Soil Moisture, Temperature and Humidity Measurement Using Arduino

Prahlad Bhadani
Amity School of Engineering and Technology
Amity University
Noida, India
prahladbhadani52@gmail.com

Dr. Vasudha Vashisht
Associate Professor
Amity School of Engineering and Technology
Amity University
Noida, India
vvashisht@amity.edu

***Abstract*— As per the FAO statistics of world agriculture in 2010, India is the world's largest producer of many fresh fruits. In 2013, India was the seventh largest agriculture exporter, exporting $39 BN worth of agricultural goods [1]. All this data shows how big the agricultural industry in India is. To provide smart farming techniques to Indian farmers to accurately monitor essential factors of crop growth, this project is developed. The device measures three of the most important and basic parameters for growth of plants namely soil moisture, temperature and humidity. The microcontroller is Arduino Uno. The FC28 Hygrometer and DHT11 sensors are used to measure soil moisture and temperature and humidity respectively. The sensors read the data and send it to the microcontroller board. The board then processes and maps the data as per the code, and finally displays it on the LCD unit.**

Keywords*— *Arduino, FC28 Soil Hygrometer, DHT11

I. Introduction

In this world of increasing global warming and reducing water level, finding fertile soil with adequate moisture content is a difficult task. Farmers and other cultivators hence need to determine the value of soil moisture before sowing seeds or investing in crop fertilizers.

Also another aspect of farming can be the different moisture requirement, temperature and humidity of the surroundings by different crops. Some crops require less amount of soil moisture and some require more. The temperature and humidity of the surroundings also matter to different crop patterns.

In soil research, earth water study and agricultural sciences, water content contributes vitally in:

- groundwater renewal,
- agronomy, and
- Soil chemistry.

Various methods of measuring soil moisture other than Arduino [2]:

Direct Method: Known volume of soil material is taken and the volumetric water content is measured. This requires volume (Vw) and mass (Mw) of water. The formula for calculation is:

$$V_w = \frac{m_w}{\rho_w} = \frac{m_{\text{wet}} - m_{\text{dry}}}{\rho_w}$$ [5]

Lab – based methods: Chemical titration is used to determine moisture content values.

Geophysical methods:

Time- domain reflectometry (TDR)

Electrical resistivity tomography

Ground penetrating radar etc.

Satellite sensing methods

Traditional method for measuring temperature and humidity was through thermometers. Analog thermometers were not as accurate and precise as the digital methods.

The FC 28 hygrometer sensor uses concept of resistance in conduction of electricity through water. Moist soil conducts more due to presence of more ions in water. Dry soil conducts less because of absence of water content. Hence depending on the water content of the soil, a value up to 1023 may be displayed by the sensor.

The DHT11 sensor consists of a component that senses humidity and a component called a thermistor which senses the temperature. There is also an IC/ integrated circuit on the back of the sensor [5].

There can be three possible cases with the moisture content in the soil of a plant:

- If the soil of a plant is too moist, the roots get wasted and also the plant does not get enough oxygen from the soil. As a result, the plant dies.
- When the soil is too dry, the nutrient needs of a plant won't be fulfilled.
- The soil has just enough water to support effective growth of a plant.

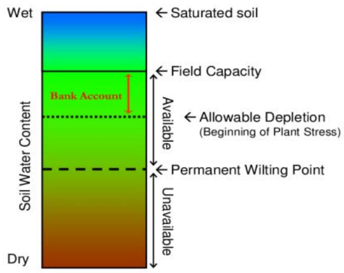

Fig. 1: Soil Water Content [7]

Humidity or more precisely relative humidity can be defined as the amount of water vapour present in the air to the total amount of water vapour the air can hold. Humidity effects the opening of stomatal pores on the leaves for transpiration or moisture exchange with the atmosphere. Stomata can also be stated as the breathing pores for the plant.

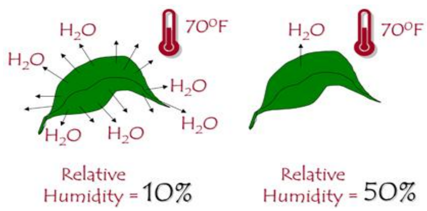

Fig 2: Effect of humidity on transpiration [13]

When the relative humidity of the air is too high, the process of transpiration or evaporation of moisture becomes very difficult, as the plant cannot make water evaporate. In relatively warm temperatures and low relative humidity, plants feel easy to transpire. This reduces the need of fertilizing the plant.

Also high humidity in the air promotes the growth of mold and bacteria on the surface of the plants. This results in plant death and crop failure. Fungus and pests which feed on the plant roots also start accelerating in growth due to high humidity levels.

Temperature required by plants to grow optimally also varies from plant to plant but obviously too high or too low temperatures kill plants.[3]

II. Ease of Use

- This device measures temperature, humidity and soil moisture using the same device addressing the portability and cost issues and providing reasonably accurate values during measurement. Hence, such a device is a must have for every farmer or someone who grows crops.
- Hobbyists and people who grow crops in their backyards can also use this device to effectively make their gardening decisions.

III. Materials and Methods

Below listed are the materials and apparatus used in this project:

A. Arduino Genuino Uno

The uno from arduino.cc is an open source board, also referred to as a microcontroller board. It is based on the "ATMega328P" microcontroller board. Arduino.cc developed this board. There are digital and analog pins for input/output. The board has 14 digital and 6 analog pins. The programming software that is used to program the board is the Arduino IDE (Integrated Development Environment). A type-B USB cable is used to connect the Arduino board to the computer system.

Technical specifications:

- The microcontroller is ATMega328P
- Operates at 5 volts
- Can work on 7-20 volts of input voltage
- 14 digital i/o pins (6 for pulse width modulation output)
- 6 analog input pins
- Direct Current per input/output pin: 0.020A
- Direct Current for 3.3 volt pin: 0.05A
- 32 KB of flash storage out of which bootloader uses 0.5 KB
- 2 KB of Static random access memory(SRAM)
- 1 KB of Electrically erasable/programmable ROM
- Processor frequency is16 Mega Hertz
- Dimensions: 6.86 cm * 5.34 mm
- Weight: 25 g

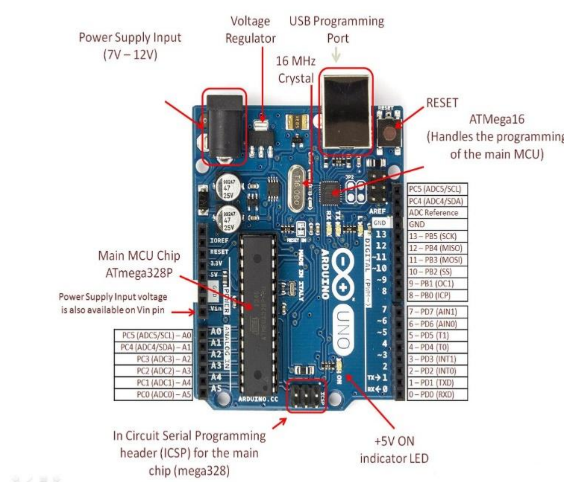

Fig. 3: Pin Configuration of Arduino Uno [9]

B. FC-28 Soil Moisture Hygrometer Sensor

Two probes estimate the volumetric content of water in the soil. Current passes through the soil and then through the probes, after which the moisture value is calculated based on the resistance offered.

In more water, soil becomes more conductive and which means resistance decreases. Therefore moisture value displayed is higher. Dry soil is a poor electricity conductor, so, less moisture means less conduction of electricity. Therefore, the moisture level is lessened.

Technical Specifications:

- I/p Voltage: 3.3–5 V
- O/p Voltage: 0–4.2 V
- I/p Current: 0.035A
- O/p Signal type: analog & digital

Pin-out

The FC-28 has four pins:

- VCC is Power
- A0 is Analog Output
- D0 is Digital Output
- GND is Ground

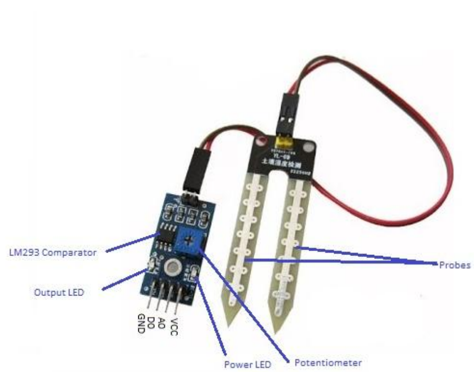

Fig. 4: Pin Configuration of FC-28 Soil Hygrometer [10]

C. DHT11 Temperature and Humidity sensor

It has a humidity measuring module, a thermistor and an integrated circuit on the back of the sensor unit. The humidity measurement module consists of two electrodes. Sandwiched between the two electrodes is a substrate that is capable of holding moisture. Change in humidity alters the conductivity of the moisture holding substrate which at the same time changes the resistance. The integrated circuit then processes the change in the resistance and humidity value is measured.

On the other hand, change in temperature changes the resistance of the thermistor which is processed by the integrated circuit and the calibration results into a value of the temperature.

Technical Specifications:

- PCB Size: 2.2cm x 2.05cm x 0.016cm
- Working Voltage: 3.3V or 5V DC
- Operating Voltage: 3.3V or 5V DC
- Measurement Range: 20-95% Relative Humidity, 0-50 ℃

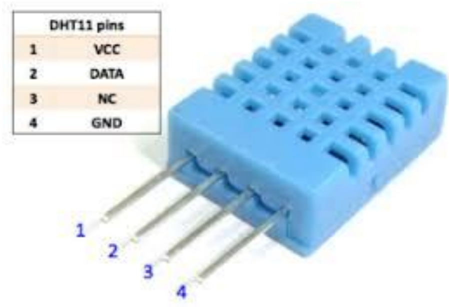

Fig. 5: Pin Diagram of DHT11 [11]

D. I2C 16X2 LCD display unit

The Liquid crystal display contains a built-in register which stores the commands and data supplied to the unit. It works in two modes, the first is READ mode and the second is WRITE mode. In the write mode, instructions to control the display unit is written in the register example clear display, shift right, cursor set etc. Also the data to be displayed is supplied in the write mode.

Two signals namely SDA and SCL are present in the BUS which are data and clock signals respectively.

Technical Specifications:

• Power supply: the board is supplied power through the Vin and the Vcc pins. Vin may or may not be used but usage of Vcc is mandatory. The Vin pin should be operated between 7V TO 12V (20 V IN WORST CASE) ;and that for Vcc pin is 4.5 volt to 5.5 volts (a typical module generally uses 5 volt supply). In case both the pins are powered, priority will be given to the Vin pin and will power the lcd module and backlight; else the Vcc powers up the full board. The I2C extender is pre-designed to function on 5 volt supply, utilizing the voltage accessible on the VCC pins, however, it can likewise be arranged to utilize 3.3V.[6]

• Maximum current that can be drawn by the lcd module is around 0.2A

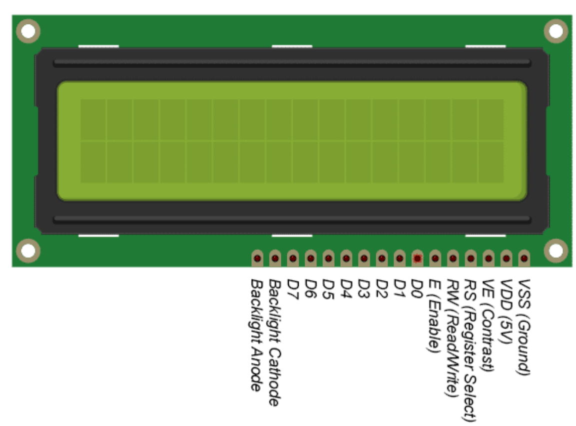

Fig. 6: Pin Configuration of 16X2 LCD [12]

IV. WORKING OF MODEL

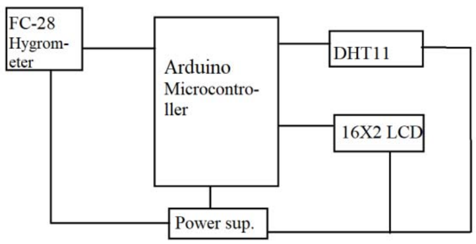

Fig. 7: Block Diagram of Circuit

The circuit is connected as shown in the circuit diagram (as shown in figure). The sensors can be connected to the board in both analog and digital ways. Both the fc 28 and the dht11 are connected to the Arduino board and the LCD display unit displays all three information i.e. temperature, humidity and soil moisture percentage. The circuit diagram is as follows:

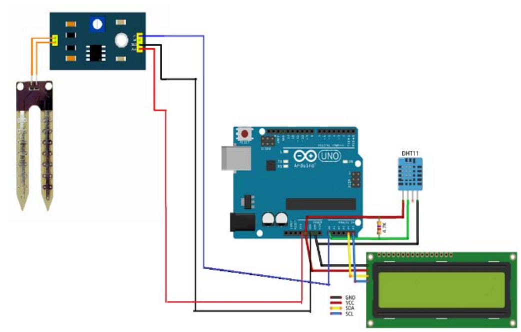

Fig 8: Circuit Diagram

The connections are as follows:

Soil moisture sensor:

A0 pin of the soil moisture sensor is connected to A0 pin of the Arduino analog pin.

VCC pin of the FC28 is connected to the 3.3V Arduino pin.

Ground pin of the fc28 to the Ground pin of the Arduino.

I2C Liquid display unit:

SCL or the clock signal to analog A5 pin.

SDA or the data signal to the A4 analog pin of the Arduino board.

VCC to 5 volt pin of the Arduino.

GND to the ground pin of the Arduino.

DHT11 temperature and humidity sensor:

Data pin of the sensor is connected to the digital pin number 7

Ground pin to the ground pin of the Arduino board.

VCC pin of the sensor is connected to the 5V supply of the Arduino.

The sensors according to their resistance values read the values from the environment, be it soil or atmosphere and transmit the signals to the Arduino board. It is the user's choice to either read it through the serial monitor or a LCD unit.

An LCD unit is a better choice because if we read values on the serial monitor, a computer system is always required which poses portability problems.

The FC28 hygrometer reads the resistance values as per the water content in the soil. The LM393 chip installed along with the sensor probes calibrates the resistance values to numeric values. Those numeric values are then mapped to percentage values using Arduino IDE. Based upon the reading it gives out at the time of measurement in dry and wet soil. DHT11 also measures resistance values. Similarly

the chip converts resistance values to temperature and humidity. The corresponding functions used to read values from the sensors are involved in the code to communicate with the microcontroller board and read the values that are displayed in the serial monitor or the LCD display.[8]

V. RESULTS AND DISCUSSIONS

The main aim for this project was to develop a tool for farmers and cultivators to check the suitability of environmental conditions in order to facilitate the growth of crops in an efficient way to get the best yield possible.

This project gives quite accurate readings in comparison to expensive soil testing apparatus. However main results depend on how the readings are mapped using the code.

The model is portable and can be carried to any location.

Once the code is uploaded to the board, it need not be re programmed each time it is used.

Using same technology we can make various other bigger projects

Measuring the values of the temperature, humidity and soil moisture, we can accordingly vary temperature, and irrigate our soil.

Fertilizers and other compost materials can be used accordingly to make the soil fertile.

Chemistry of plants can be studied using the various parameters.

A general idea of what kind of plants can and should be grown in the Indian climate can be figured out using this apparatus.

VI. CONCLUSIONS AND RECOMMENDATIONS

This project is an effective tool for farmers.

It is a wholesome involvement of computer programming and hardware interaction.It shows how computer programming is expanding in other domains like agriculture, farming etc.

How readymade boards facilitate various components like various sensors and modules. Arduino projects are like Lego blocks.

Creativity and necessity can find unlimited possibilities in the field of Arduino projects.

Internet of things is on the way of taking over the world.

Arduino coding is based on the c++ programming language.

The inheritance property of the language plays an important role in Arduino programming.

Gives another reason to learn programming languages. This project can be expanded even further to involve sprinklers and air conditioners to improve environment quality.

Fully automated farming systems can be developed keeping Arduino as a base.

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