Capacitive displacement sensor 1

$$C = \frac{2\pi \varepsilon_0 l}{\ln(b/a)}. \tag{3.21}$$

46 3 Physical Principles of Sensing

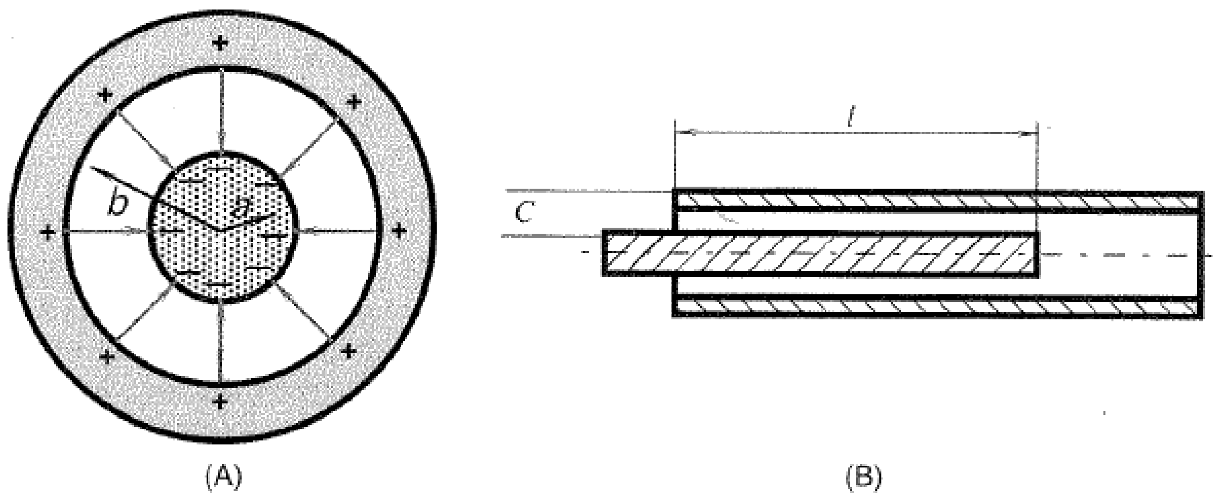
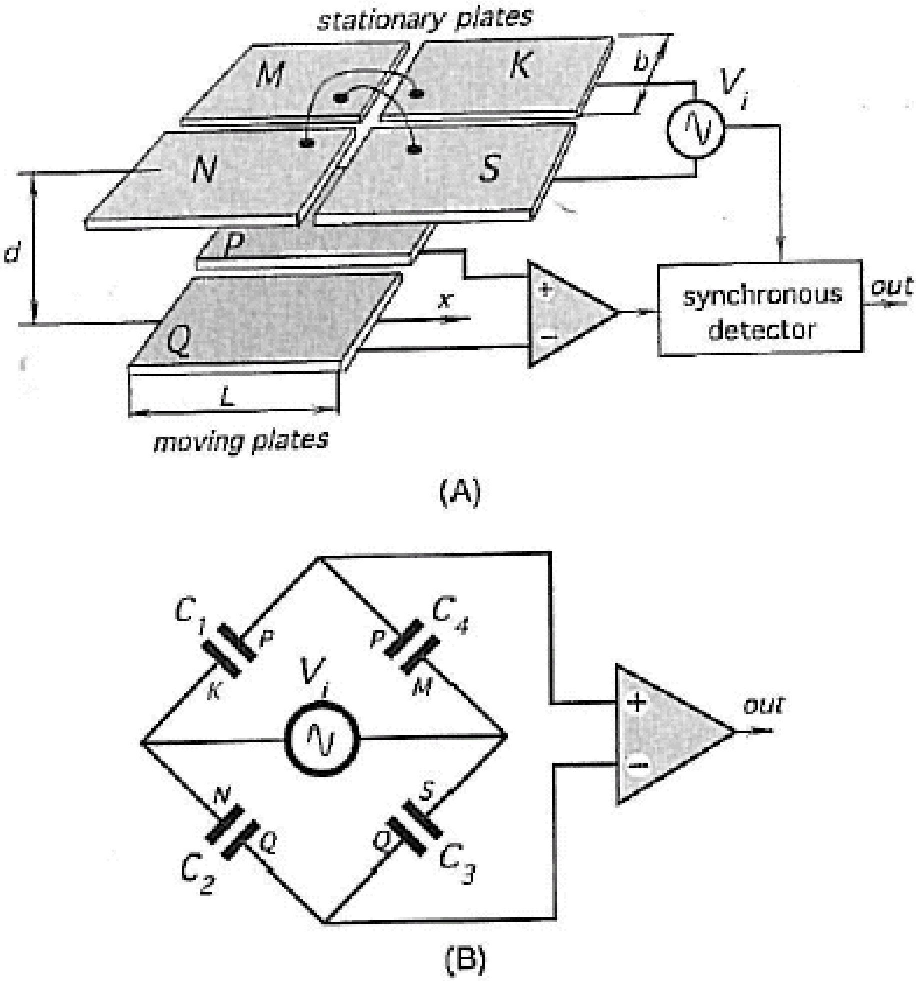


Fig. 3.5. Cylindrical capacitor (A); capacitive displacement sensor (B).

Capacitice displacement sensor 2

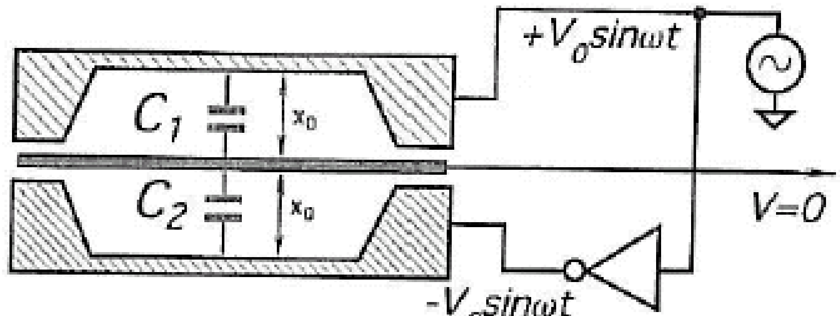
262   7 Position, Displacement, and Level



$$C = \frac{\varepsilon_0 \varepsilon_r A}{d}$$

Fig. 7.8. Parallel-plate capacitive bridge sensor: (A) plate arrangement, (B) equivalent circuit diagram

Capacitive displacement sensing 3

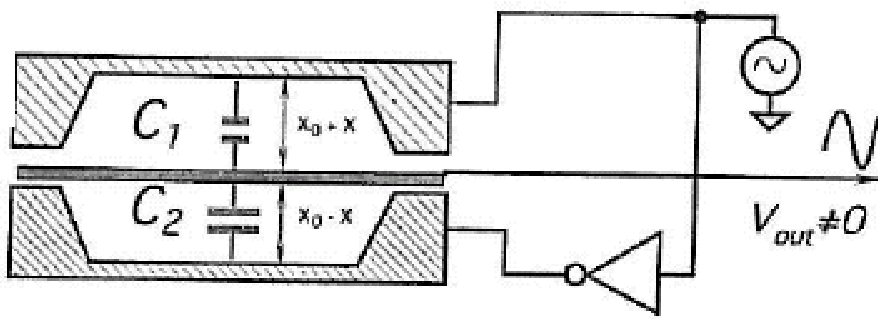


(A)

$$V = \frac{Q}{C} = \frac{\int i\,dt}{C} = \frac{i}{j\omega C}$$

$$C_1 = \frac{\varepsilon A}{x_0 + x}$$

$$C_2 = \frac{\varepsilon A}{x_0 - x},$$



$$V_{\mathrm{out}} = V_0\left(-\frac{x}{x_0 + x} + \frac{\Delta C}{C}\right).$$

(B)

7.5. Operating principle of a flat plate capacitive sensor A-balanced position; B-disbalanced tion

Electric dipoles

$$E = \frac{1}{4\pi\varepsilon_0}\frac{2qa}{r^3}, = \frac{1}{4\pi\varepsilon_0}\frac{p}{r^3}. \qquad (3.10,3.11)$$

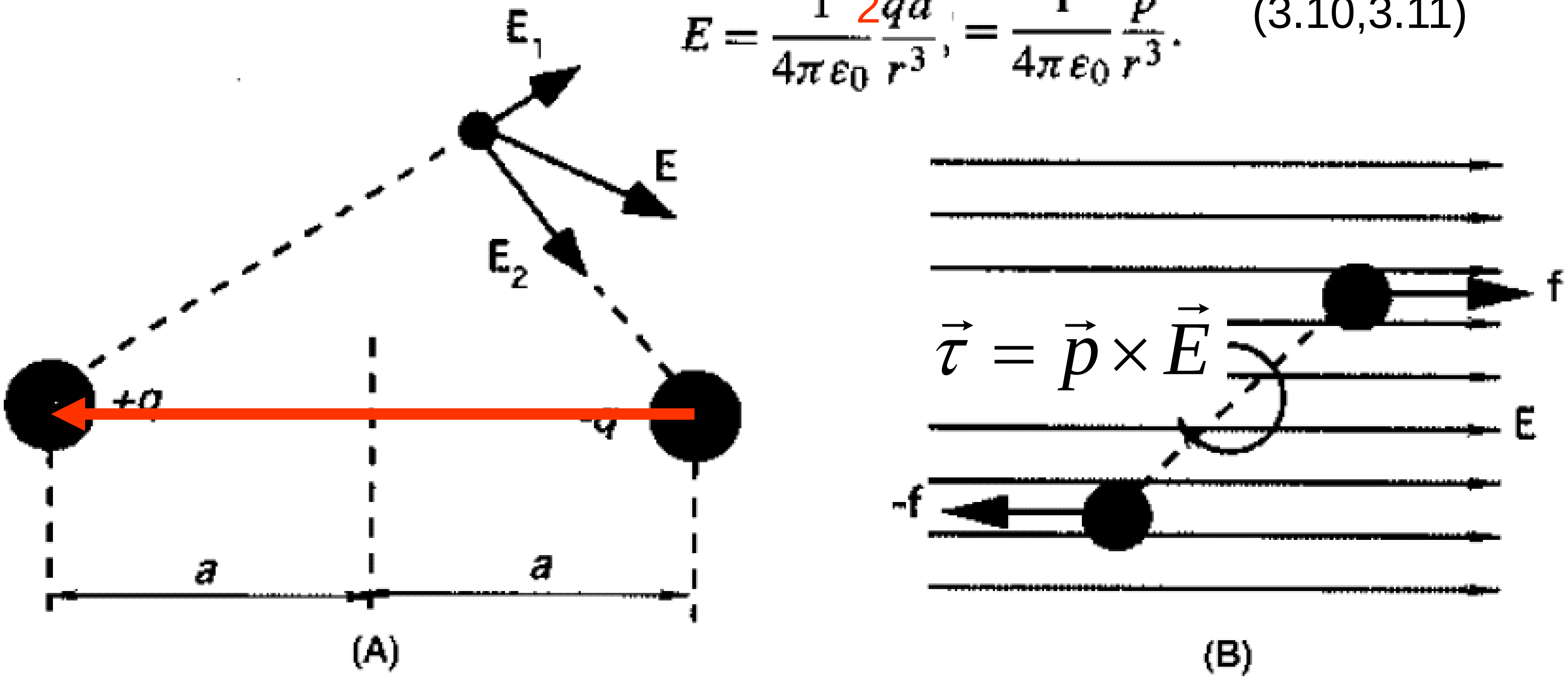


Fig. 3.3. Electric dipole (A); an electric dipole in an electric field is subjected to a rotating force (B).

Near- and far field from dipole

Far field (dipole field) depend on:
- Dipole moment (charge*separation)
- Distance from dipole (->amplitude)
- Angle with dipole (->direction)

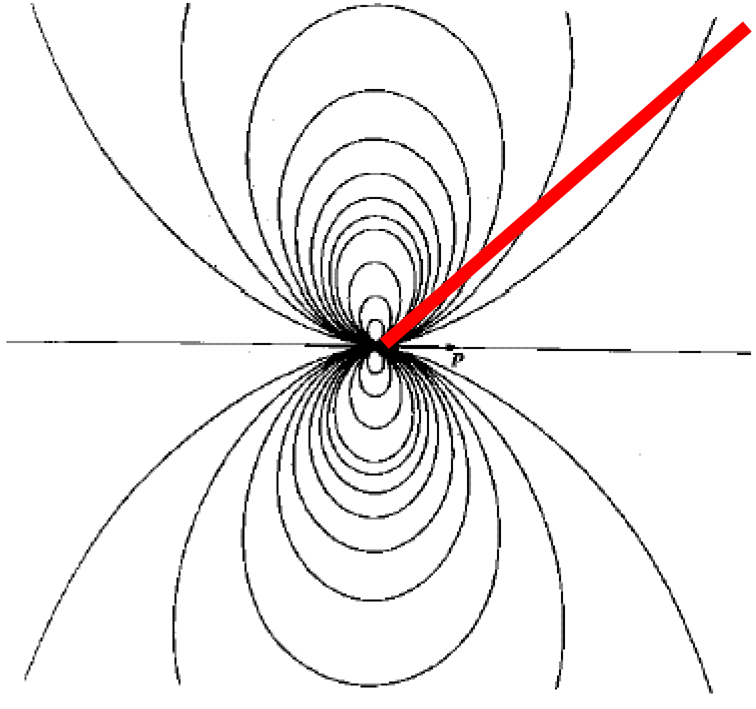
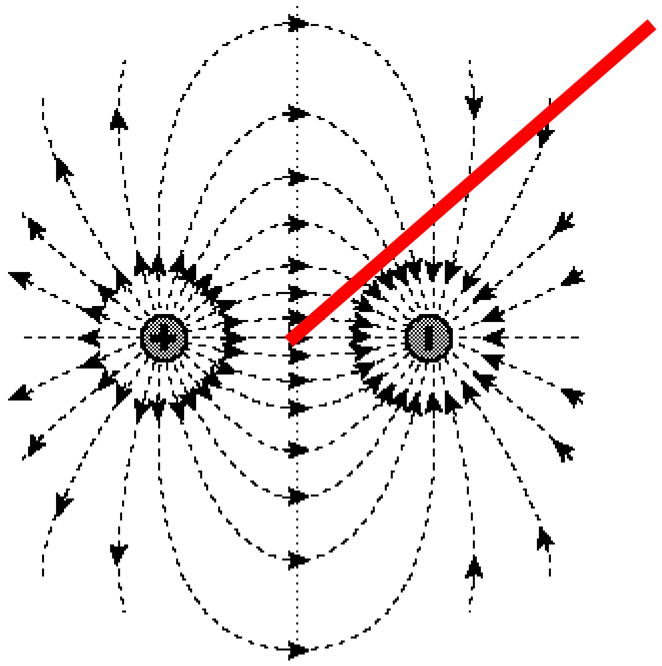


Fig. 1-26. Lines of force of the electric field of an electric dipole.

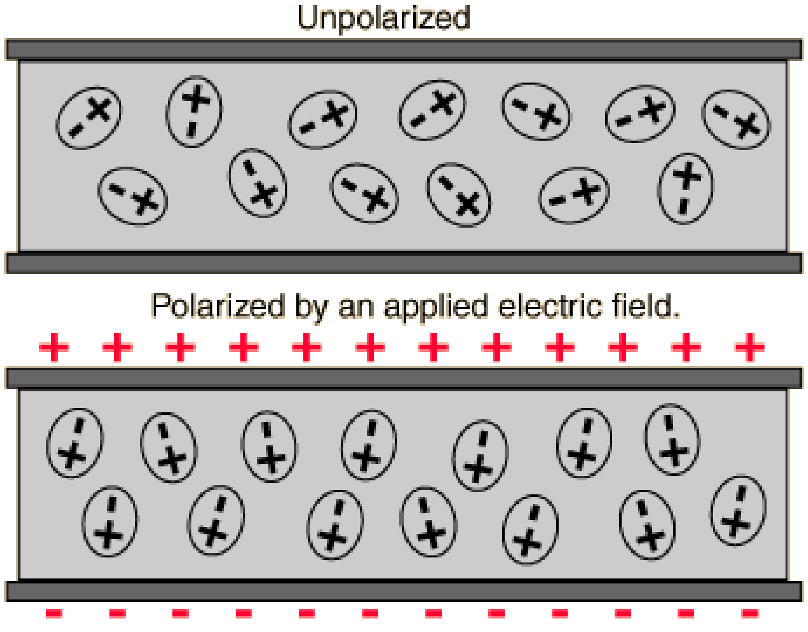
Alonso/Finn: Fundamental univeristy physics

Near field depend on:
- Charge
- Exact location of charges



Hyperphysics

Dipoles in an electric field

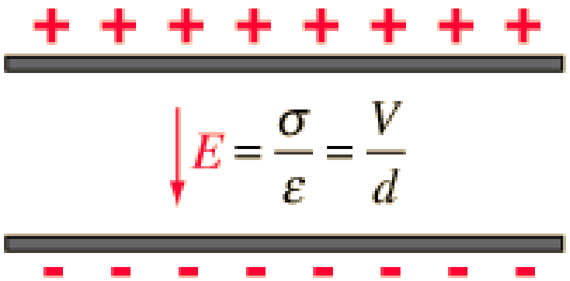


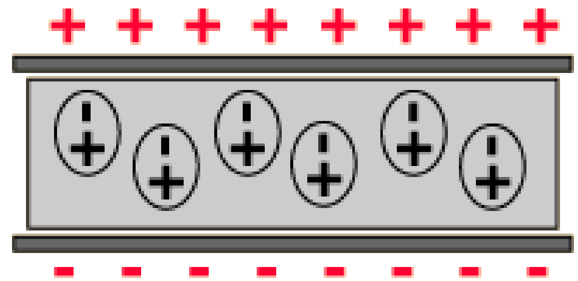
Due to thermal agitation the alignment of the dipoles is proportional to the applied field!!

http://hyperphysics.phy-astr.gsu.edu/hbase/electric/dielec.html

Fraden p.47

Displaced charge





For air, $\varepsilon \approx \varepsilon_0$

$E_{effective} = E - E_{polarization} = \frac{\sigma}{k\varepsilon_0}$

$$C = \frac{\varepsilon_0 A}{d}$$

The capacitance is increased by the factor k.

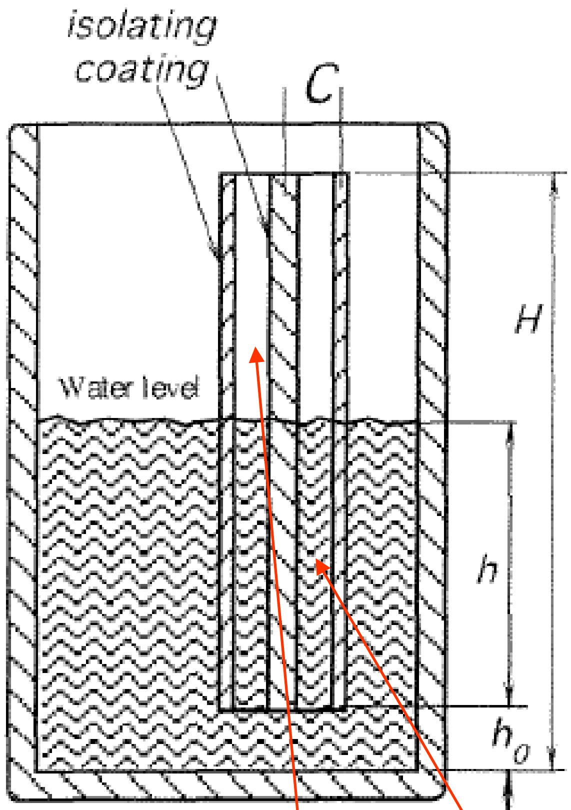
$$C = \frac{k\varepsilon_0 A}{d}$$

$$\oint_S \vec{E} \cdot d\vec{S} = \frac{q}{\varepsilon_r \varepsilon_0}$$

Total dielectric constant

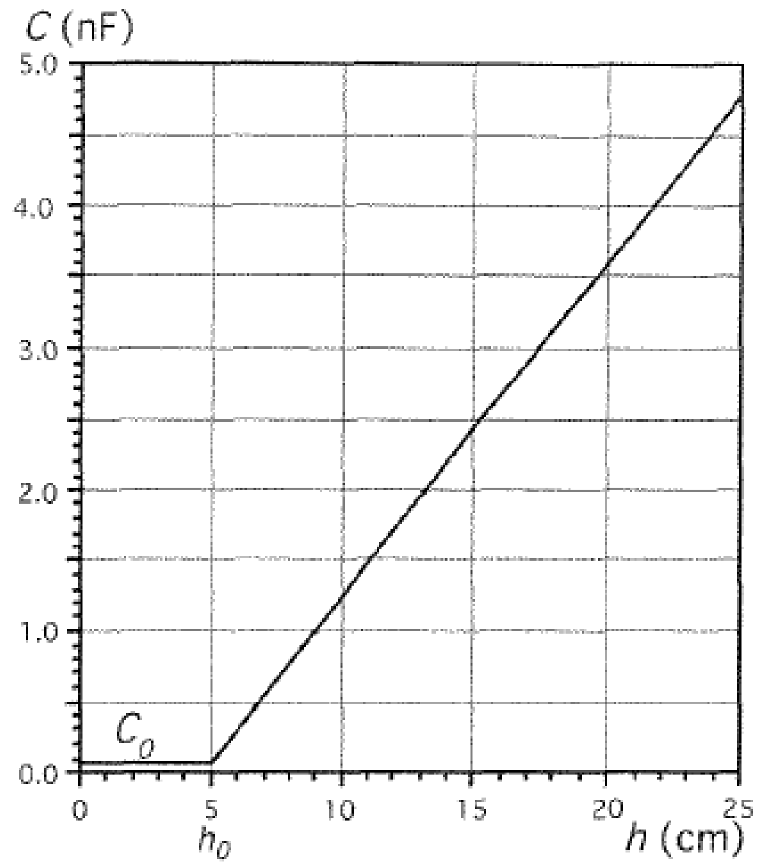
$$k = \kappa = \varepsilon_r$$

Capacitive level measurement



$$C_h = C_1 + C_2 = \varepsilon_0 G_1 + \varepsilon_0 \kappa G_2,$$

(A)



(B)

Humiditiy sensor

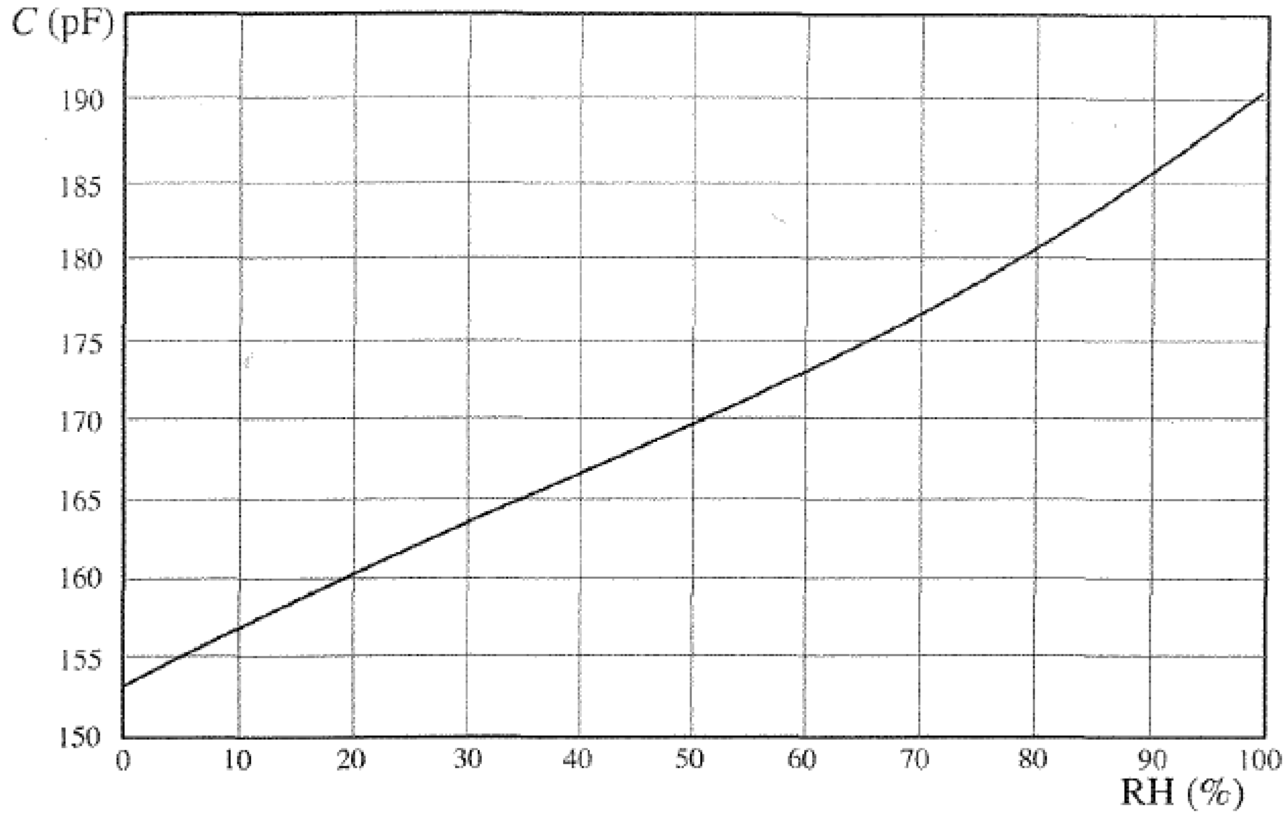
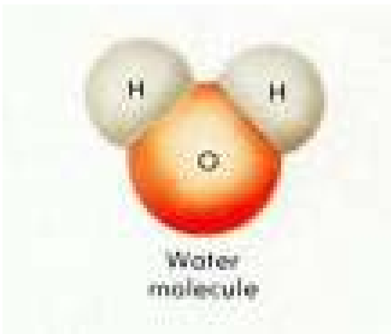


Fig. 3.9. Transfer function of a capacitive relative humidity sensor.

Occupancy



6.3 Capacitive Occupancy Detectors 233

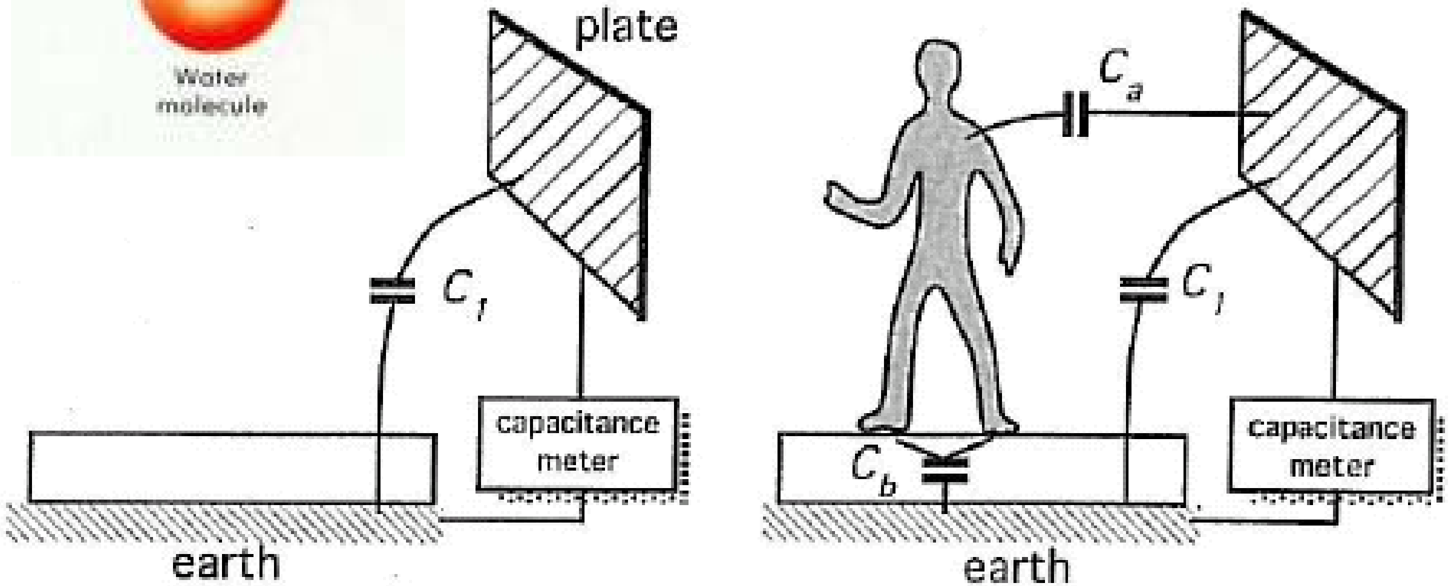
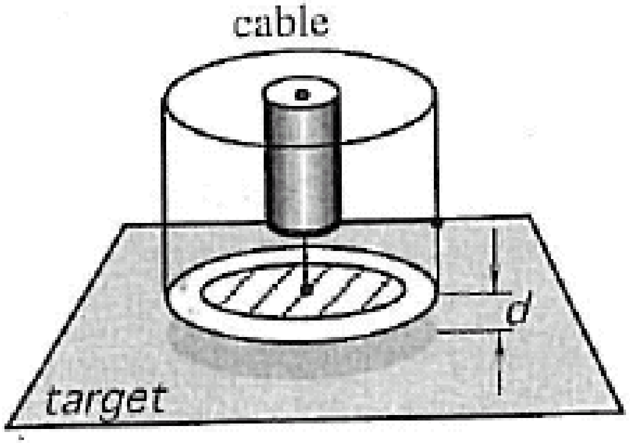
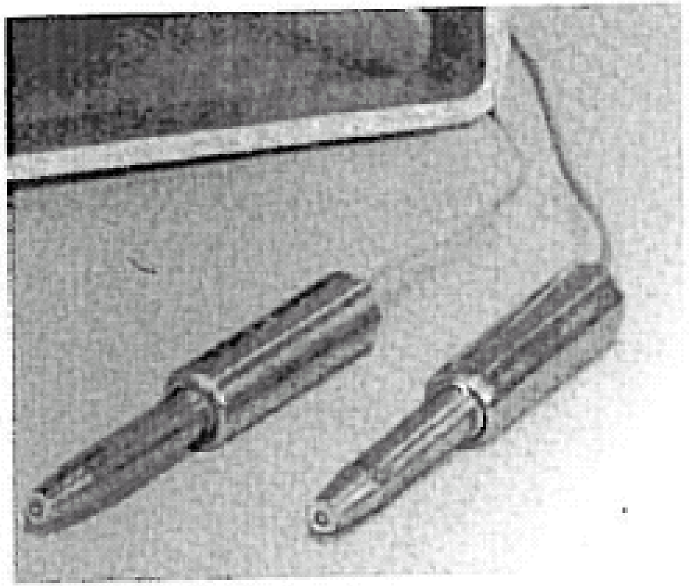


Fig. 6.3. An intruder brings in an additional capacitance to a detection circuit.

Monopolar capacitive probe



(A)



(B)

Fig. 7.6. A capacitive probe with a guard ring: (A) cross-sectional view; (B) outside view. (Courtesy of ADE Technologies, Inc., Newton, MA.)

Driven shield proximity sensor

7.3 Capacitive Sensors 261

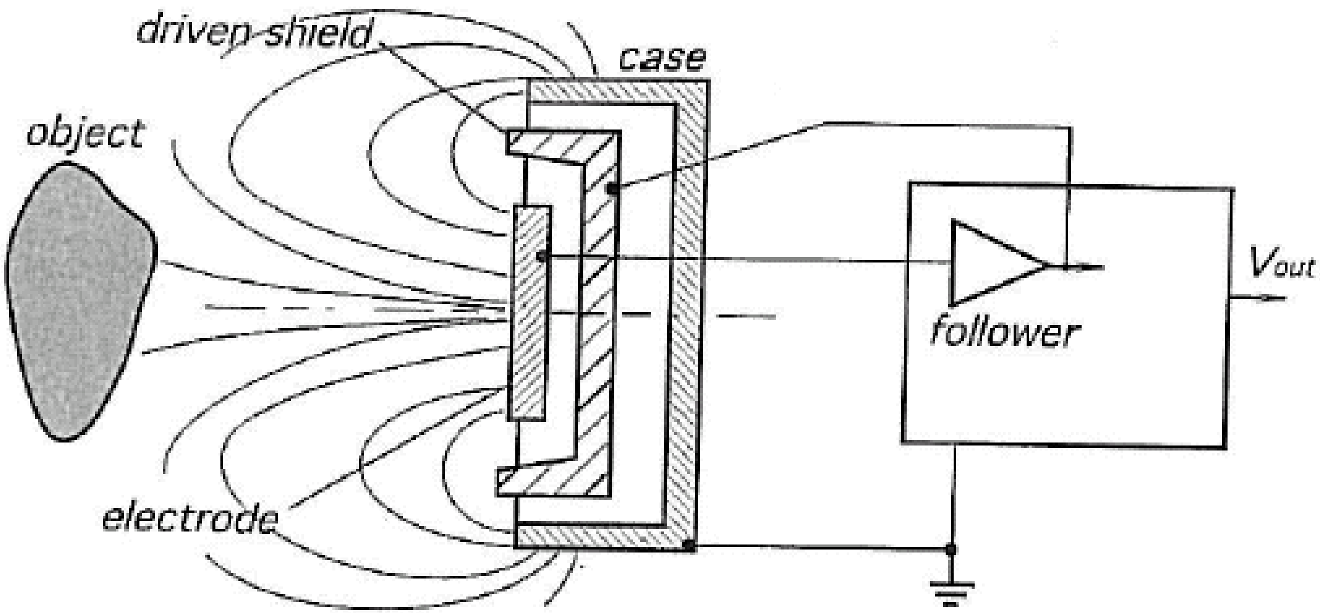


Fig. 7.7. Driven shield around the electrode in a capacitive proximity sensor.