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Smart Home using PLC

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***Abstract*- In the present work, attempt has been made to automate the home with minimal human interference by using the programmable logic controller. The purpose of this paper is to utilize the advanced technologies effectively to make home more comfortable, secure and sophisticated. This paper is to develop a self-governing system in home such as lights control, fan control, water tank level maintenance, garden watering, security system, heater, air conditioners, automatic car garage with the use of sensors and PLC. This paper gives a solution for senior and disabled people in controlling the home appliances and also it improves the standard of their daily life.**

***Keywords*- Home Automation, Delta PLC, Sensors, Security System, Ladder diagram.**

I. INTRODUCTION

Nowadays the lifestyle of the people has changed tremendously, people prefer more sophisticated, secure and luxury life. In 21st century there is a rapid development in the field of automation technologies and electronic gadgets. The home automation concept has emerged in the early 1980's with the use of relays and followed by microcontrollers. The main drawback of relay is that they are hardwired and very difficult to troubleshoot and in the case of microcontrollers it is difficult for altering the existing system i.e. changing or increasing the number of inputs and outputs. In this paper, the programmable logic controller is used to achieve home automation. The PLC is a solid state device and it is easy to program and reprogram any number of times, altering or increasing the input and output modules is possible, troubleshooting is quiet easy, can work in all environment conditions. This paper presents the design and implementation of various systems in home such as lights control, fan control, water tank level maintenance, garden watering, security system, heater, air conditioners, and automatic car garage with the use of PLC. Smart home using PLC is all about making the home automate. For a home to be smart it needs information, this information is in the form of programs and commands comes from the user, but often it will be controlled directly i.e. real time information from our home using sensors and used for automation function.

II. METHODS AND MATERIALS

The different type of components used for controlling the entire system/process (lights control, fan control, water tank level maintenance, garden watering, security system, heater, air conditioners and automatic car garage) is discussed in this section.

A. Programmable Logic Controller

The programmable logic controller that I have used in his research work is DVP14SS2 controller shown in figure 1, manufactured by Delta and the controller is programmed by using WPLSoft 2.41 software. And the controller having following specifications shown below

Specifications:

I/O ports: 14 (8inputs + 6outputs)
Max I/O ports: 494 (14 + 480)
Program capacity: 8k steps
Operating voltage: 24V
Communication port: Built in RS-232

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Figure 2: DVP-SS2 Controller

B. System Description

The block diagram of the smart home using PLC is shown in below figure 2

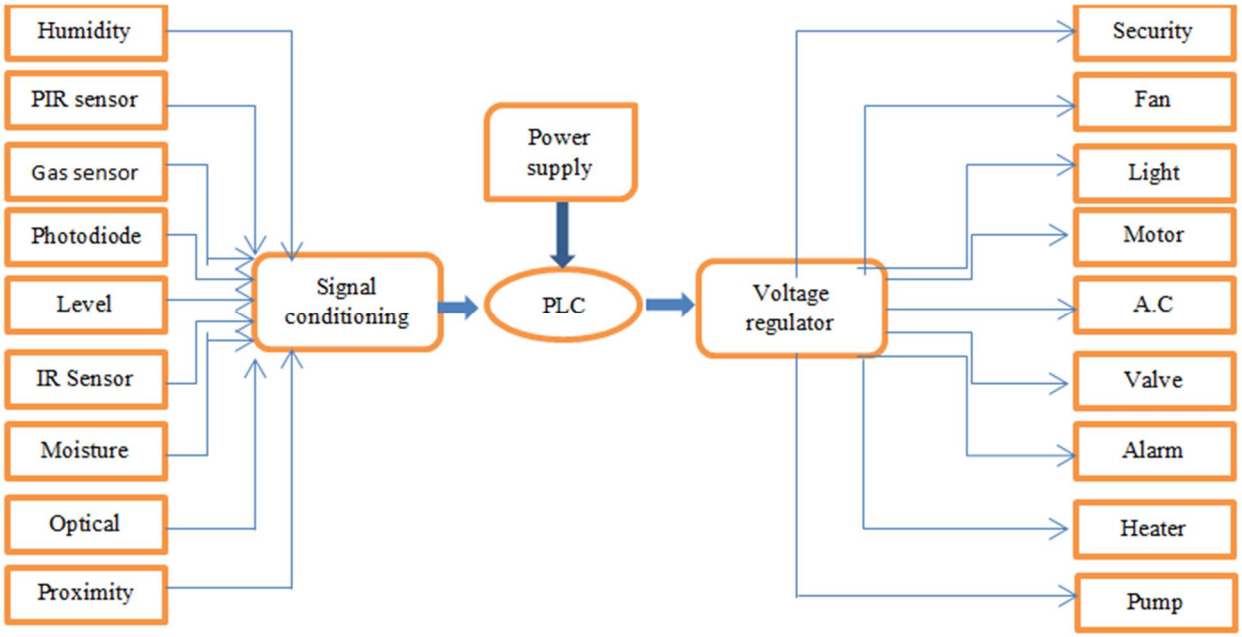


Figure 2: Block diagram of PLC based Smart Home System.

C. Sensors

Sensors are the foundation stone of any home automation system. Smart home is achieved by using the data, directly collected by the sensors listed below.

1. *Passive Infrared Sensor:* It is the most common type of motion detector technology used for domestic automation system. The PIR sensor works by detecting changes in infrared light radiations within its field of vision. In this paper PIR sensor is used for security system. This sensor is placed around the house and it informs the programmable logic controller which triggers a burglar alarm if movement is detected when it is supposed to be empty.
2. *Ultrasonic Sensor:* It is similar to PIR sensor in terms of technology, but the ultrasonic sensor is with a higher resolution. It is used for controlling the lighting, Air conditioner and fan by sensing whether the living room is occupied or not. The ultrasonic sensor identifies the presence of a person in the room just by sending high frequency sound wave in the area and will the reflected pattern, if it changes continuously then it informs the controller.
3. *Photoelectric sensor:* It is used to monitor the ambient light levels and report them back to the controller. In this paper the photoelectric sensor is used in conjunction with an occupancy sensor to switch lights automatically when someone enters a room, but only if they needed. And it is also used for outdoor lighting.
4. *Optical sensor:* It uses the light beams and intimates the controller and the alarm is triggered if particles of smoke interrupt the

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beam. This is the most common type of fire alarm sensor, and this sensor is installed in each and every part of the house except the kitchen.

5. *Heat sensor:* It detects the anomalous temperature and it is fitted in and around the kitchen. So that this will not be activated by smoke from frying things, but still it can detect fire on time and inform the controller which activates the alarm.
6. *Proximity sensor:* Switches are replaced by the proximity sensors so that by just waving the hand the respective system turns on. In this paper the proximity sensor is used for switching the fan in the living room. And the sensor is also used as a security system in car garage.
7. *Contact sensors:* They are used in windows and doors. When the windows are opened the Air conditioner automatically turns off to save energy. And in doors this sensor is used as a part of security system. When the sensor is turned ON and if the door is opened then it automatically triggers the alarm.
8. *Moisture sensor:* This sensor is just pushed into the soil in the garden. This soil moisture sensor determines the moisture content in the soil by measuring the resistance of the soil. The data collected is used to automate the watering of plants in the garden.
9. *Level sensors:* Level sensors are used to indicate the water present in the tank. Based on than data, the controller switches the water pump. Two sensors high level and low level are placed in top and bottom of the tank respectively.
10. *LPG gas sensor:* The LPG gas sensor is used as a part of safety system. It detects the presence of LPG gas in the required area. In this paper this sensor is fitted in the kitchen. Sensor detects the LPG gas by a chemical reaction that takes place when the gas comes in direct contact with the sensor and if there is a leak the sensor is activated and informs the controller.
11. *Temperature and Humidity Sensor:* It gives us the temperature and relative humidity at the same time. It is used to automatically control air conditioners or de-humidifiers. The humidity sensor uses capacitive measurement technology to determine air humidity.
12. *Limit Switch:* It is used in car garage shutter to know the upper and lower limits of the shutter. It is an electromechanical device that consists of an actuator mechanically linked to a set of contacts and when an object comes into contact with the actuator, the device operates the contacts to break or make an electrical connection.

III. SMART HOME SYSTEM OVERVIEW AND DISCUSSION

In this section we discuss about the various types of input and output and how they are controlled, conditions for performing the specific task and the ladder diagram for that task is being discussed. And the input and output coil description are shown in Table 1

Inputs	Tasks	Inputs	Tasks	Outputs	Tasks
X0	Push button (Start Entire system)	X12	Moisture sensor	Y0	Fan
X1	Push button (Stop Entire system)	X13	Proximity sensor (Car Garage entry)	Y1	Light
X2	Ultrasonic sensor	X14	Photoelectric sensor (Car Garage entry)	Y2	Light (Outdoor)
X3	Proximity sensor (Room)	X15	Limit switch	Y3	Air conditioner
X4	Photoelectric sensor (House)	X16	Limit switch	Y4	Water Pump
X5	Photoelectric sensor (Outdoor)	X17	IR Sensor	Y5	Solenoid valve
X6	Temperature & Humidity Sensor	X20	Proximity sensor(Car Garage exit)	Y6	Motor (Car garage)
X7	Contact Sensor (Window)	X21	Optical sensor	Y7	Motor (Car garage)
X10	Low level sensor	X22	Heat detector	Y10	Alarm (Fire)
X11	High level sensor	X23	LPG gas sensor	Y11	Alarm (Gas Leak)
X26	Contact sensor	X24	Push Button (ON)	Y12	Alarm (Thief Intrusion)
X27	PIR sensor	X25	Push Button (OFF)		

Table 1: Input and Output Coil Description

A. Lighting Control

The indoor lighting is controlled with the use of ultrasonic sensor and photoelectric sensor. When both the sensors are turned ON (activated) then only the light is switched ON by the plc. Suppose if any one sensor is inactive then the lights are switched OFF by

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the PLC. The ultrasonic sensor detects for the presence of humans, is yes then it sends signals to the PLC likewise the photoelectric sensor checks the ambient light level, if it is below the preset value then the sensor informs the PLC and it switches ON the light. The outdoor lighting is switched by the PLC using the photoelectric sensor (outdoor) data. The ladder diagram of lighting control is shown in figure 3(a), (b), (c), (d), (e).

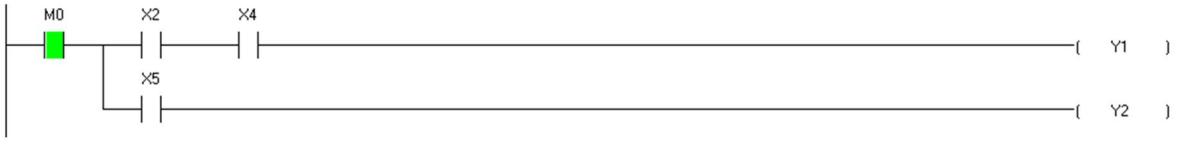


Figure 3(a): Ultrasonic and Photoelectric sensor is inactive, so light is OFF



Figure 3(b): Ultrasonic is ON but photoelectric sensor is OFF, so light is OFF

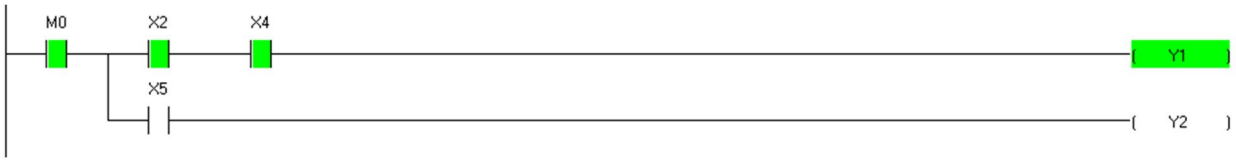


Figure 3(c): Ultrasonic and Photoelectric sensor is ON, so light (Indoor) is ON

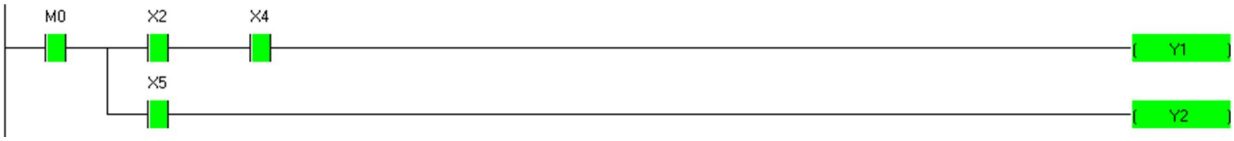


Figure 3(d): Ultrasonic and both Photoelectric sensors are ON, so both lights (indoor, outdoor) are ON

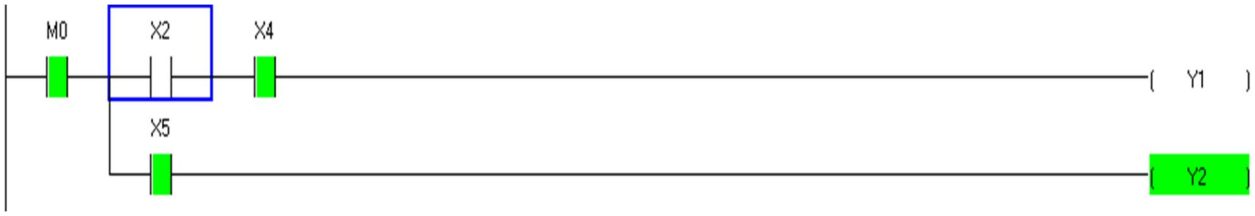


Figure 3(e): Ultrasonic, Photoelectric (indoor) is OFF and photoelectric (outdoor) is ON, so light (outdoor) is ON

B. Controlling Fan

The fan is controlled with the use of proximity and ultrasonic sensor. The fan is turned ON by the PLC only when both the sensors are activated. And switched OFF automatically when any one of this sensor is inactive. The ladder diagram of fan control is shown in figure 4(a), (b), (c).

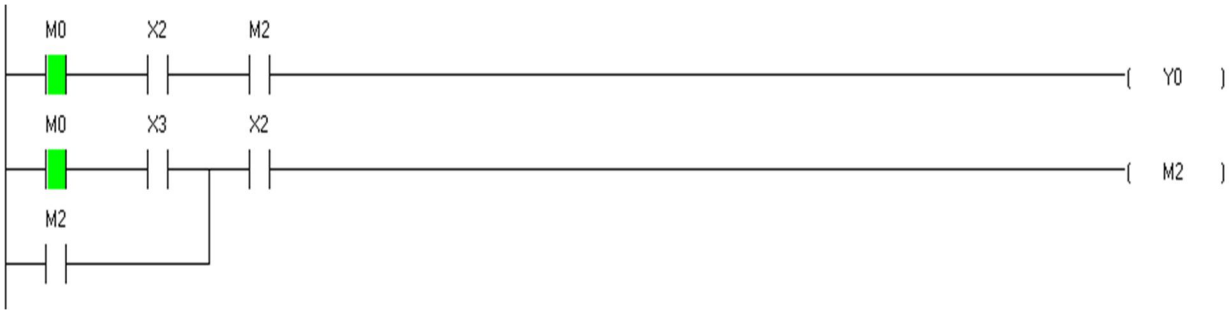


Figure 4(a): both proximity and ultrasonic are OFF, so Fan is OFF

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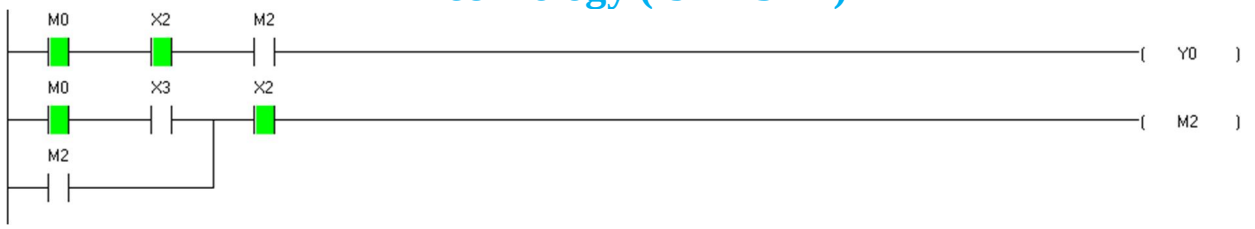


Figure 4(b): proximity is OFF but ultrasonic is ON, so Fan is OFF

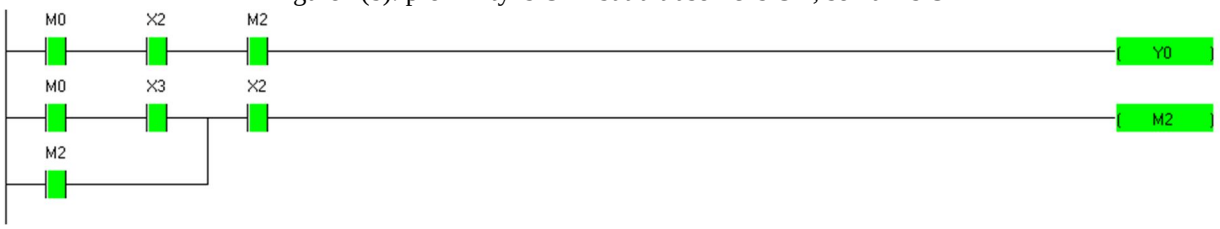


Figure 4(c): both proximity and ultrasonic are ON, so Fan is ON

C. Air Conditioner

The air conditioner is controlled with the use of ultrasonic sensor and combined temperature, humidity sensor. The air conditioner is switched by the PLC, if both are active then it is ON, if any one of them is inactive then it is switched OFF by the PLC. The ladder diagram of Air conditioner control is shown in figure 5(a), (b), (c), (d).



Figure 5(a): ultrasonic and combined temperature, humidity sensor is OFF, so A.C is OFF

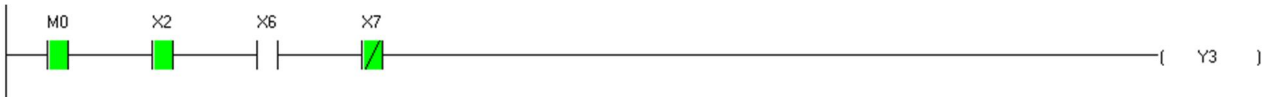


Figure 5(b): ultrasonic is ON but combined temperature, humidity sensor is OFF, so A.C is OFF



Figure 5(c): ultrasonic and combined temperature, humidity sensor is ON, so A.C is ON



Figure 5(d): ultrasonic and combined temperature, humidity sensor is ON but window is open, so A.C is OFF

D. Garden watering Control

The watering of plants in the garden is done with the use of data collected by the soil moisture sensor. The sensor sends the signal to the PLC if the moisture level is below the predefined value. The PLC turns on the Solenoid Valve. If the required value is obtained then the sensor is inactive, hence the PLC switches OFF the solenoid valve. The ladder diagram of garden watering is shown in figure 6(a), (b), (c).



Figure 6(a): soil moisture sensor is OFF, so solenoid valve is OFF

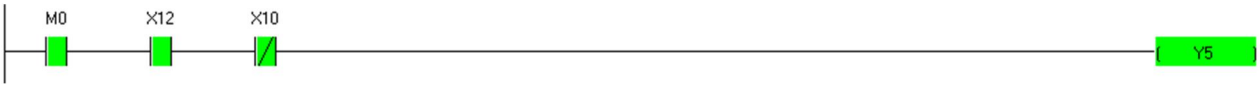


Figure 6(b): soil moisture sensor is ON, so solenoid valve is ON



Figure 6(c): soil moisture sensor is ON but low water level sensor (Tank) is ON, so solenoid valve is OFF

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E. Automatic Control of Water Pump

The water pump is turned ON/OFF by the PLC based on the data from the High level sensor and Low level sensor placed inside the water tank. The PLC turn ON the water pump only when the Low level sensor is ON and turns OFF only when the High level sensor is ON. The ladder diagram of automatic control of water pump is shown in figure 7(a), (b), (c).

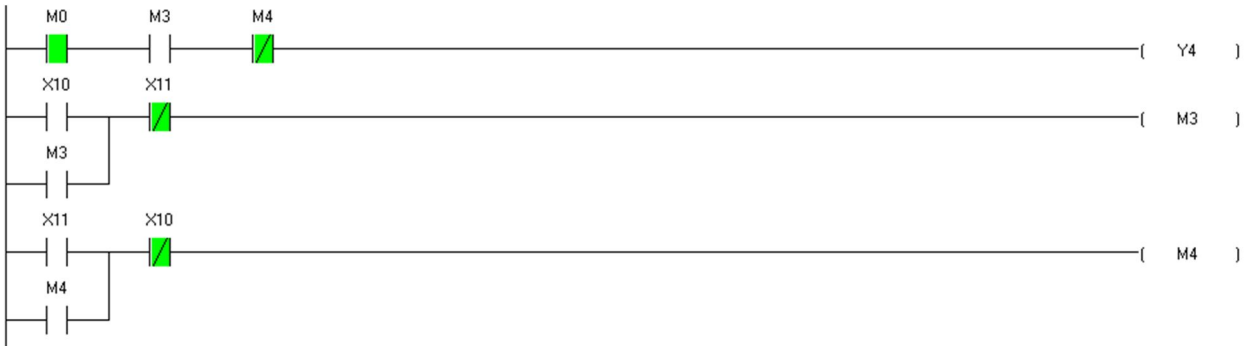


Figure 7(a): both low level and high level sensor are OFF, so water pump is OFF

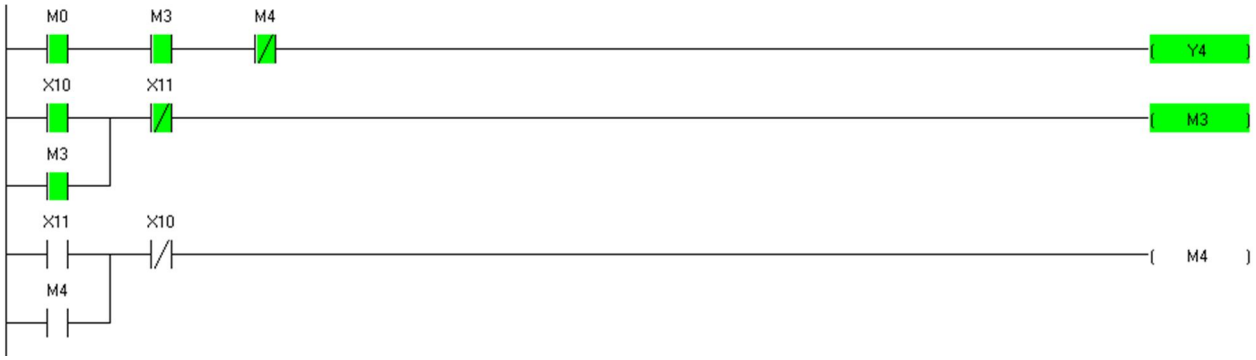


Figure 7(b): low level sensor is ON and high level sensor is OFF, so water pump is ON

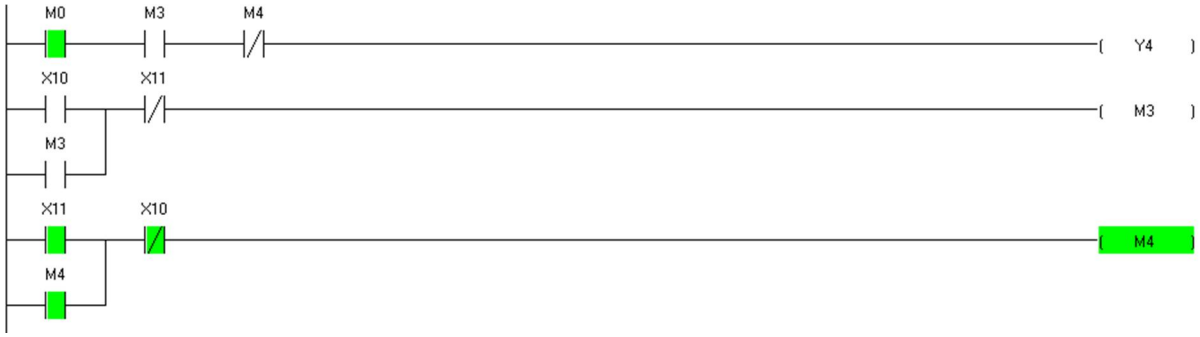


Figure 7(c): low level sensor is OFF and high level sensor is ON, so water pump is OFF

F. Security system

1) Fire alarm is triggered by the PLC when the optical sensor or the heat detector is activated. The ladder diagram is shown in figure 8(a)

2) Gas leak sensor is activated if it found the traces of LPG gas in the air. And the PLC immediately triggers the alarm. The ladder diagram is shown in figure 8(b)

3) Theft alert Siren is switched by the PLC when someone tries to open the main door without permission when it is locked. The contact sensors are used to collect the data. The ladder diagram is shown in figure 8(c), (d)

4) Unknown Intrusion alert siren is switched by the PLC when the passive infrared sensor (PIR) is activated. This system ensures that no one enters the compound when it is supposed to be empty. If someone enters it then the sensor is activated. The ladder diagram is shown in figure 8(c), (d)

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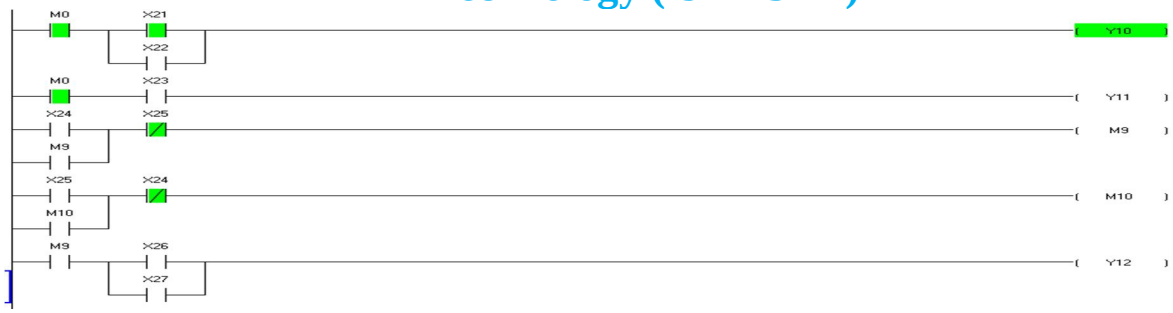


Figure 8(a): Optical sensor is ON, so Fire alarm is ON

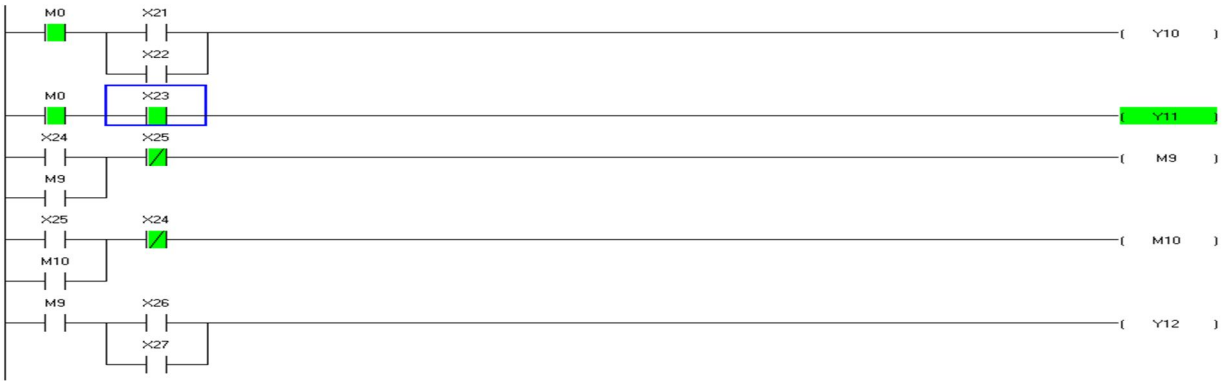


Figure 8(b): Gas detector is ON, so Alarm is ON

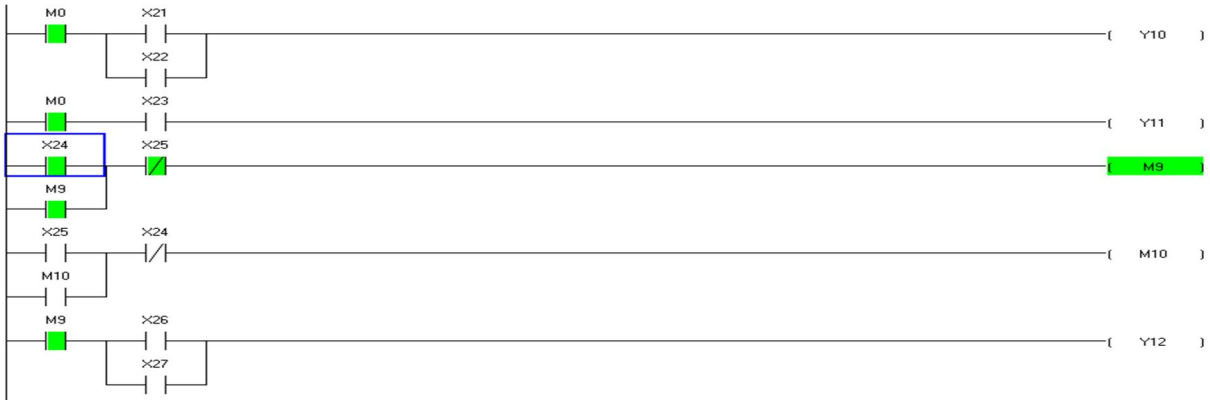


Figure 8(c): Theft alert and unknown intrusion button is turned ON

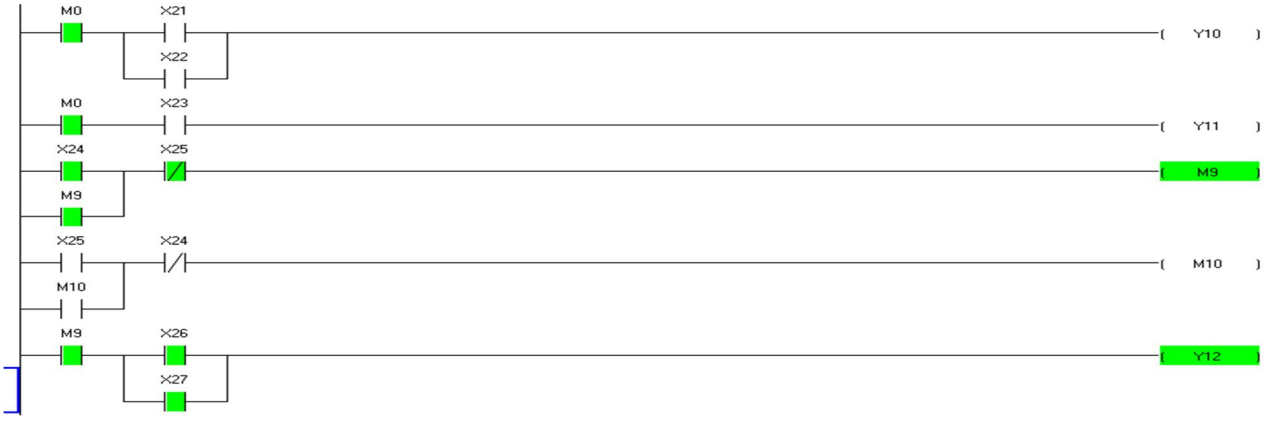


Figure 8(d): Security pushbutton is ON and both Contact, PIR sensor are ON, so security siren is ON

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G. Automatic Car Garage Security system

The automatic Car Garage security system consists of two proximity sensors one for entry and another for exit both are placed outside the car garage left and right side respectively, photoelectric sensor placed outside the garage shutter, IR sensors are placed inside the car garage, two limit switches high and low are placed at the top and bottom of the shutter respectively. And motors are used for opening and closing of the shutter. When a car arrives near the garage shutter the driver wave his hand in front of the proximity sensor. And the sensor is activated which in turn activates the timer. The password I have set to open the garage in this paper is that the driver should flash the light 5 times within 20sec if it is done the counter activates the motor and the shutter opens. The motor rotates till the high level limit switch is turned ON. And when the car is parked inside the IR sensor is activated. And the PLC switches ON the motor to close the shutter. The motor rotates till the low limit switch is turned ON.

To take the car out of the garage, the IR sensor will be turned off when the car is reversed lightly. Hence the motor is switched ON automatically and opens the garage. Motor rotates till the high limit switch is turned ON. Again when the driver waves his hand in front of the proximity sensor an it turns ON the motor to close the shutter. The motor is ON till the Low limit switch is turned ON. The ladder diagram of automatic car garage system is shown in figure 9.

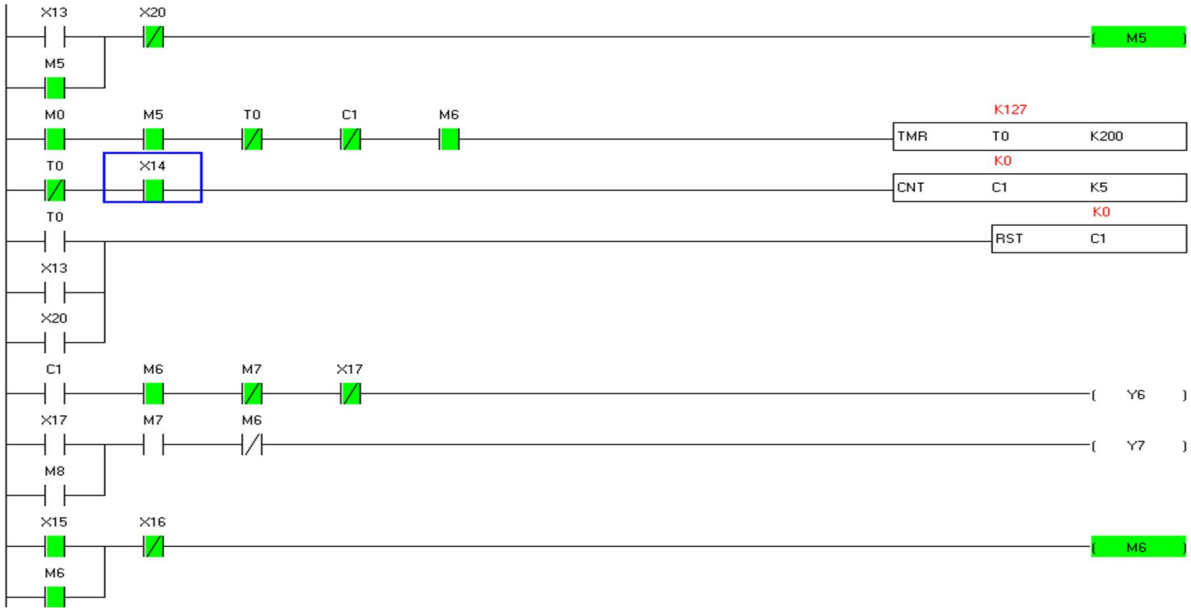


Figure 9: The Ladder diagram of automatic car garage system.

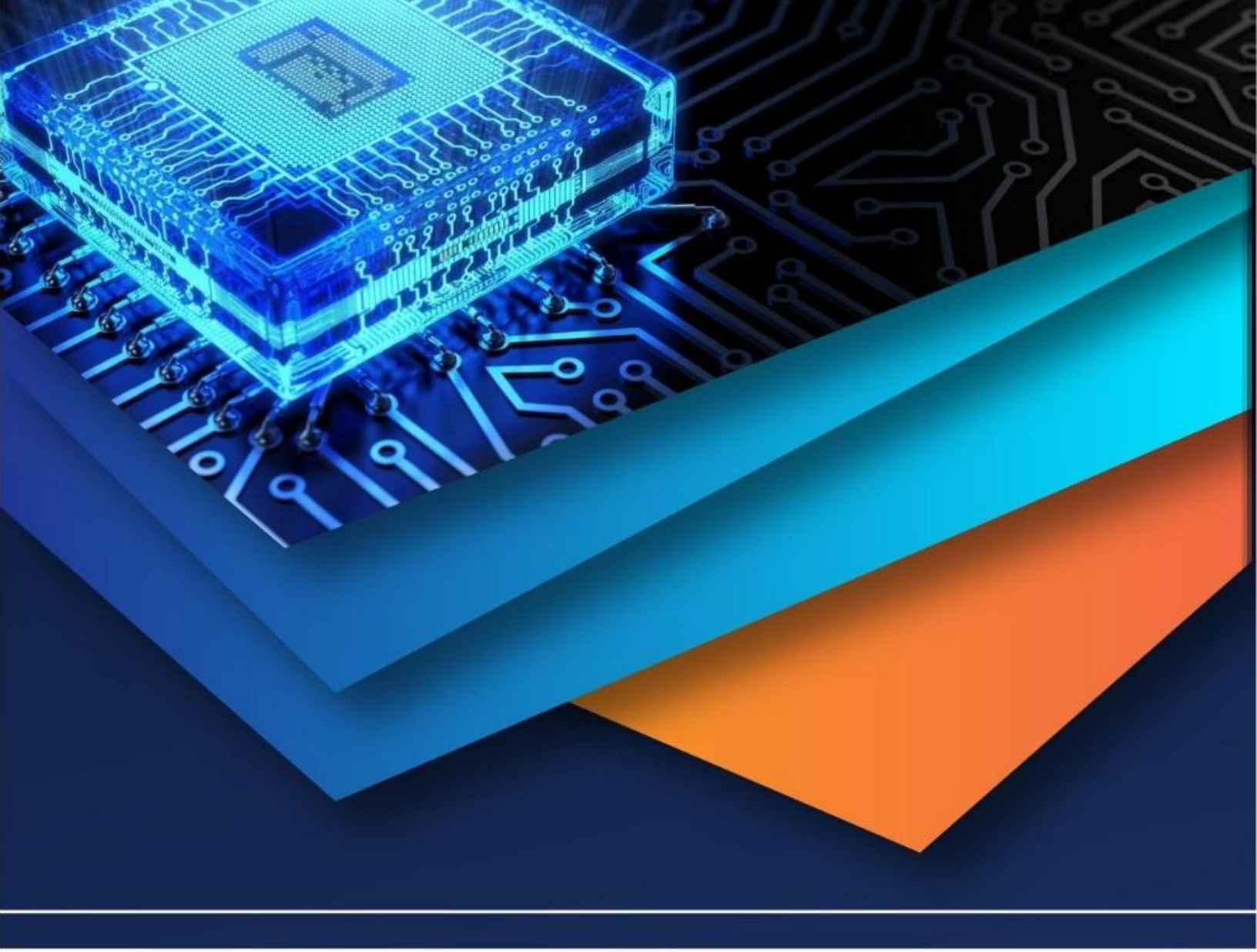
IV. CONCLUSION

The smart home system has been successfully designed and stimulated using WPLSoft software. The entire control of inputs and the outputs is carried out by the PLC. The PLC controls the outputs with the help of data from the sensors. The smart home system is more advantageous for senior, disabled people and also for those people who prefer luxury. By using PLC the entire system is compact and can alter/ add the inputs and outputs easily whenever it is required.

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