

List 9:

First and Second Order Reference Systems

Behaviour in Time and Frequency Domains

**Sample solution**

**Exercise 1** *LTI System Response*

1. Assuming from the shape of the curve that the system is a 1st order low pass filter, you can then read out the parameters like:

End value = 1 = k (gain) ; because input signal (unit step) has an amplitude of 1

Time constant where curve reaches 63% of end value tau=5s



1. One can describe the stimuli signal u(t) like the sum of two step functions:



Justification:

Sys1 is linear and time invariant, and the output signal y(t) looks like the superposition of two step responses. Therefore one can estimate that the corresponding input signal is the superposition of two step functions, with the same shift and weight observed in the system response.

**Exercise 2** *Block Diagram*

1. 
2. 
3. First order system (1 integrator block). Factor tau calculated above:  .

The output signal q(t) can follow abrupt changes of the input, because this output has a direct throughput from the input signal (feedthrough between input signal u(t) and output signal q(t) –without integrator blocks in between- ).

**Exercise 3** *First Order Systems in Time and Frequency Domains*

SysA : 1st order low pass filter



SysB : 1st order high pass filter



1. Read out the amplitude and phase values by  and calculate then the corresponding effect for yA and yB

SysA Response:



SysB Response:



1. 

|  |  |
| --- | --- |
| This function is the response to p(t) of system B (HPF) because has the same frequency as p(t) and it is not attenuated (in the Bode amplitude read out ~0dB for ω=105 rad/s. | This function is the step response of system A (LPF) because corresponds to the expect form for a 1st order LPF with gain = endvalue = k = 0,1 and time constant tau=20us. |
| This function is the step response of system B (HPF) because corresponds to the expect form for a 1st order HPF with a time constant tau=5us. | This function is the impulse response of system A (LPF) because corresponds to the expect form for a 1st order LPF with time constant tau=20us. Or one can also observe that this curve corresponds to the derivative of the step response. |
| This function is the impulse response of system B (HPF) because corresponds to the expect form for a 1st order HPF with time constant tau=5us. Or one can also observe that this curve corresponds to the derivative of the step response. | This function is the response to p(t) of system A (LPF) because has the same frequency as p(t) and it is attenuated (in the Bode amplitude read out  ~-26dB for ω=105 rad/s) |

**Exercise 4**  *Identifying System Parameters*

(a)

Because from the shape of the curves one can observe that 

Curve 1: step response x1(t)

Curve2: impulse response x2(t)

(b)

impulse envelope curve : 

step oscillating period : 

step final value (Endwert): 

**Exercise 5** *System Representations*

|  |  |  |  |
| --- | --- | --- | --- |
| Impulse Response | Step Response | Frequency Response | Parameter  (1st order: k, τ ;  2nd order: k, d, ω0 ) |
| A | Q | G | 1.Ord : k = 4 ; τ = 0,5.10-3 = 1/2k ; |
| B | R | F | 2.Ord: k = 1 ; d = 0,1; ω0 = 104 ; |
| C | P | E | 1.Ord : k = 1 ; τ = 0,25.10-4 = 1/40k; |