MCE503: Modeling and Simulation of Mechatronic Systems

Lecture 5: Basic Component Models - Part III

Reading: KMR Chapter 3

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Causality and Block Diagrams

- Bond graphs: multiports are connected using power links.
- Block diagrams: multiports are connected using signal links.
- A block diagram will have twice as many links as a bond graph.
- A sign convention is required for all signals to allow physical interpretation.
- Conversion of one into another is straightforward. Refer to KMR, Fig. 3-14.

Example: KMR Prob. 3-15

Thermal Systems and Pseudo-Bond Graphs

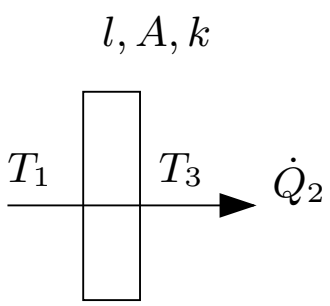
- Heat conduction problems are usually treated by analogy with resistive electrical circuits.
- Temperature is used as voltage, heat flow used as current and a blend of thermal conductivity and geometric parameters used as resistance:

$$R\dot{Q} = \Delta T$$

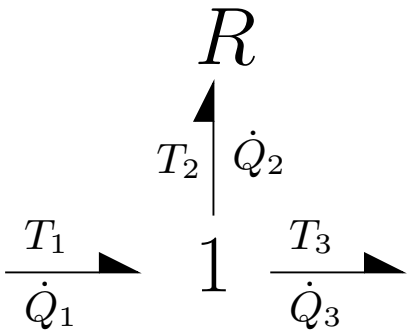
- For a uniform slab of area A, thickness l and thermal conductivity k we have $R = \frac{l}{kA}$.
- However, the product of effort and flow (T and $\dot{Q}$) does not have the dimensions of power.
- For isolated and simple cases of thermal energy transmission, bond graphs can be used. The problem is interfacing with other energy domains.

The thermal resistor

We use a 1-junction to create the temperature difference:

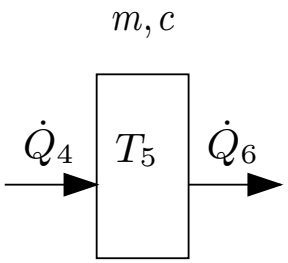


$$T_2 = T_1 - T_3$$
$$\dot{Q}_2 = \frac{T_3}{R}$$
$$R = \frac{l}{kA}$$
$$\dot{Q}_1 = \dot{Q}_2 = \dot{Q}_3$$

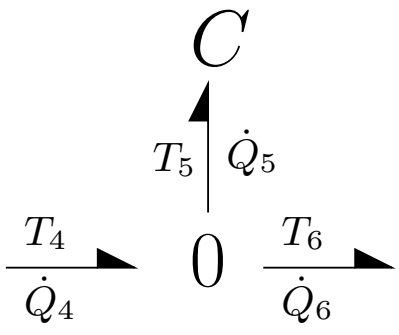


The thermal capacitor

We use a 0-junction to model net heat effects (the fact that a substance can simultaneously take in and give off heat):



$$\dot{Q}_5 = \dot{Q}_4 - \dot{Q}_6$$
$$T_5 = \frac{1}{C}\int \dot{Q}_5 dt$$
$$C = mc$$
$$T_4 = T_5 = T_6$$



Example: KMR Fig. 3-18, Prob. 3-16