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System for the Management of Plant Irrigation Based on the Internet of Things

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Abstract: *As a result, modern society is wholly reliant on cutting-edge technological advancements. Utilizing cutting-edge technology, irrigation systems are also gaining intelligence and so becoming preferable to older techniques. Utilizing data like soil moisture, weather forecasts, etc., the suggested method may maximise water use efficiency. Additionally, it will utilise IoT technology to provide feedback to the owner on the state of the soil and motor. If the proposed model detects that water is needed in a field, it can activate and deactivate the motor pump accordingly by reading the moisture level of the soil. A moisture sensor measures the moisture content of the soil in a certain region. When the water needs are met, the motor will turn off; when the field dries up, it will turn back on. An update (motor ON/OFF status) is transmitted to the farmers using IoT technology. The suggested system is entirely managed by an Arduino.*

Key words: *System, Management, Plant Irrigation, Internet of Things, Arduino.*

Introduction:

When integrated with IoT, an automated irrigation system can maximise available water for farming at a reasonable cost [1]. By using an automated irrigation system, we can show that water consumption can be cut back across a variety of agricultural uses while still maintaining crop yields [2-5]. The irrigation system ensures that just the necessary amount of water reaches the crop land. The Internet of Things allows this automatic irrigation system to be expanded to wider acres [6-11]. The amount of water used by agricultural crops has been reduced thanks to a newly created automatic irrigation system [12]. In order to keep tabs on the water levels in the tank and the soil moisture levels around the plants' roots, the system makes use of a wirelessly connected network of moisture and temperature sensors[13]. Furthermore, a gateway device processes data from sensors, activates actuators, and sends information to a web service. Motor control is handled by the Arduino Uno and is based on an algorithm that takes into account temperature, soil moisture, and water level as threshold values. Present-day water shortages can be directly attributed to population growth [14-19]. This device can detect the soil's moisture level and make decisions about whether or not irrigation is necessary, as well as how much water should be applied [20]. This initiative will help us streamline our farm monitoring procedures while also bringing them into the modern era [21-26]. The system's intention is to automatically irrigate the garden

whenever the moisture level in the soil drops below a certain threshold. When the earth is wet, the pump stops running automatically [27-35]. Remote access is available via the internet and the Thing talk Server for monitoring purposes [36].

Need of Automatic Irrigation

- Easy to set up and configure with minimal effort.
- Reduce waste and maximise efficiency by economising on energy and materials.
- Automating farm or nursery irrigation would allow farmers to spray the ideal amount of water at the ideal moment.
- Valves are used to control the on and off status of the irrigation system's motor in an automated system. Turning motors on and off manually is unnecessary when employing controllers to automate the process.
- Eliminating the need to manually change soil moisture levels, it saves time and reduces the likelihood of human error.

Literature Survey

Understanding the current methods, the process's requirements, and the need for a new system all go into the first research [37-41]. Because water is a vital resource for all forms of life, it is important to conserve it for uses like agriculture. The agricultural system is improved and water consumption is decreased via the use of various methods and technology. Monitoring the weather and sensing the many parameters like soil moisture and temperature to deliver water only when it is necessary by automated system can significantly reduce water usage in accordance with the weather conditions. According to a study by Mamta et al. [42], this technique is successful and affordable in optimising water resources for agricultural productivity. In addition to facilitating better upkeep, this method may be adapted to suit a wide range of plant types. Using this method is doable with any crop. These systems can be utilised for the mass production of greenhouse and open field crops.

Nilesh et al. [43] present several GSM-based irrigation system variants. All of these devices were remote-controlled and advocated for inexpensive data transmission using cellular phone networks. The survey findings have prompted an optimistic outlook on the role that GSM technology would play in improving irrigation practises on farms. Mobile phones and other software applications for managing the irrigation process are only two examples of the cutting-edge methods being used today to reduce water usage. As a result, agriculture will improve and become more efficient in the years to come. According to Istikoma et al. [44], plantation agriculture has been crucial to Malaysia's economic development from the early 20th century. It's easy to see how the agriculture sector has the potential to bring in a lot of money for the country and provide opportunities for people to better their lives. Government efforts that emphasise the New Economic Model (NEM) as represented by the Tenth Malaysia Plan's focus on improving palm oil and rubber productivity will go a long way toward helping Malaysia reach its 2020 goal of increasing the industry's gross national product (GNP) from RM 52.7 billion to RM 178.0 billion.

According to Suraj et al. [45], this technology saves water by delivering it precisely when and where it's needed by the crop. The use of fewer people is made possible by the fact that this is an automated irrigation system. Third, the feasibility and cost-effectiveness of this irrigation method for maximising available water for agricultural production were established. Fourth, the irrigation system may be modified to meet the needs of many different crops with minimal upkeep. With this setup, we can check the status of the motor and fan as well as the soil-moisture, temperature, and water level sensors. Optimizing water resources for agricultural production was found to be possible and cost-effective by Rayala et al., [46]'s system. With its adaptability and enhanced maintainability, this system is practical for any type of crop [47-67]. These systems can be utilised to significantly increase crop yields in both closed and open environments [68].

Working Process

In the current system, GSM is utilised to track the farms via text message [69-74]. Notifications from the sensors are relayed to the farms through GSM, which is more expensive and problematic in areas with poor or nonexistent connection (figure 1).

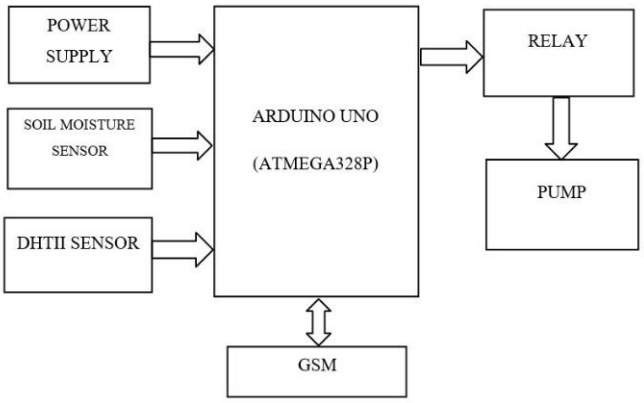

Figure 1: Block diagram of existing system

Drawbacks of Existing Process

- The current method use GSM technology to send messages to the plants to check on their health.
- Here, sensors keep track of all the plants, and GSM text messages with alerts are sent out.
- In addition, this system suffers from the issue of motor issues that are not immediately apparent.

Using sensing technologies to make farms more "intelligent" and more linked through so-called "precision agriculture," also known as "Smart Agriculture," is one strategy to address the Agriculture problems and raise the quality and quantity of agricultural production [75-81]. We're developing a sensor module that can measure humidity, temperature, soil moisture, and ph. An interface tells the farmer which seed will do best in his or her soil. Sensors for measuring environmental conditions, as well as temperature, humidity, and ph, are included into the system's design [82-89]. The programme will signal the Main Module to power the system on or off. Sensors collect data from every conceivable physical source and transform it from analogue to digital form. Field estimates of humidity and temperature can be made with the help of humidity and temperature sensors [90-115]. Capacitive soil moisture sensors are submerged in the ground to provide an approximation of the soil's moisture level (figure 2).

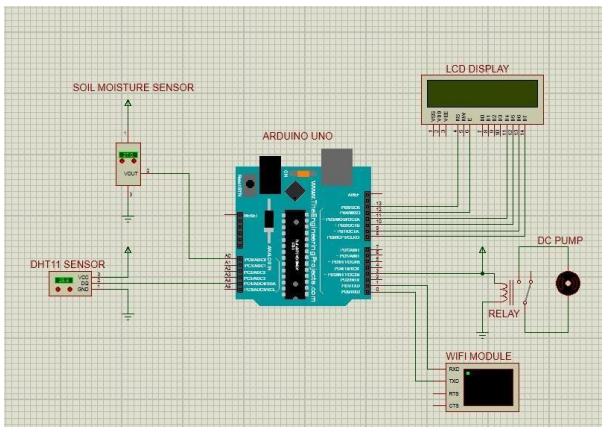

Figure 2: Circuit diagram of proposed system

Advantages of Proposed System

- The power used and the state of the motor may both be tracked by the farmer.
- All of these metrics can be tracked by the farmer wirelessly on a smartphone or computer.
- Whenever there is a change in the device's state, the server is updated immediately.
- In addition, by keeping track of how often the pump was turned on and off, we can estimate how much electricity we used (figure 3).

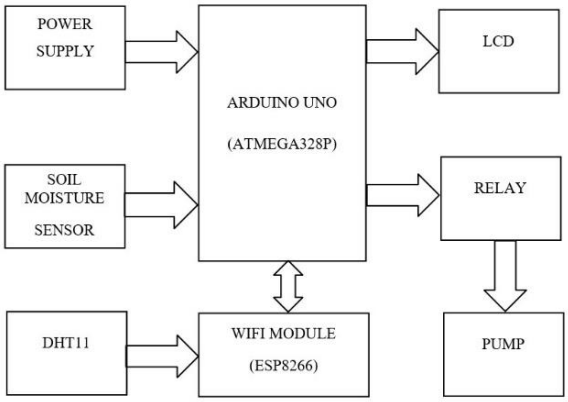

Figure 3: Block diagram of proposed system

Soil Moisture Sensor

Two probes make up the soil moisture sensor, and they're what actually determine how much water is in the soil [116-125]. By passing an electric current between the two probes and measuring the resulting change in resistance, we may determine the soil's moisture content [126-134]. More water means better electrical conductivity in the soil, which translates to less resistance. That means there'll be more moisture in the air [135-141]. Since dry soil is a poor conductor of electricity, the reduction in precipitation will increase the soil's resistance to electrical current. because of this, the relative humidity will be reduced [142].

Specifications

- 5V is the minimum operational voltage.
- Operating current is 20mA.
- Interface is of the analogue variety.
- This sensor has an optimal operating range of 10-30 degrees Celsius.

PIN Description

- Pin1 (VCC): It is a 5V DC pin
- Pin2 (GND): it is a GND (ground) pin
- Pin3 (DO): It is a low/ high output pin
- Pin4 (AO): It is an analog output pin

DHT11 Sensor

This DHT11 Temperature and Humidity Sensor can measure both air temperature and humidity and outputs a digital signal that has been calibrated for accuracy. Incorporated into its design is a powerful 8-bit microcontroller [143-156]. Its technological foundation guarantees supreme dependability and superb durability [157-168]. To measure temperatures in damp environments,

this sensor combines a resistive element with a wet-NTC temperature sensor. It's top-notch in every way; sturdy, quick to react, immune to interference, and powerful [169-171].

Features

- Total temperature compensation
- Temperature and humidity readings
- Exquisite long-term stability thanks to a calibrated digital signal
- Do not include unnecessary elements
- Transmission over a great distance
- low energy needs

Applications

- Take readings of heat and dampness
- Observatorium regionale
- Controlled temperature and humidity automatically
- Keeping an eye on the environment

Arduino UNO

Arduino is a freely available electronics development platform with user-friendly software and hardware [172-179]. Inputs such as light on a sensor, a finger on a button, or a tweet can be translated by Arduino boards into actions such as starting a motor, lighting an LED, or uploading data to the internet [180-191]. With the help of a set of instructions supplied to the board's microcontroller, the board can be told what to do [192-199]. The Arduino programming language and Arduino Integrated Development Environment (IDE) are utilised for this purpose (figure 4).

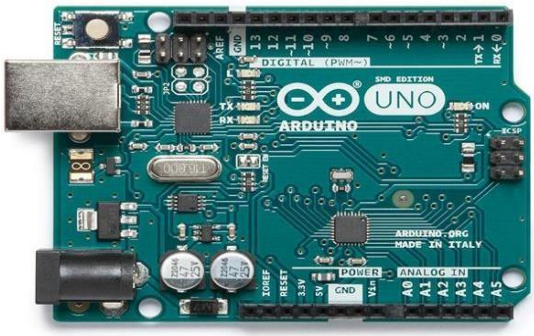

Figure 4: Arduino UNO

In response to feedback from users, Arduino has evolved from an 8-bit board to support Internet of Things (IoT) projects, wearable electronics, 3D printing, and embedded systems [200-205]. The source code for all Arduino boards is freely available, allowing anyone to create one and customise it to their specific needs [206-211]. Like the hardware, the software is open-source and is constantly improving thanks to the efforts of users all over the world [212].

ATMEGA328P – Microcontroller

Microchip's ATMEGA328P controller is a low-power powerhouse with impressive processing chops. An 8-bit microcontroller based on the AVR RISC architecture, ATMEGA328P [213]. Used in ARDUINO boards, it has become the de facto standard among AVR controllers. The ATMEGA328P controller is the most widely used due to its combination of performance and

affordability. This controller is also used in the development of ARDUINO boards due to its versatility. You may utilise ATMEGA328 just like you would any other controller. Everything is down to coding. When we send the controller a programme, it simply runs the code. The controller does nothing at all if it isn't programmed to. As previously stated, the controller must be programmed by first having the necessary programme file written to the ATMEGA328P's FLASH memory. The controller runs this code once it has been dumped and responds suitably.

PIN Description

XTAL1/XTAL2/TOSC1/TOSC2 For input and output, Port B is an 8-bit bidirectional I/O jack with built-in pull-up resistors (selected for each bit). Buffers at Port B's output can function as either a drain or a source, and their driving characteristics are balanced. Input current will be sourced if the pull-up resistors are engaged on port B pins that are externally pushed low. When a reset situation is present, the Port B pins are tri-stated even if the clock is not ticking. PB6 can function as input to the inverted oscillator amplifier or the internal clock operating circuit, depending on the settings of the clock selection fuse. The inverting oscillator amplifier can provide an output on pin PB7, depending on the clock selection fuse's position. When the chip clock is generated by the internally calibrated RC oscillator, PB7..6 serves as TOSC2. If the AS2 bit is set in ASSR, the asynchronous Timer/Counter2 will take a 1 input. This is a 7-bit bidirectional I/O port with internal pull-up resistors, and it's connected to Bus C. (selected for each bit). If the pull-up resistors are enabled, the externally pulled-low pins on Port C can be used as inputs to supply current. After a reset condition is triggered, the port C pins are tri-stated even though the clock is not ticking.

Once the RSTDISBL fuse has been set, input can be received on PC6. PC6 serves as a reset input if the RSTDISBL fuse has not been configured. When the clock is not active, a reset is triggered by a low level on this pin for longer than the minimum pulse length. Resetting with shorter pulses is not a given. As a bidirectional I/O port, Port D has internal pull-up resistors and can handle data in both directions of 8 bits (selected for each bit). Having strong sink and source capability, the port D output buffers are symmetrical in their drive characteristics. If the pull-up resistors are engaged, the port D input pins will operate as current sources even when connected to ground. A/D converter, PC3:0, and ADC7:6 are powered by the supply voltage pin AVCC. Even if you don't utilise the ADC, it still needs to be wired to VCC from the outside. A low-pass filter should be used to connect the ADC to VCC if it is to be used.

Architecture Design

With its AVR-enhanced RISC architecture, the ATmega 328P is a low-power 8-bit CMOS microcontroller. System designers can optimise power consumption versus processing speed with the ATmega48P/88P/168P/328P because of the device's ability to execute strong instructions in a single clock cycle. The 32 8-bit general-purpose working registers in the fast-access register file can be accessed in a single clock cycle. Consequently, the ALU may perform an operation in a single cycle. During a single clock cycle, an ALU can output two operands from the register file, perform the operation, and store the result back in the register file. Temporary data, local variables, and return addresses from interrupts and subroutines are often stored on the stack. Take into account that in this implementation, the stack expands from more recent to older memory locations. Regardless matter where the stack is located, the top is always shown by the stack pointer register. The subroutine and interrupt stacks are stored in the data SRAM stack area, which is referenced by the stack pointer. The status register of a versatile interrupt module also contains a global interrupt enable bit in addition to the I/O space control registers. Interrupts are represented in the database of interrupt vectors by unique interrupt numbers. Priority for interruptions is based on where they fall in the interrupt vector (figure 5).

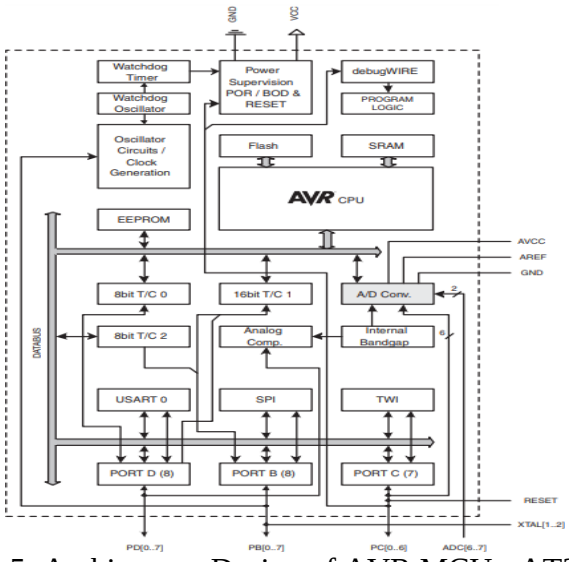

Figure 5: Architecture Design of AVR MCU - AT328P

Power Supply

It is possible to use either a USB cable or an external power supply to power the Arduino Uno. The system intelligently chooses the power supply. Both an AC-to-DC adapter (wall-wart) and a battery can supply external (non-USB) power. A 2.1mm center-positive plug can be used to connect the adapter to the board's power connector. In the POWER connector's Gnd and Vin pin headers, you can connect the battery's leads. A power supply between 6 and 20 volts can keep the board running. However, the board may become unstable if the 5V pin is provided with less than 7V. If the voltage is higher than 12V, the voltage regulator could overheat and cause the board to malfunction. Voltages between 7 and 12 volts are suggested.

Memory

The Atmega328 features 32 KB of flash memory (0.5 KB of which is required for the boot loader), 2 KB of static random access memory (SRAM), and 1 KB of erasable programmable read only memory (EEPROM) (which can be read and written with the EEPROM library). It's set up as a discrete data space where individual bytes can be read from and written to. At least one hundred thousand write/erase cycles are supported by the EEPROM. The peripherals and input/output (I/O) ports for the ATmega48P/88P/168P/328P are located in this area. To move information between the 32 general-purpose working registers and the I/O area, the LD/LDS/LDD and ST/STS/STD instructions can be used. The SBI and CBI instructions allow direct bit access to the I/O Registers in the 0x00 to 0x1F address range. Both the SBIS and SBIC commands can be used to examine individual bits in these registers. More information can be found in the manual. Addresses in the range 0x00-0x3F are required for usage with the IN and OUT I/O-specific instructions.

General Purpose Input and Output

Communication between a serial 0 (TX) and 1 (DX) device (TX). To receive and send TTL serial data, these are known as the RX and TX signals. The ATmega8U2 USB-to-TTL Serial chip has its relevant pins linked here. Two More Disruptions From Without An interrupt can be set off by a low value, a rising or falling edge, or a change in value on any of these pins. For more information, see to the attach Interrupt () method. There are 11 different types of PWM. Create 8-bit pulse-width-modulated (PWM) output using the analogue Write () command. LED 13. Digital pin 13 is wired to an internal LED, so the device may be easily debugged. As the pin's value goes from HIGH to LOW, the LED turns on and off (figure 6).

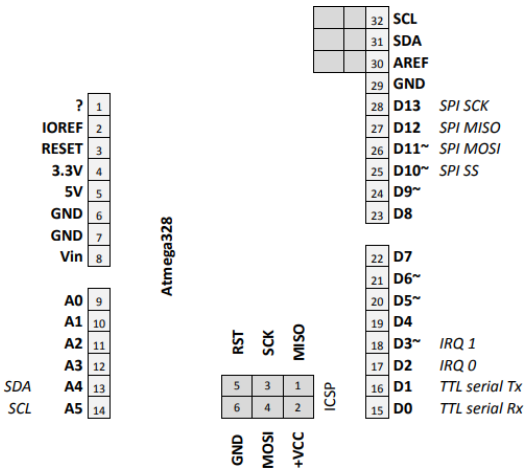

Figure 6: Layout diagram of Arduino

Benefits of Arduino

Cost-effective: Unlike competing microcontroller systems, Arduino boards don't break the bank. Universal Binary The Arduino software can be used on multiple platforms, including Windows, Mac OS X, and Linux. Microcontrollers can only run on Windows. Easy-to-understand programming environment - Anyone can pick up and use the Arduino programming environment, from complete novices to experienced pros. Arduino's software is open source, meaning that anyone with programming experience can access the code and modify it as they see fit. The Arduino is a microcontroller platform based on the open-source ATMEGA8 and ATMEGA168 chips from Atmel.

Arduino IDE Software

A developer can create firmware for novel projects with the use of an integrated development environment (IDE), which combines an editor, a linker, and a compiler. The Arduino integrated development environment (IDE) is a crucial part of the open source platform for rapid prototyping and library accessibility. All Arduino boards, including the Uno, Nano, and Mega, are supported. From the moment it was introduced to a larger audience, the Arduino board began evolving to meet the demands of its users. The company has expanded its product line from 8-bit boards to include solutions for Internet of Things (IoT) applications, wearables, 3D printing, and embedded systems (figure 7).

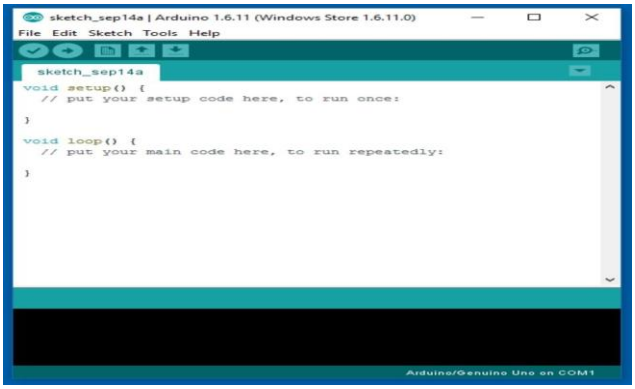

Figure 7: Arduino IDE software

Power Supply

This is a straightforward method of converting a single circuit into a dual-voltage (12V and 5V)

DC power source. Two ICs, a 7812 and a 7805, are used in the circuit to generate the necessary voltages. The transformer will reduce the high voltage from the wall outlet, the bridge will rectify the current, and the capacitor will filter the DC output. The 7812 controls this voltage so that you get 12V DC at a constant rate. With the 7805 in place, the 5V DC output from IC1 will be stable. The outputs of 12V and 5V DC are thus achieved. A relay is a coil-based electromechanical switch. A magnetic field is created as a current travels through the coil, and this movement of the switch is what makes or breaks the circuit. A relay is a device used to switch between two electrical circuits of different voltages without physically connecting them. This means that the high-voltage circuit and the low-voltage DC circuit are only connected magnetically, but not electrically (figure 8).

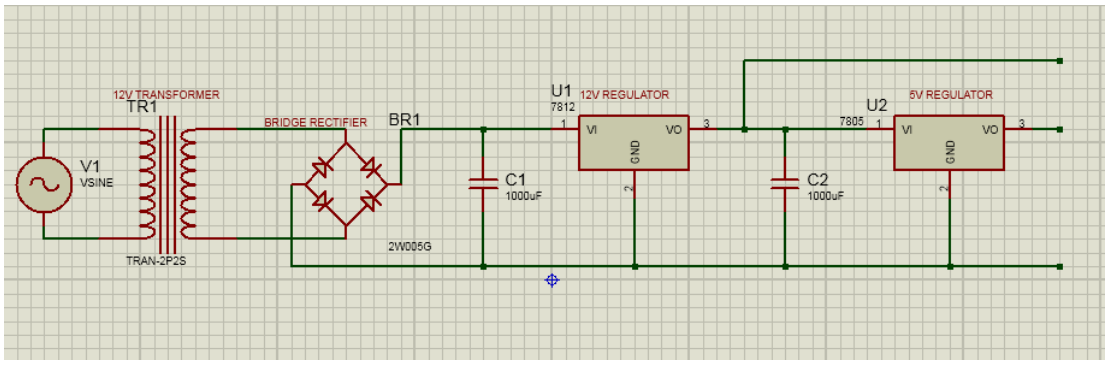

Figure 8: Circuit diagram of power supply

Operations of Relay

Small amounts of direct current (DC) flowing through the relay's coil "energise" the coil. Thus, the armature is drawn to the NO (Normally Open) pin. Armature returns to its original position when current through the coil is cut off, which is shown by the COM pin being connected to the NC (Normally Connected) pin. Every type of standard relay operates in the same way (figure 9).

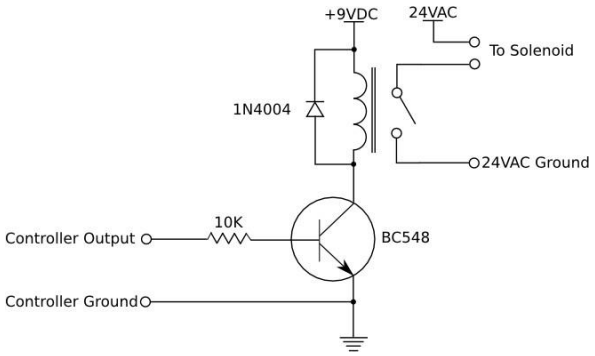

Figure 9: Circuit Diagram Of Relay Driver

DC Water Pump

Micro Submersible Pump Powered by a Micro DC 3-6V Power Source Miniature water pump for use in a do-it-yourself fountain or water garden recirculation system. Inexpensive and compact, this submersible pump motor runs on a 3–6V power source. Low power consumption of only 220mA allows it to process 120 litres of water each hour. To use, immerse the motor in water while connected to the pipe outlet, and turn on the power.

LCD Display

Hobbyists employ a wide variety of display devices. One of the most cutting edge forms of display technology they employ is liquid crystal screens. Once you figure out how to connect it, it will be the most user-friendly and dependable output device you've ever used. Furthermore, not every time any debugger can be utilised for micro controller based project. As a result, outputs can be tested with LCD screens (figure 10).

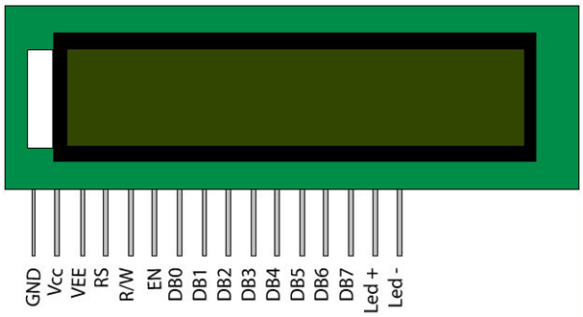

Figure 10: Pin diagram of LCD

LCD can process two different kinds of signals: data and control. Depending on the state of the RS pin, the LCD module will interpret different signals. With the R/W pin pulled high, data may now be read from the LCD screen as well. If the E pin is pulsed, the LCD screen reads the data at the falling edge of the pulse and processes it. The same is true for transmission. The time needed to display a character on an LCD screen or to carry out a command is between 39 and 43 microseconds. The time range is from 1.53ms to 1.64ms for all actions except clearing the display and seeking to the home position. Both dynamic random access memory (DDRAM) and static random access memory (CGRAM) are used in LCD displays. The DDRAM chip stores information on which ASCII character will be shown at a given address. There is a corresponding location on the LCD display for every byte of DDRAM. In order to display data on the LCD panel, the LCD controller accesses the DDRAM.

WiFi Module

The ESP8266 is an inexpensive and simple-to-use gadget that can link your creations to the internet. With its dual-functioning ability as an Access point (it can establish hotspots) and a station (it can connect to Wi-Fi), the module makes data collection and transmission over the Internet of Things (IoT) a breeze. Using application programming interfaces (APIs), it can also retrieve data from the internet, meaning that your project could gain access to any information that is publicly available online. Any microcontroller may connect to your WiFi network thanks to the ESP8266 WiFi Module, a self-contained SOC with an integrated TCP/IP protocol stack. The ESP8266 can act as a standalone application host or it can transfer the burden of handling Wi-Fi networking to another processor. Each ESP8266 module is shipped with AT command set firmware installed, so all you have to do is connect it to your Arduino to obtain the same level of built-in WiFi support as a WiFi Shield. The ESP8266 board is a very low-priced module with a sizable and expanding user base.

Result

The output picture explains how the module works as a whole; when the soil is too dry or the tank is empty, the pump is activated via the relay driver. When the amount of water in the tank reaches the predetermined "threshold moisture level," the pump turns off immediately. The module's software was written in embedded C and uploaded to an Arduino board, which controls the entire setup (figure 11).

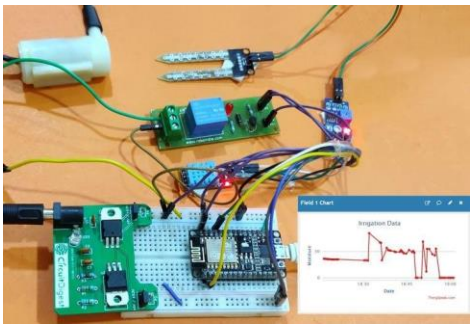

Figure 11: Overall output image

Conclusion

Consequently, our work raises consciousness about the potential of robotics and computerization in the agriculture sector. Here, plants can be irrigated automatically, cutting down on human labour, and data from the entire farm can be accessed from a smartphone app. In the future, this technology can be improved by expanding its use to a larger area. It is also possible to incorporate the system into a check of the soil quality and crop growth in each soil. Wireless communication between nodes is realised, and the sensors are successfully interfaced with the microcontroller. The results of the experiments and analyses show that this project is the best option for resolving the issues associated with fieldwork and water distribution. A higher crop yield and increased output are both possible results of using such a system in the field.

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