Laboratory no. 6

1 Theoretical aspects

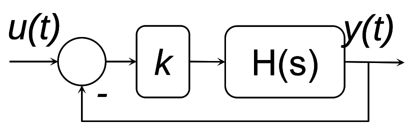
- Dead time systems
- Gain margin, phase margin (on Nyquist and Bode)

2 Aims

Stability analysis of negative feedback control systems.
The gain margin m_k and phase margin γ_k for negative feedback control systems with dead time

3 Stability analysis using frequency response

3.1 *For simplicity it is considered a rigid negative feedback control structure:*



where $H_d(s) = kH(s)$; $H_{des}(s) = H_d(s)$; $H_o(s) = \dfrac{H_d(s)}{1 + H_d(s)}$

3.2 *Relations for math quatities used in stability analysis*

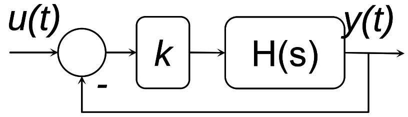
- Cutting frequency, (ω_t) from relation: $|H(j\omega_t)| = 1$;
- Frequency at $-\pi$, ($\omega_{-\pi}$) from relation $\angle H(j\omega_{-\pi}) = -\pi$;
- Gain margin, $m_k^{d\beta} = |H(j\omega_{-\pi})|^{d\beta}$;
- Phase margin, $\gamma_k = \pi + \angle H(j\omega_c)$;

3.3 *Simplified Nyquist criterion :*

$\begin{cases} \gamma_k \geq 0 \\ m_k^{d\beta} \leq 0 \end{cases}$ equivalent with the statement « The critical point (-1,0*j) left on the left side of Nyquist diagram of the open loop transfer function»

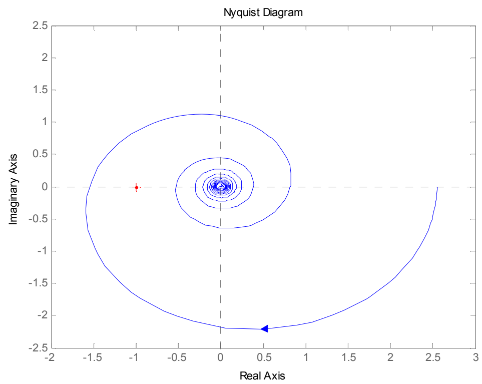
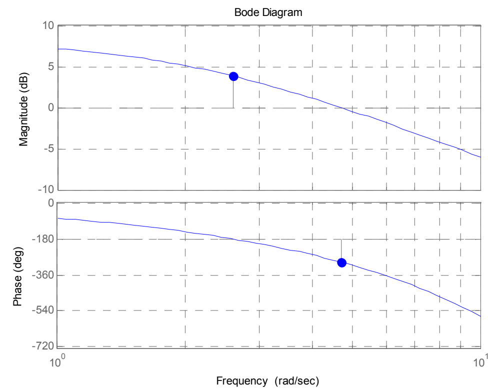
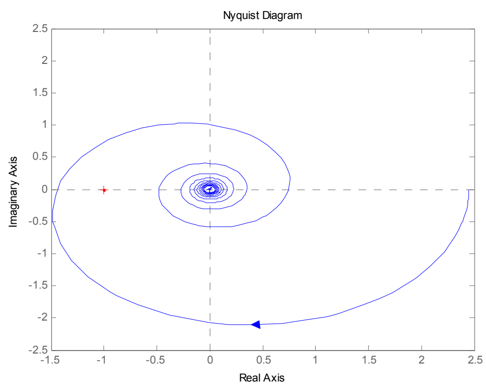
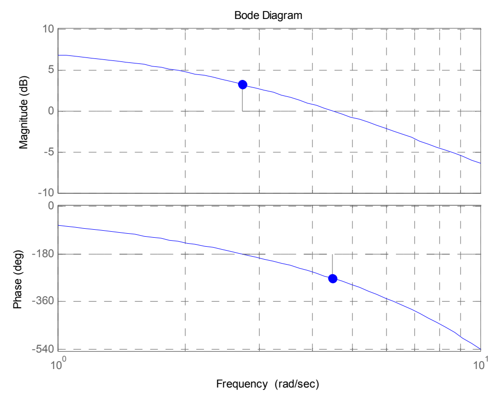
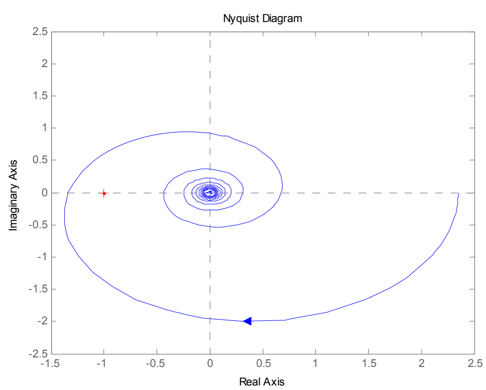
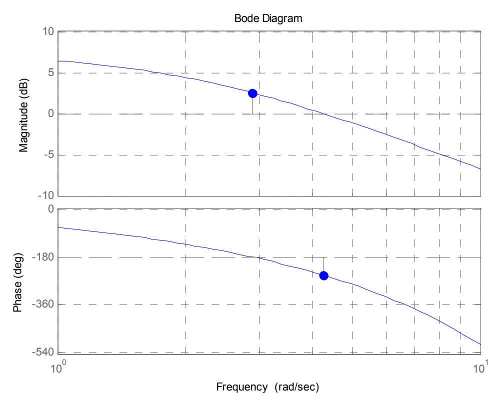
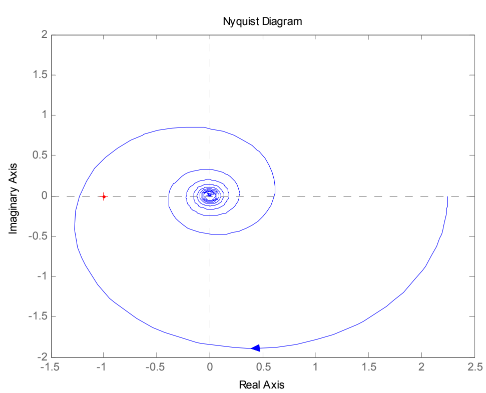
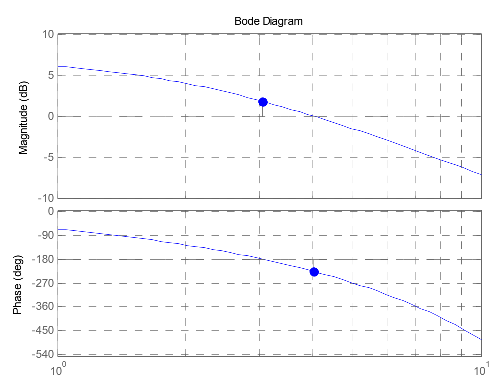
4 Problems

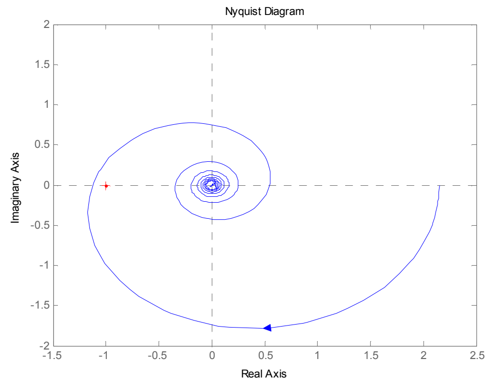
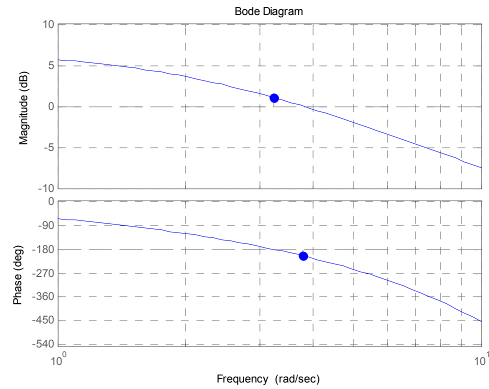
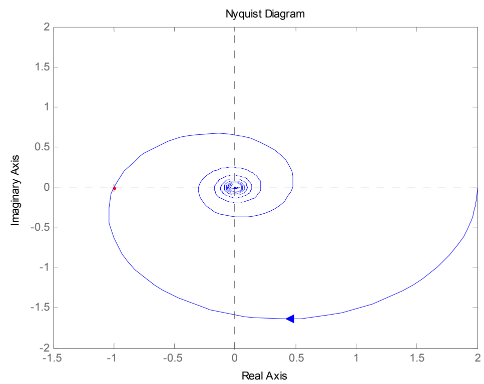
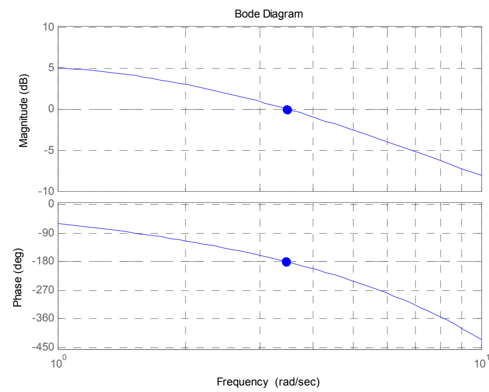
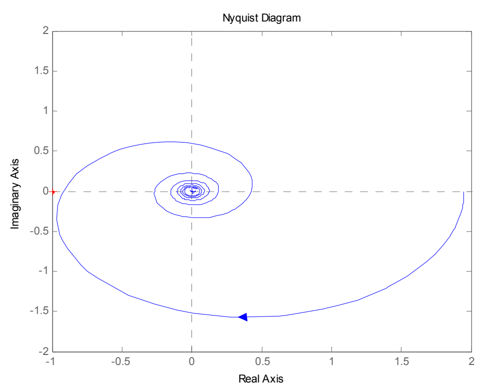
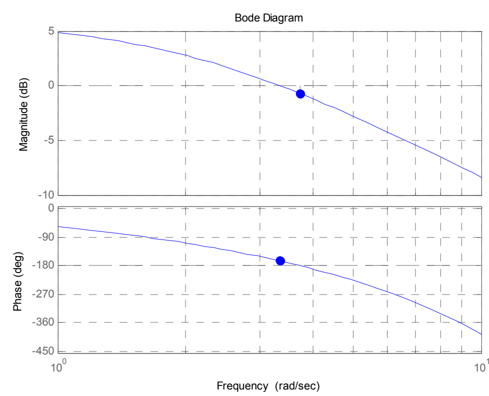
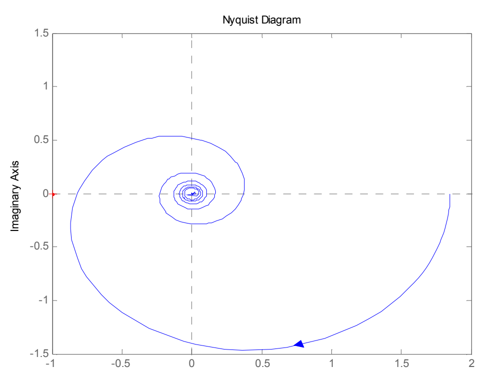
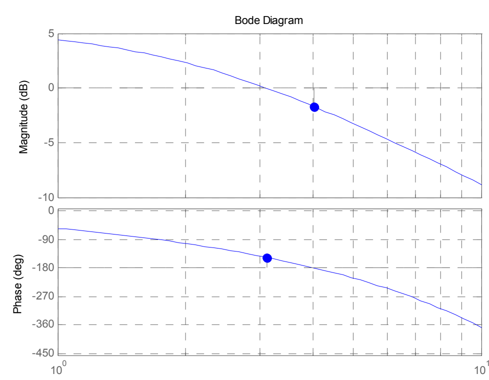
4.1 *Analyze the stability of the negative feedback structure (use simplified Nyquist, drawNyquist diagram in Matlab)*

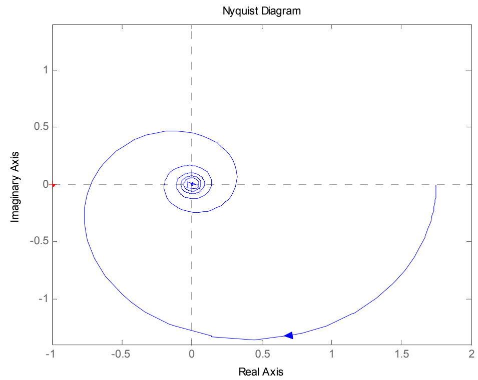
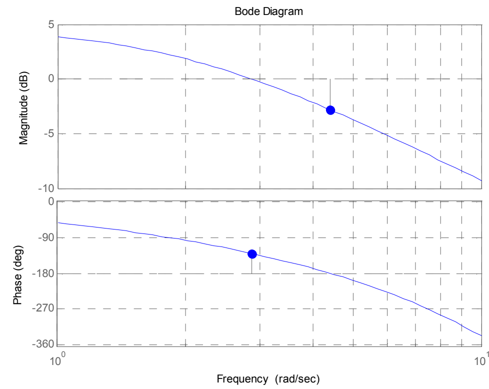
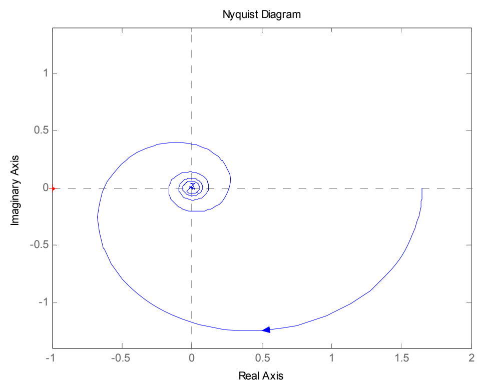
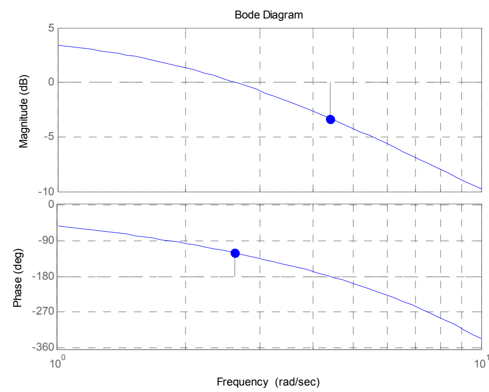
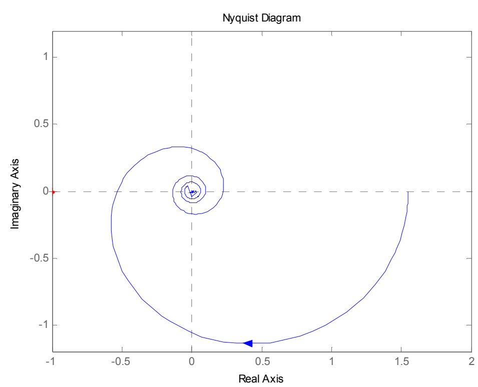
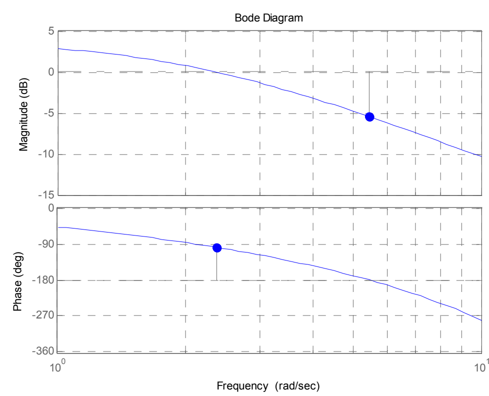
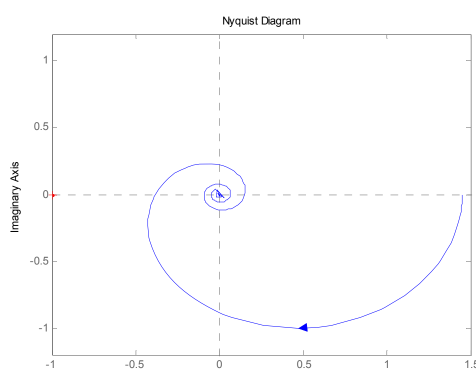
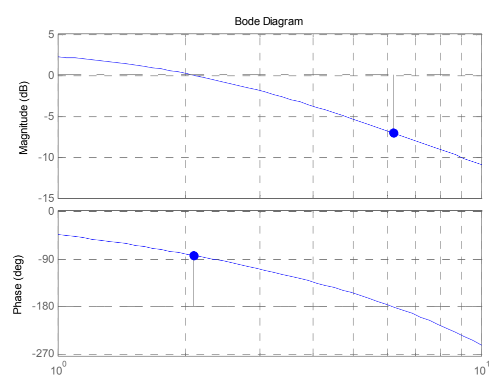


, where $k \geq 0$ şi $H(s) = \dfrac{600}{(s+2)(s+300)} e^{-\tau_m s}$

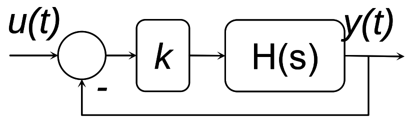
a) Draw Bode of the open loop transfer function (use asymptotes, check the result using Bode from Matlab);
b) Aproximate frequency at –π and ω_t;
c) Compute frequency at –π and ω_t and compare to the results obtained at previous point.
d) Indicate on Bode the phase and gain margin;
e) Compute the two margins.
f) Finally, analyze the stability of the closed loop system.

Nr.	k	τ_m	Nyquist	Ho	Bode
1	2.55	0.85		UNSTABLE	
2	2.45	0.8		I UNSTABLE	
3	2.35	0.75		UNSTABLE	
4	2.25	0.7		UNSTABLE	

5	2.15	0.65		UNSTABLE	
6	2	0.6		Stability Limit	
7	1.95	0.55		STABLE	
8	1.85	0.5		STABLE	

9	1.75	0.45		STABLE	
10	1.65	0.4		STABLE	
11	1.55	0.35		STABLE	
12	1.45	0.3		STABLE	

4.2 *Analyze the stability of the next closed loop system, using the same steps as in the previous problem*



, with $k \geq 0$ şi $H(s) = \frac{600}{s(s+2)(s+300)} e^{-\tau_m s}$