International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075, Volume-8 Issue-6S, April 2019

Technical Irrigation System to Predict Soil Moisture and Water Level in Agricultural Field

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Abstract: ***To make smartphone operated irrigation system using soil moisture and water sensor is proposed in this work. Internet of Things (IoT) is used in the application to support smart irrigation. The following devices are used in this application: Arduino indicator, interactive indicators, and other required sensors. This application is mainly developed for the agricultural sector to help the farmers. The proposed system indicates the soil moisture content of the agricultural land to trigger the water content to be provided for the cultivation. The smart irrigation saves power consumption which is much more in tractor irrigation. The main requirement for the successful implementation of the irrigation system is the availability of the resources for the farmers in the agricultural field with the decent knowledge of the operation of the system.***

Index Terms: ***Arduino, sensors, soil moisture, water level, smart irrigation.***

1. INTRODUCTION

The technical irrigation system is a smarter way of irrigating the crops and plants with the adequate amount of moisture and water intake [3]. It works in several phases with an induction of Arduino board by the main switch of smartphone. The setup contains soil moisture indicator to give the idea about the amount of moisture required for cultivation. Unlike canal and well irrigation, the next gadget is water level indicator only triggered relative to the moisture content indicated by soil setup [16, 23].

The additional equipment indulged in this irrigation process is reading meters for the amount of water and moisture. Also, the pipe system across the agricultural land would provide the water supply and stop as per the upper limit of the water level indicator. The capacity of the setup varies as per the unit per area of the cultivation field. The land with an area of one acre would need only one Arduino, soil moisture and water sensor whereas in regions with seventy to hundred acres would require much more quantity of this to establish a powerful setup [8]. It is an advanced form of groundwater and drip irrigation. This technical irrigation system is yet another step towards the sustainable development of life resources.

II. ARDUINO

Arduino is an open source computer hardware design to manufac-ture single board microcontroller kits. It provides a platform for constructing digital devices to sense and control the objects in the digital world.

Revised Manuscript Received on December 22, 2018.

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Arduino board design uses a variety of microproces-sors and microcontrollers. The boards are furnished with I/O pins for interface with any other types of boards, circuits or Breadboards.

A. Program structure

Arduino IDE sketch comprises two functions:

- *Setup ():* This function prototype is called once when the sketch started to initialize the libraries.
- Loop (): It is used to initialize the values of the variables.

B. Phase I

The following procedures are incorporated in Phase I.

Step I: Smartphone operated LED indicator

Connect one wire LED to the X of the Arduino and other to Y of the Arduino [21]. Compile the program for the LED indicator uses the Arduino software. Upload the program to Arduino by Arduino cable. Then, the users should download the Bluetooth Arduino App. The Bluetooth Module is to be connected to the positive and negative ends of the Arduino. Then, switch on the Bluetooth module in the smartphone and connect it to Arduino. Run the set up by clicking ON button in the App. The output LED should glow and on the next tap, it should switch off. Most Arduino boards contain Light Emitting Diode (LED) and a load resistor which is connect-ed in between pin-13 and Ground [22]. The web based irrigation system has been programmed in the equipment like LEDs. A typi-cal program for beginning Arduino program blinks the LED re-peatedly.

```
void setup() {
   pinMode (13, OUTPUT); // Set pin-13 for digital
   output.    }
void loop() {
  digitalWrite (13, HIGH);           // Turn on pin-13.
  delay (1000);           // Wait 1 second (1000
  milliseconds).
  digitalWrite (13, LOW); //Turn off the pin-13.
  delay (1000); }                    // Wait for one second.
```

The function pinMode() which configure the pin in input mode or output mode as specified; digital Write() which enable or disable the input pin. delay () which passes the program to certain time. All these functions are provided by the internal libraries.

Step 2: Soil moisture sensor

The volume of the water content present in the soil is measured by soil moisture sensors.

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Since, the straight gravimetric capacity of the soil moisture needs eliminating, weighting and dehydrating model. The indirect measurement of soil moisture is using the properties of the soil which is the proxy for the moisture content [4]. The transportable probe instrument is used by farmers.

Step 3: Application in Agricultural sector

It is important in the agricultural application to measure the moisture level in the soil. Thus it helps the farmers to manage their irrigation systems more efficiently to optimize the usage of water [20]. Knowing the accurate value of soil moistures helps the farmers and enables them to use less water to grow a crop. Hence, the quality of the crop and the yields are increased by improving the soil moisture condition at the time of critical plant growth stages. The function pinMode() which configure the pin in input mode.

Step 4: Water detector

A boon to water deficient areas, a water detector is a microelectronic device that is aimed to identify the presence of water and provide an alert in time to let the avoidance of water outflow. The device echoes an audible alarm together providing forward signaling in the occurrence of adequate water to link the connections. A leak arising inside a floor is overlooked until the hydrostatic head of pressure meant that the water originates its path through the floors below where its leaking through the ceiling would be noticed. At the more alarming rate the water would enter the joints and connectors of the power or network connections, ultimately leading to system failure due to short circuit. The water detector progresses the irrigation efficiency in water consumption [9]. This facility will be used in an engaged region near any sub-structure that is likely to leak water such as drainage pipes, water tanks and pipes, HVAC, vending machines and dehumidifiers.

C. Phase II

The following procedures are incorporated in Phase II.

Step 1: Soil moisture indicator

The sample soil is taken to measure its moisture content. For this process, upload the necessary code in the Arduino and specify the upper limit, so that the sensor activates the soil moisture sensor. Reading meter connected to the soil moisture sensor predict the reading of moisture content. Connect the Bluetooth module present in the Arduino to the smartphone. With one tap, the setup starts and the reading meter measure the moisture content. As soon as when the reading meter crossing a particular value, the sensor starts to show a red blink, indicating that the moisture con-tent has exceeded the safety levels.

Step 2: Arduino and soil moisture sensor

The soil moisture sensor (FC-28) is connected with Arduino it measures the volumetric amount of the water inside the soil. The sensor fitted for both digital and analog output is operated in digital as well as analog mode [10].

Step 3: Working principle of sensor

There are two testers in the soil moisture sensor to indicate the degree of moisture. The function of the two testers is to alter the flow of charges across the soil and to calculate the value of resistance for the soil. The excess presence of water in the soil will induce more electrical energy leading to diminished resistance [15]. Hence, the moisture level will be greater. Due to poor conduction of electricity in the dry soil it would conduct less electricity. When there is less water, which indicates more of the resistance value. Hence, the moisture level will be lesser. Fig.1 indicates part-by-part link of the connection between the potentiometer and the soil moisture sensor. This sensor is connected in analog mode. Performance of this sensor is in digital mode.

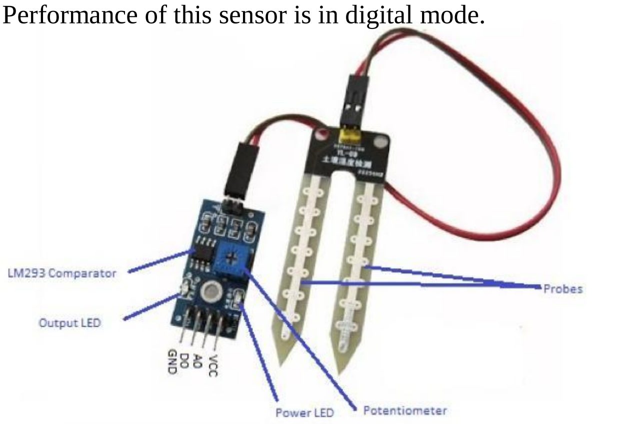

Fig. 1 Pin-out diagram.

There is a comparison between the LM393 comparator and the threshold value set by the potentiometer. As per the threshold value, the LED will glow on and off. Declare a variable for the soil moisture sensor pin to store the output of the sensor. Further, power on or off the water pump is fixed as per the diverse ranges of moisture values.

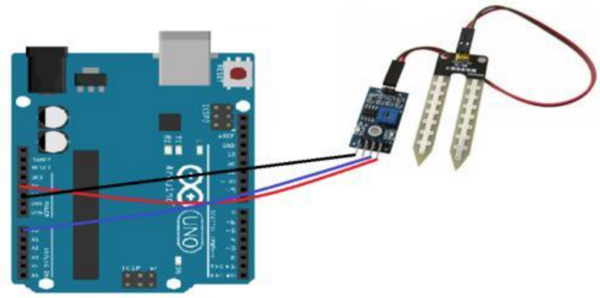

Fig. 2 Circuit diagram in analog mode.

Fig. 2 presents the soil moisture sensor and Arduino board connections. Where, red and black wires are connected to the positive and negative terminal of Arduino respectively. The middle blue wire is linked to X-terminal. The code uploaded to make a LED indicator is as follows,

```
int output_value ;
int pin_in_sens = A0;
void setter() {
 Serial.println("Input from the sensor");
Serial. Begin(value);
 Delay(value);
}
```

At Analog PIN A0 Input is given in analog mode. Serial. Begin (value) function passes the value from the Arduino and serial monitor and displays the sensor reading on the serial monitor. The code to monitor the soil is as follows,

```
void reader() {
int t;
t= analogRead(pin_in_sens);
t=resultant_value;
```

```
resultant_value=map(output_value,pin1,pin2,pin3,pin4);
Serial.print("Amount of moisture in soil :"+ resultant_value);
delay(value);
}
```

Here, the value from the sensor analog pin value in analog format is read and assigned to the resultant_ value variable. During monitoring the readings from the dry soil, the sensor value of pin1 will be noted and in the wet soil and the sensor value is entered in pin2. For pin3 and pin4 the value would oscillate between 0 to 100, due to this the percentage of moisture present in soil is calculated using map() function. After that, these values are displayed on the serial monitor. In Fig. 3, the power is trigged to the indicator from the Arduino board which starts the soil-moisture sensor placed inside the soil.

Weight of soil	Weight of added water	Accumulated Weight of Water	Soil Moisture	Meter Reading
300 grams	20 grams	20 grams	6.67%	1.5
300 grams	10 grams	30 grams	10.00%	1.5
300 grams	20 grams	50 grams	16.67%	2.5
300 grams	20 grams	70 grams	23.33%	5.2
300 grams	10 grams	80 grams	26.67%	7.0
300 grams	10 grams	90 grams	30.00%	7.5
300 grams	10 grams	100 grams	33.33%	8.2
300 grams	10 grams	110 grams	36.67%	9.2
300 grams	10 grams	120 grams	40.00%	9.0
300 grams	10 grams	130 grams	43.33%	9.5
300 grams	10 grams	140 grams	46.67%	9.7
300 grams	10 grams	150 grams	50.00%	10.0

As soon as the sensor starts blinking the upper limit of the moisture content is indicated. The following code is uploaded in Arduino,

```
int pin_value_of_LED =value;
int pin_in_sensor_ =value;
```

Two integer variables pin_in_sensor and pin_value_of_LED are declared and initialized to some random value referring the sensor digital pin and LED pin.

```
void set() {
 pinMode(pin_in_sensor, INPUT);
 pinMode(pin_value_of_LED, OUTPUT);
}
```

Here, sensor pin takes the values from the sensor so, it is given as the input in Arduino and the LED pin sets the power of the LED light value is given as the output pin in the library function pinMode().

```
void light() {
 if(digitalRead(pin_in_sensor) == LOW){
digitalWrite(pin_value_of_LED, LOW)
} Else {
digitalWrite(pin_value_of_LED, HIGH);
delay(value);
 } }
```

The values are tested using digitalRead() function of the sensor pin using if-else conditional statements where LED glows when the value is high else it will go down depending upon the threshold value. Blinking of the LED stated by the digitalWrite() function. The readings for the soil moisture sensor and the calculation of percentage of moisture in Soil by Grams are given in Table 1. The absolute percentage of soil measure is measured by the following formula.

Absolute Percentage Soil Moisture = wt of water/wt of dry soil

D. Phase III

It contains the following procedures.

Step 1: Water level indicator

A container is taken filled with water and a scale marking on it [7]. The necessary code for measuring the water level with an upper limit indicating the maximum amount of water to be filled in the container is uploaded to the Arduino. A reading meter is connected to the container to measure the reading of the water level [19]. Bluetooth of the smartphone connected to Arduino as the setup starts, pour the water into the container and reading meter reads the value. As soon as the water is about to overflow from the container, the water sensor activates and shows the red blink. This indicator works as an alarm to conserve hydro-power as well as water [12].

Fig. 3 Soil moisture indicator

Step 2: Water level indicator alarm

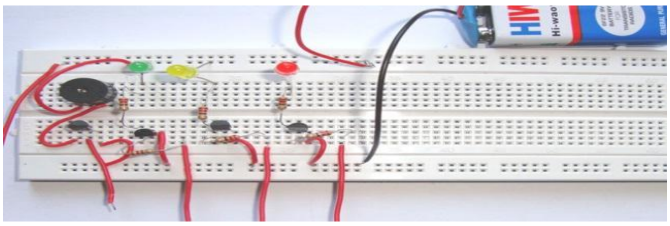

Fig. 4 Water level indicator.

Fig. 4 shows the connection between the LEDs and water sensor. When the water is under safe limits it blinks the green LED, yellow for upper limit and red indicates the danger line.

E. Problem Domain

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Run-off of water from cistern and pipes is a usual problem which eventually results in water depletion. There are many solutions for the irrigation system for water which would prevent water logging and leakage for ball valves [11]. The controllable DIY system function is to make a circuit in order to remark on the water level. It indicates if the water crosses the safety level using blinking LED [13]. Fig. 5 shows the connection of three LEDs with four transistors. The power supply is done through the power battery of 9 volts. The readings for water level indicator are shown in Fig. 6.

III. IRRIGATION SYSTEM SOLUTION MODULE

Similar to pump irrigation, a water level indicator circuit is made using LEDs and a transistor. Real time application of this circuit lies in agricultural tanks [14]. At whatever time the reservoir gets full, it gives red alert at certain stages. LEDs are used to point to diverse levels where LED at spot A indicates low, at B and C medium and high respectively, however D designates full with a Buzzer instead of LED producing bell sound and bright light to inform the danger.

A. Components of Water Level Sensors Circuit Board

The circuit contains the following components.

- 4 - BC547 transistors
- 6 - 220-ohm resistors
- 3 - color led
- 1 – buzzer
- 5 - 9v battery + battery clip

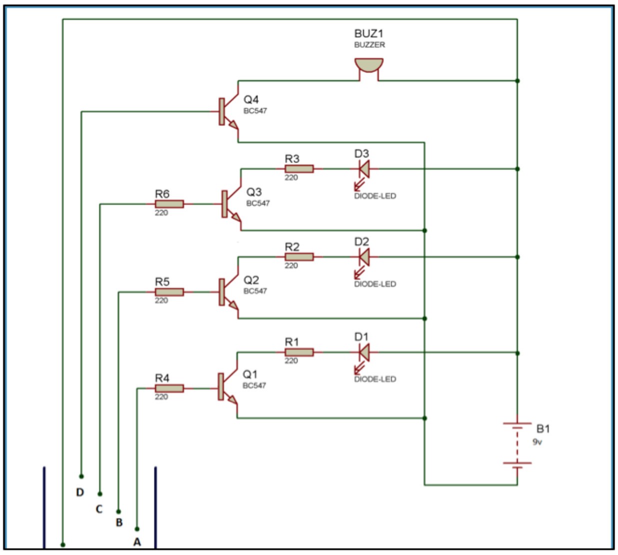

Fig. 5 Circuit diagram for water level indicator.

As soon as the water level approaches towards point A, the circuit amongst the transistor Q1 gets accomplished with LED. Thus leads to glowing of RED LED indicating low water level. In a similar fashion as the water approaches higher stages of position B, the circuit of transistor Q2 forms and Yellow LED glows, indicating medium stage while in higher stages Q3 transistor connects at position C when green light glistens. As a final point when buzzer siren rings lead to the accomplishment of the Q4 transistor and buzzer circuit at position D. The entire circuit comprises four minor circuits, each circuit point to different siren depending on the blinking position out of A, B, C, and D.

METER ODOMETER	READING EXAMPLE Odometer Shown at Left	Maximum Registration
5/8" to 1" Residential meters		
1 2 3 4 5 6 U.S. Gallons	0 1,234,560Gallon	9,999,990Gallons
1 2 3 4 5 6 Cubic Feet	1 2 123,456 Cubic Feet	999,999 Cubic Feet

Fig. 6 Reading meter - Odometers.

B. Working principle

The suggested methodology is carried out by means of a switch in place of an NPN transistor. Also, the base of the Transistor Q1 and the LED is in OFF mode and no flow of charges across the collector, emitter either. The connections of the battery are to the base and emitter of the Transistor Q1 for the positive and negative terminal respectively. The entire system switches on as soon as a positive voltage has been smeared to the base of the Q1 Transistor. To bounds, the extreme power supply to base 220 Ohm resistance devices are attached to every transistor. The transistor changes to ON state when the electrical energy of 0.7 V applied to the base. To descent the voltage applied across LEDs to prevent from the circuit where resistors R4, R5, R6 with each of the LEDs are attached.

Fig. 7 shows the transistor with the collector to receive the signals from different connections and send it to the base for further transmission whereas the emitter sends the signals to other devices.

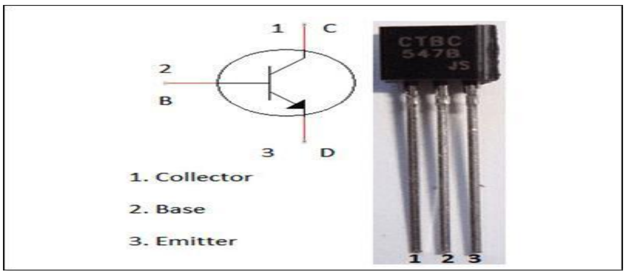

Fig. 7 Transistor

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	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Irrigation depth in mm	0	0	0	35	95	150	180	175	110	50	0	0
0	25	25	25	25	25	25	25	25	25	25	25	25
0.1	25	25	25	35	52	67	76	75	56	39	25	25
0.2	25	25	25	45	79	110	127	124	87	53	25	25
0.25	25	25	25	50	92	131	152	149	103	60	25	25
0.3	25	25	25	55	106	152	174	174	118	67	25	25
0.35	25	25	25	60	119	174	195	199	134	75	25	25
0.4	25	25	25	65	133	195	216	223	150	82	25	25
0.45	25	25	25	70	146	216	237	248	165	89	25	25
0.5	25	25	25	75	160	237	280	273	181	96	25	25
0.6	25	25	25	84	186	280	331	322	212	110	25	25
0.7	25	25	25	94	213	322	382	372	243	124	25	25
0.8	25	25	25	104	240	365	433	422	274	138	25	25
0.9	25	25	25	114	267	407	484	471	305	152	25	25
1	25	25	25	124	294	450	535	521	337	167	25	25

Table 2. Total Volume of Water Available in Cubic Meters at the Lower Rate in Acres.

Alike situation occurs when the water stage approaches the base of the transistor [18]. As in a little while a positive voltage gets applied to the Q2 transistor and the switches on. The flow of charges induces current leading to the yellow LED glows. With an equivalent standard, the water level grasps to collector green LED glows. To end with when the water stages to reaches to position D Buzzer beeps. The leftmost wire is connected to the positive voltage in the tank so should be extensive compared to other four wires in the tanks.

C. Phase IV

Phase IV contains the following procedures.

Step 1: Connection of water level indicator and soil moisture indicator.

Establishment of this connection is the foundation stone in energy conservation [11]. A code is designed for using the function calls. The soil moisture sensor has the function which would take the input value where the soil moisture sensor starts to blink. This input value is sent as an argument to the sub function for setting up the value of upper limit in the water sensor. Updated codes are uploaded to both sensors. The reading for technical irrigation system is shown in Table 2**.**

D. Phase V

It contains the following procedure.

Step 1: Connection setups – Soil Moisture Indicator

The sensor is placed in the soil top filled container [6]. A wire is used to connect the reading meter with the sensor. The reading meter is connected to a 5V battery which acts as its power plug. The battery is connected to a switch. The single switch wire is attached to the Arduino which is triggered while starts the setup.

Step 2: Water level indicator

The sensor is fixed to the container with the help of a holder [7]. The reading meter is connected to the power supply. The water level indicator is the smallest setup of the entire irrigation system like small scale irrigation [17].

IV. DISCUSSION

Unlike traditional methods like drip irrigation here, entire setup plug switch wire is connected to Arduino which has Bluetooth module fixed on its terminals [5]. The Bluetooth signal of the smartphone is detected by this module and by one click of the farmer user to initialize the power in the entire system from the LED indicator to the two sensor setups. The power reaches to the soil moisture indicator placed in the soil which shows the reading in the meter board and stops at a value which is the upper limit of the moisture content required. This value is sent to the water indicator coded in a way to trigger its start. This starts the flow of water from the pipe system attached to the agricultural land which stops as soon as the upper limit is indicated by the water sensor. The process is performed only once. Afterward, while irrigation of the crop bound to the amount of water indicated is only passed to the crops now only pipe system works [2, 20]. Finally, with one tap on the smartphone to the off button leads to disconnection of power and the irrigation system stops. The advantage of this irrigation system is it saves the soil from degradation and saves the water used for irrigation [1]. The technology used reduces the human effort and turns the hard labor to smart labor [8, 18] traditional irrigation to smart irrigation.

V. CONCLUSION

The technical irrigation system would if at all implemented in the agriculture sector; it turns out to be a boon for people or the farmers who are mainly used for agricultural works including the areas of north India suffering from crop failure due to the water scarcity. These farmers will get to know about the fact that water is adequate for the cultivation only reason for the crop failure is that they are unaware of using irrigation system wisely. This paper is an endeavor towards the conservation of water for the adequate use by present and future generations.

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