Thermal model of an intelligent house

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Abstract **This example shows how to use Matlab & Simulink to create the thermal model of an intelligent house. This system models the outdoor environment, the thermal characteristics of the house, and the house heating system.**

Keywords **Intelligent House, Thermal Model, The House Subsystem, Air Temperature.**

I.   INTRODUCTION

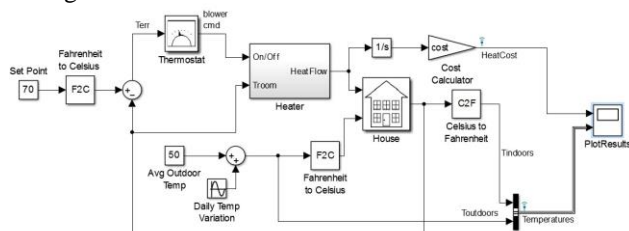Thermal model of an intelligent house is presented on Fig. 1.

Fig. 1. Thermal model of an intelligent house [1]

This model calculates heating costs for a generic house. When the model is opened, it loads the information about the house from the file. The file does the following:

- Defines the house geometry (size, number of windows)
- Specifies the thermal properties of house materials
- Calculates the thermal resistance of the house
- Provides the heater characteristics (temperature of the hot air, flow-rate)
- Defines the cost of electricity (0.09$/kWh)
- Specifies the initial room temperature (20 deg. Celsius = 68 deg. Fahrenheit)

II.   MODEL COMPONENTS

A. Thermostat

"Thermostat" is a subsystem that contains a Relay block. The thermostat allows fluctuations of 5 degrees Fahrenheit above or below the desired room temperature. If air temperature drops below 65 degrees Fahrenheit, the thermostat turns on the heater.

B. Heater

"Heater" is a subsystem that has a constant air flow rate, "M_{dot}", which is specified in the file. The thermostat signal turns the heater on or off. When the heater is on, it blows hot air at temperature T_{heater} (50 degrees Celsius = 122 degrees Fahrenheit by default) at a constant flow rate of "M_{dot}" (1kg/sec = 3600kg/hr by default). The heat flow into the room is expressed by the Equation (1).

$$\frac{dQ}{dt} = \left(T_{heater} - T_{room}\right) \cdot M_{dot} \cdot c \qquad (1)$$

where: dQ/dt – heat flow from the heater into the room, c – heat capacity of air at constant pressure, M_{dot} – air mass flow rate through heater (kg/hr), T_{heater} – temperature of hot air from heater, T_{room} – current room air temperature.

C. House

"House" is a subsystem that calculates room temperature variations. It takes into consideration the heat flow from the heater and heat losses to the environment. Heat losses and the temperature time derivative are expressed by Equation (2) and (3).

$$\left(\frac{dQ}{dt}\right)_{losses} = \frac{T_{room} - T_{out}}{R_{eq}} \qquad (2)$$

$$\frac{dT_{room}}{dt} = \frac{1}{M_{air} \cdot c} \cdot \left(\frac{dQ_{heater}}{dt} - \frac{dQ_{losses}}{dt}\right) \qquad (3)$$

where: M_{air} – mass of air inside the house, R_{eq} – equivalent thermal resistance of the house.

III.   SIMULATION AND VISUALIZING THE RESULTS

The simulation and visualizing the results are presented on Fig. 2. The heat cost and indoor versus outdoor temperatures are plotted on the scope. The temperature outdoor varies sinusoidally, whereas the indoors temperature is maintained within 5 degrees Fahrenheit of "Set Point". Time axis is labeled in hours.
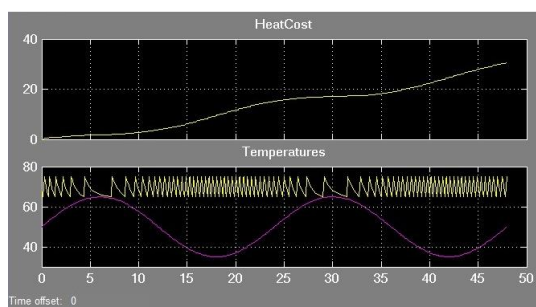

Fig. 2. Simulation results (time axis labeled in hours) [1]

IV.   CONCLUSION

This particular thermal model is designed to calculate the heating costs only. According to this model, it would cost around $30 to heat the house for two days.

V.   ACKNOWLEDGEMENTS

VI.   REFERENCES

[1] Matlab & Simulink R2013a version of The MathWorks, Inc.