

Ziegler-Nichols Hand Tuning for PID Controllers

I remembered what I wanted to go over in class today. There is another method of “trial-and-error” tuning of PID controllers that we use sometimes (since many times we don’t know the actual plant dynamics which makes it difficult to analytically design the controller). It is called Ziegler-Nichols tuning and is on page 566-570 of Ogata. This will not be on the exam, but if you are interested a brief descriptions follows.

Consider an unknown plan that may act as a double integrator (a robot arm for example)

$$\tau = J\ddot{\theta}$$

$$\frac{\theta}{\tau} = \frac{1}{Js^2}$$

We can start by increasing the Kp gain until the system oscillates at a frequency that is near the desired closed loop natural frequency we want. The fact that this would cause an oscillatory response can be seen by looking at the closed-loop eigenvalues.

$$\frac{\theta}{r} = \frac{1}{Js^2 + K_p}$$


This results in a closed-loop step response of

$$\theta(t) = A \sin(\omega_n^{CL} t) = A \sin(\sqrt{K_p/J} t)$$

So we just keep increasing Kp until we see the robot arm oscillate at some desired frequency. Then we increase the Kd term until we get slightly more damping that we desire in the final solution (because we know that adding integral control will create more overshoot).

$$\frac{\theta}{r} = \frac{1}{Js^2 + K_d s + K_p}$$


$$\theta(t) = A e^{-\zeta \omega_n t} \sin(\omega_d t)$$

Then we increase the Ki gain until we eliminate steady state error in a satisfactorily manner. We may go back and adjust Kp and Kd if needed (or may have to start over if it turns out we were too optimistic in the closed loop natural frequency we could obtain).