PHILIPS

Data handbook

PHILIPS

Electronic
components
and materials

Components and materials

Part 2b April 1976

Fixed capacitors

Variable capacitors

COMPONENTS AND MATERIALS

Part 2b **April 1976**

DATA HANDBOOK SYSTEM

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

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

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

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

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

December 1972

ELECTRON TUBES (BLUE SERIES)

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

Part 1a	**Transmitting tubes for communication and Tubes for r.f. heating Types PE05/25 ÷ TBW15/125**	**December 1975**
Part 1b	**Transmitting tubes for communication** **Tubes for r.f. heating** **Amplifier circuit assemblies**	**January 1976**
Part 2	**Microwave products** Communication magnetrons Magnetrons for microwave heating Klystrons Travelling-wave tubes Diodes Triodes T-R Switches Microwave Semiconductor devices Isolators Circulators	**October 1974**
Part 3	**Special Quality tubes;** **Miscellaneous devices**	**January 1975**
Part 4	**Receiving tubes**	**March 1975**
Part 5a	**Cathode-ray tubes**	**April 1975**
Part 5b	**Camera tubes; Image intensifier tubes**	**May 1975**
Part 6	**Products for nuclear technology** **Photodiodes** Channel electron multipliers Geiger-Mueller tubes Neutron tubes N.B. Photomultiplier tubes and Photo diodes will be issued in Part 9	**July 1975**
Part 7	**Gas-filled tubes** Voltage stabilizing and reference tubes Counter, selector, and indicator tubes Trigger tubes Switching diodes Thyratrons Ignitrons Industrial rectifying tubes High-voltage rectifying tubes	**August 1975**
Part 8	**TV Picture tubes**	**October 1975**

SEMICONDUCTORS AND INTEGRATED CIRCUITS (RED SERIES)

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

Part 1a **Rectifier diodes, thyristors, triacs** **March 1976**

- Rectifier diodes
- Voltage regulator diodes (> 1,5 W)
- Transient suppressor diodes
- Rectifier stacks
- Thyristors
- Triacs

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

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

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

Part 3 **High-frequency and switching transistors** **April 1976**

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

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

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

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

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

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

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

COMPONENTS AND MATERIALS (GREEN SERIES)

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

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

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

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

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

Part 2b **Capacitors** **April 1976**

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

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

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

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

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

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

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

- Ferroxcube memory cores
- Matrix planes and stacks
- Core memory systems

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

- Small synchronous motors
- Stepper motors
- Miniature direct current motors

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

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

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

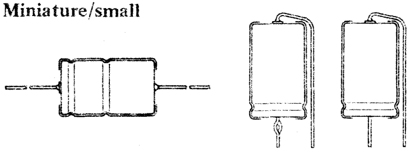
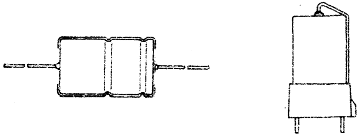
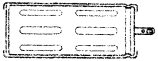
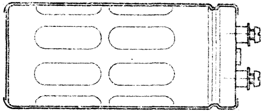
Part 9 **Piezoelectric quartz devices** **March 1976**

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

Electrolytic and solid capacitors

SURVEY

ALUMINIUM ELECTROLYTIC TYPES

type	temperature range (°C)	capacitance range (µF)	voltage range (V)	application	series number 2222 ...
Miniature/small					
	−25 to +70/85 −40 to +85 −40 to +85	0,33 to 4700	4 to 63	general industrial	015 016 ← 017
	−25 to +70	2,5 to 80	100 to 400	general high voltages	040 *) (C436) ←
	−40 to +85	2,2 to 2200	6,3 to 63	long life industrial	108
Large					
	−40 to +85	680 to 47 000	6,3 to 63	long life industrial	071 073 ←
	−40 to +85	1500 to 150 000	6,3 to 100	low impedance long life industrial	106 ← 107

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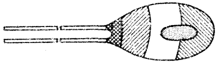
*) Maintenance type.

SOLID ALUMINIUM TYPES

type	temperature range (°C)	capacitance range (μF)	voltage range (V)	application	series number 2222 ...
Small 	−55 to +85 (for U_R) −55 to +125 (for 0,63 x U_R)	2,2 to 330	6,3 to 40	long life high reliability	121

SOLID TANTALUM TYPES

Subminiature resin dipped 	−55 to +85	0,01 to 68	1,6 to 40	ultra small dimensions hearing-aids electronic watches paging systems	146

INTRODUCTION

1. INTRODUCTION

Electrolytic and solid capacitors are most commonly used in such circuit functions as coupling, smoothing and by-passing, and for energy storage, or wherever there is a need for capacitive reactance.
These functions are often applied under specific circumstances and the requirements specified by users have grown steadily. The outcome has been a wide range of electrolytic and solid capacitor programmes to cover the different applications, for example:

General purpose	: radio, television , and general/industrial applications
Professional/industrial	: long life and high reliability - telecommunications equipment, electronic data processing.
	high temperature - motor cars.
	small size - hybrid circuits, paging systems.
	low equivalent series resistance at high frequency - switched-mode power supplies.

2. PRINCIPLES

The essential property of a capacitor is to store electrical charge. The amount of electrical charge (Q) in the capacitor (C) is proportional to the applied voltage (U).
The relationship of these parameters is :

$$Q = C.U$$

where Q = charge in coulombs (As)
C = capacitance in farads (F)
U = voltage in volts (V)

The value of capacitance is directly proportional to the (anode) surface area and inversely proportional to the thickness of the dielectric layer, thus :

$$C = \epsilon_r . \epsilon_0 . \frac{A}{d},$$

where ϵ_0 = absolute permittivity ($8,85 \times 10^{-12}$ F/m)
ϵ_r = relative dielectric constant (dimensionless)
A = surface area (m^2)
d = thickness of dielectric (oxide) layer (m)

The dielectric layer consists of either aluminium oxide ($A\ell_2O_3$) or tantalum oxide (Ta_2O_5) which are formed by an electrochemical oxidizing process from the respective metals. These layers withstand extremely high electrical field strength. During the electrochemical forming process the dielectric layer is exposed to the physical limit of electrical field strength mentioned above. So the thickness of the layer is determined by a voltage U_F, the so-called forming voltage. To avoid changing the thickness of the layer during normal use the operating voltage should always be lower than the forming voltage. For general purpose electrolytic capacitors the value of U_R/U_F is about 0,8 (U_R being the rated voltage). Types for long life performance and industrial applications are rated to 0,6. Solid capacitors are rated to approx 0,25 due to different reasons.

Table 1

material	relative dielectric constant (dimensionless)	physical limit of electrical field strength (V/m)
$A\ell_2O_3$	8	$7.\,10^8$
Ta_2O_5	24	$5.\,10^8$

3. DESCRIPTION

The above-mentioned dielectric layer is electrically contacted on one side by a metal (aluminium or tantalum) and on the other side by a conductor, being an electrolyte in case of an electrolytic capacitor and a solid semiconductor in case of a solid capacitor. The metal contact electrode is called the anode. To obtain high capacitance values per unit volume the surface of the anode is artificially enlarged by etching or sintering processes.

Aluminium electrolytic capacitors

The contacting electrode opposite to the anode is an ionic conductor in the case of an electrolytic capacitor. Because of this ionic conduction the potential of the anode should never be lower than the potential of the electrolyte: if the potential of the anode is lower than that of the electrolyte, positive hydrogen ions will move through the dielectric layer to the anode metal where they are discharged.
The so formed hydrogen gas blows up the dielectric layer, causing a high leakage current or even a short circuit. In the case of the anode being at a positive potential with respect to the electrolyte (this is the case of normal use) the oxidizing ions are driven towards the dielectric layer.
These oxidizing ions are not able to pass through the dielectric layer at field strengths lower than the physical limit mentioned in Table 1.
In the case of a defect in the dielectric layer the limiting field strength might be reached even during normal use.

In that case the oxidizing ions will pass through the defect to the anode metal where new oxide is formed, which repairs the defect.
It is necessary to make electrical contact to the electrolyte from outside. This is usually done by inserting an etched aluminium electrode into the electrolyte. This electrode, called the cathode, is always covered by a relatively thin oxide layer. To avoid direct mechanical contact between the oxide layers of cathode and anode (which would cause mechanical damage of the dielectric) a soft spacer of porous paper is used which also serves as a sponge for the electrolyte.
The total thickness of the system described is only a fraction of a millimetre. Therefore, during manufacture, long strips of the described system are wound into cylindrical bodies and encased. Fig. 1 shows a cross-section of a typical design.

Solid capacitors (Aℓ + Ta)

In a solid capacitor the contacting electrode opposite to the anode is formed by manganese dioxide (MnO_2) being a semiconductor, and called the cathode. Therefore, in principle, the potential of the anode with respect to the cathode is allowed to be positive as well as negative. However, due to the absence of oxidizing ions, no self-repairing effect of the dielectric layer by the leakage current is obtained. In practice it is advisable to maintain the anode potential positive with respect to the cathode, because no solid capacitor is absolutely free of moisture, so ionic reactions could take place.
Via the system manganese dioxide - aluminium foil - case - tinned leads, the cathode is electrically connected with the outside in our 121 series of solid aluminium capacitors (Fig. 1). To avoid direct mechanical contact between anode layer and the aluminium contact foil , a glass fibre spacer is applied.
In the 122 series of solid aluminium capacitors and the 146 series of solid tantalum capacitors, the cathode is connected to the outside by the system manganese dioxide - graphite - silver - tin solder - tinned leads (Fig. 2).

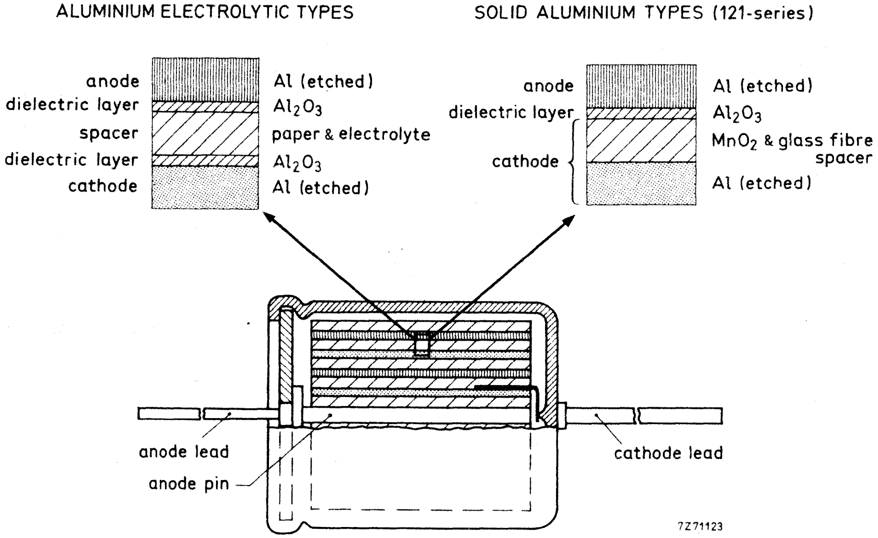

ALUMINIUM ELECTROLYTIC TYPES
anode
dielectric layer
spacer
dielectric layer
cathode
Al (etched)
Al_2O_3
paper & electrolyte
Al_2O_3
Al (etched)
SOLID ALUMINIUM TYPES (121-series)
anode
dielectric layer
cathode
Al (etched)
Al_2O_3
MnO_2 & glass fibre spacer
Al (etched)
anode lead
anode pin
cathode lead
7Z71123

Fig. 1.

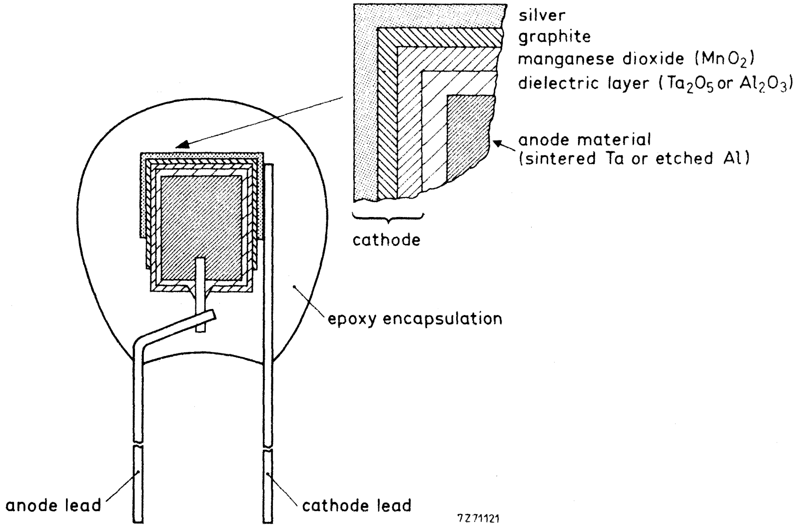

silver
graphite
manganese dioxide (MnO_2)
dielectric layer (Ta_2O_5 or Al_2O_3)
anode material
(sintered Ta or etched Al)
cathode
epoxy encapsulation
anode lead
cathode lead
7Z71121

Fig. 2.

4. THE ELECTRICAL IMPEDANCE Z OF THE CAPACITOR

The electrical impedance Z of a capacitor in its reference plane (being the connecting points) consists of a real part R, and an imaginary part j.X, thus :

$$Z = R + j.X \qquad \text{and } \tan\delta = \frac{R}{X}$$

where R = the equivalent series resistance (ESR) (Ω)
j.X = the imaginary part of the series impedance (Ω)
Z = the complex series impedance (Ω)
tan δ = dissipation factor (dimensionless)

The actual values of R and X depend upon two parameters : the frequency f and the temperature T. It is usual to express X in terms of C_S (equivalent series capacitance) and ω :

$$X = -\frac{1}{\omega C_S} \qquad \omega = 2.\pi.f \quad , \text{ f in (Hz)}$$

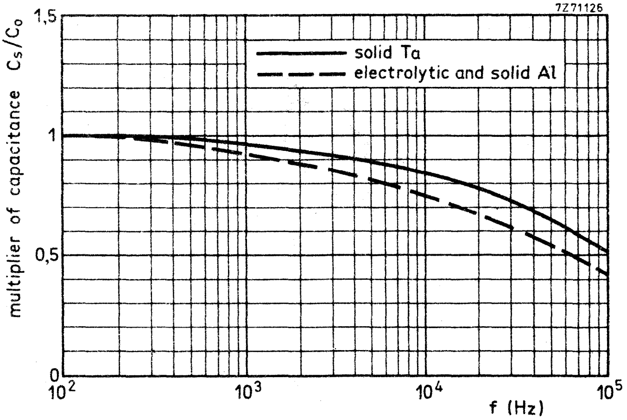


Fig. 3. Typical capacitance as a function of frequency. C_0 = capacitance at 25 °C, 100 Hz.

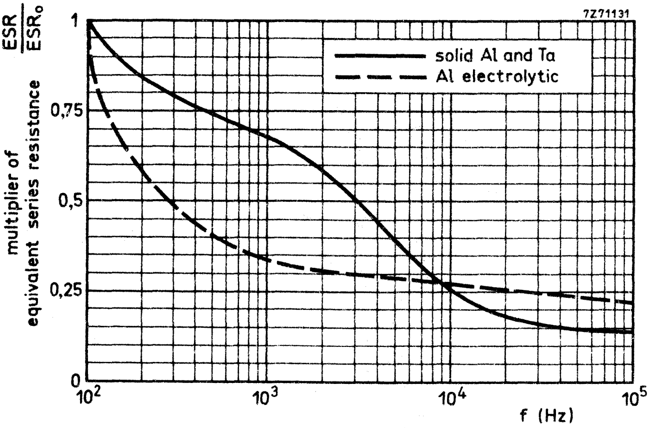


Fig. 4. Typical ESR as a function of frequency. ESR_0 = ESR at 25 °C , 100 Hz

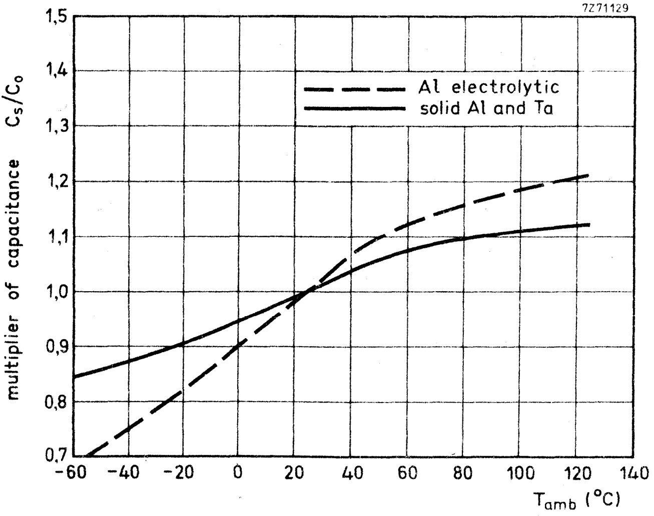


Fig. 5. Typical capacitance as a function of ambient temperature. C_0 = capacitance at 25 °C, 100 Hz.

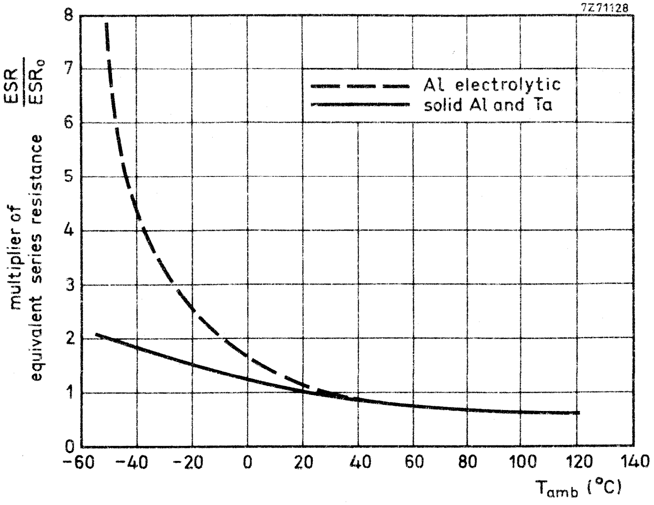


Fig. 6. Typical ESR as a function of ambient temperature. ESR_0 = ESR at 100 Hz, at 25 °C

5. RIPPLE CURRENT

In various applications a considerable amount of ripple current (I_r) passes through the capacitor. Due to the equivalent series resistance (R) power (P) is dissipated in the device :

$$P \text{ (Watt)} = I_r{}^2 \cdot R$$

The power causes an increase in temperature of the capacitor. Temperature equilibrium is reached when the power (P) passes through the case surface into the ambient. From this it is clear, that the maximum permissible ripple current depends on the maximum permissible temperature of the capacitor, value of the equivalent series resistance, case size and ambient temperature (T_{amb}).
In the data sheets the maximum permissible ripple current is specified under certain conditions.

$$I_r = \sqrt{\frac{P}{R}} = \sqrt{\frac{\alpha . S \, (T_c - T_{amb})}{R}}$$

where I_r = ripple current (A)
R = equivalent series resistance (Ω)
P = heat dissipation (W)
α = heat transfer coefficient ($W/m^2 \, ^oC$)
S = heat transfer surface area (m^2)
T_c = temperature of case surface (^oC)
T_{amb} = ambient temperature (^oC)

6. LEAKAGE CURRENT

In normal use a small amount of direct current passes through the capacitor.
This current is called the leakage current (I_ℓ) and depends on the applied voltage and temperature. The dependancy of I_ℓ/I_0 (I_0 being the leakage current at voltage U_R and 25 ^oC) on temperature, is shown in Fig. 7 for an aluminium electrolytic capacitor and a solid aluminium capacitor.

The dependancy of I_ℓ/I_0 as a function of U/U_R is given in Fig. 8 for an aluminium electrolytic capacitor and a solid aluminium capacitor, U being the working voltage.

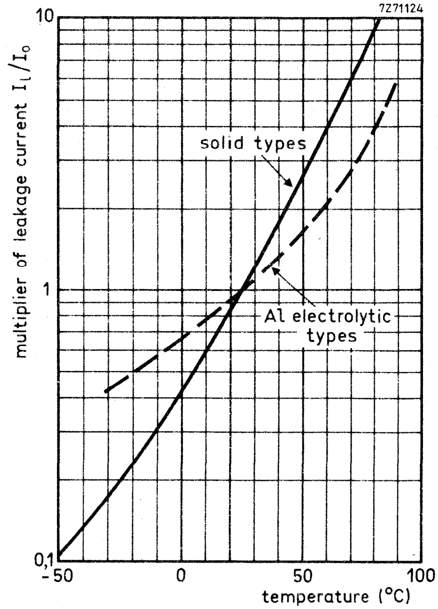


Fig. 7 Typical leakage current as a function of temperature. I_0 = leakage current during continuous operation at T_{amb} = 25 °C.

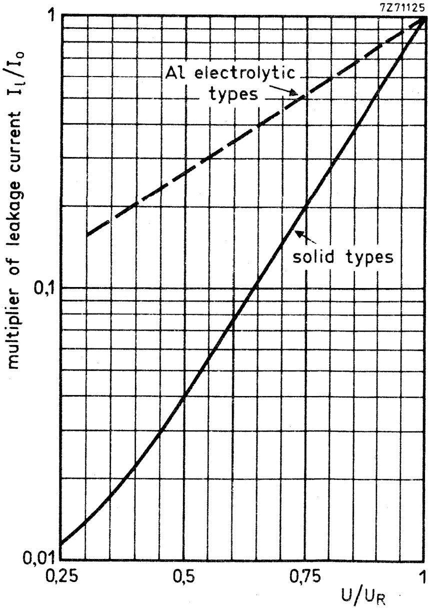


Fig. 8. Typical leakage current as a function of U/U_R. I_0 = leakage current at U_R at a discrete constant temperature within category temperature range, U is working voltage.

7. LIFE TIME

Aluminium electrolytic capacitors

The phenomena which determine the life time of an aluminium electrolytic capacitor are, among others, changes of the following parameters exceeding the specified limits :

- capacitance
- dissipation factor
- impedance
- leakage current .

Most of them are directly or indirectly caused by a failure mechanism occuring in the electrolyte (drying out, chemical reactions).

Two types of electrolyte can be distinguished:

a. glycol-electrolyte which is somewhat aggressive to the dielectric layer at higher temperatures. This liquid has a relatively high specific resistance and high temperature coefficient.

b. modern electrolytes (based upon DiMethyl Acetamide) require very good sealing (due to high diffusiveness of the volatile solvent). This liquid has a relatively low specific resistance and a low temperature coefficient, and can generally be used over a wider temperature range than the glycol type of electrolyte.

In general the life time of an aluminium electrolytic capacitor can be increased by a factor of 2 when the temperature is dropped by 10 °C.

By using the capacitor at a voltage lower than the rated voltage, the leakage current decreases, which means that the process of forming hydrogen gas at the cathode takes place at a lower rate. This also improves the life time of the capacitor.

Solid aluminium capacitors

The end of life is determined by sudden breakdown failures.
Due to the fact that no electrolyte is used in solid aluminium capacitors the associated failure mechanisms do not occur.

Solid tantalum capacitors

The end of life of solid tantalum capacitors is determined by sudden breakdown failures; even in an early stage of its service life.
An explanation of this lies in the forming of crystalline tantalum oxide beneath the existing amorphous tantalum oxide under conditions of high field strength and high temperature. The growth of this crystalline tantalum oxide eventually breaks through the amorphous oxide layer and, because the newly-formed oxide has a very low specific resistance, a current flow is originated which results in a short-circuit.
The life time of a solid tantalum capacitor can be improved be derating the voltage and ambient temperature.

8. RELIABILITY

In life testing reliability can be determined by means of a failure rate (F.R.), which is expressed as:

$$\text{Failure rate (F.R.)} = \frac{\text{number of failures during test}}{\text{number of components tested x test duration}}$$

Two types of failures can be found:

- catastrophic failures: short circuits, open circuits
- degradation failures: parameter drifts outside the specification limits.

With aluminium electrolytic capacitors degradation failures mostly occur, due to factors like:

- agressiveness of the electrolyte
- diffusion of the electrolyte
- material impurities and other accidents of production.

The failure rate of solid aluminium and tantalum capacitors is determined by short-circuits or open circuits, due to breakdown of the dielectric layer. The electronic current does not constitute a repair action in this oxide layer.
The failure rate in solid tantalum capacitors is mostly influenced by a field-crystallization process, described in above. In this case the F.R. can be improved by lowering temperature and applied voltage or placing a series resistor in the circuitry.

The phenomenon of the formation of a low resistance aluminium oxide does not exist in solid aluminium capacitors, therefore they have greater reliability than solid tantalum types. Under the most severe conditions (maximum category temperature, rated voltage), the catastrophic failure rates (with a 60% confidence level) are:

- electrolytic capacitors	10^{-6}/h
- solid aluminium capacitors	10^{-7}/h
- solid tantalum capacitors	10^{-5}/h

Analysis of failure in the field (under normal operating conditions) shows a far better F.R.: $\approx 10^{-9}$/h for solid aluminium capacitors.

ALUMINIUM ELECTROLYTIC CAPACITORS

for general and industrial applications
miniature/ small type

QUICK REFERENCE DATA			
Nominal capacitance range (E6 series)	0,33 to 4700 µF		
Tolerance on nominal capacitance	−10 to +50%	(case size 1	−10 to +100%)
Rated voltage range, U_R (R5 series)	4 to 63 V		
	case size 1	case size 2, 3, 5a	case size 4 to 03 *)
Category temperature range	−25 to +70 °C	−25 to +85 °C	−40 to +85 °C
Endurance test	1000 h at 70 °C	1000 h at 85 °C	2000 h at 85 °C
Basic specification IEC 103	type 2	type 2	type 1
Category IEC 68	25/070/56	25/085/56	40/085/56

7Z65675.2

C_{nom} (µF)	U_R (V)						
	4	6,3	10	16	25	40	63
0,33							4
0,47							1/3/4
0,68							1/4
1							1/2/3/4
1,5							1/3
2,2						1	2/3/4
3,3					1		3
4,7				1			2/3/4
6,8			1			2	3
10		1			2		3/4
15	1			2		3	4/5a
22			2		3	4/5a	5
33		2		3		4/5a	
47	2		3		4/5a	5	6
68		3		4/5a			00
100	3		4/5a		5	6	01
150		4/5a		5	6	00	01
220	4/5a		5	6	00	01	02
330	5		6	00			03
470		6	00		01	02	
680		00		01	02	03	
1000	00		01	02	03		
1500		01	02	03			
2200		02	03				
3300		03					
4700	03						

nominal dimensions (mm)	
1	∅ 3,3 x 10,5
2	∅ 4,5 x 11,5
3	∅ 6 x 11,5
5a	∅ 8 x 12,5
4	∅ 6,5 x 18
5	∅ 8 x 18
6	∅ 10 x 18
00	∅ 10 x 30
01	∅ 12,5 x 30
02	∅ 15 x 30
03	∅ 18 x 30

APPLICATION

Mainly for smoothing, coupling and decoupling purposes in consumer applications, such as audio and television circuits, and in industrial applications such as measuring and regulating circuits. Other applications are in timing and delay circuits.

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*) Case size 4, 63 V, C ≤10 µF, IEC type 2, category 40/085/56

DESCRIPTION

The capacitor has etched aluminium-foil electrodes rolled up with a porous paper spacer which separates the anode and the cathode. The spacer is impregnated with an electrolyte which is the electrical connection between dielectric and cathode foil and retains its good characteristics both at low and at high temperatures. The capacitor is housed in an aluminium case.

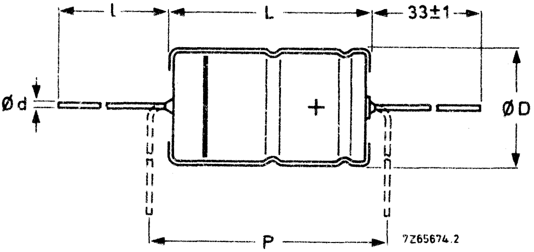
The capacitor is available in 6 styles, all with soldered-copper leads.

Style 1 : axial leads; case insulated with a blue transparent plastic sleeve.
→ Style 2 : single ended; with self-locking lead; case insulated with a blue transparent plastic sleeve.
→ Style 3 : single ended; case insulated with a blue transparent plastic sleeve.
→ Styles 4 and 5 : single ended; case insulated with a blue transparent plastic cap. The cap of style 4 has a boss and that of style 5 has a short slot so that a greater pitch between the leads can be made, if necessary.
→ Style 6 : single ended; case fitted in a yellow plastic foot.

MECHANICAL DATA

Dimensions in mm

→ Style 1; capacitors with two rills only for case sizes 00 to 03.
l = 33 ± 1 mm for case sizes 1 to 5a;
= 35 ± 1 mm for case sizes 4 to 6;
= 55 − 1 mm for case sizes 00 to 03.
See Table 1a for dimensions d, D, L and P.



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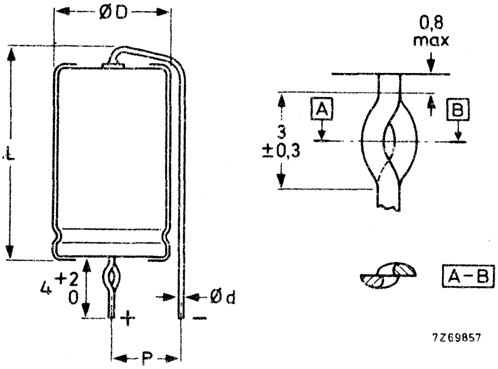
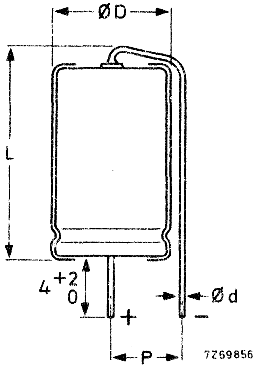


Style 2; case sizes 00 to 03
(case sizes 4, 5 and 6 on request);
see Table 1a for dimensions d,
D, L and P.

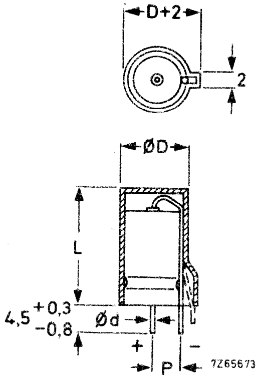


Style 3; case sizes 1 to 6
(case sizes 00 to 03 on request);
see Table 1a for dimensions d,
D, L and P.

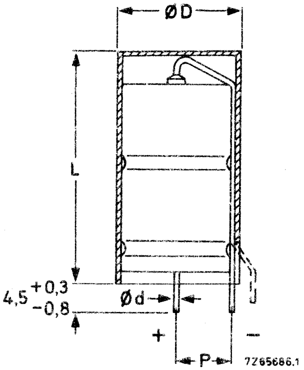
Table 1a

case size	d	style 1					style 2			style 3			mass approx. (g)
		D_{nom}	L_{nom}	D_{max}	L_{max}	P_{min}	D_{max}	L_{max}	P	D_{max}	L_{max}	P	
1	0,6	3,3	10,5	3,5	11	15				3,5	13	2,5-5	0,35
2	0,6	4,5	10	4,8	10,5	15				4,8	13	2,5-5	0,53
3	0,6	6	11,5 1)	6,1	12 1)	15				6,1	14,5 1)	5 -7,5	0,7
5a	0,6	8	11	8,3	11,5	15				8,3	13	5 -10	1,2
4	0,8	6,5	18	6,7	18,5	25	6,7	22,5	5 -10	6,7	22,5	5 -10	1,5
5	0,8	8	18	8,3	18,5	25	8,3	22,5	5 -10	8,3	22,5	5 -10	2
6	0,8	10	18	10,3	18,5	25	10,3	22,5	7,5-12,5	10,3	22,5	7,5-12,5	2,7
00	0,8	10	30	10,5	30,5	35	10,5	34	7,5-12,5	10,5	34	7,5-12,5	4,0
01	0,8	12,5	30	13,0	30,5	35	13,0	34	7,5-12,5	13,0	34	7,5-12,5	6,3
02	0,8	15	30	15,5	30,5	35	15,5	34	10 -15	15,5	34	10 -15	8,2
03	0,8	18	30	18,5	30,5	35	18,5	34	10 -15	18,5	34	10 -15	10,9

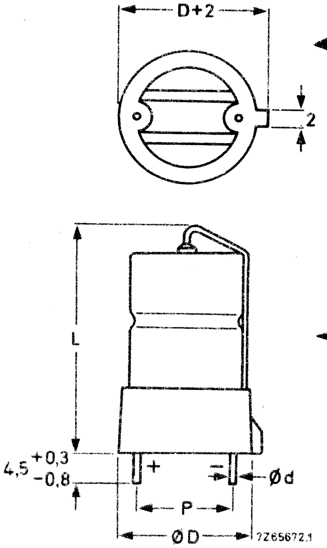
Notes - **Styles 4 and 5 are not for new designs.**
- **Style 6 is especially for use in applications with severe shocks and vibrations.**



Style 4; see Table 1b for dimensions d, D, L and P.



Style 5; see Table 1b for dimensions d, D, L and P.



Style 6; see Table 1b for dimensions d, D, L and P.

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1) This length is temporarily 1,5 mm shorter.

→ Table 1b

case size	d	style 4			style 5			style 6			mass approx. (g)
		D_{max}	L_{max}	P_{min}	D_{max}	L_{max}	P_{min}	D_{max}	L_{max}	P ±0,5	
1	0,6	4,1	12,5	2,5							0,35
2	0,6	5,6	12,5	2,5							0,53
3	0,6	6,9	14 1)	3,5							0,7
5a	0,6	9,1	13,5	5							1,2
4	0,8				8,5	22,5	5				1,5
5	0,8				10,2	22,5	5				2
6	0,8				12,1	22,5	7,5				2,7
00	0,8				11,2	32,5	7,5	12,8	39,5	10	4,0
01	0,8				13,6	32,5	7,5	15,2	39,5	10	6,3
02	0,8				16	32,5	10	17,8	39,5	12,5	8,2
03	0,8				19	32,5	10	20,8	39,5	15	10,9

Marking

The capacitors are marked with: group number, rated voltage, nominal capacitance, a band to identify the negative terminal and a letter code for country of origin.

Mounting

Styles 4 and 5 are designed for mounting on single-sided printed-wiring boards, however,
→ case sizes 4, 5 and 6 in style 5, and all style 2, 3 and 6 capacitors are also directly suitable for double-sided printed-wiring boards.

→ The diameter of the mounting holes in the printed-wiring board is:
1,3 + 0,1 mm for the anode lead and 1 mm for the cathode lead of style 2 capacitors;
0,8 mm for case sizes 1 to 5a in style 3;
1 mm for case sizes 4 to 03 in style 3.

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1) This length is temporarily 1,5 mm shorter.

ELECTRICAL DATA

Table 2; notes follow this Table. ←

Unless otherwise specified all electrical values in Table 2 apply at an ambient temperature of 20 to 25 °C, a frequency of 100 Hz, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

U_R (V)	nom. cap. (μF)	max. r.m.s. ripple current at upper cat. temp. (mA) 1)	max. leakage current at U_R after 5 min (μA) 1)	typ. ESR (Ω) 1)	max. tan δ 1)	impedance at 100 kHz (Ω 1)		case size	catalogue number 2) 2222 followed by
						typ.	max.		
4	15	10	5	26,54	0,40	12	20	1	015 .2159
4	47	26	10	8,47	0,40	4	6,8	2	015 .2479
4	100	44	20	3,98	0,40	2	3,4	3	015 .2101
4	220	70	44	1,81	0.40	1	1,7	5a	015 .2221
4	220	85	9	1,81	0,38	0,5	0,8	4	016 .2221
4	330	125	12	1,21	0,38	0,35	0,55	5	016 .2331
4	1000	325	28	0,40	0,38	0,2	0,3	00	017 .2102
4	4700	920	117	0,08	0,38	0,3	0,5	03	017 .2472
6,3	10	12	5	39,79	0,37	12	20	1	015 .3109
6,3	33	26	11	9,65	0,32	4	6,8	2	015 .3339
6,3	68	44	22	4,68	0,32	2	3,4	3	015 .3689
6,3	150	70	48	2,12	0,32	1	1,7	5a	015 .3151
6,3	150	85	10	2,12	0,30	0,5	0,8	4	016 .3151
6,3	470	190	22	0,68	0,30	0,2	0,3	6	016 .3471
6,3	680	325	30	0,47	0,30	0,2	0,3	00	017 .3681
6,3	1500	470	61	0,25	0,30	0,2	0,3	01	017 .3152
6,3	2200	630	88	0,14	0,30	0,25	0,4	02	017 .3222
6,3	3300	920	129	0,10	0,30	0,3	0,5	03	017 .3332
10	6,8	12	5	46,81	0,30	12	20	1	015 .4688
10	22	26	11	11,57	0,26	4	6,8	2	015 .4229
10	47	44	24	5,42	0,26	2	3,4	3	015 .4479
10	100	70	50	2,55	0,26	1	1,7	5a	015 .4101
10	100	85	10	2,55	0,24	0,5	0,8	4	016 .4101
10	220	125	18	1,16	0,24	0,35	0,55	5	016 .4221
10	330	190	24	0,77	0,24	0,2	0,3	6	016 .4331
10	470	325	33	0,54	0,24	0,2	0,3	00	017 .4471
10	1000	470	64	0,25	0,24	0,2	0,3	01	017 .4102
10	1500	630	94	0,17	0,24	0,25	0,4	02	017 .4152
10	2200	920	136	0,12	0,24	0,3	0,5	03	017 .4222
16	4,7	12	5	54,18	0,25	12	20	1	015 .5478
16	15	26	12	12,73	0,18	4	6,8	2	015 .5159
16	33	44	27	5,79	0,18	2	3,4	3	015 .5339
16	68	70	53	2,81	0,18	1	1,7	5a	015 .5689
16	68	85	11	2,81	0,17	0,5	0,8	4	016 .5689
16	150	125	19	1,27	0,17	0,35	0,55	5	016 .5151
16	220	190	26	0,87	0,17	0,2	0,3	6	016 .5221
16	330	325	36	0,58	0,17	0,2	0,3	00	017 .5331
16	680	470	70	0,28	0,17	0,2	0,3	01	017 .5681
16	1000	630	100	0,19	0,17	0,25	0,4	02	017 .5102
16	1500	920	148	0,13	0,17	0,3	0,5	03	017 .5152

→ Table 2 (continued); notes follow this Table.

U_R (V)	nom. cap. (µF)	max. r.m.s. ripple current at upper cat. temp. (mA) 1)	max. leakage current at U_R after 5 min (µA) 1)	typ. ESR (Ω) 1)	max. tan δ 1)	impedance at 100 kHz (Ω) 1)		case size	catalogue number 2) 2222 followed by
						typ.	max.		
25	3,3	11	5	67,52	0,22	12	20	1	015 .6338
25	10	23	13	15,92	0,15	4	6,8	2	015 .6109
25	22	37	28	7,23	0,15	2	3,4	3	015 .6229
25	47	60	56	3,39	0,15	1	1,7	5a	015 .6479
25	47	72	12	3,39	0,14	0,5	0,8	4	016 .6479
25	100	105	19	1,59	0,14	0,35	0,55	5	016 .6101
25	150	155	27	1,06	0,14	0,2	0,3	6	016 .6151
25	220	270	37	0,72	0,14	0,2	0,3	00	017 .6221
25	470	360	75	0,34	0,14	0,2	0,3	01	017 .6471
25	680	500	106	0,23	0,14	0,25	0,4	02	017 .6681
25	1000	650	154	0,16	0,14	0,3	0,5	03	017 .6102
40	2,2	11	5	86,81	0,19	12	20	1	015 .7228
40	6,8	23	14	18,72	0,12	4	6,8	2	015 .7688
40	15	37	30	8,49	0,12	2	3,4	3	015 .7159
40	22	50	44	5,79	0,12	1	1,7	5a	015 .7229
40	22	60	12	5,79	0,11	1	1,7	4	016 .7229
40	33	60	60	3,86	0,12	1	1,7	5a	015 .7339
40	33	72	12	3,86	0,11	0,5	0,8	4	016 .7339
40	47	105	16	2,71	0,11	0,35	0,55	5	016 .7479
40	100	155	28	1,27	0,11	0,2	0,3	6	016 .7101
40	150	270	40	0,85	0,11	0,2	0,3	00	017 .7151
40	220	360	57	0,58	0,11	0,2	0,3	01	017 .7221
40	470	500	117	0,27	0,11	0,25	0,4	02	017 .7471
40	680	650	167	0,19	0,11	0,3	0,5	03	017 .7681
63	0,33	4	5	289,37	0,09	6	12	4	016 .8337
63	0,47	7	5	338,63	0,16	12	20	1	015 90054 3)
63	0,47	7	5	203,18	0,09	5	8,5	3	015 .8477
63	0,47	6	5	203,18	0,09	4	6,4	4	016 .8477
63	0,68	9	5	234,05	0,16	12	20	1	015 .8687
63	0,68	9	5	140,43	0,09	3	5	4	016 .8687
63	1	9	5	159,15	0,16	12	20	1	015 90057 3)
63	1	9	5	95,49	0,09	4	6,8	2	015 90047 3)
63	1	10	5	95,49	0,09	3	5	3	015 .8108
63	1	12	5	95,49	0,09	2	3,2	4	016 .8108
63	1.5	9	5	106,10	0,16	12	20	1	015 .8158
63	1,5	12	5	63,66	0,09	2,5	4,5	3	015 90001 3)
63	2,2	12	7	43,41	0,09	4	6,8	2	015 90031 3)
63	2,2	15	7	43,41	0,09	2	3,5	3	015 .8228
63	2,2	21	5	43,41	0,09	1,4	2,2	4	016 .8228
63	3,3	17	11	28,94	0,09	2	3,5	3	015 .8338
63	4,7	22	15	20,32	0,09	2	3,5	3	015 90003 3)
63	4,7	18	15	20,32	0,09	4	6,8	2	015 .8478
63	4,7	31	5	20,32	0,09	1,2	1,9	4	016 .8478
63	6,8	25	22	14,04	0,09	2	3.5	3	015 .8688
63	10	30	32	9,55	0,09	2	3,5	3	015 .8109
63	10	44	7	9,55	0,09	0,6	0,95	4	016 .8109
63	15	43	48	6,37	0,09	1	1,7	5a	015 .8159
63	15	55	10	6,37	0,09	0,5	0,8	4	016 .8159
63	22	80	13	4,34	0,09	0,35	0,55	5	016 .8229
63	47	115	22	2,03	0,09	0,2	0,3	6	016 .8479
63	68	195	30	1,40	0,09	0,2	0,3	00	017 .8689
63	100	240	42	0,95	0,09	0,2	0,3	01	017 .8101
63	150	280	61	0,64	0,09	0,2	0,3	01	017 .8151
63	220	360	88	0,43	0,09	0,25	0,4	02	017 .8221
63	330	495	129	0,29	0,09	0,3	0,5	03	017 .8331

Notes to Table 2

1) See also corresponding paragraph.

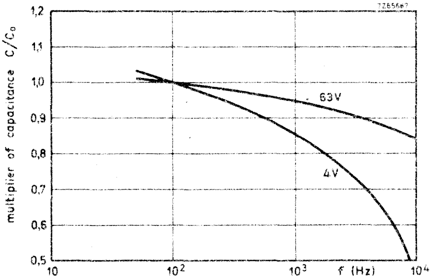
2) Replace dot in catalogue number by : 1 for style 1 on paper band;
4 for style 4 and style 5;
5 for style 6;
7 for style 2;
8 for style 3.

3) Last 5 digits in catalogue number for different styles :

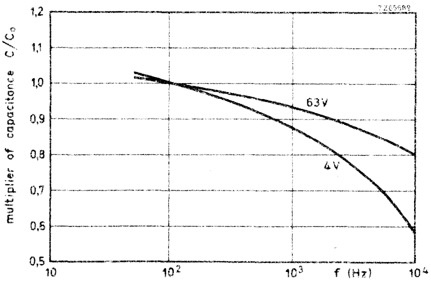
style 1	style 3	style 4
90001	90076	90002
90003	90068	90004
90054	90064	90055
90057	90065	90058
90047	90066	90061
90031	90067	90032

Capacitance

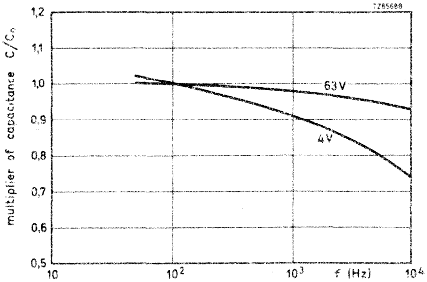
Nominal capacitance values at 100 Hz and 25 °C	see Table 2
Tolerance on nominal capacitance at 100 Hz	
case size 1	-10 to +100%
case sizes 2 to 03	-10 to +50%



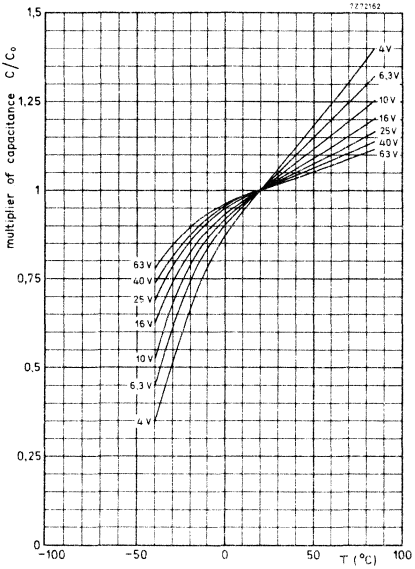
Typical capacitance as a function of frequency for case sizes 1, 2, 3, and 5a. C_0 = capacitance at 25 °C.



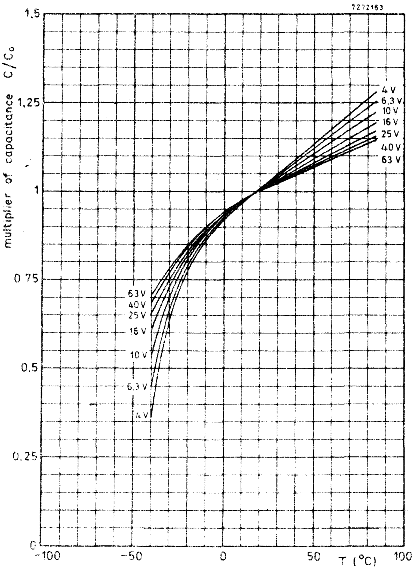
Typical capacitance as a function of frequency for case sizes 4, 5, and 6. C_0 = capacitance at 25 °C.



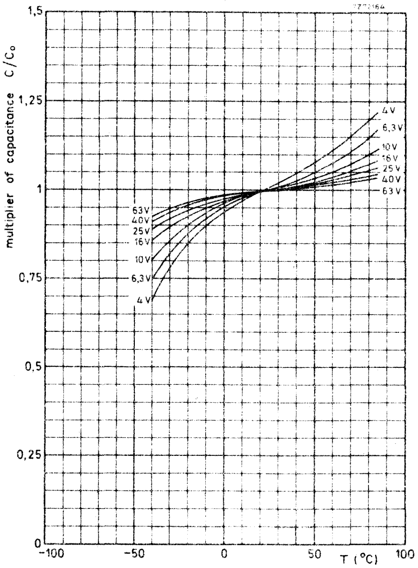
Typical capacitance as a function of frequency for case sizes 00, 01, 02, and 03. C_0 = capacitance at 25 °C.



Typical capacitance as a function of temperature for case sizes 1,2,3 and 5a.



Typical capacitance as a function of temperature for case sizes 4,5, and 6.



Typical capacitance as a function of temperature for case sizes 00, 01, 02, and 03.

Voltage

Rated voltage = max. permissible voltage
at < 40 °C $1,1 \times U_R$
at 40 °C to upper cat. temperature U_R

Ripple voltage *) = max. permissible a.c. voltage providing the following three conditions are met:

	< 40 °C	40 °C to upper category temperature
a) max. (d.c.+peak a.c.) voltage	$\leq 1,1 \times U_R$	$\leq U_R$
b) max. peak a.c. voltage with d.c. voltage applied	≤ applied d.c. voltage + 1 V	
c) max. peak a.c. voltage without d.c. voltage applied	1 V	

Surge voltage = max. permissible voltage for short periods (see also "Tests and requirements") $1,15 \times U_R$

Reverse voltage = max. d.c. voltage applied in the reverse polarity at the maximum category temperature for short periods 1 V

Ripple current

Maximum permissible r.m.s. ripple current at 100 Hz and T_{amb} = upper category temperature	see Table 2
at T_{amb} = 15 °C below upper category temperature	1,7 x values of Table 2
at T_{amb} = more than 25 °C below upper category temperature	2,2 x values of Table 2

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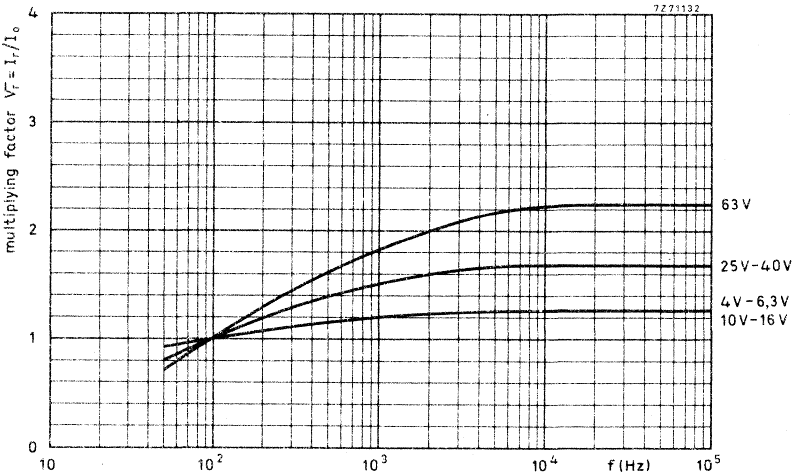
*) Ripple voltages are not applicable if the maximum permissible ripple current is exceeded. In that case the ripple current is decisive.



Multiplying factor as a function of frequency, for calculation of max. ripple current.
I_0 = maximum ripple current at 85 °C, 100 Hz .(Only for case sizes 00 to 03.)

Non-sinusoidal ripple currents have to be analyzed into a number of sinusoidal currents and the following requirements shall then be satisfied :

$$\sum_n \frac{I_n{}^2}{r_n} \leq I_{r_{max}}{}^2$$

$I_{r_{max}}$ = maximum ripple current at 100 Hz and applicable ambient temperature;

I_n = ripple current at a certain frequency;

$\sqrt{r_n}$ = multiplying factor at a same frequency.

Note

These ripple currents are not applicable if the maximum permissible ripple voltage is exceeded. In that case the ripple voltage is decisive.

Charge and discharge current

The capacitors may be charged from a source without internal resistance and they may be discharged by short-circuiting.
If the capacitors are charged and discharged continuously at a rate of several times per minute, the charge and discharge currents have to be considered as ripple currents flowing through the capacitor. The r.m.s. value of these currents should be determined and the value thus found must not exceed the applicable limit.

Leakage current

Maximum leakage current 5 min after application of the rated voltage at T_{amb} = 20 °C	see Table 2
Leakage current during continuous operation at U_R, at T_{amb} = 20 °C	approx. 0,2 of value stated in Table 2
at upper category temperature	≤ value stated in Table 2

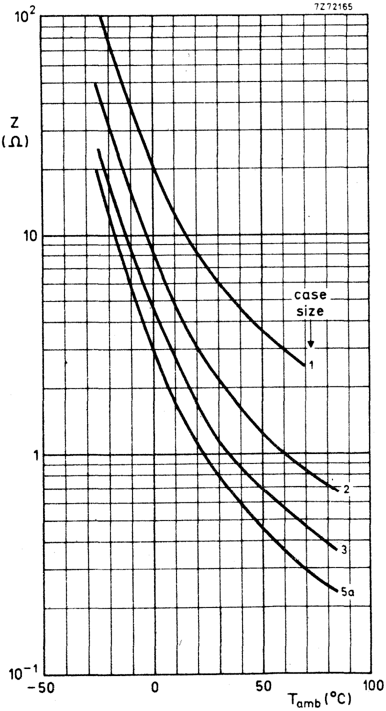
If the leakage current is too high, owing to prolonged storage and/or storage at an excessive temperature (> 40 °C), application of the rated voltage for some hours will cause the leakage current to fall to a value lower than specified in Table 2.

Tan δ (dissipation factor)

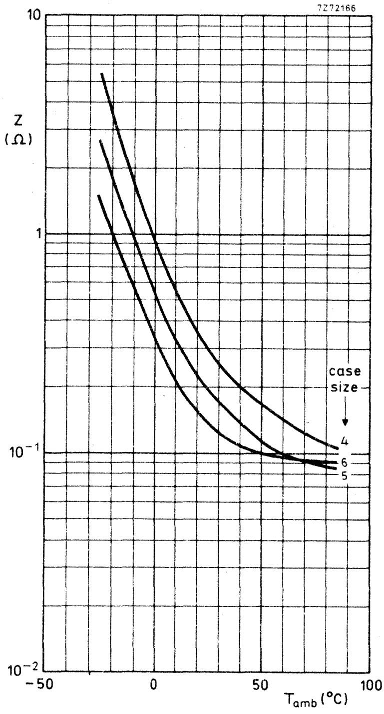
Tan δ at 100 Hz and T_{amb} = 20 °C, measured by means of a four-terminal circuit (Thomson circuit)	see Table 2

Impedance

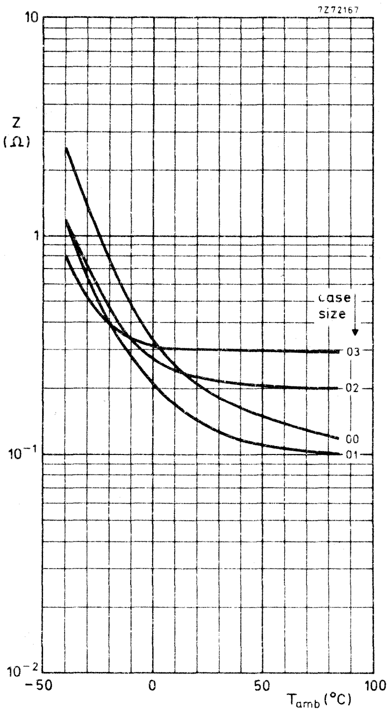
Impedance at 100 kHz and T_{amb} = 20 °C, measured by means of a four-terminal circuit (Thomson circuit)	see Table 2



Impedance as a function of temperature at 100 kHz.

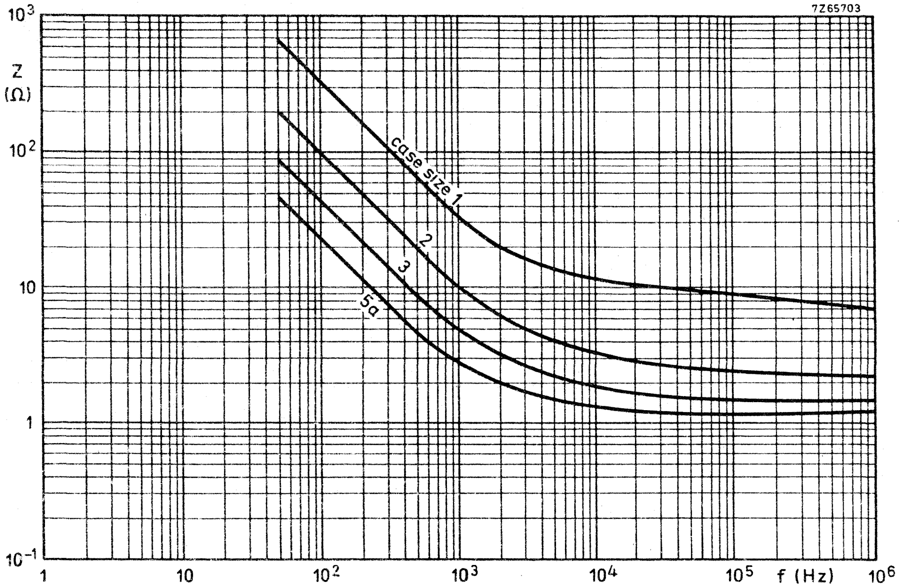


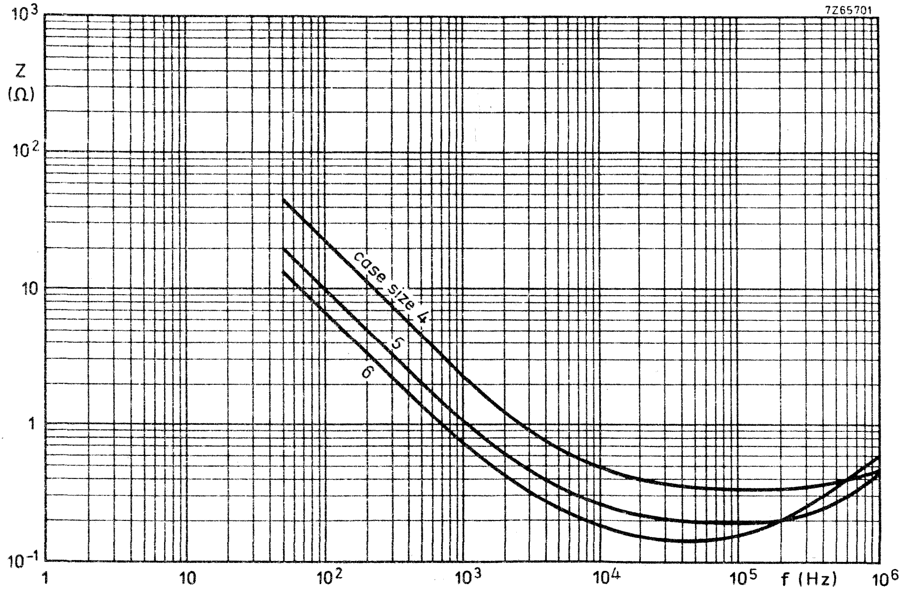
Impedance as a function of temperature at 100 kHz



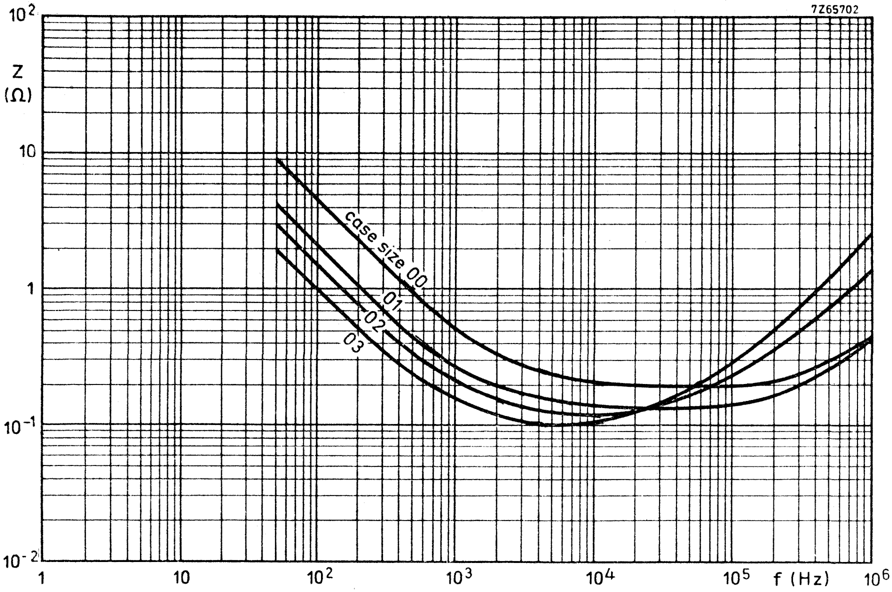
Impedance as a function of temperature at 100 kHz

Impedance as a function of frequency at 16 V and 20 °C.





Impedance as a function of frequency at 16 V and 20 °C.



Equivalent series resistance (ESR = tan δ/ωC)

→ ESR at 100 Hz and T_{amb} = 20 °C see Table 2

OPERATIONAL DATA

Category temperature range

for case size 1	−25 to +70 °C
2 and 3	−25 to +85 °C
4 to 03	−40 to +85 °C

PACKING (standard)

For 2222 015/016 : 500 pieces per box.
For 2222 017 : 200 pieces per box.

TESTS AND REQUIREMENTS

IEC 103 clause	IEC 68-2 test method	Name of test	Procedure (quick reference)	Requirements
13.6	–	Insulation resistance of insulating sleeve	Metal foil wrapped around body, 100 ± 15 V d.c. between foil and capacitor body for 1 min.	$R_{ins} \geq 100\ M\Omega$
13.7	–	Dielectric strength of insulating sleeve	Metal foil wrapped around body, 1000 V d.c. between foil and capacitor body for 1 min ± 5 s, voltage increased gradually 100 V/s	No breakdown or flashover
–	–	Lead pull	Axial pull on lead till destruction occurs.	≥ 40 N (4 kg)
14.1	Ua	Tensile strength of terminations	Loading weight 10 N (1 kg).	No visible damage
14.2	Ub	Bending, half of the lot	Two consecutive bends of 90° Loading weight 5 N (0,5 kg).	No visible damage
14.3	Uc	Torsion, other half of the lot	Two successive rotations of 180°, each rotation in 5 s .	No visible damage

TESTS AND REQUIREMENTS (continued)

IEC 103 clause	IEC 68-2 test method	Name of test	Procedure (quick reference)	Requirements
15	T3.2	Soldering (solder bath)	Solderability: axial leads: 270 $^{\circ}$C, 2 s, single-ended version : 230 $^{\circ}$C, 2 s. Resistance to heat : 350 $^{\circ}$C, 3 s. Single-ended versions immersed up to 3, 5 mm from emergence of lead.	Good tinning. No visible damage.
15	T3.3	Soldering (soldering iron)	Size A soldering iron, 10 s.	Good tinning.
15	T3.4	Soldering (solder globule)	Including accelerated ageing.	Wetting within 4 s.
16	Na	Rapid change of temperature	1 cycle of 3 h at upper cat. temperature 3 h at lower cat. temperature	No visible damage.
17	Fc *)	Vibration	10-500 Hz for category 40/085/56 and 10-55 Hz for other categories, 0, 75 mm or 10 g (whichever is the less), 3 h, each in 2 directions.	No visible damage; $\Delta C \leq 5\%$.
18	Eb	Bump	1000 ± 10 bumps, 40 g for type 2; 4000 ± 10 bumps, 40 g for type 1.	No visible damage; $\Delta C \leq 5\ \%$.

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*) This test does not apply to **style** 5 capacitors in case sizes 00 to 03.

TESTS AND REQUIREMENTS (continued)

IEC 103 clause	IEC 68-2 test method	Name of tests	Procedure (quick reference)	Requirements
19.2	Ba	Dry heat	16 h at upper category temperature with rated voltage applied.	Leakage current at 85 ^{o}C $\leq$ 5 x stated limit; at 70 ^{o}C $\leq$ 3 x. No visible damage.
19.3	D	Accelerated damp heat, first cycle	24 h at 55 ± 2 ^{o}C and R.H. 95 to 100%; no voltage applied.	After recovery immediately followed by cold test.
19.4	Aa	Cold	2 h at lower category temperature no voltage applied.	Ratio of impedance at lower category temperature to that at +20 ^{o}C at 100 Hz: $\leq$ 5 for 4 to 6,3 V ratings; $\leq$ 4 for 10 to 16 V ratings; $\leq$ 3 for $\geq$ 25 V ratings. $\Delta C \leq 5\%$; no visible damage.
19.5	Qc	Sealing	1 min in water at 90 ^{o}C.	During immersion no continuous chain of bubbles. No seepage of electrolyte.
19.6	D	Accelerated damp heat, remaining cycles	5 cycles of 24 h at 55 ^{o}C and R.H. 95-100%; no voltage applied.	No visible damage; leakage current and tan $\delta \leq$ stated limit; $\Delta C \leq 10\%$.
20	C	Damp heat (long term)	56 days at 40 ^{o}C and R.H. 90 to 95%; no voltage applied.	No visible damage; leakage current and tan $\delta \leq$ stated limit; $\Delta C \leq 20\%$.

TESTS AND REQUIREMENTS (continued)

IEC 103 clause	IEC 68-2 test method	Name of test	Procedure (quick reference)	Requirements
22	-	Endurance	Type 1 capacitors: 2000 h at 85 $^{\circ}$C with rated voltage applied; recovery time ≥ 16 h.	No visible damage; leakage current $\leq$ stated limit; $\tan\delta \leq 1,3 \times$ stated limit; $\Delta C \leq 15\%$; ratio of Z at 20 kHz before and after test ≤ 2; no insulation breakdown at 1000 V d.c.
			Type 2 capacitors: 1000 h at upper cat.temp. with rated voltage applied.	No visible damage; leakage current $\leq$ stated limit; $\tan\delta \leq 1,5 \times$ stated limit or $\tan\delta = 0,4$ whichever is greater; $\Delta C \leq 15\%$; ratio of Z at 20 kHz before and after test ≤ 5, no insulation breakdown at 1000 V d.c.
23	-	Surge	From source of $1,15 \times U_R$ (type 1:85 $^{\circ}$C) RC = 100 ± 50 ms; 5000 cycles of 10 s on, 50 s off.	Leakage current and $\tan\delta \leq$ stated limit; $\Delta C \leq 15\%$.
21.1	Ha	Storage, upper category temperature (half of the lot)	96+4 h at upper category temperature Cooling time ≥ 16 h.	Leakage current $\leq 2 \times$ stated limit; $\tan\delta \leq 1,2 \times$ stated limit; $\Delta C \leq 10\%$.
21.2	Hb	Storage, low temperature (other half of the lot)	72 h at -40 $^{\circ}$C for cat. 25/070/56 and 25/085/56 -55 $^{\circ}$C for cat. 40/085/56; recovery time ≥ 16 h.	Leakage current and $\tan\delta \leq$ stated limit; $\Delta C \leq 10\%$. No visible damage.

ALUMINIUM ELECTROLYTIC CAPACITORS

for high voltages
small type

QUICK REFERENCE DATA	
Nominal capacitance range	2, 5 to 80 μF
Tolerance on nominal capacitance	−10 to +30%
Rated voltage, U_R	100 to 400 V
Category temperature range	-25 to +70 °C
Endurance test	1000 hours at 70 °C
Basic specification	IEC 103, type 2
Category IEC 68	25/070/56

7Z50016.4

C_{nom} (μF)	U_R(V) 100	150	200	250	300	350	400
2,5						6	
3,2							
4				6			00
5						00	
6,4		6			00		01
8				00		01	
10			00		01		02
12,5		00		01		02	
16			01		02		03
20	00	01		02		03	
25			02		03		
32	01	02		03			
40			03				
50	02	03					
64							
80	03						

nominal dimensions (mm)	
6	Ø 10x18
00	Ø 10x30
01	Ø 12,5x30
02	Ø 15x30
03	Ø 18x30

APPLICATION

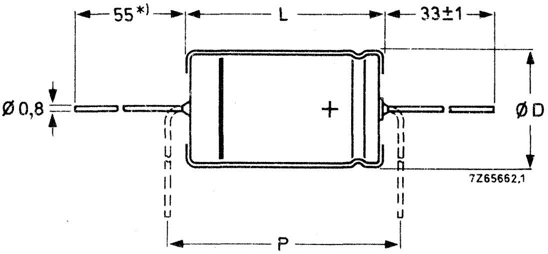
For smoothing, coupling and decoupling purposes in circuits where a high voltage is required.

DESCRIPTION

The capacitor has etched aluminium-foil electrodes rolled up with a porous paper spacer, which separates the anode and the cathode. The spacer is impregnated with an electrolyte which is the electrical connection between dielectric and cathode foil.
The capacitor is housed in an aluminium case.

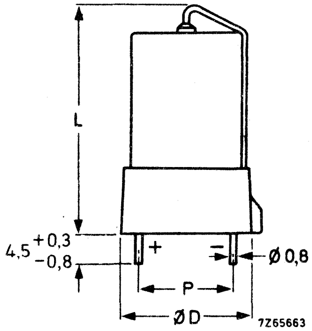
MECHANICAL DATA

Dimensions in mm



*) 35 mm for case size 6

Style 1



Style 2

Table 1

case size	style 1					style 2			weight approx (g)
	D_{nom}	L_{nom}	D_{max}	L_{max}	P_{min}	D_{max}	L_{max}	P	
6	10	18	10,5	18,5	25	12,8	26	10	2,5
00	10	30	10,5	30,5	35	12,8	39,5	10	4
01	12,5	30	13	30,5	35	15,2	39,5	10	6
02	15	30	15,5	30,5	35	17,8	39,5	12	7,2
03	18	30	18,5	30,5	35	20,8	39,5	15	9

Marking

Stamped on the case are: group number 040, rated voltage, nominal capacitance and a band to identify the negative terminal, and a letter code for country of origin.

ELECTRICAL DATA

Table 2

Unless otherwise specified all electrical values in Table 2 apply at an ambient temperature of 20 to 25 °C, a frequency of 50 Hz, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

U_R (V)	nominal capacitance (μF)	max. r.m.s. ripple current at T_{amb} = 70 °C and 100 Hz (mA) 1)	max. leakage current at U_R after 5 min (μA) 1)	maximum tan δ 1)	maximum impedance at 100 kHz (Ω) 1)	case size	catalogue number 2)
100	20	50	80	0,15	6,4	00	2222 040.0209
	32	75	115	0,15	4,0	01	.0329
	50	100	170	0,15	2,5	02	.0509
	80	125	260	0,15	1,6	03	.0809
150	6,4	25	50	0,15	15,0	6	.1648
	12,5	50	75	0,15	8,0	00	.1139
	20	75	110	0,15	5,0	01	.1209
	32	100	165	0,15	3,0	02	.1329
	50	125	245	0,15	2,0	03	.1509
200	10	25	80	0,15	8,0	00	.2109
	16	50	115	0,15	5,0	01	.2169
	25	75	170	0,15	3,0	02	.2259
	40	100	260	0,15	2,0	03	.2409
250	4	25	50	0,15	20,0	6	.3408
	8	25	80	0,15	10,0	00	.3808
	12,5	50	115	0,15	6,4	01	.3139
	20	75	170	0,15	4,0	02	.3209
	32	100	260	0,15	2,5	03	.3329
300	6,4	25	80	0,15	20,0	00	.4648
	10	50	110	0,15	15,0	01	.4109
	16	75	165	0,15	8,0	02	.4169
	25	100	260	0,15	5,0	03	.4259
350	2,5	25	45	0,15	60,0	6	.5258
	5	25	75	0,15	30,0	00	.5508
	8	25	105	0,15	20,0	01	.5808
	12,5	50	150	0,15	15,0	02	.5139
	20	75	230	0,15	8,0	03	.5209
400	4	25	70	0,15	45,0	00	.6408
	6,4	25	95	0,15	30,0	01	.6648
	10	50	140	0,15	20,0	02	.6109
	16	75	210	0,15	12,5	03	.6169

---

1) See also corresponding paragraph.

2) Replace dot in catalogue number by: 1 for axial version style 1
4 for printed-wiring version style 2

Capacitance

Nominal capacitance values at 50 Hz and T_{amb} = 20 °C	see Table 2
Tolerance on nominal capacitance at 50 Hz	−10 to +30%

Voltage

Rated voltage	= max. permissible voltage	
	at < 40 °C	1, 1 x U_R
	at 40 °C up to 70 °C	U_R
Ripple voltage *)	= max. permissible a.c. voltage providing the following three conditions are met:	

	< 40 °C	40 °C up to 70 °C
a) max. (peak a.c. voltage + U_R) applied	≤ 1, 1 x U_R	≤ U_R
b) max. peak a.c. voltage, with d.c. voltage applied	≤ applied d.c. voltage + 1 V	
c) max. peak a.c. voltage, without d.c. voltage applied	1 V	

Surge voltage	= max. permissible voltage for short periods (see also "Tests and requirements")	1, 15 x U_R
Reverse voltage	= max. d.c. voltage applied in the reverse polarity at the maximum category temperature for short periods.	1 V

Ripple current **)

Maximum permissible r.m.s. ripple current at 100 Hz and

T_{amb} = 70 °C	see Table 2
at T_{amb} = 60 °C	1, 7 x value of Table 2
at T_{amb} ≤ 50 °C	2, 2 x value of Table 2

---

*) Ripple voltages are not applicable if the maximum permissible ripple current is exceeded. In that case the ripple current is decisive.

**) Ripple currents are not applicable if the maximum permissible ripple voltage is exceeded. In that case the ripple voltage is decisive.

Charge and discharge current

The capacitors may be charged from a source without internal resistance. Do not discharge below 20% of the applied d.c. voltage.
If the capacitors are charged and discharged continuously at a rate of several times per minute, the charge and discharge currents have to be considered as ripple currents flowing through the capacitor. The r.m.s. value of these currents should be determined and the value thus found must not exceed the applicable limit.

Leakage current

Maximum leakage current 5 min after application of the rated voltage at 20 °C	see Table 2 (0,03 CU + 20 μA)
Leakage current during continuous operation at U_R, at T_{amb} = 20 °C	approx. 0,2 of value stated in Table 2
at T_{amb} = 70 °C	≤ value stated in Table 2

If owing to prolonged storage and/or storage at an excessive temperature the leakage current is too high, application of the rated voltage for some hours will cause the leakage current to fall to a value lower than specified in Table 2.

Tan δ (dissipation factor)

Tan δ at 50 Hz and 20 °C, measured by means of a four-terminal circuit (Thomson circuit)	see Table 2

Impedance

Impedance at 100 kHz and 20 °C, measured by means of a four-terminal circuit (Thomson circuit)	see Table 2

Equivalent series resistance (ESR $= \frac{\tan \delta}{\omega C}$)

Tan δ and C at 50 Hz	see Table 2

OPERATIONAL DATA

Category temperature range

for rated voltage	−25 to +70 °C

PACKING (standard)

200 pieces per box (case sizes 00 to 03).
500 pieces per box (case size 6).

TESTS AND REQUIREMENTS

IEC 103 clause	IEC 68-2 test method	Name of test	Procedure (quick reference)	Requirements
13.6	–	Insulation resistance of insulating sleeve	Metal foil wrapped around body, 100 ± 15 V d.c. between foil and capacitor body for 1 min	$R_{ins} \geq 100\ M\Omega$
13.7	–	Dielectric strength of insulating sleeve	Metal foil wrapped around body, 1000 V d.c. between foil and capacitor body for 1 min ± 5 s voltage increased gradually 100 V/s	No breakdown or flashover
–	–	Lead pull	Axial pull on lead till destruction occurs	≥ 40 N (4 kg)
14.1	Ua	Tensile strength of terminations	Loading weight 10 N (1 kg)	No visible damage
14.2	Ub	Bending, half of the lot	Two consecutive bends 90^{o} Loading weight 5 N (0,5 kg)	No visible damage
14.3	Uc	Torsion, other half of the lot	Two successive rotations of 180^{o}	No visible damage

TESTS AND REQUIREMENTS (continued)

IEC 103 clause	IEC 68-2 test method	Name of test	Procedure (quick reference)	Requirements
15	T3.2	Soldering (solder bath)	Solderability: axial leads: 270 °C, 2 s singled-ended version : 230 °C, 2 s	Good tinning
			Resistance to heat : 350 °C, 3 s Single-ended versions immersed up to 3,5 mm from emergence of lead.	No visible damage
15	T3.3	Soldering (soldering iron)	Size A soldering iron, 10 s	Good tinning
15	T3.4	Soldering (solder globule)	Including accelerated ageing	Wetting within 4 s
16	Na	Rapid change of temperature	1 cycle of 3 h at +70 °C and 3 h at −25 °C	No visible damage
17	Fc	Vibration	10-55 Hz, 0,75 mm or 10 g (whichever is the less), 3 h 1 octave/min, each in 2 directions	No visible damage $\Delta C \leq 5\%$
18	Eb	Bump	1000 ± 10 bumps, 40 g	No visible damage ΔC 5 %

TESTS AND REQUIREMENTS (continued)

IEC 103 clause	IEC 68-2 test method	Name of test	Procedure (quick reference)	Requirements
19.2	Ba	Dry heat	16 h at +70 ± 2 ^{o}C with rated voltage applied	Leakage current at 70 ^{o}C $\leq$ 3 x stated limit. No visible damage. Followed by accelerated damp heat, first cycle.
19.3	D	Accelerated damp heat, first cycle	24 h at 55 ± 2 ^{o}C and R.H. 95 to 100%: no voltage applied	After recovery immediately followed by cold test
19.4	Aa	Cold	2 h at −25 ± 3 ^{o}C: no voltage applied	$\Delta C \leq 5\%$: No visible damage ratio of impedance at −25 ^{o}C to that at +20 ^{o}C, at 100 Hz: ≤ 6 . Followed by sealing
19.5	Qc	Sealing	1 min in water at 90 ^{o}C	During immersion no continuous chain of bubbles, afterwards no seepage of electrolyte. Followed by accelerated damp heat remaining cycles
19.6	D	Accelerated damp heat, remaining cycles	5 cycles of 24 h at 55 ^{o}C and R.H. 95-100%; no voltage applied	No visible damage Leakage current and tan $\delta \leq$ stated limit; $\Delta C \leq 10\%$
20	C	Damp heat (long term exposure)	56 days at 40 ^{o}C and R.H. 90 to 95%; no voltage applied	No visible damage. Leakage current and tan $\delta \leq$ stated limit $\Delta C \leq 20\%$

TESTS AND REQUIREMENTS (continued)

IEC 103 clause	IEC 68-2 test method	Name of test	Procedure (quick reference)	Requirements
22	–	Endurance	1000 h at 70 °C with rated voltage applied recovery time ≥16 h (temp. = upper cat.temp.)	No visible damage; leakage current ≤ stated limit; tan δ ≤ 1,5 x stated limit; ΔC ≤ 15% ratio of impedance at 20 kHz before and after test ≤ 5
23	–	Surge	From source of 1,15 x U_R; RC = 100 ± 50ms; 5000 cycles of 10 s on, 50 s off	Leakage current and tan δ ≤ stated limit; ΔC ≤ 15%
21.1	Ha	Storage at upper category temperature (half of the lot)	96 ± 4 h at 70 °C Cooling time ≥ 16 h (temp. = upper cat. temp.)	Leakage current ≤ 2 x stated limit; tan δ ≤ 1,2 stated limit; ΔC ≤ 10%
21.2	Hb	Storage, low temperature (other half of the lot)	72 h at -40 °C recovery time ≥16 h (temp. see IEC 103)	Leakage current and tan δ ≤ stated limit; ΔC ≤ 10%; No visible damage

ALUMINIUM ELECTROLYTIC CAPACITORS

for industrial and long life applications
large type, solder lugs

QUICK REFERENCE DATA	
Nominal capacitance range (E6 series)	680 to 47 000 μF
Tolerance on nominal capacitance	−10 to +50%
Rated voltage range, U_R (R5 series)	6,3 to 63 V
Category temperature range	−40 to +85 °C
Typical life time	> 5000 hours at 85 °C
Basic specification	IEC 103, type 1
Category IEC 68	40/085/56
Approval	U.K.Post Office D2186

7Z65665

C_{nom} (μF)	U_R (V)					
	6,3	10	16	25	40	63
680						⑤
1000					⑤	⑥
1500						(7/8a)
2200				⑤	⑥	(8/9a)
3300			⑤	⑥	(7/8a)	⑨
4700		⑤	⑥	(7/8a)	(8/9a)	⑩
6800		⑥	(7/8a)	(8/9a)	⑨	
10000	⑥	(7/8a)	(8/9a)	⑨	⑩	
15000	(7/8a)	(8/9a)	⑨	⑩		
22000	(8/9a)	⑨	⑩			
33000	⑨	⑩				
47000	⑩					

nominal dimensions (mm)
5 = Ø 21x50
6 = Ø 25x50
7 = Ø 25x80
8a = Ø 30x50
8 = Ø 30x80
9a = Ø 35x50
9 = Ø 35x80
10 = Ø 40x80

APPLICATION

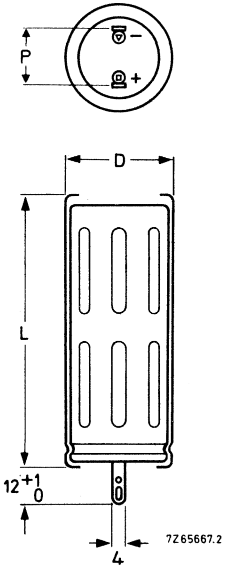
Especially for smoothing and decoupling purposes in industrial power supplies, where a long life and high ripple currents are required.
Also for coupling purposes in audio power circuits.

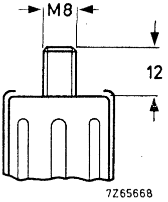
DESCRIPTION

The capacitor winding is housed in an aluminium case, sealed with a rubber-faced paper laminate disc.
The electrolyte used is of a special composition to ensure good characteristics at high and low temperatures.
The case, which has no electrical function, is covered with a blue synthetic sleeve. The capacitor is provided with soldering terminals of which the negative one is identified by the symbol Δ and the positive one by a red dot.
Each capacitor is provided with a safety vent to release gas pressure under overload conditions.

MECHANICAL DATA

Dimensions in mm





Bolt version

Table 1

case size	D + 0,6	L + 1,3	P *)	mass approx. (g)
5	21	50	13	20
6	25	50	13	30
7	25	80	13	45
8a	30	50	19	40
8	30	80	19	70
9a	35	50	19	60
9	35	80	19	100
10	40	80	19	130

Marking

The capacitors are marked with: nominal capacitance, tolerance on capacitance, rated voltage, temperature range, IEC type, max. permissible ripple current at $T_{amb} = 50\,^{o}C$, catalogue number and date code.

Mounting

The capacitor may be mounted in any position with or without a mounting clamp.
Where a number of capacitors are connected to form a capacitor bank, the proximity to one another must not be less than 15 mm, when no derating of ripple current and/or temperature is applied.
The uninsulated part of the case may only touch objects with the same potential as the negative terminal.
See also mounting accessories.

Minimum atmospheric pressure 200 mbar (15 cm Hg)

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*) P at emergence of terminals.

ELECTRICAL DATA

→ Table 2

Unless otherwise specified all electrical values in Table 2 apply at an ambient temperature of 20 to 25 °C, a frequency of 100 Hz, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

U_R (V)	nominal capacitance (μF) 1)	max. r.m.s. ripple current at T_{amb} = 85 °C (A) 1)	max. leakage current at U_R after 5 min (μA) 1)	max. tan δ 1)	maximum impedance at 100 kHz (mΩ) 1)	case size	catalogue number 2)
6,3	10000	1,8	380	0,50	60	6	2222 071 13103
	15000	2,7	570	0,50	50	7	071 13153
	15000	2,5	570	0,50	50	8a	073 13153
	22000	3,7	840	0,50	50	8	071 13223
	22000	3,3	840	0,50	30	9a	073 13223
	33000	4,9	1250	0,50	25	9	071 13333
	47000	6,3	1780	0,50	25	10	071 13473
10	4700	1,1	280	0,35	80	5	071 14472
	6800	1,8	410	0,35	60	6	071 14682
	10000	2,7	600	0,35	50	7	071 14103
	10000	2,4	600	0,35	50	8a	073 14103
	15000	3,7	900	0,35	50	8	071 14153
	15000	3,3	900	0,35	30	9a	073 14153
	22000	4,8	1320	0,35	25	9	071 14223
	33000	6,0	1980	0,35	25	10	071 14333
16	3300	1,1	320	0,25	80	5	071 15332
	4700	1,7	450	0,25	60	6	071 15472
	6800	2,6	655	0,25	50	7	071 15682
	6800	2,4	655	0,25	50	8a	073 15682
	10000	3,5	960	0,25	50	8	071 15103
	10000	3,2	960	0,25	30	9a	073 15103
	15000	4,7	1440	0,25	25	9	071 15153
	22000	6,1	2120	0,25	25	10	071 15223
25	2200	1,0	330	0,20	80	5	071 16222
	3300	1,7	495	0,20	60	6	071 16332
	4700	2,4	705	0,20	50	7	071 16472
	4700	2,2	705	0,20	50	8a	073 16472
	6800	3,3	1020	0,20	50	8	071 16682
	6800	2,9	1020	0,20	30	9a	073 16682
	10000	4,3	1500	0,20	25	9	071 16103
	15000	5,7	2250	0,20	25	10	071 16153
40	1000	1,0	240	0,15	125	5	071 17102
	2200	1,3	530	0,15	100	6	071 17222
	3300	2,4	795	0,15	80	7	071 17332
	3300	1,7	795	0,15	80	8a	073 17332
	4700	3,1	1130	0,15	80	8	071 17472
	4700	2,4	1130	0,15	50	9a	073 17472
	6800	4,1	1640	0,15	40	9	071 17682
	10000	5,3	2400	0,15	40	10	071 17103
63	680	0,8	260	0,10	125	5	071 18681
	1000	1,3	380	0,10	100	6	071 18102
	1500	2,0	570	0,10	80	7	071 18152
	1500	1,7	570	0,10	80	8a	073 18152
	2200	2,6	835	0,10	80	8	071 18222
	2200	2,4	835	0,10	50	9a	073 18222
	3300	3,5	1250	0,10	40	9	071 18332
	4700	4,5	1780	0,10	40	10	071 18472

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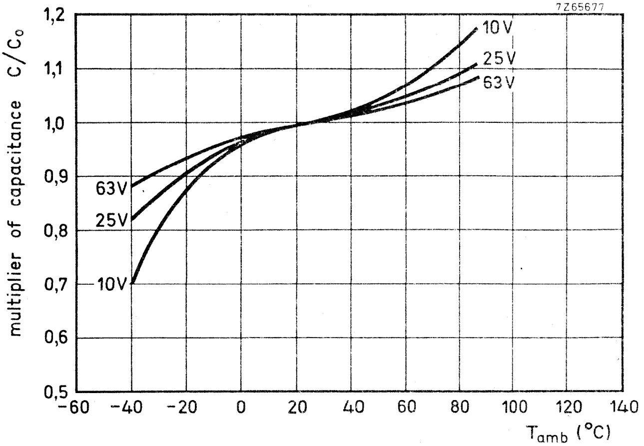
1) See also corresponding paragraph.

2) Replace 8th digit by 6 for bolt version.

Capacitance

Nominal capacitance values at 100 Hz and 20 °C	see Table 2
Tolerance on nominal capcitance at 100 Hz	−10 to +50%



Typical capacitance as a function of ambient temperature
C_o = capacitance at 25 °C, 100 Hz

Voltage

Rated voltage = max. permissible voltage

at < 40 °C	1, 1 x U_R
at 40 °C up to 85 °C	U_R

Ripple voltage *) = max. permissible a.c. voltage providing the following three conditions are met:

	< 40 °C	40 °C up to 85 °C
a) max. (d.c. + peak a.c.) voltage	≤ 1, 1 x U_R	≤ U_R
b) max. peak a.c. voltage with d.c. voltage applied	≤ applied d.c. voltage + 1 V	
c) max. peak a.c. voltage without d.c. voltage applied	1 V	

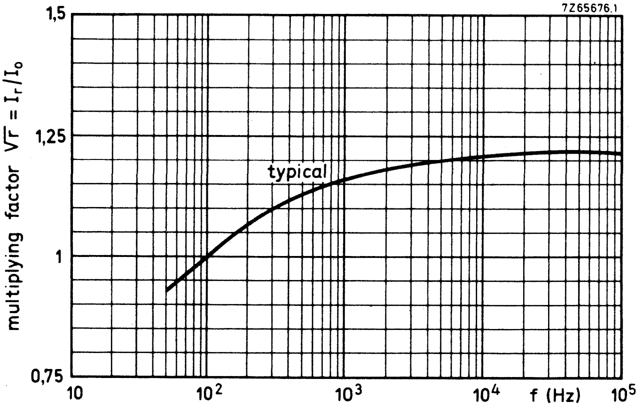
Surge voltage = max. permissible voltage for short periods (see also "Tests and requirements")	1, 15 x U_R
Reverse voltage = max. d.c. voltage applied in the reverse polarity at the maximum category temperature for short periods	1 V

---

*) Ripple voltages are not applicable if the maximum permissible ripple current is exceeded. In that case the ripple current is decisive.

Ripple current

Maximum permissible r.m.s. ripple current at 100 Hz and T_{amb} = 85 °C	see Table 2
at T_{amb} = 80 °C	1,4 x values of Table 2
at T_{amb} = 75 °C	1,7 x values of Table 2
at T_{amb} ≤ 65 °C	2,2 x values of Table 2



Multiplying factor as a function of frequency, for calculation of max. ripple current.
I_0 = maximum ripple current at 85 °C, 100 Hz.

Non-sinusoidal ripple currents have to be analyzed into a number of sinusoidal currents and the following requirements shall then be satisfied:

$$\sum_{n} \frac{{I_n}^2}{r_n} \le {I_{r_{max}}}^2$$

$I_{r\ max}$ = max. ripple current at 100 Hz and applicable ambient temperature

I_n = ripple current at a certain frequency

$\sqrt{r_n}$ = multiplying factor at a same frequency

Note

These ripple currents are not applicable if the maximum permissible ripple voltage is exceeded. In that case the ripple voltage is decisive.

Charge and discharge current

The capacitors may be charged from a source without internal resistance and they may be discharged by short-circuiting.
If the capacitors are charged and discharged continuously at a rate of several times per minute, the charge and discharge currents have to be considered as ripple currents flowing through the capacitor. The r.m.s. value of these currents should be determined and the value thus found must not exceed the applicable limit.

Leakage current

Maximum leakage current 5 min after application of the rated voltage at T_{amb} = 20 °C	see Table 2 (0,006 CU + 4 μA)

Leakage current during continuous operation at U_R,

at T_{amb} = 20 °C	approx. 0,2 of value stated in Table 2
at T_{amb} = 85 °C	≤ value stated in Table 2

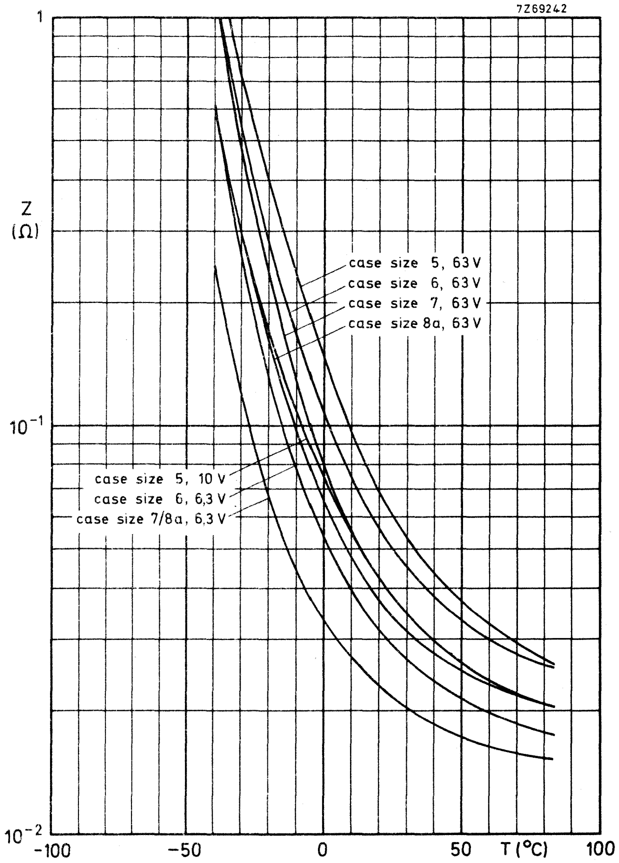
If owing to prolonged storage and/or storage at an excessive temperature the leakage current is too high, application of the rated voltage for some hours will cause the leakage current to fall to a value lower than specified in Table 2.

Tan δ (dissipation factor)

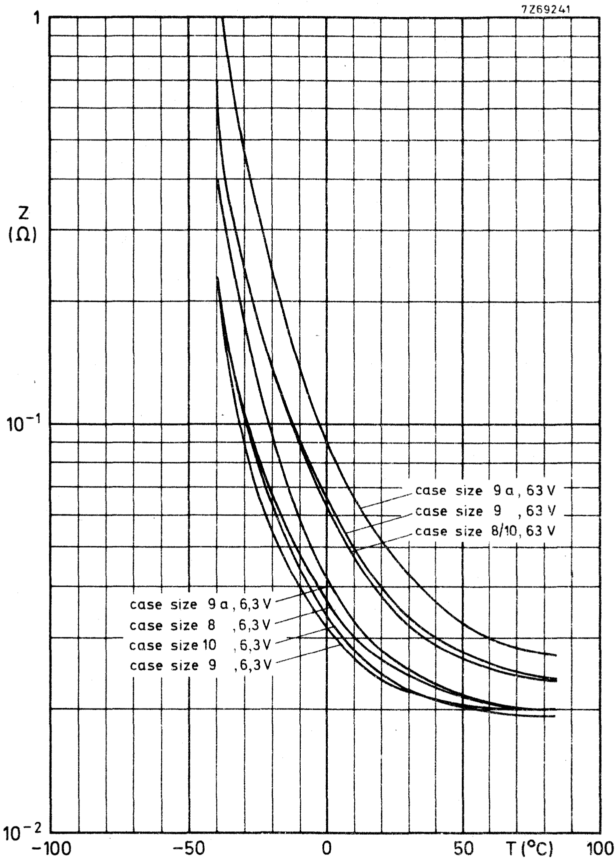
Tan δ at 100 Hz and 20 °C, measured by means of a four-terminal circuit (Thomson circuit)	see Table 2

Impedance

Impedance at 100 kHz and T_{amb} = 20 °C, measured by means of a four-terminal circuit (Thomson circuit)	see Table 2

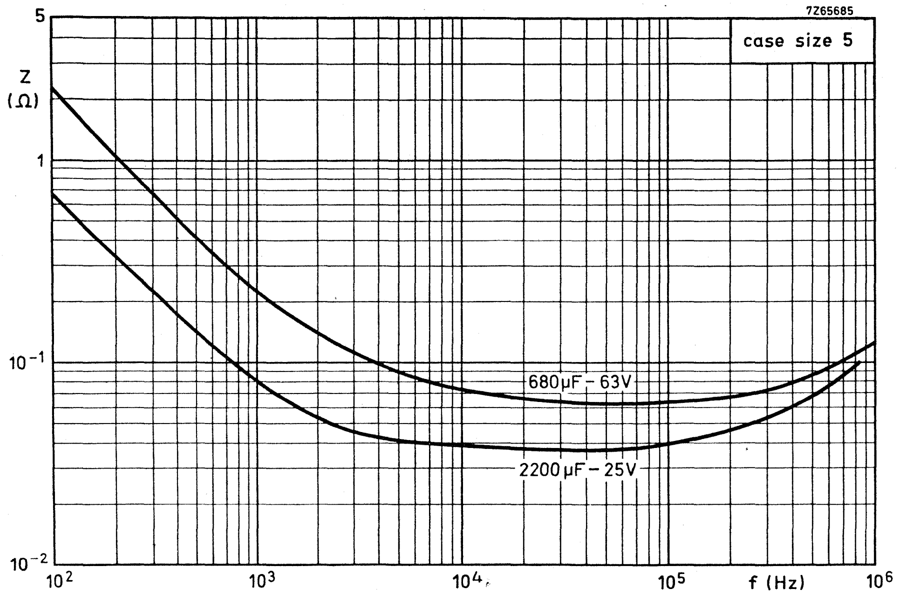


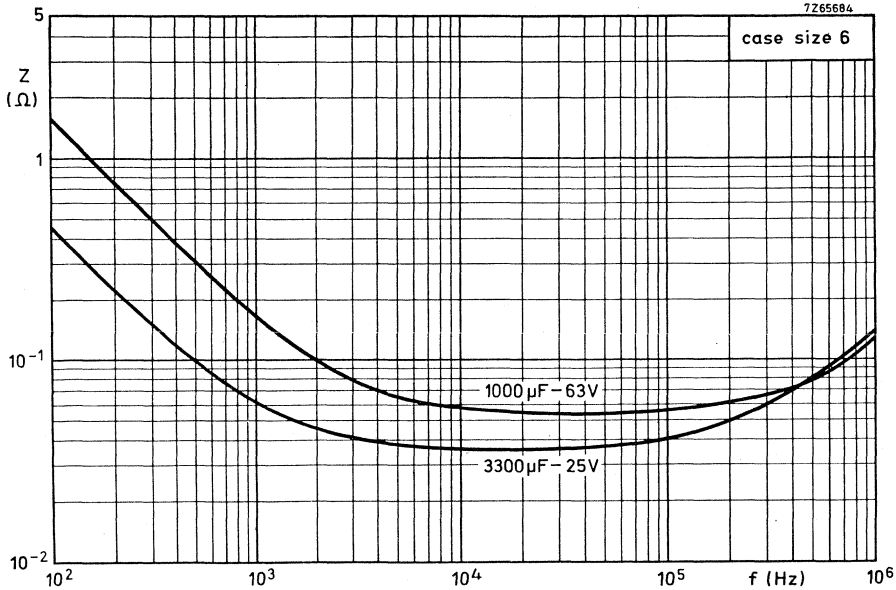
Typical impedance as a function of temperature at 100 kHz



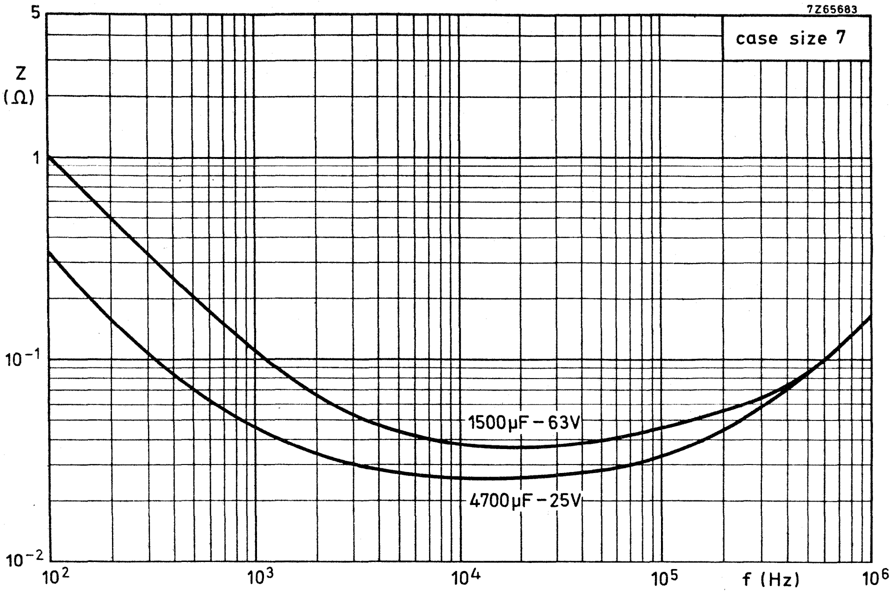
Typical impedance as a function of temperature at 100 kHz

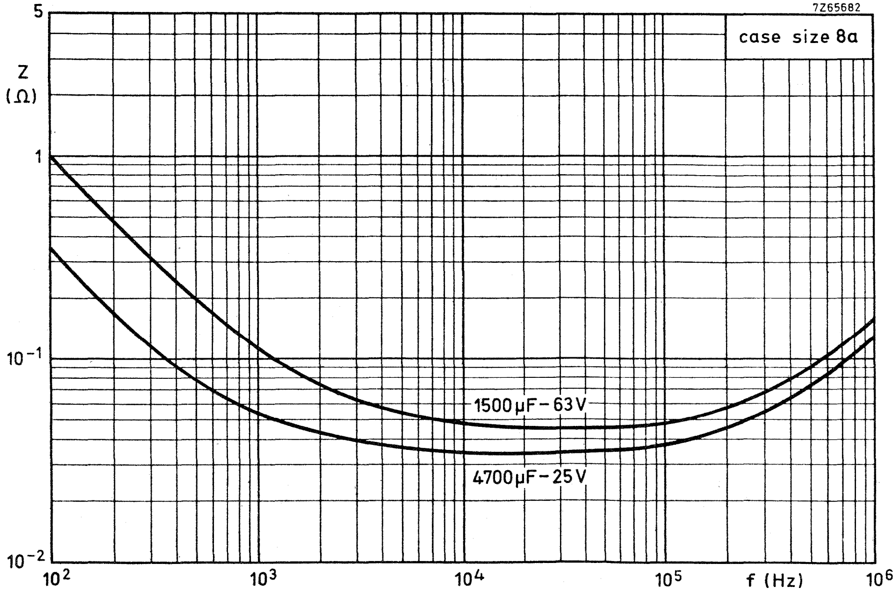
Typical impedance as a function of frequency at different voltages and $T_{amb} = +20\ ^{o}C$.



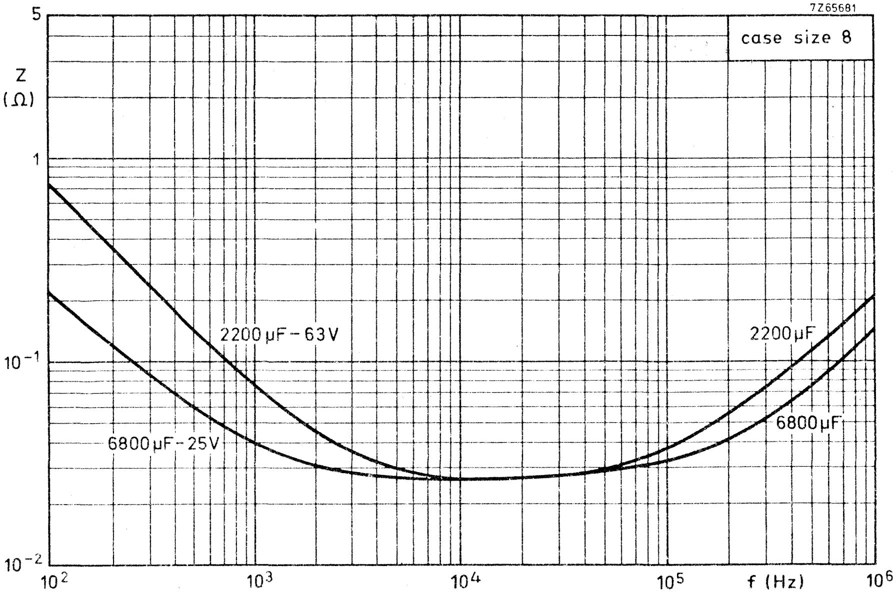


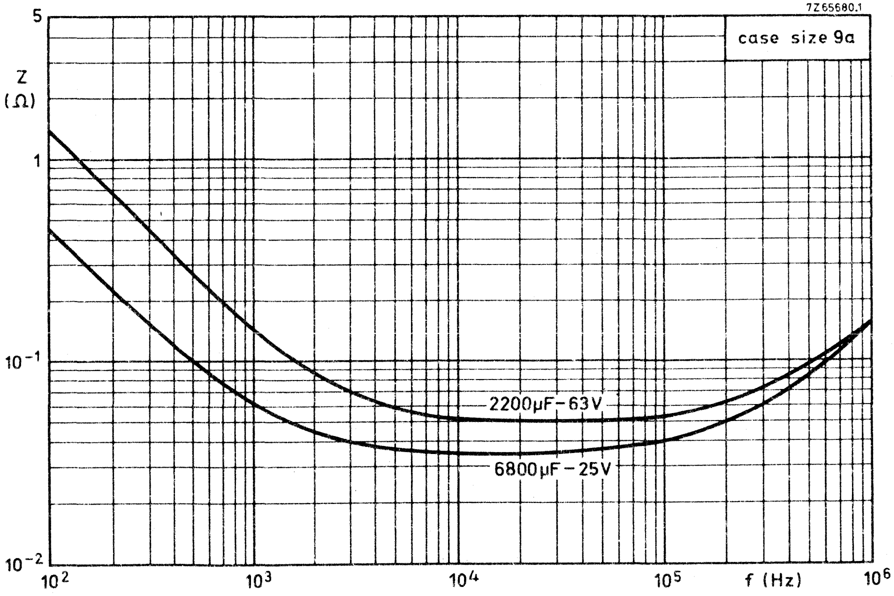
Typical impedance as a function of frequency at different voltages and T_{amb} = +20 °C.



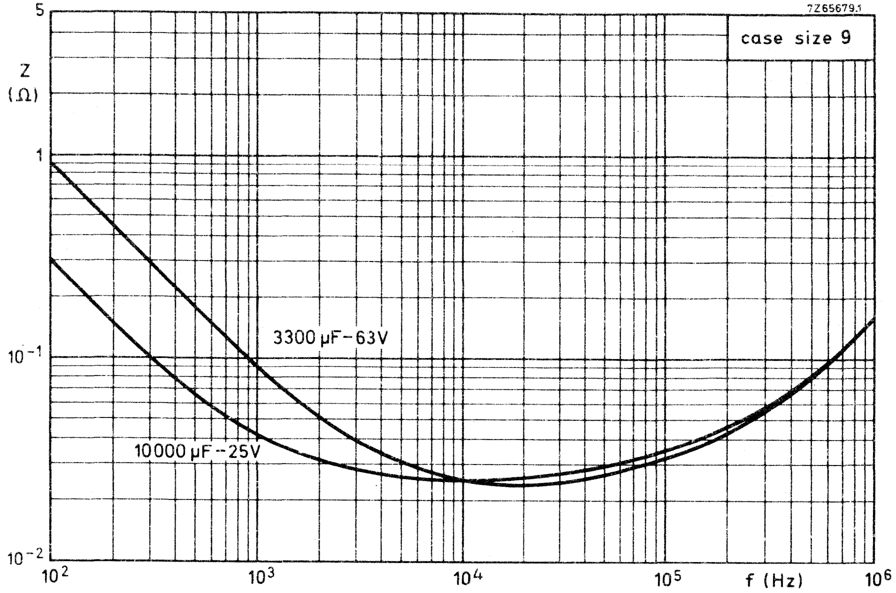


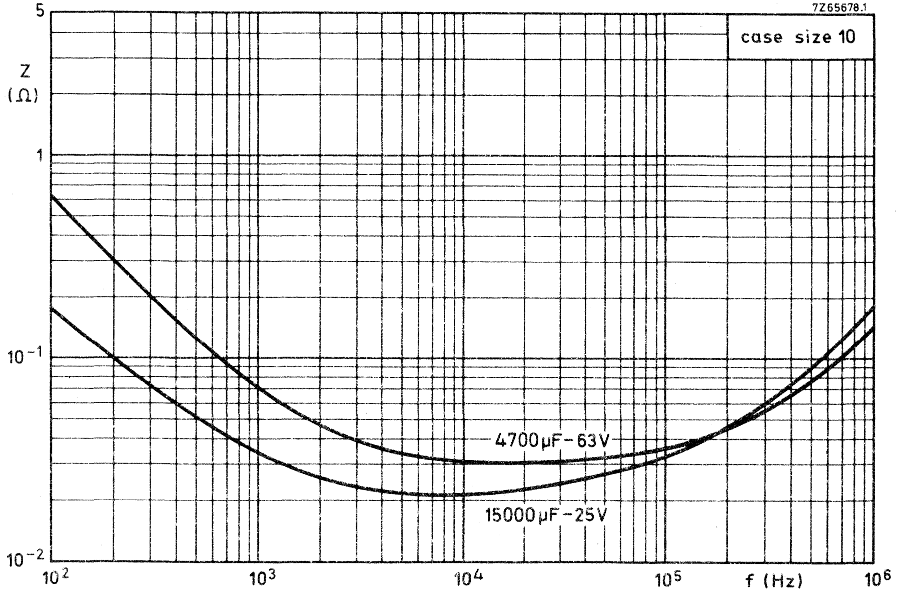
Typical impedance as a function of frequency at different voltages and T_{amb} = + 20 °C.





Typical impedance as a function of frequency at different voltages and $T_{amb} = +20\ ^{o}C$





→ Equivalent series resistance (ESR = tan δ/ωC)

Tan δ and C at 100 Hz and T_{amb} = 20 °C	see Table 2

OPERATIONAL DATA

Category temperature range

For rated voltage	−40 to +85 °C

Life expectancy

Typical life time at T_{amb} = 85 °C	> 5000 hours
at T_{amb} = 25 °C	> 15 years

PACKING

100 pieces per box.

TESTS AND REQUIREMENTS

IEC 103 clause	IEC 68-2 test method	Name of test	Procedure (quick reference)	Requirements
13.6	–	Insulation resistance of insulating sleeve	Metal foil wrapped around body, 100 ± 15 V d.c. between foil and capacitor body for 1 min	$R_{ins} \geq 100$ MΩ
13.7	–	Dielectric strength of insulating sleeve	Metal foil wrapped around body, 1000 V d.c. between foil and capacitor body for 1 min ± 5 s voltage increased gradually 100 V/s	No breakdown or flashover
–	–	Lead pull	Axial pull on terminal till destruction occurs	≥ 40 N (4 kg)
14.1	Ua	Tensile strength of terminations	Loading weight 10 N (1 kg)	No visible damage

TESTS AND REQUIREMENTS (continued)

IEC 103 clause	IEC 68-2 test method	Name of test	Procedure (quick reference)	Requirements
15	T3.2	Soldering (solder bath)	Solderability: 230 °C, 2s	Good tinning
			Resistance to heat : 350 °C, 3 s Single-ended versions immersed up to 3,5 mm from emergence of terminals	No visible damage
15	T3.3	Soldering (soldering iron)	Size A soldering iron, 10 s	Good tinning
15	T3.4	Soldering (solder globule)	Including accelerated ageing	Wetting within 4 s
16	Na	Rapid change of temperature	1 cycle of 3 h at +85 °C and 3 h at −40 °C	No visible damage
17	Fc	Vibration	10–500 Hz, 0,75 mm or 10 g (whichever is the less), 3 h, 1 octave/min, each in 2 directions	No visible damage $\Delta C \leq 5\%$
18	Eb	Bump	4000 ± 10 bumps, 40 g	No visible damage $\Delta C \leq 5\%$

TESTS AND REQUIREMENTS (continued)

IEC 103 clause	IEC 68-2 test method	Name of test	Procedure (quick reference)	Requirements
19.2	Ba	Dry heat	16 h at +85 ± 2 °C with rated voltage applied	Leakage current at 85 °C ≤ 5 x stated limit. No visible damage, no leakage Followed by accelerated damp heat
19.3	D	Accelerated damp heat, first cycle	24 h at 55 ± 2 °C and R.H. 95 to 100%; no voltage applied	After recovery immediately followed by cold test
19.4	Aa	Cold	2 h at −40 ± 3 °C; no voltage applied	Ratio of impedance at −40 °C to that at +20 °C at 100 Hz ≤ 5 for 6,3 V ratings. ≤ 4 for 6,3-16 V ratings. ≤ 3 for ≥ 25 V ratings. $\Delta C \leq 5\%$; no visible damage Followed by sealing test.
19.5	Qc	Sealing	1 min in water at 90 °C	During immersion no continuous chain of bubbles. No seepage of electrolyte. Followed by accelerated damp heat, remaining cycles.
19.6	D	Accelerated damp heat, remaining cycles	5 cycles of 24 h at 55 °C and R.H. 90-100%; no voltage applied	Leakage current and $\tan\delta \leq$ stated limit; $\Delta C \leq 10\%$. No visible damage Insulation breakdown ≥ 1000 V d.c. Insulation resistance ≥ 100 MΩ
20	C	Damp heat (long term exposure)	56 days at 40 °C and R.H. 90 to 95%; no voltage applied	No visible damage; leakage current and $\tan\delta \leq$ stated limit; $\Delta C \leq 20\%$; Insulation breakdown at ≥ 1000 V d.c. Insulation resistance ≥ 100 MΩ

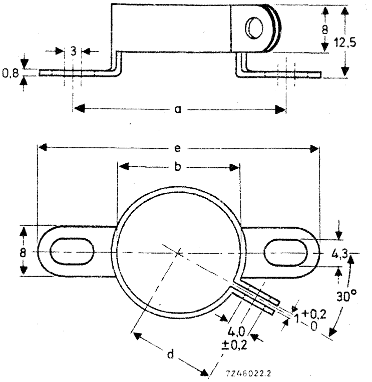
TESTS AND REQUIREMENTS (continued)

IEC 103 clause	IEC 68-2 test method	Name of test	Procedure (quick reference)	Requirements
22	-	Endurance	2000 h at 85 °C with rated voltage and ripple current applied. recovery time ≥ 16 h (temp. = upper cat. temp.)	No visible damage Leakage current ≤ stated limit; tan δ ≤ 1, 3 x stated limit; ΔC ≤15% Ratio of impedance at 20 kHz before and after test ≤ 2; insulation breakdown at ≥ 1000 V d.c.
23	-	Surge	From source of 1, 15 x U_R,85 °C RC = 100 ± 50ms; 5000 cycles of 10 s on, 50 s off	Leakage current and tan δ ≤ stated limit; ΔC ≤ 10%
13.5	-	Pressure relief	A.C. voltage test, 50 Hz	Opening of the pressure relief before rupture of the case or expulsion of the sealing disc
21.1	Ha	Storage at upper category temperature (half of the lot)	96 ± 4 h at 85 °C Cooling time ≥16 h (temp. = upper cat. temp) No voltage applied	Leakage current ≤ 2 x stated limit; tan δ ≤ 1, 2 x stated limit; ΔC ≤ 10%
21.2	Hb	Storage, low temperature (other half of the lot)	72 h at -55 °C recovery time ≥ 16 h No voltage applied.	Leakage current ≤ stated limit; tan δ ≤ stated limit; ΔC ≤ 10% No visible damage

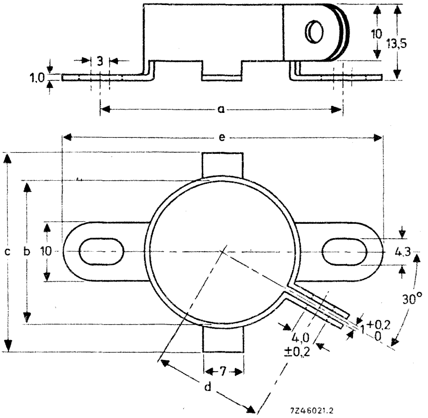
MOUNTING ACCESSORIES

Clamps

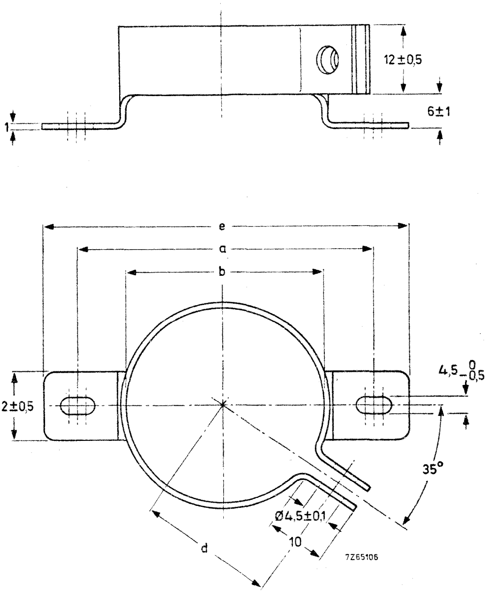
To facilitate vertical mounting, a series of rigid clamps made of cadmium plated steel are available. They can easily be slid over the capacitor and then fixed to it with a nut and bolt. They are provided with two mounting lugs.
Five types are available, one for each case diameter of the capacitor range. They are delivered without nuts or bolts.



For case size 5



For case sizes 6, 7, 8, 8a and 10



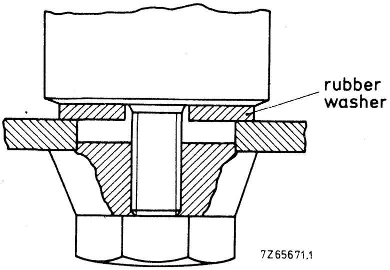
For case size9, and 9a

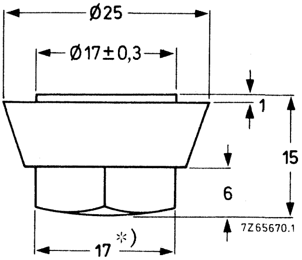
case size	dimensions in mm					catalogue number
	a	b	c	d	e	
5	37,0 ± 0,2	21	–	15,5	49	4322 043 03291
6, 7	41,5 ± 0,2	25	35	18,5	56	03301
8, 8a	46,5 ± 0,2	30	40	21	61	03311
9, 9a	51,5 ± 0,2	35	–	23,5	63	04272
10	56.5 ± 0,2	40	50	26	71	03331

Bolt/nut

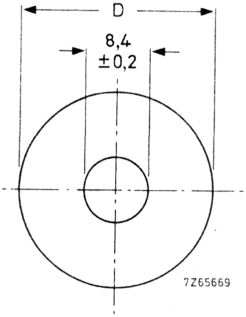
When mounting by means of the bolt, which is an integral part of the case, normal metal M8 nuts and washers can be used.
If an insulated mounting is required a synthetic nut and rubber washers are available.

dimensions in mm





Synthetic cap nut M8, threaded depth min 11,5 mm
Catalogue number 4322 043 05561



D (mm)	catalogue number
24	4322 043 05611
29	4322 043 05601
34	4322 043 05591
39	4322 043 05581

Rubber washer with a thickness of 2 mm

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*) Dimension 17 measured across flats.

ALUMINIUM ELECTROLYTIC CAPACITORS
for long life applications
large type, screw terminals

QUICK REFERENCE DATA

Nominal capacitance range (E6 series)	1500 to 150000 μF
Tolerance on nominal capacitance	−10 to +50%
Rated voltage range, U_R (R5 series)	6,3 to 100 V
Category temperature range	
2222 106	−40 to +85 °C
2222 107	−25 to +85 °C
Typical life time	> 5000 hours at 85 °C
Basic specification	IEC 103, type 1
Category IEC 68 } 2222 106	40/085/56
DIN 40040 } 2222 106	GPF (56 days)
NF C93-001 } 2222 106	554
IEC 68 } 2222 107	25/085/56
DIN 40040 } 2222 107	HPF (56 days)
NF C93-001 } 2222 107	654
Approvals	U.K. Post Office D 2186 Ministry of Defence (Navy) DEF 5134-1 FOA/FTL (Sweden)

7Z65577.1

C_{nom} (μF)	U_R (V) 6,3	10	16	25	40	63	100
1500							⑪
2200						⑪	⑫
3300						⑫	⑭
4700					⑪	⑭	⑮
6800				⑪	⑫	⑮	
10000			⑪	⑫	⑭		⑯
15000		⑪	⑫	⑭	⑮	⑯	
22000	⑪	⑫	⑭	⑮			
33000	⑫	⑭	⑮		⑯		
47000	⑭	⑮		⑯			
68000	⑮		⑯				
100000		⑯					
150000	⑯						

nominal dimensions (mm)	
11	Ø35×80
12	Ø35×112
14	Ø50×80
15	Ø50×112
16	Ø65×112

APPLICATION

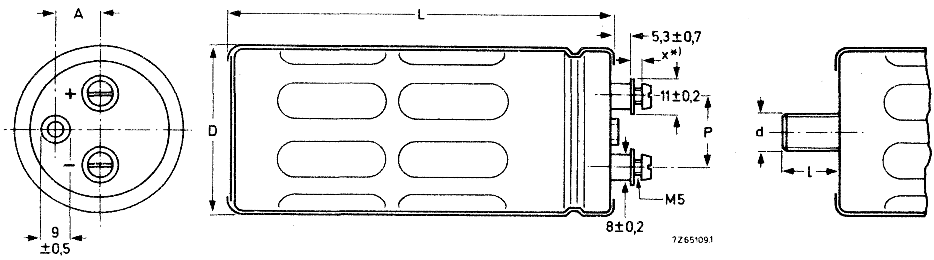
Because of their high reliability and long service life these capacitors are recommended not only for industrial but also for military applications. Their extremely low resistance and inductance values and high resistance to shock and vibration render them very suitable for applications such as:
switched-mode power supplies;
power supplies in digital equipment;
energy storage in pulse systems;
filters in measuring and control apparatus.

DESCRIPTION

The low values of impedance and inductance are achieved by a special construction with multiple internal anode and cathode connections.
The high resistance to shock and vibration is achieved by the longitudinal rills and special internal construction.
The capacitors are completely cold-welded and charge/discharge proof.
The aluminium cases are fully insulated and sealed by a synthetic resin disc with a vent. In the case of over-pressure the vent releases this pressure and closes again; the proper operation of the capacitor remains guaranteed.
The capacitors are delivered with screws and washers.

MECHANICAL DATA

Dimensions in mm



See Table 1 for dimensions D, L, P and A.

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*) Maximum permissible torque which may be applied to the termination screws at various heights (X in drawing):

2	4	6	X (mm)
1,5	1	0,5	max. permissible torque (Nm)

Table 1

case size	D + 1,5	L + 3	P ± 0,1	A ± 0,2	d x l	approx. mass (g)
11	35	80	15	8,4	M8 x 12	105
12	35	112	15	8,4	M8 x 12	140
14	50	80	22	14,3	M12 x 16	200
15	50	112	22	14,3	M12 x 16	280
16	65	112	31	19,0	M12 x 16	480

Marking

←

The capacitors are marked with: nominal capacitance, tolerance on nominal capacitance, rated voltage, temperature range, IEC type, maximum permissible ripple current at 50 °C, catalogue number and date code.

Mounting

←

The capacitor may be mounted upright or lying down, with or without mounting clamp. To ensure good working of the vent, this device should be on the upper side when the capacitor is mounted lying down. When a number of capacitors are connected to form a capacitor bank, the proximity to one another must not be less than 15 mm when no derating of ripple current and/or temperature is applied.
See also mounting accessories.

Minimum atmospheric pressure 200 mbar (15 cm Hg)

ELECTRICAL DATA

→ Table 2

Unless otherwise specified all electrical values in Table 2 apply at an ambient temperature of 20 to 25 °C, a frequency of 100 Hz, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

U_R (V)	nom. cap. (µF)	max. r.m.s. ripple current at T_{amb} = 85 °C (A) 1)	max. leakage current at U_R after 5 min (mA) 1)	typ. ESR (mΩ) 1)	max. tan δ 1)	impedance at 20 kHz (mΩ) 1)		case size	catalogue number 2)
						typ.	max.		
6,3	22000	5,5	0,9	13,0	0,32	8,5	13,0	11	2222 106 33223
	33000	7,9	1,3	8,5	0,32	7,0	10,5	12	33333
	47000	9,4	1,8	6,5	0,35	5,5	8,0	14	33473
	68000	13,2	2,6	4,5	0,35	4,0	6,0	15	33683
	150000	21,3	5,7	2,5	0,45	3,5	5,5	16	33154
10	15000	5,3	0,9	14,0	0,23	8,5	13,0	11	34153
	22000	7,5	1,4	9,5	0,23	7,0	10,5	12	34223
	33000	9,1	2,0	7,0	0,25	5,5	8,0	14	34333
	47000	12,8	2,9	5,0	0,25	4,0	6,0	15	34473
	100000	20,5	6,0	2,5	0,27	3,5	5,5	16	34104
16	10000	5,0	1,0	16,0	0,16	8,5	13,0	11	35103
	15000	7,1	1,5	10,5	0,16	7,0	10,5	12	35153
	22000	8,6	2,2	8,0	0,18	5,5	8,0	14	35223
	33000	12,4	3,2	5,0	0,18	4,0	6,0	15	35333
	68000	19,7	6,6	2,5	0,19	3,5	5,5	16	35683
25	6800	4,7	1,1	18,0	0,12	8,5	13,0	11	36682
	10000	6,7	1,5	12,0	0,12	7,0	10,5	12	36103
	15000	8,2	2,3	8,5	0,13	5,5	8,0	14	36153
	22000	11,6	3,3	6,0	0,13	4,0	6,0	15	36223
	47000	18,7	7,1	3,0	0,14	3,5	5,5	16	36473
40	4700	4,3	1,2	21,0	0,10	11,5	17,0	11	37472
	6800	6,0	1,7	14,5	0,10	8,5	13,0	12	37682
	10000	7,4	2,4	10,5	0,10	6,0	9,0	14	37103
	15000	10,6	3,6	7,0	0,10	4,5	7,0	15	37153
	33000	17,6	8,0	3,5	0,11	3,5	5,5	16	37333
63	2200	3,6	0,9	30,0	0,065	11,5	17,0	11	38222
	3300	5,2	1,3	20,0	0,065	8,5	13,0	12	38332
	4700	6,3	1,8	14,5	0,070	6,0	9,0	14	38472
	6800	8,8	2,6	10,0	0,070	4,5	7,0	15	38682
	15000	14,8	5,7	5,0	0,075	3,5	5,5	16	38153
100	1500	3,1	0,9	270	0,40	200	300	11	2222 107 30152
	2200	4,5	1,4	180	0,40	130	200	12	30222
	3300	5,4	2,0	120	0,40	90	140	14	30332
	4700	7,7	2,9	80	0,40	60	90	15	30472
	10000	12,6	6,0	40	0,40	40	60	16	30103

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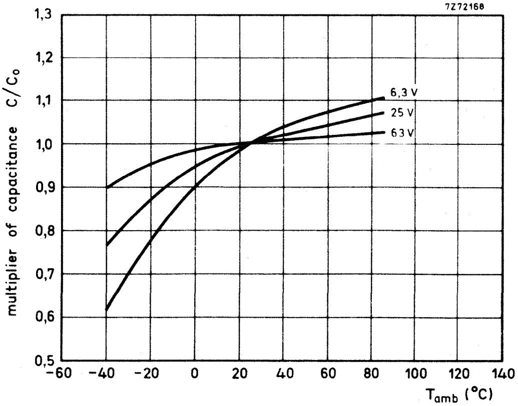
1) See also corresponding paragraph.

2) Replace 8th digit by 5 for bolt version.

Capacitance

Nominal capacitance values at 100 Hz and T_{amb} = 25 °C	see Table 2
Tolerance on nominal capacitance at 100 Hz	-10 to +50%



Typical capacitance as a function of ambient temperature;
C_0 = capacitance at T_{amb} = 25 °C, 100 Hz.

Voltage

Rated voltage = max. permissible voltage
at < 40 °C — 1, 1 x U_R
at 40 °C up to 85 °C — U_R

Ripple voltage *) = max. permissible a.c. voltage providing the following three conditions are met:

	< 40 °C	40 °C up to 85 °C
a) max. (d.c. + peak a.c.) voltage	≤ 1, 1 x U_R	≤ U_R
b) max. peak a.c. voltage, with d.c. voltage applied	≤ applied d.c. voltage + 1 V	
c) max. peak a.c. voltage, without d.c. voltage applied	1 V	

Surge voltage = max. permissible voltage for short periods (see also "Tests and requirements") — 1, 15 x U_R

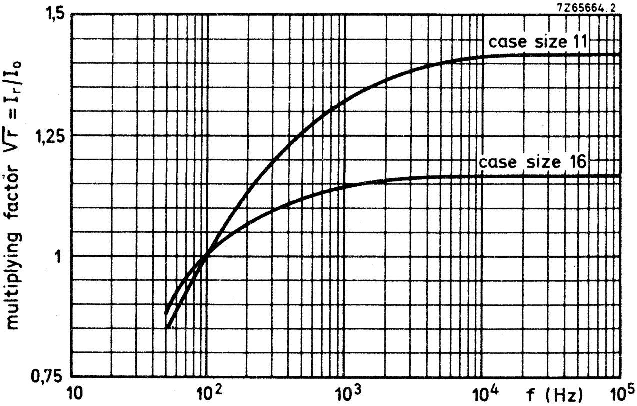
Reverse voltage = max. d.c. voltage applied in the reverse polarity at the maximum category temperature (for short periods) — 1 V

---

*) Ripple voltages are not applicable if the maximum permissible ripple current is exceeded. In that case the ripple current is decisive.

Ripple current

Maximum permissible r.m.s. ripple current at 100 Hz and T_{amb} = 85 °C	see Table 2
at T_{amb} = 80 °C	1,4 x values stated in Table 2
at T_{amb} = 75 °C	1,7 x values stated in Table 2 ¹)
at $T_{amb} \leq$ 65 °C	2,2 x values stated in Table 2 ¹)



Multiplying factor as a function of frequency, for calculation of max. ripple current ¹).
I_0 = maximum ripple current at 85 °C, 100 Hz.

Non-sinusoidal ripple currents have to be analyzed into a number of sinusoidal currents and the following requirements shall then be satisfied:

$$\sum_n \frac{I_n^2}{r_n} \leq I_r^2 \text{max.}$$

$I_{r\ max}$ = max. ripple current at 100 Hz and applicable ambient temperature;

I_n = ripple current at a certain frequency;

$\sqrt{r_n}$ = multiplying factor at same frequency.

Note

Ripple currents are not applicable if the maximum permissible ripple voltage is exceeded. In that case the ripple voltage is decisive.

---

¹) With a maximum of 30 A.

Charge and discharge current

The capacitors may be charged from a source without internal resistance and they may be discharged by short-circuiting.
If the capacitors are charged and discharged continuously at a rate of several times per minute, the charge and discharge currents have to be considered as ripple currents flowing through the capacitor. The r. m. s. value of these currents should be determined and the value thus found must not exceed the applicable limit.

Leakage current

Maximum leakage current 5 min after application of the rated voltage at T_{amb} = 20 °C	see Table 2 (0,006 CU + 4 μA)
Leakage current during continuous operation at U_R, at T_{amb} = 20 °C	approx. 0,125 of value stated in Table 2
at T_{amb} = 85 °C	≤ value stated in Table 2

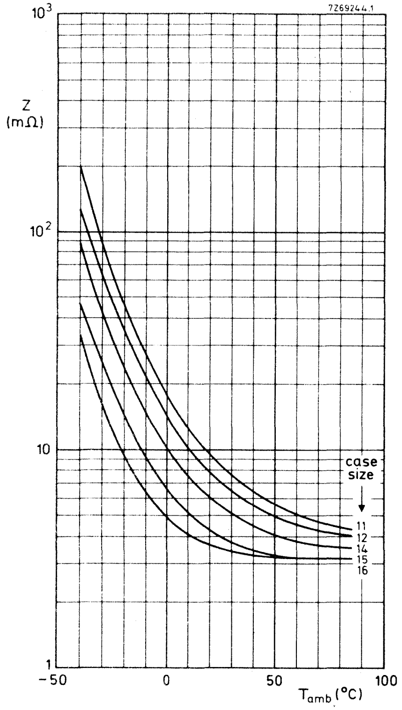
If owing to prolonged storage and/or storage at an excessive temperature the leakage current is too high, application of the rated voltage for some hours will cause the leakage current to fall to a value lower than specified in Table 2.

Tan δ (dissipation factor)

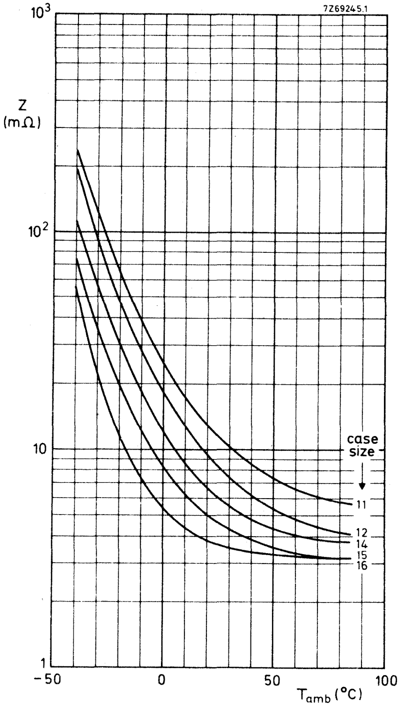
Tan δ at 100 Hz and T_{amb} = 25 °C, measured by means of a four-terminal circuit (Thomson circuit)	see Table 2

Impedance

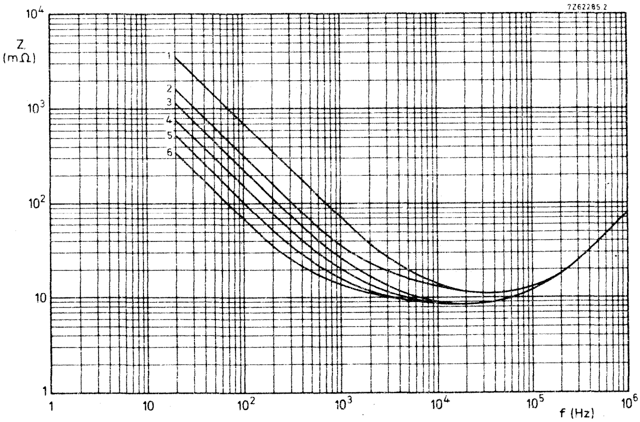
Impedance at 20 kHz and T_{amb} = 25 °C, measured by means of a four-terminal circuit (Thomson circuit)	see Table 2



Typical impedance as a function of temperature at 20 kHz for 6,3 V to 25 V types.



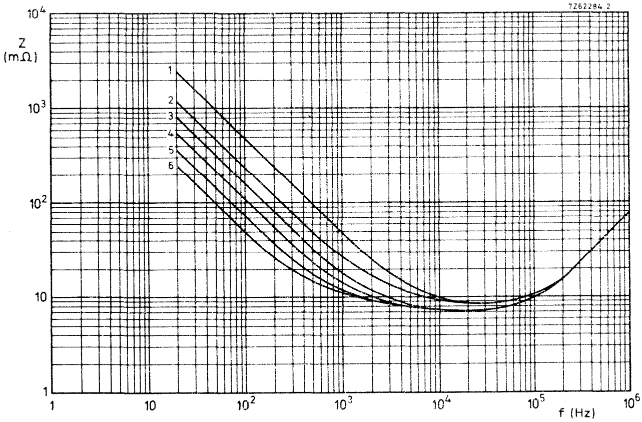
Typical impedance as a function of temperature at 20 kHz for 40 V and 63 V types.



Typical impedance as a function of frequency at T_{amb} = 25 °C.

case size 11

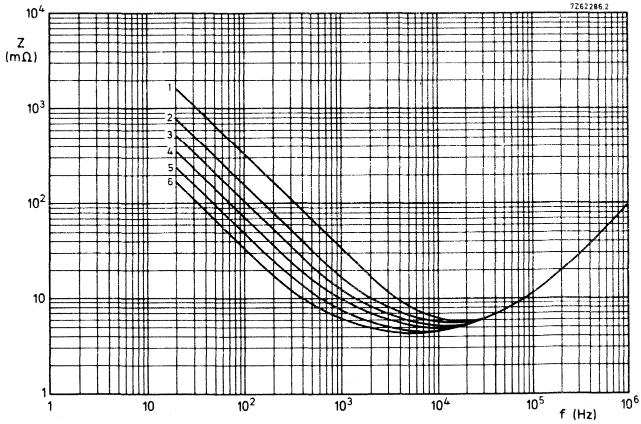
curve 1 = 2200 μF, 63 V
2 = 4700 μF, 40 V
3 = 6800 μF, 25 V
4 = 10 000 μF, 16 V
5 = 15 000 μF, 10 V
6 = 22 000 μF, 6,3 V



Typical impedance as a function of frequency at T_{amb} = 25 °C.

case size 12

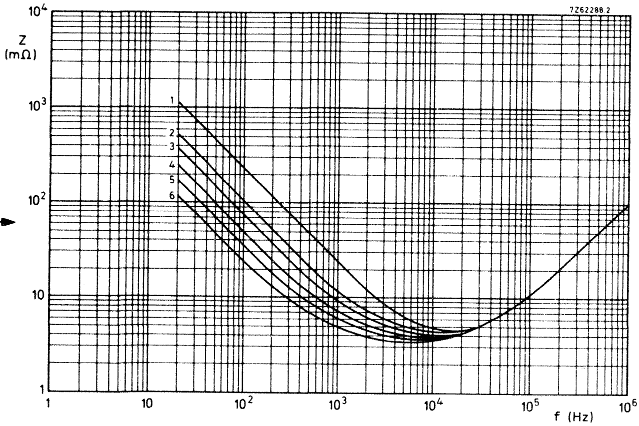
curve 1 = 3300 μF, 63 V
2 = 6800 μF, 40 V
3 = 10 000 μF, 25 V
4 = 15 000 μF, 16 V
5 = 22 000 μF, 10 V
6 = 33 000 μF, 6,3 V



Typical impedance as a function of frequency at T_{amb} = 25 °C.

case size 14

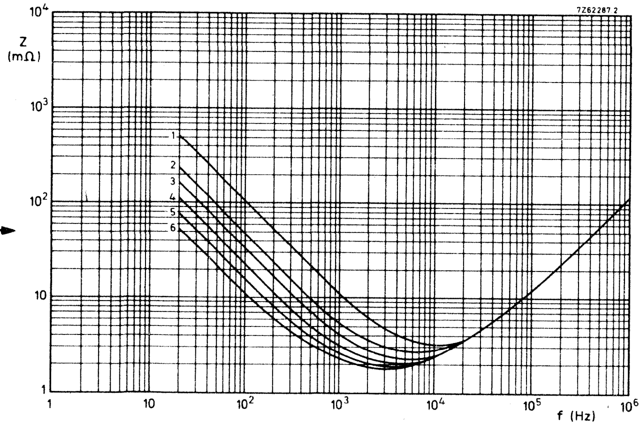
curve 1 = 4700 μF, 63 V
2 = 10 000 μF, 40 V
3 = 15 000 μF, 25 V
4 = 22 000 μF, 16 V
5 = 33 000 μF, 10 V
6 = 47 000 μF, 6,3 V



Typical impedance as a function of frequency at T_{amb} = 25 °C.

case size 15

curve 1 = 6800 µF, 63 V
2 = 15 000 µF, 40 V
3 = 22 000 µF, 25 V
4 = 33 000 µF, 16 V
5 = 47 000 µF, 10 V
6 = 68 000 µF, 6,3 V



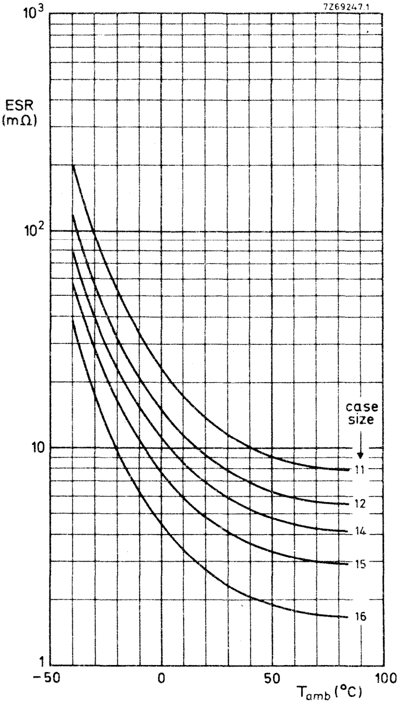
Typical impedance as a function of frequency at T_{amb} = 25 °C.

case size 16

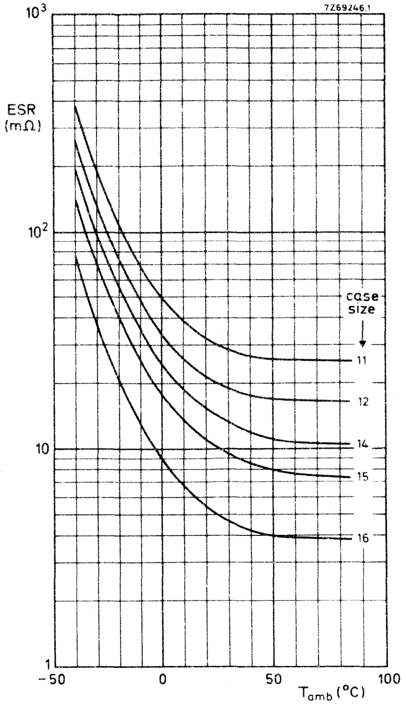
curve 1 = 15 000 µF, 63 V
2 = 33 000 µF, 40 V
3 = 47 000 µF, 25 V
4 = 68 000 µF, 16 V
5 = 100 000 µF, 10 V
6 = 150 000 µF, 6,3 V

Equivalent series resistance (ESR = tan δ/ωC)

→ ESR at 100 Hz and T_{amb} = 25 °C see Table 2



Typical ESR as a function of temperature at 100 Hz for 6, 3 V types.



Typical ESR as a function of temperature at 100 Hz for 63 V types.

Inductance

case size	typical inductance
11 and 12	12 nH
14 and 15	15 nH
16	18 nH

OPERATIONAL DATA

Category temperature range

for rated voltage, 2222 106	−40 to +85 °C
2222 107	−25 to +85 °C

Life expectancy

Typical life time at T_{amb} = 85 °C	> 5000 hours
at T_{amb} = 25 °C	> 15 years

PACKING

Case sizes 11, 12, 14 and 15: 50 pieces per box.
Case size 16: 25 pieces per box.

TESTS AND REQUIREMENTS

IEC 103 clause	IEC 68-2 test method	Name of test	Procedure (quick reference)	Requirements
13.6	–	Insulation resistance of insulating sleeve	Metal foil wrapped around body, 100 ± 15 V d.c. between foil and capacitor body for 1 min	$R_{ins} \geq 100\ M\Omega$
13.7	–	Dielectric strength of insulating sleeve	Metal foil wrapped around body, 1000 V d.c. between foil and capacitor body for 1 min ± 5 s voltage increased gradually 100 V/s	No breakdown or flashover
14.4	Ud	Torque on screw	Torque of 1,96 Nm (0,196 kgm) one time, gradually applied	No visible damage
16	Na	Rapid change of temperature	1 cycle of 3 h at +85 ^{o}C and 3 h at -40 ^{o}C (-25 to +85 ^{o}C for 2222 107)	No visible damage, no seepage of electrolyte
17	Fc	Vibration	10-500 Hz, 0,75 mm or 10 g (whichever is the less), 3 h, 1 octave/min, each in 2 directions	No visible damage $\Delta C \leq 5\%$ tan δ and leakage current ≤ stated limit
18	Eb	Bump	4000 ± 10 bumps, 40 g	No visible damage $\Delta C \leq 5\%$
–	–	Shock	100 g, 1 shock	No visible damage $\Delta C \leq 5\%$

TESTS AND REQUIREMENTS (continued)

IEC 103 clause	IEC 68-2 test method	Name of test	Procedure (quick reference)	Requirements
19.2	Ba	Dry heat	16 h at +85 ± 2 °C with rated voltage applied	Leakage current at 85 °C ≤ 5 x stated limit; no visible damage, followed by accelerated damp heat first cycle
19.3	D	Accelerated damp heat, first cycle	24 h at 55 ± 2 °C and R.H. 95 to 100%; no voltage applied	after recovery immediately followed by cold test.
19.4	Aa	Cold	2 h at −40 ± 3 °C; (-25 ± 3 °C for 2222 107) ; no voltage applied	Ratio of impedance at −40 °C (-25 °C for 2222 107) to that at +20°C (100 Hz); ≤ 5 for 6,3 V ratings ≤ 4 for 10/16 V ratings ≤ 3 for ≥ 25 V ratings $\Delta C \leq 5\%$; no visible damage followed by sealing test
19.5	Qc	Sealing	1 min in water at 90 °C	During immersion no continuous chain of bubbles; no seepage of electrolyte; both via sealing and terminals
19.6	D	Accelerated damp heat, remaining cycles	5 cycles of 24 h at 55 °C and R.H. 95-100%; no voltage applied	No visible damage; leakage current and tan δ ≤ stated limit; $\Delta C \leq 10\%$; insulation resistance ≥ 100 MΩ; insulation breakdown ≥ 1000 V d.c.
20	C	Damp heat (long term exposure)	56 days at 40 °C and R.H. 90 to 95%; no voltage applied	No visible damage; leakage current and tan δ ≤ stated limit; $\Delta C \leq 10\%$; insulation resistance ≥ 100 MΩ; insulation breakdown ≥ 1000 V d.c.

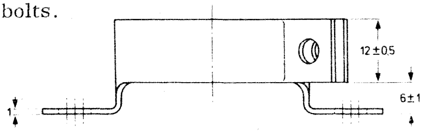
TESTS AND REQUIREMENTS (continued)

IEC 103 clause	IEC 68-2 tests method	Name of test	Procedure (quick reference)	Requirements
22	–	Endurance	2000 h at 85 °C with rated voltage and ripple current applied recovery time ≥ 16 h (temp. = upper cat. temp.)	No visible damage, leakage current ≤ stated limit; tan δ ≤ 1, 3 stated limit; ΔC ≤ 15%; Δ impedance at 20 kHz ≤ 100%; insulation breakdown at ≥ 1000 V d.c.
23	–	Surge	From source of 1, 15 x U_R , 85 °C RC = 100 ± 50 ms; 5000 cycles of 10 s on, 50 s off	Leakage current and tan δ ≤ stated limit; ΔC ≤ 15%
–	–	Pressure relief	Capacitor subjected to internal hydraulic pressure; pressure developed shall be released by opening of vent	No case structure rupture prior to ventings. No leakage at seal or terminals. No expulsion of vent. Difference between opening vent and min. structure strength ≥ 2,1 kg/cm^2 (30 lb/m^2)
21.1	Ha	Storage at upper category temperature (half of the lot)	94 ± 4 h at 85 °C Cooling time ≥ 16 h No voltage applied	Leakage current ≤ 2 x stated limit; tan δ ≤ 1, 2 x stated limit ΔC ≤ 10%
21.2	Hb	Storage, low temperature (other half of the lot)	72 h at –55 °C (-40 °C for 2222 107) recovery time ≥ 16 h No voltage applied	Leakage current and tan δ ≤ stated limit; ΔC ≤10% no visible damage

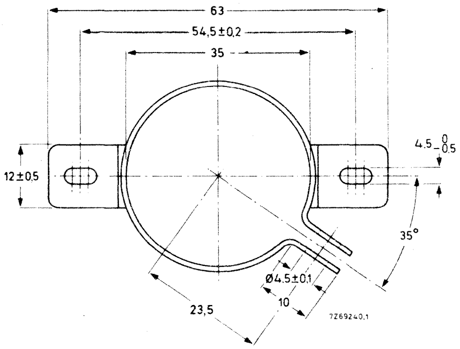
MOUNTING ACCESSORIES

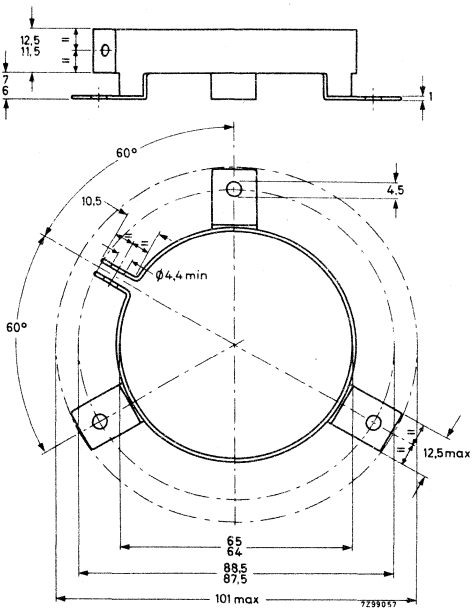
Clamps

To facilitate vertical mounting, a series of rigid clamps made of cadmium-plated steel are available. They can easily be slid over the capacitor and then fixed to it with a nut and bolt. They are provided with two or three mounting lugs. Three types are available, one for each case diameter of the capacitor range. They are delivered without nuts or bolts.

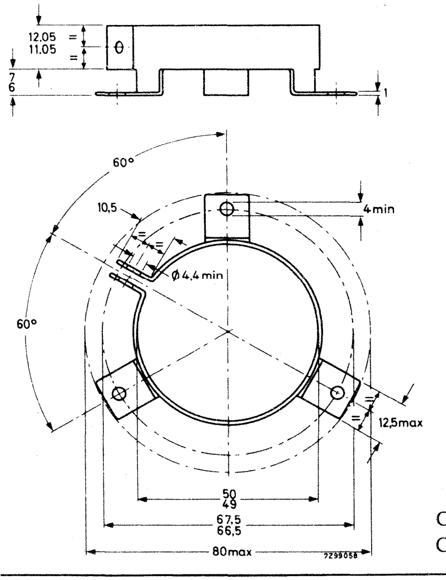


Clamp for case diameter of 35 mm.
Catalogue number: 4322 043 04272.





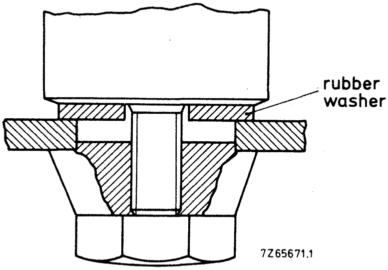
Clamp for case diameter of 65 mm.
Catalogue number 4322 043 04291.

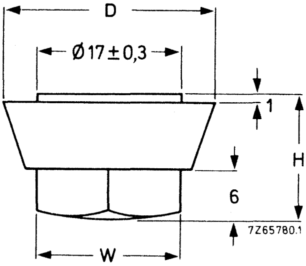


Clamp for case diameter of 50 mm.
Catalogue number 4322 043 04281.

Bolt/nut

When mounting by means of the bolt, which is an integral part of the case, normal metal M8 and M12 nuts and washers can be used.
If an insulated mounting is required a synthetic nut and rubber washers are available.

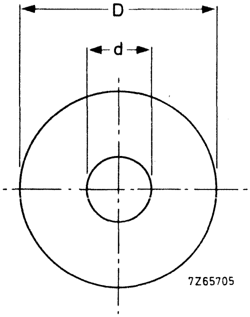




Synthetic cap nut

dimensions in mm

M	D	H	W *)	min. threaded depth	catalogue number
8	25	15	17	11,5	4322 043 05561
12	30	20	19	15,5	4322 043 05571



dimensions in mm

D	d	catalogue number
34	8,4	4322 043 05591
49	13	4322 043 05531
64	13	4322 043 05521

Rubber washer with thickness of 2 mm

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*) W measured across flats.

ALUMINIUM ELECTROLYTIC CAPACITORS

small type for industrial and long life applications

QUICK REFERENCE DATA

Nominal capacitance range (E6 series)	2,2 to 2200 μF	
Tolerance on nominal capacitance	−10 to +50%	
Rated voltage range (U_R) (R5 series)	6,3 to 63 V	
Category temperature range	−40 to +85 °C	
Typical life time at 85 °C	case sizes 5, 6	case sizes 00 to 03
	> 7500 hrs	> 10 000 hrs
Basic specification	IEC 103 (type 1) DIN 41240 (IA) DEF 5134-1 U.K. Post Office D2186 NF C 93-110 (type 1)	
Category IEC 68	40/085/56	
DIN 40040	GPF (56 days)	
NF C 93-001	554	
Approvals	U.K. Post Office D2186 Min. of Defence (Navy) DEF 5134-1	

7Z65541.2

C_{nom} (μF)	U_R (V) 6,3	10	16	25	40	63
2,2						⑤
3,3						⑤
4,7						⑤
6,8						⑤
10						⑤
15					⑤	⑥
22					⑤	⑥
33				⑤	⑥	(00)
47				⑤	⑥	(00)
68			⑤		(00)	(01)
100		⑤		⑥	(01)	(02)
150	⑤		⑥	(00)	(01)	(03)
220		⑥	(00)	(01)	(02)	
330	⑥	(00)			(03)	
470	(00)		(01)	(02)		
680		(01)	(02)	(03)		
1000	(01)	(02)	(03)			
1500	(02)	(03)				
2200	(03)					

nominal dimensions (mm)	
5	Ø8x22
6	Ø10x22
00	Ø10x32
01	Ø12,5x32
02	Ø15x32
03	Ø18x32

APPLICATION

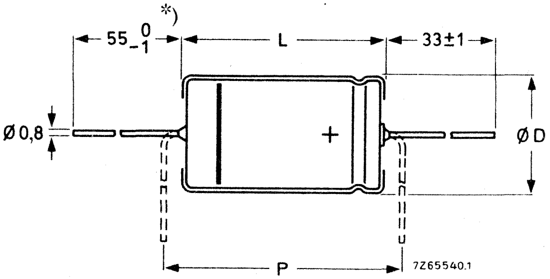
These axial-type capacitors are especially designed for those applications where extreme requirements have to be met concerning reliability and long life time both at high and low temperatures, such as in computer telecommunication and telephone apparatus.

DESCRIPTION

The capacitor has etched aluminium foil electrodes rolled up with a porous paper spacer, which separates the anode and the cathode. The spacer is impregnated with an electrolyte which retains its good characteristics both at low and high temperatures. The capacitor is housed in an aluminium case with axial leads, sealed with an synthetic disc and is insulated with a blue transparent synthetic sleeve. The all welded construction, the built-in voltage derating, and the close quality control during manufacture ensure a reliability and a life expectancy far superior to normal grade electrolytic capacitors.

MECHANICAL DATA

Dimensions in mm



*) 33± 1 for case sizes 5 and 6

Table 1

case size	dimensions			approx. weight (g)
	D + 0,5	L + 0,5	P_{min}	
5	8,0	22,0	28	1,8
6	10,0	22,0	28	2,5
00	10,0	32,0	36	4,3
01	12,5	32,0	36	6,6
02	15,0	32,0	36	8,5
03	18,0	32,0	36	11,2

Marking

Stamped on the case are: nominal capacitance, rated voltage, tolerance on capacitance, group number 108, maximum temperature, date code , a band to identify the negative terminal and "+" signs for positive terminal.

Mounting

The capacitors may be mounted in any position by their leads (see also "Tests and requirements").

ELECTRICAL DATA

Table 2

Unless otherwise specified all electrical values in Table 2 apply at an ambient temperature of 20 to 25 °C, a frequency of 100 Hz, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

U_R (V)	nom. cap. (μF)	max. r.m.s. ripple current at T_{amb} = 85 °C (mA) 1)	max. leakage current at U_R after 5 min. (μA) 1)	max. tan δ 1)	typ. ESR (Ω) 1)	impedance at 100 kHz (Ω) 1)		case size	catalogue number
						max.	typ.		
6,3	150	130	10	0,20	1,06	1,60	0,70	5	2222 108 13151
	330	220	17	0,20	0,49	0,84	0,36	6	13331
	470	325	22	0,20	0,34	0,42	0,18	00	13471
	1000	470	42	0,20	0,16	0,30	0,13	01	13102
	1500	630	60	0,20	0,11	0,22	0,10	02	13152
	2200	920	85	0,20	0,09	0,19	0,09	03	13222
10	100	120	10	0,15	1,27	1,60	0,70	5	14101
	220	205	17	0,15	0,57	0,84	0,36	6	14221
	330	325	24	0,15	0,38	0,42	0,18	00	14331
	680	470	45	0,15	0,19	0,30	0,13	01	14681
	1000	630	65	0,15	0,13	0,22	0,10	02	14102
	1500	920	95	0,15	0,09	0,19	0,09	03	14152
16	68	110	11	0,12	1,40	1.60	0,70	5	15689
	150	190	18	0,12	0,63	0,84	0,36	6	15151
	220	270	25	0,12	0,44	0,42	0,18	00	15221
	470	360	50	0,12	0,21	0,30	0,13	01	15471
	680	500	70	0,12	0,14	0,22	0,10	02	15681
	1000	650	100	0,12	0,10	0,19	0,09	03	15102
25	33	85	8	0,10	2,41	1,60	0,70	5	16339
	47	100	11	0,10	1,70	1,60	0,70	5	16479
	100	170	19	0,10	0,80	0,84	0,36	6	16101
	150	270	26	0,10	0,53	0,42	0,18	00	16151
	220	360	37	0,10	0,36	0,30	0,13	01	16221
	470	500	75	0,10	0,17	0,22	0,10	02	16471
	680	650	105	0,10	0,12	0,19	0,09	03	16681
40	15	65	6	0,08	4,24	1,60	0,70	5	17159
	22	80	9	0,08	2,89	1,60	0,70	5	17229
	33	110	12	0,08	1,93	0,84	0,36	6	17339
	47	130	15	0,08	1,36	0,84	0,36	6	17479
	68	195	20	0,08	0,93	0,42	0,18	00	17689
	100	245	28	0,08	0,63	0,30	0,13	01	17101
	150	280	40	0,08	0,43	0,30	0,13	01	17151
	220	360	55	0,08	0,34	0,22	0,10	02	17221
	330	495	85	0,08	0,20	0,19	0,09	03	17331
63	2,2	25	1,5	0,08	28,9	1,60	0,70	5	18228
	3,3	30	2	0,08	19,3	1,60	0,70	5	18338
	4,7	35	3	0,08	13,5	1,60	0,70	5	18478
	6,8	45	4	0,08	9,36	1,60	0,70	5	18688
	10	50	6	0,08	6,37	1,60	0,70	5	18109
	15	75	10	0,08	2,90	0,84	0,36	6	18159
	22	90	12	0,08	4,25	0,84	0,36	6	18229
	33	125	17	0,08	1,93	0,42	0,18	00	18339
	47	150	22	0,08	1,36	0,42	0,18	00	18479
	68	195	40	0,08	0,93	0,30	0,13	01	18689
	100	275	42	0,08	0,63	0,22	0,10	02	18101
	150	355	60	0,08	0,43	0,19	0,09	03	18151

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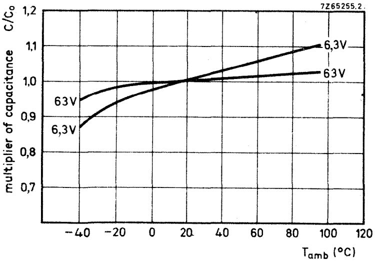
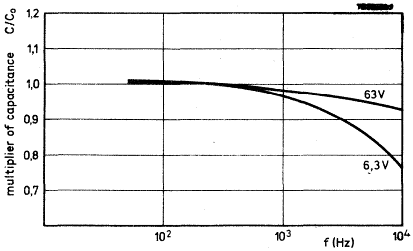
1) See also corresponding paragraph.

Capacitance

Nominal capacitance value at 100 Hz at T_{amb} = 20 °C	see Table 2
Tolerance on nominal capacitance at 100 Hz	−10 to +50%



Typical capacitance as a function of temperature
C_0 = capacitance at 20 °C, 100 Hz



Typical capacitance as a function of frequency
C_0 = capacitance at 20 °C, 100 Hz

Voltage

	< 50 °C	≥50 °C up to 85 °C
Rated voltage = max. permissible voltage	1, 1 x U_R	see Table 2, U_R
Ripple voltage *) = max. permissible a.c. voltage providing the following three conditions are met:		
a) max. (d.c. + peak a.c.) voltage	≤ 1, 1 x U_R	≤ U_R
b) max. peak a.c. voltage, with d.c. voltage applied	≤ applied d.c. voltage +1 V	
c) max. peak a.c. voltage, without d.c. voltage applied	1 V	
Surge voltage = max. permissible voltage for short periods (see also "Tests and requirements")	1, 15 x U_R	
Reverse voltage = max. d.c. voltage applied in the reverse polarity at 85 °C	1 V	

Ripple current

Maximum permissible r.m.s. ripple current at 100 Hz and T_{amb} = 85 °C	see Table 2
T_{amb} = 75 °C	1,7 x values of Table 2
T_{amb} ≤ 65 °C	2,2 x values of Table 2

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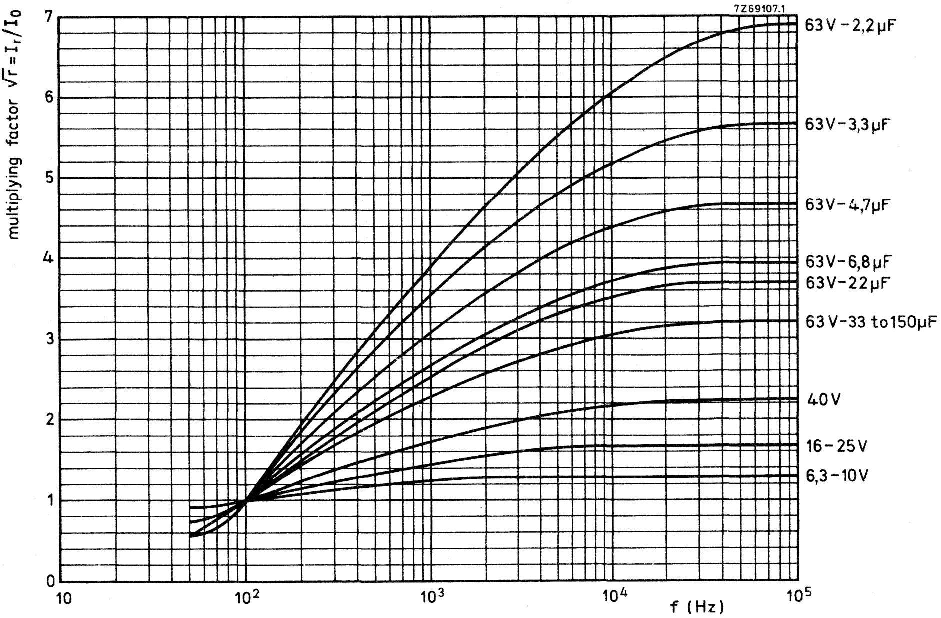
*) Ripple voltages are not applicable if the max. permissible ripple current is exceeded. In that case the ripple current is decisive.



Multiplying factor as a function of frequency.
I_0 = maximum ripple current at 85 °C, 100 Hz.

Non-sinusoidal currents

Non-sinusoidal ripple currents have to be analyzed into a number of sinusoidal currents and the following requirements shall then be satisfied:

$$\sum_n \frac{I_n^2}{r_n} \leq I_r^2 \text{ max.}$$

$I_{r\ max}$ = max. ripple current at 100 Hz and applicable ambient temperature
I_n = ripple current at a certain frequency
$\sqrt{r_n}$ = multiplying factor at same frequency

Note:

These ripple currents are not applicable if the max. permissible ripple voltage is exceeded.
In that case the ripple voltage is decisive. (see paragraph "ripple voltage").

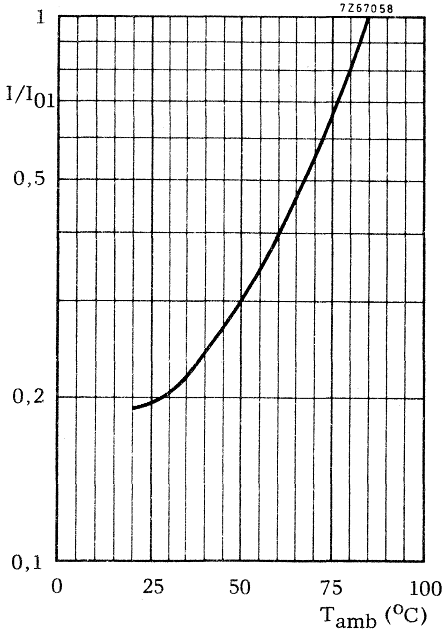
Charge and discharge current

The capacitors may be charged from a source without internal resistance and they may be discharged by short-circuiting.

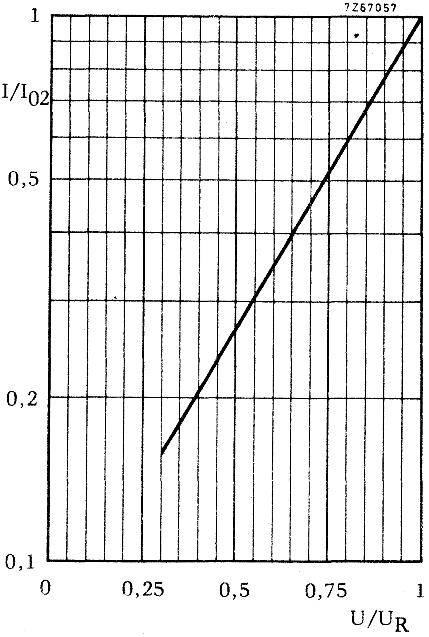
If the capacitors are charged and discharged continuously at a rate of several times per minute, the charge and discharge currents have to be considered as ripple currents flowing through the capacitor. The r.m.s. value of these currents should be determined and the value thus found must not exceed the applicable limit.

Leakage current

Maximum leakage current 5 min after application of the rated voltage at T_{amb} = 20 °C	see Table 2
Leakage current during continuous operation at U_R	
at 20 °C	approx. 0,2 of value stated in Table 2
at 85 °C	≤ value stated in Table 2



multiplier I/I_{01} as a function of temperature
I_{01} = leakage current during continuous operation at T_{amb} = 85 °C at U_R



multiplier I/I_{02} as a function of U/U_R
I_{02} = leakage current at U_R at a discrete constant temperature within category temperature range

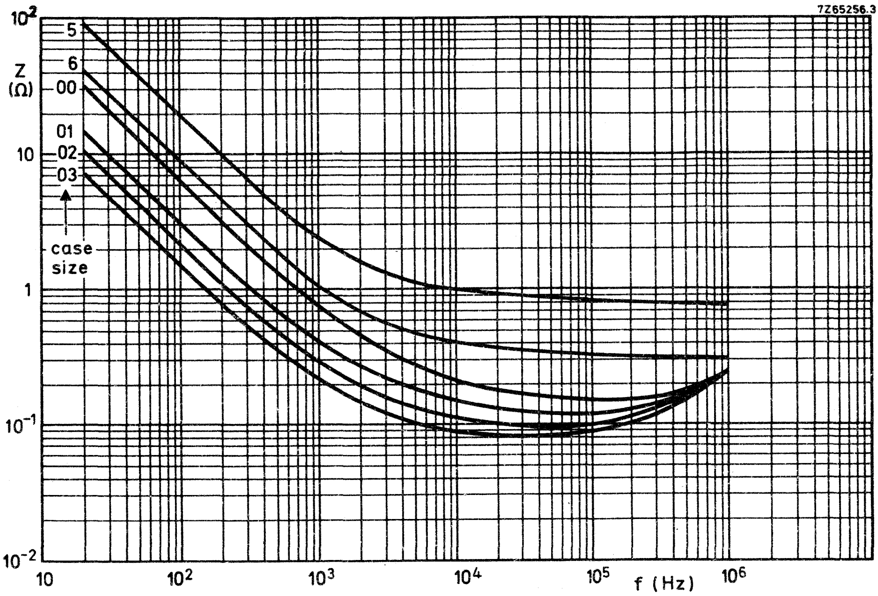
If owing to prolonged storage and/or storage at an excessive temperature (> 40 °C) the leakage current is too high, application of the rated voltage for some hours will cause the leakage current to fall to a value lower than specified in Table 2.

Tan δ (dissipation factor)

Tan δ at 100 Hz and T_{amb} = 20 °C, measured by means of a four-terminal circuit (Thomson circuit)	see Table 2

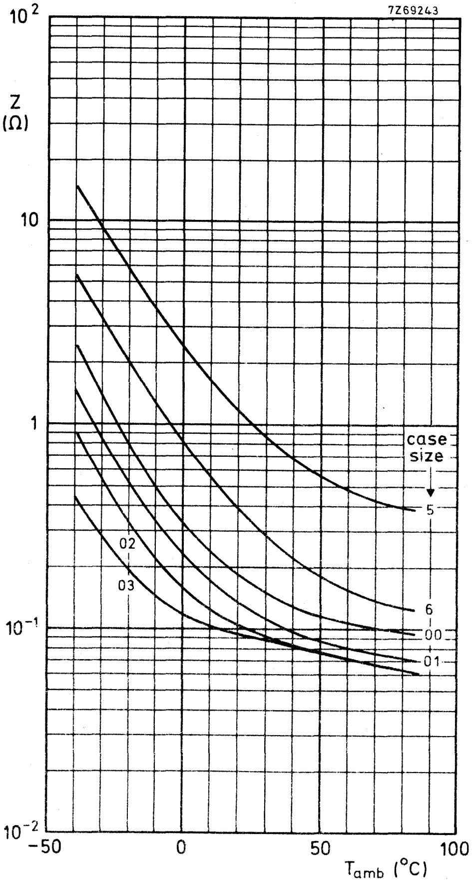
Impedance

Impedance at 100 kHz and T_{amb} = 20 °C, measured by means of a four-terminal circuit (Thomson circuit)	see Table 2



Typical impedance as a function of frequency measured at 16 V and at 20 °C

Typical impedance as a function of temperature at 100 kHz



Equivalent series resistance (ESR = tan $\delta/\omega C$)

ESR at 100 Hz and T_{amb} = 20 °C see Table 2

Inductance ≤ 40 nH

OPERATIONAL DATA

Category temperature range

for rated voltage -40 to +85 °C

Life expectancy

Guaranteed life time at + 85 °C 5000 hours

	case sizes 5 and 6	case sizes 00 to 03
Typical life time at + 85 °C	> 7 500 h	> 10 000 h
Typical life time at + 40 °C	> 120 000 h	> 160 000 h

PACKING

For case sizes 5 and 6 : 100 pieces per box.
For case sizes 00 to 03 : 250 pieces per box.

TESTS AND REQUIREMENTS

Group	IEC 103 clause	IEC 68 test method	Name of test	Procedure (quick reference)	Requirements
I	13.6	–	Insulation resistance of sleeve	Metal foil wrapped around body, 100 ± 15 V d.c. between foil and capacitor body for 1 min	$R_{ins} \geq 100\ M\Omega$
	13.7	–	Dielectric strength of insulating sleeve	Metal foil wrapped around body. 1000 V d.c. between foil and capacitor body for 1 min ± 5 s, voltage increased gradually 100 V/s	No breakdown or flashover
	–	–	Lead pull	Axial pull on lead till destruction occurs.	≥ 40 N (4 kg)
	14.1	Ua	Tensile strength of leads	Loading weight 10 N (1 kg)	No visible damage
	14.2	Ub	Bending, half of the lot	Two consecutive bends of 90 ^{o} weight 5 N (0,5 kg)	No visible damage
	14.3	Uc	Torsion, other half of the lot	Two successive rotations of 180^{o}	No visible damage
	15	(T3.2)	Soldering (solder bath)	Solderability: 270 ^{o}C, 2s flux: non-activated resin Resistance to heat: 350 ^{o}C, 3 s	Good tinning: no visible damage; coding legible $\Delta C \leq 5\%$
	15	T3.4	Soldering (solder globule)	Including accelerated ageing	Wetting within 4 s
	16	Na	Rapid change of temperature	1 cycle of 3 h at +85 ^{o}C and 3 h at −40 ^{o}C	No visible damage

TESTS AND REQUIREMENTS (continued)

Group	IEC 103 clause	IEC 68 test method	Name of test	Procedure (quick reference)	Requierements
	17	Fc	Vibration	10-500-10 Hz, 0,75 mm or 10 g (whichever is the less). 3 h each in 2 directions one along the axis of container, one perpendicular to axis; 1 octave per minute	No visible damage: $\Delta C \leq 5\%$
	18	Eb	Bump	4000 ± 10 bumps, 40 g	No visible damage: $\Delta C \leq 5\%$
	19.2	Ba	Dry heat	16 h at + 85 ± 2 ^{o}C with rated voltage applied	Leakage current at 85 ^{o}C ≤ 5 x stated limit, no visible damage, followed by accelerated damp heat, first cycle
	19.3	D	Accelerated damp heat, first cycle	24 h at 55 ± 2 ^{o}C and R.H. 95 to 100%, with no voltage applied	After recovery immediately followed by cold test.
	19.4	Aa	Cold	2 h at −40 ± 3 ^{o}C, with no voltage applied	$\Delta C \leq 5\%$; no visible damage Ratio of impedance at −40 ^{o}C to that at + 20 ^{o}C (100 Hz): ≤ 5 for 6,3 V ratings ≤ 4 for 10/16 V ratings ≤ 3 for 25/63 V ratings: followed by sealing test.
	19.5	Qc	Sealing	1 min in water at 90 ^{o}C	During immersion no continuous chain of bubbles: Afterwards no seepage of electrolyte followed by accelerated damp heat, remaining cycles

TESTS AND REQUIREMENTS (continued)

Group	IEC 103 clause	IEC 68 test method	Name of test	Procedure (quick reference)	Requirements
	19.6	D	Accelerated damp heat, remaining cycles	5 cycles of 24 h at 55 °C and R.H. 95-100%, with no voltage applied	No visible damage: leakage current and tan δ ≤ stated limit: ΔC ≤ 10% Insulation resistance ≥ 100 MΩ Insulation breakdown ≥ 1000 V (1 min.)
	20	C	Damp heat (long term exposure)	56 days at 40 °C and R.H. 90 to 95%, with no voltage applied	No visible damage: leakage current and tan δ ≤ stated limit: ΔC ≤ 10% Insulation resistance ≥ 100 MΩ Insulation breakdown ≥ 1000 V (1 min.)
	22	–	Endurance	5000 h at + 85 °C with rated voltage and ripple current applied recovery time ≥ 16 h	No visible damage: leakage current ≤ stated limit; tan δ ≤ 1,3 x stated limit; ΔC ≤ 15%; Z at 20 kHz ≤ 2 x stated limit; insulation breakdown ≥ 1000 V (1 min.)
	23	–	Surge	From source of 1,15 x U_R, 85 °C RC = 100 ± 50 ms; 5000 cycles of 10 s on, 50 s off	Leakage current and tan δ ≤ stated limit; ΔC ≤ 15%
	21.1	Ha	Storage, at upper category temperature (half of the lot)	96 ± 4 h at 85 °C Cooling time ≥ 16 h	Leakage current ≤ 2 x stated limit; tan δ ≤ 1,2 x stated limit ΔC ≤ 10%
	21.2	Hb	Storage, low temperature (other half of the lot)	72 h at −55 °C recovery time ≥ 16 h	Leakage current and tan δ ≤ stated limit; ΔC ≤ 10% no visible damage

SOLID ALUMINIUM CAPACITORS

for industrial and long life applications small type

QUICK REFERENCE DATA	
Nominal capacitance range (E6 series)	2, 2 to 330 μF
Tolerance on nominal capacitance	−20 to +20%
Rated voltage range, U_R (R5 series)	6, 3 to 40 V
Category temperature range	−55 to +125 °C
Endurance test	5000 hours at 125 °C
Category, IEC 68	at U_R 55/085/56 at 0,63 U_R 55/125/56
Approvals	U.K. Post Office FOA/FTL (Sweden)

7Z60248.4

C_{nom} (μF)	U_R (V)				
	6,3	10	16	25	40
2,2					①
3,3					①
4,7				①	②
6,8					②
10			①	②	③
15		①	②		
22	①			③	④
33		②	③	④	⑤
47	②	③	④	⑤	⑥
68	③		⑤	⑥	
100		④	⑥		
150	④	⑤			
220	⑤	⑥			
330	⑥				

nominal dimensions (mm)	
1	Ø 6,5 x 17
2	Ø 6,5 x 23
3	Ø 8 x 23
4	Ø 10 x 23
5	Ø 10 x 31
6	Ø 12,5 x 31

APPLICATION

These capacitors utilize advanced technology to achieve long life, high stability, high ripple current rating and low temperature dependence. The capacitors are not subject to a limitation on charge or discharge currents and they will function in circuits where voltage reversal may occur.

DESCRIPTION

The capacitor has etched aluminium foil electrodes separated by a layer of semiconductive material. The electrolyte is pyrolytically formed manganese dioxide. The capacitor is housed in an aluminium case with axial leads and is sealed by a ceramic disc. The cathode lead is welded to the case, which is insulated with a blue transparent plastic sleeve.

MECHANICAL DATA

Dimensions in mm

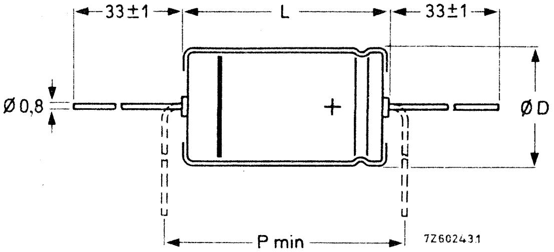


Table 1

case size	D_{nom}	L_{nom}	D_{max}	L_{max}	P_{min}	weight approx. (g)
1	6, 5	17	6, 6	17, 5	20	1, 2
2	6, 5	23	6, 6	24	27, 5	1, 6
3	8	23	8, 3	24	27, 5	2, 4
4	10	23	10, 4	24	27, 5	3, 3
5	10	31	10, 4	32	27, 5	4, 5
6	12, 5	31	12, 9	32	35	6, 3

Marking

Stamped on the case are: catalogue number, capacitance, rated and derated voltages at corresponding maximum temperatures, date code, a band to identify the negative terminal and " + " signs for the positive terminal.

Mounting

No special provisions are required for soldering to the tinned leads.
(2 mm of the anode lead nearest the body are not solderable.)

ELECTRICAL DATA

Table 2

Unless otherwise specified all electrical values in Table 2 apply at an ambient temperature of 20 to 25 °C, a frequency of 100 Hz, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

U_R (V)	nom. cap. (µF)	max. r.m.s. ripple current at $T_{amb} = 85$ °C (mA) 1)	max. leakage current at U_R after 5 min (µA) 1)	max. tan δ 1)	typ. ESR (Ω) 1)	max. impedance at 100 kHz (Ω) 1)	case size	catalogue number
6, 3	22	45	12, 5	0, 18	6, 51	2, 5	1	2222 121 13229
	47	75	25	0, 18	3, 05	1, 25	2	121 13479
	68	105	40	0, 18	2, 34	0, 75	3	121 13689
	150	170	70	0, 18	0, 95	0, 5	4	121 13151
	220	240	125	0, 18	0, 80	0, 4	5	121 13221
	330	335	150	0, 18	0, 53	0, 4	6	121 13331
10	15	40	15	0, 16	7, 43	2, 5	1	121 14159
	33	70	30	0, 16	3, 86	1, 25	2	121 14339
	47	90	50	0, 16	2, 71	0, 75	3	121 14479
	100	145	80	0, 16	1, 59	0, 5	4	121 14101
	150	220	150	0, 16	1, 17	0, 4	5	121 14151
	220	290	200	0, 16	0, 58	0, 4	6	121 14221
16	10	35	20	0, 14	9, 55	2, 5	1	121 15109
	15	50	40	0, 14	5, 31	1, 25	2	121 15159
	33	100	75	0, 14	2, 89	0, 75	3	121 15339
	47	110	100	0, 14	1, 69	0, 5	4	121 15479
	68	150	175	0, 14	1, 64	0, 4	5	121 15689
	100	205	250	0, 14	0, 95	0, 4	6	121 15101
25	4, 7	25	20	0, 14	16, 93	5	1	121 16478
	10	40	40	0, 14	11, 14	2, 5	2	121 16109
	22	70	75	0, 14	5, 06	1, 5	3	121 16229
	33	90	100	0, 14	3, 86	1	4	121 16339
	47	130	175	0, 14	4, 06	0, 8	5	121 16479
	68	170	250	0, 14	1, 87	0, 5	6	121 16689
40	2, 2	20	20	0, 12	28, 94	5	1	121 17228
	3, 3	25	20	0, 12	19, 29	5	1	121 17338
	4, 7	35	40	0, 12	16, 93	2, 5	2	121 17478
	6, 8	40	40	0, 12	11, 70	2, 5	2	121 17688
	10	55	75	0, 12	9, 55	1, 5	3	121 17109
	22	90	100	0, 12	6, 51	1	4	121 17229
	33	125	175	0, 12	4, 34	0, 8	5	121 17339
	47	165	250	0, 12	2, 37	0, 5	6	121 17479

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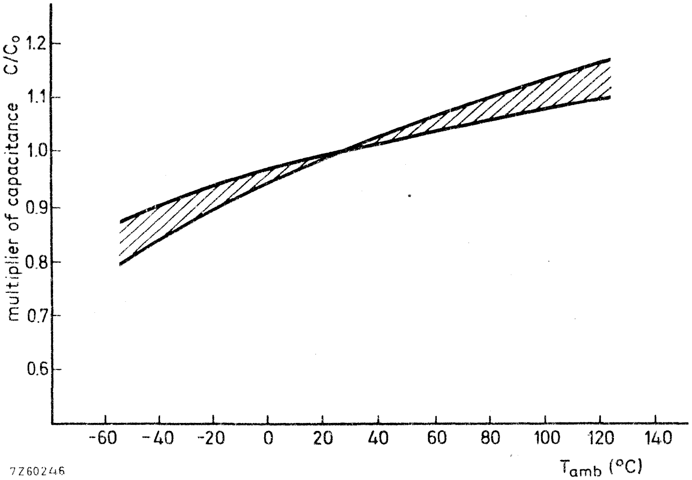
1) See also corresponding paragraph.

Capacitance

Nominal capacitance values at 100 Hz and T_{amb} = 20 °C	see Table 2
Tolerance on nominal capacitance at 100 Hz	−20 to +20%



Typical capacitance as a function of temperature
C_0 = capacitance at 25 °C and at 100 Hz

Voltage

Rated voltage	= max. permissible voltage at ≤ 85 °C	see Table 2, U_R	
Derated voltage	= max. permissible voltage at > 85 °C up to +125 °C	0, 63 x U_R	
Ripple voltage *)	= max. permissible a.c. voltage providing the following three conditions are met:	≤ 85 °C	> 85 °C up to 125 °C
	a) max.(d.c.+peak a.c.)voltage	≤ U_R	≤ 0, 63 x U_R
	b) max.peak a.c. voltage with d.c. voltage applied	≤ 1, 15 applied d.c. voltage	
	c) max.peak a.c. voltage without d.c. voltage applied	0, 15 x U_R	0, 15 x derated voltage

---

*) Ripple voltages are not applicable if the maximum permissible ripple current is exceeded. In that case the ripple current is decisive.

		≤ 85 °C	> 85 °C up to 125 °C
Surge voltage	= max. permissible voltage for short periods (see also "Tests and requirements")	1, 15 x U_R	1, 15 x derated voltage
Reverse voltage	= max. d. c. voltage applied in the reverse polarity at the maximum category temperature for short periods (see also "Tests and requirements")	0, 15 x U_R	0, 15 x derated voltage

Ripple current

Maximum permissible r. m. s. ripple current at 100 Hz and T_{amb} = 85 °C — see Table 2

The maximum permissible ripple current ($I_{r\,max}$) is a function of temperature and frequency:

$$I_{r\,max} = I_{r0}\sqrt{kr}$$

where I_{r0} = max. ripple current at 100 Hz up to 85 °C, see Table 2
k = temperature derating factor = P_{max}/P_0
r = frequency dependent derating factor = R_{s0}/R_s
while P_{max} = max. permissible power dissipation, temperature dependent
P_0 = max. permissible power dissipation up to 85 °C = $(I_{r0})^2 R_{s0}$
R_{s0} = series resistance at 100 Hz = $\frac{\tan\delta}{628C}$, C and tan δ to be read from Table 2
R_s = series resistance, frequency dependent (temperature dependence neglected).

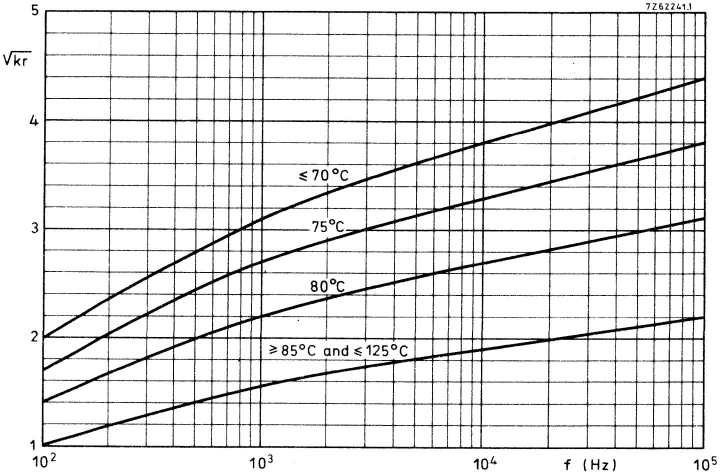
The formula is derived as follows:

$$(I_{r\,max})^2 = P_{max}/R_s = k(I_{r0})^2 R_{s0}/R_s;$$

thus $I_{r\,max} = I_{r0}\sqrt{kr}$ (see Table 2 and next graph)

Note

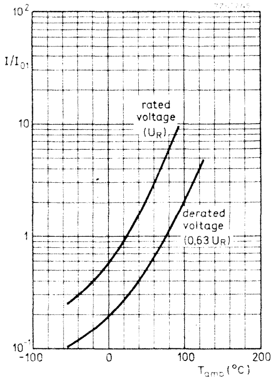
These ripple currents are not applicable if the maximum permissible ripple voltage is exceeded. In that case the ripple voltage is decisive.



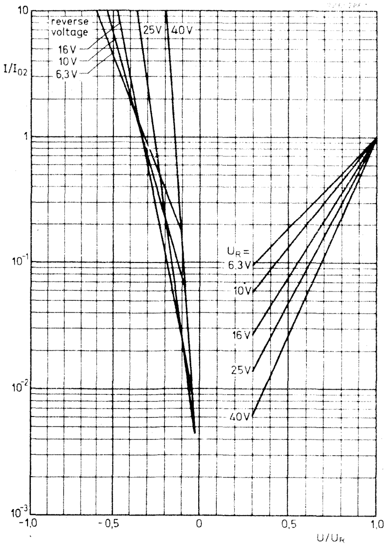
Factor $\sqrt{kr}$ as a function of frequency for calculation of maximum ripple current.

Leakage current

Maximum leakage current 5 min after application of the rated voltage	see Table 2
Leakage current during continuous operation at U_R, at 25 °C	approx. 0, 4 of value stated in Table 2
at 85 °C as well as at 0, 63 x U_R and 125 °C	approx. 4 of value stated in Table 2



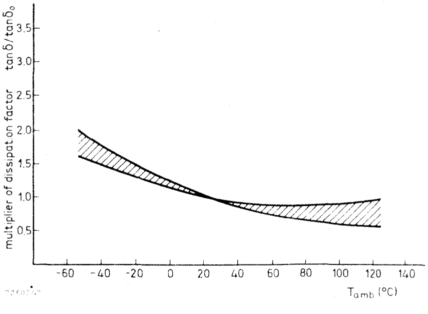
Multiplier I/I_{01} as a function of temperature
I_{01} = leakage current during continuous operation at T_{amb} = 25 °C at U_R



Multiplier I/I_{02} as a function of U/U_R
I_{02} = leakage current at U_R at a discrete constant temperature.

Tan δ (dissipation factor)

Tan δ at 100 Hz, measured by means of a four-terminal circuit (Thomson circuit) (max. values) see Table 2

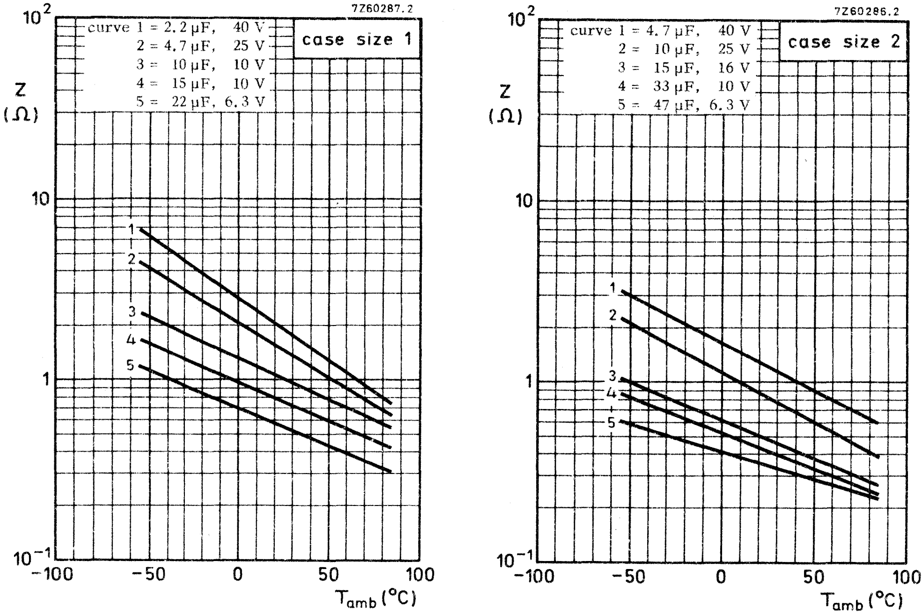


Typical dissipation factor as a function of temperature
Tan δ_0 = dissipation factor at 25 °C, 100 Hz

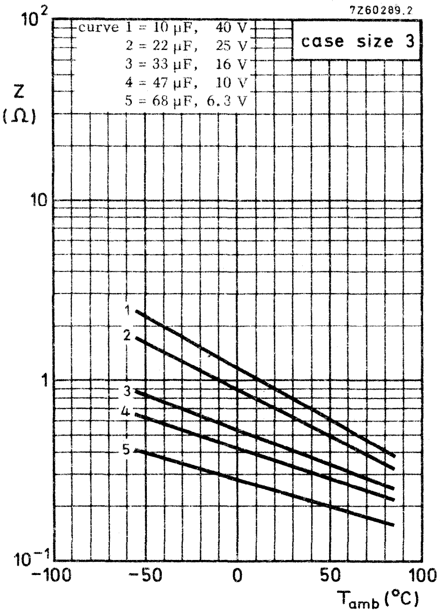
Impedance

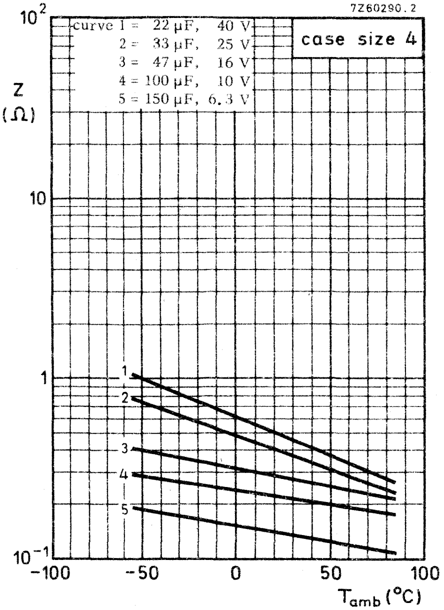
Impedance at 100 kHz, measured by means of a four-terminal circuit (Thomson circuit) (max. values) see Table 2

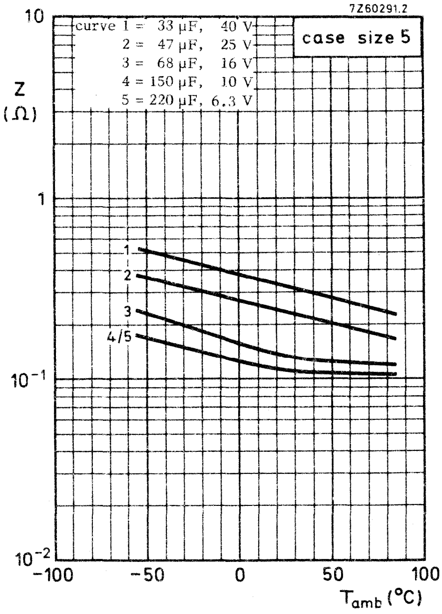
Typical impedance as a function of temperature at 100 kHz

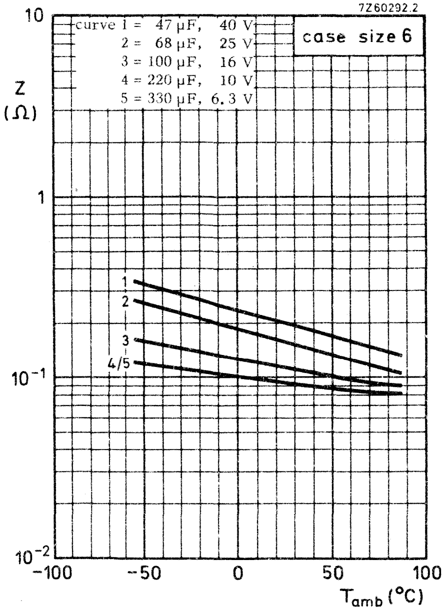


Typical impedance as a function of temperature at 100 kHz

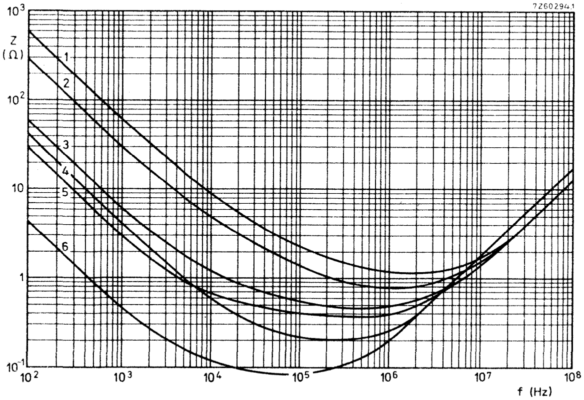






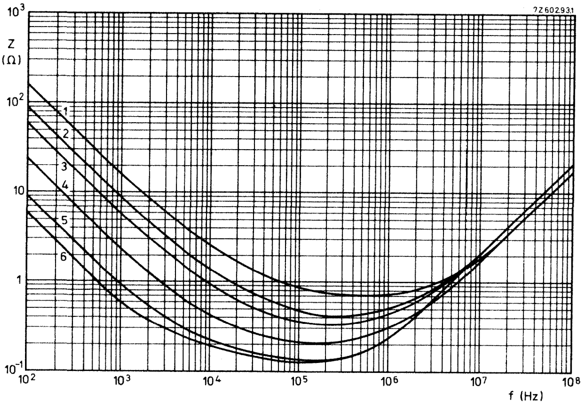


Typical impedance as a function of frequency at 25 °C



curve 1 = 2.2 μF, 40 V
2 = 4.7 μF, 40 V
3 = 22 μF, 6.3 V
4 = 47 μF, 40 V
5 = 47 μF, 6.3 V
6 = 330 μF, 6.3 V

curve 1 + 3 = case size 1
curve 2 + 5 = case size 2
curve 4 + 6 = case size 6



curve 1 = 10 μF, 40 V
2 = 22 μF, 40 V
3 = 33 μF, 40 V
4 = 68 μF, 6.3 V
5 = 150 μF, 6.3 V
6 = 220 μF, 6.3 V

curve 1 + 4 = case size 3
curve 2 + 5 = case size 4
curve 3 + 6 = case size 5

Equivalent series resistance (ESR = tan $\delta/\omega C$)

ESR at 100 Hz and T_{amb} = 20 °C	see Table 2
Self inductance	20 to 30 nH (typical values)

OPERATIONAL DATA

Category temperature range

for rated voltage	−55 to +85 °C
for derated voltage (= 0, 63 x U_R)	−55 to +125 °C

Life expectancy

at 85 °C and U_R or at 125 °C and 0, 63 U_R	>> 10 000 hours

PACKING

100 pieces per box.

TESTS AND REQUIREMENTS

Group	IEC 68-2 test method	Name of test	Procedure (quick reference)	Requirements
0		Insulation resistance of sleeve	Metal foil wrapped around body 100 ± 15 V between foil and body for 1 min	Insulation resistance > 100 MΩ
		Dielectric strength of insulating sleeve	Metal foil wrapped around body 1000 V d.c. for 1 min ± 5 s voltage rise 100 V/s	No breakdown or flashover
1	Ua Ub Uc	Robustness of terminations	During 10 s axial 10 N Bend-pull 1 cycle 5 N Torsion 1 cycle	No visible damage
	T	Soldering	Globule method	Must flow within < 4 s with Flux 201 < 2 s with Flux 202
	Na	Rapid change of temperature	3 cycles of 3 h at +125 °C with no voltage applied and 3 h at −55 °C	No visible damage Leakage current ≤ stated limit tan δ ≤ stated limit H.F. imp. ≤ stated limit $\Delta C \leq 5\%$
	Fc	Vibration	10-500-10 Hz, 0.75 mm or max. 10 g. 2 x 3 h	No visible damage $\Delta C \leq 5\%$
	Eb	Bump	4000 ± 10 bumps, 40 g	No damage $\Delta C \leq 5\%$

TESTS AND REQUIREMENTS (continued)

Group	IEC 68-2 test method	Name of test	Procedure (quick reference)	Requirements
1	Ba	Dry heat	16 h at 85 + 2 °C with rated voltage applied 16 h at 125 + 2 °C with derated voltage applied	No visible damage Immediately followed by damp heat test
	Da	Accelerated damp heat, first cycle	1 cycle 55 ± 2 °C R.H. 95 - 100% with no voltage applied	No visible damage Immediately followed by cold test
	Aa	Cold	2 h at −55 ± 3 °C with no voltage applied	No visible damage Immediately followed by low air pressure test
	M	Low air pressure	−5 min at 15 - 35 °C, 85 mbar Last minute with rated voltage applied	No damage, no breakdown Immediately followed by damp heat test (remaining cycles)
	Da	Accelerated damp heat, remaining cycles	5 cycles 24 h at 55 ± 2 °C R.H. 95 - 100% with no voltage applied	No visible damage Leakage current $\leq$ stated limit tan $\delta \leq 1.2$ x stated limit $\Delta C \leq 5\%$ with respect to tests T and Eb Insulation resistances > 100 MΩ Breakdown voltage > 1000 V d.c.
2	Ca	Damp heat steady state	56 days at 40 ± 2 °C R.H. 90 - 95% with no voltage applied	No visible damage Leakage current $\leq$ stated limit tan $\delta \leq 1.2$ x stated limit $\Delta C \leq 10\%$ Insulation resistances > 100 MΩ Breakdown voltage > 1000 V d.c.

TESTS AND REQUIREMENTS (continued)

Group	IEC 68-2 test method	Name of test	Procedure (quick reference)	Requirements
3		Endurance	5000 h at 85 ± 1.5 °C with rated voltage applied or 5000 h at 125 ± 1.5 °C with derated voltage applied	No damage Leakage current $\leq$ stated limit tan $\delta \leq 1.2$ x stated limit $\Delta C \leq 10\%$ Impedance ≤ 1.2 x stated limit Breakdown voltage > 1000 V d.c.
4		Surge a. 85 °C b. 125 °C	1000 cycles at max. category temperatures each consisting of a 30 s charge and $5\frac{1}{2}$ min discharge a. load 1, 15 x U_R b. 1, 15 x derated voltage	Leakage current $\leq$ stated limit tan $\delta \leq$ stated limit $\Delta C \leq 5\%$
		Reverse voltage a. 85 °C b. 125 °C	0.15 x rated and derated voltage in reverse polarity at max. cat. temp. during 125 h, followed by 125 h at max. category temperature in forward polarity	Leakage current $\leq$ stated limit tan $\delta \leq$ stated limit $\Delta C \leq 10\%$
5		Charge and discharge	10^6 cycles each consisting of 0, 5 s charge, 0, 5 s discharge	No damage $\Delta C \leq 5\%$
6		Storage high temperature	96 ± 4 h at + 125 °C with no voltage applied	Leakage current $\leq$ stated limit tan $\delta \leq$ stated limit $\Delta C \leq 5\%$

SOLID TANTALUM CAPACITORS

subminiature resin dipped

QUICK REFERENCE DATA

Nominal capacitance range (E6 series)	0,01 to 68 μF
Tolerance on nominal capacitance	−20 to +20%
Rated voltage range, U_R (R5 series)	1,6 to 40 V
Category temperature range	−55 to +85 °C
Endurance test	2000 hours at 85 °C
Category IEC 68	55/085/21

7Z65110.1

C nom (μF)	U_R (V) 1,6	2,5	4	6,3	10	16	25	40
0,01								①
0,015								①
0,022								①
0,033								①
0,047								①
0,068								①
0,1								①
0,15							①	②
0,22						①		②
0,33					①		②	③
0,47				①		②		③
0,68			①		②		③	④
1,0		①		②		③		④
1,5	①		②		③		④	⑤
2,2	①	②		③		④		⑤
3,3	②		③		④			⑤
4,7	②	③		④			⑤	
6,8	③		④			⑤		
10	③	④			⑤			
15	④			⑤				
22	④		⑤					
33		⑤						
47	⑤							
68	⑤							

APPLICATION

These capacitors are eminently suitable for use in electronic circuitry and are especially designed for those applications where extremely small dimensions are an absolute must and also a high stability and reliability are required, such as hearing-aids, electronic watches and paging systems.

DESCRIPTION

This pearl-shaped capacitor is a construction with sintered anode, tantalum oxide dielectric and a solid cathode. The capacitor is coated with a synthetic resin. The terminal wires are brought out on one side: the anode lead is gold-plated. The capacitor has also been provided with a coloured spot which, when viewed with the terminals downwards, has the anode at its right.

MECHANICAL DATA

Dimensions in mm

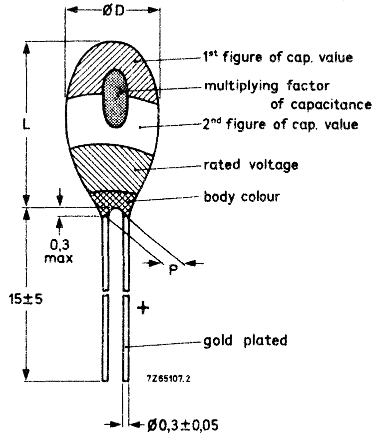


Table 1a

size	dimensions		
	D_{max}	L_{max}	P ± 0,3
DTM1	2	2,7	1
DTM2	2	4	1
DTM3	2	4,9	1
DTM4	3,2	4,5	1,1
DTM5	4	7,5	1,2

Marking According Table 1b and drawing.

Table 1b

colour code	capacitance (μF)		multiplying factor	U_R (V)
	1st figure	2nd figure		
black	–	0	1	10
brown	1	1	–	1,6
red	2	2	–	4
orange	3	3	–	40
yellow	4	4	–	6,3
green	5	5	–	16
blue	6	6	–	–
violet	7	7	10^{-3}	–
grey	8	8	10^{-2}	25
white	9	9	10^{-1}	2,5

Mounting

1 mm of the leads nearest the body are not solderable.

ELECTRICAL DATA

Table 2

Unless otherwise specified all electrical values in Table 2 apply at an ambient temperature of 20 to 25 °C, a frequency of 100 Hz, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

U_R (V)	nom. cap. (μF)	max. r.m.s. ripple current at T_{amb} = 85 °C (mA) 1)	max. leakage current at U_R after 5 min. (μA) 1)	max. tan δ 1)	case size	catalogue number
1,6	1,5	2,5	0,5	0,15	1	2222 146 10158
	2,2	3	0,5	0,15	1	10228
	3,3	4,5	1	0,15	2	10338
	4,7	5	1	0,15	2	10478
	6,8	7,5	1	0,15	3	10688
	10	9	1	0,15	3	10109
	15	22,5	1,5	0,15	4	10159
	22	15	1,5	0,15	4	10229
	47	32,5	2,5	0,15	5	10479
	68	40	2,5	0,15	5	10689
2,5	1	2,5	0,5	0,10	1	11108
	2,2	4,5	1	0,10	2	11228
	4.7	7,5	1	0,10	3	11478
	10	12,5	1,5	0,10	4	11109
	33	32,5	2,5	0,10	5	11339
4	0,68	2	0,5	0,10	1	12687
	1,5	3,5	1	0,10	2	12158
	3,3	6,5	1	0,10	3	12338
	6,8	10	1,5	0,10	4	12688
	22	27,5	2,5	0,10	5	12229
6,3	0,47	2	0,5	0,08	1	13477
	1	3,5	1	0,08	2	13108
	2,2	6,5	1	0,08	3	13228
	4,7	10	1,5	0,08	4	13478
	15	27,5	2,5	0,08	5	13159
10	0,33	1,5	0,5	0,08	1	14337
	0,68	2,5	1	0,08	2	14687
	1,5	5	1	0,08	3	14158
	3,3	7,5	1,5	0,08	4	14338
	10	20	2,5	0,08	5	14109

---

1) See also corresponding paragraph.

Table 2 (continued)

U_R (V)	nom. cap. (μF)	max. r.m.s. ripple current at T_{amb} = 85 °C (mA) 1)	max. leakage current at U_R after 5 min. (μA) 1)	max. tan δ 1)	case size	catalogue number
16	0,22	1	0,5	0,08	1	2222 146 15227
	0,47	2	1	0,08	2	15477
	1	3,5	1	0,08	3	15108
	2,2	5	1,5	0,08	4	15228
	6,8	15	2,5	0,08	5	15688
25	0,15	1	0,5	0,08	1	16157
	0,33	2	1	0,08	2	16337
	0,68	3,5	1	0,08	3	16687
	1,5	5	1,5	0,08	4	16158
	4,7	15	2,5	0,08	5	16478
40	0,01	0,25	0,5	0,08	1	17106
	0,015	0,35	0,5	0,08	1	17156
	0,022	0,4	0,5	0,08	1	17226
	0,033	0,5	0,5	0,08	1	17336
	0,047	0,6	0,5	0,08	1	17476
	0,068	0,75	0,5	0,08	1	17686
	0,1	0,85	0,5	0,08	1	17107
	0,15	1,25	1	0,08	2	17157
	0,22	1,5	1	0,08	2	17227
	0,33	2	1	0,08	3	17337
	0,47	2,5	1	0,08	3	17477
	0,68	3,5	1,5	0,08	4	17687
	1	4,5	1,5	0,08	4	17108
	1,5	7,5	2,5	0,08	5	17158
	2,2	10	2,5	0,08	5	17228
	3,3	12,5	2,5	0,08	5	17338

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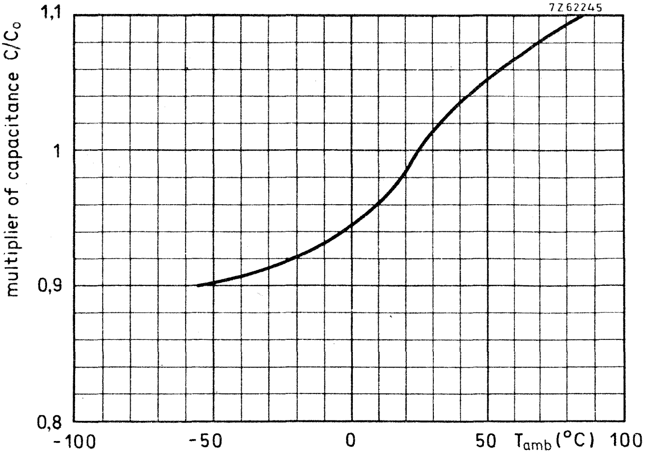
1) See also corresponding paragraph.

Capacitance

Nominal capacitance values at 100 Hz	see Table 2
Tolerance on nominal capacitance at 100 Hz	−20 to +20%



Typical capacitance as a function of ambient temperature
C_0 = capacitance at 25 °C, 100 Hz

Voltage

Rated voltage = max. permissible voltage at ≤ 85 °C — U_R

Ripple voltage*) = max. permissible a.c. voltage providing the following three conditions are met:

a) max. (d.c. + peak a.c.) voltage — $\leq U_R$
b) max. peak a.c. voltage with d.c. voltage applied — ≤ 1,05 applied d.c. voltage
c) max. peak a.c. voltage without d.c. voltage applied — $0,05 \times U_R$

Surge voltage = max. permissible voltage for short periods at 85 °C (see also "Tests and requirements") — $1,2 \times U_R$

---

*) Ripple voltages are not applicable if the maximum permissible ripple current is exceeded. In that case the ripple current is decisive.

Ripple current

Maximum permissible r.m.s. ripple current at 100 Hz and $T_{amb} = 85\ ^{o}C$ see Table 2

The maximum permissible ripple current ($I_{r\,max}$) is a function of temperature and frequency:

$$I_{rmax} = I_{r0}\sqrt{kr}$$

where I_{r0} = max. ripple current at 100 Hz up to 85 °C, see Table 2

k = temperature derating factor = P_{max}/P_0

r = frequency dependent derating factor = R_{s0}/R_s

while P_{max} = max. permissible power dissipation, temperature dependent

P_0 = max. permissible power dissipation up to 85 °C = $(I_{r0})^2R_{s0}$

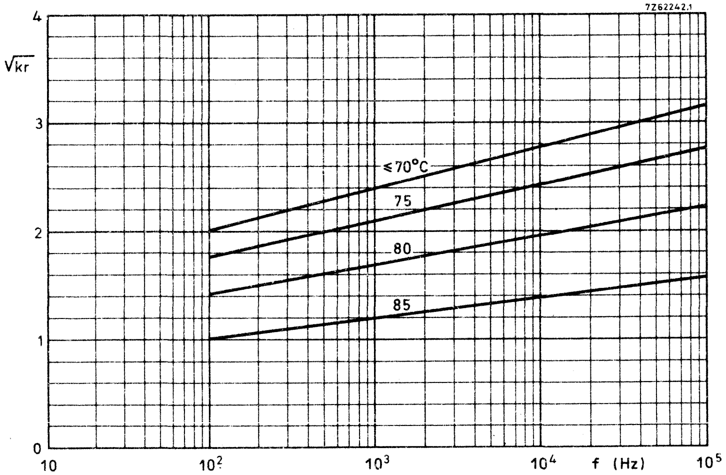
R_{s0} = series resistance at 100 Hz = $\frac{\tan\delta}{628\ C}$, C and tan δ to be read from Table 2

R_s = series resistance, frequency dependent (temperature dependence neglected).

The formula is derived as follows:

$$(I_{rmax})^2 = P_{max}/R_s = k(I_{r0})^2R_{s0}/R_s;$$

thus $I_{rmax} = I_{r0}\sqrt{kr}$ (see Table 2 and next graph)



Multiplying factor $\sqrt{kr}$ as a function of frequency for calculation of maximum ripple current.

Note

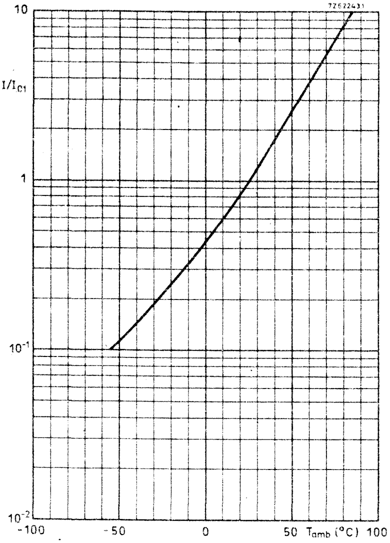
These ripple currents are not applicable if the maximum permissible ripple voltage is exceeded. In that case the ripple voltage is decisive.

Leakage current

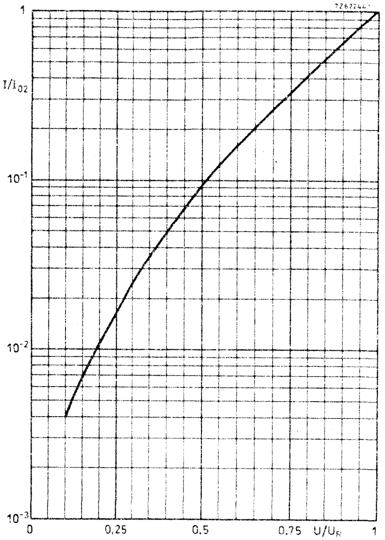
Maximum leakage current 5 min. after application of the rated voltage	see Table 2

Leakage current during continuous operation at U_R,

at $T_{amb} = 25\ ^oC$	approx. 0, 2 of value stated in Table 2
at $T_{amb} = 85\ ^oC$	approx. 2 x value stated in Table 2



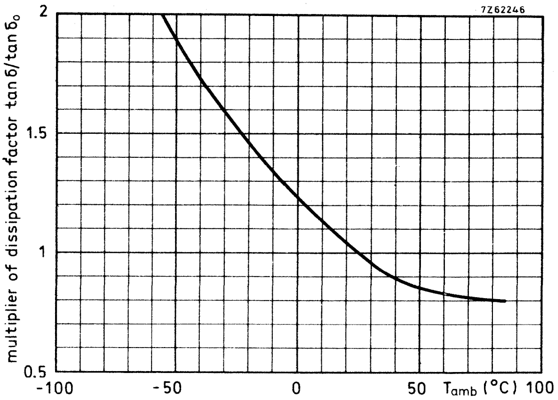
Multiplier I/I_{01} as a function of temperature
I_{01} = leakage current during continuous operation at T_{amb} = 25 ^oC at U_R



Multiplier I/I_{02} as a function of U/U_R
I_{02} = leakage current at U_R at a discrete constant temperature

Tan δ (dissipation factor)

Tan δ at 100 Hz, measured by means of a four-terminal circuit (Thomson circuit) see Table 2

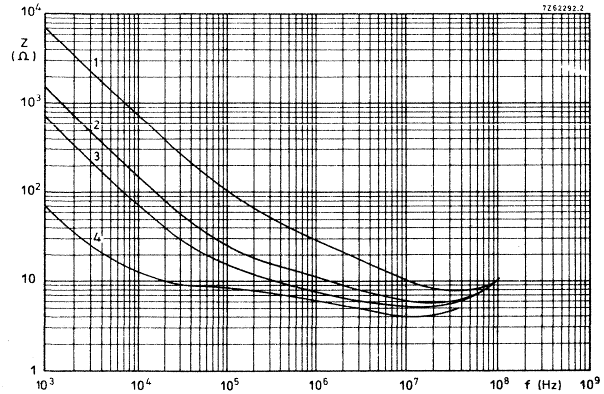


Typical dissipation factor as a function of temperature
Tan δ_0 = dissipation factor at 25 °C, 100 Hz

Impedance

Impedance at 100 kHz is measured by means of a four-terminal circuit (Thomson circuit)

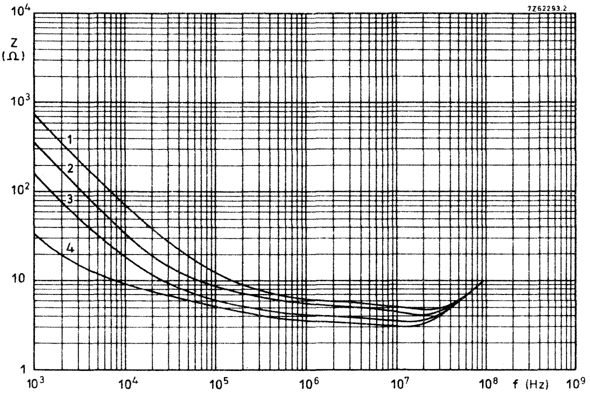
Typical impedance as a function of frequency at 25 °C



DTM1:

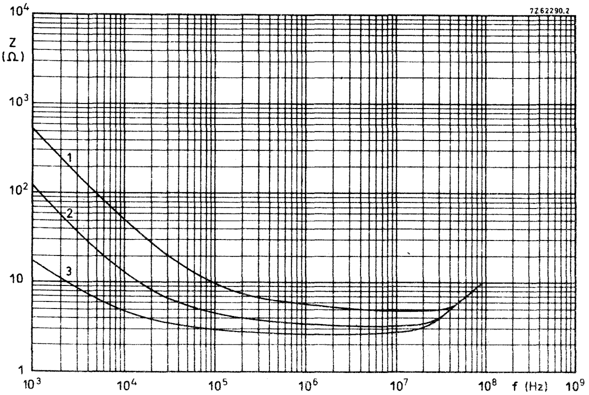
curve 1 =	0.022	μF,	40 V
2 =	0,1	μF,	40 V
3 =	0.22	μF,	16 V
4 =	2.2	μF,	1.6 V

Typical impedance as a function of frequency at 25 °C



DTM2:

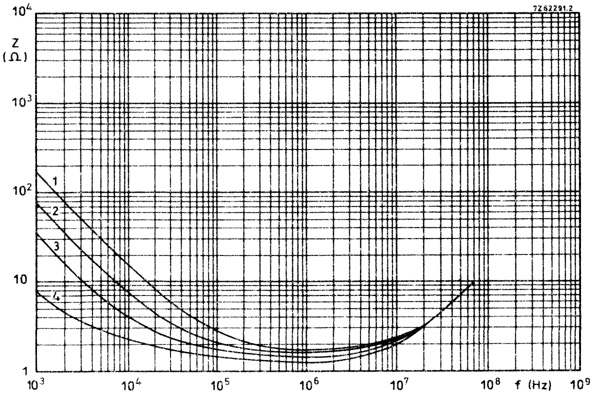
curve 1 = 0.22 μF, 40 V
2 = 0.47 μF, 16 V
3 = 1 μF, 6.3 V
4 = 4.7 μF, 1.6 V



DTM3:

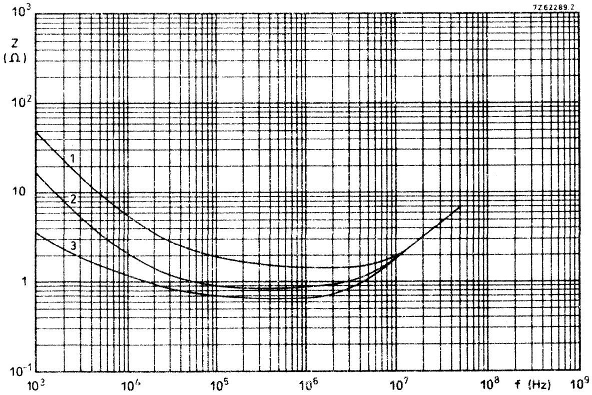
curve 1 = 0.33 μF, 40 V
2 = 1.5 μF, 10 V
3 = 10 μF, 1.6 V

Typical impedance as a function of frequency at 25 °C



DTM4:

curve 1 = 1 µF 40 V
2 = 2.2 µF, 16 V
3 = 4.7 µF, 6.3 V
4 = 22 µF, 1.6 V



DTM5:

curve 1 = 3.3 µF, 40 V
2 = 10 µF, 10 V
3 = 47 µF, 1.6 V

Equivalent series resistance (ESR = $\frac{\tan \delta}{\omega C}$)

Tan δ and C at 100 Hz see Table 2

PACKING

250 pieces per box

TESTS AND REQUIREMENTS

Group	IEC 68-2 Test method	Name of test	Procedure (Quick reference)	Requirements
Ia1	Ua Ub Uc	Robustness of terminations	During 10 s axial 2.5 N Bend-pull 1 cycle 1.25 N Torsion 2 successive rotations of 180°	No visible damage
Ia2	T	Soldering	Globule method	Must flow within 4 s with Flux 201 2 s with Flux 202
Ib1	Na	Rapid change of temperature	3 cycles of 3h at +85 °C with no voltage applied and 3h at −55 °C	No visible damage Leakage current ≤ stated limit tan δ ≤ stated limit $\Delta C \leq 5\%$
Ib2	Fc	Vibration	10-500-10 Hz 0.75 mm or max. 10 g. 2 x 3 h	No visible damage $\Delta C \leq 5\%$
Ib3	Eb	Bump	1000 ± 10 bumps, 40 g	No damage $\Delta C \leq 5\%$
Iab5	Ba	Dry heat	16h at 85 ± 2 °C with rated voltage applied	No visible damage Immediately followed by damp heat test
Iab7	Da	Accelerated damp heat, first cycle	1 cycle 55±2 °C R.H. 95 - 100% with no voltage applied	No visible damage Immediately followed by cold test

TESTS AND REQUIREMENTS (continued)

Group	IEC 68-2 Test method	Name of test	Procedure (Quick reference)	Requirements
Iab8	Aa	Cold	2h at $-55 \pm 3\,^{\circ}C$ with no voltage applied	No visible damage Immediately followed by low air pressure test
Iab9	M	Low air pressure	5 min. at 15-35 $^{\circ}C$, 85 mbar Last minute with rated voltage applied	No damage, no breakdown Immediately followed by damp heat test (remaining cycles)
Iab10	Da	Accelerated damp heat, remaining cycles	5 cycles 24h at $55 \pm 2\,^{\circ}C$ R.H. 95 - 100% with no voltage applied	No visible damage Leakage current $\leq$ stated limit tan $\delta \leq 1.2$ x stated limit $\Delta C \leq 10\%$ with respect to test T and Eb Insulation resistances > 100 MΩ Breakdown voltage > 1000 V d.c.
II-1	Ca	Damp heat steady state	21 days at $40 \pm 2\,^{\circ}C$ R.H. 90 - 95% with no voltage applied	No visible damage Leakage current $\leq$ stated limit tan $\delta \leq 1.2$ x stated limit $\Delta C \leq 10\%$ Insulation resistances > 100 MΩ Breakdown voltage > 1000 V d.c.
III-1		Endurance	2000h at $85 \pm 1.5\,^{\circ}C$ with rated voltage applied. Impedance power supply equipment < 3Ω	No damage Leakage current $\leq$ stated limit tan $\delta \leq 1.2$ x stated limit $\Delta C \leq 10\%$ Breakdown voltage > 1000 V d.c.

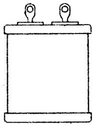
TESTS AND REQUIREMENTS (continued)

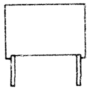
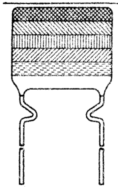
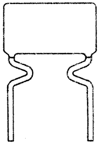
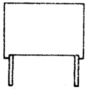
Group	IEC 68-2 Test method	Name of test	Procedure (Quick reference)	Requirements
IV-1	Ba	Characteristics at high temperature	16h at 85±2 ^{o}C with no voltage applied	After thermal stability at 85 ^{o}C leakage current $\leq$ 10 x stated limit tan $\delta \leq$ 1.2 x stated limit Δ C < ± 10%
IV-2	Aa	Characteristics at low temperature	2h at −55±3 ^{o}C with no voltage applied	After thermal stability at −55 ^{o}C leakage current $\leq$ stated limit tan $\delta \leq$ 2 x stated limit Δ C $\leq$ ± 10%
IV-3		Surge a. 85 ^{o}C	1000 cycles at max. category temperature each consisting of a 30s charge and $5\frac{1}{2}$ min. discharge over a resistance 1000±100Ω, inclusive power supply equipment. Load 1, 2 x U_R	Leakage current $\leq$ stated limit tan $\delta \leq$ stated limit Δ C $\leq$ 10%
VI-1		Storage high temperature	96±4h at + 85 ^{o}C with no voltage applied	Leakage current $\leq$ stated limit tan $\delta \leq$ stated limit Δ C $\leq$ 5%

Paper capacitors
and film capacitors

IIIIIII

SURVEY

type	series 2222...	dielectric	capacitance range	nominal voltage
PAPER CAPACITORS	241	paper	3 – 25 µF	250 Vr.m.s.
 paper a.c. capacitors	240		2 – 18 µF	300 Vr.m.s.
			1,5 – 10 µF	380 Vr.m.s.
			1 – 6 µF	440 Vr.m.s.
			on request	500 and 660 Vr.m.s.
POLYESTER AND POLYCARBONATE CAPACITORS  metallised polycarbonate a.c. capacitors	325	metallised polycarbonate film	2 – 25 µF	160 Vr.m.s.
	326		1,5 – 18 µF	220 Vr.m.s.
	327		1,5 – 10 µF	250 Vr.m.s.
 polyester capacitors ("tubular foil" type)	311	PETP film	0,01 – 1 µF	160 Vd.c.
			0,001 – 0,47 µF	400 Vd.c.
 metallised polyester and polycarbonate film capacitors ("mepolesco")	341	metallised PETP film or metallised polycarbonate film	0,047 – 4,7 µF	100 Vd.c.
			0,010 – 2,2 µF	250 Vd.c.
			0,010 – 1,0 µF	400 Vd.c.
		metallised polycarbonate film	0,010 – 0,47 µF	630 Vd.c.
			0,010 – 0,15 µF	1000 Vd.c.
			0,001 – 0,068 µF	1600 Vd.c.

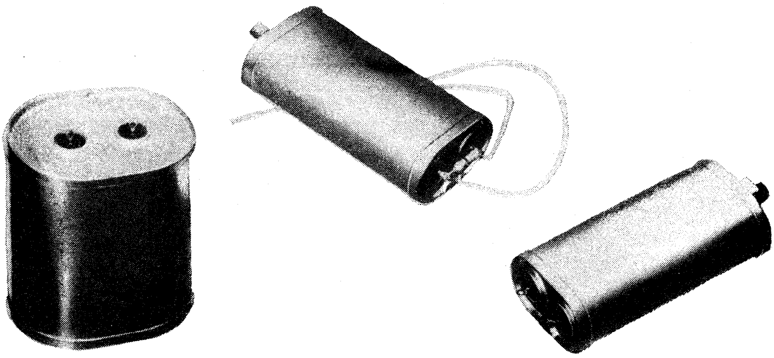
	metallized polyester and polycarbonate film capacitors ("nugget")	344	metallized PETP film or metallized polycarbonate film	0,047 - 6,8 µF 0,01 - 2,2 µF 0,01 - 1 µF	100 V (d.c.) 250 V (d.c.) 400 V (d.c.)
			metallized polycarbonate film	0,01 - 0,47 µF	630 V (d.c.)
	metallized polyester film capacitors (f.f.c.)	352	metallized PETP film	0,047 - 6,8 µF 0,001 - 2,2 µF 0,01 - 1 µF 0,01 - 0,47 µF	100 V (d.c.) 250 V (d.c.) 400 V (d.c.) 630 V (d.c.)
	polyester film/foil capacitors ("p.p.c.")	347	PETP film	0,015 - 1 µF 0,010 - 0,68 µF 0,0047 - 0,33 µF 0,0022 - 0,15 µF	100 V (d.c.) 250 V (d.c.) 400 V (d.c.) 630 V (d.c.)
POLYPROPYLENE CAPACITORS					
	polypropylene film/foil capacitors (potted type)	357	polypropylene film	0,039 - 0,82 µF	250 V (d.c.)

Note: PETP = polyethyleneterephthalate.

type	series 2222...	dielectric	capacitance range	voltage
POLYSTYRENE CAPACITORS  polystyrene film/foil capacitors (micropoco)	424 to 431	polystyrene film	1200 - 162000 pF 820 - 82000 pF 390 - 47000 pF 51 - 24000 pF	63 V (d. c.) ← 125 V (d. c.) ← 250 V (d. c.) ← 500 V (d. c.) ←
 polystyrene film/foil capacitors (p.f.c.)	443	polystyrene film	100 - 12100 pF	63 V (d. c.) ←
DUAL DIELECTRIC CAPACITORS  interference suppression capacitors, dual dielectric, single section type	276	paper/PETP film	4,7 - 330 nF	250 V (r. m. s.)
 dual dielectric capacitors for flyback purposes	278	paper/polypropylene film	10 - 27 nF 1,5 - 12 nF 1,5 - 10 nF	750 V (p) 1500 V (p) 2000 V (p)

Note: PETP = polyethyleneterephthalate.

PAPER A.C. CAPACITORS


A46069

These capacitors are specially designed for ballasts of luminous-discharge lamps but are also extensively used with single-phase asynchronous motors, and for power-factor correction in low-power devices.

Working temperature range	−20 to + 85 °C
Nominal voltage (r.m.s. value)	250, 300, 380, 440, 500 and 660 V
Working voltage	max. 1, 1 x Vnom
Working frequency	40-60 Hz, beyond 50 Hz Vnom or working temperature should be derated by 10% or 10 °C respectively
Capacitance drift during life	max. ± 5%
Test voltage for 1 min	
between the terminals	2, 15 x Vnom
between terminals and case	2500 Vr.m.s. or 3500 Vd.c.
Insulation resistance at 20 °C	
between terminals	RC ≥ 2000 s
between terminals and case	R ≥ 12 500 MΩ
Losses (tan δ) at 50 Hz	$\leq 55.10^{-4}$ ←

Type Approvals

A large part of our capacitor programme has been approved by official testing institutes:

Belgium - CEBEC
Denmark - DEMKO
Germany - VDE
Norway - NEMKO
Sweden - SEMKO
Switzerland - SEV

Besides, our capacitors comply with the British BSI specification, and the relevant IEC and CEE recommendations. If required, detailed information is available.

Dimensions in mm

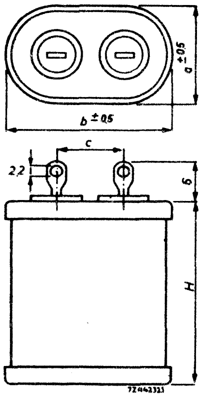


Fig.1

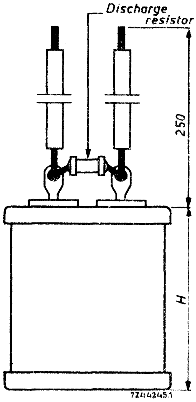


Fig.2

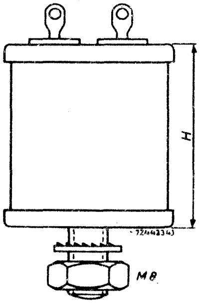


Fig.3

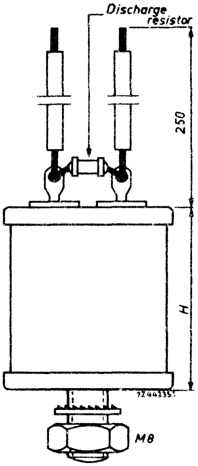
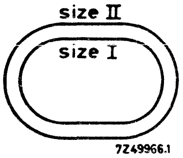


Fig.4



	a	b	c
size I	26	43	18
size II	38	55	22

250 V-range

size	cap. ± 10% (μF)	H_{max} (mm)	catalogue number 2222 241			
			Fig. 1	Fig. 2	Fig. 3	Fig. 4
I	3	50	04023	04223	04423	04623
	3,5	57	28	28	28	28
	4	57	34 *)	34	34	34 *)
	4,5	62	39	39	39	39
	5	71	45	45	45	45
	6	86	56 *)	56	56	56 *)
	7	86	67	67	67	67
	8	99	78	78	78	78
	9	109	89	89	89	89
	10	124	04101	04301	04501	04701
	12	148	05	05	05	05
II	8	57	54078 *)	54278	54478	54678 *)
	9	62	89	89	89	89
	10	71	54101 *)	54301	54501	54701 *)
	12	86	05	05	05	05
	13,5	86	08	08	08	08
	15	99	12 *)	12	12	12 *)
	18	109	18	18	18	18
	20	124	23 *)	23	23	23 *)
	25	148	34 *)	34	34	34 *)

Special 250 V-range

These capacitors are specially designed for power-factor correction of gas-discharge lamps for public lighting. They are painted grey.

size	cap. ± 10% (μF)	H_{max} (mm)	catalogue number 2222 241	
			Fig. 2	Fig. 4
II	8	57	90054	90055 *)
	10	71	56	57 *)
	15	99		59 *)
	20	124	62	63 *)
	25	148	64	65 *)

NOTE

The types marked with an asterisk are preferred types; the minimum order quantity is 100 pieces. For the other types the minimum order quantity is 500 pieces.

300 V-range

size	cap. ±5% (µF)	H_{max} (mm)	catalogue number 2222 240			
			Fig. 1	Fig. 2	Fig. 3	Fig. 4
I	2	50	07012	07212	07412	07612
	2,5	57	17 *)	17	17 *)	17
	3	62	23	23	23	23
	3,5	71	28	28	28	28
	4	86	34 *)	34	34 *)	34
	4,5	86	39	39	39	39
	5	99	45 *)	45	45 *)	45
	6	109	56	56	56	56
II	7	71	57067 *)	57267	57467 *)	57667
	8	86	78	78	78	78
	9	86	89	89	89	89
	10	99	57101 *)	57301	57501 *)	57701
	12	109	05	05	05	05
	14	124	09 *)	09	09 *)	09
	16	148	14	14	14	14
	18	148	18	18	18	18

NOTE

The types marked with an asterisk are preferred types; the minimum order quantity is 100 pieces. For the other types the minimum order quantity is 500 pieces.

380 V-range

size	cap. ± 5% (μF)	H_{max} (mm)	catalogue number 2222 240			
			Fig. 1	Fig. 2	Fig. 3	Fig. 4
I	1,5	50	11006	11206	11406	11606
	2	57	12 *)	12	12 *)	12
	2,5	71	17	17	17	17
	3	86	23	23	23	23
	3,5	99	28	28	28	28
	3,6	99	29	29	29	29
	3,7	99	31 *)	31	31 *)	31
	3,8	99	32	32	32	32
	4	99	34	34	34	34
	5	124	45	45	45	45
	5,7	148	53 *)	53	53 *)	53
	5,8	148	54	54	54	54
	5,9	148	55	55	55	55
	6	148	56	56	56	56
II	7	99	61067	61267	61467	61667
	8	99	78	78	78	78
	10	124	61101 *)	61301	61501 *)	61701

NOTE

The types marked with an asterisk are preferred types; the minimum order quantity is 100 pieces. For the other types the minimum order quantity is 500 pieces.

440 V-range

size	cap. ±5% (μF)	H_{max} (mm)	catalogue number 2222 240			
			Fig. 1	Fig. 2	Fig. 3	Fig. 4
I	1	50	15001	15201	15401	15601
	1,5	57	06 *)	06	06 *)	06
	2	71	12	12	12	12
	2,5	86	17	17	17	17
	3	99	23 *)	23	23 *)	23
	3,5	124	28	28	28	28
	4	124	34	34	34	34
II	5	86	65045	65245	65445	65645
	6	99	56 *)	56	56 *)	56

NOTE

The types marked with an asterisk are preferred types; the minimum order quantity is 100 pieces. For the other types the minimum order quantity is 250 pieces.

500 V- and 660 V-ranges

Capacitors of these ranges are available on request; the minimum order quantity is 250 pieces.

INTERFERENCE SUPPRESSION CAPACITORS

dual dielectric, single section type

QUICK REFERENCE DATA	
Nominal capacitance	4,7 to 330 nF (E6 series)
Tolerance on capacitance	± 20 %
Rated voltage	250 V r.m.s.
Dielectric	paper/PETP film
Basic specification	
capacitors class X and class Y	IEC 161 and VDE 0560-7
safety capacitor	IEC 65 and VDE 0560-2
Climatic category, IEC 68	40/085/21
DIN 40040	GPG (capacitors class X) GPF (capacitors class Y)

APPLICATION

These capacitors have been developed as radio interference suppression capacitors for a wide range of applications.
Examples:
- domestic apparatus: coffee grinders, mixers, vacuum cleaners, drilling machines
- apparatus with extended service life: TV-sets, computers, discharge lamp circuits.

Besides the capacitor 2222 276 60101 is an approved safety capacitor for use in e.g. radio and TV-sets.

DESCRIPTION

The capacitor has a cylindrical low-inductive winding of aluminium foil electrodes using paper and polyethyleneterephthalate as the dielectric. The stiff leads of tinned copper are axially attached.
The capacitor is impregnated with silicone oil and housed in a green flame-resistant polypropylene case which is sealed with green epoxy resin.

Dimensions in mm

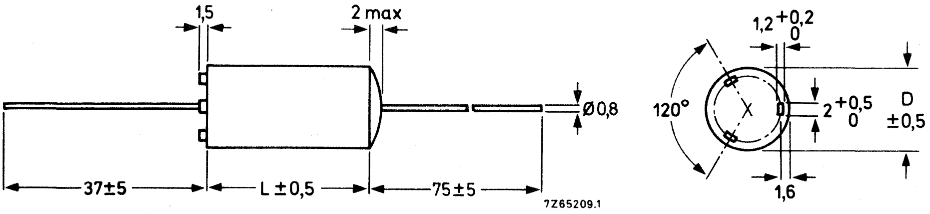


Fig. 1 For dimensions D and L see tables below.

AVAILABLE VERSIONS

nom. cap. (nF)	dimensions (mm) D	L	class *)	catalogue number
6,8	13	25	Y	2222 276 60002
10	13	25	Y	60003
10	13	25	X	10003
15	13	25	X	10004
22	13	25	X	10005
33	13	25	X	10006
47	13	25	X	10007
68	13	25	X	10008
100	13	31	X	10009
150 **)	16	36	X	10011
220 **)	18	36	X	10012
330 **)	20	41	X	10013

The capacitors have been approved by DEMKO and by VDE according to VDE 0560-7, except the capacitors marked **) for which the VDE approval has been sought.

Safety capacitor

nom. cap. (nF)	dimensions (mm) D	L	class *)	catalogue number
4,7	13	31	Y	2222 276 60101

The capacitor has been approved by: ASEV according to ASEV 1016
DEMKO according to IEC 65, CEE 1 and DHCR 21
NEMKO according to IEC 65 and NEMKO 132.56
SEMKO according to IEC 65, CEE 1 and SEMKO 101
VDE according to IEC 161, VDE 0560-7 and VDE 0560-2.

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*) According to IEC 161 and VDE 0560-7.

MECHANICAL DATA

Dimensions — see Fig. 1

Marking

The marking is according to CEE10 (part 1):

1 st line: manufacturers' identification symbol, nominal capacitance in nF
2 nd line: catalogue number
3 rd line: rated voltage and class
4 th line: category according to IEC and DIN
5 th line: approbation symbols and month and year of manufacture

Examples:

⊞ 33 n
⊟ 2222 276 10006
250 V~ X
40/085/21 GPG

VDE 560-7

6.72 BS 2135

⊞ 4 n 7
⊟ 2222 276 60101
250 V~ Y
40/085/21 GPF

SEV VDE 560 - 2
560-7

ⓑ Ⓓ Ⓝ Ⓢ

5.72 BS415

Test: 5000 VDC
SAFETY CAP

Mounting

The capacitors are suited for vertical as well as for horizontal mounting on printed-wiring boards.

ELECTRICAL DATA

Unless otherwise specified, all values have been determined at an ambient temperature of 20 ± 5 °C, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

Temperature

Rated temperature	+85 °C
Category temperature range	-40 to +85 °C
Climatic category, according to IEC 68	40/085/21
according to DIN 40040	GPG (capacitors class X) GPF (capacitors class Y)

Capacitance

Nominal capacitance values (Cn) at 1 kHz	see "Available versions"
Tolerance on nominal capacitance	± 20%

Voltage

Rated voltage at 40 to 60 Hz	250 V r.m.s.

Tangent of the loss angle (dissipation factor)

Tan δ at 1 kHz	$\leq 60 \times 10^{-4}$ (typ. 45×10^{-4})

Insulation resistance

Insulation resistance between terminations	> 6000 MΩ
between interconnected terminations and metal foil wrapped around case	> 6000 MΩ

(For capacitors class X and class Y the insulation resistance is measured after a voltage of 100 ± 15 V d.c. has been applied for 1 min; for the safety capacitor it is measured after a voltage of 500 V d.c. has been applied for 2 min.)

Resonant frequency

Resonant frequency, length of both leads 6 mm	$\geq \frac{1}{1,2\sqrt{C}}$ kHz (C in F)

TESTS AND REQUIREMENTS

The test methods and requirements are generally in conformity with IEC publications 68 and 161. Besides the safety capacitor meets the requirements of IEC 65, subclause 14.2.

Voltage test

	capacitors of class X	capacitors of class Y	safety capacitor
Test voltage between the leads for 1 min	1075 Vd.c.	2250 Vd.c. or 1500 Va.c.	5000 Vd.c. or 2500 Va.c.
for 2s	1625 Vd.c.		
between the leads and metal foil wrapped around the case for 1 min	2000 Va.c.	2500 Va.c.	2500 Va.c.
for 2s	2500 Va.c.		

Requirement: no breakdown or flashover.

Robustness of terminations

Tensile test	IEC68, test Ua; force of 20 N. Requirement: no damage.
Bending test	IEC68, test Ub; two consecutive bending cycles; force of 10 N
Torsion test	IEC68, test Uc; two successive rotations. Requirement: no damage.

Vibration

IEC68, test F; frequency 10-55-10 Hz, amplitude of 0,75 mm

Requirement: no damage; electrical properties in accordance with the values given in "Electrical data".

Solderability

IEC68, test T.3.2

Solder bath method; temperature 230 °C, for 2 s; the leads are immersed to 3,5 mm from the capacitor case.

Requirement: no damage.

Climatic sequence

Dry heat:	IEC68, test Ba; 16 hours at 85 °C. Recovery in standard atmospheric conditions for 1 to 2 hours.
Accelerated damp heat: (first cycle)	IEC68, test D; severity VI; 1 cycle of 24 hours at 55 °C and a R.H. of 95-100% immediately followed by the next test.
Cold:	IEC68, test Aa; 2 hours at -40 °C, recovery 1 to 2 hours. The next test has to be carried out within 3 days.
Accelerated damp heat: (remaining cycles)	as above, 1 cycle of 24 hours, recovery 1 to 2 hours. Requirements: no leakage or damage. Capacitance change ≤ 5% tan δ ≤ initial limit Insulation resistance > 1500 MΩ Marking still legible.

Rapid change of temperature

IEC68, test Na; 3 cycles of 3 hours at 85 °C and 3 hours at -40 °C.
Requirements: Capacitance change < 5%
Tan δ and insulation resistance shall not exceed initial requirements.

Damp heat, steady state

IEC68, test Ca, 40 °C, 90-95% R.H., 21 days.
No voltage applied to 1/3 of number of specimens
250 Vd.c. applied to 1/3 of number of specimens
20 Vd.c. applied to 1/3 of number of specimens
Recovery for 1 to 2 hours.
Requirements: no damage, capacitance change < 5%, insulation resistance ≥ 1500 MΩ, marking still legible
Capacitors withstand voltage test as mentioned above.

Life

Life test on capacitors of class X: 1000 hours at 85 °C, 1,5 x rated voltage applied.
Life test on capacitors of class Y: 1000 hours at 85 °C, 1,7 x rated voltage applied.

Life test on safety capacitors: 1500 hour at 85 °C, 500 V r.m.s., 50 Hz applied, but for 1 min/hour 1000 V r.m.s. 50 Hz applied.

Requirements: max. number of breakdowns ≤ 1%.

From the remaining capacitors is the capacitance change < 5%;
tan δ and insulation resistance shall not exceed the initial requirements.
Capacitors withstand voltage test as mentioned above.
There shall be no evidence of damage.

DUAL DIELECTRIC CAPACITORS

for fly-back purposes

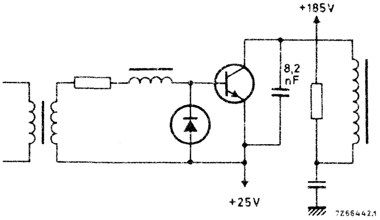
QUICK REFERENCE DATA

Nominal capacitance	10 to 27 nF	1,5 to 12 nF	1,5 to 10 nF
Maximum permissible peak voltage	750 V	1500 V	2000 V
Tolerance on nominal capacitance	± 5%		
Working temperature range	−25 to + 70 °C		
Dielectric	paper/polypropylene film		
Pulse duration	10 to 14 μs		
Repetition frequency	15 to 20 kHz		

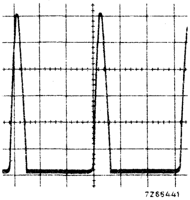
APPLICATION

These capacitors are especially designed for use as tuning capacitor in transistorized deflection circuits for monochrome and colour television.

Example:



Tuning capacitor of 8,2 nF used in a horizontal deflection circuit.



Oscillogram of the collector voltage of the transistor at a beam current of 0, 1 mA, measured with respect to chassis, 200 V per division; time scale: 20 μs per division.

DESCRIPTION

The capacitors are of the extended foil-construction and have consequently a low self-inductance. The employed dielectric is paper and polypropylene; the capacitor is impregnated with silicone oil.
The encapsulation is a green cylindrical self-extinguishing polypropylene case, which is sealed with epoxy-resin.
The stiff leads of tinned copper are axially attached.

Dimensions in mm

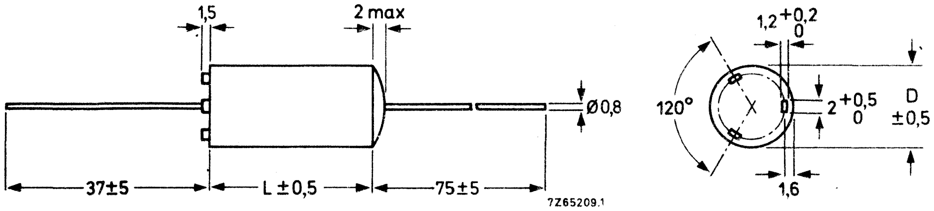


Fig. 1

AVAILABLE VERSIONS

750 V-range

nominal capacitance (nF)	dimensions (mm)		marking of cap.	catalogue number
	D	L		
10	13	25	10n	2222 278 52103
11	13	25	11n	52113
12	13	25	12n	52123
13	13	25	13n	52133
15	13	25	15n	52153
16	13	25	16n	52163
18	13	31	18n	52183
20	13	31	20n	52203
22	13	31	22n	52223
24	13	31	24n	52243
27	13	31	27n	52273

1500 V-range

nominal capacitance (nF)	dimensions (mm)		marking of cap.	catalogue number
	D	L		
1,5	13	31	1n5	2222 278 72152
1,6	13	31	1n6	72162
1,8	13	31	1n8	72182
2,0	13	31	2n0	72202
2,2	13	31	2n2	72222
2,4	13	31	2n4	72242
2,7	13	31	2n7	72272
3,0	13	31	3n0	72302
3,3	13	31	3n3	72332
3,6	13	31	3n6	72362
3,9	16	36	3n9	72392
4,3	16	36	4n3	72432
4,7	16	36	4n7	72472
5,1	16	36	5n1	72512
5,6	16	36	5n6	72562
6,2	16	36	6n2	72622
6,8	16	36	6n8	72682
7,5	16	36	7n5	72752
8,2	16	36	8n2	72822
9,1	16	36	9n1	72912
10	16	36	10n	72103
11	18	36	11n	72113
12	18	36	12n	72123

2000 V-range

nominal capacitance (nF)	dimensions (mm) D	L	marking of cap.	catalogue number
1,5	13	31	1n5	2222 278 82152
1,6	13	31	1n6	82162
1,8	13	31	1n8	82182
2,0	13	31	2n0	82202
2,2	13	31	2n2	82222
2,4	13	31	2n4	82242
2,7	13	31	2n7	82272
3,0	13	31	3n0	82302
3,3	13	31	3n3	82332
3,6	13	31	3n6	82362
3,9	16	36	3n9	82392
4,3	16	36	4n3	82432
4,7	16	36	4n7	82472
5,1	16	36	5n1	82512
5,6	16	36	5n6	82562
6,2	16	36	6n2	82622
6,8	16	36	6n8	82682
7,5	16	36	7n5	82752
8,2	16	36	8n2	82822
9,1	16	36	9n1	82912
10	16	36	10n	82103

MOUNTING

The capacitors can be mounted horizontally or vertically on printed-wiring boards or they can be used for point-to-point wiring.

ELECTRICAL DATA

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

Working temperature range	−25 to + 70 °C

Capacitance

Nominal capacitance values at 1 kHz	see "Available versions"
Tolerance on nominal capacitance	± 5%

Voltage

Maximum permissible peak voltage	750 V, 1500 V, 2000 V
Repetition frequency	15 to 20 kHz
Pulse duration	10 to 14 μs
Maximum permissible pulse steepness	750 V/μs

Tangent of the loss angle (dissipation factor)

Tan δ at 1 kHz	$\leq 30 \times 10^{-4}$
at 10 kHz	$\leq 60 \times 10^{-4}$
at 100 kHz	$\leq 150 \times 10^{-4}$

Insulation resistance

Insulation resistance between terminals measured at 500 V d.c. and 20 °C	≥ 50 000 MΩ

Temperature coefficient

Capacitance change within the working temperature range	≤ 1%

Stability

Capacitance drift after 5 000 hrs under working conditions	≤ 2%

MECHANICAL DATA

Dimensions	see "Description"

Marking

The capacitors are marked in ink as follows:
1 st line : capacitance value and tolerance
2 nd line : catalogue number
3 rd line : production period and maximum permissible peak voltage.
Example: 2n2 ± 5%
2222 278 72222
8, 70 1500 V peak

Tensile strength, solderability	see "Tests and requirements"

TESTS AND REQUIREMENTS

Voltage test

A d.c. voltage of 2 x the maximum peak voltage between the terminals for 1 min.
Requirement: No breakdown or flashover.

Robustness of terminations

Tensile

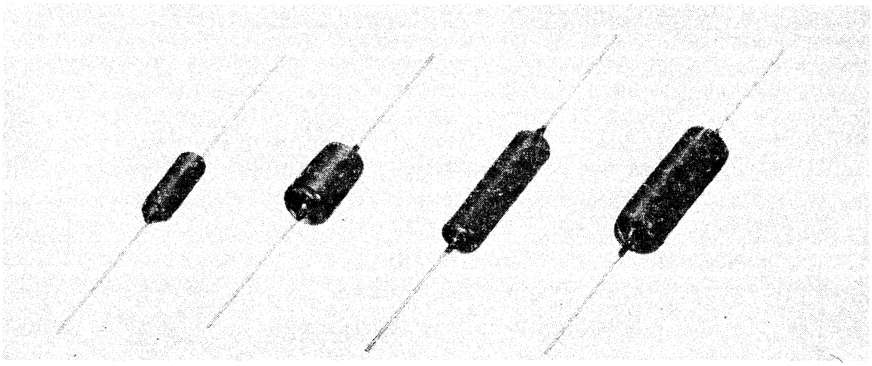
IEC 68, Test Ua: 10 N (1 kg) for 10 s in direction of leads.
Requirement: No damage.

Solderability, IEC 68-2-20, Test T. 3. 2.

The leads are immersed to 6 mm from the capacitor body for 2 ± 0, 5 s. Temperature of the soldering bath 230 ± 10 °C.
Requirements: No damage, good tinning.

POLYESTER CAPACITORS

tubular foil type



C 60505

Nominal voltage	160 V	400 V
Capacitance range	0.01-1 μF	0.001-0.470 μF

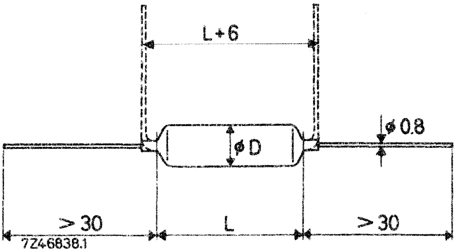
APPLICATION

These are very reliable general purpose capacitors for electronic circuits. They have found wide-spread acceptance not only in the radio and television industry, but also in industrial electronics.

CONSTRUCTION

Dielectric material	polyethylene-terephtalate

Dimensions in mm



TYPES

Composition of the catalog number

2222 311 . . . . .

nominal voltage code

3 = 160 V
5 = 400 V

capacitance code, see table

1 = 10% capacitance tolerance

Example: The catalog number of a 2200 pF/400 V capacitor is 2222 311 51222.

capacitance	capacitance code	max. dimensions (mm)			
		160 V versions 2222 311 31...		400 V versions 2222 311 51...	
		D	L	D	L
1000 pF	102			7.5	18
1500	152			7.5	18
2200	222			7.5	18
3300	332			7.5	18
4700	472			7.5	18
6800	682			7.5	18
0.010 μF	103	7.5	18	7.5	18
0.015	153	7.5	18	7.5	18
0.022	223	7.5	18	8.5	18
0.033	333	7.5	18	10	18
0.047	473	8	18	11.5	18
0.068	683	9	18	9.5	32
0.10	104	10.5	18	11	32
0.15	154	12	18	12.5	32
0.22	224	10	32	14.5	32
0.33	334	12	32	17	32
0.47	474	14	32	19.5	32
0.68	684	16	32		
1.0	105	18.5	32		

Intermediate values according to the E12 range are available on request. The dimensions are identical to those of the next higher value in the standard E6 range.

The standard capacitance tolerance is ±10 %.

TECHNICAL PERFORMANCE

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

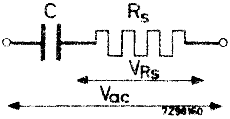
Working temperature range	-40/+85 °C
Maximum d.c. working voltage up to 85 °C	nominal voltage (V_{nom})
Maximum a.c voltage, 50-60 Hz (never to be exceeded at other frequencies)	160 V versions: 90 V 400 V versions: 150 V
Calculation of the dissipation	with the aid of Fig.1
Maximum dissipation	Fig.2
Test voltage (d.c.) for 1 minute	2 x nominal voltage
Capacitance drift during life	
d.c. loaded, at $1.5xV_{nom}$ and 85 °C	< 5%
at 25 °C	< 2%
a.c. loaded	< 5%
Capacitance as a function of temperature and frequency	Fig.3 and Fig.4
Insulation resistance (at 20 °C)	
for $C \leq 0.33$ μF	R > 50 000 MΩ
for $C > 0.33$ μF	R_C > 16 500 s (MΩ.μF)
Insulation resistance as a function of temperature	Fig.5. Decrease of minimum values is a factor 2 per 10 deg C above 20 °C
Losses (tan δ) at 1 kHz (and 20 °C)	$< 60x10^{-4}$
Losses as a function of temperature and frequency	Fig.6 and Fig.7
Resonance frequency	Fig.8
Climatic robustness	category 40/085/21; 500 hours at 40 °C and 90-95 % R.H.
Solderability conforming to	I.E.C. 68-2, test T3.2 on 6 mm from the capacitor body
Axial lead strength	> 10 N (> 1 kg)

CALCULATION OF THE MAXIMUM A.C. VOLTAGE

A maximum permissible a.c. voltage has been specified for 50-60 Hz and at 20 °C. This voltage value must also never be exceeded at other frequencies. The permissible a.c. voltage may further be limited by the requirement that the power dissipation must not exceed the specified limit P_{max}.

The power dissipated by a capacitor is a function of the voltage over the series resistance (R_s) or of the current through the series resistance and is expressed by

$$P = \frac{{V_{R_s}}^2}{R_s} = I^2 R_s \qquad (1)$$



$${V_{R_s}}^2 = \frac{{R_s}^2}{{R_s}^2 + 1/\omega^2 C^2} \; {V_{ac}}^2 \qquad (2a)$$

As for these capacitors $\tan\delta = R_s \omega C$ = always < 0.1, the formula (2a) can be simplified to

$${V_{R_s}}^2 = \frac{{R_s}^2}{1/\omega^2 C^2} \; {V_{ac}}^2 = {R_s}^2 \omega^2 C^2 \; {V_{ac}}^2 \qquad (2b)$$

Thus $$P = R_s \omega^2 C^2 \; {V_{ac}}^2 \qquad (3a)$$

or $$P = (R_s C)\, C \omega^2 \; {V_{ac}}^2 \qquad (3b)$$

The term R_sC can be found from Fig. 1. C (in farads), $\omega = 2\pi f$ and V_{ac} are assumed to be known.

The maximum permissible value of power dissipation (P_{max}), which depends on the dimensions of the capacitor and on the ambient temperature, can be found from Fig. 2. Thus, when the actual power has been calculated with formula (3b), Fig. 2 gives the minimum size of capacitor which can dissipate this power.

May be two or three capacitors having this size can be chosen, namely with different nominal working voltages.

Example of using Fig.1 and Fig.2

A tubular foil capacitor with a value of 0.47 μF should be used at an a.c. voltage of V_{ac} = 80 V, a frequency of 1 kHz and an ambient temperature of 50 °C.
The R_sC-product is 10^{-6} (from Fig.1), so that the power to be dissipated

$$P = (R_sC)\,C\omega^2\,V_{ac}{}^2$$

$$= 10^{-6} \times 0.47 \times 10^{-6} \times 4\pi^2 \times 1000^2 \times 80^2 = 0.123 \text{ W}$$

Fig.2 shows that at 50 °C capacitors with curve numbers 3 to 27 can be used, thus a minimum size of 8.5 x 18 mm. It can be seen from the table that a choice can be made between the 160 V and the 400 V capacitors of 0.47 μF.

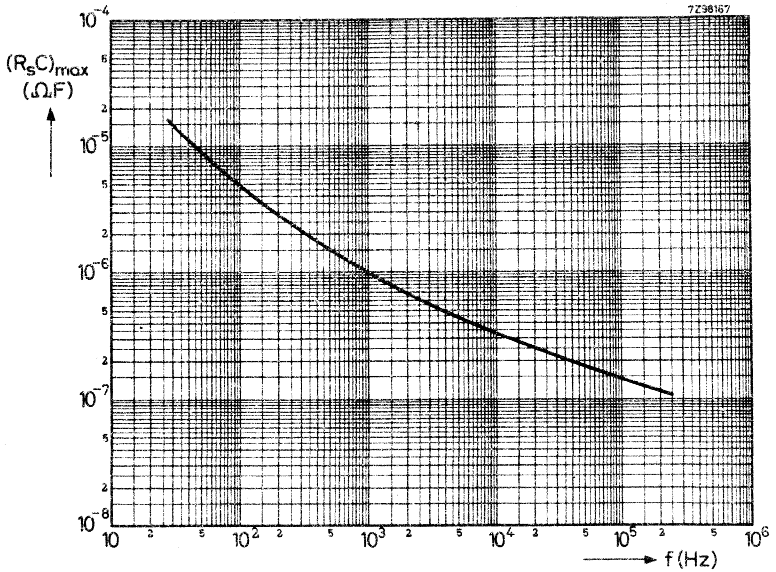
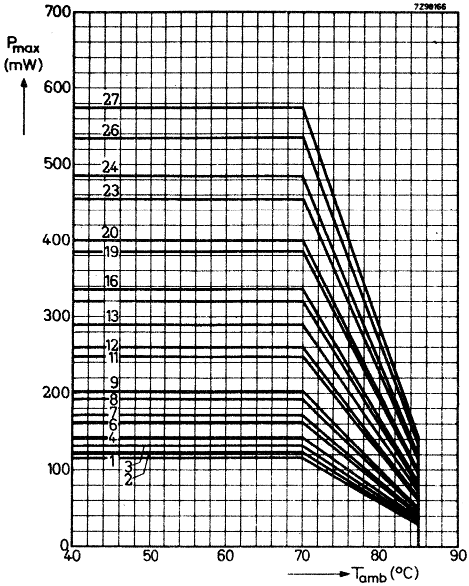


Fig.1. Maximum product of series resistance and capacitance as a function of the frequency



curve	dimensions (mm)	
	D	L
1	7.5	18
2	8	18
3	8.5	18
4	9	18
6	10	18
7	10.5	18
8	11.5	18
9	12	18
11	9.5	32
12	10	32
13	11	32
15	12	32
16	12.5	32
19	14	32
20	14.5	32
23	16	32
24	17	32
26	18.5	32
27	19.5	32

Fig.2. Maximum permissible power dissipation as a function the temperature

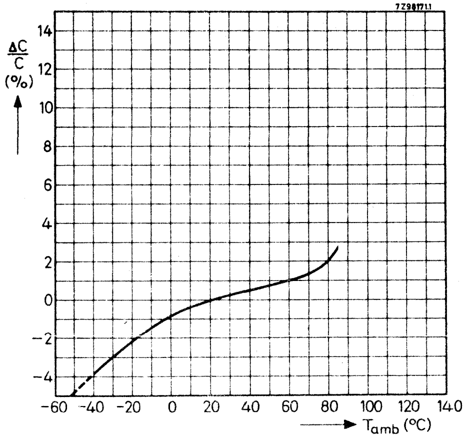


Fig.3. Capacitance as a function of the temperature

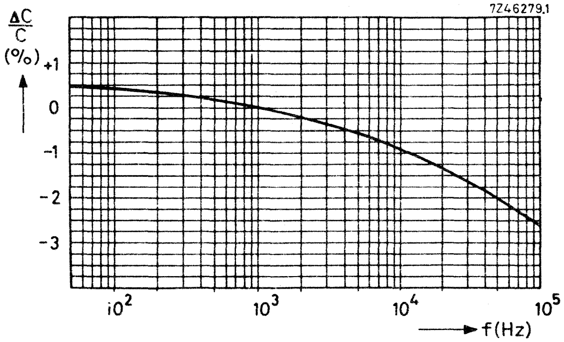


Fig.4. Capacitance as a function of the frequency

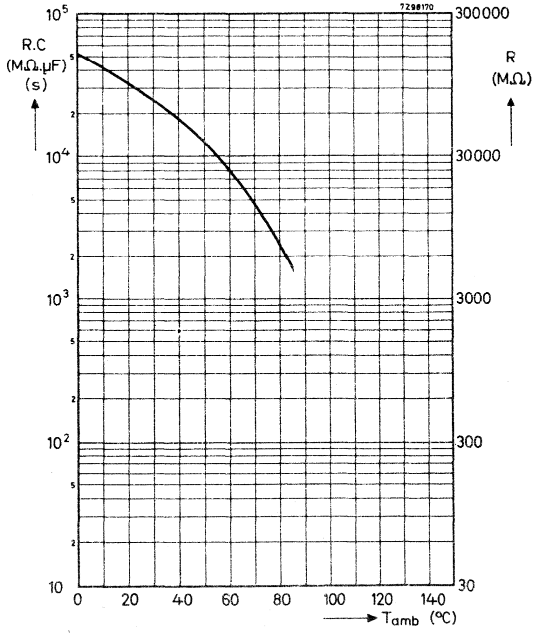


Fig.5. Insulation resistance as a function of the temperature

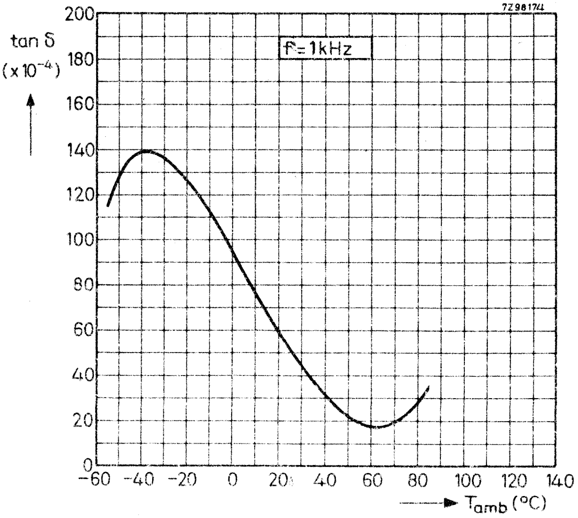


Fig.6. Losses at 1 kHz as a function of the temperature

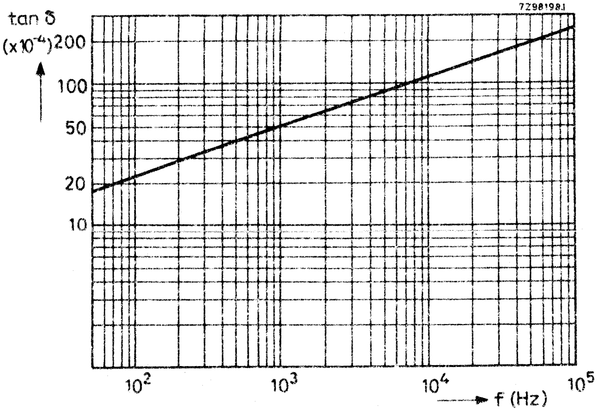


Fig.7. Losses as a function of the frequency

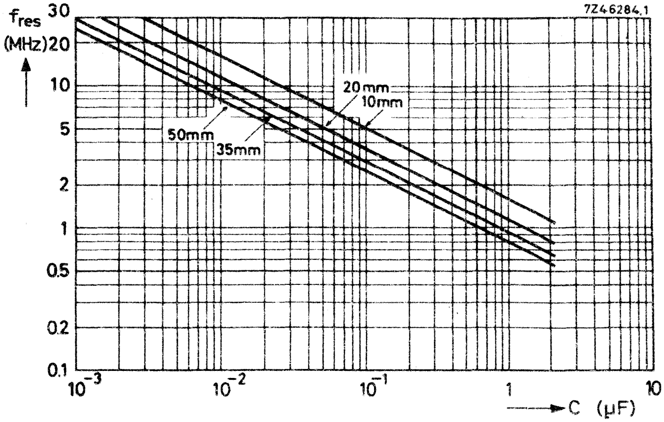
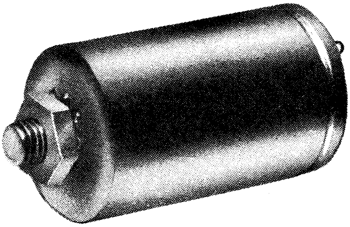


Fig.8. Resonance frequency as a function of the capacitance, at different total wire lengths

METALLIZED POLYCARBONATE A.C. CAPACITORS


RZ 20807

Capacitance range	
325-series	2 -25 μF
326-series	1,5-18 μF
327-series	1,5-10 μF
Nominal working voltage	
325-series	160 Vr.m.s.
326-series	220 Vr.m.s.
327-series	250 Vr.m.s.
Frequency range	50 -60 Hz ←

APPLICATION

- As a shunt capacitor for power factor correction of fluorescent and other discharge lamps.
- As a phase shift capacitor for single phase alternating current motors.
- Due to its low losses at higher frequencies, this capacitor is suitable for use as a commutation capacitor in thyristor circuits.

CONSTRUCTION

The capacitors are made of metallized polycarbonate. They are housed in a cylindrical aluminium casing, which is sealed with a rubber disc.
Two versions are available, see Figs. 1 and 2.
The capacitors offer many advantages over conventional paper capacitors for a.c. applications:
- they are self-healing
- they cannot leak (because they have no liquid impregnation)
- the dielectric losses are low, 60-75% lower than those of a.c. paper capacitors.

Dimensions in mm

For D and H, see table.

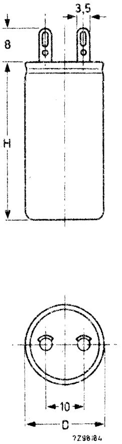


Fig. 1. Version without fastening bolt

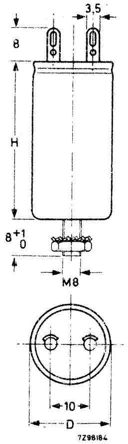


Fig. 2. Version with fastening bolt

TECHNICAL PERFORMANCE

Capacitance	see table
Tolerance on capacitance	± 10%
Frequency range	40 to 60 Hz; for other frequencies information on request.
Nominal working voltage	
325-series	160 V_{rms}
326-series	220 V_{rms}
327-series	250 V_{rms}
Test voltage for 1 minute	
- between terminals	
325-series	265 V_{rms}
326-series	365 V_{rms}
327-series	540 V_{rms}
- between interconnected terminals and casing	2500 V_{rms} or 3500 V_{dc}
Working temperature range	−40 to + 85 °C
Insulation resistance at 20 °C	
between terminals	$> \frac{10000}{C(\mu F)}$ MΩ
between interconnected terminals and casing	> 12500 MΩ

Losses (tan δ) at 50 Hz and 25-85 °C $< 25 \times 10^{-4}$
Climatic category (IEC 68) 40/085/56

Type approvals

The capacitors of the 327-series have been approved by DEMKO, NEMKO and SEMKO and comply with the British BS 4017 specification.

TYPES

Composition of the catalogue number

2222 325 . . . . .
2222 326 . . . . .
2222 327 . . . . .

code for version — code for capacitance value, see table

00 = version Fig. 1 (without fastening bolt)
50 = version Fig. 2 (with fastening bolt)

capacitance (μF)	dimensions D x H (mm)			code in catalogue number
	325-series	326-series	327-series	
1,5		30 x 40	30 x 40	155
2	30 x 40			205
2,5				255
3				305
3,5				355
4			30 x 52	405
4,5				455
5				505
6		30 x 52	35 x 52	605
7				705
8				805
9	30 x 52		40 x 52	905
10		35 x 52		106
12				126
14	35 x 52	40 x 52		146
16				166
18				186
20	40 x 52			206
25				256

METALLISED POLYESTER AND POLYCARBONATE FILM CAPACITORS
moulded type ("mepolesco")

QUICK REFERENCE DATA

Rated capacitance range (E 12 series)	0, 82 nF to 5, 6 μF
Tolerance on rated capacitance	± 10% and ± 20%
Rated voltage U_R (d.c.)	100 V, 250 V, 400 V, 630 V, 1000 V, 1600 V
Rated temperature	85 °C
Climatic category, IEC 68	55/100/56

APPLICATION

For general purpose and industrial use in electronic equipment, e.g. for coupling and decoupling applications.

DESCRIPTION

These capacitors consist of a low-inductive winding of metallised polyethyleneterephthalate (PETP) or polycarbonate film and axial leads of tinned copper wire.
The winding is moulded in yellow flame retardant polypropylene.
One end of the capacitor is provided with two stand-off ridges to allow removal of solder flux etc., when cleaning the printed-wiring board.

Composition of the catalogue number

2222 341 . . . . .

code for rated voltage, capacitance tolerance and dielectric material

code for capacitance, see tables 1 to 7

28 = 100 V; ±20%
29 = 100 V; ± 10%
48 = 250 V; ±20%
49 = 250 V; ± 10%
58 = 400 V; ±20%
59 = 400 V; ± 10%

metallised polycarbonate film

60 = 630 V; ±20%
61 = 630 V; ± 10%
70 = 1000 V; ±20%
71 = 1000 V; ± 10%
80 = 1600 V; ±20%
81 = 1600 V; ± 10%

26 = 100 V; ±20%
27 = 100 V; ± 10%
88 = 250 V; ±20%
89 = 250 V; ± 10%
54 = 400 V; ±20%
55 = 400 V; ± 10%

metallised PETP film

For ordering purposes please quote the 12-digit catalogue number.

MECHANICAL DATA Dimensions in mm

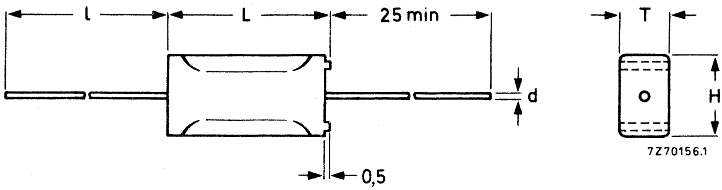


Fig. 1

For dimensions T, L, H, d and l, see tables below.

Table 1- U_R = 100 V; dielectric: metallized polycarbonate film and metallized PETP film.

rated capacitance 1) (μF)	T_{max} (mm)	L_{max} (mm)	H_{max} (mm)	d (mm)	l_{min} (mm)	weight (g)	capacitance code
0,047	4,7	14,5	8,7	0,8	40	1,0	473
0,068							683
0,10							104
0,15	5,5	14,5	9,4			1,1	154
0,22	6,5	14,5	10,4			1,4	224
0,33	6,5	18	10,4			1,7	334
0,47	7,6	18	11,5			2,0	474
0,68	7,4	23,5	11,5			2,5	684
1,0	8,7	23,5	12,8			3,2	105
1,5	10,4	23,5	14,4			4,0	155
2,2	10,4	31	14,6	1	50	5,5	225
3,3	12,4	31	19,5			8,0	335
4,7 2)	12,4	31	19,5			10,5	475
4,7 3)	15	31	22			10,5	475

---

1) Capacitance values of the E6 series as quoted are preferred; intermediate capacitance values of the E12 series are available to special order.

2) Metallized polycarbonate film dielectric.

3) Metallized PETP film dielectric.

Table 2 - U_R = 250 V; dielectric: metallised polycarbonate film.

rated capacitance [1] (μF)	T_{max} (mm)	L_{max} (mm)	H_{max} (mm)	d (mm)	l_{min} (mm)	weight (g)	capacitance code
0,010 0,015 0,022 0,033 0,047	4,7	14,5	8,7	0,8	40	1,0	103 153 223 333 473
0,068	5,5	14,5	9,4			1,1	683
0,10	6,5	14,5	10,4			1,4	104
0,15	6,5	18	10,4			1,7	154
0,22	7,6	18	11,5			2,0	224
0,33	7,4	23,5	11,5			2,5	334
0,47	8,7	23,5	12,8			3,2	474
0,68	10,4	23,5	14,4			4,0	684
1,0	10,4	31	14,6	1	50	5,5	105
1,5	12,4	31	19,5			8,0	155
2,2	15	31	22			10,5	225

---

[1] Capacitance values of the E6 series as quoted are preferred; intermediate capacitance values of the E 12 series are available to special order.

Table 3- U_R = 250 V; dielectric: metallised PETP film.

rated capacitance [1] (μF)	T_{max} (mm)	L_{max} (mm)	H_{max} (mm)	d (mm)	l_{min} (mm)	weight (g)	capacitance code
0,010	4,7	14,5	8,7	0,8	40	1,0	103
0,015							153
0,022							223
0,033							333
0,047							473
0,068	5,5	14,5	9,4			1,1	683
0,10							104
0,15	6,5	18	10,4			1,7	154
0,22							224
0,33	7,4	23,5	11,5			2,5	334
0,47							474
0,68	8,7	23,5	12,8			3,2	684
1,0	10,4	31	14,6	1	50	5,5	105
1,5	12,4	31	19,5			8,0	155
2,2							225

---

[1] Capacitance values of the E6 series as quoted are preferred; intermediate capacitance values of the E12 series are available to special order.

Table 4- U_R = 400 V; dielectric: metallised polycarbonate film and metallised PETP film.

rated capacitance [1] (μF)	T_{max} (mm)	L_{max} (mm)	H_{max} (mm)	d (mm)	l_{min} (mm)	weight (g)	capacitance code
0,010	4,7	14,5	8,7	0,8	40	1,0	103
0,015							153
0,022							223
0,033	5,5	14,5	9,4			1,1	333
0,047	6,5	14,5	10,4			1,4	473
0,068	6,5	18	10,4			1,7	683
0,10	7,6	18	11,5			2,0	104
0,15	7,4	23,5	11,5			2,5	154
0,22	8,7	23,5	12,8			3,2	224
0,33	10,4	23,5	14,4			4,0	334
0,47	10,4	31	14,6	1,0	50	5,5	474
0,68	12,4	31	19,5			8,0	684
1,0	15	31	22			10,5	105

---

[1] Capacitance values of the E6 series as quoted are preferred; intermediate capacitance values of the E12 series are available to special order.

Table 5- U_R = 630 V; dielectric: metallised polycarbonate film.

rated capacitance 1) (μF)	T_{max} (mm)	L_{max} (mm)	H_{max} (mm)	d (mm)	l_{min} (mm)	weight (g)	capacitance code
0,010	4,7	14,5	8,7	0,8	40	1,0	103
0,015	5,5	14,5	9,4			1,1	153
0,022	6,5	14,5	10,4			1,4	223
0,033	6,5	18	10,4			1,7	333
0,047	7,6	18	11,5			2,0	473
0,068	7,4	23,5	11,5			2,5	683
0,10	8,7	23,5	12,8			3,2	104
0,15	10,4	23,5	14,4			4,0	154
0,22	10,4	31	14,6	1,0	50	5,5	224
0,33	12,4	31	19,5			8,0	334
0,47	15	31	22			10,5	474

Table 6- U_R = 1000 V; dielectric: metallised polycarbonate film.

rated capacitance 1) (μF)	T_{max} (mm)	L_{max} (mm)	H_{max} (mm)	d (mm)	l_{min} (mm)	weight (g)	capacitance code
0,010	6,5	18	10,4	0,8	40	1,7	103
0,015	7,6	18	11,5			2,0	153
0,022	7,4	23,5	11,5			2,5	223
0,033	8,7	23,5	12,8			3,2	333
0,047	10,4	23,5	14,4			4,0	473
0,068	10,4	31	14,6	1,0	50	5,5	683
0,10	12,4	31	19,5			8,0	104
0,15	15	31	22			10,5	154

---

1) Capacitance values of the E6 series as quoted are preferred; intermediate capacitance values of the E12 series are available to special order.

Table 7- U_R = 1600 V; dielectric: metallised polycarbonate film.

rated capacitance 1) (µF)	T_{max} (mm)	L_{max} (mm)	H_{max} (mm)	d (mm)	l_{min} (mm)	weight (g)	capacitance code
0,0010	5,5	14,5	9,4	0,8	40	1,1	102
0,0015	6,5	14,5	10,4			1,4	152
0,0022	6,5	18	10,4			1,7	222
0,0033							332
0,0047	7,6	18	11,5			2,0	472
0,0068	7,4	23,5	11,5			2,5	682
0,010							103
0,015	8,7	23,5	12,8			3,2	153
0,022	10,4	23,5	14,4			4,0	223
0,033	10,4	31	14,6	1,0	50	5,5	333
0,047	12,4	31	19,5			8,0	473
0,068	15	31	22			10,5	683

Marking

The marking is impressed as follows :
1st line : rated capacitance 2), tolerance 3) and rated voltage
2nd line : 5th, 6th and 7th digit of the catalogue number, code for dielectric 4) and production code
The outer film connection is marked with a stroke on the body.

Mounting

The capacitors are suited for horizontal or vertical mounting on printed-wiring boards and for point to point wiring.

---

1) Capacitance values of the E6 series as quoted are preferred; intermediate capacitance values of the E12 series are available to special order.

2) in pF (without pF unit symbol), for C < 0,010 µF
in µF (without µF unit symbol), for C ≥ 0,010 µF and < 1 µF
in µF (with µF unit symbol), for C ≥ 1 µF

3) 10 = ± 10%, 20 = ± 20%, K = ± 10%, M = ± 20%.

4) MA = metallised PETP, MC = metallised polycarbonate.

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of 20 ± 5 °C, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

Capacitance

Rated capacitance values (C_R) at 1 kHz	see Tables 1 to 7
Tolerance on rated capacitance	± 10% and ± 20%

Fig. 2.

Capacitance as a function of frequency; typical curves.
—— Metallised PETP film dielectric
- - - Metallised polycarbonate film dielectric
From 100 Hz to 1 kHz the curve is valid for all capacitance values (measuring voltage 1 V).
From 1 to 10 kHz the curve is valid for capacitance values ≤ 1 μF (measuring voltage 1 V).
From 10 to 100 kHz the curve is valid for capacitance values ≤ 0, 1 μF (measuring voltage 0, 3 V).

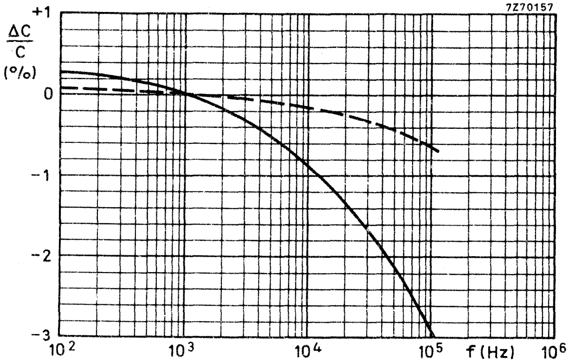
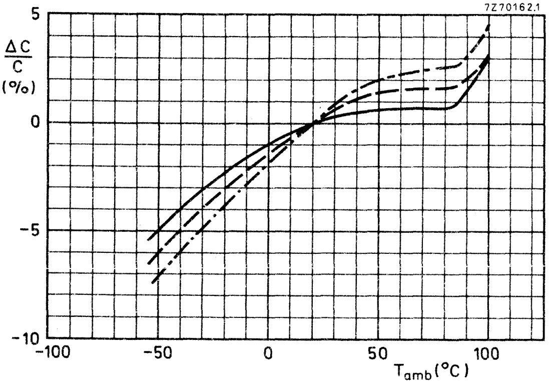


Fig. 3.

Capacitance as a function of temperature; typical curves.
Metallised PETP film dielectric
—— For all capacitance values, measured at 1 kHz, 1 V.
- - - For capacitance values ≤ 1 μF, measured at 10 kHz, 1 V.
–·–For capacitance values ≤ 0, 1 μF, measured at 100 kHz, 0, 3 V.



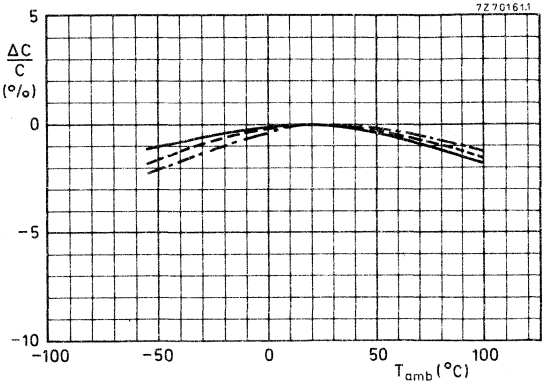


Fig. 4. Capacitance as a function of temperature; typical curves.
Metallised polycarbonate film dielectric
—— For all capacitance values, measured at 1 kHz, 1 V.
--- For capacitance values ≤ 1 μF, measured at 10 kHz, 1 V.
-·- For capacitance values ≤ 0,1 μF, measured at 100 kHz, 0,3 V.

Voltage

Rated d.c. voltage U_R	100 V, 250 V, 400 V, 630 V, 1000 V, 1600 V
Rated a.c. voltage, 50-60 Hz [1]	
100 V version	63 V
250 V version	160 V
400 V version	220 V
630 V version	220 V
1000 V and 1600 V version	250 V
Category voltage U_C	0,8 x U_R (derating of 1,25%/°C)
Overvoltage for 1 min/h	
100 V and 250 V versions	≤ 40% of U_R
400 V, 630 V, 1000 V and 1600 V versions	≤ 25% of U_R
Test voltage (d.c.) for 1 min	
between terminals	1,6 x U_R
between interconnected terminals and coating	2 x U_R (minimum 1000 V)

Notes - The sum of the d.c. voltage and the peak value of the superimposed a.c. voltage must be ≤ U_R.
- It is recommended that the capacitors are not used in low-impedance circuits where the resistive current through the capacitors can exceed 400 mA in the event of an internal breakdown of the dielectric; so direct operation from the mains should not be applied

---

[1] For higher frequencies see "Additional information".

Insulation resistance

The insulation resistance is measured after a voltage has been applied for 1 min ± 5 s, the voltage being 100 ± 15 V for the 100 V, 250 V and 400 V versions and 500 ± 50 V for the 630 V, 1000 V and 1600 V versions.

	ambient temperature	
	20 °C	100 °C
→ R between terminations		
for $C_R \le 0,33$ μF, 100 V version	> 15 000 MΩ	> 50 MΩ
250 V to 1600 V versions	> 30 000 MΩ	> 100 MΩ
→ RC between terminations		
for $C_R > 0,33$ μF, 100 V version	> 5 000 s	> 16 s
250 V to 1600 V versions	> 10 000 s	> 33 s

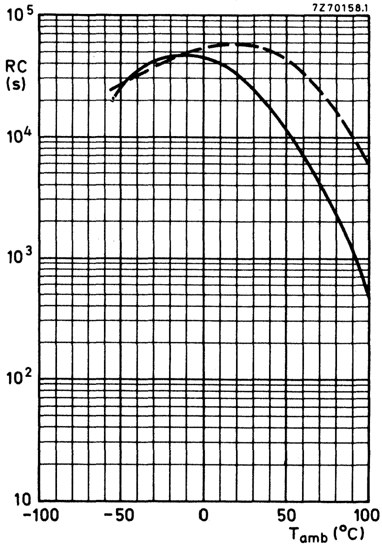


Fig. 5. Insulation resistance as a function of temperature; typical curves.
—— Metallized PETP film dielectric.
--- Metallized polycarbonate film dielectric.

Tan δ (tangent of the loss angle)

Tan δ at 10 kHz

metallised PETP film dielectric	≤ 150 x 10^{-4} (typ. 100 x 10^{-4})
metallised polycarbonate film dielectric	≤ 75 x 10^{-4} (typ. 20 x 10^{-4})

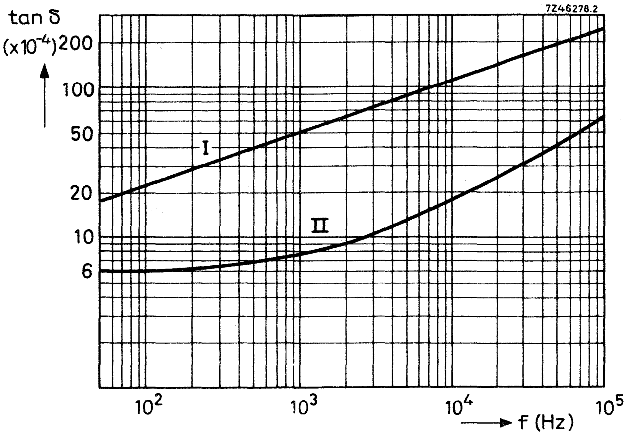


Fig. 6. Tan δ as a function of frequency; typical curves.
I = Metallised PETP film dielectric
II = Metallised polycarbonate film dielectric

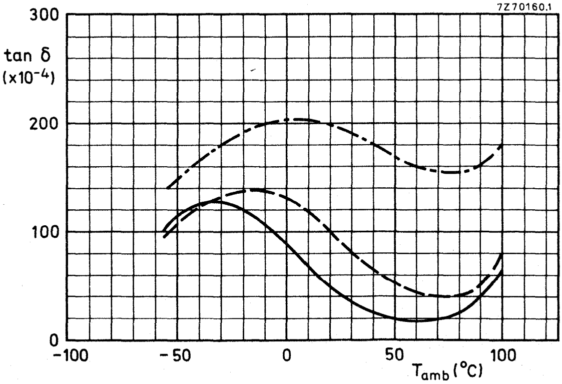


Fig. 7. Tan δ as a function of temperature; typical curves.
Metallised PETP film dielectric
—— For all capacitance values, measured at 1 kHz, 1 V.
--- For capacitance values ≤ 1 μF, measured at 10 kHz, 1 V.
-·- For capacitance values ≤ 0, 1 μF, measured at 100 kHz, 0, 3 V.

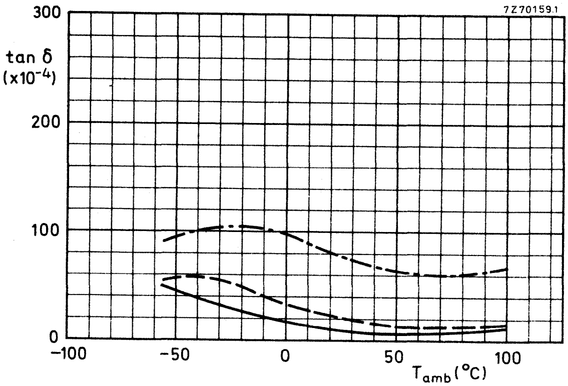


Fig. 8. Tan δ as a function of temperature; typical curves.
Metallised polycarbonate film dielectric.
—— For all capacitance values, measured at 1 kHz, 1 V.
- - - For capacitance values ≤ 1 μF, measured at 10 kHz, 1 V.
-·- For capacitance values ≤ 0,1 μF, measured at 100 kHz, 0,3 V.

Power dissipation

Maximum permissible power dissipation see chapter "Additional information"

Note - If the requirement for the maximum permissible power dissipation is satisfied, a check must be made to ascertain that the maximum permissible pulse steepness is not exceeded.

Pulse steepness

rated voltage	max. pulse steepness (V/μs)			
(V)	L = 14,5 mm	L = 18 mm	L = 23,5 mm	L = 31 mm
100	10	7	4	3
250	20	10	7	5
400	30	20	10	8
630	45	30	15	10
1000		45	30	20
1600	200	90	50	30

Note - If the pulse steepness requirement is satisfied, a check must be made to ascertain that the maximum permissible power dissipation is not exceeded.

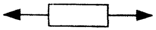
Temperature

Rated temperature	85 °C
Category temperature range	−55 to + 100 °C
Storage temperature range	−55 to + 100 °C
Climatic category, IEC 68	55/100/56

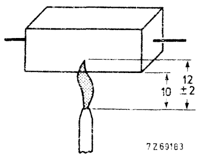
PACKING

250 pieces per box, for capacitors with $H_{max} \leq 11,5$ mm
200 pieces per box, for capacitors with $H_{max} > 11,5$ mm

TESTS AND REQUIREMENTS

IEC 68-2 test method	Name of test	Procedure (quick reference)	Requirements
Ua	Tensile strength of terminations	Loading weight in axial direction, for d = 0, 8 mm: 10 N, 10 s for d = 1 mm: 20 N, 10 s 	No damage
Ub	Bending of terminations	Loading weight, for d = 0, 8 mm: 5 N, for d = 1 mm: 10 N, two consecutive bends	No damage
Fc	Vibration	10 to 55 Hz, amplitude 0, 75 mm or 10 g (whichever is the less), 2 h in 3 directions; capacitors mounted on printed-wiring boards	No damage, no open or short circuit. $\Delta C/C \leq 0,5\%$
Eb	Bumping	40 g, 3 directions, 4000 bumps per direction, capacitors horizontally mounted on printed-wiring boards; 10 g, 3 directions, 4000 bumps per direction, capacitors vertically mounted on printed-wiring boards	No damage, no open or short circuit. $\Delta C/C \leq 0,5\%$
T3.2	Soldering (solder bath)	Solderability: 230 ^{o}C, 2 s	No damage, good tinning; $\Delta C/C \leq 0,5\%$
		Resistance to heat: 350 ^{o}C, 3 s Capacitors immersed up to 3, 5 mm from the body	No damage; $\Delta C/C \leq 0,5\%$
→ Na	Rapid change of temperature	5 cycles of 1 h at −55 ^{o}C and 1 h at +100 ^{o}C	No damage, no leakage; $\Delta C/C \leq 2\%$ Tan δ and insul. resistance shall meet initial requirements

	IEC 68-2 test method	Name of test	Procedure (quick reference)	Requirements	
→ Climatic sequence	Ba	Dry heat	16 h at +100 ± 2 ^{O}C, no voltage applied	No damage, no leakage; ΔC/C ≤ 2% (polycarbonate), ≤ 7% (PETP) at 100 ^{o}C. Insulation resistance at 100 ^{o}C for C_R ≤0, 33 μF: > 50 MΩ (100 V version), > 100 MΩ (other versions); for C_R > 0, 33 μF: RC > 16 s (100 V version), > 33 s (other versions).	
	D	Accelerated damp heat, first cycle	24 h at 55 ± 2 ^{O}C and R.H. 95 to 100%; no voltage applied		
	Aa	Cold	2 h at -55 ± 3 ^{O}C; no voltage applied	ΔC/C ≤ -3% (polycarbonate), ≤ -8% (PETP) at -55 ^{O}C	
	M	Low air pressure	1 h at 25 ± 5 ^{O}C, at atmospheric pressure of 85 mbar	During and after the test there shall be no breakdown or flashover	
	D	Accelerated damp heat, remaining cycles	5 cycles of 24 h at 55 ^{O}C and R.H. 90 to 100%, no voltage applied	ΔC/C ≤ 3% Tan δ shall meet initial requirement. Insulation resistance ≥0, 5 x initial requirements	
	Ca	Dampheat, steady state	56 days at 40 ^{O}C and R.H. 90 to 95%; 6 V applied (continuously)	ΔC/C ≤ 3% Tan δ shall meet initial requirements Insulation resistance ≥0, 5 x initial requirements	
	-	Endurance	1000 h at 85 ^{O}C, 1, 5 x U_R applied (U_R ≤ 630 V) 1, 2 x U_R (U_R > 630 V)	ΔC/C ≤ 3%	Δ tanδ ≤ 30 x 10^{-4} at 10 kHz. Insulation resistance meets initial requirements
			1000 h at 100 ^{O}C, 1, 5 x U_c applied (U_R ≤ 630 V) 1, 2 x U_c (U_R > 630 V)	ΔC/C ≤ 5%	
			1000 h at 85 ^{O}C, rated a.c. voltage applied	ΔC/C ≤ 15% (L = 14, 5 mm) ≤ 10% (L = 18 mm) ≤ 7% (L = 23, 5 mm) ≤ 5% (L = 31 mm)	

Name of test	Procedure (quick reference)	Requirements
Pulse load	10 000 cycles of charge and discharge at 25 °C, pulse steepness 1,5 x initial requirements	$\Delta \tan\delta \le 20 \times 10^{-4}$ at 10 kHz
Additional tests		
Flammability	 Bore of gas jet: ϕ 0,5 ± 0,1 mm Fuel: butane Test duration: 20 s	After removal of the flame the capacitor must not continue to burn for more than 15 s, no burning particles should drip from the capacitor
Solvent resistance	According to MIL-STD-202 E, method 215	No damage
Storage	1000 h at 100 °C	$\Delta C/C \le 3\%$ Tan δ and insulation resistance (at ≤ 10 V d.c.) shall meet initial requirements
	10 000 h at 25 °C	$\Delta C/C \le 1\%$ Tan δ and insulation resistance (at ≤ 10 V d.c.) shall meet initial requirements
Soldering test for mounting on printed-wiring boards	Board thickness: 1,6 mm, hole diameter: 1,3 mm; non-metallised holes Bath temp.: 250 ± 10 °C; dipsolder time: 5 ± 0,5 s	No damage, good tinning; $\Delta C/C \le 1\%$

ADDITIONAL INFORMATION

Power dissipation

The rated a.c. voltage has been specified for 50 Hz and at 20 °C. This voltage value must also never be exceeded at other frequencies. This permissible a.c. voltage may further be limited by the following requirements:

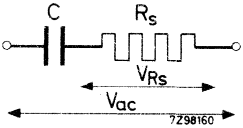
1) The power dissipation must not exceed the specified limit P_{max}.

2) The steepness of the a.c. voltage must not exceed the specified limit.

Ad 1.

The power dissipated by a capacitor is a function of the voltage over the series resistance (R_s) or of the current through the series resistance and is expressed by

$$P = \frac{V_{R_s}^2}{R_s} = I^2 R_s \qquad (1)$$



$$V_{R_s}^2 = \frac{R_s^2}{R_s^2 + 1/\omega^2 C^2} V_{ac}^2 \qquad (2a)$$

As for these capacitors $\tan \delta = R_s \omega C$ = always $< 0,1$, the formula (2a) can be simplified to

$$V_{R_s}^2 = \frac{R_s^2}{1/\omega^2 C^2} V_{ac}^2 = R_s^2 \omega^2 C^2 V_{ac}^2 \qquad (2b)$$

Thus $\quad P = R_s \omega^2 C^2 V_{ac}^2 \qquad (3a)$

or $\quad P = (R_s C) C \omega^2 V_{ac}^2 \qquad (3b)$

The term R_sC can be found from Fig. 9.C (in farads), $\omega = 2\pi f$ and V_{ac} are assumed to be known.

The maximum permissible value of power dissipation (P_{max}), which depends on the dimensions of the capacitor and on the ambient temperature, can be found from Fig. 10. Thus, when the actual power has been calculated with formula (3b), Fig. 10 gives the **minimum** size of capacitor which can dissipate this power.

May be two or three capacitors having this size can be chosen, namely with different rated voltages.

Example of using Fig.9 and Fig.10

A capacitor with a dielectric of metallised PETP film and a value of 1 μF should be used at an a.c. voltage of 130 V, a frequency of 1 kHz and an ambient temperature of 50 °C. The R_sC-product is 7,5 x 10^{-7} ΩF (from Fig. 9), so that the power to be dissipated

$$P = (R_sC)\, C\omega^2\, V_{ac}^2$$
$$= 7,5 \times 10^{-7} \times 10^{-6} \times 4\pi^2 \times 1000^2 \times 130^2 = 500\ \text{mW}$$

Fig. 10 shows that at 50 °C capacitors with curve numbers 8 to 11 can be used, thus a minimum size of 10,4 x 23,5 x 14,4 mm. It can be seen from the tables that the 1 μF/250 V capacitor can be chosen.

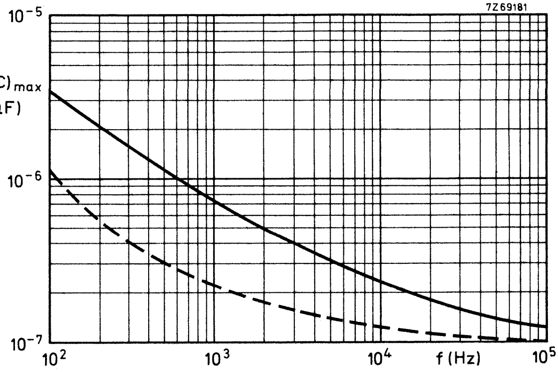


Fig. 9. Maximum product of series resistance and capacitance as a function of frequency
—— metallised PETP film dielectric
---- metallised polycarbonate film dielectric

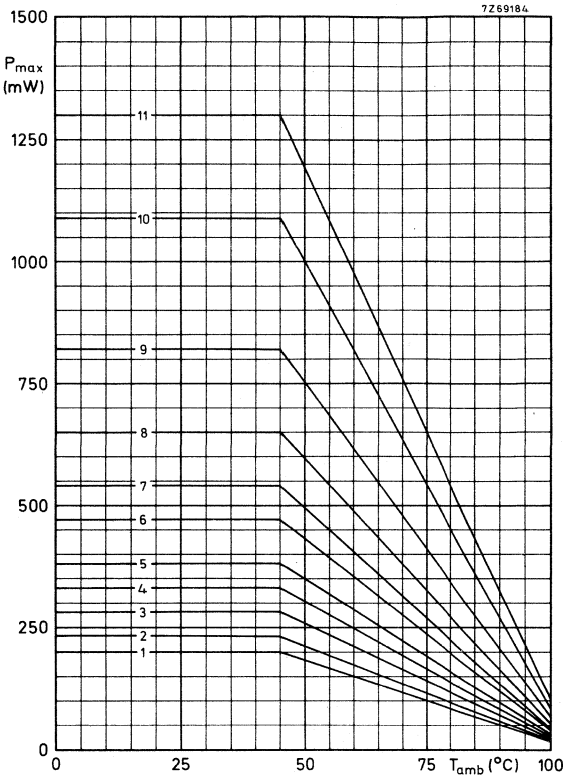


Fig. 10. Maximum permissible power dissipation as a function of temperature

curve	dimension (mm)		
	T_{max}	L_{max}	H_{max}
1	4, 7	14, 5	8, 7
2	5, 5	14, 5	9, 4
3	6, 5	14, 5	10, 4
4	6, 5	18	10, 4
5	7, 6	18	11, 5
6	7, 4	23, 5	11, 5
7	8, 7	23, 5	12, 8
8	10, 4	23, 5	14, 4
9	10, 4	31	14, 6
10	12, 4	31	19, 5
11	15	31	22

METALLIZED POLYESTER AND POLYCARBONATE FILM CAPACITORS

potted type ("nugget")

QUICK REFERENCE DATA	
Rated capacitance range (E 12 series)	0,010 to 6,8 μF
Tolerance on rated capacitance	± 10% and ± 20%
Rated voltage U_R (d.c.)	100 V, 250 V, 400 V, 630 V
Rated temperature	85 °C
Climatic category, IEC 68	55/100/56

APPLICATION

For general purpose and industrial use in electronic equipment, e.g. for coupling and decoupling applications.

DESCRIPTION

These capacitors consist of a low-inductive winding of metallized polyethyleneterephthalate (PETP) or polycarbonate film and radial leads of tinned copper wire.
The winding is potted with araldite in a yellow flame retardant polypropylene case.
Miniature types are available for each rated voltage with metallized PETP film dielectric only.
The capacitor is provided with small pips to allow removal of solder flux etc., when cleaning the printed-wiring board.

Composition of the catalogue number

2222 344 . . . . .

Code for rated voltage, capacitance tolerance and dielectric material

code for capacitance, see tables 1 to 4

metallized polycarbonate film:

20 = 100 V; ± 20%
21 = 100 V; ± 10%
44 = 250 V; ± 20%
45 = 250 V; ± 10%
50 = 400 V; ± 20%
51 = 400 V; ± 10%
60 = 630 V; ± 20%
61 = 630 V; ± 10%

metallized PETP film:

24 = 100 V; ± 20%
25 = 100 V; ± 10%
40 = 250 V; ± 20%
41 = 250 V; ± 10%
54 = 400 V; ± 20%
55 = 400 V; ± 10%

miniature types; metallized PETP film:

26 = 100 V; ± 20%
27 = 100 V; ± 10%
46 = 250 V; ± 20%
47 = 250 V; ± 10%
56 = 400 V; ± 20%
57 = 400 V; ± 10%
66 = 630 V; ± 20%
67 = 630 V; ± 10%

MECHANICAL DATA

Dimensions in mm

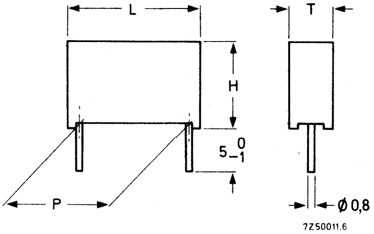


Fig. 1

For dimensions T, L, H and P, see tables below.

Table 1- U_R = 100 V; dielectric: metallised polycarbonate film and metallised PETP film.

rated capacitance [1] (μF)	T_{max} (mm)	L_{max} (mm)	H_{max} (mm)	P (mm)	weight (g)	capacitance code
0, 047	4, 5	13	10	10 ± 0, 4	0, 7	473
0, 068						683
0, 10						104
0, 15						154
0, 22	5	13	11		0, 85	224
0, 33	5	17, 5	11	15 ± 0, 4	1, 05	334
0, 47	6	17, 5	11, 5		1, 4	474
0, 68	7	17, 5	13		1, 8	684
1, 0	8, 5	17, 5	14, 5		2, 55	105
1, 5	6, 5	26	15, 5	22, 5 ±0, 4	2, 75	155
2, 2	8, 5	26	18		4, 3	225
3, 3	9, 5	26	19		5, 1	335
4, 7	11	30	20, 5	27, 5 ±0, 4	7, 4	475
6, 8	13, 5	30	23		10, 2	685
Miniature types (only metallised PETP film dielectric)						
0, 047	4, 5	10, 5	10	7, 5 ±0, 4	0, 75	473
0, 068						683
0, 10						104

---

[1] Capacitance values of the E6 series as quoted are preferred; intermediate capacitance values of the E 12 series are available to special order.

Table 2- U_R = 250 V; dielectric: metallised polycarbonate film.

rated capacitance 1) (μF)	T_{max} (mm)	L_{max} (mm)	H_{max} (mm)	P (mm)	weight (g)	capacitance code
0, 010	4, 5	13	10	10 ± 0, 4	0, 7	103
0, 015						153
0, 022						223
0, 033						333
0, 047						473
0, 068	5	13	11		0, 85	683
0, 10	5	17, 5	11	15 ± 0, 4	1, 05	104
0, 15	6	17, 5	11, 5		1, 4	154
0, 22	7	17, 5	13		1, 8	224
0, 33	8, 5	17, 5	14, 5		2, 55	334
0, 47	6, 5	26	15, 5	22, 5 ± 0, 4	2, 75	474
0, 68	7, 5	26	16, 5		3, 5	684
1, 0	9, 5	26	19		5, 1	105
1, 5	11	30	20, 5	27, 5 ± 0, 4	7, 4	155
2, 2	13, 5	30	23		10, 2	225

---

1) Capacitance values of the E6 series as quoted are preferred; intermediate capacitance values of the E12 series are available to special order.

Table 3- U_R = 250 V; dielectric: metallised PETP film

rated capacitance [1] (μF)	T_{max} (mm)	L_{max} (mm)	H_{max} (mm)	P (mm)	weight (g)	capacitance code
0,010	4,5	13	10	10 ± 0,4	0,7	103
0,015						153
0,022						223
0,033						333
0,047						473
0,068	5	13	11		0,85	683
0,10	5	17,5	11	15 ± 0,4	1,05	104
0,15						154
0,22	6	17,5	11,5		1,4	224
0,33	7	17,5	13		1,8	334
0,47	6,5	26	15,5	22,5 ± 0,4	2,75	474
0,68						684
1,0	8,5	26	18		4,4	105
1,5	11	30	20,5	27,5 ± 0,4	7,4	155
2,2						225
Miniature types						
0,022	4,5	10,5	10	7,5 ± 0,4	0,75	223
0,033						333

---

[1] Capacitance values of the E6 series as quoted are preferred; intermediate capacitance values of the E12 series are available to special order.

Table 4- U_R = 400 V; dielectric: metallised polycarbonate film and metallised PETP film.

rated capacitance 1) (μF)	T_{max} (mm)	L_{max} (mm)	H_{max} (mm)	P (mm)	weight (g)	capacitance code
0,010	4,5	13	10	10 ± 0,4	0,7	103
0,015						153
0,022						223
0,033	5	13	11		0,85	333
0,047	5	17,5	11	15 ± 0,4	1,05	473
0,068	6	17,5	11,5		1,4	683
0,10	7	17,5	13		1,8	104
0,15	8,5	17,5	14,5		2 55	154
0,22	6,5	26	15,5	22,5 ±0,4	2,75	224
0,33	7,5	26	16,5		3,5	334
0,47	9,5	26	19		5,1	474
0,68	11	30	20,5	27,5 ±0,4	7,4	684
1,0	13,5	30	23		10,2	105
Miniature types (only metallised PETP film dielectric)						
0,010	4,5	10,5	10	7,5 ±0,4	0,75	103
0,015						153

---

1) Capacitance values of the E6 series as quoted are preferred; intermediate capacitance values of the E 12 series are available to special order.

Table 5- U_R = 630 V; dielectric: metallised polycarbonate film

rated capacitance 1) (µF)	T_{max} (mm)	L_{max} (mm)	H_{max} (mm)	P (mm)	weight (g)	capacitance code
0, 010	4, 5	13	10	10 ± 0, 4	0, 7	103
0, 015	5	13	11		0, 85	153
0, 022	6	13	12		1, 0	223
0, 033	6	17, 5	11, 5	15 ± 0, 4	1, 4	333
0, 047	7	17, 5	13		1, 8	473
0, 068	8, 5	17, 5	14, 5		2, 55	683
0, 10	6, 5	26	15, 5	22, 5 ±0, 4	2, 75	104
0, 15	7, 5	26	16, 5		3, 5	154
0, 22	9, 5	26	19		5, 1	224
0, 33	11	30	20, 5	27, 5 ±0, 4	7, 4	334
0, 47	13, 5	30	23		10, 2	474
Miniature types (only metallised PETP film dielectric)						
0, 0047 0, 0068	4, 5	10, 5	10	7, 5 ±0, 4	0, 75	472 682

Marking

The capacitors are marked on the top face by embossed print, with:
1st line: rated capacitance 2), tolerance and rated voltage.
2nd line: last eight digits of the catalogue number.
The outer film connection is marked with a stroke on the top face.

Mounting

The capacitors are suited for mounting on printed-wiring boards.

---

1) Capacitance values of the E6 series as quoted are preferred; intermediate capacitance values of the E12 series are available to special order.

2) in µF
Miniature types: in pF for C < 0,010 µF
in µF for C ≥ 0,010 µF and < 1 µF.

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of 20 ±5 °C, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

Capacitance

Rated capacitance values (C_R) at 1 kHz — see Tables 1 to 5

Tolerance on rated capacitance — ± 10% and ± 20%

Fig. 2.
Capacitance as a function of frequency; typical curves.
—— Metallized PETP film dielectric.
- - - Metallized polycarbonate film dielectric.
From 100 Hz to 1 kHz the curve is valid for all capacitance values (measuring voltage 1 V).
From 1 to 10 kHz the curve is valid for capacitance values ≤ 1 μF (measuring voltage 1 V).
From 10 to 100 kHz the curve is valid for capacitance values ≤ 0, 1 μF (measuring voltage 0, 3 V).

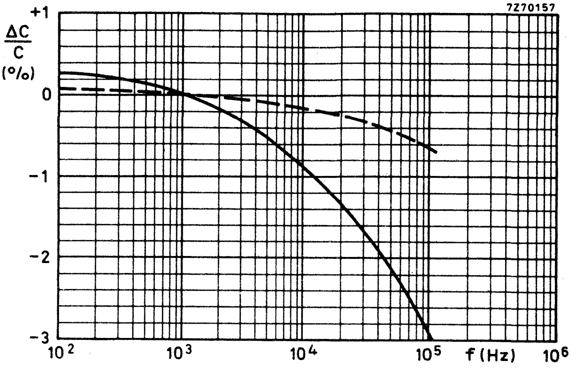
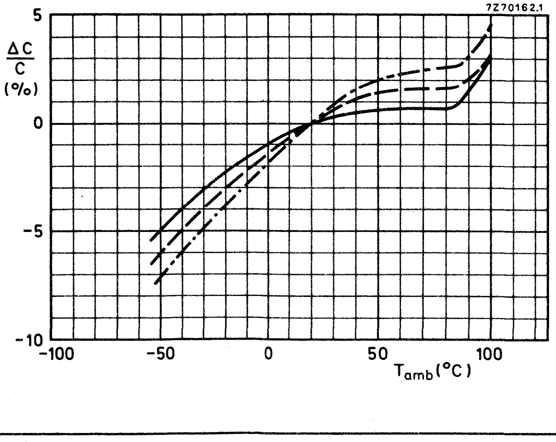


Fig. 3.
Capacitance as a function of temperature; typical curves.
Metallized PETP film dielectric.
—— For all capacitance values, measured at 1 kHz, 1 V.
- - - For capacitance values ≤ 1 μF, measured at 10 kHz, 1 V.
—·—For capacitance values ≤ 0, 1 μF, measured at 100 kHz, 0, 3 V.



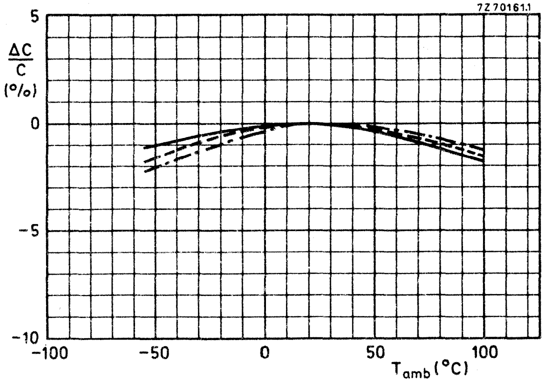


Fig. 4. Capacitance as a function of temperature; typical curves.
Metallized polycarbonate film dielectric.
—— For all capacitance values, measured at 1 kHz, 1 V.
--- For capacitance values ≤ 1 μF, measured at 10 kHz, 1 V.
-·- For capacitance values ≤ 0,1 μF, measured at 100 kHz, 0,3 V.

Voltage

Rated d.c. voltage U_R	100 V, 250 V, 400 V, 630V
Rated a.c. voltage, 50-60 Hz ¹)	
100 V version	63 V
250 V version	160 V
400 V version	220 V
630 V version	220 V
Category voltage U_C	0,8 x U_R (derating of 1,25%/°C)
Over-voltage for 1 min/h	
100 V and 250 V versions	≤ 40% of U_R
400 V and 630 V versions	≤ 25% of U_R
Test voltage (d.c.) for 1 min	
between terminals	1,6 x U_R
between interconnected terminals and coating	2 x U_R (minimum 1000 V)

Notes - The sum of the d.c. voltage and the peak value of the superimposed a.c. voltage must be ≤ U_R.
- It is recommended that the capacitors are not used in low-impedance circuits where the resistive current through the capacitors can exceed 400 mA in the event of an internal breakdown of the dielectric; so direct operation from the mains should not be applied.

---

¹) For higher frequencies see "Additional information".

Insulation resistance

The insulation resistance is measured after a voltage has been applied for 1 min ± 5 s, the voltage being 100 ± 15 V for the 100 V, 250 V and 400 V versions and 500 ± 50 V for the 630 V version.

	ambient temperature	
	20 °C	100 °C
R between terminations		
for $C_R \le 0,33$ µF, 100 V version	> 15 000 MΩ	> 50 MΩ
250 V, 400 V, 630 V versions	> 30 000 MΩ	> 100 MΩ
RC between terminations		
for $C_R > 0,33$ µF, 100 V version	> 5 000 s	> 16 s
250 V, 400 V, 630 V versions	> 10 000 s	> 33 s

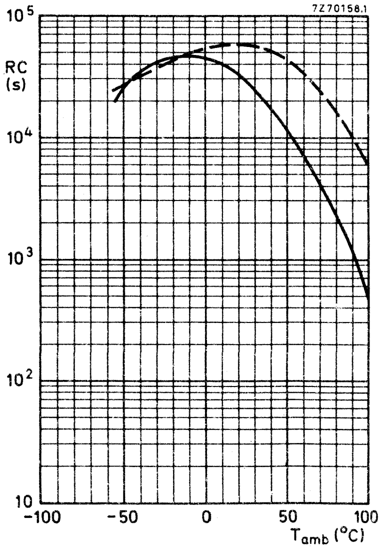


Fig. 5. Insulation resistance as a function of temperature; typical curves.
—— Metallized PETP film dielectric.
--- Metallized polycarbonate film dielectric.

Tan δ (tangent of the loss angle)

Tan δ at 10 kHz		
metallized PETP film dielectric	≤ 150 x 10^{-4}	(typ. 100 x 10^{-4})
metallized polycarbonate film dielectric	≤ 75 x 10^{-4}	(typ. 20 x 10^{-4})

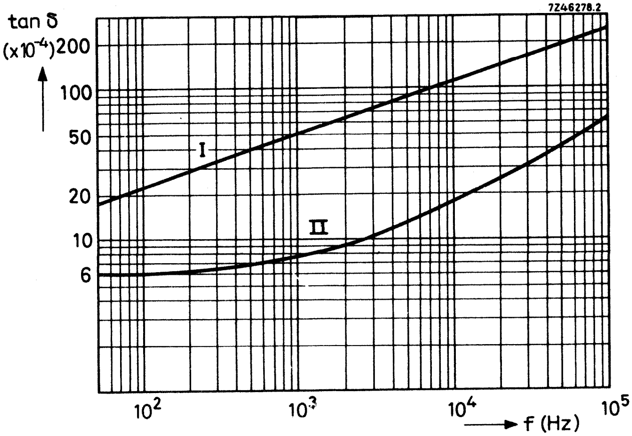


Fig. 6 Tan δ as a function of frequency; typical curves.
I = Metallized PETP film dielectric
II = Metallized polycarbonate film dielectric

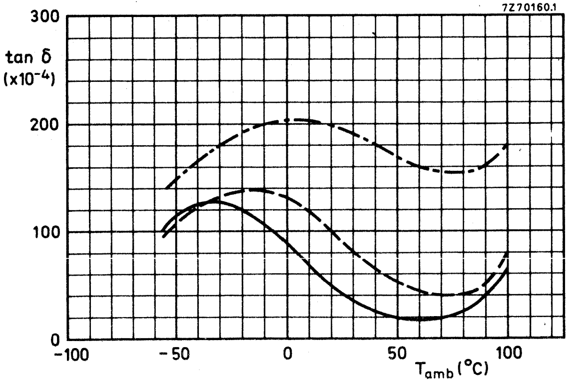


Fig. 7. Tan δ as a function of temperature; typical curves.
Metallized PETP film dielectric
—— For all capacitance values, measured at 1 kHz, 1 V.
--- For capacitance values ≤ 1 μF, measured at 10 kHz, 1 V.
-·- For capacitance values ≤ 0, 1 μF, measured at 100 kHz, 0, 3 V.

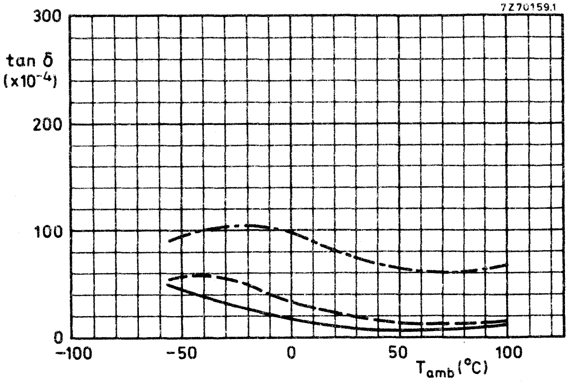


Fig. 8. Tan δ as a function of temperature; typical curves.
Metallized polycarbonate film dielectric.
—— For all capacitance values, measured at 1 kHz, 1 V.
- - - For capacitance values ≤ 1 μF, measured at 10 kHz, 1 V.
-·- For capacitance values ≤ 0,1 μF, measured at 100 kHz, 0,3 V.

Power dissipation

Maximum permissible power dissipation see "Additional information"

Note - If the requirement for the maximum permissible power dissipation is satisfied, a check must be made to ascertain that the maximum permissible pulse steepness is not exceeded.

Pulse steepness

rated voltage	max. pulse steepness (V/μs)				
(V)	L = 10,5 mm	L = 13 mm	L = 17,5 mm	L = 26 mm	L = 30 mm
100	10	10	7	3,5	3
250	25	20	10	6	5
400	40	30	20	9	8
630	60	45	30	13	10

Note - If the pulse steepness requirement is satisfied, a check must be made to ascertain that the maximum permissible power dissipation is not exceeded.

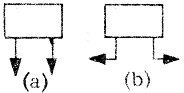
Temperature

Rated temperature	85 °C
→ Category temperature range	−55 to +100 °C
→ Storage temperature range	−55 to +100 °C
→ Climatic category, IEC 68	55/100/56

PACKING

500 pieces per box, for capacitors with $L_{max} = 30$ mm
1000 pieces per box, for capacitors with $L_{max} < 30$ mm

TESTS AND REQUIREMENTS

IEC 68-2 test method	Name of test	Procedure (quick reference)	Requirements
Ua	Tensile strength of terminations	Loading weight 10 N in axial direction of the wire, 10 s (a)  5 N in radial direction of the wire, 10 s (b)	No damage
Ub	Bending of terminations	Loading weight 5 N. two consecutive bends	No damage
Fc	Vibration	10 to 55 Hz, amplitude 0,75 mm or 10 g (whichever is the less), 2 h in 3 directions; capacitors mounted on printed-wiring boards	No damage, no open or short circuit. $\Delta C/C \leq 0,5\%$
Eb	Bumping	40 g, 3 directions, 4000 bumps per direction, capacitors mounted on printed-wiring boards	No damage, no open or short circuit. $\Delta C/C \leq 0,5\%$
T3.2	Soldering (solder bath)	Solderability: 230 °C, 2 s	No damage, good tinning; $\Delta C/C \leq 0,5\%$
		Resistance to heat: 350 °C, 3 s Capacitors immersed up to 3,5 mm from the body	No damage; $\Delta C/C \leq 0,5\%$
→ Na	Rapid change of temperature	5 cycles of 1 h at −55 °C and 1 h at +100 °C	No damage, no leakage; $\Delta C/C \leq 2\%$ Tan δ and insul.resistance shall meet initial requirements

	IEC 68-2 test method	Name of test	Procedure (quick reference)	Requirements	
→ climatic sequence	Ba	Dry heat	16 h at +100 ± 2 °C, no voltage applied	No damage, no leakage; ΔC/C ≤ −2% (polycarbonate), ≤ +7% (PETP) at 100 °C. Insulation resistance at 100 °C for C_R ≤0,33 μF: > 50 MΩ (100 V version), > 100 MΩ (other versions); for C_R > 0,33 μF: RC > 16 s (100 V version), > 33 s (other versions).	
	D	Accelerated damp heat, first cycle	24 h at 55 ± 2 °C and R.H. 95 to 100%; no voltage applied		
	Aa	Cold	2 h at −55 ± 3 °C; no voltage applied	ΔC/C ≤ −3% (polycarbonate), ≤ −8% (PETP) at −55 °C	
	M	Low air pressure	1 h at 25 ± 5 °C, at atmospheric pressure of 85 mbar	During and after the test there shall be no breakdown or flashover	
	D	Accelerated damp heat, remaining cycles	5 cycles of 24 h at 55 °C and R.H. 90 to 100%; no voltage applied	ΔC/C ≤ 3% Tan δ shall meet initial requirement Insulation resistance ≥ 0,5 x initial requirements	
	Ca	Damp heat, steady state	56 days at 40 °C and R.H. 90 to 95%; 6 V applied (continuously)	ΔC/C ≤ 3% Tan δ shall meet initial requirements Insulation resistance ≥ 0,5 x initial requirements	
		Endurance	1000 h at 85 °C, 1,5 x U_R applied	ΔC/C ≤ 3%	Δ tan δ ≤ 30 x 10^{-4} at 10 kHz. Insulation resistance meets initial requirements
→			1000 h at 100 °C, 1,5 x U_C applied	ΔC/C ≤ 5%	
			1000 h at 85 °C, rated a.c. voltage applied	ΔC/C ≤20% (L = 10,5 mm) ≤15% (L = 13 mm) ≤10% (L = 17,5 mm) ≤ 7% (L = 26 mm) ≤ 5% (L = 30 mm)	

Name of test	Procedure (quick reference)	Requirements
Pulse load	10 000 cycles of charge and discharge at 25 °C, pulse steepness 1,5 x initial requirements	$\Delta \tan\delta \leq 20 \times 10^{-4}$ at 10 kHz
Additional tests		
Solvent resistance	According to MIL-STD-202 E, method 215	No damage
Storage	1000 h at 100 °C	$\Delta C/C \leq 3\%$ Tan δ and insulation resistance (at $\leq$ 10 V d.c.) shall meet initial requirements
	10 000 h at 25 °C	$\Delta C/C \leq 1\%$ Tan δ and insulation resistance (at $\leq$ 10 V d.c.) shall meet initial requirements
Soldering test for mounting on printed-wiring boards	Board thickness: 1,6 mm, hole diameter: 1,3 mm; non-metallized holes Bath temp.: 250 ± 10 °C; dip-solder time: 5 ± 0,5 s	No damage, good tinning; $\Delta C/C \leq 1\%$

ADDITIONAL INFORMATION

Power dissipation

The rated a.c. voltage has been specified for 50 Hz and at 20 °C. This voltage value must also never be exceeded at other frequencies. This permissible a.c. voltage may further be limited by the following requirements:

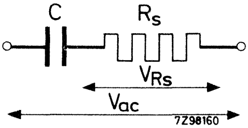
1) The power dissipation must not exceed the specified limit P_{max}.

2) The steepness of the a.c. voltage must not exceed the specified limit.

Ad. 1

The power dissipated by a capacitor is a function of the voltage over the series resistance (R_s) or of the current through the series resistance and is expressed by

$$P = \frac{V_{R_s}{}^2}{R_s} = I^2R_s \qquad (1)$$



$$V_{R_s}{}^2 = \frac{R_s{}^2}{R_s{}^2 + 1/\omega^2C^2} V_{ac}{}^2 \qquad (2a)$$

As for these capacitors tan $\delta = R_s\omega C$ = always $< 0,1$, the formula (2a) can be simplified to

$$V_{R_s}{}^2 = \frac{R_s{}^2}{1/\omega^2C^2} V_{ac}{}^2 = R_s{}^2\omega^2C^2 \; V_{ac}{}^2 \qquad (2b)$$

Thus $$P = R_s\omega^2 C^2 \; V_{ac}{}^2 \qquad (3a)$$

or $$P = (R_sC) \; C\omega^2 \; V_{ac}{}^2 \qquad (3b)$$

The term R_sC can be found from Fig. 9. C (in farads), $\omega = 2 \; \pi f$ and V_{ac} are assumed to be known.

The maximum permissible value of power dissipation (P_{max}), which depends on the dimensions of the capacitor and on the ambient temperature, can be found from Fig. 10. Thus, when the actual power has been calculated with formula (3b), Fig. 10 gives the minimum size of capacitor which can dissipate this power.

May be two or three capacitors having this size can be chosen, namely with different rated voltages.

Example of using Fig. 9 and Fig. 10

A capacitor with a dielectric of metallised PETP film and a value of 1 μF should be used at an a.c. voltage of 130 V, a frequency of 1 kHz and an ambient temperature of 50 °C. The R_SC-product is $7,5 \times 10^{-7}$ ΩF (from Fig. 9), so that the power to be dissipated

$$P = (R_SC)\, C\omega^2\, V_{ac}{}^2$$

$$= 7,5 \times 10^{-7} \times 10^{-6} \times 4\pi^2 \times 1000^2 \times 130^2 = 500 \text{ mW}$$

Fig. 10 shows that at 50 °C capacitors with curve numbers 9 to 14 can be used, thus a minimum size of 6,5 x 26 x 15,5 mm. It can be seen from the tables that a choice can be made between the 250 V and 400 V capacitors of 1 μF.

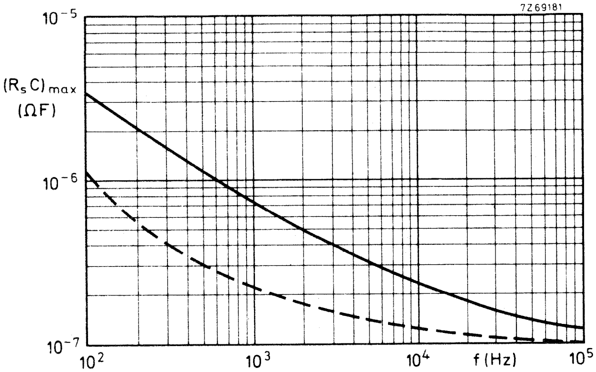


Fig. 9. Maximum product of series resistance and capacitance as a function of frequency
—— metallised PETP film dielectric
---- metallised polycarbonate film dielectric

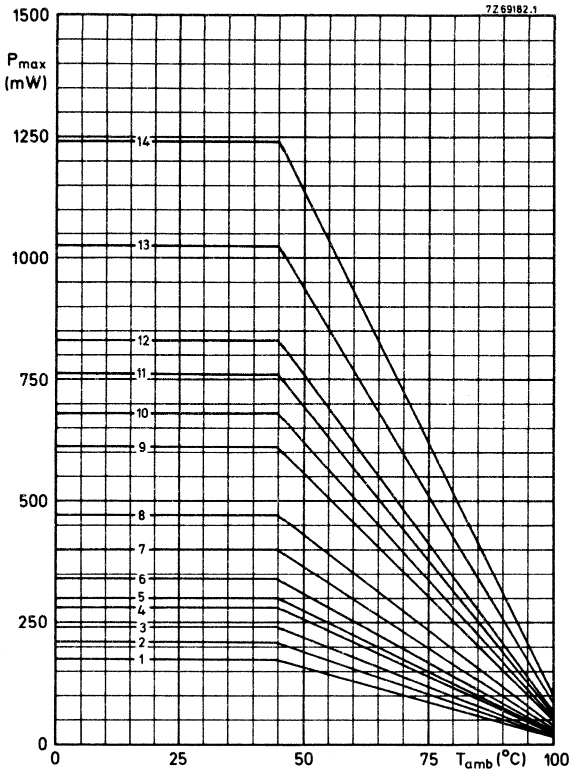


Fig. 10. Maximum permissible power dissipation as a function of temperature.

curve	dimensions (mm)		
	Tmax	Lmax	Hmax
1	4,5	10,5	10
2	4,5	13	10
3	5	13	11
4	6	13	12
5	5	17,5	11
6	6	17,5	11,5
7	7	17,5	13
8	8,5	17,5	14,5
9	6,5	26	15,5
10	7,5	26	16,5
11	8,5	26	18
12	9,5	26	19
13	11	30	20,5
14	13,5	30	23

POLYESTER FILM/FOIL CAPACITORS

flat type ("p.p.c.")

QUICK REFERENCE DATA	
Rated capacitance range (E 12-series)	2,2 nF to 1 μF
Tolerance on rated capacitance	± 10% and ± 20%
Rated voltage U_R (d.c.)	100 V, 250 V, 400 V and 630 V
Rated temperature	85 °C
Climatic category, IEC 68	40/100/21

APPLICATION

For use in wide range of consumer and industrial applications, especially where high currents and/or steep pulses occur.
The capacitors are suited for d.c. as well as for a.c. operation.

DESCRIPTION

These capacitors consist of a low-inductive wound cell of aluminium foil with a polyethyleneterephthalate (PETP) film. The cell is protected by a hard, tan coloured lacquer, which is water repellent, solvent resistant and self-extinguishing.
The radial leads are of solder-coated copper wire, which are crimped to provide optimum soldering conditions.

Composition of the catalogue number

2222 347 . . . . .

code for rated voltage and capacitance tolerance

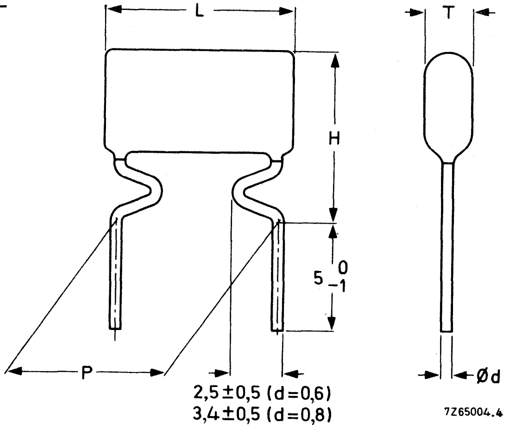
code for capacitance see tables 1 to 4

20 = 100 V; ±20%
21 = 100 V; ±10%
40 = 250 V; ±20%
41 = 250 V; ±10%
50 = 400 V; ±20%
51 = 400 V; ±10%
60 = 630 V; ±20%
61 = 630 V; ±10%

For ordering purposes please quote the 12-digit catalogue number.

MECHANICAL DATA

Dimensions in mm



For dimensions T, L, H, P and d, see tables below.

Table 1- U_R = 100 V

capacitance 1) (μF)	T_{max} (mm)	L_{max} (mm)	H_{max} (mm)	P (mm)	d (mm)	weight (g)	capacitance code
0,015	4,5	13,5	12	10,16 ± 0,3 (4e)2)	0,6	0,43	153
0,022	5,5	13,5	13			0,56	223
0,033	6	13,5	13,5			0,73	333
0,047	7	13,5	14,5			0,92	473
0,068	6	19	14,5	15,24 ± 0,3 (6e)2)	0,8	1,31	683
0,10	7	19	15,5			1,69	104
0,15	8	19	16,5			2,26	154
0,22	7	27	18,5	22,86 ± 0,3 (9e)2)		3,18	224
0,33	8,5	27	20			4,43	334
0,47	10,5	27	22			6,0	474
0,68	11	32	22,5	27,94 ± 0,3 (11e)2)		8,4	684
1,0	13,5	32	25			12,5	105

---

1) Capacitance values of the E6 series as quoted are preferred; intermediate capacitance values of the E 12 series are available to special order.

2) e = 2,54 mm (0,1 in)

Table 2 - U_R = 250 V

capacitance 1) (μF)	T_{max} (mm)	L_{max} (mm)	H_{max} (mm)	P (mm)	d (mm)	weight (g)	capacitance code
0, 010	5	13, 5	12, 5	10, 16 ± 0, 3 (4e)2)	0, 6	0, 46	103
0, 015	5, 5	13, 5	13			0, 61	153
0, 022	6, 5	13, 5	14			0, 78	223
0, 033	5, 5	19	14	15, 24 ± 0, 3 (6e)2)	0, 8	1, 12	333
0, 047	6, 5	19	15			1, 42	473
0, 068	7, 5	19	16			1, 82	683
0, 10	6, 5	27	18	22, 86 ± 0, 3 (9e)2)		2, 68	104
0, 15	8	27	19, 5			3, 45	154
0, 22	9, 5	27	21			4, 52	224
0, 33	10	32	21, 5	27, 94 ± 0, 3 (11e)2)		6, 30	334
0, 47	12	32	23, 5			9, 1	474
0, 68	15	32	26, 5			13, 1	684

Table 3 - U_R = 400 V

capacitance 1) (μF)	T_{max} (mm)	L_{max} (mm)	H_{max} (mm)	P (mm)	d (mm)	weight (g)	capacitance code
0, 0047	4, 5	13, 5	12	10, 16 ± 0, 3 (4e)2)	0, 6	0, 41	472
0, 0068	5, 5	13, 5	13			0, 53	682
0, 010	6	13, 5	13, 5			0, 68	103
0, 015	7	13, 5	14, 5			0, 87	153
0, 022	6	19	14, 5	15, 24 ± 0, 3 (6e)2)	0, 8	1, 24	223
0, 033	7	19	15, 5			1, 60	333
0, 047	8	19	16, 5			2, 06	473
0, 068	7	27	18, 5	22, 86 ± 0, 3 (9e)2)		2, 85	683
0, 10	8, 5	27	20			3, 78	104
0, 15	10, 5	27	22			5, 24	154
0, 22	11	32	22, 5	27, 94 ± 0, 3 (11e)2)		6, 90	224
0, 33	13, 5	32	25			9, 50	334

---

1) Capacitance values of the E6 series as quoted are preferred; intermediate capacitance values of the E 12 series are available to special order.

2) e = 2, 54 mm (0, 1 in)

Table 4- U_R = 630 V

capacitance 1) (μF)	T_{max} (mm)	L_{max} (mm)	H_{max} (mm)	P (mm)	d (mm)	weight (g)	capacitance code
0,0022	4,5	13,5	12	10, 16 ± 0, 3 (4e)2)	0, 6	0, 49	222
0,0033	5,5	13,5	13			0, 56	332
0,0047	6	13,5	13,5			0, 66	472
0,0068	7	13,5	14,5			0, 85	682
0,010	6	19	14,5	15,24 ± 0, 3 (6e)2)	0, 8	1, 19	103
0,015	7	19	15,5			1,51	153
0,022	8	19	16,5			1,95	223
0,033	7	27	18,5	22, 86 ± 0, 3 (9e)2)		2,76	333
0,047	8,5	27	20			3,40	473
0,068	10,5	27	22			4,40	683
0, 10	11	32	22,5	27,94 ± 0, 3 (11e)2)		6, 15	104
0, 15	13,5	32	25			8,68	154

Marking

The capacitors are marked as follows:
1st line: rated capacitance and tolerance
2nd line: rated voltage, code for dielectric (FA = non-metallised PETP film) and production code.

Mounting

The capacitors are suited for mounting on printed-wiring boards.

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1) Capacitance values of the E6 series as quoted are preferred; intermediate capacitance values of the E12 series are available to special order.

2) e = 2., 54 mm (0, 1 in)

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of 20 ± 5 °C, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

Capacitance

Rated capacitance values (C_R) at 1 kHz	see Tables 1 to 4
Tolerance on rated capacitance	± 10% and ± 20%

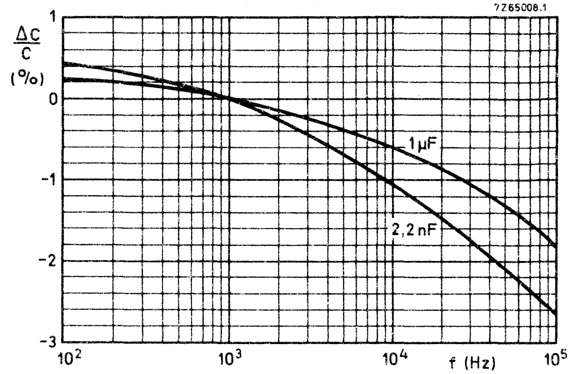

Fig. 2. Capacitance as a function of frequency; typical curves. Measuring voltage is 1 V for frequencies from 100 Hz to 10 kHz and 0,3 V for frequencies from 10 to 100 kHz.

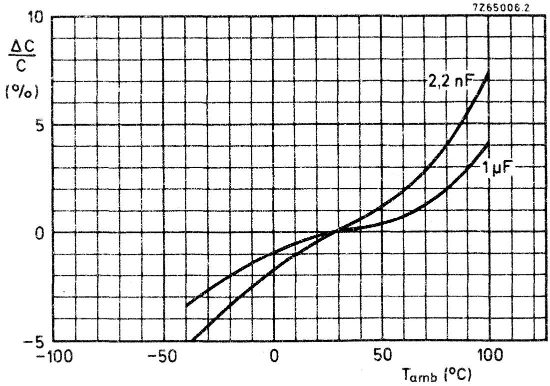

Fig. 3. Capacitance as a function of temperature; typical curves. Measuring frequencies from 1 to 100 kHz for capacitance values from 0,0022 to 0,1 μF and 1 to 10 kHz for capacitance values from 0,1 to 1 μF.

Voltage

Rated d.c. voltage U_R	100 V, 250 V, 400 V, 630 V
Rated a.c. voltage, 50-60 Hz [1]	
100 V version	50 V
250 V version	80 V
400 V version	125 V
630 V version	200 V
Category voltage U_C	0, 8 x U_R (derating of 1,25%/°C)
Test voltage (d.c.) for 1 min between terminals	2 x U_R

Insulation resistance

The insulation resistance is measured after a voltage has been applied for 1 min ± 5 s, the voltage being 100 ± 15 V for the 100 V, 250 V and 400 V versions, and 500 ± 50 V for the 630 V version.

	ambient temperature	
	20 °C	100 °C
R between terminations, for $C_R \le 0,33$ µF	> 50 000 MΩ	> 200 MΩ
RC between terminations, for $C_R > 0,33$ µF	> 16 500 s	> 65 s

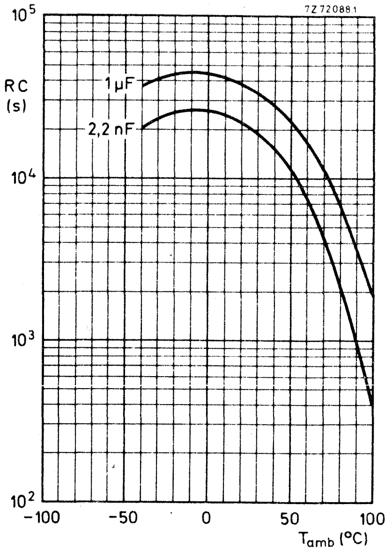

Fig. 4 Insulation resistance as a function of temperature; typical curves.

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[1] For higher frequencies see "Additional information".

Tan δ (tangent of the loss angle)

Tan δ at 10 kHz	≤ 110 x 10^{-4} (typ. 85 x 10^{-4})
at 1 kHz	≤ 60 x 10^{-4} (typ. 40 x 10^{-4})

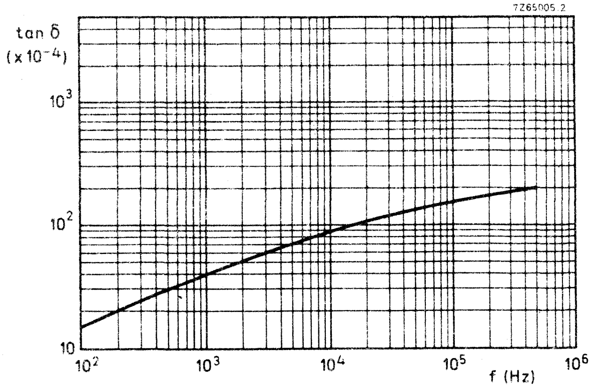


Fig. 5. Tan δ as a function of frequency; typical curve.

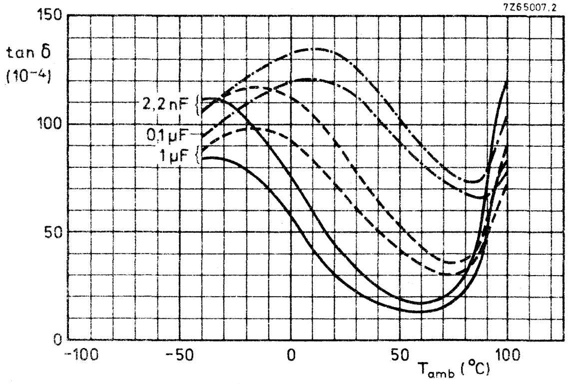


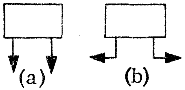
Fig. 6. Tan δ as a function of temperature; typical curves.
—— Measured at 1 V, 1 kHz.
--- Measured at 1 V, 10 kHz.
-·- Measured at 0,3 V, 100 kHz.

Power dissipation	
Maximum permissible power dissipation	see "Additional information"
Pulse steepness	unlimited
Temperature	
Rated temperature	85 °C
→ Category temperature range	−40 to +100 °C
→ Storage temperature range	−55 to +100 °C
→ Climatic category, IEC 68	40/100/21

PACKING

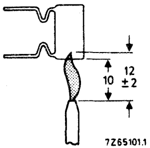
dimensions (mm) $T_{max} \times L_{max} \times H_{max}$	number of pieces per box
≤ 5, 5 x 13, 5 x 13	2000 or 16000
> 5, 5 x 13, 5 x 13 and ≤ 8 x 19 x 16, 5	2000 or 8000
> 8 x 19 x 16, 5 and ≤ 8, 5 x 27 x 20	1000 or 4000
> 8, 5 x 27 x 20 and ≤ 12 x 32 x 23, 5	500 or 2000
> 12 x 32 x 23, 5	250 or 1000

TESTS AND REQUIREMENTS

IEC 68-2 test method	Name of test	Procedure (quick reference)	Requirements
Ua	Tensile strength of terminations	Loading weight 10 N in axial direction of the wire, 10 s (a) 5 N in radial direction of the wire, 10 s (b) 	No damage
Ub	Bending of terminations	Loading weight 5 N, two consecutive bends	No damage
T3.2	Soldering (solder bath)	Solderability: 230 ^{o}C, 2 s	No damage, good tinning; $\Delta C/C \leq 0,5\%$
		Resistance to heat; 350 ^{o}C, 3 s Capacitors immersed up to 3,5 mm from the body	No damage; $\Delta C/C \leq 0,5\%$
→ Na	Rapid change of temperature	5 cycles of 1 h at −40 ^{o}C and 1 h at +100 ^{o}C	No damage, $\Delta C/C \leq 2\%$ Tan δ and insulation resistance shall meet initial requirements

	IEC 68-2 test method	Name of test	Procedure (quick reference)	Requirements
Climatic sequence	Ba	Dry heat	16 h at +85 ±2 ^{o}C, no voltage applied	No damage, $\Delta C/C \leq 7\%$ at 100 ^{o}C For capacitors ≤ 0, 33 μF, insulation resistance > 200 MΩ at 100 ^{o}C For capacitors > 0, 33 μF, RC > 65 s at 100 ^{o}C
	D	Accelerated damp heat, first cycle	24 h at 55 ± 2 ^{o}C and R.H. 95 to 100%; no voltage applied	
	Aa	Cold	2 h at −40 ± 3 ^{o}C; no voltage applied	$\Delta C/C \leq 7\%$ at −40 ^{o}C
	M	Low air pressure	1 h at 25 ± 5 ^{o}C, at atmospheric pressure of 85 mbar	During and after the test there shall be no breakdown or flashover
	D	Accelerated damp heat, remaining cycles	1 cycle of 24 h at 55 ^{o}C and R.H. 90 to 100%; no voltage applied	$\Delta C/C \leq 5\%$ Tan δ shall meet initial requirements. Insulation resistance ≥ 0, 5 x initial requirements
	Ca	Damp heat, steady state	21 days at 40 ^{o}C and R.H. 90 to 95%; no voltage applied	$\Delta C/C \leq 5\%$ Tan δ shall meet initial requirements. Insulation resistance ≥ 0, 5 x initial requirements
	-	Endurance	1000 h at 85 ^{o}C, 1, 5 x U_R applied	No damage, no short circuit $\Delta C/C \leq 5\%$; tan δ and insulation resistance shall meet initial requirements
			1000 h at 85 ^{o}C, rated a.c. voltage applied	
			1000 h at 100 ^{o}C, 1, 5 x U_C applied	

Additional tests

Name of test	Procedure (quick reference)	Requirements
Flammability	 Bore of gas jet: 0, 5 ± 0, 1 mm Fuel: butane Test duration: 20 s	After removal of the flame the capacitor must not continue to burn for more than 15 s; no burning particles should drip from the capacitor
Solvent resistance	According to MIL-STD-202 E, method 215	No damage
Soldering test for mounting on printed-wiring boards	Board thickness: 1, 6 mm, hole diameter: 1, 3 mm; non-metallized holes Bath temp.: 250 ± 10 °C; dip-solder time: 5 ± 0, 5 s	No damage, good tinning; $\Delta C/C \le 0,5\%$
Damp heat, long term exposure (IEC 68-2, test Ca)	21 days at 40 ± 2 °C, R.H. 90 to 95%; rated a.c. voltage applied for 8 h per 24 h; within 15 min after removal from the test chamber, the rated a.c. voltage applied for 1 min	No damage; $\Delta C/C \le 5\%$ Tan δ shall not exceed initial requirements. Insulation resistance $\ge 50\%$ of initial requirements.

ADDITIONAL INFORMATION

Power dissipation

The rated a.c. voltage has been specified for 50 Hz and at 20 °C. This voltage value must also never be exceeded at other frequencies. This permissible a.c. voltage may further be limited by the following requirements:

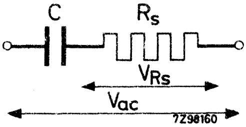
^{1}) The power dissipation must not exceed the specified limit P_{max}.

^{2}) The steepness of the a.c. voltage must not exceed the specified limit.

Ad 1.

The power dissipated by a capacitor is a function of the voltage over the series resistance (R_S) or of the current through the series resistance and is expressed by

$$P = \frac{V_{R_S}{}^2}{R_S} = I^2 R_S \qquad (1)$$



$$V_{R_S}{}^2 = \frac{R_S{}^2}{R_S{}^2 + 1/\omega^2 C^2} V_{ac}{}^2 \qquad (2a)$$

As for these capacitors tan $\delta = R_S \omega C$ = always $< 0,1$, the formula (2a) can be simplified to

$$V_{R_S}{}^2 = \frac{R_S{}^2}{1/\omega^2 C^2} V_{ac}{}^2 = R_S{}^2 \omega^2 C^2 V_{ac}{}^2 \qquad (2b)$$

Thus $$P = R_S \omega^2 C^2 V_{ac}{}^2 \qquad (3a)$$

or $$P = (R_S C) C \omega^2 V_{ac}{}^2 \qquad (3b)$$

The term $R_S C$ can be found from Fig. 7. C (in farads), $\omega = 2\pi f$ and V_{ac} are assumed to be known.

The maximum permissible value of power dissipation (P_{max}), which depends on the dimensions of the capacitor and on the ambient temperature, can be found from Fig. 8. Thus, when the actual power has been calculated with formula (3b), Fig. 8 gives the minimum size of capacitor which can dissipate this power.

May be two or three capacitors having this size can be chosen, namely with different rated voltages.

Example of using Fig.7 and Fig.8

A capacitor with a value of 0,047 μF should be used at an a.c. voltage of 100 V, a frequency of 10 kHz and an ambient temperature of 60 °C. Thus the rated d.c. voltage should be at least 400 V.
The maximum R_sC-product is $1,35 \times 10^{-7}$ ΩF (from Fig.7), so that the power to be dissipated

$$P = (RsC)\, C\omega^2\, V_{ac}^2$$

$$= 1,35 \times 10^{-7} \times 0,047 \times 10^{-6} \times 4\pi^2 \times 10^8 \times 10^4 = 250 \text{ mW}$$

Fig. 8 shows that at 60 °C capacitors with curve numbers 9 to 23 can be used, thus a minimum size of 6,5 x 19 x 15 mm. It can be seen from table 3 a 400 V capacitor can be used.

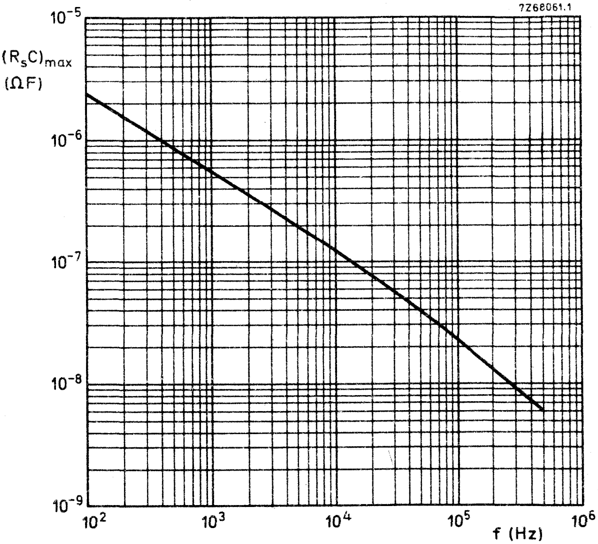


Fig. 7. Maximum product of series resistance and capacitance as a function of frequency.

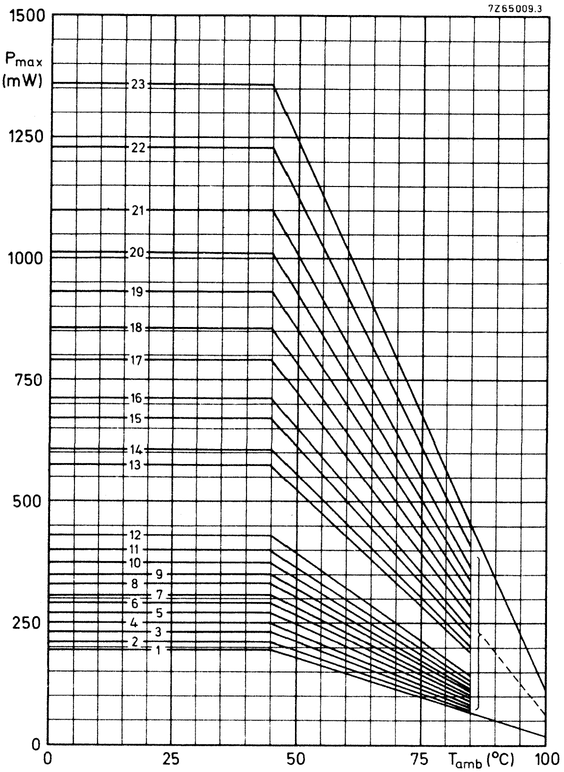


Fig. 8. Maximum permissible power dissipation as a function of temperature.

curve	dimensions in mm		
	T_{max}	L_{max}	H_{max}
1	4,5	13,5	12
2	5	13,5	12,5
3	5,5	13,5	13
4	6	13,5	13,5
5	6,5	13,5	14
6	7	13,5	14,5
7	5,5	19	14
8	6	19	14,5
9	6,5	19	15
10	7	19	15,5
11	7,5	19	16

curve	dimensions in mm		
	T_{max}	L_{max}	H_{max}
12	8	19	16,5
13	6,5	27	18
14	7	27	18,5
15	8	27	19,5
16	8,5	27	20
17	9,5	27	21
18	10,5	27	22
19	10	32	21,5
20	11	32	22,5
21	12	32	23,5
22	13,5	32	25
23	15	32	26,5

METALLISED POLYESTER FILM CAPACITORS

lacquered type (''f.f.c.)

QUICK REFERENCE DATA	
Rated capacitance range (E 12 series)	1 nF to 6, 8 μF
Tolerance on rated capacitance	± 10% and ± 20%
Rated voltage U_R (d.c.)	100 V, 250 V, 400 V, 630 V
Rated temperature	85 °C
Climatic category, IEC 68	40/100/21
Basic specification	IEC 202

APPLICATION

For general purpose and industrial use in electronic equipment, e.g. for coupling and decoupling applications

DESCRIPTION

These capacitors consist of a low-inductive winding of metallised polyethyleneterephthalate (PETP) film and radial leads of tinned copper wire, which are crimped to provide optimum soldering conditions.
The winding is protected by a hard, water repellent, solvent resistant lacquer.
The capacitors are available with both short as well as long leads.

Composition of the catalogue number

2222 352 . . . . .

Code for rated voltage, capacitance tolerance and lead length

code for capacitance, see tables 1 to 4

24 = 100 V; ± 20%	long leads	27 = 100 V; ± 20%	short leads (l = 5-1 mm)
25 = 100 V; ± 10%		28 = 100 V; ± 10%	
44 = 250 V; ± 20%		47 = 250 V; ± 20%	
45 = 250 V; ± 10%		48 = 250 V; ± 10%	
54 = 400 V; ± 20%		57 = 400 V; ± 20%	
55 = 400 V; ± 10%		58 = 400 V; ± 10%	
64 = 630 V; ± 20%		67 = 630 V; ± 20%	
65 = 630 V; ± 10%		68 = 630 V; ± 10%	

For ordering purposes please quote the 12-digit catalogue number.

MECHANICAL DATA

Dimensions in mm

For dimensions T, L, H, P, d and l, see tables below.

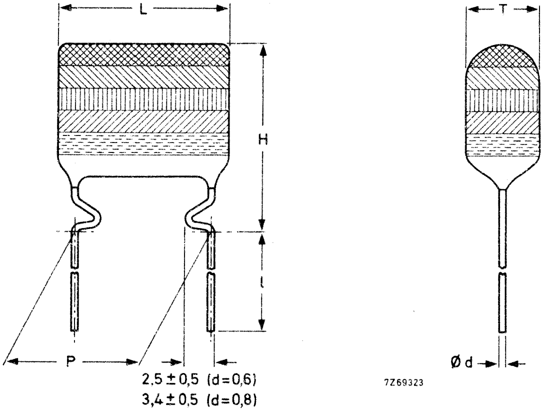


Table 1 - U_R = 100 V

Note - The capacititors mentioned in this table are also available with lead length l = 5-1 mm.

rated capacitance (µF)	T_{max}	L_{max}	H_{max}	P	d	l_{min}	approx. weight (g)	capacitance code
0, 047	4, 5	12, 5	12, 5	10, 16 ± 0, 3 (4e) 1)	0, 6	13	0, 55	473
0, 056	4, 5		12, 5				0, 55	563
0, 068	4, 5		12, 5				0, 55	683
0, 082	4, 5		12, 5				0, 55	823
0, 10	4, 5		12, 5				0, 55	104
0, 12	4, 5		12, 5				0, 55	124
0, 15	5		13				0, 55	154
0, 18	5, 5		13, 5				0, 55	184
0, 22	6		14				0, 65	224
0, 27	6, 5		14, 5				0, 75	274
0, 33	5, 5	17, 5	14, 5	15, 24 ± 0, 3 (6e) 1)	0, 8		0, 95	334
0, 39	6		15				1, 05	394
0, 47	6, 5		15, 5				1, 15	474
0, 56	7		16				1, 3	564
0, 68	6	22, 5	15	20, 32 ± 0, 3 (8e) 1)		21	1, 5	684
0, 82	6, 5		15, 5				1, 7	824
1, 0	7		16				1, 95	105
1, 2	7, 5		16, 5				2, 25	125
1, 5	8, 5		17, 5				2, 63	155
1, 8	9, 5		18, 5				3, 1	185
2, 2	8, 5	30	17, 5	27, 94 ± 0, 3 (11e) 1)		19	3, 4	225
2, 7	9, 5		18, 5				4	275
3, 3	9		21				4, 6	335
3, 9	10		22				5, 3	395
4, 7	11, 5		23, 5				6	475
5, 6	12, 5		24, 5				6, 9	565
6, 8	14		26				8	685

---

1) e = 2, 54 mm (0, 1 in)

Table 2 - U_R = 250 V

Note - The capacitors mentioned in this table are also available with lead length 1 = 5-1 mm.

rated capacitance (µF)	T_{max}	L_{max}	H_{max}	P	d	l_{min}	approx. weight (g)	capacitance code
0, 0010	4, 5	12, 5	12, 5	10, 16 ± 0, 3 (4e) 1)	0, 6	13	0, 45	102
0, 0012	4, 5		12, 5				0, 45	122
0, 0015	4, 5		12, 5				0, 45	152
0, 0018	4, 5		12, 5				0, 45	182
0, 0022	4, 5		12, 5				0, 45	222
0, 0027	4, 5		12, 5				0, 45	272
0, 0033	4, 5		12, 5				0, 45	332
0, 0039	4, 5		12, 5				0, 45	392
0, 0047	4, 5		12, 5				0, 45	472
0, 0056	4, 5		12, 5				0, 45	562
0, 0068	4, 5		12, 5				0, 45	682
0, 0082	4, 5		12, 5				0, 45	822
0, 010	4		12				0, 45	103
0, 012	4		12				0, 45	123
0, 015	4		12				0, 45	153
0, 018	4		12				0, 45	183
0, 022	4		12				0, 45	223
0, 027	4		12				0, 45	273
0, 033	4		12				0, 45	333
0, 039	4		12				0, 45	393
0, 047	4		12				0, 45	473
0, 056	4, 5		12, 5				0, 5	563
0, 068	4, 5		12, 5				0, 55	683
0, 082	4, 5		12, 5				0, 6	823
0, 10	5		13				0, 7	104
0, 12	5, 5	17, 5	14, 5	15, 24 ± 0, 3 (6e) 1)	0, 8		0, 9	124
0, 15	6		15				1	154
0, 18	6, 5		15, 5				1, 1	184
0, 22	7		16				1, 25	224
0, 27	6	22, 5	15	20, 32 ± 0, 3 (8e) 1)		21	1, 4	274
0, 33	6, 5		15, 5				1, 6	334
0, 39	7		16				1, 8	394
0, 47	7, 5		16, 5				2, 1	474
0, 56	8		17				2, 4	564
0, 68	9		18				2, 8	684
0, 82	8	30	17	27, 94 ± 0, 3 (11e) 1)		19	3, 1	824
1, 0	9		18				3, 6	105
1, 2	8, 5		20, 5				4, 2	125
1, 5	9, 5		21, 5				5	155
1, 8	10, 5		22, 5				5, 65	185
2, 2	11, 5		23, 5				6, 5	225

---

1) e = 2, 54 mm (0, 1 in)

Table 3 - U_R = 400 V

Note - The capacitors mentioned in this table are also available with lead length l = 5-1 mm.

rated capacitance (μF)	T_{max}	L_{max}	H_{max}	P	d	l_{min}	approx. weight (g)	capacitance code
0,010	4,5	12,5	12,5	10,16 ± 0,3 (4e) 1)	0,6	13	0,45	103
0,012	4,5		12,5				0,45	123
0,015	4,5		12,5				0,45	153
0,018	4,5		12,5				0,45	183
0,022	4,5		12,5				0,45	223
0,027	5		13				0,5	273
0,033	5,5		13,5				0,55	333
0,039	6		14				0,6	393
0,047	6,5		14,5				0,7	473
0,056	5,5	17,5	14,5	15,24 ± 0,3 (6e) 1)	0,8		0,9	563
0,068	6		15				1	683
0,082	6,5		15,5				1,1	823
0,10	7		16				1,25	104
0,12	6	22,5	15	20,32 ± 0,3 (8e) 1)		21	1,4	124
0,15	6,5		15,5				1,6	154
0,18	7		16				1,85	184
0,22	7,5		16,5				2,15	224
0,27	8,5		17,5				2,5	274
0,33	9,5		18,5				2,9	334
0,39	8,5	30	17,5	27,94 ± 0,3 (11e) 1)		19	3,2	394
0,47	9,5		18,5				3,7	474
0,56	9		21				4,3	564
0,68	10		22				5	684
0,82	11		23				5,65	824
1,0	12		24				6,5	105

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1) e = 2,54 mm (0,1 in)

Table 4 - U_R = 630 V

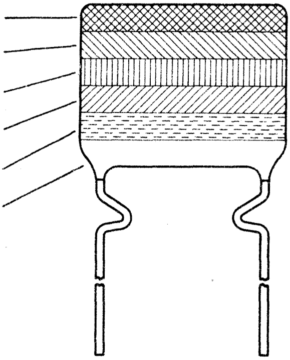
Note - The capacitors mentioned in this table are also available with lead length l = 5-1 mm.

rated capacitance (μF)	T_{max}	L_{max}	H_{max}	P	d	l_{min}	approx. weight (g)	capacitance code
0, 010	4, 5	12, 5	12, 5	10, 16 ± 0, 3 (4e) 1)	0, 6	13	0, 45	103
0, 012	5		13				0, 5	123
0, 015	5, 5		13, 5				0, 55	153
0, 018	6		14				0, 6	183
0, 022	6, 5		14, 5				0, 7	223
0, 027	5, 5	17, 5	14, 5	15, 24 ± 0, 3 (6e) 1)	0, 8		0, 9	273
0, 033	6		15				1	333
0, 039	6, 5		15, 5				1, 1	393
0, 047	7		16				1, 25	473
0, 056	6	22, 5	15	20, 32 ± 0, 3 (8e) 1)		21	1, 4	563
0, 068	6, 5		15, 5				1, 6	683
0, 082	7		16				1, 85	823
0, 10	7, 5		16, 5				2, 15	104
0, 12	8, 5		17, 5				2, 5	124
0, 15	9, 5		18, 5				2, 9	154
0, 18	8, 5	30	17, 5	27, 94 ± 0, 3 (11e) 1)		19	3, 2	184
0, 22	9, 5		18, 5				3, 7	224
0, 27	9		21				4, 3	274
0, 33	10		22				5	334
0, 39	11		23				5, 65	394
0, 47	12		24				6, 5	474

---

1) e = 2, 54 mm (0, 1 in)

Marking



colour	1 st figure of capacitance value in pF	2 nd figure of capacitance value in pF	multiplying factor	capacitance tolerance	rated voltage
black	–	0	1	± 20%	
brown	1	1	10		100 V
red	2	2	10^2		250 V
orange	3	3	10^3		
yellow	4	4	10^4		400 V
green	5	5	10^5		
blue	6	6			630 V
violet	7	7			
grey	8	8			
white	9	9		± 10%	

Mounting

The capacitors are suited for mounting on printed-wiring boards.

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of 20 ± 5 °C, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%

Capacitance

Rated capacitance values (C_R) at 1 kHz	see Tables 1 to 4
Tolerance on rated capacitance	± 20% and ± 10%

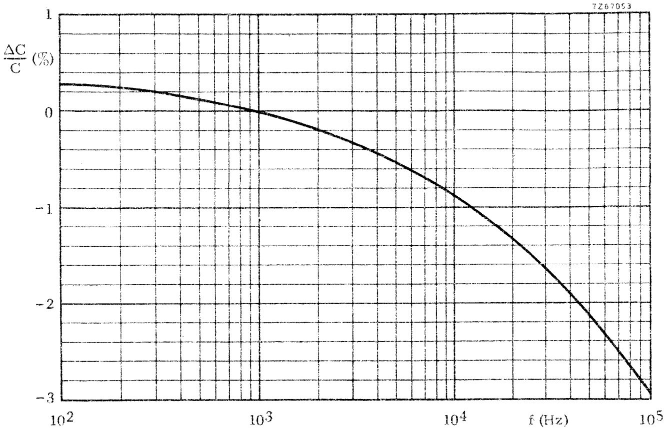


Fig. 2 Capacitance as a function of frequency; typical curve

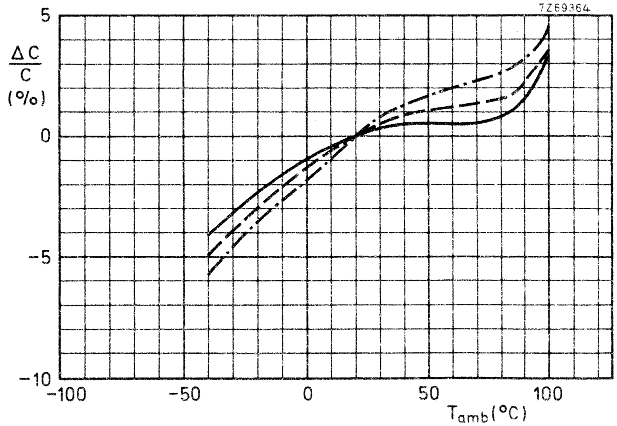


Fig. 3 Capacitance as a function of temperature; typical curves

———— For all capacitance values, measured at 1 kHz, 1 V

— — — For capacitance values ≤ 1 μF, measured at 10 kHz, 1 V

— · — · For capacitance values ≤ 0, 1 μF, measured at 100 kHz, 0, 3 V

Voltage

Rated d.c. voltage U_R	100 V, 250 V, 400 V, 630 V
Rated a.c. voltage, 50-60 Hz [1]	
100 V version	63 V
250 V version	160 V
400 V version	220 V
630 V version	220 V
Category voltage U_C	0, 8 x U_R (derating of 1,25%/°C)
Overvoltage for 1 min/h	
100 V and 250 V versions	$\leq$ 40% of U_R
400 V and 630 V versions	$\leq$ 25% of U_R
Test voltage (d.c.) for 1 min	
between terminals	1, 6 x U_R
between interconnected terminals and coating	2 x U_R (minimum 1000 V)

Notes - The sum of the d.c. voltage and the peak value of the superimposed a.c. voltage must be $\leq U_R$.

- It is recommended that the capacitors are not used in low-impedance circuits where the resistive current through the capacitors can exceed 400 mA in the event of an internal breakdown of the dielectric; so direct operation from the mains should not be applied.

Insulation resistance

The insulation resistance is measured after a voltage has been applied for 1 min ± 5 s, the voltage being 100 ± 15 V for the 100 V-, 250 V- and 400 V versions and 500 ± 50 V for the 630 V version.

	ambient temperature 20 °C	ambient temperature 100 °C
R between terminations		
for $C_R \leq$ 0, 33 µF, 100 V versions	> 15 000 MΩ	> 50 MΩ
250 V, 400 V, 630 V versions	> 30 000 MΩ	> 100 MΩ
RC between terminations		
for $C_R >$ 0, 33 µF, 100 V version	> 5 000 s	> 16 s
250 V, 400 V, 630 V versions	> 10 000 s	> 33 s

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[1] For higher frequencies see "Additional information".

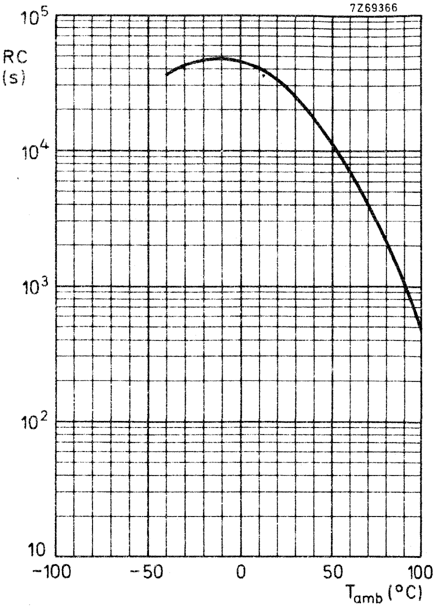


Fig. 4 Insulation resistance as a function of temperature; typical curve.

Tan δ (tangent of the loss angle)

Tan δ at 10 kHz $\leq 150 \times 10^{-4}$ (typ. 90×10^{-4})

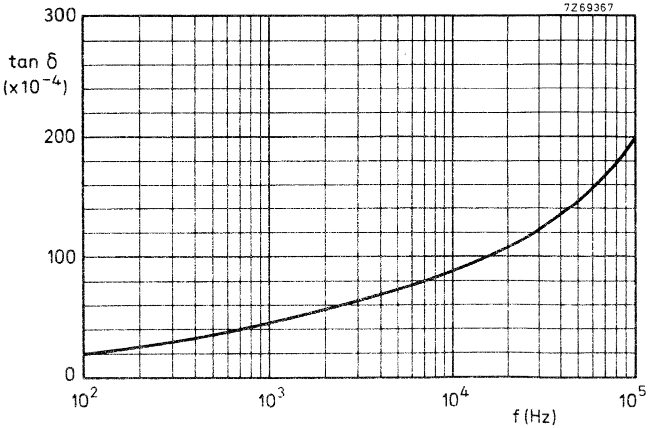


Fig. 5 Tan δ as a function of frequency; typical curve.

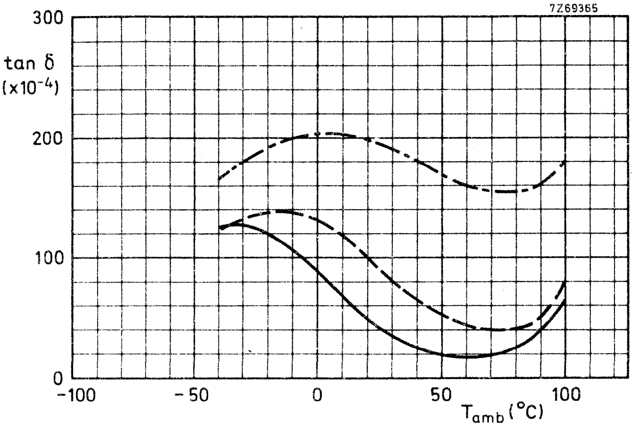


Fig. 6 Tan δ as a function of temperature; typical curves.
——— For all capacitance values, measured at 1 kHz, 1 V.
– – – For capacitance values ≤ 1 μF, measured at 10 kHz, 1 V.
– · – For capacitance values ≤ 0, 1 μF, measured at 100 kHz, 0, 3 V.

Power dissipation

Maximum permissible power dissipation see chapter "Additional information"

Note - If the requirement for the maximum permissible power dissipation is satisfied, a check must be made to ascertain that the maximum permissible pulse steepness is not exceeded.

Pulse steepness

rated voltage (V)	maximum pulse steepness (V/μs)			
	L = 12, 5 mm	L = 17, 5 mm	L = 22, 5 mm	L = 30 mm
100	10	7	4	3
250	20	10	7	5
400	30	20	10	8
630	45	30	15	10

Note - If the pulse steepness requirement is satisfied, a check must be made to ascertain that the maximum permissible power dissipation is not exceeded.

Temperature

Rated temperature	85 °C
Category temperature range	−40 to +100 °C
Storage temperature range	−40 to +100 °C
Climatic category, IEC 68	40/100/21

PACKING

500 pieces per box, for capacitors with $L_{max} = 30$ mm
1000 pieces per box, for capacitors with $L_{max} < 30$ mm

TESTS AND REQUIREMENTS

IEC202 clause	IEC68-2 test method	Name of test	Procedure (quick reference)	Requirements
14.1	Ua	Tensile strength of terminations	Loading weight 10 N in axial direction of the wire, 10 s	No damage
14.2	Ub	Bending of terminations	Loading weight 3, 5 N (d = 0, 6 mm) or 5 N (d = 0, 8 mm), two consecutive bends	No damage
15	T3.2	Soldering (solder bath)	Solderability: 230 $^{\text{o}}$C, 2 s	No damage, good tinning; $\Delta C/C \leq 0,5\%$
			Resistance to heat: 350 $^{\text{o}}$C, 3 s Capacitors immersed up to 3, 5 mm from the body	No damage; $\Delta C/C \leq 0,5\%$
16	Na	Rapid change of temperature	5 cycles of 1 h at −40 $^{\text{o}}$C and 1 h at +100 $^{\text{o}}$C	No damage, no leakage; $\Delta C/C \leq 2\%$ Tan δ and insulation resistance shall meet initial requirements

	IEC202 clause	IEC68-2 test method	Name of test	Procedure (quick reference)	Requirements	
	19.2	Ba	Dry heat	16 h at +100 ± 2 °C, no voltage applied	No damage, no leakage; ΔC/C ≤ 7% at 100 °C Insulation resistance at 100 °C, for C_R ≤ 0,33 μF: > 50 MΩ (100 V version), > 100 MΩ (250 V, 400 V, 630 V versions); for C_R > 0,33μF: > 16 s (100 V version), > 33 s (250 V, 400 V, 630 V version).	
Climatic sequence	19.3	D	Accelerated damp heat, first cycle	24 h at 55 ± 2 °C and R.H. 95 to 100%; no voltage applied		
	19.4	Aa	Cold	2 h at −40 ± 3 °C; no voltage applied	ΔC/C ≤ −7% at −40 °C	
	19.5	M	Low air pressure	1 h at 25 ± 5 °C, at atmospheric pressure of 85 mbar	During and after the test there shall be no breakdown or flashover	
	19.6	D	Accelerated damp heat, remaining cycle	1 cycle of 24 h at 55 °C and R.H. 95 to 100%; no voltage applied	ΔC/C ≤ 5% Tan δ shall meet initial requirements Insulation resistance ≥0, 5 x initial requirements	
	20	Ca	Damp heat, steady state	21 days at 40 °C and R.H. 90 to 95%; 6 V applied (continuously)	ΔC/C ≤ 5% Tan δ shall meet initial requirements Insulation resistance ≥0, 5 x initial requirements	
	21		Endurance	1000 h at 85 °C, 1, 5 x U_R applied	ΔC/C ≤ 5%	tan δ and insulation resistance shall meet initial requirements.
				1000 h at 100 °C, 1, 2 x U_R applied	ΔC/C ≤ 5%	
				1000 h at 85 °C, rated a.c. voltage applied	ΔC/C ≤ 15% (L = 12, 5 mm) ΔC/C ≤ 10% (L = 17, 5 mm) ΔC/C ≤ 7% (L = 22, 5 mm) ΔC/C ≤ 5% (L = 30 mm)	

Name of test	Procedure (quick reference)	Requirements
→ Pulse load	10 000 cycles of charge and discharge at 25 °C, pulse steepness 1, 5 x initial requirements	$\Delta \tan \delta \leq 20 \times 10^{-4}$ at 10 kHz
Additional tests Solvent resistance	According to MIL-STD-202 E, method 215	No damage
Storage	1000 h at 100 °C	$\Delta C/C \leq 3\%$ Tan δ and insulation resistance shall meet initial requirements
Damp heat	21 days at 40 ± 2 °C and R.H. 90 to 95%, rated a.c. voltage 16 h per 24 h applied	No damage
Soldering test for mounting on printed-wiring boards	Board thickness: 1, 6 mm, hole diameter: 1, 3 mm; non-metallized holes Bath temperature: 250 ± 10 °C; dip-solder time: 5 ± 1 s	No damage, good tinning; $\Delta C/C \leq 1\%$
Tensile strength of terminations	Loading weight 3, 5 N (d = 0, 6 mm) or 5 N (d = 0, 8 mm) in radial direction of the wire, 10 s	No damage

ADDITIONAL INFORMATION

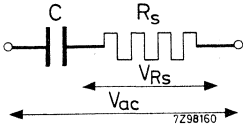
Power dissipation

The rated a.c. voltage has been specified for 50 to 60 Hz and at 20 °C. This voltage value must also never be exceeded at other frequencies. This permissible a.c. voltage may further be limited by the following requirements:
1) The power dissipation must not exceed the specified limit P_{max}.
2) The steepness of the a.c. voltage must not exceed the specified limit.

Ad 1.

The power dissipated by a capacitor is a function of the voltage over the series resistance (R_S) or of the current through the series resistance and is expressed by

$$P = \frac{V_{R_S}{}^2}{R_S} = I^2 R_S \qquad (1)$$



$$V_{R_S}{}^2 = \frac{R_S{}^2}{R_S{}^2 + 1/\omega^2 C^2} V_{ac}{}^2 \qquad (2a)$$

As for these capacitors tan $\delta = R_S \omega C$ = always $< 0,1$, the formula (2a) can be simplified to

$$V_{R_S}{}^2 = \frac{R_S{}^2}{1/\omega^2 C^2} V_{ac}{}^2 = R_S{}^2 \omega^2 C^2 V_{ac}{}^2 \qquad (2b)$$

Thus $$P = R_S \omega^2 C^2 V_{ac}{}^2 \qquad (3a)$$

or $$P = (R_S C) C \omega^2 V_{ac}{}^2 \qquad (3b)$$

The term $R_S C$ can be found from Fig. 7; C (in farads), $\omega = 2 \pi f$ and V_{ac} are assumed to be known.

The maximum permissible value of power dissipation (P_{max}), which depends on the dimensions of the capacitor and on the ambient temperature, can be found from Fig. 8. Thus, when the actual power has been calculated with formula (3b), Fig. 8 gives the minimum size of capacitor which can dissipate this power.

May be two or three capacitors having this size can be chosen, namely with different rated voltages.

Example of using Fig. 7 and Fig. 8

A capacitor of 0, 68 µF should be used at an a.c. voltage of 130 V, a frequency of 1 kHz and an ambient temperature of 50 °C.
The R_sC-product is 7, 1 x 10^{-7} ΩF (from Fig. 7), so that the power to be dissipated is

$$P = (R_sC)\, C\omega^2\, V_{ac}{}^2$$

$$= 7,1 \times 10^{-7} \times 0,68 \times 10^{-6} \times 4\,\pi^2 \times 1000^2 \times 130^2 = 322 \text{ mW}$$

Fig. 8 shows that at 50 °C capacitors with curve numbers 8 to 31 can be used, thus a minimum size of 6, 5 x 17, 5 x 15, 5 mm. It can be seen from the tables that a 0,68 µF/250 V or 0,68 µF/400 V capacitor can be chosen.

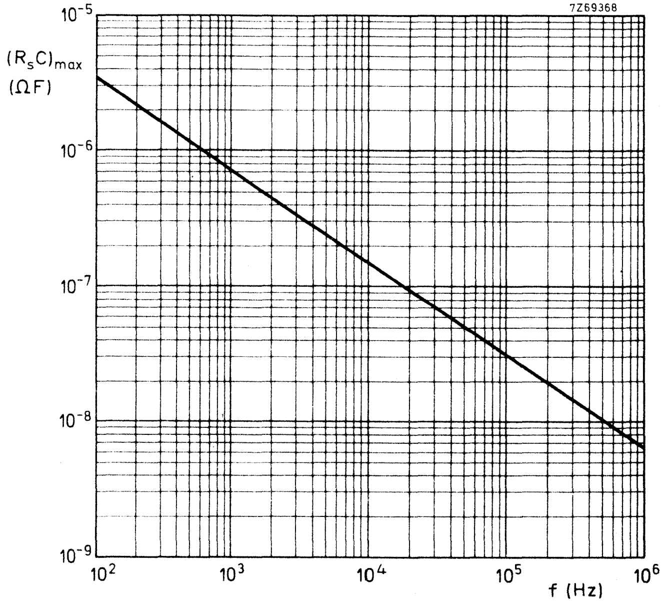
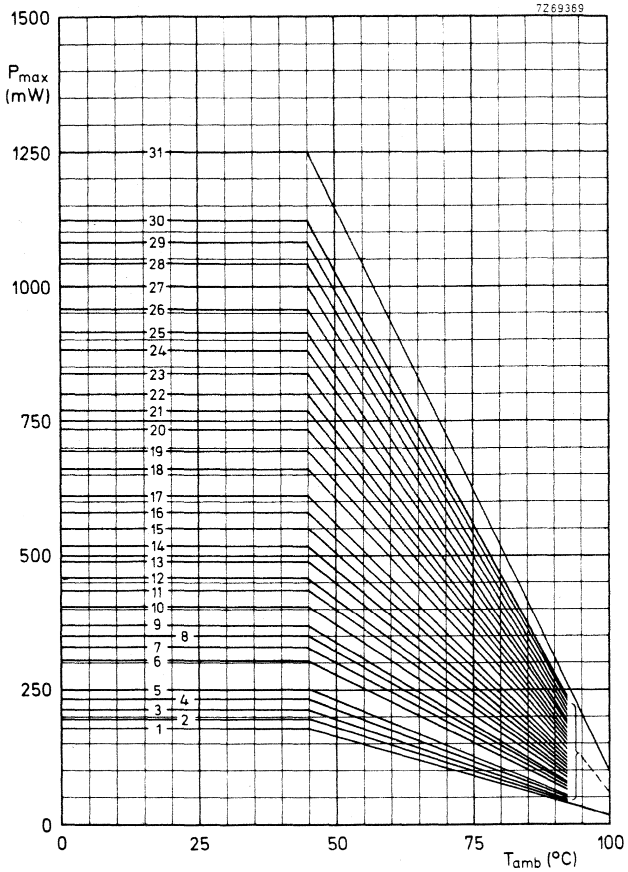


Fig. 7 Maximum product of series resistance and capacitance as a function frequency



curve	dimensions (mm)		
	T_{max}	L_{max}	H_{max}
1	4, 5	12, 5	12, 5
2	5	12, 5	13
3	5, 5	12, 5	13, 5
4	6	12, 5	14
5	6, 5	12, 5	14, 5
6	5, 5	17, 5	14, 5
7	6	17, 5	15
8	6, 5	17, 5	15, 5
9	7	17, 5	16
10	6	22, 5	15
11	6, 5	22, 5	15, 5
12	7	22, 5	16
13	7, 5	22, 5	16, 5
14	8	22, 5	17
15	8, 5	22, 5	17, 5
16	9	22, 5	18
17	9, 5	22, 5	18.5
18	8	30	17
19	8, 5	30	17, 5
20	9	30	18
21	9, 5	30	18, 5
22	8, 5	30	20, 5
23	9	30	21
24	9, 5	30	21, 5
25	10	30	22
26	10, 5	30	22, 5
27	11	30	23
28	11, 5	30	23, 5
29	12	30	24
30	12, 5	30	24, 5
31	14	30	26

Fig. 8 Maximum permissible power dissipation as a function of temperature

POLYPROPYLENE FILM/FOIL CAPACITORS
potted type

QUICK REFERENCE DATA	
Rated capacitance range (E12 series)	0,039 to 0,82 μF
Tolerance on rated capacitance	± 10%
Rated d.c. voltage U_R	250 V
Rated a.c. voltage, 50 - 60 Hz	160 V
Rated temperature	85 °C
Climatic category, IEC68	40/085/56

APPLICATION

These capacitors are intended for applications where high currents and steep pulses occur. They are mainly used for S correction in television receivers, to operate at high peak currents at line frequency.

DESCRIPTION

The capacitors consist of an impregnated, low-inductive wound cell of aluminium foil and polypropylene film. The cell is potted in a yellow flame-retardant polypropylene case.
The radial leads are solder-coated copper wire.
The capacitors can withstand solvents and rinsing liquids without damage.
They are provided with small stand-off pips to allow removal of solder flux etc., when cleaning the printed-wiring board.

Composition of the catalogue number

2222 357 51...

capacitance code, see table

For ordering purposes please quote the 12-digit catalogue number.

MECHANICAL DATA

Dimensions in mm

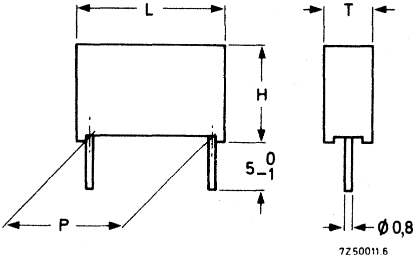


Fig. 1

For dimensions T, L, H and P, see table below.

U_R = 250 V

rated capacitance (μF)	T_{max} (mm)	L_{max} (mm)	H_{max} (mm)	P (mm)	mass (g)	capacitance code
0, 039	8	21, 5	15	15, 24 ± 0, 4 (6e) 1)	3	393
0, 047						473
0, 056						563
0, 068	10	21, 5	17		4, 5	683
0, 082						823
0, 10	8, 5	29	18, 5	22, 68 ± 0, 4 (9e) 1)	5, 5	104
0, 12						124
0, 15						154
0, 18	10	29	20		7, 5	184
0, 22	10	34	20	27, 94 ± 0, 4 (11e) 1)	8, 5	224
0, 27						274
0, 33	12	34	22		11	334
0, 39						394
0, 47	15	34	25		16	474
0, 56						564
0, 68	18	34	28		22	684
0, 82						824

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1) e = 2, 54 mm (0, 1 in).

Marking

The capacitors are marked on the top face by embossed print, with:
1st line: rated capacitance in µF [1], tolerance and rated d.c. voltage;
2nd line: 5th, 6th and 7th digit of the catalogue number, code for construction [2] and code for factory of origin.

Mounting

The capacitors are suited for mounting on printed-wiring boards. When a number of capacitors are connected to form a capacitor bank, the proximity of one to another must not be less than 10 mm.

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1) Without µF unit symbol.

2) FP = non-metallized polypropylene film.

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of 20 ± 5 °C, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

Capacitance

Rated capacitance values (C_R) at 1 kHz	see table
Tolerance on rated capacitance	± 10% (± 5% on request)
Temperature coefficient at T_{amb} ≥20 °C	-600 ppm/°C

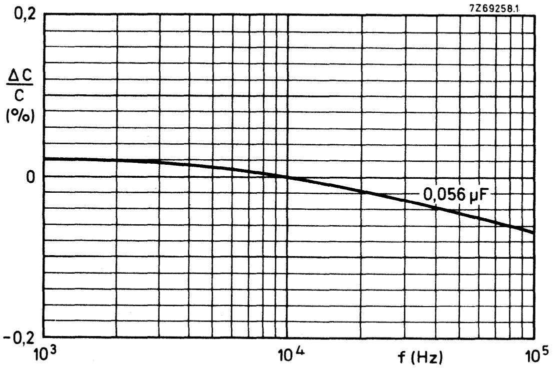


Fig. 2. Capacitance as a function of frequency; typical curve.
Measuring voltage is 0, 3 V.

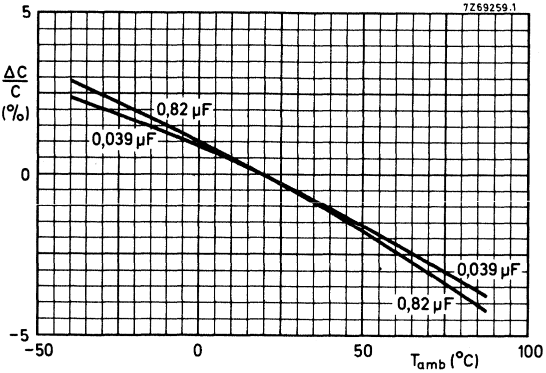


Fig. 3. Capacitance as a function of temperature; typical curves.
Measuring voltage is 0, 3 V, measuring frequency is 10 kHz.

Voltage

Rated d.c. voltage U_R	250 V
Rated a.c. voltage, 50 – 60 Hz	160 V

Note - The following two requirements must be satisfied:
the peak value of the a.c. voltage must be ≤ rated a.c. voltage x $\sqrt{2}$;
the sum of the d.c. voltage and the peak value of the superimposed a.c. voltage must be ≤ rated d.c. voltage.

Over-voltage (d.c.) for 1 min/h	≤ 50 V
Test voltage (d.c.) for 1 min ± 5 s	
between terminals	500 V
between interconnected terminals and case	3000 V
Test voltage, 50 – 60 Hz, for 1 min ± 5 s	
between interconnected terminals and case	2500 V

Insulation resistance

The insulation resistance is measured after a voltage of 100 ± 15 V has been applied for 1 min ± 5 s.

	ambient temperature	
	20 °C	85 °C
R between terminations, for $C_R \leq 0,1\ \mu F$	> 50 000 MΩ	> 500 MΩ
RC between terminations, for $C_R > 0,1\ \mu F$	> 5000 s	> 50 s

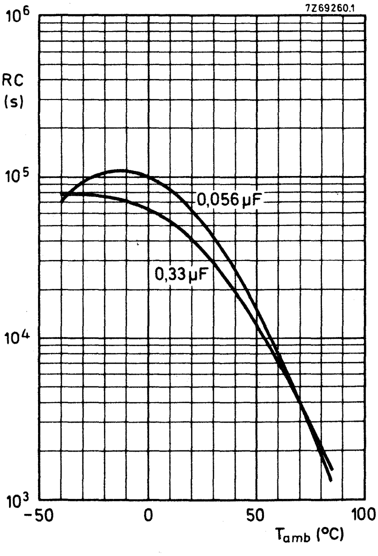


Fig. 4. RC-product as a function of temperature; typical curves.

Tan δ (tangent of the loss angle)

Tan δ at 10 kHz	≤ 10 x 10^{-4} (typ. 1 x 10^{-4})

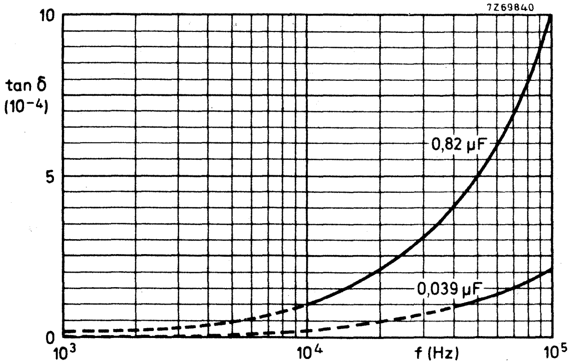


Fig. 5. Tan δ as a function of frequency; typical curves.

Temperature dependence at 100 Hz, 1 kHz, 10 kHz and 100 kHz	none

Power dissipation

Maximum permissible power dissipation	see "Additional information"
Pulse steepness	unlimited

Temperature

Rated temperature range	85 °C
Category temperature range	−40 to +85 °C
Storage temperature range	−55 to +85 °C
Climatic category, IEC68	40/085/56

PACKING

1000 pieces per box for capacitors with L_{max} = 21, 5 mm or 29 mm
500 pieces per box for capacitors with L_{max} = 34 mm

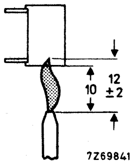
TESTS AND REQUIREMENTS

IEC68-2 test method	Name of test	Procedure (quick reference)	Requirements
Ua	Tensile strength of terminations	Loading weight 10 N in axial direction of the wire, 10 s.	No damage.
Ub	Bending of terminations	Loading weight 5 N, two consecutive bends.	No damage.
Fc	Vibration	10-55-10 Hz, amplitude 0, 75 mm or 10 g (whichever is the less), 2 h in 3 directions; capacitors mounted on printed-wiring boards.	No damage, no open or short-circuit; $\Delta C/C \leq 0,5\%$.
Eb	Bumping	25 g, 3 directions, 1000 bumps per direction, capacitors mounted on printed-wiring boards.	No damage, no open or short-circuit; $\Delta C/C \leq 0,5\%$.
T3.2	Soldering (solder bath)	Solderability: 230 °C, 2 s. Capacitors immersed up to 1, 5 mm from the body.	No damage, good tinning. $\Delta C/C \leq 0,5\%$.
		Resistance to heat: 350 °C, 3 s. Capacitors immersed up to 3, 5 mm from the body.	No damage; $\Delta C/C \leq 1\%$.
Na	Rapid change of temperature	5 cycles of 1 h at −40 °C and 1 h at +85 °C	No damage, no leakage, $\Delta C/C \leq 2\%$. Tan δ and insulation resistance shall meet initial requirements.

IEC68-2 test method		Name of test	Procedure (quick reference)	Requirements
Climatic sequence	Ba	Dry heat	16 h at +85 ± 2 ^{o}C, no voltage applied.	No damage, no leakage, $\Delta C/C \leq 5\%$ at 85 ^{o}C. Insulation resistance > 500 MΩ at 85 ^{o}C.
	Db	Accelerated damp heat, first cycle	24 h at 55 ± 2 ^{o}C and R.H. 95 to 100%; no voltage applied.	
	Aa	Cold	2 h at −40 ± 3 ^{o}C; no voltage applied.	$\Delta C/C \leq 5\%$ at −40 ^{o}C.
	M	Low air pressure	1 h at 25 ± 10 ^{o}C, at atmospheric pressure of 85 mbar.	During and after the test there shall be no breakdown or flashover.
	Db	Accelerated damp heat, remaining cycles	5 cycles of 24 h at 55 ^{o}C and R.H. 95 to 100%; no voltage applied.	$\Delta C/C \leq 1\%$. Tan δ shall meet initial requirements. Insulation resistance ≥ 0, 5 x initial requirements.
	Ca	Damp heat, steady state	56 days at 40 ± 2 ^{o}C and R.H. 90 to 95%; no voltage applied.	No damage, $\Delta C/C \leq 2\%$. Tan δ shall meet initial requirements. Insulation resistance ≥ 0, 5 x initial requirements.
	–	Endurance	1000 h at 85 ^{o}C, 1, 5 x U_R applied.	No damage, no open or short-circuit $\Delta C/C \leq 1\%$. Insulation resistance ≥ 0,5 x initial requirements; tan δ shall meet initial requirements.
			1000 h at 85 ^{o}C, 1, 5 x rated a.c. voltage, 50 Hz, applied.	

Name of test	Procedure (quick reference)	Requirements
Pulse load	10 000 cycles of charge (to rated d.c. voltage) and discharge (via a resistor of max. 10 mΩ) at 25 °C; cycle time: 1 cycle/s.	Δ tan $\delta \leq 2 \times 10^{-4}$ at 10 kHz.

Additional tests

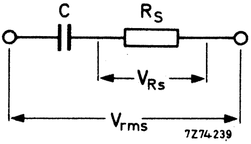
Solvent resistance	According to MIL-STD-202E, method 215.	No damage.
Soldering test for mounting on printed-wiring boards	Board thickness: 1, 6 mm, hole diameter: 1, 3 mm; non-metallized holes. Bath temp.: 250 ± 10 °C; dip-solder time: 5 ± 1 s.	No damage, good tinning; $\Delta C/C \leq 1\%$.
Damp heat, long term exposure (IEC68-2, test Ca)	56 days at 40 ± 2 °C, R.H. 90 to 95%; rated a.c. voltage applied for 8 h per 24 h.	No damage; $\Delta C/C \leq 2\%$. Tan δ shall not exceed initial requirements. Insulation resistance ≥0, 5 x initial requirements.
Flammability	 Bore of gas jet: 0,5 ± 0,1 mm. Fuel: butane. Test duration: 20 s.	After removal of the flame the capacitor must not continue to burn for more than 15 s; no burning particles should drip from the capacitor.

ADDITIONAL INFORMATION

The rated a.c. voltage, which has been specified at 50 - 60 Hz and 20 $^{\circ}$C, must also never be exceeded at other frequencies. Moreover this voltage value may further be limited by the maximum permissible power dissipation (P_{max}).

The power dissipated by a capacitor is a function of the voltage over the series resistance (R_s) or of the current through the series resistance and is expressed by

$$P = \frac{V_{R_s}{}^2}{R_s} = I^2 R_s \qquad (1)$$



$$V_{R_s}{}^2 = \frac{R_s{}^2}{R_s{}^2 + 1/\omega^2 C^2} V_{rms}{}^2 \qquad (2a)$$

As $\tan \delta = R_s \omega C$ for these capacitors is always $< 0,1$, equation (2a) can be simplified to

$$V_{R_s}{}^2 = \frac{R_s{}^2}{1/\omega^2 C^2} V_{rms}{}^2 = R_s{}^2 \omega^2 C^2 V_{rms}{}^2 \qquad (2b)$$

$$\text{Thus } P = R_s \omega^2 C^2 V_{rms}{}^2 = (R_s C)\, C \omega^2 V_{rms}{}^2, \qquad (3)$$

in which $\omega = 2\pi f$; the term (R_sC) can be found from Fig. 6.

The maximum permissible power dissipation (P_{max}), which depends on the dimensions of the capacitor and on the ambient temperature, can be found from Fig. 7.

Example

A capacitor of 0,39 μF is to be used at 40 kHz and an ambient temperature of 75 $^{\circ}$C.
The R_sC-product at 40 kHz is $1,59 \times 10^{-9}$ ΩF (Fig. 6). The maximum permissible power dissipation at 75 $^{\circ}$C is 630 mW (Fig. 7).
The maximum a.c. voltage can be calculated from (3):

$$V_{rms} = \sqrt{\left\{\frac{P_{max}}{(R_s C) C \omega^2}\right\}}$$

$$= \sqrt{\left\{\frac{0,63}{1,59 \times 10^{-9} \times 0,39 \times 10^{-6} \times 4\pi^2 \times 16 \times 10^8}\right\}} = 126 \text{ V}$$

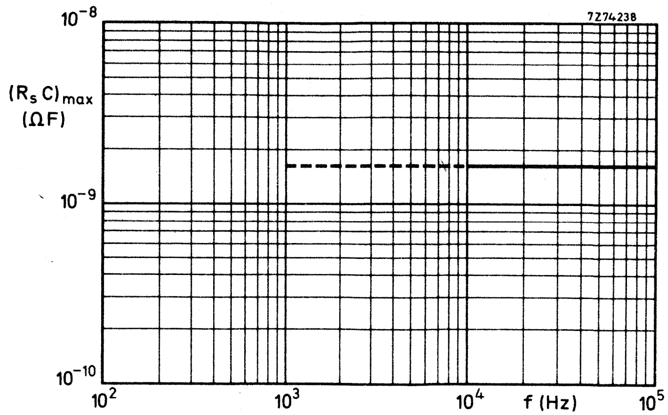


Fig. 6.
R_sC product as a function of frequency.

	dimensions in mm		
curve	T_{max}	L_{max}	H_{max}
1	8	21,5	15
2	10	21,5	17
3	8,5	29	18,5
4	10	29	20
5	10	34	20
6	12	34	22
7	15	34	25
8	18	34	28

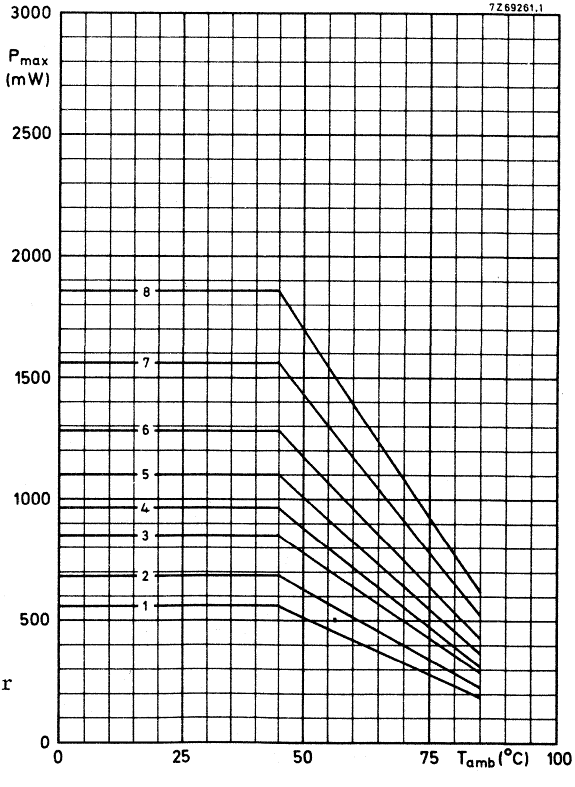
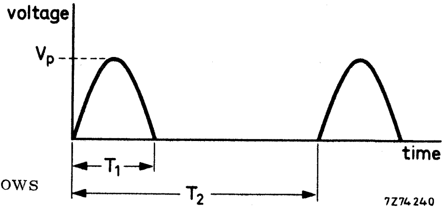


Fig. 7. Maximum permissible power dissipation as a function of temperature.

For a capacitor used with a half-sine pulse, the power dissipation as a function of the voltage over a resistance R is expressed by

$$P = \frac{T_1}{T_2}\,\frac{(1/2\,V_p\sqrt{2})^2}{R} = (V_p\sqrt{\frac{T_1}{2\,T_2}})^2\,\frac{1}{R} \qquad (4)$$



From the general expression $P = \frac{V_{rms}^{\;2}}{R}$ follows

$$V_{rms} = V_p\sqrt{\frac{T_1}{2\,T_2}} \qquad (5)$$

Substition of (5) into (3) gives

$$P = (R_sC)\,C\omega^2\,(V_p\sqrt{\frac{T_1}{2T_2}})^2,\ \text{in which} \qquad (6)$$

$\omega = 2\pi f = 2\pi\,\frac{1}{2T_1}$; the term (R_sC) can be found from Fig. 6.

The maximum permissible power dissipation (P_{max}), which depends on the dimensions of the capacitor and on the ambient temperature, can be found from Fig. 7.

Example

A capacitor of 0,056 µF is to be used at a half-sine pulse (pulse duration 12 µs, repetition time 64 µs) and an ambient temperature of 80 °C.
As the half period time is 12 µs, the pulse frequency is $\frac{1}{2 \times 12 \times 10^{-6}}$ Hz = 42 kHz.
The (R_sC) product at 42 kHz is $1,59 \times 10^{-9}$ ΩF (Fig. 6).

The maximum permissible power dissipation at 80 °C is 230 mW (Fig. 7).

The maximum peak voltage can be calculated from (6) :

$$V_p = \sqrt{\frac{P_{max}}{(R_sC)\,C\omega^2} \times \frac{2T_2}{T_1}}$$

$$= \sqrt{\frac{0,23 \times 2 \times 64 \times 10^{-6}}{1,59 \times 10^{-9} \times 0,056 \times 10^{-6} \times 4\pi^2 \times 42^2 \times 10^6 \times 12 \times 10^{-6}}}$$

= 629 V.

However this voltage may not be applied because of the restriction that the peak value of the a.c. voltage must be ≤ rated a.c. voltage x $\sqrt{2}$.
In this case $V_p \leq 160\sqrt{2} = 226$ V.

POLYSTYRENE FILM/FOIL CAPACITORS

axial type (micropoco)

QUICK REFERENCE DATA	
Rated capacitance range (E24-series)	51 to 162 000 pF
Tolerance on rated capacitance	± 5%, ± 2% and ± 1%
Rated voltage U_R (d.c.)	63 V, 125 V, 250 V and 500 V
Rated temperature	
63 V version	70 °C
125 V, 250 V, 500 V versions	85 °C
Climatic category, IEC 68	
63 V version	40/070/21
125 V, 250 V, 500 V versions	40/085/21
Basic specification	IEC 275

APPLICATION

For use in circuits where precision, reliability and low losses are of prime importance e.g. tuned circuits, filter networks, etc.

DESCRIPTION

These capacitors consist of a low-inductive wound cell of tin-lead foil with a polystyrene film. The cell is covered with a green plastic film.
The long, axial leads of solder-coated wire make the capacitor suitable for vertical or horizontal mounting on printed-wiring boards and also for point-to-point wiring.

Composition of the catalogue number

2222 ... .

code for capacitance, see Tables 1 to 4

424 = 63 V 425 = 125 V 426 = 250 V 427 = 500 V	packed in boxes	2 = ± 5% 3 = ± 2% 4 = ± 1%
428 = 63 V 429 = 125 V 430 = 250 V 431 = 500 V	packed on bandoliers and reels	6 = ± 5% 7 = ± 2% 8 = ± 1%

MECHANICAL DATA

Dimensions in mm

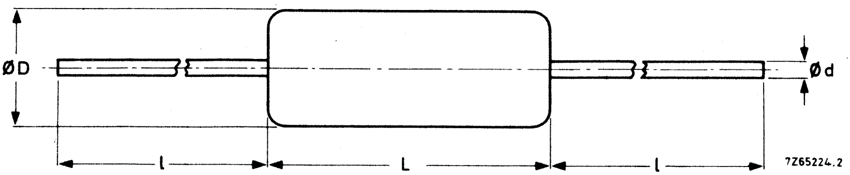


Fig. 1. For dimensions D, L, d and l see tables below.

Table 1 - U_R = 63 V

rated capacitance (pF)	D_{max}	L_{max}	d	l_{min}	approx. mass (g)	capacitance code
1200	3,5	10,9	0,6	28	0,3	1202
1300						1302
1500						1502
1600						1602
1800						1802
2000						2002
2200					0,4	2202
2400						2402
2700	4,0					2702
3000						3002
3300						3302
3600						3602
3900						3902
4300	4,5				0,5	4302
4700						4702
5100						5102
5600					0,6	5602
6200	5,0					6202
6800						6802
7500		15	0,6	25,5		7502
8200						8202
9100					0,7	9102
10000						1003
11000	5,5				0,8	1103
12000						1203
13000					0,9	1303
15000					1,1	1503
16000	6,0					1603
18000						1803
20000					1,3	2003

Table 1 - U_R = 63 V (continued)

rated capacitance (pF)	D_{max}	L_{max}	d	l_{min}	approx. mass (g)	capacitance code
22000	6,5	15	0,6	25,5	1,3	2203
24000					1,4	2403
27000	7,0				1,5	2703
30000					1,7	3003
33000	7,5				1,9	3303
36000						3603
39000	8,0				2,0	3903
43000	7,0	26	0,8	38	3,5	4303
47000	7,5					4703
51000						5103
56000	8,0				4,1	5603
62000	8,5					6203
68000						6803
75000	9,0				5,2	7503
82000	9,5					8203
91000						9103
100000	10,0				6,6	1004
110000	10,5					1104
120000	11,0					1204
130000	11,5				7,6	1304
150000	12,0				8,5	1504
160000	12,5				9,2	1604
162000						1624

Table 2 - U_R = 125 V

rated capacitance (pF)	D_{max}	L_{max}	d	l_{min}	approx. mass (g)	capacitance code
820	3,5	10,9	0,6	28	0,3	8201
910						9101
1000						1002
1100						1102
1200	4,0					1202
1300						1302
1500					0,4	1502
1600						1602
1800	4,5					1802
2000						2002
2200						2202
2400					0,5	2402
2700						2702

Table 2 - U_R = 125 V (continued)

rated capacitance (pF)	D_{max}	L_{max}	d	l_{min}	approx. mass (g)	capacitance code
3000	5,0	10,9	0,6	28	0,5	3002
3300						3302
3600					0,6	3602
3900						3902
4300		15	0,6	25,5		4302
4700						4702
5100						5102
5600					0,7	5602
6200						6202
6800	5,5				0,8	6802
7500						7502
8200	6,0				0,9	8202
9100						9102
10000					1,1	1003
11000	6,5					1103
12000					1,2	1203
13000					1,3	1303
15000	7,0				1,4	1503
16000					1,5	1603
18000	6,5	26	0,8	38	2,3	1803
20000	7,0					2003
22000					2,6	2203
24000	7,5				2,8	2403
27000						2703
30000	8,0				3,3	3003
33000	8,5					3303
36000					3,7	3603
39000	9,0				3,9	3903
43000	9,5				4,3	4303
47000						4703
51000	10,0				4,8	5103
56000	10,5				5,2	5603
62000	11,0				5,7	6203
68000	11,5				6,2	6803
75000	12,0				6,7	7503
82000	12,5				7,3	8203

Table 3 - U_R = 250 V

rated capacitance (pF)	D_{max}	L_{max}	d	l_{min}	approx. mass (g)	capacitance code
390	3,5	10,9	0,6	28	0,3	3901
430						4301
470						4701
510						5101
560						5601
620						6201
680						6801
750						7501
820	4,0				0,4	8201
910						9101
1000						1002
1100	4,5					1102
1200					0,5	1202
1300						1302
1500						1502
1600	5,0					1602
1800						1802
2000					0,6	2002
2200						2202
2400		15	0,6	25,5	0,5	2402
2700					0,6	2702
3000						3002
3300						3302
3600					0,7	3602
3900						3902
4300						4302
4700	5,5				0,8	4702
5100						5102
5600	6,0				0,9	5602
6200						6202
6800	6,5				1,1	6802
7500						7502
8200	7,0				1,3	8202
9100	7,5					9102
10000					1,5	1003
11000					1,6	1103
12000	7,0	26	0,8	38	2,4	1203
13000						1303
15000	7,5				2,6	1503
16000						1603
18000	8,0				2,9	1803
20000	8,5				3,1	2003
22000					3,3	2203
24000	9,0				3,5	2403

Table 3 - U_R = 250 V (continued)

rated capacitance (pF)	D_{max}	L_{max}	d	l_{min}	approx. mass (g)	capacitance code
27000	9,5	26	0,8	38	3,9	2703
30000	10,0				4,1	3003
33000	10,5				4,5	3303
36000					4,8	3603
39000	11,0				5,1	3903
43000	11,5				5,5	4303
47000	12,0				5,9	4703

Table 4 - U_R = 500 V

rated capacitance (pF)	D_{max}	L_{max}	d	l_{min}	approx. mass (g)	capacitance code
51	3,5	10,9	0,6	28	0,2	5109
56						5609
62						6209
68						6809
75						7509
82						8209
91						9109
100						1001
110						1101
120						1201
130						1301
150						1501
160						1601
180						1801
200						2001
220						2201
240					0,3	2401
270						2701
300						3001
330						3301
360						3601
390	4,0					3901
430						4301
470						4701
510					0,4	5101
560						5601
620	4,5					6201
680						6801

Table 4 - U_R = 500 V (continued)

rated capacitance (pF)	D_{max}	L_{max}	d	l_{min}	approx. mass (g)	capacitance code
750	5,0	10,9	0,6	28	0,4	7501
820						8201
910					0,5	9101
1000						1002
1100						1102
1200						1202
1300		15	0,6	25,5	0,6	1302
1500						1502
1600	5,5				0,7	1602
1800					0,8	1802
2000						2002
2200					0,9	2202
2400					1,1	2402
2700	6,0					2702
3000	6,5					3002
3300					1,4	3302
3600	7,0					3602
3900						3902
4300	7,5				1,7	4302
4700	8,0					4702
5100						5102
5600					2,0	5602
6200	7,5	26	0,8	38	1,8	6202
6800						6802
7500	8,0				2,1	7502
8200						8202
9100	8,5				2,3	9102
10000	9,0				2,5	1003
11000					2,7	1103
12000	9,5				2,9	1203
13000	10,0				3,1	1303
15000	10,5				3,5	1503
16000	11,0				3,7	1603
18000	11,5				4,1	1803
20000	12,0				4,5	2003
22000	12,5				4,9	2203
24000					5,2	2403

Marking

The capacitors are marked in ink as follows:
1st line: rated capacitance in pF or nF;
2nd line: tolerance code (F = ± 1%, G = ± 2%, J = ± 5%) and rated voltage;
3rd line: production code.

Mounting

The capacitors are suited for horizontal or vertical mounting on printed-wiring boards and for point-to-point wiring.
When bending, cutting or flattening the leads, one should relieve them of the applied load at the capacitor body. When soldering, the body temperature should not exceed 100 °C (see "TESTS AND REQUIREMENTS - Additional tests").

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of 23 ± 1 °C, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 50 ± 2%.

Capacitance

Rated capacitance values (C) at 1 kHz	see tables 1 to 4 [1]
Tolerance on rated capacitance	± 5%, ± 2% and ± 1% or 1 pF whichever is greater
Temperature coefficient	−125 ± 60 ppm/°C
Frequency dependence between 100 Hz and 1 MHz	none

Voltage

Rated d.c. voltage U_R	63 V, 125 V, 250 V, 500 V
Rated a.c. voltage, 50-60 Hz	
63 V version	25 V
125 V version	63 V
250 V version	125 V
500 V version	250 V
Category voltage U_C	1 x U_R
Test voltage (d.c.) for 1 min	
between terminals	2 x U_R
between interconnected terminals and coating	2 x U_R (minimum 400 V)

Insulation resistance

The insulation resistance is measured after a voltage has been applied for 1 min ± 5 s, the voltage being 10 ± 1 V for the 63 V version, 100 ± 15 V for the 125 V- and 250 V versions, and 500 ± 15 V for the 500 V version.

	ambient temperature	
	20 °C	70 °C
R between terminals, for C ≤ 100 000 pF	> 100 000 MΩ	> 100 000 MΩ
RC between terminals, for C > 100 000 pF	> 10 000 s	> 10 000 s

---

[1] Capacitance values of the E24 series as quoted in the tables 1 to 4 are preferred; intermediate capacitance values of the E96 series (with a tolerance of ± 1%) and of the E48 series (with a tolerance of ± 2% or ± 1%) are available on request.

Tan δ (tangent of the loss angle)

Tan δ at 10 kHz	for C > 20 000 pF	$\leq 5 \times 10^{-4}$
at 100 kHz	for 1000 pF < C ≤ 20 000 pF	$\leq 5 \times 10^{-4}$
at 1 MHz	for C ≤ 1000 pF	$\leq 10 \times 10^{-4}$

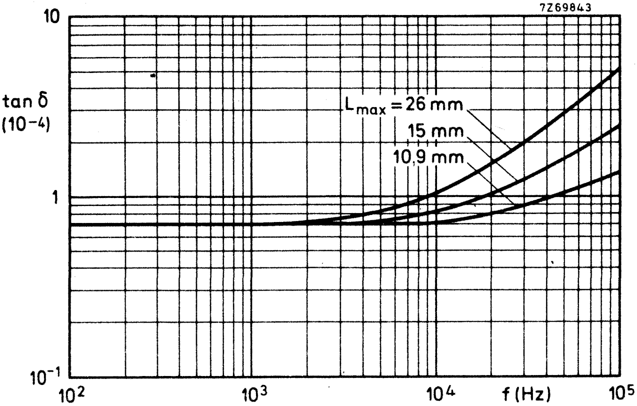


Fig. 2. Tan δ as a function of frequency; typical curves.

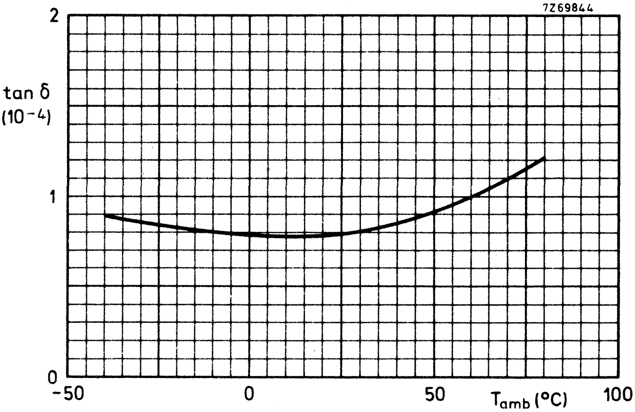


Fig. 3. Tan δ as a function of temperature; typical curve.

Resonant frequency

Resonant frequency, length between soldering points 20 mm	$\frac{1126}{\sqrt{C}}$ MHz	C in pF
length between soldering points 30 mm	$\frac{919}{\sqrt{C}}$ MHz	
length between soldering points 40 mm	$\frac{796}{\sqrt{C}}$ MHz	

Temperature

Rated temperature	
63 V version	70 °C
125 V, 250 V and 500 V versions	85 °C
Category temperature range	
63 V version	−40 to +70 °C
125 V, 250 V and 500 V versions	−40 to +85 °C
Storage temperature range	
63 V version	−55 to +70 °C
125 V, 250 V and 500 V versions	−55 to +85 °C
Climatic category, IEC 68	
63 V version	40/070/21
125 V, 250 V and 500 V versions	40/085/21

PACKING

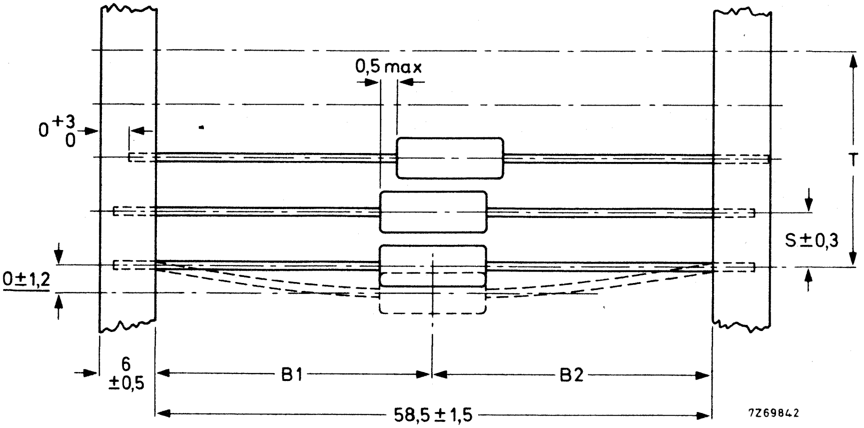
The capacitors are supplied in cardboard boxes or on bandoliers on reels.

Packing in cardboard boxes

capacitance values (pF) of				number of capacitors per box
63 V version	125 V version	250 V version	500 V version	
1200-2400	820-1100	390-750	51-360	500
2700-3900	1200-1600	820-1000	390-560	400
4300-5600	1800-2700	1100-1500	620-680	300
6200-6800	3000-3900	1600-2200	750-1200	250
7500-10000	4300-6200	2400-4300	1300-1500	300
11000-20000	6800-10000	4700-6200	1600-2700	250
22000-24000	11000-13000	6800-7500	3000-3300	200
27000-39000	15000-16000	8200-11000	3600-5600	150
43000-56000	18000-30000	12000-18000	6200-8200	600
62000-91000	33000-47000	20000-27000	9100-12000	500
100000-130000	51000-68000	30000-43000	13000-18000	400
150000-162000	75000-82000	47000	20000-24000	300

Packing on bandoliers on reels

Dimensions in mm



|B1-B2| = max. 1, 2

Fig. 4

capacitance values (pF) of				S	T for number (n) of capacitors	
63 V version	125 V version	250 V version	500 V version		n < 50	50 < n < 100
1200-5600	820-2700	390-1500	51-680	5	5(n-1) ± 2	5(n-1) ± 4
6200-39000	3000-16000	1600-11000	750-5600	10	10(n-1) ± 2	10(n-1) ± 4

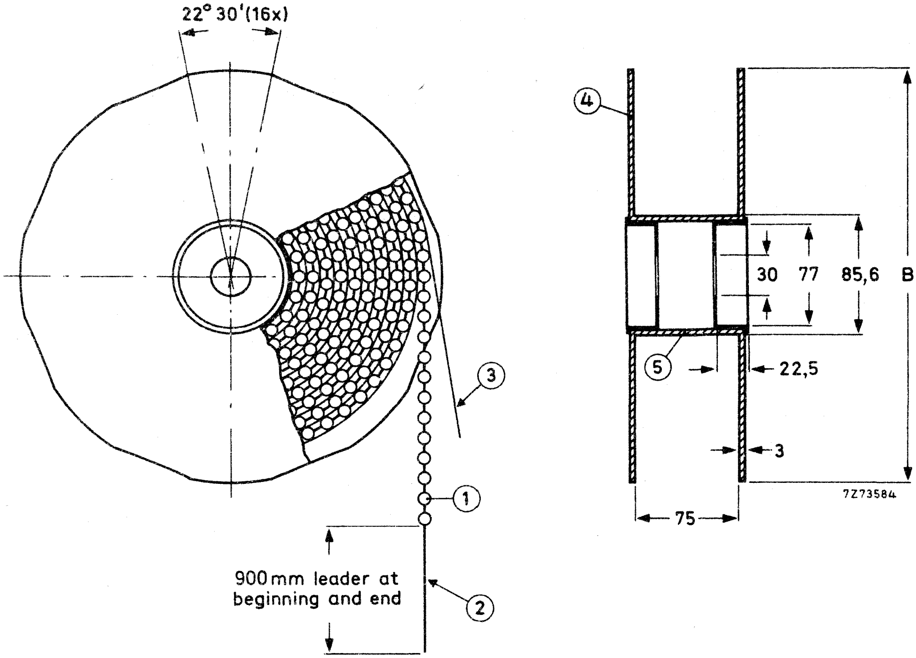


Fig. 5

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

capacitance values (pF) of				B	number of capacitors on one reel
63 V version	125 V version	250 V version	500 V version		
1200-2400	820-1100	390-750	51-360	305	3500
2700-5600	1200-2700	820-1500	390-680	305	2500
6200-20000	3000-10000	1600-6200	750-2700	356	1500
22000-39000	11000-16000	6800-11000	3000-5600	356	1000

TESTS AND REQUIREMENTS

IEC 275 clause	IEC 68-2 test method	Name of test	Procedure (quick reference)	Requirements
15.1	Ua	Tensile strength of terminations	Loading weight 10 N in axial direction of the wire, 10 s.	No damage.
15.2	Ub	Bending of terminations	Loading weight 5 N, two consecutive bends.	No damage.
	Uc	Torsion of terminations	Two successive rotations of 180° in opposite direction.	
16	Ta	Soldering (solder bath)	Solderability: 230 °C, 2 s.	No damage, good tinning; $\Delta C/C \leq 0,5\%$.
17	Na	Rapid change of temperature	5 cycles of 1 h at −40 °C and 1 h at +70 °C (63 V version) or +85 °C (other versions).	No damage, no leakage; $\Delta C/C \leq 0,5\% +$ 0,5 pF. Tan δ and insulation resistance meet initial requirements.
18	Fc	Vibration	10 to 55 Hz, amplitude 0,75 mm or 10 g (whichever is the less), 2 h in 3 directions; capacitors mounted on printed-wiring boards.	No damage

IEC 275 clause		IEC 68-2 test method	Name of test	Procedure (quick reference)	Requirements
Climatic sequence	20.2	Ba	Dry heat	16 h at +70 ± 2 °C (63 V version) or 16 h at +85 ± 2 °C (125 V, 250 V, 500 V versions); no voltage applied.	No damage, no leakage.
		Db	Accelerated damp heat, first cycle	12 h at 55 ± 2 °C, R.H. 93 ± 3%, and 12 h at 25 ± 3 °C, R.H. >95%; no voltage applied	
	20.4	Aa	Cold	2 h at −40 ± 3 °C; no voltage applied	
	20.5	M	Low air pressure	1 h at 25 ± 5 °C, at atmospheric pressure of 300 mbar.	During and after the test there shall be no breakdown or flashover.
		Db	Accelerated damp heat, remaining cycles	1 cycle of 12 h at 55 ± 2 °C, R.H. 93 ± 3 °C, and 12 h at 25 ± 3 °C, R.H. >95%; no voltage applied.	Final measurements: $\Delta C/C \leq 1\%$ ($C \geq 500$ pF), $\leq 1,5\%$ or 1 pF, whichever is greater ($C < 500$ pF). Tan $\delta \leq 2$ x initial requirements; insulation resistance > 0,5 x initial requirements.

IEC 275 clause	IEC 68-2 test method	Name of test	Procedure (quick reference)	Requirements
21	Ca	Damp heat, steady state	21 days at 40 ± 2 °C and R.H. 90 to 95%; 6 V applied (continuously)	$\Delta C/C \leq 1\%$ ($C \geq 500$ pF), $\leq 1,5\%$ or 1 pF, whichever is greater ($C < 500$ pF). Tan $\delta \leq 2$ x initial requirements. Insulation resistance $> 0,5$ x initial requirements.
		Endurance	1000 h at 70 °C (63 V version) or at 85 °C (125 V, 250 V, 500 V versions); 1,5 x U_R applied.	$\Delta C/C \leq 0,3\%$ (63 V version), $\leq 0,5\% + 0,5$ pF (other versions). Tan $\delta \leq$ initial requirements or $\leq 1,4$ x initial measurements. Insulation resistance meets initial requirements.
23	Hb	Storage at low temperature	72 h at −55 °C.	No breakdown; $\Delta C/C \leq 0,25\%$ ($C > 500$pF), $\leq 0,4\%$ ($C \leq 500$ pF).
15.5		Temperature cycling drift	1 cycle of +25 °C/−40 °C/+70 °C/ +25 °C.	$\Delta C/C \leq 0,1\%$

Additional tests

Name of test	Procedure (quick reference)	Requirements
Solderability of leads (globule method, IEC 68, test T3.2)	16 h at 155 ± 2 °C.	Good tinning, 4 s yield point.
Solderability	IEC 275-16. Bath temperature 270 ± 10 °C; 2 ± 0,5 s. The leads are immersed to 3,5 mm from the body.	No damage, good tinning. $\Delta C/C < 0,5\%$ ($C > 500$ pF), $< 0,75\%$ or 0,5 pF, whichever is greater ($C \leq 500$ pF).
Soldering test for mounting on printed-wiring boards	Capacitors mounted vertically on the board, without plated-through holes; bodies rest on the board; without forced cooling.	
	Bath temp. 260 °C, dip solder time 2 s;	$\Delta C/C \leq 1\%$.
	bath temp. 260 °C, dip solder time 3 s;	$\Delta C/C \leq 2\%$.
	bath temp. 240 °C, dip solder time 3 s;	$\Delta C/C \leq 1\%$.
	bath temp. 240 °C, dip solder time 5 s.	$\Delta C/C \leq 2\%$.
	Capacitors mounted horizontally on the board, with plated-through holes; bodies at least 1 mm from the board; max. permissible body temperature for 1 min is 100 °C.	$\Delta C/C \leq 1\%$. Forced cooling of the component side of the board gives less capacitance drift.

POLYSTYRENE FILM/FOIL CAPACITORS

potted type ("p.f.c.")

QUICK REFERENCE DATA

Rated capacitance range (E96-series)	100 to 12100 pF
Tolerance on rated capacitance	± 1%
Rated voltage U_R (d.c.)	63 V
Rated temperature	70 °C
Climatic category, IEC68	40/070/56
Basic specification	IEC275

APPLICATION

For use in LC filters, particularly in telephony equipment, where high requirements are imposed on precision, stability, humidity, dissipation factor and reliability.
The dimensions are such that, in combination with currently available ferrites, a high package density is possible.

DESCRIPTION

These capacitors consist of a low-inductance winding of polystyrene film and tin/lead foil. The winding is potted in a yellow flame retardant polypropylene case, which can withstand solvents and rinsing liquids.
The low thermal conductivity of the radial leads provides optimum soldering conditions.
The capacitors are provided with stand-off ridges to give a clearance between the capacitor and the printed-wiring board.

Composition of the catalogue number

2222 443 .....

4 = capacitors ≤ 3920 pF, according to Fig. 1a or
capacitors > 3920 pF, according to Fig. 1b

8 = capacitors ≤ 3920 pF, according to Fig. 1b

multiplying factor
1 = 1x
2 = 10x
3 = 100x

first three figures of capacitance value in pF

For ordering purposes please quote the catalogue number.

Examples: a capacitor of 4700 pF should be ordered as 2222 443 44702;
a capacitor of 121 pF according to Fig. 1b, should be ordered as 2222 443 81211;
a capacitor of 12100 pF should be ordered as 2222 443 41213.

MECHANICAL DATA

Dimensions in mm

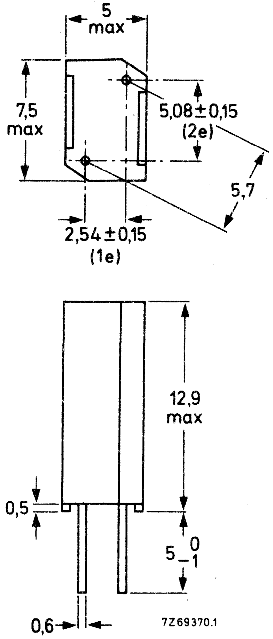


Fig. 1a Capacitors of rated capacitance range 100 to 3920 pF.

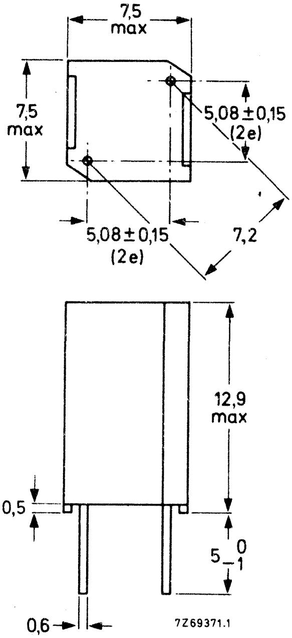


Fig. 1b Capacitors of rated capacitance range 100 to 12100 pF.

Marking

The capacitors are marked in ink on the top with:
1st line: rated capacitance (in pF to 976 pF, in nF above this value);
2nd line: tolerance code (F = ± 1%), rated voltage (d.c.) and code for dielectric (KS = polystyrene) ;
3rd line: production code.

Note - the earth side is indicated by a vertical line to the left of the 2nd and 3rd lines of marking.

Mounting

The capacitors are designed for mounting on printed-wiring boards.

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of 23 ± 1 °C, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 50 ± 2%.

Capacitance

Rated capacitance values at 1 kHz, for $C > 1000$ pF and at 1 MHz, for $C \leq 1000$ pF	100 to 12100 pF (E96-series)
Tolerance on rated capacitance	± 1%
Temperature coefficient	
$C \leq 6000$ pF	$-(125 \pm 30)$ ppm/°C
$C > 6000$ pF	$-(160 \pm 40)$ ppm/°C
Frequency dependence between 100 Hz and 1 MHz	none

Voltage

Rated d.c. voltage U_R	63 V
Rated a.c. voltage, 50-60 Hz	25 V
Test voltage (d.c.) for 1 min	
between terminals	$2 \times U_R$
between interconnected terminals and case	400 V

Insulation resistance

The insulation resistance is measured after a voltage of 10 ± 1 V has been applied for 1 min ± 5 s.

R between terminals, at 23 °C	> 500 000 MΩ
R between interconnected terminals and case, at 23 °C	> 500 000 MΩ

Tan δ (tangent of the loss angle)

Tan δ at 1 MHz, for $C \leq 500$ pF	$\leq 5 \times 10^{-4}$
at 1 MHz, for 500 pF $< C \leq 1000$ pF	$\leq 10 \times 10^{-4}$
at 1 kHz, for $C > 1000$ pF	$\leq 2 \times 10^{-4}$

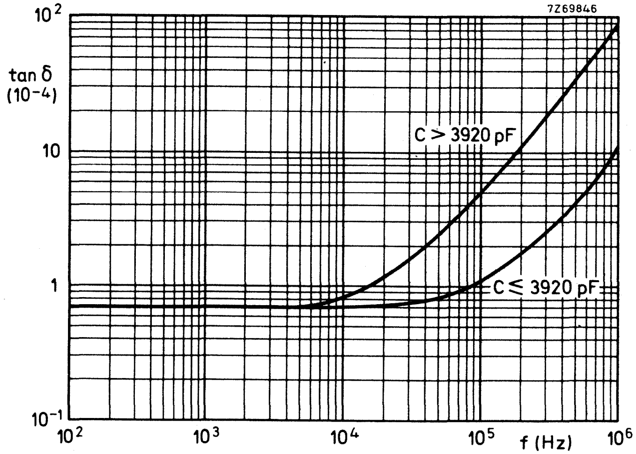


Fig. 2. Tan δ as a function of frequency; typical curves.

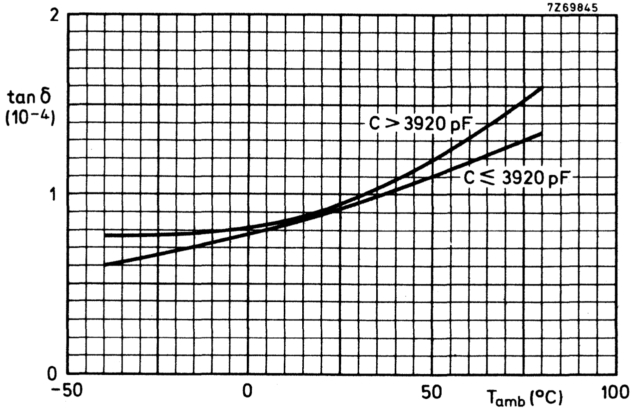


Fig. 3. Tan δ as a function of temperature; typical curves.

Resonant frequency

Resonant frequency, total lead length 2 x 1 mm $\geq \frac{8,5 \times 10^2}{\sqrt{C}}$ MHz (C in pF)

Temperature

Rated temperature	70 °C
Category temperature range	−40 to +70 °C
Storage temperature range	−55 to +70 °C
Climatic category, IEC68	40/070/56

PACKING

200 pieces per box.

TESTS AND REQUIREMENTS

IEC275 clause	IEC68-2 test method	Name of test	Procedure (quick reference)	Requirements
15.1	Ua	Tensile strength of terminations	Loading weight 10 N in axial direction of the wire, 10 s.	No damage.
16	Ta	Soldering (solder bath)	Solderability: 270 °C, 2 s.	No damage, good tinning; $\Delta C/C \leq 0,25\%$ or 1 pF whichever is the greater.
17	Na	Rapid change of temperature	5 cycles of 30 min at −40 °C and 30 min at +70 °C.	No damage, no leakage; $\Delta C/C \leq 0,2\%$. Tan δ and insulation resistance shall meet initial requirements.
18	Fc	Vibration	10 to 55 Hz, amplitude 0,75 mm or 10 g (whichever is the less), 2 h in 3 directions; capacitors mounted on printed-wiring boards.	No damage, no open or short circuit. $\Delta C/C \leq 0,1\%$.
19	Eb	Bumping	40 g, 3 directions, 4000 bumps per direction, capacitors mounted on printed-wiring boards.	No damage, no open or short circuit. $\Delta C/C \leq 0,1\%$.

IEC275 clause	IEC68-2 test method	Name of test	Procedure (quick reference)	Requirements
Climatic sequence 20.2	Ba	Dry heat	16 h at +70 ±3 °C, no voltage applied.	No damage, no leakage.
20.3	D	Accelerated damp heat, first cycle	24 h at 55 ±2 °C and R.H. 95 to 100%; no voltage applied.	
20.4	Aa	Cold	2 h at −40 ±3 °C; no voltage applied.	
20.5	M	Low air pressure	1 h at 25 ±5 °C, at atmospheric pressure of 85 mbar	During and after the test there shall be no breakdown or flashover.
20.6	D	Accelerated damp heat, remaining cycles	5 cycles of 24 h at 55 °C and R.H. 95 to 100%; no voltage applied.	Final measurements: $\Delta C/C \leq 0,5\% + 0,5$ pF. Tan δ at 1 kHz $\leq 2,4 \times 10^{-4}$ ($C > 1000$ pF); at 1 MHz $\leq 6 \times 10^{-4}$ ($C \leq 500$ pF); at 1 MHz $\leq 12 \times 10^{-4}$ (500 pF $< C \leq 1000$ pF). Insulation resistance $> 5 \times 10^5$ MΩ.
21	Ca	Damp heat, steady state	56 days at 40 °C and R.H. 90 to 95%; 6 V applied (continuously).	$\Delta C/C \leq 0,75\% + 0,5$ pF. Tan δ at 1 kHz $\leq 2,4 \times 10^{-4}$ ($C > 1000$ pF); at 1 MHz $\leq 6 \times 10^{-4}$ ($C \leq 500$ pF); at 1 MHz $\leq 12 \times 10^{-4}$ (500 pF $< C \leq 1000$ pF). Insulation resistance $> 5 \times 10^5$ MΩ.
		Endurance	1000 h at 70 °C, $1,5 \times U_R$ applied.	$\Delta C/C \leq 0,3\% + 0,3$ pF. Tan δ at 1 kHz $2,8 \times 10^{-4}$ ($C > 1000$ pF); at 1 MHz 7×10^{-4} ($C \leq 500$ pF); at 1 MHz 14×10^{-4} (500 pF $< C \leq 1000$ pF). Insulation resistance shall meet initial requirement.
23	Hb	Storage at low temperature	72 h at −55 °C.	No breakdown; $\Delta C/C \leq 0,25\%$ or 1 pF, whichever is the greater.

ADDITIONAL TESTS

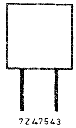
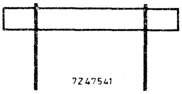
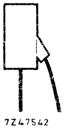
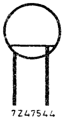
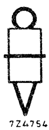
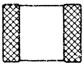
Name of test	Procedure (quick reference)	Requirements
Long term stability	10 000 h at 55 °C, 25 V d.c. applied.	$\Delta C/C \leq 0,3\% + 0,3$ pF.
Endurance	2000 h at 70 °C, 1,5 x U_R applied.	$\Delta C/C \leq 0,3\% + 0,3$ pF.
Solderability of leads (solder bath method, IEC68, test Ta)	16 h at 155 ± 2 °C.	Good tinning.
Soldering test for mounting on printed-wiring boards	Board thickness : 1,6 mm, hole diameter : 0,8 mm; plated-through holes. Bath temp. : 250 ± 10 °C; dip solder time : 5 ± 0,5 s. Bath temp. : 260 ± 10 °C; dip solder time : 3 ± 0,5 s.	$\Delta C/C \leq 0,25\%$ or 1 pF whichever is the greater.
Voltage test (destructive test)	5 x U_R between terminals for 1 s.	No breakdown.

Ceramic capacitors

SURVEY

Application type 1 - for tuning and other applications where low losses and a linear temperature dependence are required.

Application type 2 and 3 - for all coupling and decoupling purposes.

version	application	capacitance range (pF)	rated d.c. voltage (V)	capacitor series	page
plate 				2222 631-632	
	1	0,56- 560	63/100	2222 638	
				2222 641-643	67
		0,47- 220	500	2222 650	83
	2	1000- 22000	63	2222 629	
		180- 4700	100	2222 630	
		1000- 10000	100	2222 640	55
		100- 2700	500	2222 655	93
	3	22000-100000	6	2222 675	101
tubular 	1	0,8- 820	500	2222 555	37
	2	680- 22000	500	2222 552	33
	safety	22- 4700	400 (a.c.)	2212 619	9
tubular 	2	1,5- 10000	500	2222 563 *)	
		2200- 10000	125	2222 565	41
disc 				2222 625	
	1	0,47- 100	400	2222 626	47
	2	100- 3900	400	2222 627	51
		33- 560	2000	2222 659	15
		220- 2200	250 (a.c.)	2212 660	21
	safety	33- 1000	400 (a.c.)	2212 661	27
feed-through  	2	2,5- 2200	350	2222 700	
		2,5- 4700	350	2222 702	107
chip 	1	10- 10000	50		
	2	100-470000	50	2222 851-856	111

*) Obsolescent.

MARKING

Colour code

	temperature coefficient	capacitance value			tolerance on capacitance	
		first digit	second digit	multiplier for the capacitance	C ≤ 10 pF (pF)	C > 10 pF (%)
red/violet	P100					
black	NP0		0	1		±20
brown	N033	1	1	10	±0, 1	±1
red	N075	2	2	10^2	±0, 25	±2
orange	N150	3	3	10^3		
yellow	N220	4	4	10^4		
green	N330	5	5		±0, 5	±5
blue	N470	6	6			
violet	N750	7	7			
grey		8	8	10^{-2}		
white		9	9	10^{-1}	±1	±10
orange/orange	N1500					

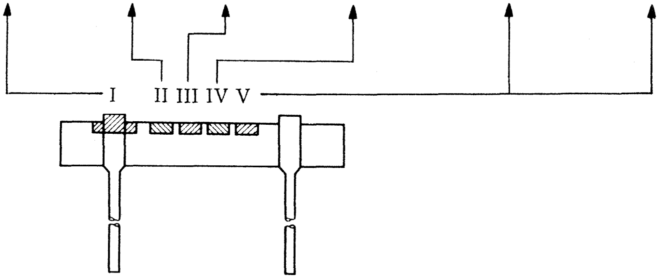
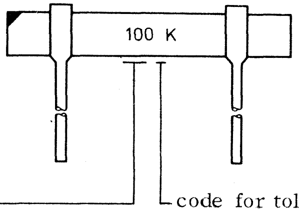


Figure code



colour code for temp. coefficient, see Table above

capacitance value in pF, using K for the thousands

code for tolerance on capacitance:

C ≤ 10 pF		C > 10 pF	
tol (pF)	code	tol (%)	code
±0,25	C	±1	F
±0, 5	D	±2	G
±1	F	±5	J
		±10	K
		±20	M
		−20/+50	S

INTRODUCTION

Ceramic capacitors are widely used in electronic circuitry for coupling and decoupling, and in filters. These different functions require different capacitor properties.

Ceramic capacitors can be divided into three classes:

Type 1 In these capacitors dielectric materials are used which have very high specific resistance, very good Q and linear temperature dependence (ϵ_r from 6 up to 250). They are used in such applications as oscillators and filters where low losses, capacitance drift compensation and high stability are required.

Type 2 These capacitors show higher losses and have non-linear temperature characteristics ($\epsilon_r > 250$). They are used in all kinds of electronic circuits for coupling and decoupling purposes.

The survey below shows the various materials we use with their basic chemical composition.

TYPE 1 $\epsilon_r = 6$ up to 250 T.C. types			TYPE 2 $\epsilon_r > 250$ high-K types
P100	(+100 ppm/°C)	$MgTiO_3$, Mg_2SiO_4	$\epsilon_r = 2000$ $BaTiO_3$
NP0	(0 ,, ,,)	$MgTiO_3$	$\epsilon_r = 5000$ (Ba, Ca)(Ti, Zr)O_3 + add.
N075	(-75 ,, ,,)	$Ba_2Ti_9O_{20} + TiO_2$	$\epsilon_r = 16000$ (Ba, Ca)(Ti, Zr)O_3 + add.
N150	(-150 ,, ,,)		
N220	(-220 ,, ,,)		
N330	(-330 ,, ,,)		
N470	(-470 ,, ,,)		
N750	(-750 ,, ,,)	TiO_2 + additions	
N1500	(-1500 ,, ,,)	$CaTiO_3$ + additions	

Type 3 Capacitors of this class have a special semiconductive dielectric material that, together with the electrodes, is oxidized on both sides thus forming diodes in anti-series. The very high specific capacitance per mm^2 results in capacitance values up to 0,1 μF with, however, a limiting d.c. working voltage of 6 V. They are used for coupling and decoupling purposes in small transistorized equipment.

CONSTRUCTION

The capacitance of a ceramic capacitor depends on the area of the electrodes (A), the thickness of the ceramic dielectric (t) and the dielectric constant of the ceramic material (ϵ_r); and on the number of dielectric layers (n) with multilayer ceramic capacitors:

$$C = \epsilon_r \epsilon_o \frac{A}{t} (n)$$

The working voltage is dependent on the dielectric thickness.

Several constructions are shown in the figures below:

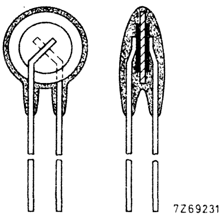


Fig. 1. Disc capacitor

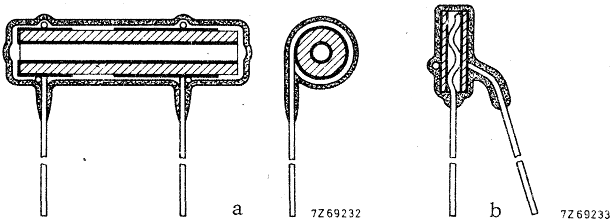


Fig. 2. Tubular capacitors

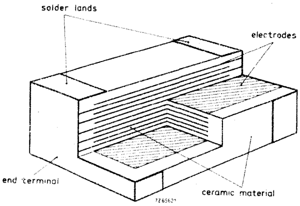


Fig. 3. Cross-section of a chip capacitor

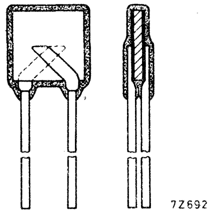


Fig. 4. Plate capacitor

The electrodes normally consist of silver or some other good electrical conductor. For multilayer capacitors palladium or platinum is used since the electrodes are applied before the ceramic is fired at a temperature where silver would oxidize.

The dielectric material

The raw materials are finely ground and carefully mixed. After calcining at a temperature below the dissociation or melting point, the resultant mass is reground. The calcined, finely ground material is mixed with, for instance, water and binding matter. The shapes are obtained by extruding or rolling. A carefully controlled drying sequence follows until ultimately the capacitor bodies are fired in a controlled atmosphere at temperatures between 1200 °C and 1400 °C.

Normally the leads are soldered to the electrodes of the capacitor body with a high melting point solder.

The capacitors are lacquered to ensure good behaviour under humid conditions and to protect the electrodes.

The capacitance value is marked on the body in clear text or in colour code (see Marking). The temperature coefficient or temperature dependence are indicated by colour coding in accordance with international standards.

EQUIVALENT CIRCUIT

Fig. 5 shows the equivalent circuit of a capacitor.

C is the capacitance between the two electrodes, plus the stray capacitances at the edges and between the leads.

R_p is the insulation resistance of insulation and dielectric. Generally R_p is very high, and of decreasing importance with increasing frequency.
R_p also represents the polarization losses of the dielectric material in an alternating electric field.

R_s represents the losses in the leads, the electrodes and the contacts. Up to several hundreds of MHz the current penetration depth is greater than the conductor thickness so that no skin-effect occurs. For ceramic capacitors R_s is extremely low.

L represents the inductance of the leads and the internal inductance of the capacitor; the latter, however, is almost negligible.
The inductance is only important in high frequency applications, since the capacitor will act as an inductance when the frequency is higher than its resonance frequency.

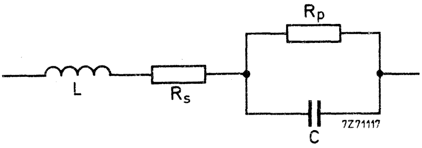


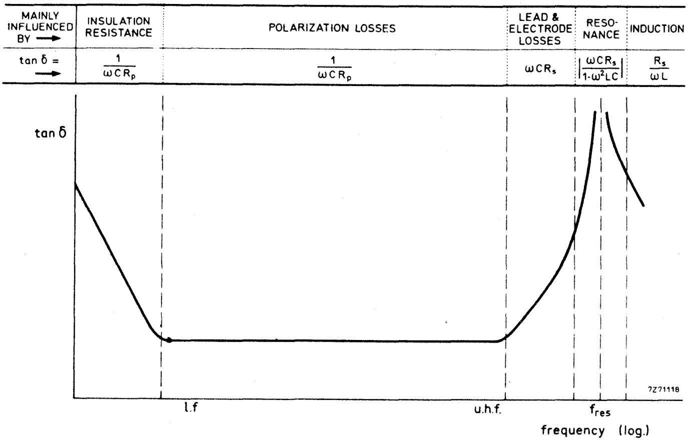
Fig. 5

TANGENT OF THE LOSS ANGLE

The losses of a capacitor are expressed in terms of tan δ which is the relation between the resistive and reactive parts of the impedance, specified as follows :

$$\tan\delta = \left|\frac{R}{X}\right| = \frac{R_p + R_s\ \{1 + (\omega C R_p)^2\}}{\omega C R_p^2 - \omega L\ \ \{1 + (\omega C R_p)^2\}}$$

From this formula, tan δ can be derived for different frequency ranges as shown diagrammatically in the graph of Fig. 6.



RELIABILITY *)

The following reliability data on our ceramic capacitors are available

range		F.R. in 10^{-6}/h			
		catastrophic + degradation		catastrophic	
		test	normalized	test	normalized
Tubular capacitors	2222 552	2,4	0,09	2,4	0,09
	2222 555	2,1	0,09	0,8	0,03
	2222 563	5,3	0,12	1,1	0,02
Plate capacitors	2222 629	1,5	0,09	0,33	0,02
	2222 630	0,4	0,01	0,4	0,01
	2222 631- 2222 643	2	0,04	1,4	0,03
	2222 650	0,96	0,02	0,37	0,01
	2222 655	1,2	0,03	1,2	0,03

Normalized failure rate = F.R. at 25 °C and nominal voltage.
Test failure rate = F.R. at maximum temperature and 1,5 x nominal voltage.

Catastrophic failures are open and short circuits and insulation resistance too low.
The degradation failures include
tan δ > 2 x requirement after 1000 h
R_{ins} < 0,1 x requirement after 1000 h

The Failure Rate has a confidence level of 60%.

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*) Detailed information is given in our Product Informations 30 and 39.

TUBULAR CERAMIC CAPACITORS
SAFETY

QUICK REFERENCE DATA	
Capacitance range	
in type 1 B	22 to 390 pF (E12 series)
in type 2	390 to 4700 pF (E12 series)
Rated a.c. voltage	400 V
Tolerance on capacitance	± 20%
Temperature dependence	type 1 B, type 2
Climatic category (IEC 68)	25/085/21
Basic specification	IEC65 SEV 1016, 1959 VDE 0560, part 2/5.70 SEMKO 101 amendment 2 DEMKO (permission for application)

APPLICATION

Safety capacitors are coupling capacitors designed to withstand considerable voltages so that they can be employed in circuits where "live" components should be isolated from conductive parts which might be touched. Such is the case with aerial terminals in radio and television sets, but also mains transformers or picture-tube rimbands can be earthed via a safety capacitor.

DESCRIPTION

The capacitors consist of a ceramic tube, fully metallized internally, and partly outside, with two tangential leads.

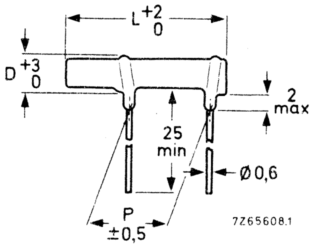
An insulated and a non-insulated version are available.

The type 1B capacitors are grey, the type 2 capacitors tan coloured.

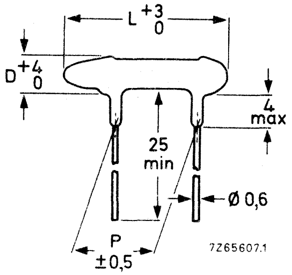
MECHANICAL DATA

Dimensions in mm

Outlines



non-insulated type



insulated type

For dimensions L, D and P, see Table 1

Marking

The body of the type 1 B capacitors is grey and of the type 2 capacitors is tan coloured. On the body is indicated in red script for the insulated types and in black script for non-insulated types: the capacitance value, a letter indicating the tolerance (see Table 1) the rated a.c. voltage, the basic part of the catalogue number 619 and the following symbols:

manufacturer's trade mark	
VDE mark (Germany)	DVE
SEMKO mark (Sweden)	Ⓢ
SEV mark (Switzerland)	+S

Approvals: type 1 B insulated : VDE, SEMKO, DEMKO, SEV
type 1 B non-insulated: VDE, SEMKO, DEMKO
type 2 insulated : SEMKO, DEMKO, SEV
type 2 non-insulated: VDE, SEMKO, DEMKO

Mounting

The non-insulated version must be so mounted that it is properly insulated from earth (chassis) and cannot be touched by accident.

Soldering conditions max. 270 °C, max. 5 s

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of 20 ± 2 °C, an atmospheric pressure of 930 to 1060 mbar and a relative humidity of max. 75%.

Capacitance values	
measured at 1 MHz, < 5 V for type 1B	22 to 390 pF, see Table 1
measured at 1 kHz, < 1,5 V for type 2	390 to 4700 pF, see Table 1
Tolerance on capacitance	±10%, ±20%, see Table 1
Rated a.c. voltage	400 V
Test voltage (a.c.) for 1 min at 85 °C	2500 V (type test)
Test voltage (a.c.) for 2 s at 15 to 35 °C	2500 V (100% test)
Test voltage (a.c.) of coating for 1 min. insulated type	2500 V
Insulation resistance at 500 V (d.c.) within 1 min.	10 000 MΩ
Tan δ at 1 MHz, < 5 V for type 1B	$\leq 10.10^{-4}$
at 1 kHz, < 1,5 V for type 2	≤ 3,5%
Category temperature range	−25 to +85 °C
Storage temperature range	−55 to +100 °C
Climatic category (IEC 68)	25/085/21

Table 1

cap. (pF)	type	dimensions			catalogue number with .. suffix
		D	L	P	
22	1 B (N750)	3	18	10	2212 619 ..229
27		3	18	10	..279
33		3	18	10	..339
39		3	18	10	..399
47		3	20	10	..479
56		3	20	10	..569
68		4	20	10	..689
82		4	20	10	..829
100		4	22	12,5	..101
120		4	22	12,5	..121
150		4	24	12,5	..151
180		4	26	15	..181
220		4	30	20	..221
270		4	34	25	..271
330		4	38	27,5	..331
390		4	42	32,5	..391
390	2 (K2000)	4	22	12,5	2212 619 ..391
470		4	22	12,5	..471
560		4	22	12,5	..561
680		4	22	12,5	..681
820		4	22	12,5	..821
1000		4	22	12,5	..102
1200		4	22	12,5	..122
1500		4	22	12,5	..152
1800		4	24	12,5	..182
2200		4	26	15	..222
2700		4	28	17,5	..272
3300		4	32	22,5	..332
3900		4	36	25	..392
4700		4	40	30	..472

		suffix for cat. number	
type	tolerance	non-insulated	insulated
1 B	± 20%*)	42	52
2	± 20%	62	72

---

*) For type 1B a capacitance tolerance of ± 10% is available on request.

TESTS AND REQUIREMENTS

Essentially all tests mentioned in the schedule of IEC publication 187, category 25/085/21 (temperature range −25 to +85 °C; damp heat, long term, 21 days) are carried out along the lines of IEC publication 68, see Table below:

IEC 187 clause	IEC 68 test method	test	procedure	requirements
14.1	U	Robustness of terminations Tensile strength of leads	leads are charged with load of 10 N for 10 s in direction of lead	no damage
14.2	Ub	Bending	2 x 90^0	no damage
15	T	Soldering (solder bath)	solderability: 4 s 235 °C, non activating flux applied	good tinning
19.2	B	Climatic sequence Dry heat	16 h + 85 °C	no visible damage
19.3	D	Damp heat (accelerated) first cycle	16 h +55 °C 95-100% R.H.	no visible damage, after recovery of 1-2 h immediately followed by cold test
19.4	A	Cold	2 h −25 °C	no visible damage
19.6	D	Damp heat (accelerated) remaining cycles	5 cycles 16 h 55 °C 95-100% R.H.	after drying 6 h at 55 °C, 20% R.H. and 1-2 h recovery; $R_{ins} \geq 1500\,M\Omega$ after 24 h $\frac{\Delta C}{C} \leq 5\%$
20.1	Ca	Damp heat (long term)	21 days +40 °C, 90 to 95% R.H.	after drying 6 h at 55 °C ≤ 20% R.H. and 1-2 h recovery: $R_{ins} \geq 1500\,M\Omega$, after 24 h $\frac{\Delta C}{C} \leq 5\%$
21.3	-	Endurance	1500 h +85 °C, 800 V a.c. During the test each hour the tension has to rise up to 1600 V a.c. for 0,1 s	after cooling down to 20 °C no breakdown or flash-over; after supply of 2500 V a.c. for 2 s: $R_{ins} \geq 1500\,M\Omega$, after 24 h $\frac{\Delta C}{C} \leq 10\%$

TESTS AND REQUIREMENTS (continued)

IEC 65 clause	IEC 68 test method	test	procedure	requirements
14.2	–	Discharge	The capacitor shall be subjected to 50 discharges at a maximum rate of 12 per minute from a 1 nF capacitor charged to 10 kV	1) The component shall withstand without breakdown for a period of 1 minute 2500 V a.c. at 15-35 $^{\circ}$C, tension between the terminals. 2) Only for insulated version: Same requirement as under 1), however, tension between the terminals connected together and a metal foil wrapped closely around the body of the capacitor but maintaining a 3 mm distance between the foil and each component terminal. 3) The insulation resistance between the terminals shall not have changed by more than 50% of the value measured before the test.

PACKAGING

250 pcs per box.

Marking on the box: catalogue number, number of pcs, packing date.

CERAMIC DISC CAPACITORS

TYPE 2

high voltage

QUICK REFERENCE DATA	
Capacitance range	33 to 820 pF (E12 series)
Rated voltage, 33-560 pF	2 kV (d.c.) and 2 kV, (pulse, 16 kHz)
33-820 pF	1 kV (d.c.) and 1 kV, (pulse, 16 kHz)
Tolerance on capacitance, 2 kV version	± 10%, ± 20%
1 kV version	± 20%
Basic specification	IEC 187
Category (IEC 68)	40/085/21

APPLICATION

These capacitors can be used in television and other circuitry where high d.c. or high pulse voltages (16 kHz) are applied (e.g. line deflection).

DESCRIPTION

The capacitors consist of a ceramic disc, both sides being metallized and provided with connecting leads. They are insulated by a coating that ensures excellent behaviour under humid conditions.
The capacitors are insulated with a tan coloured lacquer.
This lacquer has an excellent resistance against organic cleaning solvents and is uninflammable (acc. MIL 202 D test 215 and MIL 202 C test 111).

MECHANICAL DATA

Dimensions in mm

Outlines

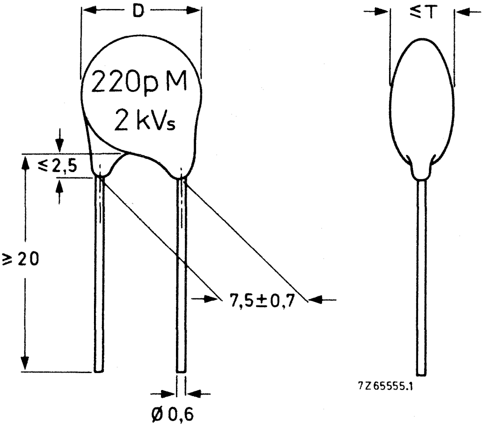


Fig. 1. For dimensions D and T see Tables 1 and 2.

Marking

The body of the capacitors is tan coloured. On the body is indicated in black script the capacitance value, a letter indicating the tolerance (see Table 1) and the rated peak voltage.

Mounting

When bending, cutting or flattening the leads, they should be relieved of the applied load at the capacitor body.

Soldering conditions max. 270 °C, max. 5 s

ELECTRICAL DATA

The capacitors meet the essential requirements of IEC 187. Unless otherwise specified all electrical values apply at an ambient temperature of 20 ± 2 °C, an atmospheric pressure of 930 to 1060 mbar and a relative humidity of 45 to 75%.

Capacitance values measured at 1 kHz ≤ 1,5 V	33 to 820 pF (E 12 series), see Tables 1 and 2 ←
Tolerance on capacitance	± 10%, ± 20%, see Tables 1 and 2
Rated voltage, 33-560 pF	2 kV (d.c.); 2 kV, (pulse, 16 kHz) ←
33-820 pF	1 kV, (pulse, 16 kHz) ←
Test voltage for 2 s, 2 kV version	4 kV (d.c.)
1 kV version	2 kV (d.c.)
Insulation resistance at 500 V (d.c.) after 1 min	≥ 10 000 MΩ
Tan δ at 1 kHz, ≤ 1,5 V	≤ 3,5%
Category temperature range	−40 to +85 °C
Storage temperature range	−55 to +125 °C
Climatic category (IEC 68)	40/085/21
Capacitance change versus temperature	see Fig. 2

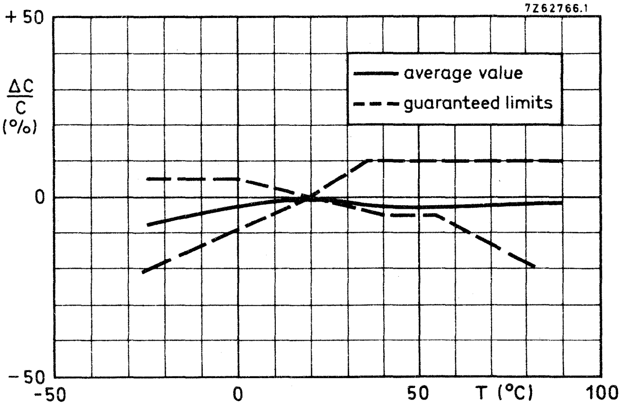


Fig. 2 Capacitance change with respect to the capacitance value at 20 °C as a function of temperature.

Table 1 (2 kV version)

cap. (pF)	D_{max} (mm)	T_{max} (mm)	marking of capacitance	catalogue number	
				tolerance ± 10% mark K	tolerance ±20% mark M
33	7	6,5	33 p	2212 659 00339	2212 659 01339
39	7	6	39 p	00399	01399
47	7	5,5	47 p	00479	01479
56	7	5	56 p	00569	01569
68	8	5,5	68 p	00689	01689
82	8	5	82 p	00829	01829
100	7	6	100 p	00101	01101
120	7	5,5	120 p	00121	01121
150	7	5	150 p	00151	01151
180	7	5	180 p	00181	01181
220	8	5	220 p	00221	01221
270	8	5	270 p	00271	01271
330	10	5	330 p	00331	01331
390	10	5	390 p	00391	01391
470	11	5	470 p	00471	01471
560	11	4,5	560 p	00561	01561

Table 2 (1 kV version)

cap. (pF)	D_{max} (mm)	T_{max} (mm)	marking of capacitance	catalogue number
				tolerance ±20% mark M
33	7	4,5	33 p	2212 659 03339
39	7	4	39 p	03399
47	8	4,5	47 p	03479
56	8	4	56 p	03569
68	7	4,5	68 p	03689
82	7	4,5	82 p	03829
100	7	4	100 p	03101
120	8	4,5	120 p	03121
150	8	4	150 p	03151
180	7	5	180 p	03181
220	7	4,5	220 p	03221
270	7	4,5	270 p	03271
330	8	4,5	330 p	03331
390	8	4,5	390 p	03391
470	10	4,5	470 p	03471
560	10	4,5	560 p	03561
680	11	4,5	680 p	03681
820	11	4,5	820 p	03821

TESTS AND REQUIREMENTS

Essentially all tests mentioned in the schedule of IEC publication 187, category 40/085/21 (temperature range −40 to +85 ^{o}C; damp heat, long term, 21 days) are carried out along the lines of IEC publication 68, see Table below:

IEC 187 clause	IEC 68 test method	test	procedure	requirements
14.1	Ua	Robustness of terminations Tensile strength of leads	wires charged with load of 10 N for 10 s in direction of lead	no damage
14.2	Ub	Bending	2 x 90^{o}	no damage
15	T	Soldering (solder bath)	solderability: 4 s 235 ^{o}C, non-activating flux applied	good tinning
-	(acc. MIL STD 202C, test 111)	Inflammability	3 x 5 s, in flame of bunsen burner with flame-height 30 mm	self-extinguishing within 1 s after removal of bunsen burner
-	(acc. MIL STD 202D method 215)	Resistance to solvents	3 x 1 min immersion in benzene, chloroethane, freon, TMC and trichloroethane	no damage
		Climatic sequence		
19.2	B	Dry heat	16 h +85 ^{o}C	no visible damage, $R_{ins} \geq 6000$ MΩ
19.3	D	Damp heat (accelerated) first cycle	16 h +55 ^{o}C 95-100% R.H.	no visible damage after recovery of 1-2 h immediately to be followed by cold test
19.4	A	Cold	2 h −40 ^{o}C	no visible damage
19.6	D	Damp heat (accelerated) remaining cycles	5 cycles 16 h 55 ^{o}C 95-100% R.H.	after drying 6 h at 55 ^{o}C 20% R.H. and 1-2 h recovery: $R_{ins} \geq 1500$ MΩ; after 24 h $\frac{\Delta C}{C} \leq 5\%$

TESTS AND REQUIREMENTS (continued)

IEC 187 clause	IEC 68 test method	test	procedure	requirements
20. 1	Ca	Damp heat (steady state)	21 days +40 ^{o}C, 90 to 95% R. H. 1/3 part with 1, 5 x rated voltage applied 1/3 part with 0, 2 x rated voltage applied 1/3 part no voltage applied	after drying 6 h at 55 ^{o}C $\leq$ 20% R. H. and 1 to 2 h recovery: $R_{ins} \geq$ 1500 MΩ; after 24 h $\frac{\Delta C}{C} \leq 5\%$; voltage test 4 kV (d. c.) for 2 s
21. 3	–	Endurance	1000 h +85 ^{o}C with pulse change 1, 5 x rated voltage pulse time 13 μs pulse frequency 16 kHz	after cooling down to 20 ^{o}C no breakdown or flashover; $R_{ins} \geq$ 1500 MΩ; after 24 h $\frac{\Delta C}{C} \leq 10\%$

PACKAGING

Multiples of 250 pieces.

CERAMIC DISC CAPACITORS

TYPE 2

interference suppression

QUICK REFERENCE DATA	
Capacitance range	220 to 2200 pF (E 12 series)
Rated a.c. voltage	250 V
Tolerance on capacitance	±20%
Basic specification	IEC 161 VDE 0560 part 7/11.67
Category (IEC 68)	40/085/21

APPLICATION

These capacitors are in accordance with the VDE 0560 part 7/11.67. Therefore they can be used as interference suppression e.g. in home appliances as "X and Y-capacitor".

DESCRIPTION

The capacitors consist of a ceramic disc, both sides being metallized and provided with connecting leads. They are insulated by a coating that ensures excellent behaviour under humid conditions.

The capacitors are insulated with a tan coloured lacquer.

This lacquer has an excellent resistance against organic cleaning solvents and is uninflammable (acc. MIL 202 D test 215 and MIL 202 C test 111).

MECHANICAL DATA

Dimensions in mm

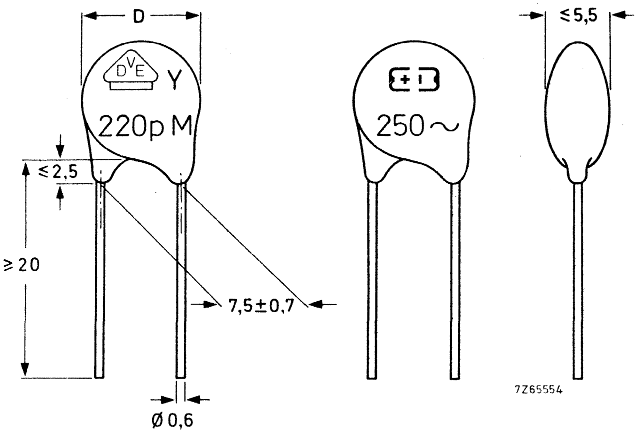


Fig.1. For dimension D, see Table 1

Marking

The body of the capacitors is brown coloured. On the body is indicated in black script the capacitance value, a letter indicating the tolerance (see Table 1), the rated voltage, and the following symbols:

manufacturer trade mark

VDE mark Y

Mounting

When bending, cutting or flattening the leads, one should relieve them of the applied load at the capacitor body.

Soldering conditions max. 270 °C, max. 5 s

ELECTRICAL DATA

The capacitors meet the essential requirements of IEC 161. Unless otherwise specified all electrical values apply at an ambient temperature of 20 ± 2 °C, an atmospheric pressure of 930 to 1060 mbar and a relative humidity of 45 to 75%.

Capacitance values measured at 1 kHz ≤ 1,5 V	220 to 2200 pF (E 12 series)
Tolerance on capacitance	± 20%
Rated a.c. voltage	250 V
Test voltage (a.c.) for 2 s	1800 V (100% tested)
Test voltage (a.c.) for 1 min at 85 °C	1500 V (type test)
Insulation resistance at 500 V (d.c.) after 1 min	≥ 10 000 MΩ
Tan δ at 1 kHz, ≤ 1,5 V	≤ 3,5%
Category temperature range	−40 to +85 °C
Storage temperature range	−55 to +125 °C
Climatic category (IEC 68)	40/085/21
Capacitance change versus temperature	see Fig. 2

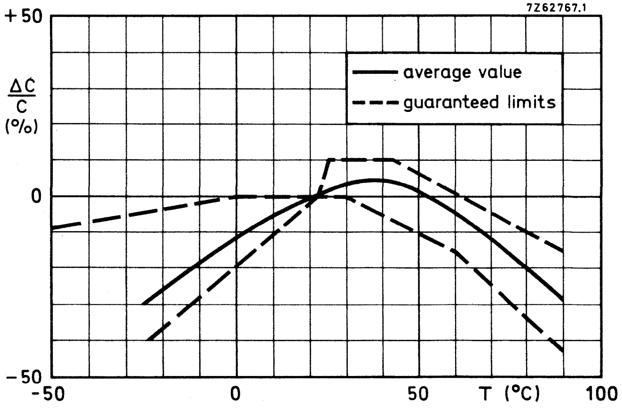


Fig. 2 Capacitance change with respect to the capacitance value at 20 °C as a function of temperature.

Table 1

cap. (pF)	tolerance	D_{max} (mm)	marking of		catalogue number
			capacitance	tolerance	
220	± 20%	8	220 p	M	2212 660 01221
270	± 20%	7	270 p	M	01271
330	± 20%	7	330 p	M	01331
390	± 20%	7	390 p	M	01391
470	± 20%	7	470 p	M	01471
560	± 20%	7	560 p	M	01561
680	± 20%	7	680 p	M	01681
820	± 20%	8	820 p	M	01821
1000	± 20%	10	1n0	M	01102
1200	± 20%	10	1n2	M	01122
1500	± 20%	10	1n5	M	01152
1800	± 20%	10	1n8	M	01182
2200	± 20%	11	2n2	M	01222

TESTS AND REQUIREMENTS

Essentially all tests mentioned in the schedule of IEC publication 161, category 40/085/21 (temperature range −40 to +85 °C; damp heat, long term, 21 days) are carried out along the lines of IEC publication 68, see Table below:

IEC 161 clause	IEC 68 test method	test	procedure	requirements
13.1	Ua	Robustness of terminations Tensile strength of leads	wires charged with load of 10 N for 10 s in direction of lead	no damage
13.2	Ub	Bending	2 x 90°	no damage
14.1	T	Soldering (solder bath)	solderability: 4 s 235 °C, non-activating flux applied	good tinning
-	(acc. MIL STD 202C, test 111)	Inflammability	3 x 5 s, in flame of bunsen burner with flame-height 30 mm	self-extinguishing within 1 s after removal of bunsen burner
-	(acc. MIL STD 202D method 215)	Resistance to solvents	immersion 3 x 1 min in benzene, chloroethane, freon, TMC and trichloroethane	no damage
19.2	B	Climatic sequence (10 pcs) Dry heat	16 h +85 °C	**no visible damage**, $R_{ins} \geq 6000\ M\Omega$
19.3	D	Damp heat (accelerated) first cycle	16 h +55 °C 95-100% R.H.	no visible damage after recovery of 1-2 h immediately to be followed by cold test
19.4	A	Cold	2 h −40 °C	no visible damage
19.6	D	Damp heat (accelerated) remaining cycles	5 cycles 16 h 55 °C 95-100% R.H.	after drying 6 h at 55 °C 20% R.H. and 1-2 h recovery: $R_{ins} \geq 1500\ M\Omega$; after 24 h $\frac{\Delta C}{C} \leq 5\%$

TESTS AND REQUIREMENTS (continued)

IEC 161 clause	IEC 68 test method	test	procedure	requirements
20.1	Ca	Climatic sequence (15 pcs) Damp heat (long term)	21 days +40 °C, 90 to 95% R.H. 1/3 with 250 V d.c. applied 1/3 with 20 V d.c. 1/3 without voltage	after drying 6 h at 55 °C ; 20 % R.H. and 1-2 h recovery: $R_{ins} \geq 1500$ MΩ, after 24 h $\frac{\Delta C}{C} \leq 5$ %
21.3	–	Climatic sequence (10 pcs) Endurance	1000 h +85 °C, 425 V a.c.	after cooling down to 20 °C no breakdown or flash over after supply of 1800 V a.c. for 2 s, $R_{ins} \geq 1500$ MΩ, after 24 h $\frac{\Delta C}{C} \leq 10$ %

H.F. DATA VDE 0560/7

The resonance frequency can be measured with the circuit shown in Fig. 3.

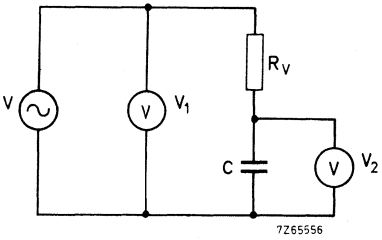


Fig. 3

When $V_1 >> V_2$ and $R_v >> \frac{1}{\omega C}$, the impedance for C is $Z_c = \frac{V_2}{V_1} \times R_v$.

At the resonance frequency $f_r = \frac{1}{2\pi\sqrt{LC}}$, Z_c will reach a minimum

(L = selfinductance of the capacitor including the leads)

The resonance frequency shall be above or equal to the frequency shown in Fig. 4. Lowest resonance frequency $f_r = \frac{1}{1,2\sqrt{C_N}}$.

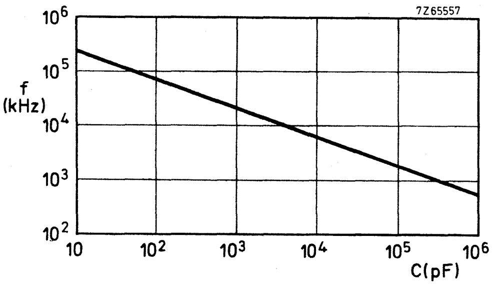


Fig. 4

PACKAGING

Multiples of 250 pieces.

CERAMIC DISC CAPACITORS
TYPE 2
SAFETY

QUICK REFERENCE DATA	
Capacitance range	33 to 1000 pF (E 12 series)
Rated a.c. voltage	400 V
Tolerance on capacitance	± 10%, ± 20%, −20 to +50%
Basic specification	IEC 65
Category (IEC 68)	40/085/21

APPLICATION

These capacitors can be used for the galvanic separation of mains and conductive parts which might be touched e.g. antenna inputs in radio and television sets.

DESCRIPTION

The capacitors consist of a ceramic disc, both sides being metallized and provided with connecting leads. They are insulated by a coating that ensures excellent behaviour under humid conditions.
The capacitors are insulated with a tan coloured lacquer.
This lacquer has an excellent resistance against organic cleaning solvents and is uninflammable (acc. MIL 202 D test 215 and MIL 202 C test 111).

APPROVALS

FEMKO	–	Finland	–	2701
SEMKO	–	Sweden	–	101, with amendment 2
SEV	–	Switzerland	–	1016, 1959 for 33 to 220 pF incl. only
U.L.	–	U.S.A.	–	recognized
VDE	–	Germany	–	0560 part 2/5.70

MECHANICAL DATA

Dimensions in mm

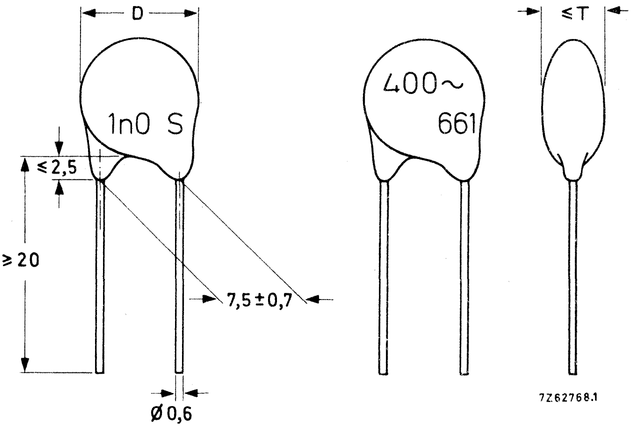


Fig. 1. For dimensions D and T, see Table

Marking

The body of the capacitors is brown coloured. On the body is indicated in black script the capacitance value, a letter indicating the tolerance (see Table), the rated a.c. voltage, the type number and the following symbols :

manufacturer's trade mark	+I
VDE mark (Germany)	DVE
SEMKO mark (Sweden)	Ⓢ
SEV mark (Switzerland)	+S

Mounting

When bending, cutting or flattening the leads, they should be relieved of the applied load at the capacitor body.

Soldering conditions max. 270 °C, max. 5 s

ELECTRICAL DATA

The capacitors meet the essential requirements of IEC 65. Unless otherwise specified all electrical values apply at an ambient temperature of 20 ± 2 °C, an atmospheric pressure of 930 to 1060 mbar and a relative humidity of 45 to 75%.

Capacitance values measured at 1 kHz ≤ 1,5 V	33 to 1000 pF (E 12 series)
Tolerance on capacitance	± 10%, ± 20%, −20 to +50%
Rated a.c. voltage	400 V
Test voltage (a.c.) for 1 min, at 85 °C	2500 V (type test)
Test voltage (a.c.) of coating for 1 min, at 85 °C	2500 V
Insulation resistance at 500 V (d.c.) after 1 min	≥ 10 000 MΩ
Tan δ at 1 kHz, ≤ 1,5 V	≤ 3,5%
Category temperature range	−40 to +85 °C
Storage temperature range	−55 to +125 °C
Climatic category (IEC 68)	40/085/21
Capacitance change versus temperature for 33 to 220 pF for 270 to 1000 pF	 see Fig. 2 see Fig. 3

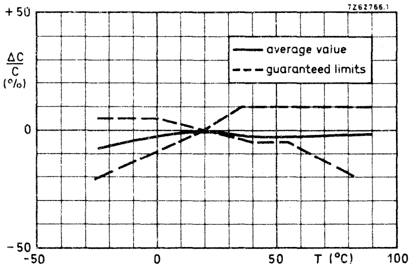


Fig. 2. Capacitance change with respect to the capacitance value at 20 °C as a function of temperature for capacitors of 33 to 220 pF.

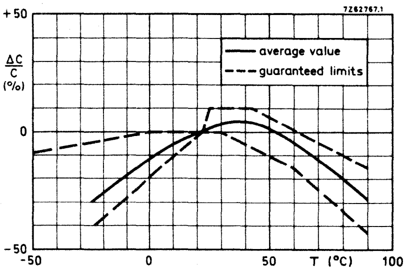


Fig. 3. Capacitance change with respect to the capacitance value at 20 °C as a function of temperature for capacitors of 270 to 1000 pF.

Table

cap. (pF)	D_{max} (mm)	T_{max} (mm)	marking of capacitance	catalogue number	
				tolerance ± 20% mark M	tolerance −20 to +50% mark S
33	8	7,5	33 p	2212 661 01339	
39	8	6,5	39 p	01399	
47	8	6,5	47 p	01479	
56	8	6	56 p	01569	
68	8	6,5	68 p	01689	
82	8	6	82 p	01829	
100	8	7	100 p	01101	
120	8	6,5	120 p	01121	
150	8	6	150 p	01151	
180	8	6,5	180 p	01181	
220	8	6	220 p	01221	
270	8	6,5	270 p		2212 661 02271
330	8	6	330 p		02331
390	8	6,5	390 p		02391
470	8	6	470 p		02471
560	11	7	560 p		02561
680	11	6,5	680 p		02681
820	11	6	820 p		02821
1000	11	6	1n0		02102

Available on request:

the capacitance values 33 to 220 pF with a tolerance of ± 10%
the capacitance values 270 to 1000 pF with a tolerance of ± 20%

TESTS AND REQUIREMENTS

Essentially all tests mentioned in the schedule of IEC publication 187, category 40/085/21 (temperature range −40 to +85 ^oC; damp heat, long term, 21 days) are carried out along the lines of IEC publication 68, see Table below:

IEC 187 clause	IEC 68 test method	tests	procedure	requirements
14.1	Ua	Robustness of terminations Tensile strength of leads	wires charged with load of 10 N for 10 s in direction of lead	no damage
14.2	Ub	Bending	2 x 90^0	no damage
15	T	Soldering (solder bath)	solderability: 4 s 235 ^oC, non-activating flux applied	good tinning
-	(acc. MIL STD 202C, test 111)	Inflammability	3 x 5 s, in flame of bunsen burner with flame-height 30 mm	self-extinguishing within 1 s after removal of bunsen burner
-	(acc. MIL STD 202D method 215)	Resistance to solvents	3 x 1 min immersion benzene, chloroethane, freon, TMC and trichloroethane	no damage
		Climatic sequence		
19.2	B	Dry heat	16 h +85 ^oC	no visible damage, $R_{ins} \geq 6000\ M\Omega$
19.3	D	Damp heat (accelerated) first cycle	16 h +55 ^oC 95-100% R.H.	no visible damage after recovery of 1-2 h immediately to be followed by cold test
19.4	A	Cold	2 h −40 ^oC	no visible damage
19.6	D	Damp heat (accelerated) remaining cycles	5 cycles 16 h 55 ^oC 95-100% R.H.	after drying 6 h at 55 ^oC 20% R.H. and 1-2 h recovery: $R_{ins} \geq 1500\,M\Omega$; after 24 h $\frac{\Delta C}{C} \leq 5\%$

TESTS AND REQUIREMENTS (continued)

IEC 187 clause	IEC 68 test method	test	procedure	requirements
20.1	Ca	Damp heat (long term)	21 days +40 °C, 90 to 95% R.H.	after drying 6 h at 55 °C ≤ 20% R.H. and 1 - 2 h recovery: $R_{ins} \geq 1500$ MΩ, after 24 h $\frac{\Delta C}{C} \leq 5\%$
21.3	-	Endurance	1500 h +85 °C, 800 V a.c.	after cooling down to 20 °C no breakdown or flash over after supply of 2500 V a.c. for 2 s, $R_{ins} \geq 1500$ MΩ, after 24 h $\frac{\Delta C}{C} \leq 10\%$
IEC 65 14.2	-	Discharge test	The capacitor shall be subjected to 50 discharges at a maximum rate of 12 per minute from a 1 nF capacitor charged to 10 kV	1) The component shall withstand without breakdown for a period of 1 minute 2500 V a.c. at 15-35 °C, tension between the terminals. 2) Only for insulated version: Between the terminals connected together and a metal foil wrapped closely around the body of the capacitor but maintaining a 3 mm distance between the foil and each component terminal. 3) The insulation resistance between the terminals shall not have changed by more than 50% of the value measured before the test.

PACKAGING

Multiples of 250 pieces.

TUBULAR CERAMIC CAPACITORS
TYPE 2

QUICK REFERENCE DATA	
Capacitance range	680 to 22 000 pF, E6 series
Rated d.c. voltage	500 V
Tolerance on capacitance	-20/+50%
Climatic category (IEC 68)	40/085/21

APPLICATION

Type 2 tubular ceramic capacitors are made of high-K dielectric materials. They are suitable for bypass and coupling purposes in all kinds of equipment where a high capacitance and small dimensions are of importance and the losses need not be minimized.

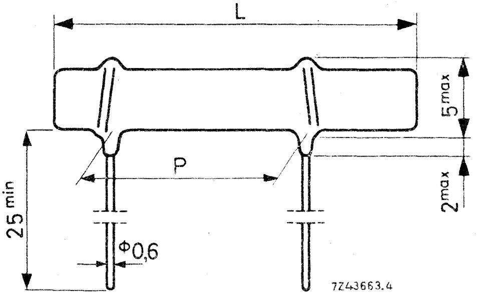
DESCRIPTION

The capacitors consist of a ceramic tube, internally and partly externally covered with a fired-on coating of silver. Two leads of tinned copper, wound around the tube, are soldered to these coatings. A coating of transparant lacquer protects the non-insulated version aganist atmospheric influences. The coating of the insulated capacitors allows them to be mounted close together or against a metal frame.

MECHANICAL DATA

Dimensions in mm

Outlines



For L and P see table

Marking Colour code or figure code, see Survey Ceramic Capacitors.

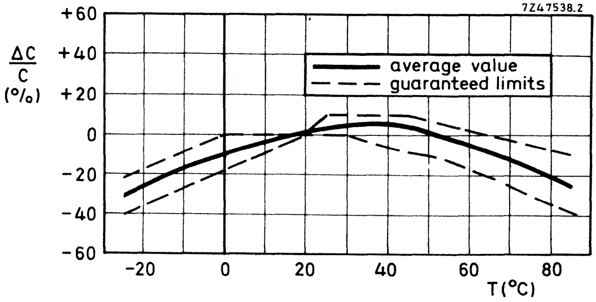
Mounting

Soldering conditions max. 270 °C, max. 10 s

ELECTRICAL DATA

Unless otherwise specified, all electrical values apply at a temperature of 20 ± 2 °C, an atmospheric pressure of 930 to 1060 mbar and a relative humidity of ≤ 75%.

Capacitance values at 1 kHz, < 3,5 V	680 to 22 000 pF, E6 series, see table
Tolerance on capacitance	−20/+50%
Rated d.c. voltage	500 V
Test voltage (d.c.) for 1 min	1250 V
Test voltage (d.c.) of coating (insulated capacitors) for 1 s	750 V
Insulation resistance at 500 V (d.c.) (after 1 min) for C ≤ 10 000 pF	> 10 000 MΩ
for C > 10 000 pF	$> \frac{10\,000 \times 10^{10}}{C\ (\text{pF})}\ \Omega$
Tan δ at 1 kHz, < 3,5 V	< 3,5%
Temperature dependence	see graph below
Category temperature range	−40 to +85 °C
Climatic category (IEC 68)	40/085/21



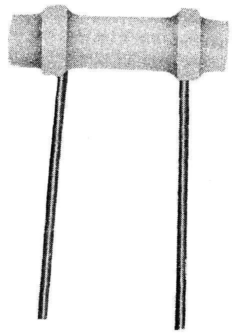
Capacitance change with respect to the capacitance value at 20 °C as a function of the temperature.

Table

capacitance (pF)	L (mm)	P (mm)	catalogue number	
			insulated	non-insulated
680	10	5	2222 552 04681	2222 552 03681
1000	10	5	04102	03102
1500	10	5	04152	03152
2200	10	5	04222	03222
3300	12	7.6	04332	03332
4700	16	10.2	04472	03472
6800	20	15.2	04682	03682
10000	22	17.7	04103	03103
15000	30	20.3	04153	03153
22000	40	30.5	04223	03223

TUBULAR CERAMIC CAPACITORS
TYPE 1B

QUICK REFERENCE DATA	
Capacitance range	0,8 to 820 pF
Rated d.c. voltage	500 V
Tolerance on capacitance	±5%, ±0,5 or ±0,25 pF
Temperature coefficients	NP0, N150, N750
Basic specification	IEC 108, type 1B
Category (IEC 68)	40/085/21



RZ 22070-1

APPLICATION

Because low-K ceramic material is used, these capacitors have low losses, a high stability and display a linear temperature dependence of the capacitance. These features render the capacitors ideally suited for application in high frequency equipment, especially in resonant circuits in which advantage can be taken of the linear temperature coefficient to compensate the temperature dependence of other components.
These capacitors have connecting leads of 0,6 mm diameter with a pitch of a multiple of one tenth of an inch, so that they are suitable for printed wiring circuits.

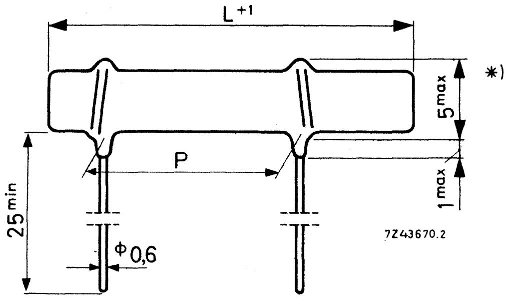
DESCRIPTION

The capacitors consist of a ceramic tube, partly metallized on the outside and, except for the smallest capacitances, internally metallized. A coating of transparent lacquer protects the capacitors against atmospheric influences. The temperature coefficient, the capacitance and the tolerances are indicated by means of a colour or a figure code. The inner electrode is connected to the lead at the side of the colour dot for the temperature coefficient.

MECHANICAL DATA

Dimensions in mm

Outlines



Mass

0,4 to 0,9 g, depending on the dimensions.

Marking

Colour coded or figure coded, see Survey Ceramic Capacitors.

Mounting

Soldering conditions	max. 270 °C, max. 10 s.

ELECTRICAL DATA

The capacitors are in conformity with IEC 108.
Unless stated otherwise, all electrical values apply at an ambient temperature of 20 ± 2 °C, an atmospheric pressure of 930 to 1060 mbar and a relative humidity of 45 to 75%.

Capacitance values with tolerances measured at 1 MHz, < 5 V	see table II
Rated d.c. voltage	500 V
Test voltage (d.c.) for 1 min	1250 V

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*) Maximum 6 mm for capacitors of 2,7 and 3,3 pF.

Insulation resistance at 500 V d.c. after 1 min.	> 10.000 MΩ
Tan δ at 1 MHz, < 5 V for C of 5 to 50 pF	$\leq (15/C + 0,7).10^{-3}$ (C in pF)
for C > 50 pF	$\leq 10 \times 10^{-4}$, average $< 5 \times 10^{-4}$
Category temperature range	−40 to +85 °C
Climatic category (IEC 68)	40/085/21

Temperature coefficients (Table I)

temperature coefficient (ppm/degC)	tolerance on temperature coefficient (ppm/degC)	
NP0 : 0	for capacitance < 3 pF	: −30/+250
	3 to < 6 pF	: −30/+120
	6 to < 10 pF	: −30/+60
	10 to < 15 pF	: −30/+40
	≥ 15 pF	: ± 30
N150 : -150	for capacitance < 3 pF	: −30/+250
	3 to < 6 pF	: −30/+120
	6 to < 10 pF	: −30/+60
	10 to < 15 pF	: −30/+40
	≥ 15 pF	: ± 30
N750 : -750	for capacitance < 3 pF	: −120/+250
	3 to < 6 pF	: ± 120
	6 to < 10 pF	: ± 120
	10 to < 15 pF	: ± 120
	≥ 15 pF	: ± 120

Capacitors with a temperature coefficient according to P100, N033, N075, N220, N330, N470 and N1500 can be supplied, provided acceptable quantities are ordered.

Capacitance and tolerance

The following table gives the E12 capacitance series with a tolerance of 0.25 pF, 0.5 pF and 5%, depending on the capacitance value. On request values appertaining to the E24 series can be supplied, provided acceptable quantities are ordered. This also applies to capacitors with tolerances of 20% of the E6 series, of 10% of the E12 series and with 2% and 1% tolerances for higher capacitance values.

---

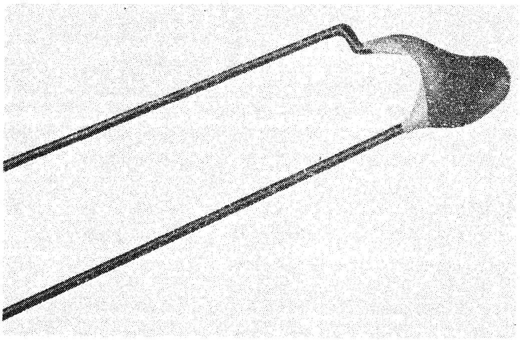
*) If the capacitor is connected to an a.c. source, the r.m.s. current must not exceed 500 mA, whilst the maximum r.m.s. voltage is $\frac{500}{\sqrt{2}}$ volts.

Table II

capacitance		temperature coefficient								
		NP0			N150			N750		
nom. (pF)	tol. (±)	L (mm)	P (mm)	suffix	L (mm)	P (mm)	suffix	L (mm)	P (mm)	suffix
0.8	0.25 pF							12	7.6	57807
1	0.25 pF							12	7.6	57108
1.2	0.25 pF							12	7.6	57128
1.5	0.25 pF							12	7.6	57158
1.8	0.25 pF	12	7.6	09188				12	7.6	57188
2.2	0.25 pF	12	7.6	09228				12	7.6	57228
2.7	0.5 pF	12	7.6	08278				12	7.6	56278
3.3	0.5 pF	12	7.6	08338				12	7.6	56338
3.9	0.5 pF	12	7.6	08398				12	7.6	56398
4.7	0.5 pF	12	7.6	08478				12	7.6	56478
5.6	0.5 pF	12	7.6	08568	12	7.6	32568	12	7.6	56568
6.8	0.5 pF	12	7.6	08688	12	7.6	32688	12	7.6	56688
8.2	0.5 pF	10	5.1	08828	10	5.1	32828	10	5.1	56828
10	5 %	10	5.1	08109	10	5.1	32109	10	5.1	56109
12	5 %	10	5.1	08129	10	5.1	32129	10	5.1	56129
15	5 %	10	5.1	08159	10	5.1	32159	10	5.1	56159
18	5 %	10	5.1	08189	10	5.1	32189	10	5.1	56189
22	5 %	10	5.1	08229	10	5.1	32229	10	5.1	56229
27	5 %	12	7.6	08279	12	7.6	32279	10	5.1	56279
33	5 %	12	7.6	08339	12	7.6	32339	10	5.1	56339
39	5 %	12	7.6	08399	12	7.6	32399	10	5.1	56399
47	5 %	14	7.6	08479	12	7.6	32479	10	5.1	56479
56	5 %	14	7.6	08569	14	7.6	32569	12	7.6	56569
68	5 %	16	10.2	08689	16	10.2	32689	12	7.6	56689
82	5 %	18	12.7	08829	16	10.2	32829	12	7.6	56829
100	5 %	20	15.2	08101	18	12.7	32101	12	7.6	56101
120	5 %	22	17.7	08121	20	15.2	32121	14	7.6	56121
150	5 %	26	20.3	08151	24	17.7	32151	16	10.2	56151
180	5 %	30	20.3	08181	26	20.3	32181	18	12.7	56181
220	5 %	34	25.4	08221	30	20.3	32221	20	15.2	56221
270	5 %				36	25.4	32271	22	17.7	56271
330	5 %							24	17.7	56331
390	5 %							28	20.3	56391
470	5 %							32	25.4	56471
560	5 %							38	30.5	56561
680	5 %							44	35.6	56681
820	5 %							52	40.6	56821

CATALOGUE NUMBER (for ordering) 2222 555 . . . . . , for suffix see Table II

UPRIGHT-MOUNTING CERAMIC CAPACITORS
TYPE 2



RZ 22070-12

563-series:	Capacitance range	1,5 to 10 000 pF
	Rated d.c. voltage	500 V
565-series:	Capacitance range	2200 to 10 000 pF
	Rated d.c. voltage	125 V

APPLICATION

These ceramic capacitors are suitable for bypass, coupling and general purposes, where low losses and high stability of capacitance are not of major importance. They feature a high insulation resistance and a low inductance. The configuration of the terminals is adapted to the printed wiring technique; when mounted in a vertical position, the capacitors occupy a small area.

The 565-series of capacitors have been designed for application where high voltages are not required, e.g. transistor equipment.

DESCRIPTION

The capacitor consists of an internally and externally fully metallized ceramic tube. The connecting leads are of tinned copper, soldered to the metal layers. The capacitors are coated with a tan-coloured insulation lacquer, which acts as a seal against moisture and mechanical damage, and permits the capacitors to be mounted close together, or against a metal plate.

MECHANICAL DATA

Dimensions in mm

563-series

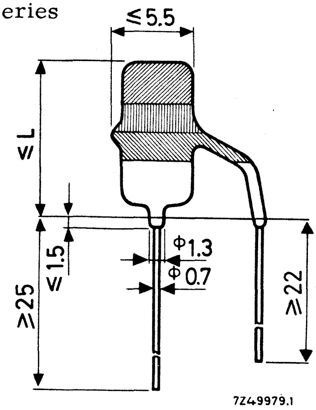


Fig. 1

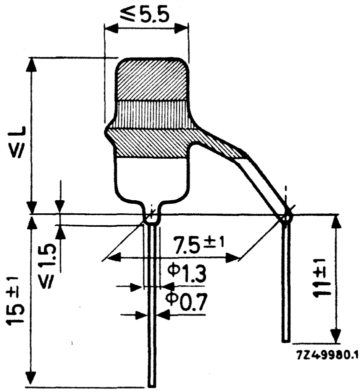


Fig. 2

565-series

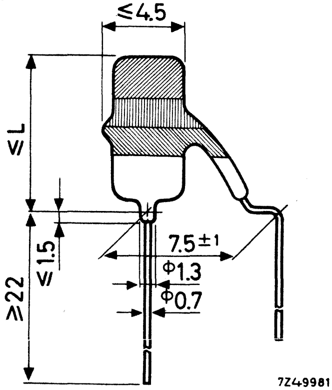


Fig. 3

Marking

The capacitance value is indicated on the capacitor in colour code (see Survey Ceramic Capacitors).

ELECTRICAL DATA

Unless otherwise specified, all electrical values apply at a temperature of 20 ± 5 °C, at atmospheric pressure of 930-1060 mbar and a relative humidity of $\leq$ 75 %.

	563-series	565-series
Rated voltage	500 V d.c.	125 V d.c.
Test voltage for 1 min	1250 V d.c.	375 V d.c.
Test voltage against coating for 1 min	1250 V d.c.	1250 V d.c.
Insulation resistance at 500 V d.c. (within 1 min)	> 10 000 MΩ	
Insulation resistance at 100 V d.c. (within 1 min)		
for $C < 2500$ pF		> 10 000 MΩ
for $C > 2500$ pF		$> \frac{2500 \times 10\,000}{C\ (\mathrm{pF})}$ MΩ
Losses measured at < 3.5 V		
for $C \leq 10$ pF, parallel damping at 100 kHz	> 5 MΩ	
for C = 10 to 180 pF, tan δ at 100 kHz	see Table I	
for $C > 200$ pF, tan δ at 1 kHz	see Table I	$< 350.10^{-4}$
Temperature dependence from −25 to +85 °C	see Table I	+30 to −50 %
Category temperature range	−40 to +85 °C	−25 to +85 °C
Climatic category (IEC68)	40/085/21	25/085/21

AVAILABLE VERSIONS

563-series (500 V)

Catalogue number 2222 563 . . . . .
suffix, see table I

Table I

capacitance (pF)	tolerance	L (mm)	tan δ ($\times 10^{-4}$)	$\frac{\Delta C}{C} = f(T)$	suffix of Fig.1 versions	suffix of Fig.2 versions
1.5	1 pF	7		±10 %	01158	05158
2		7.5			01208	05208
3		7			01308	05308
4		6.5			01408	05408
5		7.5			01508	05508
6		7.5			01608	05608
7		7			01708	05708
8		7.5			01808	05808
9		8.5			01908	05908
10		7.5			01109	05109
15	20 %	7.5	25		02159	06159
22		7.5			02229	06229
33		7			02339	06339
47		9	100	+15/-25 %	02479	06479
68		8			02689	06689
100		7.5			02101	06101
150		7.5			02151	06151
220		8			02221	06221
330		9	350		02331	06331
470		9.5			02471	06471
680		8			02681	06681
1 000	-20/+50 %	8		+15/-40 %	03102	07102
1 500		8			03152	07152
2 200		8.5			03222	07222
3 300		11			03332	07332
4 700		14			03472	07472
6 800		19			03682	07682
10 000		27			03103	07103

565-series (125 V)

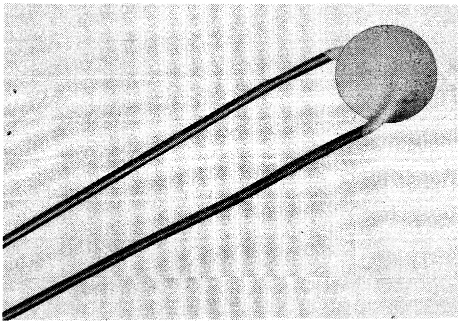
Catalogue number 2222 565 .....
suffix, see table II

Table II

capacitance (pF)	tolerance	L (mm)	suffix of Fig.3 versions
2 200	-20/+50 %	8	02222
3 300		9	02332
4 700		9.5	02472
6 800		12	02682
10 000		16.5	02103

DISC TYPE CERAMIC CAPACITORS

TYPE 1B



RZ 22070-9

Capacitance range	0,47 to 100 pF
Rated d.c. voltage	400 V

APPLICATION

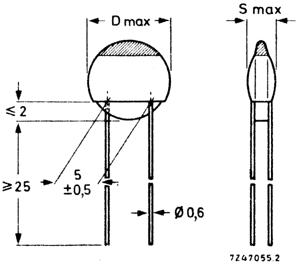
Because low-K ceramic material is used, these capacitors have low losses, a high stability and display a linear temperature dependence of the capacitance. These features render the capacitors ideally suited for application in high frequency equipment, especially in resonant circuits in which advantage can be taken of the linear temperature coefficient to compensate the temperature dependence of other components.

DESCRIPTION

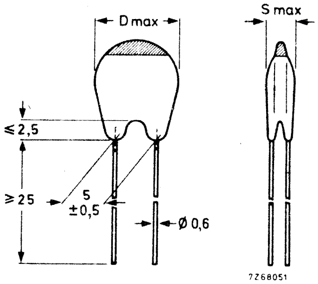
The capacitor consists of a ceramic disc, provided with a silver plating at both sides to which the connecting leads are soldered. The body of version 2222 626 is covered with a grey lacquer that ensures an excellent behaviour under humid conditions. The body of version 2222 625 is partly covered with a grey lacquer so that the leads remain clean; the whole is protected against atmospheric influences by a coating of material which permits soldering of the leads.

MECHANICAL DATA

Dimensions in mm



2222 625
partly insulated



2222 626
insulated

For D and S see Table II.

Marking

Figure code for capacitance value (see Survey Ceramic Capacitors), colour code for temperature coefficient (see Table 1).

ELECTRICAL DATA

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

Rated voltage	400 V d.c.
Test voltage for 1 min	1100 V d.c.
Insulation resistance at 500 V d.c. (within 1 min)	> 10 000 MΩ
Losses (tan δ) at 1 MHz, measured at a voltage of < 3.5 V a.c.	
for C < 10 pF	$< \frac{0.01}{C\,(pF)}$
for C ≥ 10 pF	$< 10 \times 10^{-4}$
Category temperature range	−40 to +85 °C
Climatic category (IEC68)	40/085/21
Capacitances and tolerances	see Table II

Temperature coefficients (Table I)

temp. coeff. (10^{-6}/deg C)	tolerance (10^{-6}/deg C)	t.c. marking colour
P100: +100	-40 to +120	red/violet
NP0: 0	for $C \leq 20$ pF: -40 to +120 for $C > 20$ pF: -40 to +40	black
N150: -150	for $C \leq 20$ pF: -40 to +60 for $C > 20$ pF: -40 to +40	orange
N750: -750	for $C \leq 20$ pF: -120 to +250 for $C > 20$ pF: -120 to +120	violet

Capacitors with temperature coefficients according to N075, N220, N470 and N1500 can be supplied, provided acceptable quantities are ordered.

Composition of the catalogue number

Partly insulated version: 2222 625 .....

Insulated version: 2222 626 .....

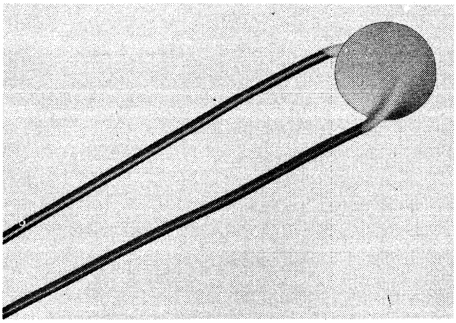
suffix, see Table II

Capacitances and tolerances (Table II)

capacitance		temperature coefficient												nom. cap.
		P100			NP0			N150			N750			
nom. (pF)	tol. (±)	D_{max} (mm)	S_{max} (mm)	cat. No suffix	D_{max} (mm)	S_{max} (mm)	cat. No suffix	D_{max} (mm)	S_{max} (mm)	cat. No suffix	D_{max} (mm)	S_{max} (mm)	cat. No suffix	(pF)
0, 47	0, 25 pF	5	4, 5	03477										0, 47
0, 75	0, 25 pF	5	3, 5	03757										0, 75
1, 0	0, 25 pF	6	3	03108										1, 0
1, 2	0, 25 pF	5	4	03128										1, 2
1, 5	0, 25 pF	5	3, 5	03158										1, 5
1, 8	0, 25 pF	5	3, 5	03188	5	3, 5	09188				5	5	57188	1, 8
2, 2	0, 25 pF	6	3, 5	03228	6	3, 5	09228	5	5	33228	5	4, 5	57228	2, 2
2, 7	0, 5 pF	6	3	02278	5	4	08278	5	4, 5	32278	5	4	56278	2, 7
3, 3	0, 5 pF	6	3	02338	5	3, 5	08338	5	4	32338	5	3, 5	56338	3, 3
3, 9	0, 5 pF	6	3	02398	6	4	08398	5	3, 5	32398	6	4	56398	3, 9
4, 7	0, 5 pF	8	3	02478	6	3, 5	08478	5	3	32478	6	3, 5	56478	4, 7
5, 6	0, 5 pF	8	3	02568	6	3	08568	6	3, 5	32568	6	3	56568	5, 6
6, 8	0, 5 pF	8	3	02688	6	3	08688	6	3	32688	5	4	56688	6, 8
8, 2	0, 5 pF	8	3	02828	6	3	08828	6	3	32828	5	3, 5	56828	8, 2
10	0, 5 pF	8	3	02109	6	3	08109	6	3	32109	5	3	56109	10
12	5 %	8	3	02129	8	3	08129	6	3	32129	6	3, 5	56129	12
15	5 %	9	3	02159	8	3	08159	8	3	32159	6	3	56159	15
18	5 %	9	3	02189	8	3	08189	8	3	32189	6	3	56189	18
22	5 %				8	3	08229	8	3	32229	6	3	56229	22
27	5 %				8	3	08279	8	3	32279	8	3	56279	27
33	5 %				9	3	08339	8	3	32339	8	3	56339	33
39	5 %				9	3	08399	9	3	32399	8	3	56399	39
47	5 %							9	3	32479	8	3	56479	47
56	5 %										8	3	56569	56
68	5 %										8	3	56689	68
82	5 %										9	3	56829	82
100	5 %										9	3	56101	100

DISC TYPE CERAMIC CAPACITORS

TYPE 2



RZ 22070-9

Capacitance range	100 to 3300 pF
Rated d.c. voltage	400 V

APPLICATION

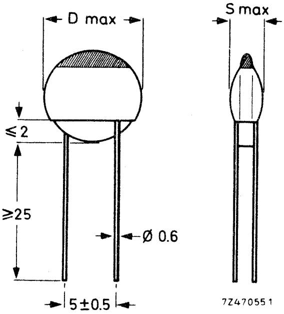
These capacitors are suitable for coupling and decoupling where a low self-inductance and a high insulation resistance are required. They occupy only a small area on printed-wiring boards.

DESCRIPTION

The capacitor consists of a ceramic disc, provided with a silver plating at both sides to which the connecting leads are soldered. The body of the capacitor is partly covered with a brown lacquer so that the leads remain clean. The whole is protected against atmospheric influences by a coating of material which permits soldering of the leads.

MECHANICAL DATA

Dimensions in mm



For D and S see Table.

Marking

The capacitors are figure coded, see Survey Ceramic Capacitors. They are provided with a blue mark at the top for the applied ceramic material.

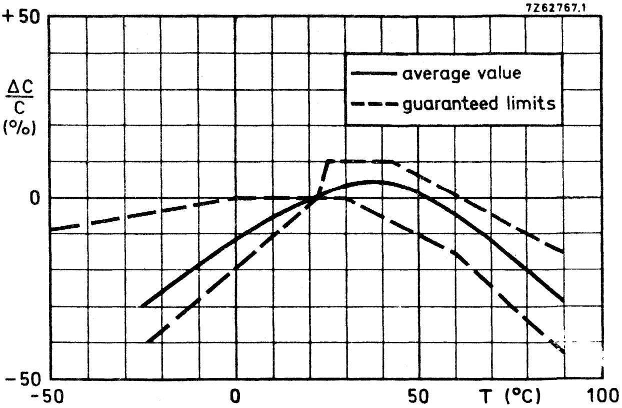
ELECTRICAL DATA

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

Rated voltage	400 V d.c.
Test voltage for 1 min	1250 V d.c.
Insulation resistance at 500 V d.c. (within 1 min)	> 10 000 MΩ
Losses (tan δ) at 1 kHz, measured at < 3.5 V a.c.	$< 350.10^{-4}$
Category temperature range	−40 to +85 °C
Climatic category (IEC68)	40/085/21

capacitance (pF)	tolerance (%)	Dmax (mm)	Smax (mm)	suffix of cat. number
100	−20/+50	5	4,5	14101
150		5	3,5	14151
220		6	3,5	14221
330		6	3,5	14331
470		6	3	14471
680		6	3	14681
1000		8	3	14102
1500		9	3	14152
2200		8	3	14222
3300		9	3	14332

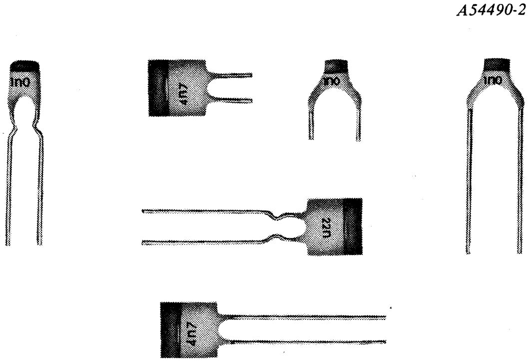
Catalogue number 2222 627 .....
suffix, see Table above



Capacitance change with respect to the capacitance value at 20 °C as a function of temperature.

MINIATURE CERAMIC PLATE CAPACITORS
TYPE 2

QUICK REFERENCE DATA			
	2222 629-series	2222 630-series	2222 640-series
Capacitance range	1000-22000 pF	180-4700 pF	1000-10000 pF
	E3 series	E12 series	E6 series
Rated d.c. voltage	63 V	100 V	100 V
Tolerance on capacitance	-20/+80%	± 10%	-20/+50%
Basic specification	IEC 187	IEC 187	IEC 187
Category (IEC 68)	10/055/21	55/085/21	55/085/21



APPLICATION

In a great variety of electronic circuits where a non-linear change of the capacitance with the temperature is permissible and very low losses are not of major importance, e.g. coupling and decoupling purposes. Because of their small dimensions and close tolerance on lead-spacing the capacitors are very suitable for circuitry with a high component density.

DESCRIPTION

The capacitors consist of a thin rectangular ceramic plate, both sides being metallized and provided with solder-coated connecting leads that are fixed with solder having a high melting point.

The capacitors are protected by several layers of lacquer that ensures a good behaviour under humid conditions and is resistant against the commonly used cleaning solvents. They are tan coloured.
No silver migration can occur.

MECHANICAL DATA

Dimensions in mm

The capacitors are available in six versions:

Table 1

lead spacing	lead length L	lead dia.	Fig.	catalogue number *)
5,08 (0,2 in)	≥ 15	0,6 (0,024 in)	1	2222 629 03... 2222 630 03... 2222 640 03...
5,08 (0,2 in)	$6^{\ 0}_{-2}$	0,6 (0,024 in)	1	2222 629 06... 2222 630 06... 2222 640 06...
2,54 (0,1 in)	≥ 15	0,6 (0,024 in)	2	2222 629 01... 2222 630 01... 2222 640 01...
2,54 (0,1 in)	$6^{\ 0}_{-2}$	0,6 (0,024 in)	2	2222 629 05... 2222 630 05... 2222 640 05...
2,54 (0,1 in)	≥ 15	0,4 (0,016 in)**)	3	2222 629 02... 2222 630 02... 2222 640 02...
3,0	≥ 10	0,6 (0,024 in)	4	2222 629 07... 2222 630 07... 2222 640 07...

Outlines

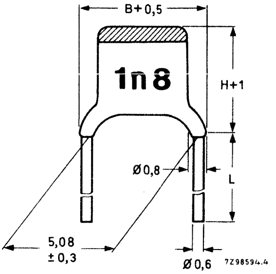


Fig. 1

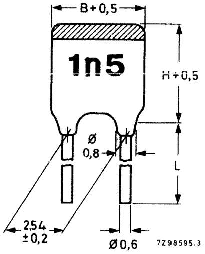


Fig. 2

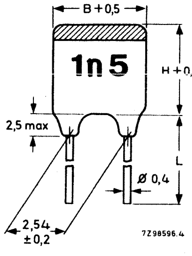


Fig. 3

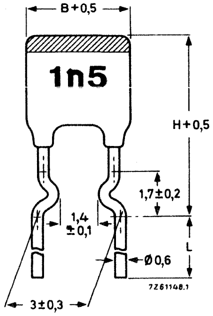


Fig. 4

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*) 3 dots to be replaced by code for capacitance value, see Tables 3, 4 and 5.
**) Flexible leads.

Table 2

size	B x H (mm) Fig. 1	Figs. 2 and 3	Fig. 4	approx. mass (g)
I	6 x 5	3 x 4	3 x 7,5	0,14
II	6 x 6	4 x 5	4 x 8,5	0,15
III	6 x 7	5 x 6	5 x 9,5	0,17
IV	6 x 8	6 x 7	6 x 10,5	0,20

The thickness of the capacitors does not exceed 2,1 mm (0,08 in), except for a few types as is indicated in Table 4.

Lacquer on the leads

When capacitors shown in Figs. 1 and 2 are mounted on printed-wiring boards with a thickness of 1,5 mm and with holes of 1,3 mm diameter or on printed-wiring boards with a thickness of 1 mm and with holes of 0,8 mm diameter, there will be no lacquer on the leads at the lower side of the board. Capacitors, shown in Fig. 4 are very suitable for mounting on printed-wiring boards with plated-through holes.

Marking

The body of the capacitors is tan coloured. The capacitors also have a colour mark on top indicating the temperature dependence of the capacitance; green for type 2222 629, yellow for type 2222 630, and blue for type 2222 640. The capacitance value is indicated on the body in black script according to Tables 3, 4 and 5.

Mounting

When bending, cutting or flattening the leads, one should relieve them of the applied load at the capacitor body.

Soldering conditions	max. 250 °C, max. 5 s max. 270 °C, max. 3 s

Capacitors shown in Fig. 4 can be mounted on printed-wiring boards with a pitch of 2,54 mm or 5,08 mm (hole diameter 0,8 mm).
The leads are self-clamping and hold the capacitor body at a fixed distance from the board.

Capacitors 2222 629 (colour mark green)

→ The capacitors are in conformity with the IEC 187.
Unless otherwise specified all electrical values apply at a temperature of 20 ± 2 °C, an atmospheric pressure of 930-1060 mbar and a relative humidity ≤ 75%.

Capacitance values measured at 1 kHz, ≤ 1,5 V	1000 - 22000 pF; E3 series (see Table 3)
Tolerance on the capacitance	−20 to +80%
Rated d.c. voltage at 55 °C	63 V
Derated d.c. voltage at 85 °C	40 V
Test voltage (d.c.) for 1 min	200 V
→ Test voltage (d.c.) of coating for 1 min	200 V
Insulation resistance at 10 V (d.c.) after 1 min	> 1000 MΩ
Tan δ at 1 kHz, ≤ 1,5 V	< 3,5%
Category temperature range	−10 to +55 °C
Storage temperature range	−40 to +85 °C
Climatic category (IEC 68)	10/055/21

Table 3

cap. (pF)	size see Table 2	marking	code in catalogue number, see Table 1
1000	I	1n0	102
2200	I	2n2	222
4700	I	4n7	472
10000	II	10n	103
22000	IV	22n	223

→

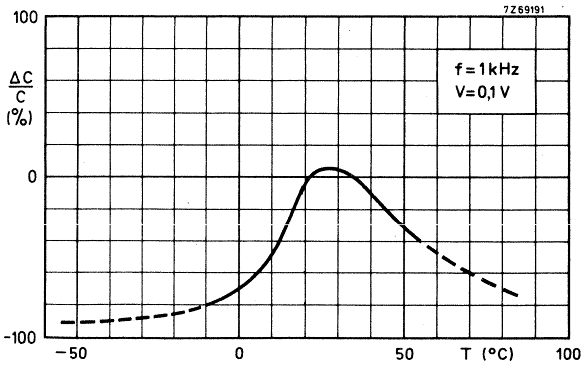

Fig. 5
Typ. capacitance change with respect to the capacitance at 20 °C versus temperature. The dotted lines give an indication of the behaviour at higher and lower temperatures.

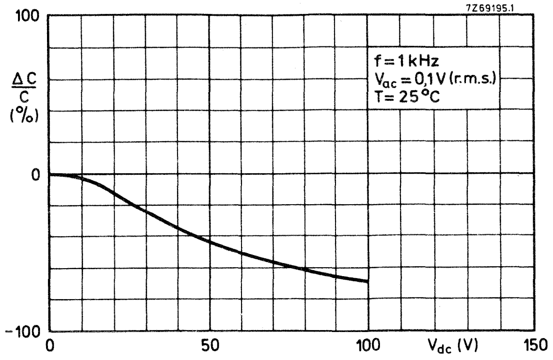

Fig. 6
Typical capacitance change with respect to the capacitance value at 0 V, as a function of d.c. voltage.

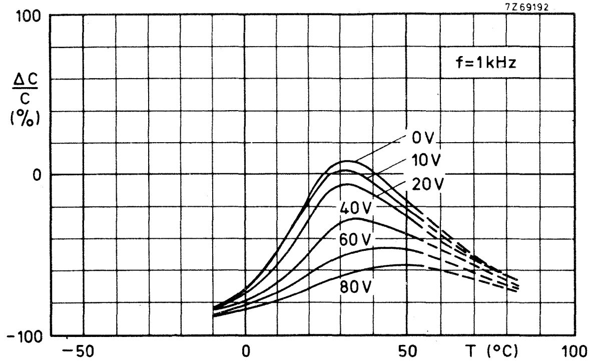

Fig. 7
Typical capacitance change with respect to the capacitance value at 0 V and 25 °C, as a function of temperature at different d.c. voltages.

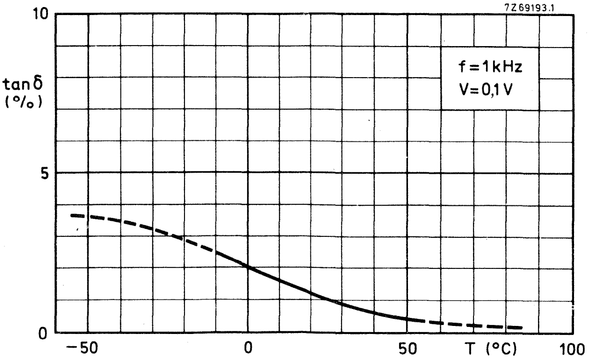

Fig. 8
Typical tan δ as a function of temperature.

ELECTRICAL DATA

Capacitors 2222 630 (colour mark yellow)

The capacitors are in conformity with IEC 187.
Unless otherwise specified all electrical values apply at a temperature of 20 ± 2 °C, an atmospheric pressure of 930 to 1060 mbar and a relative humidity of 45 to 75%.

Capacitance values, measured at 1 kHz, ≤ 1,5 V	180 - 4700 pF, E12 series (see Table 4)
Tolerance on the capacitance	± 10%
Rated d.c. voltage	100 V
Test voltage (d.c.) for 1 min	300 V
Test voltage (d.c.) of coating for 1 min	300 V
Insulation resistance at 100 V (d.c.) after 1 min	> 1000 MΩ
Tan δ at 1 kHz, ≤ 1,5 V	< 3,5%
Maximum voltage dependence of the capacitance between 0 and 40 V	-5%
Category temperature range	-55 to +85 °C
Storage temperature range	-55 to +85 °C
Climatic category (IEC 68)	55/085/21

Table 4

cap. (pF)	size see Table 2	marking	code catalogue number see Table 1
180 *)	I	n18	181
220 *)	I	n22	221
270	I	n27	271
330	I	n33	331
390	I	n39	391
470	I	n47	471
560	I	n56	561
680	I	n68	681
820	I	n82	821
1000	II	1n0	102
1200	II	1n2	122
1500	II	1n5	152
1800	II	1n8	182
2200	III	2n2	222
2700	III	2n7	272
3300	IV	3n3	332
3900	IV	3n9	392
4700	IV	4n7	472

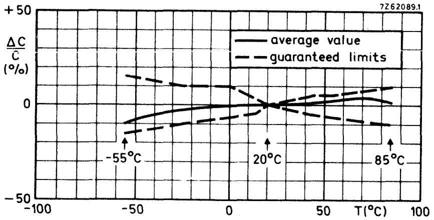

Fig. 9. ΔC with respect to C at 20 °C, as a function of temperature.

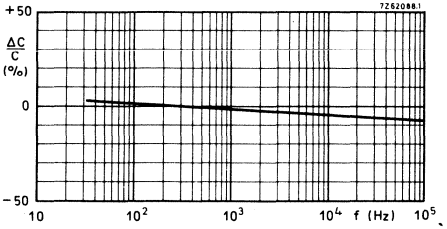

Fig. 10. Typ. ΔC with respect to C at 300 Hz, as a function of frequency.

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*) Maximum thickness 2,5 mm (0,1 in).

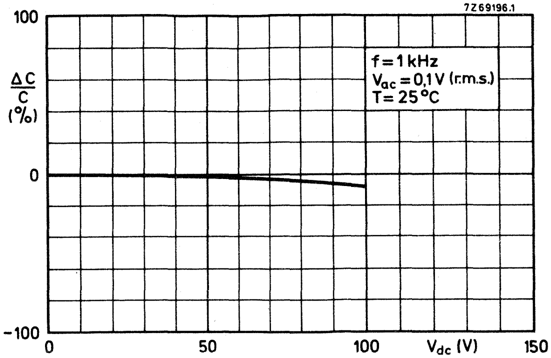


Fig. 11
Typical capacitance change with respect to the capacitance value at 0 V, as a function of d.c. voltage.

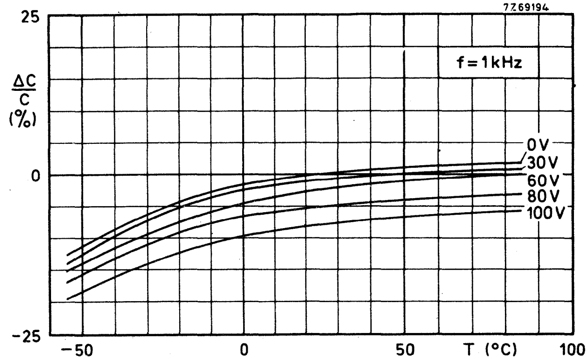


Fig. 12
Typical capacitance change with respect to the capacitance value at 0 V and 25 °C, as a function of temperature at different d.c. voltages.

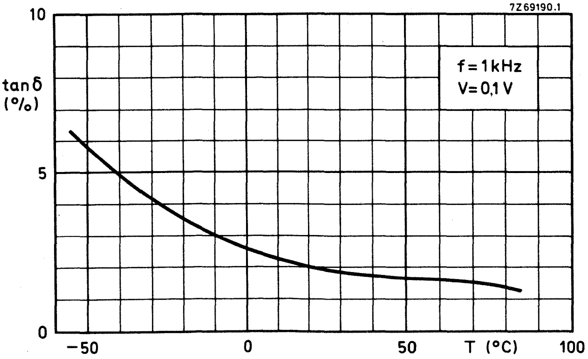


Fig. 13
Typical tan δ as a function of temperature.

ELECTRICAL DATA

Capacitors 2222 640 (colour mark blue)

The capacitors meet the essential requirements of IEC 187.
Unless otherwise specified all electrical values apply at a temperature of 20 ± 2 °C, an atmospheric pressure of 930 to 1060 mbar and a relative humidity of 45 to 75%.

Capacitance values, measured at 1 kHz, $\leq$ 1 V	1000-10 000 pF; E6-series (see Table 5)
Tolerance on the capacitance	−20/+50%
Rated d.c. voltage	100 V
Test voltage (d.c.) for 1 min	300 V
Test voltage (d.c.) of coating for 1 min	300 V
Insulation resistance at 100 V (d.c.) after 1 min	$\geq$ 3000 MΩ
Tan δ at 1 kHz, $\leq$ 1 V	< 3,5%
Category temperature range	−55 to +85 °C
Storage temperature range	−55 to +85 °C
Climatic category (IEC 68)	55/085/21

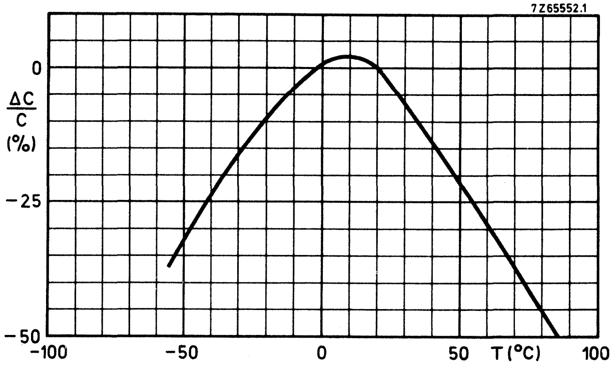


Fig. 14. Typical capacitance change versus temperature.

Table 5

capacitance (pF)	size see Table 2	marking	code in catalogue number, see Table 1
1000	I	1n0	102
1500	I	1n5	152
2200	I	2n2	222
3300	II	3n3	332
4700	II	4n7	472
6800	III	6n8	682
10000	IV	10n	103

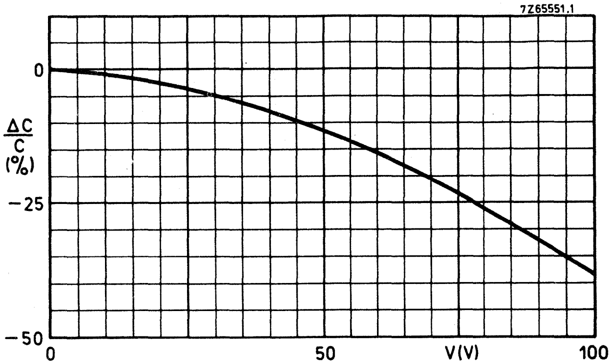


Fig. 15. Typical capacitance change with respect to the capacitance at 20 °C versus temperature.

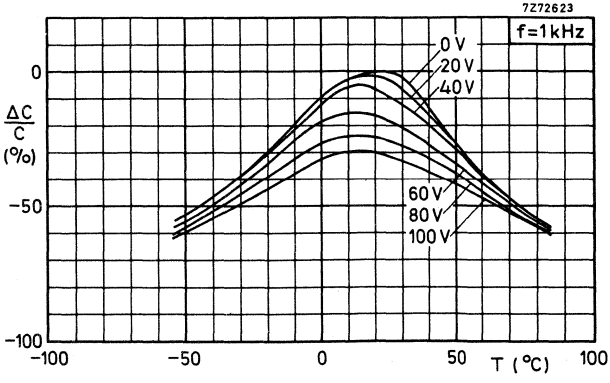
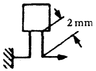


Fig. 16. Typical capacitance change with respect to the capacitance value of 0 V and 25 °C, as a function of temperature at different voltages.

TESTS AND REQUIREMENTS

After manufacturing each capacitor is checked on capacitance, tan δ and test voltage. Apart from this the following quality checks are carried out by frequent inspections.
Essentially all tests mentioned in the schedule of IEC publication 187, category 55/085/21 (temperature range −55/+85 °C; damp heat, long term, 21 days) are carried out along the lines of IEC publication 68.

Table 6

IEC 187 clause	IEC 68 test method	Test	Procedure	Requirements
– 14.1	– Ua	Robustness of terminations Pull-off Tensile strength	 pull velocity 15 cm/min load 5 N lead dia 0,6 mm: axial force 10 N lead dia 0,4 mm: axial force 5 N	no wire breakage or complete damage of capacitor
14.2	Ub	Bending (half number of samples)	load 5 N, 4 x 90°	no wire breakage
15	T	Soldering (solder bath)	solderability: 5 s at 250 °C 3,5 mm from the body, non-activating flux applied	good tinning, ΔC/C after 24 h, 2222 630: ± < 10% 2222 629, 2222 640: ± < 20%
16	–	Rapid change of temperature	pre-conditioning 2222 629 : 1 h + 55 °C 2222 630, 2222 640: 1 h + 85 °C reference measurements after 24 h	
16.3	Na		1 cycle 2222 630: 3 h −55 °C/3 h + 85 °C 2222 640: 3 h −55 °C/3 h + 85 °C 2222 629: 3 h −10 °C/3 h + 55 °C	no damage, ΔC/C after 24 h, 2222 630: ± < 10% 2222 629, 2222 640: ± < 20%

17.1	Fb	Vibration	10-55-10 Hz 0,75 mm displacement 3 directions, 6 h	no visible damage electr. parameters/within specification
18.1	Eb	Bump	4000 bumps in 2 directions, 40g; pulse time 6 ms	no visible damage electr. parameters within specification
-	-	Inflammability	15 s, 35 mm above bunsen burner with flame-height 40-60 mm	self extinguishing within 15 s after removal of bunsen burner
-	-	Resistance to solvents	3 min ultrasonic washing in trichloroethylene 1 min drying, 30 °C 10 brush strokes	marking and colour coding must remain legible and not discoloured; no mechanical or electrical damage or deterioration of the material
19.1	-	Climatic sequence Pre-conditioning	2222 630, 2222 640: 1 h + 85 °C 2222 629: 1 h + 55 °C reference measurements after 24 h	
19.2	B	Dry heat	16 h +85 °C and +55 °C respectively	no visible damage
19.3	Da	Damp heat (accel.) 1 st cycle	1 day +55 °C, 95 to 100% R.H.	no visible damage; after recovery of 1 -2 h immediately followed by cold test
19.4	A	Cold	2222 630, 2222 640: 2 h −55 °C 2222 629: 2 h −10 °C	no visible damage
19.5	M	Low air pressure	1 h at 85 mbar, last 2 min rated voltage applied	no breakdown or flashover
19.6	Da	Damp heat (accel.) remaining cycles	1 day +55 °C, 95 to 100% R.H.	after 1 -2 h recovery: $\Delta C/C$, 2222 630 $\pm < 10\%$ 2222 629, 2222 640 $\pm < 20\%$ $\tan\delta < 7\%$ $R_{ins} > 100\ M\Omega$

Table 5 (continued)

IEC 187 clause	IEC 68 test method	Test	Procedure	Requirements
20.1	Ca	Damp heat **(steady state)**	21 days +40 °C, 90 to 95% R.H. half number of samples 100 V (d.c.), half number of samples no voltage applied	no visible damage; after 1-2 h: $\Delta C/C$, 2222 630 ± < 10% 2222 629, 2222 640: ± < 20% $\tan\delta < 7\%$ $R_{ins} > 100\ M\Omega$
21.1	-	Endurance Ageing	2222 630, 2222 640: 1 h +85 °C 2222 629: 1 h +55 °C reference measurements after 24 h	
21.3	-	Endurance	1000 h (IEC) 2222 630, 2222 640: +85 °C, 150 V (d.c.) 2222 629: +55 °C, 100 V (d.c.)	after 24 h at 20 °C: $\Delta C/C$, 2222 630 ± < 10% 2222 629, 2222 640 ± < 20% $\tan\delta < 5,25\%$ $R_{ins} > 300\ M\Omega$
-	H	Storage	72 h −65 °C, recovery 1-2 h	electr. parameters within specification

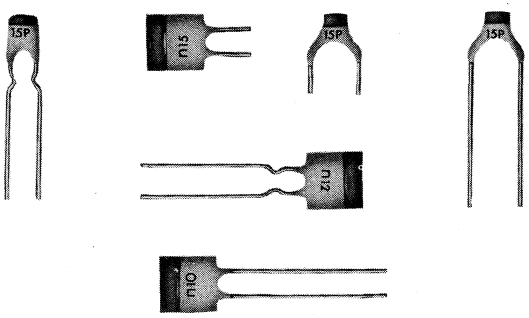
PACKAGING 1000 pieces per box.

MINIATURE CERAMIC PLATE CAPACITORS

TYPE 1B

temperature compensating types

QUICK REFERENCE DATA	
Capacitance range	0,56 to 560 pF (E 12 series)
Rated d.c. voltage	63 V or 100 V
Tolerance on capacitance	±2% or ±0,25 pF
Temperature coefficients	P100, NP0, N075, N150, N220 N330, N470, N750, N1500
Basic specification	IEC 108, type 1B
Category (IEC publ. 68)	55/085/21



A54490-2

APPLICATION

In a wide variety of electronic equipment, e.g. as temperature compensating capacitors in tuning circuits and filters, as coupling and decoupling capacitors in high-frequency circuits where low losses and good d.c. behaviour are required.
Their small dimensions are an advantage in all cases where space-saving is important.

MINIATURE CERAMIC PLATE CAPACITORS
TYPE 1B

DESCRIPTION

The capacitors consist of a thin rectangular ceramic plate, both sides being metallized and provided with connecting leads. They are insulated by a coating method that ensures an excellent behaviour under humid conditions.
The colour of the capacitor body is grey.
The capacitors distinguish themselves by small dimensions, narrow tolerances on the lead spacing and very little and well defined lacquer on the leads. The electrical properties are characterized by low losses, a very close standard tolerance on the capacitance (± 0,25 pF or 2%), high stability and, owing to the absence of silver, an extremely good d.c. behaviour *).

MECHANICAL DATA

The capacitors are available in six versions:

Table 1

lead spacing	lead length L	lead diameter	Fig.	catalogue number ***)
5,08 (0,2 in)	≥ 15	0,6 (0,024 in)	1	2222 638 .....
5,08 (0,2 in)	$6^{\ 0}_{-2}$	0,6 (0,024 in)	1	2222 642 .....
2,54 (0,1 in)	≥ 15	0,6 (0,024 in)	2	2222 631 .....
2,54 (0,1 in)	$6^{\ 0}_{-2}$	0,6 (0,024 in)	2	2222 641 .....
2,54 (0,1 in)	≥ 15	0,4 (0,016 in)**)	3	2222 632 .....
3,0	≥ 10	0,6 (0,024 in)	4	2222 643 .....

Outlines

Dimensions in mm

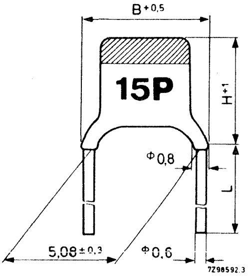


Fig. 1

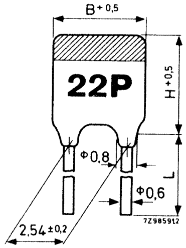


Fig. 2

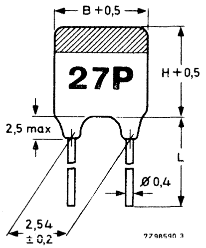


Fig. 3

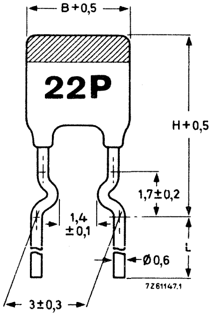


Fig. 4

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*) Capacitors with silver electrodes suffer from the "silver migration" effect. Silver particles move from one electrode to the other under the influence of a d.c. voltage and moisture. Capacitors with silver electrodes are considerably larger.

**) Flexible leads.

***) For suffix see Tables 3 to 11.

Table 2

size	B x H (mm)			approx. mass
	Fig. 1	Fig. 2, 3	Fig. 4	(g)
I	6 x 5	3 x 4	3 x 7,5	0, 14
II	6 x 6	4 x 5	4 x 8,5	0, 15
IIII	6 x 7	5 x 6	5 x 9,5	0, 17
IV	6 x 8	6 x 7	6 x 10,5	0, 20
V	6 x 11	6 x 10	6 x 13,5	0, 20

The thickness of the capacitors does not exceed 2, 1 mm (0, 08 in), except for a few types as is indicated in Tables 3 to 11.

Lacquer on the leads

When capacitors shown in Figs. 1 and 2 are mounted on printed-wiring boards with a thickness of 1, 5 mm and with holes of 1, 3 mm diameter, or on printed-wiring boards with a thickness of 1 mm and with holes of 0, 8 mm diameter, there will be no lacquer on the leads at the lower side of the board.
Capacitors shown in Fig. 4 are very suitable for mounting on printed-wiring boards with plated-through holes.

Marking

The temperature coefficient is indicated by a colour code as per IEC and EIA recommendations.
The capacitance value is indicated by figures in black script.

Mounting

When bending, cutting or flattening the leads, they should be relieved of the applied load at the capacitor body.

Soldering conditions	max. 250 °C, max. 5 s or max. 270 °C, max. 3 s.

Capacitors shown in Fig. 4 can be mounted on printed-wiring boards with a grid of 2, 54 mm or 5, 08 mm (hole diameter 0, 8 mm).
In either case the leads are self-clamping and keep the capacitor body at a certain spacing from the board.

PACKAGING

1000 pieces per box.

ELECTRICAL DATA

The capacitors meet the essential requirements of IEC 108.
Unless stated otherwise all electrical values apply at an ambient temperature of 20 ± 2 °C, an atmospheric pressure of 930 to 1060 mbar and a relative humidity of 45 to 75%.

Capacitance values and tolerances, measured at 1 MHz, < 5 V *)	see Tables 1 to 9
Rated d. c voltage	63 V or 100 V
Test voltage (d. c.) for 1 min	200 V or 300 V
Test voltage (d. c.) of coating for 1 min	200 V or 300 V
Insulation resistance after 1 min	
at 100 V(d. c.) for 63 V capacitors	
at 100 V(d. c.) for 100 V capacitors	> 10 000 MΩ
Tan δ at 1 MHz, < 5 V *)	
for C < 50 pF	$\leq 15\left(\frac{15}{C}+0,7\right)10^{-4}$; max. 55.10^{-4}
for C > 50 pF	$\leq 15.10^{-4}$
Category temperature range	−55 to +85 °C
Climatic category (IEC68)	55/085/21

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*) Including 2 mm per connecting lead.

Capacitors with a temperature coefficient P100, rated voltage 100 V(d.c.)

Capacitance range	0,56 to 47 pF (E 12 series)
Temperature coefficient of the capacitance ($\frac{\Delta C}{C.\Delta T}$)	+100 ppm/°C
Tolerance on the temperature coefficient for C < 20 pF	-40 to +120 ppm/°C
for C > 20 pF	±40 ppm/°C
Marking colour of the temperature coefficient	red/violet

Table 3

cap. (pF)	tolerance	size see Table 2	marking	suffix of catalogue number see Table 1
0,56*)	±0,25 pF	I	p56	03567
0,68*)	±0,25 pF	I	p68	03687
0,82*)	±0,25 pF	I	p82	03827
1,0 *)	±0,25 pF	I	1p0	03108
1,2	±0,25 pF	I	1p2	03128
1,5	±0,25 pF	I	1p5	03158
1,8	±0,25 pF	I	1p8	03188
2,2	±0,25 pF	I	2p2	03228
2,7	±0,25 pF	I	2p7	03278
3,3	±0,25 pF	I	3p3	03338
3,9	±0,25 pF	I	3p9	03398
4,7	±0,25 pF	I	4p7	03478
5,6	±0,25 pF	I	5p6	03568
6,8	±0,25 pF	I	6p8	03688
8,2	±0,25 pF	II	8p2	03828
10	±2%	II	10p	04109
12	±2%	II	12p	04129
15	±2%	II	15p	04159
18	±2%	III	18p	04189
22	±2%	III	22p	04229
27	±2%	IV	27p	04279
33	±2%	IV	33p	04339
39	±2%	V	39p	04399
47	±2%	V	47p	04479

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*) Maximum thickness 2,5 mm (0,1 in).

Capacitors with a temperature coefficient NP0, rated voltage 100 V(d.c.)

Capacitance range		1, 8 to 120 pF (E 12 series)
Temperature coefficient of the capacitance ($\frac{\Delta C}{C.\Delta T}$)		0 ppm/^{o}C
Tolerance on the temperature coefficient	for C < 20 pF	−40 to +120 ppm/^{o}C
	for C > 20 pF	±40 ppm/^{o}C
Marking colour of the temperature coefficient		black

Table 4

cap. (pF)	tolerance	size see Table 2	marking	suffix of catalogue number see Table 1
1, 8*)	±0, 25 pF	I	1p8	09188
2, 2*)	±0, 25 pF	I	2p2	09228
2, 7	±0, 25 pF	I	2p7	09278
3, 3	±0, 25 pF	I	3p3	09338
3, 9	±0, 25 pF	I	3p9	09398
4, 7	±0, 25 pF	I	4p7	09478
5, 6	±0, 25 pF	I	5p6	09568
6, 8	±0, 25 pF	I	6p8	09688
8, 2	±0, 25 pF	I	8p2	09828
10	±2%	I	10p	10109
12	±2%	I	12p	10129
15	±2%	I	15p	10159
18	±2%	I	18p	10189
22	±2%	II	22p	10229
27	±2%	II	27p	10279
33	±2%	II	33p	10339
39	±2%	II	39p	10399
47	±2%	III	47p	10479
56	±2%	III	56p	10569
68	±2%	IV	68p	10689
82	±2%	IV	82p	10829
100	±2%	V	n10	10101
120	±2%	V	n12	10121

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*) Maximum thickness 2, 5 mm (0, 1 in).

Capacitors with a temperature coefficient N075, rated voltage 63 V(d.c.)

Capacitance range	3, 9 to 120 pF (E 12 series)
Temperature coefficient of the capacitance ($\frac{\Delta C}{C.\Delta T}$)	-75 ppm/°C
Tolerance on the temperature coefficient for C < 20 pF	-40 to +60 ppm/°C
for C > 20 pF	±40 ppm/°C
Marking colour of the temperature coefficient	red

Table 5

cap. (pF)	tolerance	size see Table 2	marking	suffix of catalogue number see Table 1
3, 9*)	±0, 25 pF	I	3p9	27398
4, 7*)	±0, 25 pF	I	4p7	27478
5, 6	±0, 25 pF	I	5p6	27568
6, 8	±0, 25 pF	I	6p8	27688
8, 2	±0, 25 pF	I	8p2	27828
10	±2%	I	10p	28109
12	±2%	I	12p	28129
15	±2%	I	15p	28159
18	±2%	I	18p	28189
22	±2%	II	22p	28229
27	±2%	II	27p	28279
33	±2%	II	33p	28339
39	±2%	II	39p	28399
47	±2%	III	47p	28479
56	±2%	III	56p	28569
68	±2%	IV	68p	28689
82	±2%	IV	82p	28829
100	±2%	V	n10	28101
120	±2%	V	n12	28121

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*) Maximum thickness 2, 5 mm (0, 1 in).

Capacitors with a temperature coefficient N150, rated voltage 100 V(d.c.)

Capacitance range	3, 9 to 150 pF (E 12 series)
Temperature coefficient of the capacitance $(\frac{\Delta C}{C.\Delta T})$	−150 ppm/°C
Tolerance on the temperature coefficient for C < 20 pF	−40 to +60 ppm/°C
for C > 20 pF	±40 ppm/°C
Marking colour of the temperature coefficient	orange

Table 6

cap. (pF)	tolerance	size see Table 2	marking	suffix of catalogue number see Table 1
3, 9*)	±0, 25 pF	I	3p9	33398
4, 7*)	±0, 25 pF	I	4p7	33478
5, 6	±0, 25 pF	I	5p6	33568
6, 8	±0, 25 pF	I	6p8	33688
8, 2	±0, 25 pF	I	8p2	33828
10	±2%	I	10p	34109
12	±2%	I	12p	34129
15	±2%	I	15p	34159
18	±2%	I	18p	34189
22	±2%	I	22p	34229
27	±2%	II	27p	34279
33	±2%	II	33p	34339
39	±2%	II	39p	34399
47	±2%	II	47p	34479
56	±2%	III	56p	34569
68	±2%	III	68p	34689
82	±2%	IV	82p	34829
100	±2%	IV	n10	34101
120	±2%	V	n12	34121
150	±2%	V	n15	34151

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*) Maximum thickness 2, 5 mm (0, 1 in).

Capacitors with a temperature coefficient N220, rated voltage 63 V (d.c.)

Capacitance range	3,9 to 150 pF (E12 series)
Temperature coefficient of the capacitance ($\frac{\Delta C}{C.\Delta T}$)	-220 ppm/^{o}C
Tolerance on the temperature coefficient for C < 20 pF	-40 to +60 ppm/^{o}C
for C > 20 pF	± 40 ppm/^{o}C
Marking colour of the temperature coefficient	yellow

Table 7

cap. (pF)	tolerance	size see Table 2	marking	suffix of catalogue number see Table 1
3,9 *)	± 0,25 pF	I	3p9	39398
4,7 *)	± 0,25 pF	I	4p7	39478
5,6 *)	± 0,25 pF	I	5p6	39568
6,8	± 0,25 pF	I	6p8	39688
8,2	± 0,25 pF	I	8p2	39828
10	± 2%	I	10p	40109
12	± 2%	I	12p	40129
15	± 2%	I	15p	40159
18	± 2%	I	18p	40189
22	± 2%	I	22p	40229
27	± 2%	II	27p	40279
33	± 2%	II	33p	40339
39	± 2%	II	39p	40399
47	± 2%	II	47p	40479
56	± 2%	III	56p	40569
68	± 2%	III	68p	40689
82	± 2%	IV	82p	40829
100	± 2%	IV	n10	40101
120	± 2%	V	n12	40121
150	± 2%	V	n15	40151

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*) Maximum thickness 2,5 mm (0,1 in).

Capacitors with a temperature coefficient N330, rated voltage 100 V(d.c.)

Capacitance range	4,7 to 180 pF (E12 series)
Temperature coefficient of the capacitance $(\frac{\Delta C}{C.\Delta T})$	-330 ppm/^{o}C
Tolerance on the temperature coefficient	± 60 ppm/^{o}C
Marking colour of the temperature coefficient	green

Table 8

cap. (pF)	tolerance	size see Table 2	marking	suffix of catalogue number see Table 1
4,7 *)	± 0,25 pF	1	4p7	45478
5,6 *)	± 0,25 pF	I	5p6	45568
6,8	± 0,25 pF	I	6p8	45688
8,2	± 0,25 pF	I	8p2	45828
10	± 0,25 pF	I	10p	46109
12	± 2%	I	12p	46129
15	± 2%	I	15p	46159
18	± 2%	I	18p	46189
22	± 2%	I	22p	46229
27	± 2%	I	27p	46279
33	± 2%	II	33p	46339
39	± 2%	II	39p	46399
47	± 2%	II	47p	46479
56	± 2%	II	56p	46569
68	± 2%	III	68p	46689
82	± 2%	III	82p	46829
100	± 2%	IV	n10	46101
120	± 2%	IV	n12	46121
150	± 2%	V	n15	46151
180	± 2%	V	n18	46181

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*) Maximum thickness 2,5 mm (0,1 in).

Capacitors with a temperature coefficient N470, rated voltage 100 V(d. c.)

Capacitance range	6, 8 to 220 pF (E12 series)
Temperature coefficient of the capacitance $(\frac{\Delta C}{C.\Delta T})$	-470 ppm/$^{\circ}$C
Tolerance on the temperature coefficient for C < 20 pF	-90 to +250 ppm/$^{\circ}$C
for C > 20 pF	± 90 ppm/$^{\circ}$C
Marking colour of the temperature coefficient	blue

Table 9

cap. (pF)	tolerance	size see Table 2	marking	suffix of catalogue number see Table 1
6, 8 *)	± 0, 25 pF	I	6p8	51688
8, 2 *)	± 0, 25 pF	I	8p2	51828
10	± 2%	I	10p	52109
12	± 2%	I	12p	52129
15	± 2%	I	15p	52159
18	± 2%	I	18p	52189
22	± 2%	I	22p	52229
27	± 2%	I	27p	52279
33	± 2%	I	33p	52339
39	± 2%	II	39p	52399
47	± 2%	II	47p	52479
56	± 2%	II	56p	52569
68	± 2%	II	68p	52689
82	± 2%	III	82p	52829
100	± 2%	III	n10	52101
120	± 2%	IV	n12	52121
150	± 2%	IV	n15	52151
180	± 2%	V	n18	52181
220	± 2%	V	n22	52221

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*) Maximum thickness 2, 5 mm (0, 1 in).

Capacitors with a temperature coefficient N750, rated voltage 100 V(d.c.)

Capacitance range	3, 9 to 330 pF (E12 series)
Temperature coefficient of the capacitance ($\frac{\Delta C}{C.\Delta T}$)	-750 ppm/$^{\circ}$C
Tolerance on the temperature coefficient for C < 20 pF	-120 to $+250$ ppm/$^{\circ}$C
for C > 20 pF	± 120 ppm/$^{\circ}$C
Marking colour of the temperature coefficient	violet

Table 10

cap.	tolerance	size see Table 2	marking	suffix of catalogue number see Table 1
3, 9 *)	± 0, 25 pF	I	3p9	57398
4, 7	± 0, 25 pF	I	4p7	57478
5, 6	± 0, 25 pF	I	5p6	57568
6, 8	± 0, 25 pF	I	6p8	57688
8, 2	± 0, 25 pF	I	8p2	57828
10	± 2%	I	10p	58109
12	± 2%	I	12p	58129
15	± 2%	I	15p	58159
18	± 2%	I	18p	58189
22	± 2%	I	22p	58229
27	± 2%	I	27p	58279
33	± 2%	I	33p	58339
47	± 2%	I	47p	58479
56	± 2%	II	56p	58569
68	± 2%	II	68p	58689
82	± 2%	II	82p	58829
100	± 2%	II	n10	58101
120	± 2%	III	n12	58121
150	± 2%	III	n15	58151
180	± 2%	IV	n18	58181
220	± 2%	IV	n22	58221
270	± 2%	V	n27	58271
330	± 2%	V	n33	58331

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*) Maximum thickness 2, 5 mm (0, 1 in).

Capacitors with a temperature coefficient N1500, rated voltage 100 V(d.c.)

Capacitance range	18 to 560 pF (E12 series)
Temperature coefficient of the capacitance ($\frac{\Delta C}{C.\Delta T}$)	-1500 ppm/°C
Tolerance on the temperature coefficient	+500 ppm/°C
Marking colour of the temperature coefficient	orange/orange

Table 11

cap. (pF)	tolerance	size see Table 2	marking	suffix of catalogue number see Table 1
18 *)	± 2%	I	18p	70189
22	± 2%	I	22p	70229
27	± 2%	I	27p	70279
33	± 2%	I	33p	70339
39	± 2%	I	39p	70399
47	± 2%	I	47p	70479
56	± 2%	I	56p	70569
68	± 2%	I	68p	70689
82	± 2%	I	82p	70829
100	± 2%	II	n10	70101
120	± 2%	II	n12	70121
150	± 2%	II	n15	70151
180	± 2%	II	n18	70181
220	± 2%	III	n22	70221
270	± 2%	III	n27	70271
330	± 2%	IV	n33	70331
390	± 2%	IV	n39	70391
470	± 2%	V	n47	70471
560	± 2%	V	n56	70561

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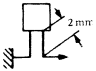
*) Maximum thickness 2, 5 mm (0, 1 in).

TESTS AND REQUIREMENTS

After manufacture, each capacitor is checked on capacitance, tan δ and test voltage. Apart from this the following quality checks are carried out by frequent inspections.
Essentially all tests mentioned in the schedule of IEC publication 108, category 55/085/21 (temperature range −55/+85 °C; damp heat, long term, 21 days) are carried out along the lines of IEC publication 68, see Table 12 below.

Table 12

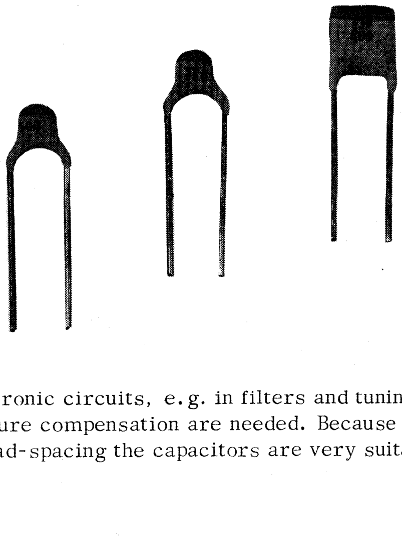
IEC 108 clause	IEC 68 test method	test	procedure	requirements
		Robustness of terminations		
–	–	Pull-off	pull velocity 15 cm/min load 5 N 	no wire breakage or complete damage of capacitor
15.1	Ua	Tensile strength	lead dia 0,6 mm, axial force 10 N lead dia 0,4 mm, axial force 5 N	
15.2	Ub	Bending	load 5 N, 4 x 90^o	no wire breakage
16	T	Soldering (solder bath)	solderability: 5 s 250 °C, 3,5 mm from the body: non-activating flux applied	good tinning, $\Delta C/C < 0,5\%$ or 0,5 pF after 30 min to 1 h
17.2	Na	Rapid change of temperature	3 hours −55 °C/3 hours +85 °C, 1 cycle	no damage, $\Delta C/C < 0,5\%$ or 0,5 pF
18.1	F	Vibration	10-55-10 Hz 0,75 mm displacement 3 directions, 6 h	no visible damage
19.1	E	Bump	4000 bumps in 2 directions, 40g; pulse time 6 ms	no visible damage

–	–	Inflammability	15 s, 35 mm above bunsen burner with flame-height 40-60 mm	self-extinguishing within 15 s after removal of bunsen burner
14.5	–	Temperature coefficient	between +20 and +85 °C	within tolerance as specified for each particular material ←
		Climatic sequence		
20.2	B	Dry heat	16 h +85 °C	no visible damage
20.3	D	Damp heat (accel.) 1st cycle	1 day +55 °C, 100% R.H.	after recovery of 1-2 h immediately followed by cold test
20.4	A	Cold	2 h −55 °C	no visible damage
20.5	M	Low air pressure	1 h 85 mbar	no breakdown or flash over
20.6	D	Damp heat (accel.)	1 day +55 °C, 100% R.H.	$\Delta C/C \leq 1\%$ or 1 pF $\tan \delta < 2 \times$ spec. value R_{ins} after 1-2 h > 100 MΩ
21	Ca	Damp heat, steady state (half number of the lot at rated voltage, other half at zero voltage)	21 days +40 °C 90 to 95% R.H.	$\Delta C/C \leq 1\%$ or 1 pF $\tan \delta \leq 2 \times$ specified $\tan \delta$ R_{ins} after 1-2 h > 100 MΩ
22	–	Endurance	1000 h at +85 °C, 150 V (d.c.)	$\Delta C/C \leq 1\%$ or 1 pF $\tan \delta \leq 1,5 \times$ specified $\tan \delta$ $R_{ins} > 300$ MΩ

MINIATURE CERAMIC PLATE CAPACITORS
TYPE 1B, 500 V (d.c.)
temperature compensating types

QUICK REFERENCE DATA	
Capacitance range	0, 47 to 270 pF (E12 series)
Rated d.c. voltage	500 V
Tolerance on capacitance	± 2% or ± 0, 25 pF
Temperature coefficients	P100, NP0, N150, N750, N1500
Basic specification	IEC 108, type 1B
Category (IEC68)	55/085/21

RZ 29887-3



APPLICATION

In a great variety of electronic circuits, e.g. in filters and tuning circuits where high stability and/or temperature compensation are needed. Because of their small dimensions and close tolerance on lead-spacing the capacitors are very suitable for circuitry with high component density.

DESCRIPTION

The capacitors consist of a rectangular ceramic plate, both sides being metallised and provided with connecting leads. They are insulated by a coating that ensures an excellent behaviour under humid conditions. The colour of the capacitor body is grey. Characteristic electrical properties are low losses, a very close tolerance on the capacitance (0.25 pF or 2%) and high stability. As the capacitors do not have silver electrodes, no silver migration [1] can occur.

MECHANICAL DATA

Dimensions in mm

Table 1

size	B x H (mm)	approx. weight (g)
I	6 x 5	0.15
II	6 x 6	0.15
III	6 x 7	0.17
IV	6 x 8	0.21
V	6 x 11	0.23

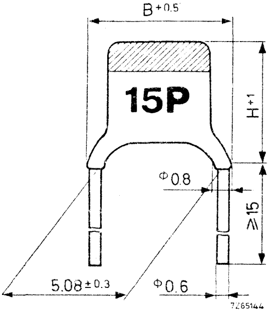


Fig. 1

The thickness of the capacitor does not exceed 2.1 mm except for a few types as indicated in Table 2.

Lacquer on the leads

When the capacitors are mounted on printed-wiring boards with a thickness of 1.5 mm and with holes of 1.3 mm diameter, or on printed-wiring boards with a thickness of 1 mm and with holes of 0.8 mm diameter, there will be no lacquer on the leads at the lower side of the board.

Marking

The temperature coefficient is indicated by a colour code as per IEC and EIA recommendations. The capacitance value and the voltage are indicated in black script on the capacitor, see Tables 2 to 6

Mounting

When bending, cutting or flattening the leads, one should relieve them of the applied load at the capacitor body.

Soldering conditions	max. 250 °C, max. 5 s or max. 270 °C, max. 3 s.

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[1] Silver migration is the movement of silver particles from one electrode to the other, under the influence of a d.c. voltage and moisture, which may cause short circuits.

PACKAGING

1000 pieces per box.

ELECTRICAL DATA

The capacitors meet the essential requirements of IEC 108. Unless stated otherwise all electrical values apply at an ambient temperature of 20 ± 2 °C, an atmospheric pressure of 930 to 1060 mbar and a relative humidity of 40 to 75 %.

Capacitance values and tolerances, measured at 1 MHz, < 5 V *)	0,47 to 270 pF, E12 series, see Tables 2 to 6
Rated d.c. voltage	500 V
Test voltage (d.c.) for 1 minute	1250 V
Test voltage (d.c.) of coating for 1 minute	1250 V
Insulation resistance at 500 V (d.c.) after 1 min	> 10 000 MΩ
Tan δ at 1 MHz, < 5 V *)	
for C < 50 pF	$\leq 15\left(\frac{15}{C} + 0{,}7\right) . 10^{-4}$, (max. $55 . 10^{-4}$)
for C > 50 pF	$\leq 15 . 10^{-4}$
Category temperature range	−55 to +85 °C
Storage temperature range	−65 to +125 °C
Climatic category (IEC 68)	55/085/21

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*) Including 2 mm per connecting lead.

Capacitors with temperature coefficient P100

Capacitance range		0, 47 to 33 pF (E12 series)
Temperature coefficient of the capacitance ($\frac{\Delta C}{C.\Delta T}$)		+100 ppm/^{o}C
→ Tolerance on the temperature coefficient	for C < 20 pF	-40 to +120 ppm/^{o}C
	for C > 20 pF	± 40 ppm/^{o}C
Marking colour of the temperature coefficient		red/violet

Table 2

capacitance (pF)	tolerance	size	marking	catalogue number
0, 47 *)	± 0, 25 pF	I	P47 500	2222 650 03477
0, 68 *)	± 0, 25 pF	I	P68 500	03687
1, 0 *)	± 0, 25 pF	I	1P0 500	03108
1, 2 *)	± 0, 25 pF	I	1P2 500	03128
1, 5 *)	± 0, 25 pF	I	1P5 500	03158
1, 8 *)	± 0, 25 pF	I	1P8 500	03188
2, 2	± 0, 25 pF	I	2P2 500	03228
2, 7	± 0, 25 pF	I	2P7 500	03278
3, 3	± 0, 25 pF	I	3P3 500	03338
3, 9	± 0, 25 pF	I	3P9 500	03398
4, 7	± 0, 25 pF	II	4P7 500	03478
5, 6	± 0, 25 pF	II	5P6 500	03568
6, 8	± 0, 25 pF	II	6P8 500	03688
8, 2	± 0, 25 pF	II	8P2 500	03828
10	± 2%	III	10P 500	04109
12	± 2%	III	12P 500	04129
15	± 2%	III	15P 500	04159
18	± 2%	IV	18P 500	04189
22	± 2%	IV	22P 500	04229
27	± 2%	V	27P 500	04279
33	± 2%	V	33P 500	04339

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*) Maximum thickness 2, 5 mm.

Capacitors with a temperature coefficient NP0

Capacitance range	0, 82 to 47 pF (E12 series)
Temperature coefficient of the capacitance ($\frac{\Delta C}{C.\Delta T}$)	0 ppm/^{o}C
Tolerance on the temperature coefficient for $C < 20$ pF	-40 +120 ppm/^{o}C
for $C > 20$ pF	± 40 ppm/^{o}C
Marking colour for the temperature coefficient	black

Table 3

capacitance (pF)	tolerance	size	marking		catalogue number
0, 82 *)	± 0, 25 pF	I	P82	500	2222 650 09827
1 *)	± 0, 25 pF	I	1P0	500	09108 ←
1, 2 *)	± 0, 25 pF	I	1P2	500	09128
1, 5 *)	± 0, 25 pF	I	1P5	500	09158
1, 8 *)	± 0, 25 pF	I	1P8	500	09188
2, 2 *)	± 0, 25 pF	I	2P2	500	09228
2, 7 *)	± 0, 25 pF	I	2P7	500	09278
3, 3 *)	± 0, 25 pF	I	3P3	500	09338
3, 9	± 0, 25 pF	I	3P9	500	09398
4, 7	± 0, 25 pF	I	4P7	500	09478
5, 6	± 0, 25 pF	I	5P6	500	09568
6, 8	± 0, 25 pF	II	6P8	500	09688
8, 2	± 0, 25 pF	II	8P2	500	09828
10	± 2%	II	10P	500	10109
12	± 2%	II	12P	500	10129
15	± 2%	III	15P	500	10159
18	± 2%	III	18P	500	10189
22	± 2%	III	22P	500	10229
27	± 2%	IV	27P	500	10279
33	± 2%	IV	33P	500	10339
39	± 2%	V	39P	500	10399
47	± 2%	V	47P	500	10479

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*) Maximum thickness 2, 5 mm.

Capacitors with a temperature coefficient N150

Capacitance range	2.2 to 56 pF (E12 series)
Temperature coefficient of the capacitance $(\frac{\Delta C}{C.\Delta T})$	$-150.10^{-6}/^{o}C$
Tolerance on the temperature coefficient	
for C < 20 pF	$(-40+60).10^{-6}/^{o}C$
for C > 20 pF	$\pm 40.10^{-6}/^{o}C$
Marking colour of the temperature coefficient	orange

Table 4

capacitance (pF)	tolerance	size	marking		catalogue number
2.2 *)	±0.25 pF	I	2P2	500	2222 650 33228
2.7 *)	±0.25 pF	I	2P7	500	33278
3.3 *)	±0.25 pF	I	3P3	500	33338
3.9 *)	±0.25 pF	I	3P9	500	33398
4.7	±0.25 pF	I	4P7	500	33478
5.6	±0.25 pF	I	5P6	500	33568
6.8	±0.25 pF	I	6P8	500	33688
8.2	±0.25 pF	II	8P2	500	33828
10	±2%	II	10P	500	34109
12	±2%	II	12P	500	34129
15	±2%	II	15P	500	34159
18	±2%	II	18P	500	34189
22	±2%	III	22P	500	34229
27	±2%	III	27P	500	34279
33	±2%	IV	33P	500	34339
39	±2%	IV	39P	500	34399
47	±2%	V	47P	500	34479
56	±2%	V	56P	500	34569

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*) maximum thickness 2.5 mm

Capacitors with a temperature coefficient N750

Capacitance range	1, 8 to 120 pF (E12 series)
Temperature coefficient of the capacitance ($\frac{\Delta C}{C.\Delta T}$)	-750 ppm/^{o}C
Tolerance on the temperature coefficient for C ≤ 18 pF	-120 +250 ppm/^{o}C
for C > 18 pF	± 120 ppm/^{o}C
Marking colour of the temperature coefficient	violet

Table 5

capacitance (pF)	tolerance	size	marking		catalogue number
1, 8 *)	± 0, 25 pF	I	1P8	500	2222 650 57188
2, 2 *)	± 0, 25 pF	I	2P2	500	57228
2, 7 *)	± 0, 25 pF	I	2P7	500	57278
3, 3 *)	± 0, 25 pF	I	3P3	500	57338
3, 9 *)	± 0, 25 pF	I	3P9	500	57398
4, 7 *)	± 0, 25 pF	I	4P7	500	57478
5, 6 *)	± 0, 25 pF	I	5P6	500	57568
6, 8 *)	± 0, 25 pF	I	6P8	500	57688
8, 2	± 0, 25 pF	I	8P2	500	57828
10	± 2%	I	10P	500	58109
12	± 2%	I	12P	500	58129
15	± 2%	I	15P	500	58159
18	± 2%	II	18P	500	58189
22	± 2%	II	22P	500	58229
27	± 2%	II	27P	500	58279
33	± 2%	II	33P	500	58339
39	± 2%	III	39P	500	58399
47	± 2%	III	47P	500	58479
56	± 2%	III	56P	500	58569
68	± 2%	IV	68P	500	58689
82	± 2%	IV	82P	500	58829
100	± 2%	V	n10	500	58101
120	± 2%	V	n12	500	58121

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*) Maximum thickness 2, 5 mm.

Capacitors with a temperature coefficient N1500

Capacitance range	8, 2 to 270 pF (E12 series)
Temperature coefficient of the capacitance ($\frac{\Delta C}{C.\Delta T}$)	-1500 ppm/^{o}C
Tolerance on the temperature coefficient	-0 $+500$ ppm/^{o}C
Marking colour of the temperature coefficient	orange/orange

Table 6

capacitance	tolerance	size	marking		catalogue number
8, 2 *)	± 0, 25 pF	I	8P2	500	2222 650 69828
10 *)	± 2%	I	10P	500	70109
12 *)	± 2%	I	12P	500	70159
15 *)	± 2%	I	15P	500	70159
18	± 2%	I	18P	500	70189
22	± 2%	I	22P	500	70229
27	± 2%	I	27P	500	70279
33	± 2%	II	33P	500	70339
39	± 2%	II	39P	500	70399
47	± 2%	II	47P	500	70479
56	± 2%	II	56P	500	70569
68	± 2%	II	68P	500	70689
82	± 2%	III	82P	500	70829
100	± 2%	III	n10	500	70101
120	± 2%	III	n12	500	70121
150	± 2%	IV	n15	500	70151
180	± 2%	IV	n18	500	70181
220	± 2%	V	n22	500	70221
270	± 2%	V	n27	500	70271

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*) Maximum thickness 2, 5 mm.

TESTS AND REQUIREMENTS

Essentially all tests mentioned in the schedule of IEC publication 108, category 55/085/21 (temperature range −55/+85 °C: damp heat, long term, 21 days) are carried out along the lines of IEC publication 68, see Table 7 below.

Table 7

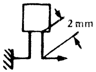
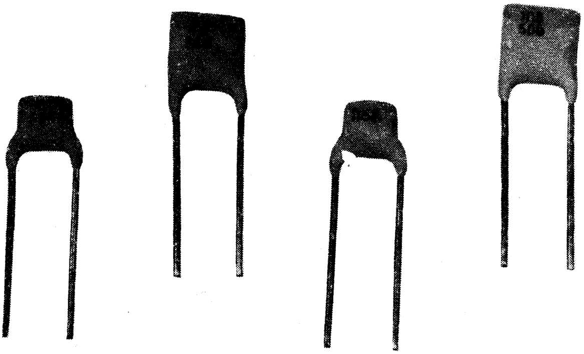
IEC 108 clause	IEC 68 test method	test	procedure	requirements
–	–	Robustness of terminations Pull-off	pull velocity 15 cm/min max. load 5 N 	no wire breakage or complete damage of capacitor
15.1	Ua	Tensile strength of leads	axial force 10 N	
15.2	Ub	Bending	load 5 N, 4 x 90°	no wire breakage
16	T	Soldering	solderability: 5 s 250 °C, 3,5 mm from the body: non-activating flux applied	good tinning, $\Delta C/C < 0,5\%$ or 0,5 pF after 30 min to 1 h
17.2	Na	Rapid change of temperature	3 hours −55 °C/3 hours +85 °C, 1 cycle	no damage, $\Delta C/C < 0,5\%$ or 0,5 pF
18.1	F	Vibration	10-55-10 Hz 0,75 mm displacement 3 directions, 6 h	no visible damage
19.1	E	Bump	4000 bumps in 2 directions, 40g; pulse time 6 ms	no visible damage
–	–	Inflammability	15 s, 35 mm above bunsen burner with flame height 40-60 mm	self-extinguishing within 15 s
–	–	Resistance to solvents	3 min ultrasonic washing in trichloroethylene 1 min drying, 30 °C, 10 brush strokes	marking and colour code must remain legible and not be discoloured; no mechanical or electrical damage or deterioration of the material.

Table 7 continued

IEC 108 clause	IEC 68 test method	test	procedure	requirements
14.5	-	Temperature coefficient	between +20 and +85 °C	within tolerance as specified for each particular material
20.2	B	Climatic sequence Dry heat	16 h +85 °C	no visible damage
20.3	Da	Damp heat (accel.) 1^{st} cycle	1 day +55 °C, 100 % R.H.	after recovery of 1-2 h immediately followed by cold test
20.4	A	Cold	2 h −55 °C	no visible damage
20.5	M	Low air pressure	1 h 85 mbar	no breakdown or flashover
20.6	D	Damp heat (accel.)	1 day +55 °C, 100 % R.H.	
21	Ca	Damp heat, steady state (half number of the lot at rated voltage, other half at zero voltage)	21 days +40 °C 90 to 95 % R.H.	$\Delta C/C \leq 1\%$ or 1 pF $\tan\delta \leq 2 \times$ specified $\tan\delta$, R_{ins} after 1-2 h > 5000 MΩ
22	-	Endurance	100 h +85 °C, 750 V (d.c.)	$\Delta C/C \leq 1\%$ or 1 pF $\tan\delta \leq 1,5 \times$ specified $\tan\delta$ $R_{ins} > 3000$ MΩ

MINIATURE CERAMIC PLATE CAPACITORS
TYPE 2A, 500 V (d.c.)
high-K type

QUICK REFERENCE DATA	
Capacitance range	100 - 2700 pF (E12 series)
Rated d.c. voltage	500 V
Tolerance on capacitance	± 10%
Basic specification	IEC 187 type 2
Category (IEC 68)	55/085/21


RZ 29887-2

APPLICATION

In a great variety of electronic circuits, where a non-linear change of the capacitance with the temperature is permissible and low losses are not of major importance, e.g. coupling and decoupling purposes. Because of their small dimensions and close tolerance on lead spacing the capacitors are very suitable for circuitry with high component density.

MINIATURE CERAMIC PLATE CAPACITORS

DESCRIPTION

The capacitors consist of a rectangular ceramic plate, both sides being metallised and provided with connecting leads. They are insulated by a coating that ensures an excellent behaviour under humid conditions. The capacitor body is tan coloured. The temperature dependence of the capacitance is very small and non-linear. As the capacitors do not have silver electrodes no "silver migration" [1] can occur.

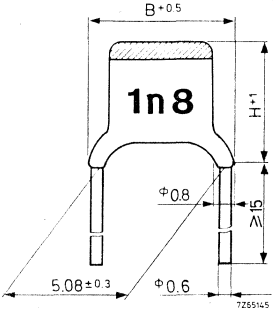
MECHANICAL DATA

Dimensions in mm

Table 1

size	B x H	approx. weight (g)
I	6 x 5	0.15
II	6 x 6	0.15
III	6 x 7	0.17
IV	6 x 8	0.21
V	6 x11	0.23

Fig. 1



The thickness of the capacitor does not exceed 2.1 mm except for a few types, as indicated in Table 2.

Lacquer on the leads

When the capacitors are mounted on printed-wiring boards with a thickness of 1.5 mm and with holes of 1.3 mm diameter or on printed-wiring boards with a thickness of 1 mm and with holes of 0.8 mm diameter there will be no lacquer on the leads at the lower side of the board.

Marking

The temperature dependence is indicated by a yellow colour cap.
Capacitance value and voltage are indicated in black script according to Table 2.

Mounting

When bending cutting or flattening the leads, one should relieve them of the applied load at the capacitor body.

Soldering conditions max. 250 °C, max. 5 s
max. 270 °C, max. 3 s

---

[1] Silver migration is the movement of silver particles from one electrode to the other, under the influence of a d.c. voltage and moisture, which may cause short circuits.

ELECTRICAL DATA

The capacitors meet the essential requirements of IEC 187. Unless stated otherwise all electrical values apply at an ambient temperature of 20 ± 2 °C, an atmospheric pressure of 930 to 1060 mbar and a relative humidity of 45 to 76%.

Capacitance values, measured at 1 kHz ± 10% < 1,5 V	100 to 2700 pF, E12 series, see Table 2
Tolerance on the capacitance	± 10%
Rated d.c. voltage	500 V
Test voltage (d.c.) for 1 min	1250 V
Test voltage (d.c.) of coating for 1 min	1250 V
Insulation resistance at 500 V (d.c.) after 1 min	> 3000 MΩ
Tan δ at 1 kHz, < 1,5 V	< 3,5%
Category temperature range	-55 to +85 °C
Climatic category	55/085/21
Storage temperature range	-65 to +125 °C
Capacitance change versus temperature	see Fig. 2
Capacitance change versus frequency	see Fig. 3

Table 2

capacitance (pF)	size	marking		catalogue number
100 *)	I	n10	500	2222 655 03101
120 *)	I	n12	500	03121
150 *)	I	n15	500	03151
180 *)	I	n18	500	03181
220 *)	I	n22	500	03221
270	I	n27	500	03271
330	I	n33	500	03331
390	II	n39	500	03391
470	II	n47	500	03471
560	II	n56	500	03561
680	II	n68	500	03681
820	II	n82	500	03821
1000	III	1n0	500	03102
1200	III	1n2	500	03122
1500	IV	1n5	500	03152
1800	IV	1n8	500	03182
2200	V	2n2	500	03222
2700	V	2n7	500	03272

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*) Maximum thickness 2,5 mm.

TESTS AND REQUIREMENTS

Essentially all test mentioned in the schedule of IEC publication 187, category 55/085/21 (temperature range −55/+85 °C; damp heat, long term, 21 days) are carried out along the lines of IEC publication 68, see Table 3 below.

Table 3

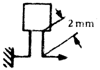
IEC 187 clause	IEC 68 test method	test	procedure	requirements
–	–	Robustness of terminations Pull-off	pull velocity 15 cm/min load 5 N 	no wire breakage or complete damage of capacitor
14.1	Ua	Tensile strength	lead dia 0,6 mm; axial force 10 N lead dia 0,4 mm; axial force 5 N	
14.2	Ub	Bending	load 5 N, 4 x 90°	no wire breakage
15	T	Soldering (solder bath)	solderability: 5 s at 250 °C 3,5 mm from the body, non-activating flux applied	good tinning, ΔC/C between +20 % and −10 % after 24 h
16	–	Rapid change of temperature	deaging 1 h +85 °C reference measurement after 24 h	
16.3	Na		3 h −55 °C/3 h +85 °C 1 cycle	no damage, ΔC/C after 24 h ≤ 10 %
17.1	Fb	Vibration	10-55-10 Hz 0,75 mm displacement 3 directions, 6 h	no visible damage
18.1	Eb	Bump	4000 bumps in 2 directions, 40g; pulse time 6 ms	no visible damage
–	–	Inflammability	15 s, 35 mm above bunsen burner with flame-height 40-60 mm	self-extinguishing within 15 s after removal of bunsen burner

Table 3 continued

IEC 187 clause	IEC 68 test method	test	procedure	requirements
–	--	Resistance to solvents	3 min. ultrasonic washing in trichloroethylene 1 min drying, 30 °C, 10 brush strokes	marking and colour coding must remain legible and not discoloured; no mechanical or electrical damage or deterioration of the material.
19.1	–	Climatic sequence Pre-conditioning	1 h +85 °C reference measurement after 24 h	
19.2	B	Dry heat	16 h +85 °C	no visible damage
19.3	Da	Damp heat (accel.) 1st cycle	1 day +55 °C 100% R.H.	no visible damage; after recovery of 1-2 h immediately followed by cold test
19.4	A	cold	2 h −55 °C	no visible damage

Table 3 (continued)

IEC 187 clause	IEC 68 test method	Test	Procedure	Requirements
19.5	M	Low air pressure	1 h at 85 mbar, last 5 min 500 V d.c. applied	no breakdown or flash over
19.6	D	Damp heat (accel.) remaining cycles	1 day +55 °C, 100% R.H.	after recovery of 1-2 h $\Delta C/C < 10\ \%$ $\tan\delta < 700.\ 10^{-4}$ $R_{ins} > 1000\ M\Omega$
20.1	Ca	Damp heat (long term)	21 days +40 °C, 90 to 95% R.H.	$\Delta C/C \leq 10\%$ $\tan\delta \leq 700.10^{-4}$ R_{ins} after 1-2 h > 1500 MΩ
21.3	-	Endurance	1000 h +85 °C, 750 V d.c.	$\Delta C/C \leq 10\%$ $\tan\delta < 525.10^{-4}$ $R_{ins} > 1000\ M\Omega$ after 24 h

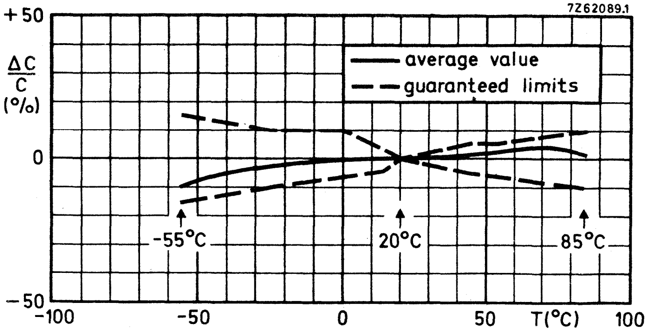


Fig. 2

Capacitance change with respect to the capacitance at 20 °C as a function of temperature.

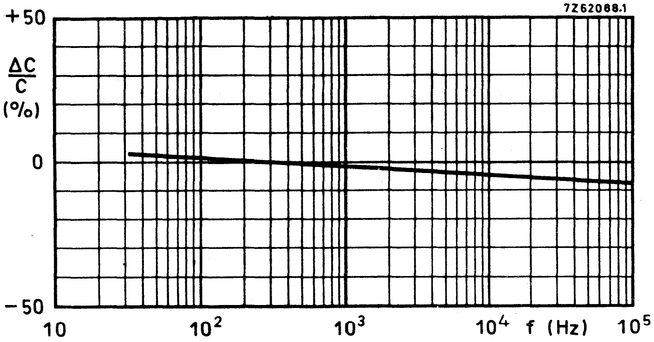


Fig. 3

Typical capacitance change with respect to the capacitance value at 300 Hz as a function of frequency.

PACKAGING : 1000 pieces per box.

CERAMIC BARRIER LAYER CAPACITORS

TYPE 3

QUICK REFERENCE DATA	
Capacitance range	22 000 / 47 000 / 100 000 pF
Rated d.c. voltage	6 V
Tolerance on capacitance	−20 /+80 %
Basic specification	IEC 324 (type 3)
Category (IEC 68)	25/085/21

APPLICATION

The capacitors have a very high capacitance in very small dimensions. Therefore they are very suitable for coupling and decoupling purposes in small transistorized equipment, for example in i.f. stages , hearing aids, etc.

DESCRIPTION

The capacitors consist of a thin square ceramic plate, which has been given semiconducting properties by a reducing process. The surface is oxidized on both sides, thus forming a barrier layer. Both surfaces are metallized and provided with connecting leads. Thus two capacitances with a series resistance in between are formed (see Fig.1).
The whole is covered with a blue insulating lacquer. The capacitors are provided with rigid connecting leads of 0,6 mm dia. or with flexible connecting leads of 0,4 mm dia.

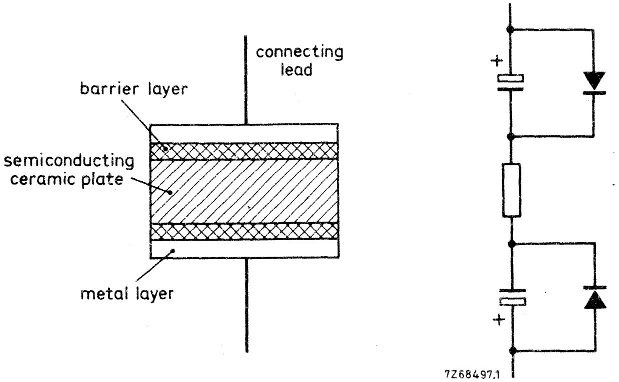


Fig. 1

MECHANICAL DATA

Dimensions (mm)

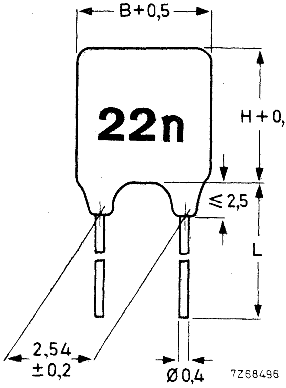


Fig. 2 Type with flexible connecting leads; d = 0,4 mm

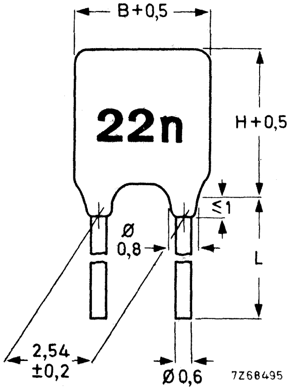


Fig. 3 Type with rigid connecting leads; d = 0,6 mm

For maximum thickness, T_{max}, see Table.

nominal capacitance (pF)	dimensions (mm)				marking	catalogue number 2222 675	
	B	H	T_{max}	L		0,6 mm leads version	0,4 mm leads version
22 000	3	4	2,5	≥ 15	22n 6V	20223	21223
47 000	4	5	2,1	≥ 15	47n 6V	20473	21473
100 000	6	7	2,1	≥ 15	µ10 6V	20104	21104

Marking

The body of the capacitors is blue. The capacitance value and rated voltage are indicated on the body in black script (according the table).

Mounting

The capacitors with leads of 0,,6 mm diameter are intended to be used on printed-wiring boards with a pitch of 0,1 inch. The distance between the leads is 2,54 mm with a tolerance of ± 0,2 mm, which assures an easy mounting. It must be pointed out that the leads should not be bent, e.g. for use on printed-wiring boards with a pitch of 5 mm.
For the latter application use must be made of the version with connecting leads of 0,4 mm diameter.
When bending, cutting or flattening the leads, they should be relieved of the applied load at the capacitor body.

Soldering conditions max 250 °C, max 5 s.

ELECTRICAL DATA

The capacitors are in concormity with IEC 324.
Unless otherwise specified, all electrical values apply at a temperature of 20 ± 2 °C, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%

Capacitance values, measured at 1 kHz, 0,1 V	22 000/47 000/100 000 pF
Tolerance on the capacitance	-20 to +80%
Rated d.c. voltage	6 V
Test voltage (d.c.) for 1 min	7,5 V
Test voltage (d.c.) of coating for 1 min	100 V
Insulation resistance at 6V (d.c.) after 1 min	RC ≥0,025 s
Tan δ at 1 kHz, 0,1 V	≤ 10%
Impedance at 10 MHz	
for C = 22 000 pF	≤ 10 Ω
for C = 47 000 pF	≤ 5 Ω
for C = 100 000 pF	≤ 5 Ω
Category temperature range	-25 to +85 °C
Storage temperature range	-40 to +85 °C
Climatic category (IEC 68)	25/085/21

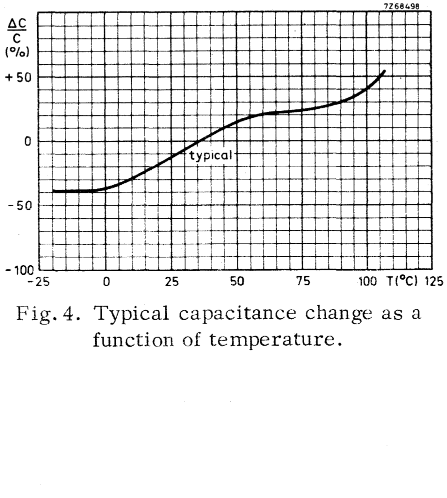


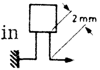
Fig. 4. Typical capacitance change as a function of temperature.

PACKAGING

1000 pieces per box.

TESTS AND REQUIREMENTS

Essentially all tests mentioned in the schedule of IEC publication 324, category 25/085/21 (temperature range −25 to +85 °C; damp heat, long term, 21 days) are carried out along the lines of IEC publication 68, (and EIA RS 198), see Table below:

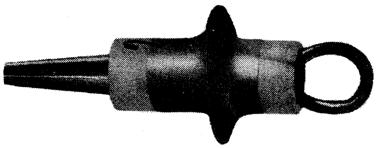
IEC 324 clause	IEC 68 test method	test	procedure	requirements
12	-	Visual examination and check of dimensions Construction and appearance	-	capacitors must be in accordance with mechanical specification
13.1		Electrical test Capacitance	measured at 1 kHz, ≤ 0, 1 V, 20 °C	capacitance tolerance within specification
13.2		Tan δ Impedance	at 1 kHz, ≤ 0, 1 V, 20 °C at 10 MHz ≤ 0, 1 V, 20 °C	tan δ ≤ 10 % 47 nF, 100 nF: ≤ 5 Ω 22 nF ≤ 10 Ω
13.3		Voltage tests (between electrodes, both polarities)	7, 5 V (d. c.) for 1 min, between both electrodes and coating 100 V (d. c.) for 1 min	no breakdown or flashover
13.4		Insulation resistance	6 V (d. c.) for 1 min between electrodes, between electrodes and coating	RC ≥0, 025 s ≥3000 MΩ
--	-	Robustness of terminations Pull-off	pull velocity 15 cm/min load 5 N 	
14.1	Ua	Tensile strength	lead dia 0,4 mm: axial force 5 N lead dia 0,6 mm: axial force 10 N	no wire breakage or complete damage of the capacitor
14.2	Ub	Bending	0, 4 mm dia leads with 2,5 N load 0,6 mm dia leads with 5 N load 4 x 90°	no wire breakage or complete damage of the capacitor

15.1		Soldering (solder bath)	solderability: 5 s, 250 °C, 3,5 mm from the body; non-activated flux applied	good tinning $\Delta C/C \leq -10/+20\,\%$ after 24 h
		(mounting test)	capacitors mounted on p.w. board immersed in solder bath 250 °C load of 1 N pulled in direction of leads	no damage within 10 s.
		Inflammability	15 s 35 mm above bunsen burner with flame height 40 to 60 mm	self extinguishing within 15 s after removal of bunsen burner
		Resistance to solvents	3 min ultrasonic washing in trichloroethylene at 30 °C	marking and colour coding must remain legible and not discolour; no mechanical or electrical damage or deterioration of the material
16.1		Rapid change of temperature	deaging 1 h +85 °C after 24 h cap. measuring at 1 kHz ≤ 0,1 V at 20 °C for reference	
16.3	Na		3 h max, temperature +85 °C 3 h min, temperature −25 °C	no visible damage
17.1	Fc	Vibration	10 - 50 - 10 Hz, 0,75 mm displacement, 120 cycles in 3 directions, 6 h total	no visible damage
18.1	Eb	Bumping	4000 ± 10 bumps in 2 directions, 40 g (390 m/s^2) pulse time 6 ms	no visible damage; electrical parameters within stated limit
19.1.1		Climatic sequence	deaging 1 h at +85 °C	
19.1.2		Capacitance	at 1 kHz ≤ 0,1 V at +20 °C for reference	after 24 h within specified tolerance
19.2	Ba	Dry heat	16 h at +85 °C	no visible damage

IEC 324 clause	IEC 68 test method	test	procedure	requirements
19.3	Da	Damp heat (accel.) 1st cycle	1 day +55 °C 95 to 100 % R.H.	no visible damage
19.4	Aa	Cold	after 1 - 2 h recovery 2 h at −25 °C	no visible damage
19.5	M	Low air pressure	2 min at 85 mbar I_{min} after test 6 V (d.c.) for 5 min	no breakdown or flashover
19.6	Da	Damp heat (accel.) remaining cycles	1 day +55 °C, 95 to 100 % R.H.	no visible damage after 1 - 2 h $\Delta C/C \leq 20\%$ tan δ within specifications, R_{ins} and impedance within stated 0 h limits
20.1	Ca	Damp heat (steady state)	21 days +40 °C, 90 to 95 % R.H. half number of samples 6 V (d.c.) half number of samples no voltage applied	no visible damage after 1 - 2 h $\Delta C/C \leq 20\%$ tan δ, R_{ins} and impedance within stated 0 h limits
21.1		Endurance Aging	1 h at +85 °C reference measurement after 24 h	
21.3		Endurance	IEC 1000 h at + 85 °C at 6 V (d.c.) EIA 250 h at +85 °C	no visible damage after 24 h $\Delta C/C \leq 20\%$ tan δ, R_{ins} and impedance within stated 0 h limits
13.5		Storage	72 h, −65 °C	after recovery within 1 - 4 h at +20 °C electrical parameters within stated 0 h limits (dry capacitors)

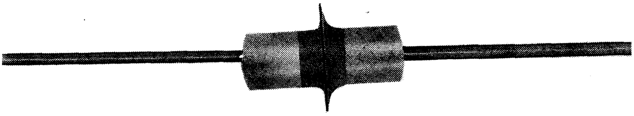
CERAMIC FEED-THROUGH CAPACITORS

TYPE 2



RZ 22070-3

700-series :	Maximum working voltage	350 V (d.c.)
	Capacitance range	2,5 to 2200 pF



RZ 22070-4

702-series :	Maximum working voltage	350 V (d.c.)
	Capacitance range	2,5 to 4700 pF

APPLICATION

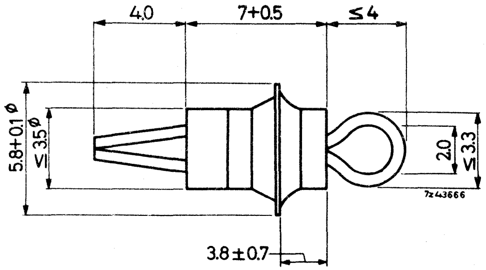
Ceramic feed-through capacitors are designed for decoupling the supply leads of high-frequency equipment, for instance in TV tuners. However, due to their extremely low inductances, they might also be used in frequency-determining circuits in similar equipment.

CONSTRUCTION

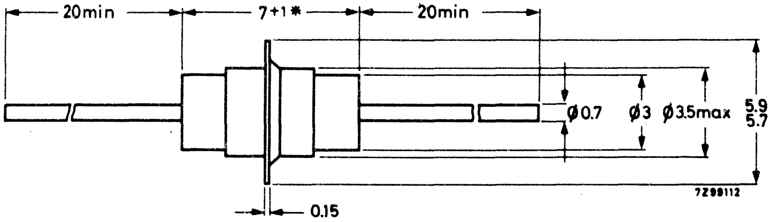
The capacitors consist of a ceramic tube provided with silver electrodes. The outer connection is formed by a flange, and the inner one by a split pen (700-series) or an axial lead (702-series). Both types are provided with sufficient soldering tin to facilitate mounting.
The split pen capacitors are marked in black script or with a colour dot. The lead feed-through type is not marked.

Dimensions in mm

700-series



702-series



*) 10^{+1} mm for the 3300pF capacitor
12^{+1} mm for the 4700pF capacitor

TECHNICAL PERFORMANCE

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

Rated voltage	350 V d.c.
Test voltage for 1 min	1050 V d.c.
Losses (tan δ) measured at < 3.5 V	
for C ≤ 68 pF at 1 MHz	$< 10.10^{-4}$
for C > 68 pF at 1 kHz	$< 20.10^{-4}$
Insulation resistance at 100 V d.c. (within 1 min)	> 10 000 MΩ
Working temperature range	−40 to +85 °C
Climatic category (IEC 68)	40/085/21

AVAILABLE VERSIONS

Split pen feed-through capacitors, catalogue number 2222 700 .....
suffix, see table

capacitance (pF)	tolerance	suffix
≤ 2.5		00258
3.3	±0.5 pF	01338
4.7	±0.5 pF	01478
6.8	±1 pF	02688
10	±1 pF	02109
15	±10 %	03159
22		03229
33		03339
47		03479
68	±20 %	04689
100		04101
150		04151
220		04221
330		04331
470		04471
680		04681
1000	-20/+50 %	05102
1500		05152
2200		05222

Lead feed-through capacitors, catalogue number 2222 702 .....
suffix, see table

cap. (pF)	tolerance	suffix
≤ 2.5	± 0.5 pF	04258
3.3		04338
4.7		04478
6.8		04688
10	±10%	05109
15		07159
22		07229
33		07339
47		07479
68		07689
100	± 20 %	08101
150		08151
220		08221
330		08331
470		08471
680	-20/+50 %	09681
1000		09102
1500		09152
2200		09222
3300		09332
4700		09472

Capacitance values of the E12 series are subject to minimum order release requirements.

MULTILAYER CERAMIC CHIP CAPACITORS

QUICK REFERENCE DATA

Capacitance range		
NP0 (C0G) dielectric	10 to 10 000 pF	(E 12 series)
K1800 (X7R) dielectric	100 to 470 000 pF	(E 12 series)
Rated d.c. voltage	50 V	
Tolerance on capacitance		
NP0 (C0G)	± 10%	
K1800 (X7R)	± 20%	
Basic specification	IEC draft 40 (C0) 343 (EIA RS198/B)	
Climatic category (IEC 68)		
NP0 (C0G)	55/125/56	
K1800 (X7R)	55/125/56	

APPLICATION

These multilayer ceramic capacitors provide a very high capacitance per unit volume which, together with physical size and performance, makes them very suitable for use in hybrid and other micro-circuitry. These small size components can be applied to the same functions as other ceramic capacitors i.e., coupling, by-passing, blocking, frequency discrimination, etc.

DESCRIPTION

The capacitors consist of a rectangular block of ceramic dielectric in which a number of interleaved precious-metal electrodes yield a high capacitance per unit volume.
The capacitors are Pd Ag metallized at the end terminal. (See Fig. 2.)

MECHANICAL DATA

Dimensions in mm

Outlines

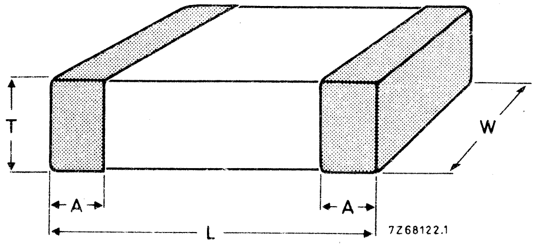


Fig. 1

Table 1

size	L	W	T		A	
			min.	max.	min.	max.
0805	2,0 ± 0,2	1,25 ± 0,2	0,6	1,2	0,3	0,6
1210	3,2 ± 0,3	2,5 ± 0,2	0,6	1,9	0,3	1,0
1808	4,5 ± 0,3	2,0 ± 0,2	0,6	1,9	0,3	1,0
1812	4,5 ± 0,3	3,2 ± 0,3	0,6	1,9	0,3	1,0
2220	5,7 ± 0,4	5,0 ± 0,4	0,6	1,9	0,3	1,0

Soldering

Limiting conditions	min.	220 °C, 3 s
	max.	250 °C, 60 s

PACKAGING

Multiples of 100 pieces.

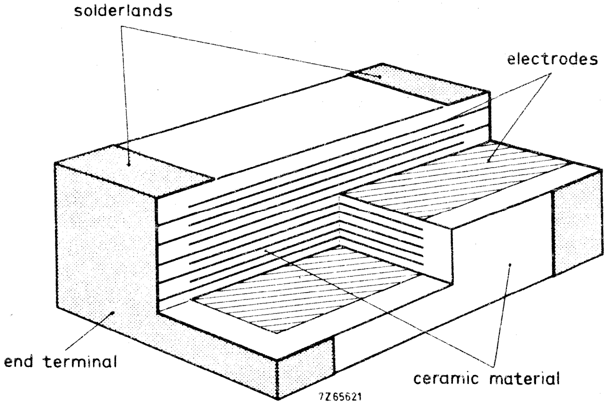


Fig. 2

COMPOSITION OF THE CATALOGUE NUMBER

2222 ... .

style code

851 for size 0805
852 for size 1210
854 for size 1808
855 for size 1812
856 for size 2220

	tolerance	
NP0 (C0G)	10%	13
K1800 (X7R)	20%	48

capacitance value code, first two significant figures of the capacitance value (pF) according E12 series followed by multiplying factor:
- 9 for x 1
- 1 for x 10
- 2 for x 10^2
- 3 for x 10^3
- 4 for x 10^4

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of 20 ± 7 °C, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

Type 1 High-Q, NP0 (EIA : C0G)

Capacitance range	
$\leq$ 1000 pF measured at 1 MHz, 1 V $>$ 1000 pF measured at 1 kHz, 1 V	see Table 2, (E 12 series)
Tolerance on capacitance	± 10%
Rated d.c. voltage (U_R)	50 V
D.C. test voltage for 1 min	150 V
Dissipation factor, measured at 1 V, 1 MHz, $C < 30$ pF	$10\,(\frac{10}{C} + 0,7)\,.\,10^{-4}$
1 MHz, 30 pF $< C \leq$ 1000 pF	$< 10\,.\,10^{-4}$
1 kHz, $C >$ 1000 pF	$< 10\,.\,10^{-4}$
Insulation resistance	$>$ 100 000 MΩ
Category temperature range	−55 to +125 °C
Capacitance change as a function of temperature, −55 to +125 °C	± 30 ppm/°C

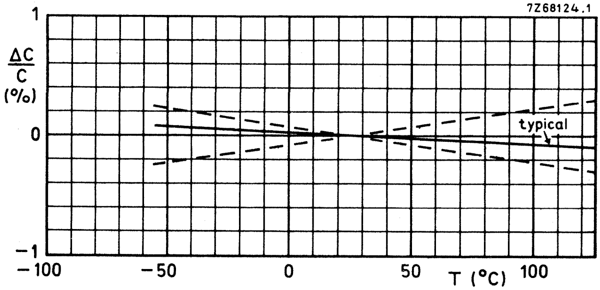


Fig. 3. Typical capacitance change as a function of temperature. Dotted lines indicate the limits.

Table 2 : NP0 (C0G)

cap. (pF)	size				
	0805	1210	1808	1812	2220
10	2222 851 13109				
12	13129				
15	13159				
18	13189				
22	13229				
27	13279				
33	13339				
39	13399				
47	13479	2222 852 13479			
56	13569	13569			
68	13689	13689			
82	13829	13829			
100	13101	13101	2222 854 13101		
120	13121	13121	13121		
150	13151	13151	13151		
180	13181	13181	13181		
220	13221	13221	13221		
270	13271	13271	13271		
330		13331	13331	2222 855 13331	
390		13391	13391	13391	
470		13471	13471	13471	2222 856 13471
560		13561	13561	13561	13561
680		13681	13681	13681	13681
820		13821	13821	13821	13821
1000		13102	13102	13102	13102
1200		13122	13122	13122	13122
1500		13152	13152	13152	13152
1800		13182	13182	13182	13182
2200		13222	13222	13222	13222
2700		13272	13272	13272	13272
3300			13332	13332	13332
3900				13392	13392
4700				13472	13472
5600				13562	13562
6800					13682
8200					13822
10000					13103

Type 2, K1800 (EIA : X7R)

Capacitance range measured at 1 kHz, 1 V	see Table 3 (E12 series)
Tolerance on capacitance	± 20%
Rated d.c. voltage (U_R)	50 V
D.C. test voltage for 1 min	150 V
Dissipation factor, measured at 1 kHz, 1 V	$< 300 \cdot 10^{-4}$
Insulation resistance, C ≤ 10 000 pF	> 100 000 MΩ
C > 10 000 pF	$R_{ins} \times C > 1000$ s
Category temperature range	−55 to +125 °C
Maximum capacitance change as a function of temperature	± 15%, see Fig. 4

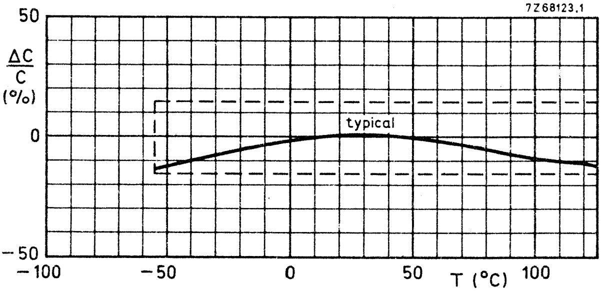


Fig. 4. Typical capacitance change as a function of temperature. Dotted lines indicate the limits.

Table 3 : K1800 (X7R)

cap. (pF)	size				
	0805	1210	1808	1812	2220
100	2222 851 48101				
120	48121				
150	48151				
180	48181				
220	48221				
270	48271				
330	48331				
390	48391				
470	48471				
560	48561				
680	48681				
820	48821				
1000	48102				
1200	48122				
1500	48152				
1800	48182				
2200	48222	2222 852 48222	2222 854 48222		
2700	48272	48272	48272		
3300	48332	48332	48332		
3900	48392	48392	48392		
4700	48472	48472	48472	2222 855 48472	
5600	48562	48562	48562	48562	
6800	48682	48682	48682	48682	
8200	48822	48822	48822	48822	
10000	48103	48103	48103	48103	
12000	48123	48123	48123	48123	2222 856 48123
15000	48153	48153	48153	48153	48153
18000	48183	48183	48183	48183	48183
22000	48223	48223	48223	48223	48223
27000		48273	48273	48273	48273
33000		48333	48333	48333	48333
39000		48393	48393	48393	48393
47000		48473	48473	48473	48473
56000		48563	48563	48563	48563
68000		48683	48683	48683	48683
82000		48823	48823	48823	48823
100000		48104	48104	48104	48104
120000				48124	48124
150000				48154	48154
180000				48184	48184
220000				48224	48224
270000					48274
330000					48334
390000					48394
470000					48474

TESTS AND REQUIREMENTS–IEC

sam-pling group	number of samples	IEC 384-1 par.	draft 40(C.O.) 343 par.	test	procedure	requirements
1 A	20	7	8.5	Visual inspection and check of dimensions	any applicable method	in accordance with specification
		10	8.6	Capacitance	$C \leq 1000$ pF f = 1 MHz $C > 1000$ pF f = 1 kHz measuring voltage 1 V, T = + 25 °C	within specified tolerance
		11	8.7	Tan δ	see 8.6	in accordance with specification
		8	8.8	Insulation resistance	at 10 V (d.c.)	in accordance with specification
		9	8.9	Voltage proof	3 x U_R for 1 min	no breakdown or flashover
1B	20		8.15	Solderability	unmounted chips completely immersed for 4 ± 1 s in a solder bath of 230 ± 10 °C	the termination of the chip must be well tinned. capacitance within tolerance
2A	55	same measurements as group 1A, however, the capacitors are mounted on a substrate				capacitance and tan δ shall be used as a reference for further tests. R_{ins}: same as 8.8 test voltage: same as 8.9
2B2	15		8.13	Adhesion	a force of 5 N shall be applied normal to the line joining the terminations and in a plane parallel to the substrate	no visible damage
		19	8.14	Vibration IEC 68, test Fc	severity IV	no visible damage

2B2		18	8. 16	De-ageing and recovery	K1800: 1 h at max. temperature	
					K1800: cap. measured after 24 h recovery for reference	within specified tolerance
				Rapid change of temperature	3 h at max. temperature followed by 3 h at min. temperature (1 cycle)	no visible damage NP0: $\Delta C/C \pm \leq 1\%$ or 1 pF after 24 h recovery K1800: $\Delta C/C \pm \leq 10\%$
		21	8. 17	Climatic sequence De-ageing and recovery	K1800: 1 h at max. temperature	
		21. 1			K1800: cap. measured after 24 h recovery for reference	
		21. 2		Dry heat	16 h at max. temperature	no visible damage
		21. 3		Damp heat accelerated, 1 cycle	24 h, R.H. 100% at 55 ^{o}C	no visible damage
		21. 4		Cold	2 h at min. temperature	no visible damage
		21. 6		Damp heat accelerated, remaining cycles	at 55 ^{o}C, R.H. 100% 5 cycles of 24 h	after recovery $\leq$ 8 h: no visible damage $\Delta C/C$, NP0: $\pm \leq 2\%$ or 2 pF K1800: $\pm \leq 10\%$ tan δ, NP0: $\leq$ 2 x specified tan δ in group 2 A K1800: $\pm \leq 5\%$ R_{ins}: $> 2.10^3$ MΩ for C $\leq$ 25000 pF or RC $>$ 50 s for C $>$ 25000 pF

TESTS AND REQUIREMENTS–IEC (continued)

sampling group	number of samples	IEC 384-1 par.	IEC draft 40(C.O.) 343 par.	test	procedure	requirements
2B3	15	22	8. 18	Damp heat, steady state	56 days, R.H. 90-95% at 40 °C, no voltage applied	no visible damage. electrical data same as 8. 16, however ΔC deviation from group 2A
2B4	5		8. 10	Temperature coefficient	NP0: between min. and max. temperature	in accordance with specification
			8. 11	Temperature characteristic	K1800: 96 h drying at 55 °C K1800: +25, −55, +25, +125 °C	$\Delta C/C \pm \leq 15\%$
2B5	20	24	8. 19	Endurance		
				Preconditioning	1 h at max. temperature	no visible damage, after 24 h recovery ΔC/C, NP0 : $\pm \leq 2\%$ or 2 pF K1800 : $\pm \leq 10\%$ tan δ, NP0 : $\leq 1,5 \times \tan\delta$ in group 2A K1800 : $\leq 3,75\%$ R_{ins}, NP0 : $> 15.10^3$ MΩ for $C \leq 25$ nF K1800 : $> 5.10^3$ for $C \leq 25$ nF $RC > 125$ s for $C > 25$ nF
				Capacitance	after 24 h recovery	
				Test	1000 h at max. temperature with $1,5 \times U_R$ applied	

TESTS AND REQUIREMENTS–EIA

sam-pling group	number of samples	EIA RS 198/B test	par.	test	procedure	requirements
1	50		4.4	Construction and appearance	any applicable method	chips shall be in accordance with specification
		1.6.1	1.5.2	Capacitance	C0G, C ≤ 1000 pF at 1 MHz C > 1000 pF at 1 kHz X7R at 1 kHz; measuring voltage 1 V	capacitance shall be within specified tolerance
		1.6.2 2.5.2	1.5.3 2.4.3	Tan δ	see 1.5.2	C0G at 1 MHz, 30 pF ≤ C ≤ 1000 pF : $< 10.10^{-4}$ at 1 kHz, C > 1000 pF : $< 20.10^{-4}$ C < 30 pF acc. EIA RS198 par 1.5.3.1 X7R ≤ 2,5%
		1.6.3 2.5.3	1.5.4 2.4.4	Insulation resistance	for 1 min at U_R	in accordance with specification C0G, $R_{ins} > 10^5$ MΩ X7R, C ≤ 10 nF, $R_{ins} > 10^5$ MΩ C > 10 nF, RC > 1000 s
		1.6.4 2.5.4	1.5.5 2.4.6	Test voltage	for 1 s at 2,5 x U_R	no breakdown or flashover
2	5	1.6.5	1.5.6	Temperature coefficient	C0G: +25, −55, +25, +85, +25 °C, temp. coefficient = $\frac{\Delta C}{C25.\Delta T}$	max. ΔC/C : ± 30 ppm/°C in accordance with specification
		2.5.5	2.4.6	Temperature characteristic	X7R: +25, −55, +25, +125 °C	max. ΔC/C : ± 15%

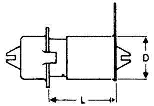
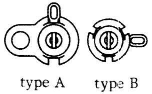
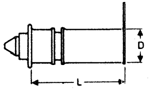
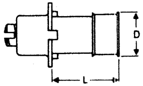
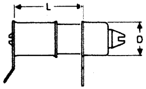
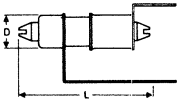
IIIIIII

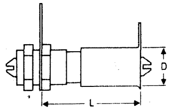
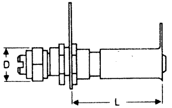
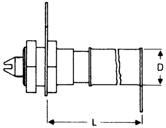
TESTS AND REQUIREMENTS–EIA (continued)

sam-pling group	number of samples	EIA RS 198/B test	 par.	test	procedure	requirements
3	20	1.6.6 2.5.6	1.5.7 2.4.7	Seal test	5 cycles of 15 min. at +25 °C, −20 °C, +25 °C and +85 °C followed by 100 h at R.H. 90-95% and 40 °C	within 30 min to be measured; $\Delta C/C$, C0G : ± ≤ 2% or 0, 25 pF X7R : ± ≤ 20% tan δ, C0G : ≤ two times initial value of group 1 X7R : ≤ 5% R_{ins} , C0G : > 10^4 MΩ X7R, C ≤ 10 nF, R_{ins} > 10^4 MΩ C > 10 nF, RC > 100 s
4	20	1.6.7	1.5.8	Endurance		
		2.5.7	2.4.8	Preconditioning	1 h at max. temperature	
				Capacitance	see group 1	in accordance with specification
				Test	250 h at max. temper-ature with 2 x U_R applied	see group 3

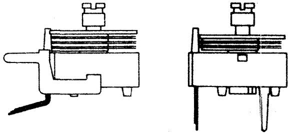
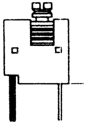
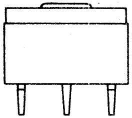
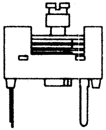
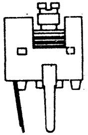
Variable capacitors

SURVEY

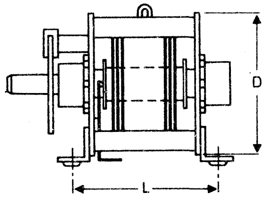
model		capacitance max. C_{min}/ min. C_{max} (pF)	rated voltage (d.c.) (V)	temperature coefficient (ppm/°C)	temperature range (°C)	dimensions L x D (mm)	catalogue number 2222 followed by
TUBULAR CERAMIC TRIMMERS							
	type A	0, 8/3 0, 8/6 0, 9/9 1/12	500	−200 ± 200	−50 to +100	5, 5 x 6 8, 5 x 6 11, 5 x 6 14, 5 x 6	801 20001 20002 20003 20004
	type B	0, 8/3 0, 8/6 0, 9/9 1/12				5, 5 x 6 8, 5 x 6 11, 5 x 6 14, 5 x 6	20005 20006 20007 20008
		0, 8/3 0, 8/6	400	−200 ± 200 −300 ± 200	−50 to +100	8 x 4 11 x 4	801 20051 20052
		0, 7/6 0, 5/3	500	+150 ± 100 +150 ± 150	−50 to +100	8, 5 x 6	801 96002 96003
		0, 3/1, 5 0, 5/3, 5 1, 0/6, 0	400	+50 ± 100 −200 ± 200 −300 ± 300	−50 to +100	13 x 4 13 x 4 13 x 4	801 96124 96127 96135
		0, 5/3, 0 1, 0/5, 5	400	+150 ± 200 +100 ± 300	−50 to +100	5 x 4 5 x 4	801 96138 96139

	0, 8/3 0, 8/6 0, 9/9 1, 0/12 1, 7/8	500	−200 ± 200	−50 to +100	11 x 6 14 x 6 17 x 6 20 x 6 20 x 6	802 20001 20002 20003 20004 20005
	0, 5/3 0, 6/4, 5 0, 7/6 0, 9/9 1, 0/12	500	−10 ± 60 −10 ± 60 −10 ± 60 −250 ± 250 −250 ± 250	−50 to +100	12, 4 x 6 15, 4 x 6 17, 9 x 6 15, 4 x 6 18, 4 x 6	802 20011 20012 20013 20014 20015
	0, 5/3 to 1, 0/12	400 to 500	−10 ± 60 to −200 ± 150	−50 to +100	8, 8 x 4 to 20 x 5, 5	802 960. .

SURVEY (continued)

model		capacitance max.C_{min}/ min.C_{max} (pF)	rated voltage (d.c.) (V)	temperature coefficient (ppm/°C)	temperature range (°C)	dimensions (mm)	catalogue number 2222 followed by
FILM DIELECTRIC TRIMMERS 	1)	1, 4/5, 5 to 12/120	250	0 ± 300 to −750 ± 300	−40 to +70	7, 5 ø 10 ø 13, 5 ø	← 808 . . . . .
	2)	1/3, 5 1, 8/10 2/18	300	−250 ± 150 −300 ± 75 −350 ± 75	−40 to +125	8 x 6	809 05001 05002 05003
	1)	1/3, 5 1, 8/10 2/18		−250 ± 150 −300 ± 75 −350 ± 75			05004 05005 05006
	2)	2, 5/20 to 7/100	200 to 350	0 ± 200	−40 to +125	14 x 11	809 070. .
	1)	4/40 5/60	300	−250 ± 150	−40 to +125	11 x 10	809 08002 08003
	1)	1, 4/5, 5 2/9 2/18	250	−250 ± 150	−40 to +125	9 x 8	809 09001 09002 09003

PRECISION TUNING CAPACITORS

model	capacitance range (pF)				L x D (mm)			catalogue number
	stator types	40 x 40 mm linear	60 x 60 mm linear	60 x 60 mm logarithmic	number of gangs	D = 40 x 40 mm	D = 60 x 60 mm	
 temperature range: −40 to +85 °C	single 1-4 gangs split 1-4 gangs differential 1 gang	16-250 10-64 64-160	100-640 25-125 –	100-500 25-125 –	1 2 3 4	L = 45 L = 76,5 L = 108 L = 139,5	L = 67 L = 117,5 L = 168 L = 218,5	2222 805 .....

Notes

- Some data on our trimmers, such as the temperature coefficient and the climatic category, are defined on the basis of type approval tests.
- All specified values are continuously checked by a random test system of which the results are gathered in periodical surveys from which typical values can be derived and made available on request.

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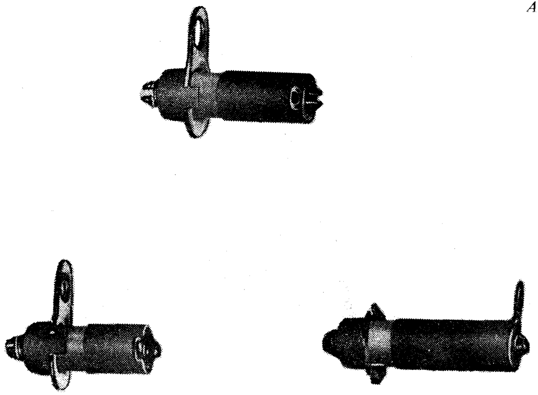
[1] Top and bottom adjustment available.
[2] Top adjustment only.

TUBULAR CERAMIC TRIMMERS

screw-driver slot at both ends

QUICK REFERENCE DATA	
Capacitance swing	3, 6, 9, 12 pF
Overall dimensions	11 x 6 to 20 x 6 mm
Rated voltage (d.c.)	500 V
Tan δ at 1 MHz and C_{max}	max. 20.10^{-4}
Climatic category (IEC 68)	50/100/21



A46055

APPLICATION

The trimmers have been designed for v.h.f. applications in radio and television receivers. For many applications the negative temperature coefficient results in a favourable compensation at varying temperatures. The two modes of mounting increase the universal applicability.

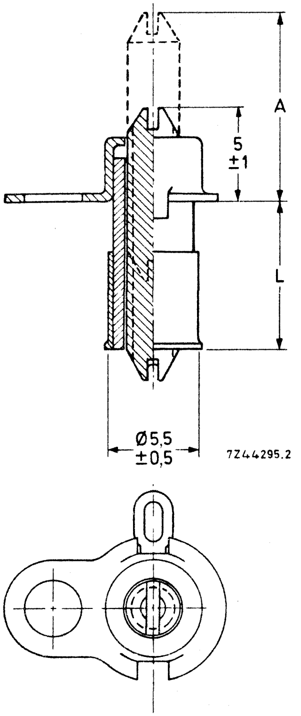
DESCRIPTION

The trimmers consist of an internally ground ceramic tube in which a helical rotor of invar metal can be screwed up and down. Both rotor ends are slotted for screwdriver operation.
The rotor is guided by means of a wire spring which is interposed between the tube and a silver-plated brass fixture. This fixture is pressed on to the top of the tube (2 versions are available). The external bottom part of the tube acts as a stator and is provided with a soldering tag.

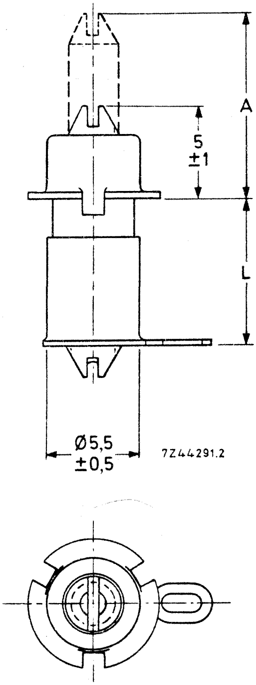
MECHANICAL DATA

Dimensions (mm)

version A



version B

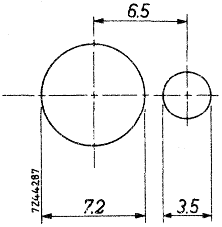


capacitance swing (pF)	dimensions (mm)		catalogue number	
	L	A	version A	version B
3	5, 5 ± 1	13, 5 ± 1	2222 801 20001	2222 801 20005
6	8, 5 ± 1	16, 5 ± 1	20002	20006
9	11, 5 ± 1	19, 5 ± 1	20003	20007
12	14, 5 ± 1	22, 5 ± 1	20004	20008

Operating torque	4 to 50 mNm
Maximum axial thrust on the rotor during operation	2 N
Weight	approximately 2 g
Soldering	260 °C, 4 s

Mounting

Version A - the fixture is provided with a tag (hole 3, 2 mm) for mounting screw M3 [1])
mounting holes (mm) :



Version B - the fixture is intended to be soldered directly to the mounting panel.
mounting hole 7 mm

ELECTRICAL DATA

Capacitance swing	min.	3	6	9	12 pF
Zero capacitance	max.	0, 8	0, 8	0, 9	1 pF
Effective angle of rotation		$3x360^{o}$	$5x360^{o}$	$7x360^{o}$	$9x360^{o}$
Temperature coefficient		-200 ± 200 ppm/°C			
Rated voltage (d.c.)		500 V			
Test voltage (d.c.) for 1 min.		1000 V			
Category temperature range		-50 to + 100 °C			
Insulation resistance		min. 10 000 MΩ			
Contact resistance		max. 10 mΩ			
Tan δ at 1 MHz and C_{max}		max. 20.10^{-4}			
Climatic category (IEC 68)		50/100/21			

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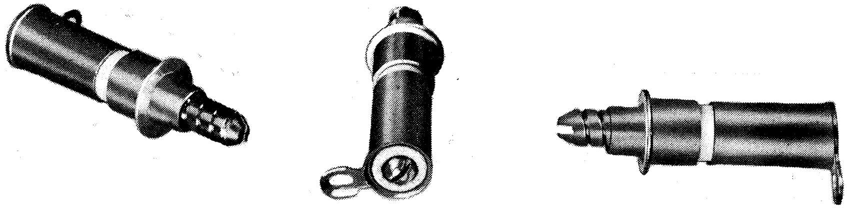
[1]) Can also be soldered directly to the panel

MIDGET TUBULAR CERAMIC TRIMMERS

screw-driver slot at both ends

QUICK REFERENCE DATA	
Capcitance swing	3 and 6 pF
Overall dimensions	19 x 4 x 6, 5 and 25 x 4 x 6, 5 mm
Rated voltage (d.c.)	400 V
Tan δ at 1 MHz and C_{max}	max. 20.10^{-4}
Climatic category (IEC 68)	50/100/21

RZ21046-1



APPLICATION

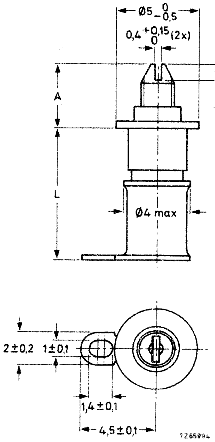
These trimmers have been developed for v.h.f. application in radio and television sets, especially in miniaturised equipment.

DESCRIPTION

A thin ceramic tube, internally ground, fits closely a threaded invar spindle (rotor). This spindle is guided by a U-shaped spring which is kept in place by a silver-plated brass cap. Both ends of the spindle are provided with a screwdriver slot to facilitate adjustment. The stator is a silver-plated brass tube ; it makes a tight fit with the ceramic tube. The cap, which must be soldered to the chassis, and a soldering tag on the stator enable a reliable connection with the circuit.

MECHANICAL DATA

Dimensions (mm)



L	A at C_{min}	catalogue number
8, 2 ± 0, 5	10, 5 ± 1	2222 801 20051
11, 2 ± 0, 5	13, 5 ± 1	2222 801 20052

Operating torque	1 to 20 mNm
Maximum axial thrust on the rotor during operation	2 N

Mounting

The trimmers can be fixed by soldering the cap to the chassis. The diameter of the required mounting hole is 4, 2 mm.

Soldering

Stator tag : in conformity with IEC 68, test T

Cap : the soldering temperature must lie between 240 °C and 260 °C, maximum soldering time 10 s

ELECTRICAL DATA

		2222 801 20051	2222 801 20052	
Capacitance swing	min.	3	6	pF
Zero capacitance	max.	0, 8	0, 8	pF
Temperature coefficient		-200 ± 200	-300 ±200	ppm/°C

Rated voltage (d.c.)	400 V
Test voltage (d.c.) for 1 minute	800 V
Category temperature range	-50 to +100 °C
Insulation resistance	min. 10 000 MΩ
Contact resistance	max. 10 mΩ
Tan δ at 1 MHz and C_{max}	max. 20.10^{-4}
Climatic category (IEC 68)	50/100/21

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D and IEC410

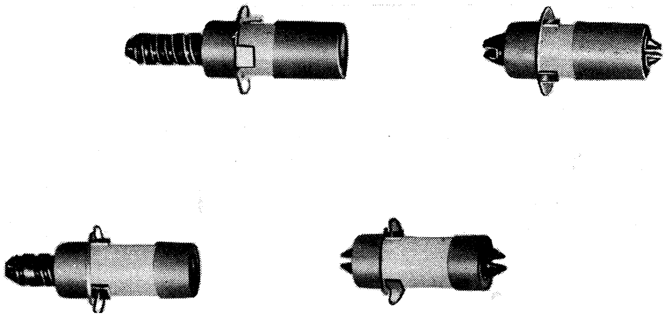
A.Q.L. 0, 4 %, major defects
A.Q.L. 1, 5 %, minor defects

See also Note under Survey of variable capacitors (General section).

TUBULAR CERAMIC TRIMMERS

screw-driver slot at both ends

QUICK REFERENCE DATA	
Capacitance swing	3 and 6 pF
Overall dimensions	14 x 8,5 mm
Rated voltage (d.c.)	500 V
Tan δ at 1 MHz and C_{max}	max. 20.10^{-4}
Climatic category (IEC 68)	50/100/21



A46050

APPLICATION

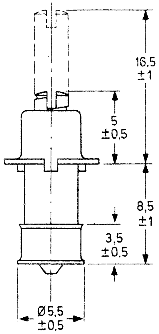
These trimmers have been designed for v.h.f. applications and are particularly suitable for u.h.f. tuners and other electronic circuits operating in the higher frequency ranges.

DESCRIPTION

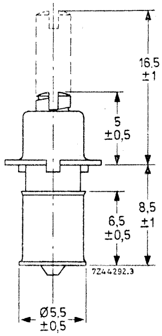
Since a brass rotor is used, the series resistance of the trimmers is low and the Q value quite acceptable, even at very high frequencies ; see the graph in which Q has been plotted as a function of working frequency.
Because, rather than wire leads, connecting strips being an integral part of the circuit are appropriate at high frequencies, the stator is not provided with a soldering tag and it is silver-plated to ensure good solderability.
The fixture on the top of the ceramic tube is likewise intended for being soldered on directly to the mounting panel. In order to obtain items of equal lengths, the fixture is attached at the same height of the tube irrespective of the capacitance rating.

MECHANICAL DATA

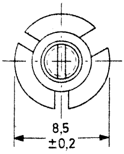
Dimensions (mm)



2222 801 96003



2222 801 96002



Operating torque	4 to 50 mNm
Maximum axial thrust on the rotor during operation	2 N
Weight	1, 8 g approx.

Mounting

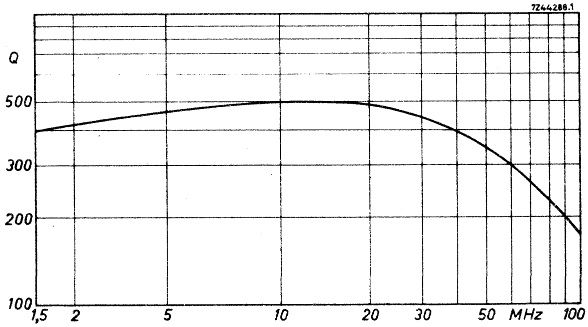
The mounting hole should have a diameter of 6, 5 mm.

Soldering

The soldering temperature, which should not exceed 250°C, can be achieved either in a uniformly heated furnace (max.4 s) or by means of h.f. heating (max.7 s). In both cases, adequate connections will be obtained without impairment of the characteristics, provided that low-melting tin is used in conjunction with an appropriate flux.

ELECTRICAL DATA

	2222 801 96003	2222 801 96002	
Minimum capacitance swing	3	6	pF
Maximum zero capacitance	0, 5	0, 7	pF
Temperature coefficient	+150 ± 150	+150 ± 100	ppm/°C
Rated voltage (d.c.)	500 V		
Test voltage (d.c.) for 1 minute	1000 V		
Category temperature range	-50 to +100 °C		
Insulation resistance	min. 10 000 MΩ		
Contact resistance	max. 3 mΩ		
Tan δ at 1 MHz and C_{max}	max. 20.10^{-4}		
Climatic category (IEC 68)	50/100/21		



QUALITY LEVEL

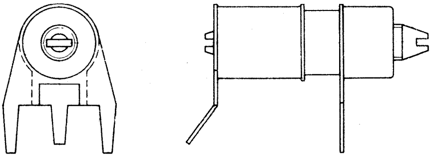
Sampling and data evaluation for quality level in accordance with MIL-STD-105D and IEC410

A.Q.L. 0,4%, major defects
A.Q.L. 1,5%, minor defects

See also Note under Survey of variable capacitors (General section).

TUBULAR CERAMIC TRIMMERS

QUICK REFERENCE DATA	
Max. C_{min}/min. C_{max}	0,3/1,5, 0,5/3,5 and 1/6 pF
Overall dimensions	9 x 6 x 6 mm
Rated voltage (d.c.)	400 V
Tan δ at 1 MHz	max. 20.10^{-4}
Climatic category (IEC 68)	50/100/21



APPLICATION

These trimmers are particularly suitable for u.h.f. tuners and other electronic circuits operating in the higher frequency ranges.

DESCRIPTION

The basic trimmer design consists of an internally ground ceramic tube, accurately matched to a threaded invar rotor spindle, which is slotted for screwdriver adjustment of capacitance. The stator is a silver-plated brass tube, tightly fitted on the ceramic tube. One terminal pin extending from the stator, and two from the rotor cap, are spaced for direct insertion into printed-wiring boards having a 2,54 mm (0,1 in) grid.

MECHANICAL DATA

Dimensions (mm)

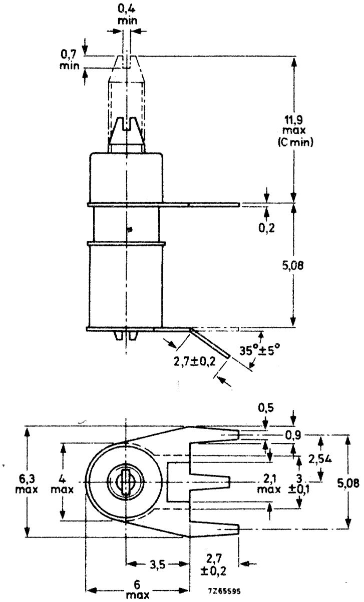


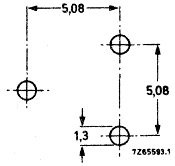
Fig. 1

Weight	0, 6 g
Marking (colour of ceramic tube)	version 96124 black, version 96127 beige version 96135 red
Operating torque	1 to 20 mNm
Maximum axial thrust	2 N
Soldering	max. 250 °C, 10 s
Bending of the tags	may be bent by 90 °

Mounting

The trimmers may be mounted on printed-wiring boards having holes with a minimum diameter of 1, 25 mm. The hole pattern is given in Fig. 2.

Fig. 2



ELECTRICAL DATA

catalogue number		2222 801 96124	2222 801 96127	2222 801 96135
Minimum C_{max}	(pF)	1,5	3,5	6
Maximum C_{min}	(pF)	0,3	0,5	1
Temperature coefficient	(ppm/^{o}C)	+50 ± 100	−200 ± 200	−300 ± 300
Capacitance change with axial thrust of 2 N	(pF)	< 0,01	< 0,03	< 0,05
Tan δ at C_{max} and 1 MHz		max. 20.10^{-4}		
Rated voltage (d.c.)	(V)	400		
Test voltage (d.c.) for 1 min, V_{test}	(V)	800		
Contact resistance, R_c	(mΩ)	max. 10		
Insulation resistance, R_{ins}	(MΩ)	min. 10 000		
Category temperature range	(^{o}C)	−50 to +100		
Climatic category (IEC68)		50/100/21		

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D and IEC410

A.Q.L. 0,4%, major defects
A.Q.L. 1,5%, minor defects

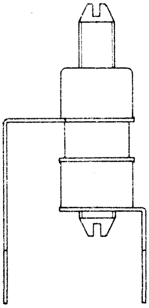
See also Note under Survey of variable capacitors (General section).

PACKAGING

Blister packs in cardboard boxes. 1440 pieces per box (minimum ordering quantity).

TUBULAR CERAMIC TRIMMERS

QUICK REFERENCE DATA	
Max. C_{min}/min. C_{max}	0,5/3 and 1/5,5 pF
Overall dimensions	12 x 4 x 8 mm
Rated voltage (d.c.)	400 V
Tan δ at 1 MHz	max. 20.10^{-4}
Climatic category (IEC 68)	50/100/21



APPLICATION

These trimmers are particularly suitable for u.h.f. tuners and other electronic circuits operating in the higher frequency ranges.

DESCRIPTION

The basic trimmer design consists of an internally ground ceramic tube, accurately matched to a threaded brass rotor spindle, which is slotted for screwdriver adjustment of capacitance. The stator is a silver-plated brass tube, tightly fitted on the lower end of the ceramic tube. One terminal pin extending from the stator, and one from the upper metal cap (rotor), are spaced for direct insertion into printed-wiring boards having a 2,54 mm (0,1 in) grid.

MECHANICAL DATA

Dimensions (mm)

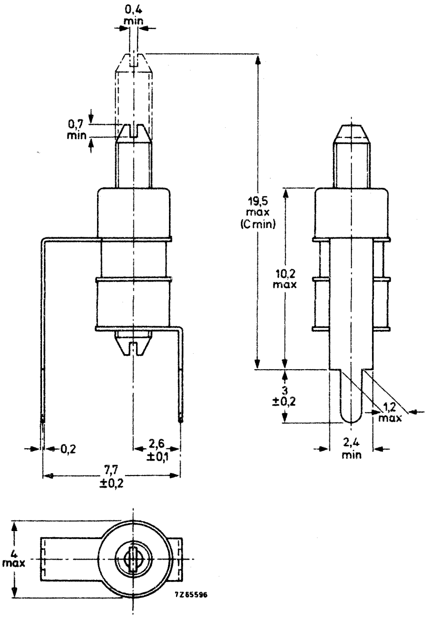


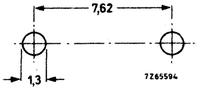
Fig. 1

Weight	0, 6 g
Marking (colour of ceramic tube)	version 96138 beige, version 96139 red
Operating torque	1 to 20 mNm
Maximum axial thrust	2 N
Soldering	max. 250 ^{o}C, 10 s
Bending of the tags	may be bent by 90 ^{o}

Mounting

The trimmers can be mounted on printed-wiring boards having holes with a minimum diameter of 1, 25 mm. The hole pattern is given in Fig. 2.

Fig. 2



ELECTRICAL DATA

catalogue number		2222 801 96138	2222 801 96139
Minimum C_{max}	(pF)	3	5, 5
Maximum C_{min}	(pF)	0, 5	1
Temperature coefficient	(ppm/^{o}C)	+150 ± 200	+100 ± 300
Capacitance change with axial load of 2 N	(pF)	max. 0, 03	max. 0, 05
Tan δ at C_{max} and 1 MHz		max. 20 x 10^{-4}	
Rated voltage (d. c.)	(V)	400	
Test voltage (d. c.) for 1 min. (V_{test})	(V)	800	
Contact resistance (R_c)	(mΩ)	max. 10	
Insulation resistance (R_{ins})	(MΩ)	min. 10 000	
Category temperature range	(^{o}C)	−50 to +100	
Climatic category (IEC68)		50/100/21	

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D and IEC410

A.Q.L. 0, 4%, major defects
A.Q.L. 1, 5%, minor defects

See also Note under Survey of variable capacitors (General section). ←

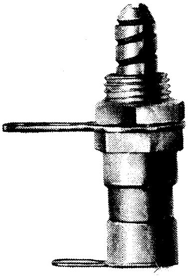
PACKAGING

Blister packs in cardboard boxes. 1440 pieces per box (minimum ordering quantity).

TUBULAR CERAMIC TRIMMERS

screw-driver slot at both ends

QUICK REFERENCE DATA	
Capacitance swing	3, 6, 9, 12, 18 pF
Overall dimensions	13, 5 x 5, 5 x 17 to 41, 5 x 5, 5 x 17 mm
Rated voltage (d.c.)	500 V
Tan δ at 1 MHz and C_{max}	max. 20.10^{-4}
Climatic category (IEC 68)	50/100/21



721214-13-01

APPLICATION

These capacitors have been disigned for the precision trimming of industrial equipment which operate at the higher frequencies.
Their simple form of construction guarantees high reliability and facilitates, moreover, a high breakdown voltage, good stability and high adjustment accuracy.
For many applications the negative temperature coefficient characteristic results in adequate compensation of various temperatures.
The small dimensions contribute to the miniaturisation of electronic equipment.

DESCRIPTION

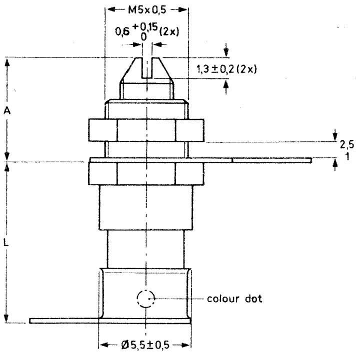
The trimmers consist of an internally ground ceramic tube, in which an invar rotor is guided by a silver-plated steel wire spring.
Both ends of the rotor are provided with a slot for screw-driver operation.

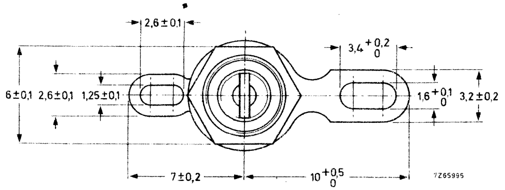
2222 802 20001–
2222 802 20005

TUBULAR CERAMIC TRIMMERS
screw-driver slot at both ends

MECHANICAL DATA

Dimensions (mm)





capacitance swing (pF)	zero capacitance (pF)	angle of rotation a° (approx.)	dimensions (mm)		catalogue number
			L	A at C_{min}	
≥ 3	≤ 0,8	7 x 360	10 ± 1	13,5 ± 1	2222 802 20001
≥ 6	≤ 0,8	7 x 360	13 ± 1	16,5 ± 1	20002
≥ 9	≤ 0,9	9 x 360	16 ± 1	19,5 ± 1	20003
≥ 12	≤ 1,0	11 x 360	19 ± 1	22,5 ± 1	20004
≥ 18	≤ 1,7	11 x 360	19 ± 1	22,5 ± 1	20005

Operating torque 4,5 to 50 mNm

Marking

The trimmers have a colour dot:
2222 802 20001 : orange dot
2222 802 20002 : blue dot
2222 802 20003 : white dot
2222 802 20004 : red dot
2222 802 20005 : grey dot

Mounting

The trimmers can be fixed to panels up to 2 mm thick by means of the nut supplied. The diameter of the required mounting hole is 5,2 mm.

ELECTRICAL DATA

Rated voltage (d.c.)	≤ 500 V
Test voltage (d.c.)	1000 V
Category temperature range	-50 to +100 °C
Temperature coefficient	-200 + 200 ppm/°C
Contact resistance (between tag and rotor)	≤ 10 mΩ
Tan δ at 1 MHz and C_{max}	max. 20.10^{-4}
Insulation resistance	min. 10 000 MΩ
Capacitance change with an axial thrust of 2 N for 2222 802 20001	≤ 0,03 pF
2222 802 20002	≤ 0,04 pF
2222 802 20003	≤ 0,06 pF
2222 802 20004	≤ 0,08 pF
2222 802 20005	≤ 0,2 pF
Climatic category (IEC 68)	50/100/21 ; also in accordance with equivalent MIL requirements.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D and IEC 410

A.Q.L. 0,4%, major defects
A.Q.L. 1,5%, minor defects

See also Note under Survey of variable capacitors (General section).

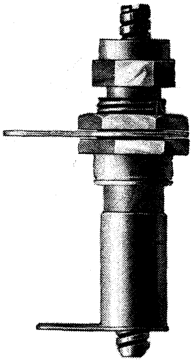
PACKAGING

Blister packs of 50 pieces. Smallest order quantity is one pack.

HIGH STABILITY TUBULAR CERAMIC TRIMMERS
with locking device

QUICK REFERENCE DATA

Capacitance swing	3, 4,5, 6, 9, 12 pF
Overall dimensions	35,2 x 5,8 x 17 to 46 x 5,8 x 17 mm
Rated voltage (d.c.)	500 V
Tan δ at 1 MHz and C_{max}	max. 20.10^{-4}
Climatic category (IEC 68)	50/100/21



721214-13-02

APPLICATION

These capacitors have been designed for the precision trimming of industrial equipment which operate at the v.h.f. frequencies.
Their simple form of construction guarantees high reliability and facilitates, moreover, a high breakdown voltage, good stability and high adjustment accuracy.
For many applications the negative temperature coefficient characteristic results in adequate compensation at various temperatures.
The small dimensions contribute to the miniaturisation of electronic equipment.

DESCRIPTION

The trimmers consist of a low-k ceramic tube (for the values 3, 4,5 , 6 pF and a higher-k ceramic tube for 9 and 12 pF), internally ground, in which an invar rotor is guided by a threaded cap. This invar rotor has a copper coating which is nickel-plated *), one end is provided with a slot for screw-driver operation. By means of a locking nut the rotor can be locked after adjustment.

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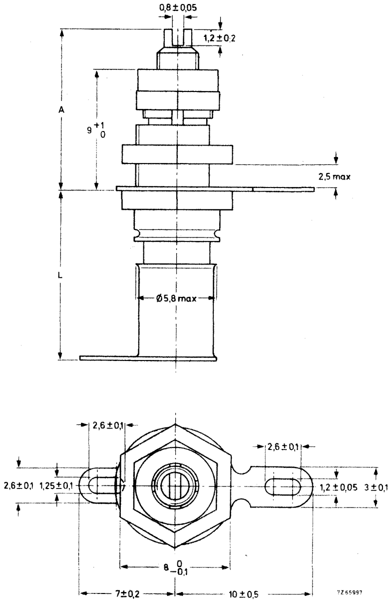
*) Silver-plated rotor can be delivered on request.

Dimensions (mm)

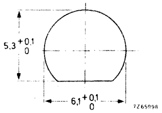


capacitance swing (pF)	zero capacitance (pF)	temperature coefficient (ppm/°C)	angle of rotation a° (approx.)	dimensions (mm)		catalogue number
				L	A at C_{min}	
≥ 3	≤ 0,5	− 10 ± 60	8 x 360	12,7 ±0,5	22,5 ± 1	2222 802 20011
≥ 4,5	≤ 0,6	− 10 ± 60	10 x 360	15,7 ±0,5	25,5 ± 1	20012
≥ 6	≤ 0,7	− 10 ± 60	11 x 360	18,2 ±0,5	28 ± 1	20013
≤ 9	≤ 0,9	− 250 ± 250	10 x 360	15,7 ±0,5	25,5 ± 1	20014
≤ 12	≤ 1,0	− 250 ± 250	11 x 360	18,7 ±0,5	28 ± 1	20015

Operating torque	4 to 40 mNm 100 mNm if locked with 420 mNm

Mounting

Mounting in specially shaped hole.



ELECTRICAL DATA

Rated voltage (d.c.)	≤ 500 V
Test voltage (d.c.)	1000 V
Category temperature range	-50 to +100 °C
Contact resistance (between tag and rotor)	≤ 3 mΩ
Tan δ at 1 MHz and C_{max}	max. 20.10^{-4}
Insulation resistance	min. 10 000 MΩ
Capacitance change with an thrust of 2 N	≤ 0,005 pF
Climatic category (IEC 68)	50/100/21 ; also in accordance with equivalent MIL requirements.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D and IEC 410

A.Q.L. 0,4%, major defects
A.Q.L. 1,5%, minor defects

See also Note under Survey of variable capacitors (General Section). ←

PACKAGING

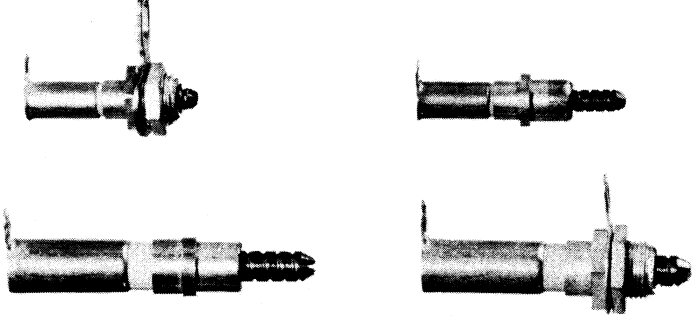
Blister packs of 50 pieces each. Smallest order quantity is one pack.

HIGH STABILITY TUBULAR CERAMIC TRIMMERS

with friction locking device

QUICK REFERENCE DATA

Capacitance swing	3, 4,5, 6, 9, 12 pF
Overall dimensions	17 x 4 x 6,5 to 23,5 x 5,5 x 17 mm
Rated voltage (d.c.)	400 V
Tan δ at 1 MHz and C_{max}	max.20.10^{-4}
Climatic category (IEC 68)	50/100/21



RZ 24124-4

APPLICATION

These trimmers have been designed for u.h.f. applications, where high stability has to be maintained even under severe mechanical conditions, e.g. television aerial amplifiers.

DESCRIPTION

The dielectric of the trimmers is formed by a ceramic tube, in which a gold-plated-copper-clad invar rotor is guided by an U-shaped spring. This spring is clamped between the ceramic tube and the fixing cap. A P.T.F.E. locking ring, which is pressed into the fixing cap, guarantees a high stability. The trimmers are available with a ceramic tube with low dielectric constant (k6 material, class A) and with a high dielectric (k20 material, class B). Trimmers of both classes are delivered in a screw mounting type as well as in a solder mounting type. For mounting the last mentioned type, the cap has to be soldered to the chassis.

MECHANICAL DATA

Dimensions (mm)

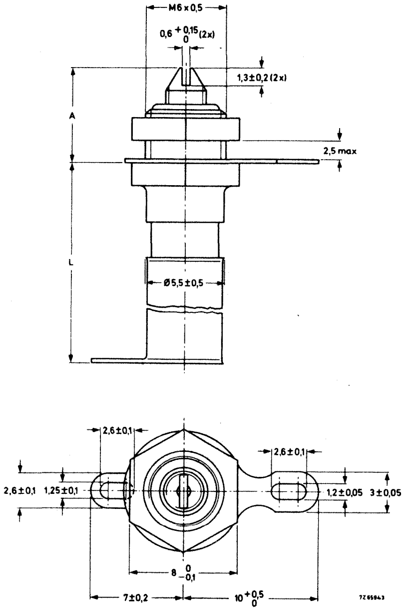


Fig. 1 Screw mounting type.

Mounting hole diameter is
6, 2 + 0, 2 mm.

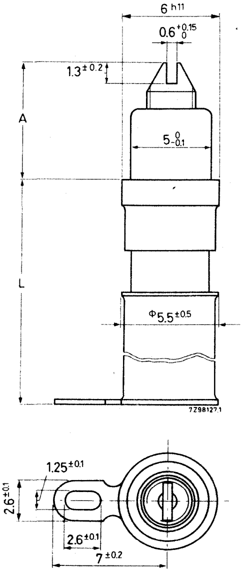
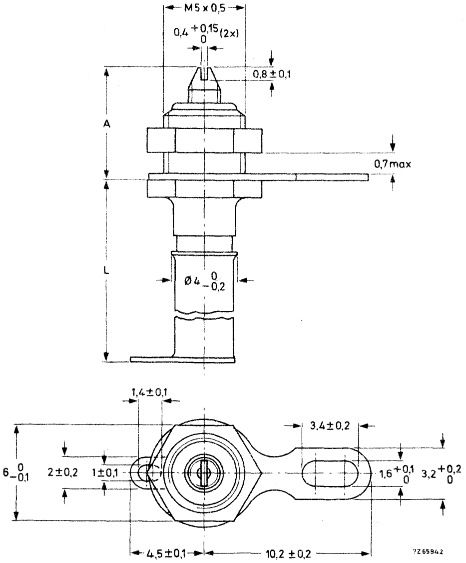


Fig. 2 Solder mounting type.

Mounting hole diameter is
5, 1 + 0, 2 mm.



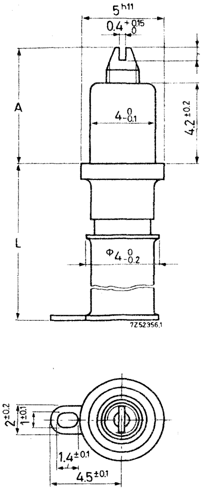


Fig.3 Screw mounting type.

Mounting hole diameter is
5, 2 + 0, 2 mm.

Fig.4 Solder mounting type.

Mounting hole diameter is
4, 1 + 0, 2 mm.

cap. swing (pF)	zero cap. (pF)	class	dimensions (mm)		catalogue number	
			L	A at C_{min}	screw mounting type	solder mounting type
			see Figs. 1 and 2		Fig. 1	Fig. 2
≥ 3	≤ 0. 8	B	10 ± 1	13, 5 ± 1	2222 802 96044	2222 802 96051
≥ 6	≤ 0. 8		13 ± 1	16, 5 ± 1	45	52
≥ 9	≤ 0. 9		16 ± 1	19, 5 ± 1	46	53
≥ 12	≤ 1. 0		19 ± 1	22, 5 ± 1	47	54
≥ 3	≤ 0.5	A	13 ± 1	16, 5 ± 1	66	69
≥ 4. 5	≤ 0. 6		16 ± 1	19, 5 ± 1	67	71
≥ 6	≤ 0. 7		18 ± 1	22, 5 ± 1	68	72
			see Figs. 3 and 4		Fig. 3	Fig. 4
≥ 3	≤ 0. 8	B	9 ± 1	8±0, 5	2222 802 96055	2222 802 96057
≥ 6	≤ 0. 8		12 ± 1	11±0, 5	56	58

Soldering

Soldering temperature 350 °C, 3 s

ELECTRICAL DATA

	class A	class B		
	types according Fig. 1 and 2	types according Fig. 1 and 2	types according Fig. 3 and 4	
Rated voltage (d.c.)	500	500	400	V
Test voltage (d.c.)	1000	1000	800	V
Temperature coefficient	-10 ± 60	-200 ± 150	-200 ± 150	ppm/^{o}C
Insulation resistance	min. 10 000	min. 10 000	min. 10 000	MΩ
Category temperature range	-50 to + 100	-50 to + 100	-50 to + 100	^{o}C
Contact resistance between rotor and tag	max. 5	max.5	max. 5	mΩ
Tan δ at 1 MHz and C_{max}	max. 20.10^{-4}	max. 20.10^{-4}	max. 20.10^{-4}	
Capacitance change with an axial thrust of 2 N	max. 0,006	max. 0,01	max. 0,006	pF
Climatic category (IEC 68)	50/100/21. Also in accordance with equivalent MIL requirements.			

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D and IEC 410

A.Q.L. 0,4%, major defects
A.Q.L. 1,5%, minor defects

See also Note under Survey of variable capacitors (General section).

PACKAGING

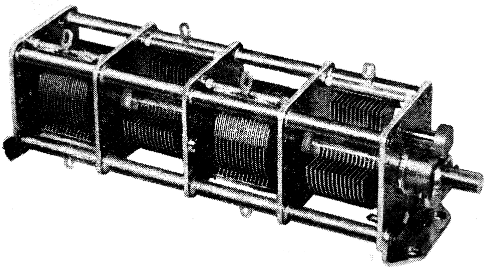
Blister packs of 50 pieces each. Smallest order quantity is one pack.

PRECISION TUNING CAPACITORS

QUICK REFERENCE DATA			
types	40 x 40 mm standard torque	60 x 60 mm standard torque	
	linear law	linear law	logarithmic law
single stator 1 -4 gangs	16 -250 pF *)	100 -640 pF	100 -500 pF
split stator 1 -4 gangs	10 -64 pF	25 -125 pF	25 -125 pF
differential 1 gang	64 -160 pF *)		
Law and ganging tolerances		± 0,7 %	

*) 1 gang types also available with high torque and spindle-end slotted.

37482-57



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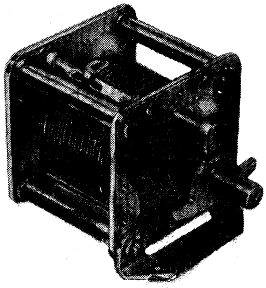


APPLICATION

These air dielectric capacitors are applicable where a high accuracy of adjustment and a high degree of stability are required.
They are available with one to four gangs.

DESCRIPTION

Frame

Nickel-plated brass plates and bars, assembled by riveting and soldering.

Spindle

Ball bearings on both ends.

Rotor

Clean brass vanes soldered to the shaft. The rotor sections are insulated from the frame and from each other by siliconized ceramic bars.

Stator

Clean brass vanes supported and insulated by siliconized ceramic balls.

Protruding spindle end

Diameter 6 mm, standard free length 10 and 14.5 mm for (40x40 mm) version and (60x60 mm) version respectively.

Direction of rotation

Clockwise for increasing capacitance.

Angle of rotation

180° or 360° at choice.

Owing to the eccentric rotor vanes, the versions with logarithmic laws have 180° as maximum angle of rotation.

High stability and freedom from noise are obtained by soldering all the metal parts together. Low contact resistance is ensured by silver contact points on the rotor drag spring and a gold plated contact ring soldered to the rotor.
Silicone treated ceramics are used exclusively for insulation ensuring that the insulation resistance is high and the losses are low, even in humid conditions. The resistance to shock and vibration is high as the stator is supported by and insulated with ceramic balls. The ceramic spindles are able to withstand severe impact and vibration.
The standard spindle end is provided with a detent which, together with a removable stop on the front plate, permits the accurate setting of a rotation angle of 15° as a reference for checking the capacitance and its variation as a function of rotation. For rotation angles of 165° and above, the stop should be removed.

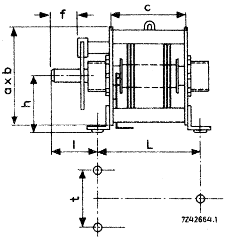
Single capacitors of the (40x40 mm) version for direct drive operation have the spindle end slotted for screwdriver adjustment.

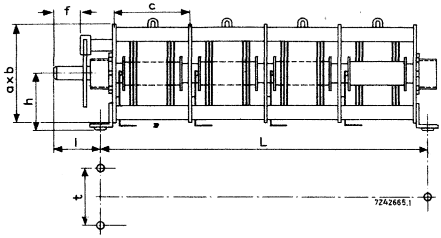
The capacitors are built entirely of basic parts with symmetrically placed stator and rotor packs. Non-listed combinations having non-standard capacitances, extra compartments, longer spindle ends (protruding up to 50 mm from both faces) and different connections, can be obtained on customers specification.

Fully customer-built capacitors, of which the technical specification has been discussed with the local field engineer, can also be supplied.

MECHANICAL DATA

Dimensions (mm)





dimensions in mm		a x b	number of gangs			
			1	2	3	4
distance between mounting holes (±0.5)	L	40 x 40	45	76,5	108	139,5
		60 x 60	67	117,5	168	218,5
	t	40 x 40	22			
		60 x 60	35			
compartment length (±0.2)	c	40 x 40	31,5			
		60 x 60	50,5			
spindle length (±0.5)	l	40 x 40	16			
		60 x 60	18			
spindle height (±0.5)	h	40 x 40	22,5			
		60 x 60	32,5			
free spindle length	f	40 x 40	10			
		60 x 60	14,5			
weight (g)		40 x 40	120	200	300	400
		60 x 60	400	700	1000	1300

Direction of rotation for increase in capacitance		clockwise
Effective angle of rotation,	linear capacitor	360^o
	logarithmic capacitor	180^o
Maximum axial thrust		50 N

Operating torque	1 gang		2 gangs	3 gangs	4 gangs	
	direct drive	indirect drive				
Minimum	20					mNm
Maximum	50	20	25	30	35	mNm

Mounting

The capacitors can be mounted by means of screws passed through the three holes in the mounting brackets.

Connecting leads
Two wires of 1.5 mm^2 maximum diameter can be connected to each soldering tag.

ELECTRICAL DATA

Nominal capacitance swing	see C_{var} in table I
Maximum capacitance at 0°	see C_0 in table I
Test voltage	see V_{test} in table I
Permissible peak voltage	$\leq \frac{1}{2} V_{test}$
Coupling capacitance	
between stator packs	$\leq$ 0.02 pF
between rotor packs (if insulated)	$\leq$ 0.05 pF
Insulation resistance between stator and rotor and between frame and stator and rotor	> 10 000 MΩ
Contact resistance between any soldering tag and the relative rotor pack	$\leq$ 5 mΩ
Parallel damping at 1.5 MHz with 50 pF (or max. capacitance if < 50 pF)	> 10 MΩ

Temperature coefficient of capacitance for the first compartment, (at C = 1/3 cap. swing + capacitance at 15°) in ppm/°C.

version	40 x 40 mm	60 x 60 mm
1 gang	20 ± 20	30 ± 30
2 gangs	20 ± 20	30 ± 30
3 gangs	30 ± 30	50 ± 50
4 gangs	50 ± 50	50 ± 50

Capacitance law

angle of rotation	capacitance increase (% of capacitance swing)	
	linear law	logarithmic law
15°	0	0
20°	3.12	0.83
30°	9.38	2.68
40°	15.62	4.81
50°	21.88	7.28
70°	34.38	13.41
90°	46.88	21.58
110°	59.38	32.49
130°	71.88	47.03
150°	84.38	66.42
175°	100	100

Capacitance tolerance

For angles of rotation between 15° and 175°, the capacitance tolerance in the first compartment is given by the expression:

$$\pm 0.7\ (0.11\ C + C')/100$$

where

C = capacitance swing (minimum 25 pF)

C' = capacitance increase calculated from the capacitance law.

Ganging tolerance (rotation angles between 15° and 175°)

The capacitance in the second, third, and fourth compartments will not differ from the actual capacitance in the first compartment by more than ±0.7%.

Backlash (reproducibility) (for indirect drive capacitors)	Better than 150×10^{-6} pF/pF
Temperature range	−40 to +85 °C

Electrical Data continued

Table I

	size a x b = 40 x 40 mm linear capacitance law				size a x b = 60 x 60 mm linear capacitance law				size a x b = 60 x 60 mm logarithmic capacitance law			
	single-stator or differential type		split-stator type		single-stator type		split-stator type		single-stator type		split-stator type	
C_{var} (pF)	C_o± 1 pF[1] (pF)	V_{test}[2] (V d.c.)	C_o± 1pF (pF)	V_{test}[3] (Vd.c.)	C_o± 1pF (pF)	V_{test}[3] (Vd.c.)	C_o± 1pF (pF)	V_{test}[3] (Vd.c.)	C_o± 1pF (pF)	V_{test}[3] (Vd.c.)	C_o± 1pF) (pF)	V_{test}[3] (Vd.c.)
10			3	3000								
16	8	2500	3.6	2000								
25	8.5	2000	4	2000			5	4000			5	2500
32							5	3000			5	2500
40	9	1500	4	1600			5	3000			5.5	2000
50							5	2500			5.5	2000
64	9	1000	4	1300			5.5	2000			5.5	1600
80							5.5	2000			5.5	1600
100	10	1000			14.5	2000	5.5	2000	13	1500	5.5	1600
125					15	2000	6	1600	13	1250	5.5	1300
160	11	800			15.5	1500			14.5	1000		
200					16	1250			14.5	1000		
200	11.5	650[4]			16	1250			14	1000		
320					17.5	1000			14	800		
400					19	1000			14	800		
500					20.5	1000			14	650		
640					21.5	800						

[1] For the differential version the C_o values are 1 pF less than the tabulated values

[2] Between rotor and stator

[3] Between the two stators

[4] Differential type only up to and including C_{var} = 160 pF

CATALOGUE NUMBERS

2222 805 .. ... suffix, see Tables II and III

00 for 40 x 40 mm version
02 for 60 x 60 mm version

Table II 40 x 40 mm version

type	C_{var} (pF)	single-stator		split-stator	differential type	
		indirect drive 1)	direct drive 2)	indirect drive 1)	indirect drive 1)	direct drive 2)
1 gang	10			187		
	16	131	173	188		
	25	132	178	189		
	40	133	174	191		
	64	134	175	192	239	252
	100	135	176		241	253
	160	136	177		242	254
	250	137	179			
2 gangs	2 x 10			194		
	2 x 16	138		195		
	2 x 25	139		196		
	2 x 40	141		197		
	2 x 64	142		198		
	2 x 100	143				
	2 x 160	144				
	2 x 250	145				
3 gangs	3 x 10					
	3 x 16	146		201		
	3 x 25	147		202		
	3 x 40	148		203		
	3 x 64	149		204		
	3 x 100	151		205		
	3 x 160	152				
	3 x 250	153				
4 gangs	4 x 10			207		
	4 x 16	154		208		
	4 x 25	155		209		
	4 x 40	156		211		
	4 x 64	157		212		
	4 x 100	158				
	4 x 160	159				
	4 x 250	161				

---

1) low torque

2) high torque

Table III 60 x 60 mm version

type	Cvar (pF)	single-stator		split-stator	
		linear law	logarithmic law	linear law	logarithmic law
1 gang	25			298	345
	32			299	346
	40			301	347
	50			302	348
	64			303	349
	80			304	351
	100	196	249	305	352
	125	197	251	306	353
	160	198	252		
	200	199	253		
	250	201	254		
	320	202	255		
	400	203	256		
	500	204	257		
	640	205			
2 gangs	2x 25			307	354
	2x 32			308	355
	2x 40			309	356
	2x 50			311	357
	2x 64			312	358
	2x 80			313	359
	2x 100	206	258	314	361
	2x 125	207	259	315	362
	2x 160	208	261		
	2x 200	209	262		
	2x 250	211	263		
	2x 320	212	264		
	2x 400	213	265		
	2x 500	214	266		
	2x 640	215			

Table III continued

type	C_{var} (pF)	single-stator		split-stator	
		linear law	logarithmic law	linear law	logarithmic law
3 gangs	3 x 25			316	363
	3 x 32			317	364
	3 x 40			318	365
	3 x 50			319	366
	3 x 64			321	367
	3 x 80			322	368
	3 x 100	216	267	323	369
	3 x 125	217	268	324	371
	3 x 160	218	269		
	3 x 200	219	271		
	3 x 250	221	272		
	3 x 320	222	273		
	3 x 400	223	274		
	3 x 500	224	275		
	3 x 640	225			
4 gangs	4 x 25			325	372
	4 x 32			326	373
	4 x 40			327	374
	4 x 50			328	375
	4 x 64			329	376
	4 x 80			331	377
	4 x 100	226	276	332	378
	4 x 125	227	277	333	379
	4 x 160	228	278		
	4 x 200	229	279		
	4 x 250	231	281		
	4 x 320	232	282		
	4 x 400	233	283		
	4 x 500	234	284		
	4 x 640	235			

FILM DIELECTRIC TRIMMERS

QUICK REFERENCE DATA

Min. C_{max}	5,5	10	15	22	22	27	40	65	80	120	pF
Max. C_{min}	1,4	2	2	2	3	2	5,5	5,5	5,5	12	pF
Diameter	7,5 mm, 10 mm, 13,5 mm										
Rated voltage (d.c.)	250 V										
Climatic category (IEC68)	40/070/21										

APPLICATION

These film dielectric trimmers have been designed for use on printed-wiring boards, e.g. in radio sets. Moreover, thanks to their good stability, these trimmers have even proved their value in industrial equipment.

DESCRIPTION

The vanes are stacked on a sturdy plastic base. The dielectric is a film of polyaethylene, polypropylene or polycarbonate which supports the vanes in such a way that good stability is ensured and no microphony can occur. Flux absorption between the vanes is prevented. The trimmers are resistant to all standard cleaning solvents except those with polycarbonate film (2/27 pF, 6/80 pF and 12/120 pF).

Table 1, Versions

	diameter	position of spindle	angle between 2 rotor tags	adjustment		Fig.
				top	bottom	
A	7,5 mm	vertical	180 °	screwdriver	key	1
B	10 mm	vertical	90 ° [1]	screwdriver	key	2
C1		vertical	180 °	screwdriver	key [2]	3
C2		vertical	180 °	spanner	key	3
D1		horizontal		screwdriver	key	4
D2		horizontal		spanner	key	4
E1	13,5 mm	vertical	180 °	screwdriver	screwdriver	5
E2		vertical	180 °	spanner	–	5
F1		horizontal		screwdriver	screwdriver	6
F2		horizontal		spanner	–	6

---

[1] Non-preferred.

[2] See Fig. 8.

The spanner adjustment is specially designed for the trimming of car radios. It enables the manufacturer to adjust the trimmer from the front by means of a long flexible rod provided with a hexagonal hole. The special shape of the trimmer head prevents a bending load on the trimmer spindle when the adjustment rod and spindle are not in line.
The connection tags are arranged to fit a grid of 2, 50 mm or 2, 54 mm (0, 1 inch).

MECHANICAL DATA

Dimensions in mm

Outlines

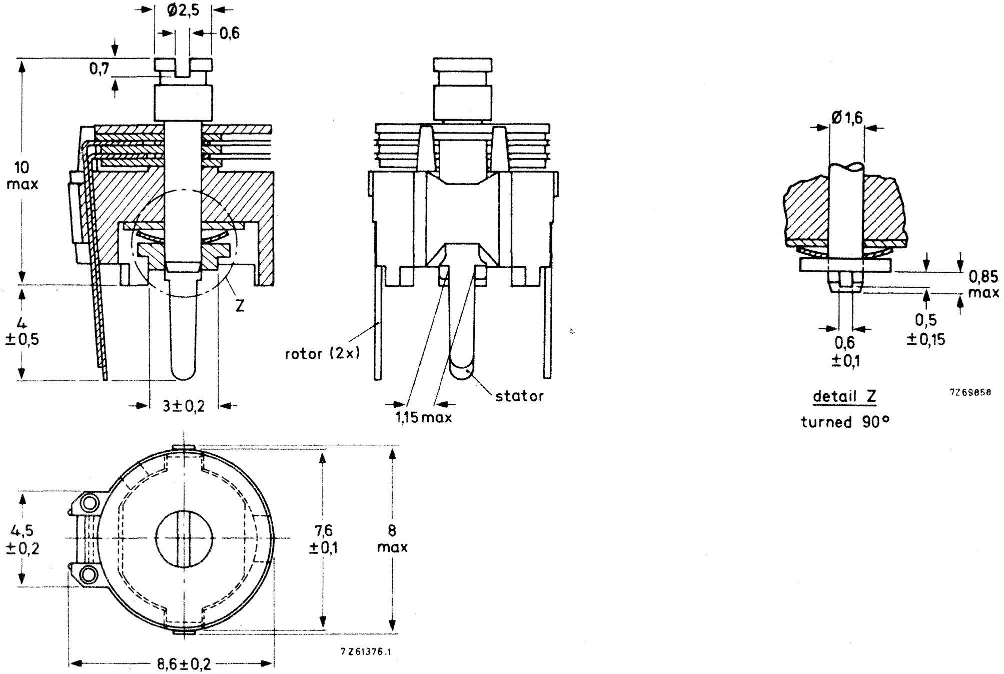


Fig. 1. Version A

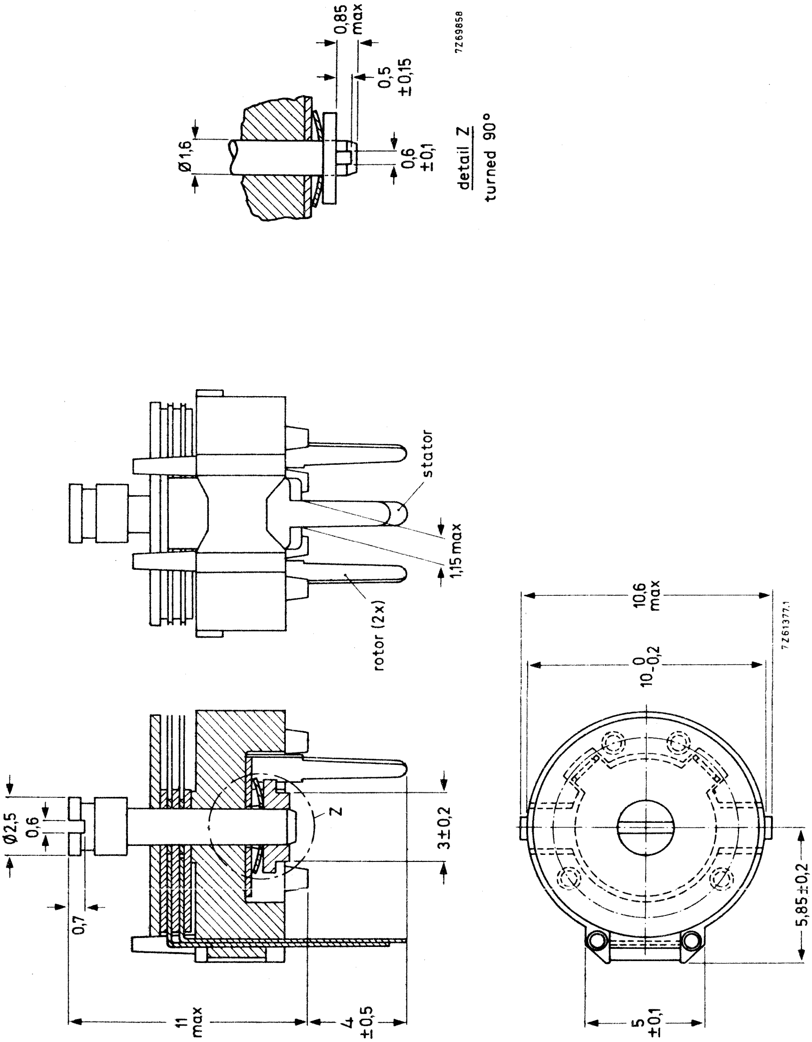
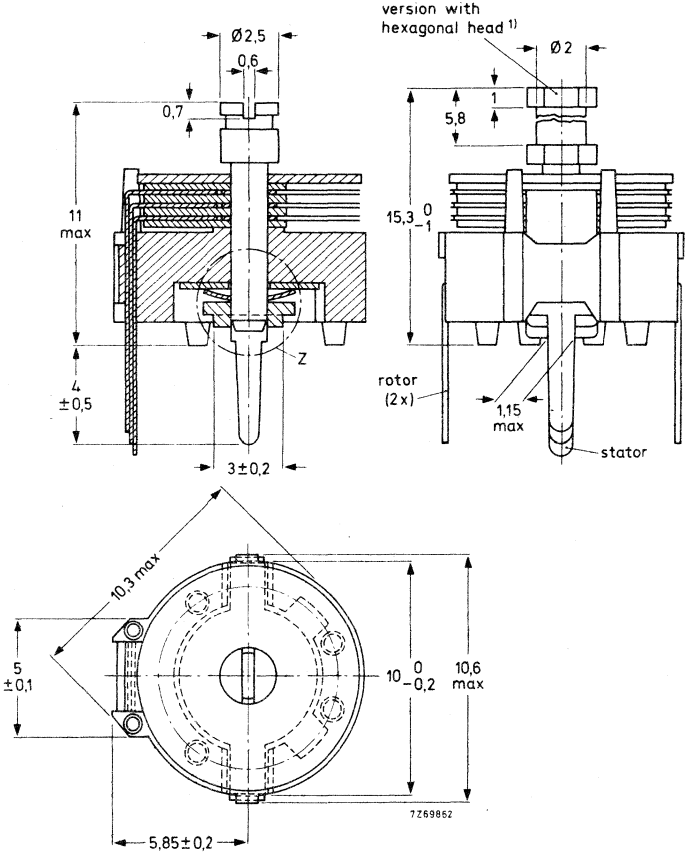


Fig. 2. Version B



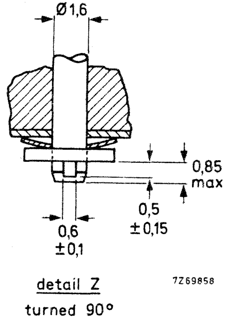


Fig. 3. Versions C1 and C2

[1] Distance across flats 2,5 – 0,06 mm.

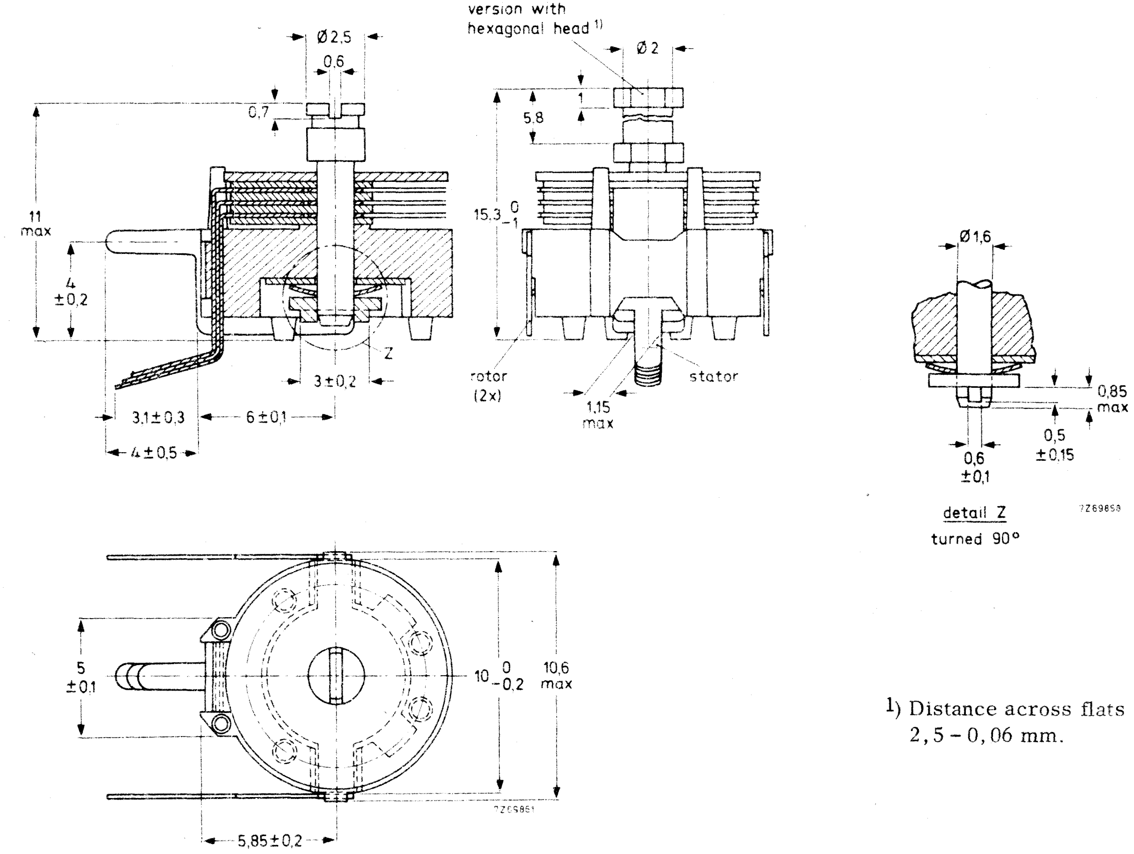


Fig. 4. Versions D1 and D2

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1) Distance across flats 2,5 − 0,06 mm.

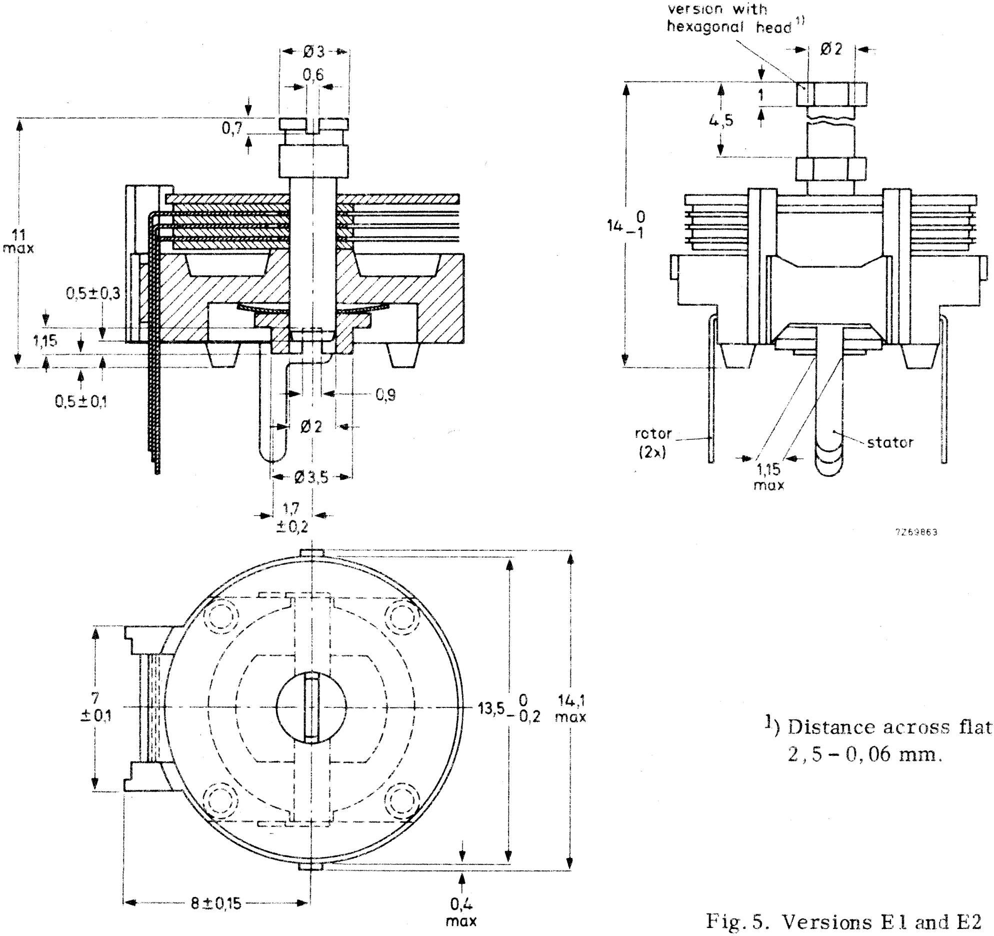

Fig. 5. Versions E1 and E2

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1) Distance across flats
2,5 – 0,06 mm.

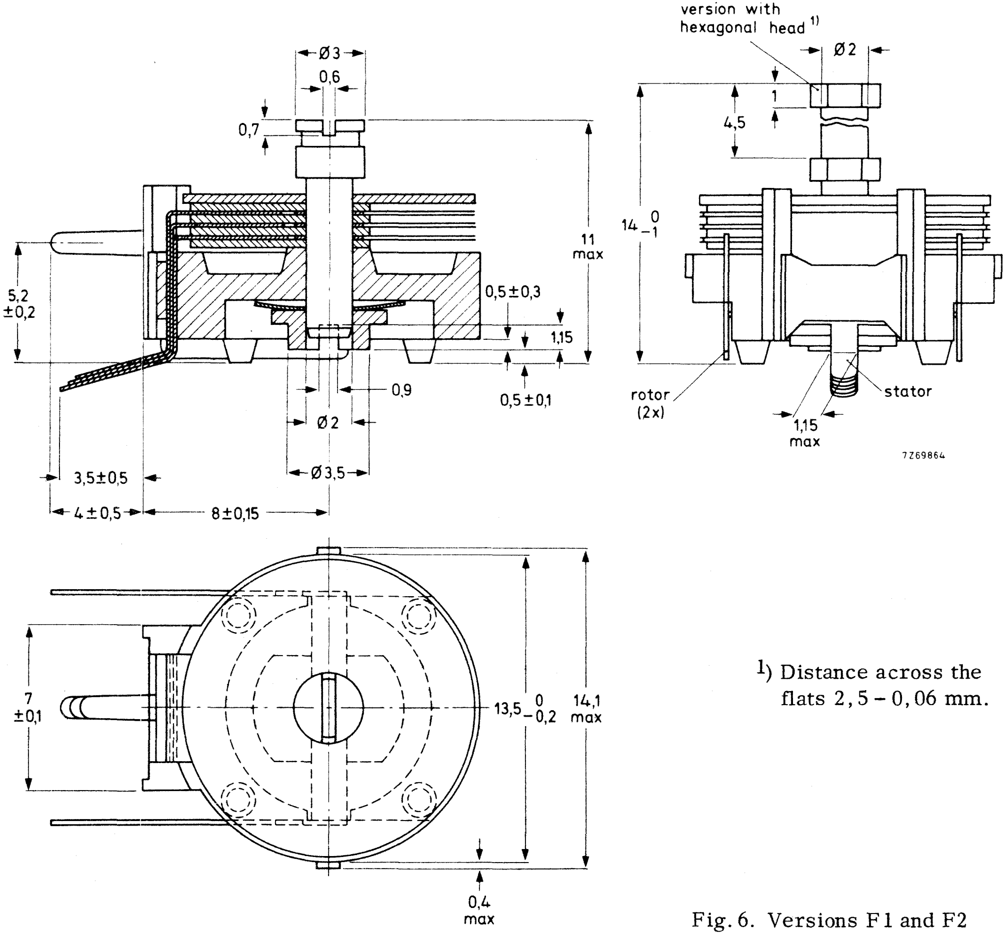


Fig. 6. Versions F1 and F2

---

[1] Distance across the flats 2,5 – 0,06 mm.

Table 2

	∅ 7,5 mm	∅ 10 mm	∅ 13,5 mm
Operating torque	1 - 15 mNm	2 - 25 mNm	2 - 20 mNm
Maximum axial thrust	2 N	2 N	2 N
Mass (approximately)	0,8 g	1,3 g	2 g

Marking

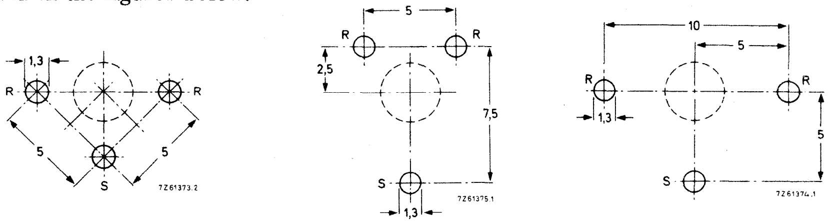
The different types can be identified by the colour of the base, see Table 3.

Soldering

Soldering conditions: max. 260 °C, max. 10 s.

Mounting

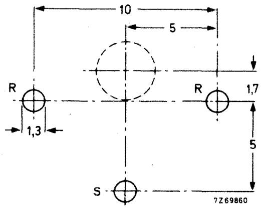
The trimmers can be mounted on printed-wiring boards with a pitch of 2,50 mm or 2,54 mm (0,1 in) and holes with a minimum diameter of 1,25 mm. The hole pattern is given in the figures below.



a
For types of Fig. 1

b
For types of Fig. 2

c
For types of Figs 3, 4 and 6



d
For types of Fig. 5

Fig. 7. R = rotor
S = stator

Note: The large hole is necessary for bottom adjustment only. Diameter determined by the user's requirements.

Key for adjustment

The dimensions essential for the design of a key are given in Fig. 8.

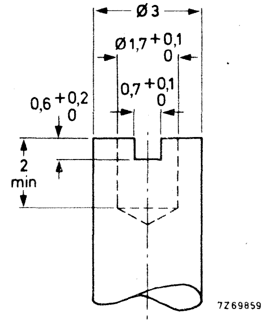


Fig. 8

ELECTRICAL DATA Table 3

version (see Table 1)	reference C_{min}/ C_{max} 1) (pF)	guaranteed max C_{min}/ min C_{max} (pF)	tan δ at C_{max} x 10^{-4} 1 MHz	100 MHz	temperature coefficient (ppm/°C)	colour of base	Fig.	catalogue number
A	1,2/6	1,4/5,5	≤ 10	≤ 25	−750 ± 300	grey	1	2222 808 11558
	1,4/10	2/10	≤ 10	≤ 25	−200 ± 300	yellow	1	11109
	1,6/15	2/15	≤ 10	≤ 25	−400 ± 300	blue	1	11159
	1,8/22	2/22	≤ 10	≤ 25	−350 ± 250	green	1	11229
	2/30	2/27	< 50		0 ± 300	red	1	11279
B	1,8/15	2/15	≤ 10	≤ 25	−100 ± 400	blue	2	32159
	2,5/25	3/22	≤ 10	≤ 25	−100 ± 400	green	2	32229
	4/40	5,5/40	≤ 10	≤ 25	−150 ± 350	grey	2	32409
	4,5/70	5,5/65	≤ 10	≤ 25	−200 ± 300	yellow	2	32659
	5/90	5,5/80	≤ 50		−100 ± 300	red	2	32809
C1	1,8/15	2/15	≤ 10	≤ 25	−100 ± 400	blue	3	31159
	2,5/25	3/22	≤ 10	≤ 25	−100 ± 400	green	3	31229
	4/40	5,5/40	≤ 10	≤ 25	−150 ± 350	grey	3	31409
	4,5/70	5,5/65	≤ 10	≤ 25	−200 ± 300	yellow	3	31659
	5/90	5,5/80	≤ 50		−100 ± 300	red	3	31809
C2	5/90	5,5/80	≤ 50		−100 ± 300	red	3	34809
D1	1,8/15	2/15	≤ 10	≤ 25	−100 ± 400	grey	4	61159
	2,5/25	3/22	≤ 10	≤ 25	−100 ± 400	yellow	4	61229
	4/40	5,5/40	≤ 10	≤ 25	−150 ± 350	yellow	4	61409
	4,5/70	5,5/65	≤ 10	≤ 25	−200 ± 300	yellow	4	61659
	5/90	5,5/80	≤ 50		−100 ± 300	red	4	61809
D2	5/90	5,5/80	≤ 50		−100 ± 300	red	4	64809
E1	8/130	12/120	≤ 50		−150 ± 300	green	5	41121
E2	8/130	12/120	≤ 50		−150 ± 300	green	5	44121
F1	8/130	12/120	≤ 50		−150 ± 300	green	6	71121
F2	8/130	12/120	≤ 50		−150 ± 300	green	6	74121

Rated voltage (d.c.)	250 V
Test voltage (d.c.) for 1 minute	500 V
Category temperature range	−40 to +70 °C
Contact resistance	max. 10 mΩ
Insulation resistance	min. 10 000 MΩ
Climatic category (IEC68)	40/070/21

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1) This column indicates the reference values of the capacitance ranges currently available on the market which are equivalent to our range.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D and IEC410

A.Q.L. 0,4%, major defects
A.Q.L. 1,5%, minor defects

Each capacitor is tested for minimum C_{max}, and is also subjected to the full test voltage. See also Note under Survey of variable capacitors (General section).

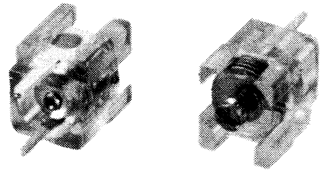
PACKAGING

Bulk packing in cardboard boxes lined with expanded plastic.

FILM DIELECTRIC TRIMMERS

high temperature type

QUICK REFERENCE DATA	
Max. C_{min}/min. C_{max}	1 / 3,5 pF 1,8 /10 pF 2 /18 pF
Overall dimensions	6 x 8 x 9 mm
Rated voltage (d.c.)	300 V
Temperature range	– 40 to + 125 °C



RZ 30185-5

APPLICATION

For use in miniaturised measuring and telecommunication equipment, specially where high temperatures occur and a low temperature coefficient is important, e.g. for fine adjustment of h.f. tuned circuits.

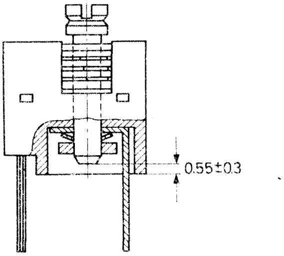
DESCRIPTION

The trimmers consist of a polysulphone housing, brass rotor and silver-plated brass stator with either a P.T.F.E., or a polyimide/F.E.P. sandwich film as the dielectric. The stator plates with their tag are heat sealed to the housing. The rotor contact surfaces are gold plated to ensure a long life and a stable contact even under severe climatic conditions.
The capacitors can be supplied with top adjustment, and with top and bottom adjustment. Top adjustment should be done by means of a screwdriver, bottom adjustment by means of the key, catalogue number 8122 088 23660 , which can be made available on request.

MECHANICAL DATA

Dimensions in mm

type with
top adjustment



type with
top and
bottom adjustment

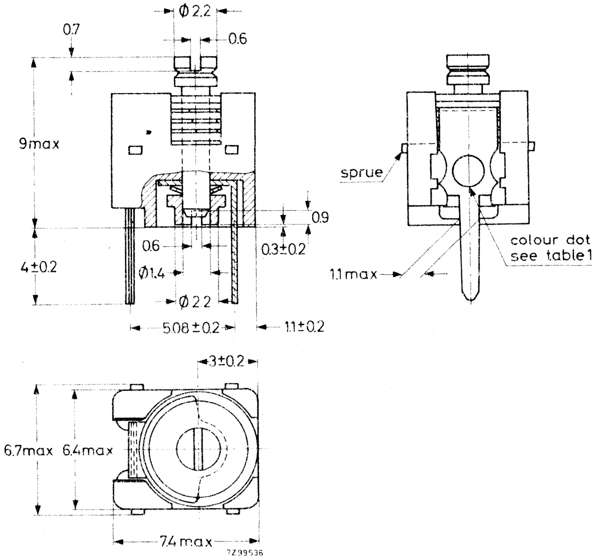


Table 1

max. capacitance	3,5 pF	10 pF	18 pF
effective angle of rotation	180°	180°	180°
operating torque	1 to 15 mNm	2,5 to 20 mNm	2,5 to 20 mNm
maximum axial thrust	2 N	2 N	2 N
weight approx.	0,7 g	0,7 g	0,7 g
colour dot	orange	white	red

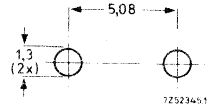
Bump	IEC68, test Eb - 4000 bumps of 40 g
Vibration	IEC68, test F - 10 - 55 Hz, acceleration 5g for 1,5 h

Marking

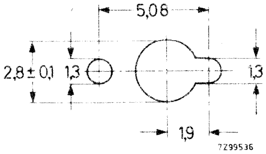
The capacitors are marked with a colour dot, see Table 1.

Mounting

The trimmers can be mounted on printed-wiring boards having holes with a minimum diameter of 1,25 mm. The hole patterns are given in the figures below.



Hole pattern for type with top adjustment



Hole pattern for type with top and bottom adjustment

Soldering conditions max. 260 °C, max. 10 s

Bending the tags by 90 degrees is permitted.

ELECTRICAL DATA

min. C_{max} (pF)	max. C_{min} (pF)	max. tan δ at 1 MHz	max. tan δ at 100 MHz	temperature coefficient *) (ppm/°C)	catalogue number	
					top adjustment	top + bottom adjustment
≥ 3,5	≤ 1	10.10^{-4}	20.10^{-4}	-250 ± 150	2222 809 05001	2222 809 05004
≥ 10	≤ 1,8	10.10^{-4}	20.10^{-4}	-300 ± 75	2222 809 05002	2222 809 05005
≥ 18	≤ 2	25.10^{-4}	40.10^{-4}	-350 ± 75	2222 809 05003	2222 809 05006

Rated voltage (d.c.)	300 V
Test voltage (d.c.)	600 V
Contact resistance	max. 5 mΩ
Insulation resistance between stator and rotor	min. 10 000 MΩ
Category temperature range	-40 to +125 °C
Climatic category (IEC68)	40/125/21

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D and IEC410

A.Q.L. 0,4%, major defects
A.Q.L. 1,5%, minor defects

Each capacitor is tested for minimum C_{max}, and is also subjected to the full test voltage.

See also Note under Survey of variable capacitors (General section).

PACKAGING

Blister packs of 100 pieces each. Smallest order quantity is one pack.

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*) Between +20 and +70 °C at C_{max}.

TESTS AND REQUIREMENTS

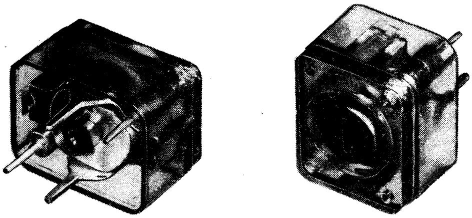
	IEC 68 test method	Test	Procedure
		Robustness of terminations	
	Ua	Tensile	load 2, 5 N; 10 s
	Ub	Bending	clause 2. 3, 1 bend
	T	Soldering	
		Solderability	clause3. 2: solder bath method, 240 °C
		Resistance to heat	clause 3. 2. 4, 350 °C, 3 s
	Na	Rapid change of temperature	30 min −40 °C/30 min +125 °C; 5 cycles
	Eb	Bump	4000 ± 10 bumps, 40 g, pulse duration 6 ms
	Fc	Vibration	10-55 Hz, 0, 35 mm or 5 g, 0, 5 h in 3 directions
	Ba	Dry heat	16 hours 100 °C
	Ca	Damp heat, steady state	21 days 40 °C; 90-95% R.H.
	–	Endurance (mech.)	25 cycles (rotations from C_{max} to C_{min} and back) at room temperature

	Requirements		
	05001	05002	05003
Visual exam.	no damage		
Visual exam.	good tinning		
Visual exam.	no damage		
ΔC after 1h recovery (pF)	$< 0,05$	$< 0,1$	$< 0,1$
ΔC hor. (pF)	$< 0,03$	$< 0,04$	$< 0,08$
vert.	$< 0,02$	$< 0,03$	$< 0,06$
Visual exam.	no damage	no damage	no damage
ΔC (pF)	$< 0,004$	$< 0,004$	$< 0,006$
ΔC (pF)	$< 0,05$	$< 0,08$	$< 0,3$
R_{ins} (MΩ)	$> 10^4$	$> 10^4$	$> 10^4$
R_c (mΩ)	≤ 5	≤ 5	≤ 5
Tan δ at 1 MHz	$\leq 10.10^{-4}$	$\leq 10.10^{-4}$	$\leq 25.10^{-4}$
ΔC (pF)	$< 0,07$	$< 0,05$	$< 1,1$
Tan δ at 1 MHz	$\leq 20.10^{-4}$	$\leq 20.10^{-4}$	$\leq 40.10^{-4}$
R_{ins} (MΩ)	$> 10^4$	$> 10^4$	$> 10^4$
R_c (mΩ)	≤ 5	≤ 5	≤ 5
V_{test} (d.c.) (V)	> 600	> 600	> 600
Visual exam.	no damage	no damage	no damage
C_{max} (pF)	> 3	> 10	> 18
R_c (mΩ)	≤ 5	≤ 5	≤ 5
V_{test} (d.c.) (V)	> 600	> 600	> 600
Oper. torque (mNm)	2 to 17,5	2 to 17,5	2 to 17,5

FILM DIELECTRIC TRIMMERS

high temperature type

QUICK REFERENCE DATA		
Max. C_{min}/min. C_{max},	single stator type	2,5/20 pF to 7/100 pF
	split stator type	1,5/5 pF to 3/25 pF
	differential type	2,5/20 pF to 7/100 pF
Overall dimensions		11 x 14 x 9 mm
Rated voltage (d.c.)		200 to 375 V
Temperature range		−40 to +125 °C



RZ 24762-1

APPLICATION

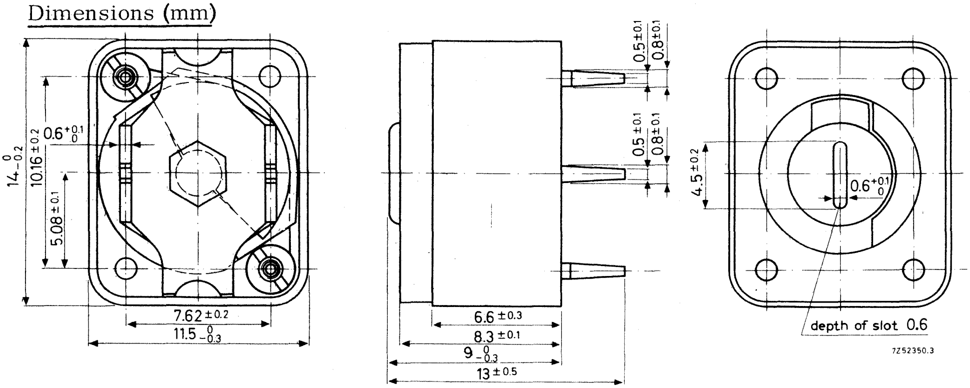
For use in miniaturised measuring and telecommunication equipment, specially where high temperatures occur and a low temperature coefficient is important, e.g. single-stator trimmers are suitable for fine adjustment of h.f. tuned circuits, split-stator trimmers for symmetrically built h.f. circuits and differential types for capacitive volume or voltage control.

DESCRIPTION

The trimmers consist of a polysulphone housing, brass rotor and stator with P.T.F.E. film as the dielectric. The stator plates are stacked on pins and separated by rings, so that it is possible to produce a single-stator, a split-stator or a differential type. The rotor contact surfaces are silver plated to ensure a long life and a stable contact even under severe climatic conditions.
The capacitors can be adjusted from the top by means of a screwdriver.

MECHANICAL DATA

Dimensions (mm)



	single stator type	differential type	split stator type
effective angle of rotation	180°	180°	180°
operating torque	1 to 35 mNm	1 to 35 mNm	1 to 35 mNm
max. axial thrust	2N	2N	2N
weight approx.	2,3 g	2,9 g	2,8 g

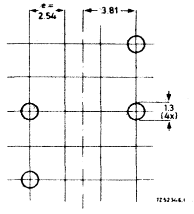
Bump	IEC68, test Eb - 4000 bumps of 40 g
Vibration	IEC68, test F - 10 - 55 Hz, acceleration 5g for 1,5 h

Marking

Capacitance value in pF plus letter E, in the case of a differential capacitor followed by the letter D, in the case of a split-stator type by the letter S.

Mounting

The trimmers can be mounted on printed-wiring boards having holes with a minimum diameter of 1,25 mm. The hole pattern is given in the figure below.



Soldering conditions
max. 260 °C, max. 10 s

Bending the tags by 90 degrees is not permitted.

ELECTRICAL DATA

type	min. C_{max} (pF)	max. C_{min} (pF)	max. tan δ at 100 MHz	V_{test} (d.c.) (V)	catalogue number
single-stator	≥ 20	≤ 2.5	17.10^{-4}	700	2222 809 07004
	≥ 40 *)	≤ 4	17.10^{-4}	700	07008
	≥ 60 *)	≤ 5	25.10^{-4}	400	07011
	≥ 80	≤ 6	25.10^{-4}	400	07013
	≥ 100 *)	≤ 7	25.10^{-4}	400	07015
split-stator	≥ 5	≤ 1.5	17.10^{-4}	700	07001
	≥ 10	≤ 2	17.10^{-4}	700	07002
	≥ 15	≤ 3	25.10^{-4}	400	07003
	≥ 20	≤ 3	25.10^{-4}	400	07005
	≥ 25	≤ 3	25.10^{-4}	400	07007
differential	≥ 20	≤ 2.5	17.10^{-4}	700	07006
	≥ 40	≤ 4	17.10^{-4}	700	07009
	≥ 60	≤ 5	25.10^{-4}	400	07012
	≥ 80	≤ 6	25.10^{-4}	400	07014
	≥ 100	≤ 7	25.10^{-4}	400	07016

Rated voltage	50% of test voltage (see Table)
Tan δ at 1 MHz	max. 10.10^{-4}
Contact resistance	max. 5 mΩ
Insulation resistance between stator and rotor	min. 10000 MΩ
Temperature coefficient **)	(0 ± 200) ppm/°C
Ambient temperature range	−40 to +125 °C
Climatic category (IEC 68)	40/125/21

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D and IEC 410

A.Q.L. 0,4%, major defects
A.Q.L. 1,5%, minor defects

Each capacitor is tested for minimum C_{max}, and is also subjected to the full test voltage.

See also Note under Survey of variable capacitors (General section).

PACKAGING

Blister packs of 50 pieces each. Smallest order quantity is one pack.

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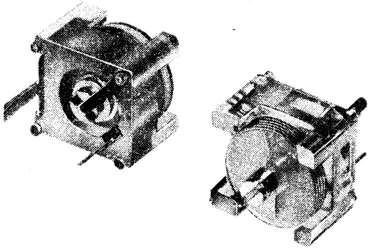
*) Preferred versions.

**) Between +20 and +70 °C at C_{max}.

FILM DIELECTRIC TRIMMERS

high temperature type

QUICK REFERENCE DATA	
Max. C_{min}/min. C_{max}	4/40 pF 5/60 pF
Overall dimensions	10 x 11 x 11 mm
Rated voltage (d.c.)	300 V
Temperature range	−40 to +125 °C



APPLICATION

For use in miniaturised measuring and telecommunication equipment, specially where high temperatures occur and a low temperature coefficient is important, e.g. for fine adjustment of h.f. tuned circuits.

DESCRIPTION

The trimmers consist of a polysulphone housing, brass rotor and silver-plated brass stator with polyimide/F.E.P. sandwich film as the dielectric. The stator plates with their tag are heat sealed to the housing. The rotor contact surface is gold plated to ensure a long life and a stable contact even under severe climatic conditions. The rotor is operated by means of a screwdriver; it can be adjusted from the top and from the bottom.

MECHANICAL DATA

Dimensions in mm

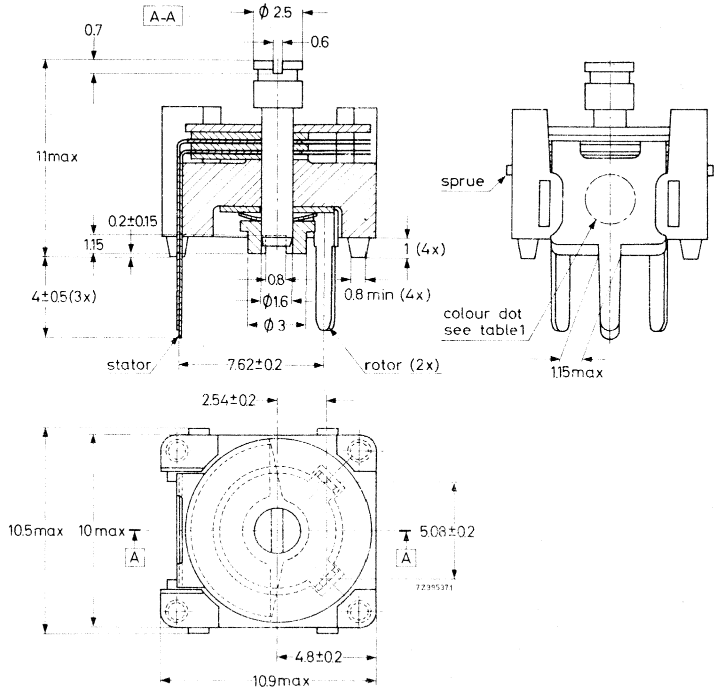


Table 1

max. capacitance	40 pF	60 pF
effective angle of rotation	180^{0}	180^{0}
operating torque	2 to 25 mNm	2 to 25 mNm
maximum axial thrust	2 N	2 N
weight	1,6 g	1,6 g
colour dot	yellow	blue

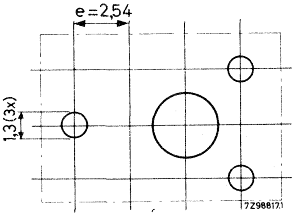
Bump IEC68, test Eb - 4000 bumps of 40 g
Vibration IEC68, test F - 10 - 55 Hz, acceleration 5g for 1,5 h

Marking

The capacitors are marked with a colour dot, see Table 1.

Mounting

The trimmers can be mounted on printed-wiring boards having holes with a minimum diameter of 1,25 mm. The hole pattern is given in the figure below.



Note: Large hole is necessary only if bottom adjustment is to be used

Soldering conditions
max. 260 °C, max. 10 s

Bending the tags by 90 degrees is permitted.

ELECTRICAL DATA

min. C_{max} (pF)	max. C_{min} (pF)	max. tan δ at 1 MHz	max. tan δ at 100 MHz	temperature coefficient (ppm/°C)	catalogue number
≥ 40	≤ 4	25.10^{-4}	35.10^{-4}	-250 ± 150	2222 809 08002
≥ 60	≤ 5	25.10^{-4}	35.10^{-4}	-250 ± 150	2222 809 08003

Rated voltage (d.c.)	300 V
Test voltage (d.c.)	600 V
Contact resistance	max. 5 mΩ
Insulation resistance between stator and rotor	min. 10000 MΩ
Category temperature range	−40 to +125 °C
Climatic category (IEC 68)	40/125/21

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D and IEC 410

A.Q.L. 0,4%, major defects
A.Q.L. 1,5%, minor defects

Each capacitor is tested for minimum C_{max}, and is also subjected to the full test voltage.

See also Note under Survey of variable capacitors (General section). ←

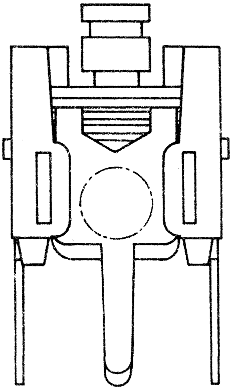
PACKAGING

Blister packs of 50 pieces each. Smallest order quantity is one pack.

FILM DIELECTRIC TRIMMERS

high temperature type

QUICK REFERENCE DATA	
Max. C_{min}/min. C_{max}	1,4/5,5 pF 2 / 9 pF 2 /18 pF
Overall dimensions	8 x 9 x 10 mm
Rated voltage (d.c.)	300 V
Temperature range	−40 to +125 °C



APPLICATION

For use in measuring and telecommunication equipment, specially where high temperatures occur and a low temperature coefficient is important, e.g. for fine adjustment of h.f. tuned circuits.

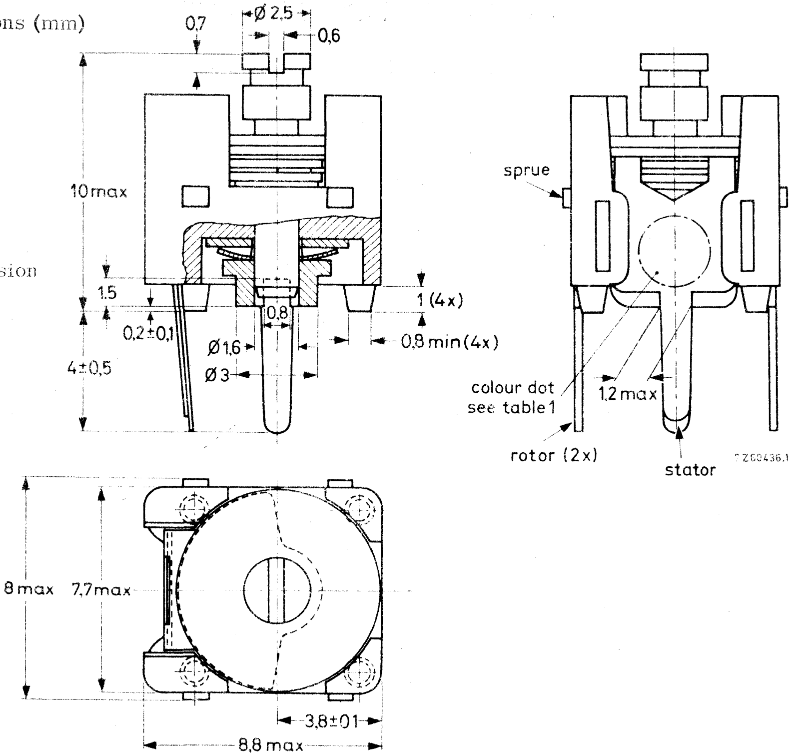
DESCRIPTION

The trimmers consist of a polysulphone housing, brass rotor and silver-plated brass stator with a P.T.F.E. film as the dielectric. The stator plates with their tag are heat sealed to the housing. The rotor contact is made by a silver-plated spring against gold plated surfaces to ensure a long life and a stable contact even under severe climatic conditions.
The capacitors can be adjusted from both sides by means of a screwdriver.
Two types are available viz. with one rotor tag and with two rotor tags.
The connection tags are arranged to fit a grid of 2,54 mm (0,1 inch).

MECHANICAL DATA

Dimensions (mm)

3-tag version



2-tag version

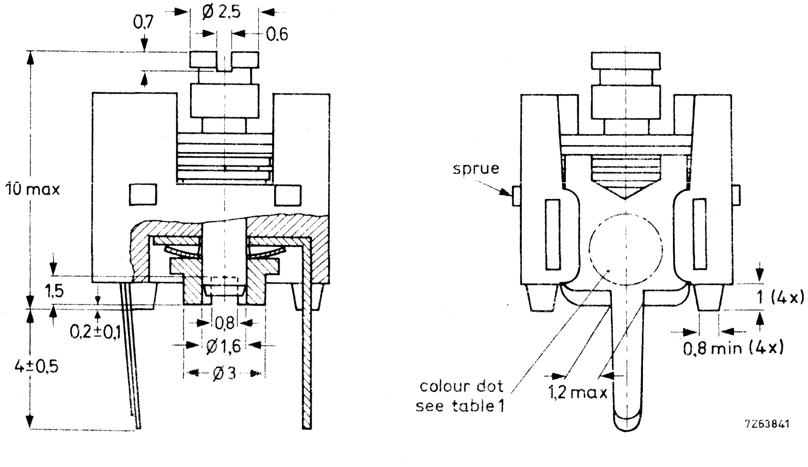


Table 1

max. capacitance	5,5 pF	9 pF	18 pF
effective angle of rotation	180°	180°	180°
operating torque	1 to 15 mNm	2,5 to 20 mNm	2,5 to 20 mNm
maximum axial thrust	2 N	2 N	2 N
weight approx.	0,8 g	0,8 g	0,9 g
colour dot	green	white	red

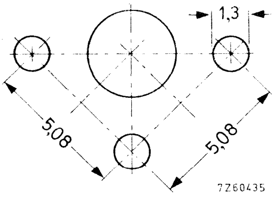
Marking

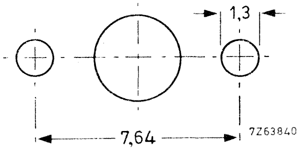
The capacitors are marked with a colour dot, see Table 1.

Mounting

The trimmers can be mounted on printed-wiring boards having holes with a minimum diameter of 1,25 mm. The hole pattern is given in the figure below.

3-tag version





2-tag version

Soldering conditions max. 260 °C, max. 10 s

Bending the tags by 90 degrees is permitted.

ELECTRICAL DATA

min. C_{max} (pF)	max. C_{min} (pF)	max. tan δ at 1 MHz	max. tan δ at 100 MHz	temperature coefficient (ppm/°C)	catalogue number 2222 809	
					2-tag version	3-tag version
≥ 5,5	≤ 1,4	10.10^{-4}	15.10^{-4}	-250 ± 150	09004	09001
≥ 9	≤ 2	10.10^{-4}	15.10^{-4}	-250 ± 150	09005	09002
≥ 18	≤ 2	10.10^{-4}	15.10^{-4}	-250 ± 150	09006	09003

Rated voltage (d.c.)	300 V
Test voltage (d.c.)	600 V
Contact resistance	max. 5 mΩ
Insulation resistance between stator and rotor	min. 10000 MΩ
Category temperature range	-40 to +125 °C
Climatic category (IEC 68)	40/125/21

PACKAGING

In blisters containing 100 capacitors, 9 blisters per box.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D and IEC 410

A.Q.L. 0,4%, major defects
A.Q.L. 1,5%, minor defects

Each capacitor is tested for minimum C_{max}, and is also subjected to the full test voltage.

See also Note under Survey of variable capacitors (General section).

MAINTENANCE TYPE LIST

The types listed below are not included in this Handbook.

Detailed information will be supplied on request.

ELECTROLYTIC CAPACITORS

Aluminium electrolytic capacitors	2222 106 1.... 2222 107 1....

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STANDARD SERIES OF VALUES IN A DECADE
for resistances and capacitances
according to I.E.C. publication 63

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