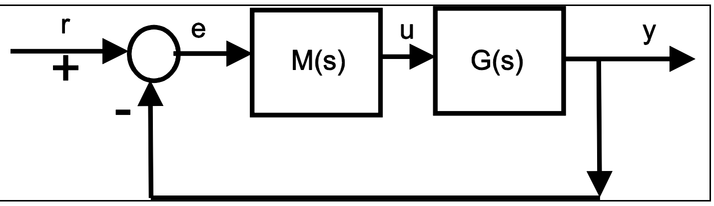
Modelling and control summaries

by Anthony Rossiter

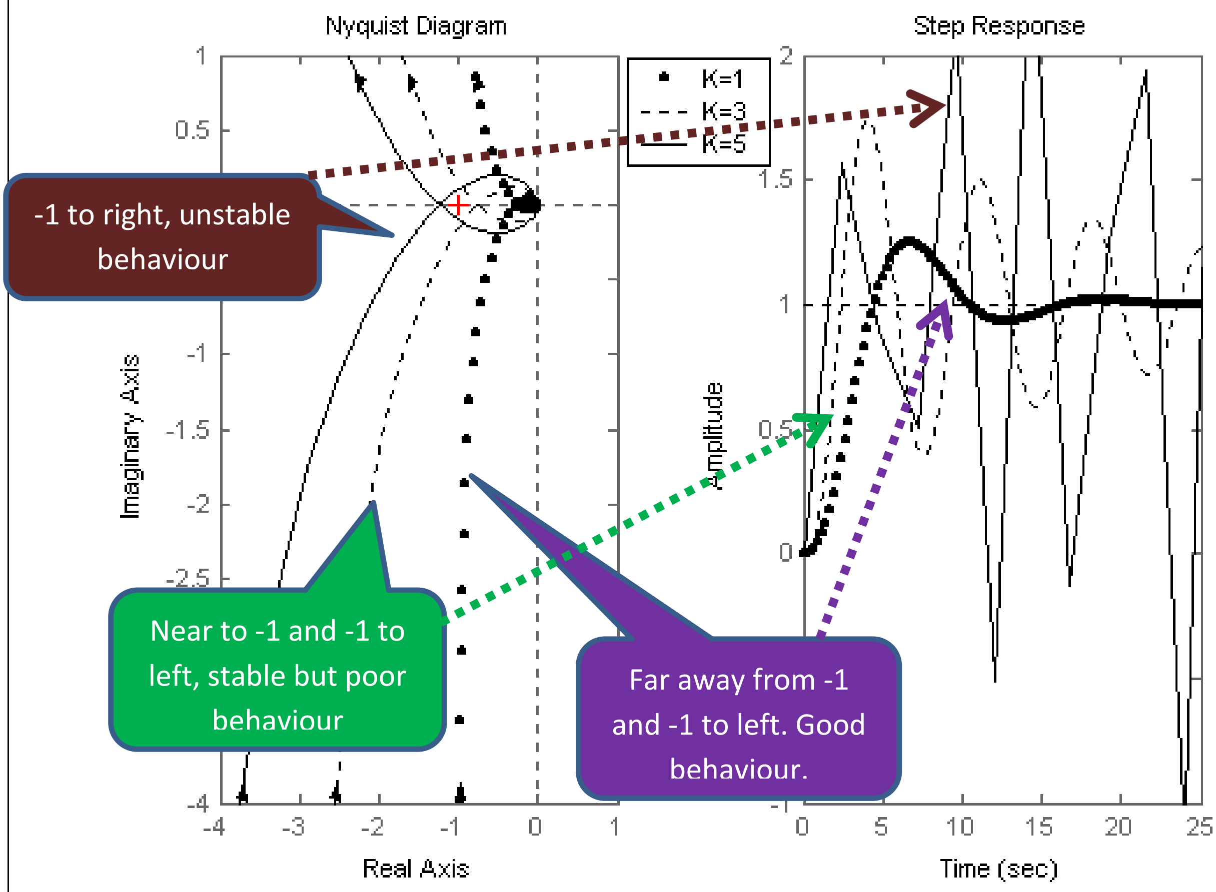
Nyquist 8: Links to closed-loop stability

When using Nyquist to infer closed-loop stability, you do the Nyquist diagram of the loop transfer function - NOT the closed-loop transfer function. **To infer stability of this loop, plot Nyquist diagram of G(s)M(s)!**



EVIDENCE OF LINK BETWEEN NYQUIST AND CLOSED-LOOP BEHAVIOUR

Consider G(s) with M(s)=K=1,3,5 $G = \frac{1}{s(s+1)^2}$



Appears to be a strong link between proximity to -1 point and closed-loop behaviour. Same link can be evidenced on many examples - TRY SOME FOR YOURSELF!

Summary of key points	
1. If the Nyquist diagram passes with -1 well to the left, good performance. 2. If Nyquist passes with -1 to the right, closed-loop unstable. 3. If Nyquist is close to -1, oscillation.	$G = \frac{2\times10^{-4}(s+4)}{s(s+0.1)(s+1)}$; $G = \frac{2(s+2)}{(s+0.1)(s+1)^2}$

This is unsurprising because

Closed-loop poles can be defined by 1+G(s)M(s) = 0.

Closed-loop poles can be defined by G(s)M(s)=-1.

HENCE, if the Nyquist diagram goes through -1, G(jw)M(jw)=-1 implies jw is a closed-loop pole!

CORROLLARY: If the Nyquist diagram passes close to -1, then a closed-loop pole is close to the imaginary axis which implies a strong likelihood of significant oscillation.

Example MATLAB commands for self study

```
G=tf([2 4],poly([-0.1 -1 -1]));
figure(3);clf reset
nyquist(G*0.1,G*0.5,G,G*2);
figure(2);clf reset
overlaymany(G,0.1,0.5,1,2);
figure(1); xlim([0,10]);
```