SIMULATION OF NOVEL MODULE MULTILEVEL INVERTER USING INTELLIGENT CONTROLLERS

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Abstract*: The aim of this study is to implement the of novel module multilevel inverter using intelligent controllers, to design and development of 11 levels MLI for marine applications. Our main objective of the concept is to improve the power quality of inverter and to reduce the TOTAL HARMONIC DISTORTION with absence of filter. We obtain to get best optimized THD results when we are using the controller which has a name of FUZZY controller and PI controller. Eventually, we are comparing which type of controller has to produce the robust good efficient THD results and we have been obtained in our project. Simulations and experimental results are used to utilize the controller performance and inverter output voltage and Induction motor speed control performance. We have implemented mainly, to reduce the switches in the inverter domain and as well as switching losses only we would be approached our own topology of new Multi-level inverter.

Keywords: Fuzzy Logic Control, PI Control, Multilevel Inverter

I. INTRODUCTION

This is to design and development of a single phase Multilevel Inverter using PI controller and FUZZY logic controller. Solar Photovoltaic is an elegant technology which produces electricity from sunlight without moving parts. In a Photovoltaic cell, sunlight separates electrons from their hosts silicon molecules. Tiny packets of light energy called photons are captured by electrons, and impart energy to kick the electron free of its host atom.

Among the various renewable energy resources, solar energy potential is the highest in India. The demand for renewable energy has increased significantly over the years because of shortage of fossil fuels and greenhouse effect. Among various types of renewable energy sources, solar energy and wind energy have become very popular and demanding due to advancement in power electronics techniques. Our strategy is to enhance the deployment of renewable energy including that originated from sunlight. In a photovoltaic (PV) system, an inverter is installed to convert DC power generated from the PV module into AC power. Photovoltaic's (PV) sources are used today in many applications as they have the advantages of being maintenance and pollution free. Solar-electric-energy demand has grown consistently by 20%-25% per annum over the past 20 years, which is mainly due to the decreasing costs and prices. This decline has been driven by the following factors: 1) an increasing efficiency of solar cells; 2) manufacturing technology improvements; 3) economics of scale. In most parts of India, clear sunny weather is experienced 250 to 300 days a year. The annual radiation varies from 1600 to 2200 kWh/m2, which is comparable with radiation received in the tropical and sub-tropical regions. The equivalent energy potential is about 6,000 million GWh of energy per year. Solar energy has a great potential as future energy source.

A. MPPT

An MPPT, or Maximum Power Point Tracking is an electronic DC to DC converter that optimizes the match between the solar array (PV panels), and the battery bank or utility grid. To put it simply, they convert a higher voltage DC output from solar panels down to the lower voltage needed to change batteries. MPPT is electronics tracking – using digital. The charge controller looks at the output of the panels and compares it to the battery voltage. It then figures out what is the best power that the panel can put out to charge the battery. It takes this and converts it to best voltage to get maximum AMPS into the battery. (Remember it is amps into the battery that counts). Most modern MPPT's are around 93-97% efficient in the conversion. You typically get a 20 to 45% power gain in winter and 10-15% in summer. Actual gain can vary widely depending weather, temperature, battery state of charge and other factors. The major principle of Maximum Power Point Tracker is to extract the maximum available power from PV module by making them operate at the most efficient voltage (maximum power point), MPPT checks output of PV module, compares it to battery voltage then fixes what is the best power that PV module can produce to change the battery and converts it to the best voltage to get maximum current into battery. It can also supply power to a DC load, which is connected directly to the battery.

MPPT is most effective under these conditions:
1. Cold weather, cloudy or hazy day: Normally, PV module works better at cold temperatures and MPPT is utilized to extract maximum power available from them.
2. When battery is deeply discharged: MPPT can extract more current and change the battery if the state of the charge in the battery is lower.

B. DC – DC CONVERTER

A DC to DC converter which converts a source of direct current from one voltage level to another level is used. Power level ranges from very low to very high. DC to DC converters developed to maximize the energy harvest for photovoltaic systems. Nowadays, many renewable energy sources such as solar photovoltaic (PV) and wind energy are well developed and have been put in the limelight as the alternative energy as part of effort in limiting the dependency on the conventional energy sources like fossil fuels, coal, and natural gas. This energy is free and sustainable and as attracted many researches. Energy resources such as PV are simply easy to integrate with existing topology of switched mode DC-DC power converter. A DC-DC converter controlled by PWM control technique is placed between the solar panel and the batteries, in order to boost up the voltage of solar panel to charge the batteries at any time even when the panel voltage is less than battery charging voltage. Generally, boost converter operates in two basic modes of work operation, i.e. Continuous Conduction Mode (CCM) and Discontinuous Conduction Mode (DCM). The state of the converter in which the inductor current is never zero for any period of time is called (CCM) meanwhile, in the (DCM); the inductor current is zero during a portion of switching period.

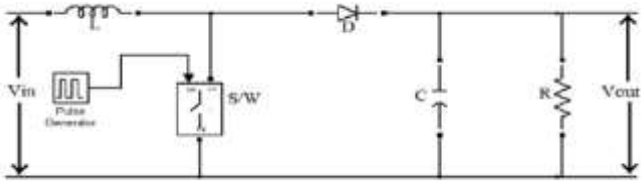

Figure 1 DC-DC Converter

C. MULTILEVEL INVERTER

Power electronics device which converts dc power into ac power at desired output voltage and frequency is known as inverter. The Multilevel inverter topology concept was introduced in early 1975 with three level converters. It is possible to increase the power rating with high number of voltage levels in the inverter. A multilevel inverter generates a smooth sinusoidal waveform from several dc voltage levels as its input. It has become an interesting area in the industrial applications for high power and voltage ranges. It can be easily interfaced with renewable energy sources for various high-power applications. In multilevel inverters there is Lower switching frequency and there are less switching losses.

Multilevel Inverters has gained a attention due to wide applications in distributed power systems and electrical drives. A better sinusoidal form of ac output from dc sources like batteries, solar cells, fuel cells etc can be attained from MLIs. Such output can be directly interfaced to the grid or a load with filter circuit in it output. MLI's stepped waveform depicts a better harmonic profile.

D. PI CONTROLLER

A PI Controller is mainly used to eliminate the steady state error resulting from P controller. However, in terms of the speed of the response and overall stability of the system, it has a negative impact. This controller is mostly used in areas where speed of the system is not an issue. Since PI controller has no ability to predict the future errors of the system it cannot decrease the rise time and eliminate the oscillations. If applied, any amount of I guarantees set point overshoot. The PI controller computes and transmits a controller output signal every sample time, to the final control element. The control signal from the PI algorithm is influenced by the controller tuning parameters and the controller error e(t).

PI controllers have two tuning parameters to adjust. While this makes them more challenging to tune than a P controller, they are not as complex as the three parameter PID Controller. Integral action enables PI controllers to eliminate offset, a major weakness of a P controller. Thus, PI controller provides a balance of complexity and capability that makes them by far the most widely used algorithm in process control applications.

II. LITERATURE REVIEW

J.Bangarraju and V.Rajagopal whose literature review's proposes the "H-Bridge Based MLI-INVERTER" The voltage sources connected in a series and parallel and reduced the number of switching devices. The proposed inverter gives the greater number of output voltages and slightly reduces the total harmonic distortion. This report concluded the using of these topologies we can obtained reliable switching devices.

Rahul choudhary, HM Suryawanshi concerns "Modified multi-level topology of high-power solar PV" these topology concerns about the reduces stress on H-bridge switches. They are experimented using 7-level single phase modified topology for grid connection. The results are obtained optimized way, filter requirement is reduced.

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Mohan M. Renge and Hiralal M. Suryawanshi. The author suggests the "Five-level diode clamped inverter". In this paper, approaches to reduce eliminate the common mode voltage (CMV) using five-level diode clamped multilevel inverter (DCMLI) are presented.

Xiaoming Yuan and Ivo Barbi. They are describing about the fundamental "Diode clamped inverter (multi-level)". The paper proposes a new diode clamping inverter, which works without the series association of the clamping diodes. An auxiliary resistive clamping network solving the indirect clamping problem of the inner devices is also discussed for both the new and conventional diode clamping inverter.

Souvik and Tapas Roy authors are discussing application of "MLI-Inverter in closed loop control of Induction motor. This topology of MLI is called Nested Topology Which helps in reducing harmonics. Proposed topology increases efficiency output by reducing losses respectively.

Ezzidin and M.A.Hannan has been proposed "Low spikes and low harmonic Distortion MLI-Inverter for IM Implementation" in 2017. The discussed implementation suggested different modulation technologies. The Utility of the technique is further checked by showing how effective it is reducing the harmonic spikes in these implementations.

Jeyraj and Nasrudin A.Rahim whose literature review described about the "Multi-level Inverter for the grid-connected PV system Employing Digital PI controller" in 2017. A digital PI current control algorithm is implemented in DSP TMS320F2812 to optimize the performance of the inverter.

Jose Antonio Juarez and Hebertt Sira-Ramirez has been shown to presented a "PI Tracking Controller for a Single-Phase MLI-cascaded inverter for FPGA Implementation". This paper proved a robust linear generalized proportional integral control scheme for the output reference tracking trajectory task on load current.

Gregory Zigirks and John Kalmiros has been concluded here about the "Intelligent speed controller for single-phase induction motors using fuzzy". A sensor less v/f speed controller for single phase induction motor is proposed based on a 3-phse to single-phase matrix converter and fuzzy asymmetrical PWM modulation technique.

Serres and Greece which authors proposed to shown "The voltage control of single-phase IM using Asymmetrical PWM and fuzzy logic". The suggested fuzzy switching regulator is verified both in simulation and circuit prototype.

III. CLOSED LOOP CONTROL OF ML1-11 LEVEL WITH PI CONTROLLER

The speed control of an induction motor dynamic performance using PI CONTROLLER and then output of the inverter performance and THD results. Here, additionally we insist the proportional controller functions and working principle based on our project. Normally, the closed loop which means the feedback system required to fulfil the any type of closed loop-based plant system. Open loop which loops system does not require the feed-back system but closed loop system mainly insist the feed-back system is that reason only we could call closed-loop control system is the feed-back control system. A closed loop control system utilizes feedback to compare the actual output to the desired output response. In this chapter, the induction motor is implemented and simplified by using SPWM switching technique with PI controller and performance of the drives is verified using MATLAB - Simulink, can be presented below subheading.

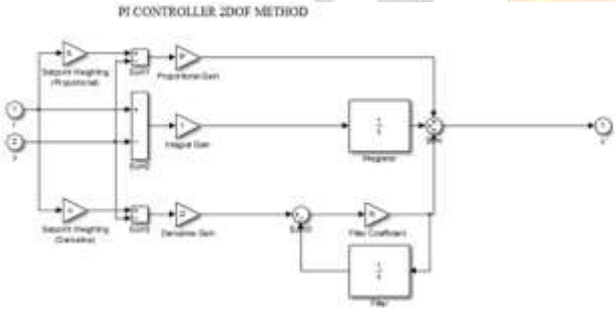

Figure 2 shows that the functional main diagram of the performance about the controller

In this section we are going to consulting about the PI controller performance and functions. As well as the controller how it will performing when synchronizing into a single-phase asynchronous machine. Especially, the pi controller presented here for the solid reason to tracking the speed of the motor such as set point tracking, weight value tuning. Now a day's advanced automatically tuning methods are simulated in matlab simulink. So that even either manual (or) automatically tuning the value itself.

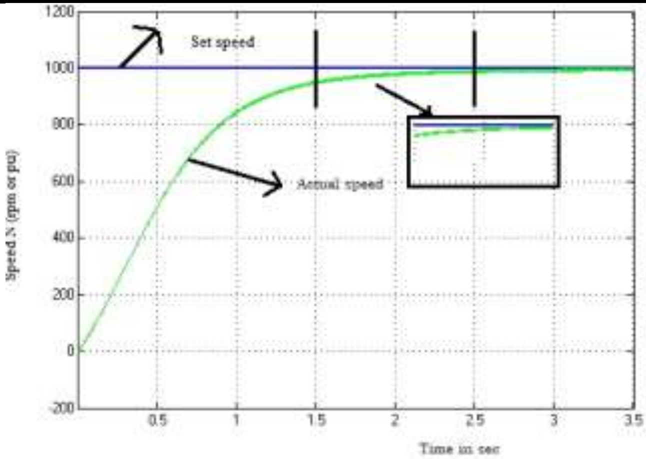

Figure 3 Speed response for PI Controller

The simulation result of the PI controller motor speed performance. Here we assure to shown the efficient set speed and actual speed performance of the speed control of induction motor with help of the PI controller, derivative term here not presented because of we declare derivative term into zero initial state.

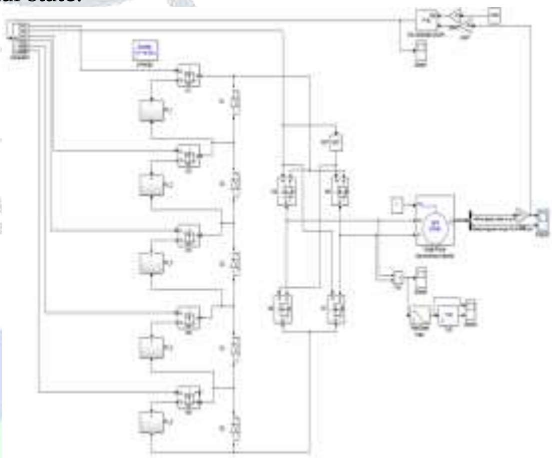

Figure 4 Simulation diagram for closed loop using PI Controller

In this sub-section we discuss about the closed loop simulation and experimental result and also implementing the PI controller utilized. we obtained the best possible way to get the THD when using the proportional and integral controller. The gain value kp and ki values are declared 0.01 because of the speed control of IM. If we change the values the output it will be change. Here, we are eliminating the derivative part, so that we assume proportional value is 1 and integral value also 1 and derivative value is zero.

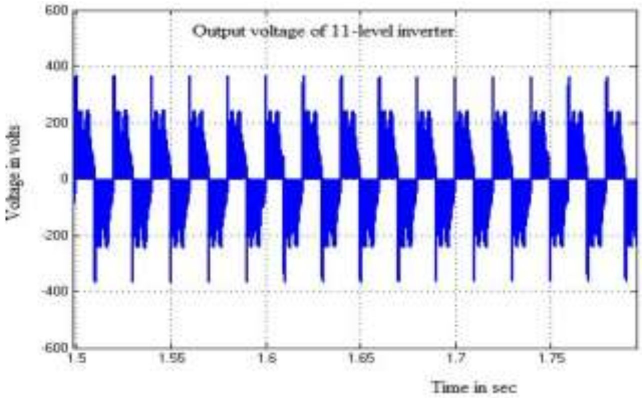

Figure 5 MLI – 11 Level Output

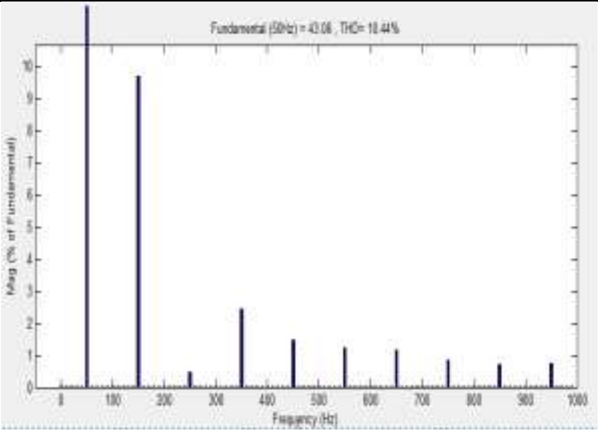

Figure 6 THD result of PI

In this closed loop control of MLI with IM using PI controller, we obtained the THD results with optimized way it shows in the above experimental and simulation result.

IV. CLOSED LOOP CONTROL OF ML1-11 LEVEL WITH FUZZY LOGIC CONTROLLER

In this modelling method, both inputs and outputs can be either discrete time series or continuous time signals modelling method such as a mathematical formula mapping, differential equation. Thus, here we are implementing Linguistic statement. And also, it has a static and dynamic fuzzy system.

Fuzzy logic is a logic that logic refers to the study of the methods and principles of the human reasoning, here in these modelling functions are described, first of all the error signal given into the error detector after that error signal fed into the memory mapping these memories taking the error signal give to the controller and it will act upon the method of modulation index these methods changing the signal into the voltage while error signal brought the PWM block. After all the process over the feedback system gave the output pulses. The logical operations AND, OR specified for the FLC.

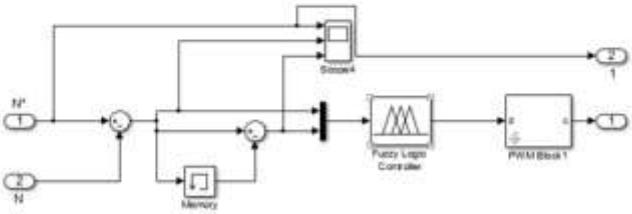

Figure 7 Fuzzy System Modeling

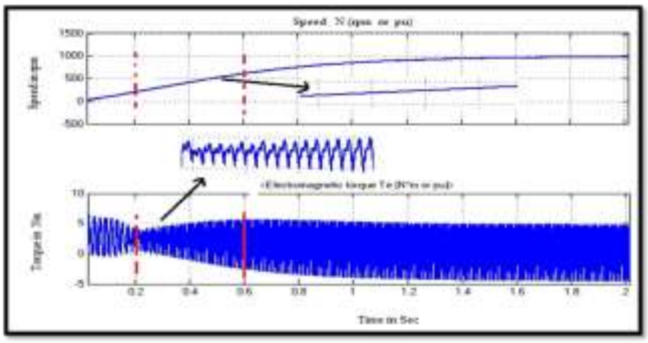

Figure 8 Speed Torque characteristics using FLC

In this section above simulation result may prove to be the FLC is the best optimization for controlling the speed of the induction motor. These experimental shows motor speed-torque quickly saturated and controller fastly tracking the set point of the motor speed. The torque is inversely proportional to the speed because the speed is increases where as the torque decreases. In such a case, speed reaches the set speed, the torque it will be maintained a constant saturation. Compare to PI controller it will decreases the rising time.

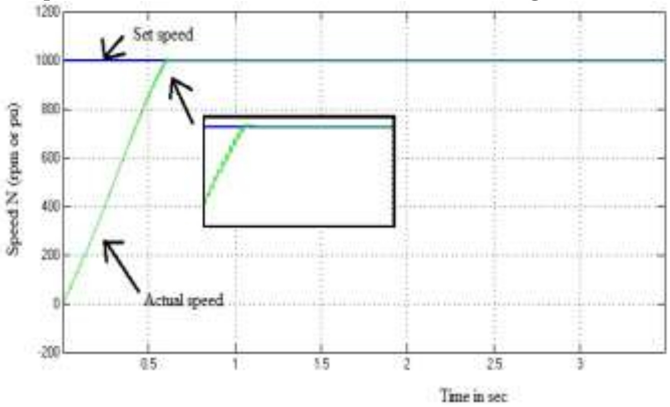

Figure 9 Speed response for Fuzzy Logic Controller

Figure shows that the FLC controlling speed of induction motor, and also, it's clearly shows the set speed, actual speed when it's quickly settled compare to the PI controller.

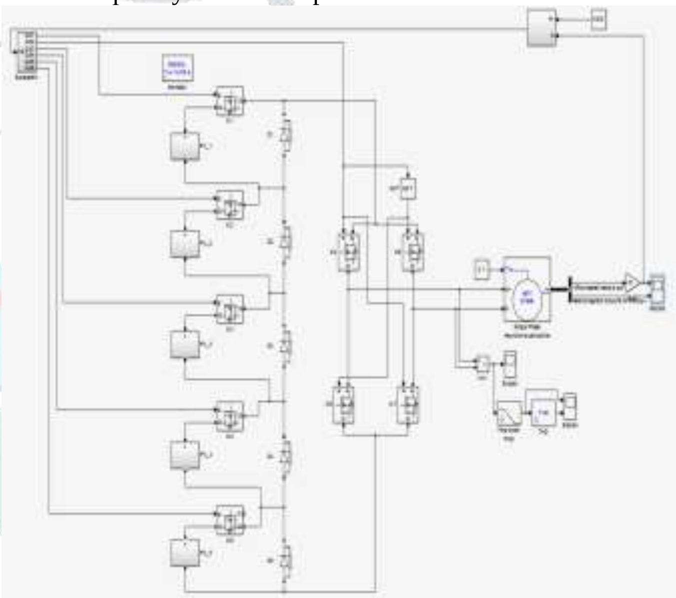

Figure 10 Simulation diagram for closed loop using Fuzzy Controller

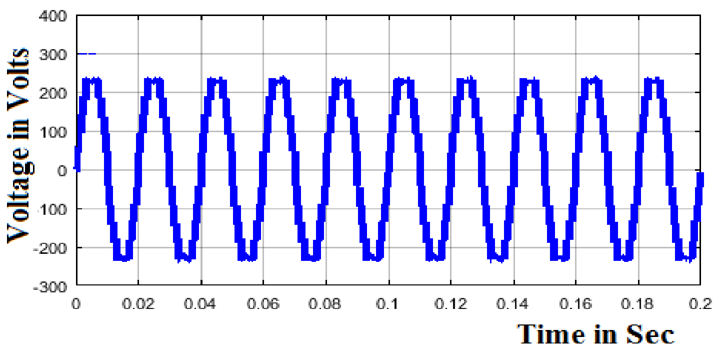

Figure 11 MLI – 11 Level Output

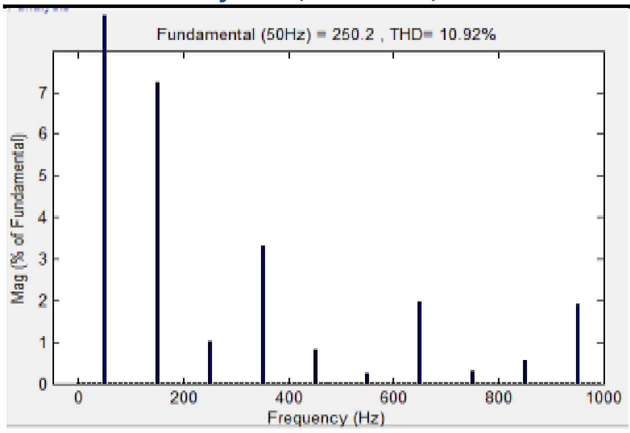

Figure 12 THD result of FLC

V. CONCLUSION

The experimental results reveal that the maximum efficiency was measured while we have been using a fuzzy logic controller and also, we have obtained the THD results of 10.92%. This result has implemented by using fuzzy logic controller. The proposed inverter is suitable to reduce the switching stresses this application is preferred in most applications. However, it is efficiently functioned on the dc-ac conversion multi-level inverters. This limitation is worthy to be investigated in the future research.

The major scientific contributions of the proposed multi-level inverter are recited as follows, for developing multilevel output, this paper is planned to suggest fuzzy based multi-level inverter. In this conclusion, based on the THD in the inverter output current the presentation assessment of closed loop with PI controller and closed loop with fuzzy controller well are found out. We obtained the THD results of 10.92%. And also, we have optimized the THD a result of which controller has a better maximum efficiency. As our project research revealed compare to PI controller which has a least efficiency, fuzzy have a liberally output. It was examined that the suggested method is highly preferable to improve the presentation of TOTAL HARMONIC DISTORTION.

REFERENCES

1. Gui-Jia, Su; , "Multilevel DC-link inverter," Industry Applications, IEEE Transactions on , vol.41, no.3, pp. 848- 854, May-June 2005.
2. Gui-Jia, Su; ,"Multilevel DC link inverter," Industry Applications Conference, 2004. 39th IAS Annual Meeting. Conference Record of the 2004 IEEE, vol.2, no., pp. 806- 812 vol.2, 3-7 Oct. 2004
3. Ceglia, G.; Guzman, V.; Sanchez, C.; Ibanez, F.; Walter, J.; Gimenez, M.I.; , "A New Simplified Multilevel Inverter Topology for DC -AC Conversion," Power Electronics, IEEE Transactions on , vol.21, no.5, pp.1311-1319, Sept. 2006.
4. Martins, G.M.; Pomilio, J.A.; Buso, S.; Spiazzi, G.; , "Three-Phase Low-Frequency Commutation Inverter for Renewable Energy Systems," Industrial Electronics, IEEE Transactions on , vol.53, no.5, pp.1522-1528, Oct. 2006.
5. Hinago, Y.; Koizumi, H.; , "A single phase multilevel inverter using switched series/parallel DC voltage sources," Energy Conversion Congress and Exposition, 2009. ECCE 2009. IEEE, vol., no., pp.1962-1967, 20-24 Sept 2009.
6. Hinago, Y.; Koizumi, H.;, "A Single-Phase Multilevel Inverter Using Switched Series/Parallel DC Voltage Sources," Industrial Electronics, IEEE Transactions on , vol.57, no.8, pp.2643-2650, Aug. 2010.
7. Choi, W.; Kang, F.;, "H-bridge based multilevel inverter using PWM switching function," Telecommunications Energy Conference, 2009. INTELEC 2009. 31st International, vol., no., pp.1-5, 18-22 Oct. 2009.
8. Choi, W.; Kang, F.;, "H-bridge based multilevel inverter using PWM switching function," Telecommunications Energy Conference, 2009. INTELEC 2009. 31st International, vol., no., pp.1-5, 18-22 Oct. 2009.