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# Linear Multivariable Systems

## Finalità

The purpose of the course is the presentation of the fundamental concepts of system theory with particular reference to the time-invariant systems.

Some methods of analysis are introduced for applications in different sectors of the engineering with particular attention to the problems of the industrial automation.

## Programma

Linear algebra and matrixes theory: Vector spaces and linear transformations. Matrixes, eigenvalues and eigenvectors, normed vector spaces. Norm of a matrix.

Dynamical systems: Introduction and generality. Input-output description and internal description of continuous time systems and discrete time systems. Linear time-varying systems. Controllability and observability.

Multi-input/multi-output, linear and time-invariant systems: State and output evolution. State transition matrix and exponential matrix. Behaviour of the discrete-time systems. Impulse response matrix. The Z-Transform. Sampled data systems. Stability of linear systems. Equivalence of systems.

Controllability and Observability: General concepts. Reachability and Controllability. The reachability and controllability Gramian. Reachable subspace. Controllability test. Observability and Constructability. The observability and constructability Gramian. Unobservable subspace. Test of observability. Standard form of reachability and observability. Kalman decomposition. Standard form of controller and observer. Poles and zeros of a time-invariant system. Input-output stability.

State feedback and state observers: Linear state feedback. Eigenvalues assignment. Ackermann's formula. Optimal control. Asymptotic state estimators. Observer based dynamic controllers: separation property.

Realization theory: Markov parameters. Minimality of realizations. Poles polynomial and order of minimal realization. Realizations in Controller Form and Observer Form

## Testi consigliati

- 1) S. Rinaldi, C. Piccardi - I Sistemi Lineari: Teoria, Modelli, Applicazioni. UTET, 1997.
- 2) P.J. Antsaklis, A.N. Michel - Linear Systems. McGraw-Hill, 1997.
- 3) G. Basile, G. Marro - Controlled and Conditioned Invariants in Linear System Theory. Prentice-Hall, 1992.