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MEP 480 B.Sc. Design Project - July 2016/2017

Design of an Automatic Bottling Production Line System Using PLC & HMI

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Supervised by

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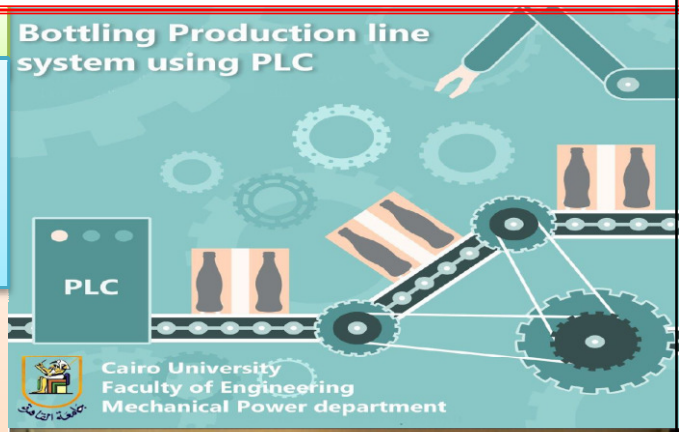
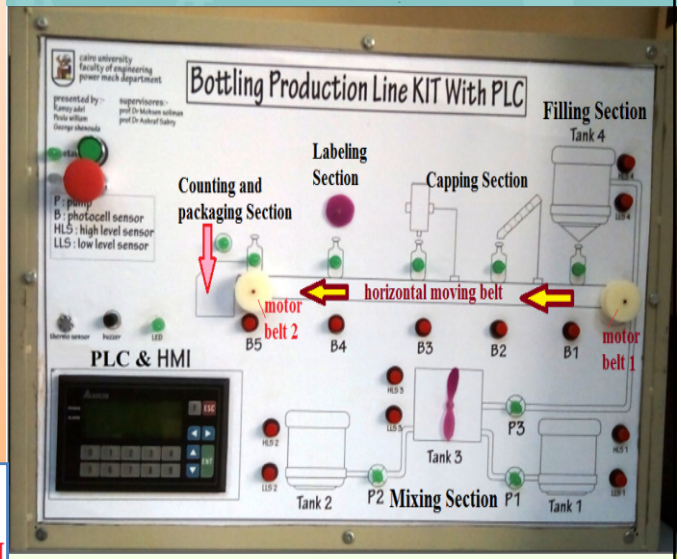


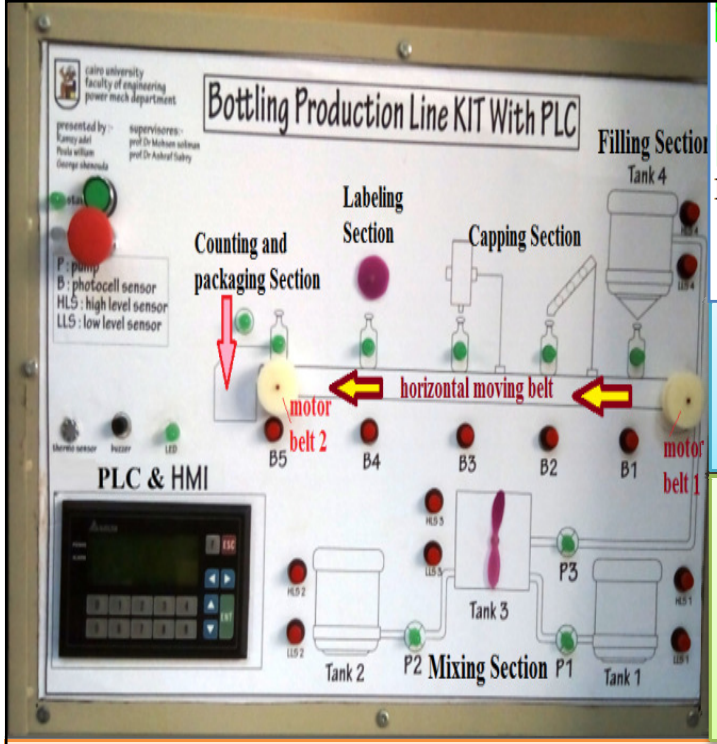
Abstract: **This project is an example for experimental practical application of PLC & HMI (Programmable Logic Controller & Human Machine Interface) Systems in Mechanical Power Engineering. Initial project proposal objectives are to study and investigate deeply various types of PLC, Hydraulic & electric control circuits in an real automatic bottling production Line System Using PLC & HMI. The strategic project objectives are to design and execute simplified practical training model which uses both PLC & HMI techniques & simulates the real System. In addition to selecting specific PLC & HMI which are proper for producing the Training Kit, project required selecting and using several types of electric digital switches, Relays, LEDs & input/output I/O devices. Further more, in order to do and practice different aspects of using PLC, the project includes also running and testing practical PLC-Simulation software to diagnose possible errors & trouble-shooting of both automatic control PLC&HMI systems of sequential programming. Finally the project includes detailed & carefully prepared documentation procedure report for both SFC, Sequential Function chart, LAD program & wiring of the Garage practical Training Kit .**



Overview: This is an automatically controlled bottling production line system. The objective is to provide a mixed liquid which could be a juice, milk or any wanted liquid depending on demand of the factory in a simple way using both PLC & HMI

من ضمن أهداف ومخرجات المشروع:

- دراسة أساسيات ومكونات PLC والتعرف على إمكانياته وخصائصه التقنية فى عمليات التحكم الإوتوماتيكى ثم تحديد التفاصيل الفنية وعناصرالنوع المناسب لكل منظومة تحكم محددة.
- دراسة بعض عناصرالميكاترونيكس الرقمية والتناظرية Input & Output devices for PLC (مثل أجهزة القياس والحساسات والمفاتيح وبعض أنواع أجهزةالخرج Output actuators).
- تعلم تقنيات وخطوات تصميم برنامج للتحكم المنطقى المتعاقب وممارسة وتنفيذ مخطط لوظائف التشغيل المتعاقب SFC: Sequential Flow Chart
- تنفيذتقنيات البرمجةالمتعاقبة Sequential Programming وما تتضمنه من ضرورةوجودبرمجةمتوازيةأوإختيارية Parallel or Selective Branching حسب متطلبات عملية التحكم.
- تعلم عناصرلغة برمجة أجهزةPLC الخاصة بالمشروع وتعلم برامج ومهارات الكتابة والتوثيق للبرنامج PLC Ladder diagram
- تعلم تقنيات برامج المحاكاة PLC Simulation software لتنفيذ برنامج التحكم بالحاسب الآلى PC لتشخيص أخطاء البرمجة قبل التنفيذ العملى.
- تحديدكافةالحساسات والاجهزةالمصاحبةالمختلفةلكل من Input &Output devices التى يجب توافرهاوتعلم كيفيةتوصيلها بأجهزة PLCلإستكمال منظومةالتحكم عندتشغيل PLC.
- تصميم وإنشاء وتنفيذ وتوثيق جهاز تجربة معملية جديدة ووحدة تدريب دائمة بإستخدام جهاز الحاكم المنطقى المبرمج PLCمع كافة المكونات الكهربية والإلكترونية المطلوبة.
- إكتساب Soft skills وخبرةلعمل تقريرهندسى متكامل Technical Engineering Report وتقديمعرض presentation للجهازونتائج المشروع بوسائل عرض سمعيةوبصرية حديثة.



The Main components of the Bottling system

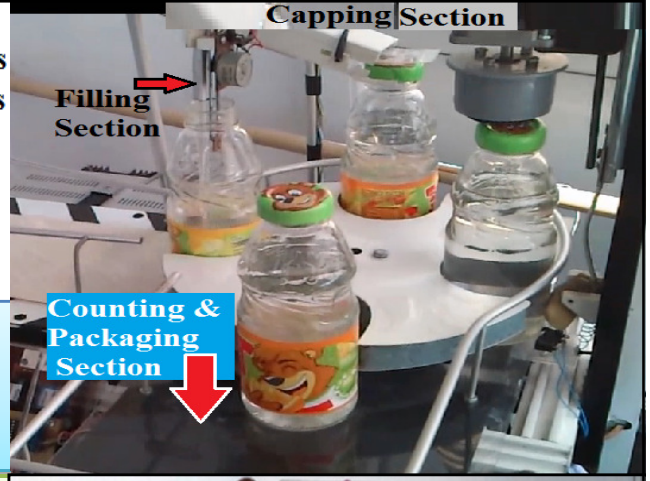
PLC with Built-in HMI Photo-cell Sensors Level Seitches
Solenoid Flow Control Valves Pumps Motors LEDs PBs

Input Components

Photo-cell Sensors Level Seitches PBs HMI

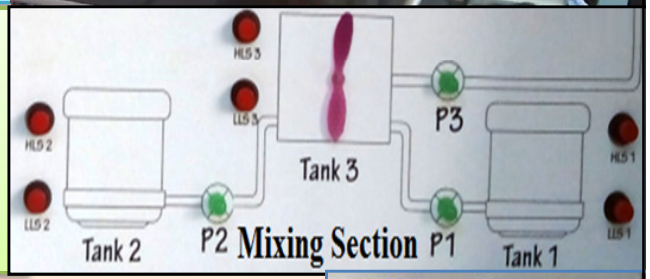
Output components

Solenoid Flow Control Valves Pumps Motors LEDs



Note: real signals of IR or level sensors are simulated by manual Push Buttons to get the PLC-inputs. All PLC-outputs to the field devices & actuators are simulated by LEDs & motors which come ON if output is activated.

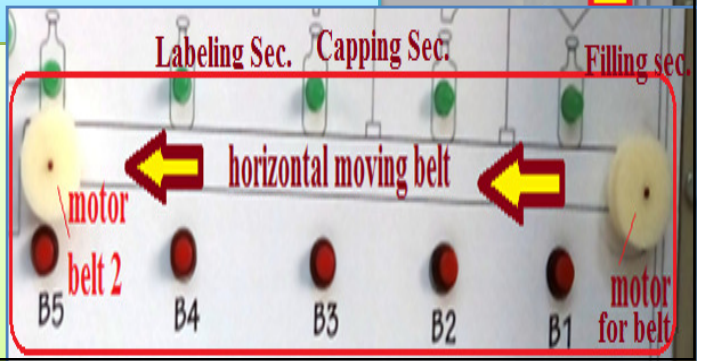
Bottling Training-Kit: upper fig. is real Bottling system which has some sections in a Bottling line similar to Kit. As seen on 2nd fig. to the left of our Kit is divided into 4 main sections (in addition to last Sec. part for counting &packaging). All the sections seen on Training Kit operate as follows:

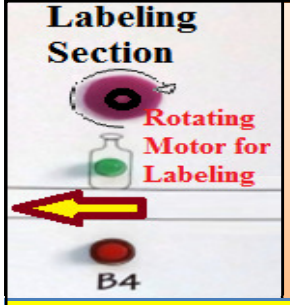


1) **Mixing section:** when power is ON & Start PB is pushed, 1st process begins by starting the 2 pumps P1&P2 to draw & feed liquids from tanks 1&2 to mixing tank 3. Both pumps have same capacity. If a High Level sensor in any tank HLS1/HLS2 is pushed, tank's pump stops to prevent overflow. If a Low Level sensor LLS1/LLS2 in any tank is pushed, tank's pump stops to protect pump. Mixer in tank 3 is used to mix the 2 liquids. To save time, mixer may start running (at any specified time in the LAD) after starting pumps 1&2. After mixing, liquid is drawn from thank 3 to feed Filling tank4. High & Low Level sensors HLS3&LLS3 are used to control time of starting or stopping pump 3.

2) **Filling process:** when the mixture in feeding tank4 reaches to Low Level sensor LLS4, all operation stops to prevent having empty bottles. When the mixture in feeding tank4 reaches High Level sensor HLS4 all operation stops to prevents overflow of Tank4. In both cases the filling process can be resumed only if the liquid in Tank4 is above LLS4 and below HLS4. and the2 pumps have to both run to fill the main tank3 again the same process starts to happen again.

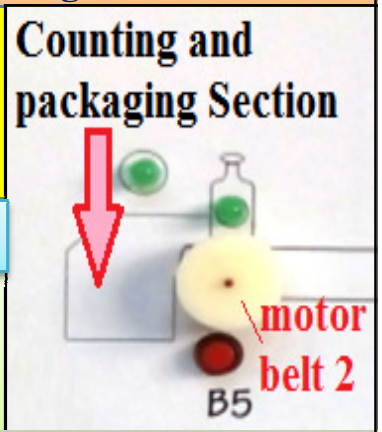
3) **Bottle moving on the belt:** as seen we have 4 input PBs that correspond to 4 photocells B1, B2, B3,B4 located along the belt bath. Each photocell detects the passing of one bottle in a specific section (Filling, Capping then Labeling). In order to move the belt, the motor has to run (by PLC output from LAD) after Tank 4 is filled. If we push PB-B1 at Filling location, LED is ON at filling bottle Sec. If we push PB-B2 at capping sec. 1st LED is ON & if PB-B3 is then pushed, 2nd LED is ON. If PB-B4 is pushed, LED at capping sec. is ON as belt motor is ON.





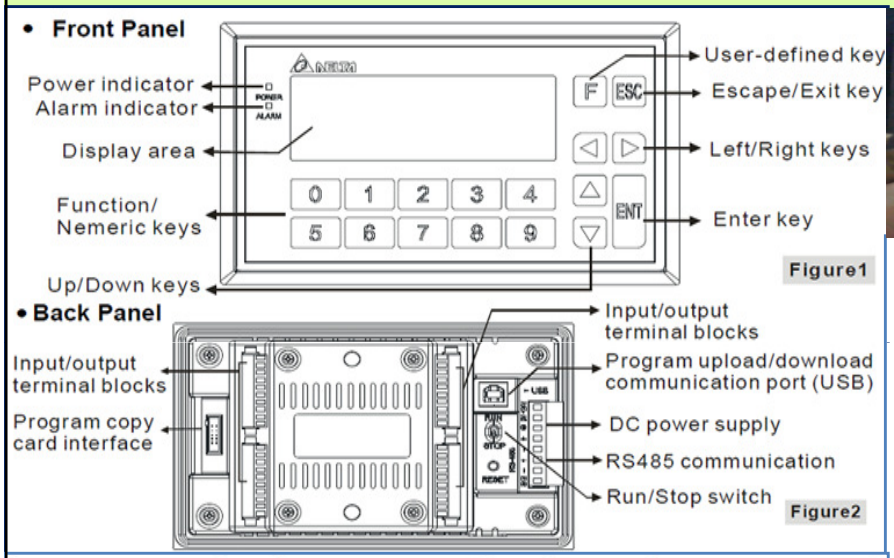
4) Capping and labeling: In real Bottling line, there are several methods for capping and labeling. As shown above, capping for our Kit is done by pushing B2then B3. The Labeling sec. includes a rotating motor to do this task. Motor is activated to run by PLC output from the LAD after the PB-B4 is pushed. LED on bottle is ON indicating the progress of Labeling process. Depending on the sequence of pushing B1,B2, B3, B4, we may have all filling , capping and labeling are done at the same time on different bottles. This should be indicated by all LEDs are turned ON and staying ON while the motor belt is ON indicating belt motion.

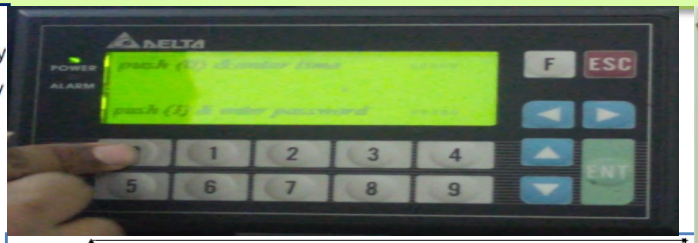
5) Counting & Packaging Section: as shown, a 2nd motor belt 2 is provided to perform the packaging process. This step is initiated and started by pushing PB-B5. The motor belt 2 is ON to run by PLC output from the LAD after PB-B5 is pushed. As a result the LED becomes ON indicating the progress of counting and packaging process. At the same time the HMI unit shows acounter display of number of bottles which have been counted in one package.

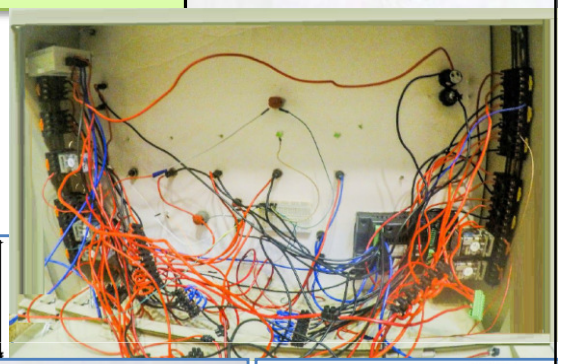


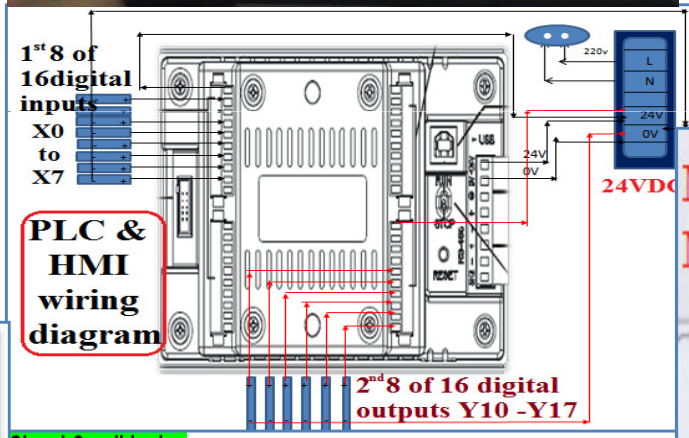
Technical data & Wiring Diagram of Delta-PLC with built-in HMI (TP04P-32TP1R)

24VDC Delta-PLC with built-in HMI is used. It has 16 digital inputs&16digital outputs. Real input limit switches, Infra-red sensors are modeled by16 Push-buttons. Real PLC output signals to Relays, hydraulic circuit or other electric actuators are modeled by many LEDs and DC motors.





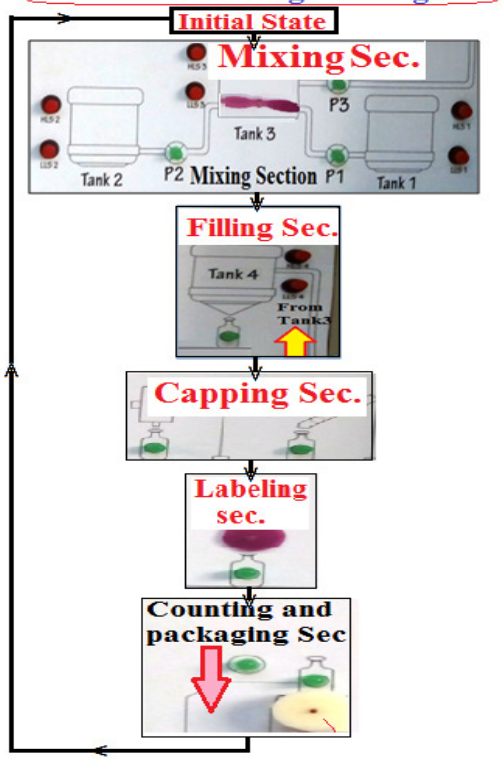




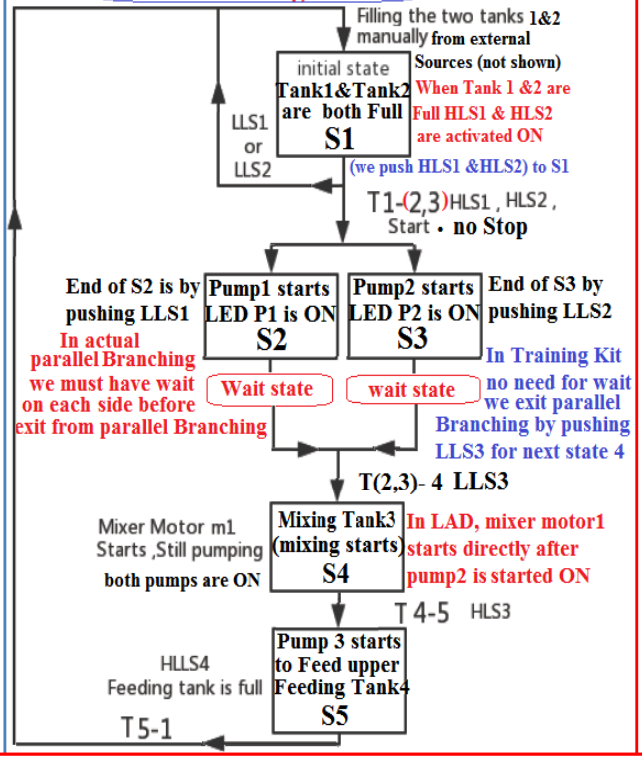
Signal Conditioning

The output of the sensors cannot be given directly to the PLC as the input voltage to the PLC should be 24V. Hence they are given through signal conditioning circuits which condition the input signals and in turn give it as an input to the PLC . For safety purposes the input are given directly to the PLC .They are given through relay circuits . The relay consists of 3 terminals-common. NO and NC . the 24V which is to be inputted into the PLC will be available in the common terminal .

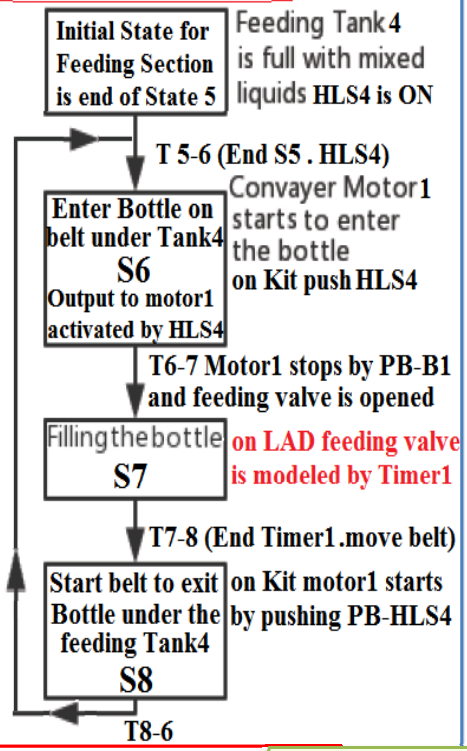
SFC for all Bottling Training Kit



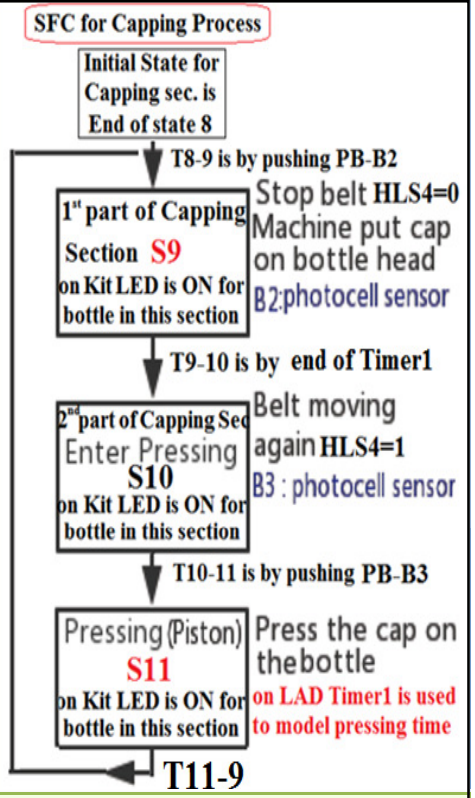
SFC for Mixing Process



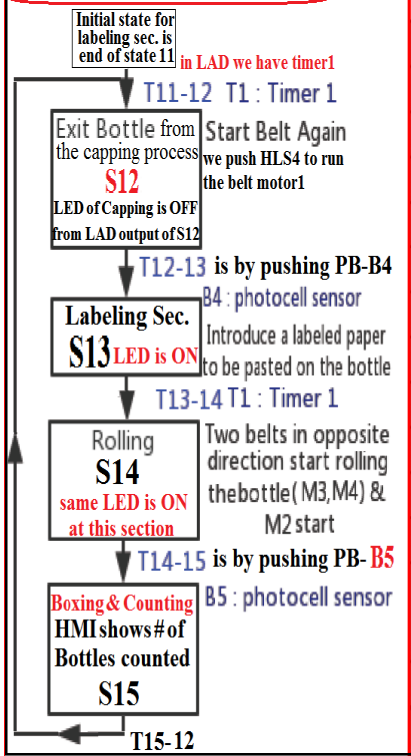
SFC for Feeding Process



SFC for Capping Process



Labeling, Boxing & Counting Processes



All PLC Inputs, Outputs & Relays in LAD

start	start	X0	pump1 P1 : pump 1 Led	Y0
stp	stop	X1	pump2 P2 : pump 2 Led	Y1
HLS3	HLS3 : high level sensor three	X10	valve V1 : valve Led	Y10
HLS4	HLS 4 : high level sensor four	X11	diaplay LED of Buzzer	Y11
LLS1	LLS1 : low level sensor one	X12	cap Led of capping process	Y12
LLS2	LLS2 : low level sensor two	X13	pump3 P3 : pump 3	Y2
LLS3	LLS3 : low level sensor three	X14	motor1 M1 : motor one (mixing motor	Y3
LLS4	LLS 4 : low level sensor four	X15	motor2 M2 : motor two (belt Motor	Y4
b1	B1 : photoelectric sensor one	X2	motor3 M3 : motor three (labeling motor	Y5
b2	B2 : photoelectric sensor two	X3	motor4 M4 : motor four (labeling motor	Y6
b3	B3 : photoelectric sensor three	X4	M5 : motor five (packing motor	Y7
b4	B4 : photoelectric sensor four	X5	Buzzer	Y13
b5	B5 : photoelectric sensor five	X16	Led of labeling process	Y14
HLS1	HLS1 : high level sensor one	X6	led of start pushbutton	Y15
HLS2	HLS2 : high level sensor two	X7	led of stop pushbutton	Y16
TTs	Thermo sensor Fire case	X17	led of thermo sensor	Y17

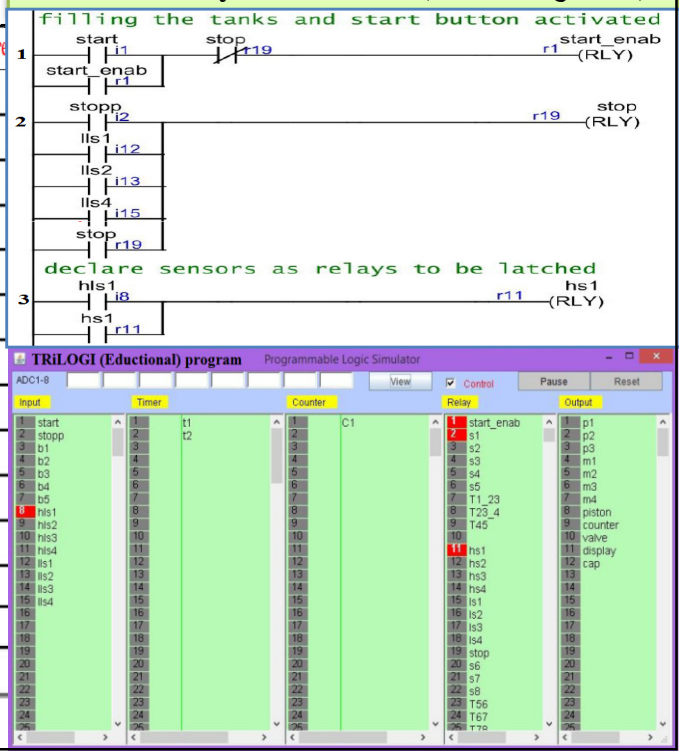
PLC Inputs 15 Push Buttons +Thermostate(fire case)

16 PLC Outputs (motors + Buzzer + LEDs)

Relays used for Transitions & all States in the LAD

Identifiers	Addres of Relays	Identifiers	Addres of Relays	Identifiers	Addre
cc	C0	SS8	M23	T1011	M39
start_enab	M0	TT56	M24	ss3	M4
ss1	M1	TT67	M26	T1112	M40
hs1	M10	TT78	M27	T1213	M41
hs2	M11	TT89	M28	T1314	M42
hs3	M12	SS9	M29	T1415	M43
hs4	M13	SS10	M30	TT151	M44
LS1	M14	SS11	M31	ss4	M5
LS2	M15	SS12	M32	ss5	M6
LS3	M16	SS13	M33	T1_23	M7
LS4	M17	SS14	M34	T23_4	M8
SSTOP	M18	SS16	M35	TT45	M9
ss2	M2	SS15	M36	timer1	T1
SS6	M20	SS17	M37	timer2	T2
SS7	M21	T910	M38		

SFC1st tested by TRiLOGI SW(المشروع به التفاصيل)



Ladder Diagram " ISPsoft " In This project we used ISPsoft to be the ladder diagram program used .

ISPSoft V2.0 Highly Accessible Programming Software

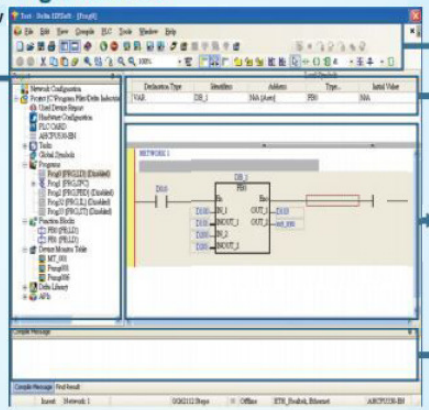
Fully Integrated Interface

Advanced Programming Interface + Visualized Hardware Configuration + Simplified Network Configuration

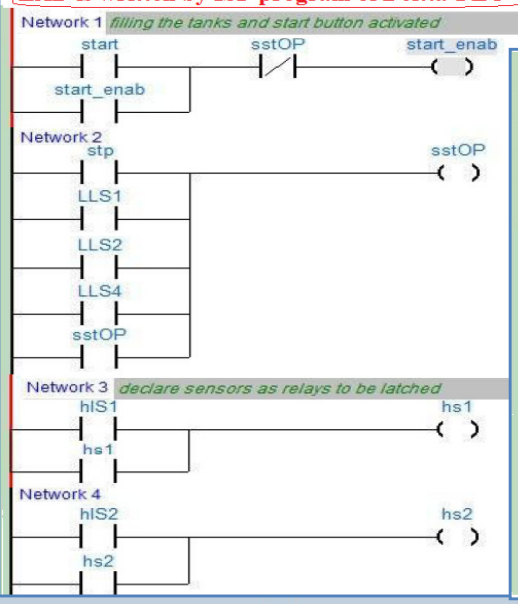
Advanced Programming Interface

Project Management Window

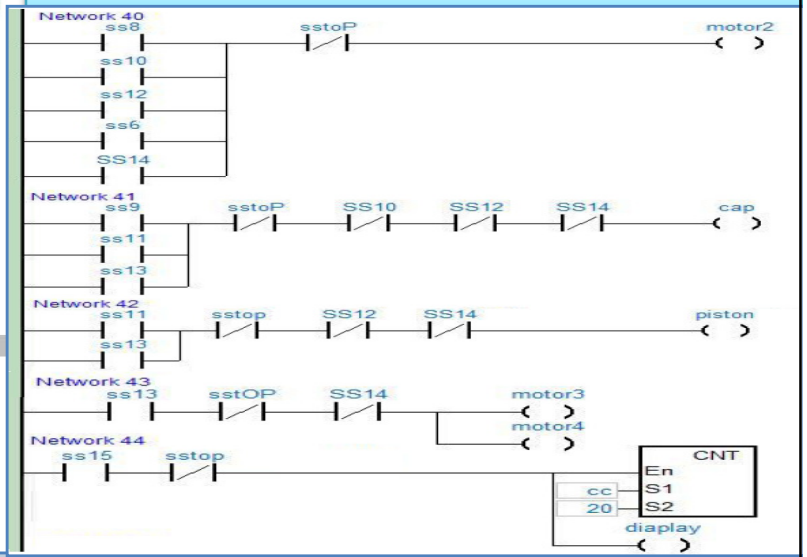
- **New functions:** Network configuration, hardware configuration and PLC card
- Supports 5 programming languages (LD/FBD/SFC/IL/ST)
- **Function Blocks:** Symbols can be introduced in call-by-value or call-by-reference types. Function blocks can be called in function block for up to 32 levels
- **Monitor Table:** It can be stored and managed separately. Multiple monitor tables can be stored in a single project
- **User Library:** Users can design frequently used instructions for specific applications in different industries
- **Task:** Supports cyclic, I/O interrupt, timer interrupt, external interrupt, etc. Software will provide the usable tasks for different CPU



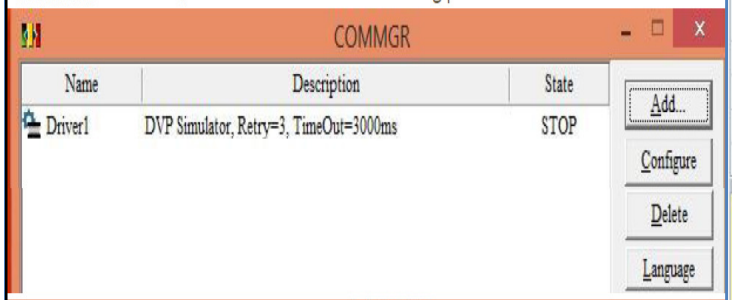
LAD is written by ISP program of Deltta-PLC

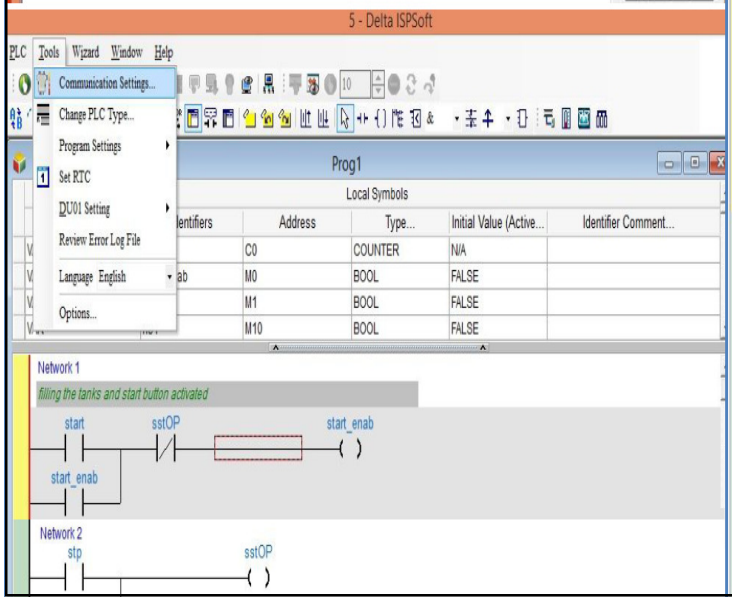


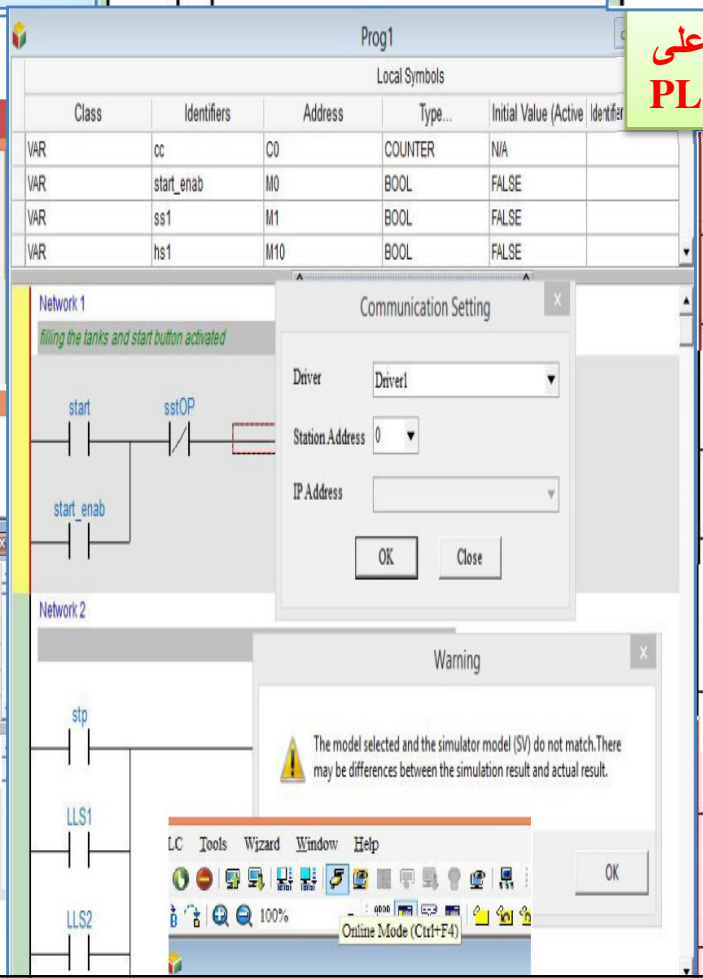
يوجدبالمشروعصورلكل تفاصيل برنامجLAD on ISP



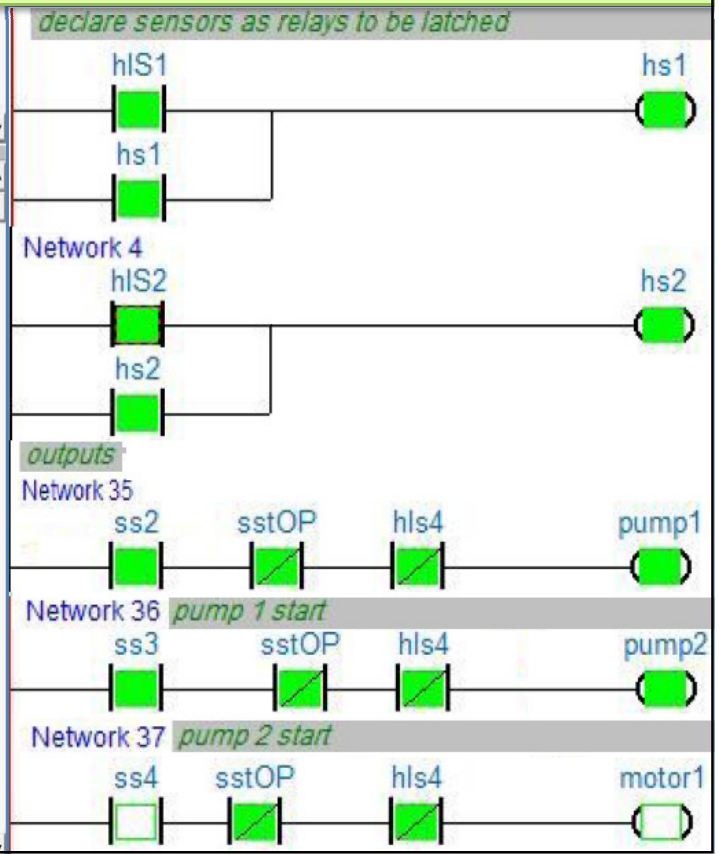
Simulation on " ISPsoft " To simulate the whole process on the used program we used "COMMGR" software , and continue with the following procedure :







يوجدفىالمشروعصوركثيرةمنمحاكاةتشغيلالبرنامجعلى الحاسبلتشخيصأخطاءالبرمجةقبلتشغيلهعملى بPLC



Steps to run all the process of Bottling Production Line

- To start all processes push on start pushbutton
- filling the two tanks (tank 1 and 2) manually to HLS1 and HLS2 and make sure all the pumps does not work
- when the HLS1 and HLS2 activated by push on HLS1 pushbutton and HLS2 pushbutton the two pumps (P1 , P2) start to work(the leds will light up) and filling the mixing tank
- when the LLS3 activated by push on it the mixing motor (M1) will start to work and the two pumps still working
- when the HLS3 activated by push on it the P1 , P2 and M1 will stop
- then the pump three (P3)(led will lights up) will start to send the liquid to the feeding tank
- when the HLS 4 in the feeding tank activated by push on it the P3 will stop
- then the conveyer motor M2 will work and first bottle enters to the filling process
- when the photo sensor (B1) activated by push on it the M2 will stop and the bottle will stop under the feeding tank and the valve will (V1) open and fill the bottle for time (T1)
- when T1 ended the M2 will work and the bottle will move to the capping process
- when the B2 activated by push on it the M2 will stop and the bottle stop under the capping machine for the same time T1
- when T1 ended the M2 will work again and the bottle will move to the next process
- when B3 activated by push on the M2 will stop and the bottle will stop under the piston and will compress the cap on the bottle and will wait for T1
- when the T1 will ended the M2 will work and the bottle will move to the labeling process
- when B4 activated by push on the labeling motors M3 , M4 will start to work
- the label will stick on the bottle
- the M3 and M4 will drive a belt to press on the label
- when the B5 activated by push on the led will lights up and show on the front panal (HMI) counter number of passes bottles
- at the end the bottle fall on the box
- when the number of passes bottles reach to 6 the M5 will drive a belt and another box enters to hold the bottles
- when fire happens the thermo sensor send a signal to the buzzer and the led will lights up and the all processes will stop
- when the LLS 1 and LLS2 and LLS3 activated by push on one of them the all processes will stop

Modifications& Recommendations for Future Work

The main objective of this paper was to develop a bottling filling and packing system based on certain specifications. This is was successfully implemented. We consider this paper a journey where we acquired knowledge and also gained some insights into the subject which we have shared in this report .

We have a future vision we can apply to this project as a part of progress and technologies application to the production line system .

Trouble Shooting of the Kit

1) if any bottle not entrance or there is no next bottle during the system working , the sensor B1 has not signal and the filling valve stop

2) if the bottle has not complete liquid , there is a sensor to detect this case and then the horizontal piston get rid of it out of the belt

3) if the bottle is not capped there is a sensor with capping piston stop the piston motion and the horizontal piston push this bottle out of system

4) if there is a fire in a system place or in the line , the thermo sensor detect it and shut off the system

5)if the labeling paper is finished , the buzzer gives alarm sound to quickly replace the new one

Multi-Mixing Technique

Although proposed system illustrates the mixing process of two liquids , any number of liquids may be mixed in varying portions as we can use more than two tanks with other portions of liquids .