CE PLC Sheet 2

- We were not presented with a formal way to identify system states in the lecture

→ TA used 'State flow graphs' (drawing the state diagram as we read through the problem)

Problem 1)

- System consists of a single load, red lamp, yellow lamp with start and stop push buttons

Inputs

Start P.B. : X0

Stop P.B. : X1

Outputs

Load : Y0

Red lamp : Y1

Yellow lamp : Y2

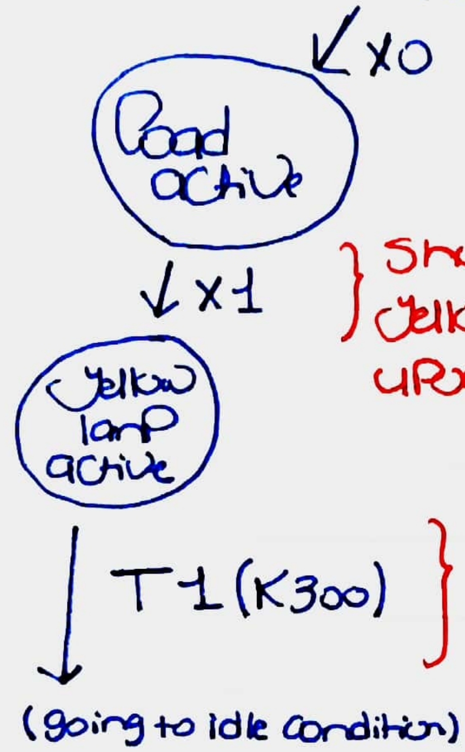
- When start pushbutton is pressed, load is activated. To deactive the load, STOP P.B should be pressed (while it's active.)

→ Hence, we identify a "load active state"

} entered through X0 press with X1 press being the exit condition

- When the load is deactivated, by pressing STOP P.B. the yellow lamp is turned on for 30 seconds

(coming from idle condition: all states off)

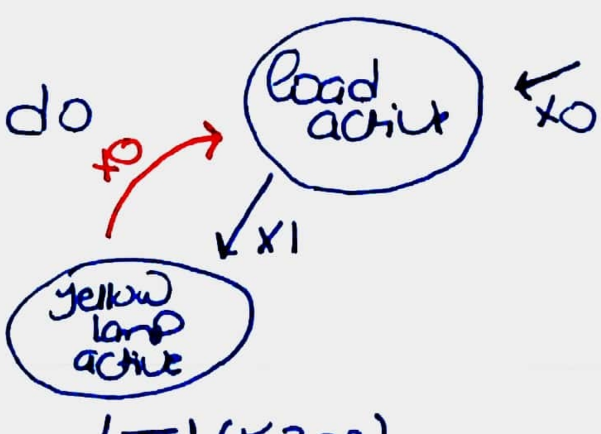


} should enter the yellow lamp state upon deactivation

} should exit yellow lamp active after 30 seconds

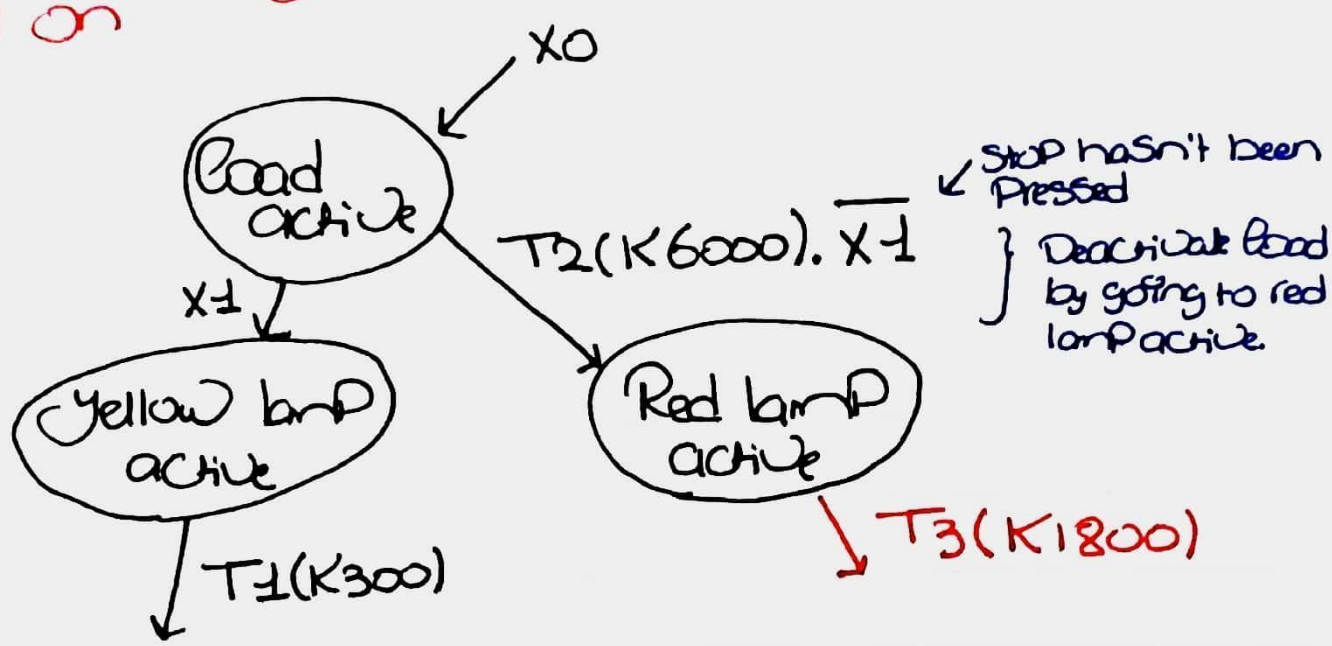
- During this period, can't restart lamp

(i.e. don't do)



- After this delay, yellow lamp should be turned off and load can be started again by START.
  → This is already satisfied by diagram (since we go to idle condition after the 30 seconds)

• If the load remains active for 10 minutes and Stop has not been pressed then load should be automatically deactivated and red lamp is turned on



• it should remain on for 3 minutes during which the load cannot be restarted ← implicitly satisfied

• After this, red lamp should be turned off and load can be started by pressing start (satisfied as we go to the idle (initial) condition)

2) Markers: (active, logic)

M1: Load active

M2: Yellow lamp active

M3: Red lamp active

3)

$$M1 \equiv (X0\,\overline{M2}\,\overline{M3} + M1).\,\overline{M2}\,\overline{M3}$$

why not $\overline{X1}\,\overline{T2}$?
· check M1 in [Lec.10, 10]

Start Pressed

Coming from idle condition

(can't activate load in 2 other states)

entering any of the other 2 = exiting this one (interlock)

#load logic

· can simplify the expression
$(X0 + M1)\overline{M2}\,\overline{M3}$

$$M2 \equiv (X1.\,M1 + M2).\,\overline{T1}$$

Stop Pressed

entering from M1

go to idle upon time out (exit)
(no new state is activated)

#yellow lamp

$$M3 \equiv (T2\,M1\,\overline{X1} + M3).\,\overline{T3}$$

load timer times out

entering from M1

Stop not Pressed

3 minutes Passed

#Red lamp

$T1(K300) \equiv M2$ (yellow lamp)
$T2(K6000) \equiv M1$ (load)
$T3(K1800) \equiv M3$ (red lamp)

$Y0 \equiv M1$
$Y1 \equiv M3$
$Y2 \equiv M2$

· ladder has 9 rungs with 3 self-latches (routine)

Problem 2)

System consists of a single load, yellow lamp, red lamp with a single START/STOP P.B.

1) Inputs

Start/Stop P.B. (toggle): X0

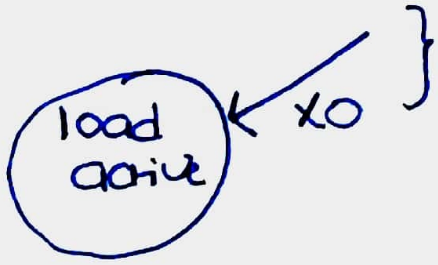
Outputs

Load: Y0

Yellow lamp: Y1

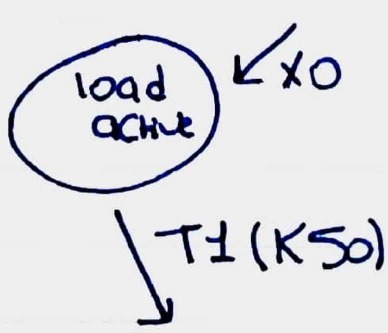
Red lamp: Y2

- while load isn't active and the red lamp is off, pressing X0 activates the load



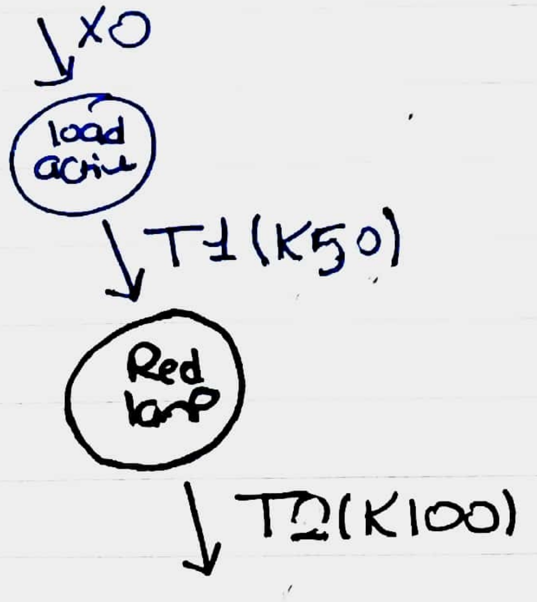
Comes from idle, can't enter from red lamp

- while load is active if X0 is continuously pressed for 5 seconds the load is deactivated



- The yellow lamp should be turned on when X0 is pressed while the load is active (i.e. we are still in the active load state) and turned off once X0 is released
  - → The yellow lamp output is hence X0M1 (no new state or anything, this pertains to the same load active state but triggers some output under some given condition)

- After the load is deactivated, the red lamp should be on for 10 seconds during which, the load cannot be started.



2)

Markers

M1: Load Logic
M2: Red Lamp logic

3)

$$M1 \equiv (X0\overline{M2} + M1).\overline{M2}$$

• must be entering from idle State

• entering M2 = exiting M1

• can simplify

$$M2 \equiv (T1M1 + M2).\overline{T2}$$

• Coming from M1 when its exit cond. is satisfied

• go back to idle State when T2 times out

$$T1(K50) \equiv X0$$ (Press duration)

$$T2(K100) \equiv M2$$ (red lamp on duration)

$$Y0 \equiv M1$$
$$Y1 \equiv X0M1$$
$$Y2 \equiv M2$$

• Ladder has 7 rungs with 2 Self-latches

Problem 3)

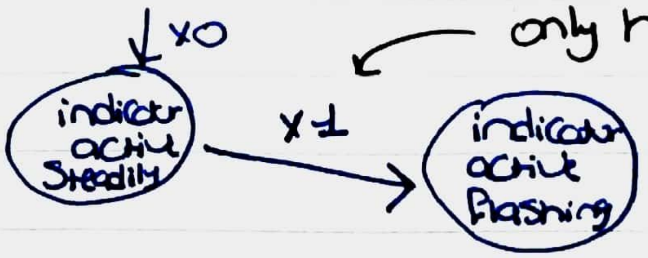
- The control panel of an indicator has STEADY, FLASH, STOP pushbuttons

Inputs:
STEADY P.B.: X0
Flash P.B. : X1
STOP P.B. : X2

Outputs
Indicator : Y0

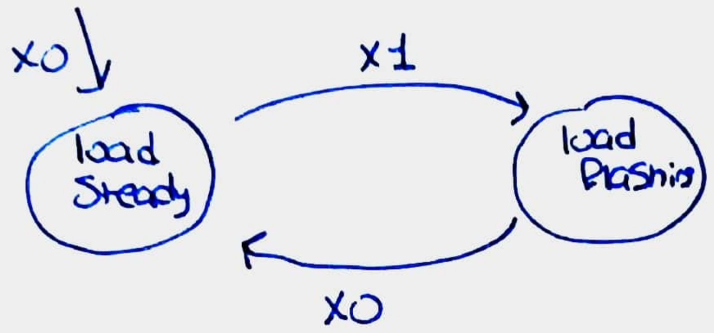
- When STEADY is pressed, indicator is turned on

- When Flash is pressed while indicator is steadily on it will start flashing (0.5s off and 1s on), pressing flash while its off should have no effect.

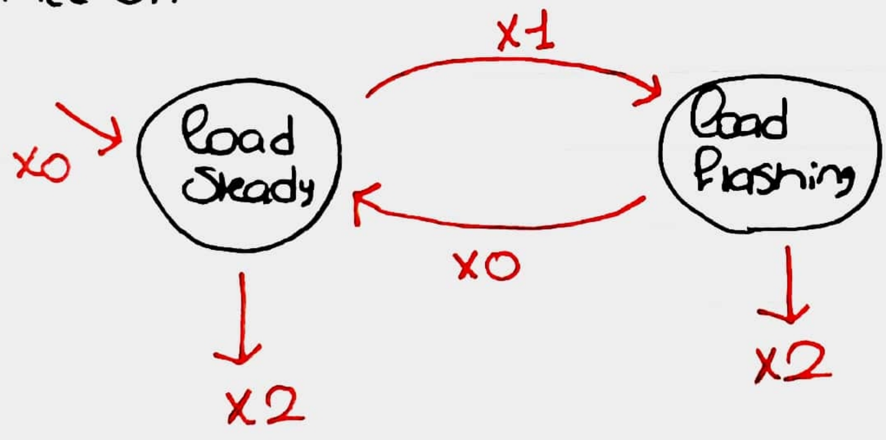


only has effect (state transition when indicator is on)

. if Steady is Pressed while indicator is flashing it becomes on Steadily



. when STOP is Pressed in either case the indicator is turned off



Markers)

M1: load Steady logic
M2: load flashing logic

$$M1 \equiv (X0 + M1) \cdot \overline{X2} \cdot \overline{M2}$$

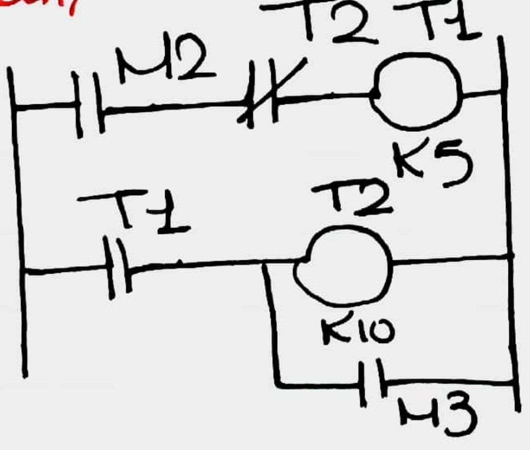
- $X0$: STEADY Pressed (Coming from idle or flashing is okay)
- $M1$: Self-latch
- $\overline{X2}$: Stop (leads to idle)
- $\overline{M2}$: enter flashing → exit steady
- this can't be $\overline{X1}$ (else would never enter M2)
- Hence, we interlock

$$M2 \equiv (X1 \cdot M1 + M2) \cdot \overline{X2} \cdot \overline{X0}$$

- $X1$: Flash Pressed
- $M1$: Must be coming from steady
- $\overline{X2}$: Stop
- we can't have $\overline{M1}$ here ($\overline{M2}$ is in M1 so M1 would never be on while $M2 \equiv 1$)
- Thus, $M2 \equiv 0$ { 1- go from M2 to idle condition ($\overline{X0}$)
  2- Since $X0 \equiv 1$, it takes you to $M1 \equiv 1$

. Now we need to include timers to implement M2's flashing logic (Output should flash as long as M2 is high)

. Recall,



$$T1(K5) \equiv M2\overline{T2}$$

$$T2(K10) \equiv T1 \equiv M3$$

. Now M3 is what should be passed to output (driven by flashing state M2)

→ this should be included in main ladder diagram

Now,

$$Y0 \equiv M1 + M3$$

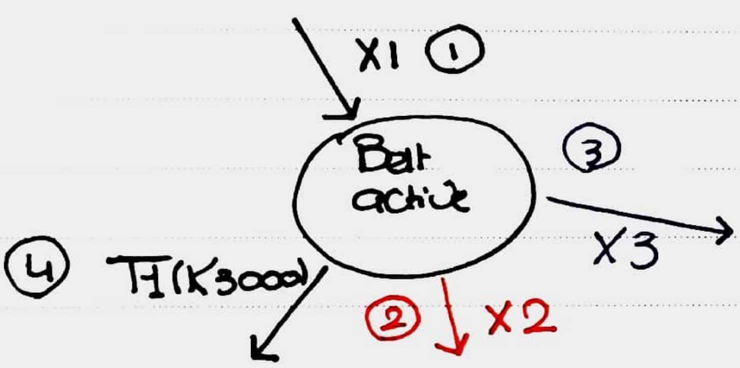
. and we know only one of them is ever active.

Sheet Addendum

- Validating the method by reading then trying to draw it.

[CE lecture 10, 5]

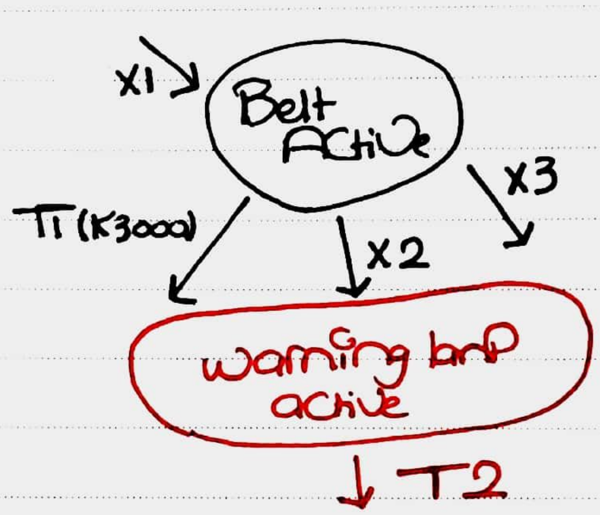
inputs		outputs	
Start	X1	Motor	Y1
limit S.	X2	warning lamp	Y2
Stop	X3		



$$M1 \equiv (X1 + M1)\,\overline{X2}.\overline{X3}.\overline{T1}$$

$$Y \equiv M1$$

[CE lecture 10, 8]

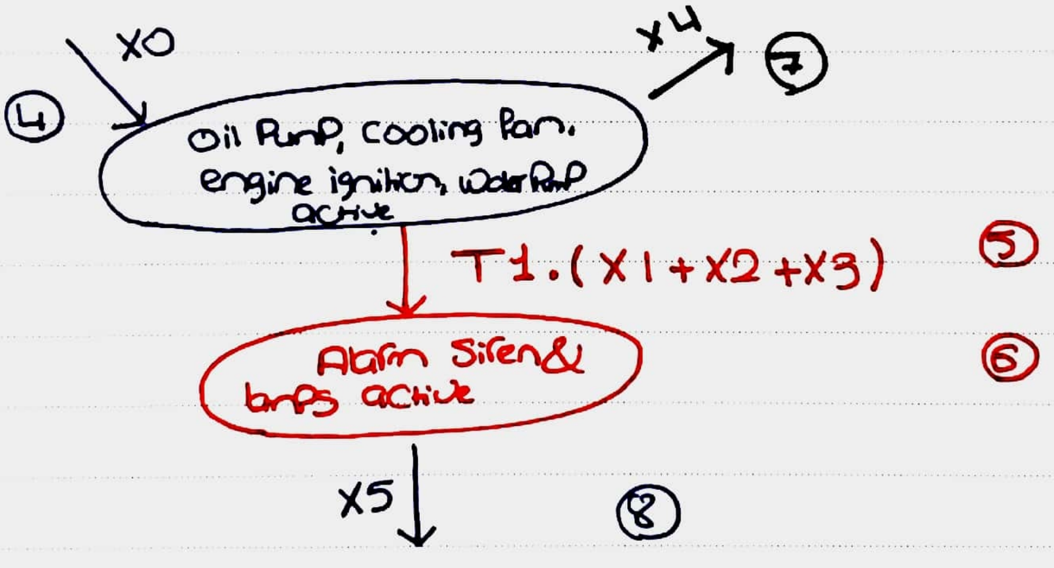


$$M1 \equiv (X1\overline{M2} + M1).\,\overline{M2}$$

$$M2 \equiv (M1(T1+X2+X3)+M2).\,\overline{T2}$$

[CE lecture 10, 12]

Inputs	Outputs
Start: X0	Oil Pump: Y1
Temp. Sensor: X1	Cooling Fan: Y2
Oil level Sensor: X2	Cooling Water Pump: Y3
Oil Pressure Sensor: X3	Engine Ignition: Y4
Stop: X4	Alarm Siren: Y5
Reset Alarm: X5	Temp. Warning Lamp: Y11
	Oil Level lamp: Y12
	Oil Pressure lamp: Y13



$$M1 \equiv (\overline{M2}\,X0 + M1).\overline{X4}.\overline{M2}$$

$$M2 \equiv (M1.T1.(X1+X2+X3) + M2).\overline{X5}$$

- $Y1 \equiv Y2 \equiv Y3 \equiv Y4 \equiv M1$
- $Y5 \equiv M2$. $Y11 \equiv (M2.T1X1 + Y11)\overline{X5}$

. Similarly, Y12 and Y13

* After Checking the Sol.:
  → Can be good practice to break down big states like M2

Alarm & → lamp1 → lamp2 → lamp3

.[CE lecture 10, 14]. last point.