

Control Instrumentation System

DI03000181

Gujarat Technological University

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Lecture Overview & Background of Control Engineering I

Historical Evolution & Context

Control engineering plays a crucial role in modern industrial technology. From early mechanical regulators like James Watt's centrifugal governor to digital Distributed Control Systems (DCS) and Programmable Logic Controllers (PLCs), control systems ensure precision, safety, and efficiency.

- **Interdisciplinary Scope:** Combines electrical, mechanical, chemical, and computer engineering principles.
- **Automation Impact:** Reduces human error, optimizes energy consumption, and maintains operational consistency.
- **Core Definition:** Systematic manipulation of physical quantities to achieve desired system behaviors.

Lecture Overview & Background of Control Engineering II

Fundamental System Mapping

Mathematically, a dynamic physical system maps an dynamic input signal $u(t)$ to an output response $y(t)$:

$$y(t) = \mathcal{T}\{u(t)\}$$

where $\mathcal{T}$ represents the dynamic transfer operator governing physical state transitions.

What is Control Instrumentation?

Control Instrumentation is the branch of engineering focused on measuring physical variables (e.g., temperature, pressure, flow rate, level, speed) and processing these measurements to automatically manipulate system behavior.

- **Measurement / Sensing:** Sensing physical variables using calibrated transducers.
- **Signal Conditioning & Transmission:** Amplifying, filtering, and converting signals (e.g., 4–20 mA standard current loop).
- **Computation & Control:** Evaluating error $e(t) = r(t) - y(t)$ and determining control law commands.
- **Actuation:** Converting low-power electrical/pneumatic control outputs into physical action.

Primary Engineering Objectives

- 1 **Stability:** Ensuring system variables remain bounded under all operating conditions.
- 2 **Accuracy:** Minimizing steady-state deviation from reference setpoints.
- 3 **Speed of Response:** Achieving fast transient settling times without excessive overshoot.
- 4 **Disturbance Rejection:** Attenuating environmental noise and load variations.