

Systems Identification and Simulation

Study programme: N0714A270012 Control of Machines and Processes
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1. Goals and methods of the systems identification and simulation. Basic terms - system, dynamic system, basic dynamic relations, separability principle. Model development process, terms black box, white box, grey box.
2. State model of the dynamic system, general structure. State of the system, steady state, state trajectory, types of the steady states. Linearization around the steady state. Linear dynamic system.
3. Transformation of the transfer function into the state space model of the system – method of the sequential integration, parallel and serial programming. Transformation of the more differential equations and nonlinear differential equation describing the system into the state space model.
4. Typical nonlinearities – characteristics, description and modelling. Limited integration.
5. Curve fitting – approximation of the functions, linear regression, polynomial interpolation, least square method.
6. Interpolation using cubic spline, periodic and cyclic spline function.
7. Numerical integration methods, numerical derivation methods.
8. Numerical methods for solving differential equations – one step methods, multi steps methods. Errors of the numerical solution of the differential equations, estimation of the error.
9. Stability of the numerical solution of the differential equations, stability area of the numerical methods for the solution of differential equations. Stiff systems. A-stable methods.
10. Mathematical-physical modelling, mathematical similarity, physical similarity, physical analogy.
11. Basic principles and laws used by the modelling of the mechanical systems doing linear and rotating motion. Mechanical elements and their use by the modelling.
12. Modelling of the systems with more degrees of freedom, Lagrange's equations.
13. Basic principles of the modelling of the electrical systems, used physical laws and methods by the modelling of the dynamic properties – example DC-motor with permanent magnet.
14. Mathematical models of the basic circuits with operational amplifiers. Op-amp properties, realization of the transfer functions – controllers, filters.
15. Basic principles and laws of the modelling of the hydraulic systems. Modelling of the tank systems, control of the liquid level position.
16. Modelling of the fluid power systems. Hydraulic resistances. Mathematical model of the hydraulic cylinder, flow control valves.
17. Modelling of the thermal processes. Types of the heat transfer – conduction, convection, radiation. Mathematical model of the vessel with thermal capacity and thermal losses.
18. Deterministic method of the experimental identification – used input signals, technical feasibility. Evaluation of the step response to the rectangular impulse and to the ramp signal.
19. Step response approximation (Strejc's methods), approximation of the step response with time delay.
20. Step response and impulse response parameterisation methods.

21. Experimental methods of the evaluation of the frequency response (Bode plot).
22. Stochastic methods of the identification. Random process, stationary process, ergodic process, white noise. Testing signals, pseudo random signals. Characteristics of the realization of the random signal (average value, variance, probability density function, distribution function. Auto-correlation function, cross-correlation function. Power spectral density.
23. System identification using the random signal, Wiener-Hopf equation. Evaluation of the impulse and step response.
24. Mathematical models of the random process AR, ARMA and of the dynamic systems ARX, ARMAX. Evaluation of the model parameters using the least square method, weighting coefficients, exponential forgetting. Recursive methods of the identification.
25. Simulation programmes – classification, (equation oriented, block diagrams oriented, physical modelling. MATLAB-Simulink. Application of the simulation models by the design and testing of the control systems. Hardware in the Loop Simulation, hardware for the real time simulation (dSPACE).