Bridge Control Automation using PLC

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Abstract— Nowadays, automation in the industry as well as in real life is a global need for ease of operation, flexibility and operational safety. This paper presents automation on controlling the movement of a bridge using a programmable logic controller. The idea is to automate the process of ship detection, opening or closing of a bridge, controlling the signals and road barriers. The purpose of the research is to replace the manual system which is currently used, compare the time and manpower requirement for both the existing system with the proposed automated system. The siemens S7 200 series PLC is used to mechanize the system. Sensors such as IR are used to provide input to the system. And motor such as servo and DC motor serves as an output. Ladder diagram as a programming language is used to control the whole system between the input and output. With the help of IR sensor the arrival and leaving of the system is Monitored and bridge is operated accordingly.

Key words: PLC, DC Motor, Servo Motor, IR Sensor

I. INTRODUCTION

In today's world, the need for transportation is very high, whether it is road transportation, water transportation or air transportation.

For solving the problem of rivers between two cities, intelligent humans have built bridges to travel across the river. But suppose that river is also used for water transportation so obviously cargo ships are also passing through the river, but we have built the bridge then how can ships of big size pass through that river?

To overcome this problem humans have built a bridge that can open and close. It converts the road transportation into water transportation. The river can thus be used for two way transportation, namely road and water. This process has been accomplished by pulling levers or pushing buttons till now. But this method is not very safe, sometimes it can cause accidents. So this paper presents an effective solution to this problem by automating the whole process.

Programmable Logic Controllers (PLCs), also referred to as programmable controllers, are in the computer family. They are used in commercial and industrial applications. A PLC monitors inputs, makes decisions based on its program, and controls outputs to automate a process or machine. Various types of PLCs by various companies are available today like Siemens, ABB etc.

PLC siemens S7 200 is used for this purpose. Ship is detected by IR sensor which is placed at certain distance from the bridge. Sensor output provides input to the PLC and it'll drive DC motor, Servo motor and Signal Poles according to programming.

The Automatic Bridge Control System consists of three important parts. The first part is the PLC controller and second part is hardware. These usually comprise of prototype model of bridge. The third part is the sensor. The sensor checks the presence of Ship.

II. LITERATURE REVIEW

Muhammad Arshad Khattak et al expressed his idea related to interfacing of Sensor with PLC in one of his paper. The main object of their paper was to design and simulate an intelligent traffic control system. The system developed is able to detect the presence or absence of vehicles within certain range by setting the appropriate duration for the traffic signals to react accordingly. By employing mathematical functions to calculate the appropriate timing for the green signal to on, the system can help to solve the problem of traffic congestion. Hardware simulation tests were successfully performed on the algorithm implemented into a PLC [1].

A. Description

The PLC checks the status of the sensors. The system resolution is depend on the output provided by the sensors, Then PLC Checks the importance and then provides output signal to the traffic lights poles for ON or OFF the Red, yellow or Green lights and ON time is dependent on the specific priorities.

Block Diagram of the system is as shown in fig.1.

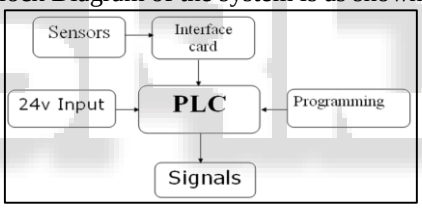

Fig. 1: interfacing of sensor with PLC

The interface card is used between the sensors output and PLC for interfacing purpose. In this system card used is opto coupler. When the input is detected by the sensor then a current limiting resistor is used for reducing the current and drops the voltage for a certain limit. When sensors provide output then a resistor is used in series with the opto-coupler [1].

Acy M. Kottalil et al in his Paper automatic railway gate control shows a procedure to open and close the railway crossing according to condition of the sensors which sense presence or absence of train. The main objective of this paper is to provide an automatic railway gate at a railway crossing replacing the gates operated by the gatekeeper [2]. These types of gates can be employed in an unmanned level crossing where the probability of accidents is higher and reliable and flexible operation is required. Since, the operation is automatic; error due to manual operation is prevented with the help of IR sensors .The arrival and leaving of the train is monitored and the gate is operated accordingly. For controlling the Gate servo motor is used. A servo is a mechanical motorized device that can be instructed to move the output shaft attached to a servo wheel or arm to a specific position. Inside the servo box there is a dc motor mechanically linked to a position

feedback potentiometer, gearbox, electronic feedback control loop circuitry and a motor drive electronic circuit as shown in fig.2

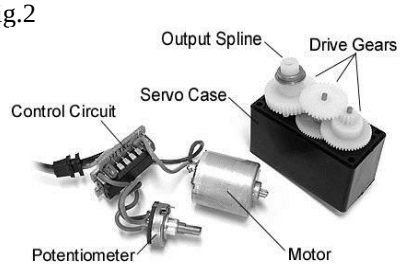

Fig. 2: Servo component

Servos are controlled by sending them a pulse of variable width. The control wire is used to send this pulse which controls the movement of a motor. The parameters for this pulse are that it has a minimum pulse width, a maximum pulse width, and a repetition rate. Given the rotation constraints of the servo, neutral is defined to be the position where the servo has exactly the same amount of rotation in the anticlockwise direction as it does in the clockwise direction. It is important to note that different servo motor will have different constraints on their rotation but they all have a neutral position, and that position is always approximately around 1.5 milliseconds. The angle is determined by the duration of a pulse that is given to the control wire.

When a pulse is given to a servo motor that is less than 1.5 ms then servo rotates to a position and holds its output shaft some number of degrees anti-clockwise from the neutral point. When the pulse is larger than 1.5 ms then opposite occurs. Generally the minimum pulse width will be approximately about 1 ms wide and the maximum pulse width will be 2 ms wide. This way servo motor rotates maximum 180 degree. It does not rotate continuously [2]. This motor is best for our application to operate road barrier.

III. PROPOSED SYSTEM

The system deals with controlling the process of opening and closing of bridge automatically with the help of PLC. The efforts were initiated to build a system using PLC, IR sensor, DC motor and servo motor.

System block diagram is as shown in fig.3

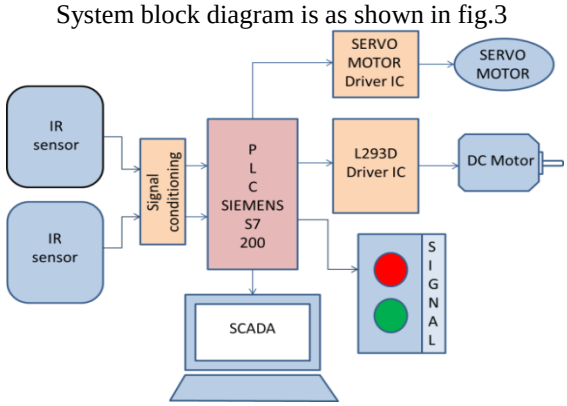

Fig. 3: Block Diagram of system

A. IR Receiver

IR Receiver is used to detect the ship. When ship arrives it'll be detected by IR receiver TSOP 1738. It has carrier frequency 38 kHz When ship will be detected its output goes from high to low [6]. Here IR receiver is used only for model purpose but in actual system High range ultrasonic sensor can be used for ship detection.

B. IR sensor

IR sensor is used to check the movement of the bridge. Here simple IR transmitter and receiver are used. When bridge is fully opened or closed this would be monitored by IR sensor and it would give signal to PLC.

C. Signal Conditioning

Signal conditioning is used to interface sensors with PLC. In signal conditioning relay card is used.

D. Programmable Logic Controller

PLC siemens S7 200 (MPU 222) is being used as a controlling unit. There are 8 digital inputs and 6 digital outputs in this PLC. [4] All the inputs and outputs are interfaced with PLC. PLC takes input from IR Sensor and it provides output to DC motor, Servo Motor, and signal Pole according to Programming [3].

E. L293D Driver

It is used to operate the DC motor and rotate in both direction clock-wise direction and anti-clockwise direction. This IC provides maximum 500mA current to each channel [5].

F. DC motor

It is used to open and close the bridge. Here DC Johnson motor is used. Full load torque provided by this motor is 20 kg.cm. And R.P.M. is 30. Maximum supply current required for full load is 400mA.

G. Servo motor

Servo motor is used to open and close road barriers according to movement of bridge. Servo motor basically works on pulse of variable width. Generally the width of the pulse ranges from 1 ms to 2 ms, hence servo motor rotates maximum up to 180º and it cannot rotate continuously like DC motor [2].

H. Signal pole

Signal pole is used to indicate vehicle to stop. When ship would be detected, red light would be ON to indicate vehicle to stop because bridge will be about to open and when will ship pass through bridge, so after that bridge is closed then Green lights is turned ON again.

IV. PROTOTYPE MODEL OF SYSTEM

The Prototyping Model is a method of system development in which a prototype is built and tested. Or we can also say this is an early approximation of how actual system would work.

Fig. 4: Prototype model of Bridge

Fig. 4 shows the model of Bridge. Here model of bridge is made from wood and here bridge will be open or close with the help of strings.

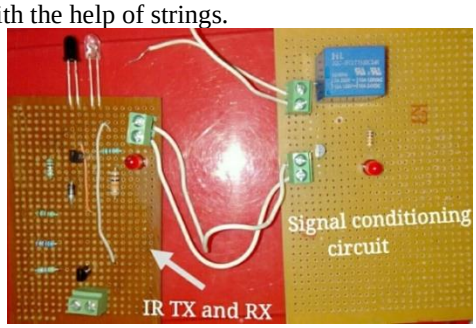

Fig. 5: IR TX-RX with Signal conditioning

Fig.5 shows simple IR TX-RX with signal conditioning circuit. This circuit checks the condition of bridge weather it is opened or not. Signal conditioning circuit is used to interface this sensor with PLC.

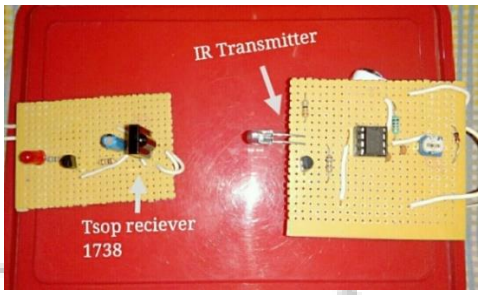

Fig. 6: TSOP 1738 implementation

Fig. 6 shows implementation of IR Receiver TSOP- 1738. Here this circuit is used to detect the ship on both sides of bridge.

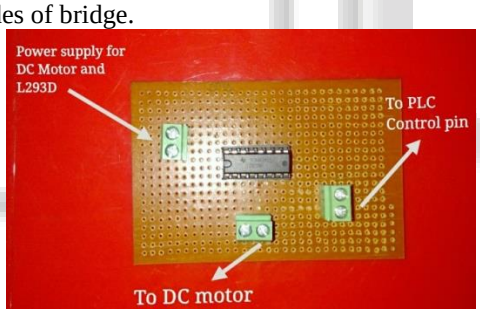

Fig. 7: L293D Driver

Fig.7 shows L293D Driver implementation for DC motor. With the help of this driver DC motor can drive in both clockwise and anti-clockwise direction.

Fig.5 and Fig.6 is the input of PLC and Fig.7 is the output of PLC. According to programming PLC checks condition of sensors and drive DC motor in clockwise or anti-clockwise direction. And in synchronization with this bridge will open or close.

V. SYSTEM SETUP AND EXPECTED OUTCOME

This system is designed to control the process of opening and closing bridge automatically when ship will be detected. Ship would be detected by IR Receiver TSOP 1738 which is placed at certain distance from the bridge. When ship will be detected it sends high to low pulse to PLC via Signal-conditioning. As soon as PLC gets high to low signal it drives the servo motor to close road barriers and signal changes from green to red. Then after PLC drives DC motor to open the bridge and it will continuously monitor the states of IR sensor. IR sensor is used to check the status of the bridge, whether bridge is open or not. As PLC gets signal from IR sensor it would stop DC motor. Hence the bridge is opened. As soon as ship passes through the bridge it'll detect by sensor at other side of the bridge and it will send high to low signal to PLC. PLC first drives DC motor in reverse direction until bridge is totally closed. Then road barrier will be opened and signal changes from red to green.

Automation is very important technology which is required for higher degree of accuracy and for safety of operation.

The process has been made automatic so it can reduce the need of manpower and it would result into flexible operation.

Installation of system is initially costly but overall performance proves it to be cost-effective.

VI. CONCLUSION AND FUTURE SCOPE

A. Conclusion

In this paper, we presented designing of a PLC based control system for automatic opening and closing of bridge. The automated process efficiently reduces the man power required for the process and also increases the efficiency. The use of PLC for controlling action of the system effectively leads to intelligent system which requires less time compared to human and this system also ensures safety.

B. Future Scope

SCADA (supervisory control and data acquisition) implementation can be done for monitoring all the process.

Bi-directional Detection of ship movement can be done.

CCTV camera can be utilized for more accuracy in the ship detection.

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