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Research Paper

AUTOMATIC IRRIGATION SYSTEM USING PROGRAMMABLE LOGIC CONTROLLER

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This paper presents a design of a programmable logic controller based system to control an automatic irrigation system. The system is composed of three modules: the programmable logic circuits, sensor system and the SCADA monitoring. The irrigation system composes of three samples, simulating three different agriculture fields. The Humidity of each field is different from that of other fields according to the requirement of different plantation. It is controlled by two sensors for minimum and maximum humidity respectively. Each sample is irrigated by a separate valve. The valves are controlled by the PLC. If the maximum humidity is reached, the PLC turns off the concerned valve feeding the concerned sample. When all samples have reached their respective maximum humidity, the PLC turns off the main pump. The system has been designed, built and tested successfully. This project is proposed to overcome difficulties faced by the farmers in gaining more profit by increasing the productivity and reducing the consumption of water and electricity by using a renewable source of energy. Farmers will be able to monitor and control the irrigation system from one place with the help of software called SCADA (supervisory control and data acquisition) which does the controlling action through PLC (Programmable Logic Controller).

Keywords: SCADA, Programmable logic controller, Data register, Master Terminal Unit (MTU), Human Machine Interface (HMI)

INTRODUCTION

In recent years, global water problems are attracting increasing attention. India is a big agricultural country with a serious water shortage. At present, 70% of India's total annual water consumption, about 550 billion cubic meters, is agricultural water, of which 90% is irrigation water. On one hand, India's agricultural irrigation water shortage is about 300 billion cubic meters, and an average annual the drought stricken area is about 300 million mus. These are led to reduce food production from 15 billion to 30 billion kilograms. On the other hand, due to the backward irrigation technology, the Indian effective utilization ratio of irrigation water is

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only 40%, only about half of the developed. Grain production capacity is only about 0.87 kilograms per cubic meter, much lower than the developed for more than 2 kilograms. If the utilization ratio of irrigation water increases form 10% to 15%, savings of water per year are about 60 billion to 80 billion cubic meters. Therefore, development of water-saving irrigation technology is urgently needed.

Nowadays, with the increasingly shortage of the water resources, promote water-saving irrigation has become the inevitable choice to ease the water crisis. Meeting the crop water demand is the trend of current water-saving agriculture. The irrigation is PLC based, using sensing technology to collect the soil information, and achieved intelligent control by control engineering algorithms. Indian research in water saving irrigation is not much compared with the developed. A lot of irrigation in rural areas was operated by the artificial, even the same in the greenhouse cultivation. Against the situation of India, we has developed PLC based intelligent water-saving irrigation device (a patented product). The product has been preliminarily completed the industrial transformation.

The main parts of the irrigation device are a battery, sensors (electric probes), Programmable logic controller (Omron CP1E), solenoid valves, and etc. It controls the electromagnetic valve with low-power technologies to open by using electronic circuits.

The use of this controller in the field Without commercial power and routing, micro-power valve's opening or closing can be achieved by an integrate technology of solar power, Nano-materials, electro-hydraulic drive technology, and, etc. This intelligent water-saving irrigation can be implemented according to the plant's needs by the sensing unit detecting soil moisture. Here the sensing unit acts as a conducting switch, when the water reaches both the probes the circuit conducts and this is detected by PLC and output is given the respective solenoid valve supplies water to that particular sensing unit.

The controlling unit is a Programmable logic controller (OMRON-CP1E), which is a typical controller that requires CX-programmer CP1E software for downloading program into the controller and OMRON HOST LINK is the I\O driver that is used to communicate the controller with the SCADA.

Supervisory Control and Data Acquisition (SCADA) is the remote monitoring and control unit that helps the user to monitor as well as control the irrigation system through Personal Computer from a stationary area. It communicates with PLC with the help of the I\O driver named OMRON HOST LINK. The communication takes place via the access name that was given in the SCADA and the configure setting in the OMRON HOST LINK driver. Both the name should be similar.

BASIC OPERATION OF A PLC

The figure shows the basic operation cycle of a PLC. All PLCs have four basic stages of operations that are repeated many times per second. Initially when turned on the first time it will check its own hardware and software for faults. If there are no problems it will copy all the input and copy their values into memory, this is called the input scan. Using only the memory copy of the inputs the ladder logic program will be solved once, this is called the logic scan. While solving the ladder logic the output values are only changed in temporary memory. When the ladder scan is done the outputs will be updated using the temporary values in memory, this is called the output scan. The PLC now restarts the process by starting a self check for faults. This process typically repeats 10 to 100 times per second. That is the PLC does

- Self test
- Input scan
- Logic solve
- Output scan

Self Test

Checks to see if all cards error free, reset watch-dog timer, etc. (A watchdog timer will cause an error, and shut down the PLC if not reset within a short period of time this would indicate that the ladder logic is not being scanned normally).

Input Scan

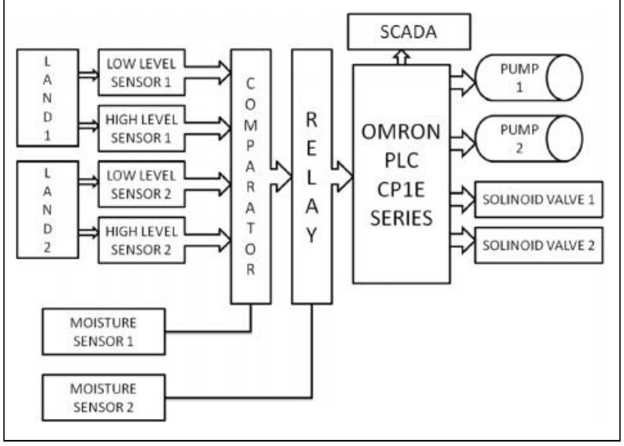
Reads input values from the chips in the input cards, and copies their values to memory. This makes the PLC operation faster, and avoids cases where an input changes from the start to the end of the program (e.g., an emergency stop). There are special PLC functions that read the inputs directly, and avoid the input tables. LOGIC SOLVE/SCAN - Based on the input table in memory, the program is executed 1 step at a time, and outputs are updated. This is the focus of the later sections.

Ooutput Scan

The output table is copied from memory to the output chips. These chips then drive the output devices. Input scan takes a snapshot of the inputs, and solves the logic. This prevents potential problems that might occur if an input that is used in multiple places in the ladder logic program changed while half way through a ladder scans. Thus changing the behaviors of half of the ladder logic program. This problem could have severe effects on complex programs that are developed later in the book.

One side effect of the input scan is that if a change in input is too short in duration, it might fall between input scans and be missed. When the PLC is initially turned on the normal outputs will be turned off. This does not affect the values of the inputs.

Figure 1: Block Diagram



OMRON-CP1E

In this project PLC is used to control the process, SCADA to monitor the process and moisture sensors ensure optimum usage of water for irrigation. Since renewable resources of energies are not dependable in these days, we implemented solar energy for producing power supply for our system.

The PLC we used in our system is OMRON-CP1E. OMRON PLC-based Process Control system is based on the SYSMAC CS/CJ PLC

Figure 2: Model of OMRAN PLC-CP1E

Series. By adding PLC-based Process Control units to the basic system configuration, PLC process control functions can be simply added on to the basic functions already installed in the PLC. Thus it can be used for devices that it is compatible with such process control system in which was used before or devices in which several controllers were used combined. With the PLC Installation System, analog processing is carried out by the loop control section or the loop control unit/board (hereafter "loop controller"), and ladder processing is handled by the CPU. Communication between the two sections is made using bits of memory. Since the analog processing and ladder processing can be completely separated and the program is simpler than a ladder only program, the engineering process to construct the system is facilitated. The PLC Unit utilizes a variety of different data including user programs, I/O Memory data and comments, CPU Unit and Special I/O units, Parameters and Registered I/O Table information etc. All of this data that is used by the PLC is stored in the memory area within the CPU unit.

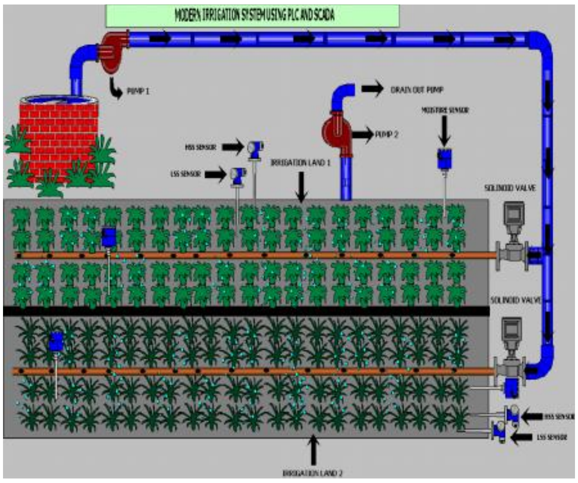
The I/O memory area is accessed by command operands. It records information such as the CIO, Internal I/O Area, holding area, auxiliary area, DM Area, EM Area, Timer Completion Flags/Present Value, Completion Flag/Present Value, Task Flags, Index Register, Data Register, Condition Flags, Clock Pulse, etc. The data in the I/O Memory Area locates in or is in areas in which the contents are cleared every time the power is turned back on, and areas in which prior information is retained. (In some areas you can select whether to clear or retain).

The parameter area contains all of the information regarding initial parameters used by the PLC. It records information such as the PLC System Parameters, Registered I/O Table, Routing Table, and PLC Setup for CPU Bus unit.

SCADA SYSTEM ARCHITECTURE

Specific terminology is associated with the components of SCADA systems. These SCADA elements are defined as follows:

Figure 3: SCADA Simulation



Operator

Human Operator Who Monitors the SCADA System and Performs Supervisory control functions for the remote plant operation.

Human Machine Interface (HMI)

Presents data to the operator and provides for Control inputs in a variety of formats, including graphics, schematics, windows, pull down menus, touch-screens, and so on.

Master Terminal Unit (MTU)

Equivalent to a master unit in a master/slave architecture. The MTU presents data to the operator through the HMI, gathers data from the distant site, and transmits control signals to the remote site. The transmission rate of data between the MTU and the remote site is relatively low and the control method is usually open loop because of possible time delays or data flow interruptions communication method between the MTU and remote controllers. Communication can be through the Internet, wireless or wired networks, or the switched public telephone network.

Remote Terminal Unit (RTU)

Functions as a slave in the master/slave architecture. Sends control signals to the device under control, acquires data from these devices, and transmits the data to the MTU. An RTU may be a PLC. The data rate between the RTU and controlled device is relatively high and the control method is usually closed loop. As discussed previously, a SCADA architecture comprises two levels: a master or client level at the supervisory control center and a slave or data server level that interacts with the processes under control. In addition to the hardware, the software components of the SCADA architecture are important.

Moisture Sensors

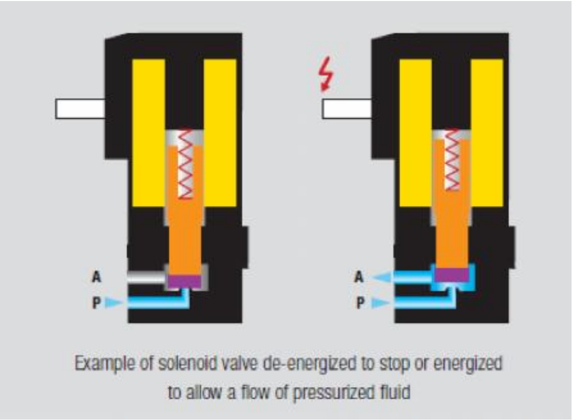
It helps us to detect the soil moisture so that to ensure the optimum usage of water. Type of irrigation used here is drip irrigation. Moisture sensors are immersed in different part of the field so that it will continuously monitor the water content of the soil. The output from the moisture sensor is compared with the set point and accordingly water to that area is either limited or provided.

In our proposed system, a moisture parameter is pre set and the output from the moisture sensor is detected and the water required is given to the area. Since we are using drip irrigation, solenoid valves are used at the start point of water pipe.If the output given by the moisture sensor in a particular area is lesser than the set point parameter then plc gives signal to the solenoid valve of that particular area and its open, if its vice versa valve will be closed or the flow will be controlled. Effective use of SCADA in our system reduces manpower and tiresome in farming job. With help of SCADA one can monitor and control the whole irrigation land from a control room.

The valves used here is the solenoid valve. The specifications of the valves are given below.

- Source needed: 24 v dc.
- Terminals: Two terminals
- I/O: Water in, and Water out
- Description: The input valve will allow the input water to pass through it when a signal is applied to its terminals. After the signal is disconnected, the valve will return to its normal operation (prevent water to pass).

Figure 4: Solenoid Valves



We needed five valves in this model: One is major to guarantee that the pump works only when the water level in the tank is suitable that we maintain the pump, and increase its hypothetical age. There are further four secondary valves distributed on the agricultural areas for the favor of control on the irrigation process though opening, and closing those valves according to the soil's need to water.

ULN2803-RELAY DRIVER

A ULN2803 is an Integrated Circuit (IC) chip with a High Voltage/High Current Darlington

Figure 5: ULN2803 Relay Driver

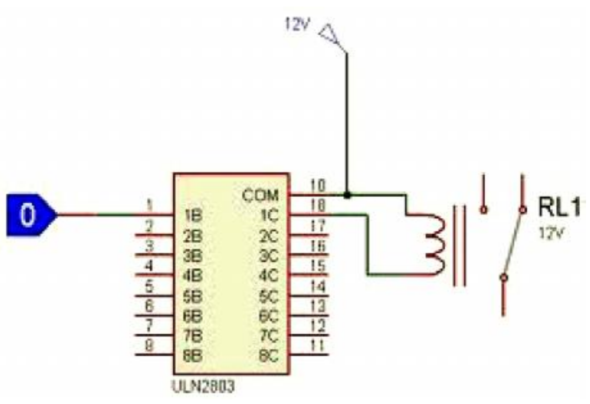
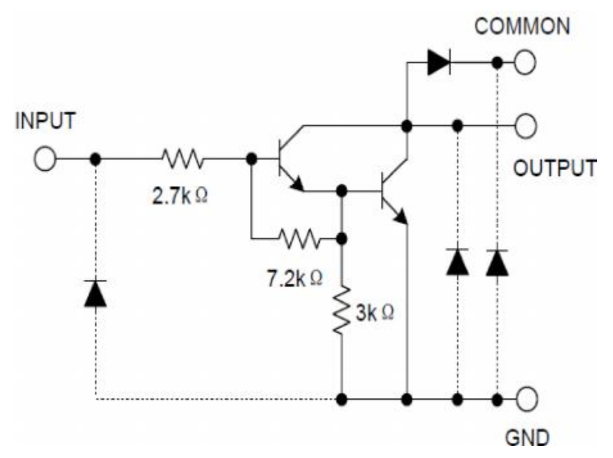


Figure 5: Schematic Diagram of Driver



Transistor Array. It allows you to interface TTL signals with higher voltage/current loads. In English, the chip takes low level signals (TLL, CMOS, PMOS, NMOS—which operate at low voltages and low currents) and acts as a relay of sorts itself, switching on or off a higher level signal on the opposite side.

A TTL signal operates from 0-5 V, with everything between 0.0 and 0.8V considered "low" or off, and 2.2 to 5.0 V being considered "high" or on. The maximum power available on a TTL signal depends on the type, but generally does not exceed 25 mW (~5 mA @ 5 V), so it is not useful for providing power to something like a relay coil. Computers and other electronic devices frequently generate TTL signals. On the output side the ULN2803 is generally rated at 50V/500mA, so it can operate small loads directly. Alternatively, it is frequently used to power the coil of one or more relays, which in turn allow even higher voltages/currents to be controlled by the low level signal. In electrical terms, the ULN2803 uses the low level (TTL) signal to switch on/turn off the higher voltage/current signal on the output side.

Figure 6: ULN2803 IC

The ULN2803 comes in an 18-pin IC configuration and includes eight (8) transistors. Pins 1-8 receive the low level signals; pin 9 is grounded (for the low level signal reference). Pin 10 is the common on the high side and would generally be connected to the positive of the voltage you are applying to the relay coil. Pins 11-18 are the outputs (Pin 1 drives Pin 18, Pin 2 drives 17, etc.).

CONCLUSION:

In the near future resources like water and electricity will be vanished unless or until we use renewable energy and the modern technology to save water and increase the productivity of food. This project has a tremendous scope for future in saving water and electricity.

PLC and SCADA are the latest technologies that have to be implemented in application like industrial automation, robotics, power plants, and agricultural irrigation. The person can monitor and control the irrigation system through personal computer with the help of supervisory control and data acquisition unit.

Future enhancement of the project is to replace personal computer by mobile phone. Developing an android application like SCADA which will communication through internet or GSM. This will facilitate the farmer to control the irrigation system from anywhere by monitoring.

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