Automated Irrigation using PLC Programming

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ABSTRACT

India is an Agrarian country where 60% of its people directly or indirectly depend on Agriculture as a source of income. With recent technological advancements along with factors such as shortage of labour, water scarcity, higher demand for efficient farming from a limited piece of land etc. the need for automated solutions for repetitive tasks has increased in the field of agriculture. As water has become an even more precious resource in the recent years, proper storage and optimum distribution is a key for a well planned crop cycle. Also, crops which are sensitive to even the smallest of the weather changes require special attention. In cases like these high precision based automated control becomes even more relevant. Programmable Logic Controllers (PLC) have been in use since the 1970s. They have undergone tremendous upgradation. Also the affordability of these Programmable Logic Controllers has increased due to a huge market competition in this field. Therefore, using the reliability and the flexibility of the PLC systems for a relevant problem like lack of necessary resources for farming, is very important. In this paper we have explained the process in which we studied PLC programming software and then implemented a programme demonstrating an Automated Irrigation process. A Visualisation or a Human Machine Interface (HMI) is also made. Through this HMI a person can control and monitor the entire process from just one location. This paper defines a simple automated irrigation system design for water level and flow control using moisture sensor, float level sensor, solenoid valve etc.

Keywords: Automated Irrigation, PLC, HMI. etc.

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1. Introduction

Agriculture is the backbone of Indian economy. India ranks 2nd in farm output on a worldwide scale. With advancements in technology, the economic contribution of agriculture is falling, but it employs more people than any other sector in India. India exported $39 billion worth of agricultural products in 2013, making it the seventh largest agricultural exporter worldwide and the sixth largest net exporter. The irregularity in rainfall pattern and uneven availability of groundwater resources are the main issues faced.

"Slow agricultural growth is a concern for policymakers as some two-thirds of India's people depend on rural employment for a living. Current agricultural practices are neither economically nor environmentally sustainable and India's yields for many agricultural commodities are low. Poorly maintained irrigation systems and almost universal lack of good extension services are among the factors responsible. Farmers' access to markets is hampered by poor roads, rudimentary market infrastructure, and excessive regulation."

— World Bank: "India Country Overview 2008"[5]

The major reasons for the need of a system like this are:

- India is a predominantly agricultural country with 2/3rd of the people engaged in agriculture in one way or the other.
- In the recent years , with unpredictable monsoon and prevailing drought, agriculture community is the worst victim of the conditions.
- Rapid Urbanization has led to an increase in the burden on a limited area of farming.
- A system like this can help in increasing the output from a piece of land.
- This will replace the repetitive tasks and will be convenient for the farmer.

Programmable Logic Controllers are controllers which offer high reliability, convenient programming and quick fault detection. They were conceived for use in the automation of the automobile industry to replace hard wired relays. They are rugged and are suitable for a wide range of harsh environment. Programmable Logic Controllers are modular. Hence they can be used for a handful of inputs and outputs (I/Os) or they can be scaled up to a thousand I/Os due to their modular nature.

Nowadays, PLCs are programmed using proprietary softwares by the same PLC manufacturers. These softwares are installed on the personal computers (PC) and are connected to the PLC through a Ethernet cable. The programming softwares and languages are based on the IEC61131–3 standards[6]. The most predominantly used languages for PLC programming are:

- Ladder Diagram (LD)
- Structured Text (ST)
- Function Block Diagram (FBD)

2. PROBLEM DEFINITION

In India, agriculture is dependant on rainfall, but the rainfall patterns are getting irregular. Also groundwater table is not consistent. In times like these water storage and water saving techniques have become very relevant. Manual Irrigation is mainly based on the past experience of the farmer/worker. But these methods of manually controlled Irrigation have some obvious limitations. Delayed water supply, lack of precise water distribution based on the exact need of crops, adequate water storage etc. are some of the main issues faced.
In this System design, a prototype is designed to demonstrate the real life application.

3. SYSTEM DESIGN

The System Design consists of the following components:

- Submersible Pump
- Float Level Switches
- Solenoid Valve
- Moisture Sensor

A schematic diagram for the System Design is shown below,

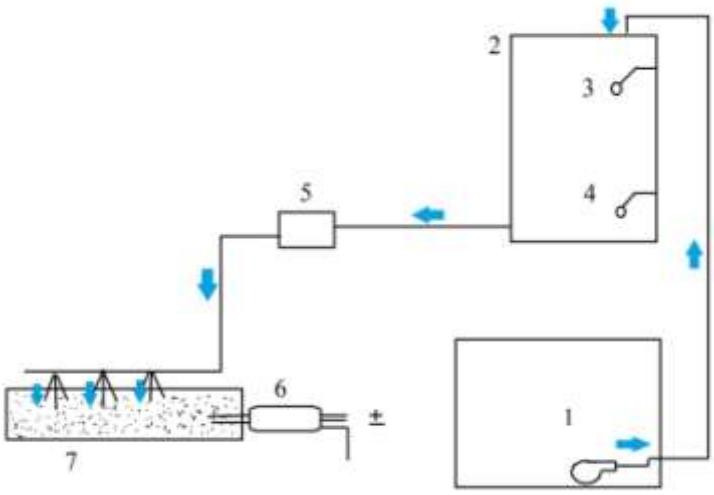

Fig-1 Schematic System Design of the Prototype
[Labels: (1)Sump tank with Submersible Pump; (2)Overhead Tank; (3)Float Level High; (4)Float Level Low; (5)Solenoid Valve; (6))Moisture Sensor; (7)Soil sample]

Two parts which are concentrated upon, while implementing the automated irrigation process are:

1. Water Level Control.
2. Water Flow Control.

3.1. WATER LEVEL CONTROL

In this part following components are used

1. Submersible Pump (240 V AC)
2. Float level Switches (one each to show the high and the low level status)

The submersible pump and the Float levels are connected to the PLC. The submersible pump is switched ON when the overhead tank is dry. The cycle of filling the tank goes on automatically in case of a continuous water supply. Otherwise a manual soft button is provided on the HMI screen to start/stop the pump as per user's convenience.

Fig-2 Magnetic Float Level Switch

The PLC programme for this part is shown below in Fig-3

Fig-3 Ladder Diagram PLC Programme for Water Level Control

This programme has 2 Digital Inputs [DI] and one Digital Output [DO]
Variables used in this program are

1. blevellow- Boolean Level Low (NC contact) [DI]
2. blevelhigh- Boolean Level Low (NC contact) [DI]
3. bpump- Boolean Pump (coil and it is used for latching as an NO contact) [DO]

3.2. WATER FLOW CONTROL

In this part following components are used

1. Moisture Sensor (5V)
2. Solenoid Valve (24V DC)

The moisture sensor and the solenoid valve is connected to the PLC. The moisture sensor requires a 5V supply. Its output voltage is based on the conductivity of the soil, which in turn is directly dependant on the wetness of soil. This output voltage for the Dry soil state to completely Wet soil state, ranges in between 0.95 V - 3.35 V. These voltage values are converted into Integer values inside the PLC. The Switching ON/OFF of the solenoid valve is thus, dependant on the moisture values of the soil.

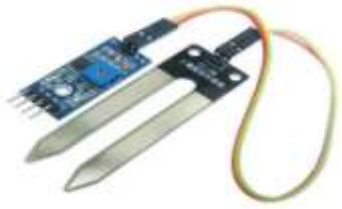

Fig-4 Moisture Sensor

The PLC programme for this part is shown below in Fig-5

```
IF
    (amoisturesensor <= 3000 AND amoisturesensor > 2700)

    THEN
    bsolenoidvalve:=0;
ELSIF
    (amoisturesensor > 3000 AND amoisturesensor < 5300)
    THEN

        bsolenoidvalve:=1;
    END_IF
```

Fig-5 Structured Text PLC Programme for Water Flow Control

This programme has 1 Analog Input [AI]and 1 Digital output [DO]
Variables used in this programme are

1. amoisturesensor- Analog Moisture Sensor (Integer values) [AI]
2. bsolenoidvalve- Boolean Solenoid Valve [DO]

4. HUMAN MACHINE INTERFACE (HMI) / VISUALISATION

HMI or Visualisation is used to control and monitor the status of the process remotely from one place. Three screens are designed which can be navigated through the buttons for screen change.

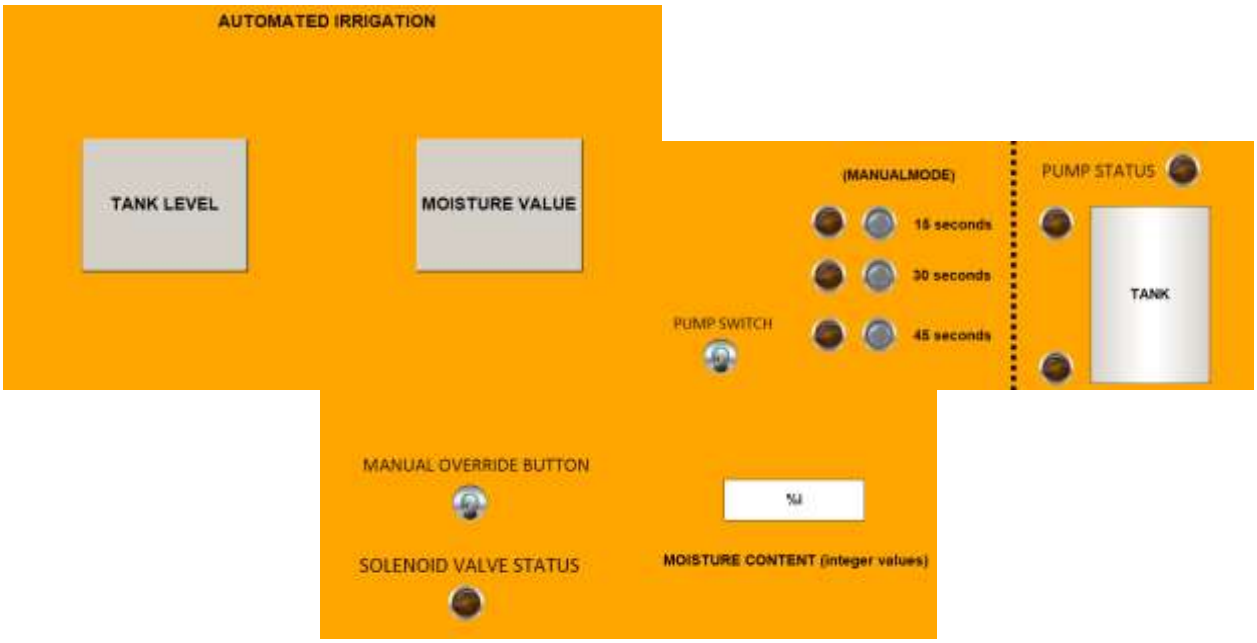

Fig-6 Visualisation Screens

The Visualisation/ HMI consists of the following screens:

1. Home screen
2. Water Tank Level Monitor.
3. Moisture Level Monitor.

This makes it very simple and easy for the user to have control over the process. Also fault detection in the process can be detected.

5. CONCLUSION

Thus, this prototype proves that one PLC can be used to control the mentioned processes. As the PLCs are Flexible and Modular, the number of I/Os can be increased as per requirement. Also, the Monitoring and Fault detection process becomes easier due to the Visualisation/HMI screens. The successful execution of the PLC programme using the prototype is a proof of concept for real life application of Automated Irrigation using PLC programming.

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