DISCRETE SEMICONDUCTORS

Semiconductor Sensors

BOOK SC17 1989

Philips Components

PHILIPS

SEMICONDUCTOR SENSORS

page

Selection guide

General

Device data in alpha-numerical sequence

SELECTION GUIDE

Magnetic field sensors

type	field range kA/m	supply voltage V	T_{amb} °C	sensitivity $\frac{mV/V}{kA/m}$	bridge resistance kΩ*	integrated temperature compensation	page
KMZ10A	−0.5 to + 0.5	5	−40 to 150	14	1.7 ± 0.5		47
KMZ10B	−2.0 to + 2.0	5	−40 to 150	4	1.7 ± 0.5		51
KMZ10C	−7.5 to + 7.5	5	−40 to 150	1.5	1.4 ± 0.4		55

Note: In air, 1 kA/m corresponds to approximately 12.5 G or to 1.25 mT.

Pressure sensors

type	pressure range bar note 1	supply voltage V	T_{amb} °C	sensitivity (T_{amb} = 25 °C) mV/Vbar	bridge resistance kΩ*		page
KP100A	+ 1 to 2 ((abs.)	7.5	−40 to 105	13	1.8 ± 0.4	Y	61
KP100A1	0 to 2 (abs.)	5	−40 to 125	200	1.8 ± 0.4	Y	61
KP101A	0 to 1.2 (abs.)	5	−40 to 125	50	1.6 ± 0.4	Y	65
KPZ20G	−1 to 2 (rel.)	7.5	−40 to 125	10.5 ± 3.5	2.0 ± 1.0	N	69
KPZ21G	−1 to 10 (rel.)	7.5	−40 to 125	3.5 ± 3.5	2.0 ± 1.0	N	73
KPZ21GE	−1 to 10 (rel.)	4.75 to 7.0	−40 to 120	500	N/A note 2	Y	77

Notes

1. 1 bar corresponds to 100 kPa and to 14.5 PSI.
2. Integrated signal processing; R_L = 5 kΩ min.

Temperature sensors

type	temperature range °C	resistance R at T_{amb}		sensor accuracy at T_{amb}		sensor current mA	page
		Ω	°C	°C	°C		
KTY81-110	−55 to 150	990 to 1010	25	± 1.3	25	1	103
KTY81-120(1)	−55 to 150	980 to 1020	25	± 2.5	25	1	103
KTY81-121	−55 to 150	980 to 1000	25	± 1.3	25	1	103
KTY81-122	−55 to 150	1000 to 1020	25	± 1.3	25	1	103
KTY81-150(2)	−55 to 150	950 to 1050	25	± 6.3	25	1	103
KTY81-151	−55 to 150	950 to 1000	25	± 3.2	25	1	103
KTY81-152	−55 to 150	1000 to 1050	25	± 6.3	25	1	103
KTY81-210	−55 to 150	1980 to 2020	25	± 1.3	25	1	107
KTY81-220(1)	−55 to 150	1960 to 2040	25	± 2.5	25	1	107
KTY81-221	−55 to 150	1960 to 2000	25	± 1.3	25	1	107
KTY81-222	−55 to 150	2000 to 2040	25	± 1.3	25	1	107
KTY81-250(2)	−55 to 150	1900 to 2100	25	± 6.3	25	1	107
KTY81-251	−55 to 150	1900 to 2000	25	± 2.5	25	1	107
KTY81-252	−55 to 150	2000 to 2100	25	± 2.5	25	1	107

Temperature sensors

type	temperature range °C	resistance R at T_{amb} Ω	°C	sensor accuracy at T_{amb} °C	°C	sensor current mA	page
KTY83-110	–55 to 175	990 to 1010	25	± 1.3	25	1	111
KTY83-120(1)	–55 to 175	980 to 1020	25	± 2.6	25	1	111
KTY83-121	–55 to 175	980 to 1000	25	± 1.3	25	1	111
KTY83-122	–55 to 175	1000 to 1020	25	± 1.3	25	1	111
KTY83-150(2)	–55 to 175	950 to 1050	25	± 6.6	25	1	111
KTY83-151	–55 to 175	950 to 1000	25	± 3.3	25	1	111
KTY83-152	–55 to 175	1000 to 1050	25	± 3.3	25	1	111
KTY84-130	0 to 300	970 to 1030	100	± 4.9	100	2	115
KTY84-150(2)	0 to 300	950 to 1050	100	± 8.2	100	2	115
KTY84-151	0 to 300	950 to 1000	100	± 4.1	100	2	115
KTY84-152	0 to 300	1000 to 1050	100	± 4.1	100	2	115
KTY85-110	–40 to 125	990 to 1010	25	± 1.3	25	1	119
KTY85-120(1)	–40 to 125	980 to 1020	25	± 2.6	25	1	119
KTY85-121	–40 to 125	980 to 1000	25	± 1.3	25	1	119
KTY85-122	–40 to 125	1000 to 1020	25	± 1.3	25	1	119
KTY85-150(2)	–40 to 125	950 to 1050	25	± 6.6	25	1	119
KTY85-151	–40 to 125	950 to 1000	25	± 3.3	25	1	119
KTY85-152	–40 to 125	1000 to 1050	25	± 3.3	25	1	119
KTY86-205	–40 to 150	1990 to 2010	25	± 1.3	25	1	125
KTY87-205	–40 to 125	1990 to 2010	25	± 0.7	25	0.1	131
KTY87-205	–40 to 125	3327 to 3361	100	± 0.8	100	–	131

Notes

1. Contains the groups –21 and –22 which are marked accordingly.
2. Contains the groups –51 and –22 which are marked accordingly.

Proximity detectors

type	switching distance mm	supply voltage V	max. output current mA	at V_B V	T_{amb} °C	page
OM286; M	1 to 5	4,5 to 30	250	24	–40 to 85	139
OM287; M	1 to 5	–4,5 to –30	250	–24	–40 to 85	139
OM386B	1 to 5	10 to 30	250	10 to 30	–40 to 85	145
OM387B	1 to 5	–10 to –30	250	–10 to –30	–40 to 85	145
OM386M	1 to 5	10 to 30	200	10 to 30	–40 to 85	151
OM387M	1 to 5	–10 to –30	200	–10 to –30	–40 to 85	151
OM388B	2 to 5	10 to 30	250	10 to 30	–40 to 85	157
OM389B	2 to 5	–10 to –30	250	–10 to –30	–40 to 85	157
OM390	2 to 5	10 to 30	250	10 to 30	–40 to 85	163
OM391	2 to 5	–10 to –30	250	–10 to –30	–40 to 85	163

TYPE NUMBER SURVEY

TYPE NUMBER SURVEY

In this survey we give an alphanumeric list of all devices contained in this book.

		page
KGZ10	Oxystor	91
KGZ20/21	Oxygen probe assembly	83
KMZ10A	Magnetic field sensor, –0.5 to +0.5 kA/m	47
KMZ10B	Magnetic field sensor, –2.0 to +2.0 kA/m	51
KMZ10C	Magnetic field sensor, –7.5 to +7.5 kA/m	55
KP100A	Pressure sensor, 0 to 2 bar	61
KP100A1	Pressure sensor, 0 to 2 bar	61
KP101A	Pressure sensor, 0 to 1.2 bar	65
KPZ20G	Pressure sensor, –1 to +2 bar	69
KPZ21G	Pressure sensor, –2 to +10 bar	73
KPZ21GE	Pressure sensor, –1 to +10 bar	77
KRX10	Dual element pyroelectric infrared sensor	197
KRX11	Dual element pyroelectric infrared sensor	203
KTY81-110	Temperature sensor, –55 to +150 °C	103
KTY81-120	Temperature sensor, –55 to +150 °C	103
KTY81-121	Temperature sensor, –55 to +150 °C	103
KTY81-122	Temperature sensor, –55 to +150 °C	103
KTY81-150	Temperature sensor, –55 to +150 °C	103
KTY81-151	Temperature sensor, –55 to +150 °C	103
KTY81-152	Temperature sensor, –55 to +150 °C	103
KTY81-210	Temperature sensor, –55 to +150 °C	107
KTY81-220	Temperature sensor, –55 to +150 °C	107
KTY81-221	Temperature sensor, –55 to +150 °C	107
KTY81-222	Temperature sensor, –55 to +150 °C	107
KTY81-250	Temperature sensor, –55 to +150 °C	107
KTY81-251	Temperature sensor, –55 to +150 °C	107
KTY81-252	Temperature sensor, –55 to +150 °C	107
KTY83-110	Temperature sensor, –55 to +175 °C	111
KTY83-120	Temperature sensor, –55 to +175 °C	111
KTY83-121	Temperature sensor, –55 to +175 °C	111
KTY83-122	Temperature sensor, –55 to +175 °C	111
KTY83-150	Temperature sensor, –55 to +175 °C	111
KTY83-151	Temperature sensor, –55 to +175 °C	111
KTY83-152	Temperature sensor, –55 to +175 °C	111
KTY84-130	Temperature sensor, 0 to 300 °C	115
KTY84-150	Temperature sensor, 0 to 300 °C	115
KTY84-151	Temperature sensor, 0 to 300 °C	115
KTY84-152	Temperature sensor, 0 to 300 °C	115
KTY85-110	Temperature sensor, –40 to +125 °C	119
KTY85-120	Temperature sensor, –40 to +125 °C	119
KTY85-121	Temperature sensor, –40 to +125 °C	119
KTY85-122	Temperature sensor, –40 to +125 °C	119
KTY85-150	Temperature sensor, –40 to +125 °C	119
KTY85-151	Temperature sensor, –40 to +125 °C	119
KTY85-152	Temperature sensor, –40 to +125 °C	119
KTY86-205	Temperature sensor, –40 to +150 °C	125
KTY87-205	Temperature sensor, –40 to +125 °C	131

Type Number Survey (continued)

		page
OM286;M	proximity detector, 250 mA	139
OM287;M	same as OM276;M but with reverse polarity	139
OM386B	proximity detector, 250 mA	145
OM387B	same as OM386B but with reverse polarity	145
OM386M	proximity detector, 250 mA	151
OM387M	same as OM386M but with reverse polarity	151
OM388B	proximity detector, 250 mA	157
OM389B	same as OM388B but with reverse polarity	157
OM390	proximity detector, 250 mA	163
OM391	same as OM390, but with reverse polarity	163
P2105	Single element pyroelectric IR sensor, 90 V/W, SOT49G	209
RPW100	Dual element pyroelectric IR sensor, TO-39	215
RPW101	Dual element pyroelectric IR sensor, SOT49M	221
RPW102	Dual element pyroelectric IR sensor, TO-39	227
RPY100	Single element pyroelectric IR sensor, 150 V/W TO-39	223
RPY102	Single element pyroelectric IR sensor, 75 V/W TO-39	241
RPY107	Single element pyroelectric IR sensor, 130 V/W TO-39	249
RPY109	Single element pyroelectric IR sensor, 65 V/W TO-39	257
RPY222	Two channel pyroelectric IR sensor, SOT49N	265

INTRODUCTION TO MAGNETIC FIELD SENSORS

MAGNETIC FIELD SENSORS

The KMZ10 is a highly-sensitive magnetic-field sensor and provides an excellent means of measuring both linear and angular displacement. This is because even quite small movement of actuating components in machinery (metal rods, cogs, cams etc.) can create measurable changes in magnetic field. Examples where this property is put to good effect can be found in instrumentation and control equipment, which often requires position sensors capable of detecting displacements in the region of tenths of a millimetre, and in electronic ignition systems, which must be able to determine the angular position of an internal-combustion engine with great accuracy.

If the KMZ10 is to be used to maximum advantage, however, it's important to have a clear understanding of its operating principles and characteristics, and of how its behaviour may be affected by external influences and by its magnetic history.

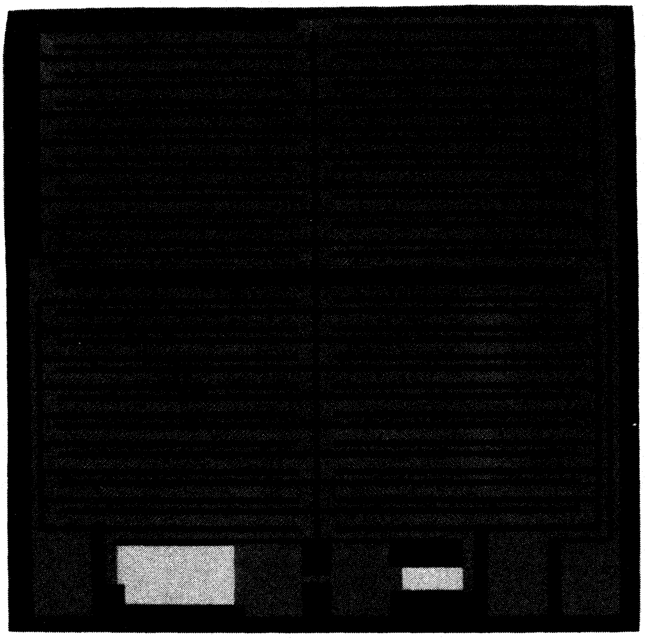
KMZ10 MAGNETIC FIELD SENSORS

	KMZ10A	KMZ10B	KMZ10C	units
H_{max} (typ)	500	2000	7,500	A/m
open-circuit sensitivity	12,0	5,0	1,1	(mV/V)/(kA/M)

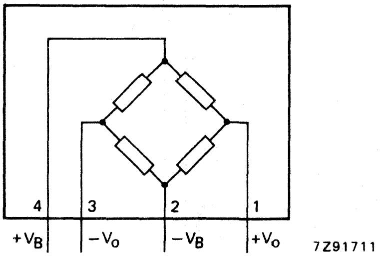
KMZ10 OPERATING PRINCIPLES

The KMZ10 makes use of the *magnetoresistive effect,* the well known property of a current-carrying magnetic material to change its resistivity in the presence of an external magnetic field. This change is brought about by rotation of the magnetization relative to the current direction. In the case of permalloy for example (a ferromagnetic alloy containing 20% iron and 80% nickel), a 90° rotation of the magnetization (due to the application of a magnetic field normal to the current direction) will produce a 2 to 3% change in resistivity.

In the KMZ10, four permalloy strips, are arranged in a meander pattern on a silicon substrate (Fig.1), and connected to form the four arms of a Wheatstone bridge. The degree of bridge imbalance is then used to indicate the magnetic field strength, or more precisely, the variation in magnetic field in the plane of the permalloy strips normal to the direction of current.



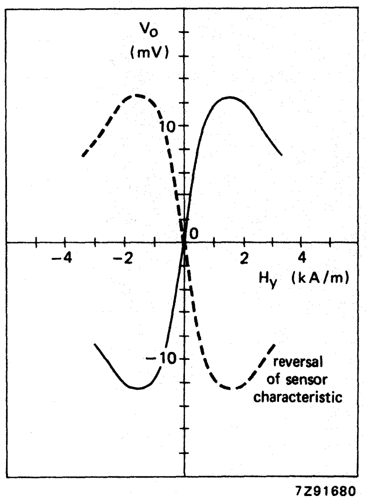
(a)



(b)

Fig.1 (a) The KMZ10 chip is made up of four permalloy strips arranged in a meander pattern and connected to form the four arms of a Wheatstone bridge. The chip incorporates special resistors that are trimmed during manufacture to give zero offset at 25 °C.

(b) Bridge configuration of the KMZ10. V_B – supply voltage, V_O – output voltage

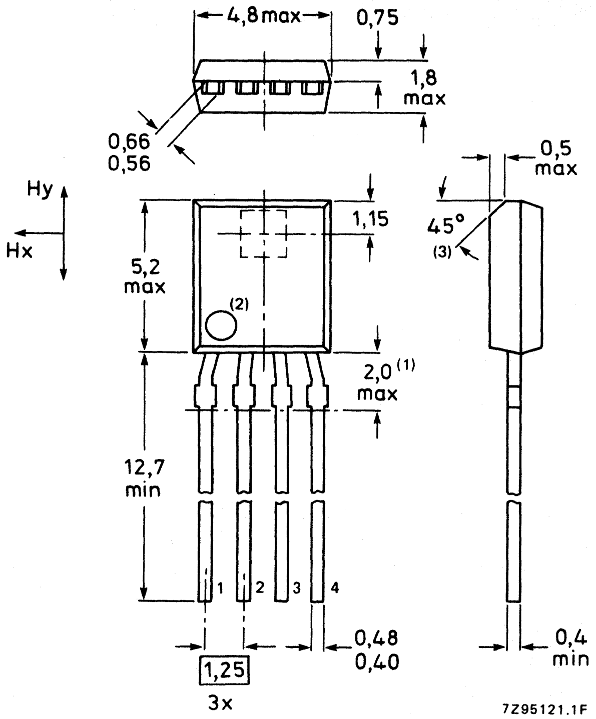


(a)

Fig.2

(a) Sensor characteristic. The unbroken line shows the characteristics of a 'normal' sensor (with the magnetization oriented in the +x direction), and the broken line shows the characteristic of a 'flipped' sensor.

(b) Dimensional drawing of the KMZ10 showing pinning and magnetic field direction for normal operation



(b)

KMZ10 CHARACTERISTIC BEHAVIOUR

During manufacture, a strong magnetic field is applied parallel to the strip axis. This imparts a preferred magnetization direction to the permalloy strips. So even in the absence of an external magnetic field, the magnetization will always tend to align with the strips.

The internal magnetization of the sensor strips therefore has two stable positions, so that if for any reason, the sensor should come under the influence of a powerful magnetic field opposing the internal aligning field, the magnetization may flip from one position to the other, and the strips become magnetized in the opposite direction (from say the +x to the −x direction). As Fig.2 shows, this can lead to drastic changes in sensor characteristics.

In Fig.2 the unbroken line shows the characteristics of a normal sensor (i.e. with the sensor magnetization oriented in the +x direction), and the broken line shows the characteristics of a 'flipped' sensor.

The field, $\hat{H}_{-x}$ say, needed to flip the sensor magnetization (and hence the characteristic) depends on the magnitude of the transverse field H_y — the greater the field H_y, the smaller the field $\hat{H}_{-x}$. This is quite reasonable when you think of it, since the greater the field H_y, the closer the magnetization's rotation approaches 90°, and hence the easier it will be to flip it into a corresponding stable position in the −x direction.

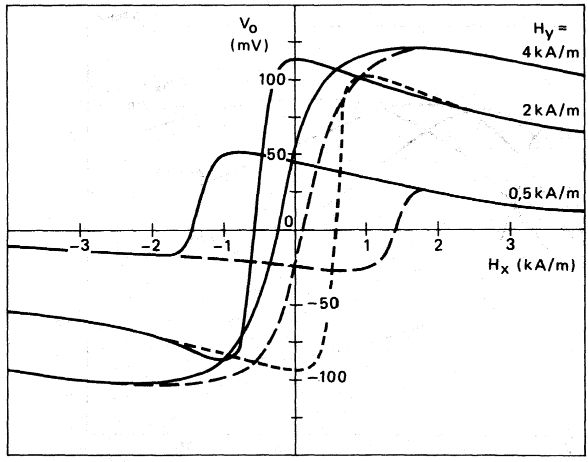


Fig.3 Sensor output V_o versus H_x for several values of H_y. The curves illustrate several things: first, that the sensor exhibits hysteresis, second, that the flipping is not instantaneous, and third, that sensitivity falls with increasing H_x

This is illustrated in Fig.3, which shows sensor output signal V_O versus H_X for several values of H_y.

Take the curve for $H_y = 0{,}5$ kA/m. For such a low transverse field, the sensor characteristic is stable for all positive values of H_X, and a reverse field of around 1 kA/m is required before flipping occurs. At $H_y = 4$ kA/m, on the other hand, the sensor will flip at even positive values of H_X (at around 1 kA/m).

Figure 3 also illustrates that the flipping itself is not instantaneous; this is because not all the permalloy strips flip at the same rate. Also in Fig.3 you can see the hysteresis effect exhibited by the sensor. Finally, Fig.3 and Fig.4 show that the sensitivity of the sensor falls with increasing H_X. This again is reasonable since the moment imposed on the magnetization by H_X directly opposes that imposed by H_y, thereby reducing the degree of bridge imbalance and hence the output signal for a given value of H_y.

From the foregoing discussions we arrive at the following general recommendations for operating the KMZ10:

- to assure stable operation, avoid operating the sensor in an environment where it's likely to be subjected to negative external fields H_{-X}. Preferably, apply a positive auxiliary field H_X of sufficient magnitude to prevent any likelihood of flipping within the operating range (i.e. the range of H_y) you intend to use the sensor

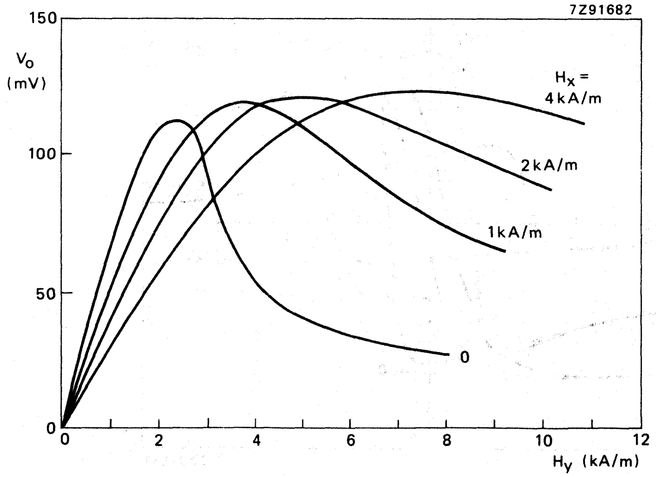


Fig.4 Output V_O versus H_y for several values of H_X. This illustrates, even better than Fig.3, the fall in sensitivity (i.e. initial gradient) with increasing H_X

- use the minimum auxiliary field that will assure stable operation. Remember, the larger the auxiliary field, the lower the sensitivity. For the KMZ10B sensor, we recommend a minimum auxiliary field of around 1 kA/m
- and finally, before using the sensor for the first time, apply a positive auxiliary field of at least 3 kA/m. This will effectively erase the sensor's history and will ensure that no residual hysteresis remains (see Fig.3). Note: to *guarantee* stable operation, you should, in fact, operate the sensor in an auxiliary field of 3 kA/m (the value we recommend in our data sheets).

These recommendations (particularly the first one) define a kind of SOAR for the sensors. This can be seen from Fig.5, which is an example (for the KMZ10B sensor) of the SOAR graphs you'll find in our data sheets. The graph shows the SOAR of a KMZ10 as a function of auxiliary field H_x and of disturbing field H_d opposing H_x. The greater the auxiliary field, the greater the disturbing field that can be tolerated before flipping occurs. For auxiliary fields above 3 kA/m, the SOAR graph shows that the sensor is completely stable regardless of the magnitude of the disturbing field. You can also see from Fig.5 that the SOAR can be extended for low values of H_y. In this graph (for the KMZ10B sensor) we've shown the extension in SOAR for $H_y < 1$ kA/m.

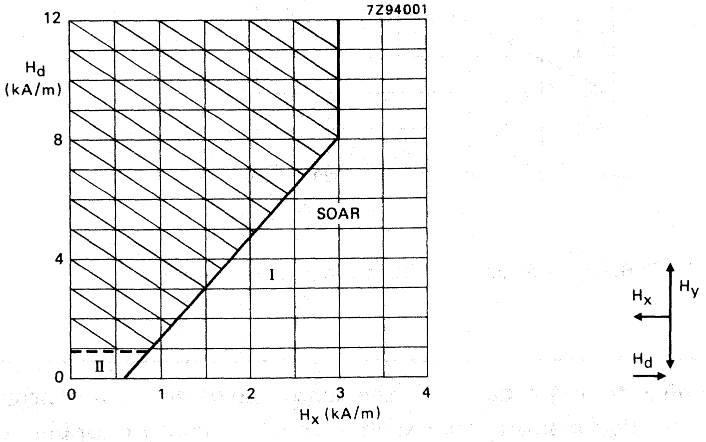


Fig.5 SOAR of a KMZ10B sensor as a function of auxiliary field H_x and of disturbing field H_d opposing H_x (area I). The SOAR can be extended slightly (area II) for values of $H_y < 1$ kA/m

Effect of temperature on behaviour

Figure 6 shows that the bridge resistance increases linearly with temperature. This variation comes, of course, from the fact that the bridge resistors themselves (i.e. the permalloy strips) vary with temperature, and as we see below, it can be put to good effect when operating with a constant-current supply. Figure 6 shows only the variation for a typical KMZ10B sensor. The data sheets show also the spread in this variation due to manufacturing tolerances, and this should be taken into account when incorporating the sensor into practical circuits.

Not just the bridge resistance but the sensitivity too varies with temperature. This can be seen from Fig.7 which plots output voltage against transverse field H_y for various temperatures. The figures shows that sensitivity falls with increasing temperature. The reason for this is rather complicated and is connected with the energy-band structure of the permalloy strips.

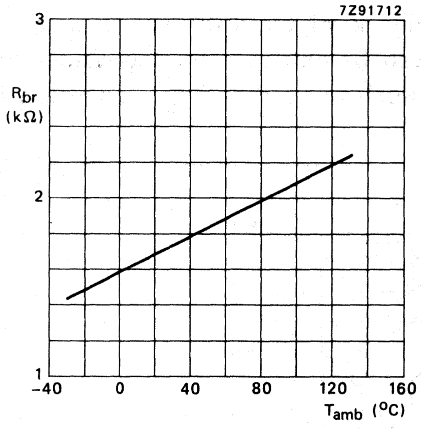


Fig.6 Bridge resistance as a function of temperature

Figure 8 is similar to Fig.7 but with the sensor powered by a constant-current supply. The figure shows that with a constant current supply, the temperature dependence of sensitivity is significantly reduced. This is a direct result of the increase of bridge resistance with temperature (Fig.5) which partially compensates the fall in sensitivity by increasing the voltage across the bridge and hence the output voltage. The figure, therefore, adequately demonstrates the advantages of operating with constant current.

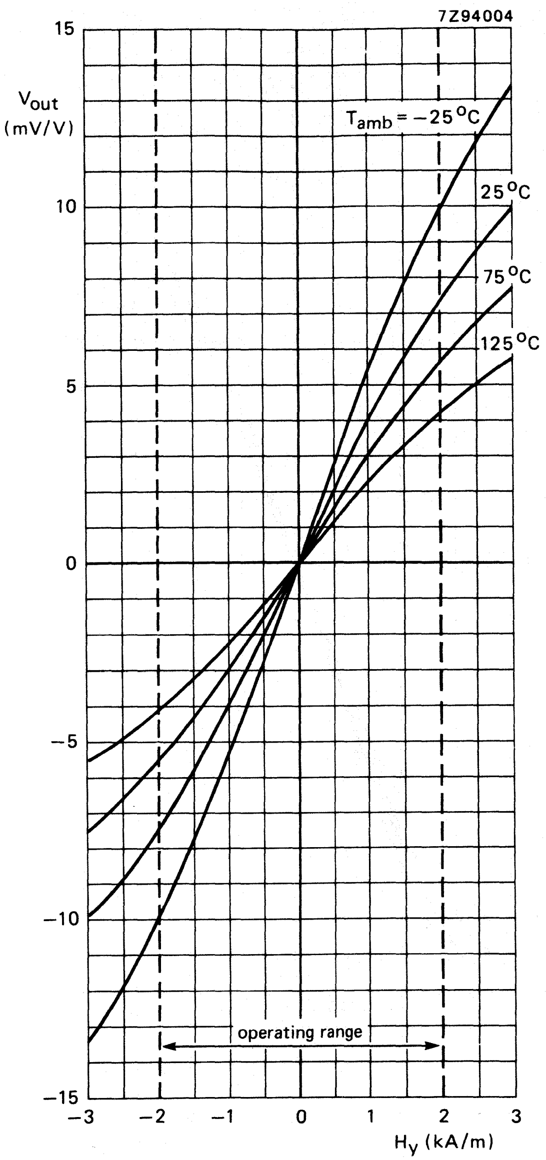


Fig.7 Output voltage V_o (as a fraction of the supply voltage) versus transverse field H_y for several temperatures. The figure illustrates that sensitivity falls with increasing temperature

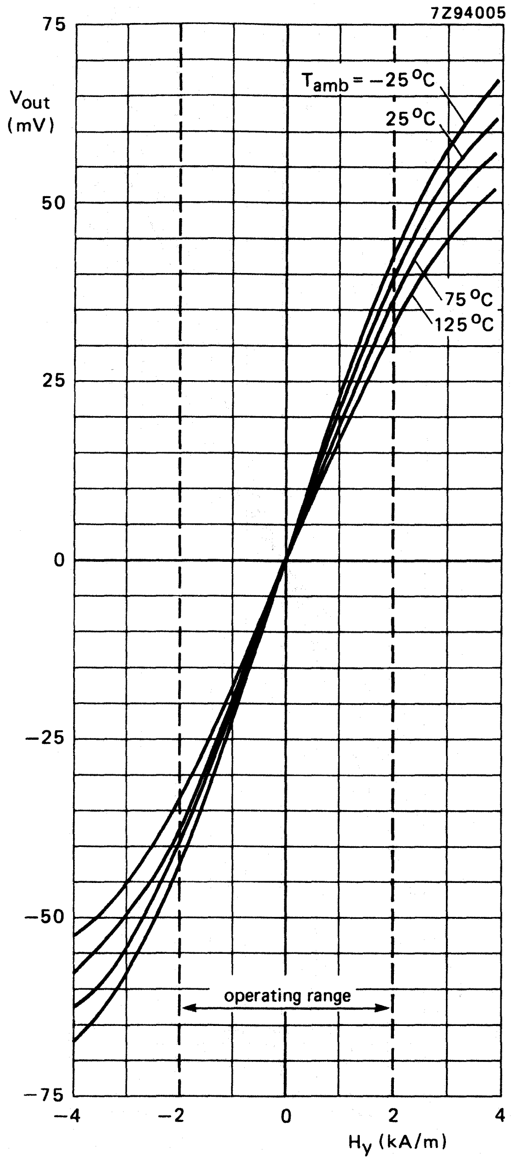


Fig.8 Output voltage V_O versus transverse field H_y for several temperatures, with the sensor powered by a constant-current supply. The reduction in temperature dependence of sensitivity is a result of the increase of bridge resistance with temperature, which increases the bridge voltage to partially compensate the fall in sensitivity

USING THE KMZ10

Displacement measurement using permanent magnets

Figures 9 and 10 show probably one of the simplest arrangements for using a sensor/permanent-magnet combination to measure linear displacement, and exposes some of the problems likely to be encountered if proper account is not taken of the effects described above.

When the sensor is placed in the field of a permanent magnet, it's exposed to magnetic fields in both the x and y directions. If the magnet is oriented with its axis parallel to the sensor strips (i.e. in the x direction) as shown in Fig.9(a), H_x then provides the auxiliary field and the variation in H_y can be used as a measure of x displacement. Figure 9(b) shows how both H_x and H_y vary with x, and Fig.9(c) shows the corresponding output signal as a function of x.

In the example shown in Fig.9, H_x never exceeds $\pm\hat{H}_x$ (the field that can cause flipping of the sensor) and the sensor characteristic remains stable and well-behaved throughout the measuring range.

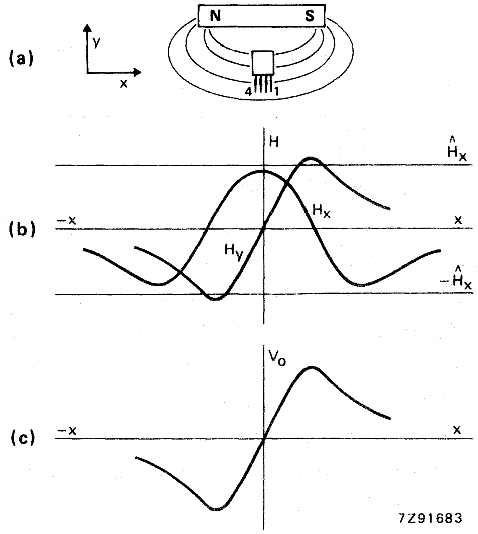


Fig.9 Sensor output in the field of a permanent magnet as a function of its displacement x parallel to the magnetic axis. The magnet provides both the auxiliary and transverse fields. In the example shown, the auxiliary field is always less than the field $\hat{H}_x$ that will cause flipping. Note the pinning arrangement in this figure, which indicates that the sensor is viewed from the rear. Reversal of the sensor relative to the permanent will reverse the characteristic

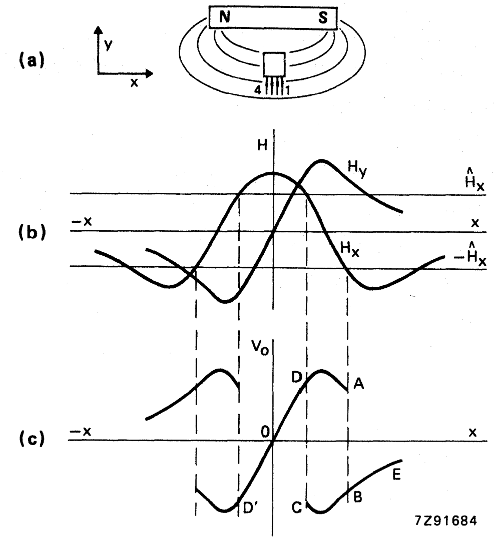


Fig.10 Sensor output in the setup of Fig.9, but in which the auxiliary field sometimes exceeds H_x

Consider now the example shown in Fig.10. Here for certain values of x, H_x exceeds $\pm\hat{H}_x$, (Fig.10(b)). This could happen if, for example, the magnet were powerful or if the sensor should pass close to the magnet, and as Fig.10(c) shows, the effects on the output signal can be drastic.

Suppose the sensor is initially on the transverse axis of the magnet ($x = 0$ say). H_y will be zero and H_x will be at its maximum value ($>\hat{H}_x$). So the sensor will be oriented in the +x direction and the output voltage will vary as in Fig.9(a). As the sensor moves in the +x direction H_y and hence V_o increases, and H_x falls to zero and then increase negatively until it exceeds $-\hat{H}_x$. At this point the sensor characteristic flips and the output voltage reverses, moving from A to B in Fig.10(c). Further increase of x causes the sensor voltage to move along BE. If the sensor is moved in the opposite direction, however, H_x increases until it exceeds $+\hat{H}_x$ and V_o moves from B to C. At this point the sensor characteristic again flips and V_o moves from C to D.

Under these conditions, then, the sensor characteristic will trace the hysteresis loop ABCD, and a similar loop in the −x direction. Figure 10(c) is, in fact, an idealized case and the reversals are never as abrupt as shown in this figure. It does, however, illustrate the effects that can occur if the sensor is placed close to a powerful permanent magnet. Note that under certain circumstances, particularly where there are likely to be temporary of fluctuating external fields, it may be advantageous to operate under these conditions, since over the region DD′ the field of the permanent magnet will have a stabilizing effect on the sensor (i.e. it will tend to correct any flipping of the sensor due to transient magnetic fields). Note also that reversal of the permanent magnet will give rise to the same sensor characteristic as shown in Figs.9(c) and 10(c) (i.e. with positive slope) since the sensor will then be forced to operate in its flipped state.

Figure 11 shows the sensor characteristic at distances of 10 mm and 20 mm from a permanent magnet, and amply illustrates the effects show in Figs.9 and 10.

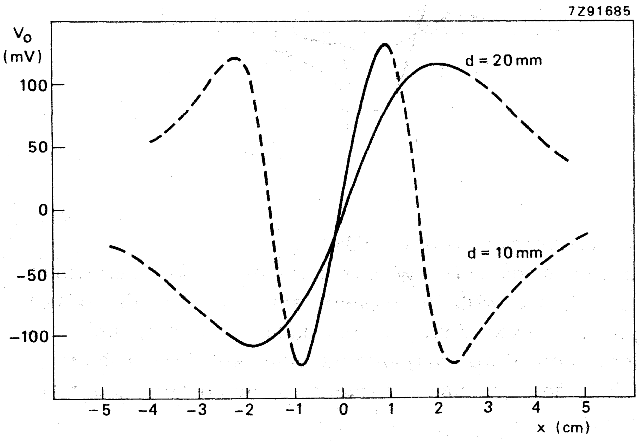


Fig.11 Measured sensor output at distances d of 10 mm and 20 mm from a permanent magnet as functions of displacement x parallel to the magnetic axis

One-point position measurement with the KZM10

Figure 12(a) shows how a KMZ10B may be used to make position measurements of a metal object, a steel plate for instance. The sensor is located between the plate and a permanent magnet oriented with its magnetic axis normal to the axis of the plate. A discontinuity in the plate's structure, such as a hole or region of non-magnetic material, will disturb the magnetic field and produce a variation in the output signal from the sensor.

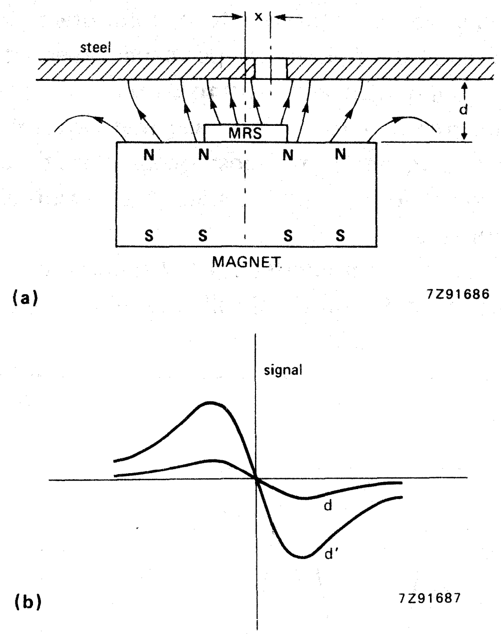


Fig.12 One-point measurement with the KMZ10.

(a) The sensor is located between a metal plate and a permanent magnet oriented with its magnetic axis normal to the axis of the plate. A discontinuity in the plate's structure, such as a hole or region of non-magnetic material, will disturb the magnetic field and produce a variation in the output signal from the sensor.

(b) Output signal versus hole/sensor offset x for two values of magnet/plate spacing d. The figure shows that the crossover point, is independent of d, which greatly simplifies adjustment procedures

This is shown in Fig.12(b) which gives the sensor output signal versus hole/sensor offset x, for two values of magnet/plate spacing d. The interesting point of this figure is that the crossover point, i.e. the point where the hole and sensor precisely coincide, is independent of d. The obvious advantage of this setup is that precise location of the sensor/magnet combination is unimportant for one-point position measurements, so adjustment procedures in a practical device would be greatly simplified. Although not shown in Fig.12(b), the crossover point is also independent of temperature. This is not surprising since it is effectively a null measurement, and it could be a major advantage in practical applications.

Angular position measurement with the KMZ10

Figure 13 shows a practical setup for measuring angular position using a KMZ10C. The sensor itself is located in the magnetic field produced by two RES190 permanent magnets fixed to a rotable frame. The output of the sensor will then be a measure of the rotation of the frame (Fig.15). Taking the zero position for measurement to be parallel to the x axis of the sensor (i.e. with the magnetic field in the H_x direction), then the device can measure rotation up to around ±85°. Beyond that and the sensor is in danger of flipping.

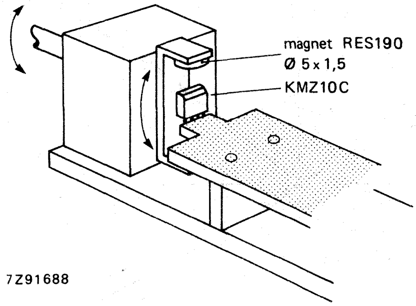


Fig.13 Angular measurement with the KMZ10

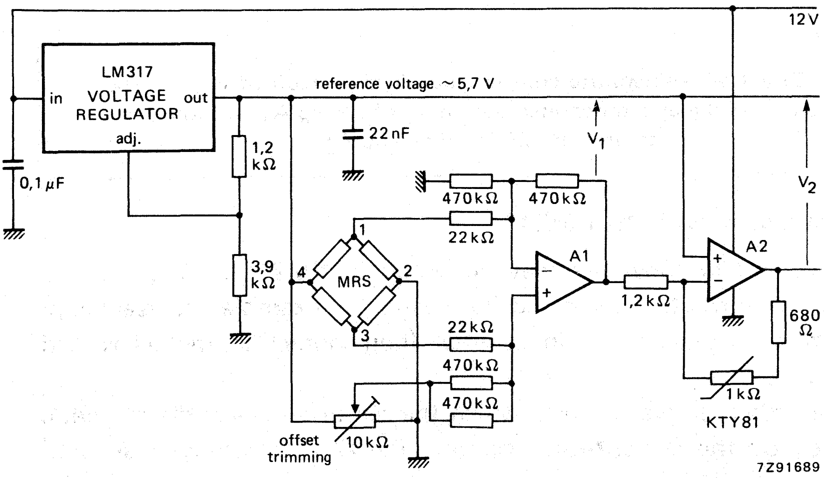


Fig.14 Circuit for measuring sensor output in the setup of Fig.13

Figure 14 shows a circuit for measuring the sensor output in the setup of Fig.13. The output signal of the sensor bridge is amplified by opamps A_1 and A_2. A KTY81 silicon temperature sensor in the feedback loop of A_2 varies the gain of the amp to provide temperature compensation for the output signal. Fig.15 shows the effectiveness of this temperature compensation by comparing the output V_2 of A_2 with the direct output V_1 from opamp A_1 for a range of temperatures.

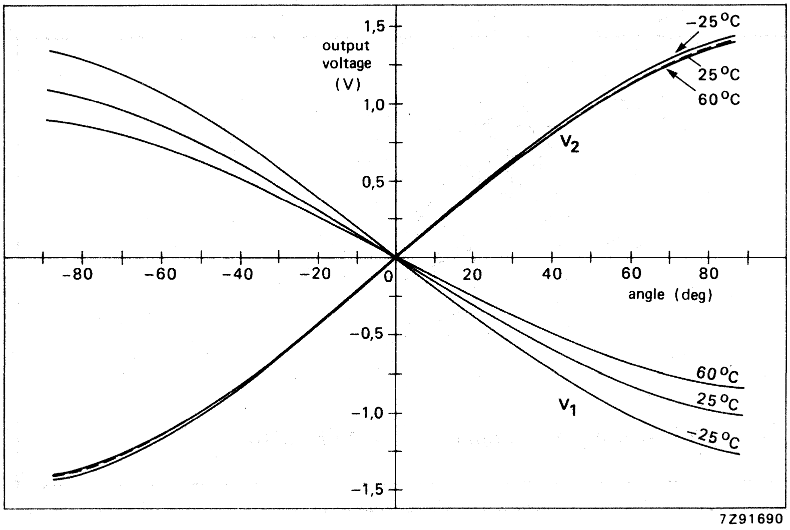


Fig.15 Effect of temperature compensation in the circuit of Fig.14. The figure compares the uncompensated output V_1 of opamp A_1 with the compensated output V_2 of opamp A_2

Current measurement with the KMZ10

Finally Figs.16 and 17 show two ways in which the KMZ10B can be used to measure electric current. This could be useful, for example, in headlamp-failure systems in automobiles or in clamp-on (non-contacting) meters as used in the power industry.

Fig.16 is a rather simple setup in which the sensor measures the magnetic field generated by the current-carrying wire. Fig.17 is a more sophisticated arrangement in which the current-carrying wire is wrapped around a ferrite core, with the sensor located in the air gap between its ends. This arrangement provides a more accurate means of measuring current and lends itself more to precision applications. What's important to bear in mind in both these examples, however, is that they allow current measurement without any break in or interference with the circuit – and thereby they provide a distinct advantage over thermistor-based systems.

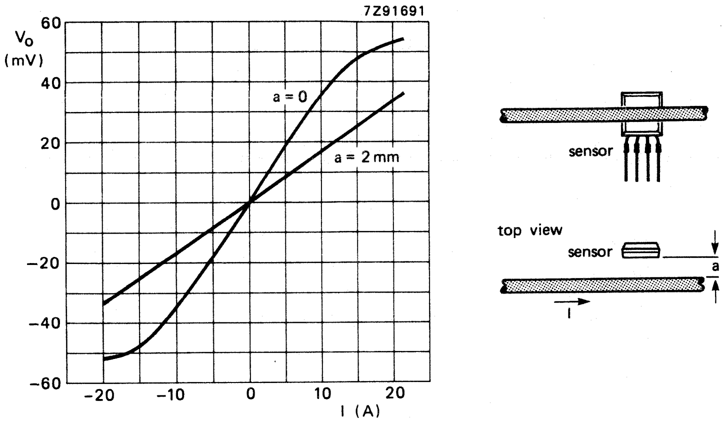


Fig.16 Simple setup for measuring current with a KMZ10 sensor. The sensor simply measures the magnetic field generated by a current-carrying wire

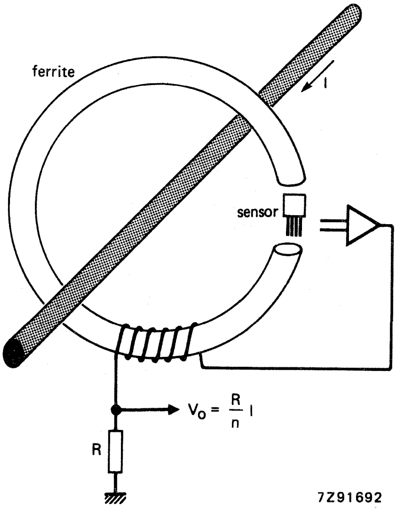


Fig.17 Current measurement with the KMZ10 sensor. In this setup a current-carrying wire is wrapped around a ferrite core, with the sensor located in the air gap between its ends

INTRODUCTION TO TEMPERATURE SENSORS

SILICON TEMPERATURE SENSORS

General

With their high accuracy and reliability, the KTY81/83/84 silicon temperature sensors provide an attractive alternative to more conventional sensors using NTC or PTC thermistors.

They use n-type silicon with a doping level between 10^{14} and $10^{15}/cm^3$, providing a nominal resistance of about 1000 Ω. Note, however, that variants of the KTY81 series exist, the KTY81-210 and KTY81-220, with a nominal resistance of 2000 Ω.

QUICK REFERENCE DATA

KTY81-110	R_{25} = 1000 Ω ± 1%	SOD-70 encapsulation
KTY81-120	R_{25} = 1000 Ω ± 2%	
KTY81-210	R_{25} = 2000 Ω ± 1%	
KTY81-220	R_{25} = 2000 Ω ± 2%	
KTY83-110	R_{25} = 1000 Ω ± 1%	DO-34 encapsulation
KTY83-120	R_{25} = 1000 Ω ± 2%	
KTY84-130	R_{100} = 1000 Ω ± 3%	DO-34 encapsulation
KTY84-150	R_{100} = 1000 Ω ± 5%	
KTY85-110	R_{25} = 1000 Ω ± 1%	SOD-80 encapsulation
KTY85-120	R_{25} = 1000 Ω ± 2%	
KTY85-150	R_{25} = 1000 Ω ± 5%	
KTY86-205	R_{25} = 2000 Ω ± 0.5%	VO-69 encapsulation
KTY87-205	R_{25} = 2000 Ω ± 0.5% R_{100} = 3344 Ω ± 0.5%	

Resistance-temperature characteristics — manufacturing tolerances

Silicon temperature sensors are normally produced to quite fine tolerances: ΔR between ± 1% and ± 2% (see quick reference data). Figure 1 illustrates how these tolerances are specified for the KTY81 and KTY83 sensors. The tolerance on resistance quoted in our data sheets is given by the resistance spread ΔR measured at 25 °C.

Because of spread in the slope of the resistance-temperature characteristic, ΔR will increase each side of the 25 °C point to produce the butterfly curve shown in Fig. 1. To give an indication of this spread in slope, we also quote the ratio of resistance at two other temperatures (−55 °C and 100 °C) to the nominal resistance at 25 °C, i.e. R_{-55}/R_{25}, and R_{100}/R_{25}.

The user, however, is usually more interested in the temperature spread ± ΔT (standard deviation). So we also provide this in the data sheets as a graph of ΔT versus T.

ESD SENSITIVITY

Electro static discharges may lead to changes in resistance value of the KTY sensors and in extreme cases even to destruction. Circuitry should be so designed that the sensor element is not exposed to voltage pulses > 300 V or to energy pulses > 20×10^{-6} W.

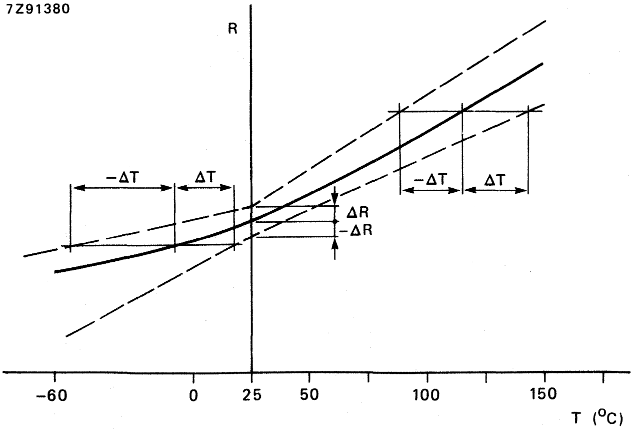


Fig.1 Resistance and temperature tolerances of the KTY81 and KTY83 sensors (exaggerated for clarity).

For the high-temperature KTY84, we specify the resistance spread at 100 °C. This is, however, an extrapolation from the measured spread at 25 °C.

Resistance-temperature characteristics — linearization

The resistance-temperature characteristics of the KTY81 and KTY83 temperature sensors are non linear, and in some applications, e.g. control systems requiring high accuracy, linearization becomes necessary.

A simple way to do this is to shunt the sensor (resistance R_T) with a fixed resistor R (Fig. 2). The resistance $RR_T/(R+R_T)$ of the parallel combination then effectively becomes a linear function of temperature, and the output voltage V_T of the linearizing circuit can be used to regulate the control system.

If the circuit is powered by a constant-voltage source, a resistor can be connected in series with the sensor, the voltages across the sensor and across the resistor will then again be approximately linear functions of temperature.

The value of the series or parallel resistor depends on the required operating-temperature range of the sensor. A method for finding this resistance is described here that gives zero temperature error at three equidistant points T_a, T_b and T_c say.

Consider the parallel arrangement. If the resistance of the sensor at the three points is R_a, R_b and R_c, and the corresponding resistance of the parallel arrangement R_{pa}, R_{pb} and R_{pc}, the requirement for linearity at the three points is

$$R_{pa} - R_{pb} = R_{pb} - R_{pc}$$

i.e.

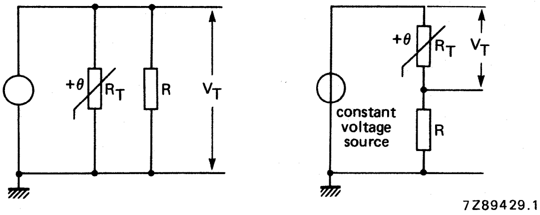
$$\frac{RR_a}{R + R_a} - \frac{RR_b}{R + R_b} = \frac{RR_b}{R + R_b} - \frac{RR_c}{R + R_c}$$

So

$$R = \frac{R_b\,(R_a + R_c) - 2R_aR_c}{R_a + R_c - 2R_b} \qquad (2)$$

The same resistor turns out to be suitable for the series arrangement as well.

As an example, Fig. 3 shows the deviation from linearity to be expected from a nominal KTY81 sensor linearized over the temperature range 0 to 100 °C with a linearizing resistance of 2870 Ω.



(a) (b)

Fig.2 Linearization of sensor characteristics

a) with a resistor R shunted across the sensor

b) with a resistor R in series with the sensor and the system powered by a constant-voltage source

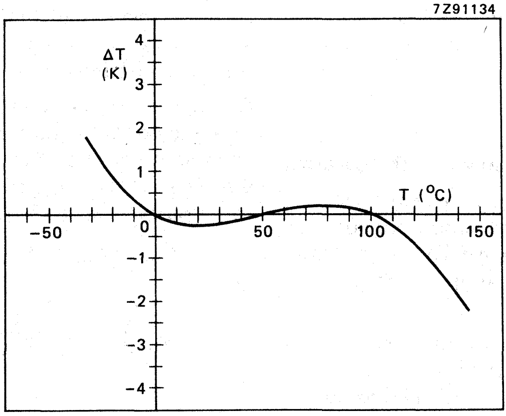


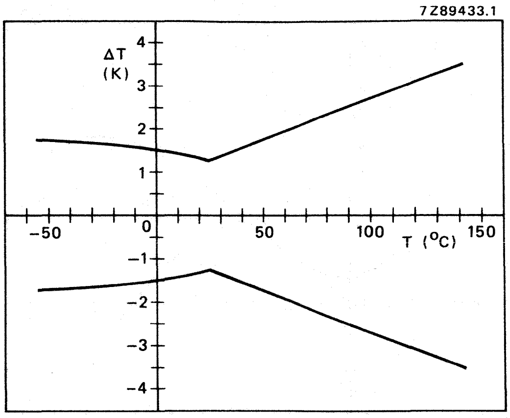
Fig.3 Temperature error ΔT to be expected from a nominal KTY83 sensor linearized over the temperature range 0 to 100 °C (linearizing resistance 2870 Ω).

Note: because the KTY84 is chiefly intended for use at higher temperatures, say above 100 °C, its almost linear characteristic at these temperatures often renders linearization unnecessary.

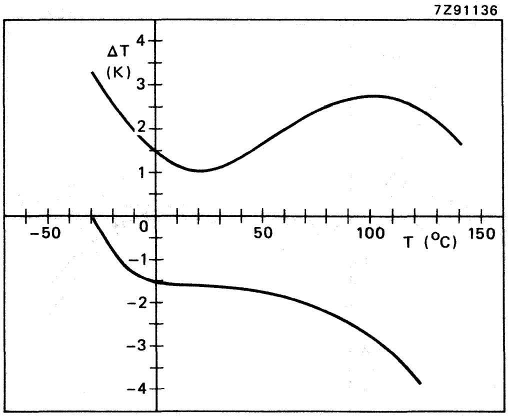
Effect of tolerances on linearized sensor characteristics

In practical applications with an arbitrary sensor, the total uncertainty in the sensor reading will be a combination of spread due to manufacturing tolerances and linearization errors.

As an example, Fig.4 shows the combined effect of manufacturing-tolerances and linearization errors for the KTY81 sensor linearized over the temperature range 0 to 100 °C. Calibration of the subsequent circuitry (op amps, control circuitry etc.) can reduce this error significantly. Figure 5a shows the temperature error of the system with (linear) output circuitry calibrated at 50 °C, and Fig.5b shows the error of the same system calibrated at 0 and 100 °C.



(a)

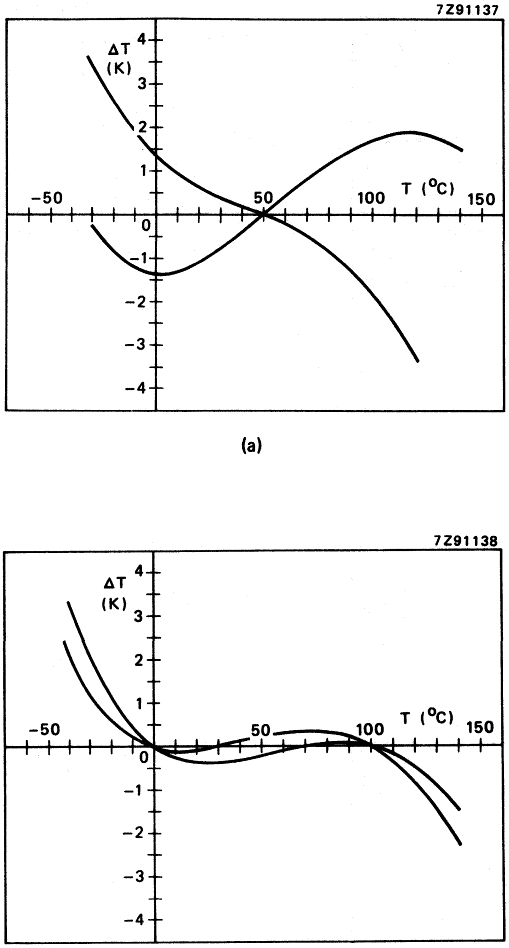


(b)

Fig. 4

a) absolute error ΔT expected of a silicon temperature sensor.

b) combined effect of manufacturing-tolerances and linearization errors for the KTY83 sensor.



(a)

(b)

Fig.5

a) temperature error of system with linear output circuitry calibrated at 50 °C

b) error of the same system calibrated at 0 and 100 °C.

INTRODUCTION TO PRESSURE SENSORS

GENERAL

The trend towards integration in electronic control and measuring systems has created a growing demand for fast, accurate pressure sensors. In this field both the KP-family of monolithic pressure sensors and the KPZ-family of thin-film pressure sensors stand in a leading position. Not only are they both very fast and accurate, they are also highly compatible with the electronic system that they are intended to serve.

The KP100A and the KP101A are essentially aneroid gauges, in that they rely for their pressure signals on the movement of a diaphragm closing an evacuated chamber, but unlike conventional aneroid gauges the KP100A/101A have no need of mechanical or optical means to detect diaphragm movement. In the KP100A/101A movement is detected directly by a series of piezoresistive strain gauges implanted in the diaphragm in a Wheatstone bridge configuration.

The advantages of an all silicon device include highly stable characteristics, principally due to the well defined behaviour of silicon, plus high reliability and low cost. The wealth of experience in semiconductor manufacture is shown in its production.

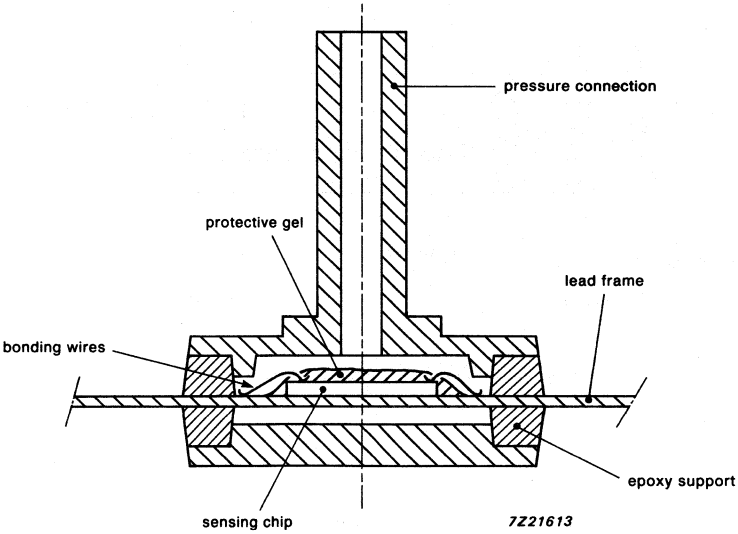


Fig. 1 KP100A/101A pressure sensor; cross section.

INTRODUCTION

The KPZ20G and KPZ21G are reference pressure sensors, which measure the applied pressure with reference to atmospheric pressure. The sensor consists of a thin metal membrane with condensed semiconducting thin-film strain gauges. In the KPZ-sensors the active system is separated from the pressure medium by the metallic membrane. The pressure medium acts on the reverse side of that membrane in contrast to the sensors of the KP-family, where pressure acts on the electrically active side of the crystal. The sensors of the KPZ-family can therefore be used for more dirty pressure media.

Both families of devices can be used in a wide range of applications; the KP-sensors for applications from simple pressure switches in domestic appliances, to altimeters and depth gauges, from domestic and professional barometers to automotive control systems. The KPZ-sensors can be used for detection of small differential pressures (i.e. burglar alarm systems), flow control, control of pneumatic systems and automotive systems (oil pressure, air brake systems, etc.). The KPZ-sensors may also be used for measurement of small mechanical forces acting on the reverse side of the metallic membrane.

Both families of sensors are also available with a new signal conditioning IC, which for many applications replaces much of the external control circuitry and provides linear output signal, temperature compensation and facilities for offset and sensitivity trimming.

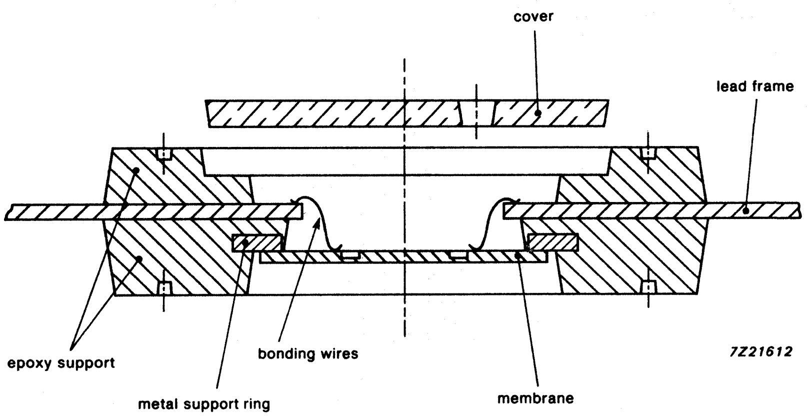


Fig. 2 KPZ20G/21G pressure sensors; cross section.

Piezoresistive strain gauges

In metals and semiconductors, both the mobility and concentration of carriers may change with strain. In semiconductors concentration changes come from a change in energy gap with strain. Depending on the type of doping, an increase in strain may produce either a fall or a rise in material resistivity; this is the piezoresistive effect.

The amount by which resistance changes with strain in given terms of the gauge factor, defined as the fractional change of resistance ($\Delta R/R$) per unit strain ($\Delta L/L$). For semiconductors, gauge factors between 50 and 100 are common, metals have gauge factors around 2.

Figure 3 shows as an example in plan and elevation, the major features of the KP100A. Essentially the KP100A consists of a Wheatstone bridge located in the centre of a rectangular silicon membrane ($1200 \times 2400\ \mu m^2$) closing an evacuated chamber.

Flexure of this membrane produced by external pressure, causes strain in the resistive elements of the bridge, and so (by virtue of the piezoresistive effect) imbalance of the bridge is then used as a measure of the external pressure.

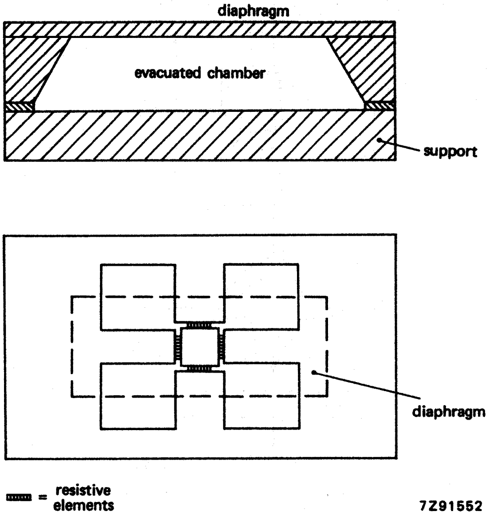


Fig. 3 KP100A in plan and elevation. The strain gauges are centrally located in a rectangular silicon membrane enclosing an evacuated chamber.

Note: The device relies for its action on the fact that the membrane is non-square, and hence that adjacent arms of the bridge experience different strains. If the membrane were square, all arms would experience exactly the same strain and no bridge imbalance would occur.

INTRODUCTION (continued)

Temperature compensation for monolithic pressure sensors

Figure 4 shows the basic bridge arrangement. The sensitivity of the bridge is around 13 mV/V bar at 25 °C (for the KP100A), but since the resistive elements are temperature sensitive, the sensitivity of the bridge itself varies with temperature by about 0.2 %/K. To compensate for this, and to allow its use for wide temperature ranges, the device incorporates integrated V_{BE}-multipliers, these increase the voltage across the bridge as the temperature rises, and so compensates the loss of sensitivity due to rise in temperature.

With a multiplier in circuit, sensitivity of the bridge falls to around 7.5 mV/V bar, but its temperature coefficient falls to an insignificant ± 0.02 %/K. The KP100A/101A has in fact five such integrated multipliers with different temperature characteristics, each optimized for a specific operating voltage.

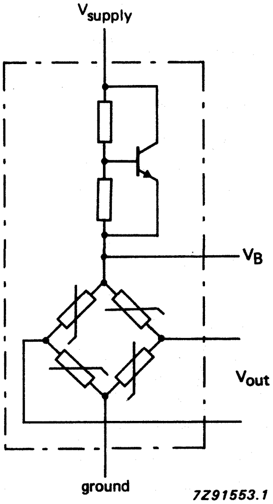


Fig. 4 Bridge configuration. The device incorporates integrated V_{BE}-multipliers that increase the voltage across the bridge as the temperature rises, and so compensate the loss in sensitivity due to rise in temperature.

The relationship between bridge output voltage and pressure, with supply voltage as the parameter, for the KP100A, is shown in Fig. 5 and Fig. 6. These figures illustrate two main points; firstly that the relationship is substantially linear and secondly how the V_{BE}-multiplier functions. In Fig. 5 the multiplier in circuit is optimized for a supply voltage of 4 V, and it is seen that variation in sensitivity over a 25 to 100 °C temperature range is very small, amounting to no more than about 1.5% over the whole temperature range. Figure 6 shows the same relationship using the multiplier optimized for a supply of 10 V.

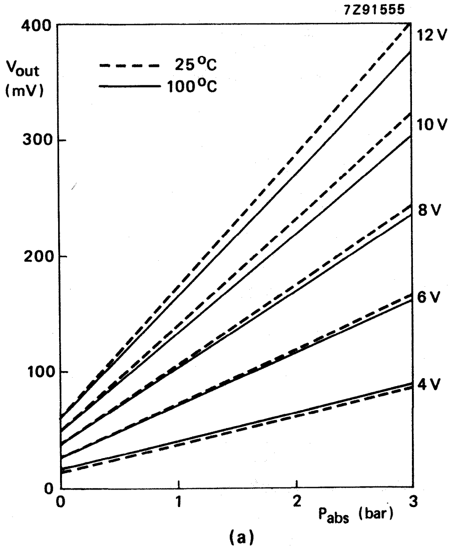


Fig. 5 Bridge output voltage as a function of pressure with supply voltage as a parameter and V_{BE}-multiplier in circuit. Supply voltage optimized at 4 V.

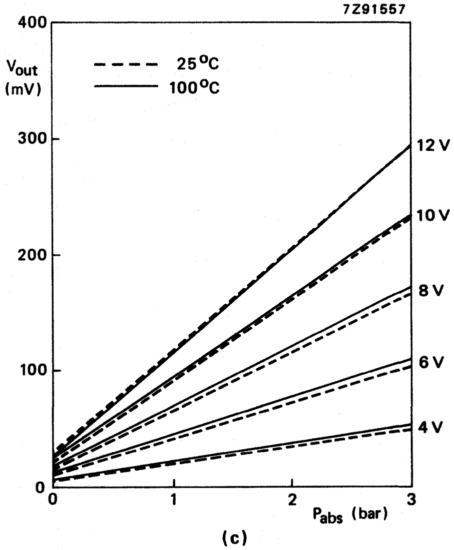


Fig. 6 Bridge output voltage as a function of pressure with supply voltage as a parameter and V_{BE}-multiplier in circuit. Supply voltage optimized at 10 V.

INTRODUCTION (continued)

Further illustration of benefits gained from temperature compensation are shown in Fig. 7. The output voltage is plotted against temperature with pressure as a parameter.

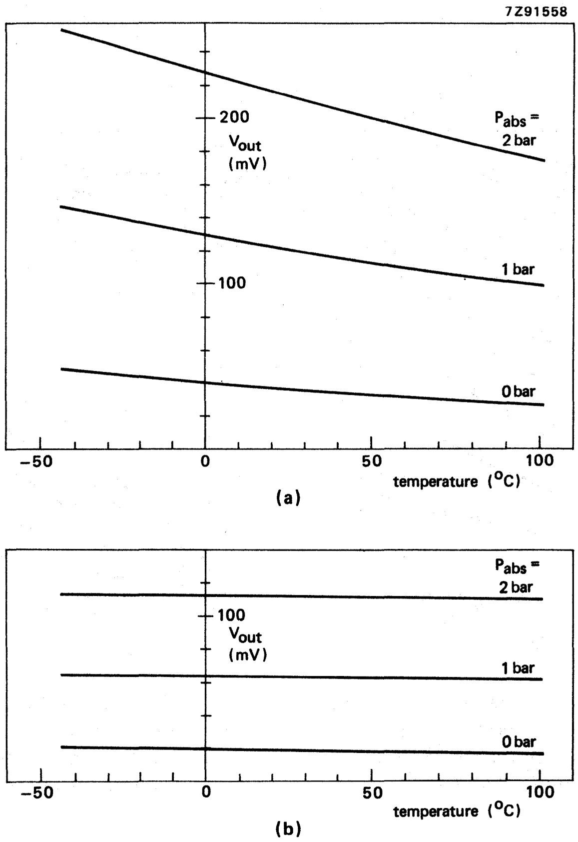


Fig. 7 Output voltage as a function of temperature with pressure as a parameter, (a) without compensation, and (b) with compensation.

The sensor KP100A is optimized for 7.5 V operation, the KP100A1 for 5 V operation. The 1 bar-sensor KP101A is optimized for 5 V operation.

Thin-film pressure sensors

A schematic drawing of the elastic element of the KPZ-sensor (9700 x 9700 μm^2) is shown in Fig. 8. The element consists of a stiff outer rim, a stiff central plunger and two (four in the KPZ21G) bending beams connecting rim and plunger. By application of pressure on the reverse side of the membrane the central plunger is displaced relatively to the fixed outer rim, and the bending beams are deformed. In the regions of maximum positive and negative strain (" ") the thin-film strain gauges are deposited. The strain gauges are connected, by means of a metallized layer, to a Wheatstone bridge circuit. Figure 8 shows the sensor before encapsulation.

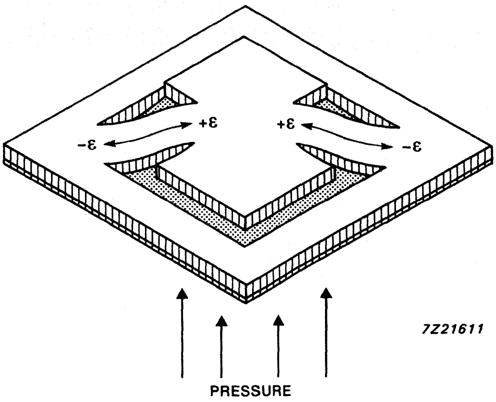


Fig. 8 Elastic element of the thin-film pressure sensor.

INTRODUCTION (continued)

Signal-conditioning IC for pressure sensors

The pressure sensors are also available with a dedicated signal-conditioning IC within the encapsulation. The IC requires an external power supply and provides the following functions:

- an output signal proportional to pressure, ranging from 10 to 90% of the supply voltage;
- temperature compensation;
- facility for offset and sensitivity trimming.

The IC can operate from a range of supply voltages from 4.75 V to 7 V (stabilized).

The circuit is based on a p-type silicon substrate with aluminium metallization. It incorporates low-ohmic WTi and high-ohmic CrSi thin-film resistors. All active areas of the circuit are protected by silicon dioxide glassover.

The functional layout of the IC, which incorporates a preamplifier stage, a current limiting stage and a feedback control line is shown in Fig. 9.

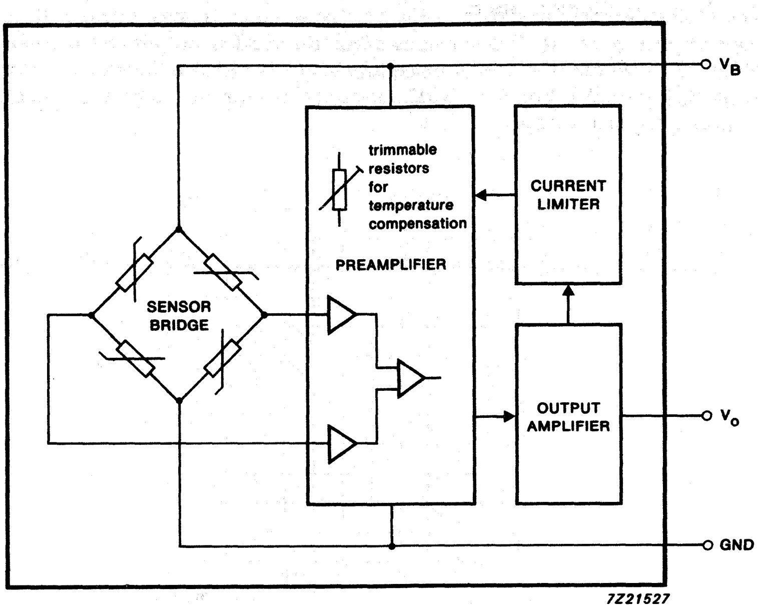


Fig. 9 Signal-conditioning IC.

The preamplifier stage, which incorporates a series of operational amplifiers and trimmable WTi and CrSi-sensors, amplifies the bridge signal by between 20 and 80. Moreover it compensates for the bridge's offset at low operating pressures, and for its temperature coefficients of offset and sensitivity.

The analogue output stage comprises 10 parallel-connected pnp transistors (one of which is utilized for current limiting), to provide an output signal of at least 90% of the supply voltage (for loads from 5 kΩ to infinity). The output stage has a low voltage drop (no more than about 0.5 V), so to prevent oscillation a capacitance of at least 0.1 μF with a series resistor of 60 Ω is connected externally across the output as shown in Fig. 10.

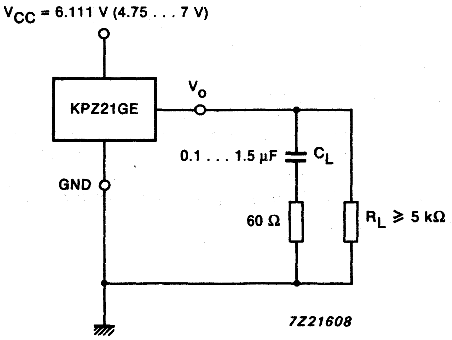


Fig. 10 Output circuit for the pressure sensor KPZ21GE.

The accuracy of the circuit depends on trimming. With very fine trimming a tolerance of about ± 2% can be realized.

INTRODUCTION (continued)

The sensor/IC combination of the KPZ21GE has an effective measuring range from + 1000 kPa relative pressure to below 0 kPa as shown in Fig. 11. The variation is linear down to the point where the residual output voltage of the IC becomes manifest; this residual output voltage is load dependent. As shown in Fig. 12 the linear relationship extends to —44 kPa and gives a residual voltage of 0.285 V for zero load (at V_{CC} = 6 mV). For R_L = 5 kΩ however, the linear relationship extends down to —87 kPa and gives a residual voltage of 0.07 V.

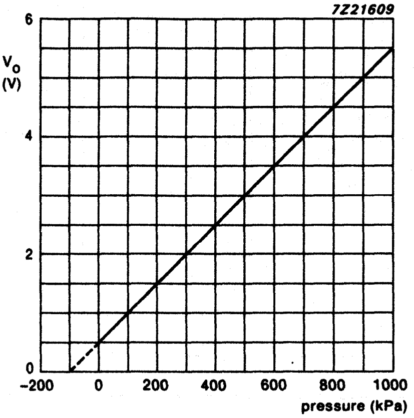


Fig. 11 Output voltage of the KPZ21GE sensor as a function of pressure, for a 6.111 V supply and 5 kΩ load.

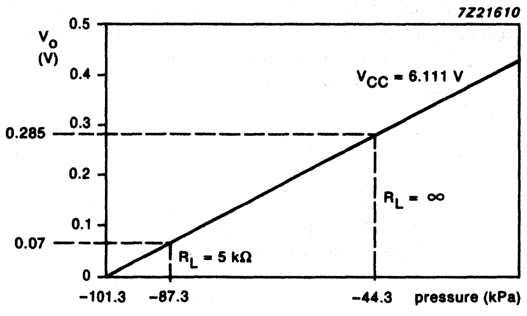


Fig. 12 KPZ21GE residual output voltage dependent on load resistance; supply voltage = 6.111 V.

MAGNETIC FIELD SENSORS

MAGNETIC FIELD SENSOR

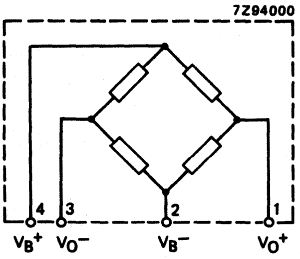
The KMZ10A is an extremely sensitive magnetic field sensor employing the magneto-resistive effect of thin film permalloy.
Its properties enable this sensor to be used in a wide range of applications for navigation, current and field measurement, revolution counters, angular or linear position measurement and proximity detectors, etc.

QUICK REFERENCE DATA

Operating voltage	V_B	=	5	V
Operating range	H_y	=	± 0.5	kA/m
Auxiliary field	H_x	=	0.5	kA/m
Sensitivity	S	=	14	$\frac{mV/V}{kA/m}$
Offset voltage	V_{off}	⩽	± 1.5	mV/V
Bridge resistance	R_{bridge}	=	0.9 to 1.7	kΩ

MECHANICAL AND ELECTRICAL DATA

Dimensions in mm



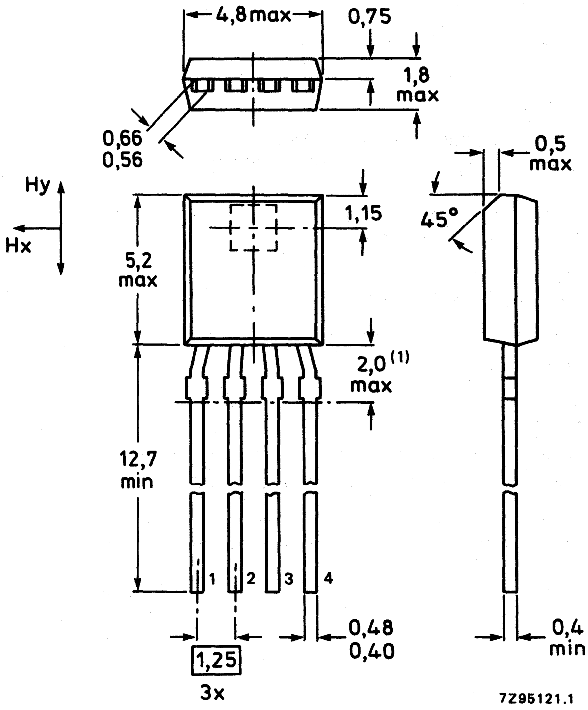


Fig. 1 SOT195.

(1) Terminal dimensions uncontrolled within this area.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Operating voltage	V_B	max.	9	V
Total power dissipation up to T_{amb} = 134 °C	P_{tot}	max.	90	mW
Storage temperature range	T_{stg}		−65 to + 150	°C
Operating bridge temperature range	T_{bridge}		−40 to + 150	°C

THERMAL RESISTANCE

From junction to ambient	$R_{th\ j\text{-}a}$	=	180	K/W

CHARACTERISTICS

T_{amb} = 25 °C and H_x = 0.5 kA/m (1) unless otherwise specified

Bridge supply voltage	V_B	=	5	V
Operating range (1)	H_y	=	± 0.5	kA/m
Open circuit sensitivity (1)	S	=	11 to 17	$\frac{mV/V}{kA/m}$
Temperature coefficient of output voltage				
V_B = constant; T_j = −25 to + 125 °C	TCV_o	typ.	−0.4	%/K
I_B = constant; T_j = −25 to + 125 °C	VCV_o	typ.	−0.15	%/K
Bridge resistance	R_{br}		0.9 to 1.7	kΩ
Temperature coefficient of bridge resistance at T_j = −25 to + 125 °C	TCR_{br}	typ.	0.25	%/K
Offset voltage	V_{off}	⩽	± 1.5	mV/V
Temperature coefficient of offset voltage at T_{bridge} = −25 to + 125 °C	TCV_{off}	⩽	± 6	$\frac{\mu V/V}{K}$
Linearity deviation of output voltage at				
H_y = 0 to ± 0.25 kAm^{-1}	FL	<	0.8	% FS
H_y = 0 to ± 0.4 kAm^{-1}	FL	<	2.5	% FS
H_y = 0 to ± 0.5 kAm^{-1}	FL	<	4.0	% FS
Hysteresis of output voltage		<	0.5	% FS
Operating frequency	f_{max}	=	1	MHz

Note

Before first operation or after operation outside the SOAR (Fig. 2) the sensor has to be reset by application of an auxiliary field H_x = 3 kA/m.

(1) No disturbing field (H_d) allowed; for stable operation under disturbing conditions see Fig. 2 (SOAR) and see Fig. 3 for decrease of sensitivity.

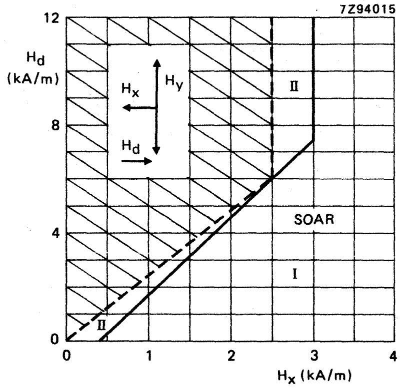


Fig. 2 Safe Operating Area (permissible disturbing field H_d as a component of auxiliary field H_x).

I Region of permissible operation.

II Permissible extension if $H_y < 0.15$ kA/m.

Note: In applications with $H_x < 3$ kA/m, the sensor has to be reset, after leaving the SOAR, by an auxiliary field of $H_x = 3$ kA/m.

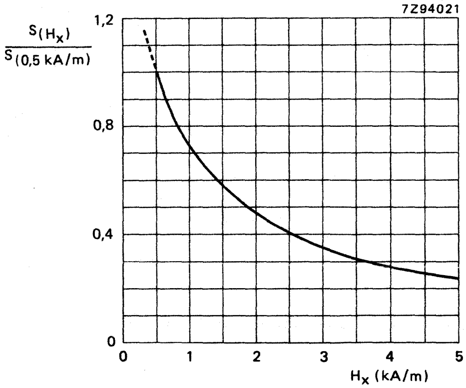


Fig. 3 Relative sensitivity (ratio of sensitivity at certain H_x and sensitivity at $H_x = 0.5$ kA/m.
Note: In applications with $H_x \leq 3$ kA/m the sensor has to be reset by an auxiliary field of $H_x = 3$ kA/m before using.

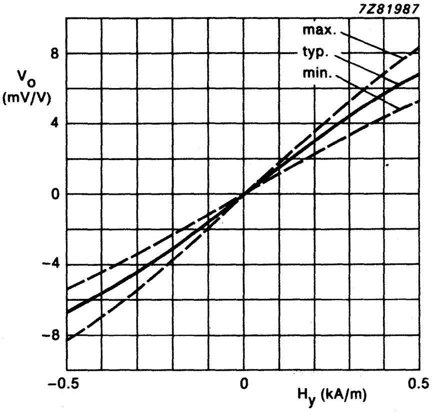


Fig. 4 Sensor output characteristic
$H_x = 0.5$ kA/m $T_{amb} = 25^oC$. Voff =0

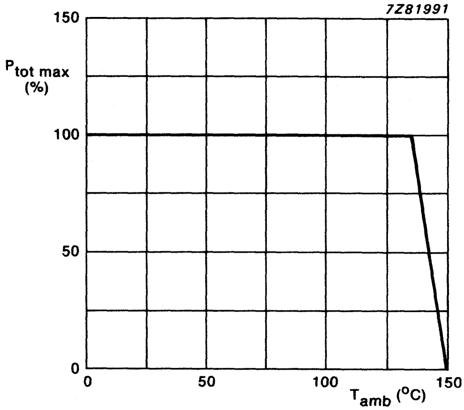


Fig. 5 Power derating curve.

MAGNETIC FIELD SENSOR

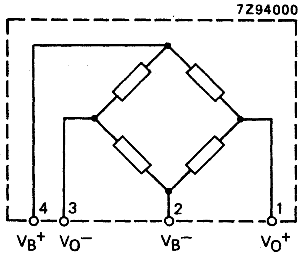
The KMZ10B is a sensitive magnetic field sensor employing the magneto-resistive effect of thin film permalloy.
Its properties enable this sensor to be used in a wide range of applications for current and field measurement, revolution counters, angular or linear position measurement and proximity detectors, etc.

QUICK REFERENCE DATA

Operating voltage	V_B	=	5	V
Operating range	H_y	=	± 2.0	kA/m
Auxiliary field	H_x	=	3	kA/m
Sensitivity	S	=	4	$\frac{\text{mV/V}}{\text{kA/m}}$
Offset voltage	V_{off}	$\leqslant$	± 1.5	mV/V
Bridge resistance	R_{bridge}	=	1.2 to 2.2	kΩ

MECHANICAL AND ELECTRICAL DATA

Dimensions in mm



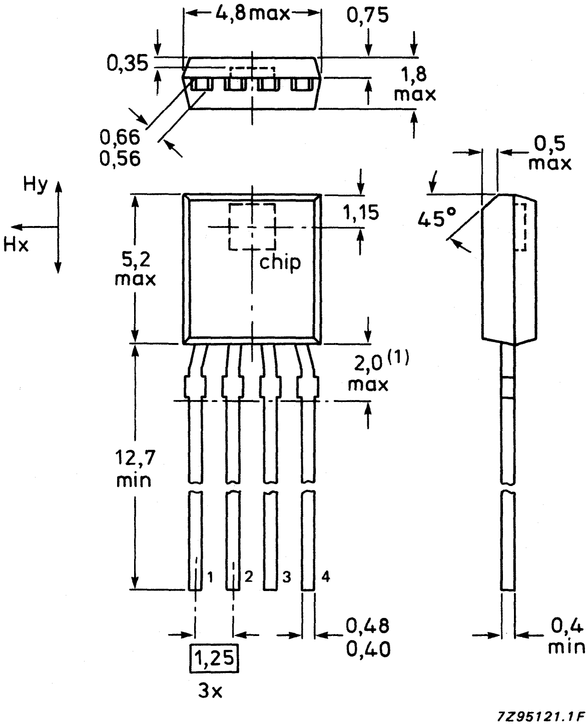


Fig. 1 SOT195.

(1) Terminal dimensions uncontrolled within this area.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Operating voltage	V_B	max.	12	V
Total power dissipation up to $T_{amb} = 130$ °C	P_{tot}	max.	120	mW
Storage temperature range	T_{stg}		–65 to + 150	°C
Operating bridge temperature range	T_{bridge}		–40 to + 150	°C

THERMAL RESISTANCE

From junction to ambient	$R_{th\,j\text{-}a}$	=	180	K/W

CHARACTERISTICS

$T_{amb} = 25$ °C and $H_x = 3$ kA/m[1] unless otherwise specified ←

Operating voltage	V_B	=	5	V	
Operating range of magnetic field	H_y	=	± 2.0	kA/m	
Open circuit sensitivity	S	=	3.2 to 4.8	$\frac{mV/V}{kA/m}$	←
Temperature coefficient of output voltage					
V_B = constant; $T_j = -25$ to + 125 °C	TCV_o	typ.	–0.4	%/K	
I_B = constant; $T_j = -25$ to + 125 °C	TCV_o	typ.	–0.10	%/K	
Bridge resistance	R_{br}		1.2 to 2.2	kΩ	
Temperature coefficient of bridge resistance at $T_{bridge} = -25$ to + 125 °C	TCR_{br}	typ.	0.30	%/K	
Offset voltage	V_{off}	$\leqslant$	± 1.5	mV/V	
Temperature coefficient of offset voltage at $T_j = -25$ to + 125 °C	TCV_{off}	$\leqslant$	± 3	$\frac{\mu V/V}{K}$	
Linearity deviation of output voltage at					
$H_y = 0$ to ± 1 KAm^{-1}	FL	<	± 0.5	% FS	
$H_y = 0$ to ± 1.6 KAm^{-1}	FL	<	± 1.7	% FS	
$H_y = 0$ to ± 2 KAm^{-1}	FL	<	± 2.0	% FS	
Hysteresis of output voltage	V_{oH}	<	0.5	% FS	←
Operating frequency	f_{max}	=	1	MHz	

Note

In applications with Hx < 3 kA/m, the sensor has to be reset before first operation by application of an auxiliary field $H_x = 3$ kA/m.

←

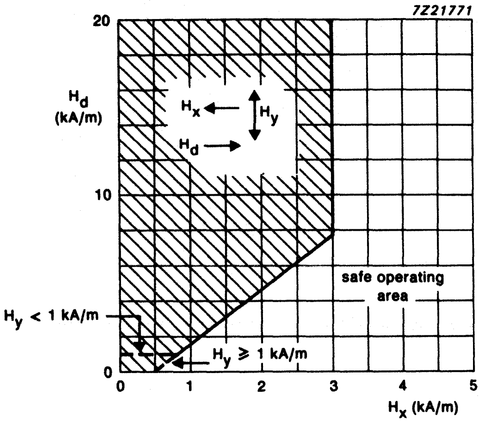


Fig. 2 Safe Operating Area (permissible disturbing field H_d as a component of auxiliary field H_x).

I Region of permissible operation.

II Permissible extension if $H_y < 1$ kA/m.

Note: In applications with $H_x < 3$ kA/m, the sensor has to be reset after leaving the SOAR, by an auxiliary field of $H_x = 3$ kA/m.

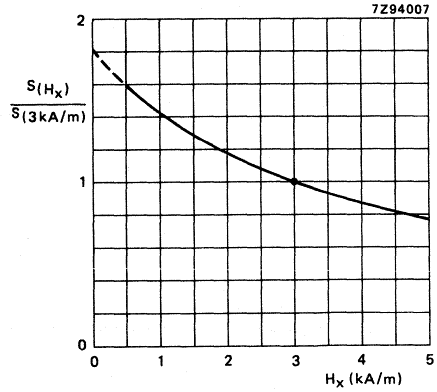


Fig. 3 Relative sensitivity (ratio of sensitivity at certain H_x and sensitivity at $H_x = 3$ kA/m.

Note: In applications with $H_x \leqslant 3$ kA/m the sensor has to be reset by an auxiliary field of $H_x = 3$ kA/m before using.

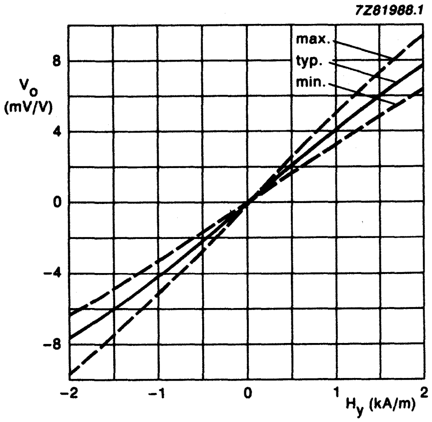


Fig. 4 Sensor output characteristic V_B = constant; $T_{amb} = 25\ ^oC$; $H_x = 3$ kA/m; $V_{off} = 0$.

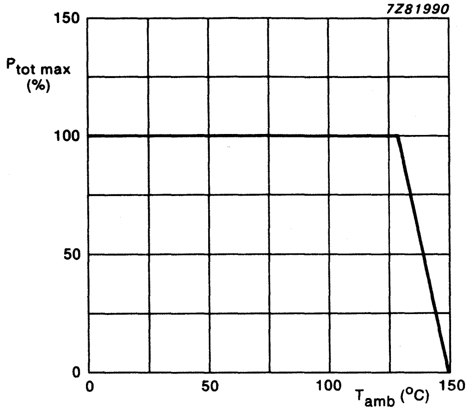


Fig. 5 Power derating curve.

MAGNETIC FIELD SENSOR

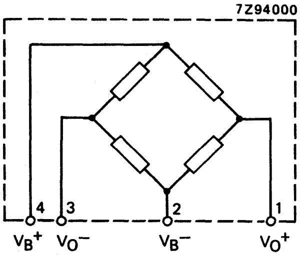
The KMZ10C is a magnetic field sensor employing the magneto-resistive effect of thin film permalloy. Its properties enable this sensor to be used in a wide range of applications for current and field measurement, revolution counters, angular or linear position measurement and proximity detectors, etc.

QUICK REFERENCE DATA

Operating voltage	V_B	=	5	V
Operating range	H_y	=	± 7.5	kA/m
Auxiliary field	H_x	=	3.0	kA/m
Sensitivity	S	=	1.5	$\frac{mV/V}{kA/m}$
Offset voltage	V_{off}	⩽	± 1.5	mV/V
Bridge resistance	R_{bridge}	=	1.0 to 1.8	kΩ

MECHANICAL AND ELECTRICAL DATA

Dimensions in mm



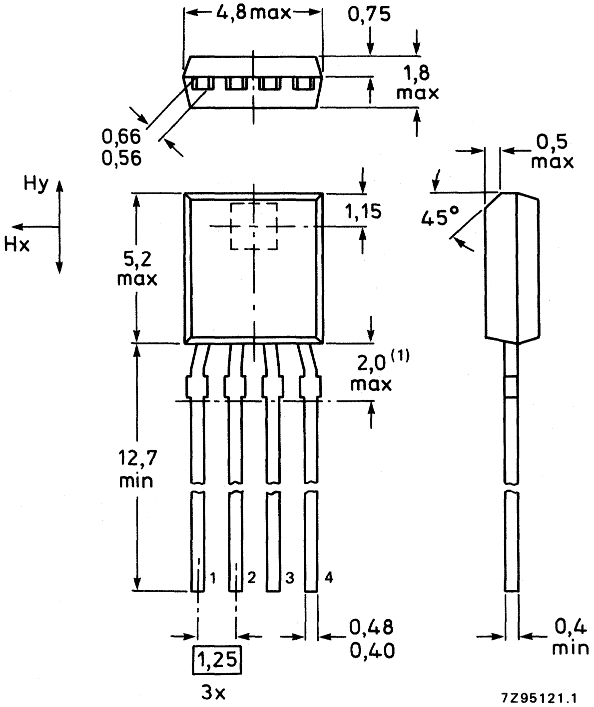


Fig. 1 SOT 195.

(1) Terminal dimensions uncontrolled within this area.

RATINGS

Limiting values in accordance with the Absolute Maximum System(IEC 134)

Operating voltage	V_B	max.	10 V
Total power dissipation up to T_{amb} = 132 °C	P_{tot}	max.	100 mW
Storage temperature range	T_{stg}		–65 to + 150 °C
Operating bridge temperature range	T_{bridge}		–40 to + 150 °C

THERMAL RESISTANCE

From junction to ambient	$R_{th\,j\text{-}a}$	=	180 K/W

CHARACTERISTICS

T_{amb} = 25 °C and H_x = 3 kA/m⁽¹⁾ unless otherwise specified

Operating voltage	V_B	=	5 V
Operating range of magnetic field	H_y	=	± 7.5 kA/m
Open circuit sensitivity	S		1 to 2 $\frac{\text{mV/V}}{\text{kA/m}}$
Temperature coefficient of output voltage			
V_B = constant; T_j = –25 to + 125 °C	TCV_o	typ.	–0.5 %/K
I_B = constant; T_j = –25 to + 125 °C	VCV_o	typ.	–0.15 %/K
Bridge resistance	R_{br}		1.0 to 1.8 kΩ
Temperature coefficient of bridge resistance at T_j = –25 to + 125 °C	TCR_{br}	typ.	0.35 %/K
Offset voltage	V_{off}	⩽	± 1.5 mV/V
Temperature coefficient of offset voltage at T_{bridge} = –25 to + 125 °C	TCV_{off}	⩽	± 2 $\frac{\mu\text{V/V}}{\text{K}}$
Linearity deviation of output voltage at			
H_y = 0 to ± 3.75 kAm^{-1}	FL	<	± 0.8 %= FS
H_y = 0 to ± 6.0 kAm^{-1}	FL	<	± 2.4 %= FS
H_y = 0 to ± 7.5 kAm^{-1}	FL	<	± 2.7 %= FS
Hysteresis of output voltage	VoH	<	0.5 %= FS
Operating frequency	f_{max}	=	1 MHz

Note

1. In applications with $H_x < 3$ kA/m the sensor has to be reset before first operation by application of an auxiliary field H_x =3 kA/m.

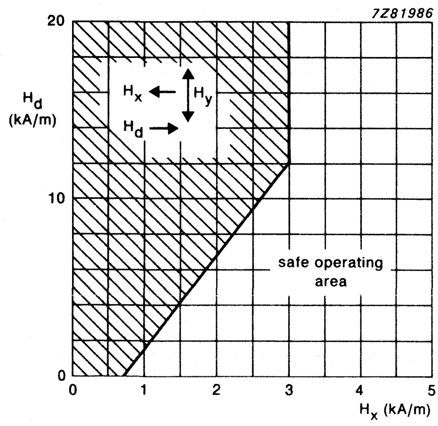


Fig. 2 Safe Operating Area (permissible disturbing field H_d as a component of auxiliary field H_x).
Note: In application with H_x < 3 kA/m, the sensor has to be reset after leaving the SOAR, by an auxiliary field of $H_x = 3$ kA/m.

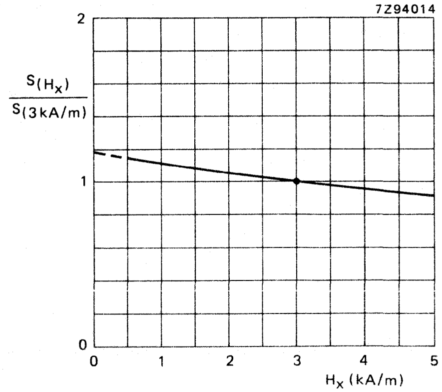


Fig. 3 Relative sensitivity (ratio of sensitivity at certain H_x and sensitivity at $H_x = 3$ kA/m.
Note: In application with H_x $\leqslant 3$ kA/m the sensor has to be reset by an auxiliary field of $H_x = 3$ kA/m before using.

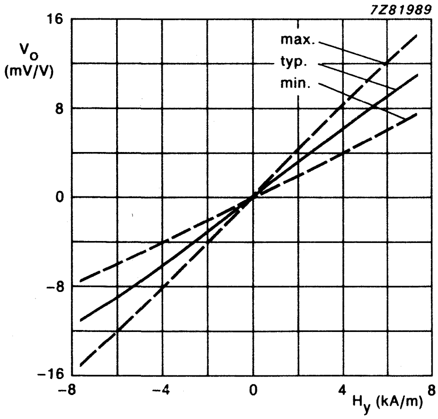


Fig. 4 Sensor output characteristic $H_x = 3$ kA/m $T_{amb} = 25$ °C Voff =0.

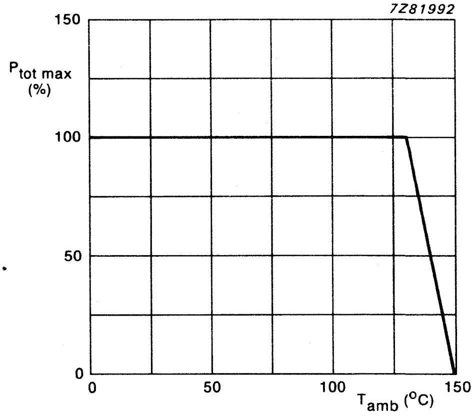


Fig. 5 Power derating curve.

PRESSURE SENSORS

MONOLITHIC PRESSURE SENSOR

The KP100A is designed for measurement of absolute pressures from 0 to 200 kPa.
The sensor comprises a monolithic silicon vacuum cell incorporating diffused strain gauge resistors and integral sensitivity temperature compensation.

The housing is a plastic moulded 6-pin DIL package with a rigid capillary tube for the pressure connection.

QUICK REFERENCE DATA

Operating pressure range	P	0 to 200	kPa
Operating voltage	V_t, V_e	7.5	V
Operating ambient temperature range	T_{amb}	−40 to + 125	°C

MECHANICAL DATA

Dimensions in mm

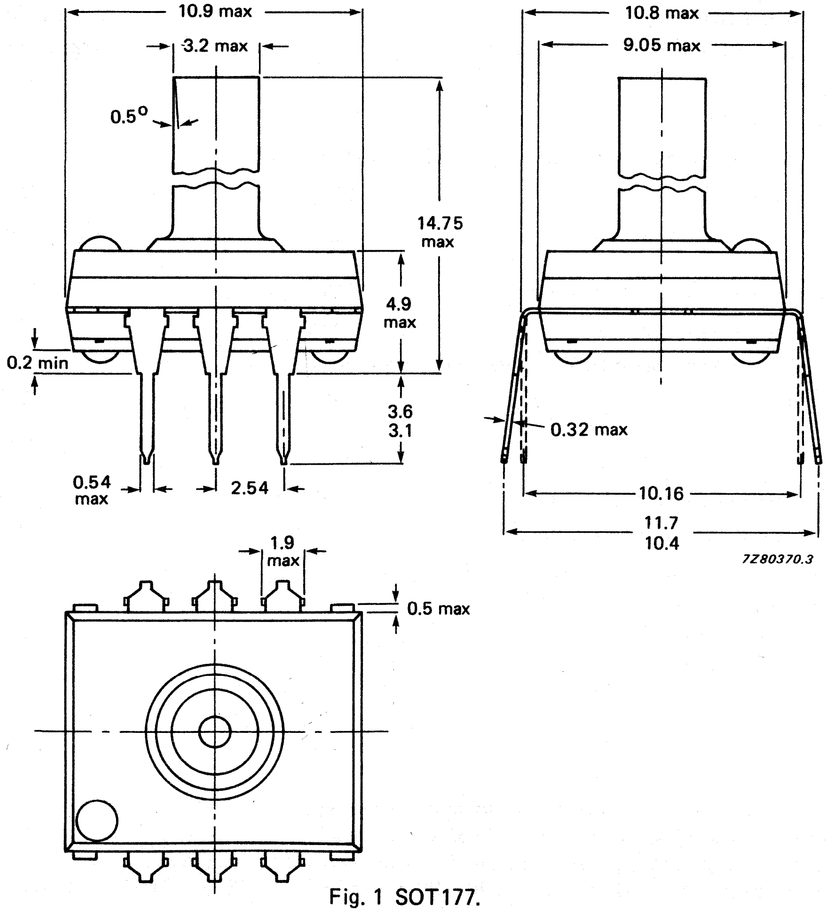


Fig. 1 SOT177.

The pressure transducer is suitable for use with non-ionic and non-corrosive media. The silicon diaphragm is covered with Si_3N_4 for protection.

The pressure port is defined for using flexible tubes with 3 mm internal diameter.

The SOT117 envelope is designed for soldering on a PCB.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Operating voltage	V_t, V_e	max.	12	V
Pressure (absolute)	P_{max}	max.	400	kPa
Burst pressure (absolute)	P_b	$\geqslant$	600	kPa
Operating ambient temperature range	T_{amb}		−40 to + 125	°C
Storage temperature range	T_{stg}		−65 to + 150	°C
Lead soldering temperature at $t_{sld} < 10$ s	T_{sld}	max.	260	°C

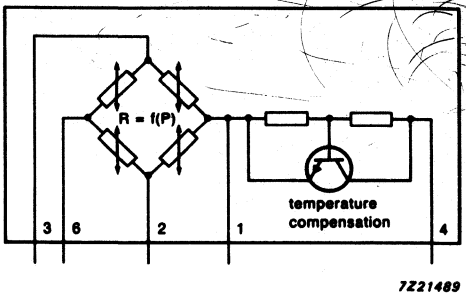
CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

Operating pressure range	P		0 to 200	kPa
Bridge resistance (see Fig. 2)	R_{br}		1800 ± 400	Ω
Linearity (2)	FL	=	± 0.5	%FS
Pressure hysteresis (3)		=	0.1	%FS
For V_t = 7.5 V (operation without temperature compensation)				
Offset voltage (1)	V_{off}	$\leqslant$	± 37.5	mV
Sensitivity (1)	S		0.68 to 1.27	$\frac{mV}{kPa}$
Temperature coefficient of offset voltage	TCV_{off}	=	± 0.05	%FS/K
Temperature coefficient of sensitivity	TCS	=	−0.22	%/K
For V_e = 7.5 V (operation with temperature compensation)				
Offset voltage	V_{off}	$\leqslant$	± 25.0	mV
Sensitivity	S	=	0.30 to 0.90	$\frac{mV}{kPa}$
Temperature coefficient of sensitivity	TCS	=	± 0.06	%/K
Temperature coefficient of offset voltage	TCV_{off}	=	± 0.06	%FS/K
Temperature coefficient of compensation circuit	TCV_{comp}	=	−12	mV/K
For T_{amb} = −10 to 85 °C: temperature hysteresis (4)	TH	=	0.5	%FS

Notes

1. Transducer output voltage is ratiometric to operating voltage.
2. Deviation from Best Straight Line (BSL) in pressure range.
3. Deviation of output voltage at same pressure point by increasing or decreasing pressure.
4. Measurement cycle from −10 °C to +85 °C = 30 min. and from +85 to −10 °C = 30 min.



Pin connections:

1	V_t	Bridge operating voltage
2	V_{p+}	Positive output voltage
3	V_{p-}	Negative output voltage
4	V_e	Excitation voltage
5	n.c.	Not connected
6	V_g	Ground

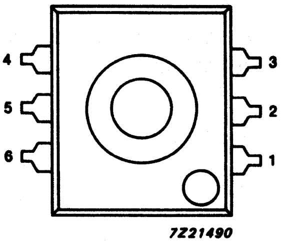


Fig. 2 Schematic diagram.

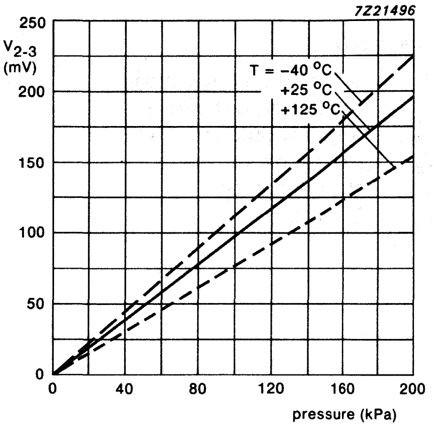


Fig. 3 Operation without temperature compensating circuit.

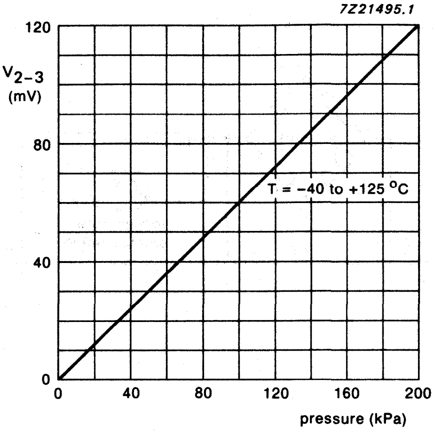


Fig. 4 Operation with temperature compensating circuit.

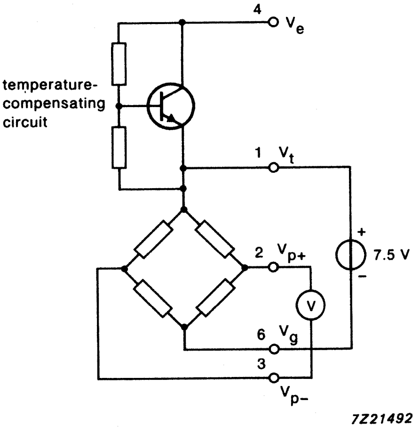


Fig. 5 Schematic without temperature compensation.

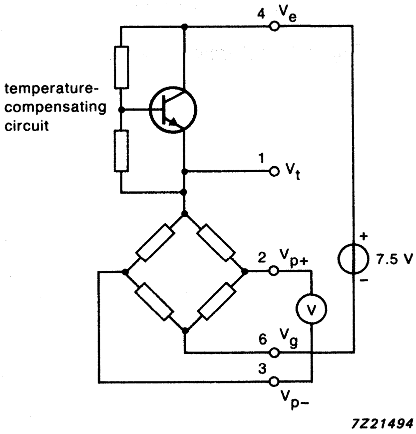


Fig. 6 Schematic with temperature compensation.

MONOLITHIC PRESSURE SENSOR

The KP100A is designed for measurement of absolute pressures from 0 up to 120 kPa.
The sensor comprises a monolithic silicon vacuum cell incorporating diffused strain gauge resistors and integral sensitivity temperature compensation.

The housing is a plastic moulded 6-pin DIL package with a rigid capillary tube for the pressure connection.

QUICK REFERENCE DATA

Operating pressure range	P	0 to 120	kPa
Operating voltage	V_t, V_e	5.0	V
Operating ambient temperature range	T_{amb}	−40 to + 125	°C

MECHANICAL DATA

Dimensions in mm

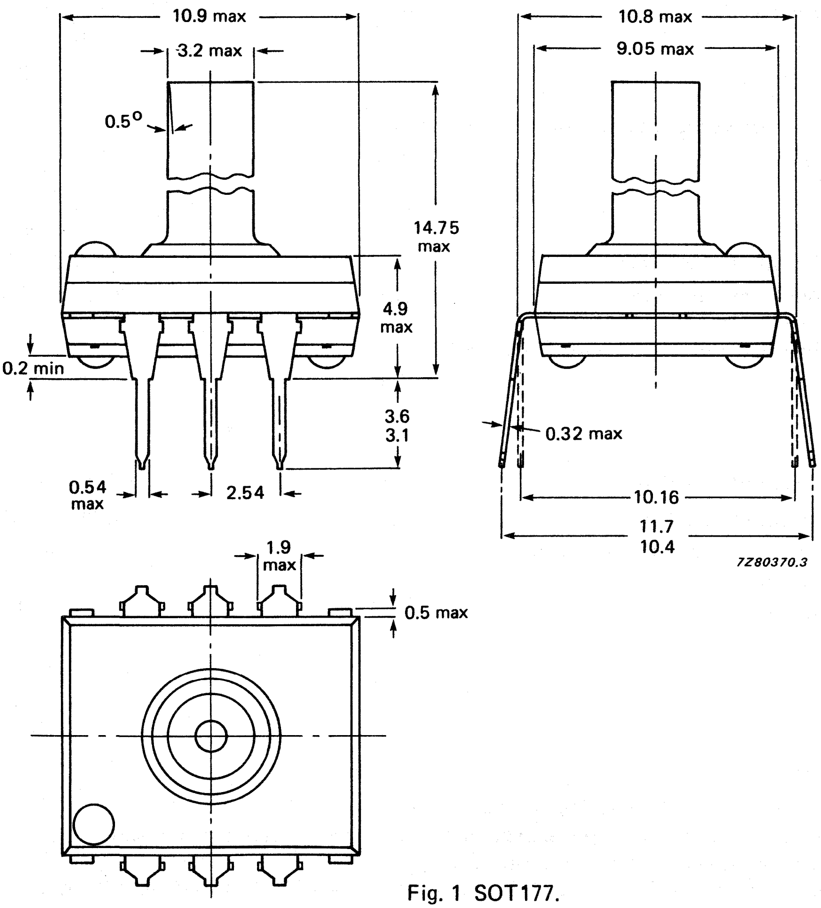


Fig. 1 SOT177.

The pressure transducer is suitable for use with non-ionic and non-corrosive media. The silicon diaphragm is covered with Si_3N_4 for protection.

The pressure port is defined for using flexible tubes with 3 mm internal diameter.

The SOT-177 envelope is designed for soldering on a PCB.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Operating voltage	V_t, V_e	max.	12	V
Pressure (absolute)	P_{max}	max.	250	kPa
Burst pressure (absolute)	P_b	$\geqslant$	600	kPa
Operating ambient temperature range	T_{amb}		−40 to + 125	°C
Storage temperature range	T_{stg}		−65 to + 150	°C
Lead soldering temperature at $t_{sld} < 10$ s	T_{sld}	max.	260	°C

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

Operating pressure range	P		0 to 120	kPa
Bridge resistance (see Fig. 2)	R_{br}		1600 ± 500	Ω
Linearity (note 1)	FL		± 0.5	%FS
Pressure hysteresis (note 2)	PH	=	0.1	%FS

For V_t = 5.0 V (operation without temperature compensation)

Offset voltage (note 3)	V_{off}	$\leqslant$	± 25.0	mV
Sensitivity (note 3)	S		0.70 to 1.40	$\frac{mV}{kPa}$
Temperature coefficient of offset voltage	TCV_{off}	=	± 0.05	%FS/K
Temperature coefficient of sensitivity	TCS	=	−0.22	%/K

For V_e = 5.0 V (operation with temperature compensation)

Offset voltage	V_{off}	$\leqslant$	± 15.0	mV
Sensitivity	S	=	0.25 to 0.75	$\frac{mV}{kPa}$
Temperature coefficient of sensitivity	TCS	=	± 0.06	%/K
Temperature coefficient of offset voltage	TCV_{off}	=	± 0.06	%FS/K
Temperature coefficient of compensation circuit	TCV_{comp}	=	−12	mV/K
For T_{amb} = −10 to +85 °C: temperature hysteresis (note 4)	TH	=	0.5	%FS

Notes to the characteristics

1. Deviation from Best Straight Line (BSL) in pressure range.
2. Deviation of output voltage at same pressure point by increasing or decreasing pressure.
3. Transducer output voltage is ratiometric to operating voltage.
4. Measurement cycle from −10 °C to +85 °C = 30 min. and from +85 °C to −10 °C = 30 min.

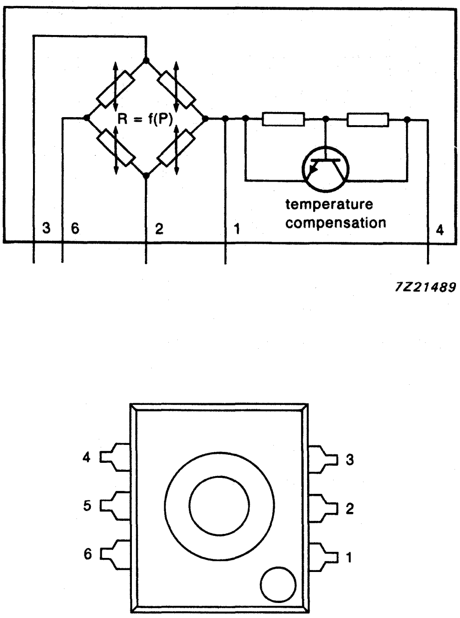


Fig. 2 Schematic diagram.

Pin connections:

1	V_t	Bridge operating voltage
2	V_{p+}	Positive output voltage
3	V_{p-}	Negative output voltage
4	V_e	Excitation voltage
5	n.c.	Not connected
6	V_g	Ground

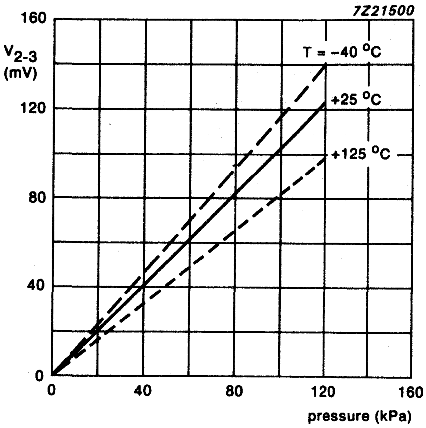


Fig. 3 Operation without temperature compensating circuit.

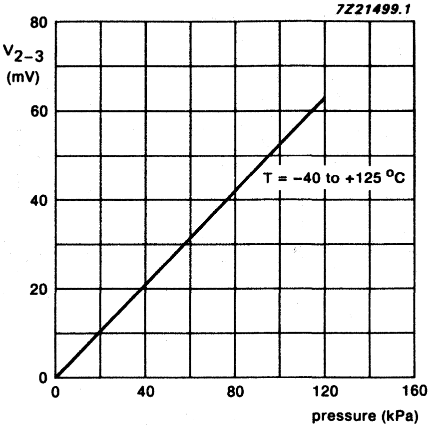


Fig. 4 Operation with temperature compensating circuit.

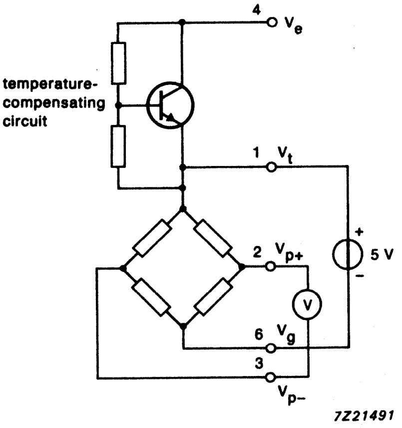


Fig. 5 Schematic without temperature compensation.

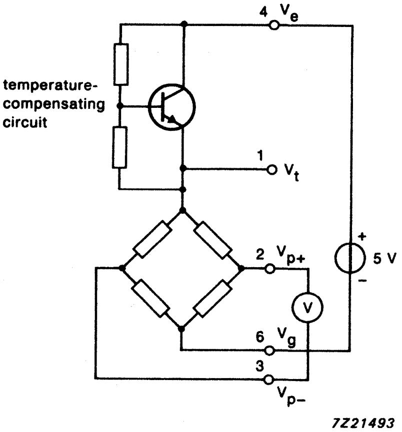


Fig. 6 Schematic with temperature compensation.

THIN-FILM PRESSURE SENSOR

The KPZ20G is designed for measurement of relative pressures from −1 up to 2 bar and for a wide range of gases or fluids. The sensor employs thin-film semi-conductor strain gauges deposited on a copper alloy isolating diaphragm. Sealing is obtained by pressure contact using an O-ring in a groove provided in the transfer-moulded body and electrical connections are made via silver plated lead-outs to form a dual-in-line configuration.

All pressure media, which do not attack copper alloy, HC10 envelope plastic, epoxy glue and assembly parts, may be used. For the sensor reference side, only non-conductive and non-corrosive media are allowed.

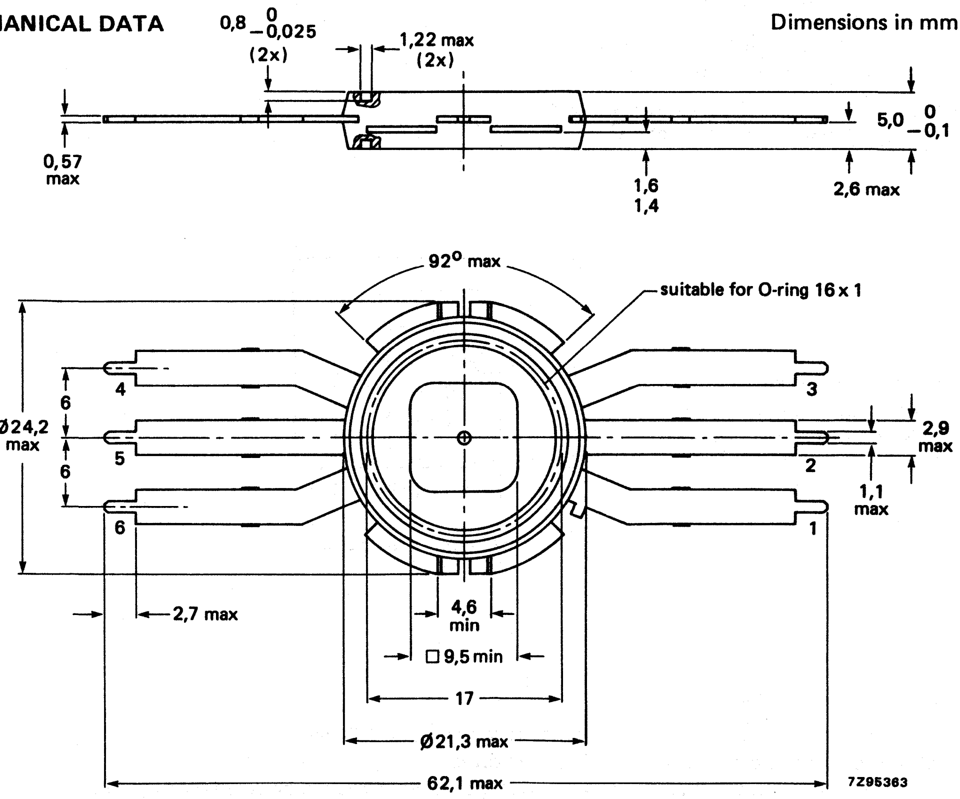
QUICK REFERENCE DATA

Pressure range	P		−100 to 200 kPa
Supply voltage	V_B	typ.	7.5 V
Operating ambient temperature	T_{amb}		−40 to + 125 °C

MECHANICAL DATA

Dimensions in mm

Fig. 1.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Supply voltage	V_B	max.	16	V
Maximum pressure	P_{max}	max.	500	kPa
Destructive pressure ($t < 10$ min.)	P_b	min.	1000	kPa
Operating ambient temperature range	T_{amb}		−40 to + 125	°C
Storage temperature range	T_{stg}		−65 to + 150	°C
Soldering temperature ($t < 10$ s)	T_s	max.	260	°C

CHARACTERISTICS

$V_B = 7.5$ V; $T_{amb} = 25$ °C unless otherwise specified

Pressure range	P		−100 to 200	kPa
Sensitivity (note 1)	S		0.07 to 0.14	mV/VkPa
Bridge resistance	R_{br}	=	2.0 ± 1.0	kΩ
Offset voltage (note 1)	V_{off}	$\leqslant$	± 5.0	mV/V
Linearity (note 2)	FL	=	± 0.5	%FS
Pressure Hysteresis (note 3)	PH	=	0.2	%FS
Diaphragm natural frequency	f_d	>	5	kHz
Temperature coefficient of sensitivity T_{amb} between −40 and + 85 °C	TC_s	=	−0.15	%/K
Temperature coefficient of offset voltage T_{amb} between −40 and + 85 °C	TC_{off}	=	± 0.05	%FS/K

V_B = supply voltage
V_P = output voltage
pins 3 and 6: not connected

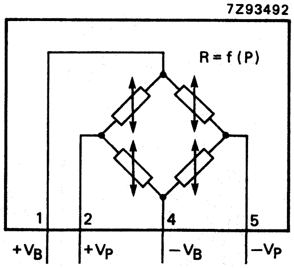


Fig. 2 Schematic diagram.

Notes to the characteristics

1. Transducer operating voltage is ratiometric to operating voltage.
2. Deviation from Best Straight Line (BSL) in pressure range.
3. Deviation of output voltage at same pressure point by increasing or decreasing pressure.

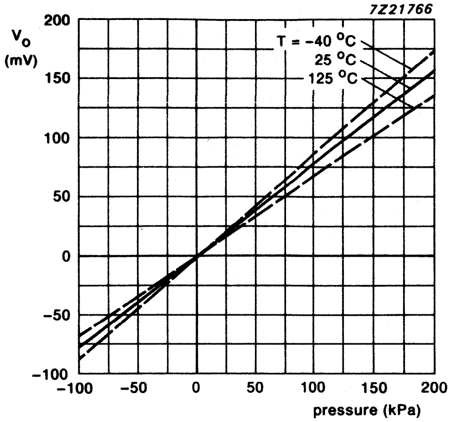


Fig. 3 Nominal output characteristic KPZ20G.
Output voltage (V_o) as a component of pressure (kPa)
at V_B = 7.5 V.

THIN-FILM PRESSURE SENSOR

The KPZ20G is designed for measurement of relative pressures between −100 and 1000 kPa and for a wide range of gases or fluids.

The sensor employs thin-film semi-conductor strain gauges deposited on a copper alloy isolating diaphragm. Sealing is achieved by pressure contact using an O-ring in a groove provided in the transfer-moulded body; electrical connections are made via silverplated lead-outs to form a dual-in-line configuration.

All pressure media, which do not attack copper alloy, HC10 envelope plastic, epoxy glue and assembly parts, may be used on the pressure transducer pressure side. For the sensor reference side, only non-corrosive and non-conductive media are permitted.

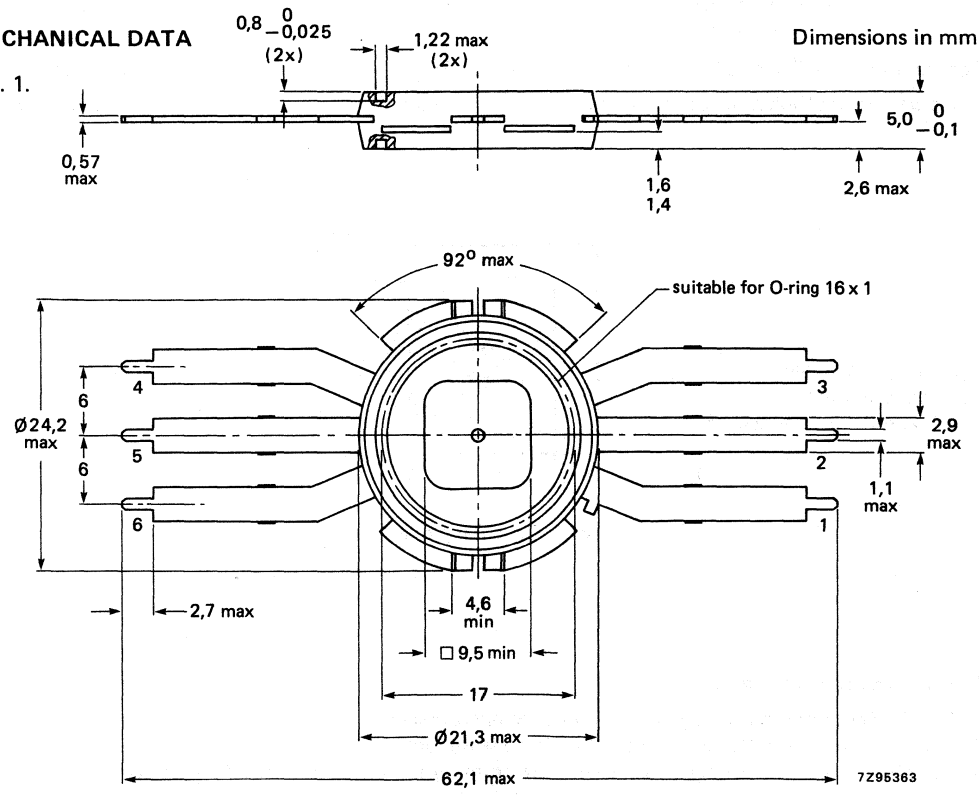
QUICK REFERENCE DATA

Operating pressure range	P	=	−100 to 1000	kPa
Operating voltage	V_B	typ.	7.5	V
Operating ambient temperature	T_{amb}		−40 to + 125	°C

MECHANICAL DATA

Dimensions in mm

Fig. 1.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Operating voltage	V_B	=	16.0	V
Maximum pressure	P_{max}	=	2000	kPa
Destructive pressure ($t < 10$ min.)	P_b	$\geqslant$	3000	kPa
Operating ambient temperature range	T_{amb}	=	−40 to + 125	°C
Storage temperature range	T_{stg}	=	−65 to + 100	°C
Soldering temperature ($t < 10$ s)	T_{sld}	max.	260	°C

CHARACTERISTICS

$V_B = 7.5$ V; $T_{amb} = 25$ °C unless otherwise specified

Operating pressure range	P	=	−100 to 1000	kPa
Sensitivity (note 1)	S	=	0.025 to 0.045	mV/VkPa
Bridge resistance	R_b	=	2.0 ± 1.0	kΩ
Offset voltage (note 1)	V_{off}	$\leqslant$	± 5.0	mV/V
Linearity (note 2)	FL	=	± 0.3	%FS
Pressure Hysteresis (note 3)	PH	=	0.2	%FS
Diaphragm natural frequency	f_d	>	5	kHz
For $T_{amb} = -40$ to $+ 85$ °C:				
Temperature coefficient of sensitivity	TC_s	=	−0.15	%/K
Temperature coefficient of offset voltage	TC_{off}	=	± 0.05	%FS/K

V_B = supply voltage
V_P = output voltage
pins 3 and 6: not connected

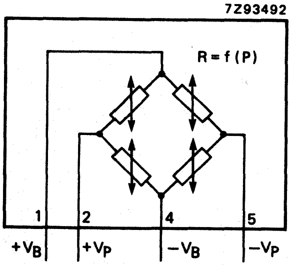


Fig. 2 Schematic diagram.

Notes to the characteristics

1. Transducer operating voltage is ratiometric to operating voltage.
2. Deviation from Best Straight Line (BSL) in pressure range.
3. Deviation of output voltage at same pressure point by increasing or decreasing pressure.

DEVELOPMENT DATA

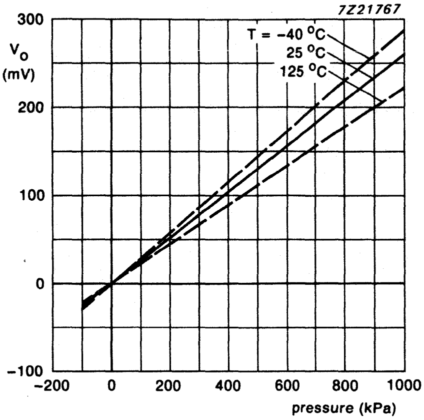


Fig. 3 Nominal output characteristic KPZ21G.
Output voltage as a component of pressure.
$V_B = 7.5$ V.

THIN-FILM PRESSURE SENSOR

The KPZ21GE is designed for measurement of relative pressures between −100 and 1000 kPa and is provided with a laser trimmed amplifier IC which is calibrated for offset and sensitivity with internal temperature compensation. The sensor is mounted in a SOT198D1 plastic envelope.

The sensor employs thin-film semi-conductor strain gauges deposited on a copper alloy isolating diaphragm. Sealing is achieved by pressure contact using an O-ring in a groove provided in the transfer-moulded body; electrical connections are made via silverplated lead-outs to form a dual-in-line configuration.

All pressure media, which do not attack copper alloy, HC10 envelope plastic, epoxy glue and assembly parts, may be used on the pressure transducer pressure side. For the sensor reference side, only dry gases are permitted. The thin film bridge resistors and the amplifier IC are covered with silicon gel for protection.

QUICK REFERENCE DATA

Operating pressure range	P	=	−100 to 1000	kPa
Operating voltage	V_B	=	6.111	V
Operating ambient temperature	T_{amb}		−40 to + 120	°C

MECHANICAL DATA

See Fig. 1.

MECHANICAL DATA

Dimensions in mm

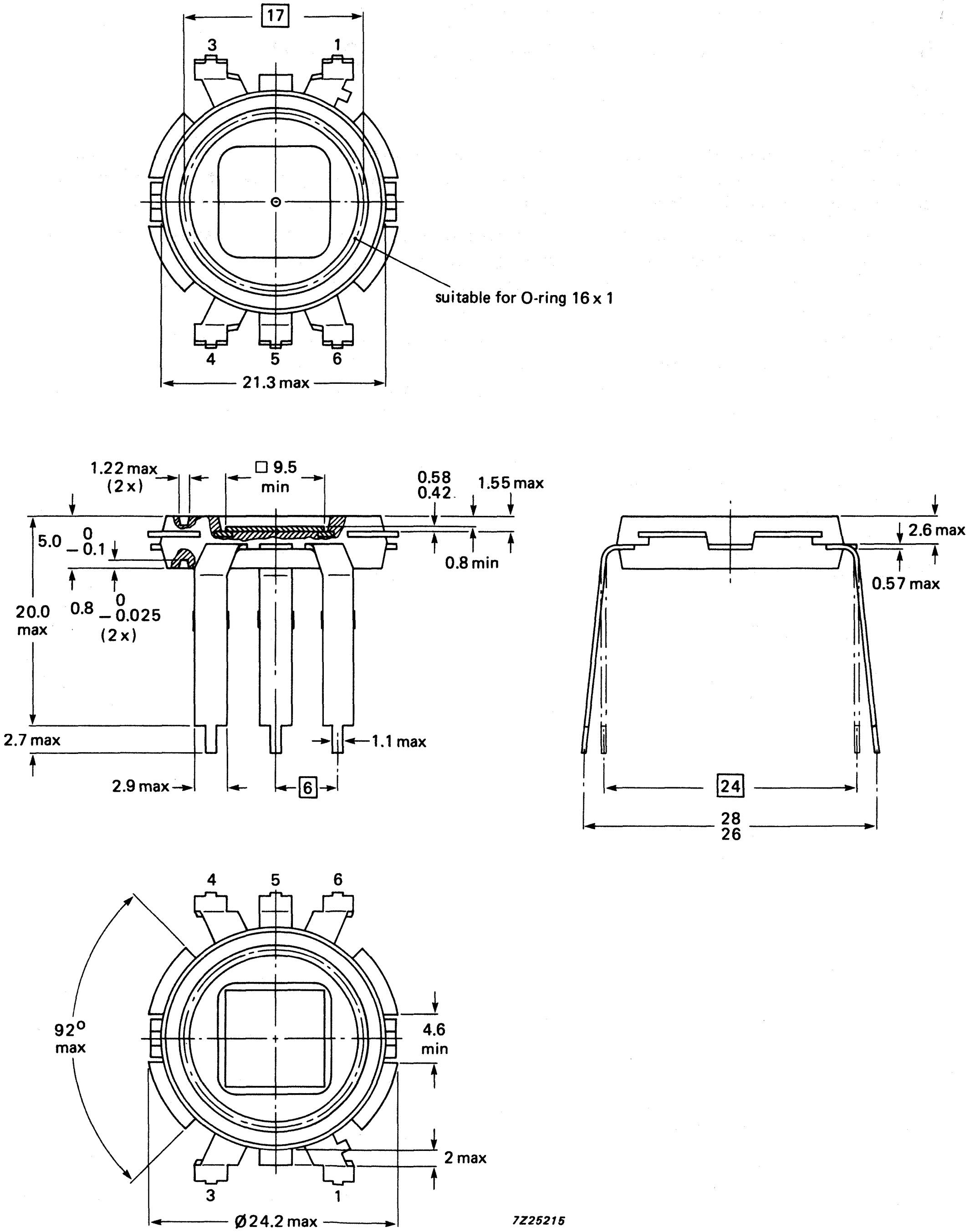


Fig. 1 SOT198D1.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Maximum operating voltage	V_B	=	8.0	V
Maximum pressure	P_{max}	=	2000	kPa
Destructive pressure ($t < 10$ min.)	P_b	$\geqslant$	3000	kPa
Operating ambient temperature range	T_{amb}	=	−40 to + 120	°C
Storage temperature range	T_{stg}	=	−65 to + 150	°C
Soldering temperature ($t < 10$ s)	T_{sld}	max.	260	°C

CHARACTERISTICS

$V_B = 6.111$ V; $T_{amb} = 25$ °C unless otherwise specified

Supply voltage	V_B	=	4.75 to 7.5	V
Supply current (with no load)	I_B	$\leqslant$	8	mA
Operating pressure range (note 1)	P	=	−100 to 1000	kPa
Sensitivity (notes 2 and 5)	S	=	5.0	mV/VkPa
Offset voltage (notes 2 and 5)	V_{off}	=	0.500	V
Linearity and pressure hysteresis combined (note 3)		$\leqslant$	1.0	%FS
Short circuit output current limitation	I_{sc}	$\leqslant$	7.0	mA
Load capacitor (with a series resistor of 60 ± 10 Ω)	C_L	=	0.1 to 1.5	μF
Load resistor	R_L	$\geqslant$	5	kΩ
Diaphragm natural frequency	f_d	>	5	kHz
Sensor response time for full scale pressure step (note 4)	t_r	$\leqslant$	10	ms
Effective leakage area (note 6)	A_{eff}	$\leqslant$	10^{-7}	cm^2

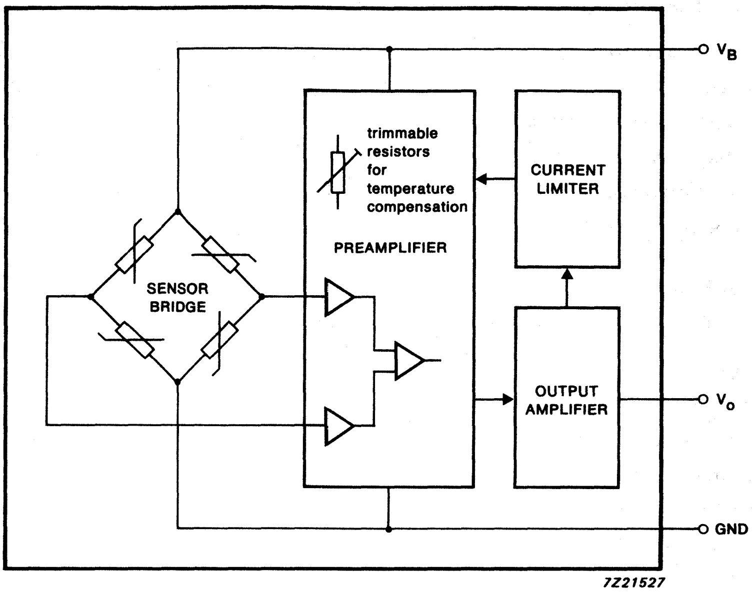


Fig. 2 Circuit diagram.

Notes to the characteristics

1. See residual voltage diagram (Fig. 5) for negative pressure values.
2. Transducer output voltage is ratiometric to operating voltage.
3. Deviation from Best Straight Line (BSL) in pressure range.
4. For $C_L = 0.1\ \mu F$.
5. Combined error (pressure and temperature) see error band specification.
6. Calculated by $\frac{1.58\ (10^{-3})\ V}{t\sqrt{3.325\ T}} \ln \frac{P_0}{P_t}$
   with V = Volume (cm^3); t = time(s); T = abs. temperature (K); P_0 = start pressure (kPa); P_t = pressure after time t (kPa).

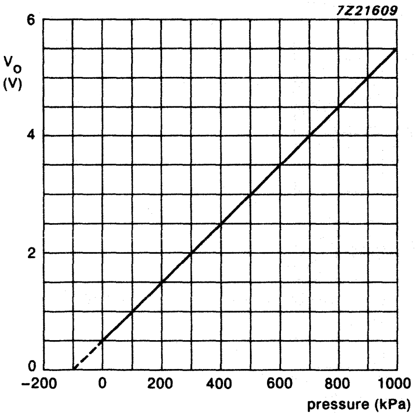


Fig. 3 Nominal output characteristic KPZ21GE.
Output voltage as a component of pressure;
$V_B = 6.111$ V.

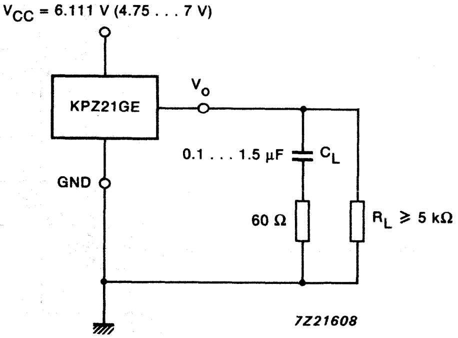


Fig. 4 Recommended output circuit:
$R_s = 60\ \Omega \pm 10\ \Omega$;
$C_L = 0.1$ to $1.5\ \mu F$;
$R_L >= 5\ k\Omega$.

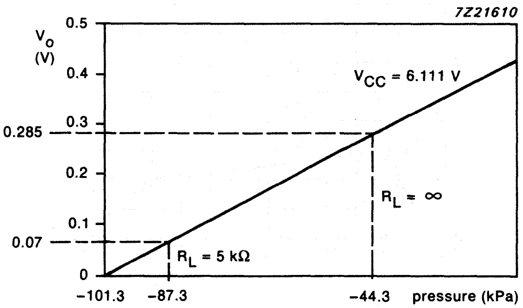


Fig. 5 Residual voltage.
Minimum output voltage as a component
of load resistance; $V_B = 6.111$ V.

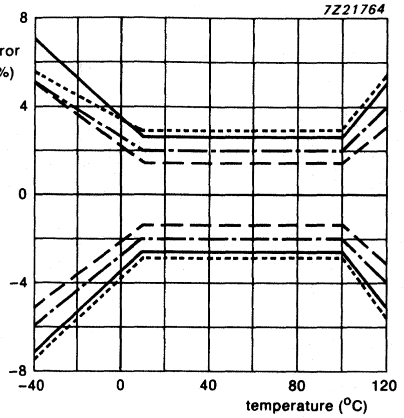


Fig. 6 KPZ21GE error band.
Error (%FS) as a component of temperature.

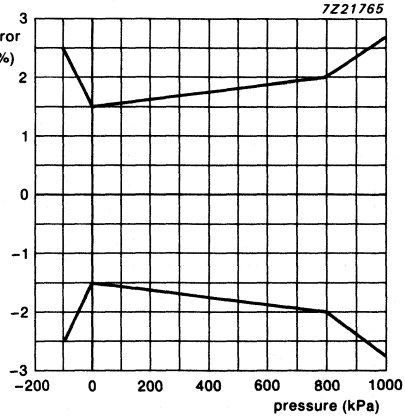


Fig. 7 KPZ21GE error band.
Error (%FS) as a function of pressure (kPa).

OXYGEN PROBE ASSEMBLY

The Oxygen Probe Assembly is used for measuring the oxygen partial pressure in flue gases of industrial gas, and oil, fired heating systems or in oxygen control systems.

The Oxygen Probe Assembly consists of a ZrO_2 oxygen sensor and an electronic interface circuit. The sensor comprises two ZrO_2 discs with a small hermetically sealed chamber in between. It is mounted at the tip of a stainless steel rod and it is heated by an internal filament.

The interface circuit comprises a voltage amplifier for the sense signal, a constant current source for the pump and a 1 kHz amplifier for temperature control.

The Oxygen Probe Assembly has to be operated with a measuring assembly which controls the sensor operation and the signal processing. All specified data apply to operation with stabilized sensor temperature.

QUICK REFERENCE DATA

Oxygen pressure range	2 mbars to 1 bar
DC supply voltage	–5 V to + 7 V
Heater supply	5.5 V; (typ.) 1.8 A
Sense voltage levels	4 - 36 - 76 mV
Average pump current	32 μA (typ.)
Sensor operating temperature	700 °C
Maximum gas temperature	400 °C
Operating ambient temperature	0 to 60 °C

MECHANICAL DATA

See Fig. 1.

MECHANICAL DATA

Dimensions in mm

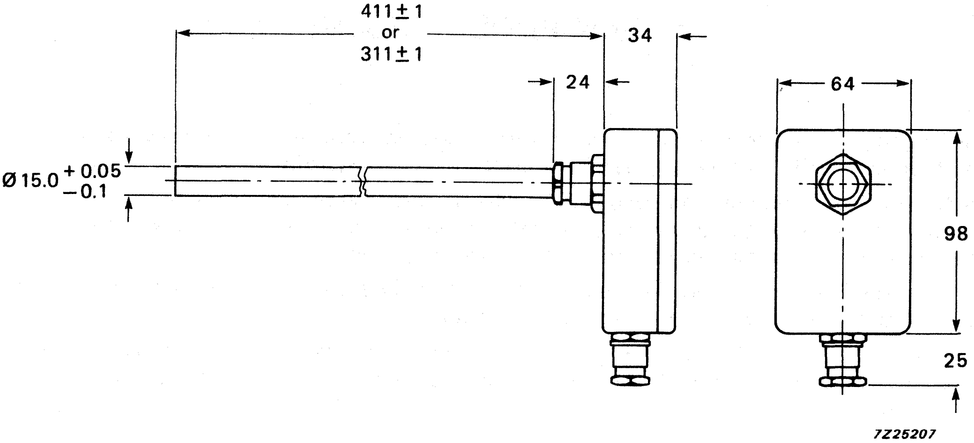


Fig. 1 Oxygen probe assembly.

The sensor is mounted at the end of a stainless steel rod which has a length of 311 mm (KGZ20), or 411 mm (KGZ21). The electronic interface circuit is housed within an epoxy coated aluminium box which has a Pg 9 cablegland.

The probe assembly should be fitted in the flue with a hermetically closed swivel. It must be mounted in such a way that no water or condensation can reach the sensing element. The preferred method of mounting is with the top of the probe pointing approximately 15° downwards.

The temperature of the interface box should not exceed 60 °C.

ELECTRICAL DATA

The pump current is applied as a block signal between 0 and 2 I_p (pressurization), I_p being the average pump current. The 1 kHz pump voltage output is used for temperature control.

1	+ 7 V
2	1 kHz signal
3	+ I_p control
4	Heater supply
5	Mass
6	Heater supply
7	− I_p control
8	Sense voltage
9	−5 V

Fig. 2 Terminals interface box.

Terminal connections:

1\. Positive supply voltage + 7 V ± 5%; I = 2.5 mA max.
9\. Negative supply voltage −5 V (−12 V ± 0.5% with respect to positive supply). I = 2.5 mA max.
5\. Ground (connected to the housing and to the common of the sensing element).
4; 6. Heater supply (typ. 1.8 A; 5.5 V).
2\. 1 kHz pump voltage output: 50 mV RMS*
8\. Sense voltage output (x 50).
3; 7. Control of pump current switch.

Positive pump current (+ I_p) (evacuation):
terminal 3: 1 kHz block signal, T/2, L = −4 V, H = + 6 V
terminal 7: (DC voltage) + 6 V

Negative pump current ($-I_p$) (pressurization):
terminal 3: (DC voltage) + 6 V
terminal 7: 1 kHz block signal, T/2, L = −4 V, H = + 6 V.

The required shape of the block signal is shown in Fig. 3. The output impedance of the control circuit should be < 1 kΩ.

The Kroschu Low Voltage Cable LiYCY is recommended as a connection cable.

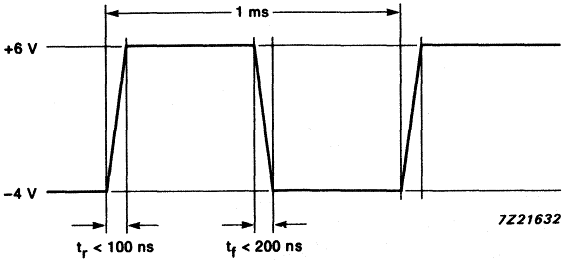


Fig. 3 Required shape of pump switch block signal.

* Heater voltages to be adjusted for V_{2-5} = 50 mV RMS.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Positive supply voltage V_{1-5}	min.	0 V	max.	+ 18 V
Negative supply voltage V_{9-5}	min.	−18 V	max.	0 V
Total supply voltage V_{1-9}			max.	18 V
Pump current switch control inputs 3-7			max.	0.5 V (note 1)
	min.	0.5 V (note 2)		
DC current to inputs 3 and 7			max.	10 mA
Pump and sense voltage outputs 2 and 8			short circuit protected	
Heater supply connections 4 and 6			max.	40 V (note 3)
Storage temperature range				−40 to + 150 °C
Ambient operating temperature				0 to −60 °C
Gas temperature			max.	400 °C
Gas flow rate			max.	20 m/s
Heater power			max.	15 W
Repetitive permissible acceleration			max.	5 g
Incidental permissible acceleration			max.	30 g

CHARACTERISTICS

(Operation with stabilized sensor temperature)

Oxygen pressure range	2 mbar to 1 bar
Sense voltage levels	4 - 36 - 76 mV
Pump current	typ. 32 μA
Heater supply (note 4)	typ. 1.8 A; 5.5 V
Operating temperature	nom. 700 °C
1 kHz pump resistance at 700 °C	typ. 200 Ω
Sensitivity (note 5)	16.51 ms/mbar
Accuracy (note 6)	better than 2 mbar in the range 10 - 255 mbar (when calibrated in ambient air)
Response time	< 10 s
Warming-up time	< 100 s

Notes

1. Above positive supply voltage.
2. Below negative supply voltage.
3. With respect to ground and sensing element.
4. Heater voltage to be adjusted for V_2 = 50 mV RMS.
5. The sensitivity is related to the differential cycle time 4 - 36 - 76.
6. Calibration can be done with ambient air. The reading should be: 0.207 x barometric pressure (in mbar).

APPLICATION NOTES

The sensor can be used in the exhaust gases after combustible and many other gas mixtures. Halides, lead an particulate matter can degrade performance over long periods of operation. Reducing atmospheres may in time impair the catalytic effect of the platinum electrodes.

The sensor should remain at operating temperature when exposed to exhaust gases. When not in operation, storage in ambient air is recommended.

Block diagrams of the qxygen probe assembly and the external circuitry (measuring assembly) are shown in Fig. 4.

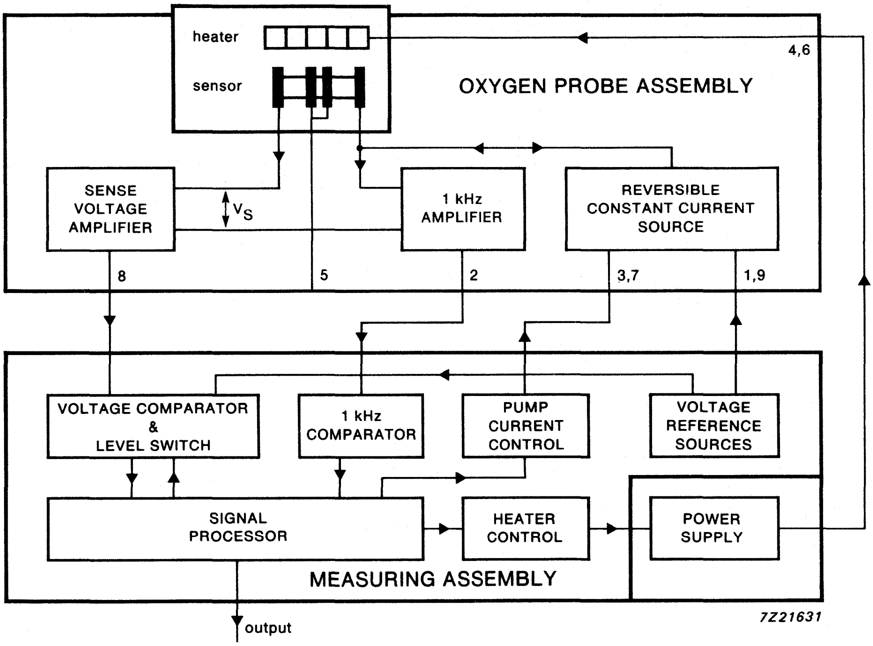


Fig. 4 KGZ20/21 Oxygen Probe and Measuring Assemblies.

The concept of cyclic evacuation and pressurization and the cycle periods t_p and t_d are illustrated in Fig. 5. The pump current is reversed at the Nernst voltage levels of 0 and 80 mV. Actual O_2-measurements take place using the periods t_1, t_2, t_4 and t_5, determined by the additional preset levels at 4, 36 and 76 mV.

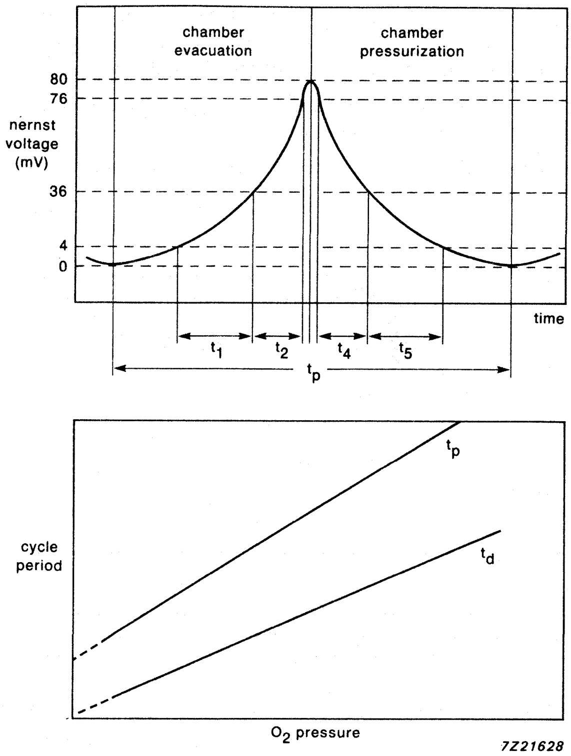


Fig. 5 Cyclic evacuation and pressurization; $t_d = t_1 - t_2 + t_5 - t_4$.

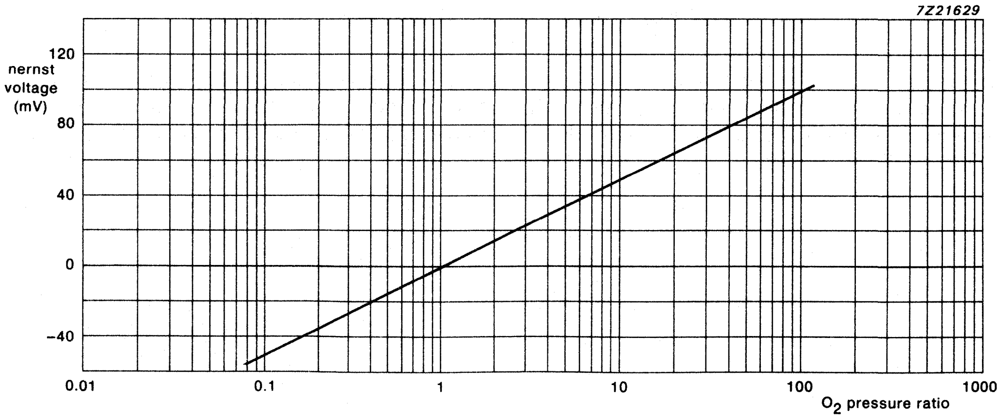


Fig. 6 Nernst voltage as a component of O_2 pressure ratio.

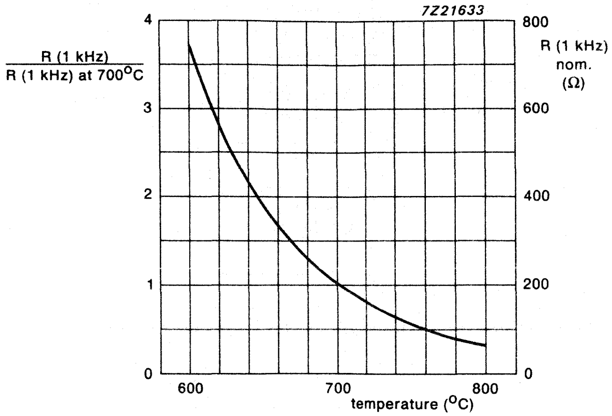


Fig. 7 Change in electrical resistance of pump element as a function of temperature.

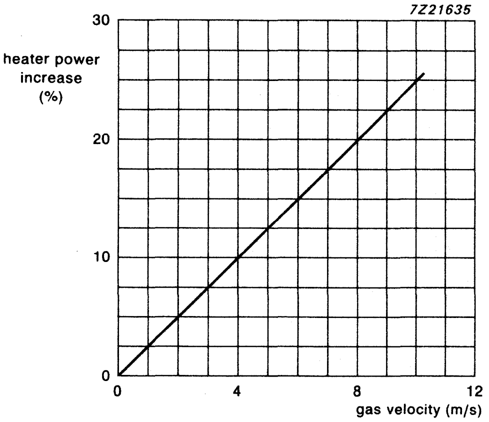


Fig. 8 Increase of required heater power as a function of gas velocity (sensor temperature 700 °C, gas temperature 20 °C).

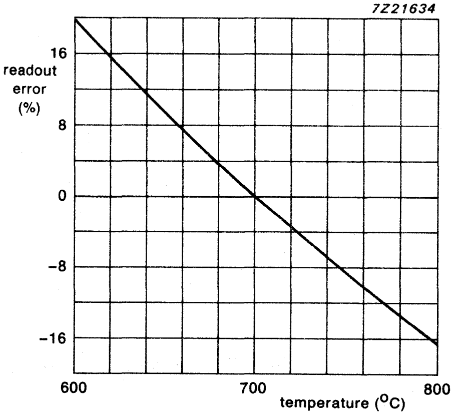


Fig. 9 Calculated temperature dependence of sensor readout.

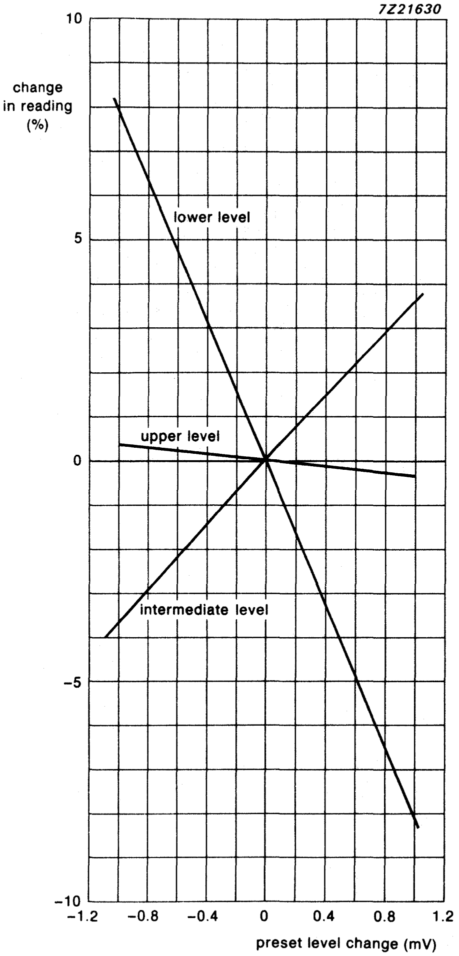


Fig. 10 Change of O_2 readout with change of sense preset levels.

OXYSTOR

The Oxystor can be used for measuring the oxygen partial pressure in flue gases of gas and of oil fired heating systems or in oxygen control systems.

The Oxystor consists of a ZrO_2 oxygen sensing element within a protective housing. The sensing element comprises two ZrO_2 discs with a small hermetically sealed chamber in between. It is mounted on a stainless steel base plate and surrounded by a porous stainless steel cap. The sensor is heated by an internal filament. The Oxystor has a 4-fold faston connector at the back.

The Oxystor has to be operated with a measuring assembly which controls the sensor operation and the signal processing.

Two types of operation are possible:

1. With unstabilized sensor temperature (TC = 0 mode; no heater power control).
2. With stabilized sensor temperature (700 °C) and optimized accuracy.

QUICK REFERENCE DATA

Oxygen pressure range	2 mbar to 1 bar
Heater supply voltage	4.35 V; 1.85 A
Sense voltage levels	45 - 64 - 85 mV (TC — 0 mode) 4 - 36 - 76 mV (stab. mode)
Pump current	40 μA
Sensor operating temperature	700 °C
Max. gas temperature	300 °C
Operating ambient temperature range	0 to 80 °C

MECHANICAL DATA

Dimensions in mm

S = Sense
C = Common
P = Pump
H = Heater
M = Marker

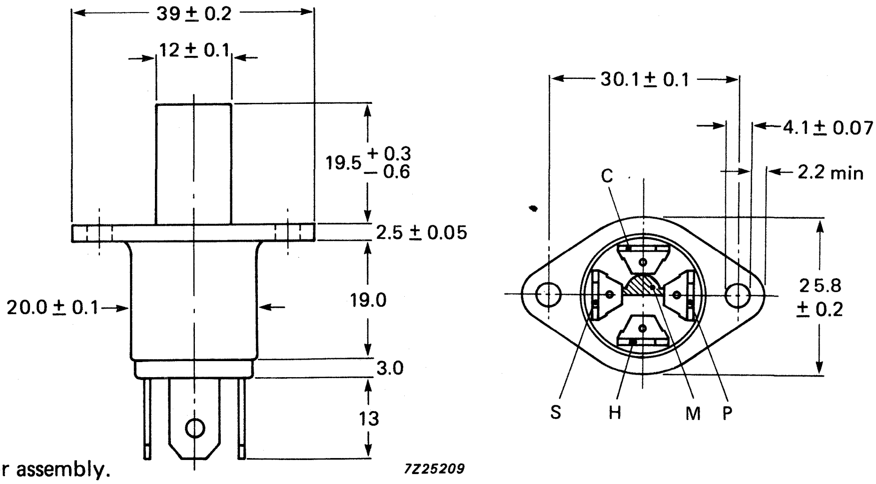


Fig. 1 Oxystor assembly.

One side of the heater is connected to the sensor housing. The dimensions of the fastons are 8.0 x 0.7 mm.

The Oxystor should be mounted in the flue in such a way that erratic operation caused by direct contact with water as a result of condensation is prevented.

RECEPTACLES FOR THE OXYSTOR KGZ10

In the connector of the oxystor, four 8.0 x 0.7 mm faston contact tabs are mounted at the back. This size of faston is normally used in headlight installations in automobiles. Receptacles for 8.0 mm faston contact tabs are available in various materials (and with various finishes). The choice of material and finish depends on the operating temperature of the contact and on the environmental conditions. The following list shows some materials (and finishes) and their allowable connection temperatures (in accordance with AMP Holland BV).

material	finish	allowable connection temperature °C
brass	–	90
	tin plated	110
	silver plated	130
phosphor bronze	–	90
	tin plated	110
	silver plated	130
steel	nickel plated	250

Currently, the most used receptacles are made of tin plated brass. Under normal circumstances (flue gas temperature < 300 °C, ambient temperature 20 °C), these receptacles are suitable for use with the Oxystors. Under unfavourable conditions, when the connection temperature is expected to rise above 110 °C (high flue gas temperature, less convection, mounting in an enclosed volume), it is advisable to use nickel plated steel receptacles.

The synthetic material at the back of the Oxystor connector can withstand 250 °C. This temperature is normally not reached. Even when the Oxystor bottom plate has a temperature of 300 °C, the temperature of the synthetic material is found to be only 180 °C.

ELECTRICAL DATA

The **heater** can be supplied with either a DC or an AC voltage (typ. 4.35 V at 1.85 A).

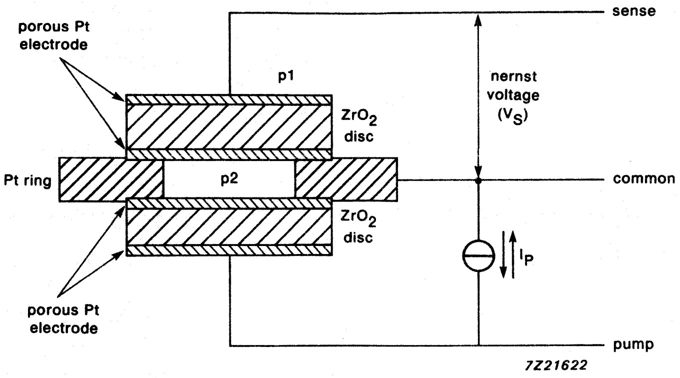


Fig. 2 Oxygen sensor cross section, showing the pump disc and the pressure sensing disc. The heating coil is not shown.

The pump current of 40 μA can be supplied as a DC current (TC = 0 mode) or as a 1 kHz pulsed current (stabilized mode). In the latter case, the 1 kHz resistance value of the pump disc is used for temperature readout control.

When using a sense voltage amplifier, the input resistance of the amplifier should be $>$ 1 MΩ.
The leads between the Oxystor and the amplifier should not exceed 50 cm.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Heater supply voltage	max.	5	V
Sensor connections (pump, common, sense) voltage with respect to sensor housing			
Mutually			
when at operating temperature	max.	1	V
without heater supply voltage	max.	5	V
Pump (or sense) current; $t_{max.}$ = 10 s	max.	100	μA
Permissible intern. O_2-pressure	max.	1	bar
Permissible intern. O_2-pressure	min.	0.01	mbar
Storage temperature range		−40 to + 80	^oC
Ambient operating temperature range		0 to 80	^oC
Gas temperature	max.	300	^oC
Temperature of base plate	max.	300	^oC
Gas flow rate	max.	20	m/s
Repetitive permissible acceleration	max.	5	g
Incidental permissible acceleration	max.	30	g

CHARACTERISTICS

Oxygen pressure range	2 mbar to 1 bar
Sense voltage levels	45 - 64 - 85 mV (TC = 0 mode) 4 - 36 - 76 mV (stabilized mode)
Pump current	40 μA DC (TC = 0 mode) 40 μA avg. 1 kHz pulse (stabilized mode)
Heater supply	4.35 V; 1.85 A (typ.)
Operating temperature	700 °C (nom.) 625 to 800 °C (TC = 0 mode)
Pump resistance at 700 °C	DC 1 kΩ (typ.) 1 kHz 120 Ω (typ.)
Sensitivity (typical values) (note 1)	1.05 ms/mbar (TC = 0 mode) 13 ms/mbar (stabilized mode)
Accuracy (note 2)	better than 5 mbar (TC = 5 mbar) better than 2 mbar (stabilized mode)
Response time	< 4 s (TC = 0 mode) < 10 s (stabilized mode)
Warming-up time	< 100 s

Notes to the characteristics

1. The sensitivities are related to the differential cycle periods 45 - 64 - 85 and 4 - 36 - 76.
2. The accuracy quoted is for the pressure range 10 to 255 mbar and after calibration in ambient air. During calibration, the reading should be: 0.207 x barometric pressure (mbar).

APPLICATION NOTES

The Oxystor can be used in exhaust gases after combustion, and many other gas mixtures. Halides, lead a particulate matter can degrade performance over long periods of operation. Reducing atmospheres may in time impair the catalytic effect of the platinum electrodes.

The sensor should remain at operating temperature when exposed to exhaust gases. When not in operation, storage in ambient air is recommended.

Figure 3 illustrates the concept of cyclic evacuation and pressurization and the cycle periods t_p and t_d. The pump current is reversed at the Nernst voltage levels of 41 and 89 mV (TC = 0 mode) or 0 and 80 mV (stabilized mode). Actual O_2 measurements take place using the periods t_1, t_2, t_4 and t_5, determined by the additional preset levels at 45, 64 and 85 mV (TC mode) or 4.36 and 76 mV (stabilized mode).

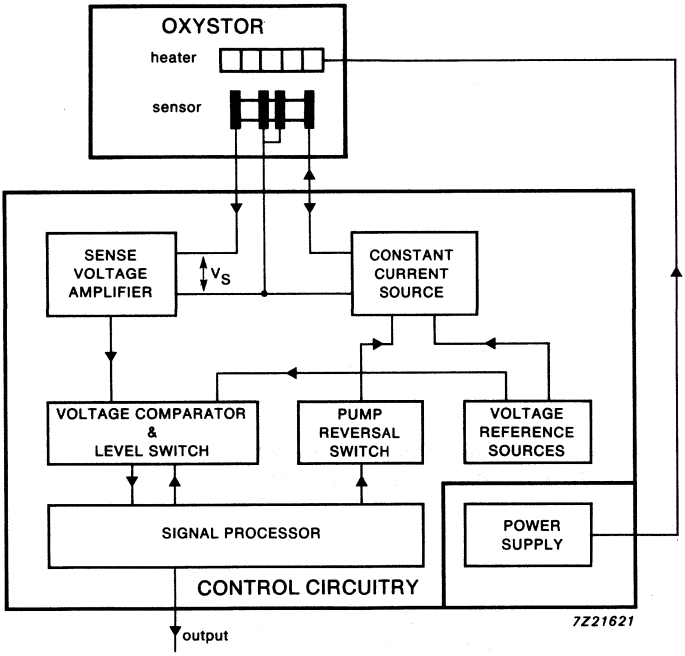


Fig. 3 Oxystor control block diagram.

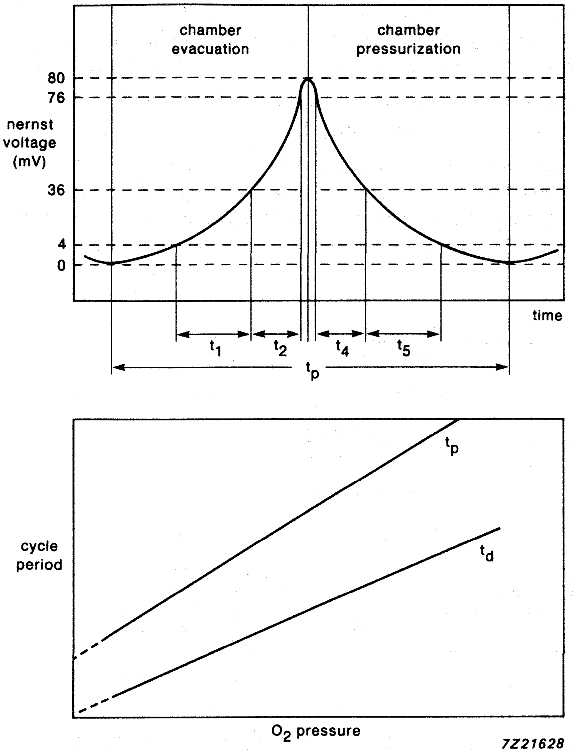


Fig. 4 Concept of differential period t_d, with 3 additional preset levels 4, 30 and 76 mV in the measurement of the period.

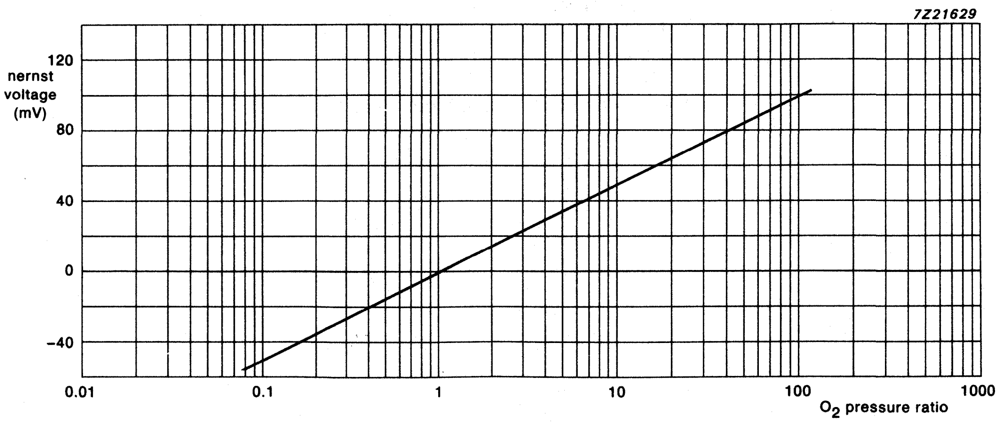


Fig. 5 Nernst voltage as a function of O_2 pressure ratio; T = 1000 ^{o}K.

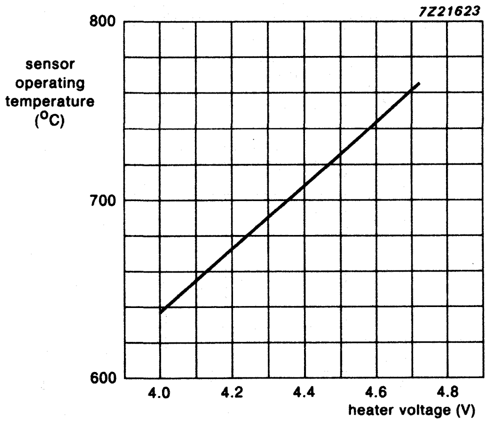


Fig. 6 Sensor operating temperature as a component of heater voltage.

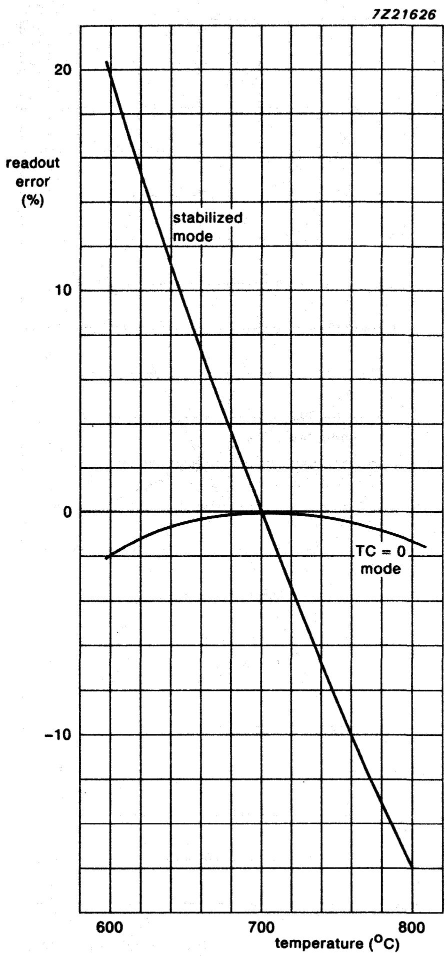


Fig. 7 Calculated temperature dependence of the sensor readout in TC = 0 mode and in stabilized mode.

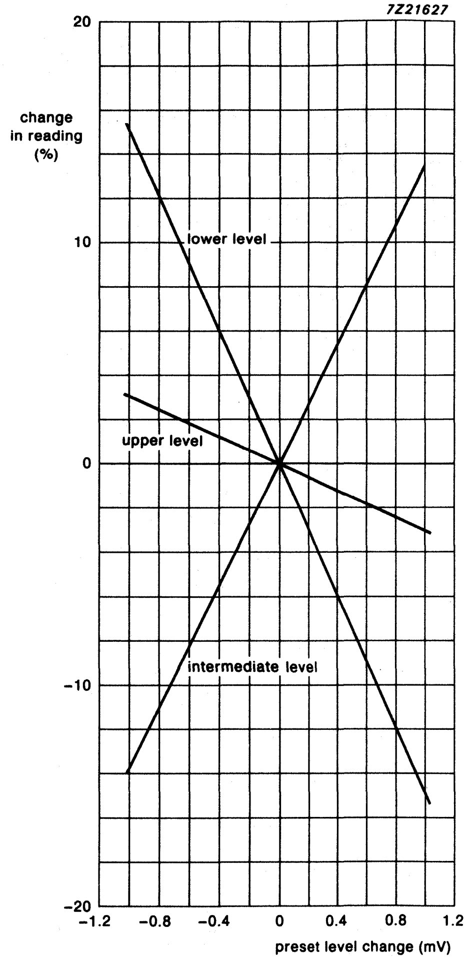


Fig. 8 Change in reading as a component of preset level change, TC = 0 mode.

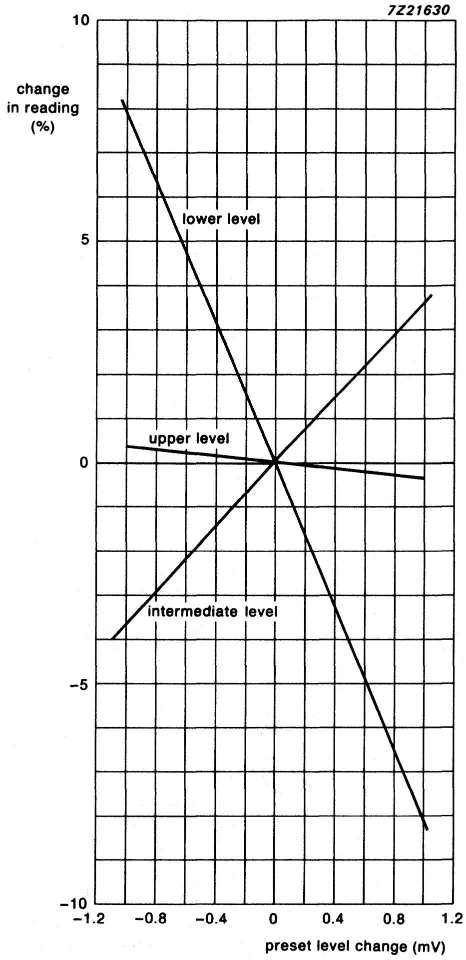


Fig. 9 Change in reading as a component of preset level change, stabilized mode.

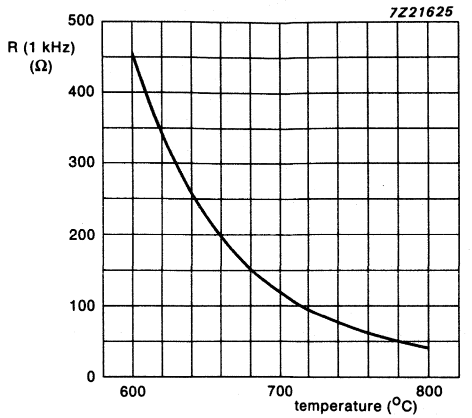


Fig. 10 Temperature as a component of 1 kHz pump resistance.

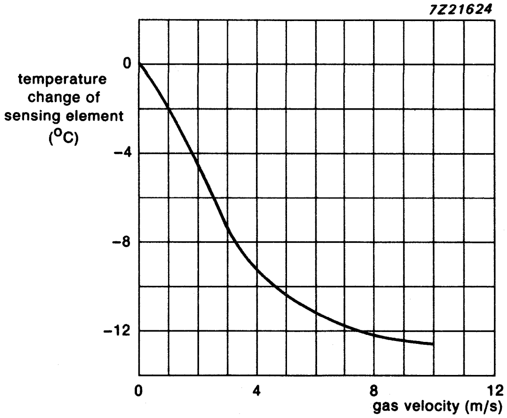


Fig. 11 Change of sensing element temperature as a component of gas velocity.

TEMPERATURE SENSORS

SILICON TEMPERATURE SENSORS

These sensors have a positive temperature coefficient of resistance and are for use in measurement and control.

QUICK REFERENCE DATA

Resistance at T_{amb} = 25 °C
I_C = 1 mA

KTY81-110	R_{25}	990 - 1010 Ω
KTY81-120	R_{25}	980 - 1020 Ω
KTY81-121	R_{25}	980 - 1000 Ω
KTY81-122	R_{25}	1000 - 1020 Ω
KTY81-150	R_{25}	950 - 1050 Ω
KTY81-151	R_{25}	950 - 1000 Ω
KTY81-152	R_{25}	1000 - 1050 Ω

KTY81-120 is composed of groups −121 and −122 and is correspondingly designated.

KTY81-150 is composed of groups −151 and −152 and is correspondingly designated.

Operating ambient temperature range T_{amb} −55 to +150 °C

MECHANICAL DATA

Dimensions in mm

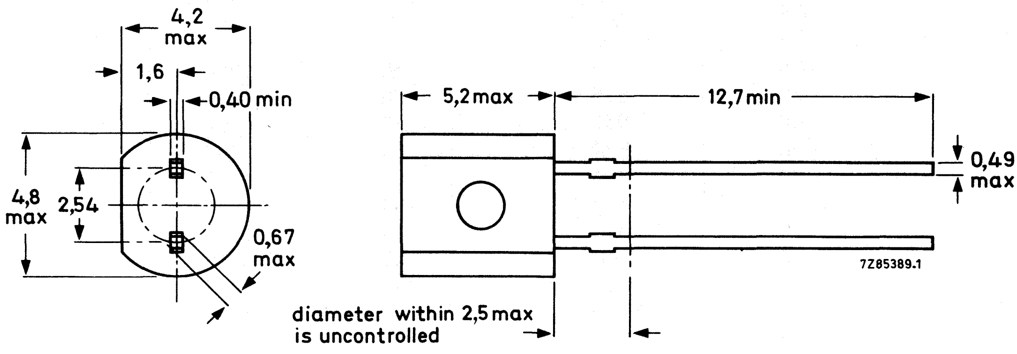


Fig. 1 SOD-70.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Continuous sensor current in free air			
$T_{amb} = 25\ ^{o}C$	I_C	max.	10 mA
$T_{amb} = 150\ ^{o}C$	I_C	max.	2.0 mA

CHARACTERISTICS

(Based on the measurements in liquid at $T_{amb} = 25\ ^{o}C$ unless otherwise specified).

Resistance				
$I_C = 1$ mA	KTY81-110	R_{25}	990 - 1010 Ω	
	KTY81-120	R_{25}	980 - 1020 Ω	
	KTY81-121	R_{25}	980 - 1000 Ω	
	KTY81-122	R_{25}	1000 - 1020 Ω	
	KTY81-150	R_{25}	950 - 1050 Ω	
	KTY81-151	R_{25}	950 - 1000 Ω	
	KTY81-152	R_{25}	1000 - 1050 Ω	
Temperature coefficient		typ.		0.79 %/K
→ Resistance ratio		R100/R25	1.696 ± 0.020	
		R−55/R25	0.490 ± 0.010	
Thermal time constant*				
in still air		typ.		30 s
in still liquid**		typ.		5.0 s
in flowing liquid**		typ.		3.0 s
Measuring temperature range				−55 to +150 °C

T_{amb} °C	Resistance Ω
−55	490
−50	515
−40	567
−30	624
−20	684
−10	747
0	815
10	886
20	961
25	1000
30	1040
40	1122
50	1209
60	1299
70	1392
80	1490
90	1591
100	1696
110	1805
120	1915
130	2023
140	2124
150	2211

Ambient temperature and corresponding average resistance values of sensor ($I_C = 1$ mA).

---

* The thermal time constant is the time the sensor needs to reach 63.2% of the total temperature difference. For instance, the time needed to reach a temperature of 72.4 °C, when a sensor with an initial temperature of 25 °C is put into an ambient with a temperature of 100 °C.

** Inert liquid FC43 of 3M company.

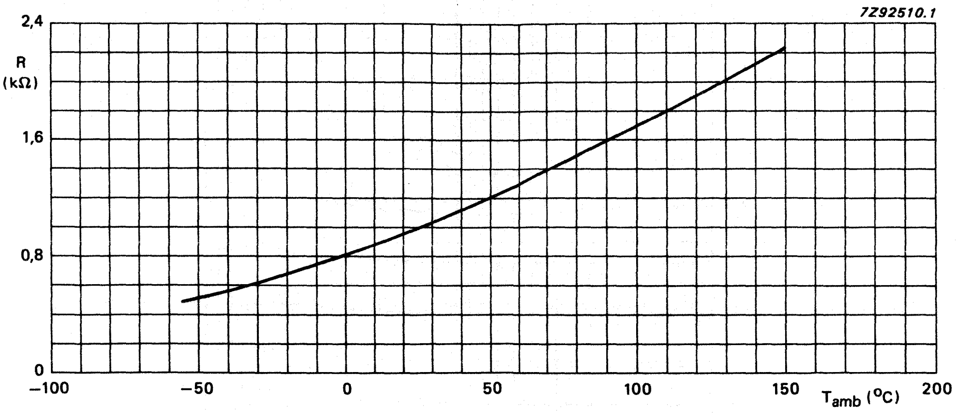


Fig. 2 Average resistance value of sensor at I_C = 1 mA as a function of temperature.

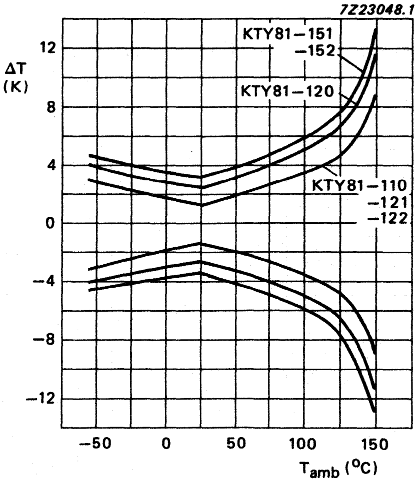


Fig. 3 Maximum expected temperature error ΔT.

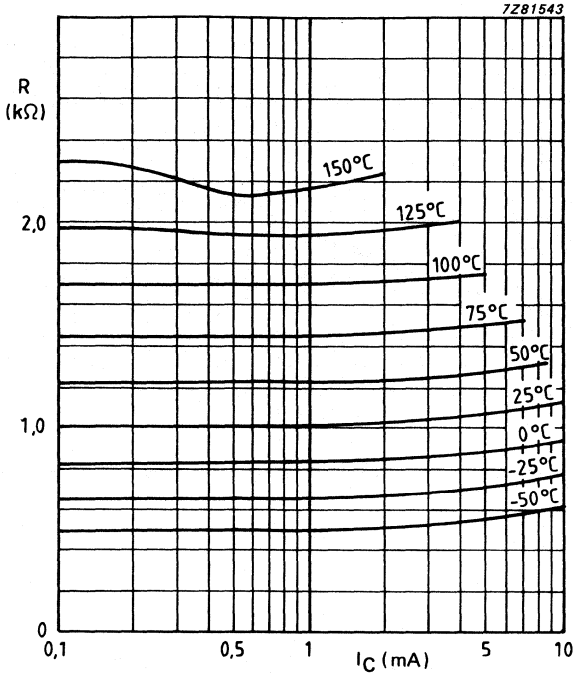


Fig. 4 Sensor resistance as a function of operating current (see Note).

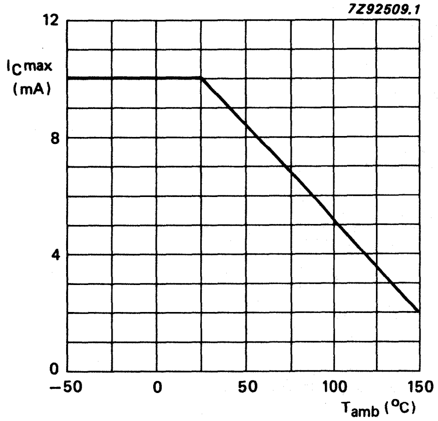


Fig. 5 Maximum operating current for safe operation.

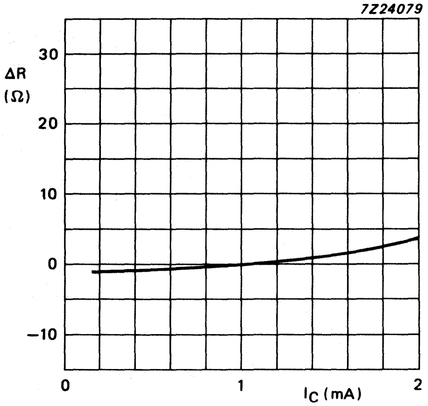


Fig. 6 Resistance deviation as a function of measuring current in still liquid; T_{amb} = 25 °C.

Note

To minimize temperature error, an operating current of I_C = 1 mA is recommended for temperatures above 100 °C.

SILICON TEMPERATURE SENSORS

These sensors have a positive temperature coefficient of resistance and are for use in measurement and control systems.

QUICK REFERENCE DATA

Resistance at T_{amb} = 25 °C
I_C = 1 mA

KTY81-210	R_{25}	1980 - 2020 Ω
KTY81-220	R_{25}	1960 - 2040 Ω
KTY81-221	R_{25}	1960 - 2000 Ω
KTY81-222	R_{25}	2000 - 2040 Ω
KTY81-250	R_{25}	1900 - 2100 Ω
KTY81-251	R_{25}	1900 - 2000 Ω
KTY81-252	R_{25}	2000 - 2100 Ω

KTY81-220 is composed of groups –221 and –222 and is correspondingly designated.

KTY81-250 is composed of groups –251 and –252 and is correspondingly designated.

Operating ambient temperature range T_{amb} –55 to +150 °C

MECHANICAL DATA

Dimensions in mm

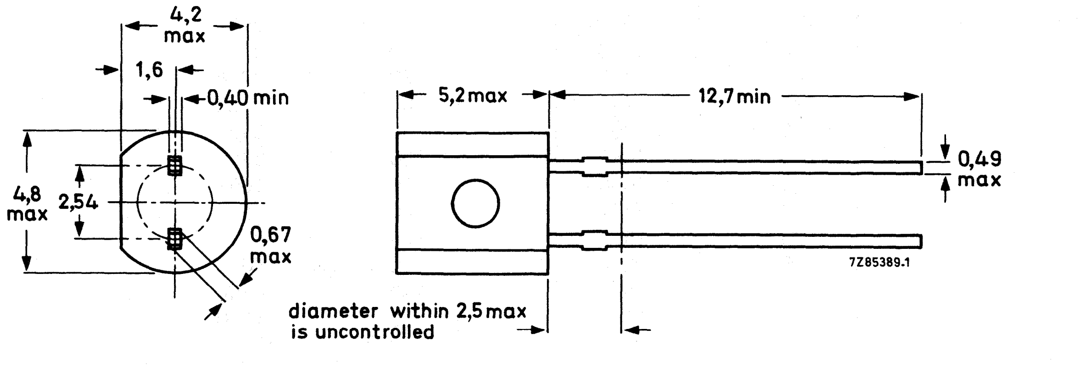


Fig. 1 SOD-70.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Continuous sensor current in free air

T_{amb} = 25 °C	I_C	max.	10 mA
T_{amb} = 150 °C	I_C	max.	2.0 mA

CHARACTERISTICS

(Based on the measurements in liquid at T_{amb} = 25 °C unless otherwise specified).

Resistance				
I_C = 1 mA	KTY81-210	R_{25}	1980 - 2020 Ω	
	KTY81-220	R_{25}	1960 - 2040 Ω	
	KTY81-221	R_{25}	1960 - 2000 Ω	
	KTY81-222	R_{25}	2000 - 2040 Ω	
	KTY81-250	R_{25}	1900 - 2100 Ω	
	KTY81-251	R_{25}	1900 - 2000 Ω	
	KTY81-252	R_{25}	2000 - 2100 Ω	
Temperature coefficient			typ.	0.79 %/K
→ Resistance ratio		R100/R25		1.696 ± 0.020
		R−55/R25		0.490 ± 0.010
Thermal time constant*				
in still air			typ.	30 s
in still liquid**			typ.	5 s
in flowing liquid			typ.	3 s
Measuring temperature range ***				−55 to +150 °C

T_{amb} °C	Resistance Ω
−55	980
−50	1030
−40	1135
−30	1247
−20	1367
−10	1495
0	1630
10	1772
20	1922
25	2000
30	2080
40	2245

T_{amb} °C	Resistance Ω
50	2417
60	2597
70	2785
80	2980
90	3182
100	3392
110	3607
120	3817
125	3915
130	4008
140	4166
150	4280

→ Ambient temperatures and corresponding resistance values of sensor (IC = 1 mA).

* The thermal time constant is the time the sensor needs to reach 63.2% of the total temperature difference. For instance, the time needed to reach a temperature of 72.4 °C, when a sensor with an initial temperature of 25 °C is put into an ambient with a temperature of 100 °C.

** Inert liquid FC43 of 3M company.

*** Restricted accuracy in the temperature range 125 °C to 150 °C.

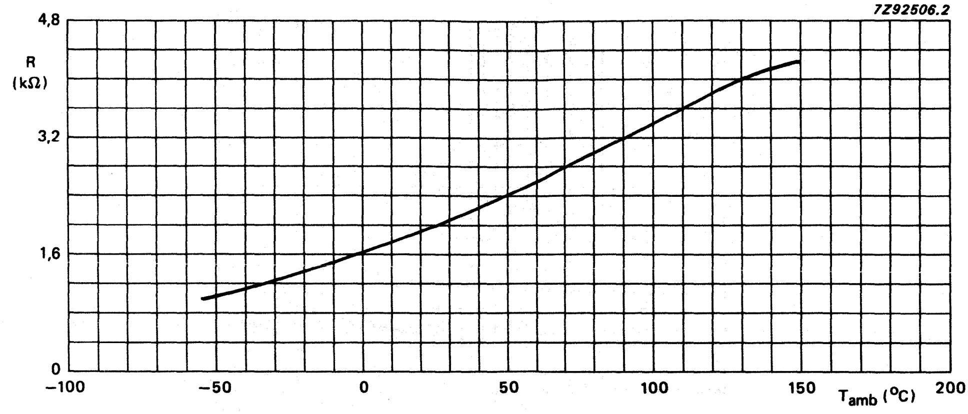


Fig. 2 Average resistance value of sensor at I_C = 1 mA as a function of temperature.

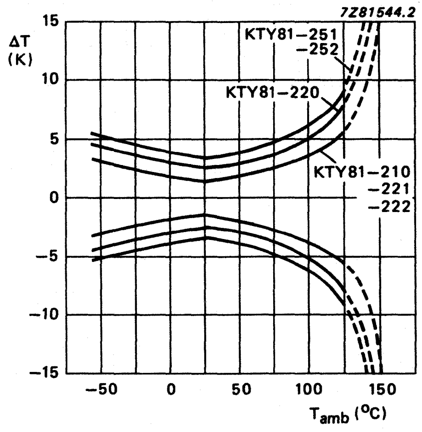


Fig. 3 Maximum expected temperature error ΔT.

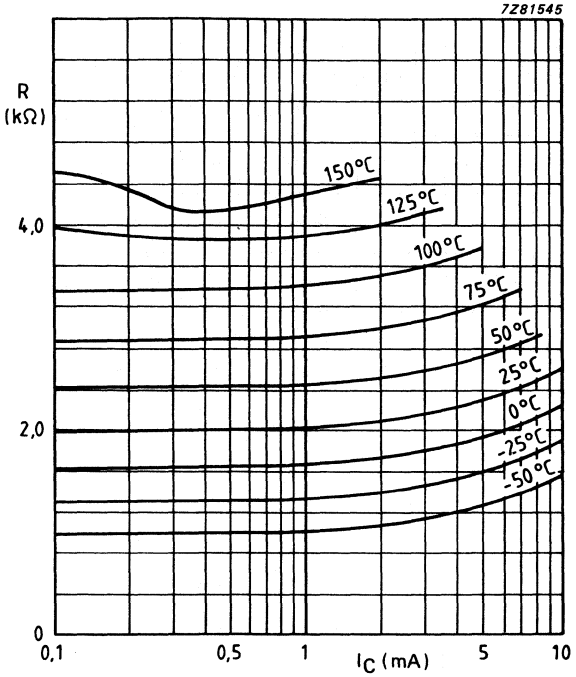


Fig. 4 Sensor resistance as a function of operating current (see Note).

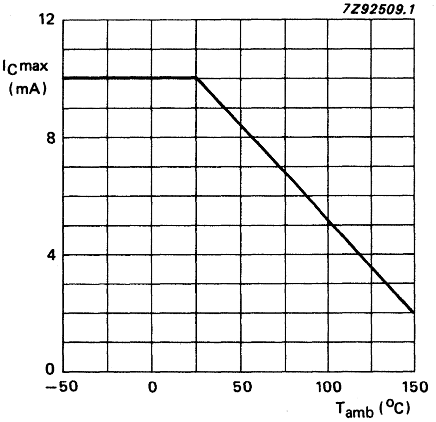


Fig. 5 Maximum operating current for safe operation.

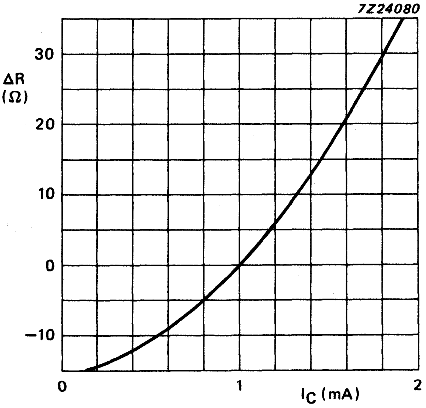


Fig. 6 Resistance deviation as a function of measuring current in still liquid; T_{amb} = 25 °C.

Note

To keep the temperature error low, an operating current of I_C = 1 mA is recommended for temperatures above 100 °C.

SILICON TEMPERATURE SENSORS

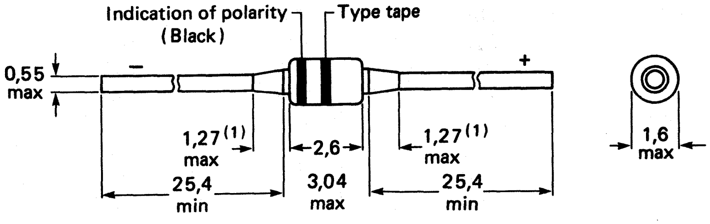
These sensors have a positive temperature coefficient of resistance and are for use in measurement and control.

QUICK REFERENCE DATA

		Type tape (identification colour)
Resistance at T_{amb} = 25 °C I_C = 1 mA	KTY83-100	R_{25} = 990 - 1010 Ω; yellow
	KTY83-120	R_{25} = 980 - 1020 Ω; white or green
	KTY83-121	R_{25} = 980 - 1000 Ω; white
	KTY83-122	R_{25} = 1000 - 1020 Ω; green
	KTY83-150	R_{25} = 950 - 1050 Ω; black or blue
	KTY83-151	R_{25} = 950 - 1000 Ω; black
	KTY83-152	R_{25} = 1000 - 1050 Ω; blue
	KTY83-120	is composed of groups −121 and −122 and is correspondingly designated.
	KTY83-150	is composed of groups −151 and −152 and is correspondingly designated.
Operating ambient temperature range T_{amb}		−55 to +175 °C

MECHANICAL DATA

Dimensions in mm



(1) Lead diameter in this zone uncontrolled

Fig. 1 DO-34 (SOD-68).

Note

The sensor has to be operated with the lower potential at the marked connection (black type).

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Continuous sensor current in free air

T_{amb} = 25 °C	I_C	max.	10 mA
T_{amb} = 175 °C	I_C	max.	2.0 mA

CHARACTERISTICS

(Based on the measurements in liquid at T_{amb} = 25 °C unless otherwise specified)

Resistance

I_C = 1 mA	KTY83-110	R_{25} = 990 - 1010 Ω
	KTY83-120	R_{25} = 980 - 1020 Ω
	KTY83-121	R_{25} = 980 - 1000 Ω
	KTY83-122	R_{25} = 1000 - 1020 Ω
	KTY83-150	R_{25} = 950 - 1050 Ω
	KTY83-151	R_{25} = 950 - 1000 Ω
	KTY83-152	R_{25} = 1000 - 1050 Ω

Temperature coefficient	typ.	0.76 %/K
→ Resistance ratio	R100/R25	1.67 ± 0.02
	R–55/R25	0.50 ± 0.01
Thermal time constant*		
in still air	typ.	20 s
in still liquid**	typ.	1.0 s
in flowing liquid**	typ.	0.5 s
Measuring temperature range		–55 to +175 °C

T_{amb} °C	Resistance Ω
–55	500
–50	525
–40	577
–30	632
–20	691
–10	754
0	820
10	889
20	962
25	1000
30	1039
40	1118
50	1202
60	1288

T_{amb} °C	Resistance Ω
70	1379
80	1472
90	1569
100	1670
110	1774
120	1882
125	1937
130	1993
140	2107
150	2225
160	2346
170	2471
175	2535

Ambient temperatures and corresponding resistance values of sensor (I_C = 1 mA).

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* The thermal time constant is the time the sensor needs to reach 63.2% of the total temperature difference. For instance, the time needed to reach a temperature of 72.4 °C, when a sensor with an initial temperature of 25 °C is put into an ambient with a temperature of 100 °C.

** Inert liquid FC43 of 3M company.

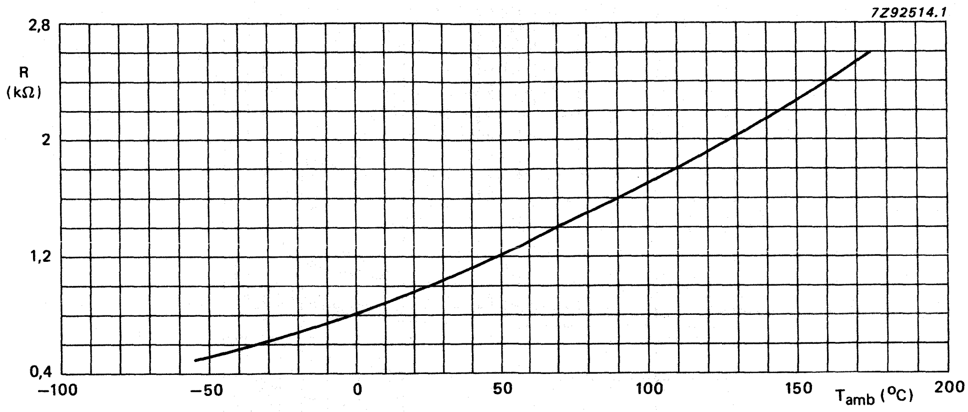


Fig. 2 Average resistance value of sensor at I_C = 1 mA as a function of temperature.

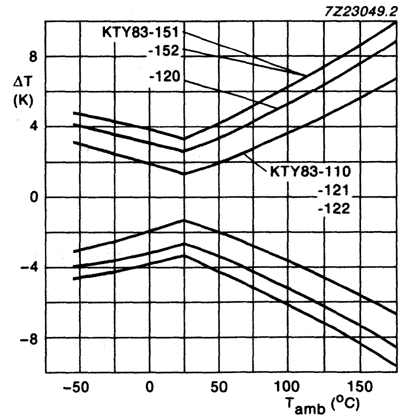


Fig. 3 Maximum expected temperature error ΔT.

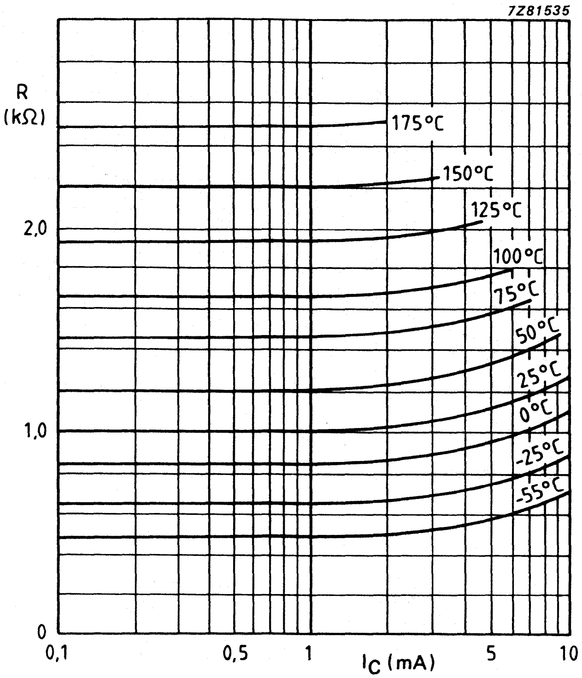
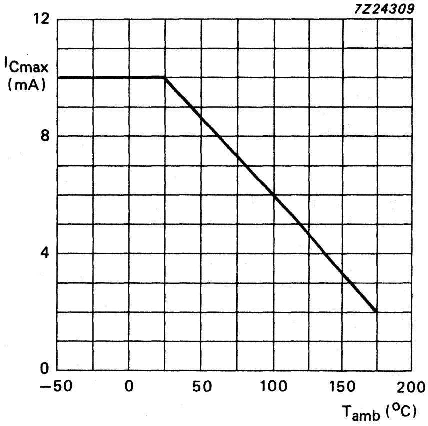


Fig. 4 Sensor resistance as a function of operating current.



→ Fig. 5 Maximum operating current for safe operation.

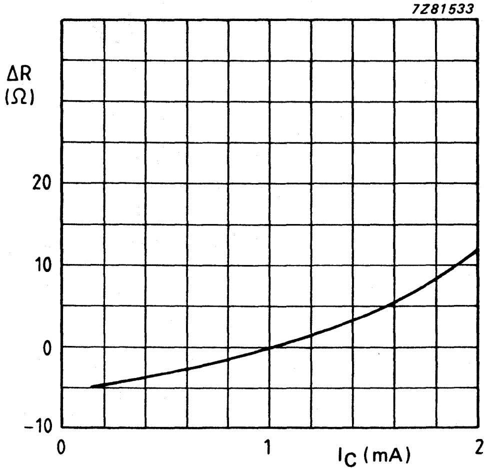


Fig. 6 Resistance deviation as a function of measuring current in still liquid; T_{amb} = 25 °C.

SILICON TEMPERATURE SENSORS

These sensors have a positive temperature coefficient of resistance and are for use in measurement and control.

QUICK REFERENCE DATA

Resistance at T_{amb} = 100 °C

I_C = 2 mA

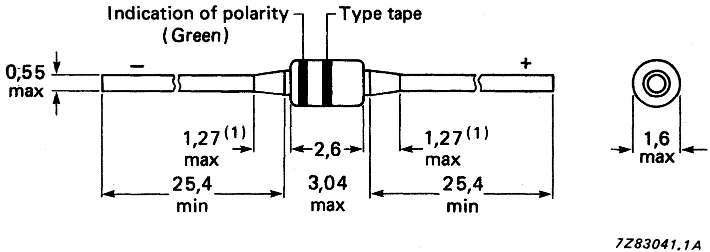
		Type tape (identification colour)
KTY84-130	R100 = 970 - 1030 Ω;	yellow
KTY84-150	R100 = 950 - 1050 Ω;	black or blue
KTY84-151	R100 = 950 - 1000 Ω;	black
KTY84-152	R100 = 1000 - 1050 Ω;	blue

KTY84-150 is composed of groups −151 and −152, and is correspondingly designated.

Measuring temperature range 0 to +300 °C

MECHANICAL DATA

Dimensions in mm



(1) Lead diameter in this zone uncontrolled

Fig. 1 DO-34 (SOD-68).

Notes

1. The sensor has to be operated with the lower potential at the marked connection.
2. Leads of the sensor are covered with a nickel layer. Hard soldering or welding is recommended.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Continuous sensor current in free air			
T_{amb} = 25 °C	I_C	max.	10 mA
T_{amb} = 300 °C	I_C	max.	2.0 mA

CHARACTERISTICS

(Based on the measurements in liquid at I_C = 2 mA;
T_{amb} = 100 °C unless otherwise specified)

KTY84-130 R100 = 970 - 1030 Ω
KTY84-150 R100 = 950 - 1050 Ω
KTY84-151 R100 = 950 - 1000 Ω
KTY84-152 R100 = 1000 - 1050 Ω

Temperature coefficient	typ.	0.61	%/K
Resistance ratio	R250/R100	2.148 ± 0.050	
	R 25/R100	0.599 ± 0.007	
Thermal time constant*			
in still air	typ.	20	s
in still liquid**	typ.	1.0	s
in flowing liquid**	typ.	0.5	s
Measuring temperature range		0 to +300	°C
Storage temperature		–55 to +300	°C

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* The thermal time constant is the time the sensor needs to reach 63.2% of the total temperature difference. For instance, the time needed to reach a temperature of 72.4 °C, when a sensor with an initial temperature of 25 °C is put into an ambient with a temperature of 100 °C.

** Inert liquid FC43 of 3M company.

Notes

1. For temperatures > 200 °C a sensor current IC of 2 mA must be used.
2. At operating temperatures above 250 °C a reduction of life time should be taken into consideration.

T_{amb} °C	Resistance Ω
0	491
10	533
20	576
25	599
30	622
40	670
50	720
60	772
70	826
80	882
90	940
100	1000
110	1062
120	1126
130	1193
140	1261
150	1331
160	1404
170	1478
180	1555
190	1633
200	1714
210	1797
220	1882
230	1968
240	2057
250	2148
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270	2334
280	2426
290	2514
300	2592

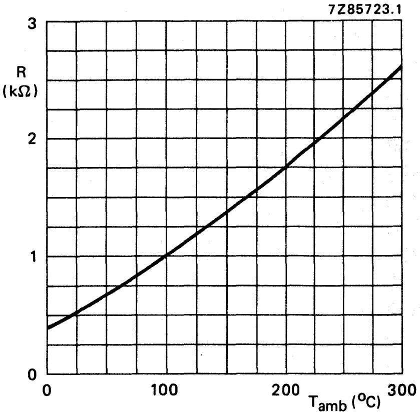


Fig. 2 Resistance value of sensor at I_C = 2 mA as a function of ambient temperature.

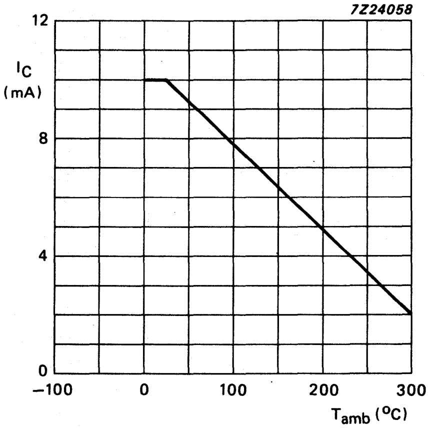


Fig. 3 Maximum operating current for safe operation.

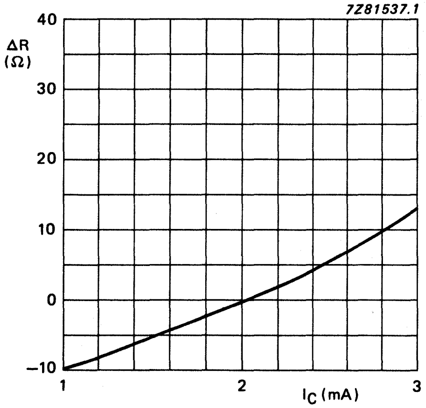


Fig. 4 Deviation of sensor resistance R as a function of operating current I_C in still liquid; T_{amb} = 100 °C.

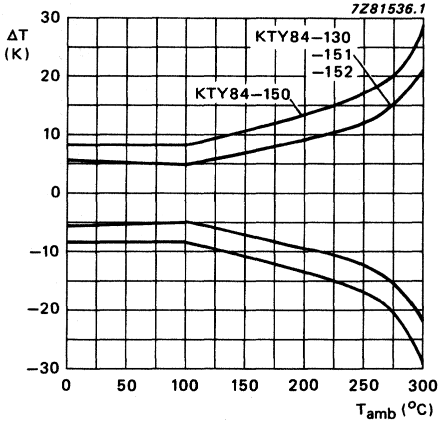


Fig. 5 Maximum expected temperature error Δ T.

SILICON TEMPERATURE SENSORS

These sensors have a positive temperature coefficient of resistance and are for use in measurement and control.

QUICK REFERENCE DATA

Resistance at T_{amb} = 25 °C

I_C = 1 mA

		Type tape (identification colour)
KTY85-110	R_{25} = 990 - 1010 Ω	yellow
KTY85-120	R_{25} = 980 - 1020 Ω	white or green
KTY85-121	R_{25} = 980 - 1000 Ω	white
KTY85-122	R_{25} = 1000 - 1020 Ω	green
KTY85-150	R_{25} = 950 - 1050 Ω	black or blue
KTY85-151	R_{25} = 950 - 1000 Ω	black
KTY85-152	R_{25} = 1000 - 1050 Ω	blue

KTY85-120 is composed of groups −121 and −122, and is correspondingly designated.

KTY85-150 is composed of groups −151 and −152, and is correspondingly designated.

Operating ambient temperature range T_{amb} −40 to +125 °C ←

MECHANICAL DATA

Dimensions in mm

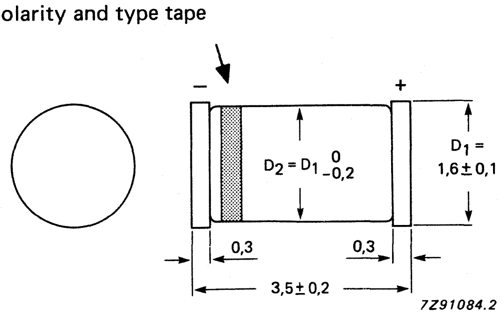


Fig. 1 SOD-80.

Note

The sensor has to be operated with the lower potential at the marked connection.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Continuous sensor current in free air

T_{amb} = 25 °C	I_C	max.	10	mA
T_{amb} = 125 °C	I_C	max.	2.0	mA

CHARACTERISTICS

(Based on the measurements in liquid at T_{amb} = 25 °C
unless otherwise specified)

Resistance				
I_C = 1 mA	KTY85-110	R_{25} =	990 - 1010 Ω	
	KTY85-120	R_{25} =	980 - 1020 Ω	
	KTY85-121	R_{25} =	980 - 1000 Ω	
	KTY85-122	R_{25} =	1000 - 1020 Ω	
	KTY85-150	R_{25} =	950 - 1050 Ω	
	KTY85-151	R_{25} =	950 - 1000 Ω	
	KTY85-152	R_{25} =	1000 - 1050 Ω	
Temperature coefficient		typ.	0.76	%/K
→ Resistance ratio		R100/R25	1.670 ± 0.020	
		R−40/R25	0.577 ± 0.008	
Thermal time constant*				
in still air		typ.	20	s
in still liquid**		typ.	1.0	s
in flowing liquid**		typ.	0.5	s
Measuring temperature range			−40 to +125	°C

---

* The thermal time constant is the time the sensor needs to reach 63.2% of the total temperature difference. For instance, the time needed to reach a temperature of 72.4 °C, when a sensor with an initial temperature of 25 °C is put into an ambient with a temperature of 100 °C.

** Inert liquid FC43 of 3M company.

T_{amb} °C	Resistance Ω
−40	577
−30	632
−20	691
−10	754
0	820
10	889
20	962
25	1000
30	1039
40	1118
50	1202
60	1288
70	1379
80	1472
90	1569
100	1670
110	1774
120	1882
125	1937

Ambient temperatures and corresponding resistance values of sensor (I_C = 1mA).

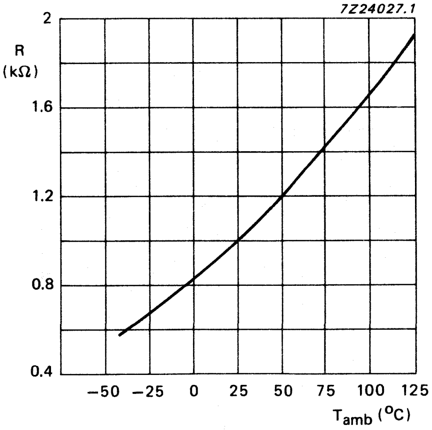


Fig. 2 Average resistance value of sensor at I_C = 1 mA as a function of ambient temperature.

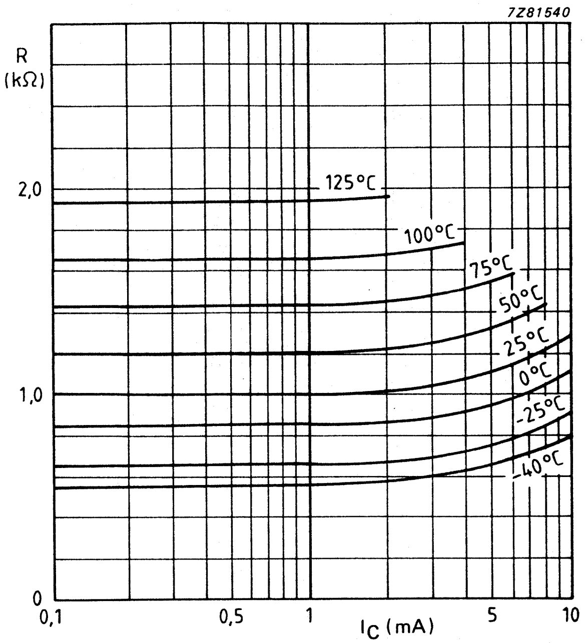


Fig. 3 Sensor resistance as a function of operating current.

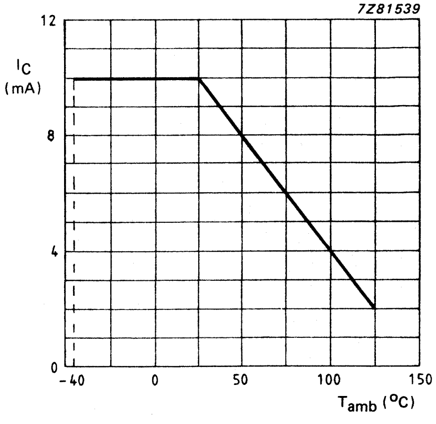


Fig. 4 Maximum operating current for safe operation.

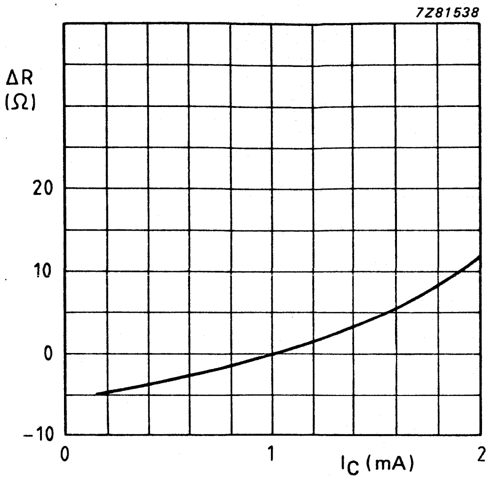


Fig. 5 Deviation of sensor resistance R as a function of operating current I_C in still liquid; T_{amb} = 25 °C.

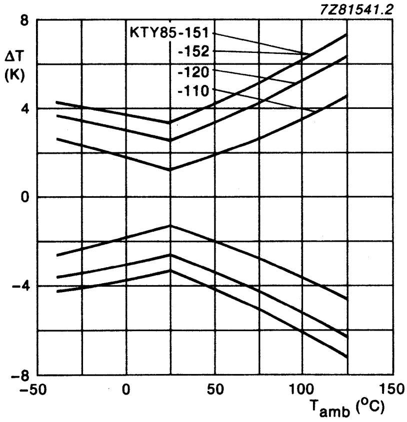


Fig. 6 Maximum expected temperature error ΔT.

←

SILICON TEMPERATURE SENSORS

These sensors are high accuracy temperature sensors with a positive temperature coefficient of resistance. Each sensor consists of a pair of 1000 Ω sensors in series and its main application fields are the measurement and control of temperature.

QUICK REFERENCE DATA

Resistance at T_{amb} = 25 °C I_C = 0.1 mA	KTY86-205	R_{25}	2000 ± 10 Ω
Operating ambient temperature range		T_{amb}	−40 to + 150 °C

MECHANICAL DATA

Dimensions in mm

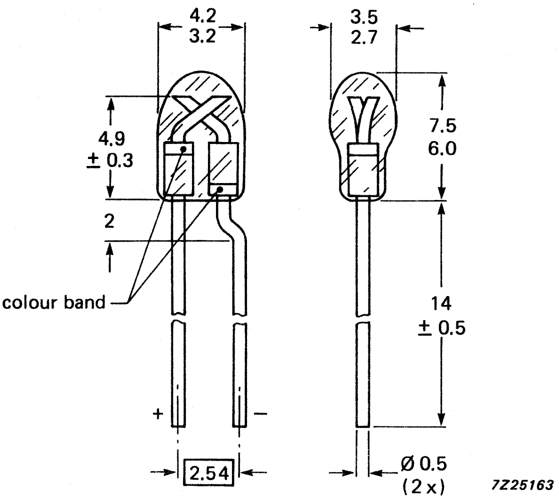


Fig. 1 VO-69; colour band is white.

Note

The sensor has to be operated with the lower potential at the bent lead.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Continuous sensor current in free air

T_{amb} = 25 °C	I_C	max.	10 mA
T_{amb} = 150 °C	I_C	max.	2.0 mA

CHARACTERISTICS

(Based on the measurements in liquid at T_{amb} = 25 °C; I_C = 0.1 mA unless otherwise specified).

→ Resistance	KTY86-205	R_{25} =	2000 ± 10	Ω
Resistance ratio				
$R_{100\,°C}/R_{25\,°C}$			1.672 ± 0.020	
$R_{-40\,°C}/R_{25\,°C}$			0.577 ± 0.008	
Temperature coefficient		α_{-40}	0.93	%/K
		α_{25}	0.76	%/K
		α_{100}	0.61	%/K
Thermal time constant*				
in still air		typ.	30	s
in still liquid**		typ.	2.2	s
in flowing liquid**		typ.	1.7	s
Measuring temperature range			−40 to +150	°C

---

* The thermal time constant is the time the sensor needs to reach 63.2% of the total temperature difference. For instance, the time needed to reach a temperature of 72.4 °C, when a sensor with an initial temperature of 25 °C is put into an ambient with a temperature of 100 °C.

** Inert liquid FC43 of 3M company.

T_{amb} °C	Resistance Ω
−40	1154
−30	1265
−20	1383
−10	1508
0	1640
10	1779
20	1924
25	2000
30	2077
40	2237
50	2404
60	2578
70	2759
80	2947
90	3142
100	3344
110	3553
120	3769
130	3992
140	4222
150	4459

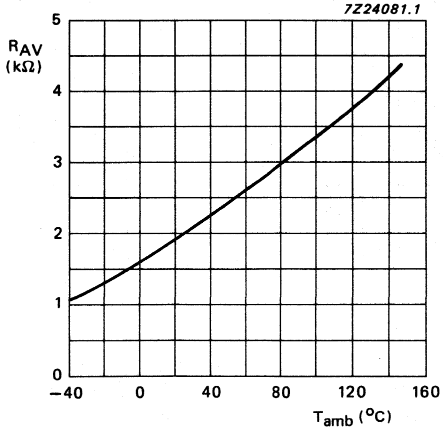


Fig. 2 Average resistance value of sensor at $I_C = 0.1$ mA as a function of ambient temperature.

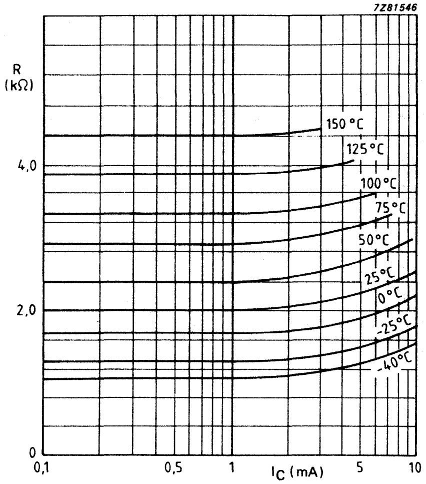


Fig. 3 Sensor resistance as a function of operating current.

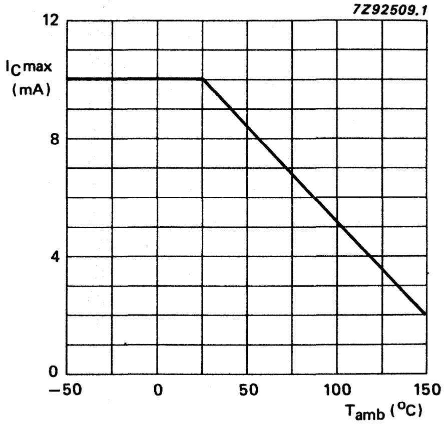


Fig. 4 Maximum operating current for safe operation.

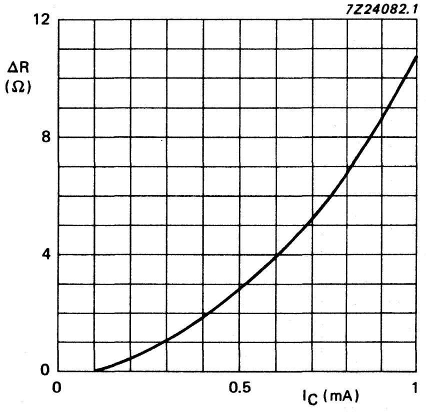


Fig. 5 Deviation of sensor resistance R versus operating current I_C in still liquid; T_{amb} = 25 °C.

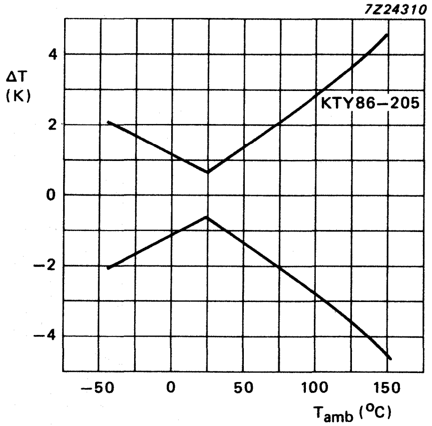


Fig. 6 Maximum expected temperature error ΔT.

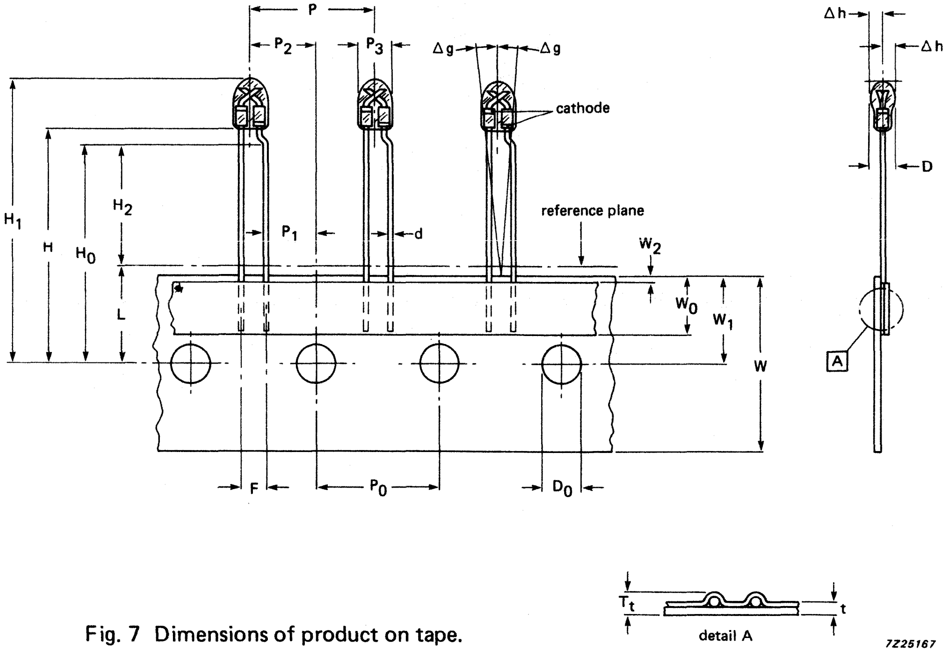


Fig. 7 Dimensions of product on tape.

Table 1 Dimensions of product on tape

symbol	dimensions
D	2.7 - 3.5
D_0	4.0 ± 0.2
d	0.48 - 0.56
F	2.54 + 0.4/–0.1
Δg	0 + 5°
H	24.0 ± 1.0
H_0	22.0 ± 1.0
H_1	32.5 max.
H_2	11.0 ± 1.0
Δh	± 2.0
L	10.0 max.
P	12.7 ± 1.0
P_0	12.7 ± 0.3
P_1	5.09 ± 0.7
P_2	5.95 ± 1.0
P_3	3.2 - 4.2
Tt	1.5 max.
t	0.7 ± 0.2
W	18.0 ± 1.0/–0.5
W_0	6.0 min.
W_1	9.0 ± 0.5
W_2	0 - 1.5

SILICON TEMPERATURE SENSORS

The KTY87 are high precision temperature sensors with a positive temperature coefficient of resistance for temperature measuring and temperature control.

QUICK REFERENCE DATA

Resistance at $I_C = 0.1$ mA	
$T_{amb} = 25\ ^{o}C$	$R_{25} = 2000 \pm 10\ \Omega$
$T_{amb} = 100\ ^{o}C$	$R100 = 3344 \pm 17\ \Omega$
Operating temperature range	−40 to + 125 °C

MECHANICAL DATA

Dimensions in mm

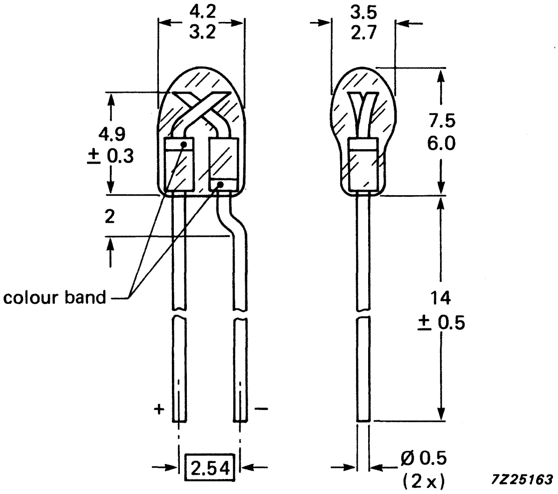


Fig. 1 VO-69; colour band is green.

Note

The sensor has to be operated with the lower potential at the bent lead.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Continuous sensor current in free air			
T_{amb} = 25 °C	I_C	max.	10 mA
T_{amb} = 125 °C	I_C	max.	2.0 mA

CHARACTERISTICS

(Based on the measurements in liquid at T_{amb} = 25 °C; I_C = 0.1 mA unless otherwise specified)

Resistance			R25 = 2000 ± 10 Ω
T_{amb} = 100 °C			R100 = 3344 ± 17 Ω
Temperature coefficient	at −40 °C	=	0.93 %/K
	at 25 °C	=	0.75 %/K
	at 100 °C	=	0.61 %/K
Thermal time constant *			
in still air		typ.	30 s
in still liquid**		typ.	2.2 s
in flowing liquid**		typ.	1.7 s
Operating temperature range			−40 to + 125 °C

---

* The thermal time constant is the time the sensor needs to reach 63.2% of the total temperature difference. For instance, the time needed to reach a temperature of 72.4 °C, when a sensor with an initial temperature of 25 °C is put into an ambient with a temperature of 100 °C.

** Inert liquid FC43 of 3M company.

T_{amb} °C	Resistance Ω
−40	1154
−30	1265
−20	1383
−10	1508
0	1640
10	1779
20	1924
25	2000
30	2077
40	2237
50	2404
60	2578
70	2759
80	2947
90	3142
100	3344
110	3553
120	3769
125	3880

DEVELOPMENT DATA

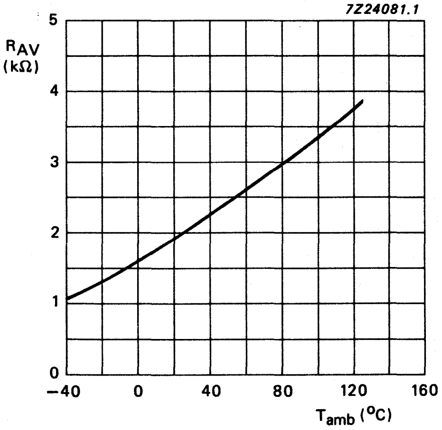


Fig. 2 Average resistance value of sensor at $I_C = 0.1$ mA as a function of ambient temperature.

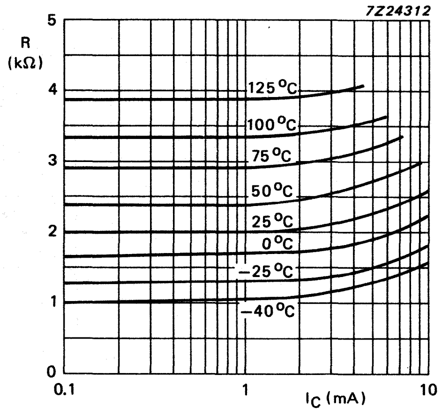


Fig. 3 Sensor resistance as a function of operating current.

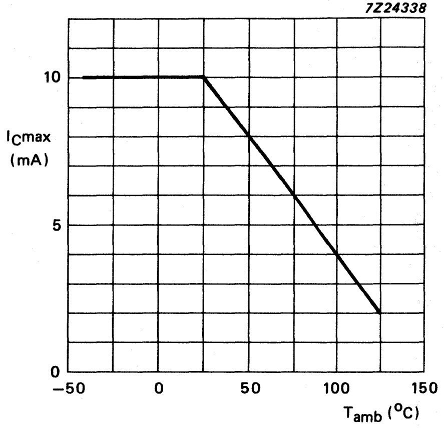


Fig. 4 Maximum operating current for safe operation.

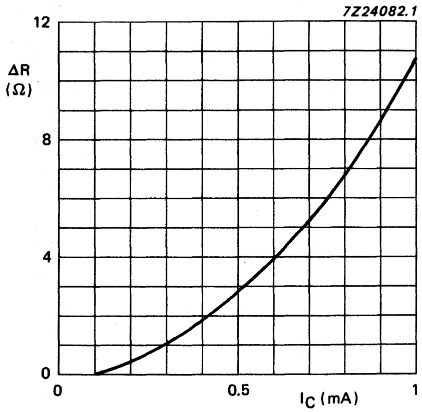


Fig. 5 Deviation of sensor resistance R versus operating current I_C in still liquid.

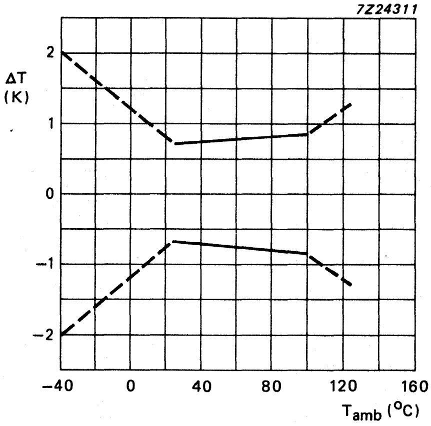
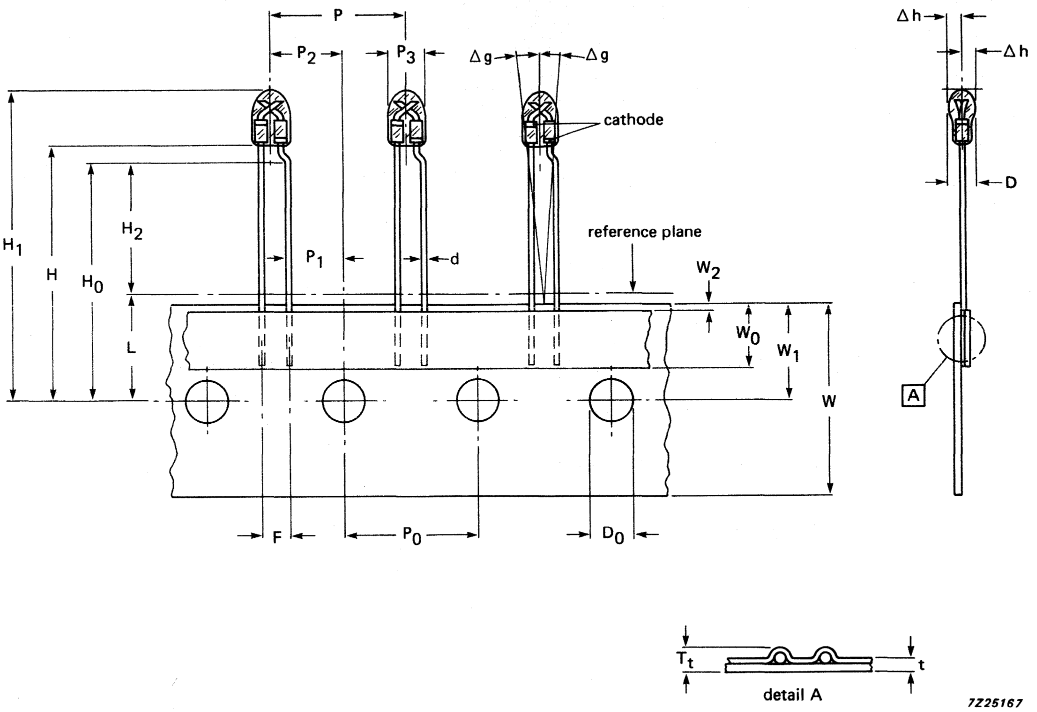


Fig. 6 Maximum temperature error ΔT.



DEVELOPMENT DATA

Table 1 Dimensions of product on tape

symbol	dimensions
D	2.7 – 3.5
D_0	4.0 ±0.2
d	0.48 – 0.56
F	2.54 +0.4/–0.1
Δg	$0\ +5^{\circ}$
H	24.0 ±1.0
H_0	22.0 ±1.0
H_1	32.5 max
H_2	11 ±1.0
Δh	±2.0
L	10.0 max
P	12.7 ±1.0
P_0	12.7 ±0.3
P_1	5.09 ±0.7
P_2	5.95 ±1.0
P_3	3.2 – 4.2
Tt	1.5 max
t	0.7 ±0.2
W	18.0 + 1.0/–0.5
W_0	6.0 min
W_1	9.0 ±0.5
W_2	0 – 1.5

Fig. 7 Dimensions of product on tap.

HYBRID INTEGRATED CIRCUITS FOR INDUCTIVE PROXIMITY DETECTORS

HYBRID INTEGRATED CIRCUITS FOR INDUCTIVE PROXIMITY DETECTORS

OM-	L x W mm (max.)	V_S V	I_o mA	false polarity protection	short-circuit/ overload prot.	R_x discr.	integr.
286	35,2 x 5	4,5 – 30	50 – 250*	supply	no	yes	no
287	35,2 x 5	4,5 – 30	50 – 250*	supply	no	yes	no
286M	22,6 x 5	4,5 – 30	50 – 250*	supply	no	yes	no
287M	22,6 x 5	4,5 – 30	50 – 250*	supply	no	yes	no
386B	43,6 x 5	10 – 30	250	supply/load	yes	yes	yes
387B	43,6 x 5	10 – 30	250	supply/load	yes	yes	yes
386M	22,5 x 5**	10 – 30	200	supply/load	yes	yes	yes
387M	22,5 x 5**	10 – 30	200	supply/load	yes	yes	yes
388B	25,6 x 8,2	10 – 30	250	supply/load	yes	yes	yes
389B	25,6 x 8,2	10 – 30	250	supply/load	yes	yes	yes

* Depending upon supply voltage (for odd-numbered types: reverse polarity).

** After assembling.

NOTE: The 300-series provide the possibility of directly connecting a LED for function control, without additional power dissipation.

HYBRID INTEGRATED CIRCUITS FOR INDUCTIVE PROXIMITY DETECTORS

Hybrid integrated circuits intended for inductive proximity detectors in tubular construction, especially the M8 hollow stud. The OM286 and OM286M are for positive supply voltage and the OM287 and OM287M are for negative supply voltage. The circuit consists of an oscillator, a rectifier stage, a Schmitt trigger and an output stage. The circuit performs a make function: when actuated the current flows through the load, which can be e.g. the coil of an electromagnetic relay, a LED or a photocoupler.

The output transistor is protected against transients from the inductive load by a voltage regulator diode. The circuit is protected against false polarity connection of the supply voltage.

The devices OM286/OM287 are thick-film circuits and the OM287M/OM287M are thin-film circuits deposited on ceramic substrates. They may be potted, together with the oscillator coil and a resistor (R_X), in a non-magnetic tube.

QUICK REFERENCE DATA

D.C. supply voltage range	V_B		4,5 to 30	V
Output current at V_B = 24 V	I_o	max.	250	mA
Operating (switching) distance (depends on R_X value and oscillator coil)	S		1 to 5	mm
Differential travel (hysteresis in switching distance)	H		3 to 10	%
Operating (switching) frequency	f	<	5	kHz
Operating substrate temperature range*	T_s		−40 to +85	°C
Substrate length of OM286 and OM287	L		35,0 ±0,2	mm
Substrate length of OM286M and OM287M	L		22,4 ±0,2	mm
Substrate width	W		4,8 ±0,2	mm
Height of circuit including substrate	h	max.	1,7	mm

MECHANICAL DATA

Dimensions in mm

Fig. 1a and 1b (next page).

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* The tube, potting and connection materials are the main limiting factors for the operating temperature range of a completely assembled proximity detector.

MECHANICAL DATA Dimensions in mm

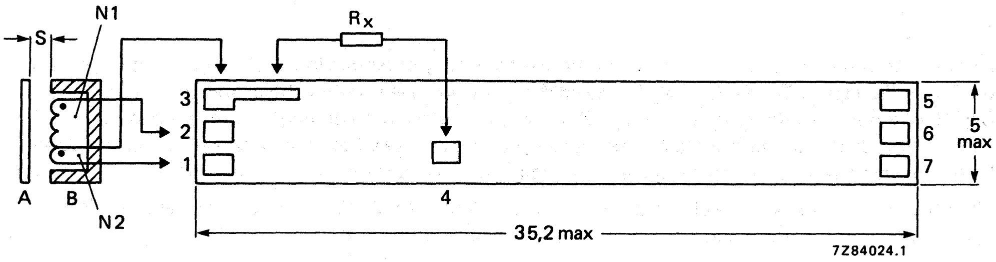

Fig. 1a OM286/OM287.

A = metal actuator
B = open potcore or
potcore half with coil

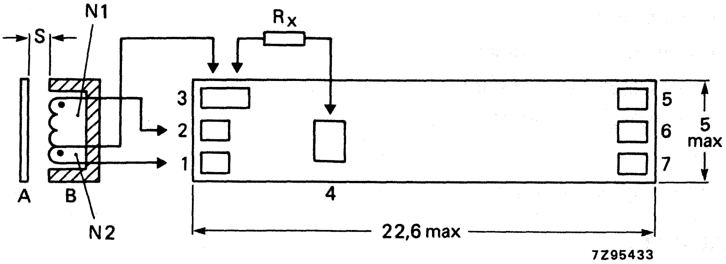

Fig. 1b OM286M/OM287M.

Mechanical outline and connections: note that the supply polarities to points 5 and 7 are given for the OM286 and OM286M; for the OM287 and OM287M the polarities are point 5: $-V_B$, and point 7: $+V_B$.

S is the operating distance.

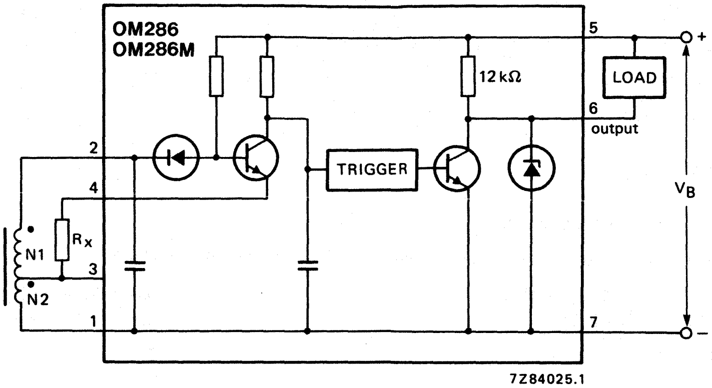

Fig. 2 Circuit diagram of OM286 and OM286M.

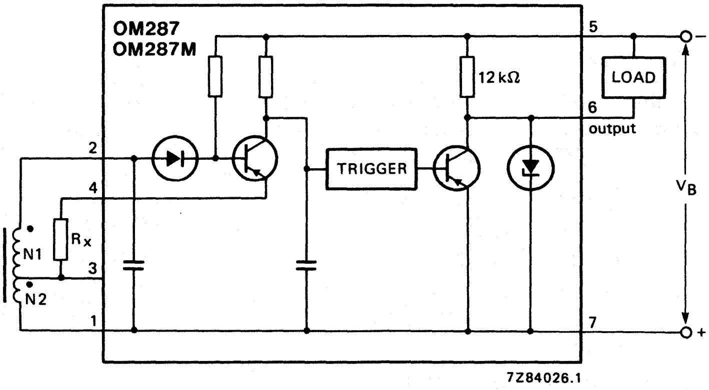

Fig. 3 Circuit diagram of OM287 and OM287M.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

D.C. supply voltage	V_B	max.	30	V
Output current	I_o	max.	250	mA
Storage temperature	T_{stg}		−40 to +125	°C
Operating substrate temperature	T_s		−40 to +85	°C

CHARACTERISTICS

Conditions (unless otherwise specified)

D.C. supply voltage	V_B	24	V
External resistor (R_X) and oscillator coil Device embedded in brass tube	see operating distance table below		
Substrate temperature	T_s	25	°C

Performances

Supply current				
output stage "ON"	I_B	typ.	9,0	mA
output stage "OFF"		typ.	7,7	mA
Voltage drop				
I_o = 250 mA	V_d	max.	1	V
I_o = 10 mA		max.	0,25	V

Operating (switching) distance*

type	oscillator coil number of turns		average operating distance S in mm at R_X (Ω)			recommended potcore	oscillator frequency kHz
	N1	N2	200	250	300		
M8	32	16	1	1,5	–	ϕ 5,8 mm (Neosid)	800
M12	40	10	2	3	–	P9 Philips**	600
M18	46	4	3	4	5	P14 Philips**	600

Differential travel (in % of S)	H		3 to 10	%
Operating frequency (according to EN 50010)	f	<	5	kHz

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* The operating distance S depends on the oscillator coil, the material of the metal actuator and R_X. For measuring purposes a square steel sheet (St 37) with dimensions such that a circle with the diameter of the core can be inscribed, and 1 mm thickness can be used. R_X must not be chosen outside the range of 200 to 300 Ω. Influence of supply voltage: −1 μm/V for V_B = 15 to 30 V.

Temperature coefficient of S:
M8 : 0,2 %/K
M12: 0,17 %/K
M18: 0,1 %/K

** Grade 3B7/3H1.

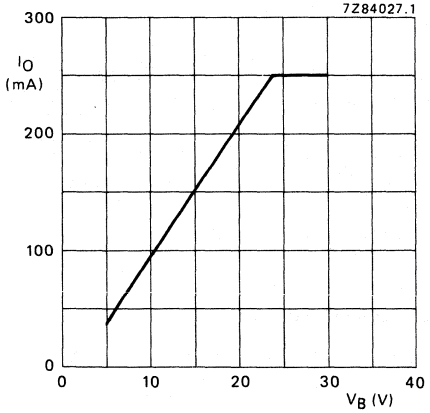


Fig. 4 Maximum allowable output current as a function of supply voltage; $T_s = 25\ ^oC$.

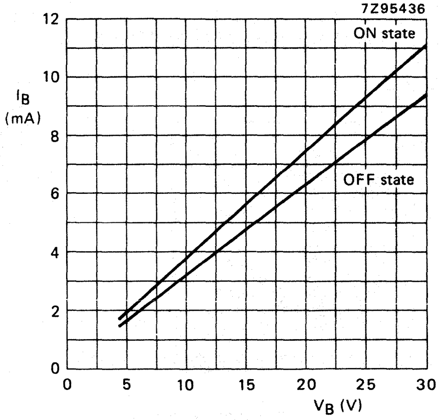


Fig. 5 Supply current as a function of supply voltage; $T_s = 25\ ^oC$; typical values.

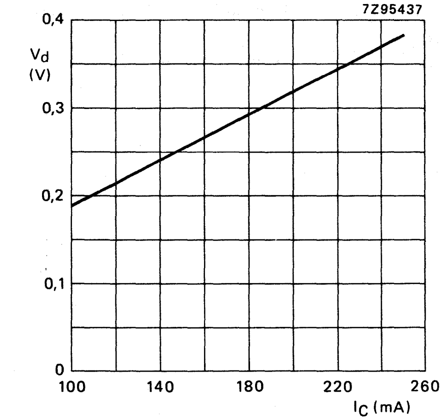


Fig. 6 Voltage drop as a function of output current; $V_B = 24$ V; $T_s = 25\ ^oC$; typical values.

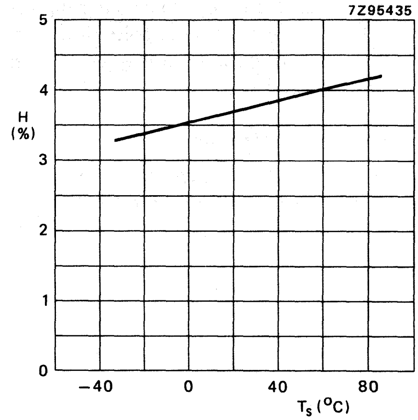
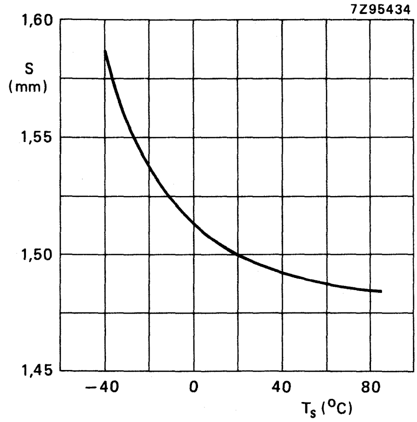


Fig. 7 Hysteresis as a function of substrate temperature; typical values.



Potcore ϕ 5,8 mm Neosid
osc. coil N1 = 32, N2 = 16 turns
$R_X = 200\ \Omega$.

Fig. 8 Operating distance as a function of substrate temperature.

MOUNTING RECOMMENDATIONS

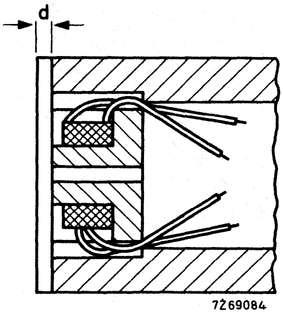


Fig. 9 Insertion of potcore in brass tube.

If a protective cap is incorporated, it should be as thin as possible, because its thickness d forms part of the operating distance S.
A brass stud wall should not extend beyond the potcore.
The exact value of S with its spread is determined by a number of variables, e.g.

- value of the adjustment resistor R_x
- the oscillator coil
- the metal of the actuator
- the material and shape of the housing.

Soldering recommendations

Use normal 60/40 solder; use a soldering iron with a fine point; soldering time as short as possible and it should not exceed 2,5 s per soldering point (T_{sld} = max. 250 °C).
The substrate is preferably preheated to a temperature of 100 °C with a minimum of 80 °C and a maximum of 125 °C.

Potting recommendations

First cover the hybrid IC with about 0,5 mm of silicone rubber, let it harden and, with the parts inserted in the tube, fill up the tube with an epoxy.

HYBRID INTEGRATED CIRCUITS FOR INDUCTIVE PROXIMITY DETECTORS

Hybrid integrated circuits intended for inductive proximity detectors in tubular construction, especially the M8 hollow stud. The OM386B is for positive supply voltage and the OM387B is for negative supply voltage. The circuit consists of a voltage regulator, an oscillator, a rectifier stage, a Schmitt trigger, an output stage and a protection circuit.

The circuit performs a make function: when actuated the current flows through the load, which can be e.g. the coil of an electromagnetic relay, a LED or a photocoupler.

Features:

- protection against short-circuit and overload
- protection of output transistor against transients by a voltage regulator diode
- protection against false polarity of the three connection leads
- choice between two methods to adjust the operating (switching) distance i.e. trimming a resistor integrated on the substrate or mounting a resistor
- possibility of connecting a LED for function control

The devices are thin-film circuits deposited on ceramic substrates. They may be potted, together with the oscillator coil, in a non-magnetic tube.

QUICK REFERENCE DATA

D.C. supply voltage range	V_B		10 to 30	V
Output current at V_B = 10 to 30 V	I_o	max.	250	mA
Operating (switching) distance (depends on R_x value and oscillator coil)	S		1 to 5	mm
Differential travel (hysteresis in switching distance)	H		3 to 10	%
Operating (switching) frequency	f	$<$	5	kHz
Operating substrate temperature range*	T_s		−40 to +85	°C
Substrate length	L		43,4 ±0,2	mm
Substrate width	W		4,8 ±0,2	mm
Height of circuit including substrate	h	max.	1,7	mm

MECHANICAL DATA

Dimensions in mm

Fig. 1 (see next page).

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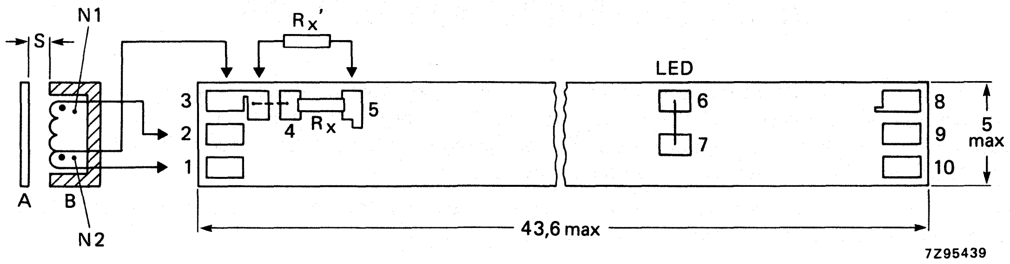
* The tube, potting and connection materials are the main limiting factors for the operating temperature range of a completely assembled proximity detector.

MECHANICAL DATA (outline and connections)

Dimensions in mm

Fig. 1.



A = metal actuator; B = open potcore or potcore half with coil.

Mechanical outline and connections: note that the supply polarities to points 8 and 10 are given for the OM386B; for the OM387B the polarities are point 8: $-V_B$, and point 10: $+V_B$.

S is the operating distance.

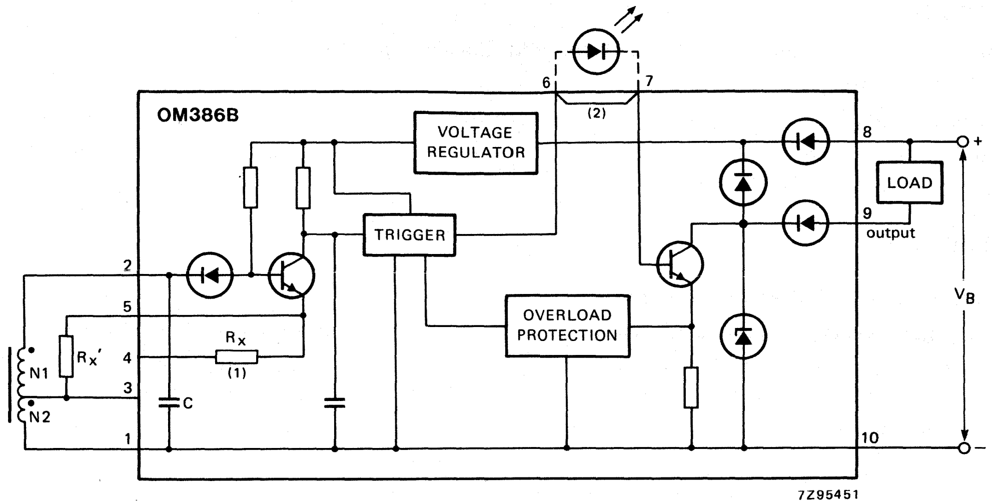


Fig. 2 Circuit diagram of OM386B.

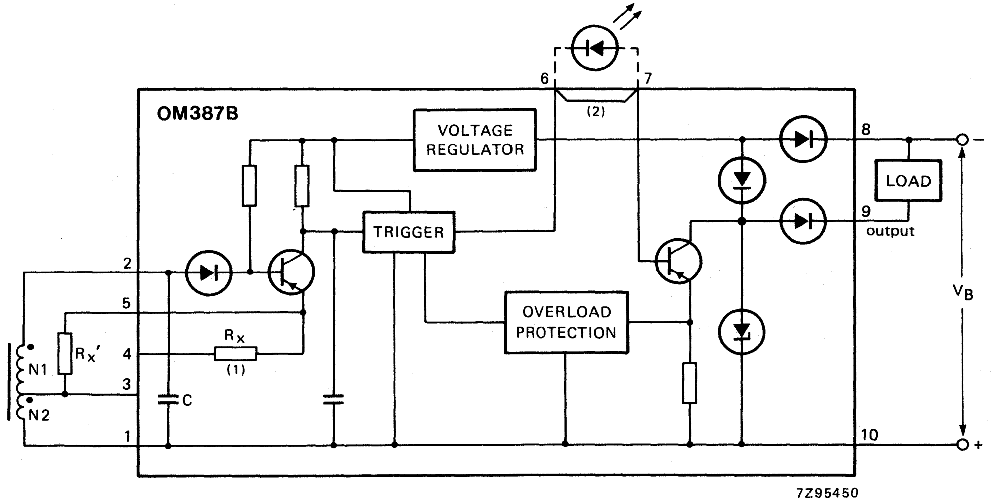


Fig. 3 Circuit diagram of OM387B.

(1) R_X is integrated on the substrate and suitable for trimming (laser or sandblasting). To use integrated resistance R_X it is necessary to connect point 3 to 4.

(2) If a LED is to be connected, the jumper between points 6 and 7 should be removed.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

D.C. supply voltage	V_B	max.	30	V
Output current	I_o	max.	250	mA
Storage temperature	T_{stg}		−40 to +125	°C
Operating substrate temperature	T_s		−40 to +85	°C

CHARACTERISTICS

Conditions (unless otherwise specified)

D.C. supply voltage	V_B	24	V
External resistor (R_X) and oscillator coil Device embedded in brass tube	see operating distance table below		
Substrate temperature	T_s	25	°C

Performances

Supply current				
output stage "ON"	I_B	typ.	8,4	mA
output stage "OFF"		typ.	4,8	mA
Voltage drop				
I_o = 250 mA	V_d	max.	1,9	V
I_o = 10 mA		max.	1,0	V

Operating (switching) distance*

type	oscillator coil number of turns		average operating distance S in mm at R_X (Ω)			recommended potcore	oscillator frequency kHz
	N1	N2	200	250	300		
M8	32	16	1	1,5	–	ϕ 5,8 mm (Neosid)	800
M12	40	10	2	3	–	P9 Philips**	600
M18	46	4	3	4	5	P14 Philips**	600

Differential travel (in % of S)	H		3 to 10	%
Operating frequency (according to EN 50010)	f	<	5	kHz

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* The operating distance S depends on the oscillator coil, the material of the metal actuator and R_X. For measuring purposes a square steel sheet (St 37) with dimensions such that a circle with the diameter of the core can be inscribed, and 1 mm thickness can be used. R_X must not be chosen outside the range of 200 to 300 Ω.

** Grade 3B7/3H1.

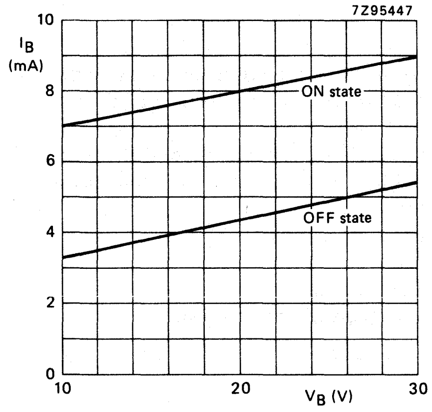


Fig. 4 Supply current as a function of supply voltage; T_s = 25 °C.

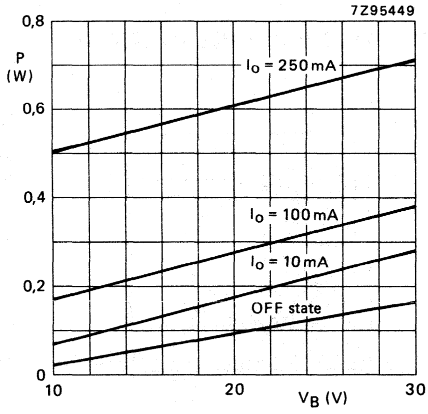


Fig. 5 Power dissipation as a function of supply voltage.

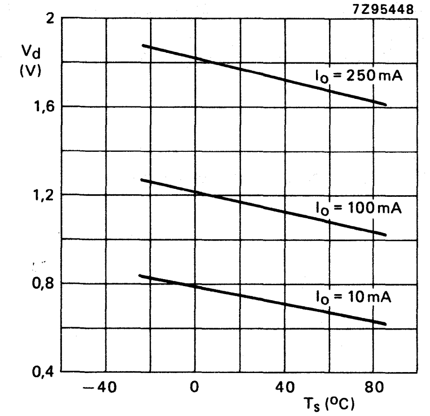


Fig. 6 Voltage drop as a function of substrate temperature.

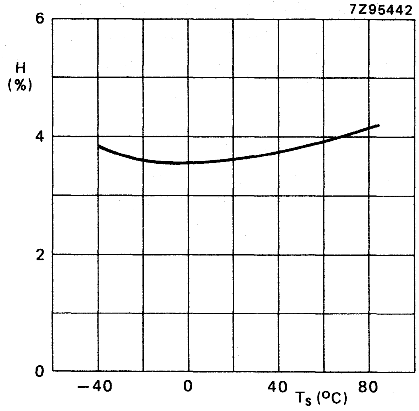
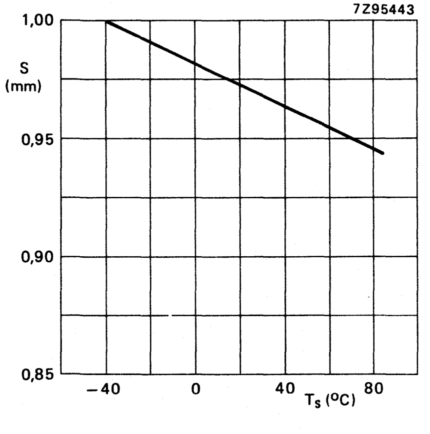


Fig. 7 Hysteresis as a function of substrate temperature.



Conditions relating to Figs 7 and 8:
potcore ϕ 5,8 mm Neosid
osc. coil N1 = 32, N2 = 16 turns
R_x = 200 Ω.

Fig. 8 Operating distance as a function of substrate temperature.

MOUNTING RECOMMENDATIONS

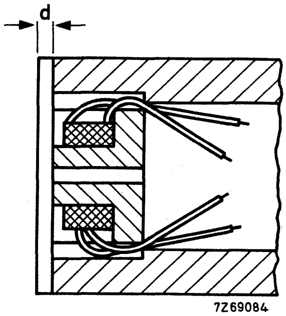


Fig. 9 Insertion of potcore in brass tube.

If a protective cap is incorporated, it should be as thin as possible, because its thickness d forms part of the operating distance S.
A brass stud wall should not extend beyond the potcore.
The exact value of S with its spread is determined by a number of variables, e.g.
– value of the adjustment resistor R_X
– the oscillator coil
– the metal of the actuator
– the material and shape of the housing.

Soldering recommendations

Use normal 60/40 solder; use a soldering iron with a fine point; soldering time as short as possible and it should not exceed 2,5 s per soldering point (T_{sld} = max. 250 °C).
The substrate is preferably preheated to a temperature of 100 °C with a minimum of 80 °C and a maximum of 125 °C.

Potting recommendations

First cover the hybrid IC with about 0,5 mm of silicone rubber, let it harden and with the parts inserted in the tube, fill up the tube with an epoxy.

HYBRID INTEGRATED CIRCUITS FOR INDUCTIVE PROXIMITY DETECTORS

Hybrid integrated circuits intended for inductive proximity detectors in tubular construction, especially the M8 hollow stud. The OM386M is for positive supply voltage and the OM387M is for negative supply voltage. The circuit consists of a voltage regulator, an oscillator, a rectifier stage, a Schmitt trigger, an output stage and a protection circuit.

The circuit performs a make function: when actuated the current flows through the load, which can be e.g. the coil of an electromagnetic relay, a LED or a photocoupler.

Compared to the types OM386B/OM387B the substrate length is drastically reduced.

Features:

- extra-small dimensions
- protection against short-circuit and overload
- protection of output transistor against transients by a voltage regulator diode
- protection against false polarity of the three connection leads
- choice between two methods to adjust the operating (switching) distance i.e. trimming a resistor integrated on the substrate or mounting a resistor
- possibility of connecting a LED for function control

The devices are thin-film circuits deposited on ceramic substrates. They may be potted, together with the oscillator coil, in a non-magnetic tube.

QUICK REFERENCE DATA

D.C. supply voltage range	V_B		10 to 30	V
Output current at V_B = 10 to 30 V	I_o	max.	200	mA
Operating (switching) distance (depends on R_X value and oscillator coil)	S		1 to 5	mm
Differential travel (hysteresis in switching distance)	H		3 to 10	%
Operating (switching) frequency	f	$<$	5	kHz
Operating substrate temperature range*	T_s		−40 to +85	^oC
Substrate length after assembly	L		22,3 ±0,2	mm
Substrate width	W		4,8 ±0,2	mm
Thickness of assembled hybrid (two parts glued together back to back)	h	max.	3,8	mm

MECHANICAL DATA

Dimensions in mm

Fig. 1 (see next page).

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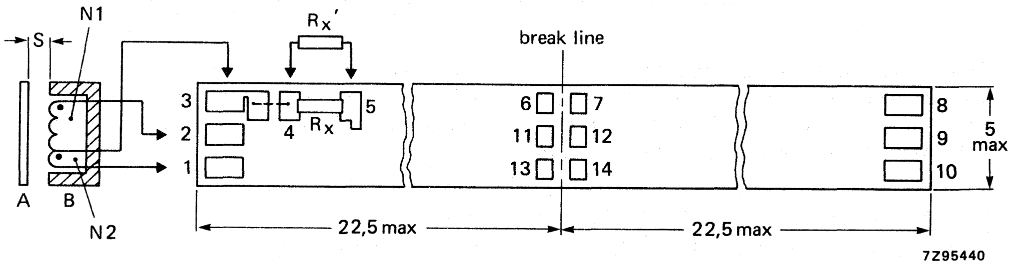
* The tube, potting and connection materials are the main limiting factors for the operating temperature range of a completely assembled proximity detector.

MECHANICAL DATA (outline and connections)

Dimensions in mm

Fig. 1.



A = metal actuator; B = open potcore or potcore half with coil.

Mechanical outline and connections: note that the supply polarities to points 8 and 10 are given for the OM386M; for the OM387M the polarities are point 8: $-V_B$, and point 10: $+V_B$.

S is the operating distance.

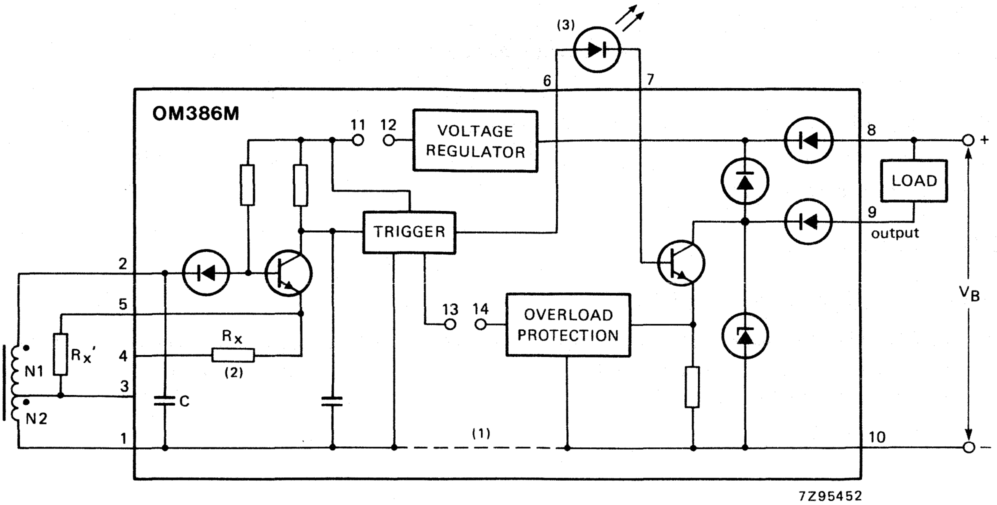


Fig. 2 Circuit diagram of OM386M.

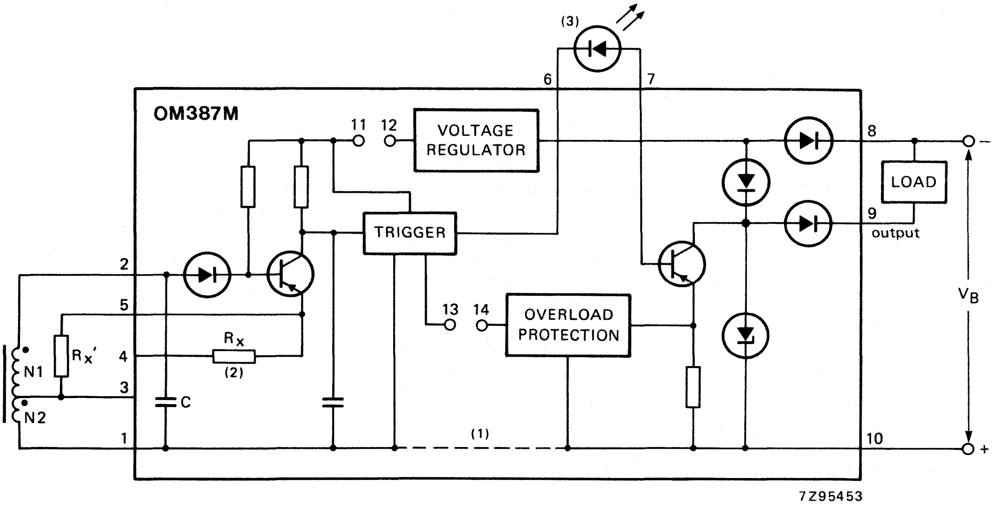


Fig. 3 Circuit diagram of OM387M.

(1) Connect point 1 to point 10 after assembling.

(2) R_X is integrated on the substrate and suitable for trimming (laser or sandblasting). To use integrated resistance R_X it is necessary to connect point 3 to 4.

(3) If no LED is used, connect point 6 to point 7.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

D.C. supply voltage	V_B	max.	30 V
Output current	I_o	max.	200 mA
Storage temperature	T_{stg}		−40 to +125 °C
Operating substrate temperature	T_s		−40 to +85 °C

CHARACTERISTICS

Conditions (unless otherwise specified)

D.C. supply voltage	V_B	24 V
External resistor (R_X) and oscillator coil Device embedded in brass tube	see operating distance table below	
Substrate temperature	T_s	25 °C

Performances

Supply current			
output stage "ON"	I_B	typ.	7,4 mA
output stage "OFF"		typ.	4,8 mA
Voltage drop			
I_o = 200 mA	V_d	max.	1,9 V
I_o = 10 mA		max.	1,0 V

Operating (switching) distance*

type	oscillator coil number of turns		average operating distance S in mm at R_X (Ω)			recommended potcore	oscillator frequency kHz
	N1	N2	200	250	300		
M8	32	16	1	1,5	–	ϕ 5,8 mm (Neosid)	800
M12	40	10	2	3	–	P9 Philips**	600
M18	46	4	3	4	5	P14 Philips**	600

Differential travel (in % of S)	H		3 to 10 %
Operating frequency (according to EN 50010)	f	<	5 kHz

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* The operating distance S depends on the oscillator coil, the material of the metal actuator and R_X. For measuring purposes a square steel sheet (St. 37) with dimensions such that a circle with the diameter of the core can be inscribed, and 1 mm thickness can be used. R_X must not be chosen outside the range of 200 to 300 Ω.

** Grade 3B7/3H1.

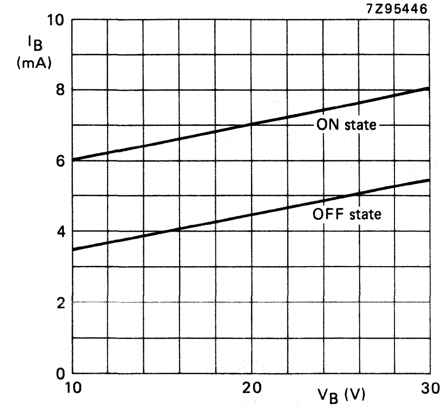


Fig. 4 Supply current as a function of supply voltage; T_s = 25 °C.

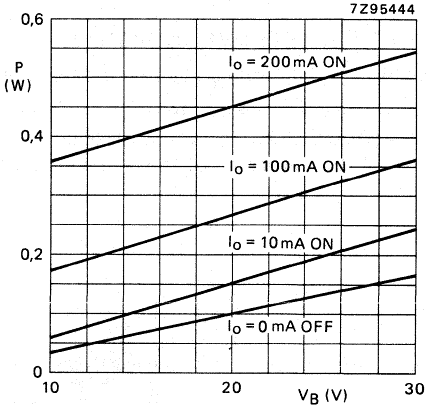


Fig. 5 Power dissipation as a function of supply voltage.

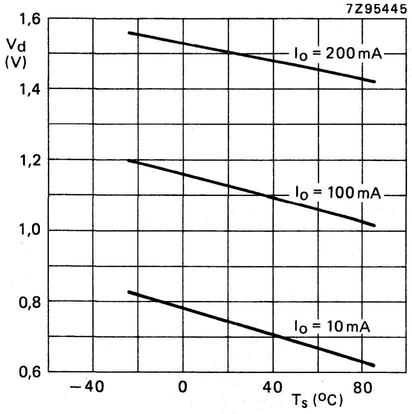


Fig. 6 Voltage drop as a function of substrate temperature.

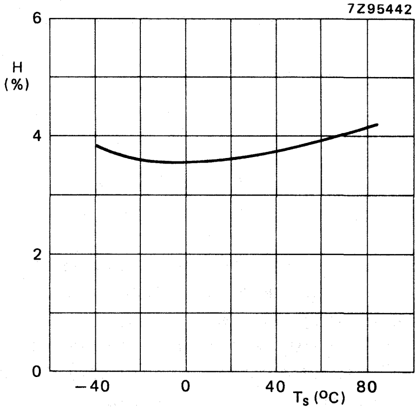
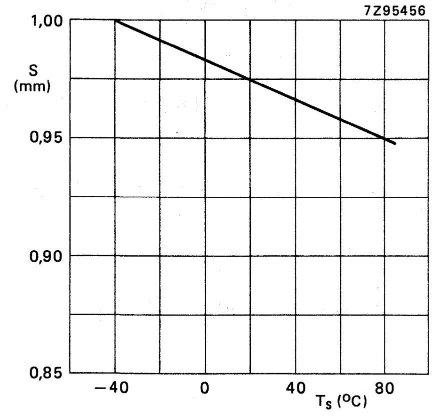


Fig. 7 Hysteresis as a function of substrate temperature.



Conditions relating to Figs 7 and 8:
potcore ϕ 5,8 mm Neosid
osc. coil N1 = 32, N2 = 16 turns
R_x = 200 Ω.

Fig. 8 Operating distance as a function of substrate temperature.

MOUNTING RECOMMENDATIONS

A. Assembling and connecting the two half substrates:

- Use the breakline to break the substrate in two pieces.
- Apply glue (e.g. epoxy Ablebond 293-1) to the blank sides of the two parts.
- After hardening of the glue connect the pads according to Fig. 9.

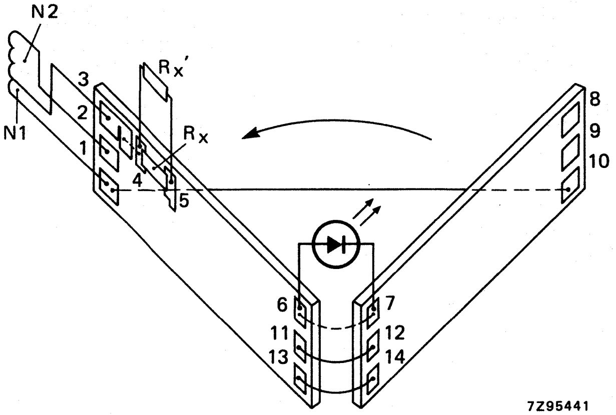


Fig. 9 If no LED is used, connect point 6 to point 7;
connect points 11 and 12, point 13 to 14 and point 1 to point 10.

B. If a protective cap is incorporated, it should be as thin as possible, because its thickness d forms part of the operating distance S.
A brass stud wall should not extend beyond the potcore.
The exact value of S with its spread is determined by a number of variables, e.g.
- value of the adjustment resistor R_X
- the oscillator coil
- the metal of the actuator
- the material and shape of the housing.

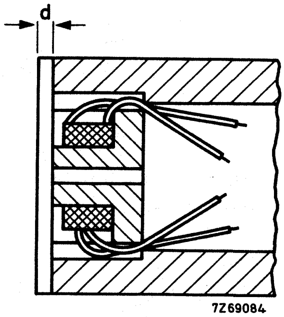


Fig. 10 Insertion of potcore in brass tube.

Soldering recommendations

Use normal 60/40 solder; use a soldering iron with a fine point; soldering time as short as possible and it should not exceed 2,5 s per soldering point (T_{sld} = max. 250 °C).

Potting recommendations

First cover the hybrid IC with about 0,5 mm of silicone rubber, let it harden and with the parts inserted in the tube, fill up the tube with an epoxy.

HYBRID INTEGRATED CIRCUITS FOR INDUCTIVE PROXIMITY DETECTORS

Hybrid integrated circuits intended for inductive proximity detectors in tubular construction, especially the M12 hollow stud. The OM388B is for positive supply voltage and the OM389B is for negative supply voltage. The circuit consists of a voltage regulator, an oscillator, a rectifier stage, a Schmitt trigger, an output stage and a protection circuit.

The circuit performs a make function: when actuated the current flows through the load, which can be e.g. the coil of an electromagnetic relay, a LED or a photocoupler.

Features:

- protection against short-circuit and overload
- protection of output transistor against transients by a voltage regulator diode
- protection against false polarity of the three connection leads
- choice between two methods to adjust the operating (switching) distance i.e. trimming a resistor integrated on the substrate or mounting a resistor
- possibility of connecting a LED for function control

The devices are thin-film circuits deposited on ceramic substrates. They may be potted, together with the oscillator coil, in a non-magnetic tube.

QUICK REFERENCE DATA

D.C. supply voltage range	V_B		10 to 30	V
Output current at V_B = 10 to 30 V	I_o	max.	250	mA
Operating (switching) distance (depends on R_x value and oscillator coil)	S		2 to 5	mm
Differential travel (hysteresis in switching distance)	H		3 to 10	%
Operating (switching) frequency	f	$<$	5	kHz
Operating substrate temperature range*	T_s		−40 to +85	°C
Substrate length	L		25,4 ±0,2	mm
Substrate width	W		8,0 ±0,2	mm
Height of circuit including substrate	h	max.	1,7	mm

MECHANICAL DATA

Dimensions in mm

Fig. 1 (see next page).

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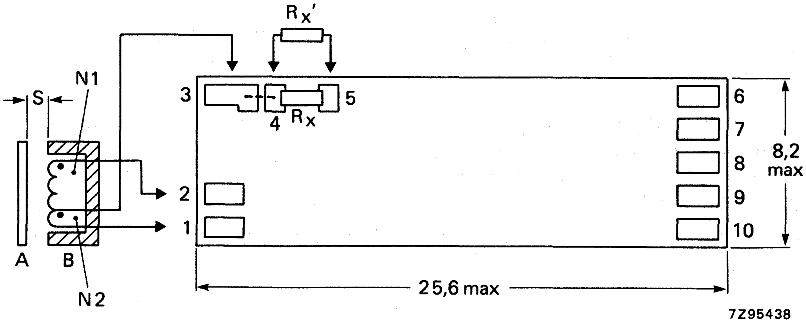
* The tube, potting and connection materials are the main limiting factors for the operating temperature range of a completely assembled proximity detector.

MECHANICAL DATA (outline and connections). Dimensions in mm

Fig. 1.



A = metal actuator; B = open potcore or potcore half with coil.

Mechanical outline and connections: note that the supply polarities to points 8 and 10 are given for the OM388B; for the OM389B the polarities are point 8: $-V_B$ and point 10: $+V_B$.

S is the operating distance.

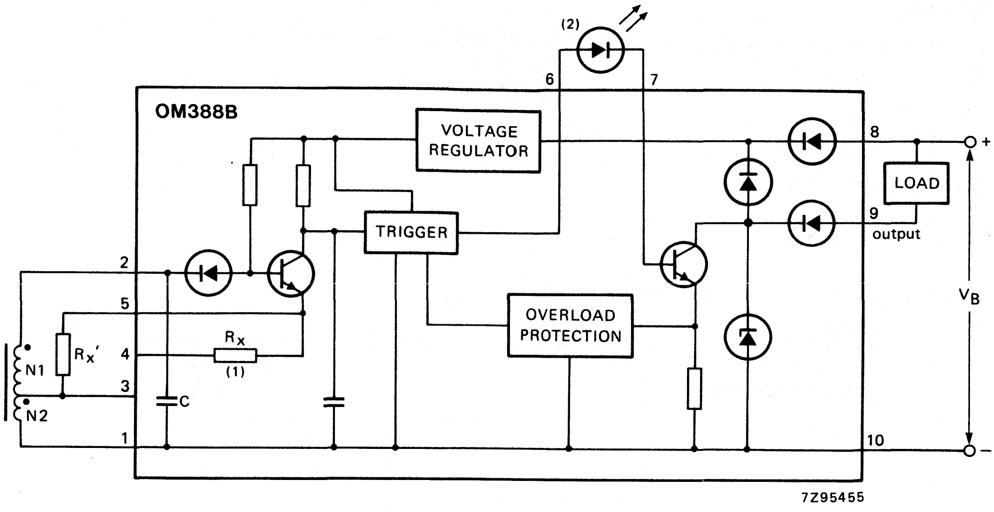


Fig. 2 Circuit diagram of OM388B.

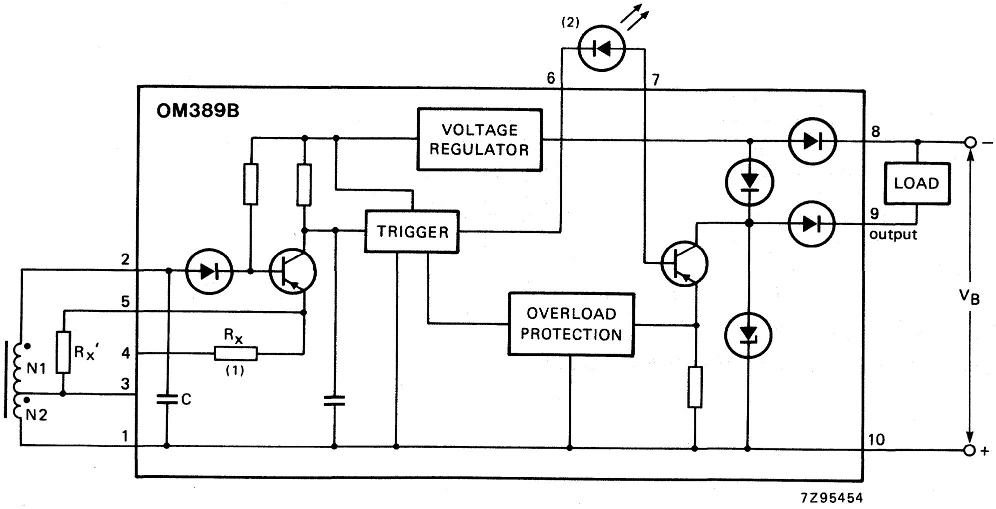


Fig. 3 Circuit diagram of OM389B.

(1) R_X is integrated on the substrate and suitable for trimming (laser or sandblasting). To use integrated resistance R_X it is necessary to connect point 3 to 4.

(2) If no LED is used, point 6 is to be connected to point 7.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

D.C. supply voltage	V_B	max.	30	V
Output current	I_o	max.	250	mA
Storage temperature	T_{stg}		−40 to +125	°C
Operating substrate temperature	T_s		−40 to +85	°C

CHARACTERISTICS

Conditions (unless otherwise specified)

D.C. supply voltage	V_B		24	V
External resistor (R_X) and oscillator coil Device embedded in brass tube	see operating distance table below			
Substrate temperature	T_s		25	°C

Performances

Supply current				
output stage "ON"	I_B	typ.	8,4	mA
output stage "OFF"		typ.	4,8	mA
Voltage drop				
I_o = 250 mA	V_d	max.	1,9	V
I_o = 10 mA		max.	1,0	V

Operating (switching) distance*

type	oscillator coil number of turns		average operating distance S in mm at R_X (Ω)			recommended potcore	oscillator frequency kHz
	N1	N2	200	250	300		
M12	40	10	2	3	–	P9 Philips**	600
M18	46	4	3	4	5	P14 Philips**	600

Differential travel (in % of S)	H		3 to 10	%
Operating frequency (according to EN 50010)	f	<	5	kHz

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* The operating distance S depends on the oscillator coil, the material of the metal actuator and R_X. For measuring purposes a square steel sheet (St 37) with dimensions such that a circle with the diameter of the core can be inscribed, and 1 mm thickness can be used. R_X must not be chosen outside the range of 200 to 300 Ω.

** Grade 3B7/3H1.

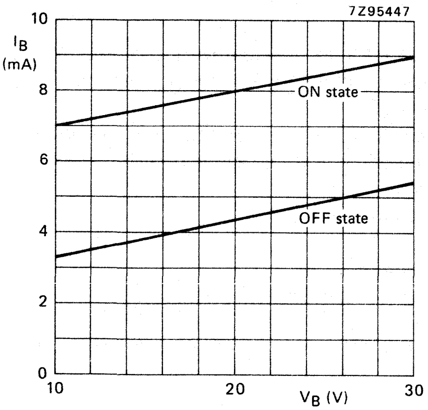

Fig. 4 Supply current as a function of supply voltage; T_s = 25 °C.

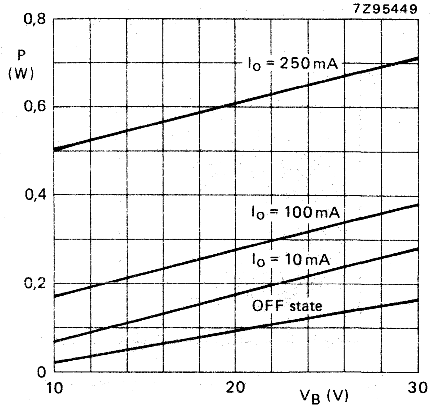

Fig. 5 Power dissipation as a function of supply voltage.

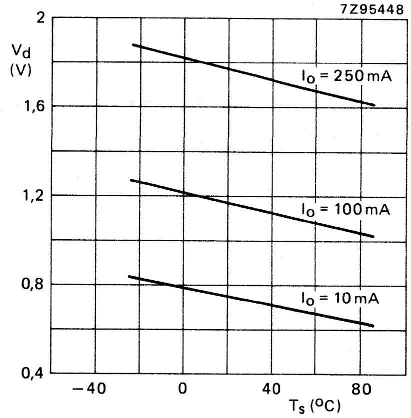

Fig. 6 Voltage drop as a function of substrate temperature.

MOUNTING RECOMMENDATIONS

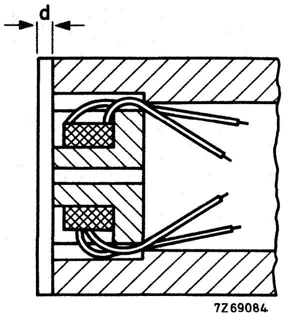

Fig. 7 Insertion of potcore in brass tube.

If a protective cap is incorporated, it should be as thin as possible, because its thickness d forms part of the operating distance S.

A brass stud wall should not extend beyond the potcore.

The exact value of S with its spread is determined by a number of variables, e.g.

- value of the adjustment resistor R_X
- the oscillator coil
- the metal of the actuator
- the material and shape of the housing.

Soldering recommendations

Use normal 60/40 solder; use a soldering iron with a fine point; soldering time as short as possible and it should not exceed 2,5 s per soldering point (T_{sld} = max. 250 °C).

The substrate is preferably preheated to a temperature of 100 °C with a minimum of 80 °C and a maximum of 125 °C.

Potting recommendations

First cover the hybrid IC with about 0,5 mm of silicone rubber, let it harden and with the parts inserted in the tube, fill up the tube with an epoxy.

HYBRID INTEGRATED CIRCUITS FOR INDUCTIVE PROXIMITY DETECTORS

Hybrid integrated circuits intended for inductive proximity detectors in tubular construction, especially the M18 hollow stud. The OM390 is for positive supply voltage and the OM391 is for negative supply voltage. The circuit consists of a voltage regulator, an oscillator, a rectifier stage, a Schmitt trigger, an output stage and a protection circuit.

The circuit performs a make function: when actuated the current flows through the load, which can be e.g. the coil of an electromagnetic relay, a LED or a photocoupler.

Features:

- Protection against short-circuit and overload
- Protection of output transistor against transients by a voltage regulator diode
- Protection against false polarity of the three connection leads
- Choice between two methods to adjust the operating (switching) distance i.e. trimming a resistor integrated on the substrate or mounting a resistor
- Possibility of connecting a LED for function control

The devices are thin-film circuits deposited on ceramic substrates. They may be potted, together with the oscillator coil, in a non-magnetic tube.

QUICK REFERENCE DATA

D.C. supply voltage range	V_B		10 to 30	V
Output current at V_B = 10 to 30 V	I_o	max.	250	mA
Operating (switching) distance (depends on R_x value and oscillator coil)	S		2 to 5	mm
Differential travel (hysteresis in switching distance)	H		3 to 10	%
Operating (switching) frequency	f	$<$	5	kHz
Operating substrate temperature range*	T_s		−40 to +85	°C
Substrate length	L		14,0 ±0,2	mm
Substrate width	W		14,0 ±0,2	mm
Height of circuit including substrate	h	max.	1,7	mm

MECHANICAL DATA

Dimensions in mm

Fig. 1 (see next page).

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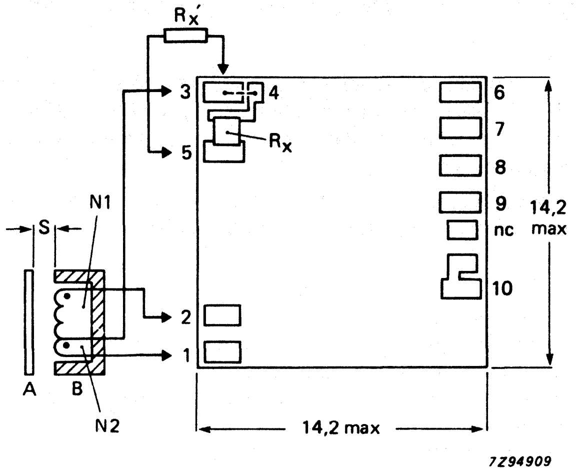
* The tube, potting and connection materials are the main limiting factors for the operating temperature range of a completely assembled proximity detector.

MECHANICAL DATA (outline and connections). Dimensions in mm

Fig. 1.



A = metal actuator; B = open potcore or potcore half with coil. S is the operating distance.

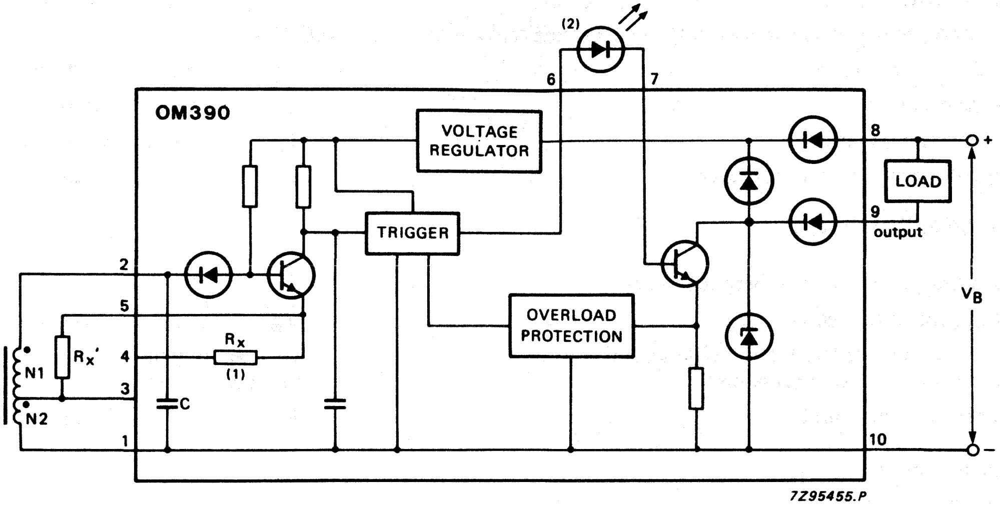


Fig. 2 Circuit diagram of OM390.

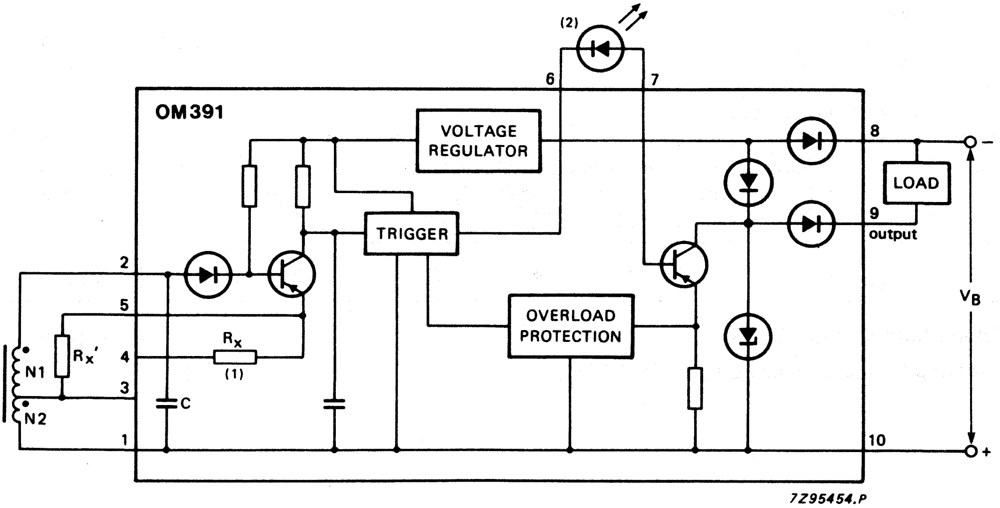


Fig. 3 Circuit diagram of OM391.

(1) R_X is integrated on the substrate and suitable for trimming (laser or sandblasting). To use integrated resistance R_X it is necessary to connect point 3 to 4.

(2) If no LED is used, point 6 is to be connected to point 7.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

D.C. supply voltage	V_B	max.	30 V
Output current	I_o	max.	250 mA
Storage temperature	T_{stg}		−40 to +125 °C
Operating substrate temperature	T_s		−40 to +85 °C

CHARACTERISTICS

Conditions (unless otherwise specified)

D.C. supply voltage	V_B	24 V
External resistor (R_X) and oscillator coil Device embedded in brass tube	see operating distance table below	
Substrate temperature	T_s	25 °C

Performances

Supply current			
output stage "ON"	I_B	typ.	8,4 mA
output stage "OFF"	I_B	typ.	4,8 mA
Voltage drop			
$I_o = 250$ mA	V_d	max.	1,9 V
$I_o = 10$ mA	V_d	max.	1,0 V

Operating (switching) distance*

type	oscillator coil number of turns		average operating distance S in mm at R_X (Ω)			recommended potcore	oscillator frequency kHz
	N1	N2	200	250	300		
M18	46	4	3	4	5	P14 Philips**	600

Differential travel (in % of S)	H		3 to 10 %
Operating frequency (according to EN 50010)	f	<	5 kHz

---

* The operating distance S depends on the oscillator coil, the material of the metal actuator and R_X. For measuring purposes a square steel sheet (St 37) with dimensions such that a circle with the diameter of the core can be inscribed, and 1 mm thickness can be used. R_X must not be chosen outside the range of 200 to 300 Ω.

** Grade 3B7/3H1.

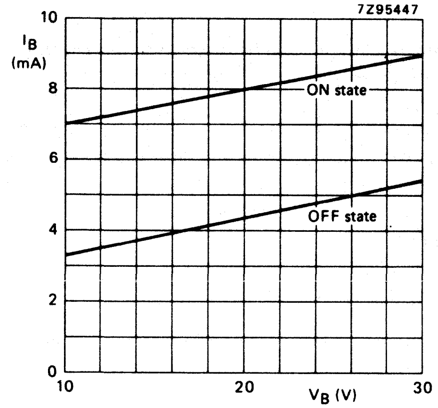


Fig. 4 Supply current as a function of supply voltage; T_s = 25 °C.

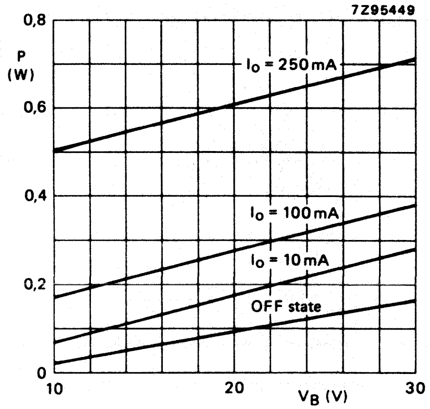


Fig. 5 Power dissipation as a function of supply voltage.

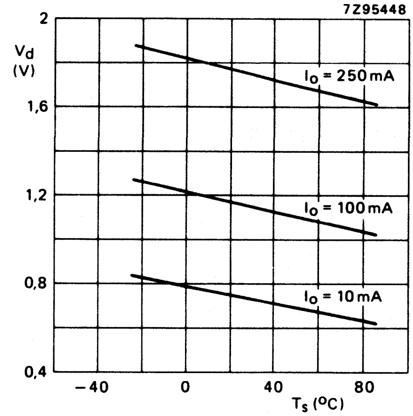


Fig. 6 Voltage drop as a function of substrate temperature.

MOUNTING RECOMMENDATIONS

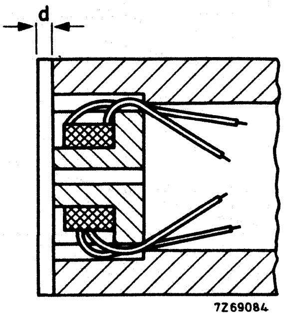


Fig. 7 Insertion of potcore in brass tube.

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Potting recommendations

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PYROELECTRIC INFRARED SENSORS

QUICK SELECTION GUIDE

Device	Spectral Response µm	Typ peak Signal (500K) µV typ	Noise (0.4 to 5 Hz bandwidth) µV p-p typ	Outline	Page
KRX10	6.5 to 14	900	25	SIL	197
KRX11	6.0 to 14	900	30	SIL	203
P2105	1.0 to 25			SOT49G	209
RPW100	6.5 to 14	800	25	TO-39	215
RPW101	6.5 to 14	800	25	SOT49M	221
RPW102	6.5 to 14	800	25	TO-39	227
RPY100	6.5 to 14	460	20	TO-39	233
RPY102	6.5 to 14	460	15	TO-39	241
RPY107	1.0 to 15	385	15	TO-39	249
RPY109	1.0 to 15	385	15	TO-39	257
RPY222	6.5 to 15	800	25	TO-39	265
RPY97	maintenance type only. Data sheet available on request.				

FUNDAMENTALS OF PYROELECTRICITY

TGS (triglycine sulphate) sensors are very sensitive thermal infrared devices which operate at room temperature without the need for cooling.

Operation of a TGS infrared sensor is based on the pyroelectric effect. Below a temperature known as the Curie point, ferroelectric materials such as TGS exhibit a large spontaneous electrical polarization. If the temperature of such a material is altered, for example by incident radiation, the polarization changes (see Fig.1).

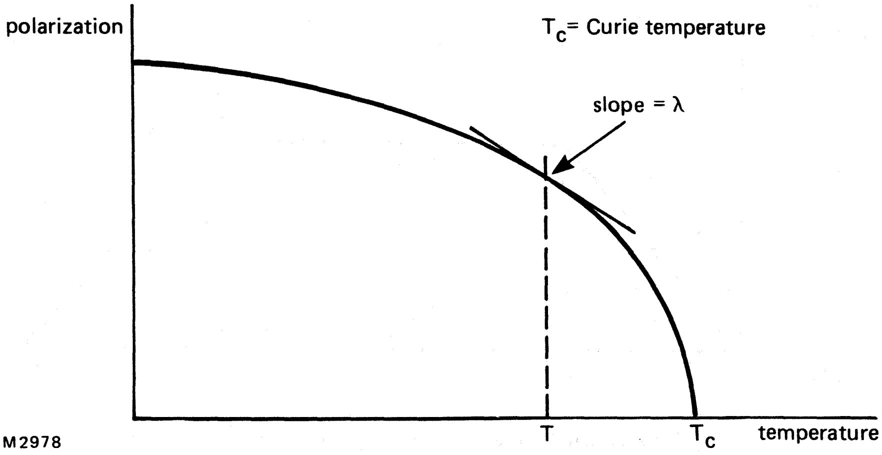


Fig.1 Polarization as a function of temperature.

Being dielectric with a high impedance the TGS material is formed into a sensing element by depositing electrodes on opposite faces of a thin slice of the material to form a capacitor. When the polarization changes, the charges induced on the electrodes can be made to produce a voltage across the slice if the external impedance is comparatively high. Hence the TGS element is normally operated in conjunction with a Field Effect Transistor, as in Fig.3, with a gate leakage resistance R or Z_g of the order of 10^{11} Ω.

The theroretical voltage responsivity (in volts/watt) first derived by Cooper[1], of such a pyroelectric sensor, is given by:—

$$R_V = \eta \frac{(\omega \lambda A R)}{G} (1 + \omega^2 \tau_T^2)^{-1/2} (1 + \omega^2 \tau_E^2)^{-1/2} \qquad \text{Eqn (1)}$$

where η is the fraction of incident radiation absorbed, λ the pyroelectric coefficient, A the area of the electrodes, R the electrical resistance and G the thermal conductance coupling the element to its surroundings.

In equation (1) $\tau_T = \frac{H}{G}$, the thermal time constant and $\tau_E = RC$, the electrical time constant. H and C are the thermal and electrical capacitances respectively.

The responsivity exhibits a frequency dependence as illustrated in Fig.2.

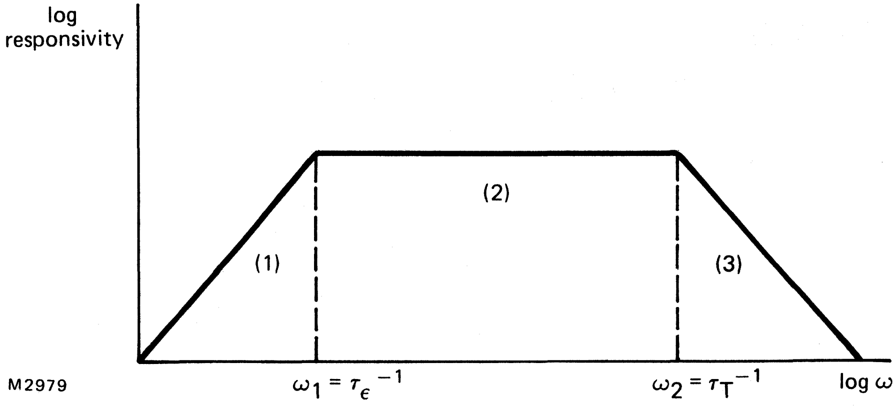


Fig.2 Responsivity as a function of ω for a theoretical sensor.

Because the electrical and thermal time constants are normally made long to maximize sensitivity, regions (1) and (2) occur at very low frequencies (<1 Hz). Consequently sensors are usually operated in region (3) where the responsivity falls linearly with frequency. In this region the equation for responsivity simplifies to:—

$$R_V = \frac{1.8 \times 10^{12} \eta \lambda}{f \epsilon A \rho C_V} \qquad \text{Eqn (2)}$$

where ρ is the density of the material, ϵ its relative permittivity and C_V its constant volume specific heat. If desired, a flat frequency response can be recovered by following the sensor with an amplifier having gain proportional to frequency (f).

Typical values of τ_E and τ_T for sensors designed to operate in the 10 to 100 Hz region would be:—

τ_E — usually in the range 0.2 to 10 s (dependent on element size and FET gate resistor)
τ_T – 150 to 200 ms

Ref.1 Cooper, J. 1962 Rev. Sci. Instrum., 33, 92.

With some sensors, the gate leakage path is provided by a pair of low leakage diodes connected in anti-parallel (Philips patent). These enable τ_E to progressively decrease under increasing conditions of signal overload, resulting in a rapid recovery when the source of overload is removed.

For sensors required to have a greater power handling capability, e.g. for use in Fourier transform spectrometers, the element mounting is designed to give much shorter values for τ_T.

From equation (2) it is apparent that responsivity is inversely proportional to element area — the smaller the element, the larger the responsivity. If the element is illuminated by a uniform energy flux, then it follows that the signal from the device is independent of the element area — halving the element size halves the energy on the element and results, from a doubling of the responsivity, in the same signal level.

NOISE IN PYROELECTRIC SENSORS

A pyroelectric element has a very high impedance (of the order of 10^{11} Ω) and in order to be able to make use of the device easily it is almost invariably coupled with a J-FET having a high input-impedance but a low output impedance (Fig.3).

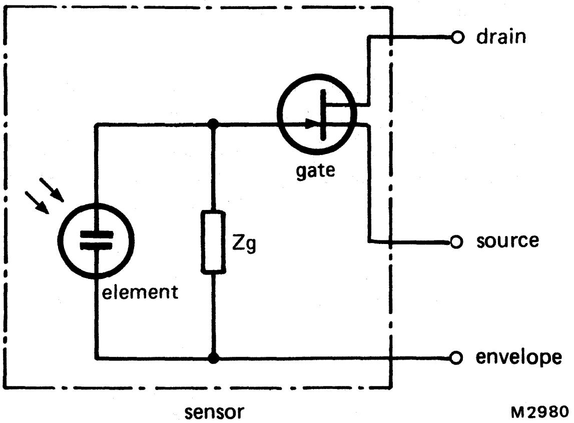


Fig.3 Sensor circuit.

Since the FET is a source of noise, the choice of FET is normally left to the sensor manufacturer and forms part of the integral structure of the sensor.

The noise from a sensor can exhibit three distinct regions as a function of frequency (Fig.4).

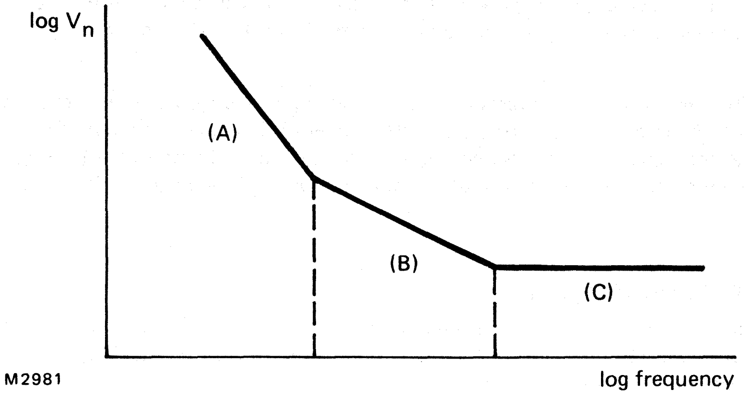


Fig.4 Noise as a function of frequency.

Regions A and C result from various noise sources in the FET and its associated components. Region B is caused by the loss conductance of the element itself in the form of Johnson noise.

If, as is usual, the sensor is being operated in region 3 of the responsivity curve, then the resulting noise equivalent power (NEP, a measure of the noise to signal ratio) varies with frequency as shown in Fig.5.

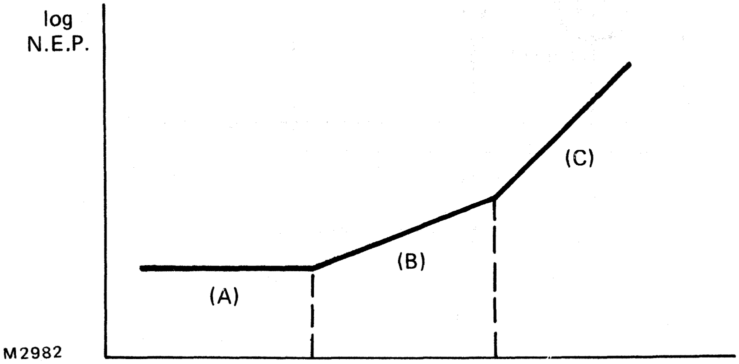


Fig.5 N.E.P. as a function of frequency.

It should be noted that the limits of the low, intermediate and high frequency regions vary; they depend on the design of the amplifier and on the loss conductance of the particular element.

TGS MATERIAL EVOLUTION

Triglycine sulphate – TGS

As already mentioned, TGS, below its Curie temperatue, exhibits a large electrical polarization which is temperature dependent. The form of the polarization/temperature curve is illustrated in Fig.1.

The pyroelectric coefficient is defined as $\lambda = \frac{dP}{dT}$, the slope of the curve at a given temperature.

Pure TGS has a Curie temperature of 49 °C. In the early phase of the development of these sensors this was quickly proved to be a fundamental problem because, if a sensor was taken to a temperature above its Curie point, the material depolarized and its sensitivity was lost. In fact, sensors proved to be unstable even below the Curie temperature with signal being lost quite spontaneously.

The discovery therefore, that the doping of TGS crystals with L-alanine during its growth produces an internal electric field which keeps the crystal polarized below its Curie temperature, was of fundamental importance to its use as a practical, reliable infrared sensing material. The doping of TGS crystals with L-alanine is a Philips patented process and material prepared this way is known as LATGS.

The introduction of the doping of TGS in this way produced another benefit, in that the electrical loss of the material was substantially reduced, resulting in detector NEP performance which has never been surpassed.

The Curie temperature of 49 °C causes the maximum operating temperature to be limited to 45 °C. By deuteration of the LATGS material, the Curie temperature is raised to 60 °C, giving an upper operating temperature of 55 °C. This material, DLATGS, is increasingly becoming the standard for this class of sensor and is the preferred material for new development types.

TGS QUALITY PROCEDURES

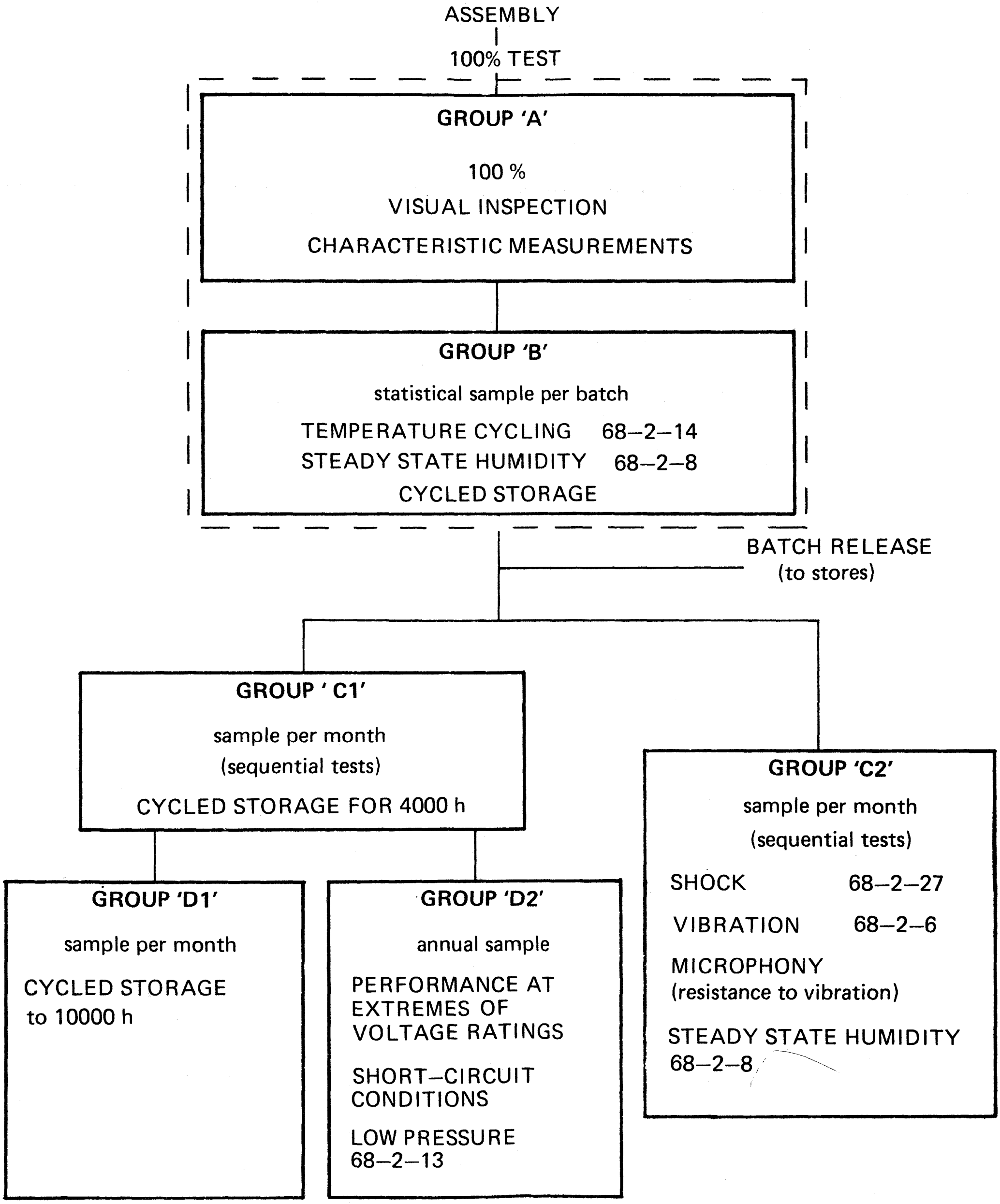
The L-alanine doped triglycine sulphate (LATGS) and the deuterated L-alanine doped, triglycine sulphate (DLATGS) infrared sensors are manufactured using methods and materials that ensure the product is rugged enough to withstand global transportation and gives reliable performance in its application.

Components for the device are inspected and tested prior to assembly into sensors and each stage of assembly is inspected to ensure conformity with design. On completion, every sensor is tested for its primary characteristics before being passed to the Quality Assurance Department. At this stage, every sensor is re-measured and a sample of the production batch is taken for environmental tests. Subject to satisfactory results at the conclusion of those checks, the batch is released.

To establish confidence in product reliability, additional samples are taken each month. These devices are submitted to either a prolonged environmental test or a series of tests designed to ensure that the device will withstand electrical overstress and severe mechanical and environmental conditions. With two exceptions, the mechanical and environmental tests are taken from the International Electrotechnical Commission (I.E.C.) "Recommended Basic Climatic and robustness Testing Procedure for Components for Electronic Equipment", publications I.E.C. 68—1 and I.E.C. 68—2—series. The two exceptions are tests devised to check device performance during an extended period of operation under varying temperature conditions and to check device ouptut whilst undergoing random vibration. Intermediate and post-test measurements are carried out on all the reliability tests.

Additional performance and reliability tests may be carried out on some products to assess their suitability in specific applications.

TYPICAL CONFORMITY AND RELIABILITY ASSESSMENT PROCEDURE



CERAMIC INFRARED SENSORS

INTRODUCTION TO CERAMIC INFRARED SENSORS

Although infrared sensitive devices were originally designed for military and scientific applications, the development of low cost models has meant that their use in industrial and consumer products is becoming both economical and practical. One important field where pyroelectric infrared sensors are making a significant impact is that of security in both the commercial and residential markets.

Our ceramic infrared sensors are currently available in single, dual and four element configurations.

The standard TO-39 single and dual element devices have been available for some time and include RPY100, RPY102, RPY107 and RPY109 (single elements), RPW100 and RPW102 (dual elements).

This TO-39 product range has now been increased to include the RPW101, a low profile, lower cost version of the RPW100, and the RPY222, a sophisticated two channel (4 element) sensor with a unique element configuration which enables intelligent signal processing to be carried out leading to improved immunity to false alarms.

In addition we now have available low cost "flatpack" sensors, the KRX10 and KRX11, for applications such as light switching and door opening, etc.

The single element sensors are intended for non-focused movement detection, low cost gas analysers and remote temperature measurement applications. The sensor element is combined with a single impedance converting amplifier specially designed to operate from a low voltage supply with low current consumption. Each sensor is sealed in a TO-39 variant can with an infrared window.

The dual element sensors all have differentially connected elements which provide improved immunity from common mode signals such as those generated by variations in ambient temperature, background radiation and acoustic noise. The wide separation of the elements in these sensors makes them compatible with most optical systems used in movement sensing applications. As with the single element sensors, the elements are combined with a single impedance converting amplifier specially designed to operate from a low voltage supply with a low current consumption.

The recently introduced RPW101 is a low profiled TO-39 version of the RPW100 and is intended to give a lower cost option to this sensor.

The two channel device RPY222 is two sensors in one TO-39 envelope. Our unique and patented "interdigitated" element construction enables the intruder alarm manufacturer to process out most of the false alarm mechanisms which may affect passive infrared systems. Each channel has its own impedance converting amplifier.

The two new envelope types designed specifically for light switching applications, KRX10 and KRX11, are both dual element sensors and, as with their TO-39 counterparts, have a single impedance converting amplifier specially designed for low voltage supply with low current consumption. Their "flatpack" envelope makes them easier to handle and also ideal for short local length optics.

MOVEMENT SENSING USING A MULTI-ELEMENT FRESNEL LENS

1. INTRODUCTION

Our pyroelectric sensors are used extensively in passive infrared movement sensing applications where high sensitivity, reliability and low cost are basic requirements.

Although these sensors may be used directly to monitor scene thermal changes, it is generally advantageous to employ collecting optics to focus radiation on to the device. Thin, highly transmitting Fresnel lenses can collect infrared radiation very efficiently and provide optical gain over a defined field of view. This publication reviews the basic properties of Fresnel lenses in terms of geometric optics and describes the use of our Fresnel lens, which has been developed for general purpose movement sensing applications.

2. THE PROPERTIES OF FRESNEL LENSES

2.1 The Fresnel Lens

In applications such as movement sensing, it is often necessary to employ short focal length, large aperture lenses, to collect sufficient radiation from what may be a weak or distant source. Unfortunately, the unavoidable thickness of such lenses rules out standard lens materials because of absorption losses. On the other hand, materials which have very low absorption, over the 6 to 14 μm wavelength range, are generally too expensive for commercial use.

Fresnel lenses, however, offer a neat solution to such problems since they can be produced in extremely thin sheets and thus allow the use of materials which have relatively poor transmission (e.g. polyethylene). They are essentially equivalent to thick conventional lenses, but with most of the bulk material between the outer surfaces removed. Without elaborating further, the equivalence of both types of lenses can be shown by considering the laws of refraction. This shows that the ray bending or refracting power of a lens is a function of surface curvature (and material refractive index) rather than the path length within the body of the lens.

In modern Fresnel lens designs, the profile of each groove facet is determined by computer simulation to produce the sharpest possible image from a distant object.

Although it is possible to produce Fresnel lenses of very large area, the effects of total internal reflection dictate that it is not useful to have a lens diameter much greater than the focal length. Radiation reaching areas beyond this is merely reflected back into the lens.

2.2 Lens operation and formulae

This section reviews the properties of lenses in terms of geometrical optics. This idealized approach gives sufficiently accurate results for most practical situations.

2.2.1. Focusing and imaging formulae

A lens is a device having refracting power and can be used to collect parallel rays (radiation) and focus them at a single point. The greater the refracting power of a lens, the closer the focal point will be to the lens. Focal length is defined as the distance between the focal point and lens centre and is a basic measure of the radiation gathering ability of a lens.

The focal length of a thin, plano-convex lens is given by:

$$\frac{1}{f} = (n-1)\frac{1}{r}$$

Where n represents the lens refractive index (approx. 1.5 for polyethylene) and r is the lens radius of curvature at its centre.

Object and image positions are related by the standard formula.

$$\frac{1}{f} = \frac{1}{\ell'} - \frac{1}{\ell}$$

Where ℓ and ℓ' are object and image distances respectively. Details regarding sign convention for this formula can be found in Reference 1.

An implication of this formula is that all rays pass through the lens centre undeviated. This can be seen by considering rays from a small object h, placed on one side of the lens, as shown in Figure 1, where ℓ is greater than f.

For clarity only two extreme and one central ray are shown per object point. These are just particular rays in what is in fact a ray cone or bundle.

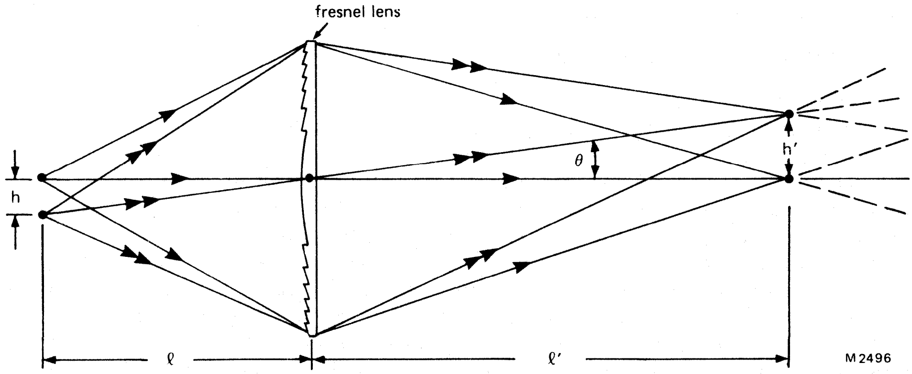


Figure 1 Image and object positions

A simple relationship exists between object and image size. By similar triangles, the magnification (M) is given directly as:

$$M = \frac{h'}{h} = \frac{\ell'}{\ell}$$

Where h and h' are object and image heights respectively.

Manipulation of the standard formula yields two further useful expressions for magnification:

$$M = 1 - \frac{\ell'}{f} \text{ and } M = \frac{1}{\frac{\ell}{f} + 1}$$

The effect of positioning an object about the focal point is shown in Figure 2.

When the object is precisely at the focal point P_1, the rays refracted by the lens emerge parallel to each other. Shifting the object away from the lens to P_2 causes the emergent rays to converge to a point P_2'. A shift towards the lens creates a divergent ray bundle.

Since the path of light rays is reversible, the points P_2 and P_2' are interchangeable. A radiating source (object) at P_2' will be imaged at P_2 the usual position for a sensing element. Moreover, radiation from a source positioned on the right hand side of the lens will be directed on to P_2 (the sensor), provided they are of the appropriate direction and within the

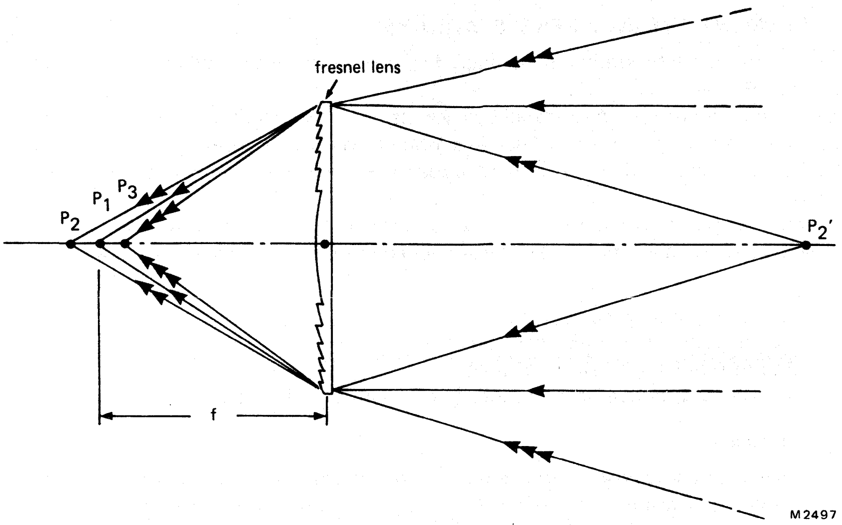


Figure 2 Effect of object shift

system 'field of view' (see section 2.2.2). In all cases, the line joining the centres of the lens and the sensor defines the direction (sensing) axis.

Returning to Figure 1, it can be seen that the ray cones overlap least at the image points. Thus the images of two adjacent sensor elements placed at P_2 (Figure 2), will be sharply defined and separated only near P_2'.

2.2.2 Field of view

An optical instrument such as a telescope may be used to view a limited area of a distant scene. This area limit, or object field of view, applies equally well to a lens and sensor system. A small object, placed near the focal point of a lens as in Figure 1, has an angular field of view (θ) given approximately as:

$$\theta = \frac{h}{f}$$

(NOTE: This angle is not to be confused with the sensor field of view).

2.2.3 Lens radiation collection

Although focal length determines the refracting power of a lens, the amount of radiation collected is also dependent on the effective collecting area.

A lens imaging a very distant source has a radiation gathering ability given by:

$$\text{Radiation collection} = \frac{K}{\text{f-number}^2}$$

Where f-number is the ratio of focal length over lens diameter and K is a constant.

An effective collecting area is implied in this expression. In general, it is simply the area within the rim of the lens; however, a lens inclined at an angle α to the direction axis has its effective area and collection reduced by a factor cos $(90-\alpha)$.

Collection is further reduced because of decreased transmission and image degradation (aberrations) of a tilted lens; the latter causes radiation to be redirected outside the defined image area.

3. MULTI-ELEMENT FRESNEL LENSES (ARRAYS)

Fresnel lens arrays are becoming increasingly favoured as radiation collecting devices for use with pyroelectric sensors.

The discrete field of view monitored by each element, coupled with a moving source, modulates the radiation incident on the sensor and thus causes pyroelectric signal generation. Significant signals occur whenever a thermal source passes from an unmonitored to monitored area, or vice versa.

By distributing many elements over the area of the array, extended coverage can be achieved.

Fresnel lens arrays have many advantages over equivalent reflecting optics arrays. Briefly these are:

- Less bulky and lighter
- Can be used without external windows
- Do not require specialized coating
- Cheaper to produce both in tooling and quantity unit costs

3.1 Our Fresnel lens array

We have developed a low cost Fresnel lens array for use with our sensors, suitable for general purpose movement sensing applications. It is designed to provide high sensitivity, long range monitoring up to a least 12 metres, with 90° volumetric coverage.

The lens specification is outlined in Table 1 and Figure 3.

Table 1 Lens Specification/Data

Focal length	30.5	mm
Nominal coverage	12 metres x 90	o
Number of monitored zones	A = 8 B = 4 C = 3	
Nominal average transmission	50	%
Material	polyethylene	

MECHANICAL DATA Nominal dimensions in mm

For mounted lens

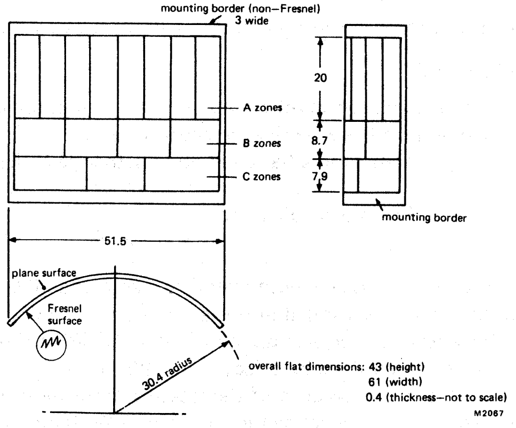
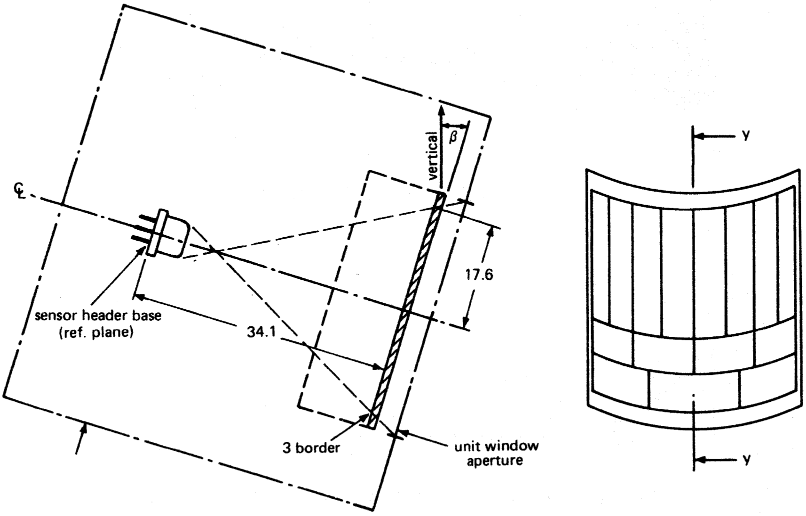


Figure 3 Lens mechanical data

The important features of the lens are:—

- A 15 element design which provides high signal sensitivity and movement discrimination.
- High quality optics match the imaging requirements of dual element sensors. Single element sensors may also be used, with reduced coverage (i.e. 50% fewer zones).
- Fresnel groove depth and thus transmission is constant over whole lens area.
- All elements are designed to give optimum radiation collection at the range limit — aspheric groove contours minimize image aberrations.
- Each element includes part of the central ring which maintains high collection efficiency — less loss due to inter-groove shadowing, scattering and diffraction.
- Can be used grooves-in or grooves-out, depending on requirements. In dusty environments grooves-in is recommended. If this is not the case, or if an external window is used, we recommend that the lens be used grooves-out, thus providing up to 20% more signal than with grooves-in.

3.1.1 Typical usage and performance



(a) side view through lens section (y—y)

(b) front view of lens

Figure 4 Typical mounting arrangement

A typical lens mounting arrangement is shown in Figures 4a and 4b, which represent the side and front views respectively. In Figure 4a the sensor plane and the lens section (y-y) are parallel and are inclined by an angle β to the vertical.

In this configuration all 'A' and 'B' elements are almost perpendicular to their respective direction axes (element to sensor centres), which ensures optimum collection along the zones. Objects positioned at the range limit are essentially in focus on the sensor. In addition, the system field of view is such that a human outline, at this range, just fills a 2 x 1 mm sensor area.

Nominal zonal coverage, corresponding to $\beta = 12^{\circ}$ and a fixing height of 2.1 metres, is depicted in Figures 5 and 6.

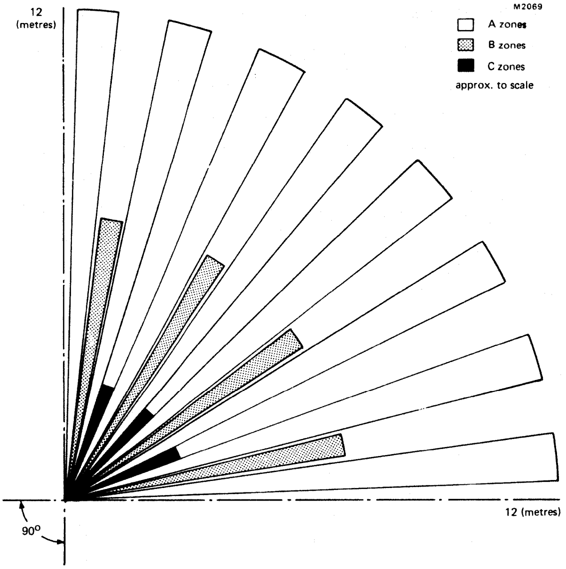


Figure 5 Nominal zonal coverage – plan view

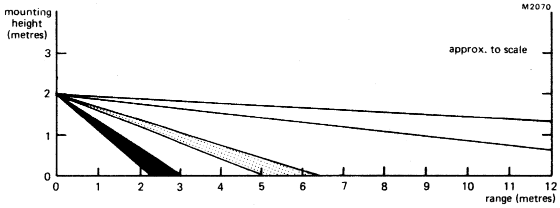


Figure 6 Nominal zonal coverage – side view

The minimum window aperture for the enclosure can be determined with reference to Figure 4a; namely by extending the dotted line from sensor to lens edges (vertically and horizontally) until they intersect the enclosure face.

A typical curve of sensor response against target range, for a single 'A' zone is shown in Figure 7. Because pyroelectric signal generation is proportional to radiant energy differences, this response curve will be strongly dependent on both background and target temperatures. The reduction of signal at short range results from minor cancellation effects. Such effects occur whenever both elements of a dual element sensor receive a proportion of energy from the same source.

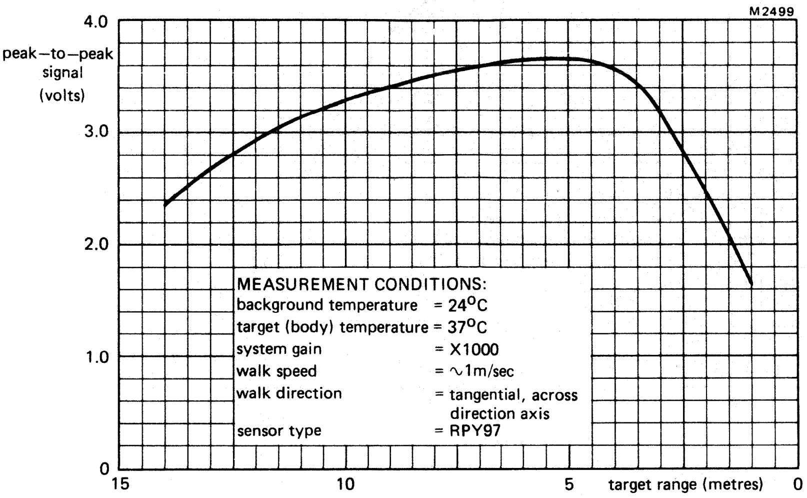


Figure 7 Typical signal level as a function of target range

3.1.2 Alternative mounting configurations

Although the mounting arrangement in Figure 4 will be suitable for most general applications, particular situations may dictate alternative configurations. Useful alternative mounting arrangements fall into two categories, **a)** where the unit is repositioned as a whole, and **b)** where the lens is repositioned relative to the sensor. Unit orientation and mounting height fall into the first category, whilst a different lens tilt angle, relative to a fixed sensor position, belongs to the latter category. The effect on system performance associated with any such changes needs careful consideration, particularly with regard to changes in zonal coverage and signal response.

The monitoring of a small room is one example where improved performance will be obtained by changes to the standard mounting arrangement. More effective coverage and increased signal levels will be achieved by inclining the zone-fan downwards or by shifting the whole zone-fan vertically downwards. The former can be achieved by a downward tilt of the unit whilst the latter simply requires a reduction in fixing height. In both cases, moving the lens and sensor as a unit does not affect the position of zones relative to one another.

The lens may be used equally well in other configurations where constraints such as unit shape restrictions dictate. In cases where it is necessary to change the position/orientation of the lens relative to the sensor, consideration must be given to associated changes in focusing as well as zonal coverage and signal response.

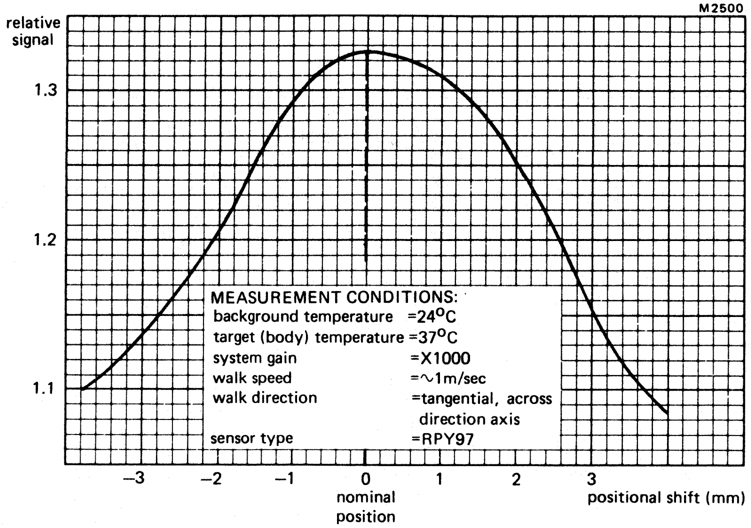


Figure 8 Typical relative signal as a function of sensor position

For guidance, a plot of signal sensitivity versus sensor position, for a single 'A' zone, is given in Figure 8, where the peak of the curve corresponds to the sensor in its nominal position. At this point, the image of the object at the design range is sharply defined so as to ensure minimum signal cancellation, after image motion across the elements.

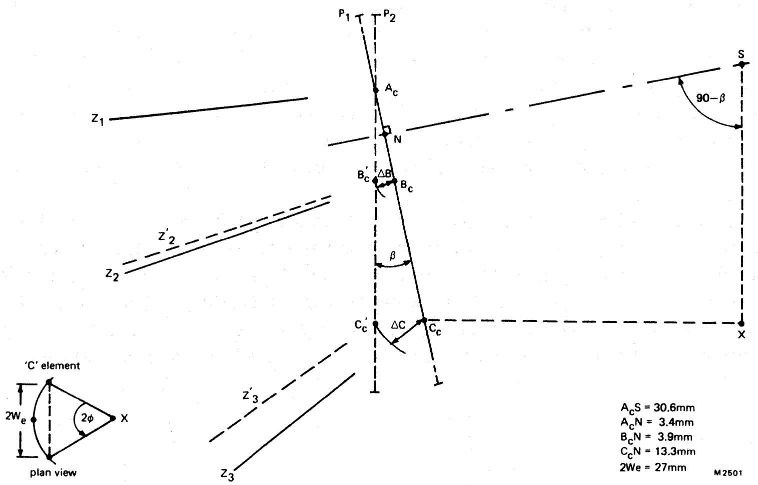


Figure 9 Zonal coverage as a function of lens tilt

The effect of lens tilt angle on zonal coverage is illustrated in Figure 9, where lens position P_1 corresponds to a 12° tilt for nominal zonal coverage. Only the central vertical section of the lens is shown. A_c is an 'A' zone element centre, and is taken as being the section. B_c and C_c are the corresponding points for the B and C elements and S is the sensor position. S, A_c, B_c and C_c define the direction axes Z_1, Z_2 and Z_3 for position P_1. Note that the outer elements also define direction axes in space but have been omitted for clarity.

Another lens position of particular interest is that with the lens vertical (zero tilt) which corresponds to P_2 in the diagram. To maintain the nominal 'A' zone direction, the lens has been vertically rotated about A_c. This rotation also ensures that 'A' zone focusing is unaffected. Although direction axis Z_1 is common to position P_2 the new directions for the 'B' and 'C' zones become Z'_2 and Z'_3. Thus the zone-fan is compressed vertically, and the greatest shift occurs along the C element direction. Even so, the 'aiming' points of the 'B' and 'C' zone axes are shifted by only approx. 400 mm, along the floor. Such small shifts can be compensated for by repositioning the sensor along A_cS, at the penalty of 'A' zone defocusing.

For all tilt angles other than 0°, the inclination of the extreme zones differs slightly from the central ones of any row. Over a lens tilt range of 0 to 14° (fixed sensor position), however, the effect is of little practical significance. At 12° tilt, for instance the extreme 'A' zone aims at a point approx. 500 mm above the central 'A' zone, at 12 metres range. Because of the shorter distances involved, the effect is also insignificant for the 'B' and 'C' zones.

The projected angle of any zone fan onto the horizontal plane is also affected by lens tilt. For tilt angles below 14° the effect is small, and may be neglected for the 'A' and 'B' zones, given fixed S and rotation as in the diagram. For the 'C' zones, the sine of the projected zone fan semi-angle ϕ changes from:

$$\sin\phi \approx \frac{W_e}{C_cX} \approx \frac{W_e}{C'_cX - A_cC_c \sin\beta} \quad \text{to}$$

$$\sin\phi \approx \frac{W_e}{C'_cX} \qquad \text{after rotation,}$$

where $C'_cX = A_cN \sin\beta + SN \cos\beta$ and W_e is the half-distance between the outer 'C' zone elements (see plan view inset). With the geometry of the lens given, simple trigonometry can be used to calculate the changes in fan angle. The total projected 'C' zone fan-angle is approximately 60° for a 14° tilt and changes to 52° at zero tilt.

Although the element to sensor distance A_cS is taken to be fixed after rotation, lens geometry is such that the focusing distance of all 'A' zone elements, (to S) also remains essentially constant. This is not the case for the 'B' and 'C' element focusing distances, which are increased by ΔB and ΔC, respectively. For both these rows of elements, images which are sharply focused at S, now correspond to object points much closer to the lens. As a consequence of defocusing, increased cancellation effects reduce signal levels for the 'B' and 'C' zones at maximum range (see Figure 7); because of the proximity of object sources, the effect is less significant for the 'B' zones.

Because of the factors outlined in section 2.2.3, signal reduction also occurs as a direct result of lens inclination to the direction axis. For the 'A' zones, lens inclination to Z_1 is similar for both 0^o and 12^o tilt, so that radiation collection is unchanged. The 'B' and 'C' direction axes, however, are increasingly inclined to the lens after rotation to P_1. Typical signal reduction factors versus lens inclination angle α can be estimated from the curve in Figure 10. In this case, the additional signal reduction for the 'B' and 'C' zones after rotation, is approximately 50% and 60% respectively.

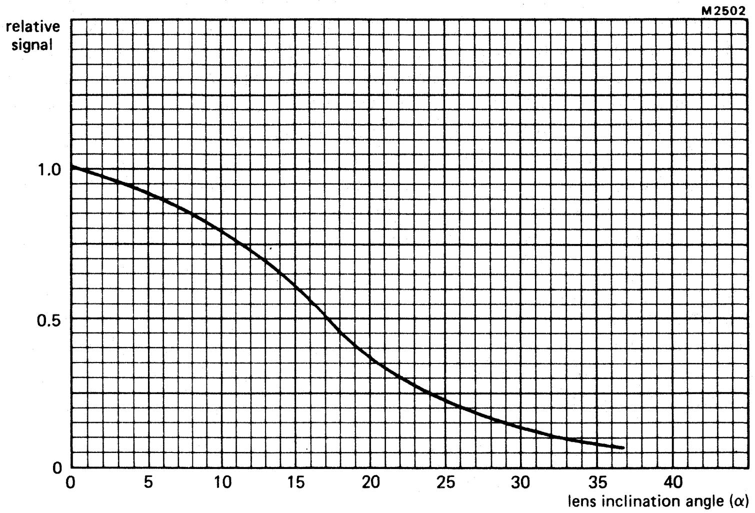


Figure 10 Typical relative signal as a function of lens inclination

Another factor which affects signal level is the sensor angle relative to a zone axis. This arises because sensor sensitivity is approximately dependent on the cosine of the angle between the sensor normal and the direction of incident radiation. In general, directing the sensor axis along SN provides a reasonable compromise. In this condition, the sensor response is within approx. 5% of maximum for both 'A' and 'B' zones, where maximum corresponds to radiation at normal incidence (0^o). The effective sensitivity of the sensor for the 'C' zone is within approx. 15% of maximum.

If desired, the optimum response may be achieved from one zone row by orientating the sensor vertically towards the effective centre of the central zone element; for the 'A' zones this corresponds approximately to a horizontal position of the sensor axis. Similarly, optimum response along the 'B' or 'C' zones can be achieved by directing the sensor axis at the centre of the appropriate element. Naturally, directing the sensor to favour a particular zone row reduces the signal response for the other rows.

In any particular configuration, account must be taken of any signal reduction factors e.g. lens inclination to a direction axis. Such factors will modify the signal sensitivity versus range curve. Because some of the effects associated with lens/sensor movement can independently affect signal cancellation, e.g. focusing and zonal coverage density, and because of the nature of real sources, the modification of overall response will only be approximated by the summation of all the separate reduction factors.

REFERENCE

1. Geometrical and physical optics, R.S. Longhurst (Longman).

ORDERING

The lens is available **only** in conjunction with one of **our** range of pyroelectric sensors and is obtainable by adding the suffix FL to **our** sensor part number.

DUAL ELEMENT PYROELECTRIC INFRARED SENSOR

Special features:	Enhanced IR sensitivity Wide field of view Pick and place compatible
Application:	For use in passive IR light switching systems
Element configuration:	Dual element series opposed
Electrical:	Incorporating impedance converting amplifier
Window:	Daylight filtered silicon

QUICK REFERENCE DATA

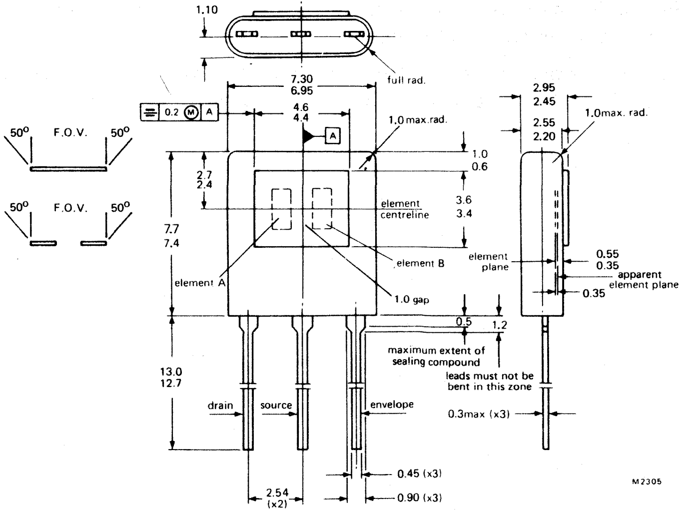
Measured in source follower mode with 100 kΩ load resistor

	min.	typ.	max.	
Noise, peak-to-peak (bandwidth 0.4 Hz to 5 Hz)	–	25	45	μV
Peak signal (500K, 1) with incident energy of 25 μWcm^{-2}	570	900	–	μV
Element dimensions	–	2 x 1	–	mm
Field of view	–	see below	–	degrees
Operating voltage	3	–	10	V
Optimum operating frequency range	0.1	–	20	Hz

This data must be read in conjunction with GENERAL SAFETY RECOMMENDATIONS – OPTOELECTRONIC DEVICES

MECHANICAL DATA

Dimensions in mm ←



see operating note 8, page 2

PRODUCT SAFETY

Modern high technology materials have been used in the manufacture of this device to ensure high performance. Some of these materials are toxic in certain circumstances. Mechanical or electrical damage is unlikely to give rise to any hazard, but toxic vapours may be generated if the device is heated to destruction. Disposal of large quantities should therefore be carried out in accordance with the latest local legislation.

SOLDERING

1. When making soldered connections to the leads, a thermal shunt should be used.
2. It is essential that any mains operated soldering iron used should be both screened and earthed. Failure to observe these precautions may lead to the introduction of line voltages and possible damage to the device. (See operating note 7).

OPERATING NOTES

1. The case potential must not be allowed to become positive with respect to the other two terminals.
2. It is inadvisable to operate the sensor at mains related frequencies.
3. To avoid the possibility of optical microphony, the sensor must be firmly mounted.
4. An increase in temperature of element A will produce a positive going signal at the output. For element B, the corresponding output will be negative going.
5. The sensor will operate outside the quoted range but may have a degraded performance.
6. Due to the high sensitivity of these sensors, care must be taken to ensure that the devices are allowed to become thermally stable before testing.
7. To avoid the possibility of electrostatic damage, precautions similar to those used with CMOS devices are necessary, namely:
   a) Earthed wrist staps should be worn.
   b) Table tops or other working surfaces should be conductive and earthed.
   c) Anti-static clothing should be worn (no wool, silk or synthetic fibres).
   d) No electrical testing should be carried out without specific, approved and written test procedures.
   e) To prevent the development of damaging transient voltages, devices should not be inserted or removed from test fixtures with power applied.
8. Because of its small dimensions, this sensor has a low thermal mass. Optimum performance will be obtained by mounting it flat onto a printed circuit board with a thermally conductive adhesive.

CHARACTERISTICS (at T_{amb} = 22 °C ± 3 °C and with recommended circuit).

Measured in source follower mode with 100 kΩ load resistor

		min.	typ.	max.	
Spectral response		6.5 ± 0.5	–	> 14	μm
Noise, peak-to-peak (bandwidth 0.4 Hz to 5 Hz)	(see note)	–	25	45	μV
Peak signal (500 K, 1) with incident energy of 25 μWcm^{-2}		570	900	–	μV
Element dimensions		–	2 x 1	–	mm
Field of view		–	see page 1	–	

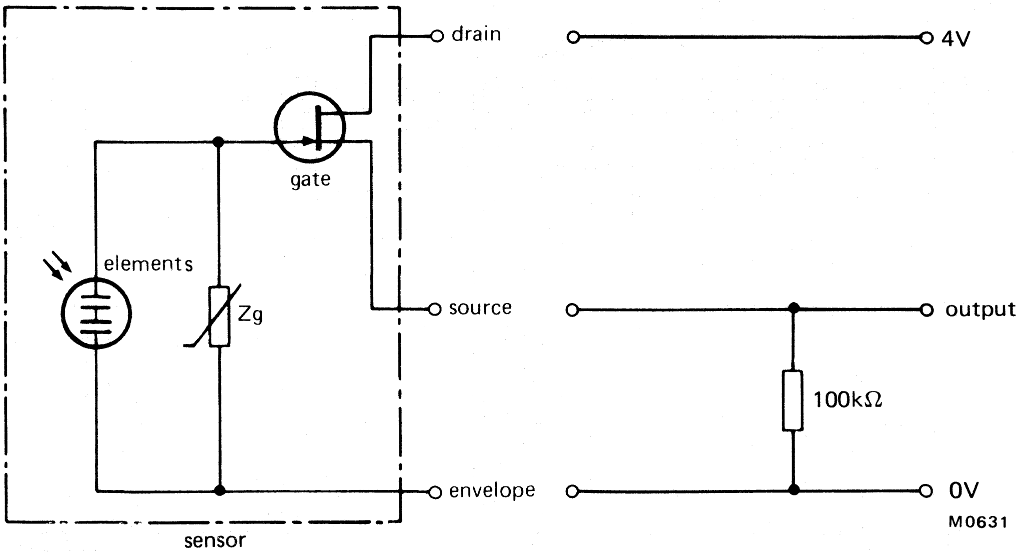
FET Characteristics (at T_{amb} = 22 °C ± 3 °C)

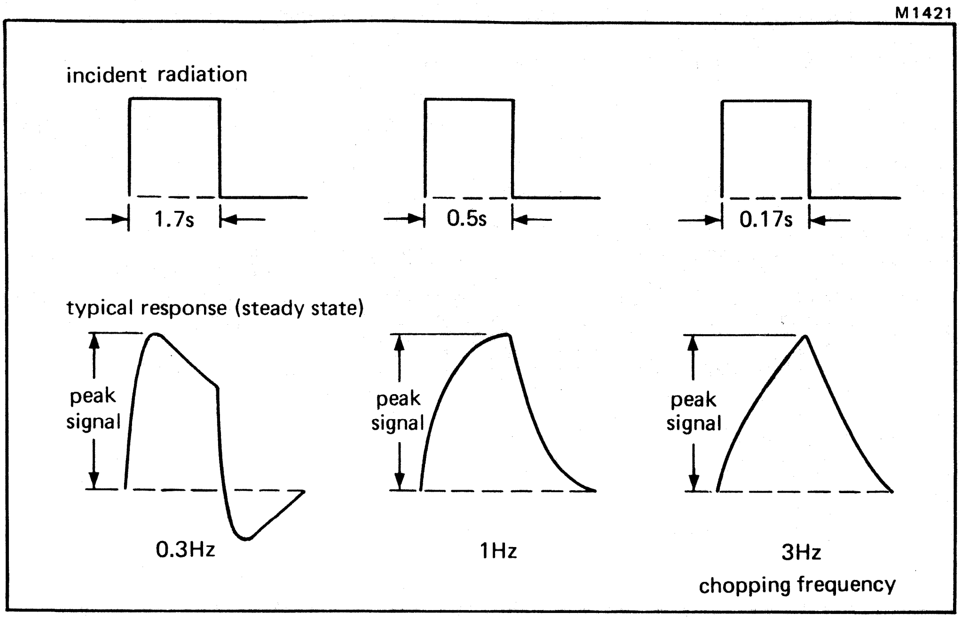
		min.	typ.	max.	
Gate-source cut-off voltage $I_D = 0.1\ \mu A$, $V_{DS} = 6$ V	$V_{(P)GS}$	–1.4	–	–0.5	V
Transfer conductance $V_{GS} = 0$, $V_{DS} = 6$ V, f = 1.0 kHz	g_{fso}	1.3	–	–	mAV^{-1}

Note

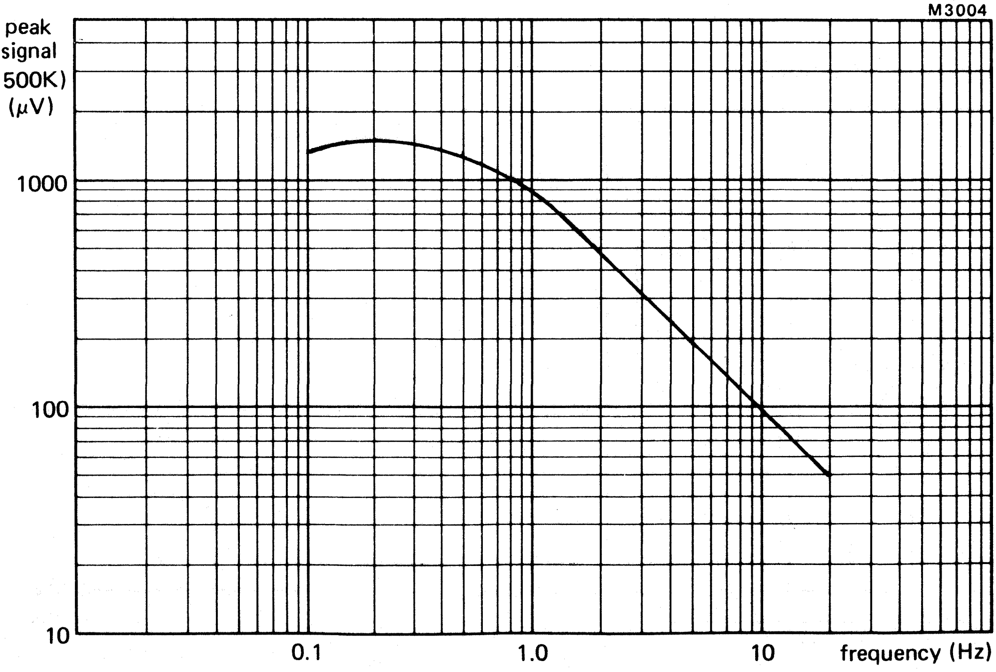
Using low noise filter with 3 dB bandwidth (0.4 Hz to 5 Hz) and roll off at 12 dB per octave. Sensors tested for 1 minute under stable electrical and thermal conditions; see operating note 6 on page 2.

RECOMMENDED CIRCUIT

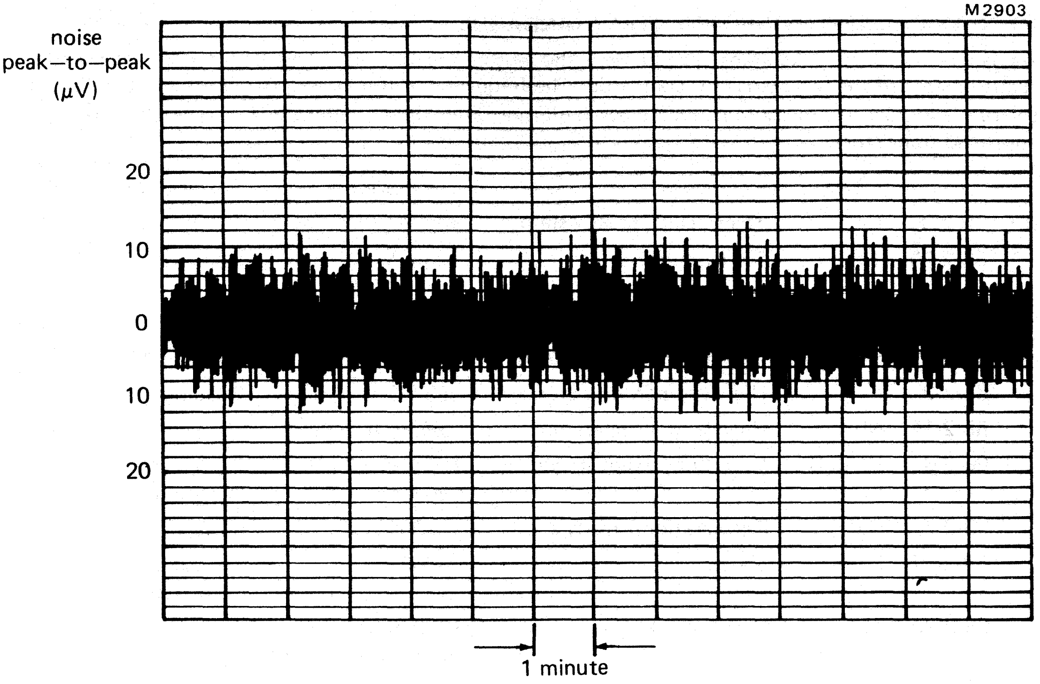




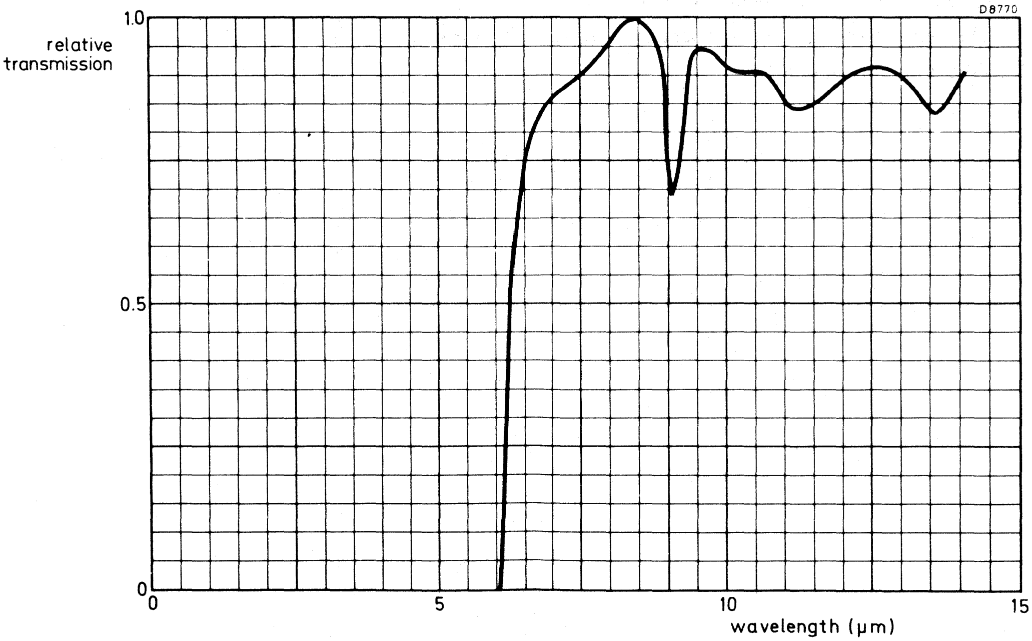
Typical response (steady state) for a given chopping frequency



Typical peak signal as a function of frequency
(energy level 25 μWcm^{-2} at the element with the other element screened)



Typical peak-to-peak noise as a function of time
(filter bandwidth 0.4 Hz to 5 Hz)



Typical normalized window transmission characteristic

MECHANICAL AND ENVIRONMENTAL STANDARDS

As part of the Quality Assurance programme, the sensors are assessed at regular intervals against the requirements of the following IEC standards. The frequency of testing and the limits and conditions for the pre- and post-test measurements are based on those stipulated for the CECC 50 000 series of approved transistors.

Test				Severity	Duration	Note
IEC	68-2-3	Ca	Damp Heat, steady state	+40 °C, 95% RH	168 hours	1
	68-2-20	Ta	Solderability	+235 °C, 1.5 mm from header	5 seconds	1
	68-2-21	Ub	Lead Fatigue	4 cycles	–	1
	68-2-1	Aa	Low Temperature Storage	–55 °C	2000 hours	2
	68-2-2	Ba	High Temperature Storage	+85 °C	2000 hours	2
	68-2-14	Nb	Change of Temperature	–55 °C to +85 °C	10 cycles	2
	68-2-6	Fc (B4)	Vibration, swept frequency	125 Hz to 2 kHz 196 ms^{-2}	2 h in each orientation	2
	68-2-7	Ga	Acceleration, steady state	196000 ms^{-2}	60 seconds	2
	68-2-27	Ea	Shock	14700 ms^{-2}	3 pulses 6 orientations	2
	68-2-20	Tb	Resistance to Solder Heat	+350 °C, 6 mm from header	3 seconds	3

Notes

1. The sensors are checked on a production batch release principle at approximately weekly intervals. This is equivalent to Group B.
2. The sensors are checked at quarterly intervals. This is equivalent to Group C.
3. This is an annual check.

DUAL ELEMENT PYROELECTRIC INFRARED SENSOR

Special features:	Enhanced IR sensitivity Wide field of view Pick and place compatible
Application:	For use in passive IR light switching systems
Element configuration:	Dual element series opposed
Electrical:	Incorporating impedance converting amplifier
Window:	Uncoated silicon

QUICK REFERENCE DATA

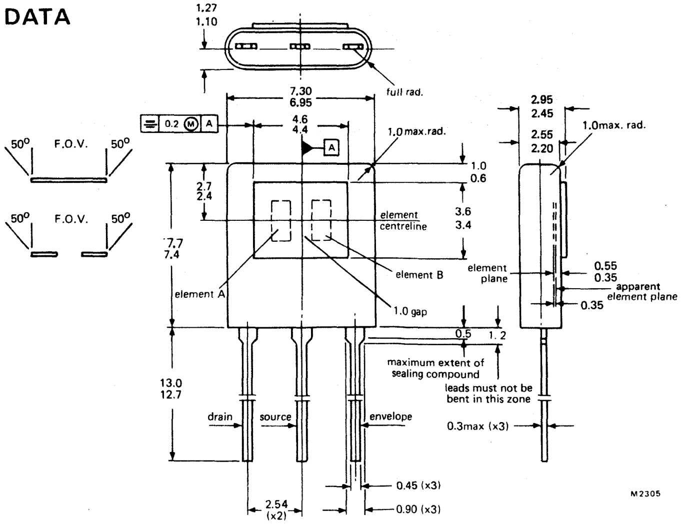
Measured in source follower mode with 100 kΩ load resistor

	min.	typ.	max.	
Noise, peak-to-peak (bandwidth 0.4 Hz to 5 Hz)	–	30	65	μV
Peak signal (500K, 1) with incident energy of 25 μWcm^{-2}	570	900	–	μV
Element dimensions	–	2 x 1	–	mm
Field of view	–	see below	–	degrees
Operating voltage	3	–	10	V
Optimum operating frequency range	0.1	–	20	Hz

This data must be read in conjunction with GENERAL SAFETY RECOMMENDATIONS – OPTOELECTRONIC DEVICES

MECHANICAL DATA

Dimensions in mm ←



See operating note 8, page 2

PRODUCT SAFETY

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SOLDERING

1. When making soldered connections to the leads, a thermal shunt should be used.
2. It is essential that any mains operated soldering iron used should be both screened and earthed. Failure to observe these precautions may lead to the introduction of line voltages and possible damage to the device. (See operating note 7).

OPERATING NOTES

1. The case potential must not be allowed to become positive with respect to the other two terminals.
2. It is inadvisable to operate the sensor at mains related frequencies.
3. To avoid the possibility of optical microphony, the sensor must be firmly mounted.
4. An increase in temperature of element A will produce a positive going signal at the output. For element B, the corresponding output will be negative going.
5. The sensor will operate outside the quoted range but may have a degraded performance.
6. Due to the high sensitivity of these sensors, care must be taken to ensure that the devices are allowed to become thermally stable before testing.
7. To avoid the possibility of electrostatic damage, precautions similar to those used with CMOS devices are necessary, namely:
    a) Earthed wrist staps should be worn.
    b) Table tops or other working surfaces should be conductive and earthed.
    c) Anti-static clothing should be worn (no wool, silk or synthetic fibres).
    d) No electrical testing should be carried out without specific, approved and written test procedures.
    e) To prevent the development of damaging transient voltages, devices should not be inserted or removed from test fixtures with power applied.
8. Because of its small dimensions, this sensor has a low thermal mass. Optimum performance will be obtained by mounting it flat onto a printed circuit board with a thermally conductive adhesive.

CHARACTERISTICS (at $T_{amb} = 22\,^{o}C \pm 3\,^{o}C$ and with recommended circuit).

Measured in source follower mode with 100 kΩ load resistor

		min.	typ.	max.	
Spectral response		–	optimized 6 to 14	–	µm
Noise, peak-to-peak (bandwidth 0.4 Hz to 5 Hz)	(see note)	–	30	65	µV
Peak signal (500 K, 1) with incident energy of 25 μWcm^{-2}		570	900	–	µV
Element dimensions		–	2 x 1	–	mm
Field of view		–	see page 1	–	

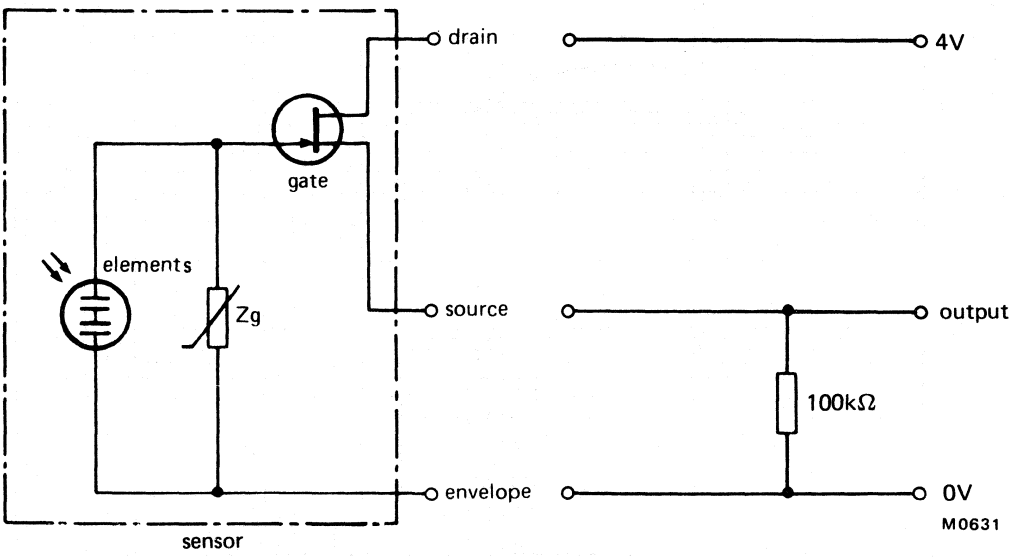
FET Characteristics (at $T_{amb} = 22\,^{o}C \pm 3\,^{o}C$)

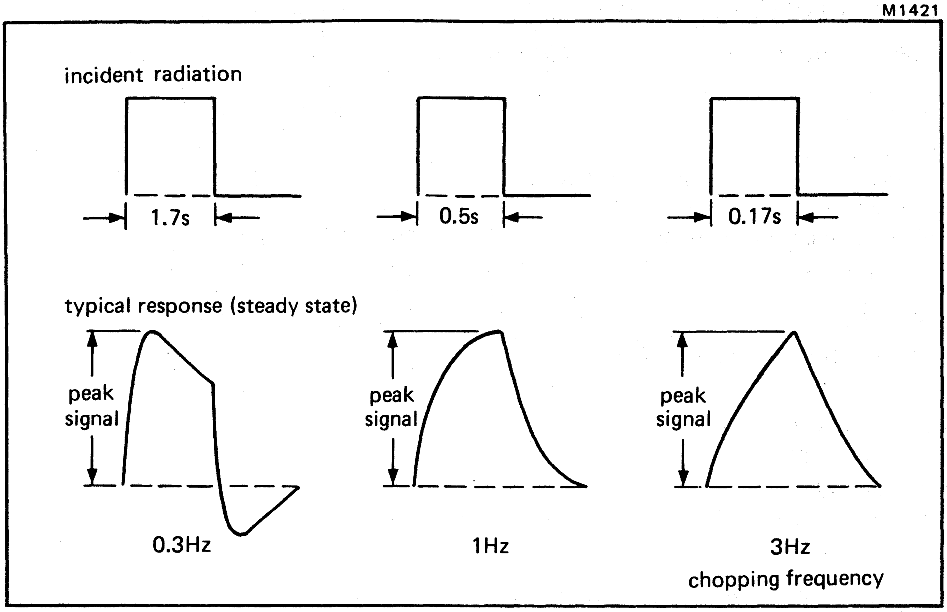
		min.	typ.	max.	
Gate-source cut-off voltage $I_D = 0.1\,\mu A$, $V_{DS} = 6\,V$	$V_{(P)GS}$	−2.0	–	−0.5	V
Transfer conductance $V_{GS} = 0$, $V_{DS} = 6\,V$, f = 1.0 kHz	g_{fso}	1.3	–	–	mAV^{-1}

Note

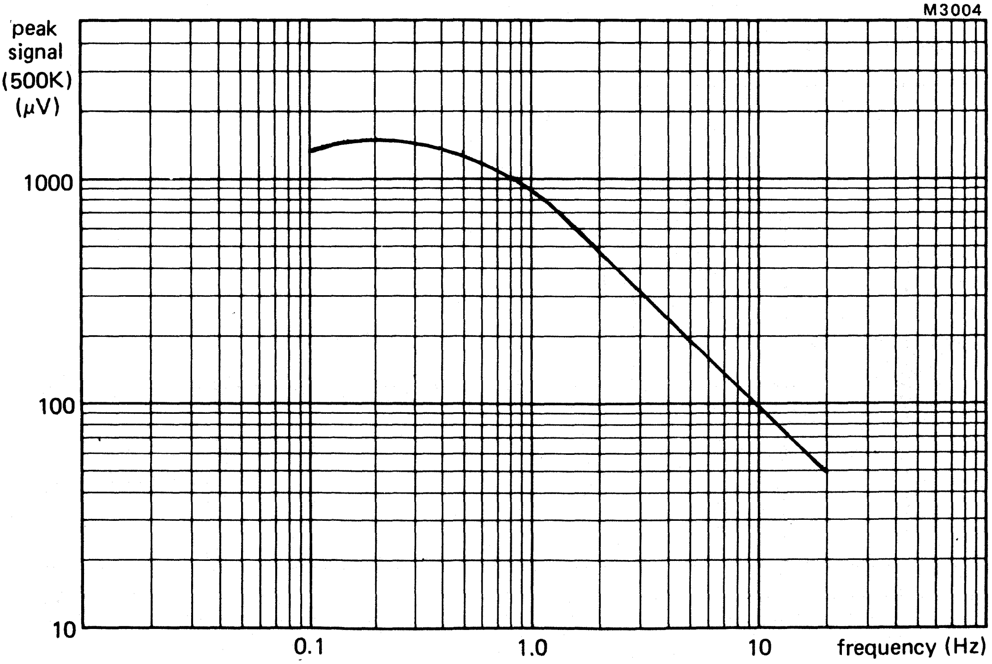
Using low noise filter with 3 dB bandwidth (0.4 Hz to 5 Hz) and roll off at 12 dB per octave. Sensors tested for 1 minute under stable electrical and thermal conditions; see operating note 6 on page 2.

RECOMMENDED CIRCUIT

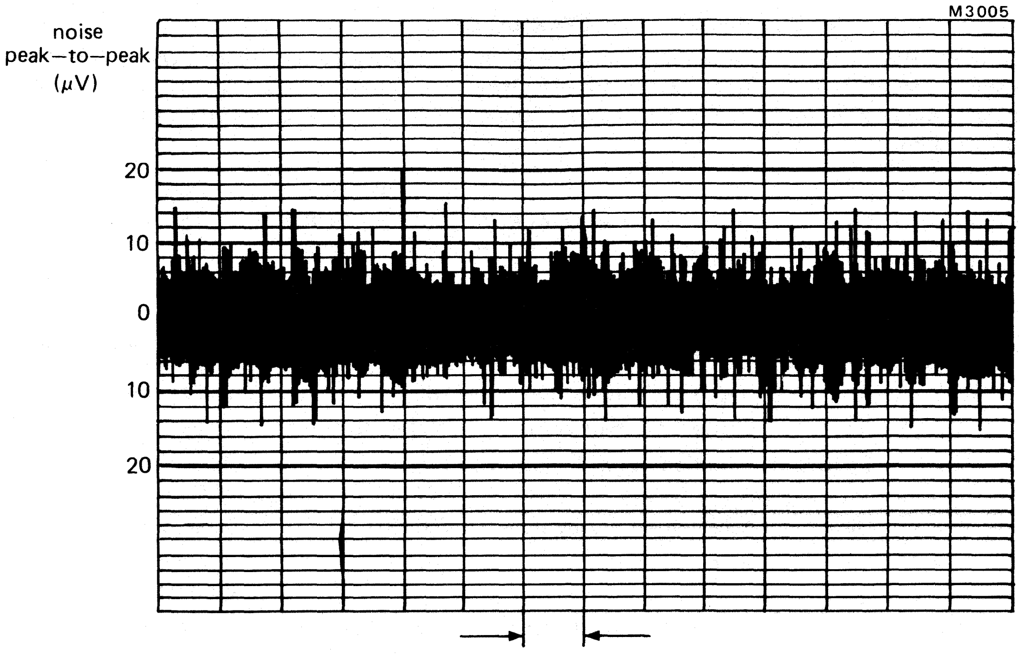




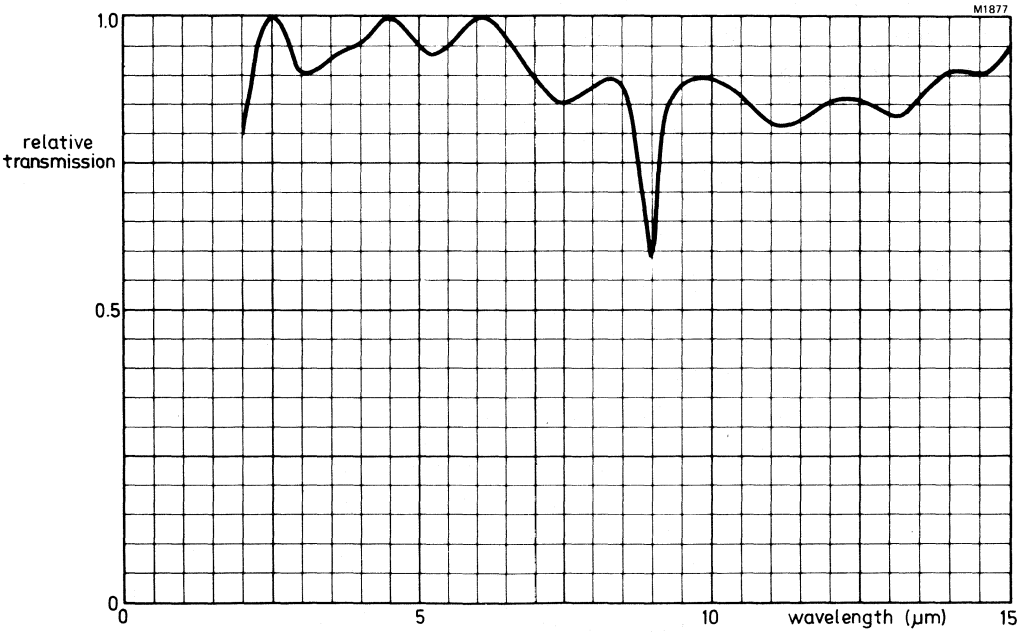
Typical response (steady state) for a given chopping frequency



Typical peak signal as a function of frequency
(energy level 25 μWcm^{-2} at the element with the other element screened)



Typical peak-to-peak noise as a function of time
(filter bandwidth 0.4 Hz to 5 Hz)



Typical normalized window transmission characteristic

MECHANICAL AND ENVIRONMENTAL STANDARDS

As part of the Quality Assurance programme, the sensors are assessed at regular intervals against the requirements of the following IEC standards. The frequency of testing and the limits and conditions for the pre- and post-test measurements are based on those stipulated for the CECC 50 000 series of approved transistors.

Test				Severity	Duration	Note
IEC	68-2-3	Ca	Damp Heat, steady state	+40 °C, 95% RH	168 hours	1
	68-2-20	Ta	Solderability	+235 °C, 1.5 mm from header	5 seconds	1
	68-2-21	Ub	Lead Fatigue	4 cycles	–	1
	68-2-1	Aa	Low Temperature Storage	–55 °C	2000 hours	2
	68-2-2	Ba	High Temperature Storage	+85 °C	2000 hours	2
	68-2-14	Nb	Change of Temperature	–55 °C to +85 °C	10 cycles	2
	68-2-6	Fc (B4)	Vibration, swept frequency	125 Hz to 2 kHz 196 ms^{-2}	2 h in each orientation	2
	68-2-7	Ga	Acceleration, steady state	196000 ms^{-2}	60 seconds	2
	68-2-27	Ea	Shock	14700 ms^{-2}	3 pulses 6 orientations	2
	68-2-20	Tb	Resistance to Solder Heat	+350 °C, 6 mm from header	3 seconds	3

Notes

1. The sensors are checked on a production batch release principle at approximately weekly intervals. This is equivalent to Group B.
2. The sensors are checked at quarterly intervals. This is equivalent to Group C.
3. This is an annual check.

SINGLE ELEMENT PYROELECTRIC INFRARED DETECTOR

This is an infrared sensitive device intended for gas analysis systems such as that used for analysing car exhausts. The element is combined with a single impedance converting amplifier which is specially designed to operate from low voltage supplies with low current consumption. The detector is sealed in a 3-lead TO-5 encapsulation modified to incorporate a potassium bromide (KBr) window.

QUICK REFERENCE DATA

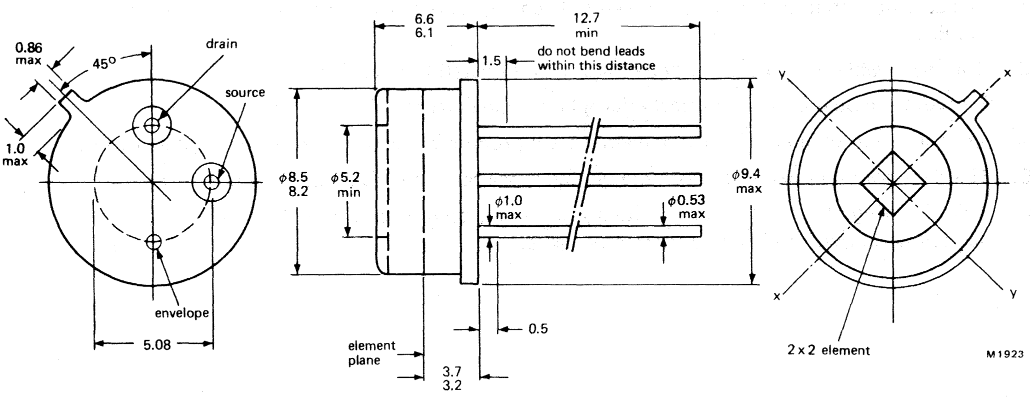
Spectral Response		1 to 25	μm
Responsivity (500 K, 10)	typ.	90	VW^{-1}
Noise Equivalent Power (N.E.P.) (500 K, 10, 1)	typ.	1.4×10^{-9}	$WHz^{-½}$
D* (500 K, 10, 1)	typ.	1.4×10^{8}	$cmHz^{½}W^{-1}$
Element dimensions	nom.	2 x 2	mm
Field of view in horizontal plane (x-x)	min.	60	degrees
Operating voltage	min.	3	V
Optimum operating frequency range		10 to 100	Hz

This data must be read in conjunction with GENERAL SAFETY RECOMMENDATIONS – OPTOELECTRONIC DEVICES

MECHANICAL DATA

Dimensions in mm

SOT-49G (TO-5 variant)



PRODUCT SAFETY

Modern high technology materials have been used in the manufacture of this device to ensure high performance. Some of these materials are toxic in certain circumstances. Mechanical or electrical damage is unlikely to give rise to any hazard, but toxic vapours may be generated if the device is heated to destruction. Disposal of large quantities should therefore be carried out in accordance with the latest local legislation.

SOLDERING

1. When making soldered connections to the leads, a thermal shunt should be used.
2. It is essential that any mains operated soldering iron used should be both screened and earthed. Failure to observe these precautions may lead to the introduction of line voltages and possible damage to the device.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134).

Supply voltage	max.	30	V
Temperature, operating range		−20 to +70	°C
Temperature, storage range		−20 to +70	°C
Lead soldering temperature, ⩾ 6 mm from header, $t_{sld} \leqslant 3$ s max.		+350	°C

OPERATING CONDITIONS

	min.	max.	
Voltage (operating note 5)	3	10	V
Frequency (operating note 5)	10	100	Hz

OPERATING NOTES

1. The case potential must not be allowed to become positive with respect to the other two terminals.
2. It is inadvisable to operate the detector at mains related frequencies.
3. To avoid the possibility of optical microphony, the detector must be firmly mounted.
4. An increase in temperature of the element will produce a positive going signal at the output.
5. The detector will operate outside the quoted range but may have a degraded performance.
6. Before testing, due to the high sensitivity of these detectors, care must be taken to ensure that the devices are allowed to become thermally stable.

CHARACTERISTICS (at T_{amb} = 22 °C ± 3 °C and with recommended circuit)

		min.	typ.	max.	
Spectral Response		1.0	–	25	μm
Responsivity (500 K, 10)		60	90	–	VW^{-1}
N.E.P. (500 K, 10, 1)		–	1.4×10^{-9}	3×10^{-9}	WHz^{-1}
D* (500 K, 10, 1)		–	1.4×10^{8}	–	$cmHz^{1/2}W^{-1}$
Field of View (x-x plane, total angle)	note 1	60	–	–	degrees
(y-y plane, total angle)	note 1	60	–	–	degrees
Quiescent current		–	10	–	μA
Element dimensions			2 x 2 nominal		mm

FET Characteristics (at T_{amb} = 22 °C ± 3 °C)

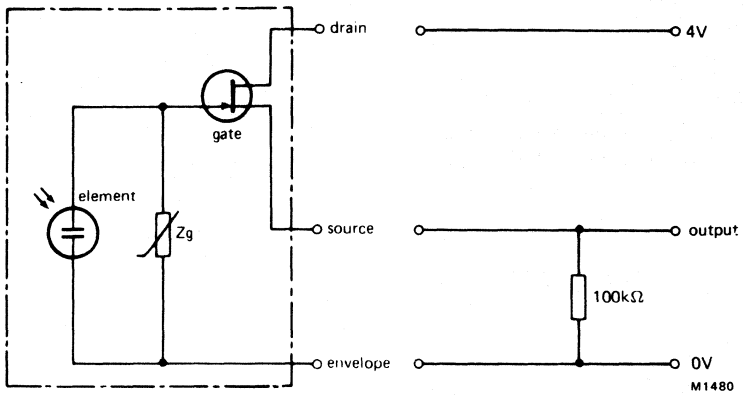
		min.	typ.	max.	
Gate-Source Cut-off Voltage $I_D = 0.1\ \mu A$, $V_{DS} = 6$ V	$V_{P(GS)}$	–1.2	–	–0.5	V
Transfer Conductance $V_{GS} = 0$, $V_{DS} = 6$ V, f = 1 kHz	g_{fso}	1.3	–	–	mAV^{-1}

Notes

1. Field of view to 50% of the maximum signal level.

DEVELOPMENT SAMPLE DATA

RECOMMENDED CIRCUIT



DEFINITIONS

1. Responsivity VW^{-1}

   This is the ratio of the r.m.s. signal in volts to the r.m.s. value of the incident, chopped radiant power. The published values of responsivity are qualified by figures in brackets, for example (500 K, 10). The 500 K denotes the temperature of the black body source of the infrared radiation generating the signal voltage, while the 10 indicates that the radiation is chopped at a frequency of 10 Hz.

2. Noise Equivalent Power (N.E.P.) $WHz^{-1/2}$

   This is the r.m.s. value of the incident, chopped radiant power necessary to produce an r.m.s. signal to r.m.s. noise ratio of unity. The r.m.s. noise refers to the value calculated for unit square root bandwidth $VHz^{-1/2}$. As with responsivity the relevant test conditions must be specified, for example (500 K, 10, 1). The 500 K is the temperature of the black body source of the incident radiation, 10 is the chopping frequency in Hz, and 1 is the bandwidth in Hz.

3. D^* $cmHz^{1/2}W^{-1}$

   This is a figure of merit for the material used in the detector and takes account of element size and signal to noise ratio. It is used to specify and compare detectors and in contrast to N.E.P., has a higher value for a better performance device.

   D* is defined by the expression:

$$D^* = \frac{\frac{V_s}{V_n}\left[A\,(\Delta f)\right]^{1/2}}{W}$$

where V_s = Signal voltage across detector terminals
V_n = Noise voltage across detector terminals
A = Detector area
(Δf) = Bandwidth of measuring amplifier
W = Radiated power incident on detector (r.m.s. value in watts)

The Noise Equivalent Power (N.E.P.) is related to D* by the expression:

$$\text{N.E.P.} = \frac{(A)^{1/2}}{D^*}$$

MECHANICAL AND ENVIRONMENTAL STANDARDS

As part of the Quality Assurance programme, the detectors will be assessed at regular intervals against the requirements of the following IEC standards. The limits and conditions for the pre- and post-test measurements are based on those stipulated for the CECC 50 000 series of approved transistors.

Test			Severity	Duration
IEC 68-2-3	Ca	Damp Heat, steady state	+20 °C, 70% RH	96 hours
68-2-20	Ta	Solderability	+235 °C, 1.5 mm from header	5 seconds
68-2-21	Ub	Lead Fatigue	4 cycles	—
68-2-1	Aa	Low Temperature Storage	–20 °C	2000 hours
68-2-2	Ba	High Temperature Storage	+70 °C	2000 hours
68-2-14	Nb	Change of Temperature	–20 °C to +70 °C	10 cycles
68-2-6	Fc (B4)	Vibration, swept frequency	125 Hz to 2 kHz 196 ms^{-2}	2 h in each orientation
68-2-7	Ga	Acceleration, steady state	196000 ms^{-2}	60 seconds
68-2-27	Ea	Shock	14700 ms^{-2}	3 pulses 6 orientations
68-2-20	Tb	Resistance to Solder Heat	+350 °C, 6 mm from header	3 seconds

DEVELOPMENT SAMPLE DATA

DUAL ELEMENT PYROELECTRIC INFRARED SENSOR

Special features:	Enhanced IR sensitivity Wide field of view Minimal reaction to ambient temperature changes
Application:	For use in passive IR intruder alarms
Element configuration:	Dual element series opposed
Electrical:	Incorporating impedance converting amplifier
Window:	Daylight filtered silicon

QUICK REFERENCE DATA

Measured in source follower mode with 100 kΩ load resistor

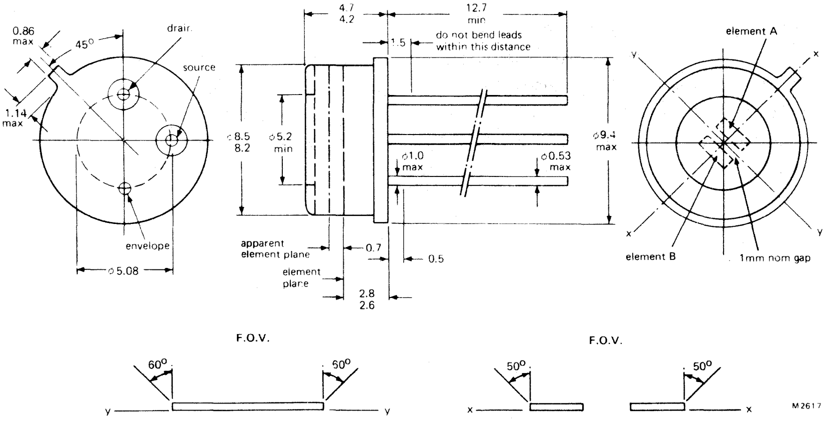
	min.	typ.	max.	
Spectral response	6.5 ± 0.5	–	> 14	μm
Noise, peak-to-peak (bandwidth 0.4 Hz to 5 Hz)	–	25	45	μV
Peak signal (500K, 1) with incident energy of 25 μWcm^{-2}	570	800	–	μV
Element dimensions	–	2 x 1	–	mm
Operating voltage	3	–	10	V
Optimum operating frequency range	0.1	–	20	Hz

This data must be read in conjunction with GENERAL SAFETY RECOMMENDATIONS – OPTOELECTRONIC DEVICES

MECHANICAL DATA

SOT-49E (TO-39 variant)

Dimensions in mm



PRODUCT SAFETY

Modern high technology materials have been used in the manufacture of this device to ensure high performance. Some of these materials are toxic in certain circumstances. Mechanical or electrical damage is unlikely to give rise to any hazard, but toxic vapours may be generated if the device is heated to destruction. Disposal of large quantities should therefore be carried out in accordance with the latest local legislation.

SOLDERING

1. When making soldered connections to the leads, a thermal shunt should be used.
2. It is essential that any mains operated soldering iron used should be both screened and earthed. Failure to observe these precautions may lead to the introduction of line voltages and possible damage to the device. (see operating note 7)

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134).

Supply voltage	max.	20	V
Temperature, operating range		−40 to +70	°C
Temperature, storage range		−55 to +85	°C
Lead soldering temperature, ⩾ 6 mm from header, $t_{sld} \leqslant 3$ s		+350	°C

OPERATING NOTES

1. The case potential must not be allowed to become positive with respect to the other two terminals.
2. It is inadvisable to operate the sensor at mains related frequencies.
3. To avoid the possibility of optical microphony, the sensor must be firmly mounted.
4. An increase in temperature of element A will produce a positive going signal at the output. For element B, the corresponding output will be negative going.
5. The sensor will operate outside the quoted range but may have a degraded performance.
6. Due to the high sensitivity of these sensors, care must be taken to ensure that the devices are allowed to become thermally stable before testing.
7. To avoid the possibility of electrostatic damage, precautions similar to those used with CMOS devices are necessary, namely:
    a) Earthed wrist straps should be worn.
    b) Table tops or other working surfaces should be conductive and earthed.
    c) Anti-static clothing should be worn, (no wool, silk or synthetic fibres).
    d) No electrical testing should be carried out without specific, approved and written test procedures.
    e) To prevent the development of damaging transient voltages, devices should not be inserted into or removed from test fixtures with power applied.

CHARACTERISTICS (at T_{amb} = 22 °C ± 3 °C and with recommended circuit)
Measured in source follower mode with 100 kΩ load resistor

	min.	typ.	max.	
Spectral response	6.5 ± 0.5	–	>14	μm
Noise, peak-to-peak (bandwidth 0.4 Hz to 5 Hz) (note)	–	25	45	μV
Peak signal (500K, 1) with incident energy of 25 μWcm^{-2}	570	800	–	μV
Element dimensions	–	2 x 1	–	mm
Field of view		see page 1		

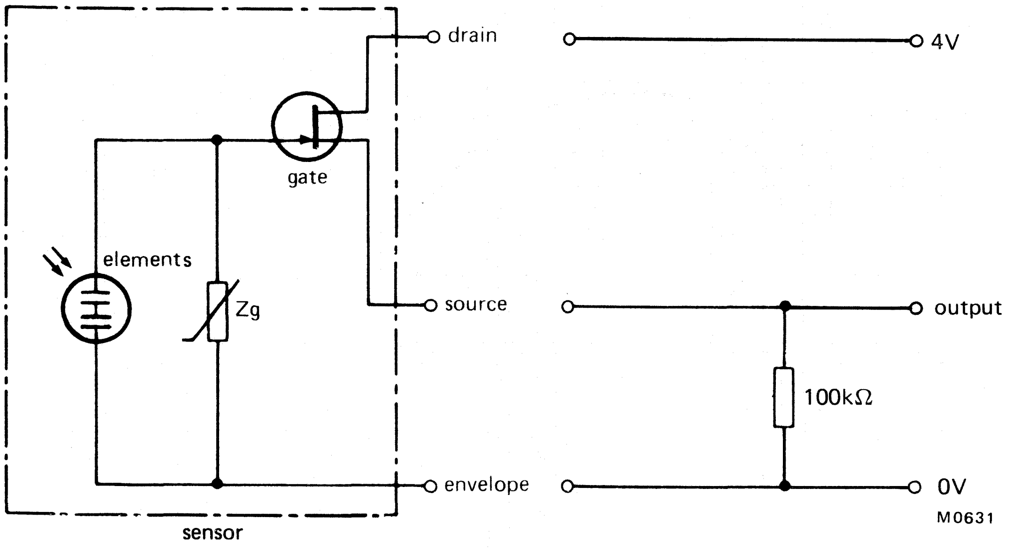
FET Characteristics (at T_{amb} = 22 °C ± 3 °C)

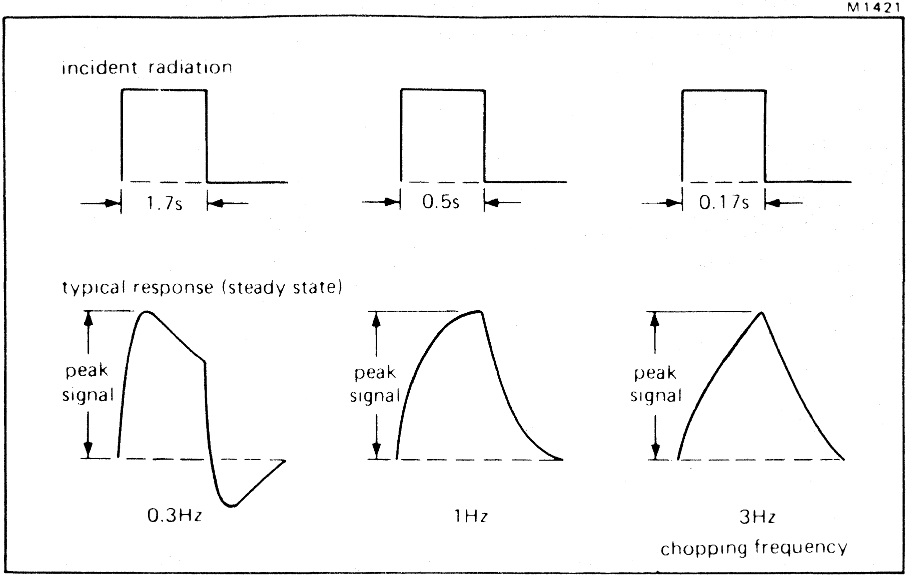
		min.	typ.	max.	
Gate-source cut-off voltage I_D = 0.1 μA, V_{DS} = 6 V	$V_{P(GS)}$	−1.4	–	−0.5	V
Transfer conductance V_{GS} = 0, V_{DS} = 6 V, f = 1 kHz	g_{fso}	1.3	–	–	mAV^{-1}

Note

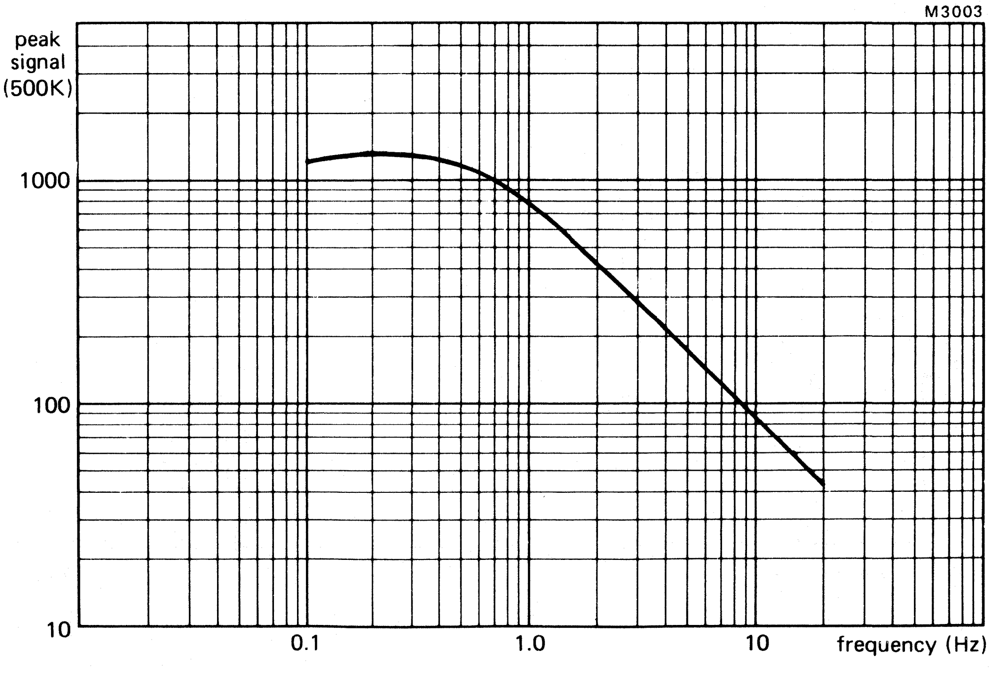
Using low noise filter with 3 dB bandwidth (0.4 Hz to 5 Hz) and roll off at 12 dB per octave. Sensors tested for 1 minute under stable electrical and thermal conditions; see operating note 6 on page 2.

RECOMMENDED CIRCUIT

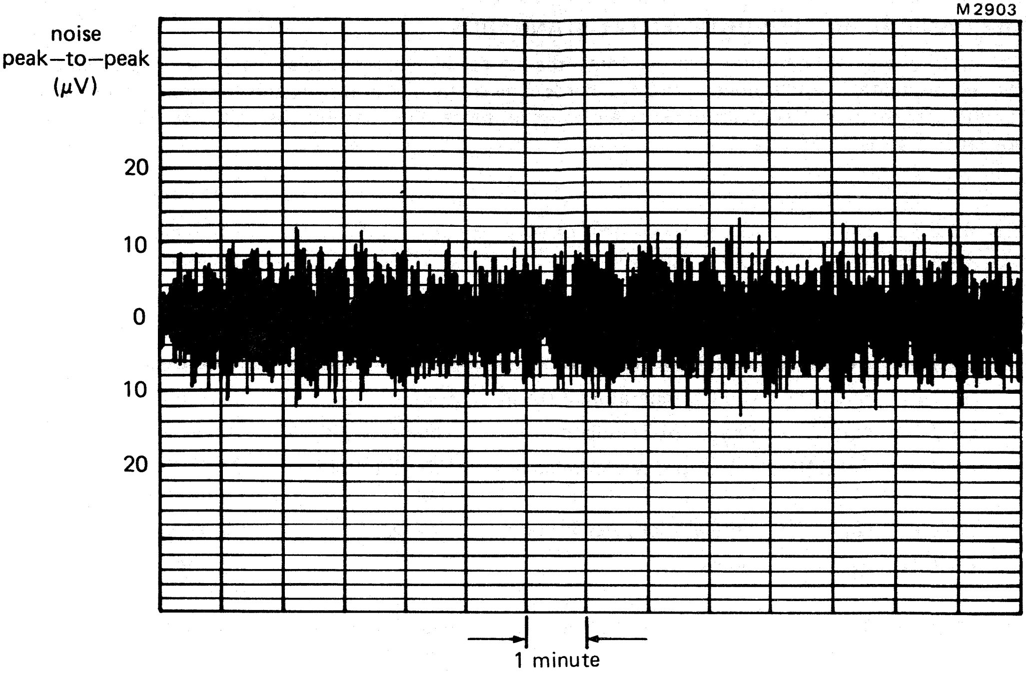




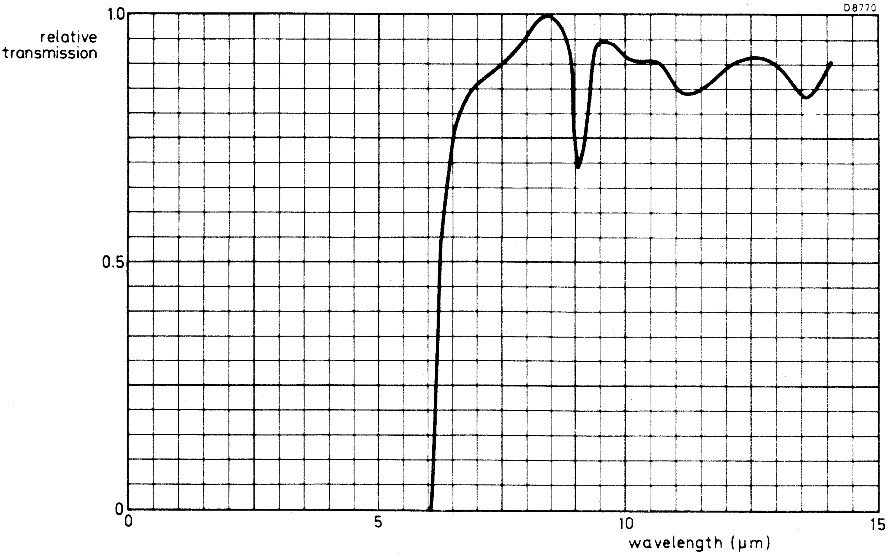
Typical response (steady state) for a given chopping frequency



Typical peak signal as a function of frequency
(energy level 25 μW cm^{-2} at the element with the other element screened)



Typical peak-to-peak noise as a function of time
(filter bandwidth 0.4 Hz to 5 Hz)



Typical normalized window transmission characteristic

MECHANICAL AND ENVIRONMENTAL STANDARDS

As part of the Quality Assurance programme, the sensors will be assessed at regular intervals against the requirements of the following IEC standards. The frequency of testing and the limits and conditions for the pre- and post-test measurements are based on those stipulated for the CECC 50 000 series of approved transistors.

Test				Severity	Duration	Note
IEC	68-2-3	Ca	Damp Heat, steady state	+40 °C, 95% RH	168 hours	1
	68-2-20	Ta	Solderability	+235 °C, 1.5 mm from header	5 seconds	1
	68-2-21	Ub	Lead Fatigue	4 cycles	–	1
	68-2-1	Aa	Low Temperature Storage	–55 °C	2000 hours	2
	68-2-2	Ba	High Temperature Storage	+85 °C	2000 hours	2
	68-2-14	Nb	Change of Temperature	–55 °C to +85 °C	10 cycles	2
	68-2-6	Fc (B4)	Vibration, swept frequency	125 Hz to 2 kHz 196 ms^{-2}	2 h in each orientation	2
	68-2-7	Ga	Acceleration, steady state	196000 ms^{-2}	60 seconds	2
	68-2-27	Ea	Shock	14700 ms^{-2}	3 pulses 6 orientations	2
	68-2-20	Tb	Resistance to Solder Heat	+350 °C, 6 mm from header	3 seconds	3

Notes

1. The sensors to be checked on a production batch release principle at approximately weekly intervals. This is equivalent to Group B.
2. The sensors to be checked at quarterly intervals. This is equivalent to Group C.
3. This is an annual check.

DUAL ELEMENT PYROELECTRIC INFRARED SENSOR

Special features:	Low profile can
Application:	For use in passive IR intruder alarms and light switches
Element configuration:	Dual element series opposed
Electrical:	Incorporating impedance converting amplifier
Window:	Daylight filtered silicon

QUICK REFERENCE DATA

Measured in source follower mode with 100 kΩ load resistor

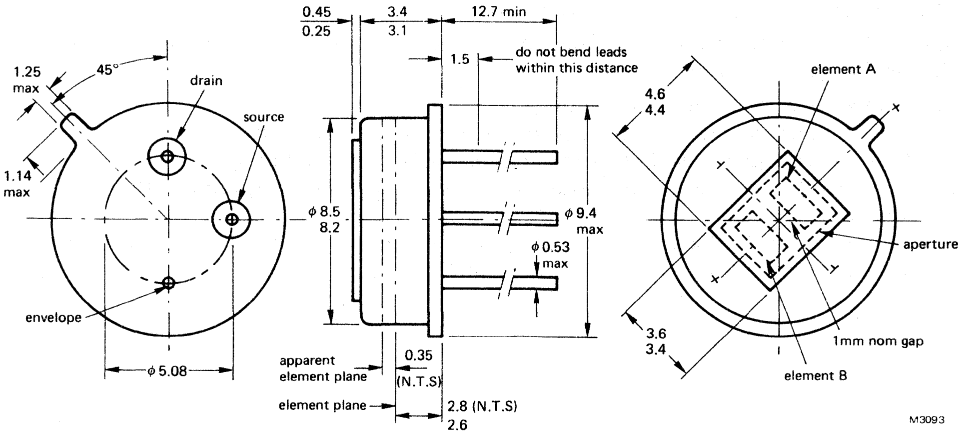
	min.	typ.	max.	
Spectral response	6.5 ± 0.5	–	> 14	μm
Noise, peak-to-peak (bandwidth 0.4 Hz to 5 Hz)	–	25	45	μV
Peak signal (500K, 1) with incident energy of 25 μWcm^{-2}	570	800	–	μV
Element dimensions	–	2 x 1	–	mm
Operating voltage	3	–	10	V
Optimum operating frequency range	0.1	–	20	Hz

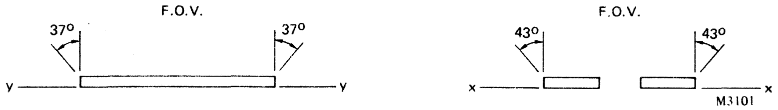
This data must be read in conjunction with GENERAL SAFETY RECOMMENDATIONS – OPTOELECTRONIC DEVICES

MECHANICAL DATA

Dimensions in mm

SOT-49M (TO-39 variant)





PRODUCT SAFETY

Modern high technology materials have been used in the manufacture of this device to ensure high performance. Some of these materials are toxic in certain circumstances. Mechanical or electrical damage is unlikely to give rise to any hazard, but toxic vapours may be generated if the device is heated to destruction. Disposal of large quantities should therefore be carried out in accordance with the latest local legislation.

SOLDERING

1. When making soldered connections to the leads, a thermal shunt should be used.
2. It is essential that any mains operated soldering iron used should be both screened and earthed. Failure to observe these precautions may lead to the introduction of line voltages and possible damage to the device. (see operating note 7)

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134).

Supply voltage	max.	20	V
Temperature, operating range		–40 to +70	°C
Temperature, storage range		–55 to +85	°C
Lead soldering temperature, ⩾ 6 mm from header, $t_{sld} \leqslant 3$ s		+350	°C

OPERATING NOTES

1. The case potential must not be allowed to become positive with respect to the other two terminals.
2. It is inadvisable to operate the sensor at mains related frequencies.
3. To avoid the possibility of optical microphony, the sensor must be firmly mounted.
4. An increase in temperature of element A will produce a positive going signal at the output. For element B, the corresponding output will be negative going.
5. The sensor will operate outside the quoted range but may have a degraded performance.
6. Due to the high sensitivity of these sensors, care must be taken to ensure that the devices are allowed to become thermally stable before testing.
7. To avoid the possibility of electrostatic damage, precautions similar to those used with CMOS devices are necessary, namely:
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   c) Anti-static clothing should be worn (no wool, silk or synthetic fibres).
   d) No electrical testing should be carried out without specific, approved and written test procedures.
   e) To prevent the development of damaging transient voltages, devices should not be inserted into or removed from test fixtures with power applied.

CHARACTERISTICS (at T_{amb} = 22 °C ± 3 °C and with recommended circuit)
Measured in source follower mode with 100 kΩ load resistor.

	min.	typ.	max.	
Spectral response	6.5 ± 0.5	–	>14	μm
Noise, peak-to-peak (bandwidth 0.4 Hz to 5 Hz) (note)	–	25	45	μV
Peak signal (500K, 1) with incident energy of 25 μWcm^{-2}	570	800	–	μV
Element dimensions	–	2 x 1	–	mm
Field of view		see page 1		

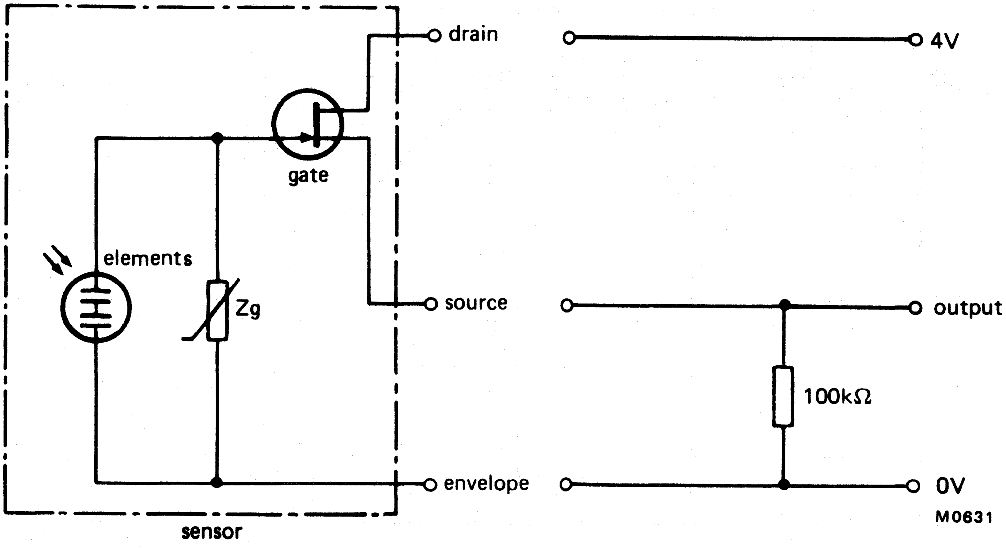
FET Characteristics (at T_{amb} = 22 °C ± 3 °C)

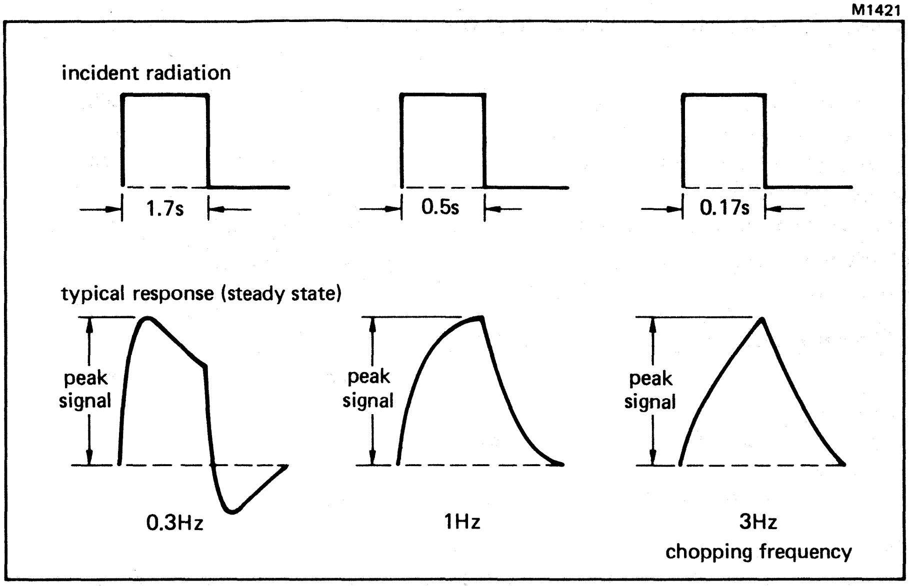
		min.	typ.	max.	
Gate-source cut-off voltage I_D = 0.1 μA, V_{DS} = 6 V	$V_{(P)GS}$	–1.4	–	–0.5	V
Transfer conductance V_{GS} = 0, V_{DS} = 6 V, f = 1 kHz	g_{fso}	1.3	–	–	mAV^{-1}

Note

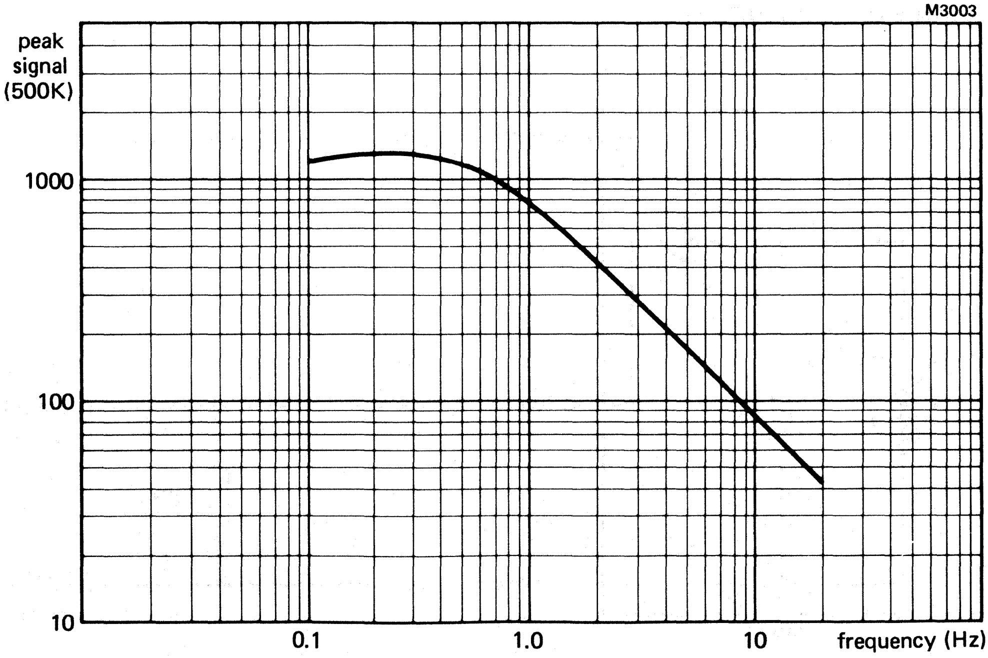
Using low noise filter with 3 dB bandwidth (0.4 Hz to 5 Hz) and roll off at 12 dB per octave. Sensors tested for 1 minute under stable electrical and thermal conditions; see operating note 6 on page 2.

RECOMMENDED CIRCUIT

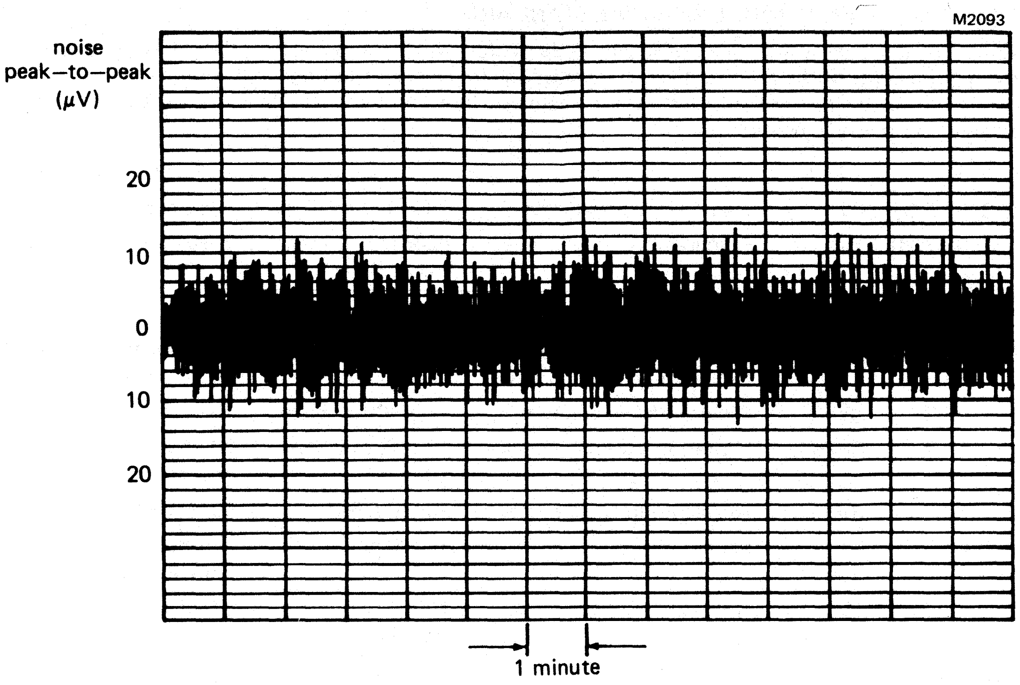




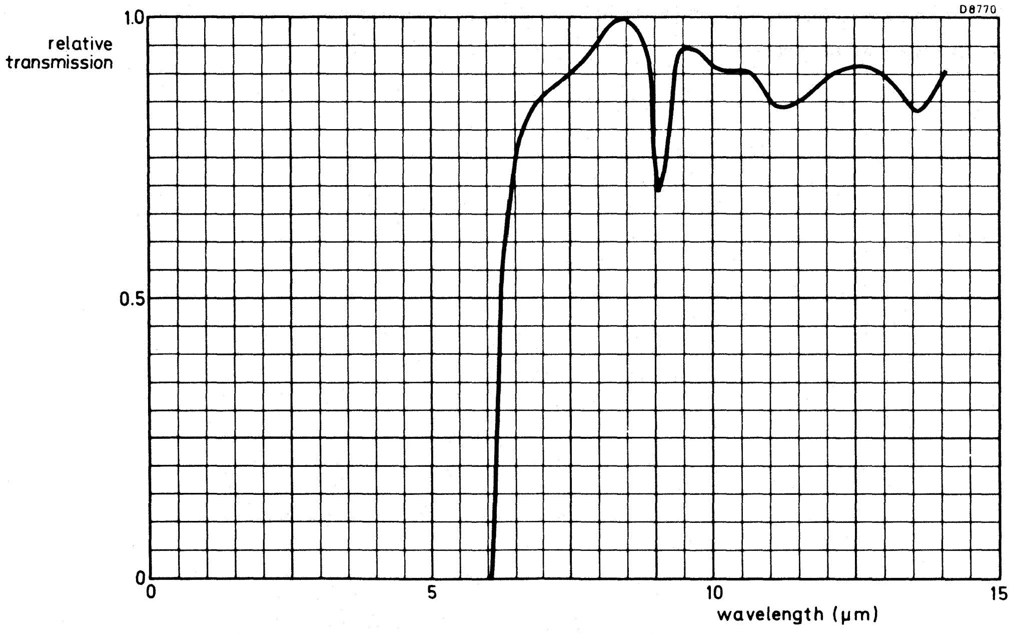
Typical response (steady state) for a given chopping frequency



Typical peak signal as a function of frequency
(energy level 25 μWcm^{-2} at the element with the other element screened)



Typical peak-to-peak noise as a function of time
(filter bandwidth 0.4 Hz to 5 Hz)



Typical normalized window transmission characteristic

MECHANICAL AND ENVIRONMENTAL STANDARDS

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Test				Severity	Duration	Note
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	68-2-21	Ub	Lead Fatigue	4 cycles	–	2
	68-2-1	Aa	Low Temperature Storage	–55 °C	2000 hours	2
	68-2-2	Ba	High Temperature Storage	+85 °C	2000 hours	2
	68-2-14	Nb	Change of Temperature	–55 °C to +85 °C	10 cycles	2
	68-2-6	Fc (B4)	Vibration, swept frequency	125 Hz to 2 kHz 196 ms^{-2}	2 h in each orientation	2
	68-2-7	Ga	Acceleration, steady state	196000 ms^{-2}	60 seconds	2
	68-2-27	Ea	Shock	14700 ms^{-2}	3 pulses 6 orientations	2
	68-2-20	Tb	Resistance to Solder Heat	+350 °C, 6 mm from header	3 seconds	3

Notes

1. The sensors to be checked on a production batch release principle at approximately weekly intervals. This is equivalent to Group B.
2. The sensors to be checked at quarterly intervals. This is equivalent to Group C.
3. This is an annual check.

DUAL ELEMENT PYROELECTRIC INFRARED SENSOR

Special features:	Enhanced IR sensitivity Low response to RFI Wide field of view Minimal reaction to ambient temperature changes
Application:	For use in passive IR intruder alarms
Element configuration:	Dual element series opposed
Electrical:	Incorporating impedance converting amplifier
Window:	Daylight filtered silicon

QUICK REFERENCE DATA

Measured in source follower mode with 100 kΩ load resistor

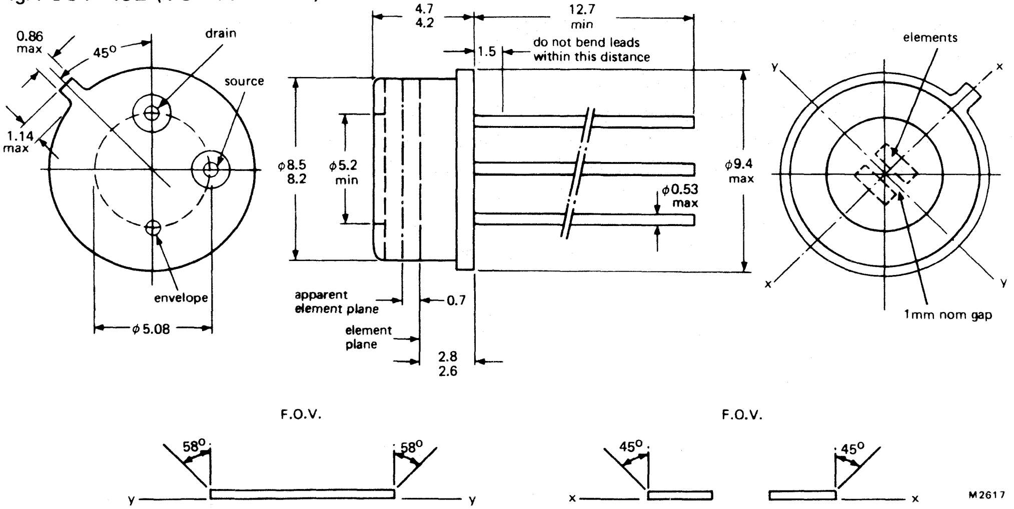
	min.	typ.	max.	
Spectral response	6.5 ± 0.5	–	>14	μm
Noise, peak-to-peak (bandwidth 0.4 Hz to 5 Hz)	–	25	45	μV
Peak signal (500K, 1) with incident energy of 25 μWcm^{-2}	570	800	–	μV
Element dimensions	–	2 x 1	–	mm
Operating voltage	3	–	10	V
Optimum operating frequency range	0.1	–	20	Hz

This data must be read in conjunction with GENERAL SAFETY RECOMMENDATIONS – OPTOELECTRONIC DEVICES

MECHANICAL DATA

Dimensions in mm

Fig.1 SOT-49E (TO-39 variant)



PRODUCT SAFETY

Modern high technology materials have been used in the manufacture of this device to ensure high performance. Some of these materials are toxic in certain circumstances. Mechanical or electrical damage is unlikely to give rise to any hazard, but toxic vapours may be generated if the device is heated to destruction. Disposal of large quantities should therefore be carried out in accordance with the latest local legislation.

SOLDERING

1. When making soldered connections to the leads, a thermal shunt should be used.
2. It is essential that any mains operated soldering iron used should be both screened and earthed. Failure to observe these precautions may lead to the introduction of line voltages and possible damage to the device. (see operating note 7)

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134).

Supply voltage	max.	20	V
Temperature, operating range		−40 to +70	°C
Temperature, storage range		−55 to +85	°C
Lead soldering temperature, ⩾6 mm from header, $t_{sld} \leqslant 3$ s		+350	°C

OPERATING NOTES

1. The case potential must not be allowed to become positive with respect to the other two terminals.
2. It is inadvisable to operate the sensor at mains related frequencies.
3. To avoid the possibility of optical microphony, the sensor must be firmly mounted.
4. An increase in temperature of element A will produce a positive going signal at the output. For element B, the corresponding output will be negative going.
5. The sensor will operate outside the quoted range but may have a degraded performance.
6. Due to the high sensitivity of these sensors, care must be taken to ensure that the devices are allowed to become thermally stable before testing.
7. To avoid the possibility of electrostatic damage, precautions similar to those used with CMOS devices are necessary, namely:
   a) Earthed wrist straps should be worn.
   b) Table tops or other working surfaces should be conductive and earthed.
   c) Anti-static clothing should be worn (no wool, silk or synthetic fibres).
   d) No electrical testing should be carried out without specific, approved and written test procedures.
   e) To prevent the development of damaging transient voltages, devices should not be inserted into or removed from test fixtures with power applied.

CHARACTERISTICS (at T_{amb} = 22 °C ± 3 °C and with recommended circuit)

Measured in source follower mode with 100 kΩ load resistor

	min.	typ.	max.	
Spectral response	6.5 ± 0.5	–	>14	μm
Noise, peak-to-peak (bandwidth 0.4 Hz to 5 Hz) (note)	–	25	45	μV
Peak signal (500K, 1) with incident energy of 25 μWcm^{-2}	570	800	–	μV
Element dimensions	–	2 x 1	–	mm
Field of view		see page 1		

FET Characteristics (at T_{amb} = 22 °C ± 3 °C)

		min.	typ.	max.	
Gate-source cut-off voltage $I_D = 0.1\ \mu A$, $V_{DS} = 6$ V	$V_{(P)GS}$	−1.4	–	−0.5	V
Transfer conductance $V_{GS} = 0$, $V_{DS} = 6$ V, f = 1 kHz	g_{fso}	1.3	–	–	mAV^{-1}

Note

Using low noise filter with 3 dB bandwidth (0.4 Hz to 5 Hz) and roll off at 12 dB per octave. Sensors tested for 1 minute under stable electrical and thermal conditions, see operating note 6 on page 2.

RECOMMENDED CIRCUIT

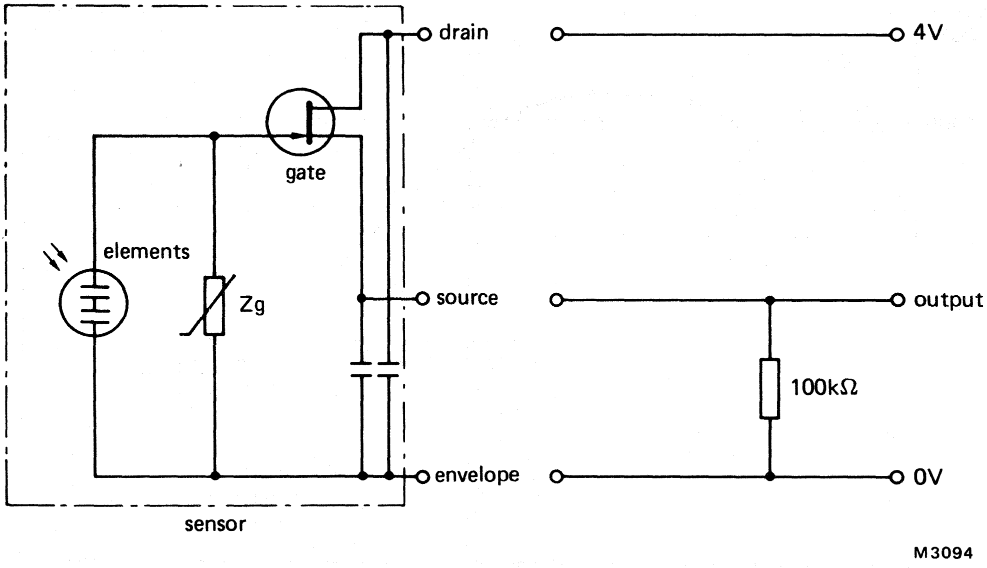


Fig. 2.

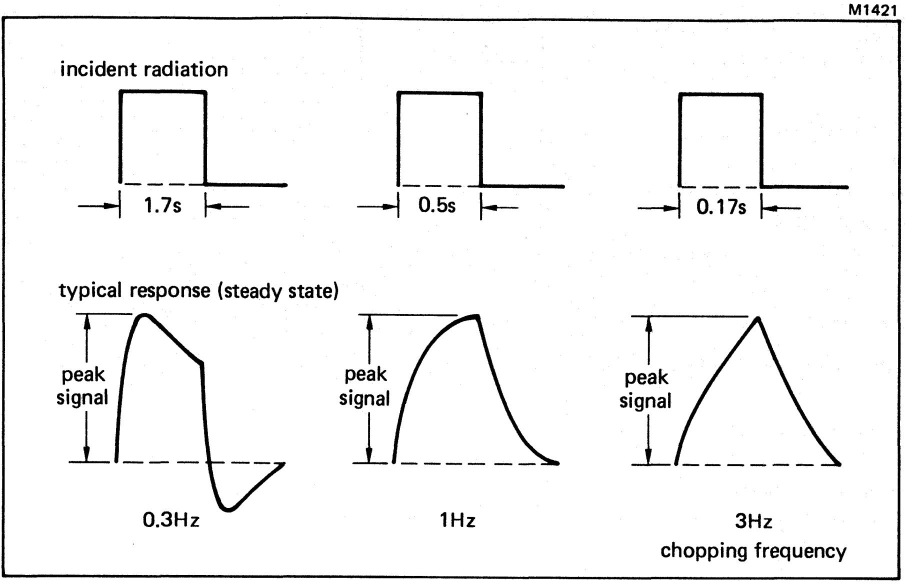


Fig. 3 Typical response (steady state) for a given chopping frequency.

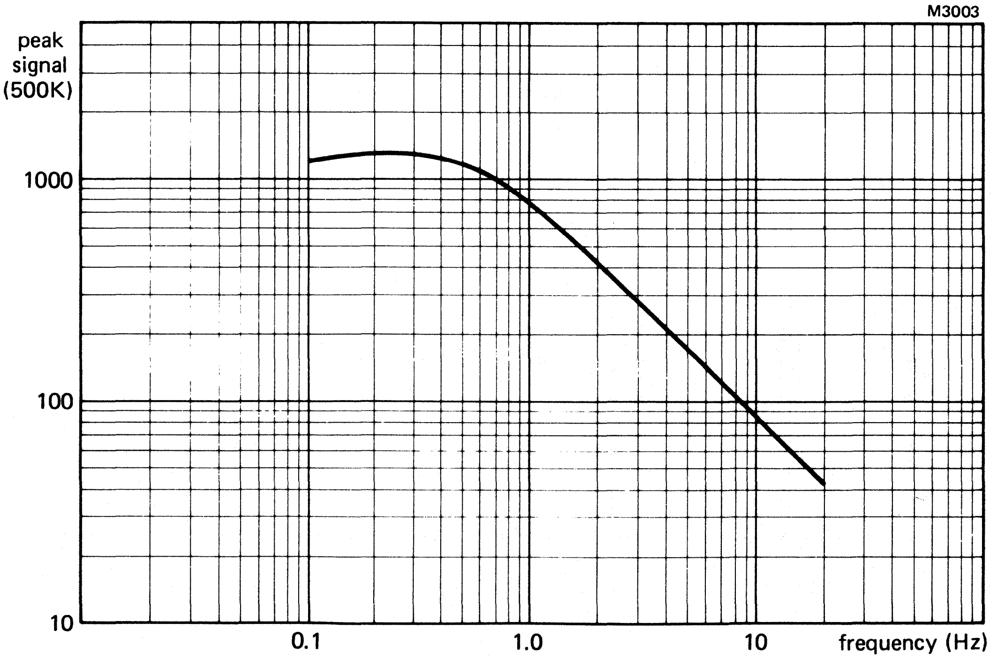


Fig. 4 Typical peak signal as a function of frequency
(energy level 25 μWcm^{-2} at the element with the other element screened).

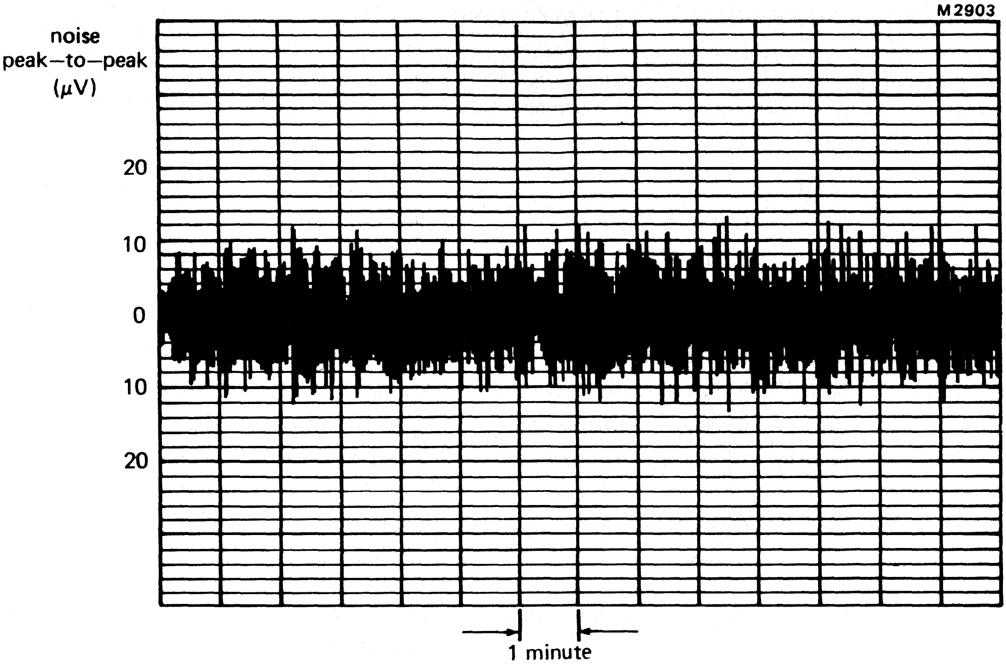


Fig.5 Typical peak-to-peak noise as a function of time (filter bandwidth 0.4 Hz to 5 Hz).

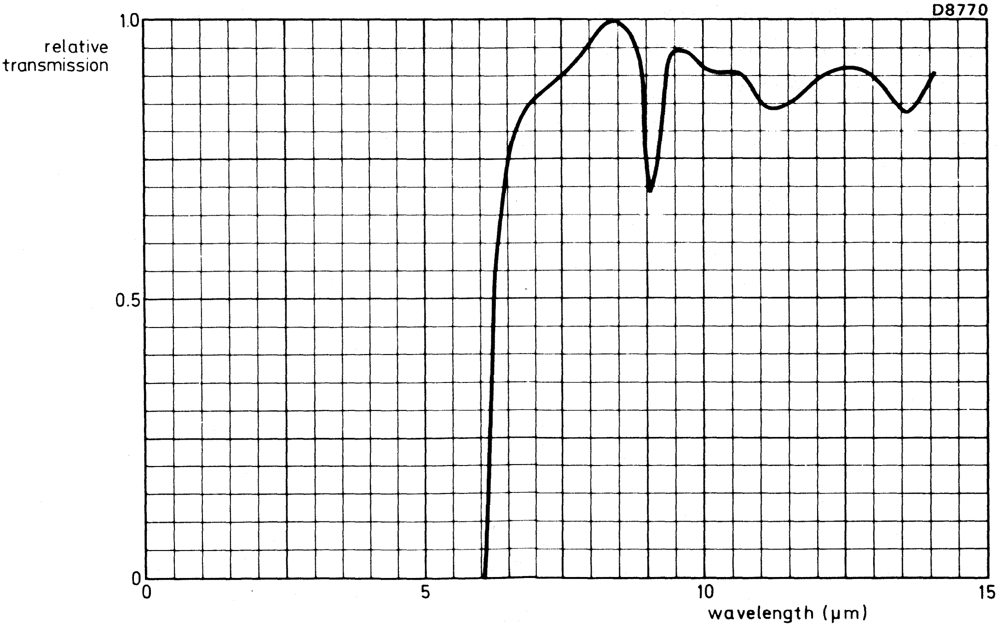


Fig. 6 Typical normalized window transmission characteristic.

MECHANICAL AND ENVIRONMENTAL STANDARDS

As part of the Quality Assurance programme, the sensors will be assessed at regular intervals against the requirements of the following IEC standards. The frequency of testing and the limits and conditions for the pre- and post-test measurements are based on those stipulated for the CECC 50 000 series of approved transistors.

Test				Severity	Duration	Note
IEC	68-2-3	Ca	Damp Heat, steady state	+40 °C, 95% RH	168 hours	1
	68-2-20	Ta	Solderability	+235 °C, 1.5 mm from header	5 seconds	2
	68-2-21	Ub	Lead Fatigue	4 cycles	–	2
	68-2-1	Aa	Low Temperature Storage	–55 °C	2000 hours	2
	68-2-2	Ba	High Temperature Storage	+85 °C	2000 hours	2
	68-2-14	Nb	Change of Temperature	–55 °C to +85 °C	10 cycles	2
	68-2-6	Fc (B4)	Vibration, swept frequency	125 Hz to 2 kHz 196 ms^{-2}	2 h in each orientation	2
	68-2-7	Ga	Acceleration, steady state	196000 ms^{-2}	60 seconds	2
	68-2-27	Ea	Shock	14700 ms^{-2}	3 pulses 6 orientations	2
	68-2-20	Tb	Resistance to Solder Heat	+350 °C, 6 mm from header	3 seconds	3

Notes

1. The sensors to be checked on a production batch release principle at approximately weekly intervals. This is equivalent to Group B.
2. The sensors to be checked at quarterly intervals. This is equivalent to Group C.
3. This is an annual check.

SINGLE ELEMENT PYROELECTRIC INFRARED SENSOR

This is an infrared sensitive device intended for battery operated passive infrared movement detectors such as intruder alarms in which high grade optics e.g. multi-faceted mirrors or Fresnel lenses are used. The element is combined with a single impedance converting amplifier which is specifically designed to function from low voltage supplies with low current consumption. The sensor is sealed in a low profile TO-39 can with a window optically coated to restrict response to wavelengths greater than 6.5 μm.

QUICK REFERENCE DATA

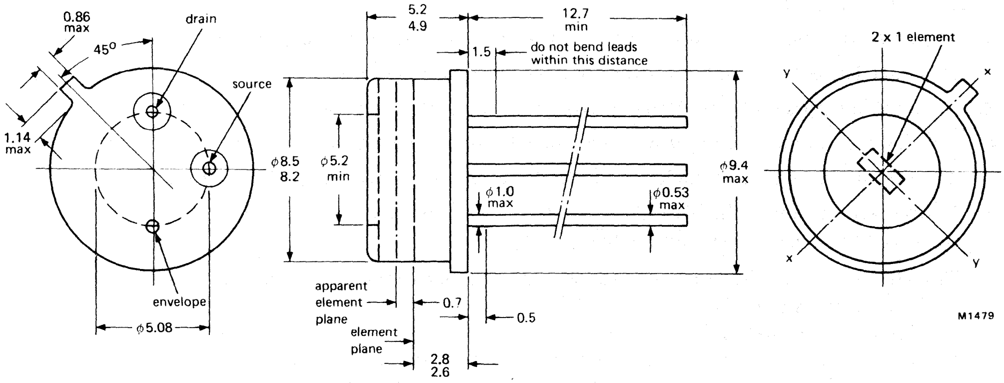
Spectral response		6.5 ± 0.5 to >14	μm
Responsivity (10 μm, 10)	typ.	150	VW^{-1}
Peak signal (500 K, 1) note 1, page 3	typ.	460	μV
Noise, peak-to-peak (bandwidth 0.4 Hz to 5 Hz)	typ.	20	μV
Element dimensions	nom.	2 x 1	mm
Operating voltage	min.	3	V
Optimum operating frequency range		0.1 to 20	Hz

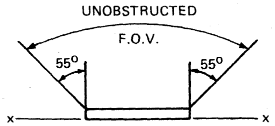
This data must be read in conjunction with GENERAL SAFETY RECOMMENDATIONS – OPTOELECTRONIC DEVICES

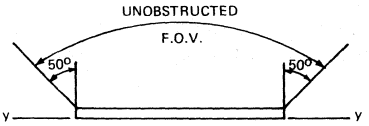
MECHANICAL DATA

Dimensions in mm

SOT-49H (TO-39 variant)







PRODUCT SAFETY

Modern high technology materials have been used in the manufacture of this device to ensure high performance. Some of these materials are toxic in certain circumstances. Mechanical or electrical damage is unlikely to give rise to any hazard, but toxic vapours may be generated if the device is heated to destruction. In the United Kindom disposal of large quantities should therefore be carried out in accordance with the Deposit of Poisonous Waste Act 1972 and the Control of Pollution Act 1974, or with the latest local legislation.

SOLDERING

1. When making soldered connections to the leads, a thermal shunt should be used.
2. It is essential that any mains operated soldering iron used should be both screened and earthed. Failure to observe these precautions may lead to the introduction of line voltages and possible damage to the device. (See operating note 7).

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134).

Supply voltage	max.	30	V
Temperature, operating range		−40 to +70	°C
Temperature, storage range		−55 to +85	°C
Lead soldering temperature, ⩾ 6 mm from header, $t_{sld} \leqslant 3$ s max.		+350	°C

OPERATING CONDITIONS

	min.	max.	
Voltage (operating note 5)	3	10	V
Frequency (operating note 5)	0.1	20	Hz

OPERATING NOTES

1. The case potential must not be allowed to become positive with respect to the other two terminals.
2. It is inadvisable to operate the sensor at mains related frequencies.
3. To avoid the possibility of optical microphony, the sensor must be firmly mounted.
4. An increase in temperature of the element will produce a positive going signal at the output.
5. The sensor will operate outside the quoted range but may have a degraded performance.
6. Before testing, due to the high sensitivity of these sensors, care must be taken to ensure that the devices are allowed to become thermally stable.
7. → To avoid the possibility of electrostatic damage, precautions similar to those used with CMOS devices are necessary, namely:
   a) Earthed wrist straps should be worn.
   b) Table tops or other working surfaces should be conductive and earthed.
   c) Anti-static clothing should be worn (no wool, silk or synthetic fibres).
   d) No electrical testing should be carried out without specific, approved and written test procedures.
   e) To prevent the development of damaging transient voltages, devices should not be inserted or removed from test fixtures with power applied.

CHARACTERISTICS (at T_{amb} = 22 °C ± 3 °C and with recommended circuit)

		min.	typ.	max.	
Spectral response		6.5 ± 0.5	–	>14	μm
Responsivity* (10 μm, 10)		100	150	–	VW^{-1}
N.E.P. (10 μm, 10, 1)		–	2.5×10^{-9}	–	$WHz^{-½}$
Peak signal (500 K, 1)	note 1	–	460	–	μV
Noise*, peak-to-peak (bandwidth 0.4 Hz to 5 Hz)	note 2	–	20	45	μV
Quiescent current		–	10	–	μA
Element dimensions			2 x 1 nominal		mm
Field of view			see page 1		

*These parameters are 100% tested with statistical sample quality inspection.

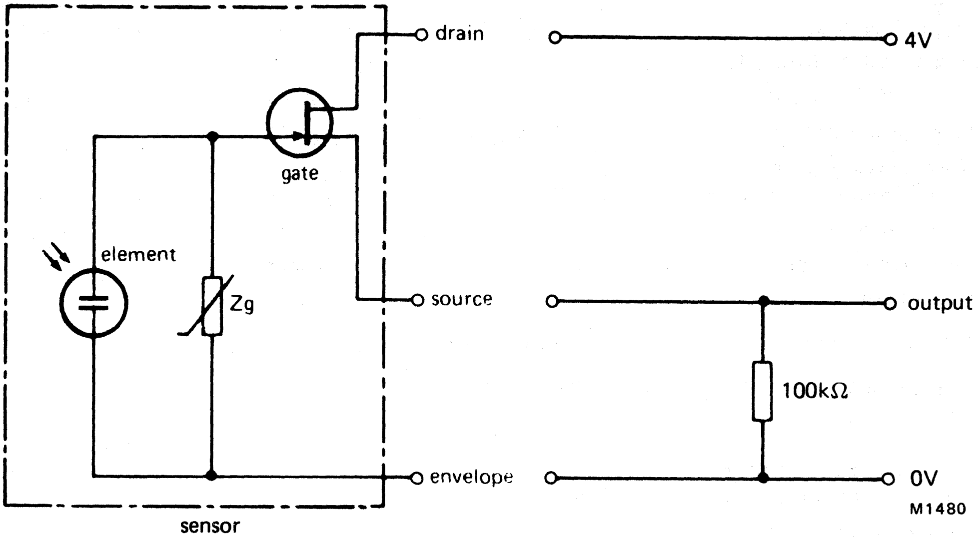
FET Characteristics (at T_{amb} = 22 °C ± 3 °C)

		min.	typ.	max.	
Gate-source cut-off voltage $I_D = 0.1\ \mu A$, $V_{DS} = 6$ V	$V_{P(GS)}$	−1.2	–	−0.5	V
Transfer conductance $V_{GS} = 0$, $V_{DS} = 6$ V, f = 1 kHz	g_{fso}	1.3	–	–	mAV^{-1}

Notes

1. At an energy level of 25 μWcm^{-2} at the element.
2. Using low noise filter with 3 dB bandwidth (0.4 Hz to 5 Hz) and roll off at 12 dB per octave. Sensors tested for 1 minute under stable electrical and thermal conditions; see operating note 6 on page 2.

RECOMMENDED CIRCUIT



DEFINITIONS

1. Responsivity VW^{-1}
   This is the ratio of the r.m.s. signal in volts to the r.m.s. value of the incident, chopped radiant power. The published values of responsivity are qualified by figures in brackets, for example (10 μm, 10). The 10 μm denotes the wavelength of the infrared radiation generating the signal voltage, while the 10 indicates that the radiation is chopped at a frequency of 10 Hz.

2. Noise Equivalent Power (N.E.P.) $WHz^{-1/2}$
   This is the r.m.s. value of the incident, chopped radiant power necessary to produce an r.m.s. signal to r.m.s. noise ratio of unity. The r.m.s. noise refers to the value calculated for unit square root bandwidth $VHz^{-1/2}$. As with responsivity the relevant test conditions must be specified, for example (10 μm, 10, 1). The 10 μm is the wavelength of the incident radiation, 10 is the chopping frequency in Hz, and 1 is the bandwidth in Hz.

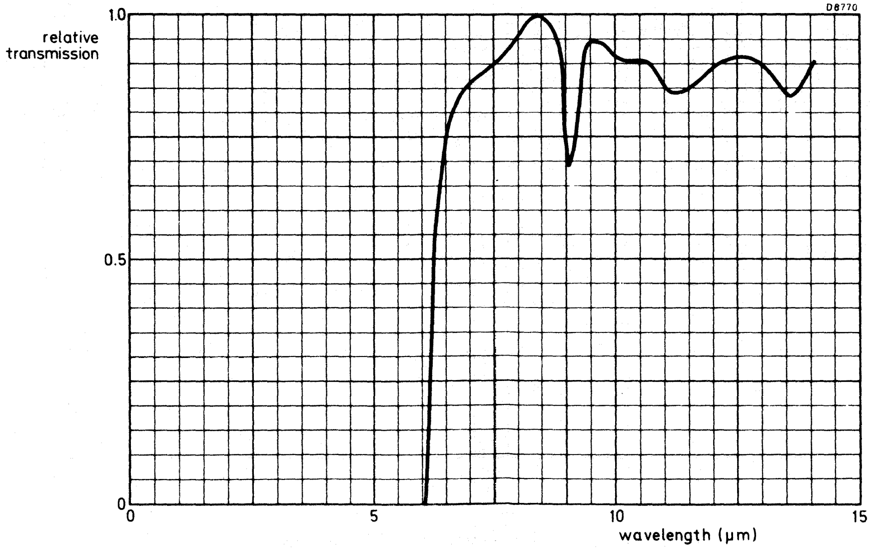
MECHANICAL AND ENVIRONMENTAL STANDARDS

As part of the Quality Assurance programme, the sensors are assessed at regular intervals against the requirements of the following IEC standards. The frequency of testing and the limits and conditions for the pre- and post-test measurements are based on those stipulated for the CECC 50 000 series of approved transistors.

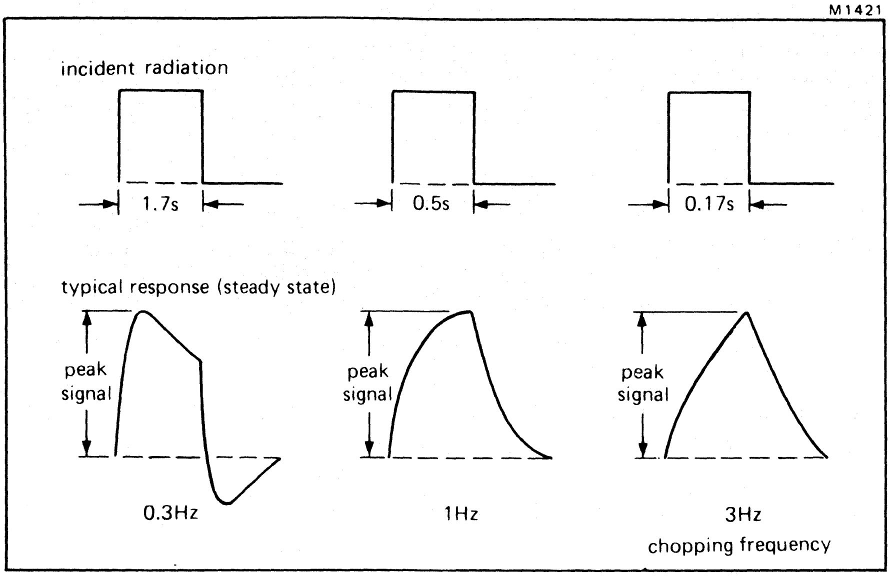
Test			Severity	Duration	Note
IEC 68-2-3	Ca	Damp Heat, steady state	+40 °C, 95% RH	168 hours	1
68-2-20	Ta	Solderability	+235 °C, 1.5 mm from header	5 seconds	1
68-2-21	Ub	Lead Fatigue	4 cycles	–	1
68-2-1	Aa	Low Temperature Storage	–55 °C	2000 hours	2
68-2-2	Ba	High Temperature Storage	+85 °C	2000 hours	2
68-2-14	Nb	Change of Temperature	–55 °C to +85 °C	10 cycles	2
68-2-6	Fc (B4)	Vibration, swept frequency	125 Hz to 2 kHz 196 ms^{-2}	2 h in each orientation	2
68-2-7	Ga	Acceleration, steady state	196000 ms^{-2}	60 seconds	2
68-2-27	Ea	Shock	14700 ms^{-2}	3 pulses 6 orientations	2
68-2-20	Tb	Resistance to Solder Heat	+350 °C, 6 mm from header	3 seconds	3

Notes

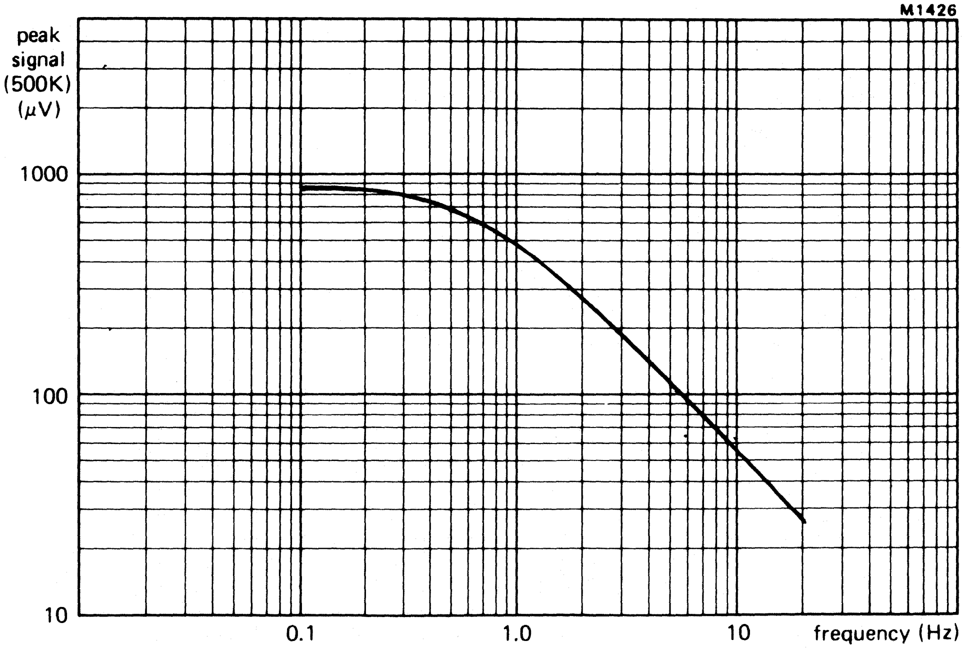
1. The sensors are checked on a production batch release principle at approximately weekly intervals. This is equivalent to Group B.
2. The sensors are checked at quarterly intervals. This is equivalent to Group C.
3. This is an annual check.



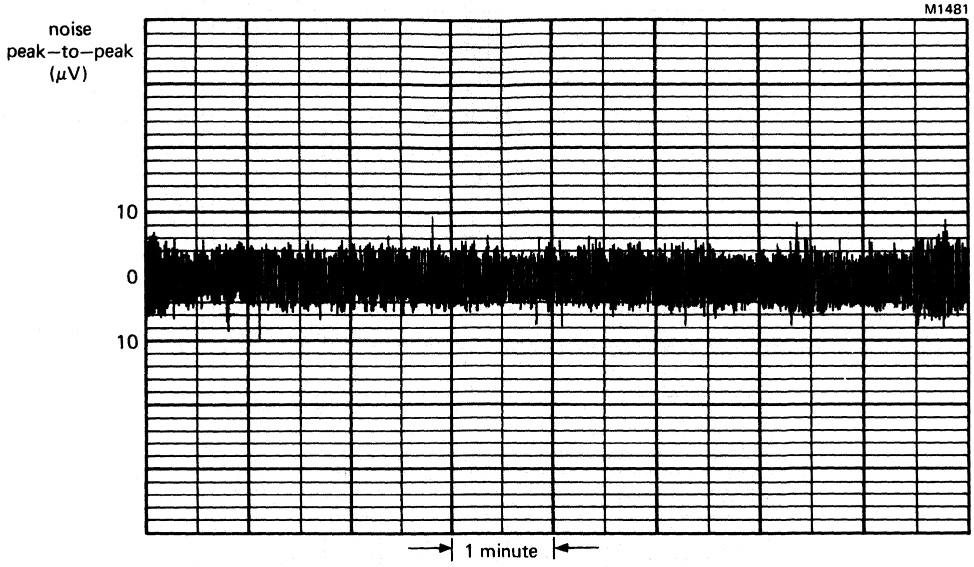
Typical normalized window transmission characteristic



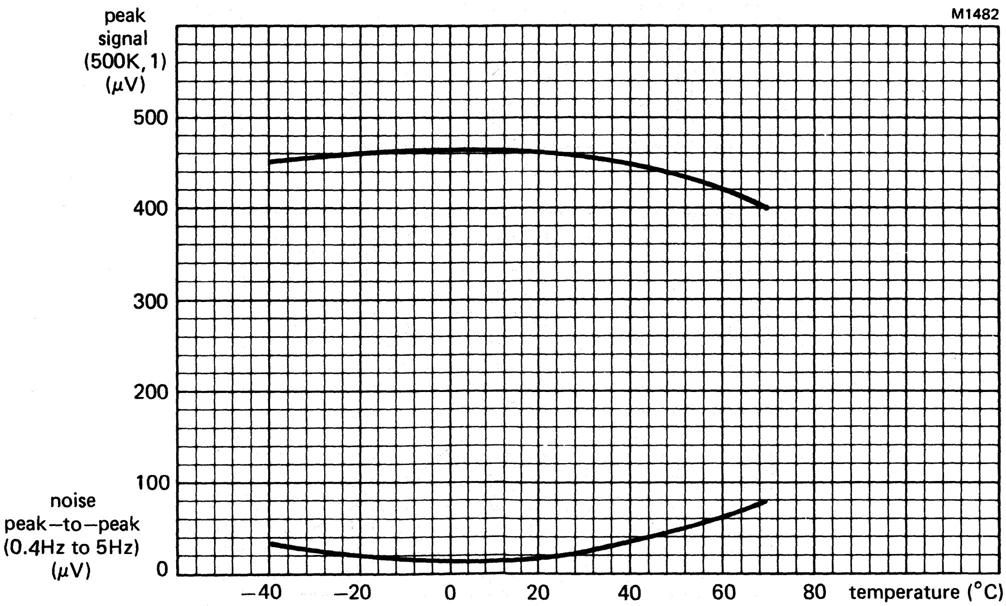
Typical response (steady state) for a given chopping frequency



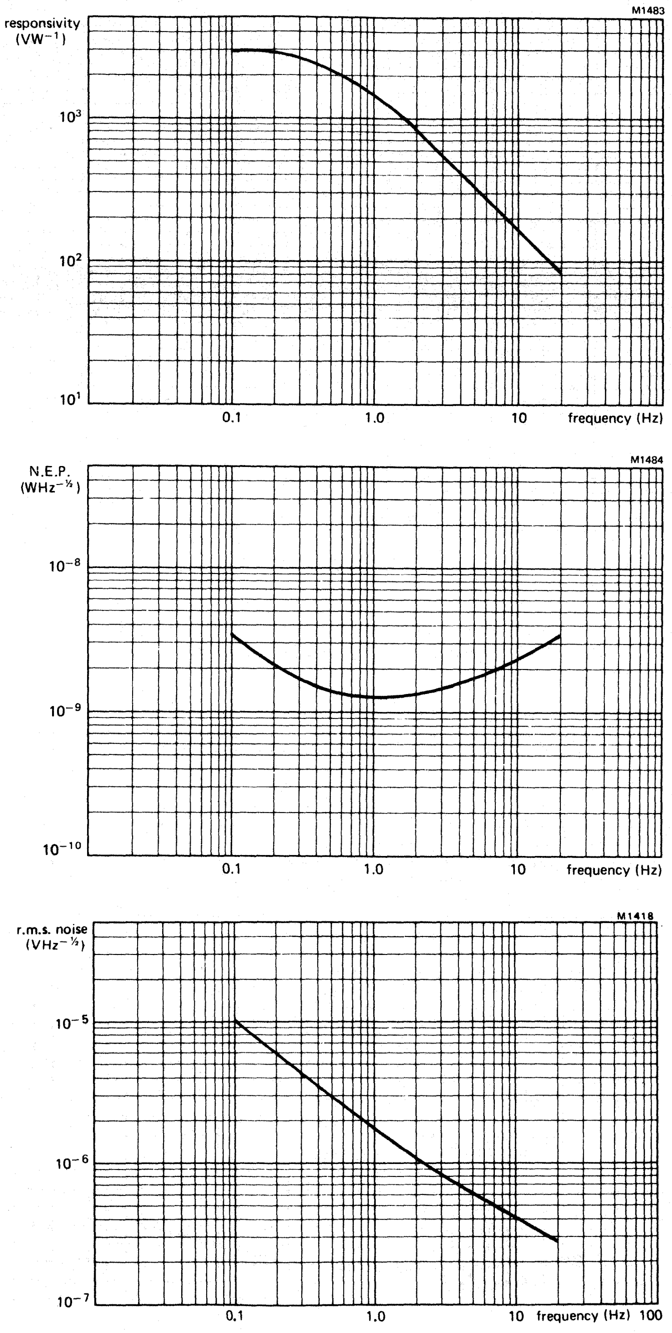
Typical peak signal as a function of frequency
(energy level 25 μWcm^{-2} at the element)



Typical peak-to-peak noise as a function of time
(filter bandwidth 0.4 Hz to 5 Hz)



Typical peak signal and peak-to-peak noise
as functions of temperature
(peak signal energy level, 25 μWcm^{-2} at the element)



Typical responsivity, N.E.P., and r.m.s. noise as functions of frequency, using recommended circuit.

Supersedes April 1984 data

SINGLE ELEMENT PYROELECTRIC INFRARED SENSOR

This is an infrared sensitive device intended for battery operated passive infrared movement detectors such as intruder alarms and light switches which use low grade or no optical focusing arrangements. The element is combined with a single impedance converting amplifier which is specially designed to function from low voltage supplies with low current consumpion. The sensor is sealed in a low profile TO-39 can with a window optically coated to restrict response to wavelengths greater than 6.5 μm.

QUICK REFERENCE DATA

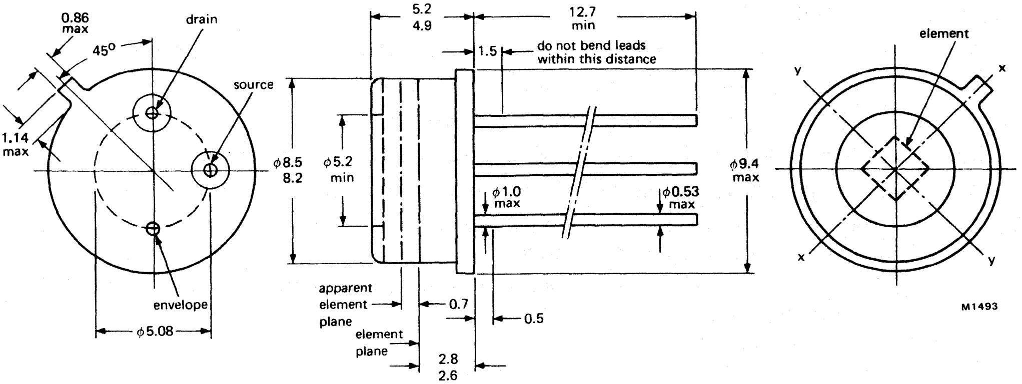
Spectral response		6.5 ± 0.5 to >14	μm
Responsivity (10 μm, 10)	typ.	75	VW^{-1}
Peak signal (500 K, 1) note 1, page 3	typ.	460	μV
Noise, peak-to-peak (bandwidth 0.4 Hz to 5 Hz)	typ.	15	μV
Element dimensions	nom.	2 x 2	mm
Operating voltage	min.	3	V
Optimum operating frequency range		0.1 to 20	Hz

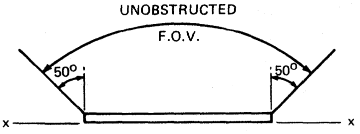
This data must be read in conjunction with GENERAL SAFETY RECOMMENDATIONS – OPTOELECTRONIC DEVICES

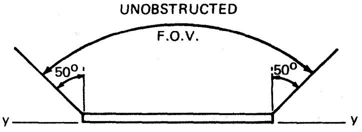
MECHANICAL DATA

Dimensions in mm

SOT-49H (TO-39 variant)







PRODUCT SAFETY

Modern high technology materials have been used in the manufacture of this device to ensure high performance. Some of these materials are toxic in certain circumstances. Mechanical or electrical damage is unlikely to give rise to any hazard, but toxic vapours may be generated if the device is heated to destruction. In the United Kindom disposal of large quantities should therefore be carried out in accordance with the Deposit of Poisonous Waste Act 1972 and the Control of Pollution Act 1974, or with the latest local legislation.

SOLDERING

1. When making soldered connections to the leads, a thermal shunt should be used.
2. It is essential that any mains operated soldering iron used should be both screened and earthed. Failure to observe these precautions may lead to the introduction of line voltages and possible damage to the device. (See operating note 7).

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134).

Supply voltage	max.	30	V
Temperature, operating range		−40 to +70	°C
Temperature, storage range		−55 to +85	°C
Lead soldering temperature, $\geqslant$ 6 mm from header, $t_{sld} \leqslant 3$ s max.		+350	°C

OPERATING CONDITIONS

	min.	max.	
Voltage (operating note 5)	3	10	V
Frequency (operating note 5)	0.1	20	Hz

OPERATING NOTES

1. The case potential must not be allowed to become positive with respect to the other two terminals.
2. It is inadvisable to operate the sensor at mains related frequencies.
3. To avoid the possibility of optical microphony, the sensor must be firmly mounted.
4. An increase in temperature of the element will produce a positive going signal at the output.
5. The sensor will operate outside the quoted range but may have a degraded performance.
6. Before testing, due to the high sensitivity of these sensors, care must be taken to ensure that the devices are allowed to become thermally stable.
7. → To avoid the possibility of electrostatic damage, precautions similar to those used with CMOS devices are necessary, namely:
   a) Earthed wrist straps should be worn.
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   d) No electrical testing should be carried out without specific, approved and written test procedures.
   e) To prevent the development of damaging transient voltages, devices should not be inserted or removed from test fixtures with power applied.

CHARACTERISTICS (at T_{amb} = 22 °C ± 3 °C and with recommended circuit)

		min.	typ.	max.	
Spectral response		6.5 ± 0.5	–	>14	µm
Responsivity* (10 µm, 10)		50	75	–	VW^{-1}
N.E.P. (10 µm, 10, 1)		–	5.0×10^{-9}	-	$WHz^{-1/2}$
Peak signal (500 K, 1)	note 1	–	460	–	µV
Noise*, peak-to-peak (bandwidth 0.4 Hz to 5 Hz)	note 2	–	15	45	µV
Quiescent current		–	10	–	µA
Element dimensions			2 x 2 nominal		mm
Field of view			see page 1		

*These parameters are 100% tested with statistical sample quality inspection.

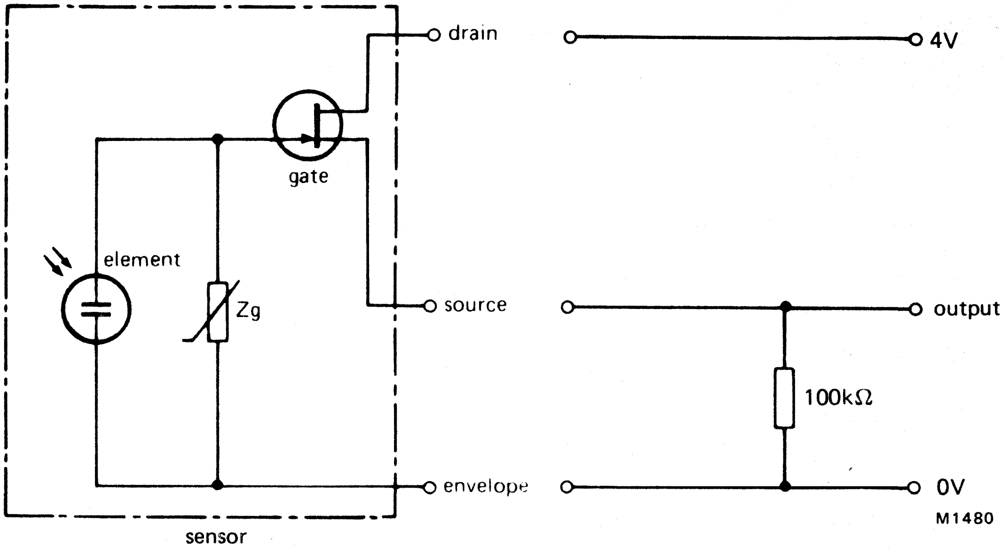
FET Characteristics (at T_{amb} = 22 °C ± 3 °C)

		min.	typ.	max.	
Gate-source cut-off voltage I_D = 0.1 µA, V_{DS} = 6 V	$V_{P(GS)}$	−1.4	–	−0.5	V
Transfer conductance V_{GS} = 0, V_{DS} = 6 V, f = 1 kHz	g_{fso}	1.3	–	–	mAV^{-1}

Notes

1. At an energy level of 25 μWcm^{-2} at the detector.
2. Using low noise filter with 3 dB bandwidth (0.4 Hz to 5 Hz) and roll off at 12 dB per octave. Sensors tested for 1 minute under stable electrical and thermal conditions; see operating note 6 on page 2.

RECOMMENDED CIRCUIT



DEFINITIONS

1. Responsivity VW^{-1}
   This is the ratio of the r.m.s. signal in volts to the r.m.s. value of the incident, chopped radiant power. The published values of responsivity are qualified by figures in brackets, for example (10 μm, 10). The 10 μm denotes the wavelength of the infrared radiation generating the signal voltage, while the 10 indicates that the radiation is chopped at a frequency of 10 Hz.

2. Noise Equivalent Power (N.E.P.) $WHz^{-1/2}$
   This is the r.m.s. value of the incident, chopped radiant power necessary to produce an r.m.s. signal to r.m.s. noise ratio of unity. The r.m.s. noise refers to the value calculated for unit square root bandwidth $VHz^{-1/2}$. As with responsivity the relevant test conditions must be specified, for example (10 μm, 10, 1). The 10 μm is the wavelength of the incident radiation, 10 is the chopping frequency in Hz, and 1 is the bandwidth in Hz.

MECHANICAL AND ENVIRONMENTAL STANDARDS

As part of the Quality Assurance programme, the sensors are assessed at regular intervals against the requirements of the following IEC standards. The frequency of testing and the limits and conditions for the pre- and post-test measurements are based on those stipulated for the CECC 50 000 series of approved transistors.

Test			Severity	Duration	Note
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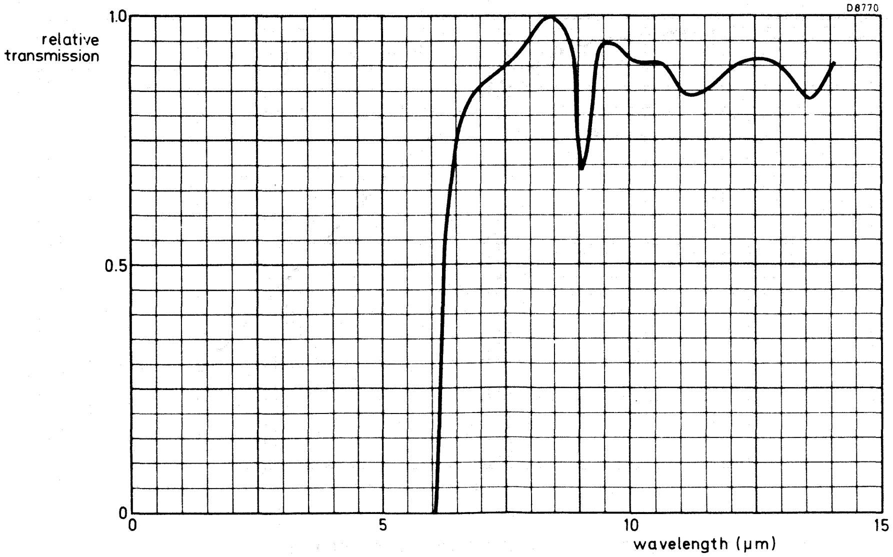
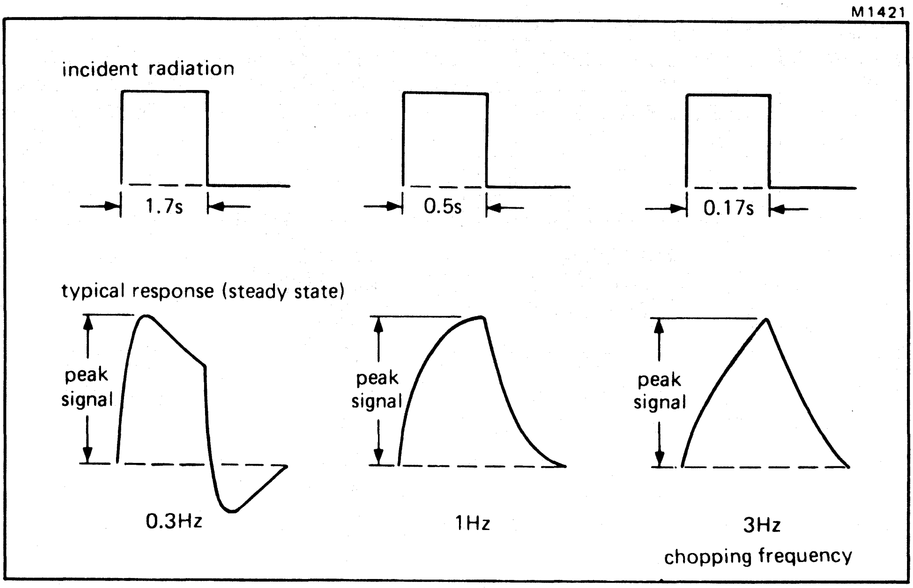
68-2-20	Ta	Solderability	+235 °C, 1.5 mm from header	5 seconds	1
68-2-21	Ub	Lead Fatigue	4 cycles	–	1
68-2-1	Aa	Low Temperature Storage	–55 °C	2000 hours	2
68-2-2	Ba	High Temperature Storage	+85 °C	2000 hours	2
68-2-14	Nb	Change of Temperature	–55 °C to +85 °C	10 cycles	2
68-2-6	Fc (B4)	Vibration, swept frequency	125 Hz to 2 kHz 196 ms^{-2}	2 h in each orientation	2
68-2-7	Ga	Acceleration, steady state	196000 ms^{-2}	60 seconds	2
68-2-27	Ea	Shock	14700 ms^{-2}	3 pulses 6 orientations	2
68-2-20	Tb	Resistance to Solder Heat	+350 °C, 6 mm from header	3 seconds	3

Notes

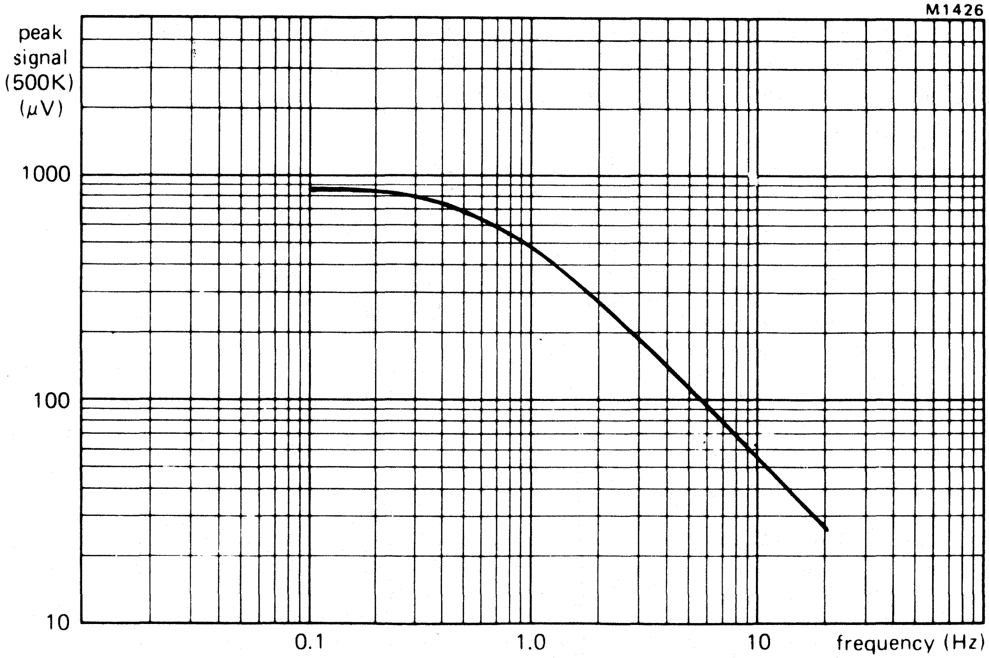
1. The sensors are checked on a production batch release principle at approximately weekly intervals. This is equivalent to Group B.
2. The sensors are checked at quarterly intervals. This is equivalent to Group C.
3. This is an annual check.



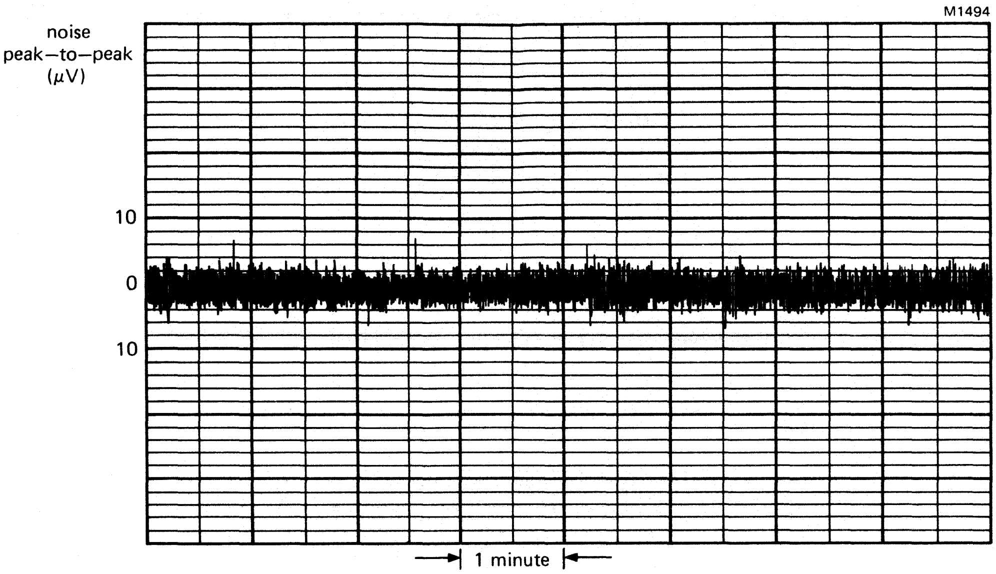
Typical normalized window transmission characteristic



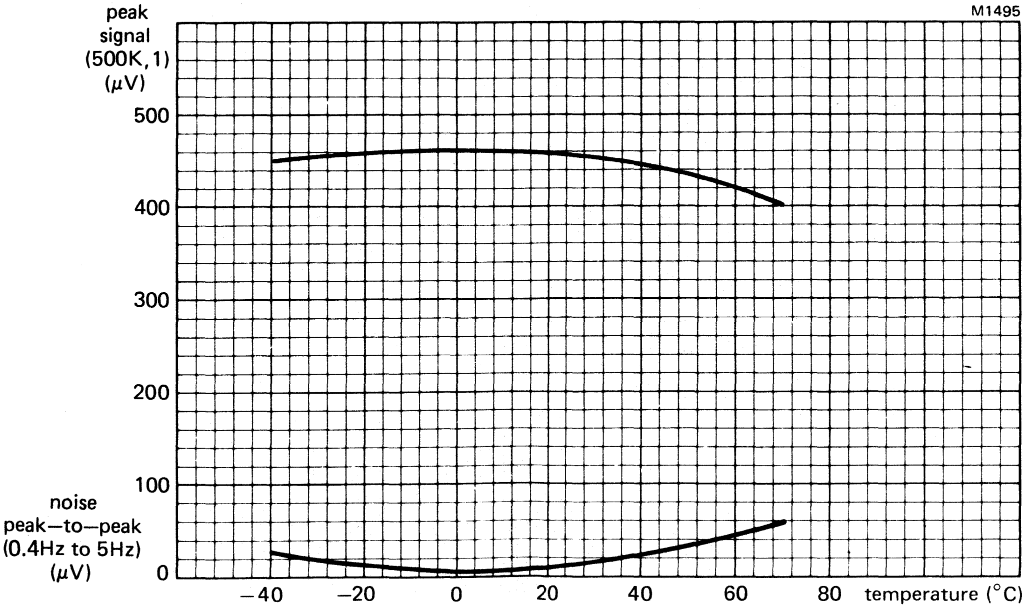
Typical response (steady state) for a given chopping frequency



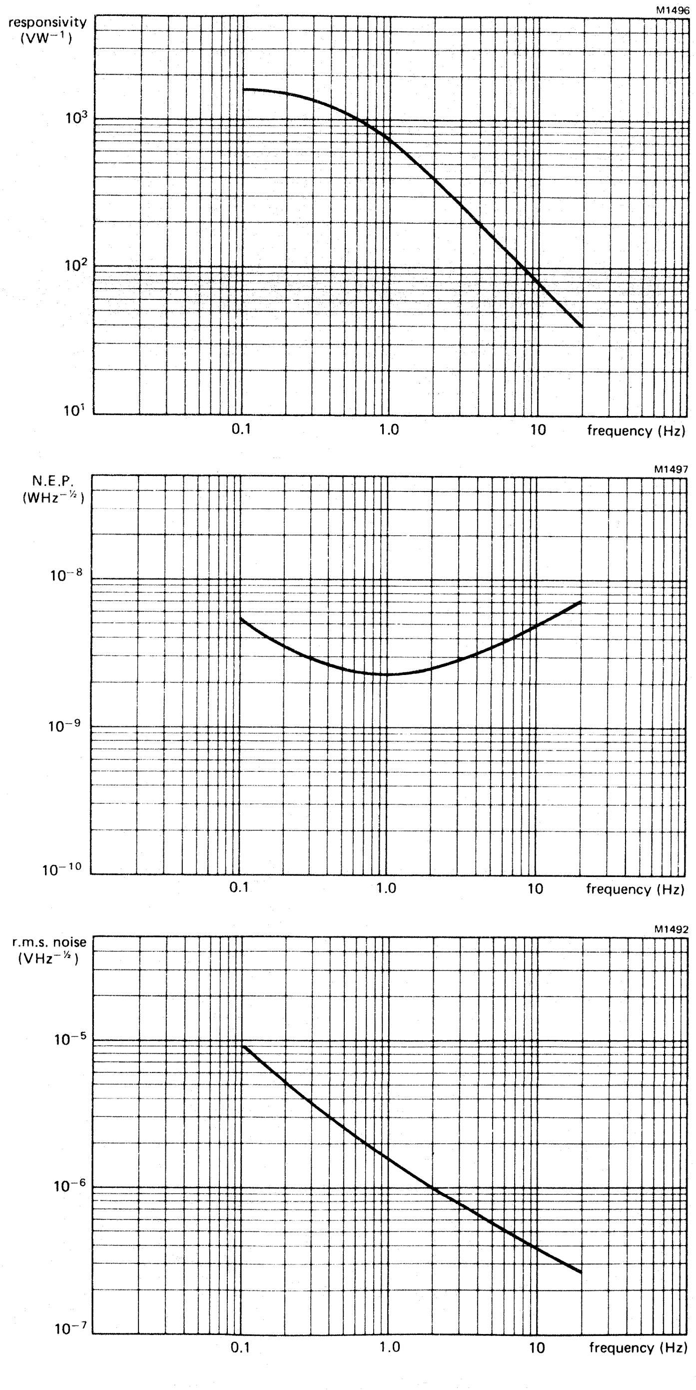
Typical peak signal as a function of frequency
(energy level 25 μWcm^{-2} at the element)



Typical peak-to-peak noise as a function of time
(filter bandwidth 0.4 Hz to 5 Hz)



Typical peak signal and peak-to-peak noise
as functions of temperature
(peak signal energy level, 25 μWcm^{-2} at the element)



Typical responsivity, N.E.P., and r.m.s. noise as functions of frequency, using recommended circuit.

SINGLE ELEMENT PYROELECTRIC INFRARED SENSOR

This is an infrared sensitive device incorporating a single impedance converting amplifier which is specially designed to function from low voltage supplies with low current consumption. The sensor is sealed in a low profile TO-39 can with an uncoated silicon window.

QUICK REFERENCE DATA

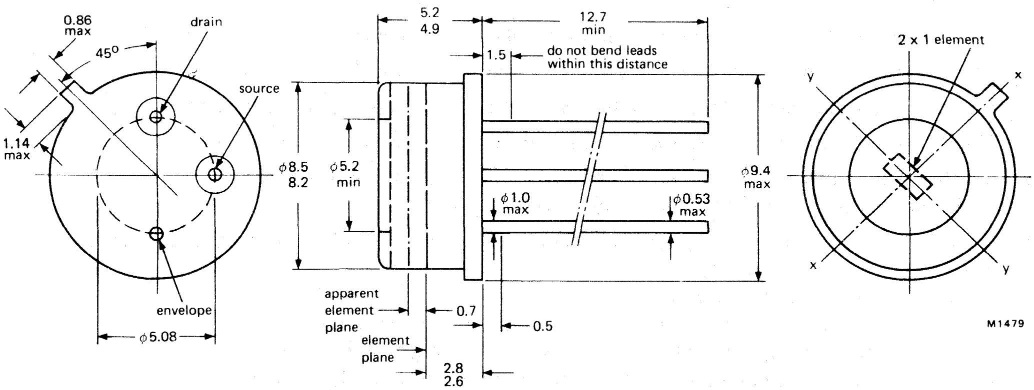
Spectral response		1.0 to >15	μm
Responsivity (500 K, 10)	typ.	130	VW^{-1}
Noise Equivalent Power (N.E.P.) (500 K, 10, 1)	typ.	3.0×10^{-9}	$WHz^{-1/2}$
Peak signal (500 K, 1) note 1, page 3	typ.	385	μV
Noise, peak-to-peak (bandwidth 0.4 Hz to 5 Hz)	typ.	20	μV
Element dimensions	nom.	2 x 1	mm
Operating voltage	min.	3	V
Optimum operating frequency range		0.1 to 20	Hz

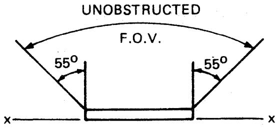
This data must be read in conjunction with GENERAL SAFETY RECOMMENDATIONS – OPTOELECTRONIC DEVICES

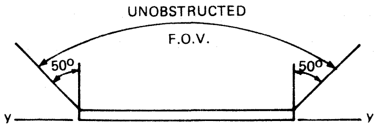
MECHANICAL DATA

Dimensions in mm

SOT-49H (TO-39 variant)







PRODUCT SAFETY

Modern high technology materials have been used in the manufacture of this device to ensure high performance. Some of these materials are toxic in certain circumstances. Mechanical or electrical damage is unlikely to give rise to any hazard, but toxic vapours may be generated if the device is heated to destruction. Disposal of large quantities should therefore be carried out in accordance with the latest local legislation.

SOLDERING

1. When making soldered connections to the leads, a thermal shunt should be used.
2. It is essential that any mains operated soldering iron used should be both screened and earthed. Failure to observe these precautions may lead to the introduction of line voltages and possible damage to the device. (See operating note 7).

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134).

Supply voltage	max.	30	V
Temperature, operating range		−40 to +70	°C
Temperature, storage range		−55 to +85	°C
Lead soldering temperature, $\geqslant 6$ mm from header, $t_{sld} \leqslant 3$ s		+350	°C

OPERATING CONDITIONS

	min.	max.	
Voltage (operating note 5)	3	10	V
Frequency (operating note 5)	0.1	20	Hz

OPERATING NOTES

1. The case potential must not be allowed to become positive with respect to the other two terminals.
2. It is inadvisable to operate the sensor at mains related frequencies.
3. To avoid the possibility of optical microphony, the sensor must be firmly mounted.
4. An increase in temperature of the element will produce a positive going signal at the output.
5. The sensor will operate outside the quoted range but may have a degraded performance.
6. Before testing, due to the high sensitivity of these sensors, care must be taken to ensure that the devices are allowed to become thermally stable.
7. → To avoid the possibility of electrostatic damage, precautions similar to those used with CMOS devices are necessary, namely:
   a) Earthed wrist staps should be worn.
   b) Table tops or other working surfaces should be conductive and earthed.
   c) Anti-static clothing should be worn (no wool, silk or synthetic fibres).
   d) No electrical testing should be carried out without specific, approved and written test procedures.
   e) To prevent the development of damaging transient voltages, devices should not be inserted or removed from test fixtures with power applied.

CHARACTERISTICS (at T_{amb} = 22 °C ± 3 °C and with recommended circuit) ←

		min.	typ.	max.	
Spectral response		1.0	–	>15	μm
Responsivity* (500 K, 10)		90	130	–	VW^{-1}
N.E.P. (500 K, 10, 1)		–	3.0×10^{-9}	–	$WHz^{-1/2}$
Peak signal (500 K, 1)	note 1	–	385	–	μV
Noise*, peak-to-peak (bandwidth 0.4 Hz to 5 Hz)	note 2	–	20	45	μV
Quiescent current		–	10	–	μA
Element dimensions			2 x 1 nominal		mm
Field of view			see page 1		

*These parameters are 100% tested with statistical sample quality inspection.

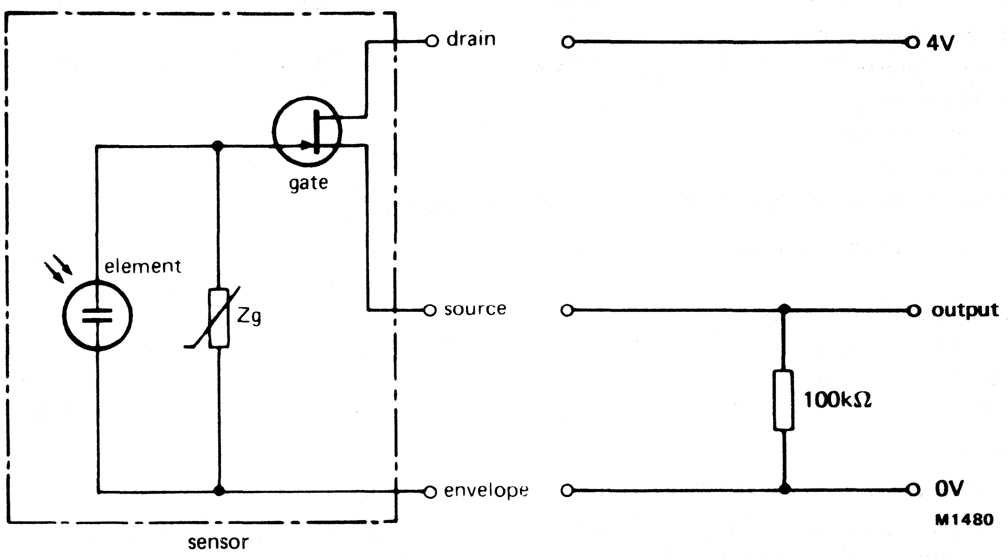
FET characteristics (at T_{amb} = 22 °C ± 3 °C)

		min.	typ.	max.	
Gate-source cut-off voltage $I_D = 0.1\ \mu A$, $V_{DS} = 6\ V$	$V_{P(GS)}$	−1.4	–	−0.5	V
Transfer conductance $V_{GS} = 0$, $V_{DS} = 6\ V$, f = 1 kHz	g_{fso}	1.3	–	–	mAV^{-1}

Notes

1. At any energy level of 25 μWcm^{-2} at the element.
2. Using low noise filter with 3 dB bandwidth (0.4 Hz to 5 Hz) and roll off at 12 dB per octave. Sensors tested for 1 minute under stable electrical and thermal conditions; see operating note 6 on page 2.

RECOMMENDED CIRCUIT



DEFINITIONS

1. Responsivity VW^{-1}
   This is the ratio of the r.m.s. signal in volts to the r.m.s. value of the incident, chopped radiant power. The published values of responsivity are qualified by figures in brackets, for example (500 K, 10). The 500 K denotes the temperature of the black body source of the infrared radiation generating the signal voltage, while the 10 indicates that the radiation is chopped at a frequency of 10 Hz.
2. Noise Equivalent Power (N.E.P.) $WHz^{-1/2}$
   This is the r.m.s. value of the incident, chopped radiant power necessary to produce an r.m.s. signal to r.m.s. noise ratio of unity. The r.m.s. noise refers to the value calculated for unit square root bandwidth $VHz^{-1/2}$. As with responsivity the relevant test conditions must be specified, for example (500 K, 10, 1). The 500 K is the temperature of the black body source of the incident radiation, 10 is the chopping frequency in Hz, and 1 is the bandwidth in Hz.

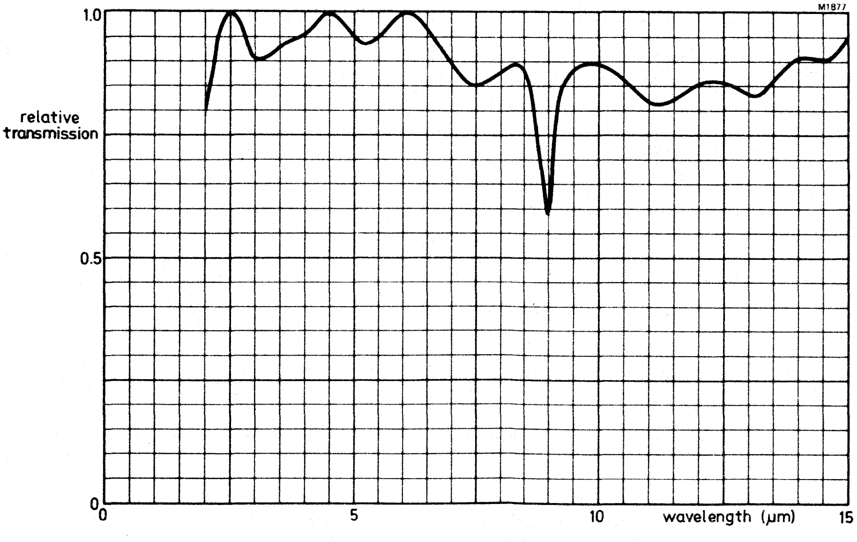
MECHANICAL AND ENVIRONMENTAL STANDARDS

As part of the Quality Assurance programme, the sensors will be assessed at regular intervals against the requirements of the following IEC standards. The frequency of testing and the limits and conditions for the pre- and post-test measurements are based on those stipulated for the CECC 50 000 series of approved transistors.

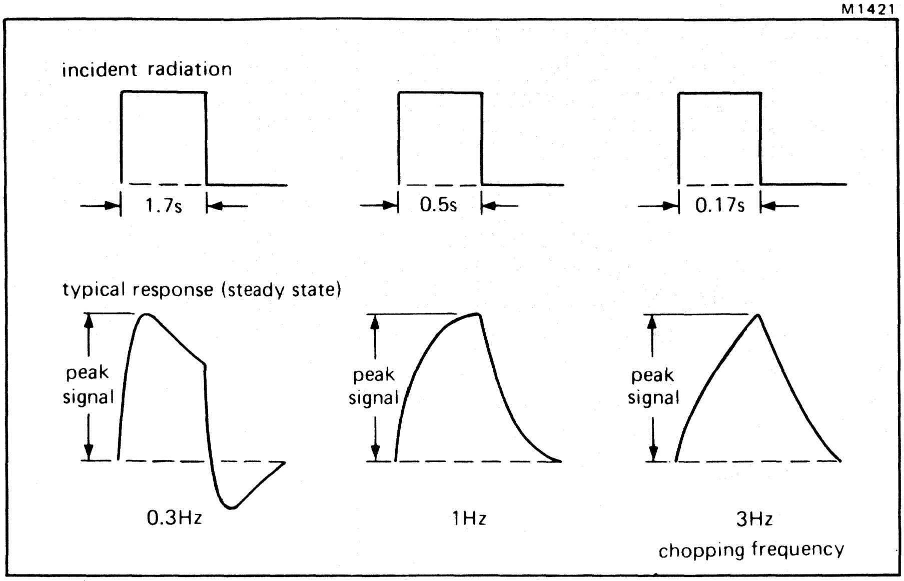
Test			Severity	Duration	Note
IEC 68-2-3	Ca	Damp Heat, steady state	+40 °C, 95% RH	168 hours	1
68-2-20	Ta	Solderability	+235 °C, 1.5 mm from header	5 seconds	1
68-2-21	Ub	Lead Fatigue	4 cycles	–	1
68-2-1	Aa	Low Temperature Storage	–55 °C	2000 hours	2
68-2-2	Ba	High Temperature Storage	+85 °C	2000 hours	2
68-2-14	Nb	Change of Temperature	–55 °C to +85 °C	10 cycles	2
68-2-6	Fc (B4)	Vibration, swept frequency	125 Hz to 2 kHz 196 ms^{-2}	2 h in each orientation	2
68-2-7	Ga	Acceleration, steady state	196000 ms^{-2}	60 seconds	2
68-2-27	Ea	Shock	14700 ms^{-2}	3 pulses 6 orientations	2
68-2-20	Tb	Resistance to Solder Heat	+350 °C, 6 mm from header	3 seconds	3

Notes

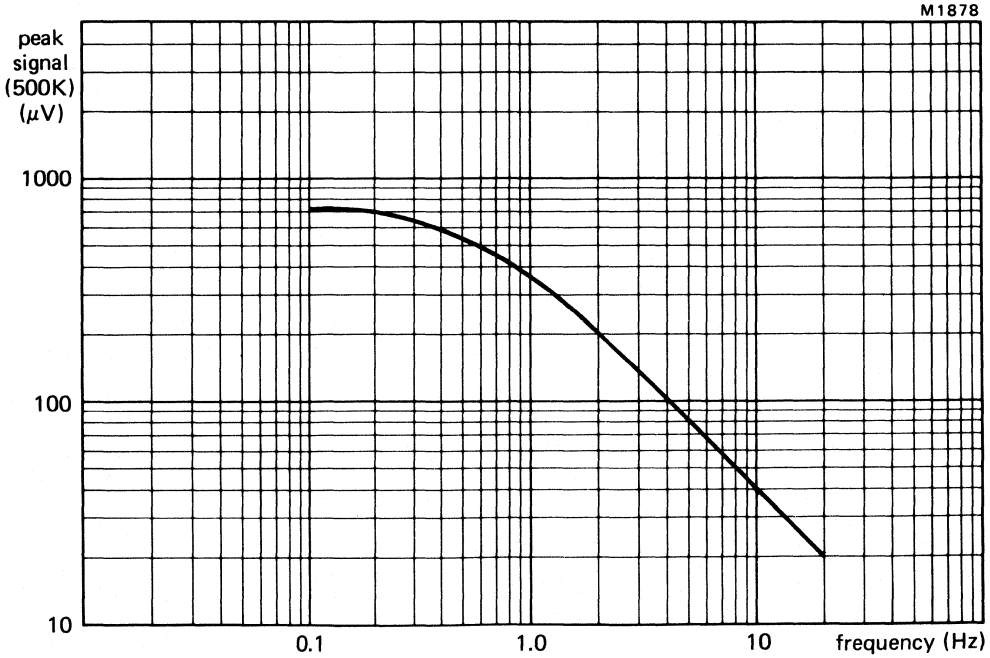
1. The sensors to be checked on a production batch release principle at approximately weekly intervals. This is equivalent to Group B.
2. The sensors to be checked at quarterly intervals. This is equivalent to Group C.
3. This is an annual check.



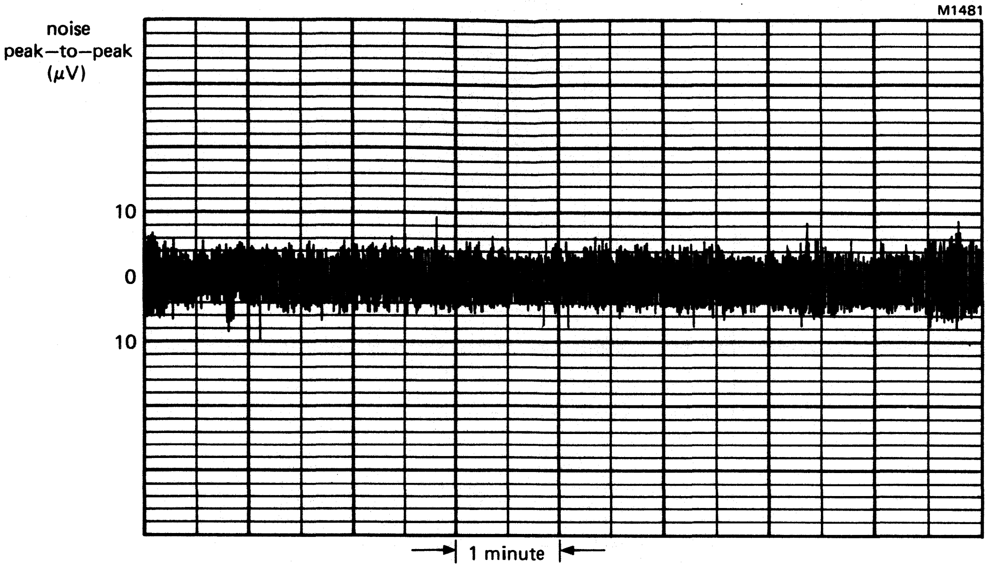
Typical normalized window transmission characteristic



Typical response (steady state) for a given chopping frequency

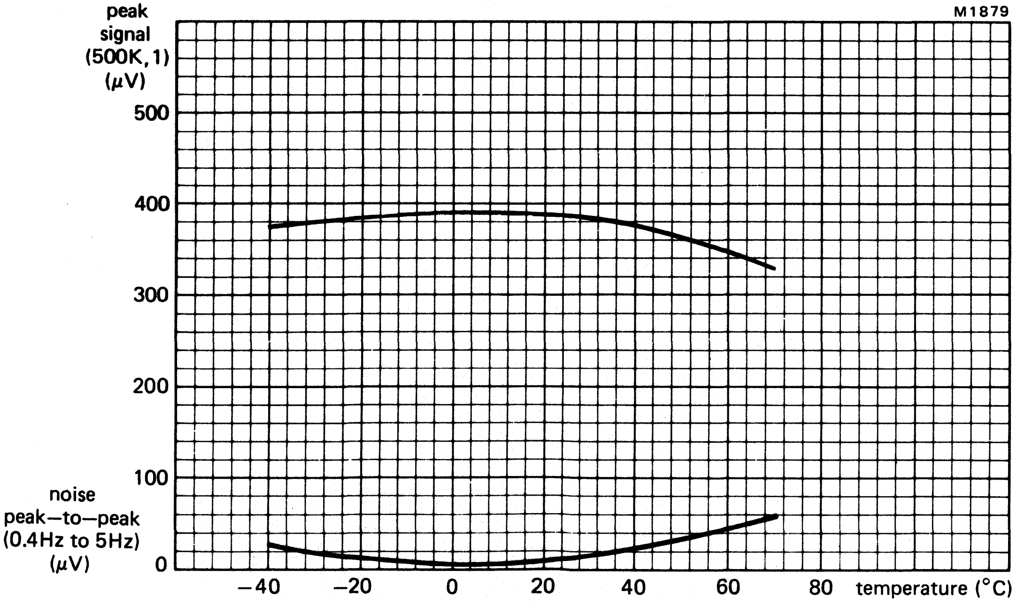


Typical peak signal as a function of frequency
(energy level 25 μWcm^{-2} at the element)



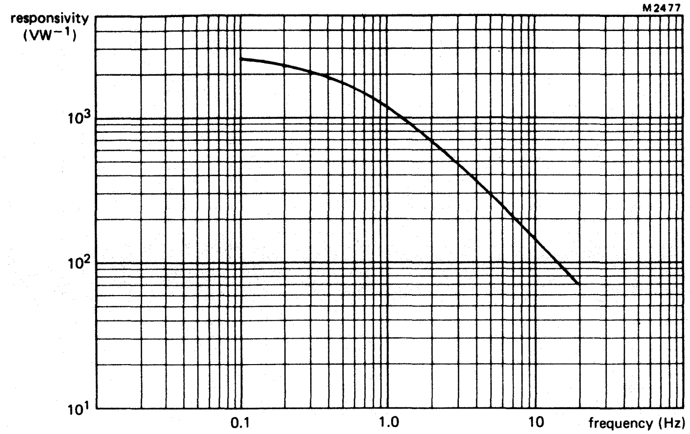
Typical peak-to-peak noise as a function of time
(filter bandwidth 0.4 Hz to 5 Hz)

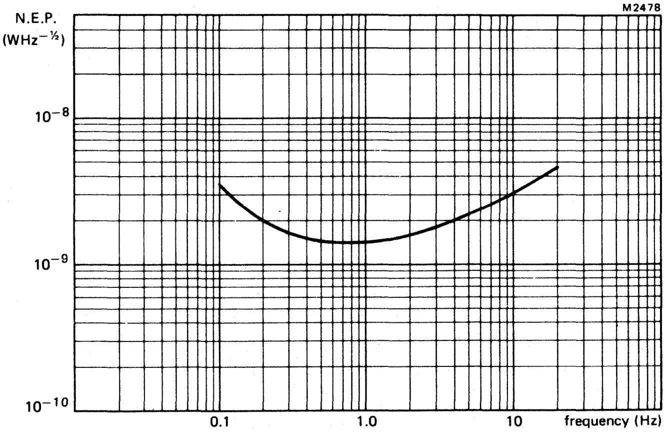
←

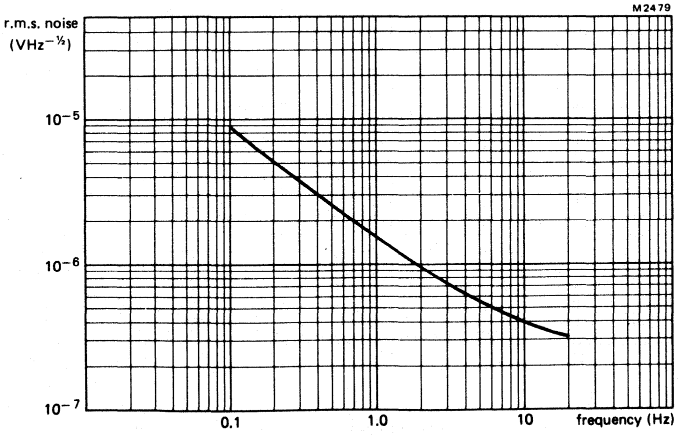


Typical peak signal and peak-to-peak noise
as functions of temperature
(peak signal energy level, 25 μWcm^{-2} at the sensor)

←







Typical responsivity, N.E.P., and r.m.s. noise as functions of frequency using recommended circuit.

Supersedes September 1984 data

SINGLE ELEMENT PYROELECTRIC INFRARED SENSOR

This is an infrared sensitive device incorporating a single impedance converting amplifier which is specifically designed to function from low voltage supplies with low current consumption. The sensor is sealed in a low profile TO-39 can with an uncoated silicon window.

QUICK REFERENCE DATA

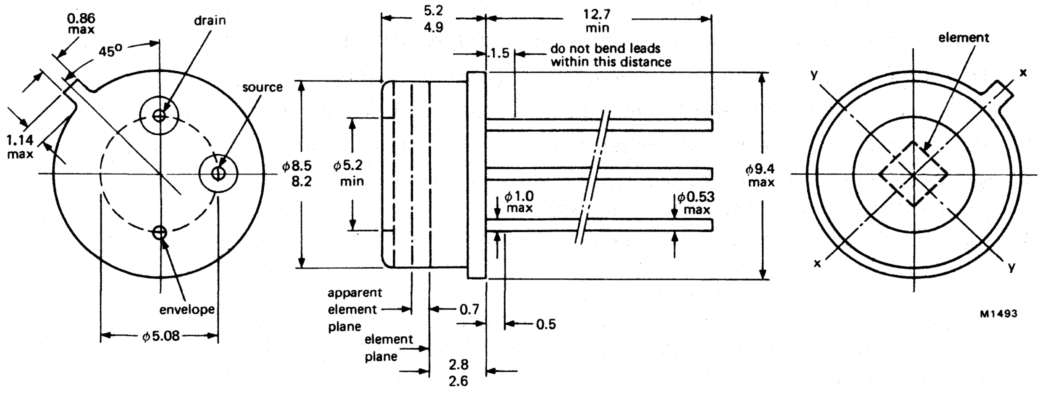
Spectral response		1.0 to >15	μm
Responsivity (500 K, 10)	typ.	65	VW^{-1}
Noise Equivalent Power (N.E.P.) (500 K, 10, 1)	typ.	6.0×10^{-9}	$WHz^{-1/2}$
Peak signal (500 K, 1) note 1, page 3	typ.	385	μV
Noise, peak-to-peak (bandwidth 0.4 Hz to 5 Hz)	typ.	15	μV
Element dimensions	nom.	2 x 2	mm
Operating voltage	min.	3	V
Optimum operating frequency range		0.1 to 20	Hz

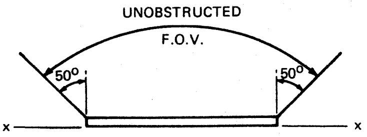
This data must be read in conjunction with GENERAL SAFETY RECOMMENDATIONS – OPTOELECTRONIC DEVICES

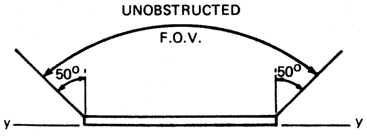
MECHANICAL DATA

Dimensions in mm

SOT-49H (TO-39 variant)







PRODUCT SAFETY

Modern high technology materials have been used in the manufacture of this device to ensure high performance. Some of these materials are toxic in certain circumstances. Mechanical or electrical damage is unlikely to give rise to any hazard, but toxic vapours may be generated if the device is heated to destruction. Disposal of large quantities should therefore be carried out in accordance with the latest local legislation.

SOLDERING

1. When making soldered connections to the leads, a thermal shunt should be used.
2. It is essential that any mains operated soldering iron used should be both screened and earthed. Failure to observe these precautions may lead to the introduction of line voltages and possible damage to the device. (See operating note 7).

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134).

Supply voltage	max.	30	V
Temperature, operating range		−40 to +70	°C
Temperature, storage range		−55 to +85	°C
Lead soldering temperature, ⩾ 6 mm from header, $t_{sld} \leqslant 3$ s max.		+350	°C

OPERATING CONDITIONS

	min.	max.	
Voltage (operating note 5)	3	10	V
Frequency (operating note 5)	0.1	20	Hz

OPERATING NOTES

1. The case potential must not be allowed to become positive with respect to the other two terminals.
2. It is inadvisable to operate the sensor at mains related frequencies.
3. To avoid the possibility of optical microphony, the sensor must be firmly mounted.
4. An increase in temperature of the element will produce a positive going signal at the output.
5. The sensor will operate outside the quoted range but may have a degraded performance.
6. Before testing, due to the high sensitivity of these sensors, care must be taken to ensure that the devices are allowed to become thermally stable.
7. → To avoid the possibility of electrostatic damage, precautions similar to those used with CMOS devices are necessary, namely:
   a) Earthed wrist straps should be worn.
   b) Table tops or other working surfaces should be conductive and earthed.
   c) Anti-static clothing should be worn (no wool, silk or synthetic fibres).
   d) No electrical testing should be carried out without specific, approved and written test procedures.
   e) To prevent the development of damaging transient voltages, devices should not be inserted or removed from test fixtures with power applied.

CHARACTERISTICS (at T_{amb} = 22 °C ± 3 °C and with recommended circuit) ←

		min.	typ.	max.	
Spectral response		1.0	–	>15	μm
Responsivity* (500 K, 10)		45	65	–	VW^{-1}
N.E.P. (500 K, 10, 1)		–	6.0×10^{-9}	-	$WHz^{-½}$
Peak signal (500 K, 1)	note 1	–	385	-	μV
Noise*, peak-to-peak (bandwidth 0.4 Hz to 5 Hz)	note 2	–	15	45	μV
Quiescent current		–	10	–	μA
Element dimensions			2 x 2 nominal		mm
Field of view			see page 1		

*These parameters are 100% tested with statistical sample quality inspection.

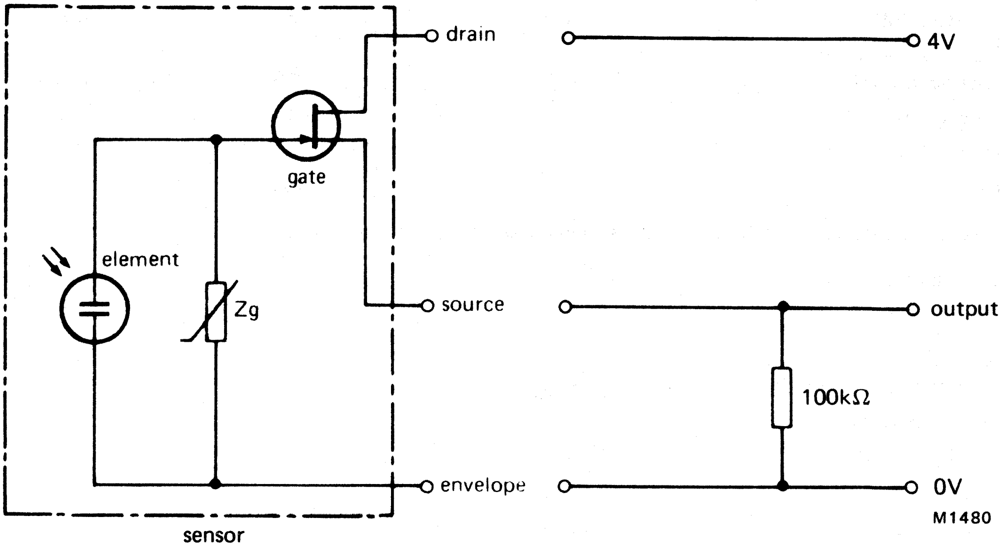
FET Characteristics (at T_{amb} = 22 °C ± 3 °C)

		min.	typ.	max.	
Gate-source cut-off voltage I_D = 0.1 μA, V_{DS} = 6 V	$V_{P(GS)}$	−1.4	–	−0.5	V
Transfer conductance V_{GS} = 0, V_{DS} = 6 V, f = 1 kHz	g_{fso}	1.3	-	–	mAV^{-1}

Notes

1. At an energy level of 25 μWcm^{-2} at the element.
2. Using low noise filter with 3 dB bandwidth (0.4 Hz to 5 Hz) and roll off at 12 dB per octave. Sensors tested for 1 minute under stable electrical and thermal conditions; see operating note 6 on page 2.

RECOMMENDED CIRCUIT



DEFINITIONS

1. Responsivity VW^{-1}
   This is the ratio of the r.m.s. signal in volts to the r.m.s. value of the incident, chopped radiant power. The published values of responsivity are qualified by figures in brackets, for example (500 K, 10). The 500 K denotes the temperature of the black body source of the infrared radiation generating the signal voltage, while the 10 indicates that the radiation is chopped at a frequency of 10 Hz.
2. Noise Equivalent Power (N.E.P.) $WHz^{-\frac{1}{2}}$
   This is the r.m.s. value of the incident, chopped radiant power necessary to produce an r.m.s. signal to r.m.s. noise ratio of unity. The r.m.s. noise refers to the value calculated for unit square root bandwidth $VHz^{-\frac{1}{2}}$. As with responsivity the relevant test conditions must be specified, for example (500 K, 10, 1). The 500 K is the temperature of the black body source of the incident radiation, 10 is the chopping frequency in Hz, and 1 is the bandwidth in Hz.

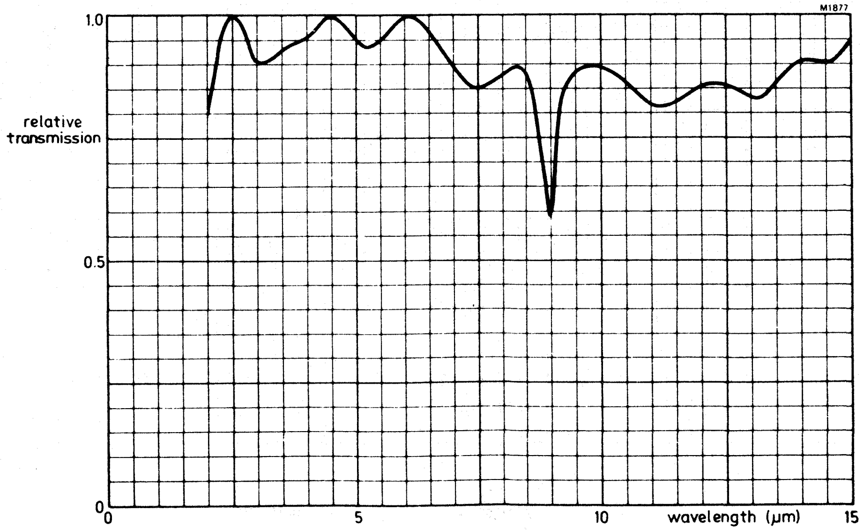
MECHANICAL AND ENVIRONMENTAL STANDARDS

As part of the Quality Assurance programme, the sensors will be assessed at regular intervals against the requirements of the following IEC standards. The frequency of testing and the limits and conditions for the pre- and post-test measurements are based on those stipulated for the CECC 50 000 series of approved transistors.

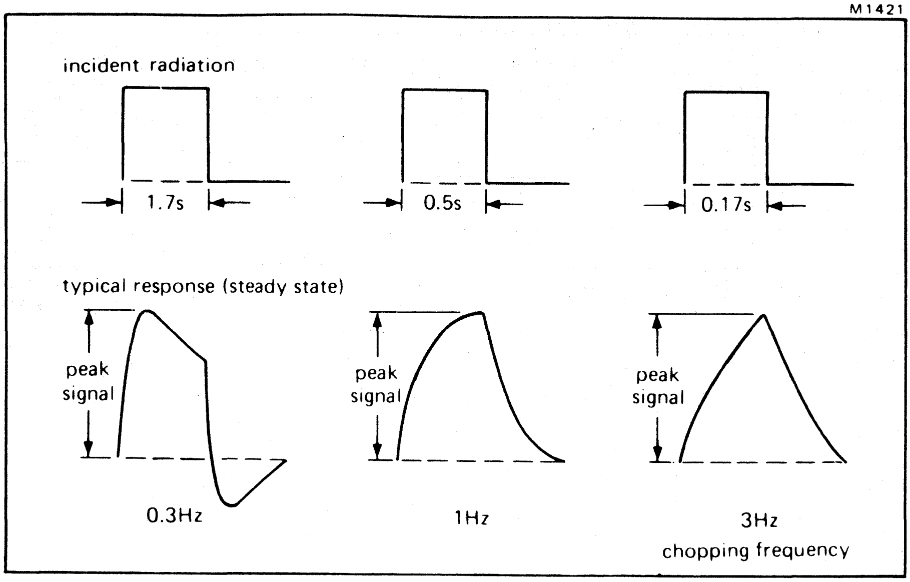
	Test			Severity	Duration	Note
IEC	68-2-3	Ca	Damp Heat, steady state	+40 °C, 95% RH	168 hours	1
	68-2-20	Ta	Solderability	+235 °C, 1.5 mm from header	5 seconds	1
	68-2-21	Ub	Lead Fatigue	4 cycles	–	1
	68-2-1	Aa	Low Temperature Storage	–55 °C	2000 hours	2
	68-2-2	Ba	High Temperature Storage	+85 °C	2000 hours	2
	68-2-14	Nb	Change of Temperature	–55 °C to +85 °C	10 cycles	2
	68-2-6	Fc (B4)	Vibration, swept frequency	125 Hz to 2 kHz 196 ms^{-2}	2 h in each orientation	2
	68-2-7	Ga	Acceleration, steady state	196000 ms^{-2}	60 seconds	2
	68-2-27	Ea	Shock	14700 ms^{-2}	3 pulses 6 orientations	2
	68-2-20	Tb	Resistance to Solder Heat	+350 °C, 6 mm from header	3 seconds	3

Notes

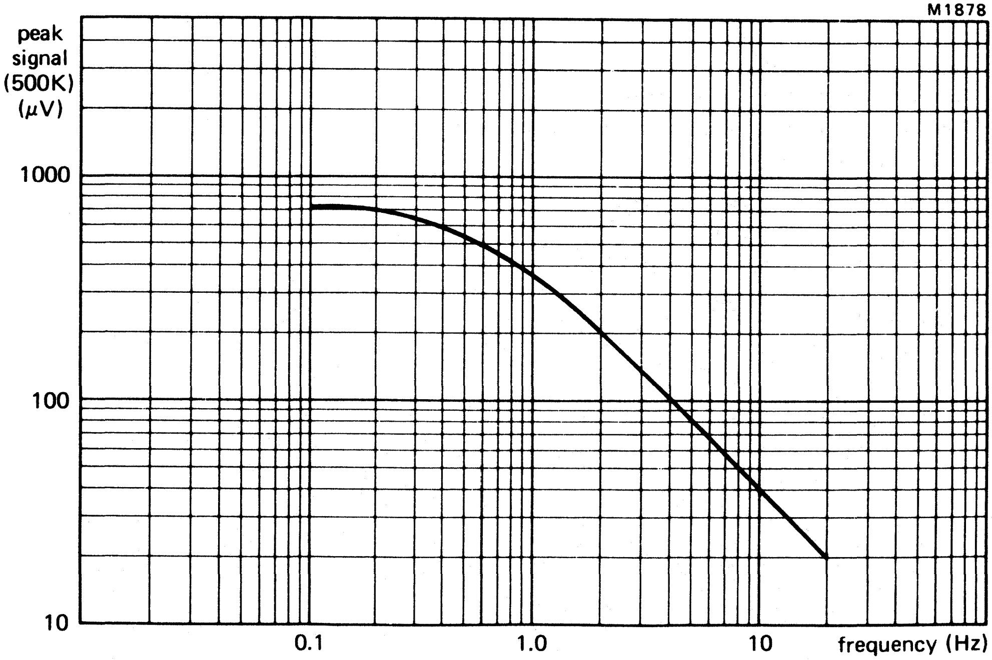
1. The sensors to be checked on a production batch release principle at approximately weekly intervals. This is equivalent to Group B.
2. The sensors to be checked at quarterly intervals. This is equivalent to Group C.
3. This is an annual check.



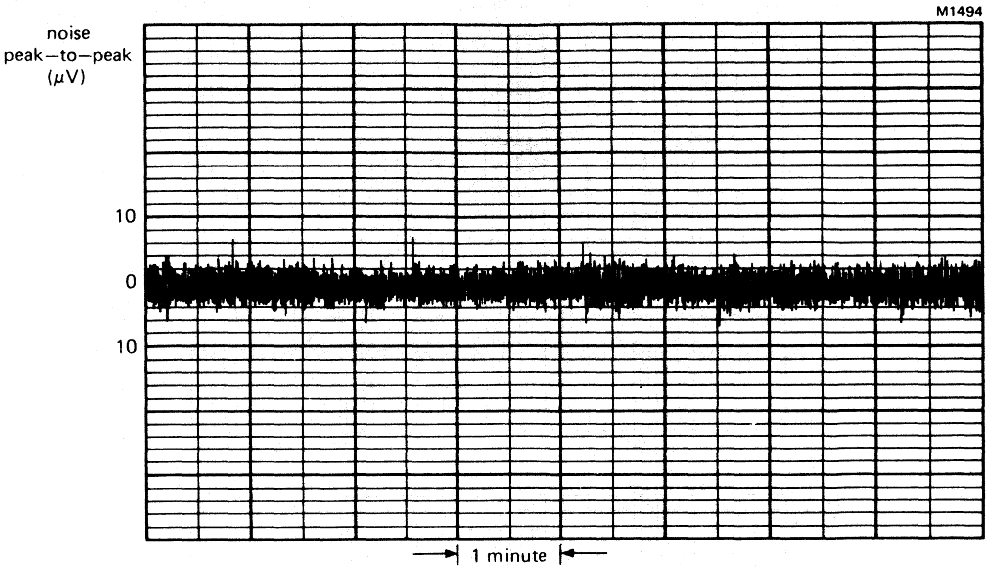
Typical normalized window transmission characteristic



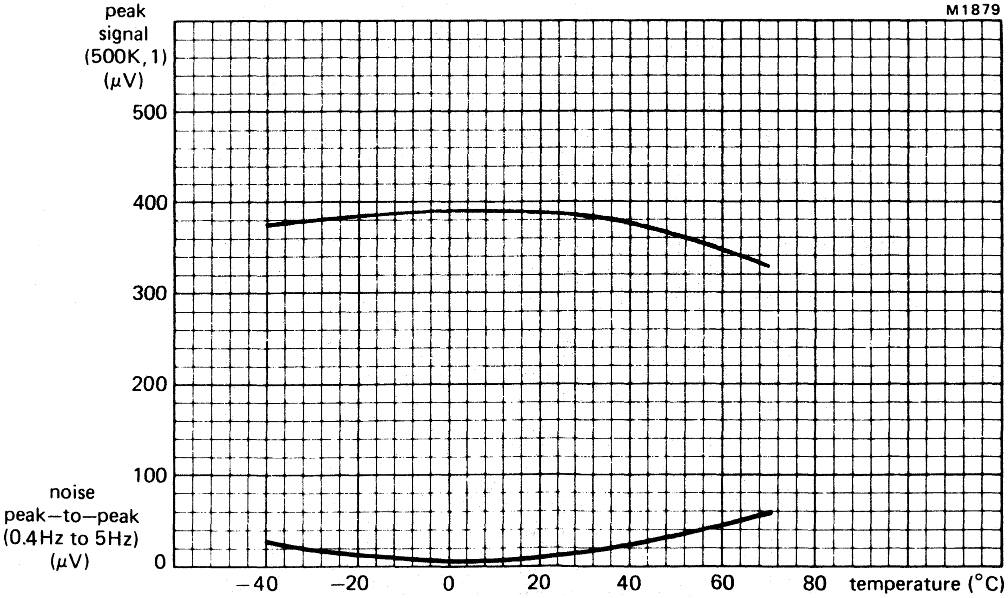
Typical response (steady state) for a given chopping frequency



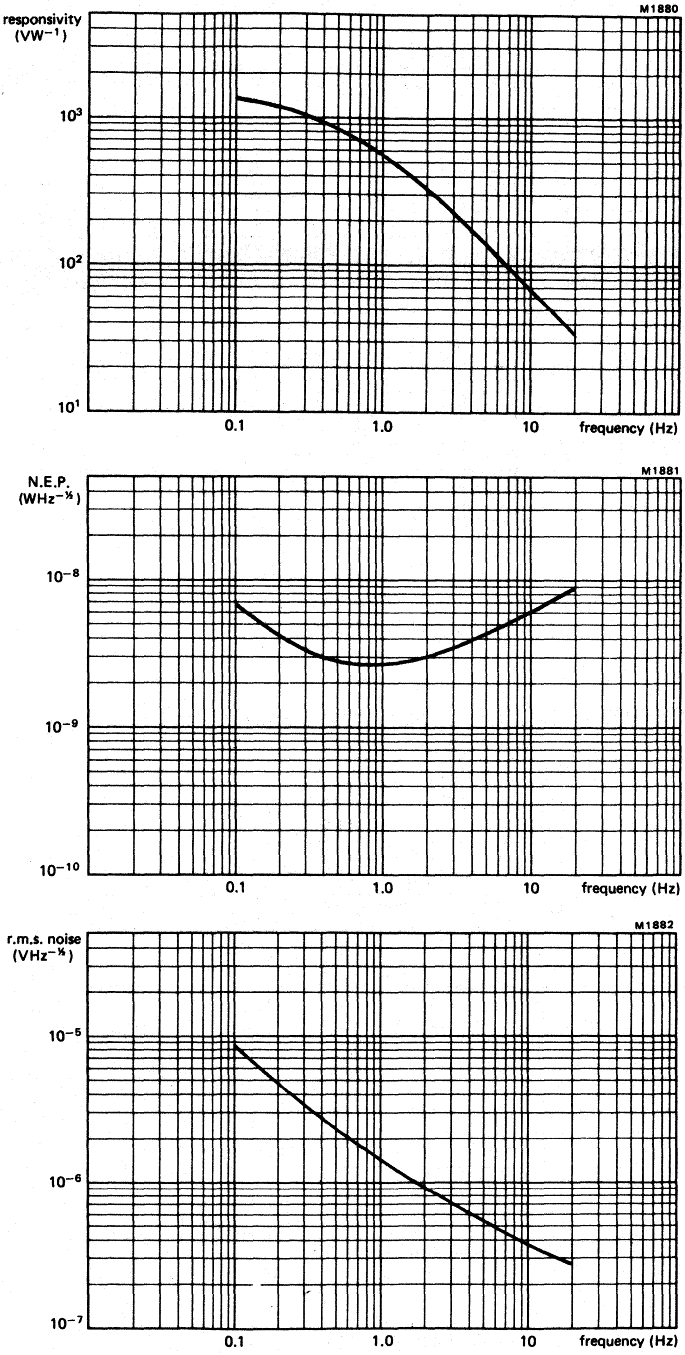
Typical peak signal as a function of frequency
(energy level 25 μWcm^{-2} at the element)



Typical peak-to-peak noise as a function of time
(filter bandwidth 0.4 Hz to 5 Hz)



Typical peak signal and peak-to-peak noise
as functions of temperature
(peak signal energy level, 25 μWcm^{-2} at the sensor)



→ Typical responsivity, N.E.P., and r.m.s. noise as functions of frequency, using recommended circuit.

TWO-CHANNEL PYROELECTRIC INFRARED SENSOR

Special features:	Two channels in one encapsulation to enable intelligent signal processing. Details of recommended scheme available on request.
Application:	For use in passive IR intruder alarms.
Element configuration:	Two series-connected interdigitated pairs.
Electrical:	An impedance converting amplifier per channel, each having separate source connections.
Window:	Daylight filtered silicon.

QUICK REFERENCE DATA

Measured in source follower mode with 100 kΩ load resistor.

	min.	typ.	max.	
Spectral response	6.5 ± 0.5	–	>14	μm
Noise, peak-to-peak (bandwidth 0.4 Hz to 5 Hz)	–	30	55	μV
Peak signal (500K, 1) with incident energy of 25 μWcm^{-2}	570	850	1450	μV
Element dimensions and configuration		see page 2		
Operating voltage	3	–	10	V
Optimum operating frequency range	0.1	–	20	Hz

This data must be read in conjunction with GENERAL SAFETY RECOMMENDATIONS — OPTOELECTRONIC DEVICES.

MECHANICAL DATA

Dimensions in mm.

Fig.1 SOT-49N.

See page 2 for outline, element configuration and field of view diagrams.

MECHANICAL DATA

Dimensions in mm

Fig.1 SOT-49N.

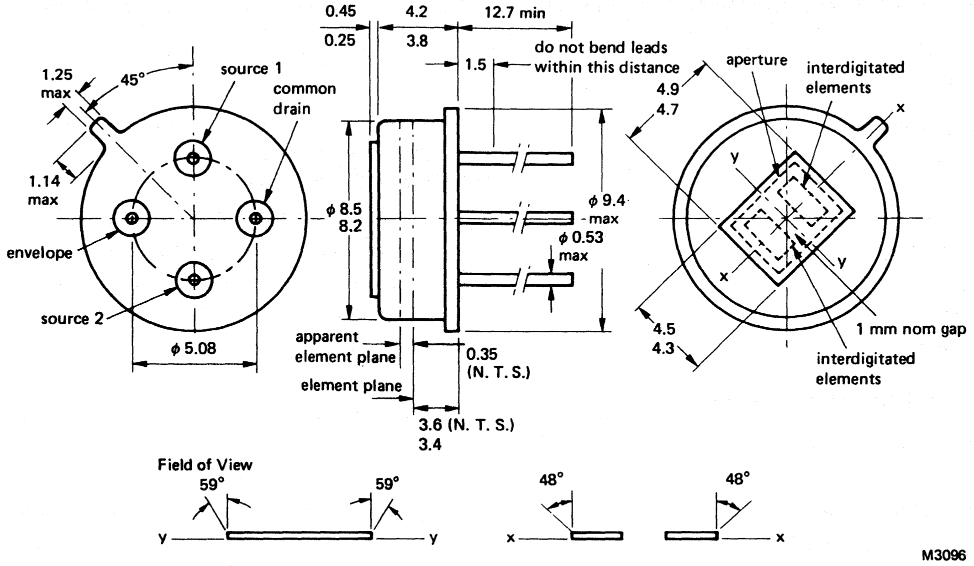
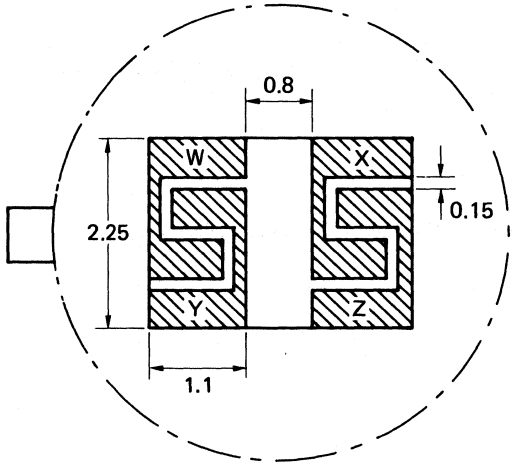


Fig.2 Element configuration.



PRODUCT SAFETY

Modern high technology materials have been used in the manufacture of this device to ensure high performance. Some of these materials are toxic in certain circumstances. Mechanical or electrical damage is unlikely to give rise to any hazard, but toxic vapours may be generated if the device is heated to destruction. Disposal of large quantities should therefore be carried out in accordance with the latest local legislation.

SOLDERING

1. When making soldered connections to the leads, a thermal shunt should be used.
2. It is essential that any mains operated soldering iron used should be both screened and earthed. Failure to observe these precautions may lead to the introduction of line voltages and possible damage to the device. (see operating note 7)

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134).

Supply voltage	max.	20	V
Temperature, operating range		−10 to +50	°C
Temperature, storage range		−30 to +70	°C
Lead soldering temperature, ⩾6 mm from header, $t_{sld} \leqslant 3$ s		+350	°C

OPERATING NOTES

1. The case potential must not be allowed to become positive with respect to the other three terminals.
2. It is inadvisable to operate the sensor at mains related frequencies.
3. To avoid the possibility of optical microphony, the sensor must be firmly mounted.
4. An increase in temperature of elements W and Y will produce a positive going signal at the output. For elements X and Z, the corresponding output will be negative going.
5. The sensor will operate outside the quoted range but may have a degraded performance.
6. Due to the high sensitivity of these sensors, care must be taken to ensure that the devices are allowed to become thermally stable before testing.
7. To avoid the possibility of electrostatic damage, precautions similar to those used with CMOS devices are necessary, namely:
   a) Earthed wrist straps should be worn.
   b) Table tops or other working surfaces should be conductive and earthed.
   c) Anti-static clothing should be worn, (no wool, silk or synthetic fibres).
   d) No electrical testing should be carried out without specific, approved and written test procedures.
   e) To prevent the development of damaging transient voltages, devices should not be inserted into or removed from test fixtures with power applied.

CHARACTERISTICS (at T_{amb} = 22 °C ± 3 °C and with recommended circuit)

Measured in source follower mode with 100 kΩ load resistor.

	min.	typ.	max.	
Spectral response	6.5 ± 0.5	–	>14	μm
Noise, peak-to-peak (bandwidth 0.4 Hz to 5 Hz) (note 1)	–	30	55	μV
Peak signal (500K, 1) with incident energy of 25 μWcm^{-2}	570	850	1450	μV
Dual element pair matching (note 2)	–	–	±20	%
Element dimensions and configuration		see page 2		
Field of view		see page 2		

F.E.T. Characteristics (at T_{amb} = 22 °C ± 3 °C)

Gate-source cut-off voltage $I_D = 0.1\ \mu A$, $V_{DS} = 6\ V$	$V_{(P)GS}$	−1.4	–	−0.5	V
Transfer conductance $V_{GS} = 0$, $V_{DS} = 6\ V$, f = 1 kHz	g_{fso}	1.3	–	–	mAV^{-1}

Notes

1. Using low noise filter with 3 dB bandwidth (0.4 Hz to 5 Hz) and roll off at 12 dB per octave. Sensors tested for 1 minute under stable electrical and thermal conditions; see operating note 6 on page 3.
2. The matching of the elements is derived from $\frac{S_W - S_X}{\frac{1}{2}(S_W + S_X)} \times 100\%$, where S_W and S_X are the peak signal values of the respective elements. A similar calculation is applicable to elements Z and Y.

RECOMMENDED CIRCUIT

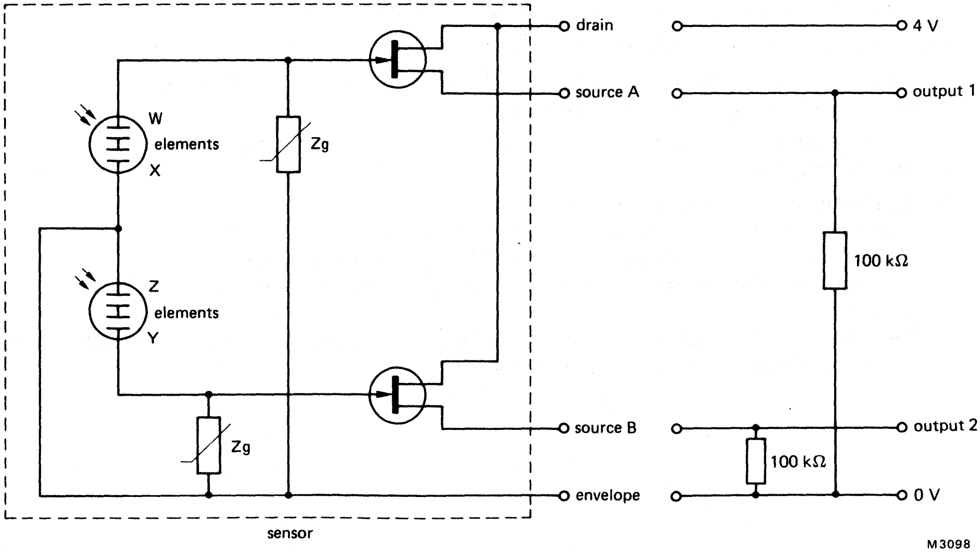


Fig.3.

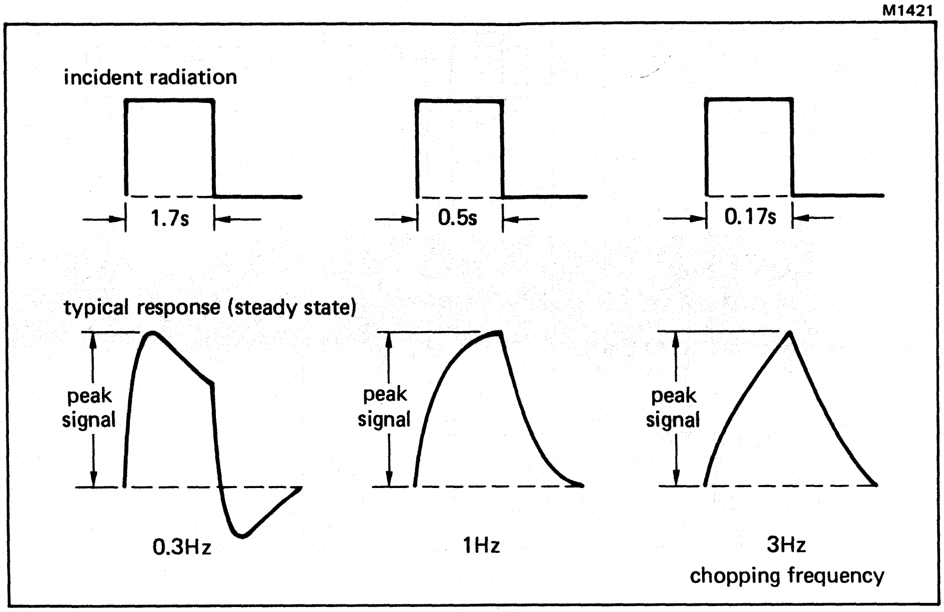


Fig.4 Typical response (steady state) for a given chopping frequency.

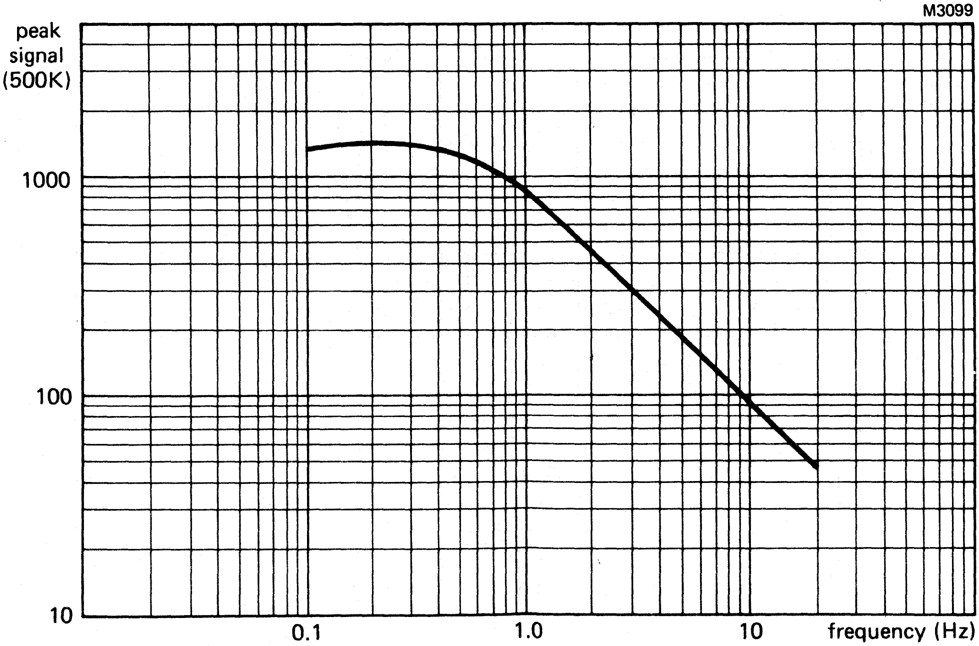


Fig.5 Typical peak signal as a function of frequency (energy level 25 μWcm^{-2} at the element with the other element of the pair screened).

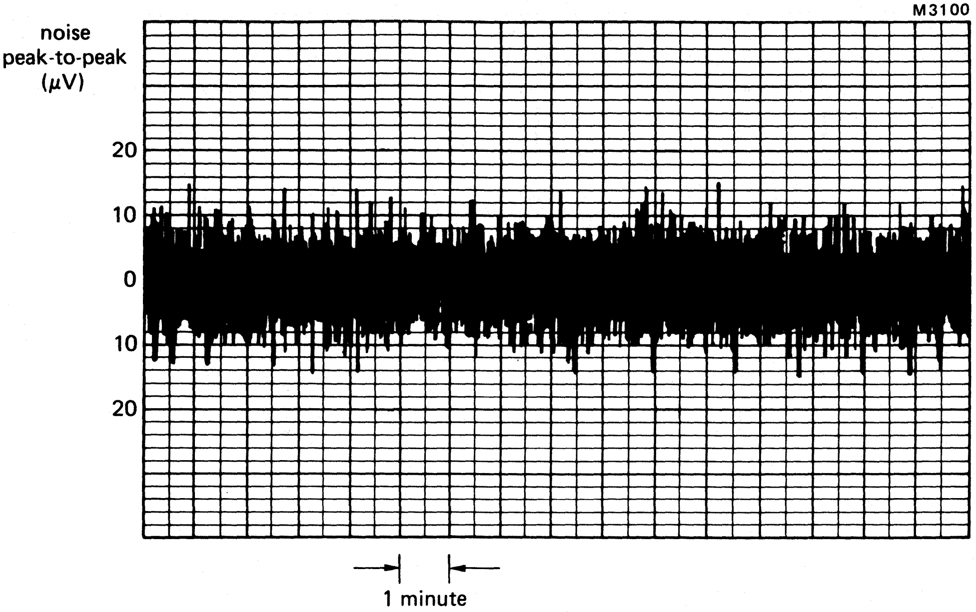


Fig. 6 Typical peak-to-peak noise as a function of time
(filter bandwidth 0.4 Hz to 5 Hz).

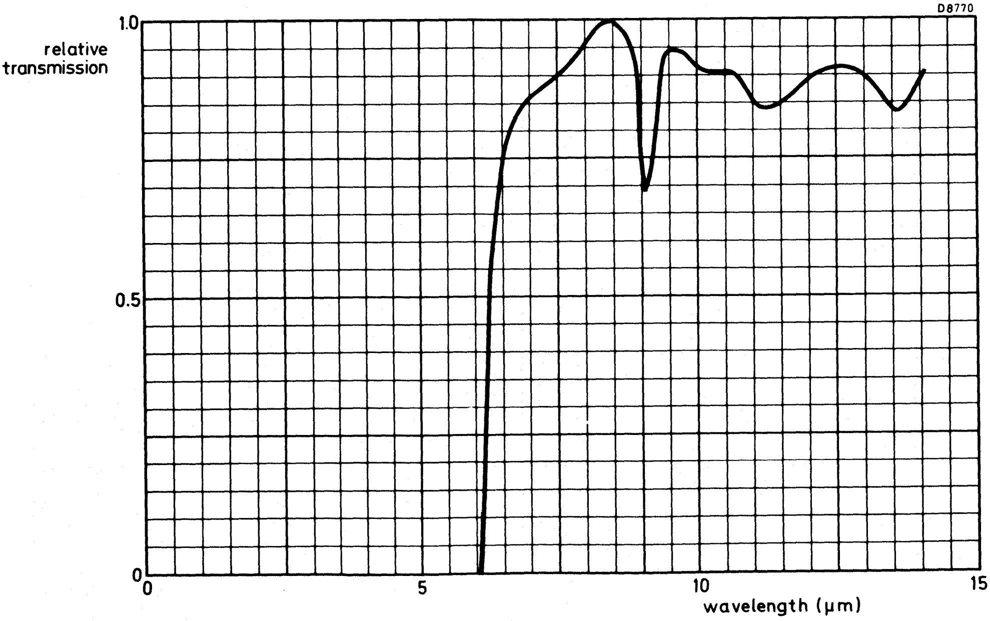


Fig.7 Typical normalized window transmission characteristic.

MECHANICAL AND ENVIRONMENTAL STANDARDS

As part of the Quality Assurance programme, the detectors will be assessed at regular intervals against the requirements of the following IEC standards. The frequency of testing and the limits and conditions for the pre- and post-test measurements are based on those stipulated for the CECC 50 000 series of approved transistors.

Test			Severity	Duration	Note
IEC 68-2-3	Ca	Damp Heat, steady state	+40 °C, 95% RH	168 hours	1
68-2-20	Ta	Solderability	+235 °C, 1.5 mm from header	5 seconds	2
68-2-21	Ub	Lead Fatigue	4 cycles	–	2
68-2-1	Aa	Low Temperature Storage	−40 °C	2000 hours	2
68-2-2	Ba	High Temperature Storage	+70 °C	2000 hours	2
68-2-14	Nb	Change of Temperature	−40 °C to +70 °C	10 cycles	2
68-2-6	Fc (B4)	Vibration, swept frequency	125 Hz to 2 kHz 196 ms^{-2}	2 h in each orientation	2
68-2-27	Ea	Shock	14700 ms^{-2}	3 pulses 6 orientations	2
68-2-20	Tb	Resistance to Solder Heat	+350 °C, 6 mm from header	3 seconds	3

Notes

1. The detectors to be checked on a production batch release principle at approximately weekly intervals. This is equivalent to Group B.
2. The detectors to be checked at quarterly intervals. This is equivalent to Group C.
3. This is an annual check.

INDEX OF TYPE NUMBERS

The inclusion of a type number in this publication does not necessarily imply its availability.

type no.	book	section
BA220	S1	SD
BA221	S1	SD
BA223	S1	T
BA281	S1	SD
BA314	S1	Vrg
BA315	S1	Vrg
BA316	S1	SD
BA317	S1	SD
BA318	S1	SD
BA423	S1	T
BA480	S1	T
BA481	S1	T
BA482	S1	T
BA483	S1	T
BA484	S1	T
BA682	S1/S7	T/Mm
BA683	S1/S7	T/Mm
BAS11	S1	SD
BAS15	S1	SD
BAS16	S7/S1	Mm/SD
BAS17	S7/S1	Mm/Vrg
BAS19	S7/S1	Mm/SD
BAS20	S7/S1	Mm/SD
BAS21	S7/S1	Mm/SD
BAS28	S7/S1	Mm/SD
BAS29	S7/S1	Mm/SD
BAS31	S7/S1	Mm/SD
BAS32	S7/S1	Mm/SD
BAS35	S7/S1	Mm/SD
BAS45	S1	SD
BAS56	S1/S7	SD/Mm
BAT17	S7/S1	Mm/T
BAT18	S7/S1	Mm/T
BAT54	S1/S7	SD/Mm
BAT74	S1/S7	SD/Mm
BAT81	S1	T
BAT82	S1	T
BAT83	S1	T
BAT85	S1	T
BAT86	S1	T
BAV10	S1	SD
BAV18	S1	SD
BAV19	S1	SD
BAV20	S1	SD
BAV21	S1	SD
BAV23	S7/S1	Mm/SD
BAV45	S1	Sp
BAV45A	S1	Sp
BAV70	S7/S1	Mm/SD
BAV74	S1	SD
BAV99	S7/S1	Mm/SD
BAV100	S7/S1	Mm/SD
BAV101	S7/S1	Mm/SD
BAV102	S7/S1	Mm/SD
BAV103	S7/S1	Mm/SD
BAW56	S7/S1	Mm/SD
BAW62	S1	SD
BAX12	S1	SD
BAX14	S1	SD
BAX18	S1	SD
BAY80	S1	SD
BB112	S1	T
BB119	S1	T
BB130	S1	T
BB204B	S1	T
BB204G	S1	T
BB212	S1	T
BB215	S7/S1	Mm/SD
BB219	S7/S1	Mm/SD
BB405B	S1	T
BB417	S1	T
BB809	S1	T
BB909A	S1	T
BB909B	S1	T
BBY31	S7/S1	Mm/T

Mm = Microminiature semiconductors for hybrid circuits
SD = Small-signal diodes

Sp = Special diodes
T = Tuner diodes
Vrg = Voltage regulator diodes
Sm = Small-signal transistors

type no.	book	section
BBY39	S1	T
BBY40	S7/S1	Mm/T
BC107	S3	Sm
BC108	S3	Sm
BC109	S3	Sm
BC140	S3	Sm
BC141	S3	Sm
BC160	S3	Sm
BC161	S3	Sm
BC177	S3	Sm
BC178	S3	Sm
BC179	S3	Sm
BC264A	S5	FET
BC264B	S5	FET
BC264C	S5	FET
BC264D	S5	FET
BC327;A	S3	Sm
BC328	S3	Sm
BC337;A	S3	Sm
BC338	S3	Sm
BC368	S3	Sm
BC369	S3	Sm
BC375	S3	Sm
BC376	S3	Sm
BC516	S3	Sm
BC517	S3	Sm
BC546	S3	Sm
BC547	S3	Sm
BC548	S3	Sm
BC549	S3	Sm
BC550	S3	Sm
BC556	S3	Sm
BC557	S3	Sm
BC558	S3	Sm
BC559	S3	Sm
BC560	S3	Sm
BC635	S3	Sm
BC636	S3	Sm
BC637	S3	Sm
BC638	S3	Sm
BC639	S3	Sm
BC640	S3	Sm
BC807	S7	Mm
BC808	S7	Mm
BC817	S7	Mm
BC818	S7	Mm
BC846	S7	Mm
BC847	S7	Mm
BC848	S7	Mm
BC849	S7	Mm
BC850	S7	Mm
BC856	S7	Mm
BC857	S7	Mm
BC858	S7	Mm
BC859	S7	Mm
BC860	S7	Mm
BC868	S7	Mm
BC869	S7	Mm
BCF29;R	S7	Mm
BCF30;R	S7	Mm
BCF32;R	S7	Mm
BCF33;R	S7	Mm
BCF70;R	S7	Mm
BCF81;R	S7	Mm
BCV26	S7	Mm
BCV27	S7	Mm
BCV61	S7	Mm
BCV62	S7	Mm
BCV63	S7	Mm
BCV64	S7	Mm
BCV65	S7	Mm
BCV71;R	S7	Mm
BCV72;R	S7	Mm
BCW29;R	S7	Mm
BCW30;R	S7	Mm
BCW31;R	S7	Mm
BCW32;R	S7	Mm
BCW33;R	S7	Mm
BCW60*	S7	Mm
BCW61*	S7	Mm
BCW69;R	S7	Mm
BCW70;R	S7	Mm
BCW71;R	S7	Mm
BCW72;R	S7	Mm
BCW81;R	S7	Mm
BCW89;R	S7	Mm
BCX17;R	S7	Mm
BCX18;R	S7	Mm
BCX19;R	S7	Mm
BCX20;R	S7	Mm
BCX51	S7	Mm
BCX52	S7	Mm
BCX53	S7	Mm
BCX54	S7	Mm
BCX55	S7	Mm
BCX56	S7	Mm
BCX58	S3	Sm
BCX59	S3	Sm
BCX70*	S7	Mm
BCX71*	S7	Mm
BCX78	S3	Sm
BCX79	S3	Sm
BCY56	S3	Sm
BCY57	S3	Sm
BCY58	S3	Sm
BCY59	S3	Sm
BCY65	S3	Sm
BCY70	S3	Sm
BCY71	S3	Sm
BCY72	S3	Sm
BCY78	S3	Sm
BCY79	S3	Sm
BCY87	S3	Sm
BCY88	S3	Sm
BCY89	S3	Sm
BD131	S4a	P
BD132	S4a	P
BD135	S4a	P
BD136	S4a	P
BD137	S4a	P

* = series
FET = Field-effect transistors
Mm = Microminiature semicondcutors for hybrid circuits
P = Low-frequency power transistors
Sm = Small-signal transistors

P = Low-frequency power transistors

type no.	book	section
BD952	S4a	P
BD953	S4a	P
BD954	S4a	P
BD955	S4a	P
BD956	S4a	P
BDT20	S4a	P
BDT21	S4a	P
BDT29	S4a	P
BDT29A	S4a	P
BDT29B	S4a	P
BDT29C	S4a	P
BDT30	S4a	P
BDT30A	S4a	P
BDT30B	S4a	P
BDT30C	S4a	P
BDT31	S4a	P
BDT31A	S4a	P
BDT31B	S4a	P
BDT31C	S4a	P
BDT32	S4a	P
BDT32A	S4a	P
BDT32B	S4a	P
BDT32C	S4a	P
BDT41	S4a	P
BDT41A	S4a	P
BDT41B	S4a	P
BDT41C	S4a	P
BDT42	S4a	P
BDT42A	S4a	P
BDT42B	S4a	P
BDT42C	S4a	P
BDT51	S4a	P
BDT52	S4a	P
BDT53	S4a	P
BDT54	S4a	P
BDT55	S4a	P
BDT56	S4a	P
BDT57	S4a	P
BDT58	S4a	P
BDT60	S4a	P
BDT60A	S4a	P
BDT60B	S4a	P
BDT60C	S4a	P
BDT61	S4a	P
BDT61A	S4a	P
BDT61B	S4a	P
BDT61C	S4a	P
BDT62	S4a	P
BDT62A	S4a	P
BDT62B	S4a	P
BDT62C	S4a	P
BDT63	S4a	P
BDT63A	S4a	P
BDT63B	S4a	P
BDT63C	S4a	P
BDT64	S4a	P
BDT64A	S4a	P
BDT64B	S4a	P
BDT64C	S4a	P
BDT65	S4a	P
BDT65A	S4a	P
BDT65B	S4a	P
BDT65C	S4a	P
BDT81	S4a	P
BDT82	S4a	P
BDT83	S4a	P
BDT84	S4a	P
BDT85	S4a	P
BDT86	S4a	P
BDT87	S4a	P
BDT88	S4a	P
BDT91	S4a	P
BDT92	S4a	P
BDT93	S4a	P
BDT94	S4a	P
BDT95	S4a	P
BDT96	S4a	P
BDV64	S4a	P
BDV64A	S4a	P
BDV64B	S4a	P
BDV64C	S4a	P
BDV65	S4a	P
BDV65A	S4a	P
BDV65B	S4a	P
BDV65C	S4a	P
BDV66A	S4a	P
BDV66B	S4a	P
BDV66C	S4a	P
BDV66D	S4a	P
BDV67A	S4a	P
BDV67B	S4a	P
BDV67C	S4a	P
BDV67D	S4a	P
BDV91	S4a	P
BDV92	S4a	P
BDV93	S4a	P
BDV94	S4a	P
BDV95	S4a	P
BDV96	S4a	P
BDW55	S4a	P
BDW56	S4a	P
BDW57	S4a	P
BDW58	S4a	P
BDW59	S4a	P
BDW60	S4a	P
BDX35	S4a	P
BDX36	S4a	P
BDX37	S4a	P
BDX42	S4a	P
BDX43	S4a	P
BDX44	S4a	P
BDX45	S4a	P
BDX46	S4a	P
BDX47	S4a	P
BDX62	S4a	P
BDX62A	S4a	P
BDX62B	S4a	P
BDX62C	S4a	P
BDX63	S4a	P
BDX63A	S4a	P

P = Low-frequency power transistors

type no.	book	section
BDX63B	S4a	P
BDX63C	S4a	P
BDX64	S4a	P
BDX64A	S4a	P
BDX64B	S4a	P
BDX64C	S4a	P
BDX65	S4a	P
BDX65A	S4a	P
BDX65B	S4a	P
BDX65C	S4a	P
BDX66	S4a	P
BDX66A	S4a	P
BDX66B	S4a	P
BDX66C	S4a	P
BDX67	S4a	P
BDX67A	S4a	P
BDX67B	S4a	P
BDX67C	S4a	P
BDX68	S4a	P
BDX68A	S4a	P
BDX68B	S4a	P
BDX68C	S4a	P
BDX69	S4a	P
BDX69A	S4a	P
BDX69B	S4a	P
BDX69C	S4a	P
BDX77	S4a	P
BDX78	S4a	P
BDX91	S4a	P
BDX92	S4a	P
BDX93	S4a	P
BDX94	S4a	P
BDX95	S4a	P
BDX96	S4a	P
BDY90	S4a	P
BDY90A	S4a	P
BDY91	S4a	P
BDY92	S4a	P
BF198	S3	Sm
BF199	S3	Sm
BF240	S3	Sm
BF241	S3	Sm
BF245A	S5	FET
BF245B	S5	FET
BF245C	S5	FET
BF247A	S5	FET
BF247B	S5	FET
BF247C	S5	FET
BF256A	S5	FET
BF256B	S5	FET
BF256C	S5	FET
BF324	S3	Sm
BF370	S3	Sm
BF410A	S5	FET
BF410B	S5	FET
BF410C	S5	FET
BF410D	S5	FET
BF420	S3	Sm
BF421	S3	Sm
BF422	S3	Sm
BF423	S3	Sm
BF450	S3	Sm
BF451	S3	Sm
BF483	S3	Sm
BF485	S3	Sm
BF487	S3	Sm
BF494	S3	Sm
BF495	S3	Sm
BF496	S3	Sm
BF510	S7/S5	Mm/FET
BF511	S7/S5	Mm/FET
BF512	S7/S5	Mm/FET
BF513	S7/S5	Mm/FET
BF536	S7	Mm
BF550;R	S7	Mm
BF569	S7	Mm
BF570	S7	Mm
BF579	S7	Mm
BF620	S7	Mm
BF621	S7	Mm
BF622	S7	Mm
BF623	S7	Mm
BF660;R	S7	Mm
BF689K	S10	WBT
BF763	S10	WBT
BF767	S7	Mm
BF820	S7	Mm
BF821	S7	Mm
BF822	S7	Mm
BF823	S7	Mm
BF824	S7	Mm
BF840	S7	Mm
BF841	S7	Mm
BF926	S3	Sm
BF936	S3	Sm
BF939	S3	Sm
BF960	S5	FET
BF964	S5	FET
BF966	S5	FET
BF967	S3	Sm
BF970	S3	Sm
BF970A	S3	Sm
BF979	S3	Sm
BF980	S5	FET
BF981	S5	FET
BF982	S5	FET
BF989	S7/S5	Mm/FET
BF990	S7/S5	Mm/FET
BF991	S7/S5	Mm/FET
BF992	S7/S5	Mm/FET
BF994	S7/S5	Mm/FET
BF994S	S7	Mm/FET
BF996	S7/S5	Mm/FET
BF996S	S7	Mm/FET
BF997	S7	Mm/FET
BFG23	S10	WBT
BFG32	S10	WBT
BFG34	S10	WBT
BFG51	S10	WBT
BFG65	S10	WBT

FET = Field-effect transistors
HVP = High-voltage power transistors
Mm = Microminiature semiconductors for hybrid circuits
P = Low-frequency power transistors
Sm = Small-signal transistors
WBT = Wideband hybrid IC transistors

type no.	book	section
BFG67	S7/S10	Mm
BFG90A	S10	WBT
BFG91A	S10	WBT
BFG92A	S10	WBT
BFG93A	S10	WBT
BFG96	S10	WBT
BFG195	S10	WBT
BFP90A	S10	WBT
BFP91A	S10	WBT
BFP96	S10	WBT
BFQ10	S5	FET
BFQ11	S5	FET
BFQ12	S5	FET
BFQ13	S5	FET
BFQ14	S5	FET
BFQ15	S5	FET
BFQ16	S5	FET
BFQ17	S7/S10	Mm/WBT
BFQ18A	S7/S10	Mm/WBT
BFQ19	S7/S10	Mm/WBT
BFQ22S	S10	WBT
BFQ23	S10	WBT
BFQ23C	S10	WBT
BFQ24	S10	WBT
BFQ32	S10	WBT
BFQ32C	S10	WBT
BFQ32M	S10	WBT
BFQ32S	S10	WBT
BFQ33	S10	WBT
BFQ33C	S10	WBT
BFQ34	S10	WBT
BFQ34T	S10	WBT
BFQ42	S6	RFP
BFQ43	S6	RFP
BFQ43S	S6	RFP
BFQ51	S10	WBT
BFQ51C	S10	WBT
BFQ52	S10	WBT
BFQ53	S10	WBT
BFQ63	S10	WBT
BFQ65	S10	WBT
BFQ66	S10	WBT
BFQ67	S7/S10	Mm/WBT
BFQ68	S10	WBT
BFQ136	S10	WBT
BFR29	S5	FET
BFR30	S7/S5	Mm/FET
BFR31	S7/S5	Mm/FET
BFR49	S10	WBT
BFR53	S7/S10	Mm/WBT
BFR54	S3	Sm
BFR64	S10	WBT
BFR65	S10	WBT
BFR84	S5	FET
BFR90	S10	WBT
BFR90A	S10	WBT
BFR91	S10	WBT
BFR91A	S10	WBT
BFR92	S7/S10	Mm/WBT
BFR92A	S7/S10	Mm
BFR93	S7/S10	Mm/WBT
BFR93A	S7/S10	Mm/WBT
BFR94	S10	WBT
BFR95	S10	WBT
BFR96	S10	WBT
BFR96S	S10	WBT
BFR101A;B	S7/S5	Mm/FET
BFS17	S7/S10	Mm/WBT
BFS17A	S10	WBT
BFS18;R	S7	Mm
BFS19;R	S7	Mm
BFS20;R	S7	Mm
BFS21	S5	FET
BFS21A	S5	FET
BFS22A	S6	RFP
BFS23A	S6	RFP
BFT24	S10	WBT
BFT25	S7/S10	Mm/WBT
BFT25R	S7	Mm
BFT44	S3	Sm
BFT45	S3	Sm
BFT46	S7/S5	Mm/FET
BFT92	S7/S10	Mm/WBT
BFT93	S7/S10	Mm/WBT
BFW10	S5	FET
BFW11	S5	FET
BFW12	S5	FET
BFW13	S5	FET
BFW16A	S10	WBT
BFW17A	S10	WBT
BFW30	S10	WBT
BFW61	S5	FET
BFW92	S10	WBT
BFW92A	S10	WBT
BFW93	S10	WBT
BFX34	S3	Sm
BFX89	S10	WBT
BFY50	S3	Sm
BFY51	S3	Sm
BFY52	S3	Sm
BFY55	S3	Sm
BFY90	S10	WBT
BG2000	S1	RT
BG2097	S1	RT
BGD102	S10	WBM
BGD102E	S10	WBM
BGD104	S10	WBM
BGD104E	S10	WBM
BGD502	S10	WBM
BGD504	S10	WBM
BGX885	S10	WBM
BGY22	S6	RFP
BGY22A	S6	RFP
BGY23	S6	RFP
BGY23A	S6	RFP
BGY32	S6	RFP
BGY33	S6	RFP
BGY35	S6	RFP
BGY36	S6	RFP
BGY40A	S6	RFP

* = series
FET = Field-effect transistors
Mm = Microminiature semiconductors for hybrid circuits
RFP = R.F. power transistors and modules
RT = Tripler
Sm = Small-signal transistors
ThM = Thyristor modules
WBM = Wideband hybrid IC modules
WBT = Wideband hybrid IC transistors

type no.	book	section
BGY40B	S6	RFP
BGY41A	S6	RFP
BGY41B	S6	RFP
BGY43	S6	RFP
BGY45A	S6	RFP
BGY45B	S6	RFP
BGY46A	S6	RFP
BGY46B	S6	RFP
BGY47 *	S6	RFP
BGY48 *	S6	RFP
BGY50	S10	WBM
BGY51	S10	WBM
BGY52	S10	WBM
BGY53	S10	WBM
BGY54	S10	WBM
BGY55	S10	WBM
BGY56	S10	WBM
BGY57	S10	WBM
BGY58	S10	WBM
BGY58A	S10	WBM
BGY59	S10	WBM
BGY60	S10	WBM
BGY61	S10	WBM
BGY65	S10	WBM
BGY67	S10	WBM
BGY67A	S10	WBM
BGY70	S10	WBM
BGY71	S10	WBM
BGY74	S10	WBM
BGY75	S10	WBM
BGY78	S10	WBM
BGY84	S10	WBM
BGY84A	S10	WBM
BGY85	S10	WBM
BGY85A	S10	WBM
BGY86	S10	WBM
BGY87	S10	WBM
BGY88	S10	WBM
BGY90A	S6	RFP
BGY90B	S6	RFP
BGY93 *	S6	RFP
BGY94 *	S6	RFP
BGY95A	S6	RFP
BGY95B	S6	RFP
BGY96A	S6	RFP
BGY96B	S6	RFP
BGY584A	S10	WBM
BGY585A	S10	WBM
BGY586	S10	WBM
BGY587	S10	WBM
BLF146	S6	RFP/FET
BLF242	S6	RFP/FET
BLF244	S6	RFP/FET
BLF245	S6	RFP/FET
BLT90/SL	S6	RFP
BLT91/SL	S6	RFP
BLT92/SL	S6	RFP
BLU20/12	S6	RFP
BLU30/12	S6	RFP
BLU45/12	S6	RFP
BLU50	S6	RFP
BLU51	S6	RFP
BLU52	S6	RFP
BLU53	S6	RFP
BLU60/12	S6	RFP
BLU97	S6	RFP
BLU98	S6	RFP
BLU99	S6	RFP
BLV10	S6	RFP
BLV11	S6	RFP
BLV20	S6	RFP
BLV21	S6	RFP
BLV25	S6	RFP
BLV30	S6	RFP
BLV30/12	S6	RFP
BLV31	S6	RFP
BLV32F	S6	RFP
BLV33	S6	RFP
BLV33F	S6	RFP
BLV36	S6	RFP
BLV45/12	S6	RFP
BLV57	S6	RFP
BLV59	S6	RFP
BLV75/12	S6	RFP
BLV80/28	S6	RFP
BLV90	S6	RFP
BLV90/SL	S6	RFP
BLV91	S6	RFP
BLV91/SL	S6	RFP
BLV92	S6	RFP
BLV93	S6	RFP
BLV94	S6	RFP
BLV95	S6	RFP
BLV97	S6	RFP
BLV98	S6	RFP
BLV99	S6	RFP
BLW29	S6	RFP
BLW31	S6	RFP
BLW32	S6	RFP
BLW33	S6	RFP
BLW34	S6	RFP
BLW50F	S6	RFP
BLW60	S6	RFP
BLW60C	S6	RFP
BLW76	S6	RFP
BLW77	S6	RFP
BLW78	S6	RFP
BLW79	S6	RFP
BLW80	S6	RFP
BLW81	S6	RFP
BLW83	S6	RFP
BLW84	S6	RFP
BLW85	S6	RFP
BLW86	S6	RFP
BLW87	S6	RFP
BLW89	S6	RFP
BLW90	S6	RFP
BLW91	S6	RFP
BLW95	S6	RFP
BLW96	S6	RFP

* = series

RFP = R.F. power transistors and modules

WBM = Wideband hybrid IC modules

FET = Field-effect transistors
Mm = Microminiature semiconductors for hybrid circuits
Sm = Small-signal transistors
PDT = Photodiodes or transistors
Th = Thyristors
RFP = R.F. power transistors and modules

* = series
PM = Power MOS transistors
SP = Low-frequency switching power transistors
Sm = Small-signal transistors
Th = Thyristors
Tri = Triacs

type no.	book	section
BUT21CF	S4b	SP
BUT22B	S4b	SP
BUT22C	S4b	SP
BUV26;A	S4b	SP
BUV26F	S4b	SP
BUV26BF	S4b	SP
BUV27;A	S4b	SP
BUV27F	S4b	SP
BUV27AF	S4b	SP
BUV28;A	S4b	SP
BUV28F	S4b	SP
BUV28AF	S4b	SP
BUV82	S4b	SP
BUV83	S4b	SP
BUV89	S4b	SP
BUV90	S4b	SP
BUV98;A	S4b	SP
BUV298(V)	S4b	SP
BUW11;A	S4b	SP
BUW11F	S4b	SP
BUW11AF	S4b	SP
BUW12;A	S4b	SP
BUW12F	S4b	SP
BUW12AF	S4b	SP
BUW13;A	S4b	SP
BUW13F	S4b	SP
BUW13AF	S4b	SP
BUW84	S4b	SP
BUW85	S4b	SP
BUW86	S4b	SP
BUW87	S4b	SP
BUW87A	S4b	SP
BUW132*	S4b	SP
BUW133*	S4b	SP
BUX46;A	S4b	SP
BUX47;A	S4b	SP
BUX48;A	S4b	SP
BUX84	S4b	SP
BUX85	S4b	SP
BUX84F	S4b	SP
BUX85AF	S4b	SP
BUX86	S4b	SP
BUX87	S4b	SP
BUX88	S4b	SP
BUX98	S4b	SP
BUX98A	S4b	SP
BUX99	S4b	SP
BUY89	S4b	SP
BUZ10	S9	PM
BUZ11	S9	PM
BUZ11A	S9	PM
BUZ14	S9	PM
BUZ15	S9	PM
BUZ20	S9	PM
BUZ21	S9	PM
BUZ23	S9	PM
BUZ24	S9	PM
BUZ25	S9	PM
BUZ31	S9	PM
BUZ32	S9	PM
BUZ34	S9	PM
BUZ35	S9	PM
BUZ36	S9	PM
BUZ41A	S9	PM
BUZ42	S9	PM
BUZ45	S9	PM
BUZ45A	S9	PM
BUZ45B	S9	PM
BUZ50A	S9	PM
BUZ50B	S9	PM
BUZ50C	S9	PM
BUZ53A	S9	PM
BUZ54	S9	PM
BUZ54A	S9	PM
BUZ60	S9	PM
BUZ63	S9	PM
BUZ64	S9	PM
BUZ71	S9	PM
BUZ71A	S9	PM
BUZ72	S9	PM
BUZ72A	S9	PM
BUZ73	S9	PM
BUZ73A	S9	PM
BUZ74	S9	PM
BUZ74A	S9	PM
BUZ76	S9	PM
BUZ76A	S9	PM
BUZ78	S9	PM
BUZ80	S9	PM
BUZ80A	S9	PM
BUZ83	S9	PM
BUZ83A	S9	PM
BUZ84	S9	PM
BUZ84A	S9	PM
BUZ90	S9	PM
BUZ90A	S9	PM
BUZ94	S9	PM
BUZ211	S9	PM
BUZ307	S9	PM
BUZ308	S9	PM
BUZ310	S9	PM
BUZ311	S9	PM
BUZ326	S9	PM
BUZ330	S9	PM
BUZ331	S9	PM
BUZ347	S9	PM
BUZ348	S9	PM
BUZ349	S9	PM
BUZ350	S9	PM
BUZ351	S9	PM
BUZ355	S9	PM
BUZ356	S9	PM
BUZ357	S9	PM
BUZ358	S9	PM
BUZ384	S9	PM
BUZ385	S9	PM
BY224*	S2a	R
BY225*	S2a	R
BY228	S1	R
BY229*	S2a	R

* = series
R = Rectifier diodes
PM = Power MOS transistors

* = series
D = Displays
LED = Light-emitting diodes
M = Microwave transistors
Mm = Microminiature semiconductors
Ph = Photoconductive devices
PhC = Photocouplers
R = Rectifier diodes
TS = Transient suppressor diodes
Vrf = Voltage reference diodes
Vrg = Voltage regulator diodes

* = series
FET = Field-effect transistors
LED = Light-emitting diodes
M = Microwave transistors
P = Low-frequency power transistors
St = Rectified stacks
WBM = Wideband hybrid IC modules

type no.	book	section
CQY11B	S8b	LED
CQY11C	S8b	LED
CQY24B(L)	S8a	LED
CQY49B	S8b	LED
CQY49C	S8b	LED
CQY50	S8b	LED
CQY52	S8b	LED
CQY53S	S8b	LED
CQY54A	S8a	LED
CQY58A	S8a/b	I
CQY89A	S8a/b	I
CQY94B(L)	S8a	LED
CQY95B	S8a	LED
CQY96(L)	S8a	LED
CQY97A	S8a	LED
ESM3045A	S4b	SP
ESM3045D	S4b	SP
ESM4045A	S4b	SP
ESM4045D	S4b	SP
ESM5045D	S4b	SP
ESM6045A	S4b	SP
ESM6045D	S4b	SP
Fresnel-lens	S13	A
H11A1	S8b	PhC
H11A2	S8b	PhC
H11A3	S8b	PhC
H11A4	S8b	PhC
H11A5	S8b	PhC
H11B1	S8b	PhC
H11B2	S8b	PhC
H11B3	S8b	PhC
H11B255	S8b	PhC
KGZ10	S13	SEN
KGZ20/21	S13	SEN
KMZ10A	S13	SEN
KMZ10B	S13	SEN
KMZ10C	S13	SEN
KP100A	S13	SEN
KP100A1	S13	SEN
KP101A	S13	SEN
KPZ20G	S13	SEN
KPZ21G	S13	SEN
KPZ21GE	S13	SEN
KRX10	S13	SEN
KRX11	S13	SEN
KTY81*	S13	SEN
KTY83*	S13	SEN
KTY84*	S13	SEN
KTY85*	S13	SEN
KTY86	S13	SEN
KTY87	S13	SEN
LAE2001R	S11	M
LAE4000Q	S11	M
LAE4001R	S11	M
LAE4002S	S11	M
LAE6000Q	S11	M
LBE1004R	S11	M
LBE1010R	S11	M
LBE2003S	S11	M
LBE2005Q	S11	M
LBE2008T	S11	M
LBE2009S	S11	M
LCE1010R	S11	M
LCE2003S	S11	M
LCE2005Q	S11	M
LCE2008T	S11	M
LCE2009S	S11	M
LJE42002T	S11	M
LKE1004R	S11	M
LKE2002T	S11	M
LKE2004T	S11	M
LKE2015T	S11	M
LKE21004R	S11	M
LKE21015T	S11	M
LKE21050T	S11	M
LKE27010R	S11	M
LKE27025R	S11	M
LKE32002T	S11	M
LKE32004T	S11	M
LTE42005S	S11	M
LTE42008R	S11	M
LTE42012R	S11	M
LV1721E50R	S11	M
LV2024E45R	S11	M
LV2327E40R	S11	M
LV3742E16R	S11	M
LV3742E24R	S11	M
LWE2015R	S11	M
LWE2025R	S11	M
LZ1418E100R	S11	M
MCA230	S8b	PhC
MCA231	S8b	PhC
MCA255	S8b	PhC
MCT2	S8b	PhC
MCT26	S8b	PhC
MJE13004	S4b	SP
MJE13005	S4B	SP
MJE13006	S4b	SP
MJE13007	S4B	SP
MJE13008	S4b	SP
MJE13009	S4B	SP
MKB12040WS	S11	M
MKB12100WS	S11	M
MKB12140W	S11	M
MO6075B200Z	S11	M
MO6075B400Z	S11	M
MPS6513	S3	Sm
MPS6514	S3	Sm
MPS6515	S3	Sm
MPS6517	S3	Sm
MPS6518	S3	Sm
MPS6519	S3	Sm
MPS6520	S3	Sm
MPS6521	S3	Sm
MPS6522	S3	Sm
MPS6523	S3	Sm
MPSA05	S3	Sm
MPSA06	S3	Sm
MPSA13	S3	Sm

* = series
I = Infrared devices
M = Microwave transistors
P = Low-frequency power transistors
Ph = Photoconductive diodes
R = Rectifier diodes
Sm = Small-signal transistors
SP = Low-frequency switching power transistors
Vrf = Voltage reference diodes

A = Accessories
FET = Field-effect transistors
I = Infrared devices
Ph = Photoconductive devices
R = Rectified diodes
RFP = R.F. power transistors and modules
SD = Small-signal diodes
Sm = Small-signal transistors
Vrf = Voltage reference diodes
WBT = Wideband transistors

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type no.	book	section
1N3913	S2a	R
1N4001G	S1	R
1N4002G	S1	R
1N4003G	S1	R
1N4004G	S1	R
1N4005G	S1	R
1N4006G	S1	R
1N4007G	S1	R
1N4148	S1	SD
1N4150	S1	SD
1N4151	S1	SD
1N4153	S1	SD
1N4446	S1	SD
1N4448	S1	SD
1N4531	S1	SD
1N4532	S1	SD
1N5059	S1	R
1N5060	S1	R
1N5061	S1	R
1N5062	S1	R
2N918	S10	WBT
2N930	S3	Sm
2N1613	S3	Sm
2N1711	S3	Sm
2N1893	S3	Sm
2N2219	S3	Sm
2N2219A	S3	Sm
2N2222	S3	Sm
2N2222A	S3	Sm
2N2297	S3	Sm
2N2368	S3	Sm
2N2369	S3	Sm
2N2369A	S3	Sm
2N2483	S3	Sm
2N2484	S3	Sm
2N2904	S3	Sm
2N2904A	S3	Sm
2N2905	S3	Sm
2N2905A	S3	Sm
2N2906	S3	Sm
2N2906A	S3	Sm
2N2907	S3	Sm
2N2907A	S3	Sm
2N3019	S3	Sm
2N3020	S3	Sm
2N3053	S3	Sm
2N3375	S6	RFP
2N3553	S6	RFP
2N3632	S6	RFP
2N3822	S5	FET
2N3823	S5	FET
2N3866	S6	RFP
2N3903	S3	Sm
2N3904	S3	Sm
2N3905	S3	Sm
2N3906	S3	Sm
2N3924	S6	RFP
2N3926	S6	RFP
2N3927	S6	RFP
2N3966	S5	FET
2N4030	S3	Sm
2N4031	S3	Sm
2N4032	S3	Sm
2N4033	S3	Sm
2N4091	S5	FET
2N4092	S5	FET
2N4093	S5	FET
2N4123	S3	Sm
2N4124	S3	Sm
2N4125	S3	Sm
2N4126	S3	Sm
2N4391	S5	FET
2N4392	S5	FET
2N4393	S5	FET
2N4400	S3	Sm
2N4401	S3	Sm
2N4402	S3	Sm
2N4403	S3	Sm
2N4427	S6	RFP
2N4856	S5	FET
2N4857	S5	FET
2N4858	S5	FET
2N4859	S5	FET
2N4860	S5	FET
2N4861	S5	FET
2N5086	S3	Sm
2N5087	S3	Sm
2N5088	S3	Sm
2N5089	S3	Sm
2N5400	S3	Sm
2N5401	S3	Sm
2N5415	S3	Sm
2N5416	S3	Sm
2N5550	S3	Sm
2N5551	S3	Sm
2N6659	S5	FET
2N6660	S5	FET
2N6661	S5	FET
4N25	S8b	PhC
4N25A	S8b	PhC
4N26	S8b	PhC
4N27	S8b	PhC
4N28	S8b	PhC
4N35	S8b	PhC
4N36	S8b	PhC
4N37	S8b	PhC
4N38	S8b	PhC
4N38A	S8b	PhC
502CQF	S8b	Ph
503CQF	S8b	Ph
504CQL	S8b	Ph
516CQF-B	S8b	Ph
56201d	S4b	A
56201j	S4b	A
56245	S3,10	A
56246	S3,10	A
56261a	S4b	A
56264	S2a/b	A
56295	S2a/b	A
56326	S4b	A

A = Accessories
FET = Field-effect transistors
I = Infrared devices
Ph = Photoconductive devices
R = Rectified diodes

RFP = R.F. power transistors and modules
SD = Small-signal diodes
Sm = Small-signal transistors
Vrf = Voltage reference diodes
WBT = Wideband transistors

type no.	book	section
56339	S4b	A
56352	S4b	A
56353	S4b	A
56354	S4b	A
56359b	S2,4b	A
56359c	S2,4b	A
56359d	S2,4b	A
56360a	S2,4b	A
56363	S2,4b	A
56364	S2,4b	A
56367	S2a/b	A
56368b	S2,4b	A
56368c	S2,4b	A
56369	S2,4b	A
56378	S2,4b	A
56379	S2,4b	A
56387a,b	S4b	A
56397	S8b	A

A = Accessories

NOTES

DATA HANDBOOK SYSTEM

DATA HANDBOOK SYSTEM

Our Data Handbook System comprises more than 70 books with specifications on electronic components, subassemblies and materials. It is made up of six series of handbooks:

PROFESSIONAL COMPONENTS*

DISCRETE SEMICONDUCTORS

INTEGRATED CIRCUITS

PASSIVE COMPONENTS**

MATERIALS**

DISPLAY COMPONENTS

The contents of each series are listed on pages iii to viii.

The data handbooks contain all pertinent data available at the time of publication, and each is revised and reissued periodically.

When ratings or specifications differ from those published in the preceding edition they are indicated with arrows in the page margin. Where application information is given it is advisory and does not form part of the product specification.

Condensed data on the preferred products of Philips Components is given in our Preferred Type Range catalogue (issued annually).

Information on current Data Handbooks and on how to obtain a subscription for future issues is available from any of the Organizations listed on the back cover.
Product specialists are at your service and enquiries will be answered promptly.

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* Will replace the Electron tubes (blue) series of handbooks.

** Will replace the Components and materials (green) series of handbooks.

PROFESSIONAL COMPONENTS

This series of data handbooks comprises:

T1	**Power tubes for RF heating and communications**
T2a	**Transmitting tubes for communications, glass types**
T2b	**Transmitting tubes for communications, ceramic types**
T3	**Klystrons**
T4	**Magnetrons for microwave heating**
T5	**Cathode-ray tubes** Instrument tubes, monitor and display tubes, C.R. tubes for special applications
T6	**Geiger-Müller tubes**
T8*	**Colour display systems** Colour TV picture tubes, colour data graphic display tube assemblies, deflection units
T9	**Photo and electron multipliers**
T10	**Plumbicon camera tubes and accessories**
T11	**Microwave semiconductors and components**
T12	**Vidicon and Newvicon camera tubes**
T13	**Image intensifiers and infrared detectors**
T15	**Dry reed switched**
T16**	**Monochrome tubes and deflection units** Black and white TV picture tubes, monochrome data graphic display tubes, deflection units

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* Handbook T8 will be issued in a new series of handbooks (Display Components) and will have the new handbook code DC01.

** Handbook T16 will be re-issued in the future in the new series of handbooks (Display Components).

DISCRETE SEMICONDUCTORS

This series of data handbooks comprises:

S1	**Diodes** Small-signal silicon diodes, voltage regulator diodes (< 1.5 W), voltage reference diodes, tuner diodes, rectifier diodes
S2a	**Power diodes**
S2b	**Thyristors and triacs**
S3	**Small-signal transistors**
S4a	**Low-frequency power transistors and hybrid modules**
S4b	**High-voltage and switching power transistors**
S5	**Small-signal field-effect transistors**
S6	**RF power transistors and modules**
S7	**Surface mounted semiconductors**
S8a	**Light-emitting diodes**
S8b	**Devices for optoelectronics** Optoelectronics, photosensitive diodes and transistors, infrared light-emitting diodes and infrared sensitive devices, laser and fibre-optic components
S9	**PowerMos transistors**
S10	**Wideband transistors and wideband hybrid IC modules**
S11	**Microwave transistors**
S13	**Semiconductor sensors**
S14	**Liquid Crystal Displays**

INTEGRATED CIRCUITS

This series of handbooks comprises:

IC01	**Radio, audio and associated systems** Bipolar, MOS
IC02a/b	**Video and associated systems** Bipolar, MOS
IC03	**ICs for Telecom** Bipolar, MOS Subscriber sets, Cordless Telephones
IC04	**HE4000B logic family** CMOS
IC05N	**HE4000B logic family — uncased ICs** CMOS
IC06	**High-speed CMOS; PC74HC/HCT/HCU** Logic family
IC08	**ECL 10K and 100K logic families**
IC09N	**TTL logic series**
IC10	**Memories** MOS, TTL, ECL
IC11	**Linear Products**
Supplement to IC11	**Linear Products**
IC12	**I^{2}C-bus compatible ICs**
IC13	**Semi-custom** Programmable Logic Devices (PLD)
IC14	**Microcontrollers and peripherals** Bipolar, MOS
IC15	**FAST TTL logic series**
IC16	**CMOS integrated circuits for clocks and watches**
IC17	**ICs for Telecom** Bipolar, MOS Radio pagers Mobile telephones ISDN
IC18	**Microprocessors and peripherals**
IC19	**Data communication products**

PASSIVE COMPONENTS

This series of handbooks comprises:

current code		new handbook code
C2	Television tuners, coaxial aerial input assemblies	DC01*
C3	Loudspeakers	DC04*
C4	Ferroxcube potcores, square cores and cross cores	MA01**
C5	Ferroxcube for power, audio/video and accelerators	
C7	Variable capacitors	PA04△
C8	Variable mains transformers	PC10△△
C9	Piezoelectric quartz devices	PA07△
C11	Varistors, thermistors and sensors	PA02△
C12	Potentiometers, encoders and switches	PA03△
C13	Fixed resistors	PA08△
C14	Electrolytic capacitors; solid and non-solid	PA01
C15	Ceramic capacitors	PA06△
C16	Permanent magnet materials	MA02**
C19	Piezoelectric ceramics	MA03**
C20	Wire-wound components for TVs and monitors	DC05*
C22	Film capacitors	PA05△

* These handbooks will be re-issued in the future in the new series of handbooks (Display Components).

** These handbooks will be re-issued in the future in the new series of handbooks (Materials).

△ These handbooks will be re-issued in the future in the new series of handbooks (Passive Components).

△△ These handbooks will be re-issued in the future in the new series of handbooks (Professional Components).

MATERIALS

This series of handbooks comprises:

MA01* **Ferrites (the current issue are handbooks C4 and C5)**
MA02* **Permanent magnet materials**
MA03* **Piezoelectric ceramics**

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* Not yet issued in the Materials series of handbooks.

DISPLAY COMPONENTS

This series of handbooks comprises:

DC01	**Colour display systems**
DC02*	**Monochrome tubes and deflection units**
DC03*	**Television tuners, coaxial aerial input assemblies**
DC04*	**Loudspeakers**
DC05*	**Wire-wound components for TVs and monitors**

* Not yet issued in the Display Components series of handbooks.

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