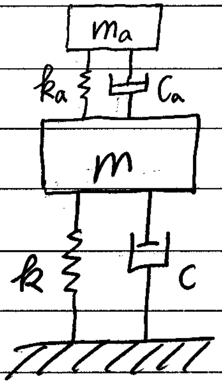
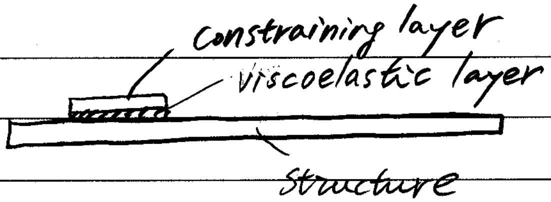
General Structural System (Lumped-Parameter):

$$M\ddot{x} + C\dot{x} + Kx = F(t)$$

- Passive Control
  - parameters (M, C, K) are synthesized off-line
  - stable, no power requirement
  - fixed design, no feedback
  - examples

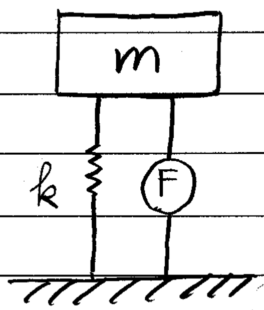


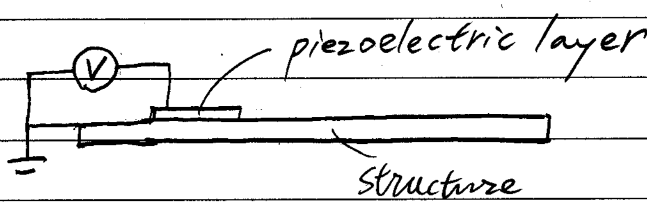
Vibration Absorber



(Passive) Constrained Layer Damping Treatment

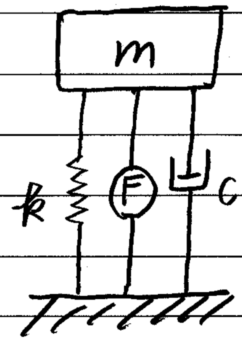
- Active Control
  - force actuators are used
  - feedback, high performance
  - high power requirement, potential for instability
  - examples

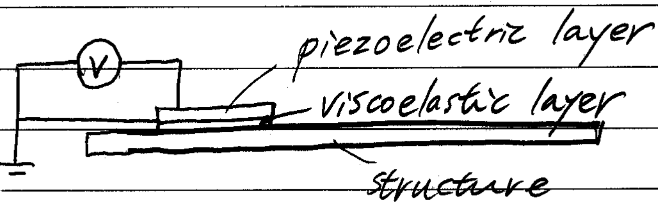




- Active-Passive Control
  - integrate active systems with well-designed passive elements
  - combine the advantages of both active (feedback, high performance) and passive (stable, fail-safe) systems
  - low power requirement

- examples



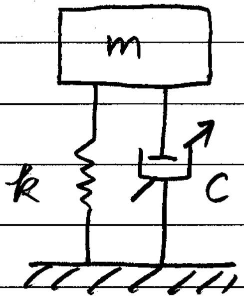


Active Constrained Layer (ACL)
Damping Treatment

- Semi-Active Control

  - parameters (M, C, K) are controllable

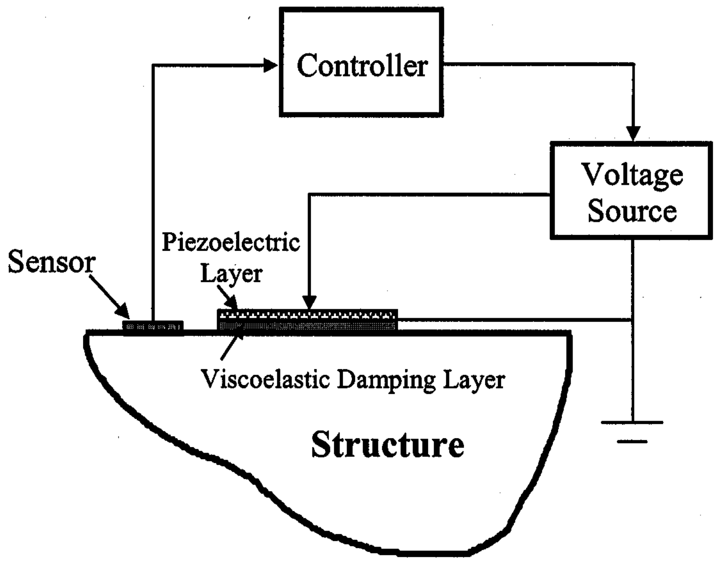
e.g., adaptable energy dissipation devices



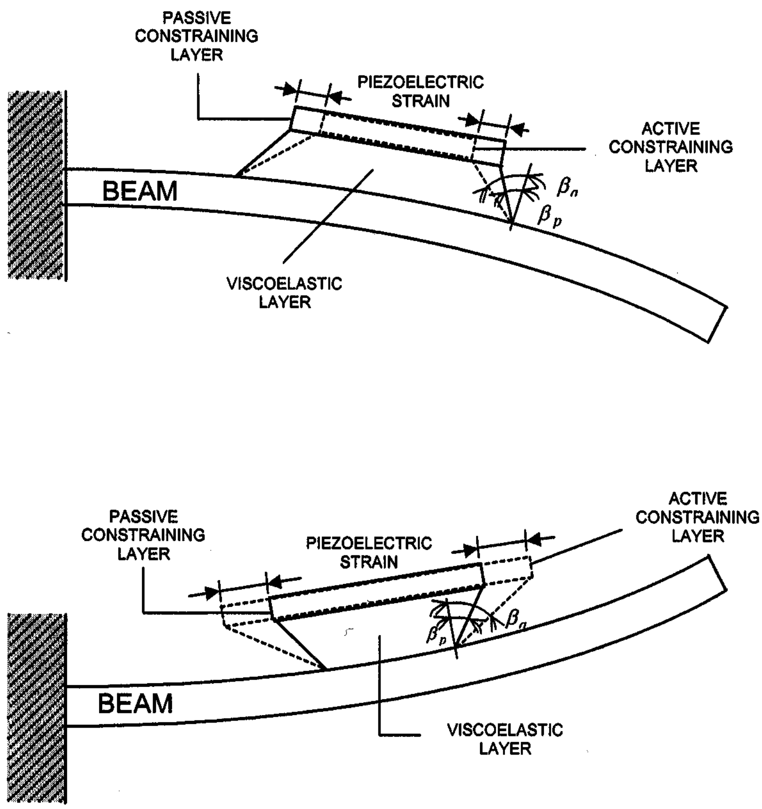
controllable damper
such as MR damper

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

  - low power requirement



Structure with the active constrained layer (ACL) damping treatment



Operating principle of the ACL treatment

$$M\ddot{q} + C\dot{q} + Kq = f(t) \qquad (a)$$

where M, C, K are mass, damping, and stiffness matrices $(N \times N)$

q is vector of generalized coordinates $(N \times 1)$

f is vector of generalized force $(N \times 1)$

Introducing the state vector

$$X(t) = \left\{ \begin{array}{c} q(t) \\ \hline \dot{q}(t) \end{array} \right\} \qquad (b)$$

We can rewrite eq. (a) in state space form:

$$\begin{aligned} \dot{x} &= Ax + Bu \\ y &= C_0 x + Du \end{aligned} \qquad (c)$$

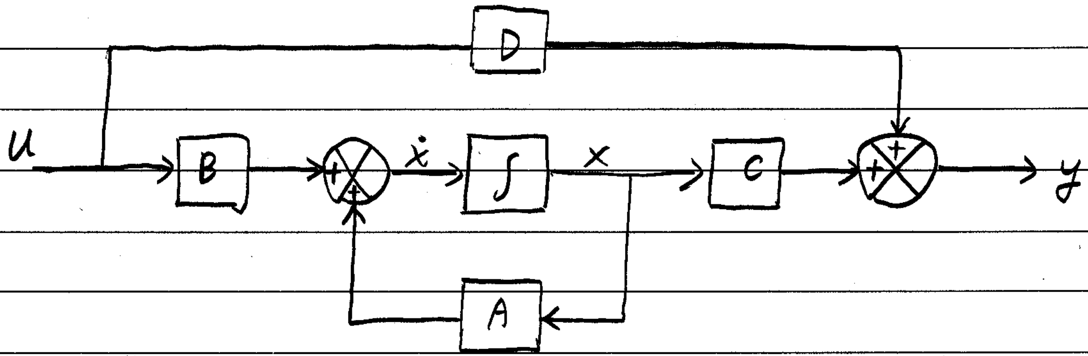
where

$$A = \left[\begin{array}{c|c} 0 & I \\ \hline -M^{-1}K & -M^{-1}C \end{array} \right] \qquad (d)$$

$$B = \left[\begin{array}{c} 0 \\ \hline M^{-1} \end{array} \right] \quad \text{for} \quad u = f(t)$$

$$\dot{x}(t) = Ax(t) + Bu(t)$$

$$y(t) = Cx(t) + Du(t) \qquad (*)$$



Block Diagram