

Topics for Master degree State Final Exam

Mechatronics

2022/23

Thematic domains A – General Mechatronics Knowledge Base

1. Electromagnetism - lumped versus distributed electrical circuits, electromagnetic components, Maxwell's equations, static electric field, steady electric currents, static magnetic field, sine-varying fields and Maxwell's equations, transient response of transmission lines, electromagnetic waves. Electromagnetic compatibility.
2. Rotary and stationary electrical machinery (DC machine, synchronous and asynchronous machine, one-phase and three phase transformers, special machines - stepper motors, linear motors), electric drives, principles of their operation, basic equations, basic properties.
3. Basic principles of frequency converters, HW arrangement, recuperation of electric energy, Indirect frequency converter with current- and voltage-source DC-link, switching diagram, direct converters, matrix converter, three-phase pulse-width modulation (synchronous-asynchronous, unipolar-bipolar).
4. Electric servomechanisms, common diagram of servomechanisms, sensors, actuators, controllers, mechanical nodes linked to the electric drives, multidrive application, industrial BUS systems.
5. Measurement of mechanical strain with strain gauges. Design and principles of operation of strain gauges. Metallic and semiconductor strain gauges. Gauge factor, temperature dependence.
6. Measurement of small resistance variations using Wheatstone bridge - quarter-bridge, half-bridge, full bridge. Temperature compensation.
7. Measurement of angle, angular velocity and angular acceleration, absolute and relative rotation displacement.
8. Measurement of three-phase current, three-phase voltages, measurement of three-phase power.
9. Measurement of acceleration and force, measurement of torsion moment, strain-gauge sensors of forces.
10. Intelligent robotics, motion planning, action plans, task planning, obstacles and their representation.



Thematic domains B – Control System in Mechatronics

11. PLC system, description of properties and architecture. PLC types, basic principles of the operation, programming possibilities and languages.
12. PLC systems and communication. Types of the industrial buses and its typical using. Distributed systems and remote peripheral devices. Interface between PLC systems and operators. Visualization of the control system state.
13. PLC open motion control, single axis control, multi axis control, synchronized motions, motion safety. Gearboxes.
14. Continuous dynamic systems: linear and nonlinear, model description, differential equations, state-space representation, linearization, principle of superposition. Basic system properties (order, gain, characteristic equation, stability, steady state).
15. Linear system responses in time domain: transfer function, poles, zeros. Input: step, unit impulse and ramp function. Time-delay systems. Discrete time system description, Z-transformation.
16. Linear system responses in frequency domain: frequency transfer function, Nyquist and Bode plots, Nyquist stability criterion, gain and phase margin. Laplace transform: application to model description and signal analysis.
17. Stability of continuous systems: algebraic and frequency stability criteria (Routh-Hurwitz, Nyquist criterion). Stability of feedback systems and systems with time delay.
18. Control system configuration, PID controllers, feedback system sensitivity, feedback responses, steady-state error, tuning of PID controllers.
19. State space description of Linear Systems, Stability, Observability, Controllability. State space control, estimation of states.

Thematic domains C – Signal Processing and Image Processing

20. Industrial communication systems, serial communication layer (RS-232, RS-485, CAN), communication protocols (CAN, Profibus, Profinet, ...).
21. Discrete time Fourier transform, correlation, convolution.
22. Digital filter, sampling, FIR filter, IIR filter.
23. Information entropy of information sources/messages, Huffman code.
24. Image acquisition and representation, image digitalization.
25. Preprocessing: transformations of pixel brightness, camera calibration, filter operations, convolution-filters, morphological filters.
26. Feature extraction: color, texture and shape descriptors.
27. Edge detectors, segmentation. Morphology. Region identification.

