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# MICROCONTROLLER BASED SOLAR POWER INVERTER

**Ruchika Thukral, Gulshan Kumar, Ankit Gupta, Nilesh Kumar Verma, Shivanchal Asthana**
Department of Electrical & Electronics Engineering, SRM University, NCR Campus, Modi Nagar, India.

**ABSTRACT**

*This paper presents the design and the implementation of a new microcontroller-based solar Power inverter. The aim of this paper is to design single phase inverter which can convert DC voltage to AC voltage at high efficiency and low cost. Solar and wind powered electricity generation are being favored nowadays as the world increasingly focuses on environmental concerns. Power inverters, which convert solar-cell DC into domestic-use AC, are one of the key technologies for delivering efficient AC power The hardware and software design are oriented towards a single-chip microcontroller-based system, hence minimizing the size and cost. With this new approach the modularization of the conversion from solar power to electric power at its maximum power point can be made more compact and more reliable.*

**Key words:** Inverter, Microcontroller, Solar Panel, H- Bridge.

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## 1. INTRODUCTION

Electronic devices run on AC power, however, batteries and some forms of power generation produce a DC voltage so it is necessary to convert the voltage into a source that devices can use. Hence a need for power rating inverter to smoothly operate electrical and electronic appliances. Most of the commercially available inverters are actually square wave or quasi square wave inverters. Electronic devices run by this inverter will damage due to harmonic contents [1]. Available sine wave inverters are expensive and their output is not so good. For getting pure sine wave we've to apply sinusoidal pulse width modulation (SPWM) technique. This technique has been the main choice in power electronics because of its simplicity and it is the mostly used method in inverter application [2]. To generate this signal, triangular wave is used as a carrier signal is compared with sinusoidal wave at desired frequency.

Advances in microcontroller technology have made it possible to perform functions that were previously done by analog electronic components. With multitasking capability, microcontrollers today are able to perform functions like comparator, analog to digital conversion (ADC), setting input/output (I/O), counters/timer, among others replacing dedicated analog components for each specified tasks, greatly reducing number of component in circuit and thus, lowering component production cost.

Flexibility in the design has also been introduced by using microcontroller with capability of flash programming/reprogramming of tasks [3] The proposed approach is to replace the conventional method with the use of microcontroller. In this project PIC16F877A microcontroller was used. It has low cost and reduces the complexity of the circuit for the single phase full bridge inverter [4]. The focus of this report is on the design and prototype testing of a DC to AC inverter which efficiently transforms a DC voltage source to a high voltage AC source similar to the power delivered through an electrical outlet (240Vrms, 50Hz) with a power rating of approximately 600W.

This paper investigates the application of microcontroller based solar power inverter operation during power disturbances. Also study the cost effectiveness and reduced the complexity of system of this microcontroller based inverter. This project builds upon the work of another project which mandated to build the DC to DC boost. In this report, it is detailed how the inverter's controls are implemented with a digital approach using a microprocessor for the control system and how effective and efficient a 3-level PWM inverter can be. The inverter device will be able to run more sensitive devices that a modified sine wave may cause damage to such as: laser printers, laptop computers, power tools, digital clocks and medical equipment. This form of AC power also reduces audible noise in devices such as fluorescent lights and runs inductive loads, like motors, faster and quieter due to the low harmonic distortion.

## 2. PROPOSED MODEL

In this paper we have tried to reduce the cost & complexity of the conversion circuit by using a Microcontroller. It has been used to generate trigger pulses for the Mosfet so as to enable high speed switching. Thus D.C. supply is converted into A.C.

In this model there are many component used are microcontroller, solar panel, timer IC555, Drivers, MOSFET, Capacitor, resistor, diode. An important piece of solar power supply is the DC to AC inverter which converts the DC voltage from a battery to an AC voltage that is necessary to operate electronic components. Due to the delicate nature of this equipment, an inverter which is capable of producing a pure sine wave is necessary to avoid noise and wear on delicate and expensive gear. Many of these devices are very expensive so it is the goal of this project to design a DC/AC inverter capable of producing a pure sine wave for use with domestic equipment.

The Objectives of this project is to design an inverter that can be derived by 24V battery and can be used to operate AC loads while minimizing the conventional inverter cost and complexity using Microcontroller are

- Generation of pure sine wave inverter from the solar panel reducing the dependency on the fossil fuel and limited the energy source
- Reducing complexity by using microcontroller to generate modulation signal

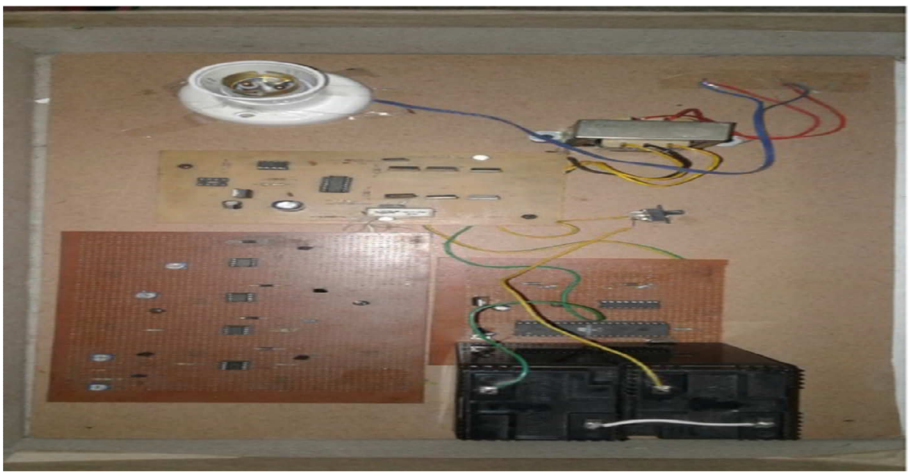

**Figure 1** Model of microcontroller based solar panel inverter.

## 3. BLOCK DIAGRAM

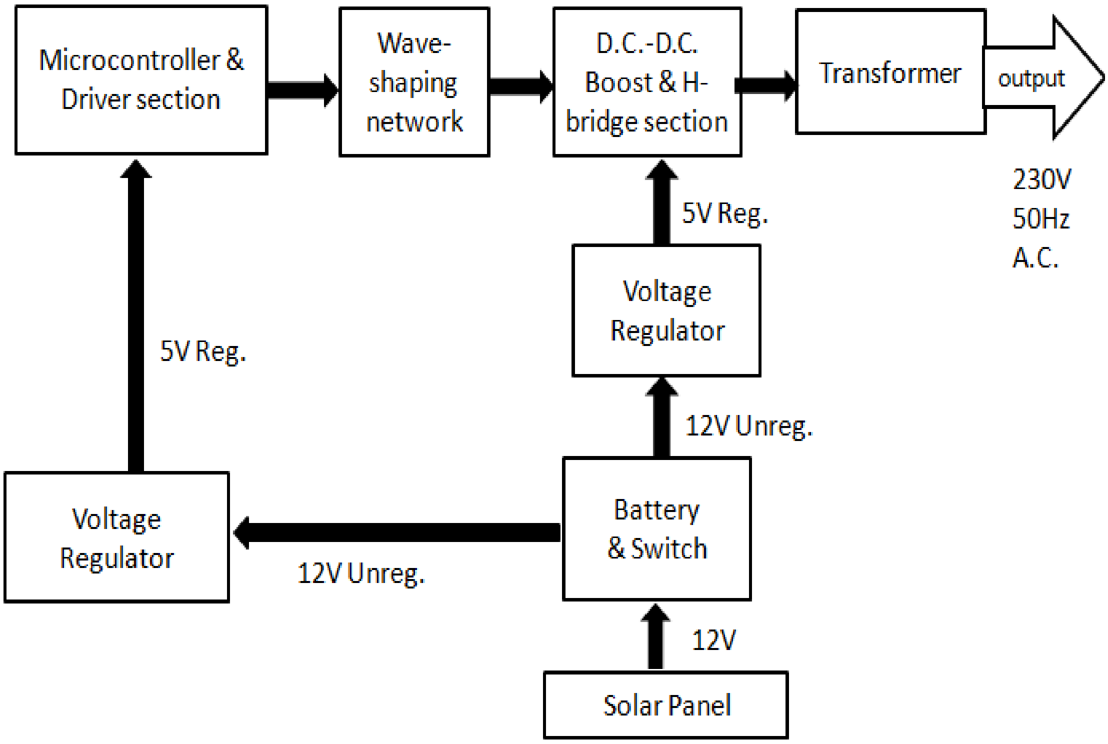


**Figure 2** Block Diagram of Microcontroller based solar powered inverter

Inverter is an electronic device which is DC to AC converter. It simply converts direct current to alternating current. Its name also indicates that it has exactly opposite operation to that of a rectifier.

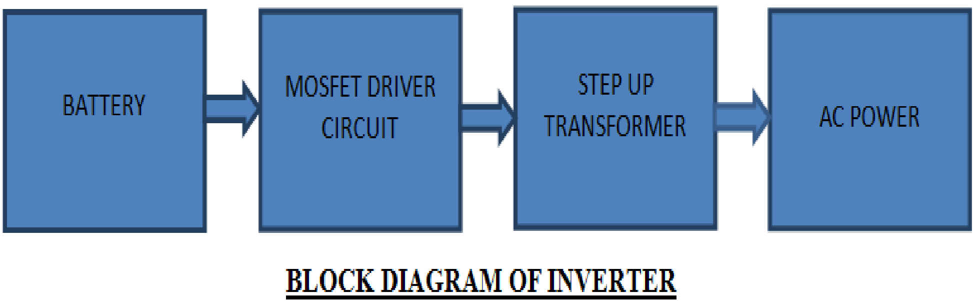


**Figure 3** Block diagram of Inverter

In this circuit DC input from battery is given to an inverter circuit and then its AC output to a transformer. When the switch is closed the current starts to rise in the circuit. This will make the transformer to generate an EMF, opposing the EMF of the battery. If we assume that the resistance of the transformer is negligible, then the current will rise at a constant rate. This rise will depend on the inductance of the transformer; the more time will be needed, to produce the required current to balance the EMF of the battery. Now if switch is opened before the current in the transformer grows fully, the current in circuit will start to fall. This will make the transformer to generate reverse EMF. Now, once the circuit current reaches zero, the switch is once again closed and this whole process will start to repeat itself. So, by producing open, close cycle of switch in this circuit, we can produce ac current output from a dc current source i.e. battery. The output from secondary winding of transformer will be a square wave of frequency at which switch is opened and closed; this is the basic working principle of inverter.

## 3.1. Pulse Width Modulation

Pulse width modulation, or PWM, has become an accepted method for generating unique signals, due to the advancement of microcontrollers and its power efficiency. To create a sinusoidal signal, PWM uses high frequency square waves with varying duty cycles. Duty cycle is the percentage of time the signal is on relative to the period. This means as the duty cycle increases, more power is transmitted. PWM requires rapid on and off signals, which can be achieved using high power MOSFETs. MOSFETs are ideal switches due to the low power loss when the device is activated. It should be noted, however, that when a MOSFET is in transition between on and off, the power loss can be significant. For this reason, the transition times and frequency should be engineered to be as short as possible. This can be achieved by minimizing the amplitude between the on and off stages and lowering the PWM frequency; however as the frequency decreases so does the signal quality.

Pulse width modulation inverter can be classified as;

- Analog bridge PWM inverter
- Digital bridge PWM inverter

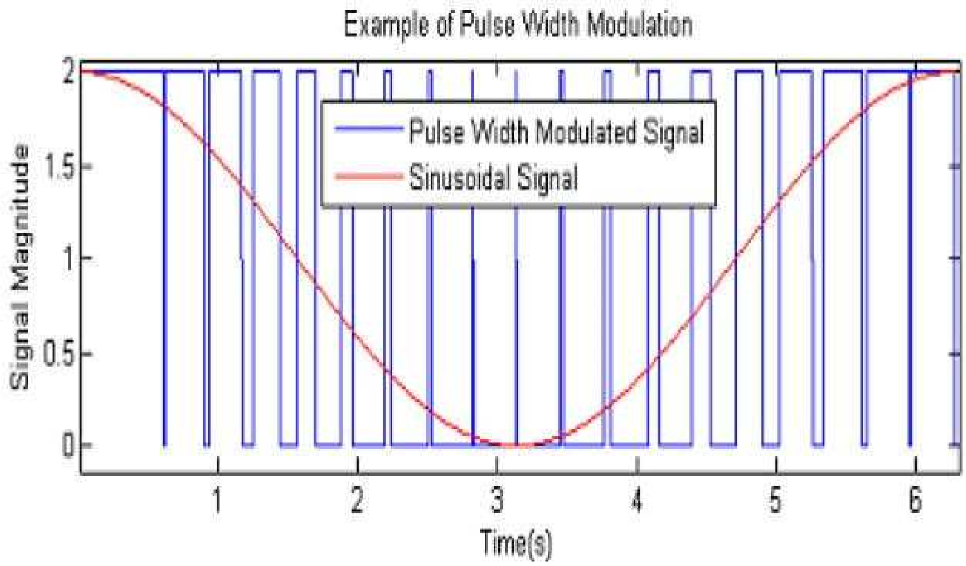


**Figure 4** Pulse width modulations

## 3.2. Project Approach

While designing an inverter can be complex, it does become easier when broken down into its component steps. The following sections detail each component within the project, as well as how each section is constructed and interacts with other blocks to result in the production of a 240V pure sine wave power inverter.

### *3.2.1. Microcontroller*

A microcontroller is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. A microcontroller can be considered a self-contained system with a processor, memory and peripherals and can be used as an embedded system.

Why use a micro-controller**?**

By reducing the size and cost compared to a design that uses a separate microprocessor, memory, and input/output devices, microcontrollers make it economical to digitally control even more devices and processes. We use AT8535. It is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry standard instruction set and pin out, memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with in-system programmable Flash on a monolithic chip, the Atmel AT8535 is a powerful microcontroller which provides a Highly-flexible and cost-effective solution too many embedded control applications.

The AT8535 provides the following standard features: 8K bytes of Flash, 256 bytes of RAM, 32 I/O lines, Watchdog timer, two data pointers, three 16-bit timer/counters, a six-vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator and clock circuitry. In addition, the AT8535 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes.

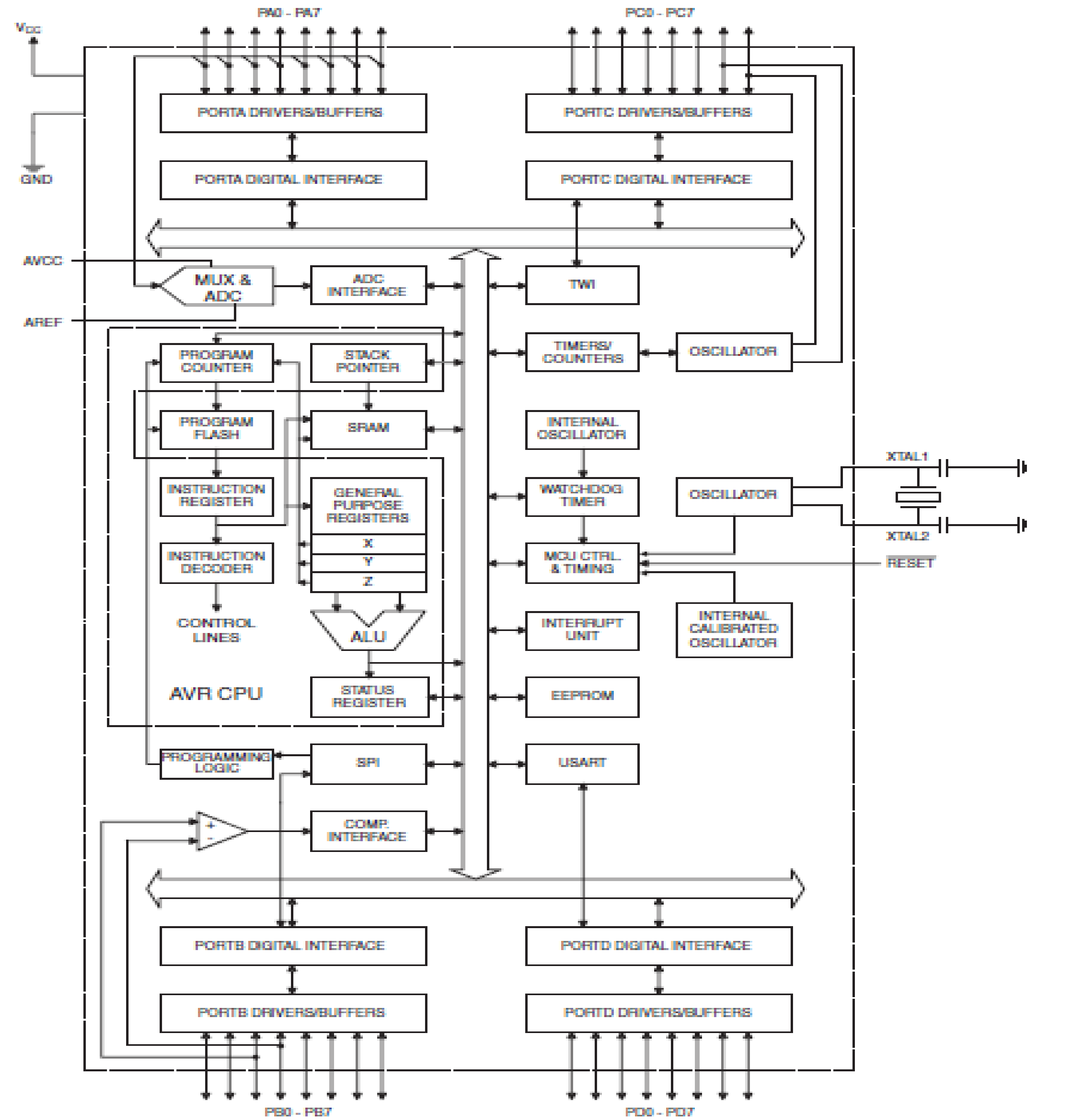


**Figure 5** Block diagram of AT 8535

### *3.2.2. Pre Amplifier (Wave Shaping)*

It is designed by using the BC 547 transistors & NE555 timer.

Pre amplifier is used to amplify output, which is present at the micro controller output terminals. By using the pre amplifier we are converting the 5v s/g to 12v which is required to drive the power MOSFETs. The pre-Amplifier converts the microamperes current from m/c to ma.

**BC 547 Transistor:**

BC547 is an NPN bi-polar junction transistor. A transistor, stands for transfer of resistance, is commonly used to amplify current. A small current at its base controls a larger current at collector & emitter terminals. BC547 is mainly used for amplification and switching purposes. It has a maximum current gain of 800. Its equivalent transistors are BC548 and BC549.

The transistor terminals require a fixed DC voltage to operate in the desired region of its characteristic curves. This is known as the biasing. For amplification applications, the transistor is biased such that it is partly on for all input conditions. The input signal at base is amplified and taken at the emitter. BC547 is used in common emitter configuration for amplifiers. The voltage divider is the commonly used biasing mode. For switching applications, transistor is biased so that it remains fully on if there is a signal at its base. In the absence of base signal, it gets completely off.

**NE 555 Timer:**

The 555 timer IC is an integrated circuit (chip) used in a variety of timer, pulse generation, and oscillator applications. The 555 can be used to provide time delays, as an oscillator, and as a flip-flop element. Derivatives provide up to four timing circuits in one package.

### *3.2.3. Power Amplifier*

Power amplifier is designed by using the power MOSFETs. The MOSFET's used are IRF840 and are connected in push pull configuration. Power amplifiers are used to improve the power handling capability of circuit. Power Amplifiers will convert the current in ma to the current in several amperes.

### *3.2.4. Voltage Booster*

Voltage booster is consisting of the transformer it will act as step up or step down on the basis of the operation mode of inverter. At the output of step up transformer we get the 230V ac output. Voltage booster will provide the input from the power amplifiers.

### *3.2.5. Transformer*

A transformer is an electrical device that transfers electrical energy between two or more circuits through electromagnetic induction. Electromagnetic induction produces an electromotive force within a conductor which is exposed to time varying magnetic fields. Transformers are used to increase or decrease the alternating voltages in electric power applications A varying current in the transformer's primary winding creates a varying magnetic flux in the transformer core and a varying field impinging on the transformer's secondary winding. This varying magnetic field at the secondary winding induces a varying electromotive force (EMF) or voltage in the secondary winding due to electromagnetic induction.

### *3.2.6. MOSFET and MOSFET Driver*

We are using the BT139 as Mosfet driver and IRF840 as a MOSFET. MOSFET is basically used to control the charging voltage by controlling the 12VDC voltage by controlling the phase angle of MOSFET. We control the 12VDC supply by giving appropriate gate pulses to it. It is used as the MOSFET driver. The metal–oxide–semiconductor field-effect transistor is a type of transistor used for amplifying or switching electronic signals.

Although the MOSFET is a four-terminal device with source (S), gate (G), drain (D), and body (B) terminals, the body (or substrate) of the MOSFET is often connected to the source terminal, making it a three-terminal device like other field-effect transistors. Because these two terminals are normally connected to each other (short- circuited) internally, only three terminals appear in electrical diagrams. The MOSFET is by far the most common transistor in both digital and analog circuits, though the bipolar junction transistor was at one time much more common.

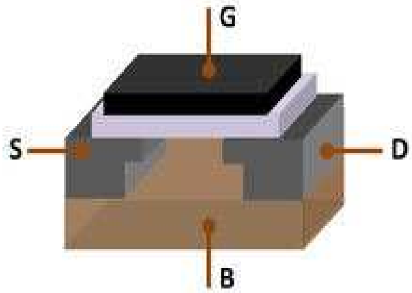


**Figure 6** MOSFET

The main advantage of a MOSFET over a regular transistor is that it requires very little current to turn on (less than 1mA), while delivering a much higher current to a load (10 to 50 times or more).In enhancement mode MOSFETs, a voltage drop across the oxide induce a conducting channel between the source and drain contacts *via* the field effect. The term "enhancement mode" refers to the increase of conductivity with increase in oxide field that adds carriers to the channel, also referred to as the *inversion layer*. The channel can contain electrons (called an nMOSFET or nMOS), or holes. In the less common *depletion mode* MOSFET, detailed later on, the channel consists of carriers in a surface impurity layer of opposite type to the substrate, and conductivity is decreased by application of a field that depletes carriers from this surface layer.

### *3.2.7. Lead Acid Battery*

It has low energy-to-weight ratio and a low energy-to-volume ratio, its ability to supply high surge currents means that the cells have a relatively large power-to- weight ratio. These features, along with their low cost, make it attractive for use in motor vehicles to provide the high current required by automobile starter motors.

As they are inexpensive compared to newer technologies, lead–acid batteries are widely used even when surge current is not important and other designs could provide higher energy densities. Large-format lead–acid designs are widely used for storage in backup power supplies in cell phone towers, high-availability settings like hospitals, and stand-alone power systems. For these roles, modified versions of the standard cell may be used to improve storage times and reduce maintenance requirements. Gel-cells and absorbed glass-mat batteries are common in these roles, collectively known as VRLA (valve-regulated lead–acid) batteries.

### *3.2.8. H Bridge*

An H bridge is an electronic circuit that enables a voltage to be applied across a load in either direction. These circuits are often used in robotics and other applications to allow DC motors to run forwards and backwards.

Most DC-to-AC converters (power inverters), most AC/AC converters, the DC-to-DC push–pull converter, most motor controllers, and many other kinds of power electronics use H bridges. In particular, a bipolar stepper motor is almost invariably driven by a motor controller containing Two H Bridges.

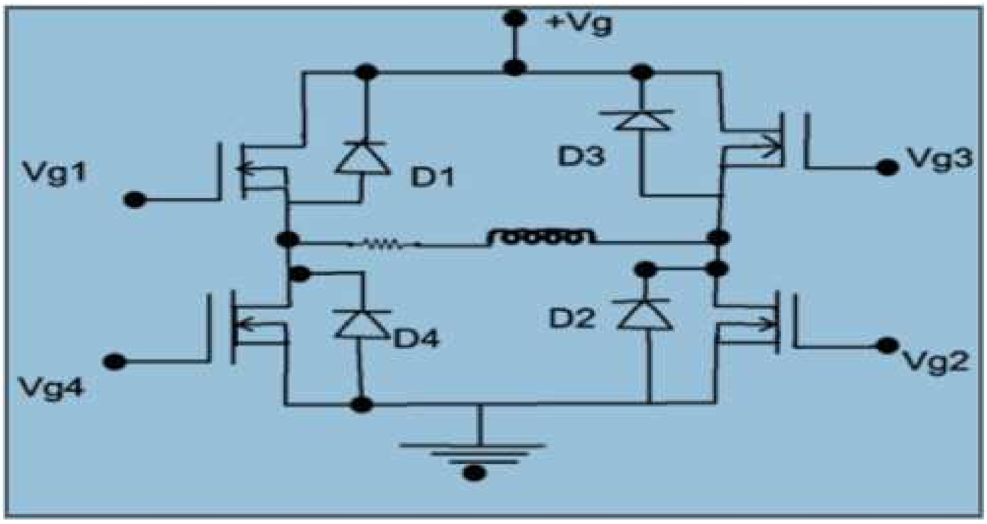


**Figure 7** H Bridge

When switch S1 and S2 are closed and switches S3 and S4 are open, a positive voltage will be applied across the load. By closing S3 and S4 switches and opening S1 and S2 switches a reverse voltage will be applied to the load.

A common use of the H Bridge is an inverter. The arrangement is sometimes known as a single-phase bridge inverter. The H Bridge with a DC supply will generate a square wave voltage waveform across the load. For a purely inductive load, the current waveform would be a triangle wave, with its peak depending on the inductance, switching frequency, and input voltage. The H-bridge arrangement is generally used to reverse the polarity/direction of the motor, but can also be used to 'brake' the motor, where the motor comes to a sudden stop, as the motor's terminals are shorted, or to let the motor 'free run' to a stop, as the motor is effectively disconnected from the circuit.

## 4. CONCLUSION

In this work, solar power inverter is design with use of microcontroller. The objective of the circuit was to invert power from high voltage DC sources or an output voltage of DC to DC boost into AC power similar to one available in our wall sockets for any load and of which was partially met. This inverter power output is usable for any load although not practically tested. Almost 90% of the project was completed within time line given and by the time this report was being submitted. The fact that I was able to integrate the whole system and achieve a desired output of both the frequency and voltage with reverence to rail voltage supplied shows that much of key parts of this project is practically achievable and with required DC voltage a complete working inverter can be achieved.

There are a few changes that need to be worked on for future work. As mentioned earlier, the inductor used in the filter is a transformer coil and therefore not suitable for the amount of power required. Proper inductor is recommended, iron core inductor that has small copper resistance which will increase the efficiency of the inverter. In addition, I would recommend housing even the prototype boards in enclosures to avoid unwanted contact with the high power sources. Also hardware designed that isolates the load from the supply in case of over voltages, under voltages and phase outs would be of great importance if this project is to be commercially produced in large scale.

So in general we can say that by utilizing wind energy we can save Conventional sources of energy, as its cost is more and are exhaustible, we should provide our weight age to the non-conventional energy resources, so this project of ours is future scope of power generation because the present scenario provokes us to provide our concentration on type of energy resources which is plenty and eco-friendly. So this paper of ours creates awareness to the people that do utilize alternative sources of energy, because they are inexhaustible, plenty, pollution free and very easy to recycle.

## 5. FUTURE SCOPE

In this paper, we try to show the glimpse of the immense potential that Renewable energy resources hold. Some advancement which can significantly boost the practicality and effectiveness of the solution provided by our project are:

- Research can be done to increase the power output so as to make it more useful and dependable.
- Bulk production of the Micro-controller based solar power Inverter will further lower the cost.

If implemented on a bigger scale, it can become quite economical.

## REFERENCE


[1] A.Ali Qazalbash, Awais Amin, Abdul Manan and Mahveen Khalid, "Design and Implementation of Microcontroller based PWM technique for Sine wave Inverter", International Conference on Power engineering, Energy and Electrical Drives, POWERENG '09. 2009 pp.163-167, IEEE.

[2] S. M. Mohaiminul Islam, Gazi Mohammad Sharif, "Microcontroller Based Sinusoidal PWM Inverter for Photovoltaic Application", First International Conference Developments in Renewable Energy Technology (ICDRET), December, 2009 pp. 1-4, IEEE.

[3] Julio Sanchez and Maria P. Canton, Microcontroller Programming the microchip pic, 1st edition, CRS press 2009.

[4] Shimi S.L, Dr. Thilak Thakur, Dr. Jagdish Kumar, Dr. S Chatterji and Dnyaneshwar Karanjkar, ANFIS Controller for Solar Powered Cascade Multilevel Inverter. *International Journal of Electrical Engineering & Technology (IJEET),* 3(3), 2013, pp. 234–240.

[5] M. H. Rashid, "Power Electronics Circuits, Devices and Applications," 3rd Edition, Prentice-Hall of India, Private limited, New-Delhi, 2004.

[6] John J. Grainger and William D. Stevenson, POWER SYSTEMS ANALYSIS McGraw-Hill, Inc.1994

[7] Gopinath. G, PG and A. Arikesh "Development of Three Step Charging H-Bridge based Sine wave Inverter" International Journal of Advanced Trends in Computer Science and Engineering, Vol.2 , No.2, Pages : 149-153 (2013)

[8] Hemlata B. Nirmal and Syed A. Naveed, Microcontroller Based Automatic Solar Power Tracking System. *International Journal of Electrical Engineering & Technology (IJEET),* 4(1), 2013, pp. 109–114.

[9] Ian F. Crowley and Ho Fong Leung, "PWM Techniques: A Pure Sine Wave Inverter" Worcester Polytechnic Institute 2011.

[10] Principles and Application of Electrical Engineering McGraw hill

[11] IR2110 (-1-2) (S) PbF/IR2113 (-1-2)(S) PbF' "HIGH AND LOW SIDE DRIVER" Data Sheet No. PD60147 rev.U International Rectifier.

[12] Application note AN-978, "HV Floating MOS-gate driver ICs" by International Rectifier.

[13] John Bird, "electrical circuit theory and technology" Revised second edition, Newnes Oxford 2003.