Automated Irrigation System: Controlling Irrigation through Wireless Sensor Network

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Abstract—**This paper describes an automated system of irrigation process which involves an arrangement of sensor in the cultivation of field, Wireless transmission of the sensor data using RF transmitter and a control system to evaluate the data to our required level and manage proper running of the irrigation pump. The main focus of this paper is to present an affordable low cost and low power solution to irrigation process in order to proliferate the automation process in it. The system includes sensors and microcontroller to send data using RF modules which thereby will be used in the control unit consisting of Arduino Nano and relay connection to the pump. User can easily set the required water level needed for the definite crop and use the system for precise irrigation process. This will in the long run help reducing water wastage and timed irrigation process.**

Index Terms—**automated irrigation system, wireless sensor networks, arduino nano, water conservation system**

I. Introduction

With the expansion of automation process and increased use of wireless sensor networks in it, it is an evident need to implement it in growing need of agriculture , in this case for irrigation system. One of the prime reason for irrigation facility not to have these facilities yet is high cost of maintenance and high power consumption. Farmers from developing countries especially are devoid of affordable and easy to run technologies. In the context of having a low cost operation for the irrigation process this paper implements necessary wireless arrangements for achieving it. Such system is especially imperative for low income farms where farmers cannot afford to have high priced technologies. Another important factor is water conservation as manual process that farmers use in a country like Bangladesh involves a lot of predictive steps which results in water wastage; smart irrigation system that we are proposing ensures proper water management as well.

In this paper we propose a system which will include use of sensors which are soil moisture sensor and water level sensors. This sensor node will be placed in a designed system in the field. This sensor will provide readings and data calculations will be done by Attiny167 microcontroller. Wireless communication system is done by RF modules which will communicate with the control unit containing Arduino Nano. The control unit will evaluate the data considering several factors for specific type of crops and ensure proper use of the shallow pump. This system will be solar powered to ensure use of renewable energy and cutting down overall cost management. The system will also be adaptable to changes in accordance with the user need.

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II. Sensor Description

A. Water Level Sensor

We will be using a liquid level sensor (SKU – 9525) by Waveshare in order to detect the submersion level of the crops which will need it. The sensor has a limit of measuring up-to 5cm of water level. The main functioning of it depends on the variation of output voltage level in accordance with the water level it is submerged in. The sensor gives out an analog data which we will use in our microcontroller to make the due calculations and send it to control unit. (Fig. 1)

Figure 1. Liquid level sensor.

We are using this particularly to ensure the paddy cultivation as it accounts to 75 percent of agricultural land use in Bangladesh. But even being the sixth largest rice producing country Bangladesh has relatively low production rate compared to Malaysia and Indonesia [1]. In order to improve the cultivation process and ensure automation in irrigation process we can use our system. The table below shows the submergence required by the crop at different level [2] (Table I)

TABLE I. Required Submergence of Rice Crop

Stage of crop	Depth of water (cm)
At transplanting	Shallow (2 - 3cm)
After transplanting (5 to 20 days)	(4- 5cm)
During tillering (22 to 42 days)	Shallow(2 -3cm)
Reproductive stage, Panicle emergence, Booting, Heading & Flowering	(4 -5cm)

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Manual Switching is available to alter between Paddy and other crops. If switched to paddy mode the system will follow the necessary data for its irrigation.

Thus with the use of the water level sensor we can ensure the proper submergence of the crop and trigger the control unit in a case where it is not.

B. Wireless Transmission

For the wireless communication we are using Radio Frequency of 433MHz. For this we are using RF modules 433MHz which has range of 100-200 meter. These sensors are very cheap and reliable. With this RF transmitter an attiny167 microcontroller is added to do the calculations of the sensor readings before sending it to the control unit. (Fig. 2 and Fig. 3)

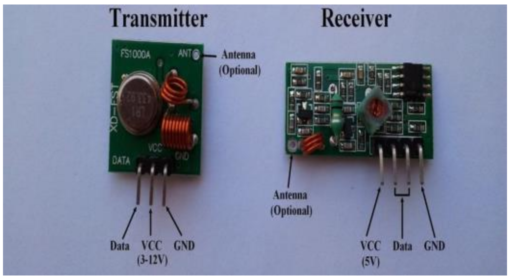


Figure 2. Transmitter and receiver.

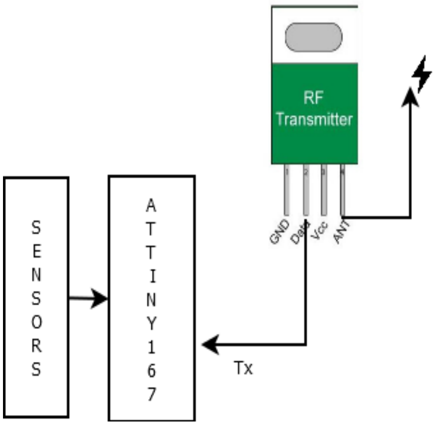


Figure 3. Wireless communication.

C. Soil Moisture Sensor

Number equations consecutively with equation numbers in In order to measure the moisture of soil we are using SparkFun (SEN-13322) soil moisture sensor which are very cheap and reliable. It has moisture sensitivity level 1 i.e. unlimited. Corrosion is a very common issue for moisture sensors. In order to lessen the corrosion of the electrodes our system is designed not to power the sensors all the time but to power it in the time of taking the reading. (Fig. 4)

The delay time of taking a reading from the soil is set according to the previously taken moisture sensor reading and relative humidity. A humidity sensor (RHTO3) is attached to microcontroller i.e. attiny167. Soil moisture content and relative humidity has linear relation between them which helps us to determine and set the reading time of the sensors to lessen the corrosion. The power supply to the sensors are also controlled by the microcontroller by using transistor switching. The sensor will stay on until the upper threshold value is reached and this function will trigger when the sensor value will be at lower threshold. (Fig. 5)

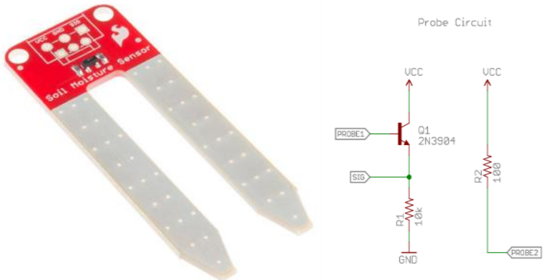


Figure 4. Soil moisture sensor.

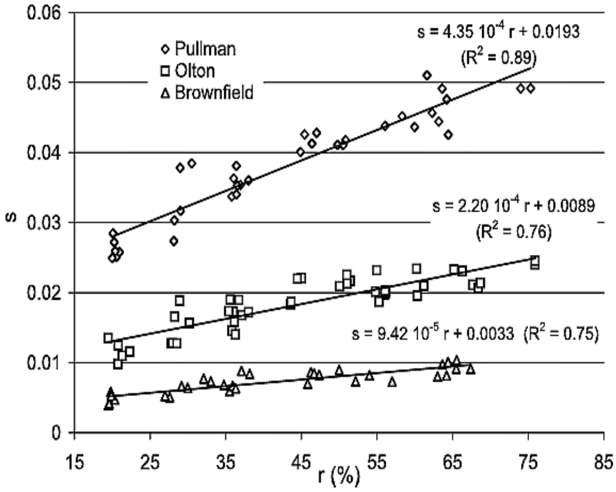


Figure 5. Surface soil moisture (s) versus relative humidity (r) for the three soils. [3].

As for the placement of the sensor it is done according to the root level of the different crops as to ensure the whole root is having moisture soil. Effective rooting depths for soil moisture sensor installation guidelines are given below. [4] (Table II)

TABLE II. ROOTING DEPTHS OF SOIL MOISTURE

Crops	**Root depth** (inches)
Field crops	
Barley, corn, cotton, flax, oats, peanuts, rye, sorghum, soybeans, sunflower, wheat, tall fescue	24
Tobacco	18
Forage crops	
Alfalfa, brome grass, orchard grass, clovers, Sudan grass, rye grass	24
Bluegrass, ladino clover, Bermuda grass	18
Fruit	
Blueberries, cane fruits and grapes, peaches, pears, cherries, apples	18-48
Watermelon, cantaloupe	18-24
Strawberries	6

Turf	
Athletic field (not active), grass sod	6
Athletic field (active), golf greens and fairways, grass sod immediate sale	4
Nursery plants	
Ericaceous ornamentals, gladioli, peonies, irises, bulb and corm plants, lining out plants, finished landscape plants, perennial ornamentals, trees, shrubs	12-24
Annual flowers, bedded plants, groundcover plants	6
Vegetables	
Asparagus, corn, cucumber, kale, peas, peppers, potatoes, snap beans, squash, tomatoes	18-24
Broccoli, cabbage, carrots, cauliflower, celery, onions, lettuce, radish, spinach	12-24

The calibration process of the sensor is very simple. There is a calibration mode in the control system when entered first the sensor reading is taken in fully saturated soil and then in open air that is when it is completely dry. That's how the threshold value is set automatically for the system to operate. [5]

III. Measuring Units

The subscript for in this section of the project all the sensors are covered along with wireless communication device. The moisture sensors are arranged like in the figure in order to cover the area to measure the whole area soil moisture. The total moisture of the soil is calculated by taking algebraic average of the sensor values and comparing with the pre-determined calibrated value of the sensors. (Fig. 6)

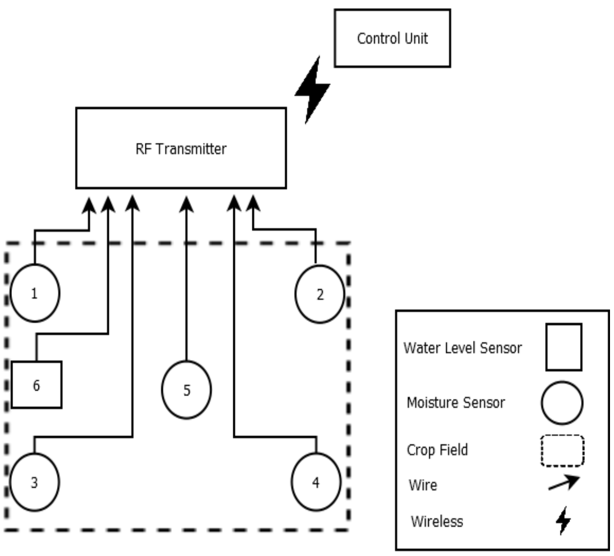
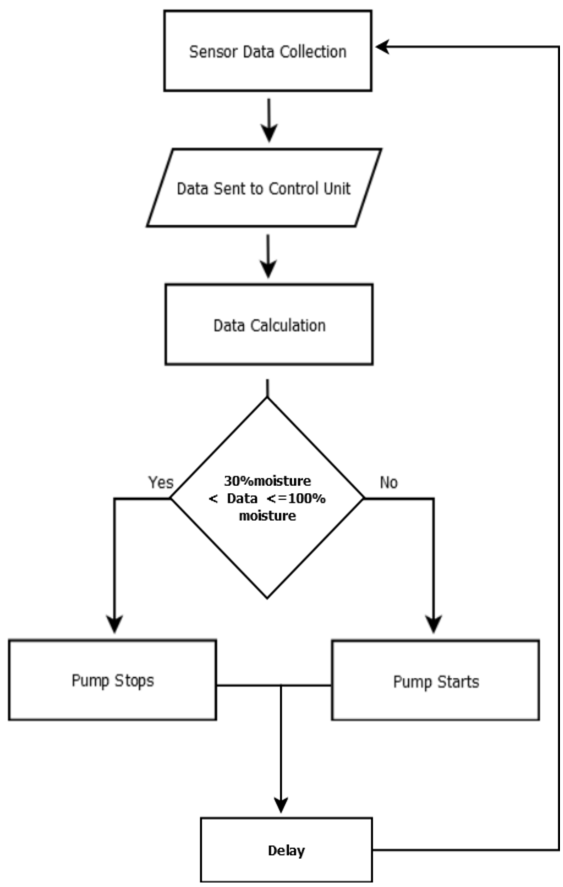


Figure 6. Measuring unit.

Water level sensor is value is taken separately as it is independent of other sensor and used for certain kinds of crop. All the measurement is taken and the calculations are done in the attiny167 microcontroller before sending it to the control unit.

IV. Control Units

This unit includes all the devices that are involved in controlling the water flow for irrigation. From the receiver data comes to Arduino Nano. According to the retrieved data by using 2n2222 NPN transistor a 12V relay is switched on and off [6]. Here several data concerning soil conditions such as water level, moisture level, plant variation are concerned to calculate proper tripping time for the relay. Generally a shallow machine is run by 120 to 240 voltage [7], [8]. The 12V relay can handle these categorized voltage levels. Here initially the Arduino Nano's digital pin is turned on to any conditioned case, thus the 5V supply from the digital pin causes current flow through a current limiting resistor to a 2n2222 NPN Transistor which works as a switch. A 12 V DC supply is then turned on that energizes the 12V relay. The NC of the relay is always connected to the common portion of the relay but after tripping the NO of relay gets connected to Shallow pump line and the pump gets turned on. The average value in the flow diagram is the upper threshold value i.e. the saturated soil. (Fig. 7 and Fig. 8).



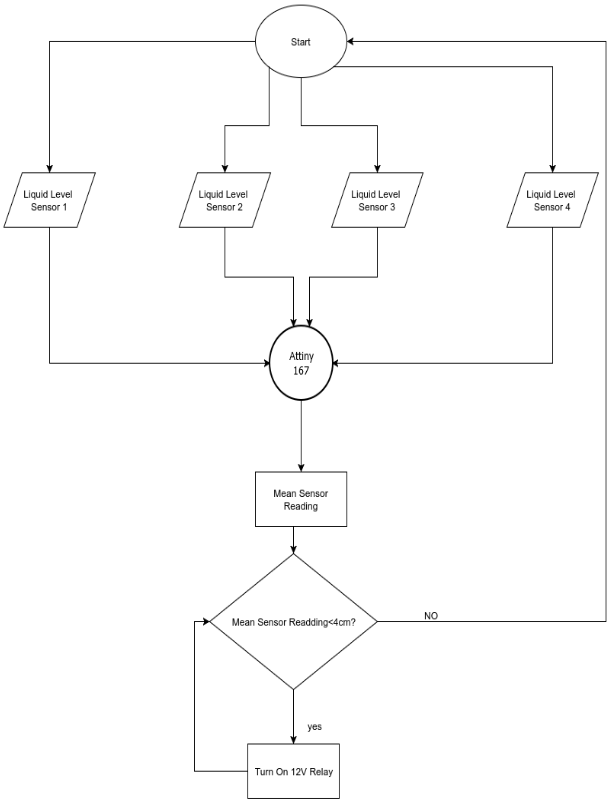


Figure 7. Work flow of the control unit.

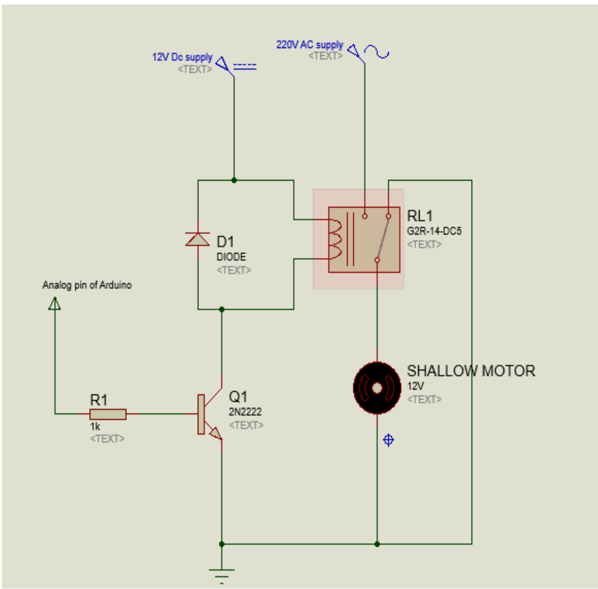


Figure 8. Control unit schematic.

V. Conclusion

In this paper, a novel automated irrigation system was introduced. This system can reduce the waste of ground level water. The system itself is a low cost monitoring system and it is solar power driven. The project is still in work progress. The writers have a plan to implement IoT to monitor a larger field with different types of crops. Also reducing the sensor number is also an objective. The total cost of the system is given in the Table III.

TABLE III. Project Costing Data

Parts	Quantity	Price($)
Arduino Nano [9]	1	22
Attiny167	1	1
RF Module	1	2
Liquid Level Sensor	2	2
Soil Moisture Sensor	5	6
Humidity Sensor	1	9
Relay	1	1
		Total=69

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Ahmad Sayeed Sayem was born in Dhaka, Bangladesh in 1996. He is currently studying Electrical, Electronic and Communication Engineering in Military Institute of Science and Technology. His current and previous research interest includes VLSI, RFIC and mix-signal circuit design, Embedded system design and robotics. His current projects includes developing Active inductor used in different IC based Oscillators with low phase noise and less power consumption features in a very small IC area. Currently he is the R&D Head of IEEE MIST SB contributing in relevant research.

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Mr. Hossain has served as an executive member of the IEEE Student Branch, Robotics Club and Career Club of his university where he has contributed in the development of research based activities among his fellow students.