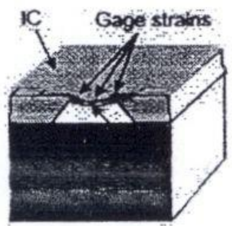
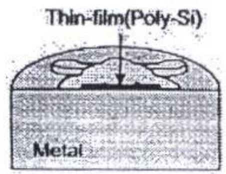
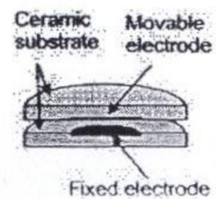
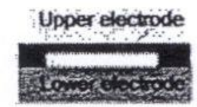
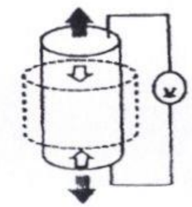
Tab. 7.3.1 Principles and features of pressure sensors

Principle	*Piezoresistance*		*Capacitance*		*Piezoelectricity*
	Silicon piezoresistance	*Thin-film piezoresistance*	*Ceramic capacitance*	*Thin-film capacitance*	*Ceramic piezoelectricity*
Structure					
Sensitivity	Middle $\Delta R = 1/2R\Delta\sigma\pi_{44}$ π_{44}= Piezoresistive coefficient	Low π_{44}=One sixth of single-crystal silicon	High	High	Low
Integration	Easy	Difficult	Difficult	Easy	Difficult
LSI process	Easy	Difficult	Difficult	Easy	Difficult

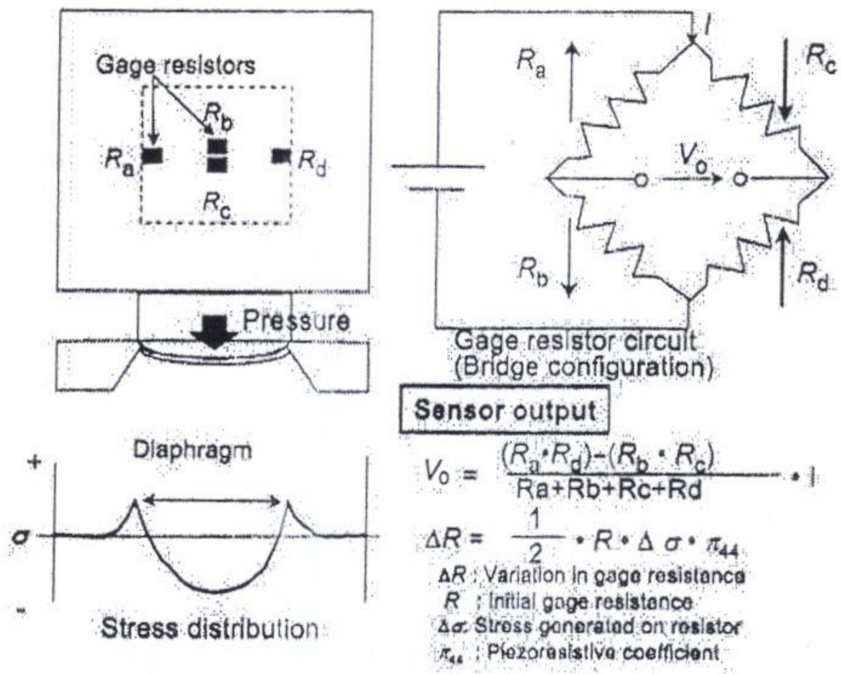


Fig. 7.3.1 Principle of piezoresistive sensor

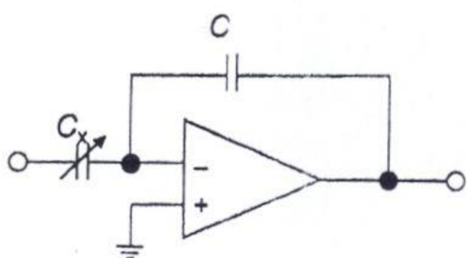


Fig. 7.3.2 Principle of capacitive sensor

$$\Delta C \propto \frac{W^4}{\Delta t^3} \times \Delta P$$

	Low	Medium	High		
ressure nge	5 k Pa	100 k Pa	1~10 M Pa	20 M Pa	200 M P
	Gasoline vapor	Intake pressure	Air-conditioning Suspension	Fuel pressure	Common
roduct					

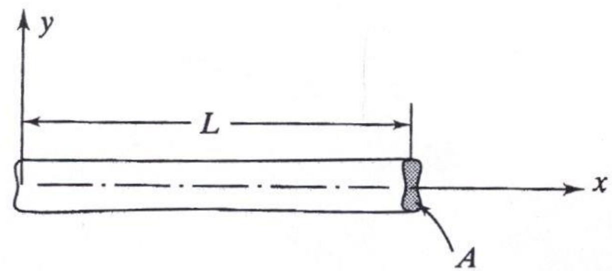
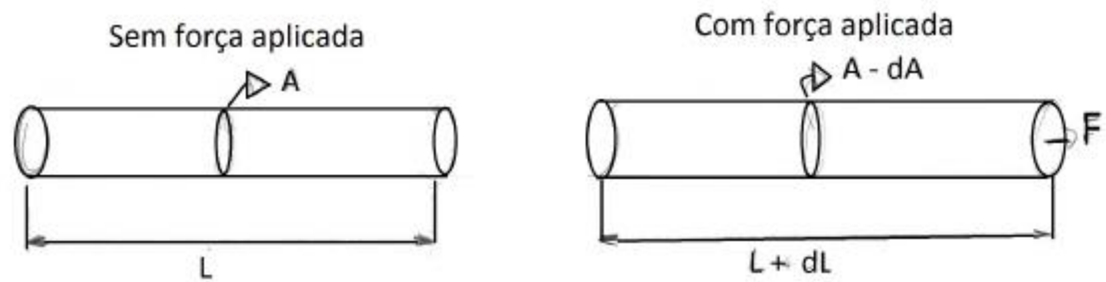
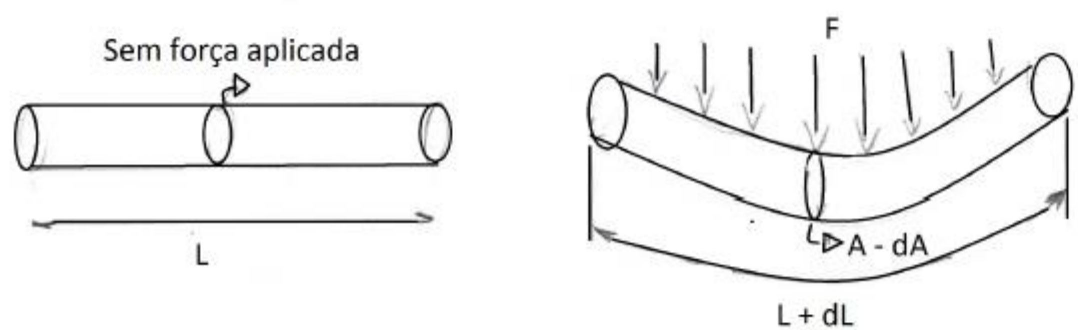


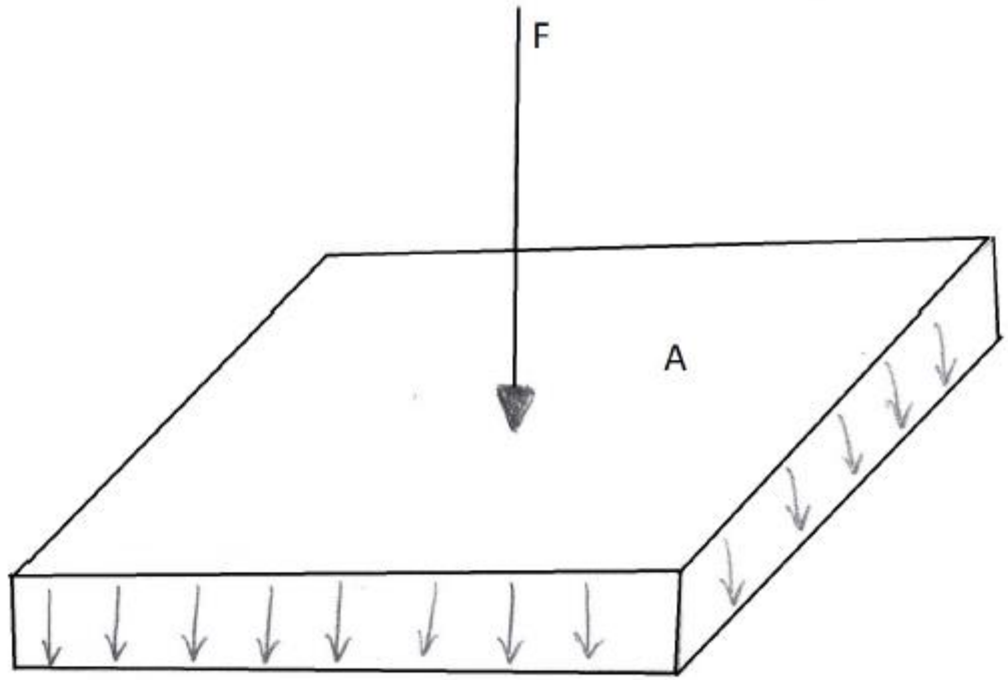
FIGURE 5-2
A wire segment.

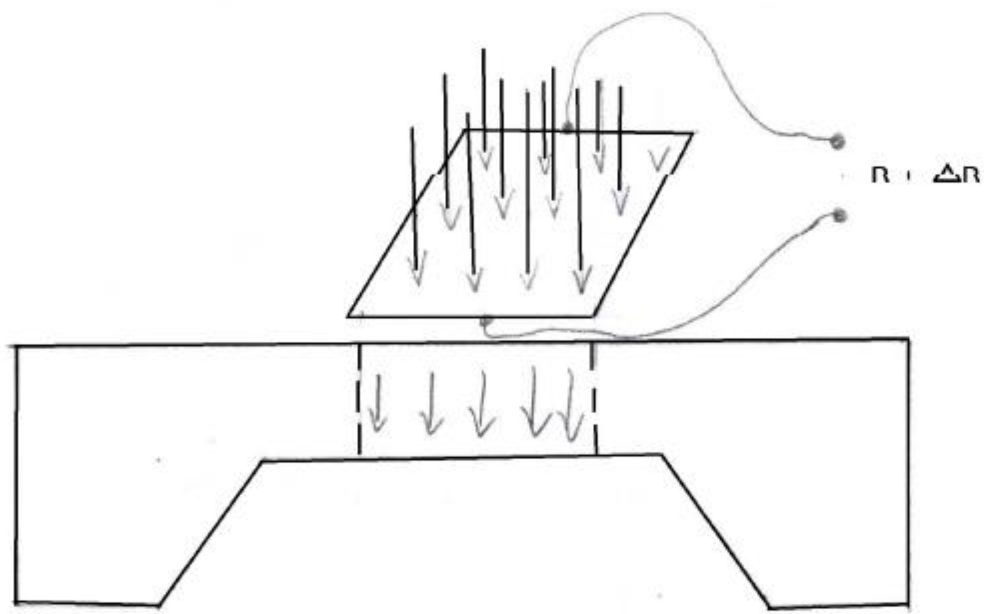
a)


Sem força aplicada
A
L
Com força aplicada
A - dA
F
L + dL

b)


Sem força aplicada
L
F
A - dA
L + dL


F
A


R + ΔR

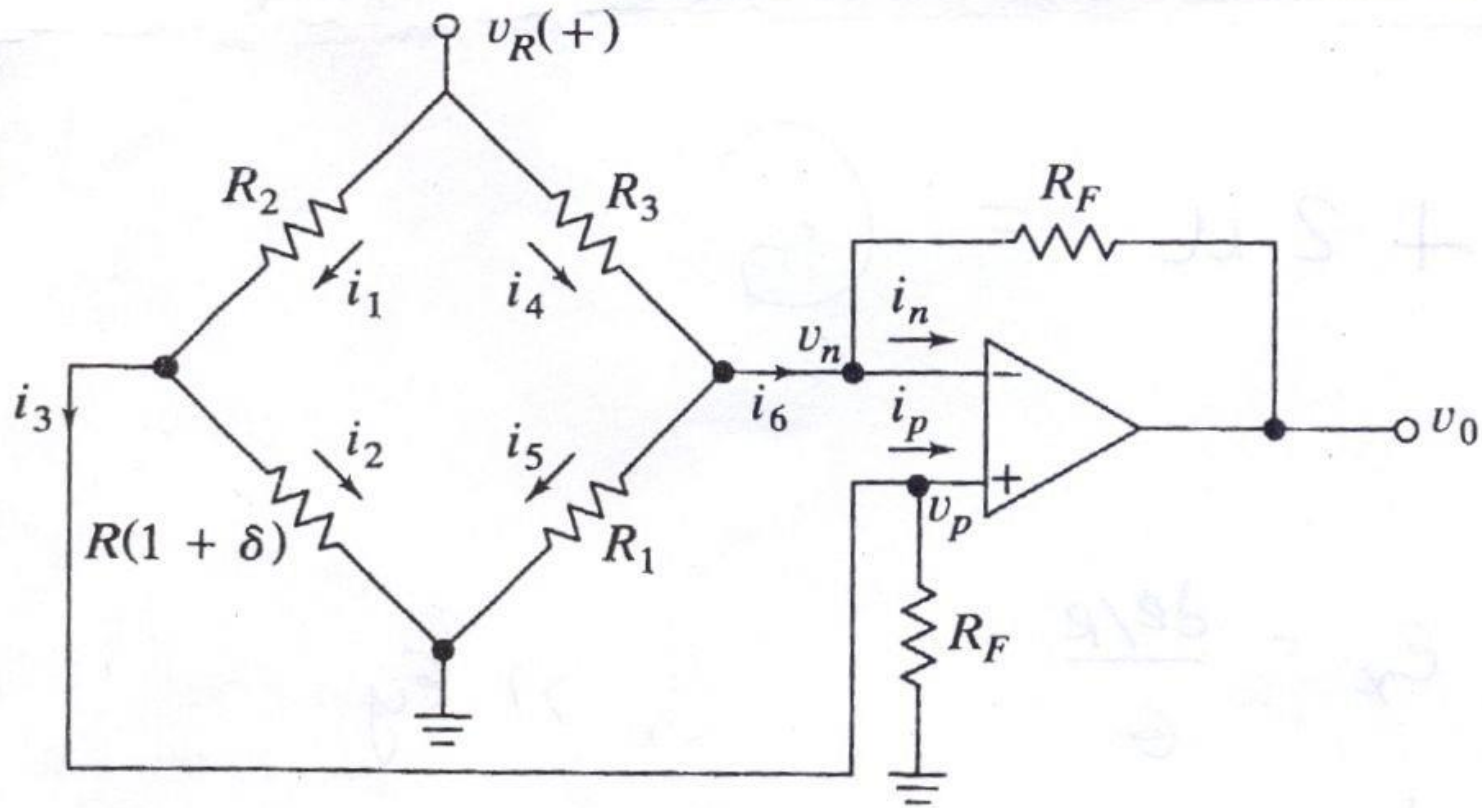


FIGURE 5-3
Strain gauge bridge circuit with differential amplifier.

$$i_1 = i_2 + i_3 \qquad \text{and} \qquad i_4 = i_5 + i_6$$

e of Ohm's law across each device, together with $i_n = 0$ and i
ally yields the equations

$$\frac{v_R - v_p}{R_2} = \frac{v_p - 0}{R(1+\delta)} + \frac{v_p - 0}{R_F}$$

$$\frac{v_R - v_n}{R_3} = \frac{v_n - 0}{R_1} + \frac{v_n - v_0}{R_F}$$

result in

$$v_p = \frac{v_R}{R_2}\frac{R(1+\delta)R_2R_F}{R_2R_F + R(1+\delta)(R_F + R_2)}$$

$$v_n = \left(\frac{v_R}{R_3} + \frac{v_0}{R_F}\right)\frac{R_1R_FR_3}{R_FR_3 + R_1R_3 + R_1R_F}$$

ing these two expressions yields v_0 in the form

$$v_0 = \frac{v_RR_F}{R_1R_3}\left[\frac{R(1+\delta)(R_FR_3 + R_1R_3 - R_1R_2) - R_1R_2R_F}{R_2R_F + R(1+\delta)(R_F + R_2)}\right]$$

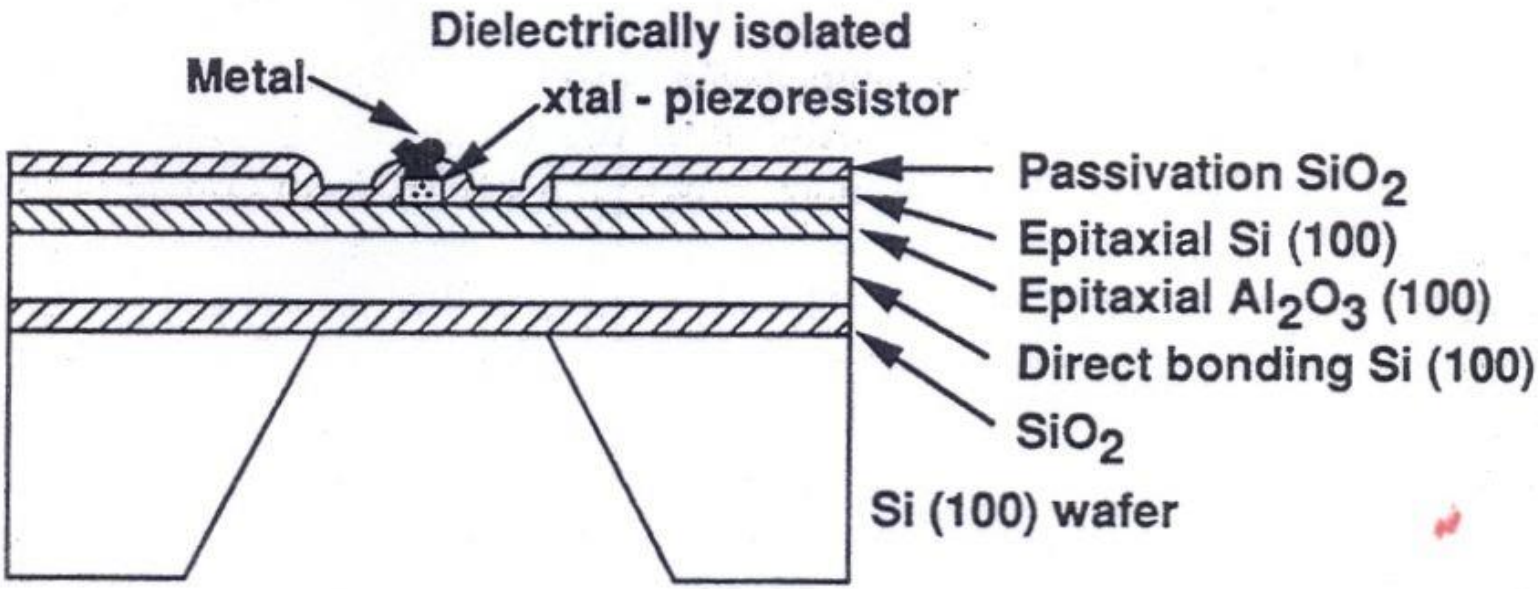
xpression simplifies considerably when two or more of the resistanc
n as equal. Thus a choice of $R_1 = R$ and $R_2 = R_3 = R_0$ yields

$$v_0 = \frac{v_RR_F}{R}\left[\frac{\delta}{\frac{R_0}{R} + (1+\delta)\left(1 + \frac{R_0}{R_F}\right)}\right]$$

$R_F \gg R_0$ and $\delta \ll 1$, the expression takes on the form

$$v_0 \approx \frac{v_RR_F}{R}\left[\frac{\delta}{\frac{R_0}{R} + 1}\right]$$

(a)



Dielectrically isolated
Metal
xtal - piezoresistor
Passivation SiO_2
Epitaxial Si (100)
Epitaxial Al_2O_3 (100)
Direct bonding Si (100)
SiO_2
Si (100) wafer

(b)

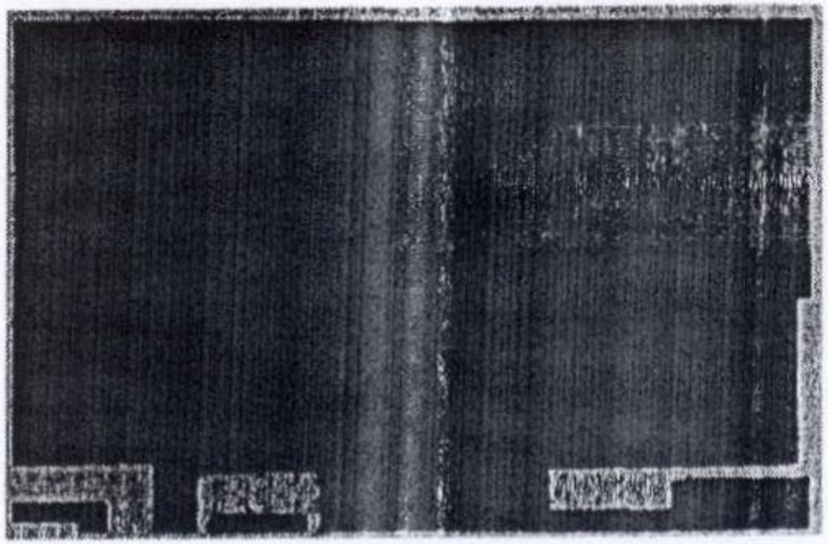


Fig. 7.3.6 Picture-frame photograph

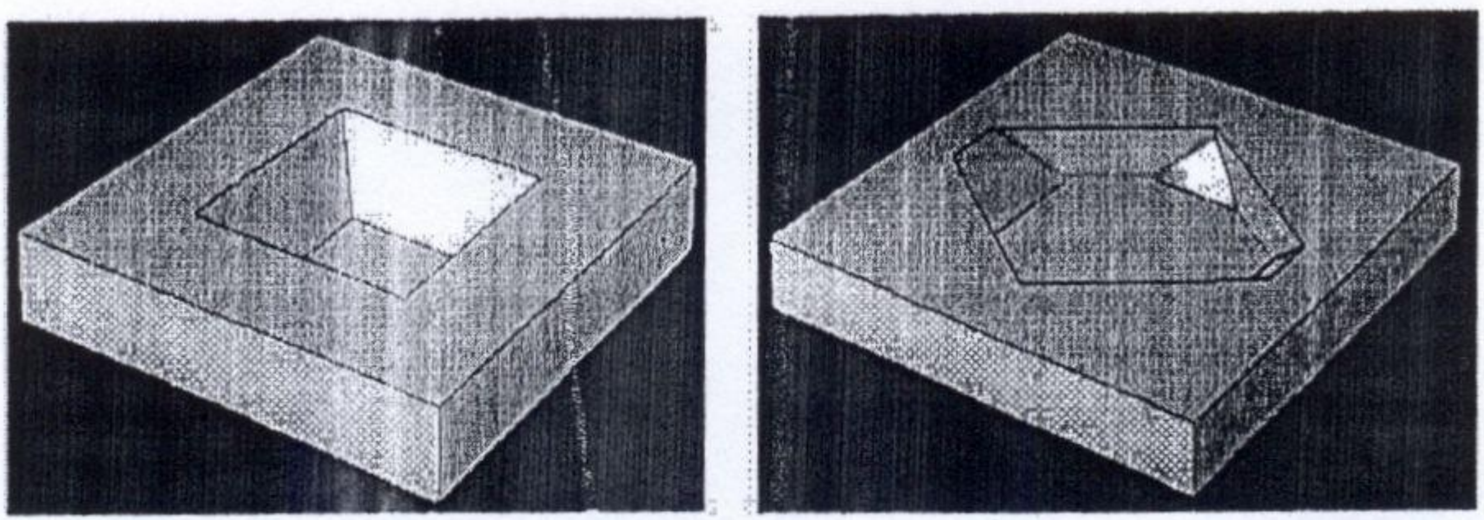
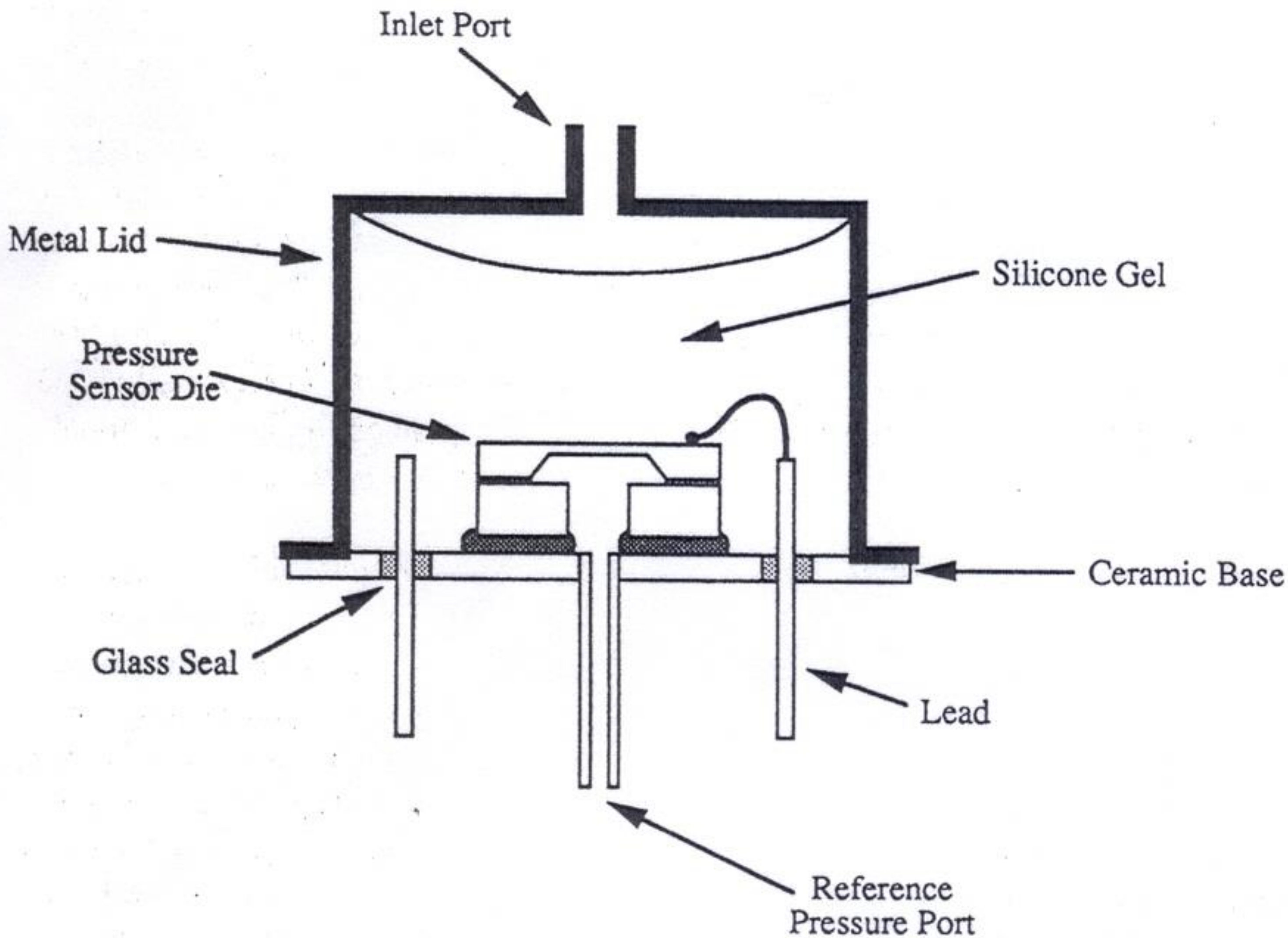
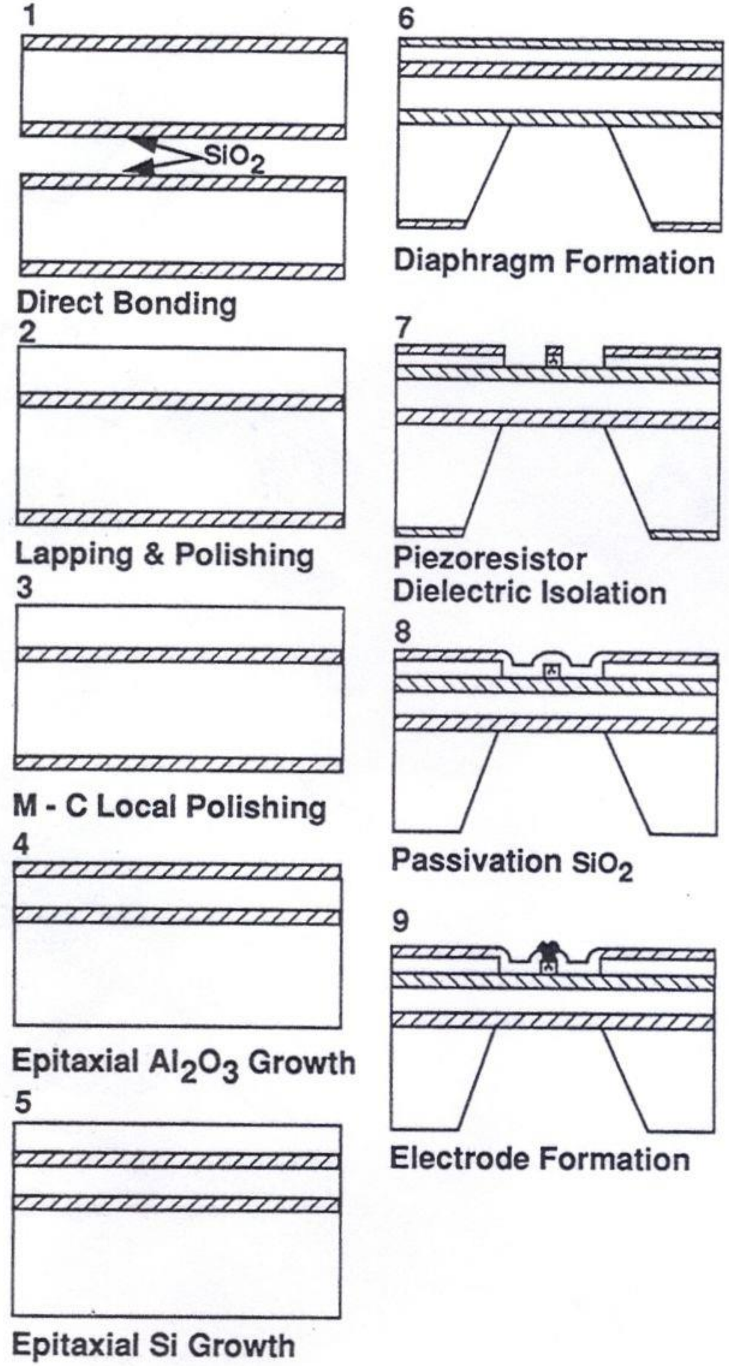
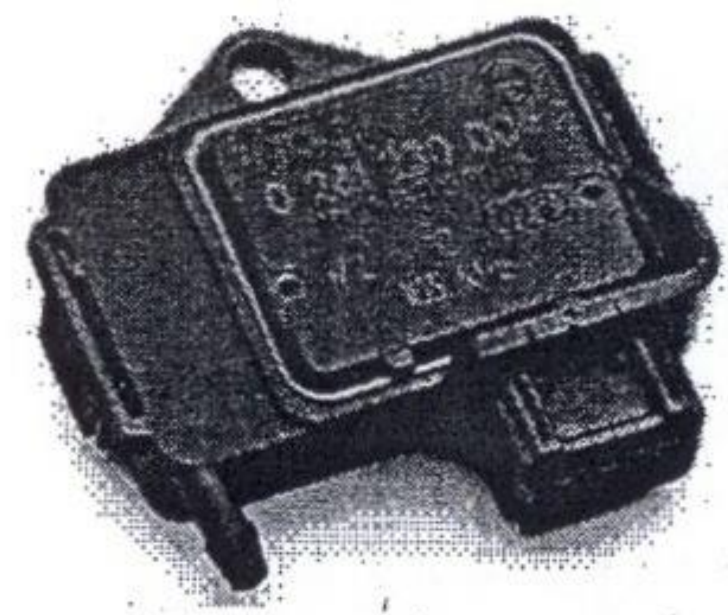


Fig. 7.3.7 Diaphragm geometries for silicon (100) and silicon (110)


Inlet Port
Metal Lid
Silicone Gel
Pressure
Sensor Die
Ceramic Base
Glass Seal
Lead
Reference
Pressure Port

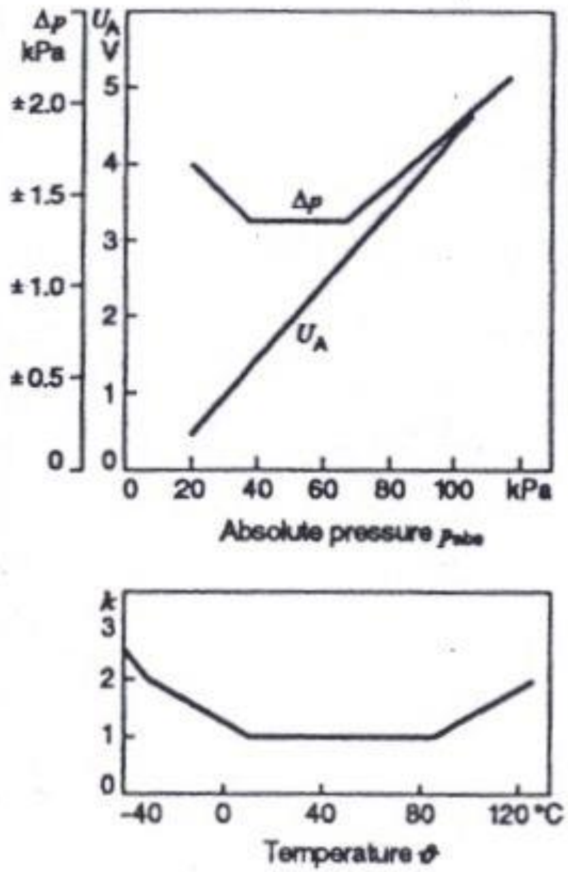
(b)


1
SiO2
Direct Bonding
2
Lapping & Polishing
3
M - C Local Polishing
4
Epitaxial Al2O3 Growth
5
Epitaxial Si Growth
6
Diaphragm Formation
7
Piezoresistor
Dielectric Isolation
8
Passivation SiO2
9
Electrode Formation



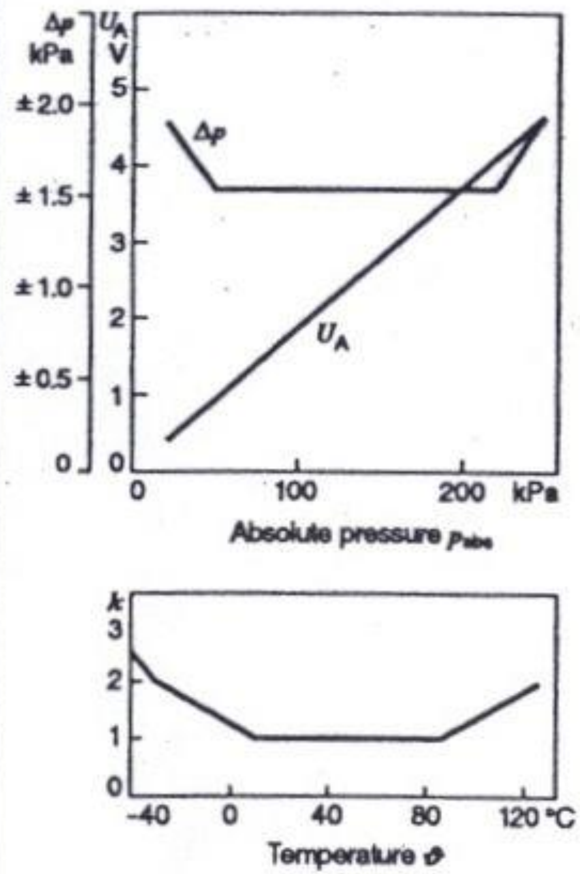
Characteristic curves 1 ($U_V = 5$ V).

$$U_A = U_V \cdot \left(0{,}01 \frac{p_{abs}}{\text{kPa}} - 0{,}12\right)$$



Characteristic curves 2 ($U_V = 5$ V).

$$U_A = U_V \cdot \left(\frac{0{,}85}{230} \cdot \frac{p_{abs}}{\text{kPa}} + 0{,}0061\right)$$



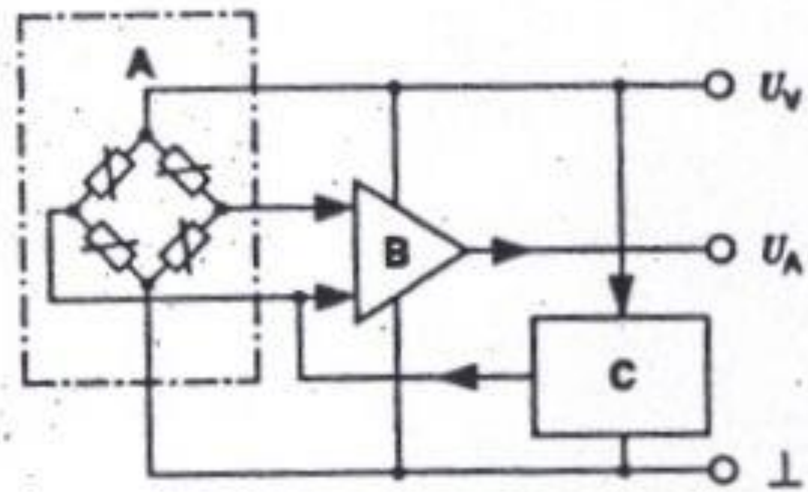
Technical data / Range

Part number		0 261 230 004	0 281 002 119
Characteristic curve		1	2
Measuring range	kPa	20...105	20...250
Max. pressure (1 s, 30 °C)	kPa	600	500
Pressure-change time	ms	≤ 10	≤ 10
Supply voltage U_V	V	4.75...5.25	4.75...5.25
Max. supply voltage	V	16	16
Input current I_V	mA	< 10	< 10
Load impedance R_L	kΩ	> 50	> 50
Operating temperature range	°C	–40...+125	–40...+120
Degree of protection		IP 54 A	–

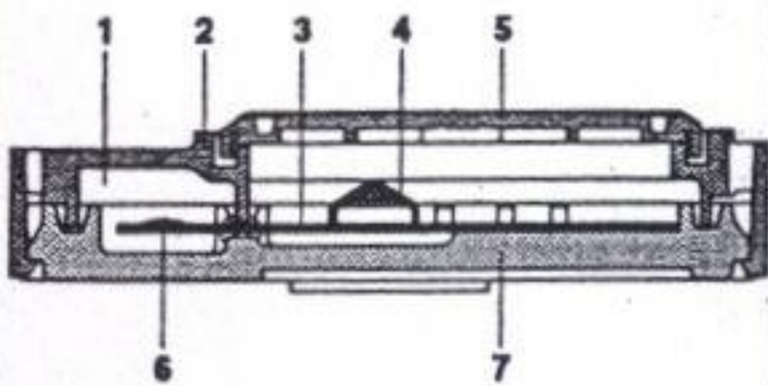
Accessories

Connector	1 237 000 039

Block diagram.
A Strain-gauge pressure-measuring cell,
B Amplifier,
C Temperature-compensation circuit



Design.
1 Strain-gauge pressure-measuring cell, **2** Plastic housing, **3** Thick-film hybrid (sensor and evaluation circuit), **4** Operational amplifier, **5** Housing cover, **6** Thick-film sensor element (sensor bubble), **7** Aluminum base plate.



Installation instructions

A hose forms the connection between the sensor and the gas pressure to be measured. Upon installation, the sensor pressure connection should point downwards to prevent the ingress of moisture.

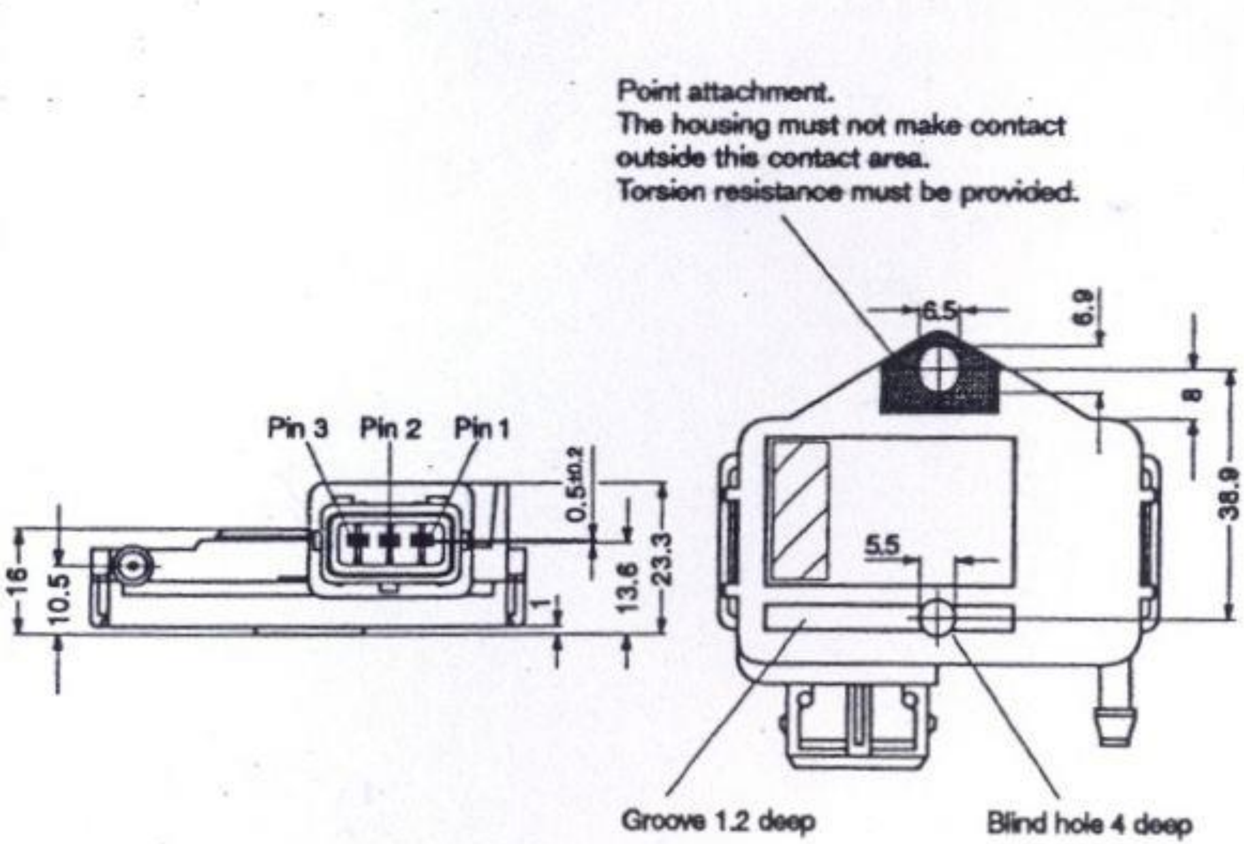
The angular position referred to the vertical must be +20°...–85°, preferably 0°.

Suggested fastening:
M6 screw with spring washer.

Connector-pin assignment

Terminal 1 $+U_V$
Terminal 2 Ground
Terminal 3 U_A

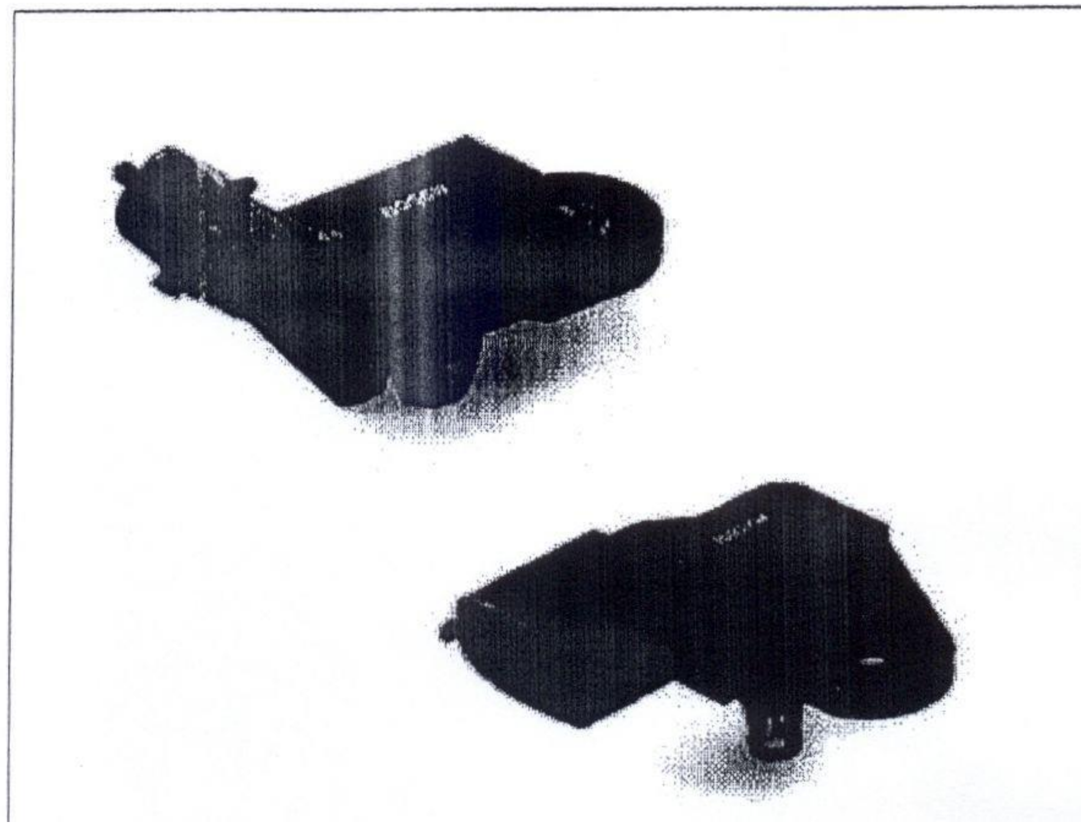
Dimension drawings.



Absolute-pressure sensors in micromechanical hybrid design

Measurement of pressures in gases up to 400 kPa

- High accuracy.
- EMC protection better than 100 V m^{-1}.
- Temperature-compensated.
- Version with additional integral temperature sensor.



Pressure range kPa ($p_1...p_2$)	Characteristic curve[1]	Features	Dimension drawing[2]	Order No.
10...115	1		1	B 261 260 136[3]
10...115	1		2	0 261 230 052
20...250	1		1	0 281 002 487
10...115	1	Integral temperature sensor	3	0 261 230 030
20...250	1	Integral temperature sensor	3	0 261 230 042
20...300	1	Integral temperature sensor	3	0 281 002 437
50...350	2	Integral temperature sensor	3	0 281 002 456
50...400	2	Integral temperature sensor	3	B 261 260 508[3]

1) The characteristic-curve tolerance and the tolerance expansion factor apply for all versions, see Page 36

2) See Page 37

3) Provisional draft number, order number available upon enquiry. Available as from about the end of 2001

Technical data

			min.	typ.	max.
Operating temperature	ϑ_B	°C	–40	–	+130
Supply voltage	U_V	V	4.5	5.0	5.5
Current consumption at $U_V = 5$ V	I_V	mA	6.0	9.0	12.5
Load current at output	I_L	mA	–1.0	–	0.5
Load resistance to U_V or ground	$R_{pull\text{-}up}$	kΩ	5	680	–
	$R_{pull\text{-}down}$	kΩ	10.0	100	–
Response time	$t_{10/90}$	ms	–	1.0	–
Voltage limitation at $U_V = 5$ V					
Lower limit	$U_{A\,min}$	V	0.25	0.3	0.35
Upper limit	$U_{A\,max}$	V	4.75	4.8	4.85

Limit data

Supply voltage	$U_{V\,max}$	V	–	–	+16
Storage temperature	ϑ_L	°C	–40	–	+130

Temperature sensor

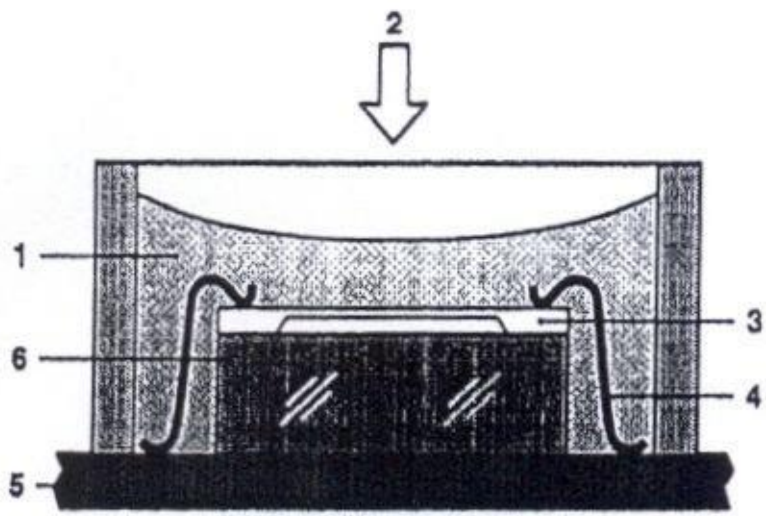
Measuring range	ϑ_M	°C	–40	–	+130
Measured current	I_M	mA	–	–	1[1]
Nominal resistance at +20 °C		kΩ	–	2.5±5%	–
Thermal time constant	t_{63}	s	–	–	10[2]

[1]) Operation at 5 V with 1 kΩ series resistor

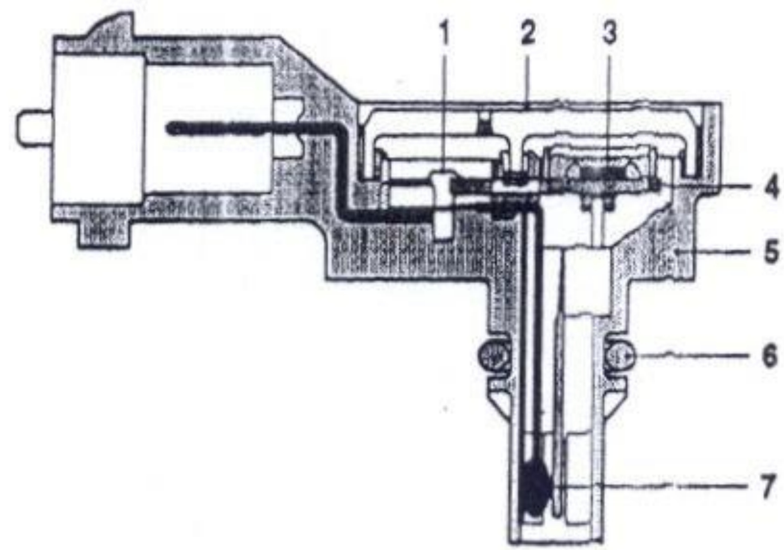
[2]) In air with a flow rate of 6 $m \cdot s^{-1}$

Sectional view.

Section through the sensor cell



Section through the DS-S2 pressure sensor

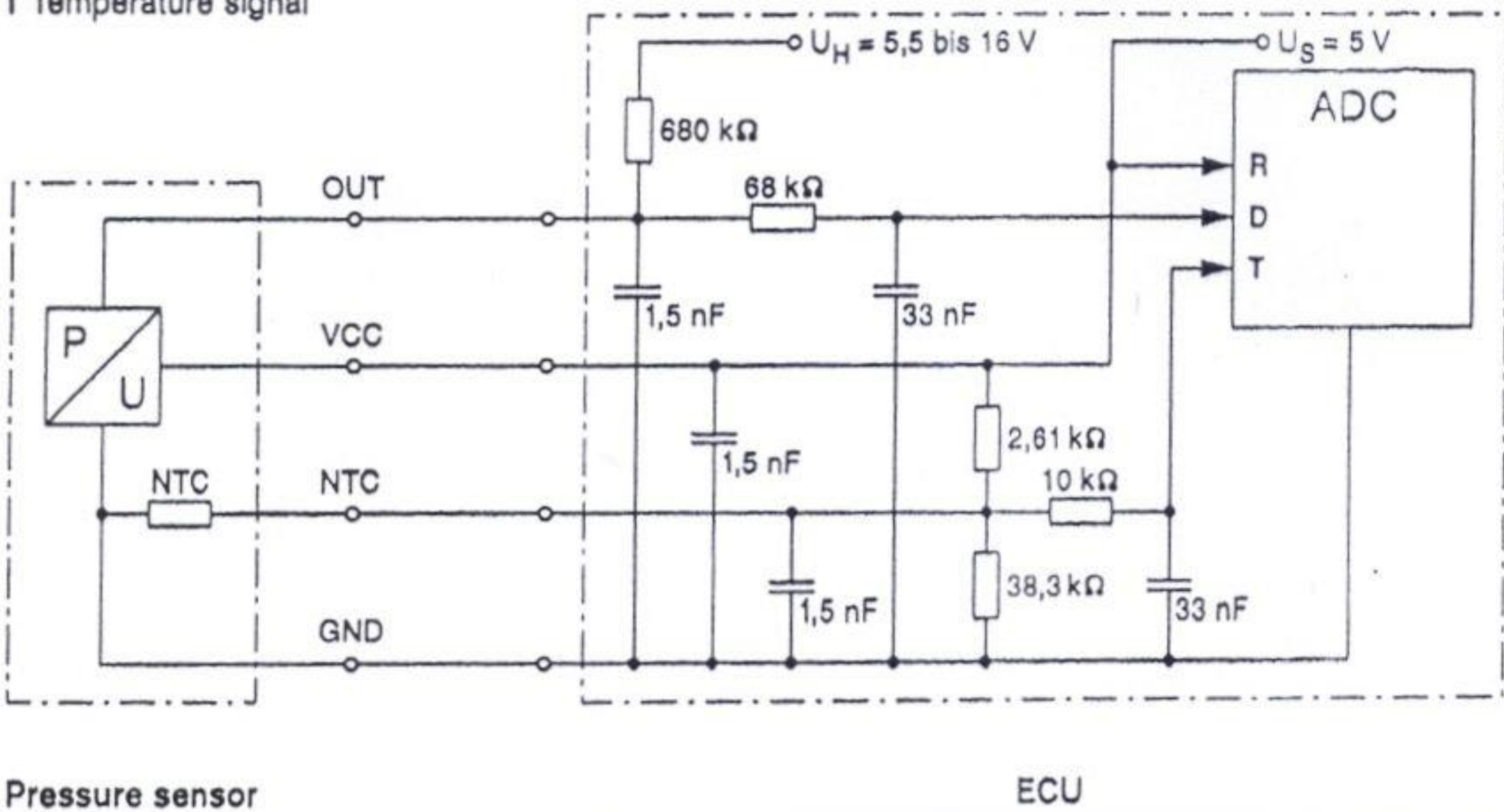


Signal evaluation: Recommendation.

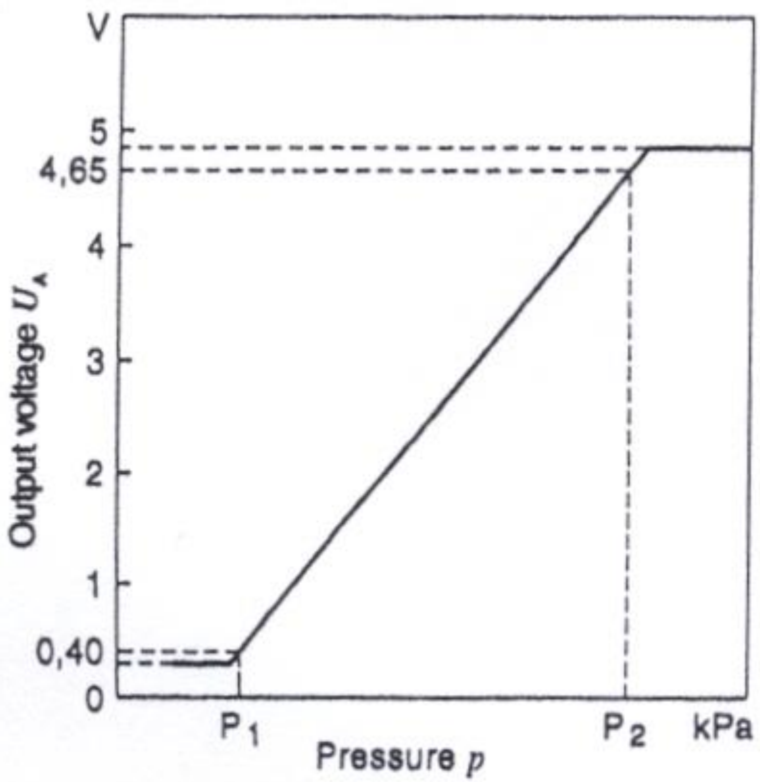
R Reference

D Pressure signal

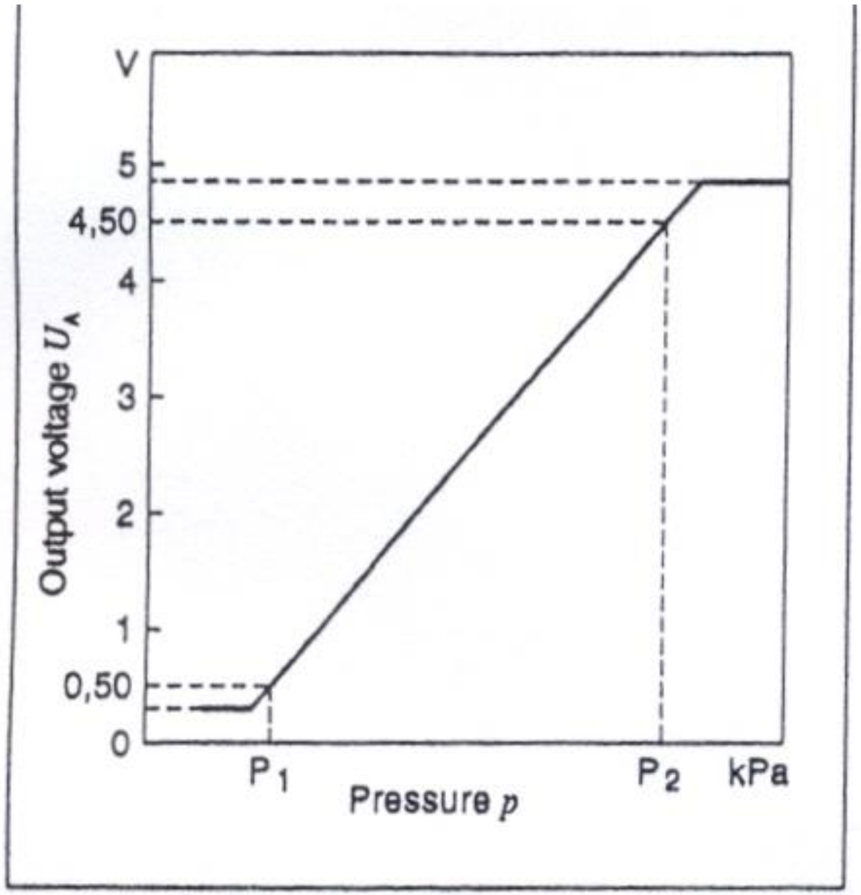
T Temperature signal



Characteristic curve 1 (U_V = 5.0 V).

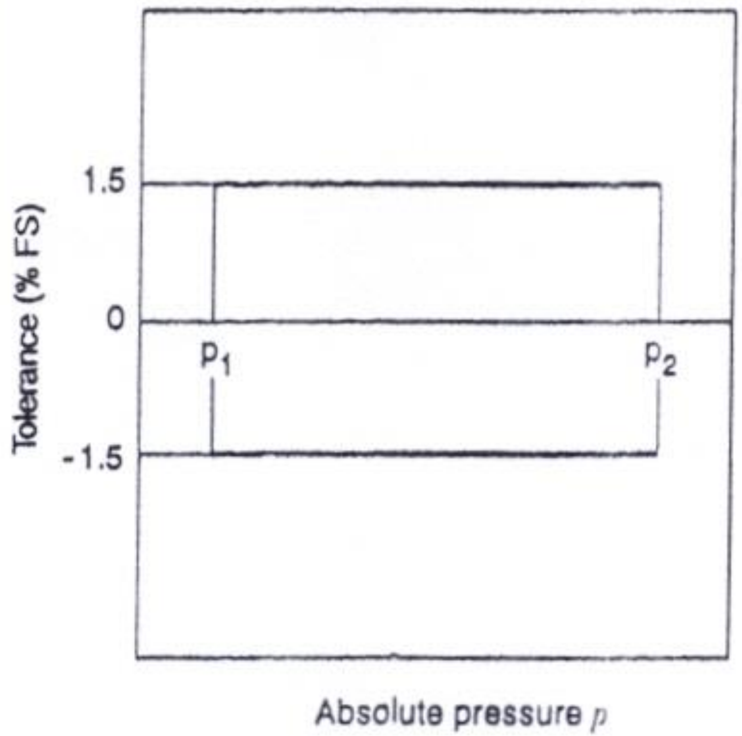


Characteristic curve (U_V = 5.0 V).



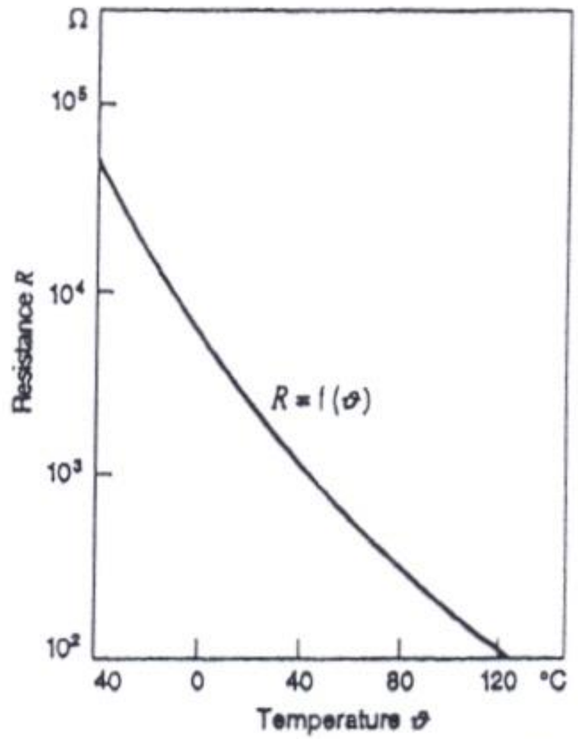
V
5
4,50
4
3
2
1
0,50
0
Output voltage U_A
P 1
P 2
kPa
Pressure p

Characteristic-curve tolerance.



Tolerance-expansion factor.

Temperature-sensor characteristic curve.



Explanation of symbols.

U_A Output voltage
U_V Supply voltage
k Tolerance multiplier
D After continuous operation
N As-new state