Feedback Control

Subjects:

- Nyquist stability criterion.

Literature: black fifth edition, red sixth edition

- 340-353: 337-351: The Nyquist Stability Criterion. For many students this mini-module is hard to understand so read the text with attention to detail.

Problems:

1. Nyquist plot

   Sketch the Nyquist plot for a system given by the open loop transfer function KGH(s):

$$KGH(s) = \frac{K}{s(\tau s + 1)}$$

   K and τ are positive constants.

2. Nyquist plot. (The submarine). (J. Nørgaard Nielsen,1991)

   - Assuming that K>0, show using Nyquist stability criterion that the depth control is unstable without the dotted feedbacks.

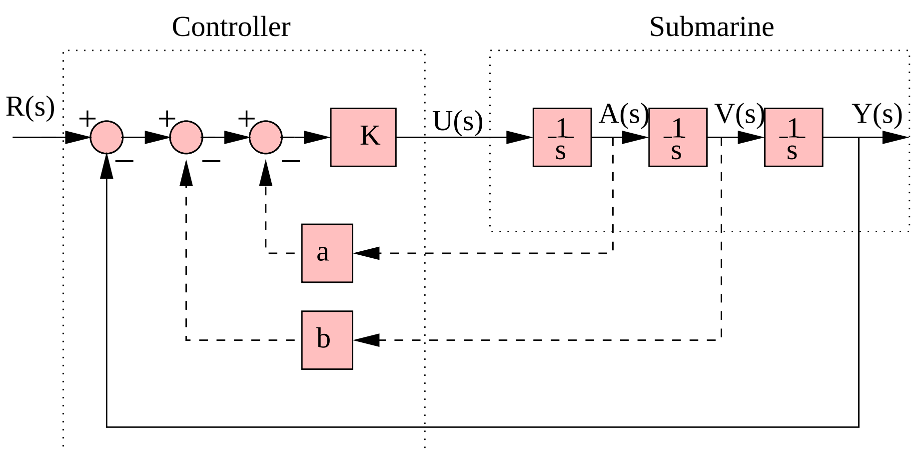

Figure 1: *Submarine*

3. Nyquist stability

In some systems there may by stability problems at low frequencies, e.g. in an electronic amplifier built of a number of single stages all with a lower corner frequency. As an example we have 3 stages all with the same lower 3dB frequency of 1 [rad/sec] and a total gain of 1000. Using unit feedback a block diagram is shown in the figure. If there is unstability in the electronic circuit it is called 'motorboating' due to the sound it produces in a loadspeaker.

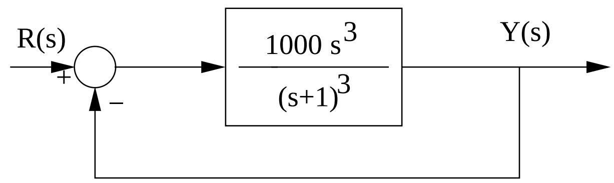

Figure 2: *Amplifier with unit feedback*

- Use Nyquist's stability criterion to determine if the system in figure 2 is stable.

4. Nyquist stability

In figure 3 is a proportional controlled system. In figure 4 is a Nyquist plot of the function $\frac{1}{(s+1)(s+1)(s+1)}$.

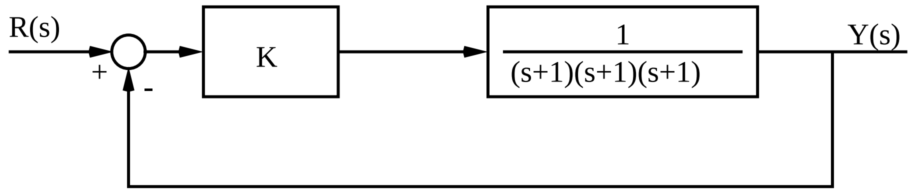

Figure 3: *Proportional controlled system*

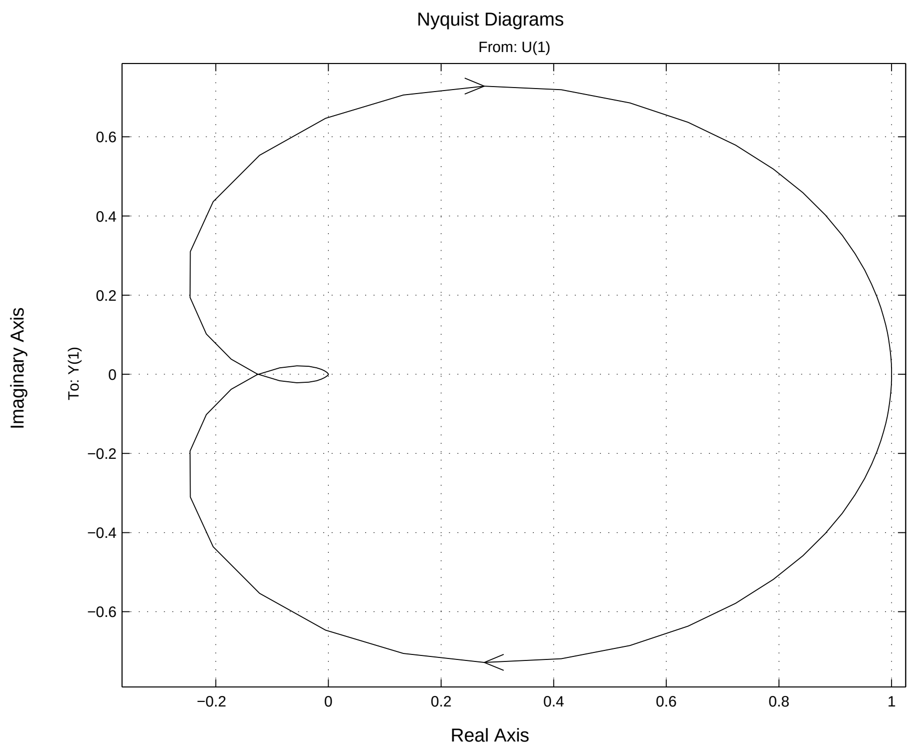

Figure 4: *Nyquist plot* $\frac{1}{(s+1)(s+1)(s+1)}$

- Use Nyquist stability criterion to deetermine the values of K giving a stable system.

General Nyquist contour:

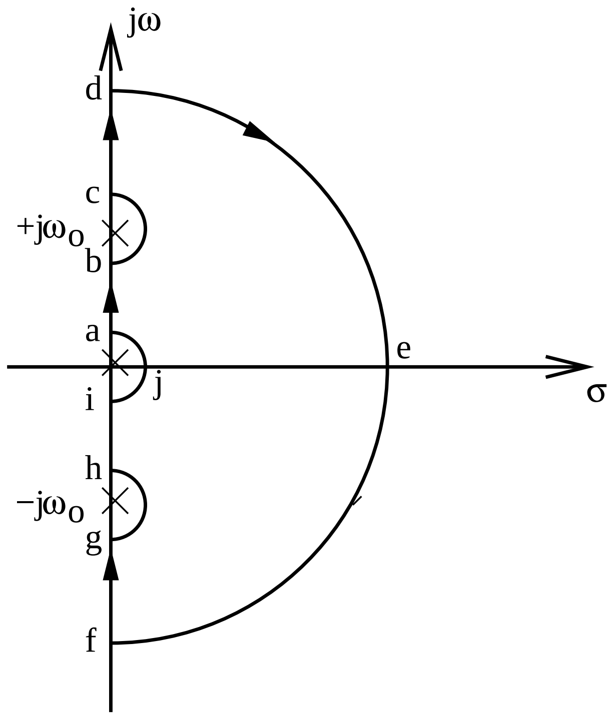

Figure 5: *General Nyquist contour*

Path	*Equation*	*Valid for*
ab	$s = j\omega$	$0 < \omega < \omega_o$
bc	$s = \lim_{r\to 0}(j\omega_o + re^{j\Theta})$	$-90^o \leq \Theta \leq +90^o$
cd	$s = j\omega$	$\omega_o < \omega < \infty$
def	$s = \lim_{R\to\infty} Re^{j\Theta}$	$+90^o \geq \Theta \geq -90^o$
fg	$s = j\omega$	$-\infty < \omega < -\omega_o$
gh	$s = \lim_{r\to 0}(-j\omega_o + re^{j\Theta})$	$-90^o \leq \Theta \leq +90^o$
hi	$s = j\omega$	$-\omega_o < \omega < 0$
ija	$s = \lim_{r\to 0} re^{j\Theta}$	$-90^o \leq \Theta \leq +90^o$