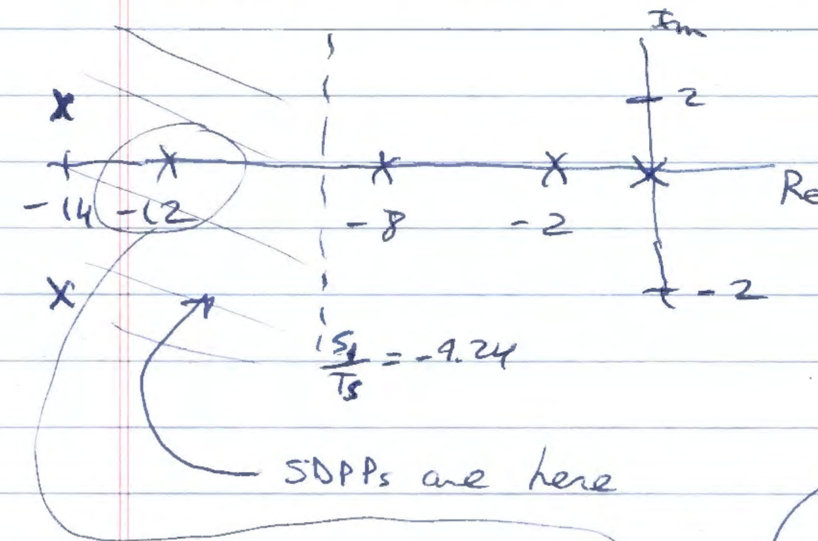
(2) Use "sufficiently damped plant poles" (SDPP)

Def: An SDPP is a plant pole (eig(A)) whose real part is "to the left" of s_1/T_s.

Example If $T_s = 0.5$ sec, $\frac{s_1}{T_s} = \frac{-4.62}{.5} = -9.24$

Suppose eig(A) $= 0, -2, -8, -12, -14 \pm j2$ (6th-order plant)



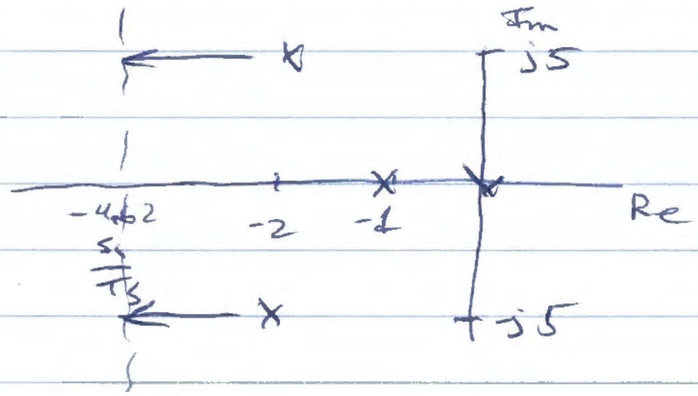
need 3 more poles to fill out spoles for a 4th_order plant

spoles = $[(-14+j2), (-14-j2), -12, s_3/T_s]$

(3) The last method, added damping is used only if the plant has complex poles whose real parts are to the right of s_1/T_s.

<u>Example</u> Suppose $T_s = 1$ sec $\Rightarrow \frac{s_1}{T_s} = -4.62$

and $\text{eig}(A) = 0, -1, \underbrace{-2 \pm j5}$ } 4th order plant



slide these complex poles over to the $\frac{s_1}{T_s}$ line.

adp = s_1/T_s + j*5
spoles = [adp conj(adp) s2/Ts]

need two more poles for 4th-order plant.

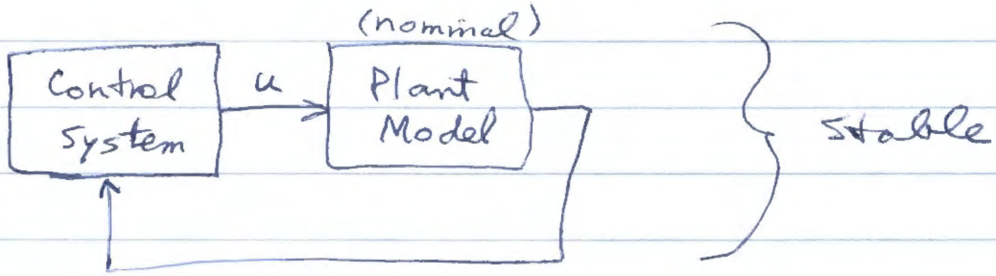
<u>Summary</u>

(1) Put all SDPPs into spoles
(2) Put all ADP poles into spoles
(3) Use a scaled Bessel cluster sm/Ts to get m additional poles so that spoles contains a total of n poles for an nth-order plant.

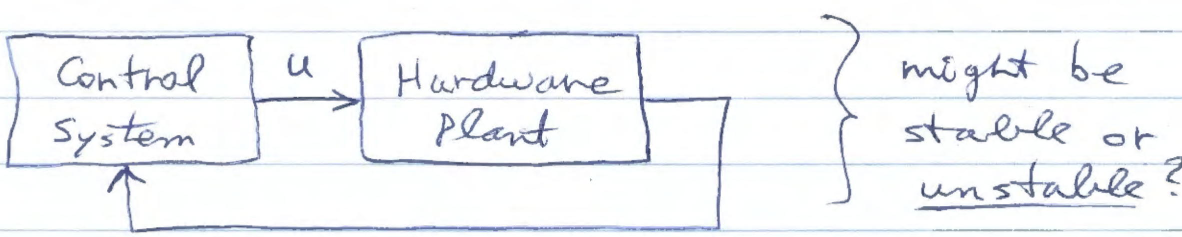
Stability Margins for a Single-Input Control System

Read sections 5.4 and 5.5 in book.

Given a mathematical model of the plant (eg. transfer function or state-space model) a control system can be designed to get a stable closed-loop system:



Then the control system is connected to the actual hardware plant

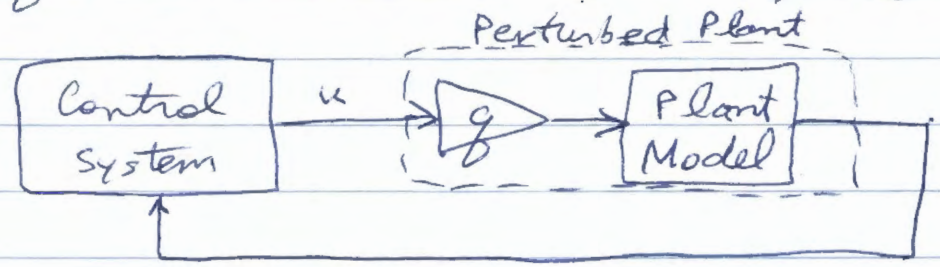


This closed-loop system might be unstable because the plant model might not be an accurate representation of the hardware plant.

To get an idea of the stability robustness of the control system, we perturb the plant model in a certain way and see how large the perturbation can get before the closed-loop system goes unstable.

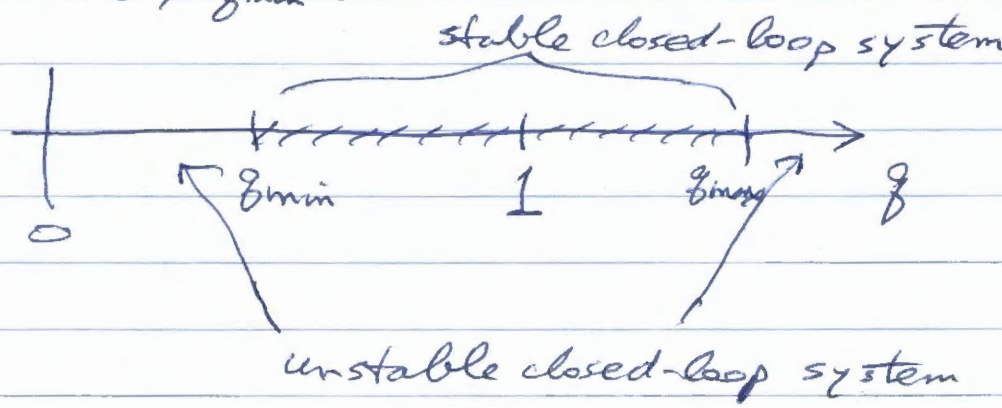
Gain Perturbation

Let g be a real number ≥ 0, and consider



where the control system was designed to get a stable CL system with the (nominal) plant model (without g, or equivalently, with $g = 1$).

As we increase g above 1, the closed-loop system remains stable until we reach some upper limit g_{max}. If we decrease g below 1, the CL system remains stable until we reach a lower limit, g_{min}.



If g_{max} is very small (e.g. 1.01) it is likely that the hardware CL system will be unstable.

Similarly if g_{min} is too big (eg .99).