Solar Smart Inverter:  
A Novel Design using Multi level Topology and Pulse Width Modulation with Load Detection

Nithin Krishnan  
PG Scholar,  
Dept.of Electronics & Communication  
MohandasCollegeofEngineering,KeralaUniversity  
Trivandrum-695541,Kerala,India

Divya H.  
Asst.Professor,  
Dept of Electronics & Communication  
MohandasCollegeofEngineering,KeralaUniversity  
Trivandrum-695541,Kerala,India

Abstract—The term solar smart inverter has become a buzzword in the electronics industry which is a blending of multilevel inverter, solar tracking and solar charging. Inverters are predominantly classified as single level inverters and multilevel inverters. Minimum harmonic distortion, reduced EMI/RFI generation are the major advantages of multilevel inverters as compared to single level inverters. Multilevel inverters can operate on various voltage levels. Multipurpose applications, such as active power filters, machine drives for sinusoidal and trapezoidal current applications can be realized by multi-stage inverter. By incorporating pulse-width modulation (PWM) control, within the inverters we can control the gain of inverters more effectively. One of the most forthright methods of describing voltage source modulation for multilevel inverter is carrier based PWM schemes that can be conceived by the intersection of a modulating signal with triangular carrier waveforms. In this paper, we are designing a Solar Multilevel Pulse Width Modulator inverter using microcontroller and cascade H bridge topology which increases the efficiency and reliability of the system. We are also assimilating Maximum Power Point Tracking for higher efficiency. The solar panel will track the sun from dusk to dawn to get maximum power of sunlight to the solar panel.

Keywords-Multilevel inverter; pulse-width modulation; H-bridge; Stepper Motor; ATmega328 microcontroller; Pic 16f877a microcontroller

I. INTRODUCTION

The problem of greenhouse effect is due to the extensive use of the fossil fuels. Cost of fossil fuel energy is rising and increase in air pollution paves a way to the study of solar energy. In this scenario, this paper emphasis on Solar Smart Inverter (SSI) which is a blending of solar tracking, charging and multilevel inverter.

In the next years the power inverter will change more than has in the past few years. The recent technology concentrates on the improvement of smart inverters. Energy economics and utility system integration are the main technical challenges addressed by the smart inverters. Energy economics highlights improving inverter reliability, increase energy harvest and improve solar power forecasting.

Multilevel Inverter topologies include the diode clamped, the flying-capacitor and the cascade H-bridge types [9][13][14][15]. Here we are using cascade H-bridge topology where switching control is done with the help of pulse width modulation (PWM)[12][11]. Along with multilevel inverter, solar tracking and charging constitute “Solar Smart Inverter” (SSI).

II. PROPOSED TOPOLOGY

Solar Smart Inverter can be divided into two sections. First section is solar tracking and secondly Multilevel Inverter. Solar tracking can be divided into solar panel movement and solar charging. Switching section and control section are major divisions of Multilevel Inverter.

In solar panel movement, the solar panel will track the sun from dusk to dawn. After that it return to initial position and automatically shut down the system in order to reduce the power consumption. Solar tracking will starts at forthcoming dusk with the help of delay provided by the microcontroller.
In solar charging, there may arise problem called common ground problem as we are using multiple level for switching. So we need a novel design to eliminate the common ground problem. In order to avoid this problem we are integrating relay with different switching time.

In switching section we are using cascaded H-bridge for switching the multiple levels of voltage. Here we are using cascaded five H-bridge circuit to get 11 levels of alternating current (AC) voltage.

In Control section we have to control the switching of cascaded H-bridge. There are so many switching scheme available nowadays. In this thesis we are mainly concentrated on Pulse width modulation scheme.

III. System Design

The work flow of Solar Smart Inverter begins with the design of solar tracker followed battery charging and obtain alternating current from multilevel inverter. Furthermore DC power is extracted separately from batteries.

A. Solar Tracking

As irradiance and temperature changes the output power obtained from photo-voltaic (PV) panel varies. In order to trap the maximum energy solar tracking is implemented using stepper motor. A stepper motor is an electromechanical device that divides a full rotation into a number of equal step without any feedback. We can move and hold the motor position using microcontroller using desired control signal. The microcontroller used for this application is Atmega328p. We can divide a motor’s fundamental step angle into micro steps by precisely controlling the current in each phase. The tracking is done by programmed time delayed movement of the panel from dusk to dawn.

B. Solar Charging

We cannot charge all batteries at a time because of common ground problem. Common ground problem arises when multilevel charging is employed. Multilevel charging needs separate ground for each battery. So we opt relay switching for charging the batteries by eliminating common ground problem.
The ac outputs of each of the different full-bridge inverter levels are connected in series such that the synthesized voltage waveform is the sum of the inverter outputs[10]. The number of output phase voltage levels \( m \) in a cascade inverter is defined by \( m = 2s + 1 \), where \( s \) is the number of separate dc sources. An example phase voltage waveform for an 11-level cascaded H-bridge inverter with 5 SDCSs and 5 full bridges is shown in Figure 7. The phase voltage \( \frac{\alpha n}{\alpha} + \frac{\alpha 2}{\alpha} + \frac{\alpha 3}{\alpha} + \frac{\alpha 4}{\alpha} + \frac{\alpha 5}{\alpha} \). For a stepped waveform such as the one depicted in Figure 7 with 5 steps, the Fourier Transform for this waveform follows:

\[
V(ut) = 4V\Pi dc \sum n[cos(n\theta 1)+cos(n\theta 2)+...+cos(n\theta s)]sin(nwt)
\]

where \( n = 1, 3, 5, 7 \)

The PWM signal generated from inbuilt PWM port of PIC16f877a. Out of the five H-bridge circuit the first H-bridge is self-restrained by PWM scheme. Other H-bridge are controlled by normal control signals.

IV. EXPERIMENTAL RESULT

To verify the performance of the solar smart inverter system a prototype based on PIC and Atmega microcontrollers is developed and tested. The main angles of panel rotation are listed in Table 1. For simplicity we used step angle as 90°. Step angle is the property of stepper motor and usually it is 1.8°.

Figure 8. Table 1

Figure 9 shows the basic prototype test platform for solar smart inverter. A 250 watt single phase 11 level solar smart inverter is developed by using PIC and atmega microcontrollers. The photograph of the integrated system is shown in the figure 10. The output from the solar smart inverter is analyzed and shown in figure. The eleven level output obtained can be approximated to a sine wave without much distortion is shown in figure 11.
V. CONCLUSION

In this paper, a new solar smart inverter system is proposed for small scale application which is the latest achievement in the power electronics wing. Solar cell movement system developed will move the panel from 180 degree east to west and returned to initial position after sunset. Also solar charging is implemented by eliminating common ground problem. The main objective of this paper is to produce sinusoidal wave form with minimum distortion from separate DC source by using multilevel inverter is validated. However the focus on multilevel inverter here is not meant to downplay the importance of solar tracking and charging system. Solar Smart Inverter has a great significant to energy savings and utility system integration. The obtained simulation and hardware results met the desired output to great extent. The load detection is incorporated with the help of current transformer inorder to detect load variation. The current transformer detect load variation and feed back to microcontroller. Microcontroller is programmed in such a manner that if unendurable load variation occurs then the system will automatically shutdown. From the findings we can enhance system by interfacing to power grid and with the assistance of weather forecasting we can minimize problem caused by the adverse effect of weather disasters. Furthermore efficiency of switching scheme can be improved by implementing space vector pulse width modulation.

REFERENCES


