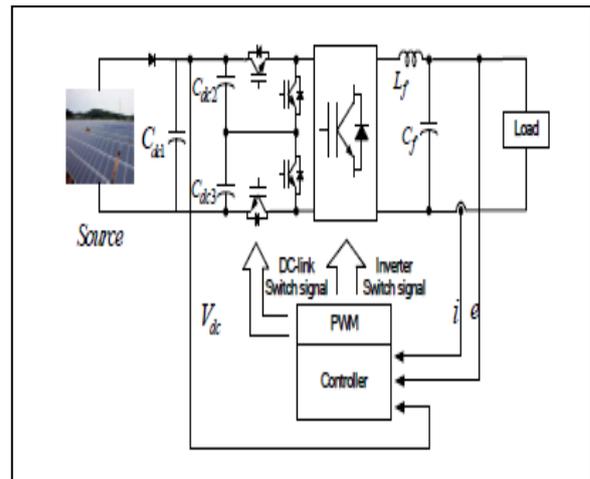


Fig. 5 : Single phase inverter system(Solar Input)

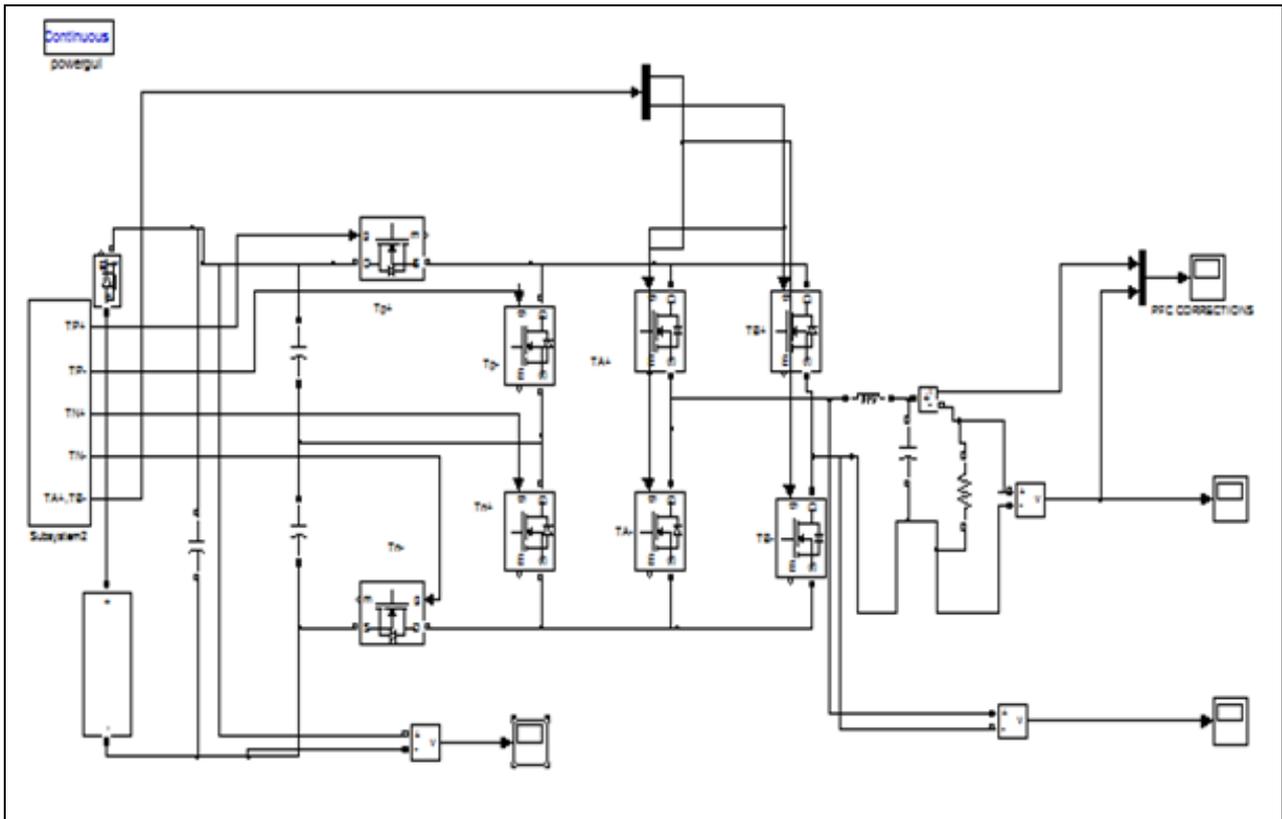


Fig. 6 : Simulation circuit for Single phase inverter system with Solar Input

VII. POWER FACTOR

The power factor of an AC electrical power system is defined as the ratio of the real power flowing to the load to the apparent power in the circuit, and is a dimensional number between 0 and 1. Real power is the capacity of the circuit for performing work in a particular time. Apparent power is the product of the current and voltage of the circuit. Due to energy stored in the load and returned to the source, or due to a non-linear load that distorts the wave shape of the current drawn from the source, the apparent power will be greater than the real power.

Power factor correction of linear loads

A high power factor is generally desirable in a transmission system to reduce transmission losses and improve voltage regulation at the load. It is often desirable to adjust the power factor of a system to near 1.0. When reactive elements supply or absorb reactive power near the load, the apparent power is reduced. Power factor correction may be applied by an electric power transmission utility to improve the stability and efficiency of the transmission network. Individual

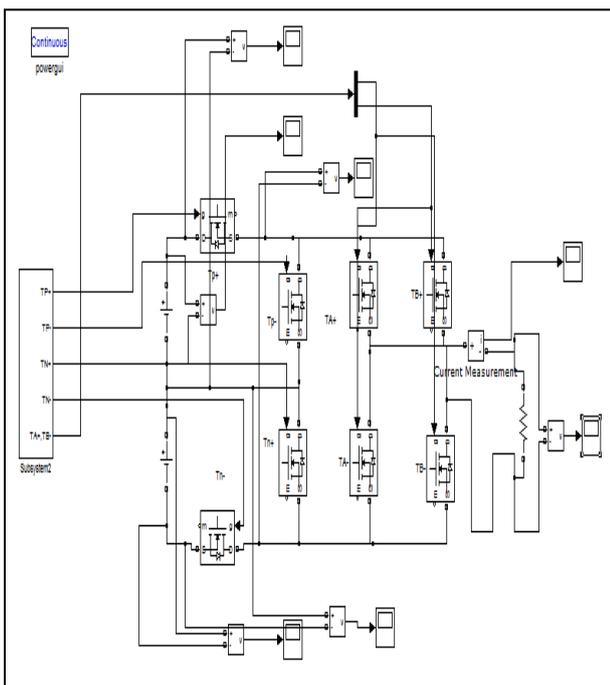


Fig. 7 : Single phase inverter system DC Supply

electrical customers who are charged by their utility for low power factor may install correction equipment to reduce those costs

Power factor correction

An automatic power factor correction unit consists of a number of capacitors that are switched by means of contactors. These contactors are controlled by a regulator that measures power factor in an electrical network. Depending on the load and power factor of the network, the power factor controller will switch the necessary blocks of capacitors in steps to make sure the power factor stays above a selected value.

Instead of using a set of switched capacitors, an unloaded synchronous motor can supply reactive power. The reactive power drawn by the synchronous motor is a function of its field excitation. This is referred to as synchors motors. It is started and connected to the electrical network. It operates at a leading power factor and puts VARS onto the network as required to support a system's voltage or to maintain the system power factor at a specified level.

Power factor correction in non-linear loads Passive PFC

The simplest way to control the harmonic current is to use a filter: it is possible to design a filter that passes current only at line frequency (50 or 60 Hz). This filter reduces the harmonic current, which means that the non-linear device now looks like a linear load. At this point the power factor can be brought to near unity, using capacitors or inductors as required. This filter requires large-value high-current inductors, however, which are bulky and expensive.

VIII. OUTPUT WAVE FORMS

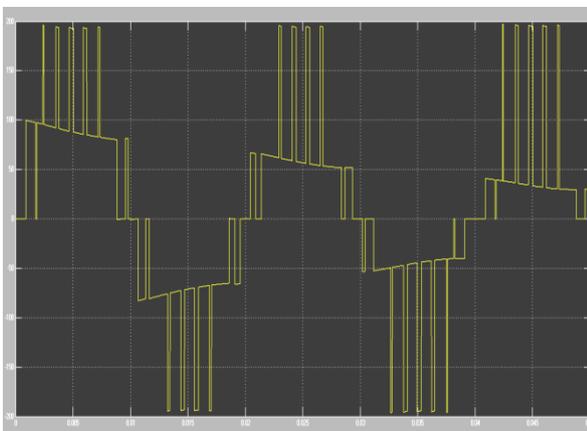


Fig. 8 : 5 Level Output waveform

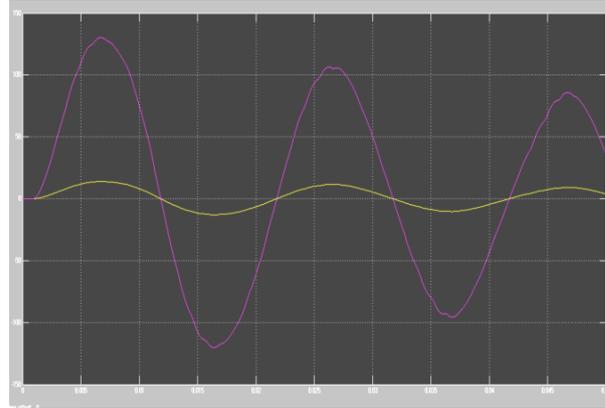


Fig.9 : Voltage & Current waveform

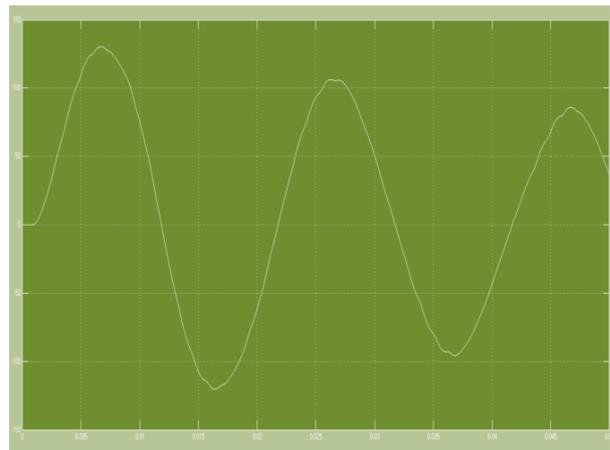


Fig .10 : Output waveform of single phase MLI

IX. CONCLUSION

This paper proposed a new multi-level inverter topology based on a H-bridge inverter with four switches connected to the dc-link. The proposed MLI has the following advantages over the conventional inverters. Number of devices of the proposed multi-level inverter is fewer than that of the conventional multi-level inverters. Therefore, the proposed system is more reliable and cost competitive than the conventional two-level and multilevel inverters.

The four switches (TA +, TA -, TB +, TB -) in the H-bridge are switched at a low frequency . Therefore, switching loss of The four switches (TA +, TA -, TB +, TB -) is almost negligible. Only one carrier signal is required to generate the PWM signals for 4 switching devices (TP +, TP -, TN +, TN -).The proposed topology can be easily extended to 9-level or higher level with minimized active device component count.The power factor can be easily improved by controlling reactive power compensation.

X. REFERENCES

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