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PV Based Automatic Irrigation System

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Abstract: ***In Because of the lack of rains and scarcity of land reservoir water, proper irrigation methods are critical in the field of agriculture. The continuous extraction of water from the earth is lowering the water level, causing a lot of land to slowly come into the unirrigated zones. Another important reason for this is because of unplanned water use, which wastes a significant amount of water. This automatic plant irrigation system is used for this purpose. Solar energy is used to power the system via photovoltaic cells. As a result, there is no need to rely on erratic commercial power. In this digital age, we demand that everything around us be automated, reducing human effort. Electronic circuits are becoming more prevalent, making life easier and simpler in today's world. Energy and water scarcity are two major issues that everyone is dealing with these days. As a result, energy and water conservation are required. The goal is to create a solar-powered prototype that will automatically irrigate the field. Consider how convenient it will be to be able to focus on your next task while your field is being irrigated automatically and at a low cost. No worries about underirrigation or over-irrigation, water waste or expensive electricity, or your busy schedule.***

Keywords: Arduino Uno-Soil Moisture Sensor Submersible Water Pump - Single Channel Relay - Solar Panel - LCD Display - Buzzer - IDE

I. INTRODUCTION

In agriculture, proper irrigation methods must be used, and it is necessary to determine how much extra content of these nutrients should be added to the soil to increase crop fertility. According to the surface's atmospheric conditions, the Arduino interface transmits the sensed voltage signal from the moisture sensor, which uses a powerful and intuitive development environment to quickly develop an automatic irrigation system for the soil. The benefit of this method is that it requires less human intervention while still ensuring proper irrigation. India is an agrarian country, with agriculture providing employment to roughly 60% of the population. Solar power is the conversion of solar energy into thermal or electrical energy. Solar energy is the most

Environmentally friendly and abundant renewable energy source currently available. Solar energy can be harnessed for a variety of purposes, including generating electricity, lighting or creating a comfortable interior environment, and heating water for domestic, commercial, industrial, and agricultural purposes. Solar energy can be harnessed in three ways: photovoltaics, solar heating and cooling, and concentrating solar power. Photovoltaics use an electronic process to generate electricity directly from sunlight, which can be used to power everything from small electronics like calculators and road signs to homes and large commercial businesses. Solar heating and cooling (SHC) and concentrating solar power (CSP) applications both use the sun's heat to provide space or water heating in SHC systems, or to power traditional electricity-generating turbines in CSP power plants. Condensed water vapour is made up of a specific amount of water that is determined by the climate, topography, type of vegetation, and hydrogeological conditions. The water layer is measured in millimetres (mm), with 1 mm of rainfall per hectare (hectare) equalling 10 tonnes of water. As a result, a farmer's primary goal is to maximise moisture accumulation, storage, and efficient use. It is, however, still difficult, necessitating additional effort and labour.

A. Importance of Soil Moisture Sensor for Efficiency Farming

On planet Earth, none of the physical processes in the atmosphere and environment can occur without water. The amount of precipitation, the intensity of plant water consumption, and air temperature are all factors that affect soil moisture. Because adequate soil moisture is critical for yields, plants will not grow and develop if the soil moisture is insufficient. Other uses for water include the following: Air content, salinity, and the presence of toxic substances are all influenced by soil moisture levels. Controls the structure, ductility, and density of the soil. Temperature and heat capacity of the soil are influenced. Prevents soil from becoming weathered. The level of water in the soil is expressed as the ratio of the amount of water to the weight of dry soil to determine the readiness of fields to be worked on (or as a percentage). Soil Moisture was added to the list of 50 Essential Climatic Variables recommended for systematic observation by the World Meteorological Organization in 2010. Soil moisture content is a measurement of how much water is in a given amount of soil; it can be expressed as a percentage, water by weight or volume of soil, or inches of water per foot of soil. The degree to which water clings to the soil is measured by soil moisture potential or soil moisture tension. It is measured in bars, which are pressure units. The more water a soil absorbs, the drier it is in general.

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The amount of water in the soil available to the plant at any given time is known as plant available water (PAW). a specific point in time the difference between the maximum amount of water that the soil can hold and the wilting point, when the plant can no longer extract water from the soil, is known as available water. It is measured in inches of water available per foot of soil. The relationship between content and potential is not universal, and it is dependent on local soil characteristics such as density and texture. The moisture difference determines the amount of water that flows. Solar energy can be harnessed in three ways: photovoltaics, solar heating and cooling, and concentrating solar power. Photovoltaics use an electronic process to generate electricity directly from sunlight and can be used to power everything from small electronics like calculators and road signs to homes and large commercial businesses. Solar heating and cooling (SHC) and concentrating solar power (CSP) applications both use the sun's heat to provide space or water heating in SHC systems, or to power traditional electricity-generating turbines in CSP power plants. Soil moisture levels must be adequate for proper plant formation and high crop yields. Water serves as a temperature regulator as well as a moisture restorer for the plant. The plant evaporates up to 99 percent of all water obtained during thermoregulation, leaving only 0.2 percent to 0.5 percent for the formation of vegetative mass. As a result, it's easy to see how the plant's moisture requirements vary depending on the weather and stage of development. Condensed water vapour is made up of a specific amount of water that is determined by the climate, topography, type of vegetation, and hydrogeological conditions. The water layer is measured in millimetres (mm), with 1 mm of rainfall per hectare (hectare) equalling 10 tonnes of water. As a result, a farmer's primary responsibility is to maximise moisture accumulation, storage, and efficient use. It is, of course, still difficult, necessitating additional effort and labour.

II. METHODOLOGY

This project emphasises the fact that the technique incorporated here is to monitor the soil's moisture content, to review different levels of moisture level based on the given crop and soil moisture levels. We chose the desired values based on the weather. We use solar power throughout the project because it is environmentally friendly and far superior to domestic power. It can be installed wherever the farmers want it. We use the Arduino for the software, and we write the conditions using Analog or Digital values based on the moisture levels. Initially, we take input from the moisture sensor and perform the entire operation based on the values. The Arduino UNO will provide directions to the single channel relay to turn on/off the motor. The single channel relay and the submersible pump are powered by the solar panel. The most important requirement in most semiarid cultivating estates is effective crop and water management. Monitoring the nature of the soil, estimating its moisture content, and controlling it in accordance is a necessity; however, there is a potential solution to support landsite irrigation management in order to treat desiccated fields and provide significant yield to farmers. In the field of agriculture, the most crucial factor is the availability of water. The project aims to develop an automatic irrigation system that does not require human intervention to turn on or off the pump. Currently, we only have an AUTO switch that is used to turn on or off the motor whenever it receives power, which results in high power consumption. and as a result, the motor has been damaged, and the amount of water wasted has increased. It will unintentionally cause crop damage.

III. DESCRIPTION OF COMPONENTS

The hardware and software components are discussed in detail in this chapter. Arduino uno and relay modules are among the components. Micro Submersible Water Pump, LCD, Solar Panel, I2C Adapter, Buzzer, Solar Moisture Sensor

A. Ardino uno

Arduino is an open-source electronic platform that uses simple hardware and software to make it easy to use. Arduino boards are capable of reading inputs and converting them to output. It can figure out what to do by sending a set of instructions to the board's microcontroller.

1) *Micro Controller:* The system's central component is the microcontroller. All of the components are connected to the board and programmed according to their functions so that they can work in unison.

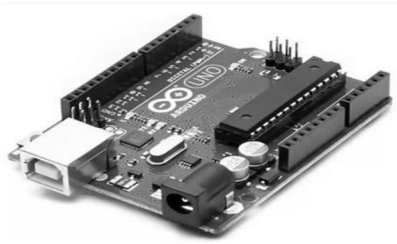


Fig.1 Arduino uno board

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The Arduino Uno is an Atmega328P-based microcontroller board. It has 14 digital input/output pins, 6 analogue inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It comes with everything you need to get started with the microcontroller; just plug it into a computer with a USB cable or power it with an AC-toDC adapter or battery, as shown in figure.

The Uno is unique in that it does not use the FTDI USBto-serial driver chip found on previous boards. Instead, it has a USB-to-serial converter built into the Atmega16U2 (Atmega8U2 up to version R2). The name "Uno" comes from the Italian word "uno," which means "one." It was chosen to commemorate the upcoming release of Arduino 1.0. Moving forward, the Uno and version 1.0 will be the reference versions of Arduino. The Uno is the latest in a line of USB Arduino boards, and the table below lists the Arduino platform's reference model as well as the Arduino Uno's specifications.

2) Arduino Power Supply: The Arduino Uno can be powered either via USB or an external power supply.

The power source is automatically selected. An AC-toDC adapter or a battery can provide external power. A 2.1mm centre-positive plug can be plugged into the board's power jack to connect the adapter. Battery leads can be inserted into the power connector's GND and Vin pin headers.

An external supply of 6 to 20 volts can be used to power the board. However, if the voltage regulator is supplied with less than 7 volts, it may overheat and damage the board. 7 to 12 volts is the recommended range.

TABLE 1;
Specifications of Arduino uno

Microcontroller	Atmega328P
Operating Voltage	12V
Input Voltage(recommended)	12-15V
Input Voltage(limit)	6-20
Digital I/O Pins	14(of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3v pin	50 mA
Flash Memory	32 KB of which 0.5 KB used by bootloader
SRAM	2 KB (Atmega328P)
EEPROM	1KB (Atmega328P)
Clock Speed	16 MHz

Pin diagram

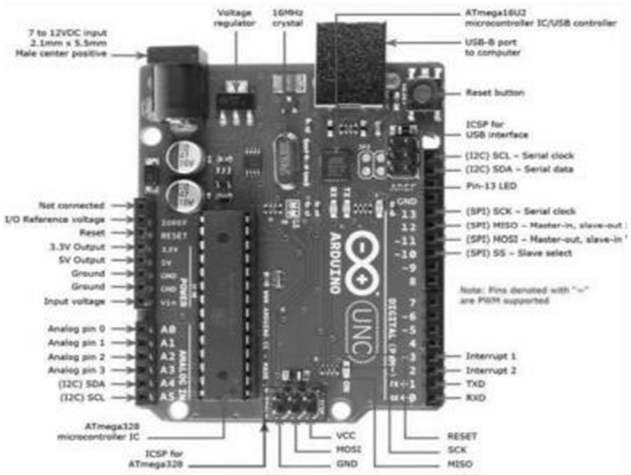


Fig.2 pin description of Arduino uno Communication:

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3) *Programming:* The Arduino software can be used to programme the Arduino Uno. Select "Arduino Uno has a bootloader that allows you to programme it without using an external hardware programmer." It uses the original STK500 protocol to communicate. You can also programme the microcontroller without using the bootloader by using the ICSP (In circuit serial programming) header; see these instructions for more information. The source code for the Atmega16U2 firmware is available. The Atmega16U2/8U2 has a DFU bootloader that can be activated by the user. Connecting the solder jumper on the back of the board and then resetting the 8U2 on Rev1 boards. A resistor pulls the 8U2/16U2 HWB line to ground on Rev2 or later boards, making it easier to put into DFU mode.

B. Soil moisture Sensor

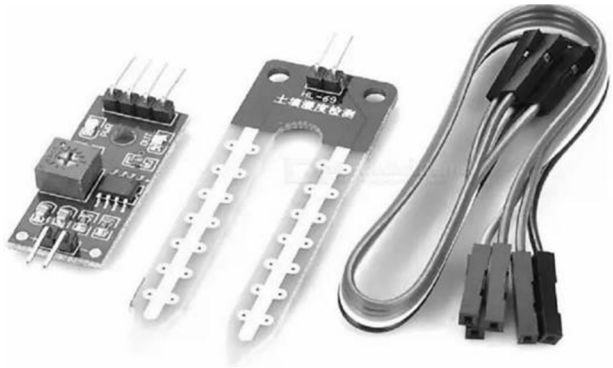


Fig.3 soil moisture sensor

Although direct (soil sampling) and indirect (soil moisture sensing) methods can be used to determine soil water status, direct methods of monitoring soil moisture are not commonly used for irrigation scheduling because they are intrusive, labour-intensive, and do not provide immediate feedback. Permanently installing soil moisture probes at representative points in an agricultural field can provide repeat moisture readings over time that can be used for irrigation management. This class of sensors determines the velocity of an electromagnetic wave or pulse through the soil by measuring the bulk permittivity (or dielectric constant) of the soil. The value of the permittivity in a composite material like soil (i.e., made up of different components like minerals, air, and water) is made up by the relative contributions of each of the components. Because liquid water has a much higher dielectric constant than the other soil constituents, the total permittivity of the soil, or bulk permittivity, is largely determined by its presence. The gravimetric method is the most basic method for determining soil water content. This method is the gold standard against which all other methods are measured because it is based on direct measurements. Unfortunately, given metric sampling is destructive, making it impossible to take repeat measurements on the same soil sample. Volumetric water contents are not usually determined directly due to the difficulty of accurately measuring dry soil and water volumes. Sensors that estimate volumetric water content are commonly referred to as soil moisture sensors. Another type of sensor measures the water potential of soils, which is a property of moisture. Tensiometers and gypsum blocks, as well as the pin description shown in table, are examples of soil potential sensors.

TABLE 2

Pins	Definition
GND	GND
Vcc	5V
A0	Analog output interface

Because direct gravimetric measurements of free-soil moisture necessitate removing, drying, and weighing a sample, soil moisture sensors indirectly measure the volumetric water content by using another property of the soil as a proxy for the moisture content, such as electric resistance, dielectric constant, or neutron interaction. The relationship between the measured property and soil moisture must be calibrated, and it can change depending on environmental factors like soil type, temperature, and electric conductivity. The soil moisture affects reflected microwave radiation, which is used for remote sensing in hydrology and agriculture. Portable probe instruments can be used by a lot of different people.

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C. Micro Submersible Water Pump



Fig.4 micro submersible water pump

The water pump is used to provide artificial water for a specific task. It can be controlled electronically by connecting it to a microcontroller. Signals can be used to turn it on and off, as shown in figure 2.5. Pumping is the process of artificially supplying water.

Water pumps come in a variety of shapes and sizes. This project uses a small water pump that is connected to an H-Bridge. Pumping water is a simple and effective technique that is far more efficient than scooping it up with one's hands or lifting it in a bucket. This is true regardless of whether the water is drawn from a fresh source, transported to a desired location, purified, or used for irrigation, washing, or other purposes.

1) Micro Submersible Water Pump Specifications

- *Operating Voltage:* 3~6V Operating Current: 220mA
- *Flow Rate:* 1.20 lit/ hour Maximum Life: 40- 110mm Driving Mode: DC, Magnetic Driving Outlet Outside Diameter: 7.5mm Outlet
- *Inside Diameter:* 5mm.

2) *Dimensions:* Width x Height x Weight 3.8cm x 4cm x 50mg

D. Single Channel Relay

A relay is an electromechanical device that opens or closes the contacts of a switch using an electric current. The single-channel relay module is much more than a simple relay; it includes components that make switching and connection easier, as well as indicators that show if the module is powered and if the relay is active or not, as shown in figure and in table.

TABLE 3
Pin description

PIN Number	PIN Name	Description
1	Relay Trigger	Input to Activate the relay
2	Ground	OV reference
3	VCC	Supply Input for powering the relay coil
4	Normally Open	Normally Open Terminal of the relay
5	Common	Common Terminal of the relay
6	Normally Closed	Normally Closed Contact of the relay

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Single channel relay

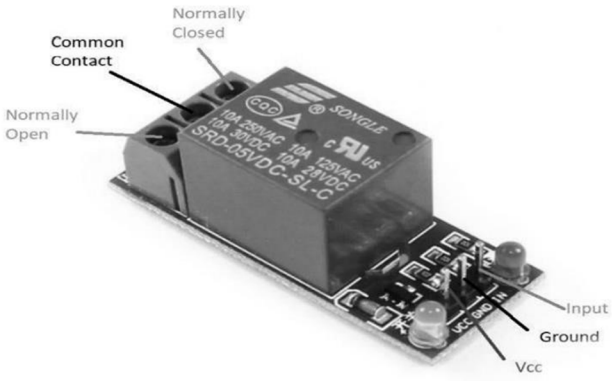


Fig.5 single channel relay

E. Solar Panel

A solar panel is made up of a number of solar cells. Solar energy is converted into electrical energy by the solar panel. The solar panel's interconnections and external terminals are made of ohmic material. As a result, the electrons produced in the n-type material pass through the electrode and into the wire. Connected to the power source The electrons reach the p-type material via the battery. In this case, the electrons and holes combine. As a result, when the solar panel is connected to the battery, it acts similarly to another battery, and the systems are connected in series in the same way that two batteries are connected in series.

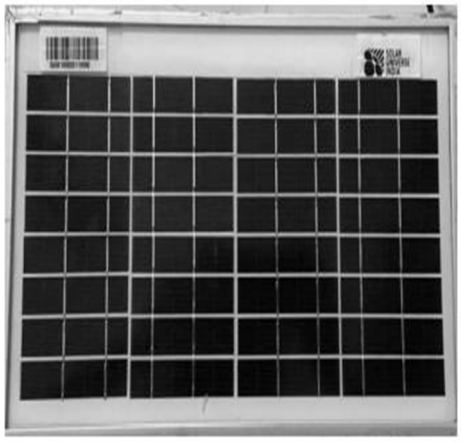


Fig.6 Solar panel

1) *Working:* The solar panel's output is its power, which is measured in watts or kilowatts. Solar panels with various output ratings, such as 5 watts, 10 watts, 20 watts, and 100 watts, are available. So, before choosing a solar panel, you must first determine how much power the load requires. The power requirement is calculated in watt hours or kilowatt hours. Average power is equal to 20 times peak power as a rule of thumb. As a result, each peak kilowatt of solar array output power corresponds to 4.8k Wh/day of energy production. That's a total of 24 hours x 1KW x 20%. Climate, sky condition, panel orientation, intensity and duration of sunlight, and the solar panel's wiring connections all affect the solar panel's performance. When the sun is shining brightly, a 12volt 15watt panel produces about 1 amp of current. A solar panel can last up to 25 years if properly maintained. The arrangement of solar panels on the rooftop must be planned. It is usually oriented at a 45-degree angle toward the east. The panel is also rotated as the sun moves from east to west using a solar tracking arrangement. The wiring connection is also crucial. A good quality wire with enough gauge to handle the current will ensure that the battery is properly charged. The charging current may be reduced if the wire is too long. As a rule, solar panels are placed at a height of 10 to 20 feet above ground level. Cleaning the solar panel properly once a month is recommended. Cleaning the surface to remove dust and moisture, as well as cleaning and reconnecting the terminals, are all included.

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F. LCD Display

A LCD (Liquid Crystal Display) is a type of display that uses liquid crystals to display information. A liquid crystal display, or LCD, gets its name from its definition. It is made up of two different states of matter: solid and liquid. A liquid crystal is used to create a visible image on an LCD. Liquid crystal displays are ultra-thin display screens that are commonly found in laptop computers, televisions, cell phones, and portable video games. When compared to cathode ray tube (CRT) technology, LCD technology allows for much thinner displays. Two polarised panel filters and electrodes are among the layers that make up a Liquid Crystal Display. LCD technology is used in notebooks and other electronic devices such as mini computers to display images. A lens projects light onto a layer of liquid crystal. The coloured image is created by combining coloured light with the grayscale image of the crystal (formed as electric current flows through the crystal). After that, the image is displayed on the screen. Either an active matrix display grid or a passive display grid makes up an LCD. The majority of Smartphones with LCD displays use active matrix displays, but some older displays still use passive matrix displays.

1) *Working:* When an electrical current is applied to a liquid crystal molecule, it tends to untwist. This is the principle behind LCDs. This causes a change in the angle of light passing through the polarised glass molecule, as well as a change in the angle of the top polarising filter. As a result, a small amount of light can pass through the polarised glass into a specific area of the LCD. As a result, that particular area will become darker than the rest. The LCD operates on the principle of light blocking. A reflected mirror is arranged at the back of the LCDs while they are being built. A polarised glass with a polarising fil is kept on top of an electrode plane made of indium-tin oxide**.**

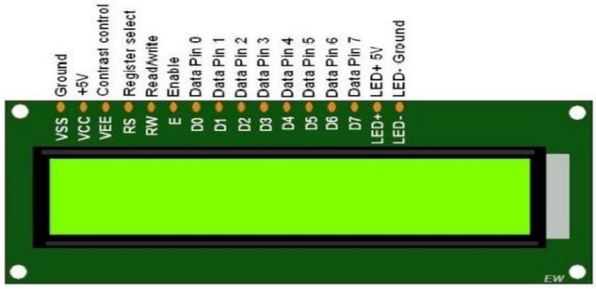


Fig.7 LCD

Table 4
Pin description of LCD

Pin No:	Pin Name:	Description
1	Vss (Ground)	Ground pin connected to system ground
2	Vdd (+5 Volt)	Powers the LCD with +5V (4.7V – 5.3V)
3	VE (Contrast V)	Decides the contrast level of display. Grounded to get maximum contrast.
4	Register Select	Connected to Microcontroller to shit between command/data register
5	Read/Write	Used to read or write data. Normally grounded to write data to LCD
6	Enable	Connected to Microcontroller Pin and toggled between 1 and 0 for data acknowledgement
7	Data Pin 0	Data pins 0 to 7 forms a 8-bit data line. They can be connected to Microcontroller to send 8-bit data. These LCD's can also operate on 4-bit mode in such case Data pin 4,5,6 and 7 will be left free.
8	Data Pin 1	
9	Data Pin 2	
10	Data Pin 3	
11	Data Pin 4	
12	Data Pin 5	
13	Data Pin 6	

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G. Buzzer

The buzzer is a small but effective component for adding sound to our project or system. Its small and compact 2-pin structure allows it to be used on a breadboard, a Perf Board, or even a PCB, making it a common component in most electronic applications.



Fig.8 Buzzer

There are two types of buzzers available on the market. The one shown here is a simple buzzer that makes a

Continuous Beep when powered. The other type of sound is a readymade buzzer, which is larger than this and produces a Beep. Beep. Beep. It produces sound due to an internal oscillating circuit. However, the one shown here is the most popular because it can be easily customised with the help of other circuits to fit our application. This buzzer can be used by simply connecting it to a DC power supply between 4 and 9 volts. A simple 9V battery can also be used, but a regulated +5V or +6V DC supply is recommended. Normally, the buzzer is associated with switching circuit.

H. I^2 C Adapter

This is an I2C Serial LCD Daughter board that is RoHS compliant and can be connected to a standard 162 or 204Character Display Module that supports 4-bit mode. 4-bit mode is supported by all Character Modules sold on our site, as well as nearly all commercially available 162and 204line character modules. The PCF8574 I2C chip on this board converts serial I2C data to parallel data for the LCD display. There are numerous examples of using this board with Arduino on the internet. Look up "Arduino LCD PCF8574" in the search engine. The I2C address is set to 0x3F by default, but three solder jumpers on the board allow you to change it. This allows you to control up to three LCD displays from a single I2C bus.

1) *Specifications and Features:* 1. 5V power supply. 2. Serial I2C control of LCD display using PCF8574. 3. Backlight can be enabled or disabled via a jumper on the board. 4.Contrast control via a potentiometer. 5. Can have 8 modules on a single I2C bus (change address via solder jumpers) address, allowing. 6. Size : 41.6 x 19.2 mm.



Fig.9 I^2 C Adapter

I. Software Tool

1) *Arduino IDE:* An Arduino programme can be written in any programming language that uses compilers to generate binary machine code for the target processor. AVR Studio (older) and Atmel Studio (newer) are development environments for Atmel's 8bit AVR and 32-bit ARM Cortex-M based microcontrollers (newer).

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2) *IDE:* The Arduino integrated development environment (IDE) is a Java-based cross-platform application that runs on Windows, Mac OS X, and Linux. It arose from the IDE for the Processing and Wiring programming languages. It comes with a code editor that includes text cutting and pasting, text searching and replacement, automatic indenting, brace matching, and syntax highlighting, as well as one-click compiling and uploading to an Arduino board. A message area, a text console, a toolbar with common function buttons, and a hierarchy of operation menus are also included. The IDE's source code is available under the GNU General Public License, version 2. The Arduino IDE uses special code structuring rules to support the languages C and C++. User-written code only needs two basic functions to start the sketch and the main programme loop, which are compiled and linked into an executable cyclic executive programme with the GNU toolchain, which is also included with the IDE distribution. The programme is used by the Arduino IDE to convert executable code into a text file in hexadecimal encoding, which is then loaded into the Arduino board's firmware by a loader programme.
3) *Summary:* The principles and operation of the Arduino Uno component were discussed in this chapter. As a switch, a relay is used. The Moisture sensor is used to detect moisture levels, and the Software IDE is used to write programmes. Arduino boards can read analogue or digital input signals from a variety of sensors and convert them to outputs such as motor control.
4) *Working Principle:* The main working principle of this system is to use the Moisture sensor to measure the moisture level of the soil and then use Arduino's level instructions to pump water into the soil, as shown in figure 3.2. The soil moisture sensor, which acts as an input and controls the water flow to the soil, measures the moisture content of the soil. If the Moisture sensor level falls below a threshold value, Arduino sends a signal to the Single channel relay module, which activates a submersible pump and delivers a certain amount of water until the soil moisture level rises; once the water is sufficient for the soil, the pump turns off.

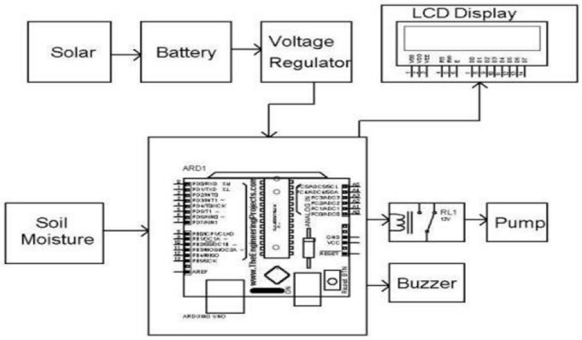


Fig.10 Circuit Diagram

The power supply's job is to power the entire system, and it is powered by solar panels with a maximum power supply of 18V. The amplifier circuit and probes are the two parts of the soil moisture sensor module. When the threshold is activated, the digital output is set to logical 1, and the analogue output is set to logical 0. The potentiometer controls the Threshold. The system uses the analogue output, which provides real-time information about the moisture in the plant.

5) *Experimental Result*

a) The soil moisture level exceeds the maximum set value. When the Moisture sensor signals are high (1), the Arduino at the water pump sends the controlling signal (LOW) to the relay, which turns the motor off.

b) The soil moisture level is less than the minimum set value. When the Moisture sensor signals are low (0), the Arduino at the water pump sends the controlling signal (HIGH) to the relay, which turns on the motor. The following are the results of the experiments.

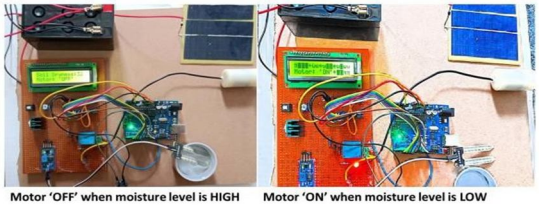


Fig.11 Hardware result

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IV. CONCLUSION & FUTURE SCOPE

As a result, the "Automatic Irrigation System Based on Solar Energy" was successfully designed and tested using a soil moisture sensor and an Arduino sensor. It was created by combining the features of all of the hardware components that were used. Every module's presence was carefully considered and placed, resulting in the best possible operation of the unit. As a result, an Arduino-based Solar-Powered Smart Irrigation System was successfully designed and tested. The water content (moisture level) of the various plants. The moisture sensor sends a signal to the Arduino board, which triggers the submersible water pump using a single channel relay as a switch if the moisture level falls below the desired and limited level.

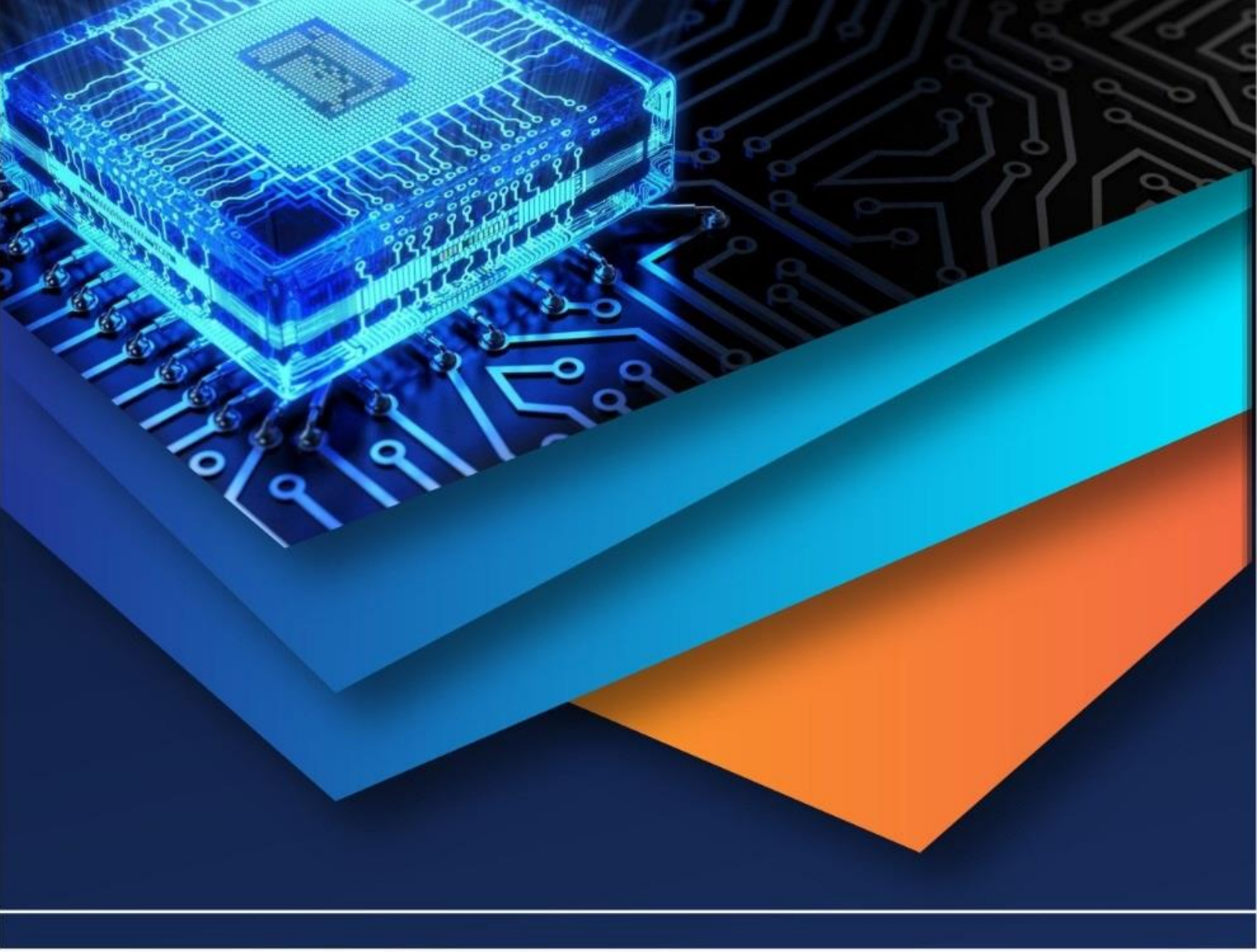
V. FUTURE SCOPE

Although it appears to be more demanding and difficult, there are many other options, such as creating complex connections of plants of similar varieties or what is known as "Plant Intent." Using multiple sensors is also an experimental venture, but there are many other experimental and challenging ideas, such as using solar power, using a timer to set an irrigation system, and so on. It could be extended to small-scale irrigation systems in the future, particularly for business crops.

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