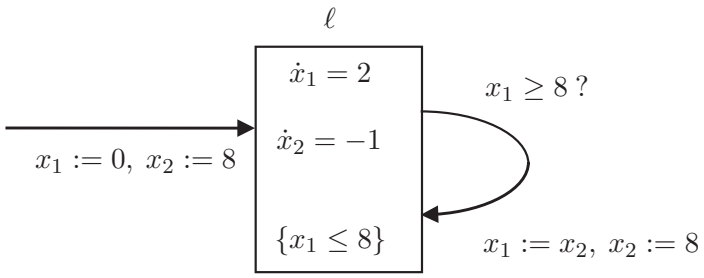
Analysis and Control of Cyber-Physical Systems

Final exam — 1 June 2023

Problem 1. [21 pts] Consider the hybrid automaton H shown below.



(a) *(3 pts)* Determine its algebraic structure and discuss if it belongs to a known subclass of hybrid automata.

(b) *(3 pts)* Write a Modelica program to simulate the evolution of the automaton.

(c) *(4 pts)* Determine (by hand) the evolution of the automaton during the time interval $t \in [0, 7]$. Describe this evolution as hybrid signal, and plot the state variables over time and also the trajectory in the state space.

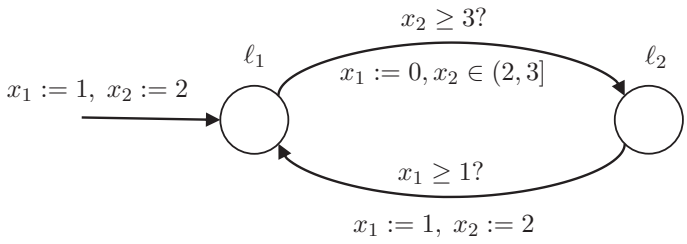
(d) *(3 pts)* Show that the automaton is zeno and compute the time T_{zeno}.

(e) *(3 pts)* Determine a zeno-free hybrid automaton H' obtained from H by time-regularization, assuming a dwell time $\delta = 0.1$.

(f) *(3 pts)* Determine the time-abstract state transition system T that describes H.

(g) *(2 pts)* Discuss if it is possible to compute the reachability set $Reach(T)$ using the procedure discussed in class. Could one convert H into an equivalent timed automata and study reachability using a finite quotient automaton?

Problem 2. [9 pts] Consider the timed automaton whose graphical representation is shown below.



(a) *(3 pts)* Determine its regions in the continuous state space.

(b) *(3 pts)* Construct the region automaton starting from the initial condition.

(c) *(3 pts)* Based on the region automaton, what can be said about the reachability of the following states?

$$i) \quad (\ell_1, (1, 2.5)); \qquad ii) \quad (\ell_2, (0.5, 2.6)); \qquad iii) \quad (\ell_1, (2, 3.5)).$$