Sonargaon University (SU)

# CONSTRUCTION OF AN EVAPORATIVE COOLER SYSTEM BY USING SOLAR ENERGY

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We are declared that this thesis title, “CONTRUCTION OF AN EVERAPORATION COOLER SYSTEM BY USING SOLAR ENERGY” and the work presented in it are our own and has been generated by me as the result of my own original research.

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# Chapter-1

# INTRODUCTION

## 1.1 Introduction:

This paper reveals the comfort conditions achieved by the device for the human body. In summer (hot) and humid conditions feel uncomfortable because of hot weather and heavy humidity. So it is necessary to maintain thermal comfort conditions. Thermal comfort is determined by the room’s temperature, humidity and air speed. Radiant heat (hot surfaces) or radiant heat loss (cold surfaces) are also important factors for thermal comfort. Relative humidity (RH) is a measure of the moisture in the air, compared to the potential saturation level. Warmer air can hold more moisture. When you approach 100% humidity, the air moisture condenses – this is called the dew point. The temperature in a building is based on the outside temperature and sun loading plus whatever heating or cooling is added by the HVAC or other heating and cooling sources. Room occupants also add heat to the room since the normal body temperature is much higher than the room temperature. Need of such a source which is abundantly available in nature, which does not impose any bad effects on earth. There is only one thing which can come up with these all problems is solar energy.

## 1.2 Objective the Project:

- To make aware of non-conventional energy sources to reduce environmental pollutions.
- To provide solution for power cut problems in villages.
- To replace existing costlier and high energy consumption cooling methods.

## 1.3 Methodology

### 1.3.1These projects mainly consist of two sections:

#### 1.3.1.1 Solar Energy Conversion

Solar energy conversion is done by using battery, inverter and charge controller. As sun light falls on solar panel, which converts into electrical energy by photoelectric effect. This electrical energy stored in battery in the form of chemical energy. Charge controller is employed in between solar panel and battery which prevents overcharging Figure 2: Solar energy conversion process and may protect against overvoltage, which can reduce battery performance or lifespan, and may pose a safety risk. The stored energy directly can use for DC loads or else need to be converted AC (alternate current) by the help of inverter.

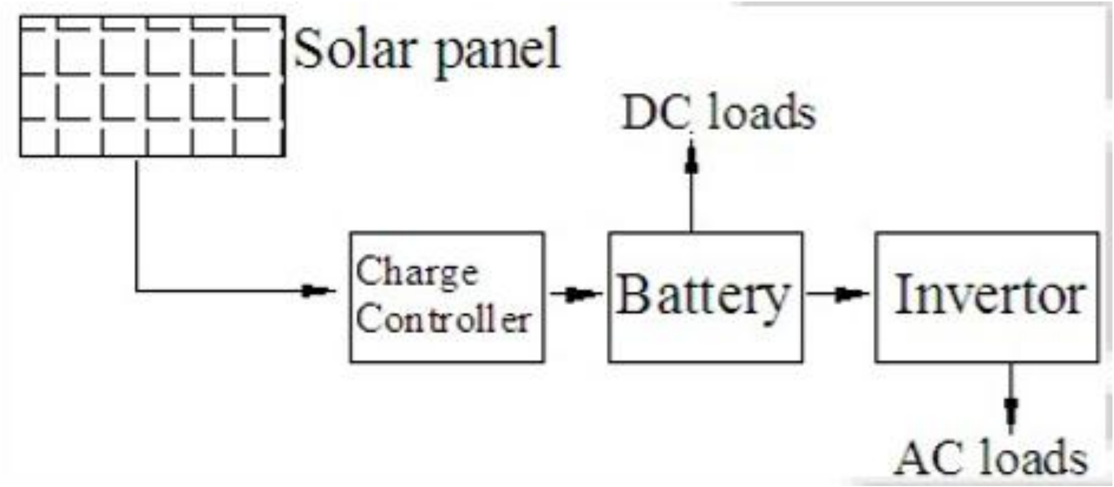


Figure 1.1: Solar energy conversion process

### 1.3.2 Cool air generation by centrifugal fan

The converted energy is used to run the centrifugal fan. This fan covered with cooling pads, through which water is passed at a specific rate. As the fan sucks the hot air through cooling pads, heat transfer occur between air and water thus generated cool air enters into the room.

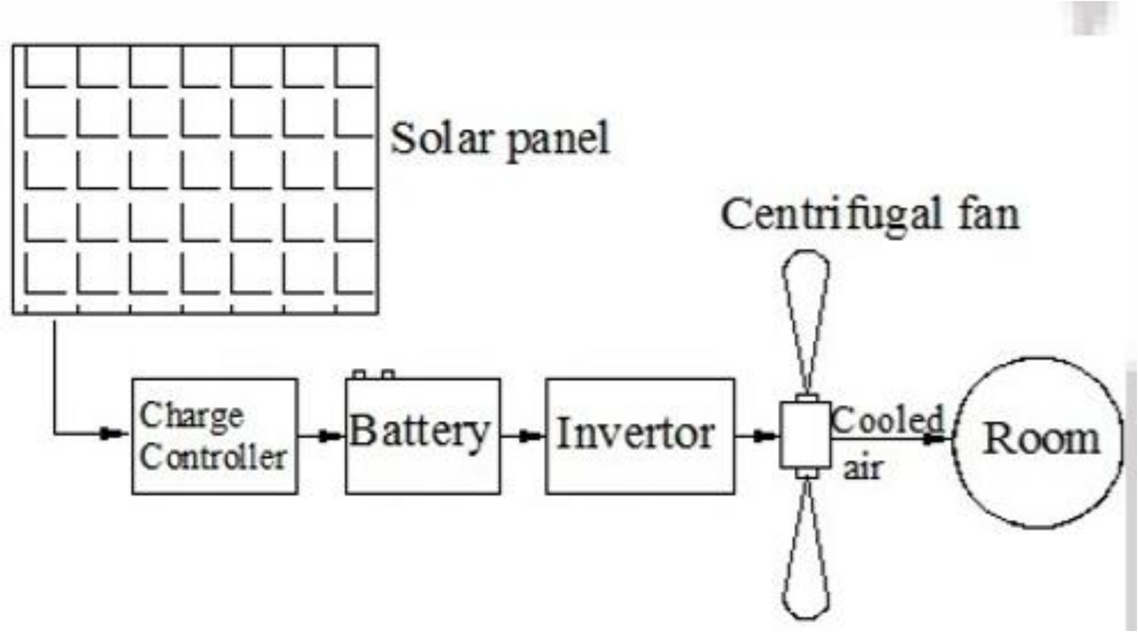


Figure 1.2: Process of cool air generation by centrifugal fan

### 1.3.3 Working Model of the Project

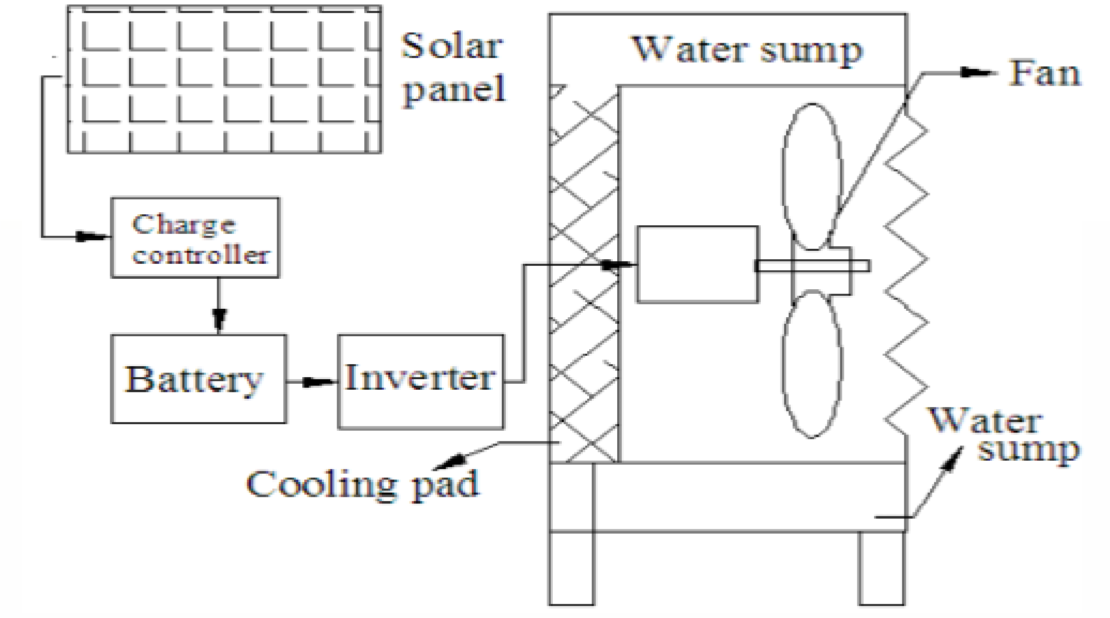


Figure 1.3: Solar powered air cooler

This concept is driven by solar energy. Components involved in this concept are solar panel, battery, charge controller, battery, inverter, blower, ceramic slabs and cooling pads. Solar panel is employed to convert sun light into electrical energy by means of photovoltaic effect. The generated electrical energy is supplied to the battery for storage purpose through charge controller which prevents from power fluctuations. As AC blower is used for cooler, so need to convert DC load from the battery to AC load by the help of inverter. Inverter converts DC load to AC. Load, now AC power can be supplied to the blower. This blower is surrounded by cooling pads through which continuous water supply is provided. When the blower is switched on, blower sucks atmospheric air into the cabin through the cooling pads, mean time heat transfer occur between water and air, so the cool air enters into the room thus providing required thermal comfort conditions.

## 1.4 Present Problem

Fossil fuels also contain radioactive materials, mainly uranium and thorium, which are released into the atmosphere, which contribute to smog and acid rain, emit carbon dioxide, which may contribute to climate change.

- The producing of electricity is ultimately responsible for hot and humid conditions i.e. global warming. As in below shown chart it is clear that major quantity of electricity is produced by coal (fossil fuel).

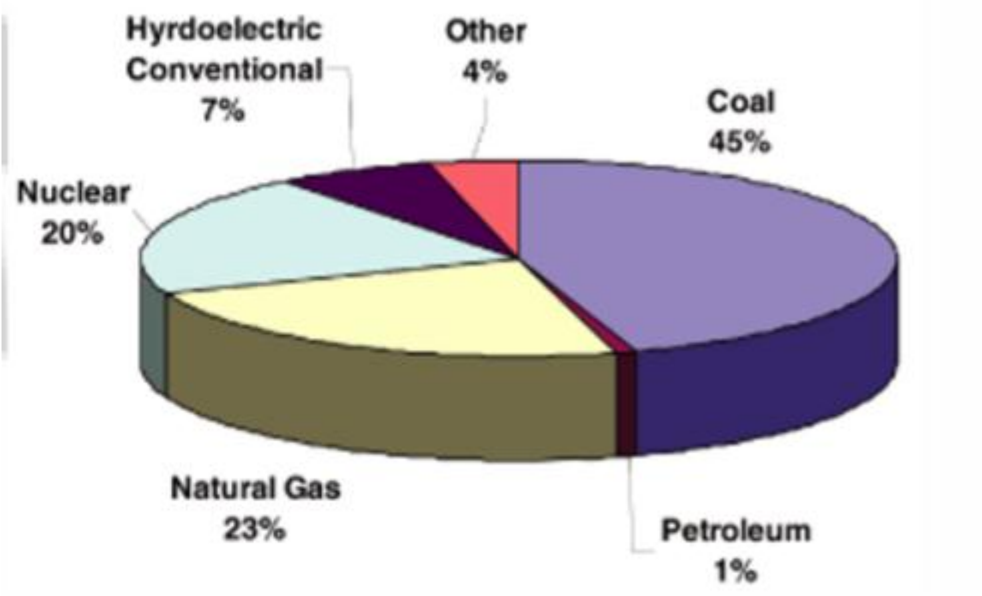


Figure1.4: Production of electricity from different sources

- Longer power cut durations in villages and high cost of cooling products.

### 1.4.1 Proposed Solution:

Need of such a source which is abundantly available in nature, which does not impose any bad effects on earth. There is only one thing which can come up with these all problems is solar energy.

# Chapter-2

# LITERATURE REVIEW

## 2.1 LITERATURE REVIEW

In the world today, there are currently two forms of electrical transmission, direct current (DC) and alternating current (AC) systems, each with their own advantages

And disadvantages. DC power is simply the application of a constant voltage across a load resulting in a constant current [6]. A battery is the most common power source for DC along with several forms of power generation. This is widely used in digital circuitry as it provides constant high and low values which represent the basic 1 and 0 bits used by computers. Thomas Edison, inventor of the light bulb, was the first to transmit electricity commercially using DC power lines. It was not capable of transmission over long distances because the technology did not exist to step-up the voltage along the transmission path over which the power would dissipate. The equation below demonstrates how high voltage is necessary to decrease power loss

$$V = IR$$

$$P = I^2 * R = \frac{V^2}{R}$$

When the voltage is increased, the current decreases and concurrently the power loss decrease exponentially. Therefore, high voltage transmission decreases power loss. AC power was found to be much more efficient at transmitting power as it alternates between two voltages at a specific frequency, making it easier to either step up or down using a transformer [6]. Today, electrical transmission is based mostly of AC power, supplying homes and businesses with 240V AC power at 50Hz.While DC power is used in many digital applications, AC power also used in many other applications such as in power tools, televisions, radios, medical devices, and lighting. Therefore, it is necessary to have an efficient means of transforming DC to AC and vice versa. Without this ability, people would be restricted to using devices that only works on the power that is supplied to them.

The solar panel is converting sun rays to the Electricity by “Photo-Voltaic Effect”. This electrical power is stored in a 12 V battery. Battery D.C power is used to run the D.C motor and D.C water pump.

Block diagram, Photo-voltaic Effect and major components of our project are already discussed in the above chapters.

The D.C motor is coupled with impeller blades. The D.C motor runs when the air cooler button is ON, the impeller blades starts rotating. The water pump is used to circulate the water to the blower unit.

The forced air flows through the water which is sprayed by water pump, so that the cold air is produced. The switch control is used to ON/OFF the solar air cooler circuit and the heater circuit.

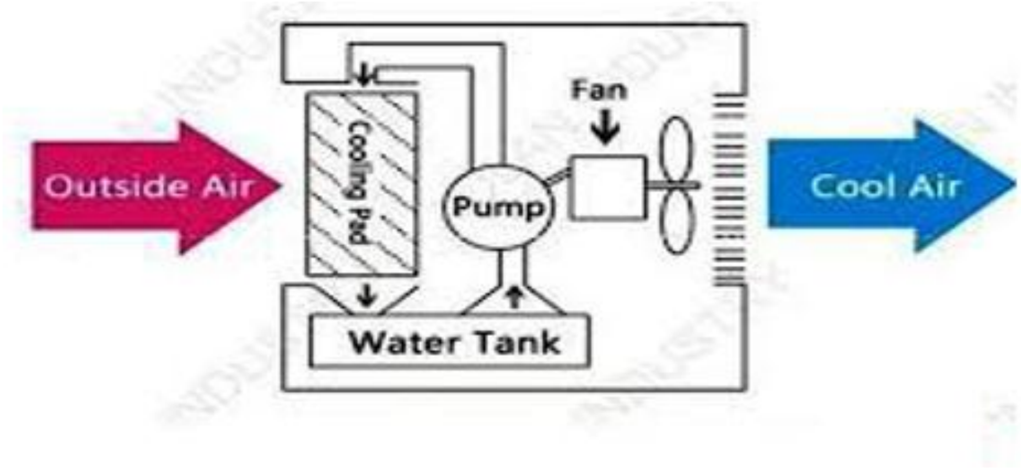


Figure 2. 1: Air cooler system

## 2.2 OVERVIEW

There exist three basic techniques which can be used to convert DC energy into AC. Which are;

(i) Step-up and chop

(ii) Chop only

(iii) Chop and transform This AC may then be fed into the grid or can be used for stand-alone operation of 240V appliances.

## 2.3 Step Up And Chop Technique

This type converts the low voltage into a high voltage first with a square-wave step-up converter and then converts the high-voltage DC into the wanted AC waveform. Advantage of this architecture: insulation between input and output, easy dimensioning of the input converter, Efficiency may be up to 95% for square-wave, slightly lower for sine-wave inverters.

## 2.4 Chop And Transform Technique

This type converts the low voltage DC into a low voltage AC first and then converts the low voltage AC into the wanted AC voltage. The advantages are the low-voltage (=safe) operation, the insulation from the grid after the inverter, the ease with which it makes sine wave which feeds into the transformer and the most important in many aspects: reliability due to the low number of semiconductors in the power path. Disadvantage is the slightly lower efficiency of the inverter, typically 92%. Also some hum can be generated by the transformer under load.

## 2.5 Chop Only Technique

This type requires the input voltage to be higher than the output voltage and converts it directly into the wanted AC waveform. As show below in figure 3.1. The advantage of this is the high efficiency of the inverter, typical 96%. The main disadvantage is the lack of insulation between the solar modules and the grid voltages. Also the input voltages always require a large number of modules [5]. This is the architecture which is designed and implemented in this paper.

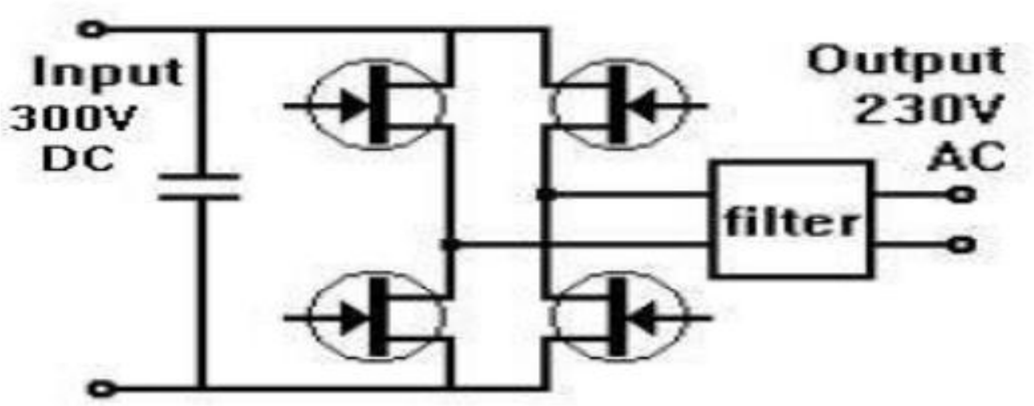


Figure 2.2 : Chop only inverter topology

## 2.6 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.

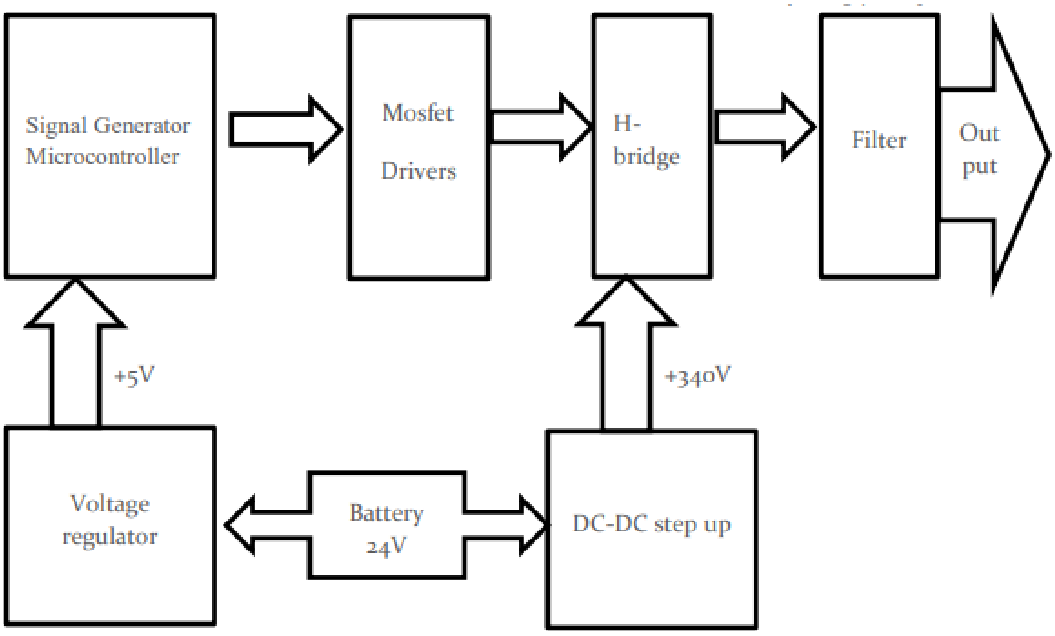


Figure 2.3: Overall Block Diagram

# Chapter-3

# METHODOLOGY

## 3.1 Design

In this project we used step down transformer ,LCD, Microcontroller ,LED, Buzzer ,LDR,12 V battery, Power switch, capacitor ,Variable resistor,. At first we use step down transformer, for 220v convert to 10-12 v .Then DC Battery connected with it .Then we can source in circuit by using a voltage regulator at 5 v .its just like vcc .Then we connected vcc at microcontroller 20 pin and GND at pin 8 .For frequency oscillator .it is connected with 9 and 10 pin for running the microcontroller the pin 2,3connected with variable resistor of LDR and connected temperature sensor .The LED and fan connected with pin 3,14 and 11,12 and also connected buzzer with pin 15.The LCD display with connected with pin 21,22,23,24,25,26 on the other hand ,The row light matrix open and analog OP-Amplifier of comparator node .The amplifier connected with IR sensor

## 3.2 Step Up DC-DC

The DC output voltage from the battery is in relatively small amplitude compared to standard nominal single phase voltage rating for use with domestic household products or to be transferred at grid. The boosts DC-DC converter circuit will step-up the unregulated DC voltage to 340V DC regulated [5]. In this design the DC-DC boost will be developed and implemented by another project hence it will not be discussed at depth in this report.

## 3.3 Microcontroller

The main component of this inverter is a microcontroller as it is used to generate control signals. The theory of encoding a sine wave with a PWM signal is relatively simple. A sine wave is needed for the reference that will dictate the output, and a triangle wave of higher frequency is needed to sample the reference and actuate the switches. The process can also be done with a microcontroller and crystal oscillators as shown in fig 3.3. Since the control technique which will be used is a sinusoidal pulse width modulated PIC16F877A was chosen to generate required signal. This microcontroller is specially developed for the generation of Sinusoidal PWM (SPWM) and therefore it is programmed to generate two PWM signal and two rectangular pulse signals. Pins RC1, RC2 are output pin for sinusoidal pulse width modulation and RA1, RA2 are output pin for rectangular pulse signals. Also for safety purposes and to indicate when the inverter is ON led has been added and programmed at pin RA0 to light green whenever the inverter is functioning.

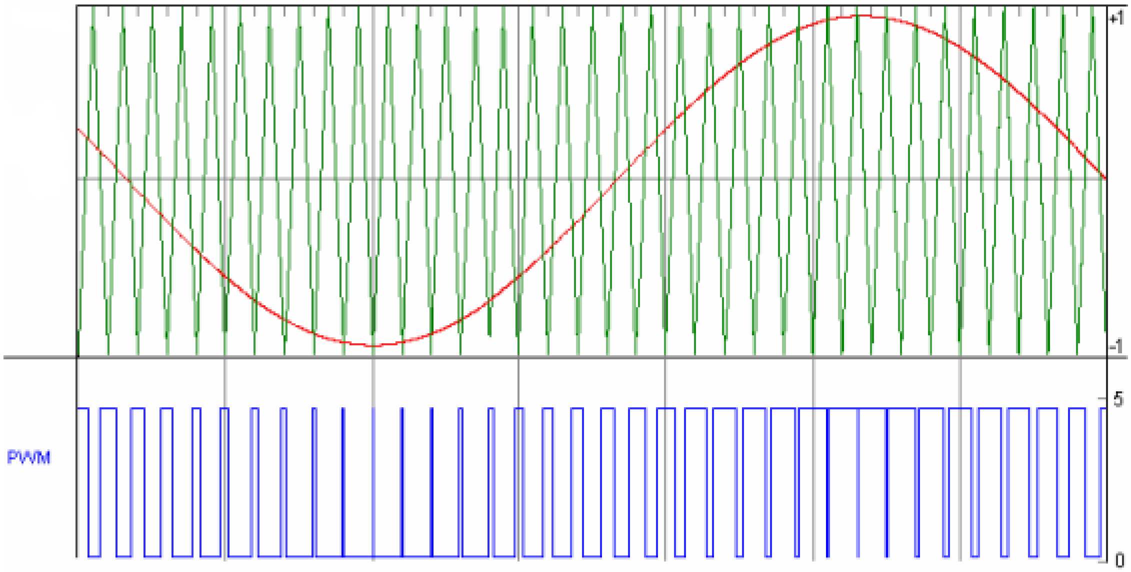


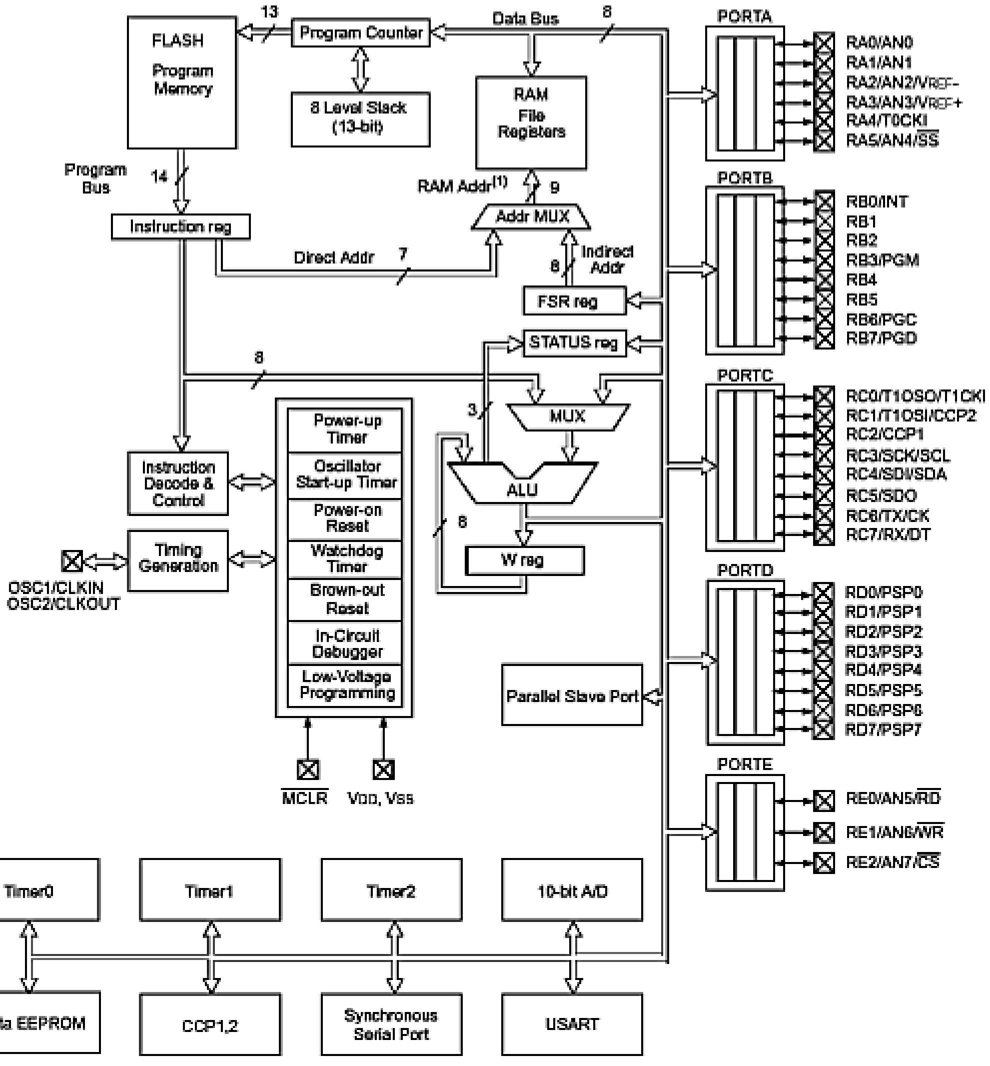
Figure 3.1 : PWM generation

## 3.4 WHY PIC MICROCONTROLLER

### 3.4.1 Internal Architecture

PIC16F877a has Harvard architecture [4]. Harvard architecture is a newer concept than von Neumann. It rose out of the need to speed up the work of a microcontroller. In Harvard architecture data bus and address bus are separate. Thus a greater flow of data is possible through the central processing unit and of course a greater speed of work. Separating a program from data memory makes it further possible for instructions not to have to be 8-bits instructions which allows for all instructions to be one word instructions. It is also typical for Harvard architecture to have fewer instructions than von-Neumann's, and to have instructions usually executed in one cycle. Microcontrollers with Harvard architecture are also called "RISC microcontrollers Fig.3.4 presents the internal block of the PIC16F877a.

| Device | Program FLASH | Data Memory | Data EEPROM |
|---|---|---|---|
| PIC16F874 | 4K | 192 Bytes | 128 Bytes |
| PIC16F877 | 8K | 368 Bytes | 256 Bytes |



Note 1: Higher order bits are from the STATUS register.

Figure 3.2: internal structure of PIC16F877A microcontroller

## 3.4.2 COST PIC16F877A

is an 8 bit microcontroller classified under medium range microcontrollers which makes it very cost competitive with other similar products in the market and hence its pocket friendly. Due to its low cost the overall cost of the inverter ends up being low and market competitive given that the microcontroller is the most expensive chip in the design.

### 3.4.3 Availability In The Market

Since in our country we don’t have a plant to fabricate microchips it is very important to choose a chip which readily available in the local market to avoid incurring extra cost of shipping. PIC16F877A was available in the local stores hence the reason to using it. PIC16F877a perfectly fits many uses, from automotive industries and controlling home appliances to industrial instruments, remote sensors, electrical door locks and safety devices. It is also ideal for smart cards as well as for battery-supplied devices because of its low power consumption

### 3.4.4 Generating Control Signals

The microcontroller is tasked with generating four control signals that are used as inputs to the MOSFET driver. They are two 50 Hz square wave and two 2-level pulse width modulated at 180 degrees out of phase. In order for the microcontroller to give this outputs it has to be programmed. The concept used is simpler and easily implement with PIC16f877. A 50Hz sinusoid with unity magnitude is multiplied with the impulse train of 5000Hz so that one complete cycle of sinusoid contains 100 impulses as shown in

Fig.3.3. 5000Hz PWM can be generated in such a manner that starting position of pulse should be same as that of impulse and duty cycle of the pulse must be equal to the product of unit impulse and value of sine at that instant as shown in Fig. 2.

# Chapter-4

# WORKING PRINCIPLE

## 4.1 Flowchart

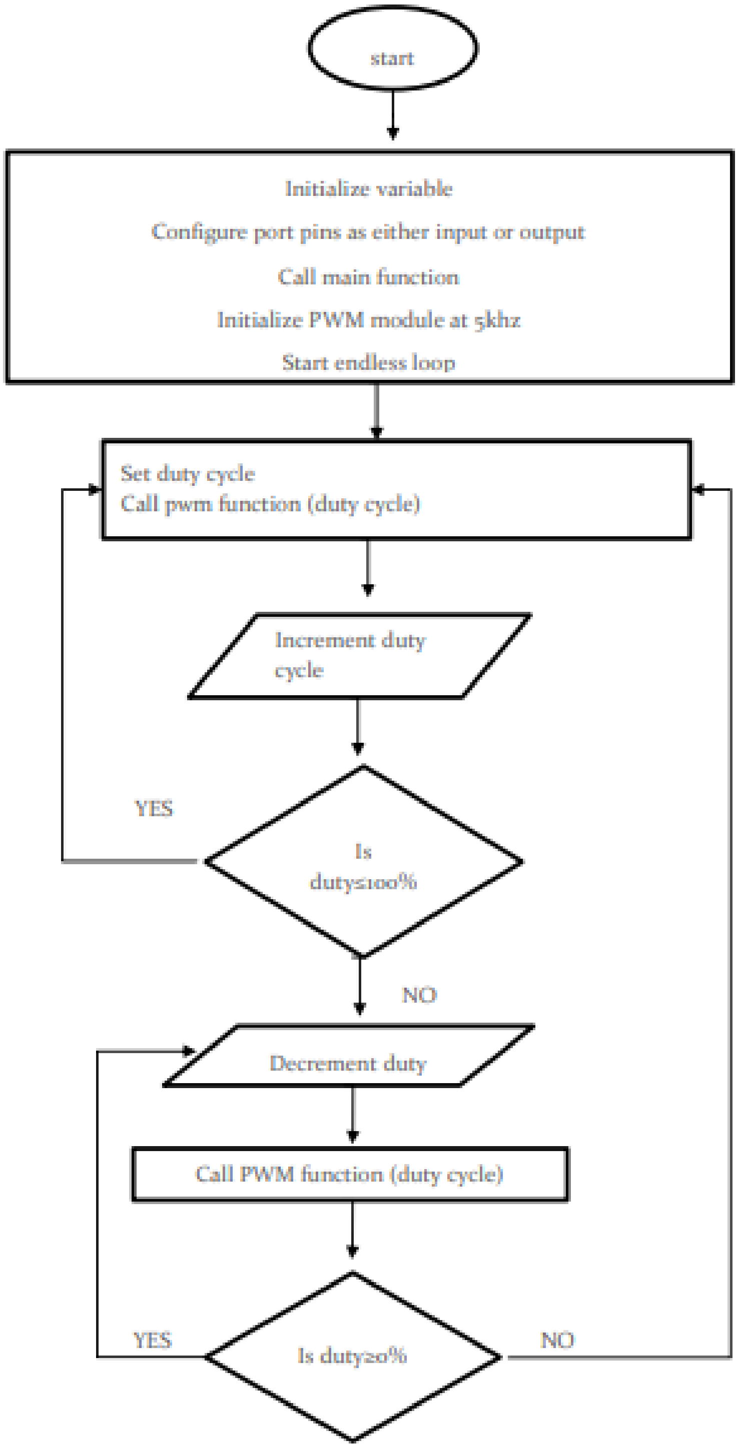


Figure 4.1: FLOWCHART

## 4.2 Coding Microcontroller

Embedded C language was used to write the code needed to program the microcontroller by following flow chart as shown in figure above. The C code is then build using micro pro compiler to produce HEX file which is burned to microcontroller or loaded to protease for simulation. A complete C program is attached in the appendix A.

## 4.3 Microcontroller Stable Operating Voltage

Signal generation begins with the power supply for the op-amps and IC’s. As a battery’s stored energy depletes, its voltage is reduced. Several of the amplifiers in the control signal generation circuits rely on the rail voltages to charge and discharge capacitors which cause a controlled oscillation Generally speaking, the correct voltage supply is of utmost importance for the proper functioning of the microcontroller system. It can easily be compared to a man breathing in the air. It is more likely that a man who is breathing in fresh air will live longer than a man who's living in a polluted environment. If VCC and VEE vary during operation, so will the amplitude and frequency of the reference sine wave and sampling triangle wave. For a proper function of any microcontroller, it is necessary to provide a stable source of supply, a sure reset when you turn it on and an oscillator. According to technical specifications by the manufacturer of PIC microcontroller, supply voltage should move between 2.0V to 5.0V in all versions. The solution comes in the form of a linear voltage regulator. There are other types of voltage regulation, mainly switching regulators, but their benefits are of little use in powering chips. Switching regulators are more efficient than linear regulators and they have the ability to boost voltages, but the supply voltage is well-defined and the op-amps require very little power relative to what a lead acid battery can provide. Thus, the simplest solution to the source of supply is using the voltage stabilizer LM7805 which gives stable +5V on its output. Its connection as per datasheet is shown below.

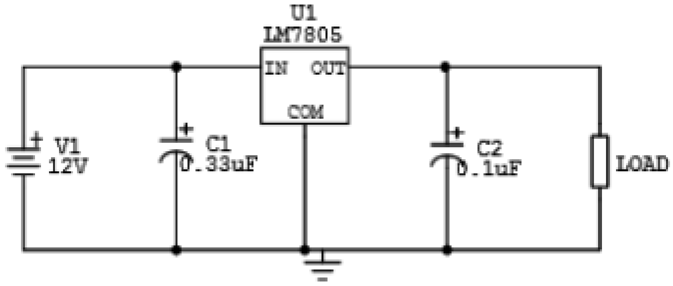


Figure 4.2: Five(5) volt regulator

In order to function properly, or in order to have stable 5V at the output (pin 3), input voltage on pin 1 of LM7805 should be between 7V through 24V. Depending on current consumption the appropriate type of voltage stabilizer LM7805 was used. In this case TO-220 with current consumption of up to 1A and the capability of additional are cooling.

### 4.3.1 H-BRIDGE

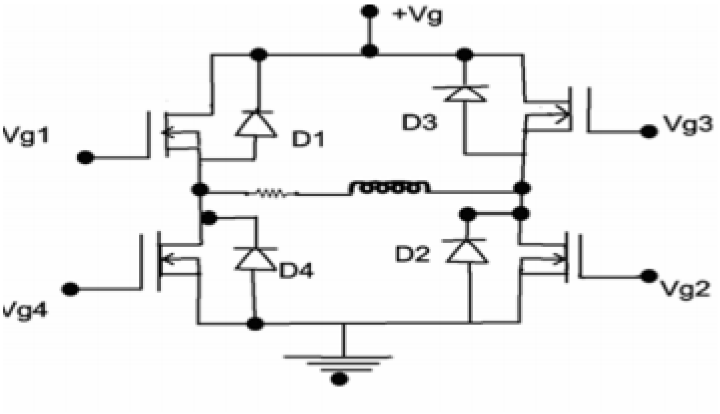
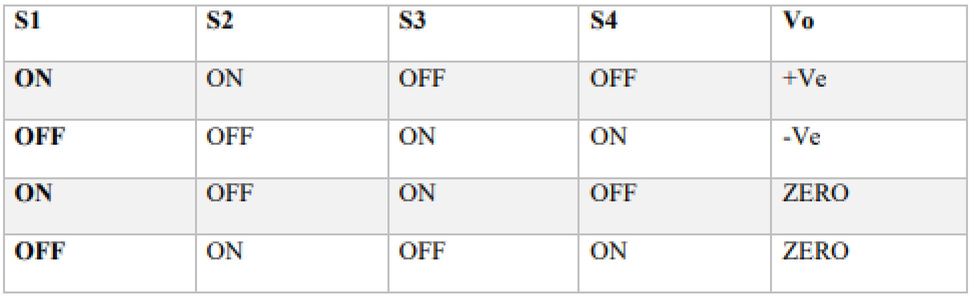


Figure 4.3: Single phase h-bridge

| 7805 Voltage Regulator | | |
|---|---|---|
| INPUT | GND | OUTPUT |
| 7V-25V DC | GND | 5V DC |

Table 1: LM 7805 voltage regulator input output voltage range

An H-Bridge or full bridge converter is a switching configuration composed of four switches in this case MOSFETs in an arrangement that resembles an H [10]. By controlling which switches are closed at any given moment, the voltage across the load can be either positive, negative, or zero. As shown in fig 3.7 a solid state h-bridge is built using four switches. When switch S1 and S2 are closed (according to fig 3.7) 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. Using nomenclature above switches S1 and S4 should never be closed at the same time as this will cause a shot circuit on between the power supply and ground, potentially damaging the devices or draining the power supply. The same applies to switches S2 and S3. This condition is known as shoot-through. The table below outlines the positions. Note that shoot-through switch positions are omitted. The switches used to implement an H-Bridge can be mechanical or built from solid state transistors. Selection of the proper switches varies greatly.



| S1 | S2 | S3 | S4 | Vo |
|---|---|---|---|---|
| **ON** | ON | OFF | OFF | +Ve |
| **OFF** | OFF | ON | ON | -Ve |
| **ON** | OFF | ON | OFF | ZERO |
| **OFF** | ON | OFF | ON | ZERO |

Table 2: H Bridge convert table

## 4.4 IGBTs vs. Power MOSFETs

While designing this circuit, a choice had to be made between the two main types of switches used in power electronics. One is the power MOSFET which is much like a standard MOSFET but designed to handle relatively large voltages and currents. The other is the insulated gate bipolar transistor (IGBT). Each has its advantages, and there is a high degree of overlap in the specifications of the two. IGBTs tend to be used in very high voltage applications, nearly always above 200V, and generally above 600W. They do not have the high frequency switching capability of MOSFETs, and tend to be used at frequencies lower than 29 kHz. They can handle high currents, are able to output greater than 5kW, and have very good thermal operating ability, being able to operate properly above 100 Celsius. One of the major disadvantages of IGBTs is their unavoidable current tail when they turn off. Essentially, when the IGBT turns off, the current of the gate transistor cannot dissipate immediately, which causes a loss of power each time this occurs. This tail is due to the very design of the IGBT and cannot be remedied. IGBTs also have no body diode, which can be good or bad depending on the application. IGBTs tend to be used in high power applications, such as uninterruptible power supplies of power higher than 5kW, welding, or low power lighting. Power MOSFETS have a much higher switching frequency capability than do IGBTs, and can be switched at frequencies higher than 200 kHz. They do not have as much capability for high voltage and high current applications, and tend to be used at voltages lower than 250V and less than 500W. MOSFETs do not have current tail power losses, which makes them more efficient than IGBTs. Both MOSFETs and IGBTs have power losses due to the ramp up and ramp down of the voltage when turning on and off (dV/dt losses). Unlike IGBTs, MOSFETs have body diode. Generally, IGBTs are the sure bet for high voltage, low frequency (>1000V, 200 kHz). In between these two extremes is a large grey area. In this area, other considerations such as power, percent duty cycle, availability and cost tend to be the deciding factors. Since this project is about design of a 600W inverter, with a 340VDC bus (ideally), and a switching frequency of 5 kHz MOSFET is the ideal choice, in spite of MOSFET switches having high ON state resistance and conduction losses. Also MOSFET being a voltage controlled device, it can be driven directly from CMOS or TTL logic and the same gate signal can be applied to diagonally opposite switches since the gate drive current required is very low. If our system was a larger, commercial application with a high power output, IGBTs would be the

## 4.5 Enhanced N-Channel Vs Enhanced P-Channel Mosfets

The use of P-Channel MOSFETs on the high side and N-Channel MOSFETs on the low side is easier, but using all N-Channel MOSFETs and a FET driver, lower “on” resistance can be obtained resulting in reduced power loss. This requires a more complex circuit since the gate of the high side MOSFET must be driven positive with respect to Vs bus voltage to turn on the MOSFET.

## 4.6 Mosfets Chara Cteristic

In this project enhanced n-channel MOSFET was chosen for both high side and low side switches of the h-bridge. For` the MOSFET to carry drain current Id (on state) a channel between the drain and source must be created. This occurs when drain to source Vgs voltage exceeds the device threshold (Vgs>Vth). Once the channel is induced the MOSFET can operate in either triode region (drain current proportional to channel resistance) or the saturation region(constant drain current). The gate to drain voltage Vgs determines whether the induced channel enters pitch-off or remains in triode region. When used as a switching device only triode and cut-off region are utilized. The device will operate at cut-off (off state) when gate to source voltage Vgs is less than threshold voltage

| | | |
|---|---|---|
| 1. | Triode region; | Vds<Vgs-Vth |
| 2. | Saturation region; | Vds>Vgs-Vth |
| 3. | Cut-off region; | Vgs<Vth |

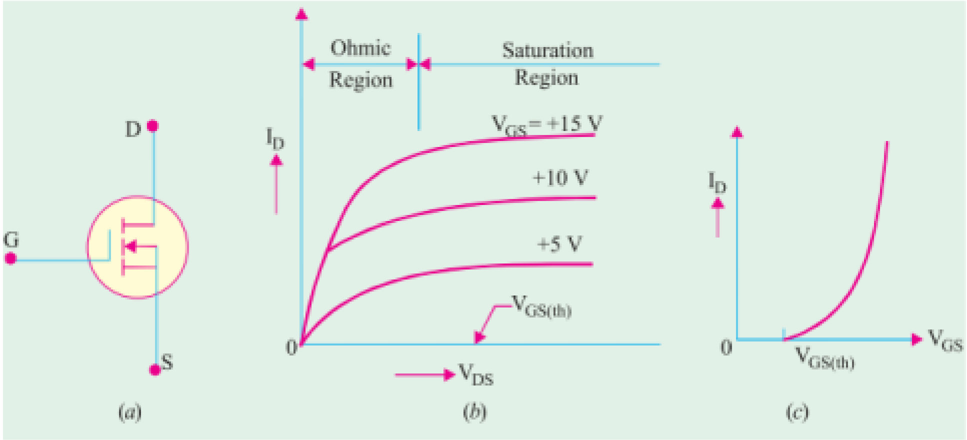


Figure 4.4: N channel MOSFET characteristic

### 4.6.1 Mosfet Driver

As stated in the previous section, it is beneficial to use N-channel MOSFETs as the high side switches as well as the low side switches because they have a lower ‘ON’ resistance and therefore less power loss. However, to do so, the drain of the high side device is connected to 340V DC power which is to be inverted into the 240V AC power. This is a problem because the 340V is the highest voltage in the system and in order for the switch to be turned on the voltage at the gate terminal must be 10V higher than the drain terminal voltage. Therefore, to drive MOSFETs in the H-Bridge

MOSFET driver IC is used with a bootstrap capacitor specifically designed for driving a half-bridge. After considering various IC options, the ideal choice was the IR2110, which is rated at 600V, with a gate driving current of 2A and a gate driving voltage of 10-20V. The turn on and turn off times are 120ns and 94ns respectively. F17/28234/2009 - 22 - The MOSFET driver operates from a signal input given from the microcontroller and takes its power from the battery voltage supply that the system uses. The driver is capable of operating both the high side and low side devices, but in order to get the extra 10V for the high side device, an external bootstrap capacitor is charged through a diode from the 18V power supply when the device is off. Because the power for the driver is supplied from the low voltage source, the power consumed to drive the gate is small. When the driver is given the signal to turn on the high side device, the gate of the MOSFET has an extra boost in charge from the bootstrap capacitor, surpassing the needed 10V to activate the device and turning the switch on.

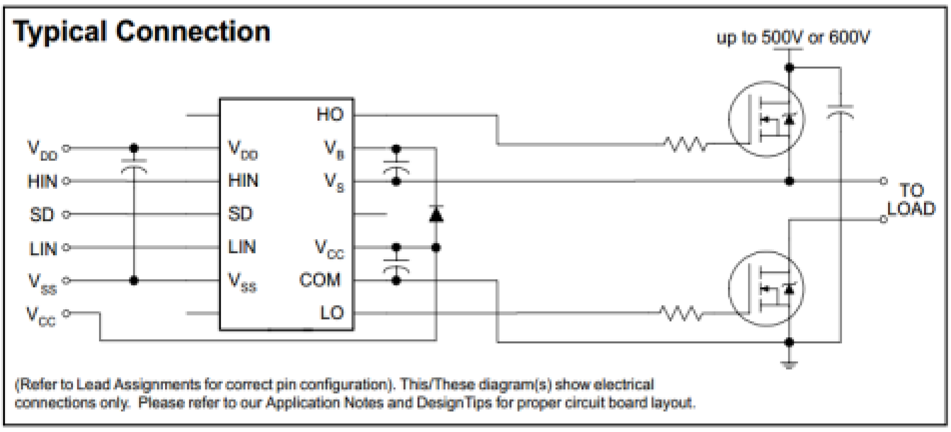


Figure 4.5: IR2110 connection

## 4.7 Bootstrap Capacitor

As shown in Figure the bootstrap diode and capacitor are the only external components strictly required for operation in a standard PWM application. Local decoupling capacitors on the VCC (and digital) supply are useful in practice to compensate for the inductance of the supply lines. The voltage seen by the bootstrap capacitor is the VCC supply only. Its capacitance is determined by the following constraints:

(i) Gate voltage required to enhance MGT
(ii) IQBS - quiescent current for the high-side driver circuitry
(iii) Currents within the level shifter of the control IC
(iv) MGT gate-source forward leakage current
(v) Bootstrap capacitor leakage current Factor

5 is only relevant if the bootstrap capacitor is an electrolytic capacitor, and can be ignored if other types of capacitor are used. Therefore it was ignored since only no electrolytic capacitors were used. The minimum bootstrap capacitor value was calculated from the following equation:

$$C \geq \frac{2\left[2Q_g + \frac{I_{qbs(max)}}{f} + Q_{Is} + \frac{I_{Cbs(leak)}}{f}\right]}{V_{cc} - V_f - V_{LS} - V_{Min}}$$

Where: Qg = Gate charge of high-side FET=63nC f = frequency of operation=5000Hz ICbs (leak) = bootstrap capacitor leakage current=250µA Iqbs (max) = Maximum VBS quiescent current=230µA VCC = Logic section voltage source=18V Vf = Forward voltage drop across the bootstrap diode=0.4V VLS = Voltage drop across the low-side FET or load=1.8V VMin = Minimum voltage between VB and VS=10V Qls = level shift charge required per cycle (typically 5nC for 500 V/600 V MGDs and 20nC for 1200 V MGDs) The values substituted into this equation were found either in driver datasheet for IR2110 IC or IRF840 MOSFET datasheet. Using these numbers minimum bootstrap capacitance value was calculated as

$$C \geq \frac{2\left[2 * 63 * 10^{-9} + \frac{230}{5000} * 10^{-6} + 5 * 10^{-9} + \frac{250}{5000} * 10^{-6}\right]}{18 - 0.4 - 1.8 - 10}$$

$$C \geq 0.078\mu F$$

The capacitor value obtained from the above equation is the absolute minimum required, however due to nature the bootstrap circuit operation, a low value of capacitor can lead to overcharging which could in turn damage the IC. Therefore to minimize the risk of overcharging and further reduce ripple on the Vds voltage the capacitor value obtained is multiplied by a factor of 15 to get a capacitor value of 1μF.

## 4.8 Bootstrap Diode

The bootstrap diode must be able to block the full voltage seen in the specific circuit and is about equal to the voltage across the power rail. The current rating of the diode is the product of gate charge times switching frequency. The high temperature reverse leakage characteristic of this diode can be an important parameter in those applications where the capacitor has to hold the charge for a prolonged period of time. For the same reason it is important that this diode have an ultra-fast recovery to reduce the amount of charge that is fed back from the bootstrap capacitor into the supply [18]. In order to improve decoupling a decoupling capacitors has to be connected directly across the VCC and COM pins as shown in fig.

## 4.9 Gate Resistor

Driving MOS-gated power transistors directly from the driver can result in unnecessarily high switching speeds. Increasing the value of the series gate resistor, results in a rapid decrease of the amplitude of the negative spike, while the turn-off time is a linear function of the series gate resistance. Selecting a resistor value just right from the “knee” in Figure 3.10 provides a good trade-off between the spike amplitude and the turn-off speed the di/dt may have to be reduced by reducing the switching speed by means of the gate resistor [18]. A graph of the negative spike and the turn-off time versus series gate resistance is shown in Figure 3.10. The layout should also minimize the stray inductance in the charge/discharge loops of the gate drive to reduce oscillations and to improve switching speed and noise immunity, particularly the “dV/dt induced turn-on”. For this design resistor values of 20 oh mswere chosen.

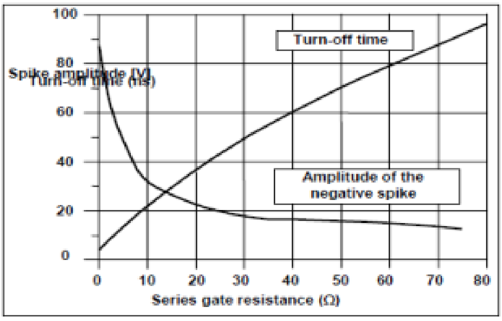


Fig 4.6: Series Gate Resistance vs. Amplitude of Negative Voltage Spike and Turn-off time

## 4.10 FILTER

In circuit theory, a filter is a network designed to pass signals having frequencies within certain bands (called pass bands) with little attenuation, but greatly attenuates signals within other bands (called attenuation bands or stop bands [19]. Ideally, a filter will not add new frequencies to the input signal, nor will it change the component frequencies of that signal, but it will change the relative amplitudes of the various frequency components and/or their phase relationships. The frequency-domain behavior of a filter is described mathematically in terms of its transfer function or network function. This is the ratio of the Laplace transforms of its output and input signals. The voltage transfer function H(s) of a filter can therefore be written as:

$$H(s) = \frac{Vout(s)}{Vin(s)}$$

To get an output of a pure sine wave we need a filter which will filter all the excess frequencies above cut-off frequency. Filters are classified as either passive or active. An active filter is easily reconfigurable and can have almost any frequency response desired. If the response is simply low pass/high pass/band pass behaviour with a set frequency, an active filter can be made to have a very sharp edge at the cut-off, resulting in enormous reductions in noise and very little attenuation of the signal. These, however, require op-amps capable of filtering a 240V RMS sine wave which are expensive, since the op-amp must be able to source hundreds of watts, and must be very large to do so without burning. Passive filter, Generally large in size and very resistive at low frequencies, these filters often seem to have more of a prototyping application, or perhaps use in a device where low cost is more important than efficiency. Given these choices, an application such as a high power sine inverter is left with only one viable option: the passive filter. This makes the design slightly more difficult to accomplish. Noting that passive filters introduce higher resistance at lower frequencies (due to the larger inductances, which require longer wires), the obvious choice is to switch at the highest possible frequency. The problem with this choice, however, is that the switching MOSFETs introduce more switching losses at higher frequencies. This would imply that we should switch slower to improve our switching efficiency, which contradicts the filter's need for a higher frequency.

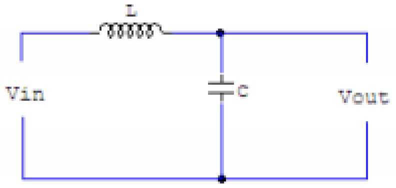


Figure 4.7: passive LC low pass filter

The circuit above shows a low pass passive filter which can be used in this design. This filter passes low frequency signals, and rejects signals at frequencies above the filter's cut-off frequency. Transfer function of the circuit is given by;

$$H(s) = \frac{\frac{1}{LC}}{S^2 + \frac{1}{LC}}$$

It is easy to see by inspection that this transfer function is a second order and by equating this equation with that of a standard second order

$$T(s) = \frac{Wc^2}{S^2 + Wc^2}$$

Cut-off frequency will be given by

$$Wc = \frac{1}{\sqrt{LC}}$$

$$fc = \frac{1}{2\pi\sqrt{LC}}$$

System response is as show in fig 3.12 below.

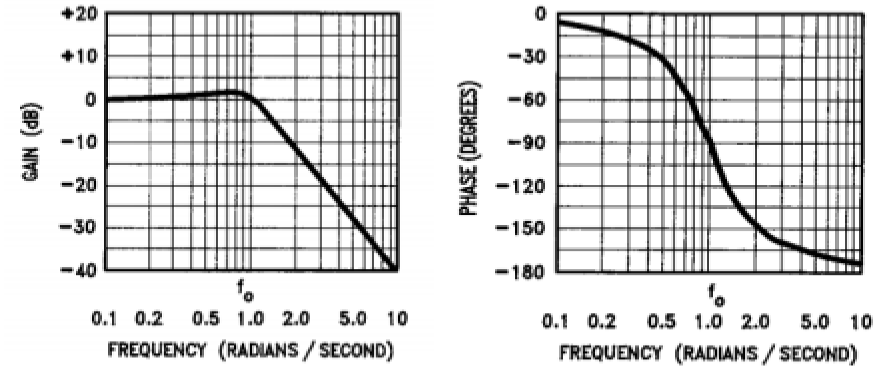


Figure 4.8: magnitude and phase response

The objective for this project was to bring the critical frequency as close as possible to the desired frequency of 50 Hz, removing other harmonics that crop up within the system. The issue with the filter is one of component size and availability. The slower the cut-off frequency, the greater the capacitance and inductance required to properly create the filter. Therefore, filter design becomes a trade-off between the effectiveness of the filter and the cost and size of the components.

## 4.11 Circuit Protection

MOSFETs turn OFF more slowly than they turn ON. If you attempt to turn on a high side MOSFET at the same time you're turning OFF a low-side MOSFET (or vice versa), you will wind up having both of them turned on at the same time, causing the dreaded "shoot-through" condition, which will lead to damage of the components [5]. For this reason one of the major factors in inverter device is its ability to protect itself from surges that could damage the circuitry. The IR2110 used in this design does not have built-in opt isolators hence it does not provide for "dead time" which is much needed in order to avoid short circuiting of the rail voltage. Another protection of the circuit needed is MOSFET gate protection, which employed a resistor between “gate” and “source”. It prevents accidental turn on of the MOSFET by external noise usually at start-up when the gate is floating. The MOSFET may sometimes turn on with a floating gate because of the internal drain to gate "Miller" capacitance. A gate to source resistor acts as a pull-down to ensure a low level for the MOSFET. The principle of operation is that when the parasitic capacitance of the circuit comes into play. The resistor creates an RC circuit complete with its time constant. And this RC delay the time the circuit switches ON just enough to allow the complementary part of the bridge circuit to switch OFF. typical values of this resistor a 1 kΩ, 10 kΩ, or 100 kΩ depending on the rail voltage of the h bridge.

1 The resistance needs to be low enough so that the gate is discharged in time, and can be held in the low state despite capacitive coupling from start-up transients. The gate of a FET has very high resistance and mostly looks capacitive. Even a large resistor can eventually discharge the gate capacitance. The limiting factor there is how fast the device might be turned off and then back on again. Usually this isn't the issue though. Keeping the gate low despite start-up transients is much harder to judge since it's almost impossible to know where these transients may be coming from and how strongly they will couple onto the gate node.

2. On the other end, pull-down resistor should not draw significant current that would otherwise go to driving the gate high quickly or at all.

A special kind of protection is also considered when dealing with inductive loads this is because an inductor cannot instantly stop conducting current; it must be dampened or diverted so that the current does not try to flow through the open switch. If not dampened the surges can cause trouble in the MOSFETs used to produce the output sine wave; when aMOSFET is turned off the inductive load still wants to push current through the switch, as it has nowhere else to go. This action can cause the switch to be put under considerable stress, the high dV/dt, dI/dt, V and I associated with this problem can cause the MOSFETs to malfunction and break. To combat this problem a zener diode is added across MOSFETswitches so that any large current surge it cannot handle gets passed through by the zener diode.

## 4.12 Physical Model Figure:

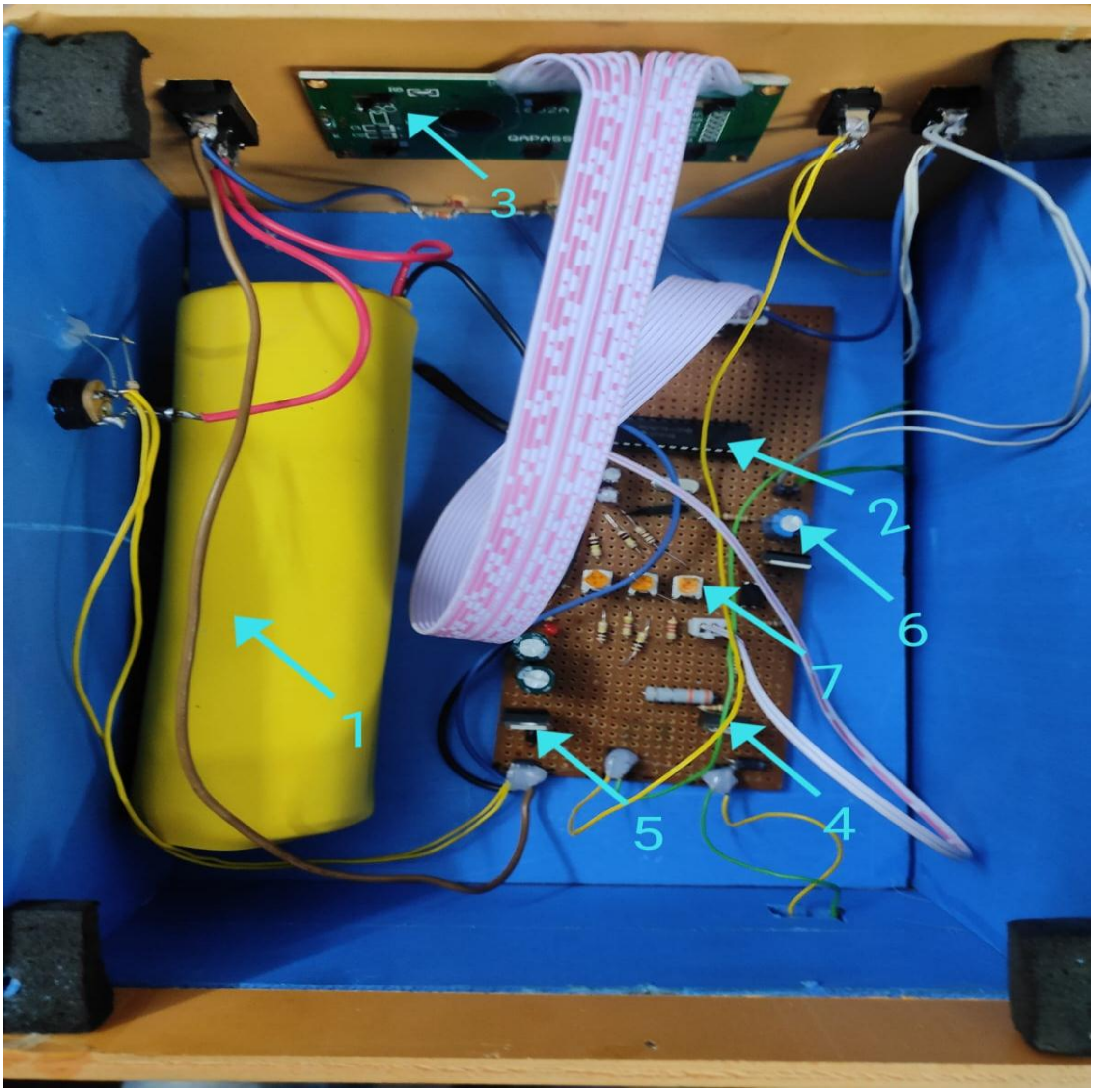


Figure 4.9: Physical model of solar Circuit board.

Figure 4.10: Physical model of solar panel

Figure 4.11: Physical model of solar Fan & Water pump

## 4.13 Panel Parts Name:

1. 12v DC Battery
2. Microcontroller PIC16F877A
3. LCD Display
4. N-Chanel mosfet
5. Variable resistor
6. Capacitor
7. Battery, Temperature, AMP sensor
8. Solar panel
9. Switch
10. Panel
11. Signal light
12. Fan
13. Water pump

# Chapter-5

# RESULT AND DISCUSSION

## 5.1 Description

Simulation of the inverter circuit is carried out using Proteus version 8.Various blocks of the circuit are interconnected and virtual instruments of the simulator used to observe and analyze results. Compiled hex file from micro pro is attached to the properties of the microcontroller. Pins 13 and 14 of the microcontroller are connected to 20MHz quartz crystal. A stable 5 volts to power the microcontroller is provided from the output of 7805 IC voltage regulator. The LED connected in pin 36 will light green to indicate when the inverter is on and switch of when it’s not working. Pins 34 and 35 outputs 50Hz square wave 180 degrees out of phase to drive one side of the H-bridge and pins 16 and 17 output pulse width modulated signal of 5KHz to drive the other side of H-bridge. During simulation IR2112 IC is used instead of IR2110 but there function is similar and they do operate the same way. Pins 10 and pin 12 receive logic inputs from the microcontroller to drive high side and low side Mosfet respectively. Signal from pin 12 is passed to pin 1 just as it is without being stepped up and from pin 1 is connected to low side Mosfet gate through a gate resistor. That from pin 10 is used to charge and discharge bootstrap capacitor which in turn provides the much needed high voltage to drive high side Mosfet through gate resistor. At the H-bridge rail voltage is provided equivalent to Vmax of the output RMS voltage needed. For this inverter a 240Vrms is the required hence Vmax is 240/√2 which is equal to 340V dc. Output of the H-bridge is a 3 level pulse with modulated signal centered at 0 voltages and with maximum voltage equal to rail voltage of H-bridge. This voltage is fed to a low pass passive filter made of inductor, capacitor and resistor. The inductor must be able to pass maximum current rated for the Mosfet and capacitor is able to handle the maximum voltage which is equal to the rail voltage. Across the output terminals of the filter is where we are now supposed to connect load. Different load types were connected and there results analyzed in the next section.

# RESULTS

## 5.2. Input and output data of solar panel

| Time | Voltage (V) | Current(mA) | Power (W) | Voltage (V) | Current(mA) | Power (W) | Temperature (TEMP) |
|---|---|---|---|---|---|---|---|
| 09:30 | 6.6 | 40.6 | 0.26796 | 6.7 | 81.3 | 0.54471 | 22°C |
| 09:50 | 6.7 | 53.5 | 0.35845 | 6.76 | 83.4 | 0.563784 | 22°C |
| 10:10 | 6.59 | 65.2 | 0.429668 | 6.67 | 88 | 0.58696 | 22°C |
| 10:30 | 6.68 | 75.1 | 0.501668 | 6.62 | 93.6 | 0.619632 | 23°C |
| 10:50 | 6.6 | 76.2 | 0.50292 | 6.63 | 93.4 | 0.619242 | 23°C |
| 11:10 | 6.67 | 79.6 | 0.530932 | 6.58 | 93.6 | 0.615888 | 23°C |
| 11:30 | 6.62 | 80.8 | 0.534896 | 6.6 | 91 | 0.6006 | 24°C |
| 12:50 | 6.64 | 100.5 | 0.66732 | 6.63 | 102.6 | 0.680238 | 25°C |
| 01:50 | 6.78 | 92 | 0.62376 | 6.65 | 93 | 0.61845 | 25°C |
| 02:30 | 6.82 | 87.5 | 0.59675 | 6.68 | 93.2 | 0.622576 | 26°C |
| 03:30 | 6.85 | 75.2 | 0.51512 | 6.72 | 88.5 | 0.59472 | 26°C |
| 03:50 | 6.87 | 65.5 | 0.449985 | 6.78 | 85.2 | 0.577656 | 26°C |

Fixed Tracking

Table 3: Input and output data of solar panel

In the morning, there is a12% increase in efficiency.

At mid-morning, there is a 6% increase in efficiency.

Since, the sun’s ray is starting to become orthogonal to the panel.

At this time both fixed and tracking panel are orthogonal to the sun’s rays.

Battery backup 1.30 hour to 2.00 hour.

# Chapter-6

# CONCLUSION AND SCOPE FOR FUTURE WORK

## 6.1 Conclusion:

By completing this project, we have achieved clear knowledge of comfort cooling system for humans by using non-conventional energy. This project would be fruitful in both domestic and industrial backgrounds. We also learned about non-conventional energy sources and utilization.

## 6.2 Scope For Future Work

This project although fulfilling our requirement has further scope for improvements. Some of the improvements that could be made in this solar air cooler unit are listed.

In future we can add in our system,

- Rh and Temperature monitoring system
- Rh and temperature control system
- Remote control system
- Or WIFI control system

## 6.3ADVANTAGES AND DISADVANTAGES

### 6.3.1 Advantages

- This system is ecofriendly in operation.
- It is portable, so it can be transferred easily from one place to other place.
- Non conversional source as fuel.
- Maintenance cost is low.
- More amount of energy is capture by auto tracking.

### 6.3.2 Disadvantages

- It does not purify air.
- Initial cost is high.
- Solar panel saves the energy during day only.

## 6.4 Applications

The solar air cooler is used in

- Home
- Industries
- Meeting halls
- Seminar halls
- By adding control circuit, we can maintain the room temperature at required level.

## 6.5 List of Components with Price

| Name | Quantity | Unit Price (TK.) | Total Price (TK.) |
|---|---|---|---|
| PIC 16F72 Microcontroller | 2 | 300 | 600 |
| 2w Solar Panel | 4 | 75 | 300 |
| Transformer | 1 | 800 | 800 |
| 4V Pencil Battery | 6 | 85 | 510 |
| fan | 2 | 700 | 700 |
| 5V Voltage Regulator | 5 | 100 | 500 |
| Display | 2 | - | 550 |
| Display | 2 | - | 550 |
| Resistor, Capacitor | - | - | 100 |
| Relay, Diode | - | - | 100 |
| Variable, Shunt Resistor | - | - | 100 |
| Water pump | - | - | 200 |
| ON/OFF Switch | 1 | 25 | 25 |
| Structural Cost | - | - | 1100 |
| Wires and connections | - | - | 150 |
| Circuit Boards | 7 | - | 220 |
| Others | - | /- | 1000 |
| Total Cost | | | 6955/- |

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# Appendix

## Programming code

```
#include <16F73.h>
#fuses NOWDT, HS, PROTECT, NOBROWNOUT, NOPUT
#use delay (clock = 16000000)
#include <flex2_lcd.c>
#rom 0x3ff={0x3444}
#byte PORTA = 0x05
#byte PORTB = 0x06
#byte PORTC = 0x07
#byte TRISA = 0x85
#byte TRISB = 0x86
#byte TRISC = 0x87
#define SPORTA PORTA
#define SPORTB PORTB
#define SPORTC PORTC
void setup(void);
void SETTINGS(void);
void LOD_CTRL(void);
voidadc_read(void);
voidlcd_show(void);
unsigned int1 UP=0,DN=0,SET=0,TOG;
floattp=0,TF=0;
//////////////////////////////////////////////////////////////////////////////////
//////////////////////////////////////////////////////////////////////////////////
void main()

{
setup();
while(1)
 {
  LOD_CTRL();
  //////////////////////////////////
  TCNT++;
if(TCNT > 50)
  TCNT=0;
  COUNT++;
if(COUNT > 250)
{
COUNT1++;COUNT =0;
adc_read();
}
if(COUNT1 > 50)
{ COUNT1 =0;TOG ^=1;lcd_show(); }
 }
}
```

```
////////////////////////////////////////////////////////////////////////////////
////////////////////////////////////////////////////////////////////////////////
void setup()
{
TRISA=0b11111111;
TRISC=0b00000000;
TRISB=0b00000000;
setup_adc(ADC_CLOCK_DIV_32);
}
////////////////////////////////////////////////////////////////////////////////
voidadc_read(void)
{
set_ADC_channel(0);
delay_ms(1);
tp = read_adc();
tp = tp * 0.2;
   TF=  1.8 * tp +32;

set_ADC_channel(1);
delay_ms(1);
LDR = read_adc();
}
////////////////////////////////////////////////////////////////////////////////
void LOD_CTRL(void)
{
if( TP > 27 )
  {
output_high(FAN1);
  }
if( TP > 28 )
  {

output_high(FAN2);
  }
if( TP < 27 )
output_LOW(FAN1);
output_LOW(FAN2);
  }
if( TP > 40 )
{
unsignedinti=0;
for(i=0;i<10;i++)
{
adc_read();
lcd_show();

output_HIGH(BUZ);
delay_ms(100);
output_LOW(BUZ);
delay_ms(100);
```

```
}

 ////////////////////////////////////

IF(PRESENT >= 1 )
 {
if( LDR < 40 )
{
if(COUNT ==2 )
 {
if( LDR > 30 )
 OCR++;
if( LDR < 30 )
OCR—

IF(OCR > 48) {OCR=48;PF=1;}
IF(OCR < 2)  {OCR=2;PF=0;}
 }

IF(TCNT > OCR)
{ output_HIGH(LOD1);output_HIGH(LOD2);}
ELSE
{ output_LOW(LOD1);output_LOW(LOD2);}
 }
 ELSE
{ output_LOW(LOD1);output_LOW(LOD2);}
 }
 ELSE
{ output_LOW(LOD1);output_LOW(LOD2);}

 ////////////////////////////////////
}
////////////////////////////////////

4void lcd_show(void)
{
lcd_gotoxy(1,1);
printf(lcd_putc, "T:%2.1f%cC  ",TP,223);
lcd_gotoxy(10,1);
printf(lcd_putc, "P:%3u ",PRESENT);

lcd_gotoxy(1,2);
printf(lcd_putc, "IN:%3u  OUT:%3u  ",IN,OUT);
 //printf(lcd_putc, "IN:%3u  OUT:%3u  ",IN,LDR);
}
//////////////////////////////////////////////////////////////////////////////
```