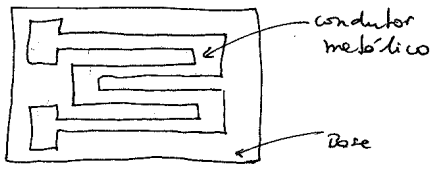
Instrumentação (Sensores)

Aula 4 – SENSORES DE DESLOCAMENTO

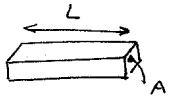
Strain gauges



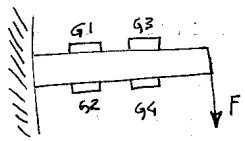
pág. 100 Wolfenbuttel

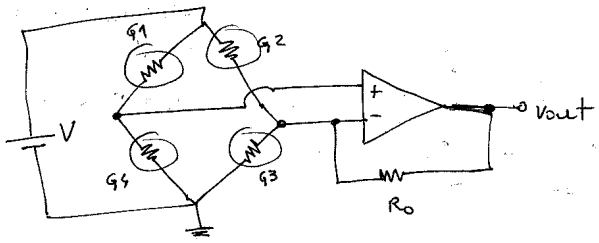
pág. 254 Tompkins

$R = \rho \frac{L}{A}$ ← resistividade

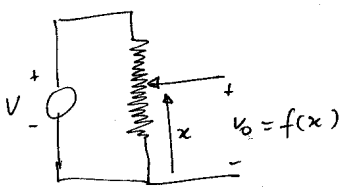


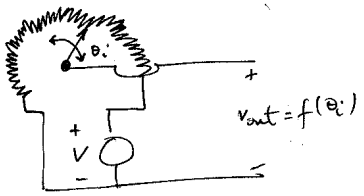
$\frac{\Delta R}{R} = \frac{\Delta L}{L} - \frac{\Delta A}{A} + \frac{\Delta \rho}{\rho}$ ← piezoresistive effect



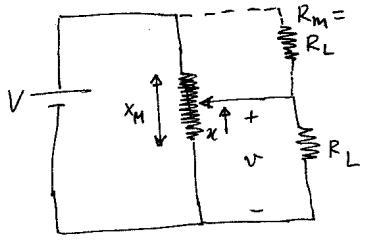


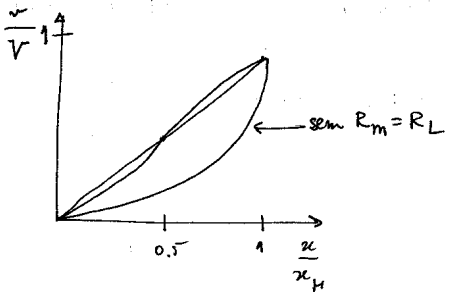
Potenciómetros como sensores de deslocamento





Linearização do potenciômetro





1° caso

$$v(x) = \frac{(R_L \parallel R_H x)}{(R_L \parallel R_H \cdot x) + R_H(1-x)}$$

2° caso

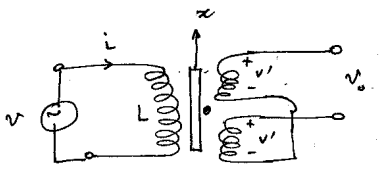
$$x(x) = \frac{(R_L \parallel R_H \cdot x)}{(R_L \parallel R_H \cdot x) + [R_H(1-x) \parallel R_L]}$$

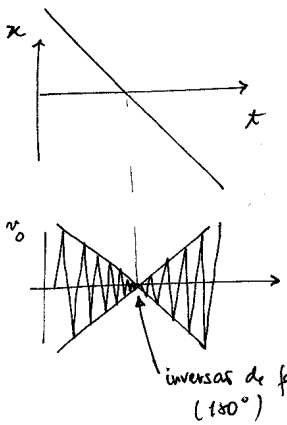
Linear variable differential transformers (LVDTs)

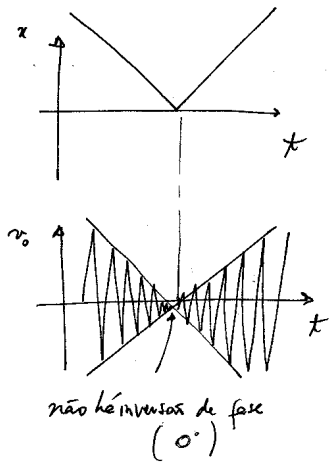
$v' = j\omega M i$; M indutância mútua

$i = \frac{1}{j\omega L} v$

$v_o = v K x$ pág 104 Wolfscball

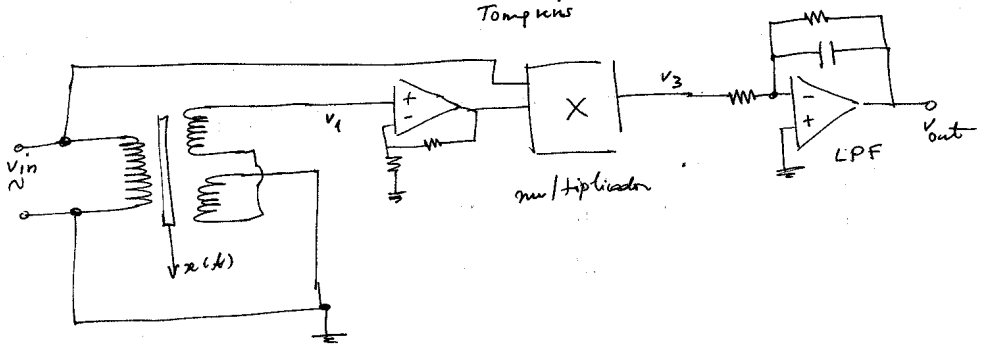






LVDT – circuito desmodulador

pag 260 Tompkins



$v_{in} = A \sin \omega t$

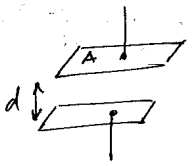
$v_1 = x(t) \sin \omega t$

$v_2 = C\, x(t) \sin \omega t$

$v_3 = C\, A\, x(t) \sin^2(\omega t) = C A\, x(t) \left[1 - \cos(2\omega t)\right]$

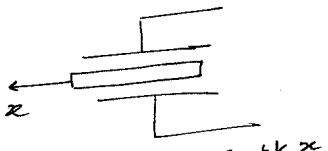
$v_{out} \cong C\, A\, x(t)$

Sensores capacitivos

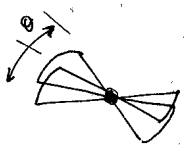


$C = \varepsilon \frac{A}{d}$

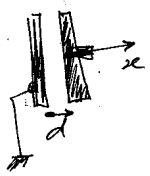
ε ↗ permitividade eléctrica do meio



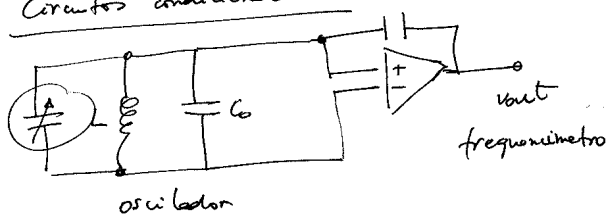
$C = C_0 + k\, x$



$C = C_0 + k'\theta$



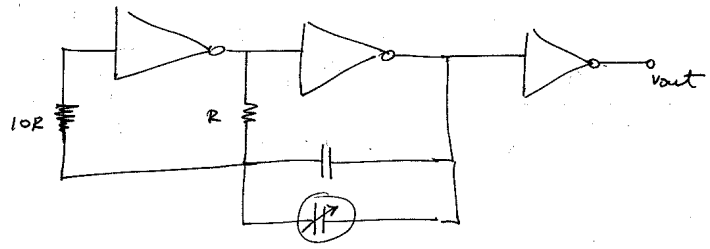
Circuitos condicionadores



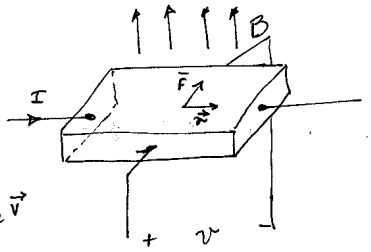
$f_0 = 2\pi L C_0$

$\frac{\Delta f}{f_0} \simeq \frac{-\Delta C}{2 C_0}$

relaxation oscillator



Efeito Hall Wolfshall pág 114 e 115

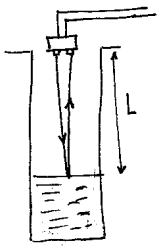


$\vec{F} = q(\vec{v} \times \vec{B})$

$\vec{E} = \mu_e \vec{V}$

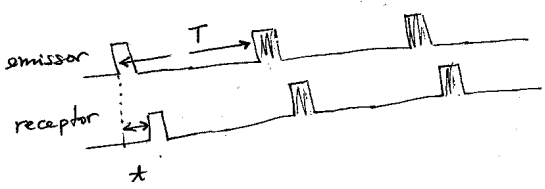
$E = -\frac{\partial V}{\partial x} =$

ultra-som



$t = \frac{2L}{c}$

c - velocidade de propagação do som no meio



$t_{max} = T$

logo $L_{max} = \frac{c}{2} T$

no ar $c \approx 400\ m/s$

se $T = 1\ s$ $L_{máx} = 200\ m$

$T = 1\ ms$ $L_{máx} = 20\ cm$

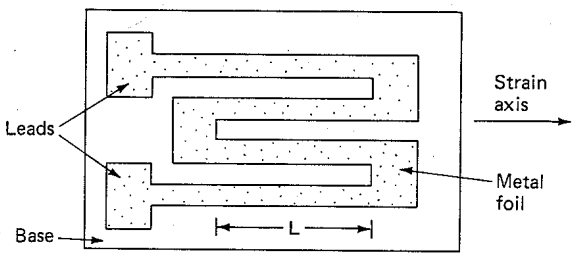


Figure 6-1 Strain gage.

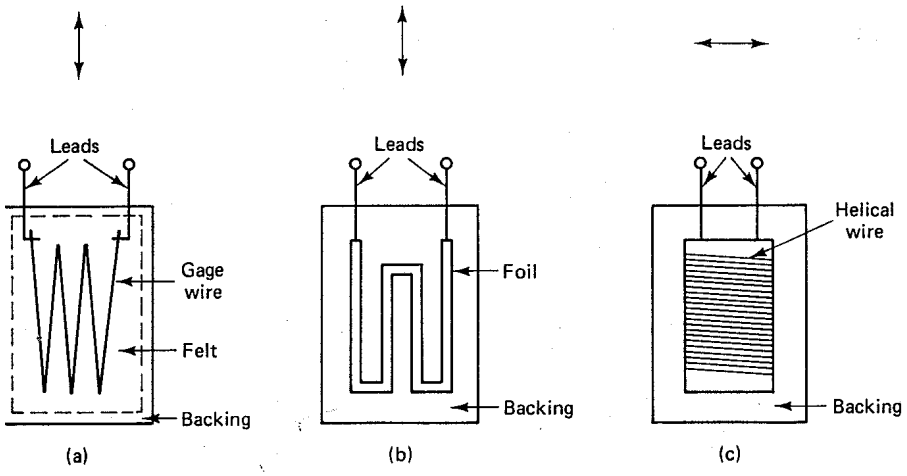


Figure 9.7 Typical bonded strain-gage units. (a) Resistance-wire type. (b) Foil type. (c) Helical-wire type. Arrows above units show direction of maximal sensitivity to strain. (From Lion, K. S. 1959. Instrumentation in scientific research, New York: McGraw-Hill.)

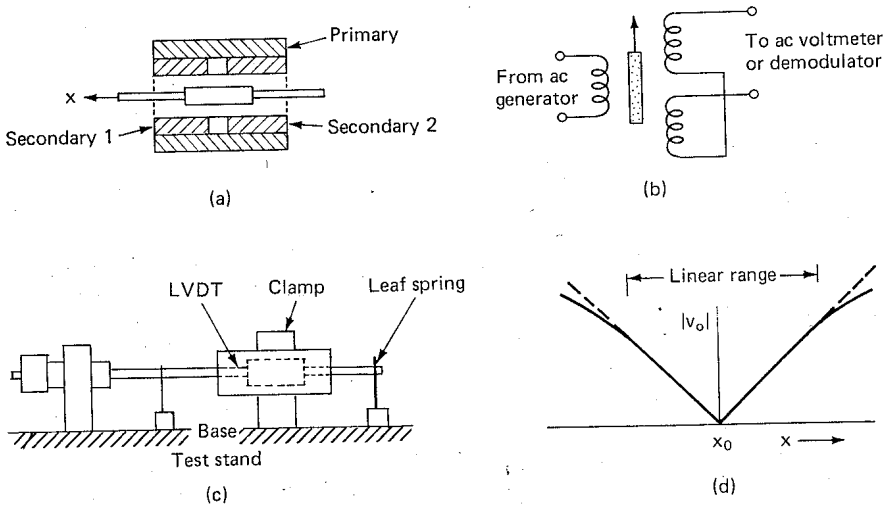
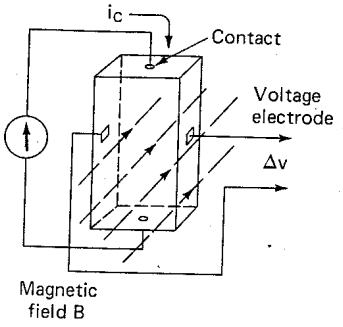
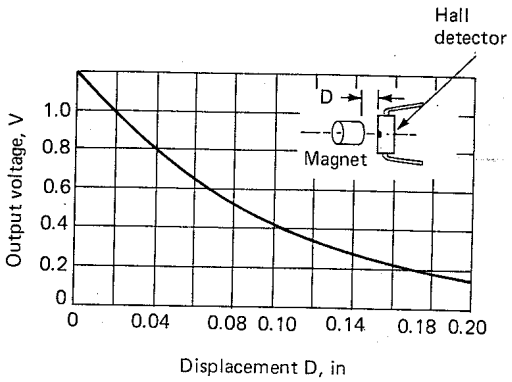


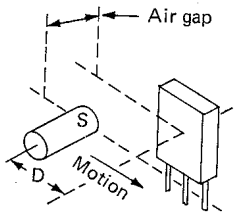
Figure 6-6 LVDT displacement sensor: (*a*) drawing; (*b*) electrical equivalent; (*c*) calibration unit; (*d*) output voltage (magnitude) versus position.


i_C
Contact
Voltage electrode
Δv
Magnetic field B

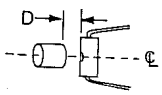
(a)

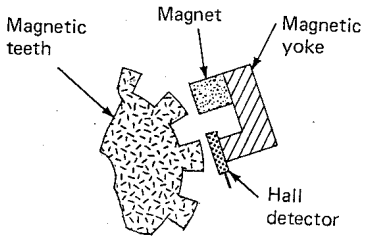

Hall detector
D
Magnet
Output voltage, V
1.0
0.8
0.6
0.4
0.2
0
0 0.04 0.08 0.10 0.14 0.18 0.20
Displacement D, in

(b)


Air gap
S
D
Motion

(a)


D
℄


Magnetic teeth
Magnet
Magnetic yoke
Hall detector

(c)