Critérios para a Seleção de Sensores

Agenda

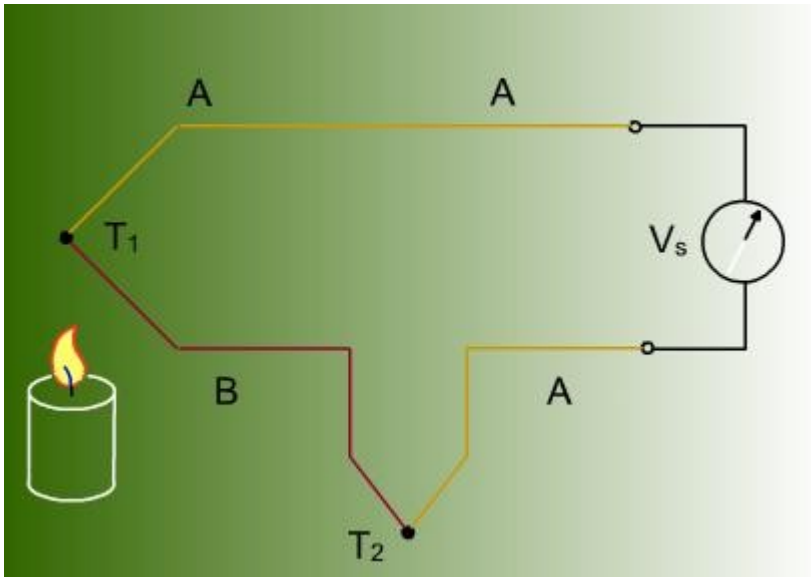
1. MEDIÇÃO DE TEMPERATURA
2. MEDIÇÃO DE VARIÁVEIS MECÂNICAS
    - 2.1. MEDIÇÃO DE FORÇA E PESO
    - 2.2. MEDIÇÃO DE PRESSÃO
    - 2.3 MEDIÇÃO DE VAZÃO
    - 2.4 MEDIÇÃO DE NÍVEL
3. *SMART SENSORS*

Critérios para a Seleção de Sensores de Temperatura

Agenda

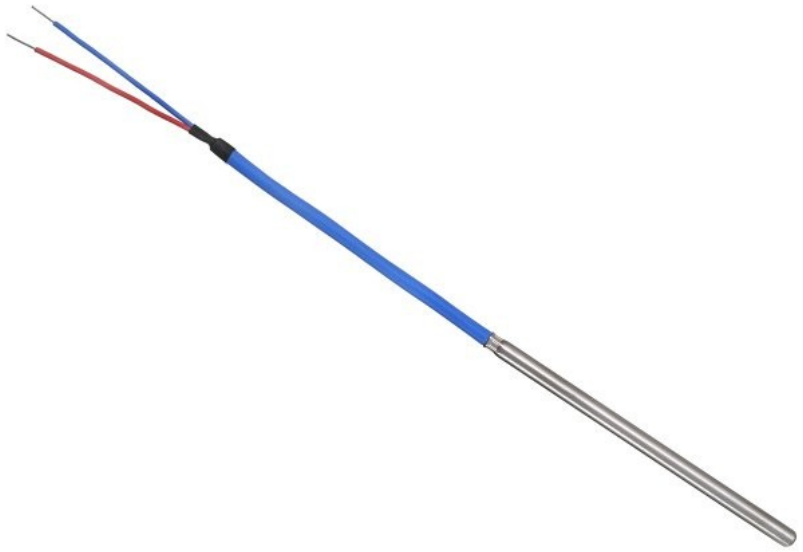
1. TERMOPARES
2. RTDs
3. TERMISTORES
4. SENSORES DE SILÍCIO

Medição de Temperatura



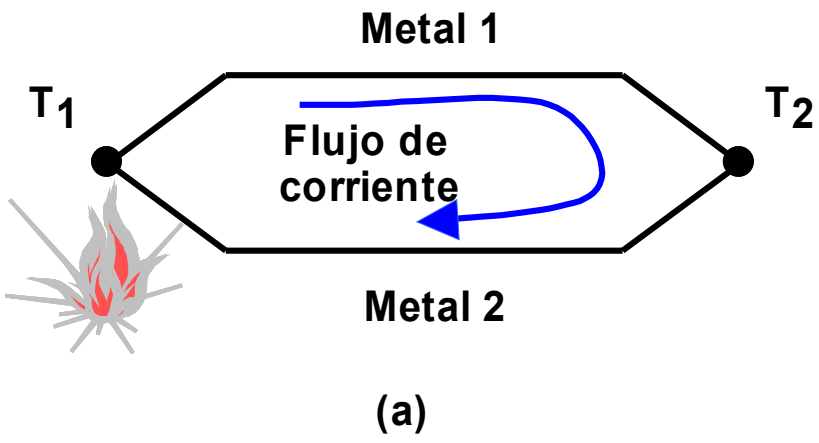
Termopares

“SENSOR DE TEMPERATURA CONSTITUÍDO POR DOIS METAIS DISTINTOS CUJA PRINCIPAL CARACTERÍSTICA É PRODUZIR UMA TENSÃO PROPORCIONAL À DIFERENÇA DE TEMPERATURA ENTRE OS PONTOS DE UNIÃO DOS DOIS METAIS.”

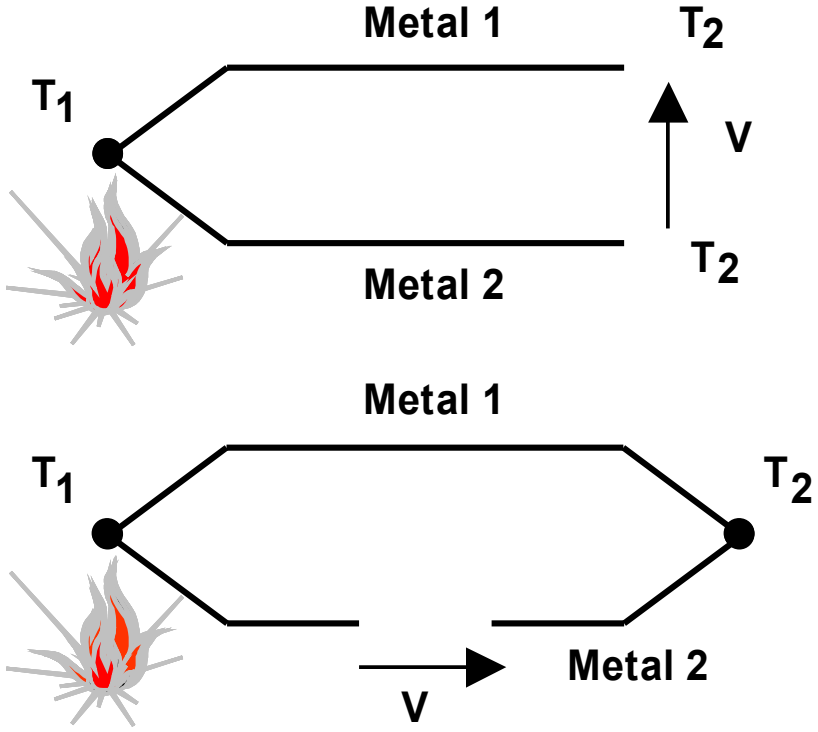


http://www.exacta.ind.br/?p=conteudo&id=61

Principio de funcionamento

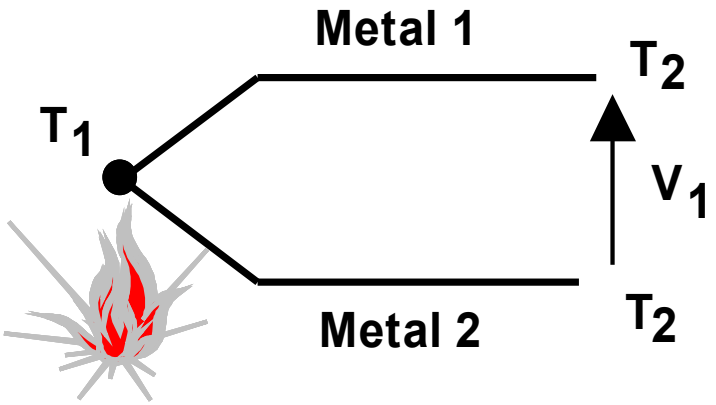


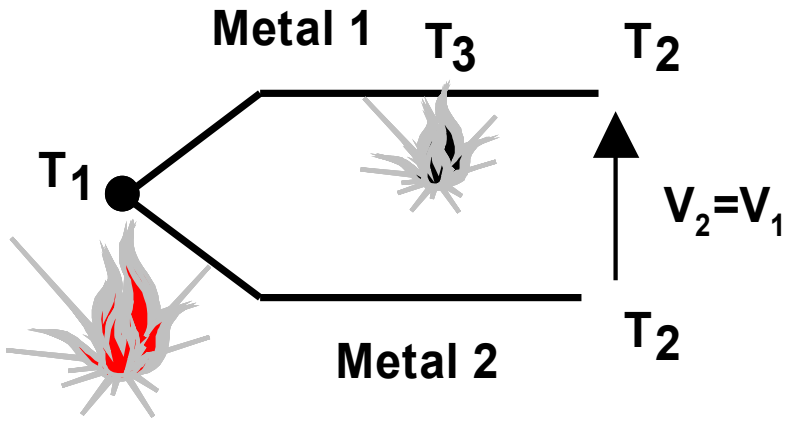
(a)



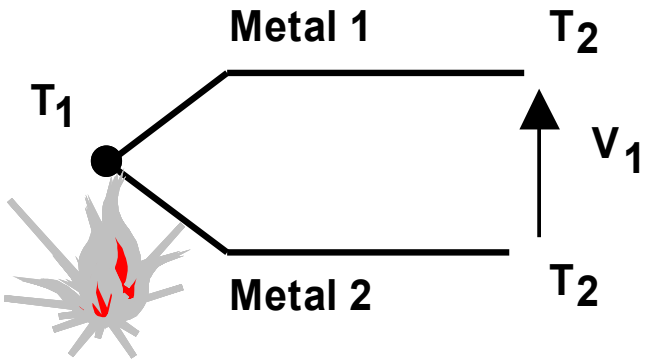
(b)

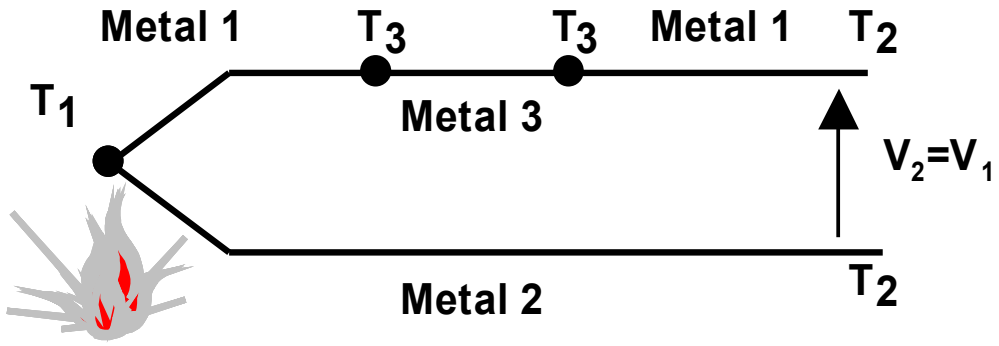
Lei dos circuitos homogêneos



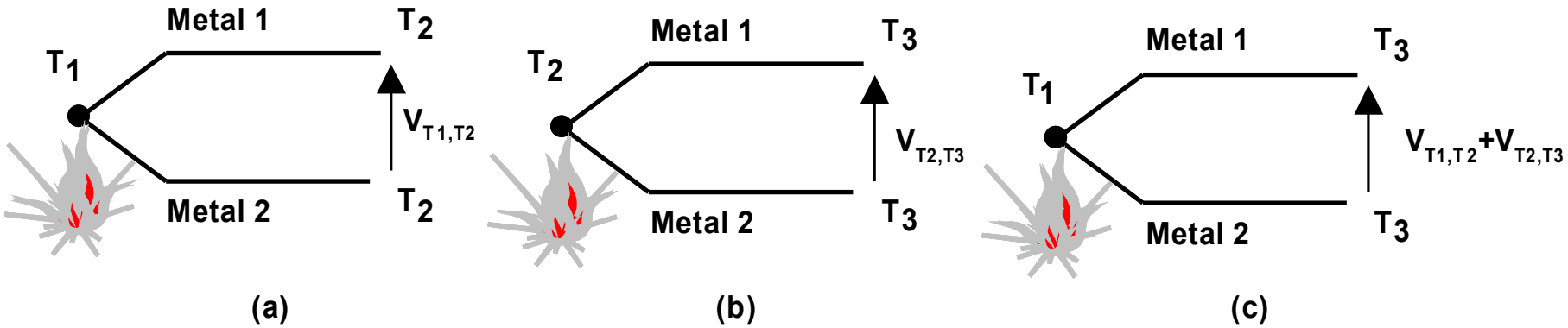


Lei dos metais intermediários

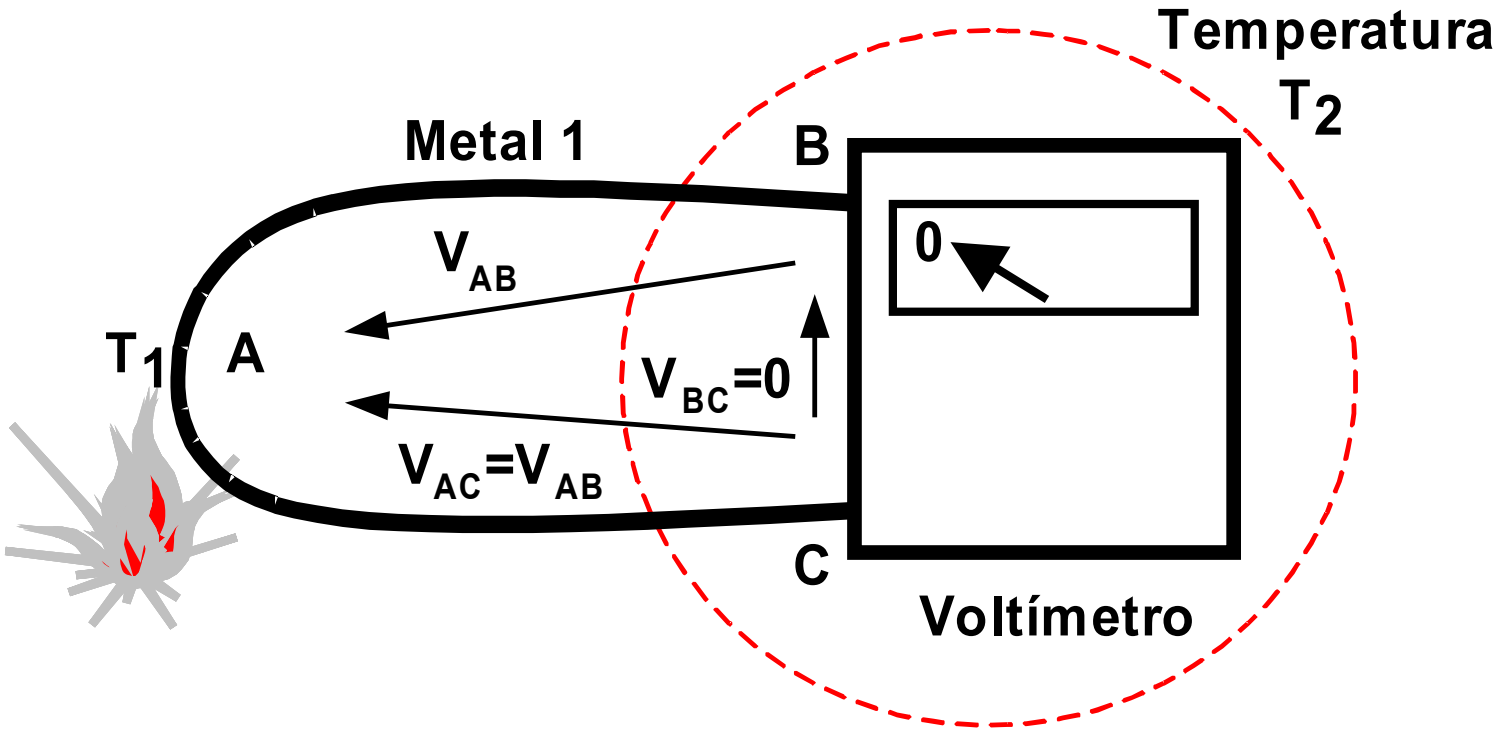




Lei das temperaturas intermediárias



Necessidade de circuitos assimétricos



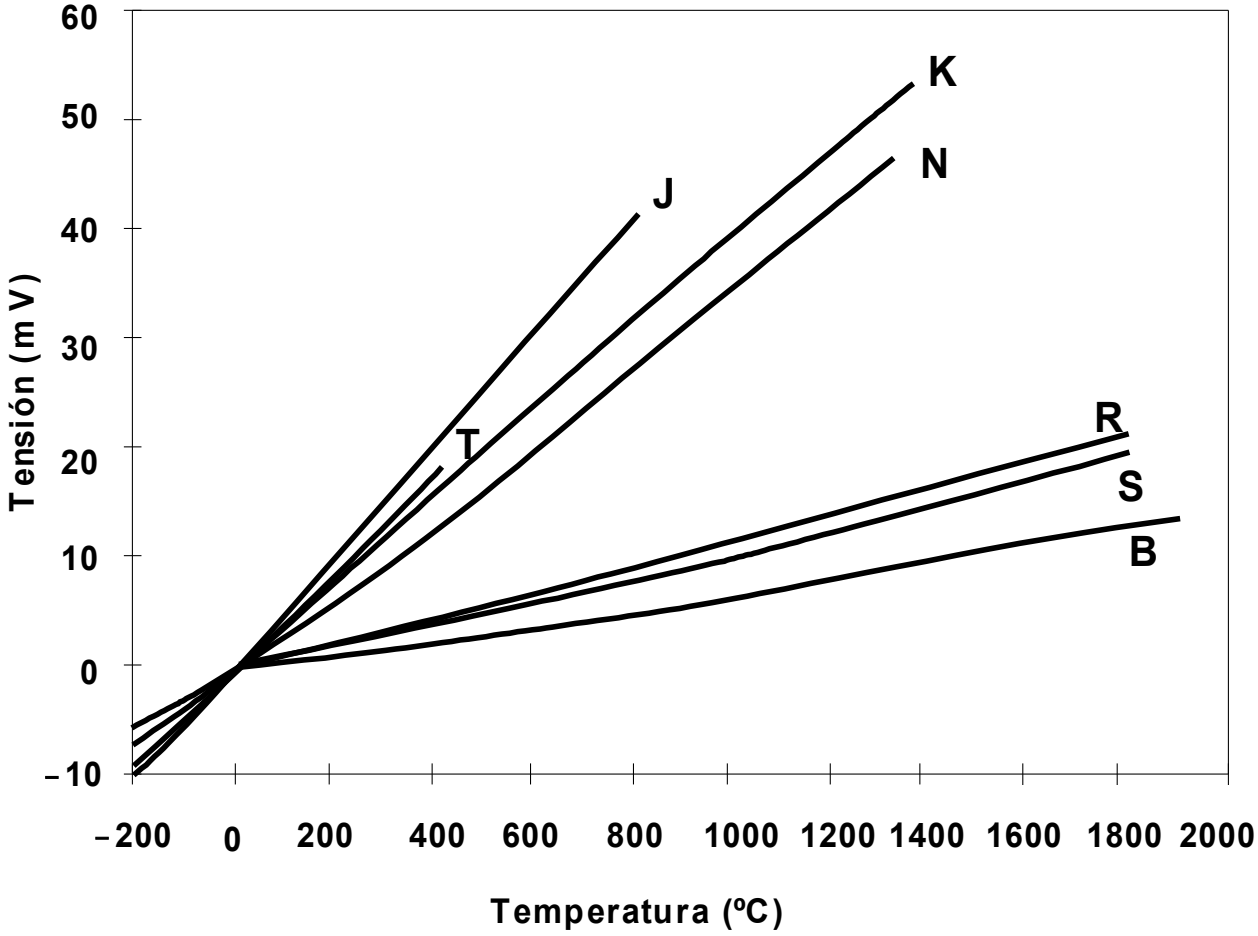
Tipos de termopares

Tipo	Composición (terminal positivo - negativo)	Campo de medida recomendado	Sensibilidad (a 25ºC)
J	Fe - Constantán*	0 a 760ºC	51,5 μV/ºC
K	Cromel* - Alumel*	-200 a 1250ºC	40,5 μV/ºC
N	Nicrosil* - Nisil*	0 a 1260ºC	26,5 μV/ºC
T	Cu - Constantán	-200 a 350ºC	41,0 μV/ºC
R	13%Pt 87%Rh - Pt	0 a 1450ºC	6 μV/ºC
S	10%Pt 90%Rh - Pt	0 a 1450ºC	6 μV/ºC
B	30%Pt 70%Rh - 6%Pt 94%Rh	800 a 1800ºC	9 μV/ºC (a 1000 ºC)

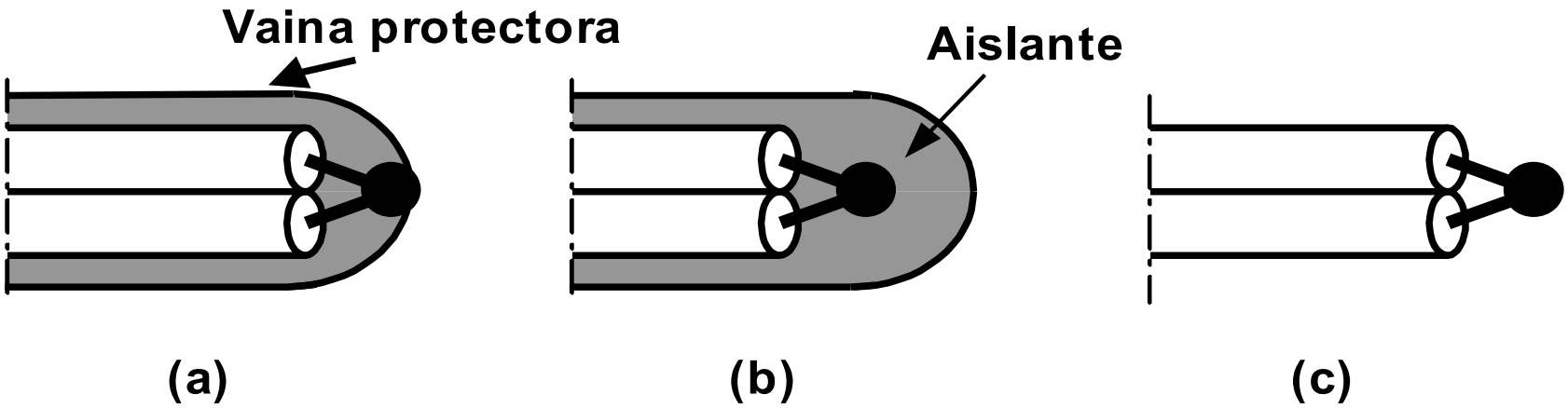
Tipos de termopares

Tipo	Aplicabilidade
J	Apropiado para atmósferas inertes o reductoras. Las atmósferas oxidantes disminuyen la vida útil debido a la presencia de hierro en el termopar que, además, se oxida muy rápidamente por encima de 538ºC. No es adecuado para bajas temperaturas (por debajo de 0ºC).
K	Muy utilizado por encima de 538ºC debido a las limitaciones del termopar de tipo J. El cromo tiende a oxidarse ante la presencia de oxígeno lo que puede llevar a importantes derivas en el margen de 816 a 1038ºC.
N	Se utiliza en aplicaciones donde el termopar de tipo K tiene problemas de oxidación.
T	Adecuado para atmósferas oxidantes, inertes y reductoras.
R, S	Recomendados para altas temperaturas. El de tipo R se utiliza industrialmente mientras que el S en laboratorios. El uso continuado a altas temperaturas provoca el crecimiento del granulado y puede sufrir una ruptura mecánica. Deben protegerse con tubos no metálicos y aislantes cerámicos. Tienden a descalibrarse debido a la difusión del rodio a la rama de platino puro y a su volatilización.
B	Semejante a los tipos R y S aunque el límite de temperatura es mayor y es menos susceptible al crecimiento del granulado.

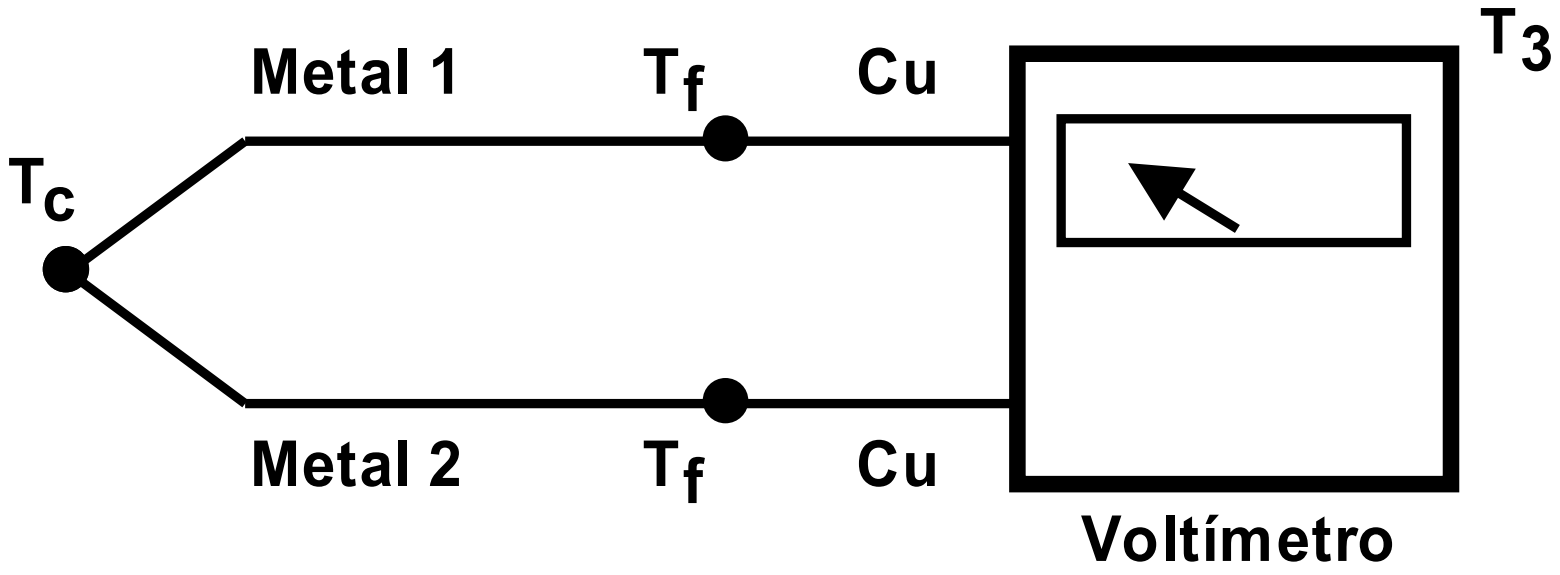
Curvas de calibração



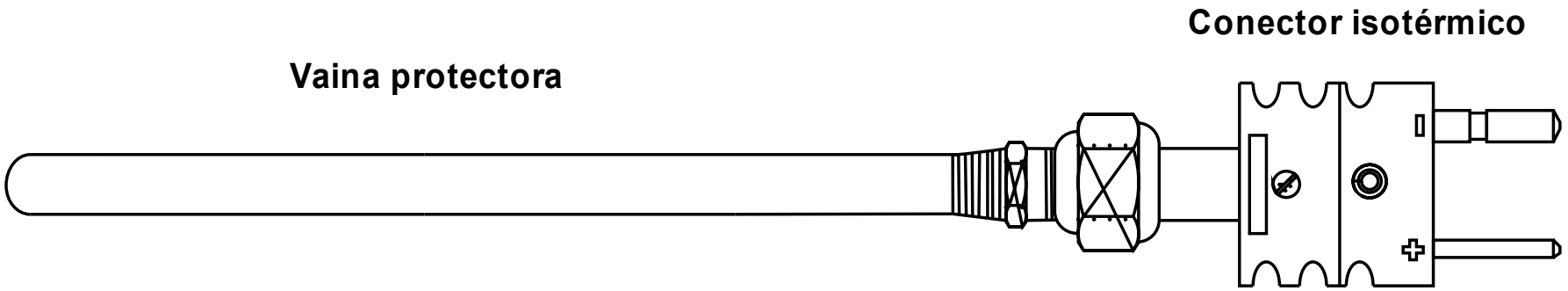
Tipos de termopares



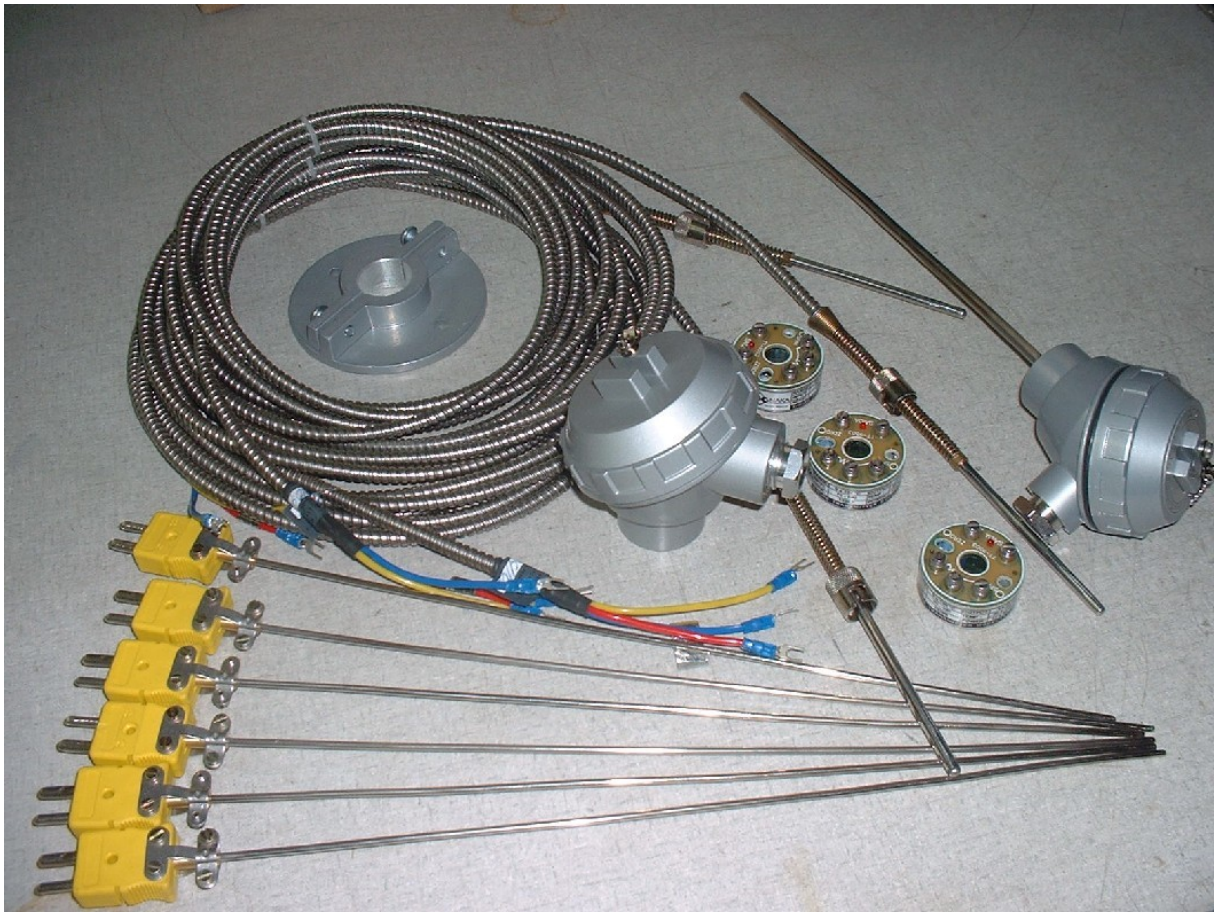
Efeito das uniões aos equipamentos de medição



Carcaça e conectores isotérmicos

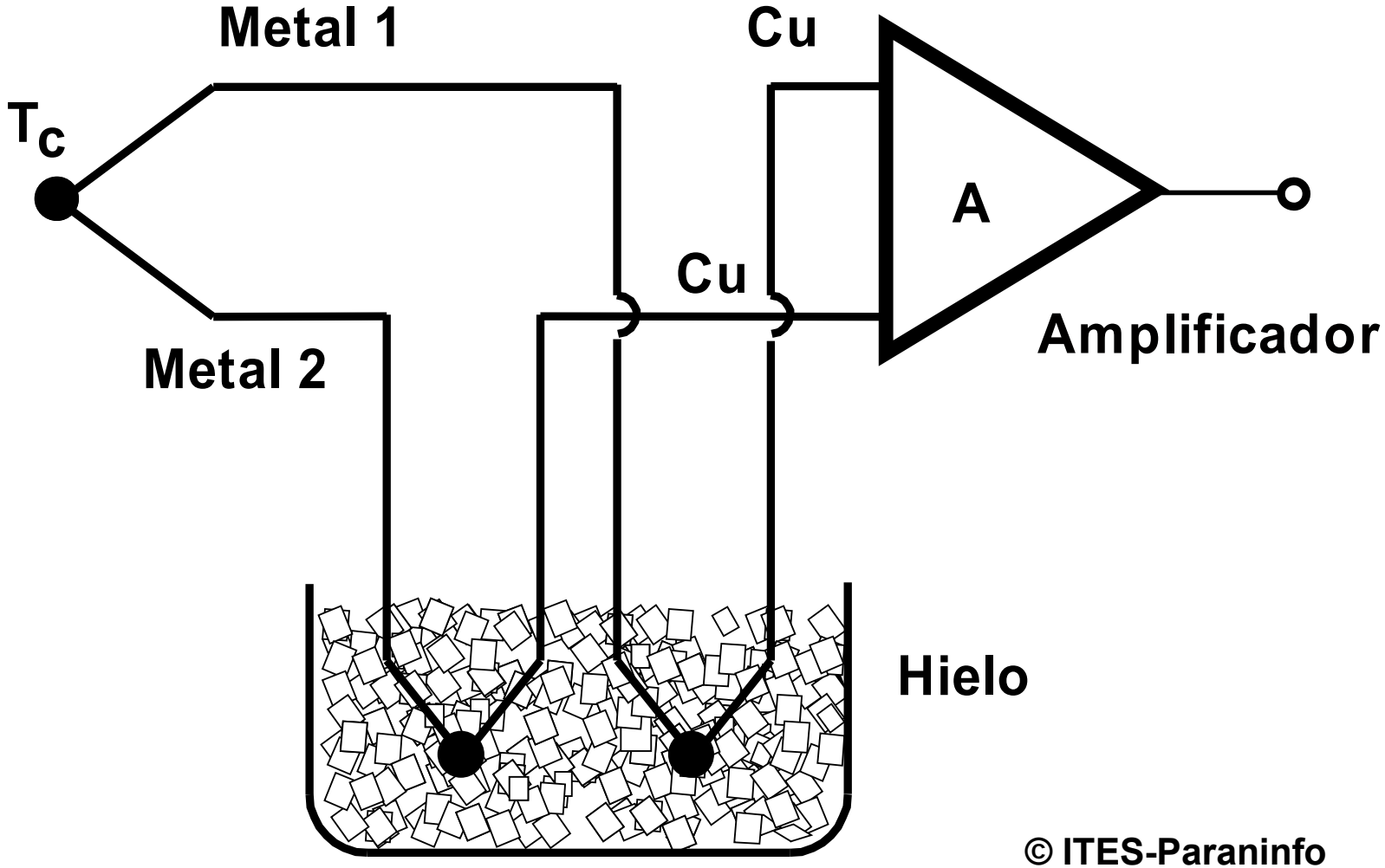


Exemplos de Termopares

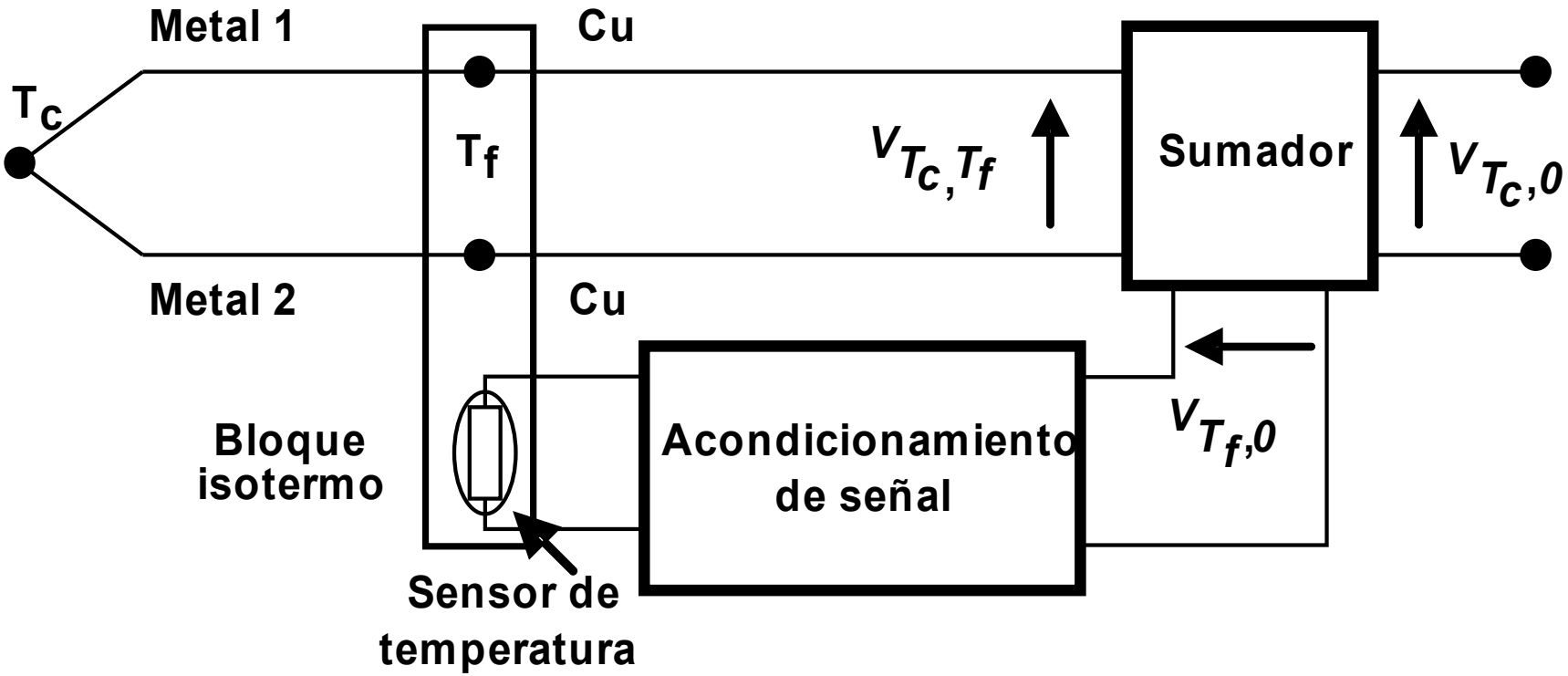


http://www.naka.com.br/

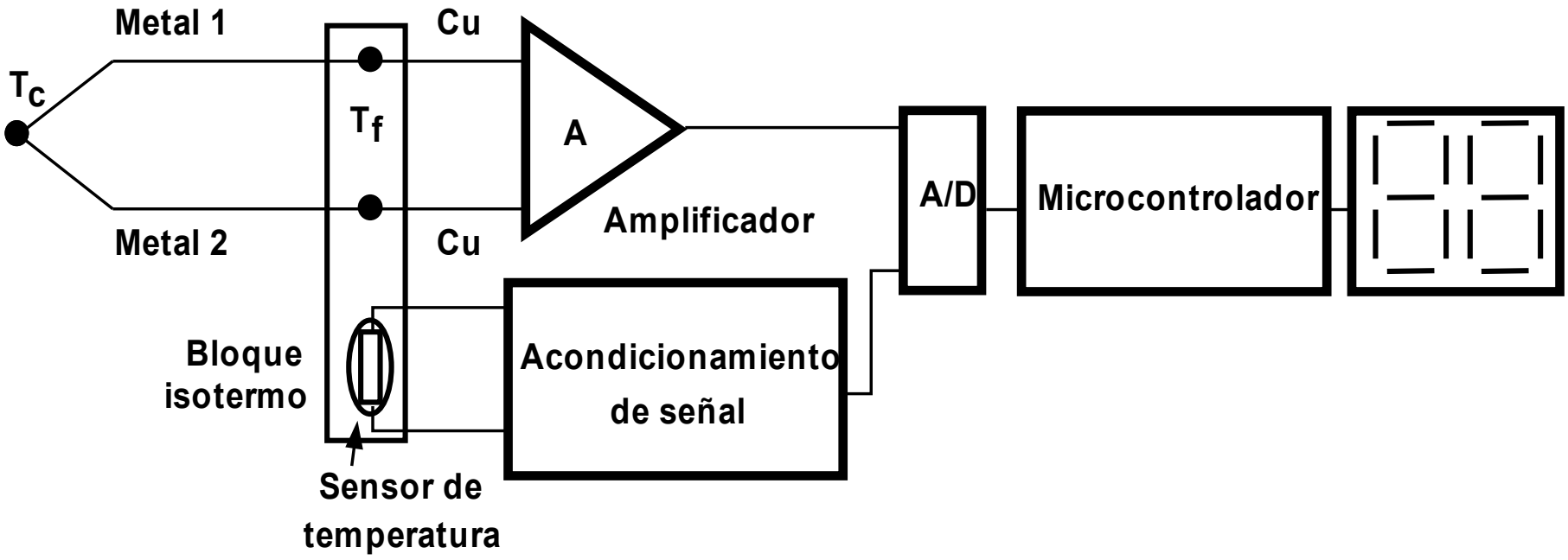
Compensação mediante banho de gelo



Compensação Analógica



Compensação Digital



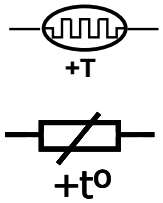
Calibrador para termopares

Características do TC-100:

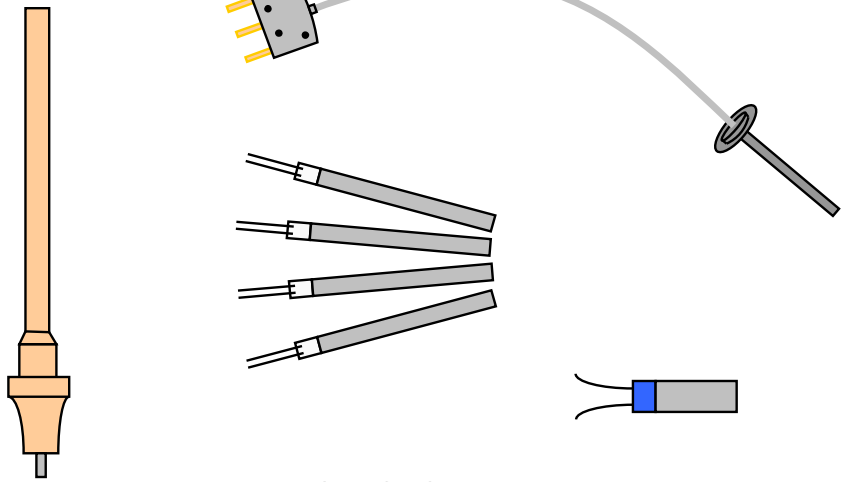
* Elevada precisão (± 0.3°C);
* 10 Tipos de termopares;
* Aceita 2 tipos de conexão de termopares; mini-plug e fios de compensação;
* 3 ajustes de 'set-points' para cada tipo de termopar.

http://www.acgtech.com.br/calibrador_temperatura_tc100.html

Resistance Temperature Detectors (RTD)



SÍMBOLO



ASPECTO

$$R = \frac{\rho \cdot l}{A}$$

$$R_T = R_0 \cdot (1 + \alpha \cdot \Delta T)$$

Nota: Se Pt-100, R_0=100 ohms e alfa=3.9e-3 K^{-1}.

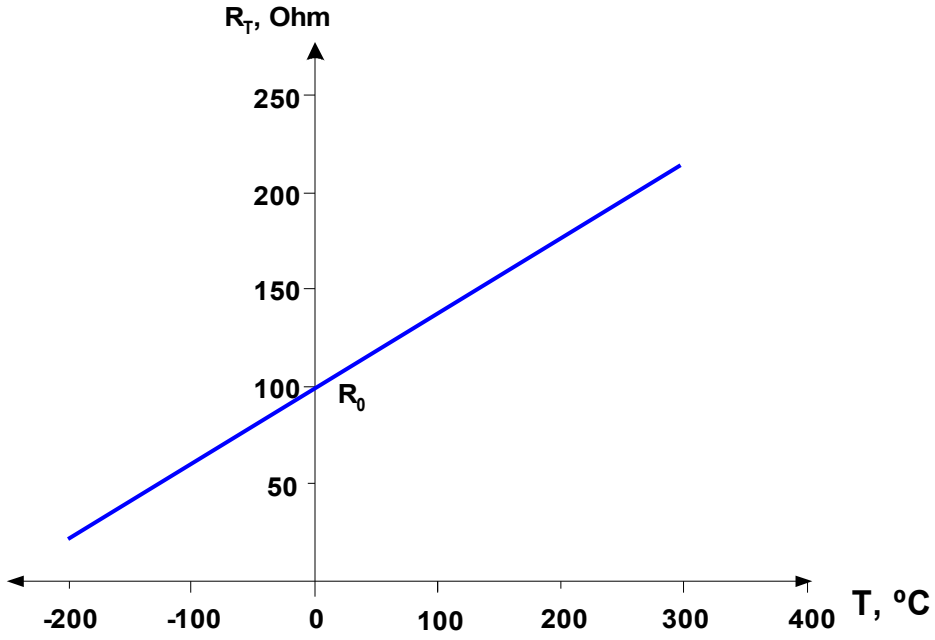
Sensores de temperatura de resistencia metálica. RTD (II).

Metales	Resistividad (ρ), Ω-m	Coeficiente térmico, $(K)^{-1}$
Platino, Pt	$10{,}6 \cdot 10^{-8}$	$3{,}9 \cdot 10^{-3}$
Níquel, Ni	$6{,}84 \cdot 10^{-8}$	$7 \cdot 10^{-3}$
Wolframio, W	$5{,}6 \cdot 10^{-8}$	$4{,}5 \cdot 10^{-3}$
Cobre, Cu	$1{,}68 \cdot 10^{-8}$	$4{,}3 \cdot 10^{-3}$

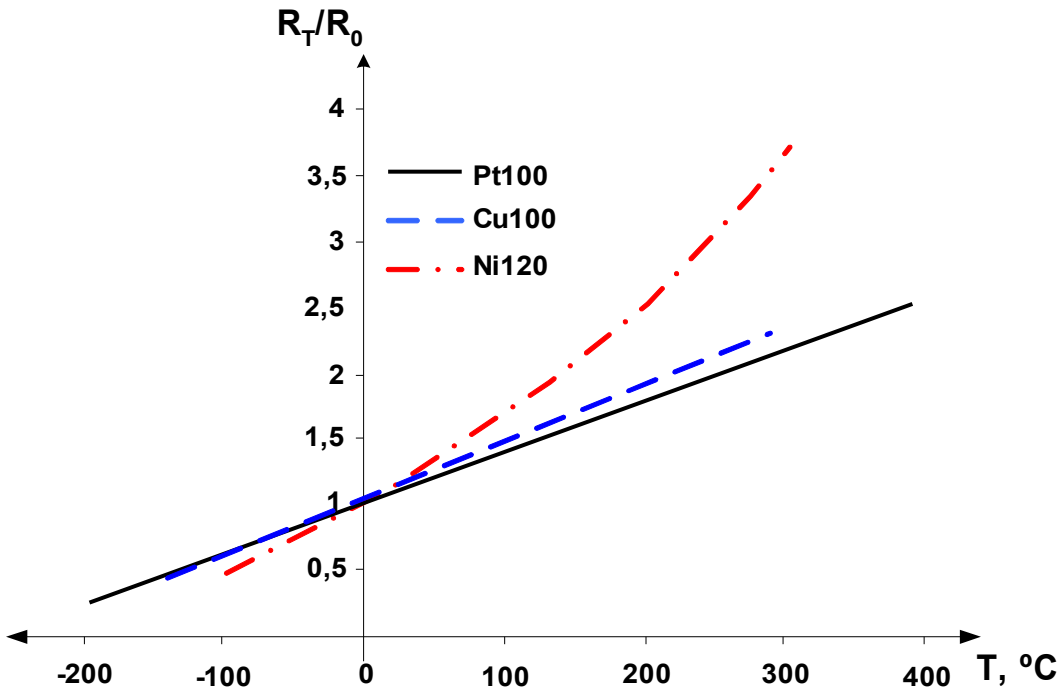
Tipos de RTD (II).

Metal	Margen útil de temperatura, (ºC)	Valores de R_0, (Ω)
Platino	-260 ÷ 900	25,100,400,500,1000 y 2000
Tungsteno	-100 ÷ 1200	10, 50, 100, 1000 y 2000
Níquel	-200 ÷ 430	120, 1000
Cobre	-200 ÷ 260	10, 100, 1000
Balco	-100 ÷ 230	100, 1000 y 2000

Curvas de calibracão (I).

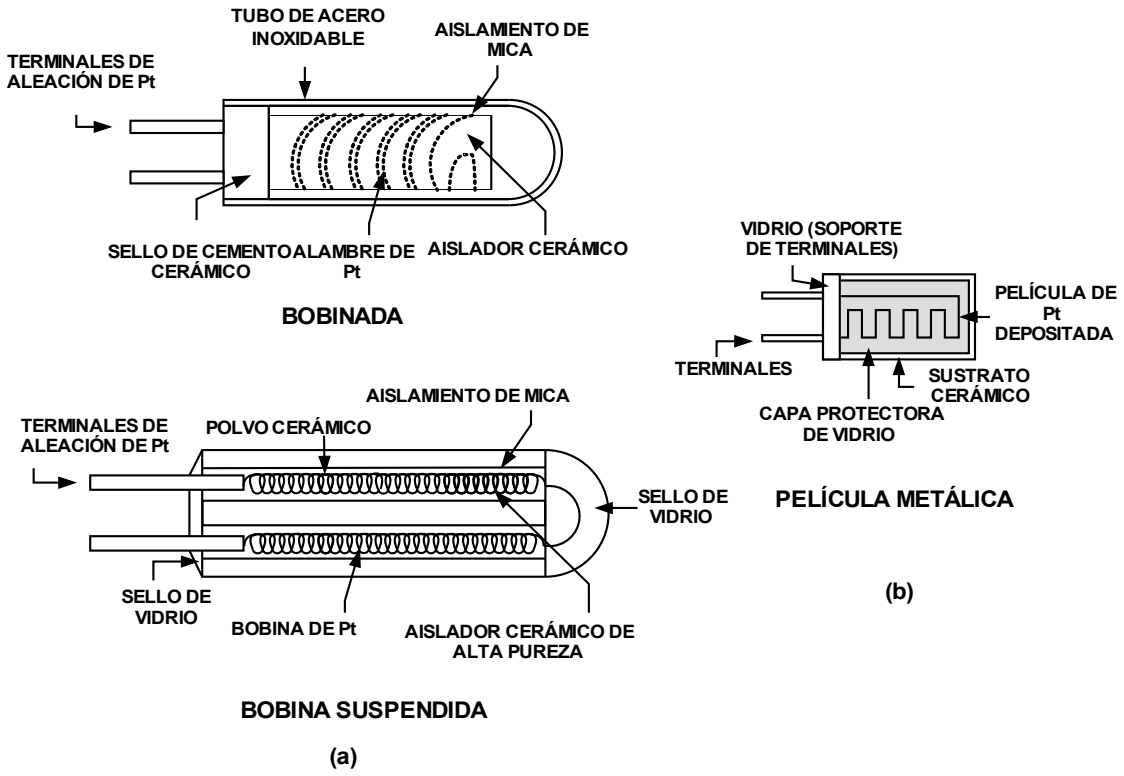


Curvas de calibração (normalizadas)



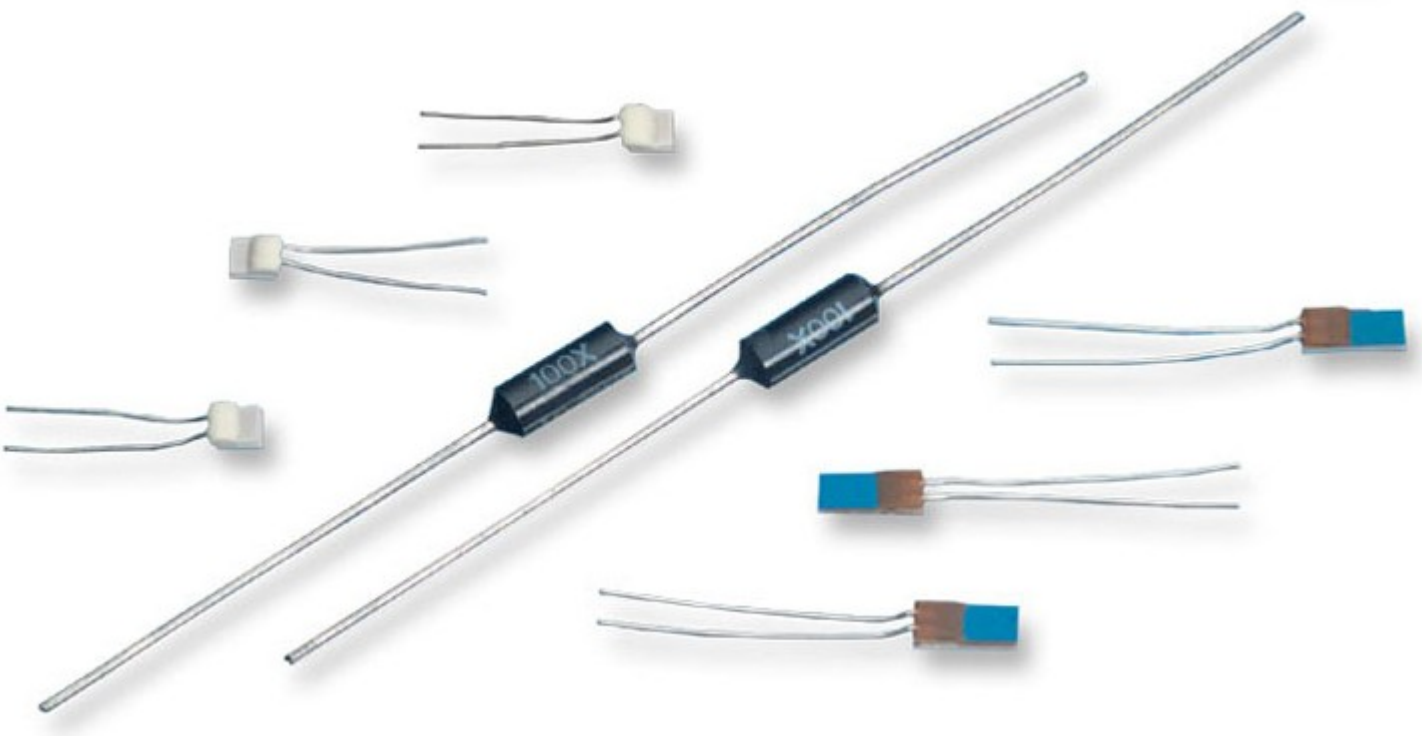
Tipos de RTD - Características

a) Forma Construtiva;
b) Tamanho (ordem do sistema e velocidade de resposta);
c) Características do Meio (e.g., fluidos e superfície);
d) Tipo de metal utilizado;
e) Valores típicos de R_0.



(a)

Exemplos de RTD



http://www.specsensors.com/rtd.asp

Exemplo de RTD – Pt-100

http://www.3bscientific.com.br/Sensor-de-temperatura-Pt100-U11330,p_83_578_1109_834.html?initOptionReferer=1

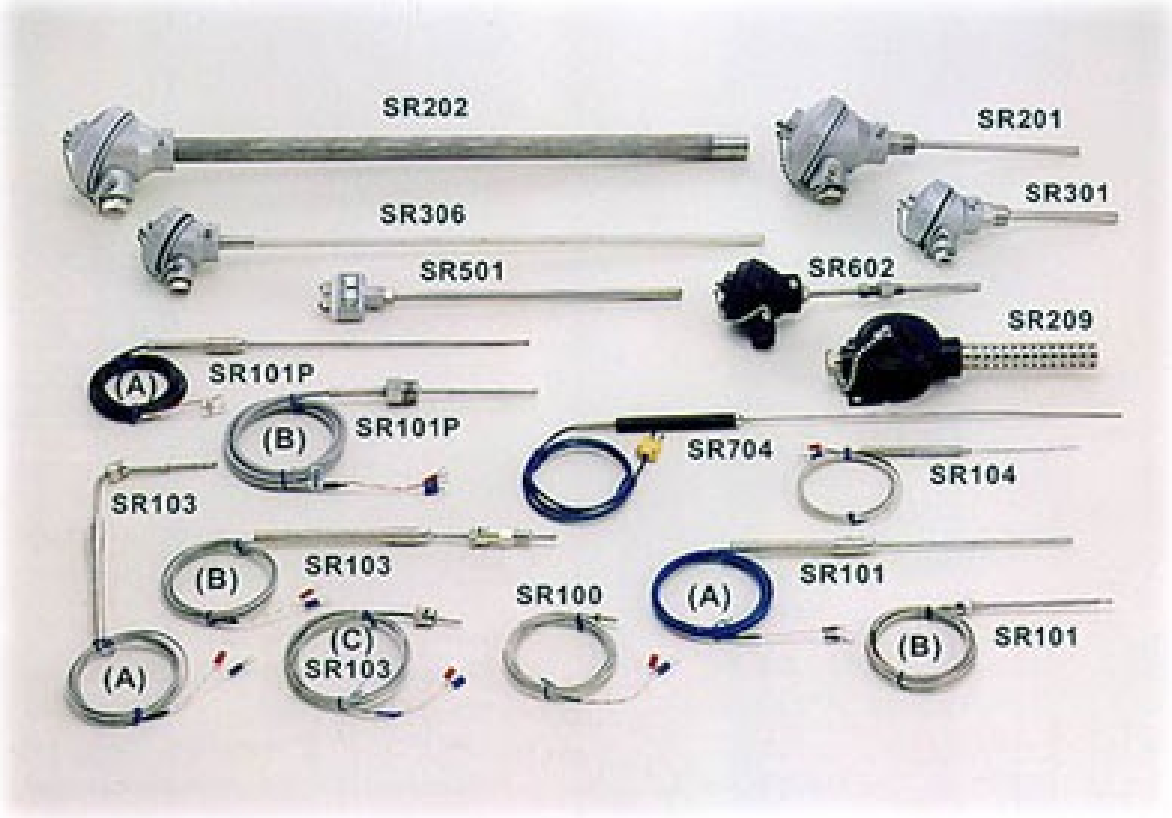
Calibrador para termopares e RTD

Características do PTC-8001:

* Precisão de ±0.4°C para termopares tipo J e de ±0.3°C para RTD 4W PT385;
* 10 tipos de termopares e 8 de RTD;
* Interface RS-232.

Termopares x RTD

- **SENSORES MAIS UTILIZADOS NA INDÚSTRIA;**
- **TERMOPARES DE DIVERSOS TIPOS (J, K etc.);**
- **RTD DE PLATINA (PELÍCULA OU BOBINADA).**



Termopares x RTD – Aspectos Comparativos

a) Faixa de Medição

TERMOPARES: -200 a 1700 ºC;

RTD: -200 a 850 ºC (limite prático: 600 ºC) .

b) Intercambiabilidade

“Faz referência ao desvio na medição de temperatura devido à tolerância do sensor.”

TERMOPARES: A norma UNE-EM 60584-2 define três classes de tolerância (Considera a substituição por termopares novos).

RTD: A norma EN60751 define duas classes de tolerância para as RTD de platina (A e B).

Nota: A intercambiabilidade sugere recalibração!

c) Estabilidade

TERMOPARES: São menos estáveis que as RTD quando expostos a temperaturas medianas e elevadas. Requerem cuidados adicionais em aplicações críticas (recalibração).

RTD: Apresentam uma excelente estabilidade. A comprovação de sua estabilidade pode ser feita em laboratório.

d) Robustez

TERMOPARES: São muito robustos e apresentam uma vida útil maior que as RTD. São ideais para ambientes sujeitos a vibrações e a choques mecânicos.

RTD: São um tanto quanto delicadas para ambientes industriais. Bobinadas – Quebra do fio de platina; Película – rompimento do contato dos fios de conexão com a platina.

e) Tamanho

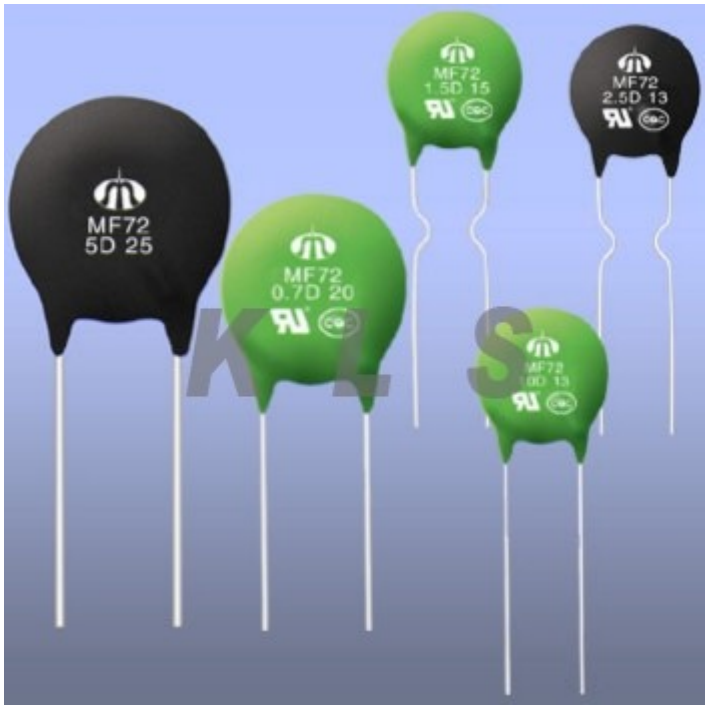
- **Termopares são, via de regra, menores que as RTD.**
- **Sonda Termométrica;**
- **Agulhas hipodérmicas;**
- **Termopares podem chegar a pontos de difícil acesso.**

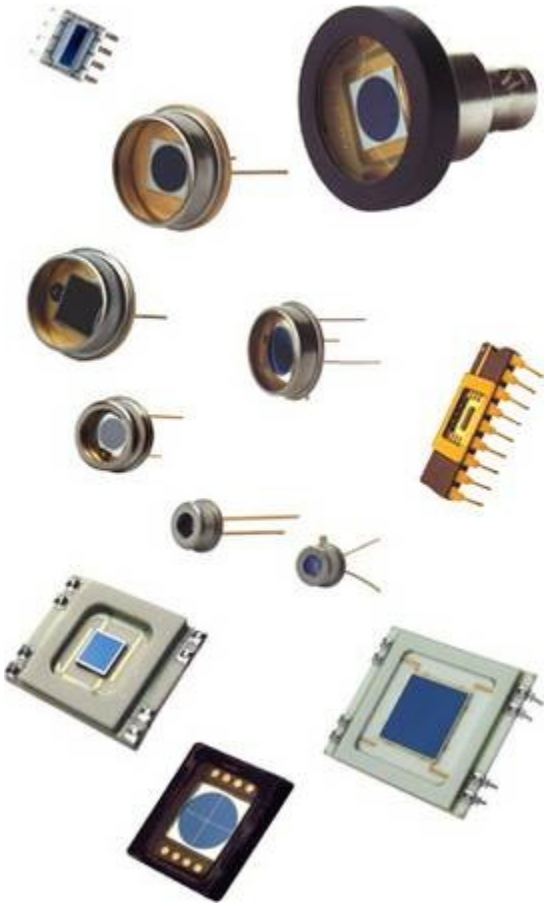
f) Outros aspectos

TERMOPARES: São os sensores mais utilizados nos ambientes industriais nos EUA e na Europa.

RTD: Para uma mesma configuração, uma solução via RTD pode custar de 4 a 10 vezes mais. Além disso, o seu tempo de resposta é maior se comparado ao tempo de um termopar.

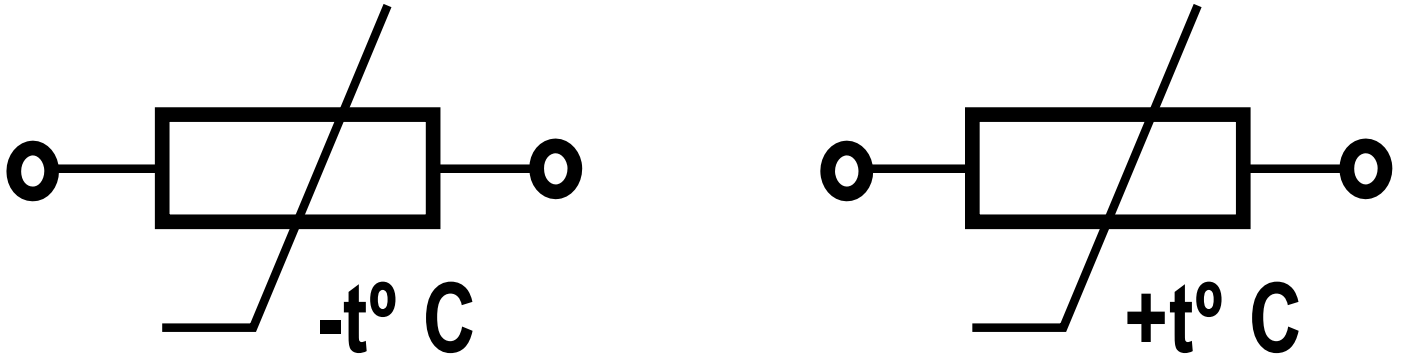
Termistores x Sensores de Si





Termistores

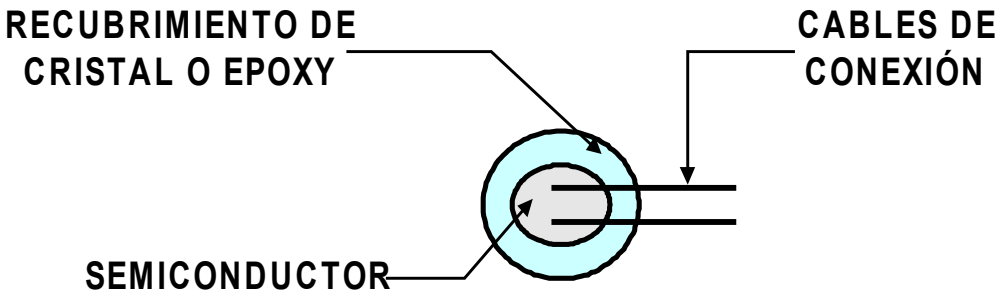
NTC e PTC - Símbolo elétrico



(a) (b)

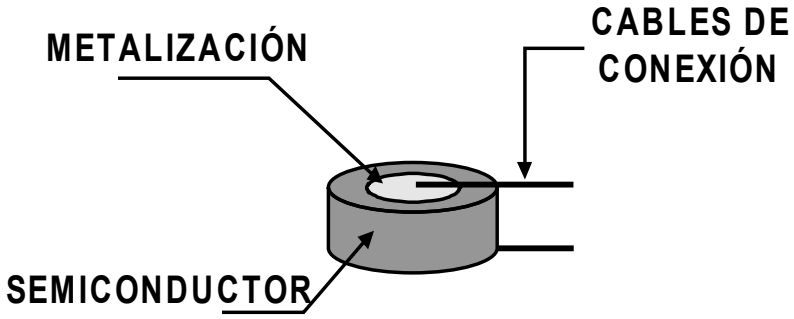
NTC - Tecnologia de fabricação

TERMISTOR DE CRISTAL EN FORMA DE GOTA
('glass bead' o 'epoxy bead')



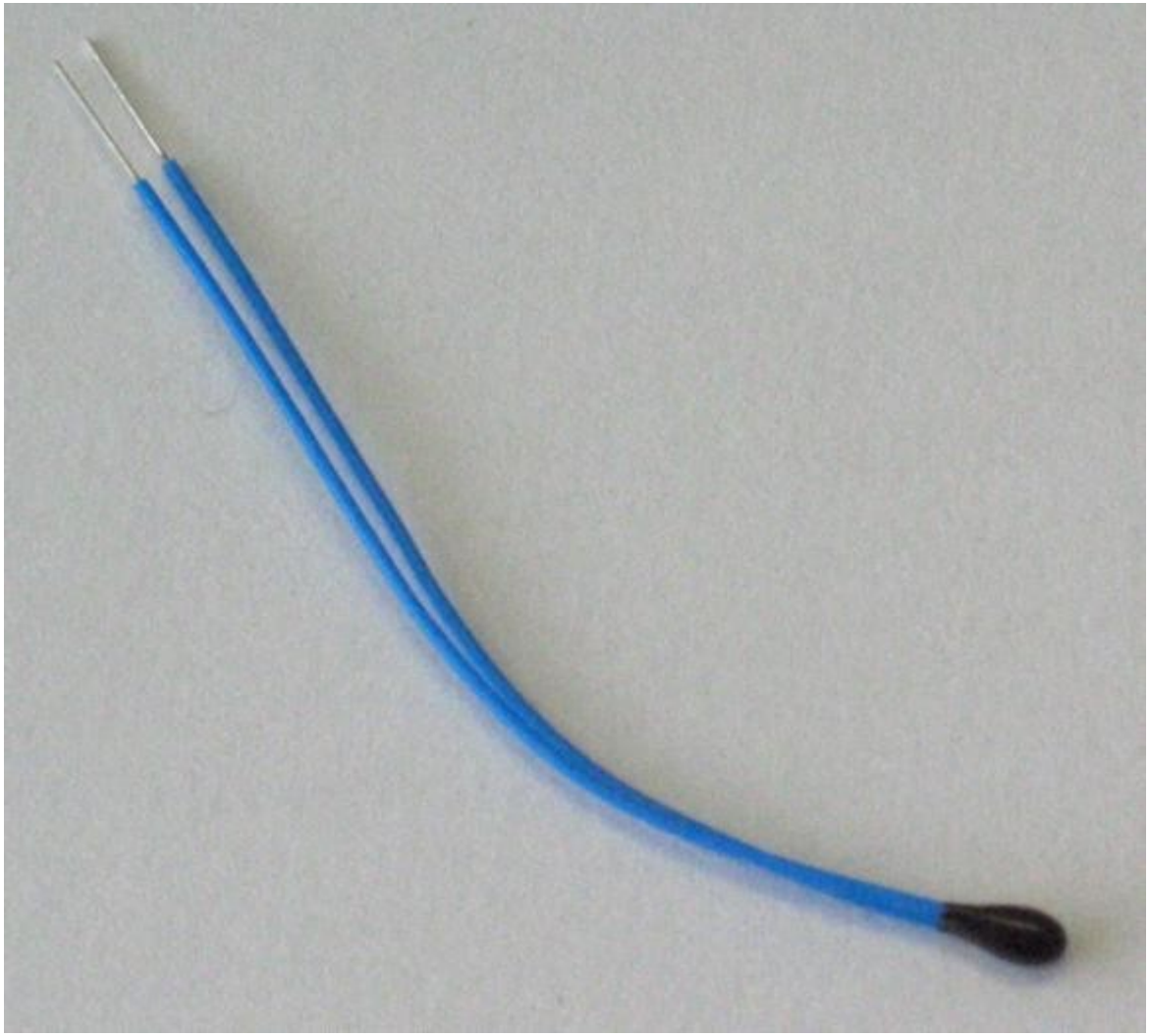
(a)

TERMISTOR EN FORMA DE DISCO
('disk')



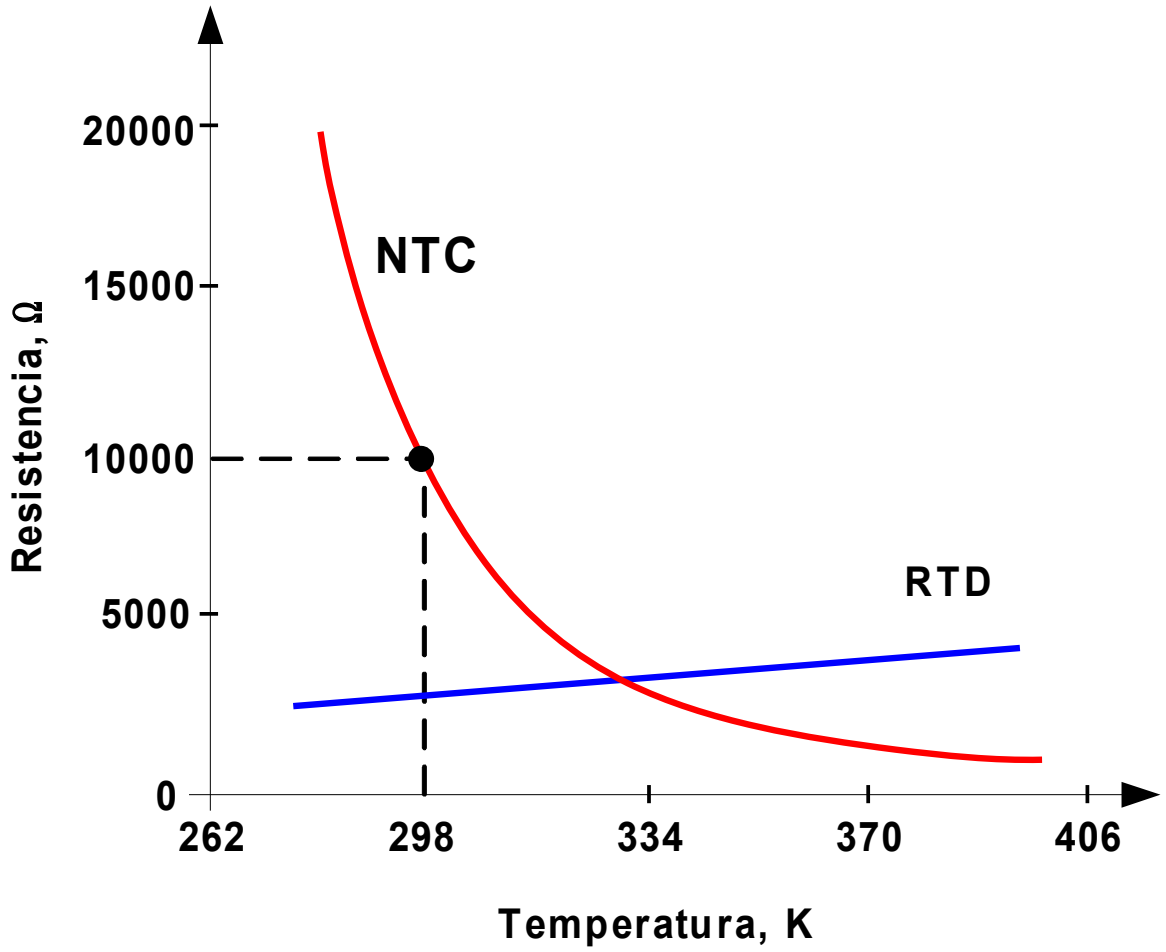
(b)

Exemplo de um NTC



http://upload.wikimedia.org/wikipedia/commons/3/3b/NTC_bead.jpg

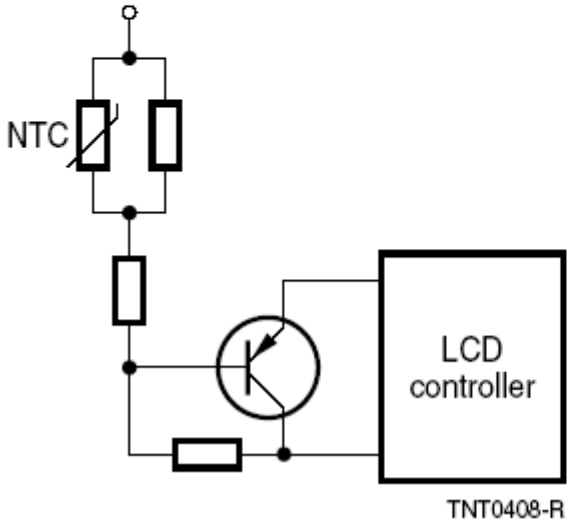
NTC - Característica RxT



Exemplos de Aplicações (1/2)

LCD

Liquid crystal displays (LCDs) are widely used in portable electronics. As the fluid used in liquid crystal displays is sensitive to temperature, LCD modules have a limited operating temperature range. If a constant voltage is applied to the LCD, the contrast increases with temperature and power is wasted at high temperature. Low temperature on the other hand means a low unclear display. The LCD in a mobile phone, however, must operate over a temperature region of –20 °C up to 70 °C.



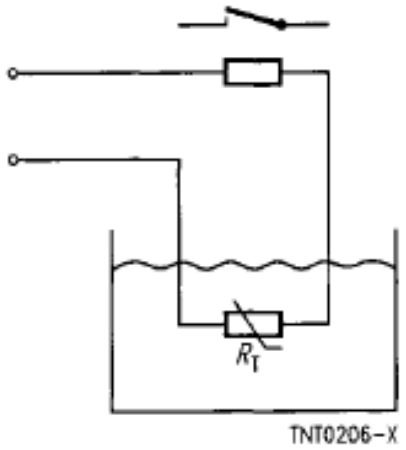
Schematic drawing of the compensation circuit of an LCD using an NTC thermistor as temperature sensor

http://www.epcos.com/

Exemplos de Aplicações (2/2)

Liquid level sensors

The temperature of an electrically loaded NTC thermistor depends on the medium surrounding the device. When the thermistor is immersed in a liquid the dissipation factor increases, the temperature decreases and the voltage lying across the NTC rises. Owing to this effect NTC thermistors are able to sense the presence or absence of a liquid.

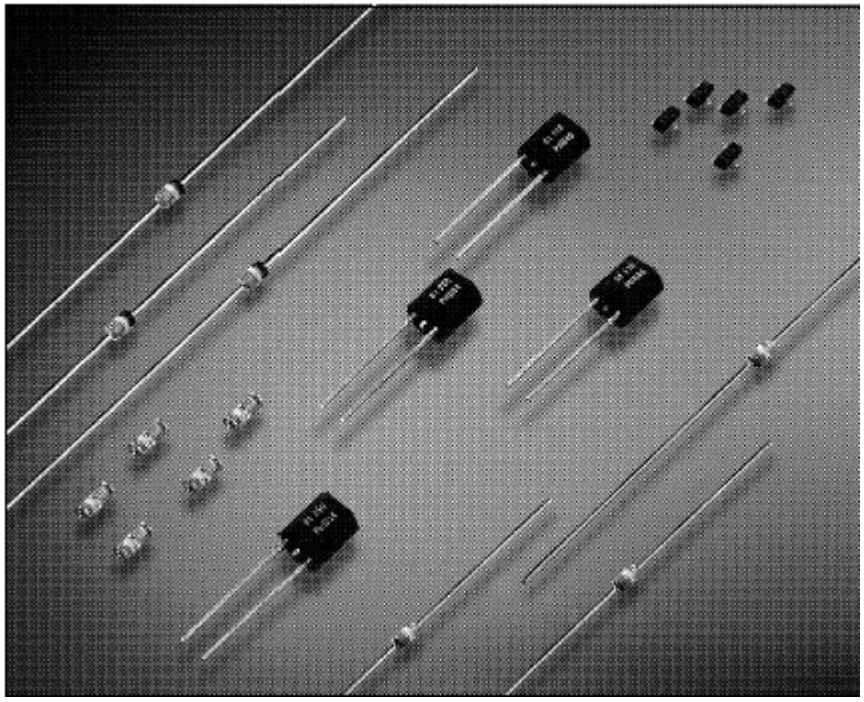


Circuit for liquid level sensing

http://www.epcos.com/

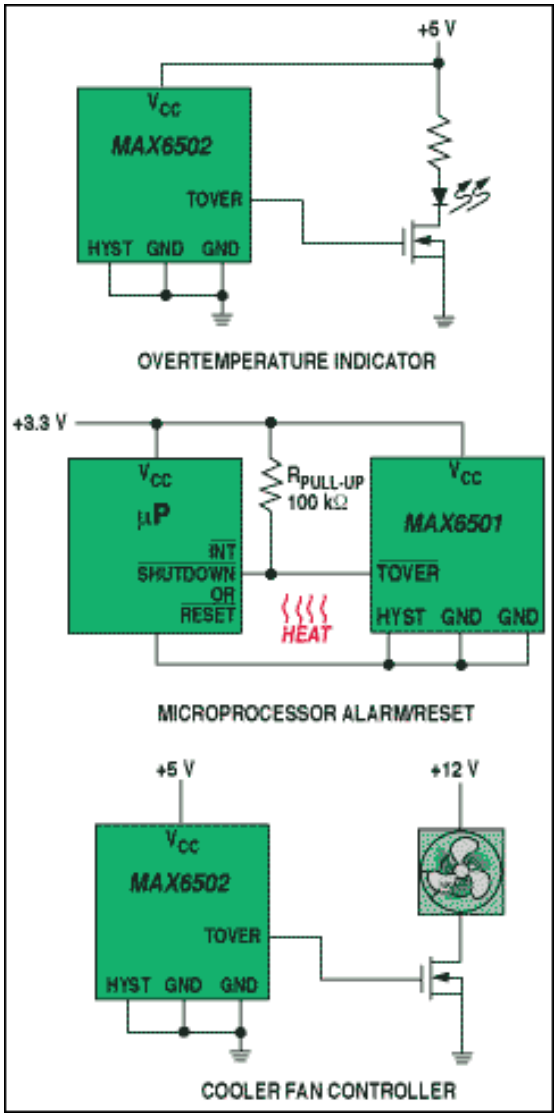
Sensores de Silício

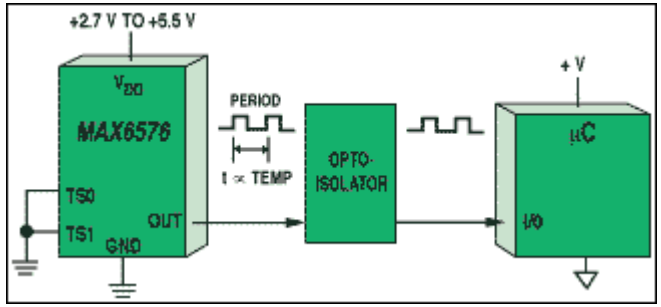
“O Sensor de Temperatura de Silício do tipo “bandgap” pode ser colocado em um CI a um custo muito baixo. Tanto os diodos quanto os transistores apresentam variação de corrente com a temperatura.”

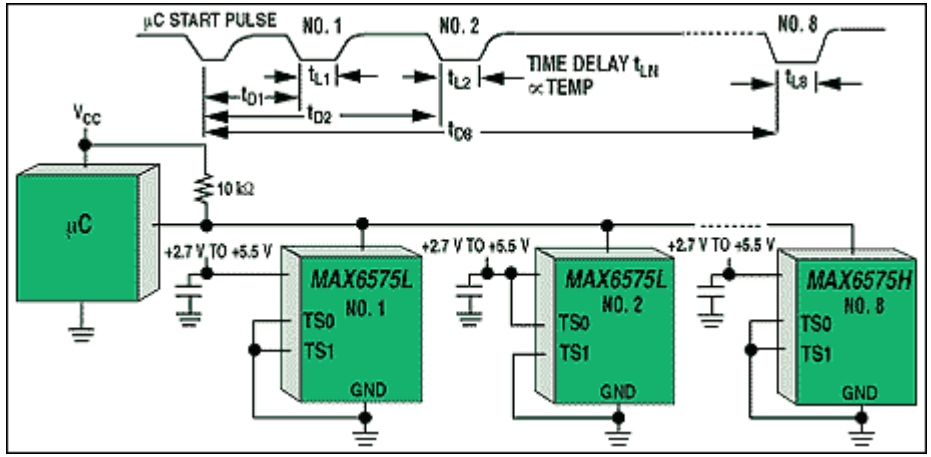


http://www.nxp.com/products/sensors/temperaturesensors/index.html

Exemplos de Aplicações







http://www.maxim-ic.com/appnotes.cfm/an_pk/694

NTC x Sensores de Si–Aspectos Comparativos

a) Faixa de Medição

NTC: Faixa de medição mais ampla (alguns chegam a 500 ºC);

Sensores de Si: -40 a 125 ºC (MAX6577).

b) Intercambiabilidade

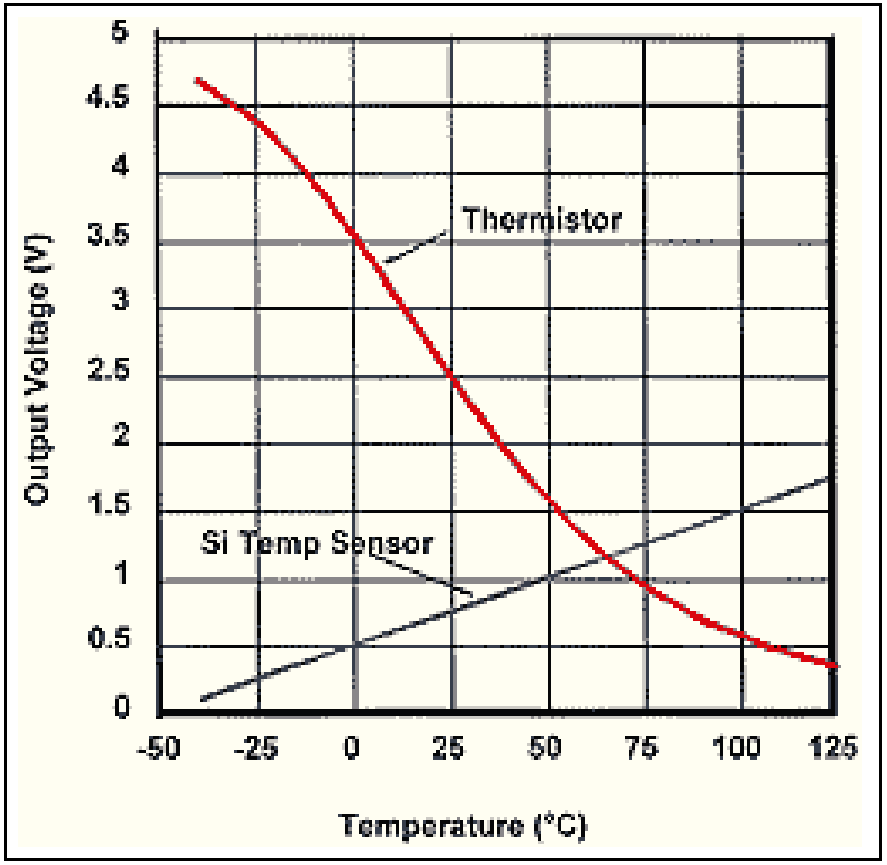
NTC: ± 10 %, ± 0,2 ºC

Sensores de Si: ±1 %, ±3 ºC .

c) Estabilidade

d) Robustez

e) Linearidade



http://www.maxim-ic.com/appnotes.cfm/an_pk/694

Comparação entre os sensores

Características	Sensor				
	RTD de platino de película	RTD de platino bobinada	Termopar	Termistor	Silicio
Coste del sensor	Moderado a bajo	Moderado	Bajo	Bajo a moderado	Bajo
Coste del sistema	Moderado	Moderado	Moderado	Bajo a moderado	Bajo
Campo de MEDIÇÃO	-200 a 750ºC (560ºC máx., típicamente)	-200 a 850ºC (600ºC máx., típicamente)	-270 a 1800ºC	-100 a 500ºC (125ºC máx., típicamente)	-40 a 125ºC
Intercambiabilidad	±0,1%, ±0,3ºC	±0,06%, ±0,2ºC	±0,5%, ±2ºC	±10%, ±0,2ºC	±1%, ±3ºC
Estabilidad	Excelente	Excelente	Pobre	Moderada	Moderada
Sensibilidad	0,39%/ºC	0,39%/ºC	40μV/ºC	-4%/ºC	10mV/ºC
Sensibilidad relativa	Moderada	Moderada	Baja	Muy elevada	Moderada
Linealidad	Excelente	Excelente	Moderada	No es lineal	Moderada
Pendiente	Positiva	Positiva	Positiva	Negativa	Positiva
Susceptibilidad al ruido	Baja	Baja	Alta	Baja	Baja

Tendências

TOP >> Product List >> Wireless Core Temperature Data Logger - Push Wireless RTR-61

An Overview : RTR-61

The RTR-61 "Wireless Core Temperature Data Logger" is a handy-type device which acts both as a thermometer and a temperature recorder that has been designed to easily measure and record the internal temperature of food items and liquid temperature, featuring a needle-type sensor. The RTR-61 enables effective HACCP-based temperature management for food safety, making it ideal for use in food-processing environments. This product has been designed to meet IP64 standards (splash resistant; rated for use in daily life).

When the <REC> button on the RTR-61 unit is pressed, the Temperature, Date / Time, User Name, Item and Over-Limit Judgment are recorded into the RTR-61. The sensor type and length can be selected to meet individual needs.

In order to carry out the downloading of data from an RTR-61 unit, it is necessary to purchase one of the Push Wireless Communication Sets "RTR-61SK or RTR-61SK-W" (sold separately).

Functions

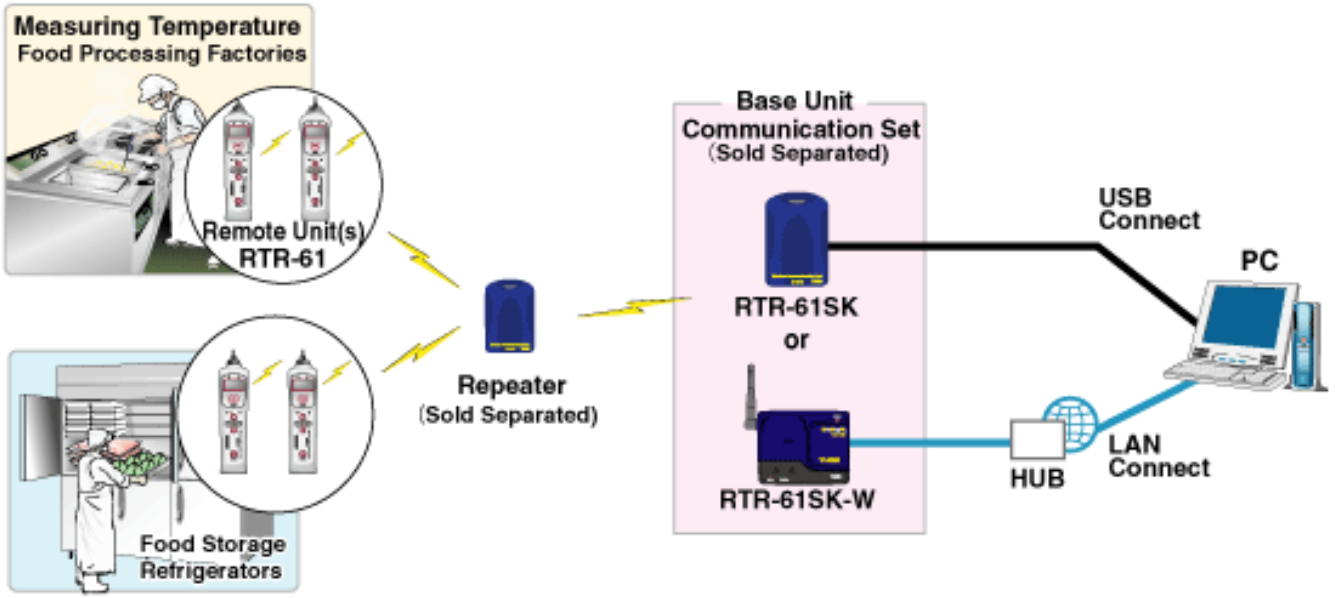
- Simple Measuring and Recording with One-Push of <REC> Button
- Simultaneously Records User Name, Item Name and Judgment Result
- Easy-to-Read LCD Display
- Communication Set enables Total Control and Management (sold separately)
- Wait for Constant Temp Function
- Send Messages and Remote Measurement Commands from PC

Obs.: *Hazard Analysis Critical Control Point* (HACCP)

Tendências (cont.)

Application Examples

- Establishing HACCP-compliant temperature management systems
- Measuring and Recording internal food and liquid temperature being stored in food storage refrigerators
- Measuring and Recording the internal food and liquid temperature being heated or cooled during processing
- Measuring and Recording the internal food and liquid temperature being sold in stores

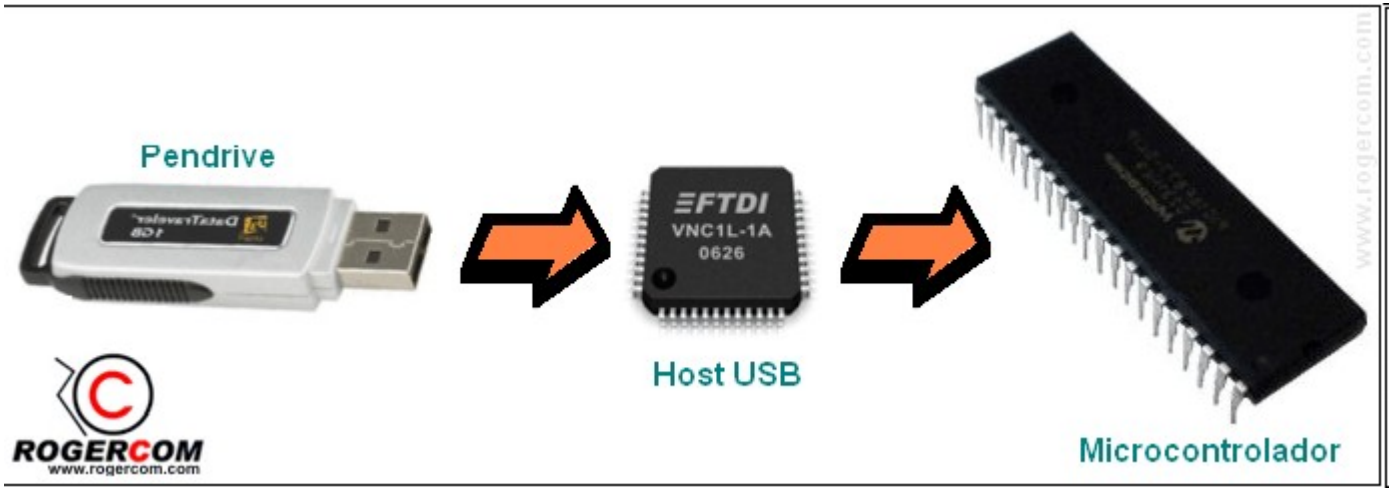


>> Back to Top of this Page

- For RTR-61SK we offer both the Serial (RS-232C) Communication Protocol and USB Communication DLL which enable remote control via PC. For the RTR-61SK-W, we offer the necessary communication DLL for remote control. By using these, the User can design and create systems to meet particular situations and needs. For details please contact your local T&D dealer.

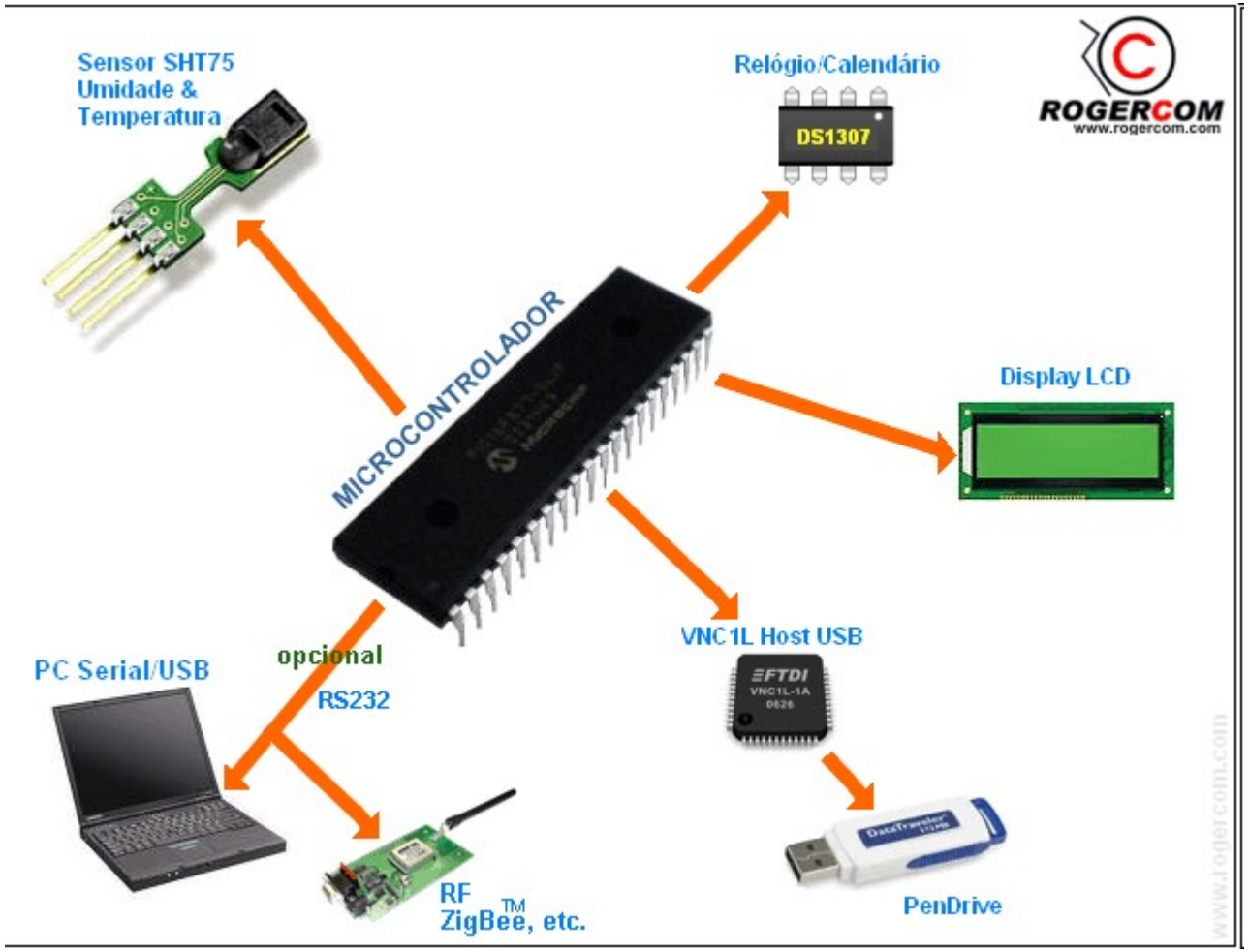
http://www.tandd.us/product/rtr61/rtr61_01feature.html#Anchor--TOP >-11626

Ideias



- **Visão parcial do sistema estação Pen-drive**

Ideias (cont.)

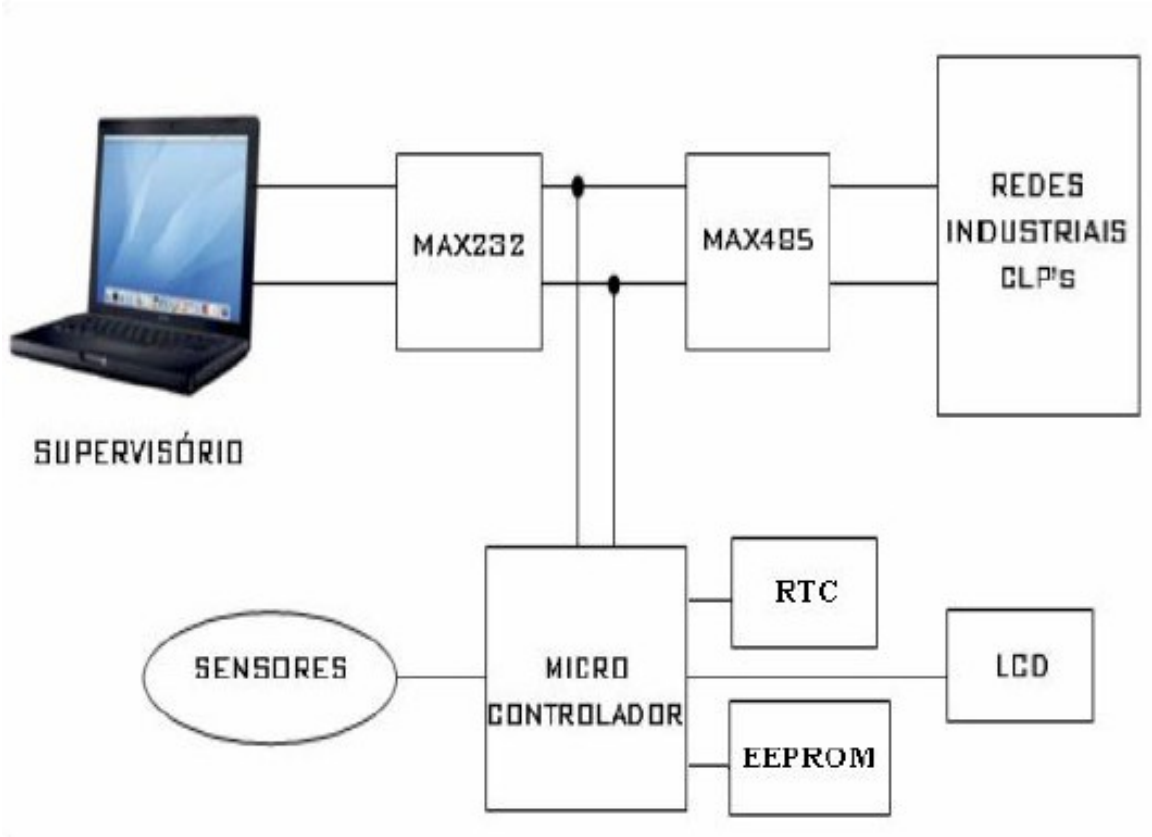


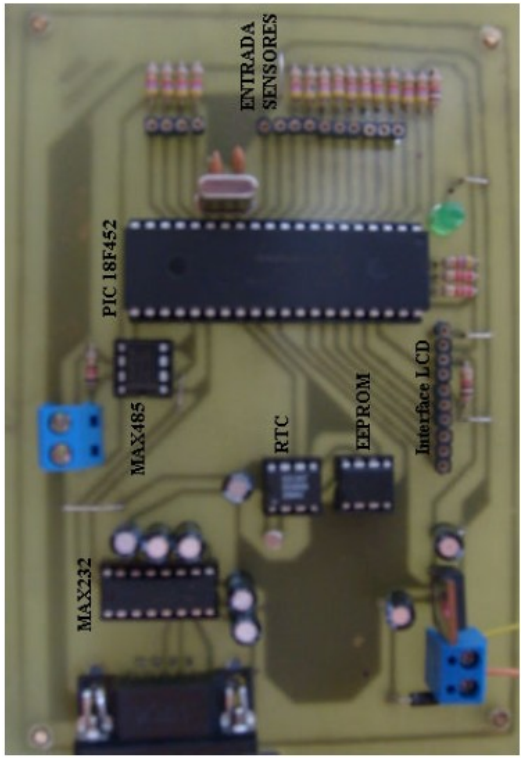
Visão geral do sistema estação Pen-drive

Ref.: http://www.rogercom.com

Ideias (cont.)

Simlogger



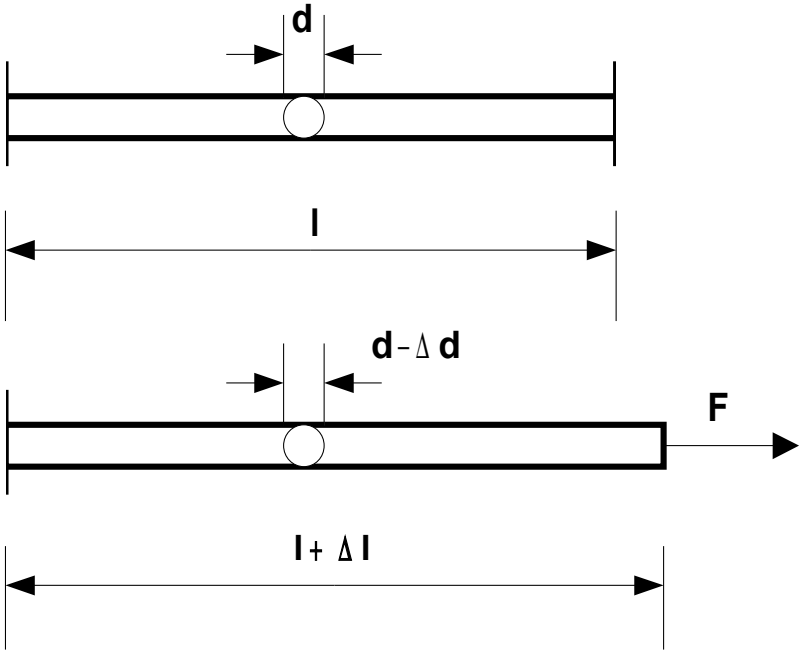


Ref.: Jucá, S.C. et al. Simlogger: Sistema de Aquisição de Dados de Baixo Custo. Anais do XVII Congresso Brasileiro de Automática, Juiz de Fora, 14-17 de Setembro de 2008.

2. Medição de Variáveis Mecânicas

2.1.1. Medição de Força e Peso - Extensômetros

Extensômetros - Princípio de funcionamento

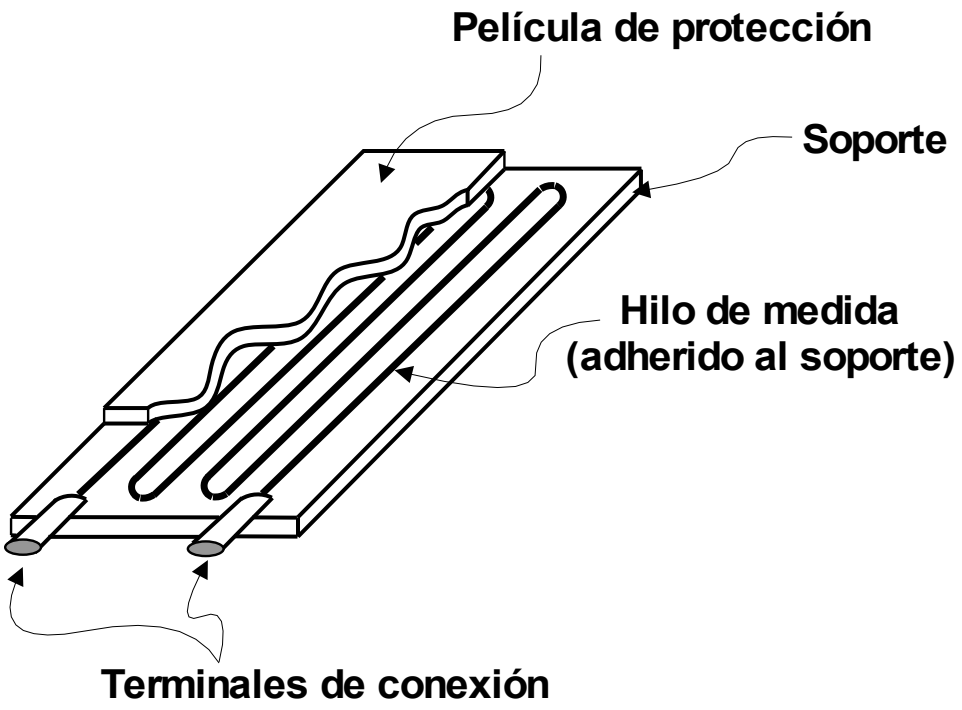


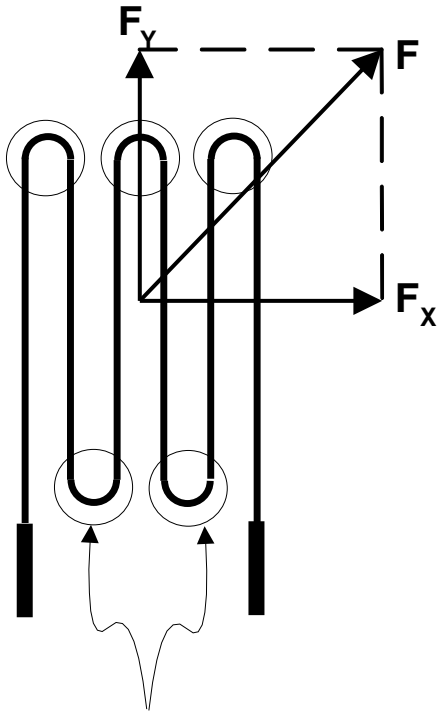
$$R = \rho \frac{l}{\frac{\pi d^2}{4}}$$

$$\frac{\Delta R}{R} = \frac{\Delta \rho}{\rho} + \frac{\Delta l}{l} - 2\frac{\Delta d}{d}$$

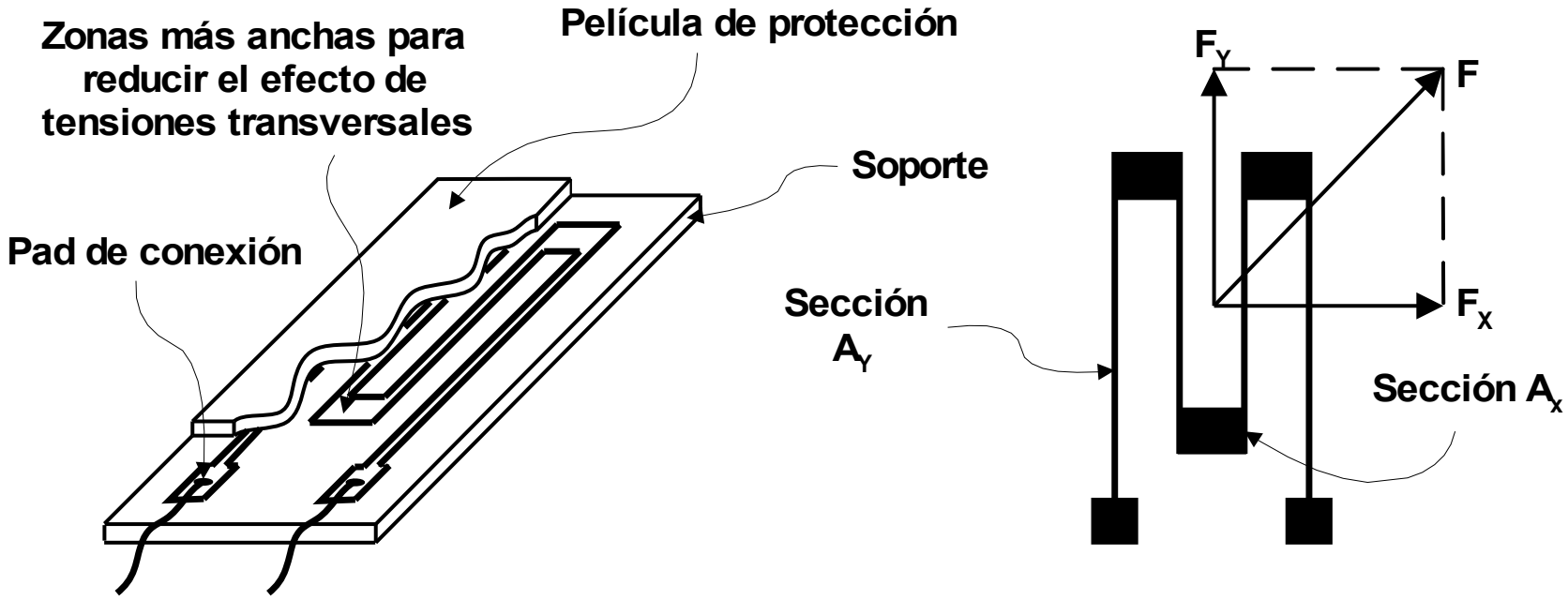
$$\Delta R = \frac{KR}{EA} F$$

Extensômetro de fio metálico

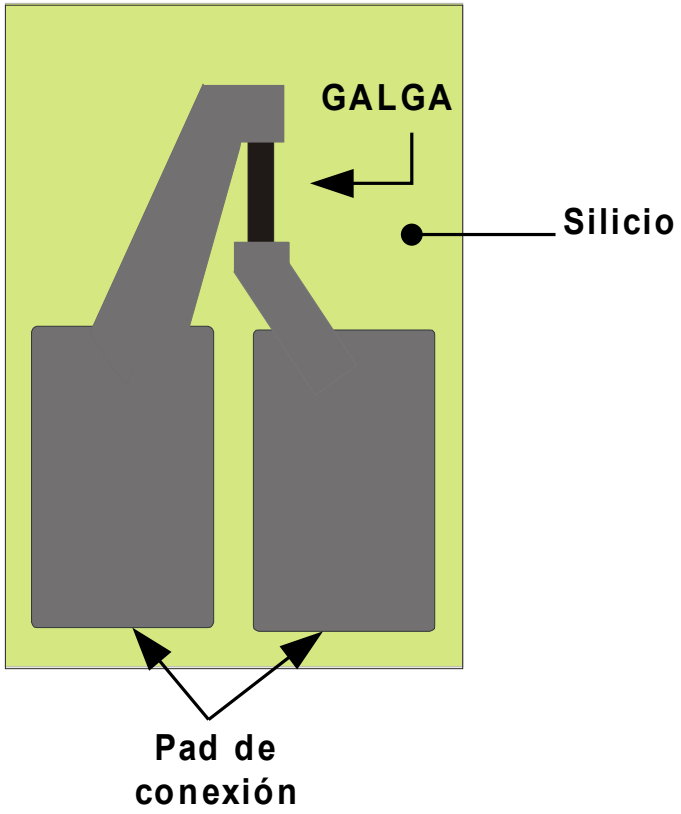




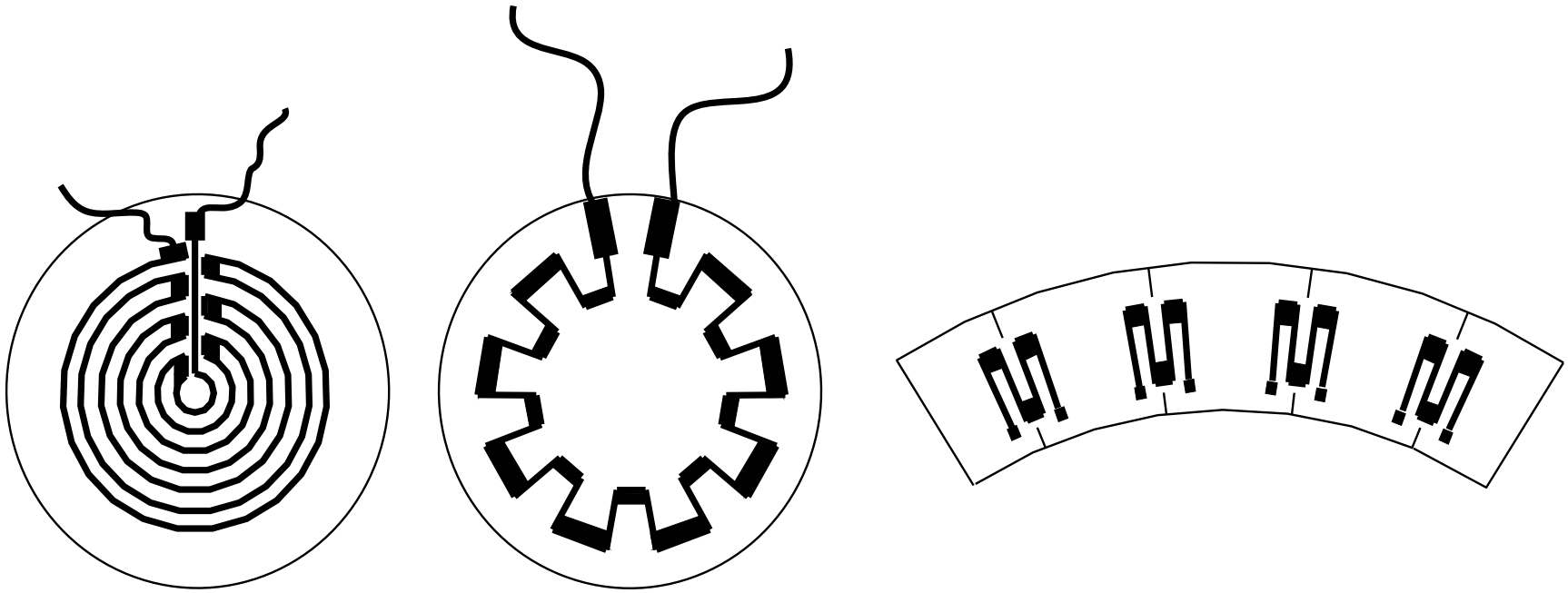
Extensômetro de película metálica



Extensômetro Semicondutor



Outras formas construtivas

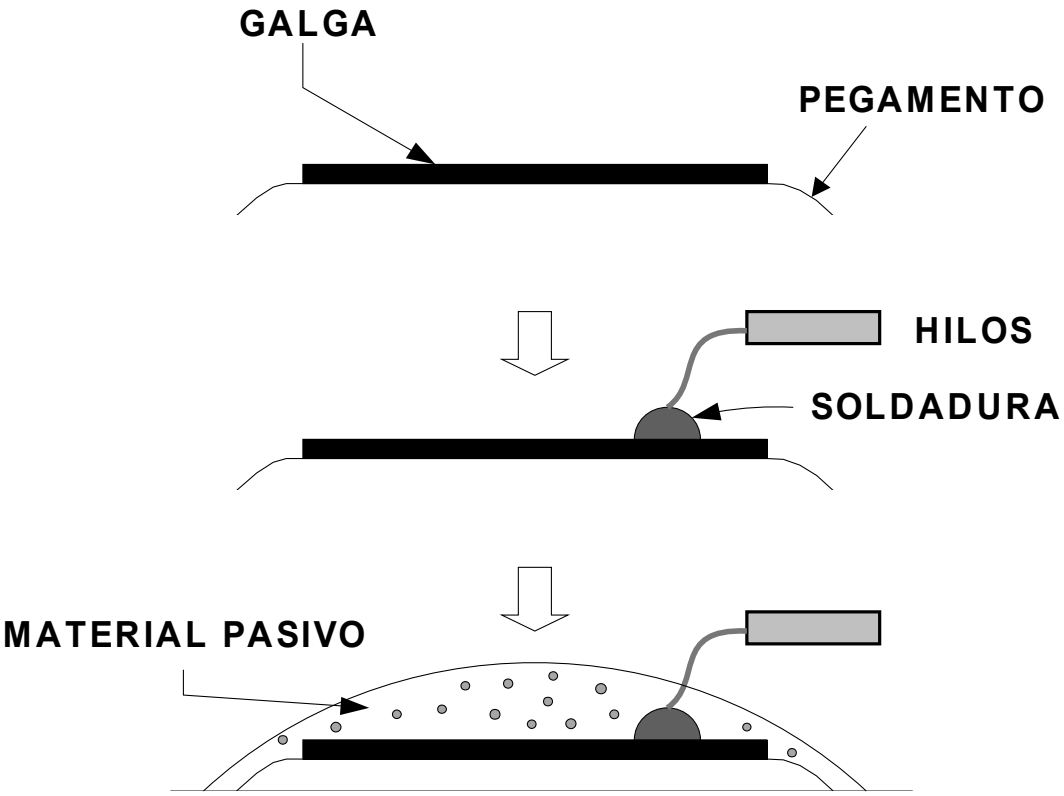


Materiais para Extensômetros

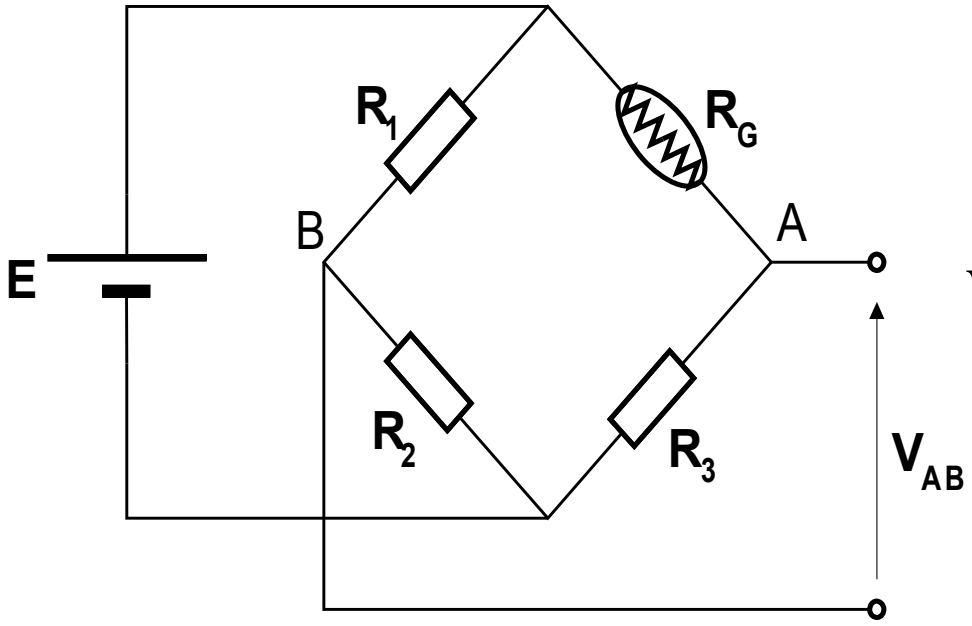
Materiales metálicos sensores		
Material	Características	Aplicaciones
Constantán	-Medidas estáticas - No usar en aplicaciones extremas - Selección compleja (pocos criterios) - Material más usado y muy barato - Autocompensación térmica sencilla	- Grandes elongaciones (estado plástico de deformación)
Isoelastic	- Gran relación S/N - Precisan control de temperatura	- Medidas dinámicas - Medida de fatiga
Karma	- Autocompensación térmica sencilla - La soldadura de terminales es compleja	- Medida a temperaturas bajas - Medida con temperaturas variables o no controladas
Aleación Pt	- Coste alto	- Medida a altas temperaturas

Materiales para el soporte		
Material	Características	Aplicaciones
Poliamida	- Es el soporte estándar - No soporta condiciones extremas de trabajo - Espesor habitual de 0,025mm	- Medidas estáticas - Aplicaciones habituales
Epoxy	- Minimiza el error introducido por el soporte - Instalación delicada - Requiere mano de obra especializada	- Medidas precisas
Fibra de vidrio reforzada con epoxy	- Soporta temperaturas moderadas - Soporta muy bien el trabajo a fatiga	- Medidas cíclicas y de fatiga

Utilização dos Extensômetros



Circuitos de medição (1/4)

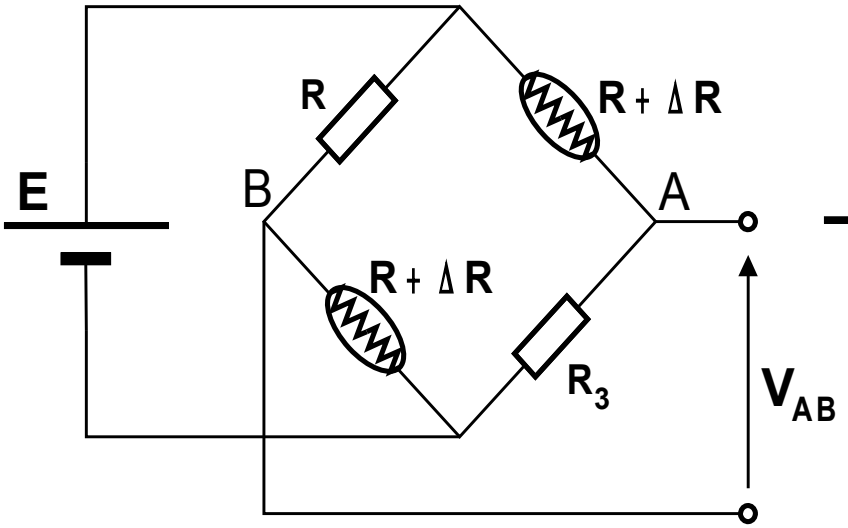


$$v_{AB} = E\left(\frac{R_3}{R_3 + R_G} - \frac{R_2}{R_1 + R_2}\right)$$

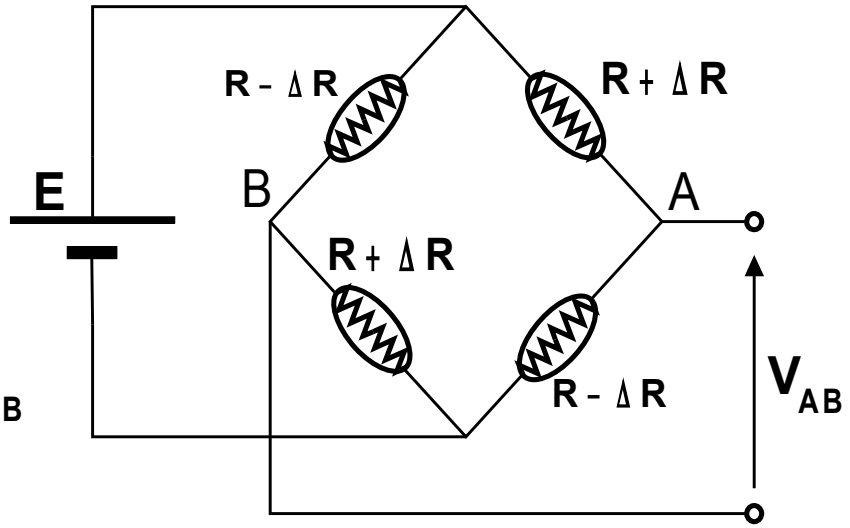
$$v_{AB} = \frac{\Delta R}{4}\frac{1}{R + \frac{\Delta R}{2}}E$$

$$v_{AB} = \frac{K\varepsilon}{4}\frac{1}{1 + \frac{K\varepsilon}{2}}E \cong \frac{K\varepsilon}{4}E$$

Circuitos de medição (2/4)

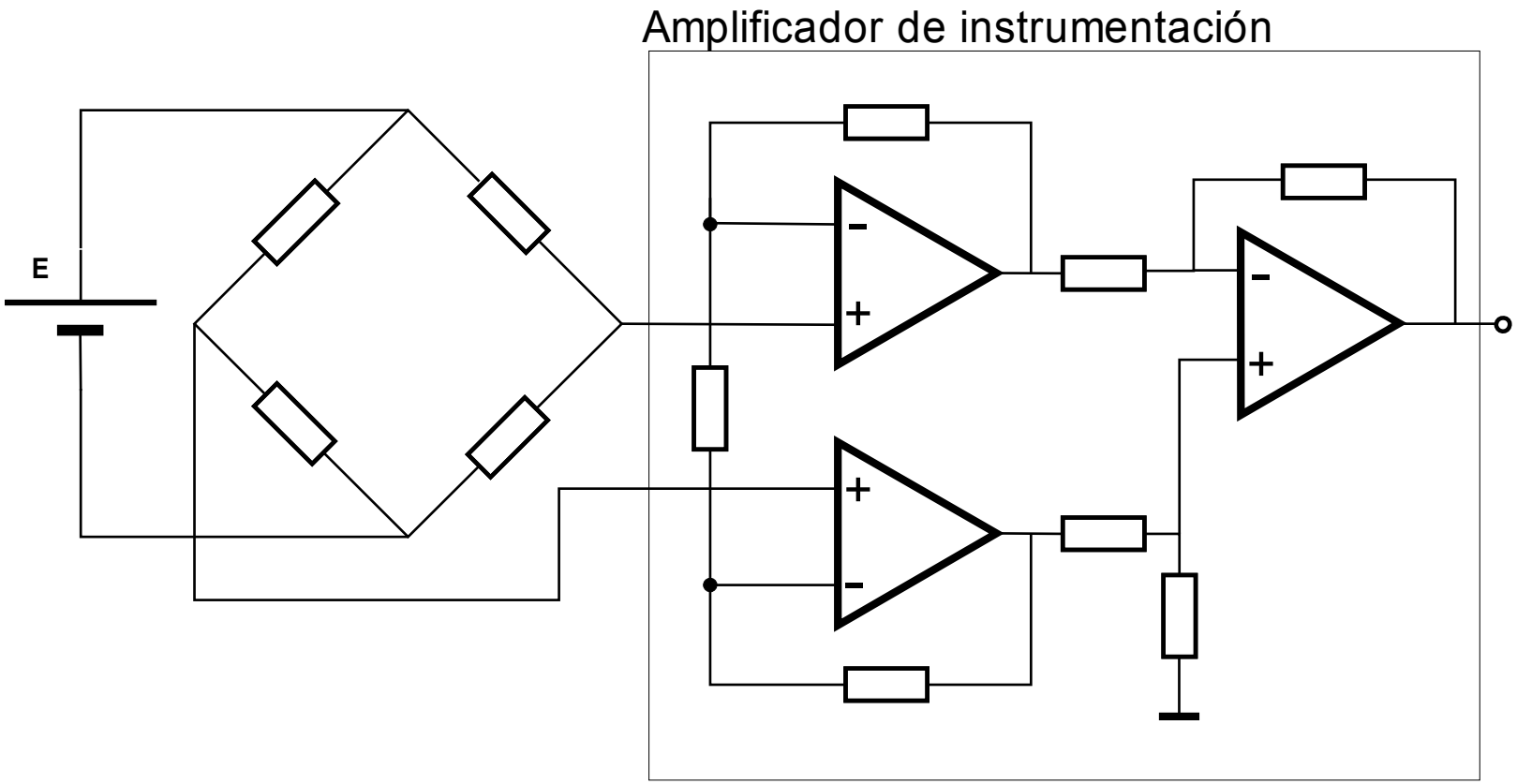


$$v_{AB} = \frac{k\varepsilon}{2} E$$

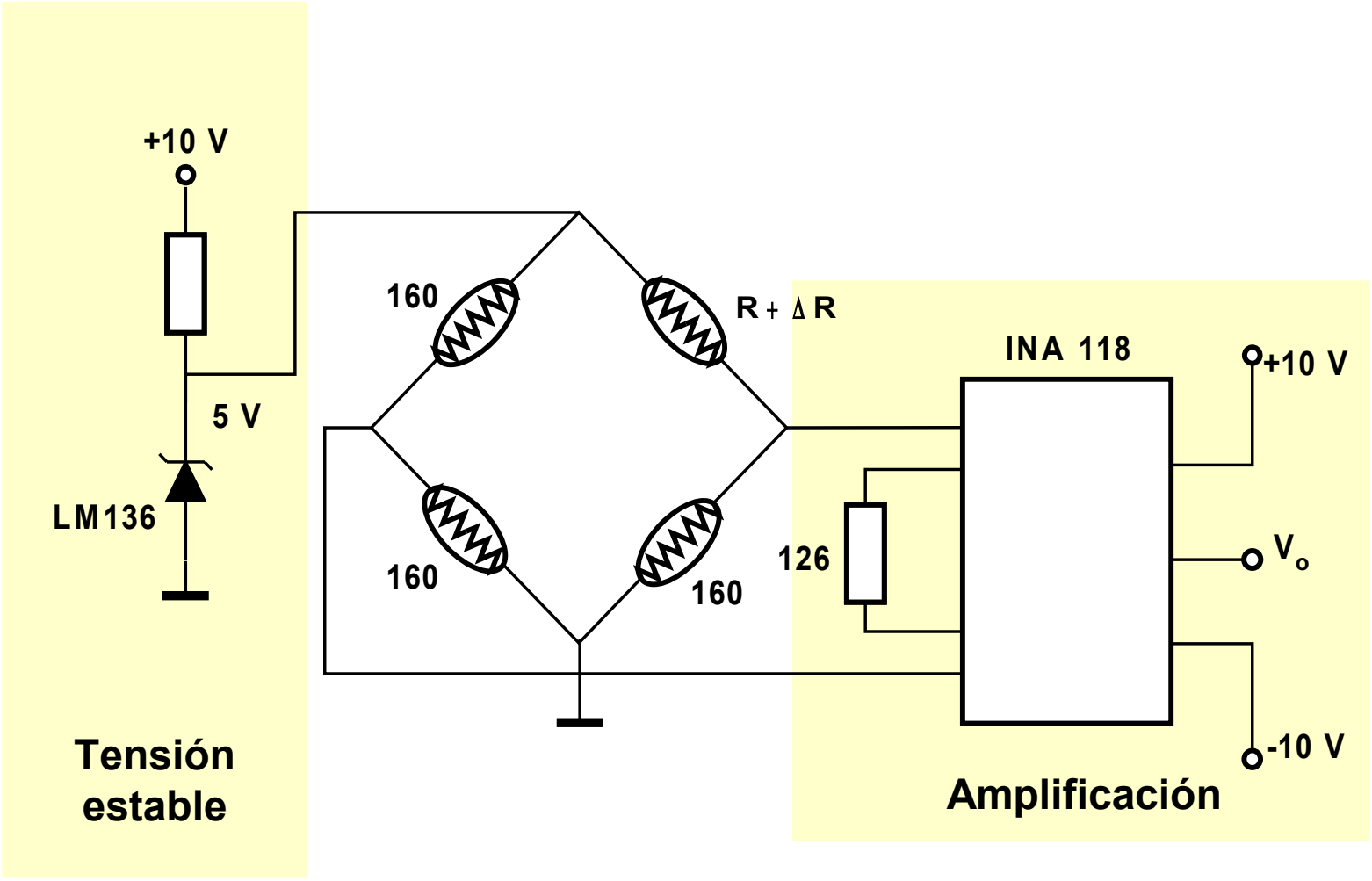


$$v_{AB} = k\varepsilon E$$

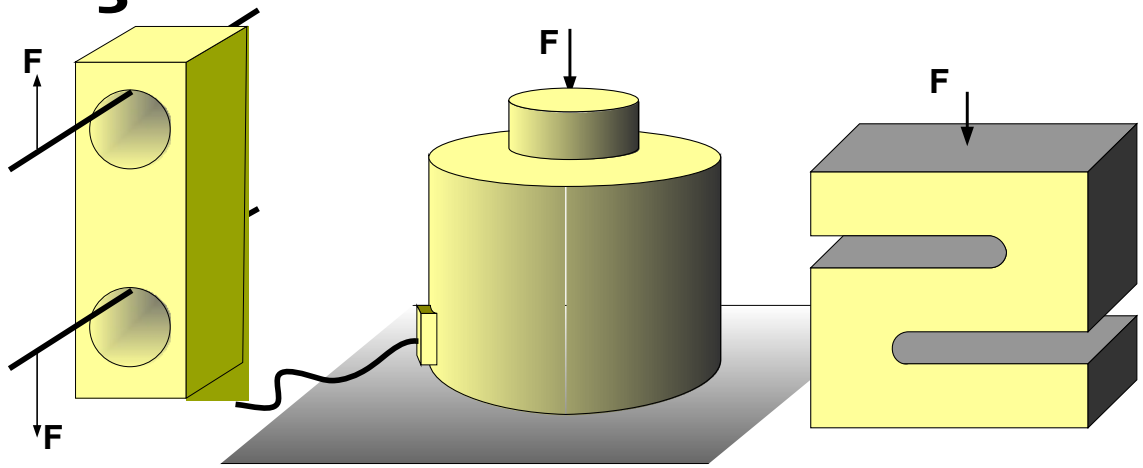
Circuitos de medição (3/4)



Circuitos de medição (4/4)



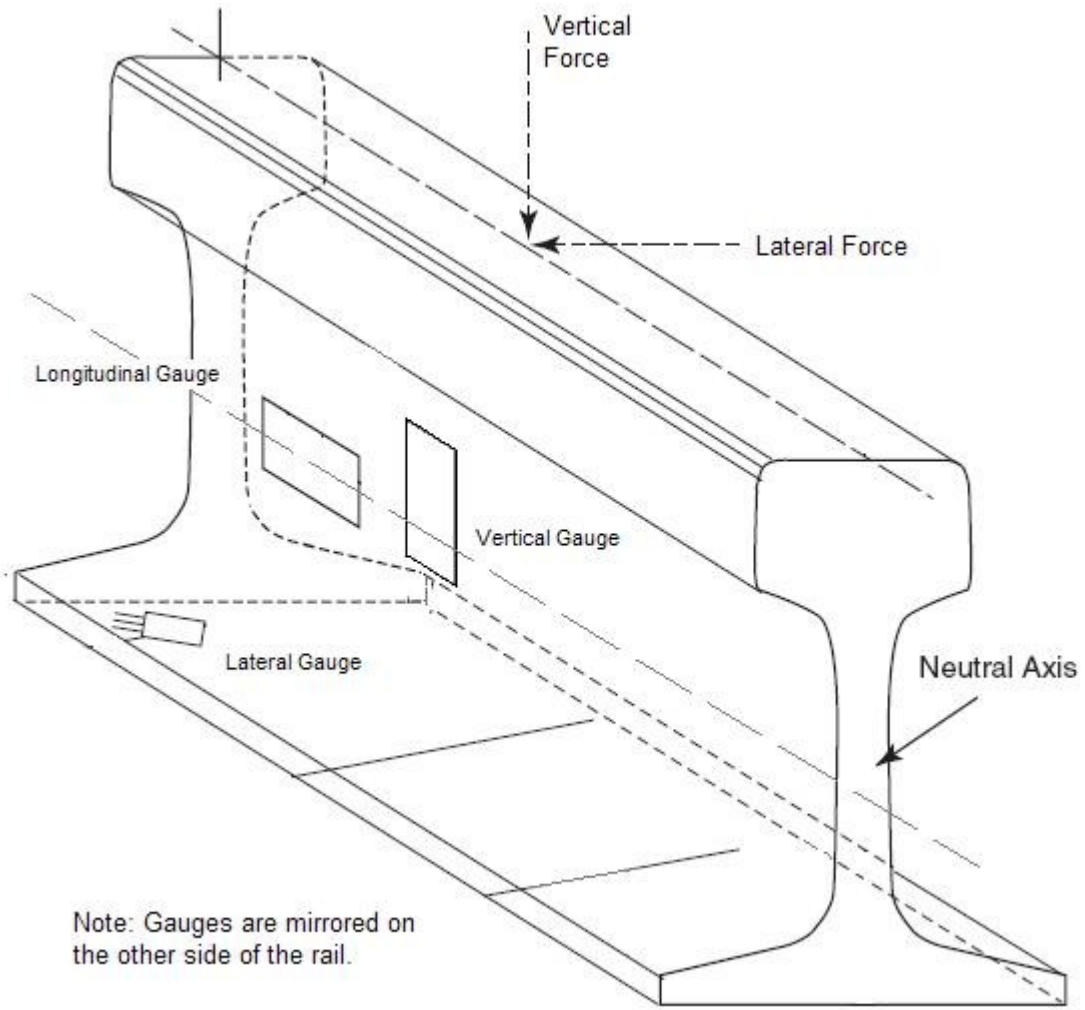
Aplicações dos Extensômetros



Criterio	Tipos de célula	Aplicaciones
Tipo de trabajo	Tracción	Medida de peso Medidas on-line Uso general
	Compresión	
	Tracción/compresión	
	Fatiga	Ensayos dinámicos
	Impacto	
Margen de medida	Microcélulas de carga	Alta precisión
	Margen amplio	Uso general
Comportamiento dinámico	Fatiga	Sistemas sometidos a fatiga
	Alta velocidad	Vibración Ensayos dinámicos

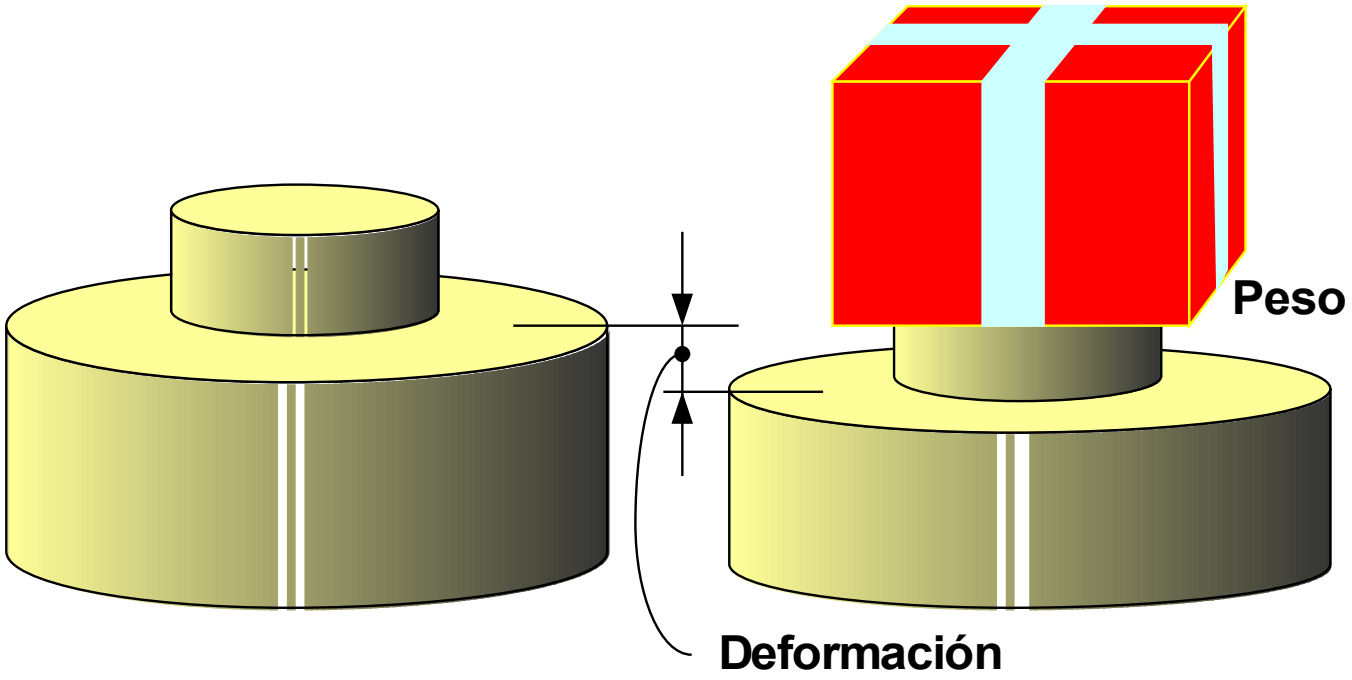
Aplicações dos Extensômetros (cont.)

“Using Strain Sensors to Measure Force in Continuously Welded Rail”



http://mechanical-engineering.suite101.com/article.cfm/strain_gauges_and_rail_forces

2.1.2. Medição de Força e Peso – Células de Carga



22 tonne Canister Loadcell

Features

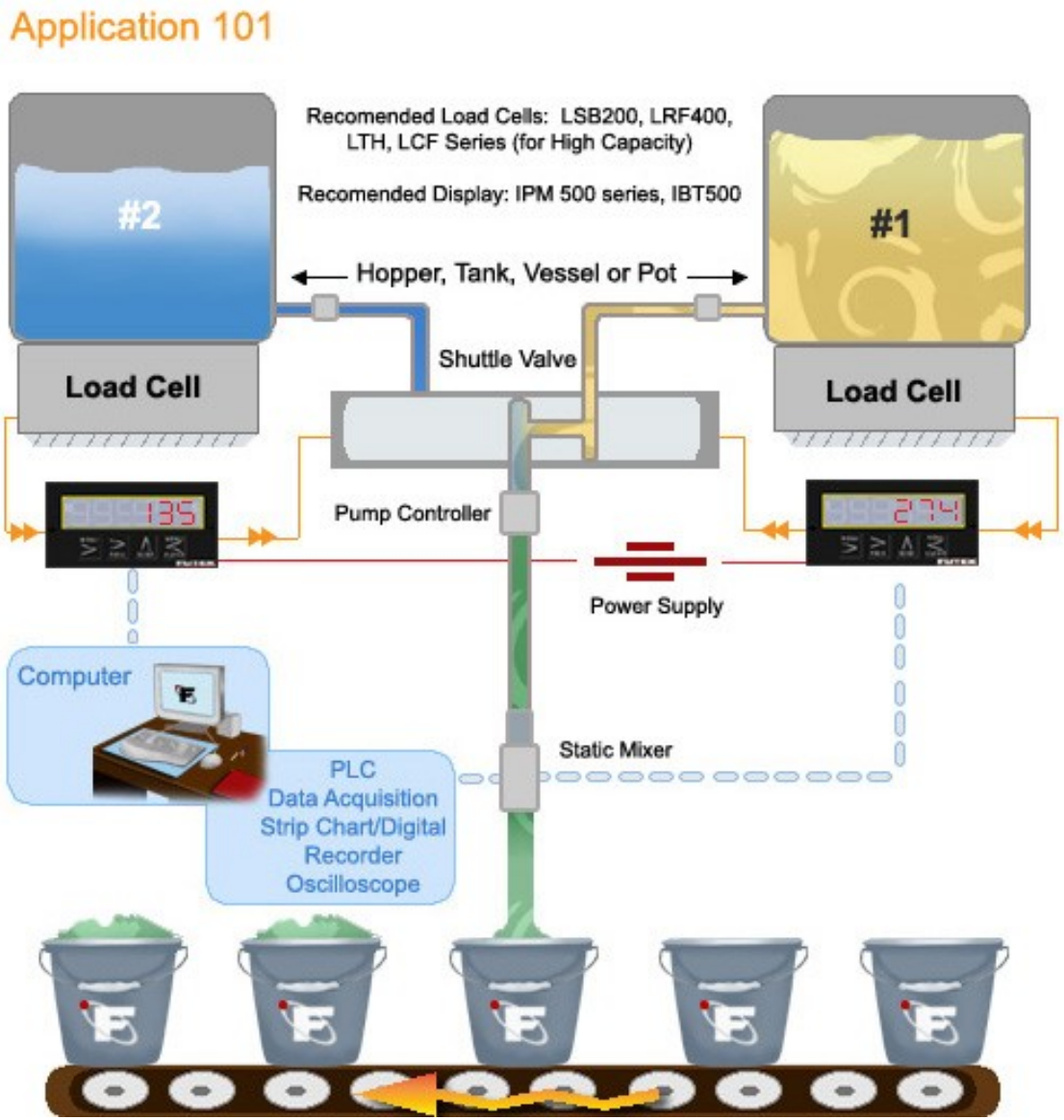
Capacity	22,000 kg
Material	Stainless Steel
Temperature Range	-10 to +40°C (+14 to +104°F)
Safe Overload	150%
Maximum Overload	300%
Cable	9 metre screened (30 feet)
Ingress Protection	Sealed to IP68
Excitation	
Recommended	5V to 12V dc
Maximum	15V
Output at rated load	2 mV/V ± 0.1%

Applications

- Motor truck scales
- Railroad track scales
- Heavy duty tank weighing systems

http://www.weightel.com/22_ton_canister_loadcell.php4

Controle de Nível de Dois Tanques via Célula de Carga



http://www.futek.com/apps_load.aspx

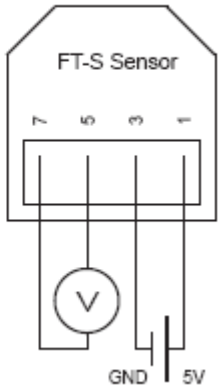
Sensor de Força FT-S270

Performance Characteristics (typical values)

Sensor force range [uN, mg]:	2000, 200
Sensitivity [uN/V, mg/V]:	1000, 100
Output signal [V]:	0-5
Output voltage at zero load [V]:	2.25
Power supply voltage [V]:	5
Mechanical resonance frequency [Hz]:	6400
Resolution at 1000Hz [uN, mg]:	2, 0.2
Resolution at 30Hz [uN, mg]:	0.4, 0.04

Pinout

Pin1: Supply voltage high (5V)
Pin2: NC
Pin3: Supply voltage low (GND)
Pin4: NC
Pin5: Signal low (GND)
Pin6: NC
Pin7: Signal high (sensor output voltage)
Pin8: Sensor probe potential (optional)

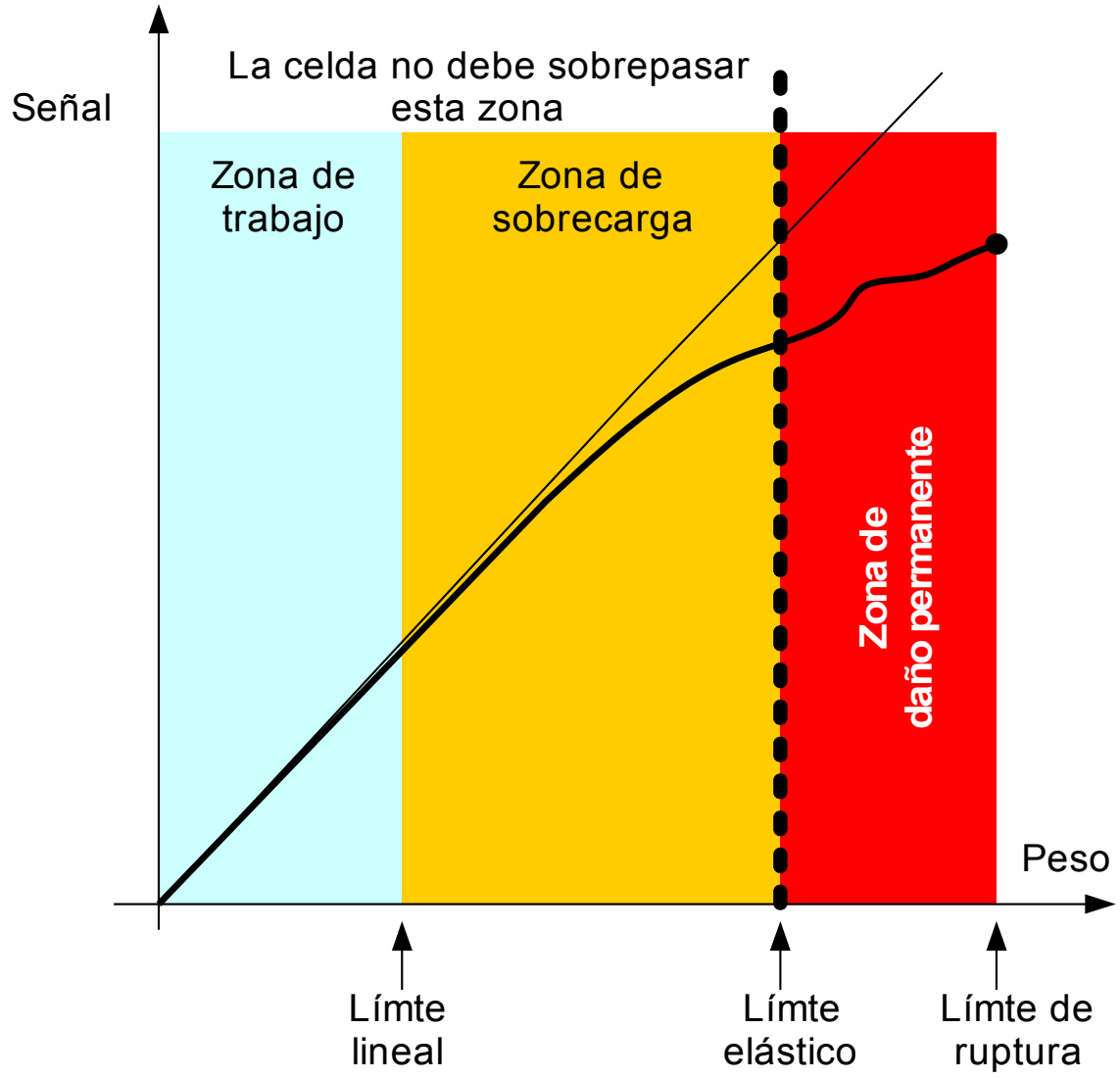


Application Areas

- Microassembly, microfactories, microrobotics
- Contact force measurements, MEMS characterization
- Nanomanipulation
- Biological and biomedical research
- Sample probing
- Material characterization
- Force controlled fiber pulling

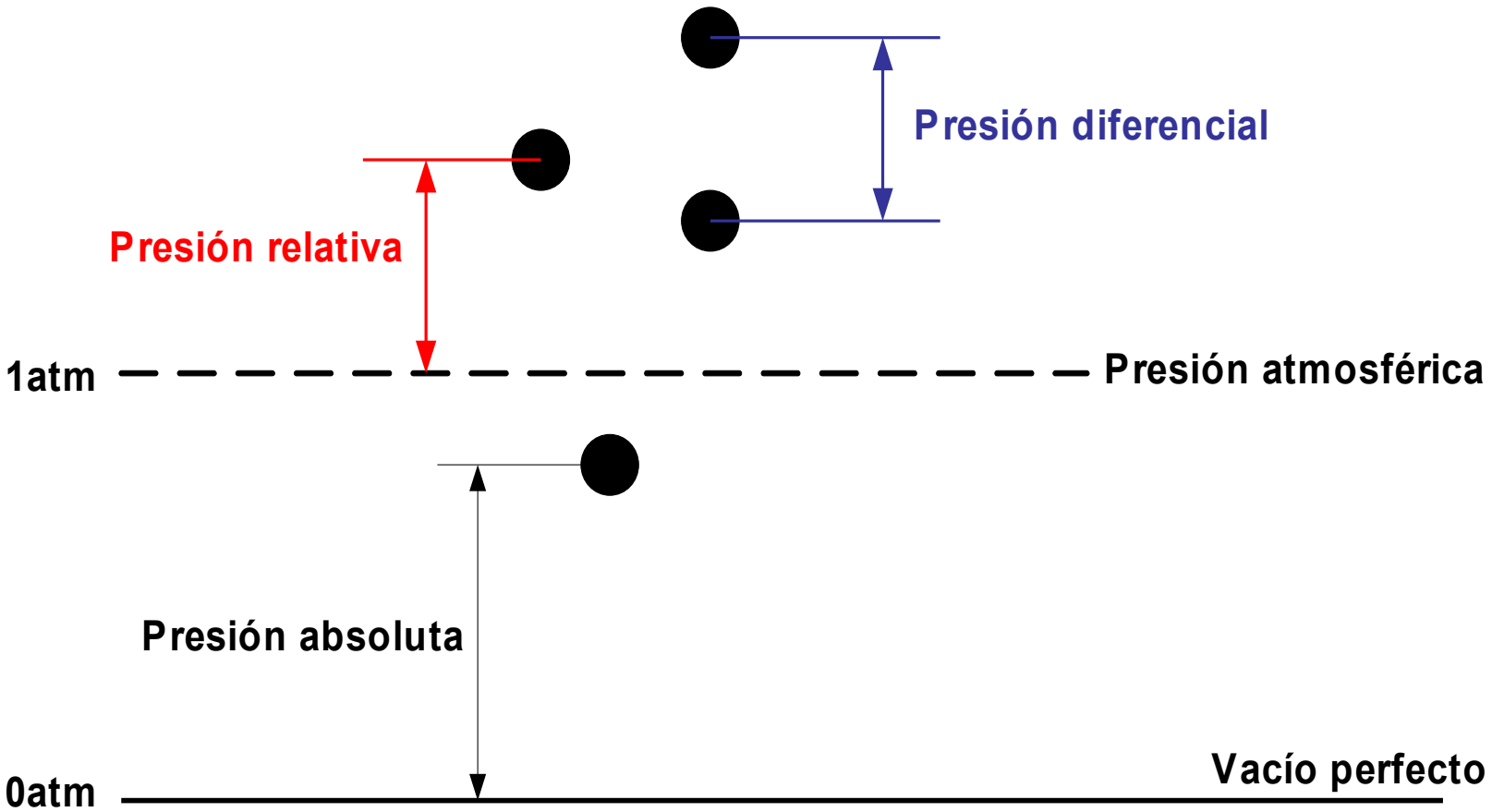
http://www.femtotools.com/products.htm

Limites de Utilização das Células de Carga



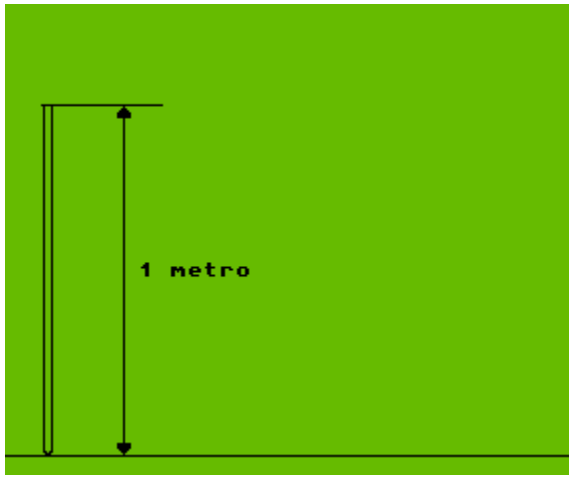
2.2. Medição de Pressão

Pressão

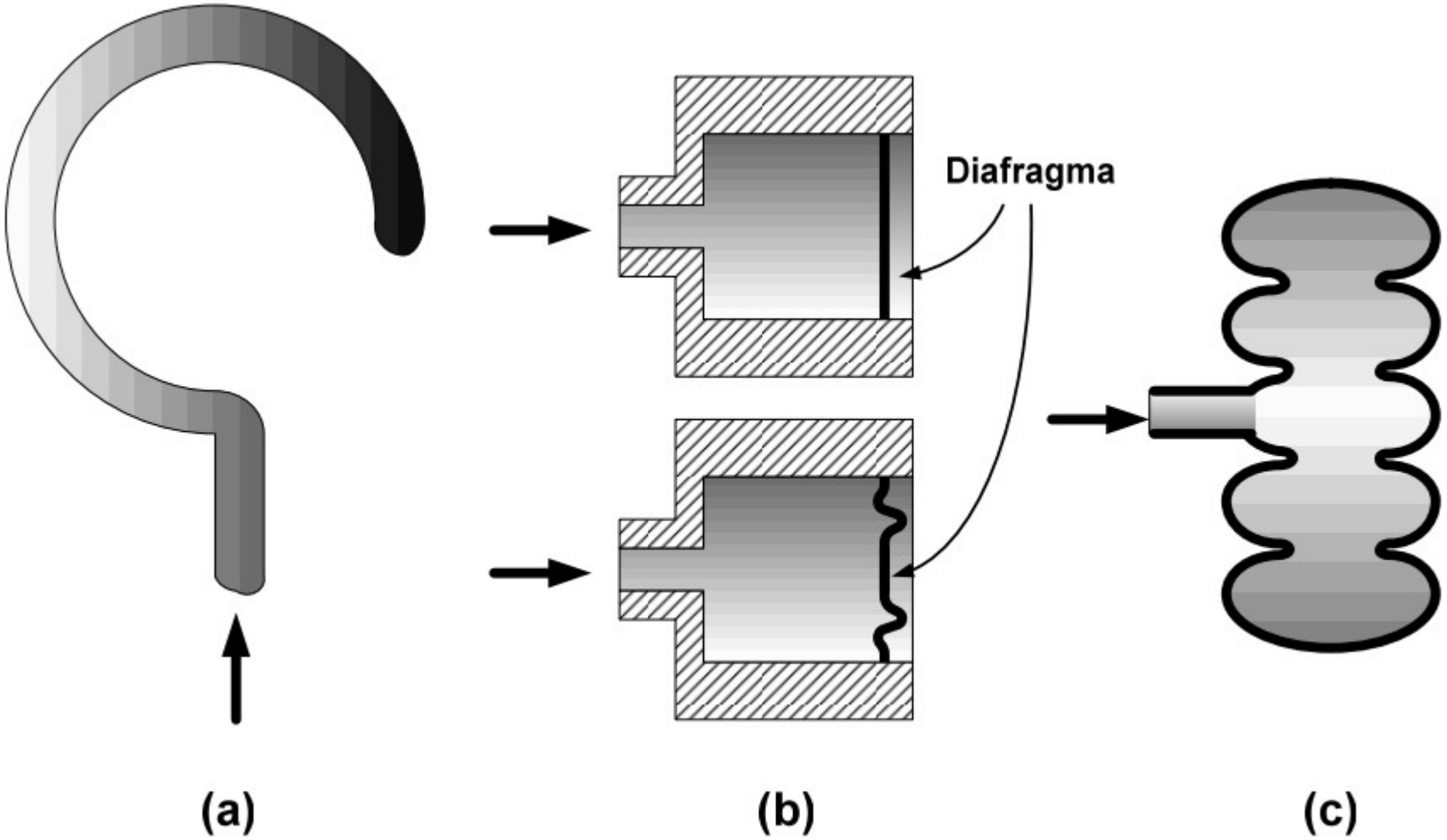

Presión diferencial
Presión relativa
1atm
Presión atmosférica
Presión absoluta
0atm
Vacío perfecto

Pressão

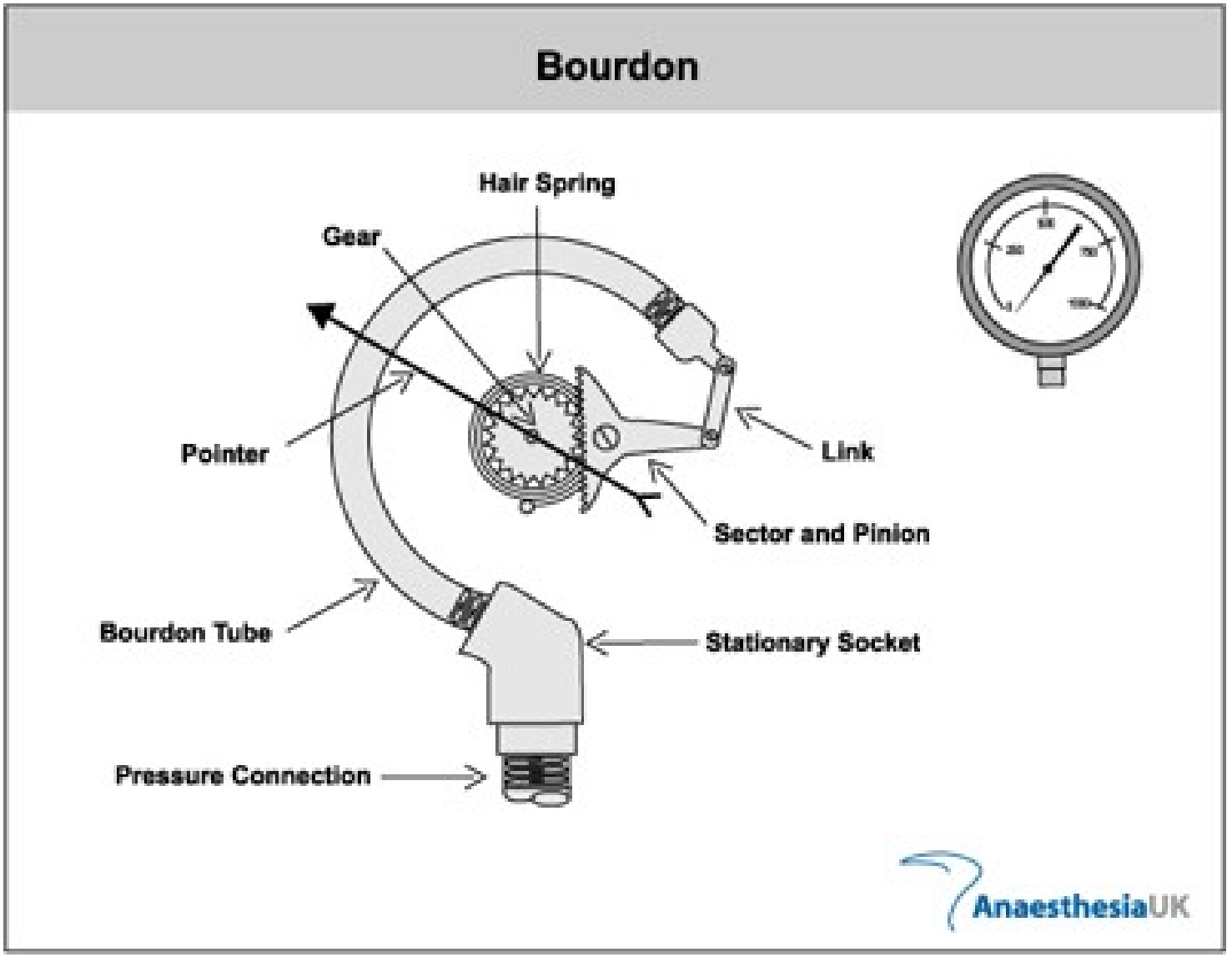
1kPa	1	0,14504	0,0098694	689,46	10,198	10^{-3}
1psi	6,8946	1	0,068046	51,714	70,310	0,068496
1atm	101,32	14,696	1	759,83	1033,3	1,0066
1mm Hg	0,13332	0,019337	0,0013161	1	1,3596	0,0013248
1cm H_2O	0,098062	0,014223	0,00096780	0,73551	1	0.00097416
1bar	10^3	14,504	0,99343	754,85	1026,5	1
	kPa	psi	Atm	mm Hg	cm H_2O	bar



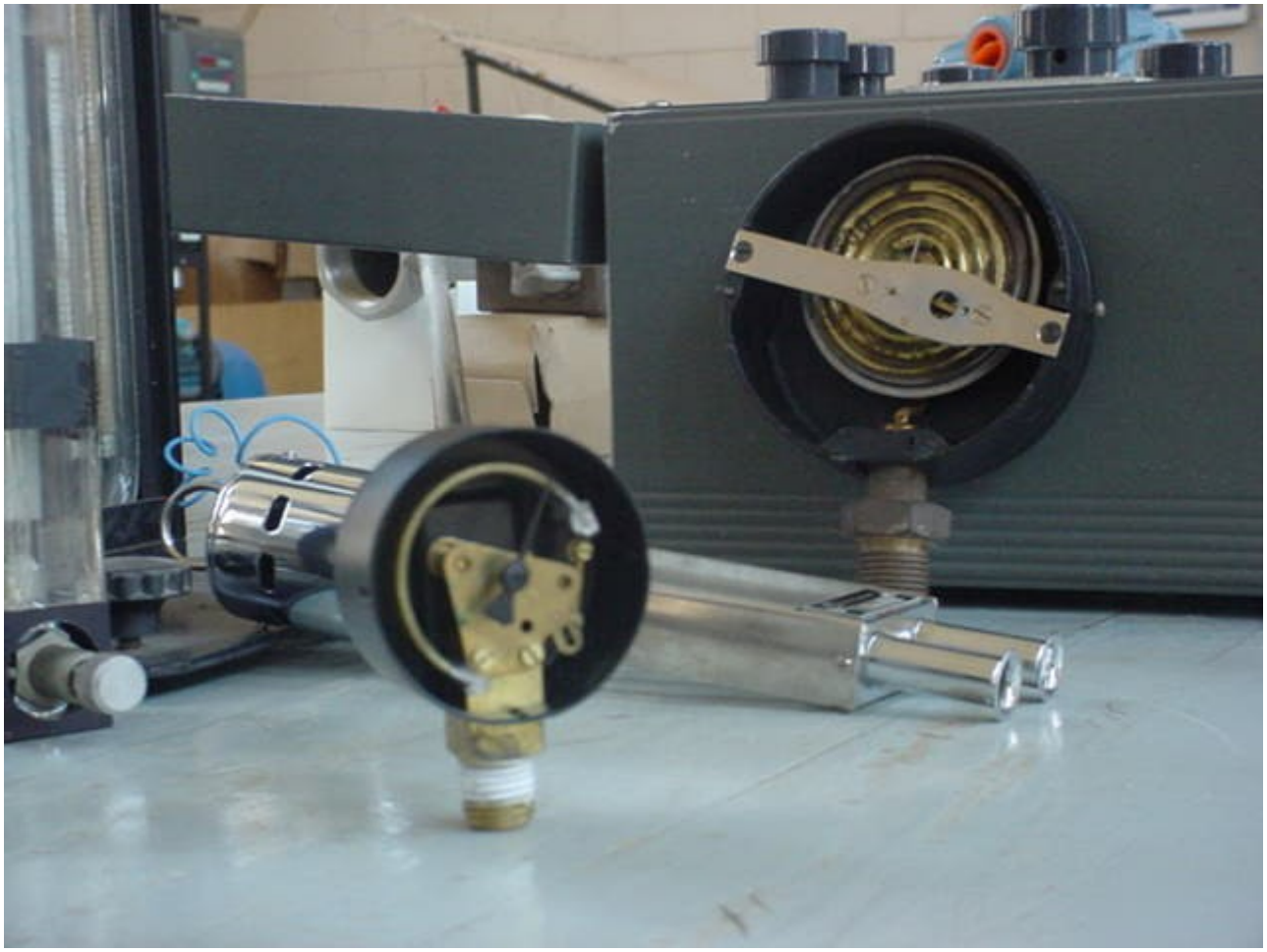
Pressão



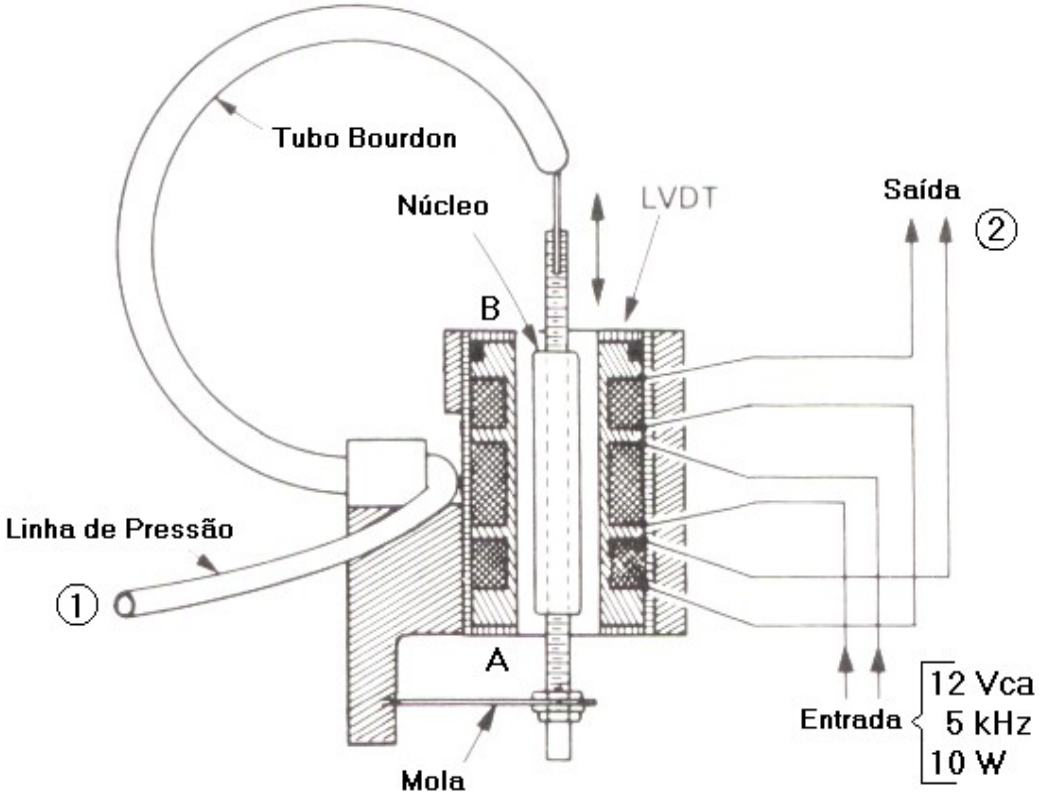
Pressão

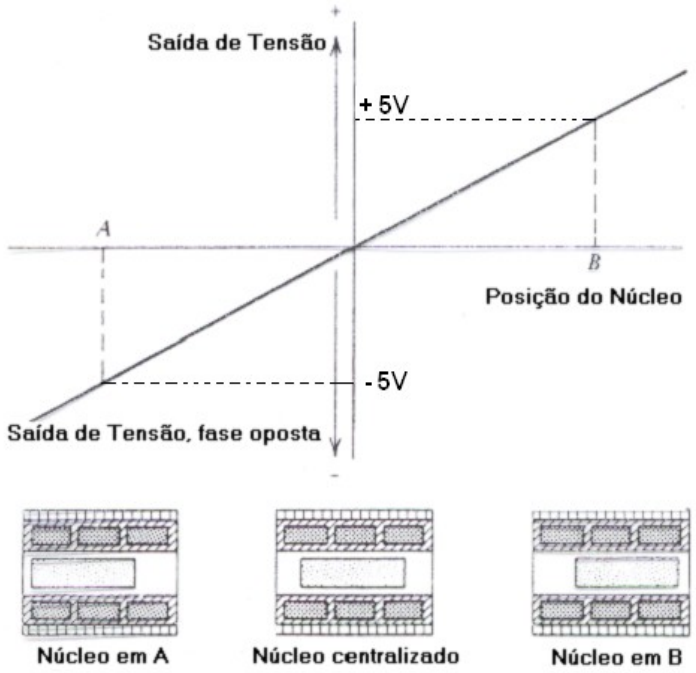

Bourdon
Hair Spring
Gear
Pointer
Link
Sector and Pinion
Bourdon Tube
Stationary Socket
Pressure Connection
AnaesthesiaUK

Pressão



Transdutor de Pressão





Ref.: Dally, James W.; Riley, William F.; McConnell, Kenneth G. *Instrumentation for Engineering Measurements*, Ed. John Wiley & Sons, 2ª edição, 1993.

Pressão – Sensores Industriais

Pressure gauge with Bourdon tube and integrated pressure sensor

Accuracy class 1,0 %

Standard Output	**4...20 mA;**	**2-wire system**
or	**0...20 mA;**	**3-wire system**
or	**0...5 VDC;**	**3-wire system**
or	**0...10 VDC;**	**3-wire system**

Features

Local Display
Safety version to EN 837-1/S 3
Corrosion resistant stainless steel
Liquid filling of case to provide damping of measuring system

Applications

Chemical and petrochemical industries
Food and beverage industries
General mechanical engineering

www.suchy-messtechnik.de/pdf/en/CD%20Sensors%20engl%2005/SMR36_gb_cpl.pdf

Pressão – Sensores Industriais

Pressure sensors with internal diaphragm with ceramic element

Accuracy 0,5 % and 1 %

Standard output : 4...20 mA; 2-wire system
or 0...5 VDC; 3-wire system
or 0...10 VDC; 3-wire system

Features
High long -therm stability
High peak pressure resistance
Corrosion resistant stainless steel design
For dynamic and static measurments

Applications
Hydraulics and pneumatics
General mechanical engineering

http://www.suchy-messtechnik.de/pdf/en/CD%20Sensors%20engl%2005/SD25_gb_cpl.pdf

Pressão – Sensores Industriais

Differential pressure transmitter for non aggressive gases

Accuracy 0,25%, 0,5% and 1,0 %

Output
4...20 mA;
or 0...20 mA;
or 0...10 VDC;
or -10...10 VDC;

Characteristics
high Overpressure optional 2 bar
short reaction time
excellent long term stability

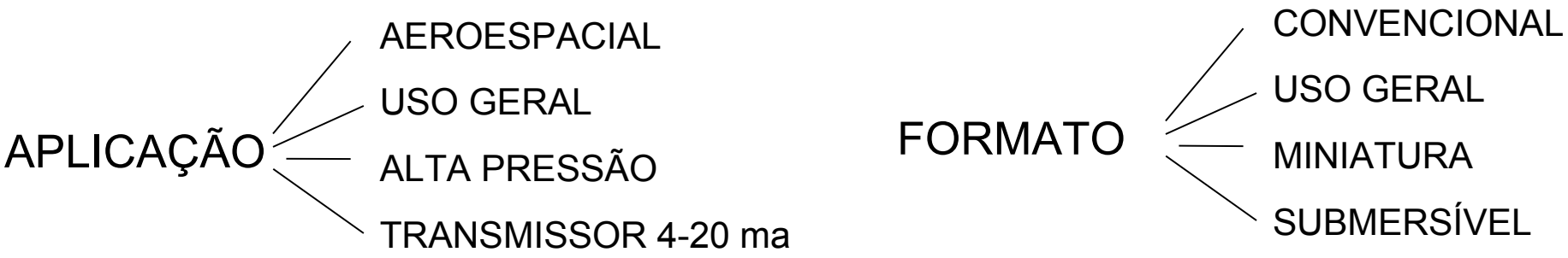
Anwendung
Für nichtaggressive Gas

Preferred areas of use are:
medical equipment
filter technology, flow measurement
heating and air conditioning

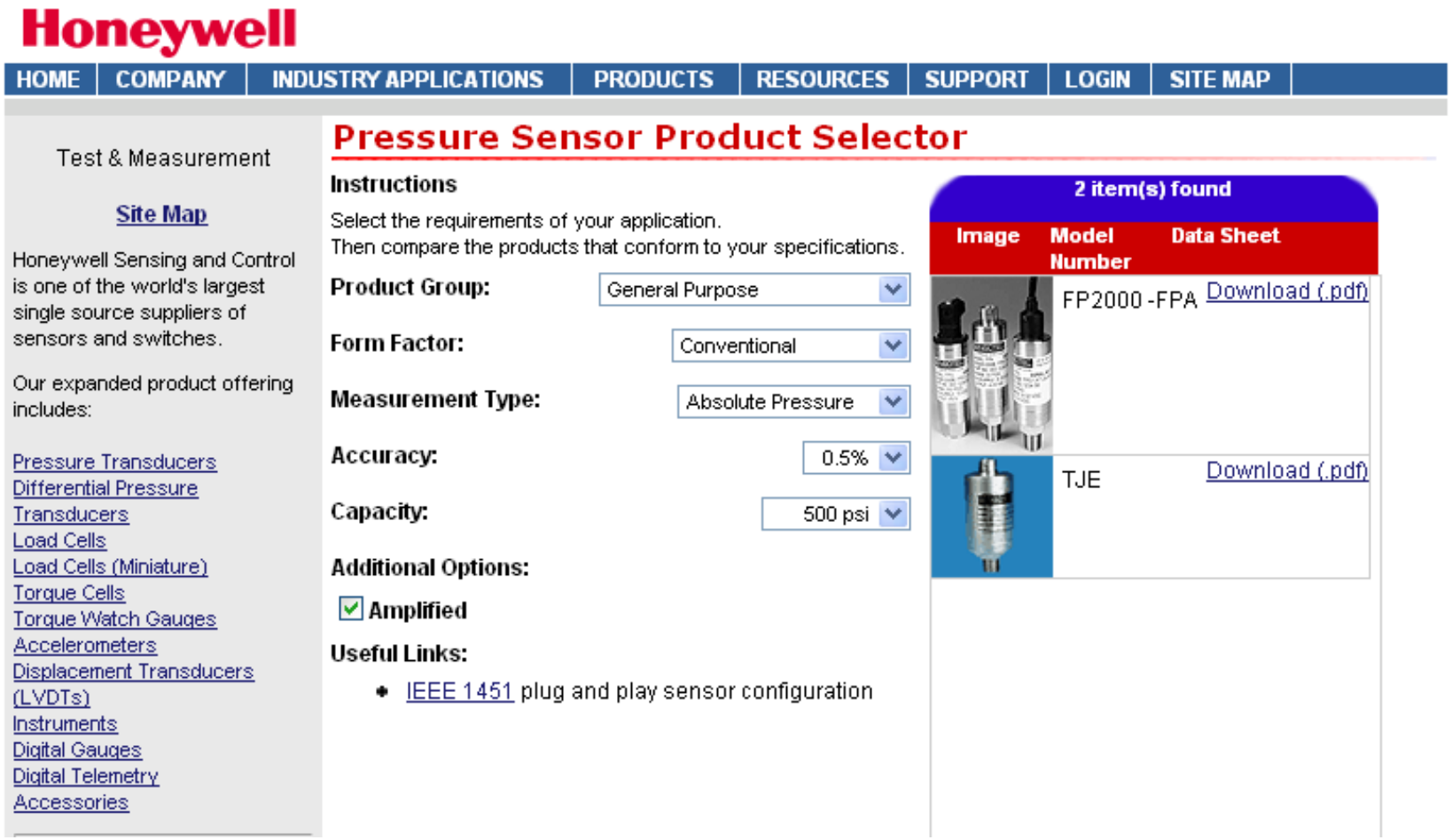
http://www.suchy-messtechnik.de/pdf/en/CD%20Sensors%20engl%2005/SD80_gb_cpl.pdf

Instalação de Sensores de Pressão

Seleção de Sensores de Pressão Honeywell



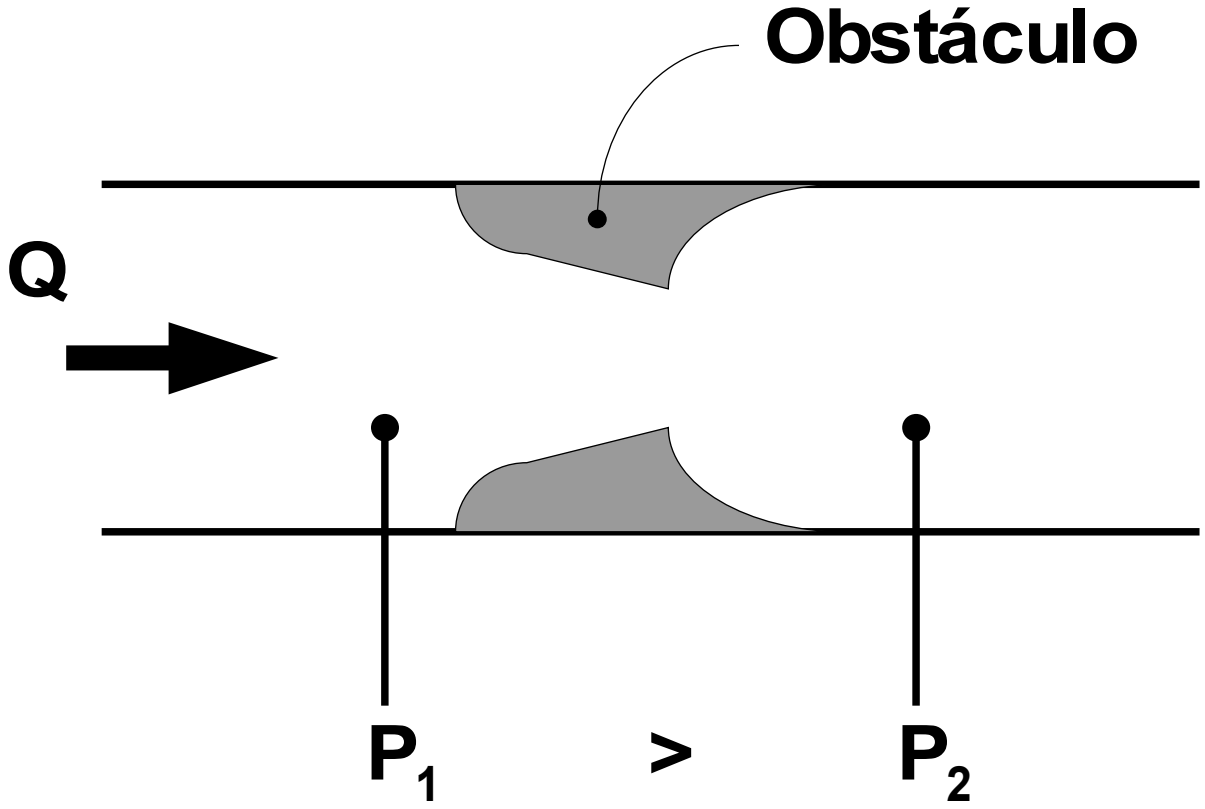
Seleção de Sensores de Pressão Honeywell (cont.)



http://www.sensotec.com/ProductSelectors/Pressure.asp

2.3. Medição de Vazão

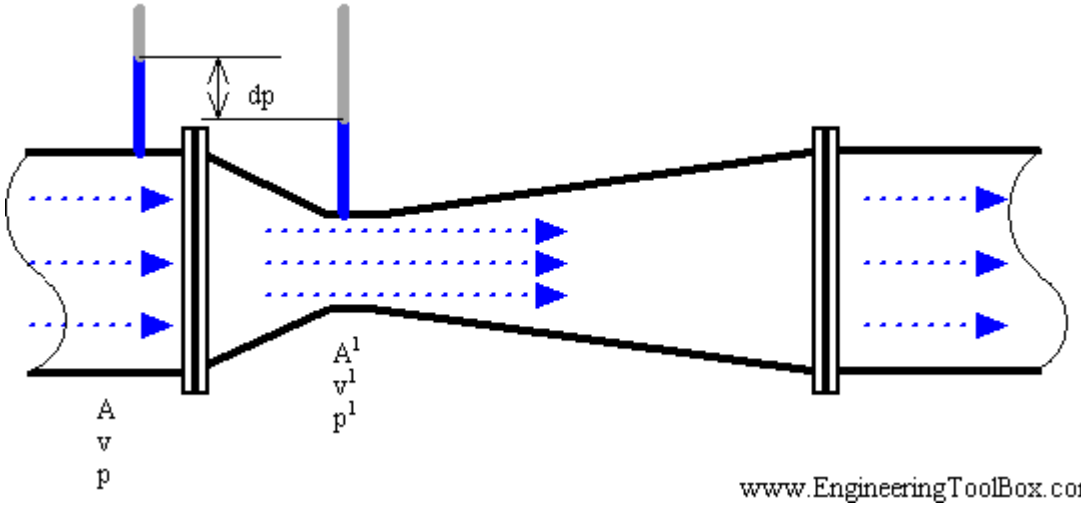
Medição de fluxo



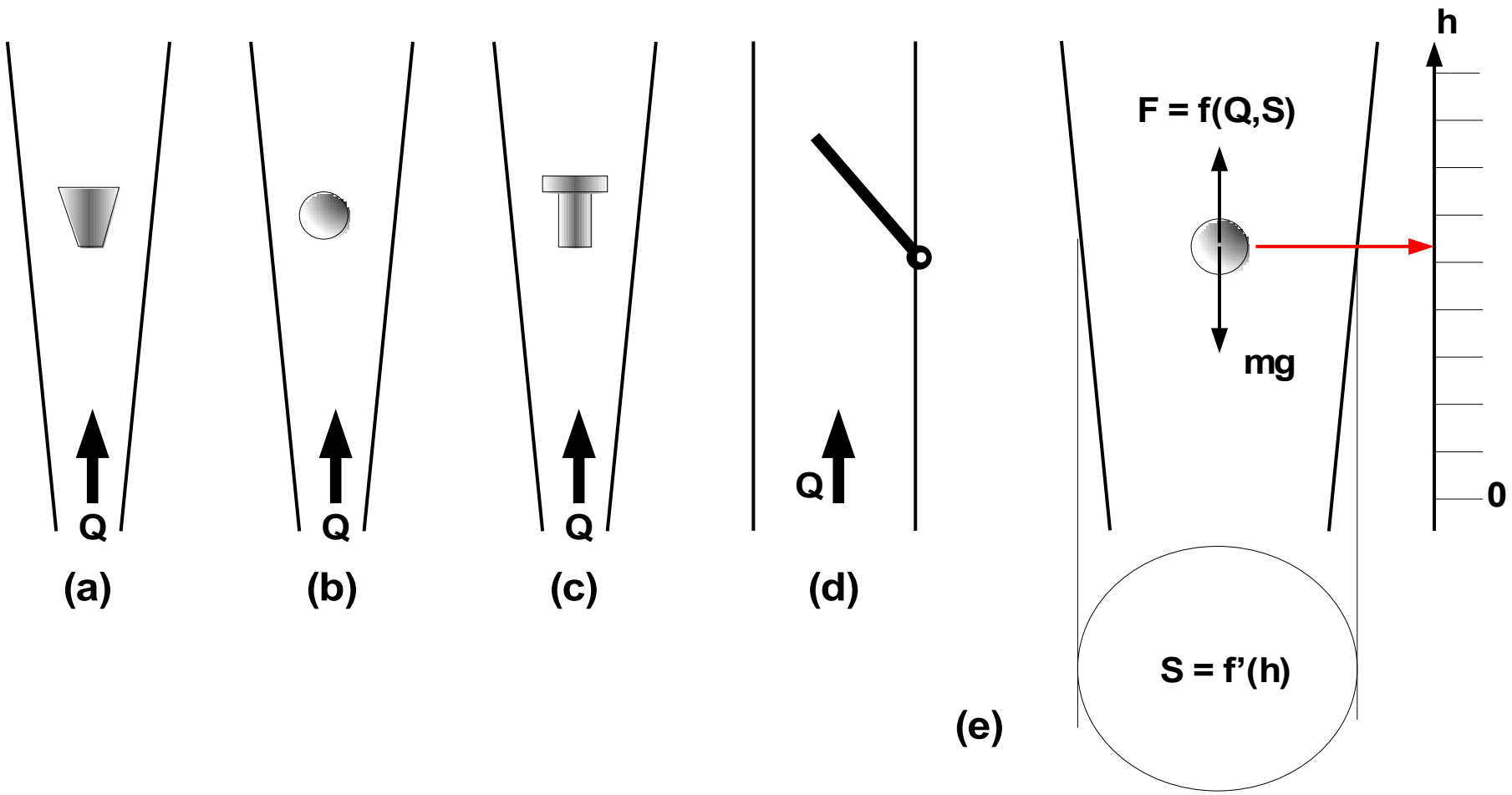
$\Delta P = P_1 - P_2 \longrightarrow$ Perturba

$\Delta P = f(Q) \longrightarrow$ Mide

Medição de fluxo

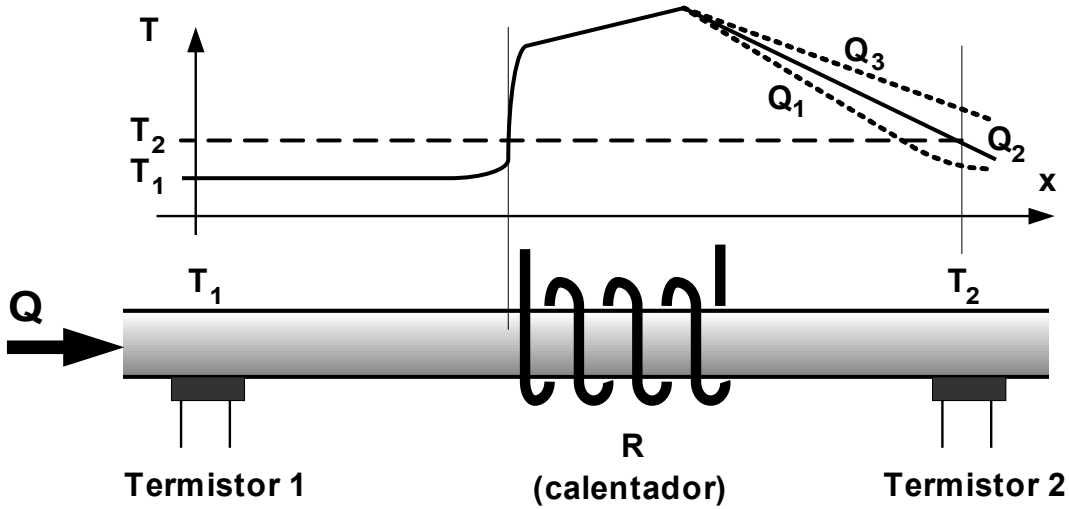


Medição de fluxo



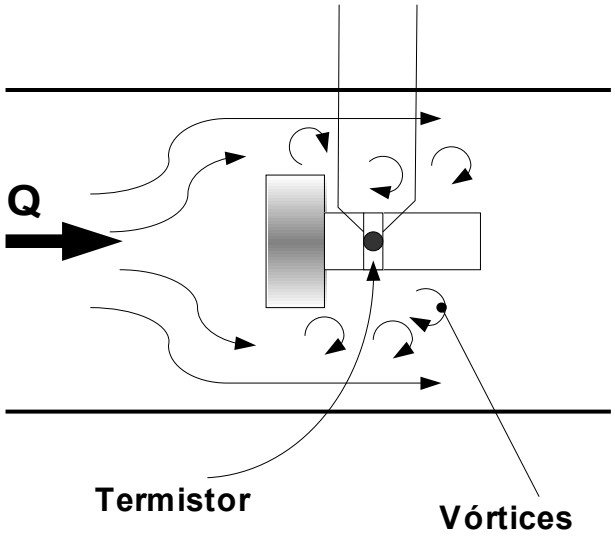
Medição de fluxo

Medição de fluxo



$\Delta T = T_1 - T_2 = f(Q)$

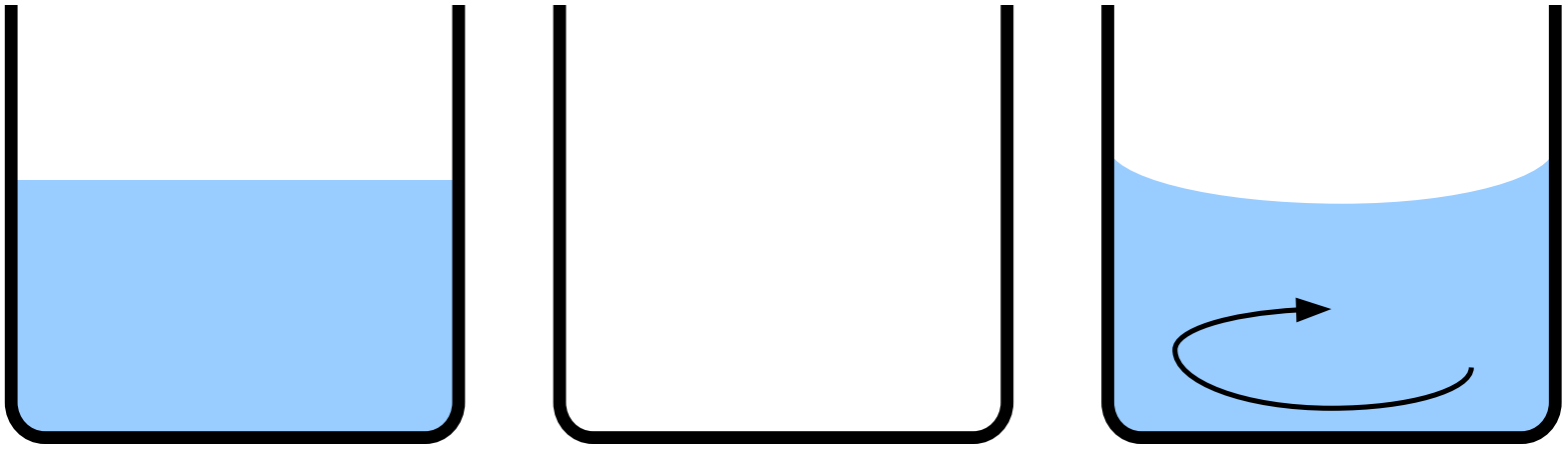
(a)



(b)

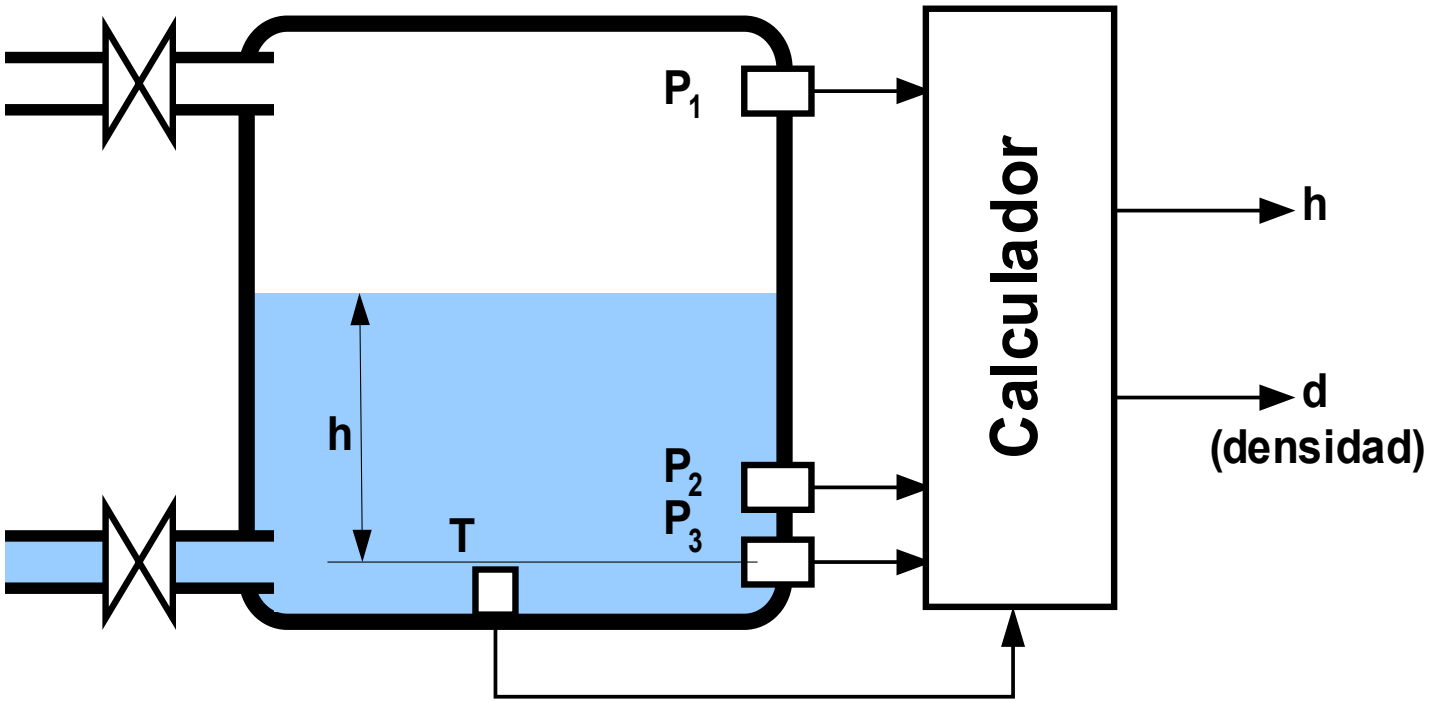
2.4. Medição de Nível

Medição de Nível

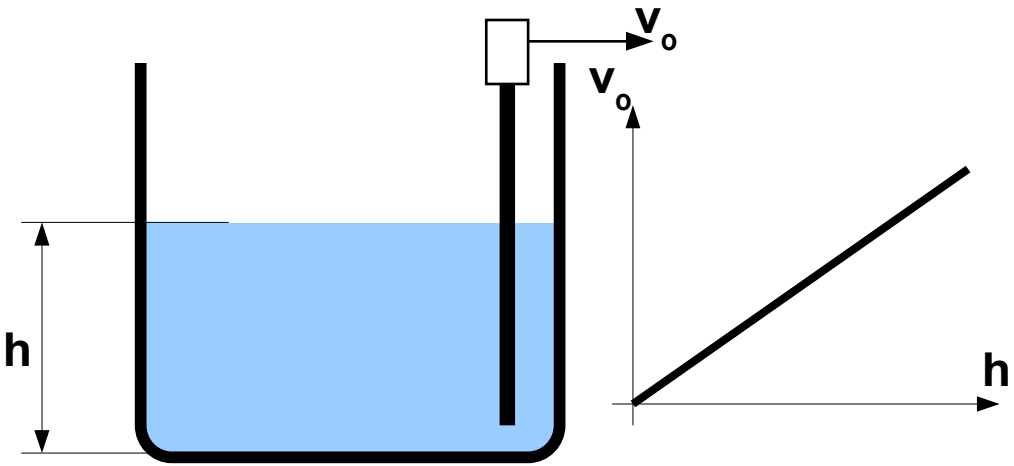


(a) (b) (c)

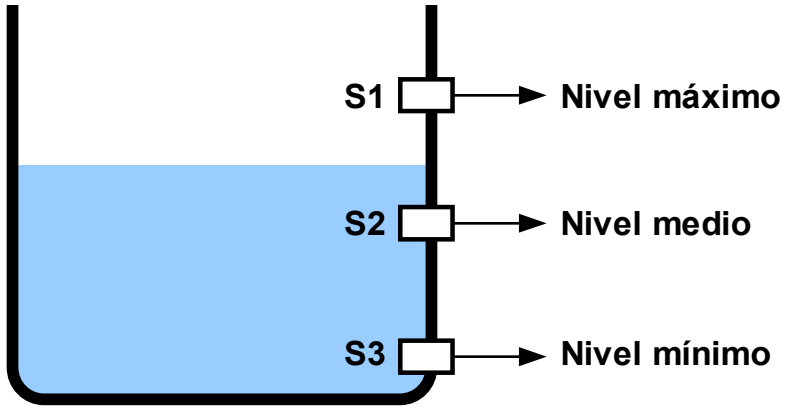
Medição de Nível



Medição de Nível

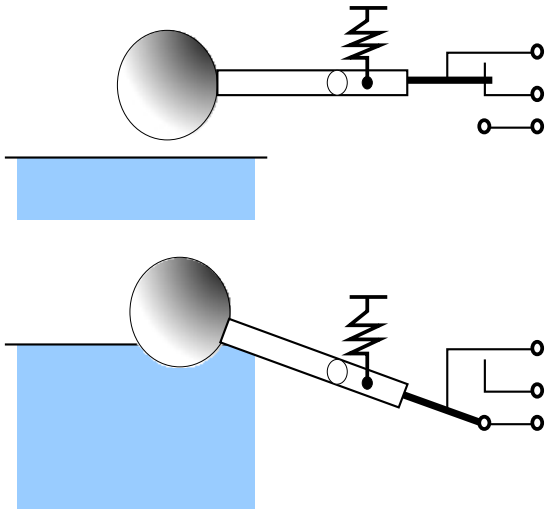


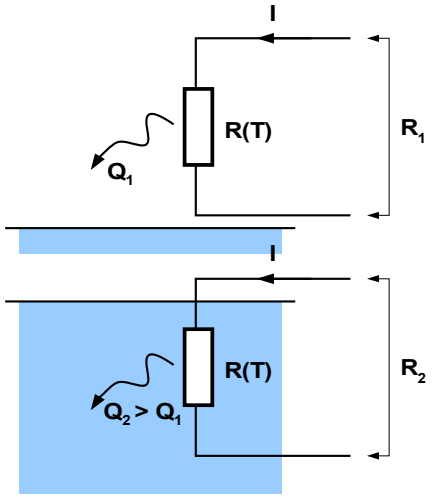
(a)

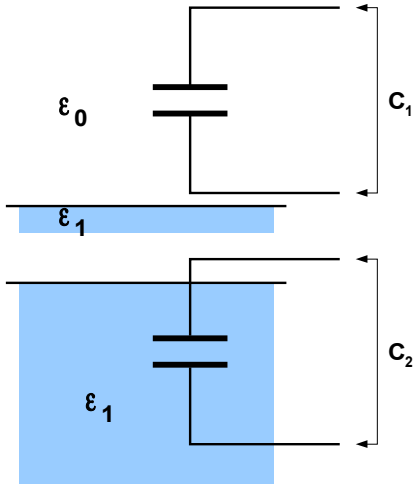


(b)

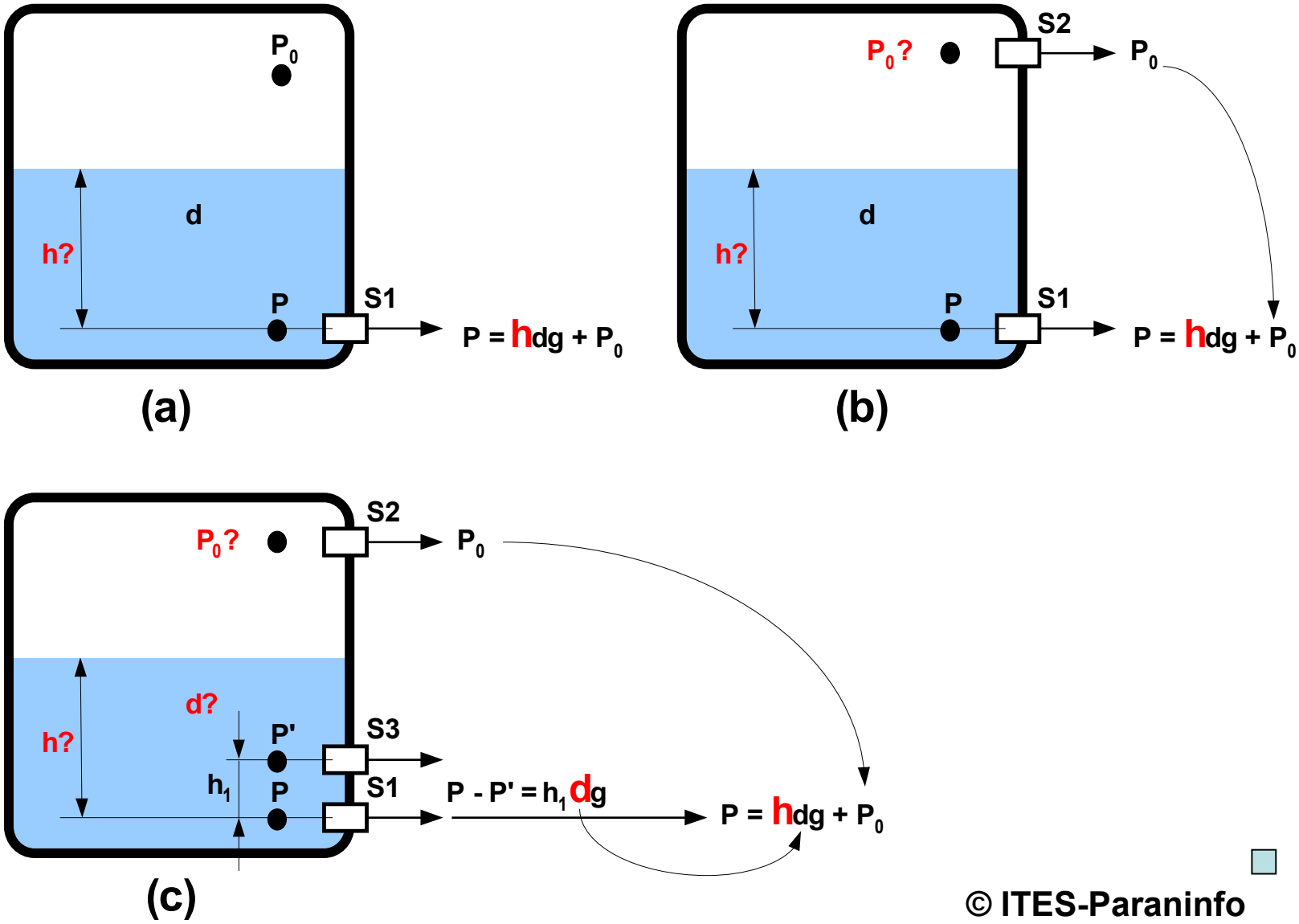
Medição de Nível





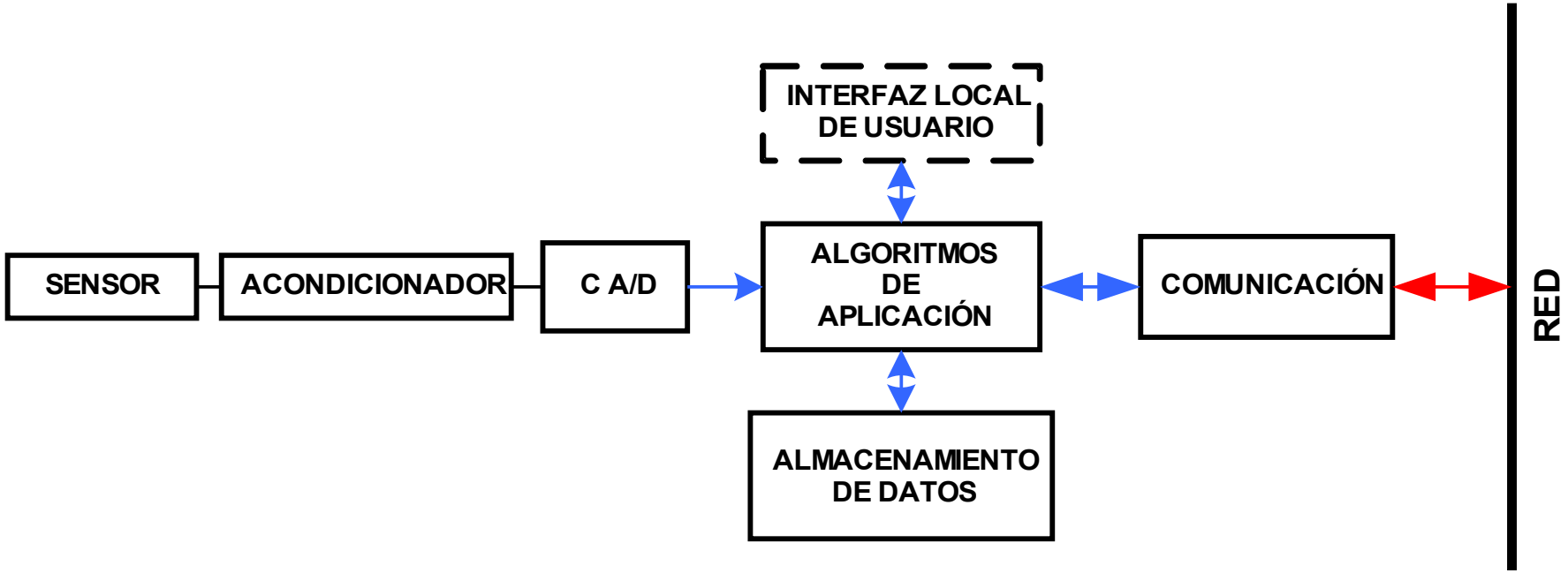


Medição de Nível

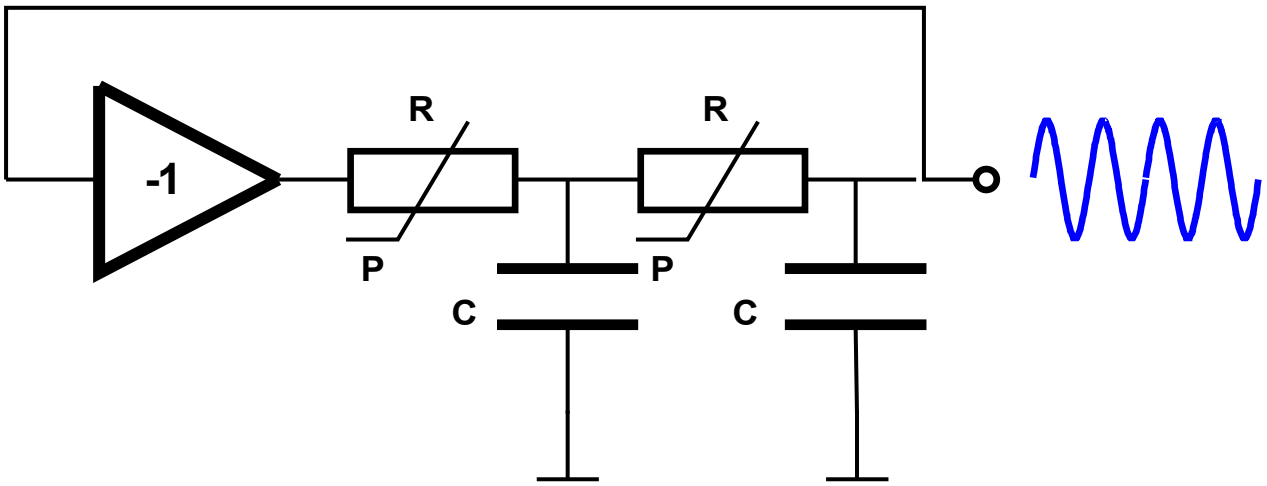


3. *Smart Sensors*

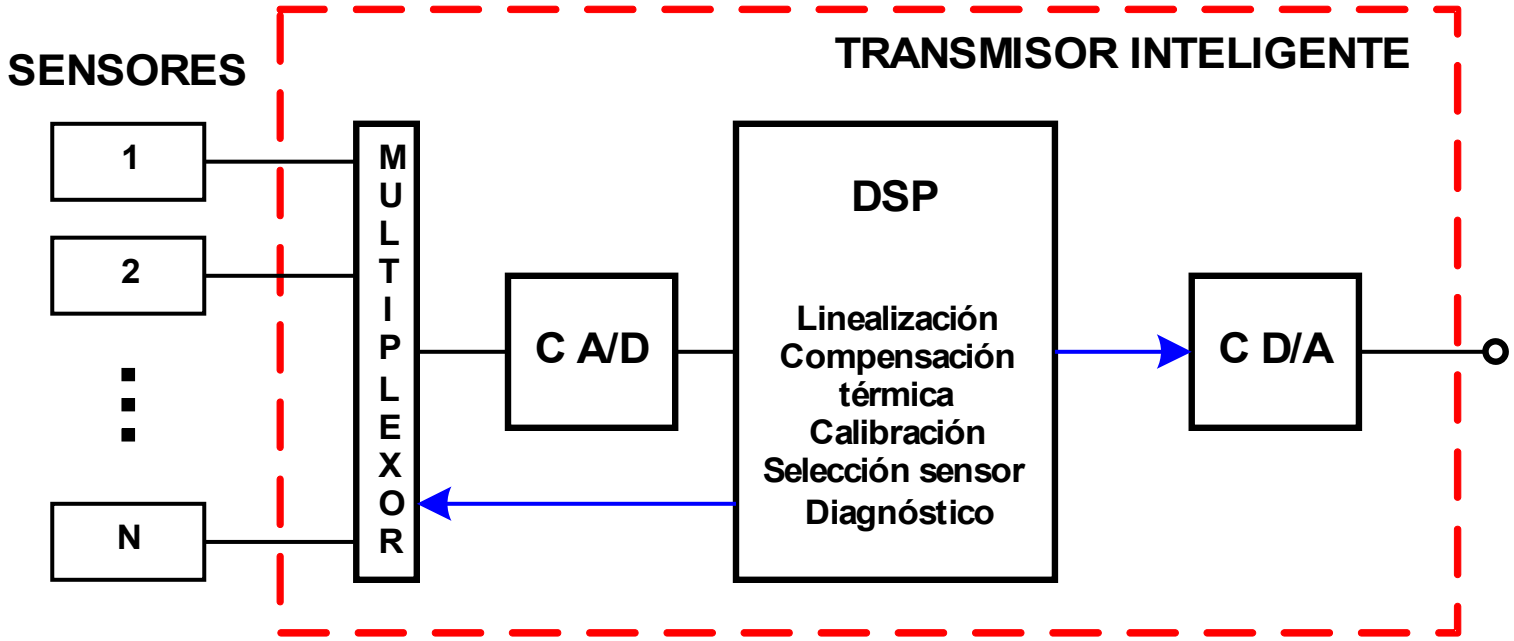
Sensores Inteligentes (‘*Smart Sensors*’)



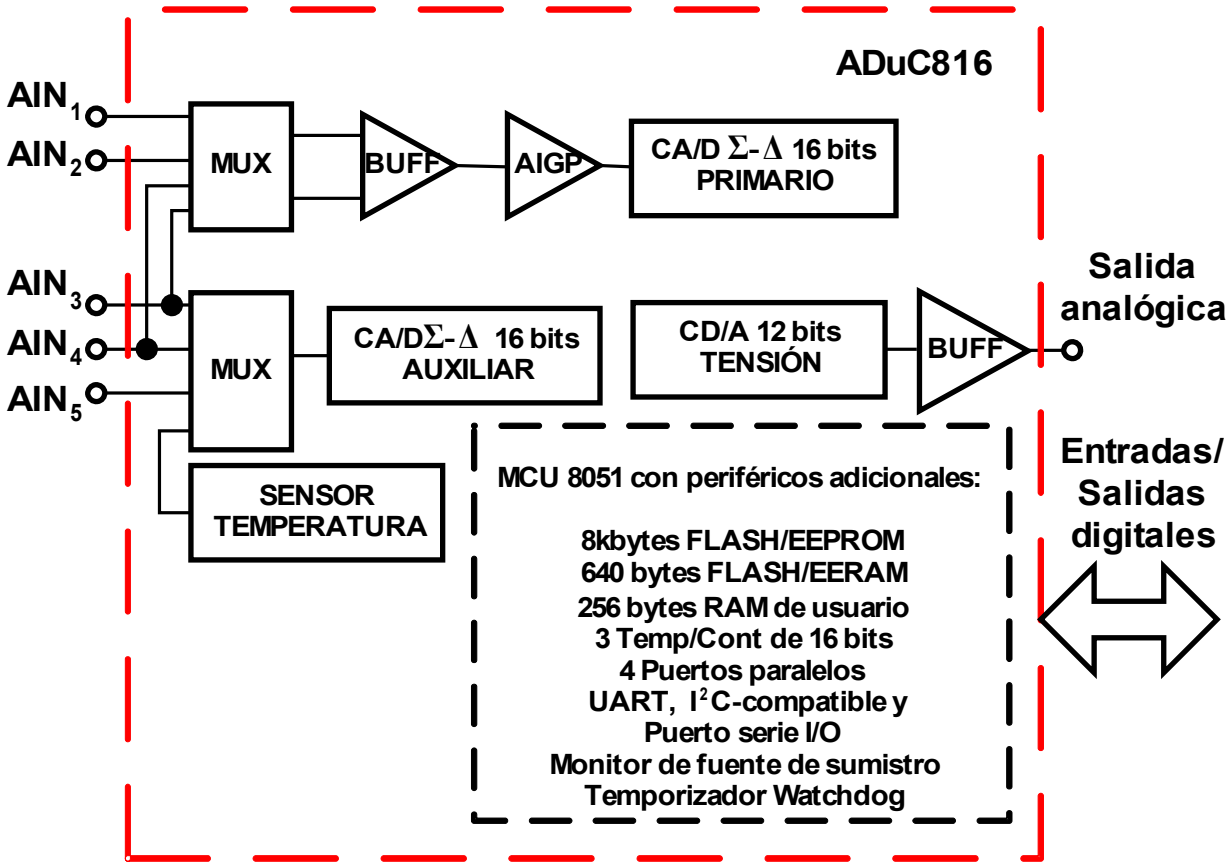
Sensores Inteligentes



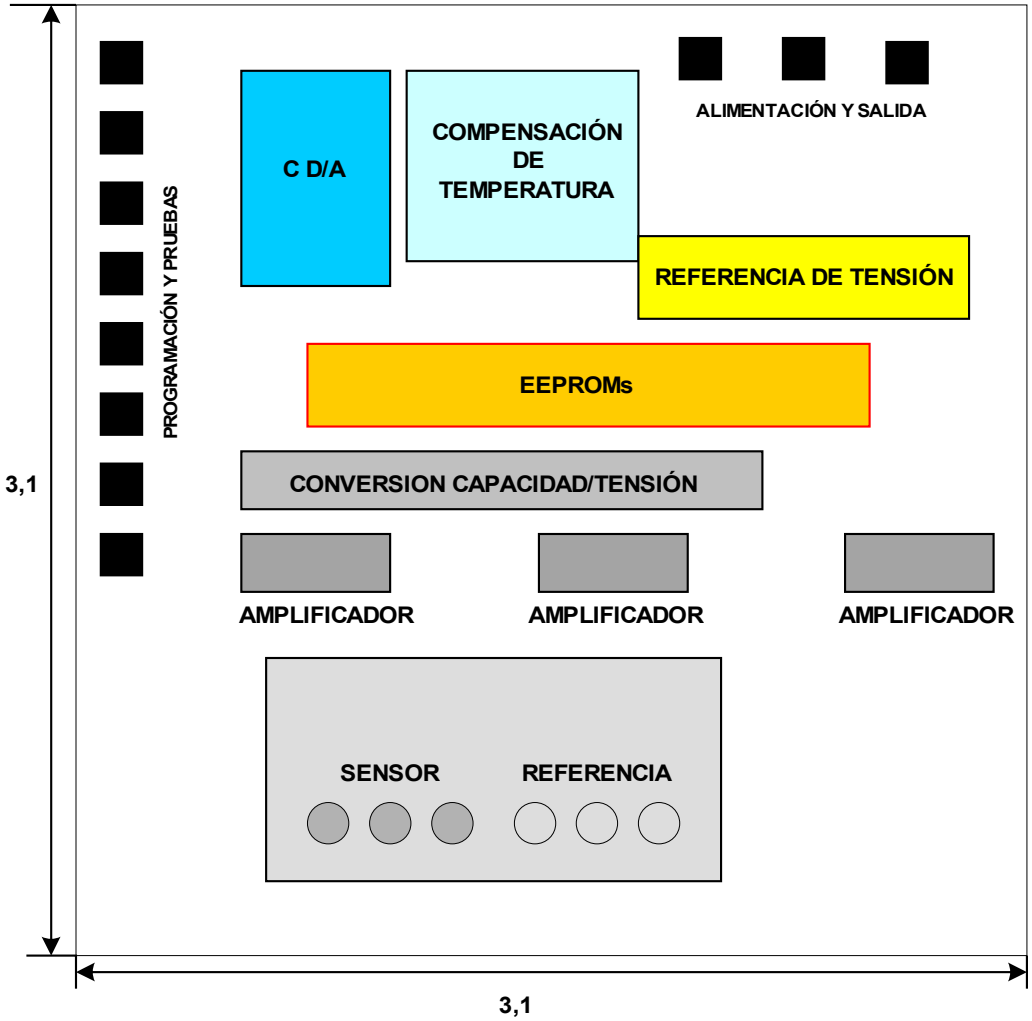
Sensores Inteligentes



Sensores Inteligentes



Sensores Inteligentes



Sensores Inteligentes