INTELLIGENT PLANT WATERING SYSTEM FOR RURAL FARMERS

John Samuel N.[1], Okonigene Robert E.[2], Samuel Peters C.[3], Okokpujie Kennedy[4]
samuel.john@covenantuniversity.edu.ng[1], robokonigene@aauekpoma.edu.ng[2],
sampet_halle09@yahoo.com[3], kennedy.okokpujie@covenantuniversity.edu.ng[4]

[1,3,4]Department of Electrical and Information Engineering, College of Engineering, Covenant University, Ota, Ogun State, Nigeria
[2]Department of Electrical and Electronics Engineering, Faculty of Engineering and Technology, Ambrose Alli University, Ekpoma, Edo State, Nigeria.

Abstract— This is an ongoing research study work. The objective of this study is to build an intelligent plant watering system for rural farmers. The study considered the availability of water supply in specific regions for five years. Also vital parameters statistics necessary for proper growth of each plant are stored in the system data base over the same period. Our study is primarily being guided by observations made in the rain fall pattern, different weather conditions, and environmental situation across the regions in the Northern and Southern parts of Nigeria. The target farmers are very poor. Therefore, our task is to produce a system that is affordable and reliable to these farmers. The complexity and stability of the system notwithstanding, overall, this study "Intelligent Plant Watering System for Rural Farmers" is being carried out to provide the rural farmers with a cheap, durable, power efficient, affordable, reliable, flexible, efficient and high performance intelligent plant watering system. Although this study is divided into three major groups, however, in this paper we try to present a subgroup that deals with soil moisture and fertility. The system based on its available statistics sets the various limits for the soil moisture, temperature and fertility. These features in the system ensure that water for irrigation is effectively managed and allowed to flow during specified temperature range. Also the soil fertility is properly regulated. This paper discursion focuses on the soil moisture and temperature.

Keyword: Irrigation, soil moisture, environmental temperature, microcontroller, artificial watering

I. INTRODUCTION

The required soil moisture is dependent on the type of plant. This is due to the fact that plants depend on water amongst others to survive. Water is extremely important to the existence of all living things. As simple as it is, the unique properties of water and its ability to appear in various forms makes it very essential in the many chemical reactions that take place, here on earth. One of these reactions is photosynthesis, the most important chemical reaction to physical life [1]. The basic process of photosynthesis can be represented as follows:

$$\underset{\text{Carbon Dioxide}}{CO_2} + \underset{\text{Water}}{H_2O} \xrightarrow{\text{light}} \underset{\text{Glucose (sugar)}}{C_6H_{12}O_6} + \underset{\text{Oxygen}}{O_2}$$

Plants need water, with other compounds and under certain circumstances, to produce energy. Almost every other living thing depends on this simple process of plant nutrition to survive [2].

To produce enough energy, plants synthesize the chemical compounds derived from the soil in the presence of Carbon dioxide, water and sunlight. It means that this process, photosynthesis, cannot take place without the presence of water. Thus, the soil around the plant should be wet regularly for the plant to produce energy regularly [3].

There are two basic methods of watering namely:

- The natural method
- The artificial method (Irrigation)

The main source of natural watering is the rainfall. During rainy seasons, plants rely comfortably on the availability of rainfall. But plants cannot solely rely on this system of watering as there is no rainfall every day throughout the year. Moreover, there are regions in Nigeria where there is very little rainfall throughout the year. Such regions are known as arid regions or zones [4].

It is important to note how climate has varied and changed in the past twenty years. An idea of the monthly mean historical rainfall and temperature data is necessary in order to understand the baseline climate and seasonality by month, for specific years, and for rainfall and temperature. In this study, the observation was that the mean historical monthly temperature for Nigeria during the time period 1995-2015 was lowest at 22^{o}C in January and highest at 30.6^{o}C in April. Equally, within this period the mean historical monthly rainfall was lowest at 7.1 mm in February and highest at 232mm in August [5 - 9].

A good way to provide adequate irrigation through artificial means is the automated irrigation system using a microcontroller to supervise the process. This system is also efficient in saving water, as the microcontroller ensures that the exact amount of water needed to saturate the soil when dry is provided. This is done by the help of a moisture sensor which ensures that water is supplied to the soil when the soil

ISBN: 1-60132-446-4, CSREA Press ©

moisture goes below a certain fixed level. The moisture sensor sends information about the soil moisture to the microcontroller. The microcontroller then receives the information, and then turns the solenoid valve on or off based on the information signal received.

The aspect of the study discussed the plant watering system that provides water in stipulated quantity when needed by the soil. With this system in place, the farmer, gardener or caretaker does not have to involve much effort in ensuring that the plant(s) are well watered. In the process it also determines the soil temperature. Temperature sensors are placed into the soil and configured with the microcontroller. The system during irrigation allows water flow only at low temperatures. This reduced the water loss due to evaporation. [10].

Irrigation is the artificial application of water to the land for various purposes which may include crop cultivation, re-vegetation of disturbed soils in dry areas and during periods of inadequate rainfall, and maintenance of landscapes.

With the invention of sensors and transducers, a great opportunity has been achieved for the application of electronics to solving physical day to day problems. Through the invention of soil moisture sensors and transducers, the real –time soil moisture status can be electronically monitored and same information can be used to determine the water requirement and through actuators, induce irrigation. Different approaches have been undertaken to manage irrigation using electronics. The task also includes the use of soil moisture sensor basic operating principles to produce a cheaper irrigation system for rural farmers.

II. PROCEDURE FOR DATA COLLATION

This part of the system is designed to manage irrigation based on response to the real-time status of the soil moisture. The system will cause the soil moisture to always be in a certain range suitable for proper crop development.

The underlying principle in this case is simple. It consists of the moisture and temperature sensors, the microcontroller, the Liquid Crystal Display, and the solenoid valve. The microcontroller converts the analog signals sent by the moisture sensor buried in the soil into digital values. It then compares this value with the accustomed value that represents the lowest allowable moisture content in the soil. For different plants the system reads the sensor value. Below the minimum set value, the microcontroller sends a “HIGH” signal to the solenoid valve to trigger it on. Also, when the sensor reads a value above the set value representing the maximum allowable moisture content in the soil, the microcontroller sends a “LOW” signal to the solenoid valve thereby causing the valve to be turned off. The temperature sensor ensures that the soil is watered when the temperature of the environment is below a preset value. All the reference information regarding the data that will be required by the microcontroller to make feature decisions about the soil moisture, temperature and fertility are stored in the database. The data are from the five years studies.

III. THE IRRIGATION CONTROL SYSTEM

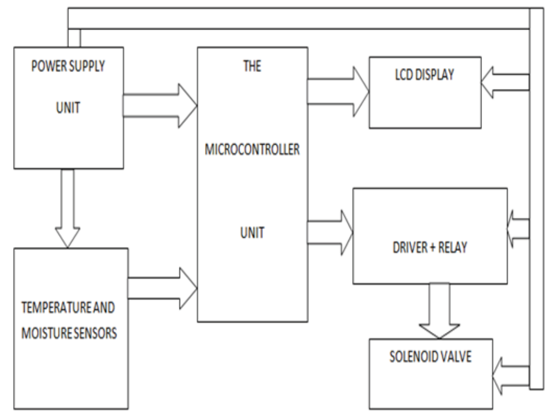

Figure 1: Block diagram description of the watering system

A. *The Sensing Unit*

Figure 1 is the block diagram of the circuit for irrigation system. The sensing units are responsible for the detection of the presence of the physical parameters and converting same to electrical form for processing. The physical parameters of interest are the soil moisture, and the ambient temperature.

B. *The Soil Moisture Sensor*

The soil moisture sensor utilized has its voltage output proportional to the quantity of water in the soil. Its specified supply voltage is from 3.3V to 5V and with this supply, it gives an output voltage of between 0V to 2.3V for the full range of complete dryness to submersion in water. Its rating for maximum operating current is 0.15A. Its output is fed into the analog-to-digital converter (ADC) input of the microcontroller.

C. *The Temperature Sensor*

The temperature sensor used in this circuit is the LM35 temperature transducer. It is a precision temperature transducer with a linear voltage output over the range of -55 ^{o}C to 150^{o}C [13]. Its favourable property is its linearity and step-wise sensitivity. It has a sensitivity of 0.01V/^{o}C starting from 0^{o}C hence its temperature can easily be calculated. The output of the transducer is applied to the ADC segment of the microcontroller for processing.

D. The Control Unit

This unit is basically the section that provides the control of the whole system. It consists of a microcontroller IC chip plus peripheral components and the control logic (firmware) which the chip functions with. The microcontroller chip is the central hardware component while the program/code written in Mikro-C language is the firmware component. The microcontroller used in this project is the PIC18F452 shown in Figure 2. The PIC18F452 is a 40-pin, 8-bit microcontroller [14]. The features of the PIC18F452 microcontroller make it a suitable choice for use in this automatic irrigation controller system.

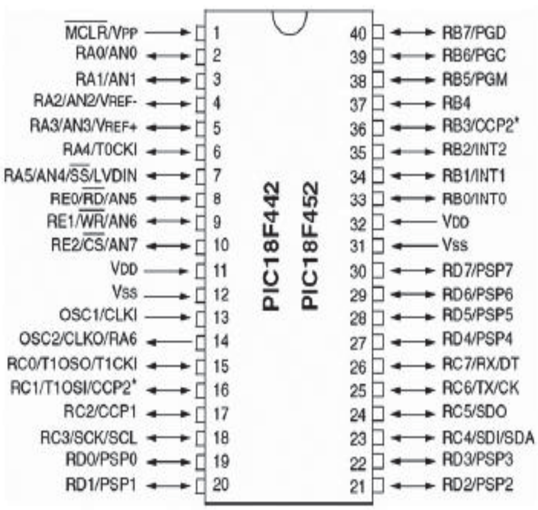

Figure 2: Pin arrangement of PIC 18F452 Micro-controller

E. The Display Unit

The display unit is simply an output unit used for the purpose of giving the user required information. The display unit is a simple 16x4 LCD module. The information displayed is the current soil moisture, the current temperature and the state of the system.

F. The Switching Unit

The switching unit consists of the BC108B transistor, the relay, and the solenoid valve.

The solenoid valve is a 12V DC solenoid valve. The solenoid valve is connected to the normally-open contact of the relay. When sufficient current enters the base of the transistor, current is allowed to flow through the coils of the relay (which is an electromagnetic switch). This sets up a voltage in the coils of the relay causing the normally-open contact to become a normally-closed contact [16]. When this occurs, current flows through the solenoid valve from the 12V DC supply and the solenoid valve is turned on.

IV. TEST RESULTS

Several tests and observations were made to ensure the proper functioning of the system. The physical model was tested and the overall response and performance of the system were checked. This covers the testing of various physical parameters of the system. Tests were done on the soil moisture sensor's natural response to pure water in order to ascertain its output voltage. Also, several soil samples were tested to determine the output voltage from the sensor at dry and saturated soil conditions. The sensor was connected to a 5V DC power supply. The ground terminal was grounded, and the output voltage was evaluated with the aid of a good voltmeter. The output of the sensor was connected to the micro-controller and the response of the micro-controller was observed. The sensor was placed in pure water giving the observed typical values shown in Table 1.

Table 1: Showing results obtained from moisture sensor test

INPUT INTO SENSOR	TEST CONDITION	OUTPUT FROM SENSOR	MICRO-CONTROLLER RESPONSE	REMARKS
5V	In Air	0V	-	Expected
5V	In Pure Water	2.3V	Gives no output, hence no watering is done.	Expected

The soil moisture sensor was placed into a sandy soil sample (due to its ease of availability). The output of the sensor was then determined in dry and wet soil conditions. The results obtained are shown in Table 2.

The temperature sensor used in this test circuit is LM35 temperature sensor. The temperature sensor was connected similar to the soil moisture sensor. The testing of the temperature sensor was done to determine the voltage output of the sensor to different changes in temperature. The sensor output was measured at room temperature (29^{o}C) and outside on a sunny afternoon (32^{o}C). The outputs of the sensor were 0.285V and 0.318V respectively. These measured values correspond with the calculated values of 0.29V and 0.32V.

Table 2: Table showing the output of the sensor with respect to different soil conditions

INPUT INTO SENSOR	SOIL CONDITION	OUTPUT FROM SENSOR	MCU RESPONSE	REMARKS
5V	Dry	0.8V	Gives a high output, hence watering should be done	Expected
5V	Wet	2.2V	Gives a low output to indicate that watering should stop	Expected

The Figure 3 and Figure 4 are the flowchart used for the control of the solenoid valve and the display unit respectively.

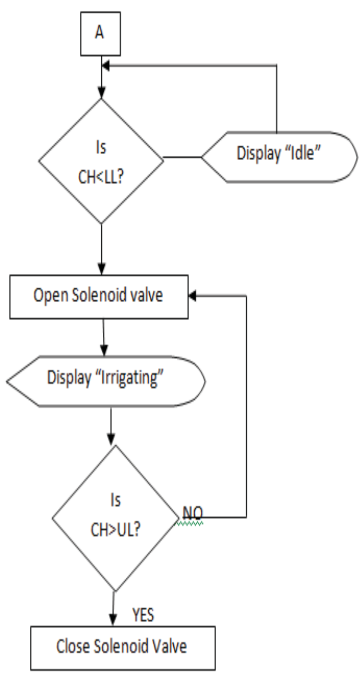

Figure 3: Flowchart of the solenoid valve control process

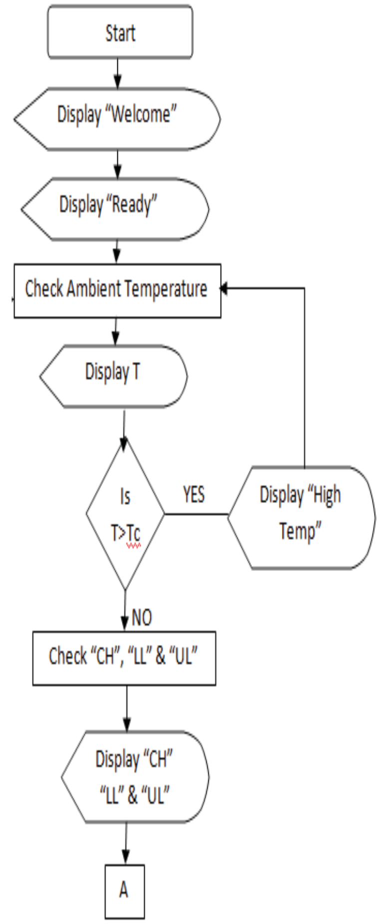

Figure 4: Flowchart representing the display unit of the system

MAJOR ACHIEVEMENTS

- A system was designed that measures the surrounding soil humidity and atmospheric temperature at a relatively very cheap cost. Most of the components are available local shops. To reduce the cost of production further we need to replace the soil moisture with very cheap models without losing the sensitivity and reliability of the overall system.
- The designed device reduced water used for irrigation by 62% as compared to what is currently being used by the rural farmers and accurately waters the plant at the right times.

The Figure 5 shows the tested circuit diagram for the automated irrigation system.

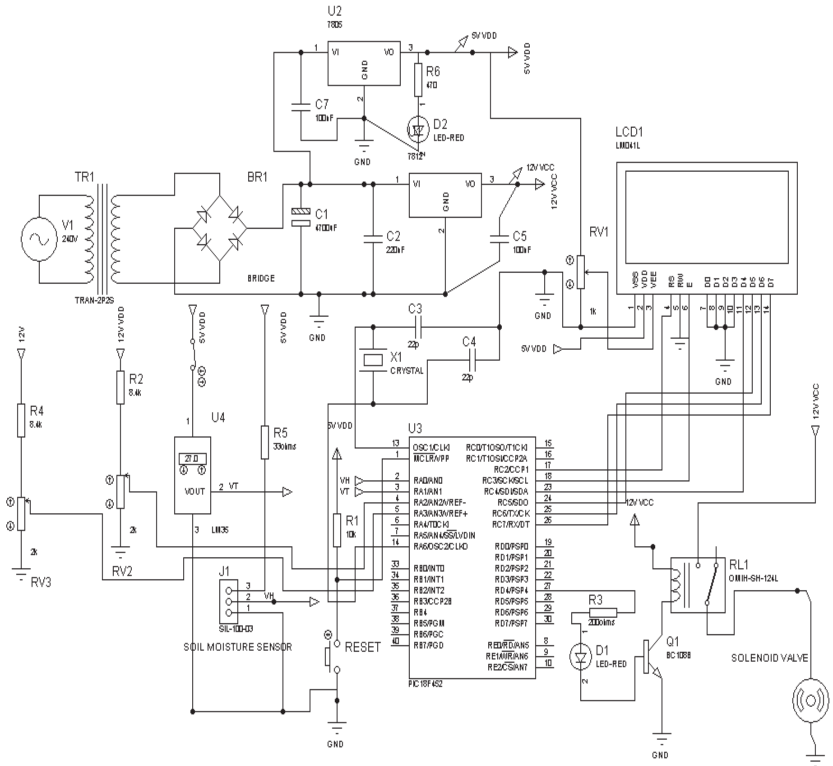

Fig 5 The circuit diagram used to test the automated irrigation system

V. CONCLUSION

The system was developed successfully, meeting the aims of workability low-cost design and simplicity of operation. Hence irrigation can be automatically controlled by rural farmers resulting to greater productivity of crops and efficiency of irrigation management. It is our desire that the entire final system will meet the set objectives for rural farmers use.

REFERENCES

[1] Michael McDarby, " Section 2 Chapter 1: Photosynthesis" http://faculty.fmcc.suny.edu/mcdarby/Animals&PlantsBook/Plants/01-Photosynthesis.htm, 2014.

[2] Shmoop Editorial Team. "Ecology: Organisms and Their Environments Terms." *Shmoop*. Shmoop University, Inc., 11 Nov. 2008. Web. 20 Mar. 2016..

[3] "10 most common herb garden mistakes" http://herbgardens.about.com, 2014.

[4] "Criteria and options for appropriate irrigation methods",

[5] Cardenas-Lailhacar, B. and M.D. Dukes. 2014. Effect of Temperature and Salinity on the Precision and Accuracy of Landscape Irrigation Soil Moisture Sensor Systems. *Journal of Irrigation and Drainage Engineering*, 0401407.

[6] Davis, S. and Dukes, M. (2015). "Methodologies for Successful Implementation of Smart Irrigation Controllers." *J. Irrig. Drain Eng.*, 141(3), 04014055.

[7] Cardenas-Lailhacar, B. and Dukes, M. (2015). Effect of Temperature and Salinity on the Precision and Accuracy of Landscape Irrigation Soil Moisture Sensor Systems. *J. Irrig. Drain Eng.*, 141(7), 04014076

[8] Dukes, M. D., B. Cardenas-Lailhacar, and G. L. Miller. 2005. Residential Irrigation Based on Soil Moisture. *Resource Magazine*, June/July. American Society of Agricultural and Biological Engineers, St. Joseph, MI.

[9] Haley, M. B., M. D. Dukes, and G. L. Miller. 2007. Residential irrigation water use in Central Florida. *Journal of Irrigation and Drainage Engineering* 133(5):427-434.

[10] "Water plants in the morning" http://www.goodhousekeeping.com/home/gardening/water-plants-morning, 2014.

[11] Elias Awili: "Design and Construction of an Automatic water sprinkler for small scale gardens," Covenant University, 2013.

[12] Purna Prakash Dondapat, K. Govinda Rajulu: "An Automated Multi Sensored Green House Management," International Journal of Technological Exploration and Learning (IJTEL), 2012

[13] G. K. Banerjee, Rahul Singhal: "Microcontroller Based Polyhouse Automation Controller", International Symposium on Electronic Systems Design (ISED), Bhubaneswar, 2010

[14] "Transformers - Faysal Electric Company" http://faysal-electric-co.com/transformer/

[15] John Bird: "Electrical Circuit Theory and Technology," Elsevier Ltd. Publishers, 2007.

[16] Illinois Capacitors Inc: "Filtering," Electronic Components Assemblies and Materials Association (ECA), 2012.

[17] "Voltage-regulator", http://www.britannica.com/EBchecked/topic/632467/voltage-regulator, 2014.

[18] Texas Instruments: "LM35 Precision Centigrade Temperature Sensors", TI publications 2013.

[19] Dogan Ibrahim: "Advanced PIC Microcontroller projects in C", Newnes publishers, 2008.

[20] "CrystalFontz America", http://www.crystalfontz.com/product/CFAH1604BNGHET, 2014.

[21] Madeline Bullock, " How Relays Works", http://electronics.howstuffworks.com/relay.htm, 1998.

[22] Otarelli, L., J. M. Scholberg, M. D. Dukes, and R. Muñoz-Carpena. 2008. Fertilizer residence time affects nitrogen uptake efficiency and growth of sweet corn. *Journal of Environmental Quality* 37(3):1271–1278.