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Design of Omron PLC Based Automatic Car Wash Prototype

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ABSTRACT

Increasing automotive production indirectly greatly affects the progress of an increasingly modern era. Indirectly, production in factories will increase to meet the needs and desires of transportation consumers. Therefore, the use of PLC in the industrial sector as production plays an important role in helping humans to do heavy work. The growing demand for increased mobility needs will indirectly require owners to take care to maintain cleanliness in mobility transportation. Therefore, we need a system that can control automatic car washing. This automatic car wash system uses PLC CJ1M with a prototype design of 24cm long, 15cm wide and 15cm high and uses an infrared sensor which is used to read the presence of the car and a pg28 dc motor which is used as the main driver. The programming language used is the ladder language in CX-Programmer. Where this ladder language is used to control several processes, namely, watering, soaping, scrubbing, rinsing water and the drying process. From this research, the researcher obtained the results that the time obtained from manual and automatic calculations to run a washing process by giving a set value of 5 on the counter will give the difference in time obtained, namely watering 1.54 seconds, sprinkling soap water 3.01 seconds, rubbing 3.13 seconds, 3.09 seconds of water rinsing and the same time for the drying process. From the use of the infrared analog sensor used, it successfully reads the presence of the car in front of it and the design of this prototype runs with a predetermined process.

1. Introduction

In today's industrial world, technology has very important benefits in production processes at industrial sites. One of them is the process of technological development in the field of automation [1]. This can be seen from the increasing demand and consumer needs for goods produced by an industry or company. To speed up production, the industry needs a system that can work efficiently and as desired [2]. In this case, one of the technologies that has a very fast process and is related to control or control that is supported by advances in the field of computers, namely PLC (Programmable Logic Controller), this PLC is usually used in production factories or is used to run a system that requires great power to get the desired control [3]. At this time the use of PLC is often used by the community to run a business. One of the businesses that uses advanced technology that uses control is the car wash business [4].

In the car washing process, which we usually do manually, this tool will help, so that maximum work efficiency is obtained [5]. In the process of washing a car, it still uses a lot of human/manual power. This control system is run by Programmable Logic Controllers (PLC) this tool can save time and effort in the car washing process [6].

With a Programmable Logic Controller (PLC) all mechanics or actuators used in car washes can be controlled quickly, easily, efficiently and accurately because the control system is combined with feedback, data processing and monitoring systems [7]. Developments have been very fast lately in all fields [8]. The development of all fields mutually support each other. Especially electronics in the industrial sector. Therefore, the authors assume that it is necessary to develop an automatic car wash system so that it is more efficient [9][10].

2. Method

This research is expected to create an automatic car wash using a PLC that is able to drive hardware and is able to control and carry out predetermined processes.

2.1. Prototype Design

The prototype design in this study is divided into 2, namely hardware design and software design. hardware manufacturing includes the installation of components in the installation, car wash body design and wiring between components. Making software includes making ladder programs and using instruction instructions in the CX-Programmer software.

2.2. Hardware Design

System design is used for a clear flow and general description of the system being made. The system design begins with making a block diagram which aims to make it easier to carry out the next stage. The system block diagram is shown in Fig. 1.

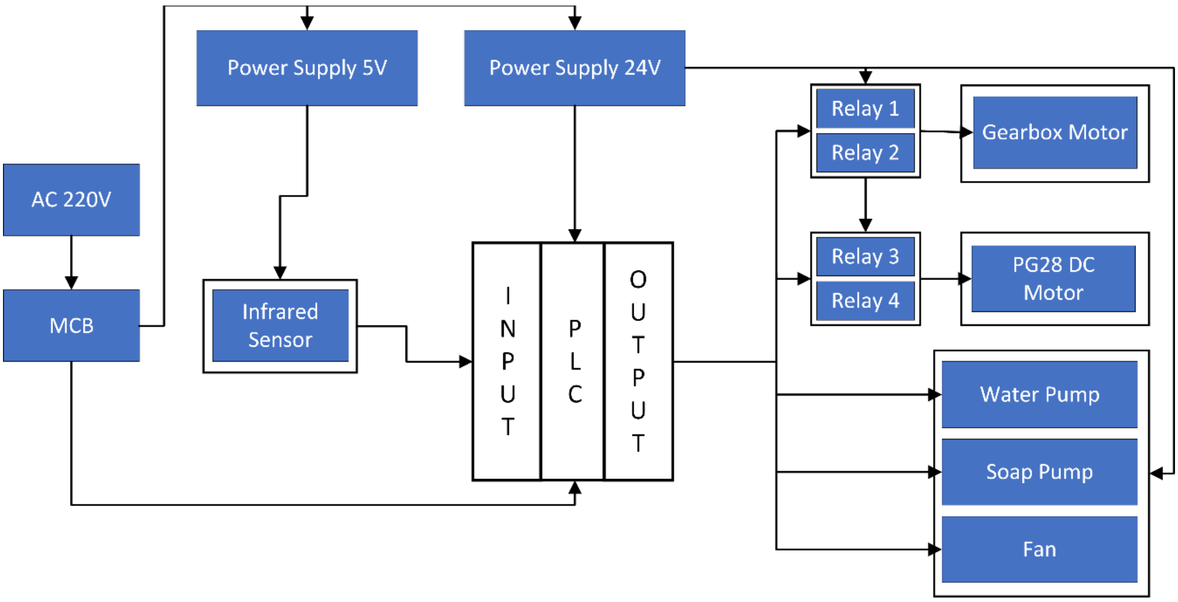

Fig. 1. Diagram Block

The block diagram in Fig. 1 shows the system workflow that will be created. The microcontroller used is a PLC (Programmable Logic Controller) with CJ1M CPU22 type. In the block diagram picture that is designed to consist of two dc power supplies, namely 5v and 24v power supplies and a PLC which is connected to a 220V AC voltage, in a circuit connected to AC voltage there is an MCB which is used to cut off the current when an overload occurs and a short circuit occurs.

Using an infrared sensor connected to the PLC as input and getting a 5v voltage from the power supply. Using the PLC connected output as a controller and getting the voltage from a 24v power supply. In the use of two pairs of relays arranged to drive the pg dc motor and the gearbox motor in cw&ccw motion, where the circuit is connected to the PLC as a controller for the direction of movement and gets a voltage from a 24v power supply.

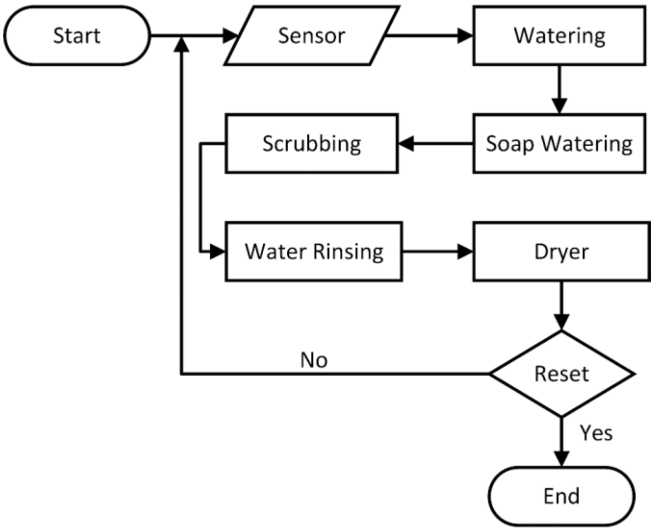

Fig. 2. Flowchart system

In Fig. 2 is a flowchart that explains the process stages that exist in a system. This automatic car wash system will start when it gets input from the entry of a car which will later be read by the sensor and the sensor will give instructions if there is a car then the water sprinkling process will run according to the time allotted, if the watering process is complete then the soap water sprinkling process will start. later it will be continued with the scrubbing process which is driven by the gearbox motor then when the process is complete it will be followed by the water sprinkling process as a rinsing process and followed by the drying process.

If all the processes have been completed then the next thing that works is the Timer on the PLC which later the system will detect the presence of the car, if the car is still there then the process will repeat itself and the process will run according to the previous process. And if the car has left, the sensor will detect the absence of a car, the process will stop and the system will reset itself. The use of PLC input and output on the PLC has several addresses connected to each actuator, as shown in Table 1.

Table 1. Address used

No	Address	Information	Function
1	3	Infrared Sensors	As a process of input / car reader
2	1.01	Relay1	Used for right motion gearbox motor
3	1.02	Relay2	Used for left motion gearbox motor
4	1.03	Relay3	Used for right motion pg28 DC motor
5	1.04	Relay 4	Used for left motion pg28 DC motor
6	1.05	Water Pump	Used for watering and rinsing processes
7	1.06	Soap Pump	Used for soap watering processes
8	1.07	Fan	Used for drying process

2.3. State Diagram

The following is a state diagram or diagram that is used to explain or describe system behavior. Fig. 3 is a state diagram of an automatic car wash and for an explanation of the state diagram shown in Table 2.

Table 2. Description of the state diagram

No	Symbol	Explanation
1	C	InsTruksi Counter
2	M1	DC motor (Motion to the right)
3	M2	DC Motor (Motion to the left)
4	P1	Water Pump
5	P2	Soap Pump
6	M3	Gearbox Motor (Motion to the right)
7	M4	Gearbox Motor (Motion to the left)
8	KA	Fan
9	T	Timer Instructions

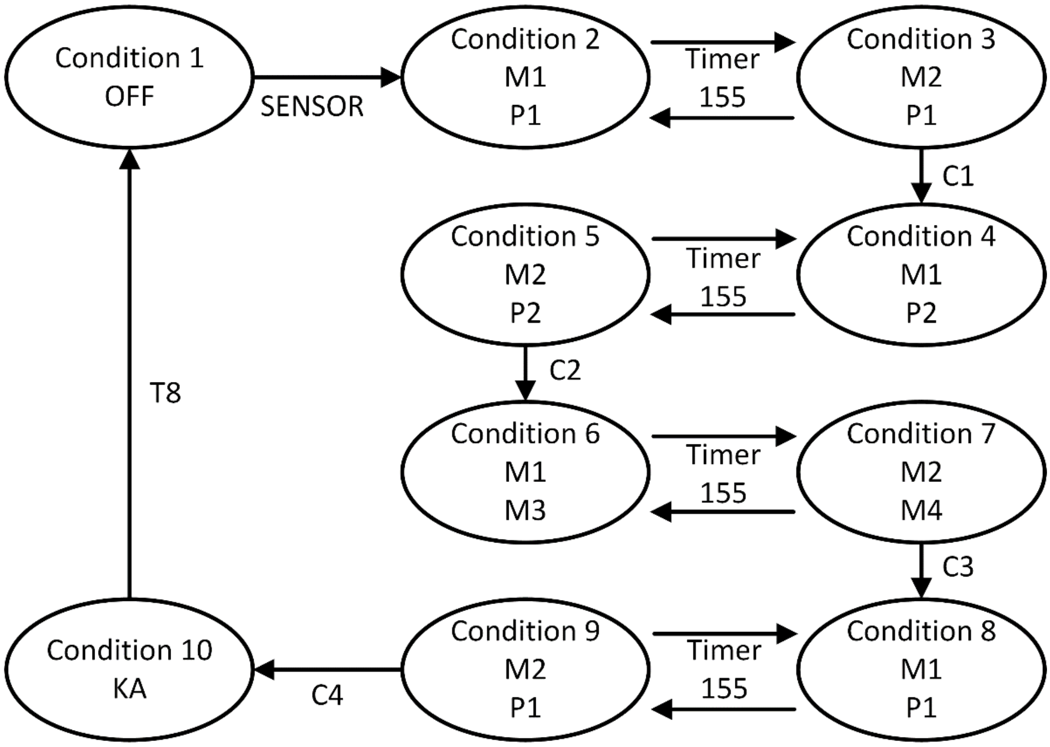

Fig. 3. State diagram

In Fig. 3 is a State diagram that is used to see conditions which will later show several working inputs and outputs and between one condition and another will be affected by instructions and input from programs and sensors. The use of the state diagram shows several processes which will later be packaged in the form of conditions where the reader can see the processes and input outputs that are working.

Condition 1 where all systems are not running and when the sensor gets a reading of the presence of a car, the sensor will move from condition 1 to conditions 2 and 3 where this condition is the water sprinkling process where M1&M2 and P1 will move alternately between conditions 2 and condition 3 with relative time given in each condition.

When condition 2 & condition 3 is complete, it will move to condition 4 and condition 5 which are moved by Counter1 where this condition is the soapy water sprinkling process where M1&M2 and P2 will move alternately between condition 4 and condition 5 with a relatively predetermined time in each condition.

When conditions 4 & condition 5 are completed, it will move to conditions 6 and condition 7 where this displacement occurs because the calculation process on C2 is complete. In condition 6 and condition 7, namely the scrubbing process where this process will run alternately which moves M1&M2 and M3&M4 where this process will move with the relative time that has been given.

When condition 6 and condition 7 are complete, it will move to condition 8 and condition 9 which are transferred to the C3 process which is complete where this condition is the water rinsing process where M1&M2 and P1 will run again, conditions 8 and condition 9 will move alternately with a relatively short time. has been determined.

When condition 8 and condition 9 are completed, it will move to condition 10 which is moved by C4 where condition 10 has a drying process where the train will run in condition 10 with the allotted time.

When all conditions have been completed, T8 will start working according to the time allotted. At T8 is the time used to wait for the car to come out of the wash. When T8 is finished and the sensor is still reading the whereabouts of the car, the process will repeat as before, if T8 is finished and does not read the whereabouts of the car, the process will finish and return to condition 1

2.4. System Wiring

Here is the wiring of a system designed to drive an automatic car wash. The use of inputs and outputs that are connected to each other is used to run the process. In designing the components, the address of the PLC is used as the actuator drive, namely 1.01 & 1.02 to drive the gearbox motor, addresses 1.03 & 1.04 are used to drive the PG 28 motor, water pump with address 1.05, soap pump using addresses 1.06 and 1.07 are used for the fan as a drying process.

Table 3. Cable colors

No	Cable Color	Information
1	Red	Positive Voltage
2	Black	Negative voltage
3	Blue	Output Relay
4	Yellow	Relay Wiring
5	Green	Sensor Data Cable

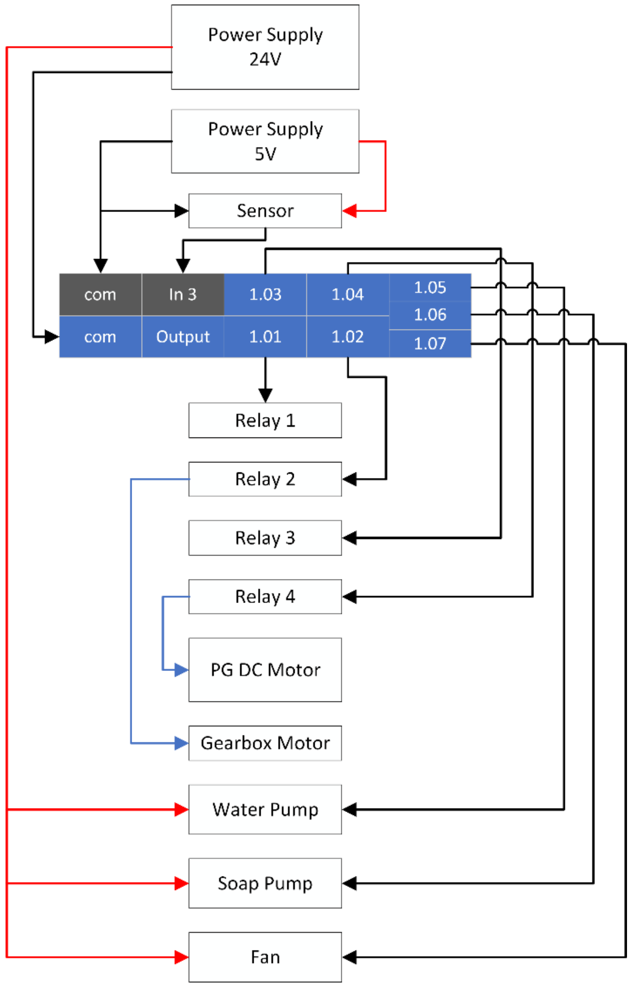

Fig. 3. Wiring System

In designing the wiring for this automatic washing prototype, it uses several input outputs and a PLC as a control. In this prototype installation, an infrared sensor is used to detect the presence of a car. By wiring, namely the negative and positive voltages connected to the 5v Power Supply and one data cable connected to the PLC analog input.

The use of a shinking circuit or what can be called an active low circuit is where it connects a negative voltage to the PLC com as a controller where the output address will give instructions to walk. In addressing the output, it uses several outputs, namely 1.01 & 1.02 as activators for relay1 and relay2 which will later drive the gearbox motor which is used as the scrubbing process, addresses 1.03 & 1.04 are used as drives for relay3 and relay4 where the relay will drive the pg dc motor as the prime mover of all processes. At address 1.05 it is connected to a water pump and gets a positive voltage from the power supply which will drive a pump that emits water as a watering and rinsing process, at address 1.06 it is connected to a soap pump where this pump is connected to a positive voltage from a 24v power supply and connected 24v negative voltage from the PLC which will turn on when it gets a control command from the PLC, the use of this soap pump in the prototype is used to spray soapy water as a soap spraying process. The use of address 1.07 is connected to a fan which will later be used as a car drying process where the fan is connected to a positive 24v voltage from the power supply and connected to a negative voltage from the PLC as a control.

2.5. 3D Design

The process of designing a tool cannot be separated from the components contained in the wiring diagram. The outer design of the prototype this time is made of acrylic with dimensions of 24cm in length, 15cm in width, 15cm in height. the actuators arranged in the prototype body are sensors, fans, gearbox motors, and PG28 DC motors.

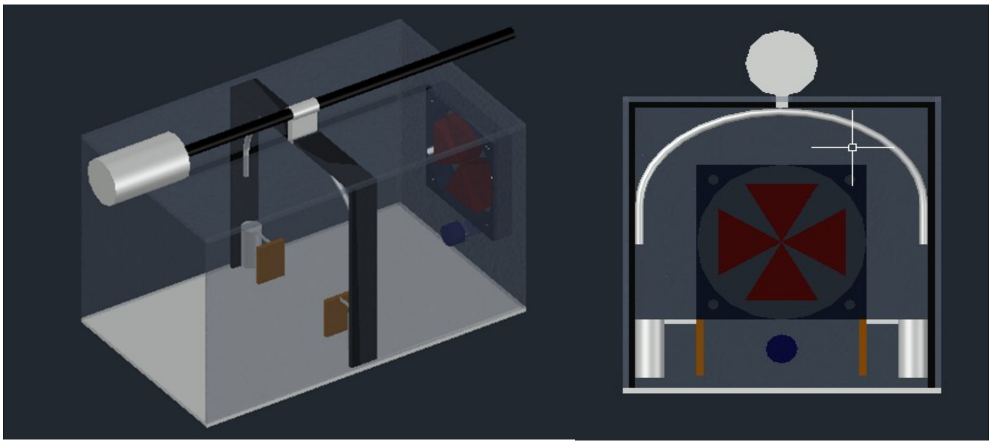

Fig. 4. 3D design

The prototype of this automatic car wash is designed to be as minimal and attractive as possible, with various actuators that are arranged on the body of the car. In Figure 2.5, the top part is designed to have a pg dc motor which is composed of a lead screw and connected to a hose carrier, which will move in CW & CCW manner. Later when the DC motor rotates, the leadscrew will carry a hose carrier that moves according to the predetermined installation. At the bottom of the hose carrier, 2 dc motors are installed which will move cw & ccw according to the wiring installation that has been designed to carry out the scrubbing process. At the front of the prototype this time a proximity sensor has been installed which will provide input that there is a car and the process will run and at the top of the sensor there is a fan which will carry out the drying process.

2.6. Software Design

Making the program using Cx-Programmer Software on this automatic washing prototype was made using the Ladder program. The workflow of this automatic car washing program will be more clearly seen in the flowchart arrangement. the system will be in the on state when it gets electric current and the MCB is ready to be turned on in the wiring installation.

The process will start running when the sensor on the prototype gets input in the form of an incoming car with a predetermined distance value, then the system runs according to the process given, namely the process of watering and then continuing with spraying soap. water sprinkling or the rinsing process and for the last, the drying process which will be dried using a fan that has been set at a time. If all processes have been completed, the process will repeat itself during the given time frame, the sensor is still reading the presence of the car. If the sensor does not read the presence of the car, the process will be complete.

In designing this software, two Cx-Programmer and Cx-Desaigner softwares are used where the Cx-Programmer software which has a connected Ladder program or program will be transferred to the Cx-Desaigner software that was previously designed. The use of these two software can be used simultaneously when the PLC is running the process.

3. Results and Discussion

In the results and discussion this time is divided into 5 parts hardware, software, sensor testing, relay testing and system wiring.

3.1. Hardware Manufacture

The hardware that is made is separated into the installation section and the prototype hardware testing results of this prototype have been prepared according to the build prototype design. As well as the installation part is arranged as simple as possible in order to reduce the capacity of the existing place. Building an prototype car wash is shown in Fig. 5 and installation system is shown in Fig. 6.

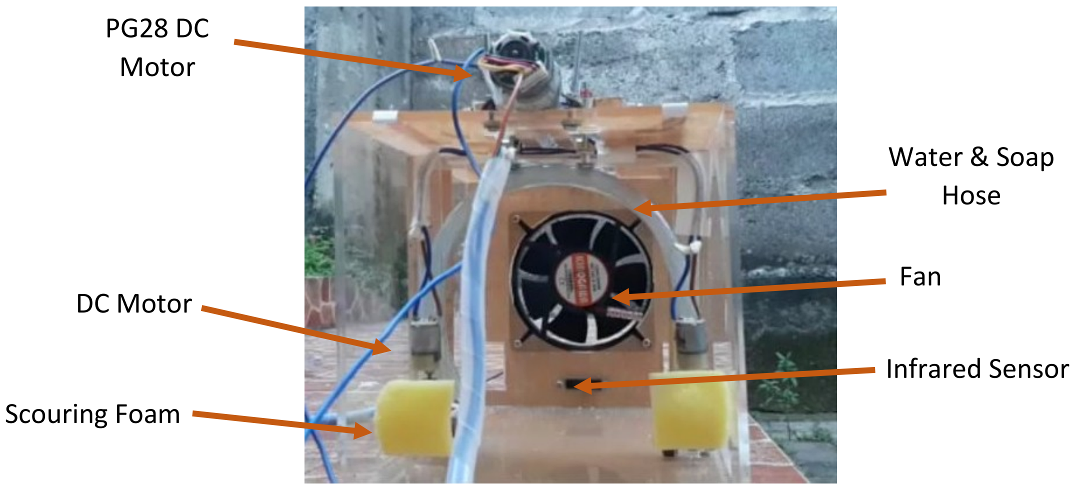

Fig. 5. Prototype design

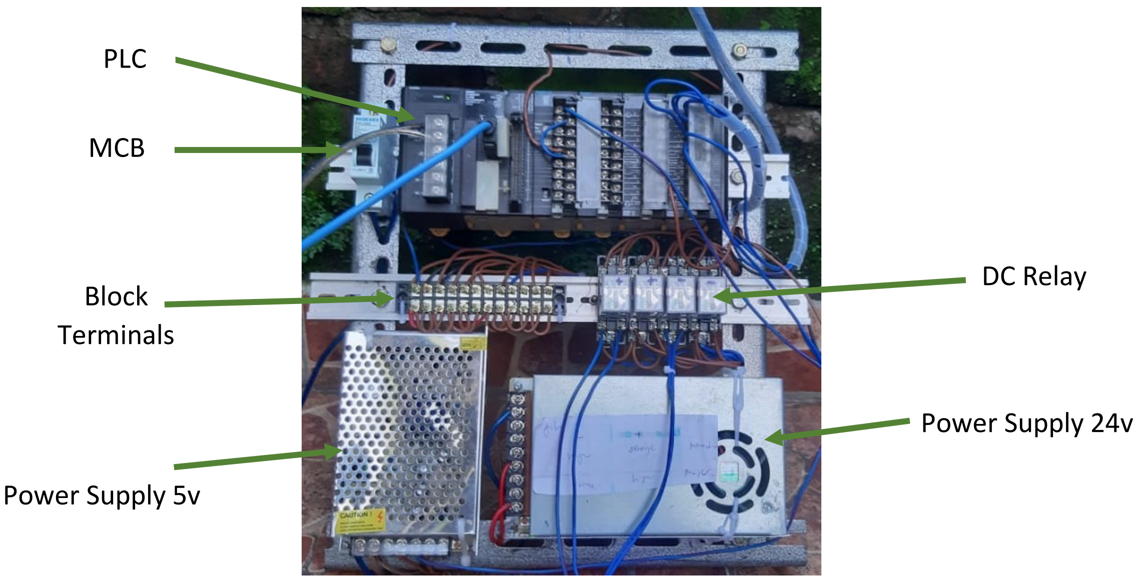

Fig. 6. Installation design

In Figure 3.2 the components are composed, namely PLC (Programmable Logic Controller), 5volt and 24volt Power Supply, 24 Volt relay and terminal block. In the use of PLC, Power Supply and relay used to run the automatic washing prototype this time using a shinking wiring installation, which means that the negative voltage is connected to the PLC while the positive voltage is directly connected to several actuators.

3.2. Software Tester

The results of the ladder program software test can be simulated in the CX-programmer software without errors. Also, the program can be transferred and used with the hardware of this automatic car wash prototype without control or error.

The use of CX-designer software is used according to the arranged input and output. The CX-designer is used to determine the input output that will work later and make it easier for users to monitor. Use of the CX-designer software can be transferred and can be run simultaneously with programs or hardware without error. The CX-designer design shown in Fig. 7.

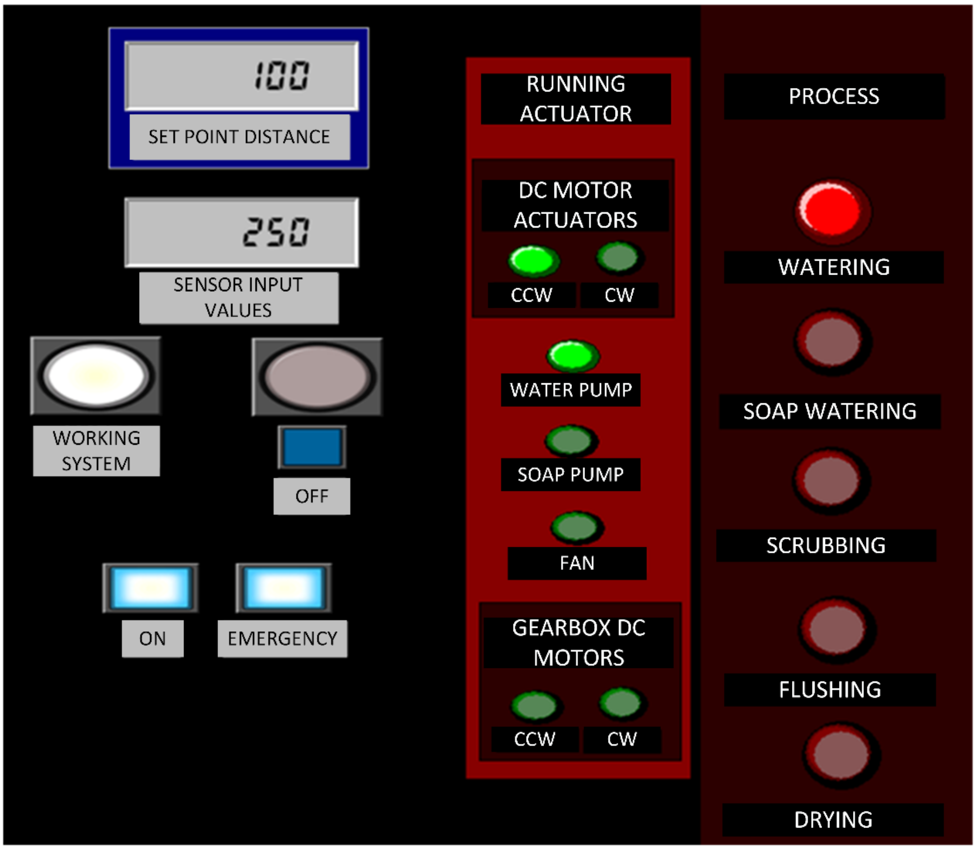

Fig. 7. Cx-desainer running

In Figure 3.3 is a Cx-designer image used to display the design or monitor several actuators that are lit. The use of this design consists of several buttons that are used to turn on and off the system. In this design series, it consists of two sets of values that are used to determine the running of the system with a given value or (Distance Set Point) and are used to read values from sensors that are read (Sensor Input Value). Each of the two set values can be determined by: manuals. In this series of designs displays the actuator that is running and displays the process that is being worked on.

3.3. Sensor Testing

The use of infrared sensors as car distance readers in cars can be used without errors. Retrieval of distance data that is read by the sensor is taken based on the value that often comes out. Value data along with the distance obtained from sensor testing can be seen in Table

Table 4. Sensor Value Testing

No	Distance (cm)	Experiment 1	Experiment 2	Experiment 3
1	50	44	40	44
2	45	90	103	115
3	40	130	142	142
4	35	162	170	160
5	30	192	193	192
6	25	231	231	224
7	20	285	292	303
8	15	380	376	420
9	10	556	580	557
10	5	548	594	621

In Table 4, the results of the use of infrared sensors are used as car input and controlled using a PLC. The use of the MOV instruction on the PLC is used to convert the values given by the sensor, where this MOV instruction functions to transfer data with a capacity of 1 word or equal to 16 bits, without changing the value read by the sensor and the value displayed by the MOV instruction in the form of decimals.

3.4. Relay Testing

The use of relays this time uses 4 relays and 3 motors, 1 PG 24V DC motor as the prime mover of this automatic washing prototype, and 2 gearbox type motors as polishers in the process. This PG DC motor uses 2 relays which are used to drive in reverse/forward. And when using a DC motor, the gearbox uses 2 relays as polishers so that it can work back and forth. The wiring circuit arranged to drive the motor back and forth is shown in Fig. 8.

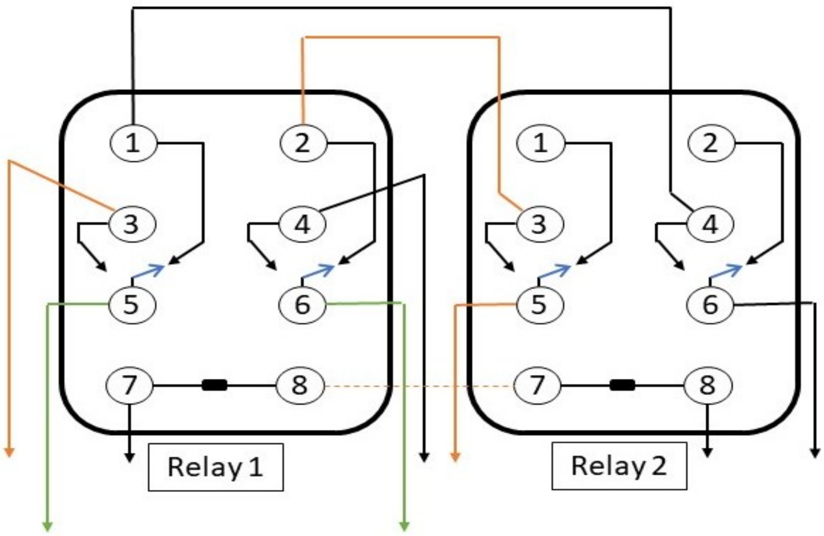

Fig. 8. Relay wiring

In Fig. 8 pin 8 on relay1 and pin 7 on relay2 are connected to a positive voltage from the power supply, and pin 7 relay1 and pin 8 relay2 are connected as input from the PLC. On relay 2 pin 5 is connected to positive voltage and pin 6 is connected to negative voltage from the power supply, while on relay 1 pin 3 is connected to positive voltage and pin 4 is connected to negative voltage.

The way these two relays work is that when pin 8 on relay2 gets input from the PLC, the blue coil will point towards pins 3 and 4, and proceed to outputs 5 and 6 on relay1 which previously had voltage from pins 5 and 6 of relay2 which each positively and negatively charged, so that way pin 5 on relay1 will be positively charged and pin 6 on relay1 will be negatively charged, so the motor will merge to the right. When pin 7 relay1 gets input from the PLC, the coil pins 5 and 6 will lead to pins

3 and 4 which are already connected with positive and negative voltages, then the results issued by the output pin 5 are positively charged and pin 6 is negatively charged and the DC motor will rotate to the left.

3.5. Program Memory Usage

The memory capacity used by the automatic car wash program is shown in Fig. 9.

Fig. 9. Memory view

Used UM is the amount of user memory used by the program. Free UM is the amount of user memory that is still available for use. Total is the sum of all user memory capacities.

Memory View is used to check the amount of used and free program memory in the PLC along with the total program memory size of the PLC. In order to show the correct amount of program memory size, the program must be uploaded to the PLC first. If the program has errors or errors, Memory View will display the words "estimate" which will be added at the end of each program size. The use of this automatic car wash memory uses a capacity of 7.3% of the total existing memory.

3.6. Time Measurement

The time measurement obtained is based on the running process on this automatic car wash prototype which aims to provide a difference in each Counter with a predetermined time. In this work, a counter is provided to count the movement of the DC motor and with different values and different results are obtained.

The timing given to the DC motor that moves CW or CCW is each given a time of 15ms which will later give time for each process, and the next process will be continued by the Counter which has finished running.

In this experiment, the processes that were calculated were the process of spraying water, spraying soapy water, scrubbing and rinsing. The time in the TIM instruction on the PLC is every 1 time which means it is equal to 0.1 second. The time formula that should be obtained from each process can be seen in Equation (1).

$$\big((15\ x\ 2) \times\ n\ (number\ of\ Counters)\big) \times 0.1\ =\ Result \qquad (1)$$

In equation (1) the value "15" is obtained from the set value timer that has been determined and multiplied by "2" because the Counter will count when the motor turns back and brings the hose carrier to its original place. The value "n" is obtained from the set value on the Counter that has been given and multiplied by "0.1" for the calculation to become a unit of time (seconds). Because the TIM instruction already has a multiplier value of "100ms". By using equation (1) a counter 5 trial calculation is carried out, the results of which are shown in Table 5.

Table 5. Counter trial 5

No	Calculated Process	The result of each process time (seconds)	The result of calculating the time with the formula (seconds)	Time difference (seconds)
1	Watering Water	13.54	15.00	01.54
2	Watering Soapy Water	11.99	15.00	03.01
3	Scrubbing	11.87	15.00	03.13
4	Water Flushing	11.91	15.00	03.09
	Average	**12.32**	**15.00**	**01.94**

In the calculation Table 5 the results of the time for each process are obtained from manual calculations using a stopwatch and the results of calculating the time using a formula using a formula that has been compiled based on the process that has been made. With the formula given ie

$$((15\ x\ 2)\ x5)\ x\ 0.1\ =\ 150\ Milliseconds.$$

$$or\ 150\ x\ 0.1\ =\ 15.00\ Seconds.$$

3.7. Time Charts

The time diagram generated from several input, output and memory data tests is shown in Fig. 9.

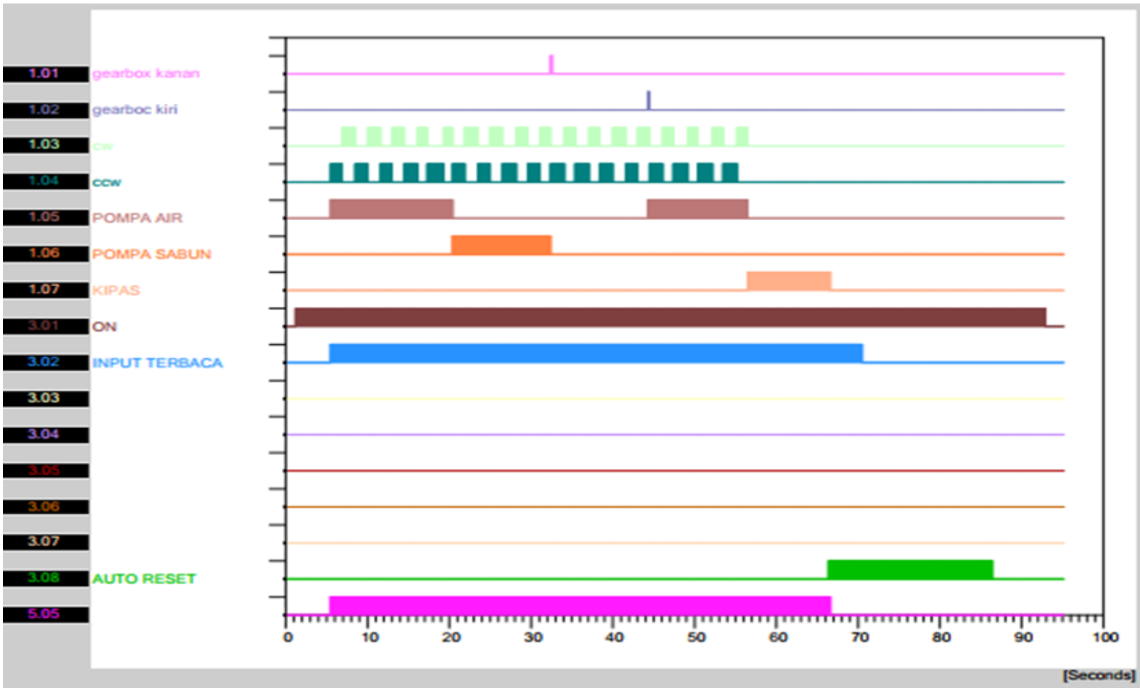

Fig. 10. Time chart I/O

Fig. 10 is a time diagram of the results of the program testing that has been made, in the figure it can be seen that several inputs and outputs are running according to the process during the specified timeframe. The test displays the process and step by step the program process is running. Addresses that do not show a timing chart are reset addresses. This test does not provide graphic information because the address entered is the reset address where the reset process will work when the process on timer T0008 has finished. And the time used to reset is very fast, therefore the process is not readable graphically.

4. Conclusion

Based on this research, it can be concluded that starting from program design to the hardware does not experience errors. The results obtained from the sensor test obtain variable values and can be accessed through the ladder program, and the use of 2 pumps and 2 dc motors and fans can run according to the given process. In the design of the wiring design and prototype design, there were a few mistakes and could be corrected. Then the use of Omron PLC can be applied in the design of this automatic washing prototype.

References

[1] M. I. Ansari, "BUMN dan Penguasaan Negara di Bidang Ketenagalistrikan," *Jurnal Konstitusi*, vol. 14, no. 1, pp. 104-123, 2017, https://doi.org/10.31078/jk1415.

[2] B. Maharmi, "Analisa Konsumsi Energi Listrik Rumah Dengan Kendali Otomatis," *SainETIn: Jurnal Sains, Energi, Teknologi, dan Industri*, vol. 2, no. 2, pp. 37–43, 2018, https://doi.org/10.31849/sainetin.v2i2.1622.

[3] Y. Efendi, "Internet Of Things (Iot) Sistem Pengendalian Lampu Menggunakan Raspberry Pi Berbasis Mobile," *Jurnal Ilmiah Ilmu Komputer Fakultas Ilmu Komputer Universitas Al Asyariah Mandar*, vol. 4, no. 2, pp. 21–27, 2018, https://doi.org/10.35329/jiik.v4i2.41.

[4] B. Prayitno and P. Palupiningsih, "Prototipe Sistem Monitoring Penggunaan Daya Listrik Peralatan Elektronik Rumah Tangga Berbasis Internet of Things," *PETIR (Jurnal Pengkajian Dan Penerapan Teknik Informatika)*, vol. 12, no. 1, pp. 72–80, 2019, https://doi.org/10.33322/petir.v12i1.333.

[5] A. Wahid, "Analisis Kapasitas Dan Kebutuhan Daya Listrik Untuk Menghemat Penggunaan Energi Listrik Di Fakultas Teknik Universitas Tanjungpura," *Jurnal Teknik Elektro Universitas Tanjungpura*, vol. 2, no. 1, 2014, https://jurnal.untan.ac.id/index.php/jteuntan/article/view/7674/7780.

[6] R. P. Gozal, A. Setiawan, and H. Khoeswanto, "Aplikasi SmartRoom Berbasis Blynk untuk Mengurangi Pemakaian Tenaga Listrik," *Jurnal Infra*, vol. 8, no. 1, pp. 39-45, 2020, https://publication.petra.ac.id/index.php/teknik-informatika/article/view/9753.

[7] J. Lianda, D. Handarly, and A. Adam, "Sistem Monitoring Konsumsi Daya Listrik Jarak Jauh Berbasis Internet of Things," JTERA (Jurnal Teknol. Rekayasa), vol. 4, no. 1, p. 79, 2019, http://dx.doi.org/10.31544/jtera.v4.i1.2019.79-84.

[8] I. S. Hudan and T. Rijianto, "Rancang Bangun Sistem Monitoring Daya Listrik Pada Kamar Kos Berbasis Internet of Things (IoT)," *Jurnal Teknik Elektro*, vol. 8, no. 1, pp. 91–99, 2019, https://ejournal.unesa.ac.id/index.php/JTE/article/view/25791.

[9] T. Tanto and D. Darmuji, "Penerapan Internet of Things (IoT) Pada Alat Monitoring Energi Listrik," *Jurnal Elektronika Listrik dan Teknologi Informasi Terapan*, vol. 1, no. 1, pp. 45–51, 2020.

[10] Z. Salam and K. M. Salim, "Generation of Pulse Width Modulation (PWM) Signals for Three-Phase Inverter Using a Single-Chip Microcontroller," *Jurnal Teknologi*, vol. 34, no. D, pp. 1–12, 2012, https://doi.org/10.11113/jt.v34.643.

[11] R. Sulistyowati and D. D. Febriantoro, "Perancangan Prototype Sistem Kontrol Dan Monitoring Pembatas Daya Listrik Berbasis Mikrokontroler," *Jurnal IPTEK*, vol. 16, no. 1, pp. 24-32, 2012.

[12] S. Anwar, T. Artono, N. Nasrul, D. Dasrul, and A. Fadli, "Pengukuran Energi Listrik Berbasis PZEM-004T," In *Prosiding Seminar Nasional Politeknik Negeri Lhokseumawe*, vol. 3, no. 1, pp. 272–276, 2019.

[13] B. B. Dahlan, "Sistem Kontrol Penerangan Menggunakan Arduino Uno Pada Universitas Ichsan Gorontalo," *ILKOM Jurnal Ilmiah*, vol. 9, no. 3, pp. 282–289, 2017, https://doi.org/10.33096/ilkom.v9i3.158.282-289.

[14] M. Hayaty and A. R. Mutmainah, "IoT-Based electricity usage monitoring and controlling system using Wemos and Blynk application," *Jurnal Teknologi Dan Sistem Komputer*, vol. 7, no. 4, pp. 161–165, 2019, https://doi.org/10.14710/jtsiskom.7.4.2019.161-165.

[15] V. C. Damayanti, "Rancang Bangun Sistem Pengunci Loker Otomatis Dengan Kendali Akses Menggunakan Rfid," *Politek. Negeri Sriwij.*, vol. 1, no. 1, pp. 33–41, 2017.

[16] F. Muallifah, “Perancangan Dan Pembuatan Alat Ukur Resistivitas Tanah,” *Jurnal Neutrino: Jurnal Fisika dan Aplikasinya*, vol. 1, no. 2, pp. 179–197, 2009, https://doi.org/10.18860/neu.v0i0.1629.

[17] A. D. Pangestu, F. Ardianto, and B. Alfaresi, “Sistem Monitoring Beban Listrik Berbasis Arduino Nodemcu Esp8266,” *Jurnal Ampere*, vol. 4, no. 1, pp. 187-197, 2019, https://doi.org/10.31851/ampere.v4i1.2745.

[18] A. Pratama, A. A. N. Amrita, and D. C. Khrisne, “Rancang Bangun Sistem Monitoring Listrik Tiga Fasa Berbasis Wireless Sensor Network Menggunakan LoRa Ra-02 SX1278,” *Majalah Ilmiah Teknologi Elektro*, vol. 20, no. 2, pp. 351-360, 2021, https://doi.org/10.24843/MITE.2021.v20i02.P20.

[19] Y. Esye and S. Lesmana, “Analisa Perbaikan Faktor Daya Sistem Kelistrikan,” *Jurnal Sains & Teknologi Fakultas Teknik*, vol. 11, no. 1, pp. 103–113, 2021.

[20] R. S. V. Simbar and A. Syahrin, “Prototype Sistem Pendeteksi Darah Menggunakan Arduino Uno R3,” *J. Teknol. Elektro, Univ. Mercu Buana*, vol. 8, no. 1, pp. 80–86, 2017.

[21] B. B. H. Siahaan, S. R. Akbar, and D. Syauqy, “Implementasi Modul Antarmuka Perangkat Sensor Dan Komunikasi Pada Uart Dan I2C Dengan Fitur Plug And Play,” *Jurnal Pengembangan Teknologi Informasi dan Ilmu Komputer*, vol. 2, no. 9, pp. 2712-2720, 2018.