PHILIPS

Data handbook

PHILIPS Electronic components and materials

Components and materials

Part 2a February 1976

Fixed resistors

Variable resistors

Non-linear resistors

Test switches

COMPONENTS AND MATERIALS

Part 2a **February 1976**

Fixed resistors

Variable resistors

Voltage dependent resistors (VDR)

Light dependent resistors (LDR)

Negative temperature coefficient thermistors (NTC)

Positive temperature coefficient thermistors (PTC)

Test switches

Maintenance type list and contents

DATA HANDBOOK SYSTEM

Our Data Handbook System is a comprehensive source of information on electronic components, subassemblies and materials; it is made up of three series of handbooks each comprising several parts.

ELECTRON TUBES	**BLUE**
SEMICONDUCTORS AND INTEGRATED CIRCUITS	**RED**
COMPONENTS AND MATERIALS	**GREEN**

The several parts contain all pertinent data available at the time of publication, and each is revised and reissued periodically.

Where ratings or specifications differ from those published in the preceding edition they are pointed out by arrows. Where application information is given it is advisory and does not form part of the product specification.

If you need confirmation that the published data about any of our products are the latest available, please contact our representative. He is at your service and will be glad to answer your inquiries.

December 1972

ELECTRON TUBES (BLUE SERIES)

This series consists of the following parts, issued on the dates indicated.

Part 1a Transmitting tubes for communications and Tubes for r.f. heating Types PE05/25 ÷ TBW15/125 — **December 1975**

Part 1b Transmitting tubes for communication — **January 1976**
Tubes for r.f. heating
Amplifier circuit assemblies

Part 2 Microwave products — **October 1974**

Communication magnetrons
Magnetrons for microwave heating
Klystrons
Travelling-wave tubes
Diodes
Triodes
T-R Switches
Microwave Semiconductor devices
Isolators Circulators

Part 3 Special Quality tubes; Miscellaneous devices — **January 1975**

Part 4 Receiving tubes — **March 1975**

Part 5a Cathode-ray tubes — **April 1975**

Part 5b Camera tubes; Image intensifier tubes — **May 1975**

Part 6 Products for nuclear technology — **July 1975**
Photodiodes

Channel electron multipliers
Geiger-Mueller tubes
Neutron tubes

N.B. Photomultiplier tubes and Photo diodes will be issued in Part 9

Part 7 Gas-filled tubes — **August 1975**

Voltage stabilizing and reference tube
Counter, selector, and indicator tubes
Trigger tubes
Switching diodes
Thyratrons
Ignitrons
Industrial rectifying tubes
High-voltage rectifying tubes

Part 8 TV Picture tubes — **October 1975**

SEMICONDUCTORS AND INTEGRATED CIRCUITS (RED SERIES)

This series consists of the following parts, issued on the dates indicated.

Part 1a **Rectifier diodes and thyristors** **June 1974**

Rectifier diodes
Voltage regulator diodes (> 1,5 W)
Transient suppressor diodes
Thyristors, diacs, triacs
Rectifier stacks

Part 1b **Diodes** **October 1975**

Small signal germanium diodes
Small signal silicon diodes
Special diodes
Voltage regulator diodes (< 1,5 W)
Voltage reference diodes
Tuner diodes

Part 2 **Low frequency transistors** **December 1975**

Part 3 **High frequency and switching transistors** **October 1974**

Part 4a **Special semiconductors** **November 1974**

Transmitting transistors
Microwave devices
Field-effect transistors
Dual transistors
Microminiature devices for thick- and thin-film circuits

Part 4b **Devices for optoelectronics** **December 1974**

Photosensitive diodes and transistors
Light emitting diodes
Photocouplers
Infrared sensitive devices
Photoconductive devices

Part 5 **Linear integrated circuits** **March 1975**

Part 6 **Digital integrated circuits** **April 1974**

DTL (FC family)
CML (GX family)
MOS (FD family)
MOS (FE family)

COMPONENTS AND MATERIALS (GREEN SERIES)

This series consists of the following parts, issued on the dates indicated.

Part 1 **Functional units, Input/output devices, Peripheral devices** — **November 1975**

High noise immunity logic FZ/30-Series
Circuit blocks 40-Series and CSA70
Counter modules 50-Series
NORbits 60-Series, 61-Series
Circuit blocks 90-Series
Input/output devices
Hybrid integrated circuits
Peripheral devices

Part 2a **Resistors** — **February 1976**

Fixed resistors
Variable resistors
Voltage dependent resistors (VDR)
Light dependent resistors (LDR)
Negative temperature coefficient thermistors (NTC)
Positive temperature coefficient thermistors (PTC)
Test switches

Part 2b **Capacitors** — **December 1974**

Electrolytic and solid capacitors
Paper capacitors and film capacitors
Ceramic capacitors
Variable capacitors

Part 3 **Radio, Audio, Television** — **February 1975**

FM tuners
Loudspeakers
Television tuners and aerial input assemblies
Components for black and white television
Components for colour television

Part 4a **Soft ferrites** — **April 1975**

Ferrites for radio, audio and television
Beads and chokes
Ferroxcube potcores and square cores
Ferroxcube transformer cores

Part 4b **Piezoelectric ceramics, Permanent magnet materials** — **May 1975**

Part 5 **Ferrite core memory products** — **July 1975**

Ferroxcube memory cores
Matrix planes and stacks
Core memory systems

Part 6 **Electric motors and accessories** — **September 1975**

Small synchronous motors
Stepper motors
Miniature direct current motors

Part 7 **Circuit blocks** — **September 1971**

Circuit blocks 100 kHz-Series
Circuit blocks 1-Series
Circuit blocks 10-Series
Circuit blocks for ferrite core memory drive

Part 8 **Variable mains transformers** — **July 1975**

Part 10 **Connectors** — **November 1975**

Fixed resistors

SURVEY

resistor type	resistance range	tolerance (%)	dissipation at (°C)	dissipation (W)	type number or basic catalogue number	page
Carbon film	1 Ω to 10 MΩ	5, 10	70	0,2	CR16	
				0,33	CR25	
				0,5	CR37	
		5		0,67	CR52	
				1,15	CR68	
				2	CR93	7
Metal film, t.c. 50 to 200 ppm/°C	4,99 Ω to 1 MΩ	1,2,5	70	0,4	MR25	
				0,5	MR30	
		1		0,75	MR52	21
Metal film, temp. coeff. 50 ppm/°C	49,9 to 681 kΩ	1	70	0,4	MR24	
				0,5	MR34	33
Metal film, according to MIL-R-10509F	10 Ω to 1 MΩ	0,1, 0,25 0,5, 1	125	0,1	MR24E, MR24C	
				0,125	MR34E, MR34C	
				0,25	MR54E, MR54C	
				0,5	MR74E, MR74C	
			70	0,125	MR24D	
				0,25	MR34D [1]	
				0,5	MR54D	
				0,75	MR74D	43
Power metal film	10 Ω to 27 kΩ	5	70	1,6	PR37	
				2,5	PR52	49
High voltage 2500 V (r.m.s.)	1 MΩ to 68 MΩ	5	70	0,5	VR37	
7000 V (r.m.s.)				1	VR68	55
Cemented wirewound	5,6 Ω to 16 kΩ	5	70	4	WR0617	
				7	WR0825	
				9,5	WR0842	
				15	WR0865	63

[1] E for temp. coeff. of 25 ppm/°C;
C for temp. coeff. of 50 ppm/°C;
D for temp. coeff. of 100 ppm/°C.

resistor type	resistance range	tolerance (%)	dissipation at (°C)	(W)	type number or basic catalogue number	page
Enamelled wirewound	4,7 Ω to 100 kΩ	5	70	4,2 7 11 17	WR0617E WR0825E WR0842E WR0865E	73
Rectangular wirewound	0,15 Ω to 12 kΩ	5, 10	40	5 8 10 15	2306 330 2306 331 2306 332 2306 333	81
Wirewound, with side terminations enamelled cemented	1 Ω to 120 kΩ	5, 10	40	8 to 100 8 to 250	2322 321 2322 323	87
Adjustable wirewound, with side terminations enamelled cemented	1,2 Ω to 47 kΩ	5, 10	40	10 to 100 10 to 250	2322 322 2322 324	91
Low-ohmic wirewound	0,1 to 10 Ω	10	70	2	2322 326	95
Low-ohmic glass-sealed	0,1 to 6,8 Ω	10	40	1	2322 327	99
Pin-head carbon	33 Ω to 180 kΩ	10, 20	70	0,05	2322 120	101

INTRODUCTION

Two basic versions of film resistors are available, namely carbon film resistors and metal film resistors.
Carbon film resistors are used if moderate demands are made on stability, temperature coefficient and tolerance. To meet higher demands on one or more of these parameters metal-film resistors are used.
The specification of these resistors is based primarily on I.E.C. publication 115, "Recommendations for fixed non-wire-wound resistors type 1 for use in electronic equipment".
A different way of specifying power ratings has been adopted, however, to give the circuit designer better guidance in selecting the proper resistor for a given application.
Before going into detail on this point some remarks have to be made about the basic behaviour of film resistors.

BASIC BEHAVIOUR

Power dissipation in a resistor causes the temperature of the resistor body to increase. The temperature rise is determined by the laws of heat conduction, convection and radiation and will be maximum at the so-called hot spot (usually the middle of the resistor body).
Theoretically in the temperature range where radiation plays only a minor part - and this is the normal temperature range of film resistors - the maximum temperature rise ΔT is proportional to the power dissipated: $\Delta T = A.P.$; experiments confirm this.
The proportionality constant A gives the temperature rise at the hot spot per watt of dissipated power and can be interpreted as a heat resistance with dimensions deg C/W. This heat resistance is a function of the dimensions of the resistor, the heat conductivity of the materials used and, to a lesser degree, of the way of mounting.
The sum of the temperature increase and the ambient temperature T_{amb} is the maximum temperature (hot spot temperature) of the resistor.

$$T_m = T_{amb} + \Delta T$$

The stability of a film resistor under endurance tests is mainly determined by the hot spot temperature and the resistance value. The lower the resistance value with the other conditions kept constant the higher the stability due to the greater film thickness for these lower resistance values.

The above relations can be summarised schematically in the following way:

dimensions determine		heat resistance
heat resistance x dissipation	=	temperature rise
temperature rise + ambient temperature	=	hot spot temperature
hot spot temperature and resistance value determine		stability

WAY OF SPECIFYING THE PERFORMANCE

Formerly a resistor was characterised by a wattage rating hardly any attention being paid to the above mentioned relations apart from giving a derating line.
In the adopted system the relation between the several variables is given for a certain heat resistance, or, in other words, for certain resistor dimensions; the materials used and the test mounting are in general the same for different resistor types. The resistor is thus characterised by its dimensions.
The dissipation is given as a function of the hot spot temperature with the ambient temperature as a parameter.

From $\Delta T = A.P.$ and $T_m = T_{amb} + \Delta T$ it follows that:

$$P = \frac{T_m - T_{amb}}{A}$$

If P is plotted against T_m for a constant value of A, parallel straight lines are obtained for different values of the ambient temperature. The slope of these lines, $\frac{dP}{dT_m} = \frac{1}{A}$, is the reciprocal of the heat resistance and is characteristic for the resistor.
The stability $\frac{\Delta R}{R}$ can be determined experimentally, for instance after 1000 hrs, as a function of the hot spot temperature with the resistance value as a parameter.
It has been found that the resistance changes exponentially with temperature, giving a straight line when $\log \frac{\Delta R}{R}$ is plotted against T_m.
A combination of the graphs of P and $\frac{\Delta R}{R}$ against T_m gives a nomogram from which the values of several variables can be determined for a resistor of a given size under different working conditions. An example of such a nomogram with fictitious values is given in Fig.1. The intersection of the dash line with the horizontal axis gives the hot spot temperature under chosen conditions.

Example 1

Assume that a 10 kΩ resistor whose characteristics are described by the nomogram is to be operated at a power dissipation of 0.4 W and an ambient temperature of 60 °C. To find out whether this dissipation is allowable at this ambient temperature and, if so, what the expected stability of the resistor will be, draw in the upper half of the nomogram a horizontal line through A (power dissipation of 0.4 W). This line intersects the 60 °C ambient temperature line at point B, corresponding to a hot spot temperature of 128 °C (point C). This is safely below the maximum indicated by the dashed line at 155 °C; therefore a dissipation of 0.4 W at an ambient temperature of 60 °C is well within the allowable limit.

Extend line BC into the lower half of the nomogram until it intersects the 10 kΩ line at point D. This means that at a hot spot temperature of 128 °C a resistance change of about 2.5% (point E) can be expected after 1000 hours of operation.

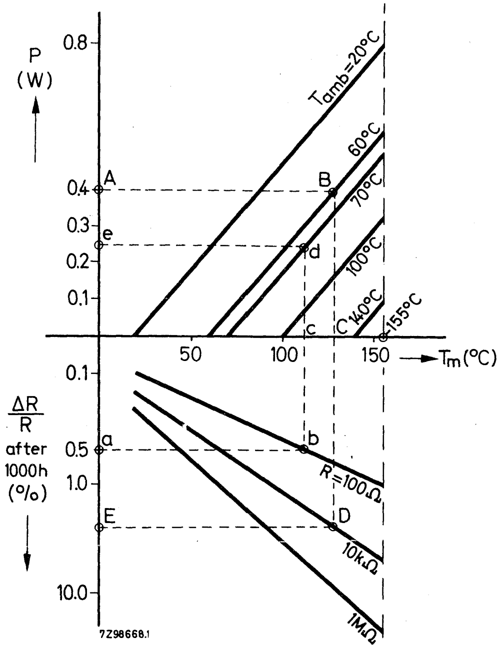


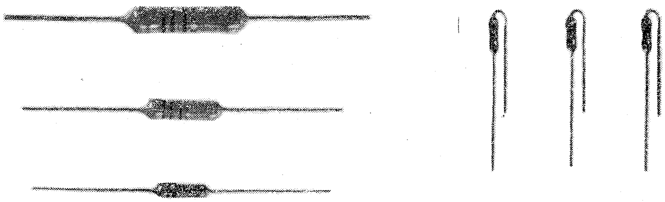
Fig.1. Performance nomogram (for a fictitious resistor) illustrating the new way of specifying the performance of film resistors.

Example 2

Assume that a 100 Ω resistor, whose characteristics are described by the nomogram, is to be operated at an ambient temperature of 70 °C with a required stability after 1000 h of 0.5%. It is desired to find the maximum permissible power dissipation. In the lower half of the nomogram, a line that corresponds to a stability of 0.5% intersects the 100 Ω resistance line at point b, corresponding to a hot spot temperature of 112 °C (point c).
Extending the line b-c into the upper half of the nomogram, it intersects the line indicating an ambient temperature of 70 °C at point d, corresponding to a maximum permissible power dissipation of 0.25 W (point e).

If the power to be dissipated exceeds the value found, a bigger type of resistor should be used.

CARBON FILM RESISTORS



RZ 16737.1

QUICK REFERENCE DATA

Resistance ranges	from 1 Ω to 10 MΩ; E12 or E24 series
Resistance tolerance	5 and 10 %
Abs. max. dissipation at T_{amb} = 70 °C *)	CR16 = 0,2 W, CR52 = 0,67 W
	CR25 = 0,33 W, CR68 = 1,15 W
	CR37 = 0,5 W, CR93 = 2 W
Basic specification	IEC publication 115-1, 115-2
Climatic category	55/155/56
Stability after	
load	see nomogram
climatic tests	ΔR max. 1,5 % for R ≤ 220 kΩ max. 3 % for R > 220 kΩ
soldering	ΔR max. 0,5 % or 0,5 Ω
short time overload	ΔR max. 1 %

*) Dissipation at T_{amb} = 70 °C which causes the maximum permissible hot-spot temperature of 155 °C to occur, irrespective of the resistance drift provoked by this condition.

APPLICATION

In a great variety of electronic circuits, from hearing aids to computers, from telecommunication equipment to portable radios.

DESCRIPTION

On a high grade ceramic body a homogeneous film of pure carbon is deposited by pyrolysis of a hydrocarbon gas.*) Contact caps of special alloy are then pressed onto the ends of the resistor body, and tinned electrolytic copper connecting wires are welded to these caps.
As a rule the required resistance value is not obtained by pyrolysis only; helixing, that is, cutting a helical groove in the carbon film, is necessary in which the desired resistance value is arrived at by regulating the pitch of the helix.
The thinner the carbon layer and the finer the pitch of the helix, the higher the resistance value.
Finally the resistors are coated with three or more layers of a tan lacquer for electrical and climatical protection.

MECHANICAL DATA

Dimensions in mm

→ Outlines

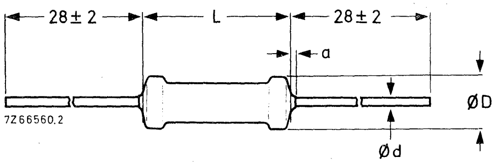


Fig. 1a

style	D_{max}	L_{max}	d
CR16	1,6	4,5	0,4
CR25	2,5	6,8	0,6
CR37	3,7	10	0,7
CR52	5,2	18	0,8
CR68	6,8	18	0,8
CR93 **)	9,0	31,7	0,8

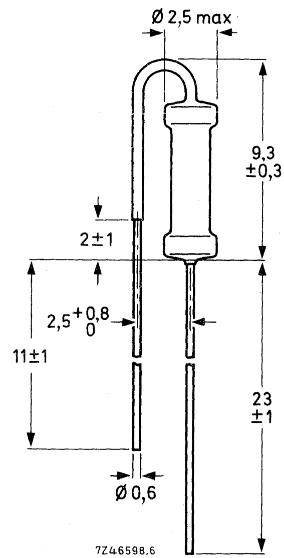


Fig. 1b. Style CR25A

The bent lead is partly covered with an insulating lacquer having a breakdown voltage of at least 50 V (d.c.)

*) Resistors with resistance values lower than 10 ohms have an electroless-deposited nickel film instead of a carbon film. The further processing, however, is the same.

**) Lead length 36 mm.

The length of the body is measured by inserting the leads into the holes of two identical gauge plates and by moving these plates parallel to each other until the resistor body is clamped without deformation (see IEC publication 294).

nominal lead diameter (mm)	dia. of hole in gauge plate (mm)
0,4	0,8
0,6/0,7	1,0
0,8	1,2

Maximum lacquer run-off on a lead is 1 mm. Total lacquer run-off on both leads together is also maximum 1 mm.

Weight (per 100 pieces)

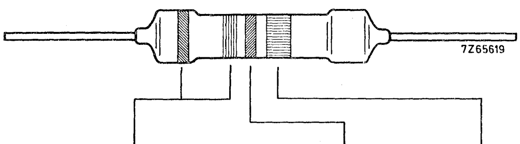
CR16	8 g	CR52	96 g
CR25	23 g	CR68	148 g
CR37	42 g	CR93	552 g

Mounting

The resistors must be mounted stress free so as to allow thermal expansion over the wide temperature range.

Marking

The nominal resistance value and the tolerance are marked on the resistors by means of four coloured bands according to IEC publication 62: "Colour code for fixed resistors". The code on style CR25A should be read downwards from the bent lead.



colour	significant figures	multiplier	tolerance
black	0	1 x	
brown	1	10 x	
red	2	100 x	
orange	3	1 000 x	
yellow	4	10 000 x	
green	5	100 000 x	
blue	6	1 000 000 x	
violet	7		
grey	8		
white	9		
silver			± 10%
gold		0,1 x	± 5%

→ ELECTRICAL DATA

style	limiting voltage 1) V (r.m.s.)	resistance range	tolerance (± %)	series 2)	catalogue number
CR 16	150	10 Ω - 220 kΩ	5	E24	2322 210 13...
		270 kΩ - 1 MΩ	10	E 12	2322 210 12...
CR 16 on reel		10 Ω - 220 kΩ	5	E24	2322 210 23...
		270 kΩ - 1 MΩ	10	E 12	2322 210 22...
CR25		1 Ω - 1 MΩ	5	E24	2322 211 13...
		1,2 MΩ - 10 MΩ	10	E 12	2322 211 12...
CR25 on reel		1 Ω - 1 MΩ	5	E24	2322 211 23...
		1,2 MΩ - 10 MΩ	10	E 12	2322 211 22...
CR25A	250	1 Ω - 1 MΩ	5	E24	2322 106 33...
		1,2 MΩ - 10 MΩ	10	E 12	2322 106 32...
CR 37	350	1 Ω - 1 MΩ	5	E24	2322 212 13...
		1,2 MΩ - 10 MΩ	10	E 12	2322 212 12...
CR 37 on reel		1 Ω - 1 MΩ	5	E24	2322 212 23...
		1,2 MΩ - 10 MΩ	10	E 12	2322 212 22...
CR52 3)	500	1 Ω - 1 MΩ	5	E24	2322 101 63...
CR68 3)	750	1 Ω - 1 MΩ	5	E24	2322 214 13...
CR93 3)	1000	10 Ω - 1 MΩ	5	E24	2322 215 13...

Composition of the catalogue number

In the above-mentioned catalogue number, replace the first two dots by the first two digits of the resistance value. Replace the third dot by a figure according to the following table:

1 - 9,1 Ω	8	10 - 91 kΩ	3
10 - 91 Ω	9	100 - 910 kΩ	4
100 - 910 Ω	1	1 - 9,1 MΩ	5
1 - 9,1 kΩ	2	10 MΩ	6

1) Limiting voltage (element and insulation).
This is the maximum voltage that may be applied continuously to the resistor element (see IEC publication 115-1 and 115-2). This voltage is also the maximum voltage that may be applied continuously to the insulation of the resistor.

2) See the table "Standard series of values in a decade" at the back of the handbook.

3) For resistance values higher than 1 MΩ, those from the VR37/VR68 series are recommended, see Fig. 3 of the relevant specification.

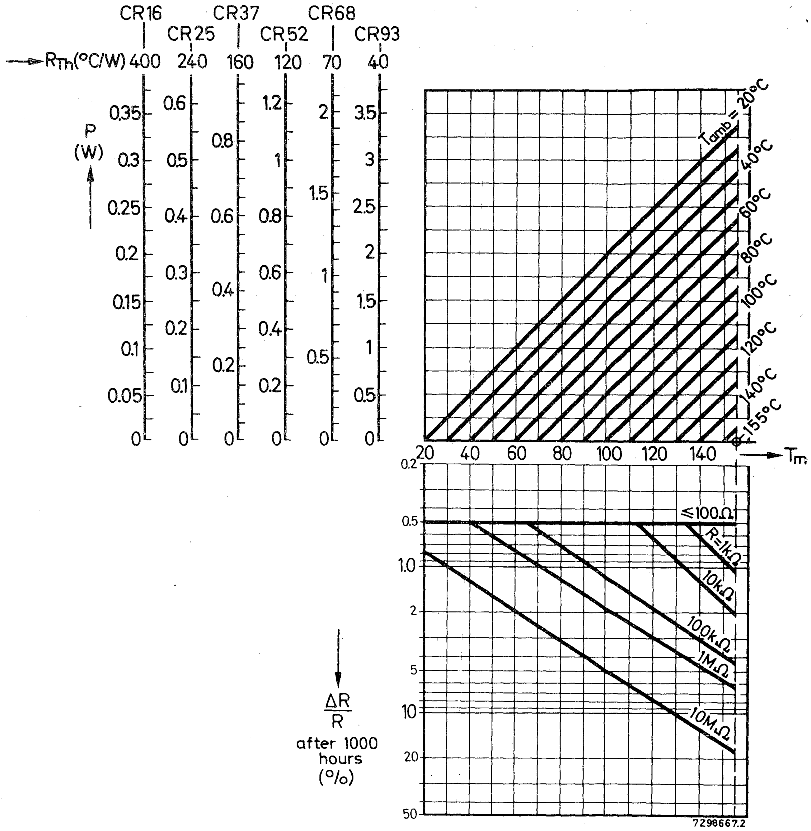


Fig. 2
Performance nomogram for different styles of resistor showing the relationship between power dissipation P, ambient temperature T_{amb}, hot-spot temperature T_m, resistance value R, and maximum resistance drift $\Delta R/R$ after 1000 h of operation.
For continuous operation longer or shorter than 1000 h, t_x, the stability can be approximated by multiplying the drift $\Delta R/R$ after 1000 h with the square root of the time ratio, so ($\Delta R/R$ after x h) = ($\Delta R/R$ after 1000 h). $(t_x/1000)^{\frac{1}{2}}$

See also remarks below.

Remarks to nomogram

1. The nomogram should not be extended beyond the maximum permissible hot-spot temperature of 155 °C.
2. The resistance change given by the nomogram for P = 0 at a particular ambient temperature is indicative of the shelf life stability of a resistor at that temperature.
3. The stability lines do not give exact values for $\Delta R/R$, but represent a probability of 95% that the real values will be smaller than those obtained from the nomogram.
4. In the nomogram the limiting voltage of the resistors has not been taken into consideration.
5. IEC publication 115-1 is still based on the conventional method of rating resistors by a fixed "rated dissipation" at 70 °C requiring at that dissipation a fixed maximum permissible drift.
   In our specification, however, the rated dissipation is no longer specified and also the guaranteed resistance drift is made dependent on the working conditions.
   To bridge the gap between the system of IEC 115-1 and our system, Fig. 3 is added. In this figure the permissible dissipation at 70 °C for a resistance drift of max. 1,5% after 1000 hours is given, taking into consideration that the hot-spot temperature should not rise above 155 °C (horizontal part of the curves).
   In our specification the curves of Fig. 3 replace the rated dissipation.

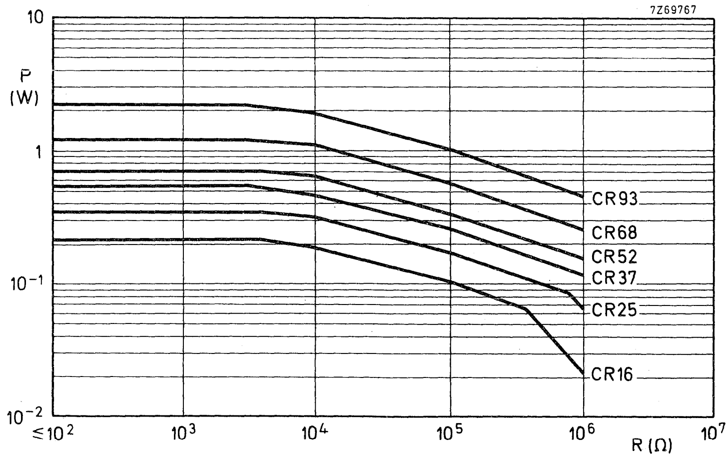


Fig. 3
Maximum permissible dissipation at T_{amb} = 70 °C as a function of the resistance value for a resistance drift of 1,5% after 1000 hours or for a maximum temperature of 155 °C without reaching the resistance drift of 1,5%, limiting voltage being taken into account.

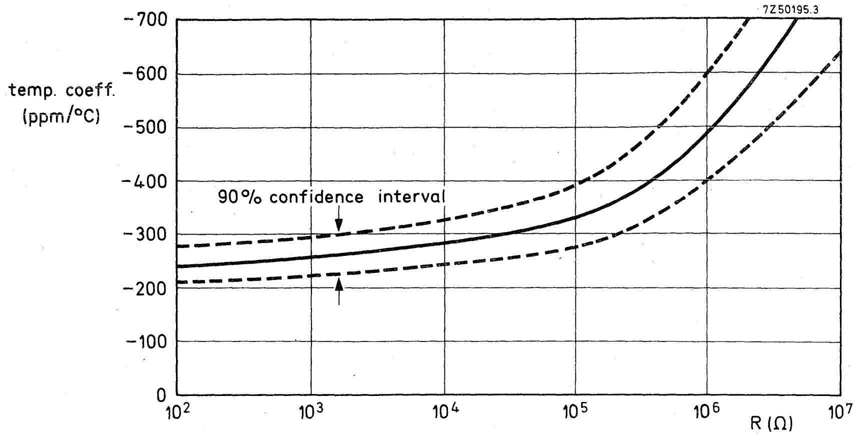


Fig. 4
Temperature coefficient as a function of the resistance value, applicable to all resistor styles. For values < 10 Ω the temperature coefficient is ≤ +200 ppm/°C.

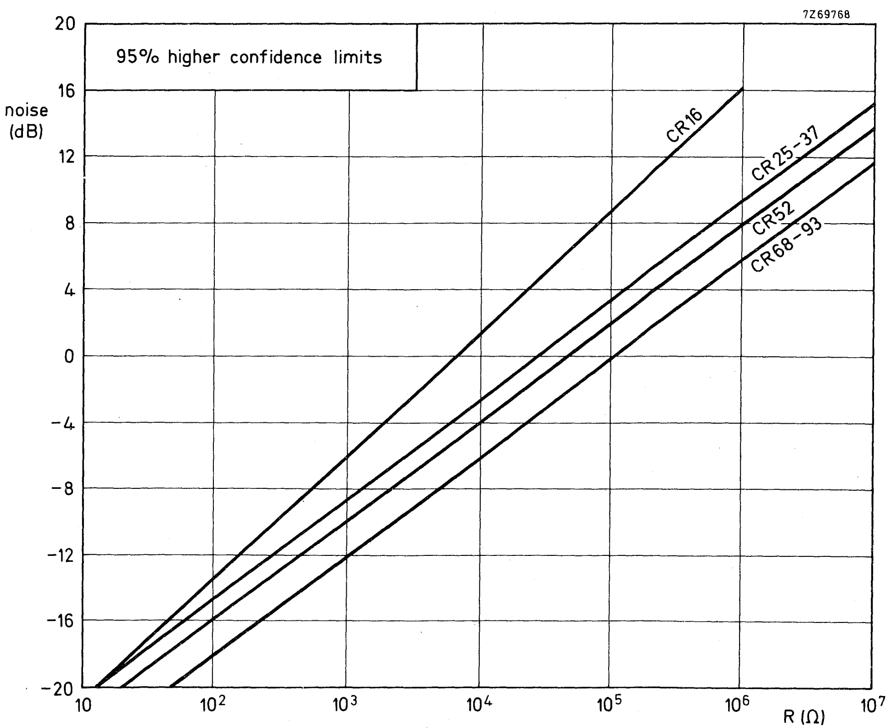


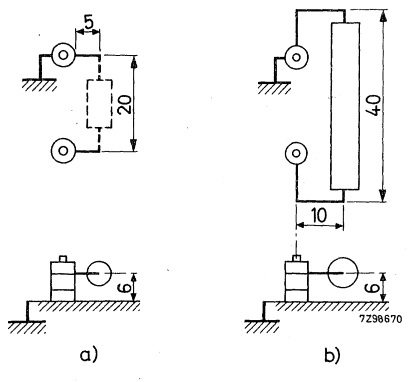
Fig. 5. Noise as a function of the resistance value. 0 dB = 1 μV/V.

High frequency behaviour

The behaviour of a resistor at high frequencies is influenced not only by its construction but also by external factors such as length of leads, environmental stray capacitances and the measuring apparatus. Thus these factors have to be considered when measuring. The following table gives typical values under test conditions at 250 MHz using the measuring arrangement shown below. An RX-meter type 250 A of Boonton Radio Corporation is used.

Frequency: 250 MHz

	CR16		CR25		CR37		CR52		CR68		CR93	
R_{nom} (Ω)	$\frac{\lvert Z \rvert}{R_{nom}}$	φ^o	$\frac{\lvert Z \rvert}{R_{nom}}$	φ^o	$\frac{\lvert Z \rvert}{R_{nom}}$	φ^o	$\frac{\lvert Z \rvert}{R_{nom}}$	φ^o	$\frac{\lvert Z \rvert}{R_{nom}}$	φ^o	$\frac{\lvert Z \rvert}{R_{nom}}$	φ^o
10	3,47	70	2,97	70	2,35	61	2,26	61	2,46	63	3,95	71
22	1,72	52	1,61	51	1,43	45	1,40	46	1,37	43	2,42	60
56	1,11	31	1,07	28	1,02	26	1,08	27	1,07	25	1,54	34
100	1,03	23	1,02	22	1,02	17	1,01	18	1,09	20	1,40	32
220	0,99	10	0,99	9	1	6	0,98	4	1	4	0,98	5
560	0,98	0	0,97	-5	0,94	-16	0,97	-5	0,90	-18	0,83	-31
1000	0,96	-9	0,92	-15	0,88	-25	0,86	-24	0,79	-31	0,48	-56
2200	0,84	-32	0,82	-35	0,69	-47	0,64	-50	0,49	-59	0,25	-71
5600	0,50	-60	0,41	-66	0,35	-69	0,31	-72	0,22	-77	0,10	-83



Measuring arrangement: (a) for CR16 to CR68, (b) for CR93

TESTS AND REQUIREMENTS

Essentially all tests mentioned in the schedule of IEC publication 115-1, category 55/155/56 (rated temperature range -55 to +155 °C; damp heat, long term, 56 days) are carried out along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the tests are listed with reference to the relevant clauses of IEC publications 115-1 and 68; a short description is also given of the test procedure and requirements.
In some instances deviations from the IEC specification were necessary for our method of specifying.

IEC 115-1 clause	IEC 68 test method	Test	Procedure	Requirements
18		Robustness of terminations		
	Ua	a. Tensile all samples	dia. 0, 4 mm: load 5 N ; 10 s dia. 0, 6; 0, 7; 0, 8 mm: load 10 N ; 10 s	
	Ub	b. Bending half number of samples	dia. 0, 4 mm: load 2, 5 N ; 4 x 90° dia. 0, 6; 0, 7; 0, 8 mm: load 5 N ; 4 x 90°	
	Uc	c. Torsion other half number of samples	3 x 360° in opposite directions	no damage ΔR max. 0, 5% or 0, 5 Ω
19	T	Soldering	solderability: 2 s 230 °C (clas II) thermal shock: 3 s 350 °C, 6 mm from body	good tinning, no damage, ΔR max. 0, 5% or 0, 5 Ω
20	Na	Rapid change of temperature	3 hours −55 °C/3 hours + 155 °C, 5 cycles	ΔR max. 0, 5% or 0, 5 Ω
22	Fc	Vibration	frequency: 10-500 Hz; displacement 1, 5 mm or acceleration 10g, three directions; total 6 h	no damage ΔR max. 0, 5% or 0, 5 Ω
21	Eb	Bumping	3 x 1500 bumps in three directions; 40g	no damage, ΔR max. 0, 5% or 0, 5 Ω

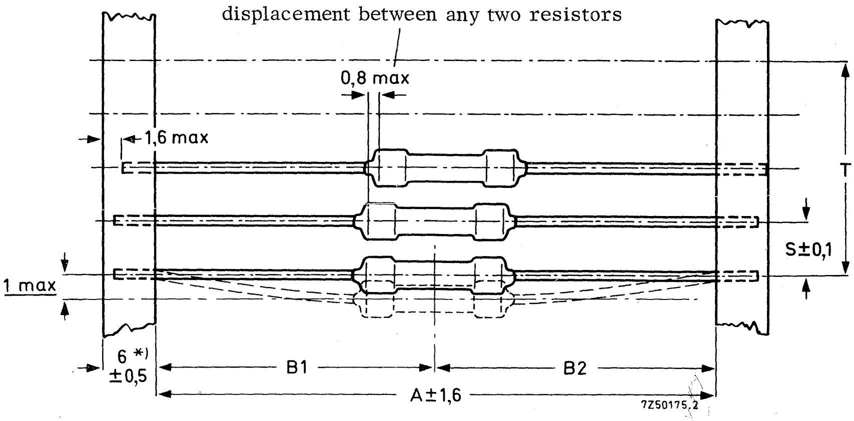
IEC 115-1 clause	IEC 68 test method	Test	Procedure	Requirements
23		Climatic sequence		
23.2	Ba	Dry heat	16 hours 155 °C	
23.3	D	Damp heat (accel) 1 st cycle	24 hours ; 55 °C; 95 - 100% R.H.	
23.4	Aa	Cold	2 hours ; −55 °C	
23.5	M	Low air pressure	1 hour ; 85 mbar; 15 - 35 °C	
23.6	D	Damp heat (accel) remaining cycles	5 days ; 55 °C; 95 - 100% R.H.	R_{ins} = min. 1000 MΩ ΔR max. 1,5% for R ≤ 220 kΩ max. 3% for R > 220 kΩ
24.2	Ca	Damp heat (steady state)	56 days; 40 °C; 90 - 95% R.H. The dissipation should not exceed 1% of the value indicated by Fig. 3.	R_{ins} : min. 1000 MΩ ΔR max. : 1,5% for R ≤ 220 kΩ; 3% for R > 220 kΩ

IEC 115-1 clause	IEC 68 test method	Test	Procedure	Requirements
26.2	-	Endurance	1000 hours; 70 °C; dissipation taken from Fig. 3	ΔR max.: 1,5%
11	-	Temperature coefficient	between −55 °C and +155 °C	see Fig. 4
10	-	Voltage proof on insulation	CR16: 250 V CR25: 500 V, CR37: 700 V, CR52: 700 V CR68: 1000 V, CR93: 1000 V, r.m.s. 1 minute	no breakdown
14	-	Noise	IEC publication 195	see Fig. 5
9	-	Insulation resistance	–	min. 10^4 MΩ
15	-	Short time overload	room temperature, dissipation 6,25 x value taken from Fig. 3 (voltage not more than 2 x limiting voltage) 10 cycles 5 s on, 45 s off	ΔR max. 1%
13	-	Voltage coefficient	–	< 5 ppm

STANDARD PACKAGING

style	number per box: bandolier	number per box: bulk	number per box: bandolier reeled
CR16	1000		5000
CR25	1000		5000
CR25A		1000	
CR37	1000		5000
CR52	1000		
CR68	1000		
CR93	250		

Configuration of bandolier (dimensions in mm)

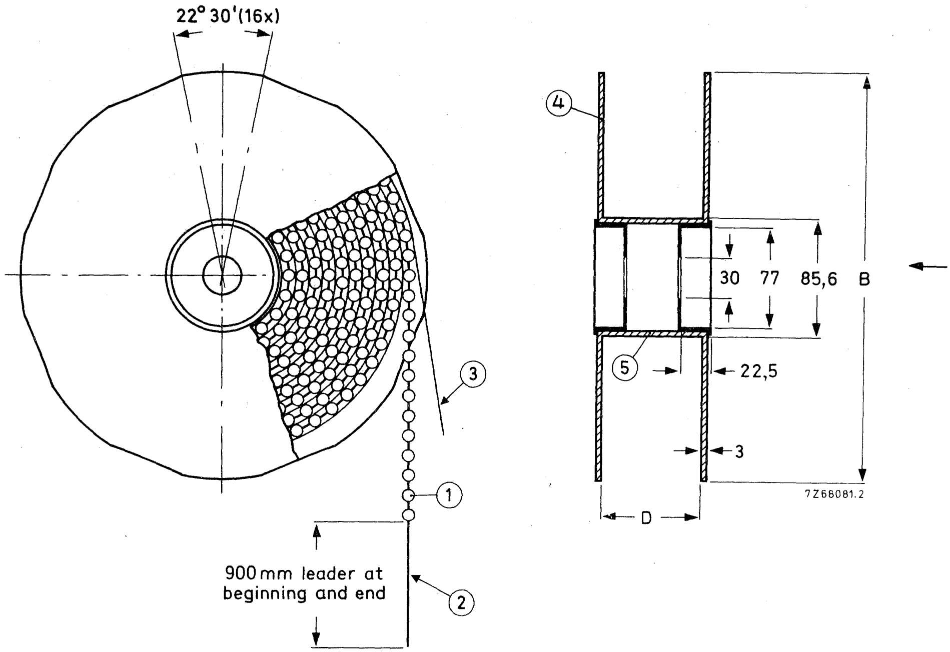


style	A	B1 - B2 ± max.	S	T for number (n) of resistors: n < 50	T for number (n) of resistors: 50 < n < 100
CR16	52,4	1,2	5	5(n-1) ± 2	5(n-1) ± 4
CR25	52,4	1,2	5	5(n-1) ± 2	5(n-1) ± 4
CR37	52,4	1,2	5	5(n-1) ± 2	5(n-1) ± 4
CR52	66,7	1,2	10	10(n-1) ± 2	10(n-1) ± 4
CR68	66,7	1,2	10	10(n-1) ± 2	10(n-1) ± 4
CR93	92 **)	1,2	10	10(n-1) ± 2	10(n-1) ± 4

*) For styles CR52 and CR68: 5 mm.

**) Tolerance +2 mm.

Reel dimensions (mm)



(1) resistor	(4) flange
(2) bandolier	(5) cylinder
(3) paper	

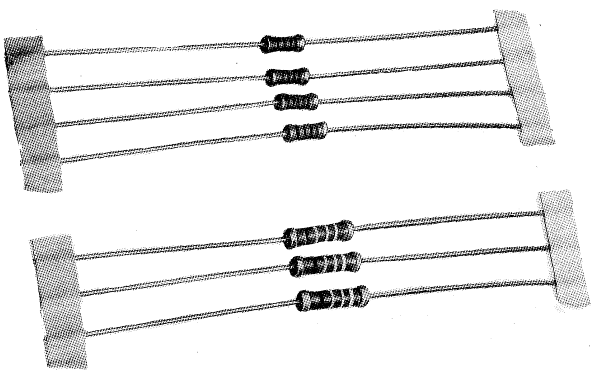
style	B	D
CR16	305	75
CR25	305	75
CR37	356	75

LACQUERED METAL FILM RESISTORS

QUICK REFERENCE DATA	
Resistance ranges	from 4,99 Ω to 1 MΩ
	E24 and E96 series
Resistance tolerance	± 1, ± 2, ± 5%
Temperature coefficient	± 50, ± 100, ± 200 ppm/^{o}C
Abs. max. dissipation at T_{amb} = 70 ^{o}C *)	MR25 0,4 W
	MR30 0,5 W
	MR52 0,75 W
Basic specification	IEC 115-1
Climatic category (IEC68)	55/155/56
Stability after:	
load	see nomogram
climatic tests	ΔR/R max. 0,5% + 0,05 Ω
soldering	ΔR/R max. 0,1%
short time overload	ΔR/R max. 0,25% + 0,05 Ω

*) This is the dissipation at T_{amb} = 70 ^{o}C which causes the max. permissible hot-spot temperature of 175 ^{o}C to occur, irrespective of the resistance drift provoked by this condition.

RZ 29284-2



APPLICATION

These resistors have been developed for applications in which precision, stability, and a low temperature coefficient are required, e.g. in computers, telecommunication equipment, measuring apparatus, etc.

DESCRIPTION

A homogeneous film of nickel-chromium *) is vacuum-deposited on a high grade ceramic body. Contact caps of special alloy are then pressed onto the ends of the resistor body, and the tinned electrolytic copper connecting wires are welded to the caps.
As a rule the required resistance value is not obtained directly by deposition of the film; helixing, that is, cutting a helical groove in the metal film, is also needed.
The resistors are protected by four or more layers of a green lacquer that is resistant against the commonly used cleaning solvents.

MECHANICAL DATA

Dimensions in mm.

Outlines

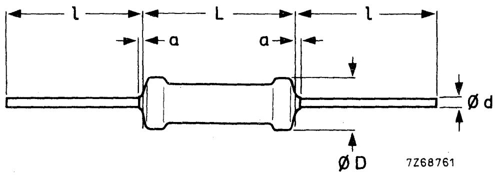


Fig. 1

Table I

style	D_{max}	L_{max}	a_{max}	l	d
MR25	2,5	6,5	1	28±2	0,6
MR30	3,0	10,0	1	28±2	0,6
→ MR52	5,2	16,5	1	38±3	0,6

The length of the body is measured by inserting the leads into the holes of two identical gauge plates and by moving these plates parallel to each other until the resistor body is clamped without deformation. (See IEC publication 294).

Diameter of hole in gauge plate 1,0 mm

Weight (per 100 pieces)

MR25 25 g
MR30 32 g
MR52 92 g

Mounting

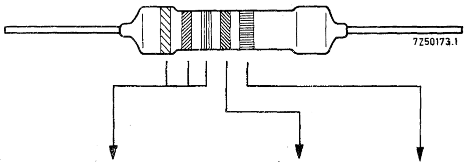
The resistors must be mounted stress free so as to allow thermal expansion over the wide temperature range.

*) Resistors with the lowest resistance values may have an electroless-deposited nickel film instead of a vacuum-deposited nickel-chromium film. The further processing, however, is the same.

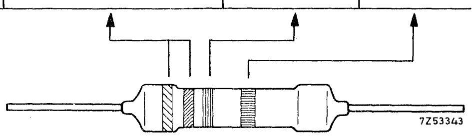
Marking

The nominal resistance value and the tolerance are marked on these resistors by means of four or five coloured bands according to IEC publication 62 "Colour code for fixed resistors" (see also IEC publication 115-1 clause 4.5).

for E96 series



colour	significant figures	multiplier	tolerance
black	0	1 x	
brown	1	10 x	± 1%
red	2	100 x	± 2%
orange	3	1 000 x	
yellow	4	10 000 x	
green	5	100 000 x	
blue	6	-	
violet	7	-	
grey	8	-	
white	9	-	
silver		0,01 x	
gold		0,1 x	± 5%



for E24 series

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the E24 series for resistors with a tolerance of ± 2% and 5%, and from the E96 series for resistors with a tolerance of ± 1%. The values of the E24 and E96 series are given in the table "Standard series of values in a decade" at the back of this book.

→ Table II, standard range

style	resistance range	tol. (± %)	series	temperature coefficient (± ppm/°C)	limiting voltage (r.m.s.) (V) 2)	cat. number 2322 followed by
MR25	4,99 Ω - 301 kΩ	1	E96	50 1)	250	151 5....
	5,1 Ω - 300 kΩ	2	E24	100	250	151 4....
	5,1 Ω - 300 kΩ	5	E24	200	250	151 6....
MR25 on reel	4,99 Ω - 301 kΩ	1	E96	50 1)	250	151 2....
	5,1 Ω - 300 kΩ	2	E24	100	250	151 1....
	5,1 Ω - 300 kΩ	5	E24	200	250	151 3....
MR30	4,99 Ω - 1 MΩ	1	E96	50 1)	350	152 5....
	5,1 Ω - 1 MΩ	2	E24	100	350	152 4....
	5,1 Ω - 1 MΩ	5	E24	200	350	152 6....
MR30 on reel	4,99 Ω - 1 MΩ	1	E96	50 1)	350	152 2....
	5,1 Ω - 1 MΩ	2	E24	100	350	152 1....
	5,1 Ω - 1 MΩ	5	E24	200	350	152 3....
MR52	4,99 Ω - 1 MΩ	1	E96	100	500	153 5....

Composition of the catalogue number

2322 ... .

Style code
see Table II

Tolerance code
2 or 5 for ± 1%
1 or 4 for ± 2%
3 or 6 for ± 5%

Resistance value code: first three significant figures of the resistance value (in Ω) followed by
8 for R of 4,99 to 9,76 Ω
9 for R of 10 to 97,6 Ω
1 for R of 100 to 976 Ω
2 for R of 1 to 9,76 kΩ
3 for R of 10 to 97,6 kΩ
4 for R of 100 to 976 kΩ
5 for R of 1 MΩ

Example

The catalogue number of a resistor MR30 of 3650 Ω with a tolerance of 1% is 2322 152 53652.

1) For resistance values lower than 49,9 Ω: 100 ppm/°C.
2) Limiting voltage (element and insulation).
This is the maximum voltage that may be applied continuously to the resistor element (see IEC publication 115-1). This voltage is also the maximum voltage that may be applied continuously to the insulation of the resistor.

For the resistance value 49,9 Ω, 1% the "Composition of the catalogue number" is not applicable. Below the relevant catalogue numbers are stated in full:

MR25	2322 151 90144
MR25 on reel	2322 151 90544
MR30	2322 152 90144
MR30 on reel	2322 152 90544
MR52	2322 153 90144

Dissipation and stability

The stability as a function of dissipation and ambient temperature is indicated in the performance nomogram of Fig. 2.

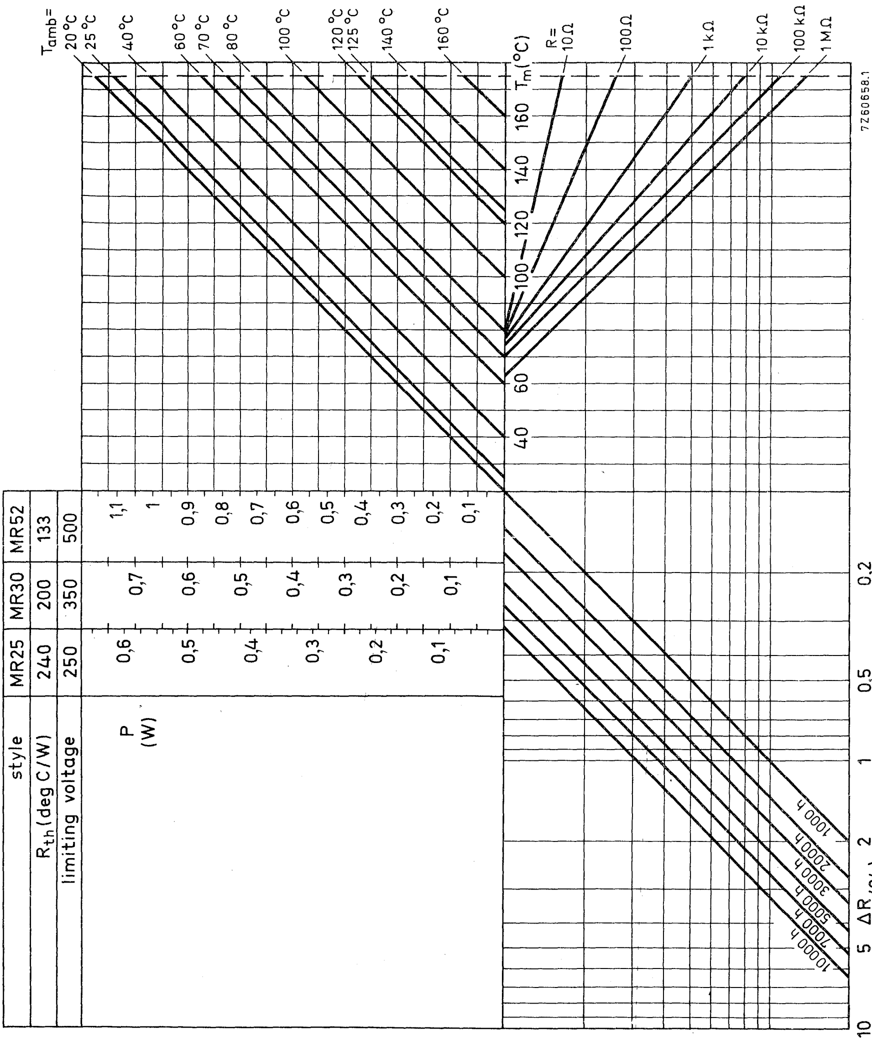


Fig. 2 Performance nomogram for different styles of resistor, showing the relationship between power dissipation P, ambient temperature T_{amb}, hot-spot temperature (T_m) and max. resistance drift $\Delta R/R$ after 1000 to 10 000 hours of operation.

Remarks to nomogram

The nomogram should not be extended beyond the maximum permissible hot-spot temperature of 175 °C

The resistance change given by the nomogram for P = 0 at a particular ambient temperature is indicative of the shelf-life stability of a resistor at that temperature.

The stability lines do not give exact values $\Delta R/R$, but represent a probability of 95% that the real values will be smaller than those obtained from the nomogram.

In the nomogram the limiting voltage of the resistors has not been taken into consideration.

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1. This means: rated temperature range −55 to + 155 °C; damp heat (long term) 56 days (see IEC publication 115-2 clause 4.1). The tests are carried out along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components".
In Table III the tests and requirements are listed with reference to the relevant clauses of IEC publications 115-1 and 68; a short description of the test procedure is also given. In some instances deviations from the IEC specifications were necessary for our method of specifying.

Table III

IEC 115-1 clause	IEC 68 test method	Test	Procedure	Requirements
18		Robustness of terminations		
	Ua	Tensile all samples	load 10 N (1 kg), 10 s	
	Ub	Bending half number of samples	load 5 N (0,5 kg), 4 x 90^{o}	
	Uc	Torsion other half number of samples	3 x 360^{o} in opposite directions	no damage ΔR max. 0,1% or 0,1 Ω
19	T	Soldering	solderability: 2 s 230 ^{o}C thermal shock: 3 s 350 ^{o}C, 6 mm from body	good tinning, no damage ΔR max. 0,1%
20	Na	Rapid change of temperature	3 hours −55 ^{o}C/3 hours + 155 ^{o}C, 5 cycles	ΔR max. 0,1% or 0,1 Ω
22	Fc	Vibration	frequency 10-500 Hz, displacement 1,5 mm or acceleration 10 g, three directions; total 6 h	no damage ΔR max. 0,1% or 0,1 Ω
21	Eb	Bump	3 x 1500 bumps in three directions, 40 g	no damage ΔR max. 0,1% or 0,1 Ω

Table III (continued)

IEC 115-1 clause	IEC 68 test method	Test	Procedure	Requirements
23		Climatic sequence		
23.2	B	Dry heat	16 hours 155 °C	
23.3	D	Damp heat (accel) 1 st cycle	24 hours ; 55 °C; 95-100% R.H.	
23.4	Aa	Cold	2 hours ; −55 °C	
23.5	M	Low air pressure	1 hour ; 85 mbar ; 15-35 °C	
23.6	D	Damp heat (accel) remaining cycles	5 days ; 55 °C; 95-100% R.H.	R_{ins} min. 1000 MΩ ΔR max. 0,5% + 0,05 Ω
24	Ca	Damp heat (long-term exposure)	56 days; 40 °C; 90-95% R.H. The dissipation should not exceed 2,5 mW for MR25, 3 mW for MR30 and 5 mW for MR52	R_{ins} min. 1000 MΩ ΔR max. 0,5% + 0,05 Ω

p.t.o.

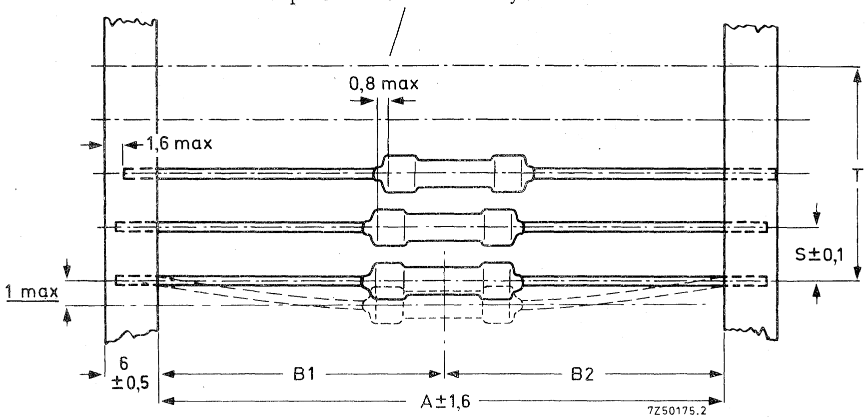
Table III (continued)

IEC 115-1 clause	IEC 68 test method	Test	Procedure	Requirements
26.2	-	Endurance	1000 hours; 70 ^{o}C : dissipation 0,25 W for MR25 0,3 W for MR30 0,45 W for MR52	ΔR max.: 0,5%
11	-	Temperature coefficient	between −55 ^{o}C and + 155 ^{o}C	≤50, ≤100, ≤200 ppm/^{o}C see Table II
13	-	Voltage proof	2 x limiting voltage (a.c.) with a maximum of 750 V (r.m.s.)	no breakdown
14	-	Noise	IEC publication 195	≤0,25 μV/V for R ≤ 100 kΩ ≤0,50 μV/V for R > 100 kΩ
9	-	Insulation resistance		min. 10^4 MΩ

STANDARD PACKAGING

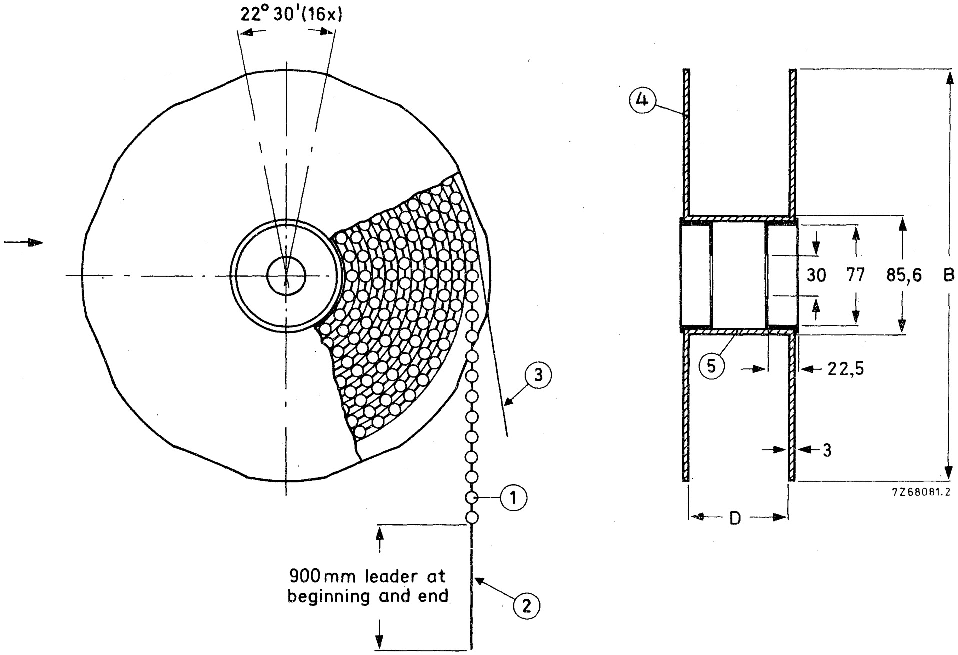
style	number per box	
	bandolier	bandolier reeled
MR25	1000	5000
MR30	1000	5000
MR52	1000	

Configuration of bandolier (dimensions in mm)



style	A	B1 - B2 ± max.	S	T for number of resistors	
				n ≤ 50	50 < n ≤ 100
MR25	52,4	1,2	5	5 (n - 1) ± 2	5 (n - 1) ± 4
MR30	52,4	1,2	5	5 (n - 1) ± 2	5 (n - 1) ± 4
MR52	66,7	1,2	10	10 (n - 1) ± 2	10 (n - 1) ± 4

Reel dimensions (mm)



(1) resistor
(2) bandolier
(3) paper
(4) flange
(5) cylinder

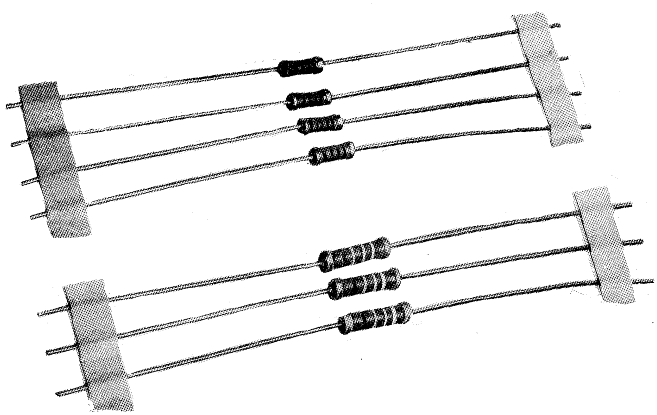
style	B	D
MR25	305	75
MR30	356	75

LACQUERED METAL FILM RESISTORS

temperature coefficient 50 ppm/°C

QUICK REFERENCE DATA	
Resistance ranges	from 49,9 Ω to 681 kΩ, E96 series
Resistance tolerance	1%
Temperature coefficient	50 ppm/°C
Typical dissipation at T_{amb} = 70 °C *)	MR24 0,4 W MR34 0,5 W
Basic specification	IEC 115-1
Climatic category (IEC68)	55/155/56
Stability after:	
load	see nomogram
climatic tests	ΔR/R max. 0,5% +0,05 Ω
soldering	ΔR/R max. 0,1% or 0,1 Ω
short time overload	ΔR/R max. 0,25% + 0,05 Ω

*) This is the dissipation at T_{amb} = 70 °C which causes the max. permissible hot-spot temperature of 175 °C to occur, irrespective of the resistance drift provoked by this condition.



RZ 29284-2

APPLICATION

These resistors have been developed for applications in which precision, stability, and a low temperature coefficient are required, e.g. in computers, telecommunication equipment, measuring apparatus, etc.

DESCRIPTION

A homogeneous film of nickel-chromium is vacuum deposited on a high grade ceramic body. Contact caps of special alloy are then pressed onto the ends of the resistor body, and next the tinned electrolytic copper connecting wires are welded to the caps.
As a rule the required resistance value is not obtained directly by deposition of the film; helixing, that is, cutting a helical groove in the metal film, is also needed.
The resistors are protected by four or more layers of a green lacquer being resistant against the commonly used cleaning solvents.

MECHANICAL DATA

Dimensions in mm

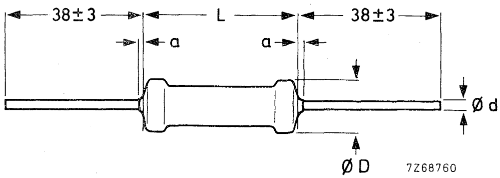


Fig. 1

style	D_{max}	L_{max}	a_{max}	d
MR24	2,5	6,5	1	0,6
MR34	3,1	10,5	1	0,6

The length of the body is measured by inserting the leads into the holes of two identical gauge plates and by moving these plates parallel to each other until the resistor body is clamped without deformation (See IEC publication 294).

Width of hole in gauge plate 1,0 mm

Weight (per 100 pcs)

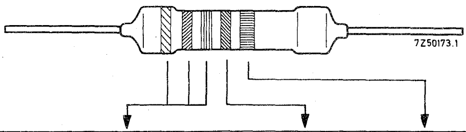
MR24 25 g
MR34 32 g

Mounting

The resistors must be mounted stress free so as to allow thermal expansion over the wide permissible temperature range.

Marking

The nominal resistance value and the tolerance are marked on these resistors by means of five coloured bands according to IEC publication 62 "Colour code for fixed resistors" (see also IEC publication 115-1 clause 4.5).



colour	significant figures	multiplier	tolerance
black	0	1 x	
brown	1	10 x	± 1%
red	2	100 x	
orange	3	1 000 x	
yellow	4	10 000 x	
green	5	-	
blue	6	-	
violet	7	-	
grey	8	-	
white	9	-	
gold		0,1 x	

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the E96 series. The tolerance is ± 1%.
The values of the E96 series are given in a table at the back of this book.

Standard range

Table II

style	resistance range	tolerance (± %)	series	limiting voltage *) (V r.m.s.)	cat.number 2322 followed by
MR24	49,9 Ω - 301 kΩ	1	E96	250	161 5....
MR34	49,9 Ω - 681 kΩ	1	E96	350	164 5....

*) Limiting voltage (element and insulation).
This is the maximum voltage which may be applied continuously to the resistor element (see IEC publication 115-1 and 2). This voltage is also the maximum voltage which may be applied continuously to the insulation of the resistor.

Composition of the catalogue number

2322 . . . .

Style code — see table II

Tolerance code — 5 for ± 1%

Resistance value code, first three significant figures of the resistance value (in Ω) followed by
9 for R of 49,9 to 97,6 Ω
1 for R of 100 to 976 Ω
2 for R of 1 to 9,76 kΩ
3 for R of 10 to 97,6 kΩ
4 for R of 100 to 681 kΩ

→ For the resistance value 49,9 Ω the "Composition of the catalogue number" is not applicable. The catalogue numbers for this value are:

for style MR24	2322 161 90144
for style MR34	2322 164 90144

Dissipation and stability

The stability as a function of dissipation and ambient temperature is indicated in the performance nomogram of Fig. 2.

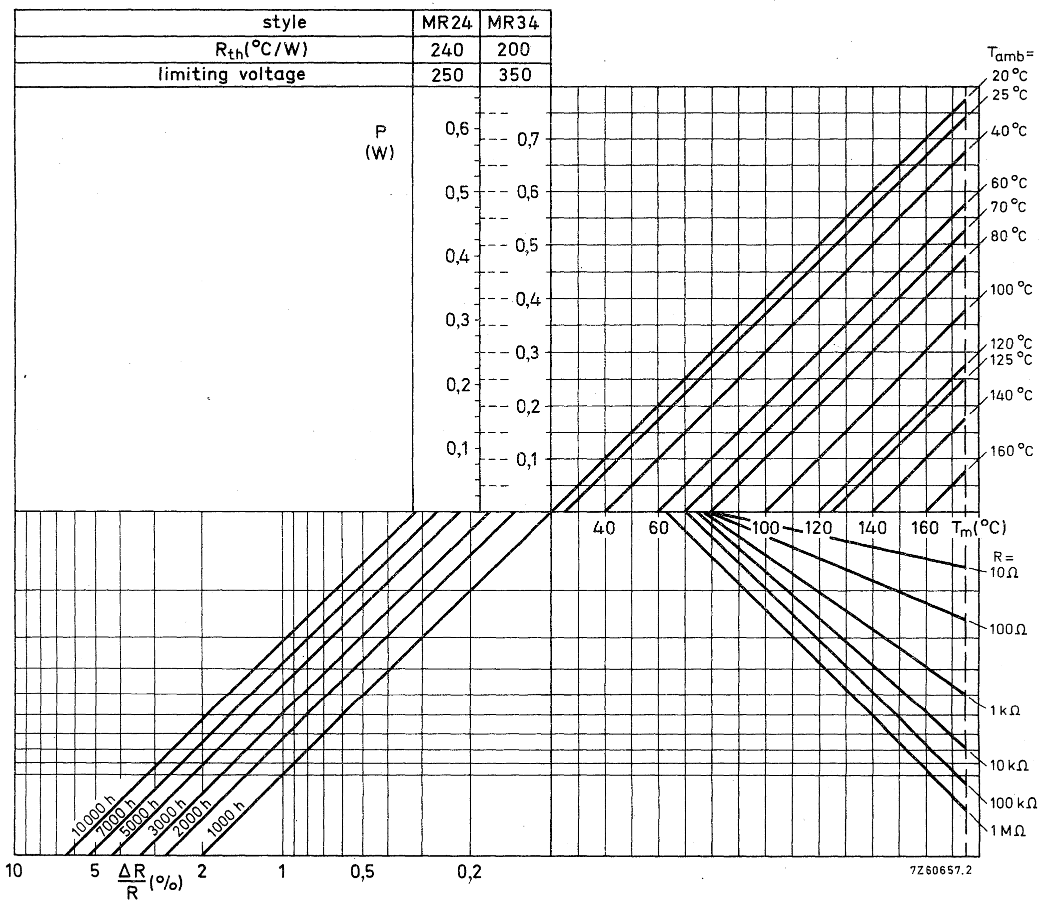


Fig. 2 Performance nomogram for different styles of resistor, showing the relationship between power dissipation P, ambient temperature T_{amb}, hot-spot temperature (T_m) and max. resistance drift $\Delta R/R$ after 1000 to 10 000 hours of operation.

Remarks to nomogram

The nomogram should not be extended beyond the maximum allowable hot spot temperature of 175 ^{o}C.

The resistance change given by the nomogram for P = 0 at a particular ambient temperature is indicative of the shelf life stability of a resistor at that temperature.

The stability lines do not give exact values $\Delta R/R$, but represent a probability of 95% that the real values will be smaller than those obtained from the nomogram.

In the nomogram the limiting voltage of the resistors has not been taken into consideration and must therefore still be taken into account.

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1. This means: rated temperature range −55 to + 155 ^{o}C; damp heat (long term) 56 days (See IEC publication 115-2, clause 4.1). The tests are carried out along the lines of IEC publication 68. "Recommended basic climatic and mechanical robustness testing procedure for electronic components".
In table III the tests and requirements are listed with reference to the relevant clauses of IEC publications 115 and 68; a short description of the test procedure is also given. In some instances deviations from the IEC specifications were necessary for the new method of specifying.

Table III

IEC 115-1 clause	IEC 68 test method	Test	Procedure	Requirements
18		Robustness of terminations		
	Ua	Tensile all samples	load 10 N (1 kg), 10 s	
	Ub	Bending half number of samples	load 5 N (0,5 kg), 4 x 90°	
	Uc	Torsion other half number of samples	3 x 360° in opposite directions	no damage ΔR max. 0, 1% or 0, 1 Ω
19	T	Soldering	solderability: 2 s 230 $^{\circ}C$ thermal shock: 3 s 350 $^{\circ}C$, 6 mm from body	good tinning, no damage ΔR max. 0, 1%
20	Na	Rapid change of temperature	3 hours −55 $^{\circ}C$/3 hours + 155 $^{\circ}C$, 5 cycles	ΔR max. 0, 1% or 0, 1 Ω
22	Fc	Vibration	frequency 10-500 Hz, displacement 1,5 mm or acceleration 10 g, three directions, total 6 h	no damage ΔR max. 0, 1% or 0, 1 Ω
21	Eb	Bump	3 x 1500 bumps in three directions; 40 g	no damage ΔR max. 0, 1% or 0, 1 Ω

Table III (continued)

IEC 115-1 clause	IEC 68 test method	Test	Procedure	Requirements
23		Climatic sequence		
23.1	Ba	Dry heat	16 hour 155 ^{o}C	
23.3	D	Damp heat (accel) 1 st cycle	1 day ; 55 ^{o}C; 95-100% R.H.	
23.4	Aa	Cold	2 hours; −55 ^{o}C	
23.5	M	Low air pressure	1 hour; 85 mbar; 15-35 ^{o}C	
23.6	D	Damp heat (accel) remaining cycles	5 days; 55 ^{o}C; 95-100% R.H.	R_{ins} = min. 1000 MΩ ΔR max. 0,5% + 0,05 Ω
24	Ca	Damp heat (steady state)	56 days; 40 ^{o}C; 90-95% R.H.; 5 V d.c. on half the number of specimens, but the dissipation should not exceed 2,5 mW for MR24, 3 mW for MR34	R_{ins} : min. 1000 MΩ ΔR max.: 0,5% + 0,05 Ω

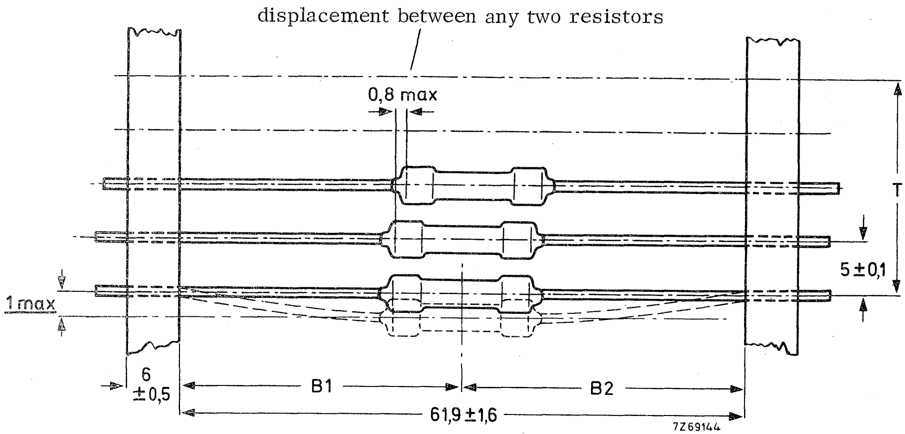
Table III (continued)

IEC 115-1 clause	IEC 68 test method	Test	Procedure	Requirements
26.2	-	Endurance	1000 hours; 70 ^{o}C : dissipation 0,25 W for MR24 0,3 W for MR34	ΔR max.: 0,5%
11	-	Temperature coefficient	between −55 ^{o}C and + 155 ^{o}C	$\leq$ 50 ppm/^{o}C
13	-	Voltage proof	2 x limiting voltage (d.c.)	no breakdown
14	-	Noise	IEC publication 195	$\leq$0,25 µV/V for R $\leq$ 100 kΩ $\leq$0,50 µV/V for R < 100 kΩ
9	-	Insulation resistance		min. 10^4 MΩ

STANDARD PACKAGING

The resistors are supplied on bandolier.

Configuration of bandolier (dimensions in mm)



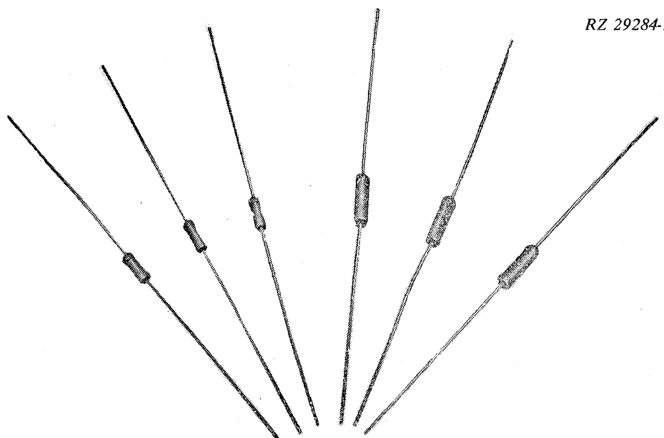
style	B1 - B2 ± max.	T for number of resistors	
		n ≤ 50	50 < n ≤ 100
MR24	1,2	5 (n - 1) ± 2	5 (n - 1) ± 4
MR34	1,2	5 (n - 1) ± 2	5 (n - 1) ± 4

LACQUERED METAL FILM RESISTORS
according to MIL-R-10509F

QUICK REFERENCE DATA

Resistance ranges	from 10 Ω to 1 MΩ, E96, E192 series	
Resistance tolerance	0.1, 0.25, 0.5, 1 %	
Rated dissipation at T_{amb} = 125 °C	MR 24E/C	0.1 W
	MR 34E/C	0.125 W
	MR 54E/C	0.25 W
	MR 74E/C	0.5 W
at T_{amb} = 70 °C	MR 24D	0.125 W
	MR 34D	0.25 W
	MR 54D	0.5 W
	MR 74D	0.75 W
Basic specification	MIL-R-10509F	
Stability after:		
load	ΔR/R max. 0.5% + 0.05 Ω	
climatic tests	ΔR/R max. 0.5% + 0.05 Ω	
soldering	ΔR/R max. 0.1% + 0.05 Ω	
short time overload	ΔR/R max. 0.25% + 0.05 Ω	

RZ 29284-1



APPLICATION

These resistors have been developed for applications in which precision, stability, and a low temperature coefficient are required, e.g. in computers, telecommunication equipment, measuring apparatus, etc.

DESCRIPTION

A homogeneous film of nickel-chromium *) is vacuum deposited on a high grade ceramic body. Contact caps of special alloy are then pressed onto the ends of the resistor body, and next the tinned electrolytic copper connecting wires are welded to the caps.
As a rule the required resistance value is not obtained directly by deposition of the film; helixing, that is, cutting a helical groove in the metal film, is also needed.
The resistors are protected by four or more layers of a green lacquer being resistant against the commonly used cleaning solvents.

MECHANICAL DATA

Dimensions in mm

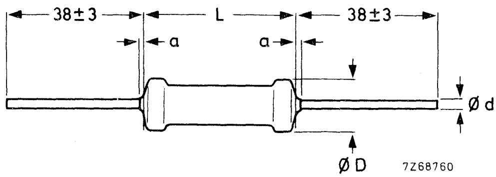


Table I

style	D_{max}	L_{max}	a_{max}	d
MR24 E/C/D	2,5	6,5	1	0,6
MR34 E/C/D	3,1	10,5	1	0,6
MR54 E/C/D	5,2	16,5	1	0,6
MR74 E/C/D	6,8	20,5	1	0,8

The length of the body is measured by inserting the leads into the holes of two identical gauge plates and by moving these plates parallel to each other until the resistor body is clamped without deformation (see IEC publication 294).

nominal lead diameter (mm)	width of hole in gauge plate (mm)
0,6	1,0
0,8	1,2

Weight (per 100 pcs)

MR24 E/C/D	25 g
MR34 E/C/D	32 g
MR54 E/C/D	92 g
MR74 E/C/D	200 g

*) Resistors with the lowest resistance values may have an electroless nickel film instead of a vacuum deposited nickel-chromium film. The further processing, however, is the same.

Mounting

The resistors must be mounted stress free so as to allow thermal expansion over the wide permissible temperature range.

Marking

The resistors are marked according to the MIL specification MIL-R-10509F.
This means that the following information is printed on the resistor:

MIL style
Value and tolerance in MIL code
Manufacturers' identification symbol

In the MIL code for value and tolerance the value is indicated by four figures and a letter: first the three significant figures according to the E192 or E96 series, a fourth figure indicating the number of zeros to follow and then a letter indicating the tolerance as follows:

B = ±0,1%; C = ±0,25%; D = ±0,5% and F = ±1%.

Example: 22,1 kΩ ± 1% is written as 2212 F
This code should not be used for ordering. Please use the catalogue number (see next page) for this purpose.

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the E96 series for resistors with a tolerance of ± 1%, from the E192 series for resistors with a tolerance of ±0,5%, ±0,25% or ±0,1% (MIL-R-10509F para 1.2.1.3). Resistors with a tolerance of ±0,1% and ±0,25% may also be requested with resistance values deviating from the E192 series, provided the value can be indicated with no more than three significant figures.
The values of the E96 and E192 series are given in a table at the back of this book.

Standard range

Table II

style	rated dissipation (W)	maximum temperature coefficient (ppm/degC)	resistance range and tolerance	max. voltage (V rms)	MIL style	style code *)
	at 125°C	±	0.1/0.25/0.5% E192 series 1% E96 series			
MR24E	0.1	25	49.9 Ω—100 kΩ	200	RN55E	160
MR24C	0.1	50	49.9 Ω—100 kΩ	200	RN55C	161
MR34E	0.125	25	49.9 Ω—499 kΩ	250	RN60E	163
MR34C	0.125	50	49.9 Ω—499 kΩ	250	RN60C	164
MR54E	0.25	25	49.9 Ω— 1MΩ	300	RN65E	166
MR54C	0.25	50	49.9 Ω— 1MΩ	300	RN65C	167
MR74E	0.5	25	24.9 Ω— 1MΩ	350	RN70E	169
MR74C	0.5	50	24.9 Ω— 1MΩ	350	RN70C	170
	at 70 °C	±	1% E96 series			
MR24D	0.125	100	10 Ω—301 kΩ	200	RN55D	162
MR34D	0.25	100	10 Ω— 1MΩ	300	RN60D	165
MR54D	0.5	100	10 Ω— 1MΩ	350	RN65D	168
MR74D	0.75	100	10 Ω— 1MΩ	500	RN70D	171

Composition of the catalogue number

2322 ... .

Style code
see table II

Tolerance code
1 for ± 1 %
2 for ± 0.5 %
3 for ± 0.25 %
4 for ± 0.1 %

Resistance value code: first three significant figures of the resistance value (in Ω) followed by
9 for R of 10 to 98.8 Ω
1 for R of 100 to 988 Ω
2 for R of 1 to 9.88 kΩ
3 for R of 10 to 98.8 kΩ
4 for R of 100 to 988 kΩ
5 for R of 1 MΩ

For the resistance values mentioned in the following table the "Composition of the catalogue number" is not applicable. In this table the last 5 digits of the catalogue number are stated in full.

*) See composition of the catalogue number

Table III

resistance value (Ω)	last 5 digits of the catalogue number			
	0,1%	0,25%	0,5%	1%
29,9	92102	92122		
39,9	92103	92123		
49,9	92104	92124	92134	92144
59,9	92105	92125		
69,9	92106	92126		
79,9	92107	92127		
89,9	92108	92128		
99,9	92109	92129		

TESTS AND REQUIREMENTS

All tests are carried out according to the schedule of MIL-R-10509F para. 4.4.2.
In the table below the tests and requirements are listed with reference to the relevant paragraphs of this specification.

Table IV

MIL method			requirement	
R 10509F paragraph	STD 202 method	procedure	MIL-R-10509F paragraph	requirement *)
4.6.4	102	Temperature cycling	3.9	$\Delta R \leq 0,25\% + 0,05\ \Omega$
4.6.5	-	Low-temperature operation	3.10	$\Delta R \leq 0,25\% + 0,05\ \Omega$
4.6.6	-	Short-time overload	3.11	$\Delta R \leq 0,25\% + 0,05\ \Omega$
4.6.7	211	Terminal strength	3.12	$\Delta R \leq 0,2\% + 0,05\ \Omega$
4.6.8	301/105	Dielectric withstanding voltage	3.13	$\Delta R \leq 0,25\% + 0,05\ \Omega$
4.6.9	302	Insulation resistance	3.14	$R_{ins} \geq 10\,000\ M\Omega$
4.6.10	210	Resistance to soldering heat	3.15	$\Delta R \leq 0,1\% + 0,05\ \Omega$
4.6.11	106	Moisture resistance	3.16	$\Delta R \leq 0,5\% + 0,05\ \Omega$ $R_{ins} \geq 100\ M\Omega$
4.6.13	108	Life	3.18	$\Delta R \leq 0,5\% + 0,05\ \Omega$
4.6.15	205	Shock, medium impact	3.20	$\Delta R \leq 0,25\% + 0,05\ \Omega$
4.6.16	204	Vibration	3.21	$\Delta R \leq 0,25\% + 0,05\ \Omega$

PACKING

Bulk packing, 100 pcs per box

*) Though our resistors with a temperature coefficient of 100 ppm/^{o}C correspond with characteristic D resistors of MIL-R-10509F, they meet the more severe test requirements of characteristic C and E resistors.

POWER METAL FILM RESISTORS

QUICK REFERENCE DATA		
Resistance range, PR37	10 Ω to 10 kΩ, E24 series	
PR52	10 Ω to 27 kΩ, E24 series	
Resistance tolerance	± 5%	
Max. body temperature (hot spot)	300 °C	
Rated dissipation at T_{amb} = 70 °C, PR37	1,6 W	
PR52	2,5 W	
Basic specification	MIL-R-11804/2B, char.G	
Climatic category (IEC 68)	55/200/56	
Stability after:	requirement	typical value
1000 h max. load	ΔR ≤ 5%	ΔR 2,5%
climatic tests	ΔR ≤ 3%	ΔR 0,5%
soldering	ΔR ≤ 1%	ΔR 0,1%
short time overload	ΔR ≤ 2%	ΔR 0,2%

DESCRIPTION

The resistive element consists of a chromium-nickel film deposited on a ceramic body and adjusted to value by spiralling. Contact caps with solder-coated copper (PR37) or copper-clad connecting wires are force-fitted onto the ends of the ceramic body.
The resistor has a red non-inflammable coating of a protective silicon lacquer. The resistor is not electrically insulated.

MECHANICAL DATA

Dimensions in mm

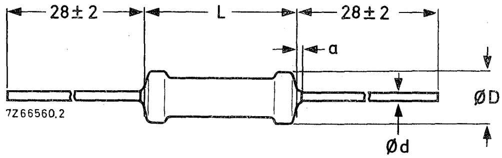


Fig. 1

style	L_{max}	D_{max}	a_{max}	d_{max}
PR37	10,0	3,7	1	0,6
PR52	16,7	5,2	1,2	0,6

The length of the body is measured by inserting the leads into the holes of two identical gauge plates and by moving these plates parallel to each other until the resistor body is clamped without deformation. (See IEC publication 294).

Width of hole in gauge plate 1,0 mm

Weight (per 100 pcs) PR37: 40 g
PR52: 92 g

Mounting

The resistors must be mounted stress free so as to allow thermal expansion over the wide permissible temperature range.

Marking

Each resistor is marked with:
- resistance value (R for Ω, K for kΩ)
- tolerance on resistance

e.g. for 27 Ω: 27 R ±5%
for 3,9 kΩ: 3K9 ±5%

ELECTRICAL DATA

Resistance range, PR37	10 Ω to 10 kΩ, E24 series *)
PR52	10 Ω to 27 kΩ, E24 series *)
Resistance tolerance	± 5%
Temperature coefficient	max. 500 ppm/°C
Maximum body temperature (hot spot)	300 °C
Rated dissipation at T_{amb} = 70 °C, PR37	1,6 W
PR52	2,5 W
Basic specification, PR37	MIL-R-11804/2B, char.G
PR52	MIL-R-11804/2B, char.G, style RD60
Climatic category (IEC 68)	55/200/56

Composition of the catalogue number

2322 19. 3. . 0.

Style code
191 for PR37
192 for PR52

Tolerance code
3 for 5%

9 for R of 10 to 91 Ω
1 for R of 100 to 910 Ω
2 for R of 1000 to 9100 Ω
3 for R of 10000 to 27000 Ω

First two digits of the resistance value (E24 series)

*) See the table "Standard series of values in a decade" at the back of the book.

Graphs

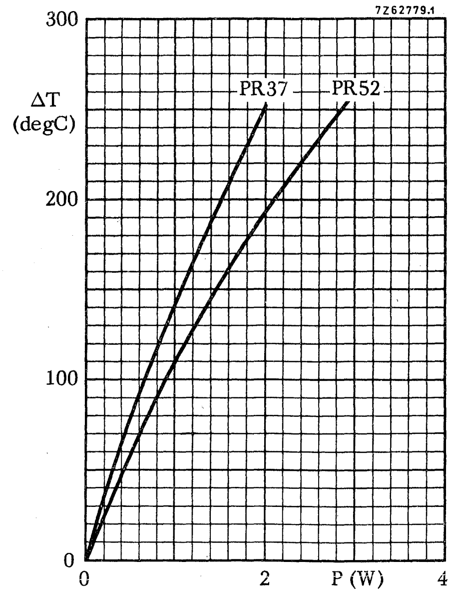


Fig. 2 Hot spot temperature rise versus dissipated power.

New graphs showing:

- Time to failure as a function of dissipated power
- Lead length as a function of dissipation with the temperature rise at the end of the lead (soldering spot) as parameter

will become available shortly.

TESTS AND REQUIREMENTS

All tests are carried out according to the schedule of MIL-R-11804E. In the table below the tests and requirements are listed with reference to the relevant paragraphs of this specification.

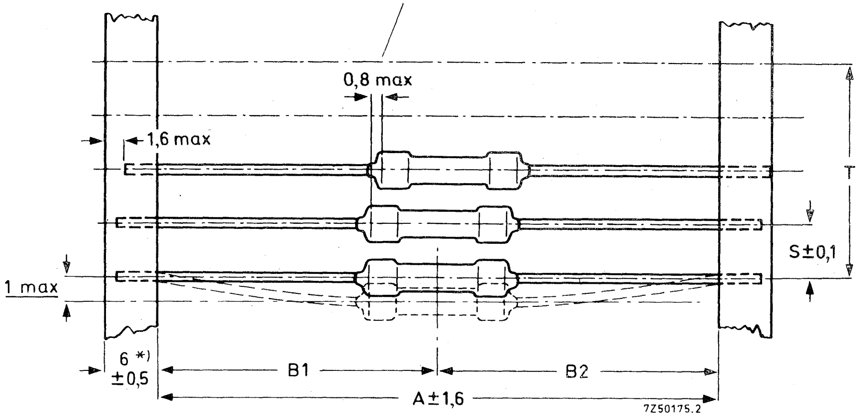
MIL test			requirement	
R-11804E paragraph	STD 202D method	procedure	MIL-R-11804 E paragraph	
4.6.1		Visual and mechanical examination	3.1; 3.3 to 3.4.3 3.21 to 3.22.1	
4.6.2	303	D.C. resistance		within tolerance
4.6.3		Temperature	3.7	ΔR ≤ 2%
4.6.6		Hot spot	3.10	see Fig. 2
4.6.7		Thermal shock	3.11	ΔR ≤ 2%, no damage
4.6.8		Momentary overload	3.12	ΔR ≤ 2%, no damage
4.6.9	106	Moisture resistance [1]	3.13	ΔR ≤ 3%
4.6.11	211	Terminal strength	3.15	ΔR ≤ 1%, no damage
4.6.12	208	Lead solderability	3.17	95% covered
4.6.13	304	Resistance versus temperature		≤ 500 ppm/degC
4.6.14	108	Load life [1]	3.18	ΔR ≤ 5%, no damage
4.6.15	205	Shock	3.19	ΔR ≤ 0.5% ± 0.05 Ω
4.6.16	204	Vibration (high frequency)	3.20	ΔR ≤ 0.5% ± 0.05 Ω no damage
IEC115	IEC68	Damp heat		ΔR ≤ 3%

[1] To dissipate the maximum wattage, the voltage shall not be exceeded

STANDARD PACKAGING

The resistors are supplied on bandolier, 1000 pieces per box.

Configuration of bandolier (dimensions in mm)



style	A	B1 - B2 ± max.	S	T for number (n) of resistors	
				n ≤ 50	50 < n ≤ 100
PR37	52,4	1,2	5	5 (n-1) ±2	5 (n-1) ±4
PR52	66,7	1,2	10	10 (n-1) ±2	10 (n-1) ±4

*) For style PR52 5 mm, but will become 6 mm in the future.

HIGH-VOLTAGE RESISTORS

QUICK REFERENCE DATA		
Resistance range, VR37	1 MΩ to 33 MΩ, E24 series	
VR68	1 MΩ to 68 MΩ, E24 series	
Resistance tolerance	± 5%	
Max. body temperature (hot spot)	155 °C	
Temperature coefficient	± 200 ppm/°C	
Rated dissipation at T_{amb} = 70 °C, VR37	0,5 W	
VR68	1,0 W	
Limiting voltage, VR37	3500 V (d.c.) or 2500 V (r.m.s.)	
VR68	10 000 V (d.c.) or 7000 V (r.m.s.)	
Dielectric withstanding voltage of the insulation for 1 minute	min 700 V (r.m.s.)	
Basic specification	IEC 115, type 1B	
Climatic category (IEC 68)	55/155/56	
	typical value	
Stability after:	VR37	VR68
1000 h max. load	ΔR 0,5%	ΔR 1%
accelerated damp heat test (6 days)	ΔR 0,5%	ΔR 1%
long-term damp heat test (56 days)	ΔR 0,5%	ΔR 1%
Noise	0,5 μV/V	0,5 μV/V

APPLICATION

These resistors have been developed for applications in which high resistance values, high stability and reliability are required at high voltages.

DESCRIPTION

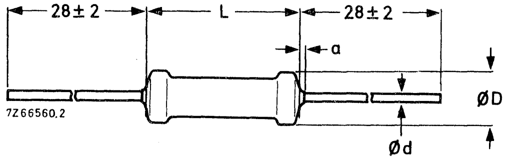
A metal-glazed film is deposited on a high grade ceramic body. Contact caps of special alloy are then pressed onto the ends of the resistor body, and the tinned electrolytic copper connecting wires are welded to the caps.
The resistors are coated with a light-blue insulating lacquer which also provides protection against environmental effects.

MECHANICAL DATA

Dimensions in mm

Outlines

Fig. 1



style	L_{max}	D_{max}	a_{max}	d
VR37	10	3,7	1,0	0,7
VR68	18	6,8	1,2	0,8

The length of the body is measured by inserting the leads into the holes of two identical gauge plates and by moving these plates parallel to each other until the resistor body is clamped without deformation. (See IEC publication 294.)

→ Diameter of hole in gauge plate 1,0 mm for d = 0,7 mm; 1,2 mm for d = 0,8 mm.

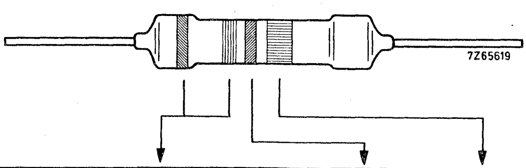
Weight (100 pieces) VR37: 42 g
VR68: 130 g

Mounting

The resistors should be used in a dust free environment and must be mounted stress free so as to allow thermal expansion over the wide temperature range.

Marking

The nominal resistance value and the tolerance are marked on these resistors by means of four coloured bands according to IEC publication 62 "Colour code for fixed resistors".



colour	significant figures	multiplier	tolerance
black	0	-	
brown	1	-	
red	2	-	
orange	3	-	
yellow	4	-	± 5%
green	5	100 000 x	
blue	6	1 000 000 x	
violet	7	-	
grey	8	-	
white	9	-	

ELECTRICAL DATA

Resistance range, VR37	1 MΩ to 33 MΩ, E24 series *)
VR68	1 MΩ to 68 MΩ, E24 series *)
Resistance tolerance	± 5%
Max. body temperature (hot spot)	155 °C
Temperature coefficient	± 200 ppm/°C
Rated dissipation at T_{amb} = 70 °C, VR37	0,5 W
VR68	1,0 W
Limiting voltage, VR37	3500 V d.c. or 2500 V r.m.s.
VR68	10 000 V d.c. or 7000 V r.m.s.
Dielectric withstanding voltage of the insulation for 1 minute	min. 700 V r.m.s.
Basic specification	IEC 115-1
Climatic category (IEC 68)	55/155/56

Stability after:	IEC requirement	typical value VR37	typical value VR68
1000 h max. load	ΔR ≤ 3%	ΔR 0,5%	ΔR 1%
accellerated damp heat test (6 days)	ΔR ≤ 3%	ΔR 0,5%	ΔR 1%
long term damp heat test (56 days)	ΔR ≤ 3%	ΔR 0,5%	ΔR 1%
Noise	2,5 μV/V	0,5 μV/V	0,5 μV/V

Composition of the catalogue number

2322 . . . 13 . . .

style code (first group of dots):
242 for VR37
244 for VR68

first digit after 13:
5 for R of 1 MΩ to 9,1 MΩ
6 for R of 10 MΩ to 68 MΩ

last two digits: first two digits of the resistance value

*) See the table "Standard series of values in a decade" at the back of the book.

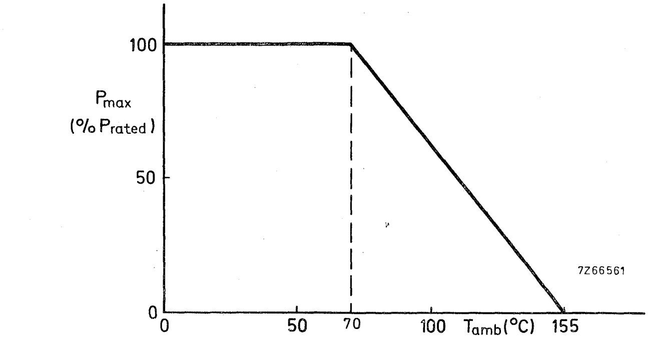


Fig. 2. Maximum dissipation (P_{max}) as a function of the ambient temperature (T_{amb}).

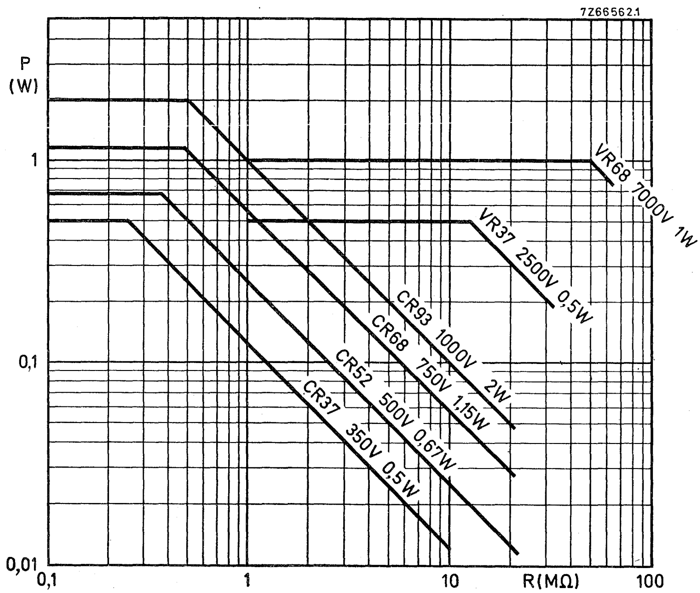


Fig. 3. Power versus resistance value of carbon- and high voltage resistors at T_{amb} = 70 °C.

TESTS AND REQUIREMENTS

IEC 115-1 clause	IEC 68 test method	Test	Procedure	Requirements
		Robustness of terminations		
18	Ua	Tensile all samples	load 10 N (1 kg) ; 10 s	
	Ub	Bending half number of samples	load 5 N (0,5 kg) ; 4 x 90^{0}	
	Uc	Torsion other half number of samples	3 x 360^{0} in opposite directions	no damage ΔR max. 0,5%
19	T	Soldering	solderability: 2 s 230 ^{0}C thermal shock: 3 s 350 ^{0}C, 6 mm from body	good tinning no damage ΔR max. 0,5%
20	Na	Rapid change of temperature	3 hours −55 ^{0}C/3 hours + 155 ^{0}C, 5 cycles	ΔR max. 0,5%
22	Fc	Vibration	frequency 10-500 Hz, displacement 1,5 mm or acceleration 10 g, three directions; total 6 h	no damage ΔR max. 0,5%
21	-	Bump	3 x 1500 bumps in three directions; 40 g	no damage ΔR max. 0,5%

TESTS AND REQUIREMENTS (continued)

IEC 115-1 clause	IEC 68 test method	Test	Procedure	Requirements
23		Climatic sequence		
23.1	Ba	Dry heat	16 hours, 155 °C	
23.3	D	Damp heat (accel) 1st cycle	24 hours, 55 °C, 95-100% R.H.	
23.4	Aa	Cold	2 hours, −55 °C	
23.5	M	Low air pressure	1 hour, 85 mbar, 15-35 °C	
23.6	D	Damp heat (accel) remaining cycles	5 days, 55 °C, 95-100% R.H.	R_{ins} min. 1000 MΩ ΔR max. 3%
24	Ca	Damp heat (steady state)	56 days, 40 °C, 90 - 95% R.H. The dissipation should not exceed: 1% of 0,5 W (5 mW) for VR37, or 1% of 1 W (10 mW) for VR68	R_{ins} min. 1000 MΩ ΔR max. 3%

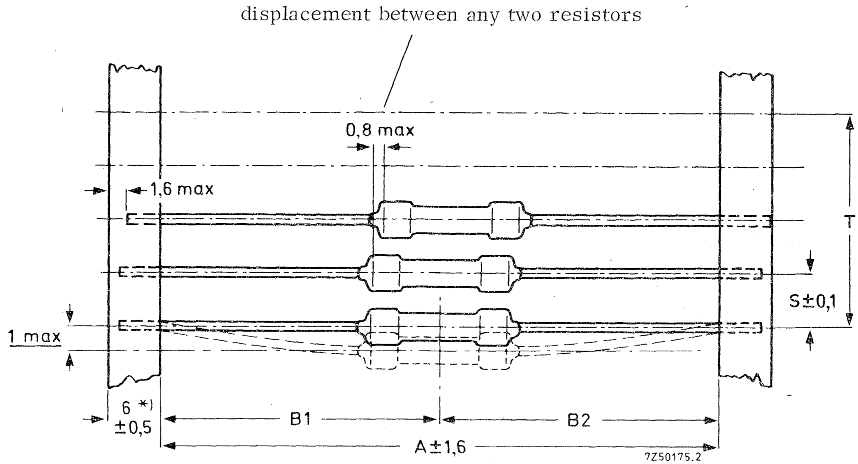
TESTS AND REQUIREMENTS (continued)

IEC 115-1 clause	IEC 68 test method	Test	Procedure	Requirements
26.2	-	Endurance	1000 hours ; 70 ^{o}C ; dissipation 0,5 W (VR37) 1,0 W (VR68) or limiting voltage	ΔR max. 3%
11	-	Temperature coefficient	between −55 ^{o}C and + 155 ^{o}C	±200 ppm/^{o}C
13	-	Voltage proof	700 V r.m.s.	no breakdown
14	-	Noise	IEC publication 195	max. 2,5 μV/V
9	-	Insulation Resistance		min. 10^4 MΩ

STANDARD PACKAGING

The resistors are supplied on bandolier, 1000 pcs per box.

Configuration of bandolier (dimensions in mm)

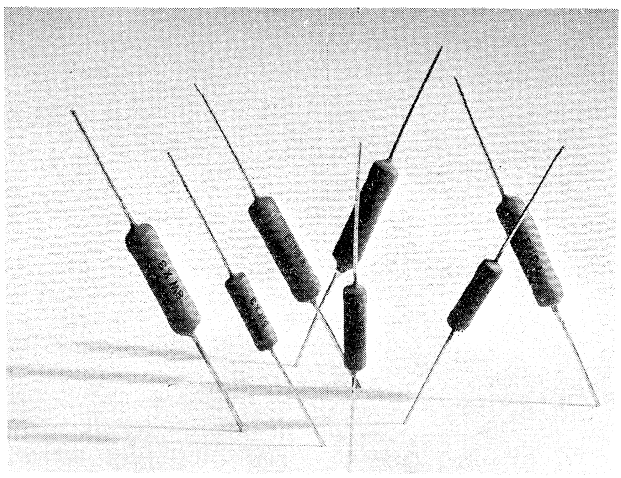


style	A	B1 - B2 ± max.	S	T for number (n) of resistors	
				n ≤ 50	50 < n ≤ 100
VR37	52,4	1,2	5	5 (n-1) ±2	5 (n-1) ±4
VR68	66,7	1,2	10	10 (n-1) ±2	10 (n-1) ±4

*) For style VR68 5 mm, but will become 6 mm in the future.

CEMENTED WIREWOUND RESISTORS

QUICK REFERENCE DATA	
Resistance ranges	from 5,6 Ω to 16 kΩ, E24 series
Resistance tolerance	5%
Max. body temperature	400 °C
Rated dissipation at T_{amb} = 70 °C	WR0617 4 W WR0825 7 W WR0842 9,5 W WR0865 15 W
Basic specification	IEC publication 266
Climatic category (IEC 68)	40/200/21 or 40/200/56
Stability after:	
load	ΔR/R max. 5%
climatic tests	ΔR/R max. 5%
short time overload	ΔR/R max. 2%



RZ 19806-1

APPLICATION

These wirewound load resistors are specifically designed to dissipate high loads in a small volume.

DESCRIPTION

On a ceramic rod with metal caps pressed over the ends a resistor element is wound in a single layer. The ends of the resistance wire and the leads are connected to the caps by welding. Tinned copperclad leads with a low heat conductivity are employed permitting the use of relatively short leads to obtain stable mounting.
The resistor is coated with a green-coloured cement which is noninflammable and cannot drip even at very high overloads.
The resistor is not electrically insulated.

MECHANICAL DATA

Dimensions in mm

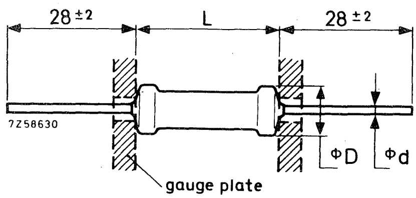


Fig. 1

Table I

Style	D_{max}	L_{max}	d
WR0617	6	19	0.6
WR0825	8	27	0.8
WR0842	8	44	0.8
WR0865	8	67	0.8

The length of the resistor body is measured by inserting the leads into the holes of two identical gauge plates and by moving these plates parallel to each other until the resistor body is clamped without deformation (see I.E.C. publication 294: Measurement of the dimensions of a cylindrical component having two axial terminations).

nominal lead diameter	dia of hole in gauge plate
0.6 mm	1.0 mm
0.8 mm	1.2 mm

Weight (per 100 pcs)

WR0617	100 g
WR0825	225 g
WR0842	530 g
WR0865	730 g

Mounting

The resistors must be mounted in such a way that:

- no stress is exerted on the leads so as to allow thermal expansion over the wide permissible temperature range.
- nearby components and materials are not affected by the dissipated heat.
- the temperature at the soldering spots of the leads does not reach the melting point of the solder.

The temperature rise of the resistor body and of the leads at various distances from the body is given as a function of the dissipation for the different resistor styles in Figs 2, 3a, 3b, 3c and 3d.

Marking

Each resistor is marked with:

- resistance value (R for Ω, K for kΩ)
  e.g. 27 Ω = 27R
  15 kΩ = 15K
- tolerance on resistance in ± %
- style
- date of manufacture

ELECTRICAL DATA

→ Table II, standard range

style	rated dissipation at T_{amb} = 70 °C (W)	resistance range (Ω)	series 1)	catalogue number
WR0617	4	5,6 - 4700	E24	2322 325 37...
WR0825	7	6,8 - 10 000	E24	2322 325 27...
WR0842	9,5	10 - 10 000	E24	2322 325 17...
WR0865	15	16 - 16 000	E24	2322 325 07...

Resistance tolerance	± 5%
Maximum permissible body temperature	400 °C
Ambient temperature range	−40 to +200 °C
Temperature coefficient	−50 to + 140 ppm/°C except for: WR0617, 10 Ω - 16 Ω and WR0825, 15 Ω - 33 Ω
Climatic category according to IEC 68	
for resistors withstanding 21 days damp heat test (Table III)	40/200/21
for resistors withstanding 56 days damp heat test (Table III)	40/200/56

Table III

style	resistance range	
	21 days damp heat test	56 days damp heat test
WR0617	160 - 4700 Ω	5,6 - 150 Ω
WR0825	430 - 10 000 Ω	6,8 - 390 Ω
WR0842	620 - 15 000 Ω	10 - 560 Ω
WR0865	910 - 16 000 Ω	16 - 820 Ω

Composition of the catalogue number

In the above-mentioned catalogue number replace the first two dots by the first two digits of the resistance value. Replace the third dot by a figure according to the following table:

5,6 -	9,1 Ω:	8
10 -	91 Ω:	9
100 -	910 Ω:	1
1 000 -	9 100 Ω:	2
10 000 -	16 000 Ω:	3

1) See the table "Standard series of values in a decade" at the back of this book.

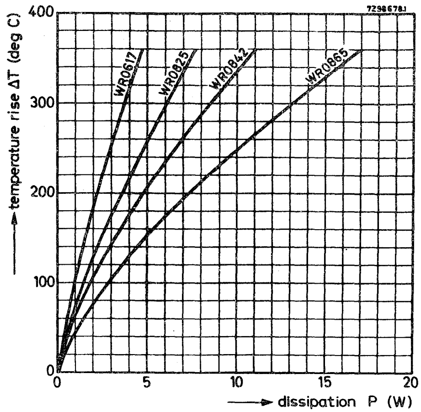


Fig. 2. Temperature rise of the resistor body as a function of the dissipation.

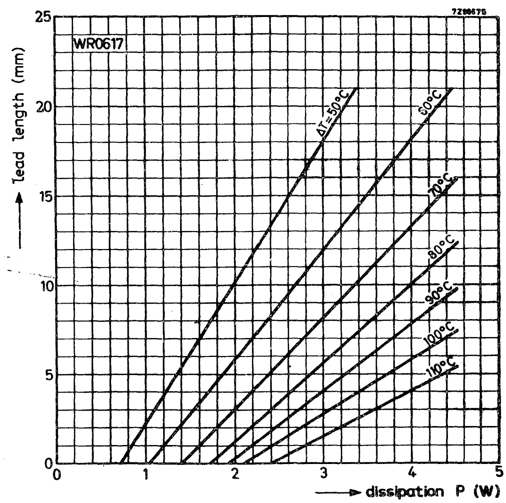


Fig. 3a. Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style WR0617.

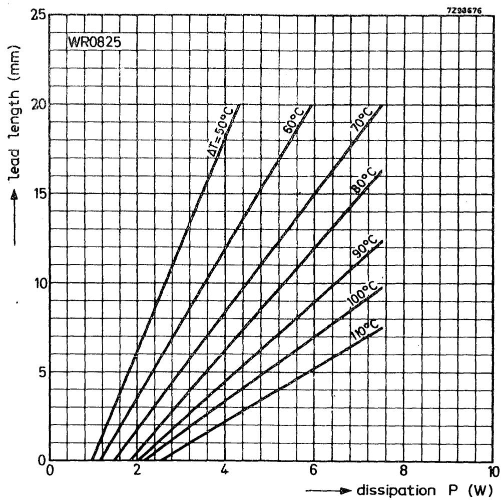


Fig. 3b. Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style WR0825.

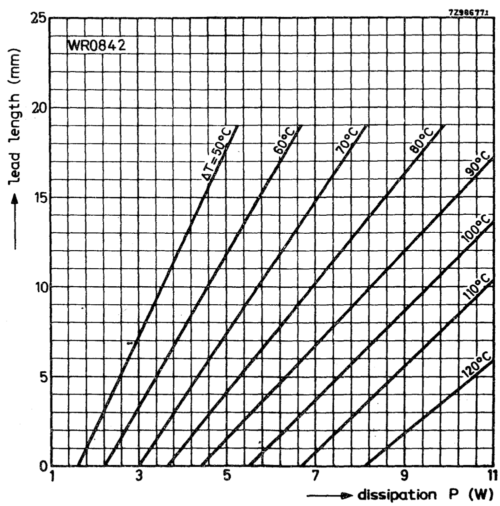


Fig. 3c. Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style WR0842.

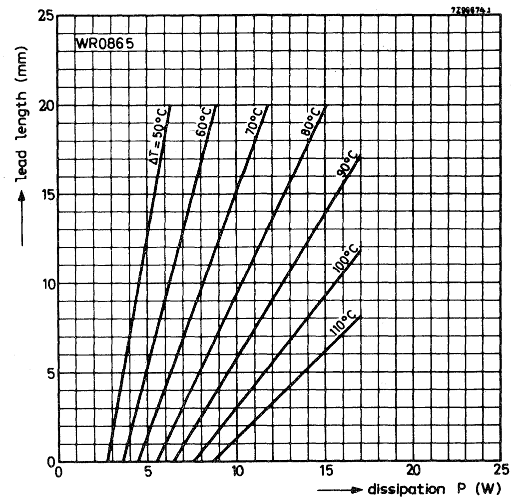
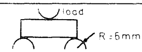


Fig.3d. Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style WR0865.

TESTS AND REQUIREMENTS (in accordance with I.E.C. publ. 266)

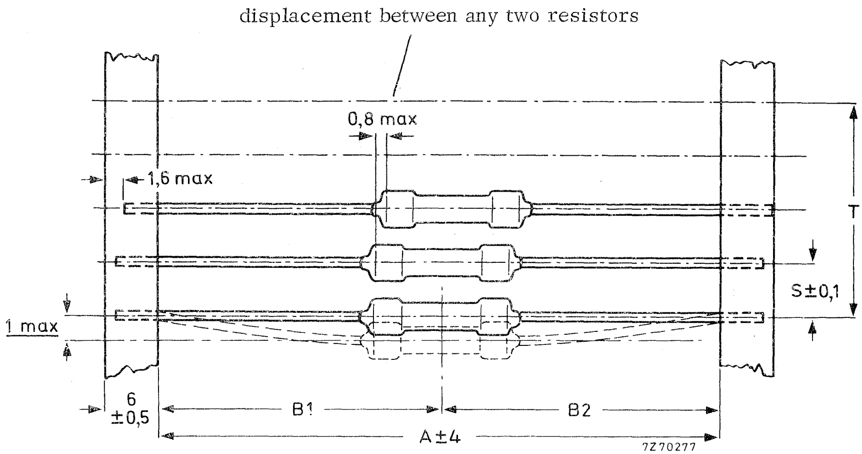
Table IV

I.E.C. 266 clause	I.E.C. 68 test method	Test	Procedure	Requirements
14		robustness of resistor body	 load 200 ± 10 N	no visible damage ΔR ≤ 0.5% or 0.05 Ω
15	U Ua Ub Uc	robustness of terminations: tensile, all samples bending, half number of samples torsion, other half number of samples	 load 10 N, 10 s load 5 N, 4 x 90° 2 x 180° in opposite directions	 no visible damage ΔR ≤ 0.5% or 0.05 Ω
16	T	soldering: solderability thermal shock	 2s 230 °C (class II) 3s 350 °C, 2.5 mm from body	 good tinning, no damage no damage, ΔR ≤ 0.5% or 0.05 Ω
17	Na	rapid change of temperature	3 h −40 °C/3 h + 200 °C, 5 cycles	no visible damage ΔR ≤ 1%
18	Fc	vibration	10 − 500 Hz, 0.75 mm or 10 g, whichever is the less, for 6 h	no visible damage ΔR ≤ 0.5% or 0.05 Ω
19	Eb	bumping	390 m/s², 4000 ± 10 bumps	no visible damage ΔR ≤ 0.5% or 0.05 Ω
20 20.2 20.3 20.4 20.5 20.6	 Ba Aa M D	climatic sequence: dry heat damp heat (accelerated) 1st cycle cold low air pressure damp heat (accelerated) remaining cycles	 16 h 200 °C 1 day 55 °C, 95-100% R.H. 2 h −40 °C 1 h 8.5 kN/m², 15-35 °C 5 days 55 °C, 95-100% R.H.	final measurements: ΔR ≤ 5%, category -/-/21 after 24 h at rated diss. ΔR ≤ 5%
21	Ca	damp heat long term	21 or 56 days (see Table III) 40 °C, 90-95% R.H., 0.01 Prated	ΔR ≤ 5%, after 24 h at rated diss. R ≤ 5%
13.6 22 23		overload endurance endurance	10 times rated dissipation, 5 s 1000 h at room temperature 1000 h at upper category temperature	ΔR ≤ 2% ΔR ≤ 5% ΔR ≤ 5%

STANDARD PACKAGING

style	number per box	
	bandolier	singles
WR0617	500	
WR0825	500	
WR0842		50
WR0865		50

Configuration of bandolier (dimensions in mm)



style	A	B1 - B2 ± max.	S	T for number (n) of resistors	
				n ≤ 50	50 < n ≤ 100
WR0617	66	1,2	10	10 (n-1) ±2	10 (n-1) ±4
WR0825	74	1,2	10	10 (n-1) ±2	10 (n-1) ±4

ENAMELLED WIREWOUND RESISTORS

QUICK REFERENCE DATA		
Resistance ranges		from 4,7 Ω to 100 kΩ, E12 or E24 series
Resistance tolerance		± 5%
Max. body temperature (hot spot)		400 °C
Rated dissipation at T_{amb} = 70 °C,	WR 0617 E	4,2 W
	WR 0825 E	7 W
	WR 0842 E	11 W
	WR 0865 E	17 W
Basic specification		IEC publication 266, type 2
Climatic category (IEC 68)		55/200/56
Stability after:		
1000 h max. load		ΔR/R max. 5 %
climatic tests		ΔR/R max. 1 %
dip-soldering test		ΔR/R max. 0,5%
short time overload		ΔR/R max. 2 % or 0,1 Ω

APPLICATION

As power resistors in electrical and electronic circuitry.

DESCRIPTION

These resistors have a single layer of resistance wire wound on a ceramic body. Leads of solder-coated copper-clad wire are secured to caps which are force-fitted on to the ends of the ceramic body.
The resistor is coated with brown enamel.

MECHANICAL DATA

Dimensions in mm

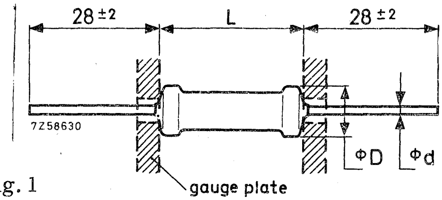


Fig. 1

Style	D_{max}	L_{max}	d
WR0617E	6	19	0,7
WR0825E	8	27	0.8
WR0842E	8	44	0.8
WR0865E	8	67	0.8

The length of the resistor body is measured by inserting the leads into the holes of two identical gauge plates and by moving these plates parallel to each other until the resistor body is clamped without deformation (see IEC publication 294: Measurement of the dimensions of a cylindrical component having two axial terminations).

Diameter of hole in gauge plate 1,0 mm

Mounting

The resistors must be mounted in such a way that:

- no stress is exerted on the leads so as to allow thermal expansion over the wide temperature range.
- nearby components and materials are not affected by the dissipated heat.

Marking

Each resistor is marked with:

Style WR0617E:
- resistance value (R for Ω, K for kΩ)
  e.g. 27 Ω = 27R
  27 kΩ = 27K
- tolerance on resistance in code: J = ±5%
- 0617

The marking of resistor 2322 330 22519 is therefore: 51RJ 0617

Style WR0825E, WR0842E, WR0865E:
- resistance value (R for Ω, K for kΩ)
- tolerance on resistance in %
- WR0825, WR0842, WR0865 respectively

The marking of resistor 2322 330 32519 is therefore: 51R 5% WR0825

ELECTRICAL DATA

style	rated dissipation at T_{amb} = 70 °C (W)	resistance range (Ω)	series 1)	catalogue number
WR0617E	4,2	4,7 - 4700	E24	2322 330 22...
WR0825E	7	6,8 - 27 000	E24	2322 330 32...
WR0842E	11	10 - 56 000	E24	2322 330 42...
WR0865E	17	15 - 100 000	E24	2322 330 52...

Resistance tolerance		±5%
Maximum body temperature (hot spot)		400 °C
Ambient temperature range		−55 to +200 °C
Temperature coefficient WR0617E	4,7 to 16 Ω	(−50 to +250) ppm/°C
	> 16 Ω	(−50 to +140) ppm/°C
WR0825E	6,8 to 33 Ω	(−50 to +250) ppm/°C
	> 33 Ω	(−50 to +140) ppm/°C
WR0842E and WR0865E		(−50 to +140) ppm/°C
Climatic category (IEC 68)		55/200/56

1) See the table "Standard series of values in a decade" at the back of this book.

Composition of the catalogue number

In the above mentioned catalogue number replace the first two dots by the first two digits of the resistance value. Replace the third dot by a figure according to the following table:

4.7	-	9.1	Ω: 8
10	-	91	Ω: 9
100	-	910	Ω: 1
1 000	-	9 100	Ω: 2
10 000	-	91 000	Ω: 3
		100 000	Ω: 4

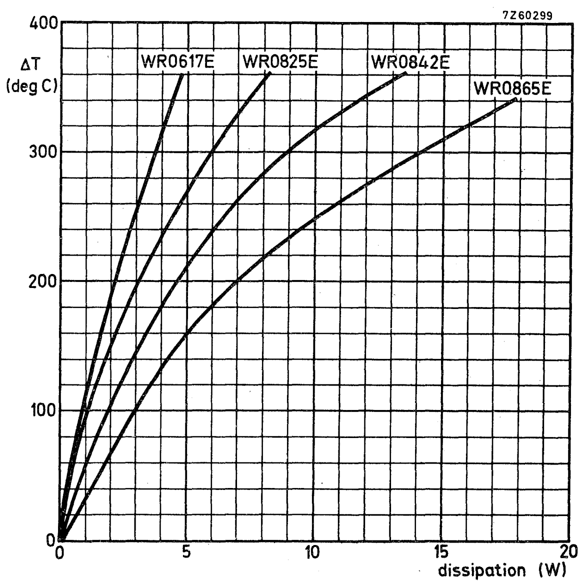
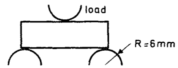


Fig. 2 Temperature rise (ΔT) of the resistor body as a function of the dissipation. Distance between cap and solder joint is 10 mm.

TESTS AND REQUIREMENTS (in accordance with IEC publ. 266)

IEC 266 clause	IEC 68 test method	Test	Procedure	Requirements
14		robustness of resistor body	 load 200 ± 10 N	no visible damage $\Delta R \leq 0.5\%$ or $0.05\,\Omega$
15	U	robustness of terminations:		
	Ua	tensile, all samples	load 10 N, 10 s	
	Ub	bending, half number of samples	load 5 N, 4 x 90^{o}	
	Uc	torsion, other half number of samples	2 x 180^{o} in opposite directions	no visible damage $\Delta R \leq 0.5\%$ or $0.05\,\Omega$
16	T	soldering: solderability thermal shock	 2s 230 °C (class II) 3s 350 °C, 6 mm from body	 good tinning, no damage no damage, $\Delta R \leq 0.5\%$ or $0.05\,\Omega$
17	Na	rapid change of temperature	3 h –55 °C/3 h + 200 °C, 5 cycles	no visible damage $\Delta R \leq 1\%$
18	Fc	vibration	10 - 500 Hz, 0.75 mm or 10 g, whichever is the less, for 6 h	no visible damage $\Delta R \leq 0.5\%$ or $0.1\,\Omega$
19	Eb	bumping	390 m/s^2, 4000 ± 10 bumps	no visible damage $\Delta R \leq 0.5\%$ or $0.1\,\Omega$

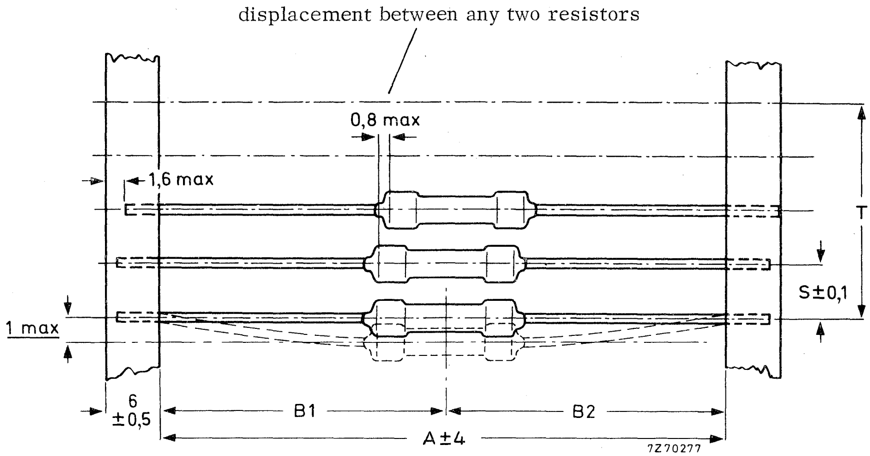
TESTS AND REQUIREMENTS, continued

IEC 266 clause	IEC 68 test method	Test	Procedure	Requirements
20		climatic sequence:		final measurements:
20.2	Ba	dry heat	16 h 200 °C	
20.3		damp heat (accelerated) 1st cycle	1 day 55 °C, 95-100% R.H.	
20.4	Aa	cold	2 h −55 °C	
20.5	M	low air pressure	1 h 8.5 kN/m^2, 15-35 °C	$\Delta R \leq 5\%$, category -/-/21
20.6	D	damp heat (accelerated) remaining cycles	5 days 55 °C, 95-100% R.H.	after 24 h at rated diss. $\Delta R \leq 5\%$
21	Ca	damp heat long term	21 or 56 days (see Table III) 40 °C, 90-95% R.H., 0.01 P_{rated}	$\Delta R \leq 1\%$, after 24 h at rated diss. $\Delta R \leq 1\%$
13.6		overload	2 times rated dissipation, 10 min 10 times rated dissipation, 5 s	$\Delta R \leq 2\%$
22		endurance	1000 h at 70 °C	$\Delta R \leq 5\%$
23		endurance	1000 h at upper category temperature	$\Delta R \leq 5\%$

STANDARD PACKAGING

style	number per box	
	bandolier	singles
WR 0617 E	500	
WR 0825 E	500	
WR 0842 E		50
WR 0865 E		50

Configuration of bandolier (dimensions in mm)



style	A	B1 - B2 ± max	S	T for number (n) of resistors	
				n ≤ 50	50 < n ≤ 100
WR 0617 E	66	1,2	10	10 (n-1) ± 2	10 (n-1) ± 4
WR 0825 E	74	1,2	10	10 (n-1) ± 2	10 (n-1) ± 4

RECTANGULAR WIREWOUND RESISTORS

QUICK REFERENCE DATA		
Resistance ranges		from 0,15 Ω to 12 kΩ E24 series
Resistance tolerance		±5% or ±10%
Max. body temperature (hot spot)		350 °C
Rated dissipation at T_{amb} = 40 °C,	2306 330	5 W
	2306 331	8 W
	2306 332	10 W
	2306 333	15 W
Basic specification		IEC publication 266
Climatic category (IEC 68)		40/200/56
Stability after:		
1000 h rated dissipation		ΔR/R max. 5 %
climatic tests		ΔR/R max. 3 %
short time overload		ΔR/R max. 2 %

APPLICATION

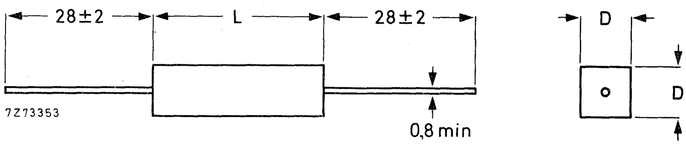
These resistors have been designed for high dissipation in a small volume. Their rectangular shape facilitates mounting against a flat surface.

DESCRIPTION

The resistor element is wound in a single layer on a glass fibre rod. Metal caps are pressed over the ends of rod and wire. Tinned copper leads are welded to the caps. The resistor is mounted in a rectangular, sand-filled, ceramic case. The ends of the body are impregnated with a protective silicon resin.

MECHANICAL DATA

Dimensions (mm)



	D max.	L max.
2306 330	7,2	26
2306 331	7,2	36
2306 332	7,2	46
2306 333	10,2	62

Weight (per 100 pcs)

2306 330	310 g
2306 331	400 g
2306 332	510 g
2306 333	1400 g

Mounting

The resistors must be mounted in such a way that:

- no stress is exerted on the leads so as to allow thermal expansion over the wide permissible temperature range.
- nearby components and materials are not affected by the dissipated heat.
- the temperature at the soldering spots of the leads does not reach the melting point of the solder.

Marking

Each resistor is marked with:

- resistance value (R for Ω, K for kΩ)
  e.g. 27 Ω = 27R
  15 kΩ = 15K
- tolerance on resistance in ± %
- rated dissipation at T_{amb} = 40 °C
- date of manufacture

ELECTRICAL DATA

Standard range

rated dissipation (W) at T_{amb} = 40 °C	70 °C	resistance range (Ω)	tolerance ± (%)	series [1]	catalogue number
5	4	0,15 - 9,1	10 [2]	E24	2306 330 02...
		10 - 4700	5	E24	2306 330 03...
8	7	0,27 - 9,1	10 [2]	E24	2306 331 02...
		10 - 8200	5	E24	2306 331 03...
10	8	0,33 - 9,1	10 [2]	E24	2306 332 02...
		10 - 10000	5	E24	2306 332 03...
15	12	0,47 - 9,1	10 [2]	E24	2306 333 02...
		10 - 12000	5	E24	2306 333 03...

Breakdown r.m.s. voltage of encapsulation	min. 1000 V
Max. permissible body temperature	350 °C
Ambient temperature range	-40 to +200 °C
Temperature coefficient 0,15 - 5,1 Ω	±400 ppm/°C
5,6 - 12000 Ω	±250 ppm/°C
Climatic category (IEC 68)	40/200/56

Composition of the catalogue number

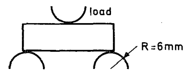
In the above-mentioned catalogue number replace the first two dots by the first two digits of the resistance value. Replace the third dot by a figure according to the following table:

0,15	-	0,91	Ω: 7
1	-	9,1	Ω: 8
10	-	91	Ω: 9
100	-	910	Ω: 1
1000	-	9100	Ω: 2
10000	-	16000	Ω: 3

1) See the table "Standard series of values in a decade" at the back of the book.

2) Tolerance of 5% on request.

TESTS AND REQUIREMENTS (in accordance with IEC publ. 266)

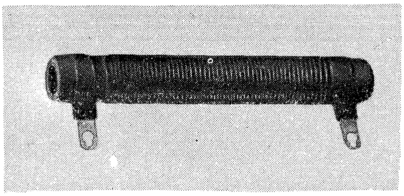
IEC 266 clause	IEC 68 test method	Test	Procedure	Requirements
14		robustness of resistor body	 load 200 ±10 N	no visible damage $\Delta R \leq 0,5\%$ or $0,05\ \Omega$
15	U	robustness of terminations:		
	Ua	tensile, all samples	load 10 N, 10 s	
	Ub	bending, half number of samples	load 5 N, 4 x 90°	
	Uc	torsion, other half number of samples	2 x 180° in opposite directions	no visible damage $\Delta R \leq 0,5\%$ or $0,05\ \Omega$
16	T	soldering: solderability thermal shock	 2s 230 °C (class II) 3s 350 °C, 2,5 mm from body	 good tinning, no damage no damage, $\Delta R \leq 0,5\%$ or $0,05\ \Omega$
17	Na	rapid change of temperature	3 h – 40 °C/3 h +200 °C, 5 cycles	no visible damage $\Delta R \leq 1\%$
18	Fc	vibration	10 - 500 Hz, 0,75 mm or 10g, whichever is the less, for 6 h	no visible damage $\Delta R \leq 0,5\%$ or $0,05\ \Omega$
19	Eb	bumping	$390 m/s^2$, 4000 ± 10 bumps	no visible damage $\Delta R \leq 0,5\%$ or $0,05\ \Omega$

TESTS AND REQUIREMENTS, continued

IEC 266 clause	IEC 68 test method	Test	Procedure	Requirements
20		climatic sequence:		final measurements:
20.2	Ba	dry heat	16 h 200 °C	
20.3		damp heat (accelerated) 1st cycle	1 day 55 °C, 95-100% R.H.	ΔR ≤ 3%
20.4	Aa	cold	2 h - 40 °C	
20.5	M	low air pressure	1 h 85 mbar, 15-35 °C	
20.6	D	damp heat (accelerated) remaining cycles	5 days 55 °C, 95-100% R.H.	after 24 h at rated diss. ΔR ≤ 3%
21	Ca	damp heat long term	56 days 40 °C, 90-95% R.H., 0,01 P_{rated}	ΔR ≤ 3%, after 24 h at rated diss. ΔR ≤ 3%
13.6		overload	10 times rated dissipation, 5 s	ΔR ≤ 2%
22		endurance	1000 h at 40 °C, rated dissipation	ΔR ≤ 5%
23			1000 h at upper category temperature	ΔR ≤ 5%

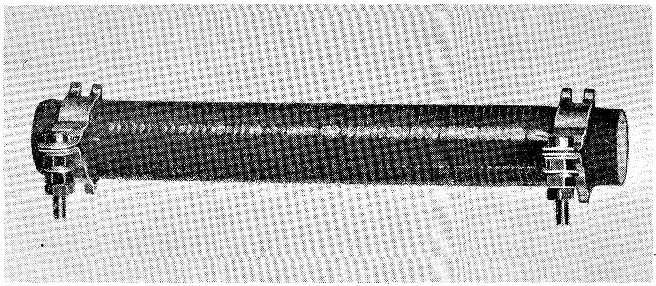
WIRE-WOUND RESISTORS WITH SIDE TERMINATIONS

$\leq$ 40 W



RZ 14250-1A

$\geq$ 60 W



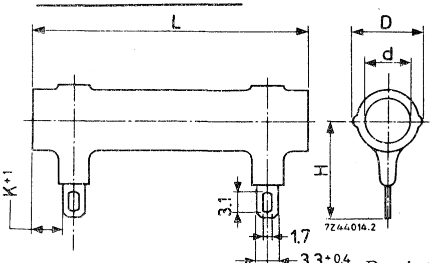
RZ 14250-1B

	cemented	enamelled
Max. dissipation at 40 °C (P_{nom})	8 - 250 W	8 - 100 W
Resistance values	1 Ω - 11 kΩ	160 Ω - 120 kΩ
Tolerance	±5 % (±10 %)	±5 %

CONSTRUCTION

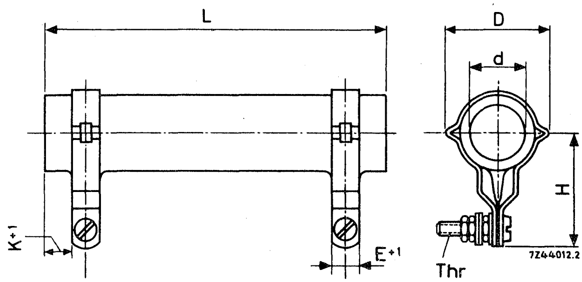
The resistors consist of one layer of resistance wire on a ceramic cylinder with side terminations. The 323-resistors are coated with cement, the 321-resistors with enamel for mechanical protection.

Dimensions in mm



P_{nom} (W)	D_{max}	d_{min}	K	L	H
8	11.5	5	2.5	26^{-2}	14
10	11.5	5	4	41^{-2}	14
16	11.5	5	4	62.5^{-2}	14
25	16	8	4	64^{-2}	20
40	16	8	4	103^{-5}	20

Resistors with $P_{nom} \leq 40$ W

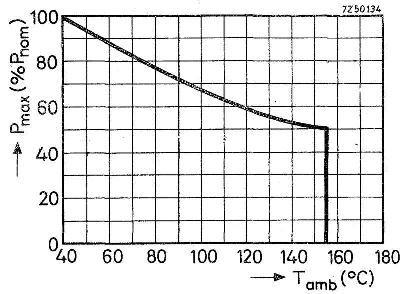


Resistors with $P_{nom} \geq 60$ W

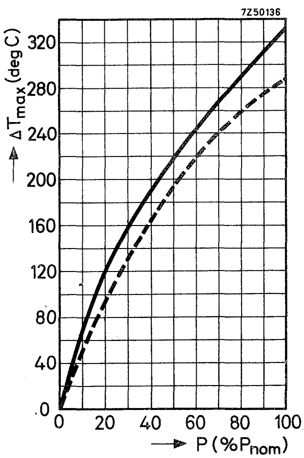
P_{nom} (W)	D_{max} (mm)	d_{min} (mm)	E (mm)	H (mm)	K (mm)	L (mm)	Thr (mm)
60	32	12.5	8.5	33	6	103^{-5}	M4
100	32	12.5	8.5	33	6	165^{-8}	M4
160	44	20	10	40	8	165^{-8}	M5
250	44	20	10	40	8	256^{-10}	M5

TECHNICAL PERFORMANCE

Max. dissipation at 40 °C (= P_{nom})	see Schedule
at > 40 °C	see relevant graph
Max. dissipation, mounted, with a bolt through the cylinder, against a metal plate	1.2 x max. dissipations given above
Max. overload at 40 °C	2 P_{nom} during 10 minutes, 10 P_{nom} during 5 seconds
Resistance values (see Schedule)	measured at P = 0.1 P_{nom}
Tolerance	±5 % (±10 %)
Temperature coefficient	(−50 to +140) 10^{-6}/deg C
Change in resistance after load tests	< 5 %
after climatic tests	<3 %
Insulation	the coating is non-insulating
Ambient temperature range	−55 to +155 °C
Climatic robustness	category 55/155/56 (IEC 68)



Max. dissipation as a function of the ambient temperature. With a bolt through the resistor, mounted against a metal plate, P_{max} can be multiplied by 1.2.



Max. temperature rise as a function of the dissipation. The broken line applies to mounting with bolt and plate.

SCHEDULE

coating	P_{nom} (W)	resistance values tol. (±..%)	min. (Ω)	max. (Ω)	D_{max} x L_{max} (mm x mm)	catalog number: 2322 followed by
cement	8	10	1	100	11.5 x 26	323 14...
		5	110	150		323 34...
enamel		5	160	6 800		321 34...
cement	10	10	1.2	27	11.5 x 41	323 12...
		5	30	300		323 32...
enamel		5	330	12 000		321 32...
cement	16	10	1.5	2.7	11.5 x 62.5	323 10...
		5	3	620		323 30...
enamel		5	680	24 000		321 30...
cement	25	10	2.7	15	16 x 64	323 08...
		5	16	820		323 28...
enamel		5	1 000	39 000		321 28...
cement	40	5	4.7	1 600	16 x 103	323 26...
enamel		5	1 800	75 000		321 26...
cement	60	5	3	2 200	32 x 103	323 24...
enamel		5	2 400	68 000		321 24...
cement	100	5	6.8	4 300	32 x 165	323 23...
enamel		5	4 700	120 000		321 23...
cement	160	5	10	6 800	44 x 165	323 22...
cement	250	5	16	11 000	44 x 256	323 21...

Standard resistance values within the given range can be chosen from the E12 series. Resistance values of the E24 series (tol. ± 5%) are available on request. (See Table at the back of this handbook)

Composition of the catalog number, for ordering

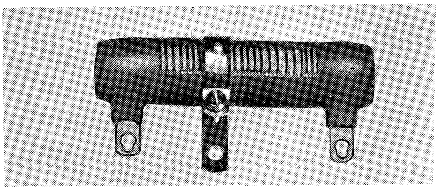
2322 ... .

See table ←

The first two digits of the resistance value, neglecting a decimal point. ←

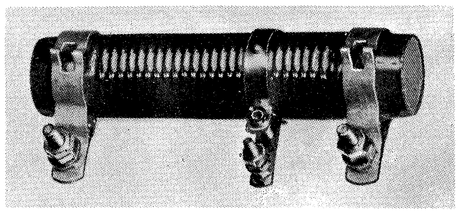
→ 8 for R of 1 to 8,2 Ω
9 for R of 10 to 82 Ω
1 for R of 100 to 820 Ω
2 for R of 1 to 8,2 kΩ
3 for R of 10 to 82 kΩ
4 for R of 100 to 120 kΩ

ADJUSTABLE WIRE-WOUND RESISTORS



RZ 14250-1C

≤ 40 W



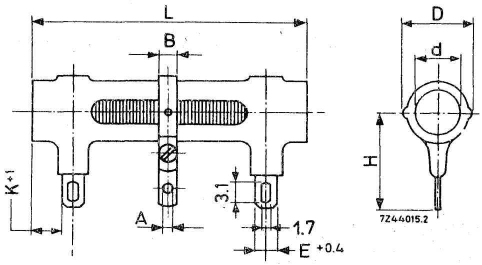
≥ 60 W

	cemented	enamelled
Max. dissipation at 40 °C (P_{nom})	10 - 250 W	10 - 100 W
Resistance values	1.2 Ω - 11 kΩ	330 Ω - 47 kΩ
Tolerance	±5 % (10 %)	±5 %

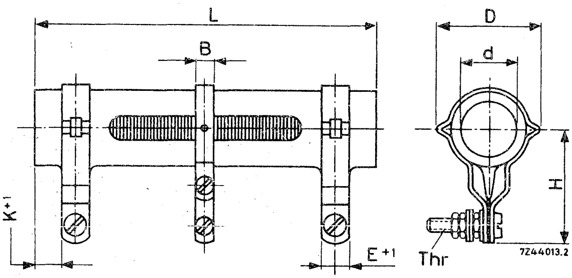
CONSTRUCTION

The resistors consist of one layer of resistance wire on a ceramic cylinder with side terminations. A strap, fitted with a silver contact, may be adjusted to any point along an uncoated strip of the resistor. The 324-resistors are coated with cement, the 322-resistors with enamel for mechanical protection.

Dimensions in mm



Resistors with $P_{nom} \leq 40$ W



Resistors with $P_{nom} \geq 60$ W

P_{nom} (W)	dimensions in mm								
	D_{max}	d_{min}	H	K	E	L	B	A	Thr
10	11.5	4.2	14	4	3.3	41^{-2}	5	2.8	-
16	11.5	4.2	14	4	3.3	62.5^{-2}	5	2.8	-
25	16	7.2	20	4	3.3	64^{-2}	6	3.2	-
40	16	7.2	20	4	3.3	103^{-5}	6	3.2	-
60	32	12.5	33	6	8.5	103^{-5}	6	-	M4
100	32	12.5	33	6	8.5	165^{-8}	6	-	M4
160	44	20	40	8	10	165^{-8}	8	-	M5
250	44	20	40	8	10	256^{-10}	8	-	M5

TECHNICAL PERFORMANCE

Identical to that of the non-adjustable wire-wound resistors with side terminations, see 323 and 321 series.

SCHEDULE

coating	P_{nom} 1) (W)	resistance values (R_{nom}) 1) tol. (±..%)	min. (Ω)	max. (Ω)	short circuit 1) (% R_{nom})	D_{max} x L_{max} (mm x mm)	cat. number 2322 followed by
cement	10	10	1.2	27	9	11.5 x 41	324 12...
		5	30	300			324 32...
enamel		5	330	3 300			322 32...
cement	16	10	1.5	2.7	5	11.5 x 62.5	324 10...
		5	3	620			324 30...
enamel		5	680	6 800			322 30...
cement	25	10	2.7	15	4	16 x 64	324 08...
		5	16	820			324 28...
enamel		5	1 000	9 100			322 28...
cement	40	5	4.7	1 600	2.5	16 x 103	324 26...
enamel		5	1 800	18 000			322 26...
cement	60	5	3	2 200	3	32 x 103	324 24...
enamel		5	2 400	24 000			322 24...
cement	100	5	6.8	4 300	1.5	32 x 165	324 23...
enamel		5	4 700	47 000			322 23...
cement	160	5	10	6 800	1.5	44 x 165	324 22...
cement	250	5	16	11 000	1	44 x 256	324 21...

Standard resistance values within the given range can be chosen from the E12 series: Resistance values of the E24 series (tol. ±5%) are available on request. (See Table at the back of this handbook)

Composition of the catalog number, for ordering

2322 ... .

See table ←

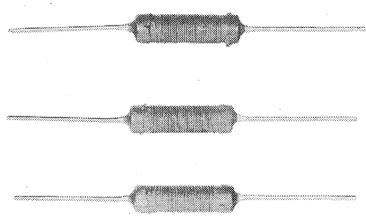
The first two digits of the nominal resistance value, neglecting a decimal point. ←

→ 8 for R of 1,2 to 8,2 Ω
9 for R of 10 to 82 Ω
1 for R of 100 to 820 Ω
2 for R of 1 to 8,2 kΩ
3 for R of 10 to 47 kΩ

1) The adjustable contact short-circuits a number of windings. The maximum resistance loss has been given as a percentage of the nominal resistance. Nominal dissipation and nominal resistance values apply if no contact strap were connected.

LOW-OHMIC WIRE-WOUND RESISTORS

QUICK REFERENCE DATA	
Resistance range	0, 1 to 10 Ω, E24 series
Resistance tolerance	± 10%
Maximum dissipation at T_{amb} = 70 °C	2 W



RZ 24108-2

APPLICATION

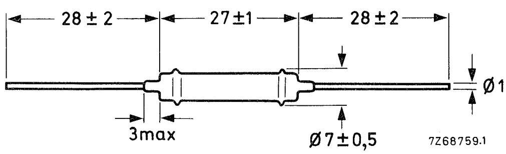
In transistor circuits

DESCRIPTION

The resistors consist of a layer of resistance wire on a ceramic bar and two caps with tinned leads. The body is coated with a green cement.

MECHANICAL DATA

Dimensions (mm)



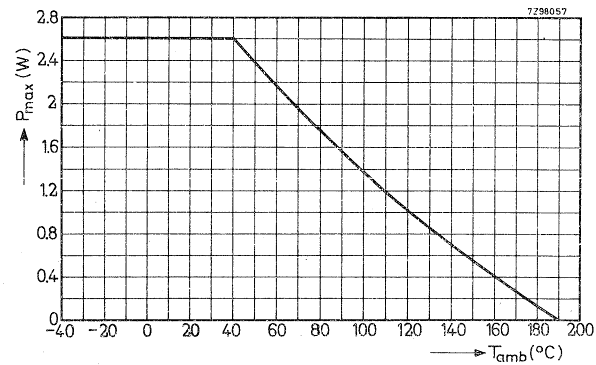
Marking

Each resistor is marked with:
- resistance value (R for Ω, K for kΩ)
- tolerance on resistance
- max. dissipation at 70 °C (2 W)
- period of production

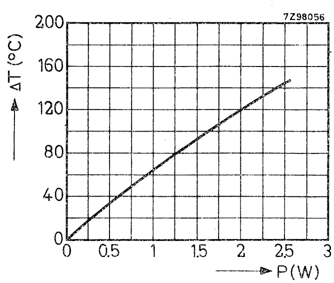
e.g. 6R8 ± 10%
2 W 24

ELECTRICAL DATA

Max. dissipation at T_{amb} = 40 °C	2,6 W
at other temperatures	see relevant graph
Operating body temperature	−40 to + 190 °C
Resistance values, measured at P ≤ 0,2 W	0,1 to 10 Ω, E24 series
Resistance tolerance	± 10%
Temperature coefficient	
for 0,1 to 1 Ω resistors	(0 to + 600) ppm/°C
for 1,1 to 10 Ω resistors	(−50 to + 25) ppm/°C
Change in resistance remaining after load tests and after climatic tests	≤ 1,5%
Climatic category conforming to NT-14-2-4	505



Maximum dissipation as a function of the ambient temperature



Rise of body temperature as a function of the dissipation

COMPOSITION OF THE CATALOGUE NUMBER

2322 326 51...

resistance code

The resistance code consists of the two significant figures of the resistance value (in Ω) followed by a figure for the multiplier, the multiplier code being:

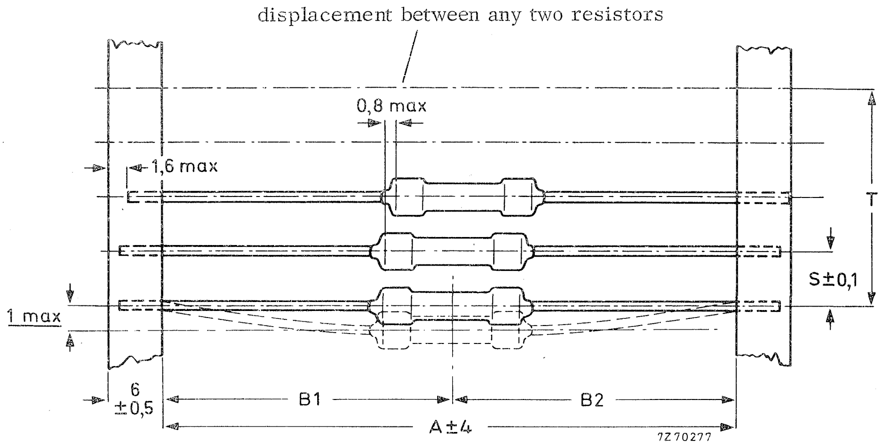
x 0,01 = 7
x 0,1 = 8
x 1 = 9

Examples: 107 for 0,1 Ω; 917 for 0,91 Ω; 438 for 4,3 Ω; 109 for 10 Ω

STANDARD PACKAGING

The resistors are supplied on bandolier, 500 pcs per box.

Configuration of bandolier (dimensions in mm)



A	B1 - B2 ± max.	S	T for number (n) of resistors	
			n ≤ 50	50 < n ≤ 100
74	1,2	10	10 (n-1) ± 2	10 (n-1) ± 4

LOW-OHMIC GLASS-SEALED WIRE RESISTORS

RZ 20704-9

Maximum dissipation at 40 °C	1 W
Resistance values	0.1 to 6.8 Ω, E12 series
Tolerance	±10 %

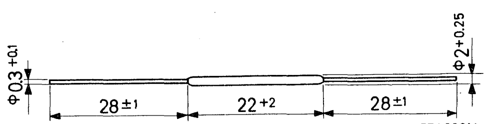
APPLICATION

In transistor circuits

CONSTRUCTION

The resistors consist of a glass-sealed resistance wire provided with tinned leads.

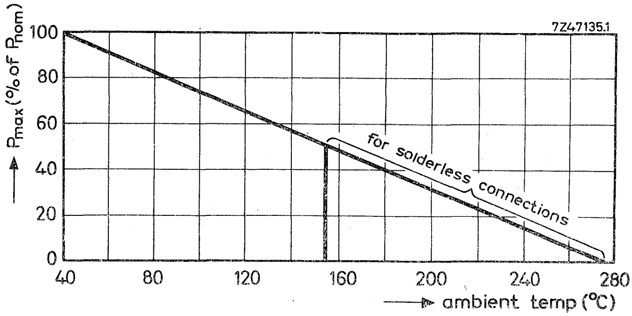
Dimensions in mm



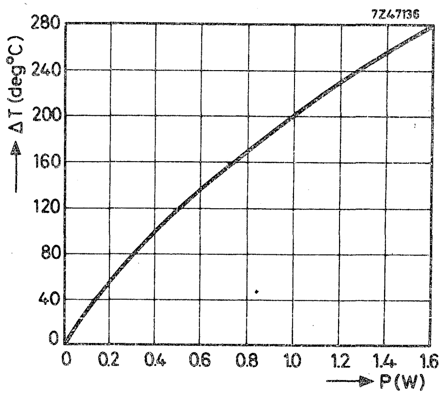
TECHNICAL PERFORMANCE

The resistances (nominal value and tolerance) are measured at P = 0.1 W and between points 30 mm apart.

Tolerance	±10 %
Resistance change remaining after climatic tests.	< 5 %
Temperature coefficient	$(-50 \text{ to } +150)10^{-6}$/deg C
Operating body temperature	−25 to +275 °C
Max. dissipation at 40 °C (P_{nom})	1 W
Climatic robustness	category 25/155/56 (IEC 68)



Maximum dissipation as a function of the ambient temperature



Rise of body temperature as a function of the dissipation

SCHEDULE

Composition of the catalog number, for ordering:

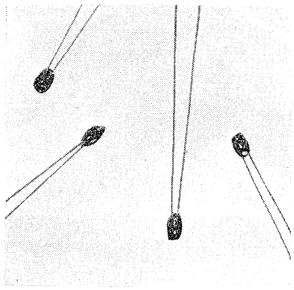
2322 327 61...
→ resistance code, see table

resistance (Ω)	resistance code
0.1	107
0.12	127
0.15	157
0.18	187
0.22	227
0.27	277
0.33	337
0.39	397
0.47	477
0.56	567
0.68	687
0.82	827

resistance (Ω)	resistance code
1	108
1.2	128
1.5	158
1.8	188
2.2	228
2.7	278
3.3	338
3.9	398
4.7	478
5.6	568
6.8	688

INSULATED PIN-HEAD CARBON RESISTORS

QUICK REFERENCE DATA	
Max. dissipation at T_{amb} = 70 °C	0,05 W
Resistance range	33 Ω to 180 kΩ, E12 series
Resistance tolerance	± 10% and ± 20%
Noise	< 10 μV/V



RZ 15568-5

APPLICATION

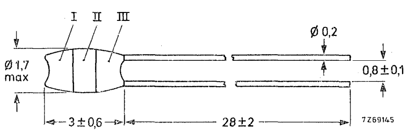
In hearing aids, small-distance communication sets, weather radio probes.

DESCRIPTION

The resistors consist of a pellet of carbon composition between the parallel connection leads. The pellet is coated with synthetic resin.

MECHANICAL DATA

Dimensions in mm



Soldering

- Do not solder or bend the leads less than 0,5 mm from the resistor body.
- The resistor is not suitable for wave soldering.

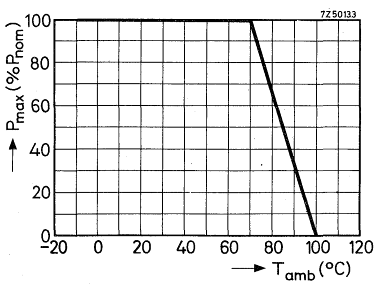
Colour code, for resistance values in Ω;

colour	band I, first digit	band II, second digit	band III, multi-plier
black	-	0	x 1
brown	1	1	x 10
red	2	2	x 100
orange	3	3	x 1000
yellow	4	4	x 10 000
green	5	5	
blue	6	6	
violet	7	7	
grey	8	8	
white	9	9	

ELECTRICAL DATA

For tests and measuring methods see IEC publications 109 and 115

Max. dissipation at 70 °C (=P_{nom}) at other temperatures	0,05 W see respective graph
Limiting voltage, peak value	50 V
Resistance values, measured at $P \leq 0,1\ P_{nom}$	33 Ω to 180 kΩ, E 12 series [1])
Tolerances	± 10% and ± 20%
Temperature coefficient (from +25 to +70 °C)	(+ 1000 to −2000) ppm/°C
Voltage dependence $\frac{\Delta R}{R} = f(V)$	< 0,3%/V
Ambient temperature range	− 10 to + 100 °C
Noise	< 10 μV/V
Change in resistance after:	
- mechanical force of 1 N (100 g) along axis of connection	< 1%
- mechanical force of 0,5 N (50 g) normal to axis of connection	< 1%
- damp-heat test C, 21 days (IEC 68)	< 20%
- endurance test, P_{nom} at 70 °C	< 10%
- 10 000 hrs storage	< 5%



[1]) See "Composition of the catalogue number".

COMPOSITION OF THE CATALOGUE NUMBER

For tolerance ± 10%: 2322 120 22...

For tolerance ± 20%: 2322 120 21...

resistance code:
first two significant figures of the resistance value (in Ω) followed by:
9 for R of 33 to 82 Ω
1 for R of 100 to 820 Ω
2 for R of 1 to 8,2 kΩ
3 for R of 10 to 82 kΩ
4 for R of 100 to 180 kΩ

e.g. the catalogue number of a resistor of 3300 Ω with a tolerance of ± 20% is 2322 120 21332.

Variable resistors

WIRE-WOUND POTENTIOMETERS

QUICK REFERENCE DATA	
Linear resistance law	
Resistance range	2, 2-22 000 Ω
Maximum permissible dissipation at 40 °C	3 W
at 70 °C	2 W
Potentiometers 2322 003	provided with solder tags at the side
Potentiometers 2322 010	provided with solder tags at the bottom

APPLICATION

In professional electric and electronic equipment where accurate and gradual resistance control and high stability are required.

CONSTRUCTION

The potentiometer consists of a single layer of resistance wire wound on a strip of resin-bonded paper and housed in a nickel-plated brass case with a bottom of black synthetic resin.
The solder tags S_1 and S_2 (see Figs. 1 to 4) are connected to the ends of the resistance element; solder tag S_3 is connected, via a central bush, to the sliding contact which is insulated from the steel spindle.
The case is attached to a support of moulded zinc, which is equipped with a location pip, an end stop, and a threaded spindle bush.
The whole is sealed dust-proof.

Note - A version with pins for printed-wiring can be supplied on request (see Fig. 6).

Dimensions (mm)

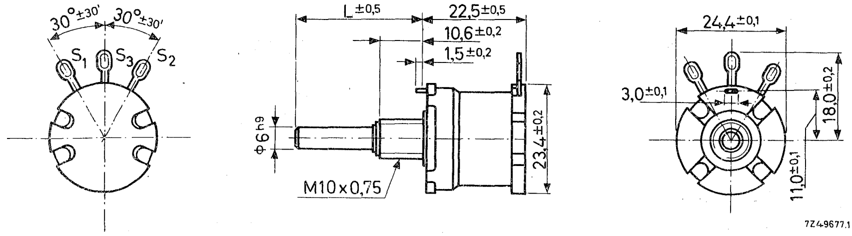


Fig. 1. Potentiometers 2322 003 . . . . . with plain spindle. The spindle length L is 17, 20, 30 or 60 mm.

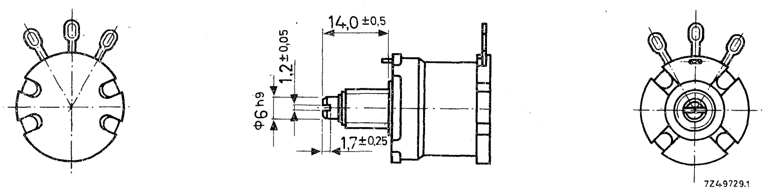


Fig. 2. Potentiometers 2322 003 . . . . . with spindle with screwdriver slot. Dimensions are identical to those in Fig. 1. except as shown.

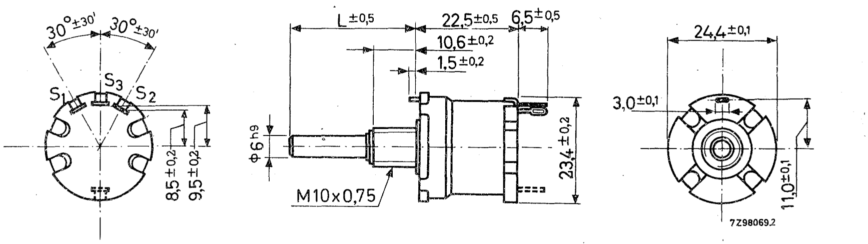


Fig. 3. Potentiometers 2322 010 . . . . . with plain spindle. The spindle length L is 17, 20, 30 or 60 mm.

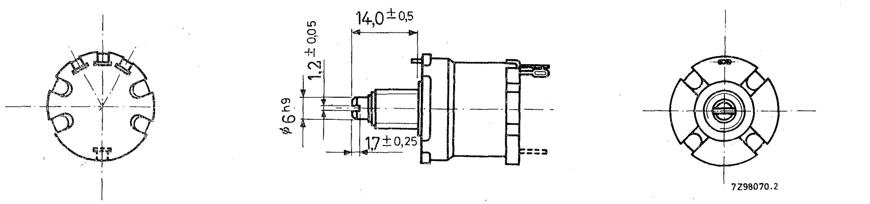


Fig. 4. Potentiometers 2322 010 . . . . . with spindle with screwdriver slot. Dimensions are identical to those in Fig. 3. except as shown.

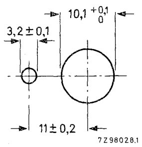


Fig. 5. Mounting holes

The potentiometers can be fixed to the chassis with the cadmium-plated mounting nut supplied (catalogue number 4322 047 00350). The minimum thickness of the chassis is 1 mm. The maximum torque for tightening is 3, 5 Nm.

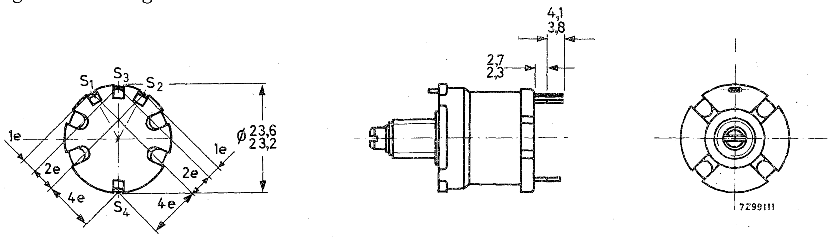


Fig. 6. Potentiometer with pins for printed-wiring; see also "CONSTRUCTION - Note".

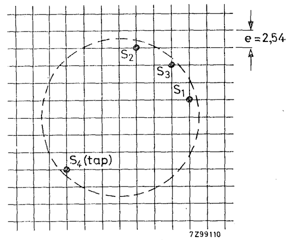


Fig. 7. Hole pattern of the printed-wiring board.

TECHNICAL PERFORMANCE

Unless otherwise specified all values apply at an ambient temperature of 20 ± 5 °C, an atmospheric pressure of 930 to 1060 mbar and a relative humidity of 45 to 75%.

Nominal resistance values (R_n), measured between the tags S_1 and S_2 (see Figs. 1 and 3)	see Table
Tolerance on the nominal resistance	
for $R_n \leq 47\ \Omega$	± 10%
for $R_n > 47\ \Omega$	± 5% and ± 10%
Resistance law	linear
Resistance at 50% of effective angle of rotation	50% ± 2% of R_{total}
Maximum permissible dissipation, the full length of the resistance element being used	see Fig. 8
Temperature coefficient of the resistance	see Table
Insulation resistance	> 1000 MΩ
Test voltage between spindle and tags for 1 min	1000 V r.m.s.

Maximum working voltage between resistance element and case	500 V peak
Working temperature range	-10 to $+85$ °C
Climatic category, IEC68	10/085/21
Number of windings	see Table
Effective angle of rotation	290 ± 10 °
Mechanical angle of rotation	300 ± 5 °
Operating torque	7,5 to 20 mNm
End stop torque	≤ 800 mNm
Maximum axial spindle load	50 N
Life, for $R_n \leq 6,8$ kΩ	in excess of 25 000 cycles
for $R_n > 6,8$ kΩ	in excess of 10000 cycles

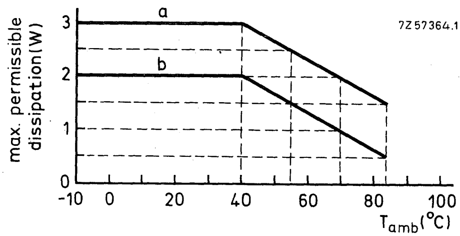


Fig. 8. Maximum permissible dissipation as a function of the ambient temperature.
Curve a : for potentiometers mounted on a metal chassis of 100 mm x 100 mm x 1 mm.
Curve b : for potentiometers mounted on an insulating panel.

COMPOSITION OF THE CATALOGUE NUMBER

2322 0 . . . . . .

figure indicating the type
03 = potentiometer with solder tags at the side
10 = potentiometer with solder tags at the bottom

figure indicating the spindle type
0 = spindle with screwdriver slot
2 = plain spindle; length 17 mm
3 = plain spindle; length 20 mm
4 = plain spindle; length 30 mm
5 = plain spindle; length 60 mm

code for resistance value, see Table

figure indicating the tolerance and tap
1 = ± 10%
2 = ± 5% ($R_n > 47$ Ω)
6 = ± 10%, with tap [1])
7 = ± 5% ($R_n > 47$ Ω) with tap [1])

[1]) Tap at 50% of the effective angle of rotation.

Table

resistance value (Ω)	temperature coefficient (ppm/degC)	number of windings ± 25%	code in catalogue number
2, 2	0 to +600	60	228
3, 3		55	338
4, 7		79	478
6, 8		71	688
10		105	109
15		102	159
22		150	229
33	−25 to +600	141	339
47		103	479
68	−25 to +25	96	689
100		142	101
150		128	151
220		188	221
330	−25 to +140	182	331
470		191	471
680	0 to +140	172	681
1 000		155	102
1 500		234	152
2 200		227	222
3 300		342	332
4 700		302	472
6 800		438	682
10 000	−20 to +140	413	103
15 000		497	153
22 000		448	223

WIRE-WOUND POTENTIOMETERS

QUICK REFERENCE DATA	
Linear resistance law	
Resistance range	10 Ω to 50 000 Ω
Maximum permissible dissipation at 40 °C	3 W
at 70 °C	1,5 W

APPLICATION

In professional electric and electronic equipment where accurate and gradual resistance control and high stability are required.
Due to the large outer diameter, a very good resolution has been obtained compared with some other types.

CONSTRUCTION

The potentiometer consists of a single layer of resistance wire wound on a strip of resin-bonded paper and housed in a case of black synthetic resin, which is dust-proof sealed by a metal bottom.
The solder tags S_1 and S_3 (see Figs. 1 and 2) are connected to the ends of the resistance element.
A resilient slider, which is insulated from the steel spindle, slides over the flat top of the winding when the spindle is turned. The slider makes a sliding contact with the solder tag S_2 by means of a slip ring. A stop prevents the slider from overrunning the resistance element.

Dimensions (mm)

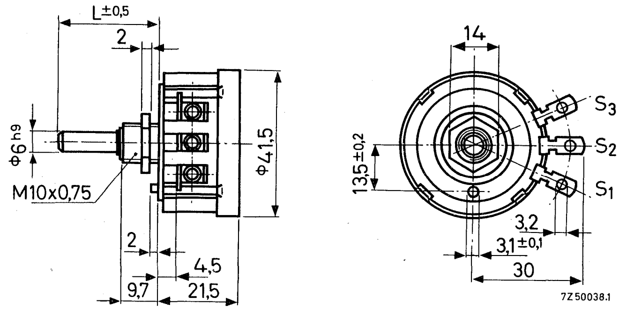


Fig. 1. Potentiometer with plain spindle. The spindle length L is 20, 25, 30, 35 or 80 mm.

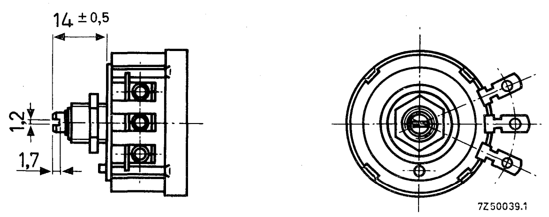
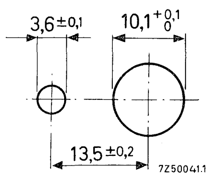


Fig. 2. Potentiometer with spindle with screwdriver slot. Dimensions are identical to those in Fig. 1 except as shown.



The potentiometers can be fixed to the chassis with the cadmium-plated mounting nut supplied (catalogue number 4322 047 00350). The maximum torque for tightening is 3,5 Nm.

Fig. 3. Mounting holes.

TECHNICAL PERFORMANCE

Unless otherwise specified all values apply at an ambient temperature of 20 ± 5 °C, an atmospheric pressure of 930 to 1060 mbar and a relative humidity of 45 to 75%.

Nominal resistance values (R_n), measured between the tags S_1 and S_3 (see Figs. 1 and 2)	see Table
Tolerance on the nominal resistance	
for $R_n \leq 75\ \Omega$	± 10%
for $R_n > 75\ \Omega$	± 5% and ± 10%
Resistance law	linear
Resistance at 50% of effective angle of rotation	50% ± 2% of R_{total}
Maximum permissible dissipation, the full length of the resistance element being used, at T_{amb} = 40 °C	3 W
at $T_{amb} > 40$ °C	see Fig. 4
Temperature coefficient of the resistance	see Table
Insulation resistance	> 100 MΩ
Test voltage for 1 min	2000 V r.m.s.
Maximum working voltage between mounting bush and solder tags	1000 V peak
Working temperature range	−55 to + 100 °C
Number of windings	see Table
Effective angle of rotation	280 ± 4°
Mechanical angle of rotation	300 ± 2°
Operating torque	10 to 30 mNm
End stop torque	≤ 800 mNm
Life, for $R_n \leq 10$ kΩ	in excess of 25 000 cycles
for $R_n > 10$ kΩ	in excess of 10 000 cycles

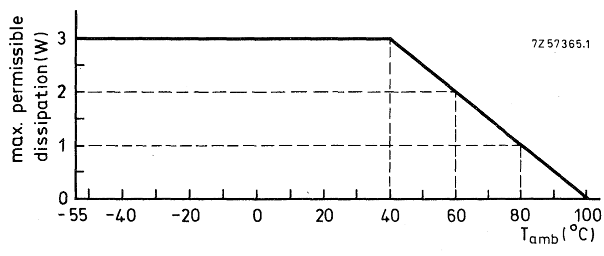


Fig. 4. Maximum permissible dissipation as a function of the ambient temperature.

COMPOSITION OF THE CATALOGUE NUMBER

2322 004 . . . . .

figure indicating the spindle type
2 = spindle with screwdriver slot
3 = plain spindle; length 20 mm
4 = plain spindle; length 25 mm
5 = plain spindle; length 30 mm
6 = plain spindle; length 35 mm
7 = plain spindle; length 80 mm

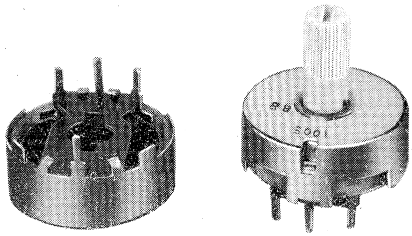
figure indicating the tolerance
1 = ± 10%
2 = ± 5% (R_n > 75 Ω)

code for resistance value, see Table

Table

resistance value (Ω)	temperature coefficient (ppm/deg C)	number of windings ±25%	code in catalogue number
10	0 to +600	160	109
15		240	159
20		200	209
25		250	259
35		220	359
50		320	509
75		300	759
100	−25 to +25	200	101
150		190	151
200		260	201
250		320	251
350		280	351
500		410	501
750		380	751
1 000		510	102
1 500	0 to +140	360	152
2 000		480	202
2 500		380	252
3 500		530	352
5 000		750	502
7 500		710	752
10 000		600	103
15 000		560	153
20 000		710	203
25 000		950	253
35 000	−20 to +20	1050	353
50 000		1200	503

WIRE-WOUND PRE-SET POTENTIOMETERS



RZ 26449-3

Linear resistance law	
Resistance range	2.2-1000 Ω
Maximum permissible dissipation	
at 40 °C	2 W
at 70 °C	1 W
Intended for mounting on printed-wiring boards	

APPLICATION

In a wide variety of electronic equipment, e.g. for pre-setting of the horizontal and vertical convergence in colour television receivers.

CONSTRUCTION

The potentiometers consist of a single layer of resistance wire housed in a metal case. The resistance element and its terminal pins (S1 and S2) are insulated from the case; the slider is connected to the case (pins S3).
Four potentiometer types are available: with or without a tap (pin S4) in the middle of the resistance element and with or without a plastic knob.

Dimensions (mm)

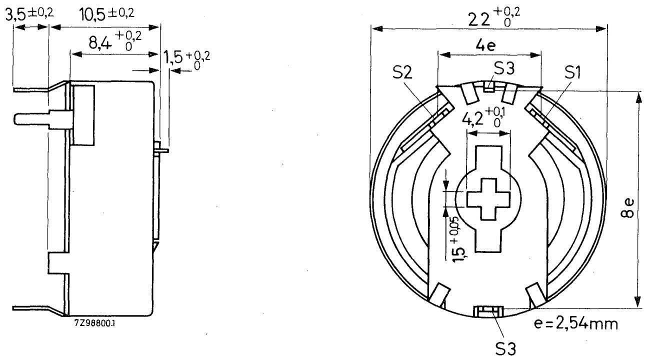


Fig. 1. Non-tapped potentiometer without knob

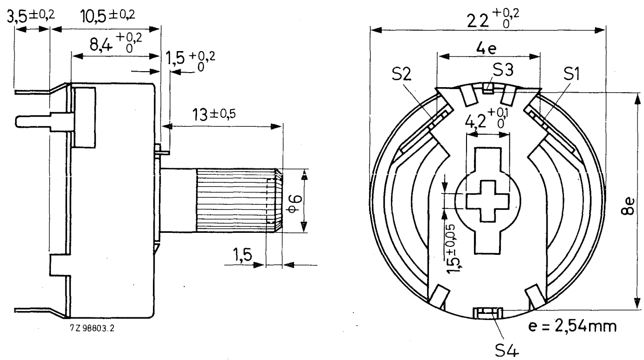


Fig. 2. Tapped potentiometer with knob

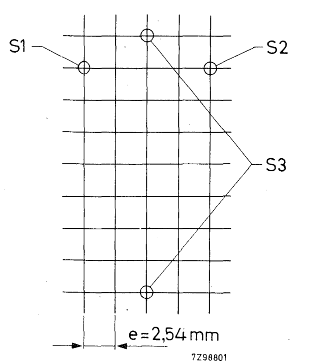


Fig. 3. Mounting holes for non-tapped potentiometers

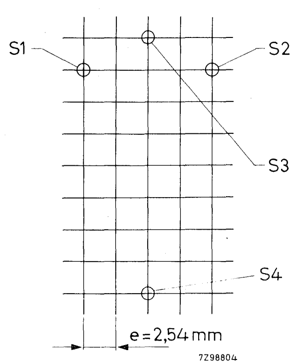


Fig. 4. Mounting holes for tapped potentiometers

TECHNICAL PERFORMANCE

Nominal resistance value (R_n) between S_1 and S_2	2.2 Ω to 1 kΩ, see Table
Resistance law	linear, see Figs. 5 and 6
Tolerance on R_n	± 10%
Resistance at beginning and end	≤ 5% of R_{total}
Resistance at 50% of effective angle of rotation	50% ± 2% of R_{total}
Contact resistance between resistance element and slider	≤ 500 mΩ
Change of contact resistance between resistance element and slider	≤ 300 mΩ
Temperature coefficient	see Table
Maximum dissipation between S_1 and S_2, potentiometer mounted on printed-wiring board (Fig. 7)	
at T_{amb} = 40 °C	2 W
at T_{amb} = 70 °C	1 W
Working temperature range	−40 to +100 °C
Mechanical angle of rotation	255 ± 10°
Effective angle of rotation	240 ± 10°
Operating torque	1-4 Ncm
Maximum end stop torque	15 Ncm
Life	250 cycles

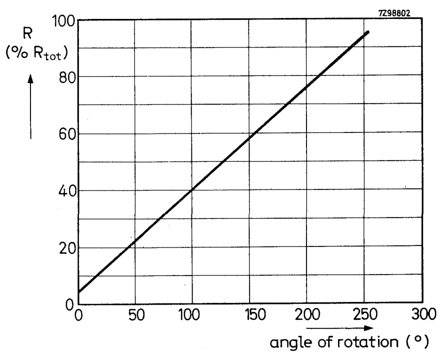


Fig. 5.
Resistance variation with the angle of rotation for non-tapped potentiometers

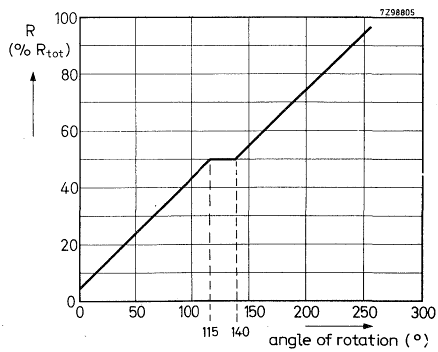


Fig. 6.
Resistance variation with the angle of rotation for tapped potentiometers

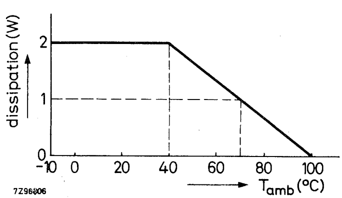


Fig. 7. Dissipation as a function of the ambient temperature; potentiometers mounted on a printed-wiring board.

Table

resistance value in Ω	temperature coefficient in 10^{-6}/degC	number of windings	code in catalogue number
2.2	0 to +600	110	228
3.3		108	338
4.7		95	478
6.8		136	688
10		126	109
15		194	159
22	-25 to + 25	113	229
33		134	339
47		120	479
68		172	689
100		160	101
120	0 to +140	138	121
150		178	151
180		207	181
220		165	221
330		155	331
470		222	471
680		200	681
1000		297	102
11 + 11	-25 to + 25	113	229
50 + 50		160	101
150 + 150	0 to +140	150	301

TYPES

Composition of the catalogue number

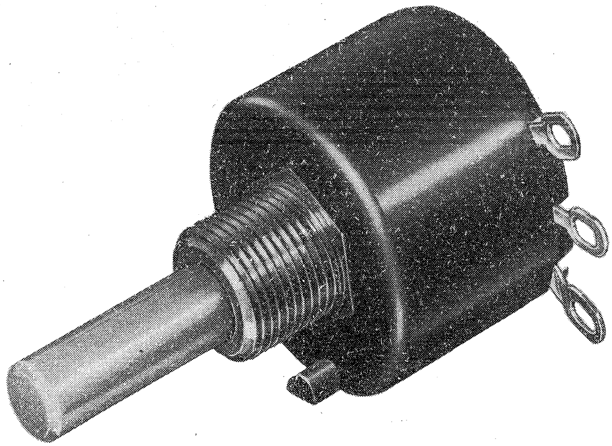
2322 011 . . . . .

resistance code, see Table

without tap or knob [1]) = 02
with tap, without knob [1]) = 03
without tap, with knob = 22
with tap and knob = 23

[1]) Knobs are available under catalogue number 4322 048 20550.

WIRE-WOUND POTENTIOMETERS



RZ 26297-1

Linear resistance law	
Resistance range	2.2-22 000 Ω
Maximum permissible dissipation at 70 °C	1 W
Potentiometers 2322 012.....	provided with a plastic spindle
Potentiometers 2322 013.....	provided with a steel spindle

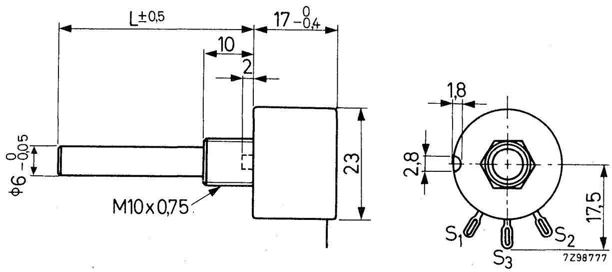
APPLICATION

In professional electric and electronic equipment where accurate and gradual resistance regulation and high stability are required.

CONSTRUCTION

The potentiometer consists of a single layer of resistance wire wound on a strip of resin-bonded paper and housed in a dust-proof case of black plastic material. The resilient slider is affixed to the spindle; a stop prevents the slider from overrunning the resistance element, and the contact between resistance wire and slider is preserved over the entire angle of rotation, so as ensure minimum wear.

Dimensions (mm)



a. Potentiometer with a spindle suited for knob adjustment.
For spindle length L, see section "TYPES".

b. Spindle with screwdriver slot (spindle fully counter-clockwise).

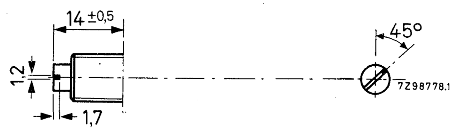
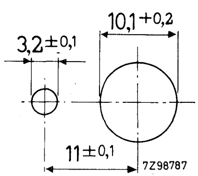


Fig. 1. Potentiometers 2322 012 . . . . . and 2322 013 . . . . . and their spindle types.
S_1 and S_2 are connected to the ends of the resistance wire; S_3 is connected to the slider contact.



The potentiometers can be fixed to the chassis with the cadmium-plated mounting nut supplied (catalogue number 4322 047 00350).

Fig. 2. Mounting holes.

TECHNICAL PERFORMANCE

Nominal resistance values (R_n), measured between the tags S_1 and S_2 (see figure above)	see Table
Tolerance on the nominal resistance	
for $R_n \leq 47\ \Omega$	± 10%
for $R_n > 47\ \Omega$	± 5% and ± 10%
Resistance law	linear
Tolerance on the resistance law	± 2% of R_n
Resistance at the beginning and end	
for $R_n \leq 15\ \Omega$	≤ 200 mΩ
for $R_n \geq 22\ \Omega$	≤ 1% of R_n

Contact resistance	see Fig. 3
Change of contact resistance	≤ 300 mΩ
Dissipation as a function of ambient temperature, potentiometers mounted on a metal chassis of 100 mm x 100 mm x 1 mm	see Fig. 4
Temperature coefficient of the resistance	see Table 1
Insulation resistance between bushing and contacts	> 1000 MΩ
Test voltage between bushing and contacts for 1 min	2000 V, 50 Hz
Maximum working voltage between bushing and contacts	1000 V_p
Working-temperature range	−10 to +100 °C
Climatic robustness	category 10/100/21 (I.E.C. 68)
Number of windings	see Table
Effective angle of rotation	245 ± 5°
Mechanical angle of rotation	270 ± 5°
Operating torque	0,3-2 Ncm
End stop torque	≤ 80 Ncm
Maximum axial spindle load	100 N
Life, for R_n ≤ 3,3 kΩ	in excess of 25 000 cycles
for R_n > 3,3 kΩ	in excess of 10 000 cycles

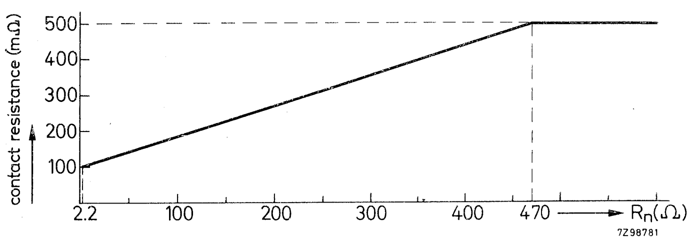


Fig. 3 Contact resistance as a function of the nominal resistance.

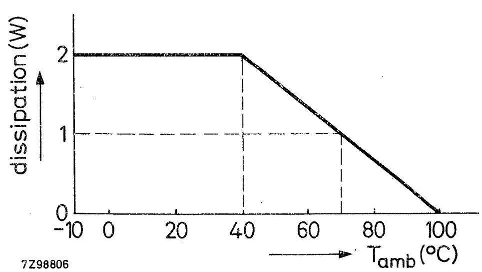


Fig. 4 Dissipation as a function of the ambient temperature.

TYPES

Composition of the catalog number 2322 01. .....

figure indicating the spindle material
2 = plastic
3 = steel

figure indicating the spindle type
0 = spindle suited for screwdriver adjustment; lenght 14 mm (only plastic)
2 = length 17 mm
3 = length 25 mm
4 = length 50 mm
5 = length 60 mm
6 = length 20 mm
7 = length 30 mm
(2–7: spindle suited for knob adjustment)

figure indicating the tolerance
1 = ±10%
2 = ±5% (R_n > 47 Ω)

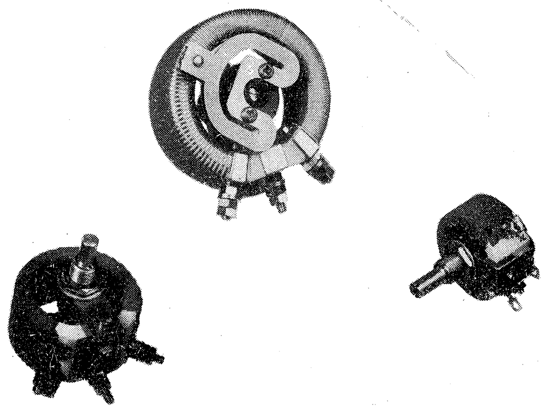
code for resistance value, see Table

Example: for a potentiometer with a nominal resistance value of 10 Ω, tolerance ±10% for screwdriver adjustment, with a plastic spindle, the catalog number is 2322 012 01109.

Table

resistance value in Ω	temperature coefficient in 10^{-6}/deg C	number of windings ± 25%	code in catalog number
2.2	0 to +600	47	228
3.3		70	338
4.7		63	478
6.8		90	688
10		85	109
15		127	159
22	−25 to +25	62	229
33		94	339
47		83	479
68		120	689
100		106	101
150		103	151
220	0 to +140	109	221
330		104	331
470		148	471
680		131	681
1 000		193	102
1 500		187	152
2 200		275	222
3 300		260	332
4 700		369	472
6 800		342	682
10 000	−20 to +140	405	103
15 000		375	153
22 000		550	223

LOAD POTENTIOMETERS



RZ 25706-9

Resistance range	0.5 Ω to 10 kΩ
Maximum permissible dissipation at 60 °C	25, 40, 100 W

APPLICATION

In electric and electronic equipment where current or voltage must be regulated continuously, e.g. control of motor speeds and control of charging current of batteries.

CONSTRUCTION

The potentiometers consist of a ceramic ring A (see figures on next pages) around which a resistance wire or ribbon (consult the Table) has been wound in a single layer - over about 280° in the case of 100 W items, and over about 250° for the other ratings. A terminal B is fitted at each end of the wire or ribbon. With the exception of the top side of the coil, the resistance element is coated with a protective layer of cement which prevents the windings from shifting. The cement is non-inflammable (melting point about 2000 °C).

A carbon brush C is affixed in a double spring-type runner E, the brush being connected to a terminal F through the intermediary of a double sliding-contact.
The spring-pressures of the sliding contact and of the carbon brush are independent of each other. In the case of resistance ribbon, the runner of the 40 W and 100 W potentiometers is equipped with an extra spring having a height of 2 and 3 mm, respectively.
By means of an insulating piece G and a central screw H, the runner is affixed to the top of a spindle J which is supported in a sturdy bracket K. A stop prevents the runner from overrunning the track, whereby the runner is not exposed to torsion.

The protrusion N prevents the potentiometers from turning.
All the metal parts are non-corrosive.

The potentiometers are suitable to be ganged (see section "Ganging").

Dimensions in mm

The spindle length L is 17 or 36 mm.

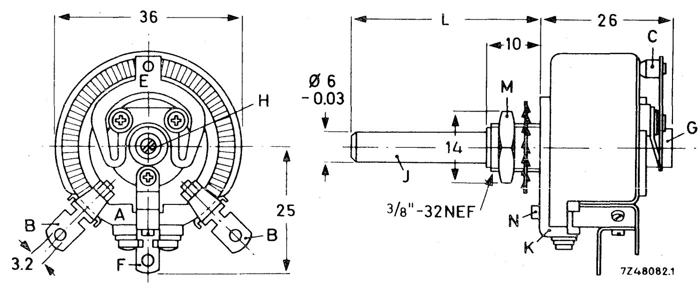


Fig.1. Potentiometers 2322 095 .....;
1 Ω to 7.5 kΩ, 25 W

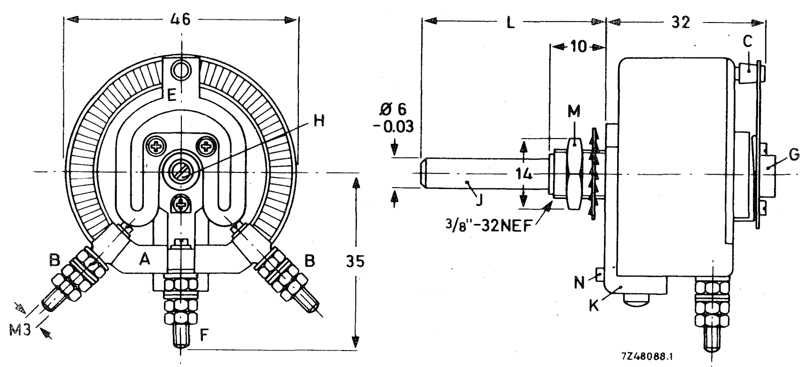


Fig.2. Potentiometers 2322 096 .....;
0.5 Ω to 10 kΩ, 40 W

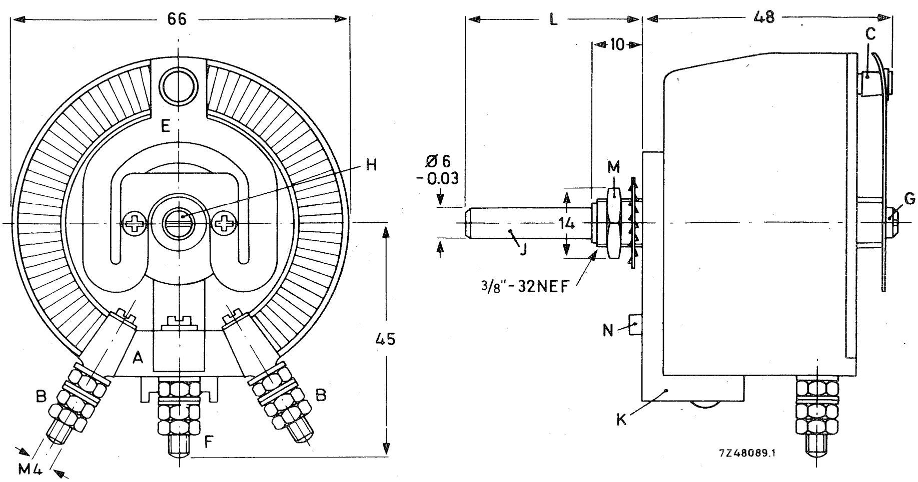
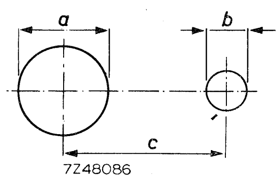


Fig.3. Potentiometers 2322 097 .....;
0.75 Ω to 10 kΩ, 100 W

Mounting and weight

type	a	b	c	panel thickness maximum	weight g
2322 095	10.5	3.5	13.5	5	60
096	10.5	4.8	20	5	95
097	10.5	4.8	20	5	240



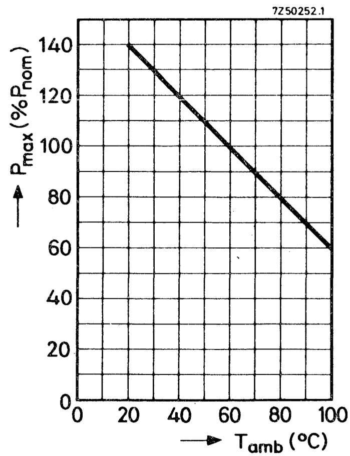
Fig, 4. Holes for mounting with supplied nut, catalogue number 4322 047 00380.

TECHNICAL PERFORMANCE

Nominal resistance values (R_n) measured between end tags at $P \leq 0.1\ P_n$	see Table
Tolerance on R_n	$\pm$ 10%
Resistance law	linear
Temperature coefficient of the resistance	(−140 to +140) 10^{-6}/deg C
Maximum permissible dissipation at T_{amb} = 60 °C (P_n)	see Table

Maximum permissible current	
at T_{amb} = 60 °C ($I_{max} = \sqrt{\frac{P_n}{R}}$)	see Table
at other temperatures	see Fig.5
Temperature rise ΔT as f (P)	see Fig.6
Working-temperature range	−55 to +100 °C
Insulation resistance	> 100 MΩ
Effective angle of rotation	
25 W, 40 W types	250 ± 10°
100 W type	280 ± 10°
Mechanical angle of rotation	
25 W, 40 W types	270 ± 5°
100 W type	300 ± 5°
Operating torque	
25 W, 40 W types	1 - 4.5 Ncm
100 W type	8 - 13 Ncm
End stop torque	≤ 200 Ncm
Maximum axial spindle load	100 Ncm
Life at maximum current	> 50 000 cycles

Fig.5



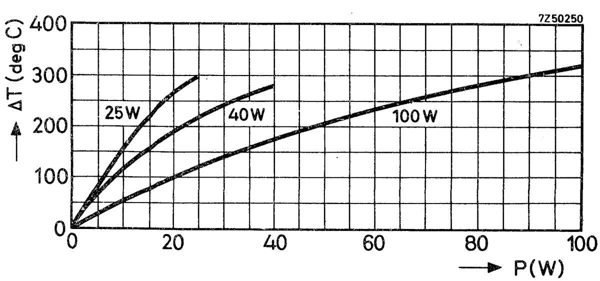


Fig.6

TYPES

Only the types for which I_{max} is listed in the table are available. If I_{max} is stated above the dashed line, the potentiometer is equipped with resistance ribbon.

Table

R_n (Ω)	P_n = 25 W		P_n = 40 W		P_n = 100 W		code in catalog number
	I_{max} (A)	number of windings	I_{max} (A)	number of windings	I_{max} (A)	number of windings	
0.5			8.9	14			507
0.75			7.3	13	11.5	23	757
1	5.0	23	6.3	14	10.0	24	108
1.5	4.0	22	5.15	21	8.15	23	158
2	3.5	23	4.45	28	7.05	24	208
2.5	3.15	22	4.0	23	6.3	32	258
3.5	2.65	23	3.35	28	5.35	42	358
5	2.2	20	2.8	25	4.45	47	508
7.5	1.8	30	2.3	23	3.65	45	758
10	1.55	41	2.0	24	3.15	43	109
15	1.3	39	1.6	27	2.55	40	159
20	1.1	37	1.4	50	2.2	43	209
25	1.0	46	1.25	49	2.0	44	259
35	0.84	60	1.07	49	1.7	75	359
50	0.70	86	0.89	105	1.4	86	509
75	0.58	82	0.73	99	1.15	75	759
100	0.50	109	0.63	132	1.0	143	101
150	0.40	103	0.51	125	0.81	135	151
200	0.35	137	0.44	105	0.70	180	201
250	0.31	108	0.40	132	0.63	142	251
350	0.26	151	0.33	184	0.53	199	351
500	0.22	136	0.28	165	0.44	179	501
750	0.18	204	0.23	157	0.36	268	751
1 000	0.15	172	0.20	210	0.31	226	102
1 500	0.13	258	0.16	214	0.25	340	152
2 000	0.11	345	0.14	286	0.22	286	202
2 500	0.10	272	0.12	357	0.20	357	252
3 500	0.08	380	0.10	392	0.17	316	352
5 000	0.07	343	0.09	417	0.14	450	502
7 500	0.06	513	0.07	395	0.11	428	752
10 000			0.06	528	0.10	570	103

Note - Spare carbon brushes can be supplied under catalog number
4322 048 03670 for 25 W types,
4322 048 01710 for 40 W types, $R_n \leq 10\ \Omega$,
4322 048 03530 for 40 W types, $R_n > 10\ \Omega$,
4322 048 03540 for 100 W types.

COMPOSITION OF THE CATALOG NUMBER

2322 ... .

095 for 25 W type
096 for 40 W type
097 for 100 W type

code for R_n, see Table

21 for spindle length L = 17 mm
31 for spindle length L = 36 mm

GANGING

For ganging two load potentiometers, sets are available for the coupling of two items and comprising the following parts (see Fig.7), packed in a plastic bag:
1 bracket D,
1 threaded spindle B,
1 cross pin C,
1 coupling E,
2 set screws K,
retaining rings

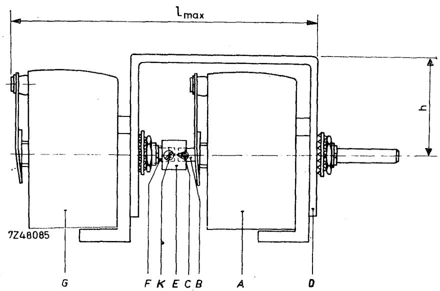


Fig.7

The catalog numbers for ordering these sets and the dimensions are:

	potentiometers	catalog number coupling set	l_{max} (mm)	h (mm)
25 W	2322 095 21... + 2322 095	4322 048 06480	83	22
40 W	2322 096 21... + 2322 096	4322 048 06490	95.5	29.5
100 W	2322 097 21... + 2322 097	4322 048 06500	129.5	40

Ganging procedure (see Fig.7)

The central screw H (Figs.1-3) is removed from the potentiometer A and replaced by spindle B having a threaded end that is firmly tightened; the other extremity of B is provided with the round cross-pin C. Thereupon, potentiometer A is attached to the bracket D by means of the hexogonal nut, and coupling E is slipped over the extruding end of B.
The second potentiometer (G) having a spindle (F) with standard length L = 17 mm, is now attached to the bracket as well. After placing the runners of both potentiometers in the same position, the coupling is affixed to F by means of the two radial set screws K in the coupling.
When the spindle of potentiometer A is rotated, potentiometer G rotates simultaneously through the intermediary of cross pin C and a V-shaped groove in the coupling. The potentiometers and the coupling should be adjusted so as to obtain a smoothly running assembly.

Mounting

The front face of bracket D is equipped with two 4 mm threaded holes, which allow of fitting two screws through the mounting panel to prevent the ganged assembly from turning when being attached. In this connection, the panel should be provided with apertures according to Fig.8.

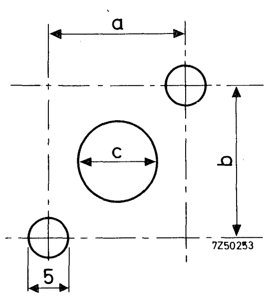


Fig.8

	dimensions in mm			
	a	b	c	panel thickness
25 W	18	20	10.5	≤ 3
40 W	18	30	10.5	≤ 3
100 W	22	30	10.5	≤ 2

INTRODUCTION

There are two main groups in our range of carbon potentiometers.

Preset potentiometers (type indication CTP or MCP): are mainly used for eliminating circuit tolerances during the assembly of electronic equipment or the readjustment of electronic circuits at a later stage.
Four series of preset potentiometers are available:

- CTP18-series: maximum dissipation 0,25 W, dimensions approx. 18 x 20 mm.
- CTP14-series: maximum dissipation 0,2 W, dimensions approx. 14 x 17 mm.
- CTP10-series: maximum dissipation 0,1 W, dimensions approx. 10 x 10 mm.
- MCP-series: rectangular multiturn potentiometers designed for use with television tuners, dimensions approx. 43,5 x 8 x 5 mm.

Control potentiometers (type indication CP or SLP): are widely used in all kinds of electronic equipment, e.g. for volume, tone, brightness and balance control.
Five series of control potentiometers are available:

- CP23-series: maximum dissipation 0,25 W (linear law), or 0,125 W (logarithmic law), diameter approx. 23 mm. Single, tandem, twin, and triple types, with or without switch, can be supplied.
- CP16-series: maximum dissipation 0,1 W (linear law), or 0,05 W (logarithmic law), diameter approx. 16 mm. Single and tandem types, with or without switch, can be supplied.
- CP13-series (knob potentiometers): maximum dissipation 0,05 W, diameter approx. 13 mm.
- SLP60-series (slide potentiometers): maximum dissipation 0,4 W (linear law), or 0,2 W (logarithmic law), dimensions approx. 87 x 16 x 10,2 mm. Single and tandem types can be supplied.
- SLP40-series (slide potentiometers): maximum dissipation 0,25 W (linear law), or 0,125 W (logarithmic law), dimensions approx. 68 x 16 x 10,2 mm. Single and tandem types can be supplied.

GLOSSARY OF TERMS

Preset potentiometers - Potentiometers of simple construction, in general without spindle, encapsulation and mounting facilities. They are specially suited for applications where resistances have to be trimmed not more than 25 times.

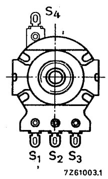
Control potentiometers - Potentiometers of more complicated construction, provided with spindle, encapsulation and mounting facilities, and having a mechanical endurance of 10 000 cycles of operation.

Single, tandem, twin, triple potentiometers
Single potentiometers are control potentiometers comprising one resistor unit.
Tandem potentiometers are control potentiometers comprising two identical resistor units.
Twin potentiometers are control potentiometers comprising two resistor units controlled by separate concentric spindles.
Triple potentiometers are control potentiometers consisting of one single and one tandem potentiometer, controlled by separate concentric spindles.

Switches - Mains-voltage or battery-voltage switches, fitted to the potentiometers and controlled by the potentiometer spindle.

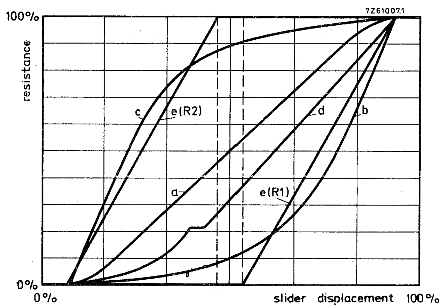
Nominal resistance (R_n) - Nominal value of the resistance between the end terminals S_1 and S_3, (Fig. 1) with the spindle in fully clockwise or counterclockwise position.

Fig. 1 Potentiometer viewed from the spindle end.



Resistance law - Relation between the displacement of the slider contact and the resistance between the end terminal S_1 and the slider terminal S_2, R_{1-2} (Fig. 1). The control potentiometers are available with several resistance laws: linear (a, Fig. 2), logarithmic (b), reversed logarithmic (c), with tap (d), balance (e).

Fig. 2



Terminal resistance - Resistance between the end terminal S_1 (Fig. 1) and the slider terminal S_2 with the spindle in fully counterclockwise position *).

Minimum resistance at the tap - Minimum adjustable resistance between the tap terminal S_4 (Fig. 1) and the slider terminal S_2.

Contact resistance (R_c) - Resistance between resistance element and slider contact.

Maximum attenuation - Maximum adjustable attenuation when the potentiometer is used as an attenuator *).

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*)

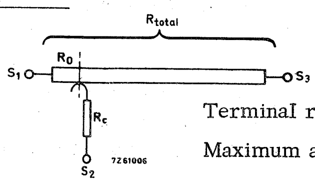


Fig. 3. Diagram of potentiometer; spindle in fully counterclockwise position.

Terminal resistance: $(R_o + R_c)\,\Omega$

Maximum attenuation: $20 \log \frac{R_o}{R_{tot}}$ dB (Voltage between S_1 and S_2 measured currentless; the value of R_c is negligible.)

Maximum dissipation (P) - Maximum amount of power which can be dissipated at a given ambient temperature, when the potentiometer is continuously loaded between the end terminals S_1 and S_3 (Fig. 1) and mounted on a steel panel of 100 x 100 x 1.5 mm.

Maximum voltage (E_{max}) - Maximum voltage that may be applied is calculated from maximum dissipation (P) and nominal resistance (R_n): $E_{max} = \sqrt{P.R_n}$, provided that the limiting element voltage is not exceeded.

Limiting slider current - Maximum current that may be passed between resistance element and slider contact.

Insulation resistance - Resistance measured between interconnected terminals and all other external metal parts.

Test voltage - Voltage to be applied for one minute between interconnected terminals and other external metal parts.

Ganging tolerance - Maximum difference between the adjusted resistances of the two sections of a tandem potentiometer (expressed in dB).

Mechanical angle of rotation (Fig. 4) - Angle over which the potentiometer spindle can be rotated.

Effective angle of rotation (Fig. 4) - Angle over which rotation of the spindle causes a change of resistance.

Switching angle (Fig. 4) - Angle over which the switch has to be actuated from the off to the on-position, or vica versa.

Backlash of the rotary switch (Fig. 4) - Angle over which the spindle has to be rotated before actuating the switch from the off to the on-position.

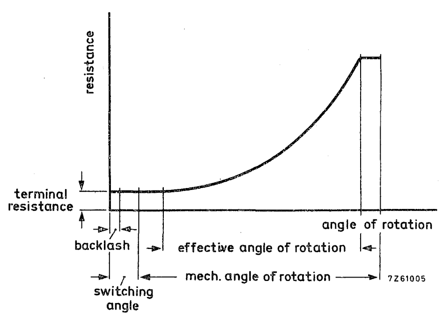


Fig. 4a

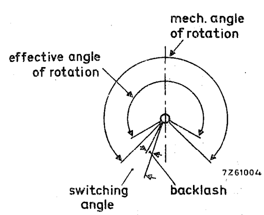


Fig. 4b

Backlash of potentiometer with push-pull switch - Angle over which the spindle can be rotated before it causes any resistance change.

SURVEY

For ordering use the 12-digit catalogue numbers, see "Composition of the catalogue number" of the relevant potentiometer.

Potentiometers CP23-series

This series contains single, tandem, twin, and triple [1] potentiometers. The different switches, terminals, mounting facilities, and spindles are given in the table below.

switch	terminals	mounting facility	spindle
s.p.s.t. rotary	solder tags	mounting bushing	plain, ϕ 6 mm
s.p.d.t. rotary	p.w. pins, long	twist tags [2]	plain, ϕ 6,35 mm
d.p.s.t. rotary	p.w. pins, short		with screwdriver slot [2]
d.p.s.t. push-pull			with flat face [2]
			knurled [2]

Potentiometers CP16-series

This series contains single and tandem [1] potentiometers. The different switches, terminals, mounting facilities and spindles are given in the table below.

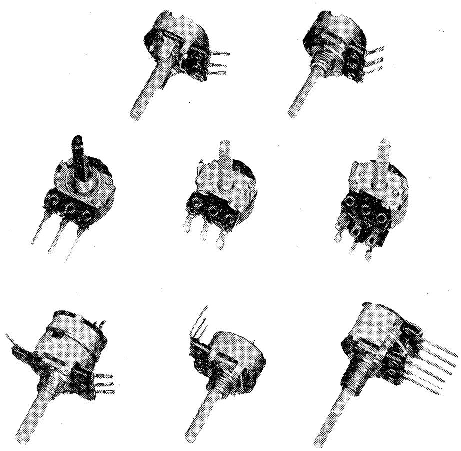
switch	terminals	mounting facility	spindle
s.p.s.t. rotary (spring actuated)	solder tags	mounting bushing	plain, ϕ 4 mm
	straight p.w. pins, long	twist tags	with screwdriver slot
s.p.s.t. rotary (direct operating)	straight p.w. pins, short		with flat face
d.p.s.t. push-pull	bent p.w. pins [1]		knurled

[1]) Only available without switch.
[2]) Only for single and tandem potentiometers.

CARBON POTENTIOMETERS

QUICK REFERENCE DATA	
Resistance range	
linear resistance law	220 Ω - 4.7 MΩ
logarithmic resistance law	1 kΩ - 2.2 MΩ
Maximum dissipation at 40 °C	
linear resistance law	0.1 W
logarithmic resistance law	0.05 W
Category (IEC publ. 68)	10/070/21

RZ 28692-3



DESCRIPTION

The CP16 carbon potentiometer series includes two types:
- single potentiometers, for general purposes,
- tandem potentiometers, for stereophonic purposes.

The single potentiometers comprise a carbon track, which is fitted on to a base plate of resin bonded paper and housed in a metal case.
The terminals S_1 and S_3 (see "Types") are connected to the ends of the carbon track; terminal S_2 is connected via a contact ring to the slider contact.
The potentiometers can be supplied with a tap (S4) at 46% (single) or 50% (tandem) of the total mechanical angle of rotation.
The potentiometers are provided with spindles of poly-acetal resin or with steel spindles.

The tandem potentiometers are composed of two carbon tracks, on base plates of resin-bonded paper, in one housing. The base plates are placed in such a way that the tracks are opposite each other.

→ The single potentiometers can be delivered without switch, with a rotary switch, or with a push-pull switch; the tandem potentiometers are only supplied without switch.
Both types are available with different connecting terminals, mounting facilities and spindles, see below.

Types

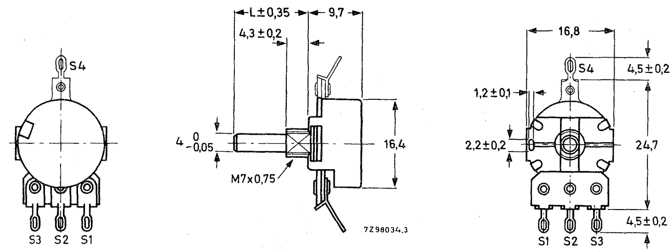


Fig. 1 Single potentiometer.

→

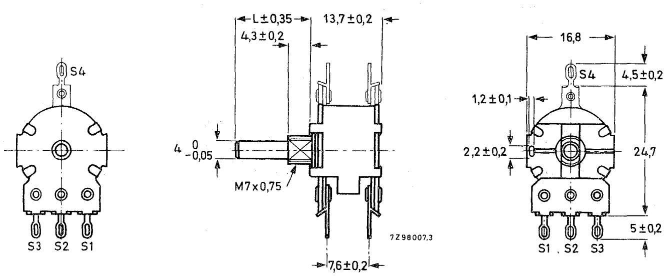


Fig. 2 Tandem potentiometer.

For the dimension L, see paragraph "Spindles".

Switches

Single-pole, single-throw, rotary switch (s.p.s.t.).

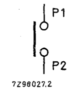


Fig. 3a. Circuit in "off"-position of spindle (spindle turned fully counter-clockwise).

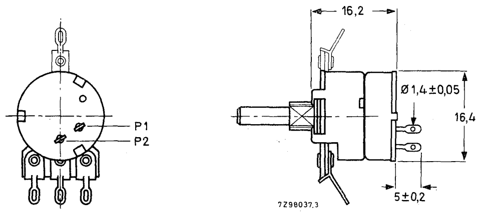


Fig. 3b. Single potentiometer with s.p.s.t. rotary switch (spring actuated).

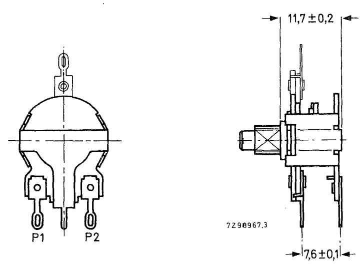


Fig. 3c. Single potentiometer with s.p.s.t. rotary switch (direct operating).

Double-pole, single-throw, push-pull switch (d.p.s.t.).

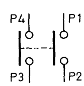


Fig. 4a. Circuit in "off"-position of spindle (spindle pushed in).

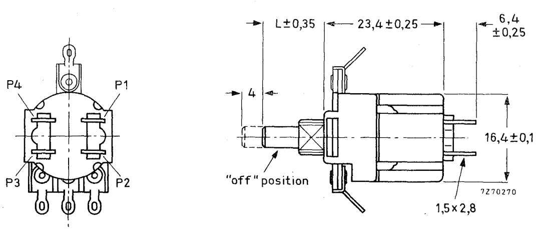


Fig. 4b. Single potentiometer with d.p.s.t. push-pull switch. This type is supplied with a spindle of polyacetal resin (steel spindle only on request).

Connecting terminals

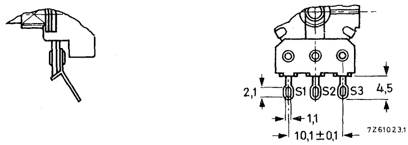


Fig. 5 Solder tags.

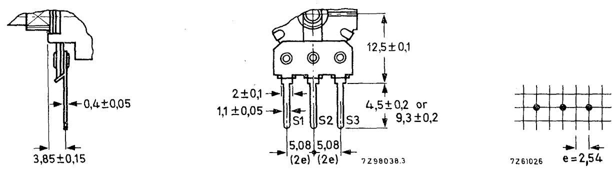


Fig. 6 Long or short printed-wiring pins (single potentiometer).

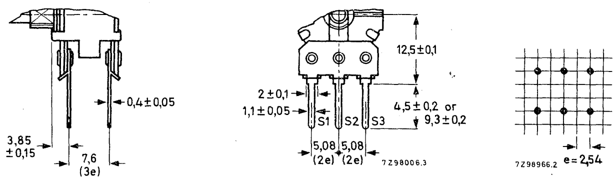


Fig. 7 Long or short printed-wiring pins (tandem potentiometer).

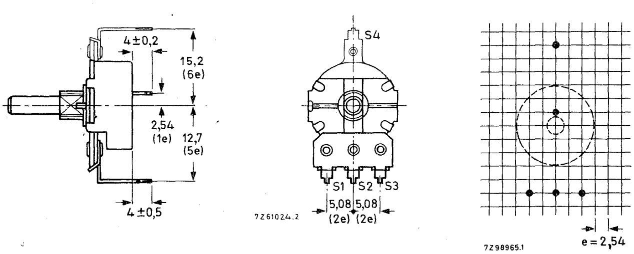
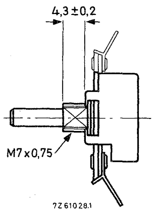
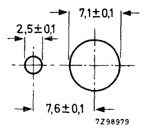
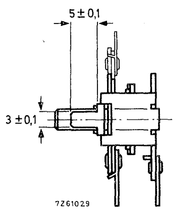
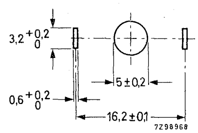


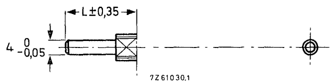
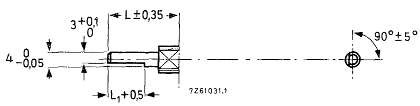
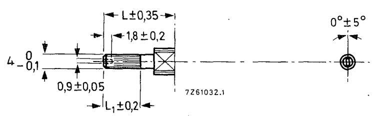
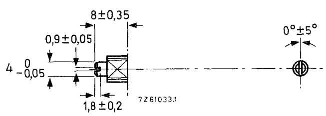
Fig. 8 Printed-wiring pins, bent backwards.

Mounting facilities

mounting facility		required mounting holes in chassis	fixing of potentiometer
mounting bushing M7 x 0,75			with supplied mounting nut [1]; max. torque for tightening = 1 Nm ; min. thickness of chassis = 1 mm
twist tags Note - not for potentiometers with push-pull switch			by twisting the tags

[1]) Catalogue number of mounting nut: 4322 047 00370.

Spindles

type	"off position"	L (mm)	L_1 (mm)	
		10		1)
		12		
		15		
		17		
		19		
		20		
		22		
		24		
		25		
		28		
		30		
		10	3,5	1)
		15	8,5	
		20	8,5	
		20	13,5	
		10	5	2)
		15	9	
		20	9	
				1) 3)

→ Note - Potentiometers with push-pull switch are supplied with a spindle of polyacetal resin. Types with steel spindles are available on request.

1) Material: steel or polyacetal resin.
2) Material: polyacetal resin.
3) Not for potentiometers with push-pull switch.

TECHNICAL DATA

Unless otherwise specified, all values have been determined at an ambient temperature of 15 to 35 °C, at atmospheric pressure of 960 to 1060 mbar and a relative humidity of 45 to 75%.
For measuring methods, see IEC publications 190 and 68. For the terms used, the "Glossary of terms" should be consulted.

nominal resistance (R_n) [1]	resistance law according to Figs. 9 and 10	max. voltage at 40 °C (V)	max. terminal resistance	max. attenuation (dB)	max. contact resistance (% R_n)	limiting slider current at 40 °C (mA)
220 Ω	a	4,5	5 Ω	–	4	21
470 Ω	a	7	5 Ω	–	4	14,5
1 kΩ	a	10	5 Ω	–	4	10
2,2 kΩ	a	14	5 Ω	–	4	7
4,7 kΩ	a	22	5 Ω	–	4	5
10 kΩ	a	31	10 Ω	–	4	3,2
22 kΩ	a	45	20 Ω	–	4	2,2
47 kΩ	a	70	35 Ω	–	4	1,5
100 kΩ	a	100	100 Ω	–	4	1,0
220 kΩ	a	140	125 Ω	–	4	0,7
470 kΩ	a	220	250 Ω	–	4	0,5
1 MΩ	a	310	1 kΩ	–	4	0,32
2,2 MΩ	a	460	2 kΩ	–	4	0,22
4,7 MΩ	a	500	5 kΩ	–	4	0,14
1 kΩ	b	7	5 Ω	50 [2]	6	7
2,2 kΩ	b	10	5 Ω	50 [2]	6	5
4,7 kΩ	b	15	5 Ω	60 [2]	6	3,2
10 kΩ	b	22	10 Ω	60 [2]	6	2,2
22 kΩ	b	31	20 Ω	60 [2]	6	1,5
47 kΩ	b	50	35 Ω	60 [2]	6	1,0
100 kΩ	b	70	50 Ω	70 [2]	6	0,7
220 kΩ	b	100	50 Ω	80 [2]	6	0,5
470 kΩ	b	155	100 Ω	80 [2]	6	0,32
1 MΩ	b	220	200 Ω	80 [2]	6	0,22
2,2 MΩ	b	310	500 Ω	80 [2]	6	0,15

[1] Measured between terminals S_1 and S_3 ; for potentiometers with a tap, between terminals S_1 and S_4 and between S_3 and S_4.
[2] Measured between terminals S_1 and S_2 ; spindle turned fully counter-clockwise.

nom. resist. (R_n) 1)	resist. law acc. to Figs. 9 and 10	max. voltage at 40 °C (V)	max. terminal resist.	max. attenuation (dB)	max. contact resist. (% R_n)	limiting slider current at 40 °C (mA)
1 kΩ	c	7	20 Ω	50 2)	6	7
2.2 kΩ	c	10	40 Ω	50 2)	6	5
4.7 kΩ	c	15	100 Ω	60 2)	6	3.2
10 kΩ	c	22	200 Ω	60 2)	6	2.2
22 kΩ	c	31	250 Ω	60 2)	6	1.5
47 kΩ	c	50	500 Ω	60 2)	6	1.0
100 kΩ	c	70	2 kΩ	70 2)	6	0.7
220 kΩ	c	100	2.5 kΩ	80 2)	6	0.5
470 kΩ	c	155	5 kΩ	80 2)	6	0.32
1 MΩ	c	220	10 kΩ	80 2)	6	0.22
2.2 MΩ	c	310	20 kΩ	80 2)	6	0.15
5 + 42 kΩ	d	50	40 Ω	60 3)	6	1.0
20 + 200 kΩ	d	100	50 Ω	80 3)	6	0.5
50 + 420 kΩ	d	155	470 Ω	80 3)	6	0.32
100 + 900 kΩ	d	220	200 Ω	80 3)	6	0.22
2 + 8 kΩ	e	22	10 Ω	60 3)	6	2.2
5 + 17 kΩ	e	31	22 Ω	60 3)	6	1.5
10 + 37 kΩ	e	50	47 Ω	60 3)	6	1.0
20 + 80 kΩ	e	70	100 Ω	70 3)	6	0.7
50 + 170 kΩ	e	100	220 Ω	80 3)	6	0.5
100 + 370 kΩ	e	155	600 Ω	80 3)	6	0.32
0.5 + 1.7 MΩ	e	310	2.2 kΩ	80 3)	6	0.15
10 kΩ	f	22	–	–	6	2.2
22 kΩ	f	31	–	–	6	1.5
47 kΩ	f	50	–	–	6	1.0
100 kΩ	f	70	–	–	6	0.7
220 kΩ	f	100	–	–	6	0.5
470 kΩ	f	155	–	–	6	0.32
1 MΩ	f	220	–	–	6	0.22

1) Measured between terminals S_1 and S_3; for potentiometers with a tap, between terminals S_1 and S_4 and between S_3 and S_4.
2) Measured between terminals S_3 and S_2; spindle turned fully clockwise.
3) Measured between terminals S_1 and S_2; spindle turned fully counterclockwise.

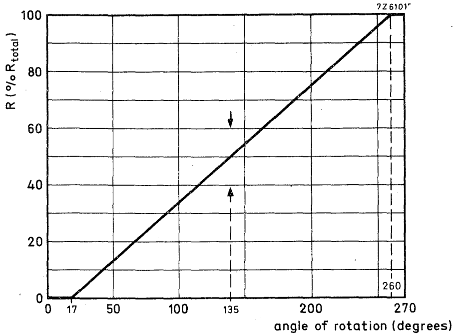


Fig. 9a. Linear resistance law, single potentiometers.

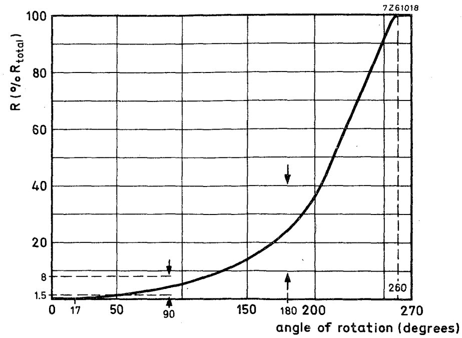


Fig. 9b. Logarithmic resistance law, single potentiometers.

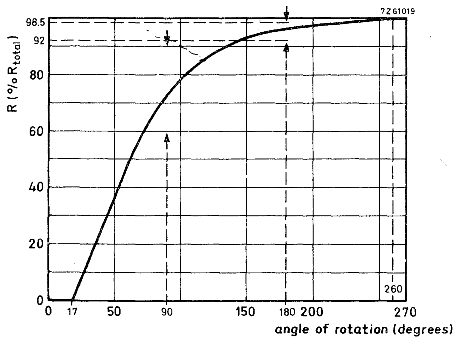


Fig. 9c. Reversed logarithmic resistance law, single potentiometers.

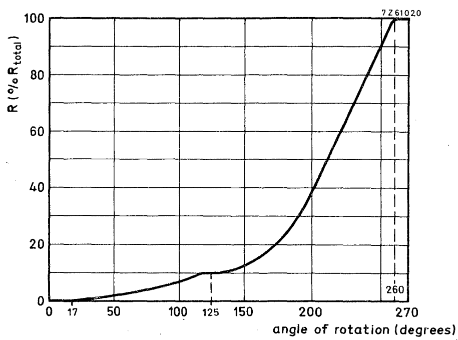


Fig. 9d. Resistance law, tap at 10%, single potentiometers.

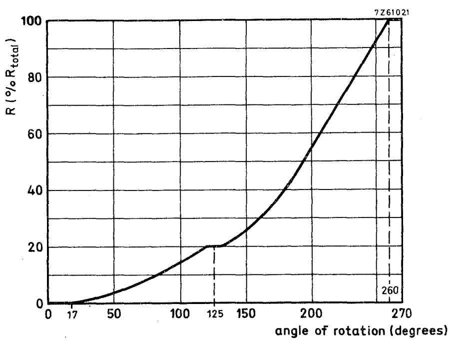


Fig. 9e. Resistance law, tap at 20%, single potentiometers.

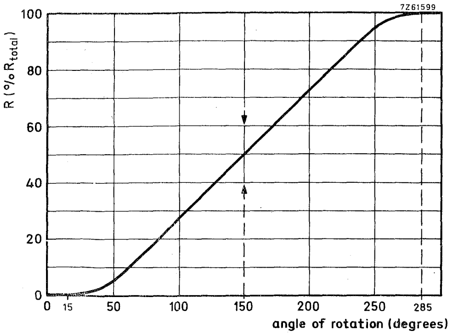


Fig. 10a. Linear resistance law, tandem potentiometers.

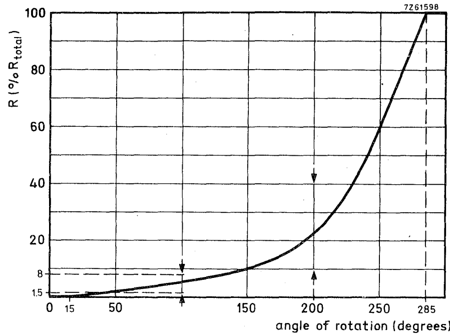


Fig. 10b. Logarithmic resistance law, tandem potentiometers.

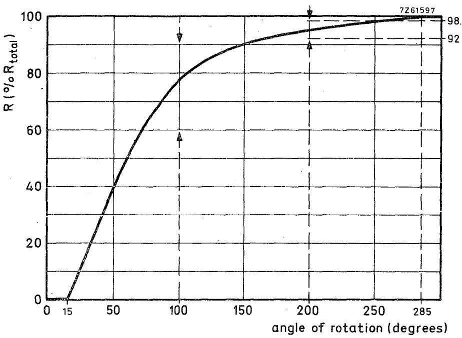


Fig. 10c. Reversed logarithmic resistance law, tandem potentiometers.

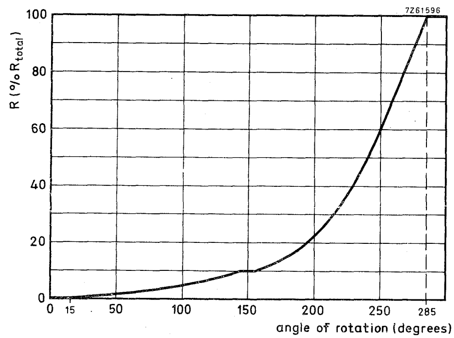


Fig. 10d. Resistance law, tap at 10%, tandem potentiometers.

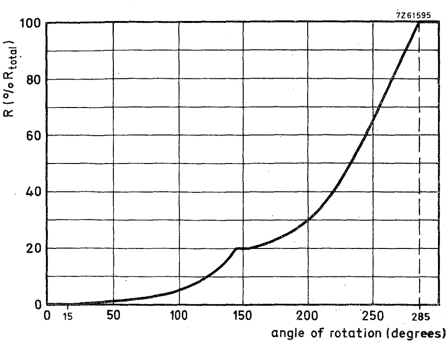


Fig. 10e. Resistance law, tap at 20%, tandem potentiometers.

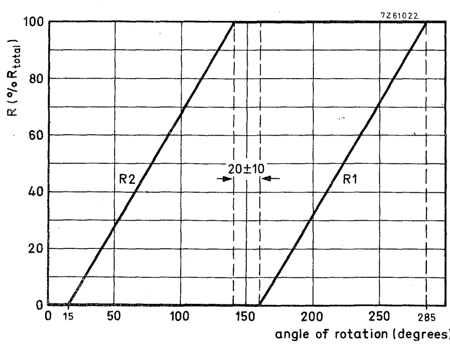


Fig. 10f. Resistance law, balance potentiometers.

Tolerance on the nominal resistance	± 20% [1]
Resistance law and tolerances	see Figs. 9 and 10
Ganging tolerance [2]	
linear resistance law	
at values between 10 and 90% of R_{total}	< 2 dB
(reversed) logarithmic resistance law	
at attenuations between 0 and −20 dB	< 2 dB
at attenuations between −20 and −30 dB	< 3 dB
at attenuations between −30 and −40 dB	< 4 dB
with a tap at 20% and	
at attenuations between 0 and −20 dB	< 2 dB
at attenuations between −20 and −30 dB	< 3 dB
at attenuations between −30 and −34 dB	< 4 dB
Minimum resistance at the tap	≤ 1,5% of R_n
Insulation resistance, initially	> 1000 MΩ
after damp heat test (IEC68, test C, 21 days)	> 25 MΩ
Maximum dissipation at 40 °C	
linear resistance law, acc. to Figs. 9a, 10a	0,1 W
resistance law, acc. to Figs. 9b (10b) to 9e (10f)	0,05 W
Test voltage	1000 V, 50 Hz
Working temperature range	−10 to +70 °C
Storage temperature range	−25 to +70 °C
Category (IEC68)	10/070/21
Operating torque [3]	0,5 - 2 Ncm
Permissible torque with slider at end stop [4]	
plain spindles	≤ 50 Ncm
spindles with flat face	≤ 40 Ncm
spindles with screw-driver slot	≤ 25 Ncm
Permissible axial spindle load	pull / push
single potentiometers	≤ 100 N / ≤ 100 N [5]
tandem potentiometers	≤ 100 N / ≤ 60 N
Axial spindle play	< 0,8 mm
Radial spindle play, measured with 2,5 N at 1 cm from the mounting plane	
potentiometers with mounting bushing	≤ 0,2 mm
potentiometers with twist tags	≤ 0,5 mm
Effective angle of rotation, single	235 - 250°
tandem	265 - 275°
balance	range of balance, half the effective angle of rotation: 20 ± 10° R_2: 125 ± 10° (counterclockwise) R_1: 125 ± 10° (clockwise)

[1]) For potentiometers with a tap the tolerance on R_1 as well as on R_2 = ± 20%.
[2]) For tandem potentiometers only.
[3]) 0,3 - 1,5 Ncm
[4]) ≤ 40 Ncm
[5]) ≤ 50 N
(footnotes 3–5:) for potentiometers with direct operating switch.

Mechanical angle of rotation	
Single potentiometers, without switch	$270 \pm 5^{\circ}$
with switch	$292 \pm 5^{\circ}$
tandem potentiometers	$300 \pm 5^{\circ}$
Life	after 10 000 cycles ΔR_{total} < 25% of R_{total}

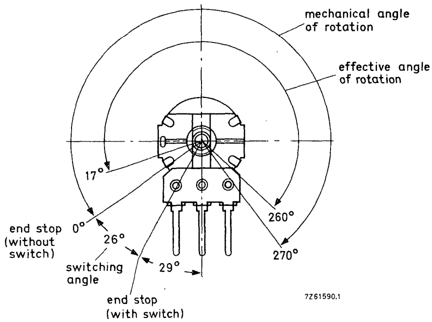


Fig. 11a. Angles of rotation of single potentiometers with or without switch

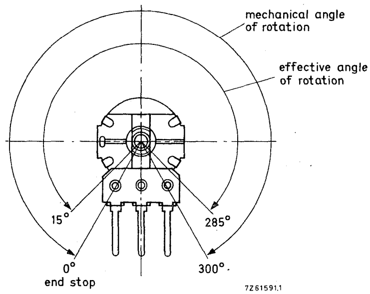


Fig. 11b. Angles of rotation of tandem potentiometers

	switch type		
	s.p.s.t. rotary, spring actuated	s.p.s.t. rotary, direct operating	d.p.s.t. push-pull
Approved by			Demko, Nemko Semko
Breaking capacity	12 V d.c. 2 A	12 V d.c. 2 A	250 V a.c., 1 A (according to IEC 65)
Contact resistance, initially after 10 000 on-off switching operations at breaking capacity	< 10 mΩ < 50 mΩ [2]	< 10 mΩ < 50 mΩ [2]	< 10 mΩ [1] < 200 mΩ [3]
Insulation resistance [4] initially after damp heat test (IEC68, test C_a, 21 days)	> 10 MΩ > 2 MΩ	> 10 MΩ > 2 MΩ	> 100 MΩ > 2 MΩ
Test voltage for 1 min [4], initially after damp heat test (IEC 68, test C_a, 21 days)	500 V d.c. 100 V d.c.	500 V d.c. 100 V d.c.	2200 V, 50 Hz
Switching torque Switching force	15 to 40 mNm	12 to 30 mNm	 1,5 to 2,5 N
Switching angle Switching stroke	26 ± 2°	26 ± 2°	 4 mm
Total mechanical angle of rotation	295 ± 5°	295 ± 5°	270 ± 5°
Backlash	≤ 10°	≤ 10°	≤ 9°
Permissible axial spindle load	≤ 100 N	≤ 50 N	≤ 100 N

1) Measured per contact (e.g. between P_1 and P_2, see "Switches").
2) Averaged over 10 measurements: < 25 mΩ.
3) Averaged over 10 measurements: < 100 mΩ.
4) Measured between the terminals, and between interconnected terminals and the case or other metal parts.

COMPOSITION OF THE CATALOGUE NUMBER

2322 ... .

- ... = code for type and switch
- .... = code for terminals, mounting facility, spindle type and length
- .. = code for resistance law and nominal resistance, see table below

code for type and switch	
without switch: single	= 380
without switch: tandem	= 390
single, with s.p.s.t. rotary switch (spring actuated) 1)	= 381
single, with d.p.s.t. push-pull switch 2)	= 382
single, with s.p.s.t. rotary switch (direct operating)	= 387
single, without switch, with p.w. pins bent backwards 3)	= 389

code for terminals, mounting facility, spindle type and length

solder tags				p.w. pins, length 4,5 mm				p.w. pins, length 9,3 mm			
mounting bushing		twist tags		mounting bushing		twist tags		mounting bushing		twist tags	
steel spindle	plastic spindle	steel spindle	plastic spindle	steel spindle	plastic spindle	steel spindle	plastic spindle	steel spindle	plastic spindle	steel spindle	plastic spindle
0..	7..	2..	4..	0..	7..	2..	4..	1..	6..	3..	5..

Spindle		solder tags	p.w. pins
plain	10 mm	= .11	= .61
	12 mm	= .09	= .59
	15 mm	= .12	= .62
	17 mm	= .13	= .63
	19 mm	= .14	= .64
	20 mm	= .15	= .65
	22 mm	= .17	= .67
	24 mm	= .19	= .69
	25 mm	= .01	= .51
	28 mm	= .02	= .52
	30 mm	= .03	= .53
with flat face	10 mm	= .42	= .92
	15 mm	= .44	= .94
	20 (L_1 = 8,5) mm	= .45	= .95
	20 (L_1 = 13,5) mm	= .46	= .96
knurled (only plastic)	10 mm	= .26	= .76
	15 mm	= .27	= .77
	20 mm	= .28	= .78
with screwdriver slot		= .10	= .60

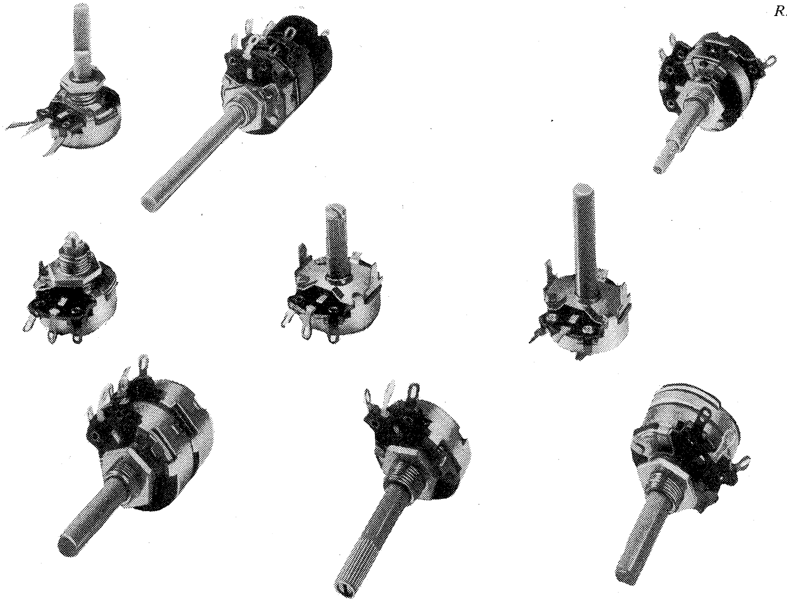
1) Only available with mounting bushing.
2) Only available with mounting bushing and plastic spindle (steel spindle on request). Not available with spindle with screwdriver slot.
3) Only available with mounting bushing and p.w. pins of 9,3 mm length.

nominal resistance	code in catalogue number			
	resist. law Figs.9a,10a	resist. law Figs.9b,10b	resist. law Figs.9c,10c	resist. law Fig. 10f
220 Ω	02			
470 Ω	03			
1 kΩ	04	24	44	
2, 2 kΩ	05	25	45	
4, 7 kΩ	06	26	46	
10 kΩ	07	27	47	91
22 kΩ	08	28	48	92
47 kΩ	09	29	49	93
100 kΩ	11	31	51	94
220 kΩ	12	32	52	95
470 kΩ	13	33	53	96
1 MΩ	14	34	54	97
2, 2 MΩ	15	35	55	
4, 7 MΩ	16			

nominal resistance	code in catalogue number	
	resist. law Figs.9d,10d	resist. law Figs.9e,10e
5 + 42 kΩ	72	
20 + 200 kΩ	67	
50 + 420 kΩ	73	
100 + 900 kΩ	64	
2 + 8 kΩ		76
5 + 17 kΩ		82
10 + 37 kΩ		86
20 + 80 kΩ		77
50 + 170 kΩ		83
100 + 370 kΩ		87
0, 5 + 1, 7MΩ		84

CARBON POTENTIOMETERS

QUICK REFERENCE DATA	
Resistance range	
linear resistance law	220 Ω - 4,7 MΩ
logarithmic resistance law	1 kΩ - 4,7 MΩ
Maximum dissipation at 40 °C	
linear resistance law	0,25 W
logarithmic resistance law	0,125 W
Category (IEC publ. 68)	10/070/21



RZ 27680-6

DESCRIPTION

The CP23 carbon potentiometer series includes four types:

- single potentiometers, for general purposes,
- tandem potentiometers, for stereophonic purposes,
- twin potentiometers, for combined controls,
- triple potentiometers, for combined stereophonic purposes.

The single potentiometers comprise a carbon track, which is fitted on to a base plate of resin bonded paper and housed in a metal case.
The terminals S_1 and S_3 (see "Types") are connected to the ends of the carbon track; terminal S_2 is connected via a contact ring to the slider contact.
The potentiometers can be supplied with a tap (S_4) at 40% of the total mechanical angle of rotation.
The material of the spindle is poly-acetal resin.

The tandem potentiometers are composed of two single potentiometers which are ganged; their resistance values and gradings are identical within narrow limits.

The twin potentiometers are composed of two single potentiometers R_1 and R_2; potentiometer R_1 is operated by means of a hollow steel spindle or a hollow plastic spindle of poly-acetal resin, through which a steel spindle protrudes for the operation of potentiometer R_2.

The triple potentiometers consist of one single (R_1) and one tandem potentiometer (R_2 and R_3); operation is done as for the twin potentiometers.

All four types, except the triple potentiometers which are all without switch, can be delivered without switch, with a rotary switch or with a push-pull switch; besides all single and tandem potentiometers are available with different connecting terminals, mounting facilities and spindles, see below.

Types

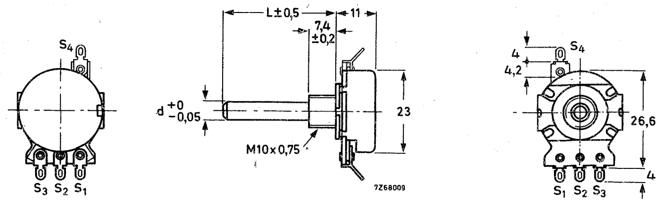


Fig. 1. Single potentiometer.

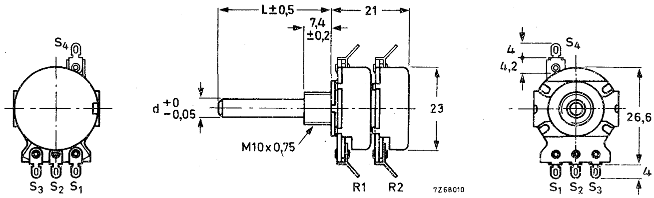


Fig. 2. Tandem potentiometer.

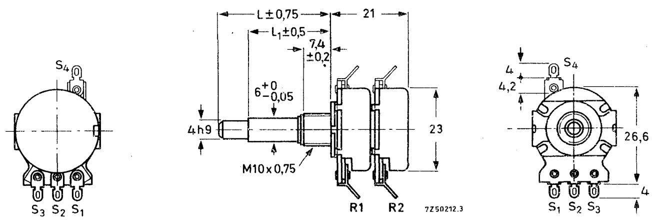


Fig. 3. Twin potentiometer.

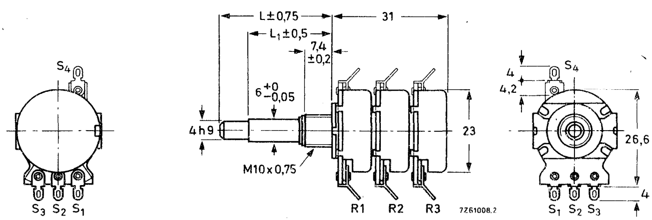
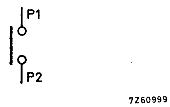
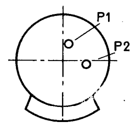
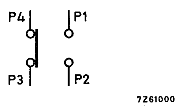
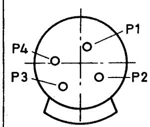
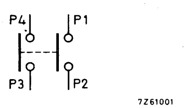
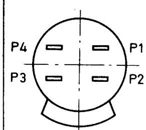
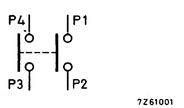
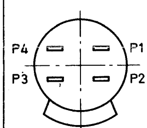


Fig. 4. Triple potentiometer.

For dimensions d, L and L_1, see paragraph "Spindles".

Switches

type	circuit in "off"-position of spindle [1]	position of terminals	Fig.	available with potentiometer type
single-pole, single-throw rotary switch (s.p.s.t.)			5 6 6	single tandem twin
single-pole, double-throw rotary switch (s.p.d.t.)			7 8	single tandem twin
double-pole, single-throw rotary switch (d.p.s.t.)			9 10 10	single tandem twin
double-pole, single-throw push-pull switch 2A (d.p.s.t.)			11 12 12	single tandem twin

[1]) Spindle turned fully counterclockwise for rotary switches or pushed in for push-pull switches.

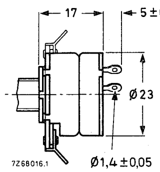


Fig. 5. S.P.S.T. rotary switch (single potentiometer).

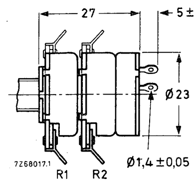


Fig. 6. S.P.S.T. rotary switch (tandem or twin potentiometer).

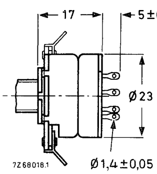


Fig. 7. S.P.D.T. rotary switch (single potentiometer).

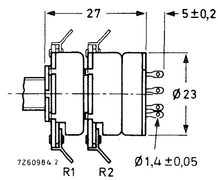


Fig. 8. S.P.D.T. rotary switch (tandem potentiometer).

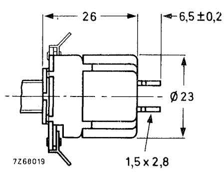


Fig. 9. D.P.S.T. rotary switch (single potentiometer).

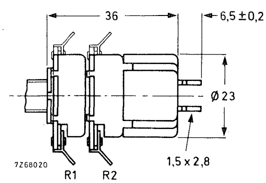


Fig. 10. D.P.S.T. rotary switch (tandem or twin potentiometer).

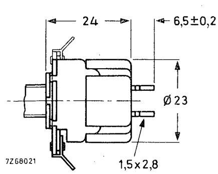


Fig. 11. D.P.S.T. push-pull switch (single potentiometer).

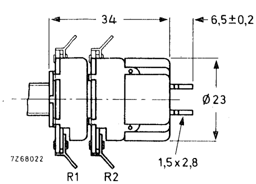


Fig. 12. D.P.S.T. push-pull switch (tandem or twin potentiometer).

Connecting terminals

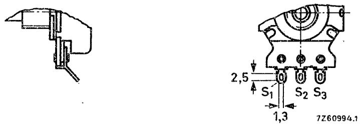


Fig. 13 Solder tags.

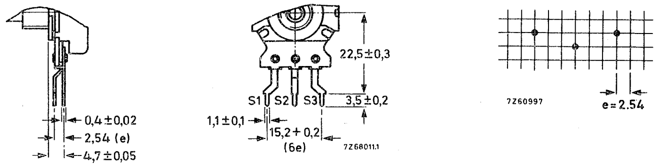


Fig. 14 Long printed-wiring pins, pin distance 15,2 mm (6e) (single potentiometer). [1]

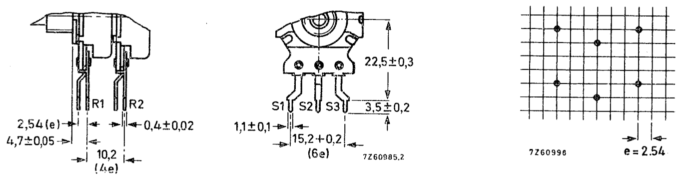


Fig. 15 Long printed-wiring pins, pin distance 15,2 mm (6e) (tandem potentiometer). [1]

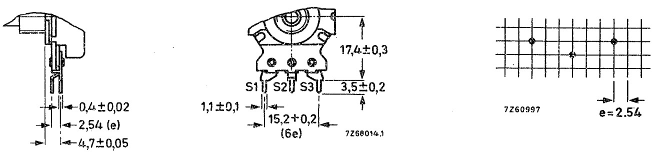


Fig. 16 Short printed-wiring pins, pin distance 15,2 mm (6e) (single potentiometer). [1]

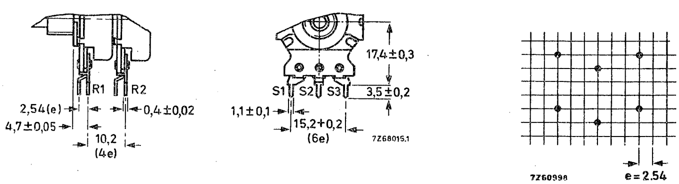


Fig. 17 Short printed-wiring pins, pin distance 15,2 mm (6e) (tandem potentiometer). [1]

[1]) Twin and triple potentiometers with printed-wiring pins are available on request.

Mounting facilities

mounting facility	required mounting holes in chassis	fixing of potentiometer
mounting bushing M10 x 0,75	(see Fig. 18)	with supplied mounting nut [1]; max. torque for tightening = 3,5 Nm; min. thickness of chassis = 1,5 mm
twist tags Note - only for single and tandem potentiometers	(see Fig. 19)	by twisting the tags

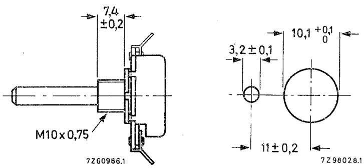


Fig. 18

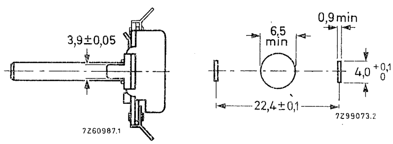
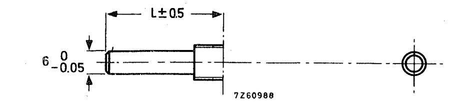
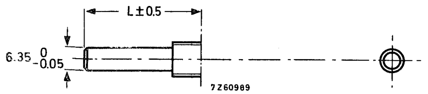
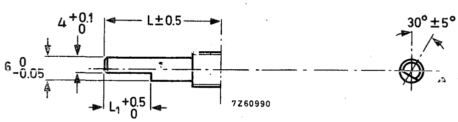
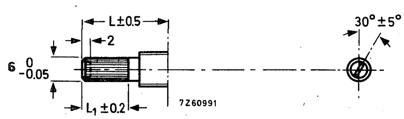
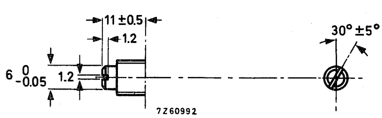
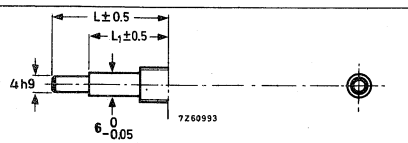


Fig. 19

[1]) Catalogue number of mounting nut: 4322 047 00350.

Spindles

type	"off position"	L (mm)	L_1 (mm)	available with potentiometer type
 		17 18 19 20 22 25 30 35 40 60 70		single tandem
		90		single
		18 25 28 30 35 40 60 70	8.5 13.5 13.5 13.5 13.5 13.5 13.5 13.5	single tandem
		90	13.5	single
		18 30 60	8 12 12	single tandem
				single tandem (not for potentiometers with push-pull switch)
		30.5 42.5	18 30	twin triple

Note - For potentiometers with push-pull switch the length L applies to "off-position" of switch.

TECHNICAL DATA

Unless otherwise specified, all values have been determined at an ambient temperature of 15 to 35 °C, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.
For measuring methods, see IEC publications 190 and 68.
For the terms used, the paragraph "Glossary of terms" of section "Introduction, carbon potentiometers" should be consulted.

nom. resist. (R_n) [1]	resist. law acc. to Fig. 20	max. voltage (V) at 40 °C	max. voltage (V) at 70 °C	max. terminal resist.	max. attenuation (dB)	max. contact resist. (% R_n)	limiting slider current at 40 °C (mA)
220 Ω [2]	a	7.4	5.7	10 Ω	–	3	40
470 Ω [2]	a	11	8.4	10 Ω	–	3	22
1 kΩ	a	16	12	25 Ω	–	3	16
2.2 kΩ	a	23	18	25 Ω	–	3	11
4.7 kΩ	a	34	26	25 Ω	–	3	7
10 kΩ	a	50	39	35 Ω	–	2.5	5
22 kΩ	a	74	57	35 Ω	–	2.5	3.5
47 kΩ	a	110	84	35 Ω	–	2.5	2.2
100 kΩ	a	160	120	100 Ω	–	2.5	1.4
220 kΩ	a	230	180	125 Ω	–	2.5	1.0
470 kΩ	a	340	265	250 Ω	–	2.5	0.65
1 MΩ	a	500	390	1 kΩ	–	2.5	0.45
2.2 MΩ	a	500	500	2.2 kΩ	–	2.5	0.32
4.7 MΩ	a	500	500	4.7 kΩ	–	2.5	0.22
330 Ω [2]	a	8.7	6.7	10 Ω	–	3	30
1 kΩ	b	12	10	5 Ω	50 [3]	4	10
2.2 kΩ	b	18	15	5 Ω	60 [3]	4	7
4.7 kΩ	b	26	22	5 Ω	60 [3]	4	4.5
10 kΩ	b	39	32	10 Ω	60 [3]	4	3.2
22 kΩ	b	57	47	22 Ω	60 [3]	4	2.2
47 kΩ	b	84	69	35 Ω	70 [3]	4	1.4
100 kΩ	b	120	100	50 Ω	70 [3]	4	1.0
220 kΩ	b	180	150	50 Ω	80 [3]	4	0.7
470 kΩ	b	265	220	100 Ω	80 [3]	4	0.45
1 MΩ	b	390	320	500 Ω	80 [3]	4	0.32
2.2 MΩ	b	500	470	2.2 kΩ	80 [3]	4	0.22
4.7 MΩ	b	500	500	4.7 kΩ	80 [3]	4	0.14

[1] Measured between terminals S_1 and S_3; for potentiometers with a tap, between terminals S_1 and S_4 and between S_3 and S_4.
[2] Not for tandem and triple potentiometers.
[3] Measured between terminals S_1 and S_2; spindle turned fully counterclockwise.

nom. resist. (R_n) [1]	resist. law acc. to Fig. 20	max. voltage (V)		max. terminal resist.	max. attenuation (dB)	max. contact resist. (% R_n)	limiting slider current at 40 °C (mA)
		at 40 °C	at 70 °C				
470 Ω	c	8.4	6.9	20 Ω	–	6	14
1 kΩ	c	12	10	50 Ω	50	4	10
2.2 kΩ	c	18	15	50 Ω	60	4	7
4.7 kΩ	c	26	22	100 Ω	60	4	4.5
10 kΩ	c	39	32	200 Ω	60	4	3.2
22 kΩ	c	57	47	250 Ω	60	4	2.2
47 kΩ	c	84	69	500 Ω	70 [2]	4	1.4
100 kΩ	c	120	100	2 kΩ	70	4	1.0
220 kΩ	c	180	150	2.5 kΩ	80	4	0.7
470 kΩ	c	260	220	5 kΩ	80	4	0.45
1 MΩ	c	390	320	20 kΩ	80	4	0.32
2.2 MΩ	c	500	470	44 kΩ	80	4	0.22
330 Ω	c	6.7	5.5	20 Ω	–	6	20
20+200 kΩ	d	180	150	50 Ω	80	4	0.7
50+420 kΩ	d	265	220	100 Ω	80 [3]	4	0.45
100+900 kΩ	d	390	320	500 Ω	80	4	0.32
0.2+ 2 MΩ	d	500	470	2.2 kΩ	80	4	0.22
0.5+1.7 kΩ	e	18	15	5 Ω	60	4	7
5+ 17 kΩ	e	57	47	22 Ω	60	4	2.2
10+ 37 kΩ	e	84	69	47 Ω	70	4	1.4
20+ 80 kΩ	e	120	100	100 Ω	70 [3]	4	1.0
50+170 kΩ	e	180	150	220 Ω	80	4	0.7
100+370 kΩ	e	265	220	470 Ω	80	4	0.45
200+800 kΩ	e	390	320	1 kΩ	80	4	0.32
0.5+1.7 MΩ	e	500	470	2.2 kΩ	80	4	0.22
400+600 kΩ	f	500	390	1 kΩ	60 [3]	2.5	0.45
200+100 kΩ	g	210	170	3 kΩ	–	4	0.7
22 kΩ	h	50	35	–	–	4	3.5
47 kΩ	h	80	55	–	–	4	2.2
100 kΩ	h	110	80	–	–	4	1.4
220 kΩ	h	160	110	–	–	4	1.0
470 kΩ	h	250	175	–	–	4	0.65
1 MΩ	h	350	250	–	–	4	0.45

[1]) Measured between terminals S_1 and S_3; for potentiometers with a tap, between terminals S_1 and S_4 and between S_3 and S_4.
[2]) Measured between terminals S_3 and S_2; spindle turned fully clockwise.
[3]) Measured between terminals S_1 and S_2; spindle turned fully counterclockwise.

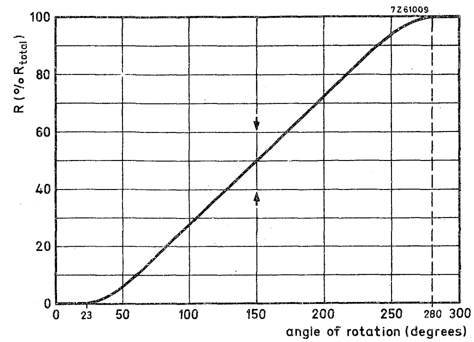


Fig. 20a. Linear resistance law.

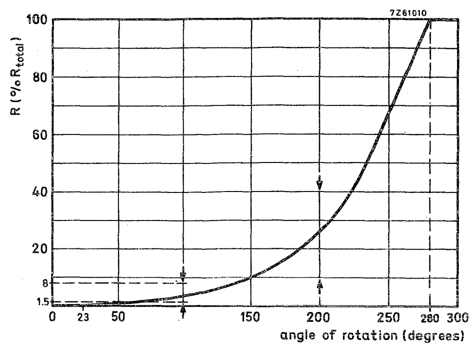


Fig. 20b. Logarithmic resistance law.

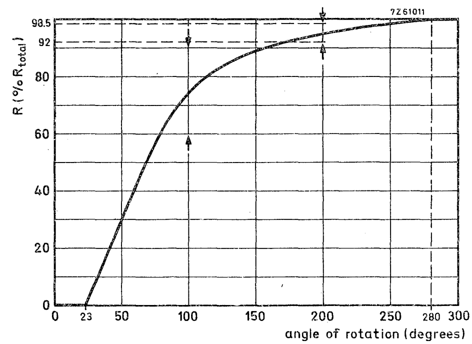


Fig. 20c. Reversed logarithmic resistance law.

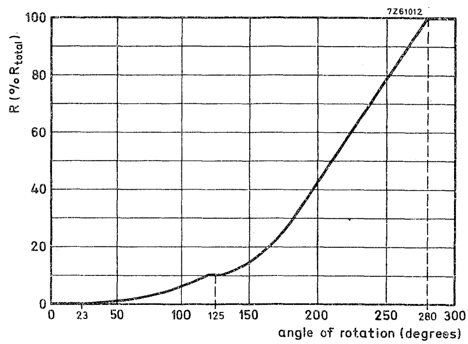


Fig. 20d. Resistance law, tap at 10%.

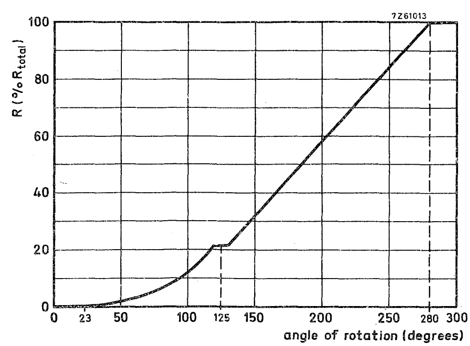


Fig. 20e. Resistance law, tap at 20%.

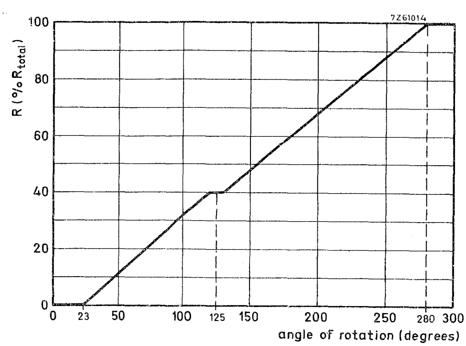


Fig. 20f. Linear resistance law, tap at 40%.

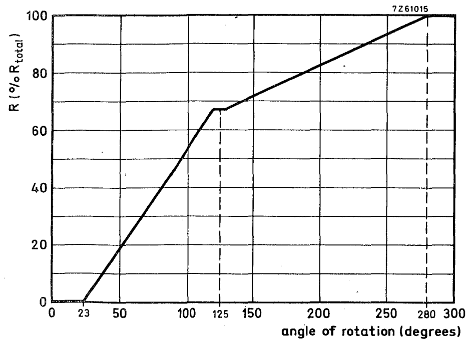


Fig. 20g. Linear resistance law,
tap at 67%.

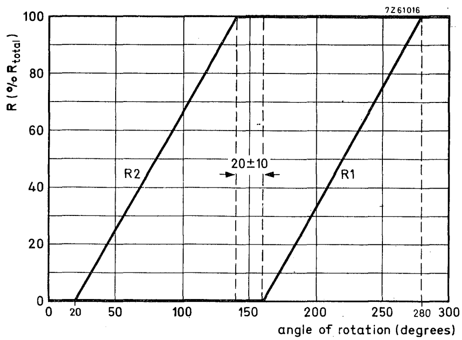


Fig. 20h. Resistance law,
balance potentiometers.

Tolerance on the nominal resistance	± 20% [1]
Resistance law and tolerances	see Figs. 20a to 20h
Ganging tolerance [2]	
linear resistance law	
at values between 10 and 90% of R_{total}	< 2 dB
with a tap at 40% and	
at attenuations between 0 and −20 dB	< 2 dB
at attenuations between −20 and −28 dB	< 3 dB
(reversed) logarithmic resistance law	
at attenuations between 0 and −20 dB	< 2 dB
at attenuations between −20 and −30 dB	< 3 dB
at attenuations between −30 and −40 dB	< 4 dB
with a tap at 10% or 20% and	
at attenuations between 0 and −20 dB	< 2 dB
at attenuations between −20 and −30 dB	< 3 dB
at attenuations between −30 and −34 dB	< 4 dB
Minimum resistance at the tap	≤ 1% of R_n
Insulation resistance after damp heat test (IEC 68, test C, 21 days)	> 100 MΩ
Maximum dissipation	
linear resistance law, acc. to Fig. 20a, at 40 °C	0.25 W
at 70 °C	0.125 W
resistance law, acc. to Figs. 20b to 20h, at 40 °C	0.125 W
at 70 °C	0.0625 W
Test voltage	1000 V, 50 Hz
Working-temperature range	−10 to +70 °C
Category (IEC 68)	10/070/21
Operating torque	
single- and twin potentiometers	0.3 - 2 Ncm
tandem- and triple potentiometers	0.7 - 3.5 Ncm
Permissible torque with slider at end stop	≤ 80 Ncm
Permissible axial spindle load	≤ 100 N

1) For potentiometers with a tap the tolerance on R_1 as well as on R_2 is ± 20%.
2) For tandem and triple potentiometers only.

Effective angle of rotation	250 - 265°
Mechanical angle of rotation	300 ± 5°
Life	after 10000 rotations $\Delta R_{total} < 25\%$ of R_{total}

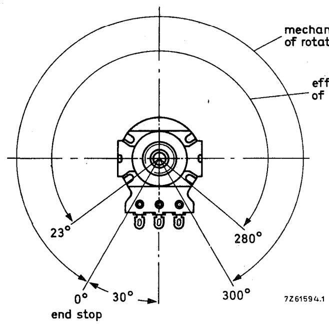


Fig. 21a. Angles of rotation of potentiometers without switch or with a push-pull switch.

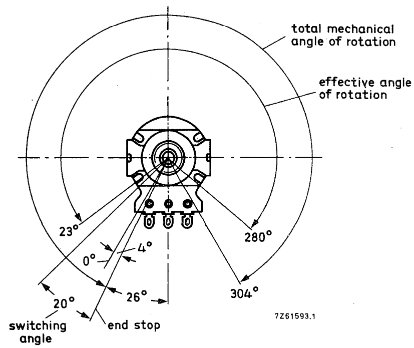


Fig. 21b. Angles of rotation of potentiometers with a s.p.s.t. rotary switch.

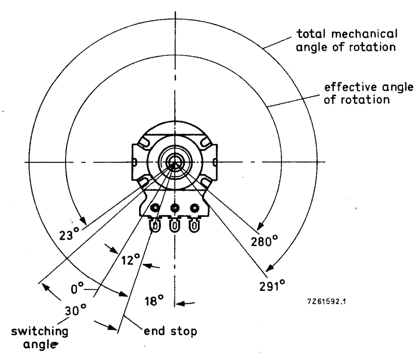


Fig. 21c. Angles of rotation of potentiometers with a d.p.s.t. rotary switch.

	switch type			
	rotary s.p.s.t.	rotary s.p.d.t.	rotary d.p.s.t.	push-pull d.p.s.t., 2A
Approved by	C.S.A.	C.S.A.	C.S.A., E.I., S.E.V., Demko, Semko, Nemko	Demko, Semko, Nemko
→ Breaking capacity	250Va.c., 0,5A, $\cos\varphi = 0,9$ 125Va.c., 1A, $\cos\varphi = 0,9$	250Va.c., 0,5A, $\cos\varphi = 0,9$ 125Va.c., 1A, $\cos\varphi = 0,9$	250 Va.c., 1,5 A/32x (IEC 65)	250 Va.c., 2 A/32x (IEC 65)
Contact resistance, initially after damp heat test (IEC 68, test C, 21 days) after 10 000 on-off switching operations at breaking capacity	< 25 mΩ < 40 mΩ ≤ 200 mΩ [2]	< 25 mΩ < 40 mΩ ≤ 200 mΩ [2]	< 20 mΩ [1] < 40 mΩ ≤ 200 mΩ [2]	< 20 mΩ [1] < 40 mΩ ≤ 200 mΩ [2]
Insulation resistance, initially after damp heat test (IEC 68, test C, 21 days)	> 100 MΩ > 2 MΩ	> 100 MΩ > 2 MΩ	> 5000 MΩ > 25 MΩ	> 5000 MΩ > 25 MΩ
Test voltage [5], initially after damp heat test (IEC68, test C, 21 days) [6]	2000 V, 50 Hz 500 V, 50 Hz	2000 V, 50 Hz 500 V, 50 Hz	2000 V, 50 Hz 2000 V, 50 Hz	2200 V, 50 Hz 2200 V, 50 Hz
Switching torque Switching force	4 - 8 Ncm [3] 4 - 9,5 Ncm [4]	4 - 8 Ncm [3] 4 - 9,5 Ncm [4]	4 - 8 Ncm [3] 4 - 9,5 Ncm [4]	3,5 - 4,5 N
Switching angle Switching stroke	20 ± 2°	20 ± 2°	25 - 35°	3,5 mm
Total mechanical angle of rotation	308 ± 5°	308 ± 5°	303 ± 5°	300 ± 5°
Backlash (rotary switch)	≤ 6°	≤ 6°	-	
Backlash (push-pull switch)				≤ 9°
Permissible axial spindle load	≤ 100 N	≤ 100 N	≤ 100 N	≤ 100 N

1) Measured per contact (e.g. between P_1 and P_2, see "Switches").
2) Averaged over 10 measurements: ≤ 100 mΩ.
3) For single and twin potentiometers.
4) For tandem potentiometers.
5) Measured at opened switch between the terminals, and between the case or spindle and interconnected terminals.
6) Measured after recovery period of 24 hours.

COMPOSITION OF THE CATALOGUE NUMBER Single and tandem types

2322 ... .

- ... : code for type and switch
- first digit of second group: code for terminals, mounting facility, type, and length of plastic spindle
- remaining digits: code for resistance law and nominal resistance, see tables below

code for type and switch		
without switch	single	= 350
	tandem	= 360
with s.p.d.t. rotary switch	single	= 352
	tandem	= 363
with s.p.s.t. rotary switch	single	= 353
	tandem	= 362
with d.p.s.t. push-pull switch, 2A	single	= 355
	tandem	= 365
with d.p.s.t. rotary switch	single	= 357
	tandem	= 366

code for terminals, mounting facility, type, and length of plastic spindle

solder tags

mounting bushing 7..		twist tags 4..	
plain ϕ6 mm	17 mm = .13	plain ϕ6.35 mm	17 mm = .33
	18 mm = .06		18 mm = .26
	19 mm = .14		19 mm = .34
	20 mm = .15		20 mm = .35
	22 mm = .17		22 mm = .37
	25 mm = .01		25 mm = .21
	30 mm = .03		30 mm = .23
	35 mm = .04		35 mm = .24
	40 mm = .05		40 mm = .25
	60 mm = .07		60 mm = .27
	70 mm = .08		70 mm = .28
	90 mm = .09		90 mm = .29
with flat face	18 mm = .40	knurled	18 mm = .11
	25 mm = .41		30 mm = .12
	28 mm = .42		60 mm = .31
	30 mm = .43		
	35 mm = .44	with screwdriver slot	= .10
	40 mm = .45		
	60 mm = .47		
	70 mm = .48		
	90 mm = .49		

long p.w. pins / short p.w. pins

long p.w. pins: mounting bushing 3.. / twist tags 5..		short p.w. pins: mounting bushing 2.. / twist tags 6..	
plain ϕ6 mm	17 mm = .63	plain ϕ6.35 mm	17 mm = .83
	18 mm = .56		18 mm = .76
	19 mm = .64		19 mm = .84
	20 mm = .65		20 mm = .85
	22 mm = .67		22 mm = .87
	25 mm = .51		25 mm = .71
	30 mm = .53		30 mm = .73
	35 mm = .54		35 mm = .74
	40 mm = .55		40 mm = .75
	60 mm = .57		60 mm = .77
	70 mm = .58		70 mm = .78
	90 mm = .59		90 mm = .79
with flat face	18 mm = .90	knurled	18 mm = .61
	25 mm = .91		30 mm = .62
	28 mm = .92		60 mm = .81
	30 mm = .93		
	35 mm = .94	with screwdriver slot	= .60
	40 mm = .95		
	60 mm = .97		
	70 mm = .98		
	90 mm = .99		

Twin and triple types

2322 ... .

code for type, switch and hollow spindle

steel hollow spindle		
without switch	twin	= 370
	triple	= 378
with s.p.d.t. rotary switch	twin	= 372
with s.p.s.t. rotary switch	twin	= 373
with d.p.s.t. push-pull switch, 2A	twin	= 375
with d.p.s.t. rotary switch	twin	= 376

plastic hollow spindle		
without switch	twin	= 470
	triple	= 478
with s.p.d.t. rotary switch	twin	= 472
with s.p.s.t. rotary switch	twin	= 473
with d.p.s.t. push-pull switch, 2A	twin	= 475
with d.p.s.t. rotary switch	twin	= 476

code for resistance law and nominal resistance of potentiometer R_2, see tables below

code for resistance law and nominal resistance of potentiometer R_1, see tables below

code for spindle lengths

plastic hollow spindle
18 and 30.5 mm = 0
30 and 42.5 mm = 1

steel hollow spindle
18 and 30.5 mm = 6
30 and 42.5 mm = 7

nominal resistance	code in catalogue number			
	resist. law Fig. 20a	resist. law Fig. 20b	resist. law Fig. 20c	resist. law Fig. 20h
220 Ω	02			
330 Ω	19		59	
470 Ω	03		43	
1 kΩ	04	24	44	
2.2 kΩ	05	25	45	
4.7 kΩ	06	26	46	
10 kΩ	07	27	47	
22 kΩ	08	28	48	92
47 kΩ	09	29	49	93
100 kΩ	11	31	51	94
220 kΩ	12	32	52	95
470 kΩ	13	33	53	96
1 MΩ	14	34	54	97
2.2 MΩ	15	35	55	
4.7 MΩ	16	36		

nominal resistance	code in catalogue number			
	resist. law Fig. 20d	resist. law Fig. 20e	resist. law Fig. 20f	resist. law Fig. 20g
20+200 kΩ	67			
50+420 kΩ	73			
100+900 kΩ	64			
0.2+ 2 MΩ	68			
0.5+1.7 kΩ		81		
5+ 17 kΩ		82		
10+ 37 kΩ		86		
20+ 80 kΩ		77		
50+170 kΩ		83		
100+370 kΩ		87		
200+800 kΩ		78		
0.5+1.7 MΩ		84		
400+600 kΩ			89	
200+100 kΩ				65

CARBON PRESET POTENTIOMETERS

QUICK REFERENCE DATA	
Resistance range (E3-series), linear law	100 Ω - 4, 7 MΩ
Maximum dissipation at 40 °C	0, 2 W
Climatic category, IEC 68	25/070/21
Basic specification	DIN44150

APPLICATION

These potentiometers have been designed for preset resistance control with provision for re-adjustments. They are particularly suitable for use in radio and television receivers.

DESCRIPTION

These preset potentiometers comprise a carbon track, which is riveted on to a base plate of resin-bonded paper. They are provided with snap-in printed-wiring pins, which hold them firmly in place on the board before soldering. They are also available with straight printed-wiring pins.
The pins S_1 and S_3 (see Figs. 1a, 2a, 3 and 4) are connected to the ends of the carbon track; pin S_2 is connected to the slider.
The slider has a central screwdriver slot, a plastic knob or a wheel for adjustment.
This potentiometer series includes two types: one for vertical and one for horizontal mounting on printed-wiring boards.

Outlines

Dimensions in mm

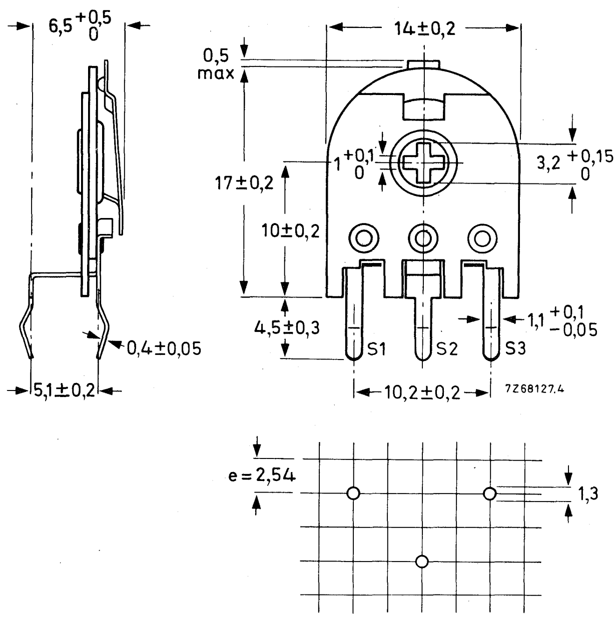


Fig. 1a Potentiometer for vertical mounting, with snap-in printed-wiring pins.

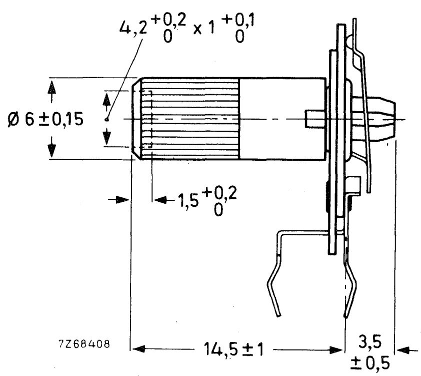


Fig. 1b Potentiometer with knob at the side of the base plate.

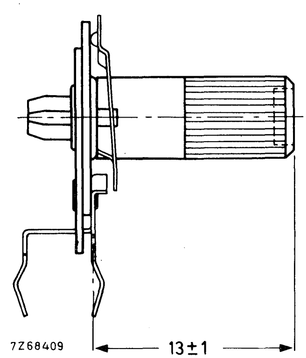


Fig. 1c Potentiometer with knob at the side of the carbon track.

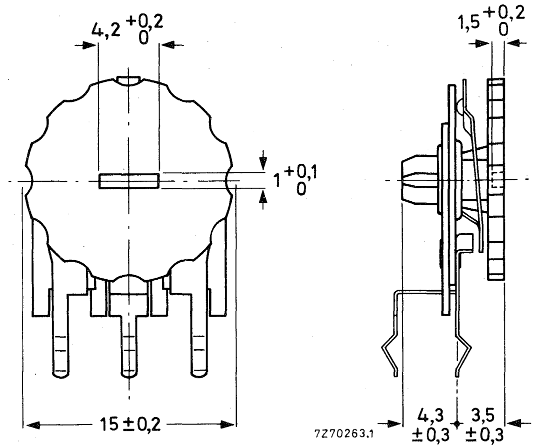


Fig. 1d Potentiometer with adjustment wheel at the side of the carbon track.

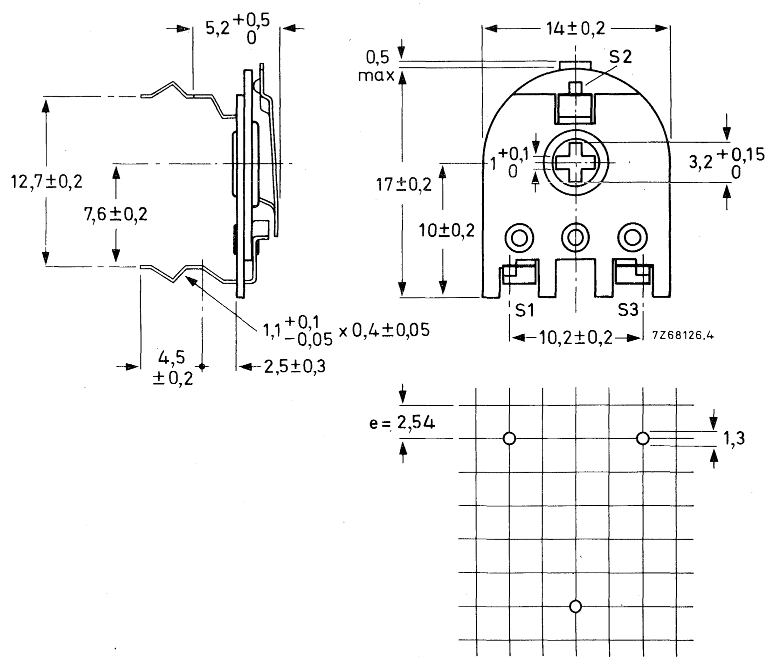


Fig. 2a Potentiometer for horizontal mounting, with snap-in printed-wiring pins.

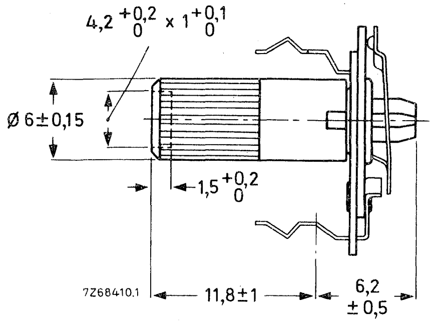


Fig. 2b Potentiometer with knob at the side of the base plate.

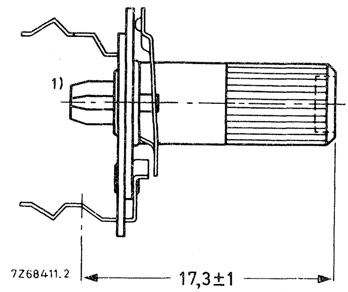


Fig. 2c Potentiometer with knob at the side of the carbon track.

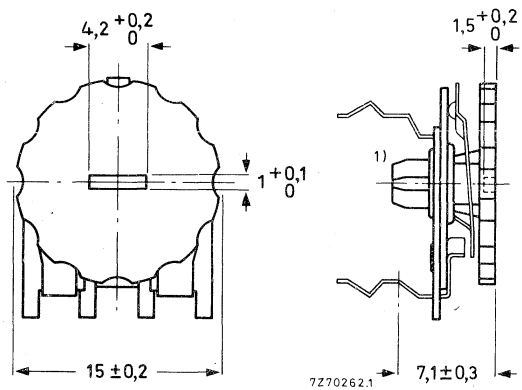
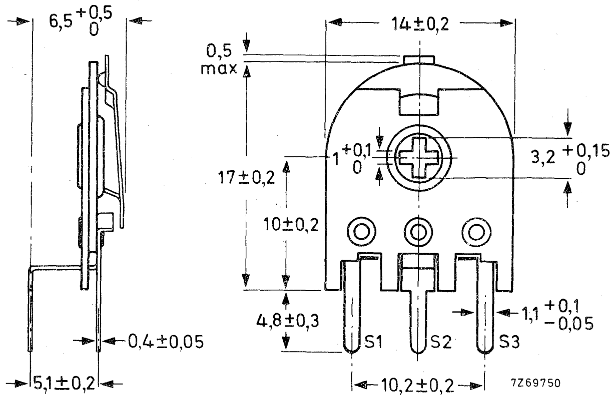


Fig. 2d Potentiometer with adjustment wheel at the side of the carbon track.

1) Required hole in printed-wiring board: $\phi 4 + 0,2$ mm.



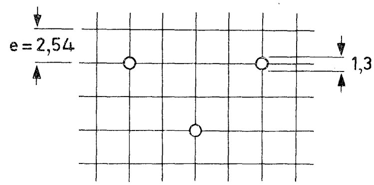
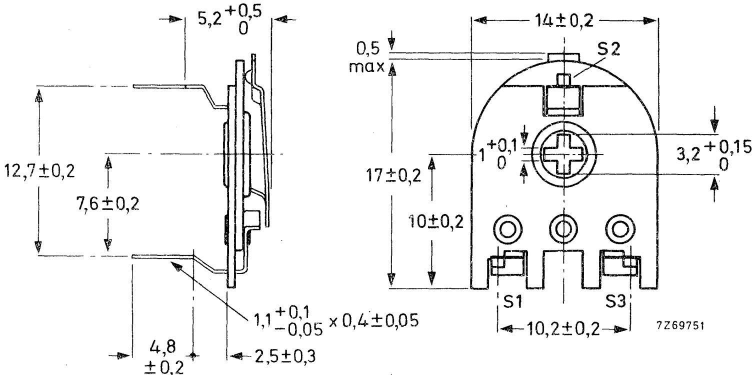


Fig. 3 Potentiometer for vertical mounting, with straight printed-wiring pins.



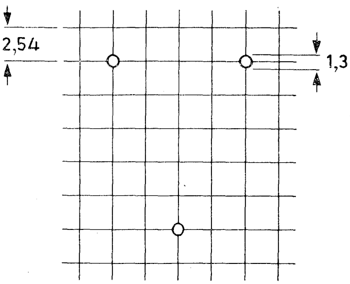


Fig. 4 Potentiometer for horizontal mounting, with straight printed-wiring pins.

Note

For dimensions of knob or wheel versions see relevant drawing of snap-in-pin counterpart.

TECHNICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of 15 to 35 °C, an atmospheric pressure of 86 to 106 kN/m^2 and a relative humidity of 45 to 75%.

nom. resistance (R_n)	max. voltage (V)		max. terminal resistance (Ω)	limiting slider current (mA)		code in catalogue number
	at 40 °C	at 70 °C		at 40 °C	at 70 °C	
100 Ω	4,5	3,2	10	40	32	01
220 Ω	6,7	4,7	10	30	21,3	02
330 Ω	8	5,7	10	24,5	17,4	19
470 Ω	9,7	6,8	10	20,6	14,6	03
1 kΩ	14,2	10	25	14	10	04
2,2 kΩ	21	14,8	25	9,5	6,7	05
4,7 kΩ	31	21,6	100	6,5	4,6	06
10 kΩ	45	31,6	200	4,5	3,2	07
22 kΩ	67	47	400	3	2,1	08
47 kΩ	97	68	1000	2	1,4	09
100 kΩ	142	100	2000	1,4	1	11
220 kΩ	210	148	4000	0,9	0,6	12
470 kΩ	310	216	10000	0,6	0,4	13
1 MΩ	450	316	20000	0,4	0,3	14
2,2 MΩ	500	470	40000	0,3	0,2	15
4,7 MΩ	500	500	100000	0,2	0,14	16

Tolerance on the nominal resistance	±20%
Resistance law	linear
Maximum dissipation (P_{max}), at 40 °C	0,2 W
at 70 °C	0,1 W
Maximum voltage	$\sqrt{P_{max} \cdot R_n}$; maximum 500 V (see table above)
Working temperature range	−25 to +70 °C
Climatic category, IEC 68	25/070/21
Operating torque	4 to 25 mNm
→ Maximum end stop torque	100 mNm
Effective angle of rotation	220 ± 10°
Mechanical angle of rotation	230 ± 5°
Life	50 cycles
Weight, potentiometer without knob	0,72 g
potentiometer with knob	1,18 g

COMPOSITION OF THE CATALOGUE NUMBER

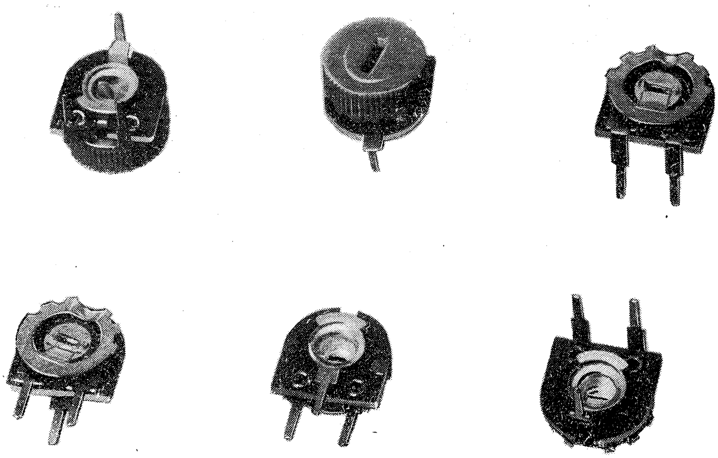
2322 409 . . . . .

0 = without knob
1 = with knob at the side of the base plate
2 = with knob at the side of the carbon track
4 = with adjustment wheel at the side of the carbon track

72 = with snap-in pins for vertical mounting (DIN 44150)
83 = with snap-in pins for horizontal mounting (DIN 44150)
52 = with straight pins for vertical mounting (DIN 44150)
63 = with straight pins for horizontal mounting (DIN 44150)

code for resistance value, see table

MINIATURE CARBON PRE-SET POTENTIOMETERS



RZ 25706-4

Linear resistance law	
Resistance range	100 Ω - 4.7 MΩ

APPLICATION

These potentiometers are destined for pre-set resistance controls with provision for re-adjustments. Due to their miniature size these high-reliable potentiometers are very suitable for use in transistorised equipment.

CONSTRUCTION

The annular carbon track is riveted on to a base plate of resin bonded paper. The stop is formed by the tag for the slider. For adjustment the slider has been provided with a central screw-driver slot and notches on the outer edge, or with a knob with central screw-driver slot.
Versions for vertical mounting as well as for horizontal mounting on printed-wiring boards are available. The tags will fit printed-wiring boards with a pitch of 2.54 mm.
The potentiometers are marked with the nominal resistance value.

Outlines

Dimensions in mm

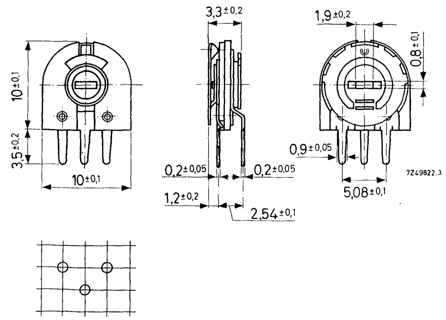


Fig. 1a Potentiometers for vertical mounting without knob, 2322 410 050 . .

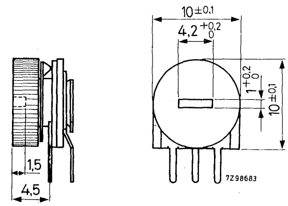


Fig. 1b Potentiometers for vertical mounting with knob, 2322 410 450 . .

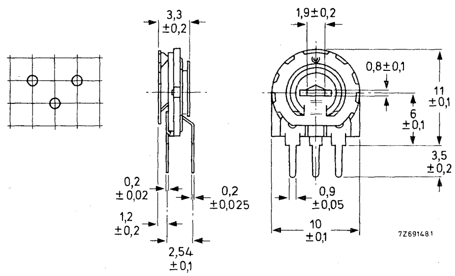


Fig. 2a Potentiometers for vertical mounting without knob, 2322 410 011 . .

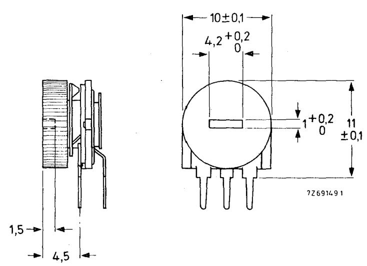


Fig. 2b Potentiometers for vertical mounting with knob, 2322 410 411 . .

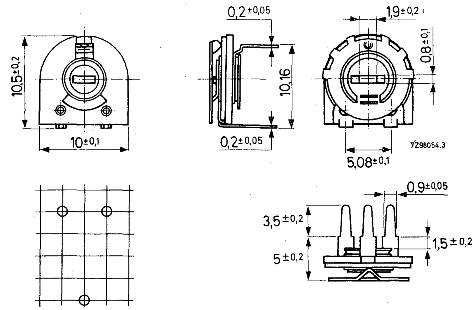


Fig. 3a Potentiometers for horizontal mounting without knob, 2322 410 033 ..

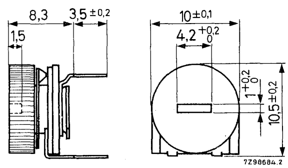


Fig. 3b Potentiometers for horizontal mounting with knob, 2322 410 433 ..

TECHNICAL PERFORMANCE

nom. resistance (R_n)	max. terminal resistance (Ω)	V_{max} (d.c. or r.m.s.) at T_{amb} = 40 °C (V)	limiting slider current (mA)	code in catalogue number
100 Ω	10	3, 2	10	01
220 Ω	10	4, 5	7	02
330 Ω	10	6	6	19
470 Ω	10	7	4, 5	03
1 Ω	20	10	3, 2	04
2, 2 kΩ	40	14	2, 2	05
4, 7 kΩ	100	22	1, 4	06
10 kΩ	200	32	1, 0	07
22 kΩ	400	45	0, 7	08
47 kΩ	1 000	70	0, 45	09
100 kΩ	2 000	70	0, 32	11
220 kΩ	4 000	70	0, 22	12
470 kΩ	10 000	70	0, 22	13
1 MΩ	20 000	70	0, 22	14
2, 2 MΩ	40 000	70	0, 22	15
4, 7 MΩ	100 000	70	0, 14	16

Resistance tolerance	± 20%
Resistance value as a function of the rotation angle	linear
Effective angle of rotation	200 ± 10^{o}
Mechanical angle of rotation	$255 - 265^{o}$
Maximum permissible power dissipation (of total resistance)	
at an ambient temperature of 40 °C	0,1 W
at an ambient temperature of 70 °C	0,05 W
Permissible ambient-temperature range	−25 to +70 °C
Resistance change after humidity test ($0,1\ P_{nom}$, 21 days, T_{amb} = 40 °C R.H. = 90 - 95%) for $R_{nom} \leq 2,2$ kΩ	< 5%
for $R_{nom} \geq 4,7$ kΩ	< 25%
Torque	0,5 - 3 Ncm
Maximum permissible torque with slider at end stop	5 Ncm

COMPOSITION OF THE CATALOGUE NUMBER

2322 410 . . . . .

0 = without knob
4 = with knob

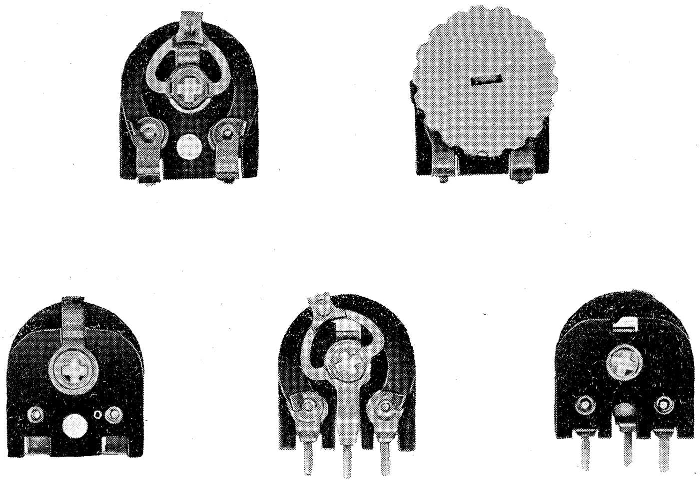
11 = vertical mounting (Fig. 2)
33 = horizontal mounting (Fig. 3)
50 = vertical mounting (Fig. 1)

code for resistance value, see table above

Note: catalogue number of knob: 4322 047 00190

CARBON PRE-SET POTENTIOMETERS

RZ 28692-1



APPLICATION

These potentiometers are destined for pre-set resistance controls with provision for re-adjustments. They are particularly suitable for use in radio and television receivers.

CONSTRUCTION

The annular carbon track is riveted onto a base plate of resin bonded paper.
For adjustment the slider has been provided with a central screwdriver slot, a plastic knob or a knurled wheel.
The material of the solder tags and pins is tinplated brass.

There are seven versions available:

Potentiometers 2322 411 .00..,	provided with solder tags, wich are perpendicular on the base plate. They are suited for direct mounting in the wiring; if necessary they can be fitted with a screw in the mounting hole (Fig. 1).
Potentiometers 2322 411 .22..,	provided with pins, for vertical mounting on printed-wiring boards (Fig. 2).
Potentiometers 2322 411 .72..*)	provided with pins, for vertical mounting on printed-wiring boards according to DIN 44 150 (Fig. 3).

*) Preferred type

Potentiometers 2322 411 .73.., provided with pins, for vertical mounting on printed-wiring boards (Fig. 4).

Potentiometers 2322 411 .33.., provided with pins, for horizontal mounting on printed-wiring boards (Fig. 5).

Potentiometers 2322 411 .83..*) provided with pins, for horizontal mounting on printed-wiring boards according to DIN 44 150 (Fig. 6).

Potentiometers 2322 411 .84.., provided with pins, for horizontal mounting on printed-wiring boards according to DIN 44 151 (Fig. 7).

All versions mentioned above are available with a knurled adjustment wheel (Fig. 8), an adjustment knob (Figs. 9 and 10) or with a slot for screwdriver adjustment.

Dimensions in mm

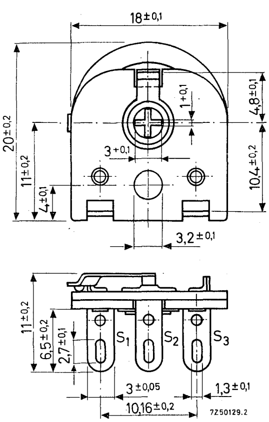


Fig. 1. Potentiometers 2322 411 000..

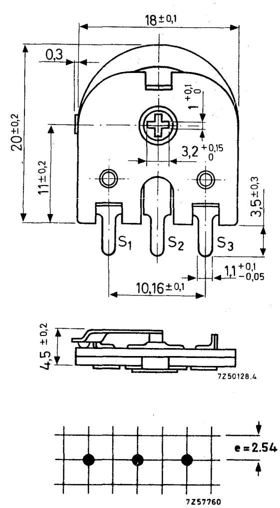


Fig. 2. Potentiometers 2322 411 022..

*) Preferred type

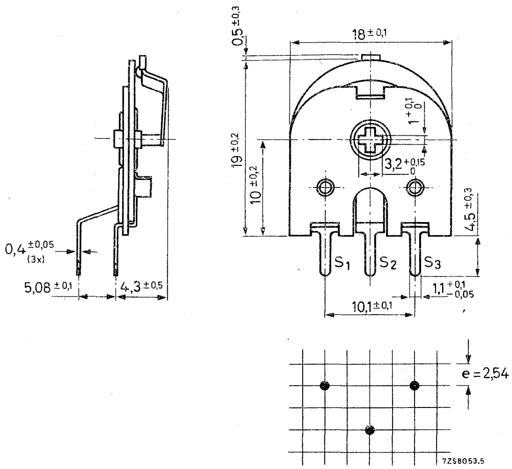


Fig. 3. Potentiometers 2322 411 072..

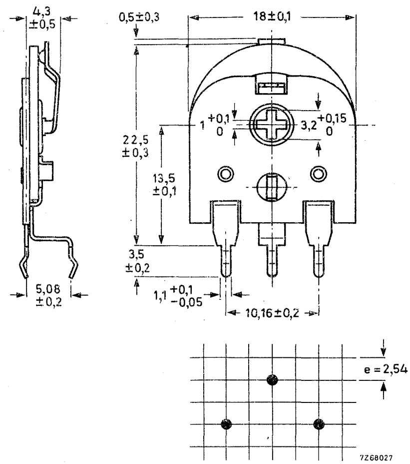


Fig. 4. Potentiometers 2322 411 073..

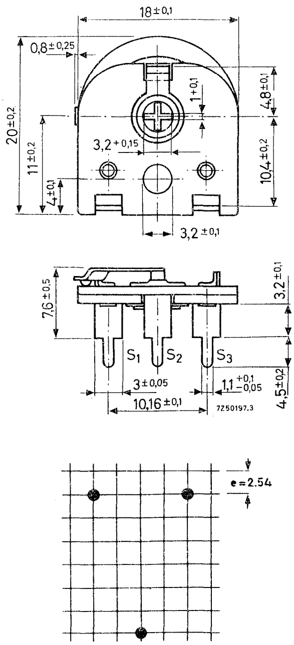


Fig. 5.
Potentiometers
2322 411 033..

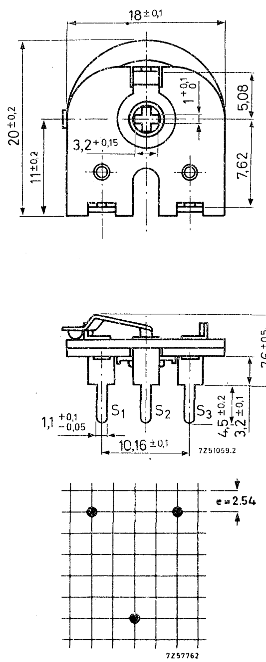


Fig. 6.
Potentiometers
2322 411 083..

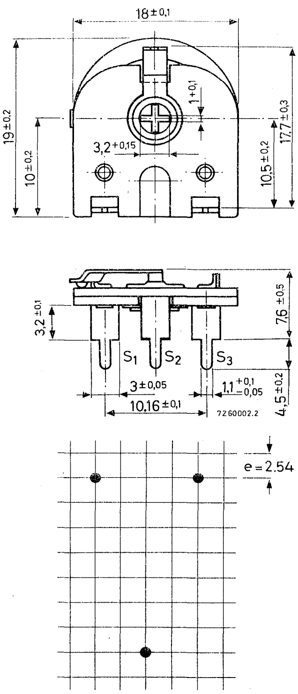


Fig. 7.
Potentiometers
2322 411 084..

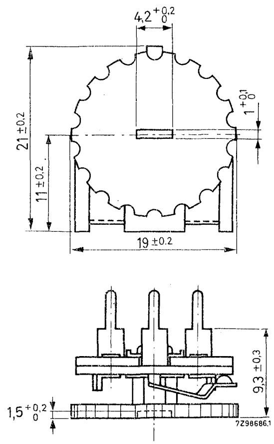


Fig. 8
Potentiometers
2322 411 433 . . (adjustment wheel at the side of the carbon track).

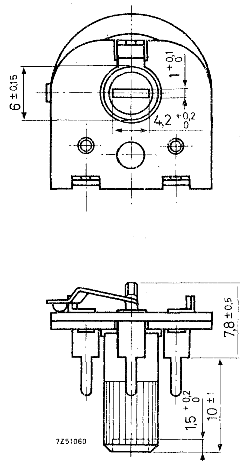


Fig. 9
Potentiometers
2322 411 133 . . (adjustment knob *) at the side of the base plate).

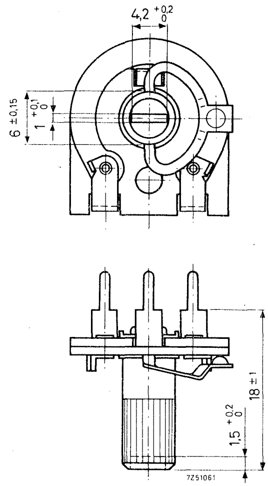


Fig. 10
Potentiometers
2322 411 233 . . (adjustment knob *) at the side of the carbon track).

TECHNICAL PERFORMANCE

nom. resistance value R_n	terminal resistance (Ω)	V_{max} (d.c. or r.m.s.) at T_{amb} = 40 °C (V)	limiting slider current (mA)	code in catalogue number
100 Ω	≤ 10	5	32	01
220 Ω	≤ 10	7	22	02
330 Ω	≤ 10	9	18	19
470 Ω	≤ 10	11	14	03
1 kΩ	≤ 25	16	10	04
2, 2 kΩ	≤ 25	22	7	05
4, 7 kΩ	≤ 100	35	4, 5	06
10 kΩ	≤ 200	50	3, 2	07
22 kΩ	≤ 400	70	2, 2	08
47 kΩ	≤ 1 000	110	1, 4	09
100 kΩ	≤ 2 000	160	1, 0	11
220 kΩ	≤ 4 000	220	0, 7	12
470 kΩ	≤ 10 000	370	0, 45	13
1 MΩ	≤ 20 000	500	0, 32	14
2, 2 MΩ	≤ 40 000	500	0, 22	15
4, 7 MΩ	≤ 100 000	500	0, 14	16

*) Potentiometers with temperature-resistant knobs (up to 230 °C) are supplied on request.

Resistance tolerance	± 20%
Resistance values as a function of the rotation angle	linear
Effective angle of rotation	200 ± 10^{o}
Mechanical angle of rotation	$215\text{-}225^{o}$
Maximum permissible power dissipation (of total resistance)	
at an ambient temperature of 25 °C	0,25 W
at an ambient temperature of 70 °C	0,15 W
Limiting voltage	500 V d.c. 500 V r.m.s.
Permissible ambient-temperature range	−25 to +70 °C
Resistance change after humidity test (21 days, T_{amb} = 40 °C, R.H. = 90 - 95%)	
after recovery of 1 h [1]	< 20%
after recovery of 24 h [1]	< 10%
Torque	0,5 - 5 Ncm
Maximum permissible torque with slider at end stop	10 Ncm

COMPOSITION OF THE CATALOGUE NUMBER

2322 411 . . . . .

First digit:
- 0 = without knob
- 1 = with knob at the side of the base plate
- 2 = with knob at the side of the carbon track
- 3 = with adjustment wheel at the side of the base plate (only for versions for vertical mounting)
- 4 = with adjustment wheel at the side of the carbon track

Next two digits:
- 00 = with solder tags (Fig. 1)
- 22 = with pins for vertical mounting (Fig. 2)
- 33 = with pins for horizontal mounting (Fig. 5)
- 72 = with pins for vertical mounting (according to DIN 44 150, Fig. 3)
- 73 = with pins for vertical mounting (Fig. 4)
- 83 = with pins for horizontal mounting (according to DIN 44 150, Fig. 6)
- 84 = with pins for horizontal mounting (according to DIN 44 151, Fig. 7)

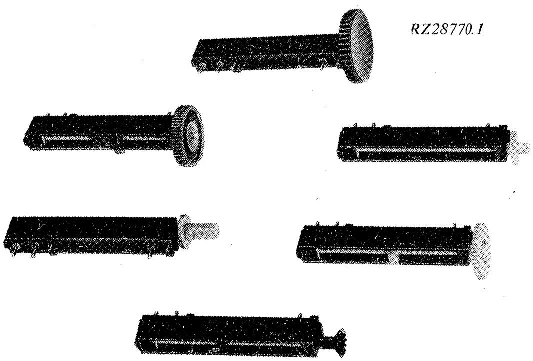
Last two digits: code for resistance value; see table

Note - catalogue number of adjustment wheel: 4322 047 08230
catalogue number of adjustment knob: 4322 047 08280

[1]) Preconditioning (min. 48 hrs) and recovery at 23 ± 1 °C, R.H. = 50 ± 2%

MULTITURN CARBON PRE-SET POTENTIOMETERS

QUICK REFERENCE DATA	
Nominal resistance values	
linear resistance law	100 Ω - 4,7 MΩ
logarithmic resistance law	1 kΩ - 2,2 MΩ
special resistance law	100 kΩ
Maximum dissipation at 40 °C	see graph (Fig. 3)
Number of turns of spindle	
potentiometers 2322 412	20
potentiometers 2322 413	10
potentiometers 2322 414	40



RZ28770.1

APPLICATION

The potentiometers have been designed for pre-set resistance adjustment in capacitance diode television tuners. However they can also be applied for capacitance diode tuning of other apparatus, e.g. radio receivers, or for any other fine resistance adjustment.

DESCRIPTION

A straight carbon track is fitted on to a base plate of resin bonded paper, which is mounted in a housing of black synthetic resin. The terminals are suited for mounting on printed-wiring boards.
The slider is activated by a silvered threaded spindle. No damage occurs when one continues to turn the spindle after the slider has reached an extreme position.
The potentiometers can be delivered with various adjustment provisions and with or without a scale indicator.
All these versions are available with linear or logarithmic resistance law; besides the 100 kΩ versions are available with special resistance law.

Dimensions of the housing (mm)

The housing has been drawn without adjustment provision and scale indicator; these parts are given in the paragraphs below.

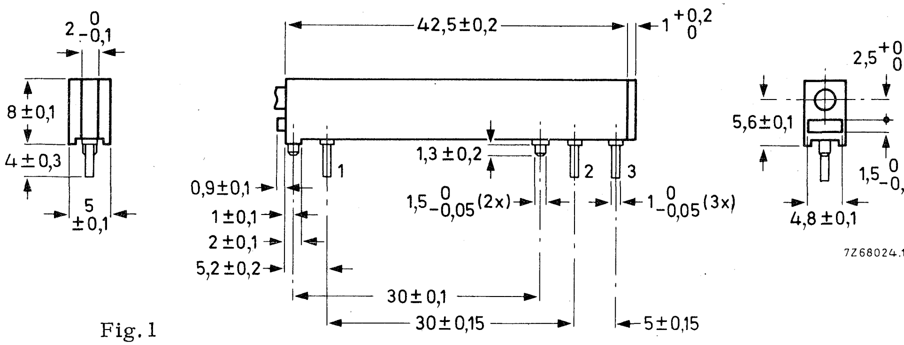
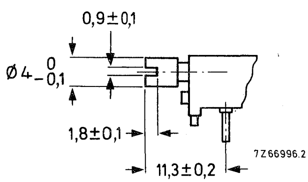
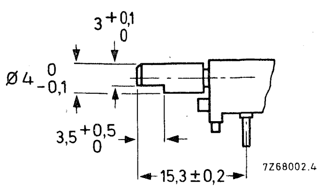


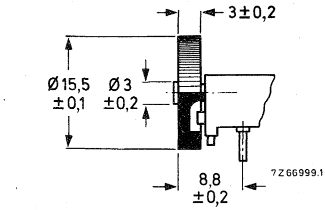
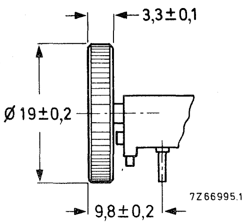
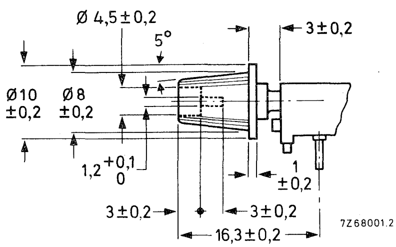
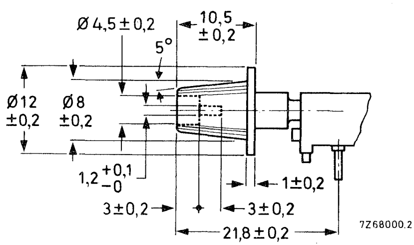
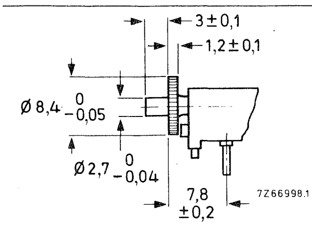
Fig. 1

Terminals 1 and 2 are connected to the ends of the carbon track; terminal 3 is connected to the slider contact.

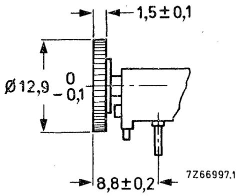
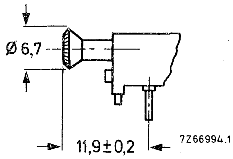
Adjustment provisions

type (dimensions in mm)	code in catalogue number *)
	51
	52

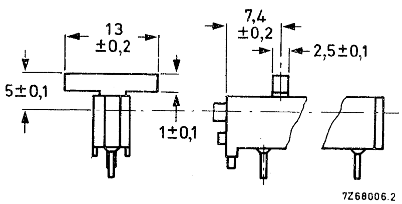
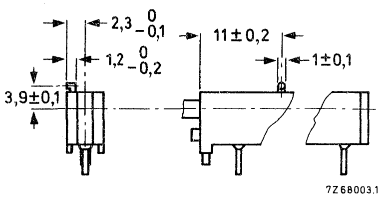
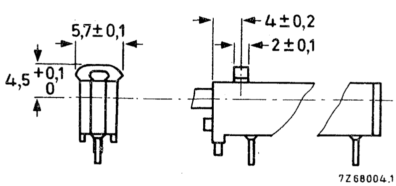
*) See "Composition of the catalogue number".

type (dimensions in mm)	code in catalogue number *)
 Knob: approx. 60 notches	61
 Knob: approx. 48 notches	62
	63
	64
 Gear-wheel: module = 0,4 number of teeth = 19 tooth height = 0,88	81

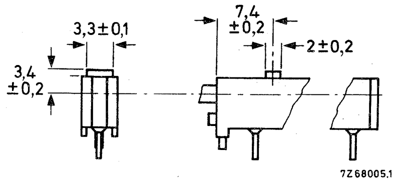
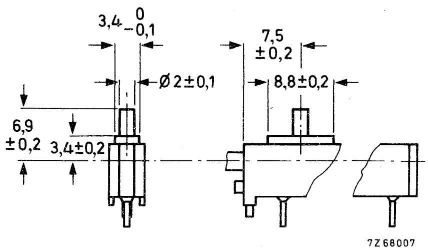
*) See "Composition of the catalogue number".

type (dimensions in mm)		code in catalogue number *)
	Gear-wheel: module = 0,5 number of teeth = 24 tooth height = 1,2	82
	Gear-wheel: module = 0,5 number of teeth = 12 shape according to DIN 867	83

Indicators

type (dimensions in mm)	with/without dust cover on the housing	code in catalogue number *)
	without	1
	without	2
	without	3

*) See "Composition of the catalogue number".

type (dimensions in mm)	with/without dust cover on the housing	code in catalogue number *)
	without	4
	without	5
without indicator	without	0
without indicator	with	8

*) See "Composition of the catalogue number".

TECHNICAL DATA

Unless stated otherwise, all electrical values have been determined at an ambient temperature of 15 to 35 °C, an air pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

nom. resist. (R_n)	resist. law	max. voltage (V d.c. or V a.c.) T_{amb} = 40 °C ΔR < 20% 1)	max. voltage (V d.c. or V a.c.) T_{amb} = 40 °C ΔR < 10% 1)	max. voltage (V d.c. or V a.c.) T_{amb} = 70 °C ΔR < 20% 1)	max. terminal resistance	max. attenuation (dB)	limiting slider current (mA)
100 Ω	linear	5,5	5,0	3,9	10 Ω	20	55
220 Ω		8,1	7,4	5,7	20 Ω	20	37
470 Ω		11,8	10,8	8,4	35 Ω	30	25
1 kΩ		17	15,8	12,2	50 Ω	30	17
2,2 kΩ		26	23	18	100 Ω	40	11
4,7 kΩ		37	34	24	200 Ω	40	8
10 kΩ		53	47	37	300 Ω	40	5,3
22 kΩ		76	66	54	600 Ω	50	3,5
47 kΩ		108	91	76	1 kΩ	50	2,3
100 kΩ		152	122	107	2 kΩ	50	1,5
220 kΩ		217	166	153	3,5 kΩ	60	0,99
470 kΩ		306	216	216	6 kΩ	60	0,65
1 MΩ		425	274	300	10 kΩ	70	0,43
2,2 MΩ		600	330	420	20 kΩ	70	0,27
4,7 MΩ		840 2)	340	590	50 kΩ	70	0,18
1 kΩ	logarithmic	10	8,9	7,1	10 Ω	40	10 3)
2,2 kΩ		14	12,8	10,2	20 Ω	50	6,6 3)
4,7 kΩ		20	17,5	14,5	35 Ω	50	4 4 3)
10 kΩ		29	24	20	50 Ω	50	2,9 3)
22 kΩ		42	34	29	100 Ω	60	1,9 3)
47 kΩ		59	47	41	200 Ω	60	1,3 3)
100 kΩ		85	63	60	250 Ω	60	0,85 3)
220 kΩ		122	87	86	500 Ω	70	0,55 3)
470 kΩ		172	112	120	1 kΩ	70	0,37 3)
1 MΩ		240	141	170	2 kΩ	80	0,24 3)
2,2 MΩ		350	182	244	5 kΩ	80	0,16 3)
100 kΩ	special	85	63	60	500 Ω	60	0,85 4)

1) Measured after 1000 h

2) Max. 600 V a.c.

3) Slider contact between 20 and 100% of R_{tot}. For slider contact positions between 0 and 20% of R_{tot} the values have to be multiplied by 6.

4) Slider contact between 20 and 100% of R_{tot}. For slider contact positions between 0 and 20% of R_{tot} the value has to be multiplied by 2,4.

Tolerance on nominal resistance	±20%
Resistance law and tolerance	see Fig. 2
Maximum permissible dissipation (P_{max})	see Fig. 3
Contact resistance between carbon track and slider contact, the slider being moved 1 mm/s (see also "Measurement of the contact resistance")	
linear resistance law	≤3% of R_{total}
logarithmic resistance law,	
for 0-40% of effective travel	≤0,75% of R_{total}
for 40-70% of effective travel	≤2% of R_{total}
for 70-100% of effective travel	≤8% of R_{total}
special resistance law,	
for 0-40% of effective travel	≤1,2% of R_{total}
for 40-60% of effective travel	≤3% of R_{total}
for 60-100% of effective travel	≤6% of R_{total}
Crackle voltage at maximum slider current of 1 mA, the slider being moved maximum 0,025 mm/s,	
R_n = 100 kΩ, linear law	≤100 mV
R_n = 100 kΩ, special law,	
for 0-60% of effective travel	≤100 mV
for 60-100% of effective travel	≤150 mV
Resistance change with temperature and humidity	see Figs. 4 and 5
Change of preset voltage with temperature and humidity	see Figs. 6 and 7
Change of preset voltage after vibration test (I.E.C. 68, test Fc) and shock test (I.E.C. 68, test Ea)	≤0,1% of total voltage typ. 0,05% of total voltage
Operating temperature range	-25 to +70 °C
Climatic category (I.E.C. 68)	25/070/21
Operating torque	1,5 - 10 mNm
Mechanical number of turns of spindle	
potentiometers 2322 412	$19 \pm \frac{1}{2}$
potentiometers 2322 413	$9\frac{1}{2} \pm \frac{1}{2}$
potentiometers 2322 414	38 ± 1
Maximum axial run-out including radial play of spindle	0,15 mm
Maximum permissible axial spindle load (push and pull)	≤ 2,5 N

Mechanical travel of slider contact	25,6 ±0,3 mm
Effective travel of slider contact	24 - 1 mm
Solderability (to I.E.C. 68-2, test T)	230± 10 °C, for 2±0,5 s
Thermal shock test (to I.E.C. 68-2, test T)	350± 10 °C, for 2±0,5 s
Life (at a rate of 20 rev/min)	50 x in both directions + 3 rotations at both ends

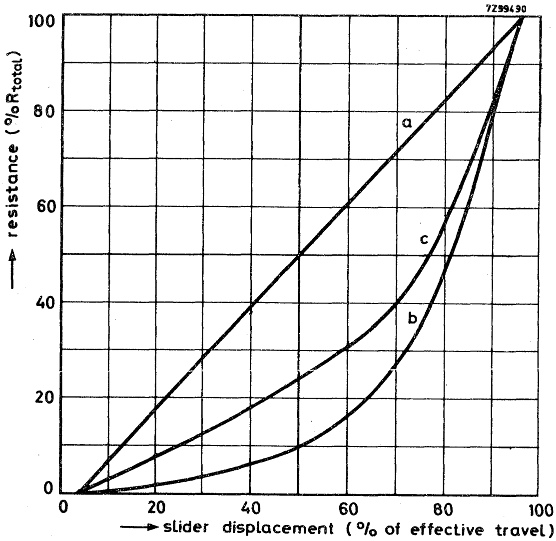


Fig. 2. Resistance as a function of slider displacement

curve	resistance law	tolerance on resistance law: displacement	tolerance on resistance law: resistance
		(% of effective travel)	(% of R_{total})
a	linear	between 36,5 and 38,5 between 61,5 and 63,5	33,5 - 41,5 58,5 - 66,5
b	logarithmic	between 36,5 and 38,5 between 61,5 and 63,5	3,5 - 8,5 12 - 26
c	special	between 36,5 and 38,5 between 61,5 and 63,5 between 86,5 and 88,5	15 - 21 28 - 38 60 - 75

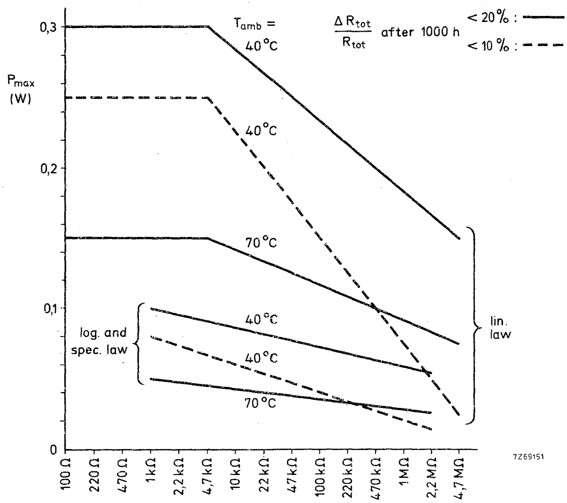


Fig. 3. Maximum permissible power dissipation

Resistance change as a function of the temperature; relative humidity 40 to 80% at 25 °C.

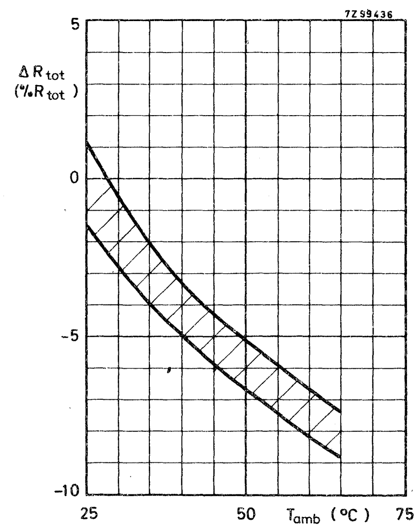


Fig. 4. R_n = 100 kΩ, linear law

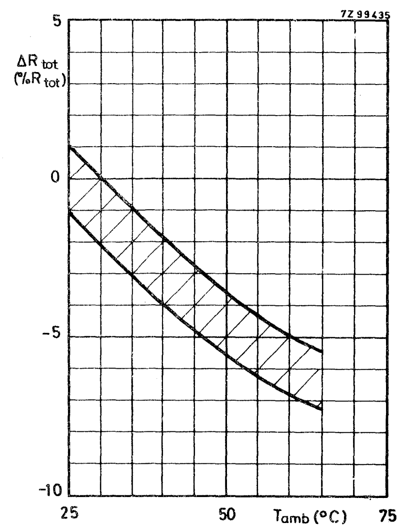


Fig. 5. R_n = 100 kΩ, special law

Change of pre-set voltage as a function of the temperature, V_{1-3} being 30% of V_{1-2}; relative humidity 40 to 80% at 25 °C.

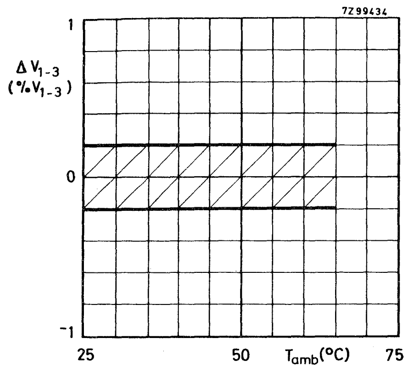


Fig. 6. R_n = 100 kΩ, linear law

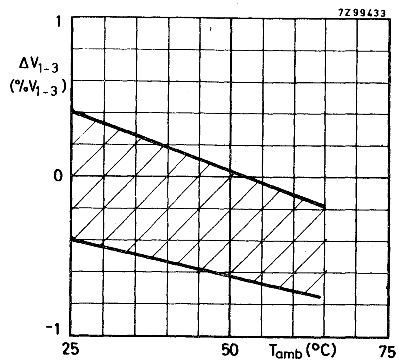


Fig. 7. R_n = 100 kΩ, special law

Measurement of the contact resistance

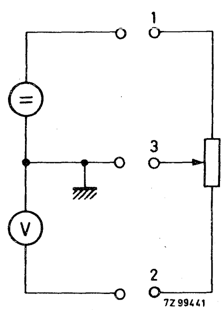


Fig. 8

A d.c. current source which supplies a constant direct current (I) of e.g. 1 mA, is connected to the pins 1 and 3 of the potentiometer.
For the diagram of the d.c. current source, see Fig. 9.
The d.c. voltage (V) resulting from the contact resistance (R_c) and the d.c. current is measured between the pins 2 and 3 ($V = I.R_c$).
During the measurement the slider contact is moved with a constant speed of 1 mm/s.
The input resistance of the d.c. voltmeter must be at least 10 MΩ.

Note - Circuit diagram of the direct current source used for measuring the contact resistance. Open-circuit output voltage is 380 V.

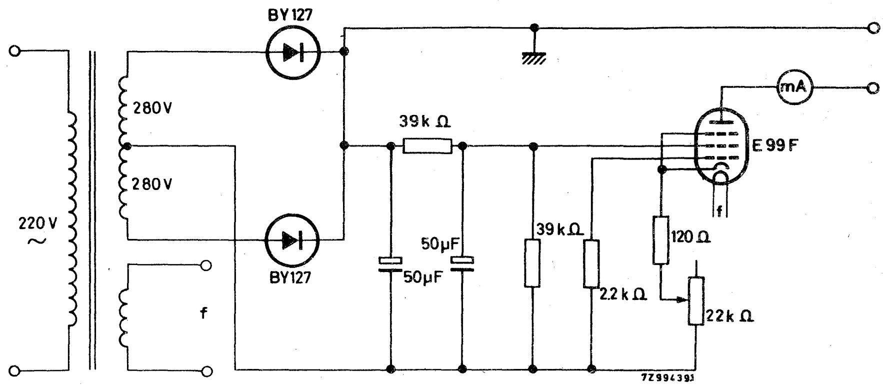


Fig. 9

MOUNTING

The terminals may be dipsoldered over a length of 2 mm max. in a solder bath of 260 ^{0}C max. for 4 s max.
When a soldering bit is used, its temperature must not exceed 360 ^{0}C for 1,5 s and neither axial nor radial stress must be exerted on the terminals.

MARKING

The potentiometers are marked with the nominal resistance value, resistance law, period and year of manufacture.

COMPOSITION OF THE CATALOGUE NUMBER

2322 41. . . . . .

code for number of turns of spindle
2 = 20 turns
3 = 10 turns
4 = 40 turns

code for indicator, see par. "Indicators"

code for nominal resistance value, see the table on the next page

code for adjustment provision, see par. "Adjustment provisions"

nominal resistance	code in catalogue number		
	linear law	logarithmic law	special law
100 Ω	01		
220 Ω	02		
470 Ω	03		
1 kΩ	04	24	
2,2 kΩ	05	25	
4,7 kΩ	06	26	
10 kΩ	07	27	
22 kΩ	08	28	
47 kΩ	09	29	
100 kΩ	11	31	38
220 kΩ	12	32	
470 kΩ	13	33	
1 MΩ	14	34	
2,2 MΩ	15	35	
4,7 MΩ	16		

SLIDE CARBON POTENTIOMETERS

QUICK REFERENCE DATA	
Nominal resistance values	
linear resistance law	220 Ω - 10 MΩ
logarithmic, reversed logarithmic and semi logarithmic resistance law	1 kΩ - 4,7 MΩ
Maximum dissipation at 40 °C	
linear resistance law	0,4 W
logarithmic, reversed logarithmic and semi logarithmic resistance law	0,2 W
Category (IEC68)	10/070/21

DESCRIPTION

This slide carbon potentiometer series includes two types:
- single potentiometers, for general purposes,
- tandem potentiometers, for stereophonic purposes.

The single potentiometers comprise a straight carbon track, which is fitted on to a base plate of resin bonded paper, mounted in a housing of black synthetic resin.

The tandem potentiometers are composed of two carbon tracks, fitted on base plates of resin bonded paper, which are situated in one housing. The base plates are placed in such a way that the tracks are opposite each other.

The terminals S_{11} and S_{13} (single) or S_{21} and S_{23} (tandem) are connected to the ends of the carbon track (see Figs. 1 and 2); terminal S_{12} (single) or S_{22} (tandem) is connected to the slider contact.
The potentiometers can be supplied with a tap at 1/2, 1/3 or at 1/3 and 2/3 of the total travel.

Both types are available with or without a metal screening at the outer surface of the potentiometer housing, providing general protection against external interference.
Besides the tandem potentiometers can be supplied with a metal screening between the two carbon tracks, thus preventing crosstalk.

The potentiometers are available with different connecting terminals, mounting facilities and adjustment provisions, see below.

Types

Dimensions (mm)

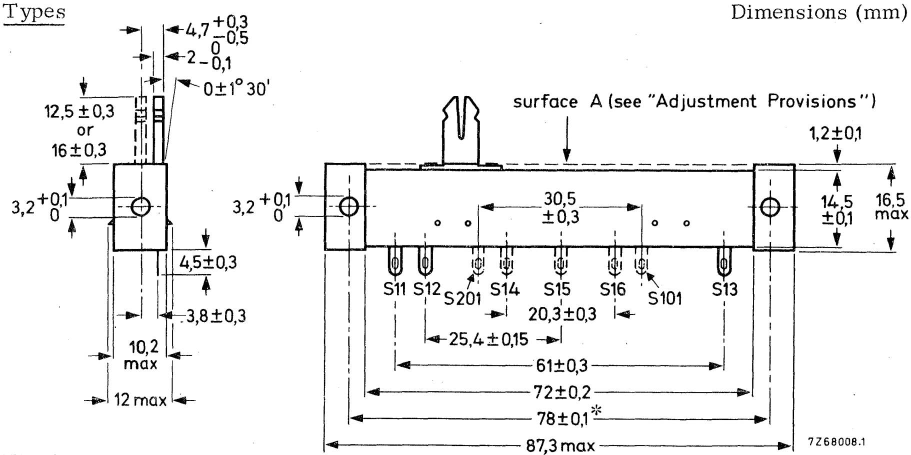


Fig. 1.

Single slide potentiometer with solder tags; facility for mounting with screws.

S_{11}, S_{13} = beginning and end terminals respectively

S_{12} = slider terminal

S_{14}, S_{15}, S_{16} = tap terminals at 1/3, 1/2 and 2/3 of the total travel respectively

S_{101}, S_{201} = earthing terminals (connected to external screening)

* = in future may be changed to 80 ± 0, 1 mm.

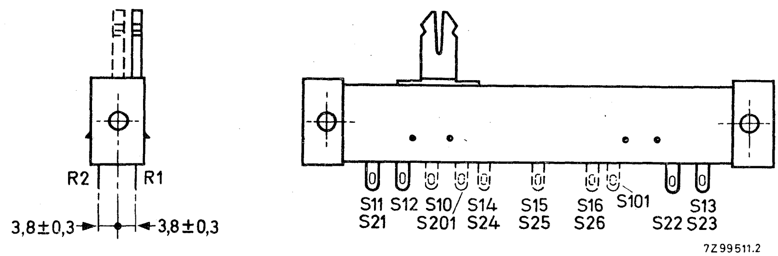


Fig. 2.

Tandem slide potentiometer with solder tags; facility for mounting with screws.
Dimensions are identical with those in Fig. 1 except as shown.

S_{11}, S_{13}	= beginning and end terminals resp.	potentiometer 1 (R1)	S_{21}, S_{23}	= beginning and end terminals resp.	potentiometer 2 (R2)
S_{12}	= slider terminal		S_{22}	= slider terminal	
S_{14}, S_{15}, S_{16}	= tap terminals at 1/3, 1/2 and 2/3 of the total travel resp.		S_{26}, S_{25}, S_{24}	= tap terminals at 1/3, 1/2 and 2/3 of the total travel resp.	

S_{101}, S_{201} = earthing terminals (connected to external screening)

S_{10} = earthing terminal (connected to internal screening)

To determine the side on which potentiometer R1 is situated, the customer should look for the marking: this is always placed at the beginning of R1.

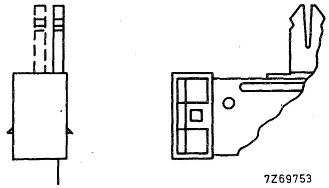


Fig. 3. Slide potentiometer with facility for mounting with self-tapping Parker screws. Dimensions are identical with those in Fig. 1.

Connecting terminals

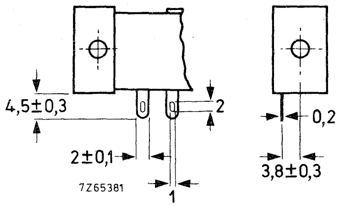


Fig. 4. Solder tags.

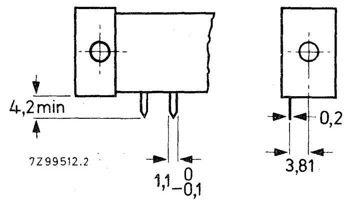


Fig. 5. Printed-wiring pins.

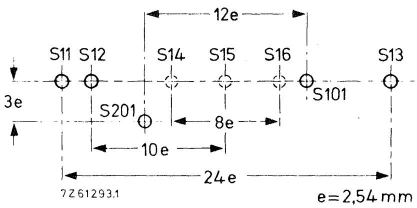


Fig. 6a. Hole pattern of the printed-wiring board for a single potentiometer (viewed on component side).

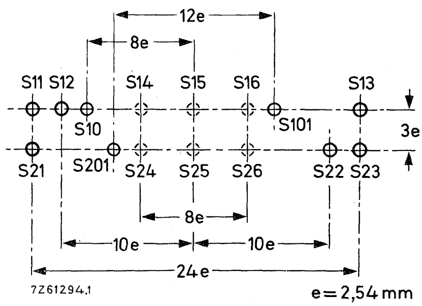


Fig. 6b. Hole pattern of the printed-wiring board for a tandem potentiometer (viewed on component side).

Mounting facilities

Potentiometers shown in Figs. 1 and 2 are mounted with two screws. They are available with one of the three screw-mounting possibilities (M3):
- making use of the holes in top and bottom;
- making use of the holes in the small sides;
- making use of the holes in front and back.

Potentiometers without screw-mounting facility are also available.

Potentiometers shown in Fig. 3 are mounted with two self-tapping Parker screws (min. length of thread 7 mm) making use of the holes in top and bottom or in front and back. Maximum torque for tightening: 500 mNm. (Minimum stripping torque: 700 mNm.)

Adjustment provisions

Four adjustment sliders are available:
- symmetrically placed, height 12, 5 mm or 16 mm
- asymmetrically placed, height 12, 5 mm or 16 mm

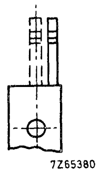


Fig. 7 End view of potentiometer with symmetrically (dotted lines) and asymmetrically placed adjustment slider.

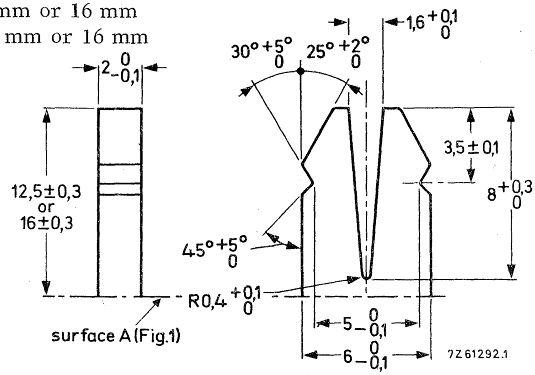


Fig. 8 Adjustment slider

TECHNICAL DATA

Unless stated otherwise, all electrical values have been determined at an ambient temperature of 15 to 35 °C, an air pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

nom. resist. (R_n) 1)	resist. law acc. to Fig. 9	tap at	max. voltage (V) at 40 °C	max. voltage (V) at 70 °C	max. terminal resist.	max. attenuation (dB)	max. contact resist. (% R_n)	limiting slider current at 40 °C (mA)
220 Ω	a	-	9, 3	7, 4	10 Ω	-	3	40
470 Ω	a	-	14	11	10 Ω	-	3	22
1 kΩ	a to d	1/3, 1/2 or 1/3 and 2/3	20	16	25 Ω	-	3	16
2, 2 kΩ	a to d		30	23	25 Ω	-	3	11
4, 7 kΩ	a to d		41	34	25 Ω	-	2	7
10 kΩ	a to d		63	50	35 Ω	-	2	5
22 kΩ	a to d		93	74	35 Ω	-	2	3, 5
47 kΩ	a to d		137	108	35 Ω	-	2	2, 2
100 kΩ	a to d		200	158	100 Ω	-	2	1, 4
220 kΩ	a to d		296	234	125 Ω	-	2	1, 0
470 kΩ	a to d		410	342	250 Ω	-	2	0, 65
1 MΩ	a to d		500	500	1 kΩ	-	2	0, 45
2, 2 MΩ	a to d		500	500	2, 2 kΩ	-	2	0, 32
4, 7 MΩ	a to d		500	500	4, 7 kΩ	-	2	0, 22
10 MΩ	a	-						
330 Ω	a	-	11, 5	9, 1	10 Ω	-	3	30

1) Measured between terminals S_{11} and S_{13} (or S_{21} and S_{23}).

nom. resist. (R_n) 1)	resist. law acc. to Fig. 9	tap at	max. voltage (V) at 40 °C	max. voltage (V) at 70 °C	max. terminal resist.	max. attenuation (dB)	max. contact resist. (% R_n)	limiting slider current at 40 °C (mA)
1 kΩ	e	-	14	11	25 Ω	50	4	10
2,2 kΩ	e	-	21	16	25 Ω	60	4	7
4,7 kΩ	e	-	31	24	25 Ω	60	4	4,5
10 kΩ	e to h	1/3, 1/2 or 1/3 and 2/3	45	35	35 Ω	60	4	3,2
22 kΩ	e to h		66	52	35 Ω	70	4	2,2
47 kΩ	e to h		97	77	35 Ω 2)	70 2)	4	1,4
100 kΩ	e to h		141	112	50 Ω	80	4	1,0
220 kΩ	e to h		210	166	50 Ω	80	4	0,7
470 kΩ	e to h		310	242	100 Ω	80	4	0,45
1 MΩ	e to h		447	354	500 Ω	80	4	0,32
2,2 MΩ	e to h		500	500	500 Ω	80	4	0,22
4,7 MΩ	e to h		500	500	1 kΩ	80	4	0,14
1 kΩ	k	-	14	11	100 Ω	50	4	10
2,2 kΩ	k	-	21	16	100 Ω	60	4	7
4,7 kΩ	k	-	31	24	100 Ω	60	4	4,5
10 kΩ	k, l	1/3	45	35	250 Ω	60	4	3,2
22 kΩ	k, l		66	52	250 Ω	70	4	2,2
47 kΩ	k, l		97	77	500 Ω	70	4	1,4
100 kΩ	k, l		141	112	2,5 kΩ 2)	80 3)	4	1,0
220 kΩ	k, l		210	166	2,5 kΩ	80	4	0,7
470 kΩ	k, l		310	242	5 kΩ	80	4	0,45
1 MΩ	k, l		447	354	25 kΩ	80	4	0,32
2,2 MΩ	k, l		500	500	25 kΩ	80	4	0,22
4,7 MΩ	k, l		500	500	50 kΩ	80	4	0,14
470 Ω	m	-	9,7	7,7	10 Ω	40	5	14
1 kΩ	m	-	14	11	25 Ω	50	4	10
2,2 kΩ	m	-	21	16	25 Ω	50	4	7
4,7 kΩ	m	-	31	24	25 Ω	60	4	4,5
10 kΩ	m to p	1/3, 1/2 or 1/3 and 2/3	45	35	35 Ω	60	4	3,2
22 kΩ	m to p		66	52	35 Ω 2)	70 2)	4	2,2
47 kΩ	m to p		97	77	35 Ω	70	4	1,4
100 kΩ	m to p		141	112	50 Ω	80	4	1,0
220 kΩ	m to p		210	166	100 Ω	80	4	0,7
470 kΩ	m to p		310	242	250 Ω	80	4	0,45
1 MΩ	m to p		447	354	500 Ω	80	4	0,32
2,2 MΩ	m to p		500	500	1 kΩ	80	4	0,22
4,7 MΩ	m to p		500	500	2,5 kΩ	80	4	0,14

1) Measured between terminals S_{11} and S_{13} (or S_{21} and S_{23}).

2) Measured between terminals S_{11} and S_{12} (or S_{21} and S_{22}); slider placed at the beginning of the travel.

3) Measured between terminals S_{13} and S_{12} (or S_{23} and S_{22}); slider placed at the end of the travel.

nom. resist. (R_n) 1)	resist. law acc. to Fig. 9	tap at	max. voltage (V) at 40 °C	at 70 °C	max. terminal resist.	max. attenuation (dB)	max. contact resist. (% R_n)	limiting slider current at 40 °C (mA)
10 kΩ	q	–	45	35	–	–	4	3, 2
22 kΩ	q	–	66	52	–	–	4	2, 2
47 kΩ	q	–	97	77	–	–	4	1, 4
100 kΩ	q	–	141	112	–	–	4	1, 0
220 kΩ	q	–	250	166	–	–	4	0, 7
470 kΩ	q	–	310	242	–	–	4	0, 45
1 MΩ	q	–	447	354	–	–	4	0, 32
2, 2 MΩ	q	–	500	500	–	–	4	0, 22
4, 7 MΩ	q	–	500	500	–	–	4	0, 14

1) Measured between terminals S_{11} and S_{13} (or S_{21} and S_{23})

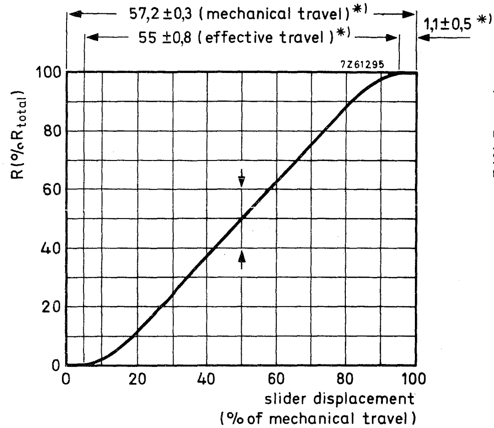


Fig. 9a Linear law; without tap

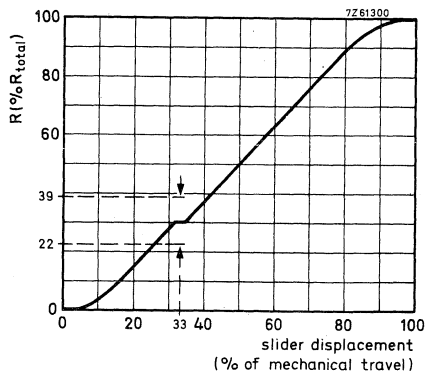


Fig. 9b Linear law; tap at 1/3

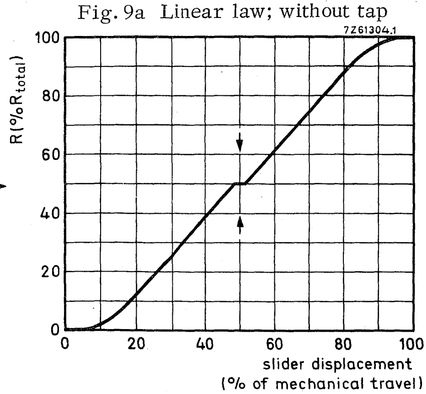


Fig. 9c Linear law; tap at 1/2

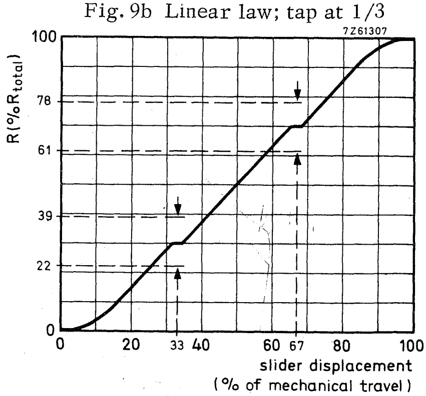


Fig. 9d Linear law; taps at 1/3 and 2/3

*) Valid for all graphs.

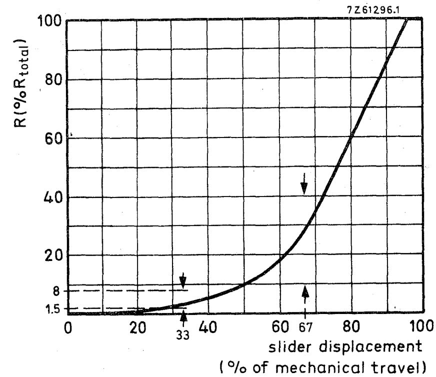


Fig. 9e Logarithmic law; without tap

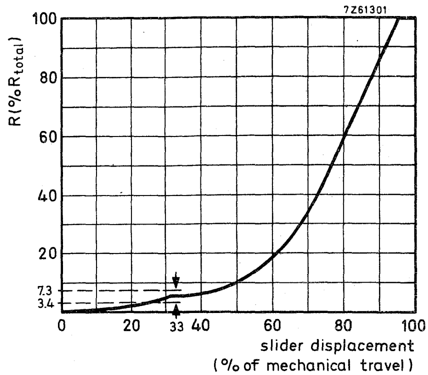


Fig. 9f Logarithmic law; tap at 1/3

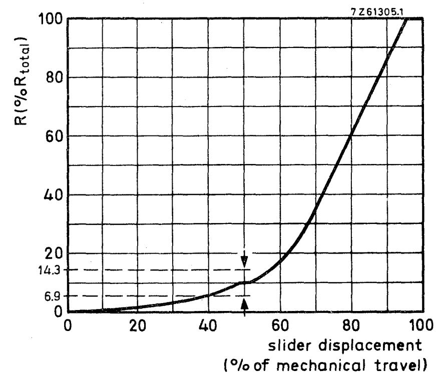


Fig. 9g Logarithmic law; tap at 1/2

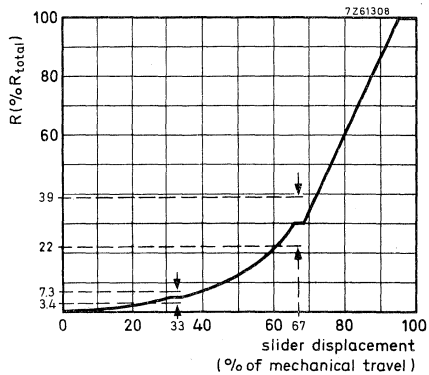


Fig. 9h Logarithmic law; taps at 1/3 and 2/3

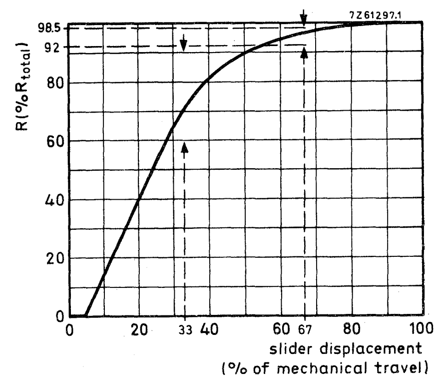


Fig. 9k Reversed logarithmic law; without tap

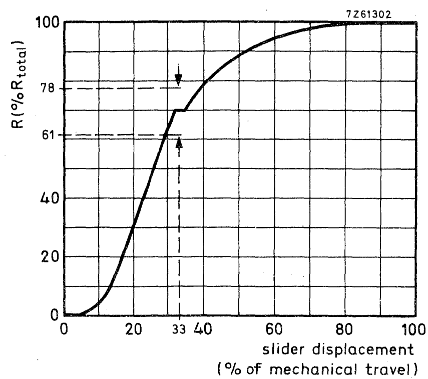


Fig. 9l Reversed logarithmic law; tap at 1/3

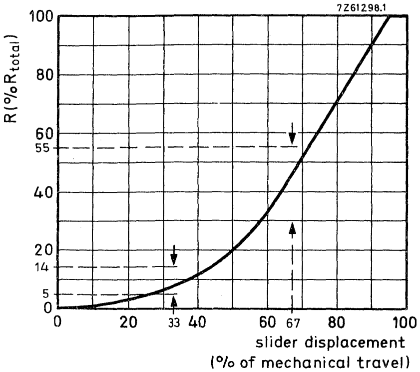


Fig. 9m Semi logarithmic law; without tap

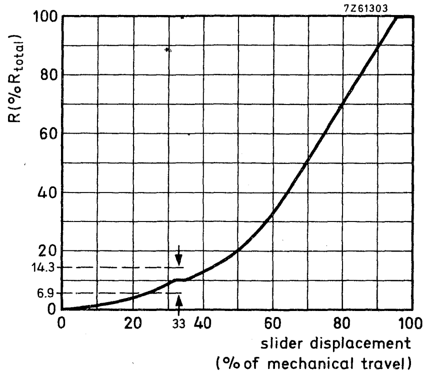


Fig. 9n Semi logarithmic law; tap at 1/3

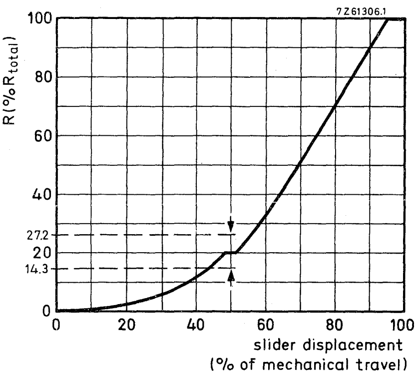


Fig. 9o Semi logarithmic law; tap at 1/2

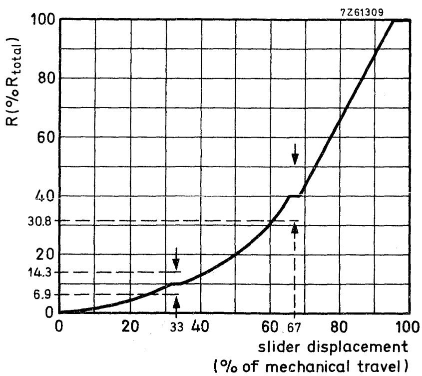


Fig. 9p Semi logarithmic law; taps at 1/3 and 2/3

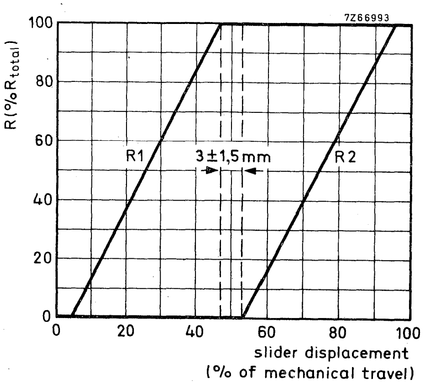


Fig. 9q Balance potentiometers

Resistance law and tolerance	linear, logarithmic, reversed logarithmic, semi-logarithmic, balance, see Figs. 9a to 9q
Tolerance on nominal resistance	± 20%
Minimum resistance at the tap(s)	≤ 1% of R_n
Insulation resistance (versions with external screening), initially	> 10^4 MΩ
Maximum dissipation (P_{max})	
linear resistance law, at 40 °C	0, 4 W
at 70 °C	0, 25 W
logarithmic, reversed logarithmic and semi-logarithmic resistance law, at 40 °C	0, 2 W
at 70 °C	0, 125 W
Test voltage for 1 min	1000 V, 50 Hz
Working temperature range	−10 to +70 °C
Storage temperature range	−25 to +70 °C
Category (IEC68)	10/070/21
Operating force (F) 1)	
single potentiometers	0, 75 - 2 N
tandem potentiometers	1, 25 - 2, 5 N
	$\frac{F_{max}}{F_{min}} \leq 1,5$
Permissible force with slider at end stop 1)	≤ 50 N (Fig. 10a)
Permissible load perpendicular to the direction of movement 1)	≤ 20 N (Fig. 10b)
Permissible torque on slider 1)	≤ 30 Ncm (Fig. 10c)
Permissible axial force on slider (push and pull) 1)	≤ 50 N

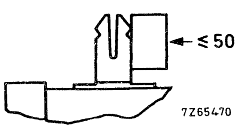


Fig. 10a

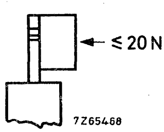


Fig. 10b

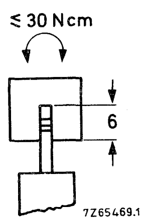


Fig. 10c

Effective travel of slider contact	55 ± 0, 8 mm	see also Fig. 9a
Mechanical travel of slider contact	57, 2 ± 0, 3 mm	
Life	10 000 x in both directions	

1) Measured for 5 s on a free slider without knob.

Ganging tolerance [1])

linear resistance law, without tap	
at values between 10 and 90% of R_{tot}	< 2 dB
linear resistance law, with one tap	
at values between 10 and 90% of R_{tot}	< 3 dB
logarithmic, reversed logarithmic and semi logarithmic resistance law, without tap	
at attenuations between 0 and −20 dB	< 2 dB
at attenuations between −20 and −30 dB	< 3 dB
at attenuations between −30 and −40 dB	< 4 dB
logarithmic, reversed logarithmic and semi logarithmic resistance law, with one tap	
at attenuations between 0 and −20 dB	< 2 dB
at attenuations between −20 and −30 dB	< 3 dB
at attenuations between −30 and −34 dB	< 4 dB

Crosstalk [1]) (measured according to Fig. 11) see table below

resistance value	potentiometers with internal screening		potentiometers without internal screening	
	at 1 kHz	at 10 kHz	at 1 kHz	at 10 kHz
220 Ω to 100 kΩ	≥ 70 dB	≥ 55 dB	≥ 60 dB	≥ 45 dB
100 kΩ to 220 kΩ	≥ 60 dB	≥ 50 dB	≥ 50 dB	≥ 40 dB
220 kΩ to 470 kΩ	≥ 60 dB	≥ 50 dB	≥ 50 dB	≥ 40 dB
470 kΩ to 2,2 MΩ	≥ 50 dB	≥ 40 dB	≥ 40 dB	≥ 30 dB

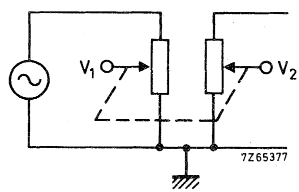


Fig. 11 Crosstalk = $20 \log \frac{V_1}{V_2}$

1) For tandem potentiometers only.

AVAILABLE VERSIONS AND COMPOSITION OF THE CATALOGUE NUMBER.

2322 42. . . . . .

code for mounting facility

- 0 = no mounting facility — single
- 1 = making use of holes in top and bottom — mounting with screws — single
- 2 = making use of holes in the small sides — mounting with screws — single
- 3 = making use of holes in front and back — mounting with screws — single
- 4 = mounting with self-tapping Parker screws — single
- 5 = no mounting facility — tandem
- 6 = making use of holes in top and bottom — mounting with screws — tandem
- 7 = making use of holes in the small sides — mounting with screws — tandem
- 8 = making use of holes in front and back — mounting with screws — tandem
- 9 = mounting with self-tapping Parker screws — tandem

code for adjustment provision

- 0 = asymmetrically placed — length 12,5 mm
- 1 = symmetrically placed — length 12,5 mm
- 2 = asymmetrically placed — length 16 mm
- 3 = symmetrically placed — length 16 mm

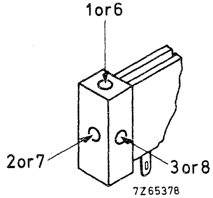
code for terminals and screening

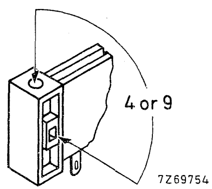
- 0 = without screening — with solder tags
- 1 = with internal screening 1) — with solder tags
- 2 = with internal and external screening 1) — with solder tags
- 3 = with external screening — with solder tags
- 5 = without screening — with printed-wiring pins
- 6 = with internal screening 1) — with printed-wiring pins
- 7 = with internal and external screening 1) — with printed-wiring pins
- 8 = with external screening — with printed-wiring pins

code for taps

- 0 = without taps
- 1 = tap at 1/3
- 2 = tap at 1/2
- 4 = taps at 1/3 and 2/3

code for resistance law and nominal resistance, see table on next page.





1) Only for tandem potentiometers.

nominal resistance	code in catalogue number				
	linear law	log. law	reversed log. law	semi log. law	balance
220 Ω	02 1)				
470 Ω	03 1)			63 1)	
1 kΩ	04	24 1)	44 1)	64 1)	
2,2 kΩ	05	25 1)	45 1)	65 1)	
4,7 kΩ	06	26 1)	46 1)	66 1)	
10 kΩ	07	27	47 2)	67	87 1)
22 kΩ	08	28	48 2)	68	88 1)
47 kΩ	09	29	49 2)	69	89 1)
100 kΩ	11	31	51 2)	71	91 1)
220 kΩ	12	32	52 2)	72	92 1)
470 kΩ	13	33	53 2)	73	93 1)
1 MΩ	14	34	54 2)	74	94 1)
2,2 MΩ	15	35	55 2)	75	95 1)
4,7 MΩ	16	36	56 2)	76	96 1)
10 MΩ	17 1)				
330 Ω	19 1)				

1) Only available without tap.

2) Only available without tap and with tap at 1/3 of the total travel.

SLIDE CARBON POTENTIOMETERS

QUICK REFERENCE DATA	
Nominal resistance values	
linear resistance law	220 Ω - 4, 7 MΩ
logarithmic, reversed logarithmic and semi logarithmic resistance law	1 kΩ - 2, 2 MΩ
Maximum dissipation at 40 °C	
linear resistance law	0, 25 W
logarithmic, reversed logarithmic and semi logarithmic resistance law	0, 125 W
Category (IEC68)	10/070/21

DESCRIPTION

This slide carbon potentiometer series includes two types:
- single potentiometers, for general purposes,
- tandem potentiometers, for stereophonic purposes.

The single potentiometers comprise a straight carbon track, which is fitted on to a base plate of resin bonded paper, mounted in a housing of black synthetic resin.

The tandem potentiometers are composed of two carbon tracks, fitted on base plates of resin bonded paper, which are situated in one housing. The base plates are placed in such a way that the tracks are opposite each other.

The terminals S_{11}, S_{13} (single) and S_{21}, S_{23} (tandem) are connected to the ends of the carbon track (see Figs. 1 and 2); terminals S_{12} (single) and S_{22} (tandem) are connected to the slider contact.
The potentiometers can be supplied with a tap at 1/2 of the total travel.

Both types are available with or without a metal screening at the outer surface of the potentiometer housing, providing general protection against external interference.
Besides the tandem potentiometers can be supplied with a metal screening between the two carbon tracks, thus preventing crosstalk.

The potentiometers are available with different connecting terminals, mounting facilities and adjustment provisions, see below.

Types

Dimensions in mm

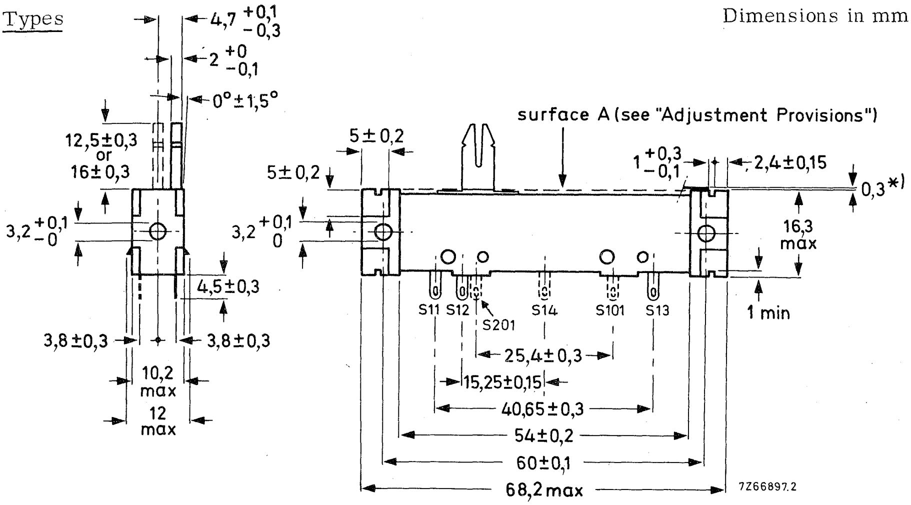


Fig. 1 Single slide potentiometer with solder tags.

S_{11}, S_{13} = beginning and end terminals respectively
S_{12} = slider terminal
S_{14} = tap terminal at 1/2 of the total travel
S_{101}, S_{201} = earthing terminals (connected to external screening)
*) Only for potentiometers with external screening.

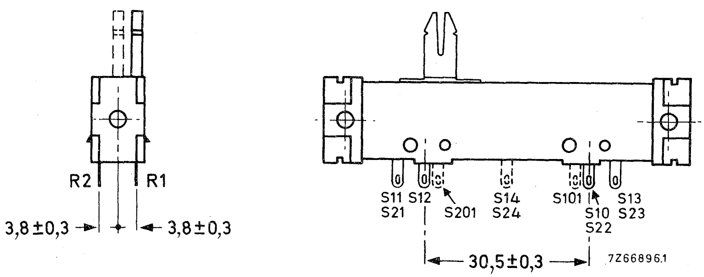


Fig. 2 Tandem slide potentiometer with solder tags.
Dimensions not shown are identical with those in Fig. 1.

S_{11}, S_{13}	= beginning and end terminals resp.	potentio-meter 1 (R1)	S_{21}, S_{23}	= beginning and end terminals resp.	potentio-meter 2 (R2)
S_{12}	= slider terminal		S_{22}	= slider terminal	
S_{14}	= tap terminal at 1/2 of the total travel		S_{24}	= tap terminal at 1/2 of the total travel	

S_{101}, S_{201} = earthing terminals (connected to external screening)
S_{10} = earthing terminal (connected to internal screening)
To make sure on which side potentiometer R1 is situated, the customer should look at the marking: this is always placed at the beginning of R1.

Connecting terminals

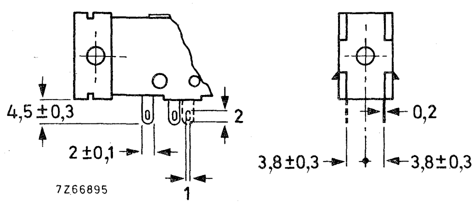


Fig. 3 Solder tags

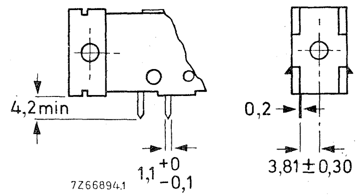


Fig. 4 Printed-wiring pins

Fig. 5 Hole pattern of the printed-wiring board for a single potentiometer (viewed on component side)

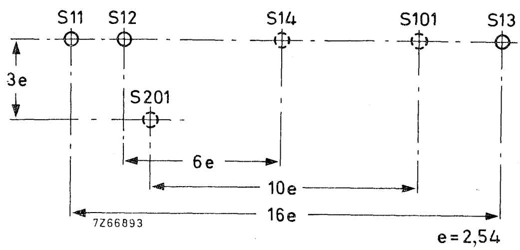
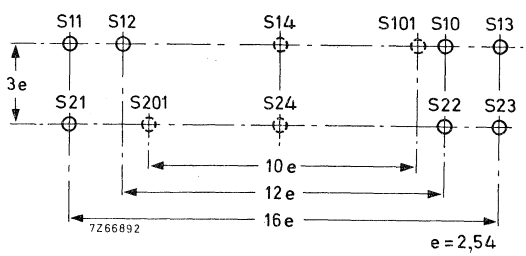


Fig. 6 Hole pattern of the printed-wiring board for a tandem potentiometer (viewed on component side)



Mounting facilities

The potentiometers are available with one of the three screw-mounting possibilities (M3):
- making use of the holes in top and bottom
- making use of the holes in the small sides
- making use of the holes in front and back

Potentiometers without screw-mounting facility are also available.

Adjustment provisions

Four adjustment sliders are available:
- symmetrically placed, height 12,5 mm or 16 mm
- asymmetrically placed, height 12,5 mm or 16 mm

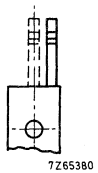


Fig. 7 End view of potentiometer with symmetrically (dotted lines) and asymmetrically placed adjustment slider.

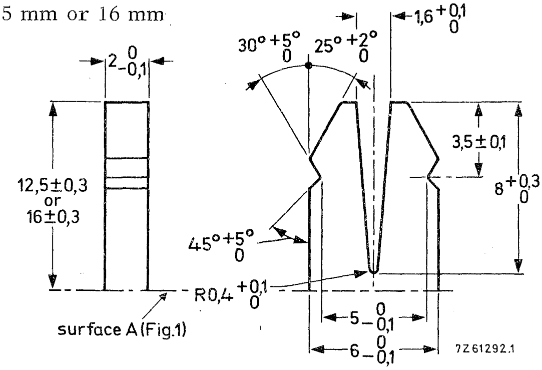


Fig. 8 Adjustment slider

TECHNICAL DATA

Unless stated otherwise, all electrical values have been determined at an ambient temperature of 15 to 35 °C, an air pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

nom. resist. (R_n) 1)	resist. law acc. to Fig. 9	tap at	max. voltage (V) at 40 °C	max. voltage (V) at 70 °C	max. terminal resist.	max. attenuation (dB)	max. contact resist. (% R_n)	limiting slider current at 40 °C (mA)
220 Ω	a	–	7,4	5,2	10 Ω	–	3	33
470 Ω	a	–	11	7,7	10 Ω	–	3	23
1 kΩ	a, b		16	11	25 Ω	–	3	16
2,2 kΩ	a, b		23	16	25 Ω	–	3	10
4,7 kΩ	a, b		34	24	25 Ω	–	2,5	7,2
10 kΩ	a, b		50	35	35 Ω	–	2,5	5
22 kΩ	a, b		74	52	35 Ω	–	2,5	3,3
47 kΩ	a, b	1/2	108	77	35 Ω	–	2,5	2,3
100 kΩ	a, b		158	112	100 Ω	–	2,5	1,6
220 kΩ	a, b		234	166	125 Ω	–	2,5	1,0
470 kΩ	a, b		342	242	250 Ω	–	2,5	0,72
1 MΩ	a, b		500	354	1 kΩ	–	2,5	0,50
2,2 MΩ	a, b		500	500	2,2 kΩ	–	2,5	0,33
4,7 MΩ	a		500	500	4,7 kΩ	–	2,5	0,23
330 Ω	a	–	9,1	6,4	10 Ω	–	3	27

1) Measured between terminals S_{11} and S_{13} (or S_{21} and S_{23}).

nom. resist. (R_n) 1)	resist. law acc. to Fig. 9	tap at	max. voltage (V) at 40 °C	max. voltage (V) at 70 °C	max. terminal resist.	max. attenuation (dB)	max. contact resist. (%R_n)	limiting slider current at 40°C (mA)
1 kΩ	c	–	11	7,9	25 Ω	50	4	11
2,2 kΩ	c	–	16	12	25 Ω	60	4	7,3
4,7 kΩ	c	–	24	17	25 Ω	60	4	5,1
10 kΩ	c, d		35	25	35 Ω	60	4	3,5
22 kΩ	c, d		52	37	35 Ω	70	4	2,4
47 kΩ	c, d		77	54	35 Ω 2)	70 2)	4	1,6
100 kΩ	c, d	1/2	112	79	50 Ω	80	4	1,1
220 kΩ	c, d		166	117	50 Ω	80	4	0,73
470 kΩ	c, d		242	170	100 Ω	80	4	0,51
1 MΩ	c, d		354	250	500 Ω	80	4	0,35
2,2 MΩ	c, d		500	370	500 Ω	80	4	0,24
1 kΩ	e	–	11	7,9	100 Ω	50	4	11
2,2 kΩ	e	–	16	12	100 Ω	60	4	7,3
4,7 kΩ	e	–	24	17	100 Ω	60	4	5,1
10 kΩ	e, f		35	25	250 Ω	60	4	3,5
22 kΩ	e, f		52	37	250 Ω	70	4	2,4
47 kΩ	e, f		77	54	500 Ω	70	4	1,6
100 kΩ	e, f		112	79	2,5 kΩ 2)	80 3)	4	1,1
220 kΩ	e, f	1/2	166	117	2,5 kΩ	80	4	0,73
470 kΩ	e, f		242	170	5 kΩ	80	4	0,51
1 MΩ	e, f		354	250	25 kΩ	80	4	0,35
2,2 MΩ	e, f		500	370	25 kΩ	80	4	0,24
1 kΩ	g	–	11	7,9	25 Ω	50	4	11
2,2 kΩ	g	–	16	12	25 Ω	50	4	7,3
4,7 kΩ	g	–	24	17	25 Ω	60	4	5,1
10 kΩ	g, h		35	25	35 Ω	60	4	3,5
22 kΩ	g, h		52	37	35 Ω 2)	70 2)	4	2,4
47 kΩ	g, h		77	54	35 Ω	70	4	1,6
100 kΩ	g, h		112	79	50 Ω	80	4	1,1
220 kΩ	g, h	1/2	166	117	100 Ω	80	4	0,73
470 kΩ	g, h		242	170	250 Ω	80	4	0,51
1 MΩ	g, h		354	250	500 Ω	80	4	0,35
2,2 MΩ	g, h		500	370	1000 Ω	80	4	0,24

1) Measured between terminals S_{11} and S_{13} (or S_{21} and S_{23}).
2) Measured between terminals S_{11} and S_{12} (or S_{21} and S_{22}); slider placed at the beginning of the travel.
3) Measured between terminals S_{13} and S_{12} (or S_{23} and S_{22}); slider placed at the end of the travel.

nom. resist. (R_n) 1)	resist. law acc. to Fig. 9	tap at	max. voltage (V) at 40 °C	max. voltage (V) at 70 °C	max. terminal resist.	max. attenuation (dB)	max. contact resist. (% R_n)	limiting slider current at 40 °C (mA)
10 kΩ	k	–	35	25	–	–	4	3, 5
22 kΩ	k	–	52	37	–	–	4	2, 4
47 kΩ	k	–	77	54	–	–	4	1, 6
100 kΩ	k	–	112	79	–	–	4	1, 1
220 kΩ	k	–	166	117	–	–	4	0, 73
470 kΩ	k	–	242	170	–	–	4	0, 51
1 MΩ	k	–	354	250	–	–	4	0, 35
2, 2 MΩ	k	–	500	370	–	–	4	0, 24

1) Measured between terminals S_{11} and S_{13} (or S_{21} and S_{23}).

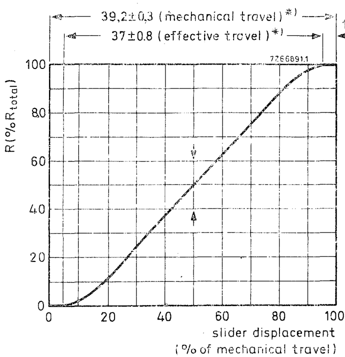


Fig. 9a Linear law; without tap

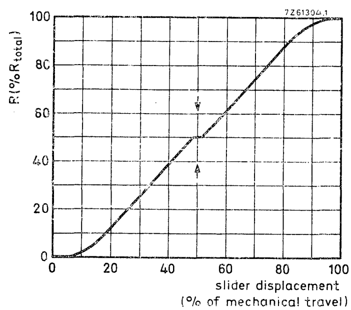


Fig. 9b Linear law; tap at 1/2

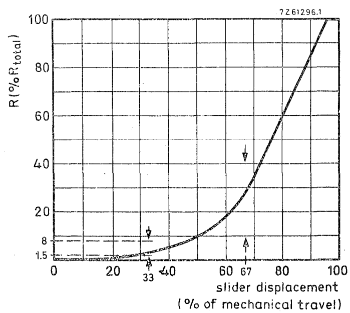


Fig. 9c Logarithmic law, without tap

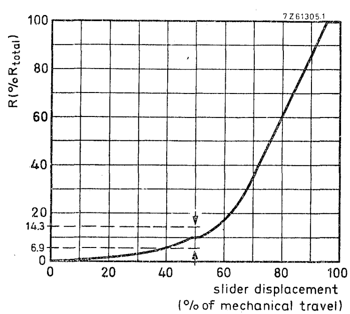


Fig. 9d Logarithmic law; tap at 1/2

*) Valid for all graphs.

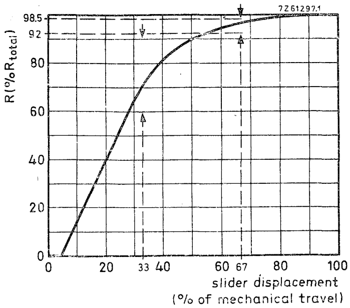


Fig. 9e. Reversed logarithmic law; without tap

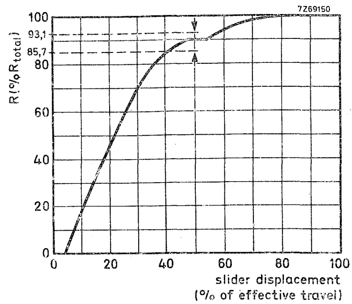


Fig. 9f. Reversed logarithmic law; tap at 1/2

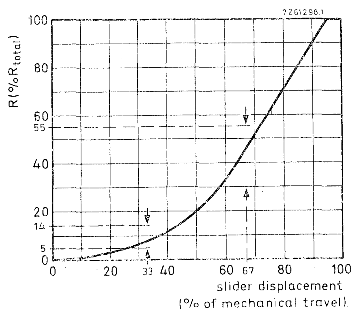


Fig. 9g. Semi logarithmic law; without tap

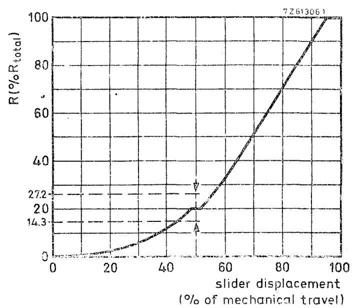


Fig. 9h. Semi logarithmic law; tap at 1/2

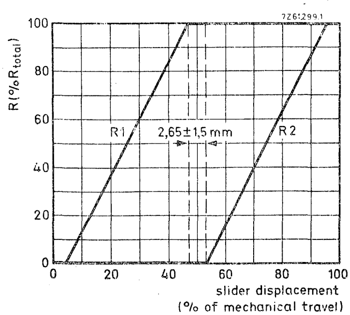


Fig. 9k. Balance potentiometers

Resistance law and tolerance	linear, logarithmic, reversed logarithmic, semi-logarithmic, balance, see Figs. 9a to 9k
Tolerance on nominal resistance	± 20 %
Minimum resistance at the tap	≤ 1 % of R_n
Insulation resistance (versions with external screening), initially	> 10^4 MΩ
Maximum dissipation (P_{max})	
linear resistance law, at 40 °C	0,25 W
at 70 °C	0,125 W
logarithmic, reversed logarithmic and semi-logarithmic resistance law, at 40 °C	0,125 W
at 70 °C	0,0625 W
Test voltage for 1 min (versions with external screening)	1000 V, 50 Hz
Working temperature range	−10 to +70 °C
Storage temperature range	−25 to +70 °C
Category (IEC68)	10/070/21
Operating force (F) [1]	
single potentiometers	0,75 - 2 N } $\frac{F_{max}}{F_{min}} \leq 1,3$
tandem potentiometers	1,25 - 2,5 N }
Permissible force with slider at end stop [1]	≤ 50 N (Fig. 10a)
Permissible load perpendicular to the direction of movement [1]	≤ 20 N (Fig. 10b)
Permissible torque on slider [1]	≤ 30 Ncm (Fig. 10c)
Permissible axial force on slider (push and pull) [1]	≤ 50 N

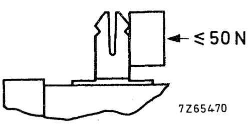


Fig. 10a

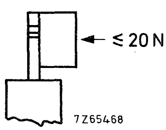


Fig. 10b

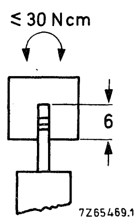


Fig. 10c

Effective travel of slider contact	37 ± 0,8 mm } see also Fig. 9a
Mechanical travel of slider contact	39,2 ± 0,3 }
Life	10 000 x in both directions

1) Measured for 5 s on a free slider without knob.

Ganging tolerance [1]

linear resistance law, without tap	
at values between 10 and 90% of R_{tot}	< 2 dB
linear resistance law, with tap	< 3 dB
logarithmic, reversed logarithmic and semi logarithmic resistance law, without tap	
at attenuations between 0 and −20 dB	< 2 dB
at attenuations between −20 and −30 dB	< 3 dB
at attenuations between −30 and −40 dB	< 4 dB
logarithmic reversed logarithmic and semi logarithmic resistance law, with tap	
at attenuations between 0 and −20 dB	< 2 dB
at attenuations between −20 and −30 dB	< 3 dB
at attenuations between −30 and −34 dB	< 4 dB

Note - Potentiometers with reversed logarithmic law are measured as those with logarithmic law.

Crosstalk [1] (measured according to Fig. 11) see table below

	potentiometers with internal screening		potentiometers without internal screening	
resistance value	at 1 kHz	at 10 kHz	at 1 kHz	at 10 kHz
220 Ω to 100 kΩ	≥ 70 dB	≥ 55 dB	≥ 60 dB	≥ 45 dB
100 kΩ to 220 kΩ	≥ 60 dB	≥ 50 dB	≥ 50 dB	≥ 40 dB
220 kΩ to 470 kΩ	≥ 60 dB	≥ 50 dB	≥ 50 dB	≥ 40 dB
470 kΩ to 2,2 MΩ	≥ 50 dB	≥ 40 dB	≥ 40 dB	≥ 30 dB

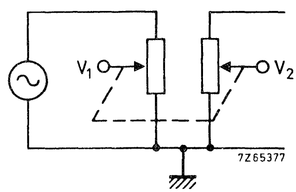


Fig. 11 Crosstalk = $20 \log \frac{V_1}{V_2}$

[1] For tandem potentiometers only.

AVAILABLE VERSIONS AND COMPOSITION OF THE CATALOGUE NUMBER

2322 43. . . . . .

code for screw-mounting facility

- single:
  - 0 = without
  - 1 = making use of holes in top and bottom
  - 2 = making use in holes in the small sides
  - 3 = making use of holes in front and back
- tandem:
  - 5 = without
  - 6 = making use of holes in top and bottom
  - 7 = making use of holes in the small sides
  - 8 = making use of holes in front and back

code for resistance law and nominal resistance, see table on next page.

code for tap

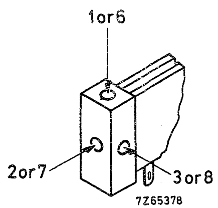
- 0 = without tap
- 2 = tap at 1/2

code for terminals and screening

- with solder tags:
  - 0 = without screening
  - 1 = with internal screening 1)
  - 2 = with internal and external screening 1)
  - 3 = with external screening
- with printed-wiring pins:
  - 5 = without screening
  - 6 = with internal screening 1)
  - 7 = with internal and external screening 1)
  - 8 = with external screening

code for adjustment provision

- length 12,5 mm:
  - 0 = asymmetrically placed
  - 1 = symmetrically placed
- length 16 mm:
  - 2 = asymmetrically placed
  - 3 = symmetrically placed

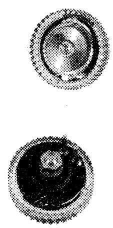


1) Only for tandem potentiometers.

nominal resistance	code in catalogue number				
	linear law	log. law	reversed log. law	semi-log. law	balance
220 Ω	02 1)				
470 Ω	03				
1 kΩ	04	24	44	64	
2,2 kΩ	05	25 1)	45 1)	65 1)	
4,7 kΩ	06	26	46	66	
10 kΩ	07	27	47	67	87
22 kΩ	08	28	48	68	88
47 kΩ	09	29	49	69	89
100 kΩ	11	31	51	71	91 1)
220 kΩ	12	32	52	72	92
470 kΩ	13	33	53	73	93
1 MΩ	14	34	54	74	94
2,2 MΩ	15	35	55	75	95
4,7 MΩ	16				
330 Ω	19 1)				

1) Only available without tap.

MINIATURE CARBON POTENTIOMETERS



RZ 27512-2

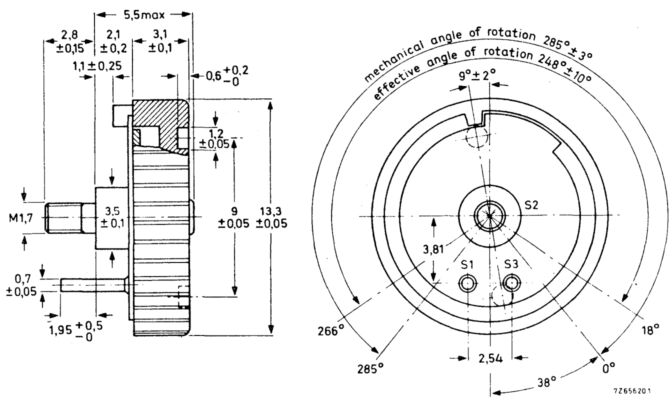
Nominal resistance values	4.7, 10 and 22 kΩ
Resistance law	linear and logarithmic

GENERAL

These potentiometers are destined for use in miniaturised electronic equipment such as hearing aids, small radio sets, etc.
On account of their application a special construction has been applied, which makes mounting of a control knob superfluous.

The potentiometers can be fixed on a chassis with the supplied mounting nut, catalogue number 4322 047 09530.

Dimensions in mm



S_1, S_2, S_3 = potentiometer terminals (S_1 and S_3 are connected to the ends of the carbon track; S_2 is connected to the slider contact)

TECHNICAL PERFORMANCE

Nominal resistance values	4,7, 10 and 22 kΩ
Tolerance on the nominal resistance	± 20%
Resistance law	linear and logarithmic
Contact resistance between carbon track and slider	
linear resistance law	≤ 5% of R_n
logarithmic resistance law	≤ 10% of R_n
Terminal resistance	
linear resistance law	≤ 1% of R_n
logarithmic resistance law	≤ 0,1% of R_n
Insulation resistance	> 1 MΩ
Maximum attenuation	≥ 60 dB
Maximum voltage over the resistance element	10 V d.c.
Current through slider	≤ 1 mA
Test voltage for 1 min	100 V, 50 Hz
Working-temperature range	−10 to +70 °C
Effective angle of rotation	248 ± 10°
Mechanical angle of rotation	285 ± 3°
Operating torque	0,2 - 1 Ncm
Maximum permissible torque with slider at end stop	5 Ncm
Life	in excess of 15 000 cycles

COMPOSITION OF THE CATALOGUE NUMBER

2322 440 100 . .

06 = 4,7 kΩ 07 = 10 kΩ 08 = 22 kΩ	linear resistance law
26 = 4,7 kΩ 27 = 10 kΩ 28 = 22 kΩ	logarithmic resistance law

23 mm SINGLE CARBON POTENTIOMETERS

QUICK REFERENCE DATA	
Resistance law	linear and logarithmic
Resistance range	
linear resistance law	220 Ω - 4, 7 MΩ
logarithmic resistance law	1 kΩ - 2, 2 MΩ
Maximum permissible dissipation at 40 °C	
linear resistance law	1 W
logarithmic resistance law	0, 5 W

APPLICATION

These potentiometers are destined for use in radio and television sets, where a dissipation of 0, 5 W (potentiometers with logarithmic resistance law) or 1 W (potentiometers with linear resistance law) is required, or where a non-inflammable potentiometer has to be used.

Note - Special versions for t.v. focus trimming are available under catalogue numbers 2322 460 90009, 2322 460 90011 and 2322 460 90012, see the relevant data sheet.

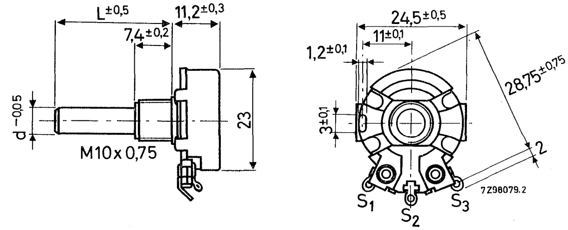
CONSTRUCTION

An annular carbon track is fitted onto a ceramic base plate and housed in a metal case (on request plastic case available).
The solder tags S_1 and S_3 (see Fig. 1) are connected to the ends of the carbon track; solder tag S_2 is connected to the slider contact via a contact ring.
The preferred types of potentiometer have a plastic spindle (polyacetal resin); potentiometers with a steel spindle are also available.

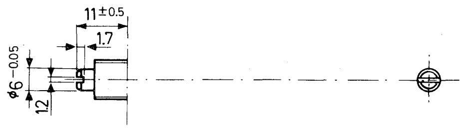
Dimensions in mm (plastic spindles)

For L and d, see Table I

a. Plain spindle



b. Spindle with screwdriver slot



c. Short spindle with flat face

d. Long spindle with flat face

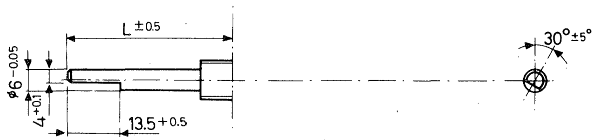


Fig. 1. Potentiometers 2322 460 ..... and their various spindle types.
Spindles c and d in fully counter-clockwise position.

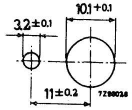


Fig. 2. Mounting holes

MOUNTING

The potentiometer can be fixed on a chassis with the supplied mounting nut. The minimum thickness of the chassis is 1,5 mm.
The maximum torque for tightening the nut is 350 Ncm.

TYPES

Composition of the catalog number

2322 460 . . . . .

code for indicating the spindle type, see Table I — code for resistance law and resistance value, see Tables 2 and 3

Table 1

		Fig.1	8th to 10th figure of catalog number [1]
plain, d = 6 mm	L = 18 mm	a	706
	L = 30 mm	a	703
	L = 60 mm	a	707
plain, d = 1/4",	L = 30 mm	a	723
	L = 60 mm	a	727
with screwdriver slot		b	710
short spindle with flat face		c	740
long spindle with flat face			
	L = 30 mm	d	743
	L = 60 mm	d	747

[1]) Preferred types (with plastic spindle), for potentiometers with a steel spindle the 8th figure is 0 instead of 7.

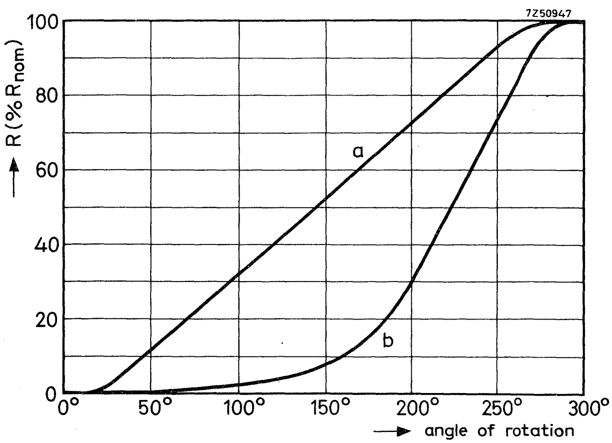


Fig.3. Resistance variation with the angle of rotation

TECHNICAL PERFORMANCE

Table 2 - Linear resistance law

nom. resistance value (R_n)	curve Fig. 3	limiting slider current (mA)	code in catalogue number
220 Ω	a	67	02
300 Ω	a	57	19
470 Ω	a	46	03
1 kΩ	a	31	04
2, 2 kΩ	a	21	05
4, 7 kΩ	a	15	06
10 kΩ	a	10	07
22 kΩ	a	6, 7	08
47 kΩ	a	4, 6	09
100 kΩ	a	3, 2	11
220 kΩ	a	2, 1	12
470 kΩ	a	1, 5	13
1 MΩ	a	0, 46	14
2, 2 MΩ	a	0, 21	15
4, 7 MΩ	a	0, 15	16

Table 3 - Logarithmic law

nom. resistance value (R_n)	curve Fig. 3	limiting slider current (mA)	min. attenuation at the beginning (dB)	code in catalogue number
1 kΩ	b	22	50	24
2, 2 kΩ	b	15	60	25
4, 7 kΩ	b	10	60	26
10 kΩ	b	7, 1	60	27
22 kΩ	b	4, 8	60	28
47 kΩ	b	3, 3	70	29
100 kΩ	b	2, 2	70	31
220 kΩ	b	1, 5	80	32
470 kΩ	b	1	80	33
1 MΩ	b	0, 71	80	34
2, 2 MΩ	b	0, 48	80	35

Tolerance on the nominal resistance	$\pm$ 20%
Resistance law	linear and logarithmic, see Fig. 3
Minimum resistance at the beginning	
linear resistance law, $R_n \leq 47$ kΩ	≤ 50 Ω
$R_n > 47$ kΩ	$\leq 0.1\%$ of R_n
logarithmic resistance law, $R_n \leq 4.7$ kΩ	≤ 5 Ω
$R_n > 4.7$ kΩ	$\leq 0.1\%$ of R_n
Minimum resistance at the end	
linear resistance law, $R_n \leq 4.7$ kΩ	≤ 50 Ω
$R_n > 4.7$ kΩ	$\leq 1\%$ of R_n
logarithmic resistance law, $R_n \leq 2.2$ kΩ	≤ 50 Ω
$R_n > 2.2$ kΩ	$\leq 2\%$ of R_n
Contact resistance between carbon track and slider contact	
linear resistance law	$\leq 3\%$ of R_n
logarithmic resistance law	$\leq 6\%$ of R_n
Insulation resistance between case and interconnected tags, after damp heat test (21 days, T_{amb} = 40 °C, R.H. = 90 - 95%)	> 100 MΩ
Maximum permissible dissipation at 40 °C	
linear resistance law	1 W
logarithmic resistance law	0.5 W
Test voltage for 1 min between case and interconnected tags	1 000 V, 50 Hz
Limiting voltage	500 V_p 500 V_{dc}
Working-temperature range	-10 to +70 °C
Climatic robustness	category 10/070/21 (I.E.C. 68)
Effective angle of rotation	250 - 265 °
Operating torque	0.3 - 2 Ncm
Permissible torque with slider at end stop	$\leq$ 80 Ncm
Mechanical angle of rotation	300 $\pm$ 5 °
Permissible axial spindle load	$\leq$ 50 N

CARBON POTENTIOMETERS
for t.v. focus trimming

QUICK REFERENCE DATA	
Resistance values	470 kΩ, 2,7 MΩ, 10 MΩ
Resistance law	linear
Maximum dissipation at 40 °C	1 W
Test voltage	10 000 V, 50 Hz
Category (IEC 68)	10/070/21

APPLICATION

These potentiometers have been developed for focus applications in television receivers.

DESCRIPTION

The potentiometers comprise a carbon track, which is fitted on to a ceramic base plate and housed in a non-inflammable plastic case. The terminals S_1 and S_3 are connected to the ends of the carbon track; terminal S_2 is connected via a contact ring to the slider contact.

Dimensions in mm

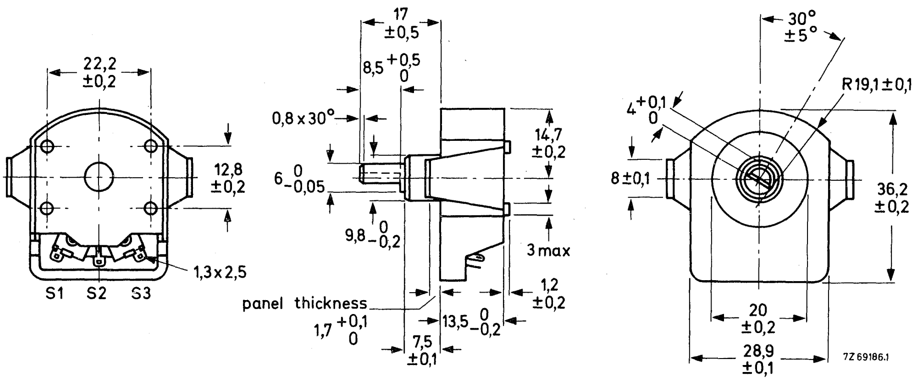


Fig. 1. Potentiometers 2322 460 900..; spindle in fully counter-clockwise position.

MOUNTING

The potentiometers can be fitted to a panel by means of the two mounting lugs. The hole pattern is given in Fig. 2.
The requisite panel thickness is 1, 8 mm. For thinner panels use must be made of packing washers.

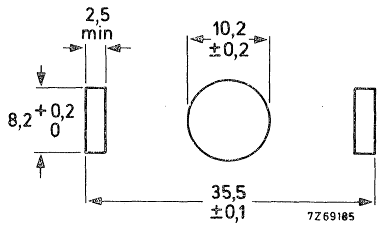


Fig. 2.

TECHNICAL DATA

Unless otherwise specified, all values have been determined at an ambient temperature of 15 to 35 °C, at atmospheric pressure of 960 to 1060 mbar and a relative humidity of 45 to 75%.
For measuring methods, see IEC publications 190 and 68. For the terms used, the paragraph "Glossary of terms" should be consulted.

Nominal resistance values (R_n) and tolerances	470 kΩ, ±20% 2,7 MΩ, ±20% 10 MΩ, −10%, +40%
Resistance law	linear
Terminal resistance	≤ 0, 1% of R_n
Contact resistance	≤ 3% of R_n
Insulation resistance	> 10^5 MΩ
Maximum dissipation at 40 °C	1 W
Limiting slider current at 40 °C, nominal resistance 470 kΩ 2,7 MΩ 10 MΩ	 1,45 mA 0,61 mA 0,32 mA
Maximum voltage at 40 °C	1500 V d.c., provided that the maximum dissipation is not exceeded
Test voltage for 1 min between interconnected terminals and chassis	10 000 V, 50 Hz
Operating temperature range	−10 to +70 °C
Climatic category (IEC 68)	10/070/21

Operating torque	3 to 20 mNm
Permissible end stop torque	≤ 800 mNm
Permissible axial spindle load	≤ 100 N
Effective angle of rotation	250 – 265°
Mechanical angle of rotation	300 ± 5°

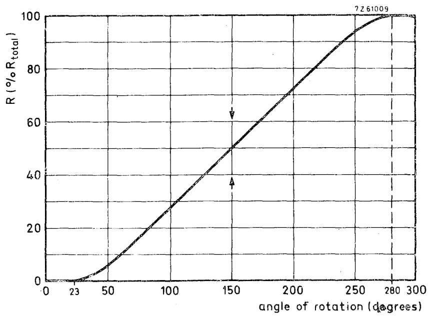


Fig. 3. Resistance as a function of the angle of rotation.

CATALOGUE NUMBERS FOR ORDERING

nominal resistance	catalogue number
470 kΩ	2322 460 90009
10 MΩ	2322 460 90011
2,7 MΩ	2322 460 90012

For ordering purposes please quote the catalogue numbers.

CERMET PRESET POTENTIOMETERS

QUICK REFERENCE DATA	
Resistance range, linear law	100 Ω to 1 MΩ (E6 series)
Maximum dissipation at 70 °C	0,5 W
Climatic category IEC 68	55/070/21

APPLICATION

These potentiometers have been designed for preset resistance control with provision for re-adjustments. They are particularly suitable for use in professional apparatus and/or in those applications where stability is of extreme importance.

DESCRIPTION

These potentiometers comprise a resistance element of thin glass film, with particles of conductive metal dispersed in it.
The element is supported by a non-conductive temperature-resistant ceramic base.
The terminals S_1 and S_2 (see Figs. 1 and 2) are connected to the ends of the resistance element; terminal S_3 is connected to the slider.
The potentiometers are available in two versions: one for vertical and one for horizontal mounting on printed-wiring boards. Both versions are available with or without a plastic dust cover.

Dimensions (mm)

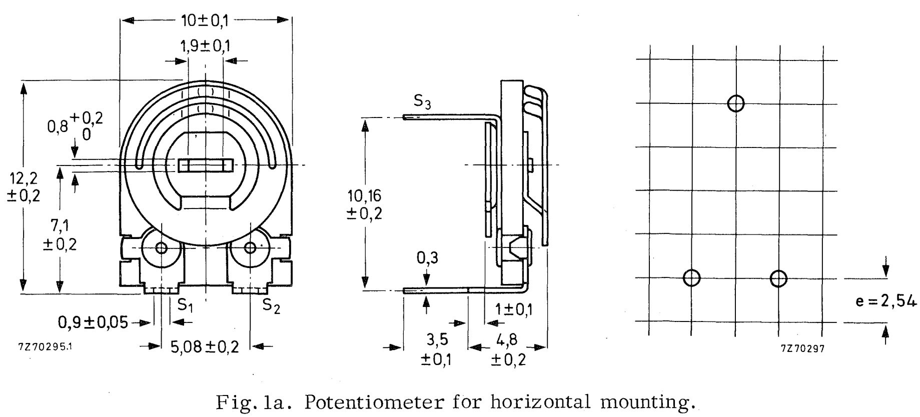


Fig. 1a. Potentiometer for horizontal mounting.

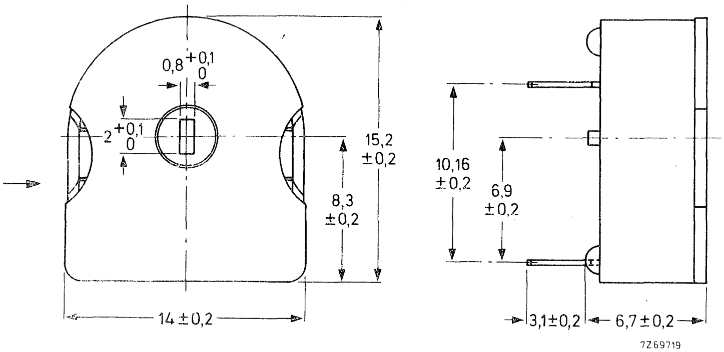


Fig. 1b. Dust-covered version of potentiometer for horizontal mounting.

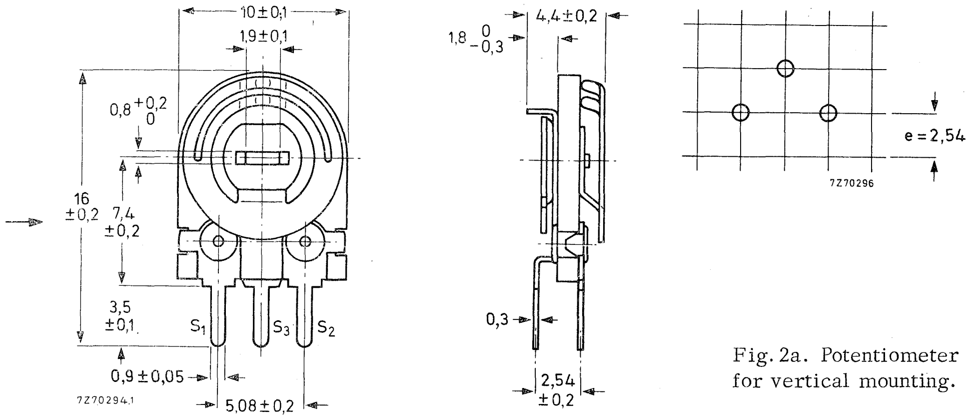


Fig. 2a. Potentiometer for vertical mounting.

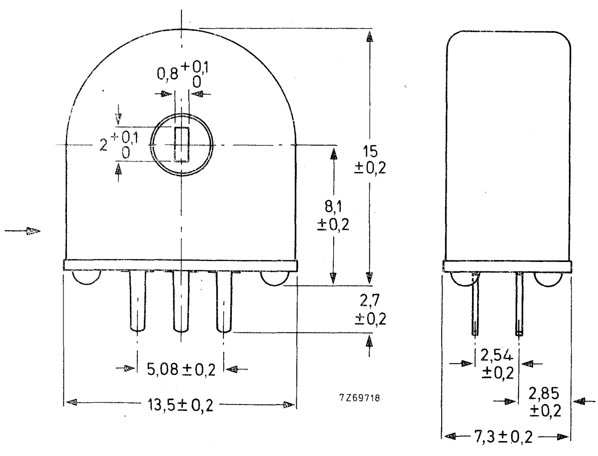


Fig. 2b. Dust-covered version of potentiometer for vertical mounting.

TECHNICAL DATA

Unless stated otherwise, all electrical values have been determined at an ambient temperature of 15 to 35 °C, an air pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.
For terms and test methods see IEC publication 393-1.

Nominal resistance values (R_n)	100 Ω to 1 MΩ (E6 series)
Tolerance on the nominal resistance	± 20%
Resistance law and tolerances	linear, see Fig. 3
Terminal resistance	≤ 0,5% of R_{total} or 2 Ω, whichever is the greater
Contact resistance variation (CRV)	≤ 1,5% of R_{total}
Maximum dissipation (P_{max}) at 70 °C	0,5 W
Limiting voltage (d.c.)	250 V
Limiting slider current	$\sqrt{\frac{P_{max}}{R_{total}}}$
Working temperature range	−55 to +70 °C [1]
Temperature coefficient	
R_n < 33 kΩ	0 to +250 ppm/°C
R_n = 33 kΩ to 470 kΩ inclusive	−150 to +150 ppm/°C
R_n > 470 kΩ	−250 to 0 ppm/°C
Operating torque	4 to 30 mNm
Permissible end stop torque	≤ 50 mNm
Effective angle of rotation	220 ± 5°
Mechanical angle of rotation	235 ± 5°
Rotational life	100 cycles
Resistance change after load life test (1000 h, 0,5 W, 70 °C)	≤ 2% of R_{total}
after damp heat test (21 days, 40 °C, 95% R.H.)	≤ 2% of R_{total}
after mechanical endurance test (100 cycles; rate of rotation 4 ± 1 cycle/min)	≤ 2% of R_{total}
Weight	approx. 1,5 g

[1]) Data are under investigation for applications above 70 °C.

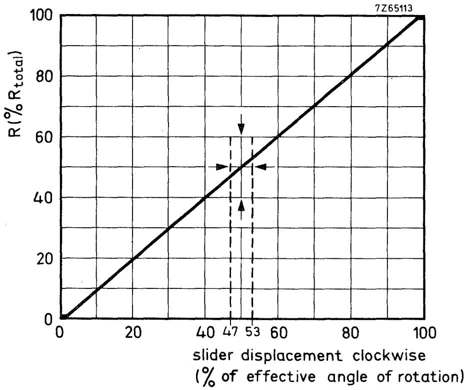


Fig. 3. Linear resistance law.

COMPOSITION OF THE CATALOGUE NUMBER

2322 482 . . . . .

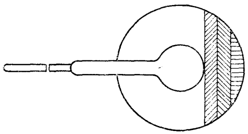
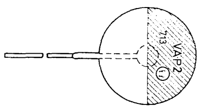
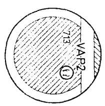
code for version — code for nominal resistance, see Table

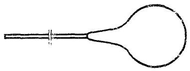
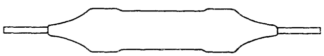
20 = potentiometer for horizontal mounting (Fig. 1a)
21 = dust-covered version of potentiometer for horizontal mounting (Fig. 1b)
30 = potentiometer for vertical mounting (Fig. 2a)
31 = dust-covered version of potentiometer for vertical mounting (Fig. 2b)

nominal resistance	code in cat. number	nominal resistance	code in cat. number
100 Ω	101	10 kΩ	103
150 Ω	151	15 kΩ	153
220 Ω	221	22 kΩ	223
330 Ω	331	33 kΩ	333
470 Ω	471	47 kΩ	473
680 Ω	681	68 kΩ	683
1 kΩ	102	100 kΩ	104
1,5 kΩ	152	150 kΩ	154
2,2 kΩ	222	220 kΩ	224
3,3 kΩ	332	330 kΩ	334
4,7 kΩ	472	470 kΩ	474
6,8 kΩ	682	680 kΩ	684
		1 MΩ	105

Voltage dependent resistors (VDR)

SURVEY

type	voltage (V)	current (mA)	dissipation (W)	β-value	catalogue number
DISC 	8 to 330	100 to 1	0, 8	0, 14 to 0, 40	2322 552 0....
	8 to 330	100 to 1	1	0, 14 to 0, 40	2322 553 0....
	8 to 330	100 to 1	2	0, 14 to 0, 40	2322 554 0....
	8 to 330	100 to 1	3	0, 14 to 0, 40	2322 555 0....
	48	1, 7 to 5	0, 25	0, 32 to 0, 35	2322 575 0.... 2322 575 3....
	48	0, 5 to 5	0, 4	0, 28 to 0, 32	2322 576 0.... 2322 576 3....
	48	0, 5 to 7	1	0, 25 to 0, 28	2322 577 0.... 2322 577 3....

SMALL DISC symmetric 	6 to 18	1	0, 1		2322 565 9000.
	2, 7 to 15	1	0, 25	0, 11 to 0, 22	2322 581 03...
	48	0, 05	0, 1	max. 0, 11	2322 592 90001 2322 592 90003
	55 to 415		0, 1	0, 035	2322 594 1....
asymmetric 	1, 0 1, 35	1	0, 03 0, 02	0, 05 to 0, 09	2322 574 90001 2322 574 90002
ROD 	56 to 1300	1 to 10	0, 8	0, 16 to 0, 36	2322 564 02... 2322 564 03... 2322 564 90...

INTRODUCTION

V(oltage) D(ependent) R(esistors), also called "Varistors", show a high degree of non-linearity between their resistance value and the applied voltage. They are made of non-homogeneous material giving a rectifying action at the contact of two particles.

Various materials are used to cause the voltage depending resistance. The principal ones are:

silicon carbide
zinc oxide
titanium oxide [1)]

The electrical characteristic of the conglomeration is determined by a large number of crystal contacts which form a complicated network of series and parallel rectifying contacts.

These resistors have found a diversity of applications in the different sectors of electronics. They offer a cheap and reliable solution for protection of electronic circuits, semi-conductor components, collectors of motors, relay contacts, etc. against over-voltages and their consequences.

MANUFACTURING PROCESS

Crystals of silicon carbide, or of metal oxides, with the right electrical and dimensional properties are pressed together with a ceramic binder to the shape of discs or rods. After a drying period the VDR's are sintered at a high temperature. Firing time, temperature and gaseous atmosphere have an important influence on the electrical characteristics. The contacts are metallized with silver or copper enabling good electrical contact. After leads have been soldered to the contacts the VDR's are lacquered and coded. Some types, made for clamp contacts or other mounting methods, are delivered unlacquered and without leads.
During and after the manufacturing process the electrical properties are controlled not only to ensure that the VDR's are within the specification but also to control stability and reliability of the resistors.

[1)] Philips Patented.

ELECTRICAL PROPERTIES

DIRECT CURRENT

The relation between voltage and current of a VDR resistor can be approximated by:

$$V = C.I^{\beta} \qquad (1)$$

where V is the voltage in volts, I the current in amperes and C and β are constants. This equation is illustrated in Fig.1. In principle the same characteristic is plotted for a specific type on a double logarithmic scale in Fig.2.
For not too small values of current this relation is a straight line which follows directly from the equation $\log V = \log C + \beta \log I$. In this case β is the directional coefficient of the straight line.

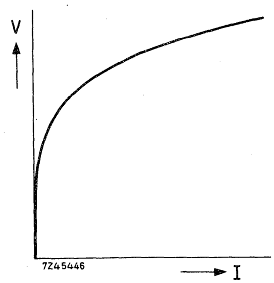


Fig.1.
Shape of the voltage/current characteristic of a VDR when plotted on a linear scale.

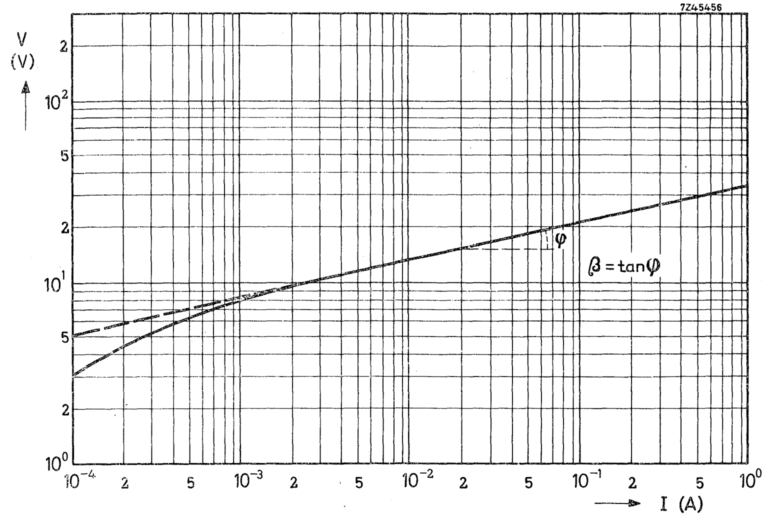


Fig.2. Voltage/current characteristic of a VDR plotted on a logarithmic scale.

In order to determine the exact values of the constants C and β it is necessary to measure three points of the characteristic. Only when these are on a straight line when plotted on a double logarithmic scale, extrapolation (only to higher values) is permitted. Equation (1) may also be written:

$$I = kV^{\alpha}, \qquad (2)$$

in which:

$$\alpha = 1/\beta \qquad (3a)$$

and

$$K = \frac{1}{C^{1/\beta}} = \frac{1}{C^{\alpha}} \qquad (3b)$$

The VDR do not have a polar effect; this means that when the voltage is changed from positive to negative, the current changes its direction, but retains its value. Strictly speaking the eqs (1) and (2) are valid only when the absolute values are taken for I and V. In a.c. calculations this may be very important.
To avoid cumbersome calculations with broken exponents eq. (1) is elaborated into a nomogram, Fig.3, which gives by a simple construction the corresponding values of voltage and current for any given VDR.
When a straight line is drawn between the point for $I = I_1$ mA on the first scale and the point for V_1 volts on the third scale, then the elongated line will intersect the β-line in question at a certain point. All straight lines starting from this point will intersect the scales for voltage and current at points which give values of I and V that belong together. E.g. for a VDR measuring 10 mA at 100 V and having a β of 0.20 it can easily be found that at 70 V the current will be 1.6 mA. The dissipated energy can be found on the second scale. In our example this is 0.11 W.

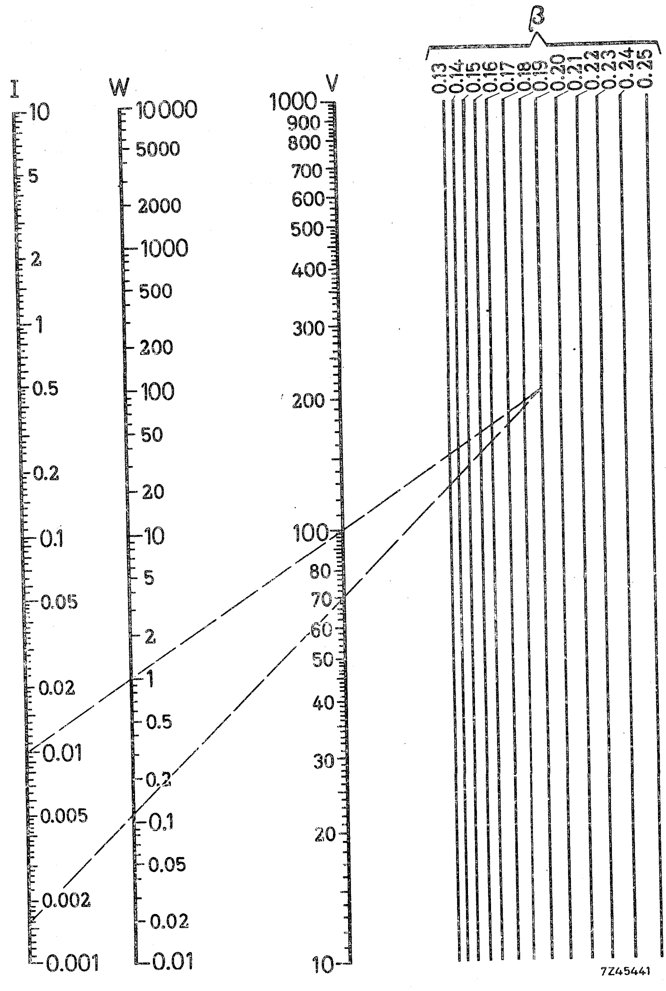


Fig.3.

Nomogram giving the relation between voltage, current, power dissipation and β-value of any VDR.

Although the nomogram will be used in most cases, it is sometimes convenient to use a normal linear scale, for example when the voltage drop across a VDR has to be determined in a series circuit with an ordinary resistor. In that case a resistance line is drawn, which intersects the VDR-curve in a point which by its ordinate directly gives the voltage across the VDR. In Fig.4 the characteristics of several standard types are drawn on a linear scale, this figure has been derived from the published voltage current relation on a double logarithmic scale. The broken lines correspond to the example shown in the insert. For a VDR 2322 552 03401 the voltage drop will be 90 V, whilst for a VDR 2322 552 02381 a drop of 140 V is found.

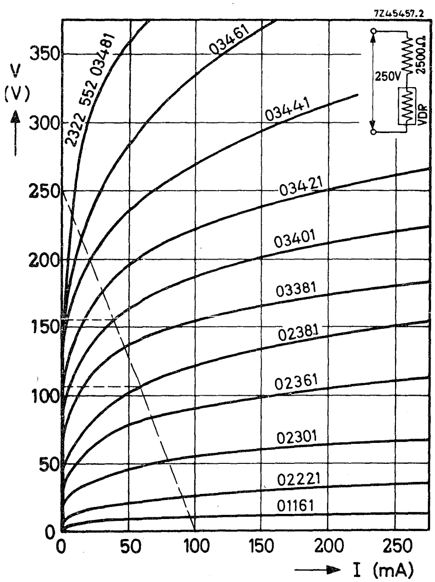


Fig.4.
Voltage/current characteristics plotted on a linear scale.

Practical values and specification

The C- and β-values of a VDR depend on the composition of the material and on the method used in the processing; the C-value depends furthermore on the shape and the dimensions of the VDR. Practical β-values range between 0,02 and 0,40. It is inherent to the material properties that the β-value of VDR with a low C-value will always be higher than that of a VDR with a high C-value. Practical C-values range from 14 to a few thousand. As the method of fabrication compels a minimum thickness and, as will be seen further, enlarging of the surface area gives little change in the C-value, the latter has for practical reasons a limited lowest value.

According to formula (1) it is possible to specify the electrical characteristics of a VDR resistor by giving its C- and β-values. The advantage of this specification is that only two parameters are used. The disadvantage is, however, that due to the inevitable tolerances on the β-values, the spread in voltages at low currents (in the working area) becomes very large. It is for this reason that the method of specifying by the C-value defined at 1 A is abandoned and we now specify the voltage across the VDR at currents which lie in the working area (1, 10 or 100 mA instead of 1 A). In this way it is possible to supply VDR's which have much closer tolerances in the area where they are used, see Fig.14. In theoretical calculations it is much easier, however to use the C-value. Therefore the formula $V = CI^{\beta}$ is used. When a calculation leads to a certain C-value, the voltage at currents of 1, 10 or 100 mA can be found with the aid of the nomogram (Fig.3).

VDR in series

For every VDR we can write the equation:

$$V = CI^{\beta} \qquad (1)$$

When n equal elements are connected in series and a voltage of n times the original voltage is applied, the current will be the same as for V volts over one VDR. Consequently we may write for a series circuit of n VDR:

$$nV = C'.I^{\beta} \qquad (4)$$

Froms eqs (1) and (4) it is evident that,

$$C' = nC, \qquad (5)$$

which means that the C-value of a VDR can be increased ad libitum by series connection.

VDR in parallel

For one VDR again we have:

$$V = CI^{\beta} \qquad (1)$$

Now when n of these VDR's are connected in parallel and the same voltage V is applied, the current in each VDR will still be the same. The total current in the circuit will be nI. This gives the following equation:

$$V = C''(nI)^{\beta} \qquad (6)$$

From eqs (1) and (6) it follows:

$$C'' = \frac{C}{n^{\beta}} \qquad (7)$$

As VDR's have a β-value from 0,02 to 0,40, it is clear that the C-value will decrease very little by connecting two or more elements in parallel.
When e.g. β = 0,20, 32 VDR's are needed for a 50 % reduction of the C-value. It is important that in parallel circuits all VDR's have about the same β- and C-values. Otherwise the current division will very much depend on the voltage across the circuit.

> Note: On no occasion may a VDR be connected in parallel with the aim of obtaining higher power dissipation.

Resistance value

When defining R as usual as the quotient of voltage and current, we find:

$$R = \frac{V}{I} = \frac{CI^{\beta}}{I} = \frac{C}{I^{1-\beta}} \qquad (8)$$

or when starting from the form $I = KV^{\alpha}$:

$$R = \frac{V}{I} = \frac{V}{KV^{\alpha}} = \frac{1}{K.V^{\alpha-1}} \qquad (9)$$

From these equations it is once more evident that the resistance value is not a constant one, but is very much dependent on the values of voltage and current.

Dissipated power

The power dissipated in a VDR is equal to the product of voltage and current, so it may be written:

$$W = I.V = K.V^{\alpha+1} \qquad (10)$$

When the coefficient α = 5, the power dissipated by the VDR is proportional to the 6th power of the voltage. A voltage increase of only 12 % will in this case double the dissipated power. Consequently it is very important that the applied voltage does not rise above a certain maximum value, as otherwise the permissible rating will be exceeded.
This is even more cogent, as the VDR have a negative temperature coefficient, which means that at higher dissipation (and accordingly higher temperature) the resistance value will decrease and the dissipated power will increase still more.

Temperature coefficient

In the foregoing formulas no temperature effects have been taken into account. These, however, may not always be neglected, as the C-value has an appreciable negative temperature coefficient. The β-value is practically independent from the temperature. With good approximation it may be written:

$$C_t = C_0 (1 + at), \qquad (11)$$

in which:

C_t = C-value of the VDR at t °C

C_0 = C-value of the VDR at 0 °C

a = temperature coefficient.

For different materials the value of a lies between −0.0010 and −0.0018.
So for circuits where the current is constant the temperature coefficient on voltage lies between −0.10 and −0.18 % per degree C.

For circuits where the voltage is constant the temperature coefficient on current lies between +0.4 and +0.8 % per degree C, depending on the β-value.

ALTERNATING CURRENT

If a sinusoidal voltage is applied to a VDR, the non-linear voltage current characteristic will cause the current to be non-sinusoidal, but the latter will for reasons of symmetry include only odd harmonics. Fig.5 shows an oscillogram of this phenomenon. If a VDR is carrying a sinusoidal current, the voltage across the VDR will be non-sinusoidal.

Sinusoidal voltage

R.M.S. value of the current

This value is defined by

$$I_{rms} = \sqrt{\frac{1}{T}\int_0^T I^2\,dt}.$$

As the momentary relation between voltage and current is given by $I = K.V^{\alpha}$ and $V = v\sin\omega t$ in which $v = V_{rms}\sqrt{2}$, it is found:

$$I_{rms} = K.V_{rms}^{\alpha}.2^{\alpha/2}\sqrt{\frac{2}{T}\int_0^{T/2}(\sin\omega t)^{2\alpha}\,dt}.$$

A d.c. voltage of $V = V_{rms}$ would cause a current in the VDR equal to:

$$I = K.V_{rms}^{\alpha}.$$

The relation $r = I_{rms}/I$ between these two current values is given by:

$$r = 2^{\alpha/2}\sqrt{\frac{2}{T}\int_0^{T/2}(\sin\omega t)^{2\alpha}\,dt}. \qquad (12)$$

This factor r has been calculated and is plotted as a function of α in Fig.6.

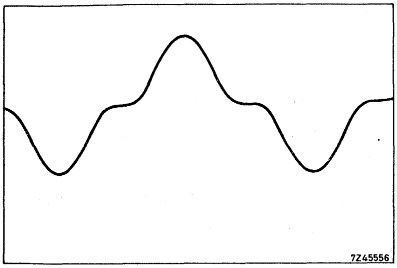


Fig.5.
Current as a function of time, when a sinusoidal voltage is applied to a VDR.

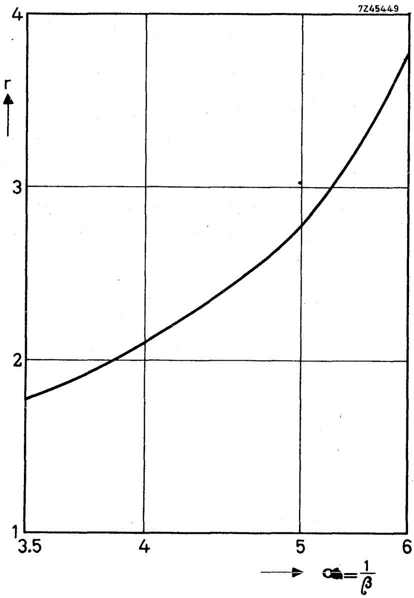


Fig.6.
Relation between the currents caused by a d.c. voltage V and an a.c. voltage V_{rms} = V.

$$r = I_{rms}/I$$

Mean value of the current in a VDR during half a cycle

This value is defined by:

$$I_m = \frac{2}{T}\int_0^{T/2} I\,dt.$$

Making the same assumption as for the I_{rms}-calculation it is found:

$$I_m = \frac{2\,K.V_{rms}^{\alpha}.2^{\alpha/2}}{T}\int_0^{T/2}(\sin\omega t)^{\alpha}\,dt.$$

Again a d.c. voltage of $V = V_{rms}$ would cause a current of

$$I = K.V_{rms}^{\alpha}$$

The relation $m = I_m/I$ between these two currents is:

$$m = \frac{2^{(\alpha+2)/2}}{T}\int_0^{T/2}(\sin\omega t)^{\alpha}\,dt. \qquad (13)$$

The factor m has been calculated for different a values and is plotted in Fig.7.

When measuring the alternating current in a VDR erroneous readings will be obtained if a moving-coil instrument, operating with rectifiers, is used. Normally these instruments are calibrated in r.m.s. values and are correct only for sinusoidal alternating voltages or currents. Actually they indicate the mean values of these magnitudes. When a current according to Fig.5 has to be measured with an assembly of this kind, the deflection of the instrument will be proportional to the mean value of the current. For obtaining the r.m.s. value the reading must be multiplied by a factor f which is given in Fig.8 as a function of a.

Dissipated power with sinusoidal alternating voltage

Again the assumptions made in the foregoing paragraphs are used and it is found:

$$W_{ac} = \frac{2}{T}\int_0^{T/2} K.V^{\alpha+1}(\sin\omega t)^{\alpha+1}\,dt =$$

$$\frac{2\,K.V_{rms}^{\alpha+1}.2^{(\alpha+1)/2}}{T}\int_0^{T/2}(\sin\omega t)^{\alpha+1}\,dt.$$

The power for a d.c. voltage of $V = V_{rms}$ is $W = KV_{rms}^{\alpha+1}$. The quotient of these power values is:

$$p = \frac{W_{ac}}{W} = \frac{2^{(\alpha+3)/2}}{T}\int_0^{T/2}(\sin\omega t)^{\alpha+1}\,dt. \qquad (14)$$

The value of p has been plotted in Fig.9 as a function of a.

Sinusoidal current

R.M.S. value of the voltage

When a sinusoidal current flows in the VDR the r.m.s.-value of the voltage across it may be expressed as follows:

$$V_{rms} = C\,I_{rms}^{\beta}.2^{\beta/2}\sqrt{\frac{T}{2}\int_0^{T/2}(\sin\omega t)^{2\beta}\,dt}.$$

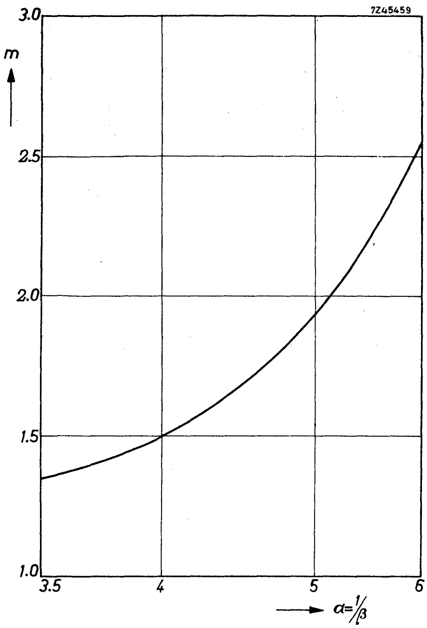


Fig.7.
Relation between the mean values of the currents caused by a d.c. voltage V and an a.c. voltage V_{rms} = V.

$m = I_m/I$

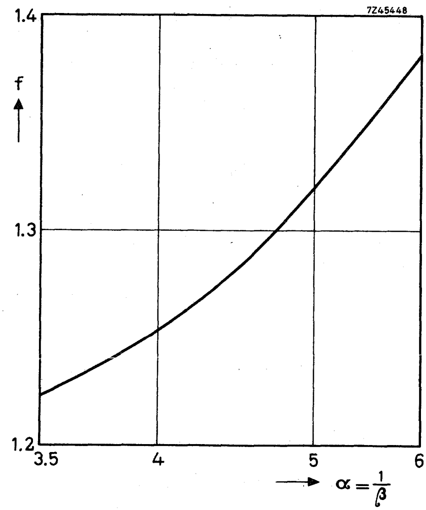


Fig.8.
Error in the reading of I_{rms} on a moving coil ammeter with rectifiers.

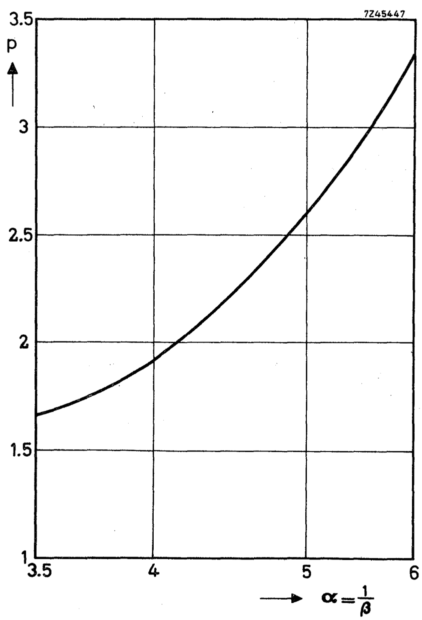


Fig.9.
Relation between the power dissipations caused by a d.c. voltage V and an a.c. voltage V_{rms} = V. The dissipation caused by the a.c. voltage is p times that caused by the d.c. voltage.

The d.c. voltage drop in a VDR when this carries a direct current $I = I_{rms}$, is:

$$V = C\, I_{rms}^{\beta}.$$

The relation $n = V_{rms}/V$ between these voltages has been calculated:

$$n = \frac{V_{rms}}{V} = 2^{\beta/2} \sqrt{\frac{2}{T} \int_0^{T/2} (\sin \omega t)^{2\beta}\, dt}. \qquad (15)$$

This value is plotted in Fig.10 as a function of β.

Dissipated power

For a sinusoidal current the dissipated power can be calculated as:

$$W_{ac} = C\, I_{rms}^{\beta+1}\, 2^{(\beta+1)/2} \frac{2}{T} \int_0^{T/2} (\sin \omega t)^{\beta+1}\, dt.$$

For a direct current $I = I_{rms}$ the dissipated power is:

$$W = C\, I_{rms}^{\beta+1}$$

The relation $I = W_{ac}/W$ has been calculated:

$$I = \frac{W_{ac}}{W} = 2^{(\beta+1)/2} \frac{2}{T} \int_0^{T/2} (\sin \omega t)^{\beta+1}\, dt. \qquad (16)$$

In Fig.11 this value is plotted as a function of β. From this graph it is clear that variations in β value have but little influence on the dissipated power, provided the current and the peak voltage are constant.
In practical use neither a sinusoidal voltage nor a sinusoidal current will generally occur. The first will only be the case if an inductance is shunted with a VDR for spark suppression. For those applications it is often required to know the power used by the VDR. The graph of Fig.9 helps in answering this question. If an ordinary linear resistance is connected in series with a VDR the shape of the current oscillogram will gradually deviate from that of Fig.5. If the linear resistance value is very large compared to the resistance value of the VDR the current will take a sinusoidal form.

Higher harmonics of the alternating current in a VDR

The curve as shown in Fig.5 can be developed into a Fourrier series. In that way the ratio of strength between the first, the third, and the fifth harmonic can be found. Harmonics of the seventh or higher order are very small and of no practical importance, Fig.12 shows the relative strength of these harmonics including the fifth, as a function of $\alpha = 1/\beta$.

High frequency alternating current

For low frequencies the small capacitance of the VDR does not affect the voltage dependency of the resistance. For high frequencies, however, this parallel capacitance may not be neglected. For low voltages and currents they may even determine the impedance of the VDR. At high voltages, the influence of the capacitance is less serious; because in that case the resistance over which this

Fig.10.
Relation between the voltages across a VDR carrying a direct current I or a sinusoidal alternating current $I_{rms} = I$.

$n = V_{rms}/V$

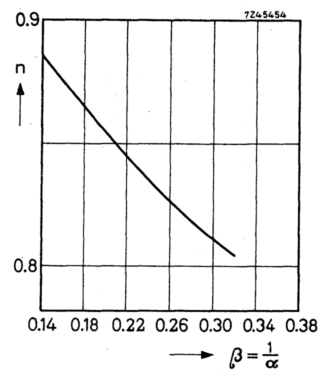


Fig.11.
Relation between the power dissipations caused by a direct current I and by a sinusoidal alternating current $I_{rms} = I$. The dissipation caused by the alternating current is I times that caused by the direct current.

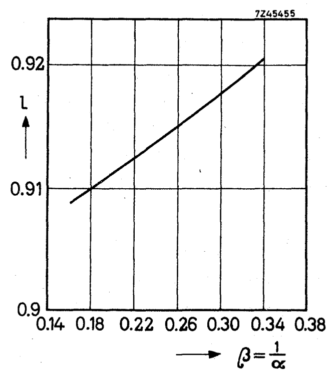
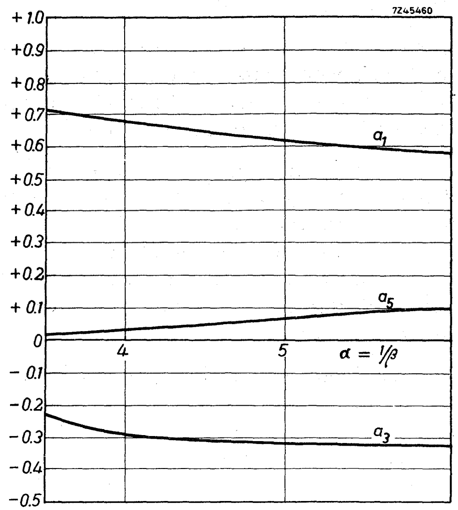


Fig.12.
Relative strength of the harmonics of a current according to Fig.5.



capacitance is shunted has decreased. In general the effect of the capacitance in h.f. circuits will be an apparent increase of β. Furthermore the voltage current graph on a logarithmic scale will no longer be a straight line.

A number of curves demonstrating this effect are given in Fig.13.

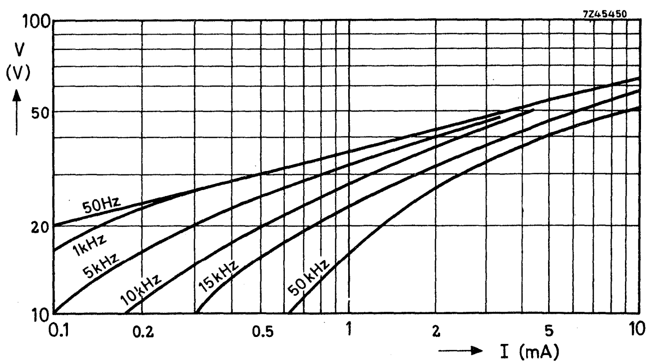


Fig.13. Voltage/current relation for different frequencies.

PERMISSIBLE DISSIPATION

The temperature which a VDR will reach is determined by the dissipated power, the heat conductivity of the material, the contact with and the nature of the surrounding medium and by the ambient temperature. As already explained the dissipated power will increase rapidly with increasing voltage.

The cooling per degree centigrade, though increasing slightly with temperature, depends mainly on the total surface area of the VDR; it can be improved by forced ventilation, by immersion in oil, or by using cooling fins or heatsinks. The permissible temperature of a VDR is generally limited by secondary effects, such as contact and insulation problems. For VDR's which are not lacquered or soldered, this limit is at about 150 ^{o}C. For lacquered VDR the permissible temperature is 120 ^{o}C.

For incidental surges, from which it may be assumed that they occur for such a short time that no heat is conducted to the surrounding medium, the rise in temperature is defined by the energy in this surge, the mass of the VDR and its heat capacity. In this case we find that a rise in temperature of 100 ^{o}C is caused by a load of 60 watt sec/gram. For a VDR having a weight of 1 gram the load may be 60 W during 1 sec or 6 W during 10 sec, etc. The shorter the time the higher the permissible load during that time. This is limited, however, by the properties of the material, which are liable to change at too high current densities.

HOW TO MEASURE VDR RESISTORS

The following points have to be considered when measuring VDR's.

1. Use only d.c. voltage.
2. Keep the measuring time as short as possible. Self-heating effects may influence the measurements due to the negative temperature coefficient of the VDR's.
3. In case the VDR's are specified at a voltage and current which is above the maximum dissipation, pulses should be used. For instance all 2322 564 VDR types which are used in television circuits are measured under pulse-conditions. These types are measured with a rectangular current pulse with a duration of 10 ms.
4. The β-value measurement needs some explanation. As mentioned on page 5 the β-value is not always constant but depends on the voltage and current. The β-values of our discs are measured between 0.3 I and 3 I, those of our rods between I and 10 I (unless otherwise specified), where I is the current at which the VDR is specified.

E.g. $\beta = \log \frac{V_2}{V_1}$; with V_2 = voltage at 3 I
V_1 = voltage at 0.3 I

TOLERANCES

Standard VDR's are specified with a certain tolerance on voltage and a spread on β-value. It can be seen in Fig.14 that due to the spread in β-value the tolerance on voltage may increase at other currents than the specified current at which the VDR is measured.
For some applications, where tolerances have to be kept as low as possible, the VDR's are measured at a current or voltage which lies near to its working point in the circuit, e.g. the standard rod types for television, series 2322 564 02 are measured at 10 mA.
For other applications, specially spark suppression, it is often important to specify the VDR at two points : a point at low current or low voltage and a point at high current or high voltage.

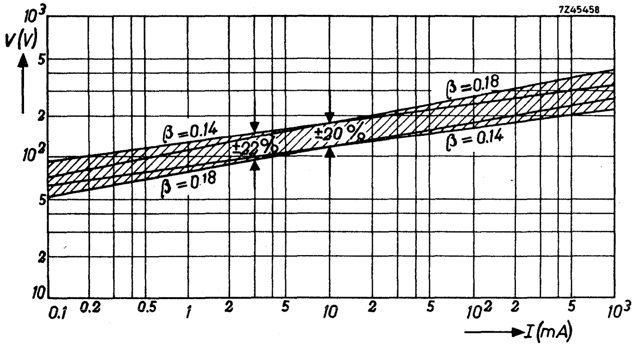


Fig. 14. Spread of voltage/current characteristic due to B-tolerance.

CHOICE OF TYPE

The voltage/current characteristics will indicate which standard type comes nearest to the required specification. The power to be dissipated will give the dimensions of the disc.
If the selected VDR has its specified values far from the working point in the circuit, it is recommended to calculate the tolerances in the working point (see section on tolerances). If necessary a 10 % tolerance can be selected instead of a 20 % type.

In case a specification is required in the form of

at V_1 volt $I < I_1$

at V_2 volt $I > I_2$

it is recommended to select a type which fulfils the first requirement (including tolerances); with the aid of a nomogram or by graphical solution on double logarithmic paper the second requirement can be checked.
If no standard type is available it is often possible to create or select a special type for a particular application.

ASYMMETRIC VDR RESISTORS

In order to extend our VDR-range to lower C-values a new VDR has been developed based on a barrier layer effect. As this device shows different characteristics in the two different directions, it is called an asymmetric VDR.
In one direction (the conduction direction) the VDR has a low C-value and a very low β-value (in the order of 0.07). In the reverse direction the resistance value and so the C-value is considerably higher.
Although there is some correspondence with diode characteristics there are important differences e.g.:

the asymmetric VDR has a high capacitance (about 0.15 μF measured in the reverse direction);

the tolerances of the asymmetric VDR are closer;

the temperature coefficient of asymmetric VDR's is very low;

the characteristic of the asymmetric VDR is steeper (low β-value);

the asymmetric VDR is made for voltages from 1 to 1.35 V at 1 mA, so higher than most semiconductor diodes.

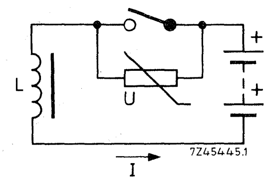
The present range is limited to two values, other types are in development.
The asymmetric VDR is applied **in radio and transistorized TV circuits.**

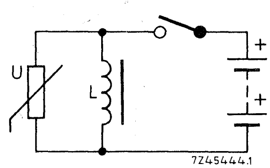
APPLICATIONS

Some of the most important application principles are given in the following pages. Well known television applications are the VDR used as a rectifier of non-symmetrical pulses, and for stabilization against supply voltage variations and aging of components. The VDR is also used in TV sets across the primary of the frame output transformer for damping oscillations, while in other parts of the circuits VDRs fulfil the functions of voltage stabilization devices. Outside the entertainment field we find VDRs used in telecommunications as relay contact protectors. A special range of VDRs has been developed for this purpose. Similar application can be found in small battery motors where the VDR increases the commutator life considerably.
There are many more uses for VDRs and the following selection is by no means complete.

Contact-protection and spark suppression

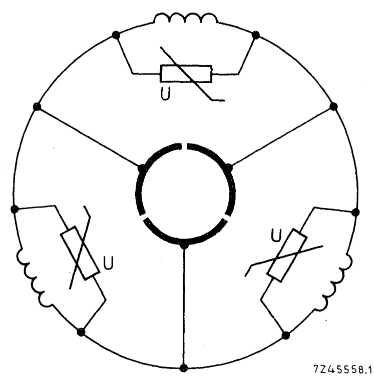
Two principal circuits are used. As soon as the contacts open, the energy stored in the inductance ($\frac{1}{2}LI^2$) is dissipated by the VDR, limiting the voltage across the contacts to a safe value.





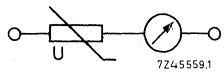
Protection of small battery motors

Sparking brush-contacts limit the commutator life and give rise to interference with nearby radio or audio circuits. A small VDR in parallel to the rotor windings prevents the sparking and so increases the commutator life considerably.



VDR for adapting meter sensitivity

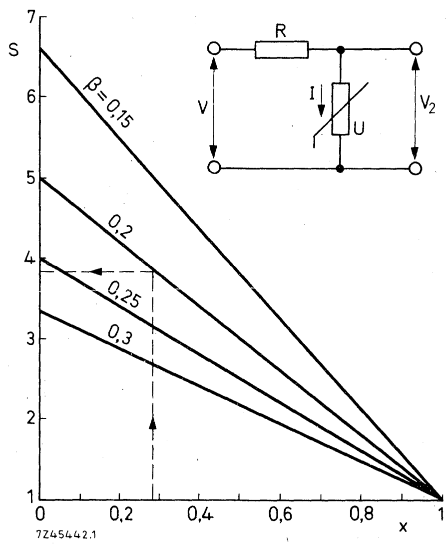
A VDR in series with a voltmeter or in parallel with a milliammeter will give increased sensitivity in a certain range.



Stabilization of a voltage without load when the supply voltage varies

It can be shown that the VDR stabilizes varying supply voltages by a factor

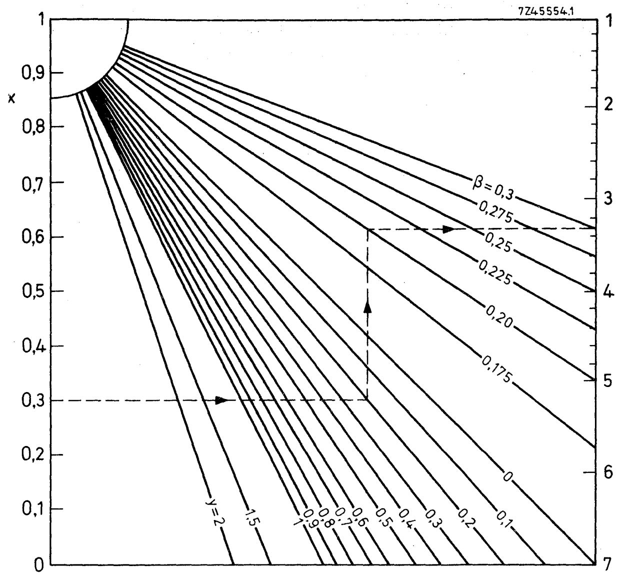
$$S = \frac{\Delta V/V}{\Delta V_2/V_2} = \frac{1}{\beta} - \frac{1-\beta}{\beta} \cdot x \text{ where } x = V_2/V.$$

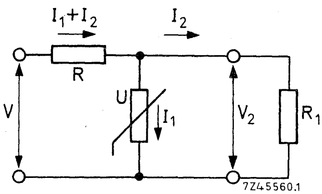


Stabilization of a voltage with load

$$S = \frac{1}{\beta} - \frac{1-\beta}{\beta} \cdot \frac{x+y}{1+y} \quad \text{where } x = V_2/V \text{ and } y = I_2/I_1$$

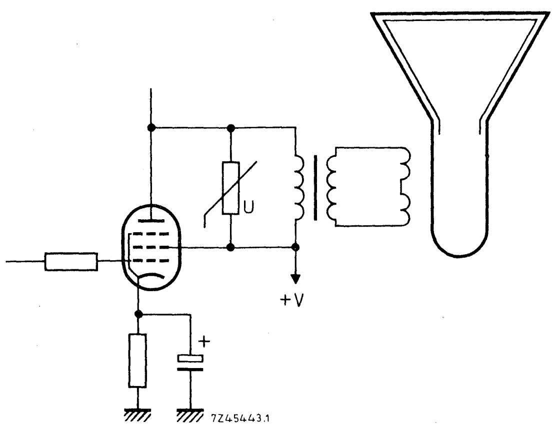
The nomogram makes S easy to find.





VDR for limiting the anode peak voltage and damping oscillations in vertical output stages of TV circuits

The VDR is shunted across the primary of the frame output transformer.

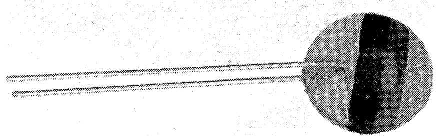


Stabilization of the operating current of transistors in an a.m. portable receiver.

It is known that the sensitivity of a portable receiver decreases with decreasing battery voltage, so the number of stations that can be clearly received is reduced. Furthermore the distortion level increases and spurious effects occur, like "motor-boating", caused by audio frequency instability.
By stabilizing the operating currents of the transistors by means of an asymmetric VDR, the above effects can be eliminated and the useful battery life will be much longer.
Extensive literature on this application and circuits is available on request.

VOLTAGE DEPENDENT RESISTORS

standard disc type with leads



RZ 19624-1

QUICK REFERENCE DATA	
Voltages at I_{nom} = 100 mA d.c.	8 to 12 V
Voltages at I_{nom} = 10 mA d.c.	8 to 68 V
Voltages at I_{nom} = 1 mA d.c.	56 to 330 V
β between 0.3 I_{nom} and 3 I_{nom}	0.14 to 0.40
Maximum dissipation	0.8 W
Operating temperature range	
at zero power	−25 to +125 °C
at maximum power	0 to +55 °C

APPLICATION

Very suitable for e.g. voltage stabilisation, contact protection and spark suppression.

DESCRIPTION

This type consists of a disc provided with two solid tinned copper wires. The resistor body is tan lacquered and impregnated, but non insulated.

MECHANICAL DATA

Dimensions in mm

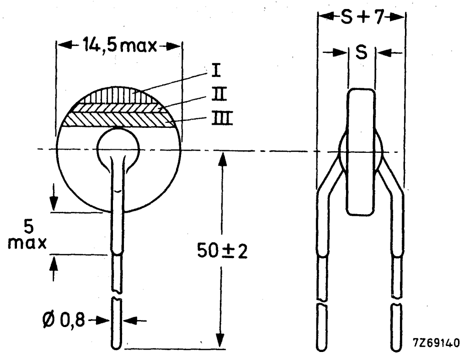


Fig. 1. For S see Table 1

Marking

The resistors are marked with three colour bands according to Fig. 1 and Table 1.

Weight

See Table 1

Mounting

In any position by soldering.

Robustness of terminations

Tensile strength	20 N
Bending	10 N

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 240 °C, max. 4 s

ELECTRICAL DATA

d.c. current I_{nom} (mA)	voltage at I_{nom} (V)	β	C approx.	S max. Fig.1 (mm)	weight (g)	colour code 2) I	colour code 2) II	colour code 2) III	catalogue number 1)
100	8	0.25-0.40	14	3	1,3	brown	brown	blue	2322 552 01161
100	10	0.25-0.40	18	3	1,3	brown	brown	grey	2322 552 01181
100	12	0.25-0.40	21	3	1,3	brown	red	black	2322 552 01201
10	8	0.25-0.40	25	3	1,3	red	brown	blue	2322 552 02161
10	10	0.25-0.40	32	3	1,4	red	brown	grey	2322 552 02181
10	12	0.25-0.40	40	3	1,4	red	red	black	2322 552 02201
10	15	0.25-0.40	48	3	1,4	red	red	red	2322 552 02221
10	18	0.21-0.35	57	3	1,45	red	red	yellow	2322 552 02241
10	22	0.21-0.35	60	3	1,45	red	red	blue	2322 552 02261
10	27	0.21-0.35	70	3	1,45	red	red	grey	2322 552 02281
10	33	0.18-0.25	85	3	1,45	red	orange	black	2322 552 02301
10	39	0.18-0.25	100	3	1,45	red	orange	red	2322 552 02321
10	47	0.18-0.25	130	5	1,45	red	orange	yellow	2322 552 02341
10	56	0.18-0.25	150	5	1,45	red	orange	blue	2322 552 02361
10	68	0.18-0.25	180	5	1,45	red	orange	grey	2322 552 02381
1	56	0.14-0.23	190	5	1,45	orange	orange	blue	2322 552 03361
1	68	0.14-0.23	230	5	1,45	orange	orange	grey	2322 552 03381
1	82	0.14-0.21	300	5	1,5	orange	yellow	black	2322 552 03401
1	100	0.14-0.21	350	5	1,6	orange	yellow	red	2322 552 03421
1	120	0.14-0.21	400	5	1,65	orange	yellow	yellow	2322 552 03441
1	150	0.14-0.21	500	5	1,75	orange	yellow	blue	2322 552 03461
1	180	0.14-0.21	600	5	1,9	orange	yellow	grey	2322 552 03481
1	220	0.14-0.21	750	5	2,15	orange	green	black	2322 552 03501
1	270	0.14-0.21	900	5	2,3	orange	green	red	2322 552 03521
1	330	0.14-0.21	1100	5	2,6	orange	green	yellow	2322 552 03541

1) For a voltage tolerance of ±10% the last figure of the catalogue number is 2 instead of 1.
2) The 10% types have an extra silver band on the top.

Tolerance on voltage at I_{nom}	±20% [1])
Maximum dissipation	0.8 W
Asymmetry	max. 2%
Operating temperature range	
at zero power	−25 to +125 °C
at maximum power	0 to +55 °C

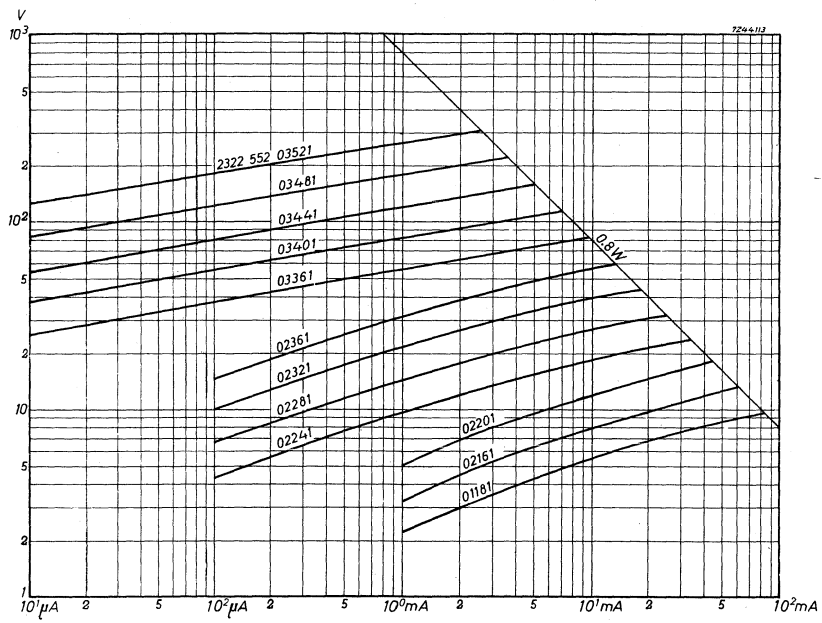


Fig. 2. Voltage/current characteristics

1) Also available with a tolerance of 10%.
The voltage is so measured that the internal heat development is negligible.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations, unless otherwise specified.

test	test method	duration	ΔV/V (%)	Δβ/β (%)
Cold at −25 °C	A	1000 h	±3	±3
Storage at +25 °C	H	1000 h	±2	±3
Dry heat at +125 °C	B	1000 h	±3	±5
Thermal shock −25 to +125 °C	Na	5 cycles	±3	±5
Damp heat at +40 °C	Ca	1000 h	±3	±5
Dissipation in damp heat		336 h	±3.5	±7
Max. dissipation at T_{amb} = +25 °C		1000 h	±5	±10
Robustness of terminations	U			
Tensile strength 20 N	Ua	10 s	[1]	
Bending 10 N	Ub	2 times	[1]	
Soldering	T			
Solderability at +230 ±10 °C	par 3.2.3	3 to 4 s	[2]	
Resistance to heat +230 ±10 °C	par 3.2.4	3 to 4 s	±2	±2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after six months storage with solder containing resin flux.

QUALITY LEVEL

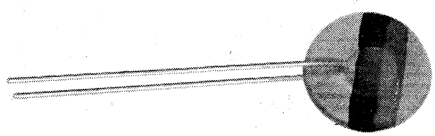
Sampling and data evaluation for quality level in accordance with MIL-STD-105D

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1.5%, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

PACKAGING

Cardboard boxes containing 100 items.

VOLTAGE DEPENDENT RESISTORS
standard disc type with leads



RZ 19624-1

QUICK REFERENCE DATA	
Voltages at I_{nom} = 100 mA	8 to 15 V
Voltages at I_{nom} = 10 mA	10 to 82 V
Voltages at I_{nom} = 1 mA	68 to 330 V
β between 0.3 I_{nom} and 3 I_{nom}	0.14 to 0.40
Maximum dissipation	1 W
Operating temperature range	
at zero power	-25 to +125 °C
at maximum power	0 to +55 °C

APPLICATION

Very suitable for e.g. voltage stabilisation, contact protection and spark suppression.

DESCRIPTION

This type consists of a disc provided with two solid tinned copper wires. The resistor body is tan lacquered and impregnated, but non insulated.

MECHANICAL DATA

Dimensions in mm

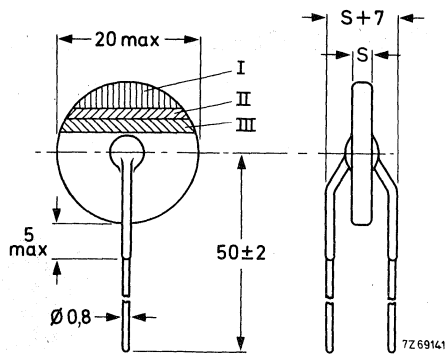


Fig. 1. For S see Table 1

Marking

The resistors are marked with three colour bands according to Fig. 1 and Table 1.

Weight

See Table 1

Mounting

In any position by soldering.

Robustness of terminations

Tensile strength	20 N
Bending	10 N

Soldering

Solderability	max. 240 ^{o}C, max. 4 s
Resistance to heat	max. 240 ^{o}C, max. 4 s

ELECTRICAL DATA

d.c. current I_{nom} (mA)	voltage at I_{nom} (V)	β	C approx.	S max. Fig. 1 (mm)	weight (g)	colour code 2) I	colour code 2) II	colour code 2) III	catalogue number 1)
100	8	0.25-0.40	14	3	1,7	brown	brown	blue	2322 553 01161
100	10	0.25-0.40	18	3	1,8	brown	brown	grey	2322 553 01181
100	12	0.25-0.40	21	3	1,9	brown	red	black	2322 553 01201
100	15	0.25-0.40	26	3	1,9	brown	red	red	2322 553 01221
10	10	0.25-0.40	32	3	1,9	red	brown	grey	2322 553 02181
10	12	0.25-0.40	40	3	2,0	red	red	black	2322 553 02201
10	15	0.25-0.40	48	3	2,0	red	red	red	2322 553 02221
10	18	0.21-0.35	57	3	2,0	red	red	yellow	2322 553 02241
10	22	0.21-0.35	60	3	2,1	red	red	blue	2322 553 02261
10	27	0.21-0.35	70	3	2,1	red	red	grey	2322 553 02281
10	33	0.18-0.25	85	3	2,1	red	orange	black	2322 553 02301
10	39	0.18-0.25	100	3	2,1	red	orange	red	2322 553 02321
10	47	0.18-0.25	130	5	2,1	red	orange	yellow	2322 553 02341
10	56	0.18-0.25	150	5	2,1	red	orange	blue	2322 553 02361
10	68	0.18-0.25	180	5	2,1	red	orange	grey	2322 553 02381
10	82	0.14-0.23	190	5	2,1	red	yellow	black	2322 553 02401
1	68	0.14-0.23	230	5	2,1	orange	orange	grey	2322 553 03381
1	82	0.14-0.21	300	5	2,1	orange	yellow	black	2322 553 03401
1	100	0.14-0.21	350	5	2,3	orange	yellow	red	2322 553 03421
1	120	0.14-0.21	400	5	2,4	orange	yellow	yellow	2322 553 03441
1	150	0.14-0.21	500	5	2,6	orange	yellow	blue	2322 553 03461
1	180	0.14-0.21	600	5	2,9	orange	yellow	grey	2322 553 03481
1	220	0.14-0.21	750	5	3,3	orange	green	black	2322 553 03501
1	270	0.14-0.21	900	5	3,7	orange	green	red	2322 553 03521
1	330	0.14-0.21	1100	5	4,2	orange	green	yellow	2322 553 03541

1) For a voltage tolerance of $\pm$ 10% the last figure of the catalogue number is 2 instead of 1.
2) The 10% types have an extra silver band on the top.

Tolerance on voltage at I_{nom}	± 20% [1]
Maximum dissipation	1 W
Asymmetry	max. 2%
Operating temperature range	
at zero power	−25 to +125 °C
at maximum power	0 to +55 °C

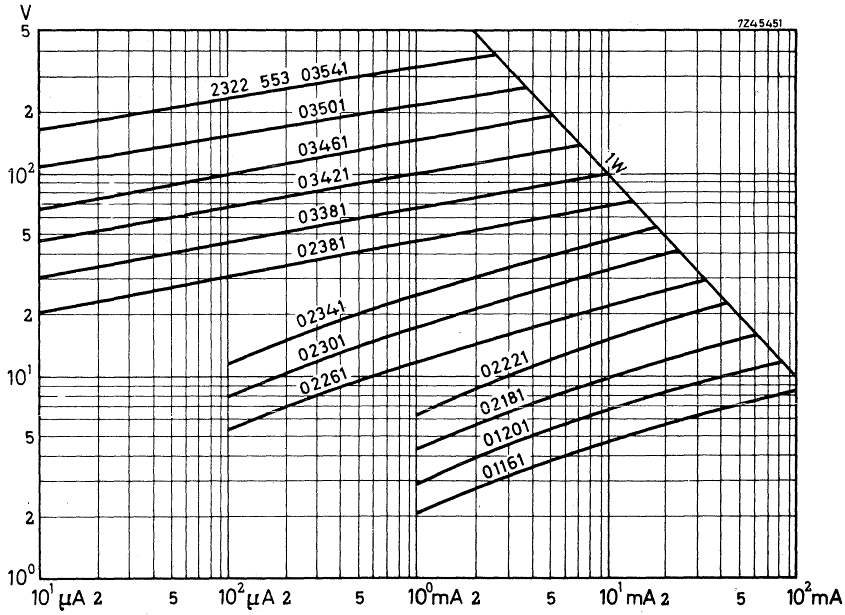


Fig. 2. Voltage/current characteristics

1) Also available with a tolerance of 10%.
The voltage is so measured that the internal heat development is negligible.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations, unless otherwise specified.

test	test method	duration	ΔV/V (%)	Δβ/β (%)
Cold at −25 °C	A	1000 h	± 3	± 3
Storage at +25 °C	H	1000 h	± 2	± 3
Dry heat at +125 °C	B	1000 h	± 3	± 5
Thermal shock −25 to +125 °C	Na	5 cycles	± 3	± 5
Damp heat at +40 °C	Ca	1000 h	± 3	± 5
Dissipation in damp heat		336 h	± 3.5	± 7
Max. dissipation at T_{amb} = +25 °C		1000 h	± 5	± 10
Robustness of terminations	U			
Tensile strength 20 N	Ua	10 s	[1]	
Bending 10 N	Ub	2 times	[1]	
Soldering	T			
Solderability at 230 ± 10 °C	par 3.2.3	3 to 4 s	[2]	
Resistance to heat at 230 ± 10 °C	par 3.2.4	3 to 4 s	± 2	± 2

[1]) Leads should neither come loose nor break.
[2]) Leads must be solderable initially and after six months storage with solder containing resin flux.

QUALITY LEVEL

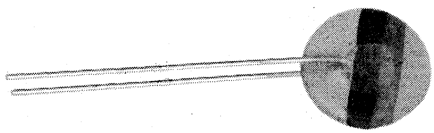
Sampling and data evaluation for quality level in accordance with MIL-STD-105D

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1.5%, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

PACKAGING

Cardboard boxes containing 100 items.

VOLTAGE DEPENDENT RESISTORS
standard disc type with leads



RZ 19624-1

QUICK REFERENCE DATA	
Voltages at I_{nom} = 100 mA	8 to 18 V
Voltages at I_{nom} = 10 mA	10 to 82 V
Voltages at I_{nom} = 1 mA	150 to 330 V
β between 0.3 I_{nom} and 3 I_{nom}	0.14 to 0.40
Maximum dissipation	2 W
Operating temperature range	
at zero power	−25 to +125 °C
at maximum power	0 to +55 °C

APPLICATION

Very suitable for e.g. voltage stabilisation, contact protection and spark suppression.

DESCRIPTION

This type consists of a disc provided with two solid tinned copper wires. The resistor body is tan lacquered and impregnated, but non insulated.

MECHANICAL DATA

Dimensions in mm

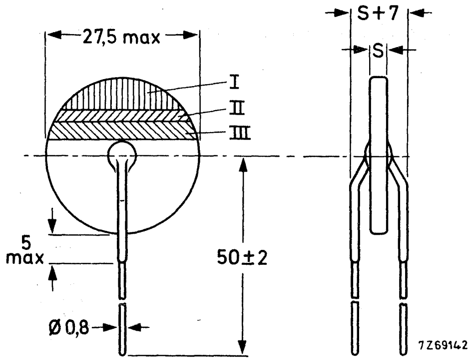


Fig. 1. For S see Table 1

Marking

The resistors are marked with three colour bands according to Fig. 1 and Table 1.

Weight

See Table 1

Mounting

In any position by soldering.

Robustness of terminations

Tensile strength	20 N
Bending	10 N

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 240 °C, max. 4 s

ELECTRICAL DATA

d.c. current I_{nom} (mA)	voltage at I_{nom} (V)	β	C approx.	S max. Fig. 1 (mm)	weight (g)	colour code 2)			catalogue number 1)
						I	II	III	
100	8	0.25-0.40	14	3	2,9	brown	brown	blue	2322 554 01161
100	10	0.25-0.40	18	3	2,95	brown	brown	grey	2322 554 01181
100	12	0.25-0.40	21	3	3,0	brown	red	black	2322 554 01201
100	15	0.25-0.40	26	3	3,0	brown	red	red	2322 554 01221
100	18	0.25-0.40	32	3	3,05	brown	red	yellow	2322 554 01241
10	12	0.25-0.40	38	3	3,05	red	red	black	2322 554 02201
10	15	0.25-0.40	47	3	3,1	red	red	red	2322 554 02221
10	18	0.21-0.35	57	3	3,1	red	red	yellow	2322 554 02241
10	22	0.21-0.35	60	3	3,2	red	red	blue	2322 554 02261
10	27	0.21-0.35	70	3	3,3	red	red	grey	2322 554 02281
10	33	0.18-0.25	84	3	3,4	red	orange	black	2322 554 02301
10	39	0.18-0.25	97	3	3,45	red	orange	red	2322 554 02321
10	47	0.18-0.25	125	5	3,5	red	orange	yellow	2322 554 02341
10	56	0.18-0.25	140	5	3,55	red	orange	blue	2322 554 02361
10	68	0.18-0.25	175	5	3,6	red	orange	grey	2322 554 02381
10	82	0.14-0.23	170	5	3,65	red	yellow	black	2322 554 02401
10	100	0.14-0.23	210	5	3,7	red	yellow	red	2322 554 02421
10	120	0.14-0.21	250	5	3,75	red	yellow	yellow	2322 554 02441
10	150	0.14-0.21	320	5	3,8	red	yellow	blue	2322 554 02461
10	180	0.14-0.21	380	5	4,2	red	yellow	grey	2322 554 02481
1	150	0.14-0.21	450	5	4,6	orange	yellow	blue	2322 554 03461
1	180	0.14-0.21	540	5	5,2	orange	yellow	grey	2322 554 03481
1	220	0.14-0.21	660	5	5,7	orange	green	black	2322 554 03501
1	270	0.14-0.21	810	5	5,7	orange	green	red	2322 554 03521
1	330	0.14-0.21	980	5	6,0	orange	green	yellow	2322 554 03541

1) For a voltage tolerance of $\pm$ 10% the last figure of the catalogue number is 2 instead of 1.
2) The 10% types have an extra silver band on the top.

Tolerance on voltage at I_{nom}	± 20% [1]
Maximum dissipation	2 W
Asymmetry	max. 2%
Operating temperature range	
at zero power	−25 to +125 °C
at maximum power	0 to +55 °C

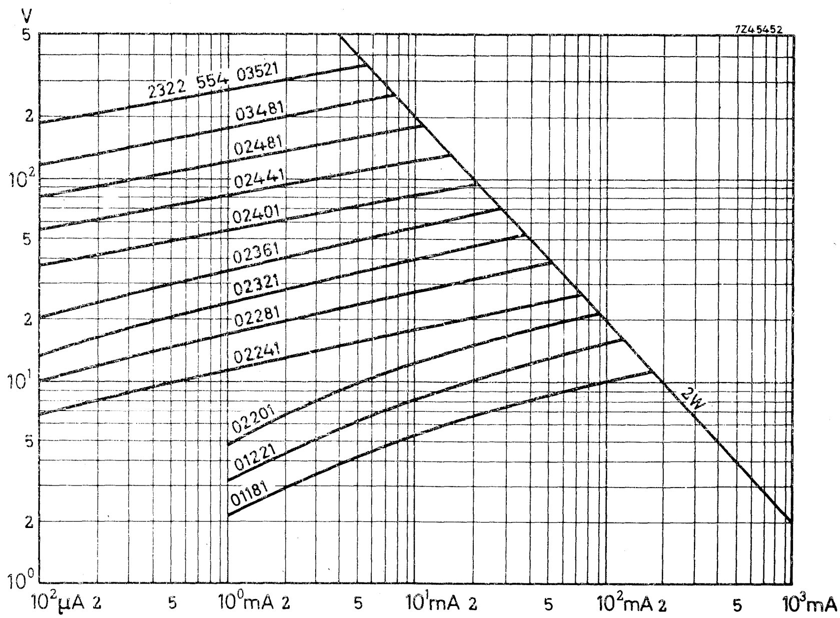


Fig.2. Voltage/current characteristics

[1]) Also available with a tolerance of 10%.
The voltage is so measured that the internal heat development is negligible.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations, unless otherwise specified.

test	test method	duration	ΔV/V (%)	Δβ / β (%)
Cold at −25 °C	A	1000 h	± 3	± 3
Storage at +25 °C	H	1000 h	± 2	± 3
Dry heat at +125 °C	B	1000 h	± 3	± 5
Thermal shock −25 to +125 °C	Na	5 cycles	± 3	± 5
Damp heat at +40 °C	Ca	1000 h	± 3	± 5
Dissipation in damp heat		336 h	± 3.5	± 7
Max. dissipation at T_{amb} = +25 °C		1000 h	± 5	± 10
Robustness of terminations	U			
Tensile strength 20 N	Ua	10 s	1)	
Bending 10 N	Ub	2 times	1)	
Soldering	T			
Solderability at 230 ± 10 °C	par 3.2.3	3 to 4 s	2)	
Resistance to heat at 230 ± 10 °C	par 3.2.4	3 to 4 s	± 2	± 2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after six months storage with solder containing resin flux.

QUALITY LEVEL

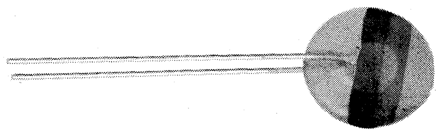
Sampling and data evaluation for quality level in accordance with MIL-STD-105D

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1.5%, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

PACKAGING

Cardboard boxes containing 50 items.

VOLTAGE DEPENDENT RESISTORS
standard disc type with leads



RZ 19624-1

QUICK REFERENCE DATA	
Voltages at I_{nom} = 100 mA d.c.	8 to 33 V
Voltages at I_{nom} = 10 mA d.c.	22 to 270 V
Voltages at I_{nom} = 1 mA d.c.	220 to 330 V
β between 0.3 I_{nom} and 3 I_{nom}	0.14 to 0.40
Maximum dissipation	3 W
Operating temperature range	
at zero power	−25 to +125 °C
at maximum power	0 to +55 °C

APPLICATION

Very suitable for e.g. voltage stabilisation, contact protection and spark suppression.

DESCRIPTION

This type consists of a disc provided with two solid tinned copper wires. The resistor body is tan lacquered and impregnated, but non insulated.

MECHANICAL DATA

Dimensions in mm

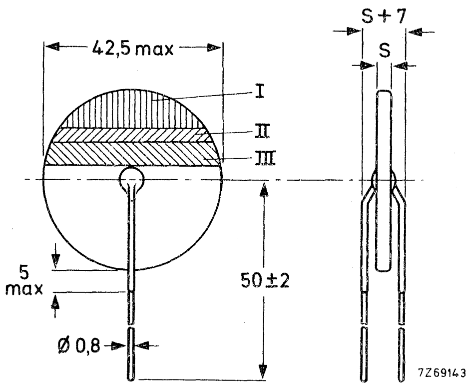


Fig. 1. For S see Table 1

Marking

The resistors are marked with three colour bands according to Fig. 1 and Table 1.

Weight

See Table 1

Mounting

In any position by soldering.

Robustness of terminations

Tensile strength	20 N
Bending	10 N

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 240 °C, max. 4 s

ELECTRICAL DATA

d.c. current I_{nom} (mA)	voltage at I_{nom} (V)	β	C approx.	S max. Fig. 1 (mm)	weight approx. (g)	colour code 2) I	colour code 2) II	colour code 2) III	catalogue number 1)
100	8	0.25-0.40	14	3	8	brown	brown	blue	2322 555 01161
100	10	0.25-0.40	18	3	8	brown	brown	grey	2322 555 01181
100	12	0.25-0.40	21	3	8	brown	red	black	2322 555 01201
100	15	0.25-0.40	26	3	8	brown	red	red	2322 555 01221
100	18	0.25-0.40	32	3	8	brown	red	yellow	2322 555 01241
100	22	0.25-0.40	39	3	8	brown	red	blue	2322 555 01261
100	27	0.25-0.40	48	3	8	brown	red	grey	2322 555 01281
100	33	0.21-0.35	53	3	8	brown	orange	black	2322 555 01301
10	22	0.21-0.35	60	3	8	red	red	blue	2322 555 02261
10	27	0.21-0.35	70	3	8	red	red	grey	2322 555 02281
10	33	0.18-0.25	84	3	8	red	orange	black	2322 555 02301
10	39	0.18-0.25	97	3	8	red	orange	red	2322 555 02321
10	47	0.18-0.25	125	5	10	red	orange	yellow	2322 555 02341
10	56	0.18-0.25	140	5	10	red	orange	blue	2322 555 02361
10	68	0.18-0.25	175	5	10	red	orange	grey	2322 555 02381
10	82	0.14-0.23	170	5	10	red	yellow	black	2322 555 02401
10	100	0.14-0.23	210	5	10	red	yellow	red	2322 555 02421
10	120	0.14-0.21	250	5	10	red	yellow	yellow	2322 555 02441
10	150	0.14-0.21	320	5	10	red	yellow	blue	2322 555 02461
10	180	0.14-0.21	380	5	10	red	yellow	grey	2322 555 02481
10	220	0.14-0.21	460	5	10	red	green	black	2322 555 02501
10	270	0.14-0.21	550	5	10	red	green	red	2322 555 02521
1	220	0.14-0.21	660	5	10	orange	green	black	2322 555 03501
1	270	0.14-0.21	810	5	10	orange	green	red	2322 555 03521
1	330	0.14-0.21	980	5	10	orange	green	yellow	2322 555 03541

1) For a voltage tolerance of $\pm$ 10% the last figure of the catalogue number is 2 instead of 1.
2) The 10% types have an extra silver band on the top.

Tolerance on voltage at I_{nom}	± 20% 1)
Maximum dissipation	3 W
Asymmetry	max. 2%
Operating temperature range	
at zero power	−25 to +125 °C
at maximum power	0 to +55 °C

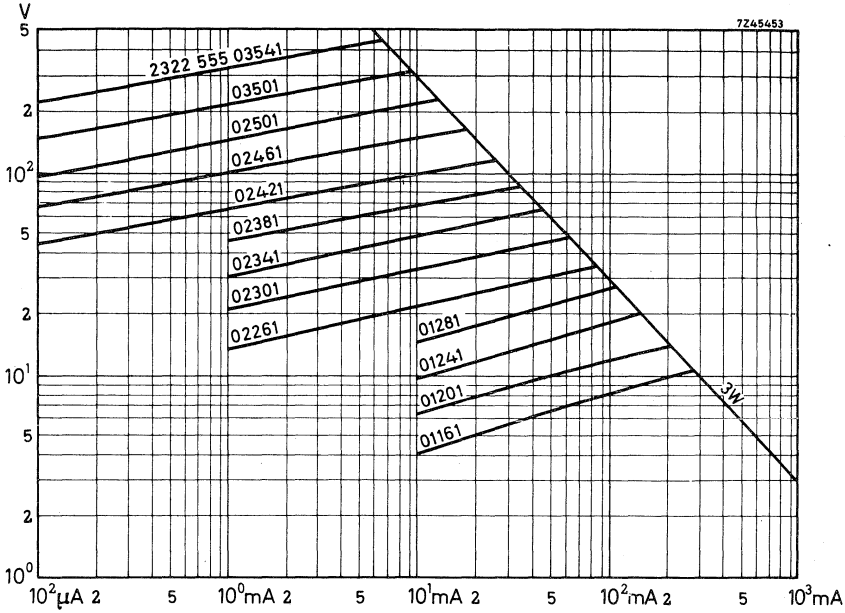


Fig. 2. Voltage/current characteristics

1) Also available with a tolerance of 10%. The voltage is so measured that the internal heat development is negligible.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations, unless otherwise specified.

test	test method	duration	$\Delta V/V$ (%)	$\Delta\beta/\beta$ (%)
Cold at −25 °C	A	1000 h	± 3	± 3
Storage at +25 °C	H	1000 h	± 2	± 3
Dry heat at +125 °C	B	1000 h	± 3	± 5
Thermal shock −25 to +125 °C	Na	5 cycles	± 3	± 5
Damp heat at +40 °C	Ca	1000 h	± 3	± 5
Dissipation in damp heat		336 h	± 3.5	± 7
Max. dissipation at T_{amb} = +25 °C		1000 h	± 5	± 10
Robustness of terminations	U			
Tensile strength 20 N	Ua	10 s	1)	
Bending 10 N	Ub	2 times	1)	
Soldering	T			
Solderability at 230 ± 10 °C	par 3.2.3	3 to 4 s	2)	
Resistance to heat at 230 ± 10 °C	par 3.2.4	3 to 4 s	± 2	± 2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after six months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1.5%, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

PACKAGING

Cardboard boxes containing 25 items.

VOLTAGE DEPENDENT RESISTORS

rod type

QUICK REFERENCE DATA	
Voltages	
types with I_{nom} = 10 mA d.c.	470 to 1300 V
type with I_{nom} = 2 mA d.c.	950 V
types with I_{nom} = 1 mA d.c.	56 to 300 V
β-values	0,16 to 0,36
Maximum dissipation	0,8 W
Operating temperature range	
at zero power	−25 to +125 °C
at maximum power	0 to +55 °C

APPLICATION

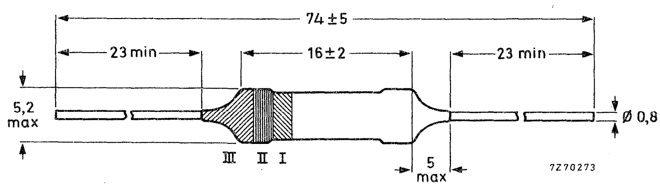
To be used for stabilization of voltages, protection of contacts, etc.

DESCRIPTION

These rods are provided with two axial solid tinned copper wires. They are tan lacquered, but not insulated.

MECHANICAL DATA

Dimensions (mm)



Marking

The thermistors are colour coded according to the table and Fig. 1

Weight 0,9 g approximately

Mounting In any position by soldering

Robustness of terminations

Tensile strength	20 N
Bending	10 N
Torsion	3 times

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s

ELECTRICAL DATA

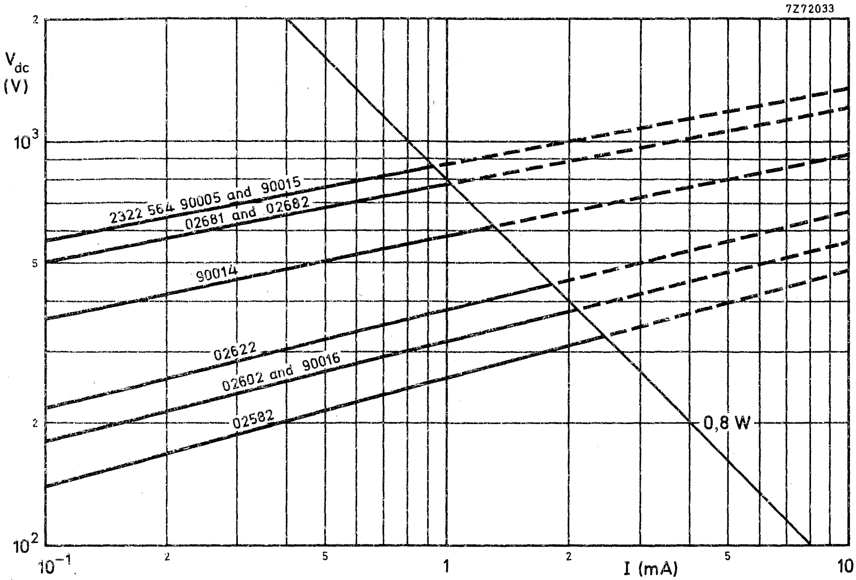
d.c. current I_{nom} (mA)	voltage at I_{nom} (V) [1]	tolerance %	β-value	colour code (see Fig. 1) band I	band II	band III	catalogue number
10	470	± 10	0,20-0,25	green			2322 564 02582
10	560	± 10	0,18-0,23	blue			2322 564 02602
10	680	± 10	0,18-0,23	violet			2322 564 02622
10	1200	± 20	0,17-0,22	grey			2322 564 02681
10	1200	± 10	0,17-0,22	brown			2322 564 02682
10	910	± 10	0,17-0,22	white			2322 564 90014
10	1300	± 10	0,16-0,21	red			2322 564 90015
2	950	± 10	0,16-0,21	black	blue		2322 564 90005
1	300	± 20	0,18-0,25	yellow	-	-	2322 564 90016
1	56	± 20 [2]	0,29-0,36	orange	orange	blue	2322 564 03361
1	68	± 20 [2]	0,29-0,36	orange	orange	grey	2322 564 03381
1	82	± 20 [2]	0,29-0,36	orange	yellow	black	2322 564 03401
1	100	± 20 [2]	0,25-0,32	orange	yellow	red	2322 564 03421
1	120	± 20 [2]	0,25-0,32	orange	yellow	yellow	2322 564 03441
1	150	± 20 [2]	0,22-0,29	orange	yellow	blue	2322 564 03461
1	180	± 20 [2]	0,22-0,29	orange	yellow	grey	2322 564 03481
1	220	± 20 [2]	0,21-0,28	orange	green	black	2322 564 03501
1	270	± 20 [2]	0,21-0,28	orange	green	red	2322 564 03521

Dissipation factor	20 mW/°C
Temperature coefficient at 1 mA between +25 and +100 °C	-0,1 %/°C
Maximum dissipation	0,8 W
Asymmetry	max. 2% [3]
Operating temperature range	
at zero power	-25 to +125 °C
at maximum power	0 to +55 °C

[1]) The voltage is so measured, that the internal heat development is negligible.

[2]) For a voltage tolerance of 10% the last figure of the catalogue number is 2 instead of 1.

[3]) Covered by the specified voltage tolerance



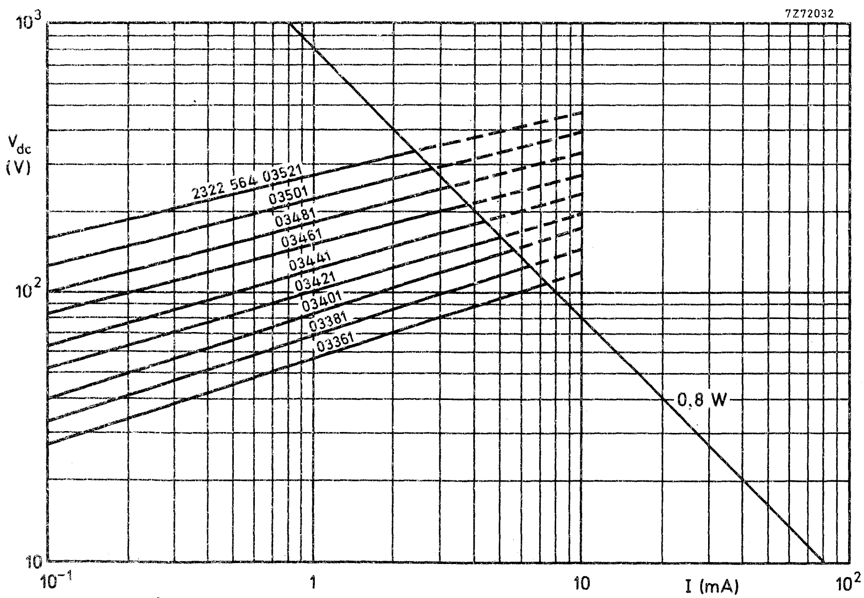


Fig. 2a and b. Typical voltage/current characteristics measured under pulse conditions.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations, unless otherwise specified.

test [1]	test method	duration	$\Delta V/V$ (%) at I_{nom}	$\Delta\beta/\beta$ (%)
Cold at −25 °C	A	1000 h	± 3	± 3
Storage at +25 °C	H	1000 h	± 2	± 3
Dry heat at +125 °C	B	1000 h	± 3	± 5
Thermal shock −25 to +125 °C	Na	5 cycles	± 3	± 5
Max. dissipation		1000 h	± 5	± 7,5
Robustness of terminations	U			
Tensile strenght 20 N	Ua	10 s	[2]	
Bending 10 N	Ub	2 times	[2]	
Torsion	Uc	3 times	[2]	
Soldering	T			
Solderability at 230 ± 10 °C	par 3.2.3	3 to 4 s	[3]	
Resistance to heat at 260 ± 5 °C	Tb	10 to 11 s	± 2	± 2

[1]) For d.c. measurements the measuring current must have the same polarity as the load current.

[2]) Leads should neither come loose nor break.

[3]) Leads must be solderable initially and after six months storage with solder containing resin flux.

QUALITY LEVEL

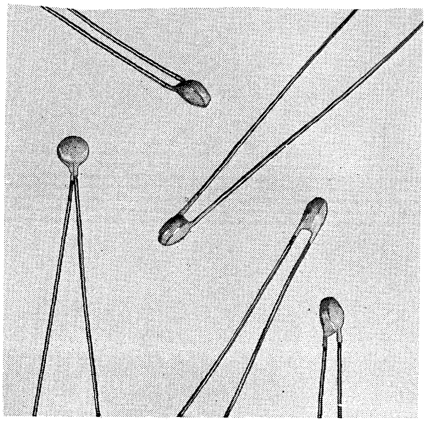
Sampling and data evaluation for quality level in accordance with MIL-STD-105D

A.Q.L. 1%, major defects - Electrical
A.Q.L. 1,5%, major defects - Mechanical
A.Q.L. 4%, minor defects - Physical

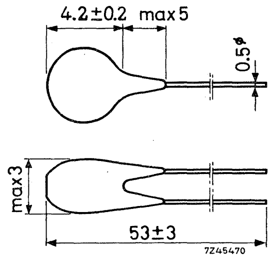
PACKING

Cardboard boxes containing 100 items.

VOLTAGE DEPENDENT RESISTORS
small disc types for special purposes



RZ 19269-8



For use in e.g. small battery motors (to protect the collector and to suppress interferences in radio and television) the 2322 565 90001 has been developed, which can be mounted in the rotor.

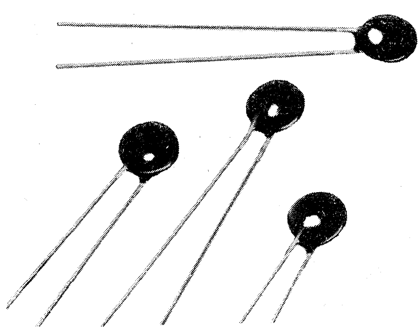
current at 5 $V_{dc} \leq$ 1 mA
current at 28 $V_{dc} \geq$ 10 mA
W_{max} 0.1 W

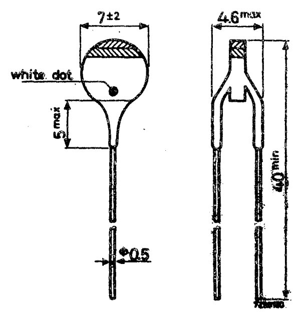
For use in colour television a special range of VDR discs has been developed:

I (mA)	E (V)	tolerance on voltage	catalog number
1	6	±20%	2322 565 90002
1	9	±20%	90003
1	12	±15%	90004
1	15	±15%	90005
1	18	±12%	90006

VOLTAGE DEPENDENT RESISTORS

asymmetric types





RZ 19225-4

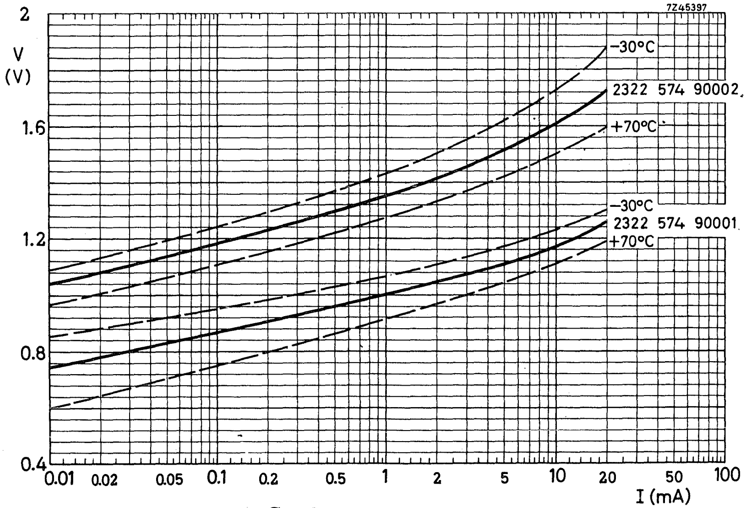
Based on a barrier-layer effect, the asymmetric voltage-dependent resistors differ in many aspects from the well-known voltage dependent resistors made of silicon carbide. Its characteristic is asymmetric; in the forward direction, the characteristic shows a very low β-value and C-value while in the reverse direction β- and C-values are much higher. Its parallel capacitance in forward as well as in reverse direction is relatively high. (See also "General").
They can be used for instance for stabilisation of the supply current in transistorised battery receivers.
For the time being two types are available.

at T_{amb} = 25 °C		catalogue number	
		2322 574 90001	2322 574 90002
forward direction	voltage at 1 mA	1.0 V ± 10 %	1.35 V ± 10 %
	temp. coeff.	> −0.2 %/deg C	> −0.2 %/deg C
	β	0.05-0.08	0.06-0.09
	capacitance at 0 mA	~ 0.15 μF	~ 0.15 μF
	at 5 mA	~ 10 μF	~ 10 μF
	max. permissible current	25 mA	20 mA
reverse direction	current at 5 V	< 2 μA	< 2 μA
	capacitance at 0 V	~ 0.15 μF	~ 0.15 μF
	at 5 V	~ 0.05 μF	~ 0.05 μF
	max. permissible voltage	5 V	5 V

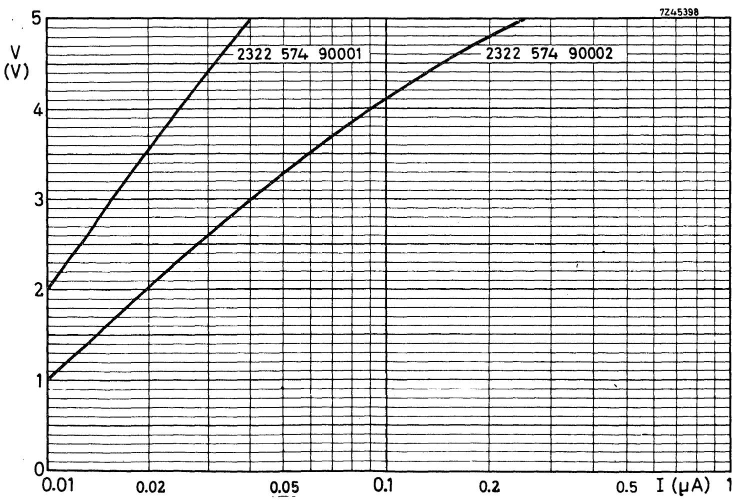
Temperature range: −30 to +70 °C
Cathode is indicated by a white dot.

Colour code	2322 574 90001	black and brown band
	2322 574 90002	black and red band

Voltage/current characteristics



Conduction direction



Reverse direction

VOLTAGE DEPENDENT RESISTORS
disc types for contact protection

QUICK REFERENCE DATA	
Nominal voltage	48 V d.c.
Max. current at nominal voltage	1,7 to 5,0 mA
Max. voltage at current for efficiency test (see Table 1)	145 V
Nominal dissipation	0,25 W
Climatic category (NF C 20-600 par. 4.3)	675 (25/055/21)
Operating temperature range, up to 48 V +20%	−25 to +55 °C

APPLICATION

These VDRs have been developed to protect relay contacts in telephone exchanges and to prolong their life considerably.

DESCRIPTION

Two versions are available:
2322 575 0. . . . (see Fig. 2), disc provided with two solid tinned wires, white lacquered.
2322 575 3. . . . (see Fig. 1), disc of which the flat faces are partly metallized. This version is impregnated but not lacquered.

Neither version is insulated.

These VDRs fully conform with the French standards NF C 93-277 of January 1973, and UTE C 93-277 of 21 Novenber 1972, article sheet 3. They have official French approval (Comité de coordination des télécommunications, certificate number 73-209 of 30 August 1973) and official Belgian approval (Comité électrotechnique belge, certificate number H 002, 1 February 1972).

MECHANICAL DATA

Dimensions (mm)

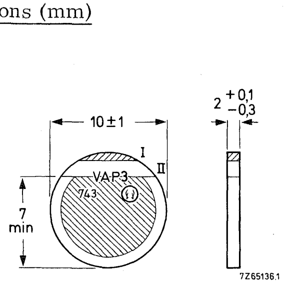


Fig. 1. 2322 575 3. . . .

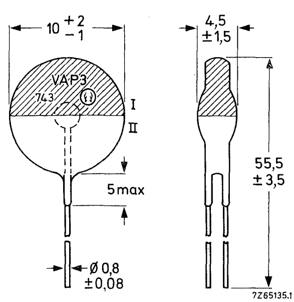


Fig. 2. 2322 575 0. . . .

Weight

2322 575 0....	1, 2 g approximately
2322 575 3....	0, 3 g approximately

Mounting

In any position,

2322 575 0....	by soldering
2322 575 3....	between contact clamps

Marking

Each VDR bears the following indications (see also Figs. 1 and 2):
a) VAP3
b) white band (version with leads has a white body), II, for nominal voltage 48 V
c) colour code, I, for class (see Table 1)
d) 3 characters for year and month of production
e) manufacturer's identification symbol.

Robustness of terminations

Tensile strength	20 N
Bending	10 N

Soldering (for version with leads only)

Solderability	max. 240 °C, max. 2, 5 s
Resistance to heat	max. 350 °C, max. 4 s

Inflammability

Self-extinguishing within 5 s, according to NF C 93-001, add. 1 par. 5.22.

ELECTRICAL DATA

Nominal voltage, V_{nom}	48 V d.c.
Max. current at V_{nom} (according to class)	1,7 to 5,0 mA, see Table 1
Max. voltage at current for efficiency test (see Table 1)	145 V
β-value between 48 V and 145 V	see Table 1
Dissipation factor	13 mW/°C approx.
Temperature coefficient (method A)	max. 0,8%/°C
Nominal dissipation	0,25 W
Asymmetry at current for efficiency test (see Table 1)	max. 2%
Climatic category (NF C 20-600 par. 4.3)	675 (25/055/21)
Operating temperature range, up to 48 V +20%	−25 to +55 °C

Table 1

class	max. current at V_{nom} (mA)	current for efficiency test (mA)	max. β-value	colour code	suffix. of catalogue No 2322 575		UTE type number	
					with leads	without leads	with leads	without leads
2	1,7	52	0,32	red	00272	30272	VAP3F2	VAP3S2
3	3,0	72	0,35	orange	00372	30372	VAP3F3	VAP3S3
4	5,0	121	0,35	yellow	00472	30472	VAP3F4	VAP3S4

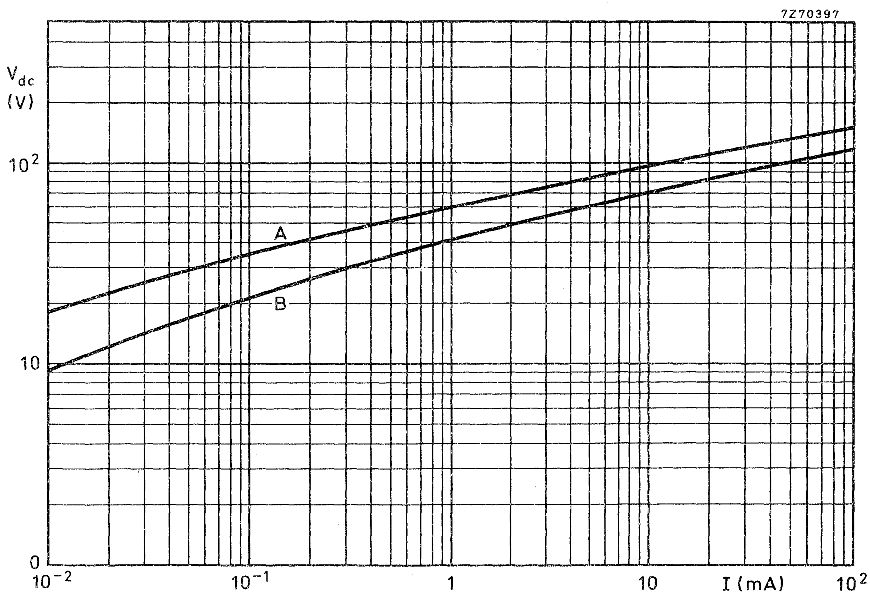


Fig. 3. Typical voltage/current characteristics
A = 2322 575 00272 and 2322 575 30272
B = 2322 575 00472 and 2322 575 30472

TESTS AND REQUIREMENTS

According to specification NF C 93-277

Table 2

test	test method	requirements
Stability after overvoltage	3.2.3	$\Delta I/I$ ± max. 10% no damage, marking legible
Combined climatic test	3.3.1	$\Delta I/I$ ± max. 30% no damage, marking legible
Damp heat	3.3.2	$\Delta I/I$ ± max. 30% no damage, marking legible
Rapid change of temperature	3.3.3	$\Delta I/I$ ± max. 30% no damage, marking legible
Robustness of terminations	3.3.4	no mechanical damage
Solderability	3.3.5	good tinning
Resistance to heat	3.3.6	$\Delta I/I$ ± max. 5% no damage, marking legible
Inflammability	3.3.7	self-extinguishing; no significant mechanical damage other than changes in colour of the body, or in the quality of the marking
Accelerated ageing	3.4.1	$\Delta I/I$ ± max. 20% no damage, marking legible; max. voltage at current for efficiency test must remain as specified
Endurance	3.4.2	$\Delta I/I$ ± max. 20% no damage, marking legible; max. voltage at current for efficiency test must remain as specified

PACKING

100 pieces per box (cardboard)

VOLTAGE DEPENDENT RESISTORS
disc types for contact protection

QUICK REFERENCE DATA	
Nominal voltage	48 V d.c.
Max. current at nominal voltage	0,5 to 5,0 mA
Max. voltage at current for efficiency test (see Table 1)	145 V
Nominal dissipation	0,4 W
Climatic category (NF C 20-600, par. 4.3)	675 (25/055/21)
Operating temperature range, up to 48 V +20%	−25 to +55 °C

APPLICATION

These VDRs have been developed to protect relay contacts in telephone exchanges and to prolong their life considerably.

DESCRIPTION

Two versions are available:
2322 576 0. . . . (see Fig. 2), disc provided with two solid tinned wires, white laquered.
2322 576 3. . . . (see Fig. 1), disc of which the flat faces are partly metallized. This version is impregnated but not lacquered.

Neither version is insulated.

These VDRs fully conform with the French standards NF C 93-277 of January 1973, and UTE C 93-277 of 21 November 1972, article sheet 3.
They have official French approval (Comité de coordination des télécommunications, certificate number 73-209 of 30 August 1973) and official Belgian approval (Comité électrotechnique belge, certificate number H002 of 1 February 1972).

MECHANICAL DATA

Dimensions (mm)

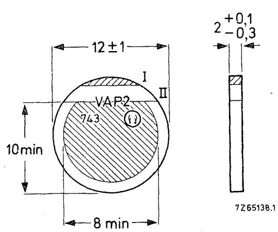


Fig. 1. 2322 576 3. . . .

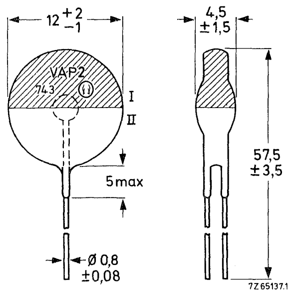


Fig. 2. 2322 576 0. . . .

Weight

2322 576 0....	1,4 g approximately
2322 576 3....	0,5 g approximately

Mounting

In any position,

2322 576 0....	by soldering
2322 576 3....	between contact clamps

Marking

Each VDR bears the following indications (see also Figs. 1 and 2):
a) VAP2
b) white band (version with leads has a white body), II, for nominal voltage 48 V
c) colour code, I, for class (see Table 1)
d) 3 characters for year and month of production
e) manufacturer's identification symbol.

Robustness of terminations

Tensile strength	20 N
Bending	10 N

Soldering (for version with leads only)

Solderability	max. 240 °C, max. 2,5 s
Resistance to heat	max. 350 °C, max. 4 s

Inflammability

Self-extinguishing within 5 s, according to NF C 93-001, add. 1 par. 5.22.

ELECTRICAL DATA

Nominal voltage, V_{nom}	48 V d.c.
Max. current at V_{nom} (according to class)	0,5 to 5 mA, see Table 1
Max. voltage at current for efficiency test (see Table 1)	145 V
β-value between 48 V and 145 V	see Table 1
Dissipation factor	17 mW/°C approx.
Temperature coefficient (method A)	max. 0,8%/°C
Nominal dissipation	0,4 W
Asymmetry at current for efficiency test (see Table 1)	max. 2%
Climatic category (NF C 20-600, par. 4.3)	675 (25/055/21)
Operating temperature range, up to 48 V +20%	−25 to +55 °C

Table 1

class	max. current at V_{nom} (mA)	current for efficiency test (mA)	max. β-value	colour code	suffix. of catalogue No. 2322 576.....		UTE type number	
					with leads	without leads	with leads	without leads
0	0,5	27	0,28	black	00072	30072	VAP2F0	VAP2S0
1	0,9	44	0,28	brown	00172	30172	VAP2F1	VAP2S1
2	1,7	65	0,30	red	00272	30272	VAP2F2	VAP2S2
3	3,0	91	0,32	orange	00372	30372	VAP2F3	VAP2S3
4	5,0	152	0,32	yellow	00472	30472	VAP2F4	VAP2S4

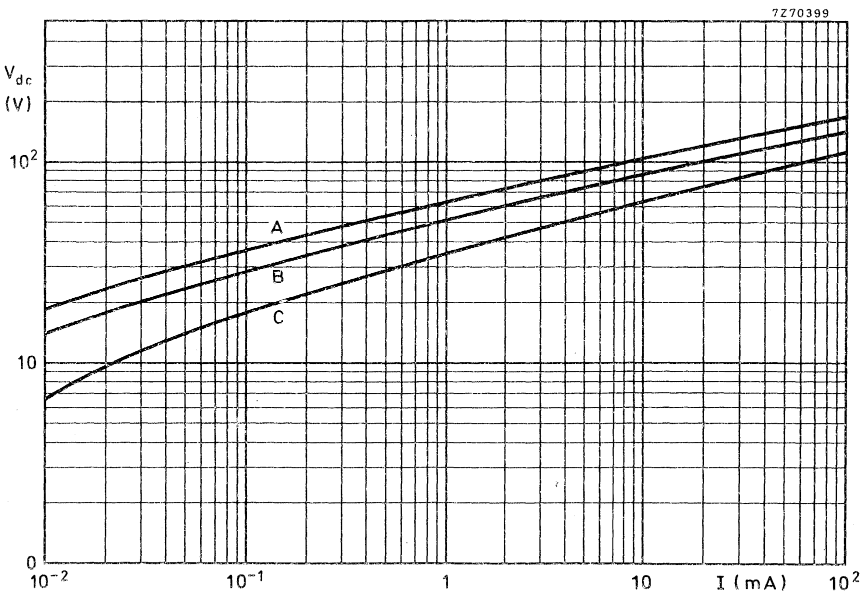


Fig. 3. Typical voltage/current characteristics
A = 2322 576 00072 and 2322 576 30072
B = 2322 576 00272 and 2322 576 30272
C = 2322 576 00472 and 2322 576 30472

TESTS AND REQUIREMENTS

According to specification NF C 93-277

Table 2

test	test method	requirements
Stability after overvoltage	3.2.3	$\Delta I/I \pm$ max. 10% no damage, marking legible
Combined climatic test	3.3.1	$\Delta I/I \pm$ max. 30% no damage, marking legible
Damp heat	3.3.2	$\Delta I/I \pm$ max. 30% no damage, marking legible
Rapid change of temperature	3.3.3	$\Delta I/I \pm$ max. 30% no damage, marking legible
Robustness of terminations	3.3.4	no mechanical damage
Solderability	3.3.5	good tinning
Resistance to heat	3.3.6	$\Delta I/I \pm$ max. 5% no damage, marking legible
Inflammability	3.3.7	self-extinguishing; no significant mechanical damage other than changes in colour of the body, or in the quality of the marking
Accelerated ageing	3.4.1	$\Delta I/I \pm$ max. 20% no damage, marking legible; max. voltage at current for efficiency test must remain as specified
Endurance	3.4.2	$\Delta I/I \pm$ max. 20% no damage, marking legible; max. voltage at current for efficiency test must remain as specified

PACKING

100 pieces per box (cardboard)

VOLTAGE DEPENDENT RESISTORS
disc types for contact protection

QUICK REFERENCE DATA	
Nominal voltage	48 V d.c.
Max. current at nominal voltage	0,5 to 7,0 mA
Max. voltage at current for efficiency test (see Table 1)	145 V
Nominal dissipation	1 W
Climatic category (NF C 20-600, par. 4.3)	675 (25/055/21)
Operating temperature range, up to 48 V +20%	−25 to +55 °C

APPLICATION

These VDRs have been developed to protect relay contacts in telephone exchanges and to prolong their life considerably.

DESCRIPTION

Two versions are available:
2322 577 o. . . . (see Fig. 2), disc provided with two solid tinned wires, white lacquered.
2322 577 3. . . . (see Fig. 1), disc of which the flat faces are partly metallized. This version is impregnated but not lacquered.

Neither version is insulated.

These VDRs fully conform with the French standards NF C 93-277 of January 1973, and UTE C 93-277 of 21 November 1972, article sheet 3. They have official French approval (Comité de coordination des télécommunications, certificate number 73-209 of 30 August 1973) and official Belgian approval (Comité électrotechnique belge, certificate number H 002 of 1 February 1972).

MECHANICAL DATA

Dimensions (mm)

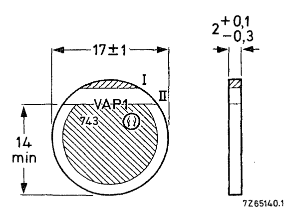


Fig. 1. 2322 577 3 . . . .

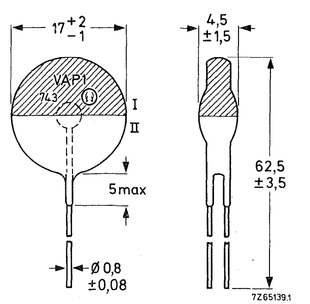


Fig. 2. 2322 577 0 . . . .

Weight

2322 577 0....	2,1 g approximately
2322 577 3....	1 g approximately

Mounting

In any position,

2322 577 0....	by soldering
2322 577 3....	between contact clamps

Marking

Each VDR bears the following indications (see also Fig. 1 and 2):
a) VAP1
b) white band (version with leads has a white body), II, for nominal voltage 48 V
c) colour code, I, for class (see Table 1)
d) 3 characters for year and month of production
e) manufacturer's identification symbol

Robustness of terminations

Tensile strength	20 N
Bending	10 N

Soldering (for version with leads only)

Solderability	max. 240 °C, max. 2,5 s
Resistance to heat	max. 350 °C, max. 4 s

Inflammability

Self-extinguishing within 5 s, according to NF C 93-001, add. 1, par. 5.22.

ELECTRICAL DATA

Nominal voltage, V_{nom}	48 V d.c.
Max. current at V_{nom} (according to class)	0,5 to 7,0 mA, see Table 1
Max. voltage at current for efficiency test (see Table 1)	145 V
β-value between 48 V and 145 V	see Table 1
Dissipation factor	24 mW/°C approx.
Temperature coefficient (method A)	max. 0,8%/°C
Nominal dissipation	1 W
Asymmetry at current for efficiency test (see Table 1)	max. 2%
Climatic category (NF C 20-600, par. 4.3)	675 (25/055/21)
Operating temperature range, up to 48 V +20%	−25 to +55 °C

Table 1

class	max. current at V_{nom} (mA)	current for efficiency test (mA)	max. β-value	colour code	suffix. of catalogue No. 2322 577..... with leads	without leads	UTE type number with leads	without leads
0	0,5	42	0,25	black	00072	30072 –	VAP1F0	VAP1S0
1	0,9	76	0,25	brown	00172	30172	VAP1F1	VAP1S1
2	1,7	115	0,26	red	00272	30272	VAP1F2	VAP1S2
3	3,0	180	0,27	orange	00372	30372	VAP1F3	VAP1S3
4	5,0	268	0,28	yellow	00472	30472	VAP1F4	VAP1S4
5	6,0	360	0,27	green	00572	30572	VAP1F5	VAP1S5
6	7,0	455	0,26	blue	00672	30672 –	VAP1F6	VAP1S6

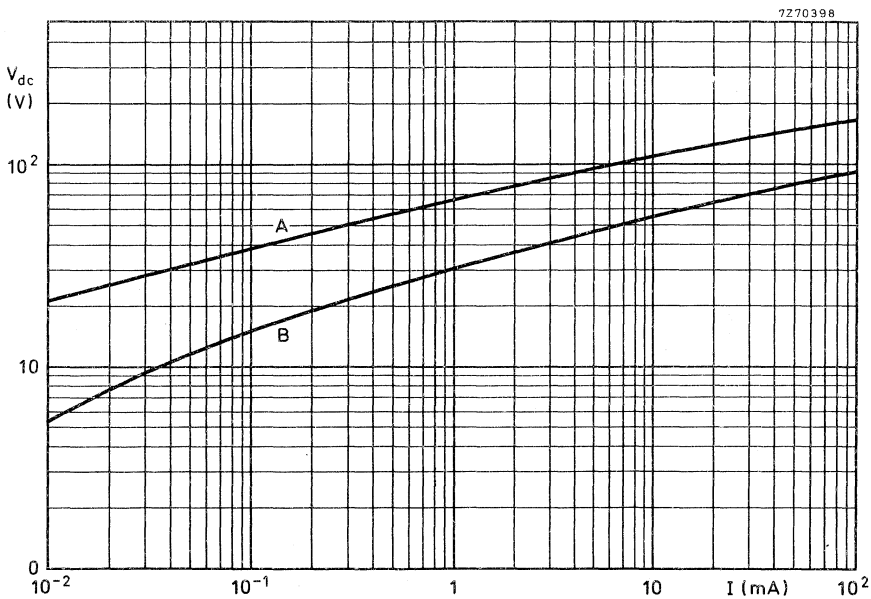


Fig. 3. Typical voltage/current characteristics
A = 2322 577 00072 and 2322 577 30072
B = 2322 577 00672 and 2322 577 30672

TESTS AND REQUIREMENTS

According to specification NF C 93-277

Table 2

test	test method	requirements
Stability after overvoltage	3.2.3	$\Delta I/I \pm$ max. 10% no damage, marking legible
Combined climatic test	3.3.1	$\Delta I/I \pm$ max. 30% no damage, marking legible
Damp heat	3.3.2	$\Delta I/I \pm$ max. 30% no damage, marking legible
Rapid change of temperature	3.3.3	$\Delta I/I \pm$ max. 30% no damage, marking legible
Robustness of terminations	3.3.4	no mechanical damage
Solderability	3.3.5	good tinning
Resistance to heat	3.3.6	$\Delta I/I \pm$ max. 5% no damage, marking legible
Inflammability	3.3.7	self-extinguishing; no significant mechanical damage other than changes in colour of the body, or in the quality of the marking
Accelerated ageing	3.4.1	$\Delta I/I \pm$ max. 20% no damage, marking legible; max. voltage at current for efficiency test must remain as specified
Endurance	3.4.2	$\Delta I/I \pm$ max. 20% no damage, marking legible; max. voltage at current for efficiency test must remain as specified

PACKING

100 pieces per box (cardboard)

VOLTAGE DEPENDENT RESISTOR

titanium oxide disc

QUICK REFERENCE DATA	
Voltage at 1 mA d.c.	2,7 to 15 V
β between 0,3 mA and 3 mA	0,11 to 0,22
Maximum dissipation	0,25 W
Operating temperature range	
at zero power	-25 to +125 °C
at maximum power	0 to +55 °C

APPLICATION

Intended for applications requiring a low β-value at a low voltage.

DESCRIPTION

This type consists of a titanium oxide disc provided with two solid tinned copper wires. The resistor body is tan lacquered but not insulated.

MECHANICAL DATA

Dimensions (mm)

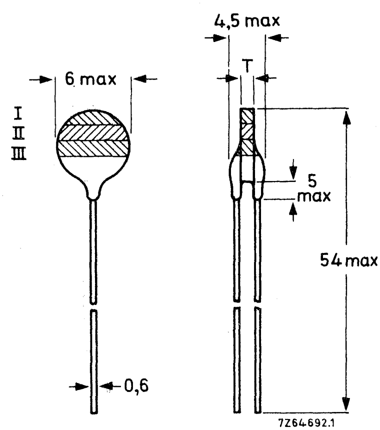


Fig. 1

Marking

The resistors are marked with three colour bands (see Fig. 1) according to the table.

Weight

0,25 g approximately

Mounting

In any position by soldering

Robustness of terminations

Tensile strength 20 N
Bending 10 N

Soldering

Solderability max. 240 °C, max. 4 s
Resistance to heat max. 240 °C, max. 4 s

ELECTRICAL DATA

d.c. voltage at 1 mA (V)	β between 0,3 - 3 mA	C approx.	capacitance (nF)	colour code I	colour code II	colour code III	catalogue number
2,7	0,16 - 0,22	10	40	orange	black	yellow	2322 581 03041
3,3	0,15 - 0,21	12	35	orange	black	blue	03061
3,9	0,14 - 0,20	13,5	30	orange	black	grey	03081
4,7	0,13 - 0,19	15	25	orange	brown	black	03101
5,6	0,12 - 0,18	16,5	20	orange	brown	red	03121
6,8	0,12 - 0,18	19	15	orange	brown	yellow	03141
8,2	0,11 - 0,17	23	15	orange	brown	blue	03161
10	0,11 - 0,17	27	15	orange	brown	grey	03181
12	0,11 - 0,17	31	12	orange	red	black	03201
15	0,11 - 0,17	40	10	orange	red	red	03221

Tolerance on voltage at 1 mA ±20%

Maximum dissipation 0,25 W

Symmetry after any measurement < 2%

Operating temperature range
at zero power −25 to +125 °C
at maximum power 0 to +55 °C

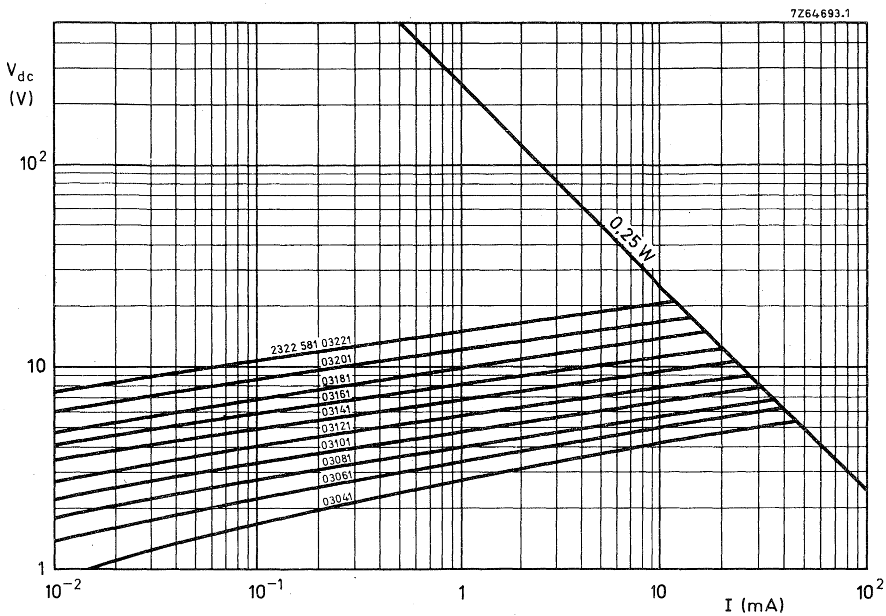


Fig. 2 Typical voltage/current characteristics

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D

A.Q.L. 1 %, critical defects - Electrical
A.Q.L. 1,5%, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

VOLTAGE DEPENDENT RESISTORS

disc type for contact protection

QUICK REFERENCE DATA	
Nominal voltage	48 V d.c.
Max. current at nominal voltage	0,05 mA
Max. voltage at current for efficiency test (152 mA)	135 V
Nominal dissipation	0,1 W
Climatic category (NF C 20-600, par. 4.3)	454 (55/085/56)
Operating temperature range, up to 48 V + 20%	−55 to +85 °C

APPLICATION

These VDRs have been developed to protect relay contacts in telephone exchanges and to prolong their life considerably.

DESCRIPTION

The VDRs consist of a disc provided with two solid tinned wires. The body is white lacquered, but not insulated.
The data given below are fully applicable to both types. Type 2322 592 90001 (VAP4), in addition, fully conforms with the French standards NF C 93-277 of January 1973, and UTE C 93-277 of 21 November 1972, article sheet 3. It has official French approval (Comité de coordination des télécommunications, certificate number 73-209 of 30 August 1973) and official Belgian approval (Comité électrotechnique belge, certificate number H 002 of 1 February 1972).

MECHANICAL DATA

Dimensions (mm)

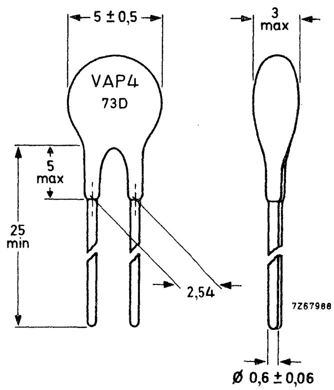


Fig. 1 (Type 2322 592 90003 has no marking)

Weight

0,25 g approximately

Mounting

In any position by soldering

Marking

Type 2322 592 90001 bears the following indications (see also Fig. 1)
a) VAP4
b) 3 characters for year and month of production
c) manufacturer's identification symbol ⑂.
Type 2322 592 90003 has no marking.

Robustness of terminations

Tensile strength	10 N
Bending	5 N

Soldering

Solderability	max. 240 °C, max. 2,5 s
Resistance to heat	max. 350 °C, max. 4 s

Inflammability

Self-extinguishing within 5 s, according to NF C 93-001, add. 1 par. 5.22.

ELECTRICAL DATA

Nominal voltage	48 V d.c.
Max. current at nominal voltage (NF C 93-277, class 7)	0,05 mA
Max. voltage at current for efficiency test (152 mA)	135 V
β-value between 0,1 mA and 1 mA	typ. 0,035
Dissipation factor	8 mW/°C approx.
Temperature coefficient (method B)	max. 0,1%/°C
Nominal dissipation	0,1 W
Asymmetry at current for efficiency test (152 mA)	max. 2%
Climatic category (NF C 20-600, par. 4.3)	454 (55/085/56)
Operating temperature range, up to 48 V + 20%	−55 to +85 °C

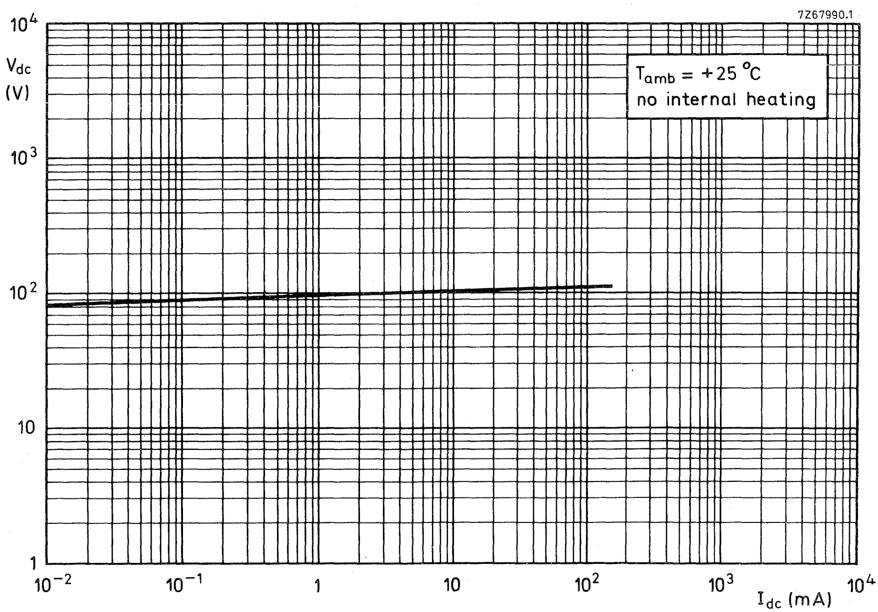


Fig. 2. Typical voltage/current characteristic

TESTS AND REQUIREMENTS

According to specification NF C 93-277

Table 1

test	test method	requirements *)
Stability after over-voltage	3.2.3	I max. 0,05 mA no damage, marking legible
Combined climatic test	3.3.1	I max. 0,05 mA no damage, marking legible
Damp heat	3.3.2	I max. 0,05 mA no damage, marking legible
Rapid change of temperature	3.3.3	I max. 0,05 mA no damage, marking legible
Robustness of terminations	3.3.4	no mechanical damage
Solderability	3.3.5	good tinning
Resistance to heat	3.3.6	I max. 0,05 mA no damage, marking legible
Inflammability	3.3.7	self-extinguishing; no significant mechanical damage other than changes in colour of the body, or in the quality of the marking
Accelerated ageing	3.4.1	I max. 0,05 mA no damage, marking legible; max. voltage at current for efficiency test must remain as specified
Endurance	3.4.2	I max. 0,05 mA no damage, marking legible; max. voltage at current for efficiency test must remain as specified

PACKING

500 pieces per box (cardboard)

*) Requirements on marking only applicable to type 2322 592 90001.

VOLTAGE DEPENDENT RESISTORS

zinc oxide disc types

QUICK REFERENCE DATA	
Minimum voltage at I_{peak} = 1 mA	82 to 680 V
Maximum voltage at I_{peak} = 1 A	140 to 1160 V
β between 1 mA and 1 A	typ. 0,035
Nominal r.m.s. working voltage	55 to 415 V
Voltage ratio V_2/V_1 for I_2/I_1 = 10	typ. 1,08
Max. non-repetitive transient energy	8 J
Operating temperature range	
at zero power	−25 to +115 °C
at maximum voltage	−25 to + 85 °C

APPLICATION

Suppression of voltage transients, contact protection, spark suppression.

DESCRIPTION

This type consists of a disc of low-β material, which is provided with two solid tinned copper wires. The item is lacquered, but not insulated.

MECHANICAL DATA Dimensions in mm

Outlines

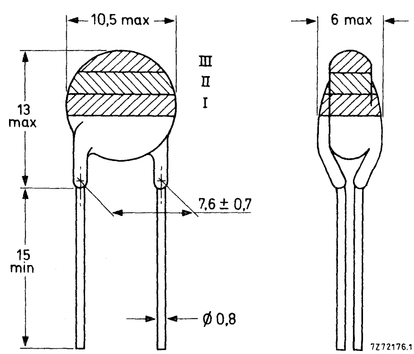


Fig. 1

Marking

The resistors are marked with three colour bands in accordance with Fig. 1 and Table 1.

Mass

1 g approximately

Mounting

In any position by soldering

Robustness of terminations

Tensile strength	10 N
Bending	5 N

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s

Inflammability

Self-extinguishing

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of +25 °C.

β between 1 mA and 1 A	typ. 0,035
Temperature coefficient at 1 mA between +25 and +85 °C	0,05%/°C approximately
Max. average *) power dissipation	100 mW
Max. non-repetitive transient energy	8 J, see Fig. 4
Operating temperature range	
at zero power	−25 to +115 °C
at maximum r.m.s. working voltage	−25 to +85 °C

*) Averaged over maximum 1 s.

nominal r.m.s. working voltage 1) (V)	minimum voltage at 1 mA peak 2) 3) (V)	maximum voltage at 1 A peak (C_{max}) 2) 4) (V)	max. d.c. working voltage at T_{amb} = +85 °C 5) (V)	maximum crest working voltage 1) (V)	capacitance at 10 kHz 6) (pF)	colour code (see Fig. 1)			catalogue number
						I	II	III	2322 594 followed by
55	82	140	40	85	1300	grey	red	black	18202
68	100	170	50	105	1150	brown	black	brown	11012
100	150	255	75	155	1150	brown	green	brown	11512
120	190	325	100	190	770	brown	white	brown	11912
140	220	375	110	220	770	red	red	brown	12212
200	330	565	165	325	245	orange	orange	brown	13312
220	350	600	175	345	235	orange	green	brown	13512
245	390	665	195	380	210	orange	white	brown	13912
290	470	805	235	455	175	yellow	violet	brown	14712
380	620	1050	310	595	135	blue	red	brown	16212
415	680	1160	340	645	125	blue	grey	brown	16812

1) Sinusoidal voltage assumed as normal input condition. Maximum allowed voltage is nominal voltage +10%. If a non-sinusoidal input is present, the peak voltage should be used for type selection from the 5th column.
2) Measurement made without internal heating occurring.
3) Pulse time 10 ms.
4) Rectangular pulse; voltage measured after 1 ms.
5) The d.c. working voltage is the average value of the applied working voltage. For ambient temperatures higher than 85 °C the maximum values must be derated as indicated in Fig. 3.
6) Test voltage ≤ 200 mV, 10 kHz (V_{dc} = 0 V).

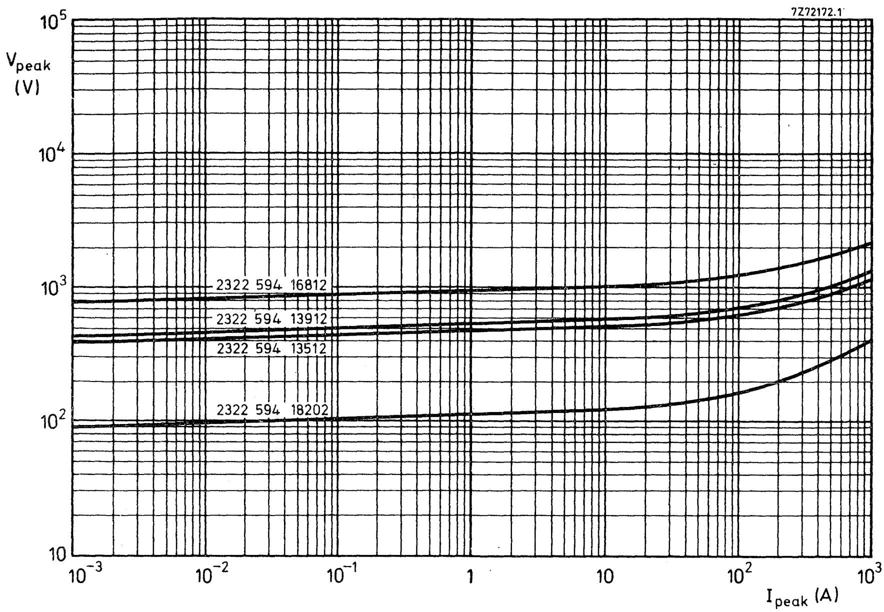


Fig. 2.

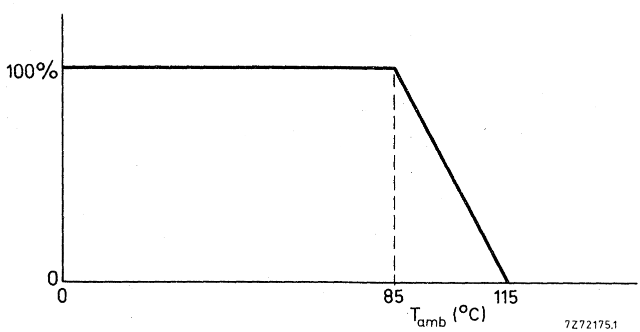


Fig. 3. Derating of maximum voltage with temperature.

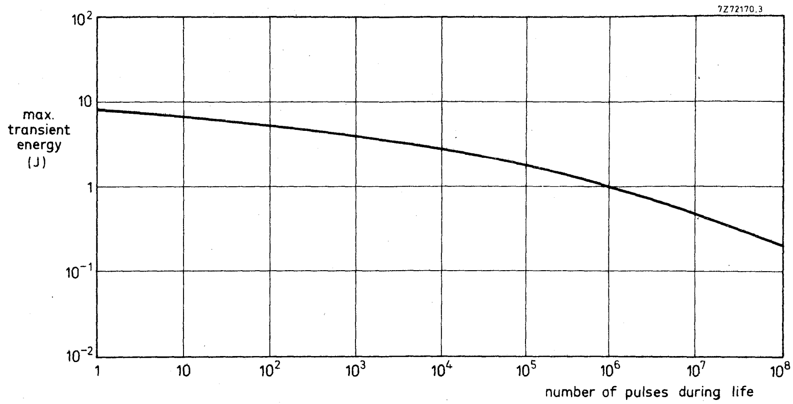


Fig. 4. A recovery time must be allowed for (of about 24 h for high energy pulses).

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	Δ V/V (%) at I_{peak} = 1 mA
Cold at −25 °C	A	1000 h	3
Storage at +25 °C	H	1000 h	3
Dry heat at +115 °C	B	1000 h	5
Thermal shock −25 to +115 °C	Na	5 cycles	5
Damp heat at +40 °C	Ca	1000 h	5
Combined cycle test	4)		5
Pulse tests, transients of 4 J at +25 °C		10 times 1 per 24 h	5
Maximum r. m. s. voltage		1000 h	5
Robustness of terminations	U		
Tensile strength	Ua	10 s	1)
Bending	Ub	2 times	1)
Soldering	T		
Solderability	par. 3.2.3.	3 to 4 s	2)
Resistance to heat	Tb	10 to 11 s	± 2
Impact	E		
Free fall	Ed	2 falls	3)

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.
3) No visual defects.
4) Combined cycle test:
- Dry heat
- Damp heat (first cycle)
- Cold
- Damp heat (remaining cycles).

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1,5%, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

PACKING

250 pieces per box (cardboard)

Light dependent resistors (LDR)

SURVEY

minimum dark resistance	light resistance	maximum dissipation at 40 °C	ambient temperature range	catalogue number
10 MΩ	75 to 300 Ω			2322 600 93001
1 MΩ	max. 110 Ω	0,1 W	− 30 to + 60 °C	2322 600 93002
10 MΩ	75 to 300 Ω			2322 600 94001
10 MΩ	75 to 300 Ω			2322 600 95001
10 MΩ	max. 250 Ω			2322 600 95003
1 MΩ	max. 110 Ω	0,2 W	− 20 to + 60 °C	2322 600 95006
10 MΩ	max. 190 Ω			2322 600 95007
10 MΩ	30 to 96 Ω			2322 600 95008
10 MΩ	150 to 300 Ω			2322 600 95009

Recovery rate min. 200 kΩ/s

INTRODUCTION

L(ight) D(ependent) R(esistors) are made from cadmium sulphide, a material which, when prepared properly, contains no or very few free electrons when kept in complete darkness. Its resistance is therefore quite high. When it absorbs light, electrons are liberated and thus the material becomes more conducting. Cadmium sulphide is therefore called a photoconductor. The electrons are free only for a limited time and when the light is switched off, they are captured again by those places where they originally came from and thus the conductor turns again to an insulator.

Let us consider a disk of cadmium sulphide provided with two electrodes (Fig.1). The distance between the electrodes is d and the length is 1. When the disk is exposed to an illumination L a number of electrons N are liberated per second in the disk between the two electrodes:

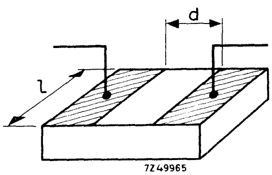


Fig.1

$$N = \eta \, L \, l \, d \qquad (1)$$

where η is a constant depending on the wave length of the light. When a voltage V is applied to the electrodes the electrons move with a velocity v which is proportional to the field strength E:

$$v = \mu E = \frac{\mu V}{d} \qquad (2)$$

The proportionality constant μ is called the mobility. Not all electrons may reach the positive electrode but only those which are liberated within a distance $v\,\tau$ from this electrode when τ = average life time of a free electron. The fraction of the electrons that contribute to the current is therefore $\frac{v\,\tau}{d}$ (3)

and the measured photocurrent i is from (1), (2) and (3) given by:

$$i = Ne\frac{v\,\tau}{d} = \frac{\eta\, e\, \mu\, \tau\, lLV}{d} \qquad (4)$$

where e = electric charge of an electron.

The resistance R, caused by the illumination, is then:

$$R = \frac{V}{i} = \frac{d}{\eta\, e\, \mu\, \tau\, l} L^{-1} \qquad (5)$$

The life time τ is usually not constant but depends on the wave length λ of the light and on the illumination L:

$$\tau = \tau_0 \, (\lambda) \, L^{-\beta} \tag{6}$$

The relation between the resistance and the illumination can therefore be expressed in good approximation by

$$R = A \, L^{-\alpha} \tag{7}$$

From (6) and (7)

$$A = \frac{d}{\eta \, e \mu \, \tau_0 \, l} \tag{8}$$

To have a sensitive L D R it is important to make A as low as possible. This can be done by choosing the right material such as cadmium sulphide with a high value of η, μ and τ_0, and by making $\frac{l}{d}$ as large as possible. The latter is done by making a long and narrow slit and then folding it up as it were on a small area. This is accomplished by giving the electrodes an interdigital comb-like structure.

MANUFACTURING PROCESS

Highly purified cadmium-sulphide powder mixed with suitable additives is pressed in the form of discs.

The discs are sintered at a high temperature and carefully controlled conditions such as atmospheric pressure, temperature and time.

The electrodes are applied by vacuum evaporation. Afterwards leads are fixed to the electrodes and the LDR disc with leads is mounted in a suitable casing or covered by a special lacquer.

ELECTRICAL PROPERTIES

RESISTANCE/ILLUMINATION CHARACTERISTICS

As shown in the introduction the relationship between resistance value and illumination can be expressed with good approximation by the formula (7):

$$R = A\,L^{-\alpha}$$

where R = resistance value in Ω
L = illumination in lux (see under "photometric concepts, definitions and units").
A and α are constants

The value of α depends e.g. on the cadmium sulphide used and the manufacturing process. Values around 0.7-0.9 are quite normal. In Fig.2 the relationship between the resistance R and the illumination in lux is depicted for a normal LDR type.

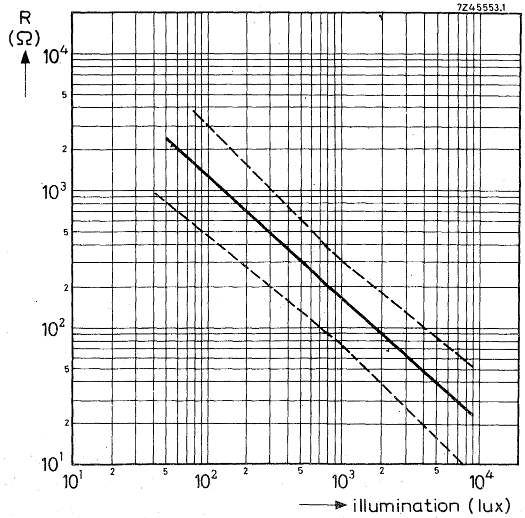


Fig.2.
Resistance/illumination characteristic of an LDR

SPECTRAL RESPONSE

LDR's only produce an electric effect with the incident radiation of a limited range of wavelengths. At the red end of the spectrum there is a threshold wavelength above which no photoelectric effect can occur. The photons (hv) of the radiation beyond that wavelength carry insufficient energy to liberate electrons. At wavelengths lower than the threshold value the response increases at first because η increases and more electrons are excited. There is, however, a critical wavelength below which the response decreases mainly because of a decrease in life time of the excited electrons.

The spectral response curve is a curve which shows the relationship between the resistance properties and the wavelength of the incident flux, the ordinates indicating the ratio of the resistance at any given wavelength to the resistance at a wavelength where the resistance is a maximum. The spectral sensitivity is determined by the properties of the photosensitive material. LDR's have their maximum response at about 6800 $^{\mathrm{o}}$A (see Fig.3).

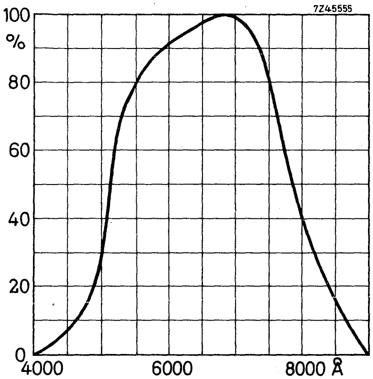


Fig.3.
Spectral response characteristic of an LDR

TEMPERATURE DEPENDENCY

Electrons can be excited not only by photons but also by thermal agitation. The dark resistance is therefore not infinite at normal temperatures. It increases with the ambient temperature and can be decreased by cooling the device.
The temperature can also affect the resistance under illumination. At practical illumination levels and normal ambient temperatures the temperature coefficient is, however, very small and can be neglected.

RECOVERY RATE

When an LDR is brought from a certain illumination level into total darkness, it can be observed that the resistance value of the LDR does not increase immediately to the dark value but only reaches it after a certain time. The recovery rate is a practical measure for the increase in resistance value in time. It is specified in kΩ/s and for current LDR types it is more than 200 kΩ/s (during the first 20 seconds starting at a light level of 1,000 lux).
The speed is much greater in the reverse direction, e.g. going from darkness to an illumination level of 300 lux, it takes less than 10 ms to reach a resistance value which corresponds with a light level of 400 lux.

HOW TO MEASURE LDR RESISTORS

Preconditioning

Before starting measurements the LDR's have to be adapted to darkness for at least 16 hours. Then, during a minimum of 1 hour and a maximum of 2 hours the LDR's must be exposed to an illumination of 1,000 lux.

Mounting

The LDR must be mounted in a blackened box or cylinder in such a way that reflections on the surface of the LDR are avoided entirely.
The distance between the lamp and the LDR must be so that the unloaded LDR does not reach a temperature above 30 ^{o}C.

Illumination

The illumination source must be a voltage stabilized incandescent lamp with a colour temperature of 2850 $^{o}K \pm 150$ ^{o}K.

Measuring the light resistance R_L

After preconditioning R_L can be measured at an illumination level of 1,000 lux. The measuring voltage has to be adjusted so that the dissipation in the LDR is less than 50 mW. The light level is controlled by a reference cell, situated at the same level as the LDR.

Measuring the dark resistance R_D

The dark resistance is measured after the LDR has been in total darkness for 30 minutes at a voltage of 20 V.

Recovery rate

When bringing an LDR from light to total darkness it takes some time before the resistance reaches an end value. The recovery rate is a check on this time, and is measured as the increase in resistance value after 20 seconds, starting from a light level of 1,000 lux. Preconditioning as above.

Drift D_L

Although not specified, it is sometimes of interest to measure the change of resistance value during a certain time at a constant light level immediately after a period of staying in total darkness.

$$D_L = \frac{R_{1L} - R_{0L}}{R_{0L}} \cdot 100\% \text{ with:}$$

R_{0L} = resistance value at t = 0 when the resistor comes out of the total darkness and is illuminated with L lux.

R_{1L} = resistance value at $t = t_1$ (1 or 2 hours), so exposed during a time t_1 to L lux.

SPREAD VALUES

The resistance illumination characteristics of LDR's are measured at two points, namely at 1,000 lux and in total darkness. At 1,000 lux a maximum and a minimum resistance value are specified. In total darkness the minimum resistance value, reached after a certain time, is specified.
As the value of α is not a constant (see section on properties of LDR's) but shows some spread, the spread at another light level may be somewhat wider than the spread values at 1,000 lux (see fig.2).

Influence of illumination level

At very high illumination levels (above 10,000 lux) the R/L characteristics tend to flatten. At this level the influence of the resistance of the electrodes (compared with the resistance of the CdS) is no longer negligible.

PHOTOMETRIC CONCEPTS, DEFINITIONS AND UNITS

A light source emits radiation of many different wavelengths and in all directions into space. The spectral distribution of the emitted radiation, i.e. the distribution of energy at different wavelengths, is determined by the properties of the source. Thus, practically all the light emitted by a sodium lamp is of one characteristic wavelength (589 mμ). This is called monochromatic light. Other sources, such as fluorescent lamps, emit light of a number of discrete wavelengths, together with a continuous spectrum, so that the spectral distribution approximates to that of daylight. On the other hand, an incandescent light source, such as a tungsten lamp, emits radiation over a continuous range of wavelengths only. The intensity of the flux depends on the material of the filament and its temperature.

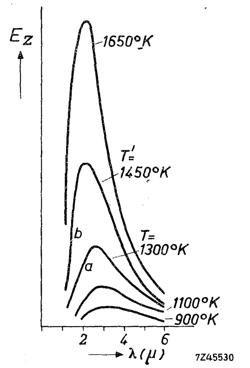


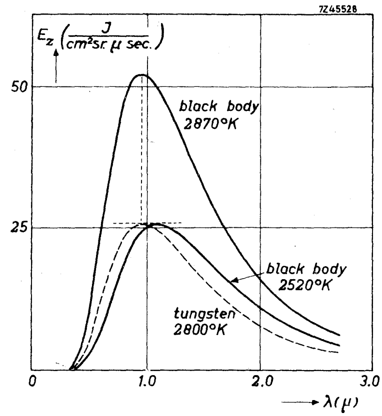
Fig.4.
Black-body radiation as a function of the wavelength.

As the radiation of a black body (full radiator) can be expressed by an exact formula, so that for a given temperature the spectral distribution of energy is fixed (Fig.4), the flux of an incandescent lamp is referred to the black-body radiation.
"Wien" has shown that curve a of Fig.4 can be transposed into curve b by multiplying the wavelengths by T/T', and the ordinates by $(T'/T)^5$. The curves therefore have a uniform shape.

Now the spectral distribution of the radiation emitted by an incandescent lamp is approximately the same as that of a black-body radiator, but with an intensity multiplied by a factor less than unity. By definition, this factor, which is called the emission factor, is equal to unity only for a black body. For tungsten the emission factor is about 0.5, slightly increasing from longer to shorter wavelengths, so that the maximum of radiation is shifted slightly to the left compared with a black body. The intensity of the radiation of a tungsten lamp can be expressed as the "luminance temperature", i.e. the absolute temperature a black body should have in order to emit radiation of the same intensity as the tungsten lamp. This luminance temperature of tungsten is obviously some hundreds of degrees below the true temperature of the filament.

Fig.5.
Curves relating the radiation of a tungsten filament with black-body radiation.

true temperature	2800 °K
luminance temperature	2520 °K
colour temperature	2870 °K



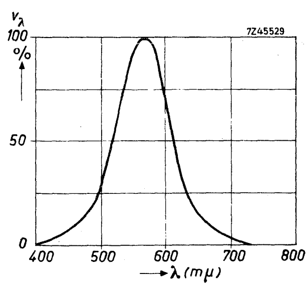


Fig.6.
Sensitivity of the human eye as a function of the wavelength.

The spectral distribution of the radiation from an incandescent lamp is expressed by the colour temperature, i.e. the absolute temperature of a black body when its maximum of radiation is of the same wavelength as that of the tungsten radiation. As the emission factor of tungsten is almost constant, the colour temperature is practically equal to the true temperature (Fig.5).
In general, the flux of energy emitted is expressed in watts. In photometry, however, it is usual to express the light flux, that is to say the total amount of visible radiation emitted or received by a given surface, in lumens. This quantity, denoted by ϕ, is given by the expression

$$\phi = 680 \int_{380}^{760} v_\lambda E_\lambda \, d\lambda \text{ lumen}$$

where E_λ is the flux in watts between λ and $\lambda+d\lambda$, and v_λ the "international luminosity factor", representing the sensitivity of the average human eye as a function of the wavelength (Fig.6). The constant 680 has the dimension of lumens per watt. It can thus be seen that at the maximum sensitivity of the eye (550 $m\mu$) 1 watt corresponds to 680 lumen (since then $v_\lambda = 1$).
In the case of an incandescent lamp the flux is completely described by its colour temperature and the number of lumens which it emits.
The illumination E of an area A is defined as the incident light flux per square metre, i.e. $E = d\phi/dA$. The unit of illumination is the lux, one lux corresponding to one lumen per square metre.
The portion of a spherical space occupied by a given beam of light emitted from a light source (point source) situated at the centre of the sphere is called the solid angle of the beam, and is expressed in steradians (sr). The steradian is defined as follows: Imagine a point source located at the centre of a sphere of 1 metre radius (Fig.7). A beam impinging upon one square metre of the surface of the sphere is said to have a solid angle of one steradian.
If the radius of the sphere is increased to R_m, this beam of 1 sr will irradiate a surface of R^2m^2. Consequently, a spherical surface S at a distance R from the source recieves radiation over a solid angle $\omega = S/R^2$ sr. A sphere contains a total of 4π sr.
The light flux in lumens emitted in a given direction per unit of solid angle is called the intensity of the source. The intensity $I = d\phi/d\omega$ and is expressed in candela (cd) or lumens per steradian.
Finally the luminance is defined as the flux in lumens radiated into a steradian of solid angle per unit of projected area as seen in the considered direction. In other words, the luminance is the intensity per projected unit area of radiating surface (in cm^2) in a given direction. Thus $L = dI/dA \cos\phi$; it is expressed in candela per square centimetre (cd/cm^2) i.e. lumens per square centimetre per steradian.
The relationships between the above-mentioned units are indicated in a simple manner in Fig.8.
If a light source which radiates with a uniform intensity of 1 cd in all directions is located at the centre of a sphere of radius 1 m, it emits a light flux of 1 lumen into each steradian of solid angle. The total emission of this light source is 4π lm. The illumination of the surface of the sphere is 1 lux. If this light source has a radiating surface of 1 cm^2 perpendicular to the considered direction, its luminance is 1 cd/cm^2.

Consider now a surface S located at a distance R from a light source of intensity 1 (cd) in the direction of the line joining the source and the surface S. This surface receives a flux of IS/R^2 lumens, provided the direction of the beam is normal to the surface, and no optical system is inserted between the lamp and the surface (Fig.9). The normal incandescent lamps are manufactured for a colour temperature of 2700-2900 ^oK. Their emission, in lumens/watt, is therefore approximately constant. A value of 13 lm/W can be taken for design calculations. If the lamps emitted equally in all directions, the intensity would be $1/4\pi$ times the flux. For practical purposes, the intensity in candela in the forward direction is equal to the number of lumens divided by 10.

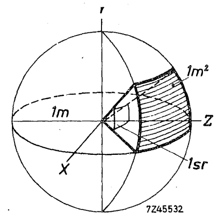


Fig.7.
Diagram illustrating the definition of the solid angle

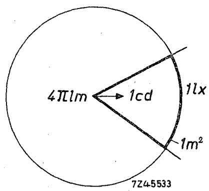


Fig.8.
Relation between various photometric units.

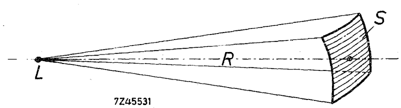


Fig.9.
Point source L illuminating area S.

The photometric units described above are those employed in modern practice. However, a number of older, obsolete units are still met with occasionally. The relation between the old and the new units is given below:

illumination E $= \dfrac{\text{light flux}}{\text{surface}}$;

unit:

lux (lx) $= \dfrac{\text{lumen}}{\text{metre}^2}$

foot-candle (fc) $= \dfrac{\text{lumen}}{\text{foot}^2}$

phot (ph) $= \dfrac{\text{lumen}}{\text{cm}^2}$

1 lux $= 1/10{,}764$ foot-candle

$= 10^{-4}$ phot.

luminance L $= \dfrac{\text{light flux}}{\text{surface area x solid angle}}$;

unit:

nit $= \dfrac{\text{candela}}{\text{metre}^2} = \dfrac{\text{lumen}}{\text{m}^2\ \text{steradian}}$

stilb $= \dfrac{\text{cd}}{\text{cm}^2}$

apostilb $= \dfrac{\text{lux}}{\pi\ \text{steradian}}$

foot-lambert $= \dfrac{\text{foot-candle}}{\pi\ \text{steradian}}$

lambert $= \dfrac{\text{phot}}{\pi\ \text{steradian}}$

1 cd/cm^2 = 1 stilb

$= 10^4$ nit

$= \pi \cdot 10^4$ apostilb

$= \dfrac{1}{3{,}426} \cdot 10^4$ foot-lambert

$= \pi$ lambert

LIGHT DEPENDENT RESISTORS

QUICK REFERENCE DATA		
Dark resistance R_D	2322 600 93001	> 10 MΩ
	2322 600 93002	> 1 MΩ
Light resistance R_L	2322 600 93001	75 to 300 Ω
	2322 600 93002	< 110 Ω
Recovery rate		> 200 kΩ/s
Maximum dissipation at 40 °C		0, 1 W
Ambient temperature range		−30 to +60 °C

APPLICATION

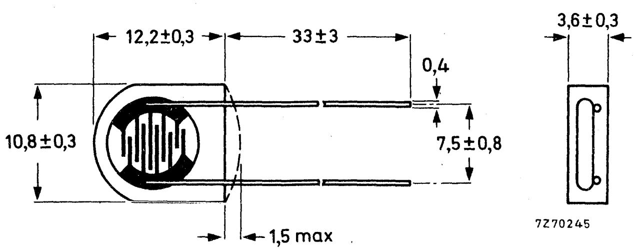
The LDR's are intended for non-critical on-off applications, in which a lamp or a relay is operated either directly (low power) or via a suitable amplifier (high power) e.g. in toys.

DESCRIPTION

These disc-like resistors are made of cadmium sulphide. They are provided with two solid tinned copper wires and are sealed by plastic coating.

MECHANICAL DATA

Dimensions (mm)



Marking

None

Weight

0,75 g approximately

Mounting

In any position by soldering the leads at least 10 mm from the body.

Robustness of terminations

Tensile strength	5 N
Bending	2,5 N

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s

ELECTRICAL DATA

Dark resistance R_D	2322 600 93001	min. 10 MΩ
	2322 600 93002	min. 1 MΩ
Light resistance R_L	2322 600 93001	75 to 300 Ω
	2322 600 93002	max. 110 Ω
Recovery rate		min. 200 kΩ/s
Maximum dissipation at 40 °C		0,1 W
Capacitance at 1000 Hz		max. 8 pF
Maximum repetitive peak voltage not exceeding max. dissipation		150 V
Dielectric withstanding peak voltage between terminals and body		min. 200 V
Dielectric d.c. test voltage between terminals for 1 s in total darkness		200 V
Ambient temperature range		−30 to +60 °C

Typical characteristics

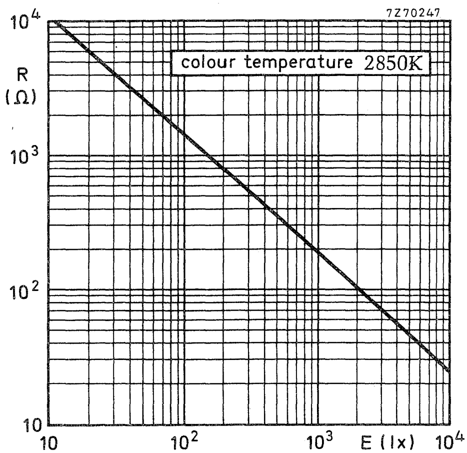


Fig. 2 Resistance as a function of illumination

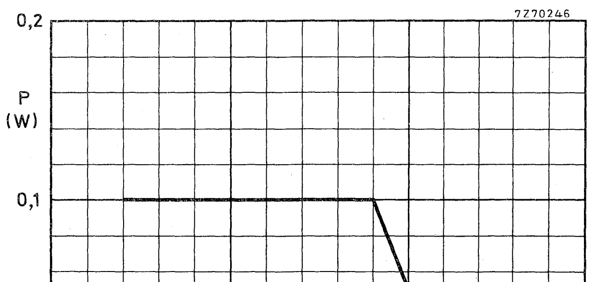


Fig. 3 Permissible dissipation as a function of ambient temperature

PACKING

100 pieces per box

LIGHT DEPENDENT RESISTOR

QUICK REFERENCE DATA	
Dark resistance R_D	> 10 MΩ
Light resistance R_L	75 to 300 Ω
Recovery rate	> 200 kΩ/s
Maximum dissipation at 40 °C	0,1 W
Ambient temperature range	− 30 to + 60 °C

APPLICATION

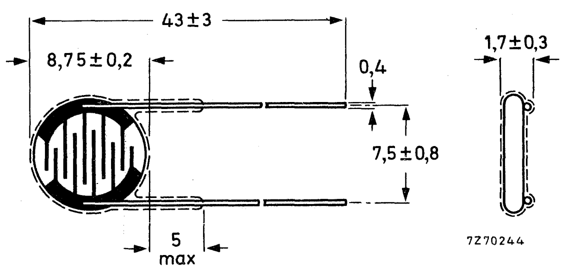
The LDR's are intended for non-critical on-off applications in which a lamp or a relay is operated either directly (low power) or via a suitable amplifier (high power), e.g. in toys.

DESCRIPTION

The items are made from cadmium sulphide in disc form. They are provided with two solid tinned copper wires and are covered with a transparant lacquer.

MECHANICAL DATA

Dimensions (mm)



Marking

None

Weight

0, 35 g approximately

Mounting

In any position by soldering the leads at least 10 mm from the body.

Robustness of terminations

Tensile strenght	5 N
Bending	2, 5 N

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s

ELECTRICAL DATA

Dark resistance R_D	min. 10 MΩ
Light resistance R_L	75 to 300 Ω
Recovery rate	min. 200 kΩ/s
Maximum dissipation at 40 °C	0, 1 W
Capacitance at 1000 Hz	max. 8 pF
Maximum repetitive peak voltage, not exceeding max. dissipation	150 V
Dielectric withstanding peak voltage between terminals and body	200 V
Dielectric d.c. test voltage between terminals for 1 s in total darkness	200 V
Ambient temperature range	−30 to +60 °C

Typical characteristics

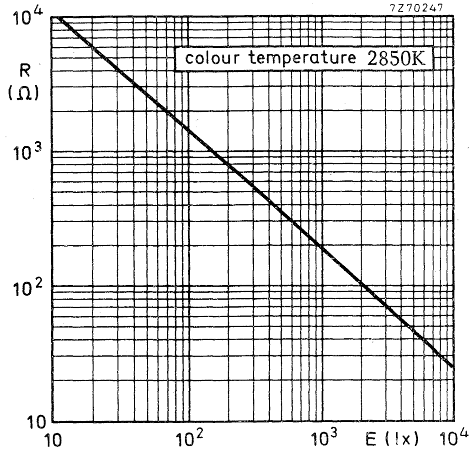


Fig. 2 Resistance as a function of illumination

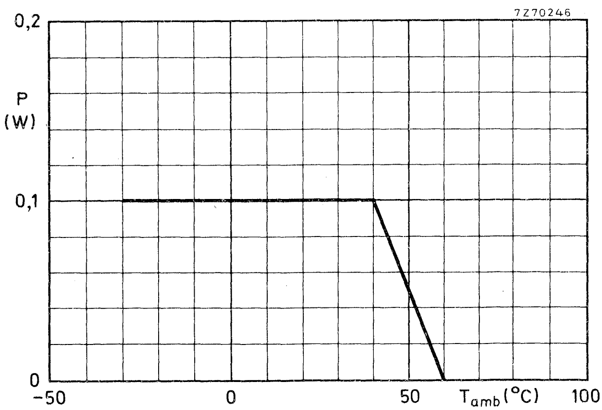


Fig. 3 Permissible dissipation as a function of ambient temperature

PACKING

100 pieces per box

LIGHT DEPENDENT RESISTORS

QUICK REFERENCE DATA	
Dark resistance R_D	> 10 MΩ 2322 600 95006 > 1 MΩ
Light resistance R_L	30 to 300 Ω
Recovery rate	> 200 kΩ/s
Maximum dissipation at 40 °C	0, 2 W
Ambient temperature range	−20 to +60 °C

APPLICATION

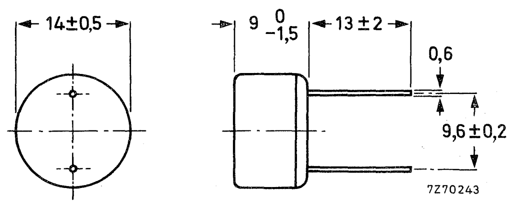
The LDR's are intended for non-critical on-off applications, in which a lamp or a relay is operated either directly (low power) or via a suitable amplifier (high power), e.g. in toys.

DESCRIPTION

These disk-like resistors are made of cadmium sulphide. They are provided with two solid tinned copper wires compounded in synthetic resin and encapsulated in plastic.

MECHANICAL DATA

Dimensions (mm)



Marking

Year and month of production is printed on the body in yellow.

Weight

1,3 g approximately.

Mounting

In any position by soldering the leads at least 10 mm from the body.

Robustness of terminations

Tensile strenght	10 N
Bending	5 N

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s

ELECTRICAL DATA

catalogue number	resistance: dark value R_D	resistance: light value R_L
2322 600 95001	min. 10 MΩ	75 to 300 Ω
95003	min. 10 MΩ	max. 250 Ω
95006	min. 1 MΩ	max. 110 Ω
95007	min. 10 MΩ	max. 190 Ω
95008	min. 10 MΩ	30 to 96 Ω
95009	min. 10 MΩ	150 to 300 Ω

Recovery rate	min. 200 kΩ/s
Maximum dissipation at 40 °C	0,2 W
Capacitance at 1000 Hz	max. 6 pF
Maximum repetitive peak voltage not exceeding max. dissipation	110 V
Dielectric withstanding peak voltage between terminals and case	150 V
Dielectric d.c. test voltage between terminals for 1 s in total darkness	150 V
Ambient temperature range	−20 to +60 °C

Typical characteristics

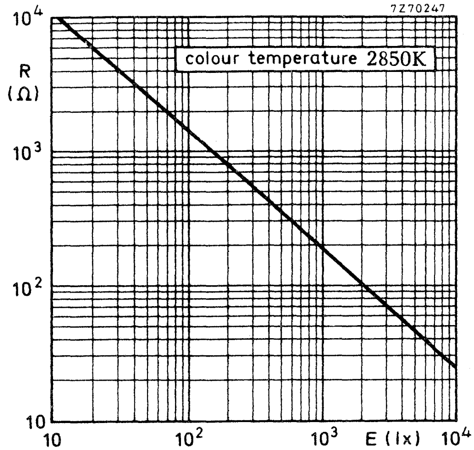


Fig. 2 Resistance as a function of illumination

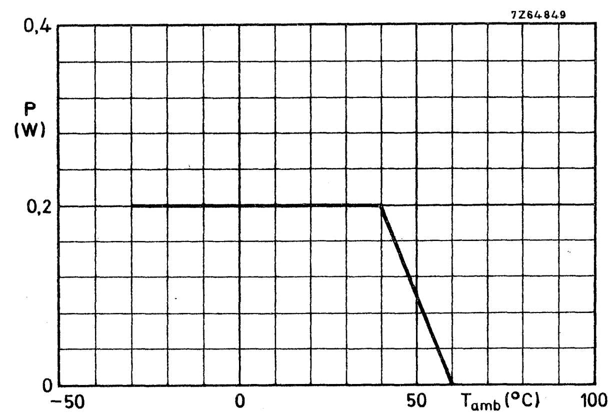


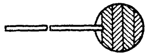
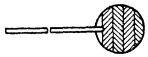
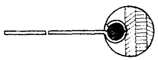
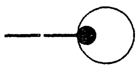
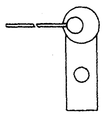
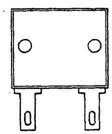
Fig. 3 Permissible dissipation as a function of ambient temperature

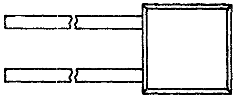
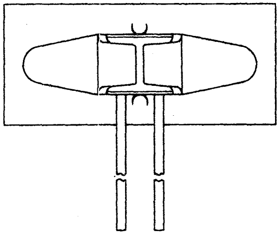
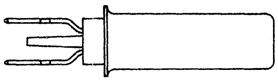
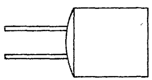
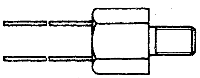
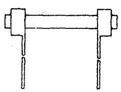
PACKING

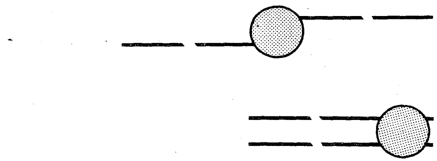
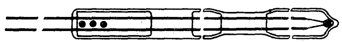
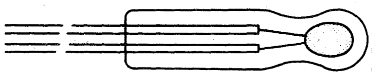
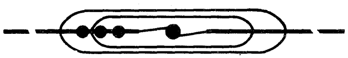
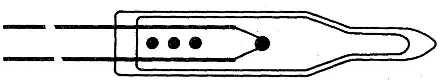
500 pieces per box

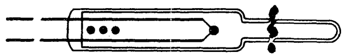
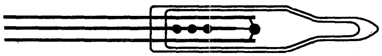
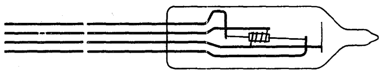
Negative temperature coefficient thermistors (NTC)

SURVEY

type		P_{max} (W)	temp. range at zero power (°C)	$B_{25/85}$-value ±5% (K)	R_{25} (Ω)	catalogue number
DISC		1	−25 to +125	2675 to 5450	2, 2 to 1300	2322 610 0....
		1	−25 to +125	2675 to 5450	2, 2 to 1300	2322 610 1....
			25 to +100		270 to 2200	2322 611
		0, 5	−25 to +125	2600 to 4700	3, 3 to 330 k	2322 642 1.....
		1 1, 5	−25 to +125	3500 to 4300	150 to 4700	2322 643 2322 644
			−25 to +155	4650 3350	82 min. 15	2322 644 90004 90005
on metal strip		1	−25 to +125	2800 to 5450	4 to 1300	2322 610 9....
moulded		0, 5	−55 to +85	3425	R_{-10} = 5000 R_{-30} = 13350	2322 640 90001

	0, 25	−25 to +85	3425	R_{-20} = 8600 R_{+25} = 1215	2322 640 90002 98002
	0, 25	−55 to +85	3425	R_{-10} = 5000 R_{-30} = 13350	2322 640 90003 98003
	0, 25	−10 to +125	3750	R_{+25} = 12000 R_{+100} = 950	2322 640 90004 98004
	0, 25	−25 to +200	4300	R_{+100} = 16700 R_{+200} = 1120	2322 640 90005 98005
in special housing 	0, 25	−10 to +125	3750	R_{+25} = 12000 R_{+100} = 950	2322 640 90007
	0, 25	0 to 350	$B_{50/150}$ = 4000	R_{+25} = 215 k R_{+320} = 235	2322 640 90008
	0, 5	−25 to +100	2600 to 4700	3, 3 to 330 k	2322 642 2....
ROD 	0, 6 1, 5 2, 3	−25 to 155	3300 to 4300 3250 to 4150 3200 to 4200	4, 7 k to 470 k 4, 7 k to 150 k 4, 7 k to 150 k	2322 635 2322 636 2322 637

type	$P_{max.}$ (W)	temp. range at zero power (^{o}C)	$B_{25/85}$ - value ± 5% (K)	R_{25} (Ω)	catalogue number
MINIATURE BEAD 		−25 to +200	2200 to 4400	680 to 680 k	2322 634 0.... 2322 634 1....
glass encapsulated 	0, 1	−25 to +200	2200 to 4400	680 to 680 k	2322 627 1....
	0, 1	−25 to +200	2200 to 4400	680 to 680 k	2322 627 2....
	0, 1	−55 to +300	3800 to 4200	100 k to 1 M	2322 627 3....
	0, 06	−25 to +200	2200 to 4400	680 to 680 k	2322 634 2....
	0, 02	−25 to +200	2200 to 4400	680 to 680 k	2322 634 3....

		−25 to +200	2200 to 4400	680 to 680 k	2322 634 4....
INDIRECTLY HEATED 	0, 035	−25 to +200	2750 and 4275	3, 3 k and 330 k	2322 628 01332 01334
 *)	0, 025 0, 025 0, 020 0, 025	−25 to +200 −25 to +200 −25 to +200 −25 to +200	 2500 2350 1650	1 k to 680 k 1800 1000 55	2322 628 2.... 2322 628 90008 2322 628 90009 2322 628 90011

*) Detailed information available on request.

INTRODUCTION

NTC thermistors are resistors with a high negative temperature coefficient of resistance. They are prepared from oxides of the iron group of transition elements e.g. Cr, Mn, Fe, Co or Ni. These oxides have a high resistivity in the pure state, but can be transformed into semiconductors by adding small amounts of foreign ions which have a different valency.
Examples are:

a) iron oxide Fe_2O_3, where a small part of the Fe^{3+}-ions are replaced by Ti^{4+}-ions. These Ti^{4+}-ions are compensated by an equal amount of Fe^{2+}-ions in order to maintain electroneutrality. At low temperatures the extra electrons of the Fe^{2+}-ions are situated on Fe-ions next to the Ti^{4+}-ions, but at higher temperatures they are gradually loosened from these sites and contribute to the conductivity. In this case we have obtained an electron- or n-type semiconductor.

b) Nickel oxide NiO, or cobalt oxide CoO, with a partial substitution of Li^{1+}-ions for the Ni^{2+} - or Co^{2+}-ions. In this case the Li^{1+}-ions are compensated by an equal amount of Ni^{3+} - or Co^{3+}-ions. At low temperatures the so-called electron-holes (missing electrons) of the trivalent ions are situated near the foreign ions and again free to move through the crystals at higher temperatures. In this case virtually a positively charged particle is the mobile charge carrier and therefore these materials are called p-type semiconductors.

Stabilizing oxides are sometimes added to obtain a better reproducibility and stability of the characteristics. Which of these compositions is used entirely depends on the required temperature coefficient and the specific resistance.

In both cases a) and b) the conductivity σ of the materials can be generally described by

$$\sigma = n e \mu$$

where e represents the unit of electric charge and n and μ the concentration and the mobility of the charge carriers respectively.

Both n and μ depend on temperature. For n this dependence is an exponential one, according to a Boltzmann law.

$$n \propto e^{-q_1/kT}$$

where q_1 is related to the electrostatic binding energy of the carriers to the foreign ions. For the mobility it is not certain whether the temperature dependence is comparable to that of charge carriers in germanium-type semiconductors ($\mu \propto T^{-b}$) or comparable to that of ionic conductors where the ions need a thermal activation energy q_2 for each jump to a neighbour site (hopping process). In the latter case the temperature dependence is described by

$$\mu \propto \frac{e^{-q_2/kT}}{T}$$

The total temperature dependence of the conductivity is generally proportional to:

$$\sigma \propto T^{-c} \cdot e^{-(q_1 + q_2)/kT}$$

where q_2 may be zero. In practice the exponential factor is the most important one, so that the resistance variation of these thermistors in a broad temperature region can be represented by the simple formula

$$R = A\, e^{B/T}$$

MANUFACTURING PROCESS

The manufacturing process can be compared with that used in ceramic industry. After intensive mixing and after addition of a plastic binder the mass is shaped into the appropriate forms by extrusion (rods) or hydraulic pressing (discs). The parts are then fired at a temperature high enough to sinter the constituent oxide. The final step is the making of the electrical contacts. This is done in the usual way by burning in with silver paste or by other methods e.g. electroplating or metal spraying.

Miniature NTC thermistors are made by applying a drop of oxide paste between two parallel platinum alloy wires, followed by drying and sintering. The platinum alloy wires are 60 μm in diameter and 0.25 mm apart. By the sintering process the bead is shrunk onto the wires, thus establishing a solid and reliable contact. For most applications the miniature NTC thermistors are mounted in glass for protection against influence by aggressive gases and fluids.

$\propto$ = direct proportional with

ELECTRICAL PROPERTIES

RESISTANCE VERSUS TEMPERATURE CHARACTERISTICS

As is shown in the introduction the relation between resistance and temperature of an NTC thermistor can be approximated by:

$$R = Ae^{B/T}, \tag{1}$$

where R is the resistance value at an absolute temperature T, A and B being constants for a given resistor and e the base of the natural logarithm (e = 2.718). This equation is illustrated in Fig. 1 where R has been plotted against the temperature in °C.
This is quite in contrast with the behaviour of metals, with which in first approximation the resistance increases proportionally to the absolute temperature.

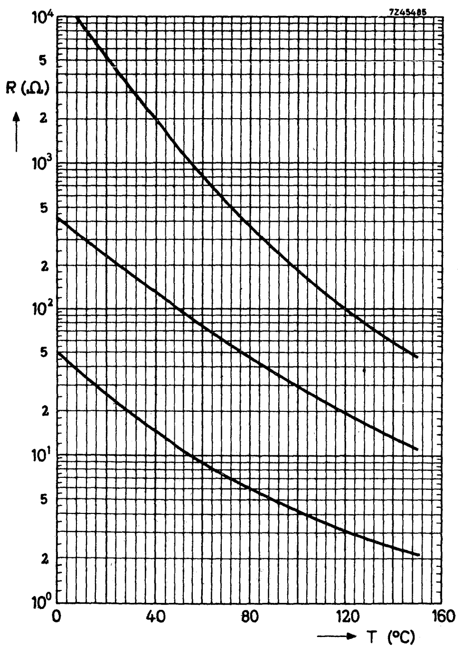


Fig. 1.
Resistance R as a function of temperature drawn for three different values of A and B.

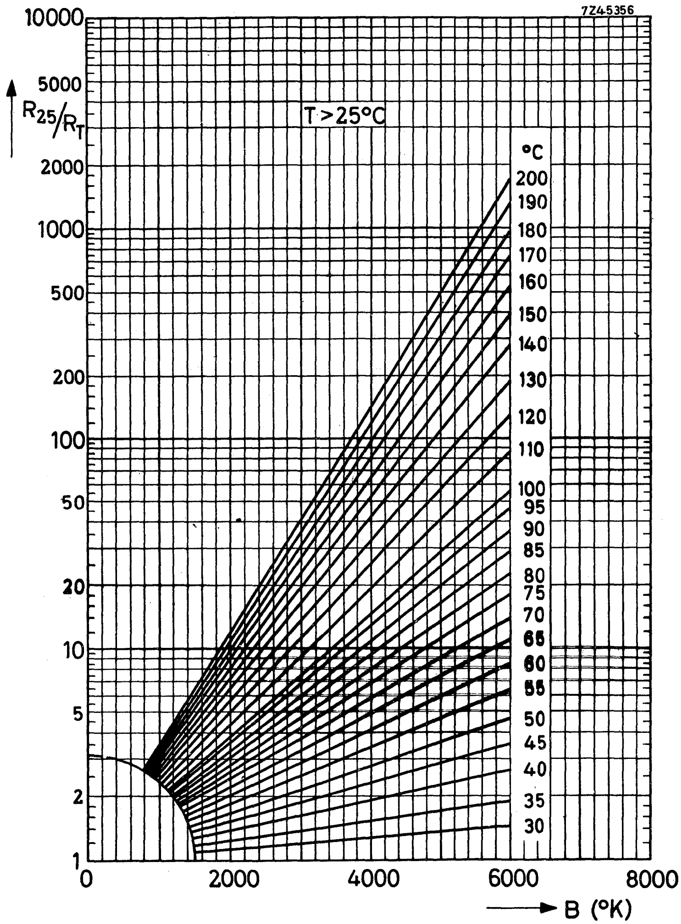


Fig.2.
R_{25}/R_T as a function of the B-value with the temperature as a parameter. Temperatures above 25 °C.

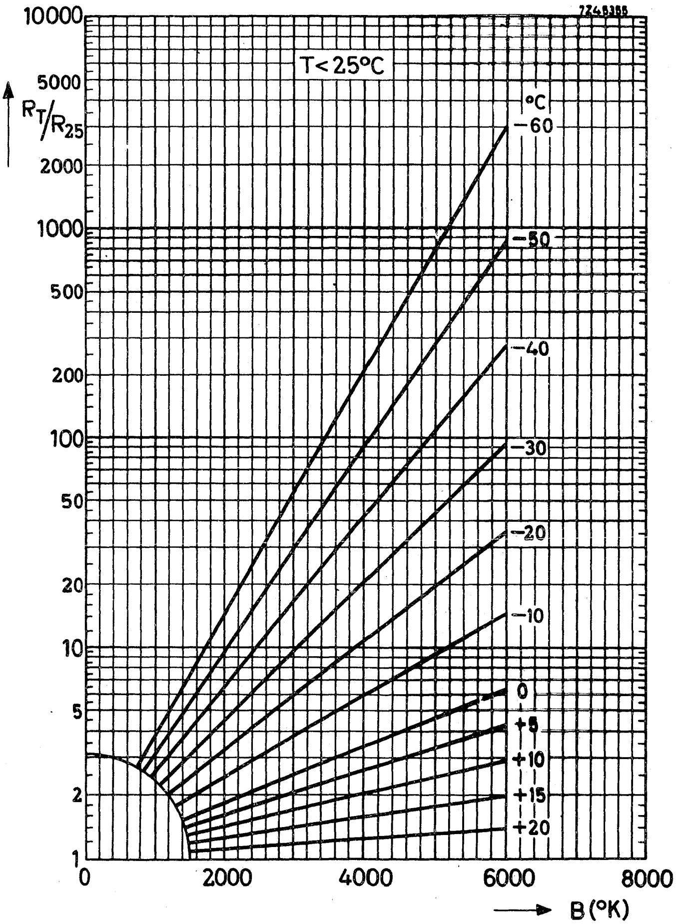


Fig.3.
R_T/R_{25} as a function of the B-value with the temperature as a parameter.
Temperatures below 25 °C.

For a given NTC thermistor the value of B may be found in the following way. The resistance value is measured at two temperatures, T_1 and T_2,

$$R_1 = Ae^{B/T_1} \text{ and } R_2 = Ae^{B/T_2};$$

dividing these two, yields:

$$\frac{R_1}{R_2} = e^{(B/T_1 - B/T_2)},$$

or:

$$\log R_1 - \log R_2 = B\,(1/T_1 - 1/T_2)\log e,$$

which gives:

$$B = \frac{1}{\log e} \cdot \frac{\log R_1 - \log R_2}{1/T_1 - 1/T_2} \qquad (2)$$

In practice B is found not to be a true constant; with increasing temperature there are small deviations.
A better formula for the resistance value is:

$$R = AT^C e^{B/T},$$

where C is a small positive or negative number and in some cases is zero. From eq. (1) the temperature coefficient of an NTC may be derived:

$$\alpha = \frac{1}{R} \cdot \frac{dR}{dT} = -\frac{B}{T^2} \qquad (3)$$

For the different materials the constant B may vary between 2000 and 5500 $^{\circ}$K. A value of e.g. 3600 yields $\alpha = -4\%$ per degree at a temperature of 300 $^{\circ}$K.
For calculating the resistance of an NTC at a given temperature, when R_{25} and B are given in the data, the graphs of Fig. 2 and 3 may be used, where for different B-values R_{25}/R_T and R_T/R_{25} are plotted against the B-value with the temperature of the NTC thermistor as parameter.

VOLTAGE VERSUS CURRENT CHARACTERISTICS

It is interesting to investigate the relation between current and voltage drop over the NTC thermistor when the latter is heated by this current to a temperature much higher than the ambient temperature. Fig.4 shows this relation for an arbitrary sample. This so-called static characteristic, plotted on a double logarithmic scale, was measured at a constant ambient temperature and the readings of V were taken after equilibrium had been reached. For very small currents, the power consumption is too small to register a distinct rise in temperature or

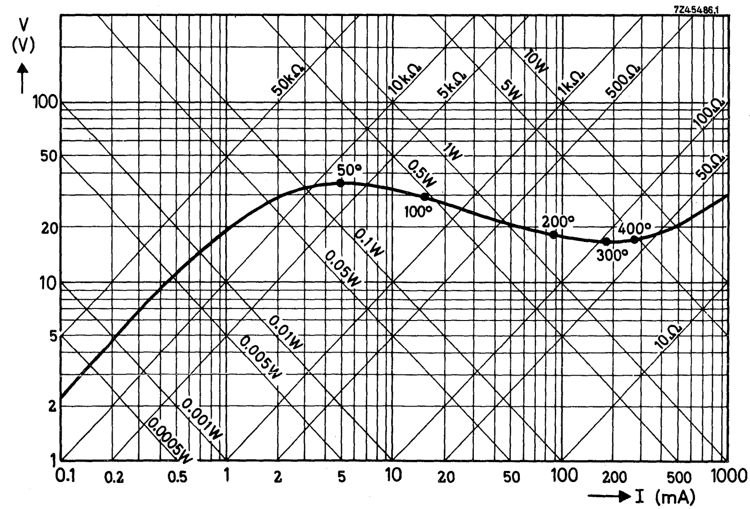


Fig.4. Voltage versus current characteristics of an NTC thermistor.

a decrease in resistance. In that part of the characteristic the relationship between voltage and current is linear. For the sample chosen this linearity ends at approximately 0.01 W.

At a certain value of I the voltage reaches a maximum value and will decrease as the current increases still further.

Assuming:

(a) a constant temperature throughout the body of the thermistor;

(b) the heat transfer to be proportional to the difference in temperature between thermistor and surrounding medium (which is true for low temperatures);

(c) the resistance to be defined by eq. (1)

$$R = Ae^{B/T};$$

the following may be written:

$$\log_e R = \log_e A + B/T \qquad (4)$$

In case of equilibrium

$$W = D\,(T - T_o), \qquad (5)$$

in which T_o is the ambient temperature and D the dissipation factor, i.e. the power needed for a rise in temperature of one degree centigrade.
From eqs (5) and (4) follows:

$$\log_e V + \log_e I = \log_e D + \log_e (T - T_o), \qquad (6)$$

$$\log_e V - \log_e I = \log_e A + B/T \qquad (7)$$

Combination of these two yields:

$$\log_e V = \tfrac{1}{2}\log_e AD + \tfrac{1}{2}\log_e (T - T_o) + B/2T \qquad (8)$$

This form has an extreme as a function of T if:

$$\frac{d \log_e V}{dT} = 0 \qquad (9)$$

In that case

$$\frac{I}{2(T - T_o)} - \frac{B}{2T^2} = 0 \qquad (10)$$

which is true only for those values of T which answer to the equation:

$$T^2 - BT + BT_o = 0, \qquad (11)$$

$$T_{max} = \tfrac{1}{2}B \pm \sqrt{\tfrac{1}{4}B^2 - BT_o} \qquad (12)$$

(The value with the minus sign gives the temperature corresponding to the maximum value of the voltage). Only if $B > 4T_o$ will this maximum be present. For the practical values of B (2000-4000 ^oK) the temperature T_{max} lies between 85 ^oC and 45 ^oC.
From these considerations, which are valid for stationary circumstances only, it follows that the temperature corresponding to the maximum voltage only depends on the B-value of the material and not the actual resistance value.

THERMAL TIME CONSTANT OF NTC THERMISTORS

If the thermistor has a uniform temperature during cooling, the following equation is valid for the cooling of an NTC in the time interval dt:

$$-HdT = D\,(T-T_o)\,dt \qquad (13)$$

in which T_o is the ambient temperature and H the heat capacity of the resistor in joules per degree C.

Eq. (13) yields:

$$(T-T_o) = (T_1-T_o)\,e^{-t/\tau} \qquad (14)$$

The value $\tau = H/D$ is termed the thermal time constant, and represents the time required for a thermistor to change 63.2% of the total difference between its initial and final body temperatures when subjected to a step function change in temperature under zero-power conditions.

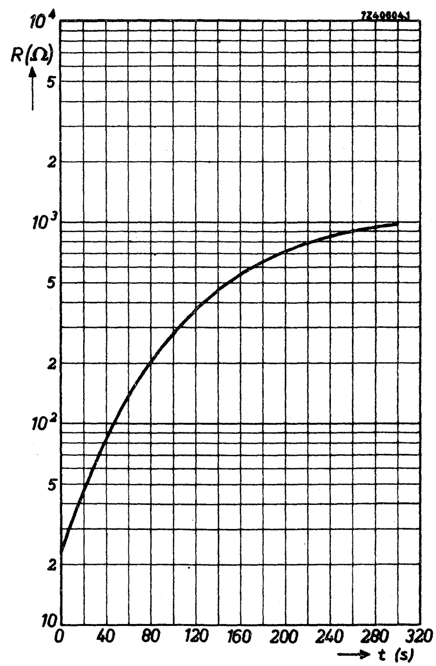


Fig.5.
Variation of resistance with time under normal cooling conditions of a rod type NTC. Ambient temperature 25 °C.

HOW TO MEASURE NTC THERMISTORS

(1) The published R_T values are measured at the temperature T.

(2) The published B-value at 25 °C is the result of a measurement at 25 °C and one at 85 °C. So please use these two temperatures for checking.

The following general precautions have to be taken when measuring NTC thermistors:

(1) Never measure thermistors in air as this is quite inaccurate and easily gives deviations of 1 or 2 °C. For measurement at room temperature or below, use petrol or some other non-conductive and non-agressive fluid. For higher temperatures use oil, preferably silicon oil.

(2) Use a thermostat with a precision of at least 0.1 °C.
Even if the liquid is well stirred, there is still a temperature gradient in the fluid.
So measure the temperature as close to the NTC as possible.

(3) After placing the NTC in the thermostat wait until temperature equilibrium between the NTC and the fluid is obtained. For some types this may take more than 1 minute.

(4) Keep the measuring voltage as low as possible otherwise the NTC will be heated by the measuring current. Miniature NTC thermistors are specially sensitive to measuring voltages. Voltages of less than 0.5 V are recommended.

(5) For high temperature measurements it is recommended to apply stem correction. See also "How to measure PTC thermistors".

SPREAD

The R_{25} and B-value are specified with a certain spread. The tolerance on 25 °C resistance is normally ±20%. The B-value has in most cases a tolerance of ± 5%. Due to the spread in B-value, the deviation from the nominal curve at other temperatures than 25 °C can be greater than the specified tolerance at 25 °C. Fig. 6

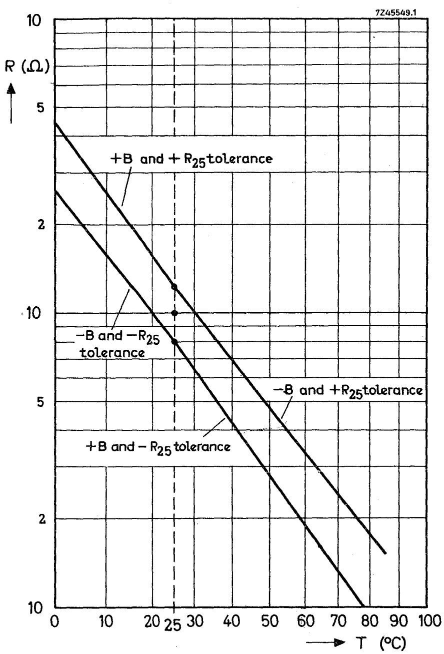


Fig. 6.
The influence of the tolerance on the B-value.

shows this for a resistor of 10 kΩ.
Starting from 25 °C the upper curves give the limit resistance values for combinations of:

(a) +B and +R_{25} tolerance going from 25 °C to lower temperatures;
(b) −B and +R_{25} tolerance going from 25 °C to higher temperatures.

The lower curves give the limit resistance values for combinations of:

(c) −B and − R_{25} tolerance going from 25 °C to lower temperatures;
(d) +B and − R_{25} tolerance going from 25 °C to higher temperatures.

The resistance value will thus always be between the upper and the lower curves, although the unfavourable combinations will obviously seldom occur in practice. For some applications a close tolerance at a given temperature is required. In these cases special selections can be made.

CHOICE OF TYPE

When an NTC thermistor has to be selected for a certain purpose, the following questions have to be considered:

(1) Which form is best suited for the purpose?
The normal types are cylindrical rods, discs or beads.

(2) What is the resistance value and temperature coefficient required?

(3) What is the power to be dissipated

(a) without perceptible change in resistance value due to heating-up

(b) with maximum change in resistance value?

(4) What is the required thermal time constant?

Whenever it is impossible to find an NTC thermistor to fulfil all requirements, it is often more economical to adapt the values of other circuit components to the value of a series-manufactured NTC. Sometimes, with simple parallel and series resistors, a standard NTC can be used where otherwise a special type would have been necessary.
If no suitable combination can be found the development of a special type can be considered. In this case a specification of the requirements is necessary. In addition a description of the circuit in which the NTC has to be used is most useful.

DEVIATING CHARACTERISTICS

The following example explains the resistance values resulting from combinations of NTC's with normal resistors.
Suppose for compensation purposes an NTC is wanted with a resistance value of 50 Ω at 30 °C and 10 Ω at 100 °C. A standard type having this characteristic is not included in our program. The problem may, however, be solved by using a standard NTC and two fixed resistors. If an NTC disc with a cold resistance of 130 Ω is mounted in a series and parallel arrangement with two fixed resistors of 6 Ω and 95 Ω as illustrated in Fig. 7, the resistance of the combination at 30 °C and at 100 °C will meet the requirements. Fig. 8 shows the new resistance versus temperature graph. together with that of the NTC thermistor.

An adaption of this kind should be calculated for every individual case. It should be remembered of course that the temperature-coefficient of the combination will always be lower than that of the NTC thermistor alone. This is clearly illustrated by Fig. 9, where the change in the resistance/temperature graph is shown for different values of series and parallel resistors.

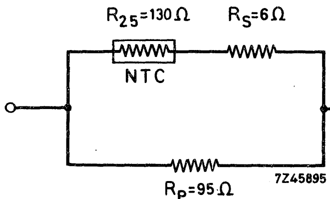


Fig. 7.
NTC thermistor connected in series and parallel with two fixed resistors to obtain deviating characteristics.

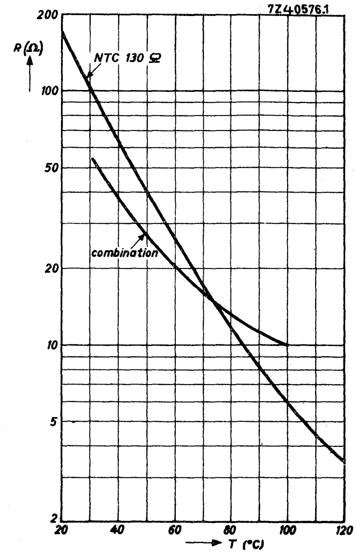


Fig. 8.
Resistance versus temperature graph of the circuit of Fig. 13.

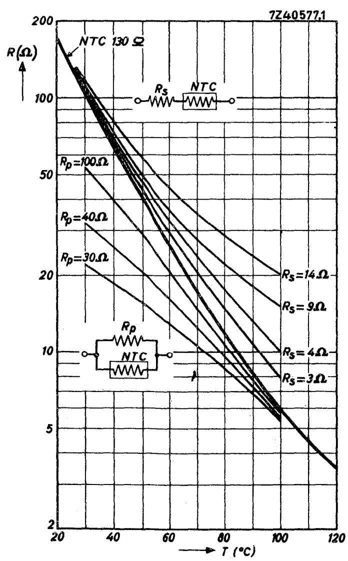


Fig. 9.
Resistance versus temperature graphs of an NTC in combination with different series or parallel resistors.

SOLDERING DISC NTC THERMISTORS

It is often necessary to solder mounting brackets or connecting leads to disc NTC's either to provide efficient thermal contact or to facilitate their mounting. Owing to the ceramic nature of the thermistor and its silver coating, special precautions must be taken to ensure a satisfactory joint.
The iron, its temperature, the solder and flux as well as the material of the bracket all affect the result.

The soldering iron

This should have a wedge shaped copper bit with an angle of 30° to 45°. Before use, and when necessary during use, it should be cleaned and tinned with the solder recommended below. It is most important that the bit temperature is maintained between 275 °C and 300 °C. A means of measuring and controlling this temperature is considered necessary.

The solder

To prevent migration of the silver coating of the thermistor into the solder and eventual failure of the joint, a silver rich solder should be used. A satisfactory composition is 56% tin, 37% lead and 7% silver, without a resin core [1]).

The flux

The correct iron temperature and an approved flux are the two most important factors in this process. It is recommended to use a flux of the following composition:

1 kg colofonium
10 g ureum
500 ml aethylalcohol 98% [2]).

The bracket or wire

Tinned copper wire is satisfactory but the end should be bent into a loop. It is best to avoid sizes heavier than 0.5 mm. Brackets should be electro-tinned copper not more than 3 mm thick. A hole, preferably star shaped and about 3 mm diameter, in the bracket should coincide with the centre of the thermistor disc.

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[1]) This is available with a diameter of 1,2 mm and 2 mm from TINEA (Compagnie francaise de l'étain), 9 Rue Denfer-Rochereau, Paris 93, France.

[2]) Also entirely satisfactory is Dynoline 59810 manufactured by DYNA of 36, Avenue Gambetta, Paris 20, France. Sufficient flux to cover the whole thermistor surface must be used.

The process

The whole face of the thermistor should be coated with special flux and the bracket or wire held in position. About a 6 mm length of solder is melted onto the iron and transferred to the joint so that the solder flows over the bracket onto the thermistor. The soldering time should be kept as short as possible. Preheating of the thermistor on a hot plate at 80 ^{o}C to 100 ^{o}C helps to ensure rapid and reliable soldering. The soldering must be completed before the flux hardens.

Unless this process is followed, it is not possible to ensure entirely satisfactory results (and no responsibility can be taken for failures).

APPLICATIONS

According to the essential properties of the NTC their applications may be classified into three main groups:

(I) Applications in which advantage is taken of the dependence of the resistance on the temperature:

$$R = f(T)$$

This group is split into two subsections:

(a) The temperature of the NTC thermistor is determined only by the temperature of the ambient medium (or by the current in a separate heater winding).

(b) The temperature of the NTC thermistor is also determined by the dissipation in the NTC thermistor itself.

(II) Applications in which the time dependence is decisive.
In that case the temperature is considered as a parameter, and is written:

$$R = f(t)$$

This group comprises all applications which make use of the thermal inertia of NTC thermistors.

(III) The third group of applications uses mainly the property of the temperature coefficient being highly negative:

$$\alpha < 0$$

Also in this group applications are listed which take advantage of the fact that the absolute value of the temperature coefficient is so high, that a part of the $V = f(I)$ curve shows a negative slope.

REMARKS ON THE USE OF NTC THERMISTORS

Do not use thermistors in parallel to obtain a higher dissipation as one of the thermistors may heat up and take all the current while the others remain cold.

Do not use unprotected thermistors in conducting fluids or aggressive and reducing gases as they may cause a change in characteristics.

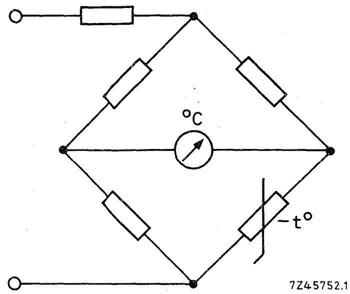
For temperature measurements do not use a too high voltage on the NTC thermistor as it may heat-up the thermistor, thus giving incorrect readings.
The dissipation constant is an indication for the maximum permissible measuring power.

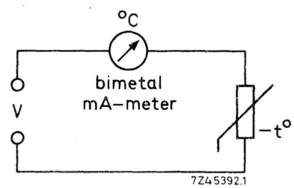
Do not solder-on NTC discs without consulting the soldering instructions.

Some of the more familiar application circuits in the entertainment and industrial field are given on the following pages.

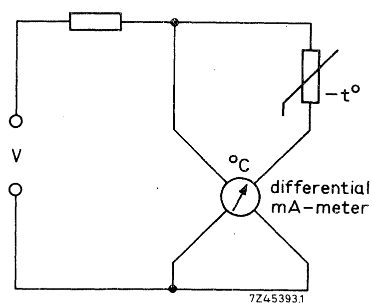
APPLICATION EXAMPLES

Temperature measurement.
Industrial and medical thermometers.

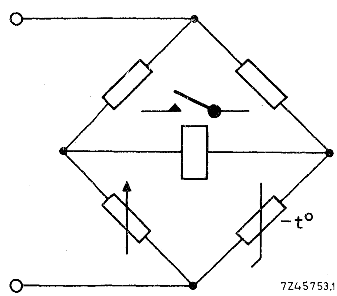


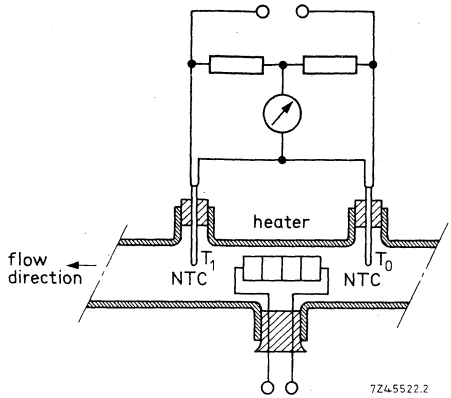


Temperature measurement in cars.
Cooling water measurements with bimetal or differential milliammeters.

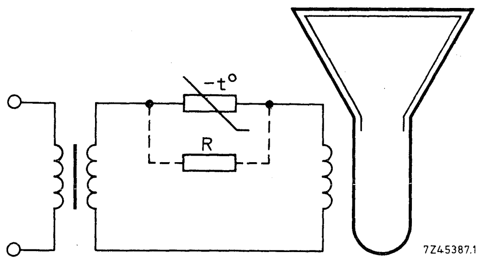


Temperature control.
The bridge incorporating an NTC and a relay can be used for a number of applications where control of temperature with a relay is acceptable.

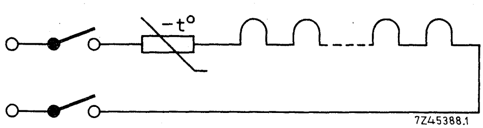




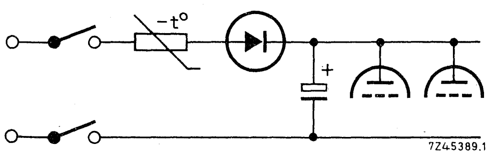
Flow measurement of liquids.
The temperature difference between T_1 and T_0 is a measure for the velocity of the fluid.



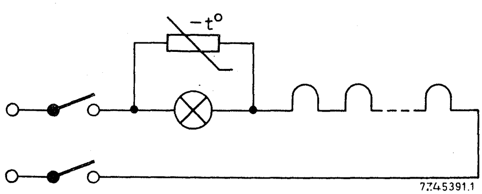
Compensation of frame deflection coils. The positive temperature coefficient of the copper windings is compensated by means of an NTC thermistor.



Heater-chain protection.
Protection against current surges in TV and radio circuits.

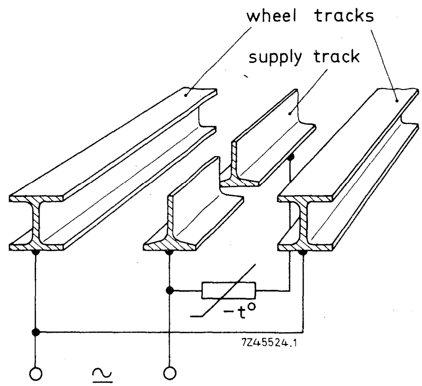


Protection of Si-diode and switch.
Protection in TV circuits using Si-diodes as rectifiers.

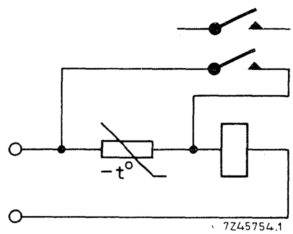


Shunt of dial lamps. If the dial lamp fails the NTC becomes low ohmic and the heater-chain is not disconnected.

Model trains.
As soon as the train comes on the isolated supply trip, it stops. The NTC heats up and gradually the train starts again.

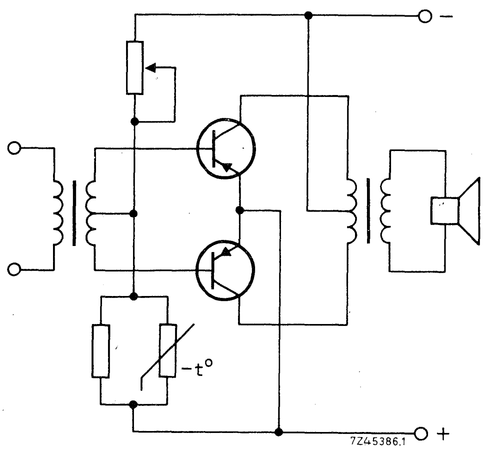


Delaying action of relays.
Due to the thermal inertia of the NTC, it takes some time before the relay is activated. If necessary the NTC can be short-circuited after the relay is activated thus leaving the NTC time for cooling.

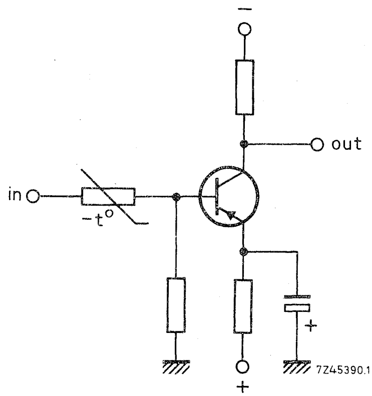


Temperature compensation in transistor circuits.

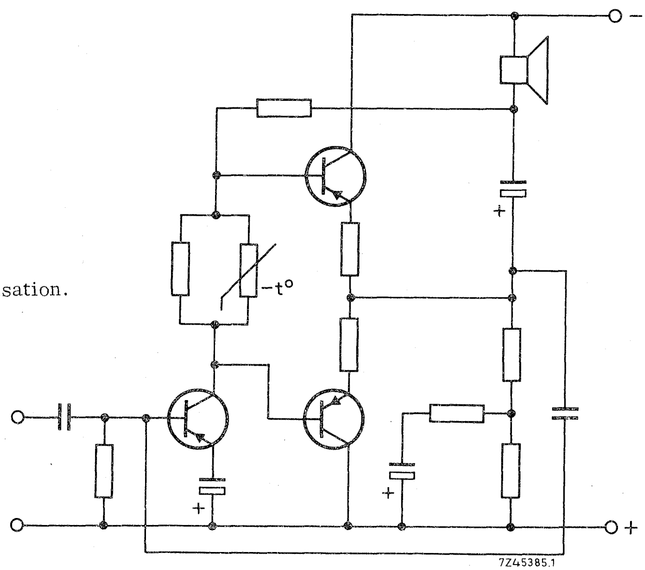
Push-pull compensation.



Gain compensation.



P-N-P and N-P-N compensation.

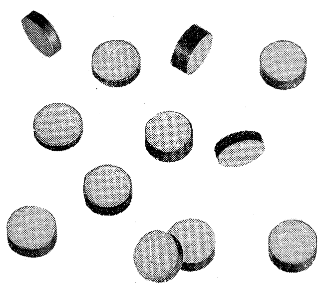


NTC THERMISTORS

disc without leads

QUICK REFERENCE DATA	
Resistance values at + 25 °C	2, 2 to 1300 Ω
$B_{25/85}$ values	2675 to 5450 K
Maximum dissipation	1 W
Operating temperature range	
at zero power	-25 to +125 °C
at maximum power	0 to +55 °C

RZ 19269-3



APPLICATION

Suitable for all kinds of applications.

DESCRIPTION

This leadless disc is not lacquered nor insulated.

MECHANICAL DATA

Dimensions in mm

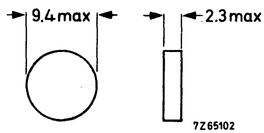


Fig. 1

Marking

The resistance value and tolerance are printed on one face of the thermistor body according to the Table below.
Actually both EKM and IEC 62 marking systems are used for marking these NTC thermistors. The IEC 62 system will progressively supersede the EKM system which will be cancelled.
Tolerance indication:

a) In the EKM marking system, devices with a tolerance of ± 20 % have no tolerance letter. Devices with a tolerance of ± 10 % are marked with a letter A preceding the resistance value.

b) In the IEC marking system, both tolerances are indicated by a letter placed after the resistance value. This letter is K in case of a tolerance of ± 10 % and M in case of a tolerance of ± 20 %.

Weight

0.6 to 0.8 g.

Mounting

In any position between clamps or with the aid of leads soldered to the faces.

Soldering

For complete soldering recommendations see relevant paragraph in section "NTC thermistors, general".

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 240 °C, max. 4 s

ELECTRICAL DATA

R_{25} (Ω)	$B_{25/85}$ ±5 % (K)	temperature coefficient (%/°C)	marking EKM system	IEC 62 system	catalogue number 2322 610 0.... tol. ± 20%	tol. ± 10%
2.2	2675	- 3.00	2E2	2R2	1228	2228
4	2800	- 3.15	4E	4R0	1408	2408
6	2825	- 3.15	6E	6R0	1608	2608
8	2900	- 3.25	8E	8R0	1808	2808
10	2950	- 3.30	10E	10R	1109	2109
12	3050	- 3.40	12E	12R	1129	2129
15	3000	- 3.40	15E	15R	1159	2159
33	3250	- 3.65	33E	33R	1339	2339
50	3300	- 3.70	50E	50R	1509	2509
82	4400	- 4.95	82E	82R	1829	2829
130	4600	- 5.15	130E	130R	1131	2131
500	5200	- 5.85	500E	500R	1501	2501
1300	5450	- 6.15	1K3	1K3	1132	2132

Maximum dissipation 1 W 1)

Operating temperature range
at zero power -25 to +125 °C
at maximum power 0 to +55 °C

1) Measurements made in still air.

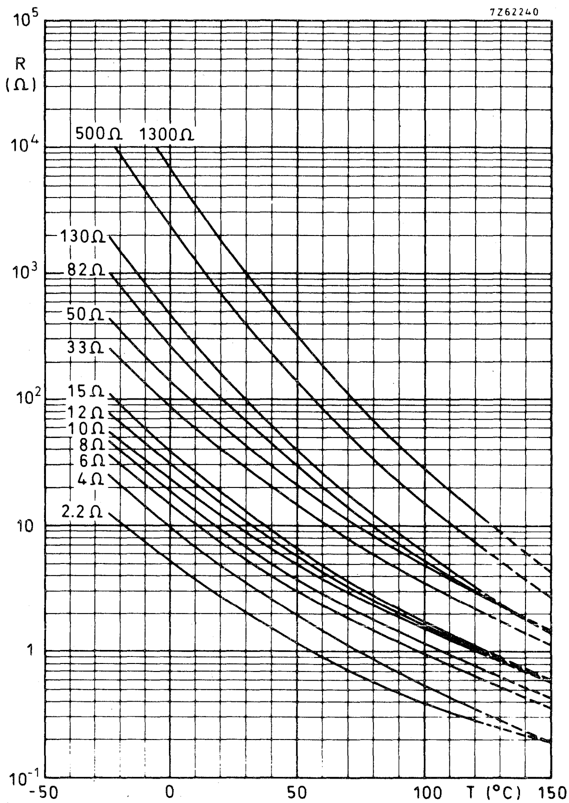


Fig.2. Typical resistance/temperature characteristics.

TESTS AND REQUIREMENTS

According to IEC recommendations, unless otherwise specified:

test	test method	duration	$\Delta R/R$(%) at 25 °C	$\Delta B/B$(%)
Cold at - 25 °C	A	1000h	± 3	± 2
Storage at + 25 °C	H	1000h	± 3	± 1
Dry heat, + 125 °C	B	1000h	± 5	± 2
Thermal shock - 25 to + 125 °C	Na	5 cycles	± 3	± 2
Damp heat	Ca	1000h	± 5	± 3
Maximum dissipation		1000h	± 5	± 2
Soldering	T			
Solderability at 230 ± 10 °C	par. 3.2.3	3 to 4 s	1)	1)
Resistance to heat at 230 ± 10 °C	par. 3.2.4	3 to 4 s	± 2	± 2

1) Thermistors must be solderable initially and after six months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1% major defects - Electrical
A.Q.L. 1.5% major defects - Mechanical
A.Q.L. 4% minor defects - Physical

PACKAGING

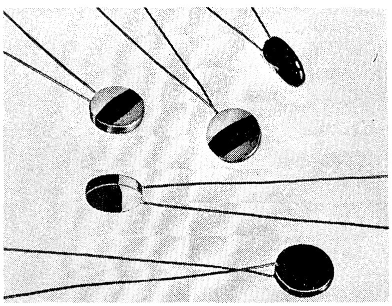
250 pieces per box (cardboard).

NTC THERMISTORS

disc

QUICK REFERENCE DATA	
Resistance value at + 25 °C	2.2 to 1300 Ω
$B_{25/85}$ values	2675 to 5450 K
Maximum dissipation	1 W
Dissipation factor	10 mW/°C
Thermal time constant	60 s approx.
Operating temperature range	
at zero power	-25 to + 125 °C
at maximum power	0 to +55 °C

RZ 19269-6



APPLICATION

Suitable for all kinds of applications.

DESCRIPTION

These thermistors consist of a disc provided with two solid tinned copper wires and with a colour code on the non-lacquered, non-insulated body.

MECHANICAL DATA

Dimensions in mm

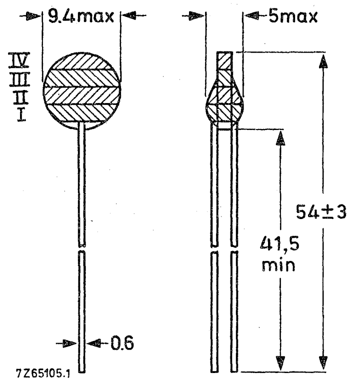


Fig. 1

Marking (see Fig. 1).

The thermistors are marked with three colour bands showing their resistance value (R_{25}) in code as indicated in the table. Thermistors with a tolerance on R_{25} of 10% have a fourth band in silver.

Weight

1.0 to 1.3 g

Mounting

In any position by soldering

Robustness of terminations

Tensile strength	10 N
Bending	5 N

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 240 °C, max. 4 s

ELECTRICAL DATA

R_{25} (Ω)	$B_{25/85}$ ±5 % (K)	temperature coefficient (%/°C)	colour code I	colour code II	colour code III	catalogue number 2322 610 1.... tol. ±10%	tol. ±20%
2.2	2675	-3.00	red	red	gold	2228	1228
4	2800	-3.15	yellow	black	gold	2408	1408
6	2825	-3.15	blue	black	gold	2608	1608
8	2900	-3.25	grey	black	gold	2808	1808
10	2950	-3.30	brown	black	black	2109	1109
12	3050	-3.40	brown	red	black	2129	1129
15	3000	-3.40	brown	green	black	2159	1159
33	3250	-3.65	orange	orange	black	2339	1339
50	3300	-3.70	green	black	black	2509	1509
82	4400	-4.95	grey	red	black	2829	1829
130	4600	-5.15	brown	orange	brown	2131	1131
500	5200	-5.85	green	black	brown	2501	1501
1300	5450	-6.15	brown	orange	red	2132	1132

Maximum dissipation — 1 W [1)]

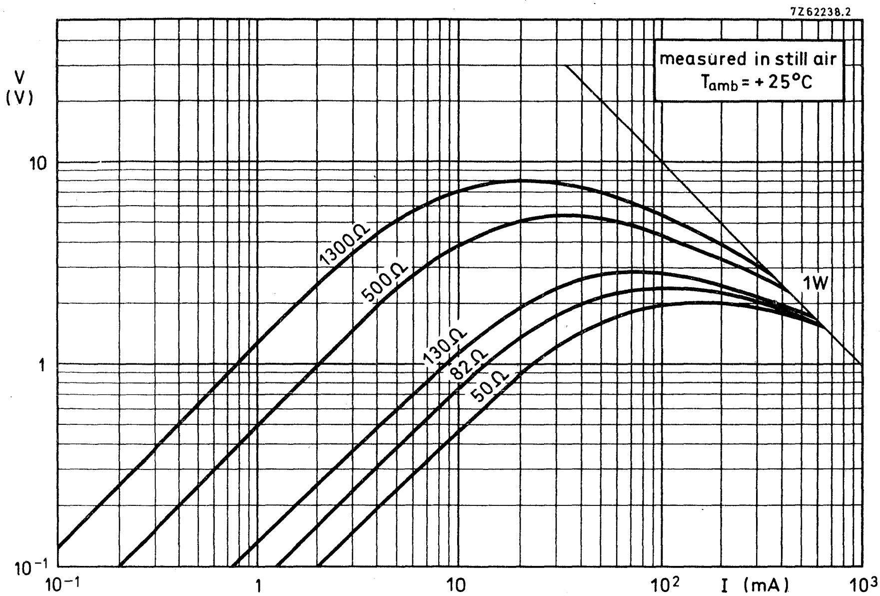
Dissipation factor — 10 mW/°C approx. [1)]

Thermal time constant — 60 s approx. [1)]

Heat capacity — 0.6 J/°C approx. [1)]

Operating temperature
- at zero power — -25 to +125 °C
- at maximum power — 0 to +55 °C.

1) Measurements made in still air, between two phosphor-bronze wires (ø 1.3mm)



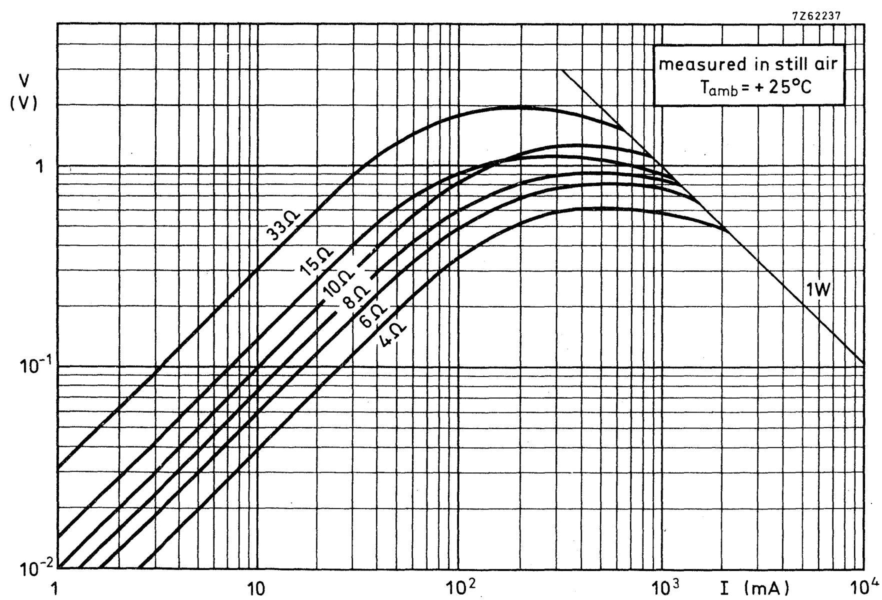


Fig. 2a and b. Typical voltage/current characteristics.

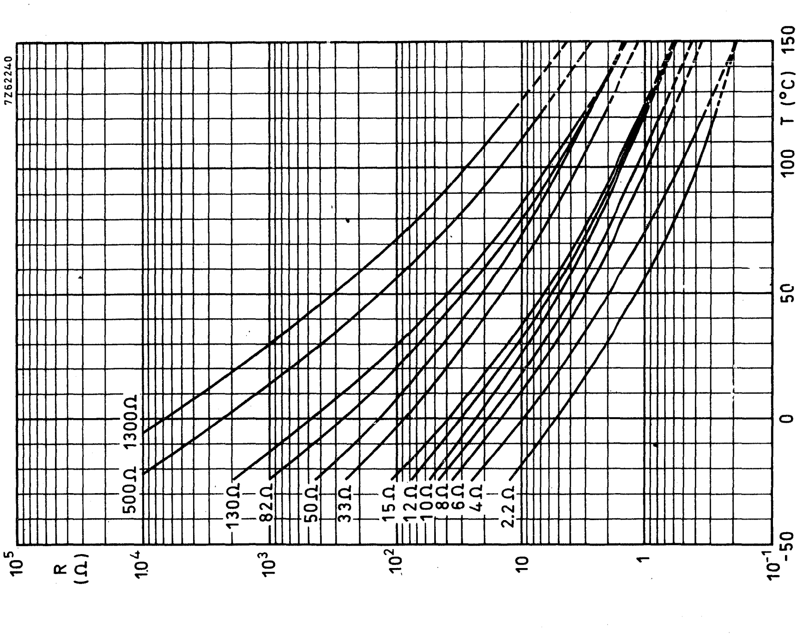


Fig. 3. Typical resistance / temperature characteristics

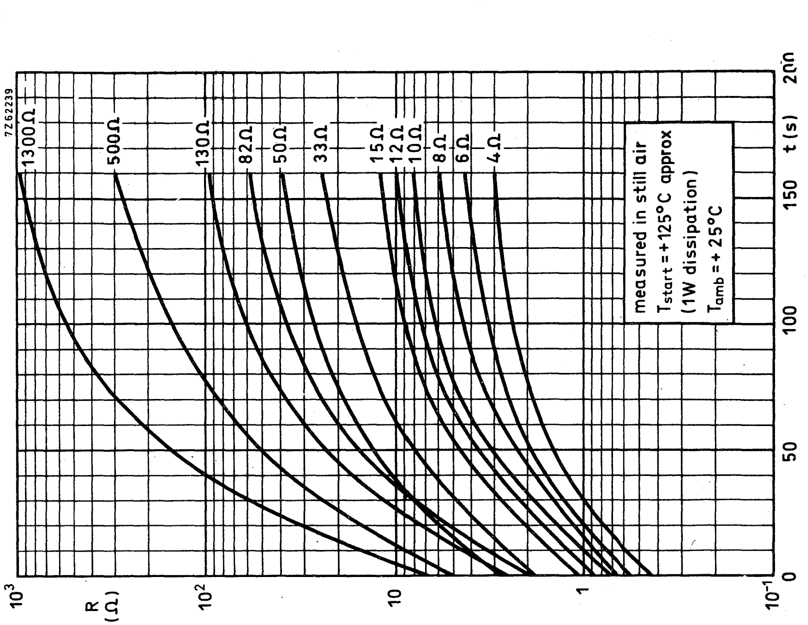


Fig. 4. Typical resistance/time (cooling) characteristics

TESTS AND REQUIREMENTS

According to IEC recommendations, unless otherwise specified.

test	test method	duration	ΔR/R (%) at +25°C	ΔB/B (%)
Cold at - 25 °C	A	1000h	± 3	± 2
Storage at + 25 °C	H	1000h	± 3	± 1
Dry heat at + 125 °C	B	1000h	± 5	± 2
Thermal shock -25 to +125 °C	Na	5 cycles	± 3	± 2
Damp heat	Ca	1000h	± 5	± 3
Maximum dissipation		1000h	± 5	± 2
Robustness of terminations	U			
Tensile strength 10 N	Ua	10 s	1)	
Bending 5 N	Ub	2 times	1)	
Soldering	T			
Solderability at 230 ± 10 °C	par 3.2.3	3 to 4 s	2)	
Resistance to heat at 230 ± 10 °C	par 3.2.4	3 to 4 s	± 2	± 2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after six months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1% major defects - Electrical
A.Q.L. 1.5% major defects - Mechanical
A.Q.L. 4% minor defects - Physical

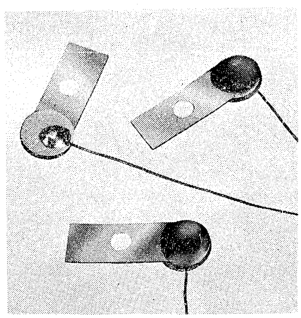
PACKAGING

250 pieces per box (cardboard)

NTC THERMISTORS
disc on metal strip

QUICK REFERENCE DATA	
Resistance values at +25 °C	4 to 1300 Ω
$B_{25/85}$ values	2800 to 5450 °K
Maximum dissipation	1 W
Operating temperature range	
at zero power	-25 to + 125 °C
at maximum power	0 to + 55 °C

RZ 19269-4



APPLICATION

Suitable for all kinds of applications.

DESCRIPTION

These thermistors consist of a disc with one solid tinned copper lead and a metal strip at an angle of 90° with the lead. The body is not lacquered nor insulated.

MECHANICAL DATA

Dimensions in mm

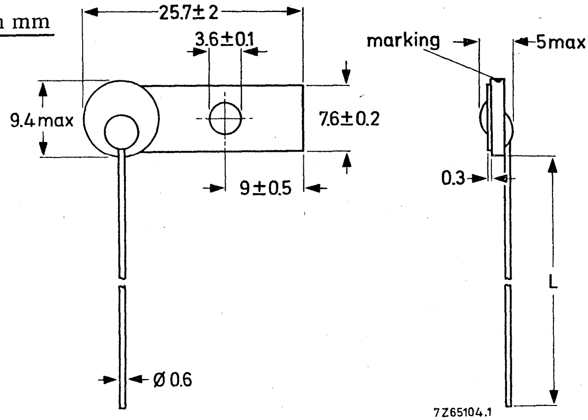


Fig. 1

Marking / Weight

marking	L_{min} (mm)	weight approx. (g)	catalogue number
none	41,6	1,40	2322 610 90004
red dot	56,6	1,40	90012
orange dot	41,6	1,60	90014
violet dot	56,6	1,60	90015
yellow dot	41,6	1,60	90016
green dot	41,6	1,60	90017
blue dot	41,6	1,60	90018

Mounting

In any position with nut and bolt; lead connected by soldering.

Robustness of terminations

Tensile strength	10 N	(strip and lead)
Torsion	5 N	(strip and lead)

Soldering (for lead only)

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 240 °C, max. 4 s

ELECTRICAL DATA

R_{25} ± 20% (Ω)	$B_{25/85}$ ± 5% (°K)	temperature coefficient (%/degC)	catalogue number
4	2800	-3, 2	2322 610 90012
6	2825	-3, 2	90014
8	2900	-3, 3	90015
50	3300	-3, 7	90016
130	4600	-5, 2	90004
500	5200	-5, 9	90017
1300	5450	-6, 2	90018

Maximum dissipation at +55 °C — 1 W 1)

Operating temperature range
at zero power — -25 to +125 °C
at maximum power — 0 to +55 °C

1) Measurements made in still air, between two phosphor-bronze wires (ø 1.3mm).

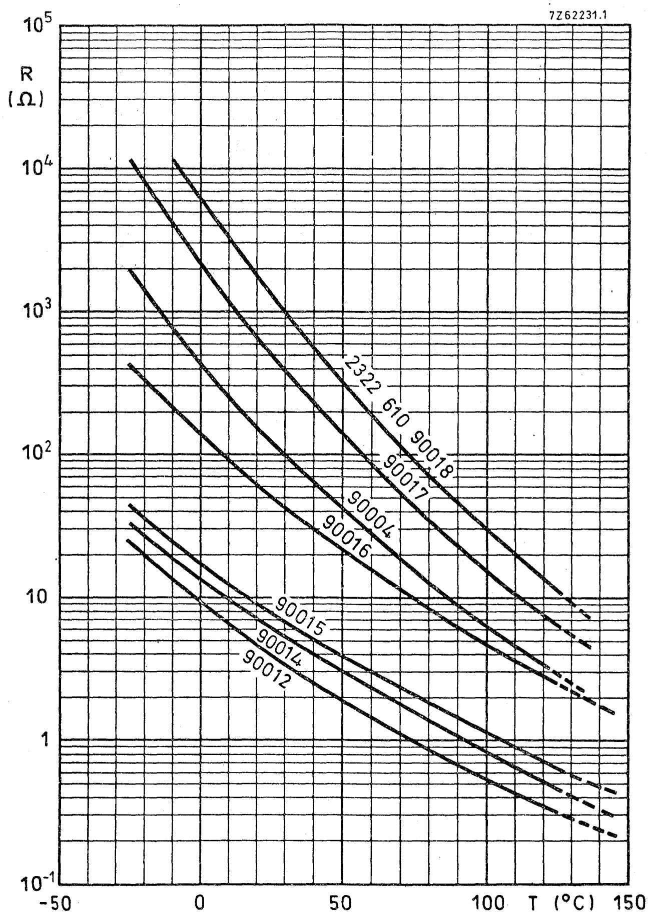


Fig. 2 Typical resistance/temperature characteristics.

TESTS AND REQUIREMENTS

According to IEC recommendations, unless otherwise specified.

test	test method	duration	ΔR/R (%) at + 25°C	ΔB/B(%)
Cold at - 25 °C	A	1000h	± 3	± 2
Storage at + 25 °C	H	1000h	± 3	± 1
Dry heat at +125 °C	B	1000h	± 5	± 2
Thermal shock -25 to +125 °C	Na	5 cycles	± 3	± 2
Damp heat at +55 °C	Ca	1000h	± 5	± 3
Maximum dissipation		1000h	± 5	± 2
Robustness of terminations	U			
Tensile strength ION	Ua	10 s	1)	
Bending 5N, lead	Ub	2 times		
strip		3 times	1)	
Soldering	T			
Solderability at 230 ± 10°C	par. 3. 2. 3	3 to 4 s	2)	
Resistance to heat at 230 ± 10 °C	par. 3. 2. 4	3 to 4 s	± 2	± 2

1) Lead or strip should neither come loose nor break.
2) Lead must be solderable initially and after six months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

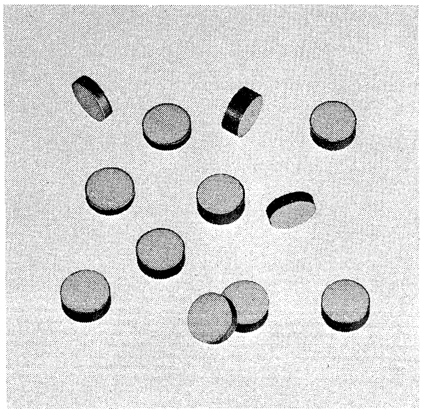
A.Q.L. 1% major defects - Electrical
A.Q.L. 1.5% major defects - Mechanical
A.Q.L. 4% minor defects - Physical

PACKAGING

250 pieces per box (cardboard)

NTC THERMISTORS

for motor cars

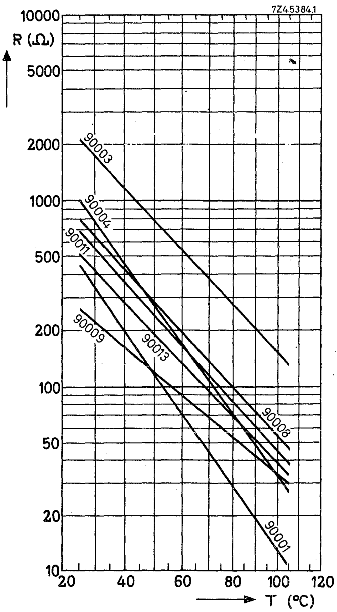


RZ 19269-3

This range of discs has been developed for temperature sensors for the cooling water in motor cars. The NTC's are specified at a medium temperature (40-50 °C) and a higher temperature (96.5 to 100 °C), so that a high accuracy at the working temperature is obtained.
They are also suitable for temperature control in household appliances, such as washing machines.

R_{25} (Ω)	R_{40} (Ω)	R_{50} (Ω)	$R_{96.5}$ (Ω)	R_{100} (Ω)	diameter (mm)	catalog number
2200	1030-1310		147-173		7.0 ± 0.3	2322 611 90003
500		175 - 215		35 - 43	6.9 ± 0.2	90013
500		92.5 - 134		12 - 15	6.9 ± 0.2	90001
1000		221.5 - 318.5		30 - 36	6.9 ± 0.2	90004
270		97 - 143		29.5 - 36.5	6.9 ± 0.2	90009
700		207 - 264		41.4 - 48.6	6.9 ± 0.2	90011
800		244 - 315		48.0 - 58.6	6.9 ± 0.2	90008

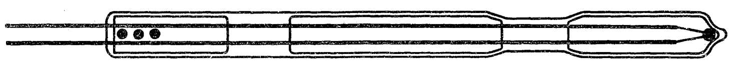
Resistance/temperature characteristics



NTC THERMISTORS

miniature bead

QUICK REFERENCE DATA	
Resistance value at +25 °C	680 Ω to 680 kΩ (E6 series)
$B_{25/85}$-value	2200 to 4400 °K
Maximum dissipation	100 mW
Dissipation factor	0,7 mW/degC
Thermal time constant	14 s
Operating temperature range	
at zero power	−25 to +200 °C
at maximum power	0 to +55 °C



APPLICATION

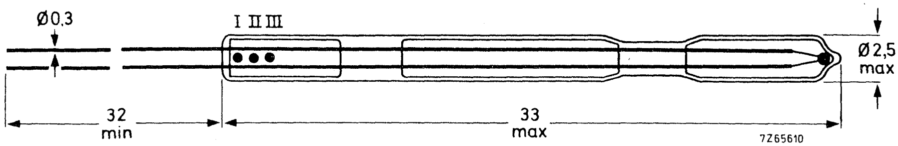
Intended for general use

DESCRIPTION

Bead thermistor with negative temperature coefficient, in a glass envelope with two solid tinned copper wires.

MECHANICAL DATA

Dimensions (mm)



Maximum bow in the centre of the glass envelope is 1 mm.

Marking

Colour dots on the glass envelope, see for colour code the table.

Weight

0,3 g approx.

Mounting

In any position by soldering.

Robustness of terminations

Tensile strength	2,5 N
Bending	1,25 N

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s

Inflammability

Uninflammable

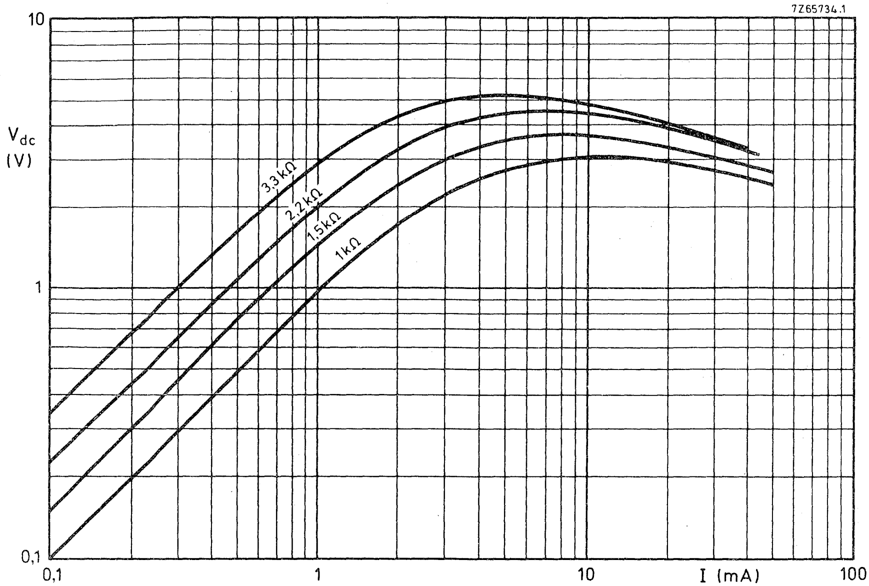
ELECTRICAL DATA

Unless otherwise specified, measured according to IEC draft publication 40 (CO) 226 and 337.

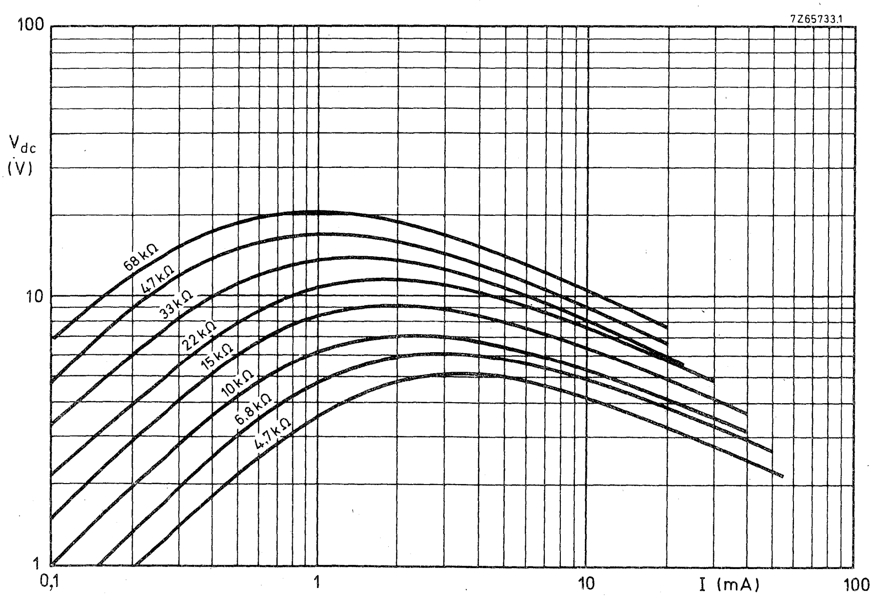
R_{25}	$B_{25/85}$-value ± 5%	temperature coefficient at 25 °C	colour code *)			catalogue number 2322 627 1....	
(Ω)	(K)	(%/°C)	I	II	III	tol. ± 10% *)	tol. ± 20%
680	2200	−2,5	blue	grey	brown	2681	1681
1000	2375	−2,7	brown	black	red	2102	1102
1500	2500	−2,8	brown	green	red	2152	1152
2200	2600	−2,9	red	red	red	2222	1222
3300	2750	−3,1	orange	orange	red	2332	1332
4700	3725	−4,2	yellow	violet	red	2472	1472
6800	3775	−4,3	blue	grey	red	2682	1682
10000	3875	−4,3	brown	black	orange	2103	1103
15000	3800	−4,3	brown	green	orange	2153	1153
22000	3850	−4,3	red	red	orange	2223	1223
33000	3800	−4,3	orange	orange	orange	2333	1333
47000	3850	−4,3	yellow	violet	orange	2473	1473
68000	3900	−4,4	blue	grey	orange	2683	1683
100000	3975	−4,5	brown	black	yellow	2104	1104
150000	4050	−4,6	brown	green	yellow	2154	1154
220000	4200	−4,7	red	red	yellow	2224	1224
330000	4275	−4,8	orange	orange	yellow	2334	1334
470000	4350	−4,9	yellow	violet	yellow	2474	1474
680000	4400	−5,0	blue	grey	yellow	2684	1684

*) Only for 10% tolerance a silver dot is added to the colour code.

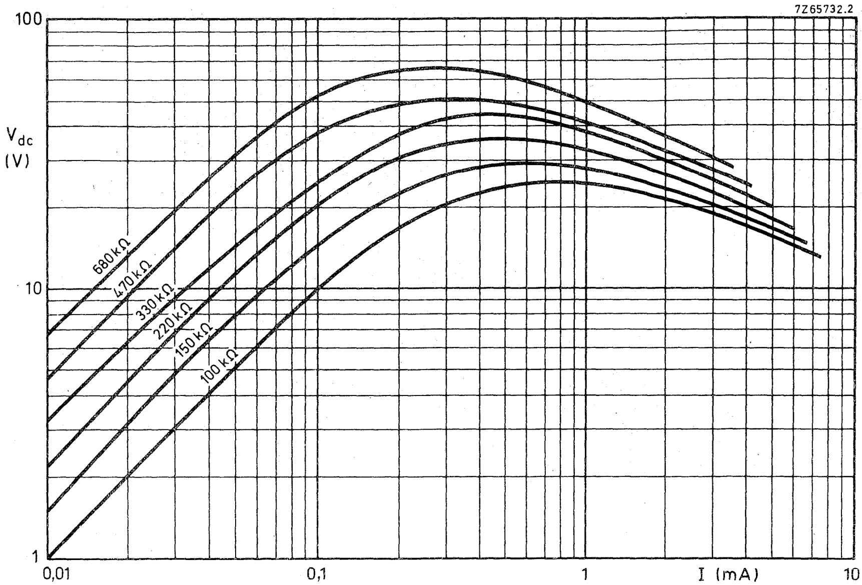
Maximum dissipation at +55 °C	100 mW
Dissipation factor	0,7 mW/°C approx.
Thermal time constant	14 s approx.
Heat capacity of ceramic	0,5 . 10^{-3} J/°C approx.
of complete component	9,8 . 10^{-3} J/°C approx.
Operating temperature range	
at zero power	−25 to +200 °C
at maximum power	0 to +55 °C
Dielectric withstanding voltage between terminals and glass envelope	min. 1500 V r.m.s.
Insulation resistance between terminals and glass envelope at 100 V d.c.	min. 100 MΩ



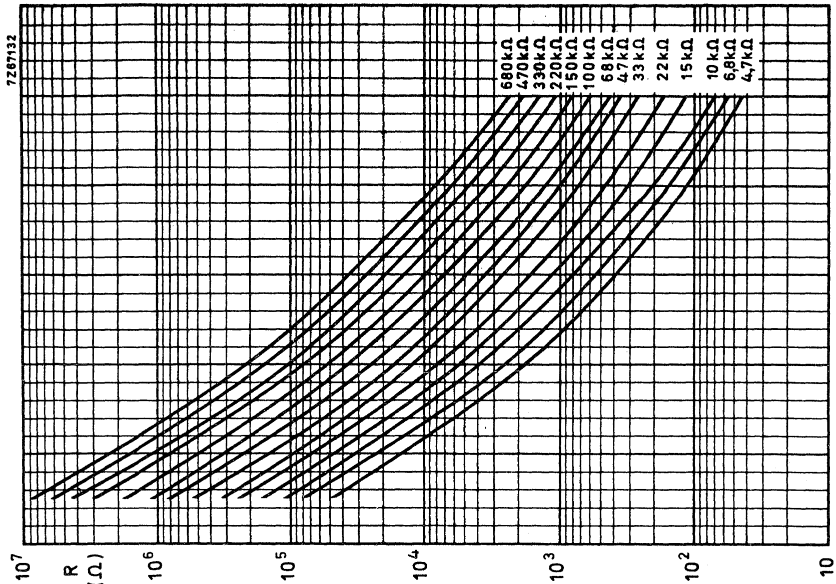
Typical voltage/current characteristics.



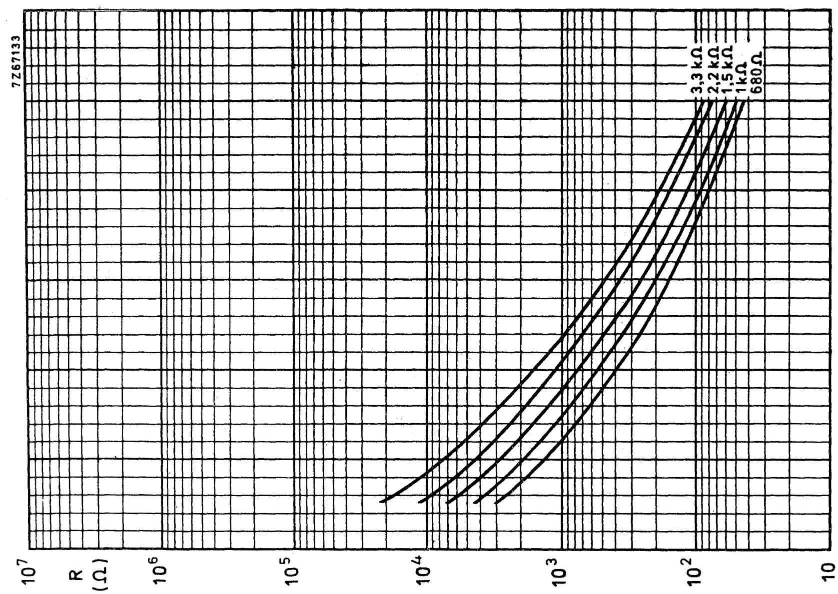
Typical voltage/current characteristics.



Typical voltage/current characteristics.



Typical resistance/temperature characteristics.



Typical resistance/temperature characteristics.

TESTS AND REQUIREMENTS

According to IEC 68 recommendation unless otherwise specified.

test	test method	duration	$\frac{\Delta R_{25}}{R_{25}}$ (%)	$\frac{\Delta B}{B}$ (%)
Cold at −25 °C	A	1000 h	± 2	± 1
Storage at +25 °C	H	1000 h	± 2	± 1
Dry heat at +200 °C	B	1000 h	± 2	± 1
Thermal shock −25 to +200 °C	Na	5 cycles	± 2	± 1
Damp heat at +40 °C	C	1000 h	± 2	± 1
Dissipation in damp heat		336 h	± 3	± 1
Max. dissipation at T_{amb} = +25 °C		1000 h	± 3	± 1
Robustness of terminations	U			
Tensile strength 2, 5 N	Ua	10 s	1)	-
Bending 1, 25 N	Ub	2 times	1)	-
Soldering	T			
Solderability at max. 240 °C	par. 3.2.3	3 to 4 s	2)	-
Resistance to heat at 260 ± 5 °C	Tb	10 ± 1 s	± 2	± 2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1,5 %, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

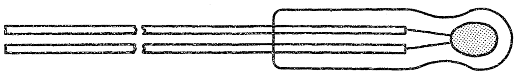
PACKAGING

100 pieces per box (cardboard)

NTC THERMISTORS

miniature bead

QUICK REFERENCE DATA	
Resistance value at +25 °C	680 Ω to 680 kΩ (E6 series)
$B_{25/85}$ - value	2200 to 4400 °K
Maximum dissipation	100 mW
Dissipation factor	0,7 mW/degC
Thermal time constant	10 s
Operating temperature range	
at zero power	−25 to +200 °C
at maximum power	0 to +55 °C



APPLICATION

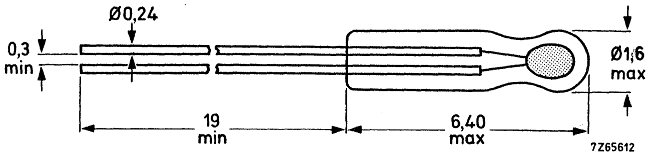
Intended for general use

DESCRIPTION

Bead thermistor with negative temperature coefficient, in a glass envelope with two solid tinned copper wires.

MECHANICAL DATA

Dimensions (mm)



Marking

None

Weight

0,03 g approx.

Mounting

In any position by soldering.

Robustness of terminations

Tensile strength	2,5 N
Bending	1,25 N

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s

Inflammability

Uninflammable

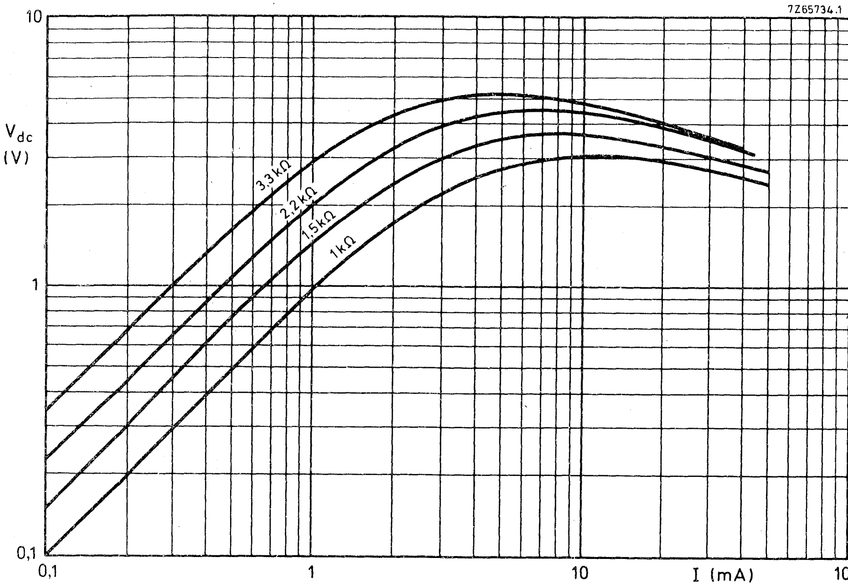
ELECTRICAL DATA

Unless otherwise specified, measured according to IEC draft publication 40 (CO) 226 and 337.

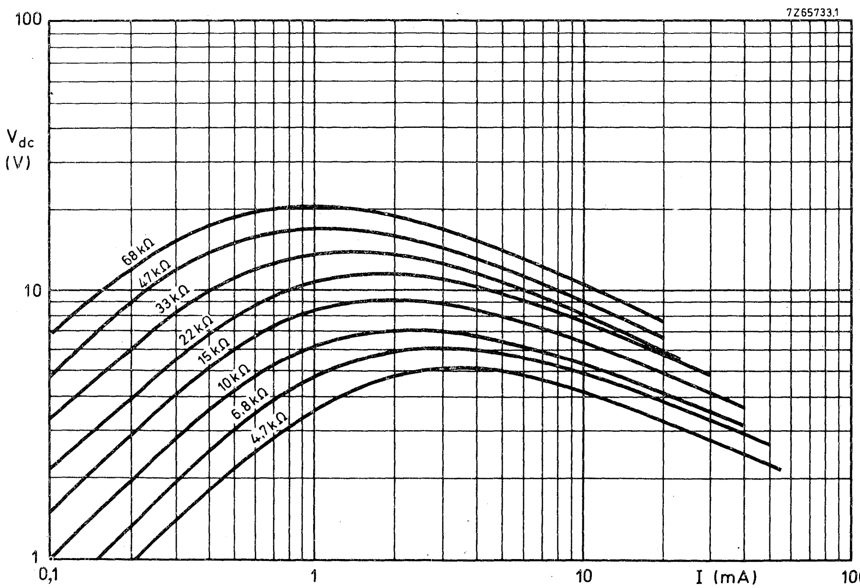
R_{25} (Ω)	$B_{25/85}$-value ± 5% (K)	temperature coefficient at 25 °C (%/°C)	catalogue number 2322 627 2.... tol. 10% **)	tol. 20%
680	2200 *)	−2,5	2681	1681
1000	2375 *)	−2,7	2102	1102
1500	2500 *)	−2,8	2152	1152
2200	2600 *)	−2,9	2222	1222
3300	2750 *)	−3,1	2332	1332
4700	3725	−4,2	2472	1472
6800	3775	−4,3	2682	1682
10000	3875	−4,3	2103	1103
15000	3800	−4,3	2153	1153
22000	3850	−4,3	2223	1223
33000	3800	−4,3	2333	1333
47000	3850	−4,3	2473	1473
68000	3900	−4,4	2683	1683
100000	3975	−4,5	2104	1104
150000	4050	−4,6	2154	1154
220000	4200	−4,7	2224	1224
330000	4275	−4,8	2334	1334
470000	4350	−4,9	2474	1474
680000	4400	−5,0	2684	1684

*) For these types the tolerance on B-value is ± 10% instead of ± 5%.
**) Only for 10% tolerance a silver dot is added to the colour code.

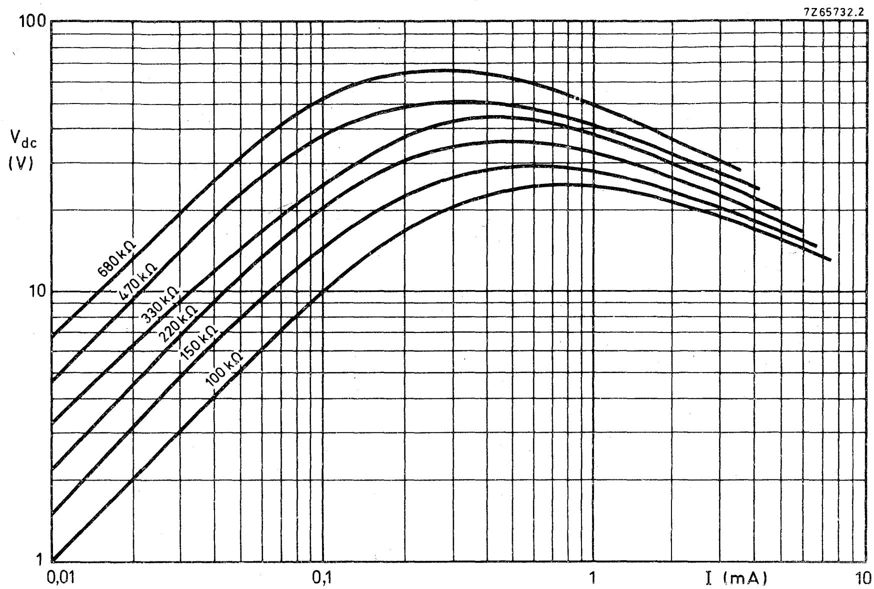
Maximum dissipation at +55 °C	100 mW
Dissipation factor	0,7 mW/°C approx.
Thermal time constant	10 s approx.
Heat capacity of ceramic	0,5 . 10^{-3} J/°C approx.
of complete component	7,0 . 10^{-3} J/°C approx.
Operating temperature range	
at zero power	−25 to +200 °C
at maximum power	0 to +55 °C
Dielectric withstanding voltage between terminals and glass envelope	min. 1500 V r.m.s.
Insulation resistance between terminals and glass envelope at 100 V d.c.	min. 100 MΩ



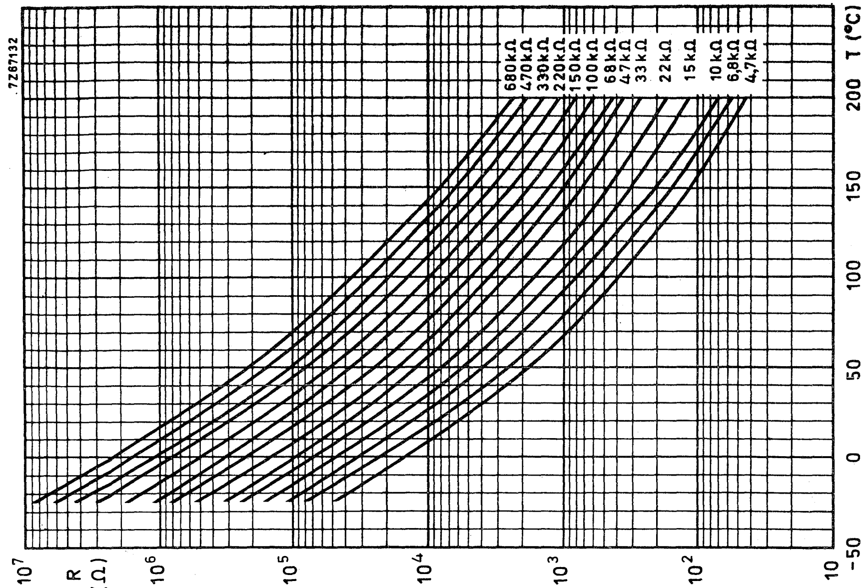
Typical voltage/current characteristics.



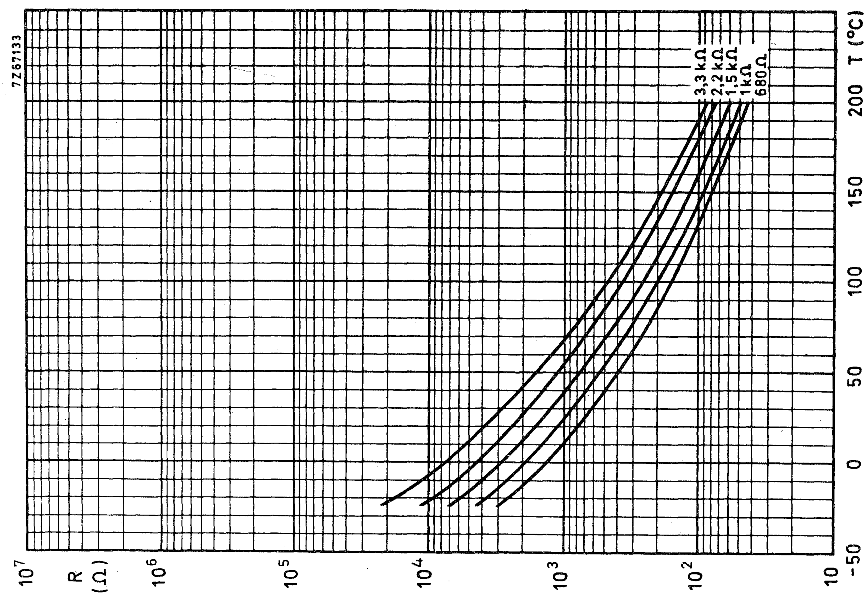
Typical voltage/current characteristics.



Typical voltage/current characteristics.



Typical resistance/temperature characteristics.



Typical resistance/temperature characteristics.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	$\frac{\Delta R_{25}}{R_{25}}$ (%)	$\frac{\Delta B}{B}$ (%)
Cold at −25 °C	A	1000 h	± 2	± 1
Storage at +25 °C	H	1000 h	± 2	± 1
Dry heat at +200 °C	B	1000 h	± 3	± 1
Thermal shock −25 to +200 °C	Na	5 cycles	± 2	± 1
Damp heat at +40 °C	C	1000 h	± 2	± 1
Dissipation in damp heat		336 h	± 3	± 1
Max. dissipation at T_{amb} = +25 °C		1000 h	± 3	± 1
Robustness of terminations	U			
Tensile strength 2, 5 N	Ua	10 s	1)	–
Bending 1, 25 N	Ub	2 times	1)	–
Soldering	T			
Solderability at max. 240 °C	par.3.2.3	3 to 4 s	2)	–
Resistance to heat at 260 ± 5 °C	Tb	10 ±1 s	± 2	± 2

1) Leads should neither come loose nor break.
2) Leads must solderable initially anf after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A. Q. L. 1 %, major defects – Electrical
A. Q. L. 1,5%, major defects – Mechanical
A. Q. L. 4 %, minor defects – Physical

PACKAGING

100 pieces per box (cardboard)

NTC THERMISTORS

miniature bead

QUICK REFERENCE DATA	
Resistance value at +25 °C	100 kΩ to 1 MΩ (E6 series)
$B_{25/85}$ - value	3800 to 4200 K
Maximum dissipation	0,1 W
Dissipation factor	0,95 mW/°C
Thermal time constant	18 s
Operating temperature range	
at zero power	−55 to +300 °C
at maximum power	0 to +55 °C

APPLICATION

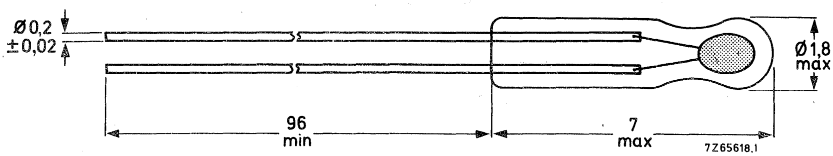
Intended for high temperature control

DESCRIPTION

Bead thermistor with negative temperature coefficient, in a glass envelope with two nickel leads.

MECHANICAL DATA

Dimensions (mm)



Marking

None

Weight

0,09 g approx.

Mounting

In any position by soldering or clamping.

Robustness of terminations

Tensile strength	2,5 N
Bending	1,25 N

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s

Inflammability

Uninflammable

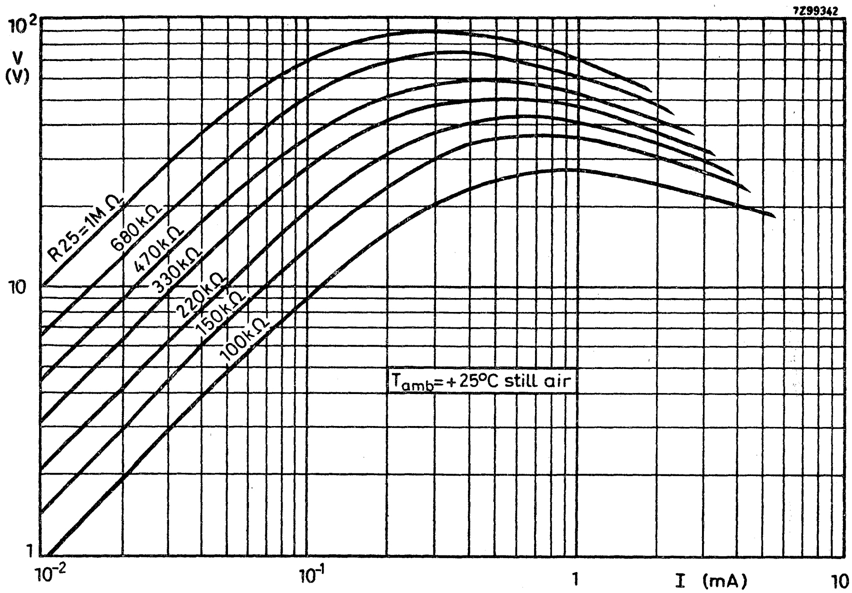
ELECTRICAL DATA

Unless otherwise specified, measured according to IEC draft publication 40 (CO) 226 and 337.

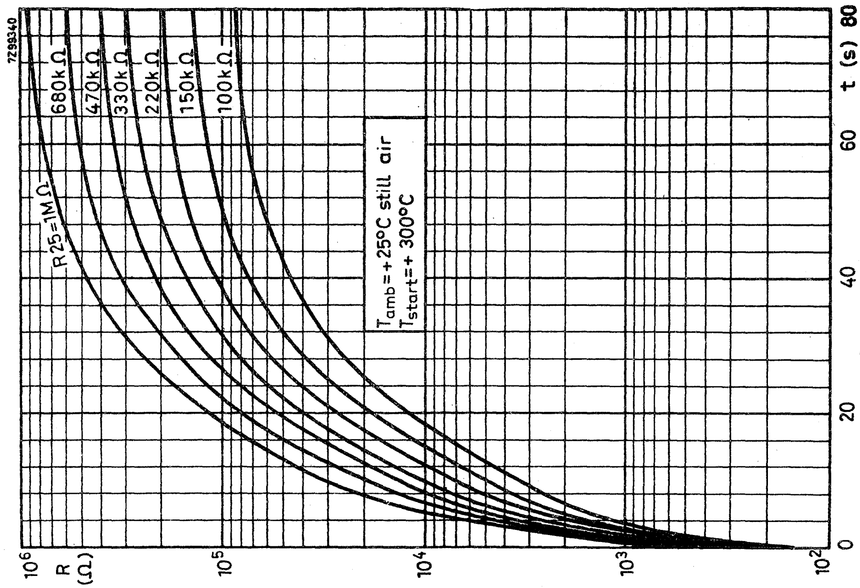
R_{25} ±20% (Ω)	$B_{25/85}$-value ± 5% (K)	catalogue number
100 000	3800	2322 627 31104
150 000	3880	31154
220 000	3920	31224
330 000	3980	31334
470 000	4030	31474
680 000	4100	31684
1000 000	4200	31105

Maximum dissipation at +55 °C	0, 1 W
Dissipation factor *)	0, 95 mW/°C approx.
Thermal time constant *)	18 s approx.
Heat capacity *)	0, 017 J/°C approx.
Response time	1 s
Operating temperature range	
at zero power	−55 to +300 °C
at maximum power	0 to +55 °C
Dielectric withstanding voltage between terminals and glass envelope	min. 1500 V r.m.s.
Insulation resistance between terminals and glass envelope at 100 V d.c.	min. 100 MΩ

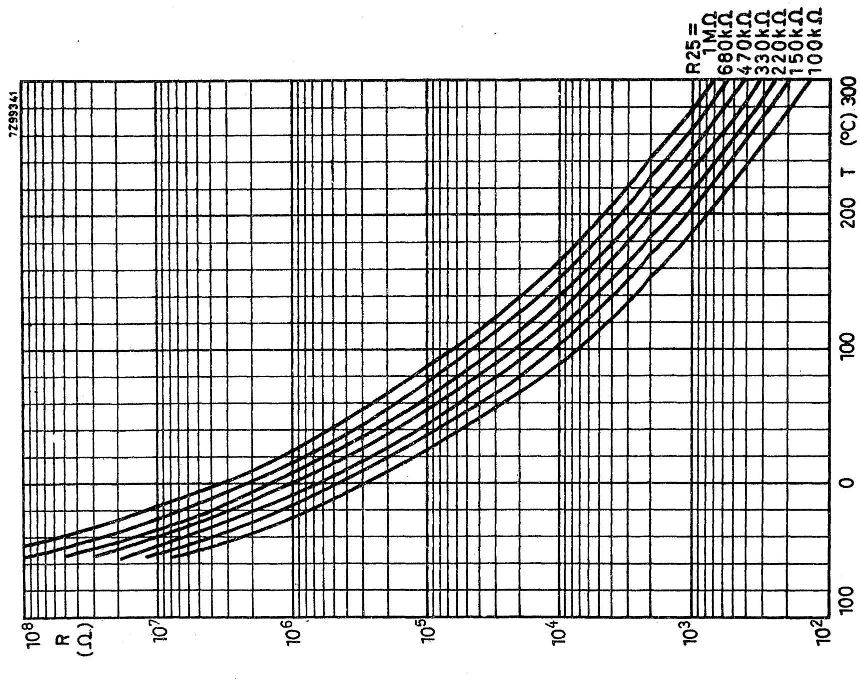
*) Measurement made with specimen in phosphor-bronze clips, in still air.



Typical voltage/current characteristics



Typical resistance/time (cooling) characteristics



Typical resistance/temperature characteristics

TESTS AND REQUIREMENTS

According to IEC recommendations, unless otherwise specified.

test	test method	duration	$\frac{\Delta R_{25}}{R_{25}}$ (%)	$\frac{\Delta B}{B}$ (%)
Cold at −55 °C	A	1000 h	± 2	± 2
Storage at +25 °C	H	1000 h	± 2	± 2
Dry heat +300 °C	B	1000 h	± 3	± 2
Thermal shock −55 to +300 °C	Na	5 cycles	± 2	± 2
Damp heat	C	336 h	± 2	± 2
Max. dissipation at T_{amb} = +55 °C		1000 h	± 3	± 2
Robustness of terminations	U			
Tensile strength 2, 5 N	Ua	10 s	1)	–
Bending 1, 25 N	Ub	2 times	1)	–
Soldering	T			
Solderability at 230 °C	par.3.2.3	3 to 4 s	2)	–
Resistance to heat at 230 °C	par. 3.2.4	3 to 4 s	± 2	± 2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects – Electrical
A.Q.L. 1,5%, major defects – Mechanical
A.Q.L. 4 %, minor defects – Physical

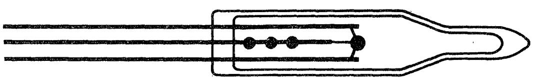
PACKAGING

100 pieces per box (cardboard)

NTC THERMISTORS

indirectly heated

QUICK REFERENCE DATA	
Resistance value at +25 °C	3,3 kΩ and 330 kΩ
Resistance of heater	100 Ω ± 10%
$B_{25/85}$-value	2750 °K and 4275 °K
Maximum dissipation of thermistor at W_h = 0 mW	35 mW
Dissipation factor	0,18 mW/deg C
Thermal time constant	15 s
Operating temperature range	
at zero power	−25 to +200 °C
at maximum power	0 to +55 °C



APPLICATION

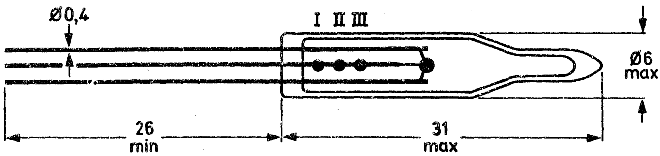
For temperature control

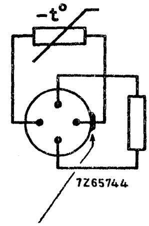
DESCRIPTION

Miniature thermistor with negative temperature coefficient, indirectly heated and vacuum mounted in a glass envelope.

MECHANICAL DATA

Dimensions (mm)





colour code

Marking

Three colour dots on the glass envelope:

type	I	II	III
2322 628 01332	orange	orange	red
2322 628 01334	orange	orange	yellow

Weight

0,95 g approx.

Mounting

In any position by soldering

Robustness of terminations

Tensile strength	5 N
Bending	2,5 N

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s

Inflammability

Uninflammable

ELECTRICAL DATA

Unless otherwise specified measured according to IEC draft publication 40 (secretariat) 279.

All values in the table without further indication are approximately values.

	2322 628 01332	2322 628 01334
Resistance at 25 °C	3,3 kΩ ± 20%	330 kΩ ± 20%
Resistance of heater	100 Ω ± 10%	100 Ω ± 10%
Resistance after t ≤ 30 s and W_h = 30 mW	< 10% of R_{25}	< 2,5% of R_{25}
$B_{25/85}$-value	2750 K ± 5%	4275 K ± 5%
Temperature coefficient	−3,1%/°C	−4,8%/°C

Maximum dissipation of thermistor at zero power of heater (W_h = 0)	35 mW
Maximum dissipation of heater at zero power in thermistor (W_{th} = 0)	35 mW
Dissipation factor	0,18 mW/°C
Thermal time constant	15 s
Heat capacity	0,0027 J/°C
Heater efficiency	97,5%
Capacitance between heater and thermistor	1,6 pF
Operating temperature range	
at zero power	−25 to +200 °C
at maximum power	0 to + 55 °C
Dielectric withstanding voltage between terminals of thermistor and heater	min 200 V r.m.s.
Insulation resistance at 50 V between terminals of thermistor and heater	min 10 MΩ

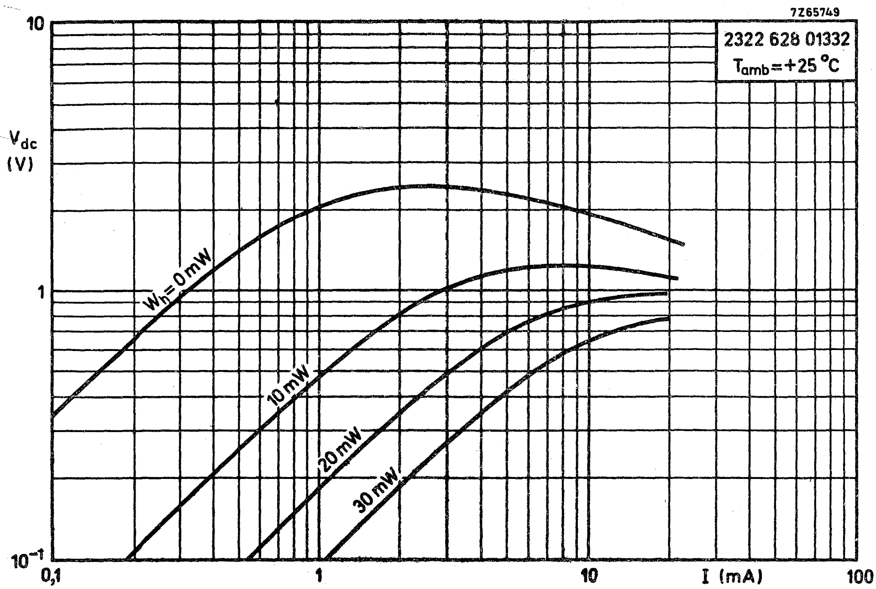


Fig.2 Typical voltage/current characteristics

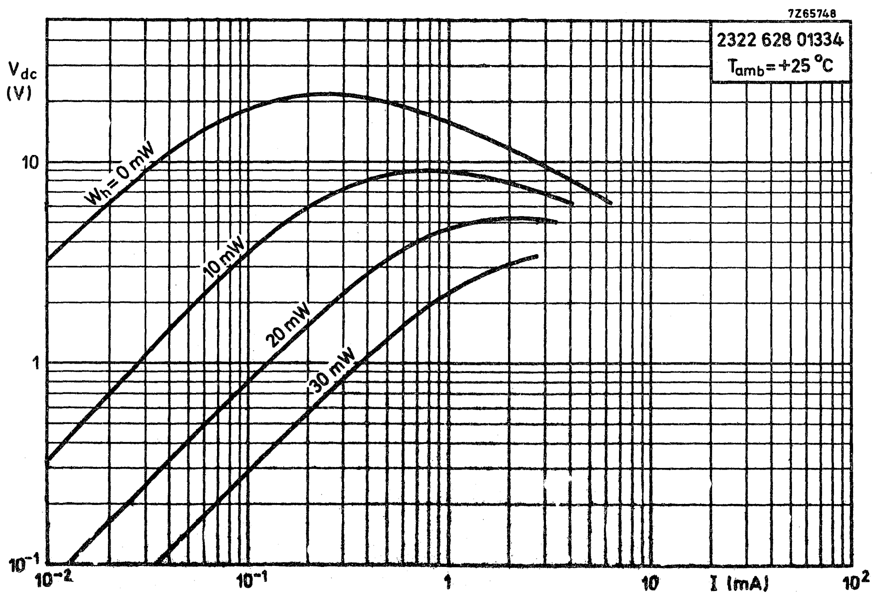


Fig.3 Typical voltage/current characteristics

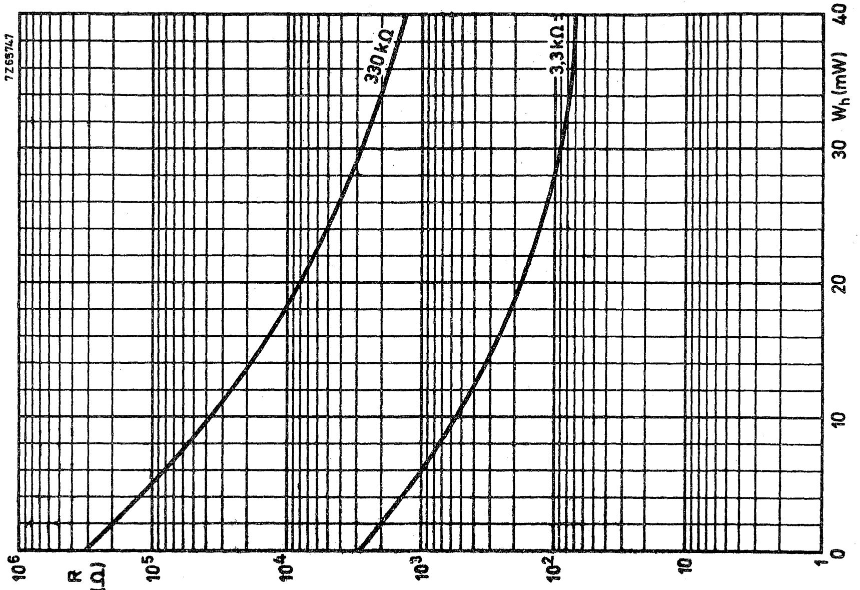


Fig.5 Typical resistance/heater power characteristics

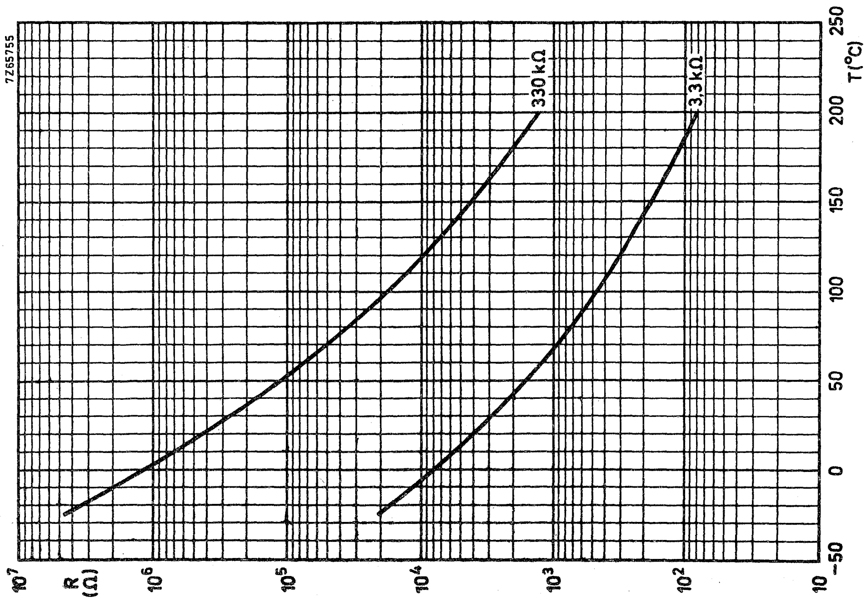


Fig.4 Typical resistance/temperature characteristics

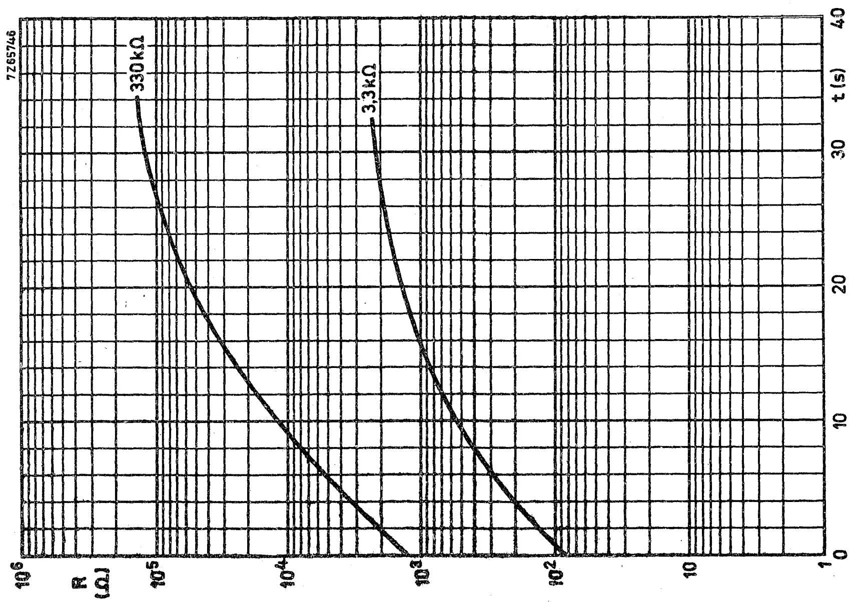


Fig.6 Typical resistance/time (cooling) characteristics

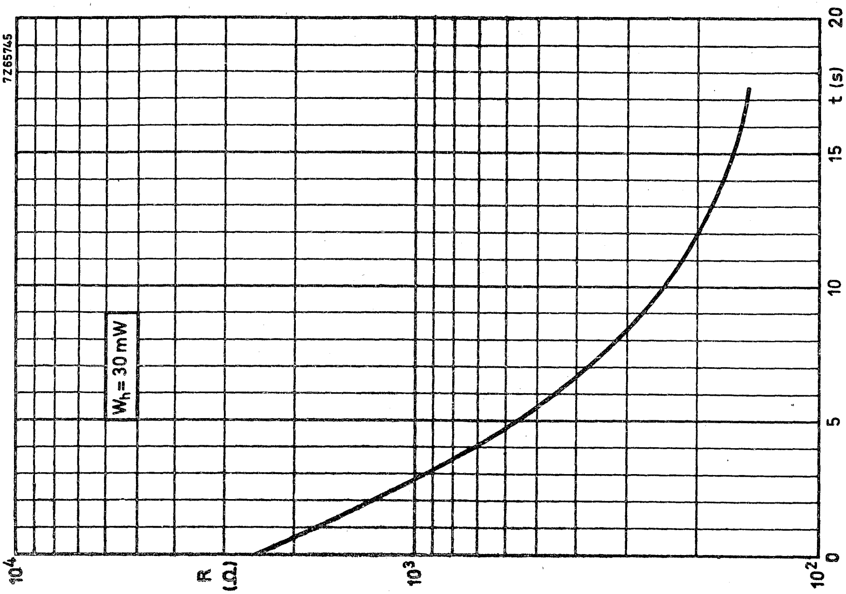


Fig.7 Typical resistance/response time characteristics

TESTS AND REQUIREMENTS

According to IEC recommendations unless otherwise specified

test	test method	duration	$\frac{\Delta R25}{R_{25}}$ (%)	$\frac{\Delta B}{B}$ (%)
Cold at −25 °C	A	1000 h	±2	±1
Storage at +25 °C	H	1000 h	±1	±1
Dry heat at +200 °C	B	1000 h	±3	±1
Thermal shock −25 to +200 °C	Na	5 cycles	±2	±1
Damp heat at +40 °C	C	1000 h	±2	±1
Dissipation in damp heat		336 h	±3	±1
Max. dissipation at T_{amb} = +25 °C		1000 h	±3	±1
Robustness of terminations	U			
Tensile strength 5 N	Ua	10 s	1)	–
Bending 2, 5 N	Ub	2 times	1)	–
Soldering	T		1)	–
Solderability	par. 3. 2. 3.	3 to 4 s	2)	–
Resistance to heat	Tb	10 ± 1 s	±2	±2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D

A.Q.L. 1 %, major defects-Electrical
A.Q.L. 1,5%, major defects-Mechanical
A.Q.L. 4 %, minor defects-Physical

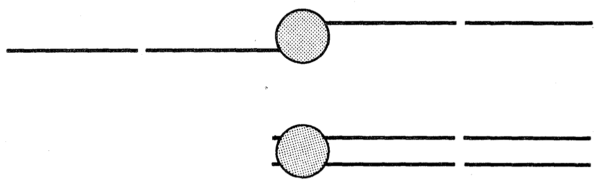
PACKAGING

100 pieces per box (cardboard)

NTC THERMISTORS

miniature bead

QUICK REFERENCE DATA	
Resistance value at +25 °C	680 Ω to 680 kΩ (E6 series)
$B_{25/85}$ - value	2200 to 4400 °K
Operating temperature range	
at zero power	−25 to +200 °C
at maximum power	0 to +55 °C



APPLICATION

Intended for general use

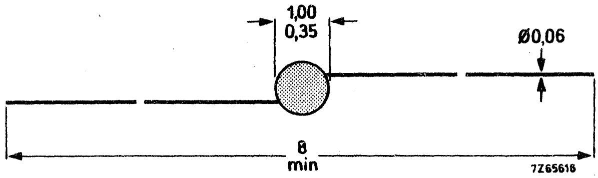
DESCRIPTION

Naked bead thermistor with negative temperature coefficient, with two solid platinairidium leads in opposition or in same direction.

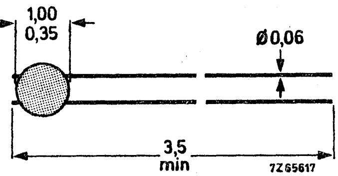
MECHANICAL DATA

Dimensions (mm)

version 2322 634 0. . . .



version 2322 634 1. . . .



Marking

None

Weight

0, 001 g approx.

Mounting

In any position by spot welding of the leads to conducting wires or other supports.

Inflammability

Uninflammable

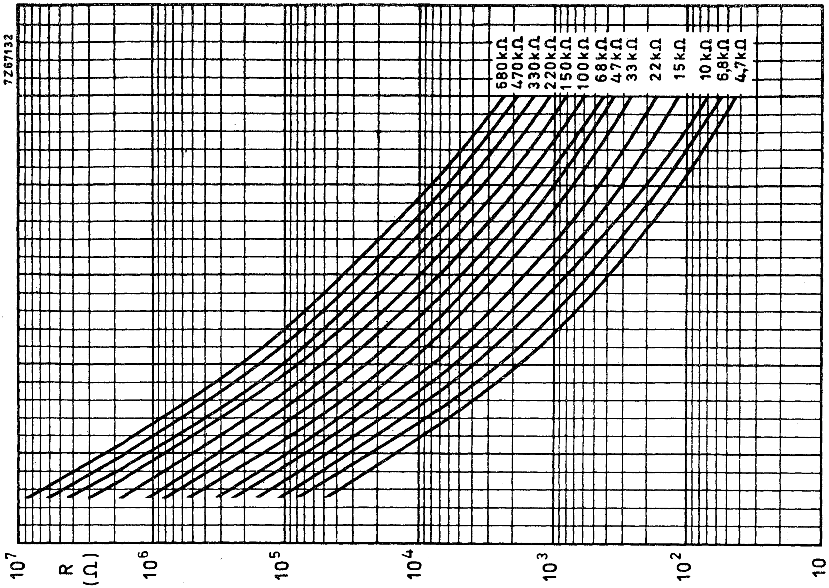
ELECTRICAL DATA

Unless otherwise specified, measured according to IEC draft publication 40 (CO) 226 and 337.

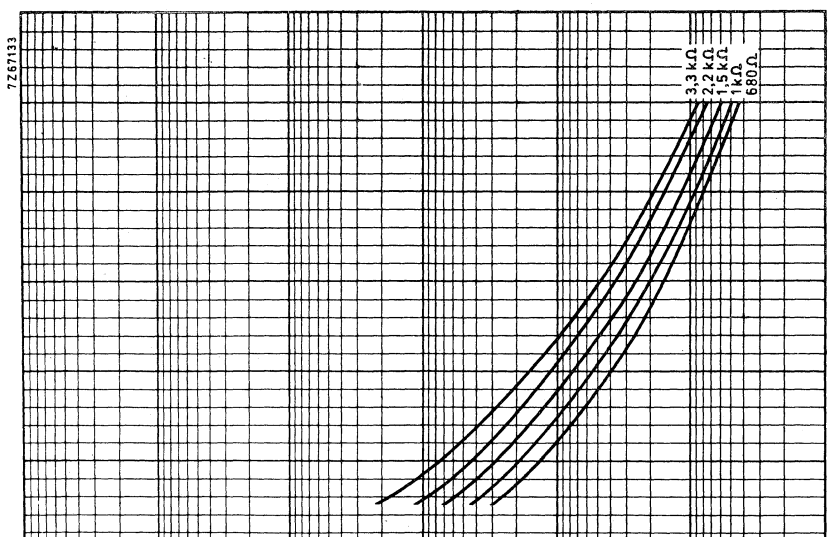
R_{25} (Ω)	$B_{25/85}$-value ± 5% (K)	temperature coefficient at 25 °C (%/°C)	catalogue number 2322 634 0.... leads in opposition		2322 634 1.... leads in same direction	
			tol. 10%	tol. 20%	tol. 10%	tol. 20%
680	2200	−2,5	2681	1681	2681	1681
1000	2375	−2,7	2102	1102	2102	1102
1500	2500	−2,8	2152	1152	2152	1152
2200	2600	−2,9	2222	1222	2222	1222
3300	2750	−3,1	2332	1332	2332	1332
4700	3725	−4,2	2472	1472	2472	1472
6800	3775	−4,3	2682	1682	2682	1682
10000	3875	−4,3	2103	1103	2103	1103
15000	3800	−4,3	2153	1153	2153	1153
22000	3850	−4,3	2223	1223	2223	1223
33000	3800	−4,3	2333	1333	2333	1333
47000	3850	−4,3	2473	1473	2473	1473
68000	3900	−4,4	2683	1683	2683	1683
100000	3975	−4,5	2104	1104	2104	1104
150000	4050	−4,6	2154	1154	2154	1154
220000	4200	−4,7	2224	1224	2224	1224
330000	4275	−4,8	2334	1334	2334	1334
470000	4350	−4,9	2474	1474	2474	1474
680000	4400	−5,0	2684	1684	2684	1684

Heat capacity — $0,5 \cdot 10^{-3}$ J/°C approx.

Operating temperature range
- at zero power — −25 to +200 °C
- at maximum power — 0 to +55 °C



Typical resistance/temperature characteristics.



Typical resistance/temperature characteristics.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	$\frac{\Delta R_{25}}{R_{25}}$ (%)	$\frac{\Delta B}{B}$ (%)
Cold at −25 °C	A	1000 h	± 2	± 1
Storage at +25 °C	H	1000 h	± 2	± 1
Dry heat at +200 °C	B	1000 h	± 3	± 1
Thermal shock −25 to +200 °C	Na	5 cycles	± 2	± 1
Max. dissipation at T_{amb} = +25 °C		1000 h	± 3	± 1

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects – Electrical
A.Q.L. 1,5%. major defects – Mechanical
A.Q.L. 4 %, minor defects – Physical

PACKAGING

100 pieces ber box (cardboard).

NTC THERMISTORS

miniature bead

QUICK REFERENCE DATA	
Resistance value at +25 °C	680 Ω to 680 kΩ (E6 series)
$B_{25/85}$ - value	2200 to 4400 °K
Maximum dissipation	60 mW
Dissipation factor	0, 4 mW/degC
Thermal time constant	9 s
Operating temperature range	
at zero power	−25 to +200 °C
at maximum power	0 to +55 °C

APPLICATION

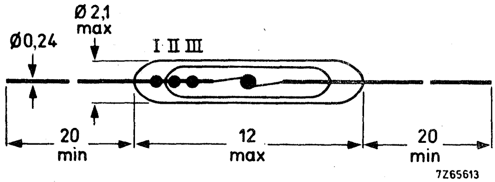
Intended for general use

DESCRIPTION

Bead thermistor with negative temperature coefficient, in a glass envelope with two solid tinned copper wires.

MECHANICAL DATA

Dimensions (mm)



Marking

Colour dots on the glass envelope, see for colour code the table.

Weight

0,1 g approx.

Mounting

In any position by soldering.

Robustness of terminations

Tensile strength	2,5 N
Bending	1,25 N
Torsion	3 times

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s

Inflammability

Uninflammable

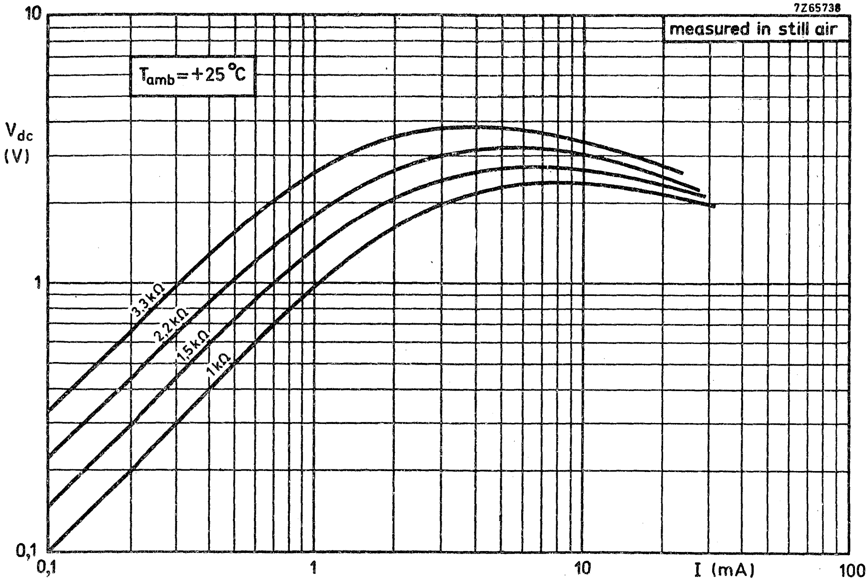
ELECTRICAL DATA

Unless otherwise specified, measured according to IEC draft publication 40 (CO) 226 and 337.

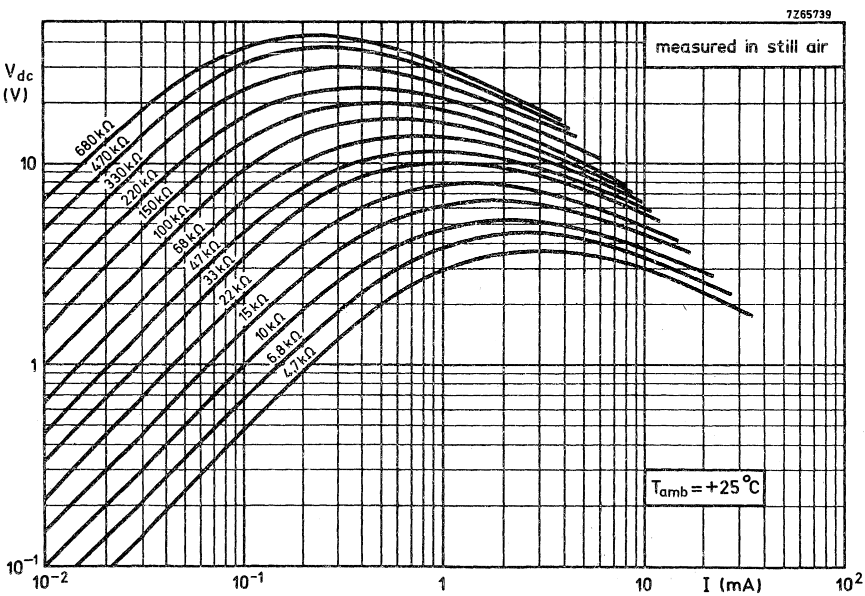
R25 (Ω)	B25/85-value ± 5% (K)	temperature coefficient at 25 °C (%/°C)	colour code *) I	II	III	catalogue number 2322 634 2.... tol. ± 10% *)	tol. ± 20%
680	2200	−2,5	blue	grey	brown	2681	1681
1000	2375	−2,7	brown	black	red	2102	1102
1500	2500	−2,8	brown	green	red	2152	1152
2200	2600	−2,9	red	red	red	2222	1222
3300	2750	−3,1	orange	orange	red	2332	1332
4700	3725	−4,2	yellow	violet	red	2472	1472
6800	3775	−4,3	blue	grey	red	2682	1682
10000	3875	−4,3	brown	black	orange	2103	1103
15000	3800	−4,3	brown	green	orange	2153	1153
22000	3850	−4,3	red	red	orange	2223	1223
33000	3800	−4,3	orange	orange	orange	2333	1333
47000	3850	−4,3	yellow	violet	orange	2473	1473
68000	3900	−4,4	blue	grey	orange	2683	1683
100000	3975	−4,5	brown	black	yellow	2104	1104
150000	4050	−4,6	brown	green	yellow	2154	1154
220000	4200	−4,7	red	red	yellow	2224	1224
330000	4275	−4,8	orange	orange	yellow	2334	1334
470000	4350	−4,9	yellow	violet	yellow	2474	1474
680000	4400	−5,0	blue	grey	yellow	2684	1684

*) Only for 10% tolerance a silver dot is added to the colour code.

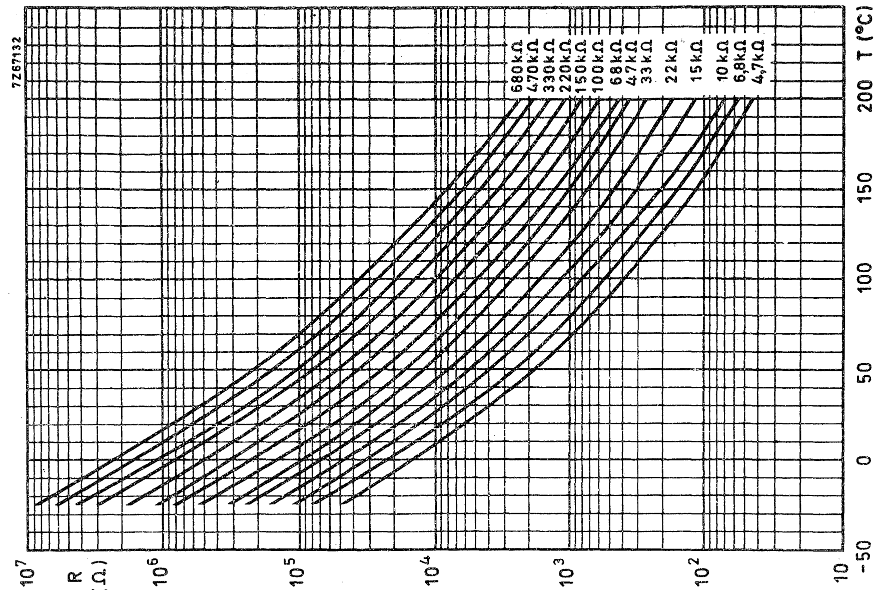
Maximum dissipation at +55 °C	60 mW
Dissipation factor	0,4 mW/°C approx.
Thermal time constant	9 s approx.
Heat capacity of ceramic	0,5 . 10^{-3} J/°C approx.
of complete component	3,1 . 10^{-3} J/°C approx.
Operating temperature range	
at zero power	-25 to +200 °C
at maximum power	0 to +55 °C
Dielectric withstanding voltage between terminals and glass envelope	min. 1500 V r.m.s.
Insulation resistance between terminals and glass envelope at 100 V d.c.	min. 100 MΩ



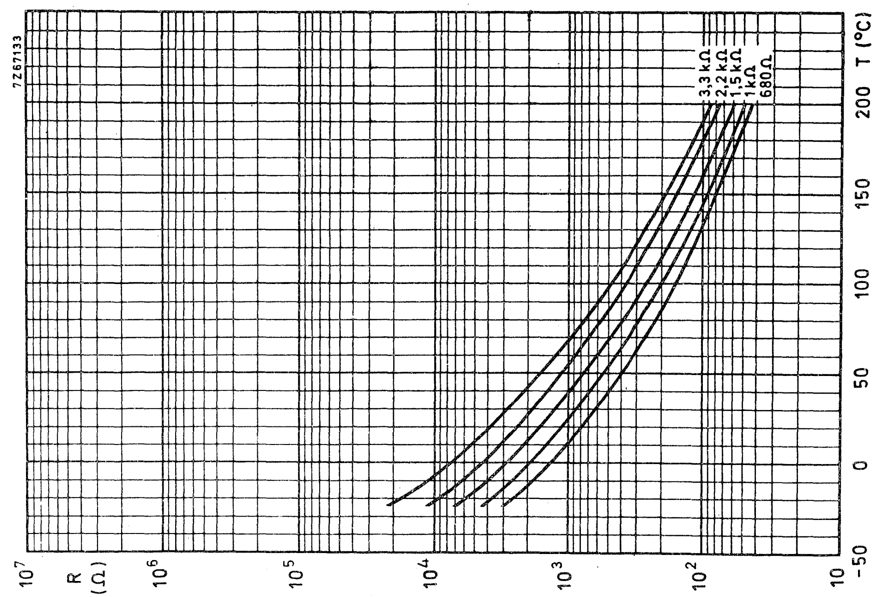
Typical voltage/current characteristics.



Typical voltage/current characteristics.



Typical resistance/temperature characteristics.



Typical resistance/temperature characteristics.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	$\frac{\Delta R_{25}}{R_{25}}$ (%)	$\frac{\Delta B}{B}$ (%)
Cold at −25 °C	A	1000 h	± 2	± 1
Storage at +25 °C	H	1000 h	± 2	± 1
Dry heat at +200 °C	B	1000 h	± 3	± 1
Thermal shock −25 to +200 °C	Na	5 cycles	± 2	± 1
Damp heat at +40 °C	C	1000 h	± 2	± 1
Dissipation in damp heat		336 h	± 3	± 1
Max. dissipation at T_{amb} = +25 °C		1000 h		
Robustness of terminations	U			
Tensile strength 2,5 N	Ua	10 s	1)	−
Bending 1,25 N	Ub	2 times	1)	−
Torsion	Uc	3 times	1)	−
Torque			1)	−
Soldering	T			
Solderability at max. 240 °C	par. 3.2.3	3 to 4 s	2)	−
Resistance to heat at 260 ± 5 °C	Tb	10 ± 1 s	± 2	± 2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects − Electrical
A.Q.L. 1,5%, major defects − Mechanical
A.Q.L. 4 %, minor defects − Physical

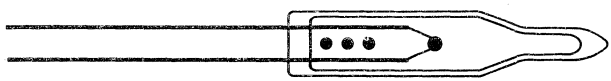
PACKAGING

100 pieces per box (cardboard).

NTC THERMISTORS

miniature bead

QUICK REFERENCE DATA	
Resistance value at +25 °C	680 Ω to 680 kΩ (E6 series)
$B_{25/85}$- value	2200 to 4400 °K
Maximum dissipation	20 mW
Dissipation factor	0,11 mW/degC
Thermal time constant	6 s
Operating temperature range	
at zero power	−25 to +200 °C
at maximum power	0 to +55 °C



APPLICATION

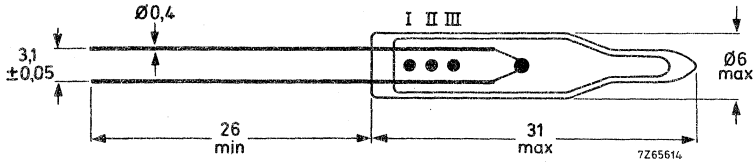
Intended for general use

DESCRIPTION

Bead thermistor with negative temperature coefficient, vacuum mounted in a glass envelope, with two solid tinned copper wires.

MECHANICAL DATA

Dimensions (mm)



Marking

Colour dots on the glass envelope, see for colour code the table.

Weight

0,6 g approx.

Mounting

In any position by soldering.

Robustness of terminations

Tensile strength	5 N
Bending	2,5 N

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s

Inflammability

Uninflammable

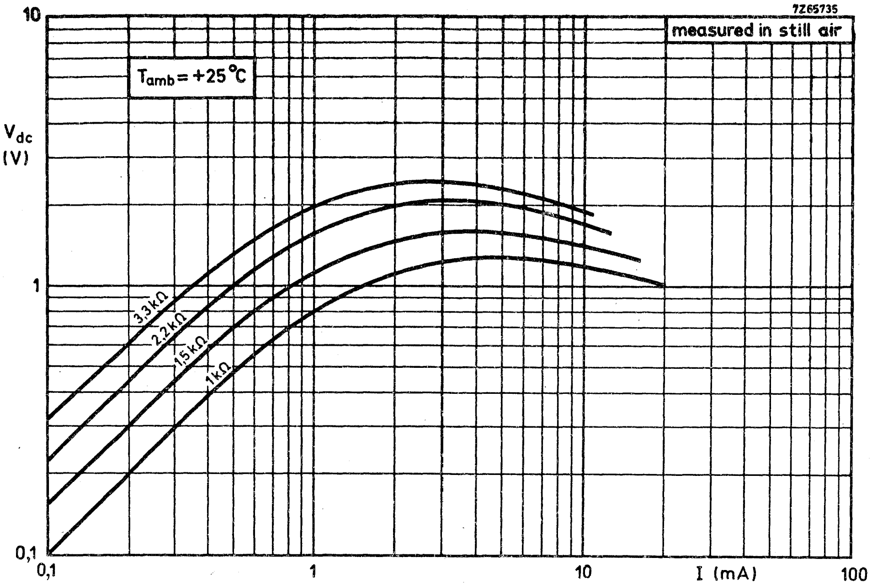
ELECTRICAL DATA

Unless otherwise specified, measured according to IEC draft publication 40 (CO) 226 and 337.

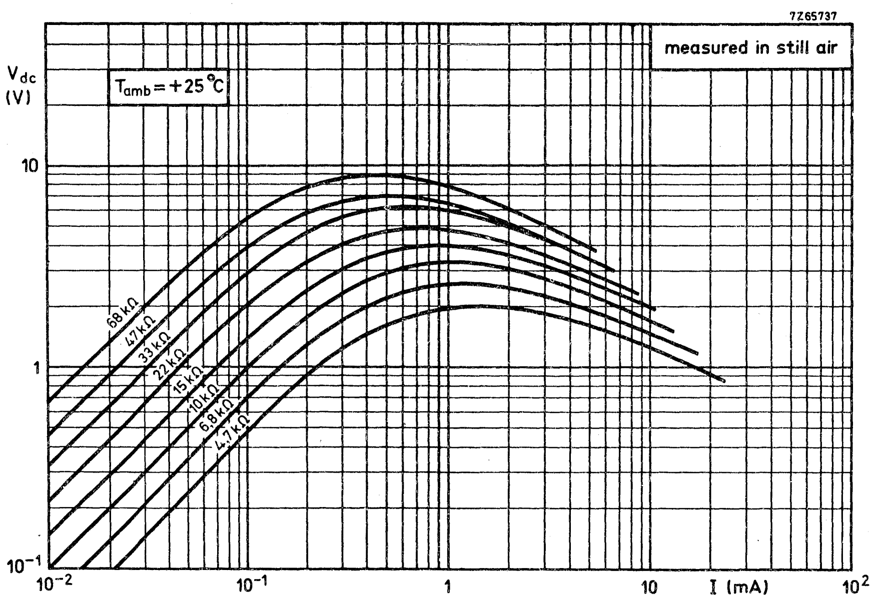
R_{25} (Ω)	$B_{25/85}$-value ± 5% (K)	temperature coefficient at 25 °C (%/°C)	colour code *) I	II	III	catalogue number 2322 634 3. . . . tol. ± 10% *)	tol. ± 20%
680	2200	−2,5	blue	grey	brown	2681	1681
1000	2375	−2,7	brown	black	red	2102	1102
1500	2500	−2,8	brown	green	red	2152	1152
2200	2600	−2,9	red	red	red	2222	1222
3300	2750	−3,1	orange	orange	red	2332	1332
4700	3725	−4,2	yellow	violet	red	2472	1472
6800	3775	−4,3	blue	grey	red	2682	1682
10000	3875	−4,3	brown	black	orange	2103	1103
15000	3800	−4,3	brown	green	orange	2153	1153
22000	3850	−4,3	red	red	orange	2223	1223
33000	3800	−4,3	orange	orange	orange	2333	1333
47000	3850	−4,3	yellow	violet	orange	2473	1473
68000	3900	−4,4	blue	grey	orange	2683	1683
100000	3975	−4,5	brown	black	yellow	2104	1104
150000	4050	−4,6	brown	green	yellow	2154	1154
220000	4200	−4,7	red	red	yellow	2224	1224
330000	4275	−4,8	orange	orange	yellow	2334	1334
470000	4350	−4,9	yellow	violet	yellow	2474	1474
680000	4400	−5,0	blue	grey	yellow	2684	1684

*) Only for 10% tolerance a silver dot is added to the colour code.

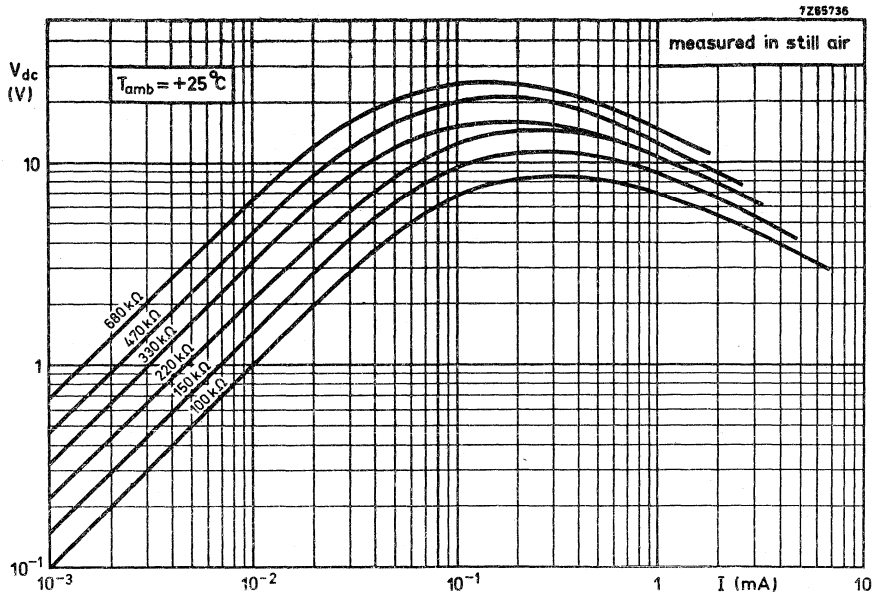
Maximum dissipation at +55 °C	20 mW
Dissipation factor	0,11 mW/°C approx.
Thermal time constant	6 s approx.
Heat capacity of ceramic	$0,5 \cdot 10^{-3}$ J/°C approx.
of complete component	$0,8 \cdot 10^{-3}$ J/°C approx.
Operating temperature range	
at zero power	−25 to +200 °C
at maximum power	0 to + 55 °C
Dielectric withstanding voltage between terminals and glass envelope	min. 1500 V r.m.s.
Insulation resistance between terminals and glass envelope at 100 V d.c.	min. 100 MΩ



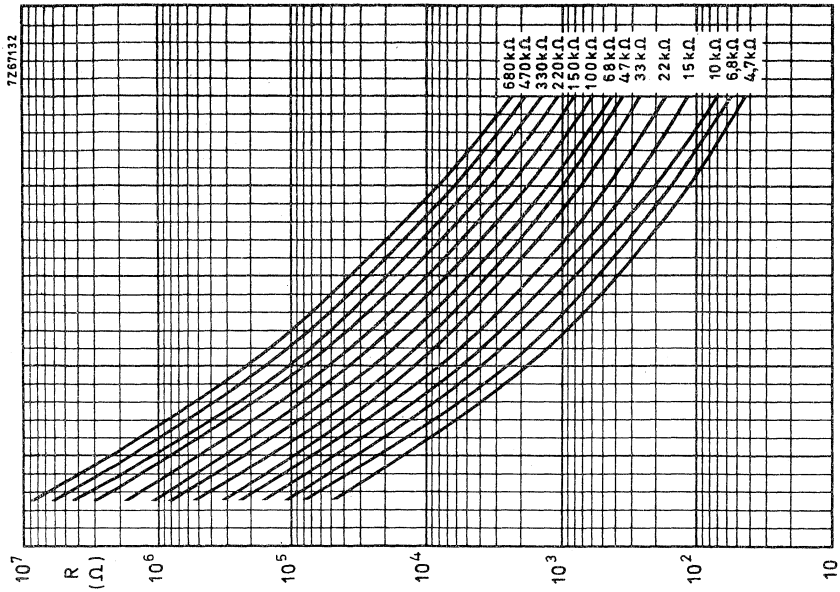
Typical voltage/current characteristics.



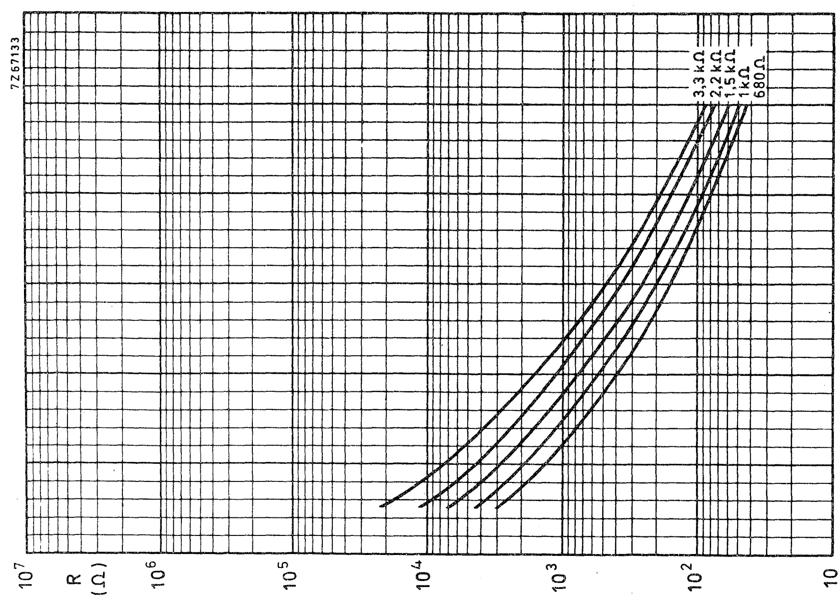
Typical voltage/current characteristics.



Typical voltage/current characteristics.



Typical resistance/temperature characteristics.



Typical resistance/temperature characteristics.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	$\frac{\Delta R_{25}}{R_{25}}$ (%)	$\frac{\Delta B}{B}$ (%)
Cold at −25 °C	A	1000 h	± 2	± 1
Storage at +25 °C	H	1000 h	± 2	± 1
Dry heat +200 °C	B	1000 h	± 3	± 1
Thermal shock −25 to +200 °C	Na	5 cycles	± 2	± 1
Damp heat at +40 °C	C	1000 h	± 2	± 1
Dissipation in damp heat		336 h	± 3	± 1
Max. dissipation at T_{amb} = +25 °C		1000 h	± 3	± 1
Robustness of terminations	U			
Tensile strength 5 N	Ua	10 s	1)	−
Bending 2,5 N	Ub	2 times	1)	−
Soldering	T			
Solderability at max. 240 °C	par.3.2.3	3 to 4 s	2)	−
Resistance to heat at 260 ± 5 °C	Tb	10 ± 1 s	± 2	± 2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects − Electrical
A.Q.L. 1,5%, major defects − Mechanical
A.Q.L. 4 %, minor defects − Physical

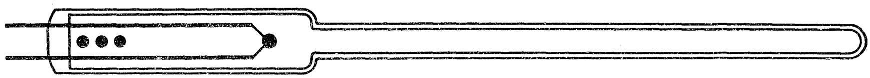
PACKAGING

100 pieces per box (cardboard).

NTC THERMISTORS

miniature bead

QUICK REFERENCE DATA	
Resistance value at +25 °C	680 Ω to 680 kΩ (E6 series)
$B_{25/85}$ - value	2200 to 4400 °K
Operating temperature range	
at zero power	−25 to +200 °C
at maximum power	0 to +55 °C



APPLICATION

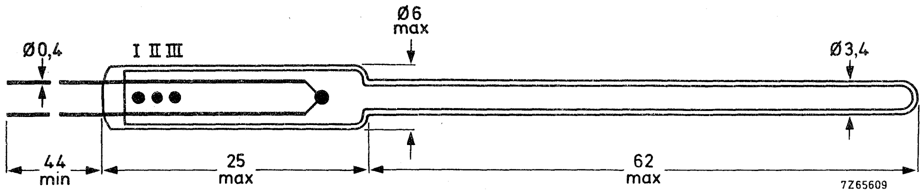
Intended for use as vacuum gauge

DESCRIPTION

Bead thermistor with negative temperature coefficient mounted in a glass envelope with a stem and with two solid tinned copper wires.

MECHANICAL DATA

Dimensions (mm)



Marking

Colour dots on the glass envelope, see for colour code the table.

Weight

0,2 g approx.

Mounting

In any position by soldering.

Robustness of terminations

Tensile strength	5 N
Bending	2,5 N

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s

Inflammability

Uninflammable

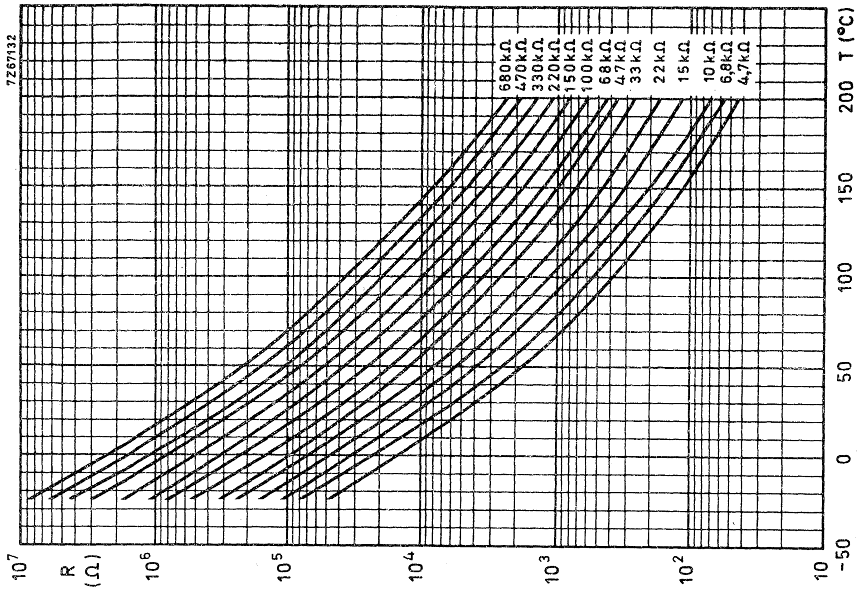
ELECTRICAL DATA

Unless otherwise specified, measured according to IEC draft publication 40 (CO) 226 and 337.

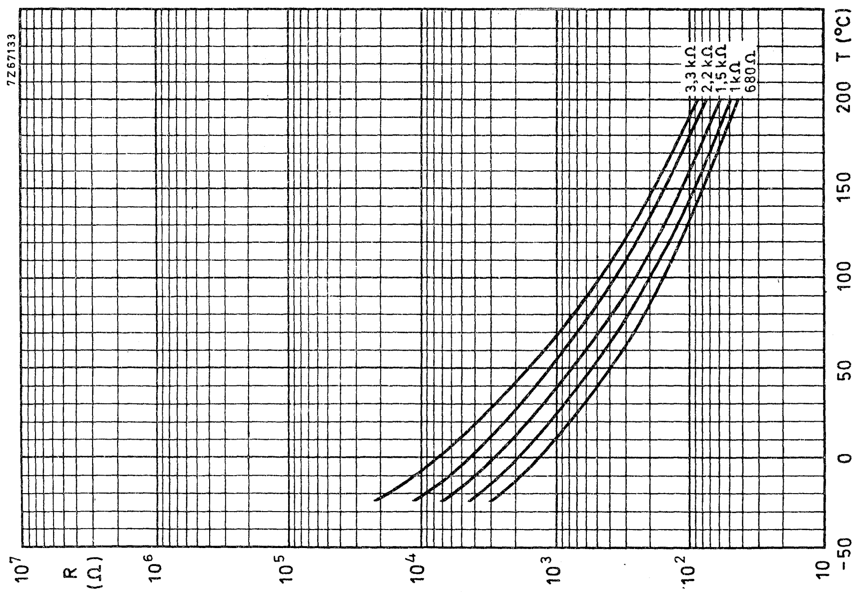
R_{25} (Ω)	$B_{25/85}$-value ± 5% (K)	temperature coefficient at 25 °C (%/°C)	colour code *) I	II	III	catalogue number 2322 634 4.... tol. ± 10 *)	tol. ± 20%
680	2200	−2,5	blue	grey	brown	2681	1681
1000	2375	−2,7	brown	black	red	2102	1102
1500	2500	−2,8	brown	green	red	2152	1152
2200	2600	−2,9	red	red	red	2222	1222
3300	2750	−3,1	orange	orange	red	2332	1332
4700	3725	−4,2	yellow	violet	red	2472	1472
6800	3775	−4,3	blue	grey	red	2682	1682
10000	3875	−4,3	brown	black	orange	2103	1103
15000	3800	−4,3	brown	green	orange	2153	1153
22000	3850	−4,3	red	red	orange	2223	1223
33000	3800	−4,3	orange	orange	orange	2333	1333
47000	3850	−4,3	yellow	violet	orange	2473	1473
68000	3900	−4,4	blue	grey	orange	2683	1683
100000	3975	−4,5	brown	black	yellow	2104	1104
150000	4050	−4,6	brown	green	yellow	2154	1154
220000	4200	−4,7	red	red	yellow	2224	1224
330000	4275	−4,8	orange	orange	yellow	2334	1334
470000	4350	−4,9	yellow	violet	yellow	2474	1474
680000	4400	−5,0	blue	grey	yellow	2684	1684

*) Only for 10% tolerance a silver dot is added to the colour code.

Heat capacity of ceramic	$0,5 \cdot 10^{-3}$ J/°C approx.
Operating temperature range	
at zero power	−25 to +200 °C
at maximum power	0 to +55 °C
Dielectric withstanding voltage between terminals and glass envelope	min. 1500 V r.m.s.
Insulation resistance between terminals and glass envelope at 100 V d.c.	min. 100 MΩ



Typical resistance/temperature characteristics.



Typical resistance/temperature characteristics.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	$\frac{\Delta R_{25}}{R_{25}}$ (%)	$\frac{\Delta B}{B}$ (%)
Cold at −25 °C	A	1000 h	± 2	± 1
Storage at +25 °C	H	1000 h	± 2	± 1
Dry heat at +200 °C	B	1000 h	± 3	± 1
Thermal shock −25 to +200 °C	Na	5 cycles	± 2	± 1
Damp heat at +40 °C	C	1000 h	± 2	± 1
Dissipation in damp heat		336 h	± 3	± 1
Max. dissipation at T_{amb} = +25 °C		1000 h	± 3	± 1
Robustness of terminations	U			
Tensile strength 5 N	Ua	10 s	1)	−
Bending	Ub	2 times	1)	−
Soldering	T			
Solderability at max. 240 °C	par.3.2.3	3 to 4 s	2)	−
Resistance to heat at 260 ± 5 °C	Tb	10 ±1 s	± 2	± 2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects − Electrical
A.Q.L. 1,5%, major defects − Mechanical
A.Q.L. 4 %, minor defects − Physical

PACKAGING

200 pieces per box (cardboard).

NTC THERMISTORS
rod

QUICK REFERENCE DATA

Resistance values at +25 °C	4,7 kΩ to 470 kΩ
$B_{25/85}$ - value	3300 to 4300 K
Maximum dissipation	0,6 W
Dissipation factor	5 mW/ °C
Thermal time constant	30 s
Operating temperature range	
at zero power	−25 to +155 °C
at maximum power	0 to +55 °C

APPLICATION

Intended for general use

DESCRIPTION

Rod thermistors with a negative temperature coefficient, provided with two tangential solid tinned copper wires. They are neither lacquered nor insulated.

MECHANICAL DATA

Dimensions (mm)

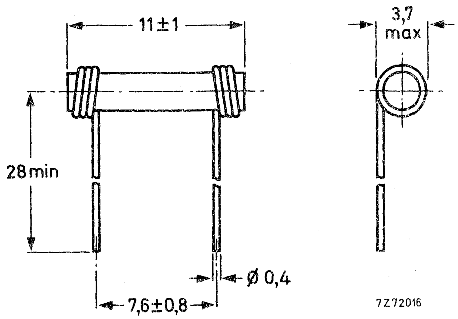


Fig. 1

Marking

The thermistors have one or two colour dots in the middle of the rod, see Table. Types with a tolerance of 10% on R_{25} also have a red dot at one end.

Weight 0, 32 g approximately

Mounting In any position by soldering

Robustness of termination

Tensile strength 5 N

Bending 2, 5 N

Soldering

Solderability max. 240 °C, max. 4 s

Resistance to heat max. 265 °C, max. 11 s

ELECTRICAL DATA

Unless otherwise specified measured according to IEC draft publication 40 (CO) 226 and 337.

R_{25} (kΩ)	$B_{25/85}$ ± 5% (K)	temperature coefficient *) (%/ °C)	colour code	catalogue number tol. ± 20%	catalogue number tol. ± 10% **)
4, 7	3300	- 3, 70	orange	2322 635 01472	2322 635 02472
15	3600	- 4, 05	green	2322 635 01153	2322 635 02153
47	3925	- 4, 25	blue	2322 635 01473	2322 635 02473
150	4075	- 4, 65	white	2322 635 01154	2322 635 02154
330	4250	- 4, 85	yellow/blue	2322 635 01334	2322 635 02334
470	4300	- 4, 75	yellow/orange	2322 635 01474	2322 635 02474

Maximum dissipation 0, 6 W

Dissipation factor 5 mW/ °C *)

Thermal time constant 30 s *)

Heat capacity of ceramic 0, 135 J/ °C *)

of complete component 0, 150 J/ °C *)

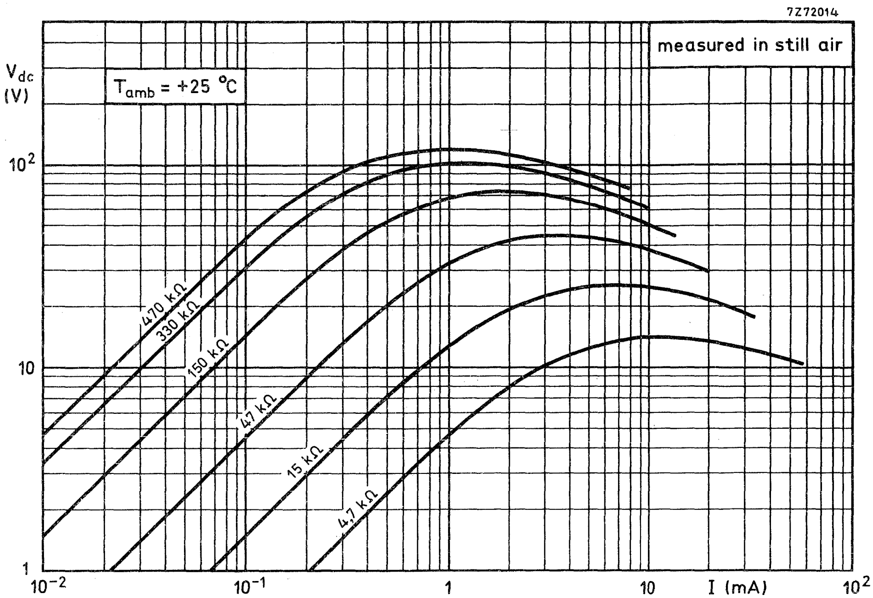
Operating temperature range

at zero power −25 to +155 °C

at maximum power 0 to +55 °C

*) approximate values, measured in the test set, according to NF C 93-271

**) on R_{25}



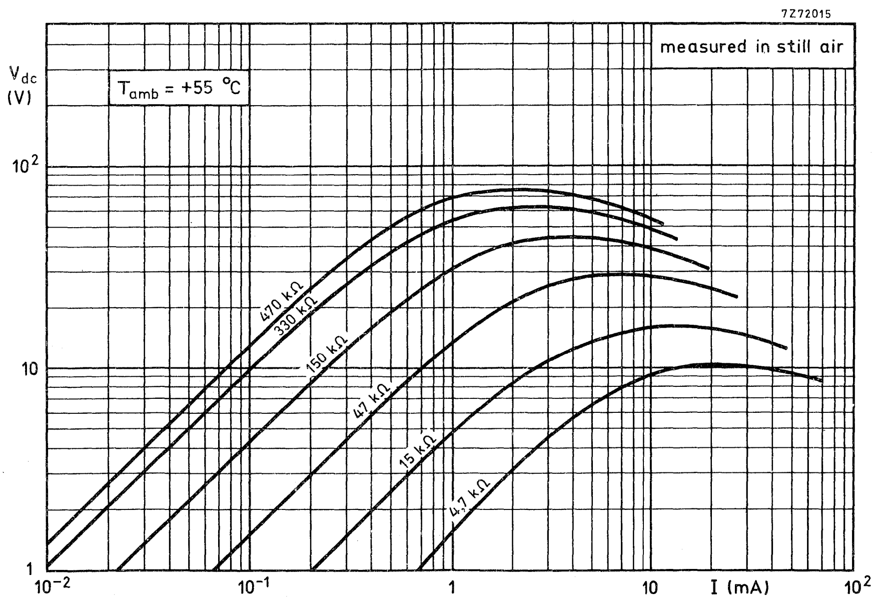


Fig. 2a and b. Typical voltage/current characteristics

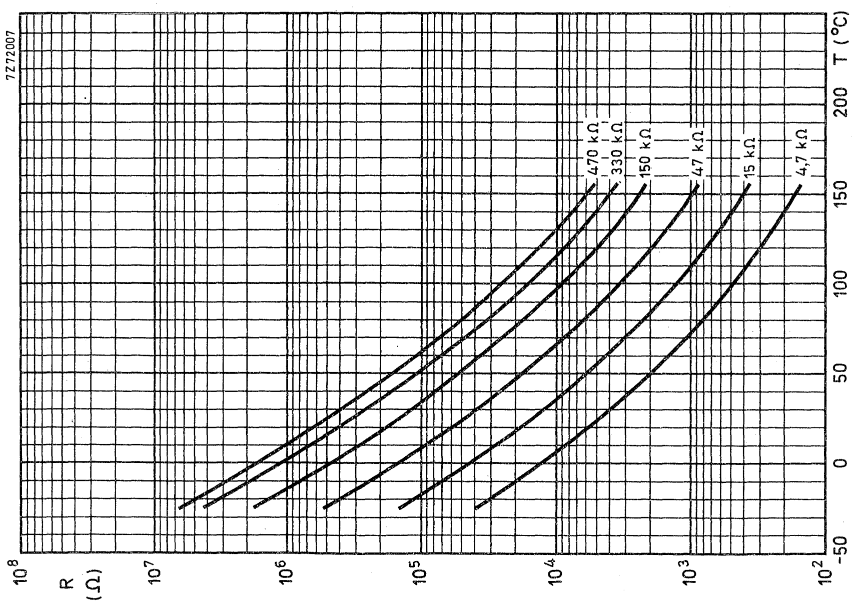


Fig. 3 Typical resistance/temperature characteristics

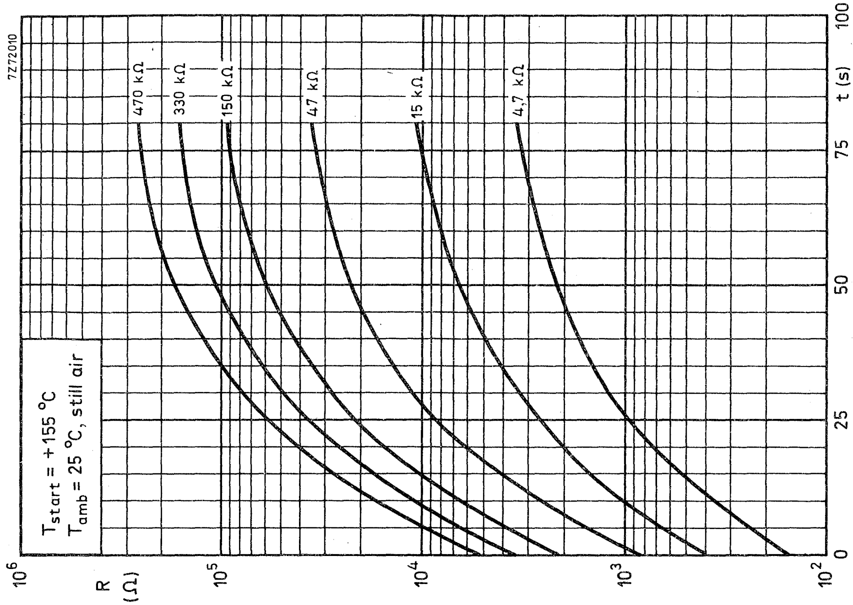


Fig. 4 Typical resistance/time (cooling) characteristics

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	ΔR/R (%) at +25 °C	ΔB/B (%)
Cold at −25 °C	A	1000 h	± 3	± 2
Storage at +25 °C	H	1000 h	± 3	± 1
Dry heat, +155 °C	B	1000 h	± 5	± 2
Thermal shock −25 to +155 °C	Na	5 cycles	± 3	± 2
Damp heat, +40 °C	Ca	1000 h	± 5	± 3
Maximum dissipation		1000 h	± 5	± 2
Robustness of terminations	U			
Tensile strength 5 N	Ua	10 s	[1]	
Bending 2,5 N	Ub	2 times	[1]	
Soldering	T			
Solderability at 230 °C	par. 3.2.3	3 to 4 s	[2]	
Resistance to heat at 260 °C	Tb	10 ± 1 s	± 2	± 2

[1]) Leads should neither come loose nor break

[2]) Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D

A.Q.L. 1%, major defects - Electrical
A.Q.L. 1,5%, major defects - Mechanical
A.Q.L. 4%, minor defects - Physical

PACKING

In cardboard boxes of 250

NTC THERMISTORS
rod

QUICK REFERENCE DATA	
Resistance values at +25 °C	4,7 kΩ to 150 kΩ
$B_{25/85}$ - value	3250 to 4150 K
Maximum dissipation	1,5 W
Dissipation factor	10 mW/°C
Thermal time constant	55 s
Operating temperature range	
at zero power	−25 to +155 °C
at maximum power	0 to +55 °C

APPLICATION

Intended for general use.

DESCRIPTION

Rod thermistors with a negative temperature coefficient, provided with two tangential solid tinned copper wires. They are neither lacquered nor insulated.

MECHANICAL DATA

Dimensions (mm)

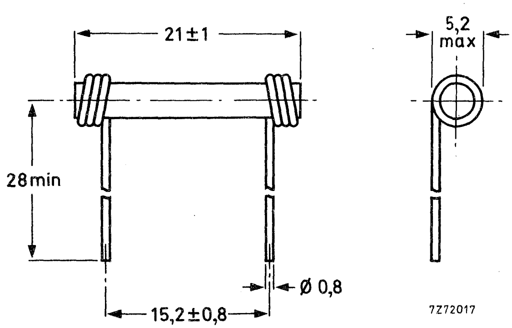


Fig.1

Marking

The thermistors have a colour dot in the middle of the rod, see Table. Types with a tolerance of 10% on R_{25} also have a red dot at one end.

Weight 1,25 g approximately

Mounting In any position by soldering

Robustness of termination

Tensile strength	20 N
Bending	10 N

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s

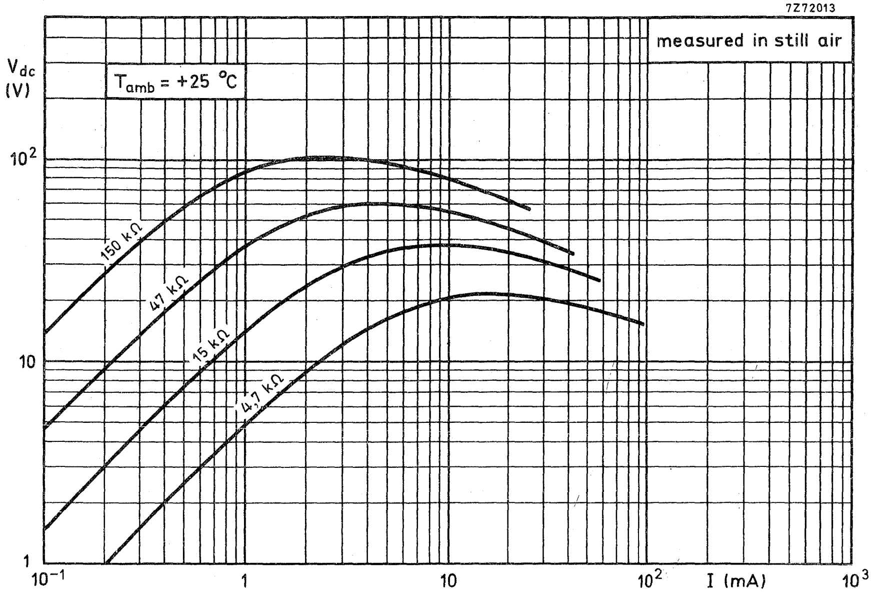
ELECTRICAL DATA

Unless otherwise specified, measured according to IEC draft publication 40 (CO) 226 and 337.

R_{25} (kΩ)	$B_{25/85}$ ± 5% (K)	temperature coefficient *) (%/ °C)	colour code	catalogue number	
				tol. ± 20%	tol. ± 10% **)
4,7	3250	−3,55	orange	2322 636 01472	2322 636 02472
15	3550	−4,0	green	2322 636 01153	2322 636 02153
47	4000	−4,5	blue	2322 636 01473	2322 636 02473
150	4150	−4,65	white	2322 636 01154	2322 636 02154

Maximum dissipation	1,5 W	
Dissipation factor	10 mW/ °C	*)
Thermal time constant	55 s	*)
Heat capacity of ceramic	0,44 J/ °C	*)
of complete component	0,55 J/ °C	*)
Operating temperature range		
at zero power	−25 to +155 °C	
at maximum power	0 to +55 °C	

*) approximate values, measured in the test set according to NF C 93-271
**) on R_{25}



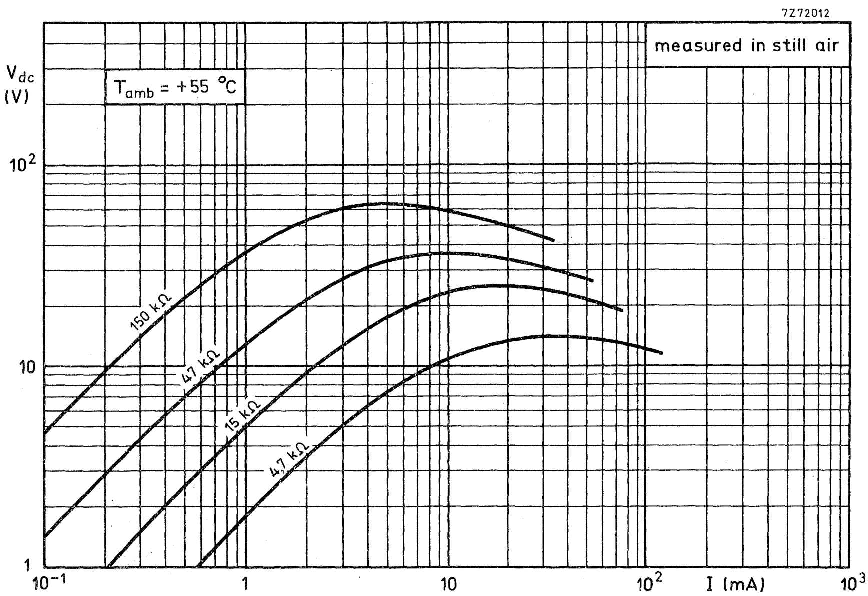


Fig. 2a and b. Typical voltage/current characteristics

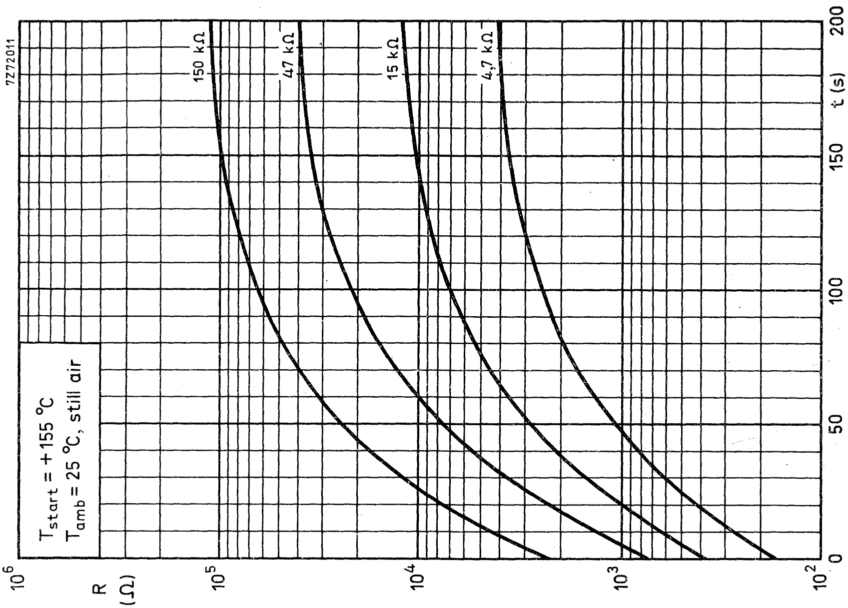


Fig. 4 Typical resistance/time (cooling) characteristics

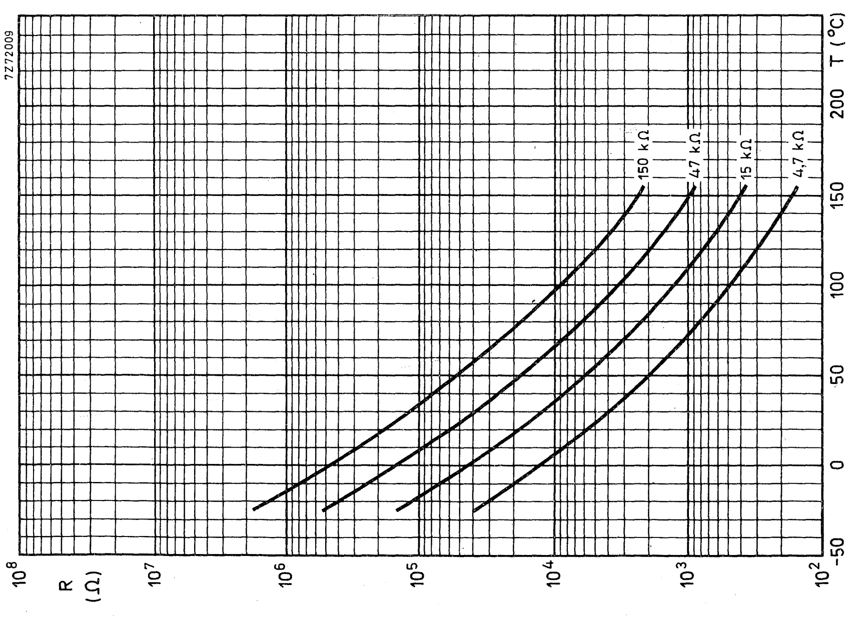


Fig. 3 Typical resistance/temperature characteristics

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	ΔR/R (%) at +25 °C	ΔB/B (%)
Cold at −25 °C	A	1000 h	± 3	± 2
Storage at +25 °C	H	1000 h	± 3	± 1
Dry heat, +155 °C	B	1000 h	± 5	± 2
Thermal shock −25 to +155 °C	Na	5 cycles	± 3	± 2
Damp heat, +40 °C	Ca	1000 h	± 5	± 3
Maximum dissipation		1000 h	± 5	± 2
Robustness of terminations	U			
Tensile strength 20 N	Ua	10 s	1)	
Bending 10 N	Ub	2 times	1)	
Soldering	T			
Solderability at 230 °C	par. 3.2.3	3 to 4 s	2)	
Resistance to heat at 260 °C	Tb	10 ±1 s	± 2	± 2

1) Leads should neither come loose nor break

2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D

A.Q.L. 1%, major defects - Electrical
A.Q.L. 1,5%, major defects - Mechanical
A.Q.L. 4%, minor defects - Physical

PACKING

In cardboard boxes of 100

NTC THERMISTORS
rod

QUICK REFERENCE DATA	
Resistance values at +25 °C	4,7 kΩ to 150 kΩ
$B_{25/85}$ - value	3200 to 4200 K
Maximum dissipation	2,3 W
Dissipation factor	17 mW/ °C
Thermal time constant	105 s
Operating temperature range	
at zero power	−25 to +155 °C
at maximum power	0 to +55 °C

APPLICATION

Intended for general use.

DESCRIPTION

Rod thermistors with a negative temperature coefficient, provided with two tangential solid tinned copper wires. They are neither laquered nor insulated.

MECHANICAL DATA

Dimensions (mm)

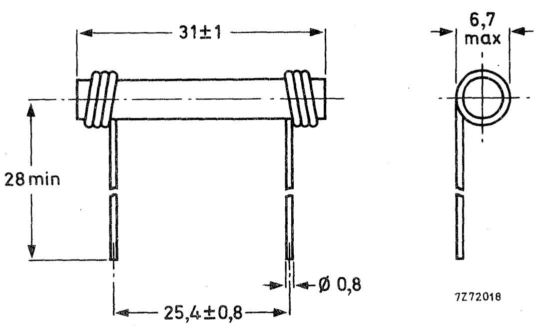


Fig. 1

Marking

The thermistors have a colour dot in the middle of the rod, see Table.
Types with a tolerance of 10% on R_{25} also have a red dot at one end.

Weight 2, 65 g approximately

Mounting In any position by soldering

Robustness of terminations

Tensile strength 20 N

Bending 10 N

Soldering

Solderability max. 240 °C, max. 4 s

Resistance to heat max. 265 °C, max. 11 s

ELECTRICAL DATA

Unless otherwise specified, measured according to IEC draft publication 40 (CO) 226 and 337.

R_{25} (kΩ)	$B_{25/85}$ ± 5% (K)	temperature coefficient *) (%/ °C)	colour code	catalogue number tol. ± 20%	catalogue number tol. ± 10% **)
4, 7	3200	− 3, 6	orange	2322 637 01472	2322 637 02472
15	3550	− 4, 0	green	2322 637 01153	2322 637 02153
47	3750	− 4, 2	blue	2322 637 01473	2322 637 02473
150	4200	− 4, 7	white	2322 637 01154	2322 637 02154

Maximum dissipation 2, 3 W

Dissipation factor 17 mW/ °C *)

Thermal time constant 105 s *)

Heat capacity 1, 785 J/ °C *)

Operating temperature range
at zero power −25 to +155 °C
at maximum power 0 to +55 °C

*) approximate values, measured in the test set according to NF C 93-271
**) on R_{25}

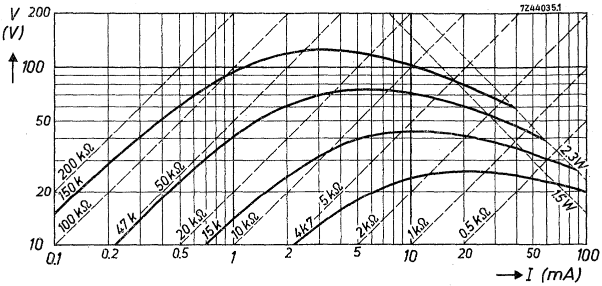


Fig. 2 Typical voltage/current characteristics

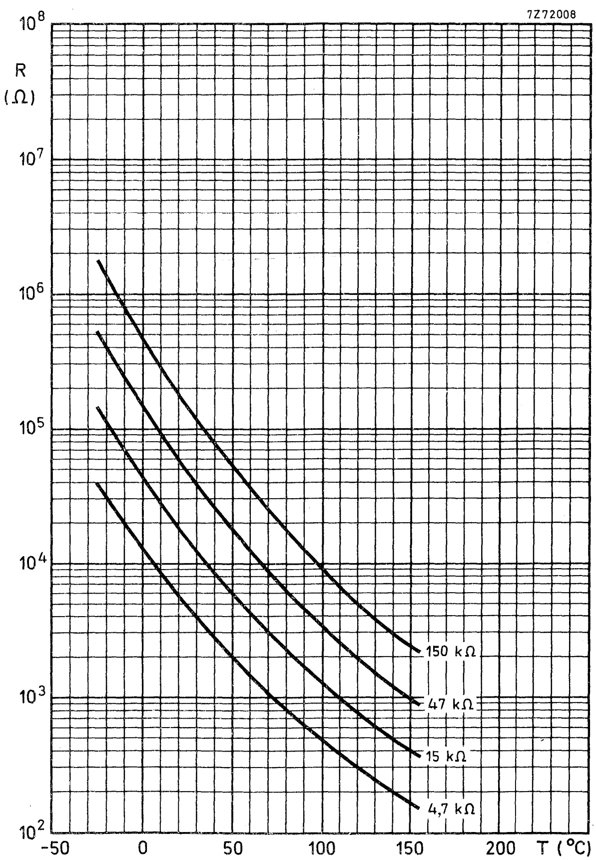


Fig. 3 Typical resistance/temperature characteristics

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	ΔR/R (%) at +25 °C	ΔB/B (%)
Cold at −25 °C	A	1000 h	± 3	± 2
Storage at +25 °C	H	1000 h	± 3	± 1
Dry heat, +155 °C	B	1000 h	± 5	± 2
Thermal shock −25 to +155 °C	Na	5 cycles	± 3	± 2
Damp heat, +40 °C	Ca	1000 h	± 5	± 3
Maximum dissipation		1000 h	± 5	± 2
Robustness of terminations	U			
Tensile strength 20 N	Ua	10 s	[1]	
Bending 10 N	Ub	2 times	[1]	
Soldering	T			
Solderability at 230 °C	par. 3.2.3	3 to 4 s	[2]	
Resistance to heat at 260 °C	Tb	10 ± 1 s	± 2	± 2

[1]) Leads should neither come loose nor break

[2]) Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D

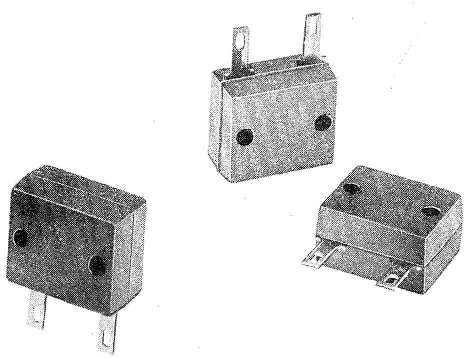
A.Q.L. 1%, major defects - Electrical
A.Q.L. 1,5%, major defects - Mechanical
A.Q.L. 4%, minor defects - Physical

PACKING

In cardboard boxes of 50

NTC THERMISTORS
moulded

QUICK REFERENCE DATA	
Resistance value at −10 °C	5000 Ω ± 4.5%
at −30 °C	13350 Ω ± 5%
$B_{25/85}$ -value	3425 °K
Maximum dissipation at T_{amb} = 55 °C	0.5 W
Dissipation factor when mounted on a heat-sink	25 mW/degC
Thermal time constant	165 s
when mounted on a heat-sink	12 s
Operating temperature range	
at zero power	−55 to +85 °C
at maximum power	−55 to +55 °C



APPLICATION

For temperature control in deep freezers.

DESCRIPTION

The thermistor has a negative temperature coefficient. The thermistor element is fitted flush with the moulded body and provided with two connecting tags.
Two holes for mounting by means of screws are made in the body.

MECHANICAL DATA

Dimensions in mm

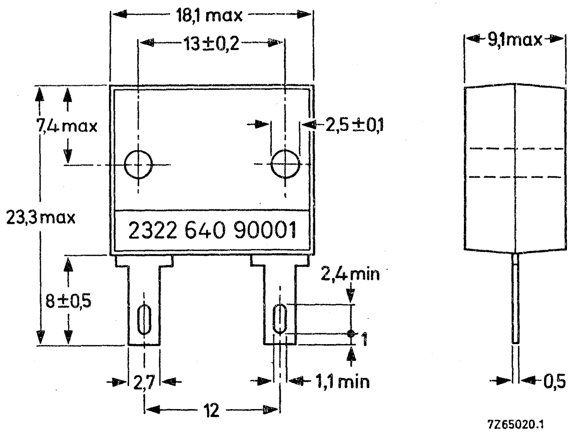


Fig. 1

Marking

The catalogue number is moulded on one side of the item.

Weight

5 g approximately.

Mounting

By means of screws or by plugging into AMP connectors.
The NTC element is situated at the side opposite to that of the catalogue number.

Robustness of terminations

Tensile strength	20 N

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s

ELECTRICAL DATA

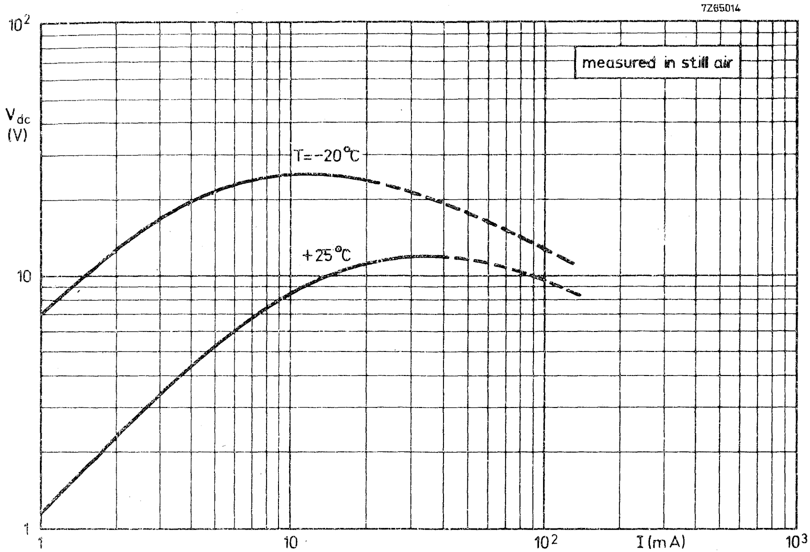
Resistance at −10 °C	5000 Ω ± 4.5%
Resistance at −30 °C	13350 Ω ± 5%
$B_{25/85}$ -value	3425 K
Temperature coefficient at 25 °C	−3,85%/°C
Maximum dissipation at T_{amb} = 25 °C	0.5 W
Dissipation factor	12 mW/°C approx. [1]
Dissipation factor when mounted on a heat-sink	25 mW/°C approx. [2]
Thermal time constant	165 s approx. [1]
Thermal time constant when mounted on a heat-sink	12 s approx. [2]
Response time, air +25 °C/oil −30 °C	19 s approx. [3]
Heat capacity of element	0,009 J/°C approx. [1]
Heat capacity of complete sensor	2,0 J/°C approx. [1]
Operating temperature range	
at zero power	−55 to +85 °C
at maximum power	−55 to +55 °C
Dielectric withstanding voltage between terminals and coating	min. 1500 V
Insulation resistance at 100 V d.c.	min. 100 MΩ

---

1) Measurements made in still air, two phosphor-bronze wires (ϕ 1.3 mm) being connected to the specimen.

2) Measurements in still air when the specimen is mounted on a heat-sink of 1 dm^2, thickness 1.5 mm and connected between phosphor-bronze wires (ϕ 1.3 mm).

3) This is the time which elapses before the body temperature has dropped by 63.2 % of the whole temperature traverse from +25°C to -30°C as a result of the thermistor being transferred from ambient air of +25°C to a silicone oil (MS200/5) bath of -30°C.



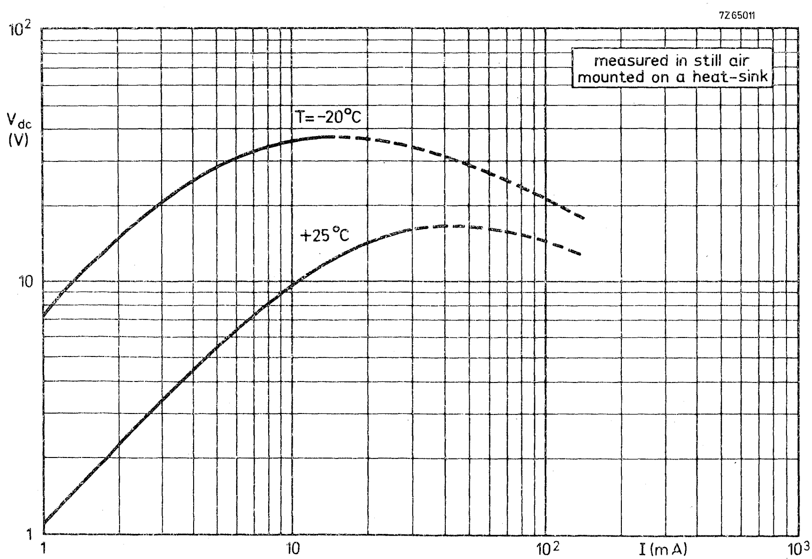


Fig. 2a and b. Typical voltage/current characteristics

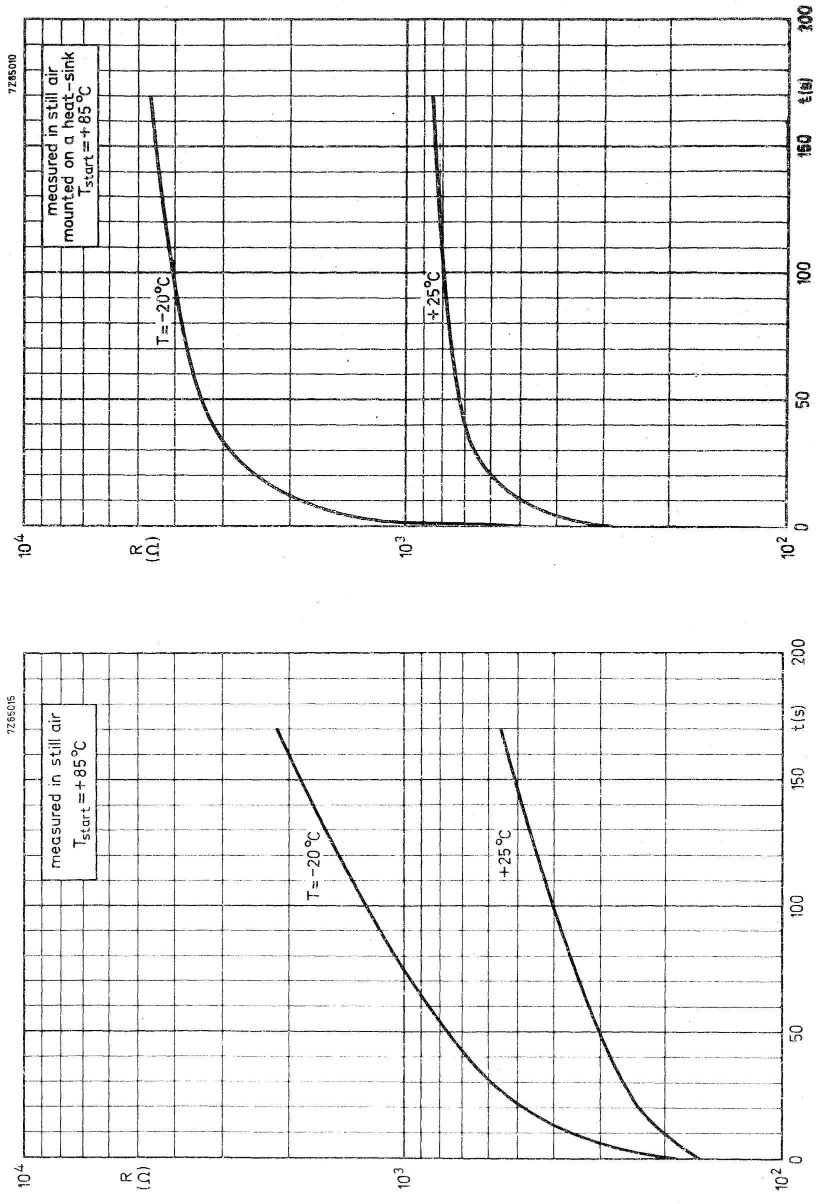


Fig.3a and b. Typical resistance/time (cooling) characteristics

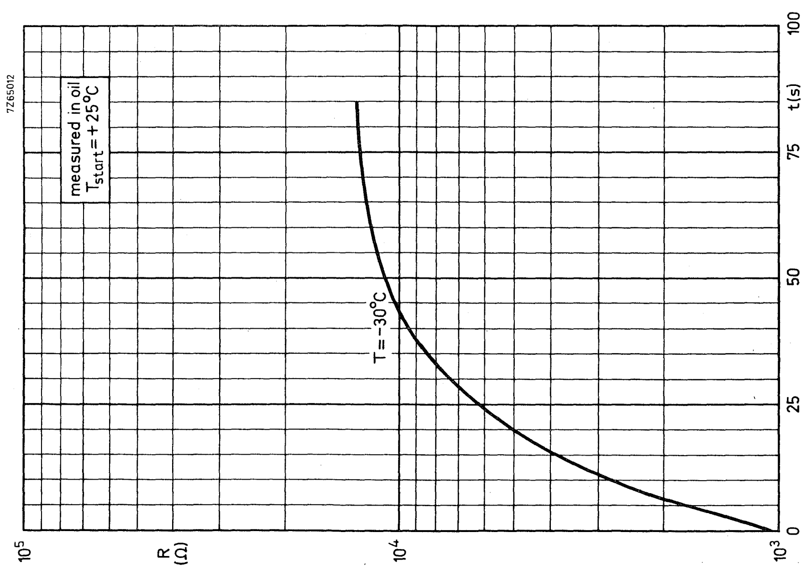


Fig. 4. Typical resistance/time (cooling) characteristic, measured in silicone oil MS 200/5

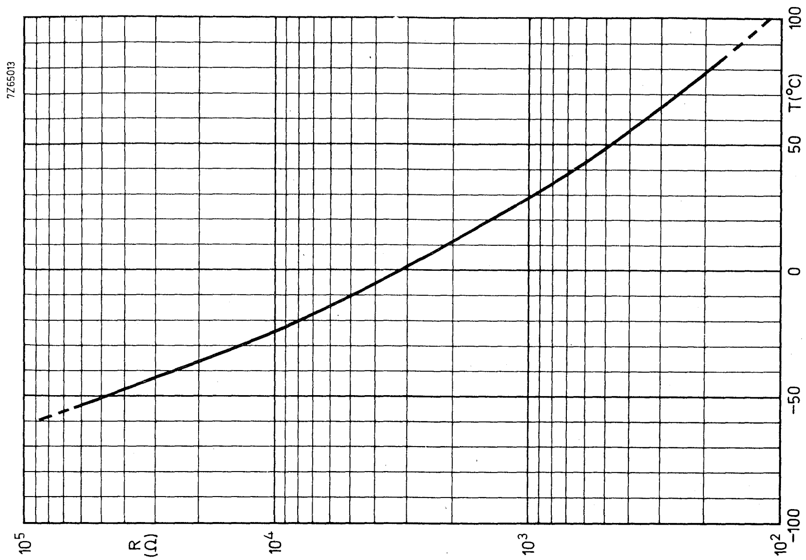
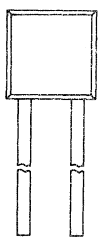


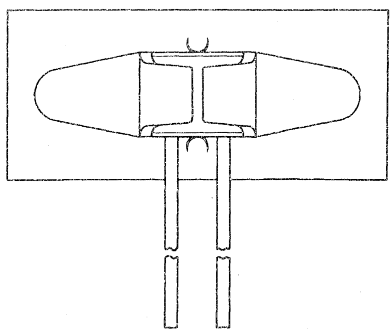
Fig. 5. Typical resistance/temperature characteristic

NTC THERMISTORS

moulded

QUICK REFERENCE DATA			
	2322 640 90002	2322 640 98002	
Resistance value at −20 °C	8600 ± 8%	8600 ± 8%	Ω
0 °C	3500	3500	Ω
+25 °C	1215 ± 7%	1215 ± 7%	Ω
$B_{25/85}$-value	3425	3425	°K
Maximum dissipation	0, 25	0, 25	W
Dissipation factor	6, 7	9	mW/degC
when mounted on a heat-sink	16	21	mW/degC
Thermal time constant	17	32	s
when mounted on a heat-sink	6	3	s
Operating temperature range			
at zero power	−25 to +85	−25 to +85	°C
at maximum power	−25 to +55	−25 to +55	°C





APPLICATION

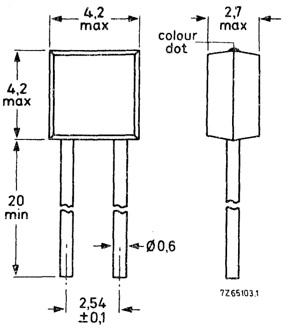
For room temperature control.

DESCRIPTION

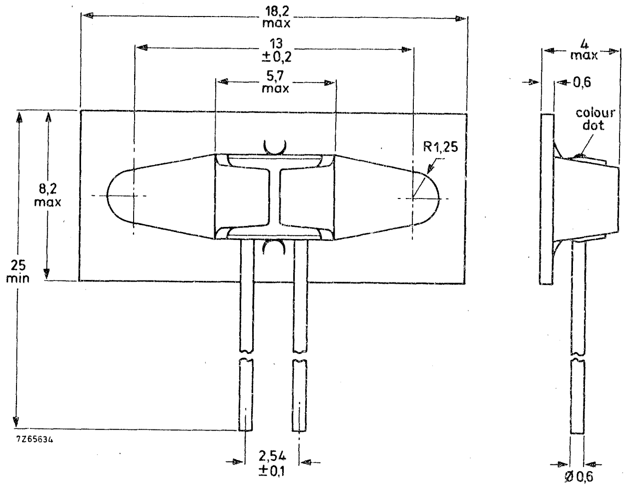
Moulded disc thermistor with negative temperature coefficient and with two solid tinned copper wires.
The thermistor 2322 640 98002 is provided with a metal strip for mounting.

MECHANICAL DATA

Dimensions (mm)



type 2322 640 90002



type 2322 640 98002
with metal strip for mounting

Marking

The thermistors have a blue dot.

Weight

Type 2322 640 90002	0,3 g approx.
Type 2322 640 98002	0,5 g approx.

Mounting

Type 2322 640 90002	in any position by soldering
Type 2322 640 98002	by means of the mounting strip

Robustness of terminations

Tensile strength	10 N
Bending	5 N

Soldering

Solderability	max. 240 ^{o}C, max. 4 s
Resistance to heat	max. 265 ^{o}C, max. 11 s

Impact

Free fall	1 m

Inflammability

Uninflammable -CCTU-01-01A specification, test 22.

ELECTRICAL DATA

Unless otherwise specified, measured according to IEC draft publication 40 (CO) 226 and 337.

All values in the table without further indication are approximate values.

	2322 640 90002	2322 640 98002	
Resistance value at −20 °C	8600 ± 8%	8600 ± 8%	Ω
0 °C	3500	3500	Ω
+25 °C	1215 ± 7%	1215 ± 7%	Ω
$B_{25/85}$-value	3425	3425	K
Temperature coefficient	−3,9	−3,9	%/°C
Maximum dissipation	0,25	0,25	W
Dissipation factor	6,7	9	mW/°C
when mounted on a heat-sink [1])	16	21	mW/°C
Thermal time constant	17	32	s
when mounted on a heat-sink [1])	6	3	s
Heat capacity of ceramic	0,009	0,009	J/°C
of complete component	0,11	0,29	J/°C
Response time [2])	3	1,3	s
Operating temperature range			
at zero power	−25 to +85	−25 to +85	°C
at maximum power	−25 to +55	−25 to +55	°C
Dielectric withstanding voltage between terminals and coating	min. 350	min. 350	V r.m.s.
Insulation resistance between terminals and coating at 100 V d.c.	min. 100	min. 100	MΩ

[1]) Measurements made in still air with the thermistor mounted on a heat-sink of 1 dm^2, thickness 1,5 mm, and connected between phosphor-bronze wires (ϕ1,3 mm).

[2]) This is the time which elapses before the body temperature has dropped by 63,2% of the whole temperature traverse from +25 to −20 °C as a result of the thermistor being transferred from ambient air of +25 °C to a silicone oil (MS200/5) bath of −20 °C.

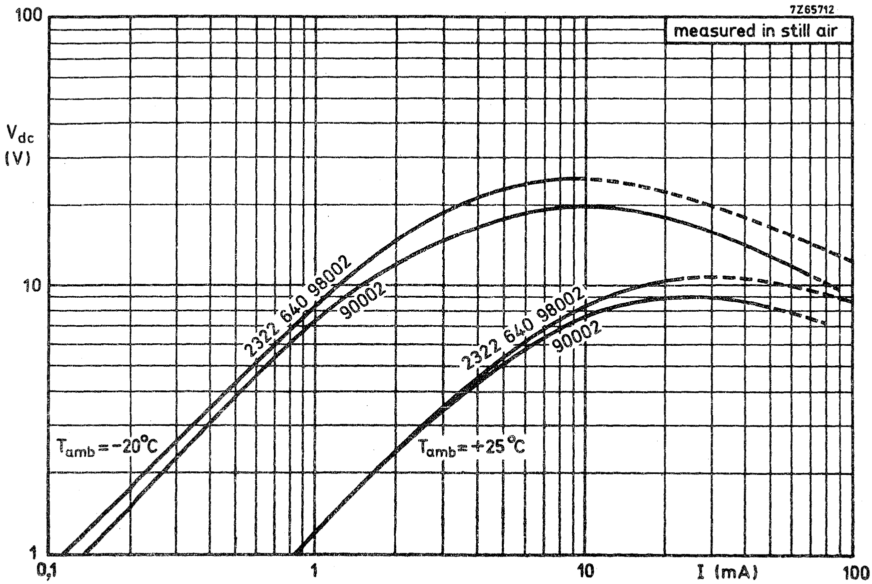


Fig. 2 Typical voltage/current characteristics.

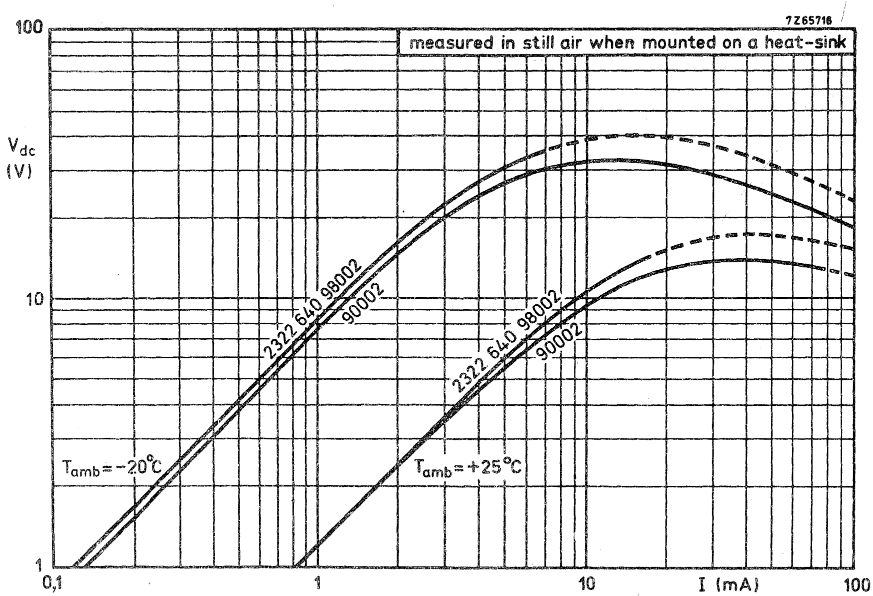


Fig. 3 Typical voltage/current characteristics.

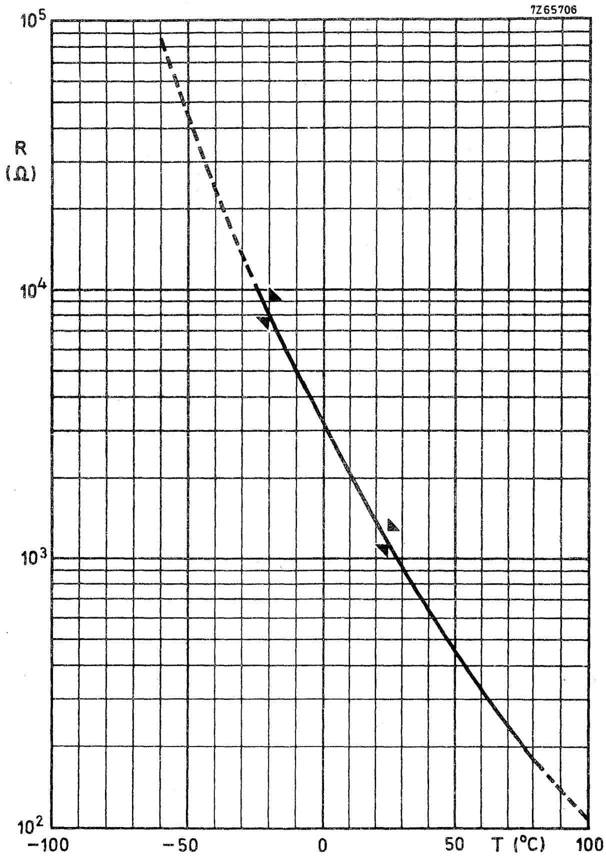


Fig. 4 Typical resistance/temperature characteristics

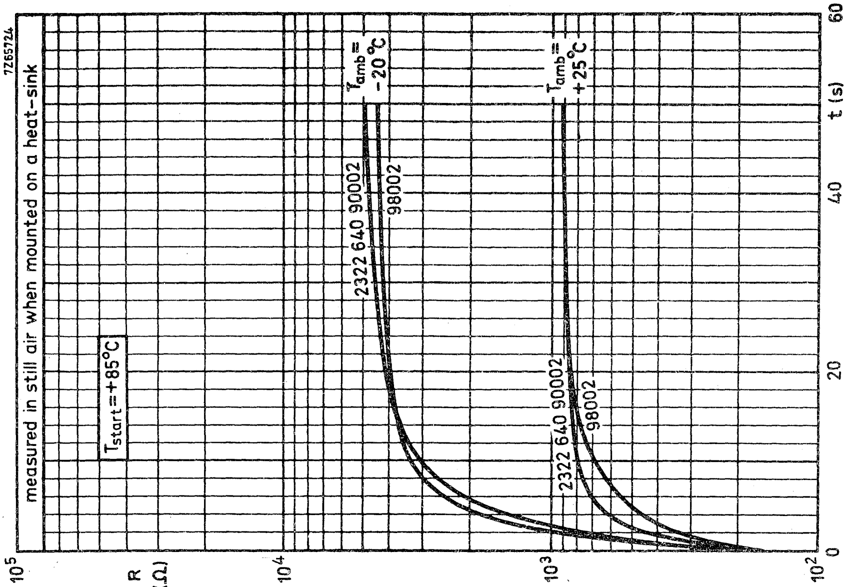


Fig. 6 Typical resistance/time (cooling) characteristics.

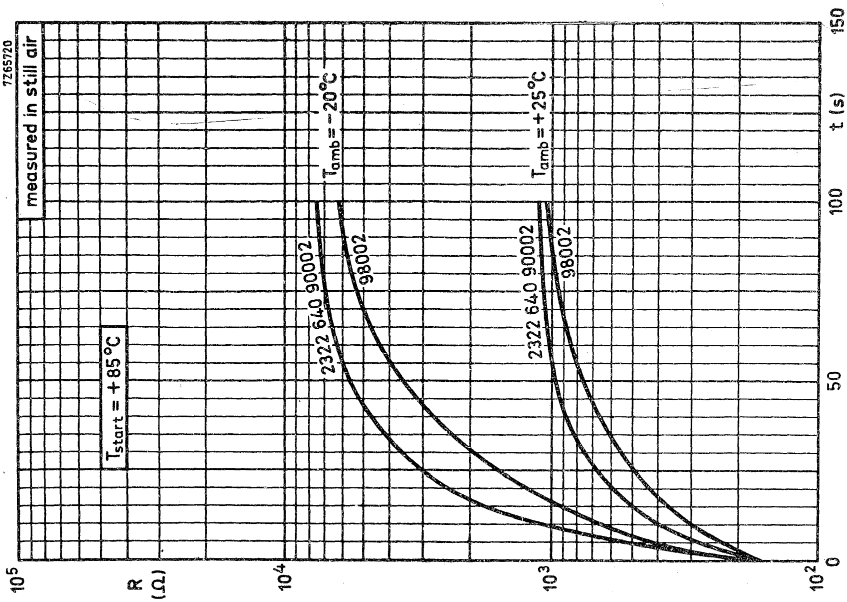


Fig. 5 Typical resistance/time (cooling) characteristics.

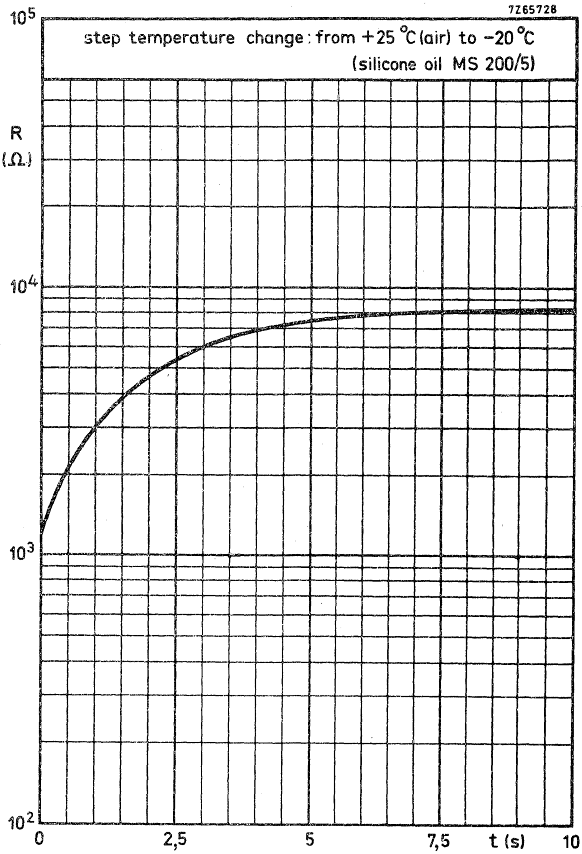


Fig. 7 Typical resistance/response time characteristics.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	$\frac{\Delta R_{25}}{R_{25}}$ (%)	$\frac{\Delta R_{-20}}{R_{-20}}$ (%)
Cold at −25 °C	A	1000 h	± 3	± 3
Storage at +25 °C	H	1000 h	± 3	± 3
Dry heat at +85 °C	B	1000 h	± 5	± 5
Thermal shock −25 to +85 °C (slow)	Na	5 cycles	± 3	± 3
Thermal cycle −25 to +85 °C (fast)		1000 cycles 3)	± 3	± 3
Damp heat at +40 °C	Ca	1000 h	± 5	± 5
Dissipation in damp heat		336 h	± 3,5	± 3,5
Maximim dissipation at T_{amb} = +25 °C		1000 h	± 5	± 5
Robustness of terminations	U			
Tensile strength 10 N	Ua	10 s	1)	
Bending 5 N	Ub	2 times	1)	
Soldering	T			
Solderability at max. 240 °C	par.3.2.3	3 to 4 s	2)	
Resistance to heat at 260±5 °C	Tb	10 ±1 s	± 2	± 2
Impact				
Free fall	Ed	2 falls	4)	

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.
3) Cycle time: 30 min. on/30 min. off.
4) No visual defects will be stated.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D

A.Q.L. 1 %, major defects – Electrical
A.Q.L. 1,5%, major defects – Mechanical
A.Q.L. 4 %, minor defects – Physical

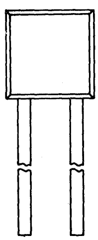
PACKAGING

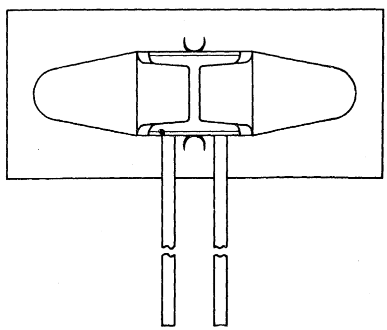
Type 2322 640 90002: 500 pieces per box (cardboard).
Type 2322 640 98002: 400 pieces per box (cardboard).

NTC THERMISTORS

moulded

QUICK REFERENCE DATA			
	2322 640 90003	2322 640 98003	
Resistance value at −10 °C	5000 ± 4,5%	5000 ± 4,5%	Ω
−20 °C	8000 ± 4 %	8000 ± 4 %	Ω
−30 °C	13350 ± 5 %	13350 ± 5 %	Ω
$B_{25/85}$-value	3425	3425	°K
Maximum dissipation	0,25	0,25	W
Dissipation factor	6,7	9	mW/degC
when mounted on a heat-sink	16	21	mW/degC
Thermal time constant	17	32	s
when mounted on a heat-sink	6	3	s
Operating temperature range			
at zero power	−55 to +85	−55 to +85	°C
at maximum power	−55 to +85	−55 to +85	°C





APPLICATION

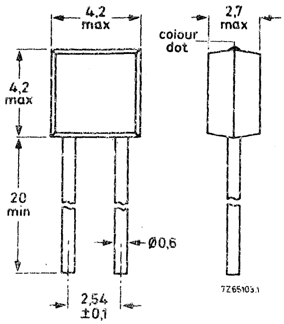
For deepfreezer temperature control.

DESCRIPTION

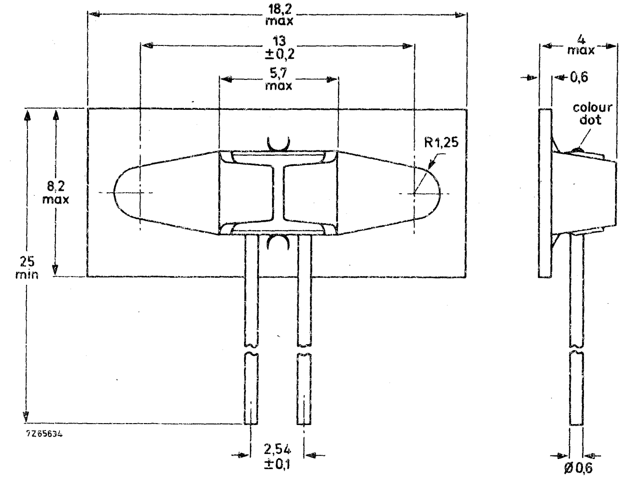
Moulded disc thermistor with negative temperature coefficient and with two solid tinned copper wires.
The thermistor 2322 640 98003 is provided with a metal strip for mounting.

MECHANICAL DATA

Dimensions (mm)



type 2322 640 90003



type 2322 640 98003
with metal strip for mounting

Marking

The thermistors have a white dot.

Weight

Type 2322 640 90003	0,3 g approx.
Type 2322 640 98003	0,5 g approx.

Mounting

Type 2322 640 90003	in any position by soldering
Type 2322 640 98003	by means of the mounting strip

Robustness of terminations

Tensile strength	10 N
Bending	5 N

Soldering

Solderability	max. 240 ^{o}C, max. 4 s
Resistance to heat	max. 265 ^{o}C, max. 11 s

Impact

Free fall	1 m

Inflammability

Uninflammable - CCTU – 01 – 01A specification, test 22.

ELECTRICAL DATA

Unless otherwise specified, measured according to IEC draft publication 40 (CO) 226 and 337.

All values in the table without further indication are approximate values.

	2322 640 90003	2322 640 98003	
Resistance value at −10 °C	5000 ± 4,5%	5000 ± 4,5%	Ω
−20 °C	8000 ± 4 %	8000 ± 4 %	Ω
−30 °C	13350 ± 5 %	13350 ± 5 %	Ω
$B_{25/85}$-value	3425	3425	K
Temperature coefficient	−3,9	−3,9	%/°C
Maximum dissipation	0,25	0,25	W
Dissipation factor	6,7	9	mW/°C
when mounted on a heat-sink 1)	16	21	mW/°C
Thermal time constant	17	32	s
when mounted on a heat-sink 1)	6	3	s
Heat capacity of ceramic	0,009	0,009	J/°C
of complete component	0,11	0,29	J/°C
Response time 2)	3	1,3	s
Operating temperature range			
at zero power	−55 to +85	−55 to +85	°C
at maximum power	−55 to +55	−55 to +55	°C
Dielectric withstanding voltage between terminals and coating	min. 350	min. 350	V r.m.s.
Insulation resistance between terminals and coating at 100 V d.c.	min. 100	min. 100	MΩ

1) Measurements made in still air with the thermistor mounted on a heat-sink of 1 dm^2, thickness 1,5 mm, and connected between phosphor-bronze wires (ϕ1,3 mm).

2) This is the time which elapses before the body temperature has dropped by 63,2% of the whole temperature traverse from +25 to −30 °C as a result of the thermistor being transferred from ambient air of +25 °C to a silicon oil (MS200/5) bath of −30 °C.

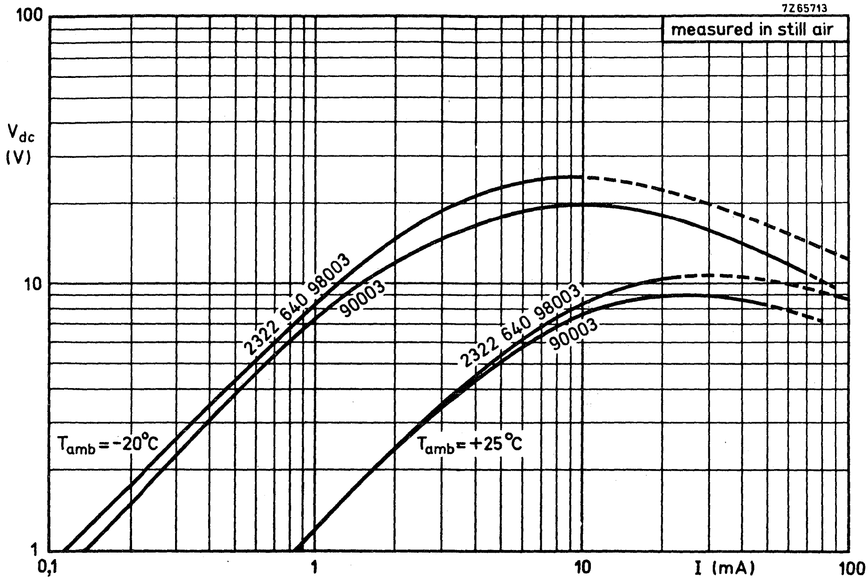


Fig. 2 Typical voltage/current characteristics.

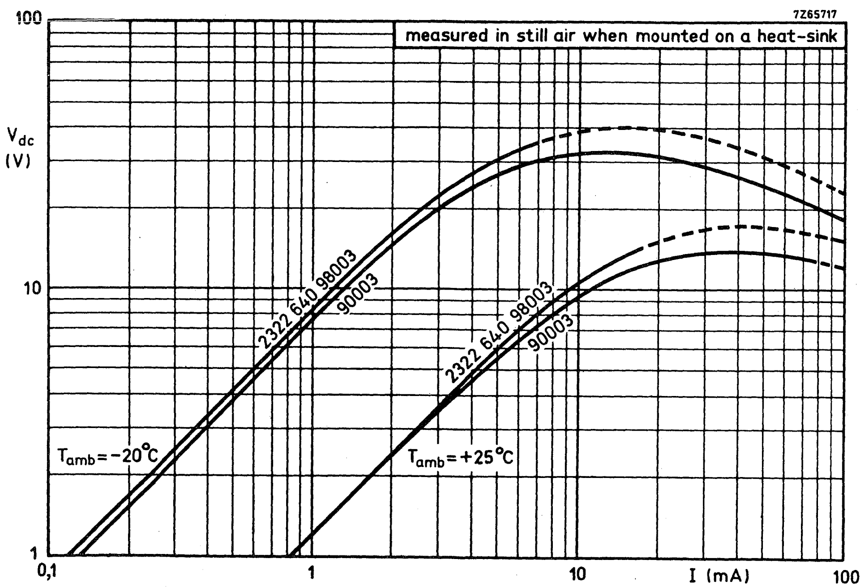


Fig. 3 Typical voltage/current characteristics.

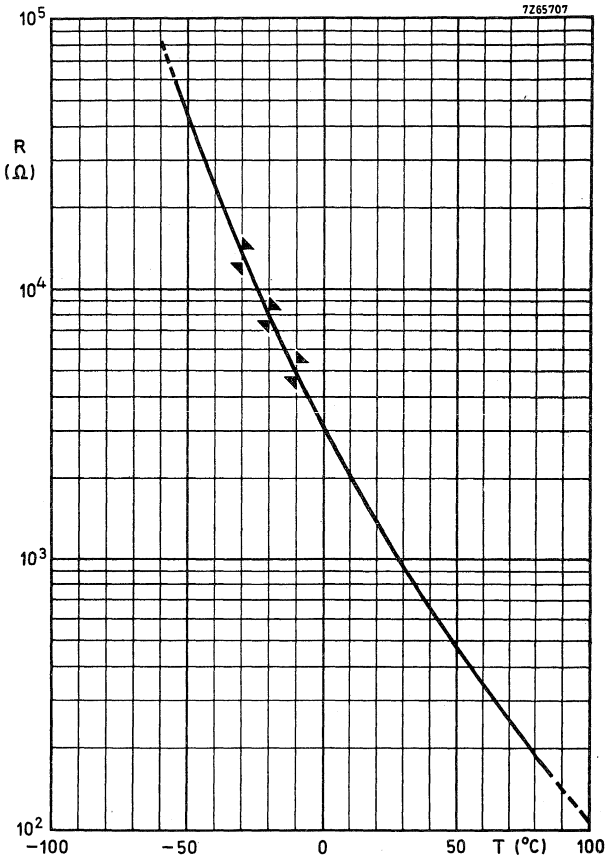


Fig. 4 Typical resistance/temperature characteristics.

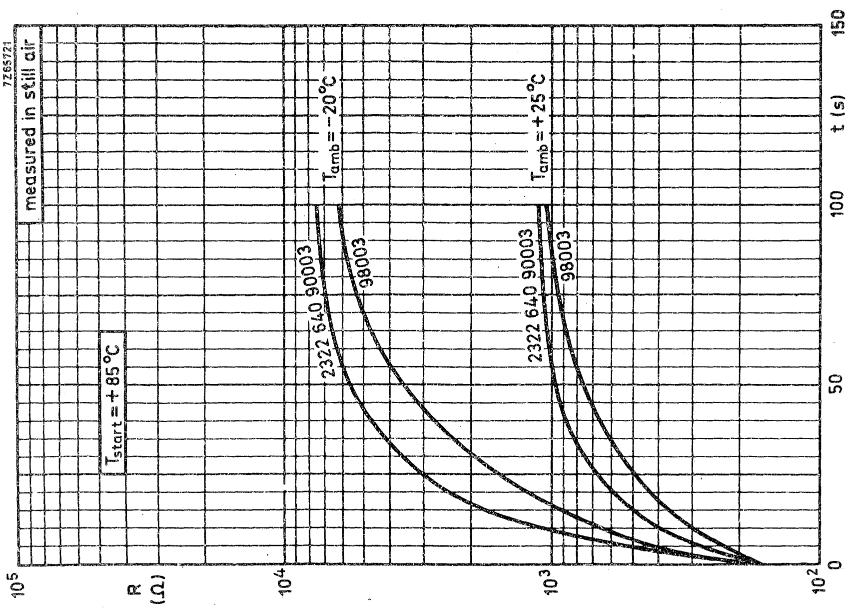


Fig. 5 Typical resistance/time (cooling) characteristics.

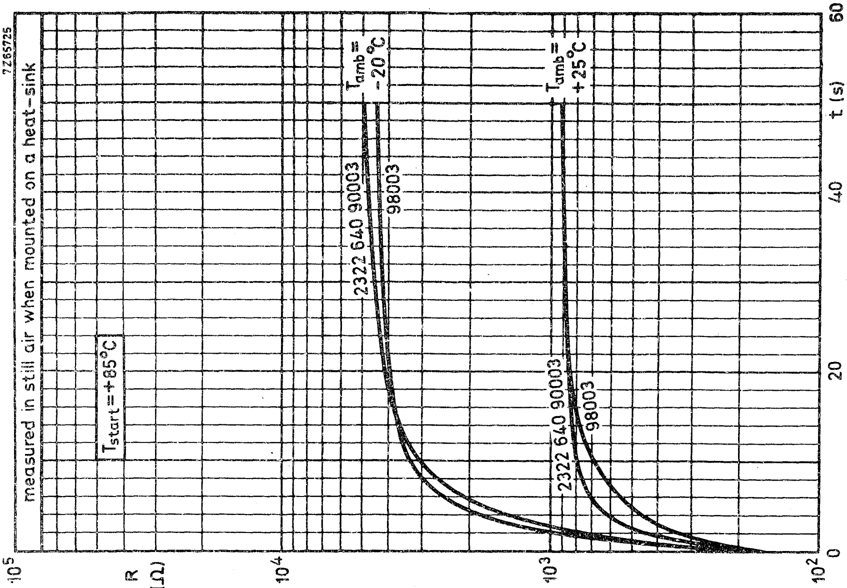


Fig. 6 Typical resistance/time (cooling) characteristics.

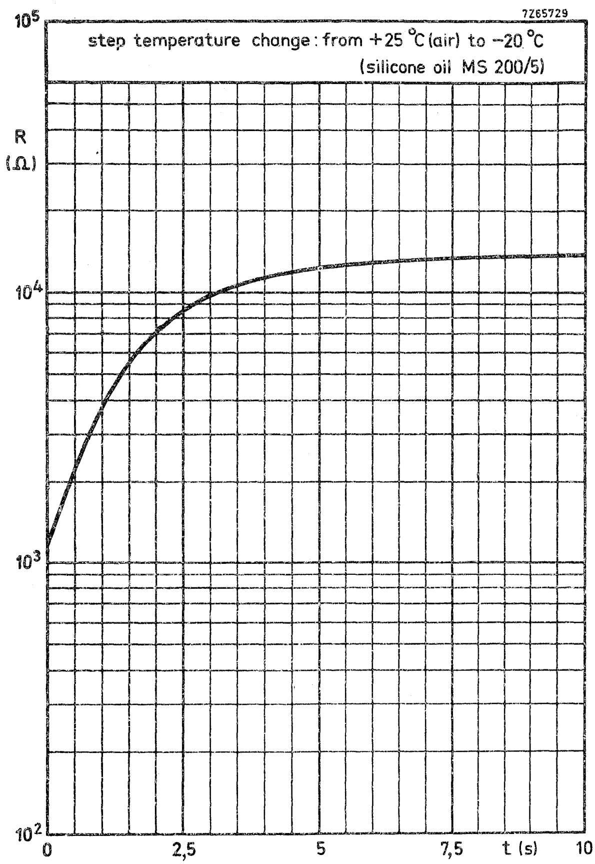


Fig. 7 Typical resistance/response time characteristics.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	$\frac{\Delta R_{-30}}{R_{-30}}$ (%)	$\frac{\Delta R_{-10}}{R_{-10}}$ (%)
Cold at −55 °C	A	1000 h	± 3	± 3
Storage at +25 °C	H	1000 h	± 3	± 3
Dry heat at +85 °C	B	1000 h	± 5	± 5
Thermal shock −55 to +85 °C (slow)	Na	5 cycles	± 3	± 3
Thermal cycle −55 to +85 °C (fast)		1000 cycles 3)	± 3	± 3
Damp heat at +40 °C	Ca	1000 h	± 5	± 5
Dissipation in damp heat		336 h	± 3, 5	± 3, 5
Maximum dissipation at T_{amb} = +25 °C		1000 h	± 5	± 5
Robustness of terminations	U			
Tensile strength 10 N	Ua	10 s	1)	
Bending 5 N	Ub	2 times	1)	
Soldering	T			
Solderability at max. 240 °C	par.3.2.3	3 to 4 s	2)	
Resistance to heat at 260 ± 5 °C	Tb	10 ± 1 s	± 2	± 2
Impact				
Free fall	Ed	2 falls	4)	

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.
3) Cycle time: 30 min on/20 min off.
4) No visual defects will be stated.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects – Electrical
A.Q.L. 1,5%, major defects – Mechanical
A.Q.L. 4 %, minor defects – Physical

PACKAGING

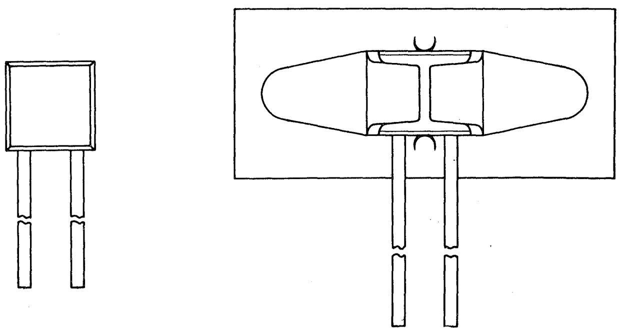
Type 2322 640 90003: 500 pieces per box (cardboard).
Type 2322 640 98003: 400 pieces per box (cardboard).

NTC THERMISTORS

moulded

QUICK REFERENCE DATA

	2322 640 90004	2322 640 98004	
Resistance value at +25 °C	12 ± 7%	12 ± 7%	kΩ
+100 °C	950 ± 5%	950 ± 5%	Ω
$B_{25/85}$-value	3750	3750	°K
Maximum dissipation	0, 25	0, 25	W
Dissipation factor	7	9, 5	mW/degC
when mounted on a heat-sink	19	27	mW/degC
Thermal time constant	19	33	s
when mounted on a heat-sink	10	5	s
Operating temperature range			
at zero power	−10 to +125	−10 to +125	°C
at maximum power	0 to +55	0 to +55	°C



APPLICATION

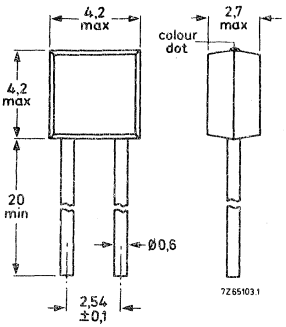
For temperature control.

DESCRIPTION

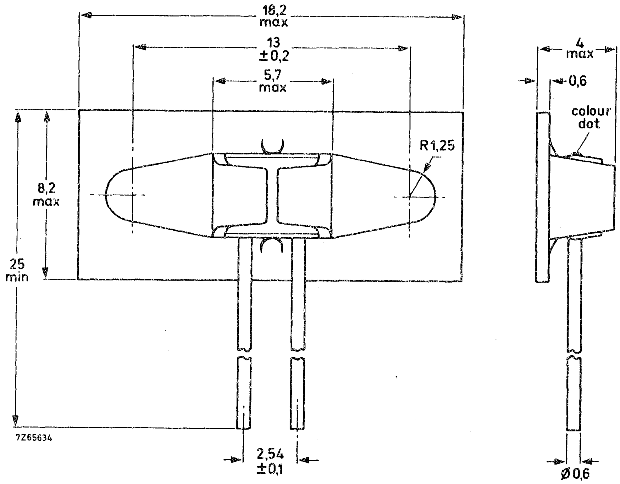
Moulded disc thermistor with negative temperature coefficient and with two solid tinned copper wires.
The thermistor 2322 640 98004 is provided with a metal strip for mounting.

MECHANICAL DATA

Dimensions (mm)



type 2322 640 90004



type 2322 640 98004
with metal strip for mounting

Marking

The thermistors have a grey dot.

Weight

Type 2322 640 90004	0,3 g approx.
Type 2322 640 98004	0,5 g approx.

Mounting

Type 2322 640 90004	in any position by soldering
Type 2322 640 98004	by means of the mounting strip

Robustness of terminations

Tensile strength	10 N
Bending	5 N

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s

Impact

Free fall	1 m

Inflammability

Uninflammable – CCTU – 01 – 01A specification, test 22.

ELECTRICAL DATA

Unless otherwise specified, measured according to IEC draft publication 40 (CO) 226 and 337.

All values in the table without further indication are approximate values.

	2322 640 90004	2322 640 98004	
Resistance at +25 °C	12 ± 7%	12 ± 7%	kΩ
+100 °C	950 ± 5%	950 ± 5%	Ω
$B_{25/85}$-value	3750	3750	K
Temperature coefficient	−4,2	−4,2	%/°C
Maximum dissipation	0,25	0,25	W
Dissipation factor	7	9,5	mW/°C
when mounted on a heat-sink [1]	19	27	mW/°C
Thermal time constant	19	33	s
when mounted on a heat-sink [1]	10	5	s
Heat capacity of ceramic	0,028	0,028	J/°C
of complete component	0,13	0,3	J/°C
Response time [2]	3	3	s
Operating temperature range			
at zero power	−10 to +125	−10 to +125	°C
at maximum power	0 to +55	0 to +55	°C
Dielectric withstanding voltage between terminals and coating/strip	min. 350	min. 350	V r.m.s.
Insulation resistance between terminals and coating/strip at 100 V d.c.	min. 100	min. 100	MΩ

[1]) Measurements made in still air with the thermistor mounted on a heat-sink of 1 dm^2, thickness 1,5 mm, and connected between phosphor-bronze wires (ϕ1,3 mm).

[2]) This is the time which elapses before the body temperature has dropped by 63,2% of the whole temperature traverse from +25 to +85 °C as a result of the thermistor being transferred from ambient air of +25 °C to a silicone oil (MS200/50) bath of +85 °C.

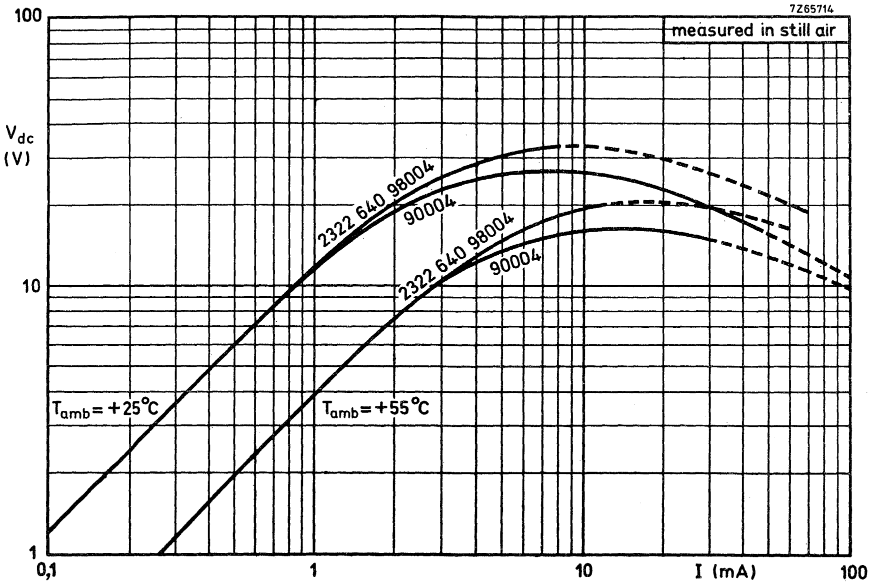


Fig. 2 Typical voltage/current characteristics.

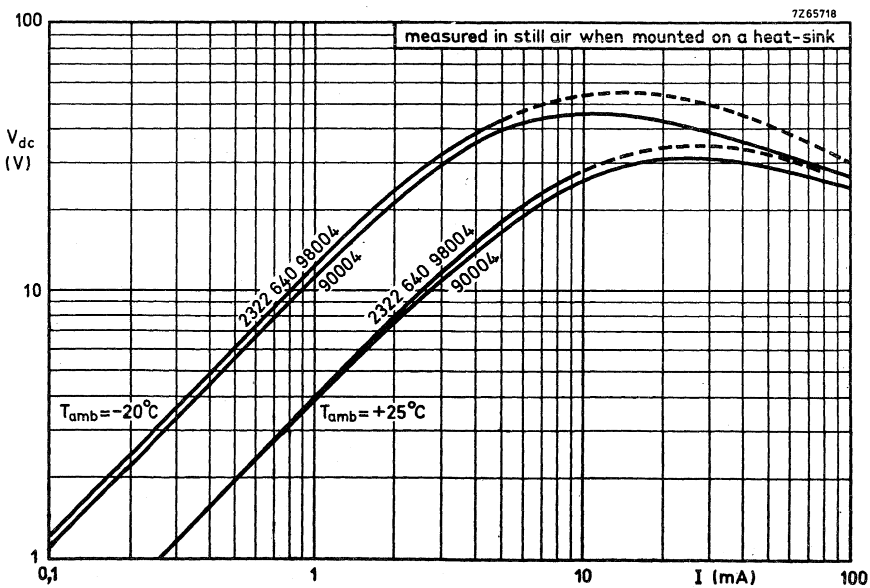


Fig. 3 Typical voltage/current characteristics.

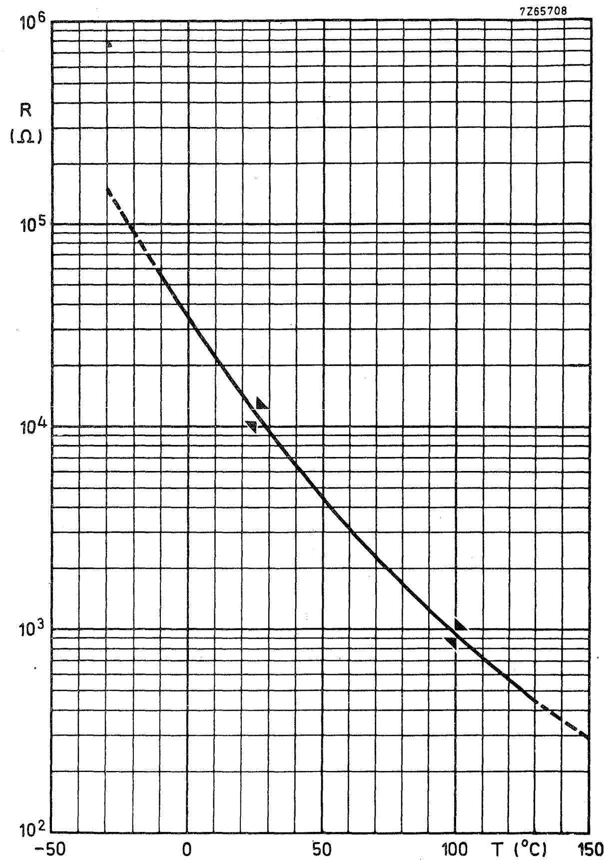


Fig.4 Typical resistance/temperature characteristics.

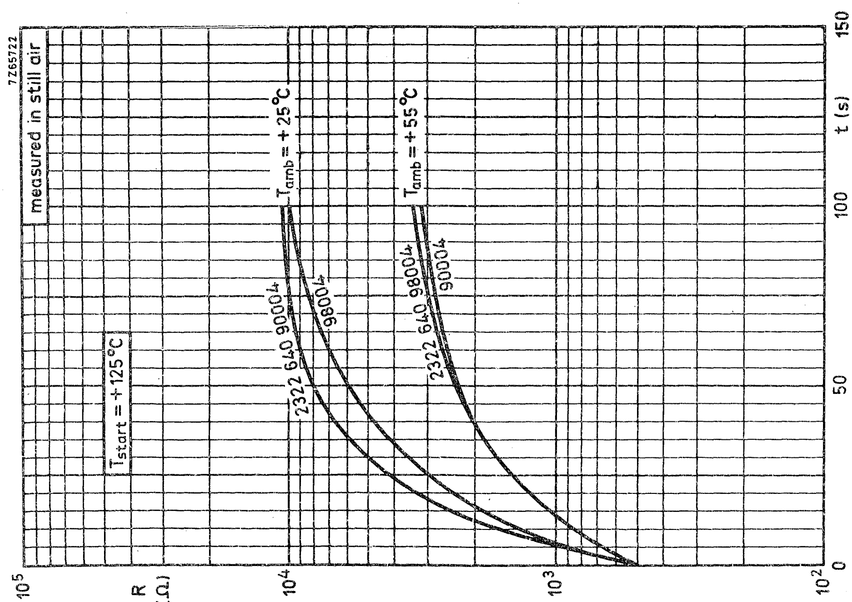


Fig. 5 Typical resistance/time (cooling) characteristics.

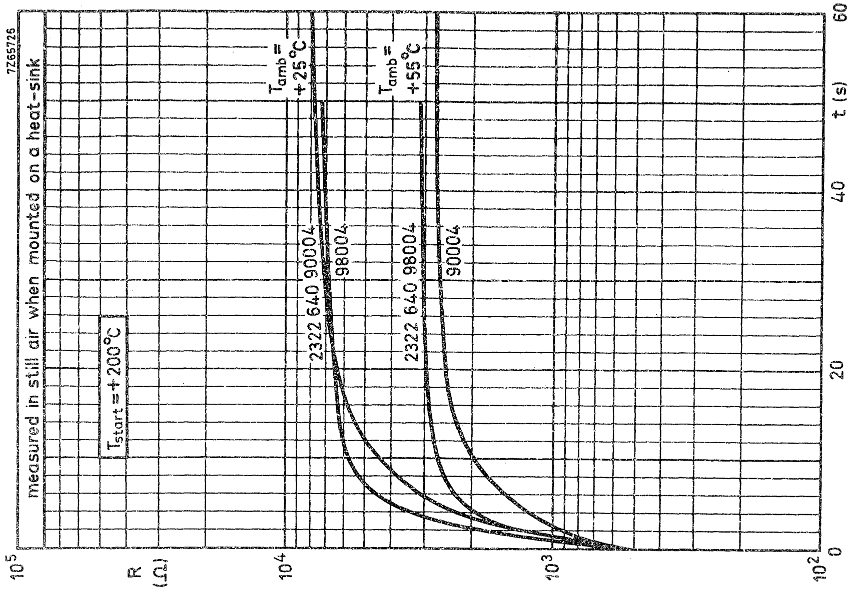


Fig. 6 Typical resistance/time (cooling) characteristics.

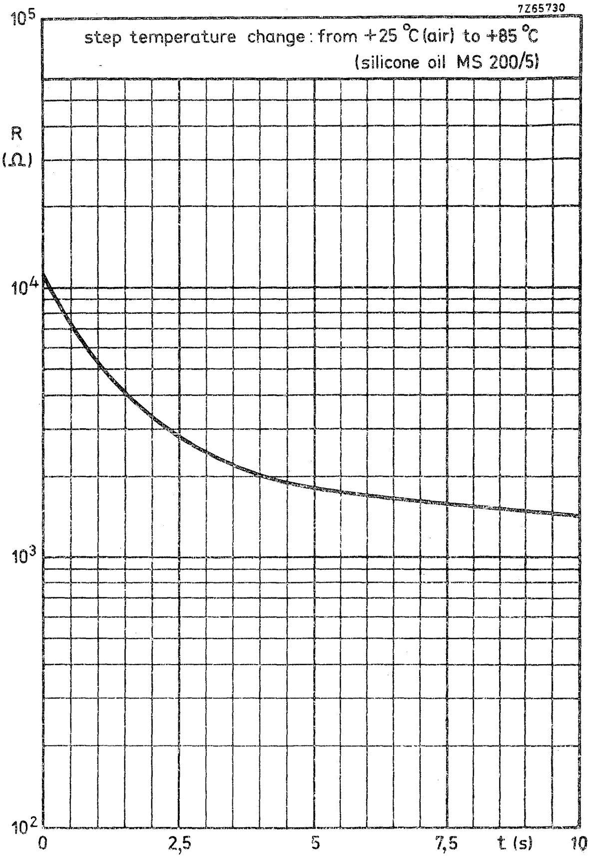


Fig. 7 Typical resistance/response time characteristics.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects – Electrical
A.Q.L. 1,5%, major defects – Mechanical
A.Q.L. 4 %, minor defects – Physical

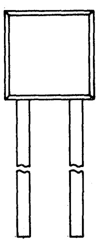
PACKAGING

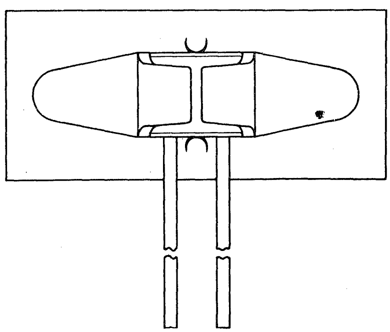
Type 2322 640 90004: 500 pieces per box (cardboard).
Type 2322 640 98004: 400 pieces per box (cardboard).

NTC THERMISTORS

moulded

QUICK REFERENCE DATA			
	2322 640 90005	2322 640 98005	
Resistance at +100 °C	16,7 ± 7%	16,7 ± 7%	kΩ
+200 °C	1120 ± 7%	1120 ± 7%	Ω
$B_{25/85}$-value	4300	4300	°K
Maximum dissipation	0,25	0,25	W
Dissipation factor	7	9,5	mW/degC
when mounted on a heat-sink	17,5	20,5	mW/degC
Thermal time constant	19	33	s
when mounted on a heat-sink	12	8,5	s
Operating temperature range			
at zero power	−25 to +200	−25 to +200	°C
at maximum power	0 to +55	0 to +55	°C





APPLICATION

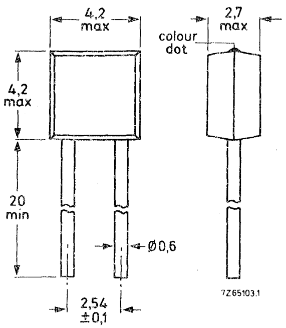
For high temperature control.

DESCRIPTION

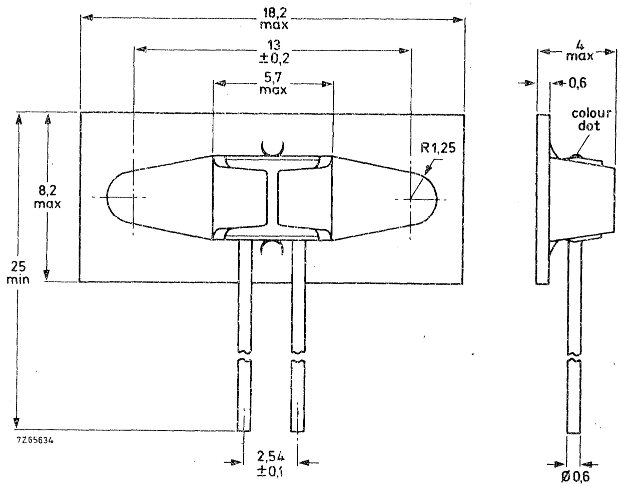
Moulded disc thermistor with negative temperature control and with two solid tinned copper wires.
The thermistor 2322 640 98005 is provided with a metal strip for mounting.

MECHANICAL DATA

Dimensions (mm)



type 2322 640 90005



type 2322 640 98005
with metal strip for mounting

Marking

The thermistors have a black dot.

Weight

Type 2322 640 90005	0,3 g approx.
Type 2322 640 98005	0,5 g approx.

Mounting

Type 2322 640 90005	in any position by soldering
Type 2322 640 98005	by means of the mounting strip

Robustness of terminations

Tensile strength	10 N
Bending	5 N

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s

Impact

Free fall	1 m

Inflammability

Uninflammable – CCTU – 01 – 01A specification, test 22.

ELECTRICAL DATA

Unless otherwise specified, measured according to IEC draft publication 40 (CO) 226 and 337.

All values in the table without further indication are approximately values.

	2322 640 90005	2322 640 98005	
Resistance at + 100 °C	16,7 ± 7%	16,7 ± 7%	kΩ
+200 °C	1120 ± 7%	1120 ± 7%	Ω
+25 °C	310	310	kΩ
$B_{25/85}$-value	4300	4300	K
Temperature coefficient	−4,85	−4,85	%/°C
Maximum dissipation	0,25	0,25	W
Dissipation factor	7	9,5	mW/°C
when mounted on a heat-sink [1]	17,5	20,5	mW/°C
Thermal time constant	19	33	s
when mounted on a heat-sink [1]	12	8,5	s
Heat capacity of ceramic	0,028	0,028	J/°C
of complete component	0,13	0,31	J/°C
Response time [2]	3	3	s
Operating temperature range			
at zero power	−25 to +200	−25 to +200	°C
at maximum power	0 to +55	0 to +55	°C
Dielectric withstanding voltage between terminals and coating	min. 350	min. 350	V r.m.s.
Insulation resistance between terminals and coating at 100 V d.c.	min. 100	min. 100	MΩ

[1] Measurements made in still air with the thermistor mounted on a heat-sink of 1 dm^2, thickness 1,5 mm, connected between phosphor-bronze wires (ϕ1,3 mm).

[2] This is the time which elapses before the body temperature has dropped by 63,2% of the whole temperature traverse from + 25 to + 85 °C as a result of the thermistor being transferred from ambient air of + 25 °C to a silicone oil (MS200/50) bath of + 85 °C.

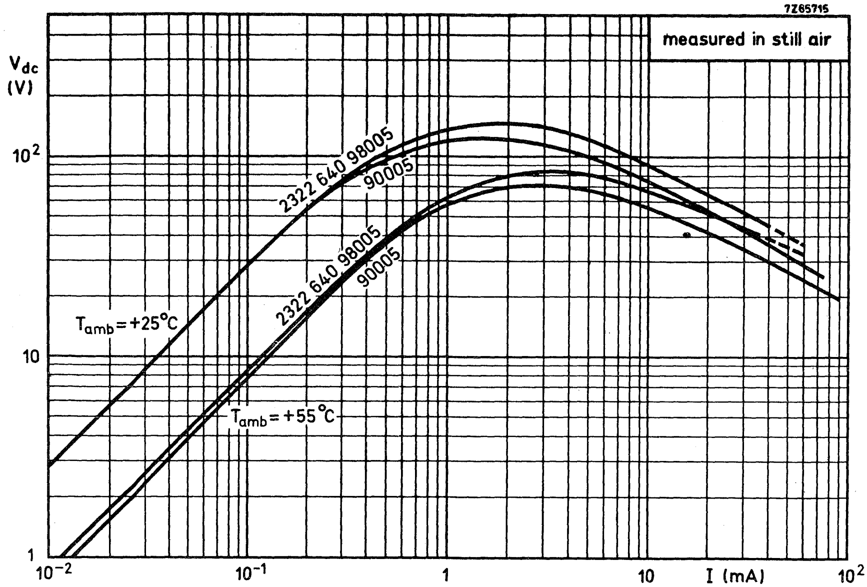


Fig. 2 Typical voltage/current characteristics.

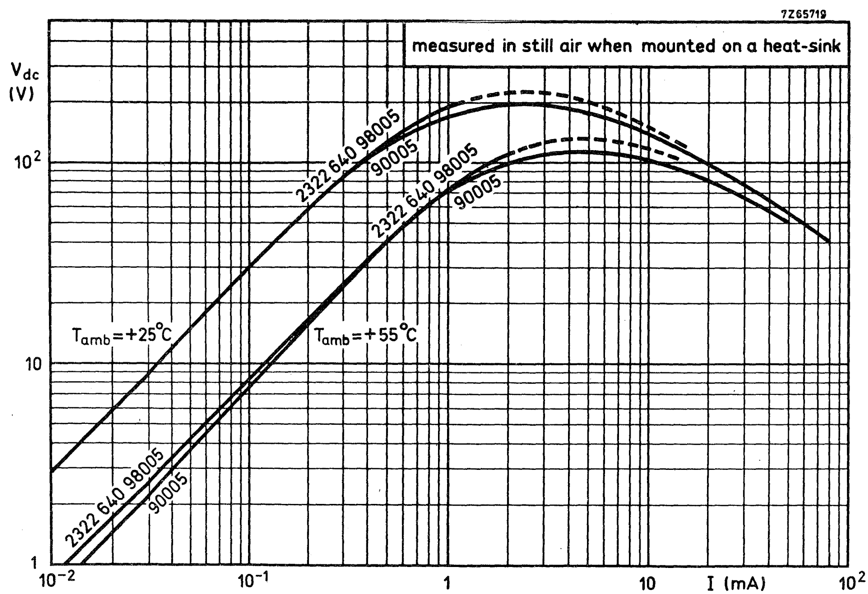


Fig. 3 Typical voltage/current characteristics.

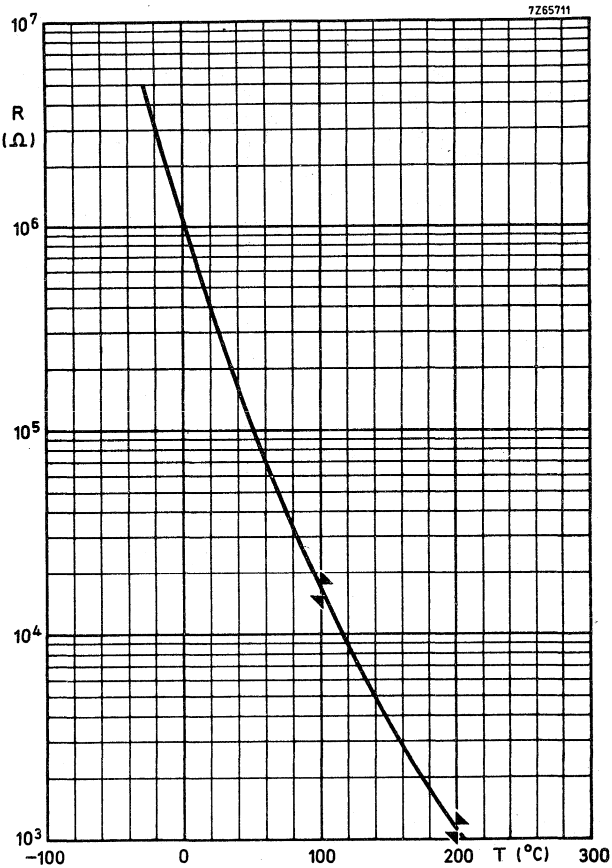


Fig.4 Typical resistance/temperature characteristics.

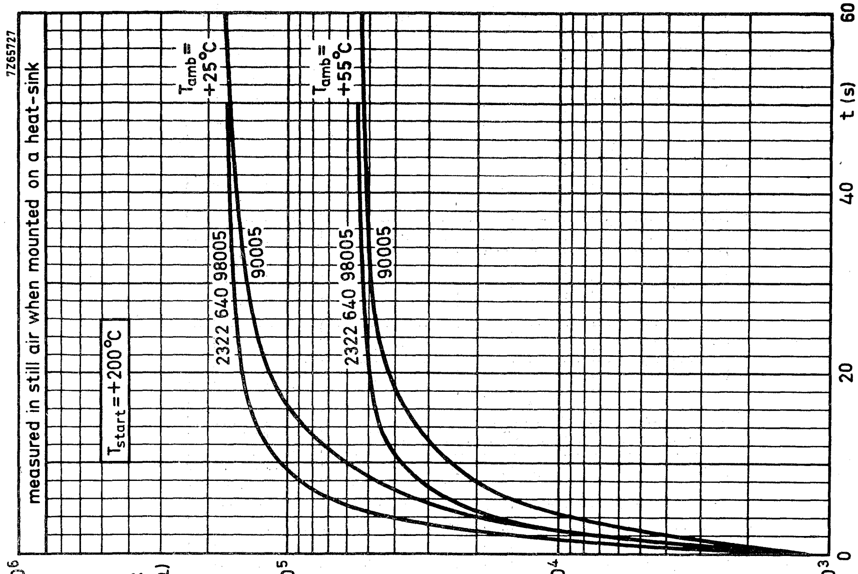


Fig.6 Typical resistance/time (cooling) characteristics.

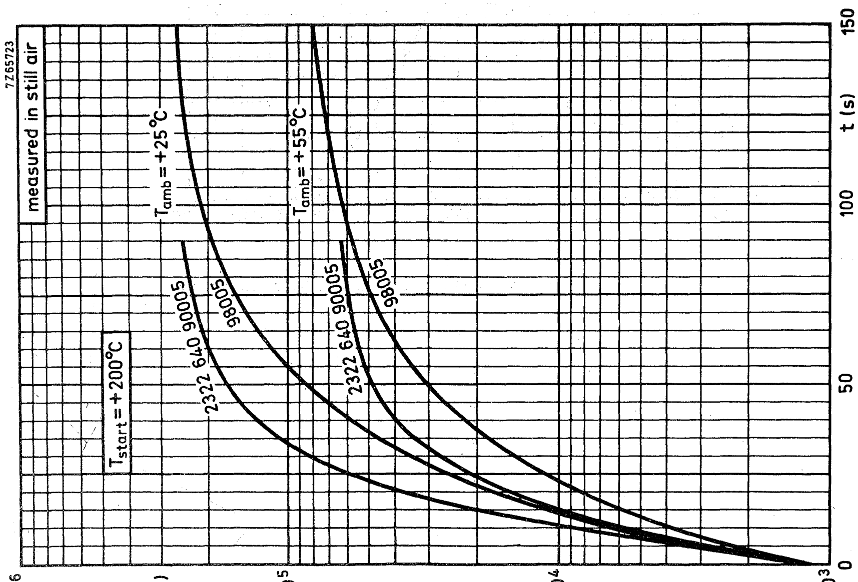


Fig.5 Typical resistance/time (cooling) characteristics.

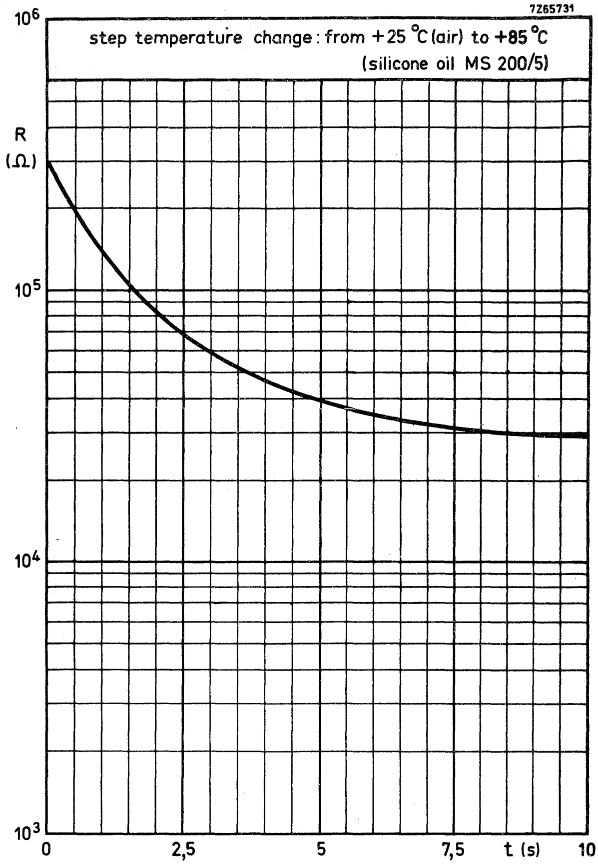


Fig. 7 Typical resistance/response time characteristics.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects – Electrical
A.Q.L. 1,5%, major defects – Mechanical
A.Q.L. 4 %, minor defects – Physical

PACKAGING

Type 2322 640 90005: 500 pieces per box (cardboard).
Type 2322 640 98005: 400 pieces per box (cardboard).

NTC THERMISTOR

QUICK REFERENCE DATA	
Resistance value at + 25 ^oC	12 000 Ω ± 7%
+100 ^oC	950 Ω ± 5%
$B_{25/85}$ -value	3750 K
Operating temperature range	−25 to +125 ^oC

APPLICATION

As a temperature sensor for water temperature control in washing machines.

DESCRIPTION

Disc thermistor with negative temperature coefficient, mounted in a capsule of stainless steel, provided with two 0, 25 inch spade connectors.

MECHANICAL DATA

Dimensions (mm)

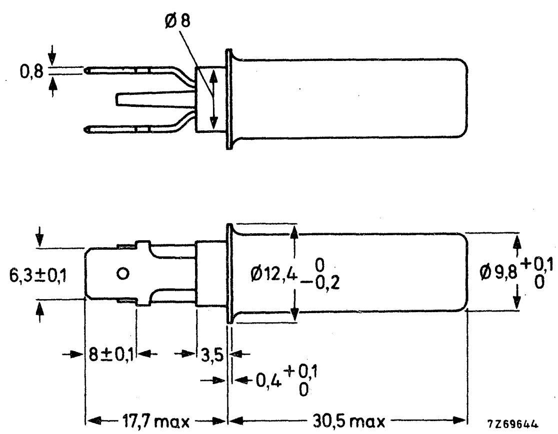


Fig. 1

Marking	None
Weight	6,7 g approximately
Mounting	In any position

Robustness of terminations

Tensile strength	20 N

Impact

Free fall	1000 mm

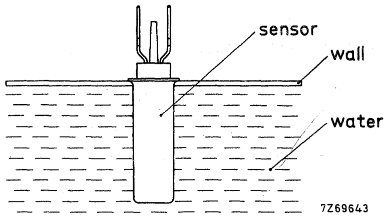
ELECTRICAL DATA

Unless otherwise specified, measured according to IEC draft publication 40 (CO) 226 and 337.

Resistance at + 25°C	12 000 Ω ± 7%
+100°C	950 Ω ± 5%
$B_{25/85}$ - value	3750 K
Temperature coefficient	−4,2 %/°C
Temperature gradient *)	0,02 °C/°C
Operating temperature range	−25 to +125 °C
Dielectric withstanding voltage (r.m.s.) between terminals and capsule	min. 1500 V
Insulation resistance between terminals and capsule at 100 V d.c.	min. 100 M Ω

*) The temperature gradient is the difference between the liquid (water) temperature and the temperature measured by the sensor per degree difference between liquid and connector temperatures.
This difference is caused by the heat conduction through the connectors.
Measuring circuit is shown in Fig. 2.

Fig. 2



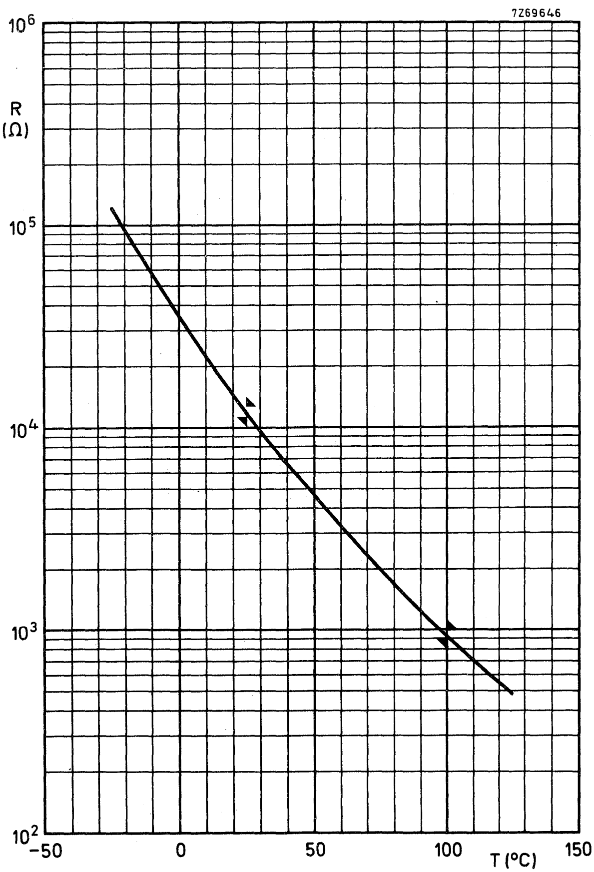


Fig. 3 Typical resistance/temperature characteristic.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	ΔR/R (%) at +25 °C	at +100 °C
Cold at −25 °C	A	1000 h	± 3	± 3
Storage at +25 °C	H	1000 h	± 3	± 3
Dry heat at +125 °C	B	1000 h	± 5	± 5
Thermal shock −25 to +125 °C	Na	5 cycles	± 3	± 3
Damp heat at +40 °C	Ca	1000 h	± 5	± 5
Dissipation in damp heat		336 h	± 5	± 5
Maximum dissipation at T_{amb} = +25°C		1000 h	± 5	± 5
Robustness of terminations Tensile strength 20 N	U Ua	10 s	[1]	
Impact Free fall	Ed	2 falls	[2]	

[1]) Terminals should neither come loose nor break.
[2]) No visual defects.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1,5%, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

NTC THERMISTOR

QUICK REFERENCE DATA	
Resistance value at + 25 °C	215 000 Ω approximately
+ 90 °C	22000 Ω ± 10%
+320 °C	235 Ω ± 75 Ω
$B_{50/150}$-value	4000 K ± 5%
Operating temperature range	
continuous	0 to +250 °C
peak	0 to +350 °C

APPLICATION

Temperature control

DESCRIPTION

Disc thermistor with negative temperature coefficient, ceramic encapsulated, with two solid silver wires.

MECHANICAL DATA

Dimensions (mm)

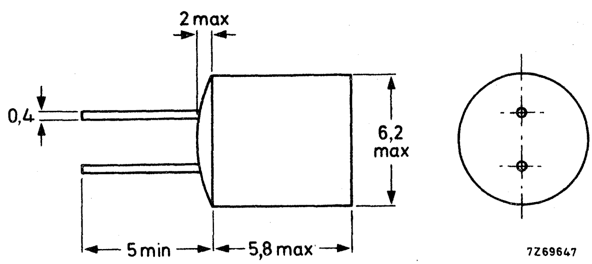


Fig. 1

Marking	None
Weight	0,36 g approximately
Mounting	In any position by soldering
Robustness of terminations	
Tensile strength	5 N
Bending	2,5 N
Soldering	
Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s
Impact	
Free fall	1000 mm
Inflammability	Uninflammable

ELECTRICAL DATA

Unless otherwise specified, measured according to IEC draft publication 40 (CO) 226 and 337.

Resistance at + 25 °C	215 000 Ω approximately
+ 90 °C	22 000 Ω ± 10%
+320 °C	235 Ω ± 75 Ω
$B_{50/150}$-value	4000 K ± 5%
Temperature coefficient	−3,8%/°C approximately
Response time [1]	5 s approximately
Operating temperature range	
continuous	0 to +250 °C
peak	0 to +350 °C
Dielectric withstanding voltage (r.m.s.) between terminals and encapsulation, T_{amb} = +350 °C	min. 1500 V
Insulation resistance between terminals and encapsulation at 100 V d.c., T_{amb} = +350 °C	min. 100 M Ω

[1]) Response time is the time required for the thermistor to reach 63,2% of the total difference between its initial and final body temperature when subjected to a step function change in ambient temperature.
Temperature step, initial : air of +25 °C
final : silicon oil (MS200/50) of +85 °C

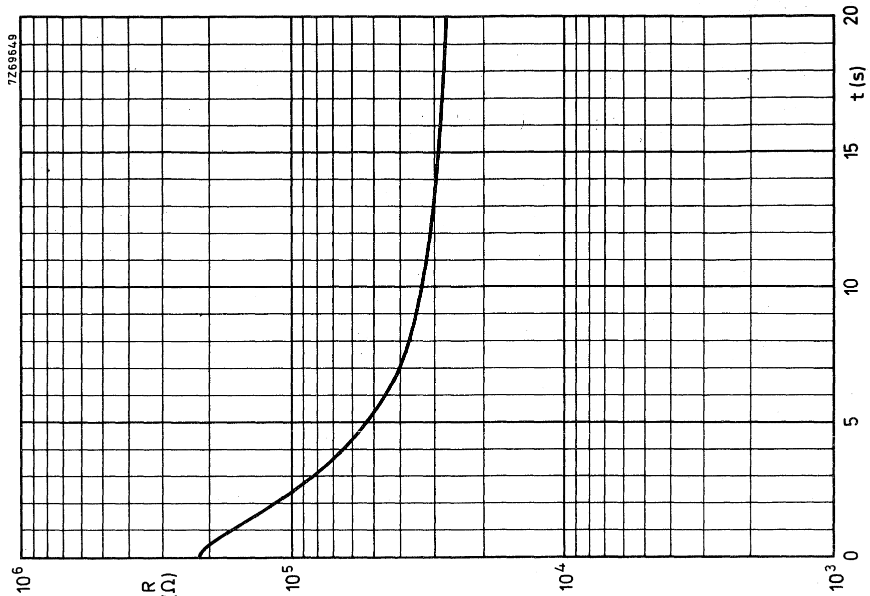


Fig. 3 Typical temperature response characteristic (+25/+85 °C step).

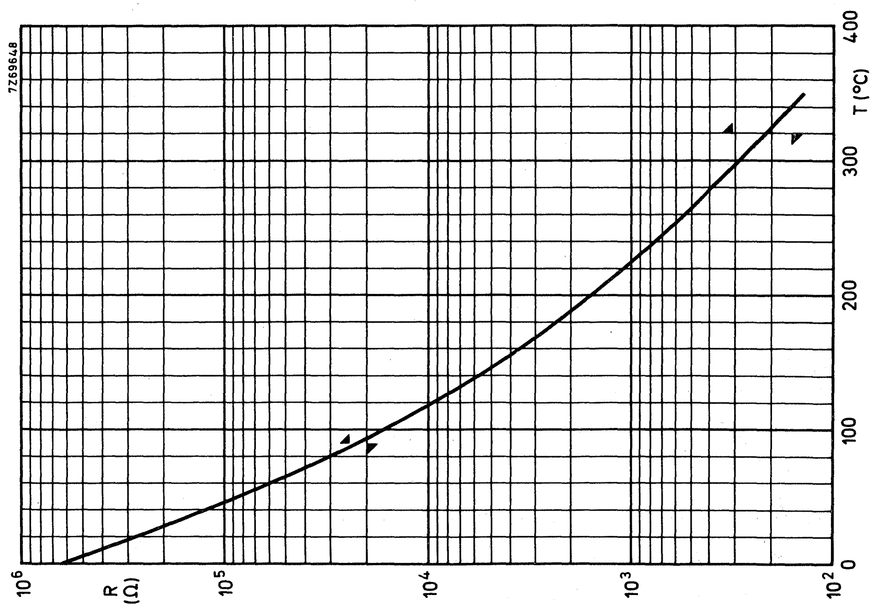


Fig. 2 Typical resistance/temperature characteristic.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	ΔR/R (%) at +90 °C	ΔB/B (%)
Cold at 0 °C	A	1000 h	± 3	± 2
Storage at +25 °C	H	1000 h	± 3	± 1
Dry heat at +250 °C +350 °C	B	1000 h 100 h	± 10	± 3
Thermal shock 0 to +350 °C	Na	5 cycles	± 10	± 3
Thermal cycle +25 to +250 °C +25 to +350 °C	see Fig. 4	30 000 cycles 100 cycles	± 10 ± 10	± 3 ± 3
Damp heat at +40 °C	Ca	1000 h	± 5	± 3
Dissipation in damp heat		336 h	± 5	± 3
Maximum dissipation at T_{amb} = +25 °C		1000 h	± 5	± 2
Robustness of terminations	U			
Tensile strength 5 N	Ua	10 s	[1]	
Bending 2,5 N	Ub	2 times	[1]	
Soldering	T			
Solderability	par. 3.2.3	3 to 4 s	[2]	
Resistance to heat	Tb	9 to 11 s	± 2	± 2
Impact	E			
Free fall	Ed	2 falls	[3]	

[1] Leads should neither come loose nor break.
[2] Leads must be solderable initially and after 6 months storage with solder containing resin flux.
[3] No visual defects.

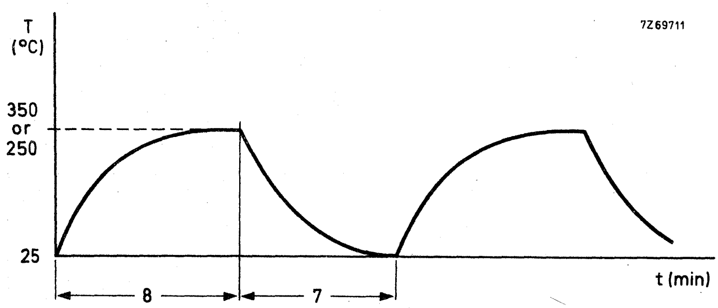


Fig. 4

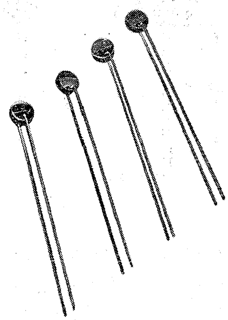
QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1,5%, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

NTC THERMISTORS
disc

RZ 27317-5



QUICK REFERENCE DATA	
Resistance values at 25 °C	3.3 Ω to 330 kΩ according to E6-series
B-values	between 2600 and 4700 K
Max. dissipation at T_{amb} = 55 °C	0.5 W
Operating temperature range at zero power	−25 to +125 °C
Dissipation factor	8 to 9 mW/°C
Thermal time constant	20 to 30 s

APPLICATION

Suitable for all kinds of applications.

DESCRIPTION

These thermistors have a negative temperature coefficient. They consist of a disc provided with two solid tinned copper wires. They are not insulated nor lacquered. The thermistors are colour coded.

MECHANICAL DATA

Dimensions in mm

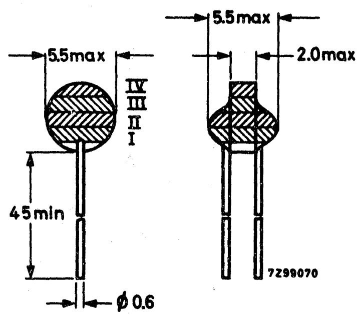


Fig. 1

Marking

The thermistors are marked with three bands showing their resistance value (R_{25}) in colour code; the types with a tolerance on R_{25} of 10% also have a silver band, those with a tolerance on R_{25} of 5% a gold band (see Fig. 1).

Weight 0.5 g approximately

Mounting In any position by soldering

Robustness of terminations

Tensile strength	10 N
Bending	5 N

Soldering

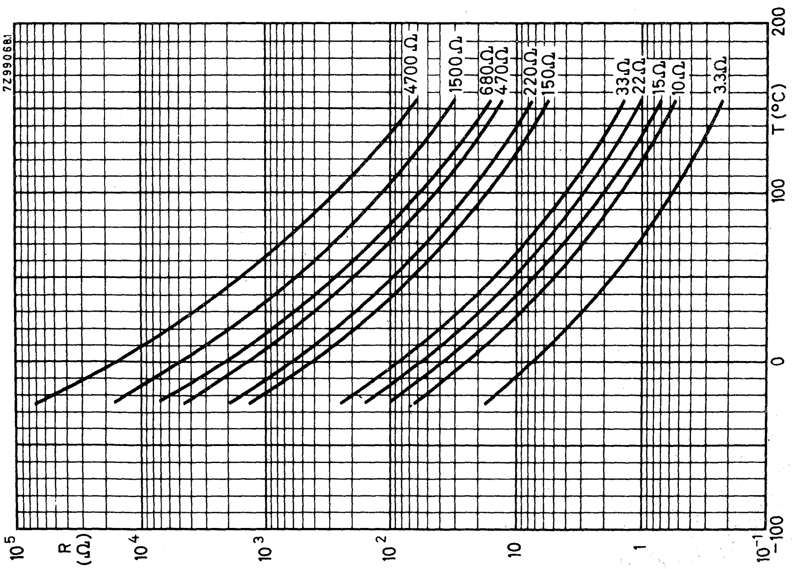
Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 240 °C, max. 4 s

ELECTRICAL DATA

Tolerance on resistance value at 25 °C (R_{25})	± 20, ± 10 and ± 5%
Tolerance on B-value	± 5%
Max. dissipation at 55 °C	0.5 W
Operating temperature range at zero power	−25 to +125 °C

R_{25} (Ω)	$B_{25/85}$ 1) (°K)	dissipation factor approx. (mW/degC)	thermal time constant approx. (s)	colour code (see Marking) I	II	III	catalogue number 2)
3.3	2600	9	30	orange	orange	gold	2322 642 1.338
4.7	2665	9	30	yellow	violet	gold	1.478
6.8	2730	9	30	blue	grey	gold	1.688
10	2800	9	30	brown	black	black	1.109
15	2870	9	30	brown	green	black	1.159
22	2935	9	25	red	red	black	1.229
33	3010	9	25	orange	orange	black	1.339
47	3070	9	25	yellow	violet	black	1.479
68	3135	8	25	blue	grey	black	1.689
100	3200	8	25	brown	black	brown	1.101
150	3280	8	25	brown	green	brown	1.151
220	3350	8	25	red	red	brown	1.221
330	3440	8	25	orange	orange	brown	1.331
470	3520	8	25	yellow	violet	brown	1.471
680	3600	8	25	blue	grey	brown	1.681
1000	3680	8	25	brown	black	red	1.102
1500	3775	8	25	brown	green	red	1.152
2200	3915	8	25	red	red	red	1.222
3300	4070	8	25	orange	orange	red	1.332
4700	4200	8	25	yellow	violet	red	1.472
6800	4300	8	25	blue	grey	red	1.682
10000	4400	8	25	brown	black	orange	1.103
15000	4375	8.5	25	brown	green	orange	1.153
22000	4200	8.5	25	red	red	orange	1.223
33000	4250	8.5	25	orange	orange	orange	1.333
47000	4325	8.5	25	yellow	violet	orange	1.473
68000	4375	8.5	25	blue	grey	orange	1.683
100000	4400	8.5	25	brown	black	yellow	1.104
150000	4600	8.5	25	brown	green	yellow	1.154
220000	4650	8.5	25	red	red	yellow	1.224
330000	4700	8.5	25	orange	orange	yellow	1.334

1) B-value is subject to change
2) Replace dot in catalogue number (9th digit) by
 1 for a tolerance of 20% on R_{25},
 2 for a tolerance of 10% on R_{25},
 3 for a tolerance of 5% on R_{25}.



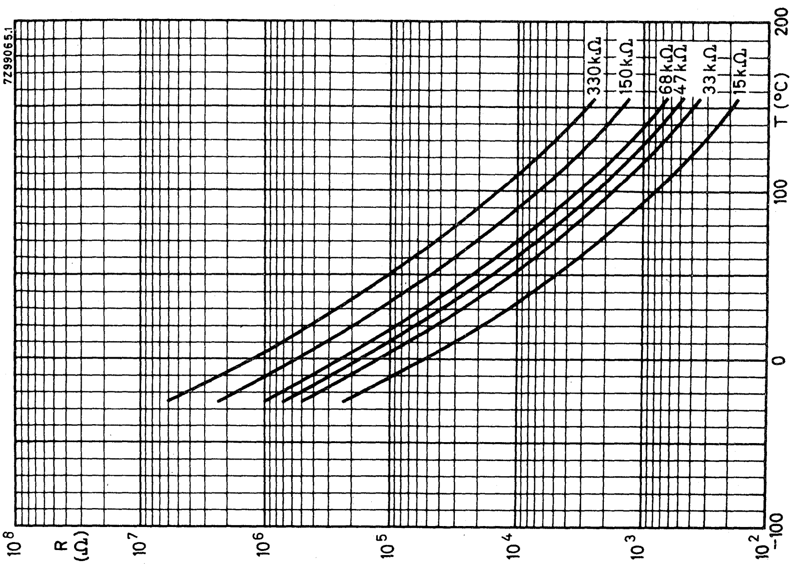
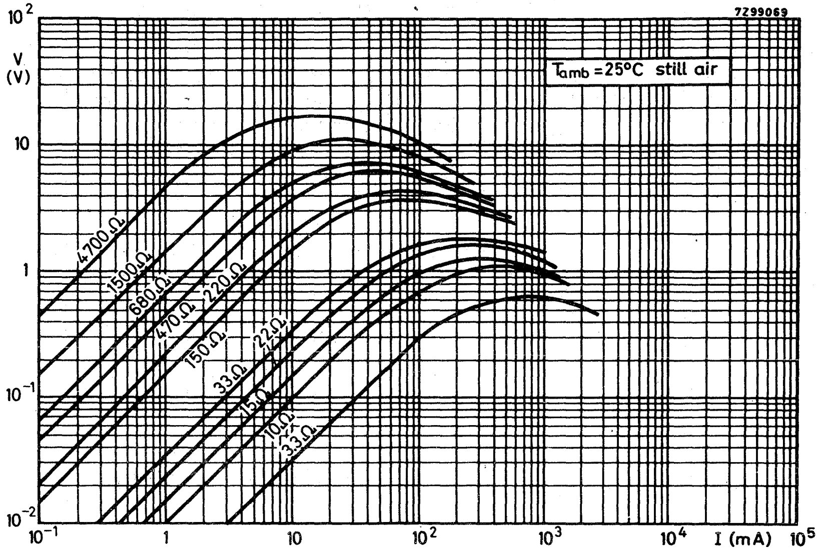
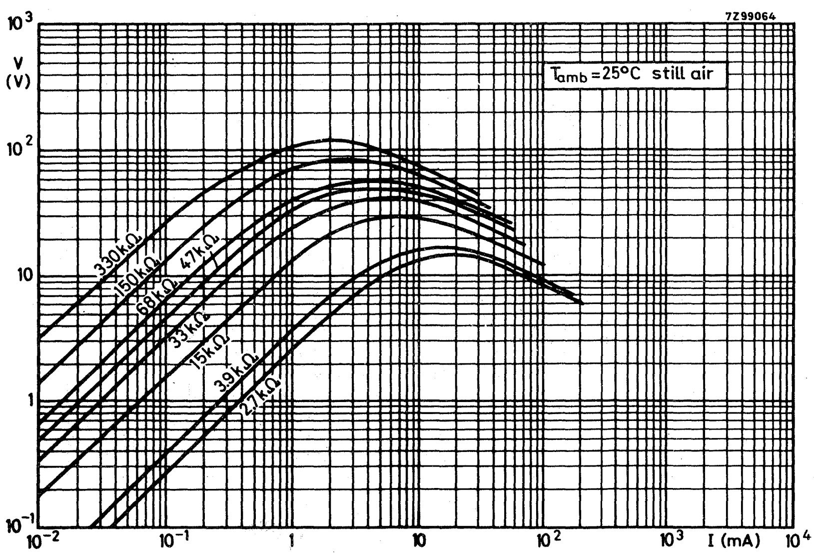


Fig.2 a and b. Resistance/temperature characteristics

Fig.3 a and b. Voltage/current characteristics





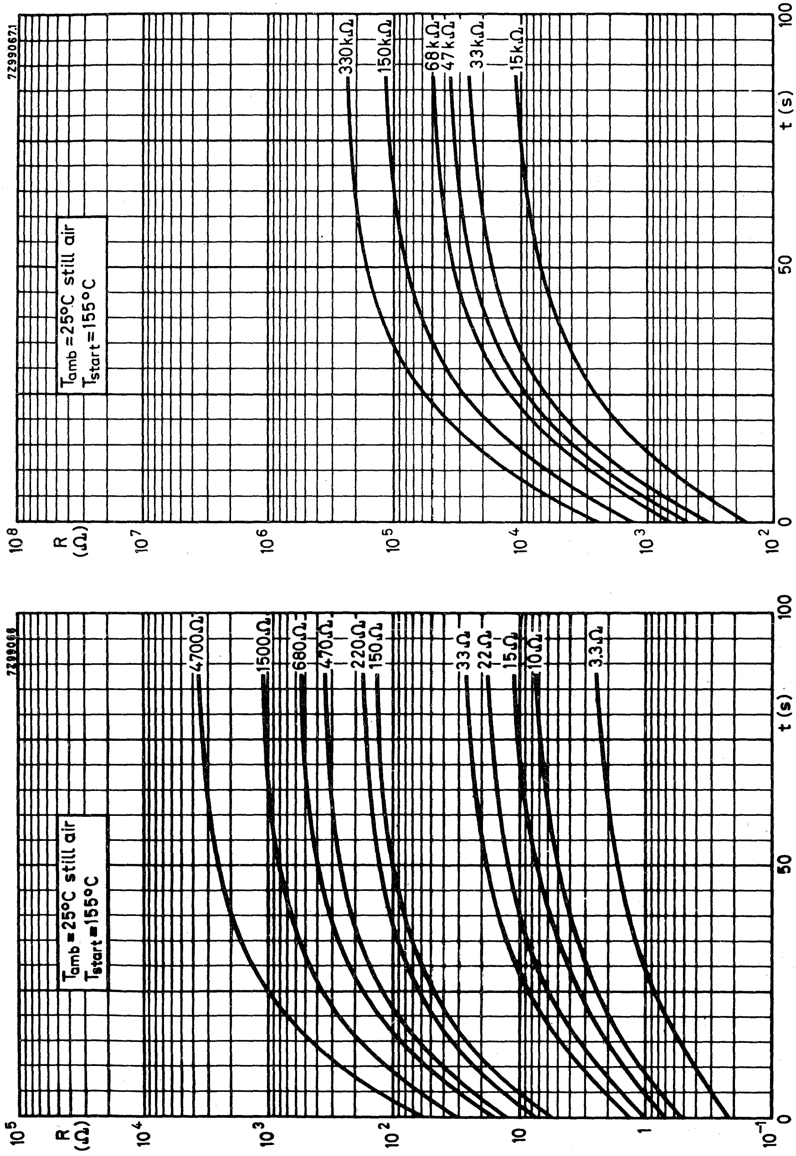


Fig.4 a and b. Resistance/time (Cooling) characteristics

TESTS AND REQUIREMENTS

According to I.E.C. publication 68

tests	I.E.C. 68 test method	duration	requirements $\Delta R/R$ (%)	$\Delta B/B$ (%)
Storage at +25 ±10 °C	H	1000 h	± 3	± 1
Dry heat at +125 °C	B	1000 h	± 5	± 2
Thermal shock −25 to +125 °C	Ha	5 cycles	± 3	± 2
Damp heat	C	1000 h	± 5	± 3
Max. dissipation at T_{amb} = +55 °C		1000 h	± 5	± 2
Robustness of terminations				
Tensile strength 10 N	Ua	10 s	*)	
Bending 5 N	Ub	2 times	*)	
Soldering	T			
Solderability at 230 °C	Par.3.2.3	3 to 4 s	**)	
Resistance to heat at 230 °C	Par.3.2.4	3 to 4 s	± 2	± 2

*) Leads should neither come loose nor break

**) Leads must be solderable initially and after six months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D

A.Q.L. 1 %, major defects-Electrical
A.Q.L. 1.5 %, major defects-Mechanical
A.Q.L. 4 %, minor defects-Physical

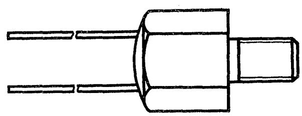
PACKAGING

250 pieces per box (cardboard)

NTC THERMISTORS

with mounting stud

QUICK REFERENCE DATA	
Resistance value at + 25 °C	3,3 Ω to 330 kΩ (E6 series)
$B_{25/85}$ - value	2600 to 4700 °K
Maximum dissipation	0,5 W
Dissipation factor	25 mW/°C
Thermal time constant	20 s
Operating temperature range	
at zero power	−25 to + 100 °C
at maximum power	0 to + 55 °C



APPLICATION

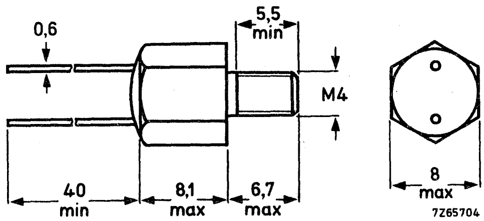
Suitable for all kinds of applications, especially when a good insulation and/or a good thermal contact with the chassis is required.

DESCRIPTION

Disc thermistor with negative temperature coefficient mounted in the head of aluminium screws M4 and provided with two solid tinned copper wires.

MECHANICAL DATA

Dimensions (mm)



Marking

The resistance value at + 25 °C (according to table) is printed on the stud in code.

Weight

1, 5 g approx.

Mounting

By means of an washer and M4 nut supplied with the device.
Applied torque shall not exceed 1, 2 Nm. Leads to be soldered.

Robustness of terminations

Tensile strength	10 N
Bending	5 N
Torque applied on screw	1, 2 Nm max.

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 240 °C, max. 4 s

ELECTRICAL DATA

Maximum dissipation	0, 5 W
Dissipation factor *)	25 mW/°C
Thermal time constant *)	20 s approx.

*) Measurements made with screw mounted on an aluminium heat-sink of 1 dm^2, thickness 1, 5 mm, in still air, T_{amb} = +25 °C.

Heat capacity	0,5 J/°C approx.
Operating temperature range	
at zero power	−25 to +100 °C
at maximum power	0 to +55 °C
Dielectric withstanding voltage between terminals and screw	min 100 V r.m.s.
Insulation resistance between terminals and screw at 100 V d.c.	min 100 MΩ

R_{25} (Ω)	$B_{25/85}$-value ± 5% (K)	temperature coefficient at 25 °C (%/°C)	catalogue number 2322 642 2.... tol. 5%	tol. 10%	tol. 20%
3,3	2600	−2,9	3338	2338	1338
4,7	2665	−3,0	3478	2478	1478
6,8	2730	−3,1	3688	2688	1688
10	2800	−3,2	3109	2109	1109
15	2870	−3,2	3159	2159	1159
22	2935	−3,3	3229	2229	1229
33	3010	−3,4	3339	2339	1339
47	3070	−3,5	3479	2479	1479
68	3135	−3,5	3689	2689	1689
100	3200	−3,6	3101	2101	1101
150	3280	−3,7	3151	2151	1151
220	3350	−3,8	3221	2221	1221
330	3440	−3,9	3331	2331	1331
470	3520	−4,0	3471	2471	1471
680	3600	−4,1	3681	2681	1681
1000	3680	−4,1	3102	2102	1102
1500	3775	−4,3	3152	2152	1152
2200	3915	−4,4	3222	2222	1222
3300	4070	−4,6	3332	2332	1332
4700	4200	−4,7	3472	2472	1472
6800	4300	−4,8	3682	2682	1682
10 000	4400	−5,0	3103	2103	1103
15 000	4375	−4,9	3153	2153	1153
22 000	4200	−4,7	3223	2223	1223
33 000	4250	−4,8	3333	2333	1333
47 000	4325	−4,9	3473	2473	1473
68 000	4375	−4,9	3683	2683	1683
100 000	4400	−5,0	3104	2104	1104
150 000	4600	−5,2	3154	2154	1154
220 000	4650	−5,2	3224	2224	1224
330 000	4700	−5,3	3334	2334	1334

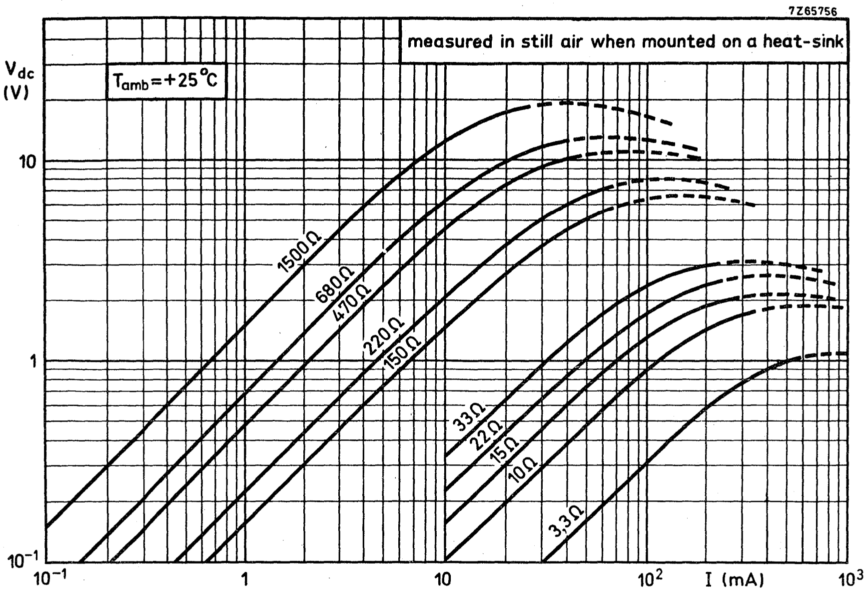


Fig.2 Typical voltage/current characteristics

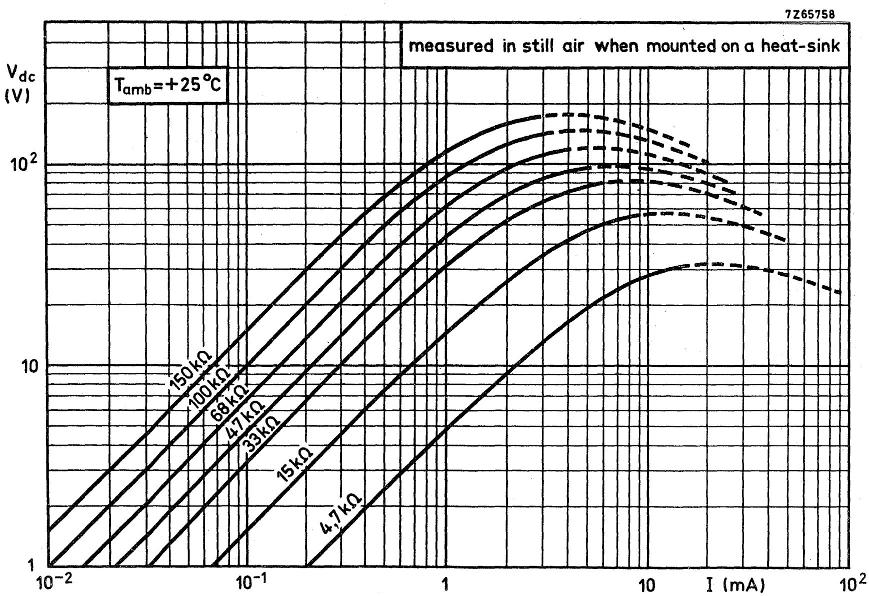


Fig.3 Typical voltage/current characteristics

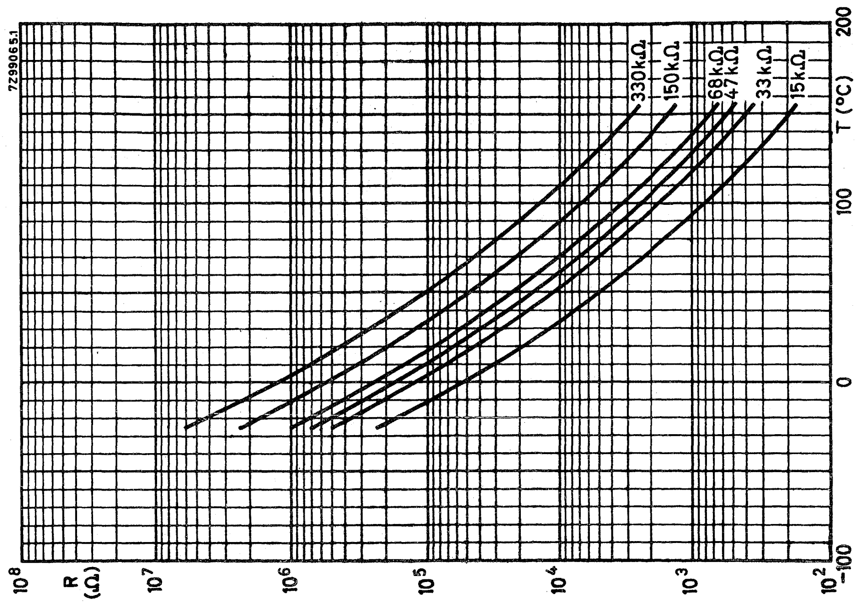


Fig.5 Typical resistance/temperature characteristics

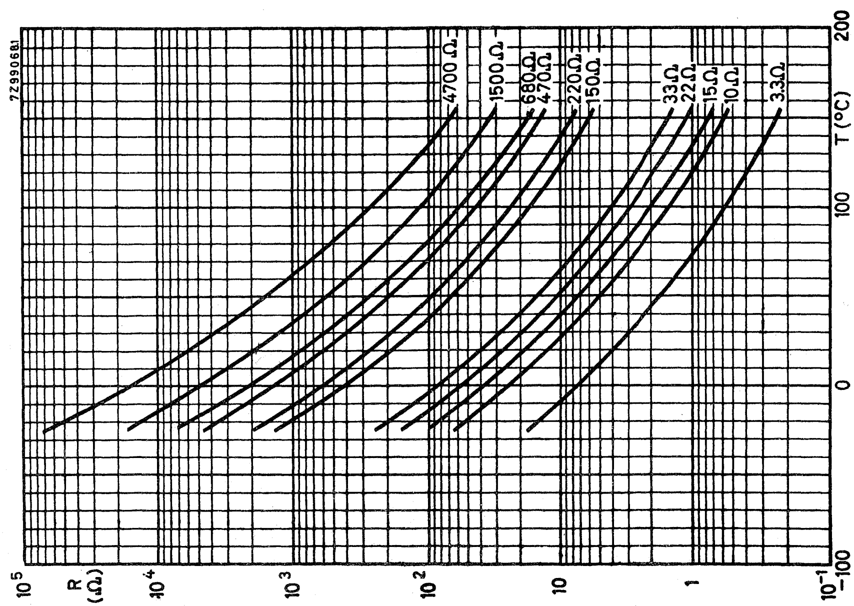


Fig.4 Typical resistance/temperature characteristics

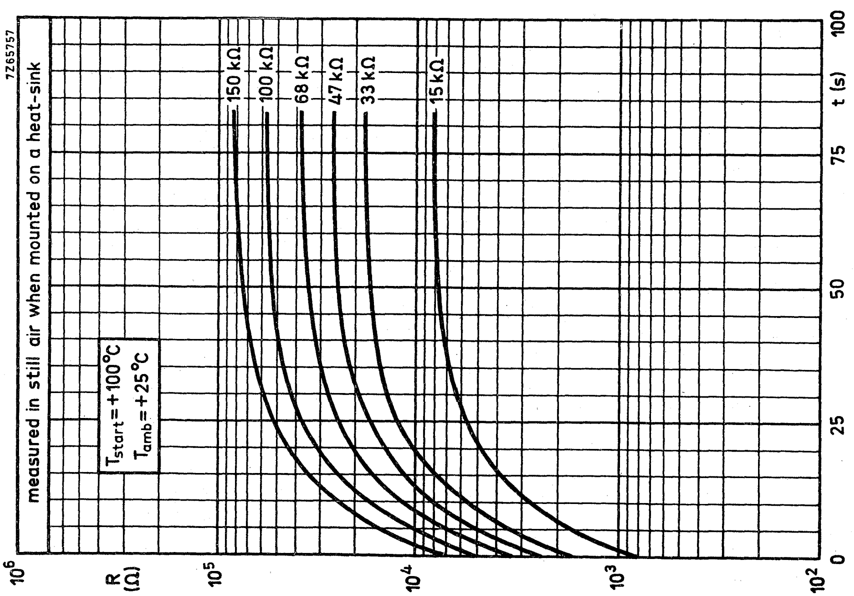


Fig.6 Typical resistance/time(cooling) characteristics

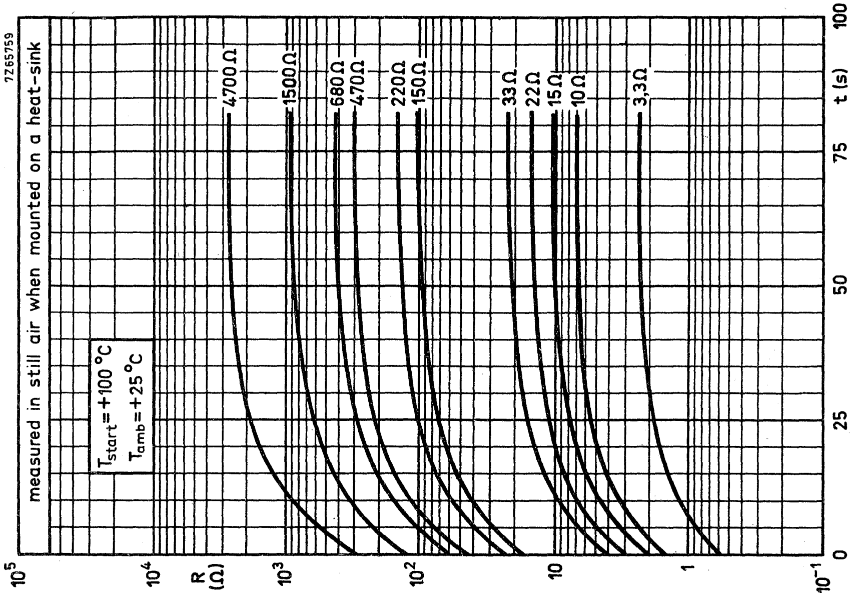


Fig.7 Typical resistance/time (cooling) characteristics

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified

test	test method	duration	$\frac{\Delta R_{25}}{R_{25}}$ (%)	$\frac{\Delta B}{B}$ (%)
Cold at −25 °C	A	1000 h	±3	±2
Storage at +25 °C	H	1000 h	±3	±1
Dry heat at +100 °C	B	1000 h	±5	±2
Thermal shock −25 to +100 °C	Na	5 cycles	±3	±2
Damp heat	C	1000 h	±5	±3
Max. dissipation		1000 h	±5	±2
Robustness of terminations	U			
Tensile strength 10 N	Ua	10 s	1)	
Bending 5 N	Ub	2 times	1)	
Torque on screw max. 1,2 Nm		once	1)	
Soldering	T			
Solderability at 230 °C	par. 3.2.3.	3 to 4 s	2)	
Resistance to heat at 230 °C	par. 3.2.4.	3 to 4 s	±2	±3

1) Leads should neither come loose nor break
2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D

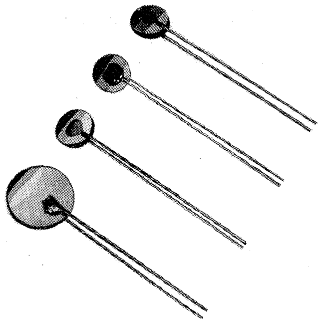
A.Q.L. 1 %, major defects-Electrical
A,Q.L. 1,5%, major defects-Mechanical
A.Q.L. 4 %, minor defects-Physical

PACKAGING

100 pieces per box (cardboard)

NTC THERMISTORS

disc



RZ 27317-8

QUICK REFERENCE DATA		
Resistance values at 25 °C	150 Ω, 470 Ω, 1,5 kΩ, 4,7 kΩ	
B-values	between 3500 and 4300 K	
Operating temperature range at zero power	−25 to +125 °C	
	type 2322 643	type 2322 644
Max. dissipation at 25 °C	1 W	1.5 W
Dissipation factor	10 mW/°C	13 mW/°C
Thermal time constant	55 s	120 s

APPLICATION

These discs are suitable for all kinds of applications.

DESCRIPTION

The thermistors have a negative temperature coefficient. They consist of a disc provided with two solid tinned copper wires. They are not insulated nor lacquered. The thermistors are colour coded.

MECHANICAL DATA

Dimensions (mm)

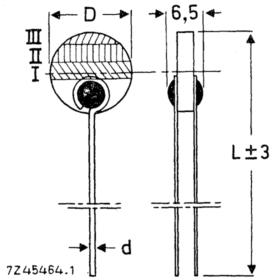


Fig. 1

series	D	L	d
2322 643	9 ± 0,5	54	0,6
2322 644	15 ± 0,7	58	0,8

Marking

The thermistors are marked with three bands showing their resistance value (R_{25}) in colour code (see Fig. 1); the types with a tolerance on R_{25} of 10% also have a silver band.

Weight

Type 2322 643 0,9 g approximately
Type 2322 644 2 g approximately

Mounting

In any position by soldering.

ELECTRICAL DATA

R_{25} (Ω)	$B_{25/85}$-value 1) (K)	P_{max} at T_{amb} = 25 °C (W)	dissipation factor approx. (mW/°C)	thermal time constant approx. (s)	colour code see Marking I	II	III	catalogue number 2)
150	3500	1	10	55	brown	green	brown	2322 643 1.151
470	3750	1	10	55	yellow	violet	brown	1.471
1500	4000	1	10	55	brown	green	red	1.152
4700	4200	1	10	55	yellow	violet	red	1.472
150	3600	1.5	13	120	brown	green	brown	2322 644 1.151
470	3900	1.5	13	120	yellow	violet	brown	1.471
1500	4200	1.5	13	120	brown	green	red	1.152
4700	4300	1.5	13	120	yellow	violet	red	1.472

Tolerance on resistance value at 25 °C (R_{25}) ±20 and ± 10% 2)

Tolerance on B-value ±5%

Operating temperature range at zero power −25 to +125 °C

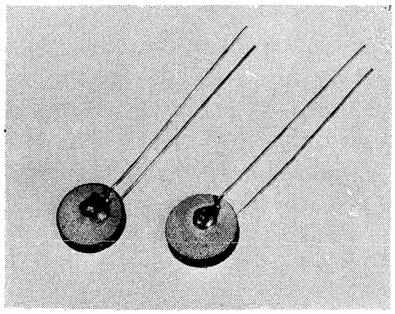
PACKAGING

Type 2322 643 250 pieces per box (cardboard)
Type 2322 644 100 pieces per box (cardboard)

1) B-value is subject to change
2) Replace dot in catalogue number (9th digit) by: 1 for a tolerance of 20% on R_{25}
2 for a tolerance of 10% on R_{25}

NTC THERMISTORS

disc



QUICK REFERENCE DATA	2322 644 90004	2322 644 90005
Resistance value at +25 °C	82 Ω ± 20%	min. 15 Ω
Resistance at T_{amb} = +25 °C, and I_{rms} = 1.7 A and 2.2 A respectively	max. 0.85 Ω	max. 1 Ω
B25/85-value	4650 °K	3350 °K
Maximum current (r.m.s.)	1.7 A	2.2 A
Dissipation factor	19 mW/degC	17 mW/degC
Thermal time constant	115 s	148 s
Operating temperature range		
at zero power	-25 to +155 °C	-25 to +155 °C
at maximum power	0 to +55 °C	0 to +55 °C

APPLICATION

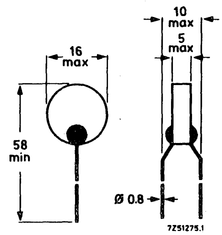
For limiting surge current, e.g. diode and switch protection.

DESCRIPTION

This thermistor has a negative temperature coefficient. It consists of a disc provided with two solid tinned copper wires. The thermistor body is neither lacquered nor insulated.

MECHANICAL DATA

Dimensions in mm



Marking

The thermistors are not marked.

Weight

Type 2322 644 90004	approx. 3.2 g
Type 2322 644 90005	approx. 4 g

Mounting

In any position by soldering. Soldering should be done at least 10 mm from the thermistor body.

Robustness of terminations

Tensile strength	20 N
Bending	10 N

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 240 °C, max. 4 s

ELECTRICAL DATA

	2322 644 90004	2322 644 90005	unit
R at 25 °C	82 ± 20%	min. 15	Ω
R at Tamb = 25 °C, Irms = 1.7 A	max. 0.85		Ω
R at Tamb = 25 °C, Irms = 2.2 A		max. 1	Ω
$B_{25/85}$-value, approx.	4650	3350	K
Max. current (r.m.s.) at T_{amb} = +55 °C	1.7	2.2	A
Dissipation factor, approx.	19	17	mW/°C
Thermal time constant, approx.	115	148	s
Heat capacity, approx.	2.2	2.5	J/°C
Operating temperature range			
at zero power	−25 to +155	−25 to +155	°C
at maximum power	0 to +55	0 to +55	°C
Max. repetitive peak voltage 50-60 Hz [1])	345	380	V

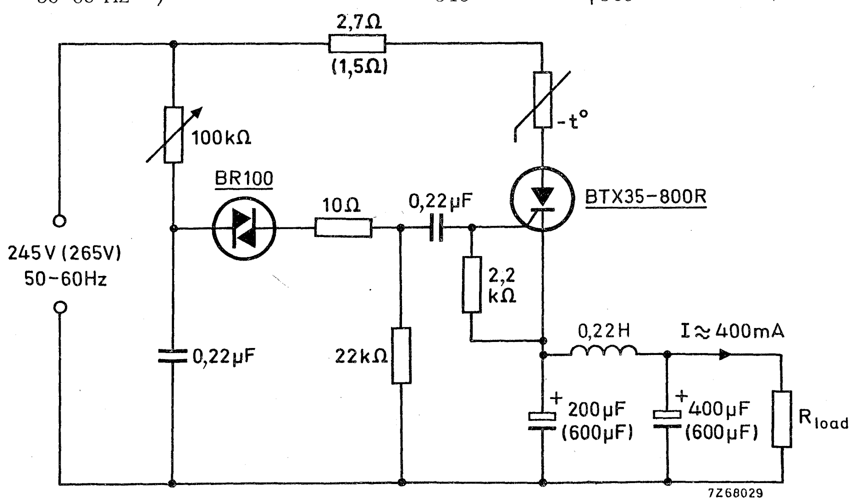


Fig.2. (Values between brackets apply to thermistor 2322 644 90005)

[1]) Measured in the circuit shown in Fig.2.

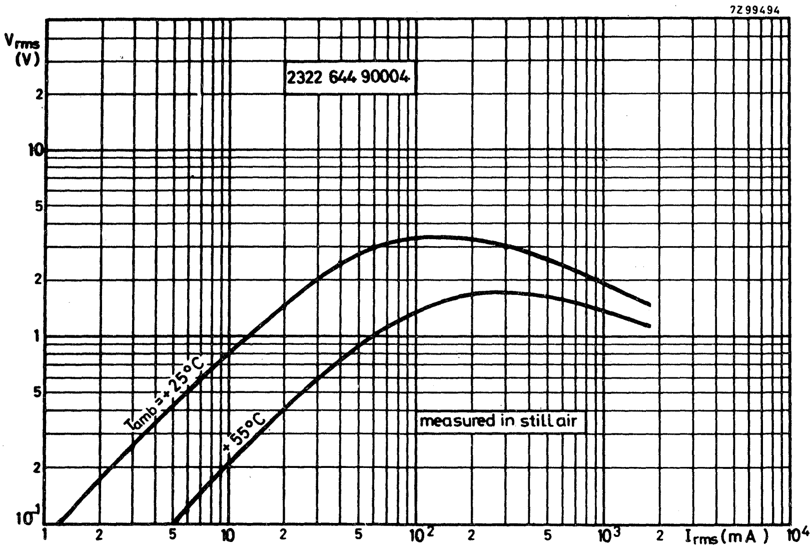


Fig. 3. Typical voltage/current characteristics

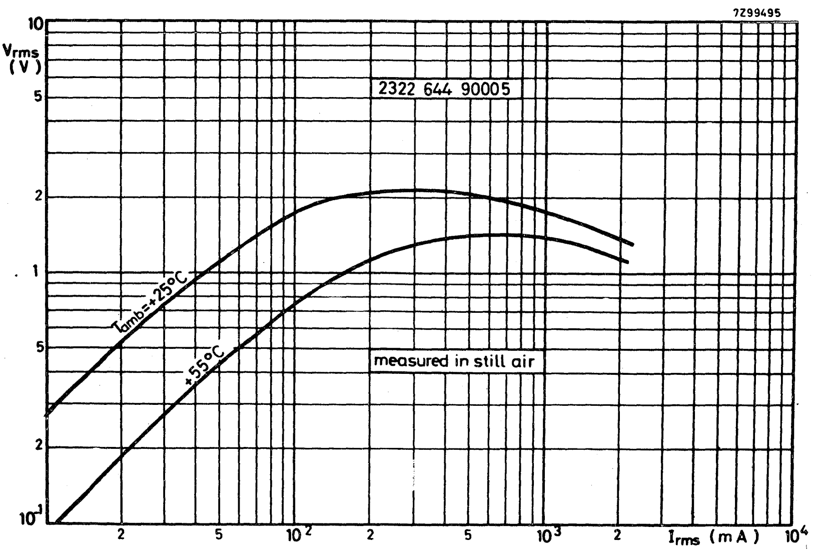


Fig. 4. Typical voltage/current characteristics

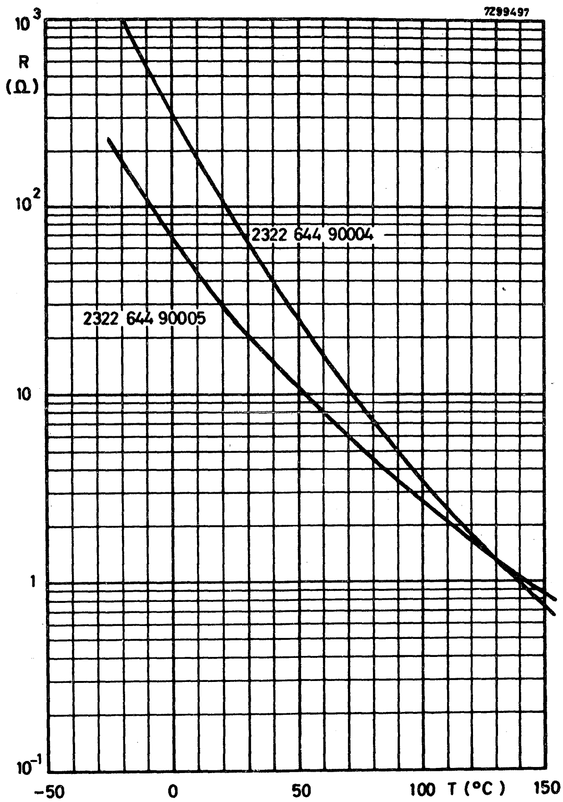


Fig. 5. Typical resistance/temperature characteristics

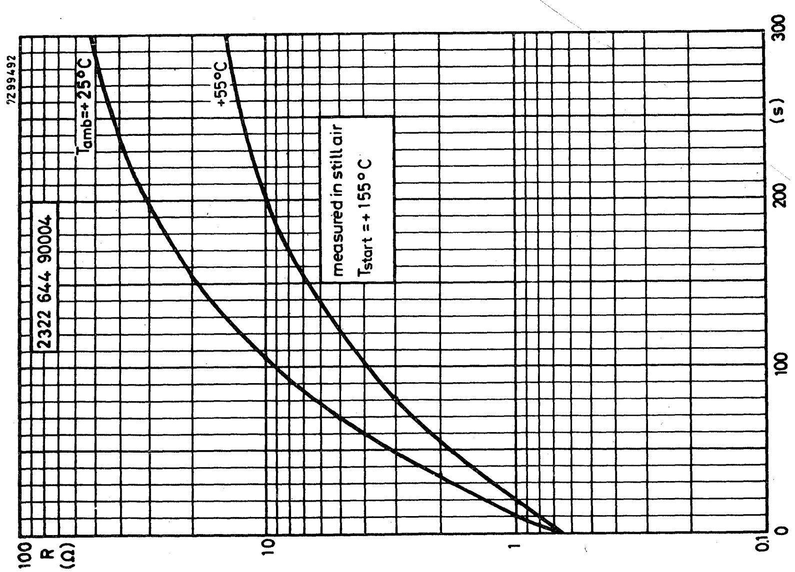


Fig. 6. Typical resistance/time (Cooling) characteristics

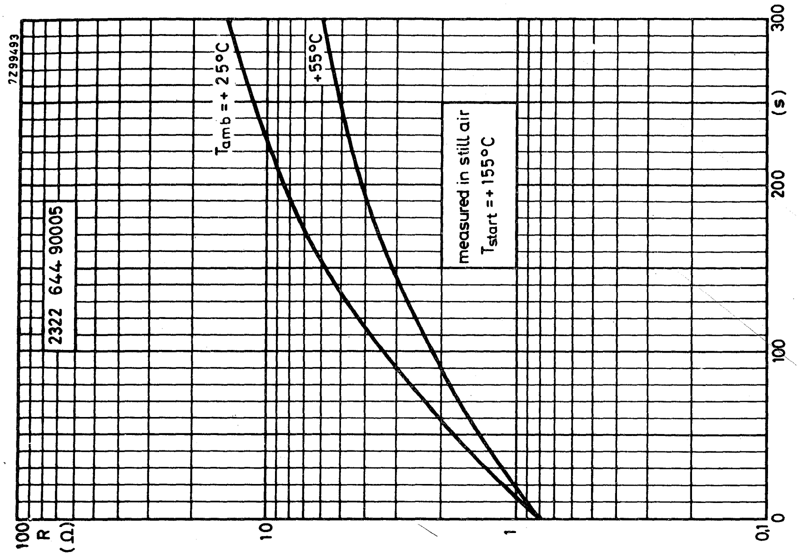


Fig. 7. Typical resistance/time (Cooling) characteristics

TESTS AND REQUIREMENTS

According to IEC 68 recommendations, unless otherwise specified.

test	test method	duration	$\Delta R/R_{25}$ (%)
Cold at −25 °C	A	1000 h	± 10
Storage at +25 °C	H	1000 h	± 10
Dry heat at +155 °C	B	1000 h	± 20
Thermal shock −25 to +155 °C	Na	5 cycles	± 20
Damp heat	Ca	1000 h	± 15
Maximum current at T_{amb} = +25 °C		1000 h	± 20
Cycling [3]			
Quick		250 cycles 5 s on/5 s off	± 20
Slow		2000 cycles 1 min on/9 min off	± 20
Robustness of terminations	U		
Tensile strength 20 N	Ua	10 s	[1]
Bending 10 N	Ub	2 times	[1]
Soldering	T		
Solderability at 230 ± 10 °C	par.3.2.3	3 to 4 s	[2]
Resistance to heat at 230 ± 10 °C	par.3.2.4	3 to 4 s	± 2

[1]) Leads should neither come loose nor break.
[2]) Leads must be solderable initially and after 6 months storage with solder containing resin flux.
[3]) Measured in the circuit shown in Fig.2.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D

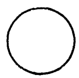
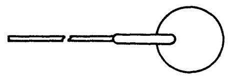
A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1.5%, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

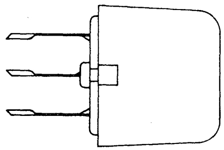
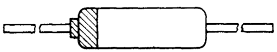
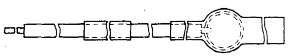
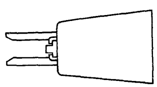
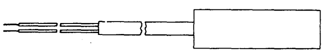
PACKAGING

Cardboard boxes containing 50 items.

Positive temperature coefficient thermistors (PTC)

SURVEY

type	R_{25} (Ω)	switch temperature (°C)	maximum voltage	dissipation factor (mW/°C)	temperature coefficient (%/°C)	catalogue number
DISC 	70 to 100	105	400 V (r.m.s.)	11,5	35	2322 662 93006
DISC with leads 	250 ±25%	6	25 V (d.c.)	6	5	2322 660 91001
	50-60 ±30%	30 to 105	25 V (d.c.)	7	7 to 40	2322 660 91006 to 2322 660 91009
	750 to 1500	115	245 V (r.m.s.)	7	26	2322 660 93001
	30 to 50 ± 15 Ω	25 to 110	40-50 V (d.c.)	6-8,5	9 to 75	2322 661 91002 to 2322 661 91005
	36 to 50	115	180 V (d.c.)	13	35	2322 662 91001
	45 to 60	75	265 V (r.m.s.)	20	20	2322 662 93036
	100 ±20%	75	265 V (r.m.s.)	15,3	35	2322 662 93066
	14 to 26	125	245 V (r.m.s.)	21	28	2322 663 93003
	≤ 0,6	85	16 V (d.c.)	27	10	2322 664 91086
	30 to 250	70 to 150	25 V (d.c.)	5,7	18 to 38	2322 672 91002 to 2322 672 91035

DUAL DISC for degaussing 	25 and 8 30 and 8 6 and 3, 5 40 and 1000 to 6000	75 75	245 V (r.m.s.) 265 V (r.m.s.) 140 V (r.m.s.) 265 V (r.m.s.)	13, 5 13, 5	23 and 25 25 and 25 20	2322 662 98001 2322 662 98003 2322 662 98006 2322 662 98009
MINIATURE for level control 	70 to 250	160	19 V (d.c.)	2 to 6	35	2322 670 90023
MOTOR PROTECTION DISC 	30 to 250	68 to 137	15 V (d.c.)	7	18 to 38	2322 672 92045 to 2322 672 92053
DISC for compensation of telephone line variations 	115 ± 25 Ω	97	33 V (d.c.)	3, 9	10	2322 672 98001
HEATING ELEMENT 			265 V (r.m.s.)			2322 680 90001

INTRODUCTION

P(ositive) T(emperature) C(oefficient) thermistors are resistors with a high positive temperature coefficient of resistance. In several aspects they differ from NTC thermistors described in this booklet:

(1) The temperature coefficient of a PTC thermistor is positive only between certain temperatures, outside these temperatures the temperature coefficient is zero or negative.

(2) The absolute value of the temperature coefficient of PTC thermistors is in most cases much higher than that of NTC thermistors.

PTC thermistors are applied as excess current limiters, temperature sensors and protection devices against overheating in all kind of apparatus such as electric motors, washing machines, alarm installations etc. They are also used as level indicators, time delay devices, thermostats, compensation resistors etc.

PTC thermistors are prepared from $BaTiO_3$, or solid solutions of $BaTiO_3$ and $SrTiO_3$ in a way which is analogous to the method for preparing NTC thermistors. A certain amount of extra electrons on the Ti-ions are created by the introduction of foreign ions having a different valency. In these compounds there are two possibilities: substitution of trivalent ions like La or Bi for Ba or substitution of pentavalent ions like Sb^{5+} or Nb^{5+} for Ti. Both methods lead to identical results. If carefully prepared, in the absence of oxygen, these semiconductors have a normal, weakly negative temperature coefficient. The interesting PTC effect is obtained by firing the ceramic samples in the presence of oxygen. It is caused by the penetration of oxygen from the atmosphere along pores and crystal boundaries during the cooling part of the firing process. The oxygen atoms, adsorbed on the crystal surfaces attract electrons from a thin zone of the semiconducting crystals. In this way electrical potential barriers are formed consisting of a negative surface charge with on both sides thin layers having a positive space charge resulting from the now uncompensated foreign ions. These barriers cause an extra resistance of the thermistor.

$$R_b \propto \frac{1}{a} \; e^{eV_b/kT}$$

Here $\underline{a}$ represents the size of the crystallites, thus $\frac{1}{a}$ the number of barriers per unit length of the thermistor. V_b represents the electrical potential of the barriers. As V_b is inversily proportional to the value of the dielectric constant of the crystals it is clear that R_b is extremely sensitive to variations of the dielectric constant. Such a variability of the dielectric constant is a special property of materials with a ferro-electric nature like $BaTiO_3$ and its solid solutions. Above their ferro-electric Curie temperature Θ the relative dielectric constant decreases with temperature according to

$$\varepsilon_r = \frac{C}{T - \Theta}$$

where C has a value of roughly 10^5 K. As a result the resistivity increases sleeply just above the Curie temperature.
Below the Curie temperature the barriers are weak or absent, partly as a result of the high effective dielectric constant of $BaTiO_3$ in strong fields and partly as a result of the spontaneous polarization of the crystals which may compensate the boundary charges.
At very high temperatures, above 160 to 200 °C, the electrons captured at the boundaries are gradually liberated. As a result the potential barriers decrease in strength, so that the PTC temperature region is followed by an NTC region. Therefore the applications of PTC thermistors are restricted by a certain temperature limit.
As the PTC effect is caused by crystal boundary barriers the extra resistance R_b is shunted by a high parallel capacitance C_b. This leads to a frequency dependence of R_b, or better of the extra impedance Z_b. Above 1 to 5 MHz Z_b has completely disappeared. The characteristic properties described in the following paragraphs are thus restricted to low frequencies.

MANUFACTURING PROCESS

The manufacturing process can be compared with that of NTC thermistors. Mixtures of barium carbonate, strontium and titanium oxides and other materials depending on the required electrical characteristics are milled, mixed and pressed into a suitable form. After drying, the PTC's are sintered at a very high temperature. After the contacts have been applied with the utmost care on this n-type semiconductor, leads can be soldered on the contact surfaces. Most PTC types with leads are further protected by a special lacquer.

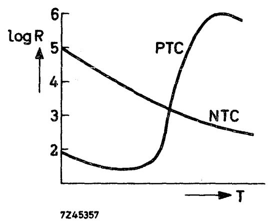
$\propto$ = directly proportional with

ELECTRICAL PROPERTIES

RESISTANCE VERSUS TEMPERATURE CHARACTERISTICS

The relation between resistance value and temperature is difficult to express in a compact formula (as was done for NTC). Being not simply the reverse of an NTC curve, the PTC characteristic is more complicated. In Fig.1 a comparison is given of the general behaviour of NTC and PTC thermistors. Generally speak-

Fig.1.
Resistance/temperature characteristics of an NTC and PTC thermistor.



ing, PTC thermistors have at the lower end of the temperature scale a zero or negative temperature coefficient of resistance. Going to higher temperatures the temperature coefficient of resistance changes to a high positive value up to a temperature of approximately 150 ^{o}C. Above that temperature the temperature coefficient decreases and becomes negative.

In some cases the resistance/temperature relation can be expressed by the formula:

$$R_T = A + Ce^{BT}, \quad \text{for } T_1 < T < T_2$$

in which R_T = resistance at the temperature T of the PTC

T = temperature of the PTC

A, C and B constants

T_1 = minimum temperature for which the formula applies.

T_2 = maximum temperature for which the formula applies.

From this formula we find after differention the temperature coefficient:

$$\alpha = \frac{1}{R} \cdot \frac{dR}{dT} = \frac{BC\, e^{BT}}{A + Ce^{BT}}$$

which yields to

$$\alpha = 100B \text{ \% per deg C}$$

for that part of the characteristic where $R_T \gg A$.

However, in practice it seldom occurs that the R/T characteristic can be described by the above or another simple formula, so calculations have to be based on graphical methods. As a practical indication of the temperature at which the PTC thermistor starts to have a usable temperature coefficient, the switch temperature T_{switch} has been introduced, being defined as the higher of the two temperatures at which the value of the resistance of the PTC is twice that of the minimum resistance [1]).

VOLTAGE VERSUS CURRENT CHARACTERISTICS

The static voltage/current characteristics are very interesting as these curves clearly show the current limiting ability of the PTC thermistors. Up to a certain voltage the V/I characteristic is a straight line following ohm's law but as soon as the PTC is heated up by the current so much that its temperature reaches the switch temperature, the resistance value increases (Fig.2).
Of course the V/I characteristic depends on the ambient temperature and on the heat transfer coefficient to the ambience.
In Fig.2 the characteristic is plotted on a linear scale, in practice, however, logarithmic scales are used more often (Fig.3). PTC thermistors show a certain degree of voltage dependency. At higher voltages the resistance value is somewhat lower than expected. This is the reason why a V/I characteristic is difficult to calculate from the R/T curve with the given dissipation constant. (see: Electrical properties of NTC thermistors, page C7).
It is, however, possible to calculate the top of the V/I characteristic with very good approximation if the R/T characteristic and the dissipation constant is known.

The calculation goes as follows:

The power dissipation is: $W = I^2R$

Thus a small increase in W: $\Delta W = 2IR\Delta I + I^2 \Delta R$

At the top of the V/I curve $\Delta I_p = 0$ thus:

$\Delta W_p = I_p^2 \Delta R_p$ (p indicates that the values are taken at the top of the V/I characteristic).

Also $\Delta W = D \Delta T$ thus:

$$\Delta W_p = D \Delta T_p = I_p^2 \Delta R_p$$

or

$$\frac{\Delta T_p}{\Delta R_p} \cdot D = I_p^2$$

[1]) The curie temperature, wellknown as an indication for the behaviour of ceramic capacitors and magnetic materials, is less suitable for use as a practical measure for PTC thermistors.

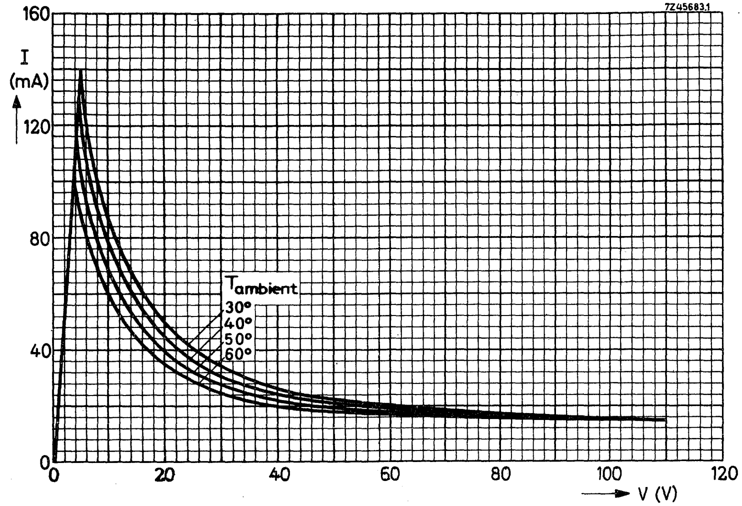


Fig.2.
Voltage/current characteristics of a PTC thermistor at different ambient temperatures on a linear scale.

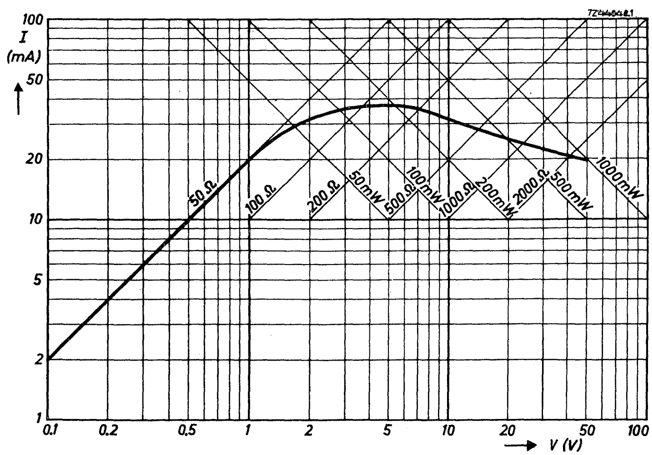
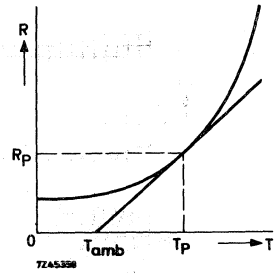


Fig.3.
Voltage/current characteristic on a logarithmic scale.

Fig.4.
Part of the resistance/temperature characteristic on a linear scale.



In Fig.4, the R/T characteristic on linear scale, we see:

$$\frac{\Delta T_p}{\Delta R_p} = \frac{T_p - T_{amb}}{R_p}$$

so

$$I_p = \sqrt{\frac{D(T_p - T_{amb})}{R_p}}$$

With given ambient temperature (T_{amb}) and D, the values R_p and T_p can easily be found (see Fig.4).
The calculation shows that if D is increased n times (e.g. by a heatsink, or ambience with better heat conductivity) I_p increases $\sqrt{n}$ times.
Furthermore it can be seen that R_p and T_p are independent of the surrounding medium.

PTC THERMISTOR IN SERIES WITH A LOAD

With the voltage/current characteristic it can be shown that due to the non-linearity of the PTC-curve three working points are possible when a load R is connected in series with the PTC (Fig.5). The characteristic of the load is a straight line intersecting the voltage ordinate at V_a, the supply voltage. P_1 and P_2 are stable working points, P_3 is unstable.
When the voltage V_a is applied to the series connection, equilibrium will be reached at P_1, a point with a relatively high current. P_2 can only be reached when the top of the V/I curve comes below the load characteristic. This may happen in the following cases:

(1) V_a increases (Fig.6);

(2) the ambient temperature increases (Fig.7);

(3) the load resistance decreases (Fig.8).

The PTC is thus an excellent protective device as it limits the current through the load to a safe value if supply voltage, temperature or current surpass a critical value.

Fig.5.
PTC thermistor in series with a load showing the possible working points.

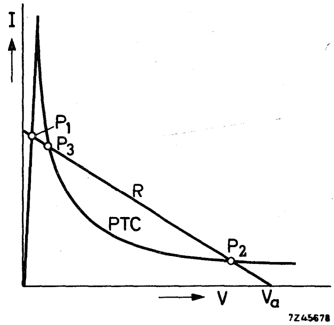


Fig.6.
PTC thermistor in series with a load showing the influence of the supply voltage V_a.

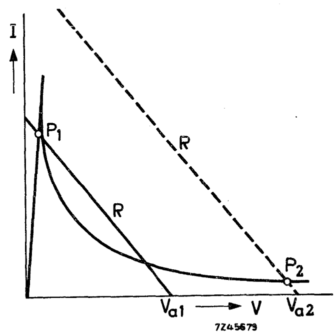


Fig.7.
PTC thermistor in series with a load showing the influence of the ambient temperature.

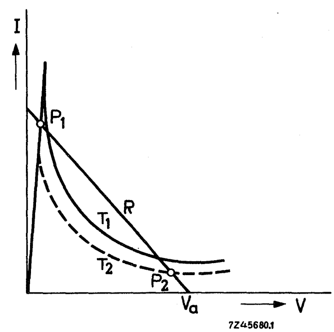
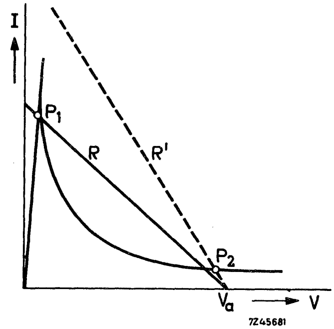


Fig.8.
PTC thermistor in series with a load showing the influence of the load resistance.



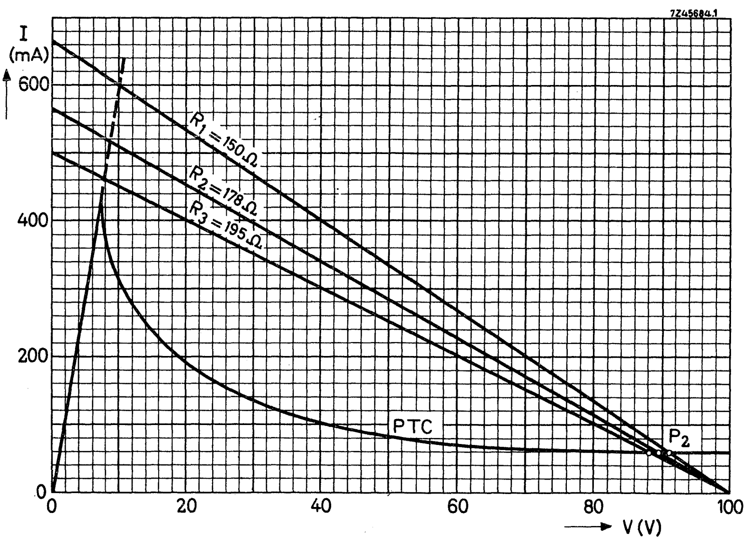


Fig. 9. PTC thermistors in series with different resistors.

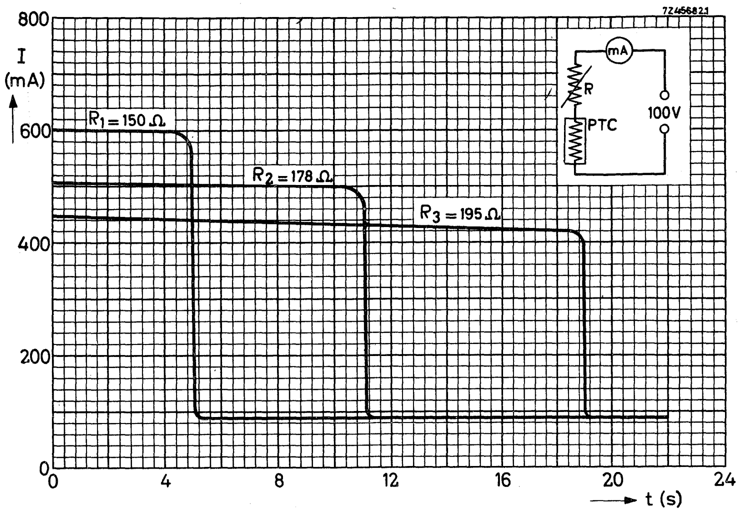


Fig.10. Current/time characteristics showing the influence of the value of the load.

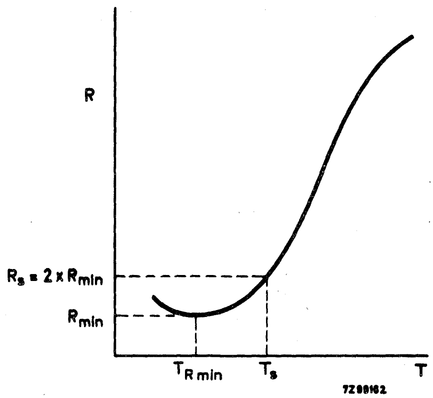
CURRENT/TIME CHARACTERISTICS

If a PTC thermistor is connected in series with a resistance of such a value that the top of the V/I curve lies under the load line, the PTC will heat up till the stable working point P_2 is reached (Fig.9). The time it takes to reach this point depends very much on the value of the load R (Fig.10) and the ambient temperature.

EXPLANATION OF TERMS

Switch temperature (T_S)

The switch temperature T_S is the higher of the two temperatures at which the resistance R_S is twice the minimum resistance R_{min} (see Fig. 1).
So, at $T_S > T_{Rmin}$: $R_S = 2\ R_{min}$

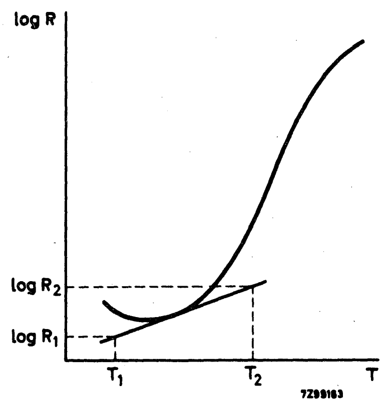


Temperature coefficient (α)

The temperature coefficient $\alpha = \frac{1}{R}\ \frac{dR}{dT}$.
For R-T curves plotted on a log R-lin T scale, as they practically all are, we can work out

$$\alpha = \frac{d \ln R}{dT} = \frac{1}{0.4343} \cdot \frac{d \log R}{dT}$$

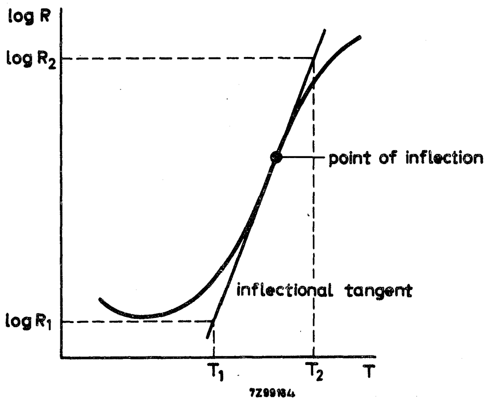
It can be seen that the tangent at a point of the R-T characteristic (see Fig.2) is proportional to the α at that point.



α can be calculated from

$$\alpha = \frac{100}{0.4343} \cdot \frac{\log R_2 - \log R_1}{T_2 - T_1} \ \%/\text{deg C}$$

where R_1 and R_2 are points on the tangent with T_1 and T_2 being the corresponding temperatures.
In the data sheets the maximum temperature coefficient is given, this is the α measured at the inflection point of the log R-lin T characteristic (i.e. the point where $\frac{d^2 \log R}{d\,T^2} = 0$, see Fig.3)



When one resistance decade is taken ($R_2 = 10\,R_1$) the formule reduces to

$$\alpha = \frac{100}{0.4343} \cdot \frac{1}{T_2 - T_1} \ \%/\text{deg C}$$

Thermal time constant (τ)

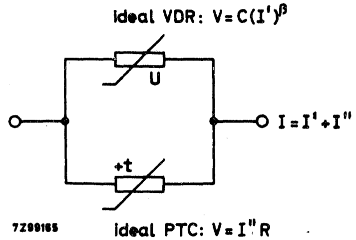
The thermal time constant represents the time required for a thermistor to change 63.2% of the total difference between its initial and final body temperatures when subjected to a step function change in temperature under zero-power conditions.
The τ given in the data is found as follows (for $T_s > 25\,^oC$):
Measure T_1, being the temperature of the PTC at V_{max}, at an ambient temperature of $T_o = 25\,^oC$; T_s is known, then τ can be calculated from:

$$\tau = \frac{t}{\ln (T_1 - T_o)/(T_s - T_o)},$$

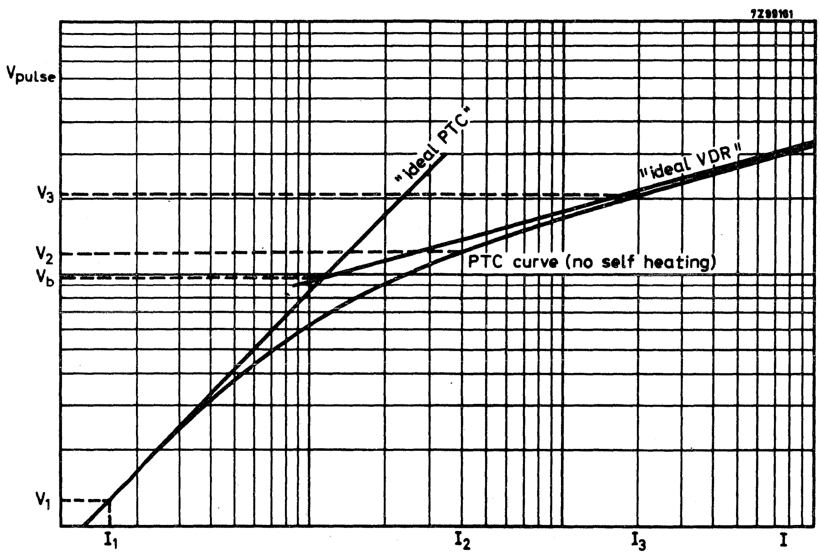
where t is the time required for cooling the PTC from T_1 to T_s in still air of 25 ^oC.

Voltage dependence aspects

PTC thermistors show a voltage dependence. This effect can be explained with the aid of a parallel connection of an "ideal PTC" having no voltage dependence and an " ideal VDR" following exactly the formula $V = C.I^{\beta}$ (see Fig. 4).



Plotted on a log I-log V scale at an arbitrary constant temperature the ideal PTC and ideal VDR can be represented by 2 straight lines (see Fig. 5).



These lines can be seen to coincide with the PTC curve (measured under pulse conditions to avoid internal heating) at low voltages where the ohmic behaviour is the deciding factor, and at high voltages where the VDR effect becomes more important.
Two aspects of the voltage dependence are specified in the data sheets:

Balance voltage (V_b)

Where the two straight lines intersect the current through the ideal PTC is equal to the current through the ideal VDR. The voltage at which this occurs is called the balance voltage V_b and is specified at a certain temperature.

Voltage dependence (β)

The β-value of the ideal VDR, being a measure for the voltage dependence of the

the PTC, can be calculated with the formula:

$$\beta = \frac{\log V3/V2}{\log (I_3 - V_3/R)/(I_2 - V_2/R)}$$

with V_3 and V_2 being pulse voltages $> V_b$ and $R = \frac{V_1}{I_1}$, measured at $V_1 \leq 1.5\ V_{dc}$.
The β-value is also specified at a certain temperature.

V_b and β-value are useful parameters for estimating the voltage dependence of a particular PTC.

HOW TO MEASURE PTC THERMISTORS

For general information regarding measuring techniques and apparatus refer to the section "How to measure NTC thermistors", which covers the same topics. As PTC thermistors often show a very high temperature coefficient especially at high temperatures, measurements at these high temperatures must be carried out with particular care. Even an error of 0,1 °C can give an error in resistance of a few percent. Specially calibrated thermometers have to be used. Stem correction has to be applied; this is often forgotten, but deviations of more than 0,1 °C may result if it is not used. (See "Handbook of Chemistry and Physics", 44th edition, for example.)
The stem correction formula for fluid thermometers is:

$$T_c = T_o + F \cdot L\,(T_o - T_m),$$

where: T_c = corrected temperature;
T_o = observed temperature;
T_m = mean temperature of exposed stem;
L = length of the exposed column in degrees above the surface of the substance whose temperature is being determined;
F = correction factor.

For approximate work, and when the liquid in the thermometer is mercury, a value for F of 0,00016 is generally used.
For example with T_o = 110 °C, T_m = 70 °C and L = 50 °C we find: T_c = 110,32 °C, thus without stem correction an error of more than 0,3 °C would have been made. It is also necessary to measure the resistance with a voltage below 2 V in order not to heat the PTC and also to diminish voltage-dependent effects.

TOLERANCES

The resistance values of standard PTC thermistors are specified at the following temperatures:

(1) 25 °C;
(2) A temperature above the switch temperature.

The switch temperature is also given.

For each standard type tolerances are specified for the R_{25} and the high-temperature resistance value. The tolerance on switch temperature is not specified; normally it is only a few degrees Celsius.
Special types are often specified according to the requirements for the particular application. The PTC thermistors for motor control, for instance, can be specified at a high temperature with a rather close tolerance, while the tolerance below the switch temperature, being less important, is much wider. PTC thermistors for current limiting applications are in most cases specified in terms of voltage and current.
It will be clear that the specification and the tolerances of PTC thermistors depend on the application, and are not limited to the standard range published in this book.

APPLICATIONS

The applications of PTC thermistors can be classified in two main groups:

(1) Applications where the temperature of the PTC is primary determined by the temperature of the ambient medium.

(2) Applications where the temperature of the PTC is primary determined by the current through the PTC thermistor.

The first group comprises applications such as temperature-measurement and control and circuits for protection against excessive temperatures (e.g. motor protection.)

The second group includes applications such as current stabilization and limiting of current relay retardation, fluid-level indication and circuits for protection against over-voltages and short circuits.
Principle circuits of the above mentioned applications are given in the following pages.

No details of component data are mentioned as these can be calculated on basis of available supply voltages and data of relays or other vital components. Details on more complicated circuits will be given on request.

REMARKS ON THE USE OF PTC THERMISTORS

Do not apply a voltage above V_{max} to the PTC, since this may result in a breakdown of the thermistor.

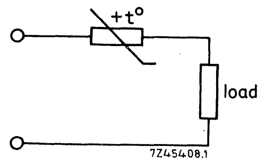
Do not connect PTC thermistors in series in order to obtain higher permissible voltages or wattages: this may lead to a breakdown of the PTC which heats up a bit faster than the other(s) which results in too high voltage over this particular PTC.

If special PTC characteristics are required which cannot be found in this book please specify your requirements as they can perhaps be fulfilled by one of our non-listed types.

APPLICATION EXAMPLES

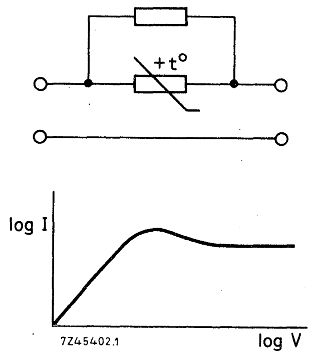
Protection against over-voltage and short-circuit

As soon as the current increases the PTC limits it to a safe value.



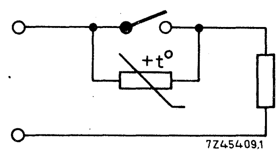
Current stabilization

By using a parallel resistor a current stabilization circuit is obtained that compensates slowly varying supply voltages.



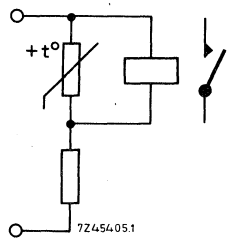
Spark suppression

A PTC across the switch acts as a spark suppressor. When the switch opens the low resistance of the cold PTC prevents sparking.



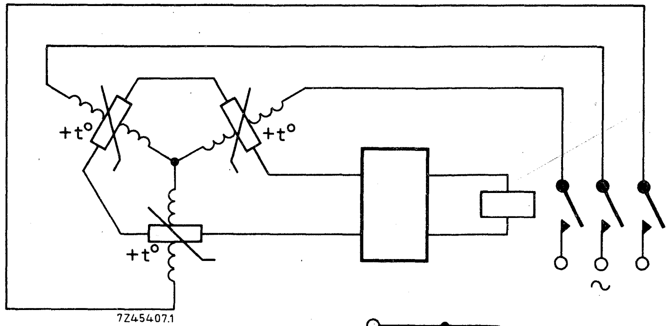
Delaying action relays

A certain time after applying the voltage the relay is activated.



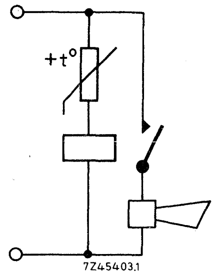
Temperature protection of electric motors

As soon as one or more windings become too hot the motor is switched-off.



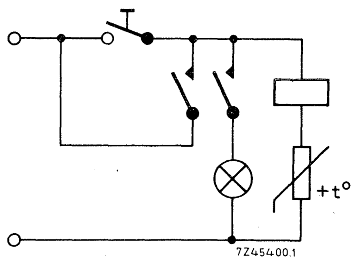
Alarm installation

The PTC reacts on ambient temperature (too low or too high).



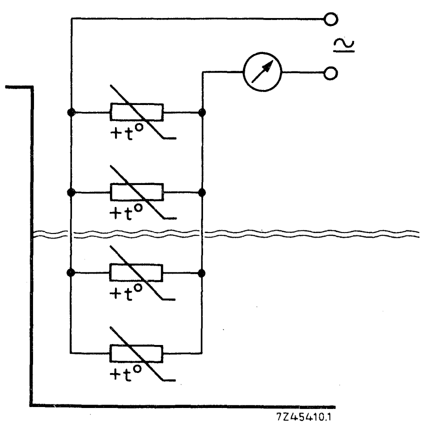
Time delay circuit

When the button is pressed the relay is activated and the lamp lights up. After some time the relay falls off due to the increase in resistance value of the PTC.



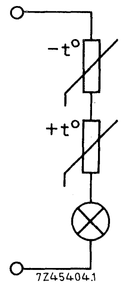
Liquid-level indication

The PTC thermistors above the fluid-level will be heated to a temperature above T_{switch}. When immersed they are cooled so that their resistance value is low.



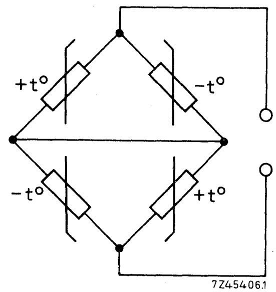
Thermal oscillator

With an NTC and a PTC thermistor in series, a thermal oscillator can be obtained.



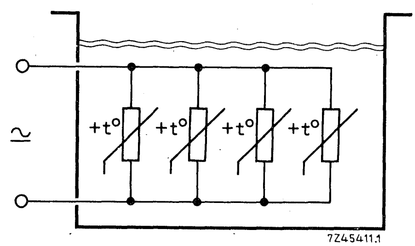
PTC-NTC multivibrator

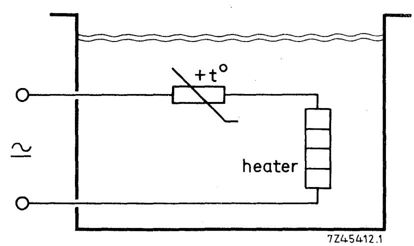
One of the PTCs will heat up, as its resistance value increases the NTC in parallel will heat up while leaving the first one time to cool, etc.



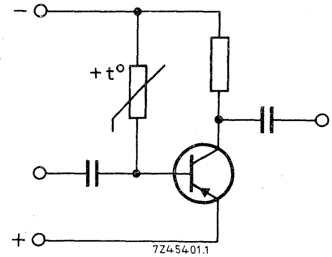
Thermostat circuits

Two principal circuits are possible.
In the first circuit the PTC thermistors act as a control element and as a heater at the same time, while in the second circuit it functions only as a control element.



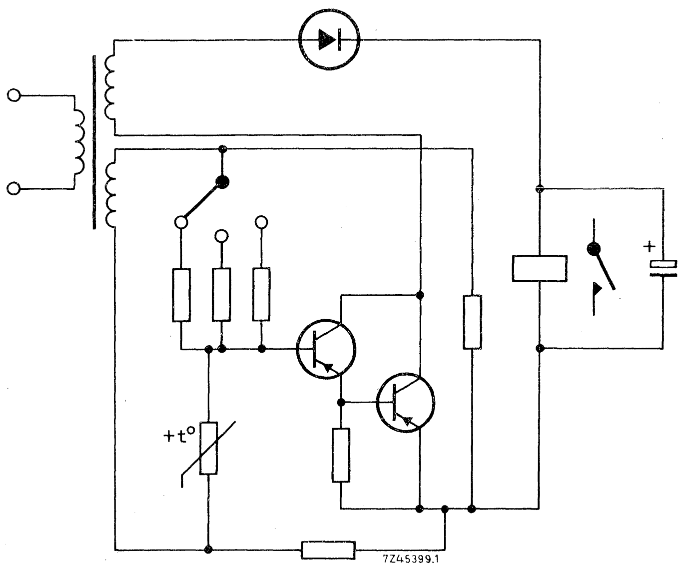


Temperature compensation of transistor circuits



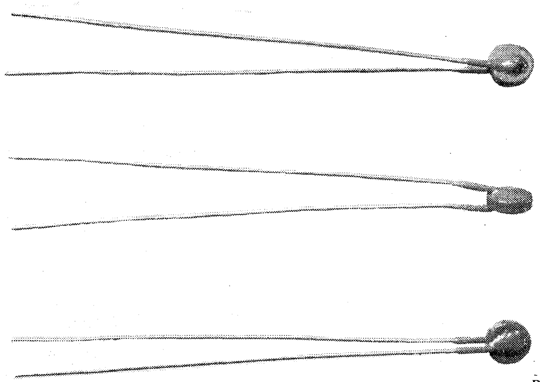
Thermostat for washing machines

A thermostat for three temperatures.



PTC THERMISTOR
disc

QUICK REFERENCE DATA	
Resistance value at +25 °C	250 Ω ± 25 %
Resistance value at +80 °C	3700 Ω ± 30 %
Switch temperature	+6 °C approx.
Temperature coefficient	+5 %/degC approx.
Max. voltage at T_{amb} = +55 °C	25 V d.c.
Dissipation factor	6 mW/degC approx.
Operating temperature range	
at zero power	−25 to +155 °C
at V_{max}	0 to +55 °C



RZ 28448-1

APPLICATION

Temperature compensating and temperature measurement purposes.

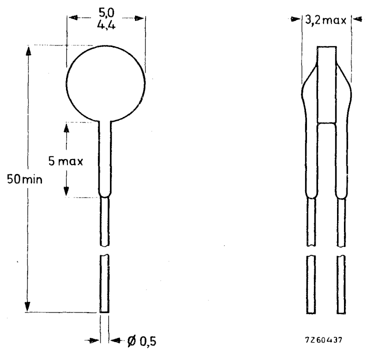
DESCRIPTION

The thermistor has a positive temperature coefficient. It consists of a disc provided with two solid tinned copper wires. The thermistor body is blue lacquered but not insulated.

MECHANICAL DATA

Dimensions in mm

Outlines



Mass 0, 3 g approximately

Mounting In any position by soldering

Robustness of terminations

Tensile strength	10 N
Bending	5 N

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s

ELECTRICAL DATA

Resistance at +25 °C (T_{ref})	250 Ω ± 25% 1)
at + 80 °C	3700 Ω ± 30% 1)
Switch temperature	+ 6 °C approx.
Temperature coefficient	+ 5%/°C approx.
Dissipation factor	6 mW/°C approx. 2)
Heat capacity	0, 1 J/°C approx. 2)
Thermal time constant	17 s approx. 2)
Operating temperature range	
at zero power	−25 to + 155 °C
at V_{max}	0 to + 55 °C
Voltage dependence at + 155 °C	0, 25 approx.
Balance voltage (d.c.)	13 V approx.
Maximum voltage (d.c.)	25 V

1) Measuring voltage not exceeding 1, 5 V(d.c.) to avoid internal heating.
2) Measurement made with specimen in phosphor bronze clips in still air.

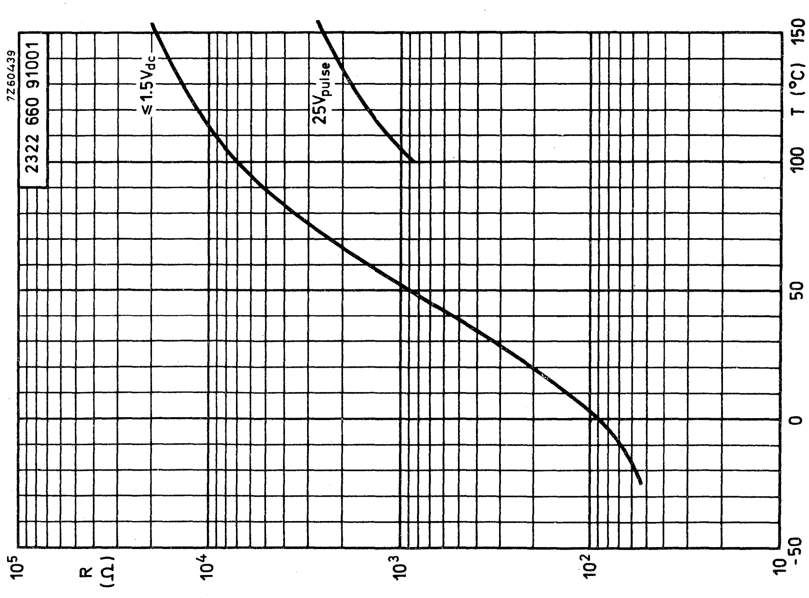


Fig. 2 Typical resistance/temperature characteristics

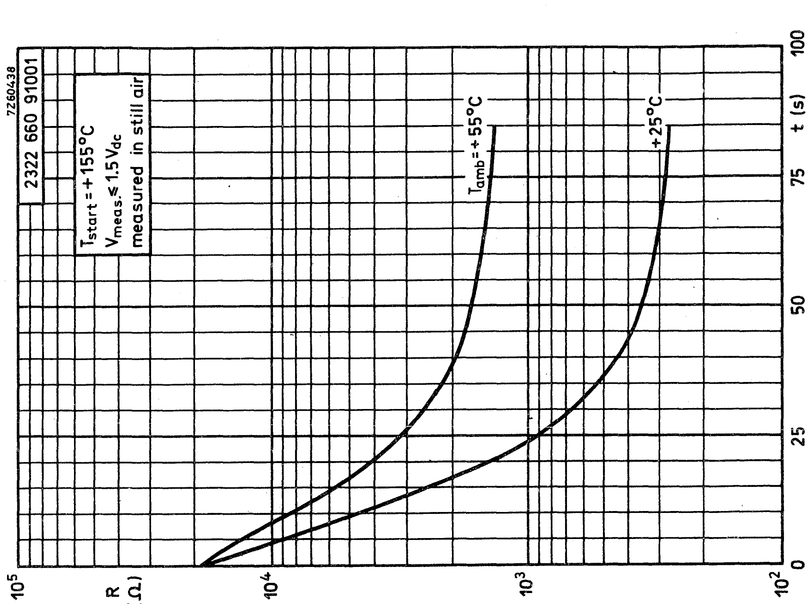


Fig. 3 Typical resistance/time (cooling) characteristics

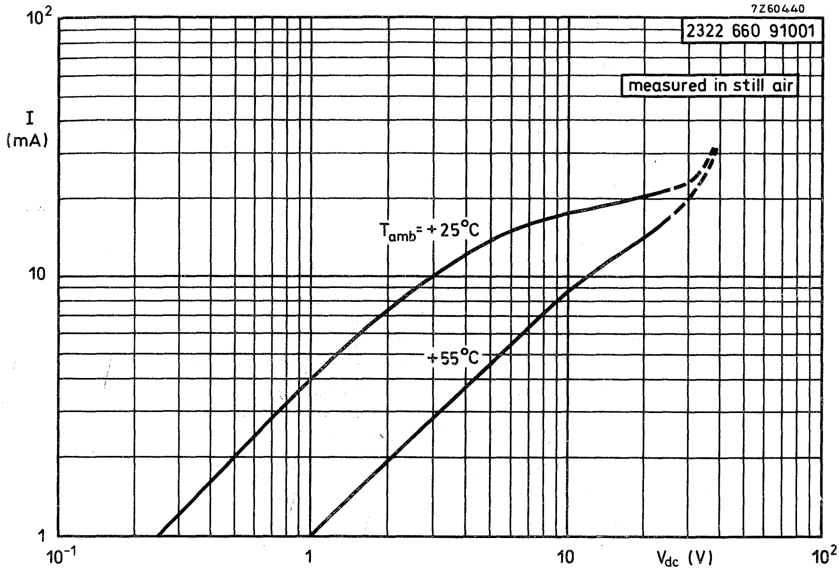


Fig. 4 Typical current/voltage characteristics

TESTS AND REQUIREMENTS

According to IEC recommandations, unless otherwise specified.

test	test method	duration	ΔR/R (%) at +25 °C	ΔR/R (%) at + 80 °C
Cold at −25 °C	A	1000 h	± 3	± 5
Storage at +25 °C	H	1000 h	± 3	± 5
Dry heat, + 155 °C	B	1000 h	± 5	± 10
Thermal shock −25 to + 155 °C	Na	5 cycles	± 3	± 7
Damp heat	Ca	1000 h	± 5	± 7, 5
Dissipation at V = 25 V d.c. and T_{amb} = + 55 °C		1000 h	± 5	± 10
Robustness of terminations	U			
Tensile strength 5 N	Ua	10 s	1)	
Bending 2, 5 N	Ub	2 times	1)	
Soldering	T			
Solderability at 230 ± 10 °C	par. 3. 2. 3	3 to 4 s	2)	
Resistance to heat at 230 ± 10 °C	par. 3. 2. 4	3 to 4 s	± 2	± 2

1) Leads should neither come loose nor break.
2) Leads must be solderable, initially and after six months storage, with solder containing resin flux.

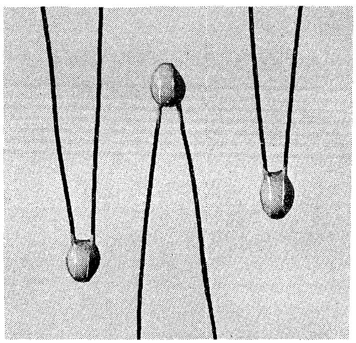
QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1,5%, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

PTC THERMISTORS
disc

QUICK REFERENCE DATA	
Resistance values at +25 °C	50 and 60 Ω ± 30%
Resistance at other temperatures Switch temperature Temperature coefficient	see table
Max. voltage	25 V d.c.
Dissipation factor	7 mW/°C approx.
Operating temperature range	
at zero power	−10 to + 125 °C [1]
at V_{max}	0 to + 55 °C



RZ 19269-

APPLICATION

Suitable for all kinds of applications.

DESCRIPTION

The thermistors have a positive temperature coefficient. They consist of a disc provided with two solid tinned copper wires. The thermistor body is blue lacquered but not insulated.

[1] PTC thermistor 2322 660 91009: −10 to + 150 °C.

MECHANICAL DATA

Dimensions in mm

catalogue number	colour band
2322 660 91006	red
2322 660 91007	orange
2322 660 91008	yellow
2322 660 91009	green

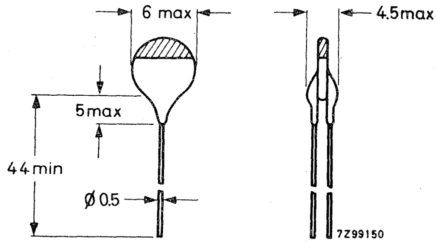


Fig. 1.

Marking

The thermistors are marked with a colour band at the top of the body according to Fig. 1.

Weight 0.4 g approximately

Mounting In any position by soldering

ELECTRICAL DATA

	catalogue number 2322 660 followed by 91006	91007	91008	91009	unit
Resistance at 25 °C 1)	60	50	50	50	Ω
Resistance at 125 °C 1)	3 to 15	100 to 500	50 to 500		kΩ
Resistance at 150 °C 1)				0.1 to 1.2	MΩ
Switch temperature	30	50	80	105	°C
Temperature coefficient	7	16	23	40	%/deg.C
Heat capacity 2)	0.13	0.13	0.13		J/deg C
Thermal time constant 2)	20	18	18		s
Voltage dependence β	0.19	0.17	0.18		
Balance voltage	35	12.5	23		V_{dc}

Tolerance on R_{25}	± 30%
Max. voltage	25 Vd.c.
Dissipation factor	7 mW/degC approx.
Operating temperature range	
at zero power	-10 to +125 °C 3)
at V_{max}	0 to +55 °C

1) Measuring voltage not exceeding 1.5 V_{dc} to avoid internal heating.
2) Measurements made with specimen in phosphor bronze clips, in still air.
-10 to +150 °C.

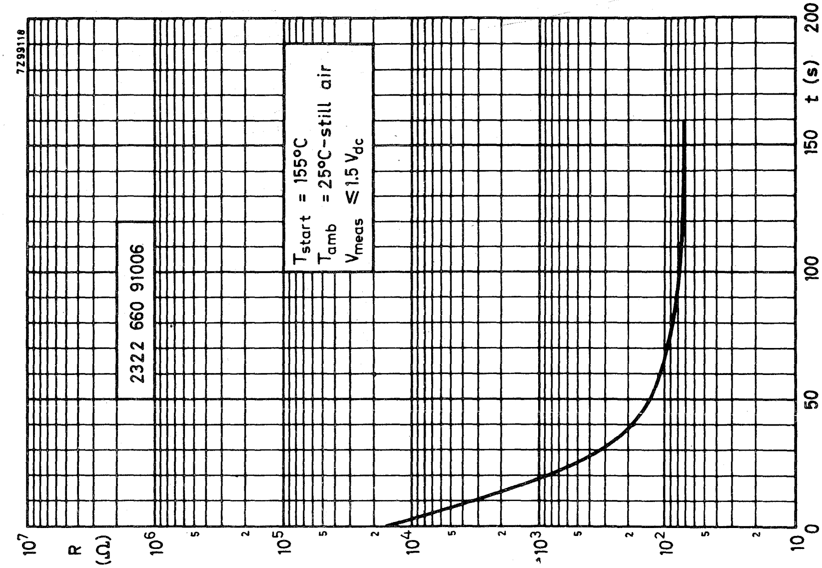


Fig.3.

Typical resistance/time (cooling) characteristic

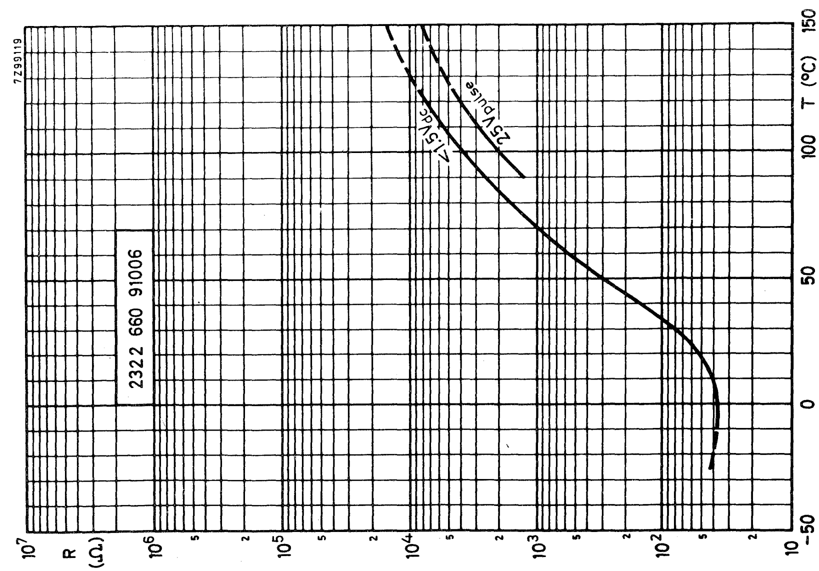


Fig.2.

Typical resistance/temperature characteristics

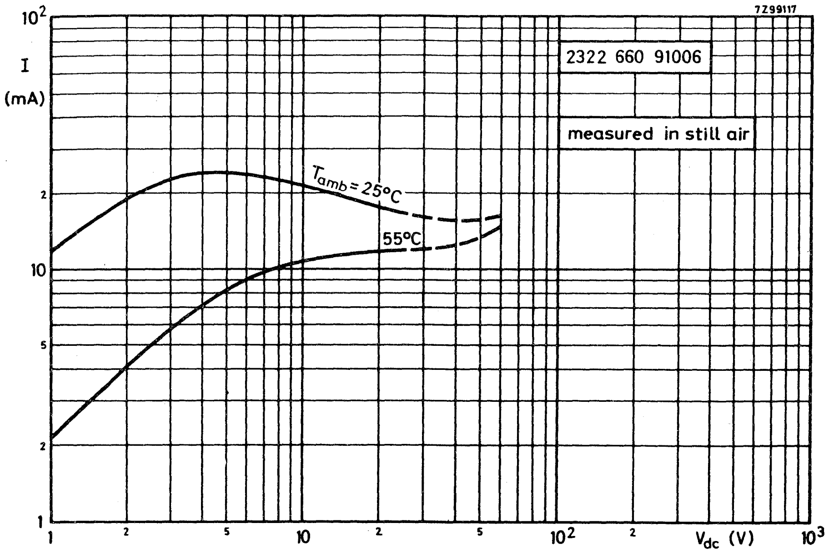


Fig.4. Typical voltage/current characteristics

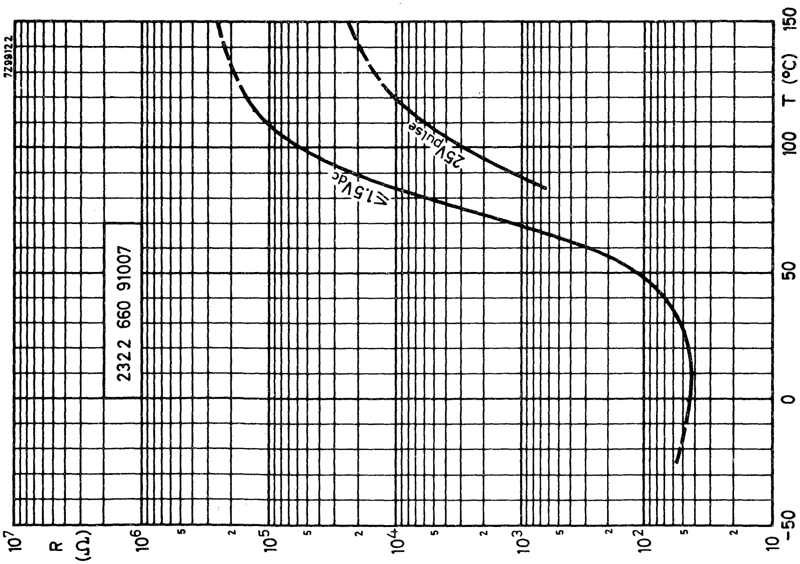


Fig. 5.
Typical resistance/temperature characteristics

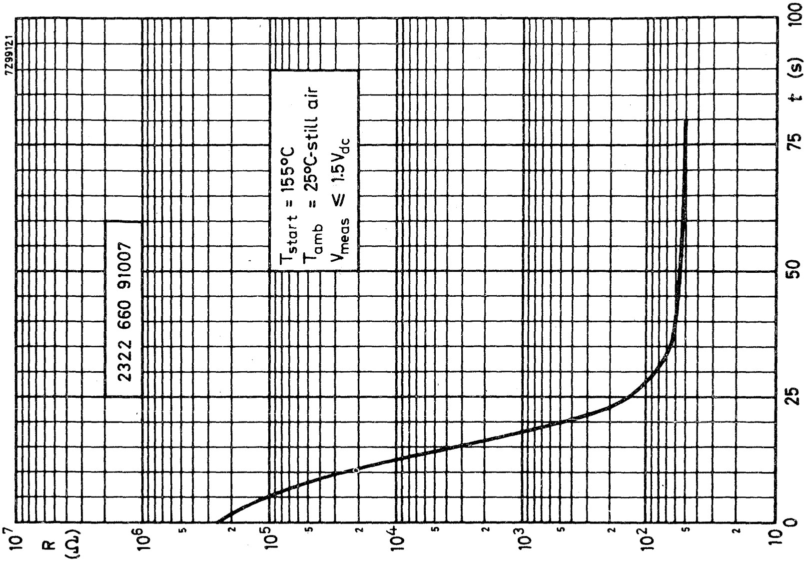


Fig. 6.
Typical resistance/time (cooling) characteristic

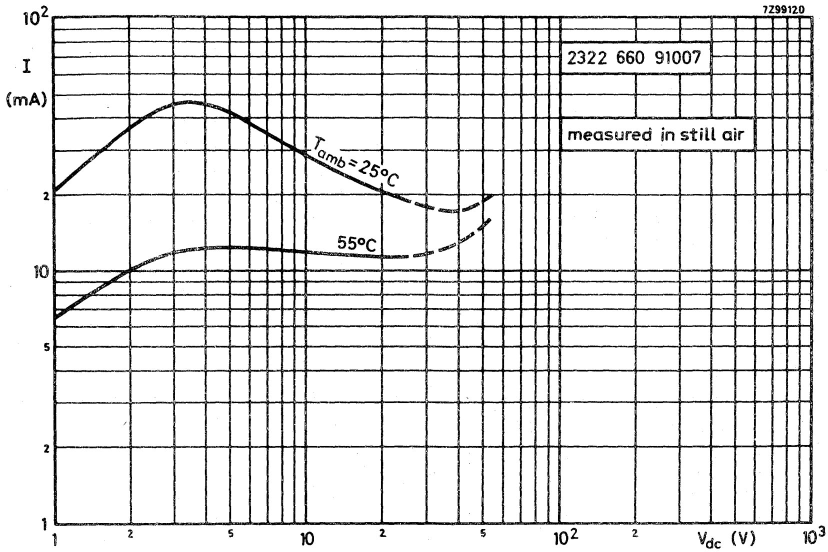


Fig. 7. Typical voltage/current characteristics

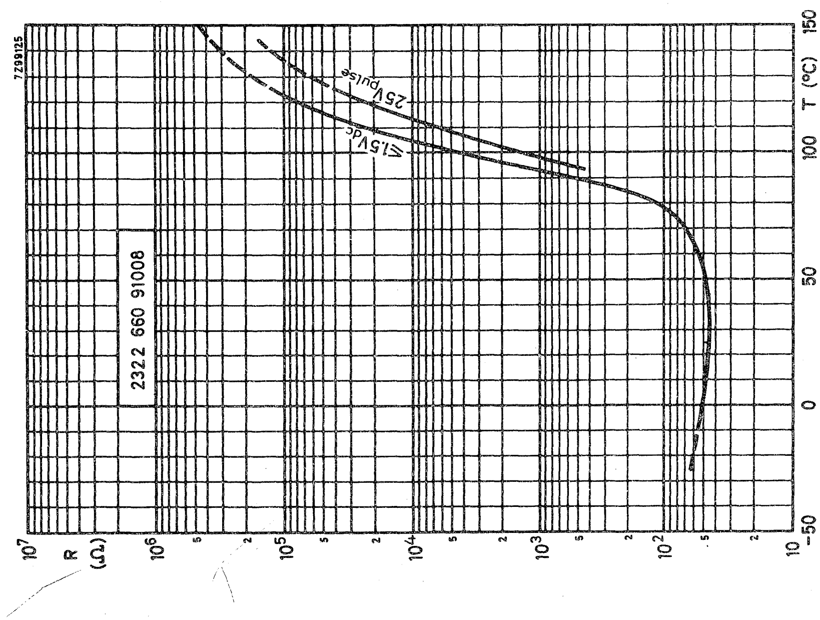


Fig. 8.
Typical resistance/temperature characteristics

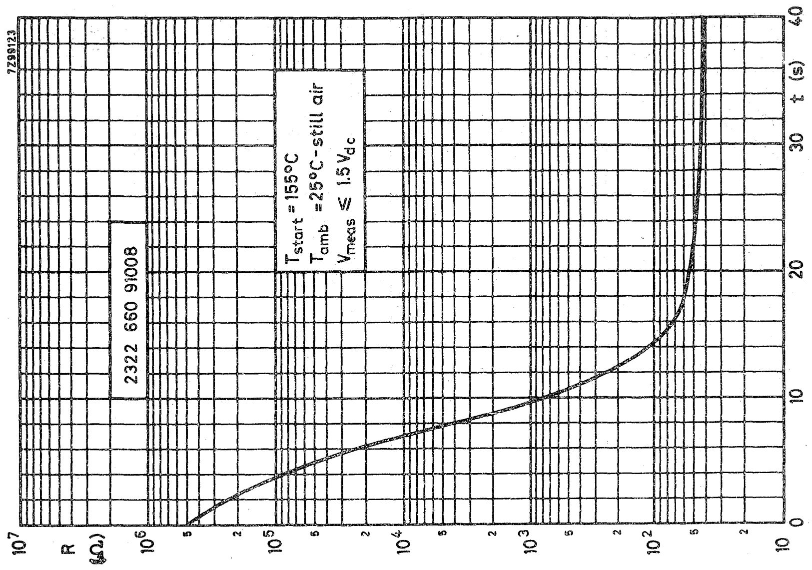


Fig. 9.
Typical resistance/time (cooling) characteristic

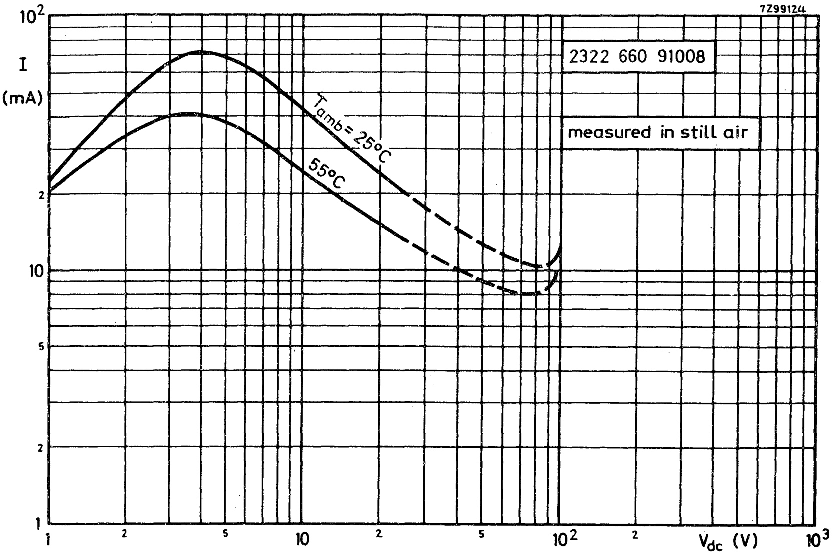


Fig. 10. Typical voltage/current characteristics

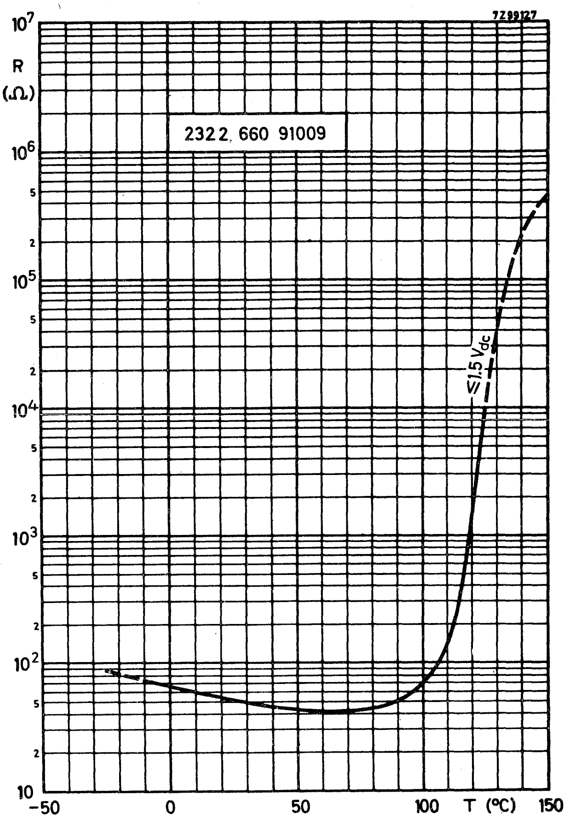


Fig. 11. Typical resistance/temperature characteristic

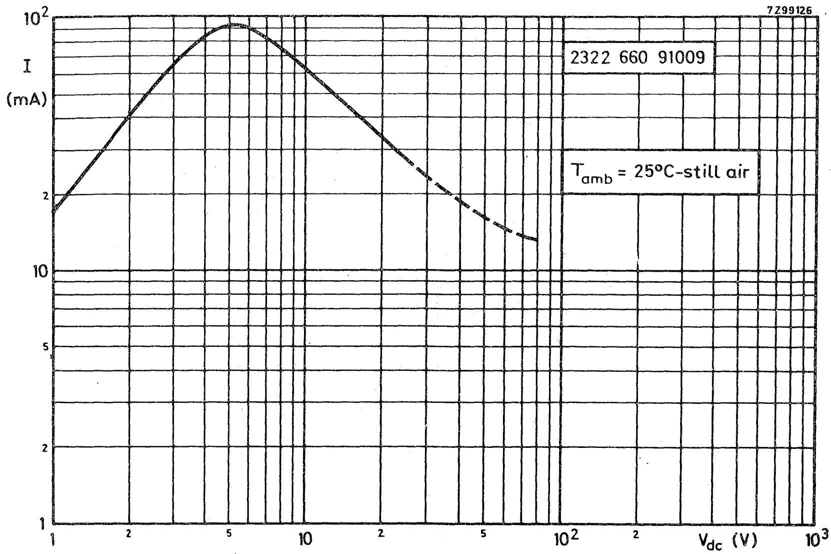


Fig. 12. Typical voltage/current characteristic

TESTS AND REQUIREMENTS

According to I.E.C.68, unless otherwise specified.

test	test method	duration	ΔR/R in % at 25 °C	ΔR/R in % at 125 °C
Cold at −10 °C	A	1000 h	± 3	± 3
Storage at + 25 °C	H	1000 h	± 3	± 3
Dry heat + 125 °C	B	1000 h	± 5	± 5
Thermal shock −10 to + 125 °C	Na	5 cycles	± 3	± 3
Damp heat	C	1000 h	± 5	± 5
Dissipation at V = 25 V_{rms} and T_{amb} = + 55 °C		1000 h	± 5	± 5
Cycle test at V= 25 V r.m.s. and T_{amb} = 0 °C		1000 cycles 1 min on/ 9 min off	± 10	± 10
Robustness of terminations	U			
Tensile strength 10 N	Ua	10 s	1)	
Bending 5 N	Ub	2 times	1)	
Soldering	T			
Solderability	par. 3.2.3	3 to 4 s	2)	
Resistance to heat	par. 3.2.4	3 to 4 s	± 2	± 2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1,5%, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

PACKAGING

250 pieces per box (cardboard)

PTC THERMISTOR
disc

QUICK REFERENCE DATA	
Resistance value at +25 °C	750 to 1500 Ω
Resistance value at + 175 °C V_{pulse} = 345 V	70 000 Ω
Switch temperature	+ 115 °C
Temperature coefficient	+ 26 %/°C
Maximum r.m.s. voltage	245 V
Dissipation factor	7 mW/°C
Operating temperature range at zero power at maximum voltage	 −25 to + 155 °C 0 to + 55 °C

APPLICATION

Suitable for all kinds of applications, e.g. stair-well lighting control.

DESCRIPTION

The thermistor has a positive temperature coefficient. It consists of a disc provided with two solid tinned copper wires. The thermistor body is blue lacquered but not insulated.

MECHANICAL DATA

Dimensions (mm)

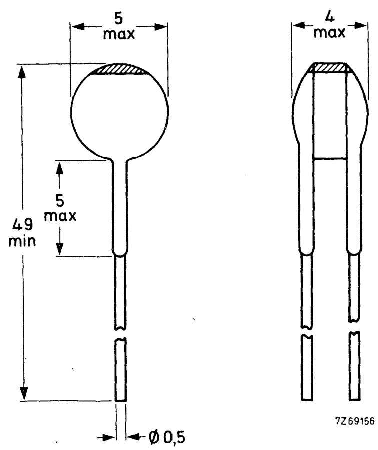


Fig. 1

Marking	Brown band on top
Weight	0,4 g approximately
Mounting	In any position by soldering
Robustness of terminations	
Tensile strength	5 N
Bending	2,5 N
Soldering	
Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s
Impact	1000 mm free fall
Inflammability	Uninflammable

ELECTRICAL DATA

Unless otherwise specified measured according to IEC draft publication 40 (secretariat) 288.

All values in the table without further indication are approximate values

Resistance at +25 °C	750 to 1500 Ω
Resistance at + 115 °C	max. 3000 Ω
Resistance at + 175 °C and V_{pulse} = 345 V [1)]	min. 70 000 Ω
Switch temperature	+ 115 °C
Temperature coefficient	+28%/°C
Dissipation factor	7 mW/°C
Heat capacity	0, 125 J/°C
of ceramic only	0,08 J/°C
Thermal time constant	17,5 s
Operating temperature range	
at zero power	−25 to + 155 °C
at maximum voltage	0 to + 55 °C
Voltage dependence at + 155 °C	0,35
Balance voltage d.c.	90 V
Maximum r.m.s. voltage	245 V

1) Measurement made without internal heating occurring.

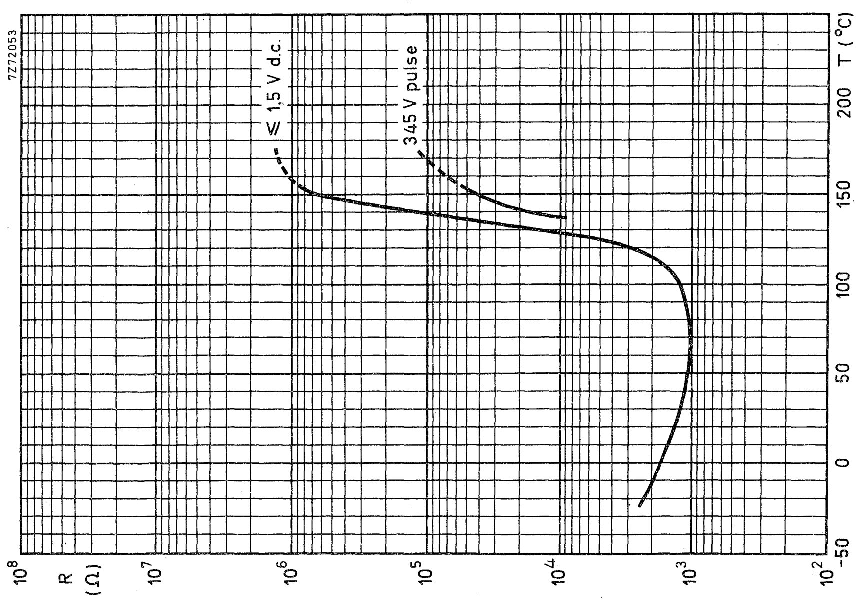


Fig. 2 Typical resistance/temperature characteristics

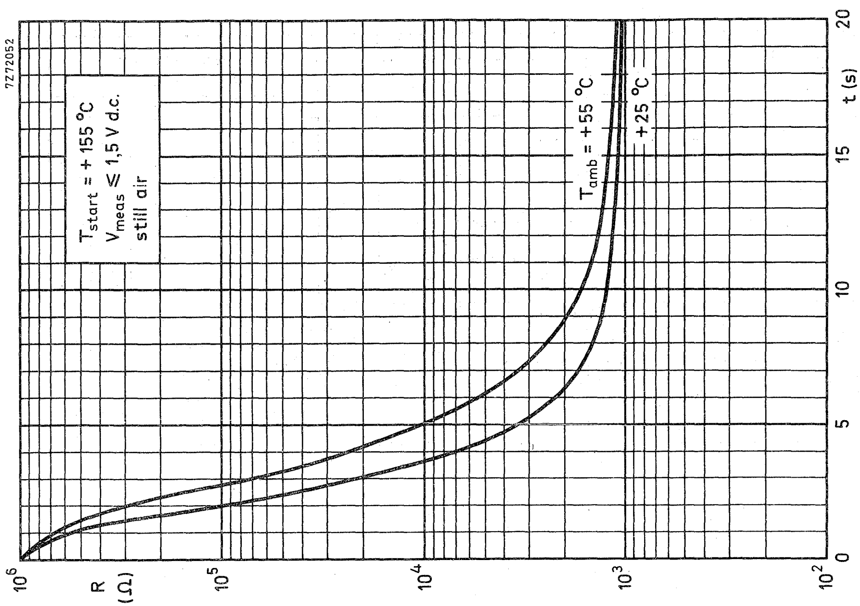


Fig. 3 Typical resistance/time (cooling) characteristics

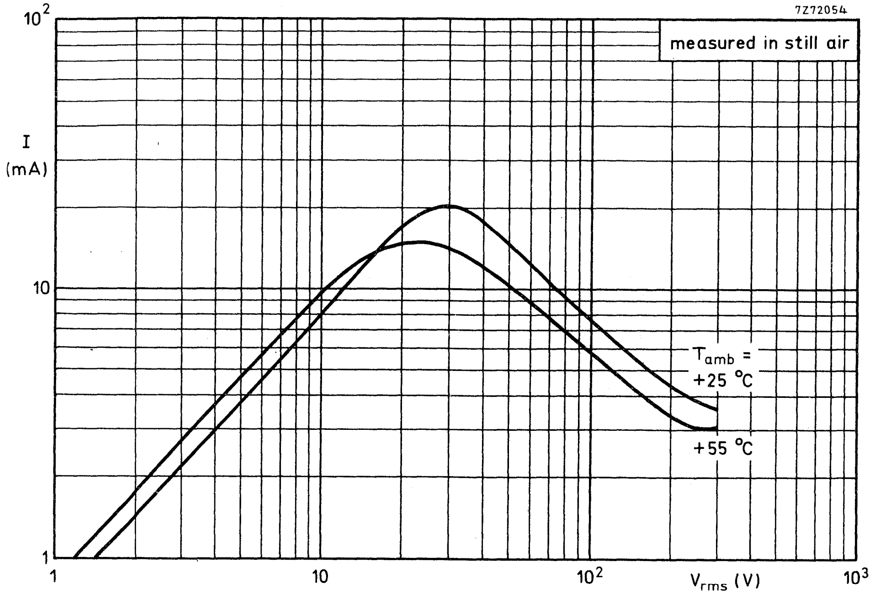


Fig. 4 Typical voltage/current characteristics

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified

test	test method	duration	ΔR/R (%) at +25 °C	at +155 °C
Cold at −25 °C	A	1000 h	± 7,5	± 12
Storage at +25 °C	H	1000 h	± 5	± 12
Dry heat at +155 °C	B	1000 h	± 10	± 12
Thermal shock −25 to +155 °C	Na	5 cycles	± 7,5	± 12
Damp heat at +40 °C	C	1000 h	± 10	± 12
Dissipation at 245 V r.m.s. and T_{amb} = +55 °C		1000 h	± 10	± 12
Cycle test at 245 V r.m.s.				
T_{amb} = 0 °C		100 cycles 3)	± 10	± 12
T_{amb} = +25 °C		2000 cycles 3)	± 7,5	± 12
Robustness of terminations	U			
Tensile strength 5 N	Ua	10 s	1)	
Bending 2,5 N	Ub	2 times	1)	
Soldering	T			
Solderability	par. 3.2.3	3 to 4 s	2)	
Resistance to heat	Tb	10 ± 1 s	± 2	± 2
Impact	E			
Free fall	Ed	2 falls	4)	

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.
3) Cycle: 1 min on/9 min off.
4) There should be no visual defects.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L.	1 %	major defects – Electrical
A.Q.L.	1,5%	major defects – Mechanical
A.Q.L.	4 %	minor defects – Physical

PACKAGING

250 pieces per box (card board).

PTC THERMISTORS
disc

QUICK REFERENCE DATA	
Resistance value at +25 °C	30 to 50 Ω
Resistance value at other temperatures Switch temperature Temperature coefficient Max. voltage Dissipation factor	see Table 2
Operating temperature range at zero power at V_{max}	 −10 to +125 °C 0 to +55 °C

APPLICATION

Suitable for all kinds of applications.

DESCRIPTION

The thermistors have a positive temperature coefficient.
They consist of a disc provided with two solid tinned copper wires. The thermistor body is blue lacquered but not insulated.

MECHANICAL DATA

Dimensions in mm

Table 1

catalogue number	colour band	H_{max}
2322 661 91002	yellow	6,5
2322 661 91003	green	6,5
2322 661 91004	orange	6,5
2322 661 91005	red	5,5

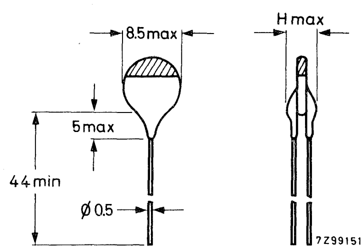


Fig. 1.

Marking

The thermistors are marked with a colour band at the top of the body according to Fig. 1.

Weight 1 g approximately

Mounting In any position by soldering

Robustness of terminations

Tensile strength	10 N
Bending	5 N

Soldering

Solderability	max. 240 °C, 4 s
Resistance to heat	max. 240 °C, 4 s

ELECTRICAL DATA

Table 2 [1)]

R_{25} 2) (Ω)	R at other temperatures 3) T (°C)	R (Ω)	switch temperature (°C)	temperature coefficient (%/deg C)	V_{max} (Vd.c.)	dissipation factor 4) (mW/deg C)	thermal time constant 4) (s)	heat capacity 4) (J/deg C)	voltage dependence β	balance voltage (V)	catalogue number
50	60 100	< 100 > 1 000	+ 80	18	50	8.5	50	0.425	0.48	110	2322 661 91002
40	95 130	< 80 > 10 000	+110	75	50	8.5	50	0.425	0.28	25	2322 661 91003
30	40 100	< 90 > 10 000	+ 45	16	50	8.5	50	0.425	0.25	65	2322 661 91004
50	100	3 000 - 20 000	+ 25	9	40	6	40	0.240	0.35	25	2322 661 91005

Tolerance on resistance at 25 °C (R_{25}) ± 15 Ω

Operating temperature range
- at zero power −10 to +125 °C
- at V_{max} 0 to +55 °C

1) Typical values, except R and V_{max}.
2) Measuring voltage not exceeding 1.5 V_{dc} to avoid internal heating.
3) Measurements made without internal heating occurring.
4) Measurements made with specimen in phosphor-bronze clips, in still air.

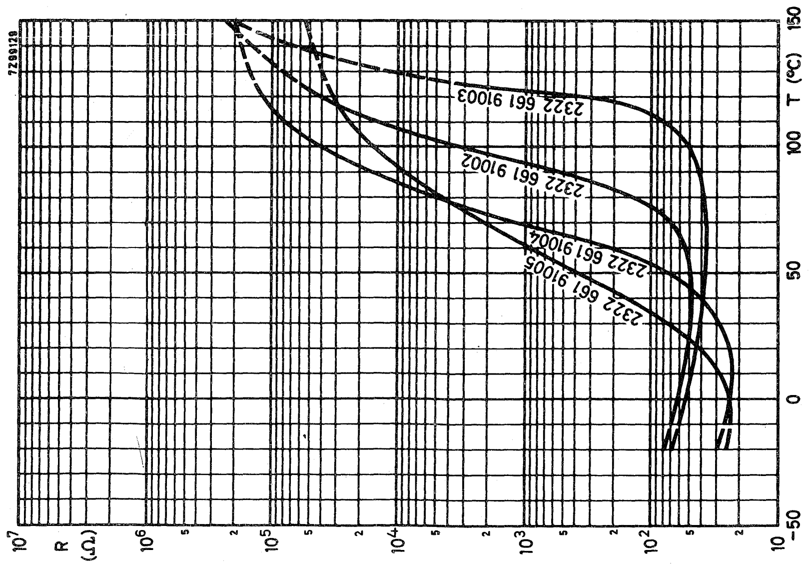


Fig.2. Typical resistance/temperature characteristics

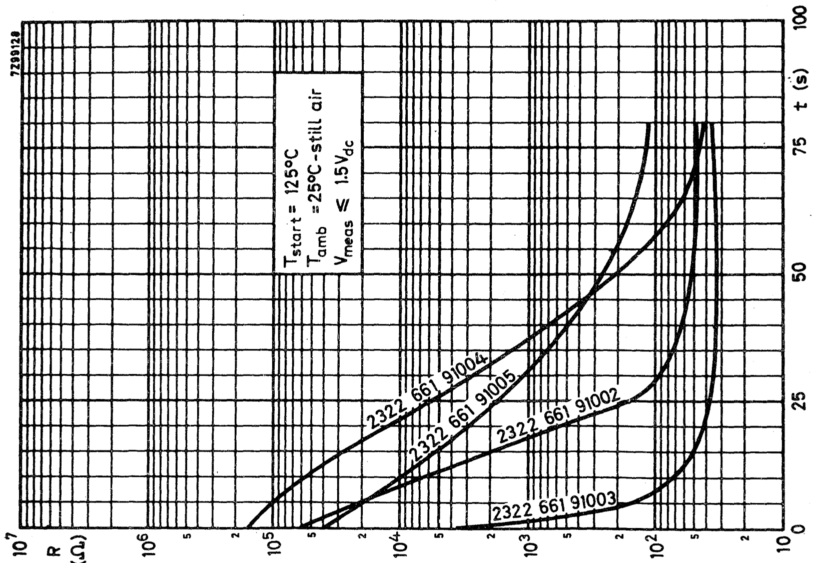


Fig.3. Typical resistance/time (cooling) characteristics

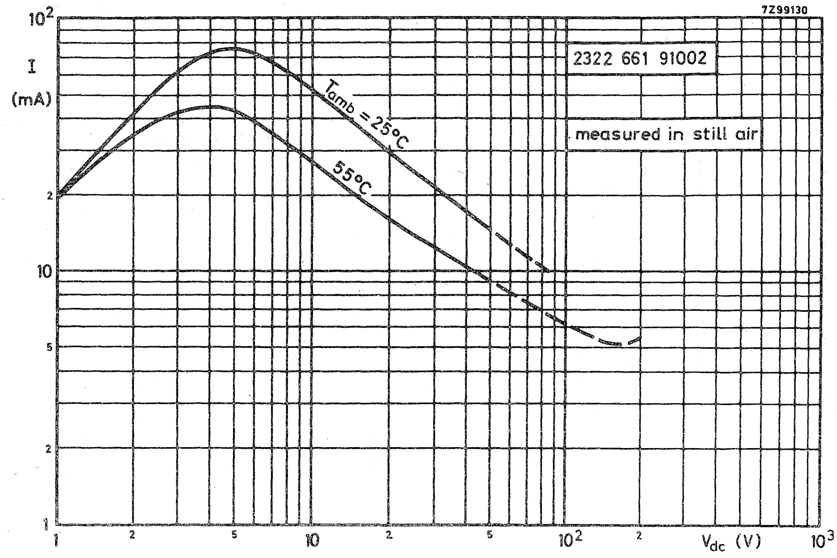


Fig.4a. Voltage/current characteristics

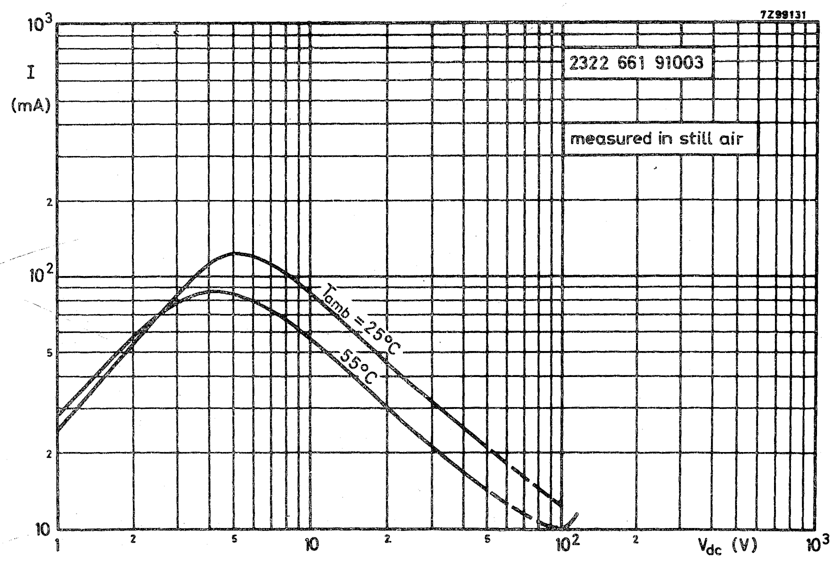


Fig.4b. Voltage/current characteristics

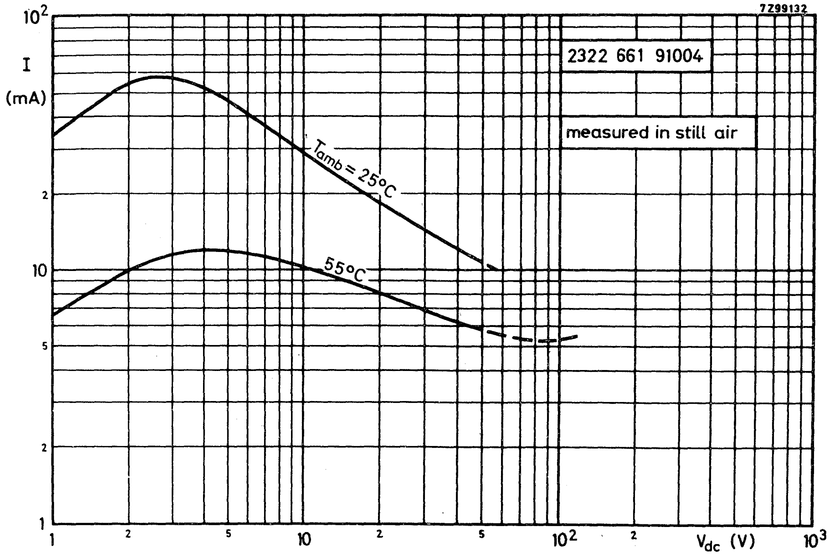


Fig.4c. Voltage/current characteristics

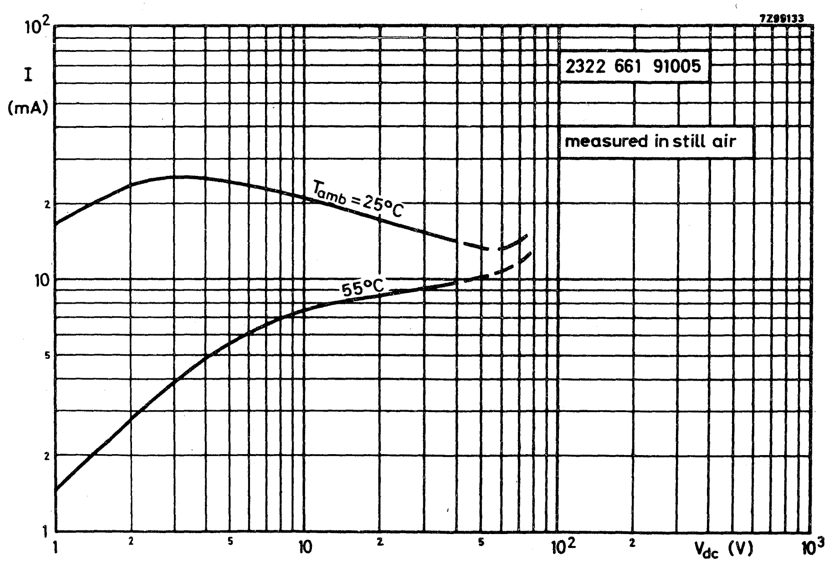


Fig.4d. Voltage/current characteristics

TESTS AND REQUIREMENTS

According to I.E.C. 68, unless otherwise specified.

Table 3

test	test method	duration	ΔR/R in % at 25 °C	ΔR/R in % at 3)
Cold at −10 °C	A	1000 h	± 3	± 3
Storage at +25 °C	H	1000 h	± 3	± 3
Dry heat +125 °C	B	1000 h	± 5	± 5
Thermal shock −10 to +125 °C	Na	5 cycles	± 3	± 3
Damp heat	C	1000 h	± 5	± 5
Dissipation at V_{max} 4) and T_{amb} = +55 °C		1000 h	± 5	± 5
Cycle test at V_{max} 4) and T_{amb} = 0 °C		1000 h 1 min on/9 min off	± 10	± 10
Robustness of terminations	U			
Tensile strength 10 N	Ua	10 s	1)	
Bending 5 N	Ub	2 times	1)	
Soldering	T			
Solderability at 230 °C	par. 3.2.3	3 to 4 s	2)	
Resistance to heat at 230 °C	par. 3.2.4	3 to 4 s	± 2	± 2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after six months storage with solder containing resin flux.
3) At temperatures stated in table 2, second column.
4) V_{max} stated in table 2.

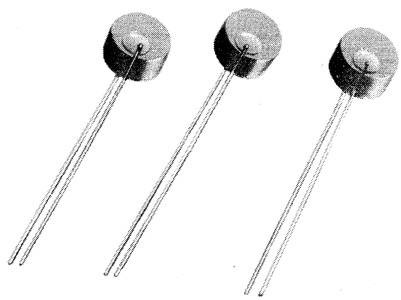
QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D
A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1.5 %, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

PACKAGING 250 pieces per box (cardboard)

PTC THERMISTOR

QUICK REFERENCE DATA	
Resistance value at +25 °C	36 to 50 Ω
Resistance value at + 165 °C V_{pulse} = 180 V	> 20 kΩ
Switch temperature	+ 115 °C approx.
Temperature coefficient	35%/°C approx.
Maximum d.c. voltage	180 V
Dissipation factor	13 mW/°C approx.
Operating temperature range at zero power at maximum d.c. voltage	 0 to + 155 °C 0 to + 55 °C



RZ 27317-11

APPLICATION

This PTC thermistor has been designed for the protection of telegraphy relay contacts.

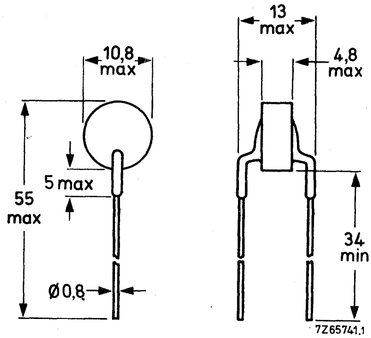
DESCRIPTION

This type has a positive temperature coefficient. It consists of a disc provided with two solid tinned brass wires. The thermistor body is blue lacquered but not insulated.

MECHANICAL DATA

Dimensions in mm

Fig. 1



Weight 0,5 g approximately

Mounting In any position by soldering

ELECTRICAL DATA

Resistance at + 25 °C (T_{ref})	36 to 50 Ω [1]
Resistance at + 115 °C	< 120 Ω [1]
Resistance at + 165 °C, V_{pulse} = 180 V	> 20 kΩ [2]
Current at + 25 °C, V_{dc} = 180 V continuously	< 10 mA [3]
Switch temperature	+ 115 °C approx.
Temperature coefficient	35%/°C approx.
Dissipation factor	13 mW/°C approx. [3]
Heat capacity	1 J/°C [3]
Thermal time constant	80 s approx. [3]
Operating temperature range	
at zero power	0 to + 155 °C
at V_{max}	0 to + 55 °C
Voltage dependence β at + 150 °C	0,3 approx.
Balance voltage	105 V d.c. approx.
Maximum voltage (V_{max}) at + 55 °C	180 V d.c.

[1] Measuring voltage not exceeding 1,5 V_{dc} to avoid internal heating.
[2] Measurement made without internal heating occurring.
[3] Measurement made with specimen in phosphor bronze clips, in still air.

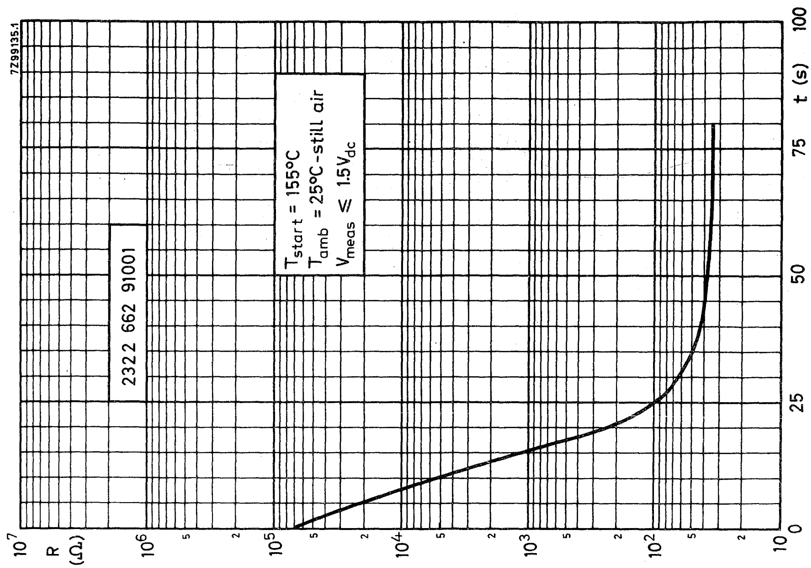


Fig. 3
Typical resistance/time (cooling) characteristic

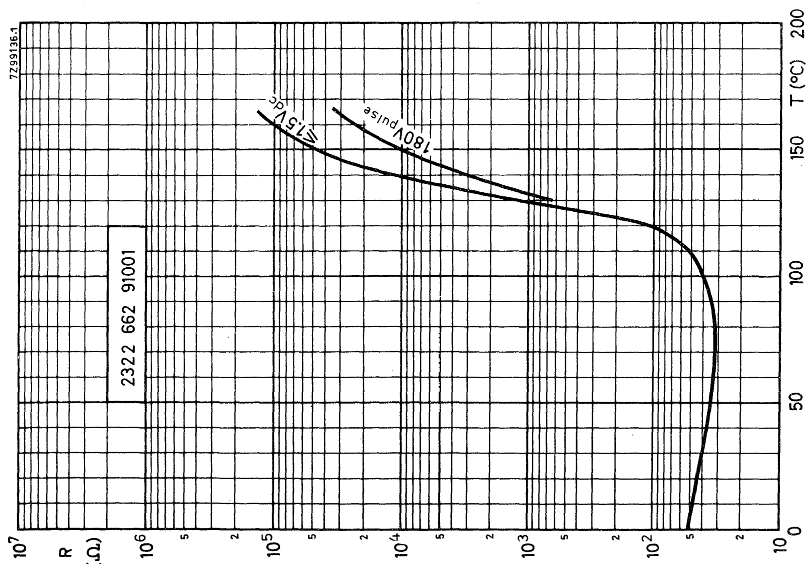


Fig. 2
Typical resistance/temperature characteristics

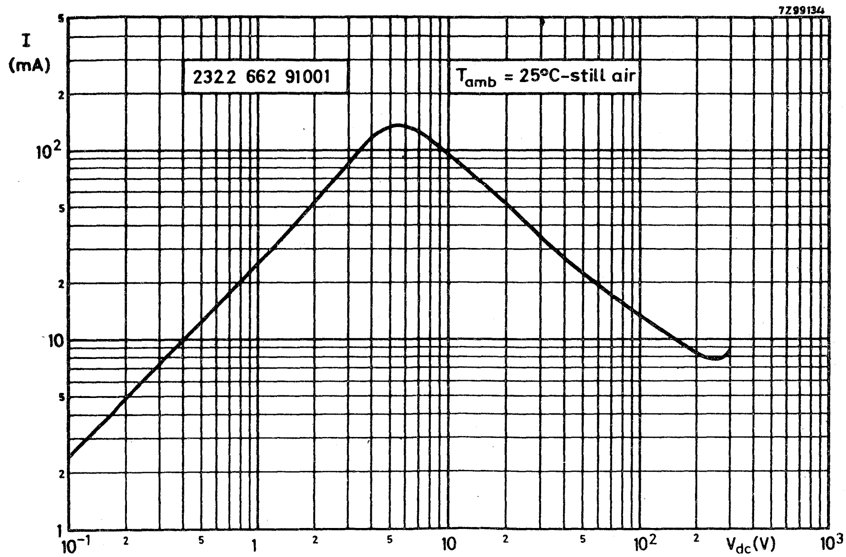


Fig.4. Typical voltage/current characteristic

TESTS AND REQUIREMENTS

According to IEC 68 recommendations, unless otherwise specified.

test	test method	duration	ΔR/R (%) at +25 °C	ΔR/R (%) at +165 °C
Cold at 0 °C	A	168 h	± 3	± 5
Storage at +25 °C	H	1000 h	± 3	± 5
Dry heat at + 155 °C	B	1000 h	± 5	± 10
Thermal shock 0 to + 155 °C	Na	5 cycles	± 3	± 7
Dissipation in damp heat at I = 50 mA d.c. approx. and T_{amb} = +40 °C		2000 h	± 5	± 7,5
Dissipation at V = 180 V d.c. and T_{amb} = +55 °C		1000 h	± 5	± 10
Cycle test at V = 180 V d.c. and T_{amb} = +25 °C		10 cycles 3)	± 5	± 10
Robustness of terminations	U			
Tensile strength 20 N	Ua	10 s	1)	
Bending 10 N	Ub	2 times	1)	
Soldering	T			
Solderability	par. 3.2.3	3 to 4 s once	2)	
Resistance to heat	Tb	10 ± 1 s once	± 2	± 2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after six months storage with solder containing resin flux.
3) Cycle: 1 min on/9 min off.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1,5%, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

PACKAGING

50 pieces per box (cardboard)

PTC THERMISTOR
disc

QUICK REFERENCE DATA	
Resistance value at +25 °C	70 to 100 Ω
Resistance value at +200 °C V_{pulse} = 650 V	140 kΩ
Switch temperature	+ 100 to + 110 °C
Temperature coefficient	+35 %/°C
Maximum r.m.s. voltage	400 V
Dissipation factor	11,5 mW/°C
Operating temperature range at zero power at maximum voltage	 −25 to + 175 °C 0 to + 85 °C

APPLICATION

Suitable for all kinds of applications, e.g. fluorescent lamp starter.

DESCRIPTION

This thermistor has a positive temperature coefficient. It is a leadless disc which is neither lacquered nor insulated.

MECHANICAL DATA

Dimensions (mm)

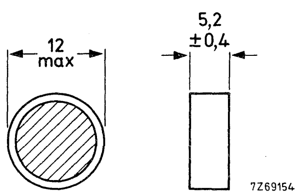


Fig. 1

Marking	None
Weight	2,7 g approximately
Mounting	In any position by clamping
Impact	100 mm free fall
Inflammability	uninflammable

ELECTRICAL DATA

Unless otherwise specified measured according to IEC draft publication 40 (secretariat) 288.

All values in this table without further indication are approximate values

Resistance at + 25 °C	70 to 100 Ω
Resistance at + 100 °C	max. 200 Ω
Resistance at + 200 °C V_{pulse} = 650 V [1]	min. 140 kΩ
Switch temperature	+ 100 to + 110 °C
Temperature coefficient	+ 35 %/°C
Dissipation factor	11,5 mW/°C
Heat capacity	1,3 J/°C
Thermal time constant	115 s
Operating temperature range at zero power at maximum voltage	 −25 to + 175 °C 0 to + 85 °C
Voltage dependence at + 175 °C	0,22
Balance voltage	230 V
Maximum r.m.s. voltage, with series resistor of 300 Ω	460 V

[1]) Measurement made without internal heating occurring.

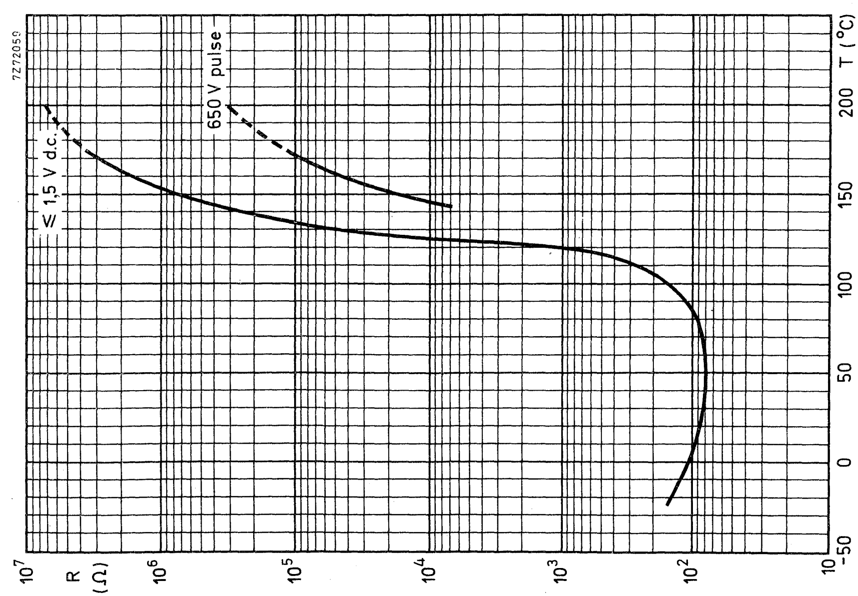


Fig. 2 Typical resistance/temperature characteristics

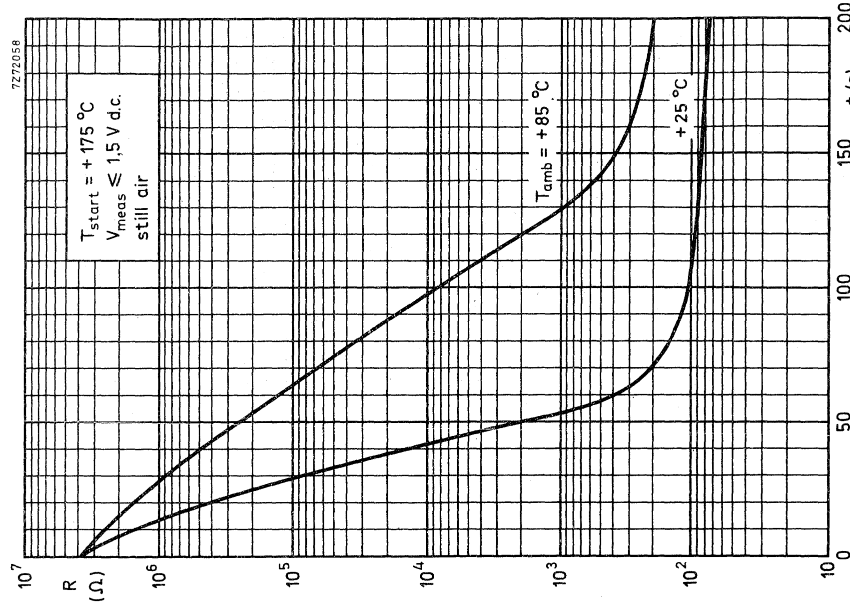


Fig. 3 Typical resistance/time (cooling) characteristics

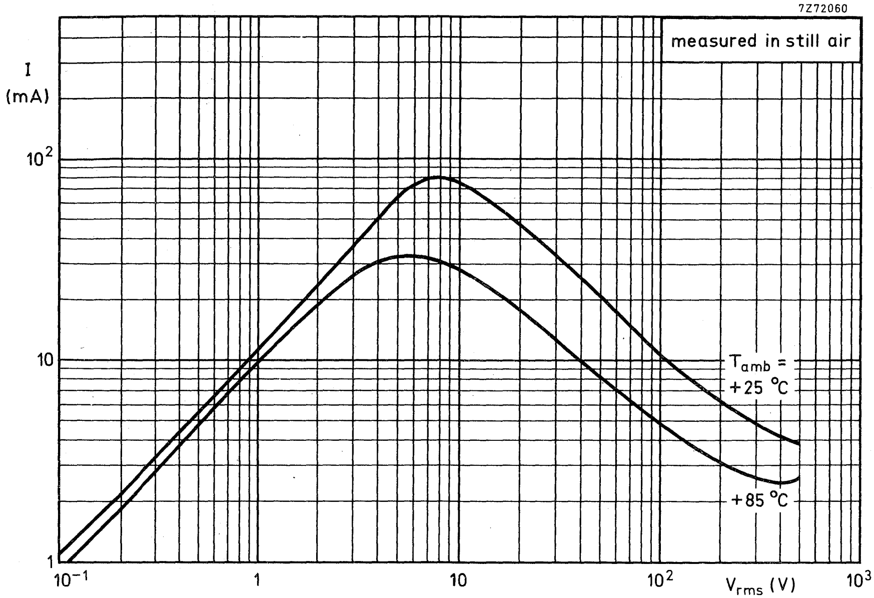


Fig. 4 Typical voltage/current characteristics

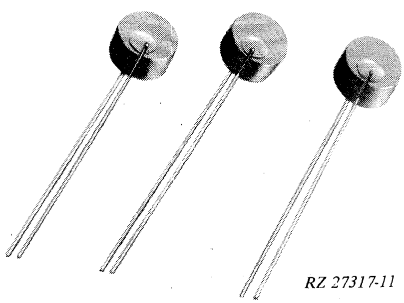
QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L.	1 %	major defects – Electrical
A.Q.L.	1,5%	major defects – Mechanical
A.Q.L.	4 %	minor defects – Physical

PTC THERMISTOR

QUICK REFERENCE DATA	
Resistance value at + 25 ^{o}C	45 to 60 Ω
Resistance value at + 150 ^{o}C V_{pulse} = 340 V	>45 kΩ
Switch temperature	+ 75 ^{o}C approx
Temperature coefficient	+ 20 %/deg C approx.
Max. voltage at $T_{amb} \leq$ 60 ^{o}C	265 V_{rms}
Dissipation factor	20 mW/deg C approx.
Operating temperature range at zero power at V_{max}	 -25 to + 155 ^{o}C 0 to + 60 ^{o}C


RZ 27317-11

APPLICATION

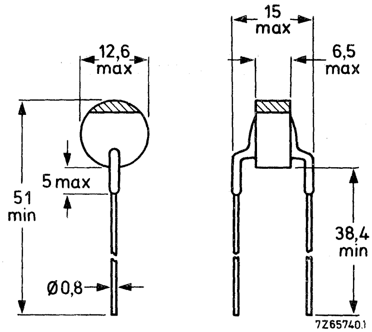
Intended primarily to be used in the degaussing circuit of colour television sets.

DESCRIPTION

This thermistor has a positive temperature coefficient. It consists of a disc provided with two solid tinned copper wires. The thermistor body is blue lacquered, but not insulated.

MECHANICAL DATA

Dimensions in mm



Marking Green colour band on top of the body.

Weight 4,5 g approximately

Mounting In any position by soldering. Soldering should be done at least 15 mm from the thermistor body.

ELECTRICAL DATA

Resistance at + 25 °C	45 to 60 Ω [1]
Resistance at + 75 °C	< 160 Ω [1]
Resistance at + 150 °C, V_{pulse} = 340 V	> 45 kΩ [2]
Switch temperature	+ 75 °C approx.
Temperature coefficient	+ 20%/°C approx.
Dissipation factor	20 mW/°C approx. [3]
Heat capacity	2,2 J/°C approx. [3]
Thermal time constant	110 s approx. [3]
Operating temperature range	
at zero power	−25 to + 155 °C
at V_{max}	0 to + 60 °C
Voltage dependence β at + 155 °C	0,29 approx.
Balance voltage	200 V d.c. approx.
Maximum voltage	265 V r.m.s.

1) Measuring voltage not exceeding 1,5 V_{dc} to avoid internal heating.
2) Measurement made without internal heating occurring.
3) Measurement made with specimen in phosphor bronze clips, in still air.

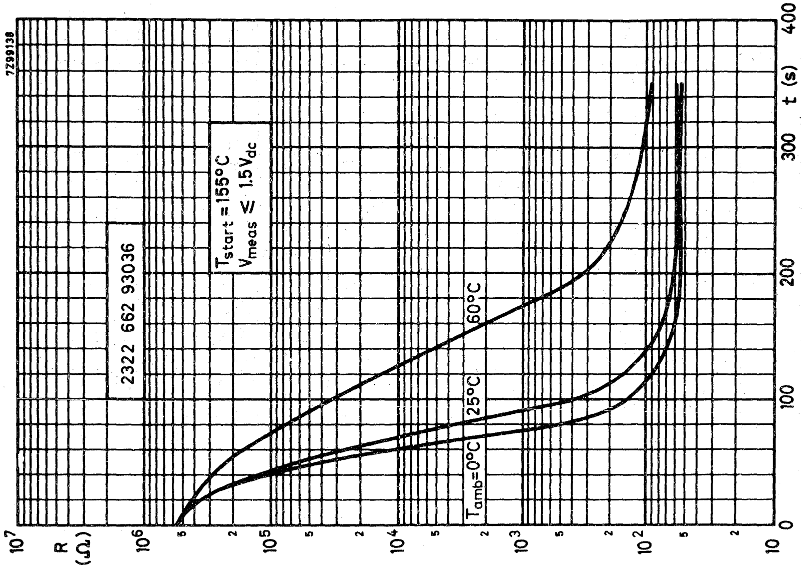


Fig.3.
Typical resistance/time (cooling) characteristics

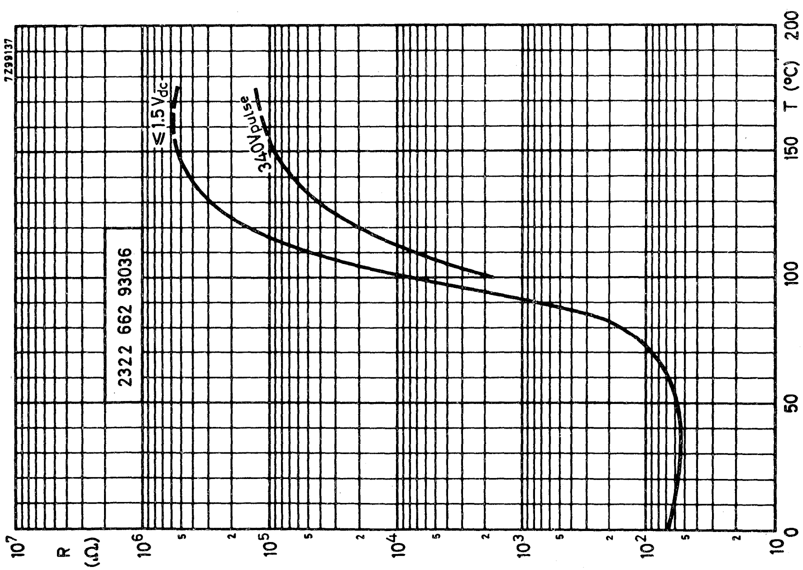


Fig.2.
Typical resistance/temperature characteristics
(no internal heating)

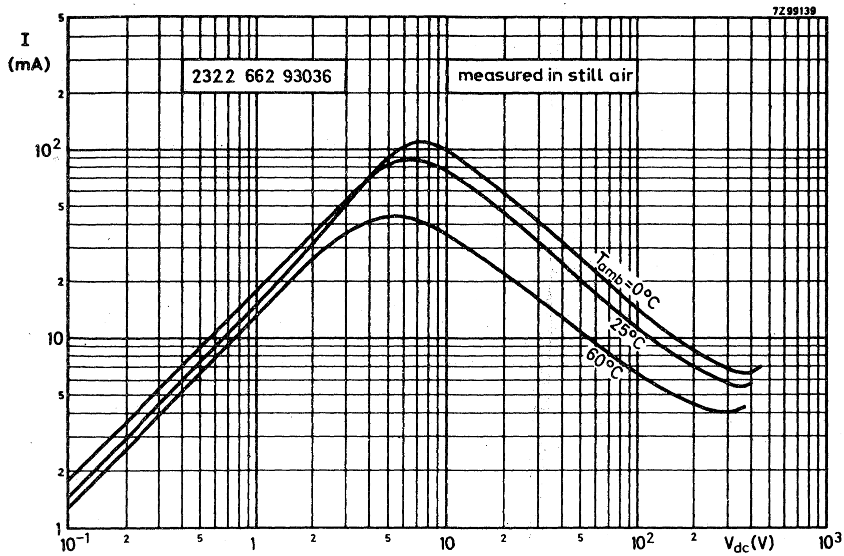


Fig.4. Typical voltage/current characteristics

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	ΔR/R (%) at +25 °C	ΔR/R (%) at +150 °C
Cold at −25 °C	A	1000 h	± 7,5	± 12
Storage at + 25 °C	H	1000 h	± 5	± 12
Dry heat at + 155 °C	B	1000 h	± 10	± 12
Thermal shock −25 to + 155 °C	Na	5 cycles	± 7,5	± 12
Damp heat at + 40 °C	C	1000 h	± 10	± 12
Dissipation at 265 V r.m.s. and T_{amb} = + 60 °C		1000 h	± 10	± 12
Cycle test at 265 V r.m.s and T_{amb} = 0 °C		100 cycles 3) 4)	± 10	± 12
and T_{amb} = 25 °C		2000 cycles 3) 4)	± 7,5	± 12
Robustness of terminations	U			
Tensile strength 20 N	Ua	10 s	1)	
Bending 10 N	Ub	2 times	1)	
Soldering	T			
Solderability	par. 3.2.3	3 to 4 s	2)	
Resistance to heat	par. 3.2.4	3 to 4 s	± 2	± 2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.
3) Cycle: 1 min on/9 min off.
4) With series resistor of 33 Ω ± 5%.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

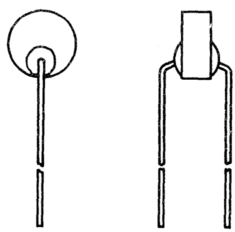
A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1,5 %, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

PACKAGING

100 pieces per box (cardboard).

PTC THERMISTOR

QUICK REFERENCE DATA	
Resistance value at +25 °C	100 Ω ± 20%
Resistance value at + 155 °C V_{pulse} = 380 V	≥ 40 kΩ
Switch temperature	75 °C
Maximum r.m.s. voltage	265 V
Dissipation factor	15 mW/°C approx.
Operating temperature range at zero power at V_{max}	 −25 to + 155 °C 0 to + 60 °C



APPLICATION

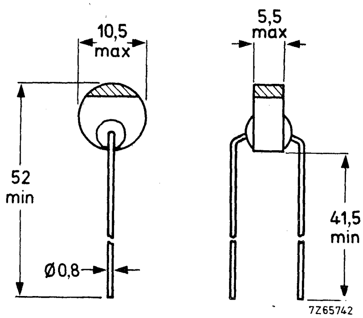
Intended primarily to be used in the degaussing circuit of colour television sets.

DESCRIPTION

This thermistor has a positive temperature coefficient. It consists of a disc provided with two solid tinned brass wires. The thermistor body is not lacquered.

MECHANICAL DATA

Dimensions (mm)



Marking

The thermistor is marked with a red colour band on top of the body.

Weight

2,7 g approx.

Mounting

In any position by soldering at min 15 mm from the body.

Robustness of terminations

Tensile strength	20 N
Bending	10 N

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 240 °C, max. 4 s

ELECTRICAL DATA

Unless otherwise specified measured according to IEC draft publication 40 (secretariat) 288.

All values in the table without further indication are approximate values.

Resistance value at + 25 °C	100 Ω ± 20% [1]
+ 72 °C	< 2 x R_{25} [1]
+ 85 °C	> 2 x R_{25} [1]
+ 155 °C and V_{pulse} = 380 V	≥ 40 kΩ [2]
Switch temperature	+ 75 °C
Temperature coefficient	+ 35 %/°C
Maximum voltage	265 V r.m.s.
Dissipation factor	15,3 mW/°C [3]
Thermal time constant	80 s [3]
Heat capacity of complete thermistor	1,2 J/°C [3]
Balance voltage	190 V d.c.
Voltage dependence at 155 °C	0,26
Operating temperature range	
at zero power	−25 to + 155 °C
at maximum voltage	0 to + 60 °C

[1] Measuring voltage not exceeding 1,5 V d.c. to avoid internal heating.
[2] Measurement made without internal heating occurring.
[3] Measurement made with specimen in phosphor bronze clips, in still air.

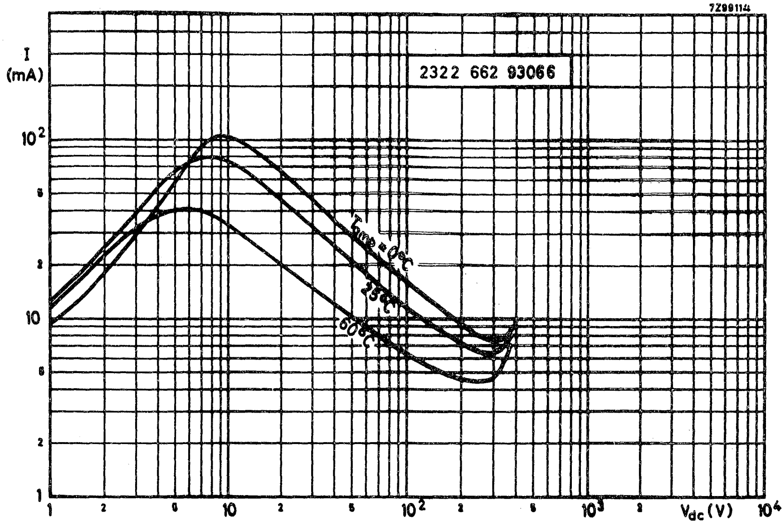


Fig.4 Typical voltage/current characteristics

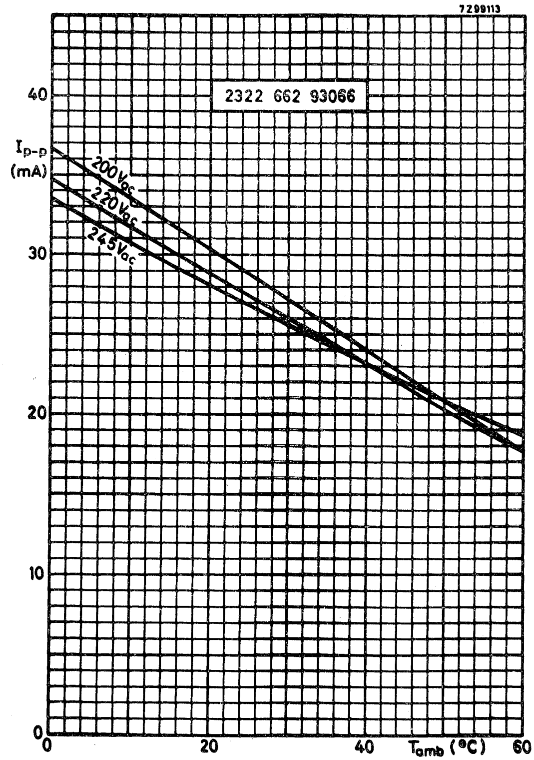


Fig.5 Typical characteristics of peak to peak current against the ambient temperature at different voltages.

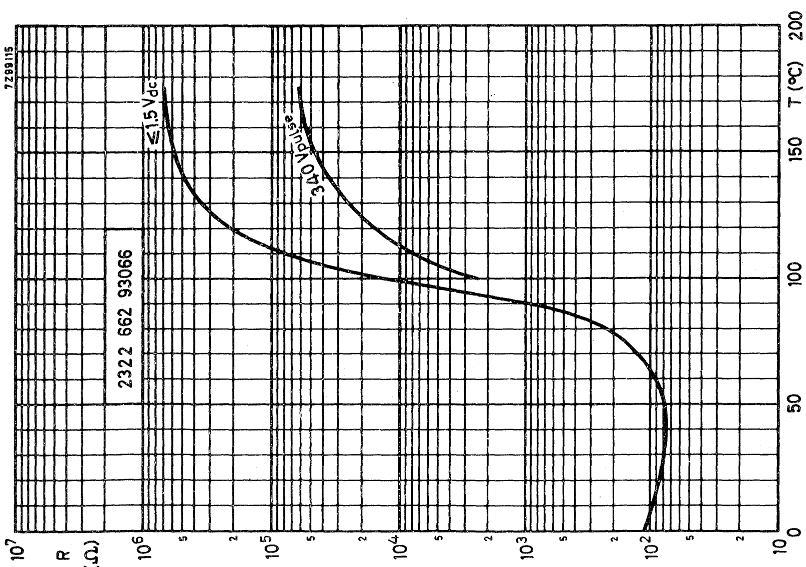


Fig. 2.
Typical resistance/temperature characteristics

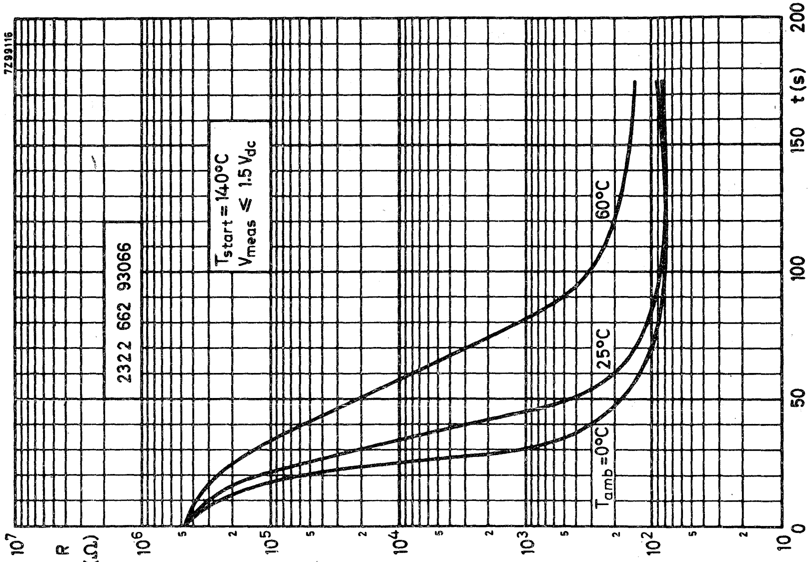


Fig. 3.
Typical resistance/time (cooling) characteristics

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified

test	test method	duration	ΔR/R (%) at + 25 °C	ΔR/R (%) at + 150 °C
Cold at −25 °C	A	1000 h	± 7,5	± 12
Storage at + 25 °C	H	1000 h	± 5	± 12
Dry heat at + 155 °C	B	1000 h	± 10	± 12
Thermal shock −25 to + 155 °C	Na	5 cycles	± 7,5	± 12
Damp heat at + 40 °C	C	1000 h	± 10	± 12
Dissipation at 265 V r.m.s. and T_{amb} = + 60 °C		1000 h	± 10	± 12
Cycle test at 265 V r.m.s. and T_{amb} = 0 °C		100 cycles [3][4]	± 10	± 12
and T_{amb} = + 25 °C		2000 cycles [3][4]	± 7,5	± 12
Robustness of terminations	U			
Tensile strength 20 N	Ua	10 s	[1]	
Bending 10 N	Ub	2 times	[1]	
Soldering	T			
Solderability	par. 3.2.3	3 to 4 s	[2]	
Resistance to heat	par. 3.2.4	3 to 4 s	± 2	± 2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.
3) Cycle: 1 min on/9 min off.
4) Two PTC's in parallel with a series resistance of 33 Ω ± 5%.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1,5%, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

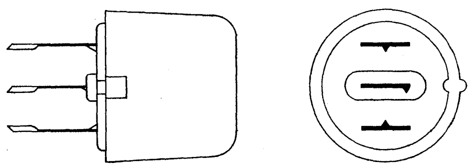
PACKAGING

100 pieces per box (card board).

DUAL PTC THERMISTORS

QUICK REFERENCE DATA

	2322 662 98001	2322 662 98003
Current through the coil measured at	200 V r.m.s	220 V r.m.s.
min. inrush peak current	5 A	5 A
max. idle peak current		
after 5 s	70 mA	70 mA
after 30 s	5 mA	5 mA
after 3 min	2 mA	2 mA
Maximum voltage	245 V r.m.s.	265 V r.m.s.
Switch temperature	75 °C	
Operating temperature range		
at zero power	−25 to +155 °C	
at maximum voltage	0 to + 60 °C	



APPLICATION

Intended primarily to be used in the degaussing circuit of colour television sets.

DESCRIPTION

The thermistor consists of two disc PTC thermistors clamped between spring contacts. This assembly ensures a good thermal contact between both discs, which is essential for function of this device.
The thermistor is enclosed in a plastic housing. The three connecting pins are arranged to fit a printed-wiring board with an 0, 1 inch grid.

MECHANICAL DATA

Dimensions in mm

Point A is to be connected
to the mains
Point C is to be connected
to the degaussing coil

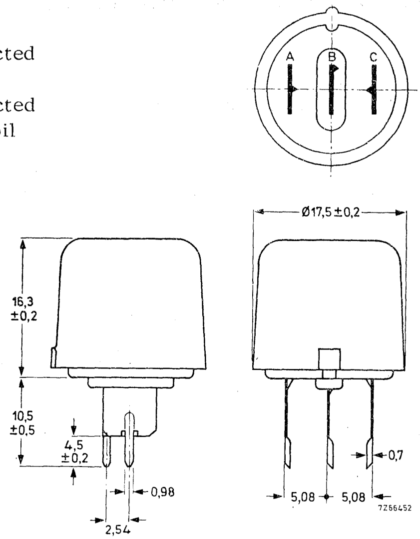


Fig.1

Marking	The thermistor is marked on the top
Weight	7, 3 g approximately
Mounting	In any position by soldering

Robustness of terminations

Tensile strength	20 N

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s

Impact

Free fall	1000 mm

ELECTRICAL DATA

	2322 662 98001	2322 662 98003
Current through the coil		
measured in circuit of Fig. 2 at	200 V r.m.s.	220 V r.m.s.
min. inrush current	5 A	5 A
max. idle peak current		
after 5 s	70 mA	70 mA
after 30 s	5 mA	5 mA
after 3 min	2 mA	2 mA
Resistance at +25 °C:		
of mains PTC [2]	25 Ω [1]	30 Ω [1]
of coil PTC [2]	8 Ω [1]	8 Ω [1]
at T_{amb} = +175 °C and 345 V pulsed		
of mains PTC [3]	≥32 kΩ	≥35 kΩ
at T_{amb} = +155 °C		
of coil PTC	≥20 kΩ	≥20 kΩ
Switch temperature of mains and coil PTC	75 °C	75 °C
Temperature coefficient		
of mains PTC	23 %/degC [1]	25 %/degC [1]
of coil PTC	25 %/degC [1]	25 %/degC [1]
Balance voltage		
of mains PTC	190 V d.c. [1]	160 V d.c. [1]
Voltage dependency at +155 °C		
of mains PTC	0,28 [1]	0,26 [1]
Maximum voltage in circuit [4]	245 V r.m.s.	265 V r.m.s.
Dissipation factor [4]	13,5 mW/degC [1]	
Thermal time constant [4]	200 s [1]	
Heat capacity of ceramic		
of mains PTC	1,6 J/degC [1]	
of coil PTC	0,47 J/degC [1]	
of complete assembly [4]	2,7 J/degC [1]	
Operating temperature range		
at zero power	−25 to +155 °C	
at maximum voltage	0 to + 60 °C	

1) approximately values
2) Measuring voltage not exceeding 1,5 V d.c. to avoid internal heating
3) Measurements have to be made without self heating of the specimen
4) Measurements made with the thermistor soldered on printed wiring board in still air

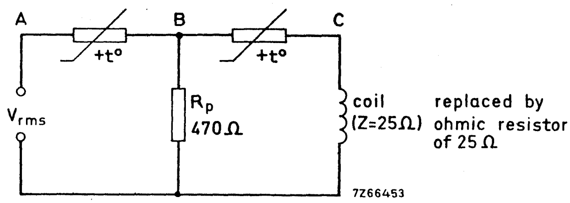


Fig. 2 Measuring circuit.
R_p must be able to withstand a peak power of 25 W for 300 ms.

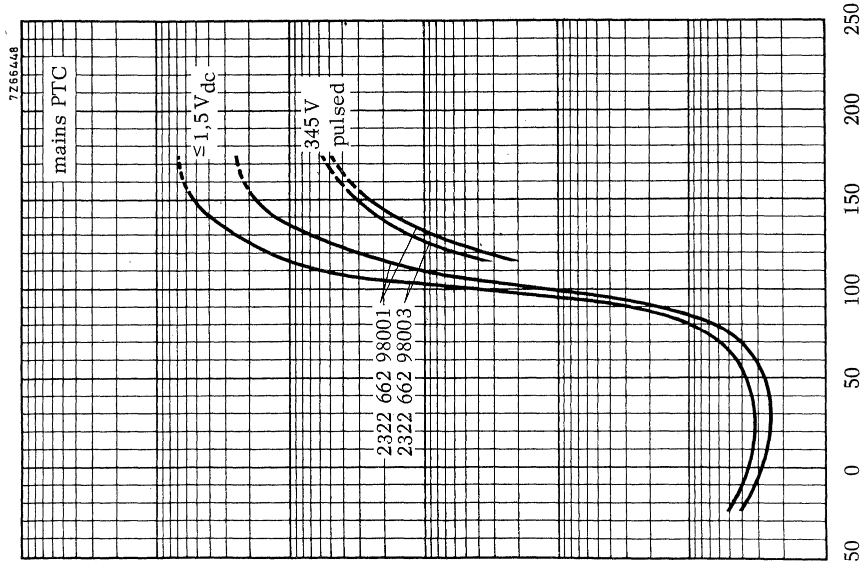


Fig. 3 Typical resistance versus temperature characteristics of the mains PTC thermistor.

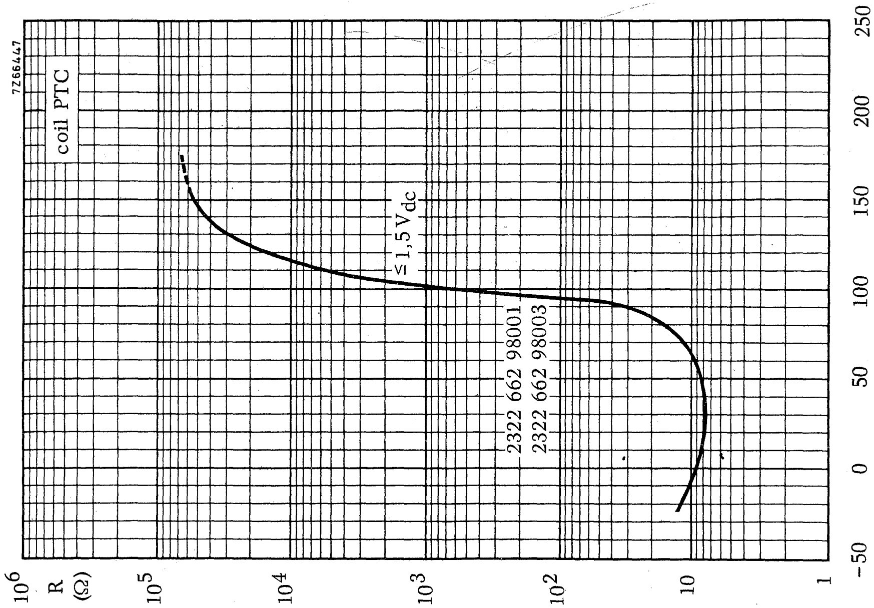


Fig. 4 Typical resistance versus temperature characteristics of the coil PTC thermistor.

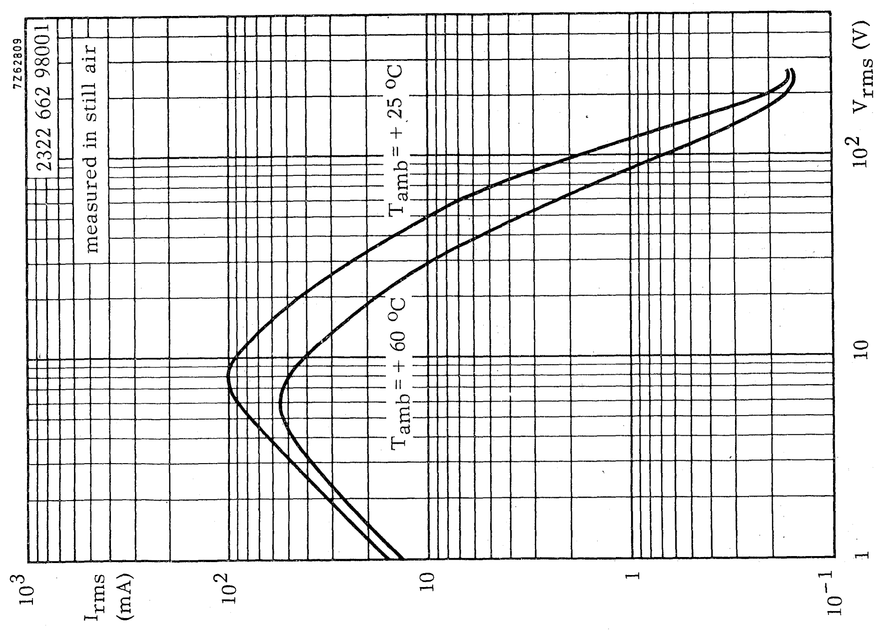


Fig. 5 Typical static current through the coil versus voltage characteristics.

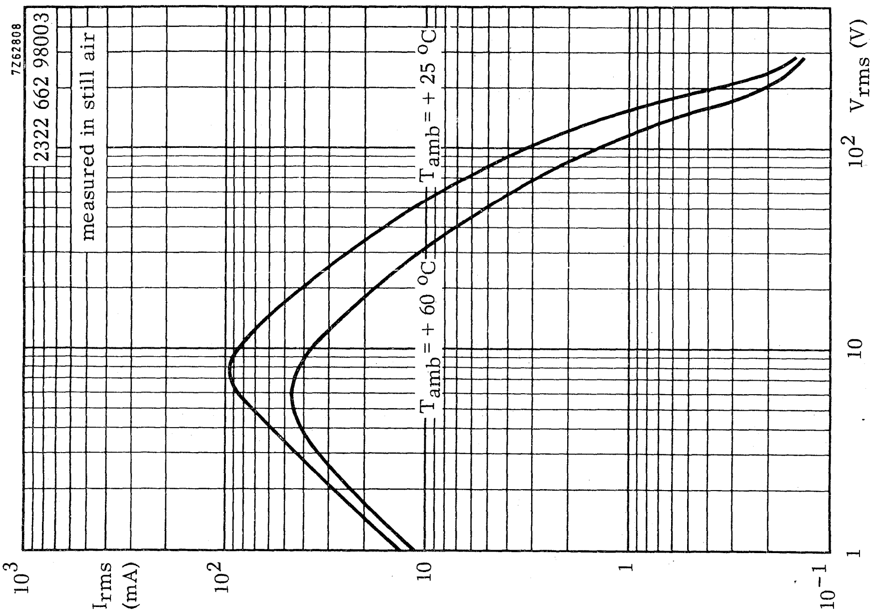


Fig. 6 Typical static current through the coil versus voltage characteristics.

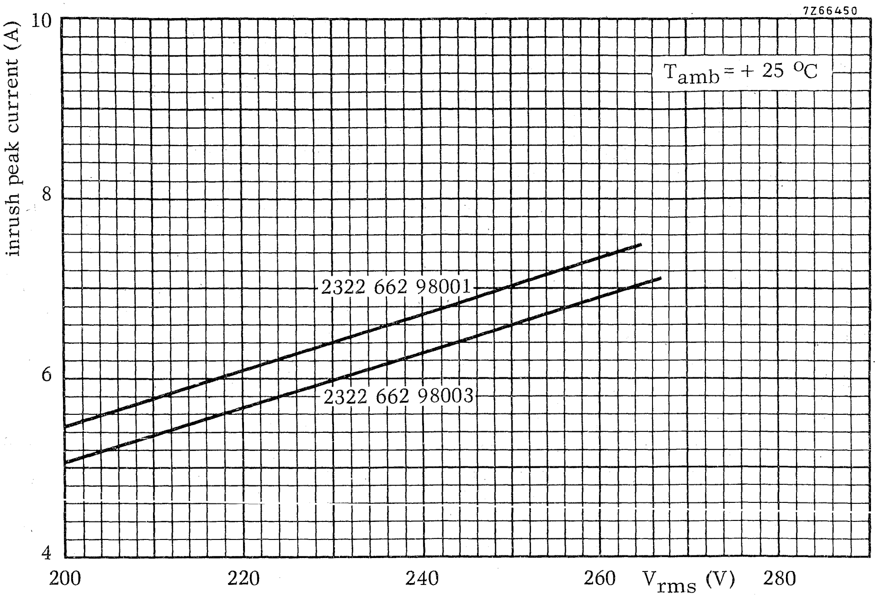


Fig. 7 Typical inrush peak current versus voltage characteristics.

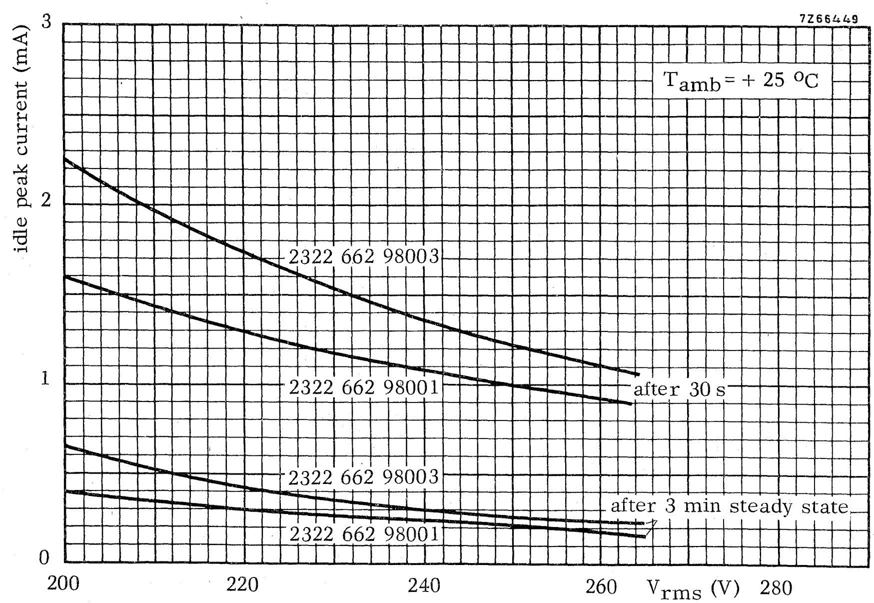


Fig. 8 Typical peak idle current versus voltage characteristics.

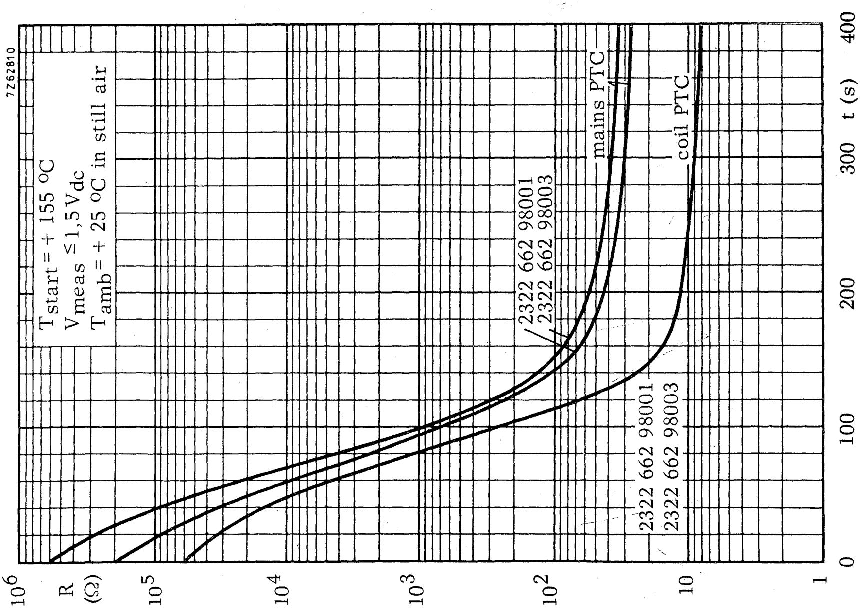


Fig. 9 Typical resistance versus cooling time characteristics of mains PTC thermistor.

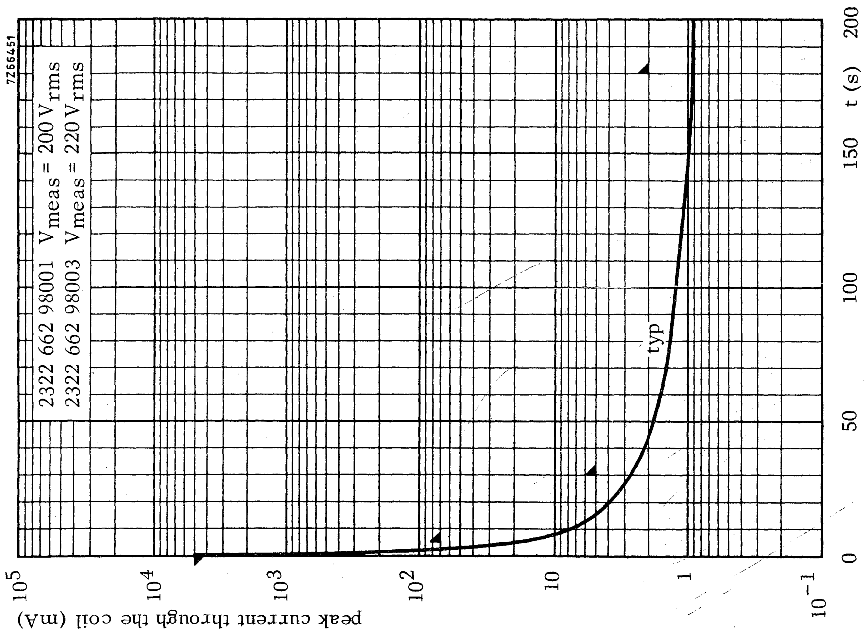


Fig. 10 Typical peak current through the coil versus time characteristic.

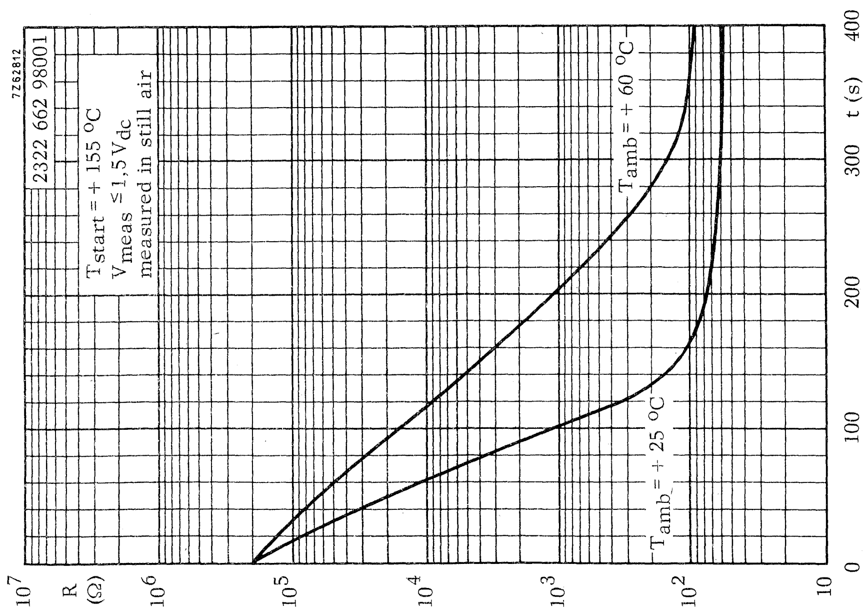


Fig. 11 Typical resistance of circuit versus cooling time characteristics.

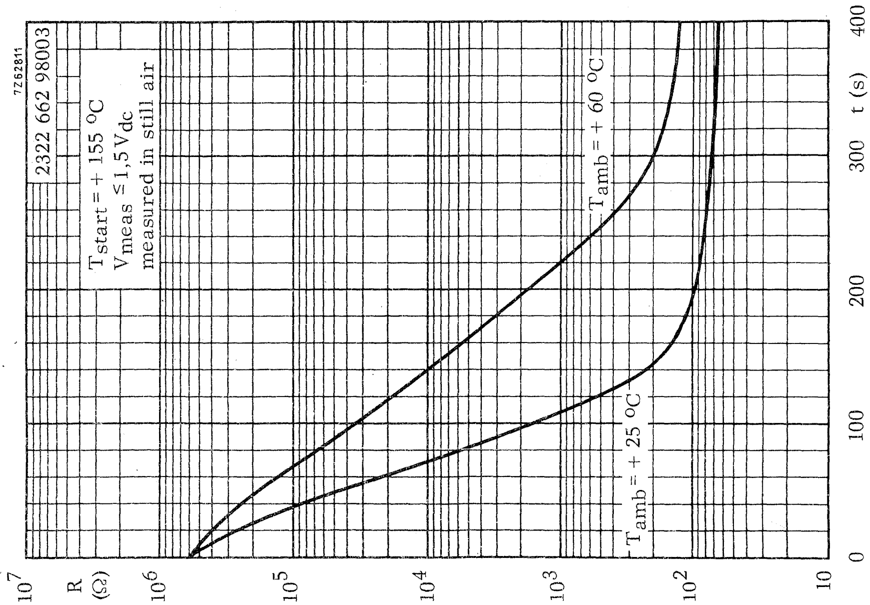


Fig. 12 Typical resistance of circuit versus cooling time characteristics.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	ΔR/R (%) at +25 °C	ΔR/R (%) at +125 °C
Cold at −25 °C	A	1000 h	± 7,5	± 12
Storage at +25 °C	H	1000 h	± 5	± 12
Dry heat at +155 °C	B	1000 h	± 10	± 12
Thermal shock −25 to +155 °C	Na	5 cycles	± 7,5	± 12
Damp heat at +40 °C	C	1000 h	± 10	± 12
Dissipation at 245 V (r.m.s.) and T_{amb} = +60 °C		1000 h	± 10	± 12
Cycle test at 245 V (r.m.s.) and T_{amb} = 0 °C		100 cycles [3]	± 10	± 12
and T_{amb} = +25 °C		2000 cycles [3]	± 7,5	± 12
Robustness of terminations	U			
Tensile strength 20 N	Ua	10 s	[1]	
Soldering	T			
Solderability	par. 3.2.3.	3 to 4 s	[2]	
Resistance to heat	Tb	10 to 11 s	± 2	± 2
Impact	E			
Free fall	Ed	2 falls	[4]	

[1]) Leads should neither come loose nor break.
[2]) Leads must be solderable initially and after 6 months storage with solder containing resin flux.
[3]) Cycle: 1 min on/9 min off.
[4]) There should be no visual defects.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1,5%, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

DUAL PTC THERMISTOR

QUICK REFERENCE DATA	
Current through the coil at 100 V (r.m.s.)	
min. inrush peak current	9 A
max. peak current	
after 5 s	140 mA
after 30 s	10 mA
after 3 min	4 mA
Maximum r.m.s. voltage	140 V
Operating temperature range	
at zero power	−25 to +155 °C
at maximum voltage	0 to +60 °C

APPLICATION

Intended primarily to be used in the degaussing circuit of colour television sets.

DESCRIPTION

The dual PTC consists of two disc PTC thermistors clamped between spring contacts. This assembly ensures a good thermal contact between both discs, which is essential for the function of this device. The thermistor is enclosed in a plastic housing of which the cap is white and the base blue. The three connecting pins are arranged to fit a printed-wiring board with an 0,1 inch grid.

MECHANICAL DATA

Dimensions in mm

Outlines

See Fig. 2 for connection of A, B and C.

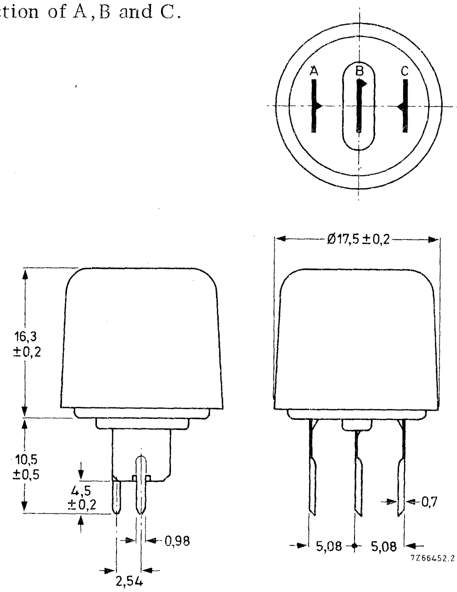


Fig. 1

Marking	None
Mass	7, 3 g approximately
Mounting	The thermistor can be soldered directly onto a printed-wiring board

Robustness

Tensile strength	between base and terminations	20 N
	between cap and base	10 N (no criterion on torsion)

Soldering

Solderability	max. 240 ^{o}C, max. 4 s
Resistance to heat	max. 265 ^{o}C, max. 11 s

Impact

Free fall	1000 mm

Inflammability	uninflammable, in accordance with IEC draft publication 50 (secretariat) 209, and VDE standard 0471-5, test flame 1.

ELECTRICAL DATA

All values are approximate unless otherwise specified.

Current through the coil at 100 V (r.m.s.) measured in circuit of Fig. 2	
min. inrush peak current	9 A
max. idle peak current	
after 5 s	140 mA
after 30 s	10 mA
after 3 min	4 mA
Resistance at +25 °C:	
of mains PTC 1)	6 Ω
of coil PTC 1)	3,5 Ω
at T_{amb} = +225 °C and 198 V pulsed of mains PTC 2)	≥ 2,9 kΩ
Switch temperature of mains and coil PTC	75 °C
Temperature coefficient of mains and coil PTC	20%/°C
Maximum r.m.s. voltage in circuit 3)	140 V
Dissipation factor 3)	13,5 mW/°C
Thermal time constant 3)	200 s
Operating temperature range	
at zero power	−25 to +155 °C
at maximum voltage	0 to +60 °C

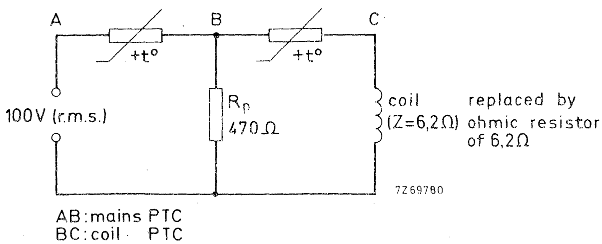


Fig. 2 Measuring circuit. R_p must be able to withstand a peak power of 25 W for 300 ms.

1) Measuring voltage not exceeding 1,5 V d.c. to avoid internal heating.
2) Measurements have to be made without self heating of the specimen.
3) Measurements made with the thermistor soldered on printed-wiring board in still air.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	ΔR/R (%) at +25 °C	ΔR/R (%) at +155 °C
Cold at −25 °C	A	1000 h	± 7,5	± 12
Storage at +25 °C	H	1000 h	± 5	± 12
Dry heat at +155 °C	B	1000 h	± 10	± 12
Thermal shock −25 to +155 °C	Na	5 cycles	± 7,5	± 12
Damp heat at +40 °C	C	1000 h	± 10	± 12
Dissipation at 140 V (r.m.s.) and T_{amb} = +60 °C		1000 h	± 10	± 12
Cycle test at 140 V (r.m.s.) and T_{amb} = 0 °C		100 cycles 3)	± 10	± 12
and T_{amb} = +25 °C		2000 cycles 3)	± 7,5	± 12
Robustness of terminations	U			
Tensile strength 20 N	Ua	10 s	1)	
Soldering	T			
Solderability	par. 3.2.3.	3 to 4 s	2)	
Resistance to heat	Tb	10 to 11 s	± 2	± 2
Impact	E			
Free fall	Ed	2 falls	4)	

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.
3) Cycle: 1 min on/9 min off.
4) There should be no visual defects.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1,5%, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

DUAL PTC THERMISTOR

parallel-series

QUICK REFERENCE DATA	
Current through the coil at 200 V r.m.s.	
min. inrush peak current	5 A
max. peak current	
after 5 s	70 mA
after 30 s	5 mA
after 3 min	2 mA
Maximum r.m.s. voltage	265 V
Operating temperature range	
at zero power	−25 to + 125 °C
at maximum voltage	0 to + 60 °C

APPLICATION

Intended primarily to be used in the degaussing circuit of colour television sets.

DESCRIPTION

The dual PTC consists of two disc PTC thermistors clamped between spring contacts. This assembly ensures a good thermal contact between both discs, which is essential for the function of this device. The thermistor is enclosed in a plastic housing of which the cap is white and the base blue. The three connecting pins are arranged to fit a printed-wiring board with an 0, 1 inch grid.
The parallel PTC thermistor is connected across the supply, the series PTC thermistor is connected in series with the degaussing coil. The series PTC would not by itself lower the current to 2 mA, but would stabilize the current above this value. By applying further heat to the series PTC, its resistance will increase to the point where the coil current is limited to 2 mA. This extra heat is provided by the parallel PTC.

MECHANICAL DATA

Dimensions (mm)

Points A and B are to be connected to the mains
Points A and C are to be connected to the degaussing coil (see also Fig. 2)

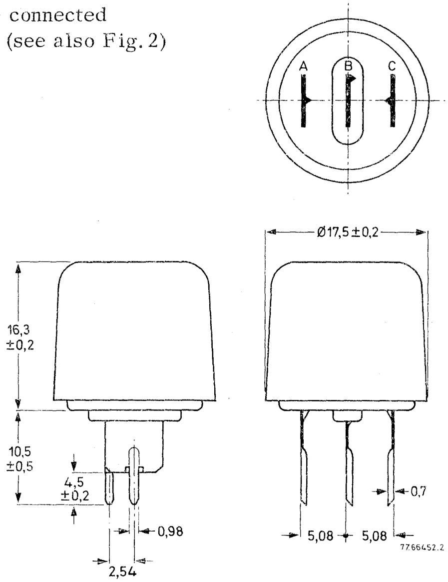


Fig. 1

Marking	The catalogue number is moulded in the top of the cap
Weight	7,3 g approximately
Mounting	The thermistor can be soldered directly onto a printed-wiring board.

Robustness of terminations

Tensile strength	20 N

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s

Impact

Free fall	1000 mm

Inflammability	uninflammable, in accordance with IEC draft publication 50 (secretariat) 209.

ELECTRICAL DATA

Unless otherwise specified measured according to IEC draft publication 40 (secretariat) 288.

Current through the coil measured in circuit of Fig. 2 at 200 V r.m.s.		
min. inrush peak current	5 A	
max. peak current		
after 5 s	70 mA	
after 30 s	5 mA	
after 3 min	2 mA	
Resistance at +25 °C, R_s	40 Ω	1)
R_p	1000 to 6000 Ω	1)
Maximum r.m.s. voltage in circuit 2)	265 V	
Operating temperature range		
at zero power	−25 to + 125 °C	
at maximum voltage	0 to + 60 °C	

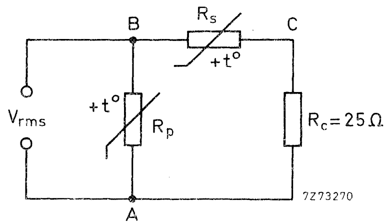


Fig. 2. Measuring circuit
R_p = parallel PTC
R_s = series PTC
R_c replaces the degaussing coil (Z = 25 Ω)

1) Approximate values.
2) Measurements made with the thermistor soldered on printed-wiring board in still air.

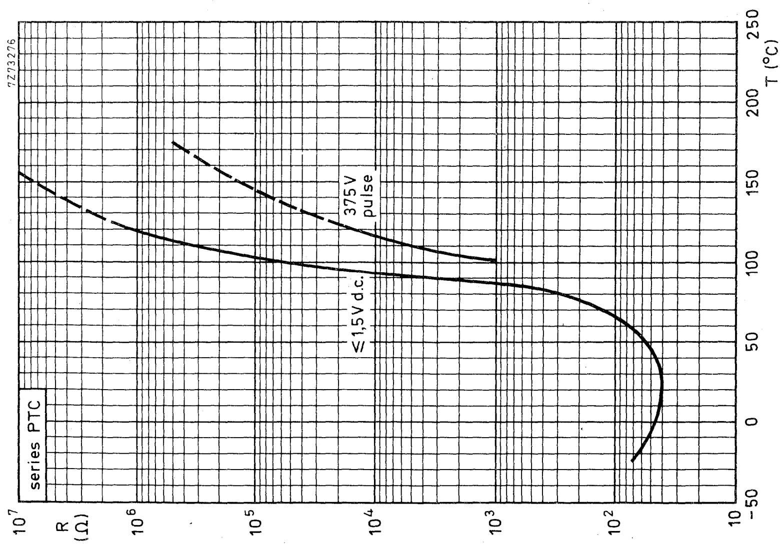


Fig. 3. Typical resistance versus temperature characteristics of the series PTC

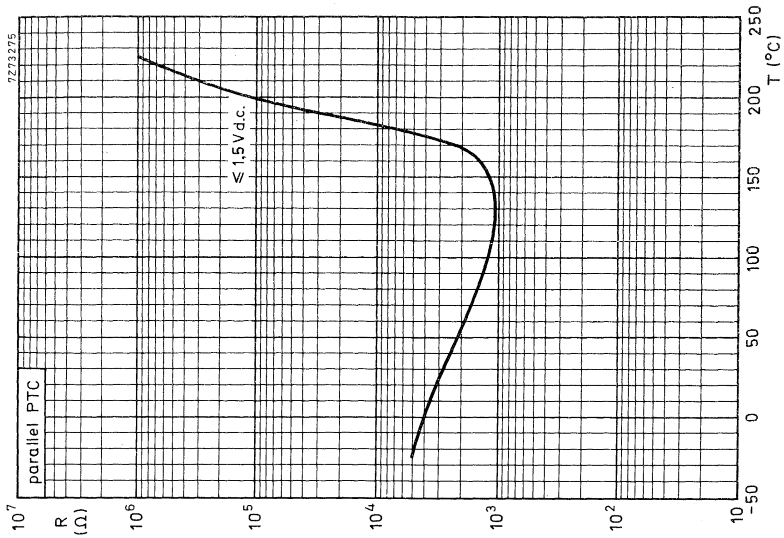


Fig. 4. Typical resistance versus temperature characteristics of the parallel PTC

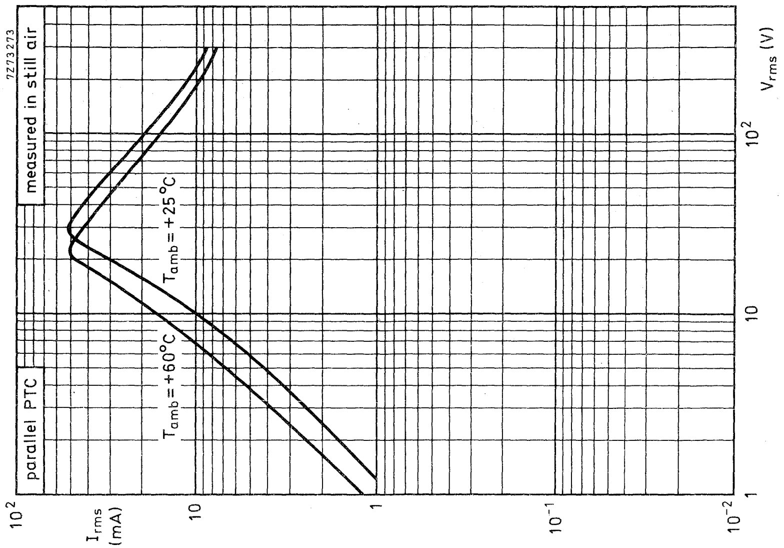


Fig. 6. Typical static current through the parallel PTC versus voltage characteristics

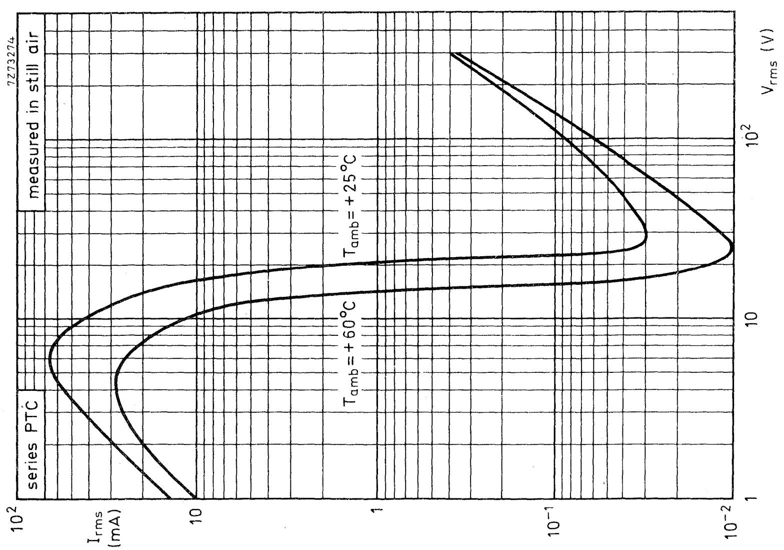


Fig. 5. Typical static current through the coil versus voltage characteristics

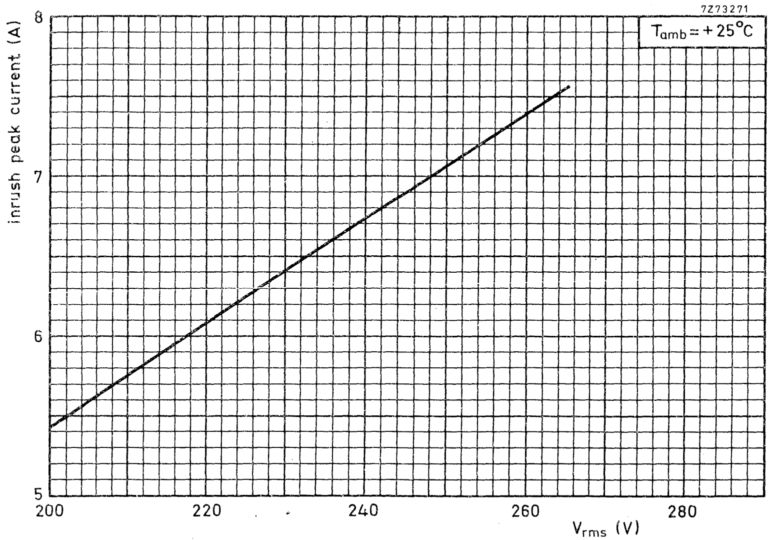


Fig. 7. Typical inrush peak current versus voltage characteristic

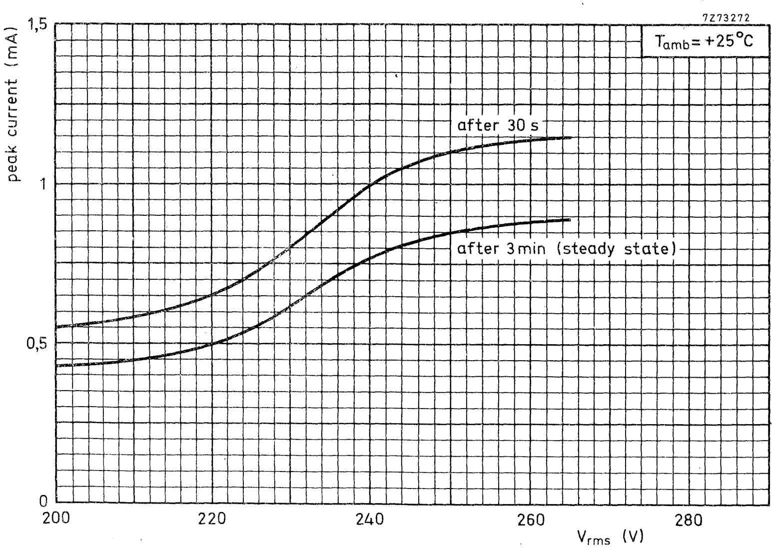


Fig. 8. Typical peak current versus voltage characteristics

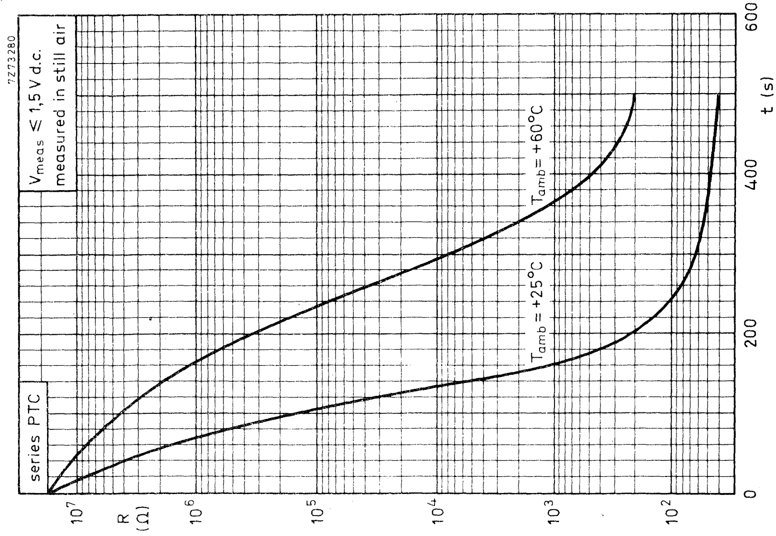


Fig. 9. Typical resistance versus cooling time characteristics of series PTC (cooling off after stationary operation at 220 V).

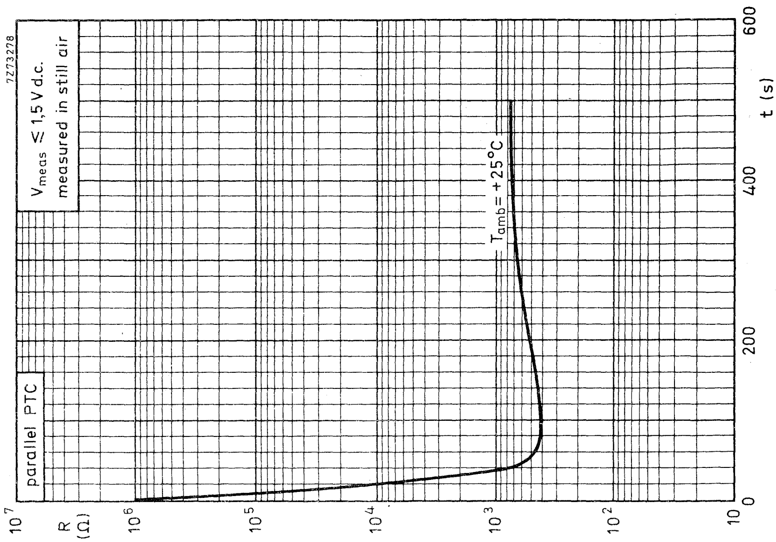


Fig. 10. Typical resistance versus cooling time characteristic of parallel PTC (cooling off after stationary operation at 220 V).

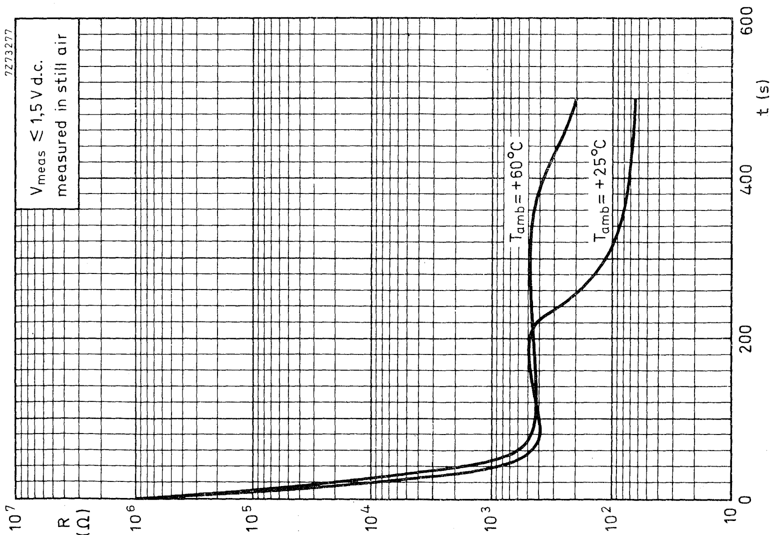


Fig. 11. Typical resistance of circuit versus cooling time characteristics (cooling off after stationary operation at 220 V).

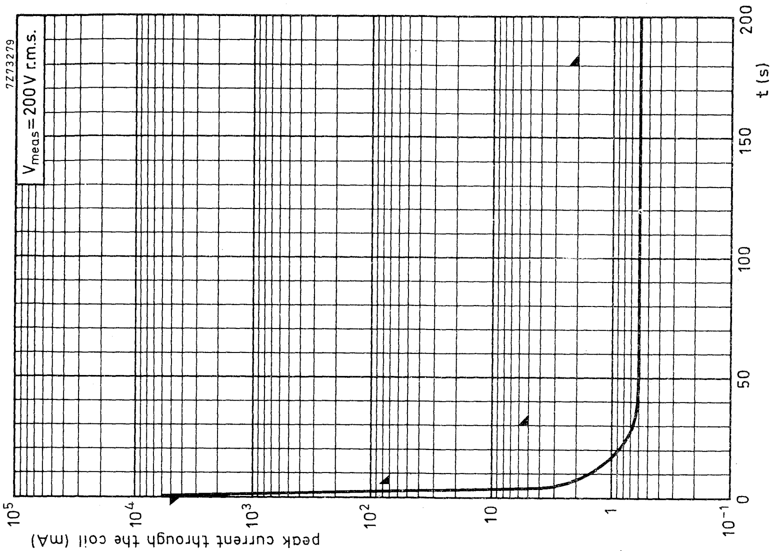


Fig. 12. Typical peak current through the coil versus time characteristic. Peak current limits are indicated by ◢

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	ΔR/R (%) at +25 °C	ΔR/R (%) at +125 °C
Cold at −25 °C	A	1000 h	± 7,5	± 12
Storage at +25 °C	H	1000 h	± 5	± 12
Dry heat at +125 °C	B	1000 h	± 10	± 12
Thermal shock −25 to +125 °C	Na	5 cycles	± 7,5	± 12
Damp heat at +40 °C	C	1000 h	± 10	± 12
Dissipation at 265 V r.m.s. and T_{amb} = +60 °C		1000 h	± 10	± 12
Cycle test at 265 V r.m.s. and T_{amb} = 0 °C		100 cycles 3) 4)	± 10	± 12
and T_{amb} = +25 °C		2000 cycles 3) 4)	± 7,5	± 12
Robustness of terminations	U			
Tensile strength 20 N	Ua	10 s	1)	
Soldering	T			
Solderability	par. 3.2.3	3 to 4 s	2)	
Resistance to heat	T_b	10 to 11 s	± 2	± 2
Impact	E			
Free fall	Ed	2 falls	4)	

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.
3) Cycle: 1 min on/9 min off.
4) There should be no visual defects.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1,5%, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

PACKAGING

600 pieces per box (cardboard).

PTC THERMISTOR
disc

QUICK REFERENCE DATA	
Resistance value at +25 °C	14 to 26 Ω
Resistance value at +200 °C V_{pulse} = 345 V	min. 20 kΩ
Switch temperature	+ 125 °C
Temperature coefficient	+28%/°C
Maximum r.m.s. voltage	245 V
Dissipation factor	21 mW/°C
Operating temperature range at zero power at maximum voltage	 −25 to + 175 °C 0 to + 80 °C

APPLICATION

Suitable for all kinds of applications, e.g. overheat protection in the ballast of a fluorescent lamp system.

DESCRIPTION

This positive temperature coefficient thermistor consists of a disc provided with two solid tinned copper wires. The body is neither lacquered nor insulated.

MECHANICAL DATA

Dimensions (mm)

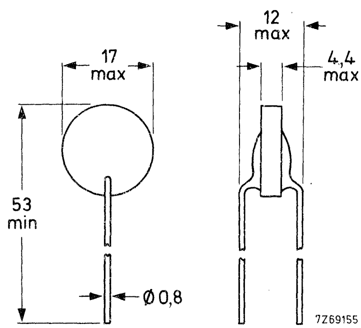


Fig. 1

Marking	None
Weight	4,3 g approximately
Mounting	In any position by soldering
Robustness of terminations	
Tensile strength	20 N
Bending	10 N
Soldering	
Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s
Impact	200 mm free fall
Inflammability	Uninflammable

ELECTRICAL DATA

Unless otherwise specified measured according to IEC draft publication 40 (secretariat) 288.

All values in the table without further indication are approximate values.

Resistance at +25 °C	14 to 26 Ω
Resistance at +125 °C	max. 70 Ω
Resistance at +200 °C V_{pulse} = 345 V [1]	min. 20 kΩ
Switch temperature	+125 °C
Temperature coefficient	+28%/°C
Dissipation factor	21 mW/°C
Heat capacity	2,3 J/°C
Thermal time constant	110 s
Operating temperature range at zero power at maximum voltage	 −25 to +175 °C 0 to +80 °C
Voltage dependence at +175 °C	0,26
Balance voltage, d.c.	100 V
Maximum r.m.s. voltage, with series resistor of 200 Ω	245 V

[1]) Measurement made without internal heating occurring.

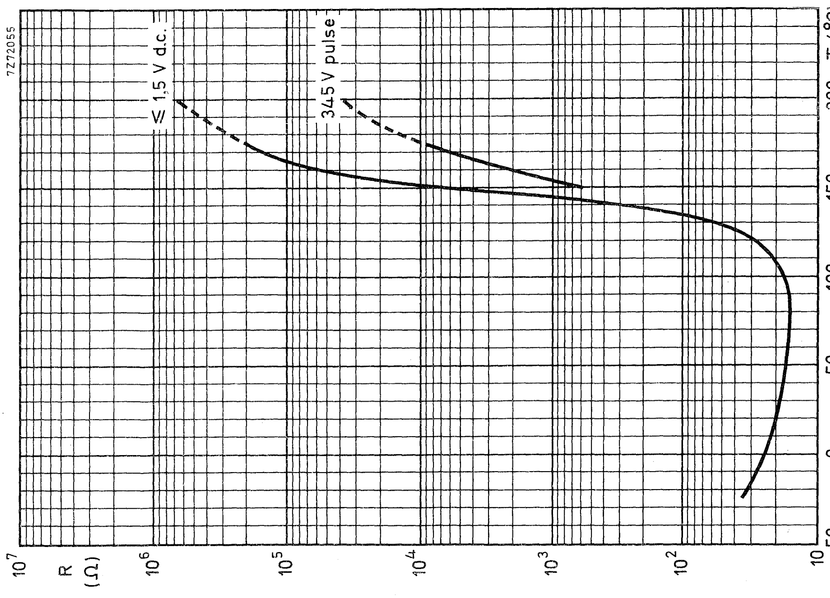


Fig. 2 Typical resistance/temperature characteristics

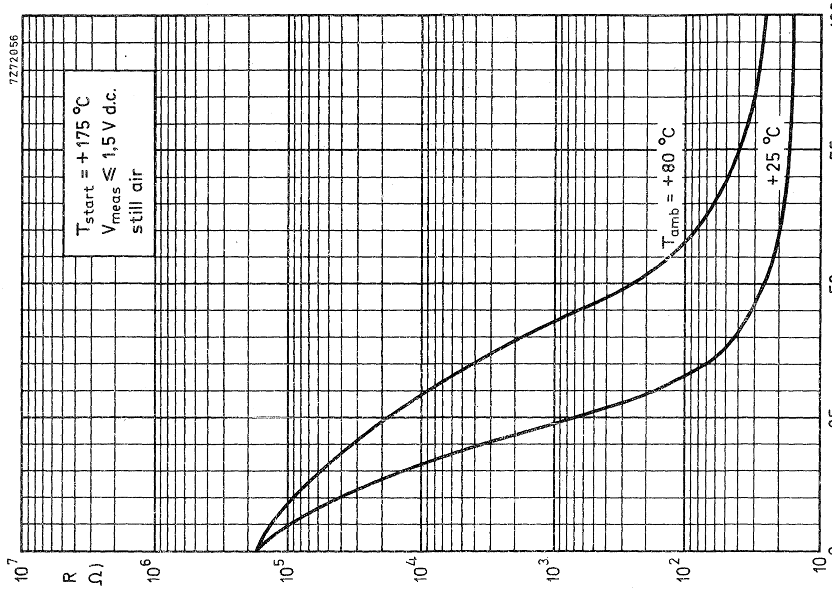


Fig. 3 Typical resistance/time (cooling) characteristics

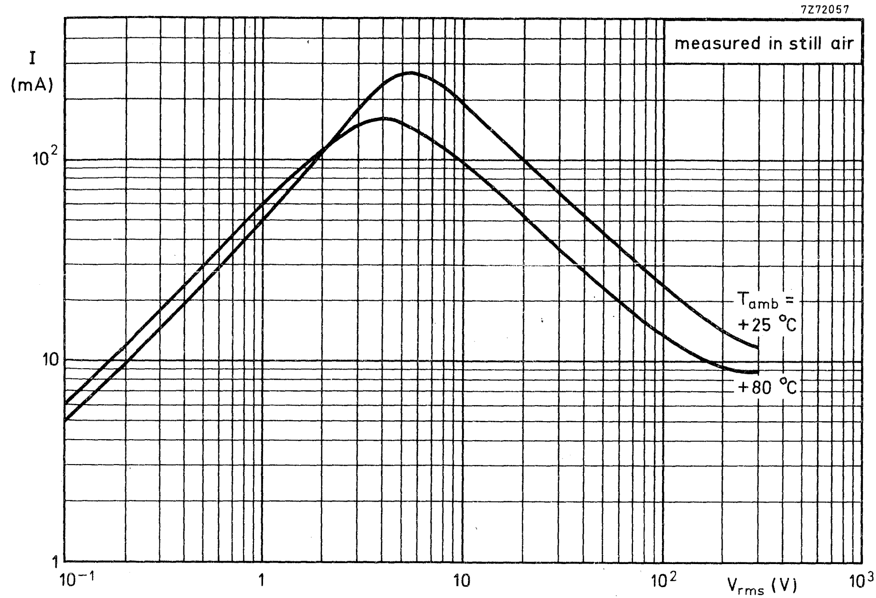


Fig. 4 Typical voltage/current characteristics

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L.	1 %	major defects	– Electrical
A.Q.L.	1,5%	major defects	– Mechanical
A.Q.L.	4 %	minor defects	– Physical

PACKAGING

100 pieces per box (card board).

PTC THERMISTOR
disc

QUICK REFERENCE DATA	
Resistance value at +25 °C	max. 0,6 Ω
Resistance value at + 150 °C V_{pulse} = 16 V	min. 40 Ω
Switch temperature	+ 85 °C
Temperature coefficient	+ 10 %/°C.
Maximum d.c. voltage	16 V
Dissipation factor	27 mW/°C
Operating temperature range at zero power at V_{max}	 −25 to + 155 °C −25 to + 55 °C

APPLICATION

For protection purposes, such like relay coils, loudspeakers, etc.

DESCRIPTION

The thermistor has a positive temperature coefficient. It consists of a disc provided with two solid tinned copper wires. The thermistor body is blue lacquered, but not insulated.

MECHANICAL DATA

Dimensions (mm)

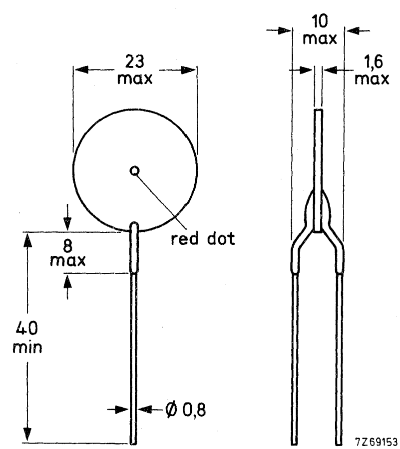


Fig. 1

Marking	The thermistors are marked with a red dot
Weight	2,3 g approximately
Mounting	In any position by soldering
Robustness of terminations	
Tensile strength	20 N
Bending	10 N
Soldering	
Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 240 °C, max. 4 s

ELECTRICAL DATA

Unless otherwise specified measured according to IEC draft publication 40 (secretariat) 288.

Resistance at −25 °C	max. 1,15 Ω 1)		
Resistance between +25 and +55 °C	max. 0,6 Ω 1)		
Resistance at +150 °C V_{pulse} = 16 V	min. 40 Ω 2)		
Switch temperature	+83 °C		*)
Temperature coefficient	10 %/°C		*)
Dissipation factor	27 mW/°C	3)	*)
Heat capacity	1,2 J/°C	3)	*)
Thermal time constant	45 s	3)	*)
Operating temperature range at zero power	−25 to +155 °C		
at maximum voltage	−25 to +55 °C		
Maximum d.c. voltage (V_{max})	16 V		

*) approximate values

1) d.c. measuring voltage not exceeding 1,5 V to avoid internal heating.

2) measurement made without internal heating occurring.

3) measurements made with specimen in phosphor bronze clips, in still air.

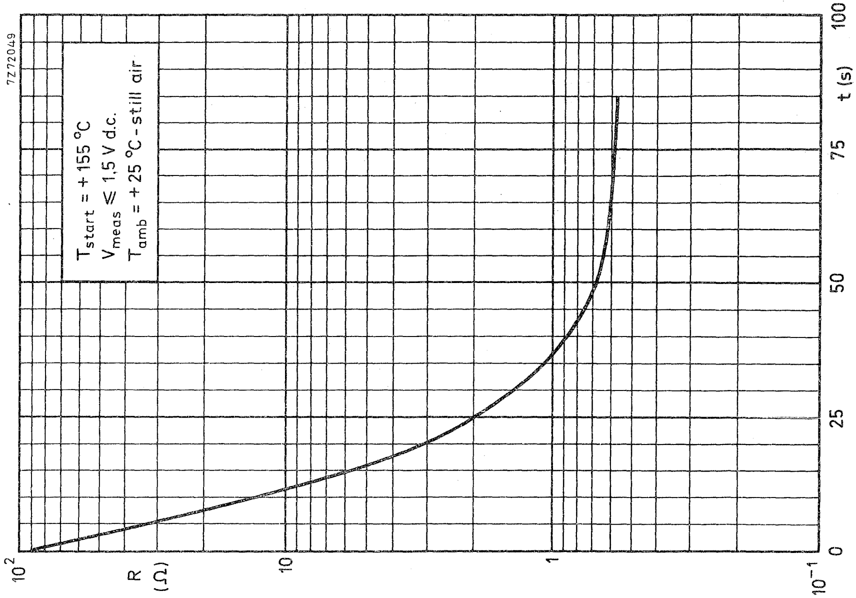


Fig. 3 Typical resistance/time (cooling) characteristic

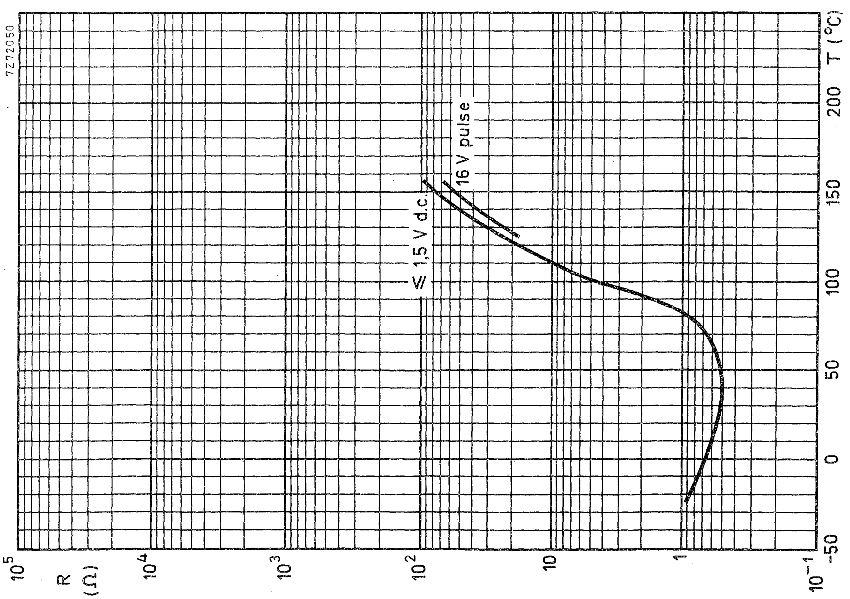


Fig. 2 Typical resistance/temperature characteristics

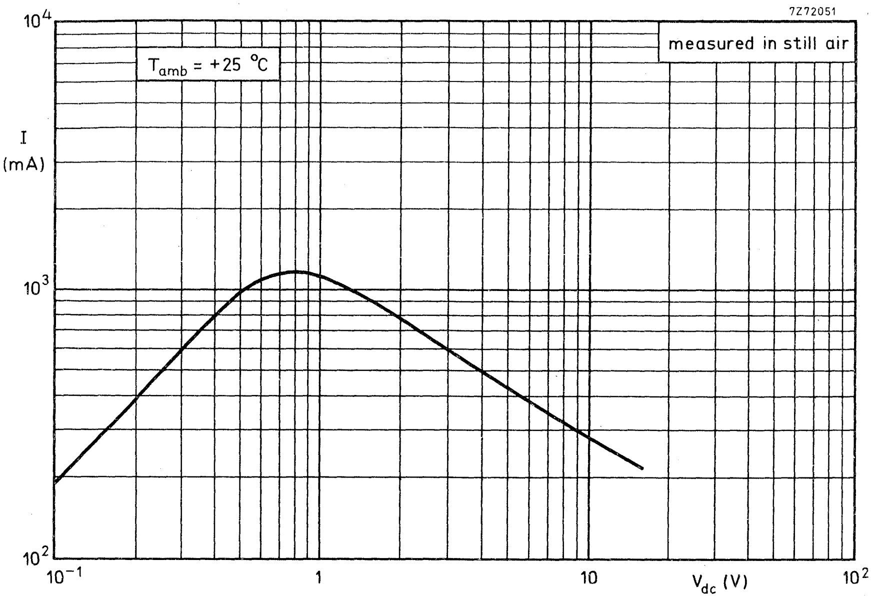


Fig. 4 Typical voltage/current characteristic

TESTS AND REQUIREMENTS

According to I.E.C. 68, unless otherwise specified.

test	test method	duration	ΔR/R in % at +25 °C	at +150 °C
Cold at −25 °C	A	1000 h	± 30	± 10
Storage at +25 °C	H	1000 h	± 20	± 10
Dry heat + 155 °C	B	1000 h	± 30	± 10
Thermal shock −25 to + 155 °C	Na	5 cycles	± 30	± 10
Damp heat	C	1000 h	± 30	± 10
Dissipation at V = 16 V d.c. and T_{amb} = +55 °C		168 h	± 30	± 10
Cycle test at V = 16 V d.c. and T_{amb} = −25 °C		100 cycles 1 min on/9 min off	± 30	± 10
Robustness of terminations	U			
Tensile strength 20 N	Ua	10 s	1)	
Bending 10 N	Ub	2 times	1)	
Soldering				
Solderability at 230 °C	par. 3.2.3	3 to 4 s	2)	
Resistance to heat at 230 °C	par. 3.2.4	3 to 4 s	± 20	± 10

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after six months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D

A.Q.L.	1 %	major defects – Electrical
A.Q.L.	1,5%	major defects – Mechanical
A.Q.L.	4 %	minor defects – Physical

PACKAGING

100 pieces per box (cardboard)

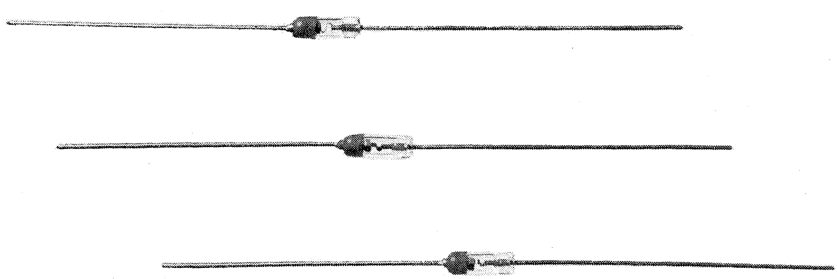
PTC THERMISTORS

for level control

QUICK REFERENCE DATA

	still air −25 °C	fuel oil +50 °C
Current at 12 V d.c.	≤ 39 mA	≥ 45 mA
16 V d.c.	≤ 30 mA	≥ 36 mA
18 V d.c.	≤ 27 mA	≥ 33 mA
Switch temperature	160 °C approx.	
Maximum voltage at +75 °C, with a series resistor of 100 Ω	19 V d.c.	
Dissipation factor		
in still air at −25 °C	2 mW/degC approx.	
in still fuel oil at +50 °C	6.25 mW/degC approx.	
Operating temperature range		
at zero power	−55 to +125 °C	
at maximum voltage, in still air	−25 to + 75 °C	
at maximum voltage, in still fuel oil	−25 to + 50 °C	

RZ 30185-12



APPLICATION

Intended for level control of fuel oil in oiltanks.

DESCRIPTION

A miniature thermistor element is mounted in a glass envelope model DO7, and provided with two connecting leads.

MECHANICAL DATA Dimensions in mm

Outlines

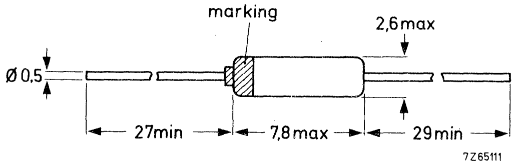


Fig. 1.

Marking

Black colour band *)

Mass

0,2 g approximately

Mounting

Vertically, to be soldered at 25 to 29 mm from the body.
Marked end to be connected to the positive pole.

Robustness of terminations

Tensile strength	10 N
Bending	5 N
Torsion	3 times 360°, in opposite directions

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 240 °C, max. 4 s

*) Was red in the past.

ELECTRICAL DATA

Resistance at +25 °C	70 to 250 Ω [1]	
Resistance at +200 °C, V_{pulse} = 18 V	min. 1,8 kΩ [1]	
	still air [2][4]	still fuel oil [2][3][4]
	at $-25^{\,0}_{-1}$ °C	at $+50^{+1}_{\,0}$ °C
Current at 12 V d.c. (−2 %)	≤ 39 mA	> 45 mA
16 V d.c. (−2 %)	≤ 30 mA	≥ 36 mA
18 V d.c. (−2 %)	≤ 27 mA	≥ 33 mA
Switch temperature	160 °C approx.	
Temperature coefficient	35 %/°C approx.	
Maximum current of static I/V characteristic in still air at $-25^{\,0}_{-1}$ °C	80 mA [5]	
Maximum voltage at +75 °C, with a series resistor of 100 Ω	19 V d.c.	
Dissipation factor		
in still air, at −25 °C	2 mW/°C approx. [4]	
in still fuel oil, at +50 °C	6,25 mW/°C approx. [3][4]	
Operating temperature range		
at zero power	−55 to +125 °C	
at maximum voltage, in still air	−25 to + 75 °C	
at maximum voltage, in still fuel oil	−25 to + 50 °C [3]	
Maximum temperature of glass envelope	+200 °C	

[1]) Measuring voltage not exceeding 1,5 V d.c. to avoid internal heating.

[2]) Each item fully checked.

[3]) Brand of fuel oil SHELL S5585.

[4]) Measurements between phosphor-bronze wires (ϕ 1,3 mm).

[5]) Even if the voltage corresponding to the maximum static current rises above 6 V, the dissipation will not be more than 480 mW.

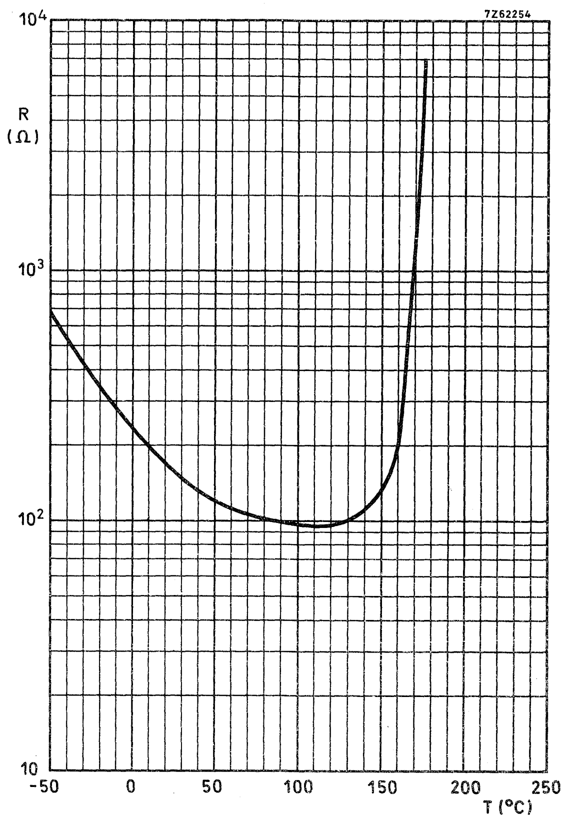


Fig. 2. Typical resistance/temperature characteristic.

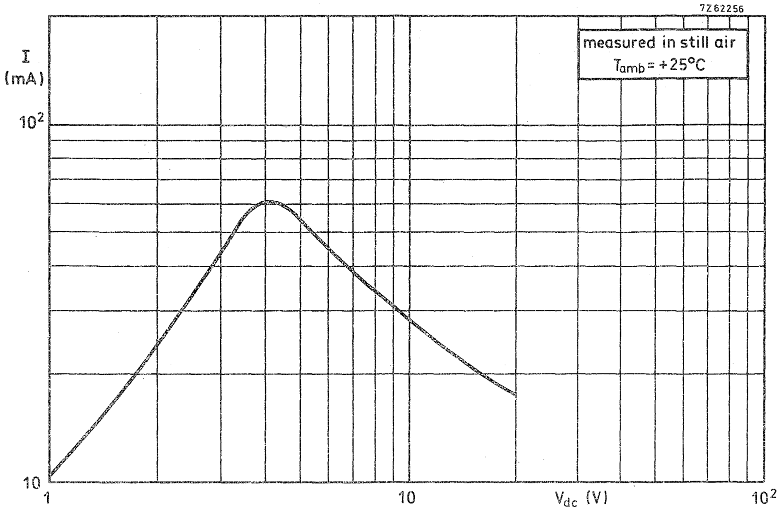


Fig. 3. Typical current/voltage characteristic

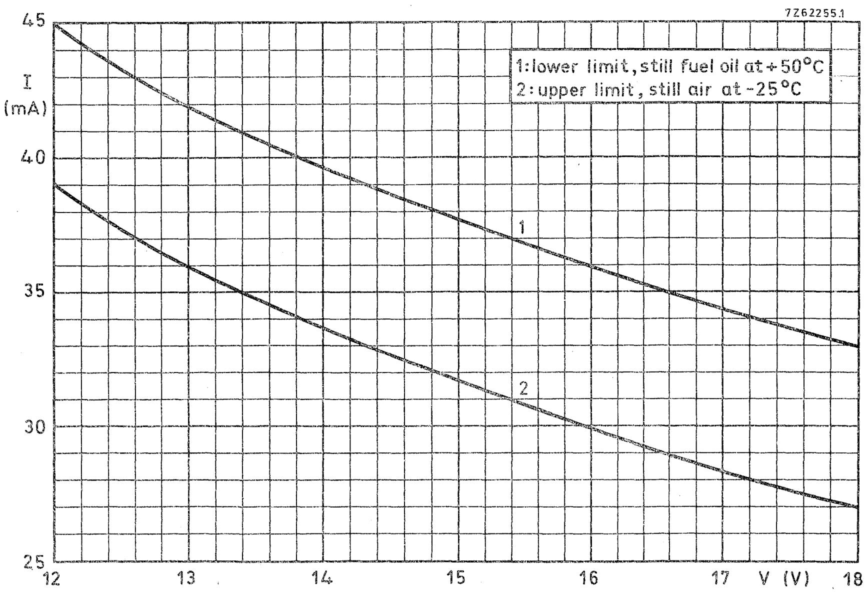


Fig. 4. Current limits versus voltage

TESTS AND REQUIREMENTS

According to IEC 68 recommendation, unless otherwise specified.

test	test method	duration	ΔR/R (%) at + 50 °C	ΔR/R (%) at −25 °C
Cold, −25 °C	A	1000 h	± 3	± 3
Storage at + 25 °C	H	1000 h	± 3	± 3
Dry heat, + 125 °C	B	1000 h	± 5	± 5
Thermal shock, −25 to + 125 °C	Na	5 cycles	± 3	± 3
Damp heat	Ca	1000 h	± 5	± 5
Cycle test at V = 16 V d.c. and T_{amb} = + 25 °C		1000 cycles 1 min on/ 10 min off	± 10	± 10
Combined cycle test	3)	6000 cycles	± 10	± 10
Robustness of terminations	U			
Tensile strength 10 N	Ua	10 s	1)	
Bending 5 N	Ub	2 times	1)	
Torsion	Uc	3 times	1)	
Sealing	4)	24 h	no visible damage	
Soldering	T			
Solderability at 230 ± 10 °C	par. 3.2.3	3 to 4 s	2)	
Resistance to heat at 230 ± 10 °C	par. 3.2.4	3 to 4 s	± 2	± 2

1) Leads should neither come loose nor break.

2) Leads must be solderable initially and after six months storage with solder containing resin flux.

3) Test method:
a. Apply voltage of 19 V ± 5% to each item connected in series with a resistor of 100 Ω
b. After 1,5 min immerse in SHELL oil S 5585
c. 0,5 min. later, cut off voltage
d. The next 0,5 min the items remain in the fuel oil without voltage applied
e. The items are taken out the fuel oil and are exposed to the air
f. Again 0,5 min later, the whole sequence is repeated.

4) Test method: The thermistors are immersed for 24 h in an alcoholic solution of fluorescein thinned with water under a pressure of 40 N/cm². Then they are submitted for visual inspection under ultraviolet light.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

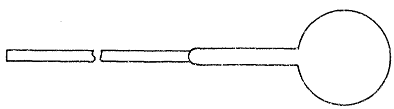
A.Q.L.	0.65 %,	major defects - Electrical
A.Q.L.	0.65 %,	major defects - Mechanical
A.Q.L.	4.0 %,	minor defects - Physical

PACKAGING

2 x 500 pieces fixed on a plastic band packed per box.

PTC THERMISTORS

QUICK REFERENCE DATA		
Resistance value between −20 and (T_S − 10) °C		30 to 250 Ω
Resistance value at (T_S +25) °C and V_{pulse} = 7,5 V		≥ 4 000 Ω
Switch temperature, T_S		70 to 150 °C
Temperature coefficient		18 to 38 %/°C
Maximum voltage		25 V d.c.
Dissipation factor (version with leads)		5,7 mW/°C
Operating temperature range	at zero power	−25 to (T_S +40) °C
	at maximum voltage	0 to (T_S +25) °C



APPLICATION

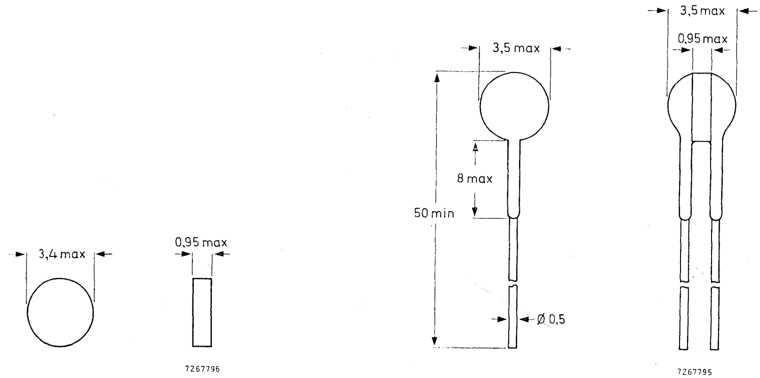
Intended as temperature sensors in domestic appliances, fire alarms, car electronics, etc.

DESCRIPTION

These thermistors have a positive temperature coefficient. They consist of a disc with or without two solid tinned copper wires.
The thermistor without leads is not lacquered nor insulated.
The thermistor with leads is lacquered but not insulated.

MECHANICAL DATA

Dimensions (mm)



version without leads　　　Fig. 1　　　version with leads

Marking

Version without leads	none
Version with leads	colour code, see Table

Weight

Version without leads	0,04 g approx.
Version with leads	0,29 g approx.

Mounting (for version with leads only)

In any position by soldering.

Robustness of terminations (for version with leads only)

Tensile strength	10 N
Bending	5 N

Soldering (for version with leads only)

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s

Impact

Free fall	1 m

ELECTRICAL DATA

All values in the electrical data without further indication are approximate values.

T_S (^oC)	temperature coefficient (%/ ^oC)	balance voltage (V d.c.)	voltage dependence β at(T_S+25)^oC	colour code for version with leads	catalogue number 2322 672 ..... with leads	without leads
70	18	19	0,32	violet	91002	91026
80	21	27	0,40	grey	91003	91027
90	31	16	0,36	white	91004	91028
100	33	17	0,35	black	91005	91029
110	38	11	0,36	brown	91006	91031
120	27	34	0,38	red	91007	91032
130	33	13	0,34	orange	91008	91033
140	33	20	0,35	yellow	91009	91034
150	23	20	0,31	green	91011	91035

Resistance value between −20 and (T_S −10) ^oC	30 to 250 Ω [1]
Resistance value at (T_S + 5) ^oC	≤ 550 Ω [1]
Resistance value at (T_S + 15) ^oC	≥ 1330 Ω [1]
Resistance value at (T_S + 25) ^oC, V_{pulse} = 7,5 V	≥ 4000 Ω [2]
Maximum voltage	25 V d.c.
Dissipation factor (version with leads)	5,7 mW/ ^oC
Thermal time constant (version with leads)	9 s
Heat capacity (version with leads)	0,05 J/ ^oC
Operating temperature range	
at zero power	−25 to (T_S + 40) ^oC
at maximum voltage	0 to (T_S + 25) ^oC

[1]) Measuring voltage not exceeding 2,5 V d.c. to avoid internal heating.
[2]) Measurements made without internal heating occurring.

Typical resistance/temperature characteristics

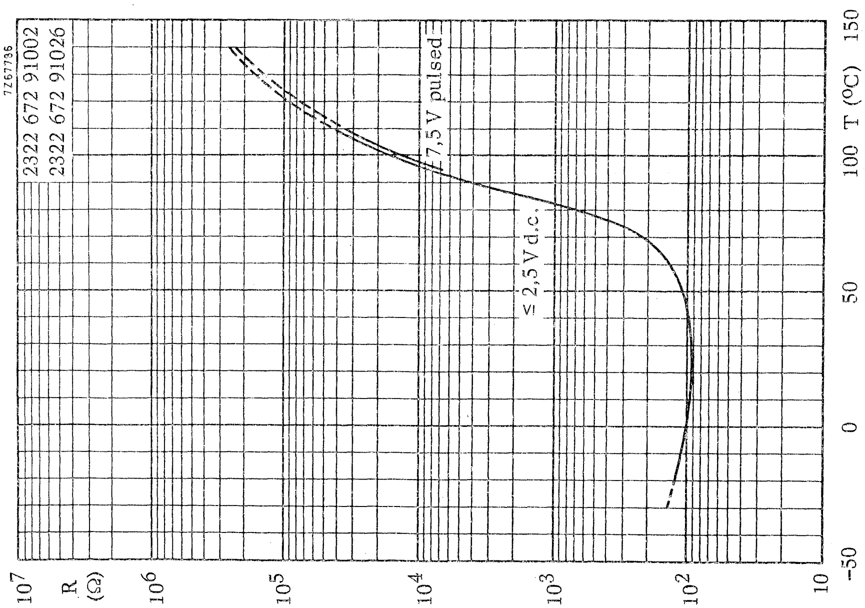


Fig. 2

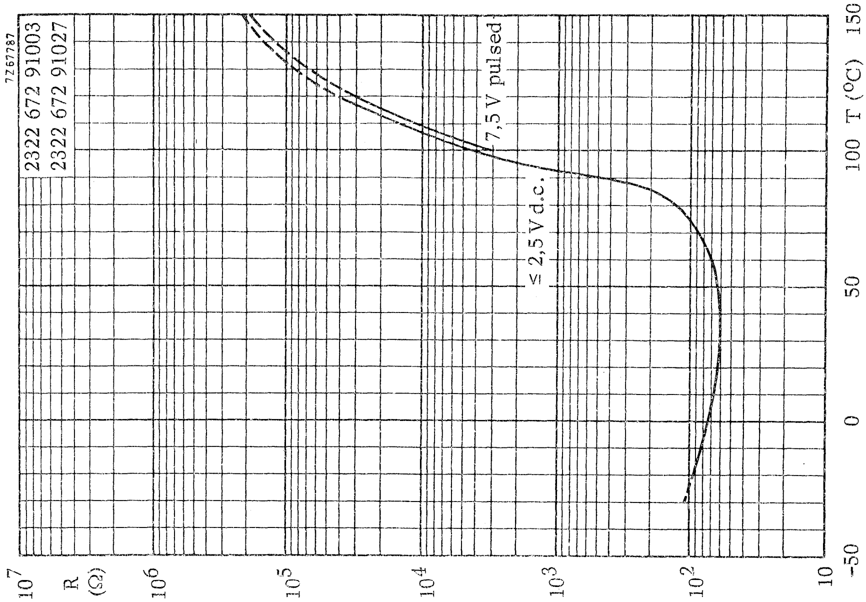


Fig. 3

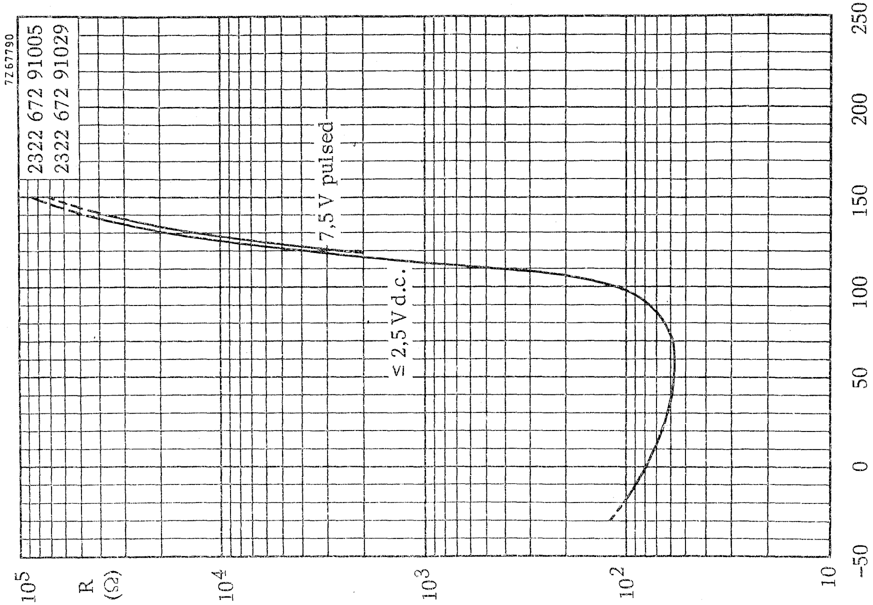

7Z67790
2322 672 91005
2322 672 91029
7,5 V pulsed
≤ 2,5 V d.c.
R
(Ω)
10
10^2
10^3
10^4
10^5
−50
0
50
100
150
200
250
T (°C)

Fig. 5

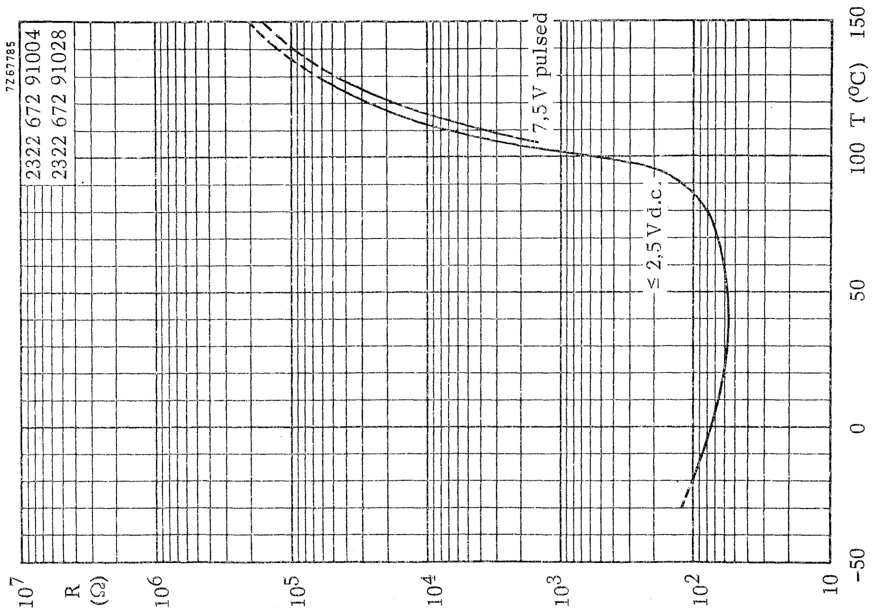

7Z67785
2322 672 91004
2322 672 91028
7,5 V pulsed
≤ 2,5 V d.c.
R
(Ω)
10
10^2
10^3
10^4
10^5
10^6
10^7
−50
0
50
100
150
T (°C)

Fig. 4

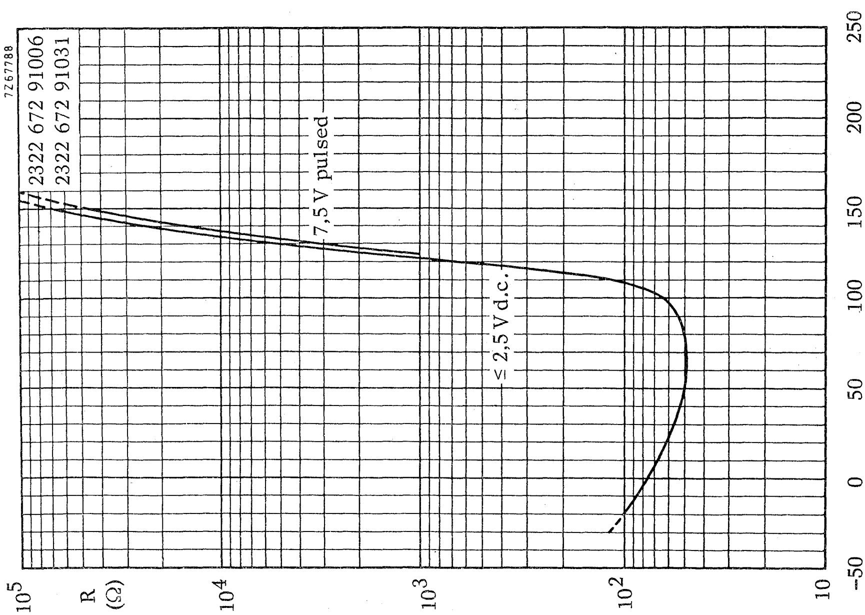

7Z67788
2322 672 91006
2322 672 91031
7,5 V pulsed
≤ 2,5 V d.c.
R
(Ω)
10^5
10^4
10^3
10^2
10
−50
0
50
100
150
200
250
T (°C)

Fig. 6

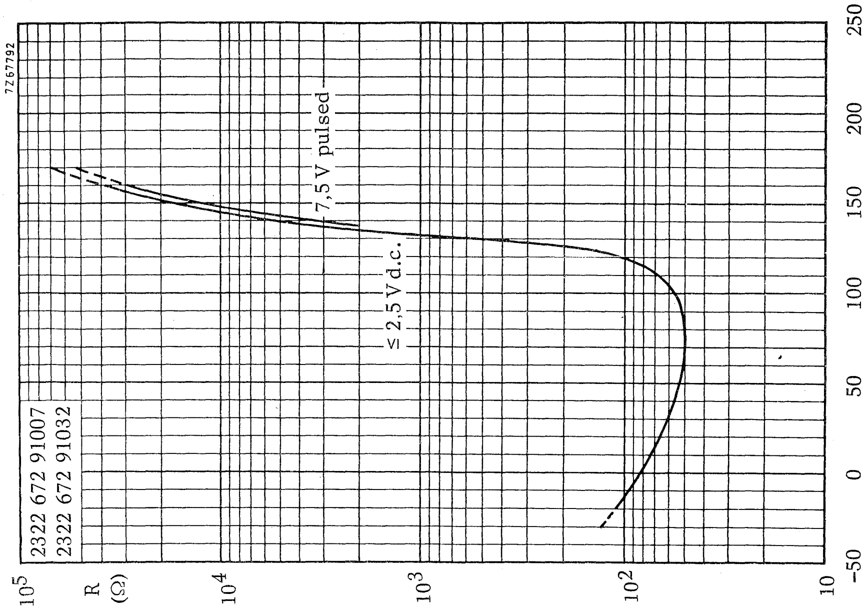

7Z67792
2322 672 91007
2322 672 91032
7,5 V pulsed
≤ 2,5 V d.c.
R
(Ω)
10^5
10^4
10^3
10^2
10
−50
0
50
100
150
200
250
T (°C)

Fig. 7

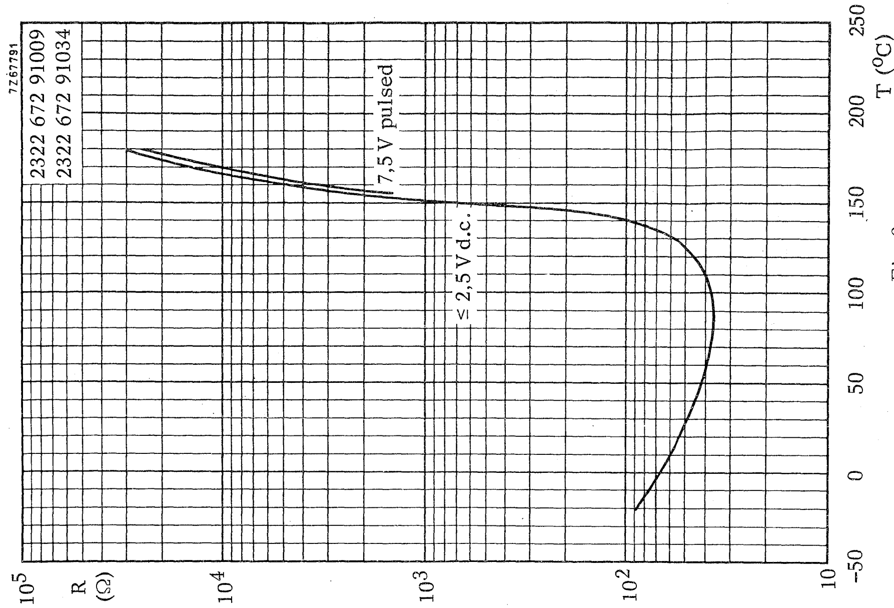

7Z67791
2322 672 91009
2322 672 91034
7,5 V pulsed
≤ 2,5 V d.c.
R
(Ω)
10^5
10^4
10^3
10^2
10
−50
0
50
100
150
200
250
T (°C)

Fig. 9

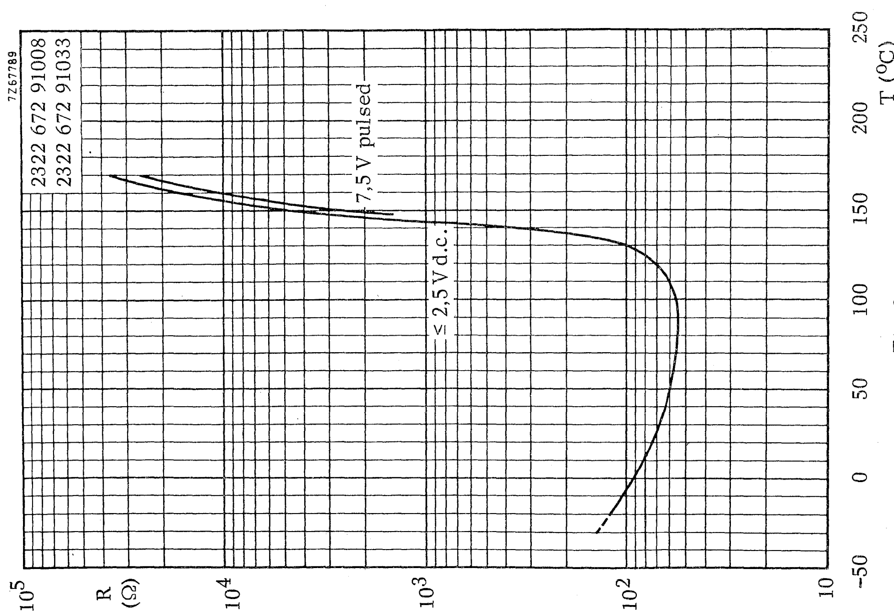

7Z67789
2322 672 91008
2322 672 91033
7,5 V pulsed
≤ 2,5 V d.c.
R
(Ω)
10^5
10^4
10^3
10^2
10
−50
0
50
100
150
200
250
T (°C)

Fig. 8

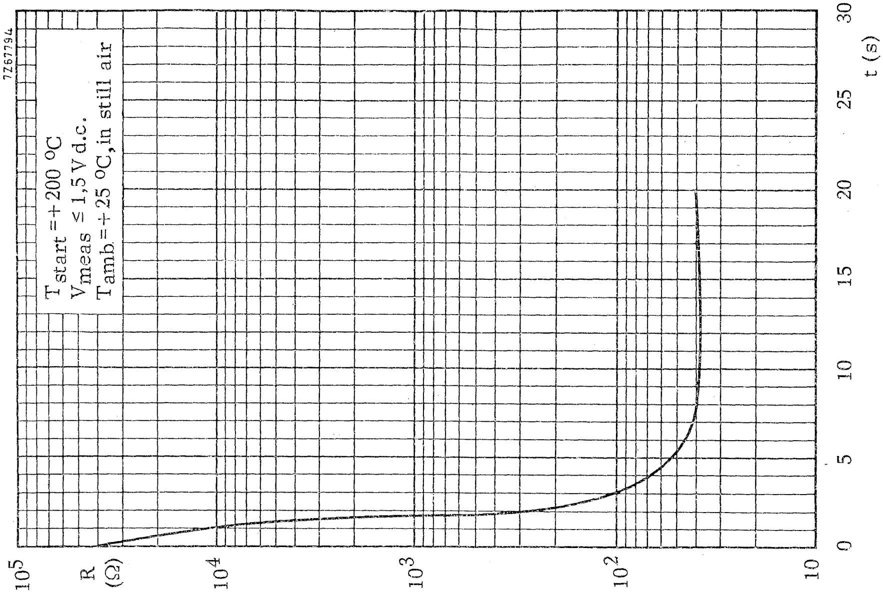


Fig. 11. Typical resistance/time (cooling) characteristic

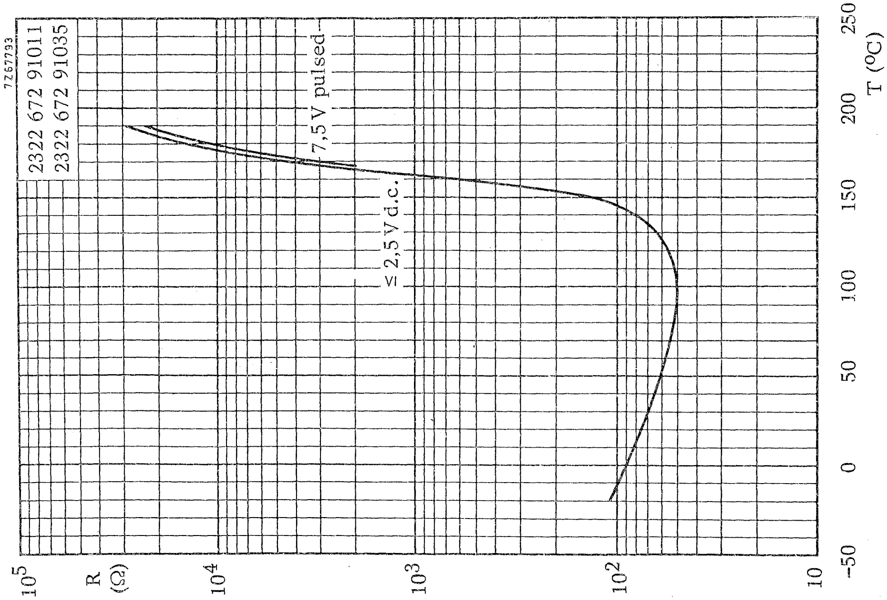


Fig. 10

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	ΔR/R in % at +25 °C	ΔR/R in % at T_S+40 °C
both versions				
Cold at −25 °C	A	1000 h	± 5	± 5
Storage at +25 °C	H	1000 h	± 5	± 5
Dry heat at (T_S+40) °C	B	1000 h	± 10	± 10
Thermal shock −25 to (T_S +40) °C	Na	5 cyles	± 10	± 10
Damp heat at +40 °C	C	1000 h	± 5	± 5
Dissipation at 25 V d.c. and T_{amb}= +25 °C		1000 h	± 5	± 5
Impact	E			
Free fall	Ed	2 falls	1)	
version with leads only				
Dissipation in damp heat		336 h	± 5	± 5
Robustness of terminations	U			
Tensile strength 10 N	Ua	10 s	2)	
Bending 5 N	Ub	2 times	2)	
Soldering	T			
Solderability	par. 3. 2. 3	3 to 4 s	3)	
Resistance to heat	Tb	10 ± 1 s	± 2	± 2

1) No visual defects will be stated.
2) Leads should neither come loose nor break.
3) Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D

A.Q.L. 1 %, major defects − Electrical
A.Q.L. 1,5 %, major defects − Mechanical
A.Q.L. 4 %, minor defects − Physical

PACKAGING

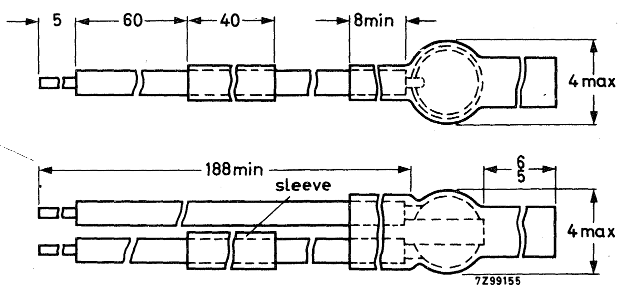
Version with leads — 500 pieces per box (cardboard)

Version without leads — 2000 pieces per box (cardboard)

PTC THERMISTORS
for motor protection

QUICK REFERENCE DATA	
Resistance value at −20 and T_{ref} −20 °C	30 to 250 Ω
Resistance value at T_{ref} + 15 °C V_{pulse} = 7.5 V	> 4000 Ω
Switch temperature	see table
Temperature coefficient	see table
Max. voltage	15 V_{dc}
Dissipation factor	7 mW/deg C approx.
Operating temperature range at zero power at V_{max}	 −20 to T_{ref} +30 °C −20 to T_{ref} +15 °C

DIMENSIONS in mm



APPLICATION

These thermistors have been designed for use in transistorized circuits for the protection of electric motors against overheating. They are to be built into the windings of the stator (one PTC thermistor per phase).

DESCRIPTION

This type has a positive temperature coefficient. It consists of a disc provided with two tinned copper "Litze" wires with a cross-section not greater than 7/.0076 inch (0.194 mm) and insulated with PTFE material complying with the requirements of the ministry of aviation specification EL 1930.

MECHANICAL DATA

See outline drawing on previous page.

Marking — The last five figures of the catalogue number are printed on the sleeve, e.g. PTC 92046

Weight — 1.6 g approximately

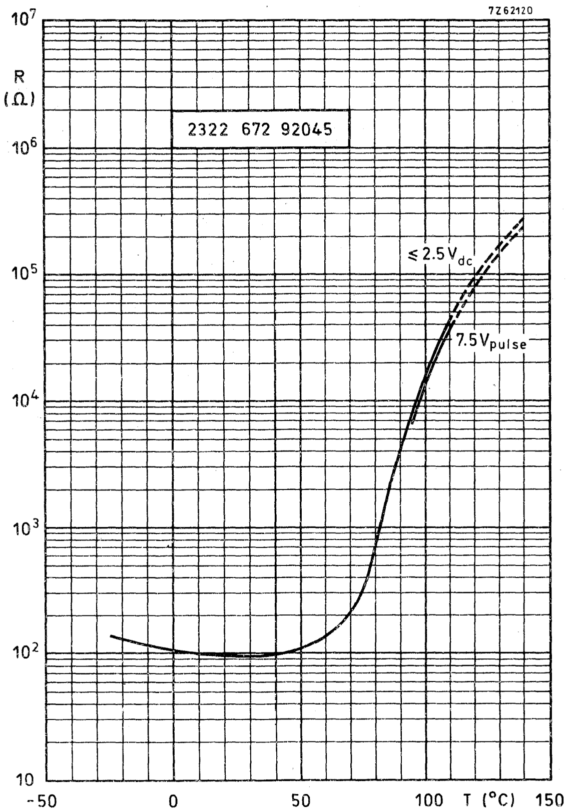
Mounting — In motor windings; connections to be soldered or clamped.

ELECTRICAL DATA

Table

T_{ref} 1) (°C)	T_s (°C)	temperature coefficient (%/ deg C)	voltage dependence β	balance voltage (V_{dc})	catalogue number
80	68	18	0.32	19	2322 672 92045
90	75	21	0.40	27	92046
100	88	31	0.36	6.5	92047
110	99	33	0.35	17	92048
120	113	38	0.36	11	92049
130	123	27	0.38	34	92051
140	130	33	0.34	13	92052
150	137	33	0.35	20	92053

Resistance between −20 and T_{ref} −20 °C	30 to 250 Ω 2)
Resistance at T_{ref} −5 °C	<550 Ω 2)
Resistance at T_{ref} +5 °C	>1330 Ω
Resistance at T_{ref} +15 °C, V_{pulse} = 7.5 V	>4000 Ω 3)
Dissipation factor	7 mW/degC approx. 4)
Heat capacity	0.1 J/degC approx. 4)
Thermal time constant	14 s approx. 4)
Response time 5)	≤8 s
Operating temperature range	
at zero power	−20 to +T_{ref} +30 °C
at V_{max}	−20 to +T_{ref} +15 °C
Maximum voltage	15 V_{dc}
Dielectric withstanding voltage between terminals and lead insulation	≥2500 V_{rms}
Insulation resistance between terminals and lead insulation	≥100 MΩ



1) T_{ref} is the temperature at which the thermistor has to make the protective system operative.

2) Measuring voltage not exceeding 1.5 V_{dc} to avoid internal heating.

3) Measurements made without internal heating occurring.

4) Measurements made with specimen in phosphor-bronze clips, in still air.

5) Response time is the time in which the thermistor-body temperature rises to 63.2% of the difference between initial and final body temperature, when the thermistor is subjected to a step function change in ambient temperature.
Initial temperature: 25 °C (air)
Final temperature : T_{ref} +15 °C (silicon oil MS 200/50)

Typical resistance/temperature characteristics of the different types

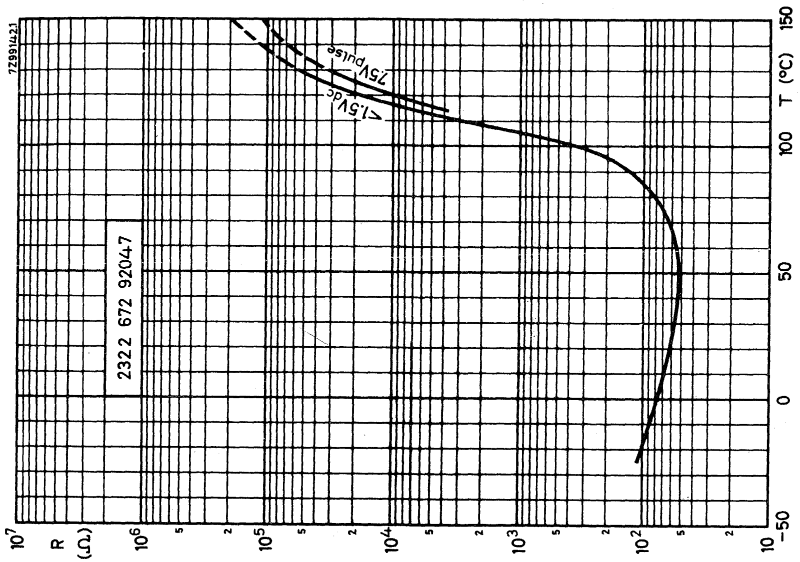


Fig.3

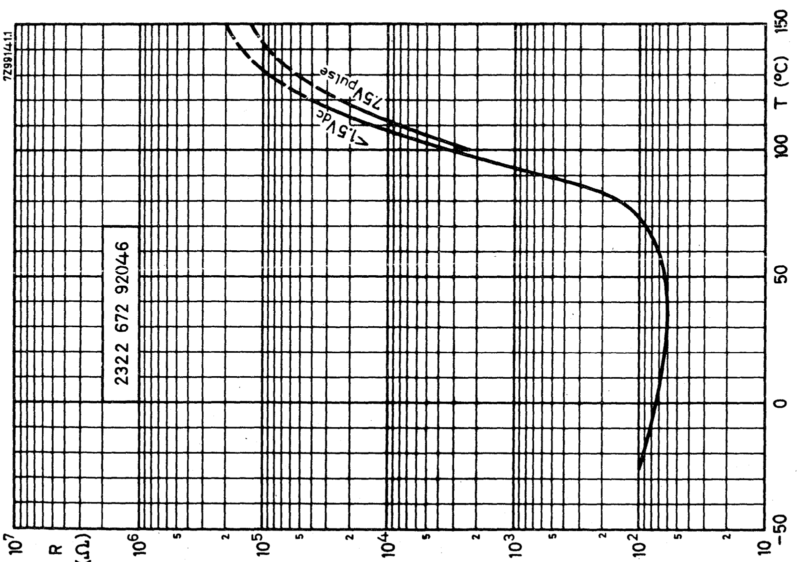


Fig.2

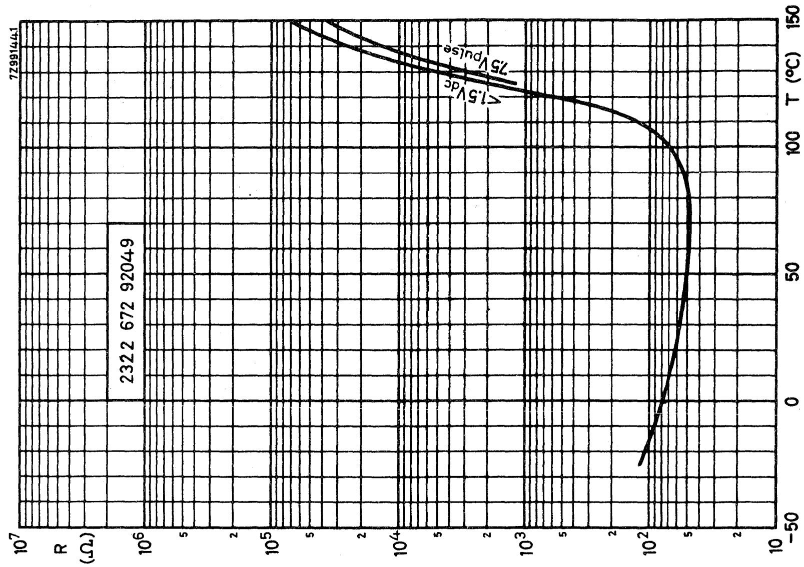

7Z99144.1
2322 672 92049
<1.5Vdc
75Vpulse
T (°C)
R (Ω)

Fig.5

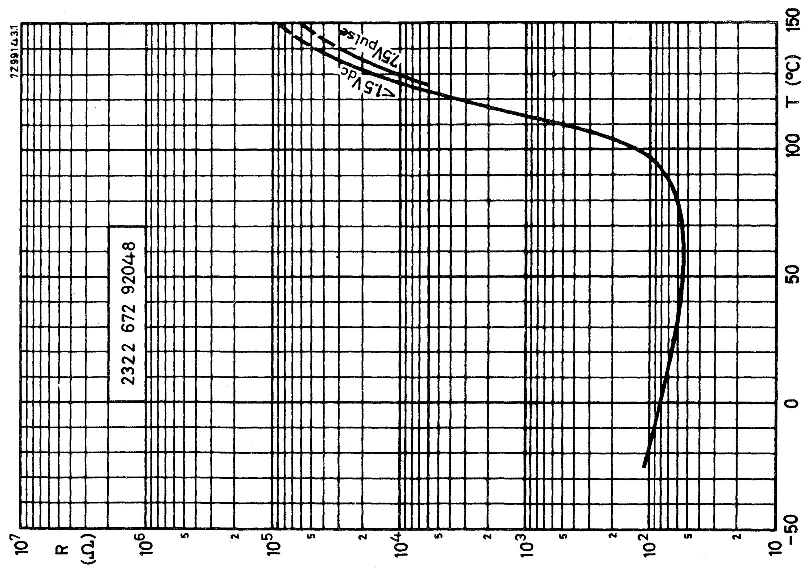

7Z99143.1
2322 672 92048
<1.5Vdc
75Vpulse
T (°C)
R (Ω)

Fig.4

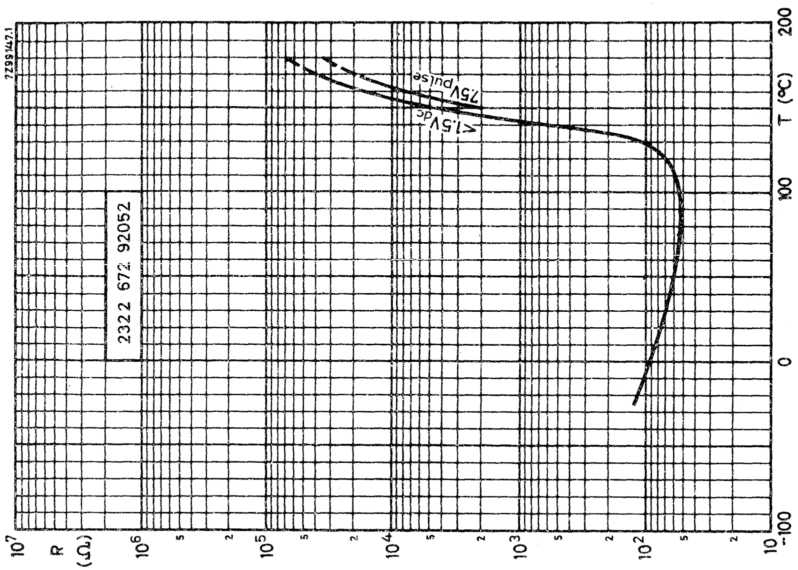

7Z99147.1
2322 672 92052
75V pulse
<1.5V dc
R (Ω)
T (°C)
10^7
10^6
10^5
10^4
10^3
10^2
10
−100
0
100
200

Fig. 7

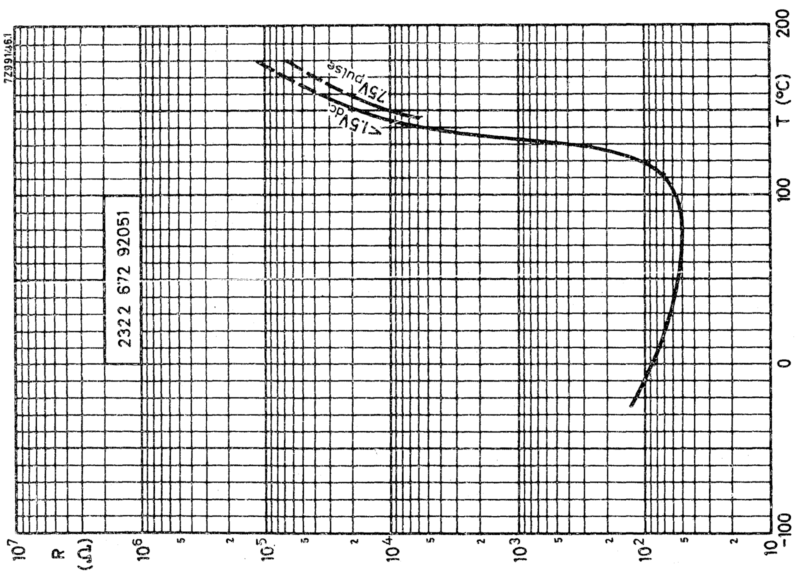

7Z99146.1
2322 672 92051
75V pulse
<1.5V dc
R (Ω)
T (°C)
10^7
10^6
10^5
10^4
10^3
10^2
10
−100
0
100
200

Fig. 6

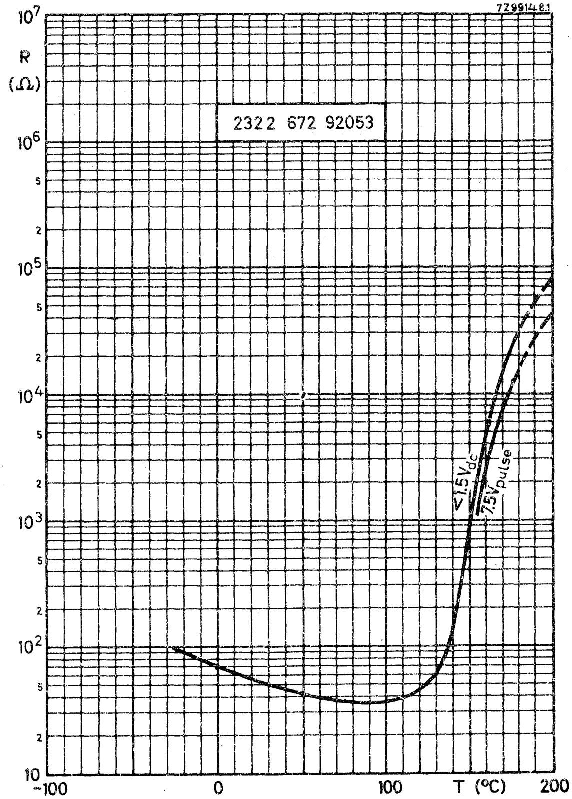

7Z99148.1
10^7
R
(Ω)
2322 672 92053
10^6
5
2
10^5
5
2
10^4
5
2
10^3
5
2
10^2
5
2
10
−100
0
100
T (°C)
200
<1.5 V_dc
7.5 V_pulse

Fig.8

Typical voltage/current characteristics

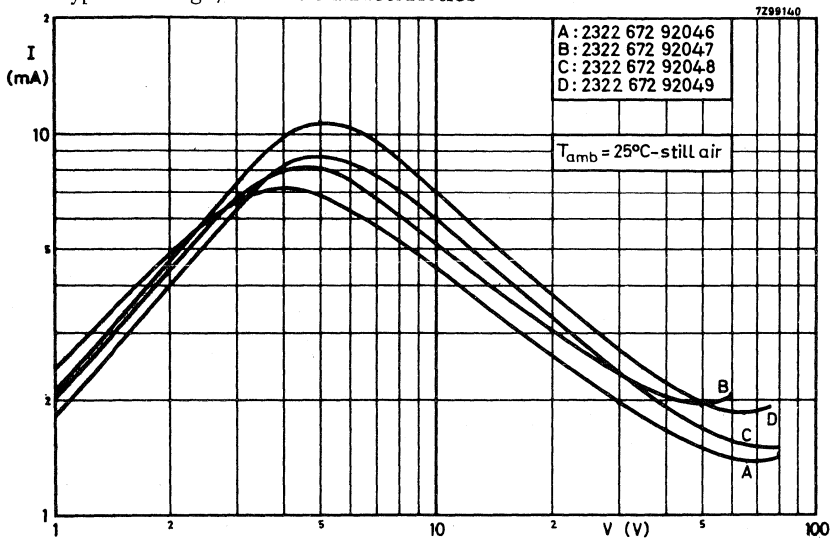


Fig. 9

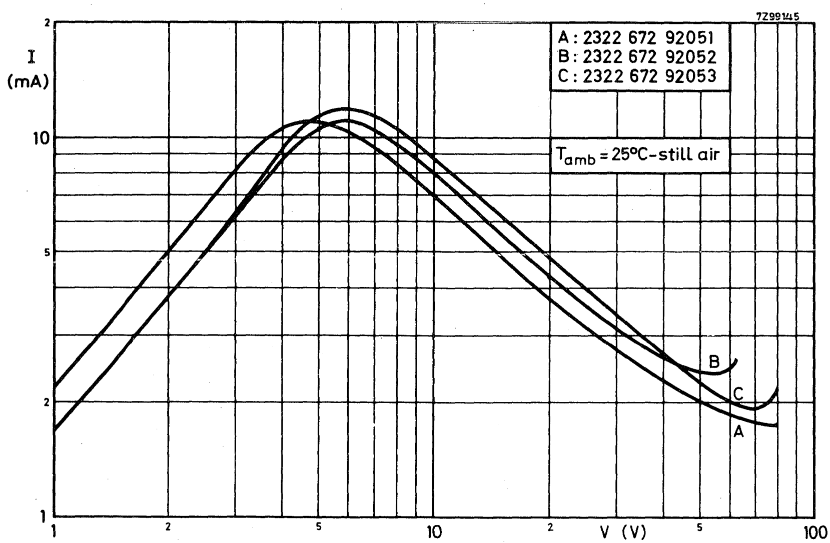


Fig. 10

TESTS AND REQUIREMENTS

According to I.E.C. 68, unless otherwise specified.

Test	test method	duration	ΔR/R in % at 25 °C	at T_{ref} +30 °C
Cold at −25 °C	A	1000 h	± 5	± 5
Storage at +25 °C	H	1000 h	± 5	± 5
Dry heat at T_{ref} +25 °C	B	1000 h	± 10	± 10
Dry heat at 200 °C	–	2 cycles 3)	± 10	± 10
Thermal shock −25 to T_{ref} +30 °C	Na	5 cycles	± 10	± 10
Max. peak temperature T_{ref} +90 °C	–	6 cycles 4)	± 20	± 20
Damp heat	C	1000 h	± 5	± 5
Dissipation at V = 15 V_{rms} and T_{amb} = +25 °C		1000 h	± 5	± 5
Robustness of terminations	U			
Tensile strength 10 N	Ua	10 s	1)	
Bending 5 N	Ub	2 times	1)	
Soldering	T			
Solderability at 230 °C	par. 3.2.3	3 to 4 s	2)	
Resistance to heat at 230 °C	par. 3.2.4	3 to 4 s	± 2	± 2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.
3) One cycle = 16 h at +200 °C, 1 h at +25 °C.
4) One cycle = 1 h at T_{ref} +90 °C, 168 h at T_{ref}, in silicon oil free of oxidation.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1.5 %, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical.

PTC THERMISTOR

QUICK REFERENCE DATA	
Resistance value at +25 °C	115 ± 25 Ω
Resistance value at +155 °C V_{pulse} = 33 V	min. 15 kΩ
Switch temperature	+97 °C approximately
Temperature coefficient	min. 10%/°C
Maximum voltage (d.c.)	33 V
Operating temperature range at zero power at maximum voltage	 −25 to +155 °C +5 to +55 °C

APPLICATION

As current stabilizer for compensation of variations in telephone line resistance.

DESCRIPTION

Disc with positive temperature coefficient, mounted between pressure contacts to ensure a long cycle life. Provided with two silvered pins for mounting in a printed-wiring board. Plastic encapsulation.

MECHANICAL DATA

Dimensions in mm

Outlines

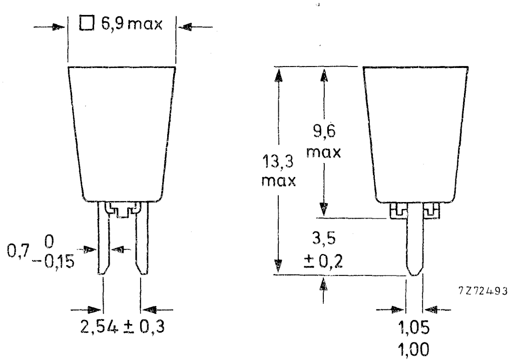


Fig. 1

Marking

Manufacturer's identification symbol and the letters TPE, representing the model, are moulded in the top of the cap.

Weight	0,4 g approximately
Mounting	to be soldered onto a printed-wiring board

Robustness of terminations

Tensile strength	10 N

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s

Vibration	in accordance with CCTU 01-01A fasc. 16 A severity 55 A

Impact

Free fall	1000 mm

Inflammability	uninflammable

ELECTRICAL DATA

Unless otherwise specified measured according to IEC draft publication 40 (secretariat) 288.

The values in the table without further indication are approximate values.

Resistance at +25 °C	115 ± 25 Ω
at +97 °C	max. 600 Ω
at +155 °C, V_{pulse} = 33 V	min. 15 000 Ω
Switch temperature	+97 °C
Temperature coefficient	min. +10%/°C
Operating temperature range	
at zero power	−25 to +155 °C
at maximum voltage	+5 to +55 °C
Voltage dependence at +155 °C	0,29
Maximum voltage (d.c.)	33 V

Maximum dielectric withstanding voltage (r.m.s.) between terminals and capsule	500 V
Insulation resistance between terminals and capsule at 100 V d.c.	min. 10 MΩ

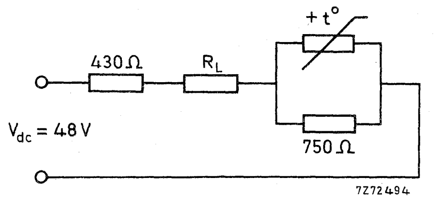
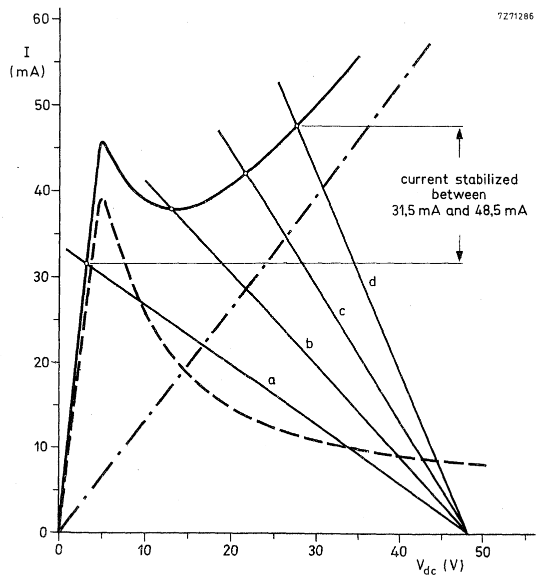


Fig. 2 Line resistance (R_L) compensation

Initial current at +5 °C and R_L = 0	min.	75 mA
	max.	95 mA
Current after 10 s at +5 °C and R_L = 0	max.	60 mA
Initial current at +55 °C and R_L = 0	min.	85 mA
	max.	105 mA
Current after 10 s at +5 °C and R_L = 0	max.	55 mA



——— PTC + parallel-connected 750 Ω resistor;
– – – PTC alone;
–·–·– 750 Ω resistor alone.

Fig. 3 (a) R_L = 1000 Ω; (b) R_L = 500 Ω; (c) R_L = 200 Ω; (d) R_L = 0 Ω.

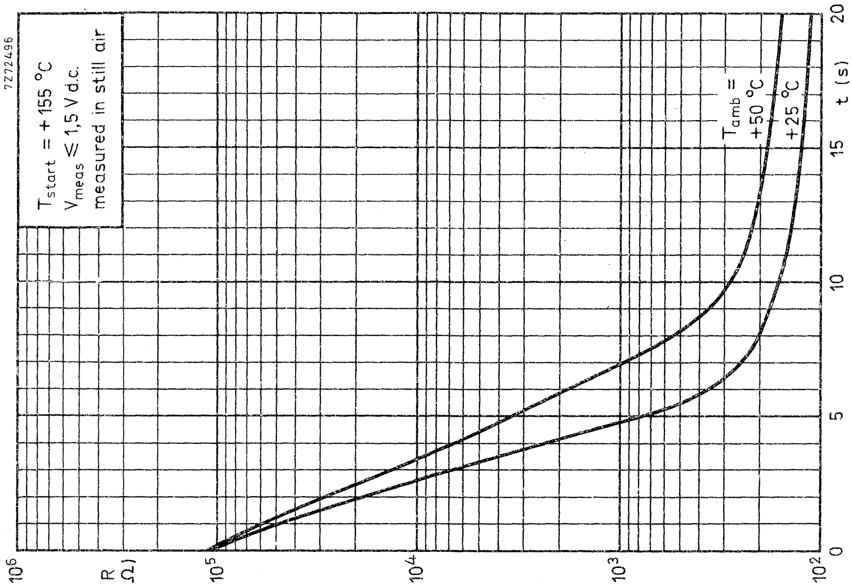


Fig. 5 Typical resistance/time (cooling) characteristics

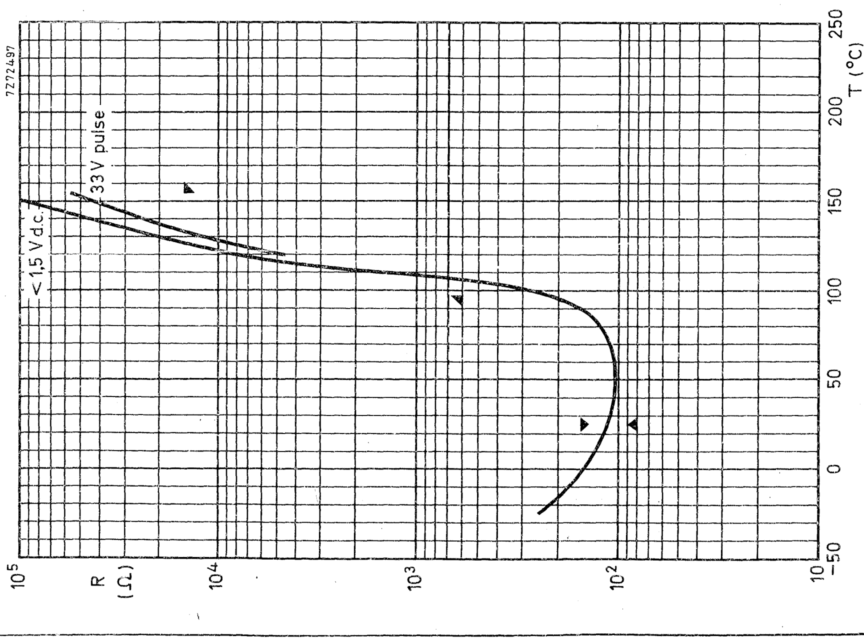


Fig. 4 Typical resistance/temperature characteristics

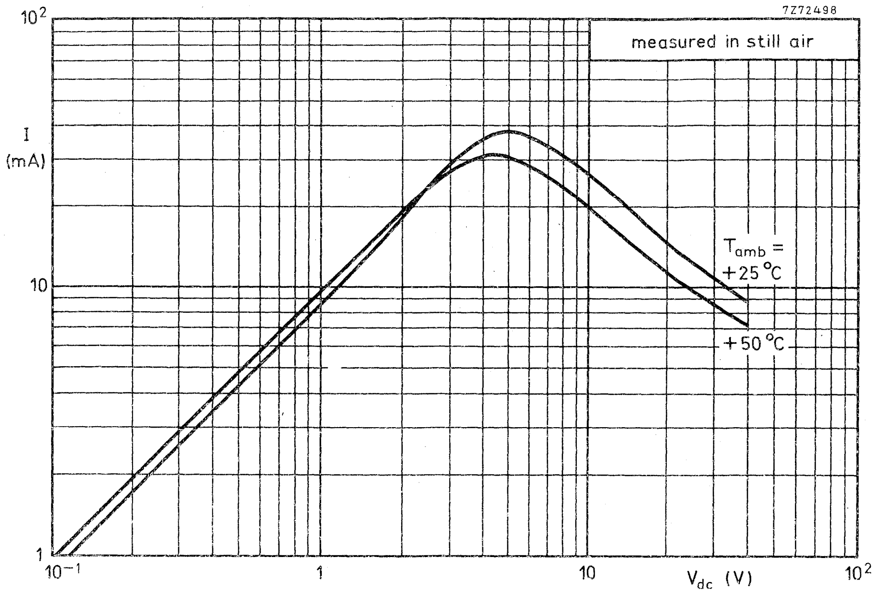


Fig. 6 Typical voltage/current characteristics

Note:
Figs 5, 6 and 7 are measured with the PTC mounted on a printed-wiring board.

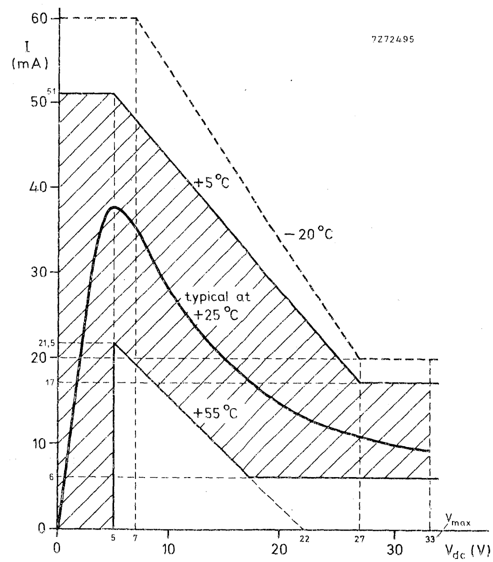


Fig. 7
Area of current/voltage characteristics

TESTS AND REQUIREMENTS

According to IEC recommendations unless otherwise specified.

test	test method	duration	ΔR/R (%) at +25 °C	ΔR/R (%) at +155 °C
Cold at −25 °C	A	1000 h	± 7,5	± 12
Storage at +25 °C	H	1000 h	± 5	± 12
Dry heat at +155 °C	B	1000 h	± 10	± 12
Thermal shock −25 to +155 °C	Na	5 cycles	± 7,5	± 12
Damp heat at +40 °C	C	1000 h	± 10	± 12
Dissipation in damp heat		336 h	± 10	± 12
Dissipation at V_{dc} = 33 V and T_{amb} = +55 °C		1000 h	± 10	± 12
Cycle test at V_{dc} = 33 V and T_{amb} = +5 °C	1)	2000 cycles	± 10	± 12
Cycle test at V_{dc} = 33 V and T_{amb} = +25 °C	1)	40 000 cycles	± 7,5	± 12
Combined cycle test			± 10	± 12
Robustness of terminations	U			
Tensile strength	Ua	10 s	± 3 2)	± 3
Soldering	T			
Solderability	par. 3.2.3	3 to 4 s	3)	
Resistance to heat	Tb	10 ± 1 s	± 2	± 2
Vibration	F		± 3	
Impact				
Free fall	Ed	2 falls	4)	

1) Cycle: 15 s on; 45 s off.
2) Leads should neither come loose nor break.
3) Leads must be solderable initially and after 6 months storage with solder containing resin flux.
4) No visual defects.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1,5%, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

PACKAGING

5000 pieces per cardboard box (containing 10 foam plastic trays).

PTC HEATING ELEMENT

QUICK REFERENCE DATA	
Voltage range (r. m. s.)	100 to 265 V
Maximum inrush power at 220 V	500 W
Steady-state power (in test tube)	18 W approximately
Time for test tube to reach +130 °C	4, 4 min approximately
Ambient temperature range at zero power and at max. voltage	-25 to +60 °C

APPLICATION

The PTC heating element has been designed for applications that require high initial dissipation followed by moderate continuous dissipation, such as hair curling tongs.

DESCRIPTION

Thermistor with positive temperature coefficient provided with two plastic layers by moulding, and with two insulated solid copper wires, partly covered by a high temperature silicone sleeve.

MECHANICAL DATA

Dimensions in mm

Outlines

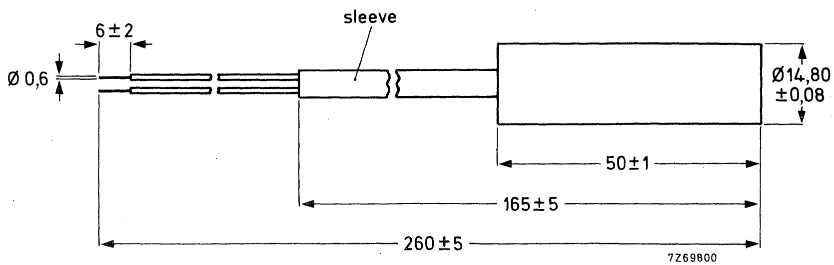


Fig. 1

Marking	None
Mass	28 g approximately
Mounting	In any position by soldering or clamping
Robustness of terminations	
Tensile strength	10 N
Bending	5 N
Soldering	
Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s
Impact	
Free fall	1000 mm
Inflammability	Self extinguishing

ELECTRICAL DATA

Unless otherwise specified measured according to IEC draft publication 40 (CO) 355, project 40/019/71 of June 1975.

Voltage range (r.m.s.)	100 to 265 V
Maximum inrush power at 220 V	500 W
Steady-state power (in test tube)	18 W approximately
Time for test tube to reach +130 °C	4,4 min approximately
Temperature at the underside of the test tube after 20 min	
at 110 V (r.m.s.)	+155 °C approximately
at 220 V (r.m.s.)	+161 ± 5 °C
Ambient temperature range at zero power and at maximum voltage	−25 to +60 °C
Dielectric withstanding voltage (r.m.s.) *) between terminals and coating	min. 4 kV
Insulation resistance between terminals and coating at 500 V (d.c.) *)	min. 10 MΩ

*) Voltage measured in solution of de-ionized water +2 g NaCl/l + 0,2 g sodium lauryl sulphate, the item being submerged for minimum 15 min over 42,5 mm ± 2,5 mm.

Schematic mounting of test tube

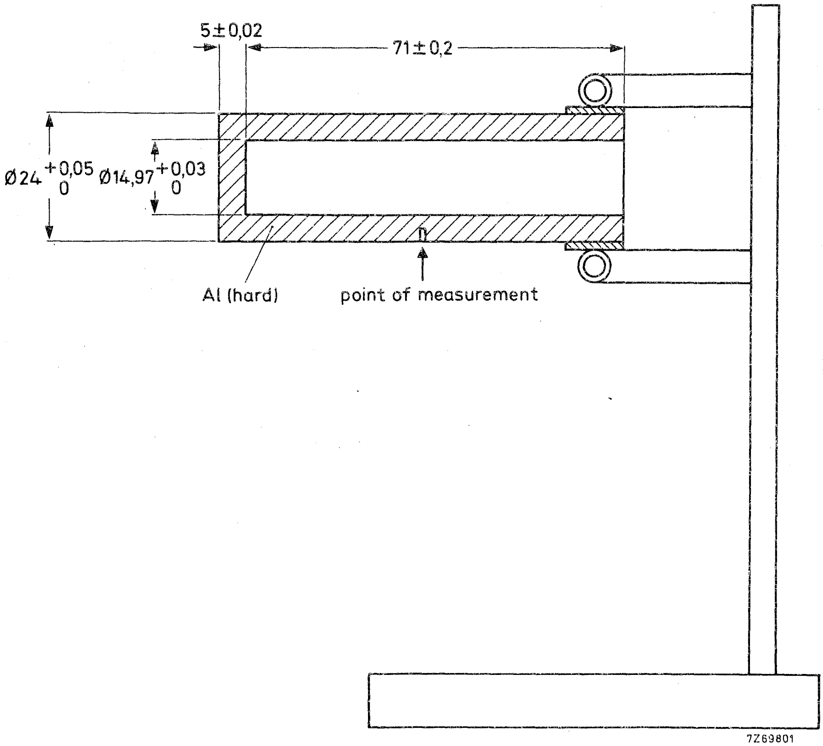


Fig. 2
The point of measurement is a radial hole, dia 0,7 mm, depth 2 mm, for insertion of a copper-constantan-iso thermocouple. Silicone grease (e.g. Eccotherm TC4) should be used for good thermal contact.

The standard test set-up can be ordered under catalogue number 8204 025 10772 (the mechanical mounting method will be changed slightly).

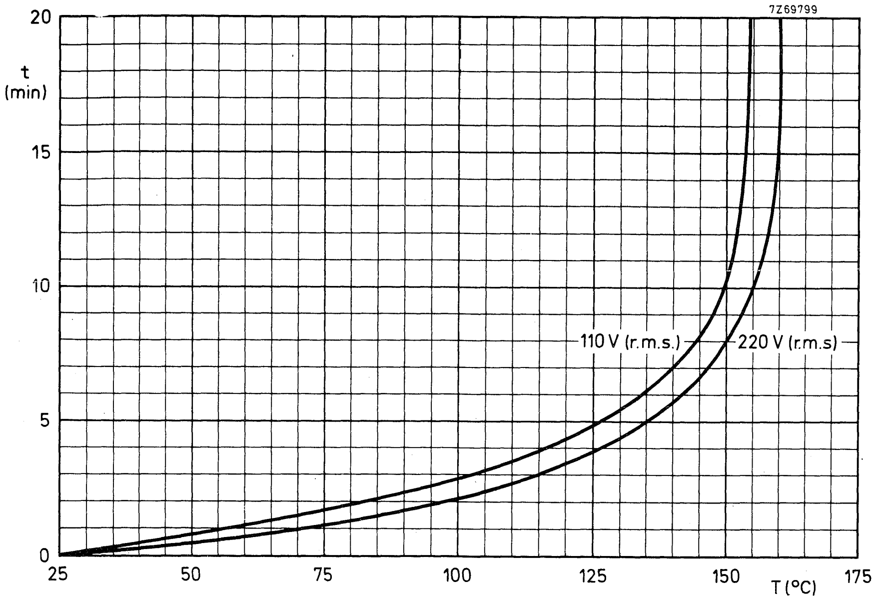

7Z69799
20
t
(min)
15
10
5
0
25
50
75
100
125
150
175
T (°C)
110 V (r.m.s.)
220 V (r.m.s)

Fig. 3

TESTS AND REQUIREMENTS

According to IEC recommendations unless otherwise specified.

test	test method	duration	requirements
Cold at $-25\ ^{\circ}C$	A	672 h	
Storage at $+25\ ^{\circ}C$	H	1000 h	within specification except the temperature on the underside of the test tube, where $\Delta T \leq 5\ ^{\circ}C$
Dry heat at $+60\ ^{\circ}C$	B	672 h	
Thermal shock -25 to $+60\ ^{\circ}C$	Na	8 cycles [1]	
Damp heat at $+40\ ^{\circ}C$	C	500 h	
Dissipation in damp heat ($V_{dc} = 10$ V)		336 h	
Dissipation at $V_{rms} = 265$ V and $T_{amb} = +25\ ^{\circ}C$		450 h	
Cycle test at $V_{rms} = 265$ V and $T_{amb} = +25\ ^{\circ}C$		1350 cycles [2]	
Robustness of terminations	U		
Tensile strength	Ua	10 s	[3]
Bending	Ub	2 times	[3]
Soldering	T		
Solderability	par. 3.2.3.	3 to 4 s	[4]
Resistance to heat	Tb	10 to 11 s	$\Delta R/R \pm 2\%$
Vibration	[5]		[6]
Impact	E		
Free fall	Ed	2 falls	[6]

1) Cycle: 8 h at $-25\ ^{\circ}C$; 16 h at $+60\ ^{\circ}C$.
2) Cycle: 10 min on; 30 min off.
3) Leads should neither come loose nor break.
4) Leads must be solderable initially and after 6 months storage with solder containing resin flux.
5) IEC draft publication 40 (CO) 355, project 40/019/71, para. 8.5.
6) No visual and electrical defects.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1,5%, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

PACKAGING

500 pieces per cardboard box.

Test switches

TEST SWITCHES

APPLICATION

These switches are designed to simplify the testing of any electronic circuit by providing a swift means of changing over from "normal working" to "test" conditions.
They are often used for testing a particular section of a circuit immediately after set assembly or later during service.

DESCRIPTION

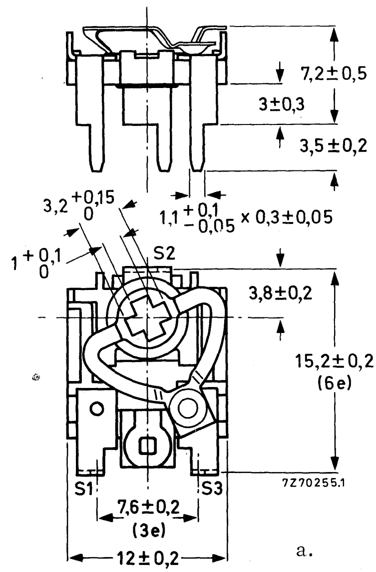
Three types of switch are available, all are designed for mounting on printed-wiring boards. The basic switch consists of a rotatable selector contact and two or three switch connections, mounted on an insulating plate. By turning the selector contact one of the switch connections can be connected to the centre contact.
The contacts are of the "break before make" type.

One switch type is provided with two active switch connections and a "centre-off" position. The second type has three active switch connections, the third type has two active switch connections (without "centre-off" position).

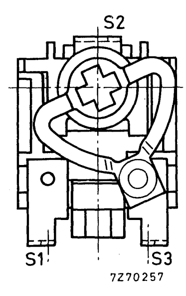
Switches are available for screwdriver-control (allowing the "flatness" of printed-wiring circuitry to be maintained), or finger-control by means of a plastic knob.

TECHNICAL DATA

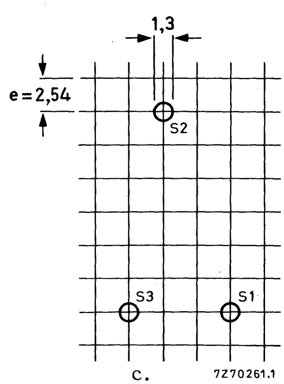
Fig. 1 Test switch with two active switch connections,
a. with "centre-off" position
b. without "centre-off" position
c. hole pattern for mounting on a printed-wiring board (solder side)



a.



b.



c.

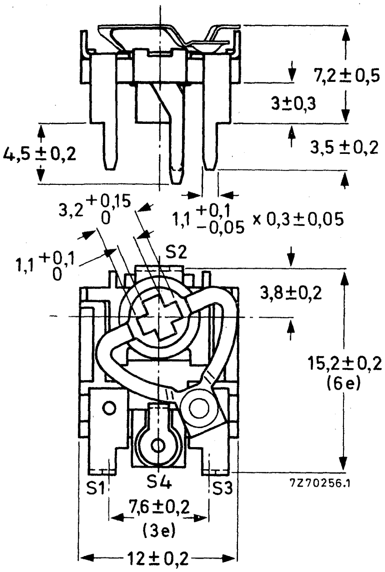


Fig. 2a. Test switch with three active switch connections

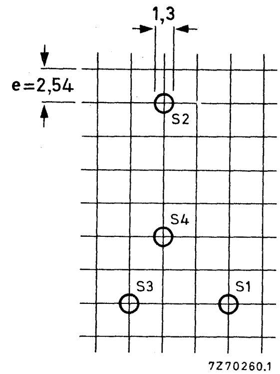
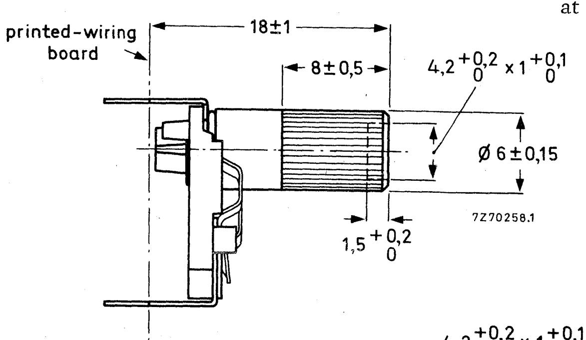


Fig. 2b. Hole pattern for mounting on a printed-wiring board (solder side)

Fig. 3. Test switch with adjustment knob at the side of the selector contact



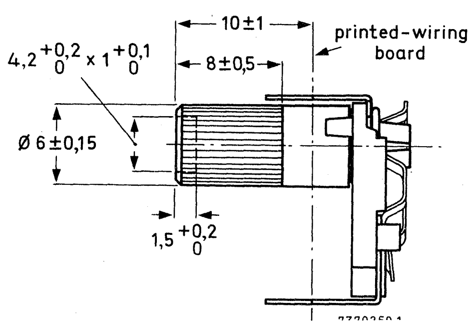


Fig. 4. Test switch with adjustment knob at the side of the base plate

Contact resistance	
initially	≤ 20 mΩ
after 50 switching operations at ≤ 10 mA, ≤ 500 V	≤ 200 mΩ
Operating torque	5 to 50 mNm
End stop torque	≥ 100 mNm
Life	≥ 50 switching operations
Weight	
switch without knob	approx. 1 g
switch with knob	approx. 1,5 g

COMPOSITION OF THE CATALOGUE NUMBER

2422 136 7. 33.

0 = without knob
1 = with knob at the side of the base plate
2 = with knob at the side of the selector contact

2 = with 2 active switch connections; with off-position
3 = with 3 active switch connections
4 = with 2 active switch connections; without off-position

MAINTENANCE TYPE LIST

The type below is not included in this Handbook.

Detailed information will be supplied on request.

VARIABLE RESISTORS

Wire-wound preset potentiometers	2322 000

STANDARD SERIES OF VALUES IN A DECADE
for resistances and capacitances
according to I.E.C. publication 63

E192	E96	E48
100	100	100
101		
102	102	
104		
105	105	105
106		
107	107	
109		
110	110	110
111		
113	113	
114		
115	115	115
117		
118	118	
120		
121	121	121
123		
124	124	
126		
127	127	127
129		
130	130	
132		
133	133	133
135		
137	137	
138		
140	140	140
142		
143	143	
145		
147	147	147
149		
150	150	
152		
154	154	154
156		
158	158	
160		
162	162	162
164		
165	165	
167		

E192	E96	E48
169	169	169
172		
174	174	
176		
178	178	178
180		
182	182	
184		
187	187	187
189		
191	191	
193		
196	196	196
198		
200	200	
203		
205	205	205
208		
210	210	
213		
215	215	215
218		
221	221	
223		
226	226	226
229		
232	232	
234		
237	237	237
240		
243	243	
246		
249	249	249
252		
255	255	
258		
261	261	261
264		
267	267	
271		
274	274	274
277		
280	280	

E192	E96	E48
284		
287	287	287
291		
294	294	
298		
301	301	301
305		
309	309	
312		
316	316	316
320		
324	324	
328		
332	332	332
336		
340	340	
344		
348	348	348
352		
357	357	
361		
365	365	365
370		
374	374	
379		
383	383	383
388		
392	392	
397		
402	402	402
407		
412	412	
417		
422	422	422
427		
432	432	
437		
442	442	442
448		
453	453	
459		
464	464	464
470		
475	475	

E192	E96	E48
481		
487	487	487
493		
499	499	
505		
511	511	511
517		
523	523	
530		
536	536	536
542		
549	549	
556		
562	562	562
569		
576	576	
583		
590	590	590
597		
604	604	
612		
619	619	619
626		
634	634	
642		
649	649	649
657		
665	665	
673		
681	681	681
690		
698	698	
706		
715	715	715
723		
732	732	
741		
750	750	750
759		
768	768	
777		
787	787	787
796		
806	806	

E192	E96	E48
816		
825	825	825
835		
845	845	
856		
866	866	866
876		
887	887	
898		
909	909	909
920		
931	931	
942		
953	953	953
965		
976	976	
988		

E24	E12	E6	E3
10	10	10	10
11			
12	12		
13			
15	15	15	
16			
18	18		
20			
22	22	22	22
24			
27	27		
30			
33	33	33	
36			
39	39		
43			
47	47	47	47
51			
56	56		
62			
68	68	68	
75			
82	82		
91			

Contents

VOLTAGE DEPENDENT RESISTORS (VDR)

LIGHT DEPENDENT RESISTORS

NEGATIVE TEMPERATURE COEFFICIENT THERMISTORS (NTC)

Fixed resistors

Variable resistors

Voltage dependent resistors (VDR)

Light dependent resistors (LDR)

Negative temperature coefficient thermistors (NTC)

Positive temperature coefficient thermistors (PTC)

Test switches

Maintenance type list and contents

Electronic components and materials
for professional, industrial and consumer uses
from a world-wide Group of Companies

Argentina: FAPESA I.y.C., Av. Crovara 2550, Tel. 652-7438/7478, BUENOS AIRES.
Australia: Philips Industries Ltd., Elcoma Division, 67 Mars Road, Tel. 42 1261, LANE COVE, 2066, N.S.W.
Austria: Österreichische Philips, Bauelemente Industrie G.m.b.H., Zieglergasse 6, Tel. 93 26 11, A-1072 WIEN.
Belgium: M.B.L.E., 80, rue des Deux Gares, Tel. 523 00 00, B-1070 BRUXELLES.
Brazil: IBRAPE S.A., Av. Paulista 2073-S/Loja, Tel. 278-7144, SAO PAULO, SP.
Canada: Philips Electron Devices, 116 Vanderhoof Ave., Tel. 425-5161, TORONTO 17, Ontario.
Chile: Philips Chilena S.A., Av. Santa Maria 0760, Tel. 39-40 01, SANTIAGO.
Colombia: SADAPE S.A., Calle 19, No. 5-51, Tel. 422-175, BOGOTA D.E. 1.
Denmark: Miniwatt A/S, Emdrupvej 115A, Tel. (01) 69 16 22, DK-2400 KØBENHAVN NV.
Finland: Oy Philips Ab, Elcoma Division, Kaivokatu 8, Tel. 1 72 71, SF-00100 HELSINKI 10.
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