CHAPTER THREE

PARKING AND GATE CONTROL SYSTEM DESCRIPTION AND STRUCTURE

3.1 Parking and gate control system description

The parking and gate control system using Programmable logic controller (PLC) has used ladder diagram for two reversible 24V DC motors to change the directions dc motor right and left, one of them to control the entrance gate situation and anther to exit gate. Both gates come with feedback sensors to indicate the presence of a car. If the reversible 24V DC motor is rotate at clockwise it move the entrance gate to up position and allow car to enter the parking, if the DC motor is rotate at anti clockwise it move the entrance gate to down position and not allow to enter the parking. In this model instead of use two reversible 24VDC motors we used 2 LEDs indicators for each motor because it is not available in local market.

When a car enter the entrance gate the PNP proximity switch senses it and changes status from 0 to 1 and send signal 1 to the PLC to illuminates entrance green led indicator, this situation represented the entrance gate opened and when a car enter the parking the PNP proximity return to previous status and entrance red led indicator illuminated to represented the exit gate is closed. This status a will in HMI screen a bear this status in sub screen entrance and exit gate.

The parking system uses six green led to indicate the parking availability according to slot status by using six limits switch The model consist two level-1 and level-2 each level consists of three slots, when a car parks in the slot it makes the limit switch ON and green led indicates the slot is occupied.

The parking system using PLC also has used another human machine interface (HMI) system to guide drivers to park in suitable slot, to tell them the parking is occupied according to the parking availability, start and stop system, levels status and entrance and exit status.

3.2 parking and gate control system structure

The model of parking and gate control system using PLC and HMI contains five main subsystems as shown in block diagram in finger (3.1), the first subsystem is programmable logic controller, the second subsystem entrance gate, the third subsystem is exit gate, the fourth subsystem is parking building structure and the fives is HMI monitor.

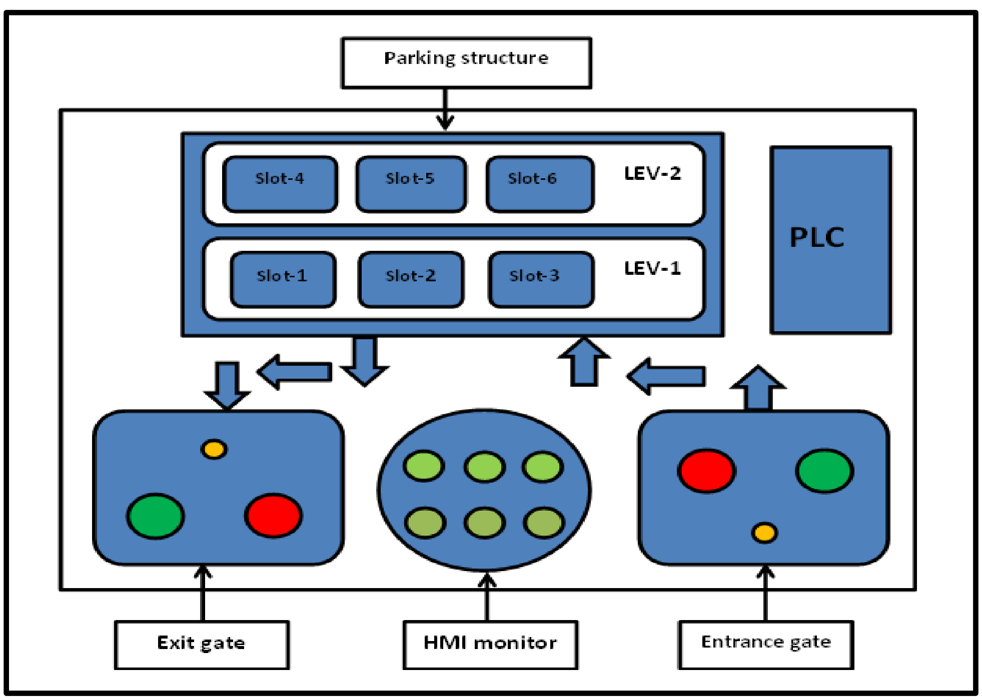


Figure (3.1): parking and gate control system structure

3.2.1 Programmable logic controller

The SIMATIC S7-300 PLC is the member of the SIMATIC S7 family of programmable controllers. There are twenty S7-300 CPU types:

- Six compact CPUs (with integrated technology functions and I/O)
- Three redesigned standard CPUs (CPU 312, CPU 314, CPU 315-2 DP)
- Five standard CPUs (CPU 313, CPU 314, CPU 315, CPU 315-2 DP, CPU 316-2 DP); superseded in the medium-term by redesigned standard CPUs
- One standard CPU 315F-2 DP
- Four SIMATIC S7-300 Outdoor CPUs (CPU 312 IFM, CPU 314 IFM, CPU 315-2 DP)
- One standard CPU 318-2 DP

The simaticS7-300 PLC has many types of digital input and output module such as SM 321(DI 64 x 24V, DI 32 x DC24V, DI 32 x AC120V, DI 16 x DC24V) and analog input and output module such as SM 331(AI 8 x 16 Bit, AI 8 x 16 Bit, AI 8 x 14 Bit High Speed, AI 8 x 13 Bit). The simaticS7-300 PLC has many types of power supply module such as PS 307-2A, PS 307-5A, PS 307-10A and PS 305-2A. The objectives of programmable logic controller are monitors inputs, make decisions based on its program, and controls outputs to automate a process [12].

3.2.1.1 PLC S7-300, CPU315-2 PN/DP features

The CPU 315-2 PN/DP is a CPU with a medium-sized program memory. It is used in installations which have distributed automation structures in addition to a centralized I/O as shown in block diagram in finger (3.2).

The CPU 315-2 PN/DP is an ideal platform for simple technology tasks implemented in software.

The CPU 315-2 PN/DP is equipped with the following:

- Microprocessor.
- 128 KB RAM.
- Flexible expansion, up to 32 modules.
- Combined MPI/DP interface.

Figure (3.2): Siemens SIMATIC S7-300-CPU315-2 PN/DP

This model has variety a range of features to aid in designing a cost-effective automation solution. The following table (3.1) provides a summary of the major features [12].

NO	Features	Description
1	**Supply voltage**	
	• 24 V DC	Yes
	• permissible range, lower limit (DC)	20.4 V
	• permissible range, upper limit (DC)	28.8 V
2	**Current consumption**	
	• Inrush current, max.	25 A
	• Current consumption (idling), type	100 mA
	• Power dissipation, typical	3.5 W
3	**Data areas**	
	• Bit memories	2048 bytes
4	**Address areas**	
	• I/O Address area	2kB
	• Process I/O image	128 / 128
	• Digital channels	16.384
	• Analog channels	1024
5	**CPU processing times**	
	• For bit instruction, min. • for word instruction, min	0.1 µs 0.1 µs
6	**S7 Counters**	
	• Number	256

7	**Counting range**	
	• lower limit to upper limit	0 to 999
8	**S7 times**	
	• Number	256
9	**Time range**	
	• lower limit	10 ms
	• upper limit	9,990 s
10	**Memory**	
	• Working memory: ▪ Integral ▪ Expandable • Load memory ▪ Pluggable ▪ Pluggable (MMC), max.	128 KByte NO Yes 8 MByte
11	**Dimensions and weight**	
	Width	Width
	80 mm	80 mm
	Depth	Depth
	130 mm	130 mm
12	**Configuration**	
	• Racks max.	4
	• Modules per rack, max	8
	Functionality	
	MPI multiple	Yes

13	▪ Number of connections	16
	DP master	Yes
	DP slave	Yes
	Point-to-point connection	No

Table (3.1): CPU315-2 PN/DP features

3.2.1.2 Power supply module PS 307-2A

The load power supplies PS 307 converts the line voltage (120/230 V AC, 24 - 110 V DC) to 24 V DC operating voltage and are mounted on the SIMATIC S7-300 mounting rail. The PS 307 modules provide 24 V DC power supply for: distributed I/O, sensors and actuators. Versions for output currents of 2 A, 5 A and 10 A are available. In this model we select PS 307-2A as shown in figure (3.3) .For dimensioning of the load power supplies, the required aggregate current (e.g., supply of digital outputs etc.) has to be taken into account [12].

- **Properties of power supply module PS 307-2A**

- Output current 2A.
- Output voltage 24 VDC; short circuit-proof, open circuit-proof.
- Connection to single phase AC mains (rated input voltage 120/230 VAC, 50/60 Hz).
- May be used as load power supply [12].

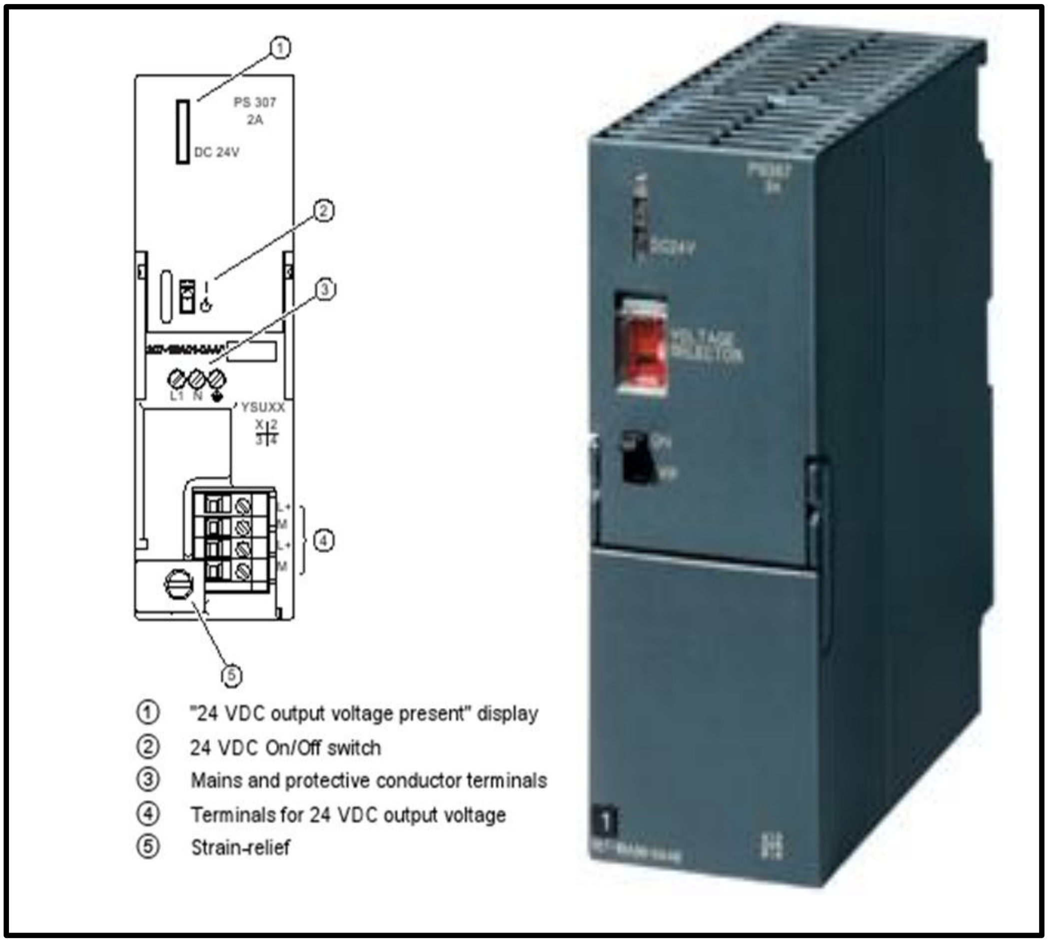


Figure (3.3): Power supply module PS 307-2A

3.2.1.3 Digital input module SM 321; DI 16 x DC 24 V

- **Properties of SM 321; DI 16 x DC 24 V**
  - 16 inputs, electrically isolated in groups of 16 as shown as figure (3.4).
  - Rated input voltage 24 VDC.
  - Suitable for switches and 2- /3-/4-wire proximity switches[12].

Figure (3.4): Digital input module SM 321; DI 16 x DC 24V

3.2.1.4 Digital output module SM 322- DO 16 x DC 24 V

- **Properties of SM 322; DO 16 x DC 24 V/0.5 A:**
  - 16 outputs, electrically isolated in groups of 8 as shown as figure (3.5).
  - Output current 0.5 A.
  - Rated load voltage 24 VDC.
  - Suitable for solenoid valves, DC contactors and signal lamp.

Figure (3.5): Digital output module SM 322- DI 16 x DC 24V

3.2.1.5 Inputs and outputs addressing

S7-300-CPU315-2 PN/DP inputs and outputs are labeled at the wiring terminations and next to the status indicators. These alphanumeric symbols identify the I/O address to which a device is connected. This address is used by the CPU to determine which input is present and which output needs to be turned on or off. **I** designate a discrete input and **Q** designates a discrete output. The first number identifies the byte, the second number identifies the bit. Input I0.0, for example, is byte 0, bit 0. The byte 0 starts from I0.0 to I0.7, it is consist of 8 bits and byte 1starts from I1.0 to I1.7 and so on. It is same to the output **Q.** This model has 10 inputs and 16 outputs. Input devices, such as limit switches and proximity sensor devices are connected to the terminal strip under the bottom cover of the PLC. The input contains of I and M address, M address mean memory address and table (3.2) illustrate the input address of model.

NO	symbol	Input address	description
1	Start_PB	M0.0	Start system
2	Stop_PB	M0.1	Stop system
3	Ent_G_Sens	I0.0	Entrance Gate Sensor
4	Exit_G_Sens	I0.1	Exit Gate Sensor
5	P_S1_Sens	I0.2	Parking slot-1 level-1 Limit switch Sensor
6	P_S2_Sens	I0.3	Parking slot-2 level-1 Limit switch Sensor
7	P_S3_Sens	I0.4	Parking slot-3 level-1 Limit switch Sensor
8	P_S4_Sens	I0.5	Parking slot-4 level-2 Limit switch Sensor
9	P_S5_Sens	I0.6	Parking slot-5 level-2 Limit switch Sensor
10	P_S6_Sens	I0.7	Parking slot-6 level-2 Limit switch Sensor

Table (3.2): Model input addresses

The outputs contains of Q and M address, the table (3.3) illustrate the output address of model.

NO	symbol	output address	description
1	Ent_G_OP	Q0.0	Led indicator Entrance gate open_green
2	Ent_G_CO	Q0.1	Led indicator Entrance gate close_red
3	Exit_G_OP	Q0.2	Led indicator Exit gate open_green
4	Exit_G_C	Q0.3	Led indicator Exit gate close_red
5	LED_Slot1	Q0.4	Led indicator slot-1 level-1
6	LED_Slot2	Q0.5	Led indicator slot-2 level-1
7	LED_Slot3	Q0.6	Led indicator slot-3 level-1
8	LED_Slot4	Q0.7	Led indicator slot-4 level-2
9	LED_Slot5	Q1.0	Led indicator slot-5 level-2
10	LED_Slot6	Q1.1	Led indicator slot-6 level-2
11	Green_LED	M0.2	Green led indicator start system
12	Red_LED	M0.3	Red led indicator stop system
13	LED_L1_F	M0.4	Led indicator parking lev-1 full
14	LED_L2_F	M0.5	Led indicator parking lev-2 full
15	LED_P_F	M0.6	Led indicator parking full
16	LED_P_W	M0.7	Led indicator welcome parking

Table (3.3): Model output addresses

3.2.2 Entrance gate

The main contains of the entrance gate are inductive proximity sensor, green led indicator and red led indicator. Figure (3.6) illustrates the components of entrance gate. The objective of the entrance gate is to allow driver to enter the parking according to status of parking slot.

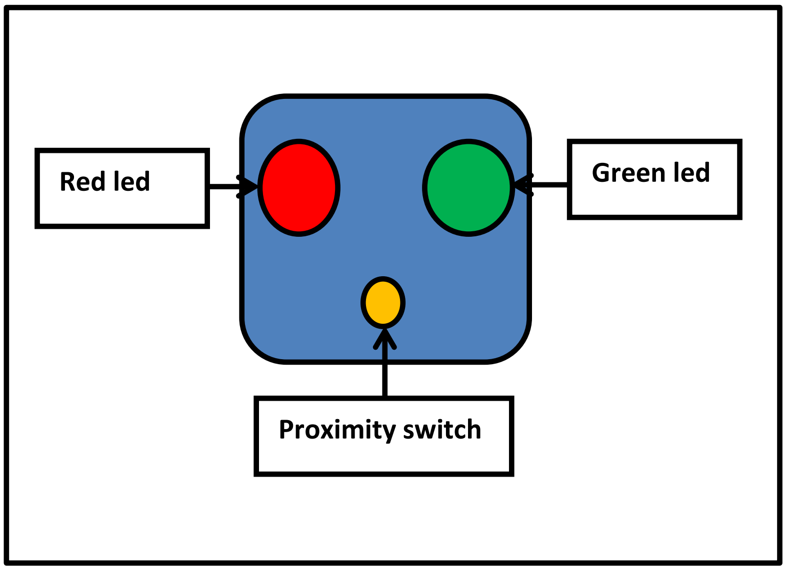


Figure (3.6): Entrance gate

3.2.2.1 Inductive proximity sensor

Inductive proximity sensors are used for non-contact detection of metallic objects. Their operating principle is based on a coil and oscillator that creates an electromagnetic field in the close surroundings of the sensing surface. The presence of a metallic object (actuator) in the operating area causes a dampening of the oscillation amplitude. The rise or fall of such oscillation is identified by a threshold circuit that changes the output of the sensor. The inductive proximity was used in the model designed is LJ12A3-

4-Z/BY as shown in figure (3.7) and used as an input (I0.0). It is connected to the PLC input module.

- **Features of Proximity Switch LJ12A3-4-Z/BY**
  - Product name: Inductive Proximity Switch.
  - Model: LJ12A3-4-Z/BY.
  - Theory : Inductive Sensor
  - Wire type: 3 Wire Type (Brown, Blue, Black).
  - Output type: PNP NO.
  - Detecting distance: 4mm.
  - Supply voltage: DC 6-36V.
  - Output current: 300mA.
  - Detect object: Iron.
  - Cable length: 1m/39.4"[13].

Figure (3.7): Proximity Switch LJ12A3-4-Z/BY

3.2.2.2 Led indicator 24V DC

All control panels include led indicator. They tell the operator when power is applied to the machine and indicate the present operating status of the machine. In this model entrance gate used two Led indicator 24V DC as shown in figure (3.8), one of them is green which is represented the open entrance gate and the second one represented the close entrance gate.it is used as output to the PLC to indicate the output status(Q0.0 and Q0.1)

Figure (3.8): Led indicator 24V DC

3.2.3 Parking structure

Parking structure consist of two floors, each floor consist of three slots to park cars. Each slot consists of led indicator and limit switch to sense the car as shown in figure (3.1). The objectives of the Parking structure are storing the cars and tell the controller about the parking situation.

3.2.3.1 Limit switch

Limit switches are usually not operator accessible. Instead they are activated by moving parts on the machine. They are usually use mechanical switches. They are sometimes called cam switches because many are operated by a camming action when a moving part passes by the switch as shown as figure (3.9). In this model parking structure consist of 6 Limit switches NO, each floor consist of three limits. Limit switches are used as input to the PLC to indicate the slots status.

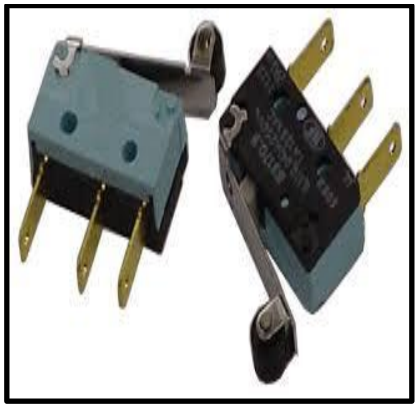


Figure (3.9): Limit switch

3.2.3.2 Led indicator 24V DC

In this model parking structure consist of 6 Led indicators, each floor consist of three led 24V DC as shown in figure (3.8). It is used as output (Q0.4-Q0.5- Q0.6 Q0.7- Q1.0-Q1.1) to the PLC to indicate the Parking structure status.

3.2.4 Exit gate

The main contents of the exit gate are inductive proximity sensor (LJ12A3-4-Z/BY), green led 24 V DC indicator and red led indicator 24 V DC. Figure (3.10) illustrates the components of exit gate. The objective of the exit gate is to allow driver to leave the parking.

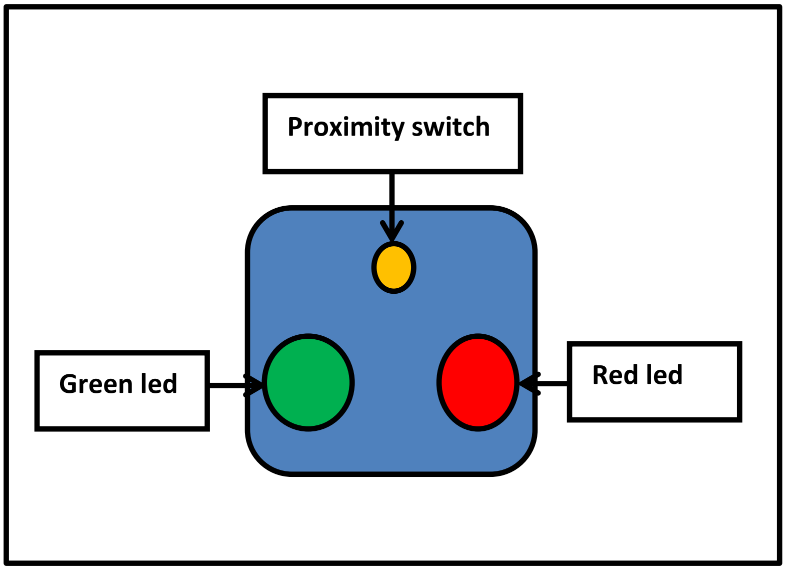


Figure (3.10): Exit gate

3.2.5 Human machine interface (HMI)

The HMI system represents the interface between man (operator) and process (machine/plant). The PLC is the actual unit which controls the process. Hence, there is an interface between the operator and WinCC flexible (at the HMI device) and an interface between WinCC flexible and the PLC. An HMI system assumes the following tasks:

- Process visualization.

  The process is visualized on the HMI device. The screen on the HMI device is dynamically updated. This is based on process transitions.

- Operator control of the process.

  The operator can control the process by means of the GUI. For example, the operator can preset reference values for control or start a motor.

- Displaying alarms.

  Critical process states automatically trigger an alarm, for example, when the set point value is exceeded.

- Archiving process values and alarms.

  The HMI system can log alarms and process values. This feature allows you to log process sequences and to retrieve previous production data.

- Process and machine parameter management.

  The HMI system can store the parameters of processes and machines in recipes. For example, it is possible download these parameters in one pass from the HMI device to the PLC to change over the product version for production [14].

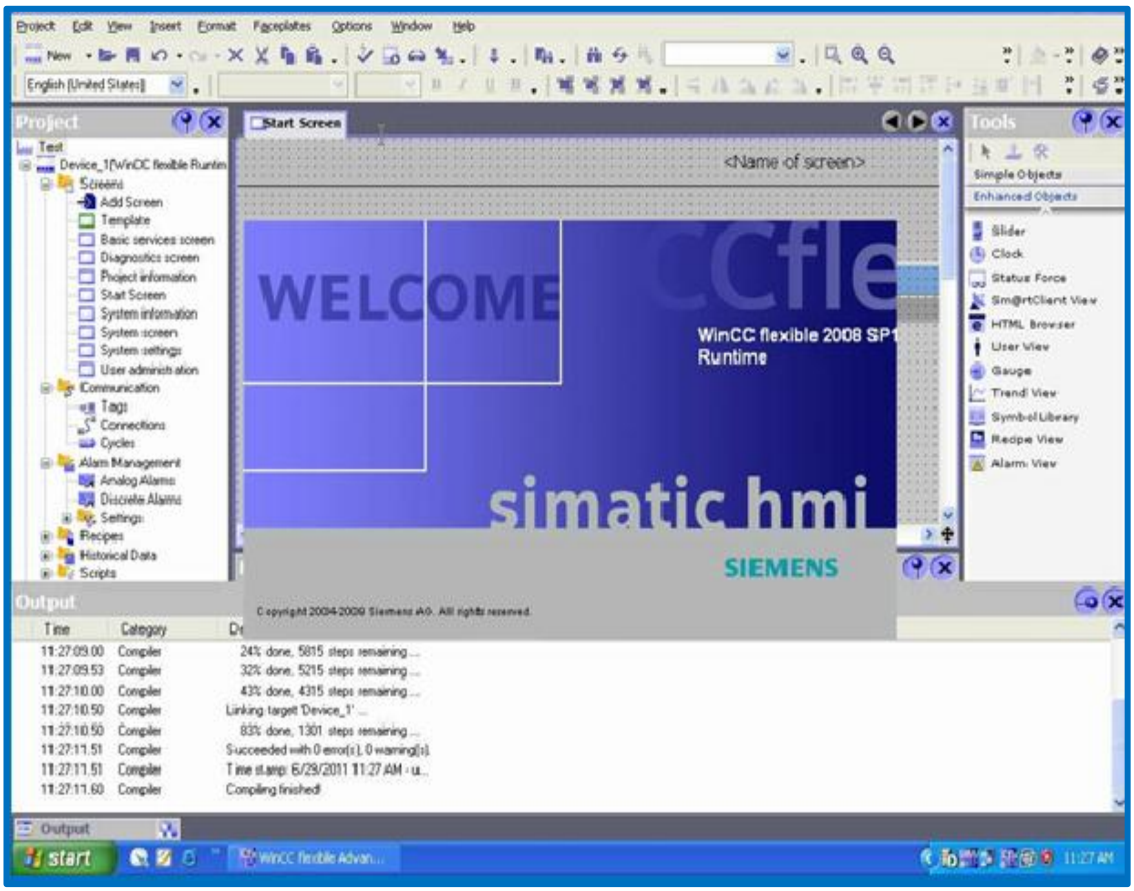


Figure (3.11): WinCC flexible software

This model used the WinCC flexible 2008 software build in pc as shown as figure (3.11) to guide drivers to park in suitable slot or to tell them the parking is occupied according to the parking availability. The HMI device which is directly connected to the PLC via the process bus is referred to as a single-user system. WinCC flexible 2008 software screen designed to show the four sub screens:

- System status
- Entrance and exit gate.
- Parking levels and welcome message.
- Slot status.

3.3 model wiring diagrams

This model consists of 8 inputs and 10 outputs:

3.3.1 Inputs wiring diagram

Inputs model consists of two proximity switches and 6 limits switches connected to the PLC input module and connected to common 24V, proximity switch Ent_G_Sens connected to I0.0 and proximity switch Exit_G_Sens connected to I0.1, where the limit switches P_S1_Sens, P_S2_Sens, P_S3_Sens, P_S4_Sens, P_S5_Sens and P_S6_Sens connected to I0.2, I0.3, I0.4, I0.5, I0.6 and I0.7 respectively as shown as appendix (A).

3.3.2 Outputs wiring diagram

Outputs model consists of 4 led indicators used for entrance and exit gate and 6 led indicators used for slot status connected to the PLC output module and connected to common 0V, 4 led indicator Ent_G_OP, Ent_G_CO, Exit_G_OP and Exit_G_C are connected to Q0.0, Q0.1 Q0.2 and Q0.3

respectively, where the 6 led indicator LED_Slot1, LED_Slot2, LED_Slot3, LED_Slot4, LED_Slot5 and LED_Slot6 are connected to Q0.4, Q0.5, Q0.6, Q0.7, Q1.0 and Q1.1 respectively as shown as appendix (B)

3.4 Model ladder program language

The parking availability and gate control system used ladder diagram language. The ladder instruction symbols can be formatted to obtain the desired control logic, which is then entered into memory. Since this type of instruction set consists of contact symbols, it is also referred to as contact symbology. The main functions of a ladder diagram program are to control outputs and perform functional operations based on input conditions .The ladder program content of 21 networks as shown as:

3.4.1 Green led indicator start system network NO.1

The function of this network illustrates the green led indicator start system M0.2. It consists of three inputs M0.0 (NO), M0.1 (NC) and M0.2 (NO). M0.0 and M0.1conected and logic to control the output coil M0.2, where input M0.2 used as a latch coil instruction to cause the energize output. If start pushbutton pressed in HMI screen system will be start and green led indicator running will illuminated. Figure (3.12) illustrate the network NO.1

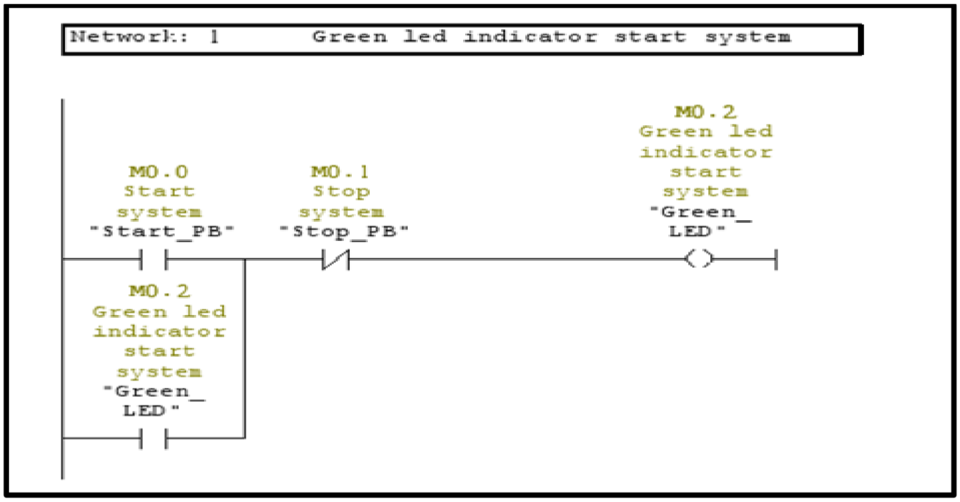


Figure (3.12): Ladder program network NO.1

3.4.2 Red led indicator stop system network NO.2

The function of this network illustrates the red led indicator stop system M0.3.Its consist one inputs M0.2 (NC), If stop pushbutton pressed in HMI screen system will be stop and red led indicator stop system will illuminated. Figure (3.13) illustrate the network NO.2

3.4.3 Led indicator parking level-1 full network NO.3

The function of this network illustrates to drivers lev-1 full and occupied with the three cars in HMI. It is consists of four inputs I0.2 (NO), I0.3 (NO) and I0.4 (NO) and M0.2 (NO) connected AND logic to control red led indicator lev-1 full M0.4. Figure (3.13) illustrate the network NO.3

The output red led indicator lev-1 full not illuminate unless the input sensors are become NC. This red led appears just in HMI software

3.4.4 Led indicator parking level-2 full network NO.4

The function of this network illustrates to drivers lev-2 full and occupied with the three cars in HMI. It is consist of four inputs I0.5 (NO), I0.6 (NO) ,I0.7 (NO) and M0.2 (NO) connected AND logic to control red led indicator lev-2 full M0.5. The output red led indicator lev-2 full not illuminate unless the three inputs sensor are become NC. This red led appears just in HMI software. Figure (3.13) illustrate the network NO.4

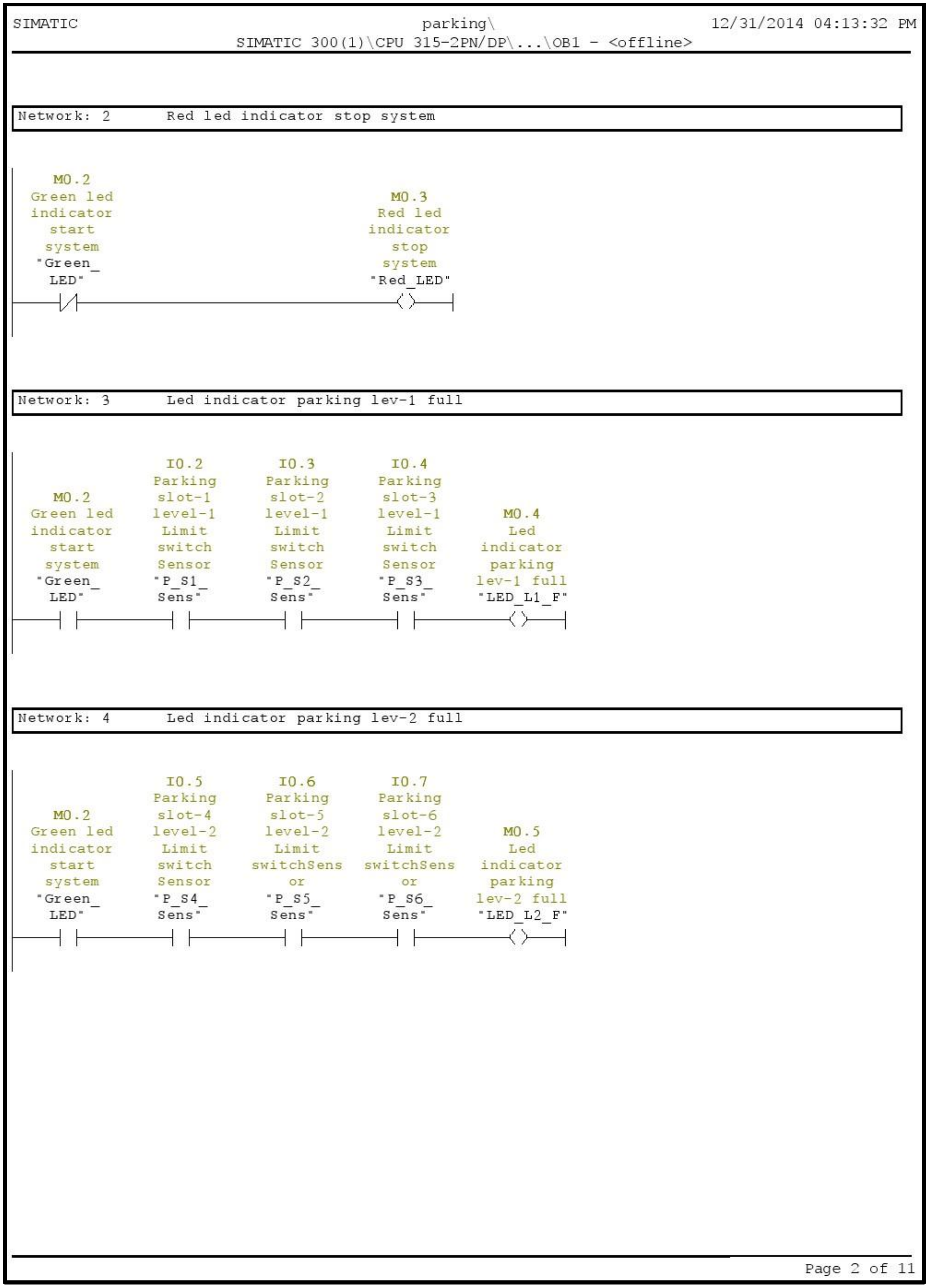


Figure (3.13): Ladder program network NO.2-3-4

3.4.5 Led indicator parking full network NO.5

The function of this network illustrates to drivers parking full and occupied with the six cars in HMI. It consists of three inputs M0.4 (NO), M0.5 (NO) and M0.2 (NO) connected AND logic to control red led indicator parking full M0.5.The output red led indicator parking full not illuminate unless the input sensors are become NC. This red led appears just in HMI software. Figure (3.14) illustrate the network NO.5

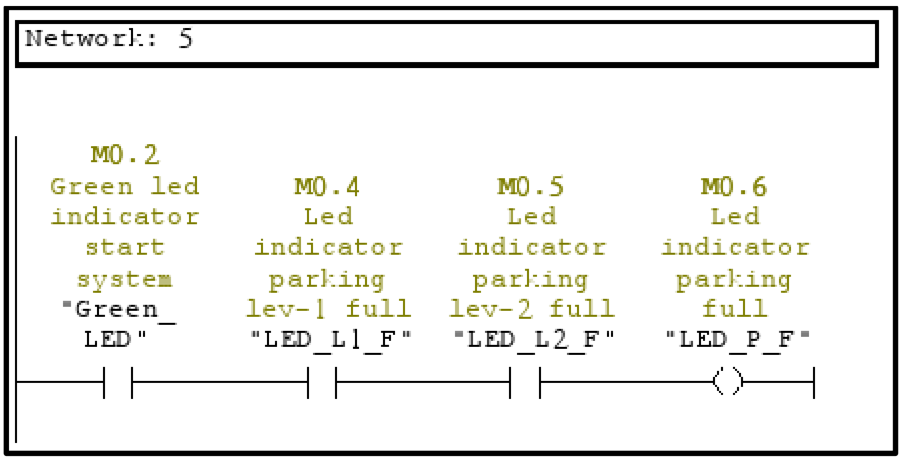


Figure (3.14): Ladder program network NO.5

3.4.6 Led indicator welcome parking network NO.6

The function of this network guides drivers and tells them to enter the parking by send welcome massage in HMI when of any slot is not occupied.

This network consists of seven inputs I0.2 (NC), I0.2 (NC) I0.3 (NC) I0.4 (NC) I0.5 (NC) I0.6 (NC) I0.7 (NC) connected OR logic and connected and with M0.2 to energized the output M0.7. Figure (3.15) illustrate the network NO.6

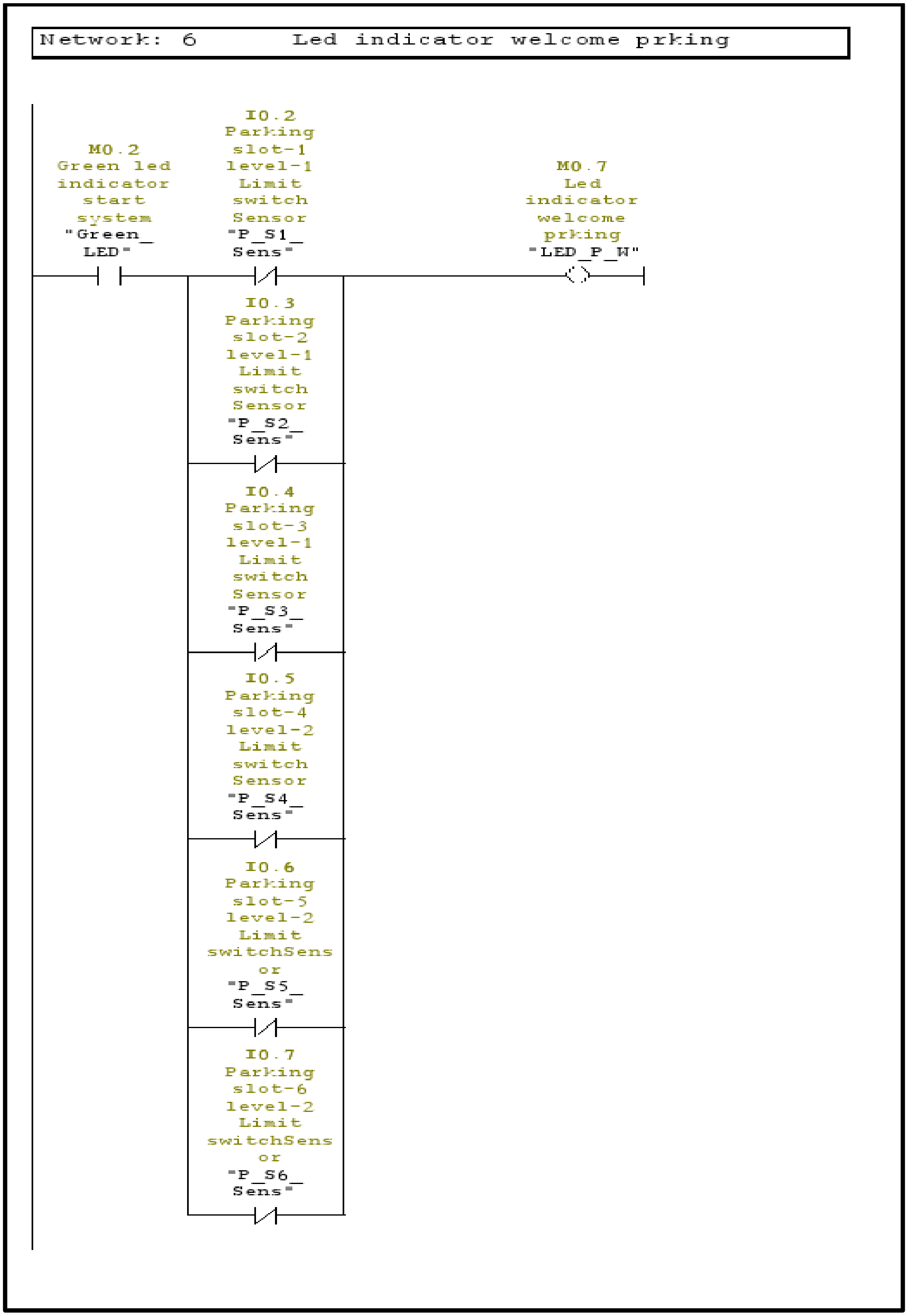


Figure (3.15): Led indicator welcome parking NO.6

3.4.7 Green led indicator entrance gate network NO.7

The function of this network is open gate when a car enters the gate. When a green led illuminated it means the gate is opened and red led illuminated it means the gate is closed. In this model the red led represented normal status.

This network consists of 12 inputs. 6 of them are the slots sensors I0.2 (NC), I0.2 (NC) I0.3 (NC) I0.4 (NC) I0.5 (NC) I0.6 (NC) I0.7 (NC) are used to sense the car in parking structure. I0.0 sensor used to sense a car when to enter the entrance gate. M0.2 is memory address used to stop system. T0 (NO) ON delay timer set to 5s start count when entrance gate I0.0 sense a car. T4 (NO) ON delay timer set to 5s start count when output energized, it is used to disconnect the green led indicator entrance gate to return to the previous status.in this network the output not energize if the all slots sensor are occupied to not allow the driver to enter the gate. Figure (3.16) illustrates the network NO.7.

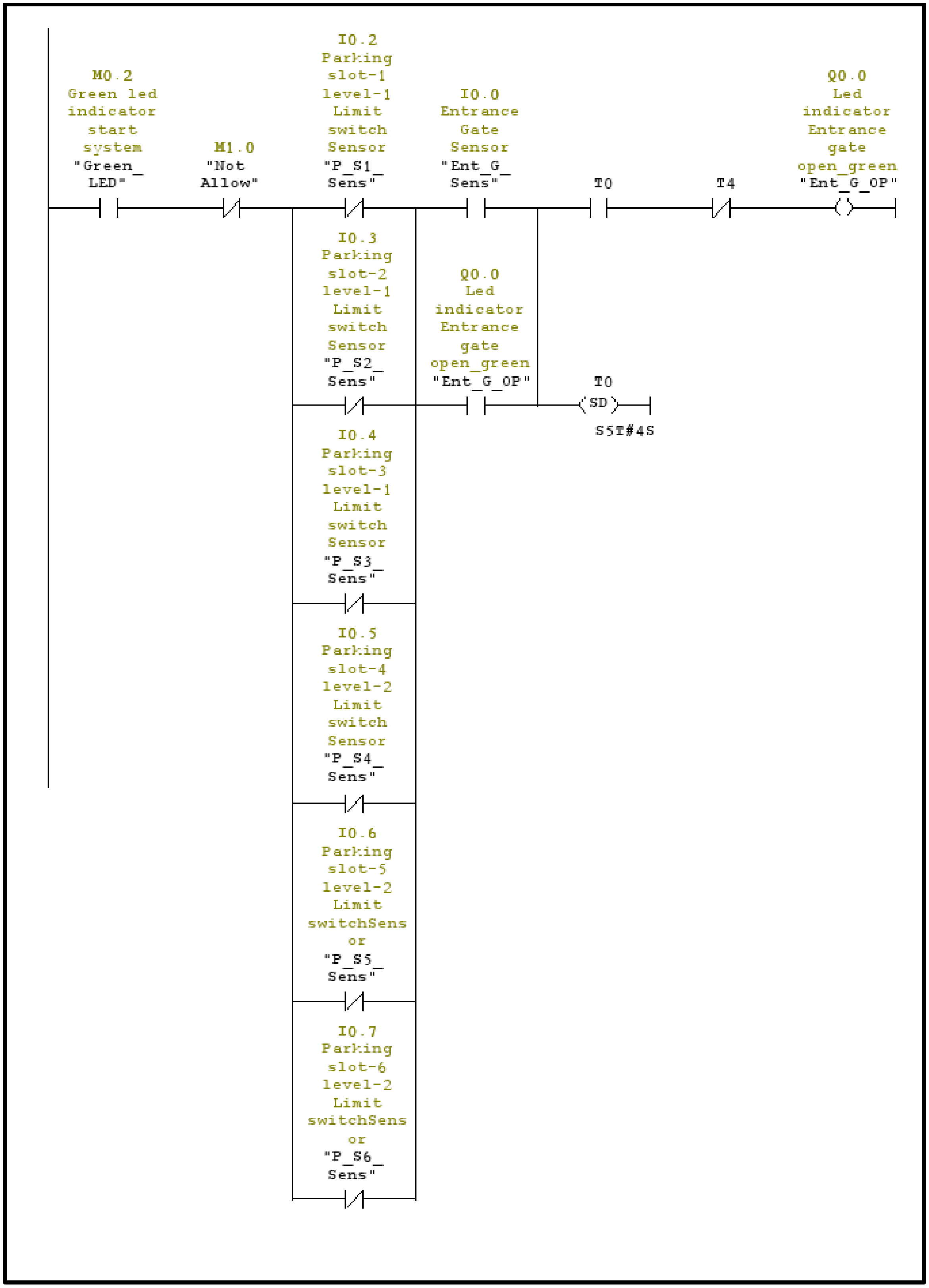


Figure (3.16): Led indicator welcome parking NO.7

3.4.8 Red led indicator closed entrance gate network NO.8

The function of this network is close gate when no car enters the gate. When a red led illuminated it means the gate is closed, this status is a normal situation. Figure (3.17) illustrate the network NO.8.

3.4.9 Green led indicator exit gate network NO.9

The function of this network is open exit when a car enters the gate. When a green led illuminated it means the gate is opened and red led illuminated it means the gate is closed. Figure (3.17) illustrates the network NO.9.

This network consists of 5 inputs.M0.2 used to stop system, O0.2 used as hold input, I0.1pproximity exit gate, T2 (NO) ON delay timer set to 5s start count when exit gate I0.1 sense a car and T5 (NO) ON delay timer set to 5s start count when output energized, it is used to disconnect the green led indicator exit gate to return to the previous status. In this network the output not energize if the all slots sensor are occupied to not allow the driver to enter the gate.

3.4.10 T4 (NO) ON delay timer network NO.10

T4 (NO) ON delay timer set to 5s start count when output energized, it is used to disconnect the green led indicator entrance gate to return to the previous status. Figure (3.17) illustrates the network NO.10

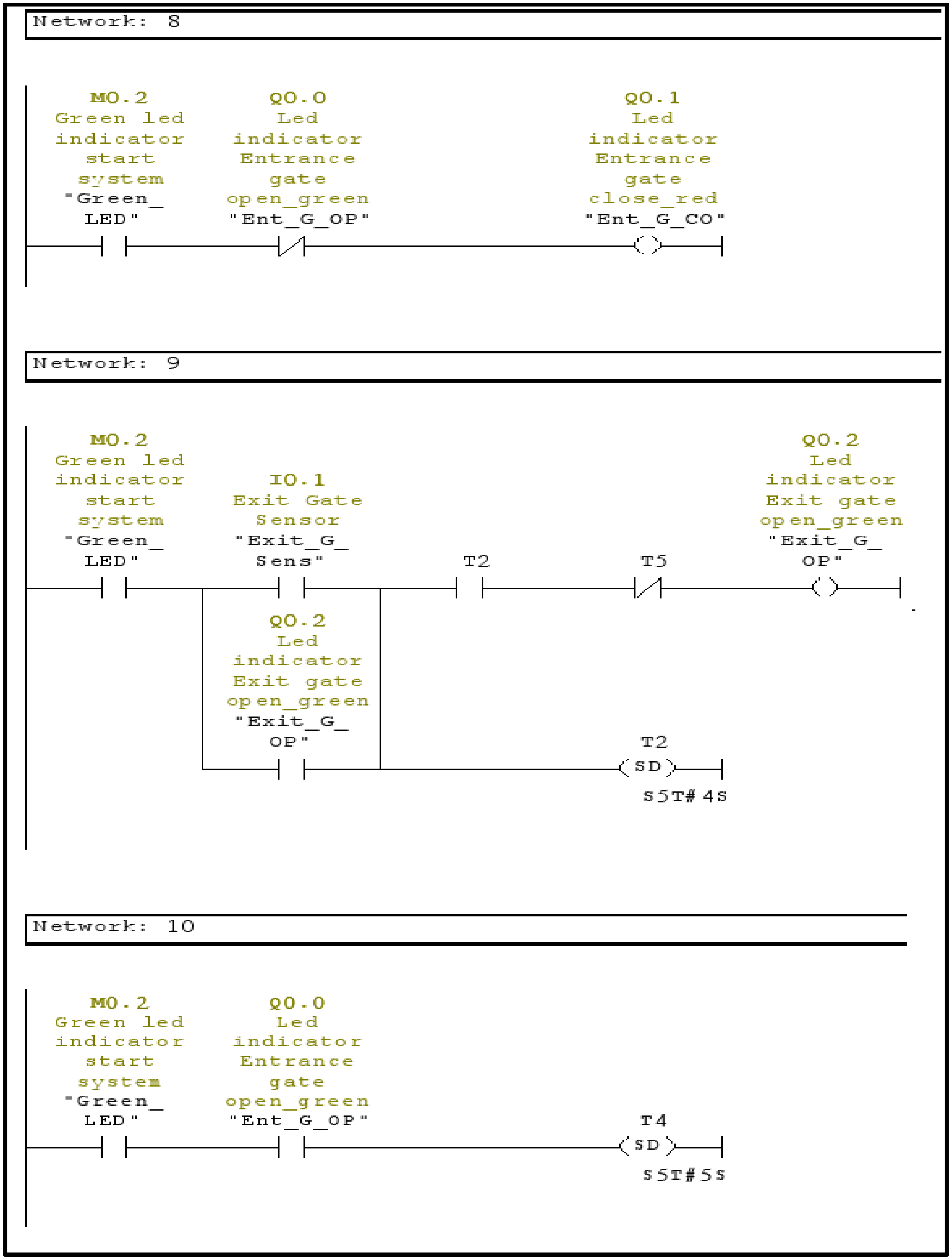


Figure (3.17): illustrate the network NO.8-9-10

3.4.11 Lock between opened exit gate and exit gate closed network NO.11

The function of this network is making lock between opened exit gate and exit gate closed. When the opened exit gate is energized the closed exit gate is disconnected and vice versus. Figure (3.18) illustrate the network NO.11

3.4.12 T5 (NO) ON delay timer network NO.12

T5 (NO) ON delay timer set to 5s start count when output energized, it is used to disconnect the green led indicator exit gate to return to the previous status. Figure (3.18) illustrate the network NO.12

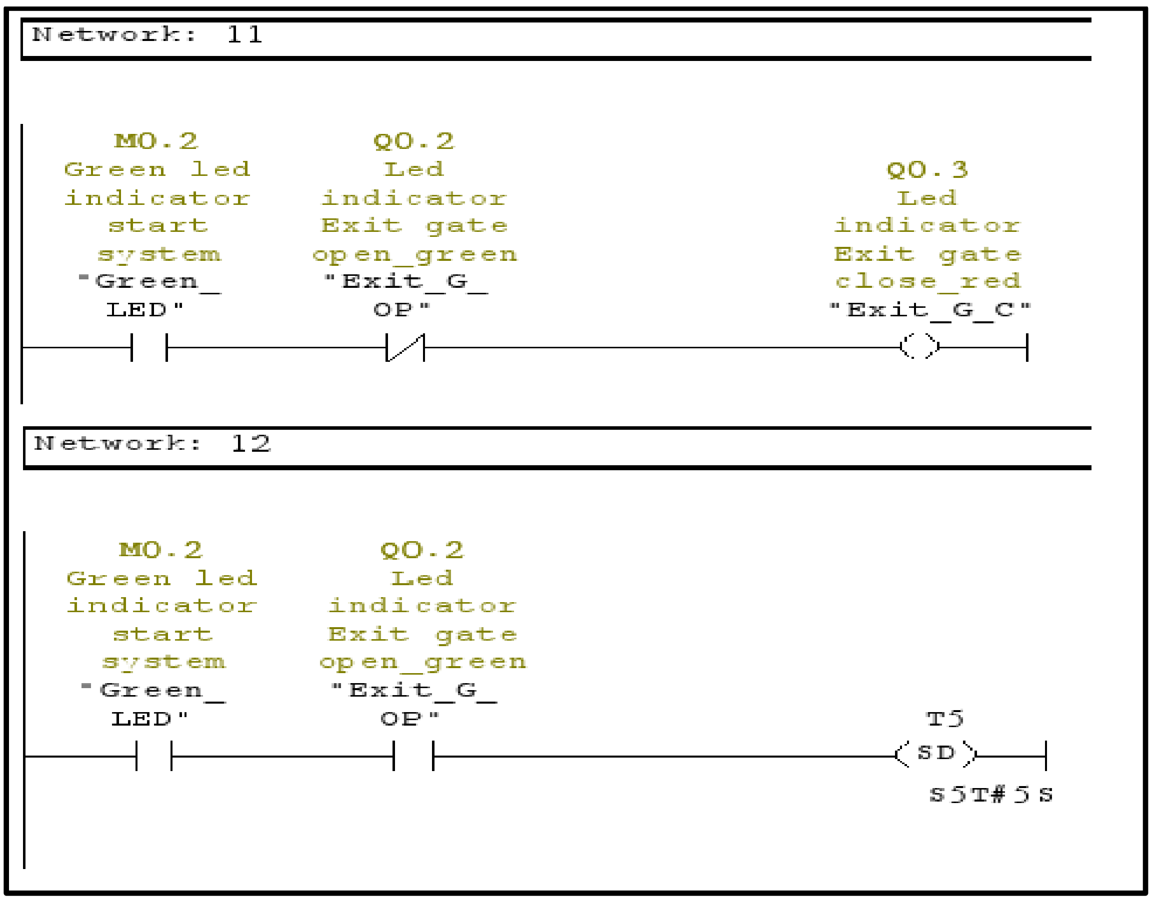
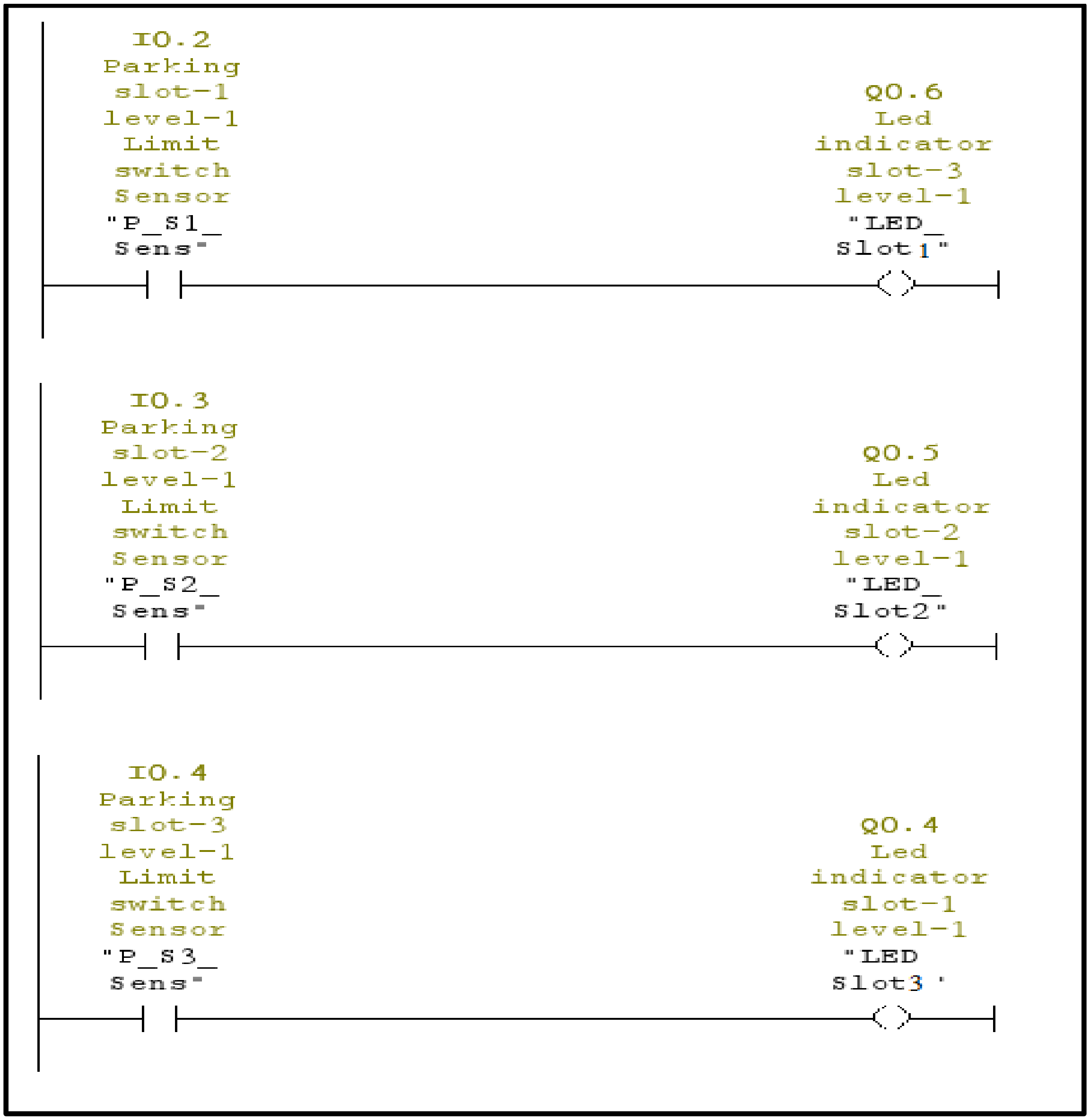


Figure (3.18): illustrate the network NO.11-12

3.4.13 led indicator slots networks

The functions of these networks are indicating the status of slots. When a cars park in any slot of level-1the limit switches I0.2, I0.3, I0.4, I0.5, I06 and I0.7 change to NC and outputs Q1.1, Q0.7, Q0.6, Q0.5, Q0.4 and Q0.3 are energized. Figure (3.19) illustrate the led indicator slots networks.



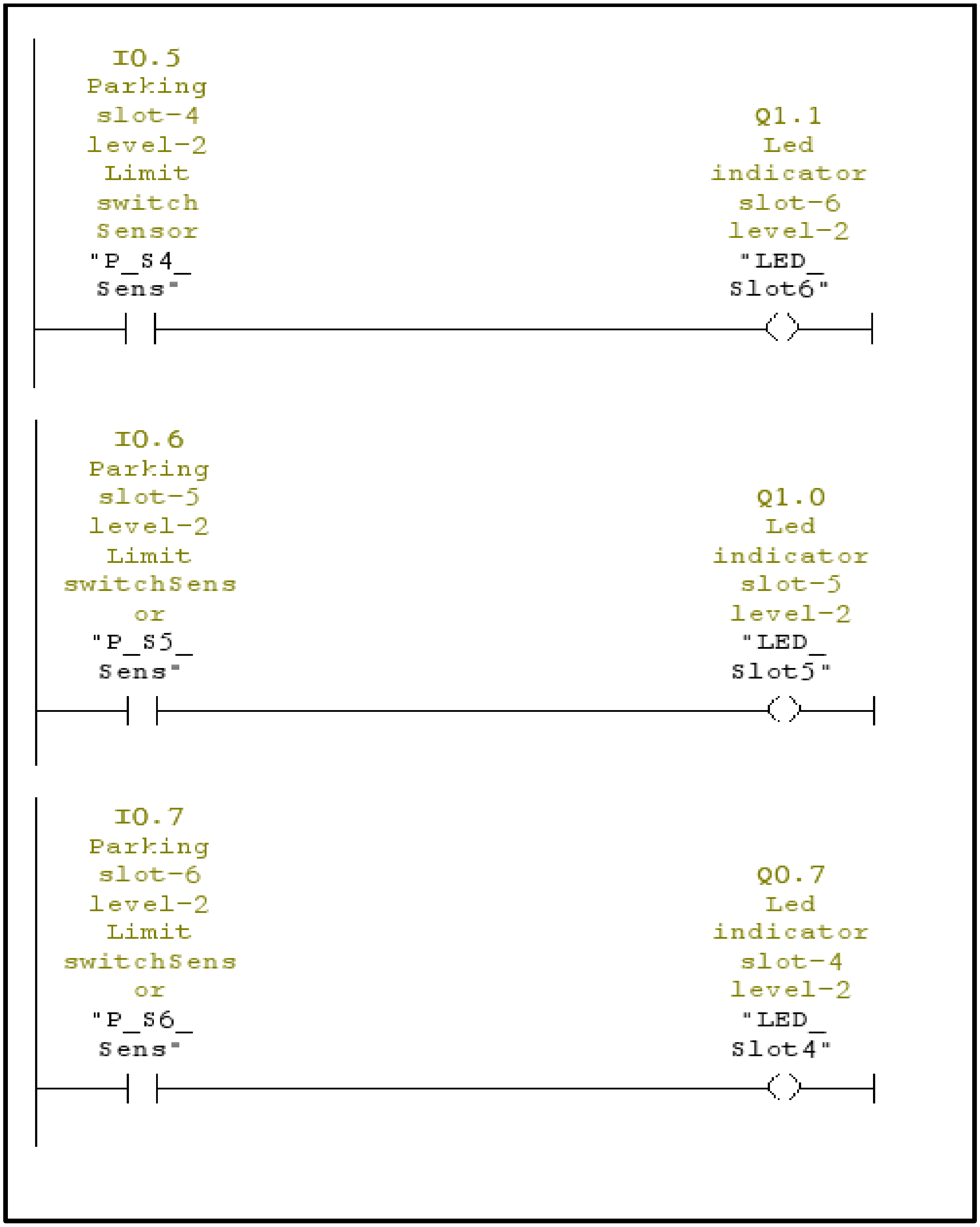


Figure (3.19): led indicator slots networks

3.4.14 Entrance and exit gate counter network NO.19

The functions of this network to count cars which are interring the entrance gate and discount the cars which are exit the exit gate. C1 has one input entrance gate sensor I0.0 to count when cars enter the entrance gate, CD discount the counter C by using exit gate sensor I0.1,S represented the set value it used the system stat led M0.2, PV preset value used preset counter value MW20 and R represented the reset which it used stop system M0.1. Figure (3.20) illustrates the network NO.19.

3.4.15 MOV and CMP instructions network NO.20-21

MOV and CMP instructions used to energized output not allow M1.0 which is used to not allow driver to inter the parking when all slots are occupied. Figure (3.20) illustrates the networks NO.20-21.

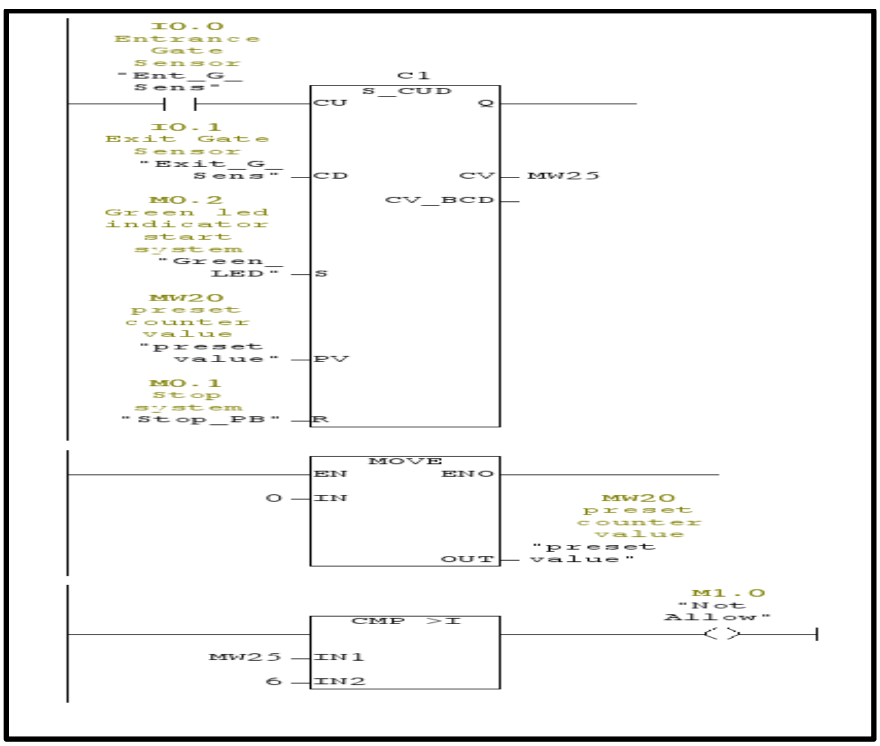


Figure (3.20): Illustration the network NO.19-20-21