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Lecture 05f
Bang/Bang Control with a Hysteresis Deadband

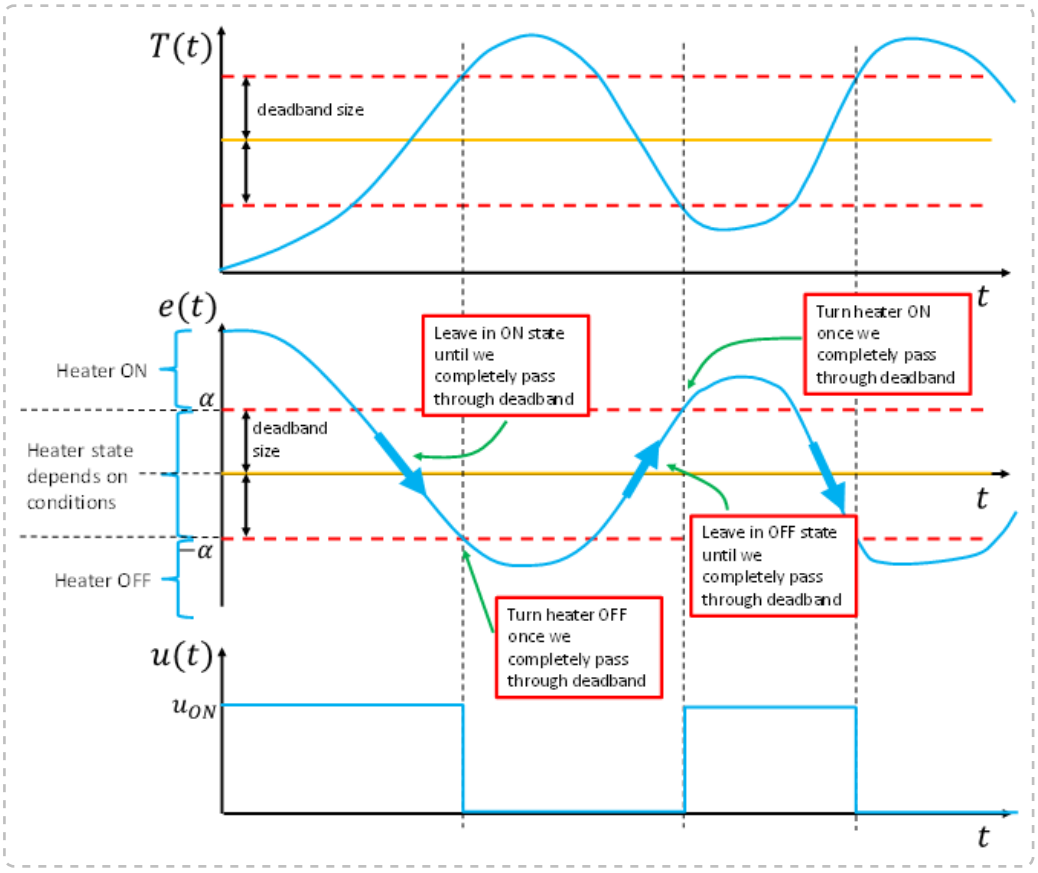
The YouTube video entitled 'Bang/Bang Control with a Hysteresis Deadband' that covers this lecture is located at https://youtu.be/q0Z3-iDV0Po.

Outline

-Bang/Bang Control with a Hysteresis Deadband
-Results
    -Simulation
    -Real Hardware
-Summary

Bang/Bang Control with a Hysteresis Deadband

Another method to ameliorate the chatter issue is to implement a hysteresis band in the controller. This functions as a type of deadband where the controller will not allow rapid transitions between ON/OFF states.

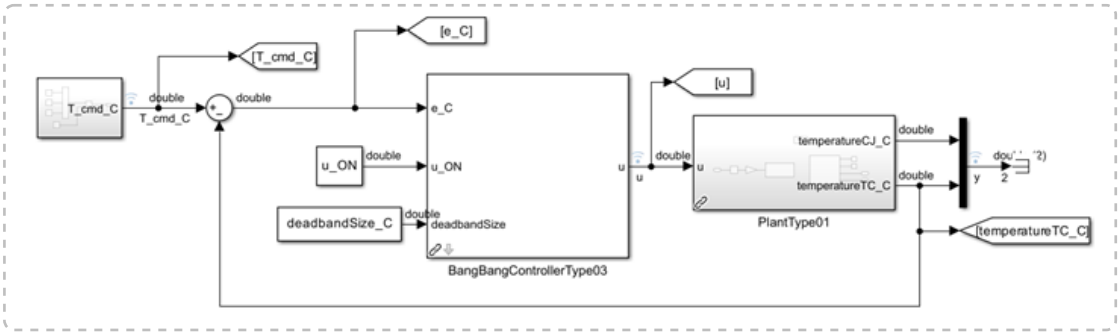


Once the controller switches its output, it commits to this value until the error passes completely through the deadband after which point it is able to change state.

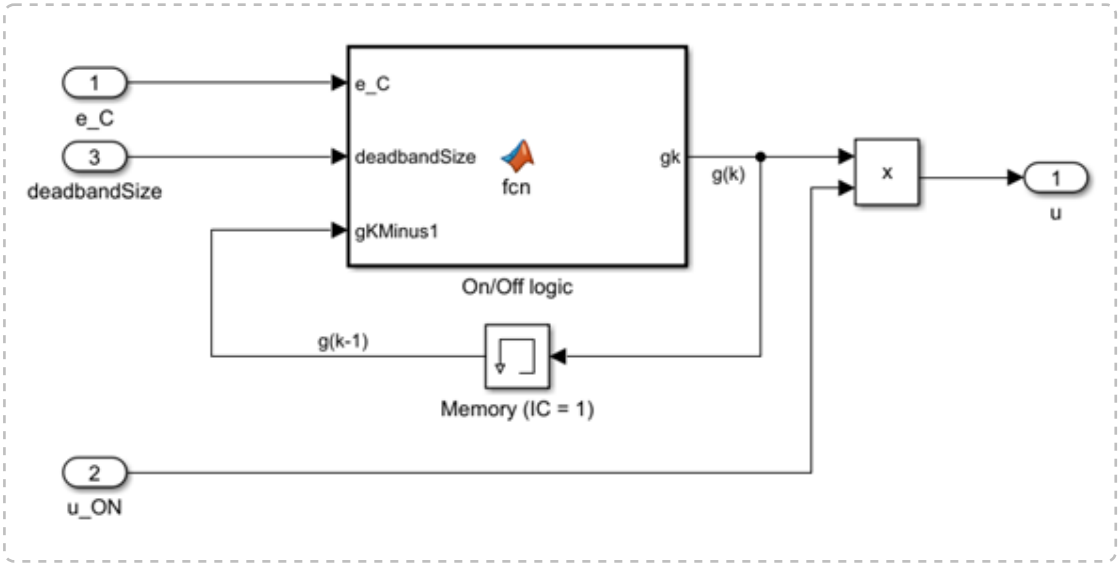
So we see that this type of controller requires an additional parameter, α

α =deadband size (positive value)

The Simulink simulation model can be updated to reflect this additional required input to the controller.



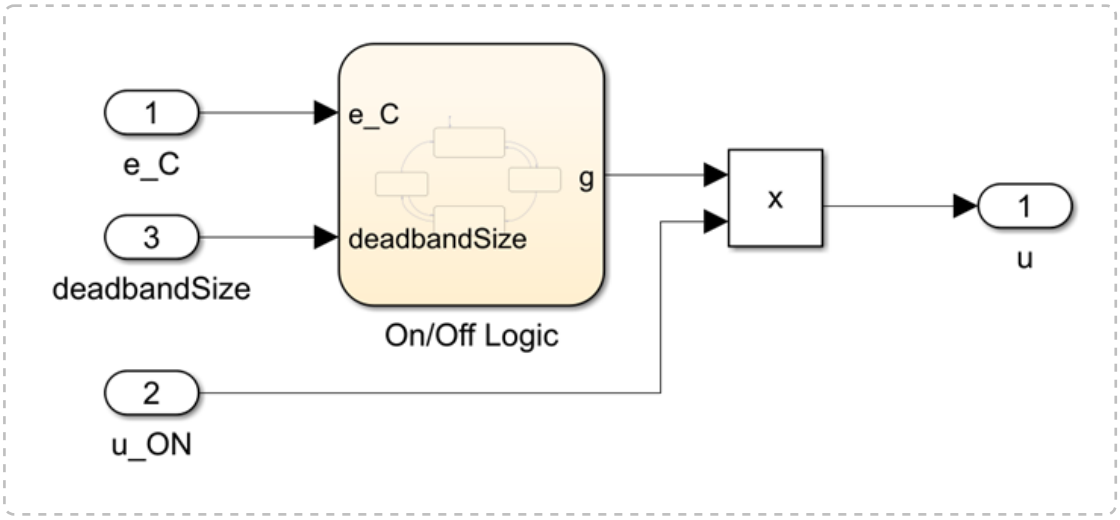
The controller can be implemented using the above logic using an 'MATLAB Function' block. The controller subsystem is shown below



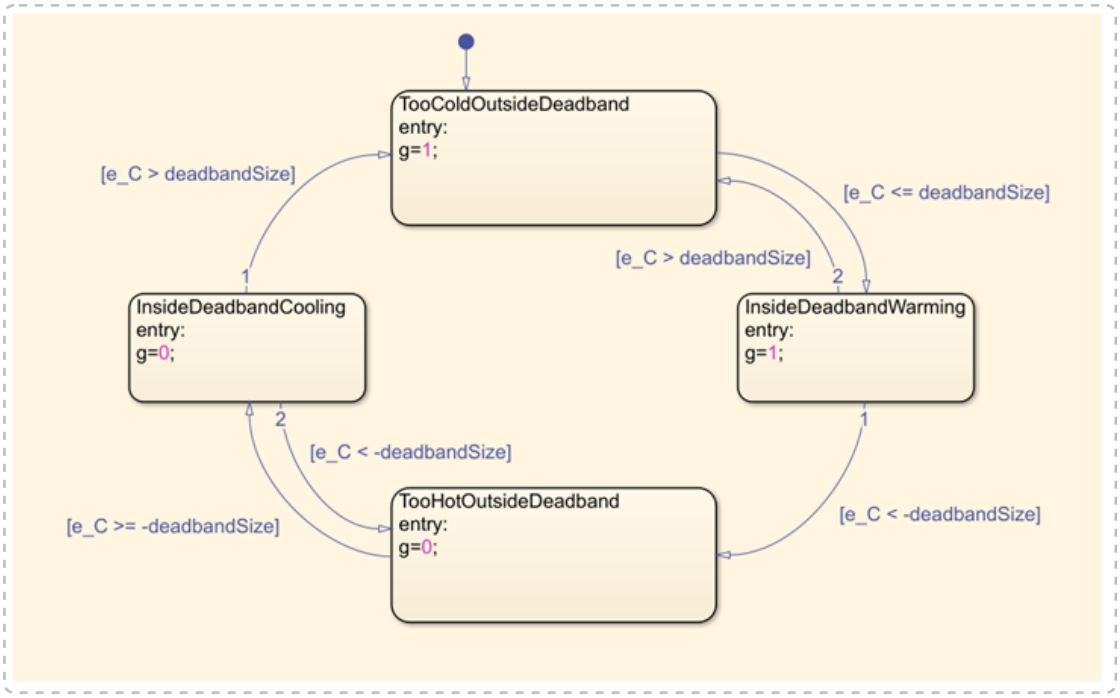
The 'MATLAB Function' can be implemented as follows

```
function gk = fcn(e_C, deadbandSize, gKMinus1)

if(e_C > deadbandSize)
    %Turn control on
    gk = 1;

elseif(e_C < -deadbandSize)
    %Turn control off
    gk = 0;

else
    %in hysteresis band (e in range [-deadbandSize,deadbandSize])
    if(gKMinus1==0)
        %keep control off
        gk = 0;

    else
        %keep control on
        gk = 1;

    end
end
```

Alternatively, this can be implemented as a finite state machine using 'Stateflow'



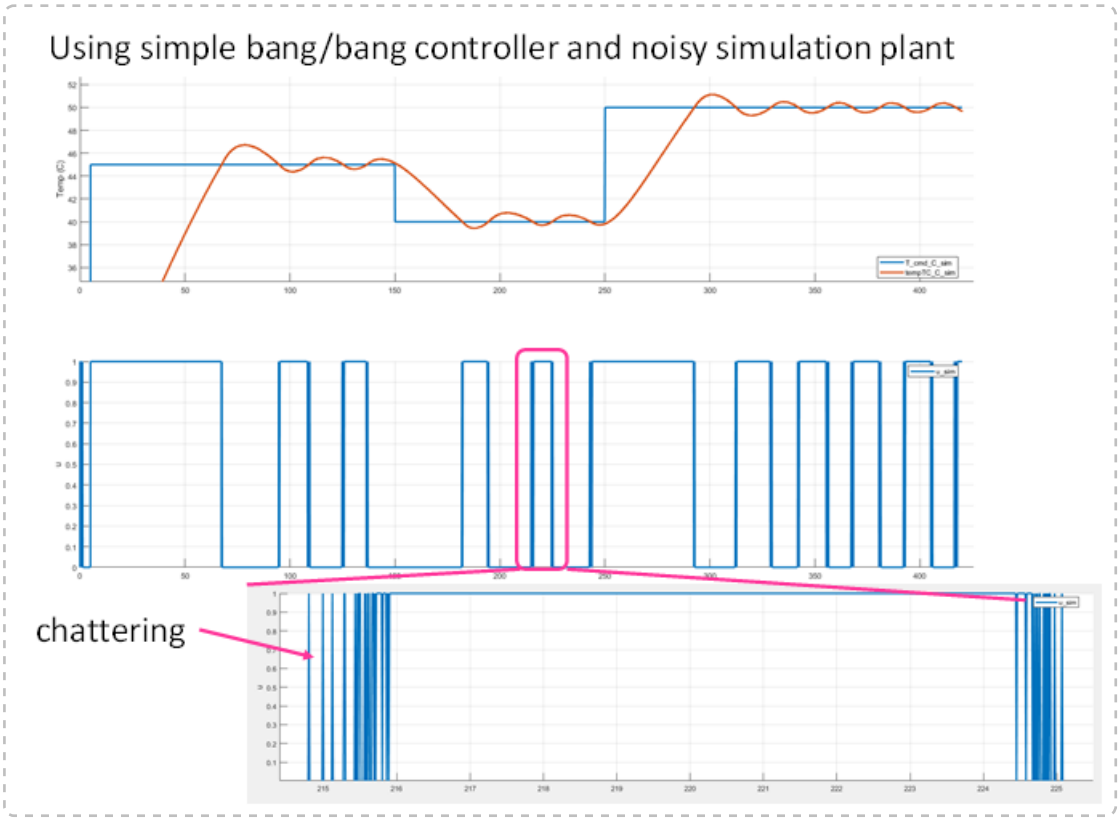
The Stateflow chart is shown below



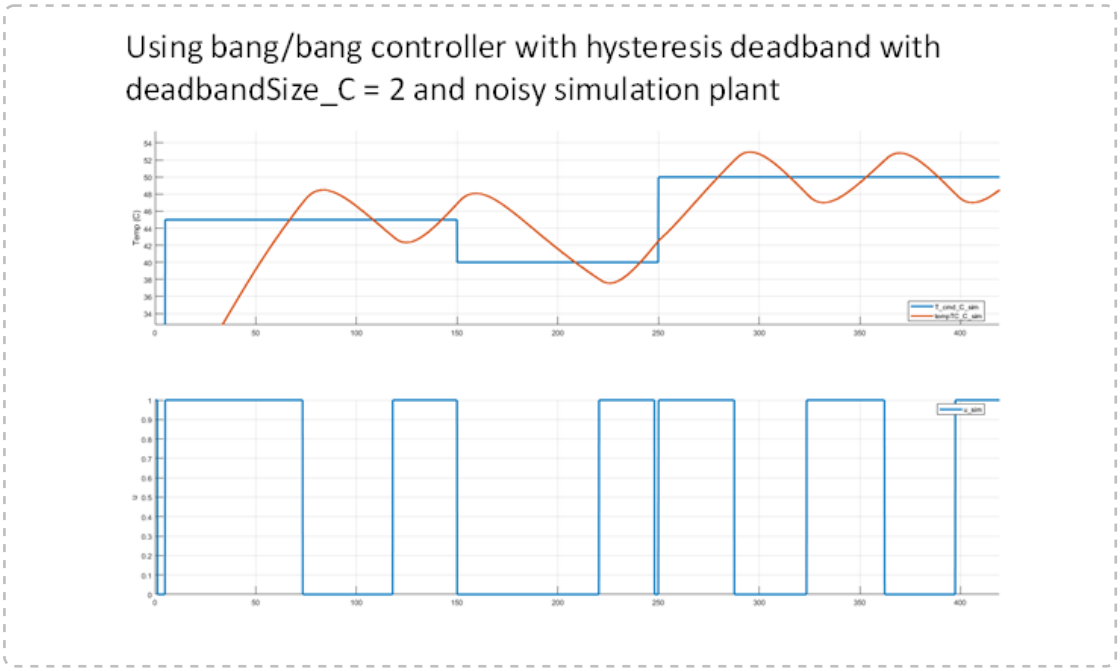
Results

Simulation

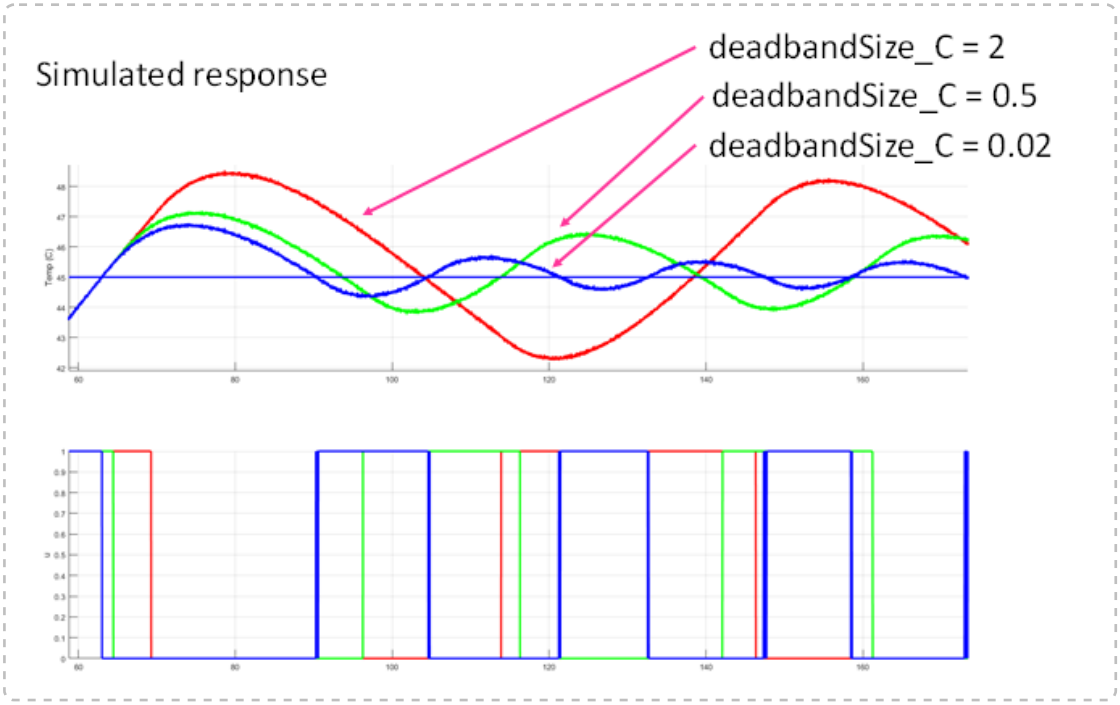
We can simulate the noisy system using a standard bang/bang controller as shown below. Notice that this system is subject to chatter.



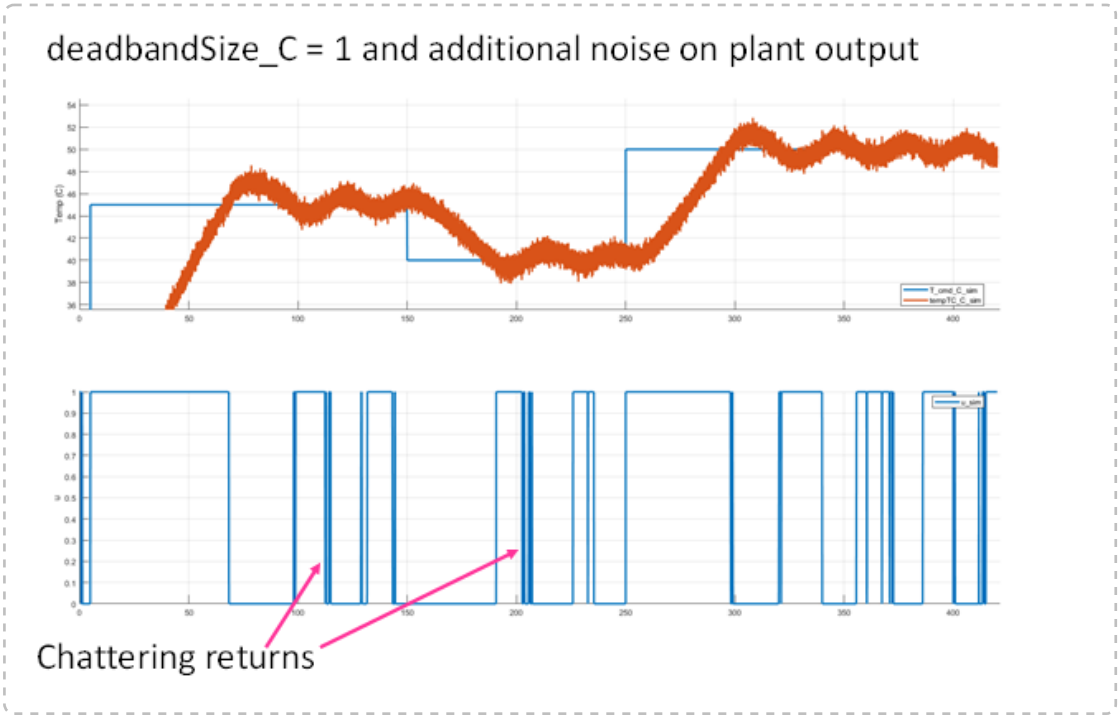
We can investigate the same scenario with a bang/bang with hysteresis controller with deadband-Size_C = 2.



As can be seen, this fixes the chattering but at the cost of additional overshoot/undershoot. This can be more easily observed if we vary the deadband size.

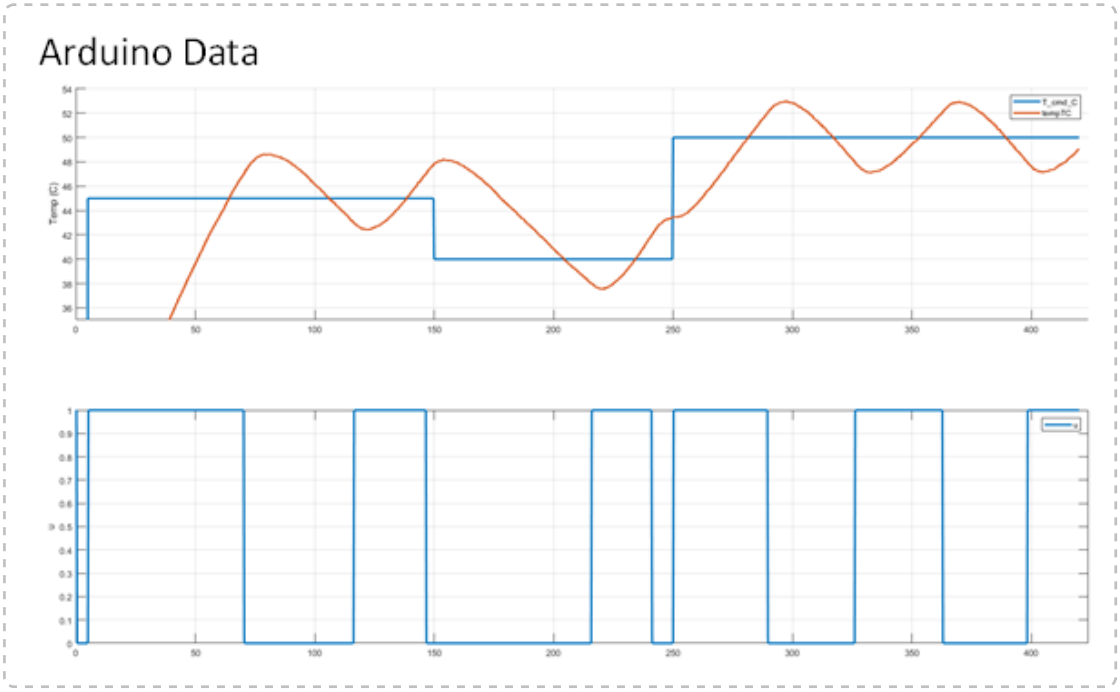


However if the deadbandSize is too small relative to the noise then the chattering problem can return.



Real Hardware

We can implement this on the Arduino to show that a Simulink model with an embedded Stateflow chart is supported by the Simulink Support Package for Arduino Hardware



Summary

The size of the deadband can be chosen to be slightly larger than the magnitude of the noise.

PROS

-Solves control/actuator chatter problems

-Does not require plant dynamics

CONS

-Increased over/undershoot

-Additional complexity

-Control design is related to sensor performance (deadband size is chosen based on sensor noise)