WATER IRRIGATION SYSTEM USING CONTROLLER

Chetna V. Maheshwari[1], Dipal Sindha[2]

[1]*Assistant Professor, Department of EC Engineering, GCET, V.V.Nagar (India)*

[2]*Department of EC Engineering, GCET, V.V.Nagar, Gujarat (India)*

ABSTRACT

In the present work, attempt has been made to design of a programmable logic controller based system to control an automatic irrigation system as a non human interface system. This paper presents the development of Programmable Logic Controllers (PLC) and their affordable price has made it possible to use them as stand-alone irrigation controllers. The purpose of this work is to develop self-governing irrigation systems that use a single climate criterion which then adapt the irrigation schedule to the observed conditions, leading to a reasonable saving in the amount of irrigation water. It must also be reliable and easily deployable in order to work under harsh outdoor conditions without the need for supervision or regular monitoring.

Keywords: PLC; Irrigation; Automation; Hargreaves; Irrigation Controller; Evapotranspiration.

I. INTRODUCTION

Water availability is a critical variable for virtually every economic activity, including agriculture and industry, the energy sector and public use. Municipalities waste thousands of cubic meters of purified water to maintain the parks and green areas in cities and towns[1,2]. Irrigation process has been converted as a complex process because of less manpower is available for low paid jobs like these and also time and over exploitation of energy made this problem as bulk[3,4]. With respect to the simpler types of irrigation controllers that involves specific run-times and days and sometimes the controller executes the same schedule regardless of the season or weather conditions. From time to time a technician may manually adjust the watering schedule, but such adjustments are usually only made a few times during the year, and are based upon the technicians [5,6]. Perceptions rather than actual watering needs. These changes to the watering schedule are typically insufficient to achieve efficient watering. So automation of irrigation system is needed to overtake these problems which apply water to the landscape based on the water requirements of the plants[7,8]. Many types of irrigation controllers have been developed for automatically controlling application of water to landscapes [9].

This paper work intends to develop a cost-effective irrigation controller that is adaptive to daily climate conditions, without the need for expensive sensors and costly weather-stations. Section 2 discusses the Particular problem of Irrigation system with simple controller. Section 3 talks about the materials and methods proposed for calculating parameters for the automation of irrigation system. The proposed system and proposed algorithm is also being discussed in the same section. Section 4 discusses results based on quality analysis. Section 5 provides the conclusion of the proposed process.

II. PROBLEM DEFINITION

In agriculture, industry, energy sector and public use water availability is becoming one of the most precious natural resources. New technique such as irrigation scheduling is available to predict the time and specific amounts of water required for crop irrigation at particular times can be derived using the soil-water plant relationship. Irrigation process has been converted as a complex process because of less manpower is available for low paid jobs like these and also time and over exploitation of energy made this problem as bulk. So automation of irrigation system is needed to overtake these problems.

The purpose of this work is to create an autonomous   irrigation systems that use a single climate criterion to adapt daily irrigation depths to plant needs. Criteria such as temperature, total radiation and total wind can be measured directly by PLCs which then adapt the irrigation schedule to the observed conditions, leading to a reasonable saving in the amount of irrigation water. Thus, this work intends to develop a cost-effective irrigation controller that is adaptive to daily climate conditions, without the need for expensive sensors and costly weather-stations.

III. MATERIALS AND METHODS

In this section we discuss the proposed algorithms. Here we have used different types of components for controlling amount of water for every weather- stations.

i) The Irrigation Controller

An irrigation controllers have additional features such as multiple programs to allow different watering frequencies for different types of plants, rain delay settings, input terminals for sensors such as rain and freeze sensors, soil moisture sensors, weather data, remote operation etc[12]. PLCs are "Programmable Logic Controllers" that are digital computers used for automation of electromechanical processes. They have a processor, some form of keyboard and screen, have analog /digital input ports and the capacity to command a number of electric devices through relays. Originally expensive and limited in capacity. The dramatic development of Programmable Logic Controllers, PLCs, and their rather affordable price has made it possible to use them as stand-alone irrigation controllers [11].

Basic parts of the PLC are as follows: Processor, Memory, Input/output devices, Programming panel and Power supply[9].Various industrial PLCs were studied, including the Siemens Micro Master, Ibercomp PLC IV, Allean Bradly and the Bipom MM-51.After careful consideration the Allean Bradly Micrologix 1400 controller was selected due to least expensive safety PLC. It provides EtherNet/IP, online editing and a built-in LCD, plus adding enhanced features, such as increased I/O, faster High Speed Counter/PTO and communication capabilities and its development is perceived by some as intuitive and easy to use [10].

ii) Irrigation Program

The PLC was programmed to carry out hourly temperature readings, and at the end of every 24h period, calculate the average, maximum and minimum temperatures [13]. With this information it calculates the ETo (Evapotranspiration). The flow chart is like following.

- Read day of the year and crop growth stage
- Read thermister voltage
- Calculate temperature
- Manage time of the day and number of measurements still needed
- Wait until next temperature measurement
- Calculate average, maximum and minimum temperatures
- If it is irrigation time Calculate ETo
- Carry out irrigation in different sectors.
- Continue making hourly temperature measurements

ii) System Description
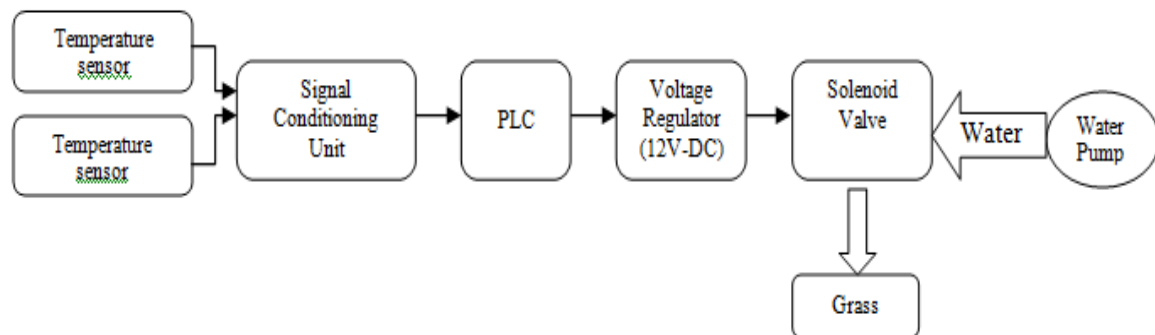The irrigation control system which is based on PLC is shown in Below figure 1.

Figure 1. Block Diagram of PLC Based Irrigation Control System

1) Temperature Sensor
Here we can use a pyranometer or a thermocouple or a thermistor to measure the air temperature.

i) Pyranometer
A pyranometer as shown in figure 2(a) is a solar radiation sensor that can be applied in scientific grade solar radiation observations. It is a temperature measuring device but unlike RTDs and thermocouples it's not in contact with the surface. It could be optical or radiation pyranometer.

ii) Thermocouple
A thermocouple as in figure 2(b) consists of two conductors of different materials (usually metal alloys) that produce a voltage in the vicinity of the point where the two conductors are in contact. Thermocouples are a widely used type of temperature senor for measurement and control and can also be used to convert a temperature gradient into electricity.
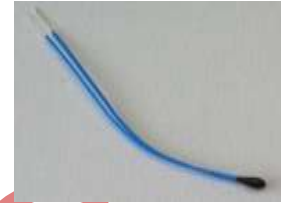
iii)Thermistor

A thermistor as in figure 2(c) is a specialized resistor, intentionally designed to be thermally sensitive and its primary characteristic is its ability to alter its electrical resistance in response to changes in case temperature. In this ,we use a 1k thermister with a 1% accuracy to measure the air temperature. It was connected in half duplex to an analog I/O port, using a 1k resistance.

A)Pyranometer   (B) Thermocouple   (C) Thermistor

Figure 2. Types of Temperature sensors.

These results indicate that the (tmax –tmin) component of the Hargreaves-Samani equation increases with height, and thus it calculates higher values of *ETo*. The thermister was placed in a ventilated box, so that the readings were not influenced by sunshine or by the crop transpiration which usually decreases air temperature.

2) Water pump

A water pump (being represented by dc motor) was a device used to move or pulls water out of a well or a pond and displaces it volume by physical or mechanical action as shown in figure 3. It is most considered as the heart of irrigation system. Before selecting an irrigation pump, a careful and complete inventory of the conditions under which the pump will operated was considered.

Figure. 3 A Water pump

3) Solenoid Valve

The irrigation system was managed by a solenoid valve connected to one of the relays. This arrangement allowed the controller to command the irrigation events without the need for supervision. Solenoid valves as shown in figure 4(a), may use metal seals or rubber seals, and may also have electrical interfaces to opened (normally open) or closed (normally closed) while the valve is not activated as in figure 4(b) & (c).
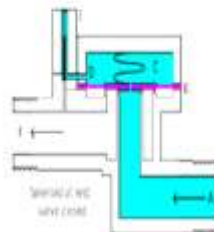
Solenoid :-

Controls the flow of fluid through a pipe line by the compared action of the plunger along with the magnetic force created by the coil. The solenoid converts electrical energy into mechanical energy which, in turn, opens or closes the valve mechanically.
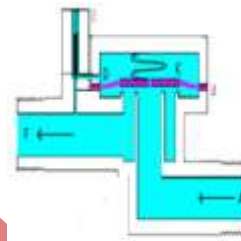
Valve:-

The valve is controlled by an electric current through a solenoid. In the case of a two-port valve the flow is switched on or off; in the case of a three-port valve, the outflow is switched between the two outlet ports.Most solenoid valves operate on a digital principle. They therefore possess two distinct states, which are (1)when the coil is activated by an electrical current, and (2) when the valve is resting (without electricity). Valve functions are defined from the resting position. The direct acting or pilot operated solenoid valves may have two functions, Normally closed (NC) & Normally Open (NO) as shown in figure 4(b) & (c).

(a)Solenoid Valve   **(b) Normally closed (NC)**   **(c) Normally Open (NO)**

Figure 4. Solenoid Valve & its Function
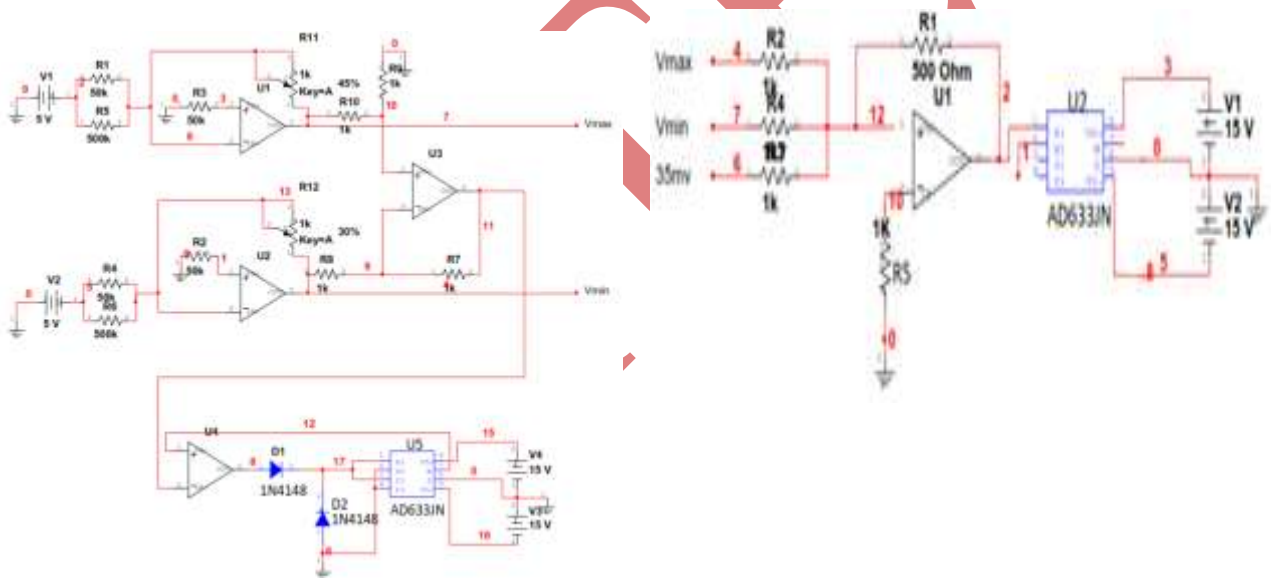
4)   Signal Conditioning Unit

Figure 5. Signal Conditioning Unit

4) PLC(Programmable Logic Controller)

In this research work we have used MicroLogix 1400 Controllers having following specification mention in Table 1.

Table-1 General   Specifications

Specification	1766 Controllers
Operating Temperature	-20…60 °C (-4…140 °F)
Non operating Temperature	-40…85 °C (-40…185 °F)
Relative Humidity	5…95% non condensing
Vibration	3 g at 10... 500 Hz
Operating Shock	30 g
Non operating Shock	Panel mount: 50 g, DIN mount: 40 g
Certifications★	UL Listed Industrial Control Equipment for use in Class 1, Division 2, Hazardous Locations, Groups A, B, C, D

5) Ladder Logic

5.1 Ladder Logic Inputs

PLC inputs are easily represented in ladder logic. There are three types of inputs ,first two are normally open and normally closed inputs, discussed previously. The *IIT* (Immediate Input) function allows inputs to be read after the input scan, while the ladder logic is being scanned. Normally open, an active input x will close the contact and allow power to flow and closed, power flows when the input x is not open as in below figure 6. IIT X immediate inputs will take current values, not those from the previous input scan.
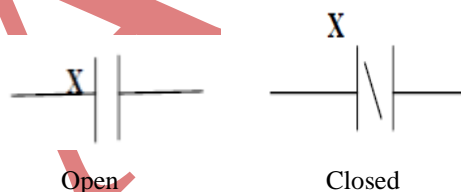

Open   Closed

Figure.6 Ladder Logic Inputs

5.2 Ladder Logic Outputs

In ladder logic there are multiple types of outputs, but these are not consistently available on all PLCs. The first is a normal output, when energized the output will turn on, and energize an output. The circle with a diagonal line through is a normally on output. When energized the output will turn off. When power is applied (on) the output x is activated for the left output, but turned off for the output on the right.

An input transition on will cause the output x to go on for one scan (this is also known as a one shot relay).

When the L coil is energized, x will be toggled on, it will stay on until the U coil is energized. This is like a flip-flop and stays set even when the PLC is turned off.

Some PLCs will allow immediate outputs that do not wait for the program scan to end before setting an output.

Figure .7 Logic Outputs

A ladder diagram in figure 8 consists of a downward line on the left side with lines branching to the right. Existing line on the left side is called the bus bar, whereas the branching lines are lines of instructions or steps. Instructions are placed along the line of a variety of conditions linked to the other instructions on the right side. Logic combination of the conditions stated when and how the existing instructions on the right side is done.
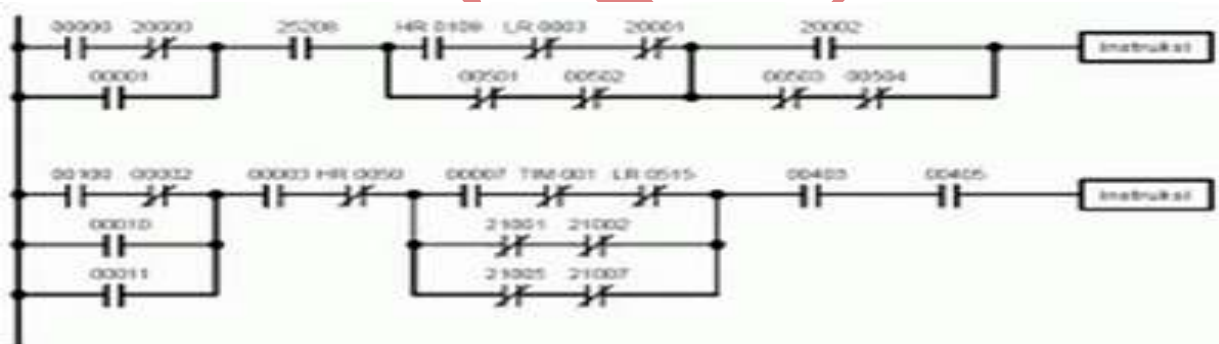

Figure.8   Example of ladder diagram

6) SCADA SYSTEM

Supervisory control and data acquisition (SCADA) systems means different things to different people, depending on their backgrounds and perspectives .It is vital component of most nations' critical infrastructures. They control pipelines, water and transportation systems, utilities, refineries, chemical plants, a wide variety of manufacturing operations, we have work on the application of this system in irrigation for the first time in the Gaza Strip in particular and Palestine in general. SCADA provides management with real-time data on production operations, implements more efficient control paradigms, improves plant and personnel safety, and reduces costs of operation. SCADA is the technology that enables a user to collect data from one or more distant facilities and/or send limited control instructions to those facilities. Or A system operating with coded signals over communication channels so as to provide control of RTU (Remote Terminal Unit) equipment. some of the typical SCADA software components are listed below :

• **SCADA master/client :**

   ---Human Machine Interface(HMI).

   ---Alarm handling.

   ---Event and log monitoring.

   ---Special applications.

   ---ActiveX controls.

• **SCADA slave/data server**

   --Real-time system manager.

   --Data processing applications.

   --Report generator.

   --Alarm handling.

   --Drivers and interfaces to control components .

   --Charting and trending.

   --Typical SCADA system architecture

   --Spreadsheet.

   --Data logging.

IV   RESULT   DISCUSSION

In this research work we have used Micro Logix 1400 Controllers. we have programmed this controller so that it controls the opening and closing of the main valve and zonal valve of the irrigation system. As a result of this programming we received the following type of condition of the valves as in below figure 9(a),(b) & (c) for the main pump, master valve and zonal valve respectively.
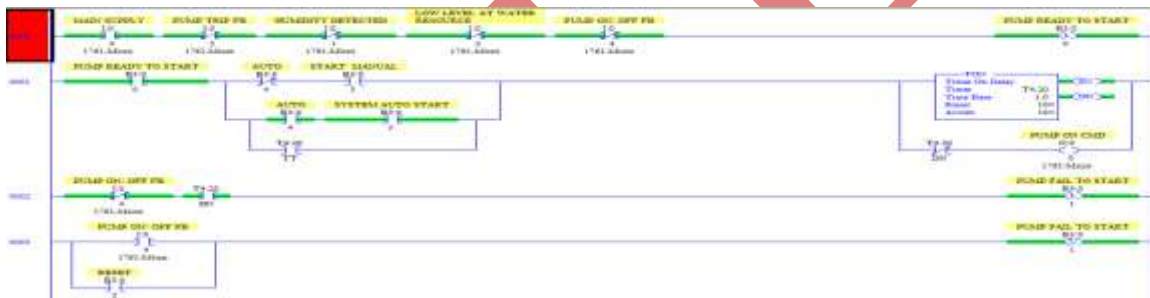
(a) Main Pump
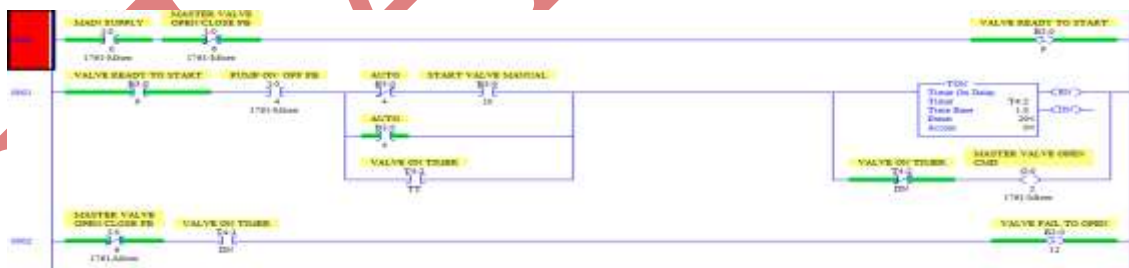
(b) Master Valve
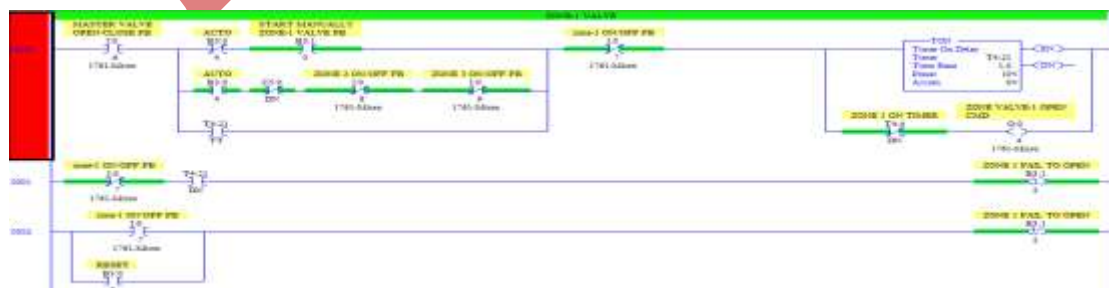
(c) Zonal Valve

Figure 9 Valve control condition

We have also implement this irrigation system using SCADA system .This system clearly shows the condition of each valve and also all pipeline as shown in below figure 10.
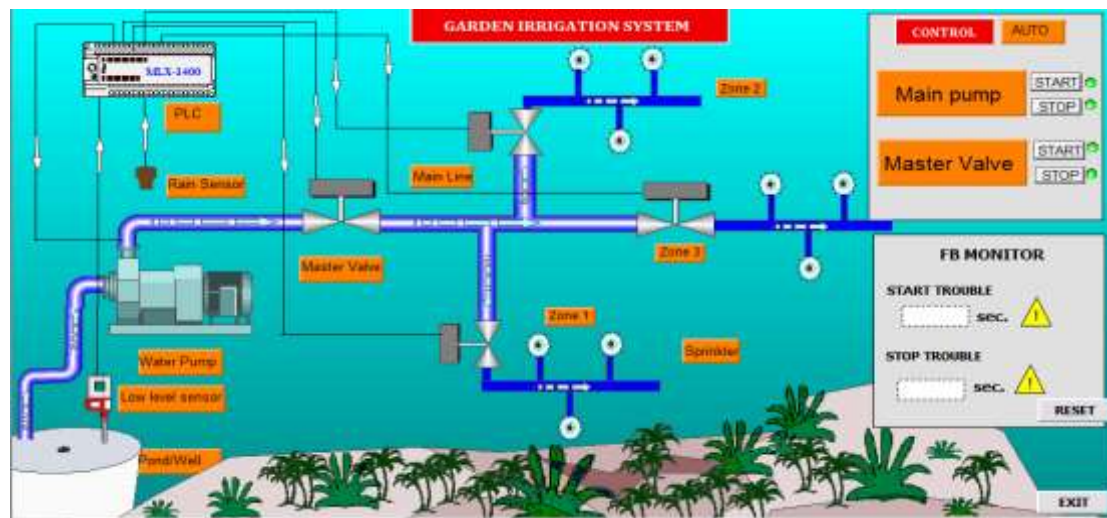

Figure 10 System Using SCADA

V   CONCLUSION

From this system we can clearly define the advantage of this irrigation system based on PLC that it is very flexible as only one single Programmable Logic Controller can easily run many machines. Correcting errors in PLC is extremely short and cost effective. Programmable Logic Control memory is getting bigger and bigger this means that we can generate more and more contacts, coils, timers, sequencers, counters and so on. We can have thousands of contact timers and counters in a single PLC. The program can be tested, validated and corrected saving very valuable time. Prices of Programmable Logic Controllers vary from few hundreds to few thousands. When running a PLC program a visual operation can be seen on the screen. Hence troubleshooting a circuit is really quick, easy and simple.

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