PHILIPS

Data handbook

Electronic components and materials

Components and materials

Book C12 1985

Potentiometers, encoders and switches

POTENTIOMETERS, ENCODERS AND SWITCHES

DATA HANDBOOK SYSTEM

Our Data Handbook System comprises more than 60 books with specifications on electronic components, subassemblies and materials. It is made up of four series of handbooks:

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

The contents of each series are listed on pages iv to viii.

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

When ratings or specifications differ from those published in the preceding edition they are indicated with arrows in the page margin. Where application information is given it is advisory and does not form part of the product specification.

Condensed data on the preferred products of Philips Electronic Components and Materials Division is given in our Preferred Type Range catalogue (issued annually).

Information on current Data Handbooks and on how to obtain a subscription for future issues is available from any of the Organizations listed on the back cover.
Product specialists are at your service and enquiries will be answered promptly.

ELECTRON TUBES (BLUE SERIES)

The blue series of data handbooks comprises:

T1 **Tubes for r.f. heating**

T2a **Transmitting tubes for communications, glass types**

T2b **Transmitting tubes for communications, ceramic types**

T3 **Klystrons**

T4 **Magnetrons for microwave heating**

T5 **Cathode-ray tubes**
Instrument tubes, monitor and display tubes, C.R. tubes for special applications

T6 **Geiger-Müller tubes**

T7 **Gas-filled tubes** (will not be reprinted)

T8 **Picture tubes and components**
Colour TV picture tubes, black and white TV picture tubes, colour monitor tubes for data graphic display, monochrome monitor tubes for data graphic display, components for colour television, components for black and white television and monochrome data graphic display

T9 **Photo and electron multipliers**

T10 **Plumbicon camera tubes and accessories**

T11 **Microwave semiconductors and components**

T12 **Vidicon and Newvicon camera tubes**

T13 **Image intensifiers**

T14 **Infrared detectors**

T15 **Dry reed switches**

Data collations on these subjects are available now.
Data Handbooks will be published in 1985.

T16 **Monochrome tubes and deflection units**
Black and white TV picture tubes, monochrome data graphic display tubes, deflection units

SEMICONDUCTORS (RED SERIES)

The red series of data handbooks comprises:

S1 **Diodes**
Small-signal germanium diodes, small-signal silicon diodes, voltage regulator diodes (< 1,5 W), voltage reference diodes, tuner diodes, rectifier diodes

S2a **Power diodes**

S2b **Thyristors and triacs**

S3 **Small-signal transistors**

S4a **Low-frequency power transistors and hybrid modules**

S4b **High-voltage and switching power transistors**

S5 **Field-effect transistors**

S6 **R.F. power transistors and modules**

S7 **Surface mounted semiconductors**

S8 **Devices for optoelectronics**
Photosensitive diodes and transistors, light-emitting diodes, displays, photocouplers, infrared sensitive devices, photoconductive devices.

S9 **Power MOS transistors**

S10 **Wideband transistors and wideband hybrid IC modules**

S11 **Microwave semiconductors** (to be published in this series in 1985)
At present available in Handbook T11

S12 **Surface acoustic wave devices**

INTEGRATED CIRCUITS (PURPLE SERIES)

The purple series of data handbooks comprises:

EXISTING SERIES		Superseded by:
IC1	**Bipolar ICs for radio and audio equipment**	
IC2	**Bipolar ICs for video equipment**	IC02N
IC3	**ICs for digital systems in radio, audio and video equipment**	
IC4	**Digital integrated circuits** CMOS HE4000B family	
IC5	**Digital integrated circuits – ECL** ECL10 000 (GX family), ECL100 000 (HX family), dedicated designs	IC08N
IC6	**Professional analogue integrated circuits**	
IC7	**Signetics bipolar memories**	
IC8	**Signetics analogue circuits**	IC11N
IC9	**Signetics TTL logic**	IC09N and IC15N
IC10	**Signetics Integrated Fuse Logic (IFL)**	IC13N
IC11	**Microprocessors, microcomputers and peripheral circuitry**	

NEW SERIES

IC01N	**Radio, audio and associated systems** Bipolar, MOS	
IC02N	**Video and associated systems** Bipolar, MOS	(published 1985)
IC03N	**Telephony equipment** Bipolar, MOS	
IC04N	**HE4000B logic family** CMOS	
IC05N	**HE4000B logic family uncased integrated circuits** CMOS	(published 1984)
IC06N	**High-speed CMOS; PC54/74HC/HCT/HCU** Logic family	(published 1985)
IC07N	**PC54/74HC/HCU/HCT uncased integrated circuits** HCMOS	
IC08N	**10K and 100K logic family** ECL	(published 1984)
IC09N	**Logic series** TTL	(published 1984)
IC10N	**Memories** MOS, TTL, ECL	
IC11N	**Linear LSI**	(published 1985)
IC12N	**Semi-custom gate arrays & cell libraries** ISL, ECL, CMOS	
IC13N	**Semi-custom** Integrated Fuse Logic	(published 1985)
IC14N	**Microprocessors, microcontrollers & peripherals** Bipolar, MOS	
IC15N	**Logic series** FAST TTL	(published 1984)

Note

Books available in the new series are shown with their date of publication.

COMPONENTS AND MATERIALS (GREEN SERIES)

The green series of data handbooks comprises:

C1 **Programmable controller modules**
PLC modules, PC20 modules

C2 **Television tuners, coaxial aerial input assemblies, surface acoustic wave filters**

C3 **Loudspeakers**

C4 **Ferroxcube potcores, square cores and cross cores**

C5 **Ferroxcube for power, audio/video and accelerators**

C6 **Synchronous motors and gearboxes**

C7 **Variable capacitors**

C8 **Variable mains transformers**

C9 **Piezoelectric quartz devices**

C10 **Connectors**

C11 **Non-linear resistors**
Voltage dependent resistors (VDR), light dependent resistors (LDR), negative temperature
— coefficient thermistors (NTC), positive temperature coefficient thermistors (PTC)

C12 **Potentiometers, encoders and switches**

C13 **Fixed resistors**

C14 **Electrolytic and solid capacitors**

C15 **Ceramic capacitors**

C16 **Permanent magnet materials**

C17 **Stepping motors and associated electronics**

C18 **Direct current motors**

C19 **Piezoelectric ceramics**

C20 **Wire-wound components for TVs and monitors**

C21 **Assemblies for industrial use**
HNIL FZ/30 series, NORbits 60-, 61-, 90-series, input devices

C22 **Film capacitors**

GENERAL

PREFACE

All dimensions on drawings are in mm unless otherwise indicated. According to the S.I. units the symbol K (kelvin) is used instead of °C in combinations such as K/W. Also ΔT is in K. Atmospheric pressure is given in kPa instead of millibars, mm Hg etc. 1000 mbar = 100 kPa (= 1000 hPa).

For easy reference, type numbers (such as CP13) are at the top of each page. Order should, however, always state the 12-figure catalogue number.

Some devices are labelled "MAINTENANCE TYPE". These are available for equipment maintenance but no longer recommended for equipment production.

Devices labelled "OBSOLESCENT TYPE" are available until stocks are exhausted.

Besides the types mentioned in this book we may be able to supply special versions. In that respect your supplier should be consulted.

INTRODUCTION

There are two main groups in our range of potentiometers: **Preset** and **Control.**

Preset potentiometers are mainly used for eliminating circuit tolerances during the assembly of electronic equipment or the readjustment of electronic circuits at a later stage. The preset types are subdivided in **single** and **multiturn** potentiometers. The single turn range includes **cermet** and **carbon** versions, either **open** or **enclosed.** The multiturn range have **carbon** tracks.

Preset:
* CMP series; rectangular multiturn potentiometers designed for use in television tuners, dimensions approx. 42,5 x 8 x 5 mm
* CTP10 series; open carbon preset, 0,1 W, dimensions approx. 10 x 10 mm
* CTP14 series; open carbon preset, 0,2 W, dimensions approx. 14 x 17 mm
* CTP18 series; open carbon preset, 0,25 W, dimensions approx. 18 x 20 mm
* ECP10 series; enclosed carbon preset, 0,1 W, dimensions approx. 10 x 12 mm
* MTP10 series; open cermet preset, 0,5 W dimensions approx. 10 x 12 mm
* EMP10 series; enclosed cermet preset, 0,5 W, dimensions approx. 10 x 12 mm
* MFU series; focus potentiometers, dimensions approx. 29 x 58 mm

Control potentiometers are widely used in all kinds of electronic equipment, e.g. for volume, tone, brightness and balance control. They are subdivided in **slide** and **rotary** potentiometers. The slide versions have a **carbon** track; the rotary versions **carbon, cermet** or **wirewound** resistance elements.

Control:
* CP13 series; carbon-knob potentiometers; 0,05 W, diameter approx. 13 mm
* CP16 series; carbon rotary, 0,1 W (lin) or 0,05 W (log), diameter approx. 16 mm, single and tandem types, with or without switch.
* CP23 series, carbon rotary, 0,25 W (lin) or 0,125 W (log), diameter approx. 23 mm, single with or without switch.
* MCP23 series; cermet rotary, 5 W, diameter approx. 23 mm, single without switch
* CSP25 series; carbon slide, 25 mm stroke, lin and log single types, dimensions approx. 43,5 x 9 x 5 mm
* CSP40 series; carbon slide, 40 mm stroke, single and tandem types, dimensions approx. 68 x 16 x 10,2 mm
* CSP60 series; carbon slide, 60 mm stroke, single and tandem types, dimensions approx. 87 x 16 x 10,2 mm
* PP17 series, modular carbon and cermet rotary potpack, single and tandem types with or without switch, with or without spindle. Also dual types, dimensions approx. 17 x 22 mm
* WP22/23/24 series, wirewound; single without switch, diameter approx. 23 mm
* WP42 series, wirewound; single without switch, diameter approx. 42 mm

SEE ALSO TYPE SELECTION ON PAGE 8

TERMS AND DEFINITIONS

Preset potentiometers – Potentiometers of simple construction, either open or enclosed. Designed for a limited number of wiper movements, i.e. for trimming, adjusting or readjusting electronic circuits. Generally an adjusting tool is required. Important characteristics are precise adjustability (settability) and good stability of the set value.

Control potentiometers – Potentiometers of more complicated construction, with or without spindle (rotary types) or with slider (straight line action types). Mechanical and electrical design permit a large number of wiper movements.

Carbon potentiometers – Preset or control potentiometers comprising a resistance element of a special carbon composition, fixed to a resin bonded substrate.

Cermet potentiometers – Preset or control potentiometers comprising a metal-glaze resistance element on a ceramic substrate. Designed for high classed industrial applications.

Wirewound potentiometers – Control potentiometers comprising a layer of resistance wire or ribbon, wound on a substrate of insulating material.

Rotary type potentiometers – Preset or control potentiometers with a rotary action.

Slide carbon potentiometers – Control potentiometers with a straight line action.

Single potentiometers – Control potentiometers comprising one resistance element.

Tandem potentiometers – Control potentiometers comprising two identical resistance elements, operated by one spindle or slider.

Dual potentiometers – Rotary type control potentiometers comprising two resistance elements, operated by separate concentric spindles.

Single turn potentiometers – Rotary type preset or control potentiometers with a mechanical angle of rotation smaller than 360^{o}.

Multiturn potentiometers – Rotary type preset or control potentiometers with a rotary operation up to 40 rotations. Preset types comprise a straight line resistance element operated by knob or gear wheel. Control types comprise a reduction gear on the rotary action. Designed for fine resistance adjustment.

Modular potentiometers – Compact rectangular shaped rotary type control potentiometers, custom built from a number of basic elements, either with or without spindle or provided with a snap-in facility for customized operating devices.

Focus potentiometers – Special unit with or without V_{g2} control to adjust the focus voltage of picture tubes.
Connection is either by soldering or by conductive rubber.

Mains or battery switches – Rotary or push-pull switches fitted to the potentiometers and usually operated by the spindle.

Test switches – Separate switches for screwdriver or knob operation in testing procedures.

Bandswitches – For bandswitching, in combination with preset multiturn carbon potentiometers.

Resistance range – Range of maximum nominal resistances.

Nominal resistance (R_{nom}) – Nominal value of the resistance between the end terminals a and c (Fig. 1), the wiper b at end-stop position.

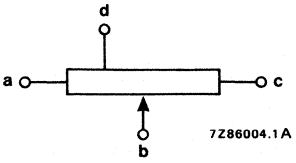


Fig. 1 Designation of terminals.

Resistance law – Function of the resistance (R_{ab}) measured between the wiper terminal (b) and the 0% end-stop (a) at wiper positions from 0 to 100% of the mechanical angle of rotation (Fig. 2).

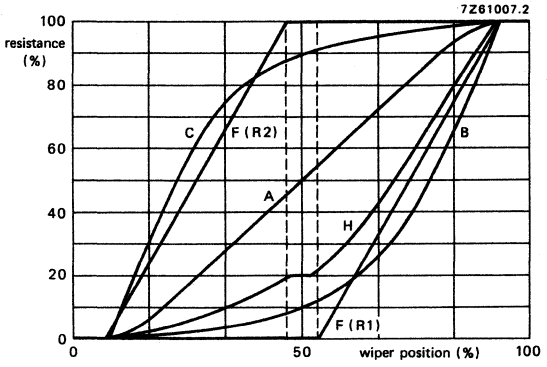


Fig. 2 Some typical resistance laws.

A = linear
B = logarithmic
C = reversed logarithmic
H = logarithmic with top
F = balance

Terminal resistance (or residual resistance) – Minimum resistance that is be obtained between either end terminals a or c and the wiper terminal b when the wiper is in end stop position. (Fig. 3).

Resistance at the tap – Minimum resistance between the tap terminal d and the resistance element.

Contact resistance CR – Resistance between resistance element and wiper contact.

Contact resistance variation (CRV) – Chance of resistance between the resistance element and the wiper contact when it is moved at a defined speed according to IEC.

Contact resistance moving (CRM) – Contact resistance when a wiper is moved at a defined speed according to IEC.

Maximum attenuation – Maximum attenuation when the potentiometer is used as an attenuator (see Fig. 3).

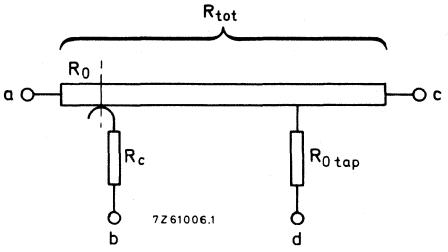


Fig. 3 Diagram of potentiometer; spindle in fully counter-clockwise position.

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

Maximum attenuation: $20 \log \frac{R_o}{R_{tot}}$ dB.

(The value of R_c is negligible.)

Maximum dissipation (P_{max}) – Maximum amount of power which can be dissipated at a given ambient temperature, when the potentiometer is continuously loaded between the end terminals a and c (Fig. 1) and mounted on a steel panel of 100 x 100 x 1,5 mm by means of a nut (or on a printed circuit board for types with printed-wiring pins).

Maximum voltage (E_{max}) – The maximum voltage that may be applied is calculated from maximum dissipation (P_{max}) and nominal resistance (R_{nom}): $E_{max} = \sqrt{P_{max} \cdot R_{nom}}$, provided that the limiting element is not exceeded.

Limiting wiper current – Maximum current that may be passed between resistance element and wiper 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 – The full extent of the travel of the actuating device of a rotary potentiometer between the end stops (Fig. 4).

Effective angle of rotation – That angle throughout which the resistance law of a rotary potentiometer is applicable (Fig. 4).

Switching angle – That angle over which the switch of a rotary potentiometer has to be actuated from the off to the on position, or vice versa (Fig. 4).

Backlash of the rotary switch – That angle over which the spindle of a rotary potentiometer has to be rotated before actuating the switch from the off to the on position (Fig. 4).

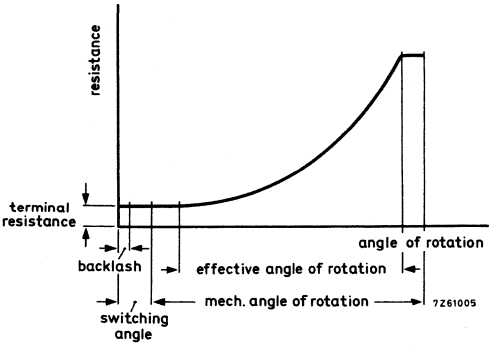


Fig. 4a.

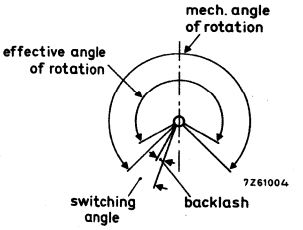
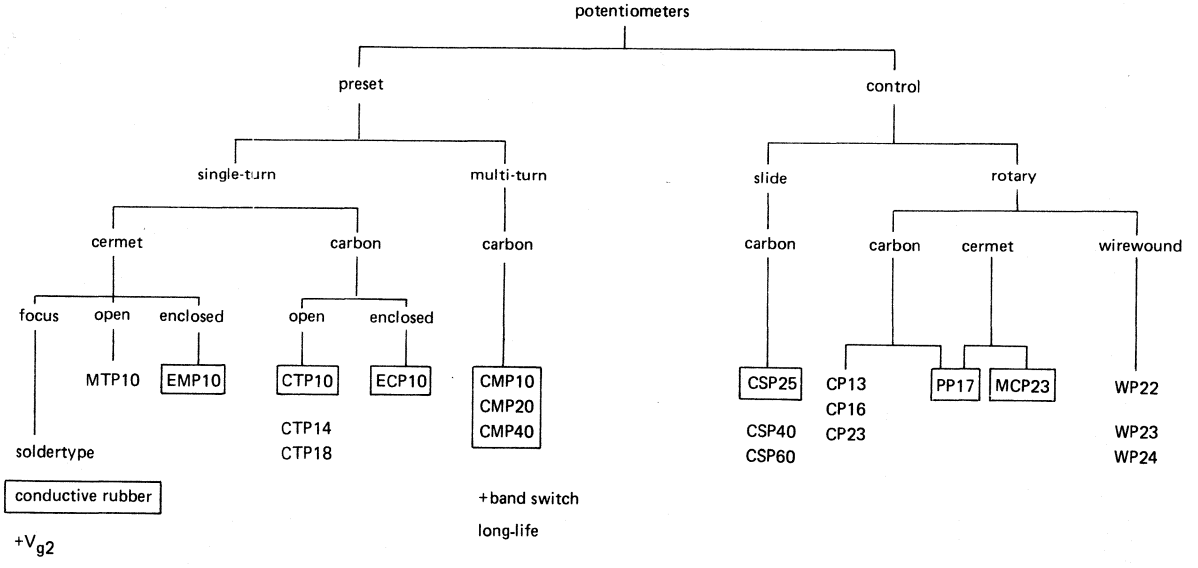


Fig. 4b.

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



Preset potentiometers are mainly used for eliminating circuit tolerances during the assembly of electronic equipment or the readjustment of electronic circuits at a later stage.

Control potentiometers are widely used in all kinds of electronic equipment e.g. for volume, tone, brightness and tolerance control.

Preferred types are encadred in the above selection scheme.

CONTROL POTENTIOMETERS

13 mm CARBON CONTROL POTENTIOMETERS

QUICK REFERENCE DATA

Resistance law	linear and logarithmic
Resistance values	4,7, 10 and 22 kΩ

GENERAL

These potentiometers are for use in miniaturized electronic equipment such as dictaphones, small radio sets, etc. On account of their application a special construction has been used, 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.

Outlines

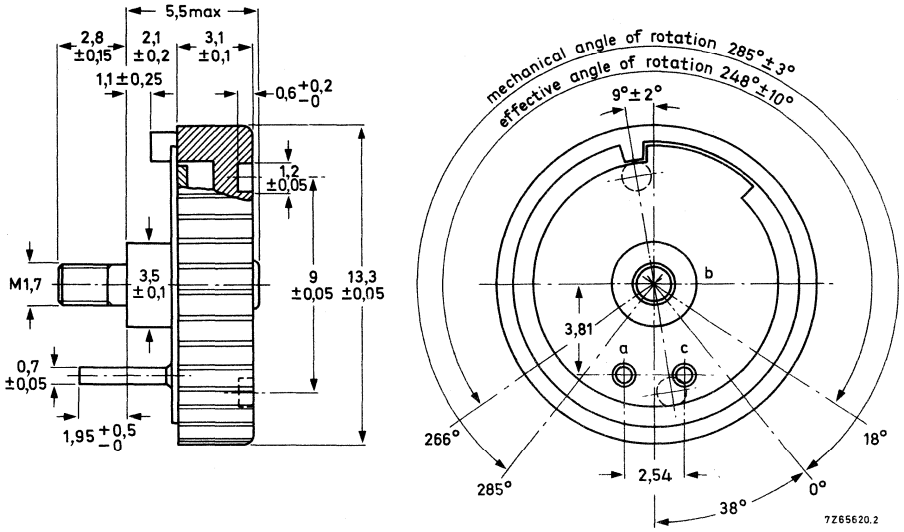


Fig. 1 a, b and c = potentiometer terminals (a and c are connected to the ends of the carbon track; b is connected to the wiper contact.)

TECHNICAL DATA

Nominal resistance	4,7, 10 and 22 kΩ
Tolerance on the nominal resistance	± 20%
Resistance law	linear and logarithmic
Contact resistance between carbon track and wiper	
linear law	⩽ 5% of R_{nom}
logarithmic law	⩽ 10% of R_{nom}
Terminal resistance	
linear law	⩽ 1% of R_{nom}
logarithmic law	⩽ 0,1% of R_{nom}
Insulation resistance	> 1 MΩ
Maximum attenuation	⩾ 60 dB
Maximum voltage over the resistance element	10 V (d.c.)
Current through wiper	⩽ 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	2 to 10 mNm
Maximum permissible torque with wiper at end stop	50 mNm
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 law
26 = 4,7 kΩ 27 = 10 kΩ 28 = 22 kΩ	logarithmic law

16 mm CARBON CONTROL POTENTIOMETERS

QUICK REFERENCE DATA

Resistance range (E3 series)	
linear law	220 Ω to 4,7 MΩ
logarithmic law	1 kΩ to 2,2 MΩ
Maximum dissipation at 40 °C	
linear law	0,1 W
logarithmic law	0,05 W
Climatic category (IEC 68)	10/070/21

DESCRIPTION

The CP16 carbon control 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 a and c (see Types) are connected to the ends of the carbon track; terminal b is connected via a contact ring to the wiper contact. The potentiometers can be supplied with a tap (d) at 46% (single) or 50% (tandem) of the total mechanical angle of rotation. The potentiometers are provided with plastic or metal 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 or with a rotary switch; the tandem potentiometers are only supplied without switch. Both types are available with different connecting terminals, mounting facilities and spindles, see below.

Types

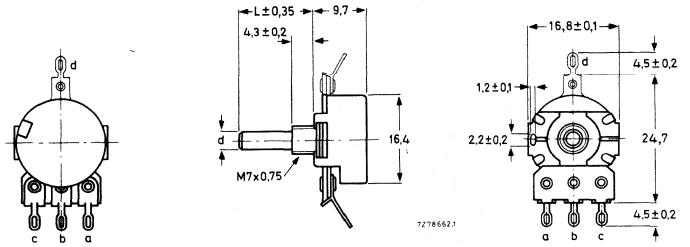


Fig. 1 Single potentiometer with mounting bushing. For dimensions d and L, see Spindles.

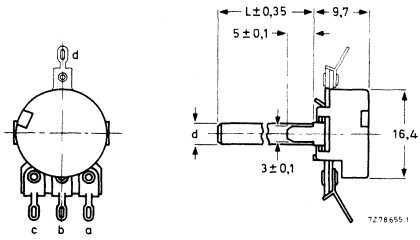


Fig. 2
Single potentiometer with twist tags. For dimensions d and L, see Spindles.

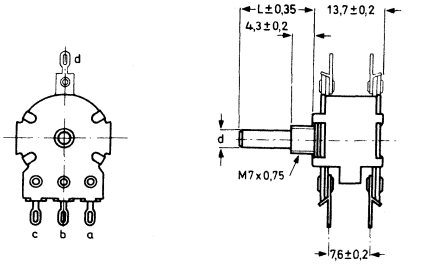


Fig. 3
Tandem potentiometer. For dimensions d and L, see Spindles.

Switches

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

Fig. 4a Circuit in off-position of spindle (spindle turned fully counter-clockwise).

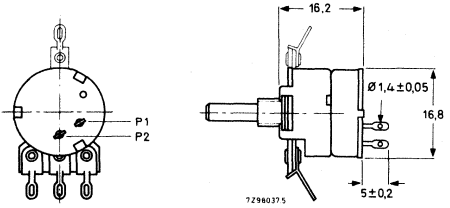


Fig. 4b Single potentiometer with s.p.s.t. rotary switch (spring actuated).

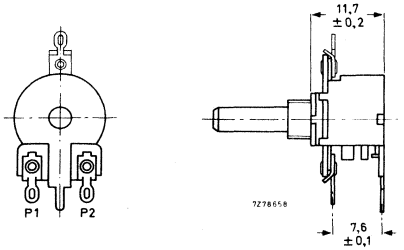


Fig. 4c Single potentiometer with s.p.s.t. rotary switch (direct operating).

Connecting terminals

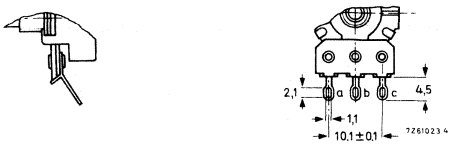


Fig. 5 Solder tags.

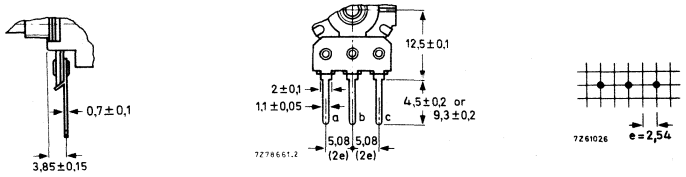


Fig. 6 Long or short printed-wiring pins (single potentiometer).

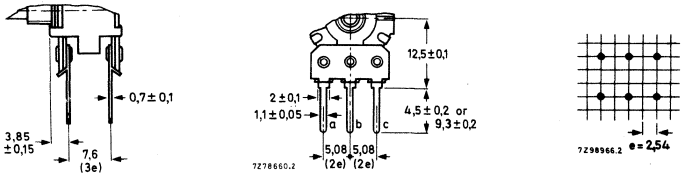


Fig. 7 Long or short printed-wiring pins (tandem potentiometer).

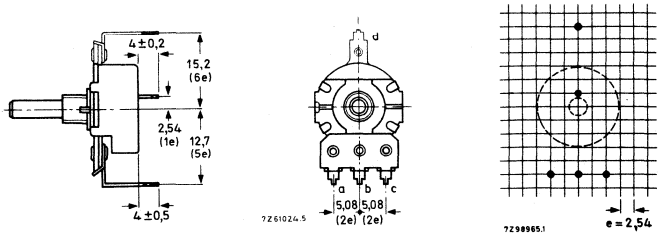
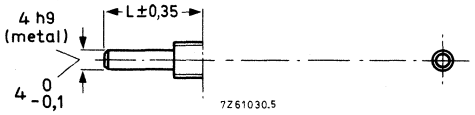
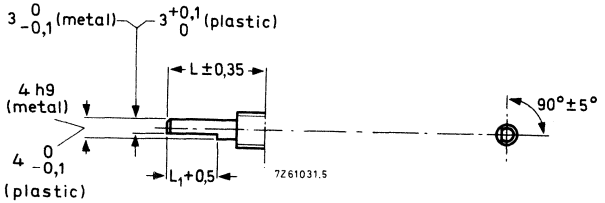
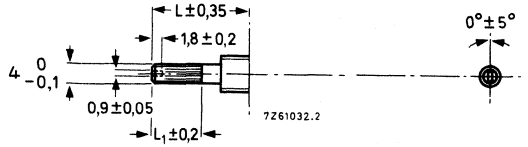
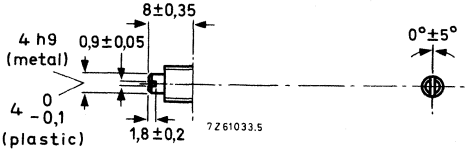
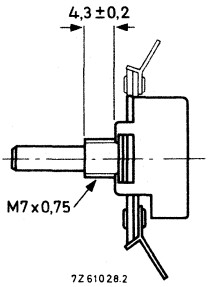
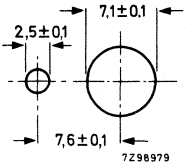
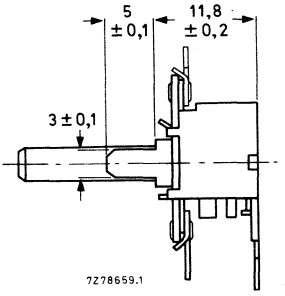
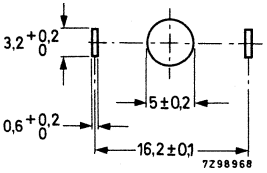


Fig. 8 Printed-wiring pins, bent backwards.

Spindles

type	off position	L mm	L_1 mm	material
		10 12 15 17 19 20 22 24 25 28 30		metal or plastic
		10 15 20 20	3,5 8,5 8,5 13,5	metal or plastic
		10 15 20	5 9 9	plastic
				metal or plastic

Mounting facilities

		required mounting holes in chassis	fixing of potentiometer
mounting bushing M7 x 0,75			with supplied mounting nut;* max. torque for tightening = 1 Nm; min. thickness of chassis = 1 mm
twist tags			by twisting the tags

MARKING

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

* Catalogue number of mounting nut: 4322 047 00370.

TECHNICAL DATA

Unless otherwise specified, all values have been determined at an ambient temperature of 15 to 35 °C, at atmospheric pressure of 96 to 106 kPa and a relative humidity of 45 to 75%.
For measuring methods, see IEC publications 190 and 68.

nominal resistance R_n*	resistance law according to Figs 9 and 10	max. voltage at 40 °C V	max. terminal resistance	max. attenuation dB	max. contact resistance % R_{nom}	limiting slider current at 40 °C mA
220 Ω	a	4,7	10 Ω	–	4	21
470 Ω	a	6,8	10 Ω	–	4	14,5
1 kΩ	a	10	25 Ω	–	4	10
2,2 kΩ	a	14	25 Ω	–	4	7
4,7 kΩ	a	22	25 Ω	–	4	5
10 kΩ	a	31	35 Ω	–	4	3,2
22 kΩ	a	45	35 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	6	7
2,2 kΩ	b	10	5 Ω	50	6	5
4,7 kΩ	b	15	5 Ω	60	6	3,2
10 kΩ	b	22	10 Ω	60	6	2,2
22 kΩ	b	31	20 Ω	60	6	1,5
47 kΩ	b	50	35 Ω ▲	60 ▲	6	1,0
100 kΩ	b	70	50 Ω	70	6	0,7
220 kΩ	b	100	50 Ω	80	6	0,5
470 kΩ	b	155	100 Ω	80	6	0,32
1 MΩ	b	220	200 Ω	80	6	0,22
2,2 MΩ	b	310	500 Ω	80	6	0,15

* Measured between terminals a and c; for potentiometers with a tap, between terminals a and d and between c and d.
▲ Measured between terminals a and b; spindle turned fully counter-clockwise.

nominal resistance R_n*	resistance law according to Figs 9 and 10	max. voltage at 40 °C V	max. terminal resistance		max. attenuation dB		max. contact resistance % R_{nom}	limiting slider current at 40 °C mA
1 kΩ	c	7	20 Ω	†	50	†	6	7
2,2 kΩ	c	10	40 Ω		50		6	5
4,7 kΩ	c	15	100 Ω		60		6	3,2
10 kΩ	c	22	200 Ω		60		6	2,2
22 kΩ	c	31	250 Ω		60		6	1,5
47 kΩ	c	50	500 Ω		60		6	1,0
100 kΩ	c	70	2 kΩ		70		6	0,7
220 kΩ	c	100	2,5 kΩ		80		6	0,5
470 kΩ	c	155	5 kΩ		80		6	0,32
1 MΩ	c	220	10 kΩ		80		6	0,22
2,2 MΩ	c	310	20 kΩ		80		6	0,15
5 + 42 kΩ	d	50	40 Ω	▲	60	▲	6	1,0
20 + 200 kΩ	d	100	50 Ω		80		6	0,5
50 + 420 kΩ	d	155	470 Ω		80		6	0,32
100 + 900 kΩ	d	220	200 Ω		80		6	0,22
2 + 8 kΩ	e	22	10 Ω	▲	60	▲	6	2,2
5 + 17 kΩ	e	31	22 Ω		60		6	1,5
10 + 37 kΩ	e	50	47 Ω		60		6	1,0
20 + 80 kΩ	e	70	100 Ω		70		6	0,7
50 + 170 kΩ	e	100	220 Ω		80		6	0,5
100 + 370 kΩ	e	155	600 Ω		80		6	0,32
0,5 + 1,7 MΩ	e	310	2,2 kΩ		80		6	0,15
10 kΩ	f	15	–		--		6	2,2
22 kΩ	f	22	–		–		6	1,5
47 kΩ	f	35	–		–		6	1,0
100 kΩ	f	50	–		–		6	0,7
220 kΩ	f	70	–		–		6	0,5
470 kΩ	f	110	–		–		6	0,32
1 MΩ	f	155	–		–		6	0,22

* Measured between terminals a and c; for potentiometers with a tap, between terminals a and d and between c and d.

† Measured between terminals c and b; spindle turned fully clockwise.

▲ Measured between terminals a and b; spindle turned fully counter-clockwise.

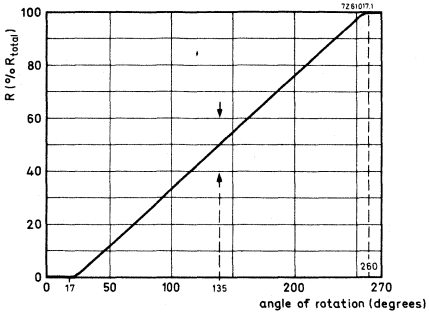


Fig. 9a Linear law, single potentiometers.

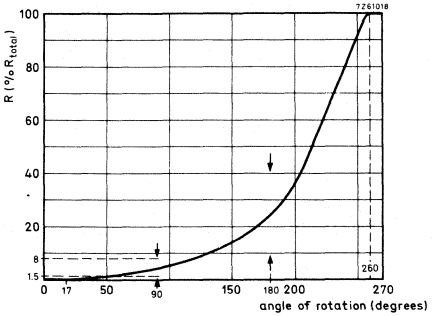


Fig. 9b Logarithmic law, single potentiometers.

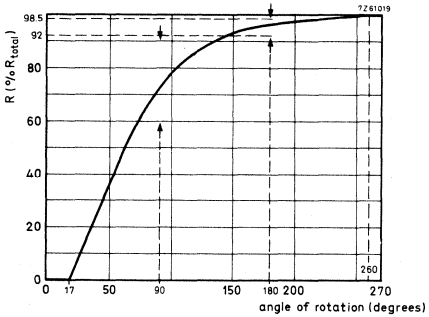


Fig. 9c Reversed logarithmic law, single potentiometers.

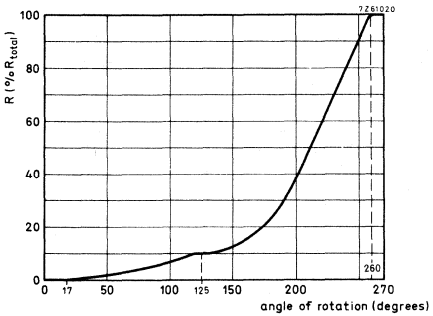


Fig. 9d Semi-logarithmic law, tap at 10%, single potentiometers.

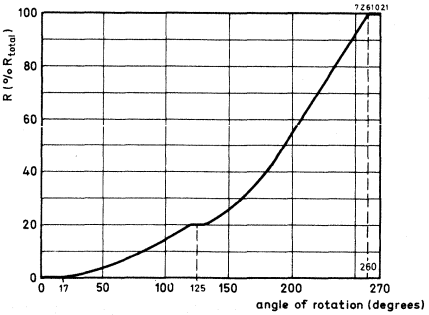


Fig. 9e Semi-logarithmic law, tap at 20%, single potentiometers.

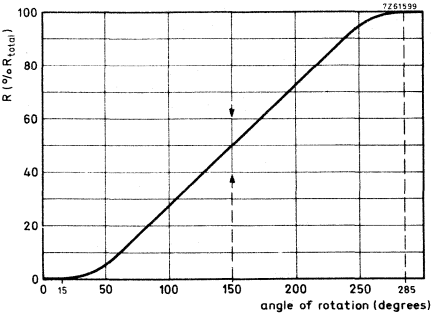


Fig. 10a Linear law, tandem potentiometers.

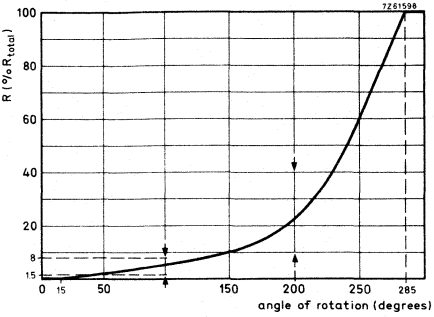


Fig. 10b Logarithmic law, tandem potentiometers.

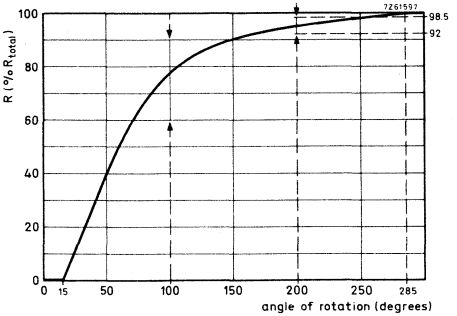


Fig. 10c Reversed logarithmic law, tandem potentiometers.

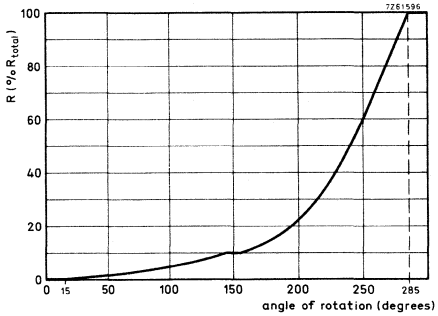


Fig. 10d Logarithmic law, tap at 10% tandem potentiometers.

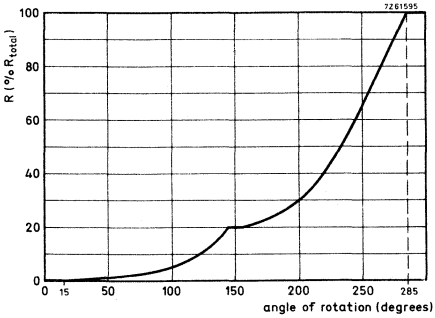


Fig. 10e Logarithmic law, tap at 20%, tandem potentiometers.

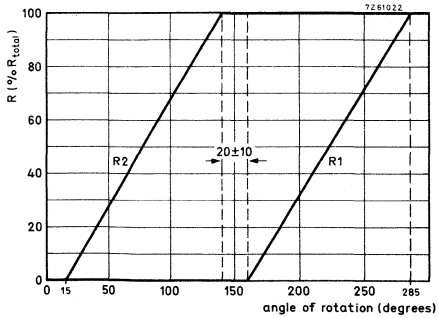


Fig. 10f Balance potentiometers.

Tolerance on the nominal resistance	± 20% (note 1)	
Resistance law and tolerances	see Figs 9 and 10	
Ganging tolerance (note 2)		
linear law		
at values between 10 and 90% of R_{total}	< 2 dB	
(reversed) logarithmic 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 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_{nom}	
Insulation resistance,		
initially	> 1000 MΩ	
after damp heat test (IEC 68, test C, 21 days)	> 25 MΩ	
Maximum dissipation at 40 °C		
linear 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 (IEC 68)	10/070/21	
Operating torque	5 to 20 mNm	
Permissible torque with wiper at end stop	plastic	metal
plain spindles	⩽ 500 mNm	⩽ 600 mNm
spindles with flat face	⩽ 400 mNm	⩽ 600 mNm
spindles with screwdriver slot	⩽ 250 mNm	⩽ 600 mNm
Permissible axial spindle load		
single potentiometers	⩽ 100 N pull	⩽ 100 N push
tandem potentiometers	⩽ 100 N pull	⩽ 60 N push
Axial spindle play	< 0,8 mm	
Radial spindle play, measured with 2,5 N		
at 10 mm 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° (counter-clockwise)	
	R_1: 125 ± 10° (clockwise)	

1. For potentiometers with a tap the tolerance on R_{ad} as well as R_{dc} = ± 20%.
2. For tandem potentiometers only.

Mechanical angle of rotation single potentiometers
- without switch: 270 ± 5°
- with switch: 292 ± 5°
- tandem potentiometers: 300 ± 5°

Life: after 10 000 cycles ΔR_{total} < 25% of R_{total}

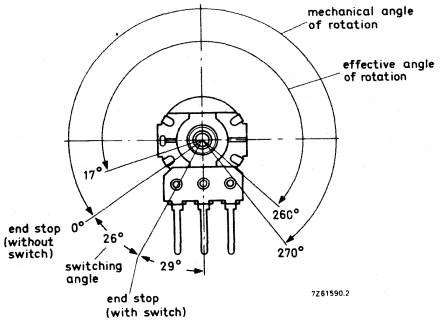


Fig. 11a Angles of rotation of single potentiometers with or without switch.

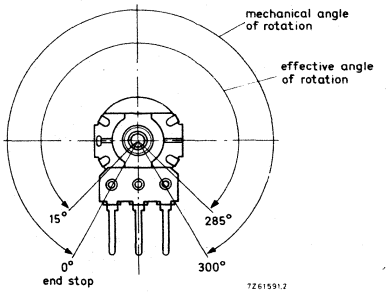


Fig. 11b Angles of rotation of tandem potentiometers.

	switch type	
	s.p.s.t. rotary spring actuated	s.p.s.t. rotary direct operating
Breaking capacity	12 V d.c., 2 A	12 V d.c., 2 A
Contact resistance, initially after 10 000 on-off switching operations at breaking capacity	< 10 mΩ < 50 mΩ*	< 10 mΩ < 50 mΩ*
Insulation resistance** initially after damp heat test (IEC 68, test C_a, 21 days)	> 10 MΩ > 2 MΩ	> 10 MΩ > 2 MΩ
Test voltage for 1 min**, 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.)
Switching torque	15 to 40 mNm	12 to 30 mNm
Switching angle	26 + 2°	26 ± 2°
Total mechanical angle of rotation	295 ± 5°	295 ± 5°
Backlash	⩽ 10°	⩽ 10°
Permissible axial spindle load	⩽ 100 N	⩽ 100 N

* Averaged over 10 measurements: < 25 mΩ.

** 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

without switch	single	= 380
	tandem	= 390
single, with s.p.s.t. rotary switch (spring actuated)*		= 381
single, with s.p.s.t. rotary switch (direct operating)		= 387
single, without switch, with p.w. pins bent backwards**		= 389

* Only available with mounting bushing.

** Only available with mounting bushing and p.w. pins of 9,3 mm length.

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	
metal spindle	plastic spindle	metal spindle	plastic spindle	metal spindle	plastic spindle	metal spindle	plastic spindle	metal spindle	plastic spindle	metal spindle	plastic spindle
0 . .	7 . .	2 . .	4 . .	0 . .	7 . .	2 . .	4 . .	1 . .	6 . .	3 . .	5 . .

		solder tags	p.w. pins, length 4,5 mm	p.w. pins, length 9,3 mm
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 (L_1 = 3,5) mm	. 42	. 92	
	15 (L_1 = 8,5) 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	

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

nominal resistance	code in catalogue number			
	linear law Fig. 9a, 10a	log. law Fig. 9b, 10b	rev. log. law Figs 9c, 10c	balance 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	
	log. law tap at 10% Figs 9d, 10d	log. law tap at 20% 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 + 1,7 MΩ		84

Note

Detent potentiometers (11 click, 41 click and centre click versions), without switch, can be supplied on request.

Only for tandem potentiometers.

23mm CARBON CONTROL POTENTIOMETERS

QUICK REFERENCE DATA

Resistance range (E3 series)	
linear law	220 Ω to 4,7 MΩ
logarithmic law	1 kΩ to 4,7 MΩ
Maximum dissipation at 40 °C	
linear law	0,25 W
logarithmic law	0,125 W
Climatic category (IEC 68)	10/070/21

APPLICATION

The potentiometers are widely used in electronic equipment.

DESCRIPTION

The CP23 carbon control potentiometer series includes single potentiometers with and without switch. The 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 a and c (see Types) are connected to the ends of the carbon track; terminal b is connected via a contact ring to the wiper contact. The material of the spindle is plastic. The potentiometers can be delivered without switch, with rotary switch or with a push-pull switch and are provided with solder tag terminals.

MARKING

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

Types

For dimensions d, L and L1, see Spindles.

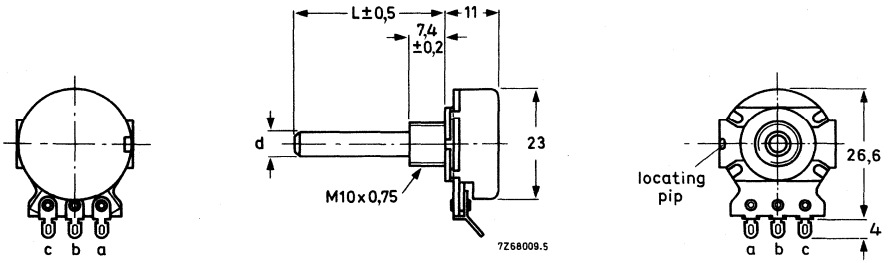
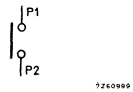
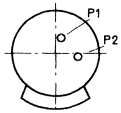
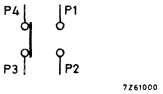
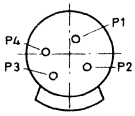
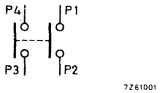
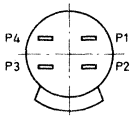
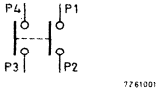
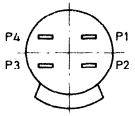


Fig. 1 Single potentiometer.

Switches

type	circuit in "off"-position of spindle	position of terminals	Fig.
single-pole, single-throw rotary switch (s.p.s.t.)			2
single-pole, double-throw rotary switch (s.p.d.t.)			3
double-pole, single-throw rotary switch (d.p.s.t.)			4
double-pole, single-throw push-pull switch 2A (d.p.s.t.)			5

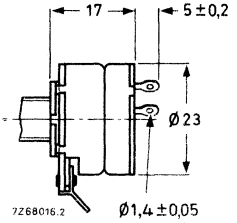


Fig. 2 S.P.S.T. rotary switch.

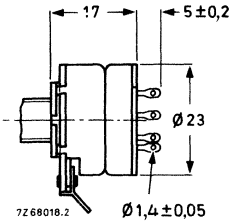


Fig. 3 S.P.D.T. rotary switch.

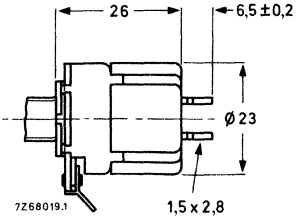


Fig. 4 D.P.S.T. rotary switch.

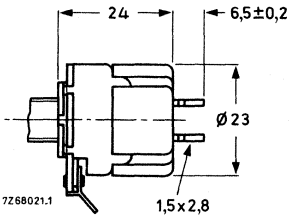


Fig. 5 D.P.S.T. push-pull switch.

Mounting facilities

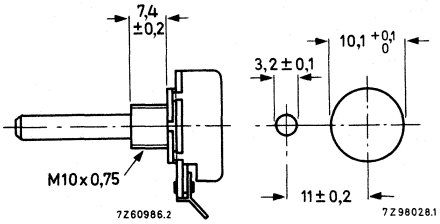
method	required mounting holes in chassis	fixing of potentiometer
mounting bushing M10 x 0,75		with supplied mounting nut (catalogue number 4322 047 00350) max. torque for tightening = 3,5 Nm; min. thickness of chassis = 1,5 mm

Fig. 6

Connecting terminals

solder tags

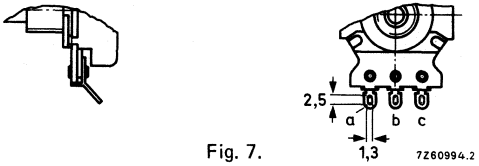


Fig. 7.

Spindles

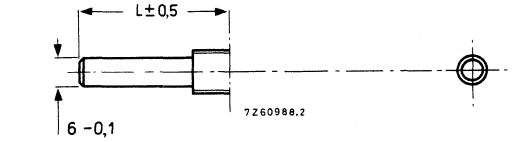
type	"off position"	L mm	L_1 mm
		17	–
		18	8,5
		19	–
		20	–
		22	–
		25	13,5
		30	–
		35	–
		40	13,5
		60	13,5
		70	–
		90	–

Fig. 8.

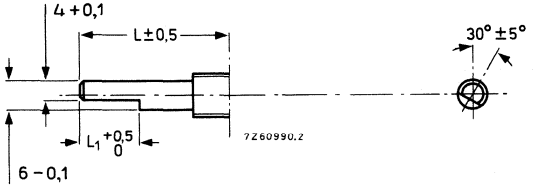


Fig. 9.

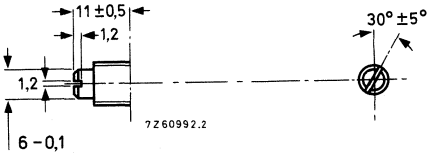


Fig. 10.

Angles of rotation

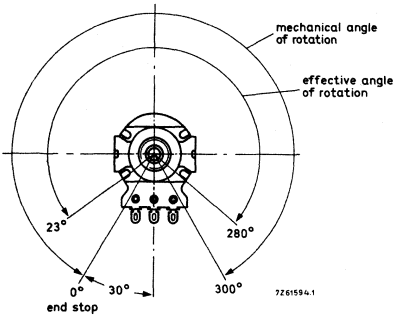


Fig. 11a Angles of rotation of potentiometers without switch or with a push-pull switch.

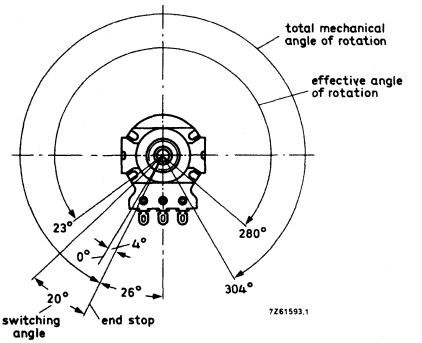


Fig. 11b Angles of rotation of potentiometers with a s.p.s.t. rotary switch.

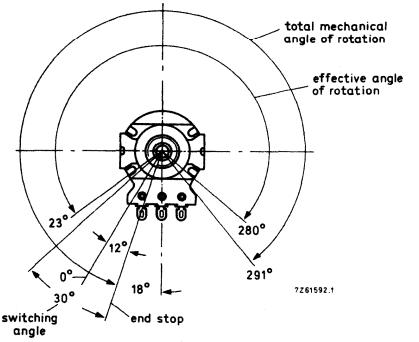


Fig. 11c Angles of rotation of potentiometers with a d.p.s.t. rotary switch.

TECHNICAL DATA

Unless otherwise specified, all values have been determined at an ambient temperature of 15 to 35 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75%.

For measuring methods, see IEC publications 190 and 68.

nominal resistance R_n*	resistance law according to Fig. 12	max. voltage (V) at 40 °C	max. voltage (V) at 70 °C	max. terminal resistance	max. attenuation dB	max. contact resist. % R_{nom}	limiting slider current at 40 °C mA
220 Ω	a	7,4	5,7	10 Ω	–	3	40
330 Ω	a	8,7	6,7	10 Ω	–	3	30
470 Ω	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 kΩ	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
470 Ω	b	8,4	6,9	5 Ω	–	6	14
1 kΩ	b	12	10	5 Ω	50	4	10
2,2 kΩ	b	18	15	5 Ω	60	4	7
4,7 kΩ	b	26	22	5 Ω	60	4	4,5
10 kΩ	b	39	32	10 Ω	60	4	3,2
22 kΩ	b	57	47	22 Ω ▲	60 ▲	4	2,2
47 kΩ	b	84	69	35 Ω	70	4	1,4
100 kΩ	b	120	100	50 Ω	70	4	1,0
220 kΩ	b	180	150	50 Ω	80	4	0,7
470 kΩ	b	265	220	100 Ω	80	4	0,45
1 MΩ	b	390	320	500 Ω	80	4	0,32
2,2 MΩ	b	500	470	2,2 kΩ	80	4	0,22

* Measured between terminals a and c.

▲ Measured between terminals a and b; spindle turned fully counter-clockwise.

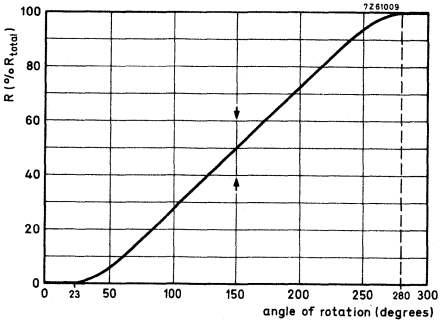


Fig. 12a Linear law.

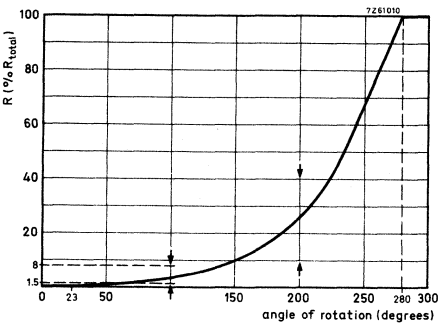


Fig. 12b Logarithmic law.

Tolerance on the nominal resistance	± 20%
Resistance law and tolerances	see Figs 12a and 12b
Minimum resistance at the tap	⩽ 1% of R_{nom}
Insulation resistance after damp heat test (IEC 68, test C, 21 days)	> 100 MΩ
Maximum dissipation	
linear law, acc. to Fig. 11a	
at 40 °C	0,25 W
at 70 °C	0,125 W
resistance law, acc. to Fig. 11b	
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	3 to 20 mNm
Permissible torque with wiper at end stop	⩽ 0,8 Nm
Permissible axial spindle load	⩽ 100 N
Effective angle of rotation	250-265°
Mechanical angle of rotation	300 ± 5°
Life	after 10 000 rotations $\Delta R_{total} < 25\%$ of R_{total}

	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			E.I., Demko, Semko, Nemko	Demko, Semko Nemko
Breaking capacity	250 V a.c., 0,5 A, cos φ = 0,9 125 V a.c., 1 A, cos φ = 0,9	250 V a.c., 0,5 A, cos φ = 0,9 125 V a.c., 1 A, cos φ = 0,9	250 V a.c., 1,5 A/32 x (IEC 65)	250 V a.c., 2 A/32 x (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 3, initially after damp heat test (IEC 68, test C, 21 days) (4)	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	4 - 8 Ncm	4 - 8 Ncm	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. Measured at opened switch between the terminals, and between the case or spindle and interconnected terminals.
4. Measured after recovery period of 24 hours.

COMPOSITION OF THE CATALOGUE NUMBER

2322 35 . 7 . . .

code for type and switch

without switch	= 0
with s.p.d.t. rotary switch	= 2
with s.p.s.t. rotary switch	= 3
with d.p.s.t. push-pull switch, 2A	= 5
with d.p.s.t. rotary switch	= 7

code for type, and length of spindle

slotted = .10

plain		flat faced	
	17 mm = 13		
	18 mm = 06		18 mm = .40
	19 mm = 14		
	20 mm = 15		
	22 mm = 17		
	25 mm = 01		25 mm = .41
	30 mm = 03		30 mm = .43
	35 mm = 04		
	40 mm = 05		40 mm = .45
	60 mm = 07		60 mm = .47
	70 mm = 08		
	90 mm = 09		

code for resistance law and nominal resistance

nominal resistance		lin law	log law
220 Ω	=	02	
330 Ω	=	19	
470 Ω	=	03	23
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
220 kΩ	=	12	32
470 kΩ	=	13	33
1 MΩ	=	14	34
2,2 MΩ	=	15	35
4,7 MΩ	=	16	

MODULAR CARBON AND CERMET POTENTIOMETERS

The PP17 series includes resistance elements (linear and logarithmic), battery switches, drive units, mounting brackets, detents, shielding, cover, and heatsink, which can be efficiently assembled to customer's order to form an almost infinite variety of carbon and cermet control potentiometers. All types of these rectangular potentiometers are custom built from standard stock parts and are therefore available within comparitively short delivery times. The surveys on the following pages show the most probable combinations of items. The various modular elements are then described, and the electrical and mechanical details of complete units are given. The resistance elements can also be supplied separately.

QUICK REFERENCE DATA

Resistance range (E3 series)*	
carbon, linear law	220 Ω to 1 MΩ (4,7 MΩ)
carbon, logarithmic law	2200 Ω (1000 Ω) to 470 kΩ (2,2 MΩ)
cermet, linear law	220 Ω to 4,7 MΩ
Maximum dissipation at T_{amb} = 40 °C	
carbon, linear law	0,2 W
carbon, logarithmic law	0,1 W
cermet, linear law	1 to 3 W
Climatic category (IEC 68)	
carbon	25/070/10
cermet, versions with metal spindle	40/125/56
cermet, versions with plastic spindle or without spindle	25/070/56

DESCRIPTION

The potentiometer family can be divided into two groups:
- versions without spindle, to be activated by customized snap-in devices (survey 1);
- versions with one of many available spindle types (survey 2);

All versions can be supplied with either carbon or cermet resistance elements, fixed in a self extinguishing glass-fiber filled polycarbonate housing (black).

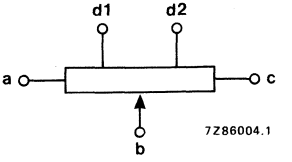
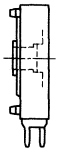
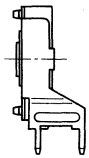
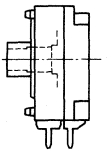
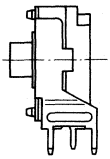


Fig. 1 Designation of terminals.

The carbon resistance element is a carbon track on a phenolic paper substrate; the cermet resistance element is Al_2O_3 substrate. The metallic slider has a multi-finger wiper and is mounted in a plastic rotor. Terminals are designated as shown in Fig. 1 in accordance with IEC 393-1, sub-clause 4.5.

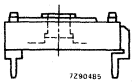
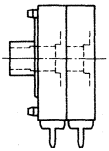
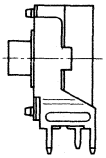
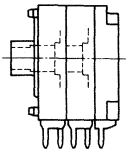
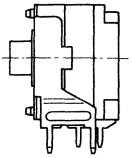
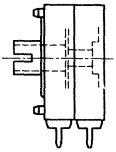
* Future extensions between brackets.

SURVEY 1, VERSIONS WITHOUT SPINDLE

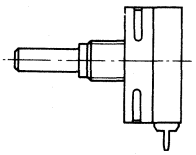
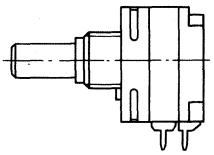
version				single vertical			
					 with bracket	 with battery switch	 with bracket and battery switch
rotor		flat, snap-in		•	•		
		protruding, snap-in		•	•	•	•
		flat, slotted		X (1)			
terminal configuration		in-line		•	•	•	•
		staggered		•	•	• tap version	X tap version
type of terminal	vertical versions	spindle height	12,5 mm	•	•	•	•
			18,0 mm	X			
		solder tag		X			
	horizontal version						
optional		metal shield		X			
		plastic cover		X			

X = available
• = preferred.

(1) Used in versions with spindle.

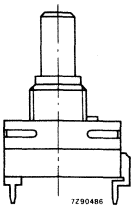
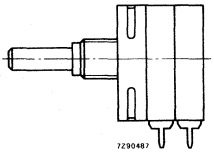
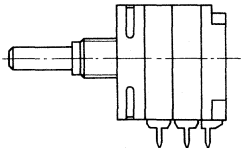
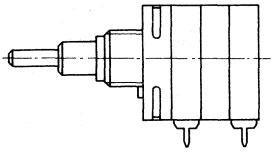
single horizontal	tandem vertical				dual vertical
		 with bracket	 with battery switch	 with bracket and battery switch	
●					
●	●	●	●	●	X
X (1)					
●	●	●	●	●	X
	●	●	● tap versions	X tap versions	X
	●	●	●	●	X
	X				X
	X				X
●					
	X	X			X
	X	X			X

SURVEY 2, VERSIONS WITH SPINDLE

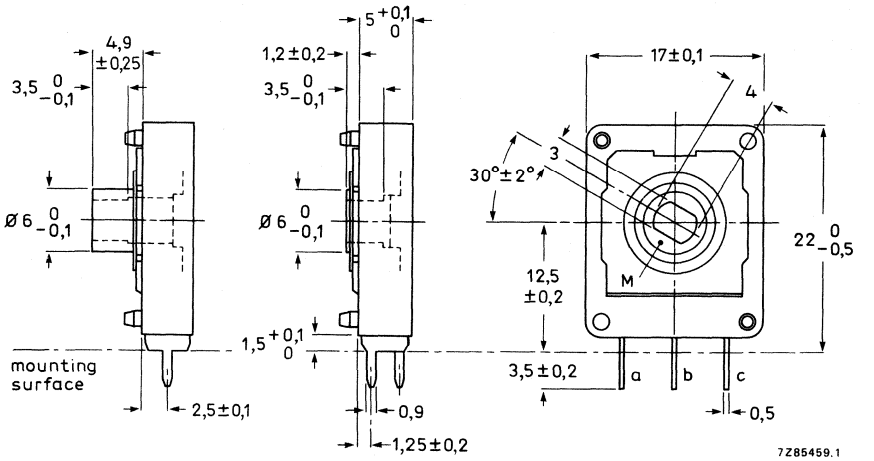
				single vertical	
version					 with battery switch
bushing L = 8 mm (1)	M7	spindle dia. 4 mm	plastic	● (10)	● (10)
			metal	● (9)	● (9)
	M10	spindle dia. 6 mm	plastic	● (10)	● (10)
			metal	● (9)	● (9)
type of terminal (2)	vertical versions	spindle height	12,5 mm	●	●
			18,0 mm	X	
		solder tag		X	X
	horizontal version				
optional	slow-motion drive 4, 6: 1			X	
	centre detent (3), carbon only			X	
	metal shield			X	
	plastic cover			X	
	heatsink, cermet only			X	

X = available.
● = preferred.

(1) The figures between brackets give the number of spindle types.
(2) See sheet of relevant version for terminal configuration.
(3) More detents on request.

single horizontal	tandem vertical		dual vertical
		 with battery switch	
• (10)	• (10)	• (10)	
• (9)	• (9)	• (9)	X (1)
• (10)	• (10)	• (10)	
• (9)	• (9)	• (9)	X (1)
	•	•	X
	X	X	X
	X	X	X
•			
X	X		
X	X		X
	X		X
	X		X
	X		X

VERSION WITHOUT SPINDLE, SINGLE VERTICAL



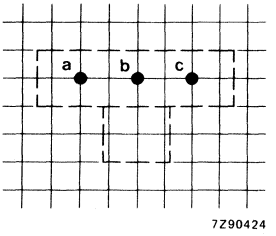
terminals in line, protruding rotor

staggered terminals, flat rotor

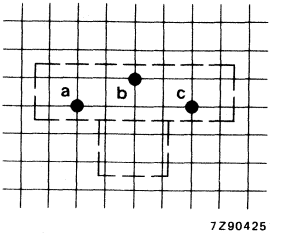
Rotor drawn at fully counter-clockwise position. M = mark for position of slider.
For other terminals see Fig. 18.

Hole patterns

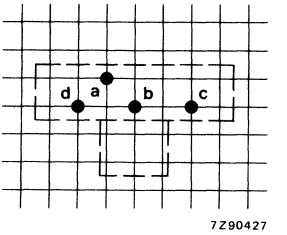
For connection to printed-wiring boards with a grid pitch of 2,54 mm, viewed from component side.
Hole diameter 1,3 ± 0,05 mm.



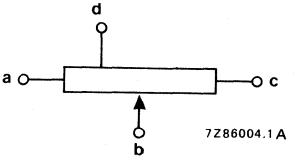
terminals in line



staggered terminals



with one tap



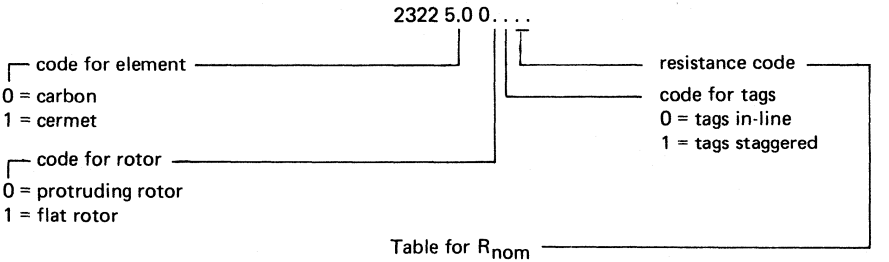
designation of terminals

Main properties

Climatic category (IEC 68)	carbon 25/070/10, cermet 25/070/56
Resistance range, E3 series	
carbon, linear (linearity 4%)	220 Ω to 1 MΩ, tolerance 20%
carbon, non-linear	2200 Ω to 470 kΩ, tolerance 20%
cermet, linear (linearity 4%)	220 Ω to 4,7 MΩ, tolerance 10%
Resistance law (see Fig. 19)	carbon A, B, C, H cermet A
Maximum dissipation at T_{amb} = 40 °C	
carbon, linear	0,2 W
carbon, non-linear	0,1 W
cermet, linear	1,25 W
Test voltage for 1 minute	500 V, 50 Hz
with plastic cover	1000 V, 50 Hz

For further information see Electrical Data and Mechanical Data.

Composition of the catalogue number, PP17 without spindle, single, vertical

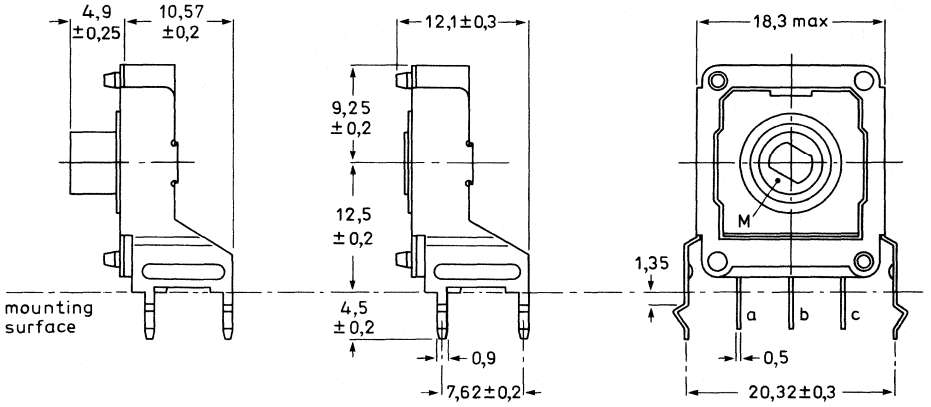


R \ law	linear	logarithmic*	rev. logarithmic*	log. with tap
220 Ω	02	–	–	–
470 Ω	03	–	–	–
1 kΩ	04	–	–	–
2,2 kΩ	05	25	45	–
4,7 kΩ	06	26	46	–
10 kΩ	07	27	47	–
22 kΩ	08	28	48	–
47 kΩ	09	29	49	–
100 kΩ	11	31	51	–
220 kΩ	12	32	52	–
470 kΩ	13	33	53	–
1 MΩ	14	–	–	–
2,2 MΩ	–	–	–	–
4,7 MΩ	–	–	–	–

* carbon only.

Catalogue numbers for other versions on request.

VERSION WITHOUT SPINDLE, SINGLE VERTICAL WITH BRACKET

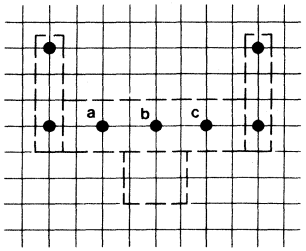


protruding rotor flat rotor

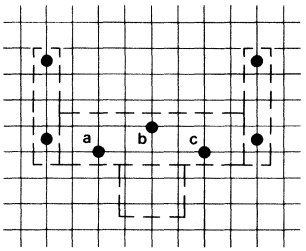
Rotor drawn at fully counter-clockwise position. M = mark for position of slider.

Hole patterns

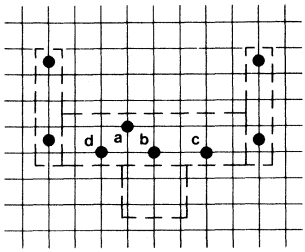
For connection to printed-wiring boards with a grid pitch of 2,54 mm, viewed from component side. Hole diameter 1,3 ± 0,05 mm.



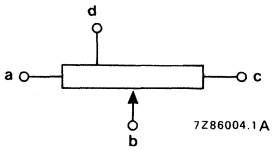
terminals in line



staggered terminals



with one tap



designation of terminals

Main properties

Climatic category (IEC 68)	carbon 25/070/10, cermet 25/070/56
Resistance range, E3 series	
carbon, linear (linearity 4%)	220 Ω to 1 MΩ, tolerance 20%
carbon, non-linear	2200 Ω to 470 kΩ, tolerance 20%
cermet, linear (linearity 4%)	220 Ω to 4,7 MΩ, tolerance 10%
Resistance law (see Fig. 19)	carbon A, B, C, H cermet A
Maximum dissipation at T_{amb} = 40 °C	
carbon, linear	0,2 W
carbon, non-linear	0,1 W
cermet, linear	1,25 W
Test voltage for 1 minute	500 V, 50 Hz
with plastic cover	1000 V, 50 Hz

For further information see Electrical Data and Mechanical Data.

Composition of the catalogue number, PP17 without spindle, single, vertical, with bracket

2322 5.0 0. . . .

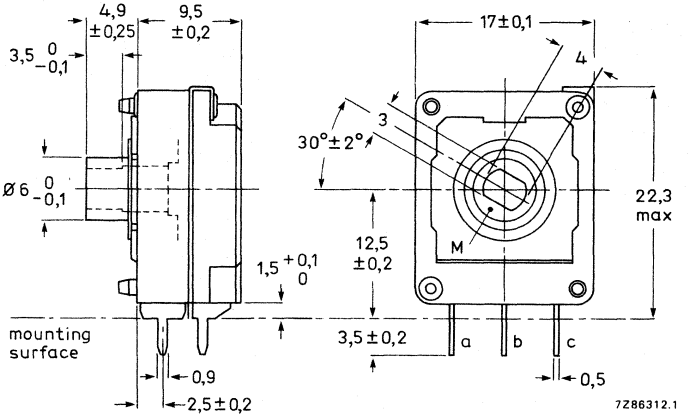
- code for element: 0 = carbon; 1 = cermet
- code for rotor: 2 = protruding rotor; 3 = flat rotor
- code for tags: 0 = tags in-line; 1 = tags staggered
- resistance code
- Table for R_{nom}

R \ law	linear	logarithmic*	rev. logarithmic*	log. with tap
220 Ω	02	–	–	–
470 Ω	03	–	–	–
1 kΩ	04	–	–	–
2,2 kΩ	05	25	45	–
4,7 kΩ	06	26	46	–
10 kΩ	07	27	47	–
22 kΩ	08	28	48	–
47 kΩ	09	29	49	–
100 kΩ	11	31	51	–
220 kΩ	12	32	52	–
470 kΩ	13	33	53	–
1 MΩ	14	–	–	–
2,2 MΩ	–	–	–	–
4,7 MΩ	–	–	–	–

* carbon only.

Catalogue numbers for other versions on request.

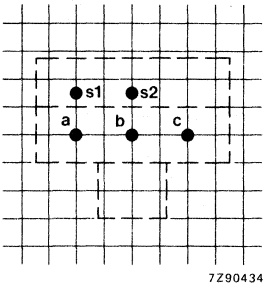
VERSION WITHOUT SPINDLE, SINGLE VERTICAL WITH BATTERY SWITCH



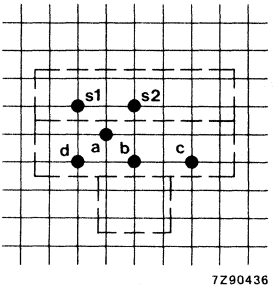
Rotor drawn at fully counter-clockwise position. M = mark for position of slider.

Hole patterns

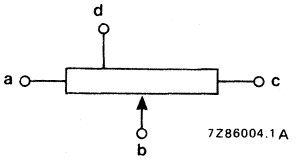
For connection to printed-wiring boards with a grid pitch of 2,54 mm, viewed from component side. Hole diameter 1,3 ± 0,05 mm.



terminals in line



with one tap



designation of terminals

Main properties

Climatic category (IEC 68)	carbon 25/070/10, cermet 25/070/56
Resistance range, E3 series	
carbon, linear (linarity 4%)	220 Ω to 1 MΩ, tolerance 20%
carbon, non-linear	2200 Ω to 470 kΩ, tolerance 20%
cermet, linear (linearity 4%)	220 Ω to 4,7 MΩ, tolerance 10%
Resistance law (see Fig. 19)	carbon A, B, C, H cermet A
Maximum dissipation at T_{amb} = 40 °C	
carbon, linear	0,2 W
carbon, non-linear	0,1 W
cermet, linear	1,25 W
Test voltage for 1 minute	500 V, 50 Hz

For further information see Electrical Data, Mechanical Data and Battery Switch.

Composition of the catalogue number, PP17 without spindle, single, vertical with switch

2322 5.0 100 . .

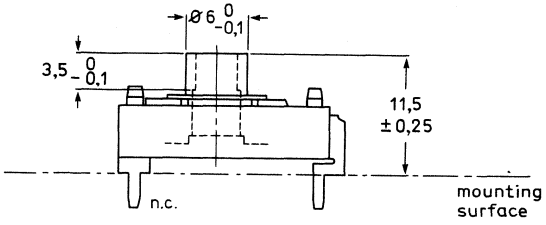
- code for element: 0 = carbon; 1 = cermet
- resistance code: Table for R_{nom}

R \ law	linear	logarithmic*	rev. logarithmic*	log. with tap
220 Ω	02	–	–	–
470 Ω	03	–	–	–
1 kΩ	04	–	–	–
2,2 kΩ	05	25	45	–
4,7 kΩ	06	26	46	–
10 kΩ	07	27	47	–
22 kΩ	08	28	48	–
47 kΩ	09	29	49	–
100 kΩ	11	31	51	–
220 kΩ	12	32	52	–
470 kΩ	13	33	53	–
1 MΩ	14	–	–	–
2,2 MΩ	–	–	–	–
4,7 MΩ	–	–	–	–

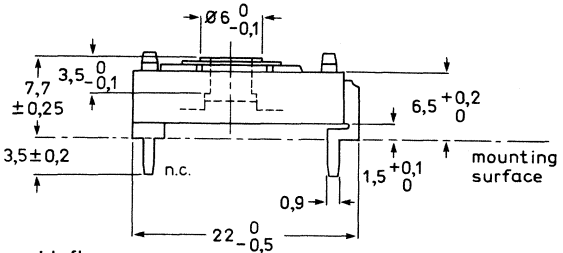
* carbon only.

Catalogue numbers for other versions on request.

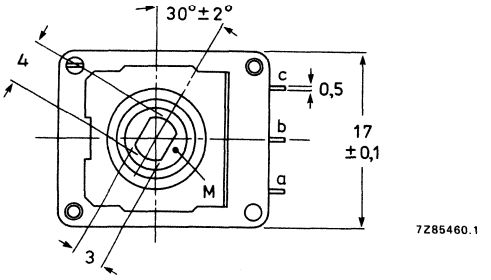
VERSION WITHOUT SPINDLE, SINGLE HORIZONTAL



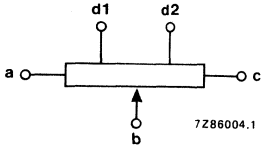
with protruding rotor



with flat rotor



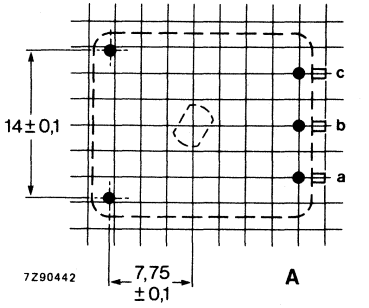
Rotor drawn at fully counter-clockwise position.
M = mark for position of slider.



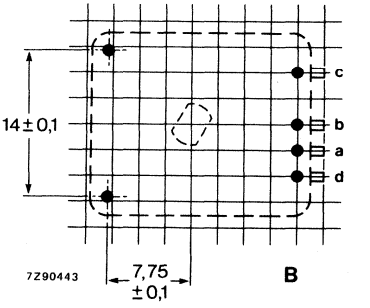
designation of terminals

Hole patterns

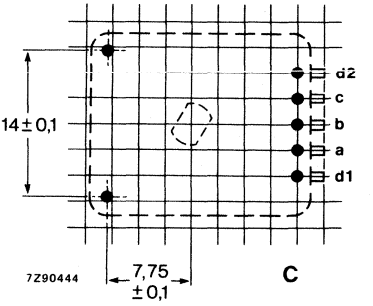
For connection to printed-wiring boards with a grid pitch of 2,54 mm, viewed from component side. Hole dia. 1,3 ± 0,05 mm.



no tap



one tap



two taps

Main properties

Climatic category (IEC 68)	carbon 25/070/10, cermet 25/070/56
Resistance range, E3 series	
carbon, linear (linearity 4%)	220 Ω to 1 MΩ, tolerance 20%
carbon, non-linear	2200 Ω to 470 kΩ, tolerance 20%
cermet, linear (linearity 4%)	220 Ω to 4,7 MΩ, tolerance 10%
Resistance law (see Fig. 19)	carbon, A, B, C, H cermet A
Maximum dissipation at T_{amb} = 40 °C	
carbon, linear	0,2 W
carbon, non-linear	0,1 W
cermet, linear	1,25 W
Test voltage for 1 minute	500 V, 50 Hz

For further information see Electrical Data and Mechanical Data.

Composition of the catalogue number, PP17 without spindle, single, horizontal

2322 5.0 0.5. .

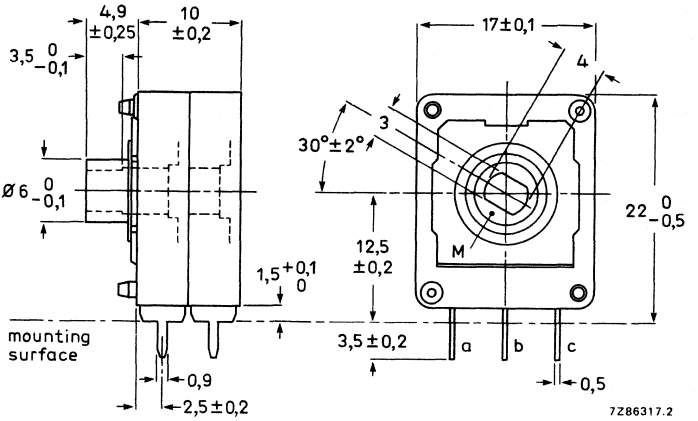
- code for element: 0 = carbon; 1 = cermet
- code for rotor: 0 = protruding rotor; 1 = flat rotor
- resistance code: Table for R_{nom}

R \ law	linear	logarithmic*	rev. logarithmic*	log. with tap
220 Ω	02	–	–	–
470 Ω	03	–	–	–
1 kΩ	04	–	–	–
2,2 kΩ	05	25	45	–
4,7 kΩ	06	26	46	–
10 kΩ	07	27	47	–
22 kΩ	08	28	48	–
47 kΩ	09	29	49	–
100 kΩ	11	31	51	–
220 kΩ	12	32	52	–
470 kΩ	13	33	53	–
1 MΩ	14	–	–	–
2,2 MΩ	–	–	–	–
4,7 MΩ	–	–	–	–

* carbon only.

Catalogue numbers for other versions on request.

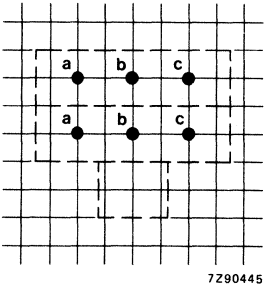
VERSION WITHOUT SPINDLE, TANDEM VERTICAL



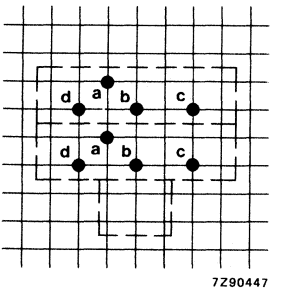
Rotor drawn at fully counter-clockwise position. M = mark for position of slider.

Hole patterns

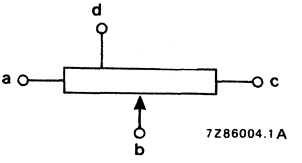
For connection to printed-wiring boards with a grid pitch of 2,54 mm, viewed from component side. Hole diameter 1,3 ± 0,05 mm.



terminals in line



with one tap



designation of terminals

Main properties

Climatic category (IEC 68)	carbon 25/070/10, cermet 25/070/56
Resistance range, E3 series	
carbon, linear (linearity 4%)	220 Ω to 1 MΩ, tolerance 20%
carbon, non-linear	2200 Ω to 470 kΩ, tolerance 20%
cermet, linear (linearity 4%)	220 Ω to 4,7 MΩ, tolerance 10%
Resistance law (see Fig. 19)	carbon A, B, C, H cermet A
Maximum dissipation at T_{amb} = 40 °C	
carbon, linear	0,2 + 0,2 W
carbon, non-linear	0,1 + 0,1 W
cermet, linear	1,25 + 1,25 W
Test voltage for 1 minute	500 V, 50 Hz

For further information see Electrical Data and Mechanical Data.

Composition of the catalogue number, PP17 without spindle, tandem, vertical

2322 5.0 050. .

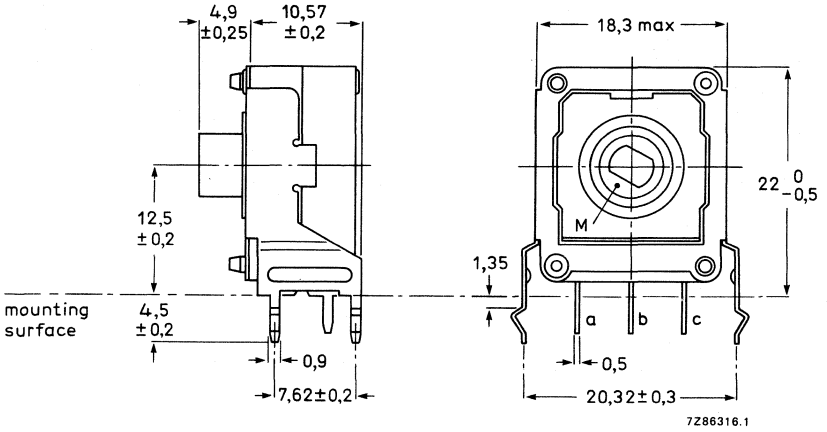
- code for element: 0 = carbon; 1 = cermet
- resistance code: Table for R_{nom}

R \ law	linear	logarithmic*	rev. logarithmic*	log. with tap
220 Ω	02	–	–	–
470 Ω	03	–	–	–
1 kΩ	04	–	–	–
2,2 kΩ	05	25	45	–
4,7 kΩ	06	26	46	–
10 kΩ	07	27	47	–
22 kΩ	08	28	48	–
47 kΩ	09	29	49	–
100 kΩ	11	31	51	–
220 kΩ	12	32	52	–
470 kΩ	13	33	53	–
1 MΩ	14	–	–	–
2,2 MΩ	–	–	–	–
4,7 MΩ	–	–	–	–

* carbon only.

Catalogue numbers for other versions on request.

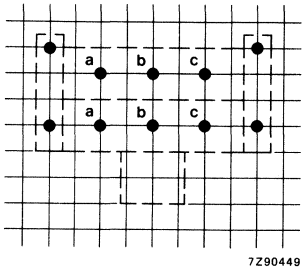
VERSION WITHOUT SPINDLE, TANDEM VERTICAL WITH BRACKET



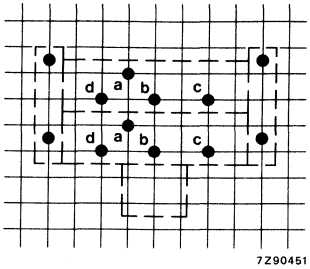
Rotor at fully counter-clockwise position. M = mark for position of slider.

Hole patterns

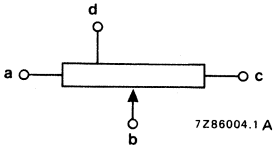
For connection to printed-wiring boards with a grid pitch of 2,54 mm, viewed from component side. Hole diameter 1,3 ± 0,05 mm.



terminals in line



with one tap



designation of terminals

Main properties

Climatic category (IEC 68)	carbon 25/070/10, cermet 25/070/56
Resistance range, E3 series	
carbon, linear (linearity 4%)	220 Ω to 1 MΩ, tolerance 20%
carbon, non-linear	2200 Ω to 470 kΩ, tolerance 20%
cermet, linear (linearity 4%)	220 Ω to 4,7 MΩ, tolerance 10%
Resistance law (see Fig. 19)	carbon A, B, C, H cermet A
Maximum dissipation at T_{amb} = 40 °C	
carbon, linear	0,2 + 0,2 W
carbon, non-linear	0,1 + 0,1 W
cermet, linear	1,25 + 1,25 W
Test voltage for 1 minute	500 V, 50 Hz

For further information see Electrical Data and Mechanical Data.

Composition of the catalogue number, PP17 without spindle, tandem, vertical with bracket

2322 5.0 070. .

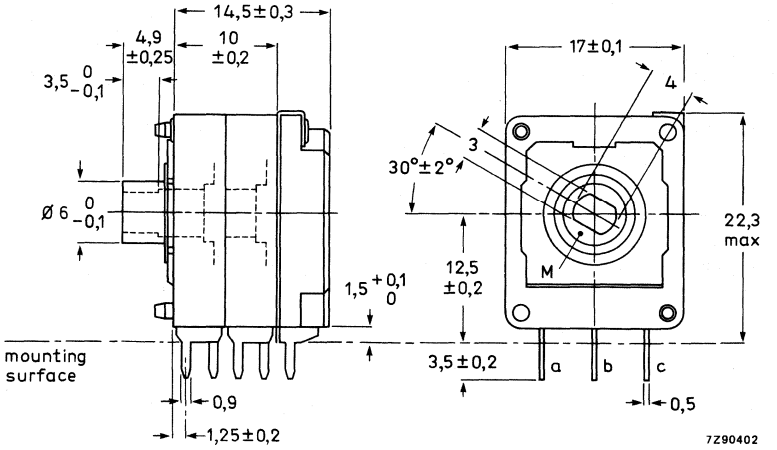
- code for element: 0 = carbon; 1 = cermet
- resistance code
- Table for R_{nom}

R \ law	linear	logarithmic*	rev. logarithmic*	log. with tap
220 Ω	02	–	–	–
470 Ω	03	–	–	–
1 kΩ	04	–	–	–
2,2 kΩ	05	25	45	–
4,7 kΩ	06	26	46	–
10 kΩ	07	27	47	–
22 kΩ	08	28	48	–
47 kΩ	09	29	49	–
100 kΩ	11	31	51	–
220 kΩ	12	32	52	–
470 kΩ	13	33	53	–
1 MΩ	14	–	–	–
2,2 MΩ	–	–	–	–
4,7 MΩ	–	–	–	–

* carbon only.

Catalogue numbers for other versions on request.

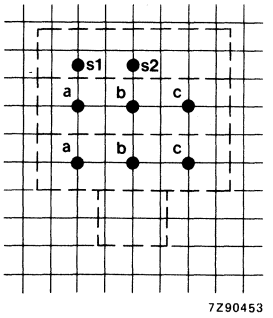
VERSION WITHOUT SPINDLE, TANDEM VERTICAL WITH BATTERY SWITCH



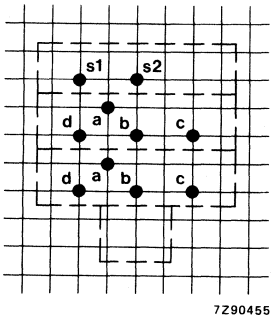
Rotor at fully counter-clockwise position. M = mark for position of slider.

Hole patterns

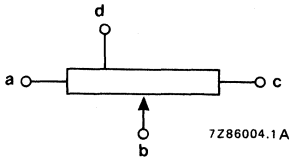
For connection to printed-wiring boards with a grid pitch of 2,54 mm, viewed from component side. Hole diameter 1,3 ± 0,05 mm.



terminals in line



with one tap



designation of terminals

Main properties

Climatic category (IEC 68)	carbon 25/070/10, cermet 25/070/56
Resistance range, E3 series	
carbon, linear (linearity 4%)	220 Ω to 1 MΩ, tolerance 20%
carbon, non-linear	2200 Ω to 470 kΩ, tolerance 20%
cermet, linear (linearity 4%)	220 Ω to 4,7 MΩ, tolerance 10%
Resistance law (see Fig. 19)	carbon, A, B, C, H cermet A
Maximum dissipation at T_{amb} = 40 °C	
carbon, linear	0,2 + 0,2 W
carbon, non-linear	0,1 + 0,1 W
cermet, linear	1,25 + 1,25 W
Test voltage for 1 minute	500 V, 50 Hz

For further information see Electrical Data, Mechanical Data and Battery Switch.

Composition of the catalogue number, PP17 without spindle, tandem, vertical with switch

2322 5.0 500. .

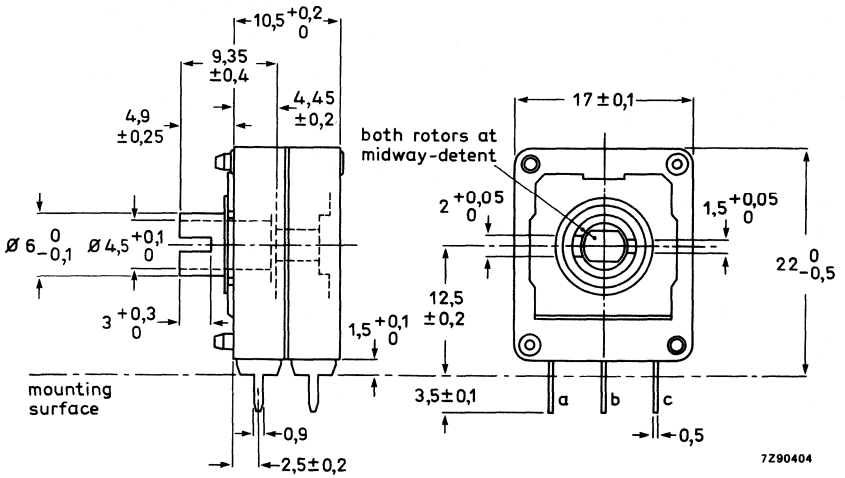
- code for element: 0 = carbon; 1 = cermet
- resistance code: Table for R_{nom}

R \ law	linear	logarithmic*	rev. logarithmic*	log. with tap
220 Ω	02	–	–	–
470 Ω	03	–	–	–
1 kΩ	04	–	–	–
2,2 kΩ	05	25	45	–
4,7 kΩ	06	26	46	–
10 kΩ	07	27	47	–
22 kΩ	08	28	48	–
47 kΩ	09	29	49	–
100 kΩ	11	31	51	–
220 kΩ	12	32	52	–
470 kΩ	13	33	53	–
1 MΩ	14	–	–	–
2,2 MΩ	–	–	–	–
4,7 MΩ	–	–	–	–

* carbon only.

Catalogue numbers for other versions on request.

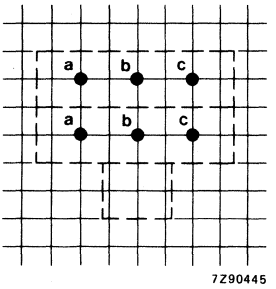
VERSION WITHOUT SPINDLE, DUAL VERTICAL



Both rotors at mid-position.

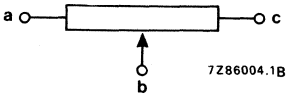
Hole pattern

For connection to printed-wiring boards with a grid pitch of 2,54 mm, viewed from component side. Hole diameter 1,3 ± 0,05 mm.



terminals in line

Dual potentiometers with tap on request.



designation of terminals

Main properties

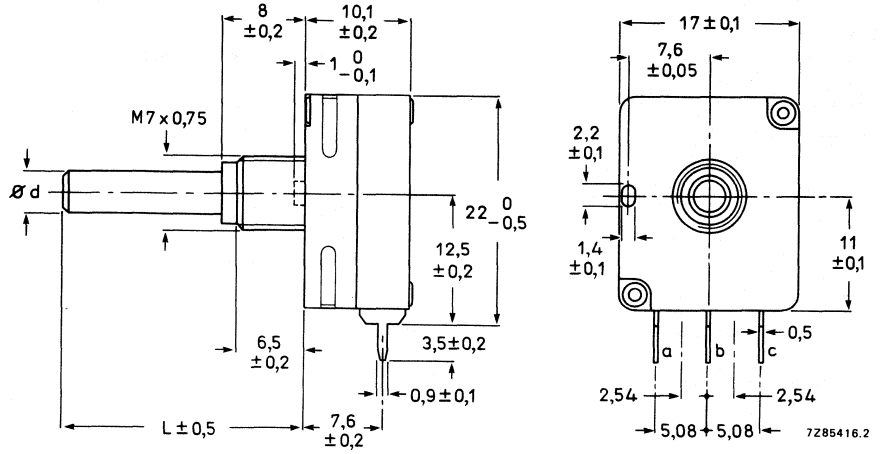
Climatic category (IEC 68)	carbon 25/070/10, cermet 25/070/56
Resistance range, E3 series	
carbon, linear (linearity 4%)	220 Ω to 1 MΩ, tolerance 20%
carbon, non-linear	2200 Ω to 470 kΩ, tolerance 20%
cermet, linear (linearity 4%)	220 Ω to 4,7 MΩ, tolerance 10%
Resistance law (see Fig. 19)	carbon, A, B, C, H cermet A
Maximum dissipation at T_{amb} = 40 °C	
carbon, linear	0,2 + 0,2 W
carbon, non-linear	0,1 + 0,1 W
cermet, linear	1,25 + 1,25 W
Test voltage for 1 minute	500 V, 50 Hz

For further information see Electrical Data and Mechanical Data.

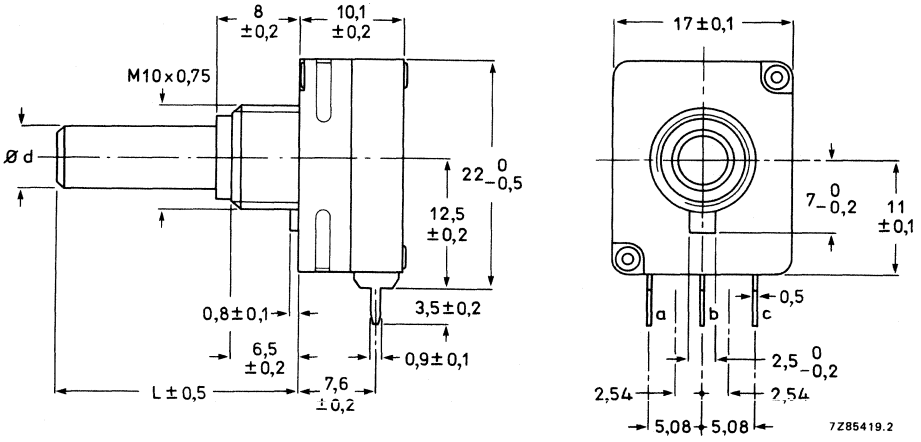
Catalogue number

On request.

VERSION WITH SPINDLE, SINGLE VERTICAL



with mounting bush M7 x 0,75 mm.

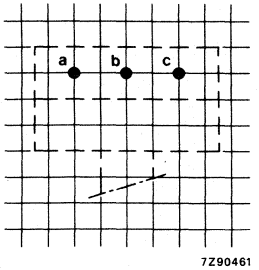


with mounting bush M10 x 0,75 mm.

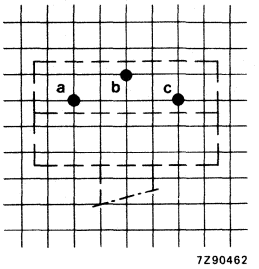
For dimensions d and L see under Spindles. For other terminals see Fig. 18.

Hole patterns

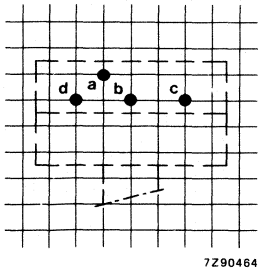
For connection to printed-wiring boards with a grid pitch of 2,54 mm, viewed from component side.
Hole diameter 1,3 ± 0,05 mm.



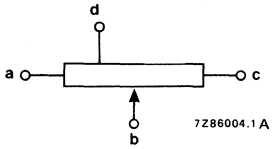
terminals in line



staggered terminals



with one tap



designation of terminals

Main properties

Climatic category (IEC 68)	metal spindle	carbon 25/070/10, cermet 40/125/56
	plastic spindle	carbon 25/070/10, cermet 25/070/56
Resistance range, E3 series		
carbon, linear (linearity 4%)		220 Ω to 1 MΩ, tolerance 20%
carbon, non-linear		2200 Ω to 470 kΩ, tolerance 20%
cermet, linear (linearity 4%)		220 Ω to 4,7 MΩ, tolerance 10%
Resistance law (see Fig. 19)		carbon A, B, C, H cermet A
Maximum dissipation at T_{amb} = 40 °C		
carbon, linear		0,2 W
carbon, non-linear		0,1 W
cermet, linear		2 W | metal spindle, 1 W | plastic spindle
cermet, with heatsink		3 W | metal spindle, 2 W | plastic spindle
Test voltage for 1 minute		500 V, 50 Hz
with plastic cover		1000 V, 50 Hz

For further information see Electrical Data and Mechanical Data.

Composition of the catalogue number, PP17 with spindle, single, vertical

2322 5.1 0. . . .

- code for element
  - 0 = carbon
  - 1 = cermet
- code for bushing; spindle dia. and material
  - 0 = M10; dia. 6, plastic
  - 2 = M7; dia. 4, plastic
  - 5 = M10; dia. 6, metal
  - 7 = M7; dia. 4, metal
- code for configuration of tags; spindle length and type
  - 0 = in-line; 20, plain
  - 1 = in-line; 30, plain
  - 2 = in-line; 20, flat
  - 3 = in-line; 30, flat
  - 5 = staggered; 20, plain
  - 6 = staggered; 30, plain
  - 7 = staggered; 20, flat
  - 8 = staggered; 30, flat
- resistance code

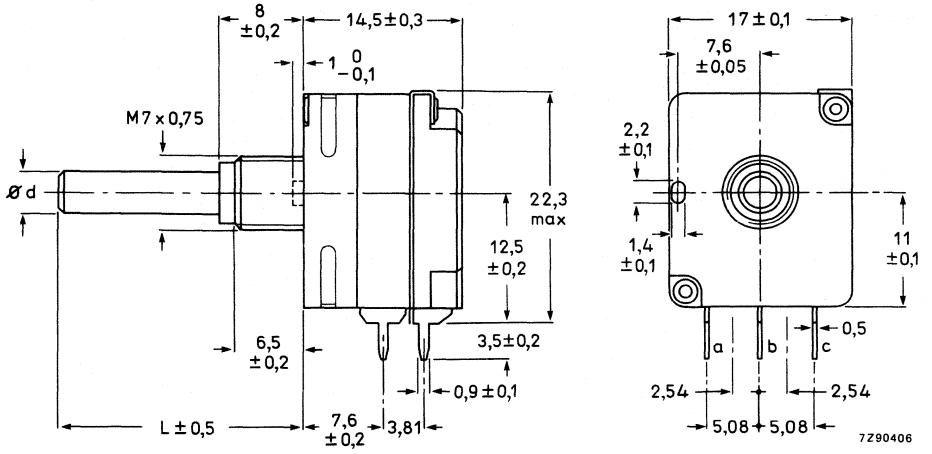
Table for R_{nom}

R \ law	linear	logarithmic*	rev. logarithmic*	log. with tap*
220 Ω	02	–	–	–
470 Ω	03	–	–	–
1 kΩ	04	–	–	–
2,2 kΩ	05	25	45	–
4,7 kΩ	06	26	46	–
10 kΩ	07	27	47	–
22 kΩ	08	28	48	–
47 kΩ	09	29	49	–
100 kΩ	11	31	51	–
220 kΩ	12	32	52	–
470 kΩ	13	33	53	–
1 MΩ	14	–	–	–
2,2 MΩ	–	–	–	–
4,7 MΩ	–	–	–	–

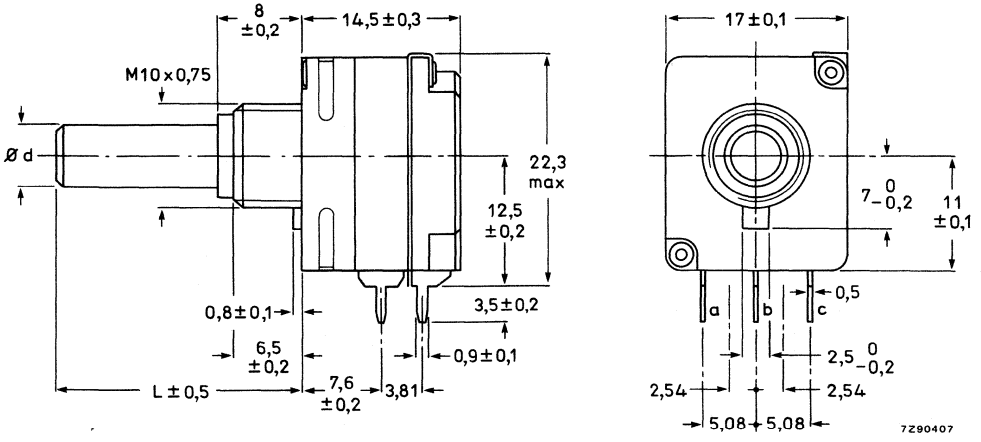
* carbon only.

Catalogue numbers for other versions on request.

VERSION WITH SPINDLE, SINGLE VERTICAL WITH BATTERY SWITCH



with mounting bush M7 x 0,75 mm.

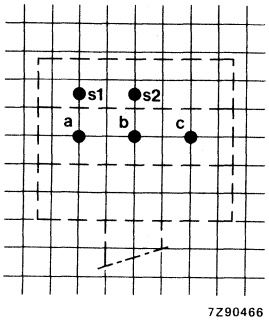


with mounting bush M10 x 0,75 mm.

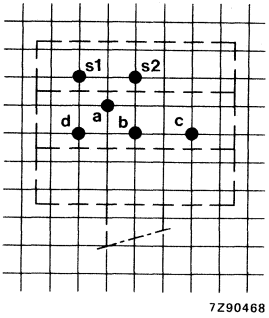
For dimensions d and L see under Spindles. For other terminals see Fig. 18.

Hole patterns

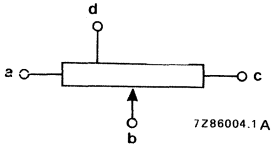
For connection to printed-wiring boards with a grid pitch of 2,54 mm, viewed from component side. Hole diameter 1,3 ± 0,05 mm.



without tap



with one tap



designation of terminals

Main properties

Climatic category (IEC 68)	metal spindle	carbon 25/070/10, cermet 40/125/56
	plastic spindle	carbon 25/070/10, cermet 25/070/56
Resistance range, E3 series		
carbon, linear (linearity 4%)		220 Ω to 1 MΩ, tolerance 20%
carbon, non-linear		2200 Ω to 470 kΩ, tolerance 20%
cermet, linear (linearity 4%)		220 Ω to 4,7 MΩ, tolerance 10%
Resistance law (see Fig. 19)		carbon A, B, C, H cermet A
Maximum dissipation at T_{amb} = 40 °C		
carbon, linear		0,2 W
carbon, non-linear		0,1 W
cermet, linear		1,25 W (metal spindle), 1 W (plastic spindle)
Test voltage for 1 minute		500 V, 50 Hz

For extended data see under Electrical Data, Mechanical Data and Battery Switch.

Composition of the catalogue number, PP17 with spindle, single, vertical with switch

2322 5.1 1. . . .

- code for element
  - 0 = carbon
  - 1 = cermet
- code for bushing; spindle dia. and material
  - 0 = M10; dia. 6, plastic
  - 2 = M7; dia. 4, plastic
  - 5 = M10; dia. 6, metal
  - 7 = M7; dia. 4, metal
- code for configuration of tags; spindle length and type
  - 0 = in-line; 20, plain
  - 1 = in-line; 30, plain
  - 2 = in-line; 20, flat
  - 3 = in-line; 30, flat
- resistance code

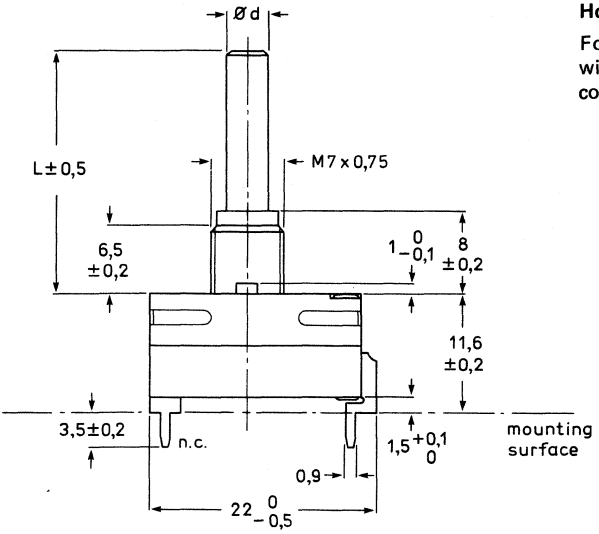
Table for R_{nom}

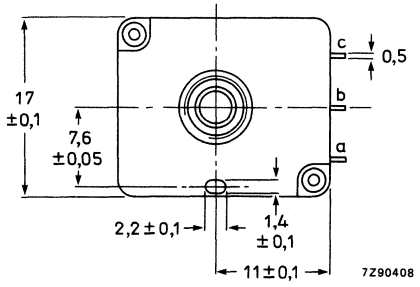
R \ law	linear	logarithmic*	rev. logarithmic*	log. with tap*
220 Ω	02	–	–	–
470 Ω	03	–	–	–
1 kΩ	04	–	–	–
2,2 kΩ	05	25	45	–
4,7 kΩ	06	26	46	–
10 kΩ	07	27	47	–
22 kΩ	08	28	48	–
47 kΩ	09	29	49	–
100 kΩ	11	31	51	–
220 kΩ	12	32	52	–
470 kΩ	13	33	53	–
1 MΩ	14	–	–	–
2,2 MΩ	–	–	–	–
4,7 MΩ	–	–	–	–

* carbon only.

Catalogue numbers for other versions on request.

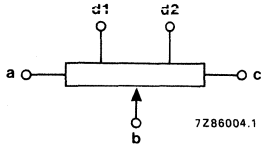
VERSION WITH SPINDLE, SINGLE HORIZONTAL





with mounting bush M7 x 0,75 mm.

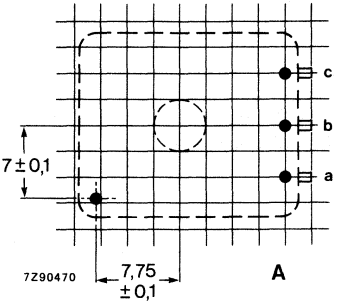
For dimensions d and L see under Spindles.



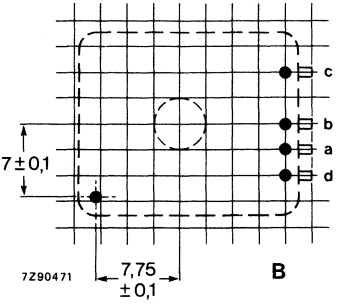
designation of terminals

Hole patterns

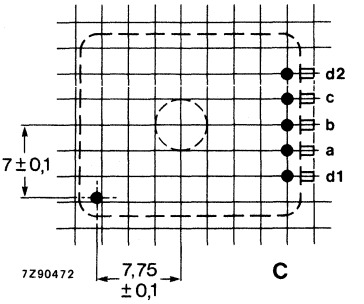
For connection to printed-wiring boards with a grid pitch of 2,54 mm, viewed from component side. Hole dia. 1,3 ± 0,05 mm.



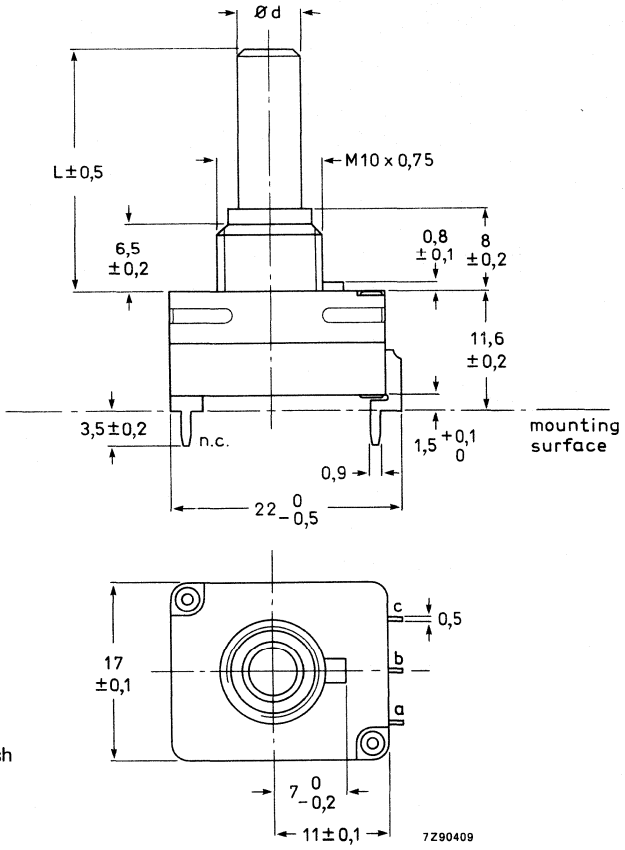
no tap



one tap



two taps



with mounting bush M10 x 0,75 mm.

Main properties

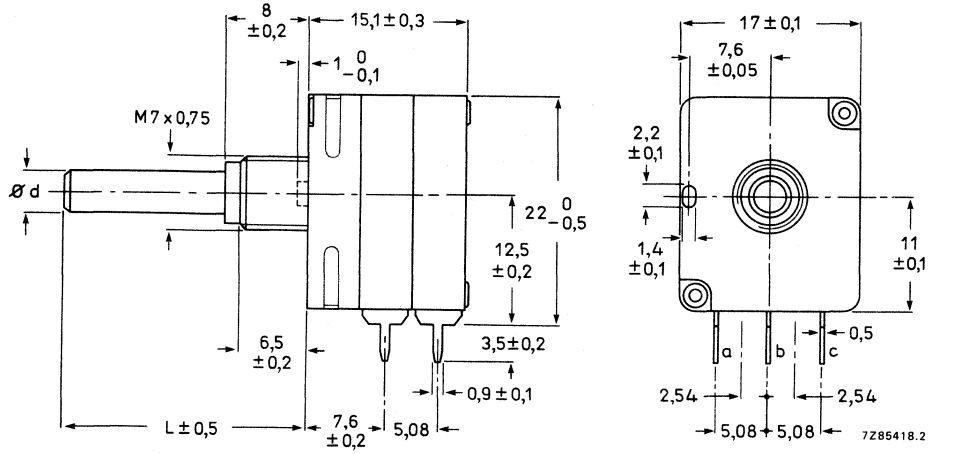
Climatic category	metal spindle	carbon 25/070/10, cermet 40/125/56
	plastic spindle	carbon 25/070/10, cermet 25/070/56
Resistance range, E3 series		
carbon, linear (linearity 4%)		220 Ω to 1 MΩ, tolerance 20%
carbon, non-linear		2200 Ω to 470 kΩ, tolerance 20%
cermet, linear (linearity 4%)		220 Ω to 4,7 MΩ, tolerance 10%
Resistance law (see Fig. 19)		carbon A, B, C, H cermet A
Maximum dissipation at T_{amb} = 40 °C		
carbon, linear		0,2 W
carbon, non-linear		0,1 W
cermet, linear		2 W (metal spindle), 1 W (plastic spindle)
Test voltage for 1 minute		500 V, 50 Hz

For further information see Electrical Data and Mechanical Data.

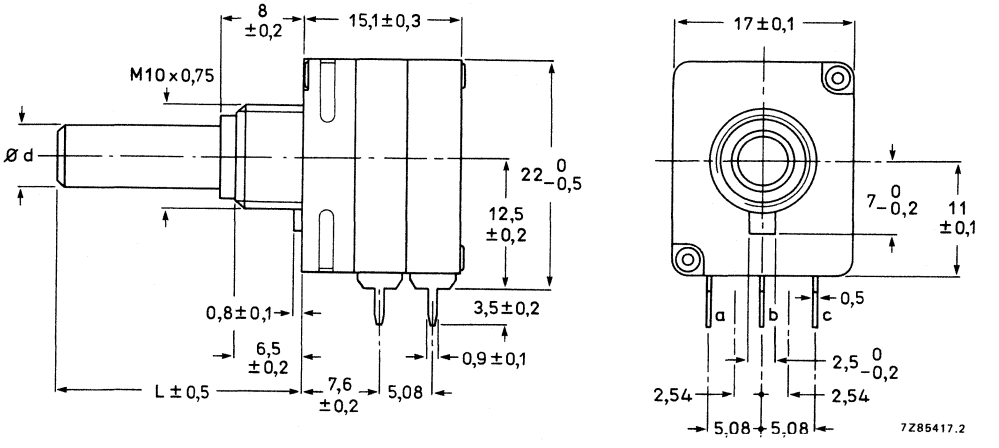
Catalogue numbers:

On request.

VERSIONS WITH SPINDLE, TANDEM VERTICAL



with mounting bush M7 x 0,75 mm.

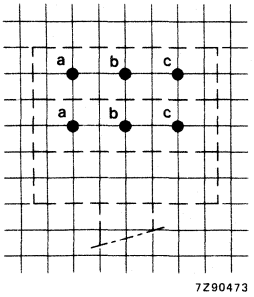


with mounting bush M10 x 0,75 mm.

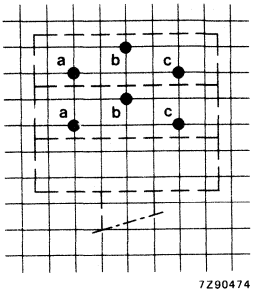
For dimensions d and L see under Spindles.

Hole patterns

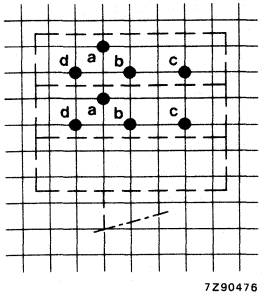
For connection to printed-wiring boards with a grid pitch of 2,54 mm, viewed from component side.
Hole diameter 1,3 ± 0,05 mm.



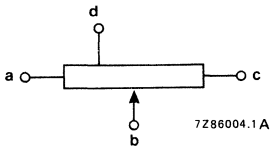
terminals in line



staggered terminals



with one tap



designation of terminals

Main properties

Climatic category (IEC 68)	metal spindle	carbon 25/070/10, cermet 40/125/56
	plastic spindle	carbon 25/070/10, cermet 25/070/56
Resistance range, E3 series		
carbon, linear (linearity 4%)		220 Ω to 1 MΩ, tolerance 20%
carbon, non-linear		2200 Ω to 470 kΩ, tolerance 20%
cermet, linear (linearity 4%)		220 Ω to 4,7 MΩ, tolerance 10%
Resistance law (see Fig. 19)		carbon A, B, C, H cermet A
Maximum dissipation at T_{amb} = 40 °C		
carbon, linear		0,2 + 0,2 W
carbon, non-linear		0,1 + 0,1 W
cermet, linear		1,25 + 1,25 W | metal spindle, 1 + 1 W | plastic spindle
cermet, with heatsink		2 + 2 W | metal spindle, 1,5 + 1,5 W | plastic spindle
Test voltage for 1 minute		500 V, 50 Hz

For further information see Electrical Data and Mechanical Data.

Composition of the catalogue number, PP17 with spindle, tandem, vertical

2322 5.2 0. . . .

code for element
0 = carbon
1 = cermet

code for bushing; spindle dia. and material
0 = M10; dia. 6, plastic
2 = M7; dia. 4, plastic
5 = M10; dia. 6, metal
7 = M7; dia. 4, metal

resistance code

code for configuration of tags; spindle length and type
0 = in-line; 20, plain
1 = in-line; 30, plain
2 = in-line; 20, flat
3 = in-line; 30, flat
5 = staggered; 20, plain
6 = staggered; 30, plain
7 = staggered; 20, flat
8 = staggered; 30, flat

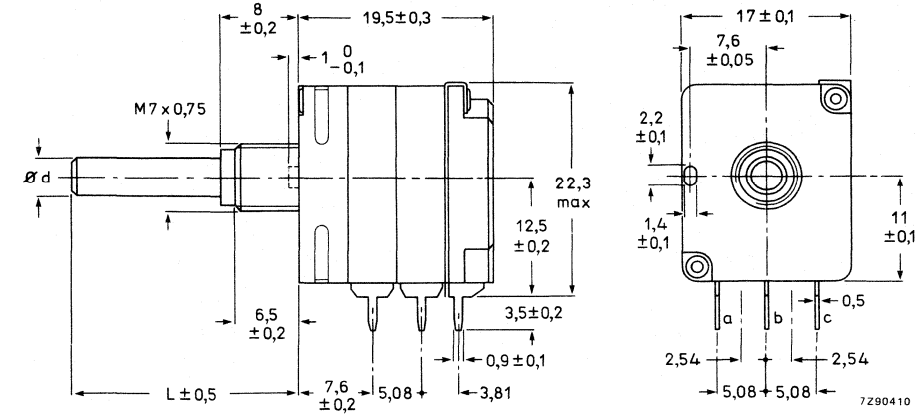
Table for R_{nom}

R \ law	linear	logarithmic*	rev. logarithmic*	log. with tap*
220 Ω	02	–	–	–
470 Ω	03	–	–	–
1 kΩ	04	–	–	–
2,2 kΩ	05	25	45	–
4,7 kΩ	06	26	46	–
10 kΩ	07	27	47	–
22 kΩ	08	28	48	–
47 kΩ	09	29	49	–
100 kΩ	11	31	51	–
220 kΩ	12	32	52	–
470 kΩ	13	33	53	–
1 MΩ	14	–	–	–
2,2 MΩ	–	–	–	–
4,7 MΩ	–	–	–	–

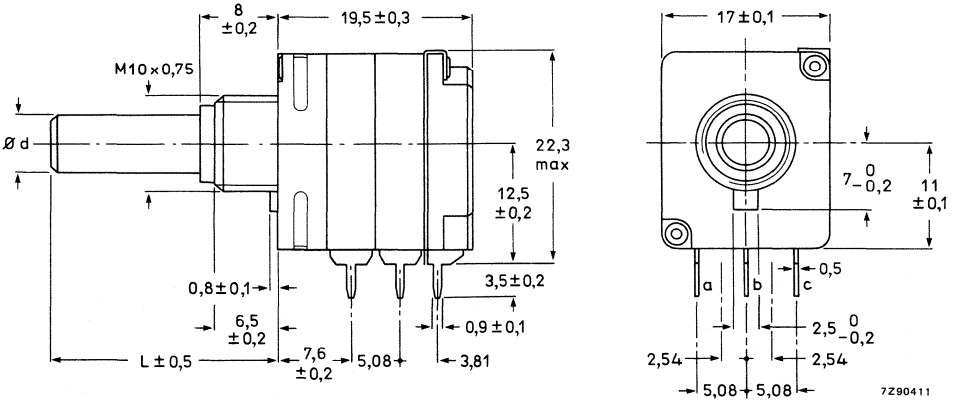
* carbon only.

Catalogue numbers for other versions on request.

VERSIONS WITH SPINDLE, TANDEM VERTICAL WITH BATTERY SWITCH



with mounting bush M7 x 0,75 mm.



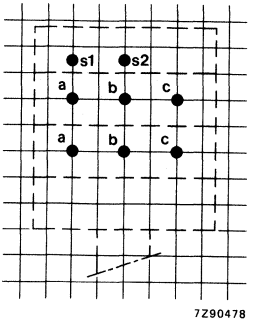
with mounting bush M10 x 0,75 mm.

For dimensions d and L see under Spindles.

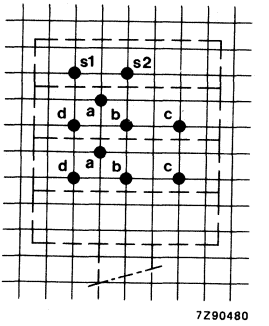
Hole patterns

For connection to printed-wiring boards with a grid pitch of 2,54 mm, viewed from component side.

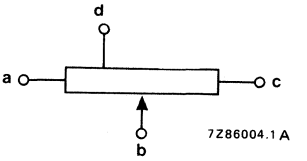
staggered terminals



no tap



with one tap



designation of terminals

Main properties

Climatic category (IEC 68)	
metal spindle	carbon 25/070/10, cermet 40/125/56
plastic spindle	carbon 25/070/10, cermet 25/070/56
Resistance range, E3 series	
carbon, linear (linearity 4%)	220 Ω to 1 MΩ, tolerance 20%
carbon, non-linear	2200 Ω to 470 kΩ, tolerance 20%
cermet, linear (linearity 4%)	220 Ω to 4,7 MΩ, tolerance 10%
Resistance law (see Fig. 19)	carbon A, B, C, H cermet A
Maximum dissipation at T_{amb} = 40 °C	
carbon, linear	0,2 + 0,2 W
carbon, non-linear	0,1 + 0,1 W
cermet, linear	1,25 + 1,25 (metal spindle), 1 + 1 W (plastic spindle)
Test voltage for 1 minute	500 V, 50 Hz

For further information see Electrical Data, Mechanical Data and Battery Switch.

Composition of the catalogue number, PP17 with spindle, tandem, vertical with switch

2322 5.1 1. . . .

- code for element
  - 0 = carbon
  - 1 = cermet
- code for bushing; spindle dia. and material
  - 0 = M10; dia. 6, plastic
  - 2 = M7; dia. 4, plastic
  - 5 = M10; dia. 6, metal
  - 7 = M7; dia. 4, metal
- code for configuration of tags; spindle length and type
  - 0 = in-line; 20, plain
  - 1 = in-line; 30, plain
  - 2 = in-line; 20, flat
  - 3 = in-line; 30, flat
- resistance code

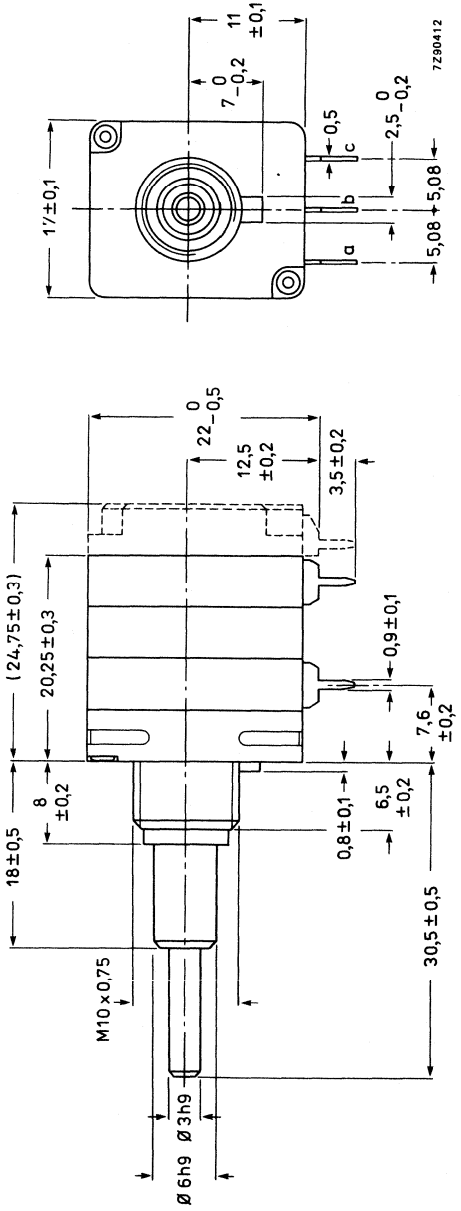
Table for R_{nom}

R \ law	linear	logarithmic*	rev. logarithmic*	log. with tap*
220 Ω	02	–	–	–
470 Ω	03	–	–	–
1 kΩ	04	–	–	–
2,2 kΩ	05	25	45	–
4,7 kΩ	06	26	46	–
10 kΩ	07	27	47	–
22 kΩ	08	28	48	–
47 kΩ	09	29	49	–
100 kΩ	11	31	51	–
220 kΩ	12	32	52	–
470 kΩ	13	33	53	–
1 MΩ	14	–	–	–
2,2 MΩ	–	–	–	–
4,7 MΩ	–	–	–	–

* carbon only.

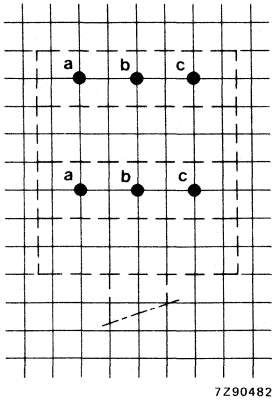
Catalogue numbers for other versions on request.

VERSIONS WITH SPINDLE, DUAL VERTICAL

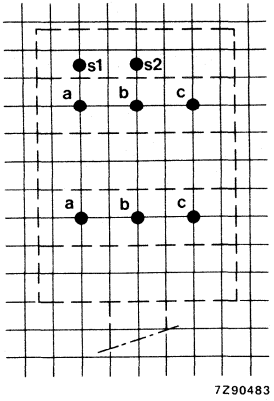


Hole patterns

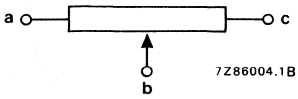
For connection to printed-wiring boards with a grid pitch of 2,54 mm, viewed from component side.
Hole diameter 1,3 ± 0,05 mm.



without switch



with switch



designation of terminals

Main properties

Climatic category (IEC 68)	carbon 25/070/10, cermet 25/070/56
Resistance range, E3 series	
carbon, linear (linearity 4%)	220 Ω to 1 MΩ, tolerance 20%
carbon, non-linear	2200 Ω to 470 kΩ, tolerance 20%
cermet, linear (linearity 4%)	220 Ω to 4,7 MΩ, tolerance 10%
Resistance law (see Fig. 19)	carbon A, B, C, H cermet A
Maximum dissipation at T_{amb} = 40 °C	
carbon, linear	0,2 + 0,2 W
carbon, non-linear	0,1 + 0,1 W
cermet, linear	1,25 + 1,25 W (metal spindle), 1 + 1 W (plastic spindle)
Test voltage for 1 minute	500 V, 50 Hz

For further information see Electrical Data, Mechanical Data and Battery Switch.

Catalogue number

On request.

BUILDING ELEMENTS FOR POTENTIOMETERS WITHOUT SPINDLE (Survey 1)

Potentiometer with flat rotor, snap-in type

To be used with snap-in actuating devices, see Fig. 6. Cannot be combined with other PP17 potentiometers and switches.

Maximum axial force	20 N
if mechanically supported, e.g. by mounting bracket	80 N

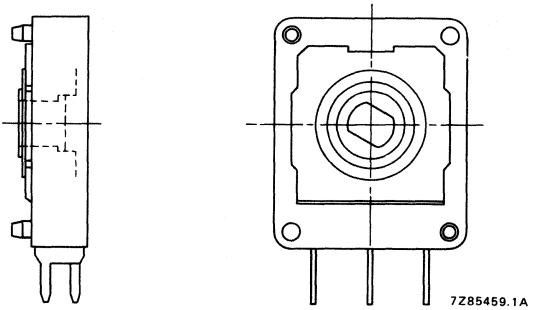


Fig. 4.

Potentiometer with protruding rotor, snap-in type

To be used with snap-in actuating devices, see Fig. 6. Can be combined with another PP17 potentiometer and/or switch.

Maximum axial force	20 N
if mechanically supported, e.g. by mounting bracket	80 N

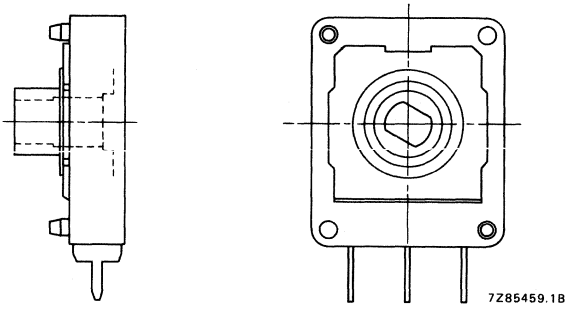


Fig. 5.

Actuating device

Figure 6 shows the snap-in part of a plastic actuating device. Actuating devices are not supplied.

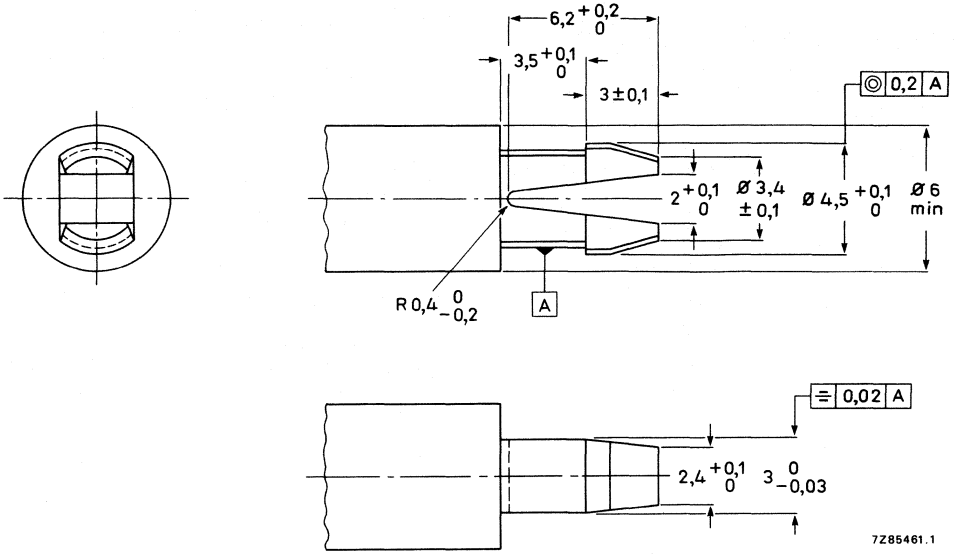


Fig. 6.

Mounting bracket

For extra stability of single vertical or tandem vertical potentiometers. Use of this bracket permits an axial force of maximum 80 N to the potentiometers opposite.

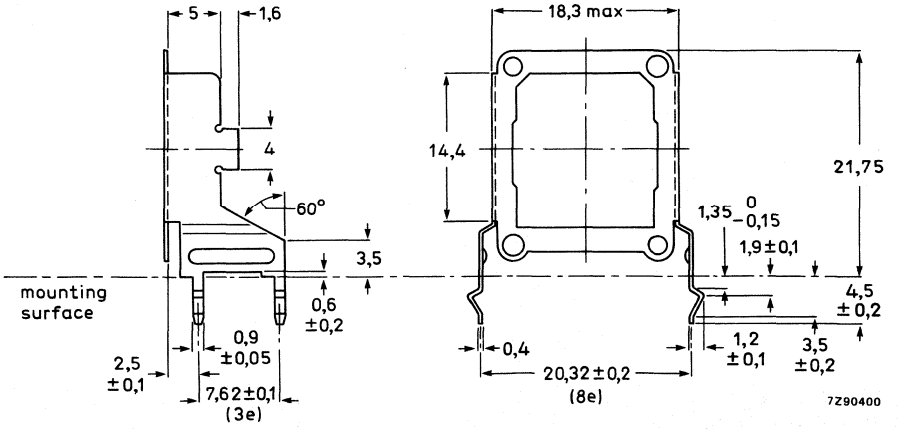


Fig. 7.

BUILDING ELEMENTS FOR POTENTIOMETERS WITH SPINDLE (Survey 2)

Potentiometer with flat rotor, slotted type

To be used with spindle as single or tandem potentiometer. Cannot be combined with a switch.

Maximum axial force 20 N

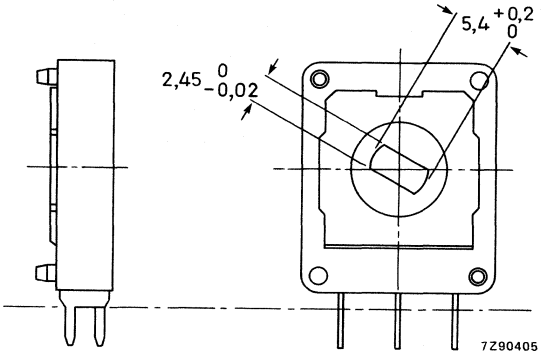


Fig. 8.

Detents

A detent spring can be mounted in the bearing bush of the spindle to provide the potentiometer with a centre detent. More detents on request.

Heatsink

Zinc heatsinks are available to increase the maximum permissible dissipation of cermet potentiometers. They can be added to single potentiometers and to both potentiometers of a tandem version.

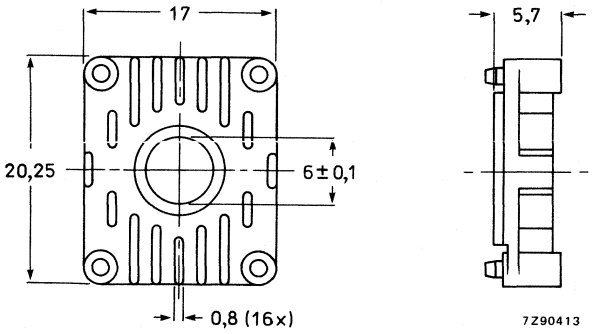
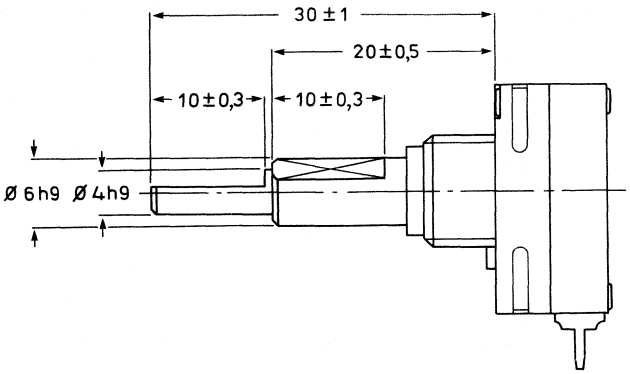


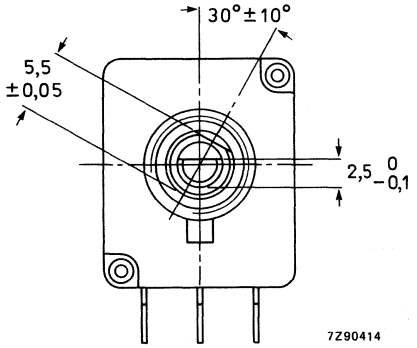
Fig. 9.

Slow-motion drive

For fine adjustment. Gear ratio 4,6: 1. (Other spindles on request.)



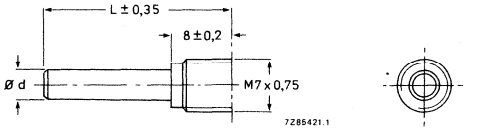
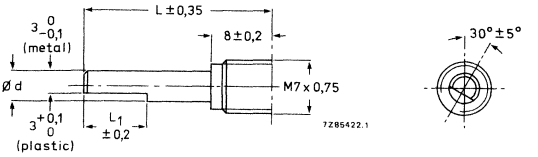
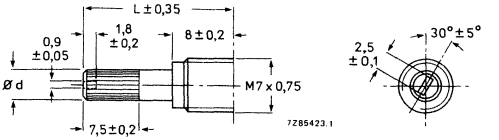
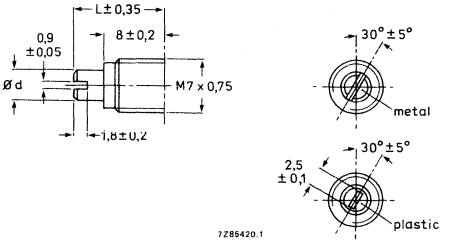
side view



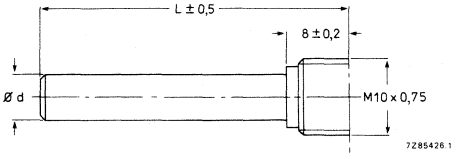
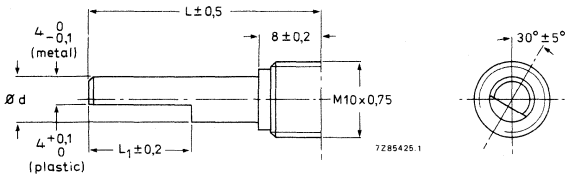
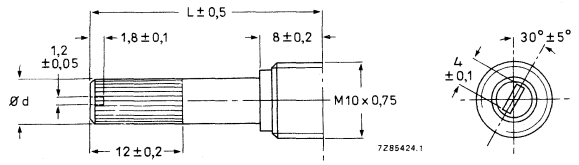
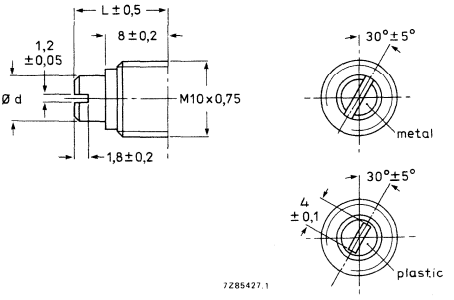
front view

Fig. 10.

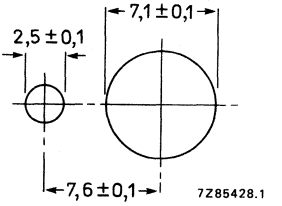
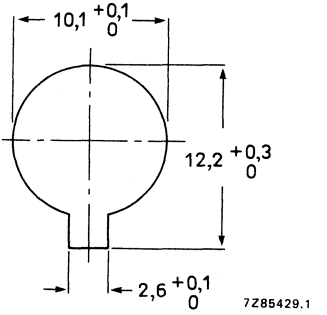
Spindles, metal or plastic, M7 bushing

CCW position	L mm	L_1 mm	d metal	d plastic
 Fig. 11a.	15		4h9	$4^{0}_{-0,1}$
	20		4h9	$4^{0}_{-0,1}$
	25		4h9	$4^{0}_{-0,1}$
	30		4h9	$4^{0}_{-0,1}$
 Fig. 11b.	15	3,0	4h9	$4^{0}_{-0,1}$
	20	7,5	4h9	$4^{0}_{-0,1}$
	25	8,5	4h9	$4^{0}_{-0,1}$
	30	8,5	4h9	$4^{0}_{-0,1}$
 Fig. 11c.	20			$4^{0}_{-0,1}$
 Fig. 11d.	12		4h9	$4^{0}_{-0,1}$

Spindles, metal or plastic, M10 bushing

CCW position	L mm	L_1 mm	d metal	d plastic
	20		6h9	$6_{-0,1}^{0}$
	30		6h9	$6_{-0,1}^{0}$
	40		6h9	$6_{-0,1}^{0}$
	60		6h9	$6_{-0,1}^{0}$
Fig. 12a.				
	20	7,5	6h9	$6_{-0,1}^{0}$
	30	13,5	6h9	$6_{-0,1}^{0}$
	60	13,5	6h9	$6_{-0,1}^{0}$
Fig. 12b.				
	30			$6_{-0,1}^{0}$
Fig. 12c.				
	12		6h9	$6_{-0,1}^{0}$
Fig. 12d.				

Mounting holes for potentiometers with spindle

for single and tandem potentiometers	required mounting holes in chassis	fixing of potentiometer
with mounting bush M7 x 0,75 mm	 Fig. 13.	with supplied mounting nut; max. torque for tightening = 1 Nm; minimum thickness of mounting plate = 1 mm
with mounting bush M10 x 0,75 mm	 Fig. 14.	with supplied mounting nut; max. torque for tightening = 3,5 Nm; minimum thickness of mounting plate = 1 mm

BUILDING ELEMENTS FOR POTENTIOMETERS WITHOUT SPINDLE (Survey 1) AND WITH SPINDLE (Survey 2)

Battery switch (s.p.s.t.)

Operating torque, initial	25 to 75 mNm
Mechanical endurance	⩾ 16 000 cycles
D.C. voltage/current rating	14,4 V/3,5 A
Test voltage	
initial	500 V d.c. for 1 minute
after 21 days humidity test IEC 68-C	100 V d.c. for 1 minute
Contact resistance	
initial	⩽ 20 mΩ
after 16 000 cycles (under load)	⩽ 50 mΩ
Insulation resistance, between switch contacts, and between interconnected contacts and housing	
initial	⩾ 100 MΩ
after 21 days humidity test IEC 68-C	⩾ 2 MΩ

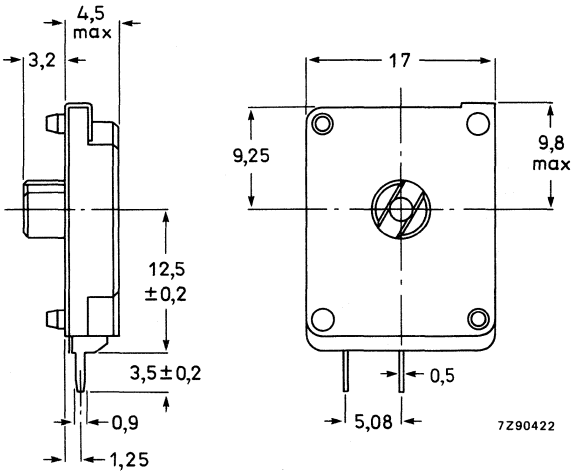


Fig. 15.

Metal shield

For the suppression of hum, crosstalk and noise. Provided with earth tag. Can be mounted at the rear of the potentiometers. Material: finished steel. Potentiometers with a switch do not need this shield (the switch already has one).

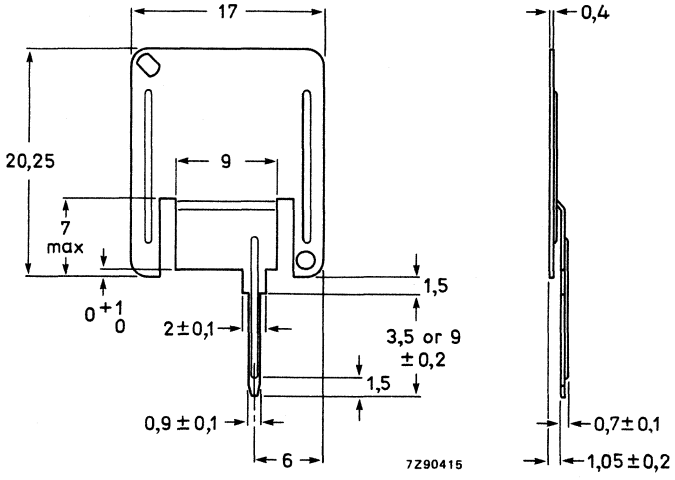


Fig. 16.

Plastic cover

Can be mounted at the rear of the potentiometer. Use is necessary if a test voltage of 1000 V a.c. must be withstood for 1 minute.

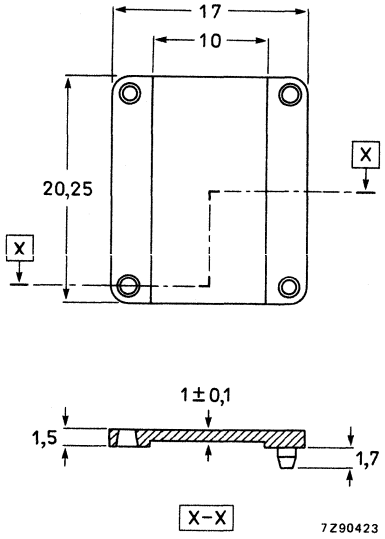
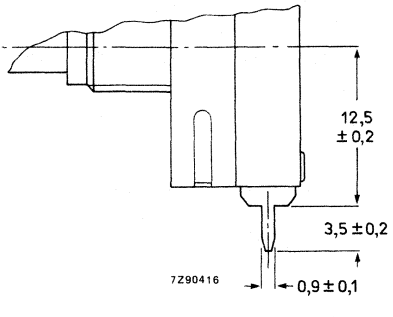
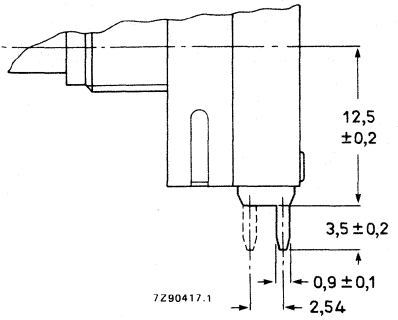
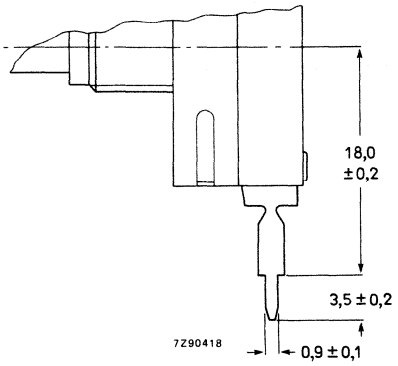


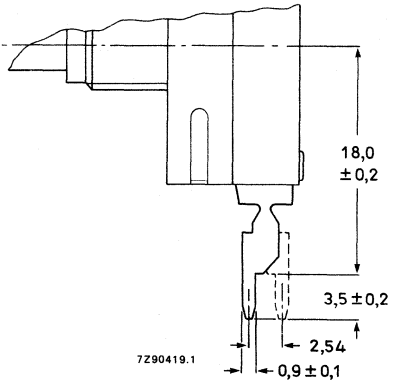
Fig. 17.

Terminals









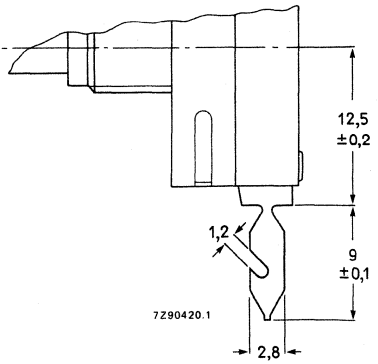


Fig. 18.

ELECTRICAL DATA

Unless otherwise specified, all values are valid at an ambient temperature of 18 to 22 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75%.

For measuring and test methods, see IEC publications 393-1 and 68. The terms used are explained in the Glossary of terms.

	carbon		cermet
Resistance range, E3 series*			
potentiometers without spindle			
linear law	220 Ω to 1 MΩ (4,7 MΩ)		220 Ω to 4,7 MΩ
logarithmic law	2200 Ω (1000 Ω to 470 kΩ (2,2 MΩ)		–
potentiometers with spindle			
linear law	220 Ω to 1 MΩ (4,7 MΩ)		220 Ω to 4,7 MΩ
logarithmic law	2200 Ω (1000 Ω) to 470 kΩ (2,2 MΩ)		–
Tolerance on resistance	± 20%**		± 10%
Resistance law and tolerances (see Fig. 19)	type A, B, C, H		type A
Ganging tolerance (tandem potentiometers)	standard	special	
linear law			
at values between 10 and 90% of R_{total}	< 2 dB		
(reversed) logarithmic law			
at attenuations between 0 and 20 dB	< 2 dB		
at attenuations between 20 and 40 dB	< 3 dB		
at attenuations between 40 and 60 dB	< 4 dB		
with a tap at 10% of R_{total}, tap load 1% of R_{total}			
at attenuations between 0 and 20 dB	< 2 dB	< 2 dB	
at attenuations between 20 and 40 dB	< 3 dB	< 3 dB	
at attenuations between 40 and 60 dB	< 4 dB	< 3 dB	
at attenuations between 60 and 70 dB	< 6 dB	< 3 dB	
at attenuations between 70 and 80 dB	< 8 dB	< 8 dB	
Terminal resistance, (residual)	⩽ 2% of R_n or 10 Ω		⩽ 1% of R_n or 10 Ω
Resistance at the tap	⩽ 1,5% or R_n or 10 Ω		
Contact resistance moving, initially,			
linear law	⩽ 4% of R_{ac}		⩽ 2,5% of R_{ac}
logarithmic law	⩽ 8% of R_{ac}		–
Contact resistance variation (CRV),			
(acc. to IEC 393-1, sub. clause 4.17) initially,			
linear law	⩽ 1%		⩽ 1% of R_{ac}
logarithmic law	⩽ 2%		–
Temperature coefficient of resistance	± 500 x 10^{-6}/K		± 100 x 10^{-4}
Insulation resistance			
after damp heat test	after 21 days		after 56 days
(IEC 68, test C)	> 100 MΩ		> 100 MΩ

* Future values between brackets.

** 10% on request.

	carbon	cermet
Maximum attenuation		
$R_{tot} \geqslant 22$ kΩ, logarithmic law	⩾ 90 dB	
$R_{tot} < 22$ kΩ, logarithmic law	⩾ 75 dB	
$R_{tot} < 22$ kΩ, linear law	⩾ 55 dB	⩾ 60 dB
Maximum dissipation at T_{amb} = 40 °C (P_{max})*		
linear law	0,2 W	1,25 W **
logarithmic law	0,1 W	
linear law, using a heatsink		3 W **
Limiting element voltage		
500 V d.c. or 350 V a.c. never to be exceeded	$\sqrt{P_{max} \times R}$	$\sqrt{P_{max} \times R}$
Limiting slider current	$\sqrt{P_{max}/R}$	$\sqrt{P_{max}/R}$
Test voltage for 1 minute	500 V, 50 Hz	500 V, 50 Hz
with cover	1000 V, 50 Hz	1000 V, 50 Hz
Working temperature range		
versions without spindle	−25 to + 70 °C	−25 to + 70 °C
versions with spindle	−25 to + 70 °C	−40 to + 125 °C
Storage temperature range		
without switch, versions without spindle	−55 to + 100 °C	−55 to + 100 °C
without switch, versions with spindle		−55 to + 125 °C
with switch	−40 to + 85 °C	
Climatic category (IEC 68)		
versions without spindle	25/070/10	25/070/56
versions with metal spindle	25/070/10	40/125/56
versions with plastic spindle	25/070/10	26/070/56

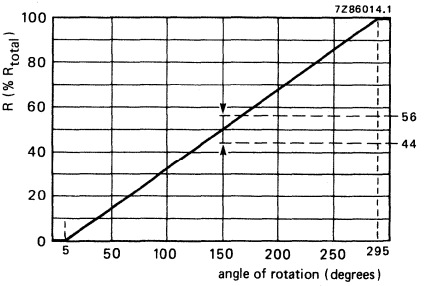
ENVIRONMENTAL TESTS

tests	requirements		
		carbon	cermet
Climatic sequence	$\Delta R_{ac}/R_{ac}$	⩽ 10%	⩽ 2%
Damp heat, steady state			
$R \leqslant 100$ kΩ	$\Delta R_{ac}/R_{ac}$	⩽ 15%	⩽ 2%
$R > 100$ kΩ		⩽ 20%	⩽ 2%
Mechanical endurance			
25 000 cycles	$\Delta R_{ac}/R_{ac}$	⩽ 10%	⩽ 2%
Electrical endurance			
1000 h at 70 °C, cyclic	$\Delta R_{ac}/R_{ac}$	⩽ 10%	⩽ 2%
Resistance to soldering heat			
(IEC 68-2, test T)	$\Delta R_{ac}/R_{ac}$	⩽ 2%	⩽ 1%
Change of temperature	$\Delta R_{ac}/R_{ac}$	⩽ 3%	⩽ 1%
	$\Delta V_{ab}/V_{ac}$	⩽ 1%	⩽ 0,5%
Bump and vibration	$\Delta R_{ac}/R_{ac}$	⩽ 2%	⩽ 0,5%
	$\Delta V_{ab}/V_{ac}$	⩽ 1%	⩽ 0,5%

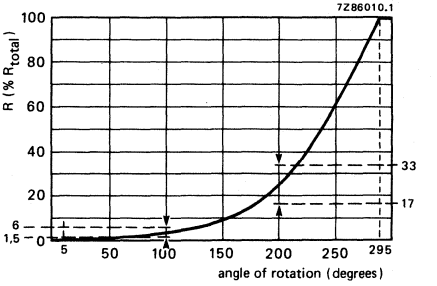
* For derating see Fig. 20.

** For versions with metal spindle. The max. dissipation of cermet types with plastic spindle is 1 W (lin. law) and 2 W (lin. law with heatsink).

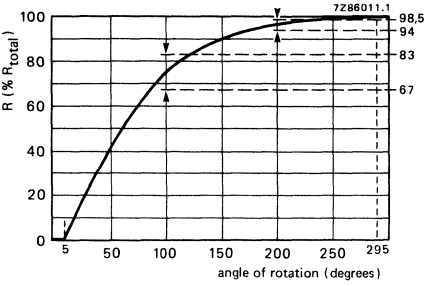
Characteristics of potentiometers without switch



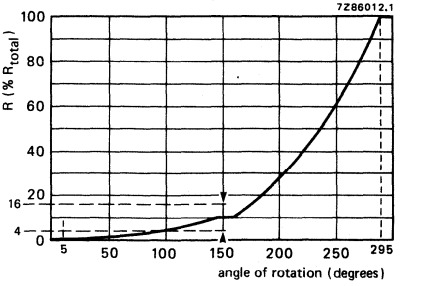
Type A
Fig. 19a Linear law.



Type B
Fig. 19b Logarithmic law.



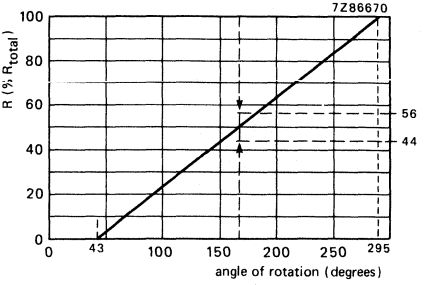
Type C
Fig. 19c Reversed logarithmic law.



Type H
Fig. 19d Logarithmic law, tap at 10%.

Characteristics of potentiometers with switch

The curves of Fig. 19a to d have to be adapted since the effective angle of rotation is from 43° to 295°. An example for linear law is given in Fig. 19e.



Type A
Fig. 19e Linear law.

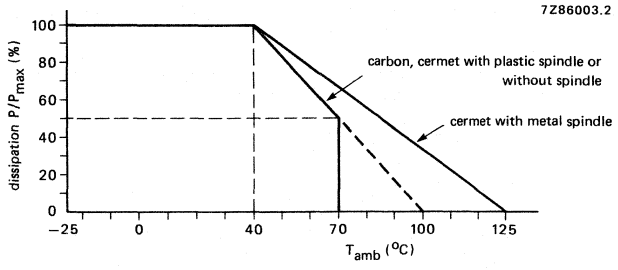


Fig. 20 Maximum permissible dissipation as a function of ambient temperature.

MARKING

The potentiometers are marked according to IEC62 as follows:
- nominal resistance (in RKM code)
- resistance law
- code for year and month of manufacture.

MECHANICAL DATA

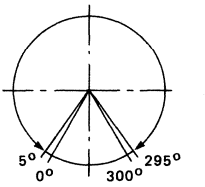
	versions without spindle		versions with spindle		
	single duo	tandem	single duo	tandem	unit
Max. axial force	80*	80*	100	100	N
Operating torque initial	4 to 16	4 to 20	5 to 20	5 to 30	mNm
Operating torque of switch	25 to 75	25 to 75	25 to 75	25 to 75	mNm
Max. permissible end-stop torque	600	600	4ϕ: 600 6ϕ: 800	4ϕ: 600 6ϕ: 800	mNm mNm
Angle of rotation	300 ± 2	300 ± 2	300 ± 2	300 ± 2	deg
Effective angle of rotation with switch	290 ± 2,5 252 ± 2,5	290 ± 2,5 252 ± 2,5	290 ± 2,5 252 ± 2,5	290 ± 2,5 252 ± 2,5	deg deg
Axial rotor/spindle play	⩽0,2	⩽0,2	⩽0,3	⩽0,3	mm
Radial rotor/spindle play	⩽0,2	⩽0,2	⩽0,1 per 10 mm	⩽0,1 per 10 mm	mm

Angle of rotation

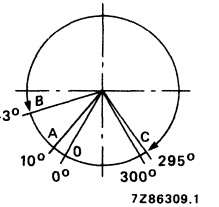
1. Types without switch
   total mechanical angle 0° to 300°
   effective R-angle 5° to 295°
   For performance see Fig. 21a

2. Types with switch
   total mechanical angle 0° to 300°
   O to A; radial spindle play in "off" position (c.c.w.) 10° max.
   O to B; switch angle 43° max.
   B to C; effective R-angle 43° to 295°
   For performance see Fig. 21b

a



b



7Z86309.1

MOUNTING

The potentiometers with printed-wiring terminals are intended for p.c. board mounting with a grid pitch of 1e (2,54 mm). The holes in the board should be 1,3 ± 0,5 mm; the board thickness not over 2 mm. Potentiometers with bushing should be mounted as described in Figs 13 and 14.

* If not supported: 20 N.

NOTES

23 mm CERMET POTENTIOMETERS

QUICK REFERENCE DATA

Resistance range (E3 series), linear law	220 Ω to 22 MΩ
Maximum dissipation at 40 °C	5 W
Climatic category, IEC 68	55/125/56

APPLICATION

These potentiometers are for control functions where high dissipation and high stability are necessary, e.g. in industrial control functions.

DESCRIPTION

These potentiometers have a metal-glaze resistive element on a ceramic base. The actuating device is an isolated rotor with a multiple wiper, operated by a metal spindle. For applications, up to 70 °C, potentiometers with a plastic spindle are also available. The resistance element is shielded by a metal housing. The bushing is profiled to act as a heatsink.

The terminals a and c (see Fig. 1) are the end terminals; b is the central terminal connected to the slider. All terminals are either solder tags (also suitable for snap-on connection), or printed wiring pins.

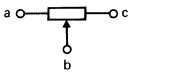


Fig. 1.

MOUNTING

The potentiometers can be mounted on a panel with a hexagonal nut which is supplied with each potentiometer (catalogue number of nut 4322 047 00350). The maximum tightening torque is 3,5 Nm.

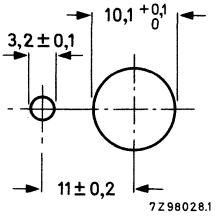


Fig. 2.

MARKING

The potentiometers are marked with:
- nominal resistance (in RKM code according to IEC 62)
- resistance law (LIN)
- code for period and year of manufacture.

Outline drawings Dimensions in mm

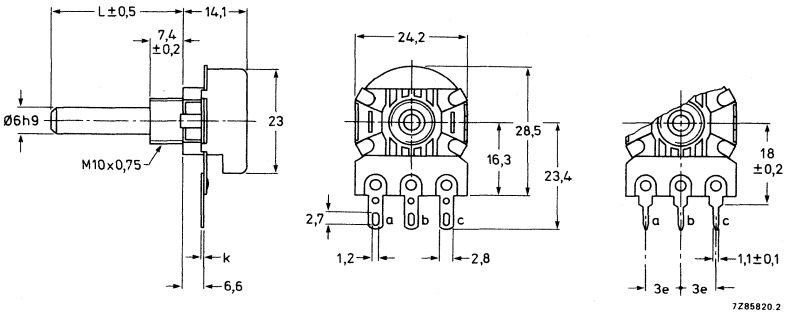


Fig. 3.

Dimension L: 18, 30 or 60
Dimension k:
(thickness of terminal) 0,4 for print and solder tags
0,8 for faston connection

TECHNICAL DATA

Unless otherwise specified, all values have been determined at an ambient temperature of 15 to 35 °C, an atmospheric pressure of 96 to 106 kPa and a relative humidity of 45 to 75%.

Resistance range (E3 series), linear law	220 Ω to 22 MΩ
Tolerance on nominal resistance	± 10%
Resistance law, see Fig. 4	
Maximum dissipation at 40 °C (P_{max})	5 W
Test voltage between interconnected terminals and chassis during 1 minute, a.c. or d.c.	1000 V
Rated element voltage	$\sqrt{P_{max} \cdot R_{nom}}$
Insulation resistance after damp heat test IEC 68, c 56 days	$\geqslant 10^5$ MΩ
Temperature coefficient	$\leqslant 100 \cdot 10^{-6}$/K
CRM (contact resistance moving), initial	$\leqslant$ 4% of R_{ac}
after life test	$\leqslant$ 6% of R_{ac}
CRV (contact resistance variation), initial	$\leqslant$ 2% of R_{ac}
after life test	$\leqslant$ 2% of R_{ac}
Climatic category according to IEC 68-2	
metal spindle	55/125/56
plastic spindle	25/70/56
Operating torque (max./min. $\leqslant$ 2)	3 to 20 mNm
Permissible end-stop torque	$\leqslant$ 800 mNm
Permissible axial spindle load	$\leqslant$ 100 N
Effective angle of rotation	270° ± 2°
Mechanical angle of rotation	300° ± 5°
Rotational life	25 000 cycles

RESISTANCE

Potentiometers covered by this specification are linear, see Fig. 4.

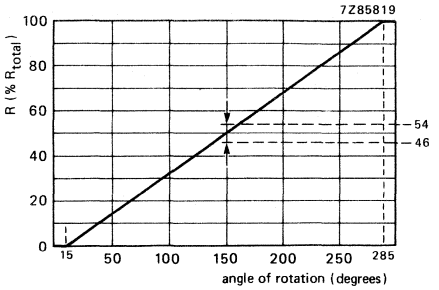


Fig. 4.

DERATING

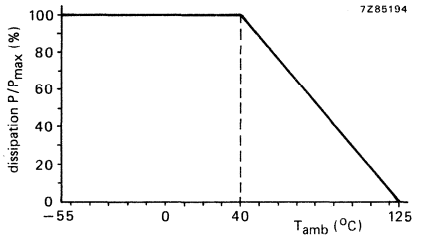


Fig. 5.

COMPOSITION OF THE CATALOGUE NUMBER

2322 481 . . . .

code for terminals and spindle material

0 = solder tags, metal spindle
1 = p.w. tags, metal spindle
2 = faston tags, metal spindle
7 = solder tags, plastic spindle
6 = p.w. tags, plastic spindle
5 = faston tags, plastic spindle

code for spindle length

06 = 18 mm length
03 = 30 mm length
07 = 60 mm length

code for nominal resistance

02 = 220 Ω	11 = 100 kΩ
03 = 470 Ω	12 = 220 kΩ
04 = 1 kΩ	13 = 470 kΩ
05 = 2,2 kΩ	14 = 1 MΩ
06 = 4,7 kΩ	15 = 2,2 MΩ
07 = 10 kΩ	16 = 47 MΩ
08 = 22 kΩ	17 = 10 MΩ
09 = 47 kΩ	18 = 22 MΩ

25 mm SLIDE CARBON POTENTIOMETERS

QUICK REFERENCE DATA

Nominal resistance, E3 series	
linear law	100 Ω – 4,7 MΩ
logarithmic law	1 kΩ – 2,2 MΩ
Maximum dissipation at 40 °C	
linear law	0,2 W
logarithmic law	0,1 W
Climatic category, IEC 68	25/070/21

APPLICATION

These potentiometers are particularly suitable for audio, television, monitors and semi-industrial applications.

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 slider contact is adjusted by means of a knob, which moves along a silvered spindle. Two types of slider knob are available. The potentiometers are available with linear or logarithmic resistance law.
The elements are provided with an external screening shield which is either black coated (shield without printed-wiring tags) or tin plated (shield with printed-wiring tags).

The terminals a and c (see Fig. 1) are the end terminals; b is the central terminal connected to the slider. All terminals are suited for mounting on printed-wiring boards.

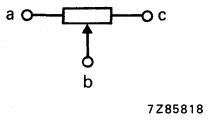


Fig. 1 Terminal allocations.

Outlines

Dimensions in mm

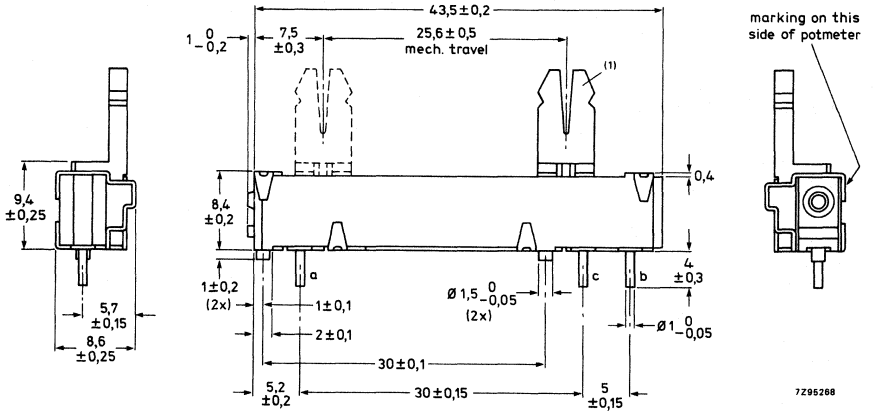


Fig. 2 Version with black coated shield without p.w. tags.

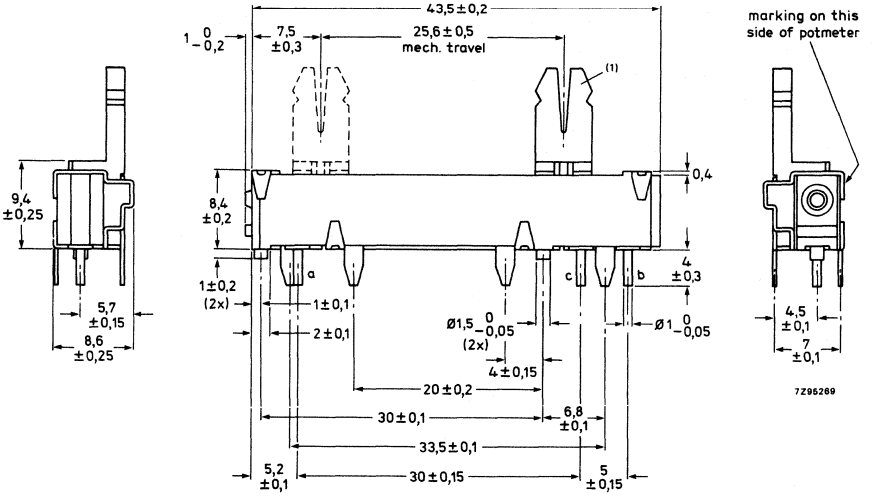


Fig. 3 Version with tin-plated shield with p.w. tags.

* For dimensions see types of slider knobs, Figs 5 and 6.

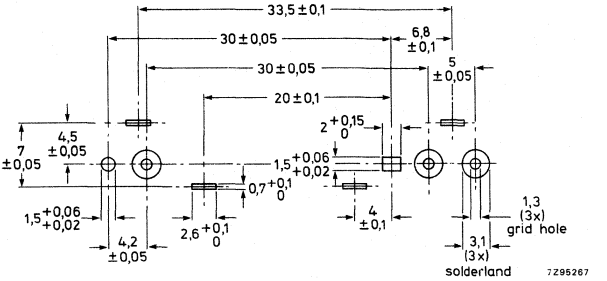


Fig. 4 Hole pattern in the printed-wiring board, viewed from the component side. The 4 oblong holes 2,6 x 0,7 are required for the accomodation of the p.w. tags of the tin plated shield, see Fig. 3.

Types of slider knobs

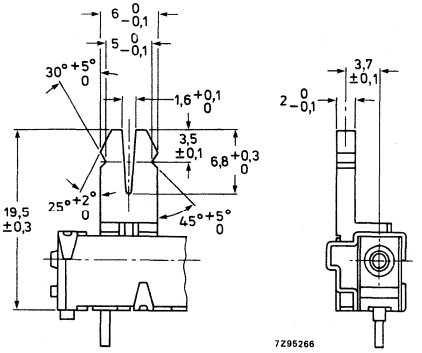


Fig. 5 Dimensions of long slider knob.

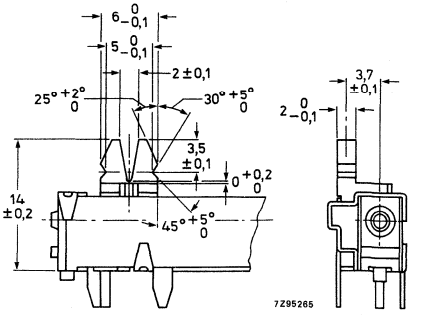


Fig. 6 Dimensions of short slider knob.

TECHNICAL DATA

Unless stated otherwise, all electrical values have been determined at an ambient temperature of 15 to 35 °C, an air pressure of 86 to 106 kPa and a relative humidity of 45 to 75%.

Table 1 Linear resistance law

nominal resistance R_{nom}	maximum terminal resistance measured between terminals b and a or b and c	maximum attenuation dB
100 Ω	10 Ω	20
220 Ω	20 Ω	20
470 Ω	35 Ω	30
1 Ω	50 Ω	30
2,2 kΩ	100 Ω	40
4,7 kΩ	200 Ω	40
10 kΩ	300 Ω	40
22 kΩ	600 Ω	50
47 kΩ	1 kΩ	50
100 kΩ	2 kΩ	50
220 kΩ	3,5 kΩ	60
470 kΩ	6 kΩ	60
1 MΩ	10 kΩ	70
2,2 MΩ	20 kΩ	70
4,7 kΩ	50 kΩ	70

Table 2 Logarithmic resistance law

nominal resistance R_{nom}	maximum terminal resistance measured between terminals		maximum attenuation dB
	b and a	b and c	
1 kΩ	10 Ω	150 Ω	40
2,2 kΩ	20 Ω	250 Ω	50
4,7 kΩ	35 Ω	500 Ω	50
10 kΩ	50 Ω	1 kΩ	50
22 kΩ	100 Ω	1,5 kΩ	60
47 kΩ	200 Ω	2,5 kΩ	60
100 kΩ	250 Ω	5 kΩ	60
220 kΩ	500 Ω	7,5 kΩ	70
470 kΩ	1 kΩ	15 kΩ	70
1 MΩ	2 kΩ	30 kΩ	80
2,2 MΩ	5 kΩ	60 kΩ	80

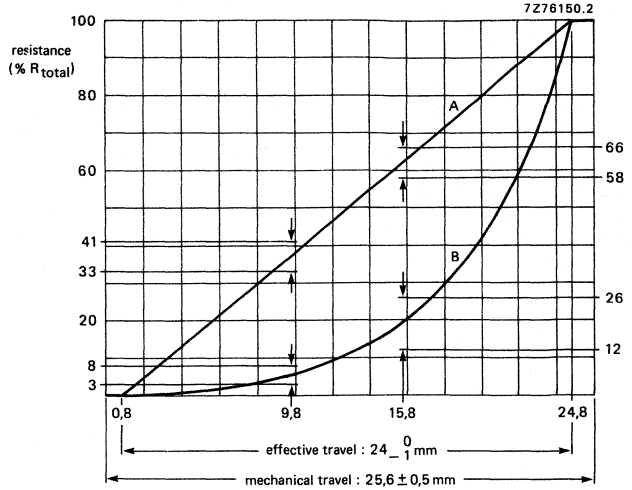


Fig. 7 Resistance as a function of slider displacement.
curve A = linear law;
curve B = logarithmic law.

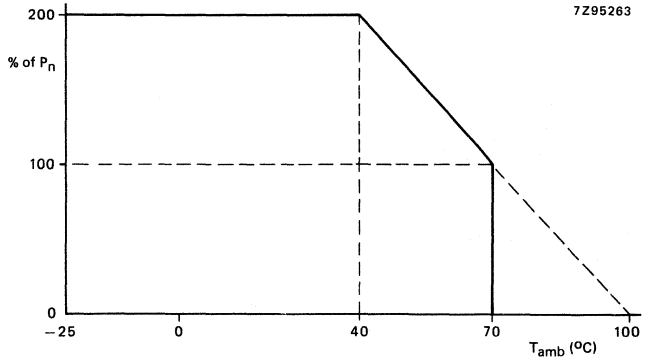


Fig. 8 Derating curve.

	linear law	logarithmic law
T_{amb} = 40°	P_{max} = 0,2 W	P_{max} = 0,1 W
T_{amb} = 70°	P_{max} = 0,1 W	P_{max} = 0,05 W

Resistance range, E3 series, see Fig. 7	
linear law	100 Ω to 4,7 MΩ
logarithmic law	1 kΩ to 2,2 MΩ
Tolerance on nominal resistance, see Fig. 7	± 20%
Terminal resistance	see Tables 1 and 2
Temperature coefficient, −25 °C to + 70 °C	-500 to $+ 500 \cdot 10^{-6}$/K
Maximum dissipation (P_{max}), see Fig. 8	
linear law, at 40 °C	0,2 W
linear law, at 70 °C	0,1 W
logarithmic law at 40 °C	0,1 W
logarithmic law at 70 °C	0,05 W
Climatic category, (IEC 68)	25/070/21
Storage temperature range	−55 °C to + 70 °C
Operating force (F)	0,75 to 2,5 N ($\frac{F_{max}}{F_{min}} \leqslant 2$)
Permissible force with slider at end stop*	⩽ 30 N
Permissible load perpendicual to the direction of movement*	⩽ 10 N
Permissible axial force on slider (push and pull)*	⩽ 20 N
Effective travel of slider contact	24 − 1 mm
Mechanical travel of slider contact	25,6 ± 0,5 mm
Life	5000 x in both directions

MOUNTING

The terminals may be dip-soldered to a depth of 2 mm max. in a solder bath of 260 °C max. for 4 s max.

When a soldering bit is used, its temperature must not exceed 360 °C for 1,5 s and neither axial nor radial stress must be exerted on the terminals.

MARKING

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

* Measured for 5 s, 5 mm above centre of potentiometer.

ENVIRONMENTAL TESTS

tests	requirements	
Climatic sequence	$\Delta R_{ac}/R_{ac}$	$\leqslant 15\%$
Damp heat, steady state	$\Delta R_{ac}/R_{ac}$	$\leqslant 15\%$
Mechanical endurance	$\Delta R_{ac}/R_{ac}$	$\leqslant 10\%$
Electrical endurance 1000 h at 70 °C, cyclic	$\Delta R_{ac}/R_{ac}$	$\leqslant 10\%$
Resistance to soldering heat (IEC 68-2, test T)	$\Delta R_{ac}/R_{ac}$	$\leqslant 3\%$
Change of temperature	$\Delta R_{ac}/R_{ac}$	$\leqslant 5\%$
Bump and vibration	$\Delta R_{ac}/R_{ac}$	$\leqslant 3\%$

COMPOSITION OF THE CATALOGUE NUMBER

2322 415 . . . . .

code for slider

6 = long (Fig. 5)

7 = short (Fig. 6)

code for shield

11 = black coated; without p.w. tags (Fig. 2)

22 = tin coated; with p.w. tags (Fig. 3)

code for nominal resistance

nominal resistance	linear law	logarithmic 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
220 kΩ	12	32
470 kΩ	13	33
1 MΩ	14	34
2,2 MΩ	15	35

40 mm SLIDE CARBON POTENTIOMETERS

QUICK REFERENCE DATA

Nominal resistance	
linear law	220 Ω – 4,7 MΩ
logarithmic and reversed logarithmic law	1 kΩ–2,2 MΩ
Maximum dissipation at 40 °C	
linear law	0,25 W
logarithmic and reversed logarithmic law	0,125 W
Climatic category (IEC 68)	10/070/21

DESCRIPTION

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

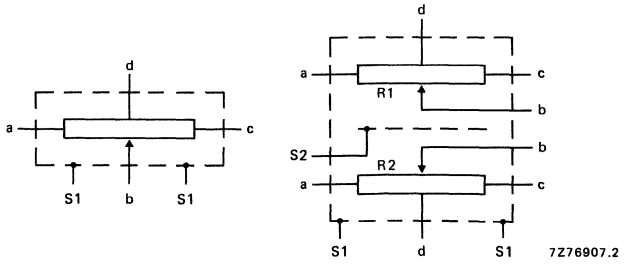
The single potentiometers have a straight carbon track on a resin bonded paper base plate mounted in a black synthetic resin housing.

The tandem potentiometers have two carbon tracks opposite each other on resin bonded paper base plates.

The terminals are connected as shown below. The potentiometers can be supplied without taps or with a tap at 50% of the total travel.

Both types of potentiometer are available with or without metal screening on the outer surface of the housing to provide protection against interference. The tandem potentiometers can also be supplied with a metal screen between the two carbon tracks to prevent crosstalk.

The potentiometers are available with a variety of connecting terminals and adjustment provisions. Detent slide potentiometers (11 click, 31 click and centre click) can be supplied to special order.



Single type Tandem type

Fig. 1 Terminal allocations.

MECHANICAL DATA

Dimensions in mm

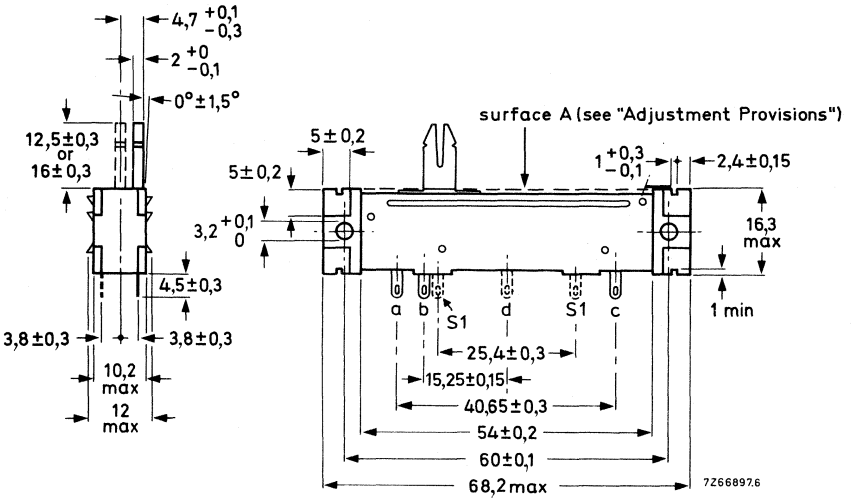


Fig. 2 Single slide potentiometer with solder tags.

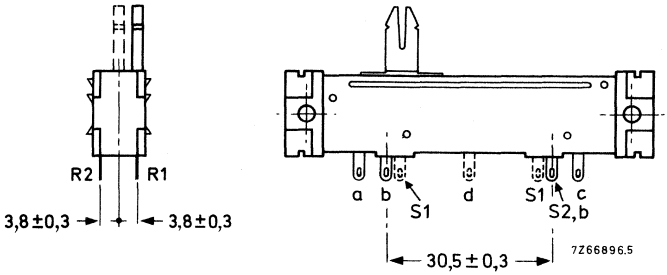


Fig. 3 Tandem slide potentiometer with solder tags.

Dimensions are identical with those in Fig. 2 except as shown.
The side on which potentiometer R1 is situated is indicated by a mark at the beginning of R1.

Mounting

Use two type 4N Parker self-tapping screws (according to UN-B1005 or UN-B1023, minimum thread length 8 mm) in the two holes spaced 80 mm apart.

Maximum tightening torque: 500 mNm. Minimum stripping torque: 700 mNm.

Connecting terminals

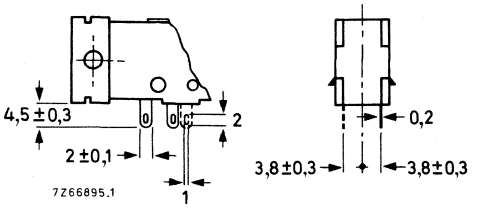


Fig. 4 Solder tags.

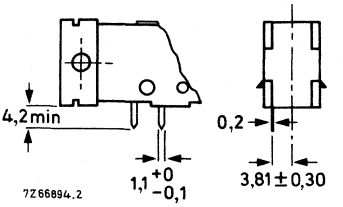


Fig. 5 Printed-wiring pins.

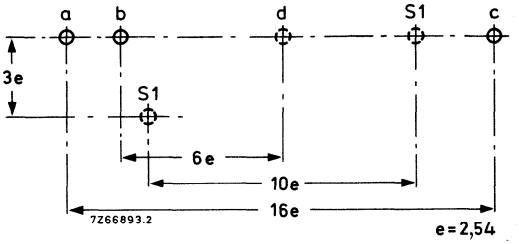


Fig. 6 Hole pattern in the printed-wiring board for a single potentiometer (viewed on component side).

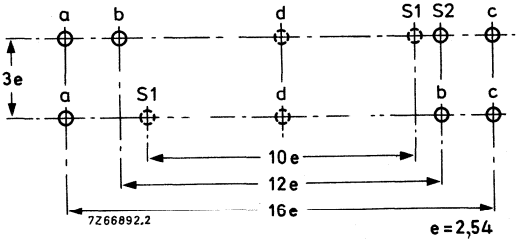


Fig. 7 Hole pattern in the printed-wiring board for a tandem potentiometer (viewed on component side).

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

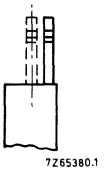


Fig. 8 End view of potentiometer with symmetrically (dotted lines) and asymmetrically placed adjustment slider.

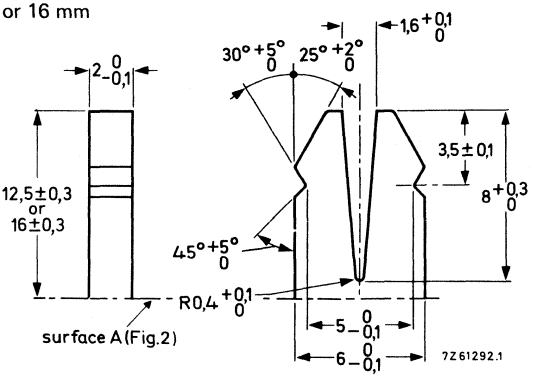


Fig. 9 Adjustment slider.

TECHNICAL DATA

Unless stated otherwise, all electrical values have been determined at an ambient temperature of 15 to 35 °C, an air pressure of 86 to 106 kPa and a relative humidity of 45 to 75%.

Linear resistance law according to Fig. 10; either without or with tap at 50%.

nom. resist. R_{nom}	max. voltage (V)		max. terminal resistance	max. attenuation dB	max. contact resistance $\%R_{nom}$	limiting slider current at 40 °C mA
	at 40 °C	at 70 °C				
220 Ω	7,4	5,2	10 Ω	–	3	33
470 Ω	11	7,7	10 Ω	–	3	23
1 kΩ	16	11	25 Ω	–	3	16
2,2 kΩ	23	16	25 Ω	–	3	10
4,7 kΩ	34	24	25 Ω	–	2,5	7,2
10 kΩ	50	35	35 Ω	–	2,5	5
22 kΩ	74	52	35 Ω	–	2,5	3,3
47 kΩ	108	77	35 Ω	–	2,5	2,3
100 kΩ	158	112	100 Ω	–	2,5	1,6
220 kΩ	234	166	125 Ω	–	2,5	1,0
470 kΩ	342	242	250 Ω	–	2,5	0,72
1 MΩ	500	354	1 kΩ	–	2,5	0,50
2,2 MΩ	500	500	2,2 kΩ	–	2,5	0,33
4,7 MΩ	500	500	4,7 kΩ	–	2,5	0,23

Logarithmic resistance law according to Figs 11 and 12; without or with tap at 50%.

nom. resist R_{nom}	max. voltage (V)		max. terminal resistance	max. attenuation dB	max. contact resistance $\%R_{nom}$	limiting slider current at 40 °C mA
	at 40 °C	at 70 °C				
1 kΩ	11	7,9	25 Ω	50	4	11
2,2 kΩ	16	12	25 Ω	60	4	7,3
4,7 kΩ	24	17	25 Ω	60	4	5,1
10 kΩ	35	25	35 Ω	60	4	3,5
22 kΩ	52	37	35 Ω	70	4	2,4
47 kΩ	77	54	35 Ω	70	4	1,6
100 kΩ	112	79	50 Ω	80	4	1,1
220 kΩ	166	117	50 Ω	80	4	0,73
470 kΩ	242	170	100 Ω	80	4	0,51
1 MΩ	354	250	500 Ω	80	4	0,35
2,2 MΩ	500	370	500 Ω	80	4	0,24

Rev. logarithmic resistance law according to Fig. 13, without tap

nom. resist R_{nom}	max. voltage (V)		max. terminal resistance	max. attenuation dB	max. contact resistance $\%R_{nom}$	limiting slider current at 40 °C mA
	at 40 °C	at 70 °C				
1 kΩ	11	7,9	100 Ω	50	4	11
2,2 kΩ	16	12	100 Ω	60	4	7,3
4,7 kΩ	24	17	100 Ω	60	4	5,1
10 kΩ	35	25	250 Ω	60	4	3,5
22 kΩ	52	37	250 Ω	70	4	2,4
47 kΩ	77	54	500 Ω	70	4	1,6
100 kΩ	112	79	2,5 kΩ	80	4	1,1
220 kΩ	166	117	2,5 kΩ	80	4	0,73
470 kΩ	242	170	5 kΩ	80	4	0,51
1 MΩ	354	250	25 kΩ	80	4	0,35
2,2 MΩ	500	370	25 kΩ	80	4	0,24

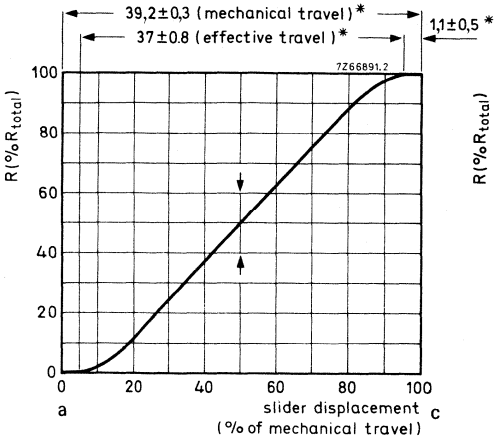


Fig. 10 Linear law; without tap.

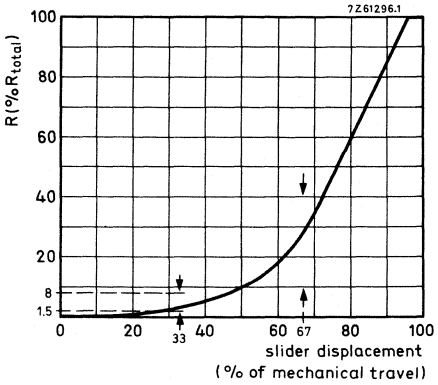


Fig. 11 Logarithmic law; without tap.

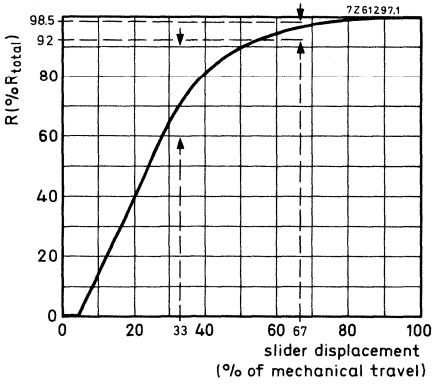


Fig. 12 Logarithmic law; tap at 50%.

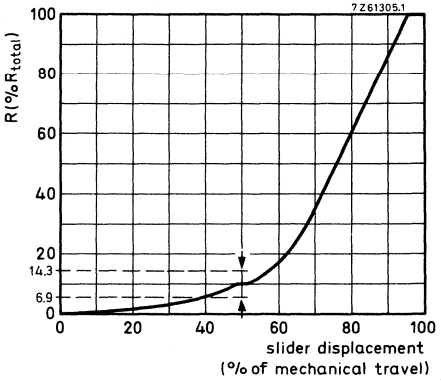


Fig. 13 Reversed logarithmic law, without tap.

* Valid for all graphs.

Resistance law	linear, logarithmic and reversed logarithmic, see Figs 10 to 13, (other laws on request)
Tolerance on nominal resistance	± 20%
Minimum resistance at the tap	$\leqslant 10\ \Omega$
Insulation resistance (versions with external screening), initially	$> 10^4\ M\Omega$
Maximum dissipation (P_{max})	
linear law, at 40 °C	0,25 W
linear law, at 70 °C	0,125 W
logarithmic and reversed logarithmic 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
Climatic category (IEC 68)	10/070/21
Operating force (F) *	
single potentiometers	0,75 – 2 N
tandem potentiometers	1,25 – 2,5 N
	$\frac{F_{max}}{F_{min}} \leqslant 1,3$
Permissible force with slider at end stop *	$\leqslant$ 50 N (Fig. 14)
Permissible load perpendicular to the direction of movement *	$\leqslant$ 20 N (Fig. 15)
Permissible torque on slider *	$\leqslant$ 0,3 Nm (Fig. 16)
Permissible axial force on slider (push and pull) *	$\leqslant$ 50 N

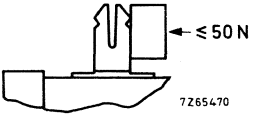


Fig. 14

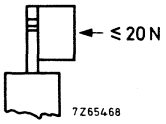


Fig. 15

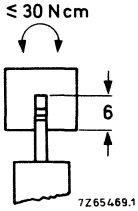


Fig. 16

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

* Measured for 5 s on a free slider without knob.

Ganging tolerance*

Linear law, without tap, at values between 10 and 90% of R_{tot}	< 2 dB
Linear law, with tap, at values between 10 and 90% of R_{tot}	< 3 dB
Logarithmic and reversed logarithmic 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 and reversed logarithmic 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

Crosstalk* (measured according to Fig. 17)

	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

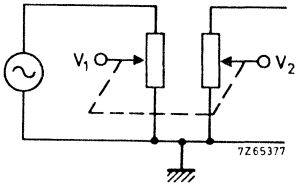


Fig. 17 Crosstalk = $20 \log \frac{V_1}{V_2}$.

MARKING

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

* For tandem potentiometers only.

AVAILABLE VERSIONS AND COMPOSITION OF THE CATALOGUE NUMBER

2322 43 . . . . .

code for type and screw-mounting facility

0 = single, without screw-mounting facility
1 = single, with screw-mounting facility
5 = tandem, without screw-mounting facility
6 = tandem, with screw-mounting facility

code for resistance law and nominal resistance, see table below

code for tap
0 = without tap
2 = tap at 50%

code for screening and terminals

screening:	solder tags	p.w. pins
without	0	5
internal *	1	6
internal and external *	2	7
external	3	8

code for adjustment provision

0 = asymmetrically placed
1 = symmetrically placed
} length 12,5 mm

2 = asymmetrically placed
3 = symmetrically placed
} length 16 mm

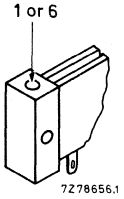


Fig. 18.

Note

Detent slide potentiometers (11 click-, 21 click- and centre - click types) can be supplied on request.

nominal resistance	code in catalogue number		
	linear law	log. law	reversed log. law
220 Ω	02		
470 Ω	03		
1 kΩ	04	24	
2,2 kΩ	05	25	45
4,7 kΩ	06	26	46
10 kΩ	07	27	47
22 kΩ	08	28	48
47 kΩ	09	29	49
100 kΩ	11	31	51
220 kΩ	12	32	52
470 kΩ	13	33	53
1 MΩ	14	34	54
2,2 MΩ	15	35	55
4,7 MΩ	16		

* For tandem potentiometers only.

60 mm SLIDE CARBON POTENTIOMETERS

QUICK REFERENCE DATA

Nominal resistance	
linear law	220 Ω – 10 MΩ
logarithmic and reversed logarithmic law	1 kΩ – 4,7 MΩ
Maximum dissipation at 40 °C	
linear law	0,4 W
logarithmic and reversed logarithmic law	0,2 W
Category (IEC 68)	10/070/21

DESCRIPTION

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

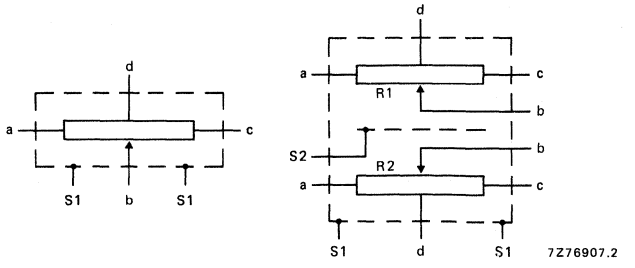
The single potentiometers have a straight carbon track on a resin bonded paper base plate mounted in a black synthetic resin housing.

The tandem potentiometers have two carbon tracks opposite each other on resin bonded paper base plates.

The terminals are connected as shown below. The potentiometers can be supplied without taps or a tap at 50% of the total travel.

Both types of potentiometer are available with or without metal screening on the outer surface of the housing to provide protection against interference. The tandem potentiometers can also be supplied with a metal screen between the two carbon tracks to prevent crosstalk.

The potentiometers are available with a variety of connecting terminals and adjustment provisions. Detent slide potentiometers (11 click, 31 click and centre click) can be supplied to special order.



Single type Tandem type 2

Fig. 1 Terminal allocations.

MECHANICAL DATA

Dimensions in mm

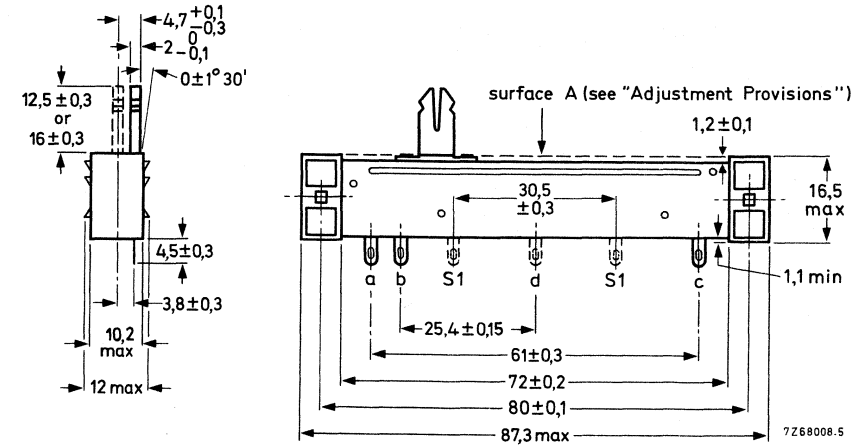


Fig. 2 Single slide potentiometer with solder tags.

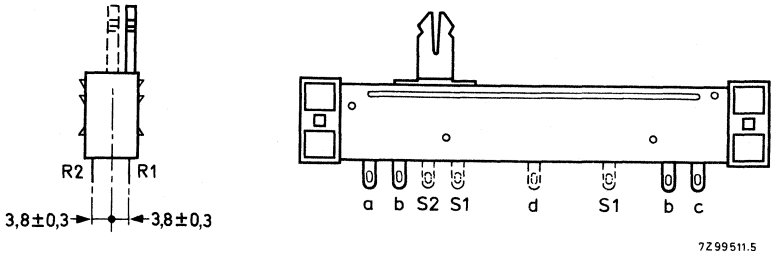


Fig. 3 Tandem slide potentiometer with solder tags.

Dimensions are identical with those in Fig. 2 except as shown.
The side on which potentiometer R1 is situated is indicated by a mark at the beginning of R1.

Mounting

Use two type 4N Parker self-tapping screws (according to UN-B1005 or UN-B1023, minimum thread length 8 mm) in the two holes spaced 80 mm apart.

Maximum tightening torque: 500 mNm. Minimum stripping torque: 700 mNm.

Connecting terminals

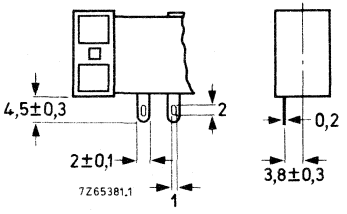


Fig. 4 Solder tags.

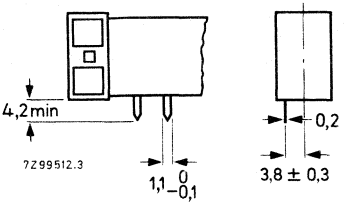


Fig. 5 Printed-wiring pins.

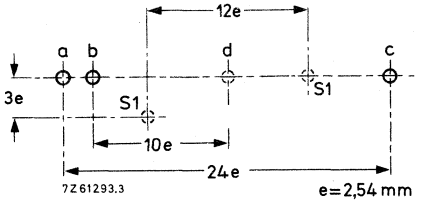


Fig. 6 Hole pattern in the printed-wiring board for a single potentiometer (viewed on component side).

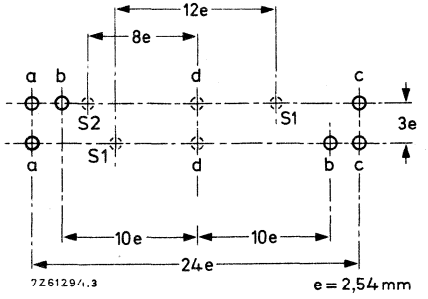


Fig. 7 Hole pattern in the printed-wiring board for a tandem potentiometer (viewed on component side).

Adjustment provisions

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

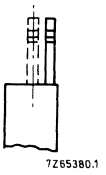


Fig. 8 End view of potentiometer with symmetrically (dotted lines) and asymmetrically positioned adjustment slider.

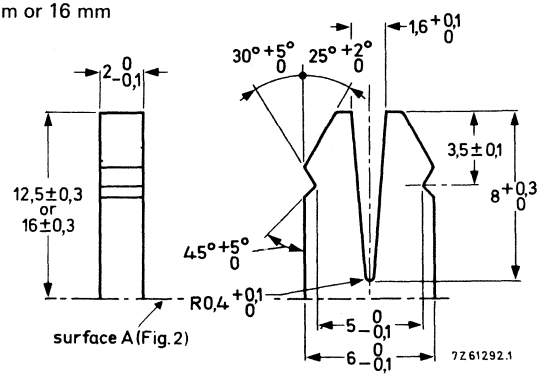


Fig. 9 Adjustment slider.

TECHNICAL DATA

Unless stated otherwise, all electrical values have been determined at an ambient temperature of 15 to 35 °C, an air pressure of 86 to 106 kPa and a relative humidity of 45 to 75%.

Linear resistance law according to Fig. 10; either without or with tap at 50%.

nom. resist. R_{nom}	max. voltage (V)		max. terminal resistance	max. attenuation dB	max. contact resistance $\%R_{nom}$	limiting slider current at 40 °C mA
	at 40 °C	at 70 °C				
220 Ω	9,3	7,4	10 Ω	–	3	40
470 Ω	14	11	10 Ω	–	3	22
1 kΩ	20	16	25 Ω	–	3	16
2,2 kΩ	30	23	25 Ω	–	3	11
4,7 kΩ	41	34	25 Ω	–	2	7
10 kΩ	63	50	35 Ω	–	2	5
22 kΩ	93	74	35 Ω	–	2	3,5
47 kΩ	137	108	35 Ω	–	2	2,2
100 kΩ	200	158	100 Ω	–	2	1,4
220 kΩ	296	234	125 Ω	–	2	1,0
470 kΩ	410	342	250 Ω	–	2	0,65
1 MΩ	500	500	1 kΩ	–	2	0,45
2,2 MΩ	500	500	2,2 kΩ	–	2	0,32
4,7 MΩ	500	500	4,7 kΩ	–	2	0,22
10 MΩ	500	500	10 kΩ	–	2	0,16

Logarithmic resistance law according to Figs 11 and 12; without or with tap at 50%.

nom. resist. R_{nom}	max. voltage (V)		max. terminal resistance	max. attenuation dB dB	max. contact resistance $\%R_{nom}$	limiting slider current at 40 °C mA
	at 40 °C	at 70 °C				
1 kΩ	14	11	25 Ω	50	4	10
2,2 kΩ	21	16	25 Ω	60	4	7
4,7 kΩ	31	24	25 Ω	60	4	4,5
10 kΩ	45	35	35 Ω	60	4	3,2
22 kΩ	66	52	35 Ω	70	4	2,2
47 kΩ	97	77	35 Ω	70	4	1,4
100 kΩ	141	112	50 Ω	80	4	1,0
220 kΩ	210	166	50 Ω	80	4	0,7
470 kΩ	310	242	100 Ω	80	4	0,45
1 MΩ	447	354	500 Ω	80	4	0,32
2,2 MΩ	500	500	500 Ω	80	4	0,22
4,7 MΩ	500	500	1 kΩ	80	4	0,14

Rev. logarithmic resistance law according to Fig. 13, without tap.

nom. resist R_{nom}	max. voltage (V)		max. terminal resistance	max. attenuation dB	max. contact resistance $\%R_{nom}$	limiting slider current at 40 °C mA
	at 40 °C	at 70 °C				
1 kΩ	14	11	100 Ω	50	4	10
2,2 kΩ	21	16	100 Ω	60	4	7
4,7 kΩ	31	24	100 Ω	60	4	4,5
10 kΩ	45	35	250 Ω	60	4	3,2
22 kΩ	66	52	250 Ω	70	4	2,2
47 kΩ	97	77	500 Ω	70	4	1,4
100 kΩ	141	112	2,5 kΩ	80	4	1,0
220 kΩ	210	166	2,5 kΩ	80	4	0,7
470 kΩ	310	242	5 kΩ	80	4	0,45
1 MΩ	447	354	25 kΩ	80	4	0,32
2,2 MΩ	500	500	25 kΩ	80	4	0,22
4,7 MΩ	500	500	50 kΩ	80	4	0,14

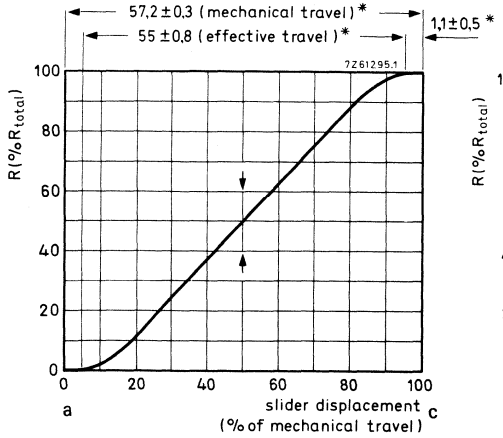


Fig. 10 Linear law; without tap.

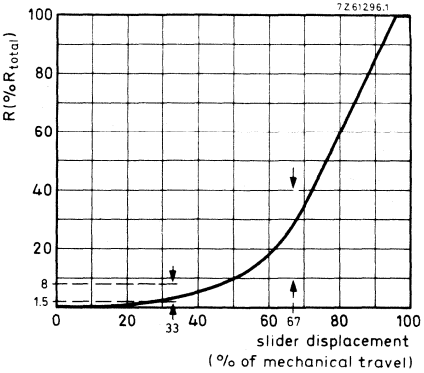


Fig. 11 Logarithmic law, without tap.

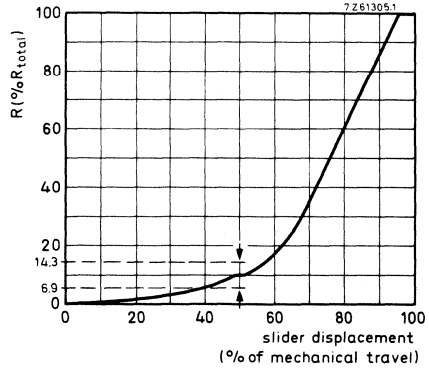


Fig. 12 Logarithmic law; tap at 50 %.

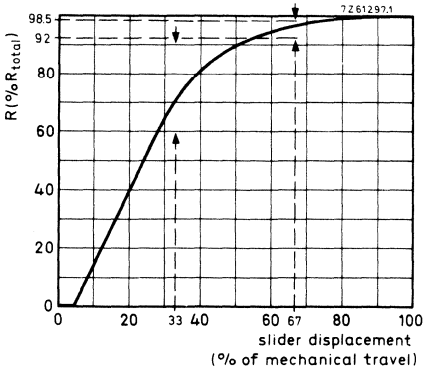


Fig. 13 Reversed logarithmic law; without tap.

* Valid for all graphs.

Resistance law	linear, logarithmic and reversed logarithmic, see Figs 10 to 13, (other laws on request)
Tolerance on nominal resistance	± 20%
Minimum resistance between the slider and the tap(s) when aligned	⩽ 10 Ω
Insulation resistance (versions with external screening), initially	> 10^4 MΩ
Maximum dissipation (P_{max})	
linear law, at 40 °C	0,4 W
at 70 °C	0,25 W
logarithmic and reversed logarithmic 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)	
single potentiometers	0,75 – 2 N $\frac{F_{max}}{F_{min}} \leqslant 1,5$
tandem potentiometers	1,25 – 2,5 N
Permissible force with slider at end stop *	⩽ 50 N (Fig. 14)
Permissible load perpendicular to the direction of movement *	⩽ 20 N (Fig. 15)
Permissible torque on slider *	⩽ 0,3 Nm (Fig. 16)
Permissible axial force on slider (push and pull) *	⩽ 50 N

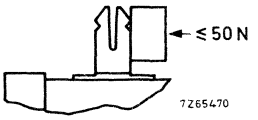


Fig. 14.

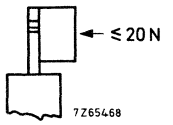


Fig. 15.

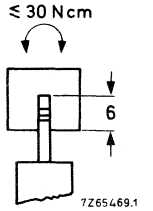


Fig. 16

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

* Measured for 5 s on a free slider without knob.

Ganging tolerance *

Linear law, without tap, at values between 10 and 90% of R_{tot}	< 2 dB
Linear law, with tap, at values between 10 and 90% of R_{tot}	< 3 dB
Logarithmic and reversed logarithmic 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 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

Crosstalk * (measured according to Fig. 17)

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

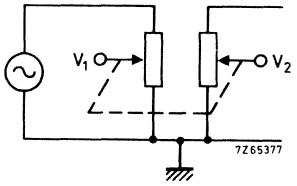


Fig. 17 Crosstalk = $20 \log \frac{V_2}{V_1}$.

MARKING

The side of the potentiometers is marked with nominal resistance, resistance law, period and year of manufacture.

* For tandem potentiometers only.

AVAILABLE VERSIONS AND COMPISITION OF THE CATALOGUE NUMBER

2322 42 . . . . . .

code for type

4 = single potentiometer
9 = tandem potentiometer

code for resistance law and nominal resistance, see table below

code for taps
0 = without taps
2 = tap at 50%

code for screening and terminals

screening:	solder tags	p.w. pins
without	0	5
internal *	1	6
internal and external *	2	7
external	3	8

code for adjustment provision

0 = asymmetrically, 1 = symmetrically — length 12,5 mm

2 = asymmetrically, 3 = symmetrically — length 16 mm

Note

Detent slide potentiometers (11 click, 31 click and centre click types) can be supplied to special order.

nominal resistance	code in catalogue number		
	linear law	log. law	reversed log. law
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
22 kΩ	08	28	48
47 kΩ	09	29	49
100 kΩ	11	31	51
220 kΩ	12	32	52
470 kΩ	13	33	53
1 MΩ	14	34	54
2,2 MΩ	15	35	55
4,7 MΩ	16	36	56
10 MΩ	17		

* For tandem potentiometers only.

LOAD POTENTIOMETERS

RZ 25706-9

QUICK REFERENCE DATA

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 diagrams on following pages) around which a resistance wire or ribbon (consult Table 1) has been wound in a single layer, over about 280° in the case of 100 W types, and over about 250° for the other types. Terminals B are fitted at each end of the wire or ribbon. With the exception of the top side of the coil, where the slider makes contact, 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 via 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 has an extra spring having a height of 2 and 3 mm, respectively.

The runner is affixed to the top of a spindle J which is supported in a sturdy bracket K by means of an insulating piece G and a central screw H. A stop prevents the runner from overrunning the track, whereby the runner is not exposed to torsion.

The protrusion N prevents the potentiometers from rotating in the fixing hole. All the metal parts are non-corrosive. The potentiometers can be ganged (see "Ganging").

Outlines

Dimensions in mm

The spindle length L is 17 or 36 mm.

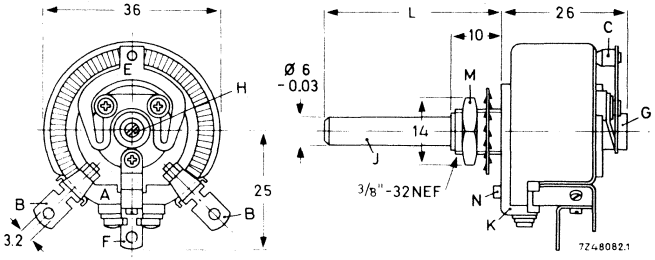


Fig. 1 Potentiometers 2322 095 .....; 1 Ω to 7,5 kΩ, 25 W.

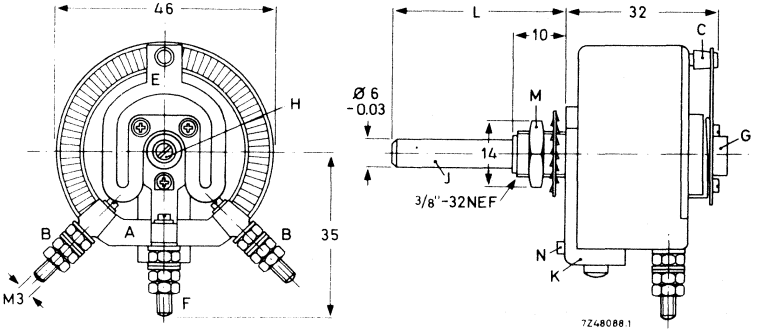


Fig. 2 Potentiometers 2322 096 .....; 0,5 Ω to 10 kΩ, 40 W.

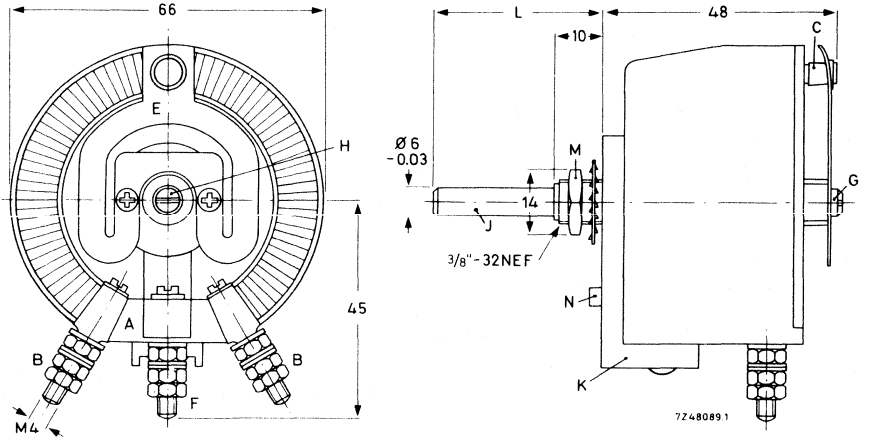
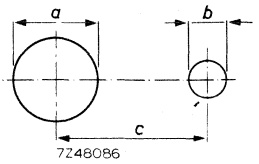


Fig. 3 Potentiometers 2322 097 .....; 0,75 Ω to 10 kΩ, 100 W.

Mounting

The potentiometers can be mounted on a panel with a maximum thickness of 5 mm or secured with a hexagonal nut which is supplied with each potentiometer (catalogue number of nut 4322 047 00380). See Fig. 4 for the required mounting holes in the panel.



type	a mm	b mm	c mm
2322 095	10,5	3,5	13,5
096	10,5	4,8	20
097	10,5	4,8	20

Fig. 4 Mounting holes

Mass

type 2322 095 60 g
2322 096 95 g
2322 097 240 g

TECHNICAL DATA

Nominal resistance (R_n) measured between terminals	
at $P \leqslant 0{,}1\ P_n$	see Table 1
Tolerance on R_n	± 10%
Resistance law	linear
Temperature coefficient of the resistance	(−140 to +140) 10^{-6}/K
Maximum permissible dissipation	
at T_{amb} = 60 °C (P_n)	see Table 1
Maximum permissible current,	
at T_{amb} = 60 °C ($I_{max} = \sqrt{\frac{P_n}{R}}$)	see Table 1
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	10 to 45 mNm
100 W type	80 to 130 mNm
End stop torque	⩽ 2 Nm
Maximum axial spindle load	1 Nm
Life at maximum current	> 50 000 cycles

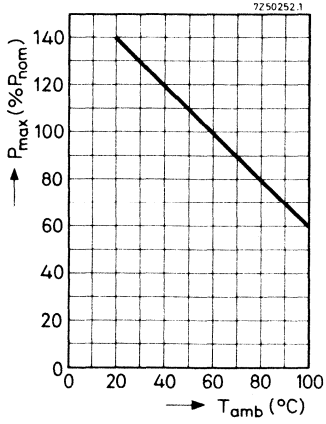

7250252.1
P_{max} (% P_{nom})
140
120
100
80
60
40
20
0
0
20
40
60
80
100
T_{amb} (°C)

Fig. 5

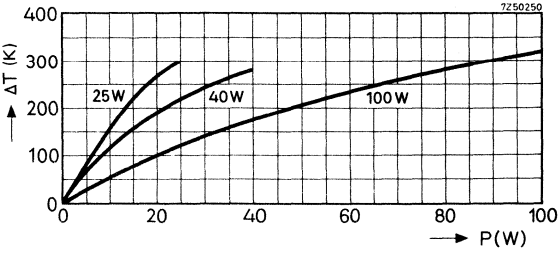

7250250
ΔT (K)
400
300
200
100
0
25W
40W
100W
0
20
40
60
80
100
P(W)

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 1

R_n Ω	P_n = 25 W		P_n = 40 W		P_n = 100 W		code in catalogue 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 are available. Catalogue numbers:

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 CATALOGUE NUMBER

2322 . . . . . .

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

code for R_n, see Table 1

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

GANGING

For ganging two load potentiometers, the following set of coupling parts is available, 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

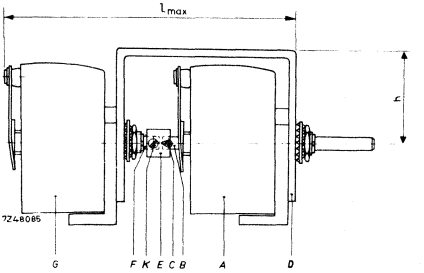


Fig. 7.

Catalogue numbers. Dimensions (Fig. 7) are:

potentiometers		catalogue 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 hexagonal 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 has two 4 mm threaded holes, which allow of fitting two screws through the mounting panel to prevent the ganged assembly from turning. The panel should be provided with apertures according to Fig. 8.

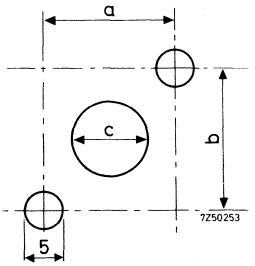


Fig. 8.

	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

WIREWOUND POTENTIOMETERS

QUICK REFERENCE DATA

Resistance range (E6-series), linear law	2,2 to 10 000 Ω
Maximum permissible dissipation at 40 °C	1,5 W
Climatic category (IEC 68)	25/085/21
Plastic housing, plastic spindle	

APPLICATION

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

DESCRIPTION

The potentiometer consists of a single layer of resistance wire wound on an insulated former and housed in a moulded plastic case, which at one end has a plastic cover plate and at the other end a press-fitted threaded metal bushing supporting the plastic spindle.

Terminals a and c (see Fig. 1) are the end terminals which are of a snap-on type; b is the central terminal which is connected to the slider through a collector ring.

The case has a locating slot for mounting purposes.

The potentiometer is dust-proof sealed.

Outlines Dimensions in mm

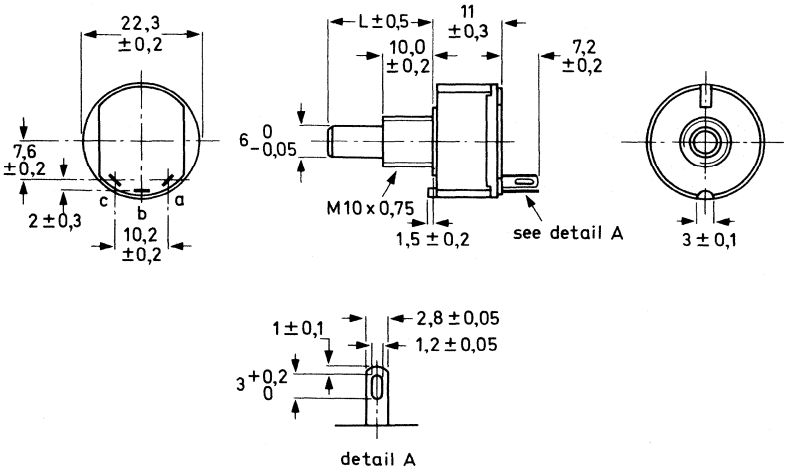


Fig. 1a Potentiometer with plain spindle; spindle length L is 17 mm, 20 mm, 30 mm or 60 mm.

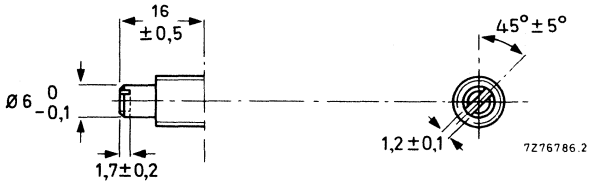


Fig. 1b Spindle with screwdriver slot; spindle fully counter-clockwise.

MOUNTING

The potentiometer can be mounted on a panel with an hexagonal nut which is supplied with the potentiometer (catalogue number of nut 4322 047 00350). The maximum torque for tightening the nut is 3,5 Nm. See Fig. 2 for the required mounting holes in the panel. A washer has to be used if the panel thickness is less than 1 mm as otherwise it might not be possible to secure the nut.

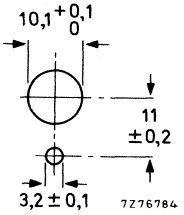


Fig. 2 Mounting holes.

TECHNICAL DATA

Unless stated otherwise, all electrical values have been determined at an ambient temperature of 15 to 25 °C, an air pressure of 93 to 106 kPa and a relative humidity of 45 to 75%.
For definitions of properties and test methods, see IEC 393–1.

Nominal resistance (R_n) between a and c	2,2 to 10 000 Ω, see Table 1
Resistance law	linear
Tolerance on R_n	±10%
Resistance at beginning and end	⩽ 2% of R_{total} or 300 mΩ whichever is greater
R gradient	0% of R_{total}
Resistance at 50% of effective angle of rotation	50 ± 2% of R_{total}
Contact resistance between resistance element and slider	⩽ 1% of R_{total} or 200 mΩ whichever is greater
Temperature coefficient	see Table 1
Maximum dissipation between a and c (Fig. 3)	
at T_{amb} = 40 °C	1,5 W
at T_{amb} = 70 °C	1,0 W
Resolution	
R_n = 2,2 to 68 Ω	< 1,5% of R_{total}
R_n > 68 Ω	< 0,8% of R_{total}
Maximum slider current	1 A
Maximum working voltage (a.c.) between case and resistance element	500 V
Test voltage (a.c.) between bearing bushing and resistance element	⩽ 2000 V
Insulation resistance	> 1000 MΩ
Ambient temperature range	−25 to +85 °C
Storage temperature range	−25 to +85 °C
Mechanical angle of rotation	270 ± 5°
Effective angle of rotation	265 ± 5°
Operating torque	3,5 to 20 mNm
Maximum end stop torque	800 mNm
Maximum axial force (push and pull)	100 N

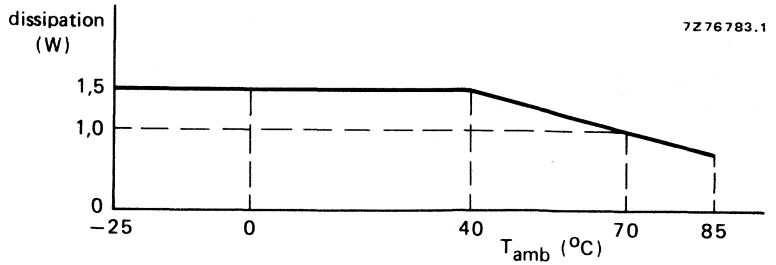


Fig.3 Dissipation as a function of ambient temperature.

Table 1

nominal resistance Ω	temperature coefficient 10^{-6}/K	number of turns ±25%	code in catalogue number
2,2		110	228
3,3		108	338
4,7		95	478
6,8		136	688
10	−25 to +600	126	109
15		194	159
22		113	229
33		134	339
47		120	479
68		172	689
100	−25 to +25	160	101
150		178	151
220		165	221
330		155	331
470		222	471
680		200	681
1 000		297	102
1 500	0 to +140	287	152
2 200		420	222
3 300		398	332
4 700		408	472
6 800	−20 to + 20	366	682
10 000		538	103

MARKING

The potentiometers are marked at the rear with nominal resistance value (according to IEC 62), resistance tolerance, power rating, production code (period and year) and name of manufacturer.

COMPOSITION OF THE CATALOGUE NUMBER

2322 018 . 1 . . .

figure indicating the spindle type
0 = slotted spindle
2 = plain spindle, L = 17 mm
3 = plain spindle, L = 20 mm
4 = plain spindle, L = 30 mm
5 = plain spindle, L = 60 mm
see Fig.1a

code for resistance value, see Table 1

figure indicating the tolerance of ±10%

TESTS AND REQUIREMENTS

IEC 393–1 test method	name of test	procedure (quick reference)	requirements
Ta	Solderability	235 ± 2 °C, 2 s.	95% of surface.
Tb (method 1B)	Resistance to soldering heat	350 °C, 3,5 s.	No damage; $\Delta R_{tot}/R_{tot} \leqslant 2\%$.
Na	Rapid change of temperature	5 cycles of ½ h at −25 °C and ½ h at +85 °C.	$\Delta R_{tot}/R_{tot} \leqslant 3\%$.
Fc	Vibration	10 to 55 Hz, 10g, 3 directions, 2 h per direction.	$\Delta R_{tot}/R_{tot} \leqslant 2\%$. 2%. No interruptions $> 100\ \mu s$.
Ba, D, Aa	Climatic sequence	16 h at 85 °C. 24 h at 55 °C, R.H. 95 to 100%. 2 h at −25 °C. 24 h at 55 °C, R.H. 95 to 100%. 1 h reconditioning at 25 °C	No damage; $R_{min} \leqslant 2\%\ R_{tot}$; $\Delta R_{tot}/R_{tot} \leqslant 5\%$. Insulation resistance $> 100M\Omega$. Test voltage for 1 min is 2000 V (a.c.). Continuity of resistance (after 4 cycles): $\Delta V/V < ^{+7\%}_{-5\%}$.
Ca	Damp heat	21 days at 40 °C, R.H. 90 to 95%.	
	Endurance	1000 h at 70 °C, 1,5 W loaded, 1,5 h in and 0,5 h out.	$\Delta R_{tot}/R_{tot} \leqslant 5\%$. Continuity of resistance (after 4 cycles): $\Delta V/V < ^{+7\%}_{-5\%}$.
	Mechanical endurance	15 000 cycles ($R_n \leqslant 4{,}7\ k\Omega$) or 10 000 cycles ($R_n > 4{,}7\ k\Omega$), 90% of effective angle of rotation; unloaded.	$\Delta R_{tot}/R_{tot} \leqslant 5\%$. Continuity of resistance (after 4 cycles): $\Delta V/V < ^{+7\%}_{-5\%}$.
	Inflammability		Self-extinguishing within 15 s after removal from the flame.

WIREWOUND POTENTIOMETERS

QUICK REFERENCE DATA

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

APPLICATION

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

CONSTRUCTION

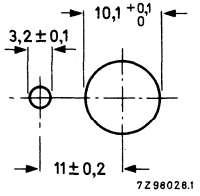
The potentiometer consists of a single layer of resistance wire wound on a strip of resin-bonded paper and is housed in a nickel-plated brass case with a bottom of black synthetic resin.

The solder tags a and c (see Figs 1 to 4) are connected to the ends of the resistance element: solder tag b 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 has a location pip, an end stop, and a threaded spindle bush.

The whole unit is sealed dust-proof.

Mounting



The potentiometers can be mounted on a panel by means of an hexagonal nut which is supplied with each potentiometers (catalogue number of the nut 4322 047 00350). The minimum thickness of the chassis is 1 mm. The maximum torque for tightening is 3,5 Nm.

Outlines

Dimensions in mm

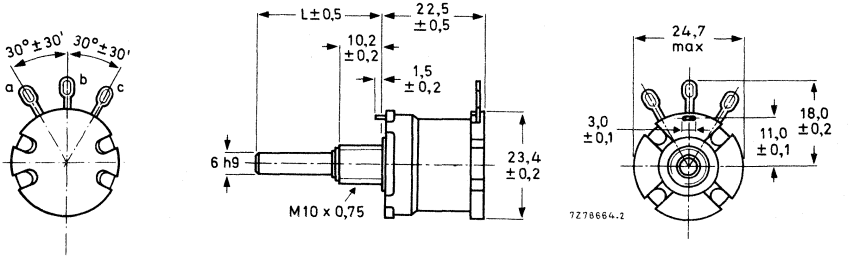


Fig. 1 Potentiometers 2322 003 . . . . . with plain spindle. The spindle length L is 17, 20, 30 or 60 mm.

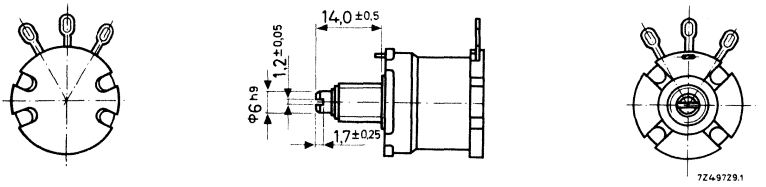


Fig. 2 Potentiometers 2322 003 . . . . . with spindle with screwdriver slot. Dimensions are identical to those in Fig. 1 except as shown.

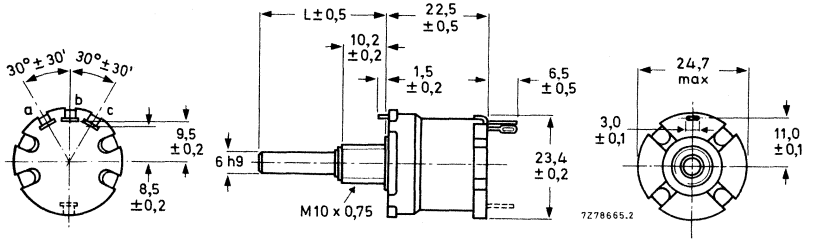


Fig. 3 Potentiometers 2322 010 . . . . . with plain spindle. The spindle length L is 17, 20, 30 or 60 mm.

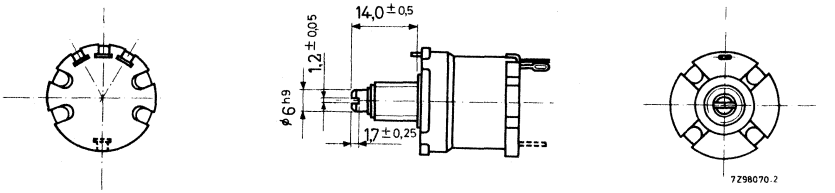


Fig. 4 Potentiometers 2322 010 . . . . . with spindle with screwdriver slot. Dimensions are identical to those in Fig. 3 except as shown.

TECHNICAL DATA

Unless otherwise specified all values apply at an ambient temperature of 20 ± 5 °C, an atmospheric pressure of 93 to 106 kPa and a relative humidity of 45 to 75%.

Nominal resistance (R_n), measured between the tags a and c (see Figs 1 and 3)	see Table 1
Tolerance on the nominal resistance	
for $R_n \leqslant 47\ \Omega$	± 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. 5
Temperature coefficient of the resistance	see Table
Insulation resistance	> 1000 MΩ
Test voltage between spindle and tags for 1 mm	1000 V
Maximum working voltage between resistance element and case	500 V peak
Working temperature range	−10 to +85 °C
Climatic category, IEC 68	10/085/21
Number of windings	see Table 1
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 $R_n \leqslant 6{,}8$ kΩ	in excess of 25 000 cycles
for $R_n > 6{,}8$ kΩ	in excess of 10 000 cycles

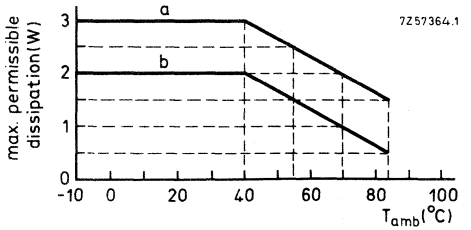


Fig. 5 Maximum permissible dissipation as a function of the ambient temperature.
Curve a: for potentiometers mounted on a metal chassis of 100 mm x 100 x 1 mm.
Curve b: for potentiometers mounted on an insulating panel.

COMPOSITION OF THE CATALOGUE NUMBER

2322 0 . . . . . .

style
03 = potentiometer with solder tags at the side
10 = potentiometer with solder tags at the bottom

spindle type
0 = slotted spindle
2 = plain spindle; length 17 mm
3 = plain spindle; length 20 mm
4 = plain spindle; length 30 mm
5 = plain spindle; length 60 mm

tolerance and tap
1 = ± 10%
2 = ± 5% ($R_n > 47\ \Omega$)
6 = ± 10%, with tap at 50%
7 = ± 5% ($R_n > 47\ \Omega$) with tap at 5%

code for resistance, see Table 1

Table 1

resistance Ω	temperature coefficient 10^{-6}/K	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

WIREWOUND POTENTIOMETERS

QUICK REFERENCE DATA

Resistance range (E6-series), linear law	2,2 to 10 000 Ω
Maximum permissible dissipation at 40 °C	2 W
Climatic category (IEC 68)	25/085/21
Metal housing, metal spindle	

APPLICATION

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

DESCRIPTION

The potentiometer consists of a single layer of resistance wire wound on an insulated former and is housed in a metal case which at one end has a plastic cover plate and at the other end a moulded zinc plate with integral threaded bushing and locating pip. The threaded bushing supports the spindle.

Terminals a and c (see Fig. 1) are the end terminals which are of a snap-on type; b is the central terminal which is connected to the slider through a collector ring and is insulated from the spindle.

The potentiometer is dust-proof sealed.

Outlines

Dimensions in mm

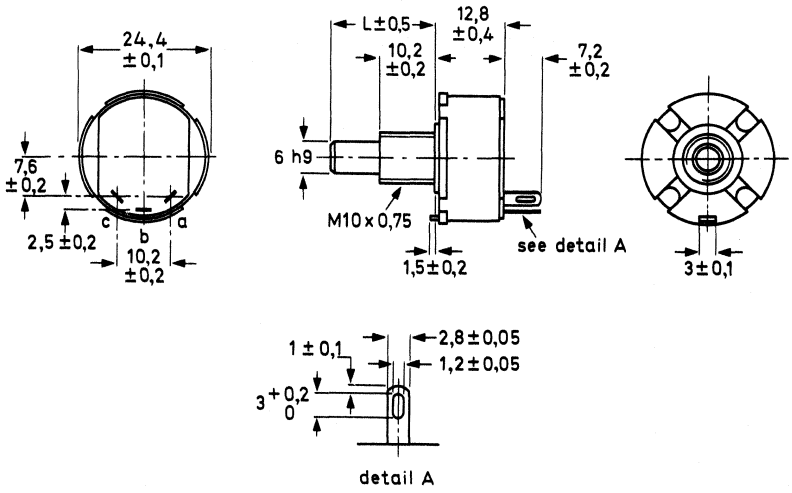


Fig. 1a Potentiometer with plain spindle; spindle length L is 17 mm, 20 mm, 30 mm or 60 mm.

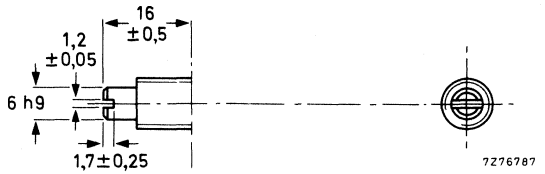


Fig. 1b Spindle with screwdriver slot; position of slot is at random.

MOUNTING

The potentiometer can be mounted on a panel with an hexagonal nut supplied with the potentiometer (catalogue number of nut 4322 047 00350). The maximum torque for tightening the nut is 3,5 Nm. See Fig. 2 for the required mounting holes in the panel.

A washer has to be used if the panel thickness is less than 1 mm as otherwise it might not be possible to secure the nut.

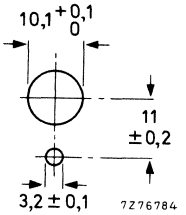


Fig. 2 Mounting holes.

TECHNICAL DATA

Unless stated otherwise, all electrical values have been determined at an ambient temperature of 15 to 25 °C, an air pressure of 93 to 106 kPa and a relative humidity of 45 to 75%.
For definitions of properties and test methods, see IEC 393–1.

Nominal resistance (R_n) between a and c	2,2 to 10 000 Ω, see Table 1
Resistance law	linear
Tolerance on R_n	±5%
Resistance at beginning and end	⩽ 2% of R_{total} or 300 mΩ whichever is greater
R gradient	0% of R_{total}
Resistance at 50% of effective angle of rotation	50 ± 2% of R_{total}
Contact resistance between resistance element and slider	⩽ 1% of R_{total} or 200 mΩ whichever is greater
Temperature coefficient	see Table 1
Maximum dissipation between a and c (Fig. 3)	
at T_{amb} = 40 °C	1,5 W
at T_{amb} = 70 °C	1,0 W
Resolution	
R_n = 2,2 to 68 Ω	< 1,5% of R_{total}
R_n > 68 Ω	< 0,8% of R_{total}
Maximum slider current	1 A
Maximum working voltage (a.c.) between case and resistance element	500 V
Test voltage (a.c.) between case and resistance element	⩽ 1500 V
Insulation resistance	> 1000 MΩ
Ambient temperature range	−25 to +85 °C
Storage temperature range	−25 to +85 °C
Mechanical angle of rotation	270 ± 5°
Effective angle of rotation	265 ± 5°
Operating torque	7,5 to 20 mNm
Maximum end stop torque	800 mNm
Maximum axial force (push and pull)	100 N

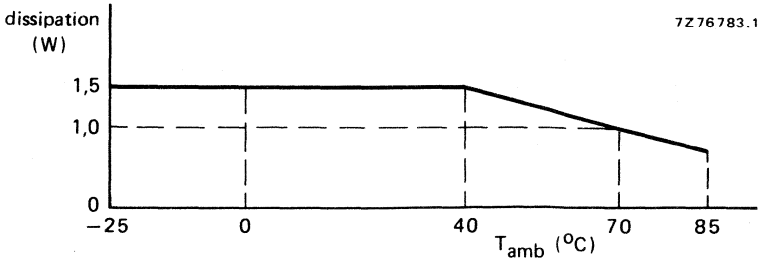


Fig. 3 Dissipation as a function of ambient temperature.

Table 1

nominal resistance Ω	temperature coefficient 10^{-6}/K	number of turns ±25%	code in catalogue number
2,2		110	228
3,3		108	338
4,7		95	478
6,8		136	688
10	−25 to +600	126	109
15		194	159
22		113	229
33		134	339
47		120	479
68		172	689
100	−25 to +25	160	101
150		178	151
220		165	221
330		155	331
470		222	471
680		200	681
1 000		297	102
1 500	0 to +140	287	152
2 200		420	222
3 300		398	332
4 700		408	472
6 800	−20 to + 20	366	682
10 000		538	103

MARKING

The potentiometers are marked at the rear with nominal resistance value (according to IEC 62), resistance tolerance, power rating, production code (period and year) and name of manufacturer.

COMPOSITION OF THE CATALOGUE NUMBER

2322 020 . 2 ...

figure indicating the spindle type
0 = slotted spindle
2 = plain spindle, L = 17 mm
3 = plain spindle, L = 20 mm
4 = plain spindle, L = 30 mm
5 = plain spindle, L = 60 mm
} see Fig.1a

code for resistance value, see Table 1

figure indicating the tolerance of ±5%

TESTS AND REQUIREMENTS

IEC 393–1 test method	name of test	procedure (quick reference)	requirements
Ta	Solderability	235 ± 2 °C, 2 s.	95% of surface
Tb (method 1B)	Resistance to soldering heat	350 °C, 3,5 s.	No damage; $\Delta R_{tot}/R_{tot} \leqslant 2\%$.
Na	Rapid change of temperature	5 cycles of ½ h at −25 °C and ½ h at +85 °C.	$\Delta R_{tot}/R_{tot} \leqslant 3\%$.
Fc	Vibration	10 to 55 Hz, 10g, 3 directions, 2 h per direction.	$\Delta R_{tot}/\Delta R_{tot} \leqslant 2\%$. No interruptions $> 100\ \mu s$.
Ba, D, Aa	Climatic sequence	16 h at 85 °C. 24 h at 55 °C, R.H. 95 to 100%. 2 h at −25 °C. 24 h at 55 °C, R.H. 95 to 100%. 1 h reconditioning at 25 °C.	No damage; $R_{min} \leqslant 2\%\ R_{tot}$; $\Delta R_{tot}/R_{tot} \leqslant 5\%$. Insulation resistance $> 100\ M\Omega$. Test voltage for 1 min is 1500 V (a.c.). Continuity of resistance (after 4 cycles): $\Delta V/V < {}^{+7\%}_{-5\%}$.
Ca	Damp heat	21 days at 40 °C, R.H. 90 to 95%.	
	Endurance	1000 h at 70 °C, 1,5 W loaded, 1,5 h in and 0,5 h out.	$\Delta R_{tot}/R_{tot} \leqslant 5\%$. Continuity of resistance (after 4 cycles): $\Delta V/V < {}^{+7\%}_{-5\%}$.
	Mechanical endurance	15 000 cycles ($R_n \leqslant 4{,}7\ k\Omega$) or 10 000 cycles ($R_n > 4{,}7\ k\Omega$), 90% of effective angle of rotation; unloaded.	$\Delta R_{tot}/R_{tot} \leqslant 5\%$. Continuity of resistance (after 4 cycles): $\Delta V/V < {}^{+7\%}_{-5\%}$.
	Inflammability		Self-extinguishing within 15 s after removal from the flame.

WIREWOUND 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 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.

CONSTRUCTION

The potentiometer consists of a single layer of resistance wire wound on a strip of resin-bonded paper and is housed in a case of black synthetic resin, which is dust-proof seated by a metal bottom.

The solder tags a and c (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 b by means of a slip ring.
A stop prevents the slider from overrunning the resistance element.

Outlines

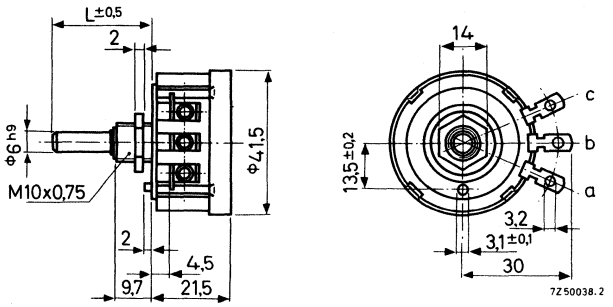


Fig. 1 Potentiometer with plain spindle. The spindle length L is 20, 25, 30, 35 or 80 mm.

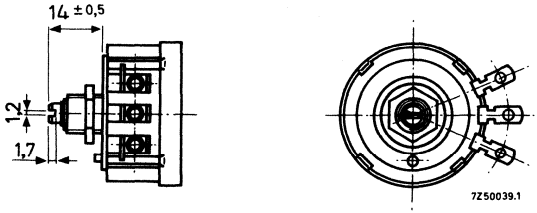


Fig. 2 Potentiometer with spindle with screwdriver slot. Dimensions are identical to those in Fig. 1 except as shown.

Mounting

The potentiometers can be mounted on a panel with an hexagonal nut which is supplied with each potentiometer (catalogue number of nut 4322 047 00350). The maximum torque for tightening is 3,5 Nm.

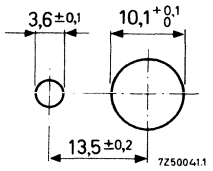


Fig. 3 Mounting holes.

TECHNICAL DATA

Unless otherwise specified all values apply at an ambient temperature of 20 ± 5 °C, an atmospheric pressure of 93 to 106 kPa and a relative humidity of 45 to 75%.

Nominal resistance (R_n), measured between the tags a and c (see Figs 1 and 2)	see Table 1
Tolerance on the nominal resistance	
for $R_n \leqslant 75\ \Omega$	± 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 1
Insulation resistance	> 100 MΩ
Test voltage r.m.s. for 1 min	2000 V
Maximum peak working voltage between mounting bush and solder tags	1000 V
Ambient temperature range	−55 to + 100 °C
Number of windings	see Table 1
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 $R_n \leqslant 10\ k\Omega$	in excess of 25 000 cycles
for $R_n > 10\ k\Omega$	in excess of 10 000 cycles

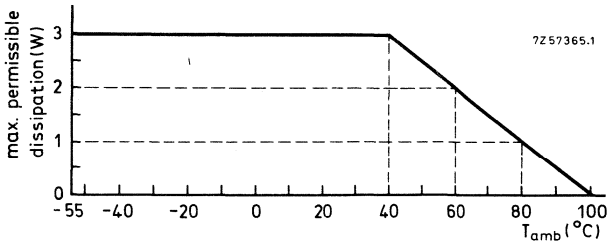


Fig. 4 Maximum permissible dissipation as a function of the ambient temperature.

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

code for resistance value, see Table 1

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

Table 1

resistance Ω	temperature coefficient 10^{-6}/K	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	1 050	353
50 000		1 200	503

PRESET POTENTIOMETERS

Survey of types **page**

10 mm CARBON PRESET POTENTIOMETERS

QUICK REFERENCE DATA

Resistance range (E3-series), linear law	47 Ω – 4,7 MΩ
Maximum dissipation at 40 °C	0,1 W
Climatic category, IEC 68	25/070/21

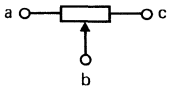
APPLICATION

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

DESCRIPTION

These potentiometers have a resistance element of a special carbon composition with a low temperature coefficient. The element is riveted to a base plate of resin bonded paper.
The potentiometers are provided with printing-wiring pins; pins a and c (see drawings) are connected to the ends of the carbon track, pin b is connected to the slider. The slider, which is provided with a double contact, has a screwdriver slot or a plastic knob for adjustment.
This potentiometer series includes types for vertical and for horizontal mounting on printed-wiring boards.

Note: The potentiometers are supplied with the slider at 50% of the angle of rotation.



7Z85818

COMPOSITION OF THE CATALOGUE NUMBER

2322 410 . . . . .

0 = without knob
4 = with knob (Fig. 2; only for 2322 410 .50..)
6 = with knob (Figs 4 and 6; only for 2322 410 .11.. and 2322 410 .33..)

code for resistance value, see Table 1

11 = vertical mounting (Fig. 3)
33 = horizontal mounting (Fig. 5)
50 = vertical mounting (Fig. 1)

Note: catalogue number of knob (Fig. 2): 4322 047 00190 (only for 2322 410 .50..);
catalogue number of knob (Figs 4 and 6): 4322 047 27740 (only for 2322 410 .11.. and 2322 410 .33..).

MARKING

The potentiometers are marked with the nominal resistance value punched on the slider.

OUTLINES

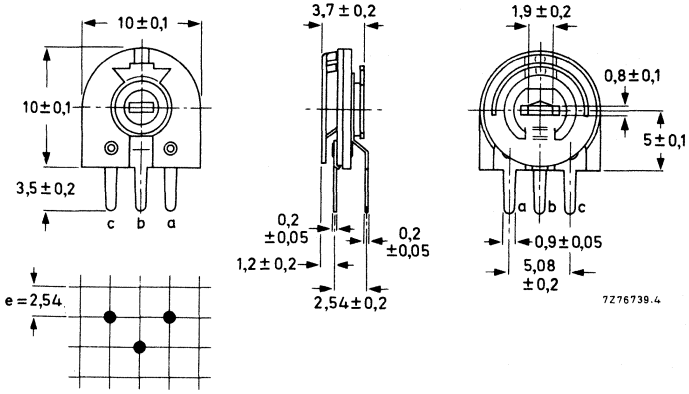


Fig.1 Potentiometer for vertical mounting 2322 410 050 . .

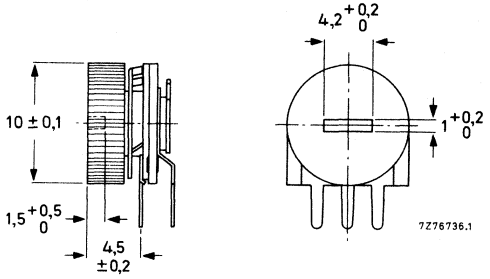


Fig.2 Potentiometer for vertical mounting with knob 2322 410 450 . .

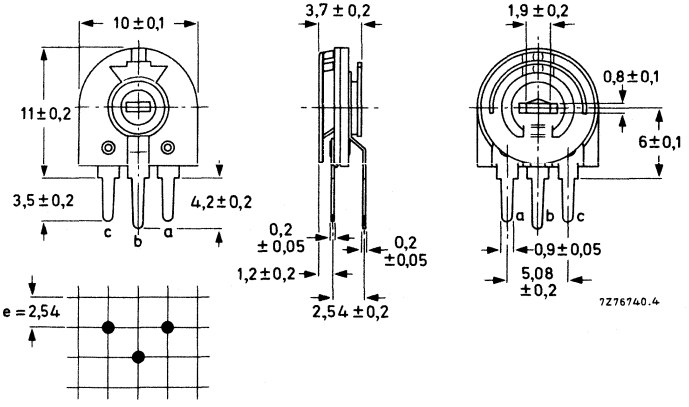


Fig.3 Potentiometer for vertical mounting 2322 410 011 . .

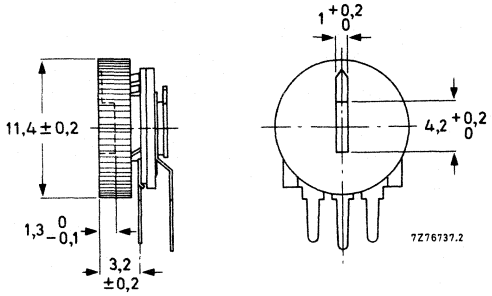


Fig. 4 Potentiometer for vertical mounting with knob 2322 410 611 . .

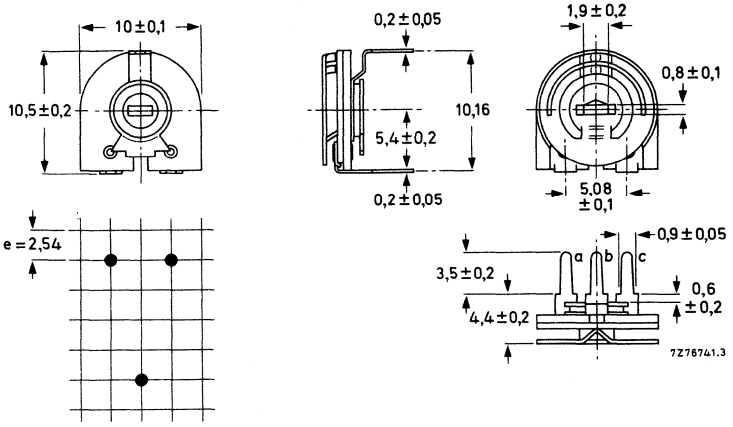


Fig. 5 Potentiometer for horizontal mounting 2322 410 033 . .

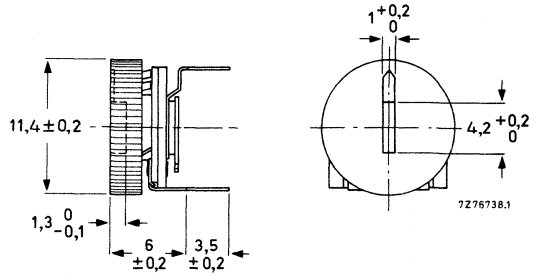


Fig. 6 Potentiometer for horizontal mounting with knob 2322 410 633 . .

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 kPa and a relative humidity of 45 to 75%.

Table 1

nom. resistance R_{nom}	max. voltage (V) at 40 °C	max. terminal resistance Ω	limiting wiper current (mA) at 40 °C	code in catalogue number
47 Ω	2,2	10	46	91
100 Ω	3,2	10	32	51
220 Ω	4,7	10	21	52
330 Ω	5,7	10	17	69
470 Ω	6,9	10	15	53
1 kΩ	10	20	10	54
2,2 kΩ	14,8	40	6,7	55
4,7 kΩ	21,7	100	4,6	56
10 kΩ	32	200	3,2	57
22 kΩ	47	400	2,1	58
47 kΩ	69	1 000	1,5	59
100 kΩ	100	2 000	1,0	61
220 kΩ	148	4 000	0,7	62
470 kΩ	150	10 000	0,32	63
1 MΩ	150	20 000	0,15	64
2,2 MΩ	150	40 000	0,068	65
4,7 MΩ	150	100 000	0,032	66

Tolerance on the nominal resistance	± 20%
Resistance law	linear
Maximum dissipation (P_{max}),	
at 40 °C	0,1 W
at 70 °C	0,05 W
Maximum voltage	$\sqrt{P_{max} R_{nom}}$; maximum 150 V (see table above)
Ambient temperature range	−25 to + 70 °C
Climatic category, IEC 68	25/070/21
Temperature coefficient	-500 to $+300 . 10^{-6}$/K
Operating torque	3,5 to 25 mNm
Maximum end stop torque	50 mNm
Effective angle of rotation	200 ± 10°
Mechanical angle of rotation	260 ± 5°
Mechanical endurance (200 cycles)	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 5\%$
Mass	
potentiometer without knob	0,40 g
potentiometer with knob	0,60 g

TESTS AND REQUIREMENTS

Clause numbers of tests and conditions of test refer to IEC 393-1 (potentiometers; part 1: terms and methods of test).

The potentiometers have been tested whilst mounted by their terminations on a printed wiring board. When drying is called for, procedure 1 of IEC 393-1, sub. 5.2 is used (24 ± 4 h, sub. 55 ± 2 °C, R.H. ⩽ 20%). When the contact resistance variation (CRV) is measured, the wiper is rotated in both directions over 90% of the effective resistance.

IEC 393-1 clause	IEC 68-2 test method	test	procedure	typical result
6.22.3	Ta	Solderability	solder bath: 230° ± 5 °C, 2 ± 0,5 s	good tinning
6.22.4	Tb	Resistance to heat	solder bath: 350 ± 10 °C 3,5 ± 0,5 s	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 0{,}5\%$
6.25	Eb	Bump	acceleration 40g number of bumps: 4000	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 12\%$
6.24	Ec	Vibration	frequency: 10 to 500 Hz amplitude: 0,75 mm or 10g, 3 directions, 2 h per direction	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 2\%$ $\frac{\Delta V_{ab}}{V_{ab}} \leqslant 0{,}3\%$
6.13	–	Temperature characteristics of resistance	temp. cycle: +20 °C; −25 °C; +20 °C; +70 °C; +20 °C	$-500 < TC < +300 \cdot 10^{-6}/K$
6.26	–	Climatic sequence		
6.26.2	Ba	Dry heat	16 h at 70 ± 2 °C	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 5\%$ operating torque ⩽ 30 mNm
6.26.3	Db	Damp heat acc. 1st cycle	24 h at 55 ± 2 °C 95 – 100% R.H.	
6.26.4	Aa	Cold	2 h at −55 ± 3 °C	
6.26.6	Db	Damp heat, remaining cycle	24 h at 55 ± 2 °C 95 – 100% R.H.	
6.30	–	Electrical endurance	T_{amb}: 70 °C, 1000 h, cycle (1,5 h on and 0,5 h off, b at 0,67 a – c) Load: 0,05 W between a and c	CRV < 2% of R_{ac} $\frac{\Delta R_{ac}}{R_{ac}} \leqslant 10\%$ $\frac{\Delta V_{ab}}{V_{ac}} \leqslant 0{,}5\%$
			Load: 0,033 W between a and b	$\frac{\Delta R_{ab}}{R_{ab}} \leqslant 10\%$

IEC 393-1 clause	IEC 68-2 test method	test	procedure	typical result
6.29	–	Mechanical endurance	200 cycles, 4 cycles/min, no load	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 3\%$ CRV $< 0{,}5\%$ of R_{ac}
6.27	C	Damp heat steady state	slider at 0,67 a - c load via a - c recovery 24 h 22 ± 1 °C, 50% R.H. ± 5%	CRV $< 0{,}5\%$ of R_{ac} $\frac{\Delta R_{ac}}{R_{ac}} \leqslant 5\%$ $\frac{\Delta R_{ab}}{R_{ab}} \leqslant 5\%$ $\frac{\Delta V_{ab}}{V_{ac}} \leqslant 0{,}2\%$

14 mm CARBON PRESET POTENTIOMETERS

QUICK REFERENCE DATA

Resistance range (E3-series), linear law	47 Ω – 4,7 MΩ
Maximum dissipation at 40 °C	0,3 W
Climatic category, IEC 68	55/100/10
Dimensions based upon spec.	DIN 44150

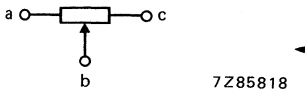
APPLICATION

These potentiometers are 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 a and c (see drawings) are connected to the ends of the carbon track; pin b 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.



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

02 = straight pins, vertical mounting
13 = straight pins, horizontal mounting
22 = snap-in pins, vertical mounting
33 = snap-in pins horizontal mounting

code for resistance value
91 = 47 Ω
51 = 100 Ω
52 = 220 Ω
69 = 330 Ω
53 = 470 Ω
54 = 1 kΩ
55 = 2,2 kΩ
56 = 4,7 Ω
57 = 10 kΩ
58 = 22 kΩ
59 = 47 kΩ
61 = 100 kΩ
62 = 220 kΩ
63 = 470 kΩ
64 = 1 MΩ
65 = 2,2 MΩ
66 = 4,7 MΩ

MARKING

The potentiometers are marked with the rated resistance value, by letter punches on the wiper or knob.

Outlines

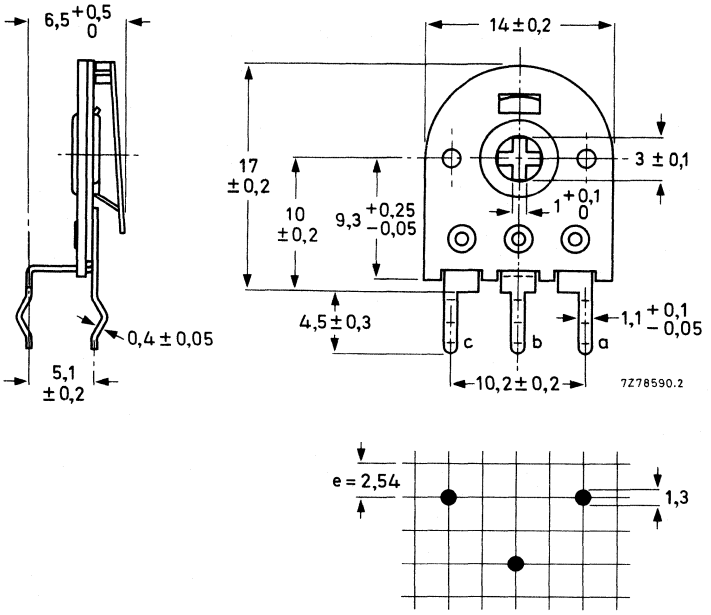


Fig.1a Potentiometer for vertical mounting, with snap-in printed-wiring pins, 2322 409 022.

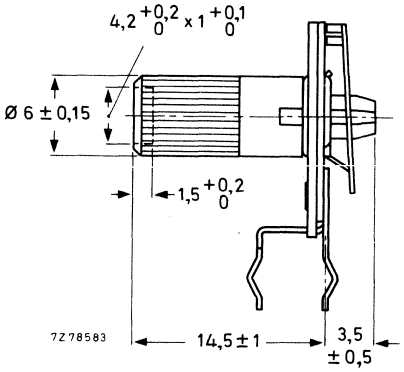


Fig. 1b Potentiometer with knob on the base plate side, 2322 409 122. .

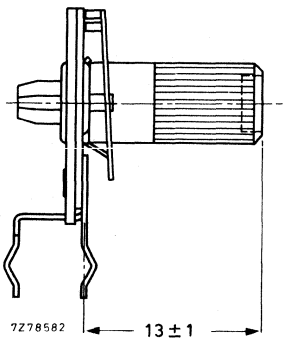


Fig. 1c Potentiometer with knob on the carbon track side, 2322 409 222. .

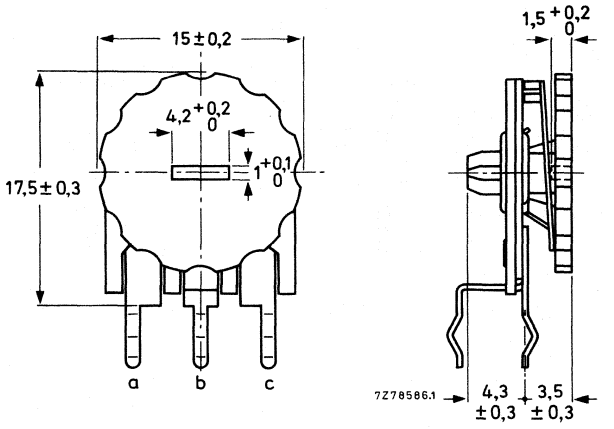


Fig.1d Potentiometer with adjustment wheel on the carbon track side, 2322 409 422. .

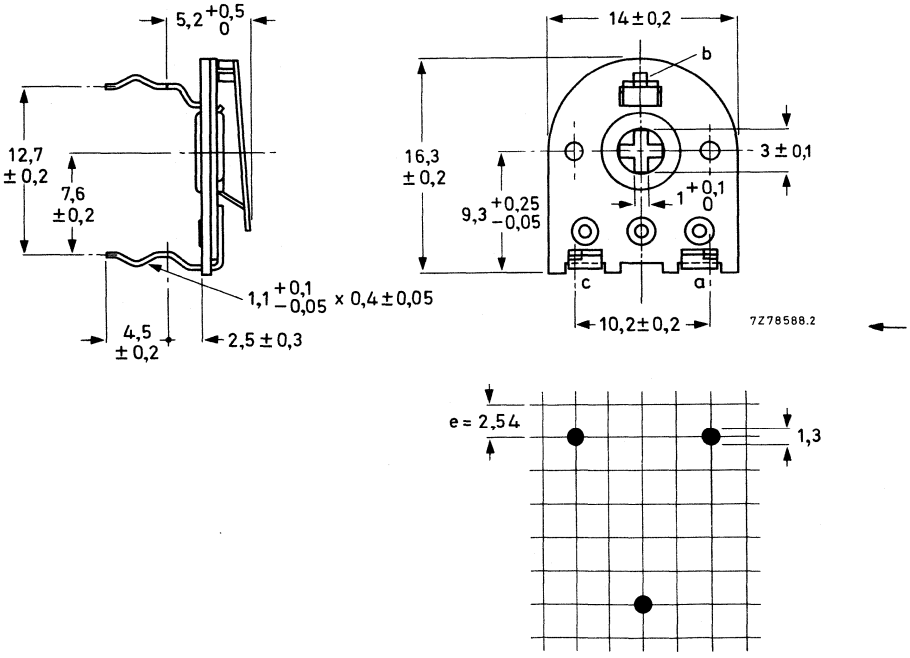


Fig.2a Potentiometer for horizontal mounting, with snap-in printed-wiring pins, 2322 409 033..

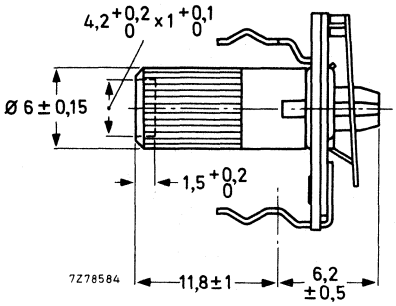


Fig. 2b Potentiometer with knob on the base plate side, 2322 409 133. .

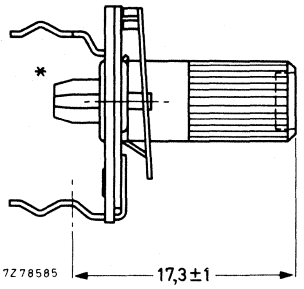


Fig. 2c Potentiometer with knob on the carbon track side, 2322 409 233. .

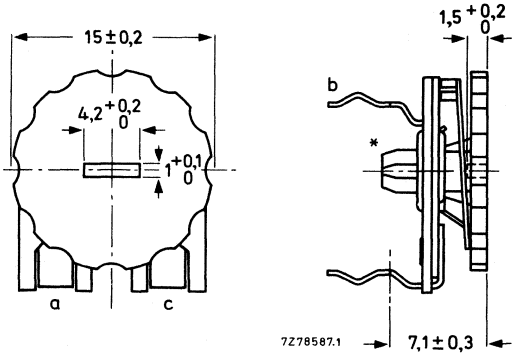
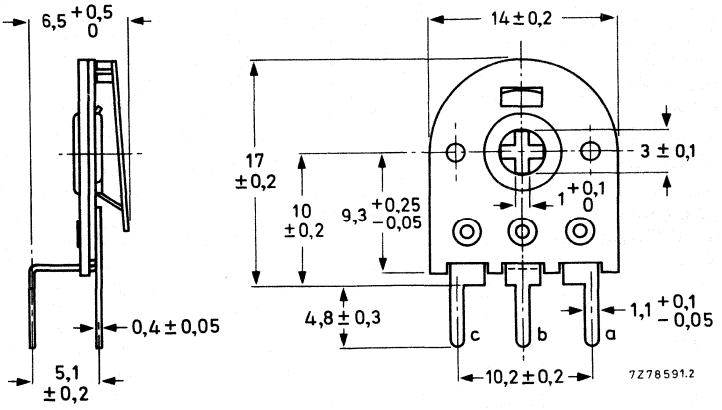


Fig. 2d Potentiometer with adjustment wheel on the carbon track side, 2322 409 433. .

* Required hole in printed-wiring board: ϕ4 + 0,2 mm.



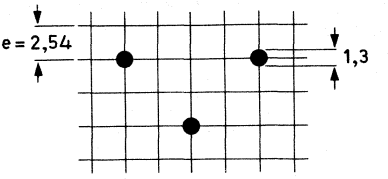
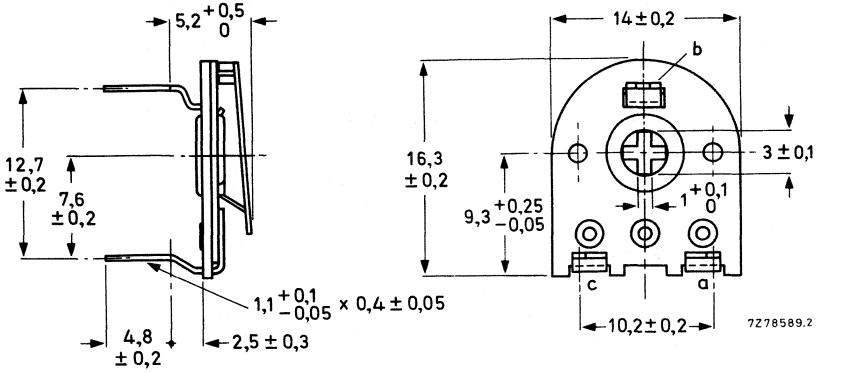


Fig.3 Potentiometer for vertical mounting, with straight printed-wiring pins, 2322 409 002..



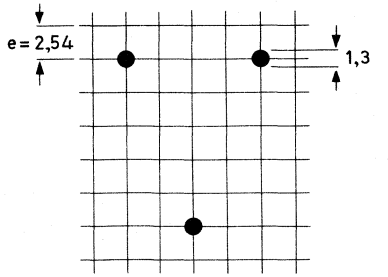


Fig.4 Potentiometer for horizontal mounting, with straight printed-wiring pins, 2322 409 013..

Note

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

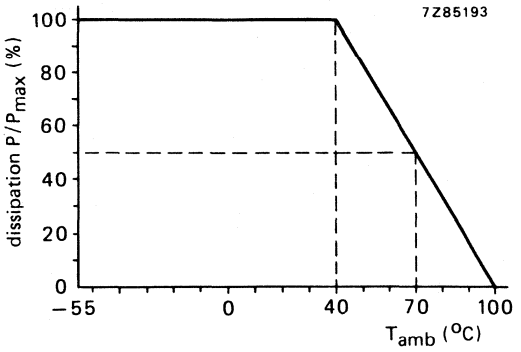
TECHNICAL DATA

Mass, per 100		
without knob		72 g
with knob		118 g
Resistance range (E3-series)		47 Ω to 4,7 MΩ
Standard tolerance		± 20%
Resistance law		linear, see Fig. 6
Rated dissipation		
at 70 °C (P_{max})		0,15 W, see Fig. 5
at 40 °C		0,3 W
Limiting element voltage		500 V (d.c.)
Limiting wiper current		$\sqrt{\frac{P_{max}}{R_{nom}}}$
Terminal resistance		⩽ 2% of R_{nom}
Contact resistance variation (CRV)		⩽ 1% of R_{ac}
Temperature coefficient in the range −55 °C to + 100 °C		-500 to $+300 \cdot 10^{-6}$/K
Starting torque		⩽ 25 mNm
Operating torque		3,5 to 25 mNm
Permissible end-stop torque		max. 100 mNm
Total mechanical angle of rotation		230 ± 5°
Effective angle of rotation		210 ± 10°
Settability		0,1% within 10 s
Climatic category according to IEC 68-2		55/100/10
Climatic sequence		$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 10\%$
Damp heat, steady state, 10 days max.	$R_{nom} \leqslant 100$ K	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 15\%$
	$R_{nom} > 100$ K	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 20\%$
Mechanical endurance (200 cycles)		$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 5\%$
Electrical endurance (1000 h at 70 °C, cyclic)		$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 10\%$
Resistance to soldering heat		$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 2\%$
Bump		$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 2\%$
Vibration		$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 2\%$
		$\frac{\Delta V_{ab}}{V_{ab}} \leqslant 0{,}5\%$

DERATING

Potentiometers covered by this specification are derated from 100% rated dissipation at 40 °C to zero dissipation at 100 °C. The dissipation below 40 °C is the rated dissipation.

100% = 0,3 W



For $\Delta R_{ac} \leqslant 10\%$

Fig. 5 Dissipation as a function of ambient temperature.

RESISTANCE LAW

Potentiometers covered by this specification are linear.

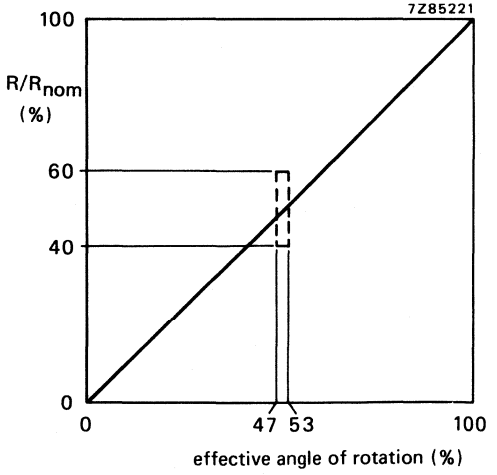


Fig. 6 Linear resistance law.

TESTS AND REQUIREMENTS

Clause numbers of tests and conditions of test refer to IEC 393-1 (potentiometers; part 1: terms and methods of test).

The potentiometers have been tested whilst mounted by their terminations on a printed wiring board. When drying is called for, procedure I of IEC 393-1, sub. 5,2 is used (24 ± 4 h, 55 ± 2 °C, R.H. ⩽ 20%). When the contact resistance variation (CRV) is measured, the wiper is rotated in both directions over 90% of the effective resistance.

IEC 393-1 clause	IEC 68-2 test method	test	procedure	typical result
6.22.3	T_a	Solderability	solder bath: 235° ± 5 °C, 2 ± 0,5 s	good tinning
6.22.4	Tb	Resistance to heat	solder bath: 350 ± 10 °C, 3,5 ± 0,5 s	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 0{,}5\%$
6.25	Eb	Bump	acceleration: 390 m/s² number of bumps: 4000	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 0{,}5\%$
6.24	Ec	Vibration	frequency: 10 to 500 Hz amplitude: 0,75 mm or 98 m/s², 6 h	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 1\%$ $\frac{\Delta V_{ab}}{V_{ab}} \leqslant 0{,}1\%$
6.13	–	Temperature characteristics of resistance	temp. cycle: +20 °C; −55 °C; +20 °C; +100 °C; +20 °C	$-300 < TC < +300 \cdot 10^{-6}/K$
6.26	–	Climatic sequence		
6.26.2	Ba	Dry heat	16 h at 100 °C	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 5\%$
6.26.3	Db	Damp heat accel. 1st cycle	24 h at 55 °C, 95 - 100% R.H.	
6.26.4	Aa	Cold	2 h at −55 °C	operating torque ⩽ 30 mNm
6.26.6	Db	Damp heat, remaining cycle	24 h at 55 °C, 95 - 100% R.H.	
6.30	–	Electrical endurance	T_{amb}: 70 °C, 1000 h, cyclic (1,5 h on and 0,5 h off, b at 0,67 a - c) Load: 0,15 W between a and c	CRV < 1% of R_{ac} $\frac{\Delta R_{ac}}{R_{ac}} \leqslant 10\%$ $\frac{\Delta V_{ab}}{V_{ac}} \leqslant 0{,}5\%$
			Load: 0,1 W between a and b	$\frac{\Delta R_{ab}}{R_{ab}} \leqslant 10\%$

IEC 393-1 clause	IEC 68-2 test method	test	procedure	typical result
6,29	–	Mechanical endurance	200 cycles, 4 cycles/min, no load	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 3\%$ CRV $< 0{,}5\%$ of R_{ac}
6.27	C	Damp heat steady state	slider at 0,67 a - c load via a - c recovery 24 h 22 ± 1 °C, 50% R.H. ± 5% (CECC 41 000 clause 4.29)	CRV $< 0{,}5\%$ of R_{ac} $\frac{\Delta R_{ac}}{R_{ac}} \leqslant 5\%$ $\frac{\Delta R_{ab}}{R_{ab}} \leqslant 5\%$ $\frac{\Delta V_{ab}}{V_{ac}} \leqslant 0{,}2\%$

18 mm CARBON PRESET POTENTIOMETERS

QUICK REFERENCE DATA

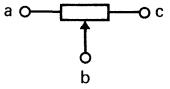
Resistance range (E3-series), linear law	100 Ω – 4,7 MΩ
Maximum dissipation at 25 °C	0,25 W

APPLICATION

These potentiometers are 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 tin-plated printed-wiring pins. The pins a and c (see drawings) are connected to the ends of the carbon track; b is connected to the slider. The slider has a centre screwdriver slot.



7Z85818

COMPOSITION OF THE CATALOGUE NUMBER

2322 411 0 . . . .

22 = with pins for vertical mounting (Fig. 1)
33 = with pins for horizontal mounting (Fig. 2)

code for resistance value, see table

MARKING

Nominal resistance and production code in ink on the base plate.

Outlines

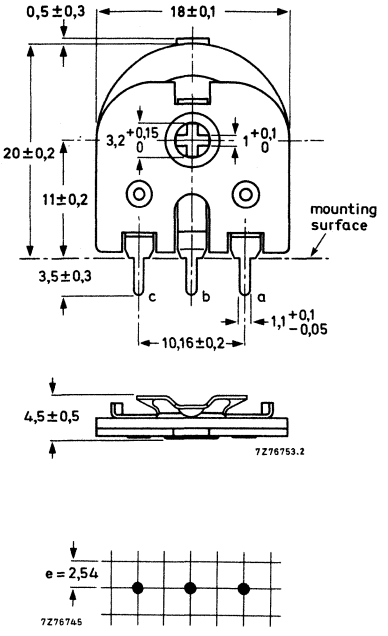


Fig. Potentiometer 2322 411 022 . .

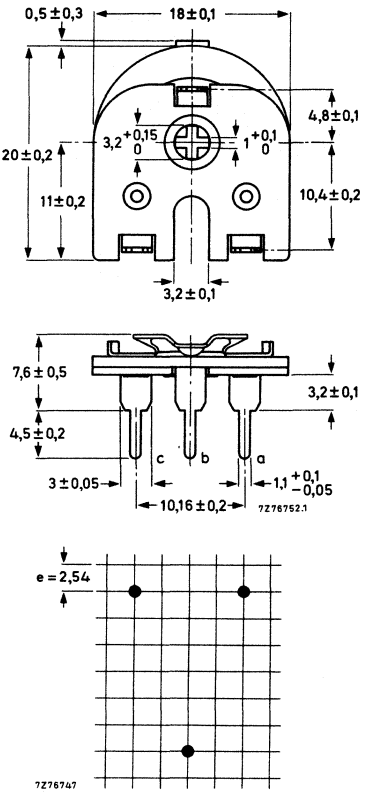


Fig. 2 Potentiometer 2322 411 033 . .

TECHNICAL DATA

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	5	32	51
220 Ω	10	7	22	52
330 Ω	10	9	18	69
470 Ω	10	11	14	53
1 kΩ	25	16	10	54
2,2 kΩ	25	22	7	55
4,7 kΩ	100	35	4,5	56
10 kΩ	200	50	3,2	57
22 kΩ	400	70	2,2	58
47 kΩ	1 000	110	1,4	59
100 kΩ	2 000	160	1,0	61
220 kΩ	4 000	220	0,7	62
470 kΩ	10 000	370	0,45	63
1 MΩ	20 000	500	0,32	64
2,2 MΩ	40 000	500	0,22	65
4,7 MΩ	100 000	500	0,14	66

Tolerance on the nominal resistance	±20%
Resistance law	linear
Maximum dissipation	
at 25 °C	0,25 W
at 70 °C	0,15 W
Limiting voltage	500 V (d.c.) 500 V (r.m.s.)
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 *	< 20%
after recovery of 24 h *	< 10%
Operating torque	5 to 35 mNm
Maximum end stop torque	100 mNm
Effective angle of rotation	200 ± 10°
Mechanical angle of rotation	215–225°
Temperature coefficient	−500 to +300 . 10^{-6}/K

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

ENCLOSED 10 mm CARBON PRESET POTENTIOMETERS

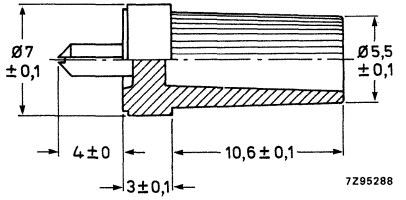
QUICK REFERENCE DATA

Resistance range (E3-series), linear law	100 Ω to 4,7 MΩ
Maximum dissipation	
at 40 °C	0,1 W
at 70 °C	0,05 W
Temperature coefficient	± 300 · 10^{-6}/K
Climatic category, IEC 68–2	25/85/10

DESCRIPTION

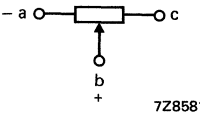
These preset potentiometers comprise a carbon resistive element on a phenolic paper base. The actuating device is a plastic rotor or a metal wiper. Adjustment is by means of cross or hexagonal slots. The overall width of 9,8 mm allows for high density use with air-gap isolation on a 2,5 mm grid; either horizontal or vertical mounting. The black glass-filled synthetic resin housing is fire resistant. The potentiometers, which are manufactured and tested fully automatically, offer stable, high quality performance and can be mounted by automatic insertion machines.

They are designed for video, audio and industrial applications and are especially suited for equipment in which automatic adjustment is practised. Versions with a hexagonal slot are available that can be provided with a knob to facilitate manual adjustment.



Example of a knob for versions with a hexagonal slot (cat. no. 8222 417 71060).

The terminals a and c are the end terminals; b is the central terminal connected to the slider. All terminals are either straight or snap-in pins for mounting on printed-wiring boards of nominal 1,0 to 1,6 mm thickness, grid pitch 2,5 or 2,54 mm.



Terminal designation.

MECHANICAL DATA

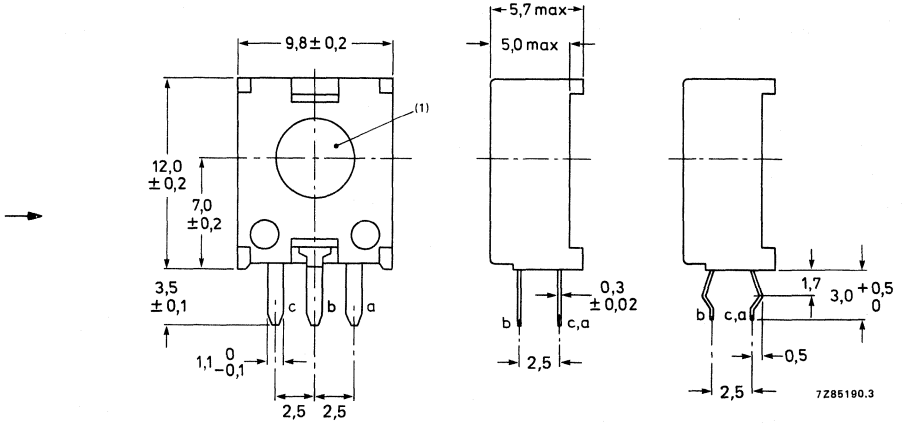


Fig. 1 Vertical mounting.

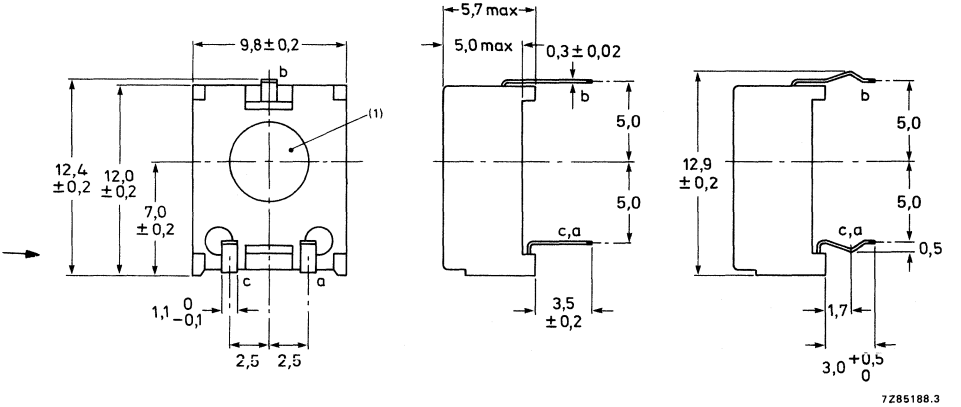


Fig. 2 Horizontal mounting.

* For details of available slots (cross, hexagonal, insulated or non-insulated wiper), see Figs 3, 4 and 5.

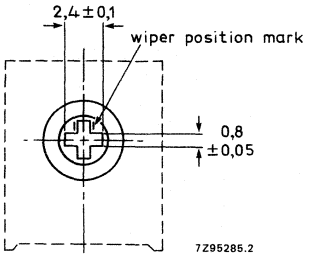


Fig. 3 Cross slot, non-insulated wiper for vertical and horizontal versions; straight pins only.

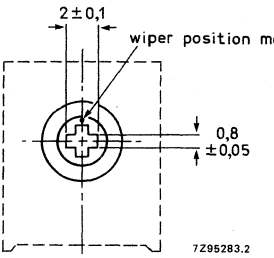


Fig. 4 Cross slot, insulated wiper for vertical and horizontal versions.

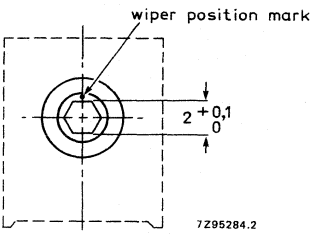


Fig. 5 Hexagonal slot, insulated wiper for vertical and horizontal versions.

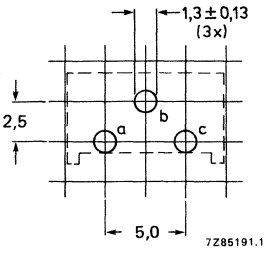


Fig. 6 Hole pattern for vertical versions, viewed from component side.

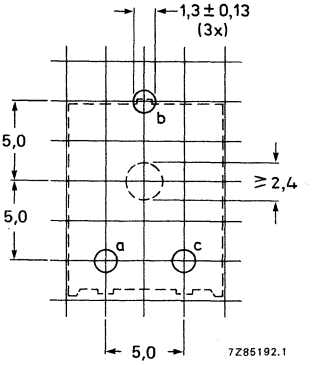


Fig . 7 Hole pattern for horizontal versions, viewed from component side.

Note: Snap-in pins are only available with versions having an insulated wiper.

TECHNICAL DATA

Mass		~ 1,5 g
Resistance range (E3-series)		100 Ω to 4,7 MΩ
Standard tolerance		± 20% and ± 10%
Resistance law		linear, see Fig. 9
Rated dissipation at 40 °C (P_{max})		0,1 W, see Fig. 8
Limiting element voltage		150 V (d.c.)
Limiting wiper current		$\sqrt{\frac{P_{max}}{R_{nom}}}$
Minimum effective resistance		⩽ 2% of R_{ac} or 10 Ω, whichever is greater
Rotational noise limits (contact resistance variation)		⩽ 1,0% of R_{nom}
Temperature coefficient in the range −25 °C to + 85 °C		± 300 · 10^{-6}/K
Operating torque		2 to 10 mNm
Permissible end-stop torque		max. 50 mNm
Permissible axial load on adjustment slot		20 N, max. 20 s
Total mechanical angle of rotation		300 ± 5°
Effective angle of rotation		295 ± 5°
Settability		0,2% within 10 s
Climatic category according to IEC 68–2		25/85/10
Climatic sequence	$\frac{\Delta R_{ac}}{R_{ac}}$	⩽ 5%
Damp heat, steady state, with or without load, between a and c, 10 days	$\frac{\Delta R_{ac}}{R_{ac}}$	⩽ 10%
Mechanical endurance (100 cycles)	$\frac{\Delta R_{ac}}{R_{ac}}$	⩽ 5%
Electrical endurance (1000 h at 70 °C, cyclic)	$\frac{\Delta R_{ac}}{R_{ac}}$	⩽ 5%
Resistance to soldering heat	$\frac{\Delta R_{ac}}{R_{ac}}$	⩽ 2%
Bump	$\frac{\Delta R_{ac}}{R_{ac}}$	⩽ 2%
Vibration	$\frac{\Delta R_{ac}}{R_{ac}}$	⩽ 2%
	$\frac{\Delta V_{ab}}{V_{ac}}$	⩽ 0,5%

DERATING

Potentiometers covered by this specification are derated from 100% rated dissipation at 40 °C to zero dissipation at 85 °C. The dissipation below 40 °C is the rated dissipation.

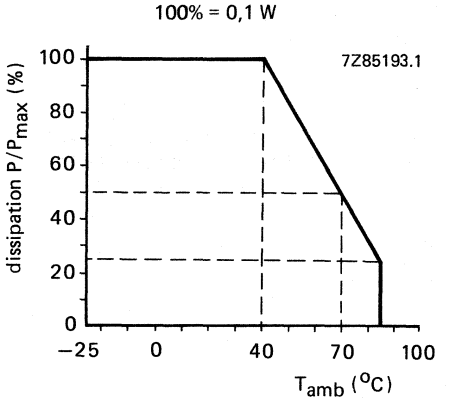


Fig. 8 Dissipation as a function of ambient temperature.

RESISTANCE

Potentiometers covered by this specification are linear.

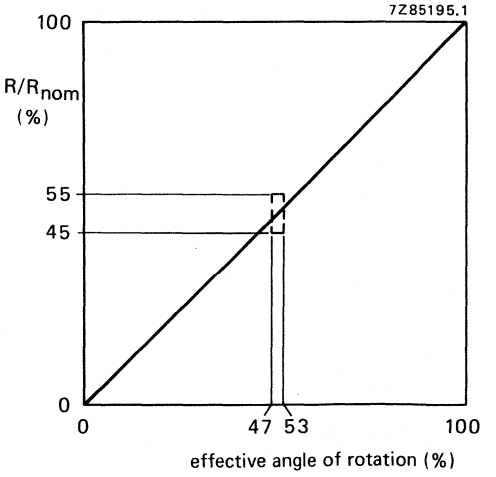


Fig. 9 Linear resistance law.

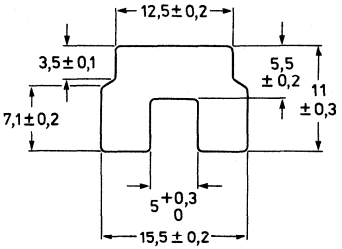
MARKING

The potentiometers are marked with the rated resistance, according to IEC 62, e.g. 220 Ω = 220 R; 10 kΩ = 10 k; 1 MΩ = 1 MO.

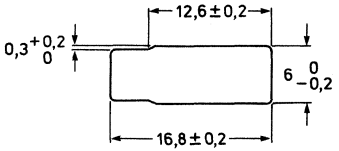
The package is marked with:
- catalogue number,
- date of production,
- quantity.

PACKAGING

The potentiometers can be supplied in bulk packaging of 1000 in a cardboard box or, especially for automatic insertion, in anti-static rail packaging of 50 per rail, 20 rails in a box. The outside dimensions of the rails, which have rubber stops at both ends, are given in Fig. 10.



For horizontal versions.



For vertical versions.

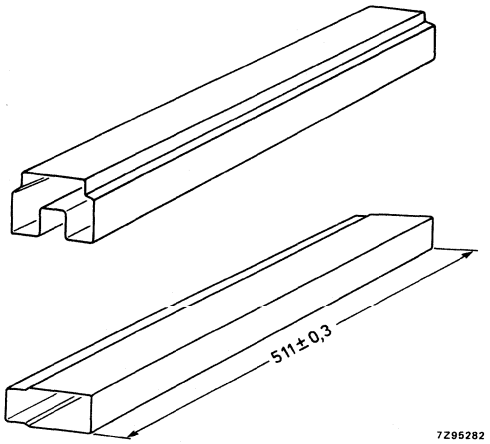


Fig. 10 Outlines of the rail packaging.

COMPOSITION OF THE CATALOGUE NUMBER

2322 483 . . . . .

code for version

0 = vertical, non-insulated cross slot*
1 = vertical, insulated hexagonal slot
2 = vertical, insulated cross slot
5 = horizontal, non-insulated cross slot*
6 = horizontal, insulated hexagonal slot
7 = horizontal, insulated cross slot

code for tolerance, tags, packaging

2 = ± 20%, snap-in pins, bulk packaging
3 = ± 10%, snap-in pins, bulk packaging
4 = ± 20%, straight pins, bulk packaging
5 = ± 10%, straight pins, bulk packaging
6 = ± 20%, snap-in pins, rail packaging
7 = ± 10%, snap-in pins, rail packaging
8 = ± 20%, straight pins, rail packaging
9 = ± 10%, straight pins, rail packaging

resistance code

101 = 100 Ω
221 = 220 Ω
471 = 470 Ω
102 = 1 kΩ
222 = 2,2 kΩ
472 = 4,7 kΩ
103 = 10 kΩ
223 = 22 kΩ
473 = 47 kΩ
104 = 100 kΩ
224 = 220 kΩ
474 = 470 kΩ
105 = 1 MΩ
225 = 2,2 MΩ
475 = 4,7 MΩ

* No snap-in pins for vertical nor horizontal version with non-insulated cross slot.

TESTS AND REQUIREMENTS

Clause numbers of tests and conditions of test refer to IEC 393–1 (potentiometers, part 1: terms and methods of test).

The potentiometers have been tested whilst mounted by their terminations on a printed wiring board.

When drying is called for procedure I of IEC 393–1, sub. 5.2. is used (24 ± 4 h, 55 ± 2 °C, R.H. 20%).

When the contact resistance variation (CRV) is measured, the wiper is rotated in both directions over 90% of the effective resistance for a total of 6 cycles. The maximum deviations in the last 3 cycles are taken into account. Wiper speed: 2 cycles/minute; bandwidth 10 Hz to 5 kHz.

IEC 393–1 clause	IEC 68–2 test method	test	procedure	typical result
6.22.3	T	Solderability	solder bath: 230 ± 10 °C	good tinning
6.22.4	Tb	Resistance to heat	solder bath: 350 ± 10 °C 3,5 ± 0,5 s	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 0{,}5\%$
6.25	Eb	Bump	acceleration: 390 m/s² number of bumps: 4000	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 2\%$ $\frac{\Delta V_{ab}}{V_{ac}} \leqslant 0{,}5\%$

IEC 393–1 clause	IEC 68–2 test method	test	procedure	typical result
6.24	Fc	Vibration	frequency: 10 - 500 Hz amplitude: 0,75 mm or 98 m/s², 6 h	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 2\%$ $\frac{\Delta V_{ab}}{V_{ac}} \leqslant 0{,}3\%$
6.13		Temperature characteristic of resistance	temp. cycle: + 20 °C; −25 °C; + 20 °C; + 70 °C + 20 °C	$-300 < TC < +300 \cdot 10^{-6}/K$
6.26	–	Climatic sequence		
6.26.2	Ba	Dry heat	16 h at 85 °C	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 5\%$
6.26.3	D	Damp heat, accel. 1st cycle	24 h at 55 °C 95 - 100% R.H.	
6.26.4	Aa	Cold	2 h at −25 °C	
6.26.6	D	Damp heat remaining cycle	24 h at 55 °C 95 - 100% R.H.	
(6.30)	–	Electrical endurance	T_{amb}: 70 °C, 1000 h cycle (1,5 h on and 0,5 h off, b at 0,67 a - c) Load: 0,05 W between a and c	CRV < 2% of R_{nom} $\frac{\Delta R_{ac}}{R_{ac}} \leqslant 5\%$ $\frac{\Delta V_{ab}}{V_{ac}} \leqslant 0{,}5\%$
			Load: 0,033 W between a and b	$\frac{\Delta R_{ab}}{R_{ab}} \leqslant 5\%$
6.29	–	Mechanical endurance	100 cycles, 4 cycles/min no load	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 5\%$ ($\leqslant 10\%$ for $R_{nom} = 4{,}7\ M\Omega$) CRV < 1,0% of R_{nom}
(6.27)	C	Damp heat steady state	wiper at 0,67 a - c *no load;* 21 days; recovery 24 h, 22 ± 1 °C, 50% R.H. ± 5%	CRV < 1,0% of R_{nom} $\frac{\Delta R_{ac}}{R_{ac}} \leqslant 5\%$ $\frac{\Delta R_{ab}}{R_{ab}} \leqslant 5\%$ $\frac{\Delta V_{ab}}{V_{ac}} \leqslant 0{,}2\%$
(6.27)	C	Damp heat steady state	*with load* between a and c, 10 days; recovery 24 h, 22 °C ± 1 °C, 50% R.H. ± 5%	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 10\%$ ($\leqslant 15\%$ for $R_{nom} = 4{,}7\ M\Omega$)

10 mm CERMET PRESET POTENTIOMETERS

QUICK REFERENCE DATA

Resistance range (E6-series), linear law	100 Ω to 6,8 MΩ
Maximum dissipation at 70 °C	0,5 W
Climatic category, IEC 68	55/125/56

APPLICATION

These potentiometers are 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 thick film, with particles of conductive metal dispersed in it. The element is supported by a non-conductive temperature-resistant ceramic base. The terminals a and c (see Figs 1 to 3) are connected to the ends of the resistance element; terminal b is connected to the wiper.

The potentiometers are available in versions for horizontal and vertical mounting on printed-wiring boards. ←

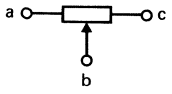


Fig. 1 Terminal allocations.

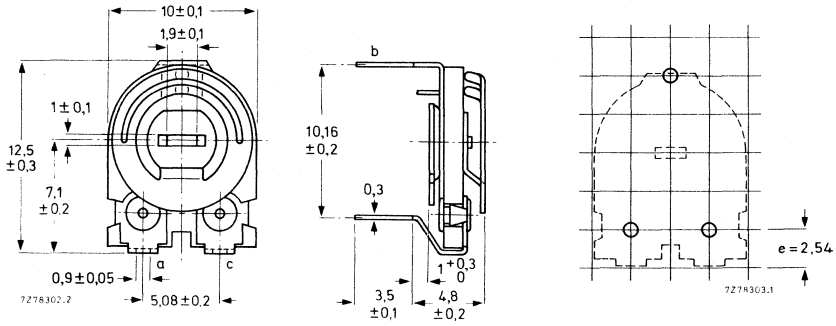


Fig. 2 Potentiometer for horizontal mounting, 2322 482 4 . . . .

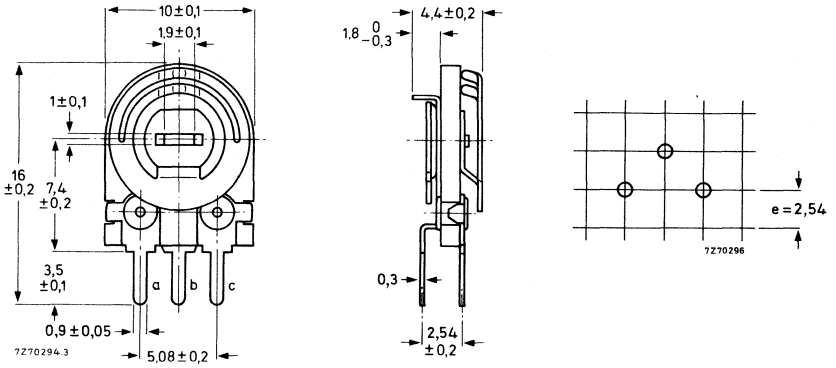


Fig. 3 Potentiometer for vertical mounting, 2322 482 3 . . . .

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 hPa and a relative humidity of 45 to 75%. For terms and test methods see IEC publication 393-1.

Nominal resistance (R_{nom})	100 Ω to 6,8 MΩ, see Table 1
Tolerance on the nominal resistance	± 20% and ± 10%
Resistance law and tolerances	linear, see Fig. 4
Terminal resistance	⩽ 0,5% of R_{ac} or 2 Ω, whichever is the greater
Contact resistance variation (CRV)	⩽ 0,5% of R_{ac}
Maximum dissipation (P_{max}) at 70 °C	0,5 W, see Fig. 5

Limiting voltage (d.c.)	250 V
Limiting wiper current	$\sqrt{\left(\frac{P_{max}}{R_{ac}}\right)}$
Operating temperature range	−55 to + 125 °C
Temperature coefficient	
$R_{nom} \leqslant 1\ M\Omega$	$\pm 50 \cdot 10^{-6}/K$
$R_{nom} > 1\ M\Omega$	$\pm 100 \cdot 10^{-6}/K$
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	200 cycles
Settability	0,1% of R_{ac} within 10 s
Mass	approx. 1,5 g

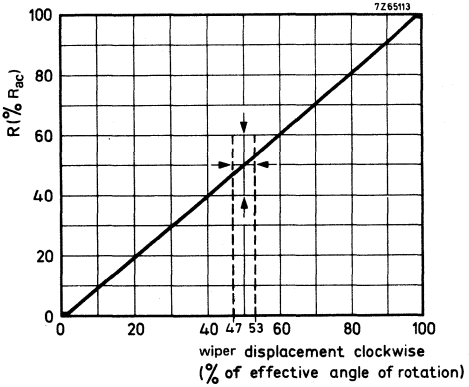


Fig. 4 Linear law.

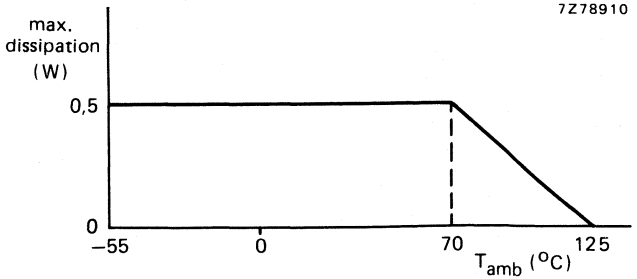


Fig. 5 Maximum dissipation as a function of ambient temperature.

COMPOSITION OF THE CATALOGUE NUMBER

2322 482 .....

code for version

3 = potentiometer for vertical mounting, according to Fig. 3
4 = potentiometer for horizontal mounting, according to Fig. 2

code for nominal resistance, see Table 1

code for tolerance
0 = ± 20%
2 = ± 10%

Table 1

nominal resistance	code in cat. number	nominal resistance	code in cat. number
100 Ω	101	33 kΩ	333
150 Ω	151	47 kΩ	473
220 Ω	221	68 kΩ	683
330 Ω	331	100 kΩ	104
470 Ω	471	150 kΩ	154
680 Ω	681	220 kΩ	224
1 kΩ	102	330 kΩ	334
1,5 kΩ	152	470 kΩ	474
2,2 kΩ	222	680 kΩ	684
3,3 kΩ	332	1 MΩ	105
4,7 kΩ	472	1,5 MΩ	155
6,8 kΩ	682	2,2 MΩ	225
10 kΩ	103	3,3 MΩ	335
15 kΩ	153	4,7 MΩ	475
22 kΩ	223	6,8 MΩ	685

TESTS AND REQUIREMENTS

Clause numbers of tests and conditions of test refer to IEC 393–1 (potentiometers, part 1: terms and methods of test).

The potentiometers have been tested whilst mounting by their terminations on a printed-wiring board.

When drying is called for, procedure I of IEC 393–1, sub. 5.2. is used (24 ± 4 h, 55 ± 2 °C, R.H. 20%).

When the contact resistance variation (CRV) is measured, the wiper is rotated in both directions over 90% of the effective resistance for a total of 6 cycles. The maximum deviations in the last 3 cycles are taken into account. Wiper speed: 2 cycles/minute; bandwidth 10 Hz to 5 kHz.

IEC 393–1 clause	IEC 68–2 test method	test	procedure	typical result
6.22.3	T	Solderability	solder bath: 230 ± 10 °C, 2 ± 0,5 s	good tinning
6.22.4	Tb	Resistance to heat	solder bath: 350 ± 10 °C 3,5 ± 0,5 s	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 0{,}1\%$
6.25	Eb	Bump	acceleration: 40g number of bumps: 4000	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 0{,}1\%$
6.24	Fc	Vibration	frequency: 10 - 500 Hz amplitude: 0,75 mm or 10g, 3 directions, 2h per direction	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 0{,}1\%$ $\frac{\Delta V_{ab}}{V_{ac}} \leqslant 0{,}2\%$
6.13		Temperature characteristic of resistance	temp. cycle: + 20 °C; –25 °C; + 20 °C; + 70 °C + 20 °C	$-50 < TC < +50.10^{-6}/K$
6.23	Na	Change of temperature	–55 °C and + 125 °C; 5 cycles, ½ h	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 0{,}5\%$ $\frac{\Delta V_{ab}}{V_{ac}} \leqslant 0{,}1\%$
6.26	–	Climatic sequence		
6.26.2	Ba	Dry heat	16 h at 70 °C	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 0{,}5\%$ operating torque ⩽ 36 mNm
6.26.3	Db	Damp heat accel. 1st cycle	24 h at 55 ± 2 °C 95 - 100% R.H.	
6.26.4	Aa	Cold	2 h at –55 ± 3 °C	
6.26.6	D	Damp heat, remaining cycle	24 h at 55 ± 2 °C 95 - 100% R.H.	
6.30	–	Electrical endurance	T_{amb}: 70 °C, 1000 h cyclic (1,5 h on and 0,5 h off, b at 0,67 ac)	CRV < 1% of R_{nom}
			Load: 0,5 W between a and c	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 1\%$ $\frac{\Delta V_{ab}}{V_{ac}} \leqslant 0{,}2\%$
			Load: 0,33 W between a and b	$\frac{\Delta R_{ab}}{R_{ab}} \leqslant 3\%$

IEC 393–1 clause	IEC 68–2 test method	test	procedure	typical result
6.29	–	Mechanical endurance	200 cycles, 4 cycles/min no load	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 2\%$ CRV $< 0{,}5\%$ of R_{nom}
6.27	Ca	Damp heat steady state	b at 0,67 a - c no load; 56 days	CRV $< 0{,}5\%$ of R_{nom} $\frac{\Delta R_{ac}}{R_{ac}} \leqslant 0{,}5\%$ $\frac{\Delta R_{ab}}{R_{ab}} \leqslant 1\%$ $\frac{\Delta V_{ab}}{V_{ac}} \leqslant 0{,}2\%$
			load a - c 0,05 W	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 0{,}5\%$ $\frac{\Delta V_{ab}}{V_{ac}} \leqslant 0{,}2\%$
			load a - c 0,03 W	$\frac{\Delta R_{ab}}{R_{ab}} \leqslant 2\%$
Immersion in cleaning solvents		Immersion in boiling mixture of 1.1.2. trichlorotrifluoraethane and isopropanol (75%/25%) for 5 ± 0,5 min., followed by 5 min drying (rubbing or wrapping excluded).		Marking legible, no damage. $\Delta R_{ac}/R_{ac} \leqslant 0{,}5\%$; CRV $\leqslant 0{,}5\%$; operating torque: 2 to 10 mNm.

ENCLOSED 10mm CERMET PRESET POTENTIOMETERS

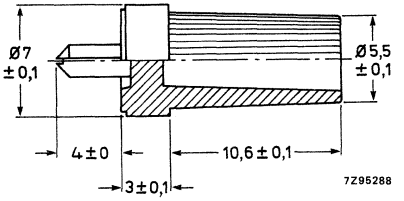
QUICK REFERENCE DATA

Resistance range (E6-series), linear law	47 Ω to 10 MΩ
Maximum dissipation at 40 °C	0,5 W
Climatic category, IEC 68-2	55/125/56

DESCRIPTION

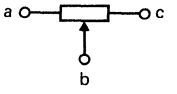
These preset potentiometers comprise a metal-glaze resistive element on a ceramic base. The actuating device is a plastic rotor. Adjustment is by means of insulated hexagonal or cross slots. The overall width of 9,8 mm alows for high density use with air-gap isolation on a 2,5 mm grid; either horizontal or vertical mounting. The glass-filled synthetic resin housing is fire resistant. The potentiometers, which are manufactured fully automatically, offer stable high quality performance and can be mounted by automatic insertion machines.

They are designed for video, audio and industrial applications and are especially suited for equipment in which automatic adjustment is practised. Versions with a hexagonal slot are available that can be provided with a knob to facilitate manual adjustment.



Example of a knob for versions with a hexagonal slot (cat. no. 8222 417 71060).

The terminals a and c are the end terminals; b is the central terminal connected to the slider. All terminals are either straight or snap-in pins for mounting on printed-wiring boards of nominal 1,0 to 1,6 mm thickness, grid pitch 2,5 or 2,54 mm.



Terminal designation.

MECHANICAL DATA

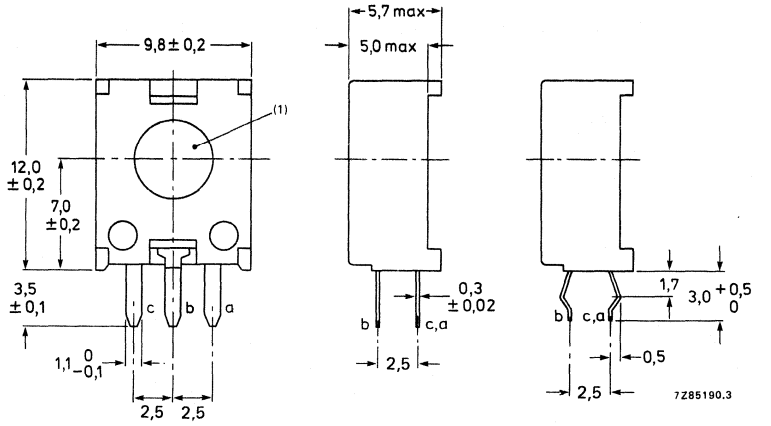


Fig. 1 Vertical mounting version.

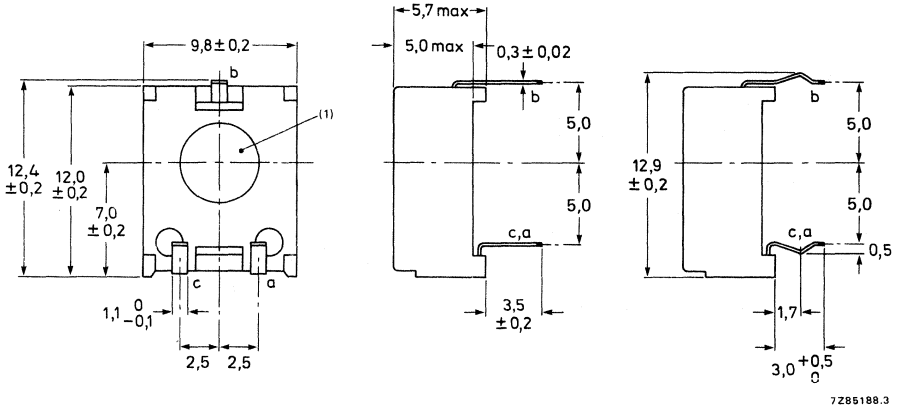


Fig. 2 Horizontal mounting.

* For details of available slots see Figs 3 and 4.

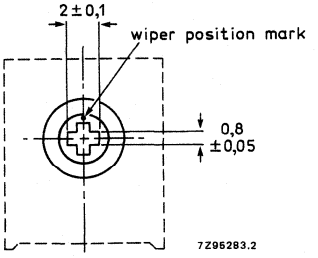


Fig. 3 Cross slot.

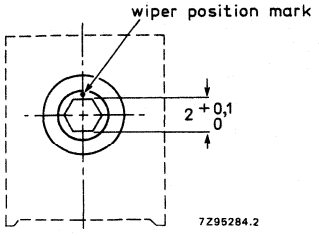


Fig. 4 Hexagonal slot.

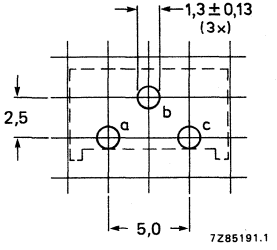


Fig. 5 Hole pattern for vertical versions, viewed from component side.

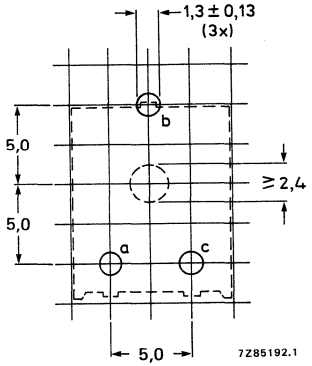


Fig. 6 Hole pattern for horizontal versions, viewed from component side.

TECHNICAL DATA

Mass		~ 1,5 g
Resistance range (E6-series)		47 Ω to 10 MΩ
Standard tolerance		± 20% and ± 10%
Resistance law		linear, see Fig. 8
Rated dissipation at 40 °C (P_{max})		0,5 W, see Fig. 7
Limiting element voltage		250 V (d.c.)
Limiting wiper current		$\sqrt{\frac{P_{max}}{R_{nom}}}$
Minimum effective resistance		⩽ 0,5% of R_{ac} or 2 Ω, whichever is greater
Rotational noise limits (contact resistance variation)		⩽ 1,0% of R_{nom}
Temperature coefficient in the range −55 °C to + 125 °C		
$R_{nom} \leqslant 100\ \Omega$		± 200 · 10⁻⁶/K
$100 < R_{nom} < 1\ M\Omega$		± 50 · 10⁻⁶/K
$R_{nom} \leqslant 1\ M\Omega$		± 100 · 10⁻⁶/K
Operating torque		3 to 20 mNm
Permissible end-stop torque		max. 50 mNm
Total mechanical angle of rotation		300 ± 5°
Effective angle of rotation		295 ± 5°
Settability		0,1% within 10 s
Climatic category according to IEC 68-2		55/125/56
Climatic sequence	$\frac{\Delta R_{ac}}{R_{ac}}$	⩽ 2%
Damp heat, steady state	$\frac{\Delta R_{ac}}{R_{ac}}$	⩽ 2%
Mechanical endurance (200 cycles)	$\frac{\Delta R_{ac}}{R_{ac}}$	⩽ 2%
Electrical endurance (1000 h at 70 °C, cyclic)	$\frac{\Delta R_{ac}}{R_{ac}}$	⩽ 2%
Change of temperature (between −55 °C and + 125 °C)	$\frac{\Delta R_{ac}}{R_{ac}}$	⩽ 2%
	$\frac{\Delta V_{ab}}{V_{ac}}$	⩽ 1%
Resistance to soldering heat	$\frac{\Delta R_{ac}}{R_{ac}}$	⩽ 0,5%
Bump	$\frac{\Delta R_{ac}}{R_{ac}}$	⩽ 1%
Vibration	$\frac{\Delta R_{ac}}{R_{ac}}$	⩽ 1%
	$\frac{\Delta V_{ab}}{V_{ac}}$	⩽ 0,5%

DERATING

Potentiometers covered by this specification are derated from 100% rated dissipation at 40 °C to zero dissipation at 125 °C. The dissipation below 40 °C is the rated dissipation.

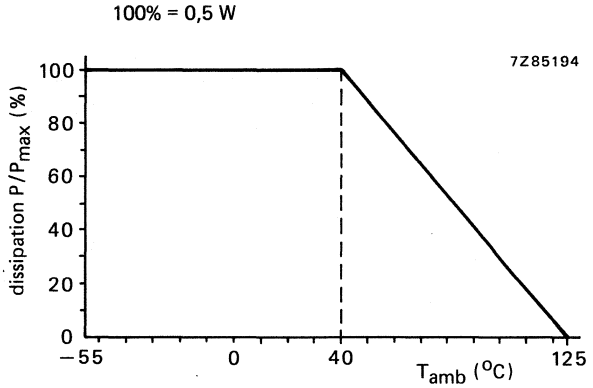


Fig. 7 Dissipation as a function of ambient temperature.

RESISTANCE LAW

Potentiometers covered by this specification are linear.

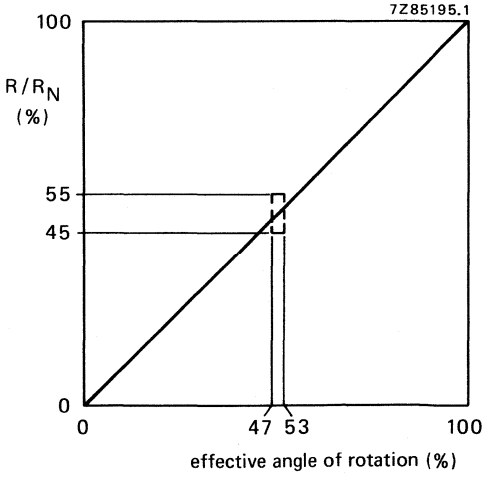


Fig. 8 Linear resistance law.

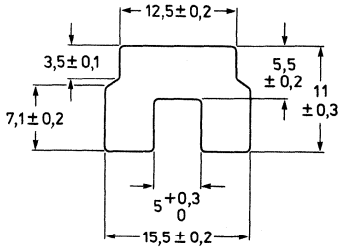
MARKING

The potentiometers are marked with the rated resistance, according to IEC 62, e.g. 220 Ω = 220 R; 10 kΩ = 10 k; 1 MΩ = 1 MO.

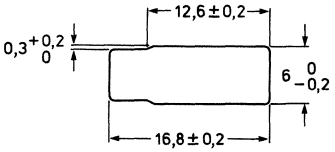
The package is marked with:
- catalogue number,
- date of production,
- quantity.

PACKAGING

The potentiometers can be supplied in bulk packaging of 1000 in a cardboard box or, especially for automatic insertion, in anti-static rail packaging of 50 per rail, 20 rails in a box. The outside dimensions of the rails, which have rubber stops at both ends, are given in Fig. 10.



For horizontal versions.



For vertical versions.

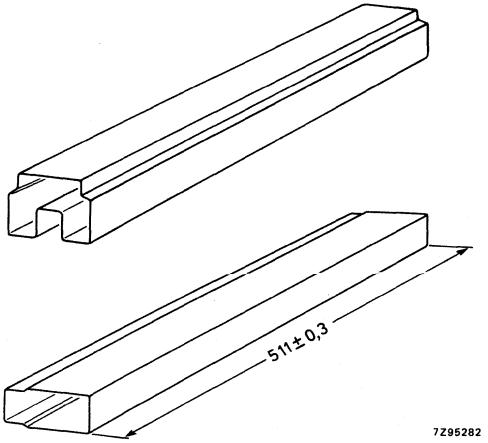


Fig. 10 Outlines of the rail packaging.

COMPOSITION OF THE CATALOGUE NUMBER

2322 484 . . . . .

code for version

1 = vertical, hexagonal slot
2 = vertical, cross slot
6 = horizontal, hexagonal slot
7 = horizontal, cross slot

code for tolerance, tags, packaging

2 = ± 20%, snap-in pins, bulk packaging
3 = ± 10%, snap-in pins, bulk packaging
4 = ± 20%, straight pins, bulk packaging
5 = ± 10%, straight pins, bulk packaging
6 = ± 20%, snap-in pins, rail packaging
7 = ± 10%, snap-in pins, rail packaging
8 = ± 20%, straight pins, rail packaging
9 = ± 10%, straight pins, rail packaging

resistance code

479 = 47 Ω	333 = 33 kΩ
689 = 68 Ω	473 = 47 kΩ
101 = 100 Ω	683 = 68 kΩ
151 = 150 Ω	104 = 100 kΩ
221 = 220 Ω	154 = 150 kΩ
331 = 330 Ω	224 = 220 kΩ
471 = 470 Ω	334 = 330 kΩ
681 = 680 Ω	474 = 470 kΩ
102 = 1 kΩ	684 = 680 kΩ
152 = 1,5 kΩ	105 = 1 MΩ
222 = 2,2 kΩ	155 = 1,5 MΩ
332 = 3,3 kΩ	225 = 2,2 MΩ
472 = 4,7 kΩ	335 = 3,3 MΩ
682 = 6,8 kΩ	475 = 4,7 MΩ
103 = 10 kΩ	685 = 6,8 MΩ
153 = 15 kΩ	106 = 10 MΩ
223 = 22 kΩ	

TESTS AND REQUIREMENTS

Clause numbers of tests and conditions of test refer to IEC 393–1 (potentiometers, part 1: terms and methods of test).

The potentiometers have been tested whilst mounted by their terminations on a printed wiring board.

When drying is called for procedure I of IEC 393–1, sub 5.2. is used (24 ± 4 h, 55 ± 2 °C, R.H. 20%).

When the contact resistance variation (CRV) is measured, the wiper is rotated in both directions over 90% of the effective resistance for a total of 6 cycles. The maximum deviations in the last 3 cycles are taken into account. Wiper speed: 2 cycles/minute; bandwidth 10 Hz to 5 kHz.

IEC 393–1 clause	IEC 68–2 test method	test	procedure	typical result
6.22.3	T	Solderability	solder bath: 230 ± 10 °C, 2 ± 0,5 s	good tinning
6.22.4	Tb	Resistance to heat	solder bath: 350 ± 10 °C, 3,5 ± 0,5 s	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 0{,}1\%$
6.25	Eb	Bump	acceleration: 390 m/s^2 number of bumps: 4000	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 0{,}1\%$
6.24	Fc	Vibration	frequency: 10 - 500 Hz amplitude: 0,75 mm or 98 m/s^2, 6 h	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 0{,}5\%$ $\frac{\Delta V_{ab}}{V_{ac}} \leqslant 0{,}3\%$

IEC 393–1 clause	IEC 68–2 test method	test	procedure	typical result
6.13		Temperature characteristic of resistance	temp. cycle: + 20 °C; –25 °C; + 20 °C; + 70 °C; + 20 °C	$-50 < TC < +50 \cdot 10^{-6}/K$
6.23	Na	Change of temperature	–55 °C and + 125 °C; 5 cycles	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 0{,}5\%$ $\frac{\Delta V_{ab}}{V_{ac}} \leqslant 0{,}1\%$
6.26	–	Climatic sequence		
6.26.2	Ba	Dry heat	16 h at 125 °C	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 0{,}5\%$
6.26.3	D	Damp heat accel. 1st cycle	24 h at 55 °C 95 - 100% R.H.	
6.26.4	Aa	Cold	2 h at –55 °C	
6.26.6	D	Damp heat, remaining cycle	24 h at 55 °C 95 - 100% R.H.	
(6.30)	–	Electrical endurance	T_{amb}: 40 °C, 1000 h, cyclic (1,5 h on and 0,5 h off, b at 0,67 ac)	CRV < 1% of R_{nom}
			Load: 0,5 W between a and c	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 1\%$ $\frac{\Delta V_{ab}}{V_{ac}} \leqslant 0{,}5\%$
			Load: 0,33 W between a and b	$\frac{\Delta R_{ab}}{R_{ab}} \leqslant 5\%$
6.29	–	Mechanical endurance	200 cycles, 4 cycles/min no load	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 1\%$ CRV < 1% of R_{nom}
(6.27)	C	Damp heat steady state	wiper at 0,67 a - c no load; recovery 24 h at 22 ± 1 °C, 50% R.H. ± 5%	CRV < 1% of R_{nom} $\frac{\Delta R_{ac}}{R_{ac}} \leqslant 1\%$ $\frac{\Delta R_{ab}}{R_{ab}} \leqslant 2\%$ $\frac{\Delta V_{ab}}{V_{ac}} \leqslant 0{,}2\%$

MULTITURN CARBON POTENTIOMETERS

MULTI-TURN CARBON PRESET POTENTIOMETERS

QUICK REFERENCE DATA

Nominal resistance	
linear law	100 Ω – 4,7 MΩ
logarithmic law	1 kΩ – 2,2 MΩ
special law	100 kΩ
Number of turns of spindle	
potentiometers CMP10	10
potentiometers CMP20	20
potentiometers CMP40	40
Climatic category (IEC 68)	25/070/21

APPLICATION

The potentiometers are for preset tuning adjustment in variable capacitance diode television tuners, but can also be used for variable capacitance diode tuning 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. The potentiometer will not be damaged if the spindle is turned beyond its extreme position. The potentiometers can be supplied with various adjustments and with or without a scale indicator.

All versions are available with linear or logarithmic resistance law; the 100 kΩ versions are also available with special resistance law.

COMPOSITION OF THE CATALOGUE NUMBER

2322 41 . . . . .

- code for number of turns of spindle
  - 2 = 20 turns, type CMP20
  - 3 = 10 turns, type CMP10
  - 4 = 40 turns, type CMP40
- code for indicator, see Indicators
- code for nominal resistance value, see Table 1
- code for adjustment provision, see Adjustment provisions.

MECHANICAL DATA

Dimensions of the housing (mm)

The housing has been drawn without scale indicator and adjustment provision; these parts are described in the relevant paragraph.

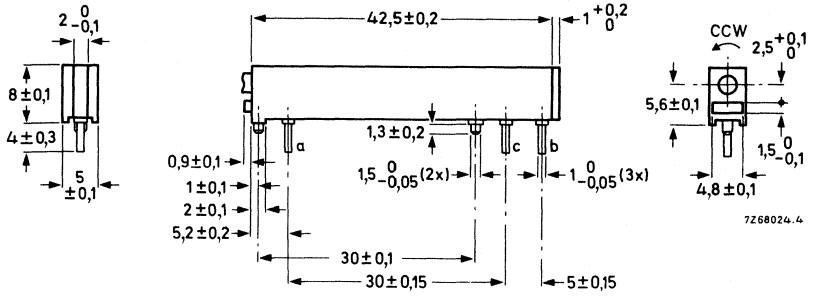


Fig. 1 Terminals a and c are connected to the ends of the carbon track; terminal b is connected to the slider contact.

Operating temperature range	−25 to + 70 °C
Climatic category (IEC 68)	25/070/21
Operating torque	1,5 to 10 mNm
Number of turns of spindle	
potentiometers CMP10	9½ ± ½
potentiometers CMP20	19 ± ½
potentiometers CMP40	38 ± 1
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 IEC 68-2, test T)	230 ± 10 °C, for 2 ± 0,5 s
Thermal shock test (to IEC 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

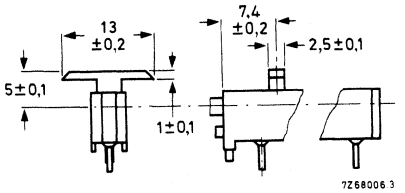
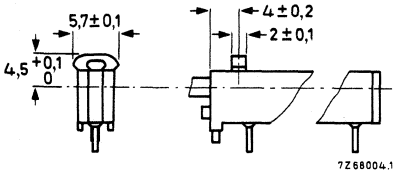
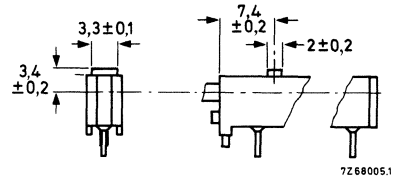
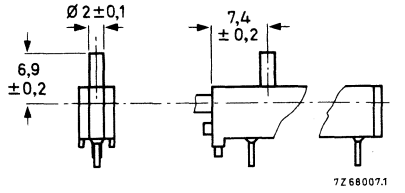
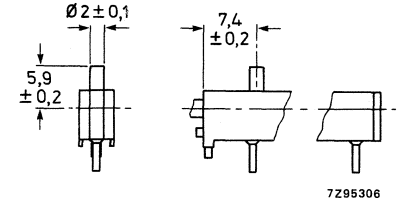
MOUNTING

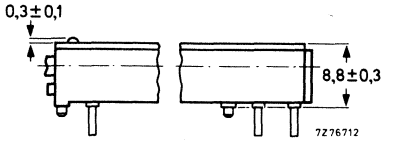
The terminals may be dip-soldered to a depth of 2 mm max in a solder bath of 260 °C max for 4 s max. When a soldering bit is used, its temperature must not exceed 360 °C for 1,5 s and neither axial nor radial stress must be exerted on the terminals.

MARKING

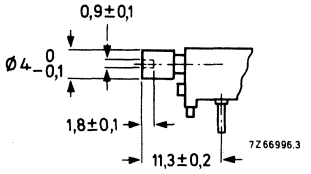
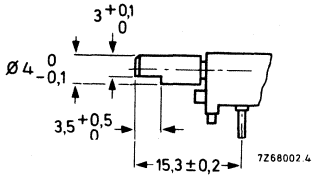
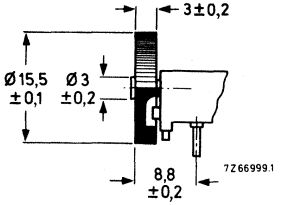
The potentiometers are marked with nominal resistance, resistance law, period and year of manufacture.

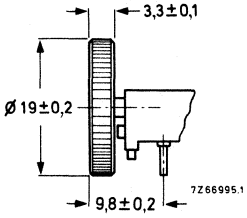
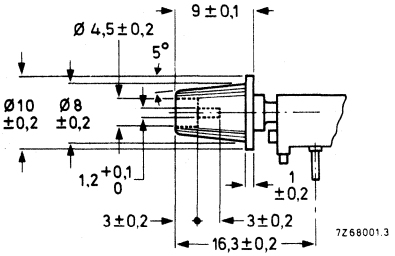
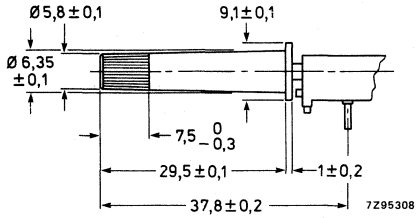
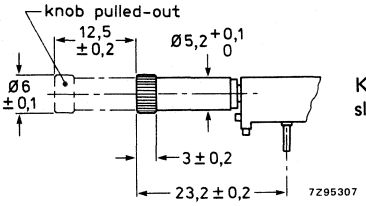
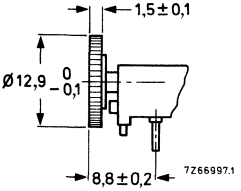
Indicators

type	colour	code in catalogue number 2322 41 . . . . .
	red	1
	red	3
	yellow	4
	red	5
	red	7 ←

type	colour	code in catalogue number 2322 41 . . . . .
without indicator		0
without indicator, with black dust cover on the housing 		8

Adjustment provisions

type	colour	code in catalogue number 2322 41 . . . . .
	grey	51
	grey	52
 Knob: approx. 60 notches	red	61

type	colour	code in catalogue number 2322 41 . . . . .
 Knob: approx. 48 notches	black	62
	black	63
 Knob with cross shaped trimming slot 4,4 x 1,6	black	69 ←
 Knob with trimming slot 4,4 x 0,8	black	71 ←
 number of teeth = 24 tooth height = 1,2	white	82

ELECTRICAL DATA

Unless stated otherwise, all electrical values have been determined at an ambient temperature of 15 to 35 °C, an air pressure of 86 to 106 kPa and a relative humidity of 45 to 75%.

Table 1

nominal resistance R_{nom}	resist. law	max. voltage (V d.c. or V a.c.) T_{amb} = 40 °C ΔR < 20% (note 1)	T_{amb} = 40 °C ΔR < 10% (note 1)	T_{amb} = 70 °C ΔR < 20% (note 1)	maximum terminal resistance	max. attenuation dB	limiting slider current mA	code in cat. no.
100 Ω	linear	5,5	5,0	3,9	10 Ω	20	55	01
220 Ω		8,1	7,4	5,7	20 Ω	20	37	02
470 Ω		11,8	10,8	8,4	35 Ω	30	25	03
1 kΩ		17	15,8	12,2	50 Ω	30	17	04
2,2 kΩ		26	23	18	100 Ω	40	11	05
4,7 kΩ		37	34	24	200 Ω	40	8	06
10 kΩ		53	47	37	300 Ω	40	5,3	07
22 kΩ		76	66	54	600 Ω	50	3,5	08
47 kΩ		108	91	76	1 kΩ	50	2,3	09
100 kΩ		152	122	107	2 kΩ	50	1,5	11
220 kΩ		217	166	153	3,5 kΩ	60	0,99	12
470 kΩ		306	216	216	6 kΩ	60	0,85	13
1 MΩ		425	274	300	10 kΩ	70	0,43	14
2,2 MΩ		600	330	420	20 kΩ	70	0,27	15
4,7 MΩ		840 (2)	340	590	50 kΩ	70	0,18	16
1 kΩ	loga-rithmic	10	8,9	7,1	10 Ω (5)	40	10 (3)	24
2,2 kΩ		14	12,8	10,2	20 Ω	50	6,8	25
4,7 kΩ		20	17,5	14,5	35 Ω	50	4,4	26
10 kΩ		29	24	20	50 Ω	50	2,9	27
22 kΩ		42	34	29	100 Ω	60	1,9	28
47 kΩ		59	47	41	200 Ω	60	1,3	29
100 kΩ		85	63	60	250 Ω	60	0,85	31
220 kΩ		122	87	86	500 Ω	70	0,55	32
470 kΩ		172	112	120	1 kΩ	70	0,37	33
1 MΩ		240	141	170	2 kΩ	80	0,24	34
2,2 MΩ		350	182	244	5 kΩ	80	0,16	35
100 kΩ	special	85	63	60	500 Ω	60	0,85 (4)	38

Notes

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.
5. Measured between terminals a and b.

Tolerance on nominal resistance	± 20%
Resistance law and tolerance	see Fig. 3
Maximum permissible dissipation (P_{max})	see Fig. 4
Contact resistance between carbon track and slider contact, the slider being moved 1 mm/s (see also Measurement of the contact resistance)	
linear law	⩽ 3% of R_{total}
logarithmic 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 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
Change of preset voltage after vibration test (IEC 68, test Fc) and shock test (IEC 68, test Ea)	⩽ 0,1% of total voltage typ. 0,05% of total voltage

Measurement of the contact resistance

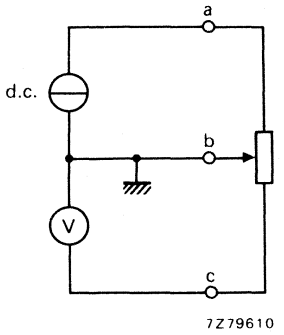


Fig. 2.

A d.c. current source which supplies a constant direct current (I) of e.g. 1 mA, is connected to pins a and b of the potentiometer. The d.c. voltage (V) resulting from the contact resistance (R_c) and the d.c. current is measured between pins b and c ($V = I.R_c$).

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.

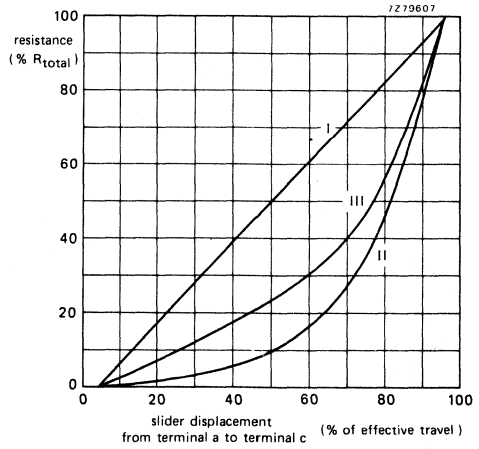


Fig. 3 Resistance as a function of slider displacement. Counter-clockwise knob rotation results in an increase of resistance between a and b (Fig. 1).

curve	resistance law	tolerance on resistance law	
		displacement	resistance
		% of effective travel	% of R_{total}
I	linear	between 36,5 and 38,5 between 61,5 and 63,5	33,5 - 41,5 58,5 - 66,5
II	logarithmic	between 36,5 and 38,5 between 61,5 and 63,5	3,5 - 8,5 12 - 26
iii	special	between 36,5 and 38,5 between 61,5 and 63,5 between 86,5 and 88,5	14 - 22 28 - 38 60 - 75

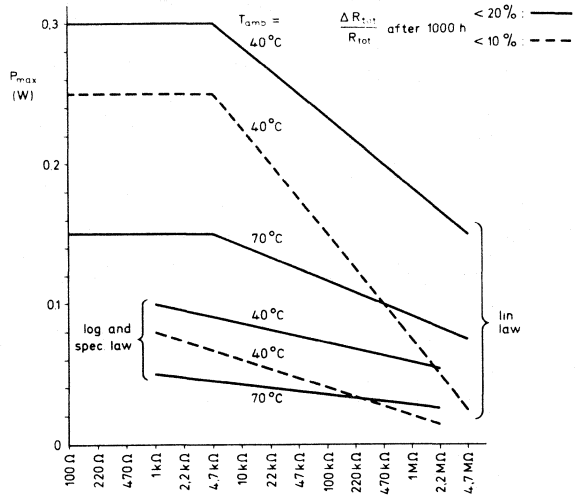


Fig. 4 Maximum permissible power dissipation.

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

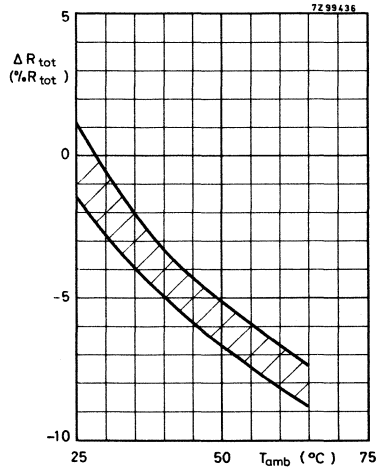


Fig. 5 R_{nom} = 100 kΩ, linear law.

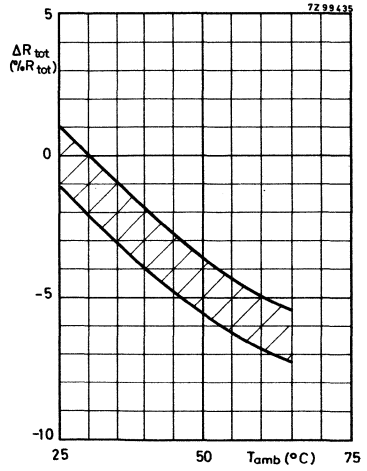


Fig. 6 R_{nom} = 100 kΩ, special law.

Change of preset voltage as a function of temperature, V_{a-b} being 30% of V_{a-c}; relative humidity 40 to 80% at 25 °C.

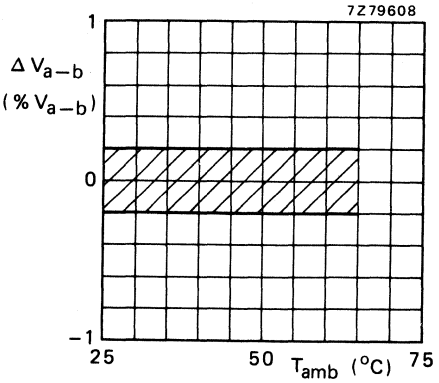


Fig. 7 R_{nom} = 100 kΩ, linear law.

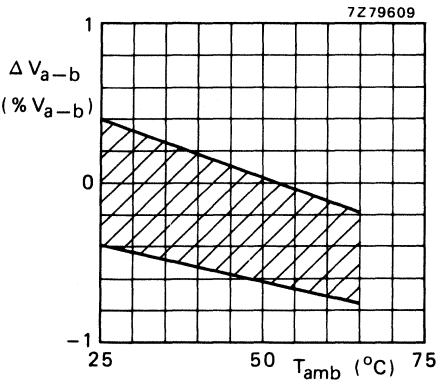


Fig. 8 R_{nom} = 100 kΩ, special law.

MULTI-TURN CARBON PRESET POTENTIOMETERS

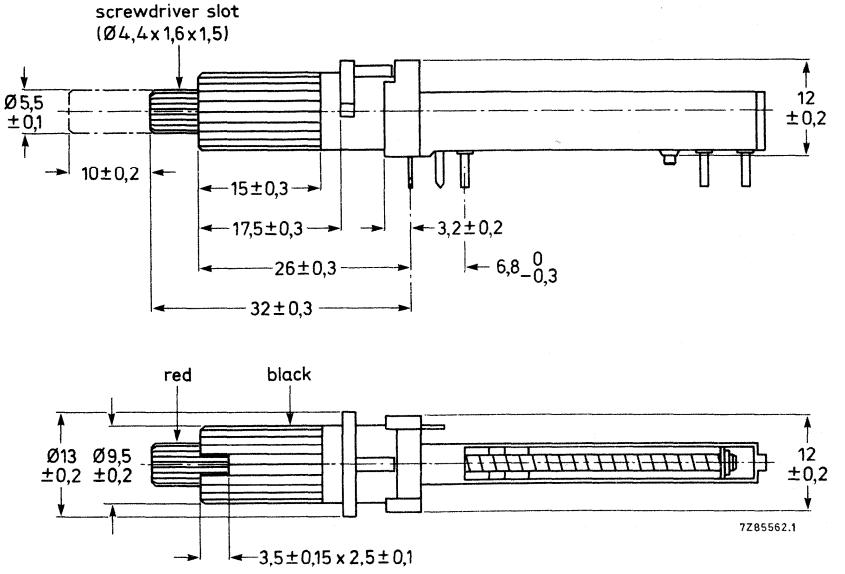
with bandswitch

This data should be read in conjunction with that multi-turn carbon preset potentiometers, types CMP10, CMP20, CMP40 (catalogue numbers 2322 413 ....., 2322 412 ..... and 2322 414 .....).

Type CMP/S. is basically identical to CMP ..., however, equipped with a 3-position bandswitch. The switch is designed for band switching in television or radio tuners and is of the "break before make" type. Two switch versions are available: /SK is equipped with a black knob, and /SL has a red lever. Other knobs and levers can be supplied on request.

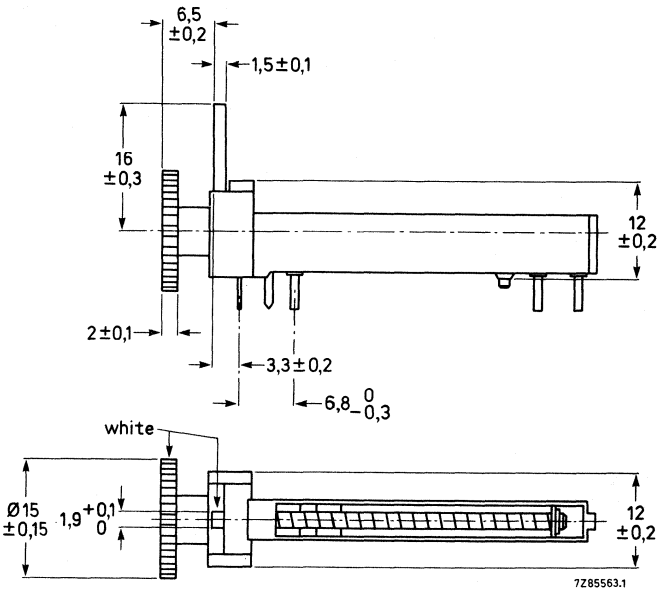
MECHANICAL DATA

Type /SK, outline drawing



Operating torque		10 to 40 mNm
End stop torque		> 250 mNm
Switching angle		2 x 40 degrees
Climatic category		25/070/21
Life		> 1000 cycles
Shaft load		
radial push	max.	2,5 N
axial pull	max.	5 N
axial push	max.	5 N

Type /SL, outline drawing



The potentiometers can be mounted on a printed wiring board with a piercing plan according to Fig. 3, viewed from the component side.

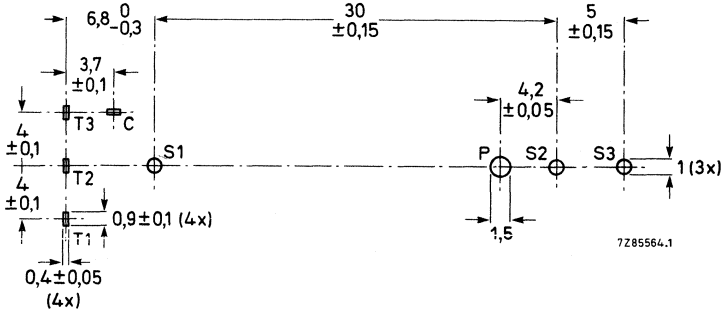


Fig. 3.

ELECTRICAL DATA of the switch

Rating (load applied)	35 V/20 mA
Function	1 section, 3 contacts
Contact resistance, max.	50 mΩ at a 5 mA

Catalogue number will be indicated on request.

MULTI-TURN CARBON PRESET POTENTIOMETERS

long life version

QUICK REFERENCE DATA

Nominal resistance, linear law (E3 series)	2,2 kΩ to 220 kΩ
Number of turns of spindle	
potentiometers CMP10L	10
potentiometers CMP20L	20
potentiometers CMP40L	40
Climatic category (IEC 68)	40/80/21

APPLICATION

The potentiometers are precision potential divider for general purpose. Typical applications are: position sensors and continuous tuning.

DESCRIPTION

A carbon resistor element is rivetted in a thermosetting housing. The electrical connection between the rivetted contacts (a and c) and the resistor element is effected by a silver-filled adhesive. The multi-finger slider is activated by a silvered threaded spindle. The potentiometer will not be damaged if the spindle is turned beyond its extreme position. The potentiometers can be supplied with various adjustments and with or without a scale indicator.

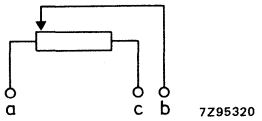


Fig. 1 Designation of terminals; slider in outer c.w. position.

COMPOSITION OF THE CATALOGUE NUMBER

2322 41 . . . . .

code for number of turns of spindle
6 = 20 turns, type CMP20L
7 = 10 turns, type CMP10L
8 = 40 turns, type CMP40L

code for indicator, see Indicators

code for nominal resistance value

05 = 2,2 kΩ	09 = 47 kΩ
06 = 4,7 kΩ	11 = 100 kΩ
07 = 10 kΩ	12 = 220 kΩ
08 = 22 kΩ	Ω

code for adjustment provision, see Adjustment provisions.

MECHANICAL DATA

Dimensions of the housing (mm)

The housing has been drawn without scale indicator and adjustment provision; these parts are described in the relevant paragraph.

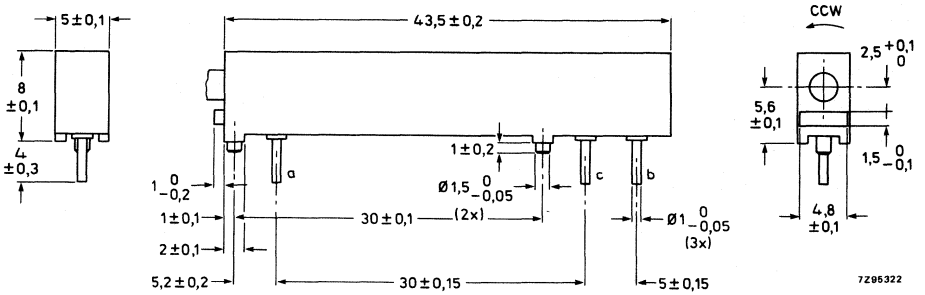


Fig. 2 Terminals a and c are connected to the ends of the carbon track; terminal b is connected to the slider contact.

MOUNTING

The potentiometers are to be mounted on printed circuit boards. Hole pattern is given in Fig. 3. The terminals may be dip-soldered to a depth of 2 mm max in a solder bath of 260 °C max for 4 s max. When a soldering bit is used, its temperature must not exceed 360 °C for 1,5 s and neither axial nor radial stress must be exerted on the terminals.

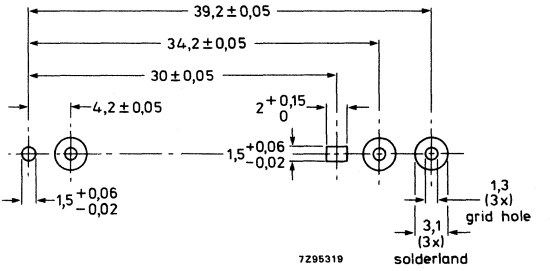


Fig. 3 Hole pattern, viewed from component side.

MARKING

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

DEVELOPMENT DATA

TECHNICAL DATA

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

Resistance law		linear, see also Fig. 4
Independent conformity		± 2%, see also Fig. 5
Nominal resistance range, E3 series		2,2 kΩ to 220 kΩ
Tolerance on the nominal resistance		± 20%
Rated dissipation at 70 °C, P_{nom}		0,125 W, see Fig. 4
Limiting element voltage (d.c.)		100 V
Insulation voltage (d.c. or a.c. peak)		150 V
Temperature coefficient, 20 to −40 °C		$\leqslant \pm 500\ 10^{-6}$/K
Temperature coefficient, 20 to 85 °C		$\leqslant \pm 300\ 10^{-6}$/K
Terminal resistance		$\leqslant$ 2% of R_{ac}
Limiting slider current		0,1 mA
Climatic category, IEC 68		40/085/21
Starting torque		1,5 to 10 mNm
Electrical endurance 1000 h at 70 °C, cyclic)	$\frac{\Delta R_{ac}}{R_{ac}}$	$\leqslant \pm$ 10%
Bump	$\frac{\Delta R_{ac}}{R_{ac}}$	$\leqslant$ 2%
Vibration	$\frac{\Delta R_{ac}}{R_{ac}}$	$\leqslant$ 2%
	$\frac{\Delta V_{ab}}{V_{ac}}$	$\leqslant$ 0,1%
Mechanical life, 10 000 cycles	$\frac{\Delta R_{ac}}{R_{ac}}$	$\leqslant$ 5%

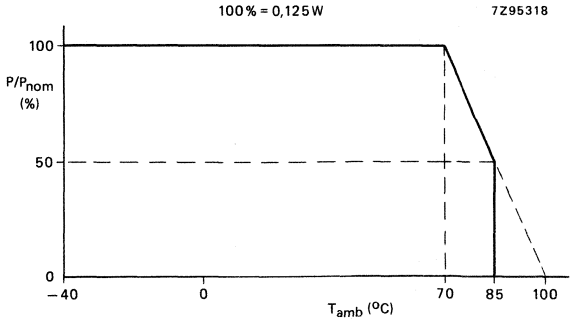


Fig. 4 Dissipation as a function of ambient temperature.

Mechanical and electrical travel

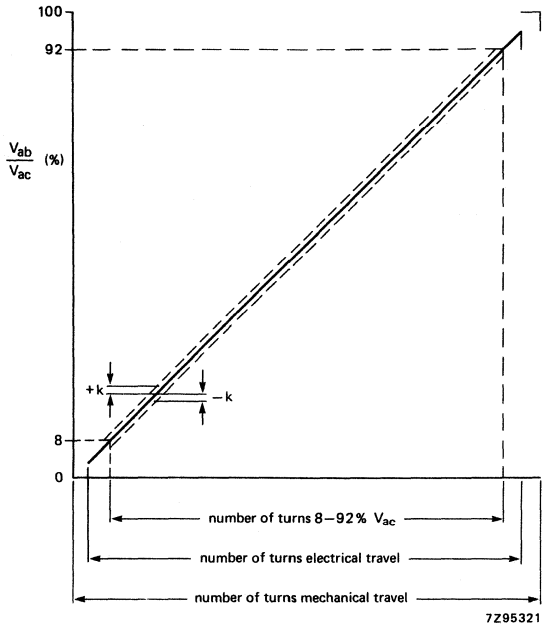


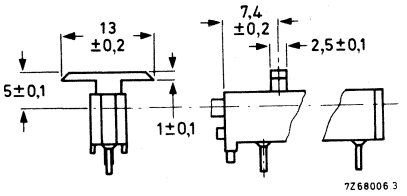
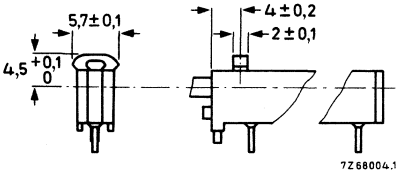
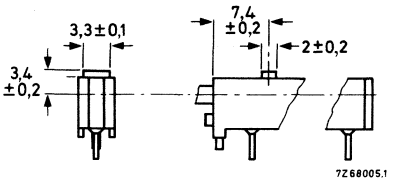
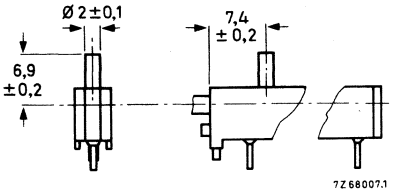
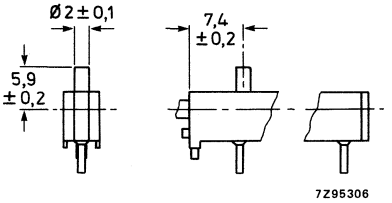
Fig. 5 Linear resistance law, K = independent conformity.

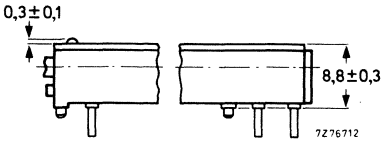
Number of turns

type	mechanical travel	electrical travel	8 to 92%
CMP10L	9,5 ± 0,5	9 ± 0,5	7,59 ± 0,4
CMP20L	19,5 ± 0,5	18 ± 0,5	15,18 ± 0,4
CMP40L	39 ± 1	36 ± 1	30,36 ± 0,8

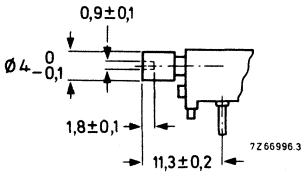
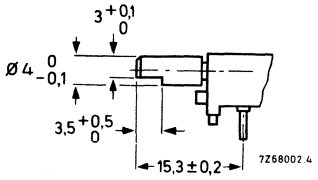
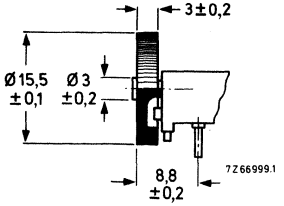
DEVELOPMENT DATA

Indicators

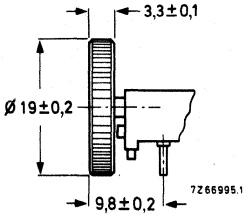
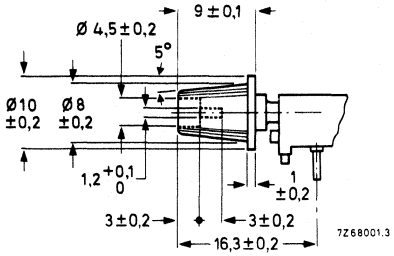
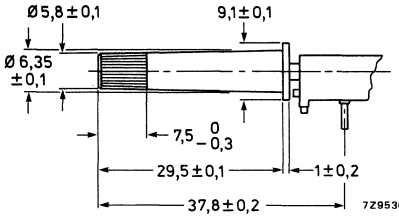
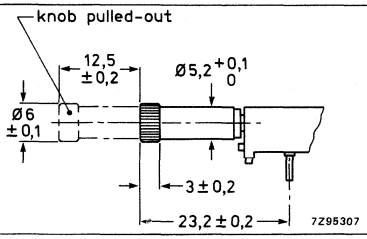
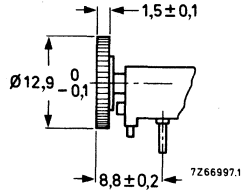
type	colour	code in catalogue number 2322 41 . . . . .
	red	1
	red	3
	yellow	4
	red	5
	red	7

type	colour	code in catalogue number 2322 41 . . . . .
without indicator		0
without indicator, with black dust cover on the housing 		8

Adjustment provisions

type	colour	code in catalogue number 2322 41 . . . . .
	grey	51
	grey	52
 Knob: approx. 60 notches	red	61

DEVELOPMENT DATA

type		colour	code in catalogue number 2322 41 . . . . .
	Knob: approx. 48 notches	black	62
		black	63
	Knob with cross shaped trimming slot 4,4 x 1,6	black	69
	Knob with trimming slot 4,4 x 1,6	black	71
	number of teeth = 24 tooth height = 1,2	white	82

TESTS AND REQUIREMENTS

Clause numbers of tests and conditions of test refer to IEC 393-1 (potentiometers, part 1: terms and methods of test).

The potentiometers have been tested whilst mounted by their terminations on a printed wiring board.

When drying is called for procedure I of IEC 393-1, sub. 5.5. is used (24 ± 4 h, 55 ± 2 °C, R.H. 20%).

When the contact resistance variation (CRV) is measured, the wiper is rotated in both directions over 90% of the effective resistance for a total of 6 cycles. The maximum deviations in the last 3 cycles are taken into account. Wiper speed: 2 cycles/minute; bandwidth 10 Hz to 5 kHz.

IEC 393-1 clause	IEC 68-2 test method	test	procedure	typical result
6.22.3	T	Solderability	solder bath: 230 ± 10 °C	good tinning
6.22.4	Tb	Resistance to heat	solder bath: 350 ± 10 °C 3,5 ± 0,5 s	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 0{,}5\%$
6.25	Eb	Bump	acceleration: 390 m/s² number of bumps: 4000	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 2\%$
6.24	Fc	Vibration	frequency: 10-500 Hz amplitude: 0,75 mm or 98 m/s², 6 h	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 2\%$ $\frac{\Delta V_{ab}}{V_{ac}} \leqslant 0{,}1\%$
6.13		Temperature characteristic of resistance	−40 °C to 20 °C 20 °C to 70 °C 20 °C to 85 °C	$500 \cdot 10^{-6}$/K $300 \cdot 10^{-6}$/K $300 \cdot 10^{-6}$/K
6.26	–	Climatic sequence		
6.26.2	Ba	Dry heat	16 h at 85 °C	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 5\%$
6.26.3	D	Damp heat, accel. 1st cycle	24 h at 55 °C 95-100% R.H.	
6.26.4	Aa	Cold	2 h at −40 °C	
6.26.6	D	Damp heat remaining cycle	24 h at 55 °C 95-100% R.H.	
(6.30)	–	Electrical endurance	T_{amb}: 70 °C, 1000 h cycle (1,5 h on and 0,5 h off, b at 0,67 a-c) Load: 0,05 W between a and c	CRV < 2% of R_{ac} $\frac{\Delta R_{ac}}{R_{ac}} \leqslant 5\%$ $\frac{\Delta V_{ab}}{V_{ac}} \leqslant 0{,}1\%$
6.29	–	Mechanical endurance	10 000 cycles, 4 cycles/min no load	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 5\%$

IEC 393-1 clause	IEC 68-2 test method	test	procedure	typical resul
(6.27)	C	Damp heat steady state	b at 0,67 a-c *no load;* 21 days; recovery 24 h, 22 ± 1 °C, 50% R.H. ± 5%	CRV < 1,0% of R_{ac} $\frac{\Delta R_{ac}}{R_{ac}} \leqslant 5\%$ $\frac{\Delta R_{ab}}{R_{ab}} \leqslant 5\%$ $\frac{\Delta V_{ab}}{V_{ac}} \leqslant 0{,}1\%$
(6.27)	C	Damp heat steady state	*with load* between a and c, 10 days; recovery 24 h, 22 °C ± 1 °C, 50% R.H. ± 5%	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 10\%$

DEVELOPMENT DATA

FOCUS POTENTIOMETERS

FOCUS POTENTIOMETER UNITS

- For low-bi colour picture tubes*, focusing voltage approx. 4,5 kV
- In conjunction with triplers or 4 diode-split line output transformers

QUICK REFERENCE DATA

	2322 460 90016	2322 460 90022
Nominal resistance	24 MΩ ± 20%	24 MΩ ± 10%
Maximum dissipation at 70 °C	3,8 W	3,8 W
Climatic category, IEC 68	20/070/21	20/070/21

APPLICATION

These focus potentiometer units are for adjustment of the focusing voltage for low-bi colour picture tubes.

DESCRIPTION

The potentiometer units comprise three resistance elements, which are connected in series. The centre element is provided with a wiper (see also Fig. 1). The resistance elements are of the thick-film type; they are attached to a non-conductive temperature-resistant base (Al_2O_3, 96%). The housing of the potentiometer units is of grey, self-extinguishing, glass-fibre-filled thermoplastic material.
The units 2322 460 90016 and 2322 460 90022 are provided with snap-in clasps for mounting.

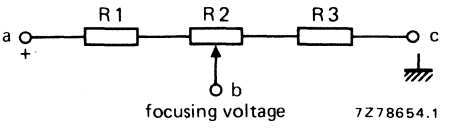


Fig. 1.

a = focus output voltage of tripler unit;
b = focusing voltage;
c = earth.

* Focus potentiometer units for hi-bi colour picture tubes are supplied under catalogue numbers 2322 460 90027, 2322 460 90028 and 2322 460 90029; see the relevant data sheet.

OUTLINES

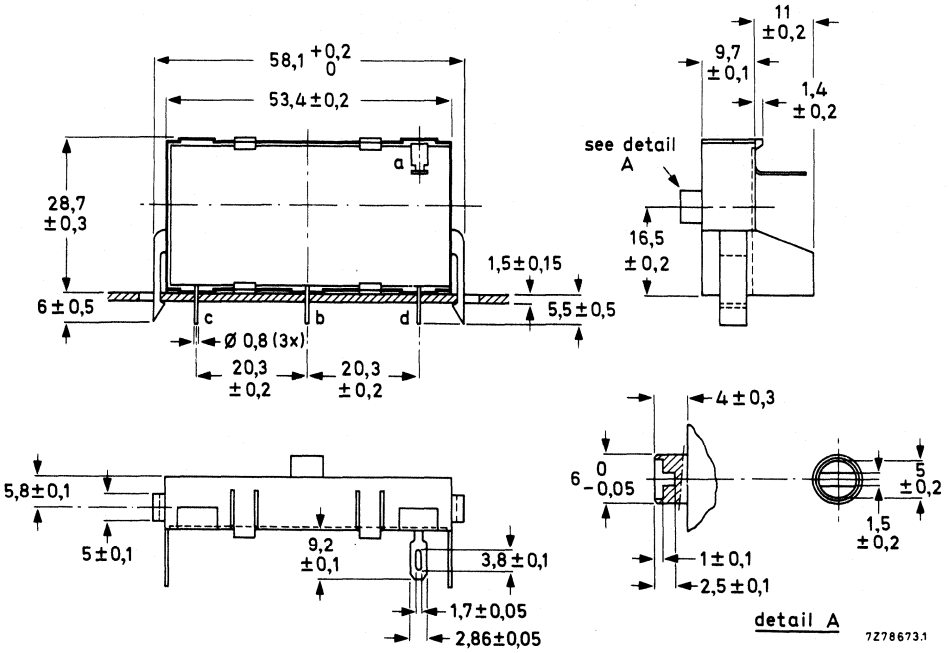


Fig. 2 Potentiometer unit **2322 460 90016**. The indication of the terminals corresponds to those shown in Fig. 1; terminal d serves for mechanical fitting of the unit. Solder tag a fits Faston receptacles (2,8 x 0,5).

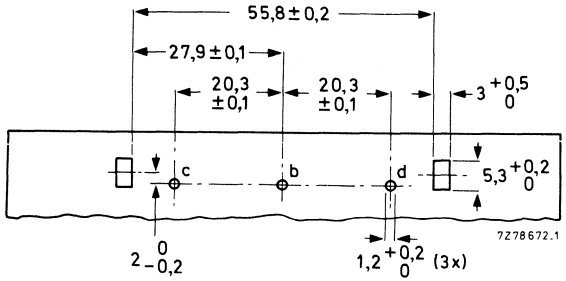


Fig. 3 Piercing diagram for board mounting of potentiometer unit **2322 460 90016** (component side).

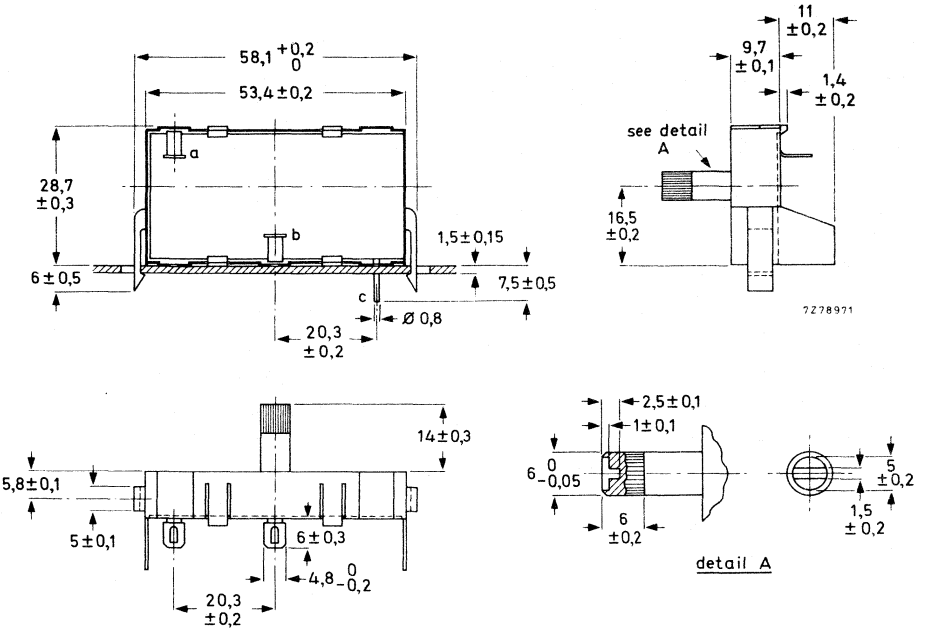


Fig. 6 Potentiometer unit **2322 460 90022.** The indication of the terminals corresponds to those shown in Fig. 1. The solder tags fit on Faston receptacles (4,8 x 0,5).

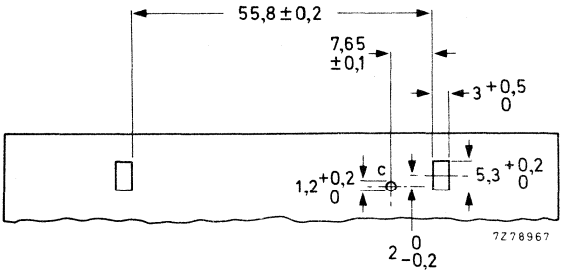


Fig. 7 Piercing diagram for board mounting of potentiometer unit **2322 460 90022** (component side).

TECHNICAL DATA

	2322 460	
	90016	90022
Nominal resistance value (R1 + R2 + R3, Fig. 1)	24 MΩ	24 MΩ
Tolerance on nominal resistance	± 20%	± 10% *
Resistance ratio at 25 °C (focusing voltage range)		
$\frac{R3 + R2}{R_{tot}}$	⩾ 0,73	⩾ 0,73
$\frac{R3}{R_{tot}}$	⩽ 0,50	⩽ 0,50
Variation in resistance ratios at 70 °C	⩽ 3%	⩽ 3%
Resistance law of R2	linear	linear
Contact resistance	⩽ 250 kΩ	⩽ 250 kΩ
Maximum dissipation at 70 °C	3,8 W	3,8 W
Limiting element voltage	8,5 kV	8,5 kV
Insulation resistance between interconnected terminals and mounting base at 500 V (d.c.)	$> 10^3$ MΩ	$> 10^3$ MΩ
Test voltage between interconnected terminals and mounting base for 1 min	10 kV	10 kV
Operation temperature range	−20 to + 70 °C	−20 to + 70 °C
Climatic category, IEC 68	20/070/21	20/070/21
Operating torque	3,5 to 50 mNm	3,5 to 30 mNm
Permissible end stop torque	⩽ 80 mNm	⩽ 80 mNm
Permissible axial spindle load	⩽ 12 N	⩽ 12 N

Note

Potentiometer units with different resistance values and resistance ratios, connecting terminals and spindles are available on request.

MARKING

The potentiometer units are marked with last five digits of the catalogue number, and period and year of manufacture.

* The ± 10% tolerance allows the possibility of applying a V_{g2} adjustment, with a total resistance of e.g. 2,7 MΩ, between terminal c and earth; as a result the resistance ratios become ⩾ 0,75 and ⩽ 0,55 respectively.

TESTS AND REQUIREMENTS

IEC 68-2 test method	name of test	procedure (quick reference)	requirements
Ta	Soldering	Solder bath, non-activated colophony flux, solder temp. 235 °C, dwell time 2 s.	Good tinning.
Na	Rapid change of temperature	5 cycles of ½ h at −20 °C and ½ h at + 70 °C.	No damage; R_{tot} and resistance ratios shall be within tolerance limits.
	Vibration	50 Hz, 1 mm, 3 directions, 2 h per direction.	
	Dry heat	16 h at + 70 °C, no voltage applied. Reconditioning 2 h.	
	Cold	16 h at −20 °C; no voltage applied; 2 h reconditioning.	
	Rotational life	50 cycles at a rate of 10 cycles/min, no voltage applied.	
	Endurance	1000 h at 70 °C, 9 kV (d.c.) applied; slider adjusted to 5 kV with respect to earth.	Stability of preset voltage ⩽ 0,5%.
	Humidity	21 days at 40 °C, R.H. 93%; 650 V (d.c.) applied.	contact resistance and insulation resistance shall meet initial requirements.
	Resistance ratios	4 h at 70 °C, 9 kV (d.c.) applied; slider adjusted to 5 kV with respect to earth at 25 °C.	variation of resistance ratios ⩽ 3%.

FOCUS POTENTIOMETER UNITS

- For hi-bi colour picture tubes*, focusing voltage approx. 7 kV
- In conjunction with diode-split line output transformers or triplers with or without 25 kV bleeder resistor

QUICK REFERENCE DATA

	2322 460 90027	2322 460 90028	2322 460 90029
Nominal resistance	24 MΩ ± 10%	83 MΩ ± 15%	83 MΩ ± 15%
Maximum dissipation at 70 °C	3,8 W	3,8 W	3,8 W
Climatic category, IEC 68	20/070/21	20/070/21	20/070/21

APPLICATION

These focus potentiometer units are for adjustment of the focusing voltage for hi-bi colour picture tubes.

DESCRIPTION

The potentiometer units comprise three resistance elements, which are connected in series. The centre element is provided with a slider (see also Figs 2, 4 and 6). The resistance elements are of the thick-film type; they are attached to a non-conductive temperature-resistant base (Al_2O_3, 96%).
Potentiometer unit 2322 460 90027 is designed for an input voltage of 8,3 kV; the units 2322 460 90028 and 2322 460 90029 are designed for applications with a 25 kV bleeder resistor.
To obtain better stability of the focusing voltage, unit 2322 460 90028 is, moreover, provided with a tap for connection to the 6,25 kV tap of a 4-diode-split line output transformer (e.g. AT2076/30); unit 2322 460 90029 has a similar tap for connection to the 8,3 kV tap of a tripler or a 3-diode-split line output transformer (e.g. AT2076/51).
The housing of the potentiometer units is of grey, self-extinguishing, glass-fibre-filled thermoplastic material.
The units are provided with snap-in clasps for mounting.

* Focus potentiometer units for low-bi colour picture tubes are supplied under catalogue numbers 2322 460 90016, 2322 460 90018 and 2322 460 90022; see the relevant data sheet.

OUTLINES

Dimensions in mm

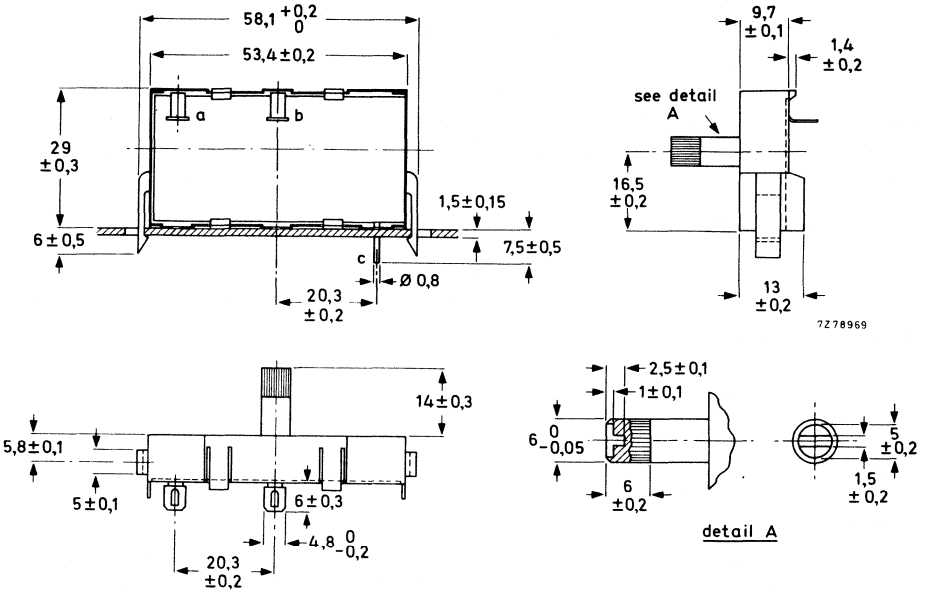


Fig. 1 Potentiometer unit **2322 460 90027**. The indication of the terminals corresponds to those shown in Fig. 2. The solder tags fit on Faston receptacles (4,8 x 0,5).

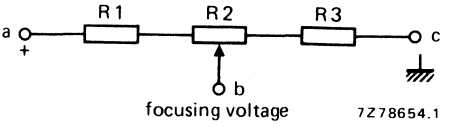


Fig. 2 Diagram of potentiometer unit **2322 460 90027**.

a = focus output voltage of e.h.t. device (8,3 kV);
b = focusing voltage;
c = earth.

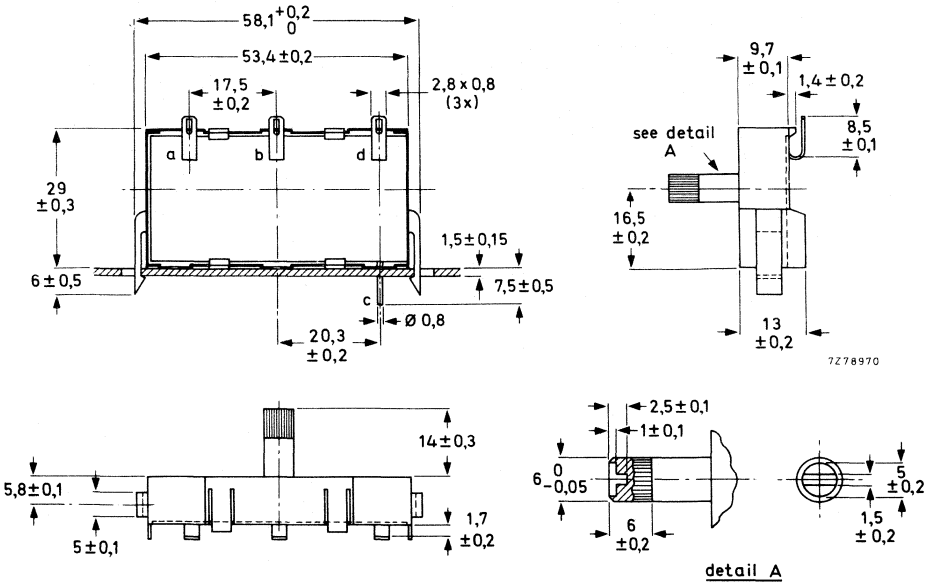


Fig. 3 Potentiometer unit **2322 460 90028.** The indication of the terminals corresponds to those shown in Fig. 4. The solder tags fit on Faston receptacles (2,8 x 0,8).

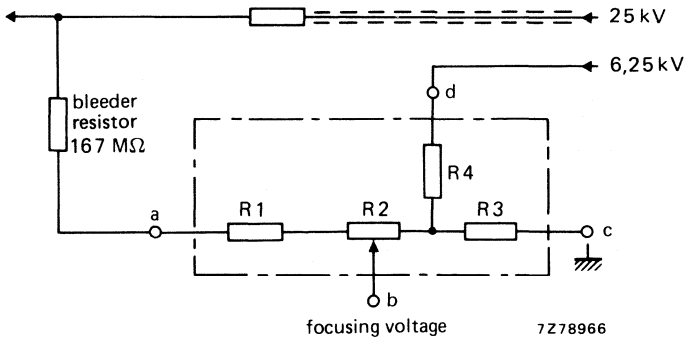


Fig. 4 Diagram of potentiometer unit **2322 460 90028.**
a = e.h.t. voltage via bleeder resistor;
b = focusing voltage;
c = earth;
d = 6,25 kV connection.

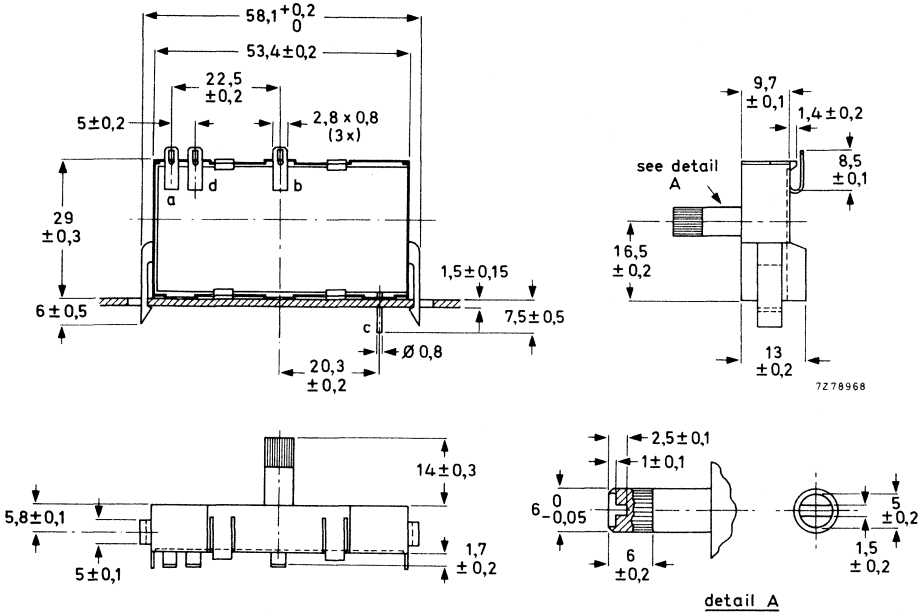


Fig. 5 Potentiometer unit **2322 460 90029.** The indication of the terminals corresponds to those shown in Fig. 6. The solder tags fit on Faston receptacles (2,8 x 0,8).

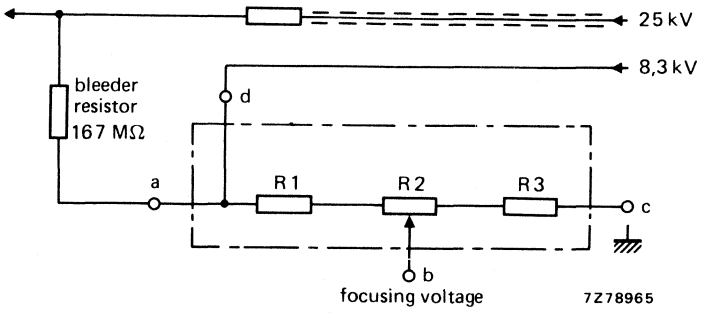


Fig. 6 Diagram of potentiometer unit **2322 460 90029.**

a = e.h.t. voltage via bleeder resistor;
b = focusing voltage;
c = earth;
d = 8,3 kV connection.

TECHNICAL DATA

	2322 460		
	90027	90028	90029
Nominal resistance value (R1 + R2 + R3, Figs 2, 4 and 6)	24 MΩ	83 MΩ	83 MΩ
Tolerance on nominal resistance	± 10% *	± 15%	± 15%
Resistance ratio at 25 °C (focusing voltage range)			
$\frac{R3 + R2}{R_{tot}}$	⩾ 0,94 (max. 0,98)	⩾ 0,94 (max. 0,98)	⩾ 0,94 (max. 0,98)
$\frac{R3}{R_{tot}}$	⩽ 0,75	⩽ 0,75	⩽ 0,75
Variation in resistance ratios at 70 °C	⩽ 3%	⩽ 3%	⩽ 3%
Resistance law of R2	linear	linear	linear
Contact resistance	⩽ 350 kΩ	⩽ 750 kΩ	⩽ 750 kΩ
Maximum dissipation at 70 °C	3,8 W	3,8 W	3,8 W
Limiting element voltage	9 kV	10 kV	10 kV
Insulation resistance between interconnected terminals and mounting base at 500 V (d.c.)	$> 10^3$ MΩ	$> 10^3$ MΩ	$> 10^3$ MΩ
Test voltage between interconnected terminals and mounting base for 1 min	10 kV	15 kV	15 kV
Operation temperature range	−20 to + 70 °C	−20 to + 70 °C	−20 to + 70 °C
Climatic category, IEC 68	20/070/21	20/070/21	20/070/21
Operating torque	3,5 to 30 mNm	3,5 to 30 mNm	3,5 to 30 mNm
Permissible end stop torque	⩽ 80 mNm	⩽ 80 mNm	⩽ 80 mNm
Permissible axial spindle load	⩽ 12 N	⩽ 12 N	⩽ 12 N

Note

Potentiometer units with different resistance values and resistance ratios, connecting terminals and spindles are available on request.

MOUNTING

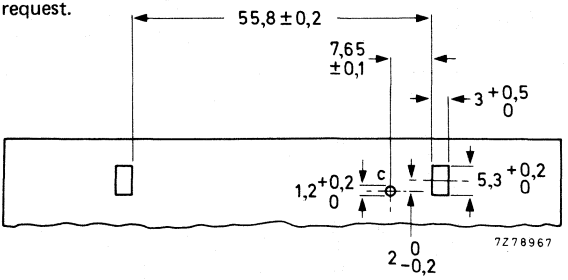


Fig. 7
Piercing diagram for board mounting (component side).

MARKING

The potentiometer units are marked with last five digits of the catalogue number, and period and year of manufacture.

* The ± 10% tolerance allows the possibility of applying a V_{g2} adjustment, with a total resistance of e.g. 3,8 MΩ, between terminal c and earth; as a result the resistance ratio $R3/R_{tot}$ becomes ⩽ 0,79.

TESTS AND REQUIREMENTS

IEC 68-2 test method	name of test	procedure (quick reference)	requirements
Ta	Soldering	Solder bath, non-activated colophony flux, solder temp. 235 °C, dwell time 2 s.	Good tinning.
Na	Rapid change of temperature	5 cycles of ½ h at −20 °C and ½ h at + 70 °C.	No damage; R_{tot} and resistance ratios shall be within tolerance limits.
	Vibration	50 Hz, 1 mm, 3 directions, 2 h per direction.	
	Dry heat	16 h at + 70 °C, no voltage applied. Reconditioning 2 h.	
	Cold	16 h at −20 °C; no voltage applied; 2 h reconditioning.	
	Rotational life	50 cycles at a rate of 10 cycles/min, no voltage applied.	
	Endurance	1000 h at 70 °C, 9 kV (d.c.) applied slider adjusted to 7 kV with respect to earth.	Stability of preset voltage ⩽ 0,5%.
	Humidity	21 days at 40 °C, R.H. 93%; 650 V (d.c.) applied	contact resistance and insulation resistance shall meet initial requirements.
	Resistance ratios	4 h at 70 °C, 9 kV (d.c.) applied; slider adjusted to 7 kV with respect to earth at 25 °C.	variation of resistance ratios ⩽ 3%.

FOCUS POTENTIOMETERS

with conductive rubber connections

- For hi-bi and lo-bi colour picture tubes, focus voltage range 3,9 to 9,3 kV
- Simple mounting and connection by conductive rubber

QUICK REFERENCE DATA

Nominal resistance	24 to 50 MΩ
Maximum dissipation	3 W
Climatic category, IEC 68	20/70/21

DESCRIPTION

The units comprise three resistance elements which are connected in series, see Fig. 1. The centre element is a potentiometer. The resistance elements are of the thick-film, metal glaze type; they are printed on an Al_2O_3 substrate. The housing of the units is of self-extinguishing, glass-fibre filled thermoplastic material. The units have two snap-in clasps for p.c. board mounting. Electrical connections are by means of conductive rubber.

For direct connections to the p.c. board, appropriate pins, mounted on the p.c. board, are plugged into the conductive rubber pads when mounting the unit. For wire connections, stripped wires, fitted in wire carriers, are plugged in the relevant channels in the housing, thus piercing into conductive rubber pads.

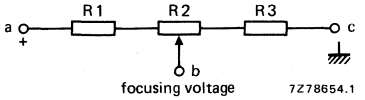
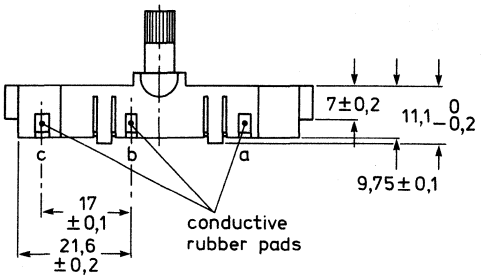


Fig. 1 Diagram of potentiometer unit.
a = focus input voltage of e.h.t. device
b = focusing voltage;
c = earth.

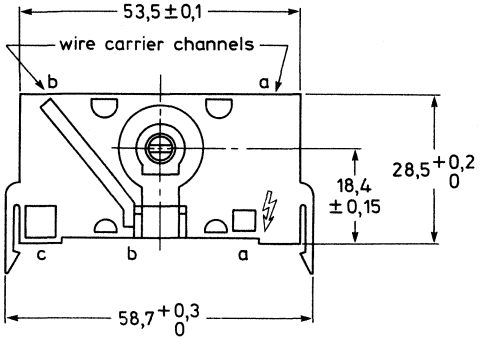
MECHANICAL DATA

Outlines (see Fig. 2)		
Mechanical angle of rotation		252 ± 5°
Operating torque		3,5 to 30 mNm
Torque against end stop	⩽	800 mNm
Permissible axial spindle load	⩽	120 N
Pull-out force of wires		t.b.f.
Push-in force of wires		t.b.f.
Inflammability		according to IEC 50 c
Climatic category, IEC 68		20/70/21

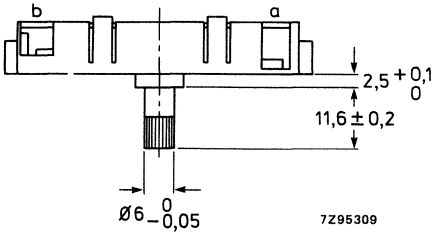
Outlines



Holes b and c are designed for pre-mounted contact pins, dia. 1 mm x 6 mm, cat. number 3122 121 63560.



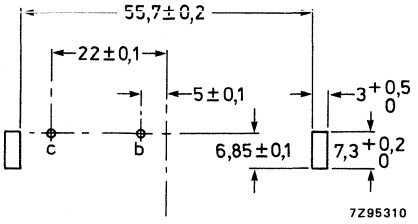
a, b and c are conductive rubber pads.



Channel a is designed for mounting wire carrier 4322 052 88750 for wire, dia. 1,8 ± 0,2 mm, stripped over a length of 7 ± 0,5 mm.

Channel b is designed for mounting wire carrier 4322 052 88730 for wire, dia. 1,8 ± 0,06 mm, stripped over a length of 6 ± 0,5 mm.

The wire carriers must be ordered extra.



Piercing diagram. Position of oblong mounting holes for snap-in clasps and of the contact pins b and c.

Fig. 2.

ELECTRICAL DATA

Nominal resistance (R_{nom})		See table below
Tolerance on R_{nom}		±10 %
Resistance ratio at 25 °C		
$\frac{R2+R3}{R_{ac}}$		See table below
$\frac{R_s}{R_{ac}}$		See table below
Variation in resistance ratio at 70 °C	⩽	1 %
Resistance law of R2		linear
Contact resistance	⩽	2% of R_{nom}
Maximum dissipation at 70 °C		3 W
Limiting element voltage		10 kV
Insulation resistance between interconnected terminals and mounting base at 500 V (d.c.)	⩾	10^3 MΩ
Test voltage between interconnected terminals and mounting base for 1 minute (d.c.)		10 kV

MARKING

The units are marked 460 followed by the last five digits of the cat. no., source code and date code (year + month of manufacture).

AVAILABLE TYPES

catalogue number	R_{ac} MΩ	e.h.t. voltage kV	focus voltage kV	$\frac{R2+R3}{R_{ac}}$ %	$\frac{R3}{R_{ac}}$ %
2322 460 90105	28	7,3	5,2 to 7,3	>71	–
2322 460 90106	24	8,5	3,9 to 6,4	>75	<46
2322 460 90107	24	8,5	6,0 to 8,0	>93	<70
2322 460 90108	40	8,5	4,2 to 6,2	>73	<50
2322 460 90111	50	9,5	6,7 to 8,8	>93	<70
2322 460 90115	50	9,5	4,4 to 7,1	>75	<46
2322 460 90119	24	8,5	3,9 to 6,4	>75	<46
2322 460 90122	40	8,5	4,2 to 6,2	>73	<50
2322 460 90123	50	9,5	6,7 to 8,8	>93	<70
2322 460 90124	50	9,5	4,4 to 7,1	>75	<46
2322 460 90127	33	9,5	7,4 to 9,3	>98	<78

TESTS AND REQUIREMENTS

IEC 393-1 clause	IEC 68-2 test method	test	procedure	typical results
6.30	–	Electrical endurance	T_{amb} = 70 °C; 1000 h load: 9,5 kV (d.c.) at 80 ± 5% of V_{ac}	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 3\%$ $\frac{\Delta V_{bc}}{V_{bc}} \leqslant 0{,}3\%$
6.27	Ca	Damp heat steady state	b at 0,80 V_{ac} no load, 21 days, T_{amb} = 40 °C, 93% R.H.	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 0{,}5\%$
6.24	Fc	Vibration	frequency 50 Hz, amplitude 1 mm, 3 directions, 2h per direction	$\frac{\Delta V_{bc}}{V_{bc}} \leqslant 0{,}1\%$
6.29	–	Mechanical endurance	50 cycles, 10 cycles/min no load	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 3\%$
9	–	Insulation resistance	500 V (d.c.)	min. 10^3 MΩ

POTENTIOMETER UNIT

- This unit has been specially developed for adjustment of the focus and screengrid voltage (V_{g2}) in television receivers and colour monitors.

DESCRIPTION

The unit is an E.H.T. bleeder resistor comprising five resistance elements, the second and fourth element are potentiometers. The thick-film metalglaze resistance elements are on a ceramic substrate (Al_2O_3).
The synthetic case is reinforced with glass-fibre and is self-extinghuishing (UL94-VO). The unit is suitable for mounting on printed-wiring boards by four snap-locks, integrated on the case.
Connections to the printed-wiring board (earth and V_{g2}), are via special pins, premounted on the board, which pierce into the conductive rubber plugs during mounting of the unit.
For E.H.T. and focus voltage connections, stripped leads are fitted into wire carriers, which are inserted into special channels in the case to pierce into conductive rubber plugs.

CATALOGUE NUMBERS

2322 460 90301	for super hi-bi picture tubes
2322 460 90302	for hi-bi picture tubes
2322 460 90303	for lo-bi picture tubes

MECHANICAL DATA

Dimensions in mm

Outlines

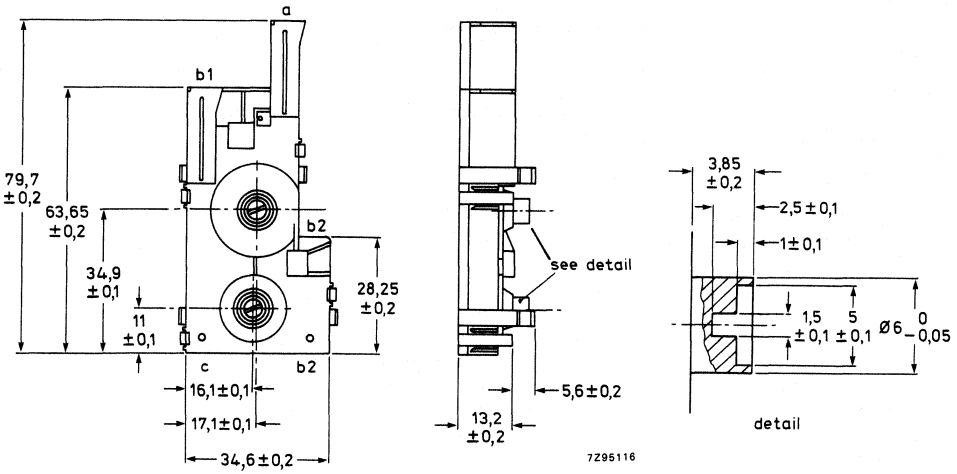


Fig. 1 a = high tension; b1 = focus; b2 = V_{g2}; c = earth. a, b1 and b2 are designed for wire carriers 4322 052 89140 or 88820 with wire ϕ 3,2 ± 0,2 mm and ϕ 1,8 ± 0,1 mm respectively. Wire carriers have to be ordered separately. Strip length for wires: 7 ± 0,5 mm. c and b2 are designed for pre-mounted contact pins ϕ 1 mm x 6 mm.

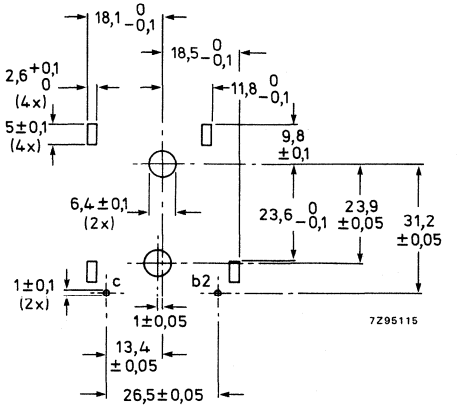


Fig. 2 Hole pattern, viewed from copper side.

Note

No electrically conductive tracks or parts are allowed in the mounting area.

Mechanical angle of rotation		
focus	180° ± 5°	
V_{g2}	222° ± 5°	
Operating torque	3 to 15	mNm
Maximum end stop torque	400	mNm
Maximum axial force	50	N
Extraction force for unit	> 30	N
Insertion force for unit	< 20	N

Inflammability
potentiometers, according to IEC 695-2--2
housing, according to IEC 65-14--4 and UL94-VO

ELECTRICAL DATA

Electrical circuit:

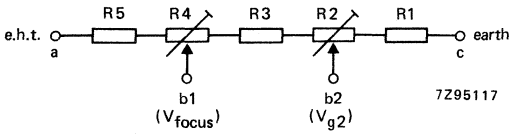


Fig. 3

versions	2322 500			
	90301	90302	90303	
Total resistance and tolerance R_{ac}	100	50	50	MΩ ± 10%
Operating voltage, d.c.	15	8,3	8,3	kV
Test voltage, d.c.	16	10	10	kV
Maximum dissipation at T_{amb} = 70 °C	2,5	1,8	1,8	W
Settability, acc. to IEC 393/6.34				
focus		± 25		V
V_{g2}		± 2,5		V
Contact resistance		< 2% of R_{ac}		

Breakdown voltage under pressure in accordance with IEC 68-2-13:
16 (resp. 10) kV (d.c.) for 1 minute on a; b1 and b2 set to maximum voltage and not connected, c earthed. At 45 °C and 464 hPa: neither flashovers nor breakdowns must occur.

Breakdown voltage in humidity in accordance with IEC 68-1:
16 (resp. 10) kV (d.c.) for 1 minute on a; b1 and b2 set to maximum voltage and not connected, c earthed. At 45 °C, 90% R.H. and 1013 hPa: neither flashovers nor breakdowns must occur.

Resistance ratio at 23 °C: version	version 2322 500 90301	2322 500 .... 2322 500 90302	2322 500 90303
$\frac{R1}{R_{ac}}$	> 0,5% < 2 %	> 0,5% < 3 %	> 0,5% < 3 %
$\frac{R1 + R2}{R_{ac}}$	> 6 % < 9 %	> 13 % < 18 %	> 13 % < 18 %
$\frac{R1 + R2 + R3}{R_{ac}}$	> 41 % < 49 %	> 62 % < 70 %	> 40 % < 46 %
$\frac{R1 + R2 + R3 + R4}{R_{ac}}$	> 60 % < 70 %	> 93 % < 99 %	> 75 % < 81 %
Climatic category		20/70/21	

MARKING

The units are marked with the last eight digits of the catalogue number, source code and period and year of manufacture.

TESTS AND REQUIREMENTS

IEC 68-2 test method	name of test	procedure (quick reference)	requirements
Na	Rapid change of temperature	5 cycles of ½ h at − 20 °C and ½ h at + 70 °C	No damage: R_{ac} and resistance ratios shall be within tolerance limits.
Fc	Vibration	50 Hz, 1 mm, 3 directions, 2 h per direction.	
Ba	Dry heat	16 h at + 70 °C, no voltage applied. Reconditioning 2 h.	
Aa	Cold	16 h at − 20 °C; no voltage applied; 2 h reconditioning.	
–	Rotational life	50 cycles at a rate of 10 cycles/min, no voltage applied.	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 3\%$
–	Endurance	1000 h at 70 °C, focus voltage 57 V ± 5% V_{g2} voltage 4 V ± 3%	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 3\%$, $\Delta V_{b1c} \leqslant 25V$ $\Delta V_{b2c} \leqslant 2{,}5V$
Ca	Humidity	21 days at 40 °C, R.H. 93%; no load applied	$\frac{\Delta R_{ac}}{R_{ac}} \leqslant 0{,}5\%$
–	Resistance ratios	4 h at 70 °C, 9 kV (d.c.) applied; slider adjusted to 7 kV with respect to earth at 25 °C.	variation of resistance ratios ⩽ 3%

ENCODER

MANUAL PULSE GENERATOR

APPLICATION

A manually operated pulse generator which produces two quadrature pulse trains for feeding angular rotation and direction of rotation information to digitally controlled equipment, e.g. microcomputer-controlled systems.

DESCRIPTION

The pulse generator employs LEDs and phototransistors to generate two pulse trains on the outputs A and B. An integrated Schmitt-trigger squares the output signals. The unit is panel mounted with a nut. The operating friction prevents flywheel action. The construction is non-sealed. The housing is of black glass-filled polycarbonate, the spindle is stainless steel. The pulse generator can be connected by a modular 0,1 inch pitch connector, such as F095, or can be soldered.

MECHANICAL DATA

Dimensions in mm

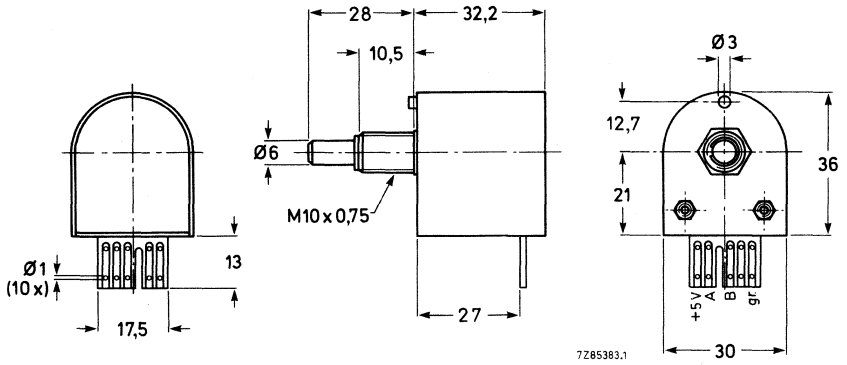


Fig. 1.

CATALOGUE NUMBER

2422 549 90001

RATINGS AND CHARACTERISTICS

Input voltage (d.c.)	typ. 5 V, TTL compatible
Input current	typ. 40 mA
Resolution	256 pulses per rev. 128 pulses output A 128 pulses output B
Phase shift between outputs A and B	$90^o \pm 45^o$ CW and CCW*
Output	see Fig. 2
Electrical circuit	see Fig. 3
Output load 10 kΩ (I_b max. = 0,5 mA)	logic "1" 4,0 V min. logic "0" 0,5 V max. square wave
Operating torque	8 - 30 mNm
Maximum allowable axial force	
push	⩽ 100 N
pull	⩽ 50 N
Mechanical life (360^o CW and 360^o CCW)	$0{,}5 \cdot 10^6$ cycles
Electrical life	50 000 h
Operating temperature	$-25\ ^oC$ to $+ 60\ ^oC$
Storage temperature	$-40\ ^oC$ to $+ 75\ ^oC$
Damp heat steady state (21 days) IEC 68-2-3(c)	no displacement
Bump IEC 68-2-29(Eb) 40g - 6 ms - 4000 bumps	no displacement
Vibration IEC 68-2-6(Fc) 10 - 150 Hz; 5g, 6 h	no displacement
Mechanical load on housing and connector	no continuous load

* Measured at a speed of 1 cycle/min.

Logic

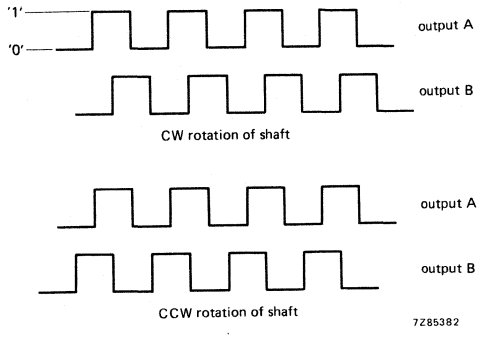


Fig. 2 Output pulses.

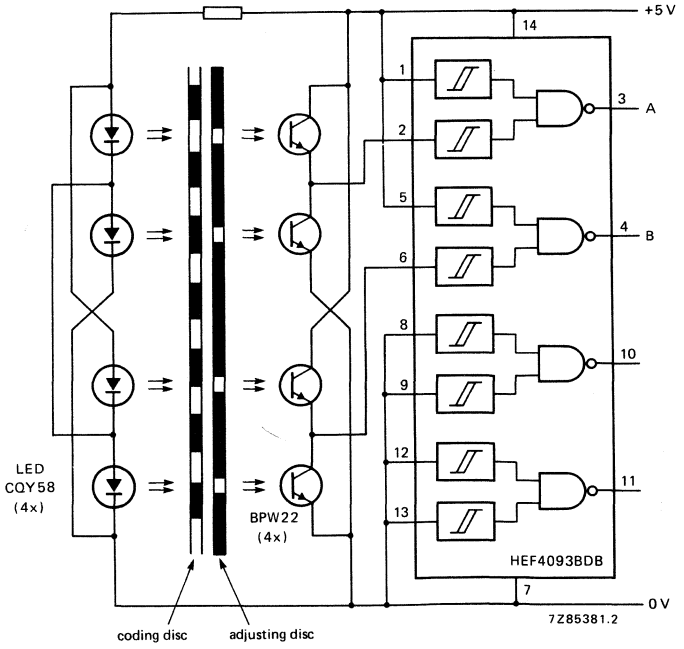


Fig. 3 Functional diagram.

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 designed for mounting on printed-wiring boards. All types can be supplied for horizontal or vertical mounting.

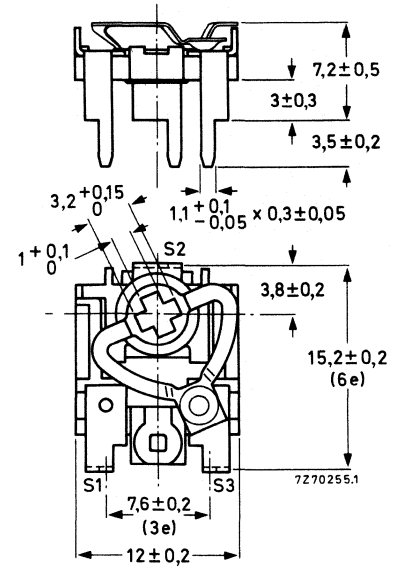
The basic switch consists of a rotatable selector contact and two or three switch connections, mounted on an insulating plate. By turning the selector contact one of the switch connections can be connected to the centre contact. The contacts are of the "break before make" type.

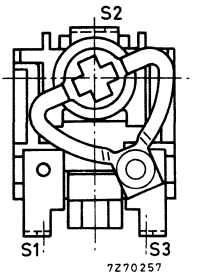
One switch type is provided with two active switch connections and a "centre-off" position. The second type has three active switch connections; the third type has two active switch connections (without "centre-off" position).

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.

OUTLINES

Dimensions in mm





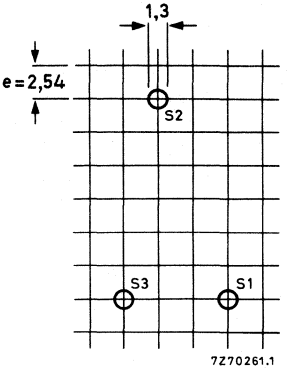


Fig. 1 Test switch for horizontal mounting, with two active switch connections:
a. with "centre-off" position,
b. without "centre-off" position,
c. hole pattern for mounting on a printed-wiring board (solder side).

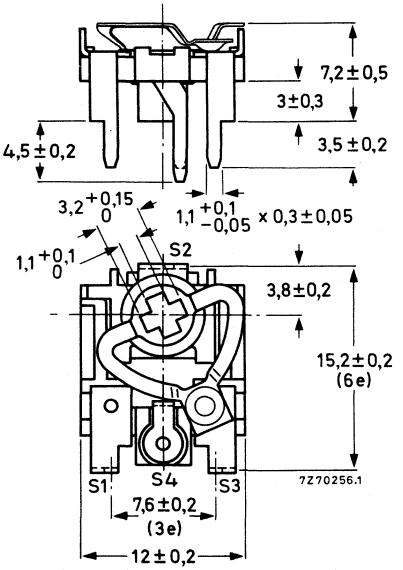


Fig. 2a Test switch for horizontal mounting, with three active switch connections.

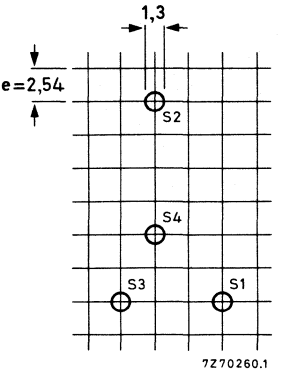


Fig. 2b Hole pattern for mounting on a printed-wiring board (solder side).

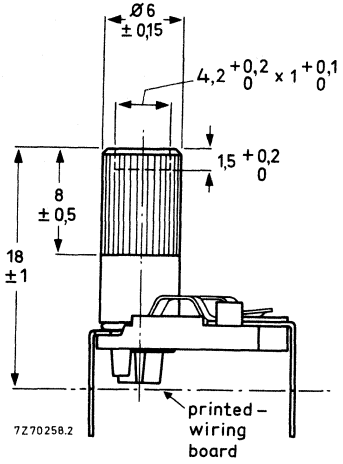


Fig. 3 Test switch for horizontal mounting with adjustment knob at the side of the selector contact.

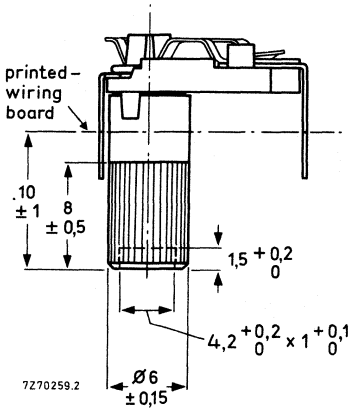


Fig. 4 Test switch for horizontal mounting with adjustment knob at the side of the base plate.

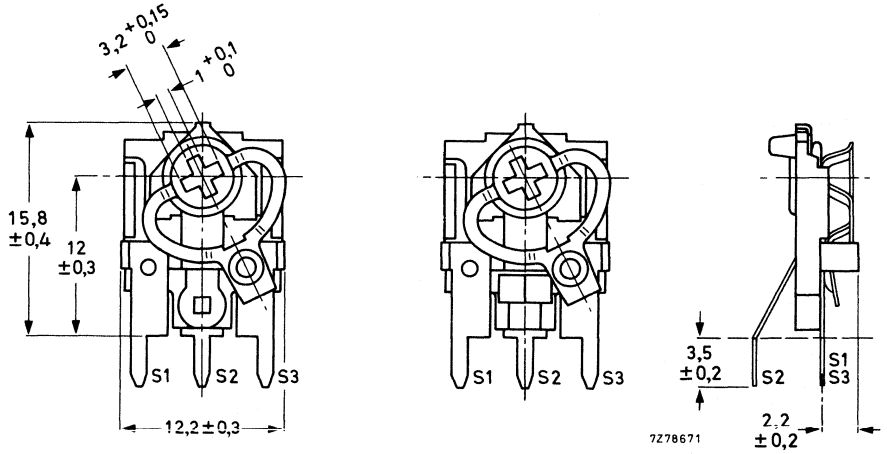


Fig. 5 Test switch for vertical mounting, with two active switch connections;
a. with "centre-off" position,
b. without "centre-off" position,
c. hole pattern for mounting on a printed-wiring board (solder side).

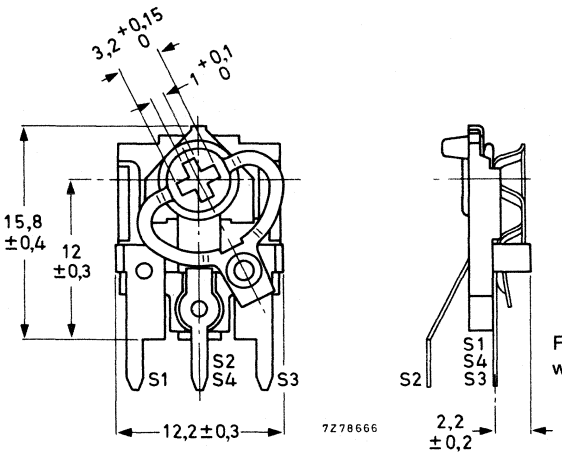


Fig. 6a Test switch for vertical mounting, with three active switch conditions.

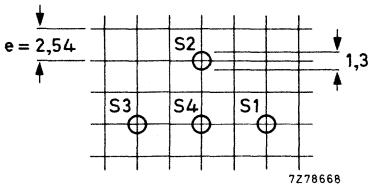


Fig. 6b Hole pattern for mounting on a printed-wiring board (solder side).

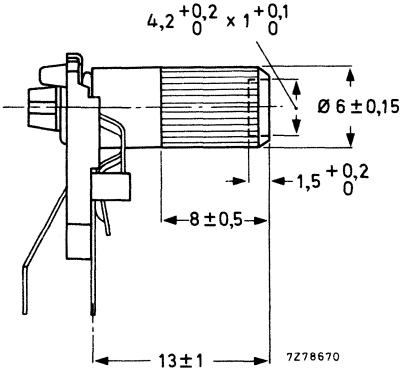


Fig. 7 Test switch for vertical mounting with adjustment knob at the side of the selector contact.

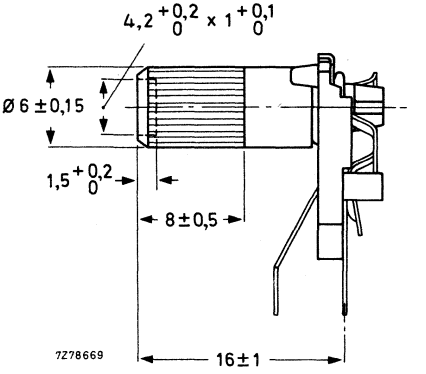


Fig. 8 Test switch for vertical mounting, with adjustment knob at the side of the base plate.

TECHNICAL DATA

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
Mass	
switch without knob	approx. 1 g
switch with knob	approx. 1,5 g

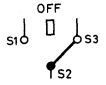
COMPOSITION OF THE CATALOGUE NUMBER

2422 136 7 ....

0 = without knob
1 = with knob at the side of the base plate
2 = with knob at the side of the selector contact

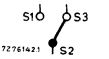
33 = horizontal mounting
72 = vertical mounting

2 = with 2 active switch connections; with off position



3 = with 3 active switch connections

4 = with 2 active switch connections; without off position



The catalogue number of a loose knob, such as used with CTP14, is 4322 047 08280.

BANDSWITCH

The switch is designed for band switching in television or radio tuners. It has three positions of the "break before make" type, and is operated by a lever. It is meant to be used with multiturn carbon preset potentiometers CMP10, CMP20, CMP40.

MECHANICAL DATA

Outline drawing

- Type 2422 136 80213

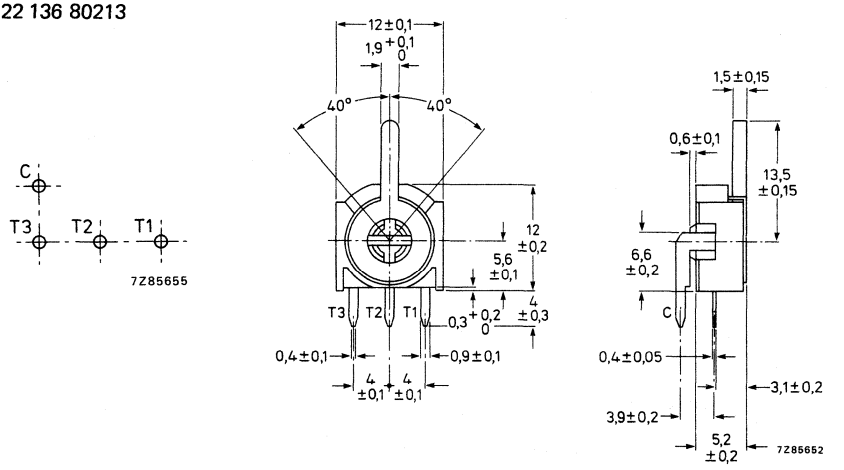


Fig. 1.

- Type 2422 136 80223

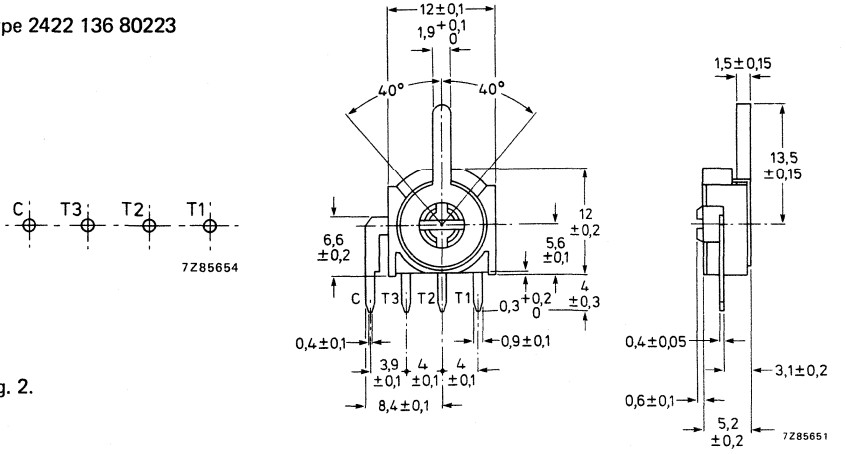


Fig. 2.

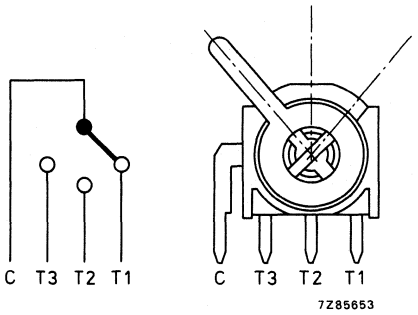


Fig. 3.

Operating turque	10 to 40 mNm
End stop torque	> 200 mNm
Switching angle	2 x 40 degrees
Climatic category	25/070/21
Life	> 250 cycles
No marking on the switch	

ELECTRICAL DATA

Rating (load applied)	12 V/40 mA
Function	1 section, 3 contacts
Contact resistance, max.	50 mΩ at 5 mA

COMPOSITION OF THE CATALOGUE NUMBER

2422 136 802..

13 = vertical, p.w. tags displaced, see Fig. 1.

23 = vertical, p.w. tags in line, see Fig. 2.

INDEX

INDEX OF CATALOGUE NUMBERS

STANDARD SERIES OF VALUES IN A DECADE

for resistances and capacitances

according to IEC publication 63

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