
Mechanical vibrations A

Finalità

The course gives the basics for the theoretical vibration analysis of lumped parameter systems and for the experimental study of vibration of mechanical systems.

Programma

1. Vibrations of single-degree-of-freedom systems. Free and forced vibrations. Base excitation.
2. Linear systems, convolution integral and impulsive response. Integral transforms (Fourier and Laplace). Transfer function. Fourier series. Response of a damped single-degree-of-freedom system to generic excitation.
3. Discrete Fourier transform. Shannon theorem. Introduction to FFT. Aliasing, leakage and time windows.
4. Power spectral energy. Autopower spectrum and autocorrelation function. Cross-power spectrum and cross-correlation function. Averaging. Frequency response function (H1, H2 and HV). Coherence. Introduction to nonlinear systems: hardening and softening systems.
5. Condition monitoring of machines by vibration measurement. Application to rotating machines: imbalance, misalignment, runout, looseness, resonances. Damage of gearboxes and rolling-element bearings.
6. Vibrations of multi-degree-of-freedom systems. Equations of motion in matrix form. Free vibrations of conservative systems; reduction to a standard eigenvalue problem. Dynamic vibration absorber. Definite and semidefinite matrices. Properties of natural frequencies and modes. Normalization, orthogonality, expansion theorem. Linear transformation of coordinates; natural coordinates. Forced vibrations of conservative systems. Proportional damping. General damping and solution by transition matrix. Complex modes. Applications.
7. Experimental measurement of vibrations in laboratory. Measurement of time-varying signals, autopower spectrum, FRF, coherence. Experimental set-up. Instrumentations: accelerometers, force transducers, hammer for modal tests, electrodynamic exciter (shaker), power and charge amplifiers, front-end.

Attività d'esercitazione

Guided experiences finalized to the use of equipment for vibration measurement.

Modalità d'esame

Written exam on the program that can be integrated with assignments and reports of laboratory experiences.

Testi consigliati

- L. MEIROVITCH, 1986, Elements of Vibration Analysis, 2nd edition, McGraw Hill.
P. SAS (editore), 1992, Course on Modal Analysis, Theory and Practice, Vol. 1 e 2, Katholieke Universiteit Leuven.
R. GARZIERA 1998, Introduzione alla diagnostica dei sistemi meccanici, dispensa del corso.