Smart Parking Lot

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***Abstract–* It happens often that motorists may enter garage spaces in search of a place to park for an extensive amount of time, only to find that there are no vacancies. The smart parking lot system intends to resolve this issue by indicating to motorists if the parking area is at capacity before the driver before he/she enters the parking space, reducing time and energy wasted. The smart parking system simply keeps track of the cars in and out, then compares the result with the maximum occupancy of the parking lot. If the parking lot has reached its maximum occupancy, an LED indicator will turn red and prevent the gate from opening. Otherwise, it will allow cars to enter until it is full. As a work in progress project, the authors build a modular replica as a proof of concept, utilizing a Programmable Logic Controller (PLC) as the control system. The model will convey a realistic view of a parking lot with operating gates, designated spaces, and model cars.**

***Keywords--* Parking, Garage, PLC, Sensor, Smart.**

I. Introduction

Many car owners struggle to find vacant parking spaces within parking structures which is frustrating and contributes to the greenhouse emissions from vehicles. Providing solutions that notify the motorists when the parking lots are at capacity will reduce extensive gas usage and time consumption. The solution used for this study is a system encompassing servo motors, magnetic sensors, LED indicators, and the Programmable Logic Controller (PLC) using ladder logic instructions. Upon the arrival of a vehicle, the entrance sensor will send out a signal, then the gate servo motor will raise the toll bar 90° from the resting position. This allows the awaiting car to enter the parking structure. While the vehicle passes through the gate, the entrance sensor sends a signal to the entrance gate servo to keep the gate from closing on top of the moving vehicle. The gate will return to its original position after the vehicle enters the facility and await the next vehicle to repeat this cycle continuously until capacity.

The same concept applies to the exit sensor, departure sensor, and exit gate servo. Once a car approaches the exit, the exit sensor will transmit a signal, which instructs the exit gate to lift 90° to allow clearance for the vehicle to exit. The departure sensor will sense when the vehicle has left, close the gate back to its resting position, and decrease the occupancy register by one. If the parking garage is at its capacity, this leads to the change in LED indicators from red to green. Red signals that the parking lot is full, meaning the capacity register equals the occupancy register, which the entrance gate will not open until a vehicle leaves the parking lot. Once a vehicle exits the parking lot, the green LED will signal that a vacant space is available, and the entrance gate will open when a vehicle approaches the parking lot.

The objectives of the smart parking lot are:

- To demonstrate its functionality in a simulated environment, where the servos open and close when the car arrives and departs.
- The LED indicators signaling occupancy levels, and
- The sensors increasing and decreasing the registers as a result of the number of present vehicles. site.

II. Methodology

The approach is to design a working model of a smart parking system to illustrate one of the many ways Electronic Engineering Technology is used in automatic control applications, using Programmable Logic Controllers (PLC). A PLC or programmable controller is an industrial computer that has been ruggedized and adapted for the control of manufacturing processes, such as assembly lines, machines, robotic devices, or any activity that requires high reliability, ease of programming, and process fault diagnosis [1]. In relation to the mechanical embodiment, a model parking lot with its surroundings will be constructed using foam board, landscaping materials, and other components. The systems will utilize the PLC with input and output field devices such as switches, actuators, motors, and diodes. The AutomationDirect CLICK PLC and student trainer was chosen for this project [2]. The CLICK PLC family is designed to combine practical PLC features in a compact and expandable design. A powered CLICK PLC unit by itself can be used as a complete PLC system with the following:

a) 8 built-in input points
b) 6 output points
c) 21 easy-to-use Ladder Logic instructions that cover most applications that are suitable for this class of PLC.

For the trainer aspect, the PLCTR16IO8 trainer component was utilized. This trainer was developed inhouse. This component features the following: 16 inputs, 8 outputs, 8 onboard toggle switches, 8 onboard push buttons, 8 onboard LED output indicator, and 8 onboard DPDT(double-pole double-throw) relays. This range of freedom allows for maximum performance and control of any components implemented.

The physical parking lot model was constructed using foam board and balsa construction. This allowed for easy manipulation and change of the layout configuration if needed. The dimensions of the model parking lot were 30 feet by 2 feet, with a specified 8 vehicle capacity. Outside the board's perimeter are the red and green LED indicators that change and communicate with servo-operated gates at the entrance and exit. Figure 1 and Figure 2 show the main controllers used to operate our parking system.

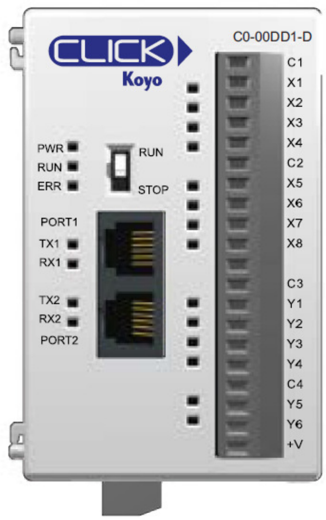

Fig. 1 CLICK PLC Component.

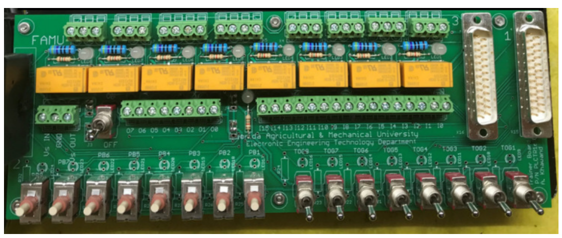

Fig. 2 The PLCTR16IO8 Trainer

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It is essential to mention the configuration of the hardware's input/output (I/O) components. For this system to perform properly, the following items were needed

a) 4 magnetic sensors
b) 2-180° servo motors
c) 2 servo controllers
d) 1 red and 1 green led.

The magnetic sensors trigger when the motorist is either near the entrance or leaving the parking lot. This sends a signal which alerts certain operation is taking place. Once that signal is received, the system decides which servo motor to communicate with, allowing the motorists to enter or exit. Shown in Figure 3 and Figure 4 are the input and output assignments. All sensors are classified as input devices, being the fact that they trigger a response. The servos and LEDs are all output devices that perform specific instructions due to the sensors being triggered. Figure 4 conveys the physical layout of each device with the respected input and output voltage.

Function	I/O	Voltage	PLC Address	Nickname	Address Comment
RESET	Input	24 VDC	X1	TOG1	Reset
Arrive Sensor	Input	24 VDC	X5	PB1	Arrive Detector
Enter Sensor	Input	24 VDC	X6	PB2	Car Inside Detector
Exit Sensor	Input	24 VDC	X7	PB3	Exiting Detector
Depart Sensor	Input	24 VDC	X8	PB4	Leave Detector
Entrance Gate Servo	Output	5 VDC	Y1	LED1/RELAY 1	Entrance Servo
Exit Gate Servo	Output	5 VDC	Y2	LED2/RELAY 2	Exit Servo
Red LED Light	Output	5 VDC	Y3	LED3/RELAY 3	Red Light
Green LED Light	Output	5 VDC	Y4	LED4/RELAY 4	Green Light

Fig. 3 Address Assignments

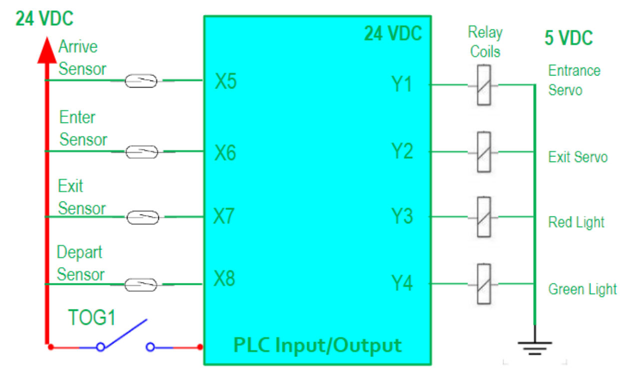

Fig. 4 PLC I/O Diagram

As mentioned earlier, this system encompasses the utilization of sensors which are magnetic sensors. The use of magnetic sensors resulted in using Reed magnetic switches, which are hermetically sealed metal conductors activated by a magnetic field from an electromagnet [3]. The conductors act as a normally open switch, which closes within proximity of a magnet. These devices are used in home alarm systems to detect when doors and windows are open. These switches were used to sense the presence of a vehicle by attaching magnets to the front end of the vehicle. The Reed switches were then embedded in the board in front of the servo gates. When a vehicle gets within close proximity of the embedded Reed switch, the switch sends a signal to the PLC, indicating that a vehicle is waiting. The PLC program responds by sending a signal to the gate servo motor to open. As seen in Figure 5, the magnet comes in direct contact with the switch, causing it to send out the signal.

The servo motors used within this system were controlled by a Pulse Width Modulated (PWM) signal with the specifications and configurations shown in Figure 6. It is also important to mention that the 555-timer circuit [4] generated the required PWM signal within a period of 20 msec. The pulse width is controlled by the amount of resistance between pins 6 and 7 of the 555 Timer in Fig 7. When the PLC closes the relay, the angle sets to 0° to open the gate. When the relay is open, the angle sets to 90° to close the gate.

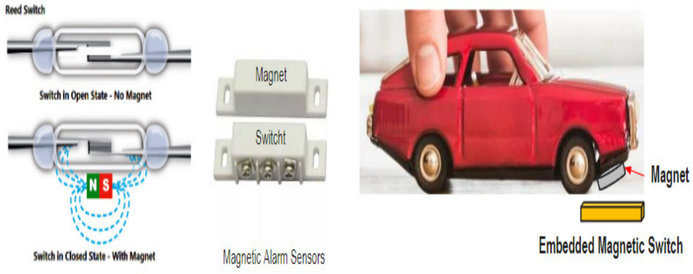

Fig. 5 Magnetic switch and sensor layout

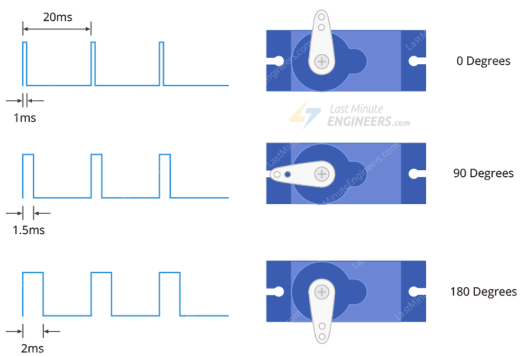

Fig. 6 Servo Motor Configuration

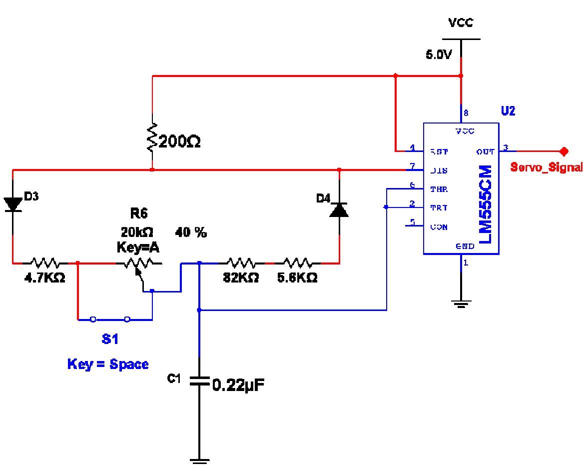

Fig. 7 Servo Motor Configuration

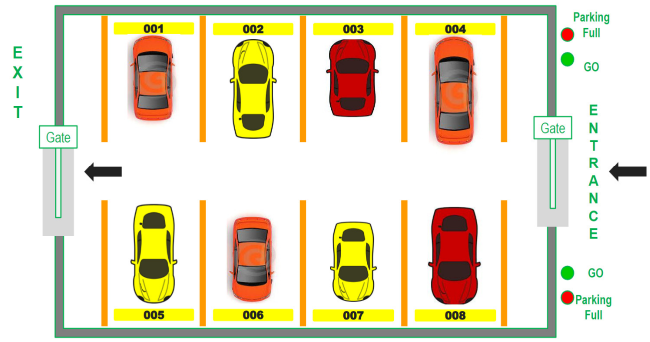

Fig. 8 Embodiment Model Block Diagram

Figure 6 through Figure 8 above shows the layout of the parking lot at capacity along with the electronic components needed to make it function.

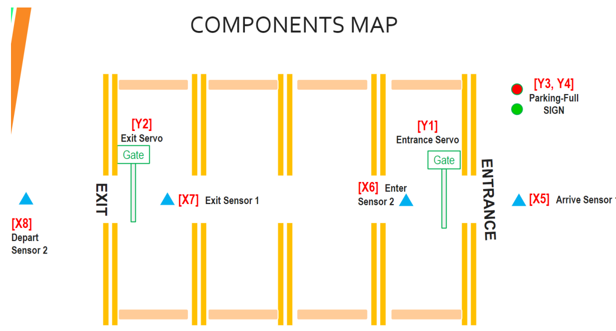

Fig. 9 Components Map

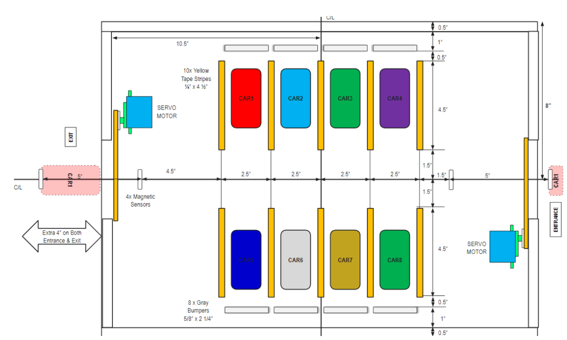

Fig. 10 Overall Lot Layout

Figure 9 and 10 serves as the component layout with the allocated names and ports. Figure 11 shows the software flow chart.

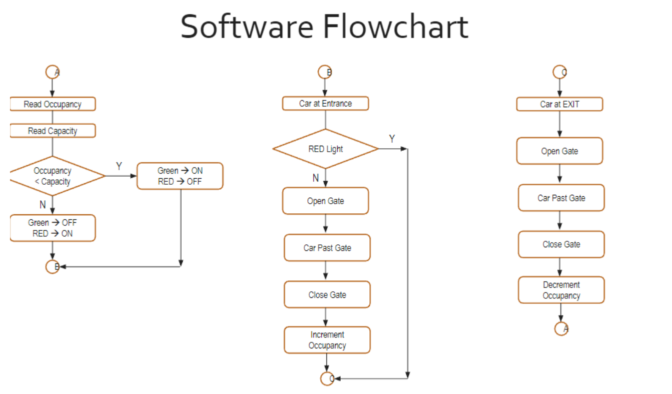

Fig. 11 Software Logic Flowchart

Fig. 12 Physical Layout

III. Discussion & Conclusion

As mentioned earlier, there is room for improvement to make the system work better and more efficiently. One of the areas is the utilization of LED arrows or signs to guide the driver to the open parking space after entering the parking lot. This will reduce the time takes for the driver to maneuver through the parking lot to find the empty space. Another improvement is the use of different sensing mechanisms for vehicles entering and leaving the parking lot such as trip lasers or color sensors which would provide a better system. The implementation of a Wi-Fi or Bluetooth control system would also cut down on excessive wiring. The ultimate goal is to have the parking system fully automated. A fully automated system would physically park and unpark the vehicles themselves. This would allow the user to approach the lot, check the availability and then allow the system to pull the vehicle in and park all in one. With the introduction of smart vehicles and smart roads, these types of systems will provide additional value to the automation of the transportation system.

The PLC-based design for the Smart Parking garage demonstrated the project's feasibility and are tested on this prototype. The main goal was to use a PLC to create proof of concept, which provides information on the parking lot's capacity, reducing time spent by motorists and gas emissions.

References

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