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Automated Carwash Using Programmable Logic Control (PLC)

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Abstract
This paper presents development of Automated Carwash using Programmable Logic Control (PLC) Controller, for supporting their technologies and protocols. The main objective of the study is to reduce the volume of water use in car wash and to help to mitigate possible hazard from prolonged chemical response or any potential injury that might occur. In Kuwait, carwash is among the activities that consume a great deal of desalination water. The total intake for washing a single car is from 50–100 gallons of fresh water. The investigation shows that 75% of the water can be filtered and reused. As feed for the final rinse and make-up, an average intake of about 25% of freshwater is required. Due to the challenge in global economy, it is better to apply an automated process in carwash to reduce the human supervision and communication. In this work, PLC was activated according to its set process and used in achieving the automatic carwash system.
Keywords: Programmable Logic Control (PLC), Automated Carwash

Introduction

The automatic carwash using Programmable Logic Control (PLC) system is as aspect electrical engineer because it relates to the design, creation and maintenance of electrical control systems, machinery, and equipment. The PLC was originally founded in 1968 by General Motors of America who wanted to produce a control device for their installations and did not need to modify the design each time a new car model was produced (Al-Odwani et. al., 2007). Car technology is one of the best interconnecting channel used in many part of world is a means of transportation or communication or business and this led to increase in the number of cars in our cities (Ridley et. al., 2003). This increased necessitate the development of an automated carwash using Programmable Logic Control (PLC) controller.

This research is concerned with the operation of a PLC as a controller, as well as the programming language used by PLCs to control systems and the execution of an automated

washing machine. This designed automatic carwash use a PLC controller system accomplished a task that saves time and money, reduce water consume to wash car, and can help to reduce the manpower that can also prevent any hazardous chemical substances in detergent that was used to wash per car (May et.al., 2019).

It is relevant to save time because it will only take 1 minutes in every phase starting when the car had been detected at entering section, the first rinse section, detergent section, brushes section, the second rinse section and lastly, the drying section until it reaches at the exit section. It also can reduce water consume to wash one car because it only will spray the car when the sensor detects the car. Besides that, we also can see the differences if someone that wash the car only let the water overflow waste just like that. The project development can save water 75% that will be reused in the rinse section (Bala et. al., 2020). Finally, it can reduce the human power saving to supervision and communicate with the carwash system that will be developed.

Methodology

This section discusses the proposed Automated Carwash with PLC Controller. The project is made up of the software development and hardware building. The software development deals with the proposed operation and the simulation of the system. While the hardware building shows the prototype of the proposed project.

To achieve a better result in designing the circuit is important to adhere to the specification and programming of the PLC, this will help in perfecting the circuit component's performance and will eliminate failure on their part. Besides, the coding needs to be accurate, otherwise, the prototype will run not as desired. So, there is needs for extra attention on these crucial parts of the system. Figure 1 represent the operation of the Automated Car wash system using PLC Controller. The operation will begin after Switch Button has been triggered or Sensor 1 detect the car entering the car wash by activating the conveyor and water spray delay in 5 second. The excess water will be filtered and be used in the rinse section. In addition, the green light indicator will turn OFF and red light indicator will light up after that. Then Sensor 2 will detect the car and will activate the detergent spray. The excess detergent also be filtered and used for the next car. Next, Sensor 3 will detect the car and activate the brushless in the brushing section. Then in, Sensor 4 when detecting car, it will activate the spray water in rinse section. Sensor 5 on detecting a car, will operate the fan in the drying section. Lastly, Sensor 6 will detect the car and start to stop the overall system in 5 second delay.

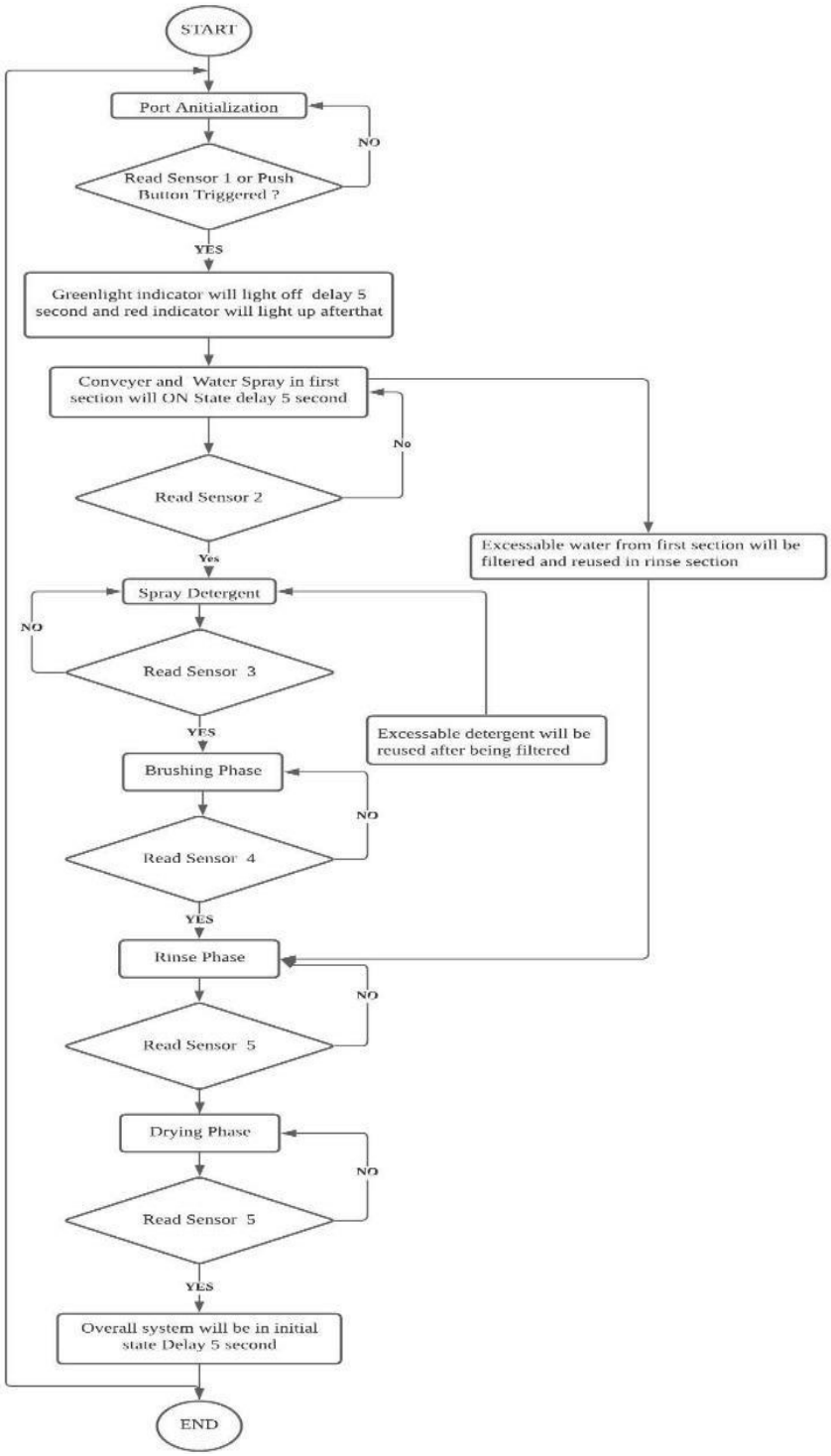

Figure 1. Flowchart operation of the system

Figure 2 represent overall Ladder Diagram of PLC based Automatic Car Washing System that has been design in CX-Programmer. CX-Programmer is one of the software that can design a ladder diagram and can setup the mnemonic code to transfer.

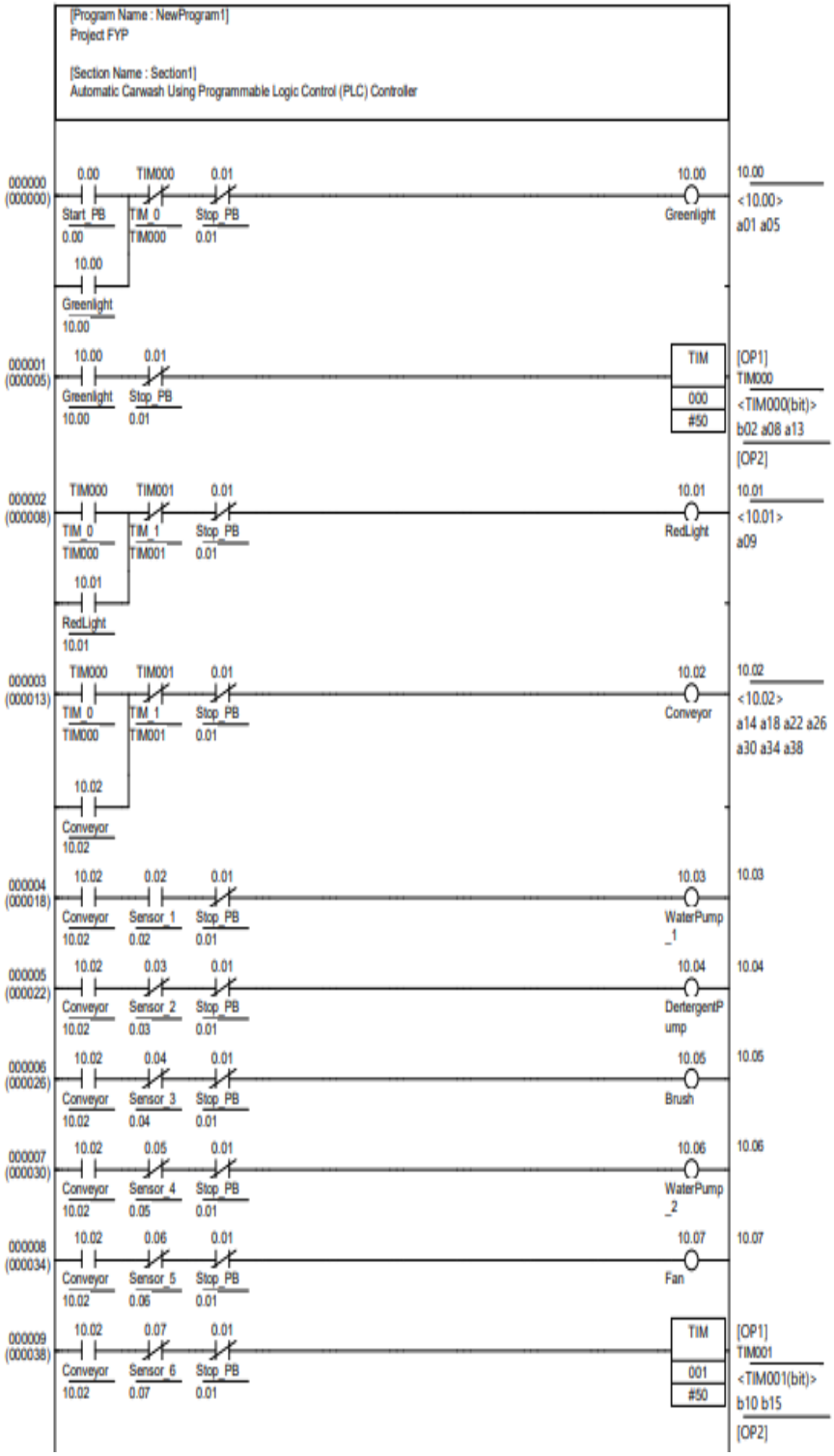

Figure 2. Overall Ladder Diagram of PLC based Automatic Car washing System

Simulation of the System

The ladder diagram of the PLC (OMRON SYSMAC CPM2A) starts the simulation shown in Figure 3. In ladder diagram, 0.00 (StartPB), 10.00 (Green Light) are used as normally open contact (NO). Meanwhile, 0.01 (StopPB) and TIM_0 are used as normally close contact (NC). Therefore, when the power supply is on, the output Greenlight is activate and triggered the TIM000 (Timer_0). After TIM_0 on state it will turn the Green Light in off state and Red Light in on state.

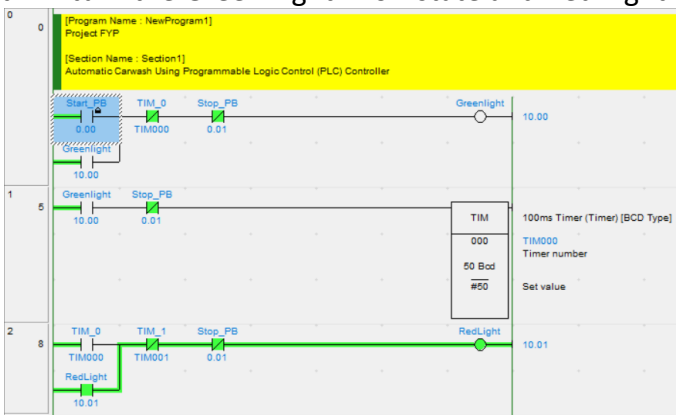

Figure 3. Start Simulation

Figure 4. Running Program for Conveyor Motor and Water Pump_1

In Figure 4, the triggered Timer 000 (TIM_0) will activate the conveyor to start its operation. Meanwhile in network 4, when conveyor is in operation all the sensors will be in ready mode. 0.02 (Sensor_1) is used in normally closed contact (NC) because the used sensor is in normally open contact (NO). So, it will trigger the 10.03 (Water Pump_1) operation. In network 5 shown in Figure 5, when the 0.03 (Sensor 2) is on state it will activate the 10.05 (Pump_2) which represent detergent spray. Until the car passes through it the 10.05 (Pump_2) will be off state. In network 6 shown in Figure 6, the car reaches 0.04 (Sensor 3), used as normally close contact (NC). When 0.04 (Sensor 3) turn to the on state it will activate 10.02 (Motor_2). The Motor_2 represent brushes that will wash the car after being sprayed with the car's detergent. It will last until the car passed through 0.04 (Sensor 3).

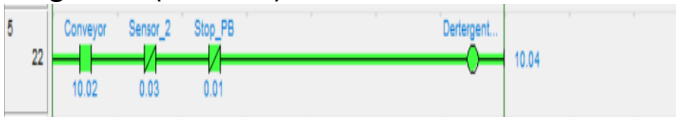

Figure 5. Running Program for Detergent Pump

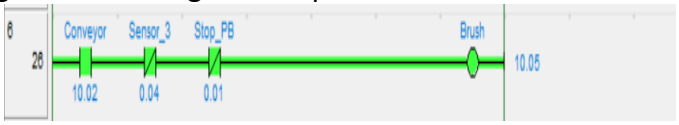

Figure 6. Running Program for Brushes

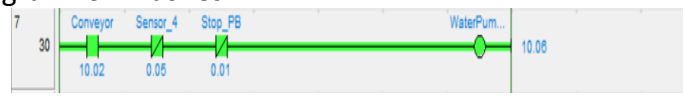

Figure 7. Running Program for Water Pump_2

In network 7 presents in Figure 7, as the operation is same as in the network 3 but it will need 0.05 (Sensor 4) to be in the on state because it is used as normally close contact (NC). The 10.06 (Pump_3) is in the on state when 0.05 (Sensor 4) is detecting signal. From network 8 until network 9 illustrated in Figure 8, 0.06 (Sensor 5) and 0.07 (Sensor 6) is used as normally close contact (NC). The 10.07 (Fan) will operate when 0.06 (Sensor_5) is in the on state. Finally, TIM003 will end all the program's 5-second delay after 0.07 (Sensor_7) has been triggered.

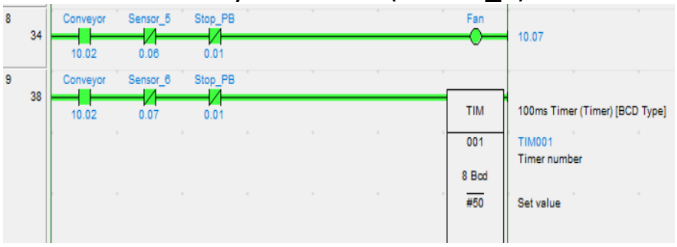

Figure 8. Running Program for Fan and stopping the overall system

Hardware Development

The overall circuit design of the proposed system is shown in Figure 9. The fundamental component of the system is the programmable logic controller. The operation of the automated washing system controlled by a PLC (OMRON SYSMAC CPM2A) in this system. It has 11 input pins and 7 output pins. The 24V power supply is being powered by 220V from the mains AC supply. The 220V AC supply can also be obtain from OMRON SYSMAC CPM2A (Kamel et. al, 2020).

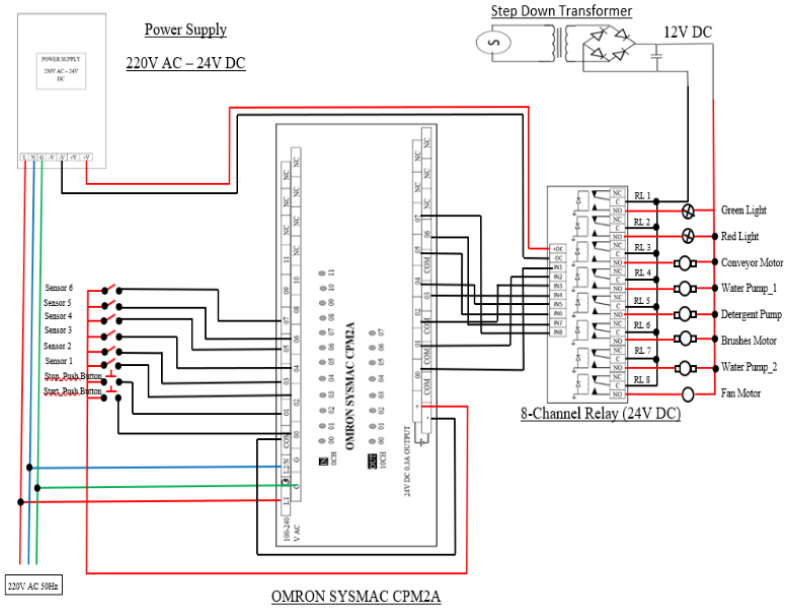

Figure 9. Overall Circuit Diagram of PLC based Automatic Car Washing System

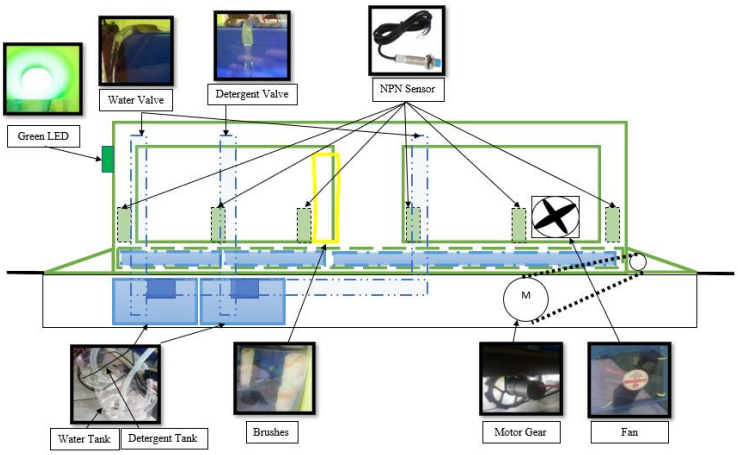

Figure 10. Front view of the hardware

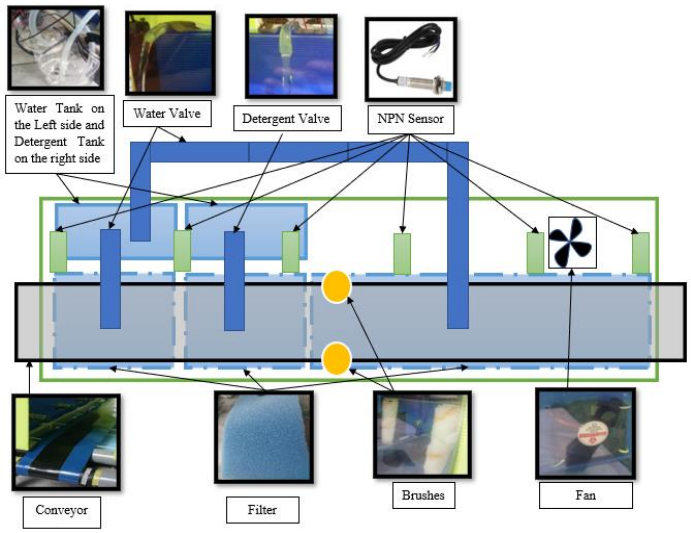

Figure 11. Top view of the hardware

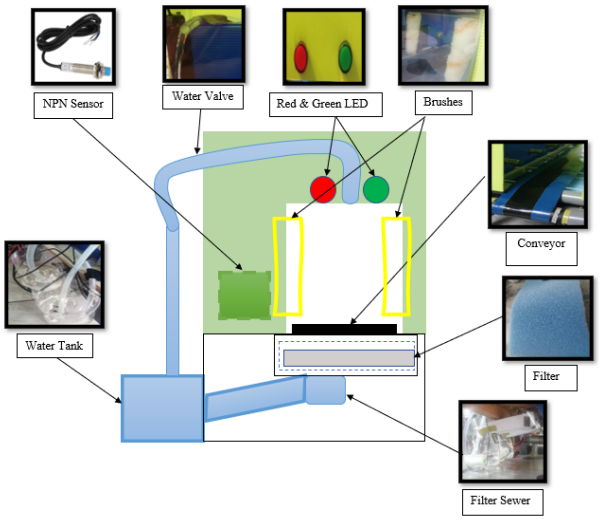

Figure 12. Side view of the hardware

Figure 10 is the front view of the hardware, Figure 11 is the top view while Figure 12 is the side view of the hardware. These three figures represent all the layout of the proposed project. Starting from front, top and side view of the hardware.

Results and Discussion

When the switch of PLC is ON, Start Push Button will be triggered to start the system so that green light start light up to triggered Timer 1. After that, Timer 1 will activate the Conveyor motor and turn off greenlight because red light is turn to the on state. Figure 13 shows that the function of green light is to state that the system is in good condition ready to run and red light is to give signal that the system is starting its process.

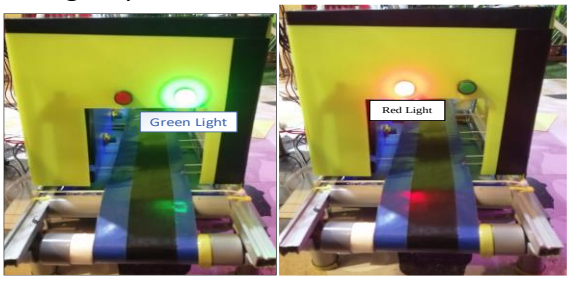

Figure 13. Greenlight, Red light and Timer

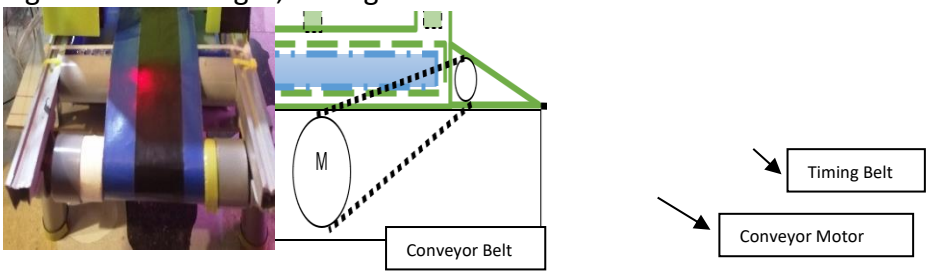

Figure 14. Conveyor Motor

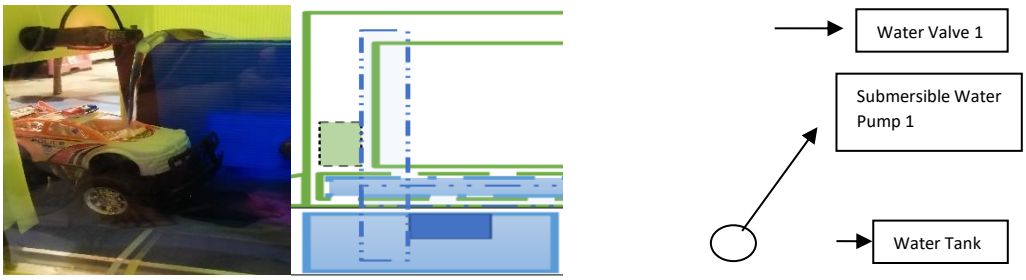

Figure 15. Testing Water Pump_1

Figure 14 shows conveyor starting to move after 5 second when the Push Button had been triggered. The water that had been used in this section will be filtered and ready to be used at the rinse section.

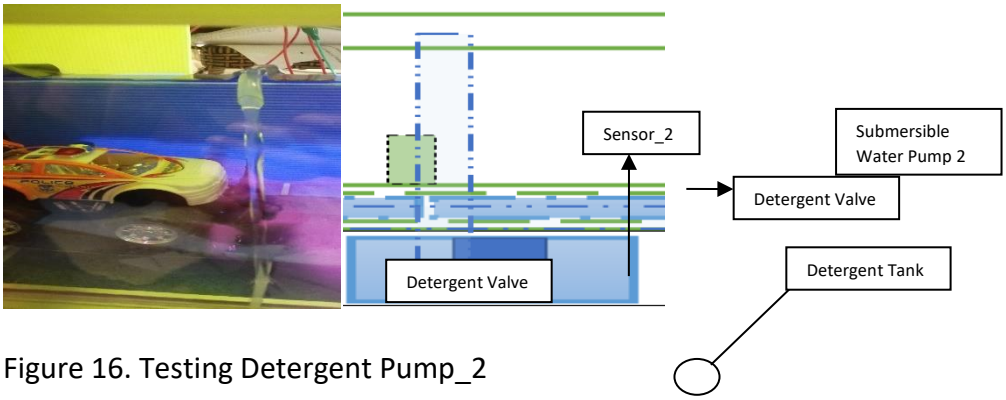

Figure 16. Testing Detergent Pump_2

Figure 15 shows the car being wash with car's detergent water. When car reaches section 2, Sensor 2 detects the car and the water pump_1 will stop because it passes through the Sensor_1. Detergent pump_2 will only operate if Sensor_2 is detecting the car and the Sensor_3 will activate brush motor in the next section 3. These operation is illustrated in Figure 16 and Figure 17. Figure 18 shows car washing with water again in section 4, after car reaches Sensor 4 and the operation of brush will stop after Sensor_3 did not detect the car.

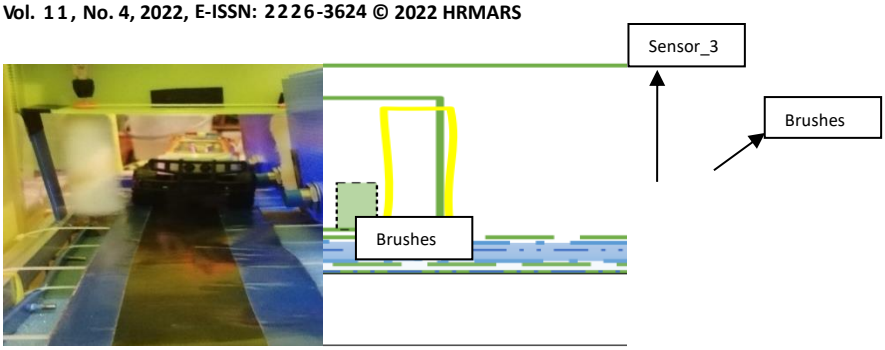

Figure 17. Testing Brush Motor

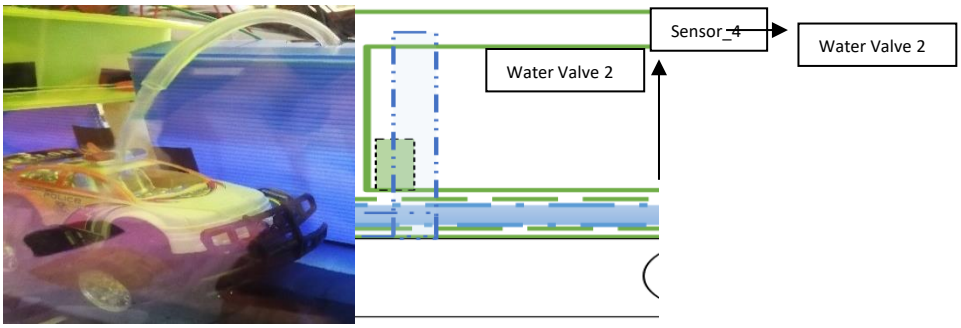

Figure 18. Testing Water Pump_2

In Figure 19, the operation of the water pump_2 will stop because the car already passed through Sensor_4 and dry fan will be activated to dry the car when the car reaches Sensor_5. When car reaches exit gate and Sensor 6 detect the car it will start to activate the Timer_2 before shutting down all the process to the initial state after 5 second delay as shown in Figure 20.

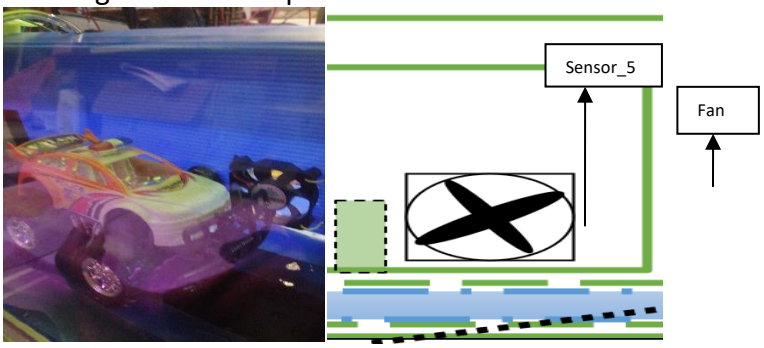

Figure 19. Dry Fan

Figure 20. Testing Program to go back to Initial State after 5 seconds

In the proposed work, the functions of combine controller and sensor is to prevent water from being wasted blindly. Thus, in developing the prototype various type of input and output such as motor, sensor, etc were constructed. In addition, the automated carwash is programmed using PLC that will manage to substitute human provision and communication. This type of substitution can reduce manpower. Thus, for a safety measure of this development the automated will be installed with an effective and quite cheap sensor that can help to detect the car and start the carwash system with carwash programmed using the PLC. Figure 21 represent that this is one of the factors in choosing an analog module such as type of proximity sensor that were used in this project and the analog input to digital value converting time (integration time). Table 1 shows the type of sensor used in the system.

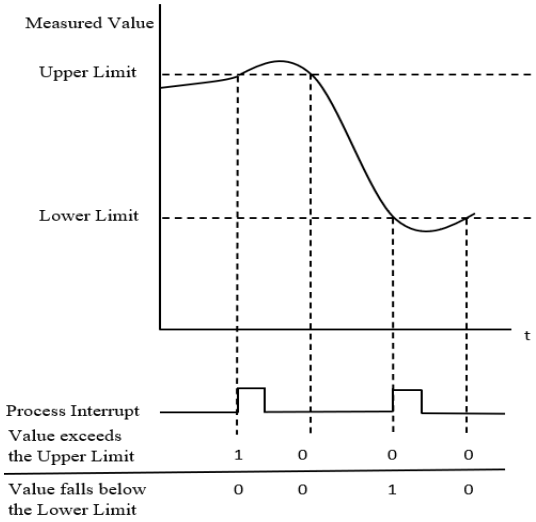

Figure 21: Conditions Interrupting for Analog Signal

Table 1
Type of Sensor with their Interference Frequency and Integration Time.

Type of Proximity Sensor	Interference Frequency (Hz)	Integration Time (ms)
NPN Sensor	0.5k	2.5
PNP Sensor	0.5k	2.5
Infrared Sensor	0.5 k	30

Conclusion

The Automated Car Wash using PLC Controller has been developed in this study. The project includes design and development of the prototype; programmed PLC and to also test run the prototype. The PLC as a controller is applied in this project because it is not complex to use. From testing and result based on the observation, the Automated Carwash using Programmable Logic Control (PLC) Controller in terms of the water that had been consumed to wash one car is reduced. This is due to the 1st phase water had been filtered and will be reused in the 4th phase which is the rinse phase. The PLC is used in the design because it easy-to-use and it is providing a ladder diagram with its coding to detect problem if there are any error. In this work the Automatic Carwash using Programmable Logic Diagram PLC Controller in achieving the main objective which is to design an efficient car wash system that minimize water usage and washing

time. It is one of the ways to avoid wastage of water in washing one car at a time. The advantages of this system are to reduce the human supervision and communication due to covid-19 pandemic.

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