A GSM Based Data Acquisition System For Climatic and Soil Hydro-Physical Parameters Measurement

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Abstract: **This paper proposes a data acquisition system that controls an automated farmland. The information received by the sensors used in this project are being sent to the microcontroller from the sensors which processes the data collected and then opens or closes a drip irrigation system valve based on the information received by the microcontroller. The data that is being read by the sensors is also sent to the user through a GSM module, displayed on the liquid crystal display (LCD) and is stored on an memory (SD) card every twenty-five minutes. The developed system increased efficiency on the field where it was implemented. The result was then collected for the period of two (2) weeks and there were variations for different days which were due to climatic conditions. The designed system worked optimally and is fully recommended for both small-scale and large-scale implementations.**

Keywords**: Data acquisition, microcontroller, GSM module, SD Card module.**

I. INTRODUCTION

Data acquisition systems have been in existence since the 1960s, when creators at IBM developed the first computer-hardware machines [1]. They put out their first official data acquisition machine in 1963. They called it the IBM 7700 Data Acquisition System. Just one year later, they released the 1800 Data Acquisition and Control System. Unlike the International Business Machines (IBM) 7700, this system featured a component for disk storage [2].

Data acquisition (DAQ) is the process of measuring an electrical or physical phenomenon such as soil moisture, soil temperature, pressure, soil humidity, voltage, current, etc. A DAQ system consists of sensors, DAQ measurement hardware and a computer with programmable software. Compared to traditional measurement systems, PC-based DAQ systems exploit the processing power, productivity, display and connectivity capabilities of industry – standard computers providing a more powerful, flexible and cost – effective measurement solution. A complete data acquisition system consists of DAQ hardware, sensors and actuators, signal conditioning hardware, and a computer running DAQ software.

An automatic drip irrigation system based on monitoring soil moisture was developed by [3], [4]. They both established the use of a microcontroller system as the central controller for such as system and showed the interfacing of a typical moisture sensor to the unit.

II. METHODOLOGY

A data acquisition system for climatic and soil hydro-physical measurement uses the soil moisture sensor, turbidity sensor and a module called GY-BMP280-3.3 to measure the atmospheric pressure [5]. The measured values will be decoded by the microcontroller that will be programmed to act accordingly. If the soil moisture level falls below a certain value (pre-set value), the microcontroller will send a signal to trigger the relay, therefore the DC water pump will be ON. And also, if the soil moisture level increases to a certain value (pre-set value) after the water pump have been ON, microcontroller will again send a signal to de-activate the relay, therefore the DC water pump will be OFF. The measured values will also be logged on the memory card and, then sent to mobile Phone through the GSM module as an SMS to a phone number added in the code. There will also be a Liquid Crystal Display (LCD) that will always be displaying the values. The microcontroller used is the Arduino Mega (ATmega2560) and it is preferred because the design requires multiple input points [6], [7].

Soil moisture sensor in Fig 1 below measures the volumetric water content in soil. Since the direct gravimetric measurement of free soil moisture requires removing, drying, and weighing of a sample, soil moisture sensors measure the volumetric water content indirectly by using some other property of the soil, such as electrical resistance, dielectric constant, or interaction with neutrons, as a proxy for the moisture content [6].

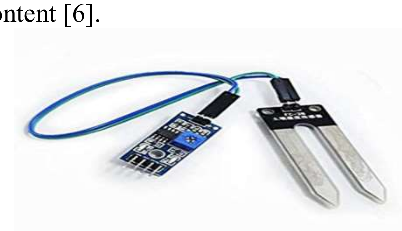

Figure 1: Soil Moisture Sensor

The sensor shown in Fig 2 below is an arduino compatible tool used for atmospheric pressure measurement in environments. Such measurements mainly allow for forecasting of short term changes in the weather.

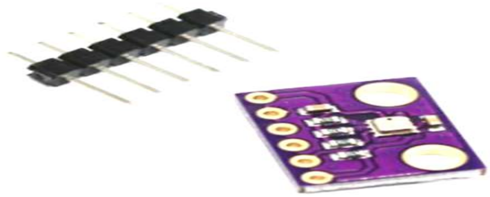

Figure 2: Atmospheric pressure sensor

The turbidity sensor shown in Fig 3 below measures light passing through a sample of water. The light transmitted through the sample is dependent on the amount of soiled particles in the water. These devices are ideally suited for use in washing machines & dishwashers as well as other water purity type applications. As the particles increase, the light transmitted decreases. The measurement produced by the turbidity sensors enables the machine to run for shorter periods, generating energy savings for the consumer and long term environmental benefits.

Figure 3: Turbidity sensor

The sensing unit contains the sensors that are used in this project. However, the moisture sensor and the turbidity sensor are analog sensors. Analog sensor senses the external parameters and gives analog voltage as an output. The output voltage may be in range of 0 to 5V. An Arduino has a feature called ADC. An Analog to Digital Converter (ADC) is a very useful feature that converts an analog voltage on a pin to a digital number.

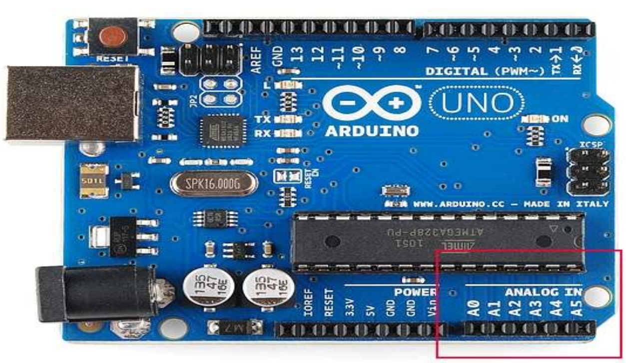

Figure 4: Arduino UNO

On the Arduino board shown in the fig 4 above, these pins have an ‘A’ in front of their label (A0 through A5). ADCs can vary greatly between microcontrollers. The ADC on the Arduino is a 10-bit ADC meaning it has the ability to detect 1,024 (2^{10}) discrete analog levels. Some microcontrollers have 8-bit ADCs (2^8 = 256 discrete levels) and some have 16-bit ADCs (2^{16} = 65,536 discrete levels) [8]. Fig 5 depicts the circuit design achieved using the PROTEUS development/simulation tool. It shows clearly the interconnections between the arduino and all associated circuitry comprising the system.

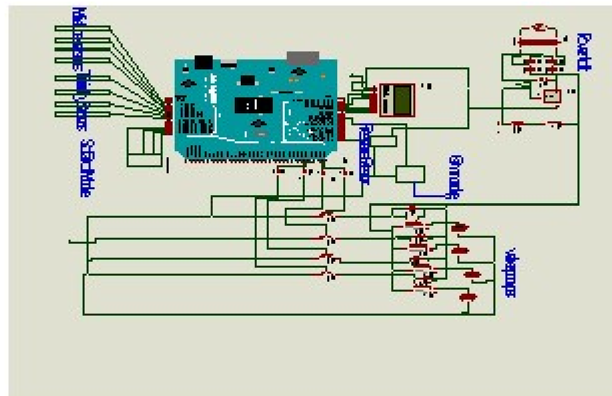

Figure 5: Circuit diagram of Entire System

The design flowchart of the entire system is represented in fig 6.

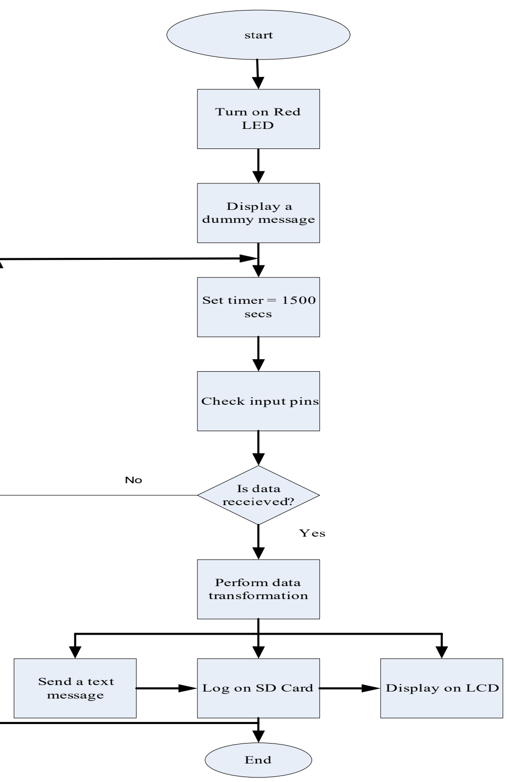

Figure 6: System flowchart

III. SENSOR MEASUREMENT METHOD

The ADC in the arduino assumes 5V for 1023 and anything less than 5V will be a ratio between 5V and 1023 according to the following equation:

$$\frac{Resolution\ of\ the\ ADC}{System\ voltage} = \frac{ADC\ Reading}{Analog\ voltage\ measured} \quad (1)$$

$$\frac{1023}{5} = \frac{ADC\ Reading}{Analog\ voltage\ measured} \quad (2)$$

If the soil moisture sensor gives analog voltage output of 2.12V, the corresponding ADC value is thus deduced as

Analog output = 2.12V

Corresponding value, x =?

1023 / 5V = x/2.12

5x = 1023 * 2.12

5x = 2168.76

x = 2168.76 / 5

x = 434

However, there is a mapping that has been written in the code for the arduino that changes the value of x to percentage (%). (i.e. a mapping is done between 0-100% in respect to 0-1023). To get the data transformation from the corresponding ADC value to percentage, the calculation will be as follow:

% value = (x / 1023) * 100

= (434 / 1023) * 100

= 42%

NOTE: The minimum voltage for the soil moisture sensor is 2V while the maximum voltage is 5V.

If the TSD-10 gives an analog voltage output of 3.37V, the corresponding ADC value is thus;

Analog output = 3.37V

Corresponding value, x =?

5x = 1023 * 3.37

5x = 3447.51

x = 3447.51 / 5

x = 689.5

There is also a mapping that has been written in the code for the arduino that changes the value of x to percentage (%). i.e. a mapping is done between 0-100% in respect to

0-1023). The data transformation to percentage is calculated as follow:

% value = (x / 1023) * 100

= (689.5 / 1023) * 100

= 67%

NOTE: The minimum voltage for the turbidity sensor is 0V while the maximum voltage is 4.5V.

If the BMP 280 gives an analog voltage output of 3.5V, the corresponding ADC value is then;

Analog output = 3.5V

1023 / 5 = x / 3.5

5x = 1023 * 3.5

5x = 3580.5

x = 3580.5 / 5

x = 716.1 hPa

IV. RESULT

The arduino and the entire circuits on the vero board were both packaged in a detachable plastic. The fully packaged design is shown in the fig 7 below

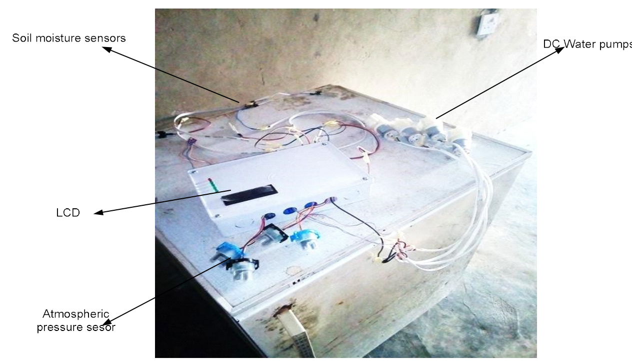

Figure 7: Complete System

The system was powered by a multi-voltage source, capable of producing 5V, DC and 12V, DC. The 5V, DC was used to provide power to the Arduino board and the sensors, while the 12V, DC was used to provide power for the connected DC water pumps in a drip irrigation system structure. Overhead water storage system will provide the required water source for drip irrigation, while a soil test bed will be required for the deployment of the system. The overall system was designed and constructed in a plug and play mode, such that in the event of a faulty unit, a similar unit can easily be replaced without the need to update the controller code.

V. CONCLUSION

The venture of this project helps in minimizing power and water utilization in the developments of agricultural plants. To aid this, DC water pumps which were controlled by the microcontroller were used. The microcontroller was modified to actuate the water pump to water the plants when the threshold is below a set value in a typical drip irrigation system. The detecting and control circuits are direct current (DC) controlled. The control unit is actuated only when information is gotten from the microcontroller. The System was able to effectively detect soil moisture content, soil turbidity and atmospheric pressure. This will aid the accurate monitoring of plant growth parameters, while acting as a suitable input for a typical drip irrigation system. The data acquisition system will be deployed to a live agricultural field/plot/vegetable bed. The growth parameters of the plant will be measured and comparatively analyzed with a control agricultural field/plot/vegetable bed to determine the effects an efficient parameter monitoring and control methodology has on overall plant health and growth

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