Experimental Methods of Mechatronics

Study programme: N0714A270004 Mechatronics
Academic year: 2024/2025

1. Static and dynamic properties of the elements of the measuring and control circuits, static characteristics and their approximation, sensitivity, accuracy, step, impulse and frequency responses.
2. Sensors and transducers - Structure and properties, range, accuracy, physical principles and sensor parameters, development trends.
3. Methods and sensors for measuring dimensions, length, presence of objects, position, level (principles of the main types of sensors for these quantities, measurement ranges, errors, examples of applications).
4. Methods and sensors for measurement of the flow rate and pressure of gases, liquids (principles and design of sensors, comparison of properties, measurement ranges, examples of the use).
5. Methods and sensors for temperature and heat measurement (physical principles and types of sensors, comparison of properties, contact and non-contact measurements, ranges and examples of their use).
6. Methods and sensors for measuring velocity, speed, mass, forces, torques and vibrations (basic principles and types of sensors, measurement ranges, examples of their use).
7. Microprocessors and single-chip microcomputers (PIC, architecture, comparison of hardware and software features, current trends in this area).
8. Basic relations and laws used for the identification of mechanical systems during linear and rotational motion, identification of mechanical systems with multiple degrees of freedom, modelling of flexible and rigid connection of elements of the mechanism. Lagrange equations of the 2nd kind.
9. Basic procedures for identifying electrical systems and used physical laws and methods. Their use in creating a model of the dynamic properties of a DC motor which is excited electrically with a field coil or with the use of a permanent magnet.
10. Basic relationships and laws used to identify hydro mechanical systems. Application of basic relations for the modelling liquid outflow from vessels, control of the liquid level inside the vessels or tanks.
11. Experimental identification methods based on step responses. Input signals, selection of replacement models, evaluation of the step responses by methods of their approximation and parameterization, advantages and disadvantages of the use of each of the selected models, possibilities of the use in technical practice. (Strejc's method, approximation of the step response of systems with a transportation delay, methods of parameterization of the step responses, method that uses a chain of integrators for step-by-stem reducing the derivative order of variables, numerical integration, selection of approximation models),
12. Use of harmonic signals to identify dynamic system properties. Description of harmonic signals, the response of dynamic systems to the test signals (harmonic, impulse, noise) at the input of the dynamic system. Measurement and evaluation of the frequency response function. Calculation of the transfer function coefficients from a measured frequency response function. Experimental methods of the evaluation of the frequency response functions.
13. Stochastic methods of identification - basic concepts - random process, stochastic formulation of dynamic system model. Determination of the weight function using random signals. Wiener - Hopf

equation. Advantages and disadvantages of stochastic methods, possibilities of their application in technical practice.

14. Mathematical models of the random process (sequence) (AR, ARMA and ARIMA) and system (ARX, ARMAX) and their use. Determination of the coefficients by the least squares method, weighted coefficients determining the past measurements, recursive procedure for the identification of the continuously operating systems, exponential forgetting.
15. Estimation of the model parameters in a closed control circuit. Meaning and area of application of the methods, their classification and characteristics. Direct and indirect identification. Identification with the use of an additional signal and without it.
16. A / D and D / A converters, quantization noise, signal-to-noise ratio. Frequency range of the measurement, Shannon-Kotelnik's sampling theorem and aliasing in frequency spectra. Nyquist frequency. Antialiasing filter.
17. Analog and digital frequency filters. Filter type and parameters, pass-band, stop-band, and transition band, ripple in pass and stop band of the frequency range. What is the difference between FIR and IIR filters? What is the effect of the linear dependency of the phase of the filter transfer function on the frequency.
18. Fourier transform (FT) direct and inverse, properties of the transform (symmetry of components with respect to Nyquist frequency), degree of acceleration of FT calculation by FFT method. What is RMS, PWR and PSD.
19. Averaging the frequency spectra and time records. Optimal overlap of the records for calculation of FFT when calculating averaged spectra. Meaning of the time windows and their types (Rectangular, Hanning and Flat Top) and their suitability for measuring and calibrating sensors with a sinusoidal signal. Explain the terms (abbreviations) RMS, PWR and PSD and where they are used.
20. Frequency spectrum and correlation function of the Dirac impulse and white noise. Use of them for measuring frequency response functions.
21. Order analysis of rotary machines. Tacho signal measurement to calculate machine rotational speed. Sampling rate control to be proportional to the rotational speed. Resampling the signal to a constant number of samples per revolution.
22. Special sensors for dynamic force, torque, vibration (displacement, velocity and acceleration) and noise (sound pressure). Charge amplifiers for piezoelectric accelerometers, The analysers and multifunction inputs of the CCLD (IEPE) type for supplying the internal electronic of the sensor. Rotational speed measurement for machine diagnostics, MEMs sensors. What is the TEDS - Transducer Electronic Data Sheet?

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