Laboratory "**Modeling and Simulation of Dynamic Systems**"
Institute of the Theory of Electrical Engineering, Measurement and Information Systems, WUT

Exercise No 2
DYNAMICS OF THE SYSTEM ON THE BASIS OF ZERO-POLE LOCATION
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1. The aim of experiments

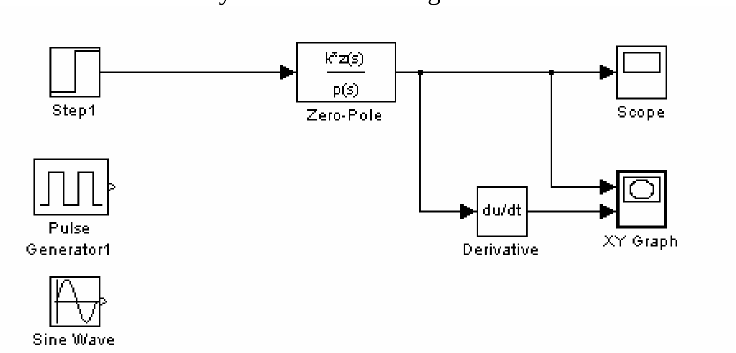
Learning the transient state in dynamic system of different order described by the zeros and poles using SIMULINK.

2. Simulink model of the system

The description of the system is given in the zero-pole form of transfer function described by

$$H(s) = k\frac{\prod_{i}^{m}(s-z_i)}{\prod_{j}^{n}(s-p_j)}$$

Fig. 1 presents the Simulink model of the system under investigation.



Rys. 1 Simulink model of the dynamic systemu

The basic block is **zero-pole** in which the zeros z, poles p and constant k are set up from the level of workspace of Matlab (before starting simulation). Different input excitations are applied:

- function **Step** at step response
- function **Pulse generator** modeling the Dirac impulse (small pulse width, for example 1% of the time interval of simulation)
- function **Sine Wave** at sinusoidal excitation.

3. Program of numerical experiments

The numerical experiments will explore the behavior of the dynamic systems of different order in transient state at zero initial conditions.

3.1 The system of the second order

- Set the positions of two poles , for example p=[-0.3-j*2, -0.3+j*2], no zeros: z=[], k=1
- Simulate the impulse and step responses using Simulink. Find the difference of both responses.
- Simulate the impulse response of the system at different placement of poles

p=[-0.4   -0.9]
p=[0.4   -0.9]
p=[-0.2+j   -0.2-j]
p=[-0.2+5*j   -0.2-5*j]
p=[-1+j -1-j]
p=[1+j   1-j]
p=[j*3   -j*3]
p=[j*3   -j*3 j*3 -j*3]

Observe stability of the system and the character of response in each case.

- For the pair of complex poles p=[-0.05+j*3 -0.05-j*3] simulate the system at sinusoidal excitation. Use the following frequencies of excitation:
  a) $\omega_{sin}=3$
  b) $\omega_{sin}=2.5$
  c) $\omega_{sin}=10$
  d) $\omega_{sin}=0.5$

How does the character of the response change with the frequency of excitation?

3.2 Higher order systems

- Generate the higher order system (N=4, 10, 20) using any of the commands: buttap, cheb1ap, ellipap (read *help* about each of them). For example the command

  [z,p,k]=cheb1ap(4, 0.5)

  will generates the 4th order Chebyshev filter of the ripple equal 0.5 decibels in the passband.
- For each set rank N draw the positions of the poles in the complex plane.
- For each set rank N simulate the step response of the system
- Repeat the same for Butterworh (buttap), Chebyshev 1 (cheb1ap) and elliptic (ellipap) approximations of the filter transfer functions.