Cairo University
Faculty of Engineering
Mech. Power Department

ACC Virtual Labs
Automatic Control Circuits & Virtual Labs for Mechanical Power Systems

دبلوم تطبيقات التحكم الأوتوماتيكى في نظم القوى الميكانيكية

MEP 599 Diploma Design Project-Term1 2017/2018

Design of Automated Parking System Using PLC

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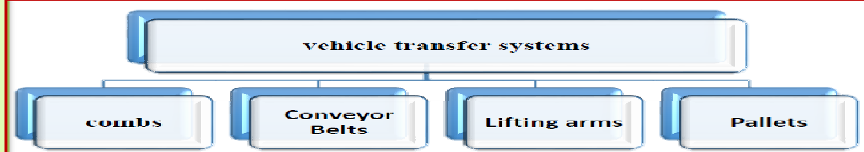
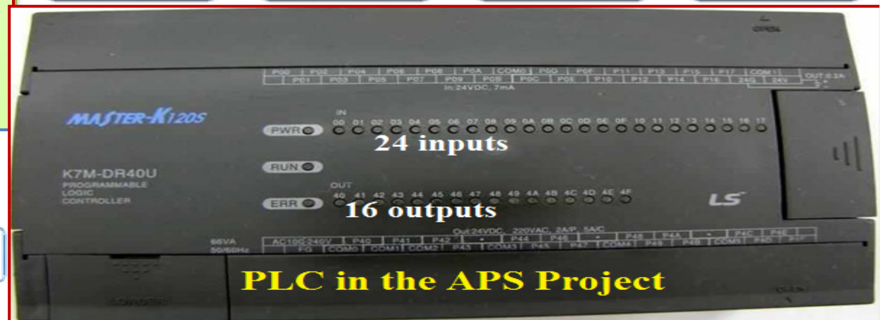
Abstract: This project is an applied case study & engg. practice for using Sequential Control algorithms&PLC technology in design of an Automated Parking System(APS). This APS facilitates full-automatic parking of cars in a multi-storied building in order to accommodate more cars in less space and also to provide security to the vehicle as it can only be accessed by the user/owner. After doing through investigation of several types of parking systems, the presented design utilizes the Crane type with Combs vehicle transfer system. A typical design and calculations for simple crane and combs models were done. In addition, an analysis was performed for the car data entry method and the car rotation and handling system in the APS entrance or admission zone. The 3-D motions needed for the crane system during car parking and retrieving were also examined and analyzed. The movement of the crane-tower and the combs are applied using 4 DC motors which are controlled using PLC output signals. The project included specifying the numbers and types of all input sensors and limit switches to be used in the APS. A complete SFC (sequential flow chart) for both car parking and retrieving is done to show all various control steps in the APS. In addition, all required transition conditions between those steps ware examined. Based on the SFC and after selecting the proper type of PLC for this project, the LAD diagram was written and then tested by PLC simulation using the TRiLOGI-Educational PLC soft-ware. Finally a simple design for a fire protection system for the APS was done to safe lives and properties in the APS.

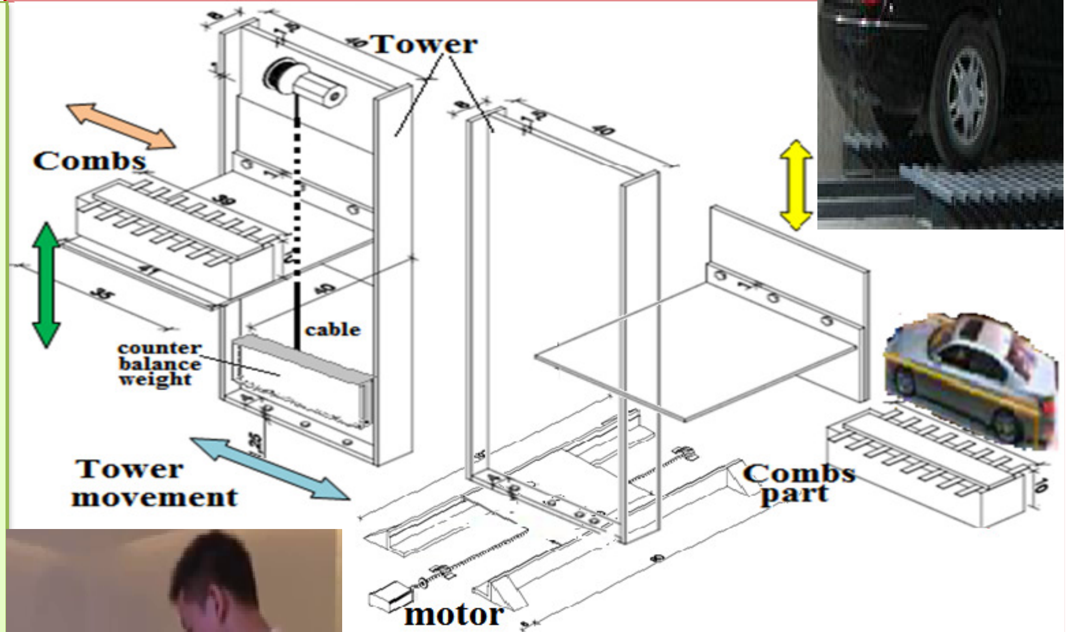


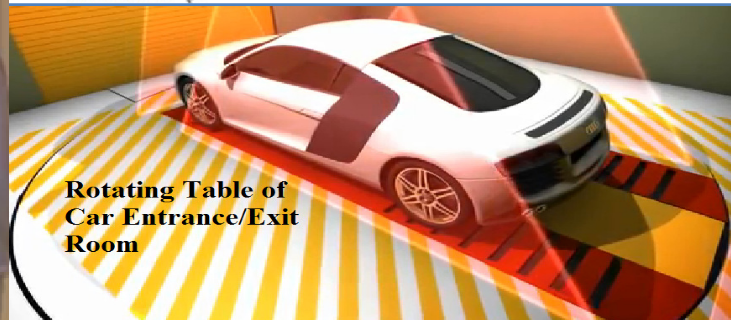


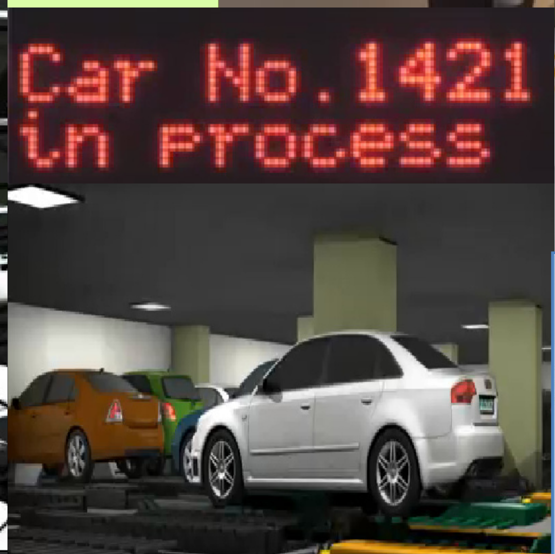
Types of Automated parking systems

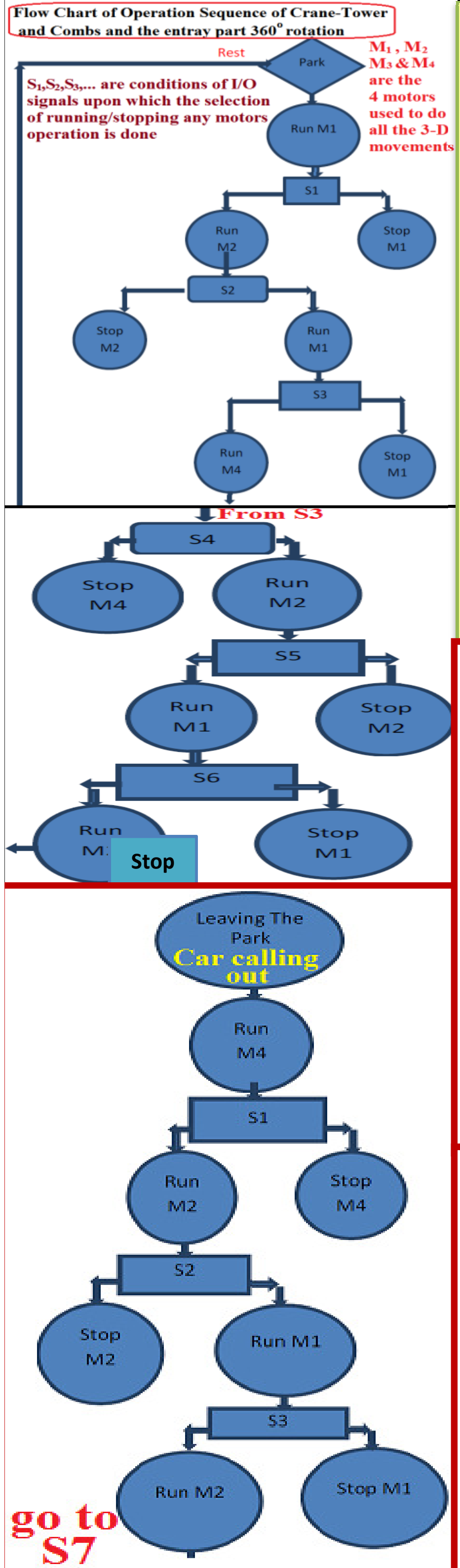
Crane and Combs System Description: **The Crane System utilizes a single mechanism to simultaneously perform the 3-D horizontal and vertical movements of the vehicle to be parked or retrieved in the parking system. The simultaneous horizontal and vertical movements allow the vehicle platform to move to and from one parking spot to another very quickly. The crane mechanism moves horizontally on rails, typically located on the floor and ceiling of the parking system, and has a vertical elevator platform fitted where vehicles to be parked and retrieved are placed. This means that a floor-to-ceiling opening in the center of the system is required for the crane(s) to operate as shown in the next figure.**

Combs or fingers are one method of lifting a vehicle under its tires so it can be moved within the automated parking system as shown in figure. A vehicle is parked on a flat surface containing combs located in the floor of the parking module. Typically when the vehicle is ready to be parked, a section of the parking module floor is lowered to allow a robot with combs to drive underneath the vehicle. Combs on the robot are then raised through the gaps of the floor combs, to lift the vehicle, before the robot returns to the parking mechanism with the vehicle. Considerations for combs transfer in automated parking APS include: - High speed and reliability of the vehicle pick up. – The Comb car stand height and cost. -Effectiveness of mechanical contact with car tires.

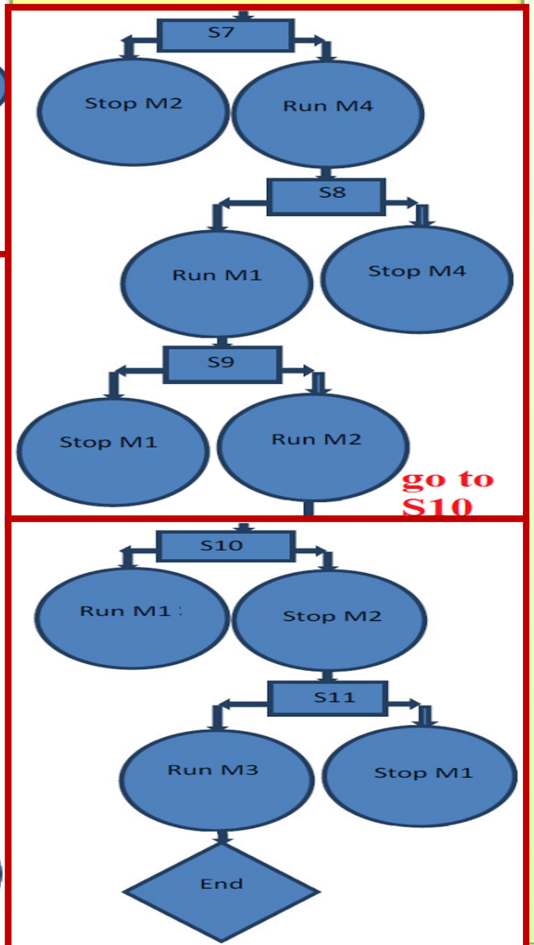








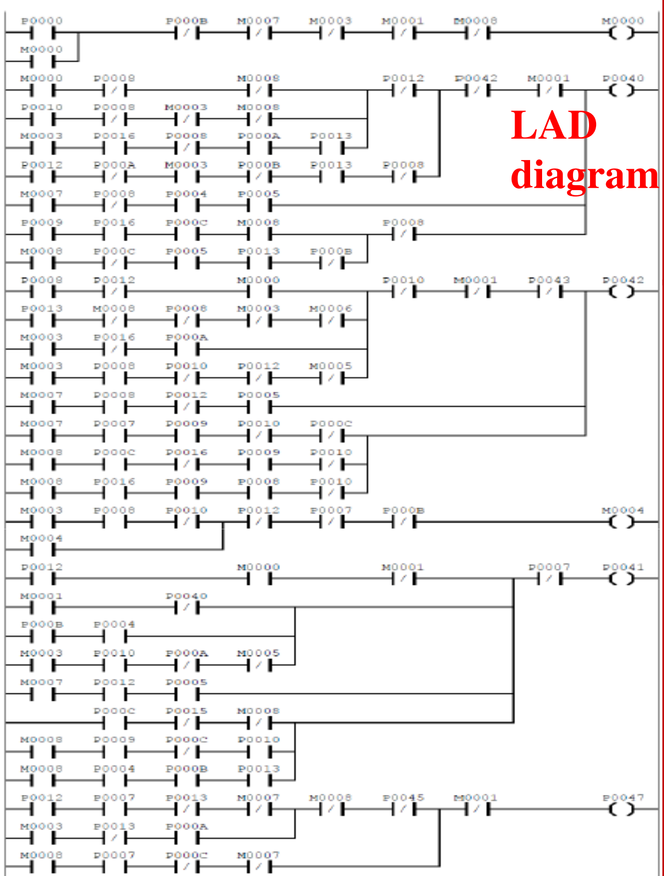
Sequence of Operation of Crane-Tower & Combs & entry 180° rotating room part: When the car enters inlet spot, the operator sends a signal to PLC through a push button so that PLC start operation of sending the car to its parking spot through the following steps: 1. PLC checks empty & occupied slots in order to choose a parking spot (based on given car data at entry). Before any car parking process, the tower has to be at its home position in front of the entrance room spot. 2.When PLC decide which parking spot is empty it gives a signal to motor M1 to move forward to entrance spot until combs become directly under the car. At this moment the combs touch a limit switch to stop the working of motor M1 and energize motor M2 which moves the tower upward to carry the car to selected parking place. 3. After carrying the car another limit switch stops motor M2 & energize motor M1 but in opposite direction in order to pull out the car from entrance spot until the combs reach its initial position again. where it touches a limit switch to stop motor M1 &energizes motor M4. 4. Motor 4 moves the tower left until reaching another limit switch which stops motor M4 and energize motor M2 to move the tower upwards until reaching its position in front of the parking spot. 5. At this point a limit switch stops motor 2 and energize motor 1 to move the combs forward to put the car in the parking spot. 6. When the combs reach the limit switch in the parking spot motor 1 stops working and motor 2 begin to move downward until the car is settled in its right position. 7. At this moment the PLC make the previous steps in reversed order until the tower reaches its home position in front of entrance spot.

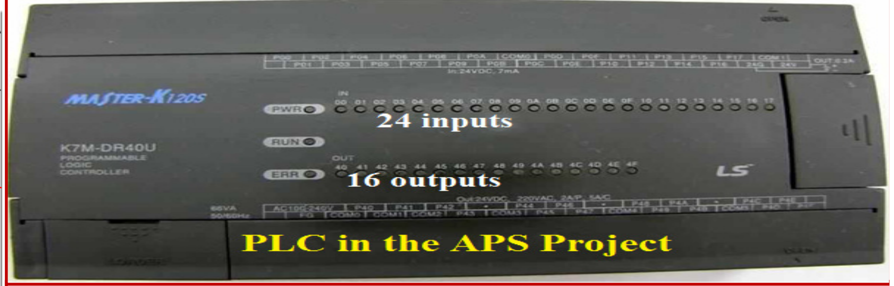


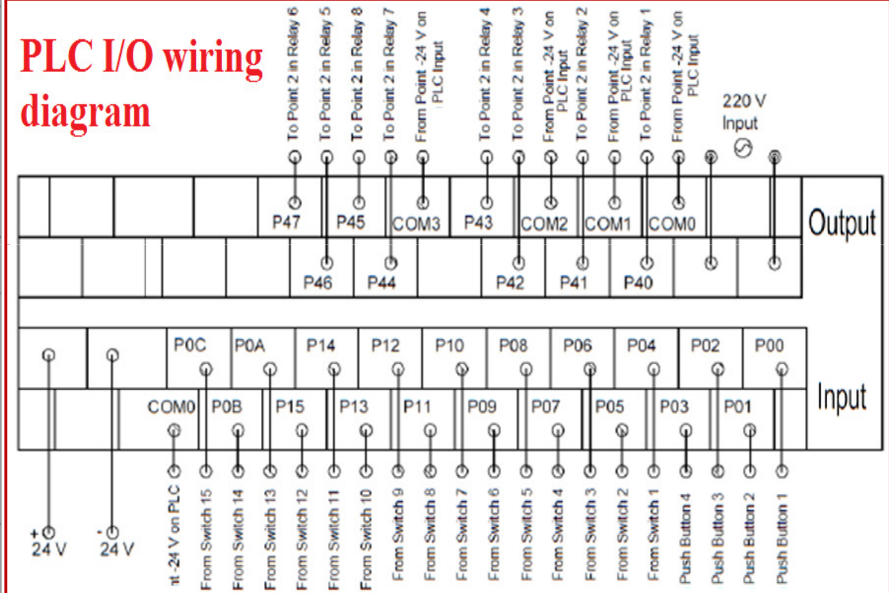
Car Calling Process: When car owner comes to the park to get his car, he has to enter 1st some security data & the location of his parking position described in the previous steps. The PLC will start doing a set of steps described as following: 1. PLC will energize motor M4 to move the tower to the left until reaching a limit switch which stops motor M4 & energizes motor M2. 2. Motor 2 moves upwards until combs reach position in front of parking spot where a limit switch stops motor M2 & energizes motor 1. 3. Motor 1 moves the combs forward to parking spot until reaching its position under car where limit switch inside parking spot stops motor 1 & energizes motor 2. 4. Motor 2 moves upward until carrying the car where a limit switch stops motor 2 & energizes motor 1 again to pull the car out from parking spot. 5. When the combs reach its initial position a limit switch stops motor 1 & energizes motor 3 which is responsible for rotating the car 180° in order to make it in a right position to be handled to the delivery or exit spot. 6. When motor 3 finishes the car-rotation, a limit switch stops motor 3 & energizes motor 2 to move the tower downward until reaching a limit switch which stops motor 2 & energizes motor 4. 7. Motor 4 moves tower right until reaching its position in front of delivery spot where a limit switch stops motor 4 & energizes motor 1. 8. Motor 1 moves the combs forward toward the delivery spot until the combs reaches a limit switch which stops motor 1 & energizes motor 2. 9. Motor 2 moves combs downward until the car reaches its delivery position where a limit switch stops motor 2 & energizes motor 1. 10. Motor 1 moves the combs backward until reaching its initial position where a limit switch stops motor 1 & energizes motor 3 to move the tower rotates and reach its initial position in front of the inlet spot.

Inputs/Outputs Table

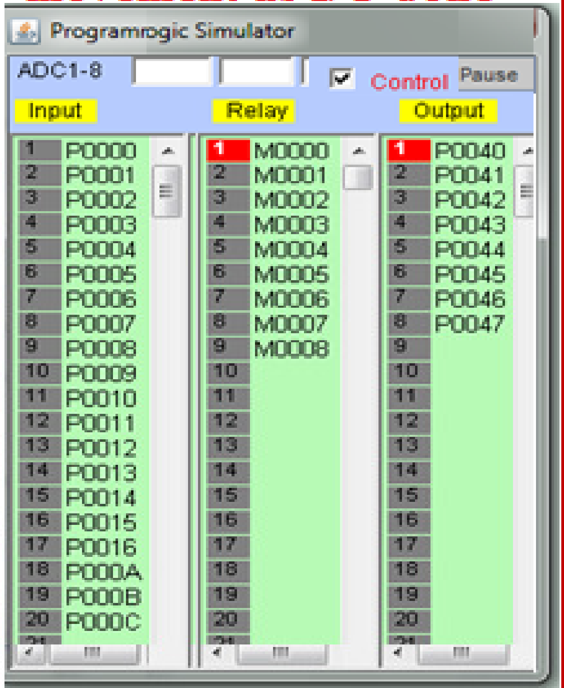
No.	Point description	TYPE DI	TYPE DO	REMARKS & PERIPHERAL EQUIPMENTS
1	Push Button	1		Volt free contact to PLC
2	Push Button	1		Volt free contact to PLC
3	Push Button	1		Volt free contact to PLC
4	Push Button	1		Volt free contact to PLC
5	Switch 1	1		Volt free contact to PLC
6	Switch 2	1		Volt free contact to PLC
7	Switch 3	1		Volt free contact to PLC
8	Switch 4	1		Volt free contact to PLC
9	Switch 5	1		Volt free contact to PLC
10	Switch 6	1		Volt free contact to PLC
11	Switch 7	1		Volt free contact to PLC
12	Switch 8	1		Volt free contact to PLC
13	Switch 9	1		Volt free contact to PLC
14	Switch 10	1		Volt free contact to PLC
15	Switch 11	1		Volt free contact to PLC
16	Switch 12	1		Volt free contact to PLC
17	Switch 13	1		Volt free contact to PLC
18	Switch 14	1		Volt free contact to PLC
19	Switch 15	1		Volt free contact to PLC
20	Relay 1		1	Relay output from PLC
21	Relay 2		1	Relay output from PLC
22	Relay 3		1	Relay output from PLC
23	Relay 4		1	Relay output from PLC
24	Relay 5		1	Relay output from PLC
25	Relay 6		1	Relay output from PLC
26	Relay 7		1	Relay output from PLC
27	Relay 8		1	Relay output from PLC

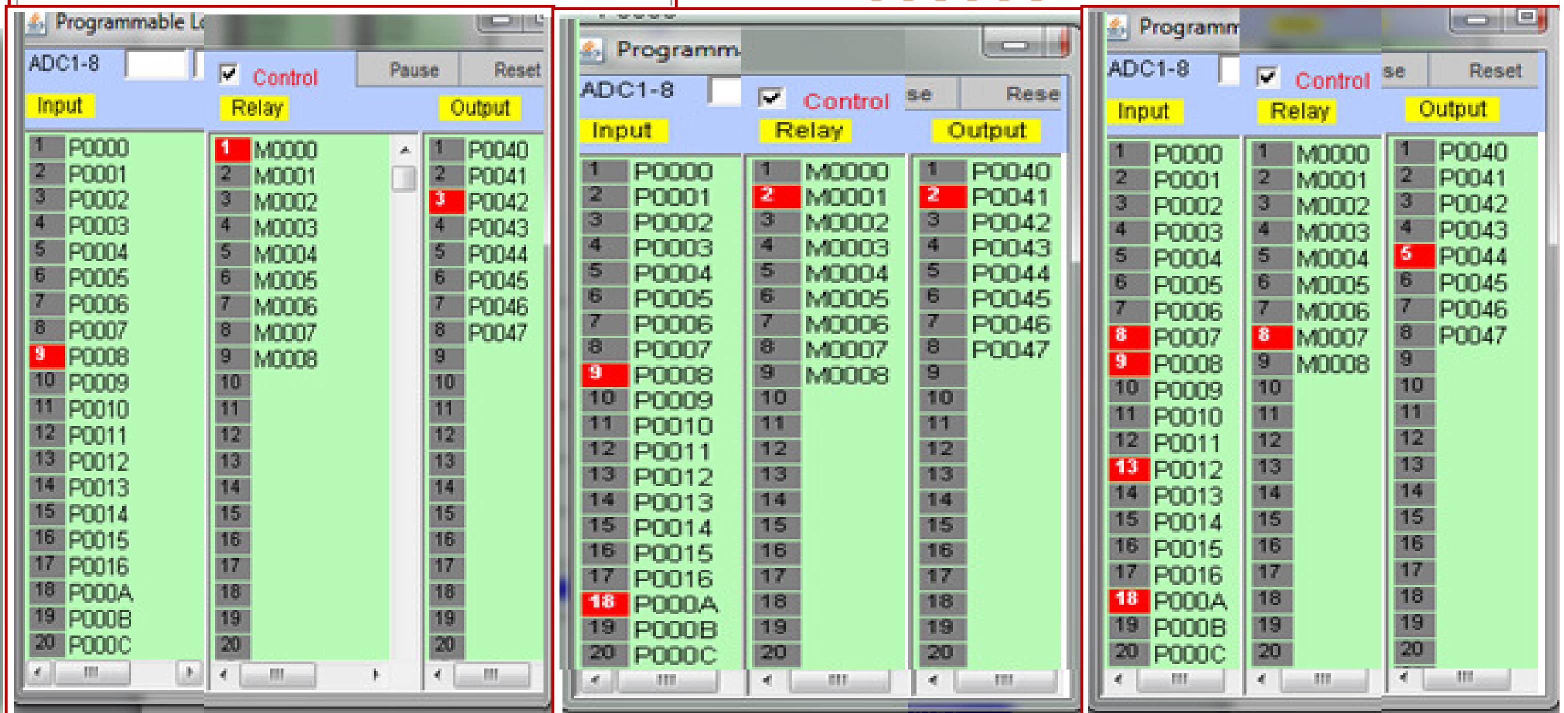






PLC simulator of Tower movement as I/O done



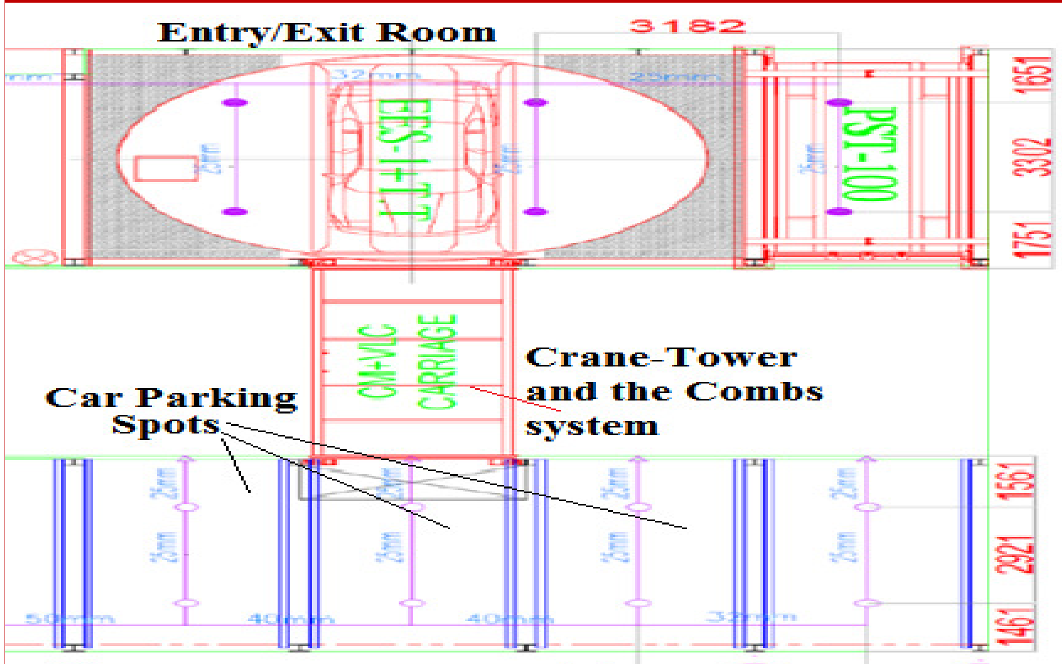


Design of fire protection systems: The procedures followed to do a reliable fire protection system are summarized as following:

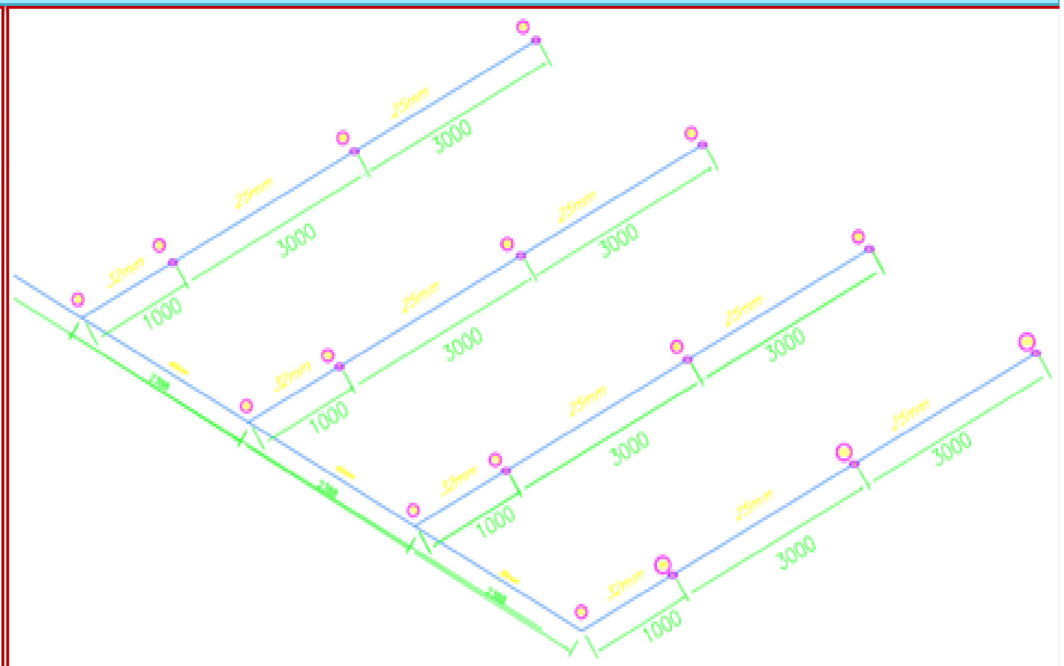
· locating risers · fire hose racks · defining zones · furnishing sprinklers · piping network · pump room · furnishing fire extinguishers

While the fire protection system sizing calculation steps could be summarized as following:

1-Identification of hazard. 2-Determination of max. area of operation. 3-Determination of discharge density. 4-Determination of hydraulically most demand area. 5-Estimating of sprinklers flow rate. 6-Determination of hose stream allowance. 7-Calculation of pump low rate. 8-Tank sizing. 9-Calculation of pump head

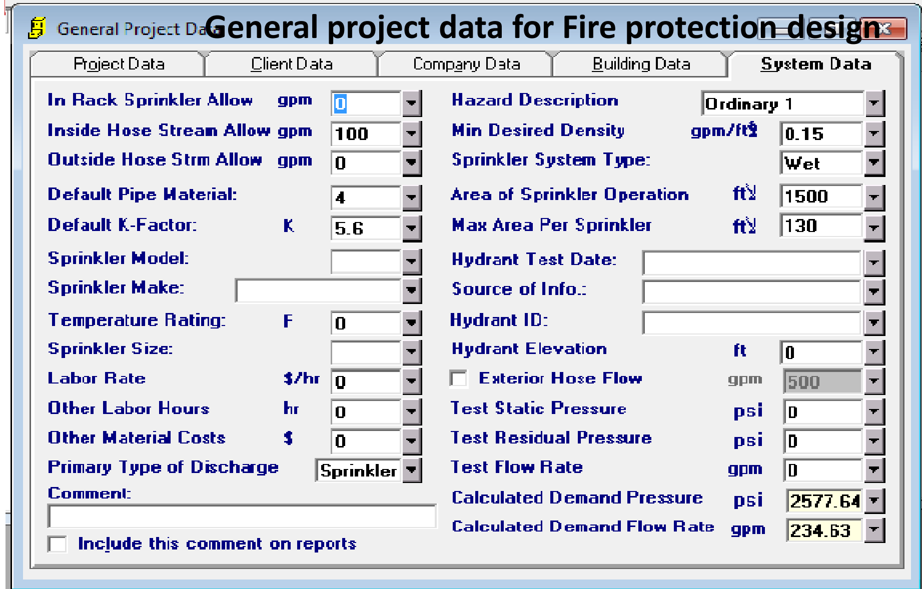


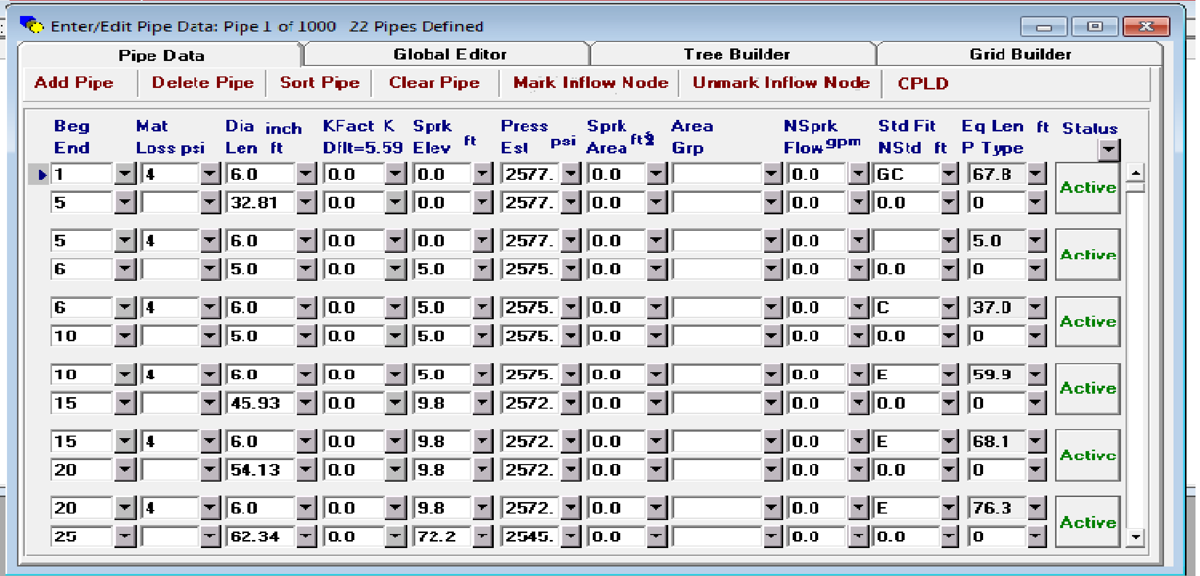
Layout of a part of the APS



sample of the route of the most remote sprinkler

General project data for Fire protection design





Beg / End	Mat / Loss psi	Dia inch / Len ft	KFact K / Dflt=5.59	Sprk Elev ft	Press Est psi	Sprk Area ft²	Area Grp	NSprk Flow gpm	Std Fit / NStd ft	Eq Len ft / P Type	Status
1	4	6.0	0.0	0.0	2577.	0.0		0.0	GC	67.8	Active
5		32.81	0.0	0.0	2577.	0.0		0.0	0.0	0	
5	4	6.0	0.0	0.0	2577.	0.0		0.0		5.0	Active
6		5.0	0.0	5.0	2575.	0.0		0.0	0.0	0	
6	4	6.0	0.0	5.0	2575.	0.0		0.0	C	37.0	Active
10		5.0	0.0	5.0	2575.	0.0		0.0	0.0	0	
10	4	6.0	0.0	5.0	2575.	0.0		0.0	E	59.9	Active
15		45.93	0.0	9.8	2572.	0.0		0.0	0.0	0	
15	4	6.0	0.0	9.8	2572.	0.0		0.0	E	68.1	Active
20		54.13	0.0	9.8	2572.	0.0		0.0	0.0	0	
20	4	6.0	0.0	9.8	2572.	0.0		0.0	E	76.3	Active
25		62.34	0.0	72.2	2545.	0.0		0.0	0.0	0	