Esempio 17.7 del libro "Chemical process control" di G.Stephanopoulos

$N := 500$

$k := 0 .. N$

$Min := -2$

$Max := 2$

$espo(k) := Min + \frac{k \cdot (Max - Min)}{N}$

$\omega_k := 10^{espo(k)}$

$K := 1$

$G(s) := (K \cdot 100) \cdot \left(1 + \frac{1}{0.25 \cdot s}\right) \cdot \left(\frac{1}{0.1 \cdot s + 1}\right) \cdot \left(\frac{1}{2 \cdot s + 1}\right) \cdot \left(\frac{1}{s + 1}\right) \cdot \left(\frac{1}{0.5s + 1}\right) e^{-0.2s}$

$G1(s) := (K \cdot 100) \cdot \left(1 + \frac{1}{0.25 \cdot s}\right)$

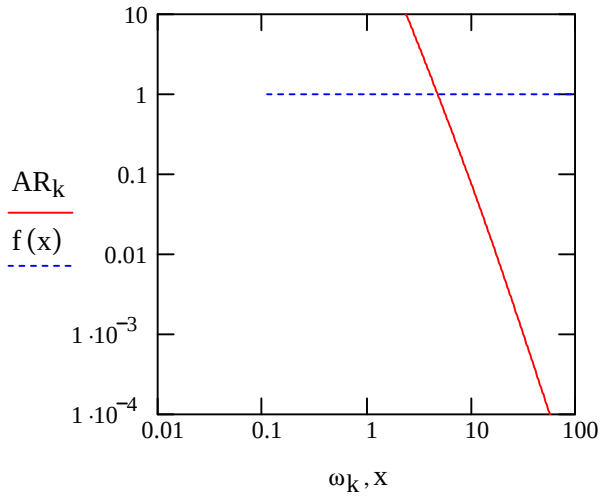
$G2(s) := \left(\frac{1}{0.1 \cdot s + 1}\right) \cdot \left(\frac{1}{2 \cdot s + 1}\right)$

$G3(s) := \left(\frac{1}{s + 1}\right) \cdot \left(\frac{1}{0.5 \cdot s + 1}\right)$

$G4(s) := e^{-0.2s}$

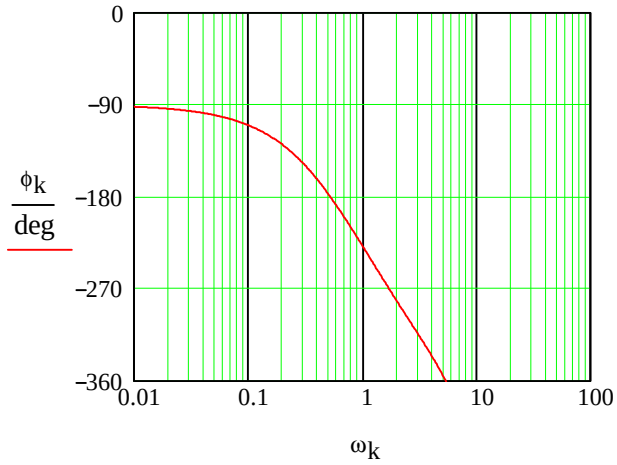
$AR1_k := \left|G1(i \cdot \omega_k)\right| \quad AR2_k := \left|G2(i \cdot \omega_k)\right| \quad AR3_k := \left|G3(i \cdot \omega_k)\right| \quad AR4_k := \left|G4(i \cdot \omega_k)\right|$

$AR_k := AR1_k \cdot AR2_k \cdot AR3_k \cdot AR4_k \qquad f(x) := 1$



$\phi 1_k := \arg(G1(i\cdot\omega_k))$ $\phi 2_k := \arg(G2(i\cdot\omega_k))$ $\phi 3_k := \arg(G3(i\cdot\omega_k))$ $\phi 4_k := -0.2\cdot\omega_k$

$\phi_k := \phi 1_k + \phi 2_k + \phi 3_k + \phi 4_k$



Applicazione del criterio di stabilità di Bode

Calcolo della frequenza di crossover

$\omega := 1$ $\phi(\omega) := \arg(G1(i\cdot\omega)) + \arg(G2(i\cdot\omega)) + \arg(G3(i\cdot\omega)) + \arg(G4(i\cdot\omega))$

Given

$\phi(\omega) = -\pi$

$\omega co := \text{Find}(\omega)$

$\omega co = 0.522$

$\phi(\omega co) = -3.142$

Calcolo del K limite

$AR(\omega) := |G1(i\cdot\omega)| \cdot |G2(i\cdot\omega)| \cdot |G3(i\cdot\omega)| \cdot |G4(i\cdot\omega)|$

$AR(\omega co) = 457.414$

$Klim := \frac{1}{AR(\omega co)}$

$Klim = 2.186\times 10^{-3}$

Diagramma di Nyquist

$N := 500$

$k := 0 .. N$

$Min := -2$

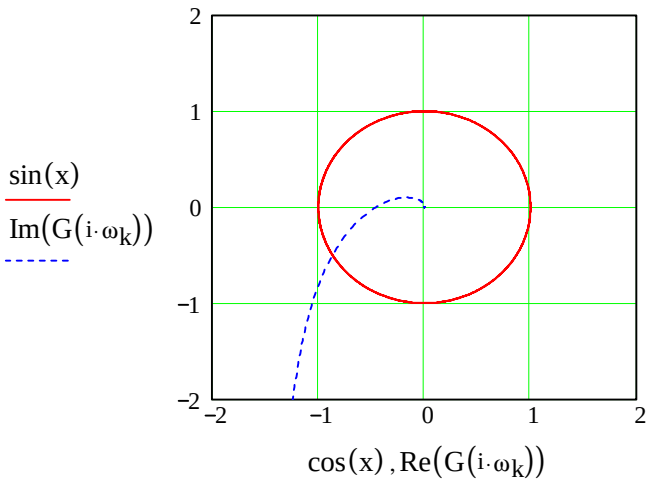
$Max := 2$

$espo(k) := Min + \frac{k \cdot (Max - Min)}{N}$

$\omega_k := 10^{espo(k)}$

$K := 1 \cdot 10^{-3}$

$$G(s) := (K \cdot 100) \cdot \left(1 + \frac{1}{0.25 \cdot s}\right) \cdot \left(\frac{1}{0.1 \cdot s + 1}\right) \cdot \left(\frac{1}{2 \cdot s + 1}\right) \cdot \left(\frac{1}{s + 1}\right) \cdot \left(\frac{1}{0.5s + 1}\right) e^{-0.2s}$$



Criterio di Nyquist: se il diagramma di Nyquist a ciclo aperto di un sistema feedback circonda il punto (-1,0) al variare della frequenza, la risposta del sistema a ciclo chiuso è instabile.

SUGGERIMENTO: provare ad inserire il Klim calcolato con il criterio di Bode e verificare il criterio di Nyquist