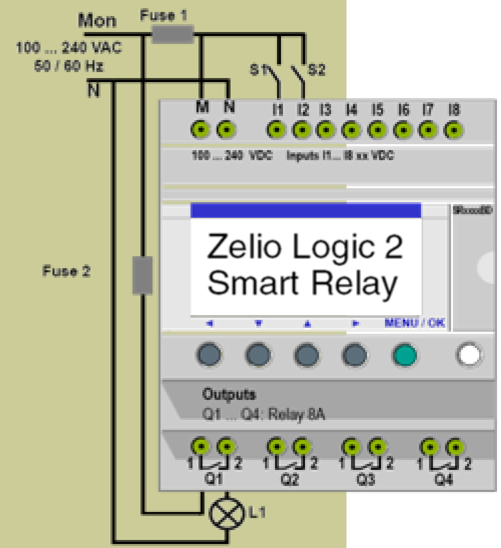

PLC Exercises

Ladder Diagram Programming

By

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Hashemite University

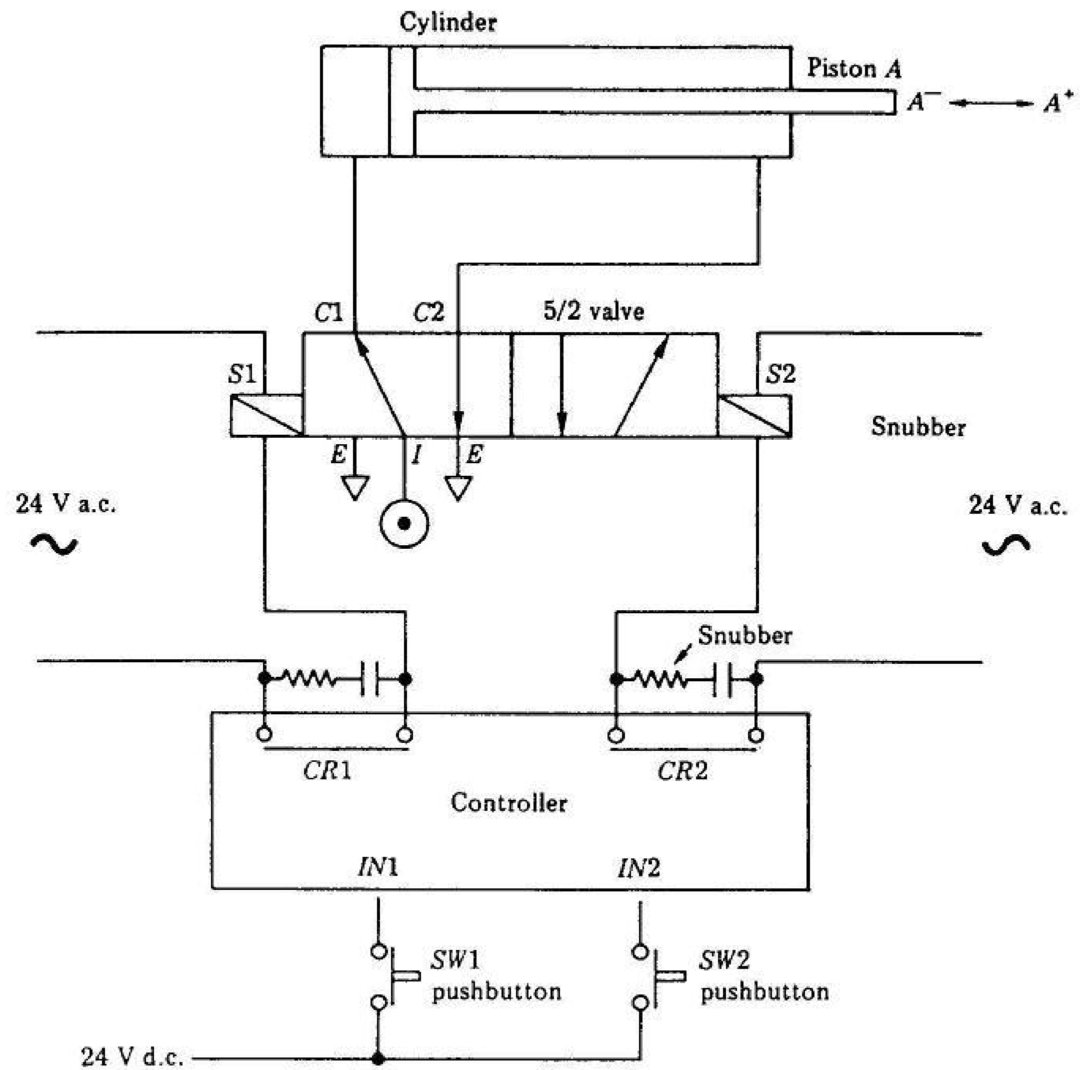
Steps for Building a Ladder Diagram

1. Determine the No. of digital I/O
2. Determine the No. of analog I/O (if needed)
3. Determine if there are special functions in the process
4. Estimate program capacity depending on the process
5. Choose a suitable PLC series
6. Prepare the wiring diagram
7. Draw flowchart or control diagram (Optional)
8. Program the PLC using the ladder diagram

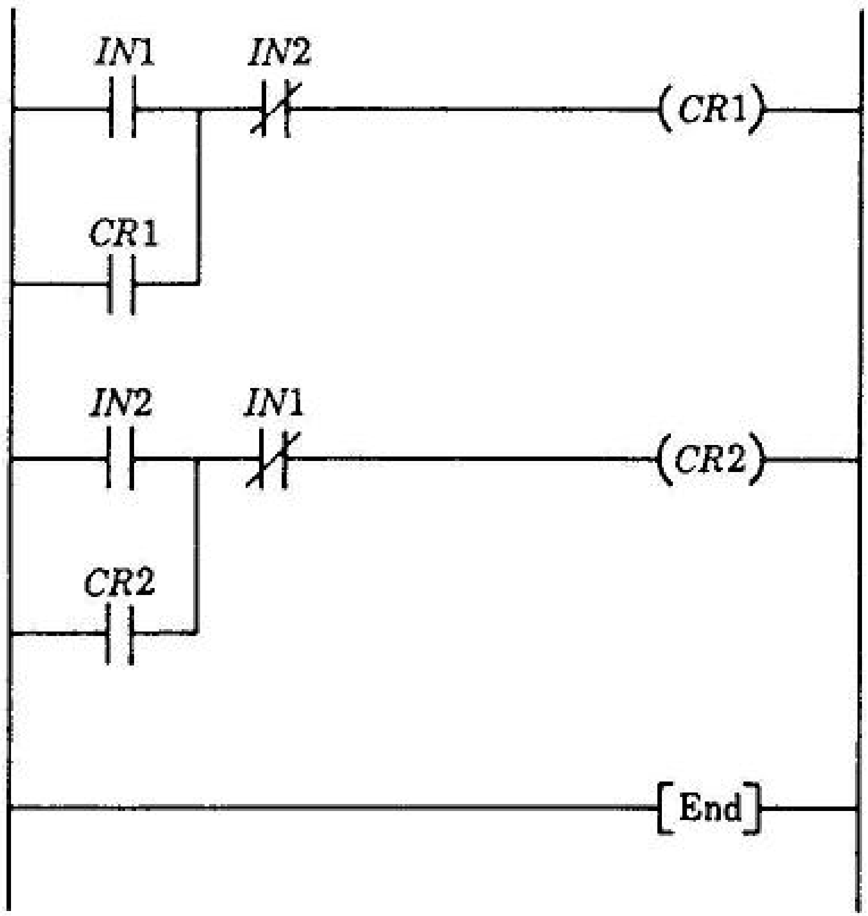
Exercise #1: Moving a Pneumatic Piston

Control Problem

The PLC task is to move the piston in and out. When switch SW1 is momentarily turned on, piston A is to move out of the cylinder in A+ direction. When switch SW2 is momentarily turned on, piston A is to move into the cylinder in A- direction.



Exercise #1: Moving a Pneumatic Piston



Address	Instruction	Data
0	LOAD	IN1
1	OR	CR1
2	AND NOT	IN2
3	OUT	CR1
4	LOAD	IN2
5	OR	CR2
6	AND NOT	IN1
7	OUT	CR2
8	END	

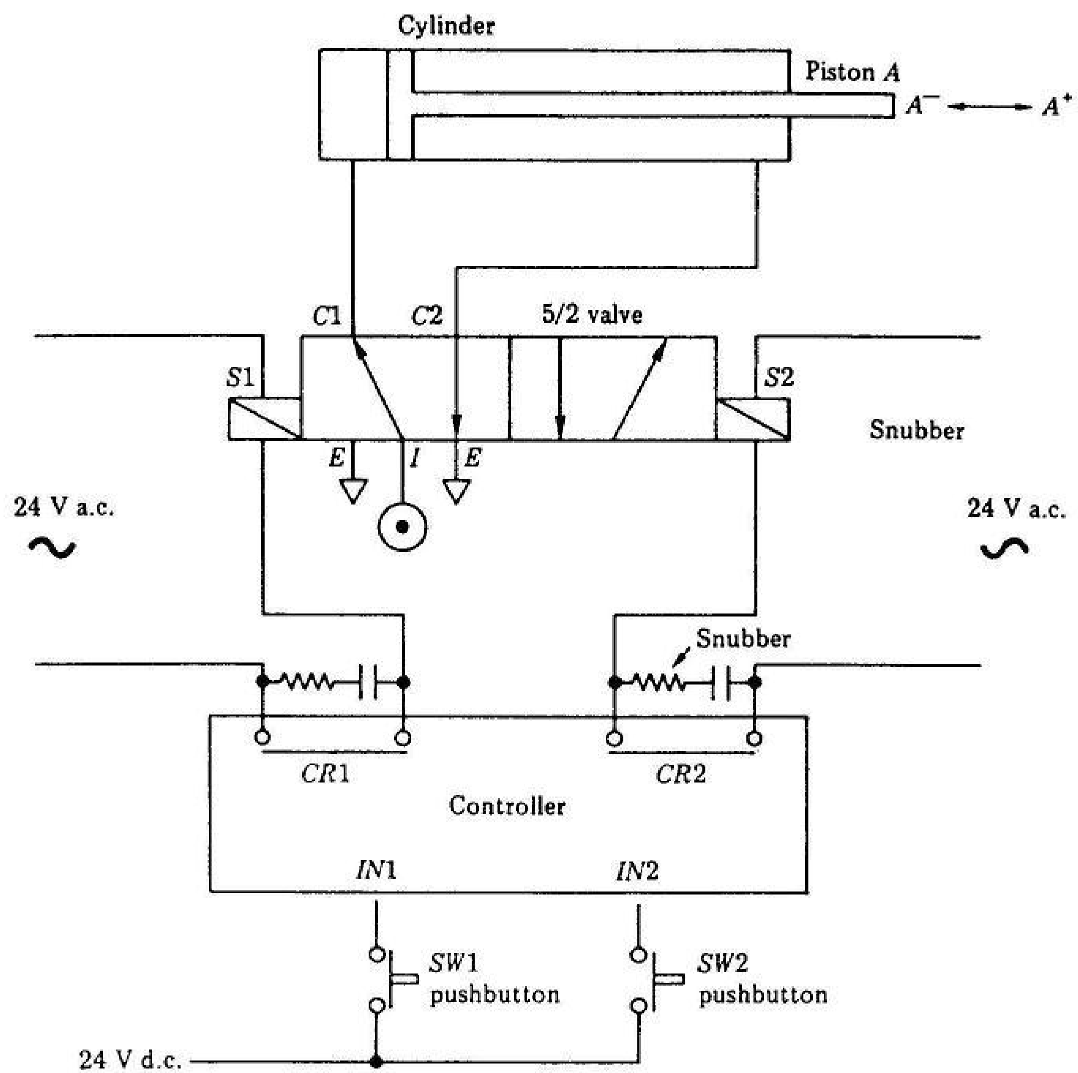
Exercise #1: Moving a Pneumatic Piston

If SW1 and SW2 are pressed together, what would happen?

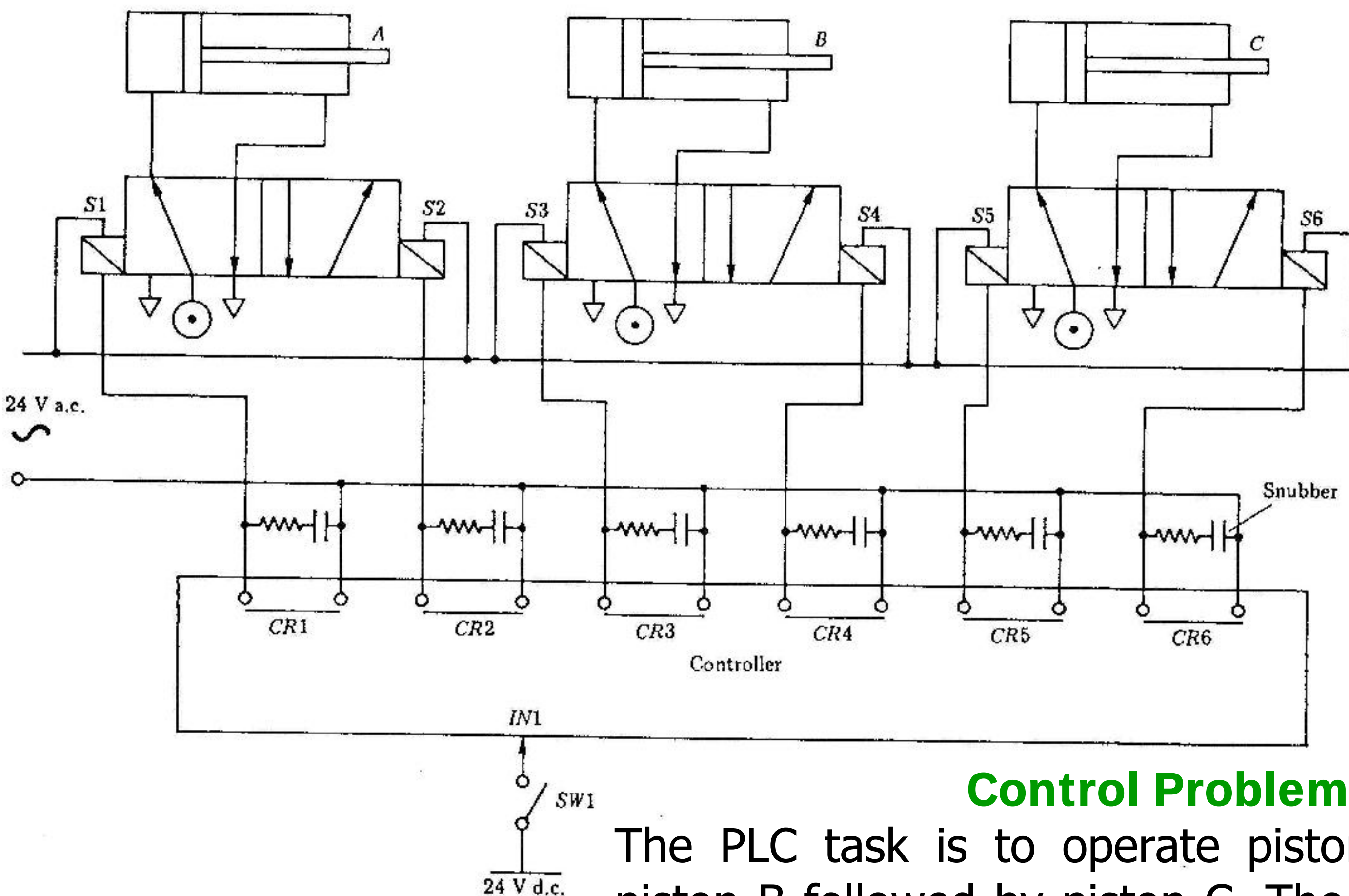
The two solenoid valves will be tuned off

How can we make an electrical interlock?

Use the contacts of the main relays instead of the input contacts



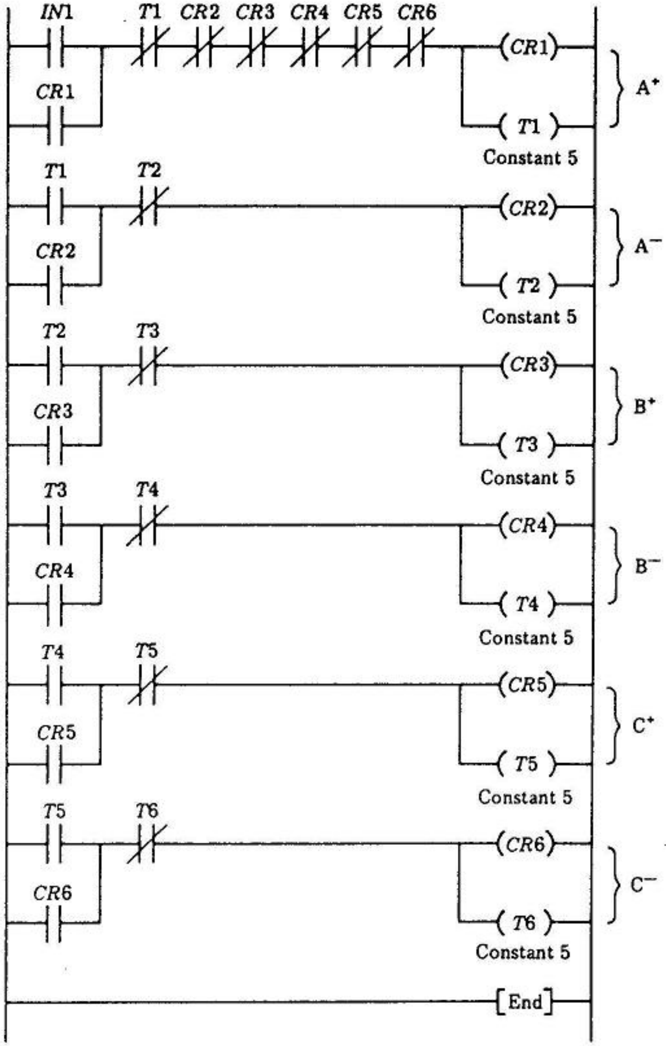
Exercise #2: Sequencing of Pneumatic Pistons



Control Problem

The PLC task is to operate piston A followed by piston B followed by piston C. The sequence is A+, A-, B+, B-, C+, C- is to be repeated when switch SW1 is turned on

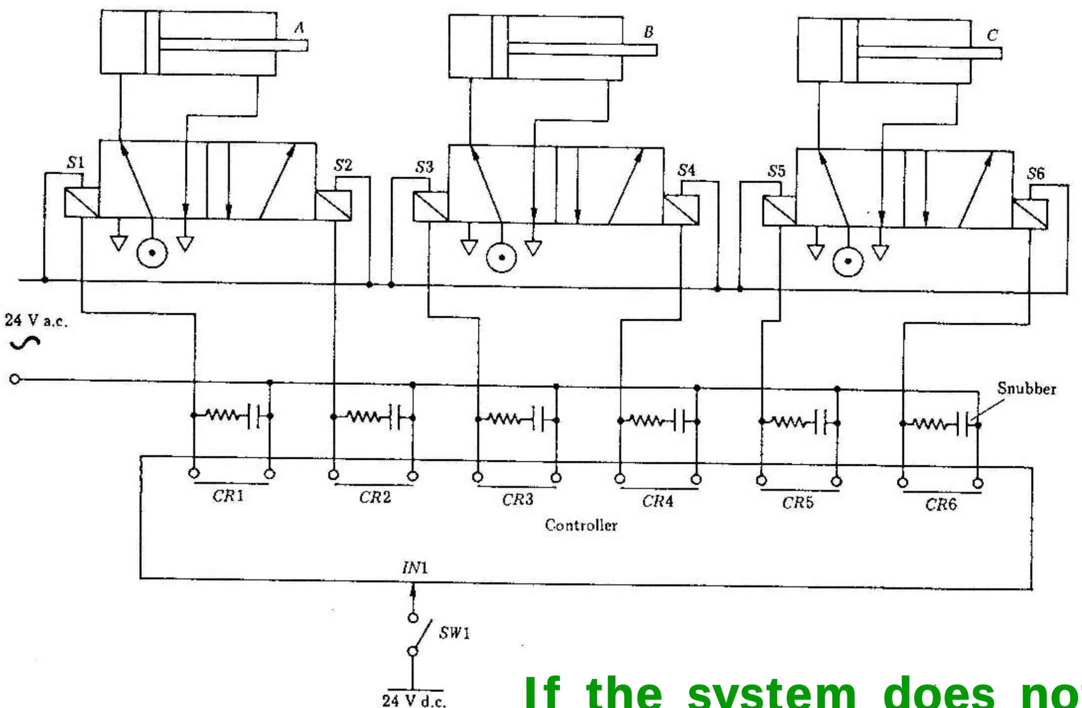
Exercise #2: Sequencing of Pneumatic Pistons



Address	Instruction	Data
0	LOAD	IN1
1	OR	CR1
2	AND NOT	T1
3	AND NOT	CR2
4	AND NOT	CR3
5	AND NOT	CR4
6	AND NOT	CR5
7	AND NOT	CR6
8	OUT	CR1
9	OUT	T1
10	CONSTANT	5
11	LOAD	T1
12	OR	CR2
13	AND NOT	T2
14	OUT	CR2
15	OUT	T2
16	CONSTANT	5
17	LOAD	T2
18	OR	CR3
19	AND NOT	T3
20	OUT	CR3
21	OUT	T3
22	CONSTANT	5
23	LOAD	T3
24	OR	CR4
25	AND NOT	T4
26	OUT	CR4
27	OUT	T4
28	CONSTANT	5
29	LOAD	T4
30	OR	CR5
31	AND NOT	T5
32	OUT	CR5
33	OUT	T5
34	CONSTANT	5
35	LOAD	T5
36	OR	CR6
37	AND NOT	T6
38	OUT	CR6
39	OUT	T6
40	CONSTANT	5
41	END	

Circuit for sequencing the pistons.

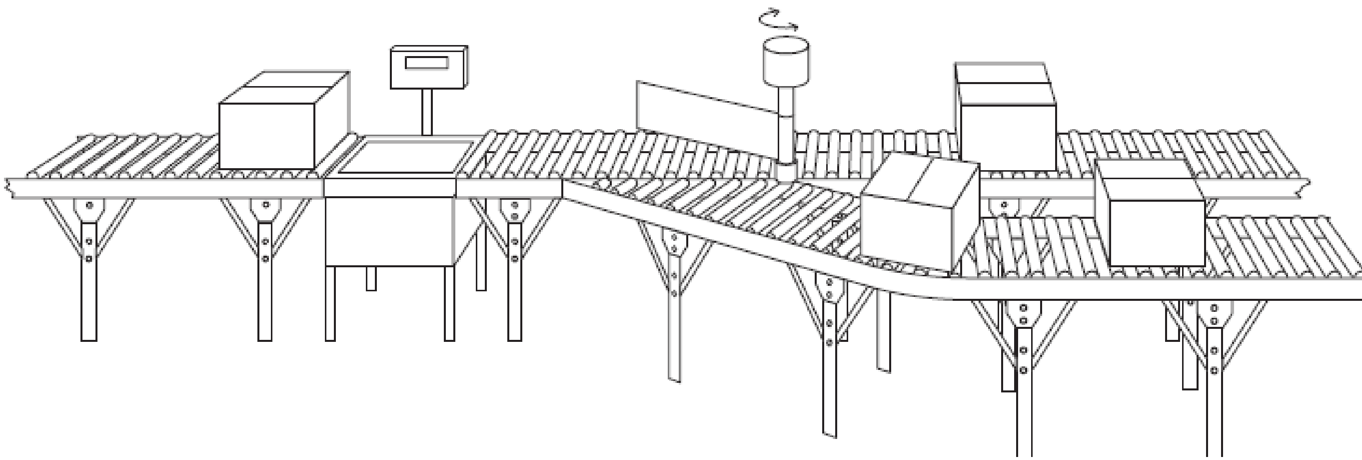
Exercise #2: Sequencing of Pneumatic Pistons

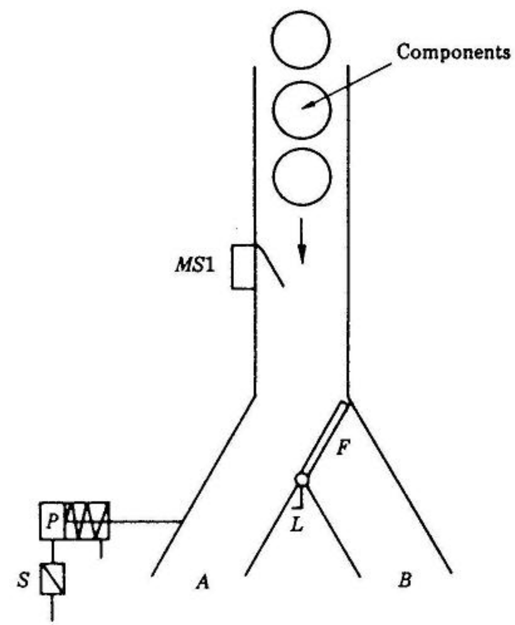


If the system does not work or sequence in not correct, what would be the possible reasons?

- Solenoid valves do not work
- The wiring of solenoid valves is not correct or not in the correct order (wiring problem)
- The ladder diagram is not properly written (sequence in not correct)

Exercise #3: Batching Machine

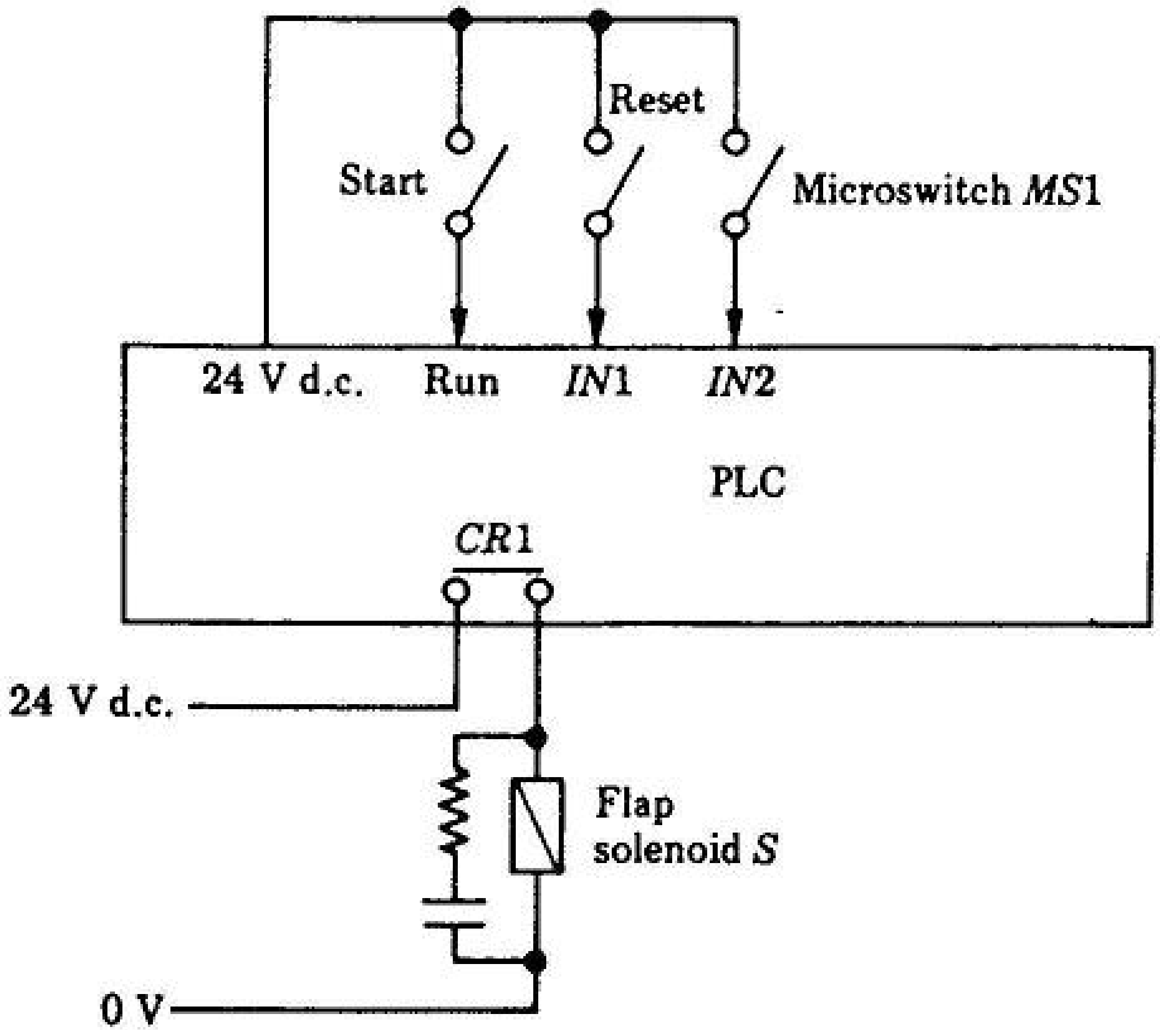




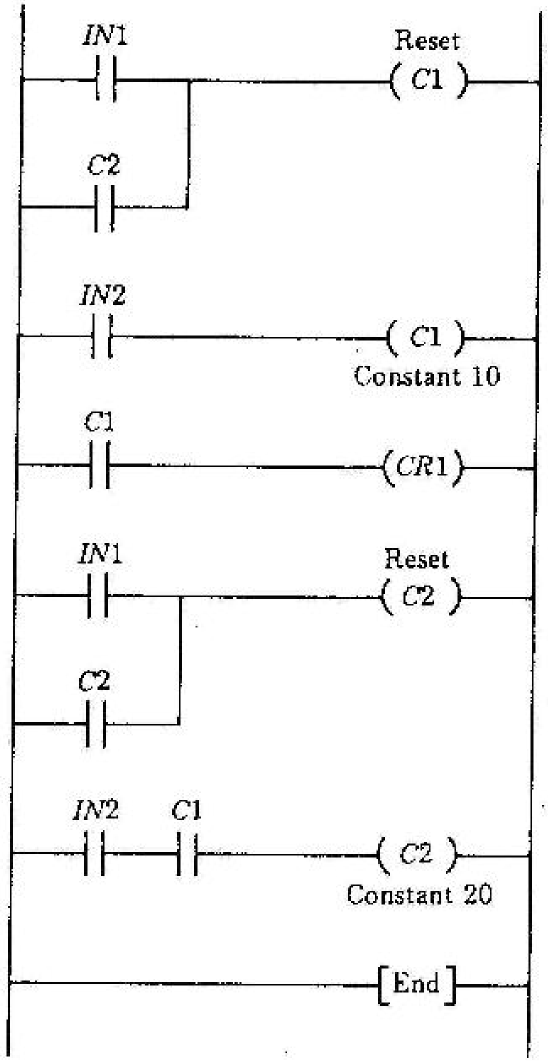
Control Problem

The PLC task is to control a simple machine which counts and batches components moving along a conveyor. It is required that ten components be channeled down route A and twenty components down route B. A reset facility is required

Exercise #3: Batching Machine



Exercise #3: Batching Machine

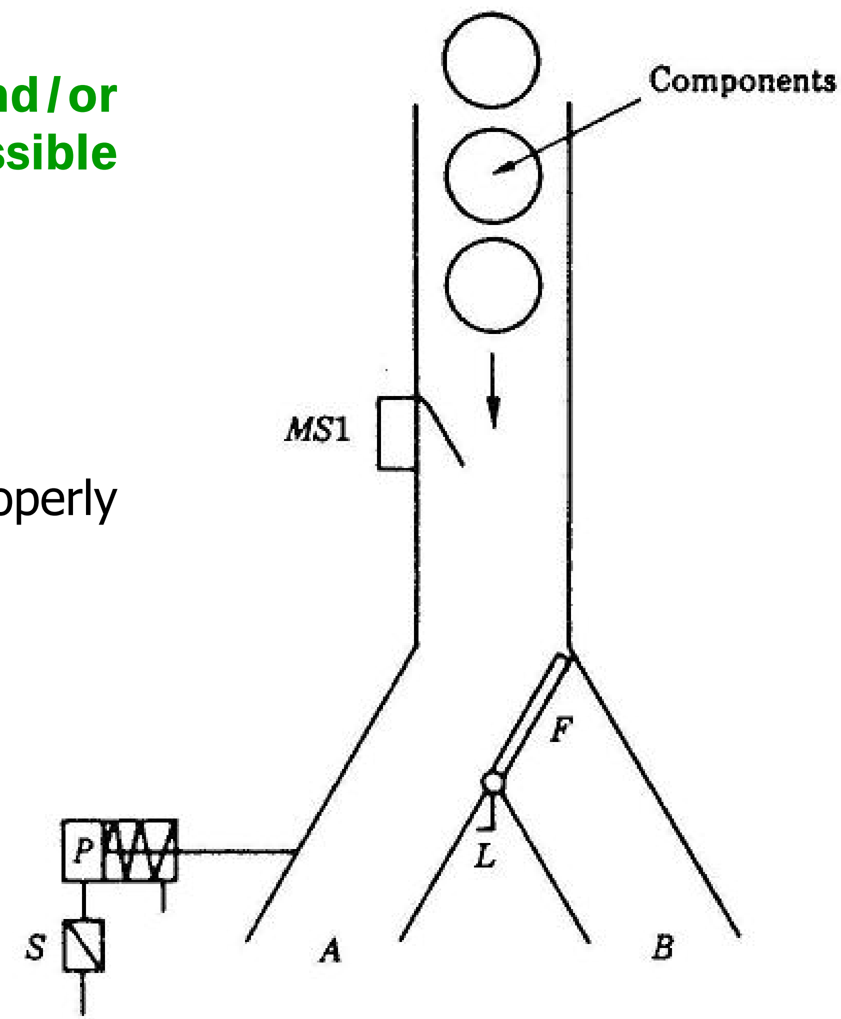


Address	Instruction	Data
0	LOAD	IN1
1	OR	C2
2	RESET	C1
3	LOAD	IN2
4	OUT	C1
5	CONSTANT	10
6	LOAD	C1
7	OUT	CR1
8	LOAD	IN1
9	OR	C2
10	RESET	C2
11	LOAD	IN2
12	AND	C1
13	OUT	C2
14	CONSTANT	20
15	END	

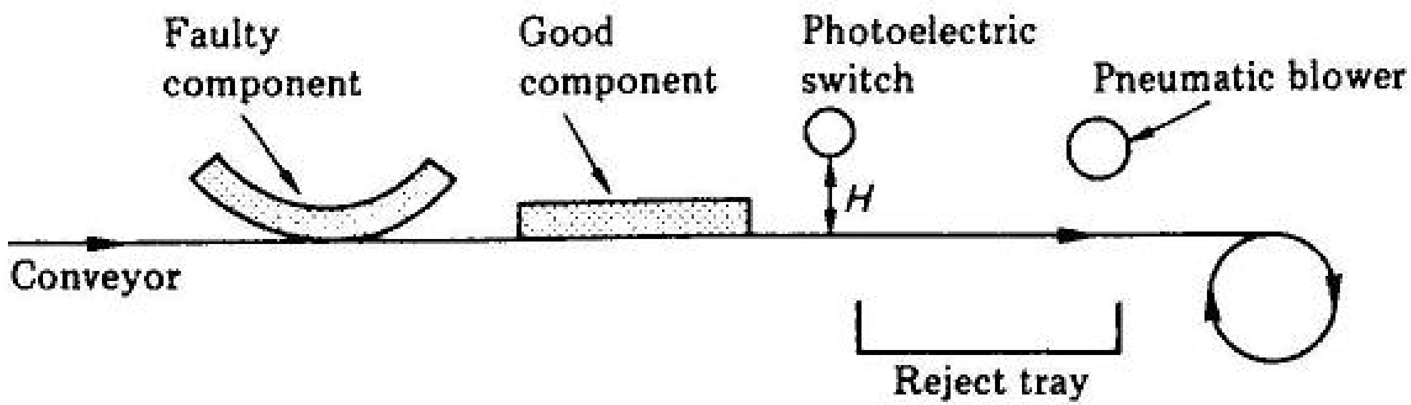
Exercise #3: Batching Machine

If the system does not batch and/or count, what would be the possible reasons?

- The reset switch is always on
- The microswitch does not work
- The flap solenoid does not work
- The ladder diagram is not properly written



Exercise #4: Reject Machine

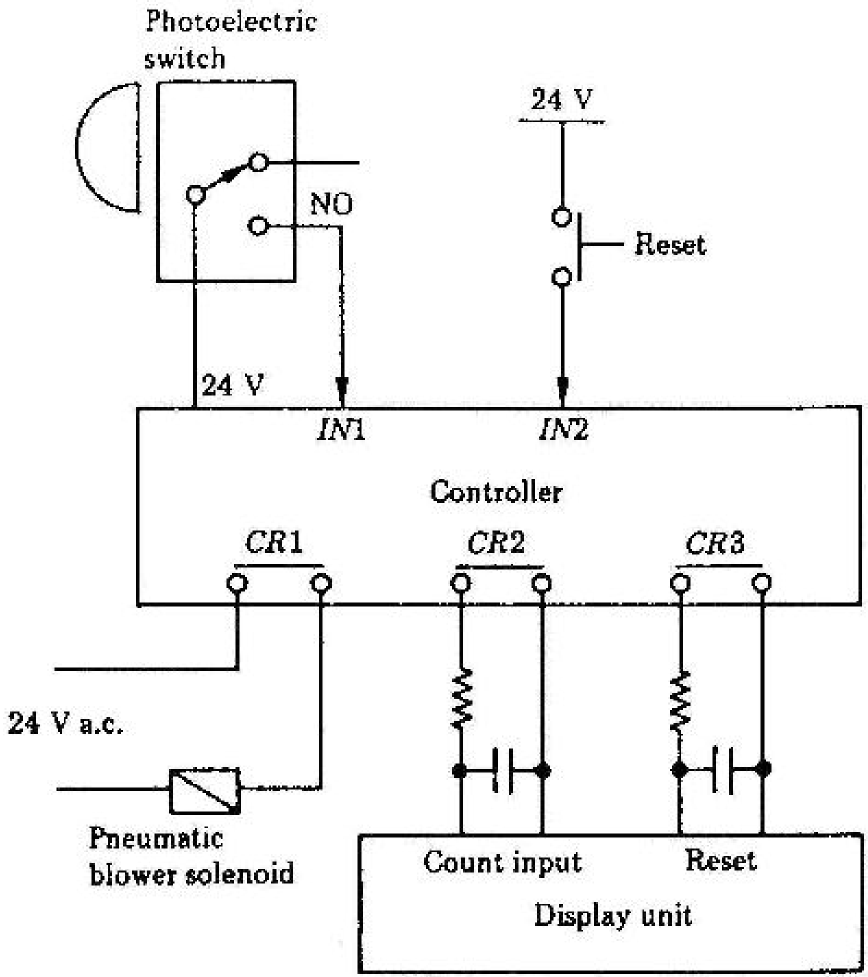


Reject system

Control Problem

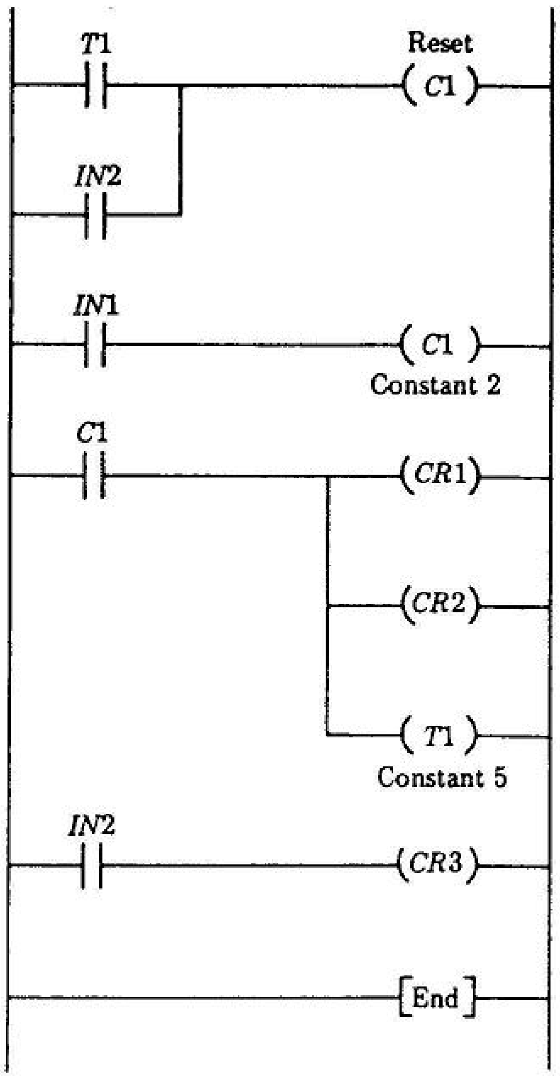
The PLC task is to detect and reject faulty components. Components are transported on a conveyor past a retro-reflective type photoelectric switch. The photoelectric switch is positioned at a height (H) above the conveyor where (H) represents a tolerance value for component height. Good components pass underneath the photoelectric switch and no signal is generated. Faulty components break the light beam twice as they pass the photoelectric switch.

Exercise #4: Reject Machine



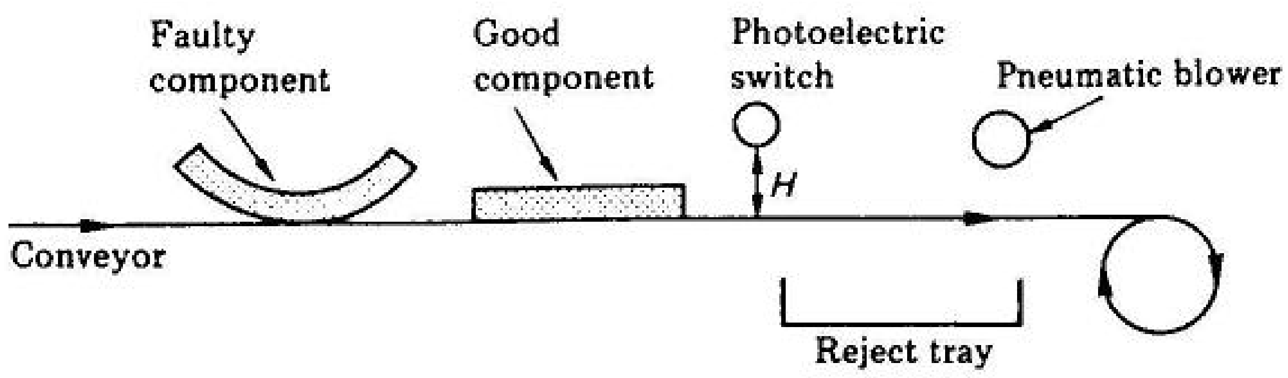
Input/output connections for the reject system

Exercise #4: Reject Machine



Address	Instruction	Data
0	LOAD	T1
1	OR	IN2
2	RESET	C1
3	LOAD	IN1
4	OUT	C1
5	CONSTANT	2
6	LOAD	C1
7	OUT	CR1
8	OUT	CR2
9	OUT	T1
10	CONSTANT	5
11	LOAD	IN2
12	OUT	CR3
13	END	

Exercise #4: Reject Machine



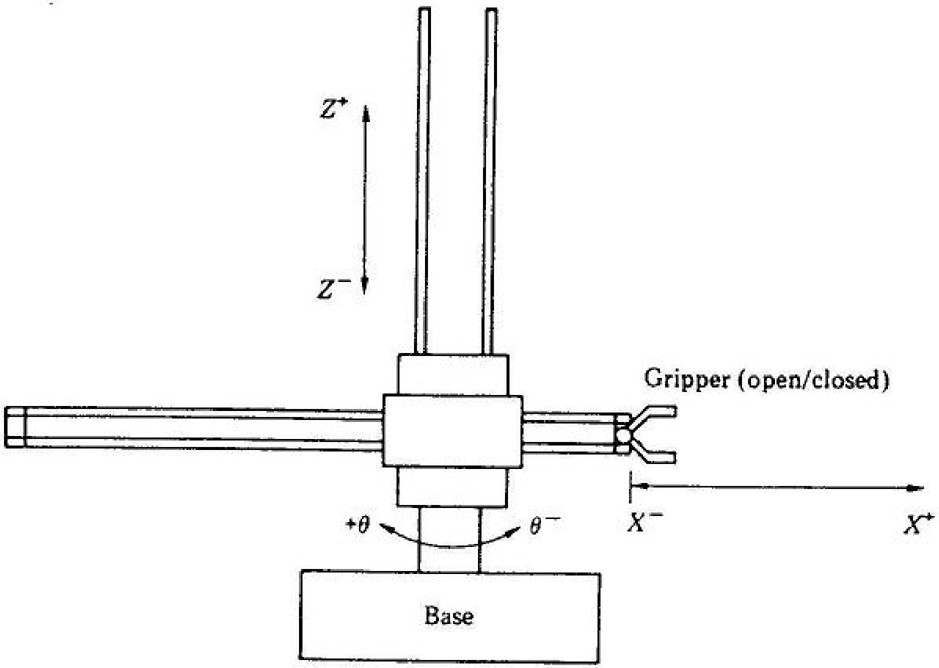
Reject system

If the system does not reject faulty components, what would be the possible reasons?

- The photoelectric switch is too high (H is too big)
- The photoelectric switch does not work
- The pneumatic blower does not work
- The ladder diagram is not properly written
- The faulty components is not as described in the drawing

Exercise #5: Pick and Place Unit

$CR1$	X^+
$CR2$	X^-
$CR3$	Z^+
$CR4$	Z^-
$CR5$	θ^+
$CR6$	θ^-
$CR7$	close gripper
$CR8$	open gripper

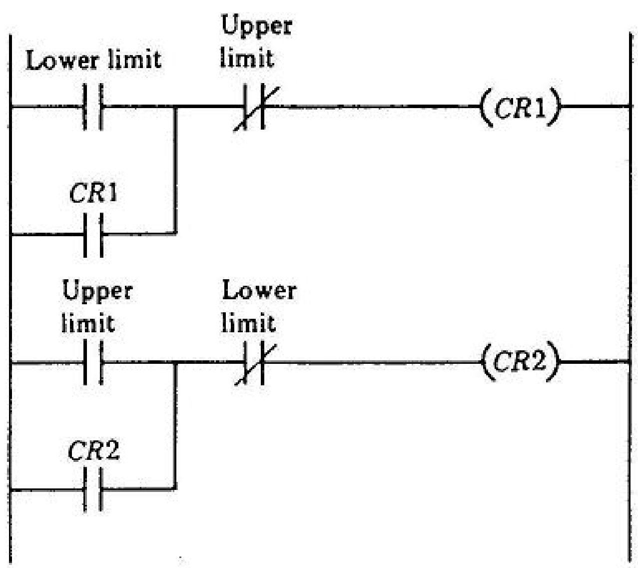


Control Problem

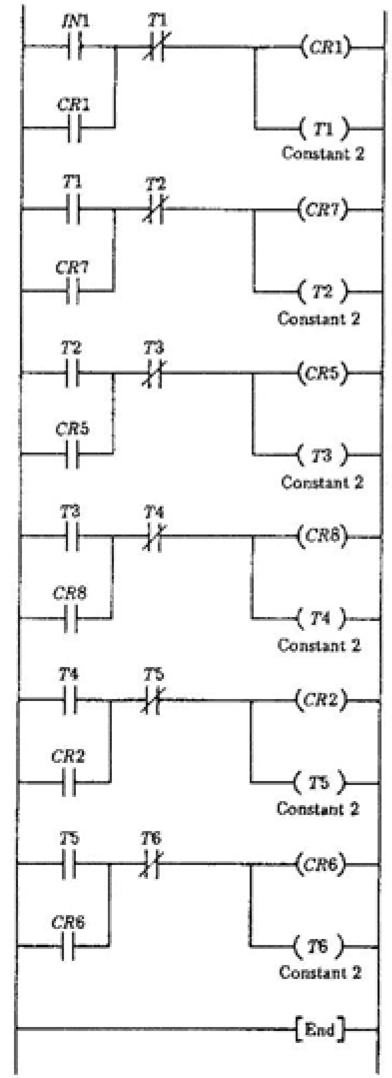
The PLC task is to:

a) move the gripper to X+ position
b) close the gripper so that it takes hold of a component
c) rotate the gripper through 180° to the Θ+ position
d) Release the component
e) Rotate the gripper back to the Θ- position so that the pick and place operation may be repeated

Exercise #5: Pick and Place Unit



Using limit switches to control the X^+ and X^- movement

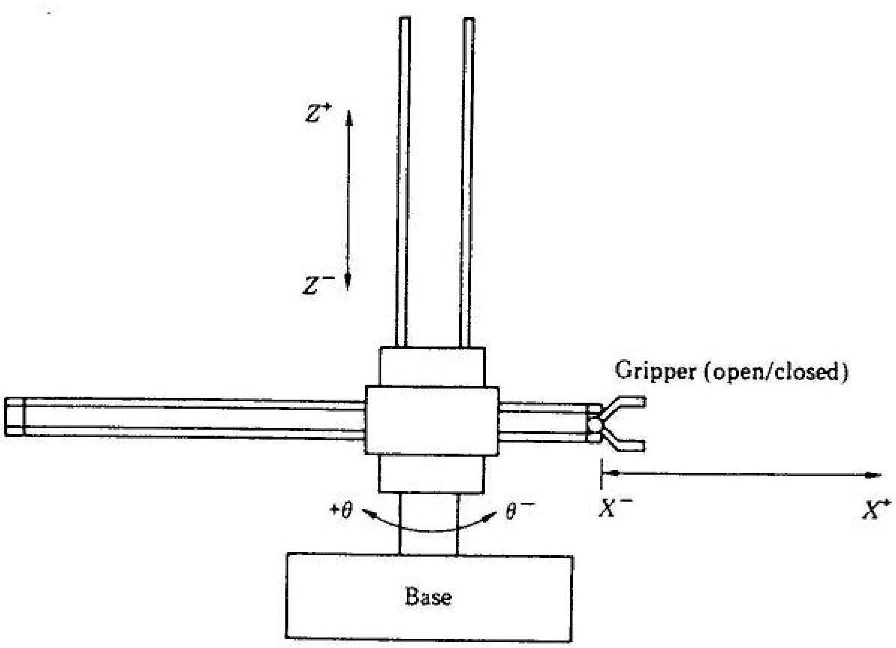


Address	Instruction	Data
0	LOAD	IN1
1	OR	CR1
2	AND NOT	T1
3	OUT	CR1
4	OUT	T1
5	CONSTANT	2
6	LOAD	T1
7	OR	CR7
8	AND NOT	T2
9	OUT	CR7
10	OUT	T2
11	CONSTANT	2
12	LOAD	T2
13	OR	CR5
14	AND NOT	T3
15	OUT	CR5
16	OUT	T3
17	CONSTANT	2
18	LOAD	T3
19	OR	CR8
20	AND NOT	T4
21	OUT	CR8
22	OUT	T4
23	CONSTANT	2
24	LOAD	T4
25	OR	CR2
26	AND NOT	T5
27	OUT	CR2
28	OUT	T5
29	CONSTANT	2
30	LOAD	T5
31	OR	CR6
32	AND NOT	T6
33	OUT	CR6
34	OUT	T6
35	CONSTANT	2
36	END	

Exercise #5: Pick and Place Unit

If the system does not work or sequence is not correct, what would be the possible reasons?

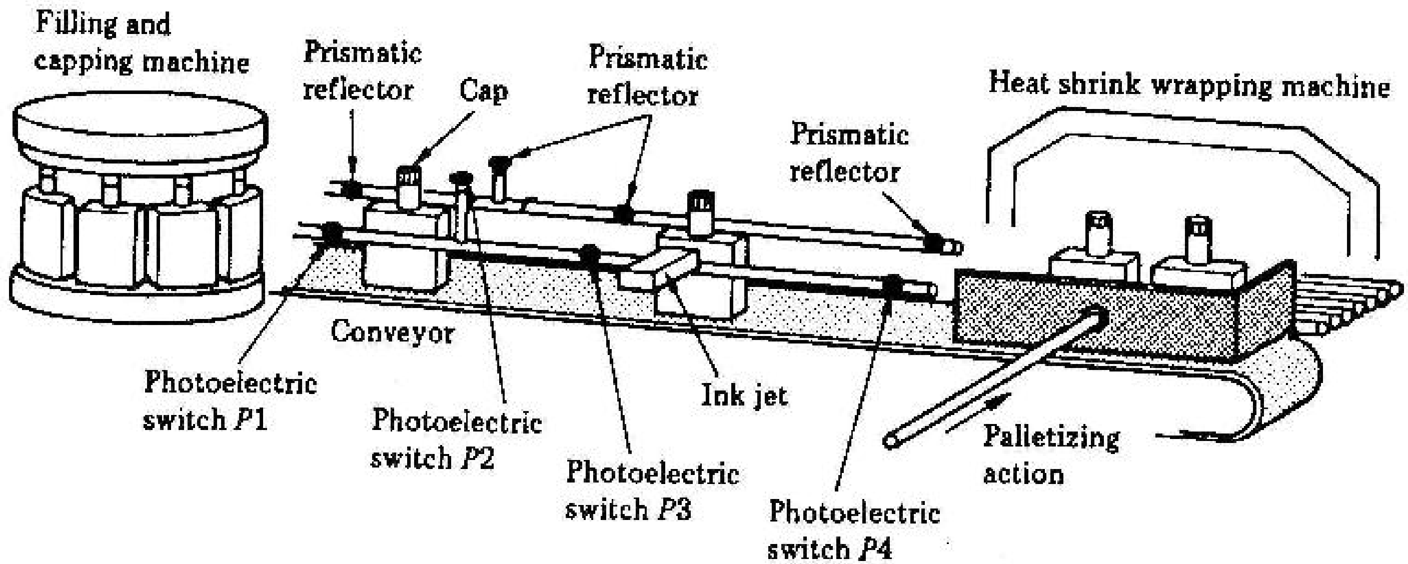
- Wiring problem
- Some solenoid valves do not work
- Timing is not correct
- The ladder diagram is not properly written (sequence in not correct)



How can we get rid of the timers in the ladder diagram/program?

Use position sensors for feedback but that would be expensive compared to using timers but more accurate and reliable in case the mechanical system starts to have some problems

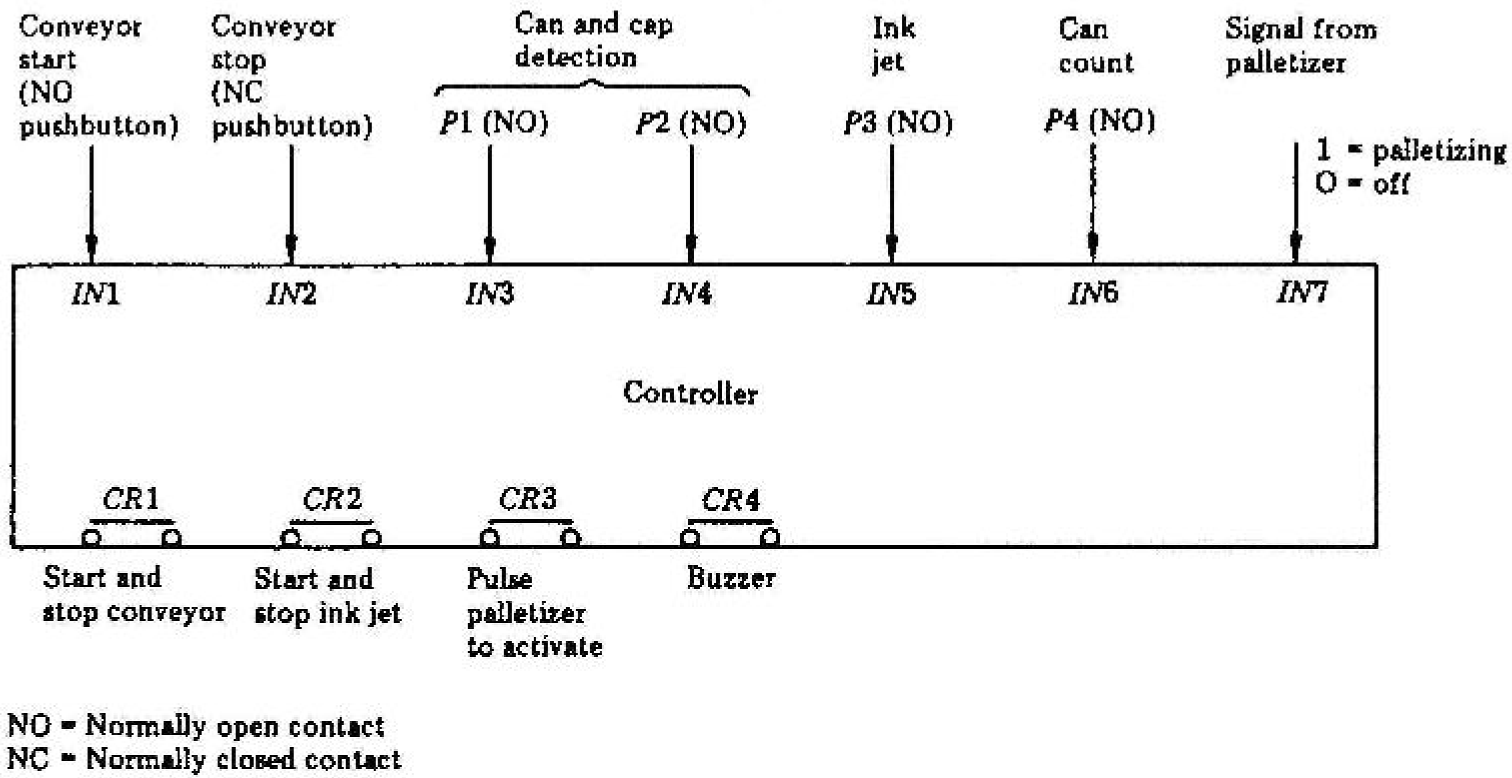
Exercise #6: Production Line



Control Problem

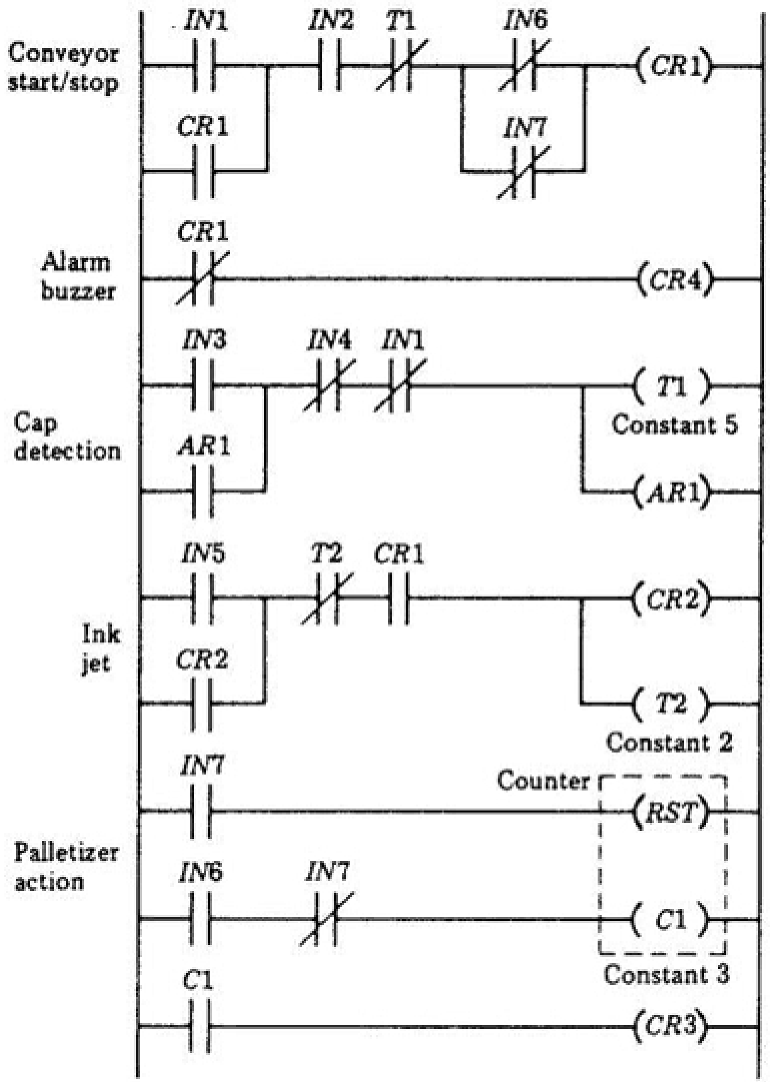
The PLC task is to organize the production process. Cans filled with fluid and capped before passing into a conveyor. The photoelectric switches P1 and P2 are used to check that each can has a cap. Photoelectric switch P3 provides a trigger for the ink jet printer which prints a batch number on each can. Photoelectric switch P4 is used to count three cans into the palletizing machine that transports three cans through a machine which heat shrinks a plastic wrapping over them. All photoelectric switches on the production line are of the retro reflective type.

Exercise #6: Production Line



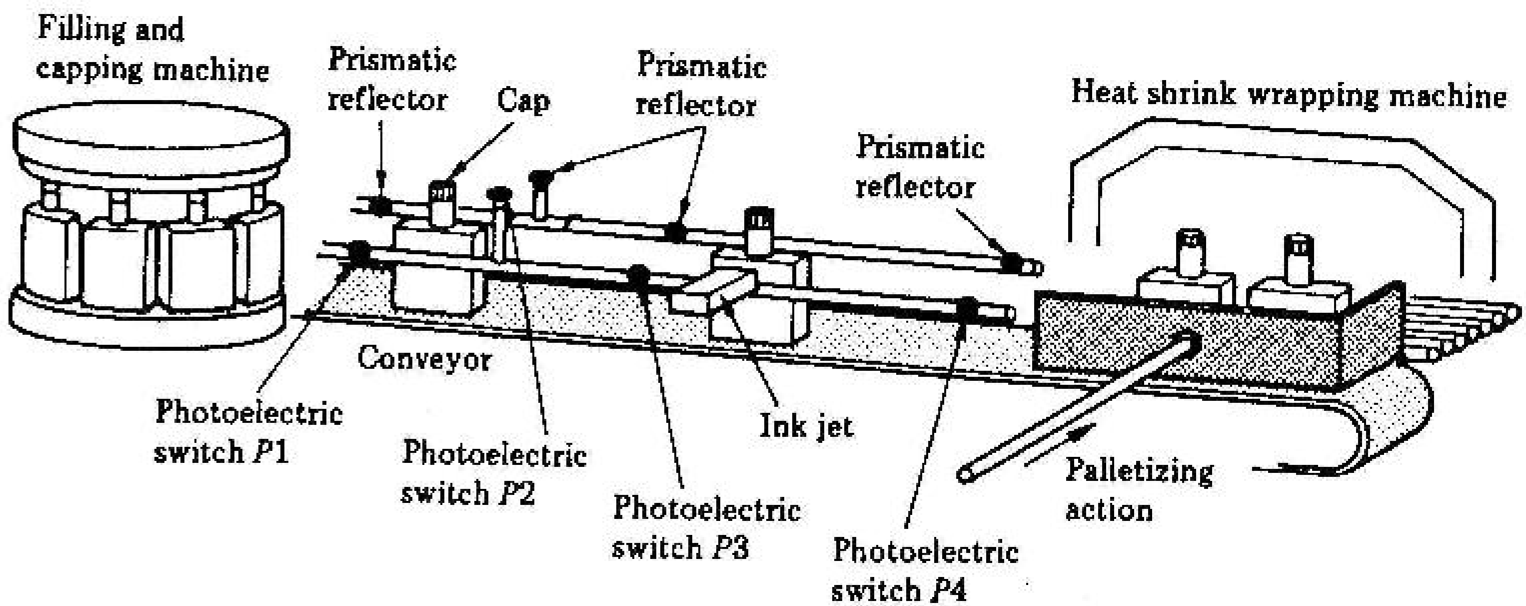
Input/output connections for the production line.

Exercise #6: Production Line



Address	Instruction	Data
0	LOAD	IN1
1	OR	CR1
2	AND	IN2
3	AND NOT	T1
4	LOAD NOT	IN6
5	OR NOT	IN7
6	AND BLOCK	
7	OUT	CR1
8	LOAD NOT	CR1
9	OUT	CR4
10	LOAD	IN3
11	OR	AR1
12	AND NOT	IN4
13	AND NOT	IN1
14	OUT	T1
15	CONSTANT	5
16	OUT	AR1
17	LOAD	IN5
18	OR	CR2
19	AND NOT	T2
20	AND	CR1
21	OUT	CR2
22	OUT	T2
23	CONSTANT	2
24	LOAD	IN7
25	RESET	C1
26	LOAD	IN6
27	AND NOT	IN7
28	OUT	C1
29	CONSTANT	3
30	LOAD	C1
31	OUT	CR3
32	END	

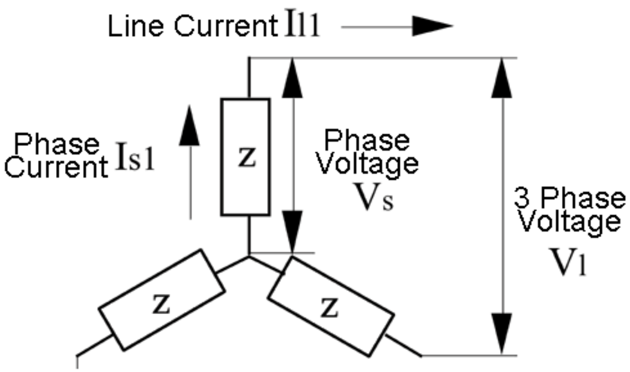
Exercise #6: Production Line



If the system allows uncapped cans to pass, what would be the possible reasons?

- The height of the photoelectric switch needs to be readjusted
- The photoelectric switch does not work (transmitter or receiver)
- The photoelectric transmitter is not aligned with the receiver
- The ladder diagram is not properly written (or timer is not set properly)

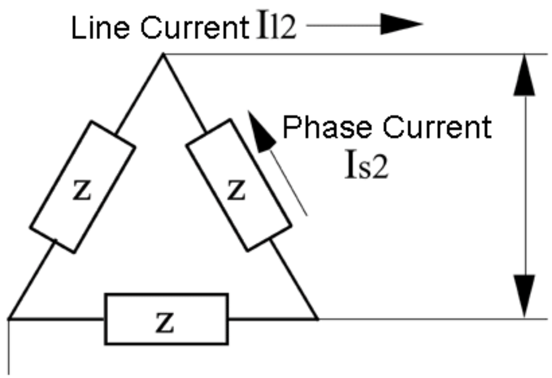
Exercise #7: Star-Delta Connection



Phase Voltage V_s = 3 Phase Voltage $V_l \times \dfrac{1}{\sqrt{3}}$

Phase Current I_{s1} = $\dfrac{\text{Phase Voltage } V_s}{Z} = \dfrac{\sqrt{3} \times V_l}{3Z}$

Line Current I_{l1} = Phase Current I_{s1} = $\dfrac{\sqrt{3} \times V_l}{3Z}$



Phase Voltage V_s = 3 Phase Voltage V_l

3 Phase Voltage V_l = Phase Voltage V_s

Phase Current I_{s2} = $\dfrac{\text{Phase Voltage } V_s}{Z} = \dfrac{V_l}{Z}$

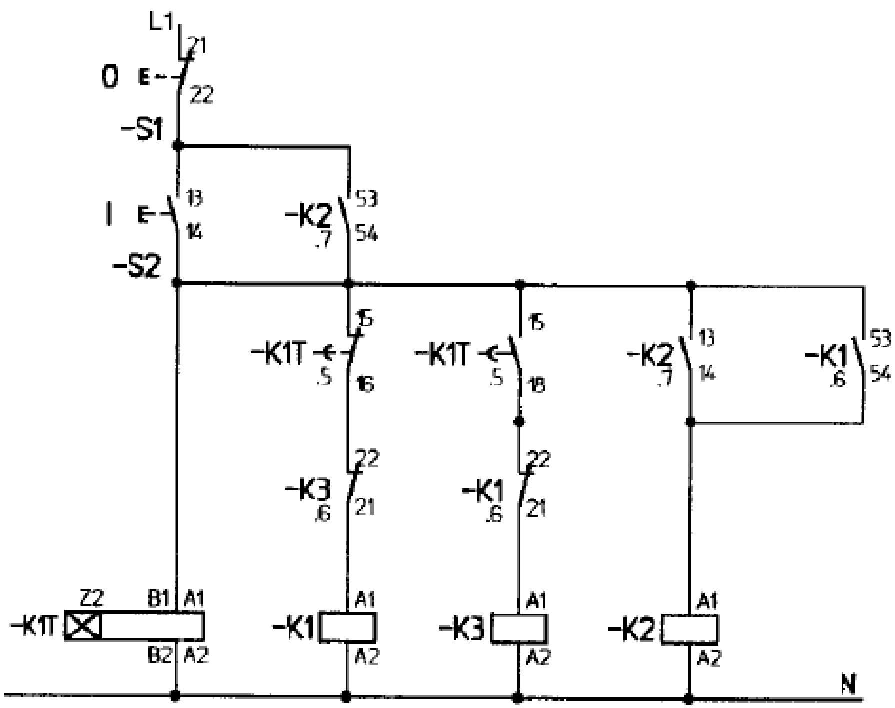
Line Current I_{l2} = $\sqrt{3} \times$ Phase Current I_{s2} = $\dfrac{\sqrt{3} \times V_l}{Z}$

The comparison result of the line currents between the star and delta connections is shown here.

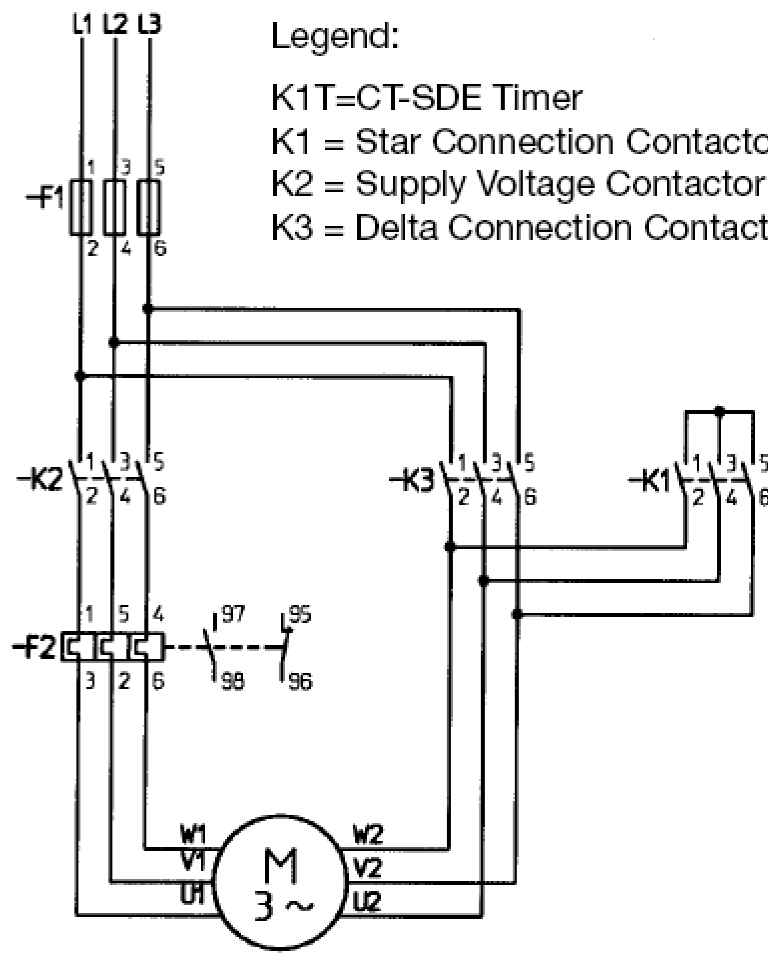
$$\frac{\text{Line Current } I_{l1}}{\text{Line Current } I_{l2}} = \frac{\sqrt{3} \times V_l}{3Z} \times \frac{Z}{\sqrt{3} \times V_l} = \frac{1}{3}$$

Exercise #7: Star-Delta Connection

Control Circuit Diagram



Power Circuit Diagram



Legend:

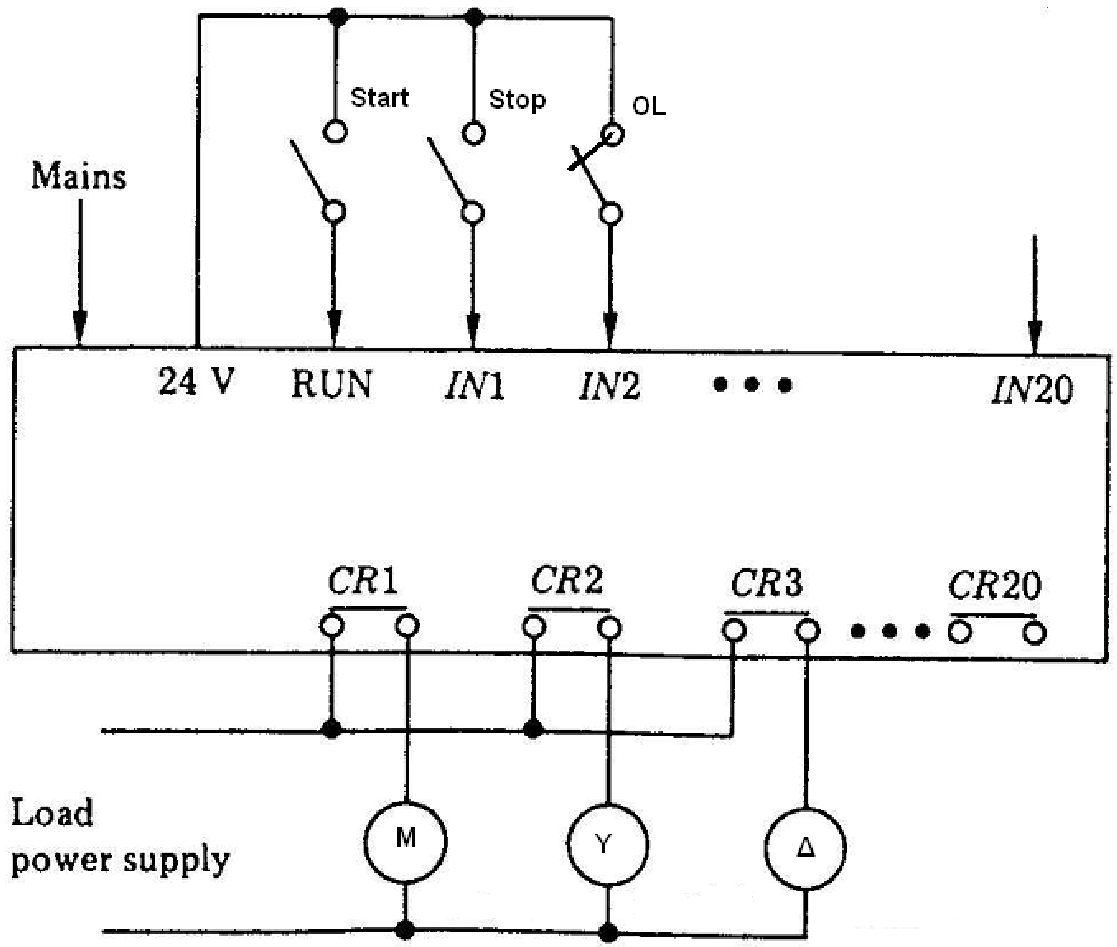
K1T=CT-SDE Timer

K1 = Star Connection Contactor

K2 = Supply Voltage Contactor

K3 = Delta Connection Contactor

Exercise #7: Star-Delta Connection



PLC system layout – Wiring diagram

Exercise #7: Star-Delta Connection