International Journal on Recent and Innovation Trends in Computing and Communication ISSN: 2321-8169
Volume: 4 Issue: 4 48 - 51

Smart Irrigation Employing Direct Root Watering

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***Abstract*—** This paper proposes implementation an automated irrigation system using which the watering is carried out bypassing the top soil and directly irrigating to the root zone of the plant. This system makes use of a soil moisture sensor that monitors the moisture content of the plant's root zone continuously and compares it with the previously set values as threshold. Monitoring the soil moisture sensor readings, water is supplied only to the root area of the plant. Zigbee modules are used to facilitate the wireless communication of remote sensor with the controller and increase the flexibility of the system. The system design eliminates the loss of water before reaching the root zone that is absorbed by the top soil and makes a system well suitable for dry and drought prone areas.

Keywords- *Direct root watering, Subsurface watering, Soil Moisture, Solenoid Valve*

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I. INTRODUCTION

Gone is those time when mankind could imagine that water opposes the standards of matters in economics. The demands for fresh water from our seared urban communities, manufacturing plants, and agricultural lands will before long outstrip the accessible water supply. The money making concerns based on fresh water could soon instigate emergency or war in all those decrepit areas of the world.

Sustenance of agriculture is solely based on scarcity in available quantity of fresh water. Ever increasing demand for all agricultural products resulting from the exponential growth in population is an issue which needs to be tended to manage the environmental balance. As clearly depicted by the International Water Management Institute (IWMI), around 70% of worldwide water utilization is for the mere agriculture. The household, mechanical and ecological water requirements rival for the availability of remaining fresh water supply.

In endeavors to resolve this always evolving issue, many methods have been undertaken with more successful structure routines for systematic irrigation and there by water management. Enhancing the productivity of watering system is the paramount need to be tended to solve the human water requirements.

Nowadays totally mechanized irrigation frameworks are utilized which can even plan and schedule the plant watering intervals and intensity or water dosage. These automated frameworks have an included point of interest of conserving power usage alongside of water. Different mechanized watering system framework utilized are sprinkler based irrigation system, drip or trickle irrigation system and soon.

One of the major issues faced with sprinkler systems is the spatial irregularity in application of water. Irregularity is caused due to two reasons; Problems in technical design of sprinkler and Meteorological obliges. Technical design considerations are spatial arrangement of sprinklers and variation in pressure and discharge in different direction. Effect of velocity of wind and water evaporation rate consists of the meteorological issues related to sprinklers. This results in decrease in yield and quality of the crop, increase in pumping cost due to decrease in system efficiency and other environmental issues [1].

The proposed system is a simple prototype for proof of concept. In order to use the Direct Root Watering system in real time applications we need a more complex algorithm which can handle the dynamics of a real field. The system is combination of software and hardware components. The product ought to have the capacity to control five variables: pipelines in the framework, water circulation, measures of crop growth, yield information, bidirectional correspondence between program, and hardware. The decisions in real time irrigation should be done based on crop, soil and operation of system [1].

A standout amongst the most significant parameters in sprinkler watering system frameworks is the consistency of water conveyance. Wind is the primary natural variable influencing sprinkler performance. Huge quantity of water is lost part of the way by dissipation, especially through drift out from the watered territory. Under blustery conditions, the pattern of water distribution of a detached sprinkler is bended and contracted [2]. Sprinkler systems with excellent design and high performance should be installed to overcome this issue which eventually leads to a very expensive system.

Drawbacks of drip irrigation system in spite of its numerous advantages are; The delicate poly tubing can be defenseless to harm from insects, rodents and pets, Very narrow water passages of drippers and micro sprinklers are susceptible to clogging, Wet area created by drip irrigation system is very small and thus it needs critical control for used water replacement to avoid stress on plants.

To decrease soil disintegration amid sprinkling, it is necessary to implement high quality watering system not permitting surface spill over. There should be a proficient soil moisture level, which depends chiefly on three variables: invasion limit of the soil, sprinkler watering system force, and watering system dose. The surface spill over amid sprinkling can be present at a small irrigation power [3].

A decrease of sprinkling power increases the volume of water sprinkled before the establishment of surface spill over. For this situation, a decrease of watering system force diminishes the productivity of equipment and builds working costs. Moreover, under states of solid winds and high evaporation rate, reducing the watering framework force is sensible just up to a certain level [3].

Despite of the fact that these systems are more precise and exact when contrasted with the customary surge watering system, this can't be seen as an ideal answer for water

preserving watering system particularly in dry arid and drought-prone region.

Introducing subsurface or direct root watering system, which depends on the idea of inundating just the root zone of a plant, while keeping up soil dampness content at the ideal level is one solution for the issue. Higher water-use productivity can be attained without much of a stretch by controlling the watering frequency and emitter placing under soil. Direct root watering system is focused around the soil moisture content obtained by utilizing soil moisture sensor.

II. METHODOLOGY

A. Hardware Description

The fundamental block diagram of the proposed framework is demonstrated in Figure 1. As delineated in the figure the root zone of the plant is ceaselessly checked for its soil moisture content. From calibrating the sensor, upper and lower threshold limit values for the moisture content are determined.

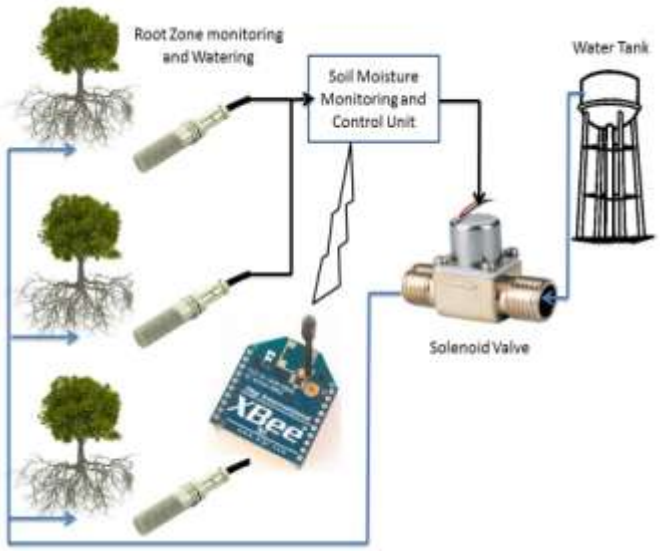

Figure 1 Proposed System Block Diagram

Once the moisture content of the root zone soil is underneath the lower limit, which indicate the water content of soil is short of the desired amount for the proper plant development. Instantly the supply into the solenoid valve is made on and the water stored in the reservoir is pumped specifically to the root zone.

The soil moisture sensor stays informed regarding the change in water content. At the point when the soil moisture is above the higher limit or threshold set, the supply to the solenoid valve is closed down accordingly ceasing the water stream towards the root zone of the plant.

In order to enhance the execution and adaptability of the framework the field is isolated into diverse areas. Every region is monitored by a separate soil moisture sensor. The regions which are not nearer to the controller are remotely associated with the controller using Zigbee communication. Hence the lumbering wiring process that need to done in the real field is additionally disposed of.

Thus the excess water wasted in the top soil, which gets evaporated before reaching the root zone is avoided. This system also protects the water wastage due to high dose of irrigation than the required for the plant.

The model created has three soil moisture sensors of which one is wirelessly associated with the controller part. The transmitter segment of the remote module is developed in Arduino UNO board and the receiver come the controller area is designed in Mbed board. Framework controls two water solenoid valves taking into account the sensor inputs to irrigate the field.

1) ***Soil Moisture Sensor****:* Moisture content in soil assumes a key part in the life of the plant. Supplements in the soil arrangement give the plant the sustenance it needs to develop. Water is likewise essential for maintaining plant temperature through the methodology of transpiration. Plant roots are better created when grown in damp soil.

Figure 2 Soil Moisture Sensor

Soil moisture sensors utilized as a part of this model are sht1x series (soil moisture and humidity) based sensor. The sensor has a copper sintered work over the electronic system as shown in Figure 2, to enhance anticorrosion performance as it is used under the soil. Additionally it has a cable length of one meter which enables easy installation of the sensor beneath the soil without interfering with the agricultural needs in the fields.

The Soil Moisture Sensor utilizes capacitance to measure the content or quantity of water in soil (by measuring the dielectric permittivity of the dirt, which is a capacity of the water content). Just embed this rough sensor into the dirt to be analyzed, and the volumetric water substance of the dirt is accounted for in percentage and temperature in Celsius and Fahrenheit.

2) ***Solenoid Valve****:* A solenoid valve is operated electromechanically. There is a solenoid coil in the valve and the valve is controlled by passing an electric current through it. The solenoid valve is controlled by regulating the water flow through it, if it is a two-port valve (made on or off); whereas the surge is exchanged in case of a three-port valve, between two of the outlet ports.

Different solenoid valves are put together on a system to control the flow. Solenoid valves are the most oftentimes utilized control components in fluidics. Their purposes are to stop, discharge, and measure, disperse or blend liquids. These valves are found in many application regions. Solenoids offer safe and quick exchanging, long administration life, high unwavering quality, great medium similarity of the utilized materials, conservative configuration and low control power.

There are two ports for a solenoid valve; inlet port and outlet port. The fluid (in this case water) enters through the

inlet port of the valve; the solenoid valve controls this flow. The fluid must course through the valve before proceeding into the outlet port. The hole is opened and shut by the plunger. The valve illustrated in Figure 3 is a typically-shut solenoid valve. Typically-shut valves utilize a spring which presses the plunger's top end against the opening of the valve. The fixing material at the top end of the plunger keeps the fluid from entering the valve, till the plunger is raised up by an electromagnetic field made by the coil.

Figure 3 Solenoid Valve

3) ***Zigbee Pair****:* Zigbee is a modification of the IEEE 80.15 low-information rate WPAN standard. The Zigbee technological innovation occurred as a distinct alternative for the Bluetooth and WiFi technologies. The difference of Zigbee from Bluetooth and Wifi is that, it obliges a very low information transfer rate (from 250 kbps - 2.4 GHZ to 20 kbps - 868 Mhz). Zigbee has low energy utilization. Furthermore, these gadgets are available for low cost.

It takes watch over a dependable conveyance of information between gadgets. The ZigBee module comprises of hardware equipment and a corresponding software part (protocol). The modules are designed and developed as separate integrated circuits as in Figure 4 and along these lines don't oblige soldering when mounted into a board.

Figure 4 Zigbee Pair

Zigbee characterizes three distinction gadget sorts: The coordinator, the router and the end device.

a) ***Coordinator:*** Start another personal area network (PAN) by selecting the channel and PAN ID. It gives permission for routers and end gadgets to join the PAN, transmit and get RF information transmission and course the information through the network.

b) ***Router****:* Transmit and get RF information from a transmission, and course information packet through the system

c) ***End Device:*** Cannot help in directing the information transmission. It transmits or gets RF information transmission and expected to be battery powered gadgets.

B. Software Description

The mbed Microcontrollers are all underpinned by the mbed.org designer site, including a lightweight Online Compiler for moment access to your workplace on Windows, Linux or Mac OS X. Additionally included is a C/C++ SDK for beneficial abnormal state programming of peripherals. Joined with the abundance of libraries and code cases being distributed by the mbed group, the stage gives a beneficial environment to accomplishing things [5].

Tera Term is a free, open-source, and terminal emulator program. It imitates diverse sorts of work stations. This emulator device is utilized for perusing the soil moisture sensor values while calibrating the same.

Zigbee configuration is carried out with the XCTU software from Digi International. The communication between the Zigbee modules (configured as transmitter and receiver) can also be viewed using the terminal available in this tool. Arduino board is programmed using the Arduino IDE (Integrated Development Environment)

III. EXPERIMENTAL SETUP

Prototype implementation of the proposed framework is shown in Figure 5. The framework has a transmitter section and a receiver added with the controller section.

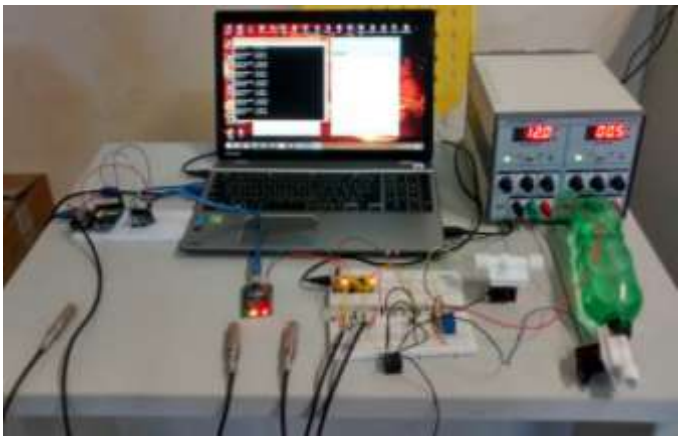

Figure 5 Complete Experimental Setup

The transmitter section is shown in Figure 6. This section has one soil moisture sensor joined with an Arduino board and communicating with the controller using Zigbee. The transmitter section is kept in parts of the field which is far from the controller and is not achievable to actualize a wired association.

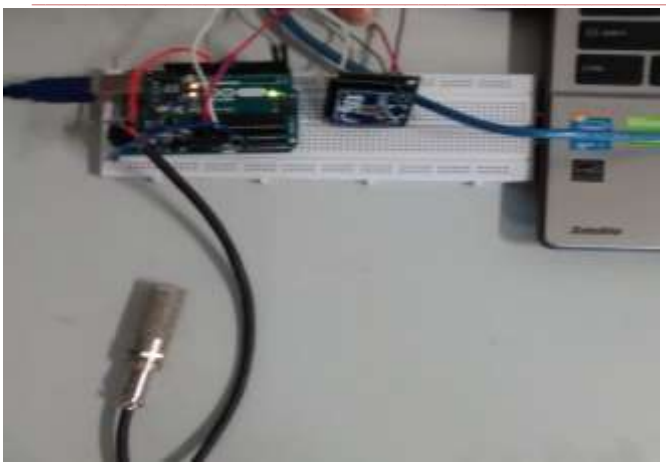

Figure 6 Transmitter Section

The receiver come the controller section Figure 7 of the prototype is designed on Mbed board. The controller has a Zigbee module to communicate with the remote transmitter and two soil moisture sensors to monitor the water content of the area closer to the controller. Based on these acquired values the controller operates the two water solenoid valves in the prototype and regulates the water flow. The watering is carried out directly to the root area.

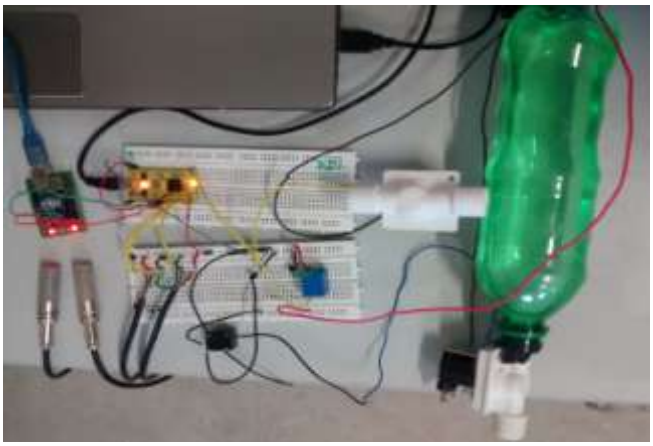

Figure 7 Transmitter Section

When moisture content is below the lower threshold value set then the controller operates the valve and turns it ON. If the moisture content is When the moisture content of the soil goes above the higher threshold the valve is turned OFF, the water supplied to the root zone in cut off by making the solenoid valve OFF.

IV. IV RESULTS AND DISCUSIONS

The humidity and temperature values of the sensor surroundings at any time can be seen either through the teraterm or the Zigbee Receiver. Figure 8 shows the teraterm reading of the sensors. Figure 9 shows reading of Zigbee receiver connected to Mbed board.

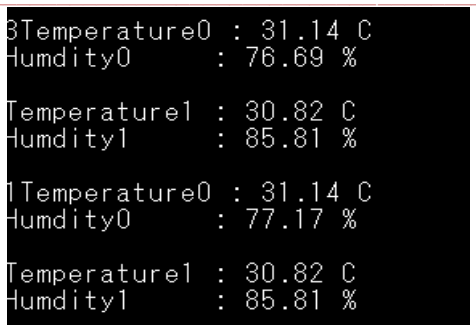

Figure 8 Reading of Sensors Connected to Controller Section Shown in teraterm

Figure 9 Reading of Remote Sensor in XCTU received by Zigbee Receiver

As we are using direct root watering the system completely avoids the wastage of water in top soil. Thus the water which normally lost in evaporation is conserved making the system appropriate for dry areas. Alongside the system also keeps track of the dosage of water provided for crops which in turn helps in avoiding the excessive use of water for irrigation that is beyond the intake capacity of crops. As a whole the total usage of water in normal sprinkle or flood irrigation system is reduced to a considerable amount with the system.

V. CONCLUSIONS

The proposed system involves an embedded system equipped with soil moisture sensors which can eliminates the wastage of water involved while using a traditional flooding irrigation system or modern sprinkler system. As the system bypasses the top soil completely and provides water directly to the root zone it is typically suitable for dry arid and drought-prone areas.

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