Modelica-based simulation of building and district energy systems

Session 6: Hands-on training / Modeling a simple house

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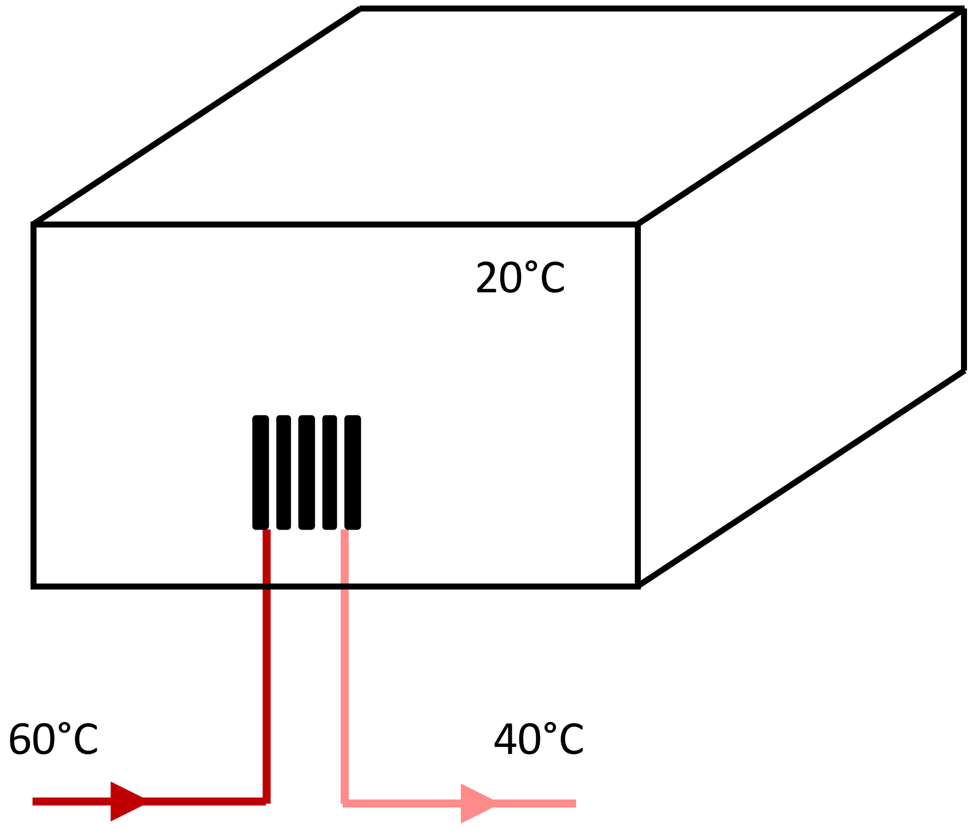
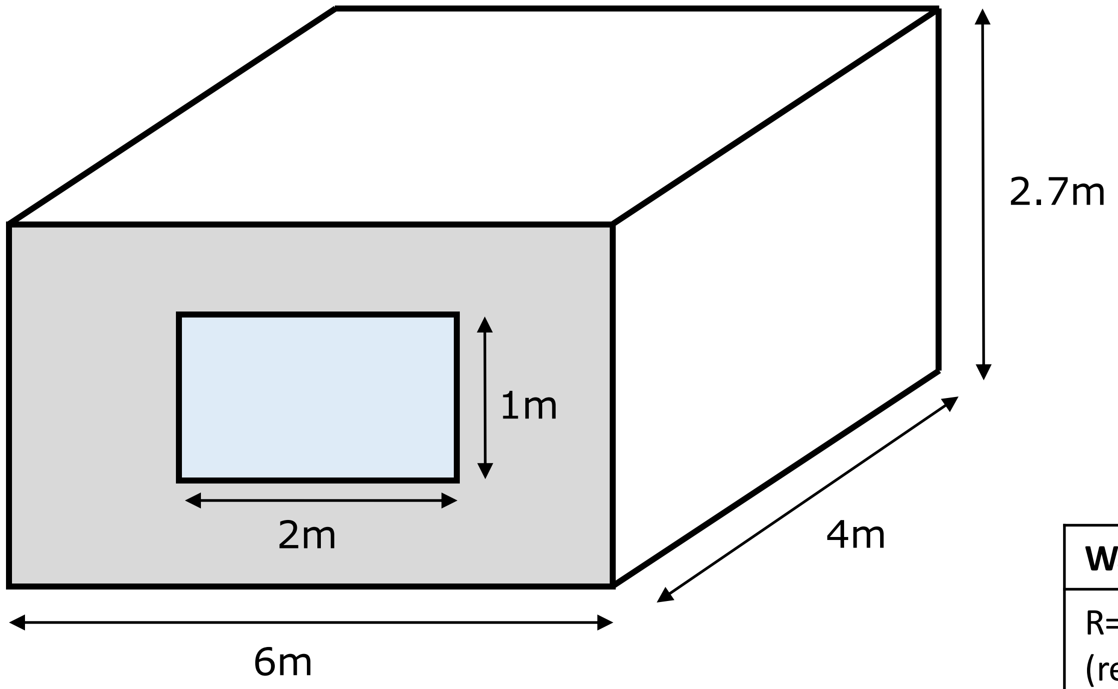
Session 6: Simple house with ideal radiator



The goal is to keep the air temperature in the house at 20°C by using a heating system

SESSION 6 – Simple house: building envelope

1. Create a model of a wall
2. Create a model of a window
3. Create a single-zone house model (combining wall and window)
4. Create models for weather conditions (outdoor air temperature and solar radiation)



Assumptions

- Consider only the grey wall for heat transfer between indoor and outdoor and thermal mass (neglect all the other five surfaces)
- Discretize the wall using one control volume
- The window has no thermal mass
- Assume an indoor convection coefficient of $3 W/m^2K$ (neglect the outdoor convection coefficient)
- Assume initial temperature of 5°C for all heat capacitors

Wall	Window	Air
R=0.118 K/W (remember to split into 2)	$U=1.5\ W/m^2K$	$\rho=1.2\ kg/m^3$
C=1718200 J/K	g=0.5	c=1000 J/KgK

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STEP 1 - Model of a wall

1. Create a package **SimpleHouse**
2. Create a package **Components** in SimpleHouse
3. Create a model **Wall** in Components
4. Drag and drop the following models from the MSL
    - `Modelica.Thermal.HeatTransfer.Components.ThermalResistor (2)`
    - `Modelica.Thermal.HeatTransfer.Components.HeatCapacitor (1)`
    - `Modelica.Thermal.HeatTransfer.Interfaces.HeatPort_a (1)`
    - `Modelica.Thermal.HeatTransfer.Interfaces.HeatPort_b (1)`

5. Connect the components according to figure 6.1.
6. Assign the value of C=1718200 J/K to the capacitance
7. Calculate the values for **R** and assign them to the models
8. Set T.start in the heat capacitor equal to 5°C
9. Go to the icon view and draw a simple icon of a wall (Fig. 6.2 is just an example. You can be creative!

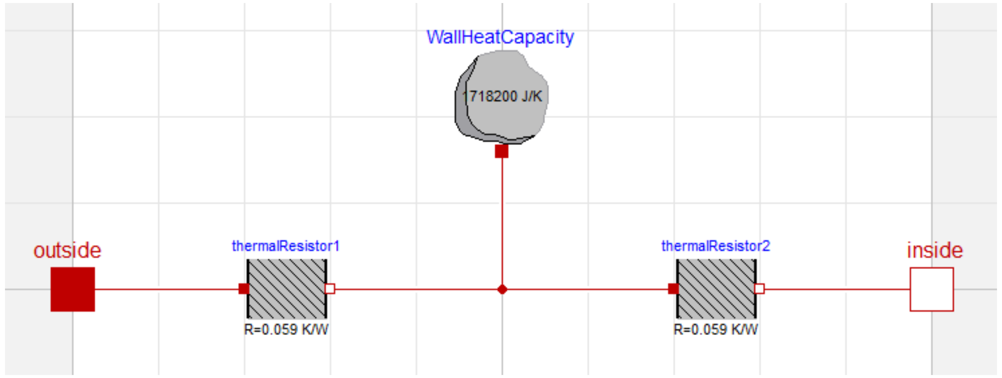

Figure 6.1: Connections in **Wall**

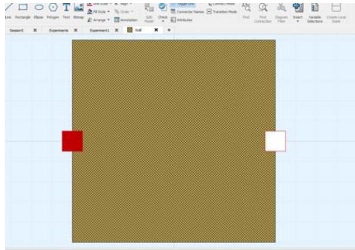

Figure 6.2: Icon of **Wall**

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STEP 2 - Model of a single-zone house with wall

1. Create a package **Building** in SimpleHouse
2. Create a model **HouseWall** in Building
3. Drag and drop the following models from the MSL

    - `SimpleHouse.Components.Wall (1)`
    - `Modelica.Thermal.HeatTransfer.Components.HeatCapacitor (1)`
    - `Modelica.Thermal.HeatTransfer.Interfaces.HeatPort_a (1)`
    - `Modelica.Thermal.HeatTransfer.Components.Convection (1)`
    - `Modelica.Blocks.Sources.RealExpression (1)`

5. Connect the components according to figure 6.3 and give values to convection coefficient and heat capacitor (how do you calculate the capacitance of the air volume?)
6. Set T.start in the heat capacitor equal to 5°C
7. Go to the icon view and draw a simple icon of a house

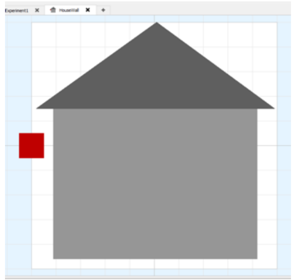

Figure 6.4: Icon of **HouseWall**

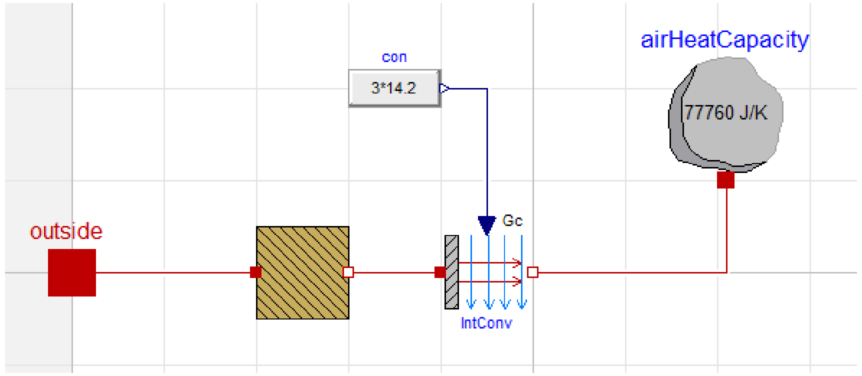

Figure 6.3: Connections in **HouseWall**

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STEP 3 - Simulate **HouseWall** model

1. Create a package **Experiments** in SimpleHouse
2. Create a model **Experiment1** in Experiments
3. Drag and drop the following models

    - `SimpleHouse.Building.HouseWall (1)`
    - `Modelica.Thermal.HeatTransfer.Sources.PrescribedTemperature (1)`
    - `Modelica.Blocks.Sources.Sine (1)`

5. Connect the components according to figure 6.5 and give values to parameters in outAirT according to the table below:

Parameter	**Value**
Amplitude	5
freqHz	1/86400
Phase	-90
Offset	273.15

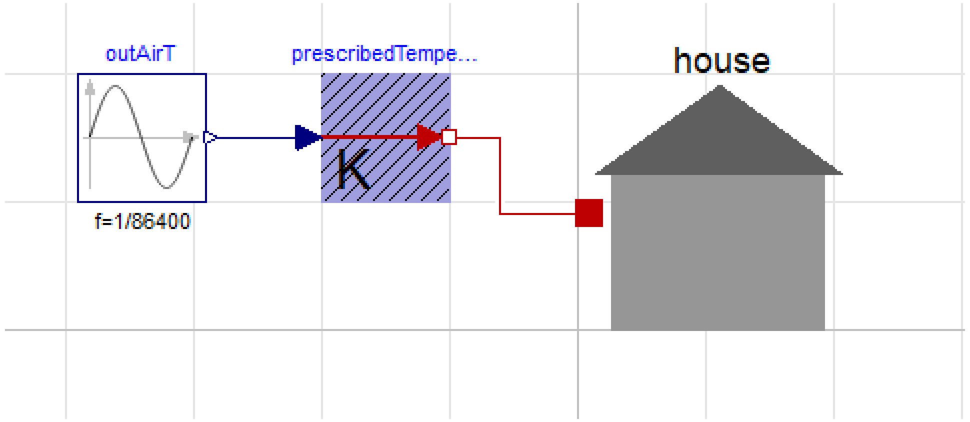

Figure 6.5: Connections in **Experiment1**

6. Simulate the model for 2 days and explore results (plot for example the air temperature in the house and the outdoor air temperature)
7. Try to reduce the heat capacity of the wall by 10 times. What happens? *(To do this, declare a* `parameter` *called "scale" in the* ***Wall*** *model and use it wisely…)*

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Results

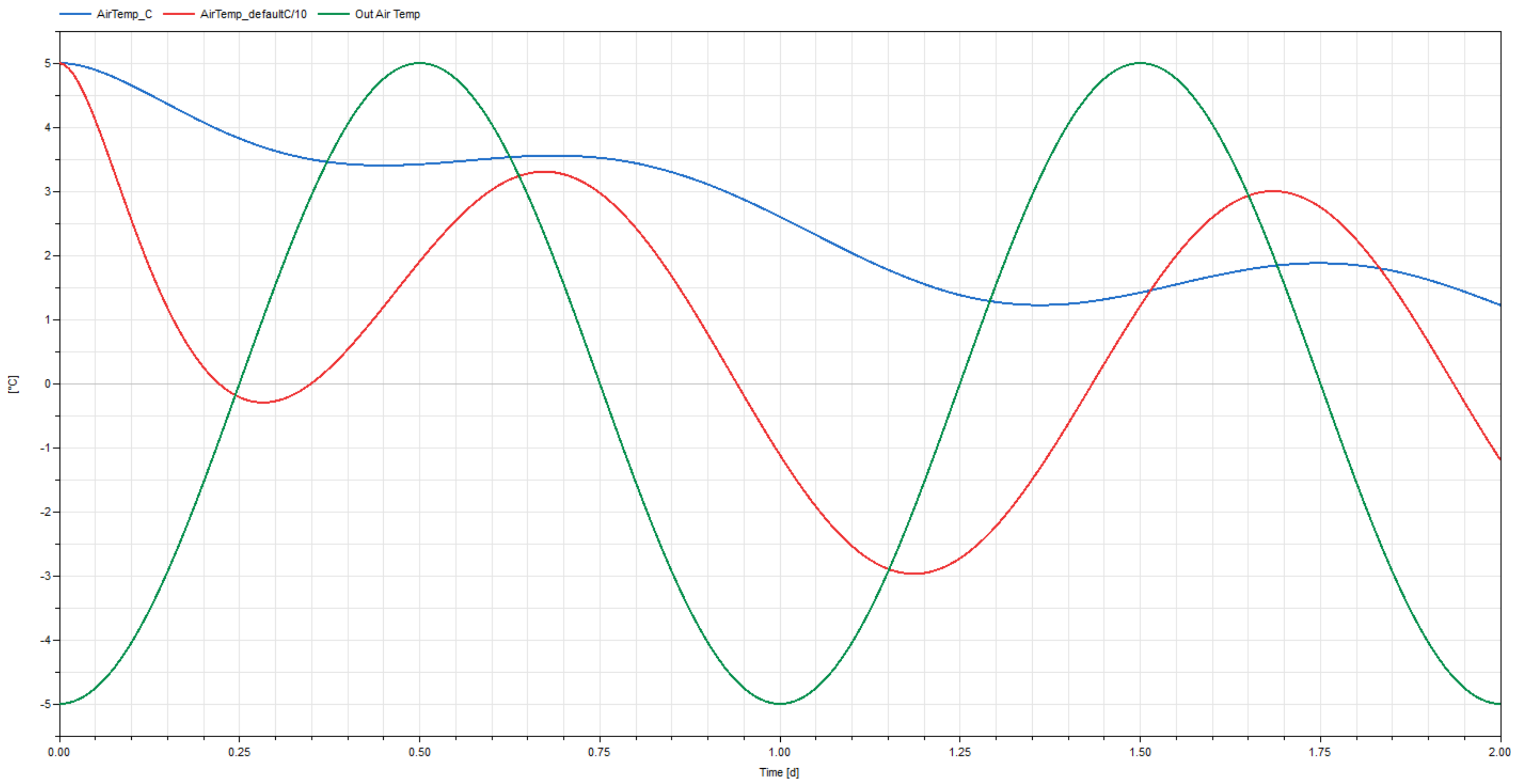

Figure 6.6: Temperature profiles

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Note that the solar gains are calculated by:
$Q_{sol} = I * A_{win} * g$

Where I is the incident radiation, A_{win} is the window area and g is the g-factor

STEP 4 - Model of a window

1. Create a models **Window** in Components
2. Drag and drop the following models from the MSL:

    - `Modelica.Thermal.HeatTransfer.Components.ThermalConductor (1)`
    - `Modelica.Thermal.HeatTransfer.Interfaces.HeatPort_a (1)`
    - `Modelica.Thermal.HeatTransfer.Interfaces.HeatPort_b (2)`
    - `Modelica.Blocks.Interfaces.RealInput (1)`
    - `Modelica.Blocks.Math.Gain (2)`
    - `Modelica.Thermal.HeatTransfer.Sources.PrescribedHeatFlow (1)`

5. Connect the components according to figure 6.7 and give them reasonable names.
6. Assign the values of area and g-value to the gain models
7. Go to the icon view and draw a simple icon of a window

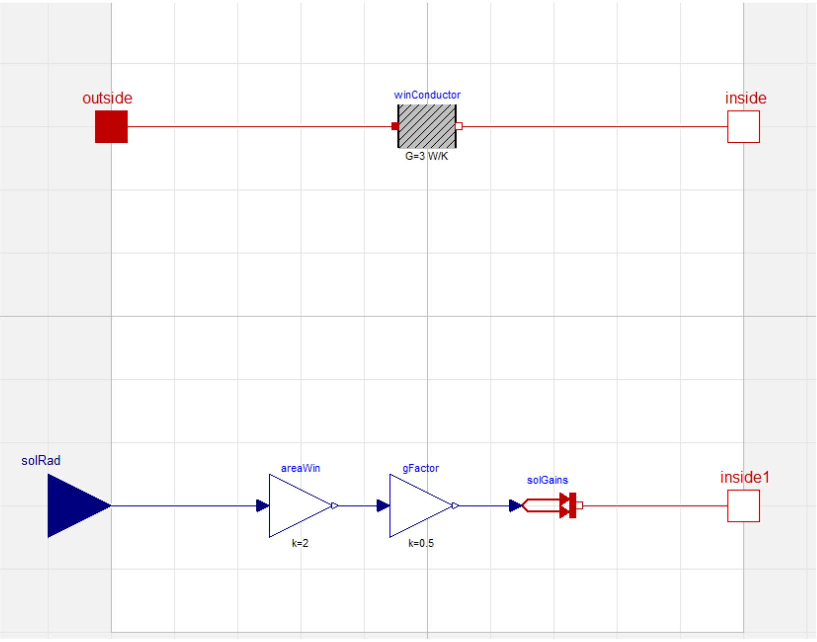

Figure 6.7: Connections in **Window**

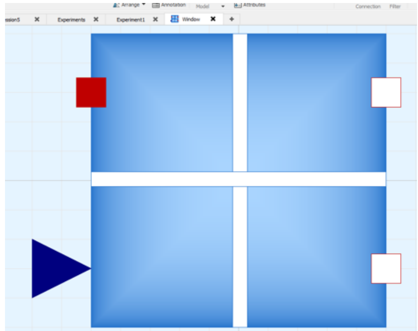

Figure 6.8: Icon of **Window**

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STEP 5 - Model of a single-zone house with wall and window

1. Duplicate **HouseWall** and create a new model **HouseWallWin** in Building
2. Drag and drop the following models:

    - `SimpleHouse.Components.Window (1)`
    - `Modelica.Thermal.HeatTransfer.Components.Convection (1)`
    - `Modelica.Blocks.Sources.RealExpression (1)`
    - `Modelica.Blocks.Interfaces.RealInput (1)`

5. Connect the components according to figure 6.9 and give the value to convection coefficient for window
6. Go to the icon view and draw a simple icon of a house with a window

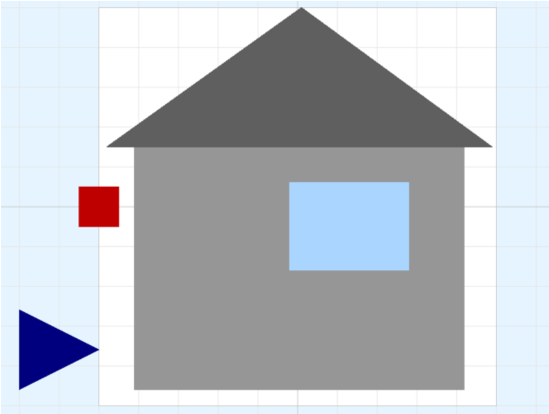

Figure 6.8: Icon of **HouseWallWin**

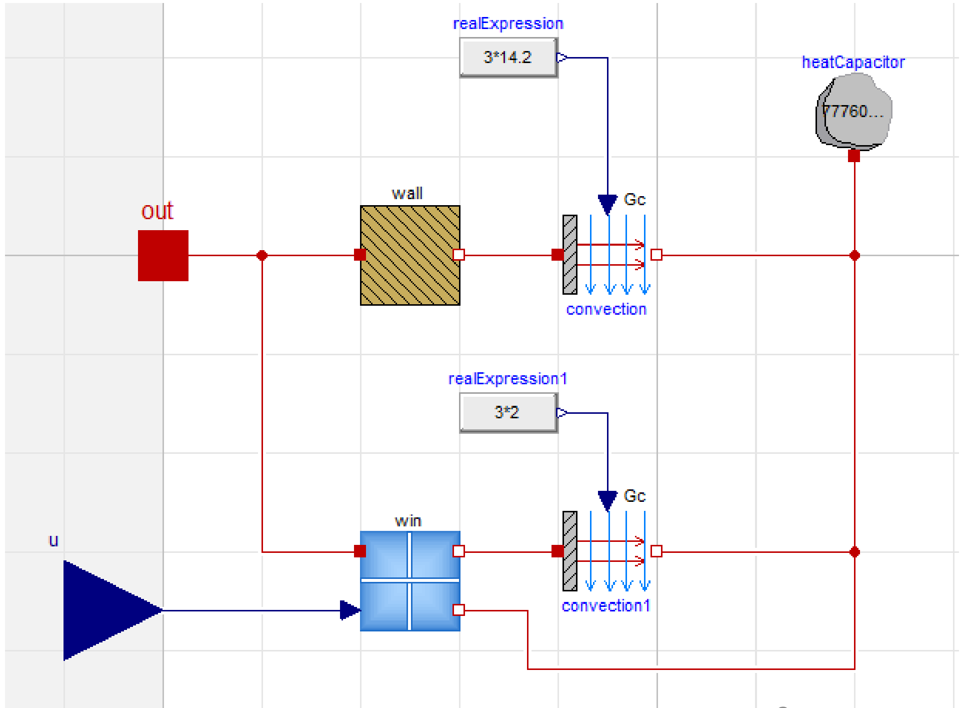

Figure 6.9: Connections in **HouseWallWin**

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STEP 6 - Simulate **HouseWallWin** model

1. Duplicate **Experiment1** and create a new model **Experiment2** in Experiments
2. Drag and drop the following models
    - `Modelica.Blocks.Sources.Sine (1)`
    - `Modelica.Blocks.Sources.Constant (1)`
    - `Modelica.Blocks.Math.Max (1)`

5. Change class of HouseWall into HouseWallWin
6. Connect the components according to figure 6.10 and the give to parameters in *sine* component the values according to the table below:

Parameter	**Value**
Amplitude	100
freqHz	1/86400
Phase	-90
Offset	0

6. Simulate the model for 2 days and explore results (plot for example the air temperature in the house, the outdoor air temperature and solar gains)
7. Compare the air temperature in the house with and without window (Experiment1 vs Experiment2)

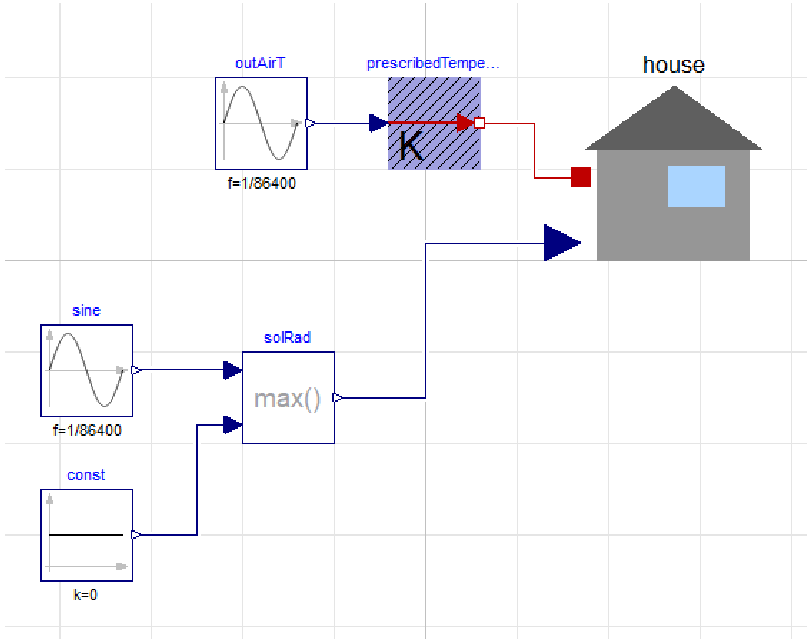

Figure 6.10: Connections in **HouseWallWin**

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Results

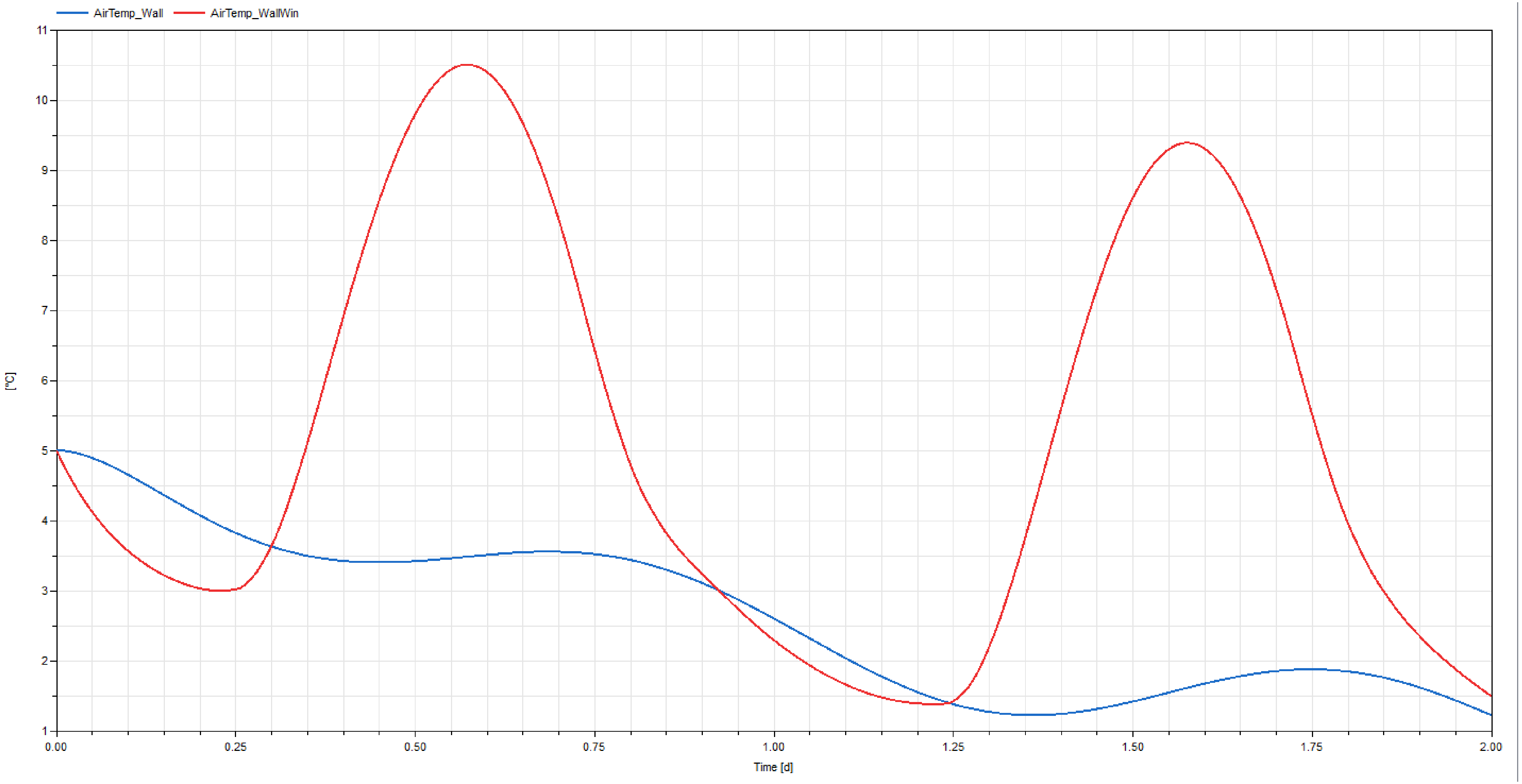

Figure 6.11: Temperature profiles (Experiment1 vs Experiment2)