The Dymola Bond Graph Library

- In this class, we shall deal with some issues relating to the construction of the Dymola Bond Graph Library.
- The design principles are explained, and some further features of the Dymola modeling framework are shown.
- An example of a hydraulic control system completes the presentation.

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Across and Through Variables

- **Dymola** offers two types of variables, the *across variables* and the *through variables*.
- In a **Dymola node**, across variables are set equal across all connections to the node, whereas through variables add up to zero.
- Consequently, if we equate *across variables* with *efforts*, and *through variables* with *flows*, **Dymola nodes** correspond exactly to the **0-junctions** of our bond graphs.

Gyro-bonds

- In my modeling book, I exploited this similarity by implementing the *bonds* as *twisted wires* (as *null-modems*).
- By requesting furthermore that:
  - 0- and 1-junctions must always toggle. No two junctions of the same gender may be connected by a bond.
  - All elements must always be attached to 0-junctions, never to 1-junctions.
- both the **0-junctions** and the **1-junctions** can be implemented as **Dymola nodes**.
Graphical Bond Graph Modeling I

- For graphical bond-graph modeling, these additional rules may, however, be too constraining.
- For example, thermal systems often exhibit 0-junctions with many bonds attached. It must be possible to split these 0-junctions into a series of separate 0-junctions connected by bonds, so that the number of bonds attached at any one junction can be kept sufficiently small.

Graphical Bond Graph Modeling II

- For this reason, the graphical bond graph modeling of Dymola defines both efforts and flows as across variables.
- Consequently, the junctions will have to be programmed explicitly. They can no longer be implemented as Dymola nodes.
The Bond Graph Connectors I

• The directional variable, \( d \), is a third across variable made available as part of the bond-graph connector, which is depicted as a grey dot.

The A-Causal Bond “Model”

• The model of a bond can now be constructed by dragging two of the bond-graph connectors into the diagram window. They are named \( \text{BondCon1} \) and \( \text{BondCon2} \).

\[
\begin{align*}
\text{Equation: } & \text{BondCon1} \cdot e = \text{BondCon1} \cdot f; \\
& \text{BondCon1} \cdot d = -1; \\
& \text{BondCon2} \cdot d = 1.
\end{align*}
\]

Place the text “ \%name \” in the icon window to get the true name of the model displayed upon invocation.
The Bond Graph Connectors II

- *Dymola* variables are usually a-causal. However, they can be made causal by declaring them explicitly in a causal form.
- Two additional bond-graph connectors have been defined. The *e*-connector treats the *effort* as an *input*, and the *flow* as an *output*.
- The *f*-connector treats the *flow* as *input* and the *effort* as *output*.

The Causal Bond “Blocks”

- Using these connectors, causal bond blocks can be defined.
- The *f*-connector is used at the side of the causality stroke.
- The *e*-connector is used at the other side.
- The causal connectors are only used in the context of the bond blocks. Everywhere else, the normal bond-graph connectors are to be used.
The Junctions I

- The junctions can now be programmed. Let us look at a 0-junction with three bond attachments.

\[
e[2] = e[1]; \\
e[3] = e[2]; \\
\]

The Junctions II

The ThreePortZero model drags the three bond connectors into the diagram window, and packs the individual bond variables into two vectors.
The Element Models

• Let us now look at the bond-graphic element models. The bond graph capacitor may serve as an example.

Making Bond Graph Circuits I
Making Bond Graph Circuits II

Library window

Diagram window

Making Bond Graph Circuits III

Flip Horizontal
Making Bond Graph Circuits V

Making Bond Graph Circuits VI
Example: Hydraulic Motor I

Icon window

Diagram window

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Hydraulic Motor II

Parameter values can be propagated from one level to another.

Diagram window

Equation window

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Servo Valve I

Icon window

Diagram window

Connectors connected to bonds.

Servo Valve II

name

mG

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Servo Valve III

Icon window

Diagram window

Connector Conventions

Bonds can be connected to either junctions or circuit elements, but never to other bonds.

Junctons can only be connected to bonds.

Hence one of the models to be connected must end in a junction, the other in a bond, if the connectors are to be connected directly to each other, i.e., without placing bonds in between.
Control System

References


• Cellier, F.E. (2001), The Dymola Bond-Graph Library.