DESIGN AND DEVELOPMENT OF PROGRAMMABLE-PI CONTROLLER FOR AUTOMATION

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Abstract - *This project indicates the design and development of programmable pi controller for automation using Raspberry Pi as the main processor to perform some specific operations. Arduino allows interfacing of both analog and digital signals hence it acts as controller for input and output module. Input module allows interfacing of sensors, switches, push button. Output module allows interfacing of different types of loads such as motors, indicators, alarms etc. Open PLC software is used for programming and this program is uploaded to raspberry pi via webserver through IP-address. This entire operation is supervised via SCADA using Modbus/TCP protocol with help of SCADA software called as SCADA LAQUIS. This is an alternative system for PLC as it reduces the cost of overall system used for automation and increases the flexibility and efficiency.*

Key Words: *SCADA, PLC, TCP/IP and Raspberry pi*

1.INTRODUCTION

In early 60's, the Industrial Automation was composed of electromechanical parts like relays, cam timers and drum sequencers. They were interconnected in electrical circuits to perform the logical control of a machine. To change a machine logic was to make an intervention on its electrical circuit, which was a long and complicated process.

In 1968, the Hydra-matic of General Motors requested proposals for an electronic replacement for hard-wired relay systems. The winning proposal came from Bedford Associates with their 084 project. The 084 was a digital controller made to be tolerant to plant floor conditions, and was latter known as a Programmable Logic Controller, or simply PLC. Within a few years, the PLC started to spread all over the automotive industry, replacing relay logic machines as an easier and cheaper solution, and becoming a standard for industrial automation. There is a strict relation between automation and development. In less developed countries, the greatest barriers are knowledge and cost. Industrial controllers are still very expensive. Companies don't provide detailed information about how these controllers work internally as they are all closed source.

A programmable logic controller (PLC), or programmable controller is an industrial digital computer which has been ruggedized and adapted for the control of manufacturing processes, such as assembly lines, robotic devices, or any activity that requires high reliability control and ease of programming and process fault diagnosis. They were first developed in the automobile industry to provide flexible, ruggedized and easily programmable controllers to replace hard-wired relays, timers and sequencers. Since then they have been widely adopted as high-reliability automation controllers suitable for harsh environments. A PLC is an example of a "hard" real-time system since output results must be produced in response to input conditions within a limited time, otherwise unintended operation will result.

In industries, PLCs are widely used for automation and controller purpose. The available PLCs are powerful but they are having high cost. As the technologies have developed microprocessors are replaced by microcontrollers in most of the areas. Inspiring from these revolutions, presenting here an idea of micro-controller-based PLC alternative solution for automation. The automation is used to reduce the need for human work and it saves the time. Many industries prefer automation to avoid the labour unavailability problem. The labours require corresponding industrial training. So that most of the valuable time is wasted as well as labour charges also. Therefore, industries started automation.

1.1 OBJECTIVE

To create alternate system for PLC using Raspberry pi as a controller mainly targeting the small-scale industrial automation. This alternate system for PLC reduces the cost of overall machine and increases the flexibility.

1.2 PROBLEM WITH EXISTING SYSTEM

Major problem with the industrial type PLC is its cost because of which it cannot be easily implemented in small-scale industries hence, the small-scale industries cannot compete with the large-scale industries even though they have capability to produce the products that have equal quality to that of products produced in large scale industry.

1.3 PROBLEM DEFINITION

Now a day's automation of industry involves PLCs but these PLCs are very much costly because of their high cost it is not possible to use these PLCs in small scale industries where only a smaller number of tasks are going to automated. Therefore, they do not prefer the automation in their small-scale industries which leaves them behind from competition.

1.4 SOLUTION FOR THE PROBLEM

The proper selection of components for the processor of the PLC and replacing it by raspberry pi and Arduino units would actually reduce the overall cost of PLCs which are manufactured by the top companies like Siemens, Allen Bradley, Omron etc.

1.5 FEATURE EXTRACTION

The feature necessary to control the input and output modules are available in Raspberry pi so the use of Raspberry pi as a processor and Open PLC software for programming discriminates this entire model from the standard PLC and makes it an open source therefore, increasing the flexibility and availability.

1.6 MOTIVATION

As every automotive industry are depended on the PLC for its operations which will cost them more because of which many young entrepreneurs tend not to take the risk. So, with the development of our project i.e., programmable-pi controller it is easy for them implement and with the SCADA interface it is much easy for them to understand the logic of the program and they do not need any individual technical person to take care of the system.

1.7 DIFFERENT ALTERNATIVE METHOD

PROGRAMMABLE AUTOMATION CONTROLLER (PAC)

A vague line differentiates these controllers from the PLCs but in general they have more advanced computing capabilities (e.g. high precision floating point arithmetic, matrix multiplication, etc.), support execution of high frequency control loops, have more advanced networking and data manipulation capabilities and are better in handling large number of IOs. Therefore, they are better suited for more complex and advanced applications.

Industrial PC

They are basically regular PCs running Windows and designed to be used in harsh industrial environment - extended temperature range, high humidity, vibrations/shocks, dust, low quality power supply, electromagnetic interference, etc. Another point on which it defers from a regular PC is higher redundancy and higher quality electronic components. They can be equipped with the networking cards that support any industrial communication protocol and therefore can be easily integrated. Designed for rack or rail mounting. Industrial PCs are used in a wide range or automation tasks.

ETHERNET I/O MODULES

You can run your control application in one of the therefore mentioned controllers or even have a cloud-based application and use Ethernet-based I/o modules in the field that support digital, analogue and other interfaces. They support wide range of protocols and are basically helping to bridge the gap between IT and OT.

RASPBERRY-PI

Raspberry Pi model B has dedicated general purpose input outputs pins. These GPIO pins can be accessed for controlling hardware such as LEDs, motors, and relays, which are all examples of outputs. As for inputs, raspberry pi can read the status of buttons, switches, or it can read sensors like temperature, light, motion, or proximity sensors. Some GPIO pins have alternate function such as UART, SPI, I2C etc. Automation different types of sensors, actuators and motors which can be interfaced with Raspberry Pi GPIO pins. Display can be connected to composite PAL of Raspberry Pi.

1.7 BLOCK DIAGRAM OF THE SYSTEM

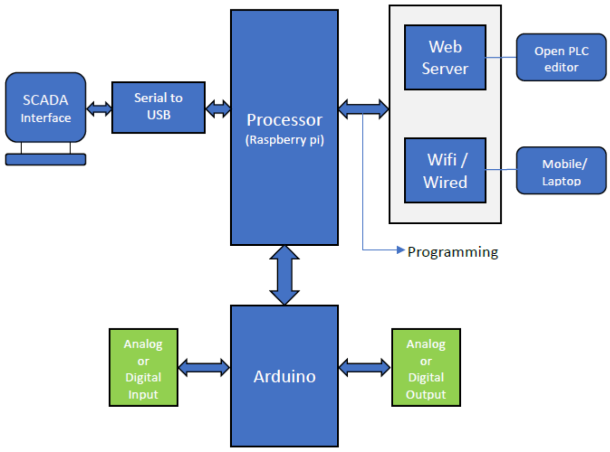

Fig 1 Block Diagram

This circuit initially has the LED powered off. When you press PB1 even for a small instant, the circuit turns the LED on (given that PB2 is not pressed also). Once the LED turns on, it bypasses the PB1 button on the circuit to turn itself on continuously even after PB1 is not pressed anymore. This is a nice trick in ladder logic, you can actually use outputs as contacts! Now, the only way to turn the LED off is by pressing PB2. Since PB2 is a negated contact, it will open the circuit once it is pressed, therefore turning off the LED.

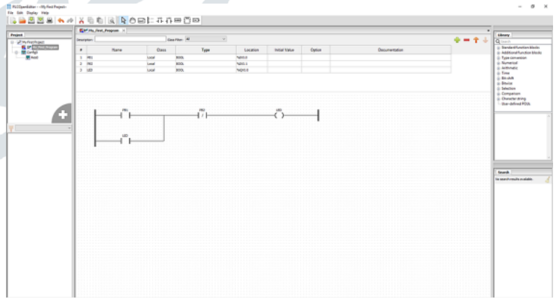

Fig 2 Block Diagram of Open Editor

The last step is to generate your program in a format that OpenPLC will understand. To do that, simply click on File->Generate Program and save the .st file on your computer. This file is your ladder logic program written in a language that OpenPLC can understand. You will later upload this .st file using OpenPLC's web interface so that OpenPLC can run your program.

1.8 UPLOADING YOUR PROJECT O OPEN PLC

The OpenPLC runtime has a built-in webserver that allows you to configure OpenPLC and also to upload new programs for it to run. This webserver can be accessed by opening a web browser on your computer and typing the IP address of your OpenPLC device at port 8080. For example, if you're running OpenPLC on a Raspberry Pi device, and your

Raspberry Pi has the IP 192.168.0.103 on your network, you should type this on your browser: On OpenPLC v2, the upload instructions are slightly different. OpenPLC v2 webserver is much simpler and don't have all the features OpenPLC v3 has. Once you access the OpenPLC v2 webserver in your browser, you should see this screen: Then all you have to do is click on "Choose File" under the Change PLC Program section and then click on "Upload Program". Your program will be uploaded and compiled right after. The logs about the compilation process will be displayed on the screen. If the compilation succeeds.

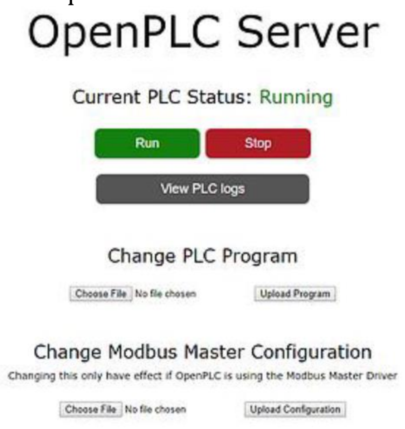

Fig 3 Block Diagram of OpenPLC server

1.9 SCADA INTERFACE

The SCADA systems also monitors the data through an integrated computers remote network (WEB or directly via TCP) in real time. Some objects are exported to HTML if WEB control is needed, and in this case, the SCADA software become a WEB server in parallel to the desktop system. A remote supervisory desktop version can be used without WEB using TCP. Exports visual objects and panels and reports and distribute to the PCs in the plant network system.

1.10 TESTING AND RESULT

1. PLC ladder program to turn on the motor after 5 seconds and to make it run continuously.

• Initially when the switch is turned on the timer starts to run and when it reaches 5 seconds the motor turns on and runs continuously.

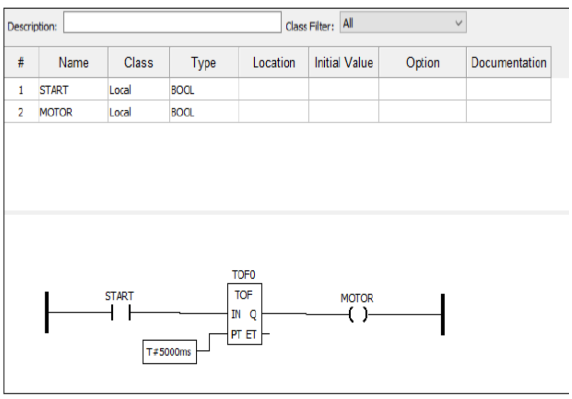

Fig 4 PLC Ladder Program

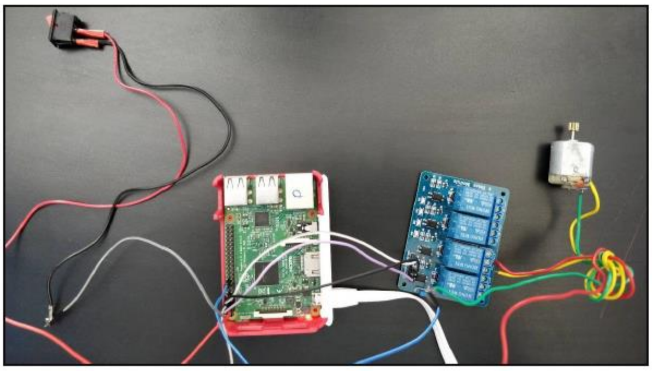

Fig 5 Hardware Setup

2. To control the speed of the motor, when

i. The system indicates the temperature is low then the motor should run at low rpm.

ii. The system indicates the temperature is medium then the motor should run at the medium pace speed.

iii. The system indicates the temperature is high then the motor should run at maximum speed in order to cool the system.

And to show the SCADA interface to the above conditions respectively.

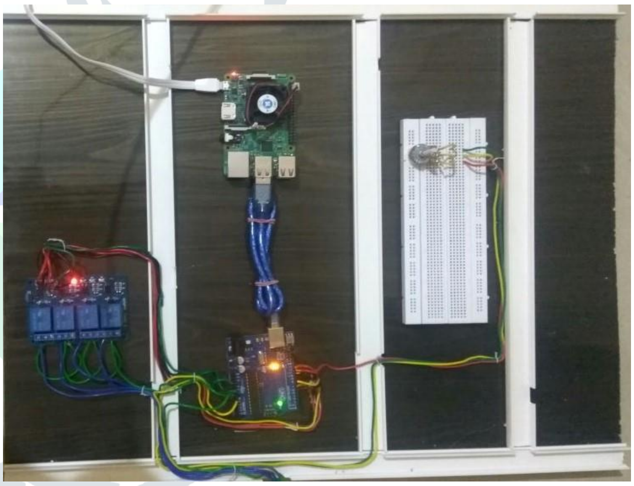

Fig 6 Hardware Setup Various Conditions

Fig 7 SCADA Setup Conditions-1

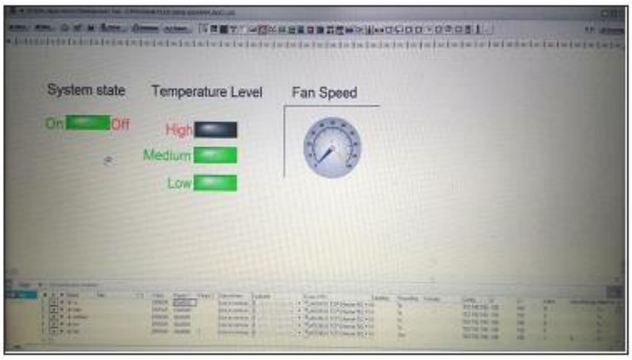

Fig 8 SCADA Setup Conditions-2

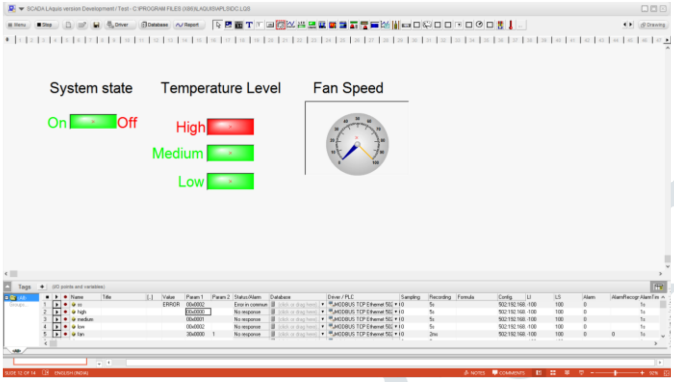

Fig 9 SCADA Setup Conditions-3

1.11 APPLICATIONS

1. Glass Industry
2. Cement Industry
3. Paper Industry
4. Home Automation
5. Industrial Automation

1.12 ADVANTAGES

1. Low cost compared to existing PLC system.
2. Programmable international standard IEC 61131-3 languages (ST, IL, SFC, FBD and Ladder).
3. Simplified Interface.
4. Easy maintenance.
5. Can be programmable remotely.
6. Can be easily altered or repaired by any EC or EEE or Mechatronics engineer who has worked on hobby projects using raspberry pi.
7. Any SCADA software can be interfaced which supports Modbus/TCP protocol.
8. SCADA system require no extra cable for communication.
9. Consumes less power and is powered using battery when there is a power cut.
10. Supports wireless communication.

CONCLUSION

1. The main aim of the project is to find an alternative method for replacing the existing PLC.

2. It can be programmed remotely.

3. Any SCADA software can be interfaced.

4. It can be easily customized according to the user.

5. No extra wiring required for the interfacing of SCADA.

FUTURE SCOPE

The implementation of programmable pi-controller in small and medium scale industries for the automation of the particular system would reduce the overall cost and even allow them to use the pi-controller more flexibly.

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BIOGRAPHIES

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