CE PLC SHEET 3 SOL

Q3)

A system having 3 loads is required to be controlled in the following manner:

- When a START pushbutton is pressed, load #1 is activated.
- After 3 minutes, load #2 which is a lamp starts flashing (0.5 sec. OFF and 1.0 sec. ON) and load #1 remains active.
- After 2 minutes from starting to flash load #2, load #1 is switched OFF, load #2 is activated steadily and load #3 is switched ON.
- After 1 minute from activation of load #3, both loads #2 and #3 are switched OFF and load #1 is activated again and the above process is repeated continuously.
- Pressing a STOP pushbutton at any moment switches OFF all the loads and the process can be restarted from the first step by pressing the START pushbutton.

It is required to develop a PLC program to control the above system.

Inputs:

Start P.B. : X1

Stop P.B. : X2

Outputs:

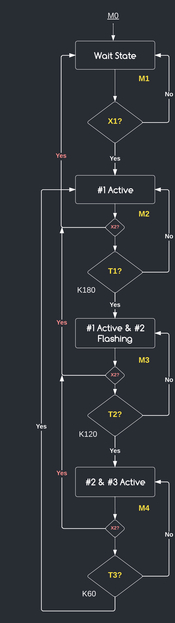
3 Loads : Y1->Y3

Analysis:

We start at an idle condition (wait state) and enter a state where #1 is activated when START is pressed. After 3 minutes we enter another state where #2 also starts flashing and after another 2 minutes we enter a state where #2 is no longer flashing (steady) and 3 is as well on. Finally, after 1 minute we repeat the cycle.

Stop can be pressed at any moment to take the system to the wait state.

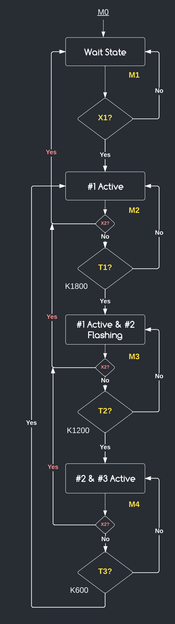
Flow Chart:



- When a START pushbutton is pressed, load #1 is activated.
  // Pretend not seeing X2? for now.
- After 3 minutes, load #2 which is a lamp starts flashing (0.5 sec. OFF and 1.0 sec. ON) and load #1 remains active.
- After 2 minutes from starting to flash load #2, load #1 is switched OFF, load #2 is activated steadily and load #3 is switched ON.
- After 1 minute from activation of load #3, both loads #2 and #3 are switched OFF and load #1 is activated again and the above process is repeated.

- Pressing a STOP pushbutton at any moment switches OFF all the loads and the process can be restarted from the first step by pressing the START pushbutton = We need the X2? after each state to be able to go back to wait state if stop is pressed.

Boolean Expressions:



Recall,
M = Start-up + EntryPaths + Self-hold . Exits

M1 = M0 + (M2 + M3 + M4) .X2 + M1.M2

M2 = M1.X1+ M4.X2.T3 + M2.M3.M1

M3 = M2.X2.T1 + M3.M4.M1

M4 = M3.X2.T2 + M4.M1.M2

M0 = M0 + M1 (Start-up Marker)

Timers:

T1(K1800) = M2
T2(K1200) = M3
T3(K600) = M4

Outputs:

Recall that given an active input X1 (in our context a state M) to make the output flash low for "LOW" deciseconds and high for "HIGH" deciseconds then we need two timers T0 and T1 then a flashing marker M1 output would be:

T0(k LOW) = X1.T1
T1(k HIGH) = M1 = T0

Thus, to flash the second load we need two extra timers and an extra marker that captures the flashing logic:

T4(k5) = M3.T5
T5(k10) = M5 = T4
// Now M5 will flash as long as M3 is ON.

Now since #1 is active if we're either in the first or second states:
Y1 = M1 + M2
and since #2 is active if we're either in the second (flashing) or third states:
Y2 = M5 + M4
// M5 captures that we're in the 2nd state (M3) and causes Y2 to flash.
// We also can't be in both M4 and M5.
and since #3 is only active in the last state:
Y3 = M4

Q4)

It is required to develop a PLC program to control a system having 3 loads, in the following manner:

- When a START pushbutton is pressed, load #1 is activated. While load #1 is active, pressing a pushbutton PB1 deactivates load #1 and activates load #2.
- While load #2 is active, pressing a pushbutton PB2 deactivates load #2 and activates load #3.
- While load #3 is active, pressing a STOP pushbutton deactivates load #3 and the system is stopped. It can be restarted by pressing the START pushbutton.
- During activation of any load, pressing a PAUSE pushbutton deactivates this load and turns ON a YELLOW lamp. This load can be reactivated and the YELLOW lamp is switched OFF by pressing a RESUME pushbutton. Pressing any pushbutton other than the RESUME pushbutton while a load is paused should have no effect.

Inputs:

Start P.B. : X1

Pushbutton PB1 : X2

Pushbutton PB2 : X3

Stop P.B. : X4

Pause P.B. : X5

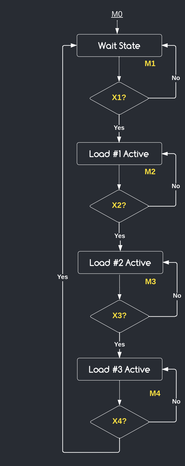
Resume P.B. : X6

Outputs:

3 Loads : Y1->Y3

Yellow Lamp : Y4

Flow Chart:

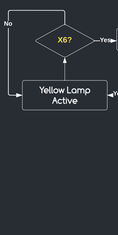


- When a START pushbutton is pressed, load #1 is activated.
- While load #1 is active, pressing a pushbutton PB1 deactivates load #1 and activates load #2
- While load #2 is active, pressing a pushbutton PB2 deactivates load #2 and activates load #3.
- While load #3 is active, pressing a STOP pushbutton deactivates load #3 and the system is stopped.

Looks like we missed this part:

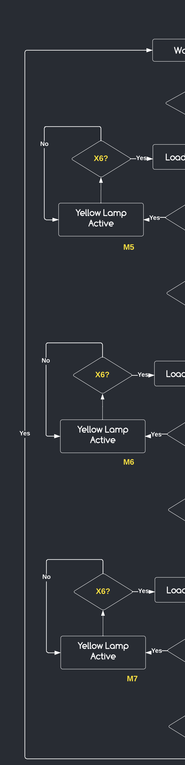
- " During activation of any load, pressing a PAUSE pushbutton deactivates this load and turns ON a YELLOW lamp. This load can be reactivated and the YELLOW lamp is switched OFF by pressing a RESUME pushbutton. Pressing any pushbutton other than the RESUME pushbutton while a load is paused should have no effect. "

In any of the three states, we should check first if pause is pressed. If it is then we should switch to a "yellow lamp" state, pressing resume does the opposite (It's a cycle). An example on load #1:



Note: checking for "pause" is what matters. Here we gave that precedence over the button press that takes us to the other state but we could have as well done the opposite (neither is enforced in the text and both are okay.)

Updating the flow chart & boolean expressions:



M1 = M0 + M4.X5.X4 + M1.M2

M2 = M1.X1+M5.X6 + M2.M3.M5

M5 = M2.X5 + M5.M2

M3 = M2.X5.X2+M6.X6 + M3.M6.M4

M6 = M3.X5 + M6.M3

M4 = M3.X5.X3+M7.X6 + M4.M7.M1

M7 = M4.X5 + M7.M4

M0 = M0 + M1 (Start-up Marker)

Outputs:

Y1 = M2

Y2 = M3

Y3 = M4

Y4 = M5 + M6 + M7 // Yellow Lamp.

Q6)

It is required to develop a PLC program to control a system with 3 loads in the following manner:

- When a START pushbutton is pressed, load #1 is activated.
- After 1 minute from activation of load #1, pressing a pushbutton PB1, at any time, deactivates load #1 and activates load #2. If PB1 is not pressed until a period of 3 minutes passed from the moment of pressing the START pushbutton, then load #1 should be switched OFF and load #2 should be switched ON.
- After 1 minute from activation of load #2, pressing a pushbutton PB2, at any time, deactivates load #2 and activates load #3. If PB2 is not pressed until a period of 5 minutes passed from the moment of pressing the START pushbutton, then load #2 should be switched OFF and load #3 should be switched ON.
- After 1 minute from activation of load #3, pressing a STOP pushbutton, at any time, deactivates load #3 and the system is stopped. It can be restarted by pressing the START pushbutton. If the STOP pushbutton is not pressed until a period of 8 minutes passed from the moment of pressing the START pushbutton, then load #3 should be switched OFF and the system is stopped. It can be restarted by pressing the SATRT pushbutton.

Inputs:

Start P.B. : X1

Pushbutton PB1 : X2

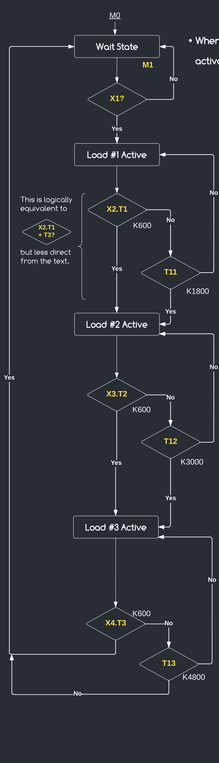
Pushbutton PB2 : X3

Stop P.B. : X4

Outputs:

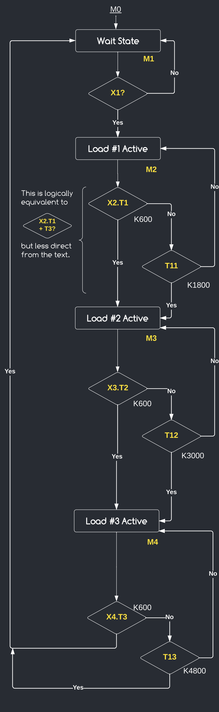
3 Loads : Y1->Y3

Flow Chart:



- When a START pushbutton is pressed, load #1 is activated.
- After 1 minute from activation of load #1, pressing a pushbutton PB1, at any time, deactivates load #1 and activates load #2.
- If PB1 is not pressed until a period of 3 minutes passed from the moment of pressing the START pushbutton, then load #1 should be switched OFF and load #2 should be switched ON.
- After 1 minute from activation of load #2, pressing a pushbutton PB2, at any time, deactivates load #2 and activates load #3.
- If PB2 is not pressed until a period of 5 minutes passed from the moment of pressing the START pushbutton, then load #2 should be switched OFF and load #3 should be switched ON.
- After 1 minute from activation of load #3, pressing a STOP pushbutton, at any time, deactivates load #3 and the system is stopped.
- It can be restarted by pressing the START pushbutton. If the STOP pushbutton is not pressed until a period of 8 minutes passed from the moment of pressing the START pushbutton, then load #3 should be switched OFF and the system is stopped. It can be restarted by pressing the SATRT pushbutton.

Boolean Expressions:



M1 = M0 + M4.(X4.T3+T13) + M1.M2

M0 = M0 + M1

Note we'd naturaly write:
M4.(X4.T3 + X4.T3.T13)
which because a+a.b = (a + a).(a + b) = a + b
is equal to
M4.(X4.T3 +T13)

M2 = M1.X1 + M2.M3

M3 = M2.(X2.T1+T11) + M3.M4

M4 = M3.(X3.T2+T12) + M4.M1

Timers:

T1(K600) = M2

T2(K600) = M3

T3(K600) = M4

T11(K1800) = M2

T12(K3000) = M2 + M3

T13(K4800) = M2 + M3 + M4 //Time spent starting from the state M2

Outputs:

Y1 = M2

Y2 =M3

Y3 = M4

Q8)

A chemical system consists of 3 tanks with 5 pumps to transfer the liquid contents through the system.
Each tank has two sensors to detect EMPTY and FULL states. Tank #2 has a heater and an associated temperature sensor. Tank #3 has a stirring arm to mix liquids A and B coming from tanks 1 and 2, respectively. Tank #3 has enough capacity to accommodate the contents of tanks 1 and 2.

The system has two modes of operation: MIXING and WASHING modes. A two-position mode selection switch enables the operator to choose between the two modes.

Upon pressing a START pushbutton with the mode selection switch on MIXING position, tanks 1 and 2 are filled simultaneously with liquids A and B through pumps 1 and 2, respectively.

When a tank FULL sensor becomes ON, the corresponding pump (1 or 2) is stopped. When tank #1 is FULL, pump1 is stopped and pump3 is activated to transfer liquid A to tank #3. When tank #2 is FULL, pump2 is stopped and the heater is activated to raise the temperature of liquid B to a required value indicated by the temperature sensor becoming ON. When this happens the heater is turned OFF and pump4 is activated to transfer heated liquid B to tank #3.

When a tank EMPTY sensor becomes ON, the corresponding pump (3 or 4) is stopped. The stirring arm is activated when either liquid A or heated liquid B starts to be pumped into tank #3. Stirring of liquid A and heated liquid B continues for 5 minutes timed from the moment when both tanks 1 and 2 are empty. Afterwards the mixture is pumped out of tank #3 through activation of pump 5. When tank #3 is EMPTY, pump5 is stopped. This marks the end of the mixing process. It can be repeated by pressing the START pushbutton with the mode selection switch on MIXING.

If the START pushbutton is pressed with the mode selection switch on WASHING position, water is pumped into tank #3 through pump 6 and the stirring arm is activated.
When tank #3 is FULL, pump 6 is stopped and stirring continues for 3 more minutes.
Afterwards the stirring arm is stopped and pump5 is activated to discharge the water out of tank #3.
When tank #3 is EMPTY, this marks the end of one step of washing. The WASHING process consists of 3 repeated steps. After the third step, the WASHING mode is finished and it can be repeated by pressing the START pushbutton with mode selection switch on WASHING position.
An indicator lamp should be turned ON during all the steps of the WASHING mode.

Inputs:

START P.B.: X0

FULL Sensors of Tanks 1->3: X1->X3

EMPTY Sensors of Tanks 1->3 : X4->X6

Mode Selection Switch : X7

Tank 2 Temp. Sensor : X10

Outputs:

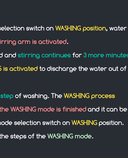
Pumps 1->5 : Y1->Y5

Pump 6 : Y6

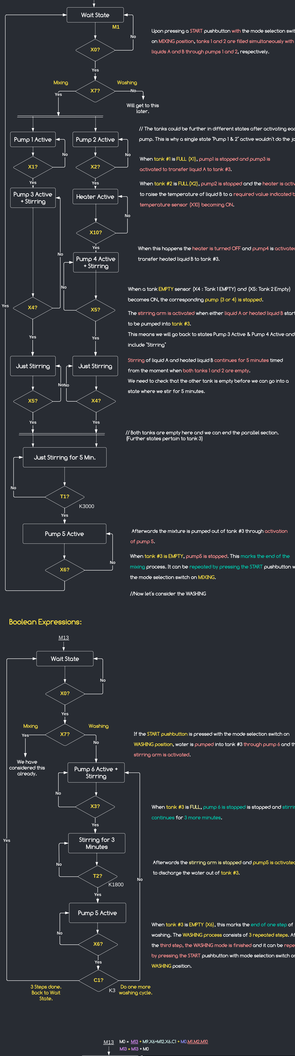
Heater : Y7

Stirring Arm : Y0

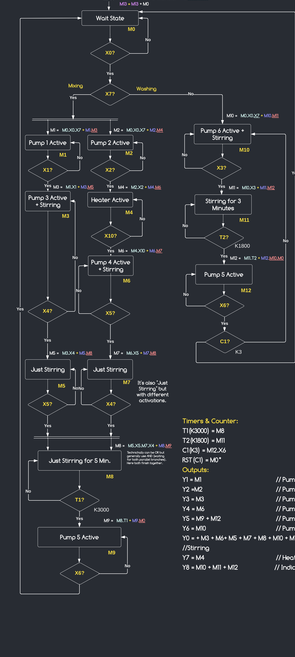
Indicator Lamp: Y8

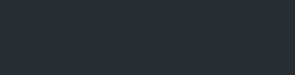


Flow Chart:



Boolean Expressions:





Q9)

A system has 'START' and 'STOP' push-buttons in addition to three loads. It also has three push-buttons: 'PB 1-2-3', 'PB 2-3-1' and 'PB 3-1-2'.

It is required to develop a PLC program to control this system in the following manner:

- If the 'START' and 'PB 1-2-3' push-buttons are pressed simultaneously, the system operates in MODE A. In this mode load #1 is activated for 5 sec. then deactivated. Afterwards load #2 is activated for 5 sec. then deactivated. Finally load #3 is activated for 5 sec. then deactivated which marks the end of MODE A operation.

- Similarly if the 'START' and 'PB 2-3-1' push-buttons are pressed simultaneously, the system operates in MODE B. In this mode the loads are activated as before but with the sequence load #2 then 3 then 1.

- Similarly if the 'START' and 'PB 3-1-2' push-buttons are pressed simultaneously, the system operates in MODE C. In this mode the loads are activated as before but with the sequence load #3 then 1 then 2.

- While the system is operating in any mode, pressing the 'STOP' push-button ends this mode. Afterwards the system can be operated in any mode as before. While the system is operating in any mode, pressing any push-button other than the 'STOP' push-button should have no effect.

- Each mode of operation has a special indicator, which should be turned ON while the system is operating in this mode and turned OFF otherwise.

Inputs:

Start P.B. : X1

Pushbutton PB1-2-3: X2

Pushbutton PB2-3-1: X3

Pushbutton PB3-1-2: X4

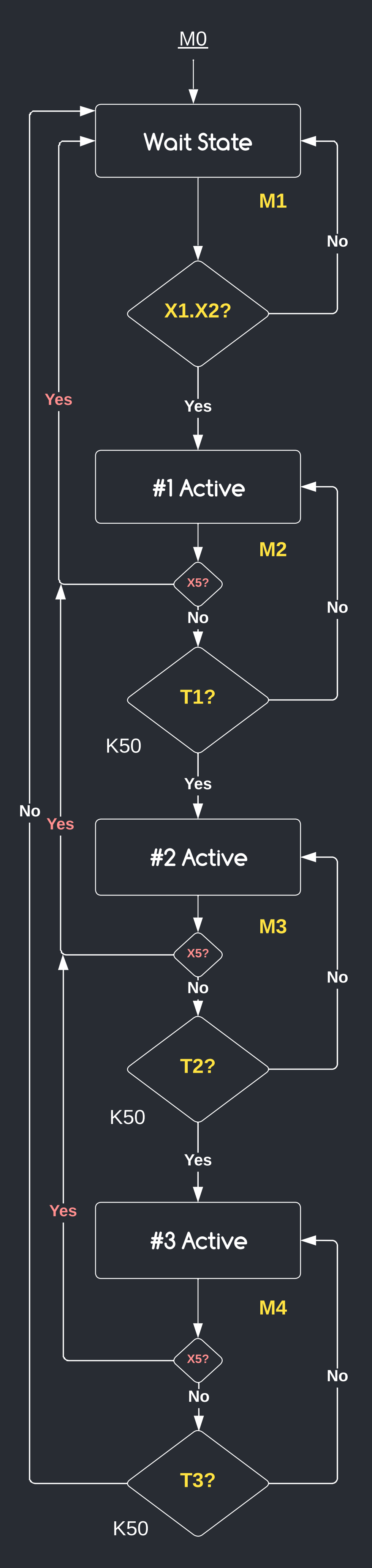
Stop P.B. : X5

Outputs:

3 Loads : Y1->Y3

3 indicators : Y11->Y13

Flow Chart:



- If the 'START' and 'PB 1-2-3' push-buttons are pressed simultaneously, the system operates in MODE A. In this mode load #1 is activated for 5 sec. then deactivated. Afterwards load #2 is activated for 5 sec. then deactivated. Finally load #3 is activated for 5 sec. then deactivated which marks the end of MODE A operation.
- Clearly need two more flow charts with an if, else if, else to choose the mode. Let's do that below

- Clearly need two more flow charts with an if, else if, else to choose the mode. Let's do that below

$M1 = (M4.T3+M7.T6+M10.T9).\overline{X5} + (M2+M3+M4+M5+M6+M7+M8+M9+M10).X5 + M1.\overline{M2}.\overline{M5}.\overline{M8} + \overline{M0}$

$M2 = M1.X1.X2 + M2.\overline{M3}.\overline{M1}$

The rest of the equations should be as easy as M2. OR the states in each mode for the three outputs.

The ladder for M1 (perhaps):

```
LD M4
AND T3
LD M7
AND T6
ORB
LD M10
AND T9
ORB
 ANI X5
// First term
LD M2
OR M3
OR M4
...
OR M10
AND X5
ORB
// First & Second term
LD M1
ANI M2
ANI M5
ANI M8
ORB
// First & Second & Third term
ORI M0
// Whole Expression
```

At this point we're only missing one problem from the handouts (Q10)