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PLC based Automatic Drawbridge Model

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Abstract: A movable bridge or drawbridge is a type of bridge that can be raised to allow the smooth passage of boats or ships beneath it. In this paper a fully automated bridge is proposed by using microcontroller and PLC thereby replacing the manual system which is currently used. The idea is to automate the process of ship detection, opening or closing of the bridge, controlling the signals and road barriers.

Keywords: PLC module, drawbridge, Johnsons motor, Ladder Logic

I. INTRODUCTION

A bridge over a navigable waterway is usually built tall enough to allow the boats and ships to cross its path. Since it is impractical to build a bridge high enough, movable bridges are designed and constructed. Such type of bridges can change its position and occasionally its shapes to permit the passage of vessels and boats in the waterway. Traffics over the bridge would be stopped whenever the waterway is opened to vessels and ships. Since the utilization of long approaches and high piers are not required, this type of bridge is cost effective. Movable bridges are of different types; the most common is the Bascule type. Technically called "bascule bridges" from the French word for seesaw, they may open at one end and lift to one side (single leaf) or open in the middle and lift to both sides (double leaf).The another common type of movable bridge is the vertical lift span, in which the movable section is supported at both ends and is raised vertically like an elevator. However in retractable bridges, the movable span slides back underneath an adjacent section of the bridge. Swing bridges have a movable span that rotates horizontally to open the bridge. Movable bridges are more expensive to operate and maintain than stationary bridge, so they are relatively rare. When they are closed they impede traffic on the water and on the roadway or rail line when they are open. Programmable Logic Controllers (PLCs) are in the computer family. They are also referred to as programmable controllers. 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. They are mainly used in commercial and other industrial applications. The important parts of Automatic Bridge Control System consist of PLC controller, a microcontroller of AVR family, hardware that usually comprise of prototype model of bridge and sensors. The sensor detects the presence of ship and vehicles on the bridge. The main objective of this paper is to design and construct a DRAWBRIDGE using a programmable logic controller and microcontroller. Ship is detected by IR sensor and is placed at certain distance from the bridge. Ultrasonic sensors are used to check the presence of vehicles on the bridge. Sensors output provides input to the microcontroller and then to PLC and it will drive Johnson motor, Servo motor and Signal Poles according to programming.

A. Design: There is a unique structure for each drawbridge designed for its particular location and traffic needs. The most common type is the bascule type beyond half a dozen different design concepts. In double-leaf or four-leaf (a double-leaf bridge with separate leaves for each direction of vehicular traffic) bascule bridges, each leaf can be raised and lowered independently. By counterbalancing each leaf with a compact weight on the opposite side of the pivot axle (turn-on), the energy required for rising and lower the bascule leaves is greatly reduced. This counterweight might be located above the roadway and allowed to pivot below the roadway as the bridge is raised, or it might be located below the roadway and allowed to descend into a basement level (often well below the waterline) as the bridge opens.

B. **Description of PLC:** The first Programmable Logic Controller, PLC was developed by a group of engineers at General Motors in 1968. It was developed for the purpose that the company was looking for an alternative to replace complex relay control system. As defined by EN 61131-1,the term “programmable logic controller” is a digitally operating electronic system which uses a programmable memory for the internal storage of user-oriented instructions .It

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implements specific functions such as logic, sequencing, timing, counting and arithmetic to control through digital or analogue inputs and outputs, various machines or process.

Ladder logic: Ladder logic is the primary programming language of programmable logic controllers, It was only natural that the initial language closely resembles the diagrams used to document the relay logic since the PLC was developed to replace relay logic control systems.. By using this approach, the engineers and technicians using the early PLCs did not need retraining to understand the program. Simple switch circuits are converted to relay logic and then to PLC ladder logic, thereby, ladder logic programming can be implemented. By changing the program, any control task modifications can be done. Therefore, the use of the PLC is preferred to the traditional hard wired circuits in industrial controls.

C. Traffic and ship detection

i. Design

The presence of vehicles on either side of the road is detected using sensors .practically Inductive Loops are used as sensors which provide interrupts to controller unit. It has two parts, a coil and a detector unit. Coil consists of one or more loops of wire embedded in the pavement [2]. This inductive coil is connected with the detector unit, which is an electronic circuit. When vehicles passes over or rests on the inductive loop then due to induction on vehicle more current flow through inductive loop and this change of current also changes frequency. Detector unit sends an interrupt signal to controller unit after detecting these changes.

ii. Hardware

In prototype design Ultrasonic sensors are used, for prototype it is not possible to design an induction loop. As the basic function of induction loop in Intelligent Traffic Control System is used to provide an interrupt signal to controller unit. We use Ultrasonic sensors rather than induction loops. In our design, Ultrasonic sensors provide an interrupt signal to controller unit. In case when vehicle reaches in front of sensors, then it provides an interrupt [1].

II.SYSTEM DESIGN

The system deals with controlling the process of opening and closing of bridge automatically with the help of PLC and microcontroller. The system is designed by using sensors such as IR sensors, Ultrasonic sensors and motors such as servo motors and Johnson motors. Figure 1 shows the 2 dimensional view of the system model. It consists if the leaves of the bascule type bridge and the supporting structures.

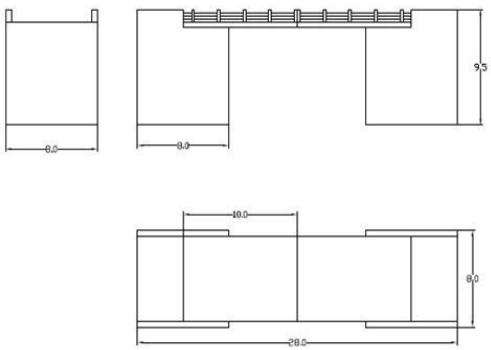

Fig 1: 2D view of the drawbridge model.

The IR sensors are placed on either side of the bridge which detects the ship arrival and departure respectively. The ultrasonic sensors are used to provide an interrupt signal to the controller unit when vehicles are detected on the bridge. The outputs of the sensors are given to the microcontroller. The servomotors open and close the toll gates placed on the either side of the road before the flaps of the bridge. Johnson motors are used to open and close the bridges.

It is connected to a rack and pinion arrangement [2] where the pinion movement facilitates the upward and downward movement of the bridge. The servomotors and Johnson motors are housed inside the supporting structures of the bridge. PLC drives the servo motors and Johnson motors as per the output given by the microcontroller.

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LEDs, buzzer, input to PLC serve as the output of microcontroller. LEDs are installed in the signal poles on either side of bridge and across the bridge for signaling of ship and vehicles respectively. Buzzer is used for alarming in case of emergency situations (if any vehicles or people do not cross the bridge in the given time) to notify the control authorities and to alarm before the bridge opens.

III. SYSTEM OPERATION

A. Block Diagram

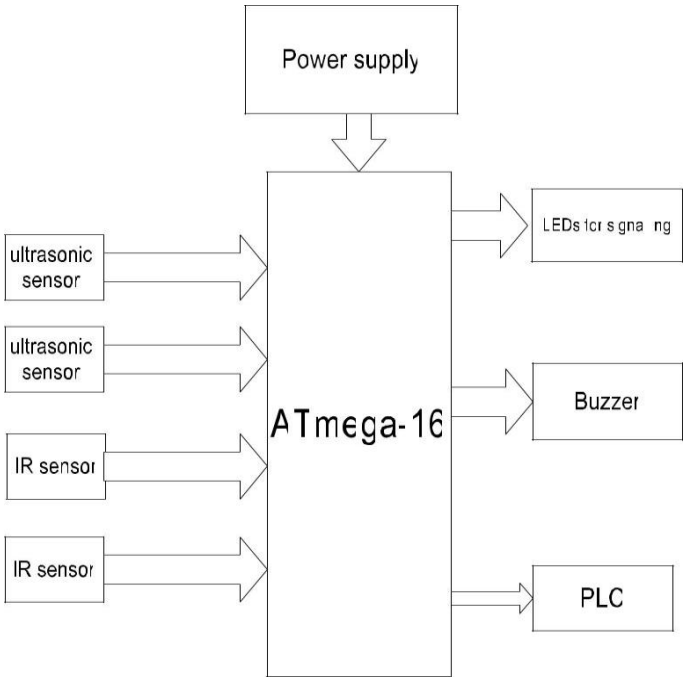

Figure 2: Block diagram of microcontroller side

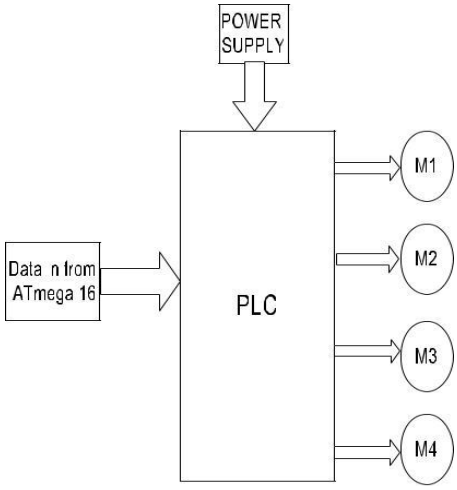

Figure 2: Block diagram of PLC side

Figure 2 and 3 shows the block diagrams of the proposed model. The output of the sensors is given to the microcontroller (AT mega 16). The LEDs used for signaling, buzzer for alarms and the data input to PLC are the output of the microcontroller. The two servo motors and two Johnson motors inputs are connected to the PLC module. According to the signals given by the microcontroller PLC drives the required motors.

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B. Flowchart

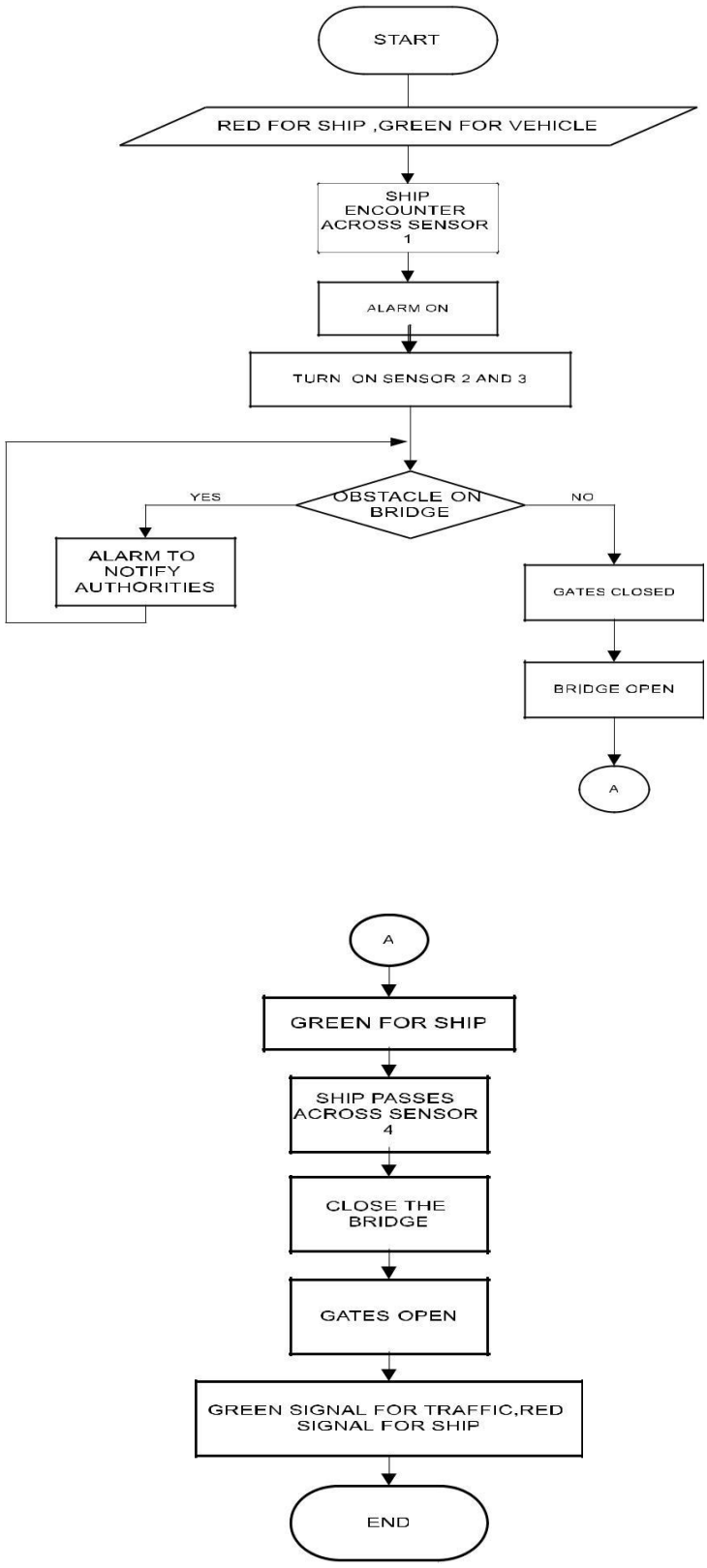

Fig 4: Flowchart of the system

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The working of the system is represented in the form of flowchart shown in figure 4. The system deals with controlling the process of opening and closing of bridge automatically with the help of PLC and microcontroller. The ship would be detected by IR Sensors located at the either side of the bridge. When arrival of the ship is detected it sends a signal to microcontroller. The microcontroller turns the buzzer on for clearing the bridge. The ultrasonic sensors detect the presence of any obstacles on the bridge before opening the bridge and an interrupt is given to microcontroller. If the bridge is clear, microcontroller sends signal to PLC to drive the servo motors to close the road barriers and signal changes from green to red. Then PLC drives Johnson motors to open the bridge and the signal for ship turns from red to green. As soon as the ship reaches the other side of the bridge, IR sensor detects its presence. As the PLC gets signal from the IR sensor through microcontroller, the PLC drives the Johnson motor in reverse direction until the bridge is totally closed. Then road barrier will be opened and signal changes from red to green for vehicles and green to red for ship.

IV. CONCLUSION

An automated drawbridge is designed with the help of a PLC based control system . The intelligence of the system is improved by the use of PLC .The automatic opening and closing of drawbridge increases the efficiency of drawbridge. Moreover the automation process reduces the involvement of man power. The process is less time consuming compared to human and also ensures safety.

FUTURE SCOPE

This project making can be implemented by using SCADA (supervisory control and data acquisition) for monitoring all the process. CCTV camera can be utilized for more accuracy in the ship detection. This process can be implemented between twin cities divided by river, lagoons it as effective measure of transport.

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