International Journal of Engineering Processing & Safety Research
Published by Cambridge Research and Publications

Vol. 25 No.5
September, 2022.

MICROCONTROLLER BASED SMART IRRIGATION SYSTEM: DESIGN, SIMULATION AND REALIZATION

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ABSTRACT
Plants in specific regions of the world especially Africa are adversely affected by prevailing draught. Presently, the major concerns in agricultural sector are; water and labor managements. This work considers the design analysis of a low-cost microcontroller-based irrigation controller capable of managing irrigation for a small area of land based on real-time values of soil moisture. The method employed is to continuously monitor the soil moisture level to decide whether irrigation is required. In particular, the microcontroller based circuit device performs the action of irrigation management through continuous monitoring of moisture content of the soil, and comparing the values with two set reference values; the upper-limit, and lower-limit, then induces the corresponding action required. When the soil moisture content goes below the lower-limit value set by the user, the system observes this and begins irrigation action. Results obtained show that this design is cost-effective, and guarantees efficient water supply and effective labor management. Also, irrigation test results show that the duration of spray largely depends on the soil texture, grass identity and moisture content. In particular, sprinkler irrigation method in loamy soil took longer than in sandy soil, while clay soil irrigation took the longest time.

Keywords: *Draught, Microcontroller, Irrigation, Moisture*

Introduction
Irrigation is an artificial supplying of water to the root of plant. It has been used to assist in the growing of agricultural crops, maintenance of landscapes, and re-vegetation of disturbed soils in dry areas and during periods of inadequate rainfall. In crop production, irrigation helps in protecting plants against frost, suppressing weed growth and also used for dust suppression,

The old method used for irrigation was the use of watering cans, water channels that have to be opened and closed manually or backpack sprinklers. In this case, a lot of water is wasted in the process.

There is need for improvement on the existing or old forms of irrigation. An automated irrigation system needs to be developed to optimize water use for agricultural crops. An intelligent automatic irrigation system has to have all the components that autonomously monitor and control the level of water available to the plants without any failure or human intervention.

In this research, an automated irrigation system was designed to minimize water input and human intervention, while satisfying the plant's needs.

An automatic irrigation system does the operation of a system without requiring manual involvement of persons. Every irrigation system such as drip, sprinkler and surface gets automated with the help of electronic appliances and detectors such as computer, timers, sensors and other mechanical devices. The intelligent system should perform the following functions:

- **i.** Continuously monitor the amount of soil water available to plants using a sensing system.
- **ii.** Determine if watering is required for the plants based on the information obtained from the sensing
- **iii.** Supply an approximate amount of water required for the plants.
- **iv.** Discontinue the supply of water when the required amount has been delivered to the plants. This feature is important as the amount of water available for the irrigation system is not infinite, therefore water management is paramount.

Related work

Mahir Dursun et al, proposed an efficient water usage system by pump power reduction using solar-powered drip irrigation system in an orchard. Soil moisture content is analyzed by Artificial Neural Networks (ANN) to provide even distribution of water for the required location. This will prevent the unnecessary irrigation and reduce the water demand. This system reduces daily water usage and energy consumption by 38 percentages. (Dursun, 2011)

Farid et al, presented a practical solution based on intelligent and effective system for a field of hyper aridity. The system consists of a feedback FLC that logs key field parameters through specific sensors and a Zigbee-GPRS remote monitoring and database platform. The system is deployed in existing drip irrigation systems without any physical modification. FLC acquires data from these sensors and fuzzy rules are applied to produce appropriate time and duration for irrigation (Farid, 2010)

Singh et al, presents a solution for an irrigation controller for cultivation of vegetable plants based on the fuzzy logic methodology. In this system the amount of water given to the plants depends on its size, moisture control of soil, which is affected by temperature of environment, evaporation due to wind velocity and water budget. The system feed water to plants in a controlled and optimal way. Solar energy conversion technology is used to feed power to the pump controller. (S. Singh, 2012.)

Xin et al, described an autonomous precision irrigation system through the integration of a center pivot irrigation system with wireless underground sensor networks. The wireless underground sensor aided center pivot system will provide autonomous irrigation management capabilities by monitoring the soil conditions in real time using wireless underground sensors. Experiments were conducted with a hydraulic drive and continuous-move center pivot irrigation system. (Xin, 2013)

Robertet al, promoted a commercial wireless sensing and control networks using valve control hardware and software. The valve actuation system included development of custom node firmware, actuator hardware and firmware, an internet gateway with control, and communication and web interface software. The system uses single hop radio range using a mesh network with 34 valve actuators for controlling the valves and water meters. (Robert,, 2013)

Awati et al design an Automatic Irrigation Control Using Wireless sensor Networks. The system was integrated with sensors into a wireless monitoring network to determine and evaluate calibration functions for the integrated sensors. The system compares the measuring range and the reaction time of both sensor types in a soil layer during drying. Data were transmitted over several kilometers and made available via Internet access. (J.S., 2012)

Nolz et al integrated the sensors into a wireless monitoring network to determine and evaluate calibration functions for the integrated sensors, and compare the measuring range and the reaction time of both sensor types in a soil layer during drying. The integration of the sensors into the telemetry network worked well. Data were transmitted over several kilometers and made available via Internet access. (Bhandari, 2013)

Christos et al described the design of an adaptable decision support system and its integration with a wireless sensor/actuator network to implement autonomous closed-loop zone-specific irrigation. Using ontology for defining the application logic emphasizes system flexibility and adaptability and supports the application of automatic inferential and validation mechanisms. A machine learning process is applied for inducing new rules by analyzing logged datasets for extracting new knowledge and extending the system ontology in order to cope (Christos, 2014)

Materials

Arduino

In this research, the Atmega328p microcontroller was used to control and coordinate all the units of the system. It operates between voltage ranges of 3–5.5 volts and has 32KB of flash memory, an 8-bit data bus, and consumes less power under certain circumstances (Rahman, 2017)

Figure 1: Atmega328p microcontroller **(Rahman, 2017)**

Moisture Sensor

FC-28 sensor moisture module was used to measures the volumetric water content indirectly by using some properties of soil, such as electrical resistance, dielectric constant, or interaction with neutron, as a proxy for the moisture content. The module has a potentiometer to adjust the level of sensitivity and requires an operating voltage between 3.3V and 5V. (Vani & Rao, 2016)

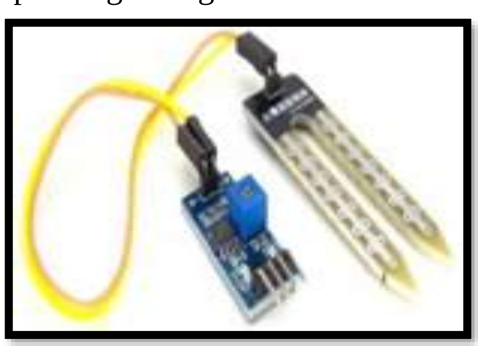


Figure 2: Structure of a FC-28Soil Moisture Sensor

Water Pump

In this research a DC pumps that operate on 12 volt was used to provide the means for moving water through the system at usable working pressures from a reservoir to the field. This type of DC pumps is the centrifugal type which uses an impeller to spray fluids.

Figure 3: Structure of a 6 Volt to 12 Volt dc Water Pump

Liquid Crystal Display (LCD)

A 16x2 Liquid Crystal Display (LCD) was used due to cost, simplicity during programming and can display a wide range of characters and animations. This LCD has Command and Data registers. The command register stores command instructions given to the LCD while the Data register stores the data to be displayed by the LCD

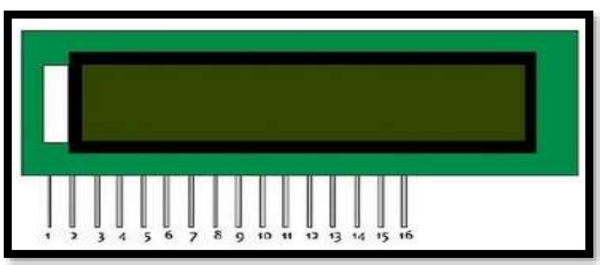


Figure 4: Structure of a liquid crystal display (LCD)

Methodology

The system has three major parts; the sensing unit, the control unit and the output unit which were achieved using sensors, controller, and actuator respectively as shown in Figure 5. The major components used to incorporate the control mechanism include; wireless sensor, controller, and actuator.

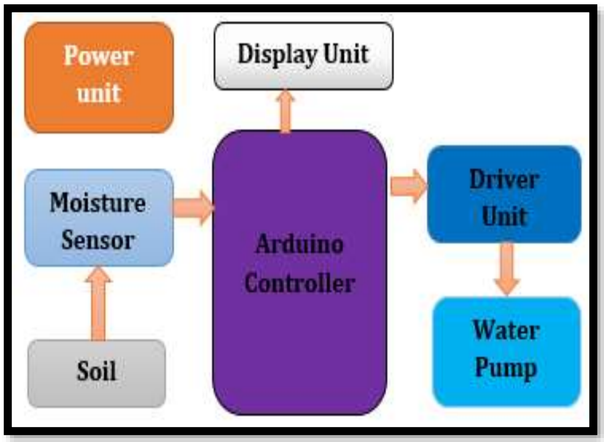


Figure 5: Block Diagram of an Irrigation System

System units

Power supply

A portable source of power was designed using a 12V/1.5A step down transformer, as shown in Figure 6. LM 7812 and LM 7805 regulators were used to produce a steady 12v and 5V respectively.

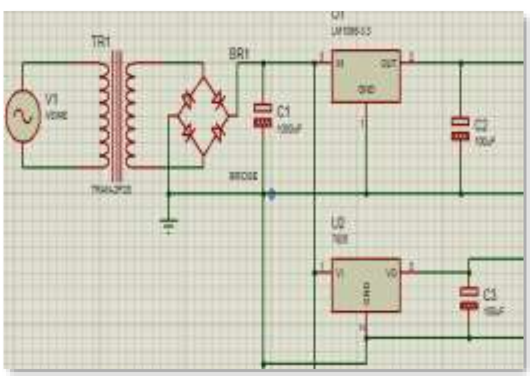
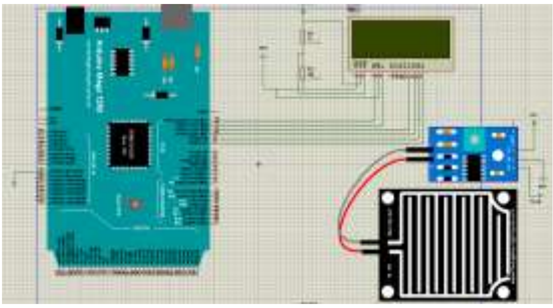


Figure 6: Circuit diagram of the systems the power unit

Sensing unit

An FC-28 moisture sensor was used to sense the level of moisture within the vicinity if the plant. It was powered by a 5v dc and its output pins was connected to pin 53 of the microcontroller as shown in Figure 7. The sensor sends voltage at a level which is proportional of the reading of moisture level to the microcontroller for processing and further action.



Control unit

Actuation unit

Figure 9 shows how the actuator was connected to the microcontroller. The primary responsibility of the actuator normalize the moisture content of the field. A 12V DC water pump to regulate the moisture level of the farm was designed and implemented for this unit and was connected to pins 14 of the microcontroller via a 10kW resistor and was powered by 12V relay switch.

Figure 9: Circuit Diagram of the actuation unit of the monitoring system.

Principle of operation

The principle of operation of the control device of the system is explained by the flowchart shown in Figure 10. Firstly, the moisture threshold values of the system was set and was uploaded into the sensing and response unit for comparison with acquired value.

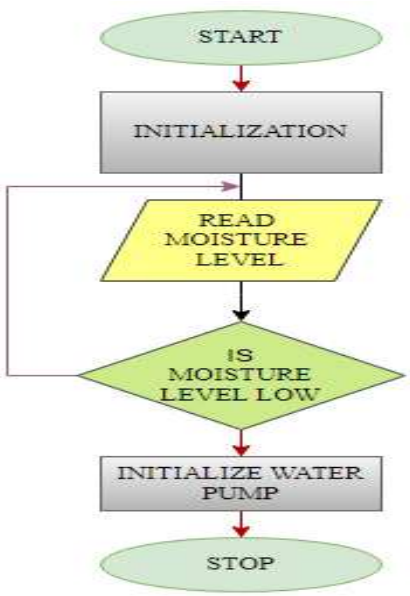


Figure 7: System Flow Chart

When powered ON, the system undergo initialization sequence, which were displayed on the LCD. The sensing device reads the moisture content of the field and the controller displays its level on the LCD, The system then compares the level of the current moisture with the threshold values uploaded. If the moisture is below the threshold value, the system energizes the actuator so as to have the required moisture level; otherwise, it will continue to read moisture level until it falls below the threshold value. The system will continuously monitor this parameters as long as it is connected to a power supply.

Result and discussion

Simulation results

This section presents simulation results that was achieved during the design of the control circuit of the monitoring device. After safe system booting, the system undergoes some series of initialization which will be displayed on the LCD as shown in Figure 8.

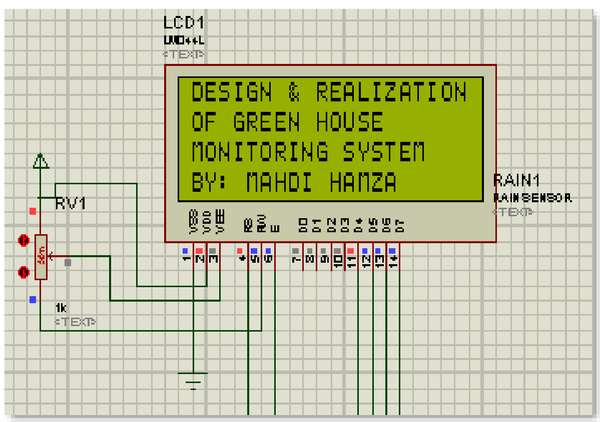


Figure 8: System welcoming note

It also display the current moisture level of the field and the status of the actuator (pump) as shown in figure 9 and 10

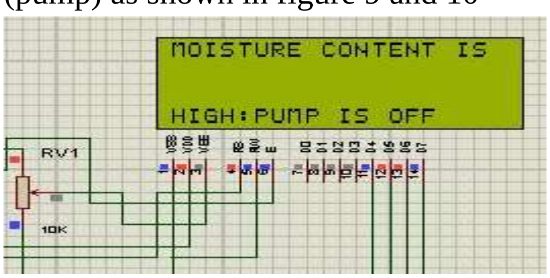


Figure 9: Farm status (favorable)

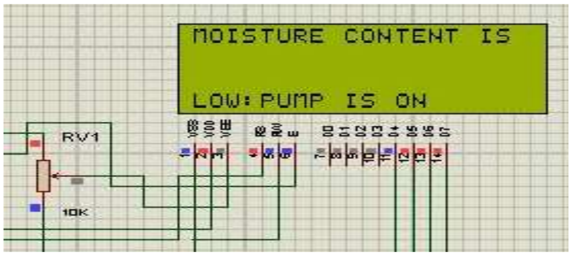
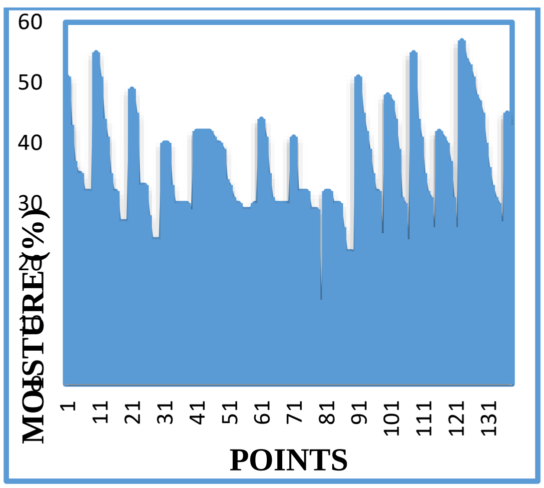


Figure 10: Farm status (Unfavorable)

Moisture variation

The instantaneous variations of moisture level of the field were displayed on the LCD. Figure 11 shows the variations of moisture level of the field that was recorded at three regular intervals per day; Mourning, Midday, and Early evening for four weeks.



The soil used in this research is a sandy-loam soil and by setting the threshold value for moisture as 15%, the result obtained showed that the maximum, minimum, and average moisture content was recorded was 55%, 18%, and 32.6% respectively. Based on the data collected, the level of moisture content of the field increases after 2-3 days.

Conclusion

This work presents the design and implementation of a low-cost microcontroller-based irrigation controller capable of managing irrigation for a small area of land based on real-time values of soil moisture. An Atmega328p microcontroller, Fc 28 moisture module and 12 dc pump were used to continuously monitor the soil moisture level of a field and then decide whether irrigation is required. When the soil moisture content goes below the lower-limit value set by the user, the system observes this and begins irrigation action. Results obtained show that by setting the threshold value for moisture as 15%, the result obtained showed that the maximum, minimum, and average moisture content was recorded was 55%, 18%, and 32.6% respectively. Based on the data collected, the level of moisture content of the field increases after 2-3 days. This design is cost-effective, and guarantees efficient water supply and effective labor management.

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