Transductores resistivos

Mediciones Biomédicas 2024
Ingeniería Civil Biomédica

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Tipos de transductores

Resistivos

Capacitivos

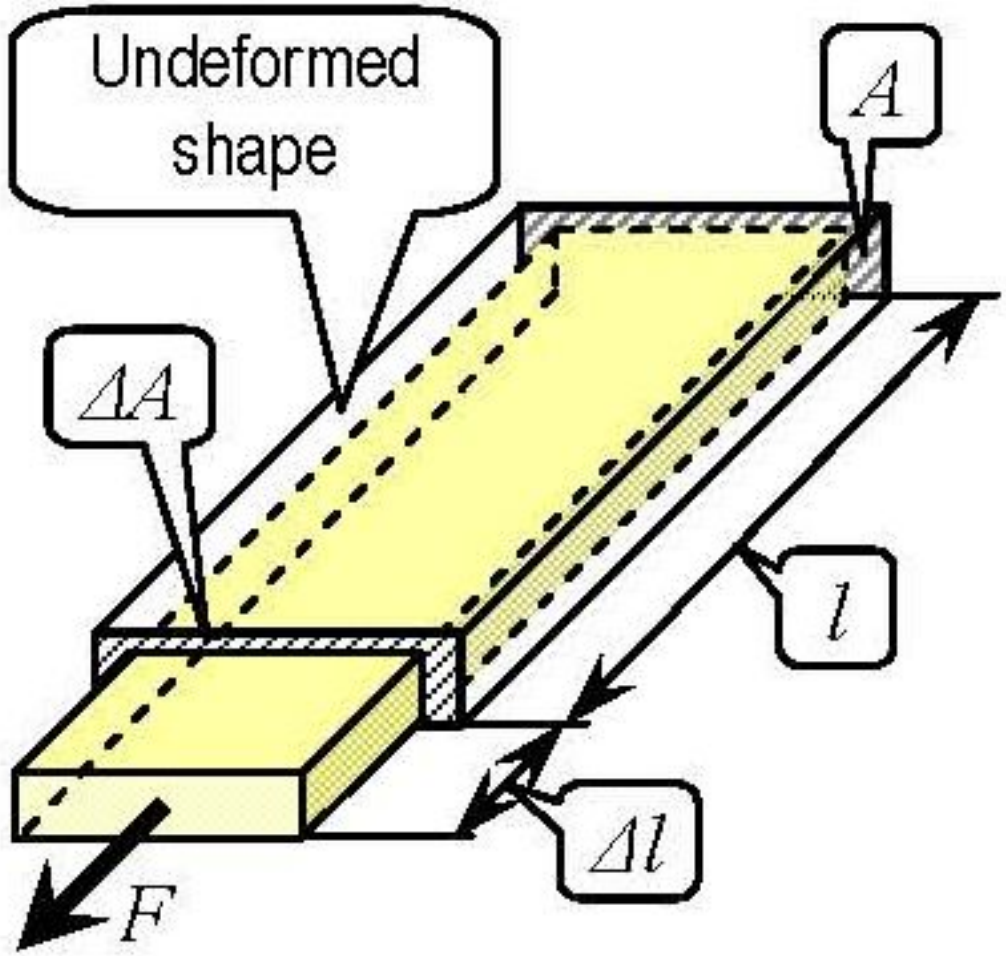
Piezoeléctricos

Inductivos/magnéticos

Térmicos

Radiación/ópticos

Electroquímicos (Cap. 4)



Undeformed shape
A
ΔA
l
Δl
F

T de R variable.

Cuatro clases.

1) R cambia en función de las dimensiones físicas del T.

2) R cambia en función de la temperatura.

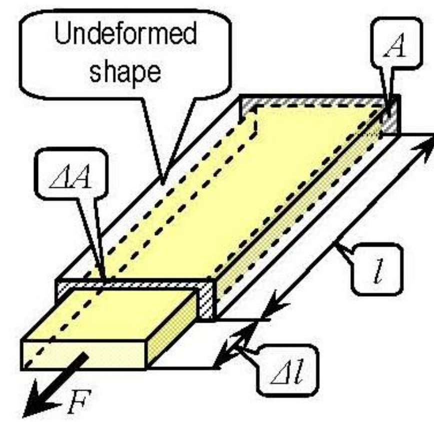
3) "sliding contact devices"

4) T hechos con semiconductores.

1) R cambia en función de las dimensiones

La resistencia de un conductor de geometría uniforme está dado por:

$$R\,(\text{ohms}) = \rho\, l / A$$



ρ : resistencia específica (Ωm)

l : largo en metros

A : área transversal en m^2.

Si una de las cantidades ρ, l ó A cambia entonces R cambiará. Para estudiar esto se expresa el diferencial:

$$dR = \frac{(\rho\, dl + l\, d\rho) A - \rho\, l\, dA}{A^2}$$

Definamos ahora:

$$A = k\delta^2$$

donde k es una constante de proporcionalidad y δ is la dimensión longitudinal.

→ Si A representa un cuadrado $k = 1$

→ Si A representa un círculo $k = \pi/4$

$$dA = d(k\delta^2) = 2k\delta\, d\delta$$

y por tanto

$$dR = \frac{k\delta^2(\rho\, dl + l\, d\rho) - 2k\delta\rho l\, d\delta}{(k\delta^2)^2}$$

Para un área transversal rectangular:

$$\frac{dR}{R} = \left(\frac{A(\rho\, dl + l\, d\rho) - \rho l\, dA}{A^2}\right)\left(\frac{A}{\rho l}\right)$$

$$= \frac{dl}{l} + \frac{d\rho}{\rho} - \frac{dA}{A}$$

$$= \frac{dl}{l} + \frac{d\rho}{\rho} - \frac{2\, dS}{S}$$

ó

$$\frac{dR/R}{dl/l} = 1 + \frac{d\rho/\rho}{dl/l} - \frac{2\, dS/S}{dl/l}$$

ó

$$\frac{dR/R}{\varepsilon_a} = 1 + \frac{d\rho/\rho}{\varepsilon_a} - 2\,\frac{\varepsilon_L}{\varepsilon_a}$$

$$= 1 + \frac{d\rho/\rho}{dl/l} + 2\mu$$

donde ε_a: es el stress axial sobre el conductor (m/m)

ε_L: stress lateral (m/m)

μ: razón de Poisson

Este principio es empleado por los galgas extensiométricas (strain gauges).

El factor $dR/R/\varepsilon_a$ se conoce como factor de galga.

Galgas extensiométricas, GE (strain gauges)

- Los parámetros característicos de las GE son:
  - Resistencia nominal R.
  - Factor de galga (gauge factor) G.
  - Coeficiente de temperatura TK.

$$G = \frac{\frac{\Delta R}{R}}{\frac{\Delta \ell}{\ell}} \qquad TK = \frac{\frac{\Delta R}{R}}{\Delta T}$$

Table 2.1 Properties of Strain-gage Materials

Material	Composition (%)	Gage Factor	Temperature Coefficient of Resistivity ($°C^{-1} - 10^{-5}$)
Constantan (advance)	Ni_{45}, Cu_{55}	2.1	±2
Isoelastic	Ni_{36}, Cr_{8} $(Mn, Si, Mo)_{4}$ Fe_{52}	3.52 to 3.6	+17
Karma	Ni_{74}, Cr_{20}, Fe_{3} Cu_{3}	2.1	+2
Manganin	Cu_{84}, Mn_{12}, Ni_{4}	0.3 to 0.47	±2
Alloy 479	Pt_{92}, W_{8}	3.6 to 4.4	+24
Nickel	Pure	−12 to −20	670
Nichrome V	Ni_{80}, Cr_{20}	2.1 to 2.63	10
Silicon	(*p* type)	100 to 170	70 to 700
Silicon	(*n* type)	−100 to −140	70 to 700
Germanium	(*p* type)	102	
Germanium	(*n* type)	−150	

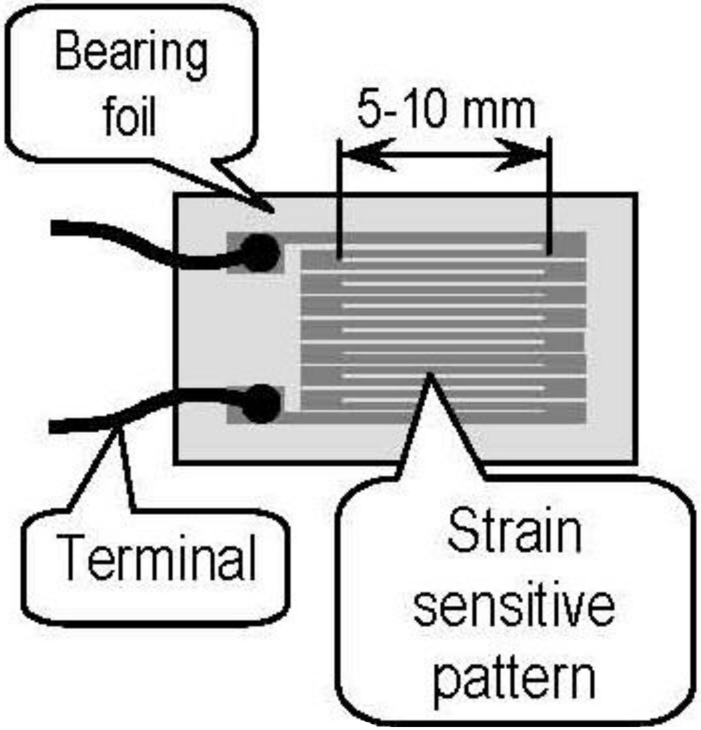
Galgas extensiométricas, GE (strain gauges)

Estructura típica.

Se forma una tira conductora larga y delgada - antiguamente enlazada (bonded), actualmente depositada sobre una capa aislante (unbonded strain gages) - siguiendo un patrón “zig-zag” de líneas paralelas.

La sensibilidad de la forma zig-zag es mucho más alta en la dirección de las líneas paralelas.

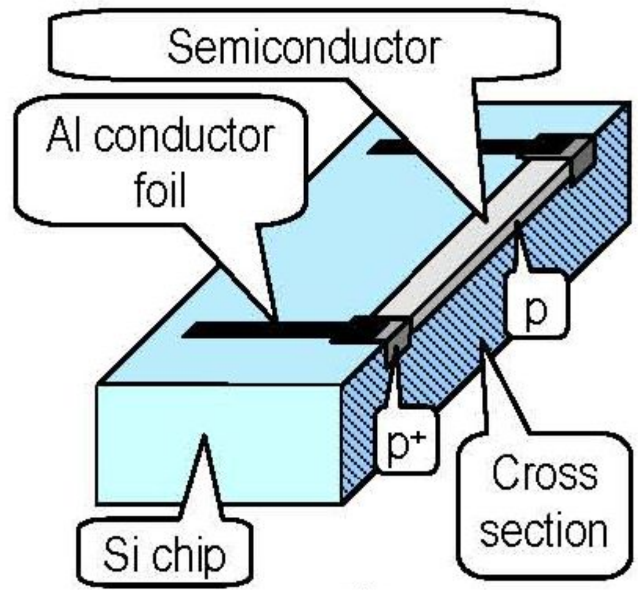
La fuerza o flexión a medir determina la extensión relativa de $\Delta\ell / \ell$.

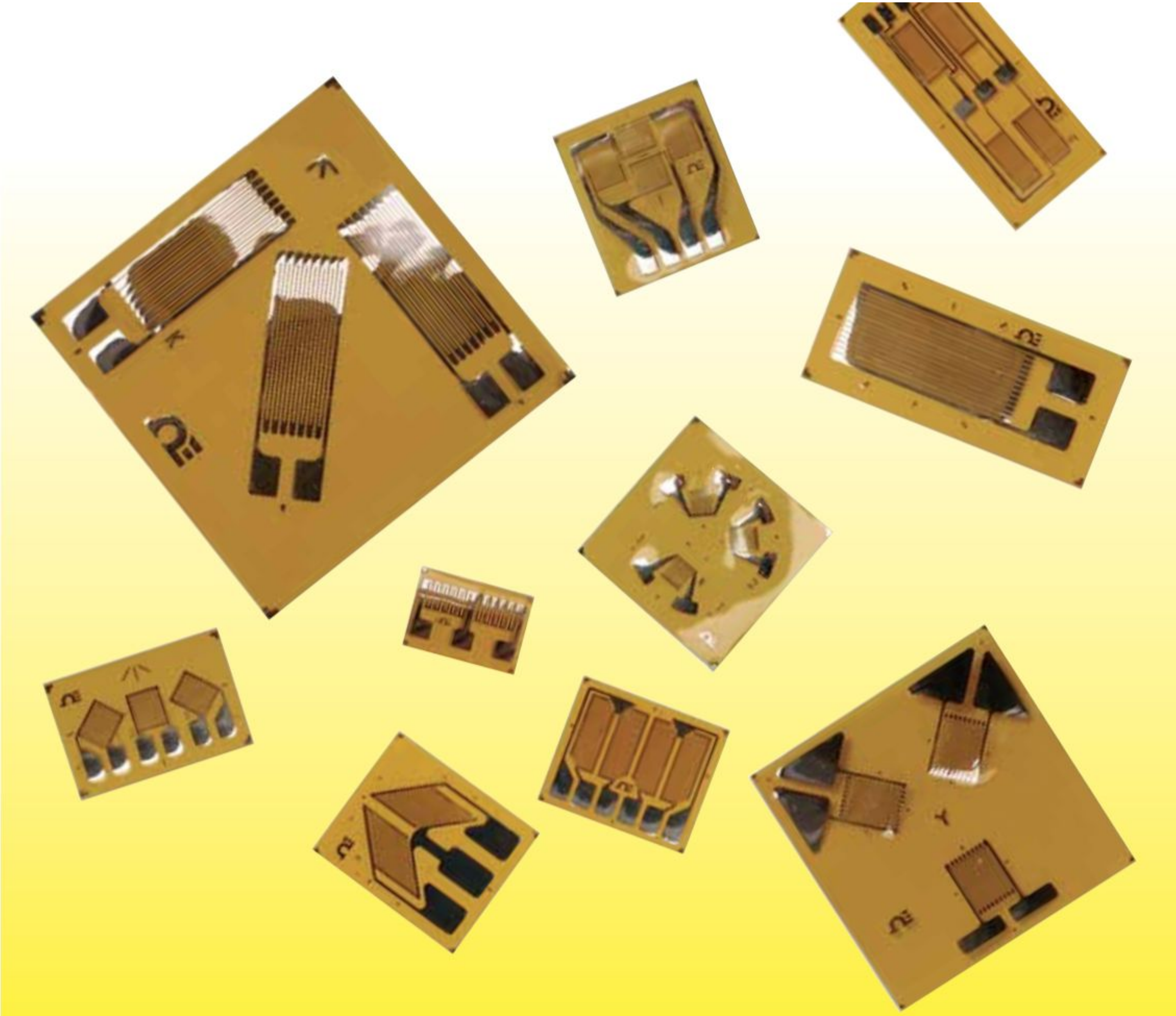


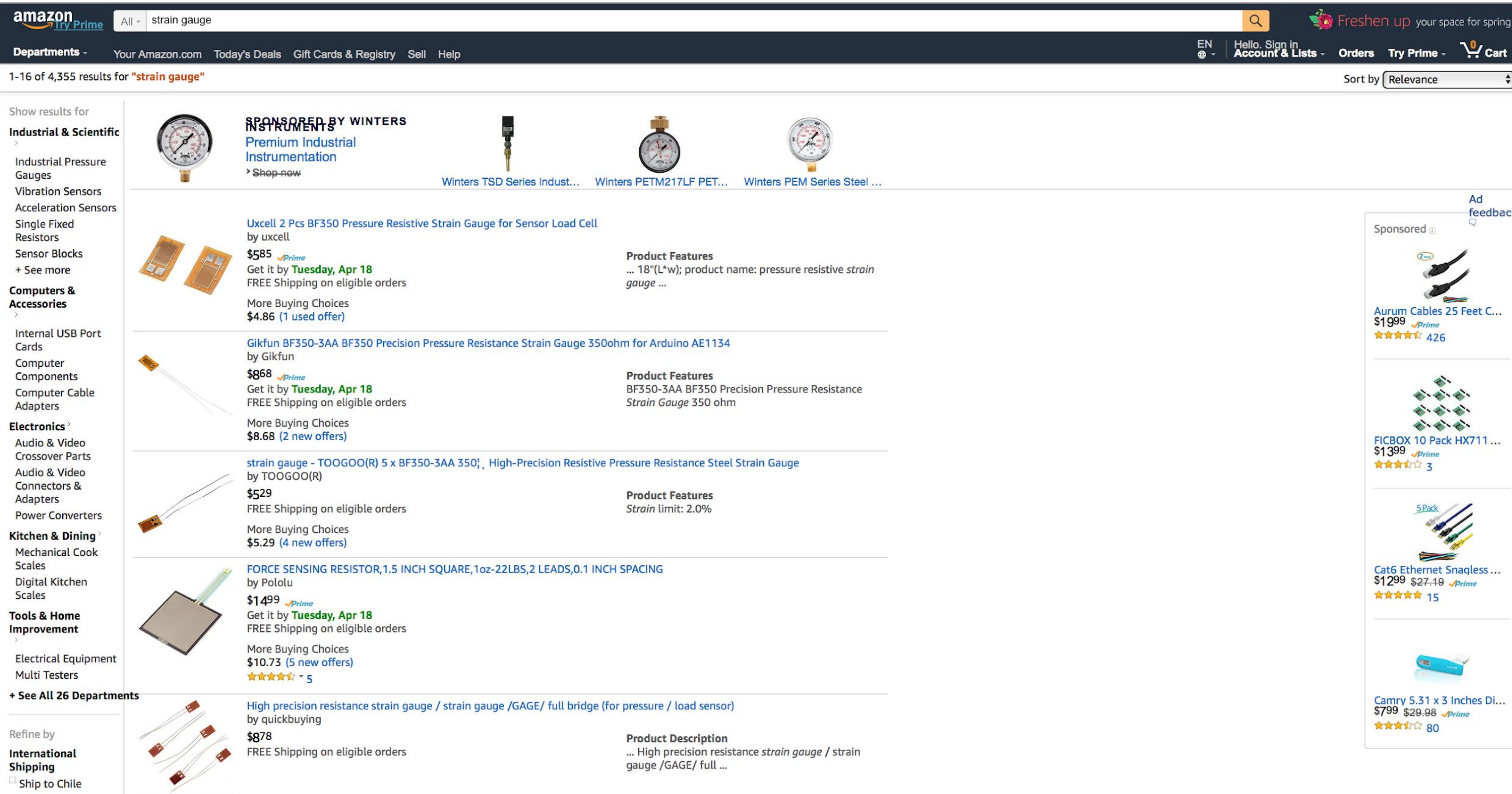
Strain Gauge Measurement
http://www.eidactics.com/Downloads/Refs-Methods/NI_Strain_Gauge_tutorial.pdf

Galgas extensiométricas, GE (strain gauges)

- Existen GE construidas con materiales semiconductores.
- Se les llama también piezoresistores.
- Tienen una mayor sensibilidad.
- No obstante, son más costosas, poseen coeficientes de temperatura mayores y son más frágiles.






amazon Try Prime
All strain gauge
Freshen up your space for spring
Departments Your Amazon.com Today's Deals Gift Cards & Registry Sell Help
EN
Hello. Sign in Account & Lists
Orders
Try Prime
0 Cart
1-16 of 4,355 results for "strain gauge"
Sort by Relevance
Show results for
Industrial & Scientific
Industrial Pressure Gauges
Vibration Sensors
Acceleration Sensors
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+ See more
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Internal USB Port Cards
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FREE Shipping on eligible orders
More Buying Choices
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Product Features
... 18"(L*w); product name: pressure resistive strain gauge ...
Gikfun BF350-3AA BF350 Precision Pressure Resistance Strain Gauge 350ohm for Arduino AE1134
by Gikfun
$8.68 Prime
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Product Features
BF350-3AA BF350 Precision Pressure Resistance Strain Gauge 350 ohm
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Strain limit: 2.0%
FORCE SENSING RESISTOR,1.5 INCH SQUARE,1oz-22LBS,2 LEADS,0.1 INCH SPACING
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High precision resistance strain gauge / strain gauge /GAGE/ full bridge (for pressure / load sensor)
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Product Description
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Ad feedback
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FICBOX 10 Pack HX711 ...
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3
Cat6 Ethernet Snagless ...
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Camry 5.31 x 3 Inches Di...
$7.99 $29.98 Prime
80

Galgas extensiométricas, GE (strain gauges)

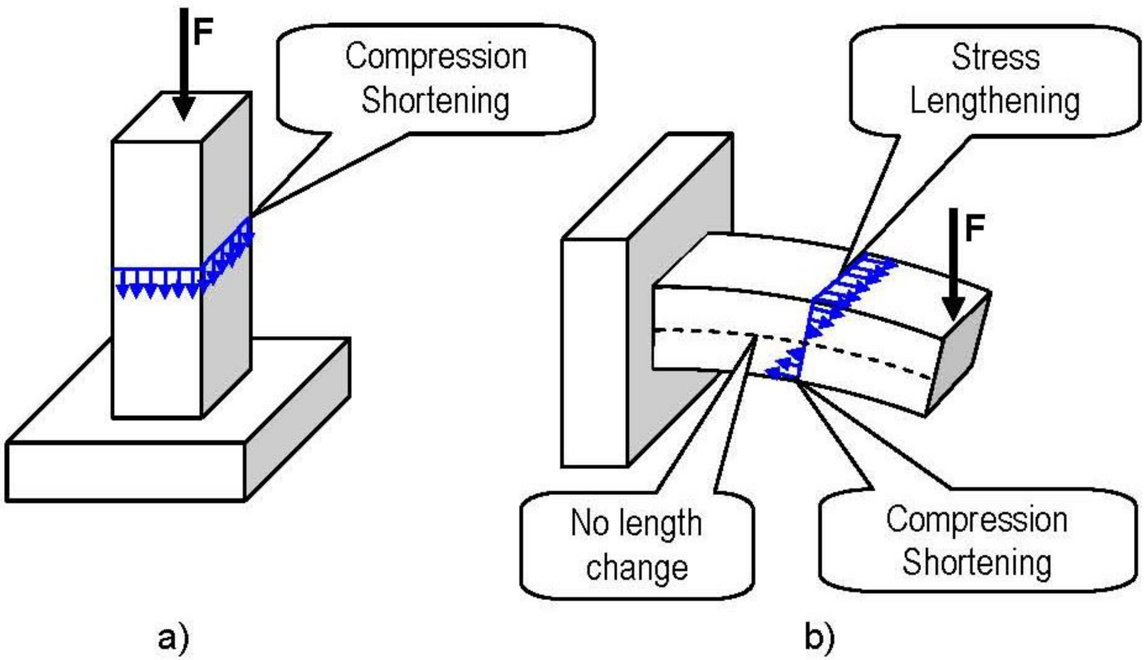
Características generales:

- La resistividad de las GE metálicas no cambia durante el stress ($\Delta\rho \approx 0$).
  - Esto resulta en valores de G cercanos a 2.
- La resistividad de las GE basadas en semiconductores cambia significativamente durante el stress.
  - $\Delta\rho/\rho \gg 1$.
  - A esto se le llama efecto piezo-resistivo.
- Las GE basadas en semiconductores son pequeñas, y a menudo se comercializan en circuitos integrados que incluyen los amplificadores necesarios.
  - Basado en esto, existen sensores de presión y aceleración integrados.

Galgas extensiométricas, GE (strain gauges)

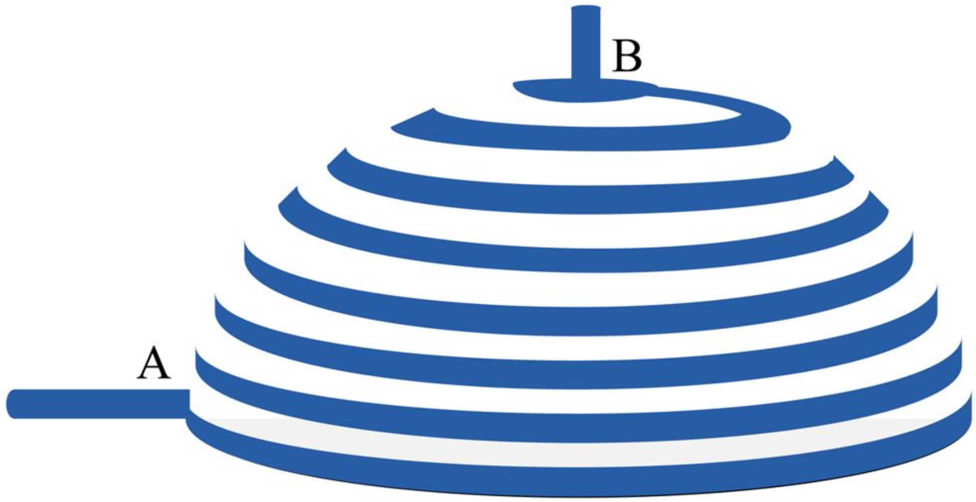
Características generales:

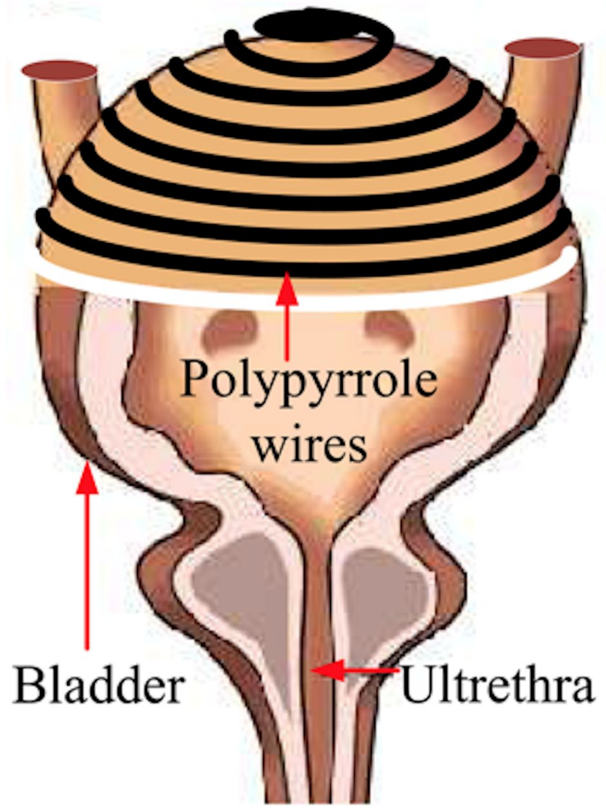
- Las GE están típicamente unidas a objetos.



Deformations to be measured (exaggerated). Deformation of a stressed or compressed object has similar deformation on each side (a). Bending of the object results in both stress and compression at the same time (b).

Rajagopalan S., Sawan M., Ghafar-Zadeh E., Savadogo O. & Chodavarapu V.P., 2008. A polypyrrole-based strain sensor dedicated to measure bladder volume in patients with urinary dysfunction. Sensors. 8, 5081-5095.





Investigation of arterial obstruction using a mercury-in-rubber strain gauge

*H. Edward Holling, M.D., F.R.C.P. (London)**
*H. Christine Boland, B.S.***
*Ellier Russ, D.S.C.****
Philadelphia, Pa.

American Heart Journal, Volume 62, Issue 2, August 1961, Pages 194-205.

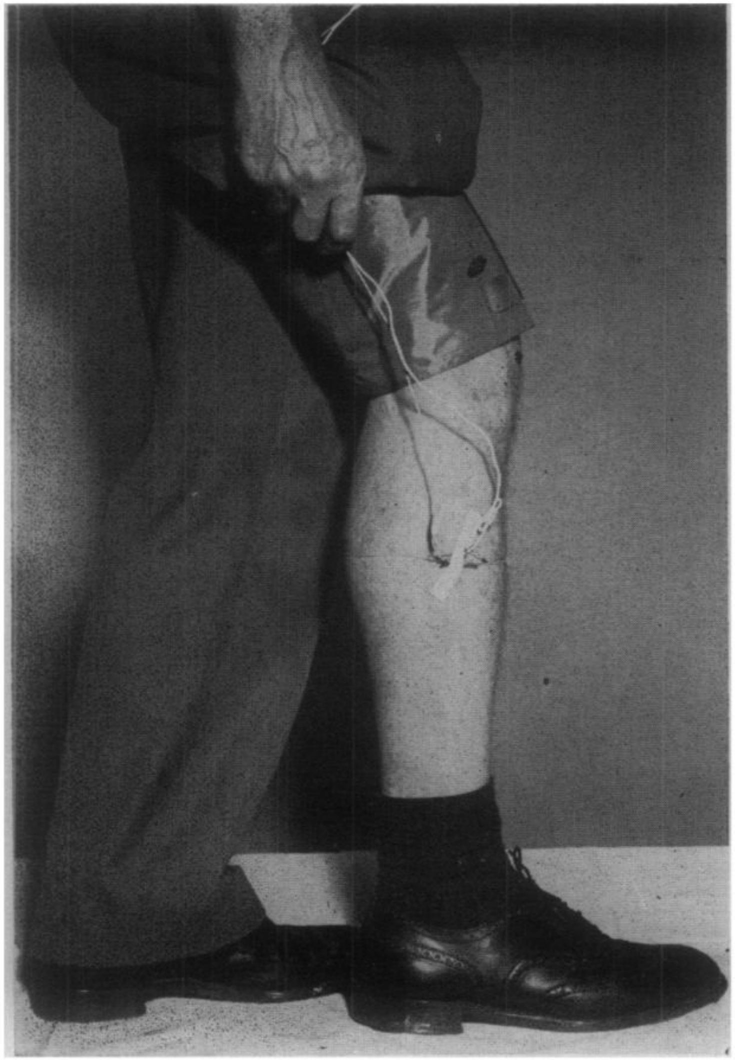


Fig. *1.* Strain gauge applied to calf for exercise test.

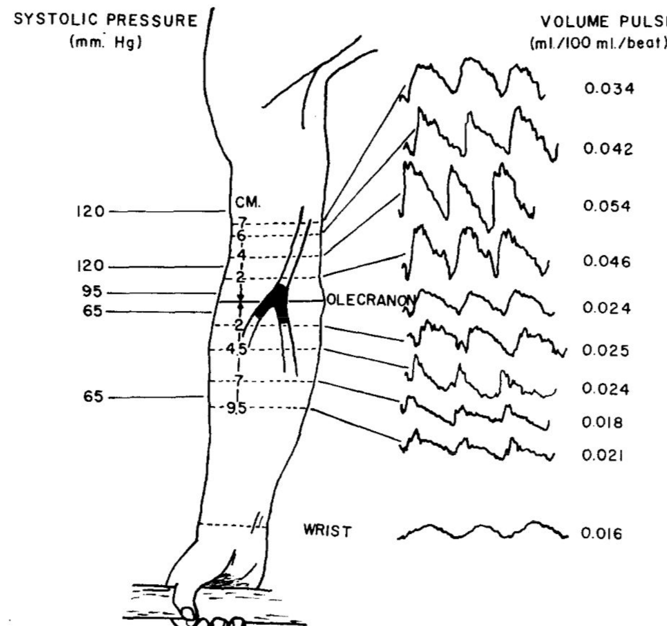


Fig. *4.* Systolic pressure (*left*) and volume pulse (*right*) in a case of embolus to the bifurcation of the right brachial artery. The figures on the arm indicate the distance in centimeters from the point of the olecranon

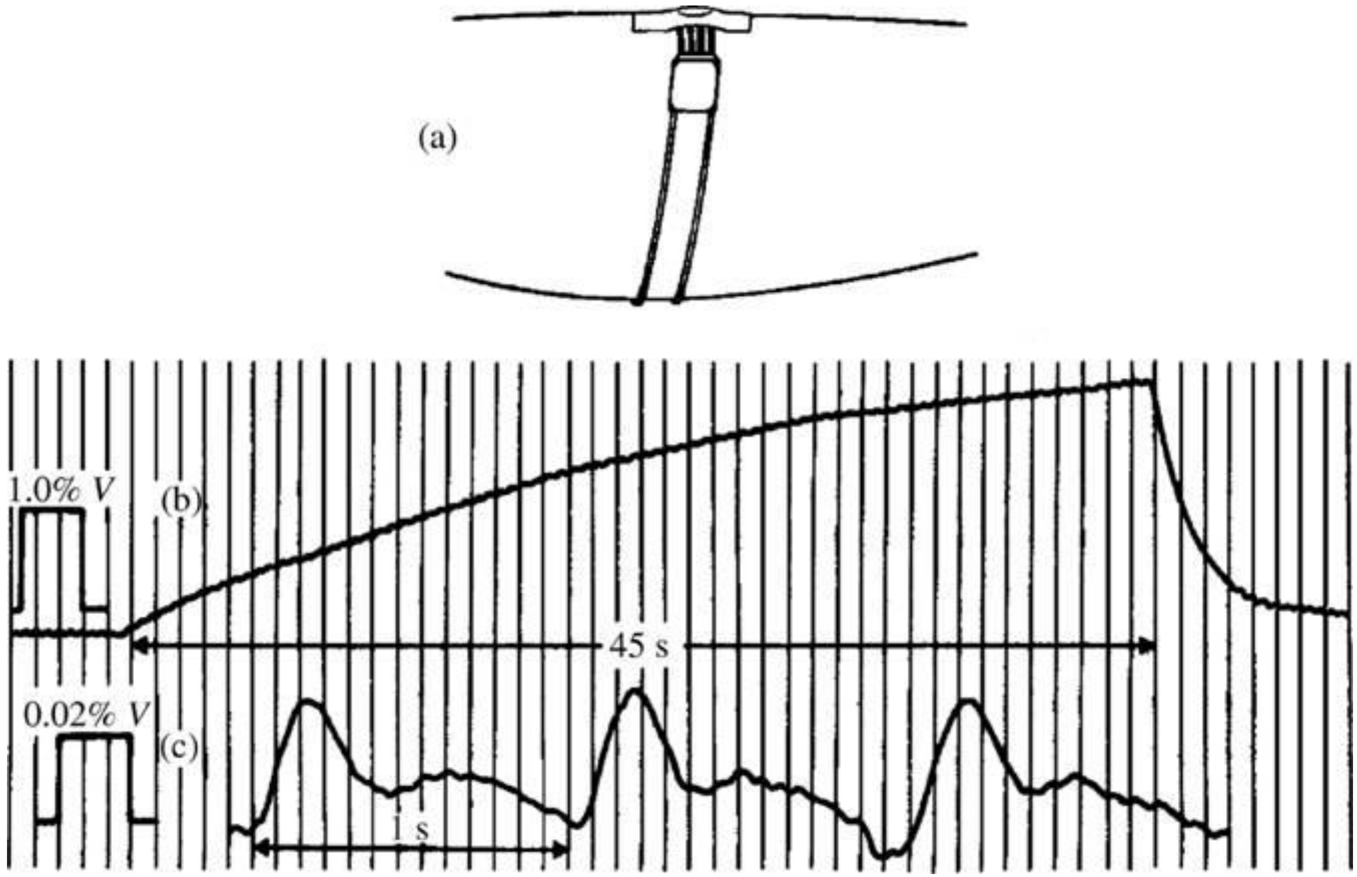
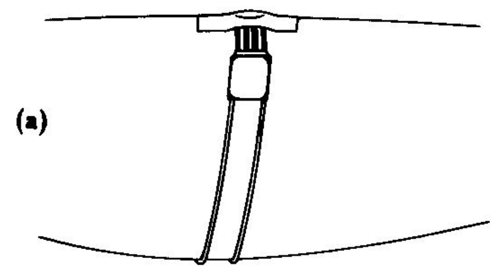


Figure 2.6 Mercury-in-rubber strain-gage plethysmography (a) Four-lead gage applied to human calf, (b) Bridge output for venous-occlusion plethysmography. (c) Bridge output for arterial-pulse plethysmography. [Part (*a*) is based on D. E. Hokanson, D. S. Sumner, and D. E. Strandness, Jr., "An electrically calibrated plethysmograph for direct measurement of limb blood flow." 1975, BME-22, 25–29; used with permission of *IEEE Trans. Biomed. Eng.,* 1975, New York.]

Elastic-Resistance Strain Gages

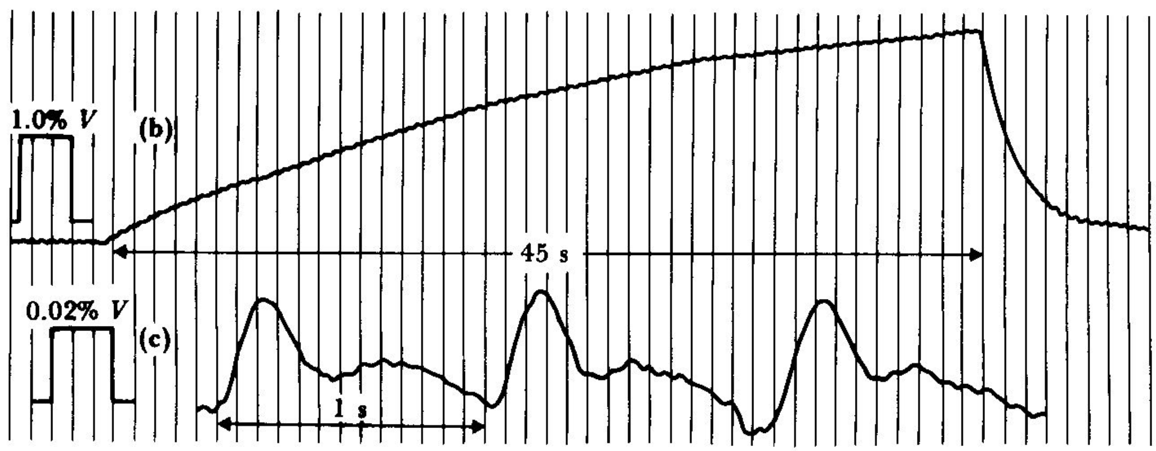
Extensively used in Cardiovascular and respiratory dimensional and volume determinations.

As the tube stretches, the diameter decreases and the length increases, causing the resistance to increase

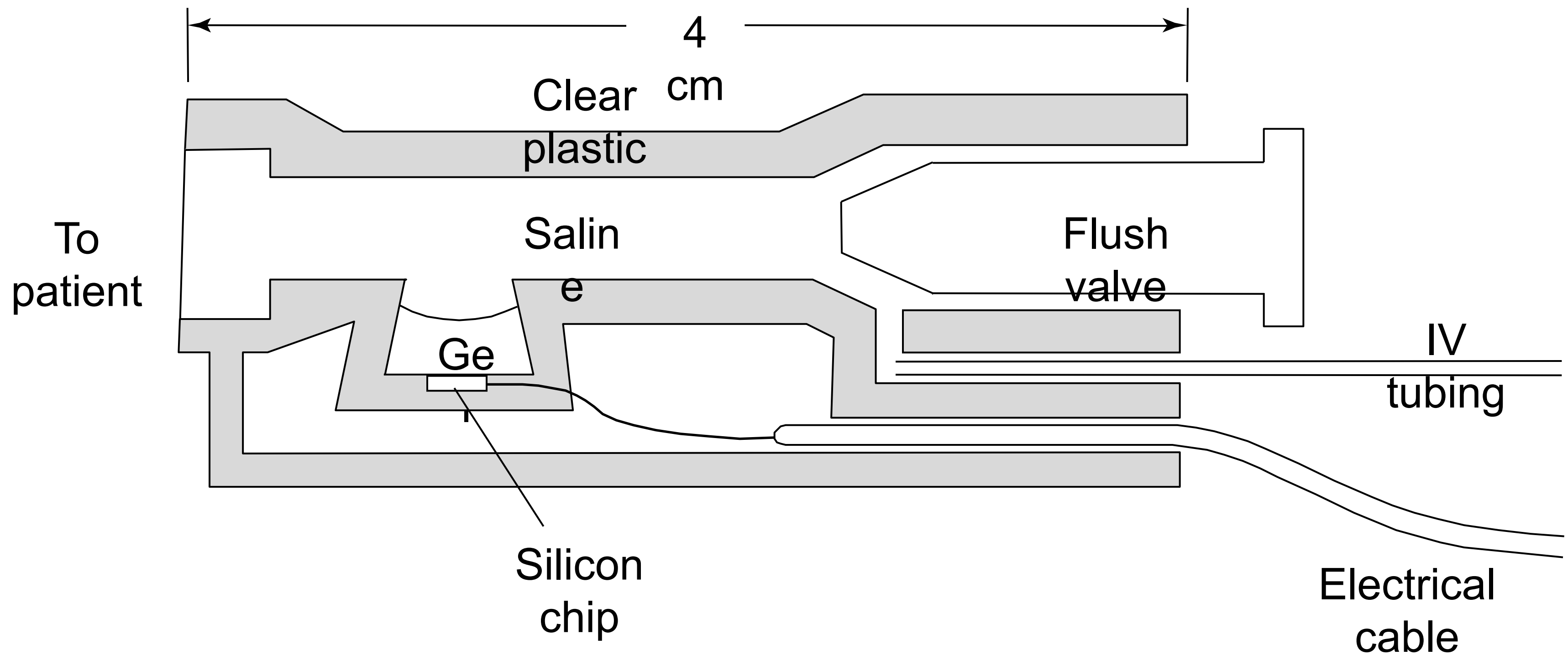


b) venous-occlusion plethysmography

c) arterial-pulse plethysmography



Filled with a conductive fluid (mercury, conductive paste, electrolyte solution.
Resistance = 0.02 - 2 Ω/cm, linear within 1% for 10% of maximal extension

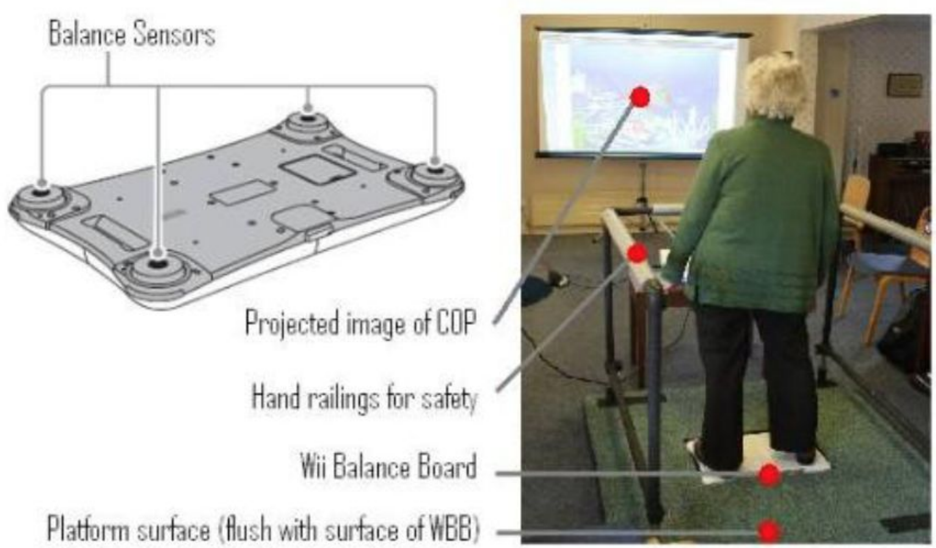


Isolation in a disposable blood-pressure sensor.
Disposable blood pressure sensors are made of clear plastic so air bubbles are easily seen. Saline flows from an intravenous (IV) bag through the clear IV tubing and the sensor to the patient. This flushes blood out of the tip of the indwelling catheter to prevent clotting. A lever can open or close the flush valve. The silicon chip has a silicon diaphragm with a four-resistor Wheatstone bridge diffused into it. Its electrical connections are protected from the saline by a compliant silicone elastomer gel, which also provides electrical isolation. This prevents electric shock from the sensor to the patient and prevents destructive currents during defibrillation from the patient to the silicon chip.

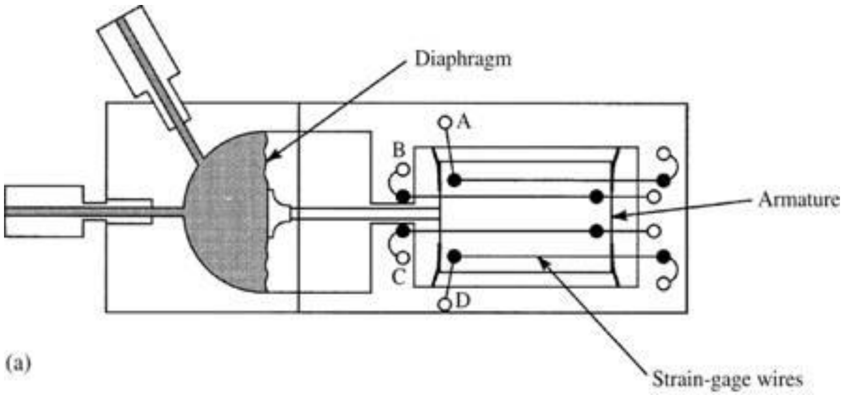
Perception Action Research Lab

Interactive Movement Games

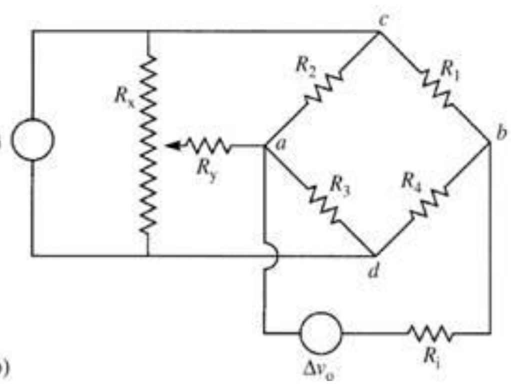
In collaboration with Dr Stuart Ferguson from the School of Electronics, Electrical Engineering and Computer Science, we have developed a way to interface the Nintendo Wii balance board with the virtual reality software 'Virtools'. By recording the bluetooth signal emmited from each pressure sensor embedded in the feet of the balance board, we can calculate the user's centre of pressure or the position of their balance. We then use this balance measure as the movement based controller in our virtual games environment (see **Young et al 2010** for details). This interface allows us to create adapted games and tests to train and assess balance in older adults and people with Parkinson's.



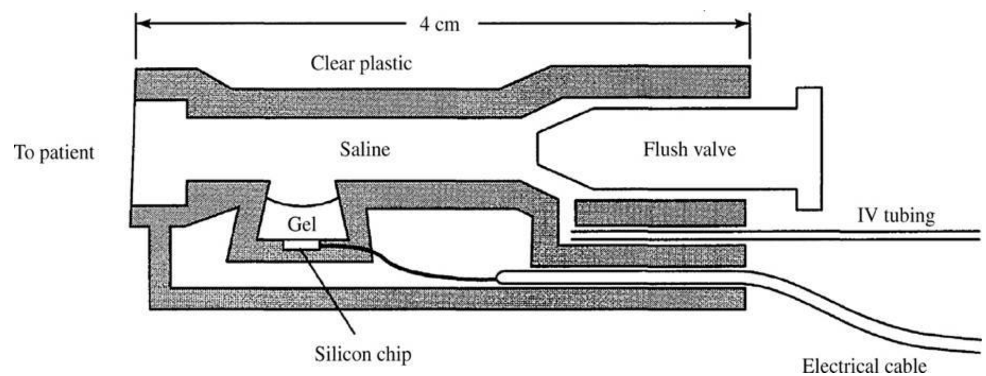
Puente de Wheatstone



(a)



(b)

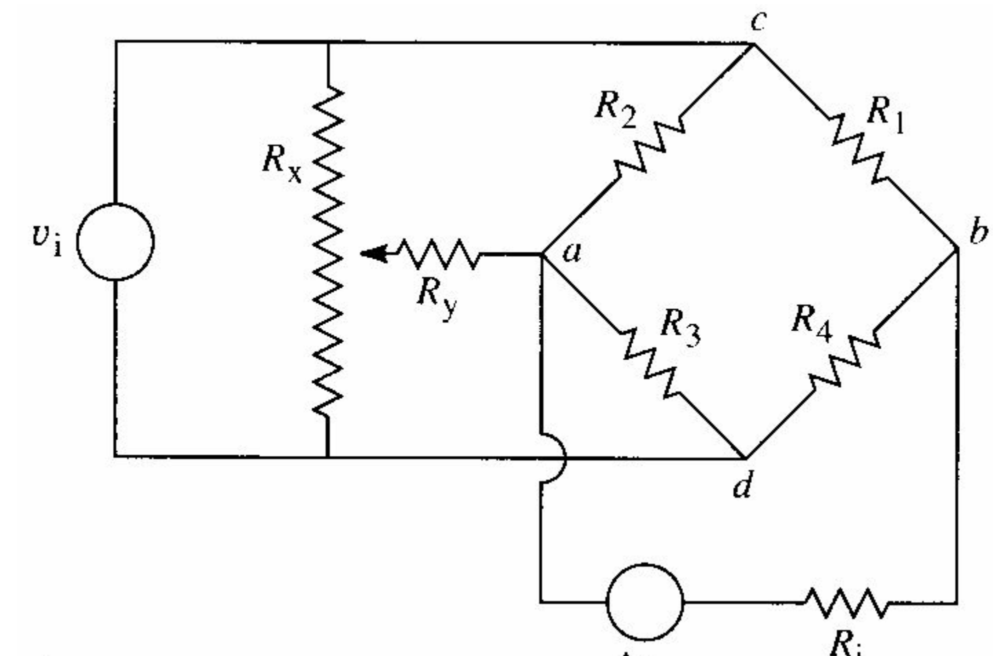


Puente de Wheatstone

Δv_o is zero when the bridge is balanced- that is when $R_1 / R_2 = R_4 / R_3$

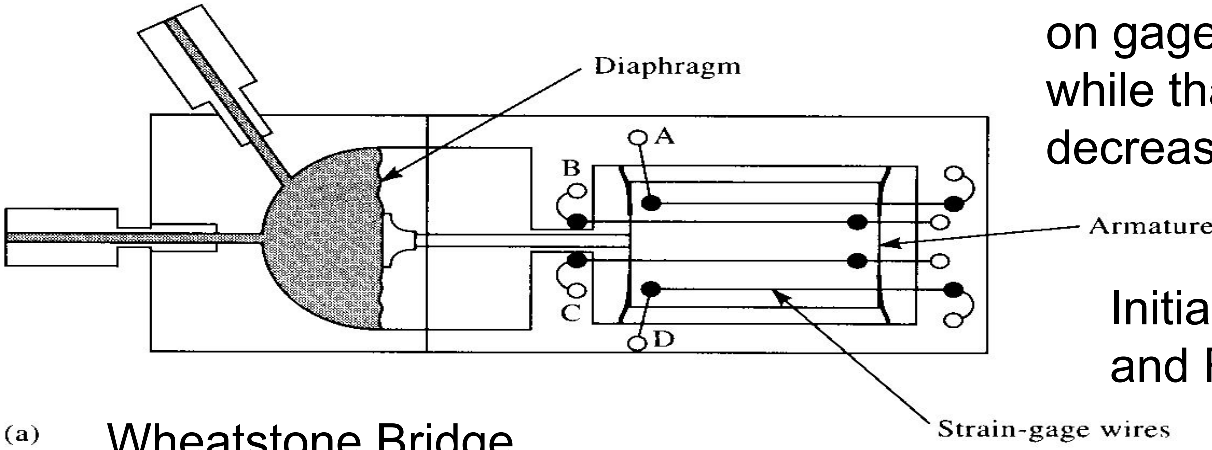
If all resistor has initial value R_0 then if R_1 and R_3 increase by ΔR, and R_2 and R_4 decreases by ΔR, then

$$\Delta v_0 = \frac{\Delta R}{R_0} v_i$$



(b)

Unbonded strain gage:

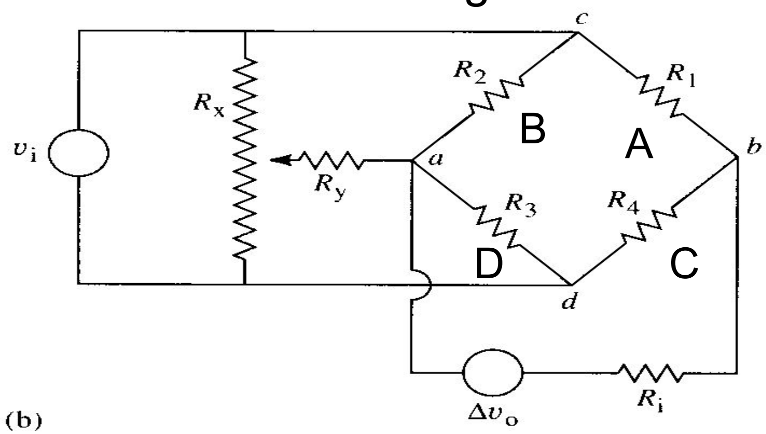


(a)

With increasing pressure, the strain on gage pair **B** and **C** is increased, while that on gage pair **A** and **D** is decreased.

Initially before any pressure $R_1 = R_4$ and $R_3 = R_2$

Wheatstone Bridge



(b)

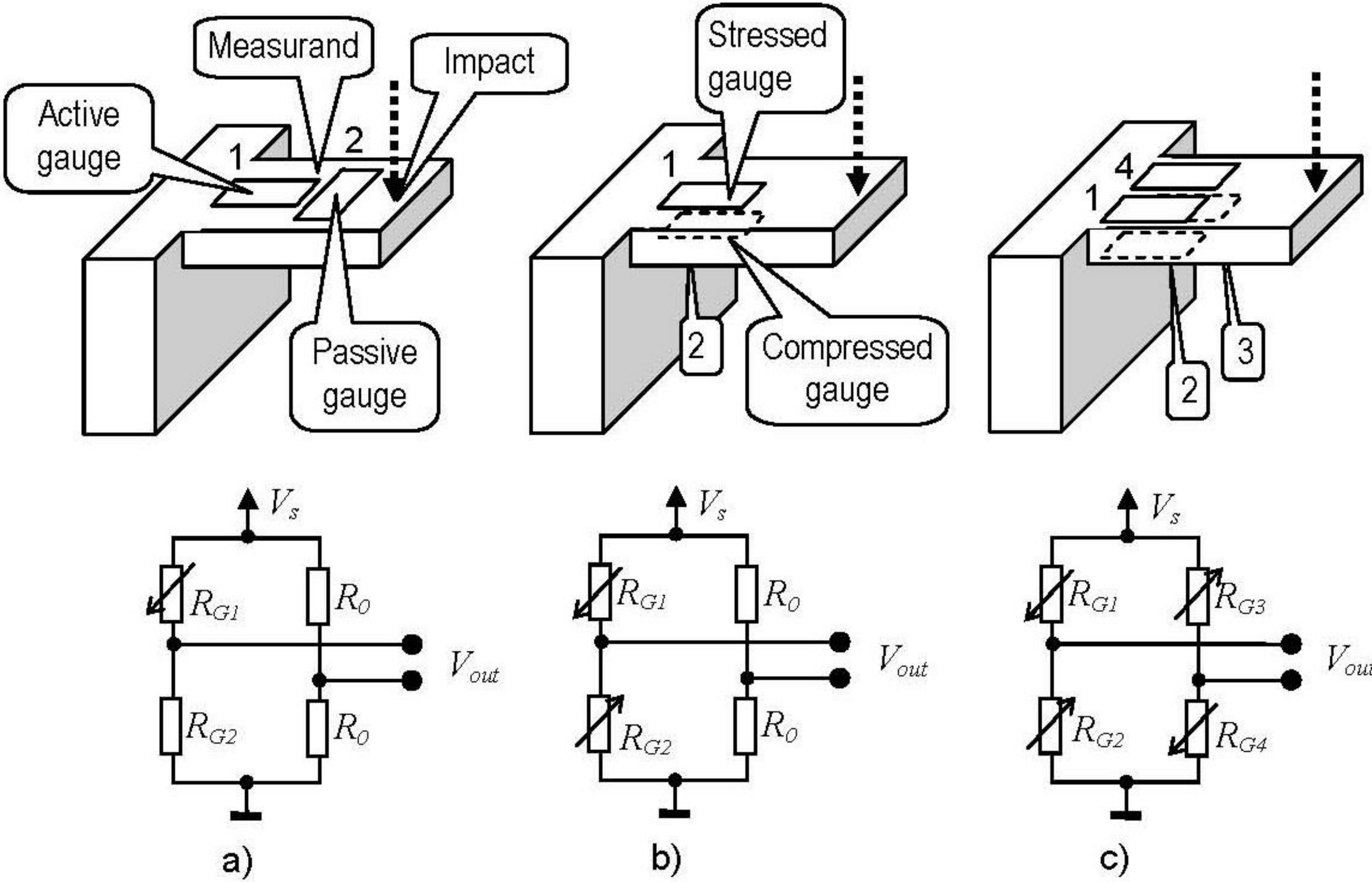
$$V_a = V_i\left(\frac{R_3}{R_2 + R_3}\right) \qquad V_b = V_i\left(\frac{R_4}{R_1 + R_4}\right)$$

$$V_o = V_a - V_b = V_i\left(\frac{R_3}{R_2 + R_3} - \frac{R_4}{R_1 + R_4}\right)$$

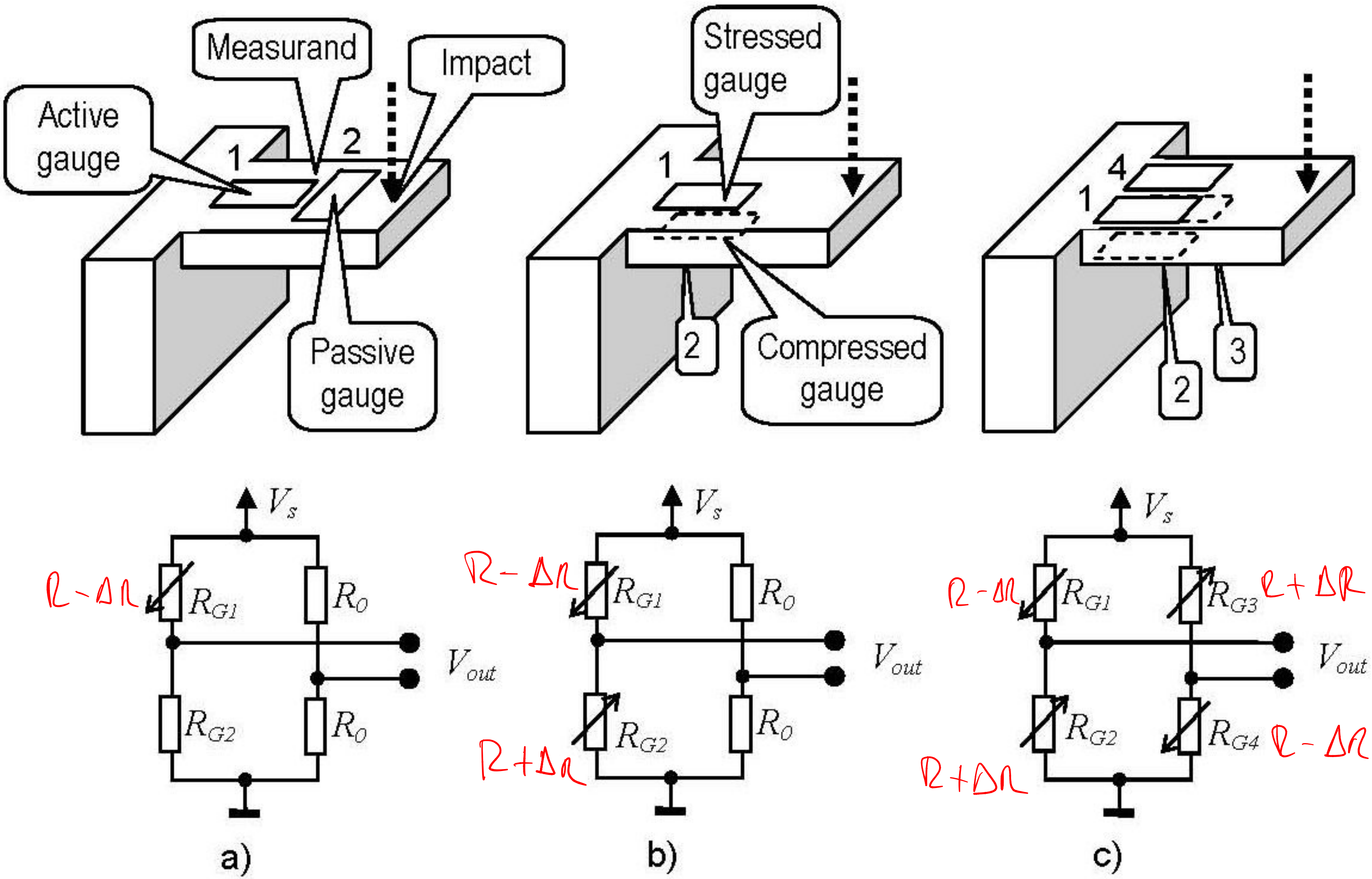
$$V_o = V_i\left(\frac{R_4(R_3 - R_2) + R_3(R_1 - R_4)}{(R_2 + R_3)(R_1 + R_4)}\right)$$

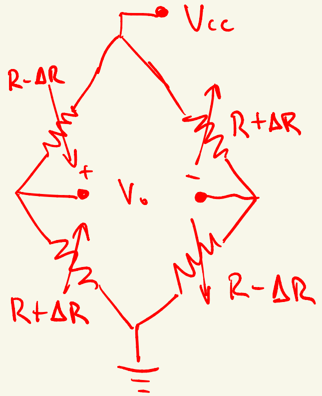
Fig. 2.2 legend: R_1 = A, R_2 = B, R_3 = D, R_4 = C

Puente de Wheatstone



Puente de Wheatstone





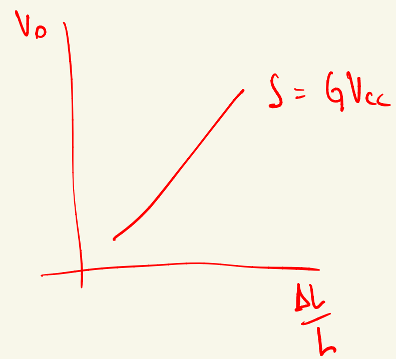
$$V_o = \left(\frac{R+\Delta R}{R+\Delta R+R-\Delta R} - \frac{R-\Delta R}{R-\Delta R+R+\Delta R} \right) V_{cc}$$

$$V_o = \frac{2\Delta R}{2R} V_{cc} = \frac{\Delta R}{R} V_{cc}$$

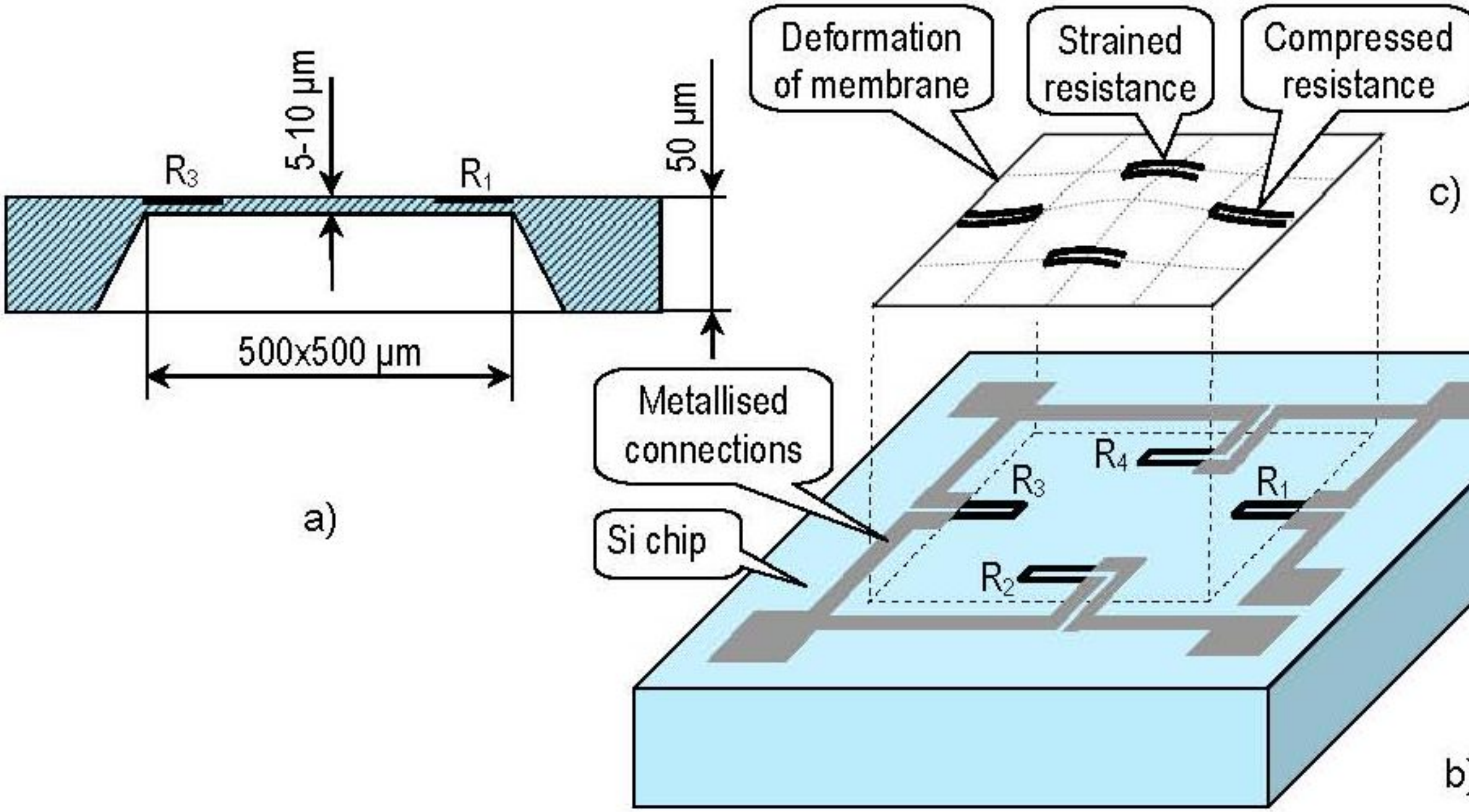
$$G = \frac{\frac{\Delta R}{R}}{\frac{\Delta L}{L}} = 2 \text{ (Factor de Galga)}$$

Determine Vo cuando se ejerce una fuerza que hace que el largo de la galga aumente un 1% respecto del largo sin fuerza.

$$V_o = G \frac{\Delta L}{L} V_{cc} = 2 \frac{0.01L}{L} V_{cc} = \underline{2 \cdot 0.01 \, V_{cc}}$$

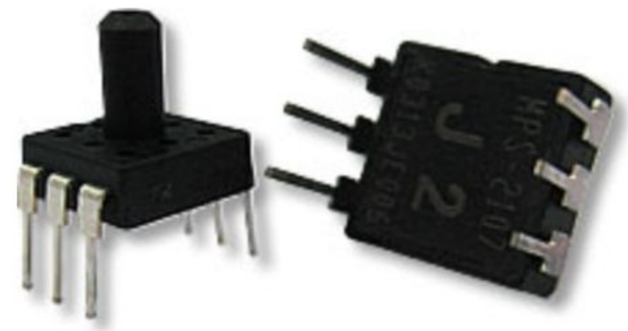


Puente de Wheatstone



Ejemplo: MPS2100 series

MPS-2100 Series Pressure Sensor



Datasheet | MPS-2100 Series

RoHS compliance

Features

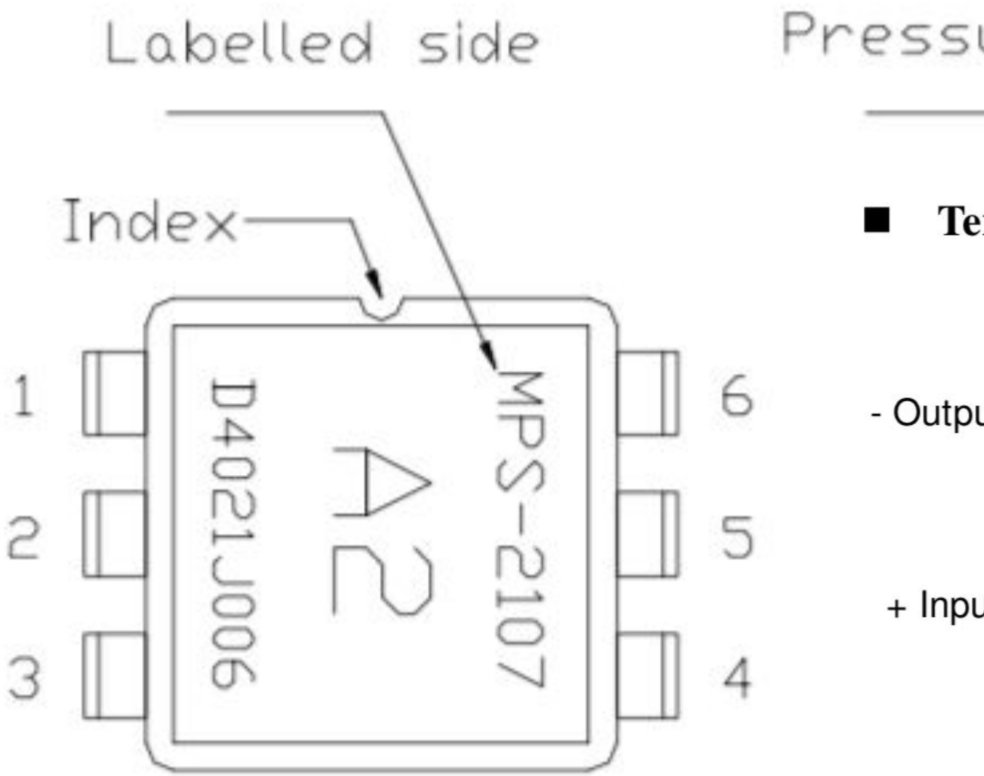
- Competitive price DIP package
- Wide operating temperature range: -40 to 85°C
- Solid-state reliability
- Easy to use
- Easily Embedded in OEM Equipment
- Gauge pressure type（1, 5.8, 15, 30, 100 psi）

Applications

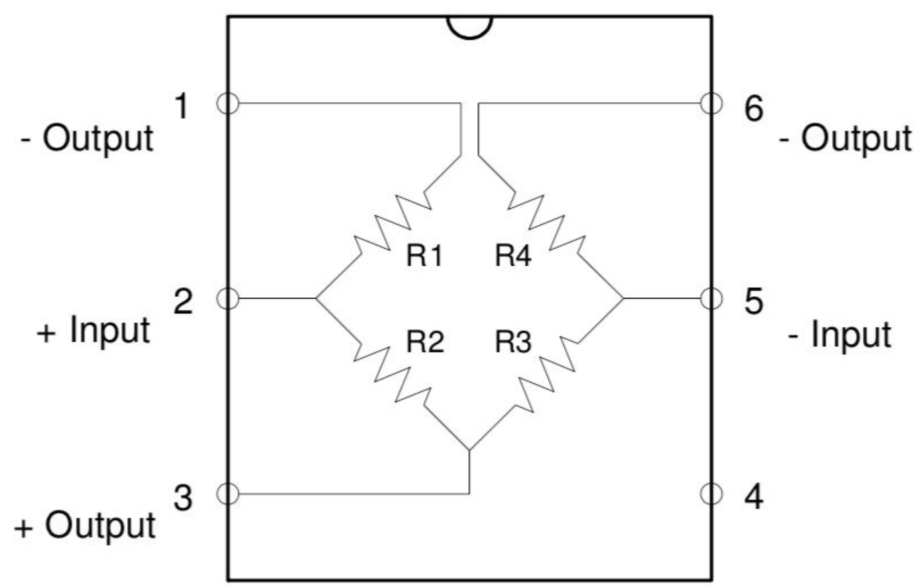
- Digital blood pressure meter
- Digital pressure gauges
- Environmental monitoring
- Consumer
- Medical instrumentation & monitoring

Description

MPS-2107-006GC



■ **Terminal connection diagram**



⇝ R cambia en función de la temperatura

$$R = R_0(1 + \alpha T + \beta T^2)$$

R_0 : Resistencia a $0°C$.

T : Temperatura ($°C$)

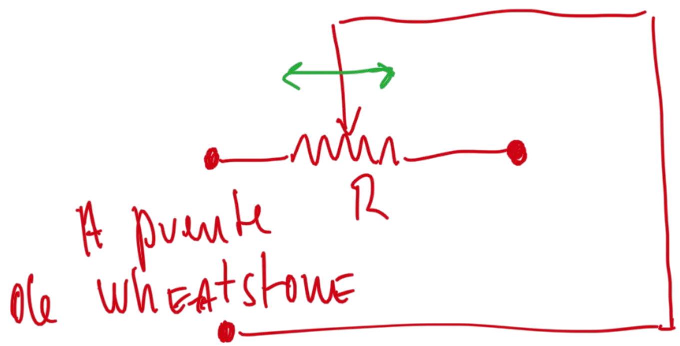
α : coeficiente de temperatura (>0 metales, <0 no metales).

β : coeficiente de temperatura de 2do orden.

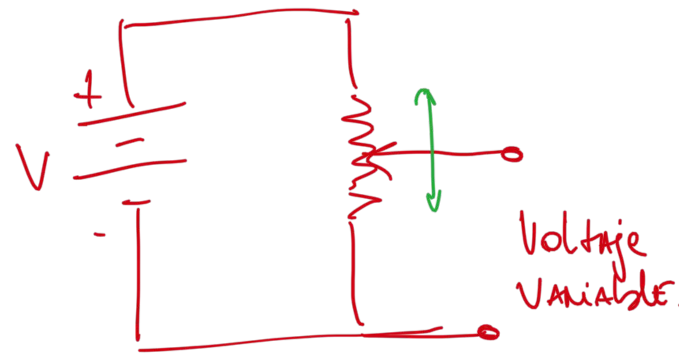
RTD (Resistance temperature devices) son un ejemplo en esta categoría. A menudo se usa una aproximación lineal:

$$R = R_0 (1 + \alpha T)$$

⇝ sliding contact devices.



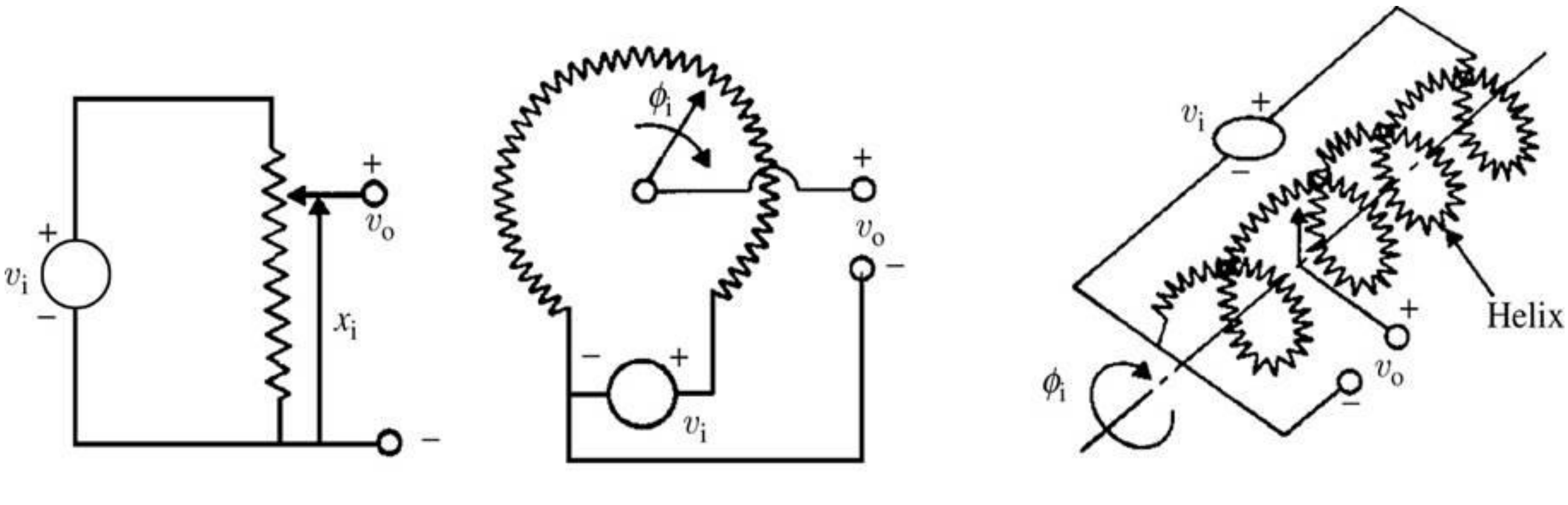
Configuración no sesgada



Configuración sesgada.

Potenciómetros

- Capaces de convertir desplazamientos lineales y angulares en un voltaje.
- 10-100 mm de desplazamiento lineal o rotación.
- La resolución es una función de la construcción del cable.

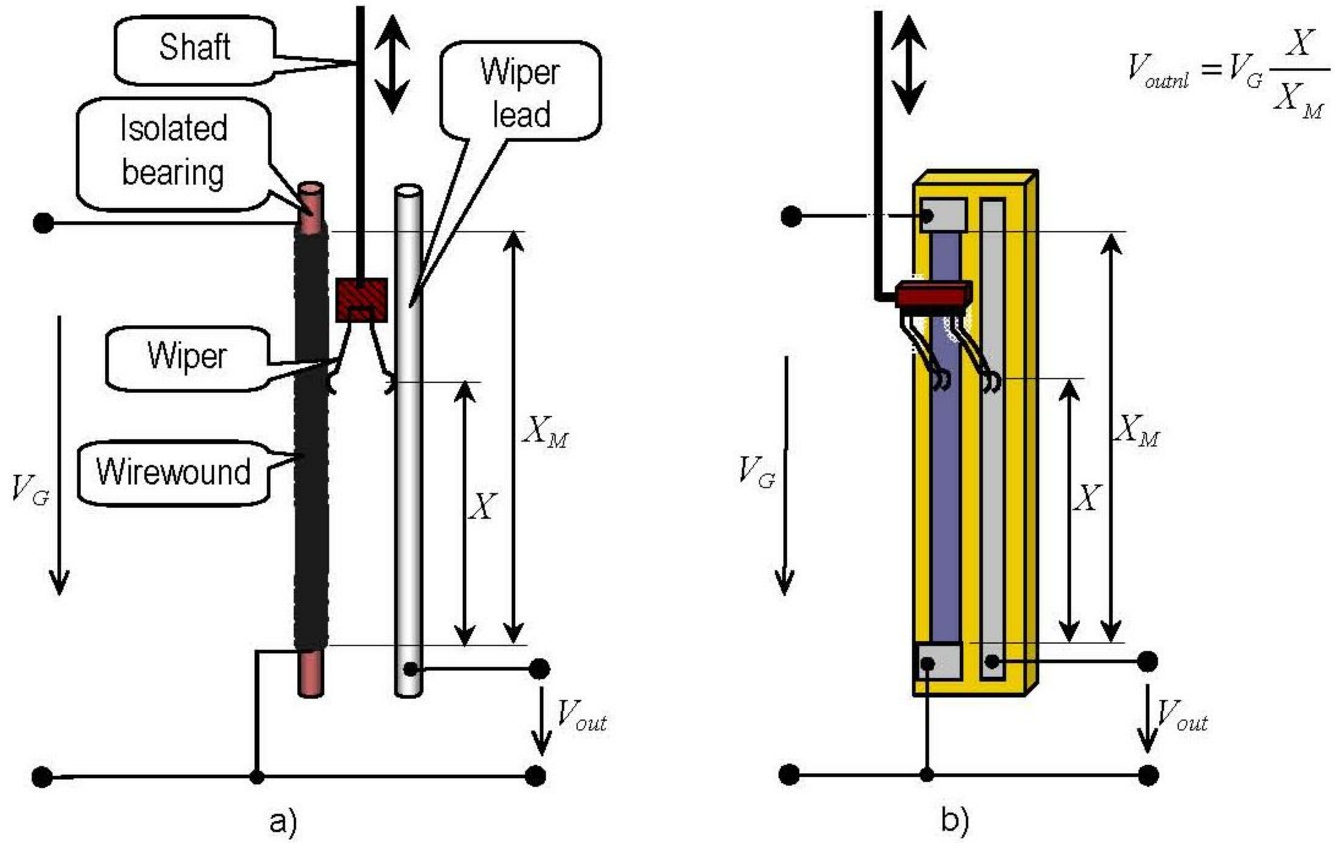


(a) Translational (b) Single turn (c) Multiturn

Los potenciómetros están disponibles en el rango 10 Ω – 10 MΩ.
Los potenciómetros usados como transductores usualmente vienen en el rango 1 kΩ – 100 kΩ.

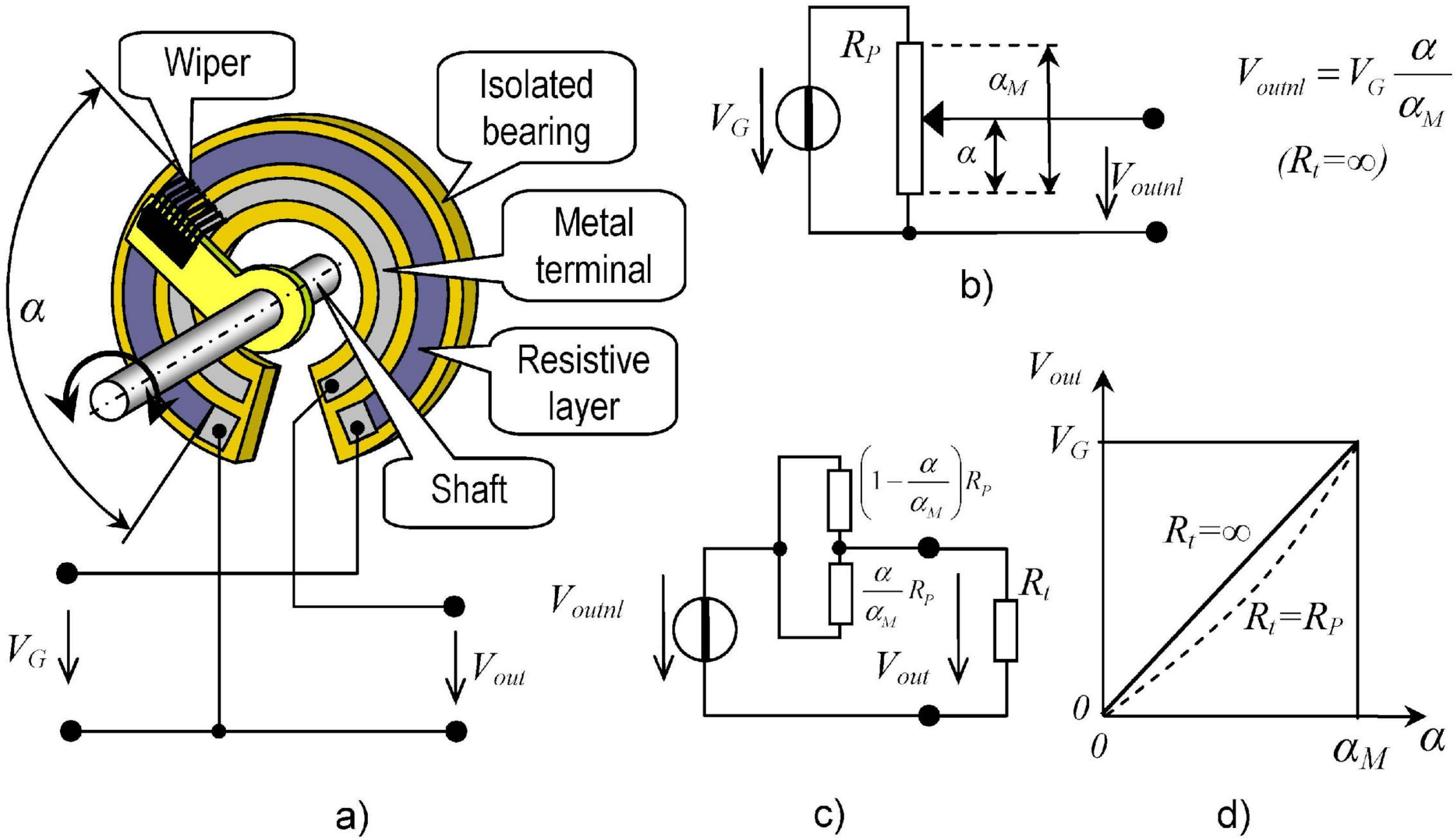
Potenciómetros

Converting linear displacement into voltage using wire wound (a) and film (carbon or cermet) potentiometer (b)



Potenciómetros

The rotary potentiometer used as a sensor. The structure (a), symbol (b), model to calculate the loaded characteristics (c), and the transfer characteristics (d).



a) b) c) d)

Adipómetro