FORCED CONVECTIVE COOLING SYSTEM WITH TEMPERATURE AND HUMIDITY CONTROL

A report submitted to the Department of Mechanical, Sonargaon University of Bangladesh in partial fulfillment of the requirements for the Award of Degree of Bachelor of Science in Mechanical Engineering.

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ABSTRACT

The forced convective cooling system with temperature and humidity control is an advanced cooling solution designed to provide efficient and sustainable climate regulation in various environments. By leveraging the natural cooling effect of water evaporation, the system maintains optimal temperature and humidity levels, ensuring comfort and energy efficiency. The system integrates sensors to monitor real-time temperature and humidity, enabling precise control and adaptability to environmental changes. Advanced controllers and feedback mechanisms automate the cooling process, enhancing performance while minimizing water and energy consumption. This technology is particularly effective in arid and semi-arid regions, where it offers a cost-effective alternative to traditional air conditioning systems. Its applications range from residential and commercial buildings to agricultural and industrial settings. The system's eco-friendly design reduces greenhouse gas emissions and supports sustainable cooling practices, addressing the growing need for energy-efficient climate control solutions in the face of global environmental challenges.

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CHAPTER 1
INTRODUCTION

1.1 Introduction

Forced convective cooling system with temperature and humidity control cooling is a physical phenomenon in which evaporation of a liquid, typically into surrounding air, cools an object or a liquid in contact with it [1-4]. Forced convective cooling occurs when air, that is not too humid, passes over a wet surface, the faster the rate of evaporation the greater the cooling. It brings the comfort by increasing the humidity in dry climates, improves the air quality, and makes the air more breathable. The most familiar example of this is cooling effect of evaporating perspiration on the human skin. In dry hot climates body temperature is partially controlled by the rapid evaporation of perspiration from the surface of the skin. [2-5] the evaporation rate is raised as air movement is increased. Both of these facts can be applied to natural cooling of structures. This evaporation results in a reduced temperature and an increased vapor content in the air. The bigger the area of contact between the air and water the more evaporation occurs, resulting in more cooling and the addition of moisture. [6-8].

In the fundamental basis for understanding any air conditioning, dehumidification and forced convective cooling is psychometrics. It consists of the interaction between heat, moisture and air. It is basically the study of air water mixture and is an essential foundation for understanding how to change air from one condition to another to rises its capacity to hold moisture. This makes moisture a very influential factor for heat gain, both for comfort and in calculation. The knowledge of the system consisting of a dry air and water vapor is essential for the design and analysis of air conditioning devices, cooling towers and industrial processes which requiring close control of the vapor content in air. Air moisture and heat interaction fortunately, this interaction can be combined in a single chart. This rate of evaporation of water purely depends on the temperature humidity of the air as well as the pressure of the particular place. Hence, sweat accumulates more on hot humid days in which the perspiration is impossible to evaporate. Energy demand worldwide for building cooling has increased sharply in the last few decades, which has raised concerns over depletion of energy resources and contributing to global warming. Current energy demand estimates stand at between 40 and 50% of total primary power consumption. In hot climate countries, the

highest share of building energy use is mainly due to space air conditioning using traditional HVAC systems [8-10].

1.2 Objective

The objectives of this project are:

- To study about f**orced convective cooling system with temperature control.**
- To manufacture cost effective **forced convective cooling system with temperature control.**
- To implement a **forced convective cooling system with temperature control.**
- To test the performance of the cooling system.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter is arranged on Literature Review. Here's a look at some of last year's literature, like our project. By reading them, we can overcome the mistakes of the previous project and make a more effective project.

2.2 Literature Review

JOURNAL OF ENVIRONMENTAL RESEARCH AND DEVELOPMENT "Design of Air Cooling System for College Auditorium",S.S. Wane and M.B. Nagadeve, Dr. Punjabrao Deshmukh Krushi Vidhyapeeth, Akola Maharashtra: In this paper we are going to explain the design of centralized air cooling system for college auditorium. The present building of college auditorium posed the problem of ill-ventilated atmosphere and suffocation in most of its part during the programs. Major part of the building exposed to the sun the roof being heated throughout the day. The object of air cooling is to establish a stable thermal environment which satisfies the majority of occupants with respect to comfort under all the climatic conditions to which the building is subjected.

Hence it was decided to provide the false ceiling and design air cooling system for college Auditorium for better comforts to the occupants during longer program. For the cooling system of auditorium requires two coolers with water requirement is estimated as 8 lit/sec and power requirement is 120 Watts. Solar and transmission heat gain through walls and roofs etc. Solar and transmission heat gain through doors, windows or wall glasses. Transmission gain through partition wall ceiling floor etc. Infiltration of direct air from some inlets like doors or windows. Internal heat gains from occupants, light appliances etc. Additional heat gains not accounted above, safety factors etc. Return duct heat gains, supply duct leakage, heat gain from door, fan and pump. [1]

INTERNATIONAL JOURNAL OF EMERGING TECHNOLOGY AND ADVANCED ENGINEERING "Design Optimization and Installation of the Evaporative Cooler.", Md. Almost Asim Mahmud, Dr. Md. Alamgir Hossain, M.A. Muktadir: This Evaporative cooling is an environmentally friendly air cooling system that operates using

induced processes of heat and mass transfer, where water and air are the working fluids. It consists, specifically, in water evaporation, induced by the passage of an air flow, thus decreasing the air temperature.

In Bangladesh, Evaporative cooler is already being used in different industries that is imported from varies countries. But most of the cases these are not efficient due to installation error & lack of adjustment with climate change over the year. Initially this paper presents the construction of an evaporative cooler using a test bench of cooling tower for the air flow and water supply facility where local materials were used as evaporative pad. Afterwards; it presents installation in different situation & adjustment of the cooling units with the climate. It concludes that under proper installation, evaporative cooling system is very cost effective & has a very large potential to propitiate thermal comfort and can still be used as an alternative to conventional systems in regions where the design wet bulb temperature is low. [2]

DESIGN OF AN AIR DISTRIBUTION SYSTEM FOR A MULTI-STORY OFFICE BUILDINGBy- Dave janquart: Earlier the use of air conditioning for comfort purpose was considered to be expensive, but now-a-day, it has been a necessity for all human beings. Window air conditioners, split air conditioners are used in small buildings, offices etc. But, when the cooling load required is very high such as big buildings, multiplex, multi-story buildings, hospitals etc. centralized unit (central air conditioners) used. The central AC's systems are installed away from building called central plant where water or air is to be cooled. This cooled air not directly supplied to the building rooms. When the cooled air cannot be supplied directly from the air conditioning equipment to the space to be cooled, then the ducts are provided. The duct systems carry the cooled air from the air conditioning equipment for the proper distribution to rooms and also carry the return air from the room back to the air conditioning equipment for recirculation.

When ducts are not properly designed, then it will lead to problem such as frictional loss, higher installation cost, increased noise and power consumption, uneven cooling in the cooling space. For minimizing this problem, a proper design of duct is needed. Equal friction method is used to design the duct, which is simple method as compared with the other design methods. The duct design for TIIR building is done, by using equal friction method. All

values are comparable with duct software called ductular. The calculated value of frictional is less or near as calculated by software. Due to less value of friction drop, duct diameter is increased but loss in total pressure (i.e. static pressure, velocity pressure) can be avoided. Due to increased duct diameter the use of damper may be decreased. Also the circular duct can carry more air in less space, because of that, less duct material, less duct surface friction and less insulation is required. Pressure loss in duct fitting can be minimized by proper design the elbow shape. Ansys 13.0 software is used to analyze the pressure loss in circular and rectangular duct. After analysis we conclude that the circular duct has minimum friction loss, so it is better shape for ducting. [3]

2.3 Summary

The above has been discussed in detail in the past few literature's which has given us a lot of motivation to do this project.

CHAPTER 3

METHODOLOGY

3.1 History

This forced convective cooling system is so effective and safe process. It is mainly used in home, hospital, factory and industrial area. After it used, we reduce the cost of money to cool air. That's way we get good efficiency. Where very cost effective to buy air-condition but our system is reducing the cost. This machine is very easy to use and it works very effectively. A working procedure relevant image is added below –

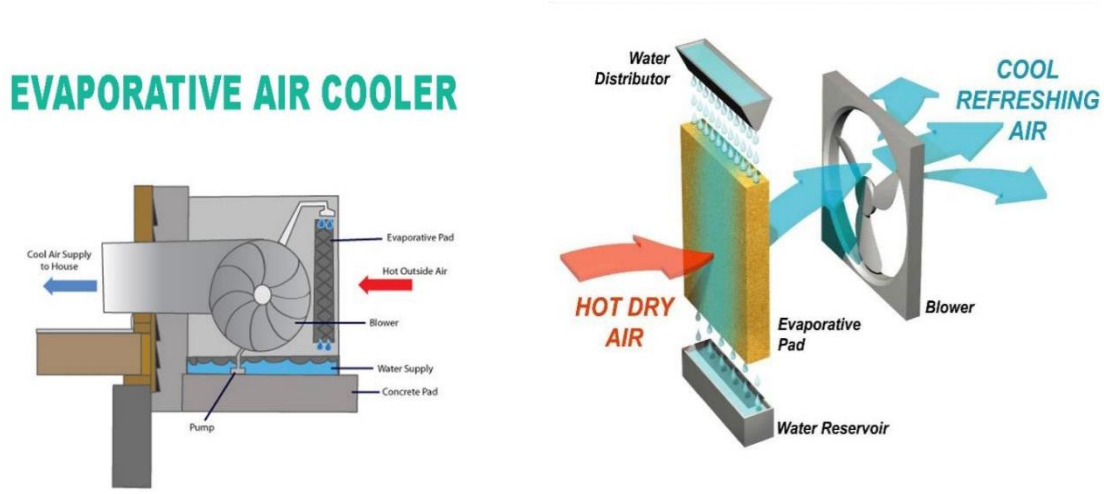


Figure 3.1: Forced convective cooling system with temperature and humidity control Cooling Working Principle.

3.2 PRINCIPLES OF FORCED CONVECTIVE COOLING SYSTEM WITH TEMPERATURE AND HUMIDITY CONTROL

When trying to understand forced convective cooling, it may be the best to think of air as being like a sponge or cooling pads, in that regard, air has an ability to absorb moisture that it come in contact with. The amount of moisture that the air will absorb depends on the state of air and the temperature of the air. If the air is warm and contains only a small amount of moisture, it will more radially absorb moisture. As air cools, it volumes decreases, and with it, its ability to absorb moisture decreases. Cooling through evaporation is a natural occurrence and the most common we all experiences is perspiration, or sweat as perspiration evaporates, it absorbs the heat to cool our body. It is a heat and mass transfer process that

requires water for evaporation for the coolness in which heat is transferred from air to water and simultaneously the temperature of air decreases [7-9].

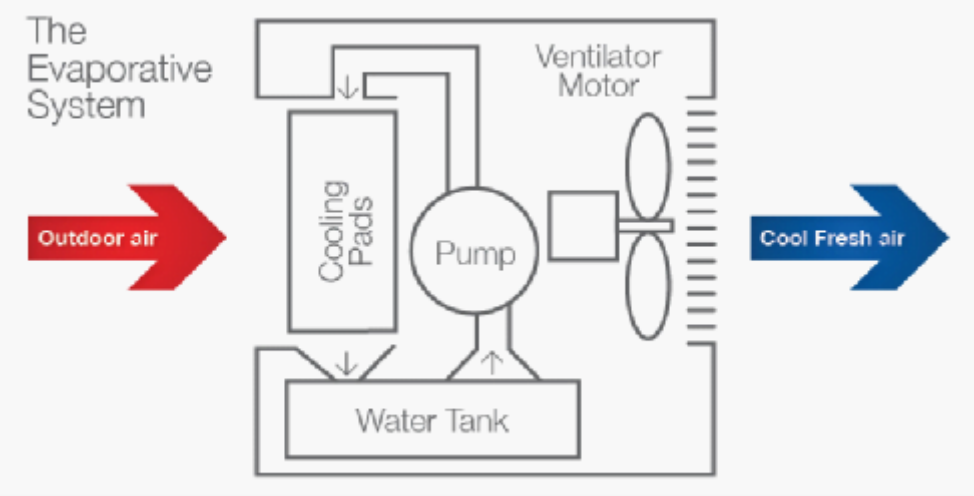


Figure 3.2: Working Principle of Forced convective cooling system with temperature and humidity control Cooling System

The principle underlying forced convective cooling is the facts that water must have heat applied to it to change from liquid to vapor. When evaporation occurs, this heat is taken from the water that remains in the liquid state, resulting in a cooler liquid. The evaporative coolers are classified as:

1] Direct Evaporative [Working fluid as water and air in direct contact]
2] Indirect Evaporative cooler [Surface plates separates the working fluid].
3] Combination of both the Direct and Evaporative Coolers [With different cooling cycles [1]

3.3 Methodology

- Creating an idea for design and construction of a forced convective Cooling System with Temperature control, with the combination of Arduino micro controller.
- And designing a block diagram & circuit diagram to know which components we need to construct it. Collecting all the components and programming the micro controller to control the whole system.
- Setting up all the components in a PCB board & then soldering. Lastly, assembling all the blocks in a board and to run the system & for checking purposes.

CHAPTER 4

DESIGN

4.1 Circuit Diagram:

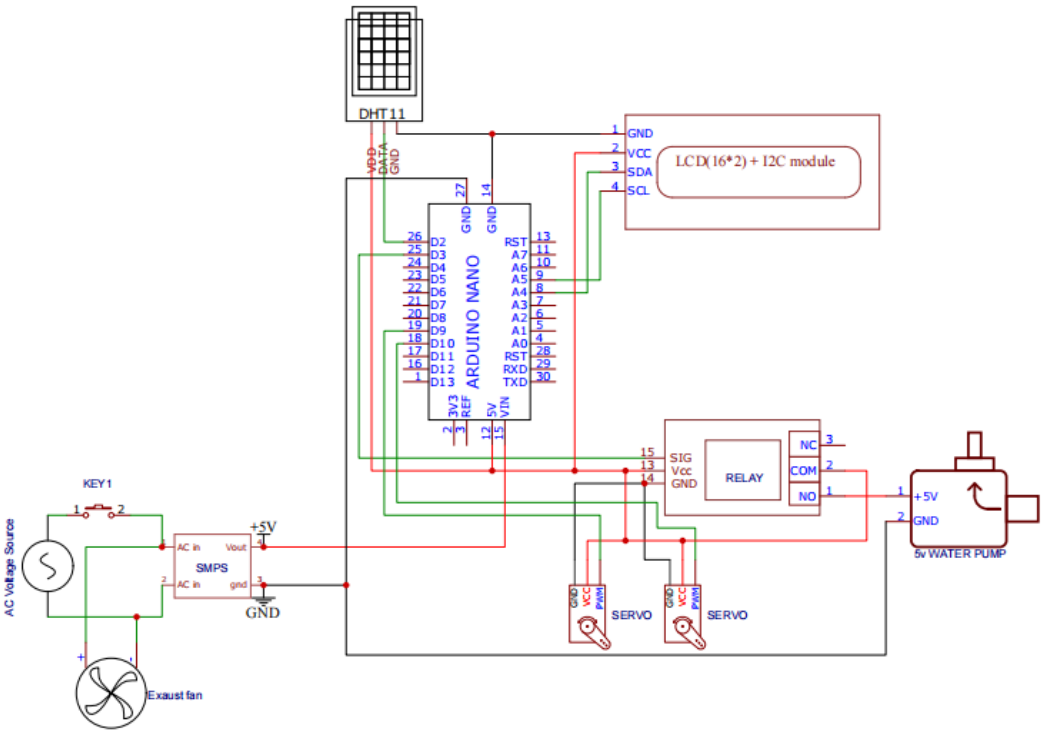


Figure 4.1: Circuit Diagram

4.2 Working Principle

The Forced convective cooling system with temperature and humidity control cooling system uses an Arduino Nano as the control unit to regulate temperature and humidity. A temperature sensor continuously monitors the environment, while a humidity sensor tracks moisture levels. Based on the data, the Arduino activates components like the DC pump motor, which circulates water to keep the evaporator pad moistair passes through the wet evaporator pad, where water evaporation cools and humidifies the air. A cooling fan ensures efficient air circulation, distributing cooled air into the environment. The system uses a relay module to control the fan and pump motor, while a servo motor adjusts airflow by opening or closing a vent.

The LCD display shows real-time temperature and humidity readings, ensuring user awareness and easy monitoring. A SMPS (Switched-Mode Power Supply) powers all components, providing efficient energy conversion. This setup ensures effective climate control, ideal for energy-efficient cooling in dry climates.

4.3 Components List:

1. SMPS (Switch Mood Power Supply)
2. DC Pump Motor
3. Evaporator Pad
4. Arduino Nano
5. Cooling Fan
6. Temperature Sensor
7. Servo Motor
8. LCD Display

4.4 Cost Analysis:

No	Product Name	Specification	Qty	Unit Price	Total Price	Market Price
01.	SMPS	5V 7Amp	1	480	480	
02.	Pump	DC	1	150	150	
03.	Evaporator	Pad	1	1100	1100	
05.	Blower Fan	12V DC	1	850	850	
06.	Others				1500	
					4080/=	5500/=

CHAPTER 5
CONSTRUCTION

5.1 Switch Mode Power Supply (SMPS):

A switched-mode power supply (switching-mode power supply, SMPS, or switcher) is an electronic power supply that incorporates a switching regulator to convert electrical power efficiently. Like other power supplies, an SMPS transfers power from a DC or AC source (often mains power) to DC loads, such as a personal computer, while converting voltage and current characteristics.

Unlike a linear power supply, the pass transistor of a switching-mode supply continually switches between low-dissipation, full-on and full-off states, and spends very little time in the high dissipation transitions, which minimizes wasted energy. A hypothetical ideal switched-mode power supply dissipates no power. Voltage regulation is achieved by varying the ratio of on-to-off time (also known as duty cycles). In contrast, a linear power supply regulates the output voltage by continually dissipating power in the pass transistor. This higher power conversion efficiency is an important advantage of a switched-mode power supply. Switched-mode power supplies may also be substantially smaller and lighter than a linear supply due to the smaller transformer size and weight.



Figure 5.1: SMPS

Switching regulators are used as replacements for linear regulators when higher efficiency, smaller size or lighter weight are required. They are, however, more complicated; their switching currents can cause electrical noise problems if not carefully suppressed, and simple designs may have a poor power factor.

12V 5A Industrial SMPS Power Supply – 60W – DC Metal Power Supply – Good Quality – Non Waterproof with Aluminum casing.

- Input Voltage: AC 100 – 264V 50 / 60Hz
- Output Voltage: 12V DC, 0-5A
- Output voltage: Adjustment Range: ±20%
- Protections: Overload / Over Voltage / Short Circuit
- Auto-Recovery After Protection
- Universal AC input / Full range
- 100% Full Load Burn-in Test
- Cooling by Free Air Convection
- High Quality and High Performance
- LED power supply with a metal body for hidden installation for LED lighting
- Design with Built-in EMI Filter, improve signal precision.
- Certifications: CE & RoHs
- No Minimum Load.
- Compact Size Light Weight.
- High Efficiency, Reliability & low energy consumption
- Category – Switch Mode Power Adaptor (SMPS)

Switched-mode power supplies are classified according to the type of input and output voltages. The four major categories are:

- AC to DC
- DC to DC
- DC to AC
- AC to AC

A basic isolated AC to DC switched-mode power supply consists of:

- Input rectifier and filter
- Inverter consisting of switching devices such as MOSFETs
- Transformer
- Output rectifier and filter
- Feedback and control circuit

The input DC supply from a rectifier or battery is fed to the inverter where it is turned on and off at high frequencies of between 20 KHz and 200 KHz by the switching MOSFET or power transistors. The high-frequency voltage pulses from the inverter are fed to the transformer primary winding, and the secondary AC output is rectified and smoothed to produce the required DC voltages. A feedback circuit monitors the output voltage and instructs the control circuit to adjust the duty cycle to maintain the output at the desired level.

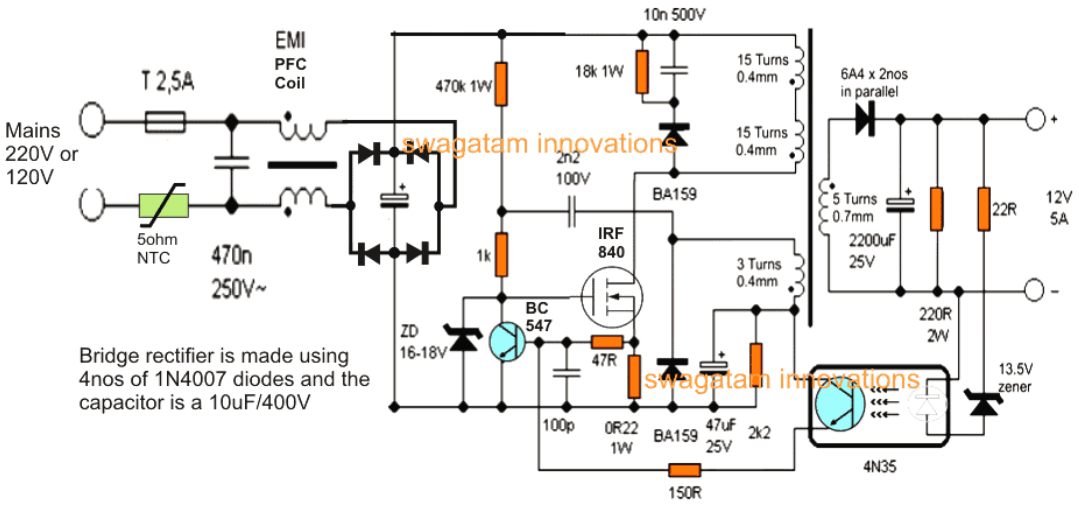


Figure 5.2: SMPS Circuit Design

Basic working concept of an SMPS

A switching regulator does the regulation in the SMPS. A series switching element turns the current supply to a smoothing capacitor on and off. The voltage on the capacitor controls the time the series element is turned. The continuous switching of the capacitor maintains the voltage at the required level.

Design basics

AC power first passes through fuses and a line filter. Then it is rectified by a full-wave bridge rectifier. The rectified voltage is next applied to the power factor correction (PFC) pre-regulator followed by the downstream DC-DC converter(s). Most computers and small appliances use the International Electro technical Commission (IEC) style input connector. As for output connectors and pin outs, except for some industries, such as PC and compact PCI, in general, they are not standardized and are left up to the manufacturer.

There are different circuit configurations known as topologies, each having unique characteristics, advantages and modes of operation, which determines how the input power is transferred to the output. Most of the commonly used topologies such as fly back, push-pull, half bridge and full bridge, consist of a transformer to provide isolation, voltage scaling, and multiple output voltages. The non-isolated configurations do not have a transformer and the power conversion is provided by the inductive energy transfer.

Advantages of switched-mode power supplies:

- Higher efficiency of 68% to 90%
- Regulated and reliable outputs regardless of variations in input supply voltage
- Small size and lighter
- Flexible technology
- High power density

Disadvantages:

- Generates electromagnetic interference
- Complex circuit design
- Expensive compared to linear supplies

Switched-mode power supplies are used to power a wide variety of equipment such as computers, sensitive electronics, battery-operated devices and other equipment requiring high efficiency.

Switch Mode Power Supply

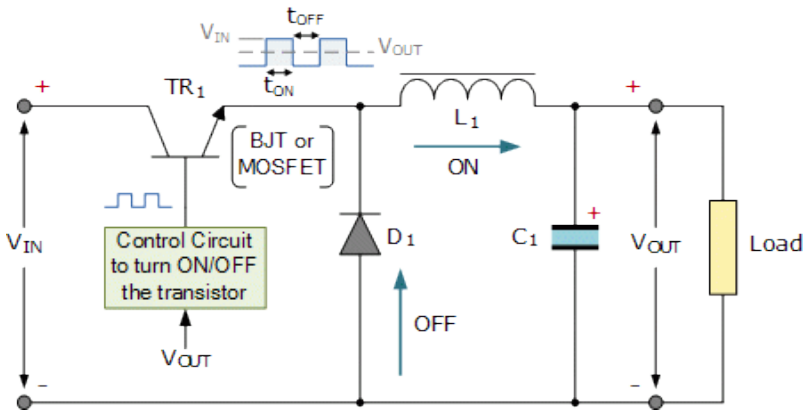


Figure 5.3: Power Supply Connection

Linear voltage IC regulators have been the basis of power supply designs for many years as they are very good at supplying a continuous fixed voltage output. Linear voltage regulators are generally much more efficient and easier to use than equivalent voltage regulator circuits made from discrete components such a zener diode and a resistor, or transistors and even op-amps. The most popular linear and fixed output voltage regulator types are by far the 78… positive output voltage series, and the 79 negative output voltage series. These two types of complementary voltage regulators produce a precise and stable voltage output ranging from about 5 volts up to about 24 volts for use in many electronic circuits.

There is a wide range of these three-terminal fixed voltage regulators available each with its own built-in voltage regulation and current limiting circuits. This allows us to create a whole host of different power supply rails and outputs, either single or dual supply, suitable for most electronic circuits and applications. There are even variable voltage linear regulators available as well providing an output voltage which is continually variable from just above zero to a few volts below its maximum voltage output.

Most D.C. power supplies comprise of a large and heavy step-down mains transformer, diode rectification, either full-wave or half-wave, a filter circuit to remove any ripple content from the rectified D.C. producing a suitably smooth D.C. voltage, and some form of voltage regulator or stabilizer circuit, either linear or switching to ensure the correct regulation of the power supplies output voltage under varying load conditions. Then a typical D.C. power supply would look something like this:

Typical DC Power Supply

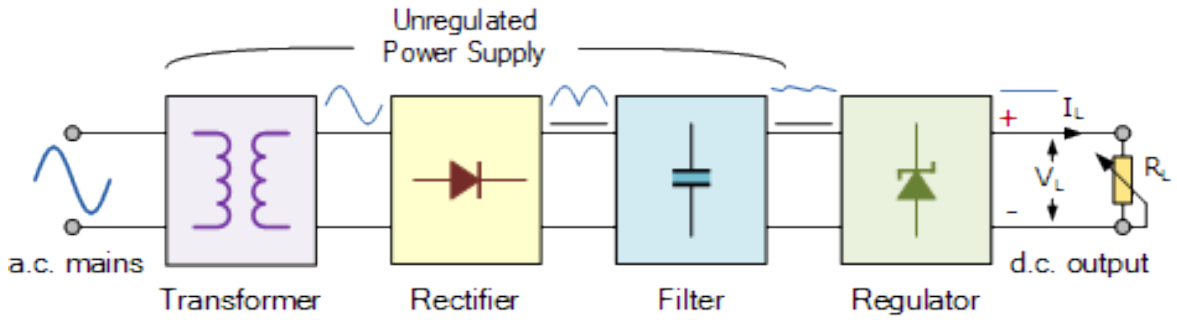


Figure 5.4: DC Power Supply Step

These typical power supply designs contain a large mains transformer (which also provides isolation between the input and output) and a dissipative series regulator circuit. The regulator circuit could consist of a single zener diode or a three-terminal linear series regulator to produce the required output voltage. The advantage of a linear regulator is that the power supply circuit only needs an input capacitor, output capacitor and some feedback resistors to set the output voltage.

5.2 Evaporator Pad

An evaporator pad is a key component used in cooling systems, particularly in evaporative coolers and humidifiers. It is designed to enhance the efficiency of the cooling process by allowing water to spread evenly across its surface. Typically made from materials like cellulose, aspen wood fibers, or synthetic polymers, the pad is structured in a honeycomb or corrugated pattern to maximize surface area for water absorption and air contact. When warm air passes through the moistened pad, the water evaporates, absorbing heat from the air and reducing its temperature. This process not only cools but also humidifies the air, making evaporator pads ideal for use in hot and dry climates. Durable and efficient, these pads require regular maintenance to prevent mineral buildup and ensure optimal performance. Properly maintained evaporator pads contribute significantly to energy-efficient, eco-friendly cooling solutions in residential, commercial, and agricultural applications.

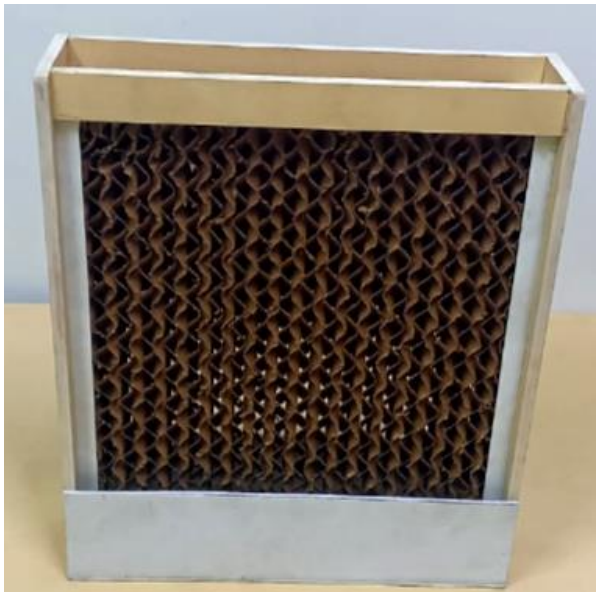


Figure 5.5: Evaporator Pad

Features

- Designed to absorb and retain water efficiently for effective cooling.
- Honeycomb or corrugated structure maximizes surface area for water evaporation and air interaction
- Constructed from cellulose, aspen wood fibers, or synthetic polymers for longevity and robustness.
- Supports energy-efficient cooling without the use of harmful refrigerants.
- Adds moisture to the air, making it suitable for dry climates.

5.3 Pump Motor

Introduction

This is a low cost, small size Submersible Pump Motor which can be operated from a 2.5 ~ 6V power supply. It can take up to 120 litters per hour with very low current consumption of 220mA. Just connect tube pipe to the motor outlet, submerge it in water and power it. Make sure that the water level is always higher than the motor. Dry run may damage the motor due to heating and it will also produce noise.



Figure 5.6: Pump Motor

Feature:

- Operating Current: 130 ~ 220mA
- Flow Rate: 80 ~ 120 L/H
- Maximum Lift: 40 ~ 110 mm
- Continuous Working Life: 500 hours
- Driving Mode: DC, Magnetic Driving
- Material: Engineering Plastic
- Outlet Outside Diameter: 7.5 mm
- Outlet Inside Diameter: 5 mm

5.4 Cooling Fan

A fan is a powered machine used to create a flow of air. A fan consists of a rotating arrangement of vanes or blades, which act on the air. The rotating assembly of blades and hub is known as an impeller, rotor, or runner. Usually, it is contained within some form of housing, or case.



Figure 5.7: Cooling Fan

Feature

- Operation Humidity - 0%~95%
- Insulation Grade - According to IEC61858 Grade F
- Voltage V - 220/230
- Frequency Hz - 50/60
- Current - 0.12/0.10
- Power(W) - 19/14
- Speed(R/Min) - 2500/2700

5.5 Arduino Nano

Arduino is open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It's intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments. Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling Lights, motors, and other actuators.

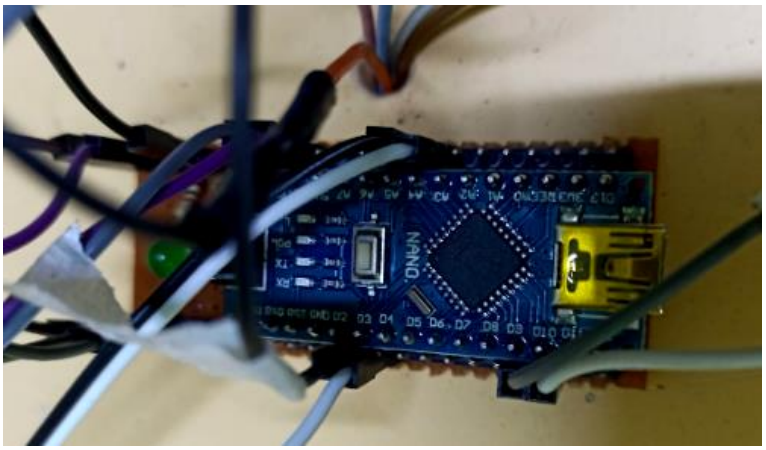


Figure 5.8: Arduino Nano

The micro-controller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software on running on a computer (e.g. Flash, Processing, Maxims'). Arduino Nano is a surface mount breadboard embedded

version with integrated USB. It is a small, complete, and breadboard friendly component. It has everything that Decimal/ Duemilanove has (electrically) with more analog input pins and onboard +5V AREF jumper. Physically, it is missing power jack. The Nano can automatically sense and switch to the higher potential source of power.

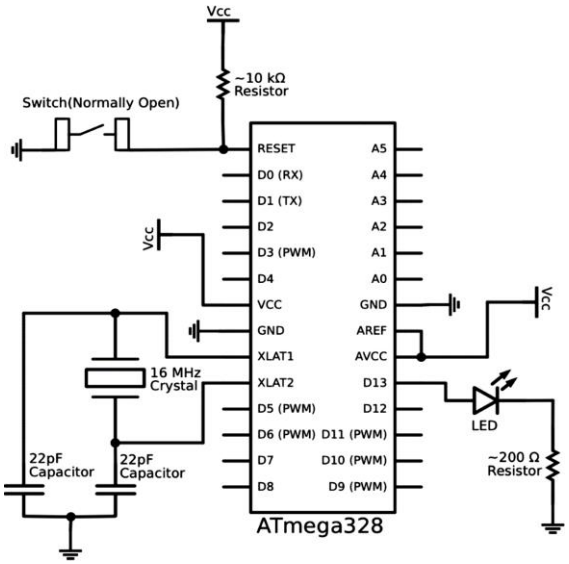


Figure 5.9: Arduino Nano Schematic Diagram

Nano's got the breadboard-ability of the Boarding and the Minibus with smaller footprint than either, so users have more breadboard space. It's got a pin layout that works well with the Mini or the Basic Stamp (TX, RX, ATN, and GND on one top, power and ground on the other). This new version 3.0 comes with ATMEGA328 which offer more programming and data memory space. It has two layers. That make it easier to hack and more affordable. One of the best features of Arduino Nano is, it's easy to use, compact and also small.

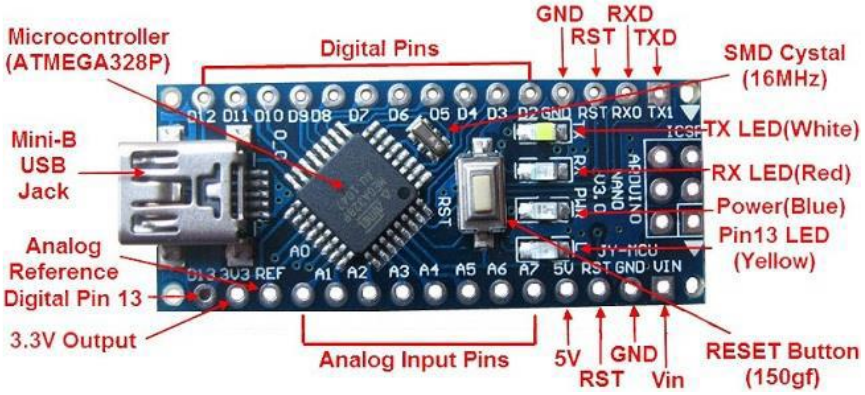


Figure 5.10: How Arduino Nano looks like

Specifications:

- Micro-controller: Atmel ATmega328
- Operating Voltage (logic level): 5 V
- Input Voltage (recommended): 7-12 V
- Input Voltage (limits): 6-20 V
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins: 8
- DC Current per I/O Pin: 40 mA
- Flash Memory: 32 KB (of which 2KB used by boot loader)
- SRAM: 2 KB
- EEPROM: 1 KB
- Clock Speed: 16 MHz
- Dimensions: 0.70” x 1.70”

Features:

- Automatic reset during program download
- Power OK blue LED
- Green (TX), red (RX) and orange (L) LED
- Auto sensing/switching power input
- Small mini-B USB for programming and serial monitor
- ICSP header for direct program download
- Manual reset switch

Micro-controller IC ATmega328p

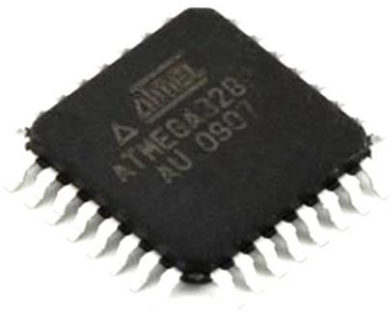


Figure 5.11: Micro-controller IC AT mega 328p

The high-performance Microchip Pico Power 8-bit AVR RISC-based micro-controller combines 32KB ISP flash memory with read-while-write capabilities, 1024B EEPROM, 2KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, a 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts. By executing powerful instructions in a single clock cycle, the device achieves throughput's approaching 1 MIPS per MHz, balancing power consumption and processing speed.

5.6 Temperature Sensor

The DHT11 is a basic, ultra-low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed). It's fairly simple to use, but requires careful timing to grab data.



Figure 5.12: DHT11 Temperature Sensor

DHT11 Specifications:

- Operating Voltage: 3.5V to 5.5V
- Operating current: 0.3mA (measuring) 60uA (standby)
- Output: Serial data
- Temperature Range: 0°C to 50°C
- Humidity Range: 20% to 90%
- Resolution: Temperature and Humidity both are 16-bit
- Accuracy: ±1°C and ±1%

5.7 Servo Motor

A servomotor is a closed-loop servomechanism that uses position feedback to control its motion and final position. The input to its control is a signal (either analogue or digital) representing the position commanded for the output shaft. The motor is paired with some type of position encoder to provide position and speed feedback. In the simplest case, only the position is measured. The measured position of the output is compared to the command position, the external input to the controller. If the output position differs from that required, an error signal is generated which then causes the motor to rotate in either direction, as needed to bring the output shaft to the appropriate position. As the positions approach, the error signal reduces to zero and the motor stops.



Figure 5.13: Servo Motor

The very simplest servomotors use position-only sensing via a potentiometer and bang-bang control of their motor; the motor always rotates at full speed (or is stopped). This type of servomotor is not widely used in industrial motion control, but it forms the basis of the simple and cheap servos used for radio-controlled models. More sophisticated servomotors use optical rotary encoders to measure the speed of the output shaft and a variable-speed drive to control the motor speed. Both of these enhancements, usually in combination with a PID control algorithm, allow the servomotor to be brought to its commanded position more quickly and more precisely, with less overshooting.

5.8 LCD Display

The LCD (liquid crystal display) screen is an electronic display module and looks for various applications. A 16x2 LCD display is a very basic module and it is very commonly used in various devices and circuits. These modules are preferred over seven sections and many other segments.

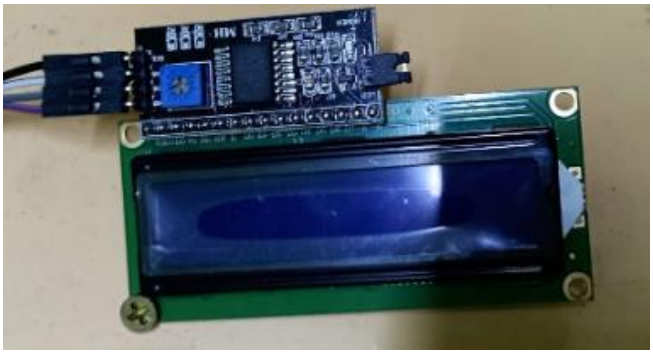


Figure 5.14: 16*2 LCD Display

The reasons for having LCD are economic; Easily programmable, special and even custom characters (different in seven sections), there are no restrictions on displaying animations. A 16x2 LCD means it can display 16 characters per line and contains 2 lines. Each character on this LCD is displayed in a 5x7 pixel matrix.

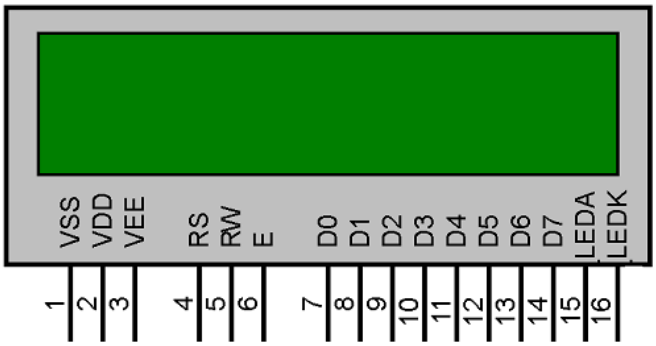


Figure 5.15: Pin out of 16*2 LCD Display

This LCD contains two articles called Command and Data. The command register stores the command instructions on the LCD. The command is a command given to the LCD to perform a predefined task such as starting it, clearing its screen, locating the cursor, controlling the display, etc.

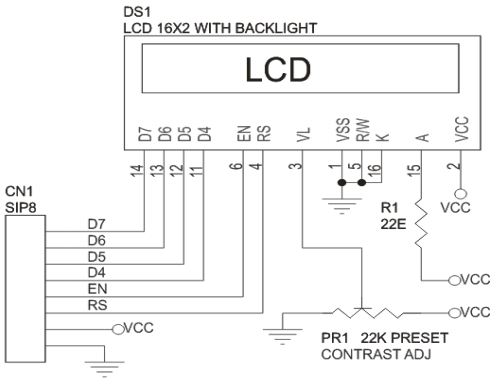


Figure 5.16: 16*2 LCD Display interfacing with Arduino

Feature

The features of this LCD mainly include the following.

- The operating voltage of this LCD is 4.7V-5.3V
- It includes two rows where each row can produce 16-characters.
- The utilization of current is 1mA with no backlight
- Every character can be built with a 5×8-pixel box
- The alphanumeric LCDs alphabets & numbers
- Is display can work on two modes like 4-bit & 8-bit
- These are obtainable in Blue & Green Backlight
- It displays a few custom generated characters

5.9 Relay Module

A relay module is an electronic component designed to control high-voltage and high-current devices using low-voltage signals. It serves as an intermediary between microcontrollers, such as Arduino, Raspberry Pi, or Node MCU, and external electrical appliances. Each module contains one or more relays, which are electromagnetic switches capable of isolating the control circuit from the high-power load for enhanced safety. The module typically includes input pins for control signals and power, along with output terminals for connecting devices. Features like optocouplers provide electrical isolation, protecting sensitive control circuits from voltage spikes or surges. Additionally, onboard indicator LEDs show the relay's operational status, making it user-friendly and easy to debug.

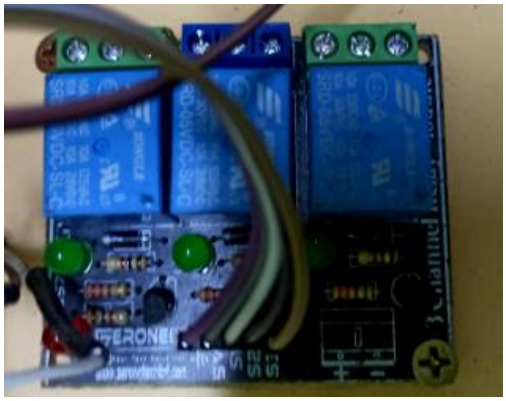


Figure 5.17: Relay Module

Relay modules are widely used in home automation, IoT projects, industrial machinery, and robotics to automate and control appliances like lights, fans, motors, and pumps. They are reliable, durable, and adaptable to various electrical systems.

5.10 Arduino IDE

The digital micro controller unit named as Arduino Pro Mini can be programmed with the Arduino software IDE. There is no any requirement for installing other software rather than Arduino. Firstly, Select "Arduino Pro Mini from the Tools, Board menu (according to the micro controller on our board). The IC used named as ATmega328 on the Arduino Pro Mini comes pre burned with a boot loader that allows us to upload new code to it without the use of an external hardware programmer.

Communication is using the original STK500 protocol (reference, C header files). We can also bypass the boot loader and programs the micro controller through the ICSP (In Circuit Serial Programming) header. The ATmega16U2 (or 8U2 in the rev1 and rev2 boards) firmware source code is available. The ATmega16U2/8U2 is loaded with a DFU boot loader, which can be activated by:

On Rev1 boards: connecting the solder jumper on the back of the board (near the map of Italy) and then resetting the 8U2. On Rev2 or later boards: there is a resistor that pulling the 8U2/16U2 HWB line to ground, making it easier to put into DFU mode. The Arduino Pro Mini is one of the latest digital micro controller units and has a number of facilities for

communicating with a computer, another Arduino, or other micro controllers. The ATmega328 provides UART TTL at (5V) with serial communication, which is available on digital pins 0 -(RX) for receive the data and pin no.1 (TX) for transmit the data. An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, an .in file is required. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board.

The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial Communication on pins 0 and 1). A Software Serial library allows for serial communication on any of the Nano's digital pins. The ATmega328 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus. Arduino programs are written in C or C++ and the program code written for Arduino is called sketch. The Arduino IDE uses the GNU tool chain and AVR Lab to compile programs, and for uploading the programs it uses argued. As the Arduino platform uses Atmel micro controllers, Atmel's development environment, AVR Studio or the newer Atmel Studio, may also be used to develop software for the Arduino.



Figure 5.18: Arduino Software Interface IDE

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuine hardware to upload programs and communicate with them.

Writing Sketches

Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension. In to The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom right-hand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor.

Uploading

Before uploading your sketch, you need to select the correct items from the Tools > Board and Tools > Port menus. The boards are described below. On the Mac, the serial port is probably something like /dev/tty. usbmodem241 (for an Uno or Mega2560 or Leonardo) or /dev/tty.usbserial-1B1 (for a Duemilanove or earlier USB board), or /dev/tty. USA19QW1b1P1.1 (for a serial board connected with a Keyspan USB-to-Serial adapter). On Windows, it's probably COM1 or COM2 (for a serial board) or COM4, COM5, COM7, or higher (for a USB board) - to find out, you look for USB serial device in the ports section of the Windows Device Manager. On Linux, it should be /dev/ttyACMx, /dev/ttyUSBx or similar. Once you've selected the correct serial port and board, press the upload button in the toolbar or select the Upload item from the Sketch menu. Current Arduino boards will reset automatically and begin the upload. With older boards (pre-Diecimila) that lack auto-reset, you'll need to press the reset button on the board just before starting the upload. On most boards, you'll see the RX and TX LEDs blink as the sketch is uploaded. The Arduino Software (IDE) will display a message when the upload is complete, or show an error.

Libraries

Libraries provide extra functionality for use in sketches, e.g. working with hardware or manipulating data. To use a library in a sketch, select it from the Sketch > Import Library menu. This will insert one or more #include statements at the top of the sketch and compile the library with your sketch. Because libraries are uploaded to the board with your sketch, they increase the amount of space it takes up. If a sketch no longer needs a library, simply delete its #include statements from the top of your code.

There is a list of libraries in the reference. Some libraries are included with the Arduino software. Others can be downloaded from a variety of sources or through the Library Manager. Starting with version 1.0.5 of the IDE, you do can import a library from a zip file and use it in an open sketch. See these instructions for installing a third-party library.

Third-Party Hardware

Support for third-party hardware can be added to the hardware directory of your sketchbook directory. Platforms installed there may include board definitions (which appear in the board menu), core libraries, bootloaders, and programmer definitions. To install, create the hardware directory, then unzip the third-party platform into its own sub-directory. (Don't use "arduino" as the sub-directory name or you'll override the built-in Arduino platform.) To uninstall, simply delete its directory.

Serial Monitor

This displays serial sent from the Arduino or Genuino board over USB or serial connector. To send data to the board, enter text and click on the "send" button or press enter. Choose the baud rate from the drop-down menu that matches the rate passed to Serial begin in your sketch. Note that on Windows, Mac or Linux the board will reset (it will rerun your sketch) when you connect with the serial monitor. Please note that the Serial Monitor does not process control characters; if your sketch needs a complete management of the serial communication with control characters, you can use an external terminal program and connect it to the COM port assigned to your Arduino board. You can also talk to the board from Processing, Flash, MaxMSP, etc (see the interfacing page for details).

5.11 Easy EDA

Easy EDA is a web-based EDA tool suite that enables hardware engineers to design, simulate, share-publicly and privately-and discuss schematics, simulations and printed circuit boards. Other features include the creation of a bill of materials, Gerber files and pick and place files and documentary outputs in PDF, PNG and SVG formats. Easy EDA allows the creation and editing of schematic diagrams, SPICE simulation of mixed analogue and digital circuits and the creation and editing of printed circuit board layouts and, optionally, the manufacture of printed circuit boards.

Subscription-free membership is offered for public plus a limited number of private projects. The number of private projects can be increased by contributing high quality public projects, schematic symbols, and PCB footprints and/or by paying a monthly subscription. Registered users can download Gerber files from the tool free of charge; but for a fee, Easy EDA offers a PCB fabrication service. This service is also able to accept Gerber file inputs from third party tools.

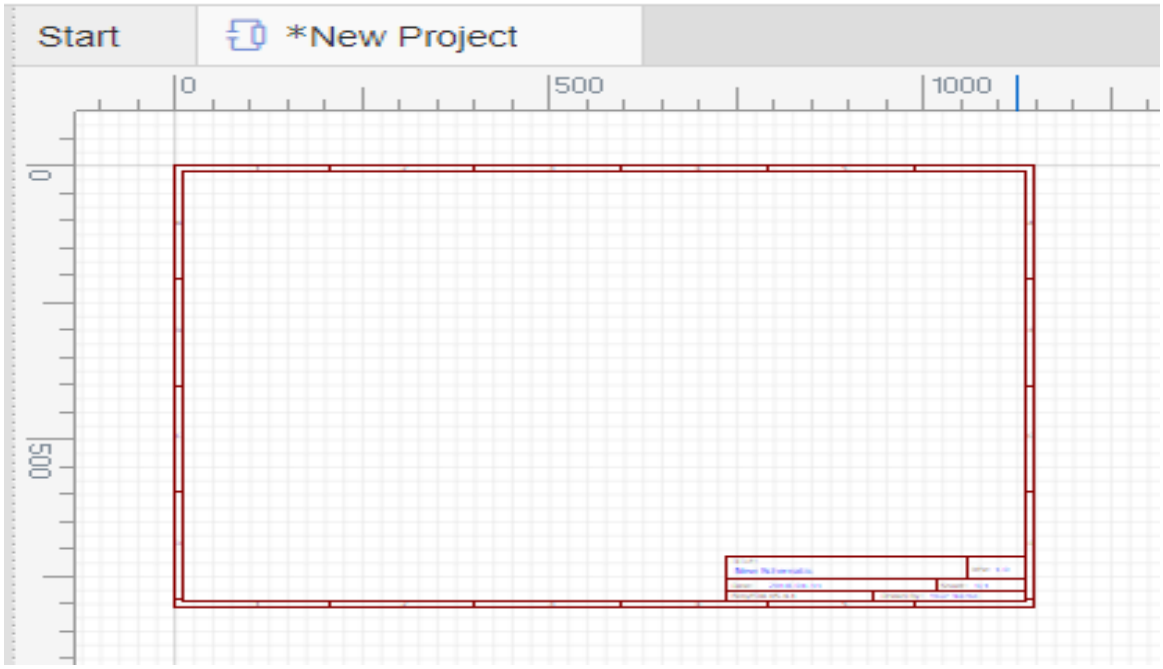


Figure 5.19: Easy EDA Software Interface

CHAPTER 6

EXPERIMENTAL RESULT

6.1 Hardware Implementation

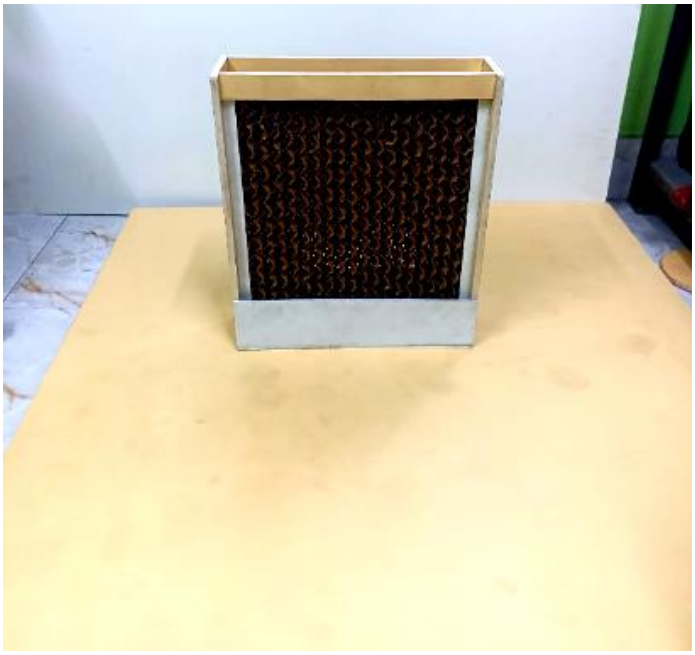


Figure 6.1 Our System Hardware Image

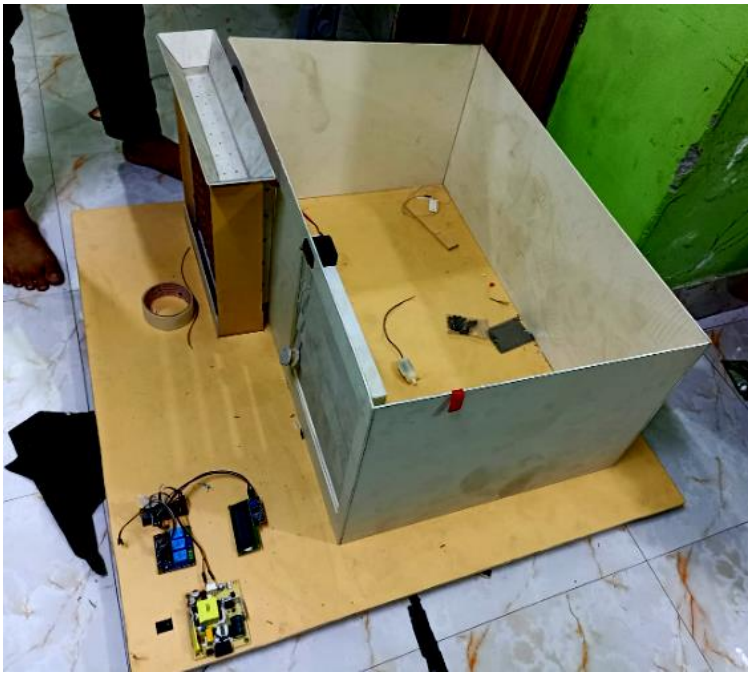


Figure 6.2 Our System Progress Image



Figure 6.3 Our Complete Project Prototype

6.2 Result

The developed forced convective cooling system effectively maintains optimal temperature and humidity levels using an Arduino Nano-based control system. Equipped with a DC pump motor, evaporator pad, cooling fan, temperature and humidity sensors, servo motor, relay module, and damper, the system demonstrates seamless automation and reliable performance.

The system successfully lowers the ambient temperature by passing air through a water-saturated evaporator pad, efficiently utilizing the cooling fan to distribute the cooled and humidified air. The servo motor-driven damper enhances airflow regulation, ensuring consistent and adaptable cooling based on environmental requirements.

Real-time data on temperature and humidity is displayed on an LCD screen, allowing users to monitor the system's performance. Powered by an SMPS, the setup ensures energy-efficient operation while minimizing power consumption. This project delivers an eco-friendly, cost-effective cooling solution ideal for residential, commercial, and agricultural applications, particularly in arid regions with hot and dry climates.

Experimental data

Table 1: Room Temperature

Time (Minute)	Temperature° (C)
1	32
2	31.2
3	30.8
4	30.2
5	29.7
6	29.1
7	28.6
8	28.0
9	28.2
10	28.0

Graph 1: Room Temperature

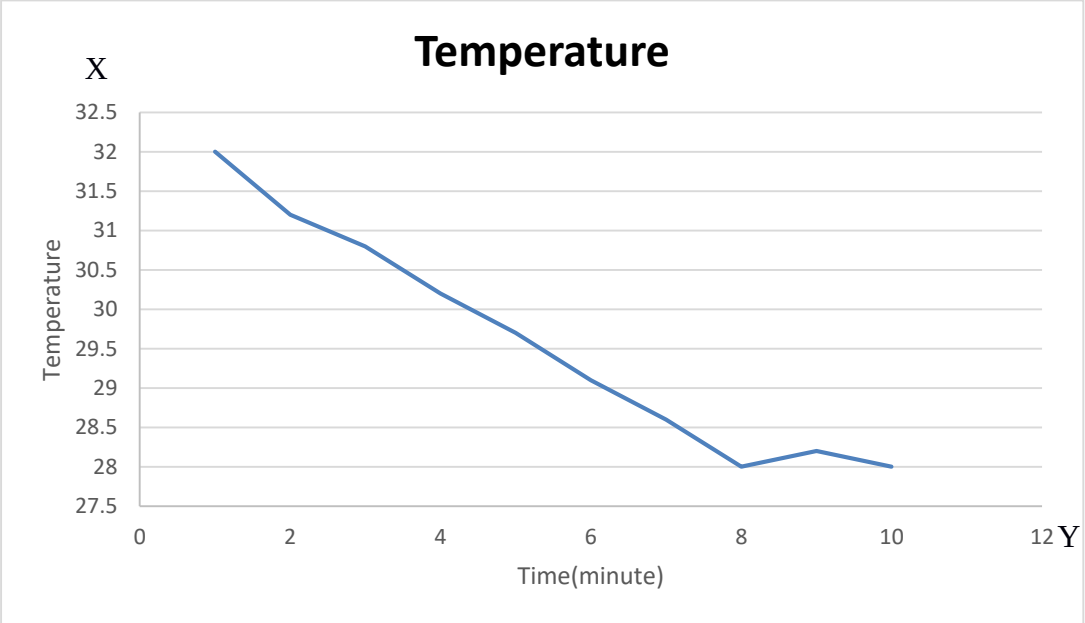
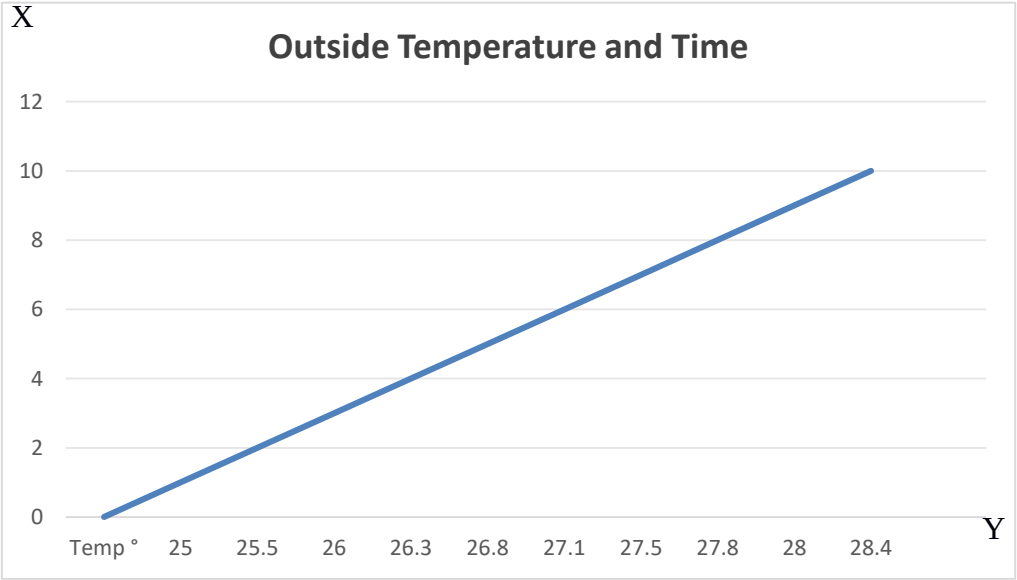


Table 2: Outside Temperature

Time (Minute)	Temperature° (C)
1	25
2	25.5
3	26
4	26.3
5	26.8
6	27.1
7	27.5
8	27.8
9	28
10	28.4

Graph 2: Outside Temperature



CHAPTER 7
DISCUSSION

7.1 Discussion

The forced convective cooling system with temperature and humidity control cooling system works effectively and makes cooling process easy, more precise and reliable and is more advantageous than the conventional methods reducing manual efforts, errors and being much efficient. The proposed prototype allows achieving an economical and a low-cost cooling system. When we made this project then we face some of problem. We did not run it smoothly. After hard work and team work, we did it.

7.2 Advantage

- Creates a comfortable and productive work environment.
- Energy-efficient ventilation and cooling solution.
- Environmentally friendly.
- Investment in this sustainable technique is often subsidized.
- Less skill technicians are sufficient to operate.
- Installation is simplified very much.
- Simple construction
- Easy of operation.

7.3 Application

The project has a major application in the

- It can be used for Industrial work.
- It can be used for indoor purpose.

7.4 Limitation

It is a demo project so we found some limitation. In future we will work for reduce this kind of limitation. These limitations are –

- • This process can’t maintain 100% of the specified humidity and temperature.

CHAPTER 8
CONCLUSION

8.1 Conclusion:

As using the water for the evaporation purpose, which leads to decrease the temperature of the air also containing the most economically environmental effective system. In this project paper of evaporating cooling technology, methods are studied for the commercial and comfort purposes. Indirect evaporative coolers have shown higher values of effectiveness and more economically operated in the terms of energy consumption saving, particularly the M-Cycle. However, the combined system of direct and indirect cooling system has similar performance or even the higher but their system consists of higher initial cost and the major problems like noise & vibrations, pressure loss and friction loss. But our system gives the better output better than previous and save the costing.

8.2 Future Scope

The model can be improved by making some changes in the hardware and components. Some suggestions are given below-

- We will increase its working accuracy level.
- We will increase its cooling system.
- We will add a sensor and a display to measure and monitoring the cooling situation.

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Appendix

```
#include <Servo.h>
#include <DHT.h>
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

// Pin and device definitions
#define DHTPIN 2        // DHT11 data pin connected to D2
#define DHTTYPE DHT11   // Define the sensor type
#define RELAY_PIN 3     // Relay module connected to D3
#define SERVO1_PIN 9    // First servo motor connected to D9
#define SERVO2_PIN 10   // Second servo motor connected to D10

// Initialize devices
DHT dht(DHTPIN, DHTTYPE);
Servo ventServo1;
Servo ventServo2;
LiquidCrystal_I2C lcd(0x27, 16, 2); // I2C address of the LCD, modify if necessary

void setup() {
  // Initialize serial communication
  Serial.begin(9600);

  // Initialize DHT sensor
  dht.begin();

  // Initialize servo motors
  ventServo1.attach(SERVO1_PIN);
  ventServo2.attach(SERVO2_PIN);
  ventServo1.write(0); // Set initial position of servo 1 to closed
  ventServo2.write(0); // Set initial position of servo 2 to closed

  // Set up relay pin
  pinMode(RELAY_PIN, OUTPUT);
  digitalWrite(RELAY_PIN, LOW); // Ensure the relay is OFF initially

  // Initialize LCD
  lcd.init();         // Initialize the LCD
  lcd.backlight();    // Turn on the backlight
  lcd.setCursor(0, 0); // Set cursor to the first line
  lcd.print("Cooling System");
  delay(2000);        // Display initial message for 2 seconds
  lcd.clear();        // Clear LCD after the initial message
}

void loop() {
```

```
// Read temperature and humidity from DHT11
float temperature = dht.readTemperature();
float humidity = dht.readHumidity();

// Check if sensor readings are valid
if (isnan(temperature) || isnan(humidity)) {
  Serial.println("Failed to read from DHT sensor!");
  lcd.setCursor(0, 0);
  lcd.print("Sensor Error   ");
  delay(2000);
  return;
}

// Print readings to serial monitor
Serial.print("Temperature: ");
Serial.print(temperature);
Serial.println("°C");

Serial.print("Humidity: ");
Serial.print(humidity);
Serial.println("%");

// Display readings on LCD
lcd.setCursor(0, 0);
lcd.print("Temp: ");
lcd.print(temperature);
lcd.print("C   ");

lcd.setCursor(0, 1);
lcd.print("Hum: ");
lcd.print(humidity);
lcd.print("%   ");

// Control relay (water pump)
if (temperature <= 30.0) {
  digitalWrite(RELAY_PIN, HIGH); // Turn the pump ON
  Serial.println("Pump: ON");
} else {
  digitalWrite(RELAY_PIN, LOW);  // Turn the pump OFF
  Serial.println("Pump: OFF");
}

// Control first servo motor
if (temperature <= 30.0) {
  ventServo1.write(0); // Open the first vent/flap
  Serial.println("Servo 1: Open");
} else {
  ventServo1.write(90);  // Close the first vent/flap
  Serial.println("Servo 1: Closed");
```

```
  }

  // Control second servo motor
  if (temperature <= 30.0) {
    ventServo2.write(0); // Open the second vent/flap
    Serial.println("Servo 2: Open");
  } else {
    ventServo2.write(90);  // Close the second vent/flap
    Serial.println("Servo 2: Closed");
  }

  // Wait 2 seconds before the next reading
  delay(2000);
}
```