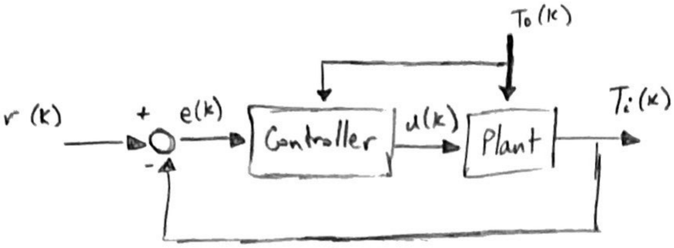
Alex Riebe Hibernacula Control Design



↳ We should subtract 7 here for the new ∅ point. Shouldn't effect the loop though.

Plant Model

10 minutes (600s) → T_s - sample period

- r - setpoint temp
- T_o - outside temp
- R_o - lb of air / hour
- t - time
- T_i - Hibernacula temp
- A_i - Amount of Hibernacula air

$$T_i(k+1) = \frac{(T_o(k) * R_o * t) + (T_i(k) * A_i)}{(R_o * t + A_i)}$$

$A_o = R_o * t = CFM * \rho_o * t = 816 * .079 * 10$

$= 644.64$ lb of air

$A_i = 1560$ lb of air

$$T_i(k+1) = \frac{644.64\,T_o(k) + 1560\,T_i(k)}{(644.64 + 1560)}$$

$= .2924\,T_o(k) + .7076\,T_i(k)$ ← relayed. could also do a percent of 10 minutes.

$T_i(k+1) = .2924\,u(k)T_o(k) + .7076\,T_i(k)$

For modelling purpose only? → I feel like this needs to come from the controller [u(k)]

$T_i(k+1) = .2924\,u(k) + .7076\,T_i(k)$

$T_i(k+1) - .7076\,T_i(k) = .2924\,u(k)$

$zT_i(z) - zT_i(\emptyset) - .7076\,T_i(z) = .2924\,U(z)$

$zT_i(z) - 7z - .7076\,T_i(z) = .2924\,U(z)$

↳ Let's use 7°C as our ∅ point. Our input r(k) is then -3 (4°C standard temp)

$zT_i(z) - .7076\,T_i(z) = .2924\,U(z)$

$(z - .7076)T_i(z) = .2924\,U(z)$

$$T_i(z)/U(z) = \frac{.2924}{z - .7076}$$

↳ Discrete Plant Model

Mapping to Analog

$s = \frac{z-1}{T_s z} \rightarrow T_s s = \frac{z-1}{z} = 1 - 1/z$

$1 - T_s s = 1/z \rightarrow z = \frac{1}{1 - T_s s} = \frac{1}{1 - 600s}$

$$T_i(s)/U(s) = \frac{.2924}{\frac{1}{1-600s} - .7076} \cdot \frac{1-600s}{1-600s} = \frac{.2924(1-600s)}{1 - .7076(1-600s)}$$

$$= \frac{.2924 - 175.4409s}{424.5591s + .2924}$$

$$T_i(s)/U(s) = \frac{.2924 - 175.4409s}{424.5591s + .2924}$$

Controller Design

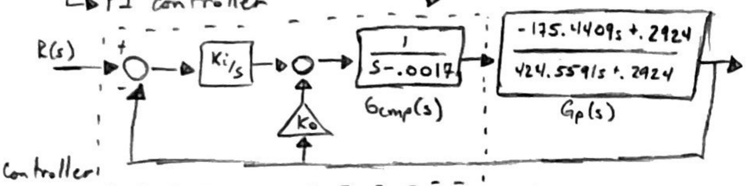
$\%OS = .125 \rightarrow \zeta = .6$

$T_s(2\%) = 1$ week $= 604800$

steady State Error $= \emptyset\%$

↳ PI controller

To cancel the plant's zero



$T_s(2\%) = 604800 = \frac{4}{\omega_n \zeta} \rightarrow \omega_n = \frac{4}{604800 \cdot .6}$

$\omega_n = .00001102$

↳ $s^2 + 2\zeta\omega_n s + \omega_n^2 = s^2 + 2 \cdot .6 * .00001102\,s + .00001102^2$

↳ $s^2 + .0000132\,3s + (1.2150 \times 10^{-10})$

$$G_{cl1}(s) = \frac{G_p(s)G_{cmp}(s)}{1 + K_o G_p(s) G_{cmp}(s)}$$

$$G_{cl2}(s) = \frac{(K_i/s)G_{cl}(s)}{1 + (K_i/s)G_{cl1}(s)}$$

$$= \frac{K_i}{-2.41996s^2 + (K_o - .001667)s + K_i} = \frac{-.4132K_i}{s^2 + \frac{(K_o - .001667)}{-2.41996}s + \frac{K_i}{-2.41996}}$$

↳ $K_i = -2.94036 \times 10^{-10}$; $K_o = 0.00163465$