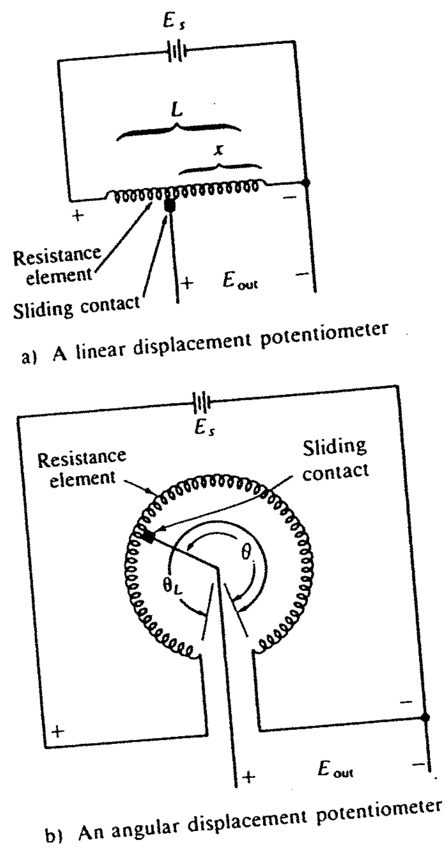
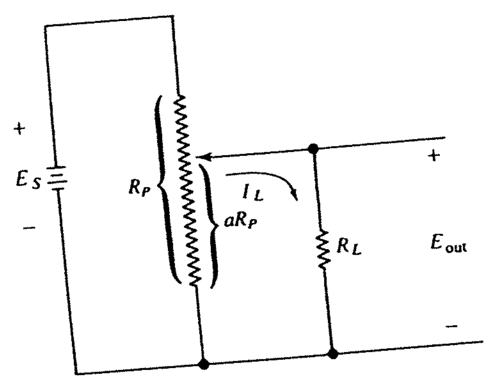


◆ **Figure 7.3** Two types of potentiometric displacement sensors: (a) linear; (b) angular. In both types, E_{out} is a measure of the position of the sliding contact.



◆ **Figure 7.4** A loading error is produced in a potentiometer when a load resistor is connected between the sliding contact and the reference terminal.

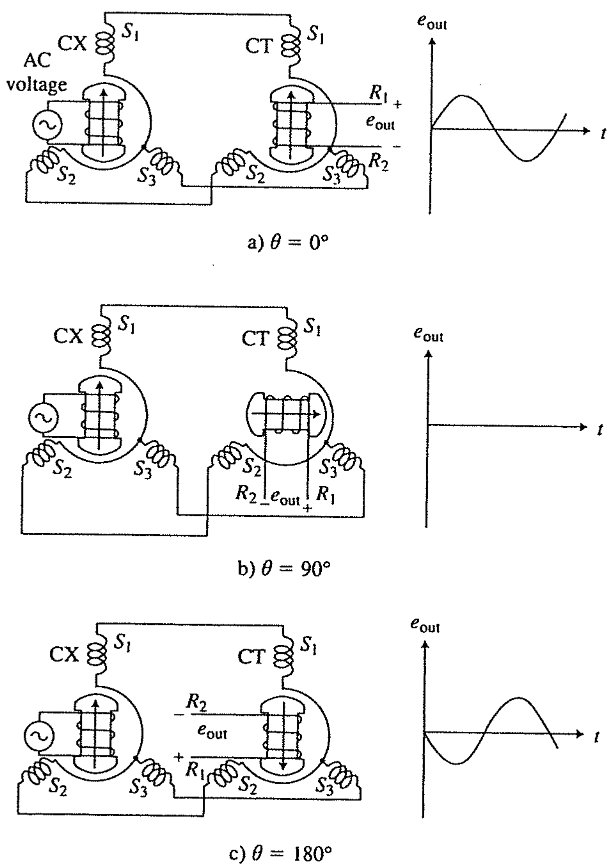
tiometer and a is the proportionate position of the sliding contact, then aR_p is the resistance of the portion of the potentiometer between the sliding contact and the reference point. The load resistor, R_L, is connected in parallel with resistance aR_p. The equivalent resistance of this parallel combination is $(R_L)(aR_p)/(R_L + aR_p)$.

Synchro Systems

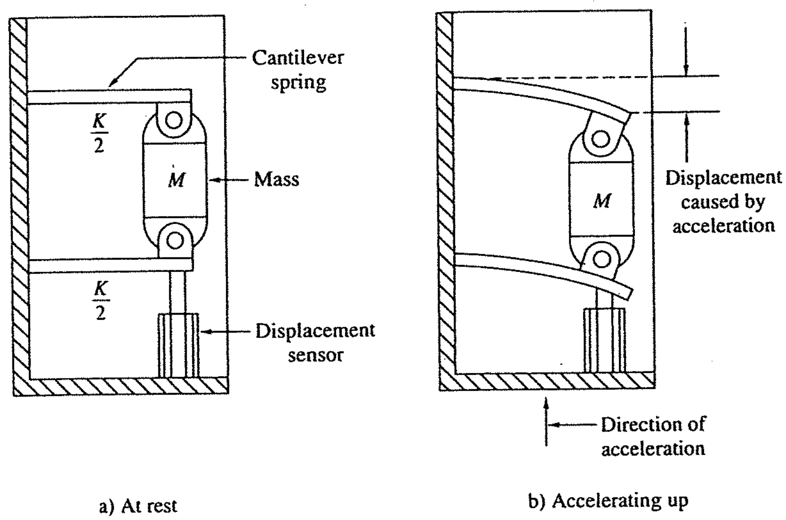
A *synchro* is a rotary transducer that converts angular displacement into an ac voltage, or an ac voltage into an angular displacement. Three different types of synchros are used in angular displacement transducers: control transmitter, control transformer, and control differential.

Synchros are used in groups of two or three to provide a means of measuring angular displacement. For example, a control transmitter and a control transformer form a two-element system that measures the angular displacement between two rotating shafts. The displacement measurement is then used as an error signal to synchronize the two shafts. The term *electronic gears* is sometimes used to describe this type of system because the two shafts are synchronized as if they were connected by a gear drive. The addition of a control differential forms a three-element system that provides adjustment of the angular relationship of the two shafts during operation.

A two-element synchro system is shown in Figure 7.6. The control transmitter is designated CX, and the control transformer is designated CT. Both the transmitter and the transformer have an H-shaped rotor with a single winding. Connections to the rotor winding are made through slip rings on the shaft. The stators each have three coils spread 120° apart and connected in a Y configuration.



◆ **Figure 7.6** A two-element synchro system measures the phase difference between two rotating shafts.



◆ **Figure 7.18** Linear accelerometer.

The accelerometer is a spring-mass-damping system similar to the control valve shown in Figure 4.5 and the second-order process shown in Figure 14.9a. A second-order system is characterized by its resonant frequency (f_0) and its damping ratio (ζ), as determined by the following equations:

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{K}{M}} \tag{7.16}$$

$$\zeta = \sqrt{\frac{b^2}{4KM}} \tag{7.17}$$

where f_0 = resonant frequency, Hz
ζ = damping ratio
K = spring constant, N/m ($K = 1/C_m$)
M = mass, kilogram
b = damping constant, N · s/m

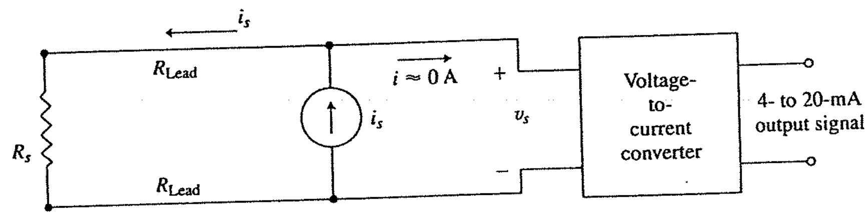
Consider the situation in which the accelerometer frame in Figure 7.18b is accelerated upward at a constant rate. The mass M will deflect the cantilever springs down until the springs exert a force large enough to accelerate the mass at the same rate as the frame. When this occurs, the spring force (Kx) is equal to the accelerating force ($f = Ma$).

$$Kx = Ma$$

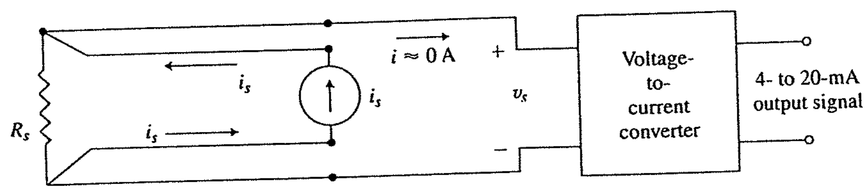
or

$$x = \frac{M}{K}a \tag{7.18}$$

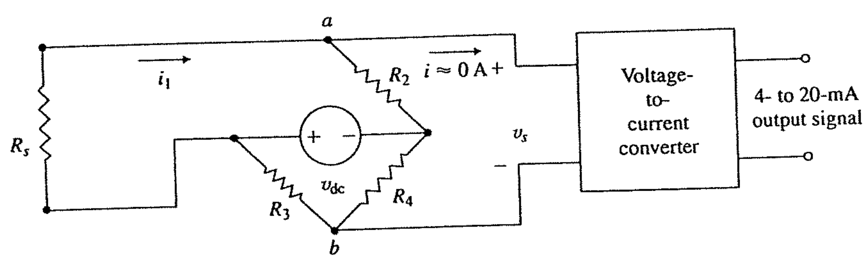
where x = displacement of the mass, m
M = mass, kg



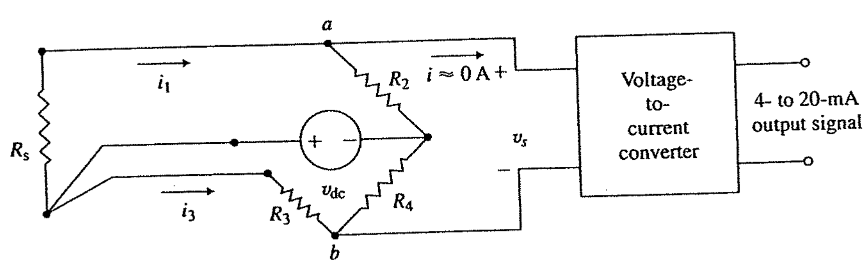
a) Two-wire direct method



b) Four-wire direct method



c) Two-wire bridge method



d) Three-wire bridge method

◆ **Figure 8.5** Four signal conditioning methods used to convert resistance changes into usable control signals.