Chapter 13
Algorithmic State Machines
SKEE2263 Digital Systems

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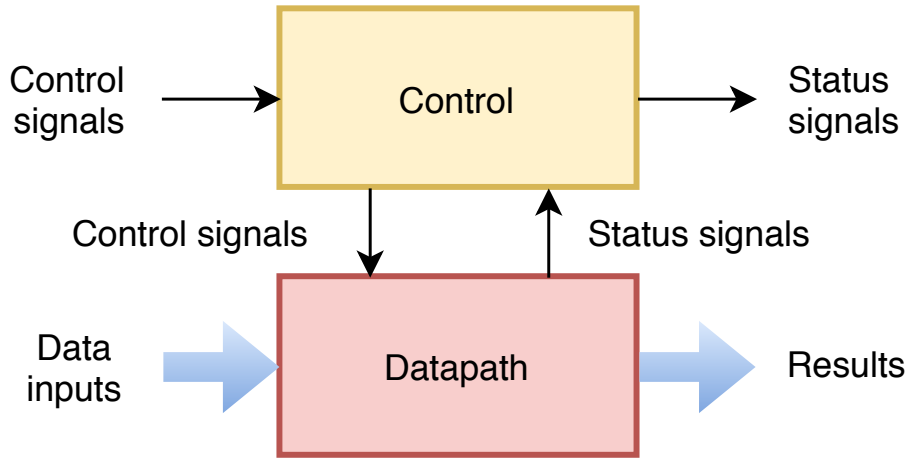
Large Digital Circuits

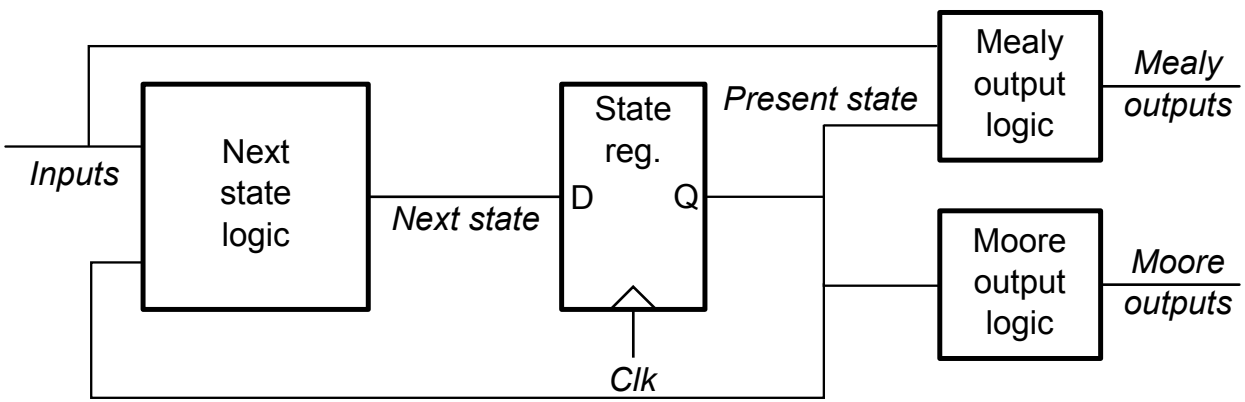
Large digital circuits:

- Consists of data path circuits and control circuits
  - Data path : store, process and move data
  - Control : determine flow of data
- May have Moore and Mealy outputs in the same circuit
- Better described using ASM charts



Large Digital Circuits

- Having Moore and Mealy outputs in the same circuit makes the system more *efficient*



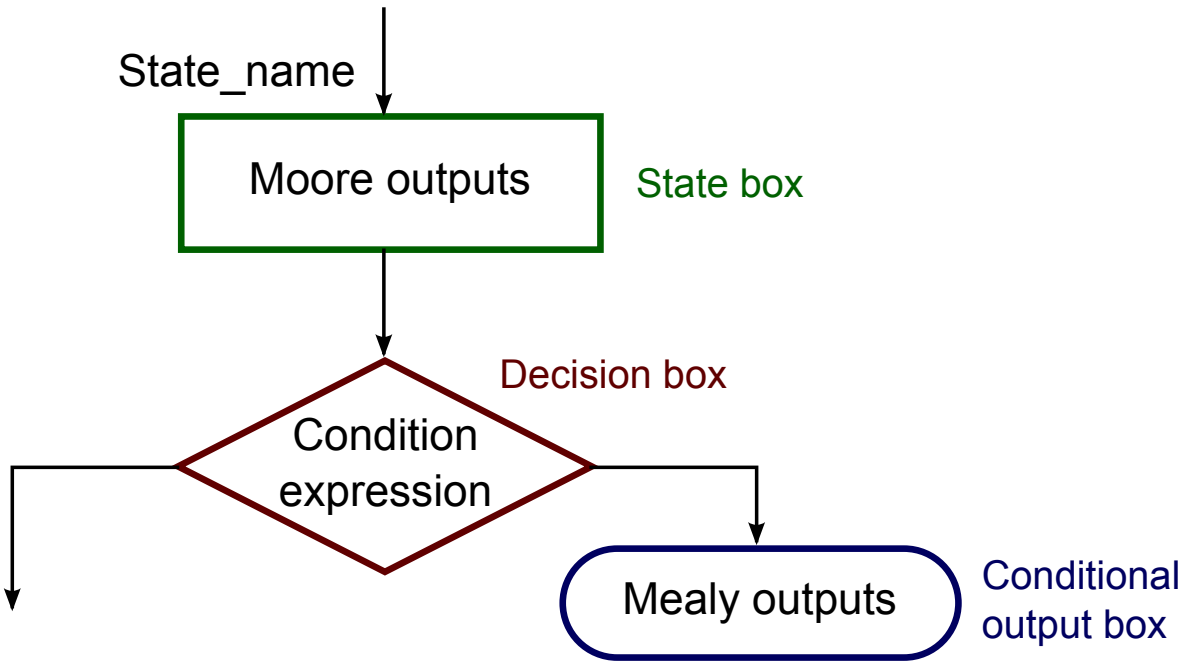
ASM Charts

ASM

Algorithmic State Machines is a method for designing large finite state machines.

- Looks like programming flow charts
- Self documenting
- Reduces design errors
- Easy to automate
- More suitable for complex digital systems with a large number of inputs and outputs
- Allows Moore and Mealy outputs in the same circuit

ASM Elements



ASM Elements

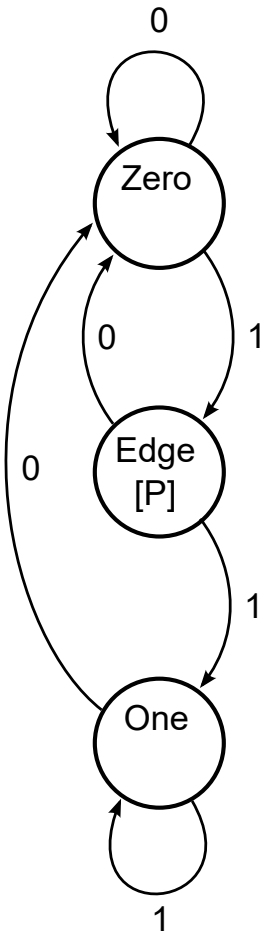
State box :
Each state box has only one exit and is usually followed by a decision box. The Moore outputs are listed in this box.

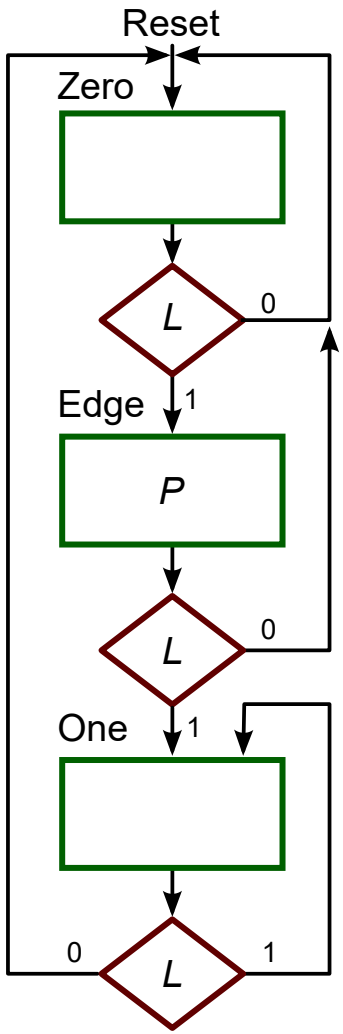
Decision box :
The decision box indicates a condition that is to be tested and the exit path that is to be chosen accordingly.

Conditional output box :
A conditional output box can only follow decision boxes. Mealy outputs are listed in this box.

State Diagram → ASM Chart

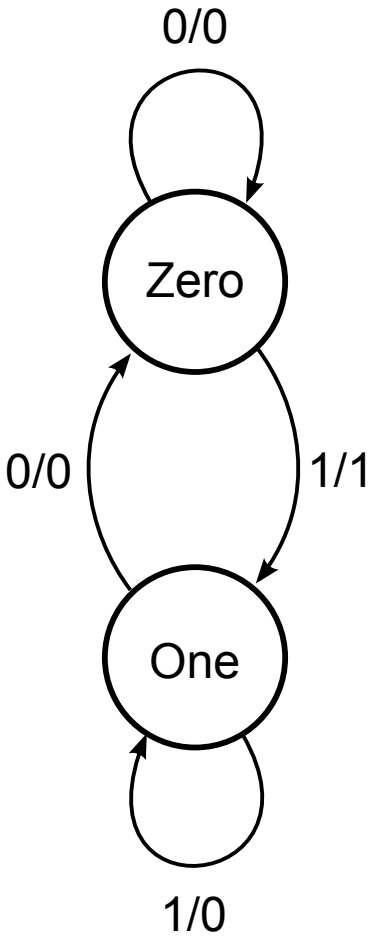
Level-to-Pulse Moore Type

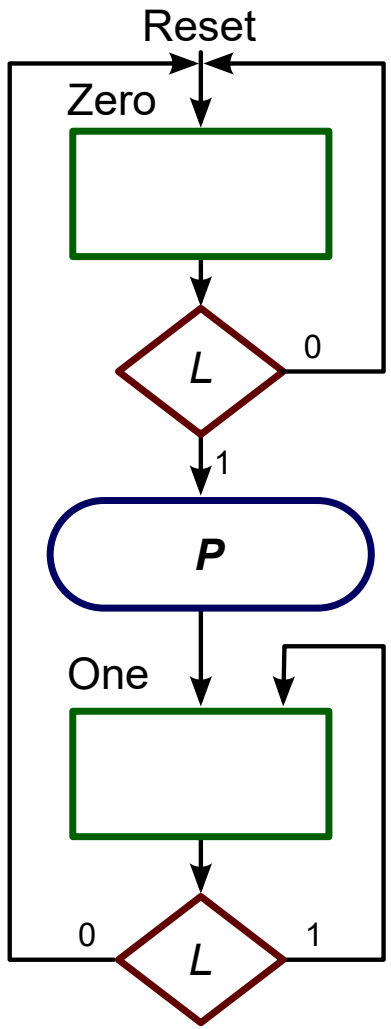




State Diagram → ASM Chart

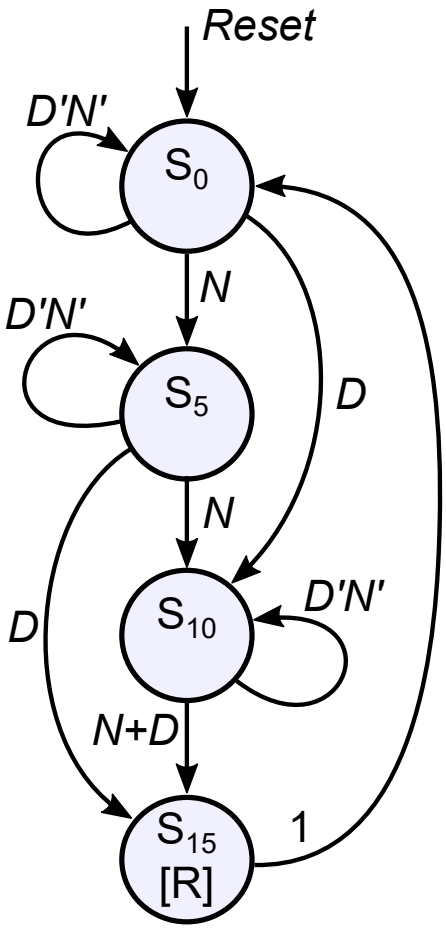
Level-to-Pulse Mealy Type

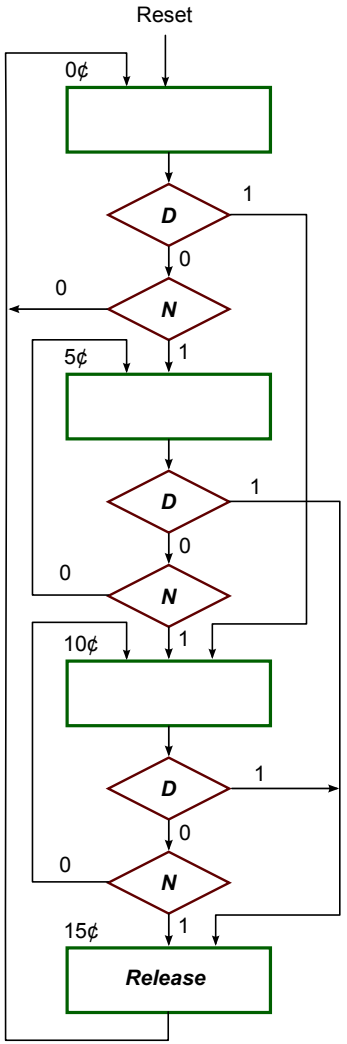




State Diagram → ASM Chart

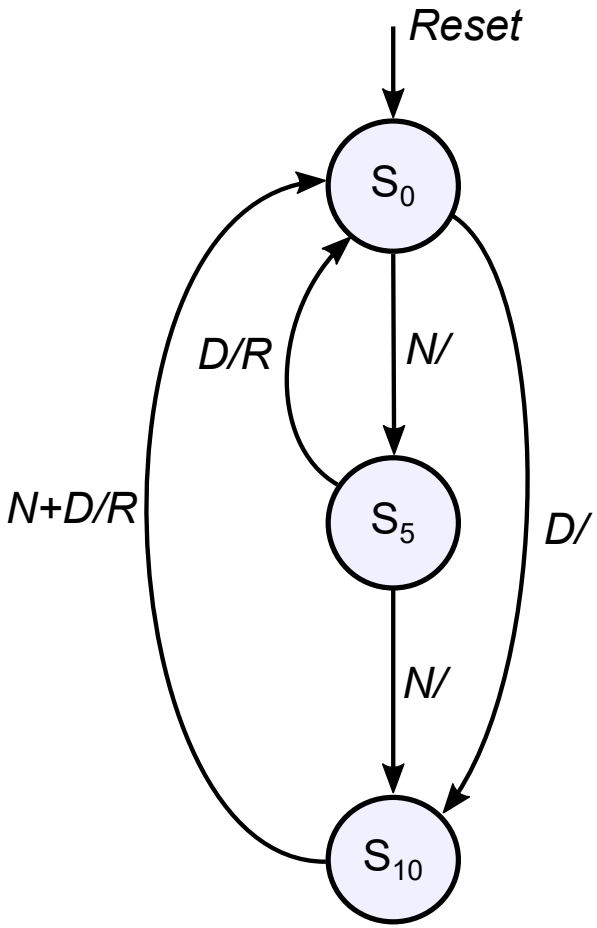
Vending Machine Moore Type

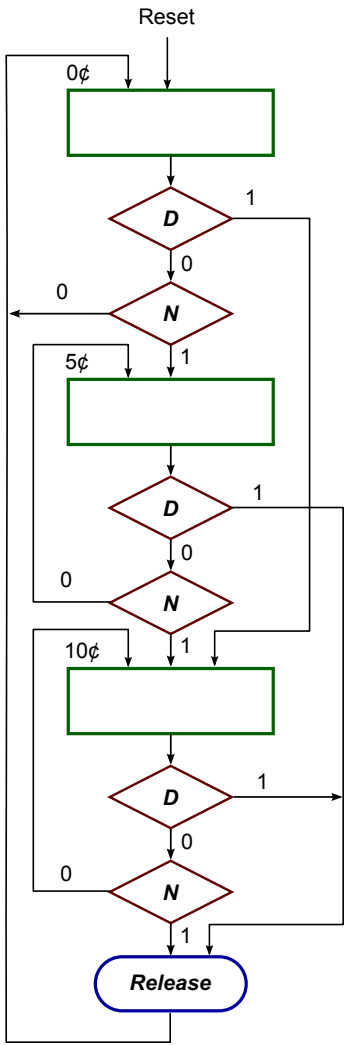




State Diagram → ASM Chart

Vending Machine Mealy Type

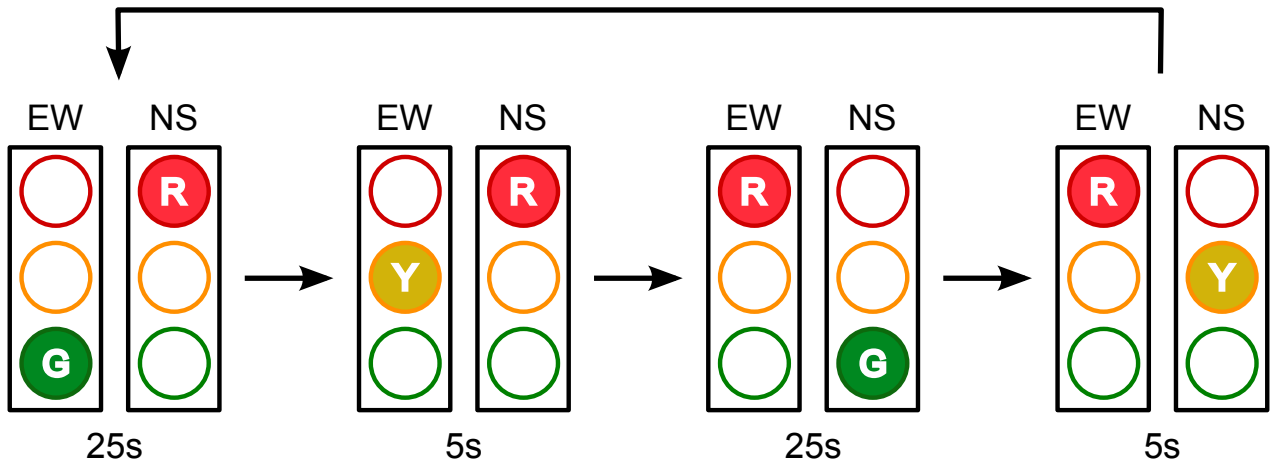


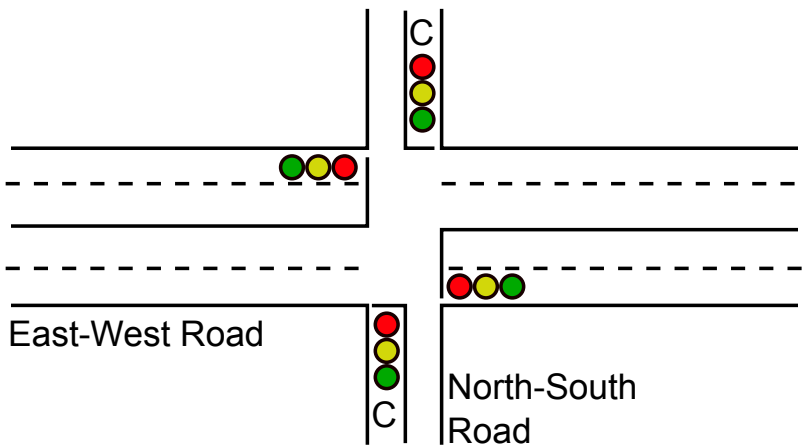


Designing FSM with ASM Chart

1. Create an algorithm, using *pseudocode*, to describe the desired operation of the device.
2. Convert the pseudocode into an *ASM chart*.
3. Design the datapath based on the ASM chart.
4. Create a *detailed ASM chart* based on the datapath.
5. Design the control logic based on the detailed ASM chart.

Traffic Light Sequencing

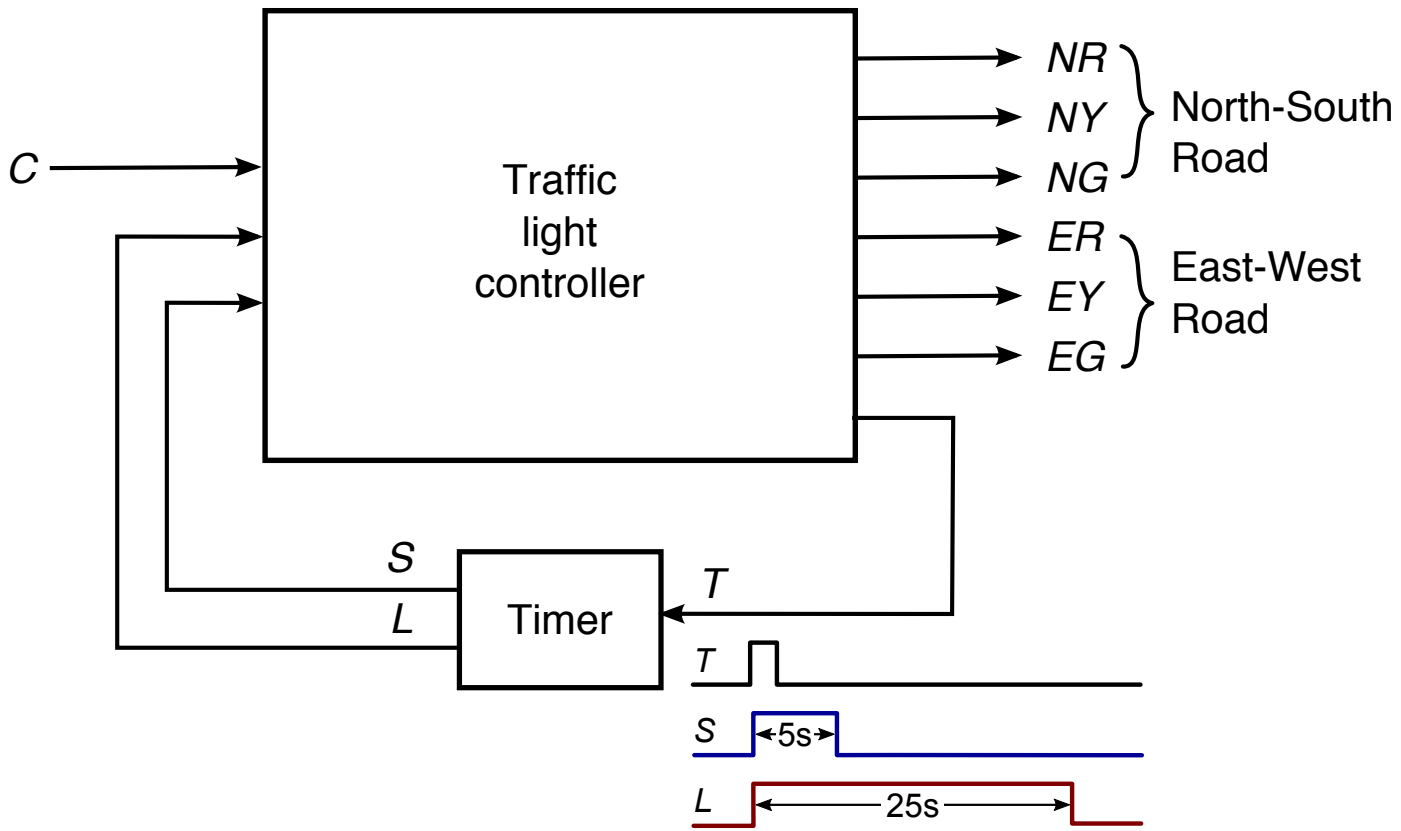




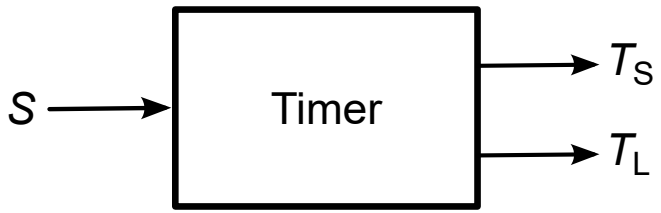
Traffic Light Sequencing

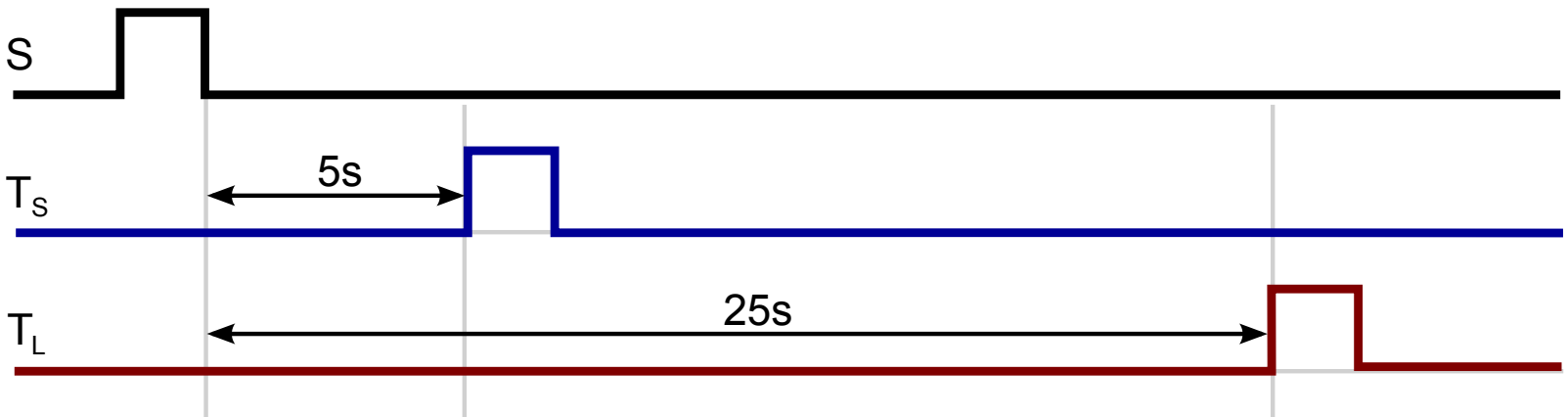
State	East-West	North-South	Delay
EG	Green	Red	25 sec.
EY	Yellow	Red	5 sec.
NG	Red	Green	25 sec.
NY	Red	Yellow	5 sec.

TLC Architecture



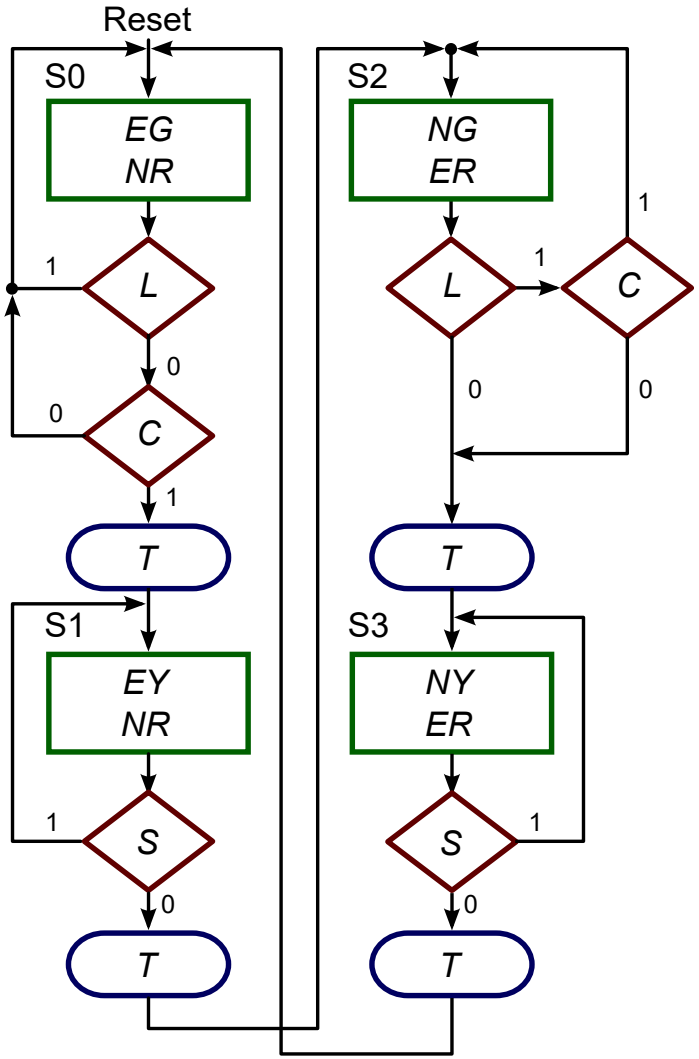
Timer Module

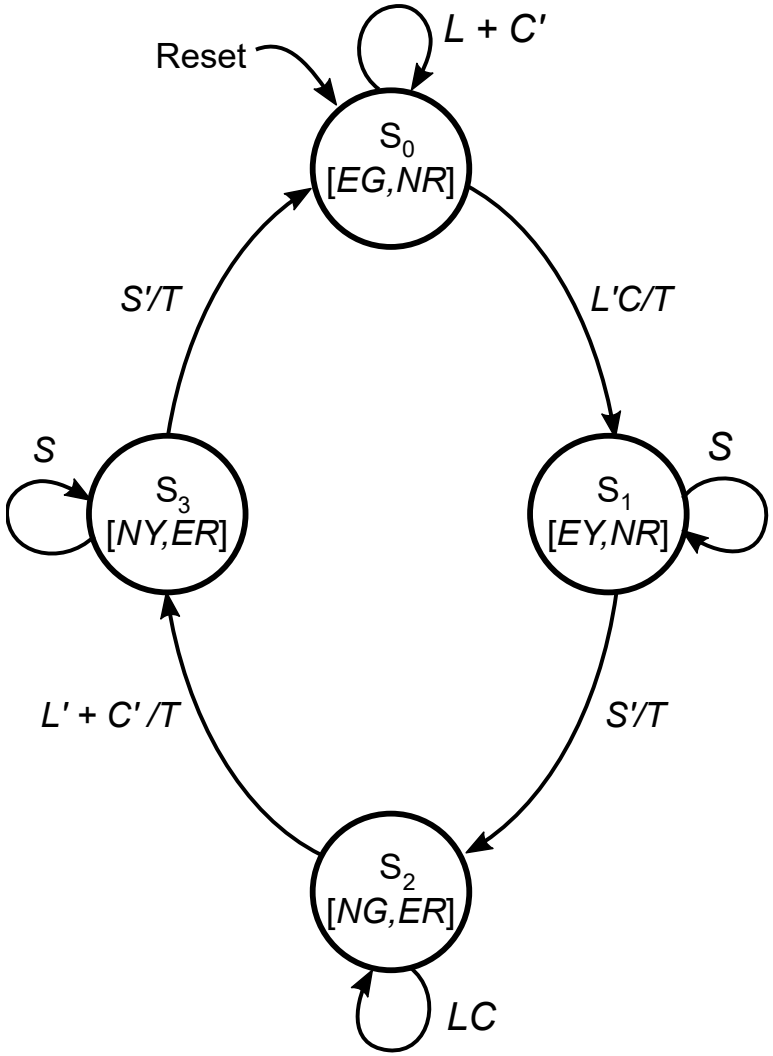




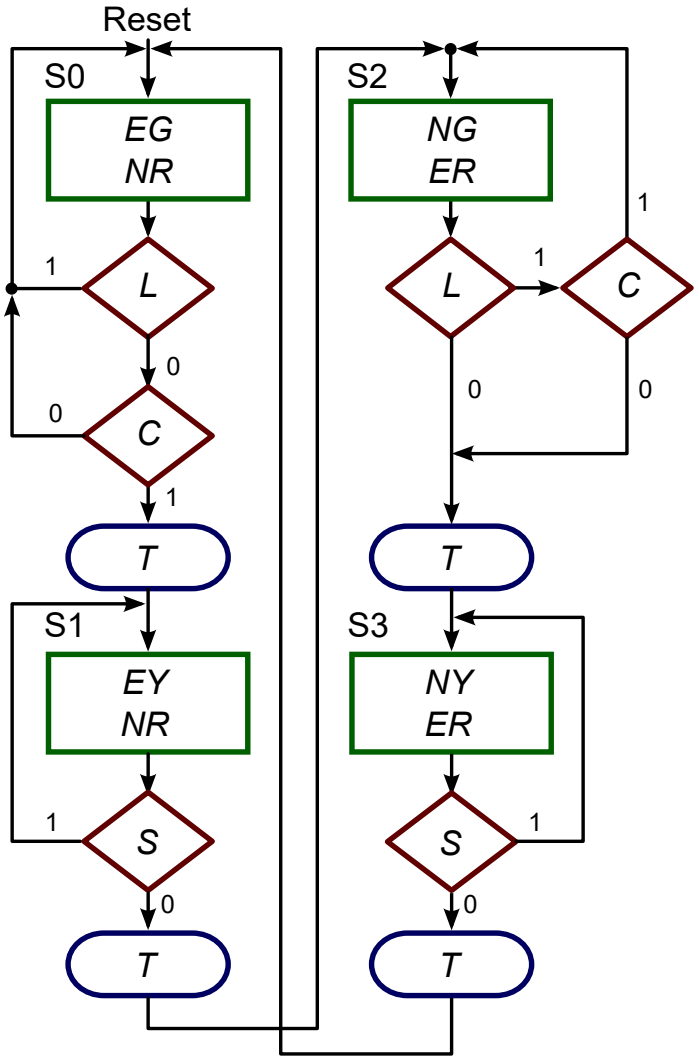
- This is a separate state machine
- Just use as is. Don't worry about the internals.

TLC with Car Detection





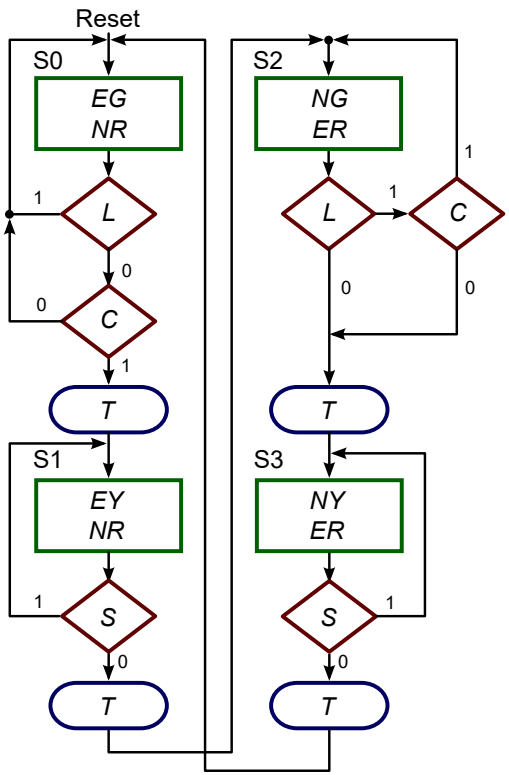
One-Hot Traffic Light Controller



One-Hot State Assignment

Symbolic	Encoding
S_0 = 0¢	1000
S_1 = 5¢	0100
S_2 = 10¢	0010
S_3 = 15¢	0001

One-Hot Traffic Light Controller



Next state equations:

$$S_0^+ = S_0(T_L' + C') + S_3T_S = S_0T_L' + S_0C' + S_3T_S$$
$$S_1^+ = S_0T_LC + S_1T_S'$$
$$S_2^+ = S_1T_S + S_2T_L'.C$$
$$S_3^+ = S_2(T_L + C') + S_3T_S' = S_2T_L + S_2C' + S_3T_S'$$

Output equations:

$$S = S_0T_LC + S_1T_S + S_2(T_L + C') + S_3T_S$$
$$EG = S_0$$
$$EY = S_1$$
$$ER = S_2 + S_3$$
$$NG = S_2$$
$$NY = S_3$$
$$NR = S_0 + S_1$$

One-Hot Traffic Light Controller