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Utilization of Irrigation Water Using Microcontroller

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Abstract The scarcity of irrigation water in the Mediterranean area highlights the importance of optimizing its use. Protected culture reduces evapotranspiration, relative to open-air cultivation, contributing to improve the use of water. Increasing the water use efficiency, relative to other conventional irrigation methods, is one of the most relevant advantages of drip irrigation, if it is properly operated an adequate management of the drip system, frequently due to inaccurate irrigation water scheduling or drippers clogging and the subsequent reduction of the emission Uniformity, limits the potential advantage of the drip system. Information on the basis of points to achieve a successful management of the drip irrigation systems and to save water in protected cultivation, from a practical point of view, is included. In our work we have used solenoids to implement the concept of drip irrigation. The main problem that comes in drip irrigation is controlling of opening and closing of the supply of water. In our work we have used solenoids to control the opening and closing mechanism for drip irrigation. The use of the concept has shown the efficiency of better utilization of irrigation water has been increased by 90%.

Keyword: *microcontroller, solenoid control, humidity, temperature, soil moisture*

1. Introduction

The continuous increasing demand of the food requires the rapid improvement in food production technology. In a country like India, where the economy is mainly based on agriculture and the climatic conditions are isotropic, still we are not able to make full use of agricultural resources. The main reason is the lack of rains & scarcity of land reservoir water [1]. The continuous extraction of water from earth is reducing the water level due to which lot of land is coming slowly in the zones of un-irrigated land. Another very important reason of this is due to unplanned use of water due to which a significant amount of water goes waste. In the modern drip irrigation systems, the most significant advantage is that water is supplied near the root zone of the plants drip by drip due to which a large quantity of water is saved. At the present era, the farmers have been using irrigation technique in India through the manual control in which the farmers irrigate the land at the regular intervals. This process sometimes consumes more water or sometimes the water reaches late due to which the crops get dried. Water deficiency can be detrimental to plants before visible wilting occurs. Slowed growth rate, lighter weight fruit follows slight water deficiency. This problem can be perfectly rectified if we use automatic micro controller based drip irrigation system in which the irrigation will take place only when there will be intense requirement of water [2].

Irrigation system uses valves to turn irrigation ON and OFF. These valves may be easily automated by using controllers and solenoids. Automating farm or nursery irrigation allows farmers to apply the right amount of water at the right time, regardless of the availability of labor to turn valves on and off. In addition, farmers using automation equipment are able to reduce runoff from over watering saturated soils, avoid irrigating at the wrong time of day, which will improve crop performance by ensuring adequate water and nutrients when needed. Automatic Drip Irrigation is a valuable tool for accurate soil moisture control in highly specialized greenhouse vegetable production and it is a simple, precise method for irrigation. It also helps in time saving, removal of human error in adjusting available soil moisture levels and to maximize their net profits [3].

The entire automation work can be divided in two sections, first is to study the basic components of irrigation system thoroughly and then to design and implement the control circuitry. So we will first see some of the basic platform of drip irrigation system [4,5,6]. Many irrigation scheduling methods have been developed over the years, but adoption by producers has been limited by cost, installation time, maintenance, and complexity of the decisions involved. A potential solution to these problems is total automation of irrigation using feedback control systems. For example, electronic feedback soil moisture sensors installed in the crop root zone have been used to accurately control high-frequency irrigation [7]. Site-specific irrigation management can be implemented using spatially variable irrigation systems to optimize yields and maximize water use efficiency for fields with variation in water availability due to different soil characteristics or crop water needs. Site-specific irrigation management is more likely to be economically viable for high value crops. A field study carried out by King et al.

(2002) demonstrated the economic benefits of site-specific irrigation management on potatoes, where it increased total yield, marketable yield, and gross income relative to conventional uniform irrigation management [8]. Spatially variable irrigation systems previously developed have typically used self-propelled irrigation systems, such as center-pivots and linear moves, as the platform for sensing and control (Buchleiter et al., 1995; Fraisse et al., 1995a,b; Sadler et al., 1996, 2000; Wall et al., 1996; McCann et al., 1997; King et al., 1999). To control irrigation of small areas in a field, spatially variable control of fixed irrigation systems such as solid-set sprinkler and micro irrigation requires a network capable of controlling a large number of sensors and valves [9]. This can be achieved by using centralized or distributed irrigation control. A centralized irrigation control system (CIC) connects individual sensors and actuators to a centrally located controller by point-to-point communication using either direct wiring or radio frequency (RF) or infrared (IR) links. In the case of direct wiring links, CIC becomes expensive, difficult to maintain, and lacks flexibility, especially for site-specific irrigation control in large irrigated fields. Depending upon the distance between individual sensors and actuators to a centrally located controller, RF or IR links could be cheaper than point-to-point wiring. Distributed irrigation control (DIC) systems, on the other hand, have autonomous controllers in discrete locations close to sensors covering relatively homogeneous areas in the field [10]. These autonomous controllers have some intercommunication, which allow the system to prioritize irrigation decisions between site-specific irrigation management units. The advantages of DIC are reduced wiring and piping costs, and easier installation and maintenance. However, since additional controller units are required for DIC, this type of system is viable for site-specific irrigation only if low-cost controllers with low-power components (sensors, actuators, etc.) are available. Most commercially available sensors and actuators assembled for irrigation system networks are too complex and/or costly to be feasible for site-specific management of fixed irrigation systems [18]. The objectives of this research were to develop and test an autonomous, low cost, feedback irrigation water controller for site-specific management of fixed irrigation systems.

2. Methodology Adopted

The irrigation controller developed in this study is designed to work autonomously without hard-wire connections between individual control units. For site-specific irrigation implementation, a field is typically divided into irrigation management units based on soil characteristics, crop water requirements, and/or economic factors prior to the installation of the control system. An irrigation controller is installed in each irrigation management unit to autonomously control the soil water potential (SWP) in the crop root zone between field capacity (FC) and management allowed deficit (MAD) set by the user. Each controller is programmed to process the feedback information received from two SWP sensors that are installed in the root zone within the irrigation management [11] unit. When two of the sensors indicate that the SWP is more negative than the MAD, the irrigation controller opens a solenoid valve, triggering irrigation of the management unit. Irrigation continues until two of the three soil sensors indicate that the SWP exceeds the MAD. Soil moisture determinations and irrigation decisions occur at fixed regular intervals set by the user. This sequential closing of irrigation valves allows irrigation requirements of the management units with the higher priorities to be met before irrigating the management units with lower priorities After sensor measurements and irrigation decisions are made, the controller stores the corresponding data that include date, time, soil temperature, SWP and valve status data. Data are stored in non-volatile memory to prevent loss if a power failure occurs [7,9,12]. The user can download recorded data to analyze system performance.

3. Technology Adopted

3.1. Hardware Model

Electronic devices, sensors, and actuators were selected to meet the low power and low cost required for the DIC system. A block diagram of the DIC hardware is shown in Figure 1. The sub-components of the controller unit are a microcontroller, real-time clock, non-volatile data storage, an analog-to-digital (A/D) converter, and a battery charger. Each irrigation controller monitors SWP, soil temperature, system pressure, and controls a solenoid valve for irrigation [7,10].The microcontroller unit (MCU) is the master device that is programmed to keep time, communicate with data storage device, read sensors, and control the actuators [9,13,14]. The MCU has a 80C52 microcontroller with 256 bytes of internal RAM, 8Kb internal ROM, 3 timers and is a 40-pin DIP package with 32 programmable I/O pins (TTL-level), and two additional pins dedicated to asynchronous communications.

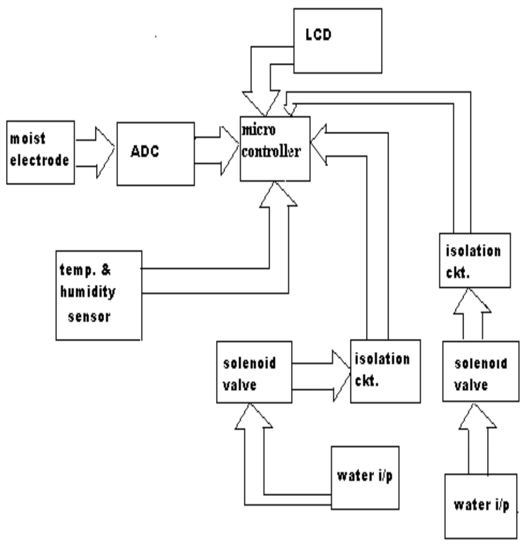

Figure 1. Block diagram for microcontroller based Drip irrigation system

This MCU was selected based on low-cost, processor speed, low power requirements, rapid software development, and ease of system integration with custom circuits. The sensor used to monitor SWP in the root zone was chosen for accuracy, reliability, durability, low maintenance, ease of interfacing with data acquisition systems, and low cost. Although no existing soil sensor scores high in all these areas, the Watermark sensor was selected as the best option [15].

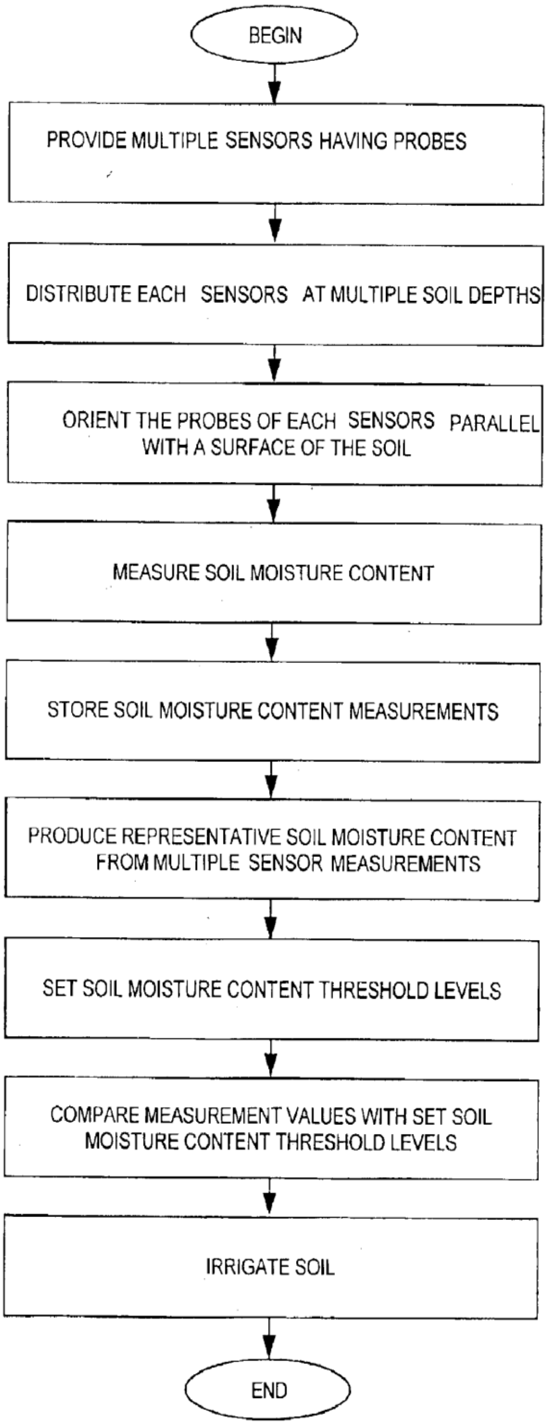

Figure 2. Algorithm of the methodology adopted

The Watermark sensor is relatively maintenance free, and exhibits a good combination of price, accuracy, and reliability. It is a resistance type sensor, which consists of two concentric electrodes embedded in a porous matrix. Once in hydraulic contact with the soil, the porous matrix absorbs or releases water in response to soil matric potential gradients until equilibrium is reached. The electrical resistance of the material between the electrodes is a function of the SWP with which the porous matrix is at equilibrium, increasing as the SWP becomes more negative.

3.2. Algorithm Developed

The whole approach of the methodology adopted can be easily reading the algorithm given below in Figure 2.

3.3. Software Methodology

The irrigation controller program was written in C, a proprietary language for microcontrollers. The program has lines of code and uses the total memory capacity of the microcontroller [9,12,13,16]. The program contains a main loop and several subroutines that enable the MCU to perform the following tasks:

- measure the air temperature, humidity and the SWP;
- compare SWP, humidity and air temperature values to threshold values programmed by the user and downloaded into EEPROM, and make a decision about opening or closing the solenoid valve [17].
- store date, time, air temperature, humidity SWP and valve status in the controller EEPROM;
- warn the user about sensor out-of-range readings by activating an audible alarm;
- when queried by the user via the asynchronous serial port, transfer data stored in the EEPROM to a remote device;
- manage the power supply.

4. Results

The developed prototype has been tested and the results obtained are discussed in this chapter. The soil is taken into consideration and the irrigation is applied on the area of 1m*1m. The soil which is under consideration has upper threshold value of 30% of SWP and lower threshold value of 10% of SWP. The two threshold values of SWP, one is upper threshold value and other is lower threshold value, decides the opening and closing of valves.

Table 1. Observation of prototype in a day

Sr.No.	Time of Observation	Temper-ature In °C	Humidity	SWP in terms of Capacitance	Duration of opening of valve In Hrs:min
1	6:00 AM	26.6°C	80%	42%	0:00
2	8:00 AM	28.9°C	67%	39%	0:00
3	10:00 AM	30.4°C	50%	36%	0:00
4	12:00 AM	33°C	34%	26%	0:30
5	2:00 PM	33.8°C	30%	28%	0:15
6	3:00 PM	34°C	30.90%	31%	0:00
7	4:00 PM	34.6°C	29%	29%	0:25
8	5:00 PM	34°C	26%	34%	0:00
9	6:00 PM	30.4°C	34%	38%	0:00
10	8:00 PM	28°C	60%	26%	0:30
11	10:00 PM	26.2°C	70%	28%	0:10

The dual temperature and humidity sensor measure the temperature and humidity of the surrounding atmosphere and send the data to the microcontroller that decide whether the measured data is within range or exceeds the threshold range. If it exceeds the threshold range then the Soil Water Potential (SWP) of the soil is measured and if SWP is below the threshold range than the valves are opened. The opening and closing of valve is dependent on the SWP of the soil. Figure 1 shows that the opening and closing of the valve is dependent on the SWP. The temperature, humidity and SWP are observed at different time and are mentioned in Table 1. The valves open when the value is below upper threshold value and valves close when it falls below the lower threshold value.

Figure 3 shows the comparison of temperature of air in atmosphere. Figure 4 shows that the temperature also has impact on opening and closing of the valves. When temperature increases the SWP of the soil decreases which results in openeing of valve.

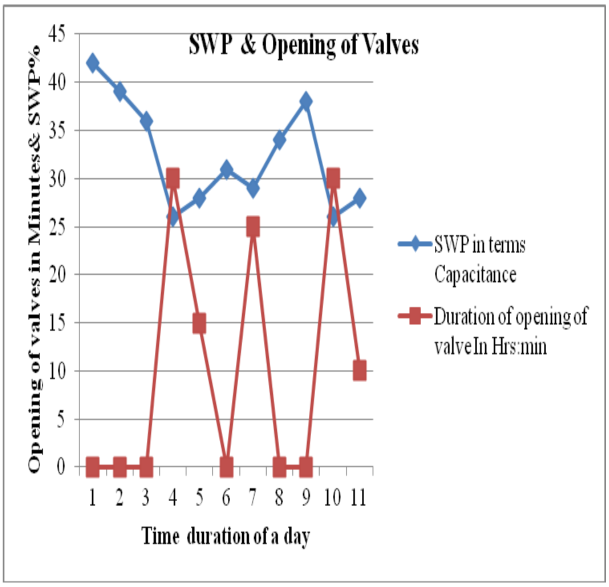

Figure 3. Graph for SWP and opening of valves

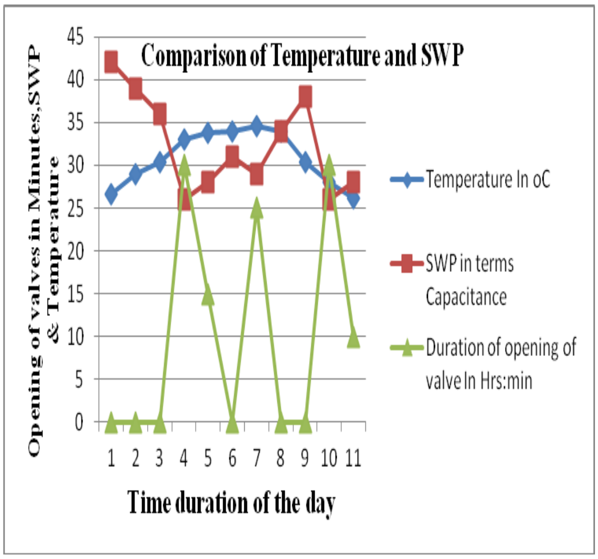

Figure 4. Comparison of temperature and SWP

The prototype is tested on different samples of soil. Each soil has different threshold value. The types of soil which are under observation are mentioned in Table 2. They are according to increasing percentage of water contents in them. All observation for SWP is done at the same time so that temperature and humidity of the atmosphere is same for all the soils under consideration. When the samples of different soil are tested then we have to set the threshold values manually. The value of SWP is mentioned in Table 2. Figure 5 indicates the condition of the valve whether it is open or close. Valves will open when SWP has value in-between higher and lower threshold value.

Table 2. Opening of valve for different soils

Type of Soil	SWP of Soil keeping Temperature and Humidity fixed	Opening of Valve in min (observing time 1 hrs)
Soil 1	34	0
Soil 2	30	15
Soil 3	28	26
Soil 4	25	38
Soil 5	14	46
Soil 6	9	0

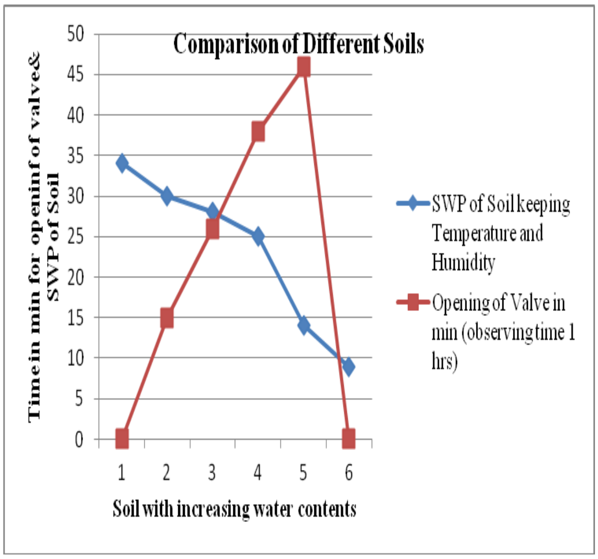

Figure 5. Comparison of different soils

It has been observed in Figure 5 that the time for opening of the valve increases as SWP decreases and suddenly falls to zero as SWP is below threshold value.

5. Conclusions

The commercially available drip irrigation system only consider the soil moisture content present in the soil neglecting the other environmental conditions or parameters. The prototype is developed to overcome the shortcomings of commercial drip irrigation control system considering the environmental conditions such as air temperature and humidity. This prototype is tested for different environmental conditions and different soils in the field area of 1m*1m. The prototype decides whether the soil moisture is adequate or inadequate, depending upon the conditions under consideration. The opening and closing of solenoid valves are controlled by microcontroller according to the SWP of the soil which is measured by soil moisture sensor. The solenoid valve closes when the SWP is adequate and opens when the SWP is inadequate. The test bed results that the developed prototype is efficient for drip irrigation. The drip irrigation is done automatically by setting the threshold values manually for different soil samples according to the desired conditions, which improves the productivity of yield with efficient use of water.

The developed product is a prototype to demonstrate the new concept. The future of the product can be enhanced by embedding it with wireless unit and all the data obtained is handled wirelessly. The sensors can be fabricated to get more précised results. The product can be made smaller and can be implemented on larger areas.

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