Research Journal of Chemical and Environmental Sciences
Res J. Chem. Environ. Sci. Vol 11 [4] August 2023: 20-25
Online ISSN 2321-1040
CODEN: RJCEA2 [USA]

Website: www.aelsindia.com/rjces.htm

RJCES

ORIGINAL ARTICLE

Design and development of integrated soil moisture and nutrient sensor based system for real time monitoring of soil moisture and nutrient status

MADHUKAR PATEL[1]*, NARENDRA AGRAWAL[2], DHIRAJ KHALKHO[3] AND M. P. TRIPATHI[4]
[1]Ph. D. Research Scholar, Department of Soil and Water Engineering, SVCAET & RS, IGKV, Raipur, Chhattisgarh, India.
madhukarpatel.60@gmail.com
[2]Assistant Professor, Department of Soil and Water Engineering, SVCAET & RS, IGKV, Raipur, Chhattisgarh, India.
[3]Professor, Department of Soil and Water Engineering, SVCAET & RS, IGKV, Raipur, Chhattisgarh, India.
[4]Professor, Department of Soil and Water Engineering, SVCAET & RS IGKV, Raipur, Chhattisgarh, India.

ABSTRACT
The present study was conducted to design, develop and evaluate a real time monitoring a automated drip fertigation system working on the basis of soil moisture and soil nutrient content. In order to get popularity and wider adoption of automated drip irrigation system, it is essential to bring out a cost-effective system. The study involved fabrication of a soil nutrient deficit-based drip automation system and testing of the system under field conditions. The system was tested and calibrated based on automatic fertigation scheduling. The nutrient automation system developed was simple, precise, sensitive, light weight, cost effective in construction and fast responding. The speed of measurement, cheapness and portability are the key advantages and the system is easily adaptable for use with automatic logging equipment. The automated system based on soil NPK sensors was found to be working efficiently without frequent supervision and maintained the pre-set nutrient content in the root zone
Key words: Soil Moisture sensor, Soil Nutrient, Sensor, Automated fertigation System.

Received 10.04.2023 Revised 12.06.2023 Accepted 02.08.2023

INTRODUCTION

India is an agricultural country with 60-70% of the economy and majority of the population dependent on agriculture for income and work. Agriculture in India uses about 80% of its total water resources for irrigation. Irrigation plays an important role in ensuring quality crop production and also contributes to the economic development of the country as proper irrigation helps in improving crop production. This requires controlled application of water and to achieve it automation of fertigation system being eyed as best alternative. A large number of experiment have been carried out on automated fertigation systems at various levels during last two decades. Automation in micro-irrigation system is gaining momentum slowly in India. This is mainly due to less dependency on labour, smooth operation during day and night hours, as well as saving of energy and water. Mainly Indian farmers choose manually controlled systems or semi-automatic control systems due to low cost and less skills requirement of operating the systems [1]. Recently, technological advances have been made in soil nutrient sensors for efficient and automatic operation of irrigation system based on crop nutrient requirement. The measurement of soil nutrient content is a critical factor to achieve precise irrigation schedules, minimize nutrient loss and to maintain optimum level of soil nutrient content in the root zone area of plant [2].
Indian agriculture faces more challenges for the production of safe and quality food. Sometimes it can cause de-merits like wilting of plants by the over application of water and lead to pollution of the environment by fertilizer application dozes higher than recommended. Hence, new innovations are must be developed in such a way that it should be both ecofriendly and accepted by marginal farmers. In the present micro irrigation systems, introduction of automation in drip system is the very best step for enlightened the equipment's to provide water to the crop according to crop requirement. Therefore, automation in drip irrigation technique has definitely improves the crop production, water saving and labour costs as compared to the manual drip irrigation systems.

In general, automation of fertigation system is costly and not affordable by the marginal farmers due to the high initial investment. Sensor based fertigation automation has number of limitations and not used by the farmers. Development of sensor based fertigation system is tedious, costly, time consuming and may lead to wrong scheduling of fertigation due to the variations occurring in the soil other than that due to change in the nutrient status. In order to get popularity and wider adoption of automated drip fertigation system, it is essential to bring out a cost effective system.

The present study was carried out to overcome the problems the sensor provides the soil moisture content and soil NPK readings in the LCD screen after installation of screen in the microcontroller unit in real time basis. LCD display can helps the user to collect different feedback from different types of soil moisture and nutrient levels from various locations in the cultivated land.

MATERIAL AND METHODS

The design and assembling of drip automation system was done at department of Soil Water Engineering, SV College of Agricultural Engineering and Technology and Research station Raipur Chhattisgarh. The system was developed taking into the considerations portability, corrosiveness, toughness to weather parameters, quick response, easy for installation and fixation of the sensors.

Components of drip automation system

The automation system is designed as simple, light weight and easy to handle. The entire unit developed is moisture proof. Block diagram of controlling system is shown in Fig. 1 and circuit for automatic irrigation system is shown in Fig. 2.

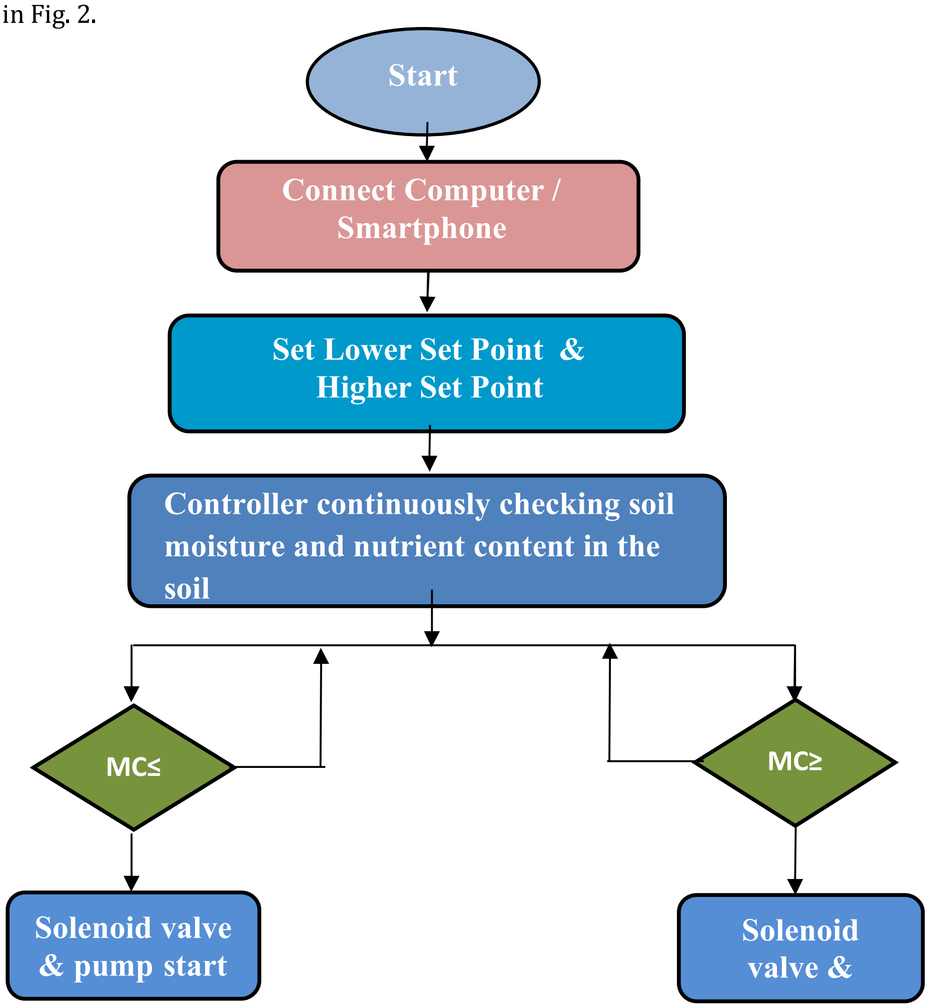


Fig. 1. Block diagram of fertigation control system

Soil moisture sensor

The conductivity sensors are made of high-quality stainless-steel probes for durability. The soil moisture sensor consisted of two electrodes i.e. positive and negative separated by a nonconductor medium that is nylon circular plate. The electrodes of the sensor were built of round cylindrical shape. The complete sensor length is 215 mm and spacing between the electrodes is 55 mm. It is made up of stainless 3 mm thick steel. The weight of the single soil moisture sensor is approximately 100 grams shown in (Fig. 3). The oxidation of the sensor occurred due to contact of water with soil can be avoided by using stainless-steel material. One probe is connected to Vcc via a 1.0 M ohm resistor, thus acting as a voltage divider and the other one is grounded. When there is sufficient moisture content in the soil, the conductivity is high, hence the voltage divider output is high. When the soil becomes dry, its conductivity decreases thus decreasing the voltage divider output. This is then given to an op-amp based voltage follower. CA3140 is used here as the operational amplifier. The output of the sensor is connected to MCU through the voltage follower made by the CA3140. Voltage follower is used here for impedance matching purpose.

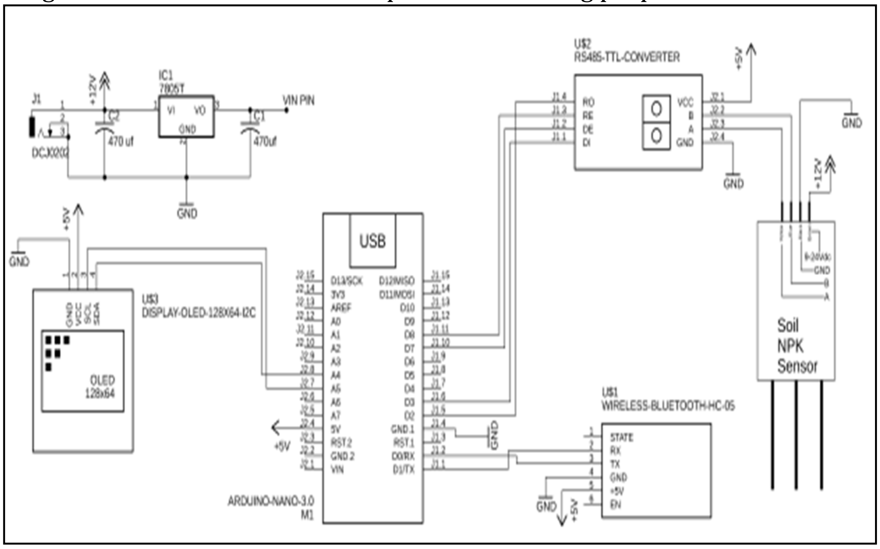


Fig. 2 Circuit diagram of the automated drip fertigation unit

Microcontroller unit

Microcontroller unit (MCU) is the heart of any automation irrigation system. In this system PIC16F877 is used as the MCU. It is used sensor output and determining the moisture level than send signal to control motor for on/off. The popular microcontroller PIC 16F877 from MICROCHIP Corporation is used as the CPU of the system. PIC microcontrollers are the most popular 8 bit microcontroller in the world. They are available in wide variety in pin outs, memory capacity and have lots of integrated peripherals like ADC, SERIAL modules and EEPROM. The PIC 16F877 is available in 40 pin DIP package and have program memory capacity of 8 Kb, RAM of 368 Bytes and 256 Bytes of EEPROM. Generally, they are low power devices and works in voltage range of 2V to 5.5V. They have 13 interrupt sources like external pulse interrupt and serial receive interrupt etc. These chips are supplied with in circuit serial programming facility and are flash technology also. The flash memory can be rewritten 1000 times.

Control keys

The micro controller unit has NEXT OR EXIT, INC, DEC, SET UP, keys and these are connected to RB1, RB2, RB3 and RB4 of the MCU. These control keys are used to adjust the resistive sensor values and the fertigation intervals. 200 K resistor array is used to interface the control keys to the MCU. Among the four control keys (micro), two keys in the middle (INC and DEC) are used for increasing and decreasing the value of moisture content limits. The last key (SET UP) is used for adjusting the sensor data and fertigation timings.

Liquid Crystal Display (LCD)

3.5-inch TFT LCD (Liquid Crystal Display) unit was used for displaying the moisture content as detected by the sensors. The LCD displays the average moisture content as well as moisture content individually recorded by each of the sensors. It also displays the pump running status as well. This TFT works as Human Machine Interface (HMI) and is being used to set or modified any logical programme in the motherboard.

Soil nutrient sensor

Basically, the Soil Nitrogen, Phosphorus, and Potassium 3 in 1 fertility sensor which is used for detecting the content of nitrogen, phosphorus and potassium in the soil. This Soil NPK Sensor is considered to be the highest precision, accurate with accuracy up to ±2%, fast speed measurement, and with increased stability. The resolution of this Soil NPK Sensor is up to 1mg kg^{-1} or (1 mg l^{-1}), this is an easy-to-carry sensor and can even be used by non-professionals, by inserting these stainless-steel rods into the soil and read the soil nutrient content.

Motor interface

This is required because the current output from the microcontroller is very small which is not sufficient to magnetize the relay which is used to control the motor. Hence it is necessary to have an amplifying circuit. The output of the microcontroller is fed to the TIP122 IC for current boosting.

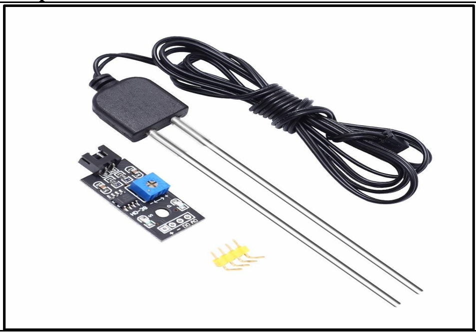
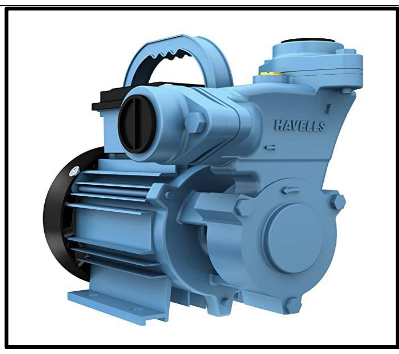


Fig. 3 Resistive type soil moisture sensor	Fig. 4 Soil NPK Sensor
	
Fig. 5 Relay module	Fig. 6 Miniature Circuit Breaker
	
Fig.7 Electrical contactor	Fig. 8 Booster Pump

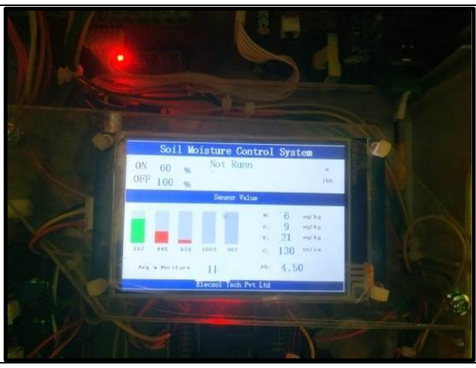



Fig. 9 LCD Dispaly	Fig. 10 Solenoid valve

RESULTS AND DISCUSSION

To set the irrigation time, the conductivity value of soil moisture sensor is required to be pre-set before installation. The upper values (field capacity of soil) were estimated by calibrating the soil moisture sensor. After pre-setting the upper value in the data logger, the soil moisture sensor was kept at the desired depth

(10 to 20 cm) within the active root zone of the crop. As the soil gets dried up, conductivity gets decreased and when it reaches the upper limit, the LED in the control panel gets illuminated indicating to start irrigation. The system can be activated by using a single-phase motor for pumping. There is also a manual option for turning the motor ON/OFF. Drip automation system switches ON the irrigation system when the sensors value reaching a pre-set reading. The irrigation system will be operated until the soil moisture content reaches the field capacity of soil. As the soil dries, water content decreases and the conductivity value in data logger decreases. The irrigation system will run until the conductivity reaches the pre-set critical value. In this way soil moisture sensors continuously record the fluctuations in soil water content under field conditions and store the data for every one hour. Similarly for nutrient sensor pre set calibrated value of NPK content were set as upper limit and lower limit.

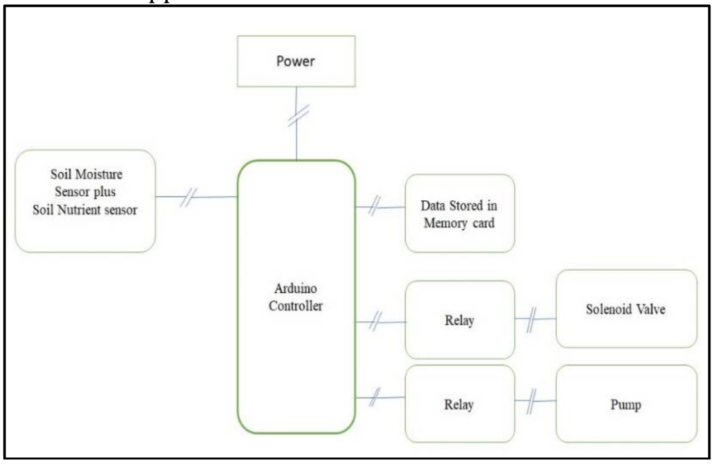


Fig. 11 Hardware connection and connectivity

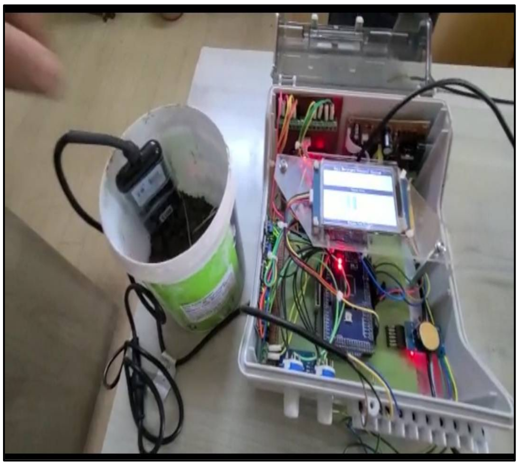


Fig. 12 Hardware setup for real time soil monitoring system

System maintenance

To run the system efficiently, following major steps were followed.

- Positive and negative terminals of the sensor were connected properly to the respective connections provide on the instruments.
- It was ensured that all parts of the sensor were properly fitted so that there existed no gap between the parts of the sensor to avoid entry of water.
- Sensor was properly inserted into the soil to avoid gap between the soil and soil moisture sensor.

CONCLUSIONS

The soil moisture and nutrient sensor based automatic drip irrigation system was designed, developed and tested for scheduling irrigation and nutrient automatically. The developed system is economical, light weight and water proof. The automation unit is simple to install and uninstall, under field conditions. Soil moisture sensors were evaluated with respect to the moisture content. It was observed that as the moisture content decreases, the soil electrical conductivity of sensors decreases. In field evaluation of the sensors in whole crop season at different crop stages, different values with respect to the moisture content was noticed. This might be due to the difference or non-uniformity in the soil texture and air gap between the soil and soil moisture sensor. In soils, cracks can be easily formed which were responsible for the air gap between the soil and the sensor. So, care should be taken while installing the sensors in the field. The system was installed in the field for a season with the crop cucumber and the system worked properly and the motor gets switched "ON" and "OFF" automatically with respect to the output of sensors.

REFERENCES

1. Carpena, R.M. and Dukes, M.D. (2005). Automatic irrigation based on soil moisture for vegetable crops. Department of Agricultural and Biological Engineering, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida.
2. Kant, R. and Naoi, T. (1998). Studies on the soil moisture extraction pattern (SMEP) of spring and summer pruned mulberry (Morns spp.) gardens. Indian J. Seric. 37(2): 167-170.
3. Kumar, J., Patel, N. and Rajput, T.B.S. (2016). Development and integration of soil moisture sensor with drip system for precise irrigation scheduling through mobile phone. Journal of Applied and Natural Science, *8*(4):1959-1965.
4. Balakrishna. K, Nethravathi. S. N, Harshitha Krishna. (2016). Real-Time Soil Monitoring System for the Application of Agriculture International Journal of Engineering Science and Computing 6(5):5326- 5331
5. Akhil R, Gokul M S, Sruthi Menon and Lekshmi S Nair (2018). Automated Soil Nutrient Monitoring for Improved Agriculture International Conference on Communication and Signal Processing, April 3-5, 2018, India.
6. Khanna, N., Singh, G., Jain, D.K. and Kaur, M. (2014). Design and development of soil moisture sensor and response monitoring system. International Journal of Latest Research in Science and Technology, 3(6):142-145.
7. Mishra, P., Mapara, S. and Vyas, P. (2015). Testing/monitoring of soil chemical level using wireless sensor network technology. International Journal of Application or Innovation in Engineering & Management, 4(11).
8. Zhang, X., Zhang, J., Li, L., Zhang, Y. and Yang, G. (2017). Monitoring citrus soil moisture and nutrients using an IoT based system. Sensors, 17(3):447.

CITE THIS ARTICLE

Madhukar Patel, Narendra Agrawal, Dhiraj Khalkho And M. P. Tripathi. Design and development of integrated soil moisture and nutrient sensor based system for real time monitoring of soil moisture and nutrient status. Res. J. Chem. Env. Sci. Vol 11 [4] August 2023. 20-25