Structural Control

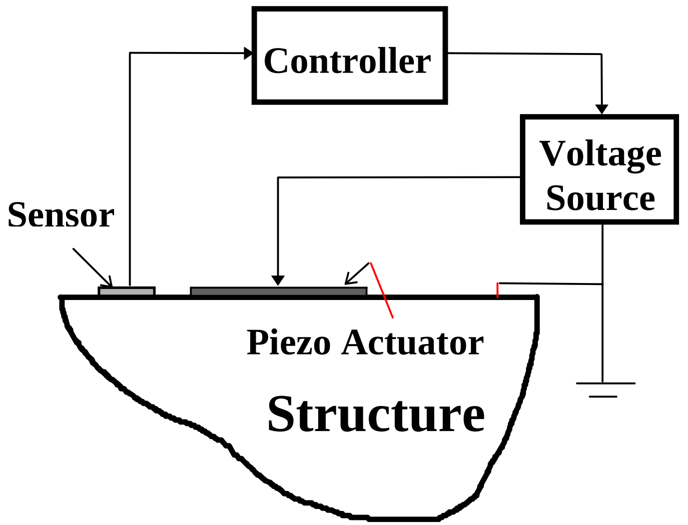
- Passive control :
  - Parameters are synthesized off-line
  - Stable, no power requirement
  - Fixed design, no feedback
- Active control :
  - Force actuators are used
  - Feedback, high performance
  - High power requirement, potential for instability

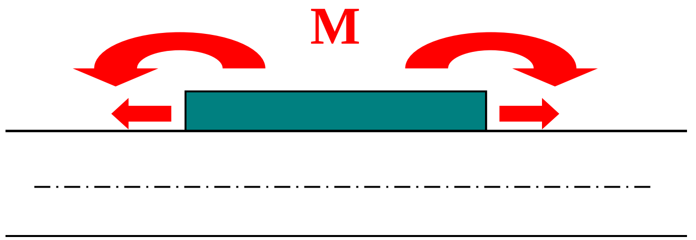
Structural Control

- Active-passive hybrid control :
  - Integrate active systems with well-designed passive elements
- Semi-active control :
  - Parameters are controllable
  - Adaptable energy dissipation devices

⇨ Combine the advantages of both active (feedback, high performance) and passive (stable, fail-safe) systems

Active Vibration Control

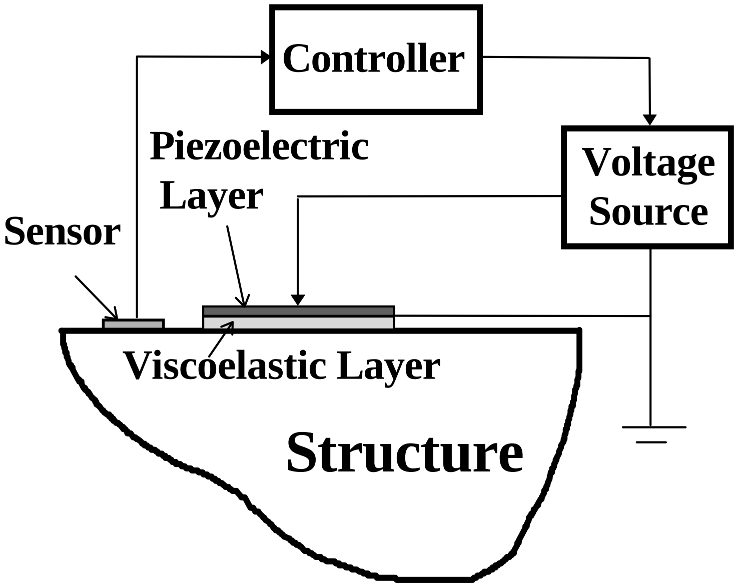


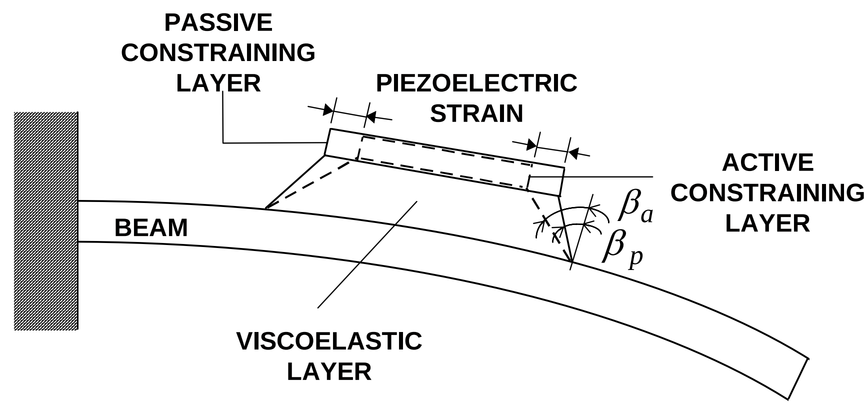


- Piezoelectric materials have shown to be effective active structural control elements:

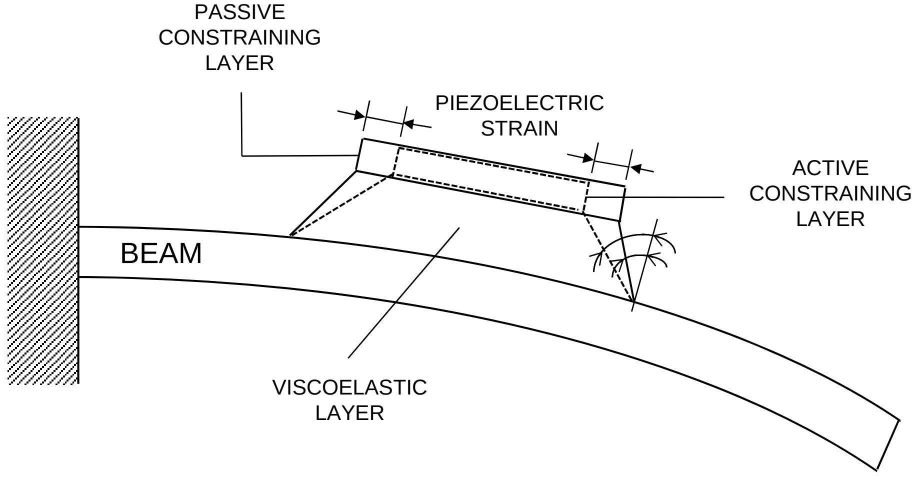
  Apply voltage => induce stress and moments

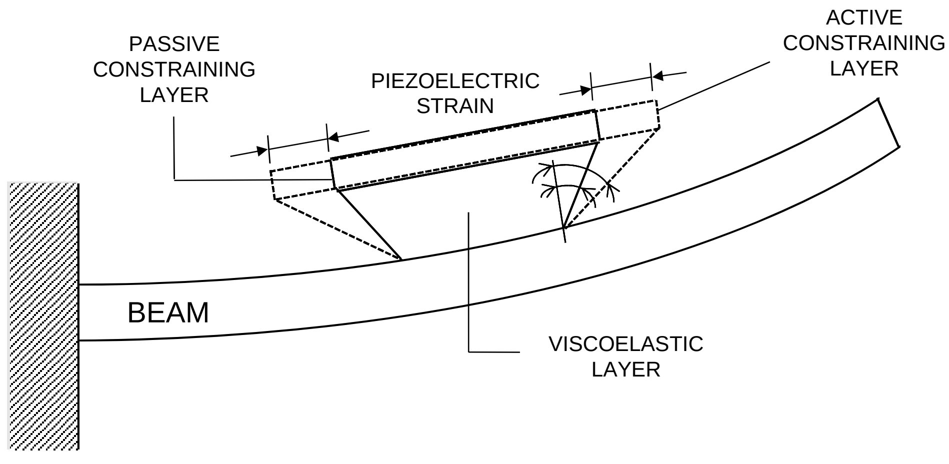
Active Constrained Layer (ACL) Damping Treatment - An Active-Passive Hybrid Approach



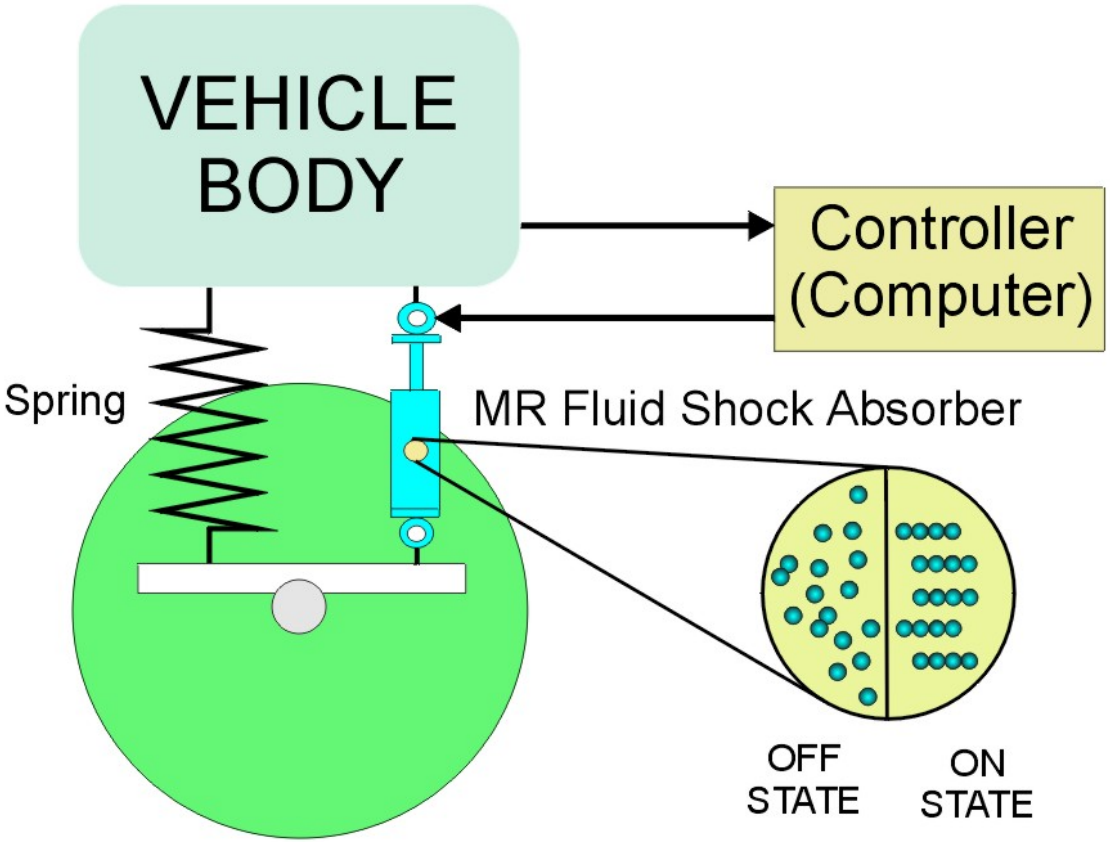


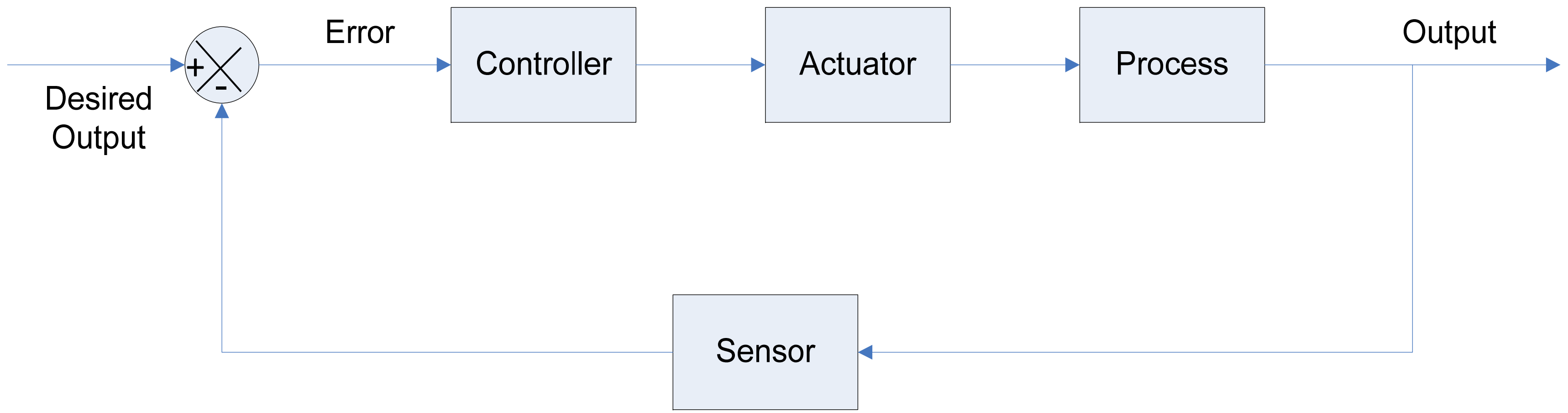
- Active piezoelectric cover sheet on passive viscoelastic constrained damping layer
- Active actions increase shear angle & enhance system damping


PASSIVE CONSTRAINING LAYER
PIEZOELECTRIC STRAIN
ACTIVE CONSTRAINING LAYER
BEAM
VISCOELASTIC LAYER


ACTIVE CONSTRAINING LAYER
PASSIVE CONSTRAINING LAYER
PIEZOELECTRIC STRAIN
BEAM
VISCOELASTIC LAYER

Semi-Active Suspension System





Block diagram of the control system

- Transducers: energy-conversion devices including sensors and actuators
  - Sensors: acquire information from the system
  - Actuators: output actions into the system
  - Smart actuators and sensors: actuators and sensors with the use of smart materials

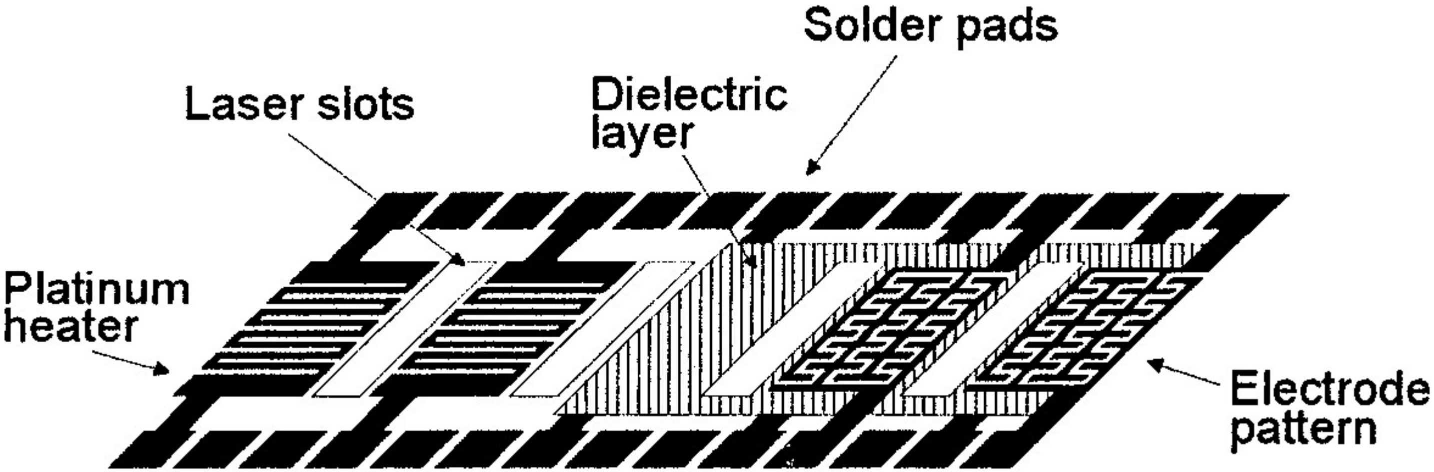
Transduction Devices for Smart Structures

- Accelerometer (sensor)
- Electrodynamic shaker (actuator)
- Electrorheological fluid (actuator)
- Electrostrictive material (actuator)
- Magnetorheological fluid (actuator)
- Magnetostrictive material (actuator)
- Optical fibers (sensor)
- Piezoelectric material (actuator or sensor)
- Shape memory alloy (actuator or sensor)
- Strain gauge (sensor)

- Major defects in primary sensors:
  - nonlinearity
  - cross-sensitivity
  - noise
  - parameter drift

- Some techniques for compensating the defects:
  - linearization processes are realizable with digital electronics
  - the material forming the sensor is physically organized to maximize the sensitivity of the device to the target variable and to minimize the response to all other physical variables
  - use sensor array approach

  e.g. *chemiresistors* (chemically sensitive resistors)



An example of an array of chemiresistors fabricated using thick-film techniques. The slots are cut by a laser and help to isolate each sensor site from its neighbors

- Some techniques for compensating the defects: (cont.)
  - use filters (analog or digital)
  - positioning is critical
  - prefer self-test and auto-calibration features
  - the entire compensation and communication system can be constructed in single-chip form

- Actuators:
  - Output quantity is an energy or power, often in the form of mechanical work
  - Input of the actuator is driven electrically whenever possible
  - Connected in series with a power provider (power amplifier)
  - Considerations: Required control authority (amount of control force, moment, strain or displacement, etc), power consumption, frequency response, and physical constraints such as size and mounting requirements, etc.

- Smart Actuators:
  - Solid-state actuators: piezoelectric actuators, shape memory actuators, magnetostrictive actuators
  - Actuators with controllable fluids (smart fluids): magnetorheological fluid actuators, electrorheological fluid actuators