# *Heat conduction with feedback control*

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*January 18, 2019*

The purpose of this assignment is to learn how to build a model of a physical effect and connect it to a controller. You can use the graphical editor of Dymola or OpenModelica. You will also refine the spatial discretization for the heat conduction, using a parameter that determines how fine the grid is.

## *System Description*

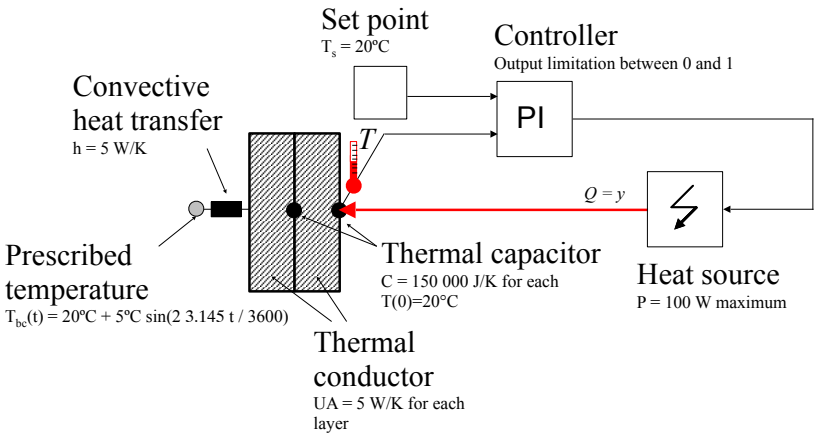


Figure 1: Schematics of the heat conduction problem.

Consider the system shown in Figure 1 that consists of a heat conductor in which one temperature is controlled by injecting heat. This model corresponds to a 1m$^2$ area of a brick wall that is 0.2 m thick and has the same boundary condition on both sides. Heat is injected in the middle of the construction. Because of symmetry, only half of the construction needs to be modeled.

## *Open Loop Response*

The first assignment is to create a model of the open loop system and simulate the open loop response in a Modelica environment.[1]

Create a plot that shows the temperature trajectories.

[1] Hint: This model can be assembled graphically in OpenModelica or Dymola using models from the Modelica Standard Library.

## *Add Feedback Control*

The control objective is the keep the temperature in the core of the heat conductor above 20°C. Use a PI controller with output limitation between 0 and 1 and anti-windup from the Modelica Standard

Library. You will need to simulate the model for more than one day. Explain why one day is not sufficient even though the disturbance has a periodicity of one day.

Create a plot that shows the temperature trajectories.

### *Refine the discretization of the wall heat conduction*

In the above models, the heat conduction in the wall was implemented with two conductors and heat storage elements in series. We arbitrarily selected two elements of each, but have not checked whether this was a good discretization of the heat conduction problem. In this step, you will modify the model to allow adjusting the level of discretization.

Combine the heat conductor and heat storage element into one model, expose its heat ports, and then instantiate an array of this combined model. Use a parameter that is an `Integer` parameter which controls how fine the spatial discretization for the heat conduction is.[2]

Change the model to use such an implementation and select ten conductor-storage element in series.

Plot the temperatures measured by the sensor for 1, 2 and 10 state variables.

[2] Hint: See `http://book.xogeny.com/components/subsystems/comp_arrays/` or `http://simulationresearch.lbl.gov/modelica/releases/latest/help/Buildings_HeatTransfer_Conduction.html#Buildings.HeatTransfer.Conduction.MultiLayer` for how to use arrays of components. You will have to enter the `connect` statements for the ports using a `for` loop in the textual editor.