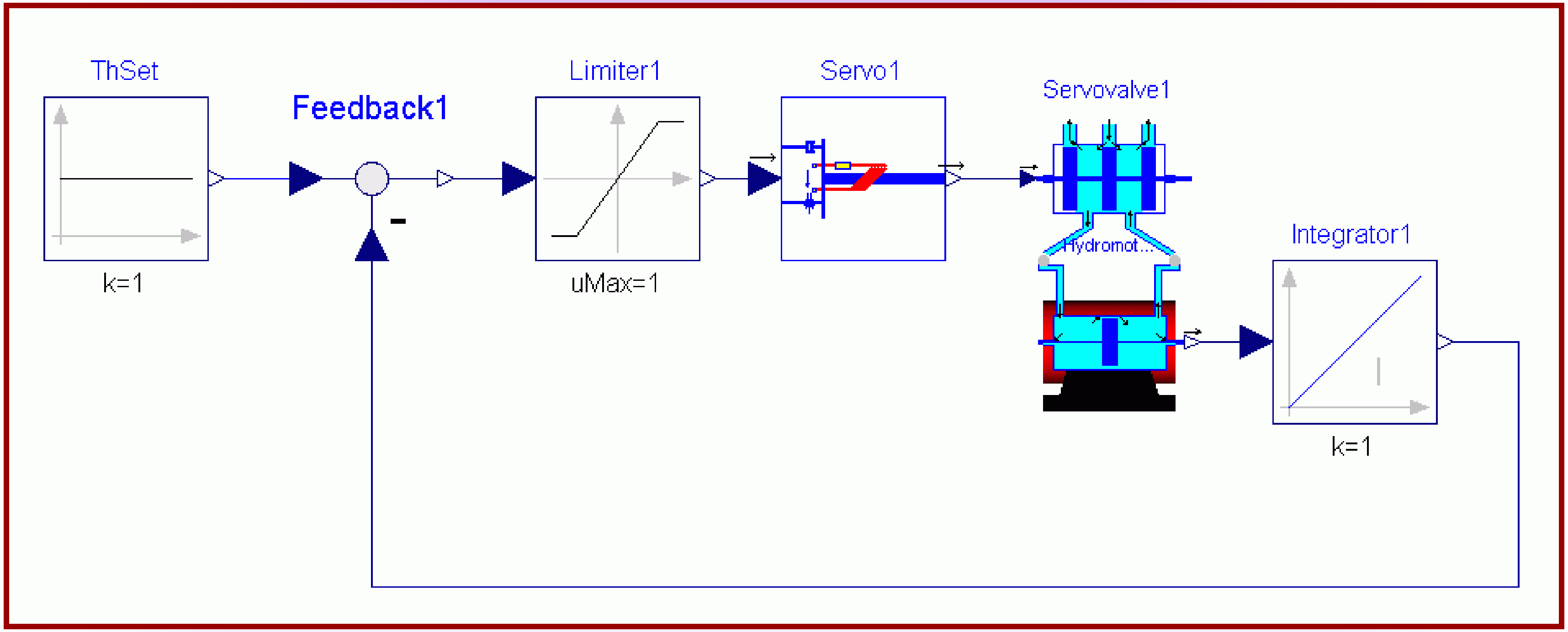
9^{th} Homework

- In this homework, we shall exercise the model wrapping technique.
- To this end, we shall create a mini-library of wrapped 1D hydraulic bond graph models replicating some of the features of the ***HyLibLight*** library that is being shipped with ***Modelica***.

- 1D hydraulic control system
- Hydraulic motor
- Servovalve
- Encapsulated bond graph
- Hydraulic mini-library
- Hydraulic motor control

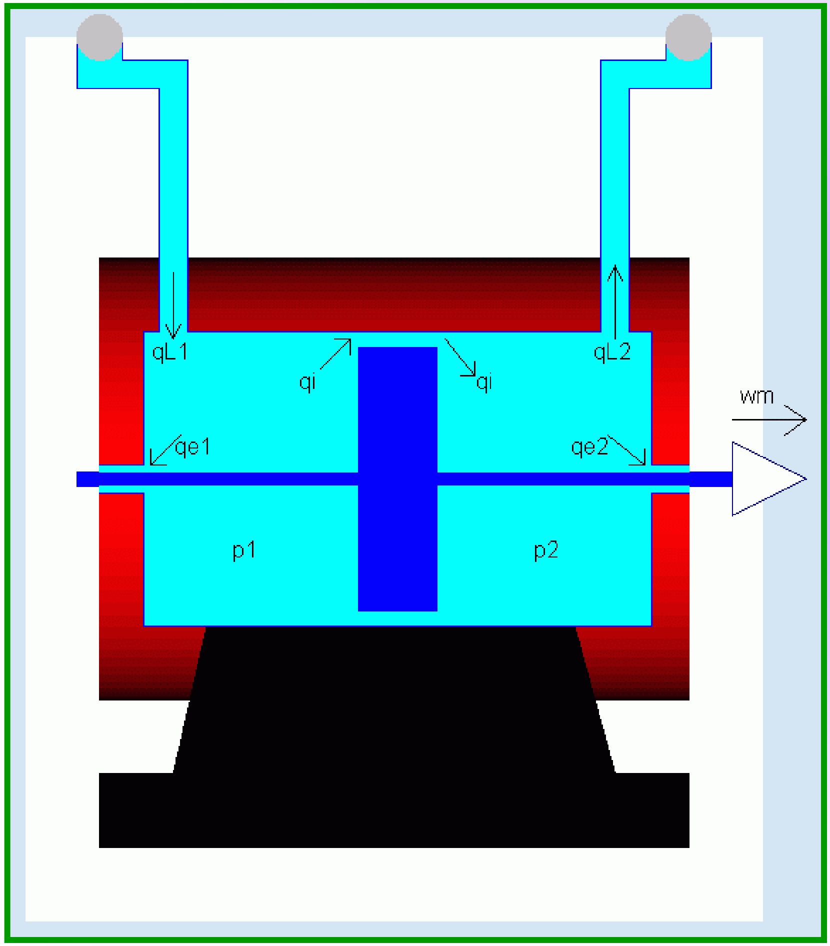
1D Hydraulic Control System

- Given the following hydraulic control system:



- You find it among the general examples of ***BondLib***.

Hydraulic Motor



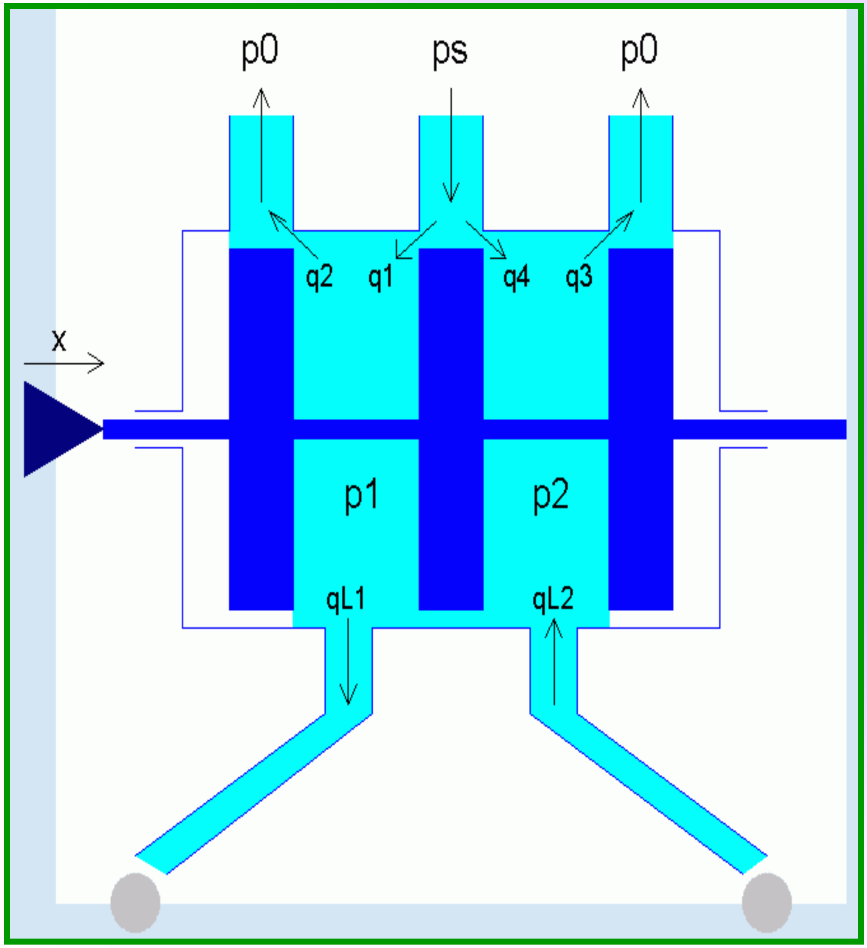
The hydraulic motor has two chambers filled with oil. A wall separates them.

The wall is connected to a screw.

If pressure p_1 is larger than p_2, there is a force pressing against the wall from the left, which makes the screw turn. Thereby, the wall moves to the right, until the two pressures are equal again.

There are internal and external laminar leakage flows.

Servovalve



The hydraulic motor is controlled by a servovalve.

If the tongue of the servovalve moves to the right, the flows q_1 and q_3 increase, whereas q_2 and q_4 decrease.

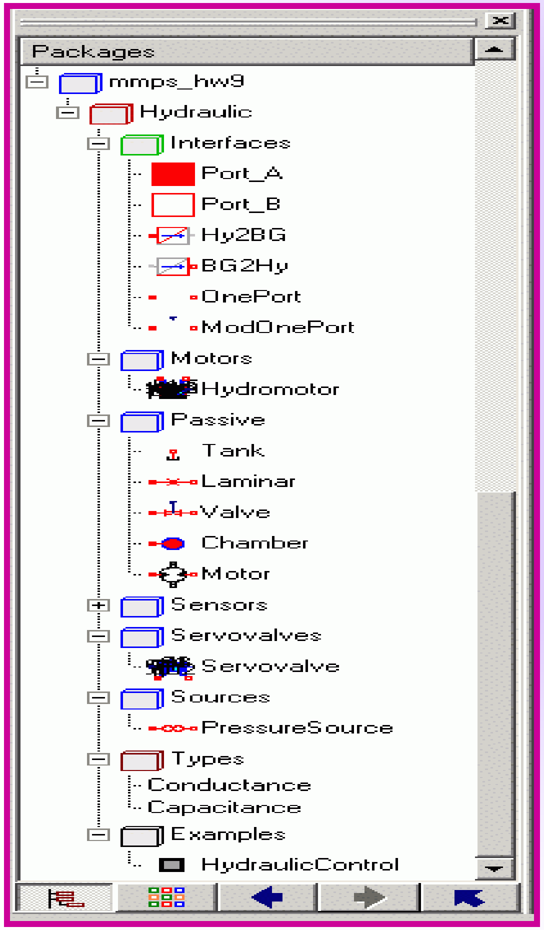
Hence p_1 increases also, whereas p_2 decreases.

The service pressure p_S is much higher than the standard atmospheric pressure p_0.

Encapsulated Bond Graph

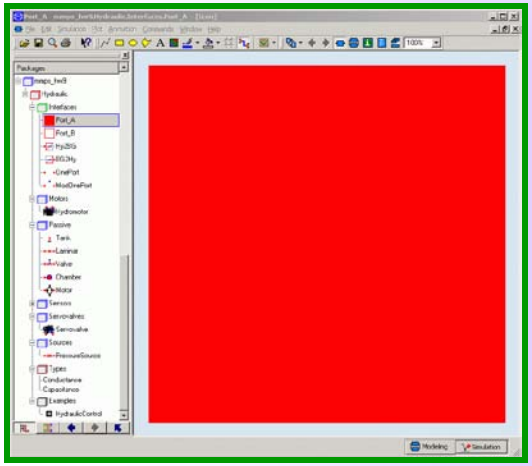
- The model was built using ***encapsulated bond graph*** technology.
- The bond graph describing the servovalve ends in bonds, whereas the bond graph describing the hydraulic motor ends in junctions.
- Therefore, the two models can be externally connected using standard bond graph connectors.
- Whereas encapsulated bond graphs may be acceptable for small applications, the ***wrapped bond graph*** technology is much more powerful, as it offers to the user a higher-level interface that is closer to the application domain knowledge.

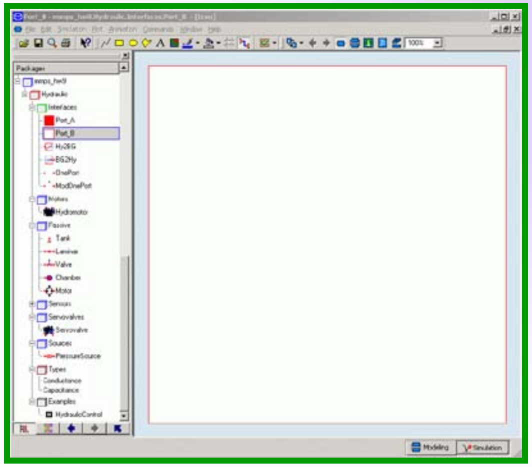
The Hydraulic Mini-Library



- The package window of the new mini-library is shown to the left.
- It contains six interface models, five passive models, one source model, as well as a model for the servovalve and one for the hydraulic motor.
- Your job is to re-create this mini-library in this homework problem.
- The models to be designed are now briefly described.

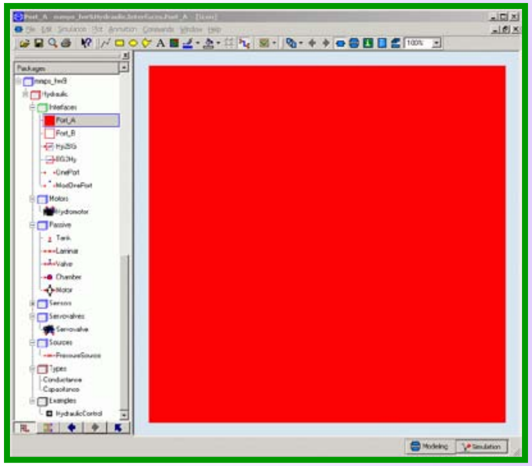
The Connector Models

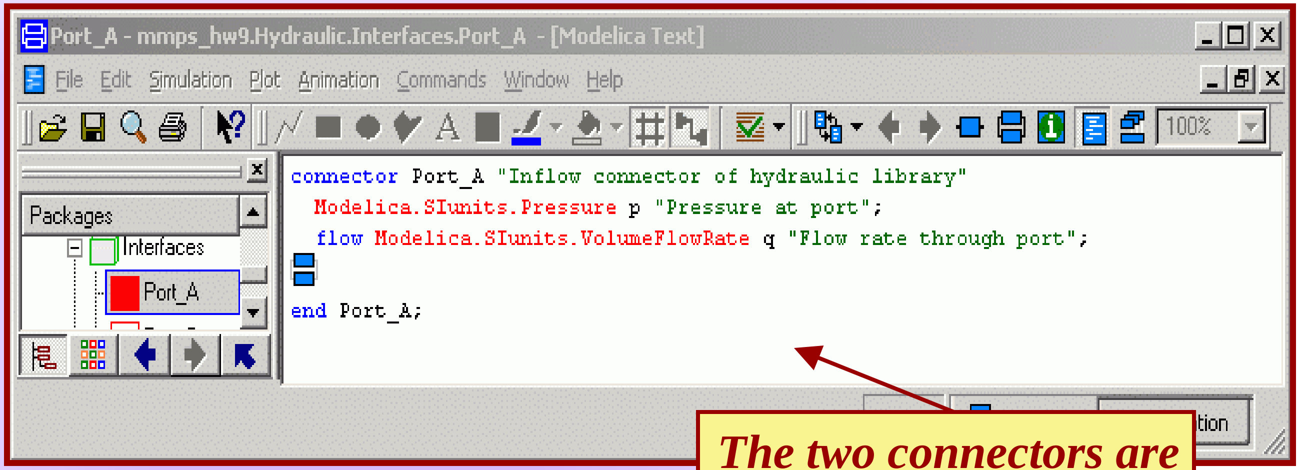




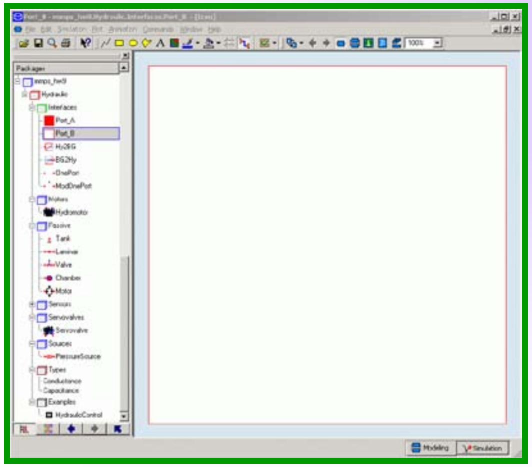
- We shall need two 1D hydraulic connectors. These are similar to those of the ***HyLibLight*** library, but they are not identical, as they don't reference the oil properties yet.
- The connectors simply list the pressure as a potential (across) variable, and the volumetric flow as a flow (through) variable.
- The two connectors are identical.

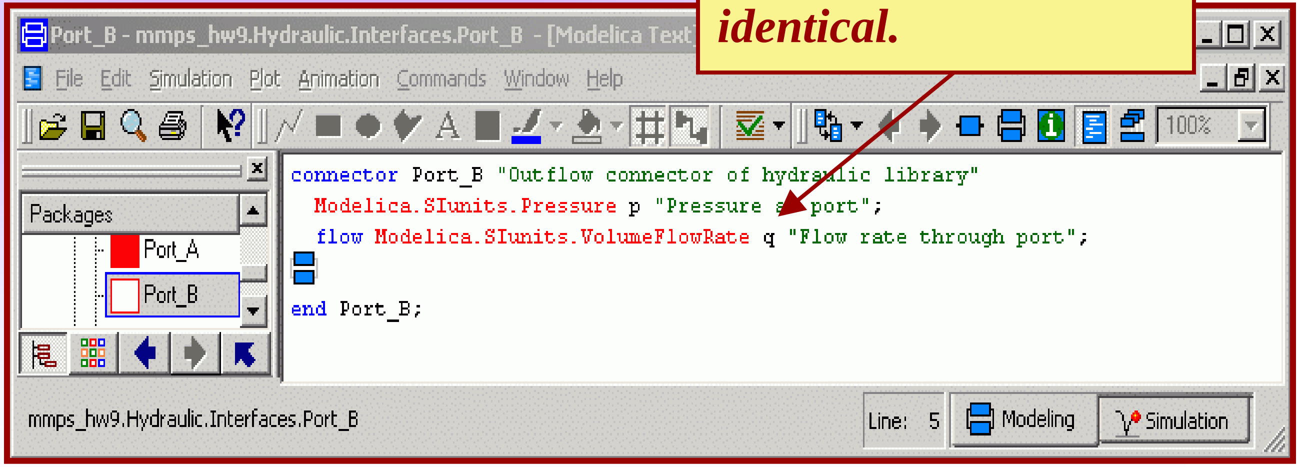
The Connector Models II



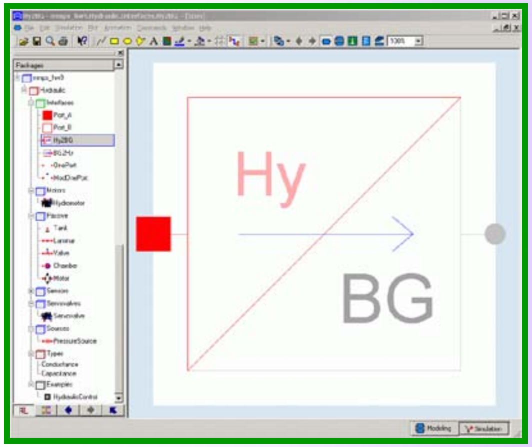


The two connectors are identical.

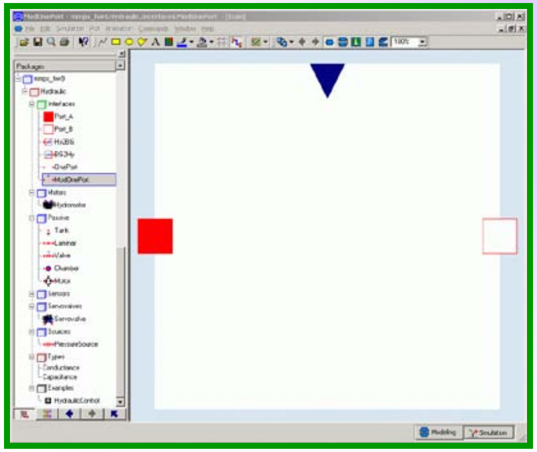




The Wrapper Models and the OnePort

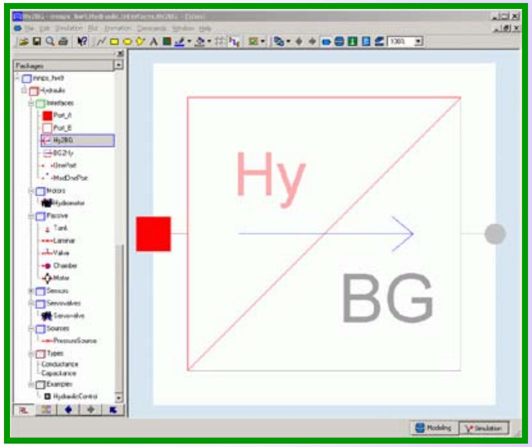


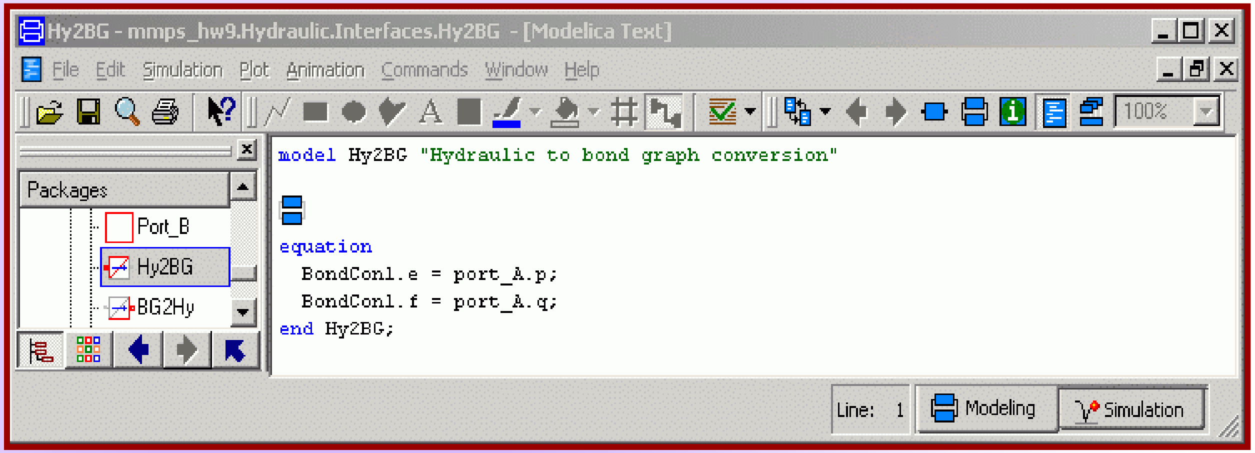
- We shall also need two wrapper models. These are similar to those of the wrapped electrical library.

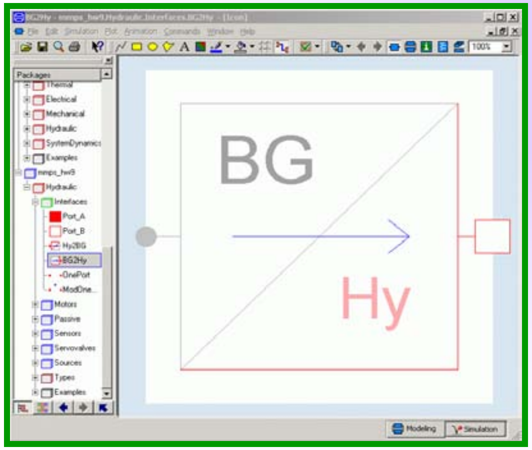


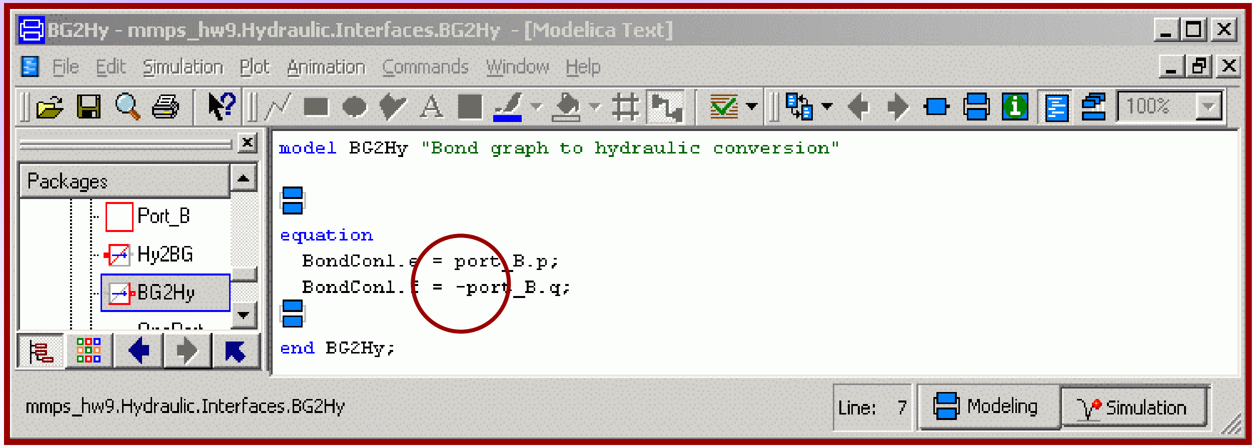
- We shall further need two OnePort partial model, one standard, the other modulated. They play the same role as the corresponding OnePort partial models of the wrapped electrical bond graph library.

The Wrapper Models and the OnePort II

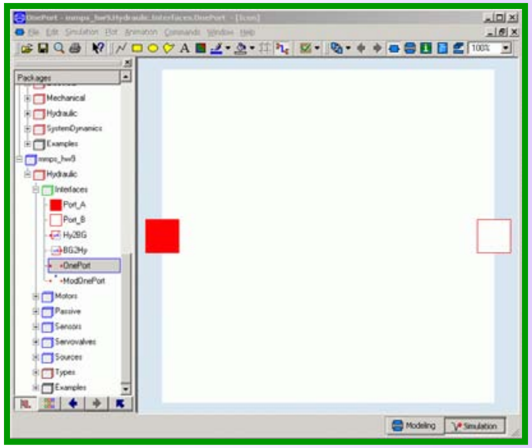


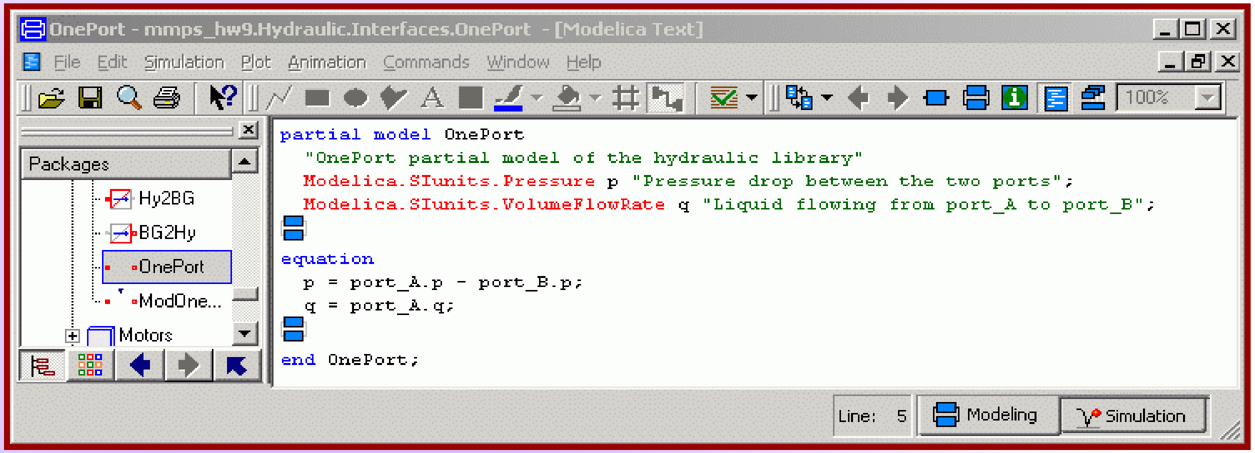


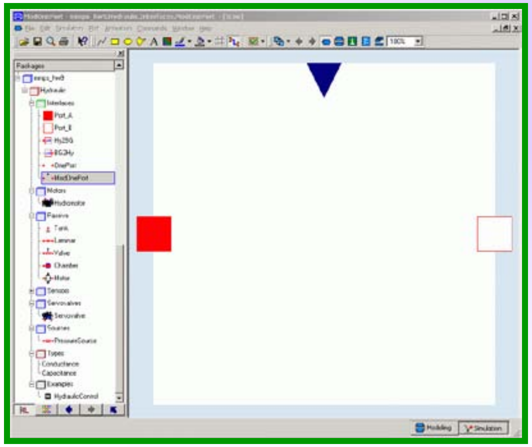


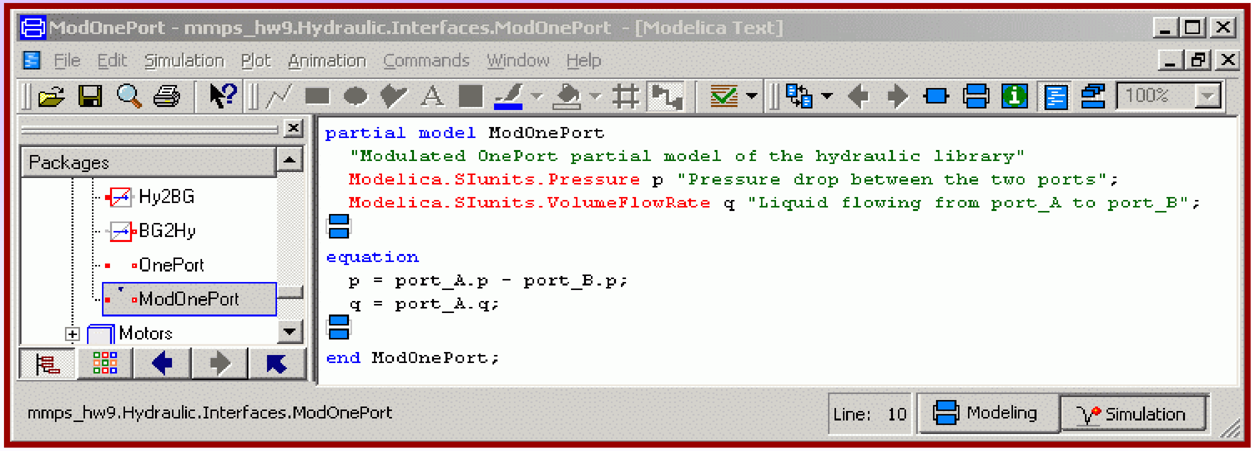


The Wrapper Models and the OnePort III

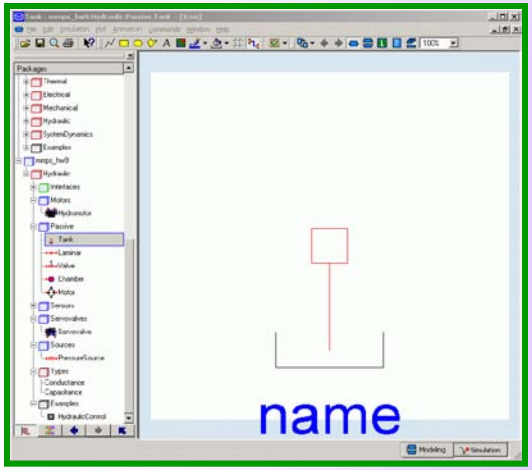


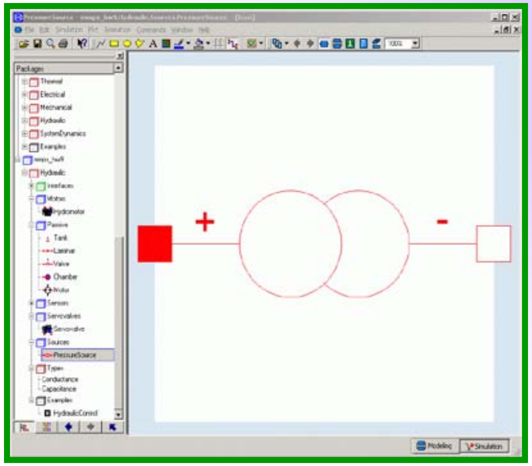






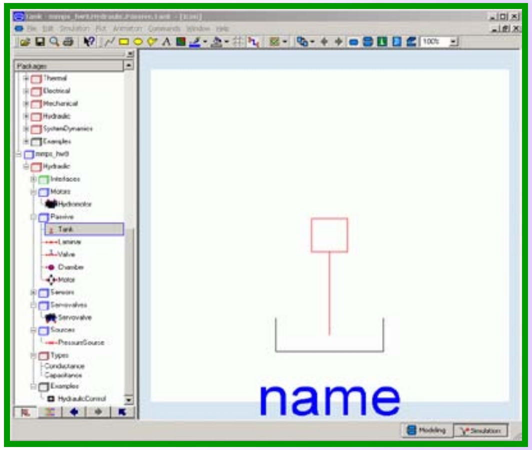
The Tank and the Pressure Source

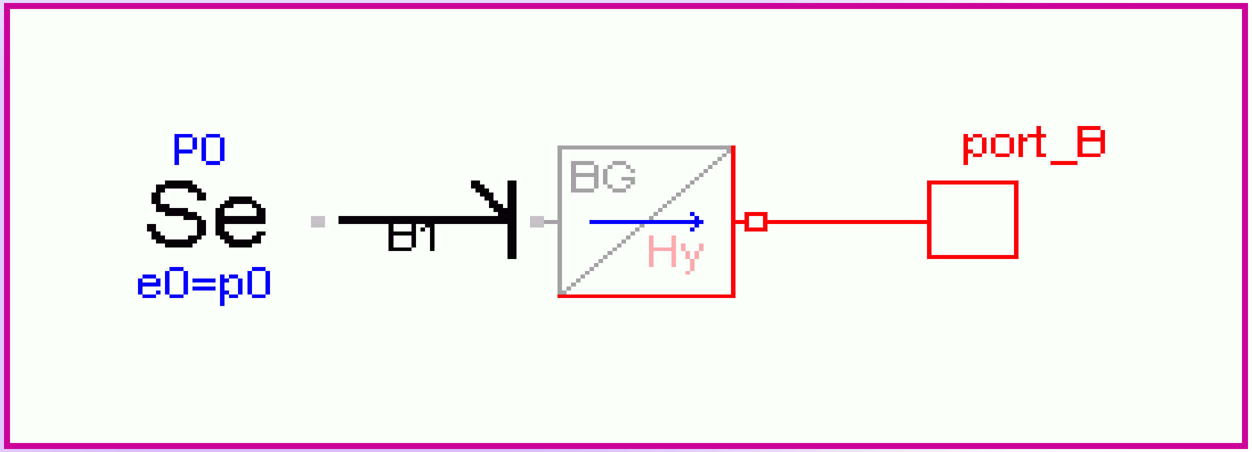


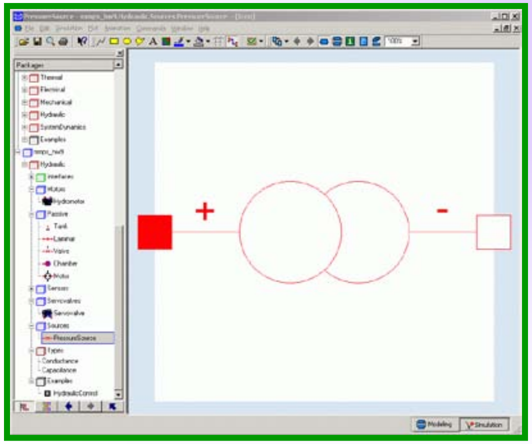


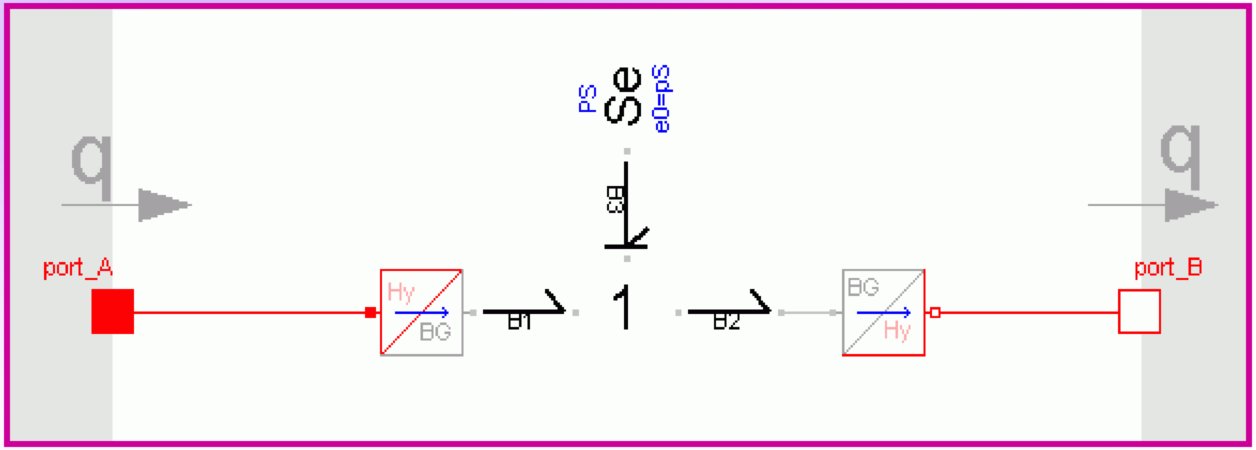
- The tank model corresponds to the ground node of the wrapped electrical library. The primary difference is that the reference pressure is not at 0 Pascal, but rather at the value of the standard atmospheric pressure, p_0.
- The constant pressure source is essentially the same model, but its semantics are such that the user defines a pressure drop between the two terminals.

The Tank and the Pressure Source II

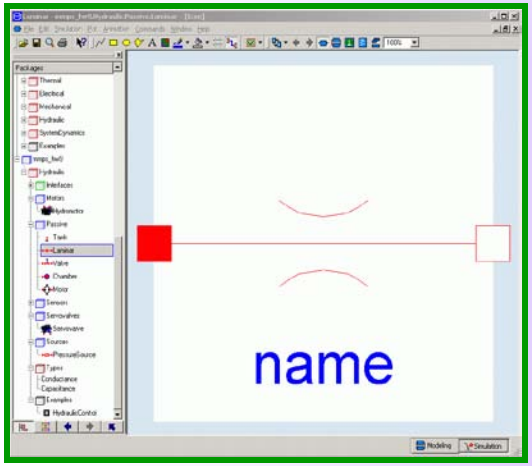




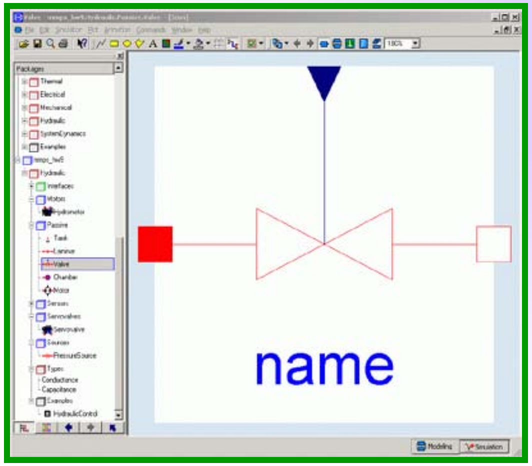




Laminar and Turbulent Resistance

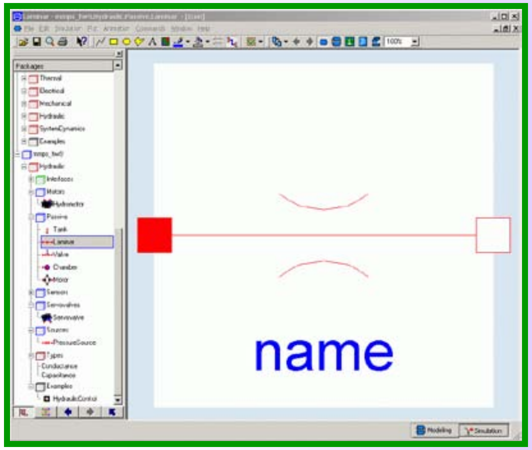


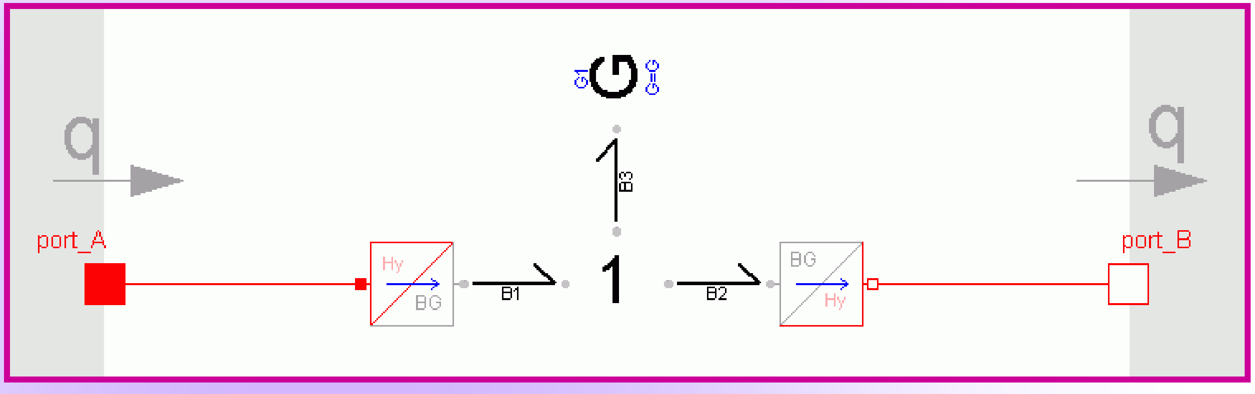
- The laminar resistance model is equivalent to the electrical conductor model. It calculates the flow as a function of the pressure drop.

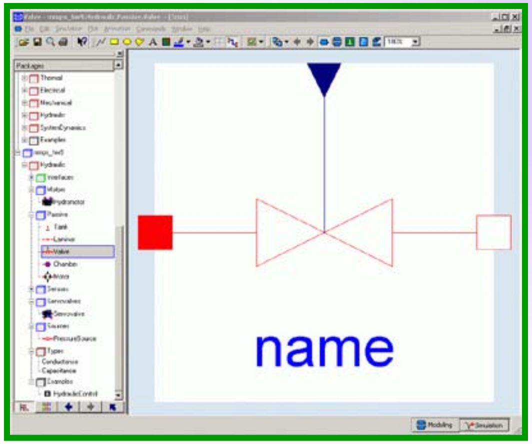


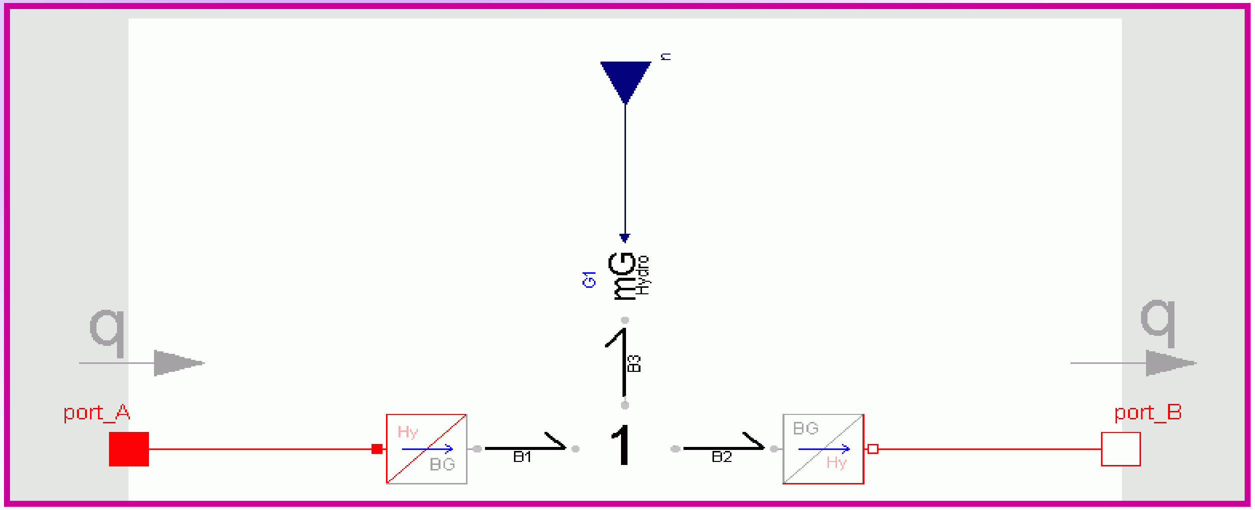
- The turbulent resistance model is a non-linear conductance model. It invokes the hydraulic conductor model of the ***BondLib*** library.

Laminar and Turbulent Resistance II

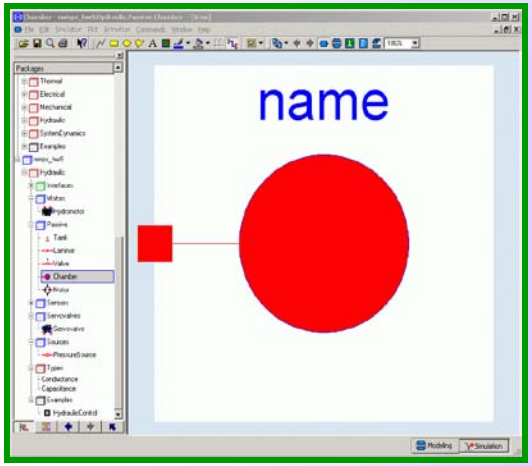




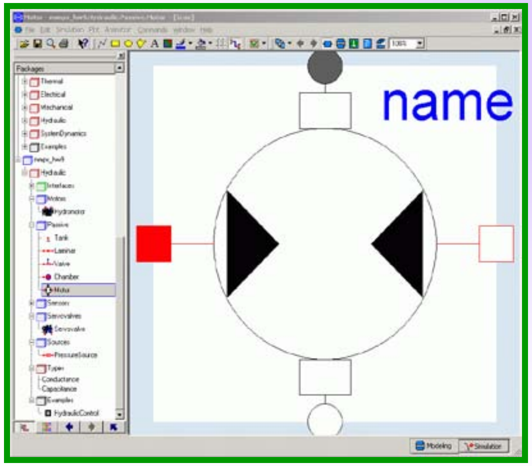




The Chamber and Motor Models

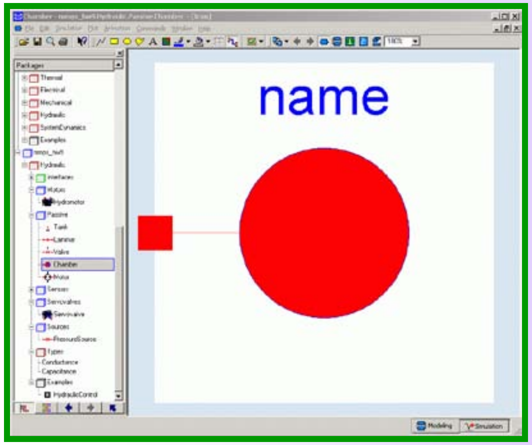


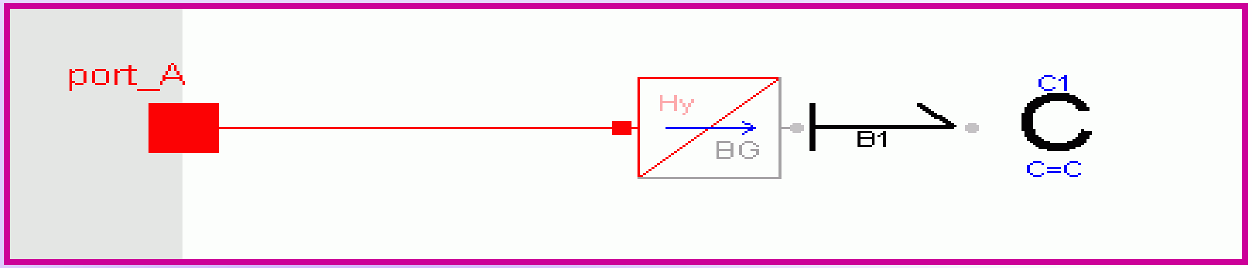
- The chamber model represents a chamber filled with a compressible fluid, usually oil. It can be represented by a capacitor.

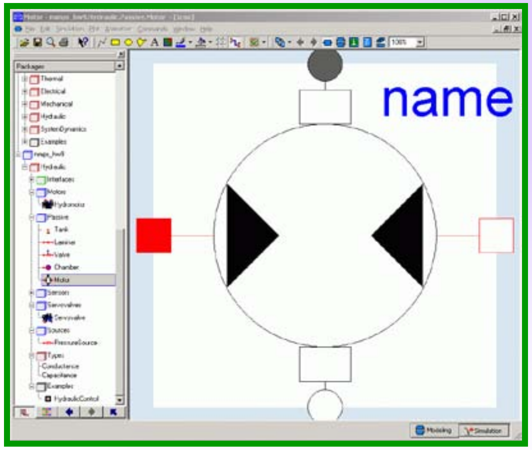


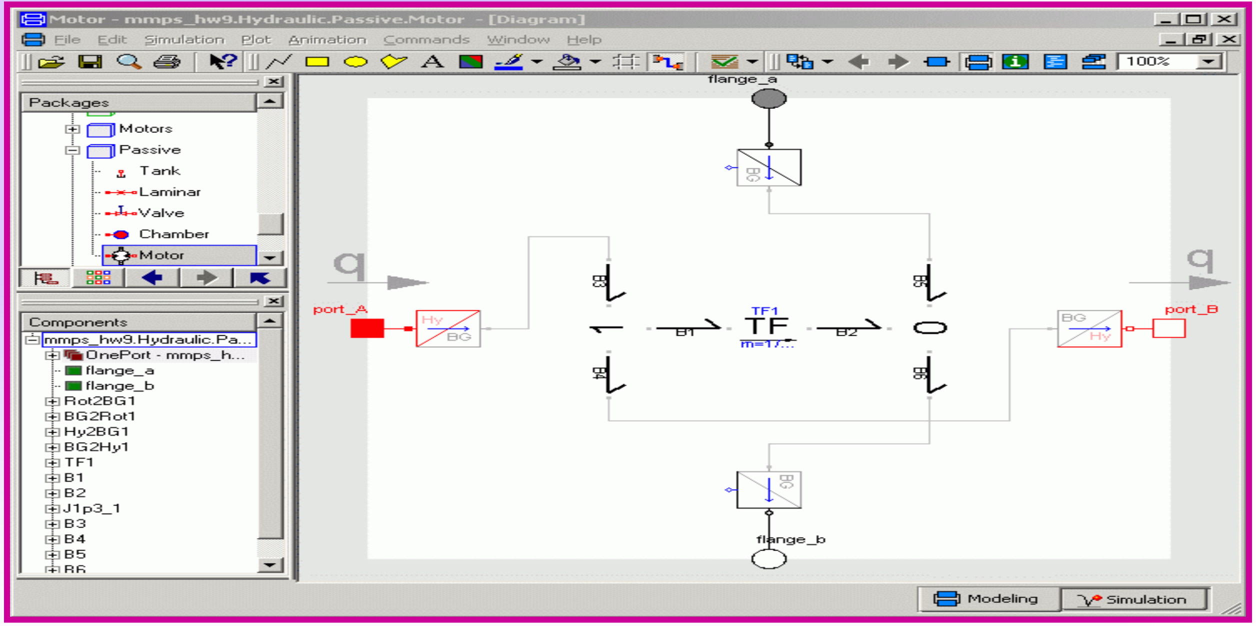
- The motor (screw) model converts hydraulic power into (induced) rotational mechanical power. It can be represented as a transformer.

The Chamber and Motor Models II





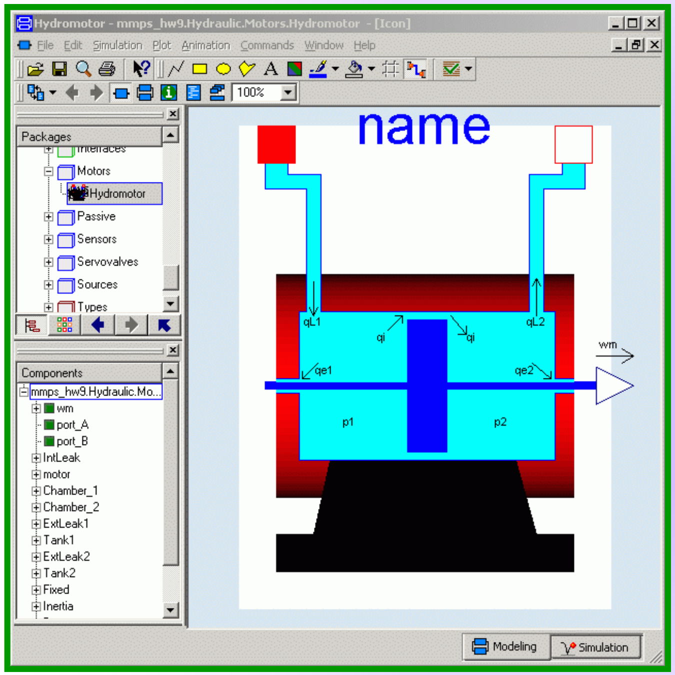


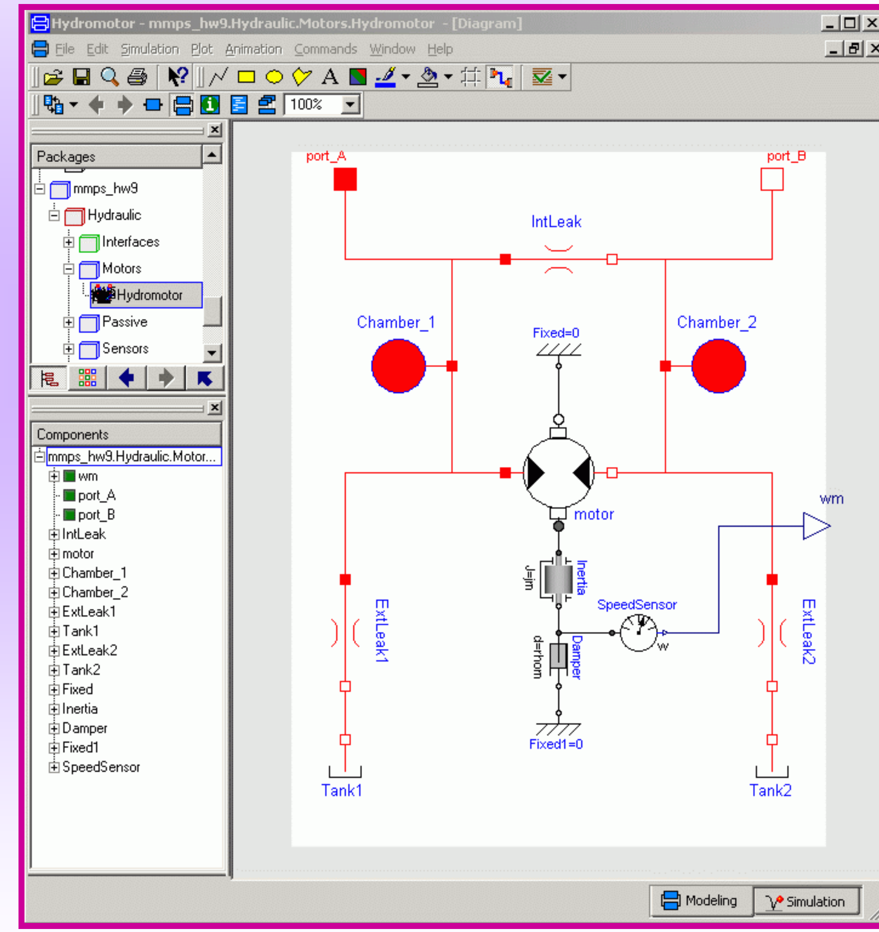


Hydraulic Motor Control

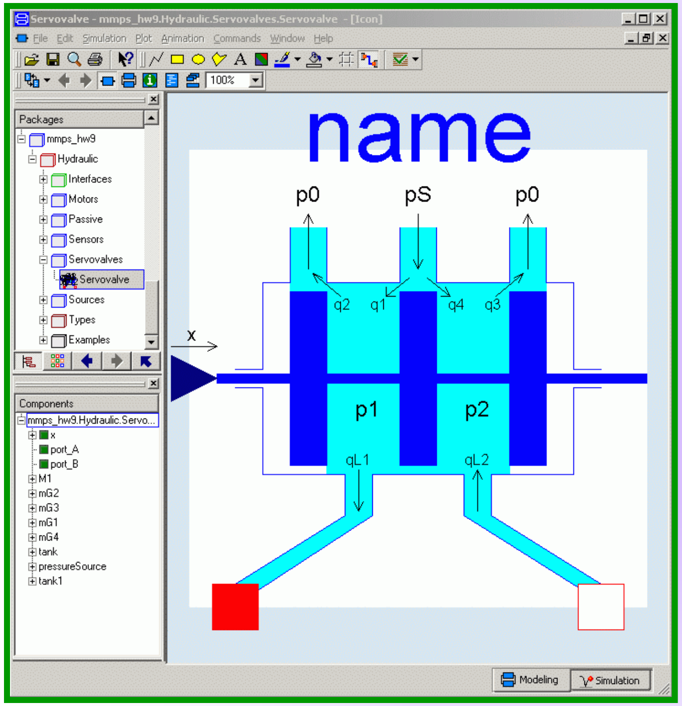
- Build a hydraulic motor model and a servovalve model as wrapped bond graph models out of the component models described above.
- Rebuild the control circuit using the example code of the BondLib library, while replacing the servovalve and hydraulic motor models by those built on wrapped bond graph technology.
- Simulate the system across 0.3 sec of time, and compare the simulation results with those obtained using encapsulated bond graph technology.

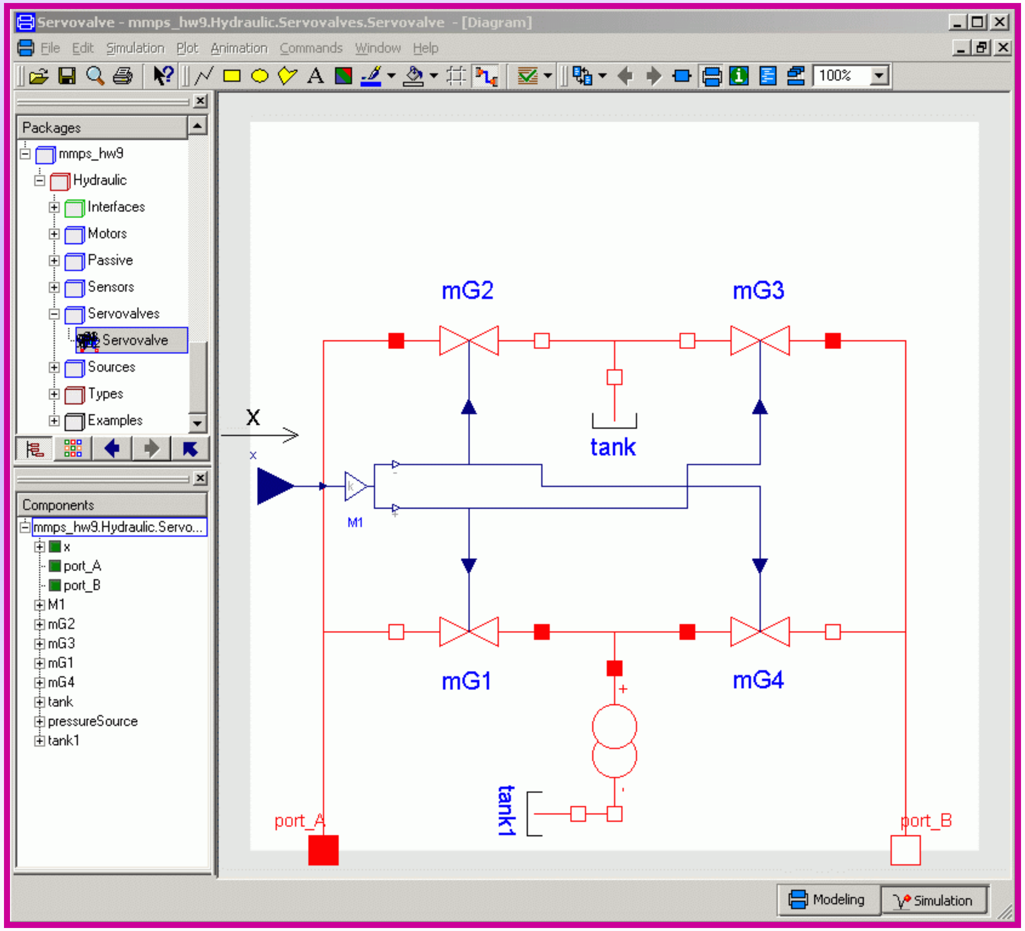
Hydraulic Motor Control II





Hydraulic Motor Control III





Hydraulic Motor Control IV