Manufacturing systems and processes - Automated control systems

Programming languages

- Programming languages C and C++, Basic control structures of these languages (cycles, conditioning, switching); operators; user functions;
- Basic data types; structured data types (array, structure, class); data type pointer;
- Memory allocation, dynamic allocation and deallocation of memory; pointer to a function; macros, conditioned compiling; user libraries; manipulation with objects.

Theory of automatic control

- Description of dynamic systems: differential equation, transfer function, step and impulse response, gain, time constants, the influence of transfer function roots on the dynamic behaviour of a system; classification of dynamic systems; the use of Laplace transformation.
- Frequency analysis: frequency response function, Nyquist diagram for static and astatic dynamic systems, the influence of transport delay on Nyquist diagram, Bode plot, measurement of Nyquist diagram and Bode plot.
- Block diagrams; methods for finding the overall transfer function of a dynamic system described by a block diagram.
- Stability of dynamic systems, required and sufficient conditions of stability, the influence of transfer function roots on stability, algebraic and frequency stability criteria.
- Automation, operating and control; closed-loop control system, feedback, types of disturbances, the transfer function of closed-loop control system; classification of controllers.
- Control loops with two-position controllers and three-position controllers; ways for improvement of the controlled process.
- PID controller: differential equation, transfer function, step response, Nyquist diagram, Bode plot, properties of PID controller.
- Tuning of PID controller, the influence of its components on the controlled process; stability regions of PID controller.
- Experimental and empirical tuning methods for PID controller; integral criteria of the quality of controlled process, tuning with the respect to these criteria.
- Discrete description of dynamic systems, difference equation and its solution, stability of discrete systems.
- State-space, state-space representation of dynamic systems, the transformation between external description (e.g. transfer function, differential/difference equation) and state-space model;the choice of phase; state trajectory.
- State-space controller, basic principle, the model (scheme) of state-space controller;measurable and unmeasurable state variables;state-space controller with the additional integrating component.
- State estimation;the model (scheme) and basic principle of state space controller with state estimator.
- PSD controller, discrete control loop; transformation between PSD and PID controller;the difference between absolute and incremental control variable.

Computer Graphics

- Basic algorithms of raster graphics, rasterization of a line, a circle and an ellipse; trimming and filling in of polygons.
- Parametric curves in computer graphics; explicit, implicit and parametric representation;Ferguson curve, Coons curve,Bezier curve; parametric surfaces and their representation; Ferguson surface, Coons surface, Bezier surface, line surface.
- Geometric modelling, 3D representation of objects, boundary representation, octant tree, constructive solid geometry, rendering of spatial scene, projection methods, shadding, coloured models.
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Algorithms and data structures

- Specification of simple data types (integer and real number, text)
- Specifying and using the following abstract data types: stack, queue, lists, and trees.
- Recursion and recursive algorithms and their use; data encoding; sorting algorithms; Numerical derivation and integration;

Simulation and identification of systems

- Matlab-Simulink: tools for simulation of the behaviour of dynamic systems; solving of differential equations using simulation schemes: method of decreasing of the derivative order and method of gradual integration, recalculation of initial conditions.
- Methods for obtaining a model of dynamic systems: analytical approach (using underlying physical principles and mathematical derivations) and experimental approach (system identification); basic implementation steps of analytical approach.
- Basic implementation steps of system identification; measurement of static characteristics, step and impulse responses; approximation of step responses; process models; parameter estimation in continuous models of dynamic systems.
- Discrete parametric identification; parameter estimation in deterministic systems; the use of least squares method; polynomial models.