Anti-windup Temperature Analysis

March 11, 2022

1 Control Of Idealized Delay+Integrator Plant

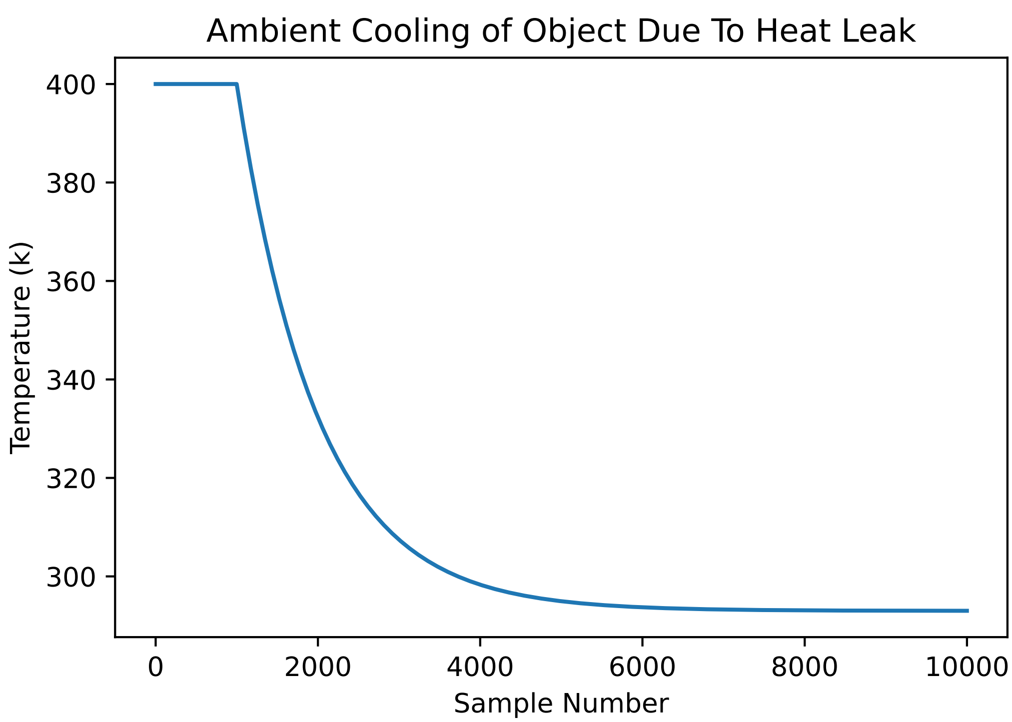
This model responds as a delay+integrator at a fixed update rate.

1.1 Plant+ Heat Leak

The plant model includes a heat leak which is the same units as the gain. A heat leak equal to the control setting will result in a constant temperature.

Show the plant cooling to the ambient temperature.

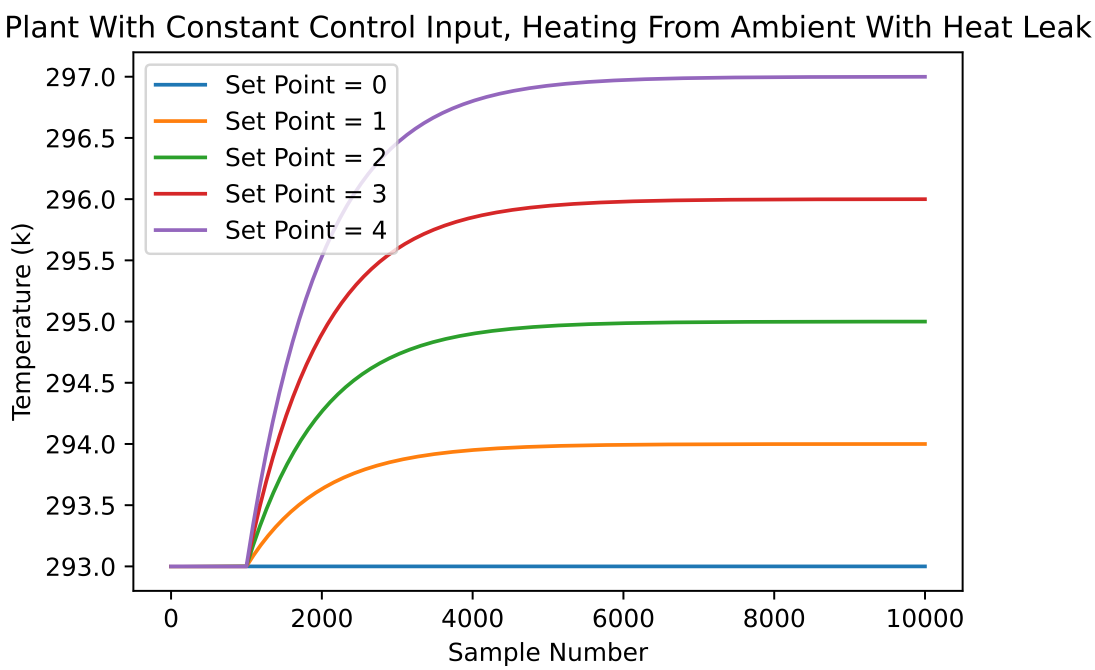
[4]:
```
Text(0, 0.5, 'Temperature (k)')
```



1.2 Constant Set Point

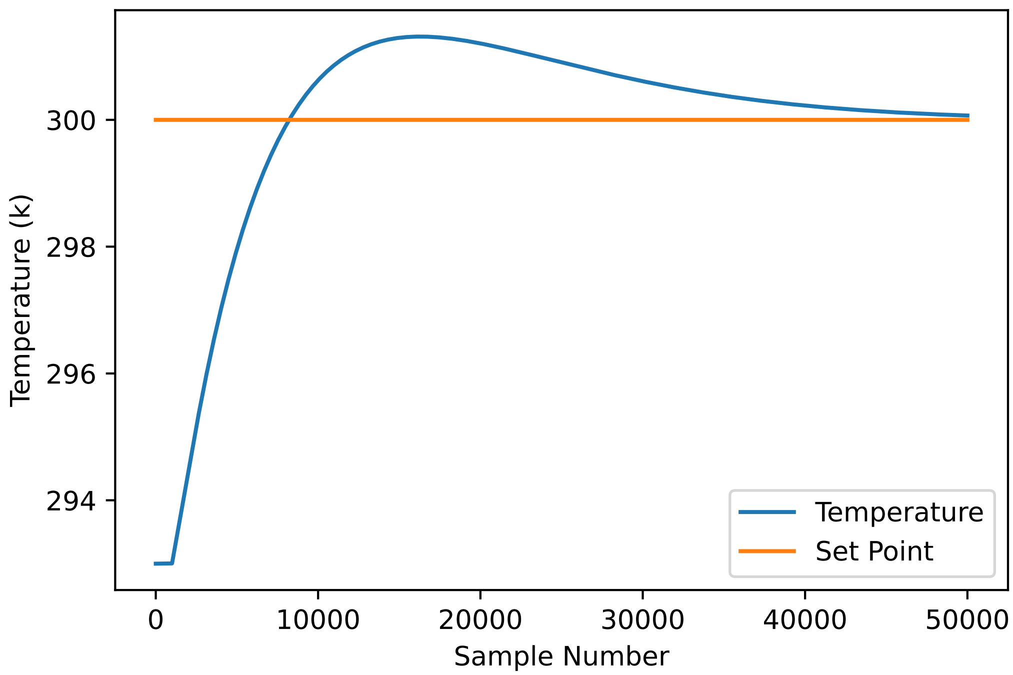
Show the plant reaching a constant temperature with different control settings. The difference will be in the temperature difference the plant rests at.

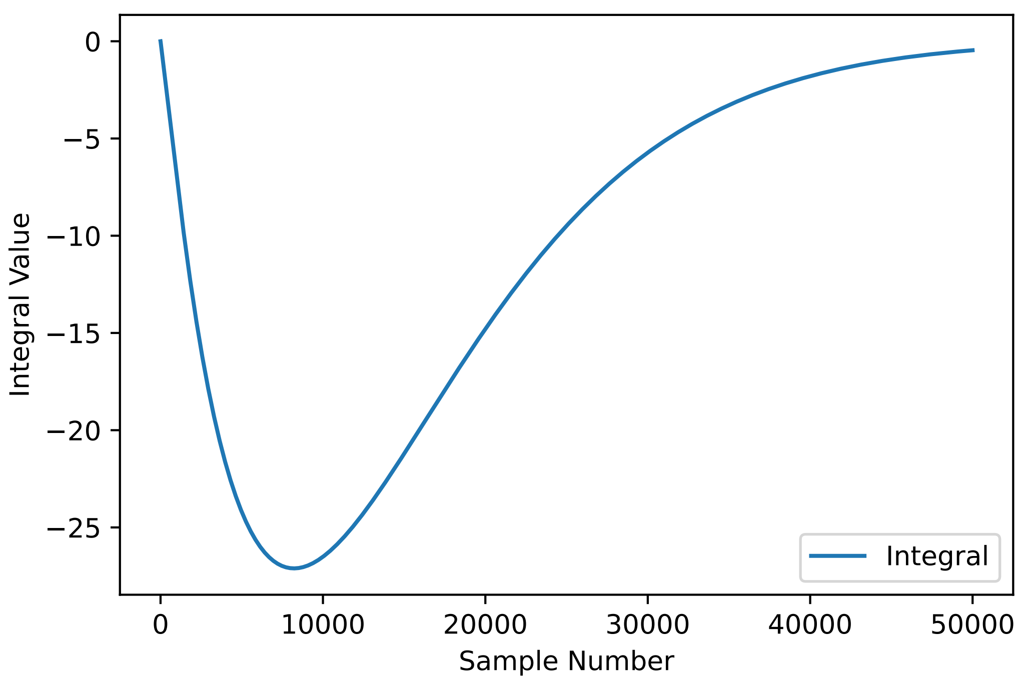
[5]: Text(0, 0.5, 'Temperature (k)')

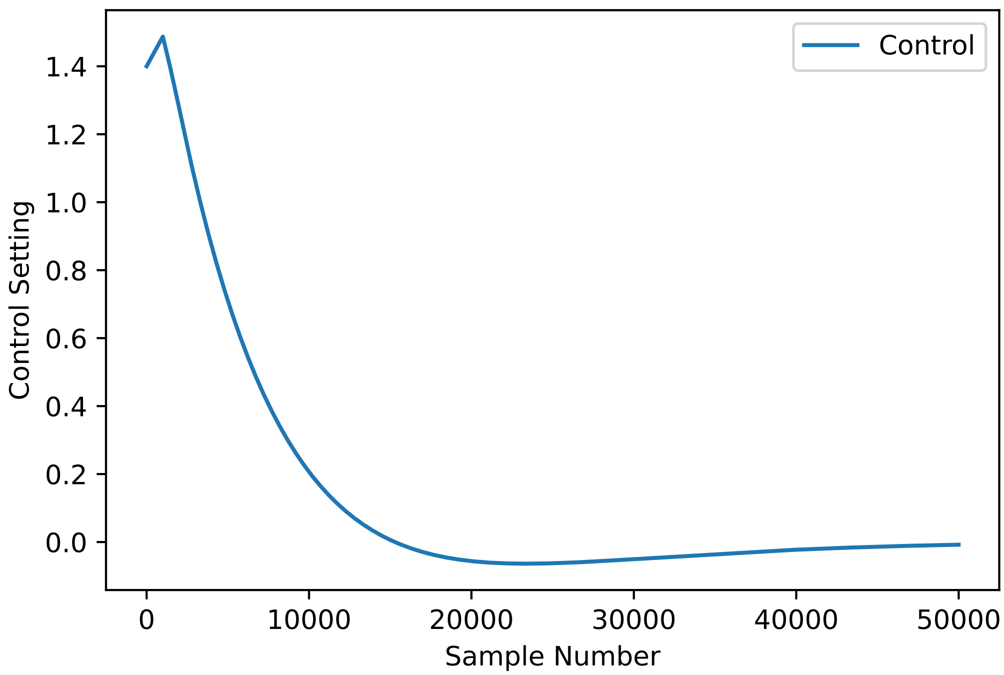


1.3 Idealized PI Filter

Introduce an idealized filter with no output limits. Remove the heat leak to get the ideal response. To start use the SMIC tuning algorithm (https://folk.ntnu.no/skoge/publications/2012/skogestad-improved-simc-pid/old-submitted/simcpid.pdf).


Temperature (k)
300
298
296
294
0
10000
20000
30000
40000
50000
Sample Number
Temperature
Set Point


Integral Value
0
−5
−10
−15
−20
−25
0
10000
20000
30000
40000
50000
Sample Number
Integral

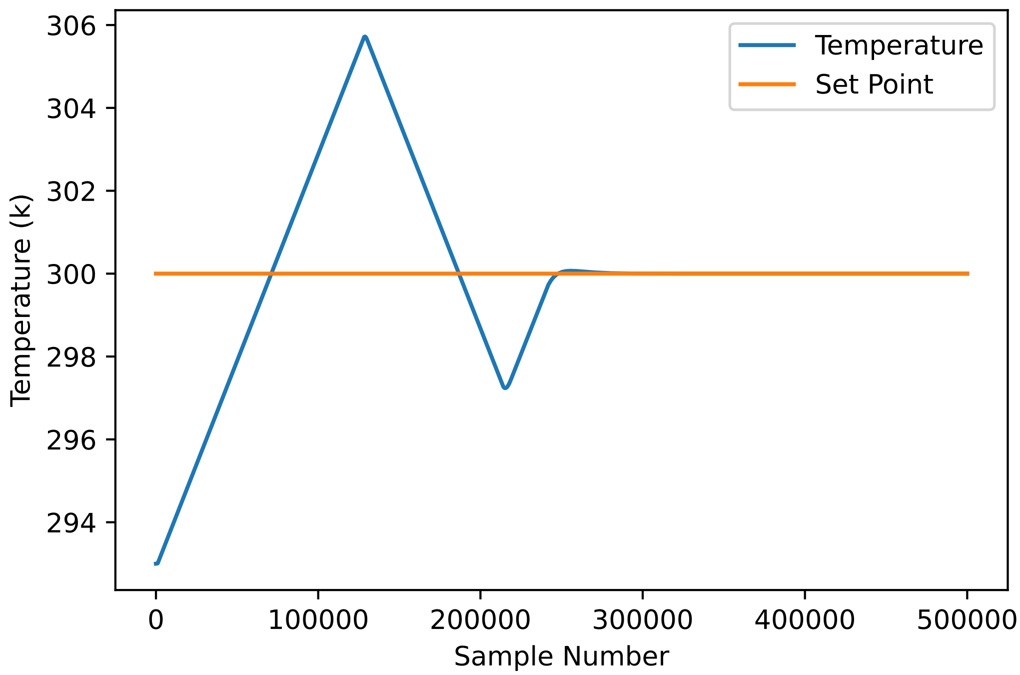


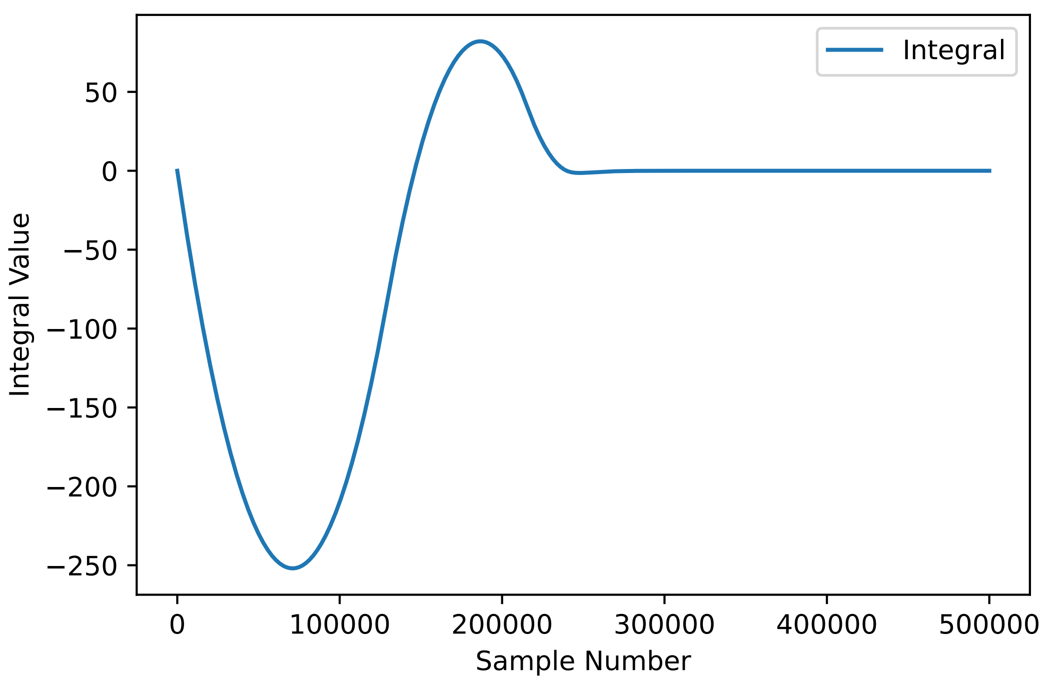
1.4 Limited Output

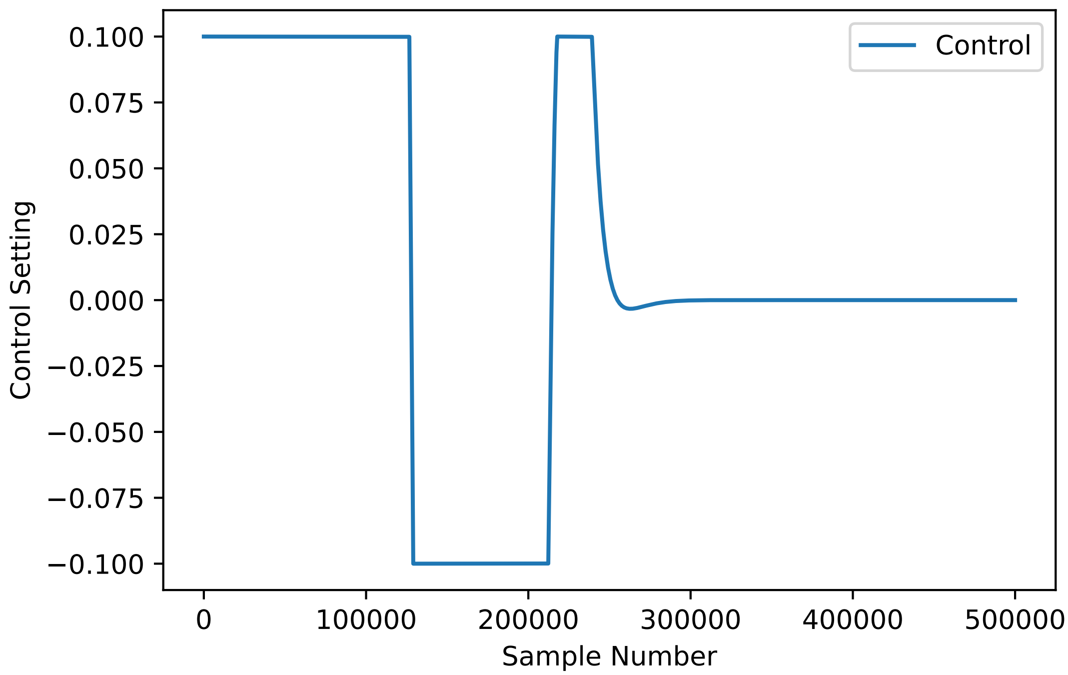
The controller usually does not have unlimited current output so we need to introduce limits. The basic implimentation just caps the output at the limit. This will cause windup of the integrator which is shown.

1.5 Integrator Windup

With the limited output the integrator windsup and causes bad behaviour.


Temperature
Set Point
306
304
302
300
298
296
294
Temperature (k)
0
100000
200000
300000
400000
500000
Sample Number

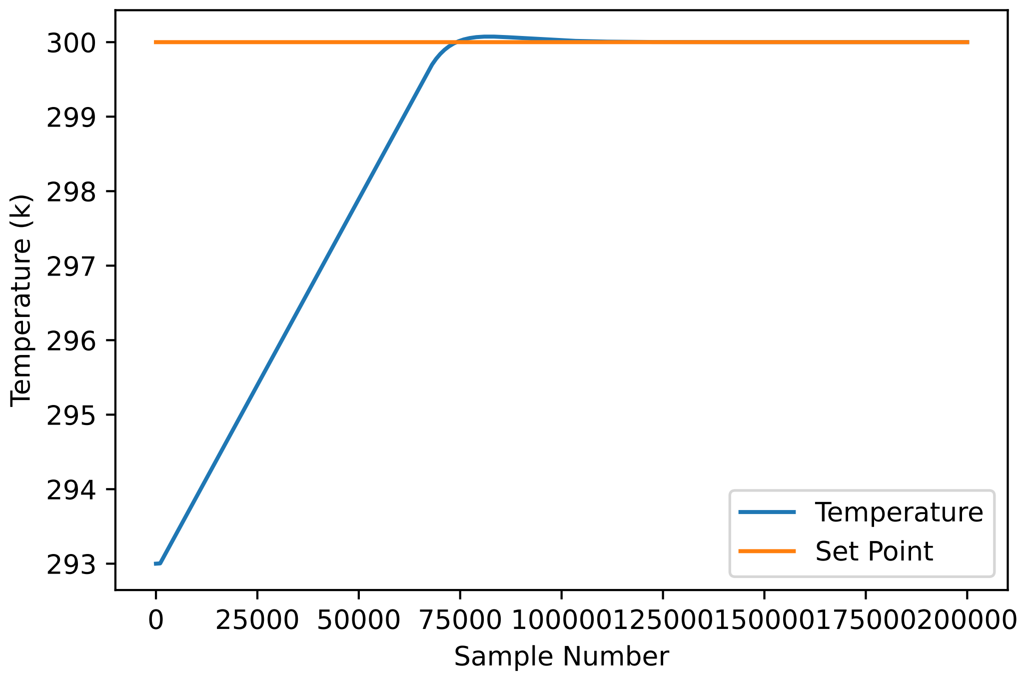

Integral
50
0
−50
−100
−150
−200
−250
Integral Value
0
100000
200000
300000
400000
500000
Sample Number

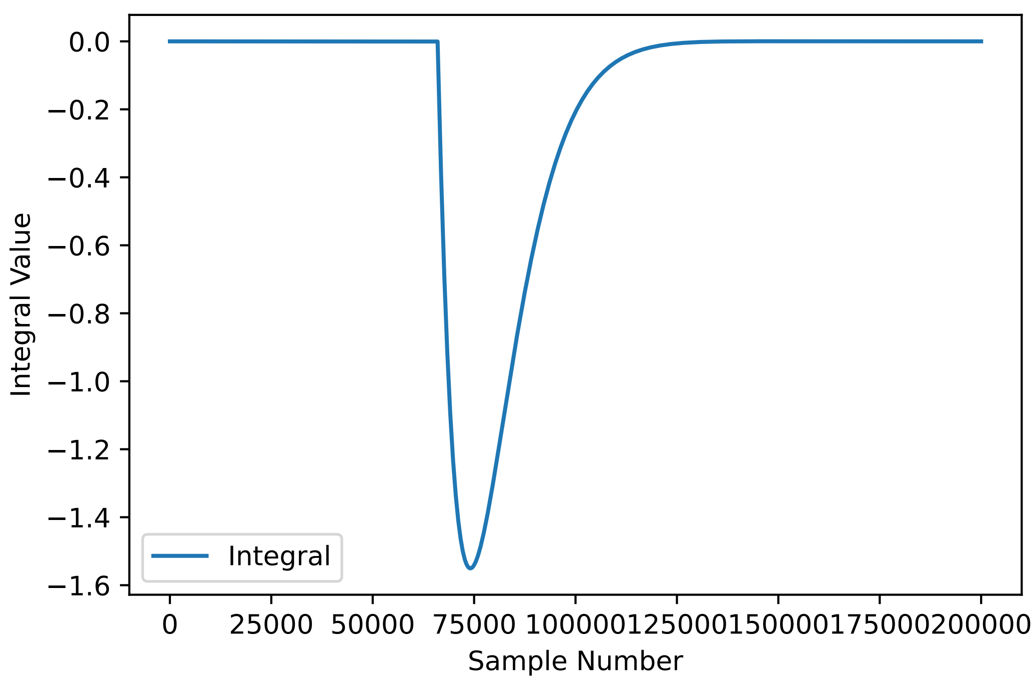


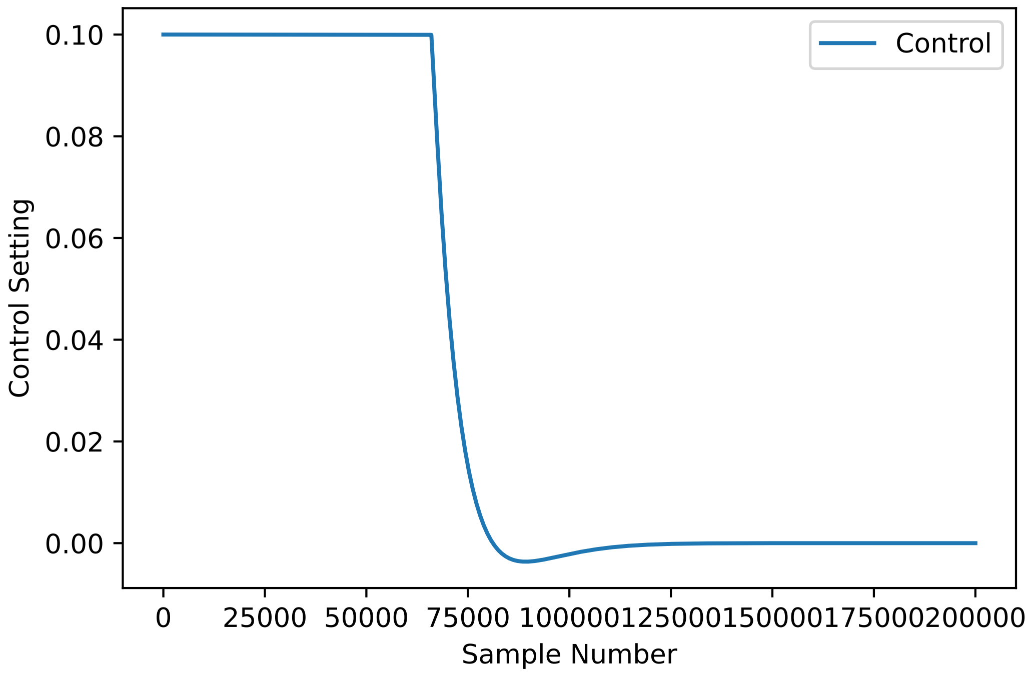
1.6 Anti-windup Controller

To prevent windup there are several methods that can be used of increasing complexity. The simpliest is freezing the integrator value at the point the control setting is beyond the controllers capability.

Freezing the integrator leads to less overshoot than the normal state and none of the ringing occurs.


300
299
298
297
296
295
294
293
Temperature (k)
0
25000
50000
75000
100000
125000
150000
175000
200000
Sample Number
Temperature
Set Point


0.0
−0.2
−0.4
−0.6
−0.8
−1.0
−1.2
−1.4
−1.6
Integral Value
0
25000
50000
75000
100000
125000
150000
175000
200000
Sample Number
Integral


Control
Control Setting
0.10
0.08
0.06
0.04
0.02
0.00
0
25000
50000
75000
100000
125000
150000
175000
200000
Sample Number