

## A Novel Prototype Model for PLC Based Intelligent Garage

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**Abstract:** Nowadays, a huge number of people are using cars every day. In big cities, parking spaces have become a very big problem and people need to save time by avoiding looking for parking areas. Parking cars in the streets are not safe and this is one of the main problems facing the people. One particular solution is the automobile turntable, which has been used successfully in a variety of applications, including commercial and residential. The intelligent garage is useful for people to park their cars and leave cars safe and secured. There are many systems introducing smart parking but they have many problems. The proposed system will solve most of those problems. Programmable Logic Controller (PLC) issued to control operation in the intelligent garage system. The DC motor will take the car up or down and park it in the empty slots. SCADA [ Supervisory Control and Data Acquisition ] system will be used to monitor the status , faults, and alarms in the garage to avoid any problems.

**Keywords and Abbreviations:** Programmable Logic Controller (PLC), Supervisory Control and Data Acquisition (SCADA), Variable Frequency Drive (VFD), Infra Red (IR), Power Over Ethernet (POE), Direct Current (DC), Distributed Peripherals (DP),

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### I. Introduction

Now, the urban land has become more scarce and expensive. So, for the parking, the traditional manual management mode that has low land utilization must be changed in order to decrease building area and enhance land utilization. For this purpose, this Paper proposes a solution based on using PLC and SCADA to control the garage parking system [1]. It is an integrated electromechanical System based on an architectural structure composed of a number of floors and each floor is composed of a number of rooms. The idea of this intelligent system spins around moving the cars automatically without any human intervention. After stopping the car owner to his vehicle and supplying his own code via smart HMI screen the role of the PLC will be started to drive the car to migrate to the available room and slots. The system will be responsible for printing the bill and has the possibility to call the car through the mobile. Many applications introduced before to solve parking problems but those applications use smart parking by guiding people to empty spaces to leave their cars. These applications cannot solve parking problems and need huge areas to build the garage. Example on these applications, a novel approach of lift control in automatic car parking using PLC [2], Intelligent Car Park Management System using Wireless Sensor Network [3], PLC based on automatic multistoried car Parking system [4] and Smart car parking using PLC and SCADA [5].

### II. Plc-Based Control System For Intelligent Garage.

#### II.1. System Design.

The intelligent Garage uses the Programmable Logic Controller (PLC) VIPA 318-C serial products of VIPA as a main control device, and the Human machine Interface (HMI) touch panel to collect the location information when picking or parking the car. After a code being calculated by VIPA 318-C, a control signal will be transmitted to relay for moving the parking platform to the assigned location.

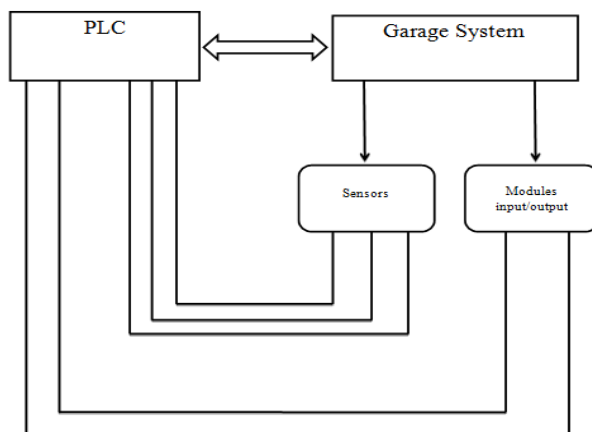


Fig 1: Main Block diagram for intelligent Garage

As shown in Fig.1, this system needs (PLC) VIPA 318-C to control the operation in the garage. The VIPA PLC is composed of many hardware modules as processor, power supply, memory, input, output and special purpose modules [6]. A programmable logic controller (PLC) is an advanced PC utilized for mechanization of expert electromechanical procedures. It could be viewed as an expert PC which has a focal handling item, memory, input-yield programming and an encoding gadget. The central dealing with unit supplies the brains of the controller. It permits data, position information from various distinguishing devices like limit switches, closeness switches, executes an individual control program set away in the memory and gives appropriate yield rules to contraptions, for instance, solenoid valves, switches, heaters, pumps, and motors. There are many types of PLC in a market as Siemens, Allen Bradely, Mitsubishi , Ge Fanuc ,...etc. In our proposed system, VIPA318-C PLC is used with Sematic step 7 programming tool .

## II.2. Hardware and Software Requirements

### II.2.1. VIPA Programmable logic Controller

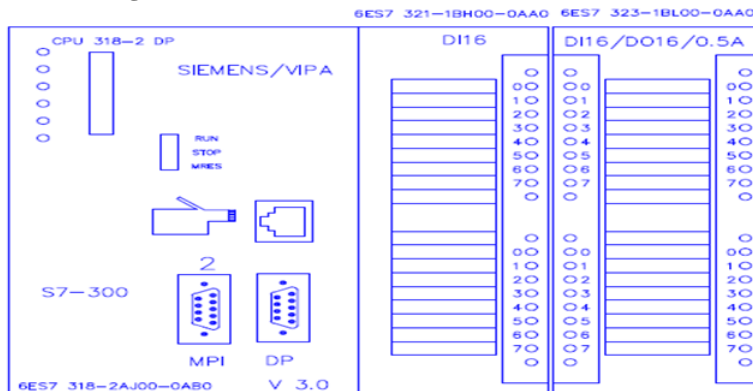


Fig 2: VIPA control processing unit (CPU)

Figure 2 shows the VIPA communication, VIPA has two communication ports, MPI and Profi-bus. MPI used in limited and small distances but Profi-bus is used in big distances. MPI Speed works between 19,2/38.4 kB to 187,5 KB, with a PC adapter on COMx port of the PC,. The MPI port can be setup at 12 MB as a Distributed Peripherals (DP) port. Profi-bus can be used at 12 MB with the same PC adapter although generally, they work at 1.5 MB. Maximum distance between MPI stations and the repeater is 500m [7].

VIPA318-C has Ethernet communication used to ensure data transfer capacity. Power Over Ethernet (PoE) is used to convey control for little switches so that electrical power wiring shouldn't be conveyed for the endpoint [8].

### II.2.2. Power supply

The power supply is very important part of PLC because it will supply energy to the PLC and it will change 220v alternative current (AC) to 24v.

### II.2.3. Input/Output Modules

Input and output modules are a very important components in the PLC to communicate with the external field. There are different types of input and output modules like digital inputs, digital outputs, analog inputs, and

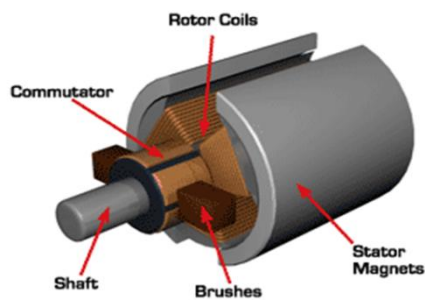
analog outputs. In the proposed system digital inputs, digital outputs, analog inputs, analog outputs and special purpose modules are used. Digital Modules are used for limit switches and pressure switches but analog modules are used to know the number of the floors and where the car will be parking. Racks and front connectors will be used to connect the power supply and the PLC modules

#### **II.2.4. Pneumatic system**

This system is based on using the air pressure .In the proposed system many pneumatic components should be used as TieRod Cylinder, Directional Valve, Flow Control and limit switches. As per the cost analysis, the cost of these items are very high . An alternative system based on using DC motors will be used replacing the pneumatic system to minimize the prototype model cost. This system is based on using an electrical signals not an air pressure as in the Pneumatic system. The stepper motor is used to rotate the plate in a circular way and reach the car to the empty slot. The plate will sense that the car is stopped on it by the sensor then the sensor will send a signal to the PLC .The PLC accordingly will send a signal to the stepper motor to move the plate.

#### **II.2.5. DC motor**

DC motor is used to convert the electrical power to mechanical power. DC motors were the essential sort comprehensively used since they could be energized by existing direct-current lighting power appropriation frameworks. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the nature of the current in its field windings. The approach of drive contraptions has made supplanting of DC motors with AC motors possible in various applications [9]. Figure 3 shows the components of the DC motor.



**Fig 3:** Components of the DC motor.

#### **II.2.6. Limit switches:**

Limit Switches are electro-mechanical devices that consist of an actuator mechanically linked to a set of contacts. When an object comes into contact with the actuator, the device operates the contacts to make or break an electrical connection. In the proposed system, limit switches are used for start and end points. Limit switches are a practical solution for sensing in most situations. Mechanical limit switches can be found in any industrial or commercial application where detection or safety is needed [10].

#### **II.2.7. Proximity switches**

The sensors provide excellent results even with difficult-to-detect objects. In the proposed system, proximity switches are used to sense the movement of the plate. Devices are available with (Normally close) N.C. or (Normally open) N.O. functions with a metal connector that can be tightened securely with a protector cord [10].

#### **II.2.8. Contactors**

Contactors can also refer to the specialized socket that connects the device under test. A contactor is an electrically controlled switch used for switching an electrical power circuit, similar to a relay except with higher current ratings and a few other differences. A contactor is controlled by a circuit which has a much lower power level than the switched circuit. Contactors range from those having a breaking current of several amperes to thousands of amperes and 24 V DC to many kilovolts[10].

#### **II.2.9. Other hardware Components**

In addition to the above mentioned main hardware components the following items will be used in the proposed systems:

- Gear box
- Robot wheel

- LEDs with green light
- LEDs with red light
- Relays

**II.3. Software Components:**

In the proposed system, SIMATIC STEP7 is used for programming the PLC and WINCC flexible will be used for the SCADA system.

**II.3.1. Simatic Step 7**

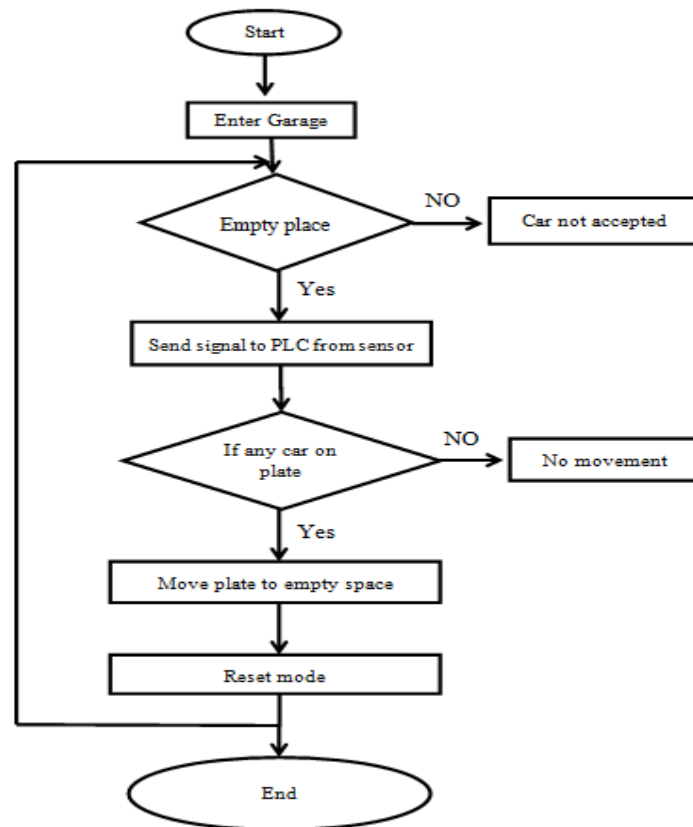
This software will be used to configure and program the PLC. STEP 7 is the standard software package used for configuring and programming SIMATIC programmable logic controllers. It is part of the SIMATIC industry software [1].

**II.3.2. SCADA**

It is an object oriented graphical user interface used for supervisory monitoring and process control. The executive interfaces which permit watching and the issuing of process rules, for instance, controller set up point changes, are managed through the SCADA supervisory PC structure. The SCADA idea started as a general method for far off access to various adjacent control modules that could be from different creators allowing access through standard robotization traditions. In the proposed system WINCC SCADA is used to monitor the car ports in all zones [9].

**II.4. Operation Sequence**

The proposed system has many rules to serve people clearly. When people needs to leave their cars in the garage in case of an empty place, the car would accept. Sensors send signals to PLC. If there is no car on the plate, the lift will not be moving. In case of having car on the plate, the sensors will send signal to PLC to start moving the lift to the selected empty space. Three motors are used in the design to cover the following functions: In/Out , UP/ Down and Rotation. Figure. 4 describes the flow chart for intelligent Garage System. When the SIMATIC software runs without any problems and accept the code without any errors then the code will be downloaded to the programmable logic control (PLC). After that, if the code contains any faults or force on any tags of inputs or outputs, the PLC will give warning by lighting the LEDS. In case, if the PLC did not give any warning, the code will start the operation



**Fig 4 :** Flow chart for the Sequence of Operation

### III. System Commissioning and Testing

Figure 5 shows the snap shots for the proposed Prototype model during testing operation . The test is started by checking the mechanism for the motors and the movement of the plates up and down. second stage for testing is to check all parking slots and the action taken by the PLC for each parking slot.



Fig 5: Testing Stage

Figure 6 demonstrates the final architectural design of the proposed system and shows how this system works with PLC. Also it demonstrates the mechanism and shows the communication between sensors, motors, and PLC.

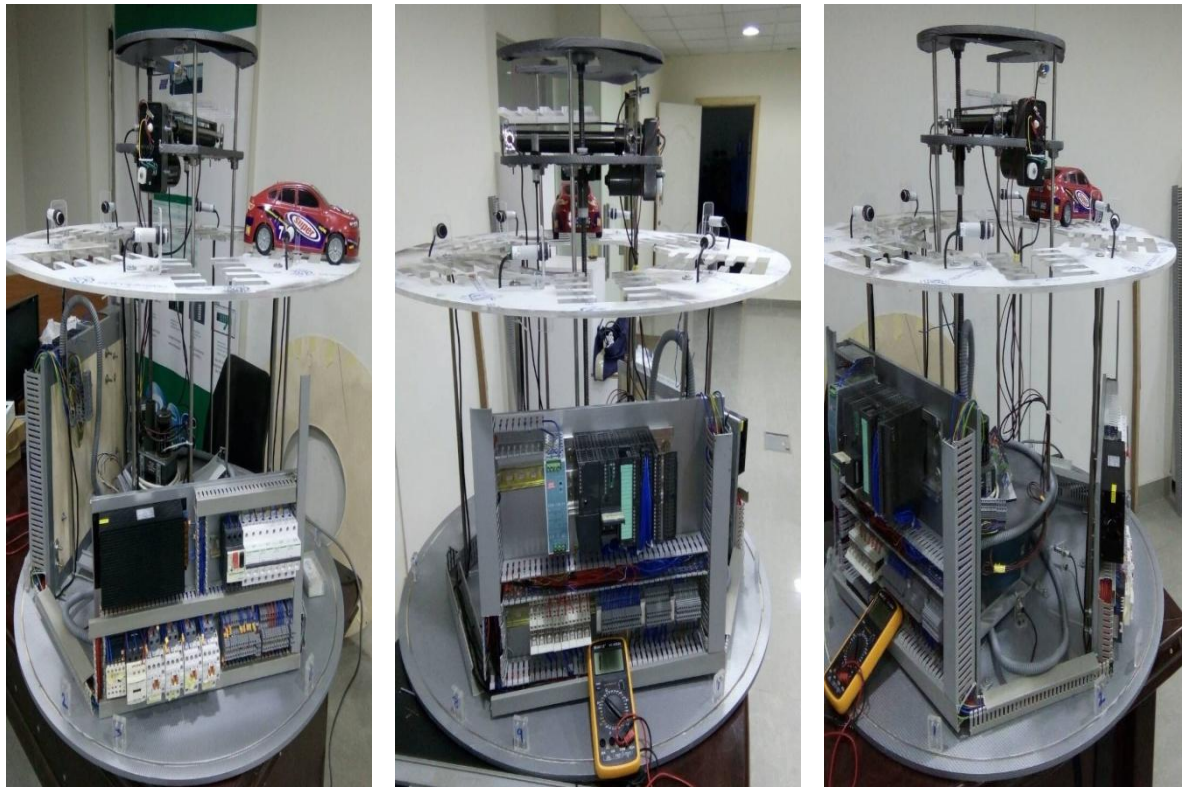


Fig 6: Final Architectural Design for Intelligent Garage

### IV. Cost Analysis

Table 1 shows the economic analysis of the proposed Intelligent Garage System prototype model. The total cost of the system using DC motors is 1980\$ compared with 2050 \$ in case of Pneumatic System as shown in table 2.

**Table.1** Cost Analysis For Motor Based Garage System

Name	Quantity	Price	Total
Power supply	3	28\$	84\$
Gear box	1	34\$	34\$
Contactora 5A	3	17\$	51\$
Limit switch	6	17\$	102\$
Light Barrier	9	13\$	117\$
Inductive Proximity switch	10	17\$	170\$
LED with green light	11	12\$	132\$
LED with red light	7	10\$	70\$
Robot wheel	7	10\$	70\$
relay	4	5\$	20\$
Sum	61\$	163\$	850\$
CPU 318	1	850\$	850\$
6ES7392-1BM01-0AA SIMATIC S7-300, FRONT CONNECTOR FOR SIGNAL MODULES WITH SPRING CONTACTS, 40-PIN	1	60\$	60\$
6ES7 323-1BL00-0AA Digital I/O module DI16 24 V + 16DO 24 V / 0.5 A	1	200\$	200\$
6ES7392-1AJ00-0AA0 SIMATIC S7-300, FRONT CONNECTOR FOR SIGNAL MODULES WITH SCREW CONTACTS, 20-PIN	1	20\$	20\$
Total			1980\$

**Table.2** Cost Analysis For Pneumatic Based Garage System

TieRod Clinder Q 40x 500mmClinder	1	80\$
mini Clinder Q25x250mm	1	50\$
mini Clinder Q20x50mm	2	90\$
directional valve 3/2 with 2 coil 24Vdc	1	80\$
directional valve 5/3 with 2 coil 24Vdc (1/4)	1	80\$
directional valve 3/2 with 1 coil 24Vdc	1	70\$
flow control	6	190\$
pressure measurement	1	80\$
pressure switch	1	100\$
compressor AIR	1	100\$
Total	16	920\$
CPU 318	1	850\$
6ES7392-1BM01-0AA SIMATIC S7-300, FRONT CONNECTOR FOR SIGNAL MODULES WITH SPRING CONTACTS, 40-PIN	1	60\$
6ES7 323-1BL00-0AA Digital I/O module DI16 24 V + 16DO 24 V / 0.5 A	1	200\$
6ES7392-1AJ00-0AA0 SIMATIC S7-300, FRONT CONNECTOR FOR SIGNAL MODULES WITH SCREW CONTACTS, 20-PIN	1	20\$
Total		2050\$



## V. Conclusion and Future work

Intelligent Parking Systems using automation are very useful for people especially in the crowded countries. So, people in big countries should encourage this investment. Intelligent parking is very secure for cars and driver and doesn't need any humans interference. In this paper a newly proposed Intelligent Garage system has been introduced. The proposed system is PLC based control using DC motors, switches, LEDs, relays, contactors, and SCADA systems for supervisory monitoring. The future work will include adding more functions to the system to increase the reliability. One of the functions is booking remotely an empty space at a specific time.

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