Modeling with Modelica, Part III

Staffan Haugwitz

Dept. of Automatic Control
Lund University

Based on material from Modelon

Lecture Outline

- Conditional expressions and hybrid modeling
- High index problems
- Stiff systems

Conditional expressions

```
equation
  throttle = if distance > 100 then FullThrottle
             else if distance > 40 then MediumThrottle
             else BreakFull;

  der(x) = if x > 0 then -1
           else if ((-0.01 < x) and (x < 0.01)) then 0
           else +1;
```

Hybrid modeling

```
model BouncingBall
  constant Real g = 9.81 ''Gravity constant'';
  parameter Real c = 0.9 ''Coefficient of restitution'';
  parameter Real radius = 0.1 ''Radius of the ball'';
  Real height (start = 1) ''Height of the ball'';
  Real velocity (start = 0) ''Velocity of the ball'';

equation
  der(height) = velocity;
  der(velocity) = -g;
  when height <= radius then
     reinit(velocity,-c*pre(velocity));
  end when;
end BouncingBall;
```

High Index Problems

+ A great advantage with Modelica is the ability to handle DAE systems, without having to rewrite them to ODEs. Just enter the model equations as they are given in the physical model (acausal modeling).
- The drawback is that it may be non-trivial to find the correct degree of freedom and the number of initial conditions to set.

Pendulum - radial coord.

$$\dot{\theta} = \omega$$
$$\dot{\omega} = -g/L \sin\theta$$

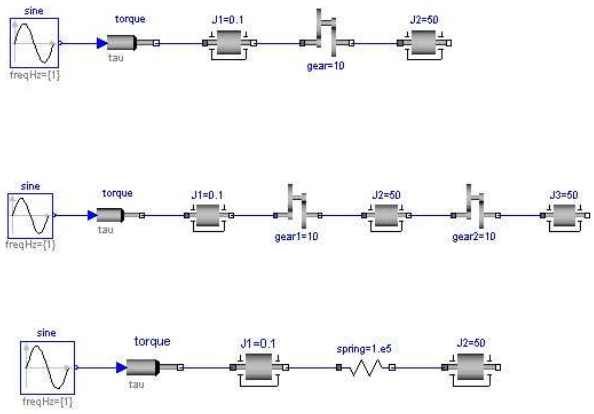
Pendulum - cartesian coord.

$$m\ddot{x} = -Fx/L$$
$$m\ddot{y} = -Fy/L - mg$$
$$x^2 + y^2 = L^2$$

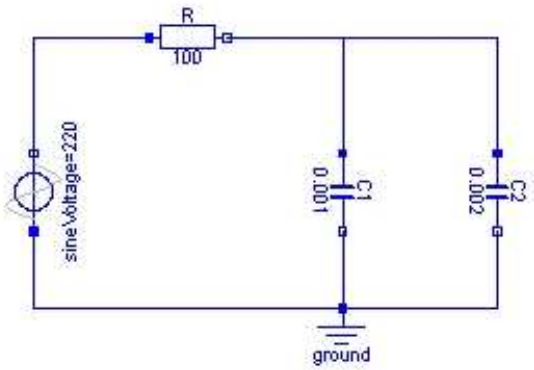
High Index Problems 2

- May appear when connecting components in e.g. mechanics, thermodynamics and chemical equilibria.
- The user needs to understand the process and the remaining degrees of freedom to set a correct number of initial conditions.
- Change of states may give better numerical properties.
- Dymola offers dynamic state selection.

Examples on High Index Problems - Mechanic

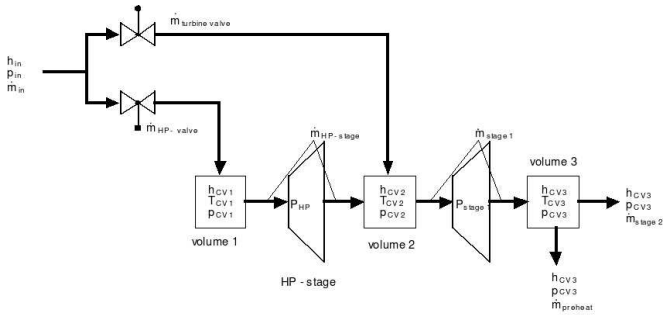


Examples on High Index Problems - Electric



Stiff systems

- A *stiff* model includes both very fast and very slow dynamics, e.g. very large and very small tanks in a water pipe model or chemical reactions with equilibrium.



Stiff systems: Solution

- Use a suitable solver (DASSL in Dymola already default)
- Approximate very fast dynamics with algebraic (steady-state) equations.
- Approximate very slow dynamics with constants.
- Change the time constants to decrease the difference.