A fully Numerical Solution of ARGESIM Comparison "C5 Two State Model" with Dymola

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Simulator: Dymola, Dynamic Modeling Laboratory, is a simulation environment suitable for modelling various kinds of physical objects. It uses an object oriented approach for modelling of large, complex and heterogeneous physical systems. A graphical editor and a specific language (Modelica) allow the user to construct models composed of mechanical, electrical and hydraulic subsystems out of predefined models.

Model:. Although the equations could be solved analytically, here the ODEs are solved by Dymola's ODE solvers, which can handle state events.

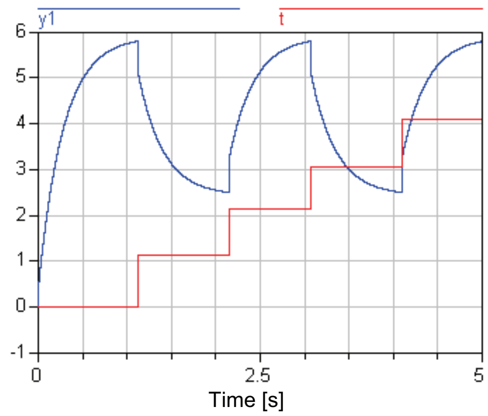
Because of the simplicity of the model a pure textual approach was taken. For modelling of state events the Dymola User Manual suggest using the `when (cond) then` statement: the `when` condition is the event condition, the `then` block describes the event. The implementation is then straightforward:

```
class Comparison5 "equation"
declaration of parameters, variables …
  algorithm
  when (y1 >= 5.8) then
    c2 := -0.3;    c4 := 2.73;k=k+1;te(k)=t
  end when;
  when (y1 <= 2.5) then
    c2 := 0.4;    c4 := 5.5; k=k +1;te(k)=t
  end when;
  equation
  der(y1) = c1*(y2 + c2 - y1);
  der(y2) = c3*(c4 - y2);
end Comparison5
```

In Dymola, all differential, algebraic and discrete equations are treated as synchronous in time; it is assumed, that all equations in a model may be active at the same time instant. In order to prevent equation conflicts, it is recommended to put redefined equations into a called `algorithm section`. Although in the Two State Model no conflicting equations are possible, the conditional equations must be they must be written in the `algorithm section`.

Task a: Simulation of the System: For the problem, a stiff system with multiple state events, three integration algorithms were suitable: DASSL, DASSLL and LSODAR.

For the resulting state y_1 in the next figure the DASSL algorithm (DAE solver by L. Petzold) with relative accuracy of 10^{-6} was used:

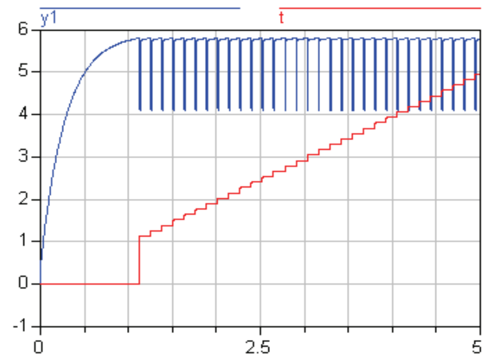


Task b: Time instants of discontinuities. To trace the time instants of the events, the current time is logged in the event directly (extension of the `then` block). The time instants and the terminal value are:

t_1=1.124042241435211 t_2=2.145426621013892
t_3=3.069897847796384 t_4=4.091282227441629
y_1(5.0)=5.794223050281934

With higher relative accuracy the results get slightly better, but not significantly. Additionally the last state event isn't found in any case. Furthermore it is only possible to solve the problem up to a relative accuracy of 10^{-12}.

Task c: Frequent events. The change of the parameters results in "oscillations" of the state y_1 (next figure). The number of discontinuities found is 62 or 63, resp. (depending on the solver).



The first, second and last found discontinuities are:
t_1= 1.124039007216077 t_L= 4.95219675857112
t_2= 1.137462807344851 y_1(5.0)= 5.77350266027292

C5 Classification : Fully Numerical Approach
Simulator : DYMOLA Rec. Version 2003