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Designing an Embedded System for Orchard Management

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Abstract Fruit Cultivation in Meghalaya is a prominent business sector for earning a good amount of state's revenue. Meghalaya being a home of wide variety of fruits and vegetables holds a unique position in production figures among other states of North-East. Fruit crops are capable of giving higher tonnage of yield per unit area than other field crops. Meghalaya produces several stone fruits such as plum, peach, pear, apricot in a restricted scale. This paper focuses on details of components for designing an embedded system for orchard management that will reduce labour cost, improve tree health, increase fruit production and boost state's economy.

Keywords: *microcontroller, sensors, constraints. Embedded system*

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1. Introduction

Meghalaya is basically an Agricultural State with about 80% of its total population depending entirely on Agriculture for their livelihood. Meghalaya has suitable climate for cultivation of wide variety of fruits. The key fruits grown in the state are pineapple, citrus fruits, banana, papaya and strawberries. Other potential fruits include plums, peaches, apricot,pear, guava, mango, litchi, lemon, etc. Fruits are found to be a rich source of vitamins and minerals. Fruits crops are capable of giving higher tonnage of yield per unit area than other field crops. Stone fruits like Plum, Peach, Pear, Apricot are found in the central plateau of East and West Khasi Hills and Jaintia Hills and have good commercial value. As the new technologies and developments have gradually become readily available in the country, the cropping and cultivating systems and production practices have also remained witness to significant metamorphosis. Fresh fruits and vegetables export has steadily increased. The foundation of tree fruit production is built on abundant physical resources: climate, soils, and water. Equally, it has relied on the energy and perservearance of the people that make up the industry in the production, handling, and distribution sectors. A dynamic scientific base and aggressive implementation of appropriate technologies form another essential component. Each of these will be equally important in enhancing the fruit production and shaping the future of our fruit industry.

Fruit Cultivation in Meghalaya is a prominent business sector for earning a good amount of state's revenue. But the low level of industrialization and the poor infrastructure base acts as a barrier to the interest of the state's economy. Plums, peaches, pear, apricots can be grown in abundance in Meghalaya. This is because Meghalaya has favourable soil and climatic conditions for stone fruit cultivation and thus holds a huge horticulture potential and also a great scope to augment business prospect.

2. Literature Review

V. Ramya, B. Palaniappan, Boby George [1] proposed an embedded system for automatic mist irrigation for cardamom field, which has a wireless sensor network for real time infield sensing and control of an irrigation system. This wireless system supports the cardamom field which has both plain and slope areas. The irrigation system updates solenoid valves for specified location of mist emitters automatically according to the set point of temperature, humidity and soil moisture. This system also senses the water level of the tank and whenever the water level is too low then the system immediately provides a visual and sound alarm and then it automatically switches ON the motor. When the water level reaches 90% of the tank then the motor is switched OFF through the remote system. Communication signals from the sensor network and irrigation controller to the base station is interfaced using XbeePRO communication. C. Arun, K. Lakshmi Sudha [2] discussed remote monitoring in agricultural greenhouse using wireless sensor and short message service (SMS); here they are sending data via sms. S. R. Kumbhar, Arjun P. Ghatule [3] presented a wireless application of drip irrigation system where irrigation is carried out using soil moisture values. Zhang Feng [4]

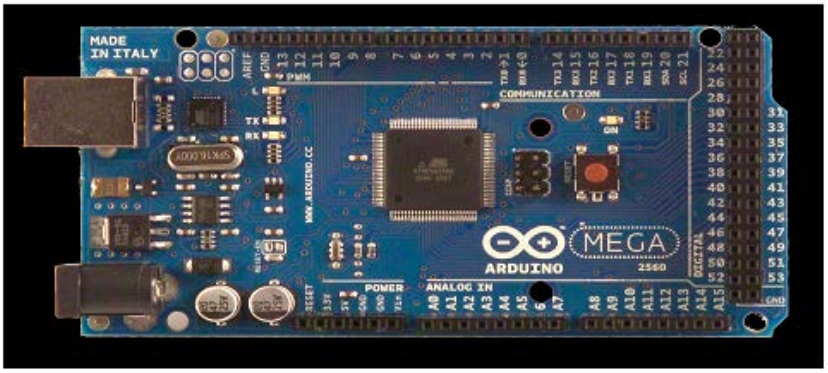
discussed the design of wireless sensor network and Internet technology of farmland automatic irrigation control method. Emphasis on an analysis of the routing protocol of sensor network nodes to achieve the system hardware and software design,middleware, and applications such as mobile phone or wireless PDA of internet of things,will constitute a variety of sensors intelligent network, thus enhancing the overall automation system and monitoring levels.The final analysis of the network in the Internet based on the agricultural plants of farmland water-saving irrigation system integrated approach. User use mobile phones or wireless PDA can easily soil moisture content of online monitoring and control to realize the irrigation automation.Application results show that system through the embedded control technology complete intelligent irrigation, improve the agricultural irrigation water use efficiency and irrigation system automatization is generally low status, can well realize water saving. Vitthal S Saptasagare,Basappa B Kodada [5] proposed a system that has several types of sensors deployed in the crop field area. It captures the physical phenomena of soil moisture, temperature, water level of the tank and ph of soil. The sensed data from various sensors goes to the central Global System for Mobile communication (GSM) node. From that the sensed data is given to the personal computer, which is used by a farmer.

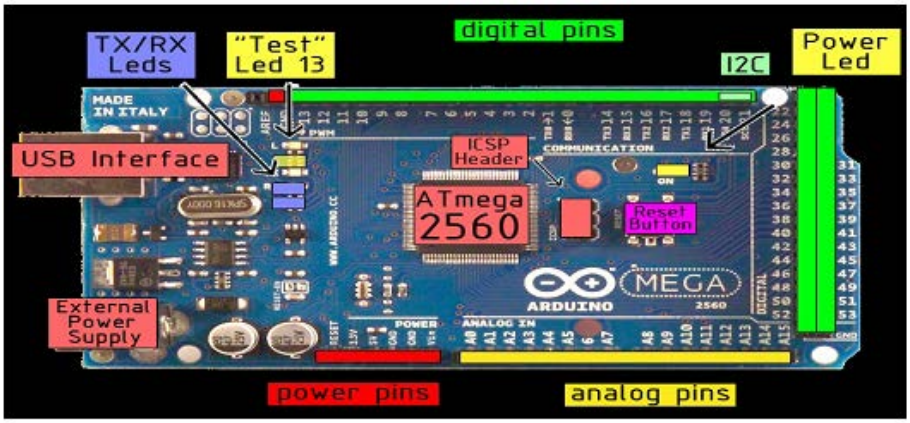
There are many other microcontrollers and microcontroller platforms available for physical computing. In this paper, the proposed embedded system is designed with Arduino. Arduino boards are relatively inexpensive compared to other microcontroller platforms. Arduino is available as an open-source on electronics platform and has a software package used to program the hardware part. It is developed to make easily accessible for designers and hobbyists and student to create an interactive and live environment to implement many objects based on electronics and automobiles. The concept of Arduino is developed by Massimo Banzi which is easily programmable and simple to deploy. The Arduino software runs on Windows, Macintosh OSX, and Linux. It has simple, clear programming environment. The microcontroller 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, Max MSP). Once we have downloaded/unzipped the arduino IDE, we can Plug the Arduino to our PC via USB cable. It is easy to implement in analog components, automatic engines, sensors, and other automobile and electronic automation devices. In the proposed system, sensors measure temperature and humidity, soil moisture, pH, rainfall. Also ultrasonic sensor, waterflow sensor, solenoid valve, water/fertisizer tank, motor, L293D IC , IN4007,TIP 120 are interfaced with Arduino. This is because Arduino can be deployed easily to establish many online functions that require many sensors.

3. Components Used

If we buy the components then the design time will be reduced and also the implementation speed will increase. The following components are used for designing an all-purpose embedded system for stone fruits of Meghalaya:

Arduino mega 2560: The Arduino mega 2560 board [6] is shown below:

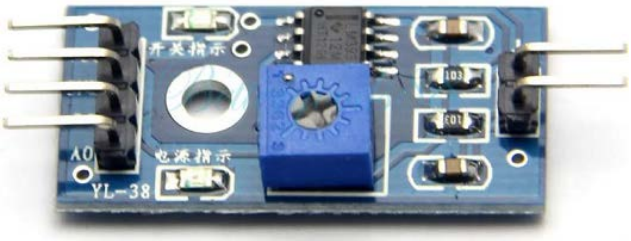




The Arduino Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Arduino Mega2560 can be programmed with the Arduino software. The Atmega2560 on the Arduino Mega comes preburned with a bootloader that allows us to upload new code to it without the use of an external hardware programmer.

Rain Sensor Module: The rain sensor module [7] is an easy tool for rain detection. It can be used as a switch when raindrop falls through the raining board and also for measuring rainfall intensity. The module features, a rain board and the control board that is separate for more convenience, power indicator LED and an adjustable sensitivity though a potentiometer. The analog output is used in detection of drops in the amount of rainfall. Connected to 5V power supply, the LED will turn on when induction board has no rain drop, and D0 output is high. When dropping a little amount water, D0 output is low, the switch indicator will turn on. Brush off the water droplets, and when restored to the initial state, outputs high level.

The rain sensor module is shown below:



Soil Moisture Sensor: The soil moisture sensor [8] is shown below:

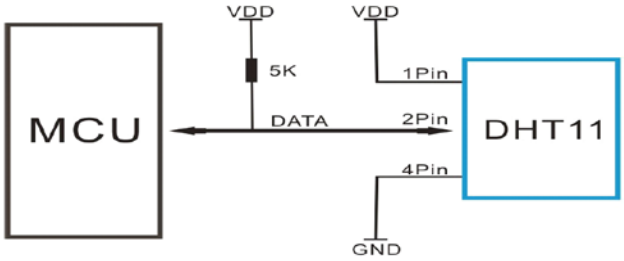
There are two types of soil moisture sensor. One is frequency domain sensor, which has an oscillating circuit. It measures the soil water content by measuring the soil's dielectric constant, which determines the velocity of an electromagnetic wave or pulse through the soil. When the soil's water content increases, the dielectric also increases, which can be used to estimate how much water the soil holds. The other one is neutron moisture gauge which utilise the moderator properties of water for neutrons. The principle is that fast neutrons are emitted from a decaying radioactive source, and when they collide with particles having the same mass as a neutron (i.e, protons, H+), they slow down. As the main source of hydrogen in soil is water, so by measuring the density of slowed-down neutrons around the probe can estimate the volume fraction of water content the soil holds. The pin configuration of soil moisture sensor is shown below:

Pin	Definition
Vcc	5V
GND	GND
D0	Digital output interface(0 and 1)
A0	Analog output interface

LM393 Driver: It consists of two independent low voltage comparators [9] designed to operate from a single supply over a wide range of voltages. Operation from split power supplies is also possible. These comparators also have a unique characteristic in that the input common-mode voltage range includes ground even though operated from a single power supply voltage. Input offset voltage specifications as low as 2.0 mV make this device an excellent selection for many applications in consumer automotive and industrial electronics.

DHT11 Humidity & Temperature Sensor: This DFRobot DHT11 Temperature & Humidity Sensor features a temperature & humidity sensor [10] complex with a calibrated digital signal output. By using the exclusive digital-signal-acquisition technique and temperature & humidity sensing technology, it ensures high reliability and excellent long-term stability. This sensor includes a resistive-type humidity measurement component and an NTC temperature measurement component, and connects to a high-performance 8-bit microcontroller, offering excellent quality, fast response, anti-interference ability and cost-effectiveness. Each DHT11 element is strictly calibrated in the laboratory that is extremely accurate on humidity calibration. The calibration coefficients are stored as programmes in the OTP memory, which are used by the sensor's internal signal detecting process. The single-wire serial interface makes system integration quick and easy. Its small size, low power consumption and up-to-20 meter signal transmission making it the best choice for various applications, including those most demanding ones. The component is 4-pin single row pin package. The DHT11 sensor is shown below:

Typical Application (figure below):



Note: 3Pin – Null; MCU = Micro-computer Unite or single chip Computer

When the connecting cable is shorter than 20 metres, a 5K pull-up resistor is recommended; when the connecting cable is longer than 20 metres, choose a appropriate pull-up resistor as needed.

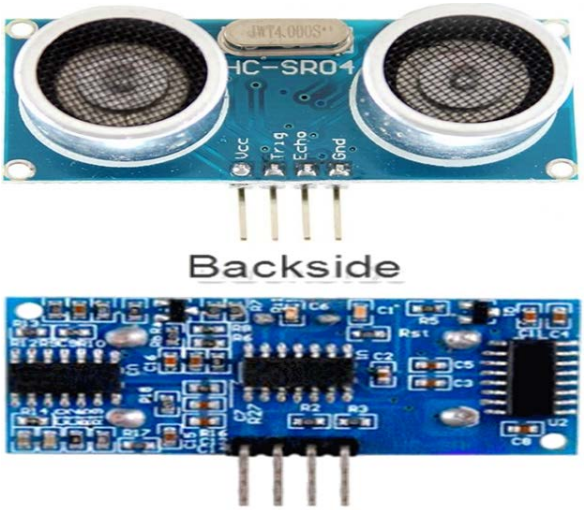
Ultra sonic Sensor: This is a low cost Ultrasonic Distance Sensor [11] provides a non-contact distance measurement with a fine accuracy of 3mm. The module is capable of measuring distance from obstacles in range of 2 cm to 400 cm or 1" to 3 Ft. Unlike IR sensors, the performance of this sensor is not dependent on the sunlight or color of the object. The module comes in a compact form factor with a ultrasonic transmitter, receiver and signal conditioning circuit on-board.

To start measurement, the Trig pin of SR04 must receive a pulse of high (5V) for at least 10µs, this will initiate the sensor will transmit out 8 cycle of ultrasonic burst at 40kHz and wait for the reflected ultrasonic burst. When the sensor detected ultrasonic from receiver, it will set the Echo pin to high (5V) and delay for a period (width) which proportion to distance. To obtain the distance, measure the width (Ton) of Echo pin.

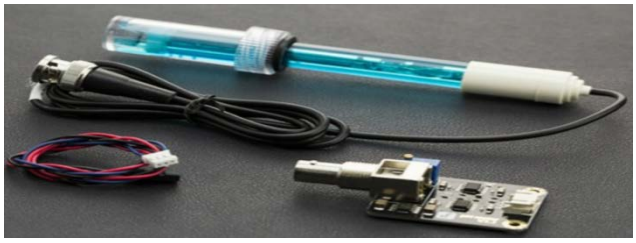
Time = Width of Echo pulse, in µS (micro second)

- Distance in centimetres = Time / 58
- Distance in inches = Time / 148
- Or we can utilize the speed of sound, which is 340m/s

The ultrasonic sensor is shown below:



pH Sensor: "pH stands for power of hydrogen, which is a measurement of the hydrogen ion concentration in the body. The total pH scale ranges from 1 to 14, with 7 considered to be neutral. A pH less than 7 is said to be acidic and solutions with a pH greater than 7 are basic or alkaline". The analog pH sensor/meter kit [12] is specially designed for Arduino controllers and has built-in simple, convenient and practical connection and features. It has an LED which works as the Power Indicator, a BNC connector and PH2.0 sensor interface. To use it, just connect the pH sensor with BNC connector, and plug the PH2.0 interface into the analog input port of any Arduino controller. The pH sensor kit is shown below:



Water flow sensor: The YF-S201 Hall Effect Water Flow Meter / Sensor sits in line with our water line and contains a pinwheel sensor to measure how much liquid has moved through it. There's an integrated magnetic hall effect sensor that outputs an electrical pulse with every revolution. The hall effect sensor is sealed from the water pipe and allows the sensor to stay safe and dry.

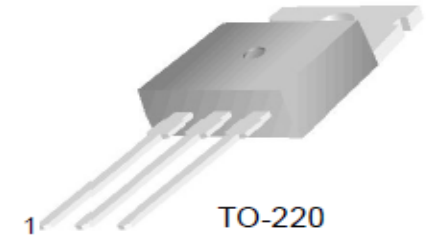
The sensor comes with three wires: red (5-24VDC power), black (ground) and yellow (Hall effect pulse output). By counting the pulses from the output of the sensor, the water flow can be easily calculated. Each pulse is approximately 2.25 milliliters. The working voltage is 5 to 18V DC (min tested working voltage 4.5V) and the working flow rate is 1 to 30 Liters/Minute. The **connection details are:** Red wire: +5V; Black wire: GND; Yellow wire: PWM output. The water flow sensor is shown below:

Solenoid Valve: The 12V Solenoid Valve - 3/4" is a controlled fluid valve. Simply connect a fluid source to the 3/4" threaded inlet and it will interrupt the flow until 12V is applied to the fast-on connectors on the solenoid.

The solenoid coil is used to translate the electric pulses into hydraulic pulses that enables opening and closing of specific solenoid valves. Solenoid coil, when mounted on the valve are connected to the controller by an electric cable. The solenoid valves are power operated devices which are used to modify the fluid flow or pressure rate in a process system. It is normally closed if there is no flow across the valve in its resting position with no current on the solenoid contacts. The quick opening of the valves, consisting of a metallic circular disc at right angles to the

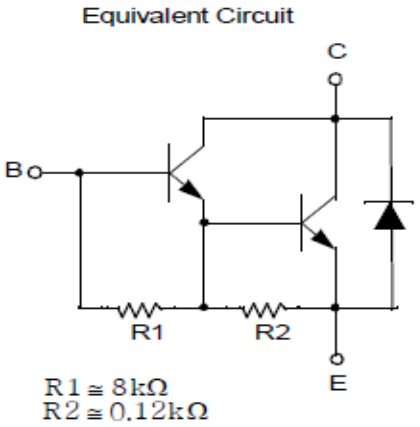
direction of flow in the pipe, which when rotated on a shaft, seals against the seats in the valve body. Solenoids offer fast and safe switching, high reliability, long service life, good medium compatibility of the materials used, low control power and compact design.

DC motor: Here a 6V DC motor is used. The operating temperature: -10°C ~ +60°C and rated voltage: 6.0VDC.

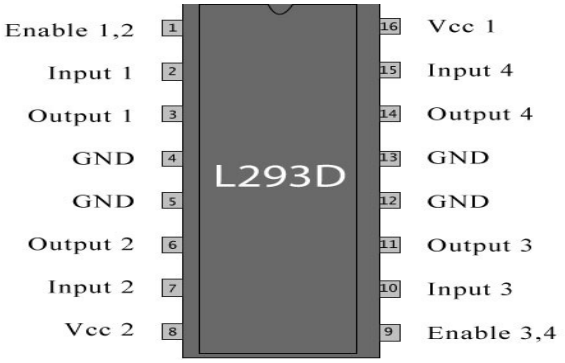


IN4007: A rectifier diode is used as a one-way check valve. Since these diodes only allow electrical current to flow in one direction, they are used to convert AC power into DC power. When constructing a rectifier, it is important to choose the correct diode for the job; otherwise, the circuit may become damaged. A 1N4007 diode is electrically compatible with other rectifier diodes, and can be used as a replacement for any diode in the 1N400x family. The 1N4007 can sustain a peak repetitive reverse voltage of 1000 volts. When the maximum allowable consistent current amount is flowing through the diode, the voltage differential between the anode and the cathode is 1.1 volts. Under these conditions, a 1N4007 diode will dissipate 3 watts of power (about half of which is waste heat).

TIP120 NPN Epitaxial Darlington Transistor: TIP120 and its equivalent circuit is shown below:



L293D IC: L293D is a dual H-bridge motor driver integrated circuit (IC). Motor drivers act as current amplifiers since they take a low-current control signal and provide a higher-current signal. This higher current signal is used to drive the motors. L293D contains two inbuilt H-bridge driver circuits. In its common mode of operation, two DC motors can be driven simultaneously, both in forward and reverse direction. The L293D IC is shown below:



The motors are rotated on the basis of the inputs provided across the input pins as LOGIC 0 or LOGIC 1. In simple words we need to provide Logic 0 or 1 across the input pins for rotating the motor. Lets consider a Motor connected on left side output pins (pin 3,6). For rotating the motor in clockwise direction the input pins has to be provided with Logic 1 and Logic 0.

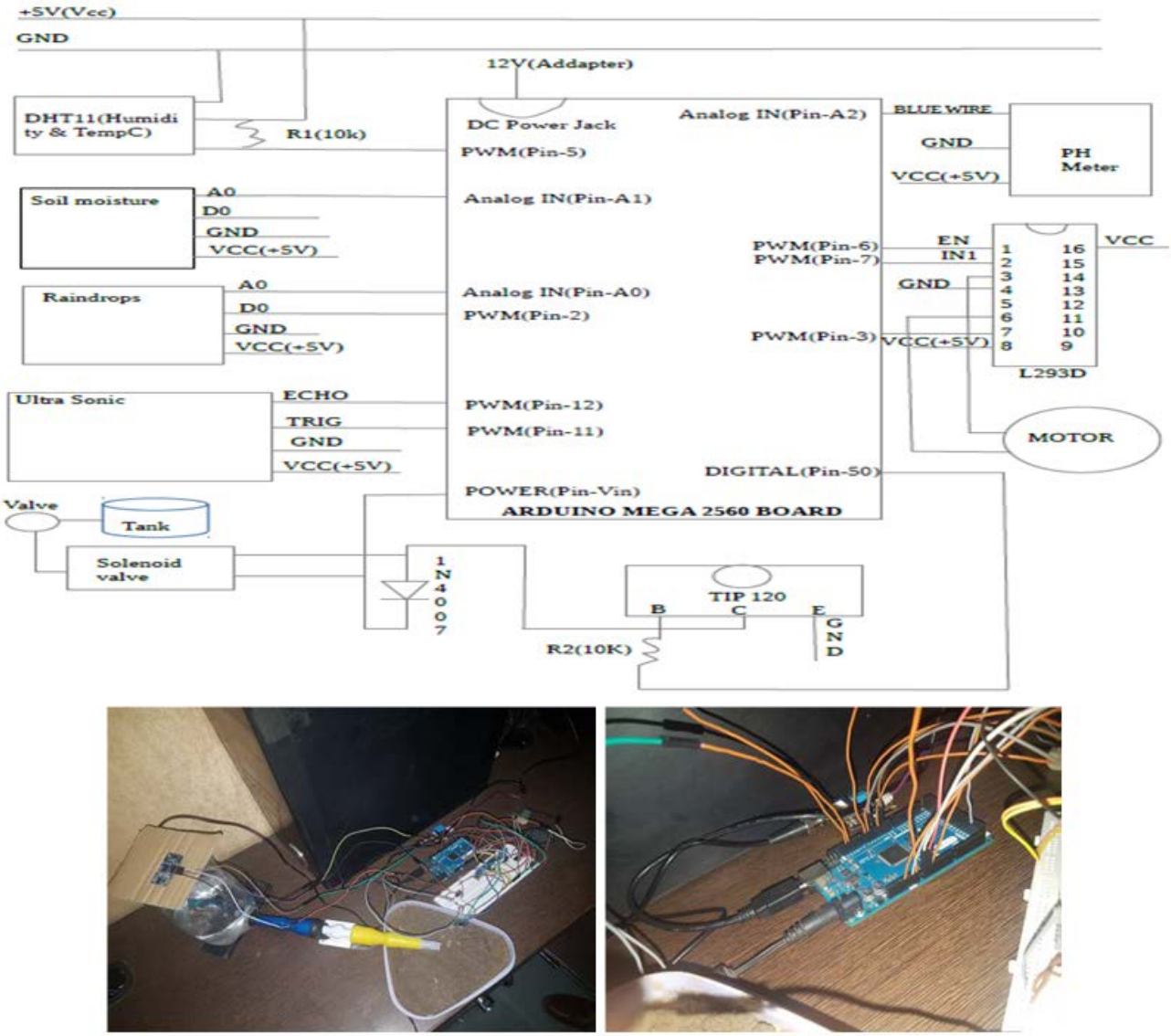
- **Pin 2** = **Logic 1** and **Pin 7** = **Logic 0** Clockwise Direction
- **Pin 2**= **Logic 0** and **Pin 7** = **Logic 1** Anticlockwise Direction
- **Pin 2**= **Logic 0** and **Pin 7** = **Logic 0** Idle [No rotation] [Hi-Impedance state]
- **Pin 2**= **Logic 1**and **Pin 7** = **Logic 1** Idle [No rotation]

Water Tank: The same tank is used for supplying water to the field and for fertiliser application when required. Organic fertilisers such as bird and animal manures, blood meal, fish meal, feather meal, ecto and endo mycorrhizae etc can also be used. Organic-based ingredients promote stable consistent plant growth with no growth spikes.

Also connecting wire, resistors, pipe, M Seal, breadboard etc are used.

Pest control: For pest control, traditional pest control method and electronic pest repellent are preferred.

Connection Diagram: The connection diagram of the proposed system is shown below**:**



4. Constraints

The state of Meghalaya is facing some of the constraints in development of this fruit sector. These include following constraints:

- Inadequate infrastructure for post-harvest management
- Land use and tenure system
- Poor transport infrastructure
- Lack of a robust distribution and marketing infrastructure for horticulture produce
- Lack of well-established processing infrastructure to manage the horticultural produce, etc.
- Supply chain and branding issue.
- Credit availability is also a serious concern.

5. Conclusive Observations

Stone fruits like Plum, Peach, Pear, Apricot are found in the central plateau of East and West Khasi Hills and Jaintia Hills and have good commercial value. Now by implementing appropriate technology, stone fruits can also be grown in other parts of the state. Cultivation of fruits will surely play a vital role in the prosperity of Meghalaya as generally stated that the standard of living of the people can be judged by per capita production and consumption of fruits. Improved management of nutrients (nitrogen, phosphorous, potassium, and micronutrients) has a fundamental and critically important impact in responsible stewardship, and given sufficient scholarly investigation, may be amenable to much more precise delivery and consequent improvements in fruit and tree quality. Though the initial cost of establishment of an orchard is high, it is compensated by higher productivity or due to high value of produce. In the long term, the revolutionary technological innovations will dramatically change the way tree fruit is produced, handled, and utilized. A dynamic scientific base and aggressive implementation of technologies form the third essential component will be equally important in addressing the globalized marketplace and shaping the future of our stone fruit industry.

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