Embedded System Design and Modeling

1. (5p) Consider a Finite State Machine to implement a **parking vehicle counter**, as follows:

   - the system must always indicate how many cars are in the parking space
   - there is 1 boolean input `In`, defined as: False = no car entering, True = one car is entering
   - there is 1 boolean input `Out`, defined as: False = no car exiting, True = one car is exiting
   - there is 1 output `Count`, an integer number
   - the parking space has only 60 parking spots available
   - the following scenarios are possible:
     - a car may enter the parking
     - a car may exit the parking
     - a car may enter the parking and another one may exit the parking simultaneously
   - the output number is not allowed to exceed 60 or go below 0.

   a. (2p) Implement a Finite State Machine to satisfy all the specifications above;
   b. (1p) Explain in words the functioning of the FSM, and how it covers all the specifications;
   c. (1p) Modify the FSM at point a). to add the following requirement:
      - there is a new input named "Freeze", of type Boolean
      - when Freeze = True, the system must freeze the count number, and ignore the inputs In and Out
      - when Freeze = False, the system resumes counting from where it was

      Explain what you did.
   d. (1p) Modify the FSM at point a). to add the following requirement:
      - after a car enters the parking, the system shall ignore the In input for the next 5 seconds (e.g. to avoid counting the same car two times, by mistake)

      Explain what you did.

2. (2p) Consider a motor controlled with a PID controller. Initially the motor is not moving. At time 0, the target speed becomes 1000 rpm, as depicted below. Sketch the motor output speed if:

   a. The controller has only the P component
   b. The controller has both the P and I components

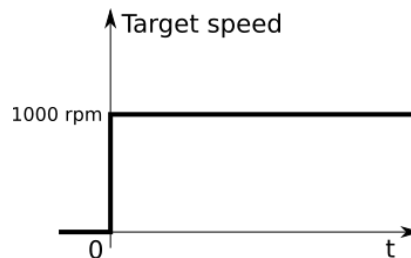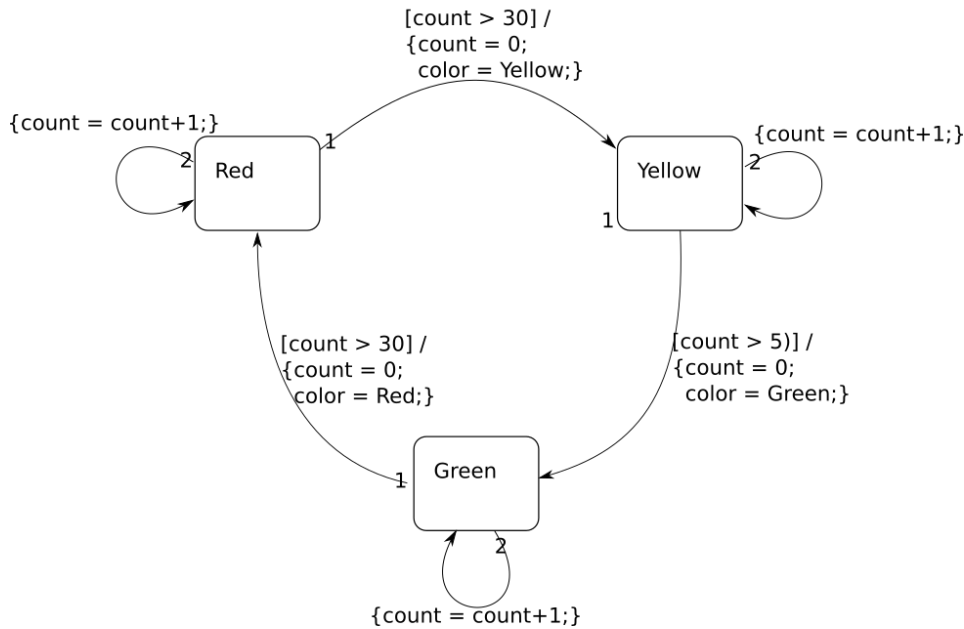   Justify your drawing and explain the difference.
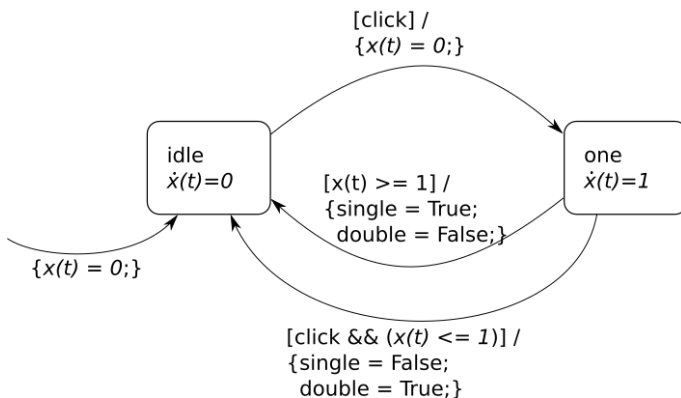

Figure 1: Target speed

3. (1p) Consider the following FSM. How many different states does the FSM have? Explain how you obtained the result. (Hint: don't count only the "bubbles").

Inputs: -
Variables: *count* (integer)
Output: *color* (Red, Yellow or Green)

[count > 30] /
{count = 0;
    color = Yellow;}

{count = count+1;}

{count = count+1;}

Red   Yellow

[count > 30] /
{count = 0;
color = Red;}

[count > 5)] /
{count = 0;
    color = Green;}

Green

{count = count+1;}

4. (1p) What does it mean that a system has **feedback composition**?

5. (2p) Explain the operation of the following timed-automaton FSM

    a. What the system does, how it operates, what happens in each state
    b. What happens to the signal x(t) (draw how the signal evolves)

Inputs: *click* (event)
Variables: *x(t) (real, continuous variable)*
Output: *single* (boolean)
            double (boolean)

[click] /
{x(t) = 0;}

idle   one
$\dot{x}(t)=0$ $\dot{x}(t)=1$

[x(t) >= 1] /
{single = True;
    double = False;}

{x(t) = 0;}

[click && (x(t) <= 1)] /
{single = False;
    double = True;}

Note. Obtain 10p for grade 10. 1p is awarded from the start ("din oficiu"). Time available: 2h