PHILIPS

Data handbook

PHILIPS

Electronic
components
and materials

Components and materials

Part 2b February 1978

Fixed capacitors

Variable capacitors

COMPONENTS AND MATERIALS

Part 2b

February 1978

Electrolytic and solid capacitors

Film capacitors

Ceramic capacitors

Variable capacitors

Contents list

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.

ELECTRON TUBES (BLUE SERIES)

Part 1a	**December 1975**	**ET1a 12-75**	**Transmitting tubes for communication, tubes for r.f. heating** Types PE05/25 to TBW15/25
Part 1b	**August 1977**	**ET1b 08-77**	**Transmitting tubes for communication, tubes for r.f. heating, amplifier circuit assemblies**
Part 2	**May 1976**	**ET2 05-76**	**Microwave products** (This book is valid until Part 2b becomes available.)
Part 2a	**November 1977**	**ET2a 11-77**	**Microwave tubes** Communication magnetrons, magnetrons for microwave heating, klystrons, travelling-wave tubes, diodes, triodes T-R switches
Part 3	**January 1975**	**ET3 01-75**	**Special Quality tubes, miscellaneous devices**
Part 4	**March 1975**	**ET4 03-75**	**Receiving tubes**
Part 5a	**August 1976**	**ET5a 08-76**	**Cathode-ray tubes** Instrument tubes, monitor and display tubes, C.R. tubes for special applications
Part 5b	**May 1975**	**ET5b 05-75**	**Camera tubes, image intensifier tubes**
Part 6	**January 1977**	**ET6 01-77**	**Products for nuclear technology** Channel electron multipliers, neutron tubes, Geiger-Müller tubes
Part 7a	**March 1977**	**ET7a 03-77**	**Gas-filled tubes** Thyratrons, industrial rectifying tubes, ignitrons, high-voltage rectifying tubes
Part 7b	**March 1977**	**ET7b 03-77**	**Gas-filled tubes** Segment indicator tubes, indicator tubes, switching diodes, dry reed contact units
Part 8	**May 1977**	**ET8 05-77**	**TV picture tubes**
Part 9	**June 1976**	**ET9 06-76**	**Photomultiplier tubes; phototubes**

SEMICONDUCTORS AND INTEGRATED CIRCUITS (RED SERIES)

Part 1a	**March 1976**	**SC1a 03-76**	**Rectifier diodes, thyristors, triacs** Rectifier diodes, voltage regulator diodes (> 1,5 W), transient suppressor diodes, rectifier stacks, thyristors, triacs
Part 1b	**May 1977**	**SC1b 05-77**	**Diodes** Small signal germanium diodes, small signal silicon diodes, special diodes, voltage regulator diodes (< 1,5 W), voltage reference diodes, tuner diodes
Part 2	**November 1977**	**SC2 11-77**	**Low-frequency and dual transistors**
Part 3	**January 1978**	**SC3 01-78**	**High-frequency, switching and field-effect transistors**
Part 4a	**June 1976**	**SC4a 06-76**	**Special semiconductors** Transmitting transistors, field-effect transistors, dual transistors, microminiature devices for thick and thin-film circuits
Part 4b	**July 1976**	**SC4b 07-76**	**Devices for optoelectronics** Photosensitive diodes and transistors, light emitting diodes, displays, photocouplers, infrared sensitive devices, photoconductive devices
Part 5a	**November 1976**	**SC5a 11-76**	**Professional analogue integrated circuits**
Part 5b	**March 1977**	**SC5b 03-77**	**Consumer integrated circuits** Radio-audio, television
Part 6	**October 1977**	**SC6 10-77**	**Digital integrated circuits** LOCMOS HE4000B family
Signetics integrated circuits 1976			Logic, Memories, Interface, Analogue, Microprocessor, Milrel

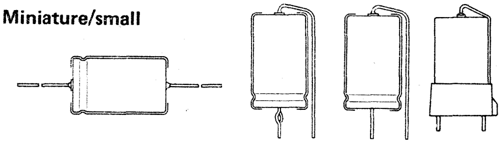
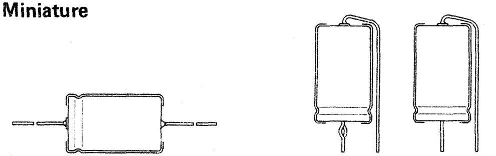
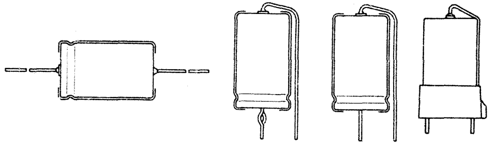
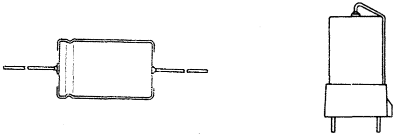
COMPONENTS AND MATERIALS (GREEN SERIES)

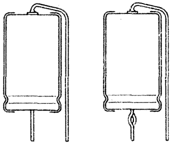
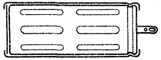
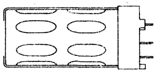
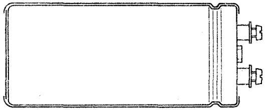
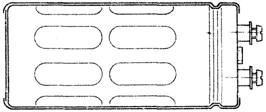
Part 1	June 1977	CM1 06-77	**Assemblies for industrial use** High noise immunity logic FZ/30-series, counter modules 50-series, NORbits 60-series, 61-series, circuit blocks 90-series, circuit block CSA70(L), PLC modules, input/output devices, hybrid circuits, peripheral devices, ferrite core memory products
Part 2a	October 1977	CM2a 10-77	**Resistors** 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	February 1978	CM2b 02-78	**Capacitors** Electrolytic and solid capacitors, film capacitors, ceramic capacitors, variable capacitors
Part 3	January 1977	CM3 01-77	**Radio, audio, television** FM tuners, loudspeakers, television tuners and aerial input assemblies, components for black and white television, components for colour television
Part 4a	October 1976	CM4a 10-76	**Soft ferrites** Ferrites for radio, audio and television, beads and chokes, Ferroxcube potcores and square cores, Ferroxcube transformer cores
Part 4b	December 1976	CM4b 12-76	**Piezoelectric ceramics, permanent magnet materials**
Part 5	July 1975	CM5 07-75	**Ferrite core memory products** Ferroxcube memory cores, matrix planes and stacks, core memory systems
Part 6	April 1977	CM6 04-77	**Electric motors and accessories** Small synchronous motors, stepper motors, miniature direct current motors
Part 7	September 1971	CM7 09-71	**Circuit blocks** Circuit blocks 100 kHz-series, circuit blocks 1-series, circuit blocks 10-series, circuit blocks for ferrite core memory drive
Part 8	February 1977	CM8 02-77	**Variable mains transformers**
Part 9	March 1976	CM9 03-76	**Piezoelectric quartz devices**
Part 10	November 1975	CM10 11-75	**Connectors**

Electrolytic and solid capacitors

SURVEY

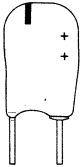
ALUMINIUM ELECTROLYTIC CAPACITORS

type	series number 2222 ...	application	category temperature ^{o}C	nominal capacitance μF	rated voltage (U_R) V
Miniature/small 	015 016 017	general industrial	−25 to + 85 or −40 to + 85 depending on case size	0,47 to 4700	4 to 100
Miniature 	030 031	general	−25 to + 70 or −25 to + 85 depending on case size	0,33 to 1000	6,3 to 100
Small 	032	general industrial	−40 to + 85	150 to 4700	6,3 to 63
Small 	040*	general, high voltages	−25 to + 70	2,5 to 80	100 to 400

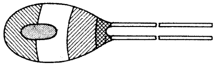
Small 	108	long life, industrial	−40 to + 85	2,2 to 2200	6,3 to 63
Small; bipolar  	039	general	−40 to + 85	3,3 to 47	U_R (a.c.) = 63 V_p U_R (d.c.) = 63 V
Large  	071 073	long life, industrial	−40 to + 85	680 to 47 000	6,3 to 63
Large 	105	long life, industrial	−25 to + 85	220 to 1000	400
	106 107	long life, military	−40 to + 85 (106) −25 to + 85 (107)	1500 to 150 000	6,3 to 100

* Maintenance type.

SOLID ALUMINIUM CAPACITORS

type	series number 2222 ...	application	category temperature °C	nominal capacitance μF	rated voltage (U_R) V
Small 	121	long life, industrial	−55 to + 125	2,2 to 330	6,3 to 40
Small; resin dipped 	122	long life, general, industrial	−55 to + 125	0,1 to 68	6,3 to 40

SOLID TANTALUM CAPACITORS

type	series number 2222 ...	application	category temperature °C	nominal capacitance μF	rated voltage (U_R) V
Hermetic seal; according to MIL-C-39003/01 	141	polarized or d.c. biased circuits	−55 to + 85	0,1 to 330	6 to 75
Hermetic seal 	143	polarized or d.c. biased circuits	−55 to + 85	0,1 to 330	6 to 50
Subminiature; resin dipped 	146	ultra-small dimensions: hearing aids paging systems	−55 to + 85	0,01 to 68	1,6 to 25

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 :

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

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).

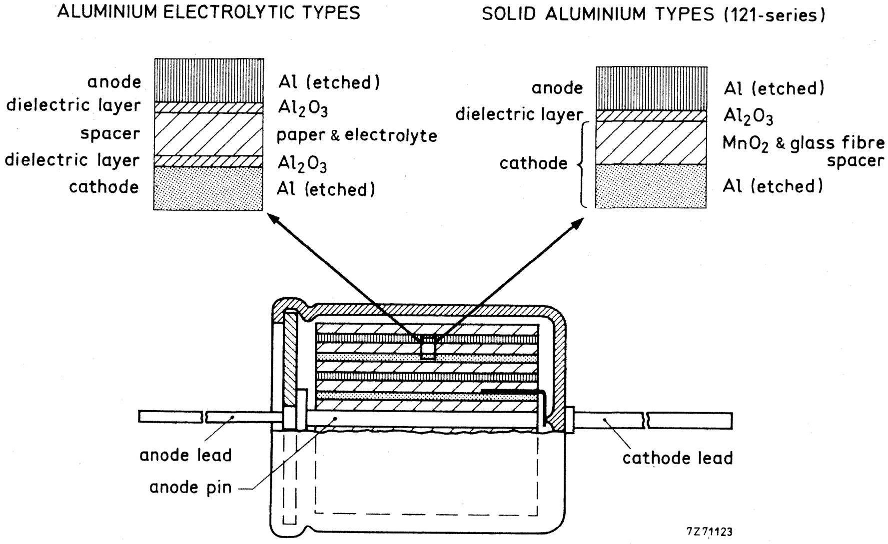

ALUMINIUM ELECTROLYTIC TYPES
anode
dielectric layer
spacer
dielectric layer
cathode
Al (etched)
Al_2O_3
paper & electrolyte
Al_2O_3
Al (etched)
SOLID ALUMINIUM TYPES (121-series)
anode
dielectric layer
cathode
Al (etched)
Al_2O_3
MnO_2 & glass fibre spacer
Al (etched)
anode lead
anode pin
cathode lead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

Fig. 1.

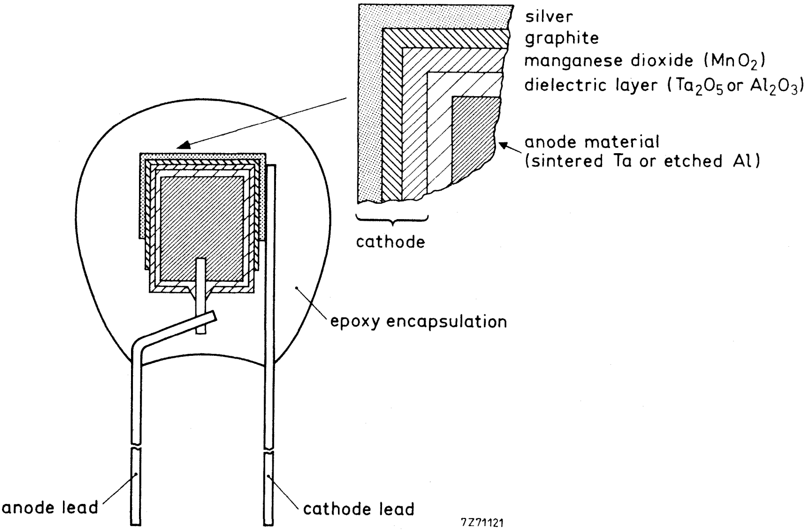

silver
graphite
manganese dioxide (MnO_2)
dielectric layer (Ta_2O_5 or Al_2O_3)
anode material
(sintered Ta or etched Al)
cathode
epoxy encapsulation
anode lead
cathode lead
7Z71121

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 :

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

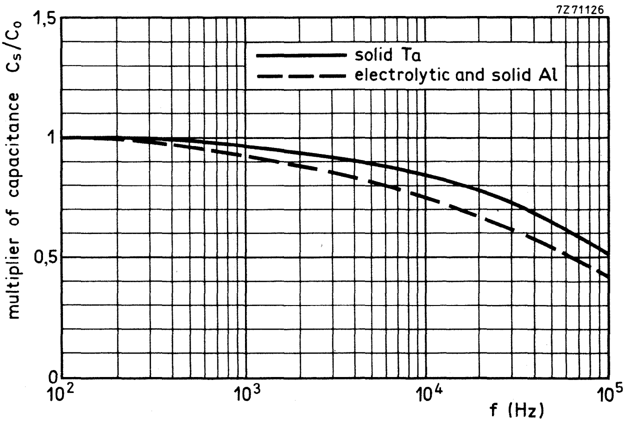


Fig. 3. Typical capacitance as a function of frequency. C_0 = capacitance at 25 °C, 100 Hz.

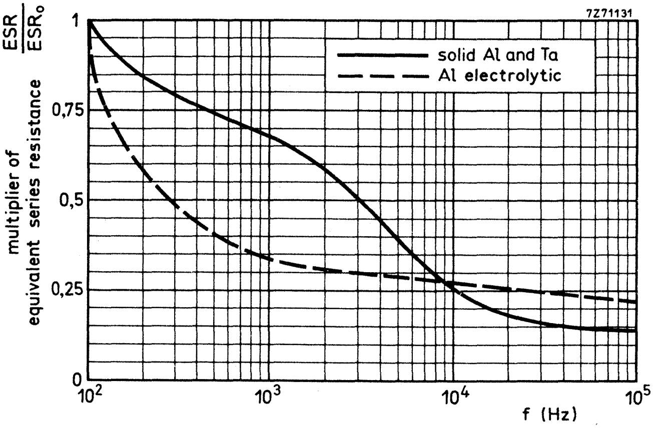


Fig. 4. Typical ESR as a function of frequency. ESR_0 = ESR at 25 °C , 100 Hz

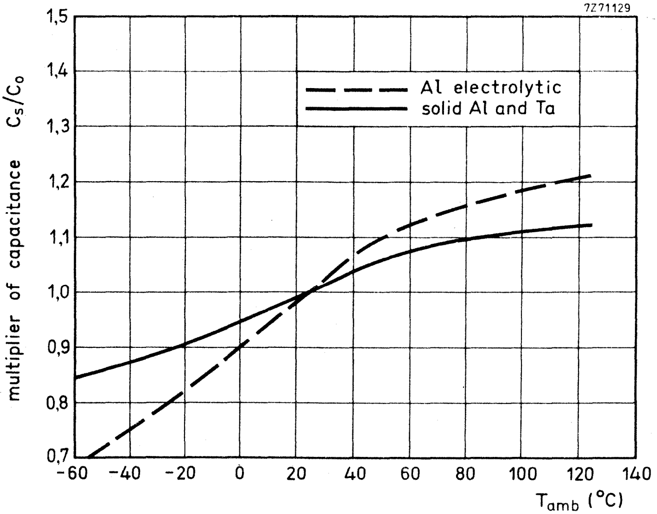


Fig. 5. Typical capacitance as a function of ambient temperature. C_0 = capacitance at 25 °C, 100 Hz.

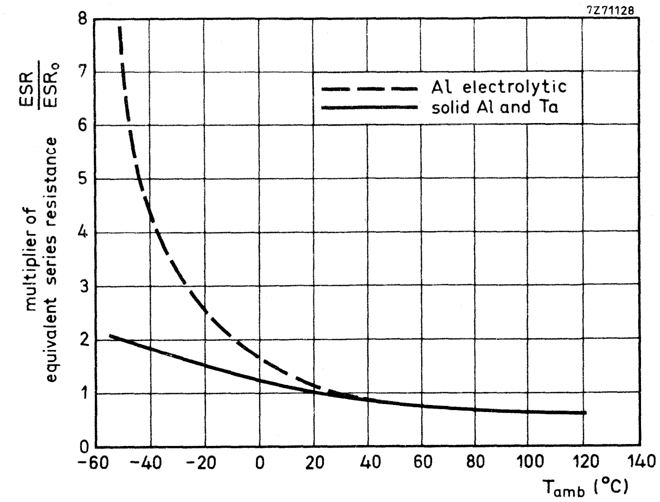


Fig. 6. Typical ESR as a function of ambient temperature. ESR_0 = ESR at 100 Hz, at 25 °C

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 ^{0}C)
S = heat transfer surface area (m^2)
T_c = temperature of case surface (^{0}C)
T_{amb} = ambient temperature (^{0}C)

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 ^{0}C) 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.

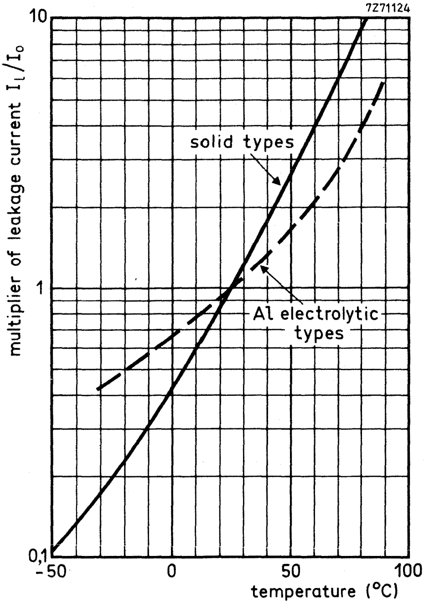


Fig. 7 Typical leakage current as a function of temperature. I_0 = leakage current during continuous operation at T_{amb} = 25 °C.

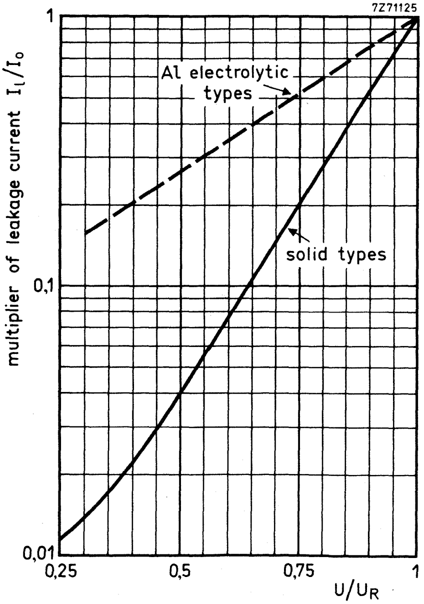


Fig. 8. Typical leakage current as a function of U/U_R. I_0 = leakage current at U_R at a discrete constant temperature within category temperature range, U is working voltage.

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.

9. TESTS AND REQUIREMENTS

←

The description of tests and requirements, given in the following tables, is valid for the complete range of aluminium electrolytic capacitors and solid aluminium capacitors. Specific tests for a certain type of capacitor are not included in these tables; those tests are given in the data sheet of the relevant type.

Aluminium electrolytic capacitors

In the description of the procedure and the requirements of the tests, in some cases distinction has to be made for the different types of aluminium electrolytic capacitors with respect to their size or with respect to their application fields. In the table this distinction is indicated in the columns 'type' with the indication for size:

m for miniature types,
s for small types,
l for large types,
lt for large types with screw terminals,

or with the indication for application fields:

1 for long-life grade types,
2 for general-purpose grade types.

If no indication is given in these columns, reference is made to all types.

IEC 384–4 sub clause	IEC 68–2 test method	name of test	procedure (quick reference)		requirements	
			type	description	type	description
–	Ua	Tensile strength of terminations	m s	Loading for 10 N for 10 s.	m s l	No visible damage.
			l	Loading force 20 N for 10 s.		
–	Ub	Bending of terminations	m s	Loading force 5 N, two consecutive bends.	m s	No visible damage.
–	Uc	Torsion of terminations	m s	Two successive rotations of 180° in opposite direction, 5 s per rotation.	m s	No visible damage.
–	Ud	Torque on nut (stud)	lt	Torque of 1,76 Nm gradually applied.	lt	No visible damage.
9.8.1	Ta	Solderability	m s l	Solder bath: 235 °C, 2 s for capacitors with printed-wiring pins, 270 °C, 2 s for capacitors with solder leads or tags	m s l	No visible damage, marking legible, $\Delta C/C \leqslant 5\%$.
9.8.2	Tb (method 1A)	Resistance to soldering heat	m s l	Solder bath: 260 °C, 10 s	m s l	No visible damage, marking legible, $\Delta C/C \leqslant 5\%$.
	Tb (method 1B)			Solder bath 350 °C, 3,5 s for capacitors with solder leads or tags.		

IEC 384–4 sub clause	IEC 68–2 test method		name of test	procedure (quick reference)		requirements	
				type	description	type	description
9.9	Na		Rapid change of temperature		5 cycles of 3 h at upper and lower category temperature.		No visible damage, no leakage of electrolyte.
9.10	Fc		Vibration	1	10 to 500 Hz, 0,75 mm or 10g (whichever is less), 2 directions, 3 h per direction.		No visible damage, no lekage of electrolyte, marking legible; ΔC/C ⩽ 5% with respect to initial measurement.
				2	10 to 55 Hz, 0,75 mm or 10g (whichever is less), 2 directions, 3 h per direction.		
9.11	Eb		Bumping	1	40g, 2 directions, 4000 bumps total.		No visible damage, no leakage of electrolyte; ΔC/C ⩽ 5% with respect to initial measurement.
				2	40g, 2 directions, 1000 bumps total.		
	Climatic sequence	Ba	Dry heat		16 h at upper category temperature, U_R applied.		No visible damage, no leakage of electrolyte.
		Db	Damp heat, cyclic		1 cycle of 24 h at 55 ± 2 °C, R.H. 95 to 100%, no voltage applied.		
		Aa	Cold		2 h at lower category temperature, no voltage applied.		No visible damage, no leakage of electrolyte.
9.12.1		M	Low air pressure		5 min. at 15 to 35 °C, at atmospheric pressure of 85 mbar, last minute U_R applied.		No visible damage, no evidence of breakdown or flashover.
		Db	Damp heat, cyclic		5 cycles of 24 h at 55 ± 2 °C, R.H. 95 to 100%, no voltage applied.		
9.12.2		Qc	Sealing		1 min. in water at upper category temperature + 5 °C.		No continuous chain of bubbles.
					Final measurement		No visible damage, no leakage of electrolyte, marking legible; leakage current ⩽ stated limit; tan δ ⩽ 1,2 x stated limit; ΔC/C ⩽ 10%.

IEC 384–4 sub clause	IEC 68–2 test method	name of test	procedure (quick reference)		requirements	
			type	description	type	description
9.9.13	Ca	Damp heat, steady state		56 days at 40 °C, R.H. 90 to 95%; no voltage aplied.		No visible damage, no leakage of electrolyte, marking legible; leakage current $\leqslant$ stated limit, tan $\delta \leqslant 1{,}2$ x stated limit, insulation resistance $> 100\ \text{M}\Omega$, no breakdown or flashover.
					1	$\Delta C/C \leqslant 10\%$.
					2	$\Delta C/C \leqslant 20\%$.
9.14	–	Endurance	1	2000 h at upper category temperature, U_R applied.		No visible damage, no leakage of electrolyte, marking legible; leakage current $\leqslant$ stated limit, insulation resistance $> 100\ \text{M}\Omega$, no breakdown or flashover.
					1	$15\% \leqslant \Delta C/C \leqslant -30\%$ for $U_R \leqslant 6{,}3$ V, $\Delta C/C \leqslant 15\%$ for $6{,}3\ \text{V} < U_R \leqslant 160$ V, $\Delta C/C \leqslant 10\%$ for $U_R > 160$ V; tan $\delta \leqslant 1{,}3$ x stated limit, impedance at 1 kHz or 10 kHz $\leqslant 2$ x stated limit.
			2	1000 h at upper category temperature, U_R applied.	2	$25\% \leqslant \Delta C/C \leqslant -40\%$ for $U_R \leqslant 6{,}3$ V, $\Delta C/C \leqslant 30\%$ for $6{,}3\ \text{V} < U_R \leqslant 160$ V, $\Delta C/C \leqslant 15\%$ for $U_R > 160$ V; tan $\delta \leqslant 1{,}5$ x stated limit or min. 0,40 (whichever is greater), impedance at 1 kHz or 10 kHz $\leqslant 3$ x stated limit.
9.15	–	Surge		From source of $1{,}15 \times U_R$ for $U_R \leqslant 315$ V or $1{,}1 \times U_R > 315$ V, RC = 100 ± 50 ms, 1000 cycles of 30 s on, 330 s off.		No visible damage, no leakage of electrolyte; leakage current $\leqslant$ stated limit, tan $\delta \leqslant$ stated limit, $\Delta C/C \leqslant 15\%$.
			1	At upper category temperature.		
			2	At 25 °C.		

IEC 384–4	IEC 68–2 test	name of test	procedure (quick reference)		requirements	
sub clause	method		type	description	type	description
9.16	–	Reverse voltage		1 V in reverse polarity followed by U_R in forward polarity, both for 125 h at upper category temperature.		Leakage current $\leqslant$ stated limit, $\tan \delta \leqslant$ stated limit, $\Delta C/C \leqslant 10\%$.
9.17	–	Pressure relief	I It	D.C. voltage applied in reverse direction producing a current of 1 to 10 A.	I It	Pressure relief opens prior to danger of explosion or fire.
9.18	Ha	Storage at upper category temperature (half of the lot)		96 ± 4 h at upper category temperature.		No visible damage, no leakage of electrolyte; leakage current $\leqslant 2$ x stated limit, $\tan \delta \leqslant 1{,}2$ x stated limit; $\Delta C/C \leqslant 10\%$.
9.19	Hb	Storage at low temperature (other half of the lot)		72 h at lower category temperature -15 °C.		No visible damage, no leakage of electrolyte; leakage current $\leqslant$ stated limit, $\tan \delta \leqslant$ stated limit; $\Delta C/C \leqslant 10\%$.
9.20		Characteristics at high and low temperature		**Step 1**: reference measurement at 20 °C of capacitance, impedance at 100 Hz and $\tan \delta$.		
				Step 2: measurement at lower category temperature.		Impedance at 100 Hz $\leqslant 7$ x value of step 1 for $U_R \leqslant 6{,}3$ V or $U_R > 160$ V, $\leqslant 5$ x value of step 1 for $6{,}3 < U_R \leqslant 16$ V, $\leqslant 4$ x value of step 1 for $16 < U_R \leqslant 160$ V.
				Step 3: Measurement at upper category temperature.		Leakage current $\leqslant 5$ x stated limit at 85 °C, $\leqslant 3$ x stated limit at 70 °C.
9.21		Charge and discharge		For $U_R \leqslant 160$ V: 10^6 cycles of charge to U_R (RC = 0,1 s for 0,5 s) and discharge (RC = 0,1 s for 0,5 s). For $U_R > 160$ V: under consideration.		No visible damage, no leakage of electrolyte, $\Delta C/C \leqslant 10\%$.

Solid aluminium capacitors

In the description of the procedure and the requirements of the tests, in some cases distinction has to be made for the two types of solid aluminium capacitors 2222 121 and 2222 122. In the table this distinction is indicated by 121 or 122 in the columns 'type'. If no indication is given in these columns reference is made to both types.

IEC 384–4 sub clause	IEC 68–2 test method	name of test	procedure (quick reference)		requirements	
			type	description	type	description
–	Ua	Tensile strength of terminations		Loading force 10 N for 10 s.		No visible damage.
–	Ub	Bending of terminations		Loading force 5 N, two consecutive bends.		No visible damage.
–	Uc	Torsion of terminations	121	Two successive rotations of 180° in opposite direction, 5 s per rotation.	121	No visible damage.
9.8.1	Ta	Solderability	122	Solder bath: 235 °C, 2 s for capacitors with printed-wiring pins.		No visible damage, marking legible, $\Delta C/C \leqslant 5\%$.
			121	Solder bath: 270 °C, 2 s for capacitors with solder leads.		
9.8.2	Tb (method 1A)	Resistance to soldering heat		Solder bath: 260 °C, 10 s.		No visible damage, marking legible, $\Delta C/C \leqslant 5\%$.
	Tb (method 1B)			Solder bath: 350 °C, 3,5 s.		
9.9	Na	Rapid change of temperature		5 cycles of 3 h at upper and lower category temperature.		Leakage current $\leqslant$ stated limit, $\tan \delta \leqslant$ stated limit.
9.10	Fc	Vibration		10 to 500 Hz, 0,75 mm or 10g (whichever is less), 2 directions, 3 h per direction.		No visible damage, marking legible; $\Delta C/C \leqslant 5\%$ with respect to initial measurement.

IEC 384–4 sub clause	IEC 68–2 test method		name of test	procedure (quick reference)		requirements	
				type	description	type	description
9.11	Eb		Bumping		40g, 2 directions, 4000 bumps total.		No visible damage; $\Delta C/C \leqslant 5\%$ with respect to initial measurement.
	Climatic sequence	Ba	Dry heat		16 h upper category temperature, U_R applied.		No visible damage.
		Db	Damp heat, cyclic		1 cycle of 24 h at 55 ± 2 °C, R.H. 95 to 100%, no voltage applied.		
		Aa	Cold		2 h at lower category temperature, no voltage applied.		No visible damage.
9.12.1		M	Low air pressure		5 min. at 15 to 35 °C, at atmospheric pressure of 85 mbar, last minute U_R applied.		No visible damage, no evidence of breakdown or flashover.
		Db	Damp heat, cyclic		5 cycles of 24 h at 55 ± 2 °C, R.H. 95 to 100%, no voltage applied.		
					Final measurement.		No visible damage, marking legible; leakage current $\leqslant$ stated limit, tan $\delta \leqslant 1{,}2$ x stated limit.
						121	$\Delta C/C \leqslant 5\%$.
						122	$\Delta C/C \leqslant 10\%$.
9.13	Ca		Damp heat, steady state		56 days at 40 °C, R.H. 90 to 95%; no voltage applied.		No visible damage, marking legible; leakage current $\leqslant$ stated limit; tan $\delta \leqslant 1{,}2$ x stated limit, insulation resistance > 100 MΩ, no breakdown or flashover.
						121	$\Delta C/C \leqslant 5\%$.
						122	$\Delta C/C \leqslant 15\%$.

IEC 384–4	IEC 68–2 test	name of test	procedure (quick reference)		requirements	
sub clause	method		type	description	type	description
9.14	–	Endurance	122	2000 h at 125 °C, derated voltage applied.		No visible damage, marking legible; leakage current $\leqslant$ stated limit, tan $\delta \leqslant 1,2$ x stated limit, insulation resistance > 100 MΩ, no breakdown or flashover, $\Delta C/C \leqslant 10\%$.
			121	5000 h at 125 °C, derated voltage applied.		
				5000 h at 85 °C, U_R applied.		
9.15	–	Surge		From source of 1,15 x U_R at 85 °C or 1,15 x derated voltage at 125 °C, RC = 100 ± 50 ms, 1000 cycles of 30 s on, 330 s off.		No visible damage; leakage current $\leqslant$ stated limit, tan $\delta \leqslant$ stated limit,
					121	$\Delta C/C \leqslant 5\%$.
					122	$\Delta C/C \leqslant 10\%$.
9.16	–	Reverse voltage	121	0,15 x U_R in reverse polarity at 85 °C for 125 h, followed by 0,15 x U_R in forward polarity at 85 °C for 125 h.		Leakage current $\leqslant$ stated limit, tan $\delta \leqslant$ stated limit, $\Delta C/C \leqslant 10\%$.
			122	0,30 x U_R in reverse polarity at 85 °C for 125 h, followed by 0,30 x U_R in forward polarity at 85 °C for 125 h.		
			121	0,15 x derated voltage in reverse polarity at 125 °C for 125 h, followed by 0,15 x derated voltage in forward polarity at 125 °C for 125 h.		
			122	0,30 x derated voltage in reverse polarity at 125 °C for 125 h, followed by 0,30 x derated voltage in forward polarity at 125 °C for 125 h.		
9.18	Ha	Storage at upper category temperature		96 ± 4 h at upper category temperature.		No visible damage; leakage current $\leqslant$ stated limit, tan $\delta \leqslant$ stated limit.
					121	$\Delta C/C \leqslant 5\%$.
					122	$\Delta C/C \leqslant 10\%$.

IEC 384–4	IEC 68–2 test	name of test	procedure (quick reference)		requirements	
sub clause	method		type	description	type	description
9.20		Characteristics at high and low temperature		**Step 1**: reference measurement at 20 °C of capacitance, impedance at 100 Hz and tan δ.		
				Step 2: measurement at lower category temperature.		Tan $\delta \leqslant 2$ x stated limit, impedance ratio $\leqslant 2$, $\Delta C/C \leqslant 20\%$.
				Step 3: measurement at upper category temperature.		Leakage current $\leqslant 10$ x stated limit, tan $\delta \leqslant$ stated limit, $\Delta C/C \leqslant 20\%$.
9.21		Charge and discharge		10^6 cycles of charge to U_R (RC = 0,1 s for 0,5 s) and discharge (RC = 0,1 s for 0,5 s).		No visible damage, $\Delta C/C \leqslant 5\%$.

ALUMINIUM ELECTROLYTIC CAPACITORS

- **Miniature and small types**
- **Axial leads (on bandoliers) or single ended**
- **General and industrial applications**

QUICK REFERENCE DATA

Nominal capacitance range (E6 series)	0,47 to 4700 µF	
Tolerance on nominal capacitance	−10 to + 50%	
Rated voltage range, U_R (R5 series)	4 to 100 V	
	case sizes 3, 5a	case sizes 4 to 03
Category temperature range	−25 to + 85 °C	−40 to + 85 °C
Endurance test at 85 °C	1000 h	2000 h
Basic specification, IEC 384-4	general-purpose grade	long-life grade
Climatic category, IEC 68	25/085/56	40/085/56

Selection chart for C_{nom} −U_R and relevant case sizes.

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

case size	nominal dimensions (mm)
3	Ø 6 x 10
5a	Ø 8 x 11
4	Ø 6,5 x 18
5	Ø 8 x 18
6	Ø 10 x 18
7	Ø 10 x 25
00	Ø 10 x 30
01	Ø 12,5 x 30
02	Ø 15 x 30
03	Ø 18 x 30

APPLICATION

These capacitors are mainly used 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. The taped versions are extremely suitable for automatic insertion and for cutting and forming equipment.

DESCRIPTION

The capacitor has etched aluminium foil electrodes rolled up with a porous paper spacer with 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 4 styles, all with soldered-copper leads.

Style 1: axial leads; case insulated with a blue plastic sleeve;

Style 2: single ended; with self-locking lead; case insulated with a blue plastic sleeve;

Style 3: single ended; case insulated with a blue plastic sleeve.

Style 4: single ended; case fitted in a yellow plastic foot.

MECHANICAL DATA

Dimensions in mm

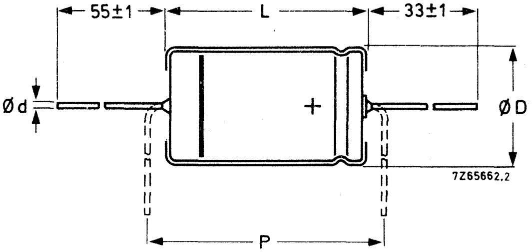


Fig. 1 Style 1; see Table 1a for dimensions d, D, L and P. Capacitors with case sizes 00 to 03 have an extra rill in the middle of the case. The given lead lengths are only valid for case sizes 00 to 03 (case sizes 3 to 7 are supplied on bandoliers in boxes or on reels).

Table 1a

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

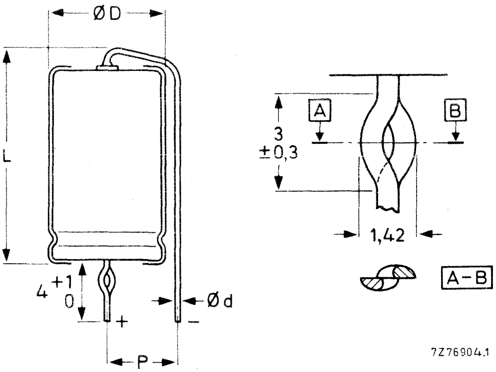


Fig. 2 Style 2, case sizes 00 to 03 (case sizes 4 to 7 on request); see Table 1b for dimensions d, D, L and P.

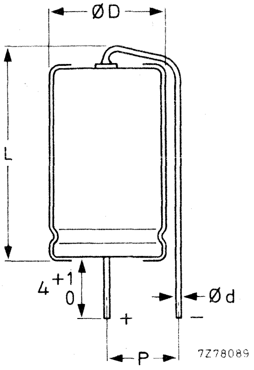


Fig. 3 Style 3, case sizes 3 to 7 (case sizes 00 to 03 (on request); see Table 1b for dimensions d, D, L and P.

Table 1b

case size	d	style 2			style 3			mass approx. g
		D_{max}	L_{max}	P	D_{max}	L_{max}	P	
3	0,6				6,3	12,5	3,5-7,5	0,7
5a	0,6				8,5	13,0	5 -10	1,2
4	0,8	6,9	22,5	5 -10	6,9	22,5	5 -10	1,5
5	0,8	8,5	22,5	5 -10	8,5	22,5	5 -10	2
6	0,8	10,5	22,5	7,5-12,5	10,5	22,5	7,5-12,5	2,7
7	0,8	10,5	28,5	7,5-12,5	10,5	28,5	7,5-12,5	3,3
00	0,8	10,5	34,0	7,5-12,5	10,5	34,0	7,5-12,5	4,0
01	0,8	13,0	34,0	7,5-12,5	13,0	34,0	7,5-12,5	6,3
02	0,8	15,5	34,0	10 -15	15,5	34,0	10 -15	8,2
03	0,8	18,5	34,0	10 -15	18,5	34,0	10 -15	10,9

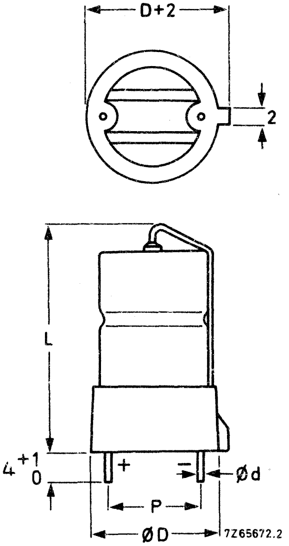


Fig. 4 Style 4; see Table 1c for dimensions d, D, L and P.

Table 1c

case size	d	style 4			mass approx. g
		D_{max}	L_{max}	P	
7	0,8	12,9	33,0	10 ± 0,5	3,3
00	0,8	12,8	39,5	10 ± 0,5	4,0
01	0,8	15,2	39,5	10 ± 0,5	6,3
02	0,8	17,8	39,5	12,5 ± 0,5	8,2
03	0,8	20,8	39,5	15 ± 0,5	10,9

Marking

The capacitors are marked with:
  nominal capacitance;
  tolerance on nominal capacitance;
  rated voltage;
  grade reference (for long-life grade only);
  group number 015, 016 or 017; code for origin;
  name of manufacturer;
  date code (year and month) according to IEC 62;
  band to identify the negative terminal;
  + signs to identify the positive terminal (on case sizes 4 to 03 only).

Mounting

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

ELECTRICAL DATA

Table 2 (notes are on page 7)

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. temperature mA	max. leakage current at U_R after 5 min µA	typ. ESR Ω	max. tan δ	impedance at 100 kHz Ω		case size	catalogue number * 2222 followed by
						typ.	max.		
4	100	44	20	4,0	0,40	2	3,4	3	015 .2101
4	220	70	44	1,8	0,40	1	1,7	5a	015 .2221
4	220	85	9	1,8	0,38	0,5	0,8	4	016 .2221
4	330	125	12	1,2	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	68	44	22	4,7	0,32	2	3,4	3	015 .3689
6,3	150	70	48	2,1	0,32	1	1,7	5a	015 .3151
6,3	150	85	10	2,1	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	270	30	0,47	0,30	0,2	0,3	7	016 .3681
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	47	44	24	5,4	0,26	2	3,4	3	015 .4479
10	100	70	50	2,6	0,26	1	1,7	5a	015 .4101
10	100	85	10	2,6	0,24	0,5	0,8	4	016 .4101
10	220	125	18	1,2	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	270	33	0,54	0,24	0,2	0,3	7	016 .4471
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	33	44	27	5,8	0,18	2	3,4	3	015 .5339
16	68	70	53	2,8	0,18	1	1,7	5a	015 .5689
16	68	85	11	2,8	0,17	0,5	0,8	4	016 .5689
16	150	125	19	1,3	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	270	36	0,58	0,17	0,2	0,3	7	016 .5331
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
25	22	37	28	7,2	0,15	2	3,4	3	015 .6229
25	47	60	56	3,4	0,15	1	1,7	5a	015 .6479
25	47	72	12	3,4	0,14	0,5	0,8	4	016 .6479
25	100	105	19	1,6	0,14	0,35	0,55	5	016 .6101

Table 2 (continued)

U_R V	nom. cap. µF	max. r.m.s. ripple current at upper cat. temperature mA	max. leakage current at U_R after 5 min µA	typ. ESR Ω	max. tan δ	impedance at 100 kHz Ω		case size	catalogue number * 2222 followed by
						typ.	max.		
25	150	155	27	1,1	0,14	0,2	0,3	6	016 .6151
25	220	220	37	0,72	0,14	0,2	0,3	7	016 .6221
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	15	37	30	8,5	0,12	2	3,4	3	015 .7159
40	22	50	44	5,8	0,12	1	1,7	5a	015 .7229
40	22	60	12	5,8	0,11	1	1,7	4	016 .7229
40	33	60	60	3,9	0,12	1	1,7	5a	015 .7339
40	33	72	12	3,9	0,11	0,5	0,8	4	016 ,7339
40	47	105	16	2,7	0,11	0,35	0,55	5	016 .7479
40	100	155	28	1,3	0,11	0,2	0,3	6	016 .7101
40	150	220	40	0,85	0,11	0,2	0,3	7	016 .7151
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	0,47	7	5	200	0,09	5	8,5	3	015 .8477
63	1	10	5	95	0,09	3	5	3	015 .8108
63	1,5	12	5	64	0,09	2,5	4,5	3	015 90043**
63	2,2	15	7	43	0,09	2	3,5	3	015 .8228
63	3,3	17	11	29	0,09	2	3,5	3	015 .8338
63	4,7	22	15	20	0,09	2	3,5	3	015 90044**
63	6,8	25	22	14	0,09	2	3,5	3	015 .8688
63	10	30	32	9,6	0,09	2	3,5	3	015 .8109
63	15	43	48	6,4	0,09	1	1,7	5a	015 .8159
63	15	55	10	6,4	0,09	0,5	0,8	4	016 .8159
63	22	80	13	4,3	0,09	0,35	0,55	5	016 .8229
63	47	115	22	2,0	0,09	0,2	0,3	6	016 .8479
63	68	165	30	1,4	0,09	0,2	0,3	7	016 .8689
63	68	195	30	1,4	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
100	2,2	25	11	43	0,09	1	1,7	4	016 .9228
100	4,7	36	22	20	0,09	0,6	0,96	4	016 .9478
100	10	60	50	9,6	0,09	0,35	0,65	5	016 .9109
100	22	104	80	4,3	0,09	0,2	0,32	6	016 .9229
100	47	145	33	2,0	0,09	0,2	0,32	7	016 90106**

Notes to Table 2

* Replace dot in catalogue number by:
1 for style 1 on paper band (case sizes 00 to 03)
2 for style 1 on bandoliers on reel (case sizes 3 to 6)
3 for style 1 on bandoliers in box (case sizes 3 to 7)
5 for style 4 (case sizes 7 to 03)
7 for style 2 (case sizes 4 to 03)
8 for style 3

** Catalogue number for style 1 capacitors on bandoliers in box is given. For other packing and styles, see Table 3 for the corresponding catalogue number.

Table 3

last 5 digits of catalogue number			
style 1 capacitors on bandoliers in box	style 1 capacitors on bandoliers on reel	style 2 capacitors	style 3 capacitors
90043	90041		90076
90044	90042		90068
90106		90113	90114

Capacitance

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

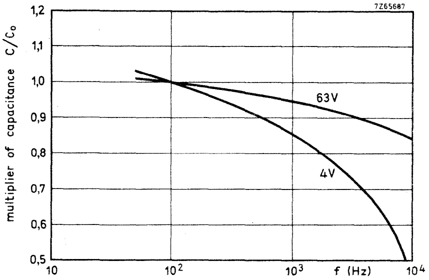


Fig. 5 Typical capacitance as a function of frequency for case sizes 3 and 5a; C_0 = capacitance at 20 °C, 100 Hz.

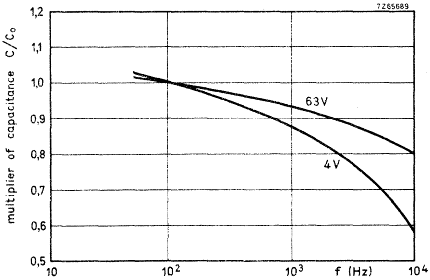


Fig. 6 Typical capacitance as a function of frequency for case sizes 4, 5 and 6; C_0 = capacitance at 20 °C, 100 Hz.

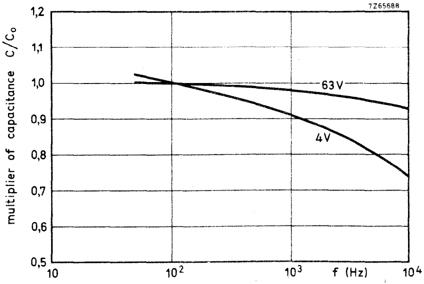


Fig. 7 Typical capacitance as a function of frequency for case sizes 7, 00, 01, 02 and 03; C_0 = capacitance at 20 °C, 100 Hz.

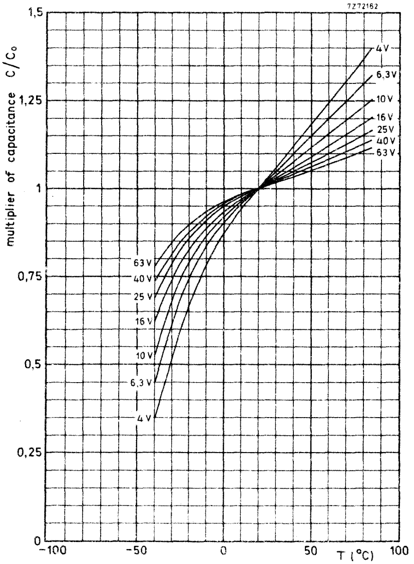


Fig. 8 Typical capacitance as a function of temperature for case sizes 3 and 5a; C_o = capacitance at 20 °C, 100 Hz.

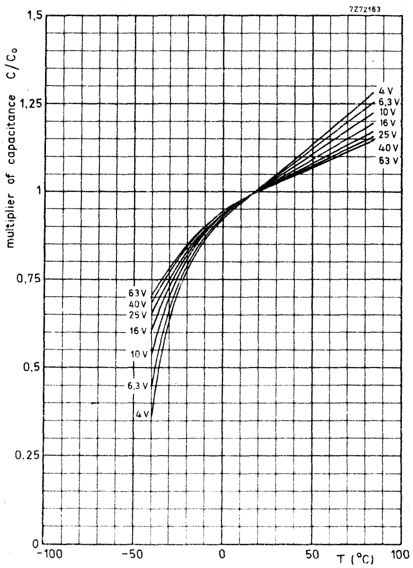


Fig. 9 Typical capacitance as a function of temperature for case sizes 4, 5, and 6; C_o = capacitance at 20 °C, 100 Hz.

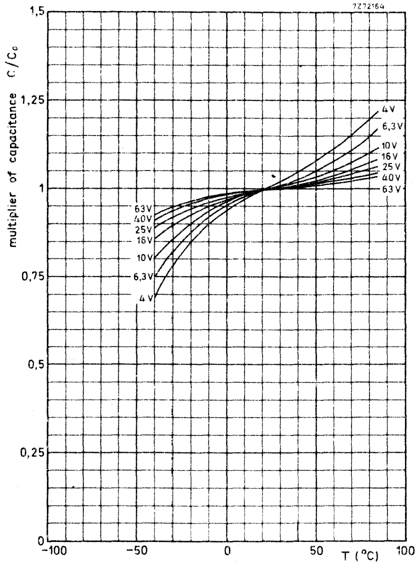


Fig. 10 Typical capacitance as a function of temperature for case sizes 7, 00, 01, 02 and 03; C_o = capacitance at 20 °C, 100 Hz.

Voltage

	$<$ 40 °C	40 to 85 °C
Rated voltage = max. permissible voltage	1,1 x U_R	U_R
Ripple voltage* = max. permissible a.c. voltage providing the following three conditions are met:		
a) max. (d.c. + peak a.c.) voltage	$\leqslant$ 1,1 x U_R	$\leqslant U_R$
b) max. peak a.c. voltage with d.c. voltage applied	$\leqslant$ 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	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} = 85 °C	see Table 2
at 100 Hz and T_{amb} = 70 °C	1,7 x values of Table 2
at 100 Hz and $T_{amb} <$ 60 °C	2,2 x values of Table 2

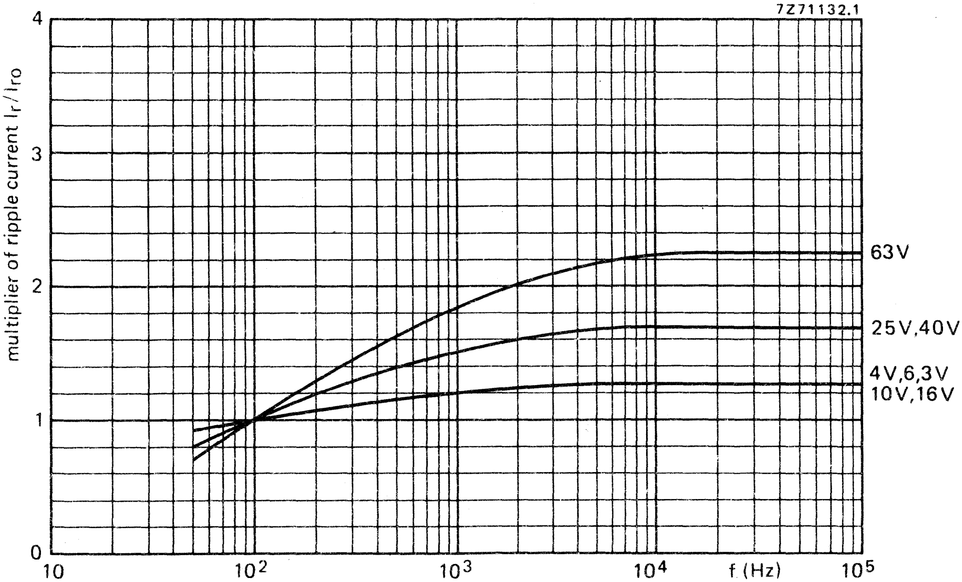


Fig. 11 Typical ripple current as a function of frequency; I_{ro} = ripple current at 100 Hz and 85 °C. (Only for case sizes 7, 00, 01, 02 and 03.)

---

* Ripple voltages are not appliceable 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.

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

$$\sum_{n} \frac{I_n^2}{r_n} \leqslant I_{rmax}^2$$

I_{rmax} = maximum ripple current at 100 Hz and applicable ambient temperature;

I_n = ripple current at a certain frequency;

$\sqrt{r_n} = I_r/I_{ro}$ = multiplying factor as a same frequency.

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 x values of Table 2
at T_{amb} = 85 °C	$\leqslant$ values of 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.

Equivalent series resistance (ESR)

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

Tan δ (dissipation factor)

Maximum 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

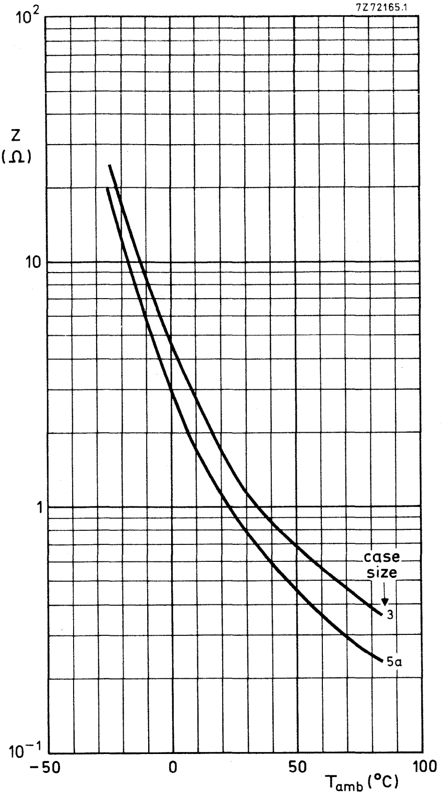


Fig. 12 impedance as a function of temperature at 100 kHz.

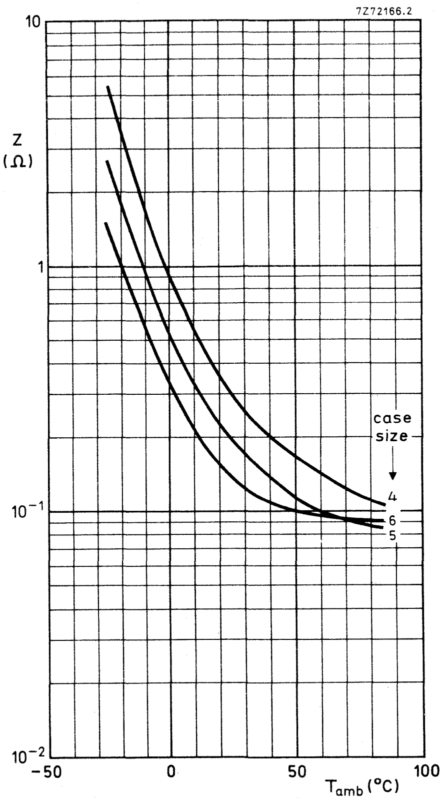


Fig. 13 Impedance as a function of temperature at 100 kHz.

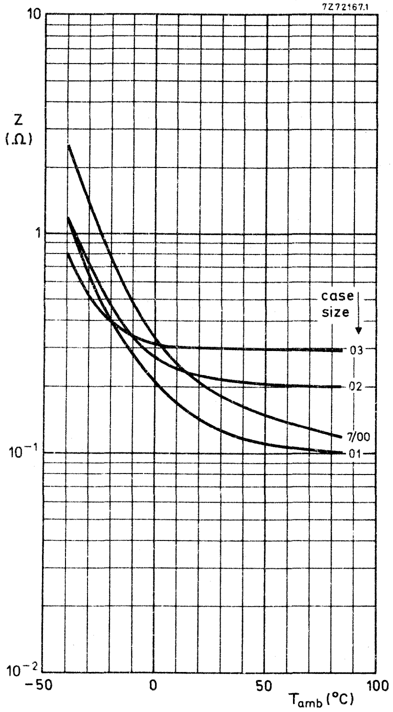


Fig. 14 Impedance as a function of temperature at 100 kHz.

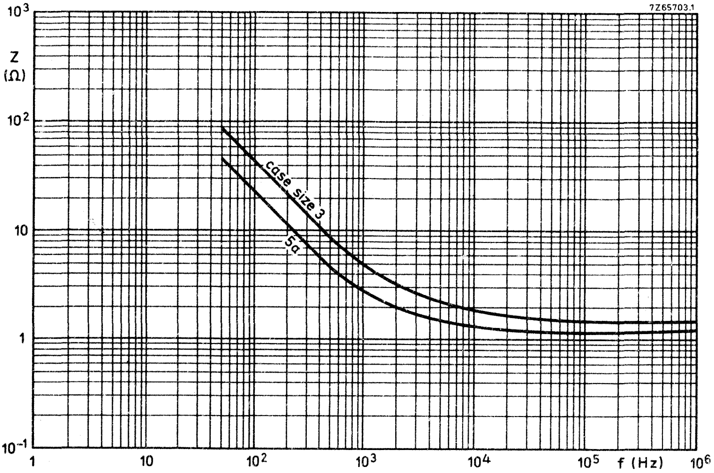


Fig. 15 Impedance as a function of frequency at 20 °C.

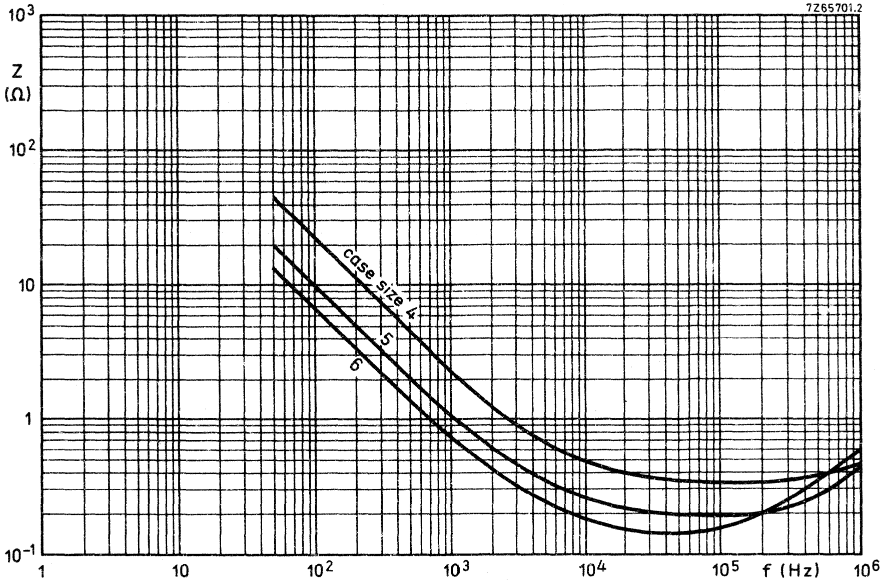


Fig. 16 Impedance as a function of frequency at 20 °C.

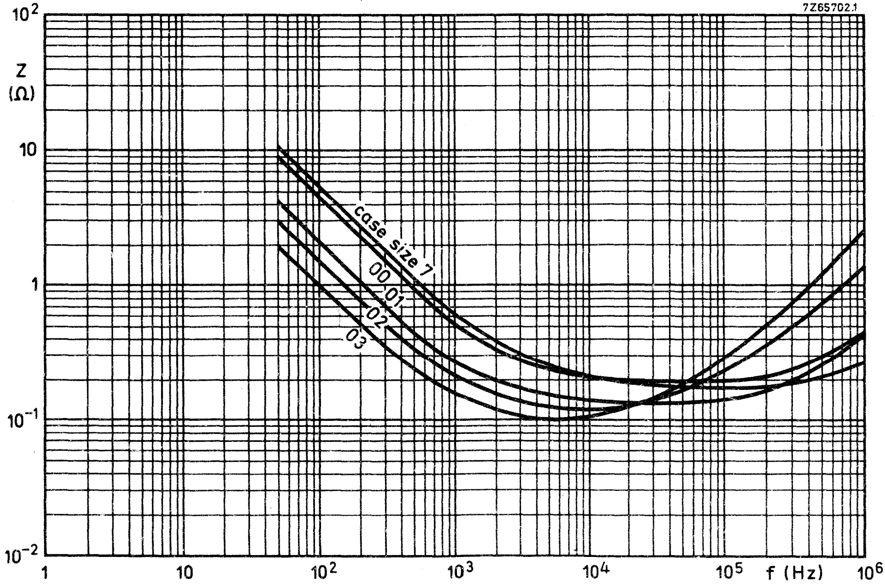


Fig. 17 Impedance as a function of frequency at 20 °C.

OPERATIONAL DATA

Category temperature range

Case sizes 3 and 5a	–25 to + 85 °C
Case sizes 4 to 03	–40 to + 85 °C

PACKING

Capacitors with case sizes 3 to 7 of style 1 are supplied in boxes of 500, those of styles 2, 3 and 4 in boxes of 1000. Capacitors with case sizes 00 to 03 (all styles) are supplied in boxes of 200.
Capacitors of style 1 are supplied on paper band (case sizes 00 to 03) or on bandoliers (case sizes 3 to 7) in boxes, or on bandoliers on reels (case sizes 3 to 6). The reels contain 1000 pieces of case sizes 3 or 4, and 500 pieces of case sizes 5, 5a or 6.

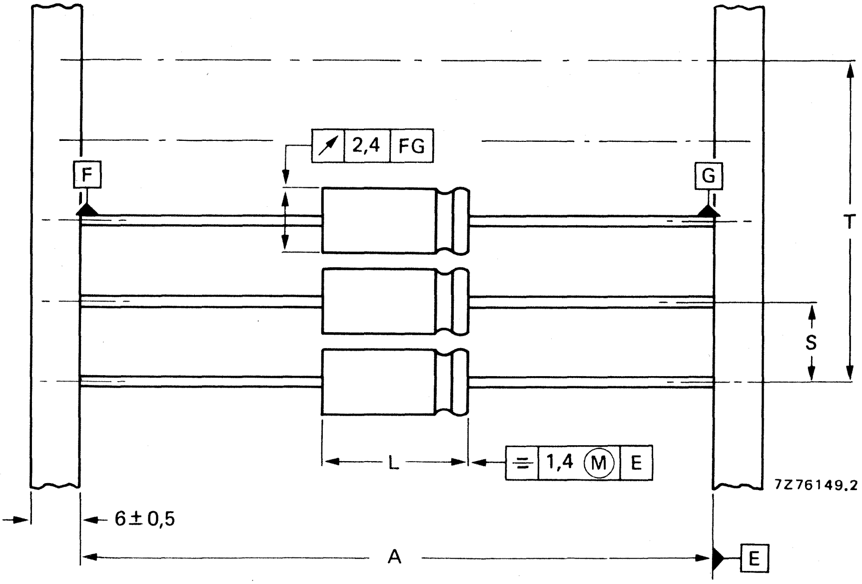


Fig. 18 Style 1 capacitors on bandoliers: the bandolier to which the negative capacitor terminals are connected is blue. See Table 4 for dimensions A, S, T and L (for the time being the positive terminal tape is red, the negative white).

Table 4; dimensions in mm

case size	A	S	T for number (n) of capacitors		L_{max}
			n < 50	50 < n < 100	
3	63,5 ± 1,6	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	10,5
5a	63,5 ± 1,6	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	11,5
4	73 ± 1,6	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	18,5
5	73 ± 1,6	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	18,5
6	73 ± 1,6	15 ± 0,75	15 (n-1) ± 2	15 (n-1) ± 4	18,5
7	73 ± 1,6	15 ± 0,75	15 (n-1) ± 2	15 (n-1) ± 4	25,0

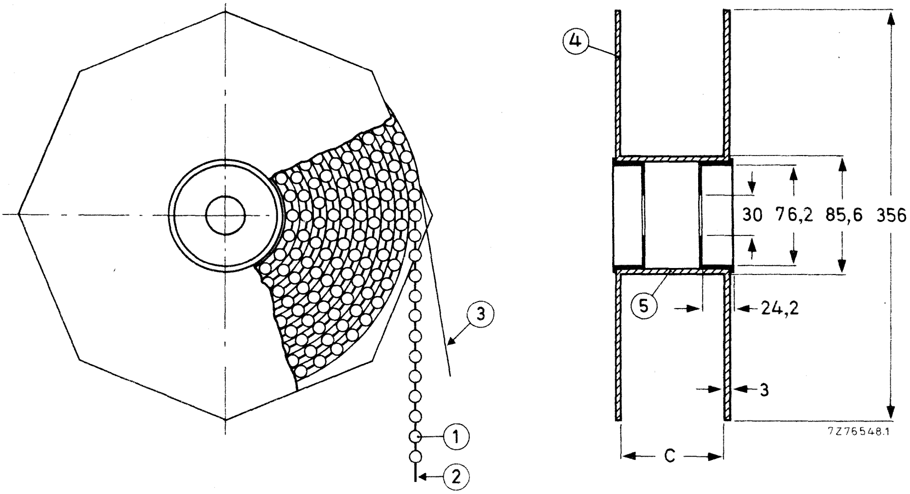


Fig. 19 Style 1 capacitors on bandoliers on reel; dimension C is 84,5 mm for case sizes 3 and 5a, and 88,0 mm for case sizes 4, 5 and 6, the overall width of the reel is 94,5 mm and 99,5 mm respectively.

1 = capacitor	4 = flange
2 = bandolier	5 = cylinder
3 = paper	

TESTS AND REQUIREMENTS

See Introduction, section 9, under aluminium electrolytic capacitors.

Note: Capacitors 2222 015 to 2222 017 belong to the miniature and small types, general-purpose grade (case sizes 3 and 5a) or long-life grade (case sizes 4 to 03).

ALUMINIUM ELECTROLYTIC CAPACITORS

- **Miniature type**
- **Axial leads (on bandoliers) or single ended**
- **General purpose**

QUICK REFERENCE DATA

Nominal capacitance range (E6 series)	0,33 to 1000 μF
Tolerance on nominal capacitance	
case size 1	−10 to + 100%
case sizes 2 to 7	−10 to + 50%
Rated voltage range, U_R (R5 series)	6,3 to 100 V
Category temperature range	
case size 1	−25 to + 70 °C
case sizes 2 to 7	−25 to + 85 °C
Endurance test	
case size 1	1000 h at 70 °C
case sizes 2 to 7	1000 h at 85 °C
Basic specification	IEC 384–4, general-purpose grade
Climatic category, IEC 68	
case size 1	25/070/56
case sizes 2 to 7	25/085/56

Selection chart for C_{nom} – U_R and relevant case sizes.

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

case size	nominal dimensions (mm)
1	Ø 3,3 x 10
2	Ø 4,5 x 10
3	Ø 6 x 10
5a	Ø 8 x 11
4	Ø 6,5 x 18
5	Ø 8 x 18
6	Ø 10 x 18
7	Ø 10 x 25

APPLICATION

These capacitors with high CU-product per unit volume are mainly used for smoothing, coupling and decoupling purposes in consumer applications, such as audio and television circuits. Other applications are in timing and delay circuits. The taped versions are extremely suitable for automatic insertion and for cutting and forming equipment.

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 3 styles, all with soldered-copper leads.

Style 1: axial leads; case insulated with a blue plastic sleeve; supplied on bandoliers in boxes or on reels;
Style 2: single ended; with self-locking lead; case insulated with a blue plastic sleeve;
Style 3: single ended; case insulated with a blue plastic sleeve.

MECHANICAL DATA

Dimensions in mm

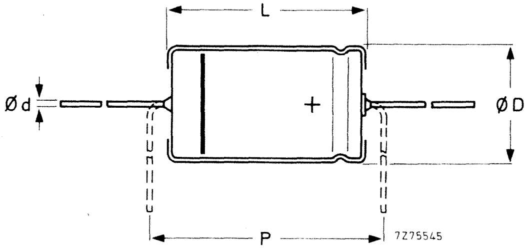


Fig. 1 Style 1; see Table 1a for dimensions d, D, L and P.

Table 1a

case size	d	style 1					mass approx. g
		D_{nom}	L_{nom}	D_{max}	L_{max}	P_{min}	
1	0,6	3,3	10,0	4,5	11,0	15	0,35
2	0,6	4,5	10,0	5,0	10,5	15	0,53
3	0,6	6,0	10,0	6,3	10,5	15	0,7
5a	0,6	8,0	11,0	8,5	11,5	15	1,2
4	0,8	6,5	18,0	6,9	18,5	25	1,5
5	0,8	8,0	18,0	8,5	18,5	25	2
6	0,8	10,0	18,0	10,5	18,5	25	2,7
7	0,8	10,0	25,0	10,5	25,0	30	3,3

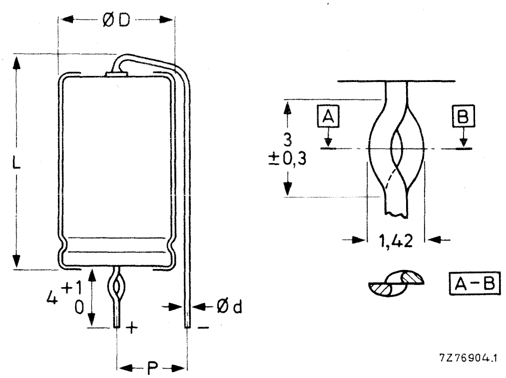


Fig. 2 Style 2; **non-preferred**; see Table 1b for dimensions d, D, L and P.

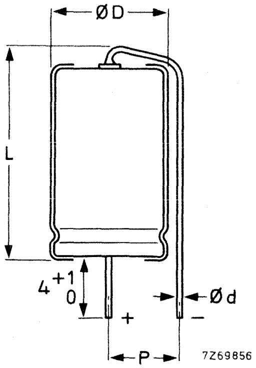


Fig. 3 Style 3; see Table 1b for dimensions d, D, L and P.

Table 1b

case size	d	style 2			style 3			mass approx. g
		D_{max}	L_{max}	P	D_{max}	L_{max}	P	
1	0,6				3,5	13,0	2,5–5	0,35
2	0,6				5,0	12,5	2,5–5	0,53
3	0,6				6,3	12,5	3,5–7,5	0,7
5a	0,6				8,5	13,0	5 –10	1,2
4	0,8	6,9	21,5	5 –10	6,9	21,5	5 –10	1,5
5	0,8	8,5	21,5	5 –10	8,5	21,5	5 –10	2
6	0,8	10,5	21,5	7,5–12,5	10,5	21,5	7,5–12,5	2,7
7	0,8	10,5	28,0	7,5–12,5	10,5	28,0	7,5–12,5	3,3

Marking

The capacitors are marked with:
nominal capacitance;
tolerance on nominal capacitance;
rated voltage;
group number 030 or 031; code of origin;
name of manufacturer;
date code (year and month) according to IEC 62;
band to identify the negative terminal;
+ signs to identify the positive terminal (on case sizes 4 to 7 only).

Mounting

The diameter of the mounting holes in the printed-wiring board is 1 + 0,1 mm, except that of the hole for the anode lead of style 2 capacitors: 1,3 + 0,1 mm.

ELECTRICAL DATA

Table 2 (notes are at end of 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 category temperature mA	max. leakage current at U_R after 5 min. μA	max. ESR Ω	case size	catalogue number * 2222 followed by
6,3	10	12	5	58,9	1	030 .3109
6,3	33	35	11	15,4	2	030 .3339
6,3	68	44	22	7,64	2	030 .3689
6,3	150	85	48	2,67	3	030 .3151
6,3	470	190	109	0,85	5	031 .3471
6,3	680	325	149	0,59	6	031 .3681
6,3	1000	400	209	0,40	7	031 .3102
10	6,8	12	5	70,2	1	030 .4689
10	22	35	11	18,8	2	030 .4229
10	47	44	24	8,85	2	030 .4479
10	100	85	50	3,20	3	030 .4101
10	220	125	86	1,45	5a	030 .4221
10	220	125	86	1,45	4	031 .4221 **
10	330	190	119	0,97	5	031 .4331
10	470	325	161	0,68	6	031 .4471
10	680	400	224	0,47	7	031 .4681
16	4,7	12	5	84,7	1	030 .5478
16	15	35	12	19,1	2	030 .5159
16	33	44	27	9,85	2	030 .5339
16	68	85	53	3,82	3	030 .5689
16	150	125	92	1,73	5a	030 .5151
16	150	125	92	1,73	4	031 .5151 **
16	220	190	126	1,18	5	031 .5221
16	330	325	179	0,79	6	031 .5331
16	470	400	246	0,55	7	031 .5471
25	3,3	11	5	106	1	030 .6338
25	10	30	13	23,9	2	030 .6109
25	22	37	28	12,5	2	030 .6229
25	47	72	56	4,68	3	030 .6479
25	100	105	95	2,20	5a	030 .6101
25	100	105	95	2,20	4	031 .6101 **
25	150	155	133	1,47	5	031 .6151
25	220	270	185	1,00	6	031 .6221
25	330	330	268	0,67	7	031 .6331
40	2,2	11	5	137	1	030 .7228
40	6,8	30	14	28,1	2	030 .7688
40	10	32	20	22,8	2	030 .7109
40	15	37	30	15,2	2	030 .7159
40	22	60	44	8,64	3	030 .7229

U_R V	nom. cap. μF	max. r.m.s. ripple current at upper catagory temperature mA	max. leakage current at U_R after 5 min. μA	max. ESR Ω	case size	catalogue number * 2222 followed by
40	33	72	60	5,76	3	030 .7339
40	47	105	77	4,04	5a	030 .7479
40	47	105	77	4,04	4	031 .7479 **
40	100	155	140	1,90	5	031 .7101
40	150	270	200	1,27	6	031 .7151
40	220	360	284	0,86	7	031 .7221
63	0,33	4	5	491	2	030 .8337
63	0,47	7	5	345	2	030 .8477
63	0,68	9	5	238	2	030 .8687
63	1,0	12	5	162	2	030 .8108
63	1,5	12	5	108	2	030 .8158
63	2,2	21	7	73,6	2	030 .8228
63	3,3	25	11	49,1	2	030 .8338
63	4,7	31	15	34,5	2	030 .8478
63	6,8	35	22	23,8	2	030 .8688
63	10	44	32	13,5	3	030 .8109
63	15	55	48	9,00	3	030 .8159
63	22	80	62	6,14	5a	030 .8229
63	22	80	62	6,14	4	031 .8229 **
63	47	115	109	2,87	5	031 .8479
63	68	195	149	1,99	6	031 .8689
63	100	240	209	1,35	7	031 .8101
100	1,0	12	5	143	2	030 .9108
100	2,2	21	11	60,0	2	030 .9228
100	3,3	25	17	40,0	2	030 .9338
100	4,7	31	24	23,4	3	030 .9478
100	6,8	55	34	16,2	3	030 .9688
100	10	80	50	11,0	5a	030 .9109
100	10	80	50	11,0	4	031 .9109 **
100	22	115	86	5,00	5	031 .9229
100	33	195	119	3,33	6	031 .9339
100	47	240	161	2,34	7	031 .9479

* Replace dot in catalogue number by:
2 for style 1 on bandolier on reel (preferred for case sizes 2 and 3)
3 for style 1 on bandolier in box (preferred to case sizes 5a, 5, 6 and 7)
7 for style 2 (non-preferred)
8 for style 3

** Not yet available.

Capacitance

Nominal capacitance values at 100 Hz and T_{amb} = 20 °C	see Table 2
Tolerance on nominal capacitance at 100 Hz	
case size 1	−10 to + 100%
case sizes 2 to 7	−10 to + 50%

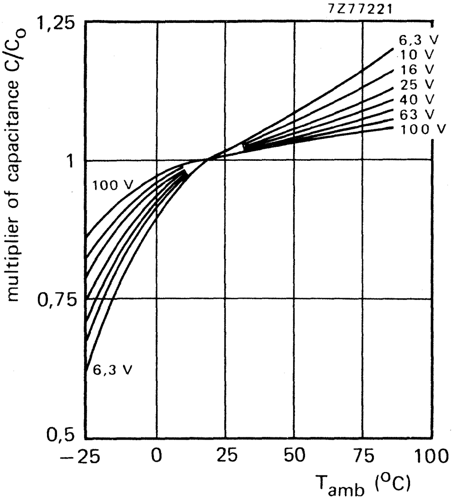


Fig. 4 Typical capacitance as a function of ambient temperature for case sizes 1, 2, 3 and 5a; C_o = capacitance at 20 °C, 100 Hz.

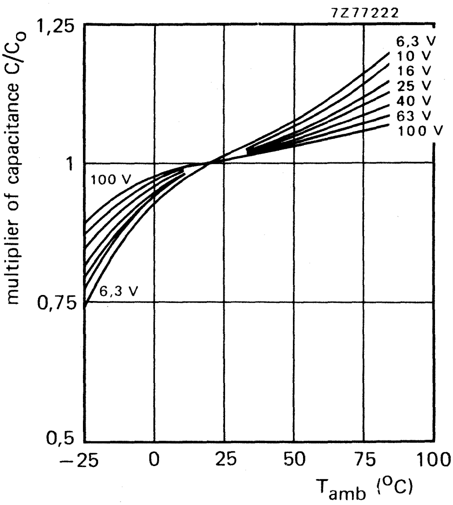


Fig. 5 Typical capacitance as a function of ambient temperature for case sizes 4, 5 and 6; C_o = capacitance at 20 °C, 100 Hz.

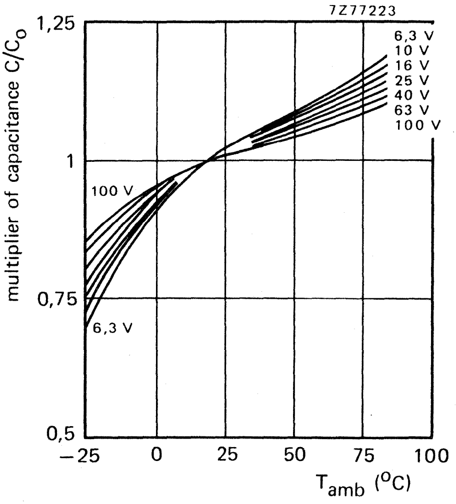


Fig. 6 Typical capacitance as a function of ambient temperature for case size 7; C_o = capacitance at 20 °C, 100 Hz.

Voltage

	< 40 °C	40 to upper category temperature
Rated voltage = max. permissible voltage	1,1 x U_R	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	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} = upper category temperature	see Table 2
at 100 Hz and T_{amb} = 15 °C below upper category temperature	1,7 x values of Table 2
at 100 Hz and T_{amb} = more than 25 °C below upper category temperature	2,2 x values of Table 2

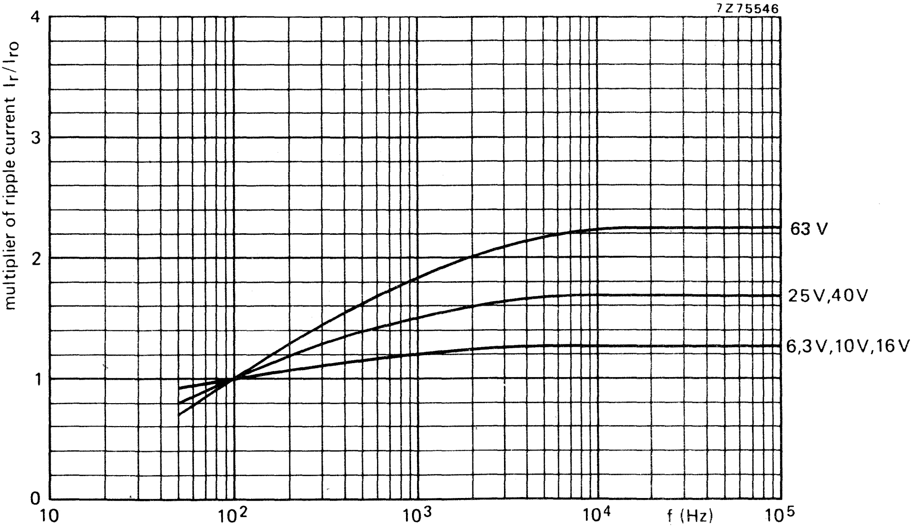


Fig. 7 Typical ripple current as a function of frequency; I_{ro} = ripple current at 100 Hz and upper category temperature.

---

* 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.

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

$$\sum_{n} \frac{I_n^2}{r_n} \leqslant I_{r\,max}^2$$

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

I_n = ripple current at a certain frequency;

$\sqrt{r_n} = I_r/I_{ro}$ = multiplying factor at a same frequency.

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 (0,03 CU + 20 μA for CU > 1000 μC; 0,05 CU or 5 μA, whichever is greater for CU ⩽ 1000 μC)
Leakage current during continuous operation at U_R, at T_{amb} = 20 °C	approx. 0,2 x values of Table 2
at upper category temperature	⩽ values of 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.

Equivalent series resistance (ESR)

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

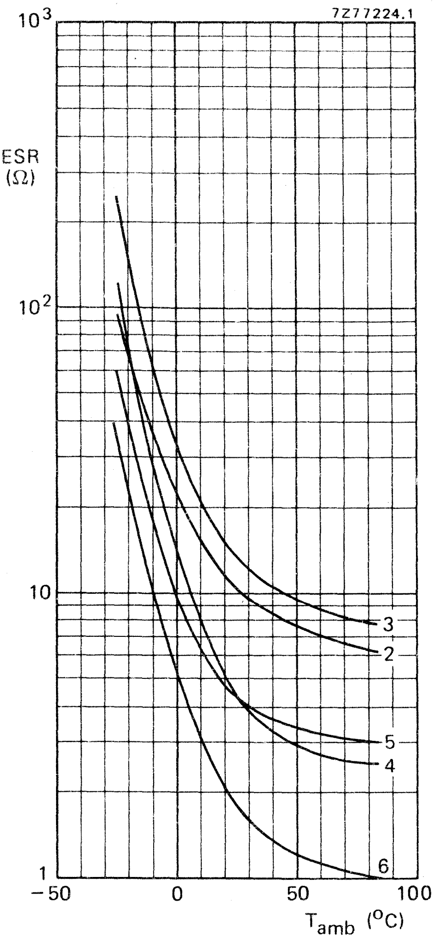


Fig. 8 ESR as a function of ambient temperature at 100 Hz;
curve 2 = case size 1, 6,3 V;
curve 3 = case size 2, 100 V;
curve 4 = case size 2, 6,3 V;
curve 5 = case size 3, 100 V;
curve 6 = case size 3, 6,3 V.

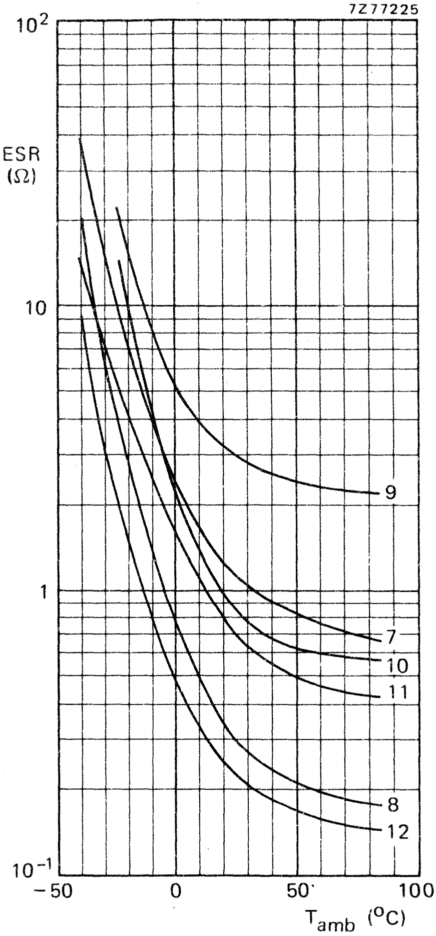


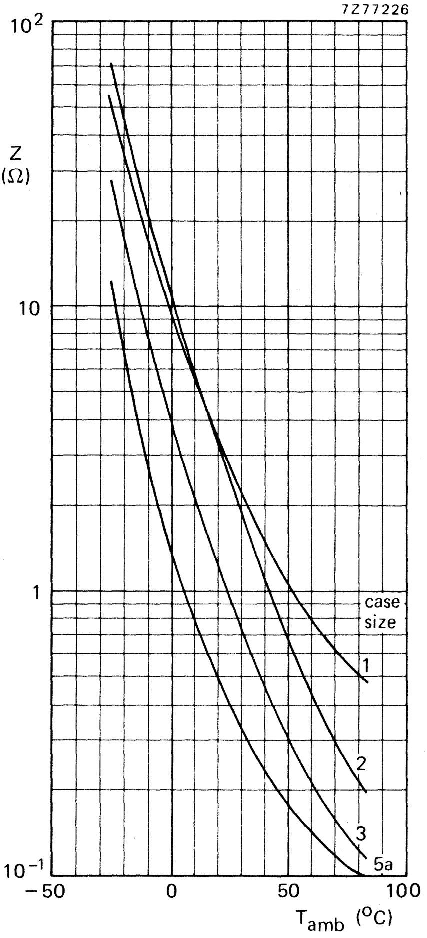
Fig. 9 ESR as a function of ambient temperature at 100 Hz;
curve 7 = case size 5, 100 V;
curve 8 = case size 5, 6,3 V;
curve 9 = case size 5a, 100 V;
curve 10 = case size 5a, 10 V;
curve 11 = case size 6, 100 V;
curve 12 = case size 6, 6,3 V.

Tan δ (dissipation factor)

Tan δ = ESR x ωC

Impedance

The impedance is measured by means of a four-terminal circuit (Thomson circuit).



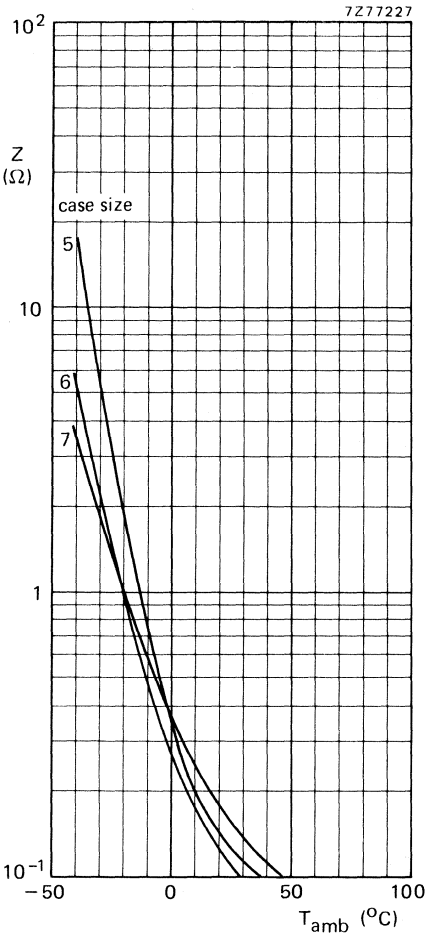


Fig. 10 Impedance as a function of temperature at 100 kHz.

Fig. 11 Impedance as a function of temperature at 100 kHz.

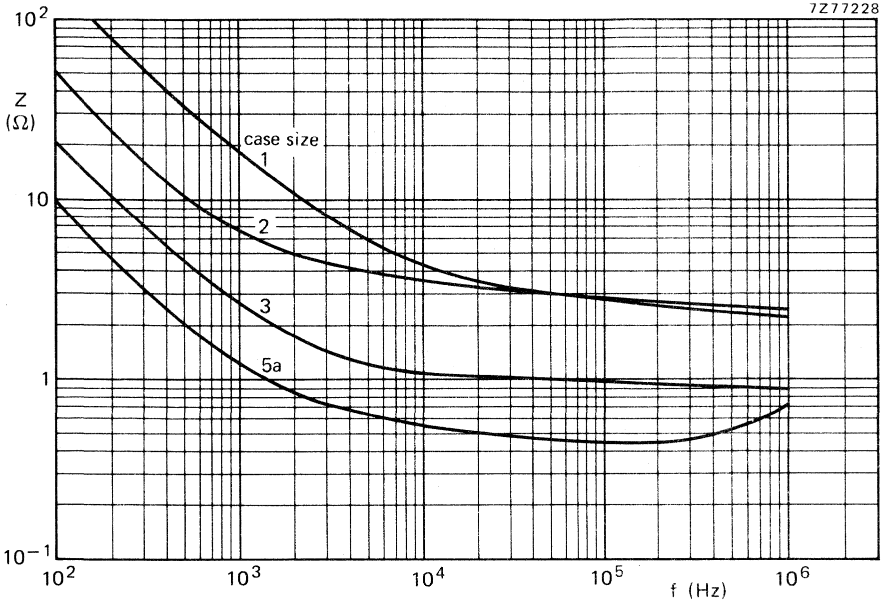


Fig. 12 Impedance as a function of frequency at 20 °C at 16 V.

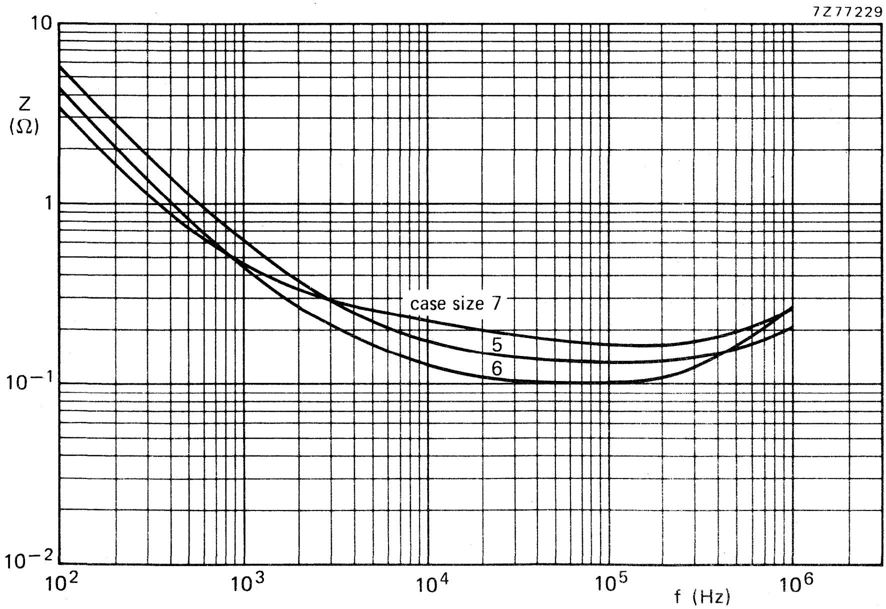


Fig. 13 Impedance as a function of frequency at 20 °C at 16 V.

OPERATIONAL DATA

Category temperature range

case size 1	−25 to + 70 °C
case sizes 2 to 7	−25 to + 85 °C

PACKING

Capacitors of styles 2 and 3 are supplied in boxes of 1000.
Capacitors of style 1 are supplied on bandoliers in boxes of 500 or on reels (case size 7 only on bandoliers in boxes). The reels contain 4000 pieces of case size 1, 3000 pieces of case size 2, 1000 pieces of case sizes 3 and 4, and 500 pieces of case sizes 5, 5a and 6.

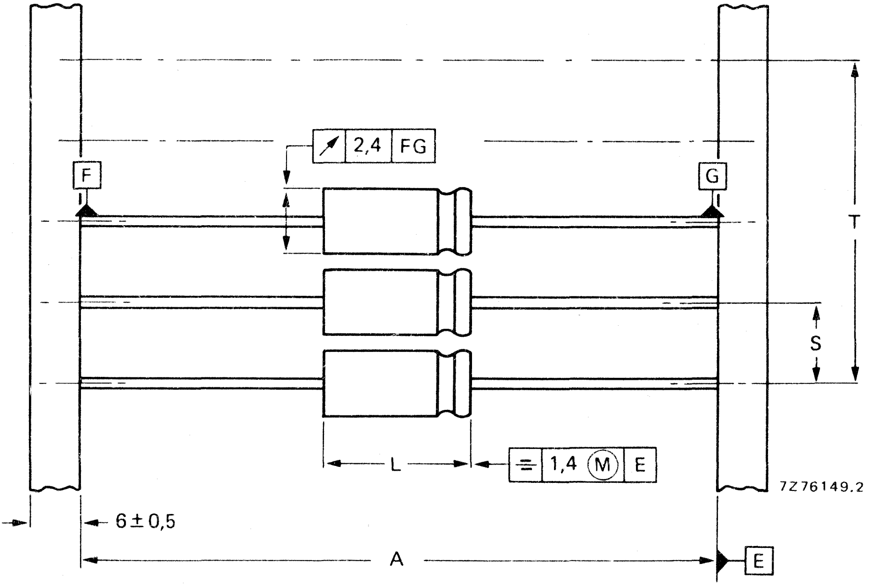


Fig. 14 Style 1 capacitors on bandoliers: the bandolier to which the negative capacitor terminals are connected is blue. See Table 3 for dimensions A, S, T and L (for the time being the positive terminal tape is red, the negative white).

Table 3

Dimensions in mm

case size	A	S	T for number (n) of capacitors		L_{max}
			n < 50	50 < n < 100	
1	63,5 ± 1,6	5 ± 0,4	5 (n-1) ± 2	5 (n-1) ± 4	11,0
2	63,5 ± 1,6	5 ± 0,4	5 (n-1) ± 2	5 (n-1) ± 4	10,5
3	63,5 ± 1,6	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	10,5
5a	63,5 ± 1,6	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	11,5
4	73 ± 1,6	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	18,5
5	73 ± 1,6	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	18,5
6	73 ± 1,6	15 ± 0,75	15 (n-1) ± 2	15 (n-1) ± 4	18,5
7	73 ± 1,6	15 ± 0,75	15 (n-1) ± 2	15 (n-1) ± 4	25,0

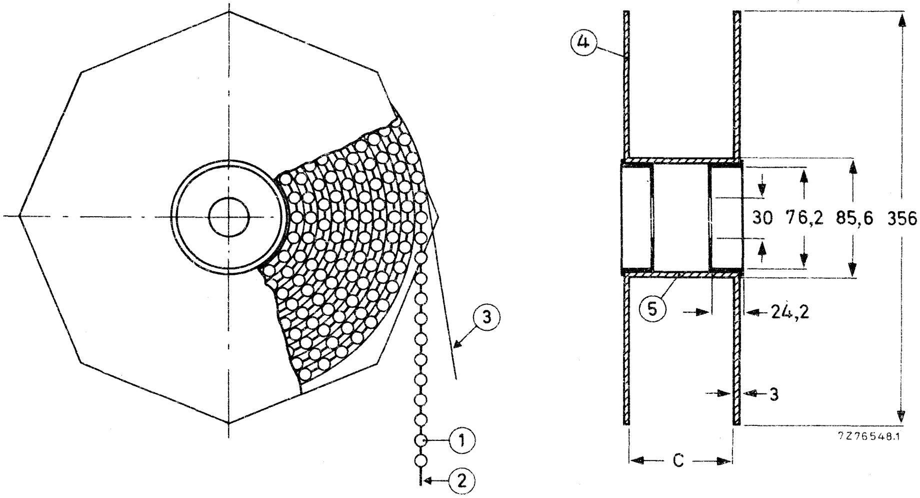


Fig. 15 Style 1 capacitors on bandoliers on reel; dimension C is 84,5 mm for case sizes 1, 2, 3 and 5a, and 88,0 mm for case sizes 4, 5 and 6; the overall width of the reel is 94,5 mm and 99,5 mm respectively.

1 = capacitor
2 = bandolier
3 = paper
4 = flange
5 = cylinder

TESTS AND REQUIREMENTS

See Introduction, section 9, under aluminium electrolytic capacitors.

Note: Capacitors 2222 030 and 2222 031 belong to the miniature types, general-purpose grade.

ALUMINIUM ELECTROLYTIC CAPACITORS

- **Small type**
- **Axial leads or single ended**
- **Long life**
- **General and industrial applications**

QUICK REFERENCE DATA

Nominal capacitance range (E6 series)	150 to 4700 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
Endurance test at 85 °C	2000 h
Basis specifications	IEC384-4, long-life grade DIN 41316
Climatic category	
IEC 68	40/085/56
DIN 40040	GPF

Selection chart for C_{nom}-U_R and relevant case sizes.

C_{nom} μF	U_R (V)					
	6,3	10	16	25	40	63
150						00
220					00	01
330					01	02
470				00	01	02
680			00	01	02	03
1000		00	01	02	03	
1500	00	01	02	03		
2200	01	02	03			
3300	02	03				
4700	03					

case size	nominal dimensions (mm)
00	Ø 10 x 30
01	Ø 12,5 x 30
02	Ø 15 x 30
03	Ø 18 x 30

APPLICATION

These capacitors with high CU-product per unit volume are mainly used for smoothing, coupling and decoupling purposes in consumer applications, such as audio and television circuits, and in other applications such as measuring, regulating, timing and delay circuits.

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 4 styles, all with soldered-copper leads.

Style 1: axial leads; case insulated with a blue plastic sleeve.

Style 2: single ended; with self-locking lead; case insulated with a blue plastic sleeve.

Style 3: single ended; case insulated with a blue plastic sleeve.

Style 4: single ended; case fitted in a yellow plastic foot.

MECHANICAL DATA

Dimensions in mm

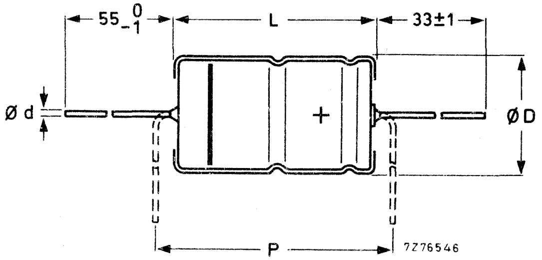


Fig. 1 Style 1; see Table 1 for dimensions d, D, L and P.

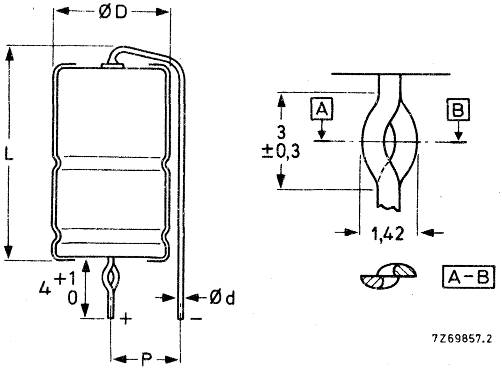


Fig. 2 Style 2; see Table 1 for dimensions d, D, L and P.

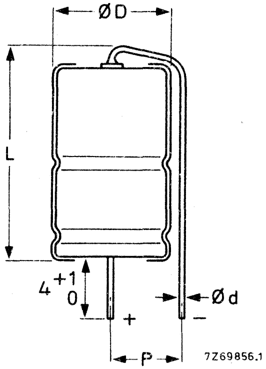


Fig. 3 Style 3; **non-preferred;** see Table 1 for dimensions d, D, L and P.

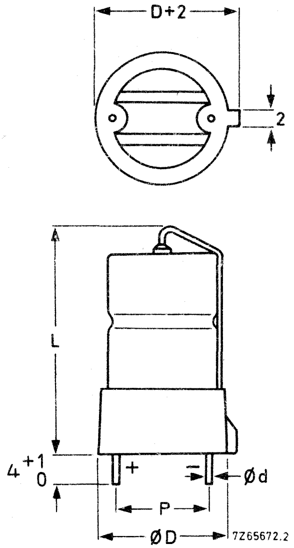


Fig. 4 Style 4; especially for use in applications with severe shocks and vibrations; see Table 1 for dimensions d, D, L and P.

Table 1

case size	d	style 1					styles 2 and 3			style 4			mass approx. g
		D_{nom}	L_{nom}	D_{max}	L_{max}	P_{min}	D_{max}	L_{max}	P	D_{max}	L_{max}	P ± 0,5	
00	0,8	10	30	10,5	30,5	35	10,5	34	7,5-12,5	12,8	39,5	10	4,0
01	0,8	12,5	30	13,0	30,5	35	13,0	34	7,5-12,5	15,2	39,5	10	6,3
02	0,8	15	30	15,5	30,5	35	15,5	34	10 -15	17,8	39,5	12,5	8,2
03	0,8	18	30	18,5	30,5	35	18,5	34	10 -15	20,8	39,5	15	10,9

Marking

The capacitors are marked with:

nominal capacitance;
tolerance on nominal capacitance;
rated voltage;
group number 032; code of origin;
name of manufacturer;
date code (year and month) according to IEC 62;
band to identify the negative terminal.

Mounting

The diameter of the mounting holes in the printed-wiring board is 1 + 0,1 mm, except that of the hole for the anode lead of style 2 capacitors: 1,3 + 0,1 mm.

ELECTRICAL DATA

Table 2

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

U_R V	nom. cap. µF	max. r.m.s. ripple current at T_{amb} = 85 ^{o}C mA	max. leakage current at U_R after 5 min µA	max. ESR Ω	case size	catalogue number 2222 032 followed by *
6,3	1500	450	61	0,299	00	. 3152
6,3	2200	610	88	0,214	01	. 3222
6,3	3300	790	129	0,153	02	. 3332
6,3	4700	1000	182	0,117	03	. 3472
10	1000	430	64	0,320	00	. 4102
10	1500	570	94	0,245	01	. 4152
10	2200	740	136	0,177	02	. 4222
10	3300	950	202	0,128	03	. 4332
16	680	400	70	0,382	00	. 5681
16	1000	550	100	0,260	01	. 5102
16	1500	680	148	0,205	02	. 5152
16	2200	880	216	0,150	03	. 5222
25	470	360	75	0,468	00	. 6471
25	680	500	106	0,323	01	. 6681
25	1000	660	154	0,220	02	. 6102
25	1500	810	229	0,179	03	. 6152
40	220	260	57	0,864	00	. 7221
40	330	370	84	0,576	01	. 7331
40	470	440	117	0,404	01	. 7471
40	680	580	167	0,279	02	. 7681
40	1000	780	244	0,190	03	. 7102
63	150	260	61	0,900	00	. 8151
63	220	350	88	0,614	01	. 8221
63	330	480	129	0,409	02	. 8331
63	470	570	182	0,287	02	. 8471
63	680	770	261	0,199	03	. 8681

* Replace dot in catalogue number by 1 for style 1; 5 for style 4; 7 for style 2; 8 for style 3.

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%

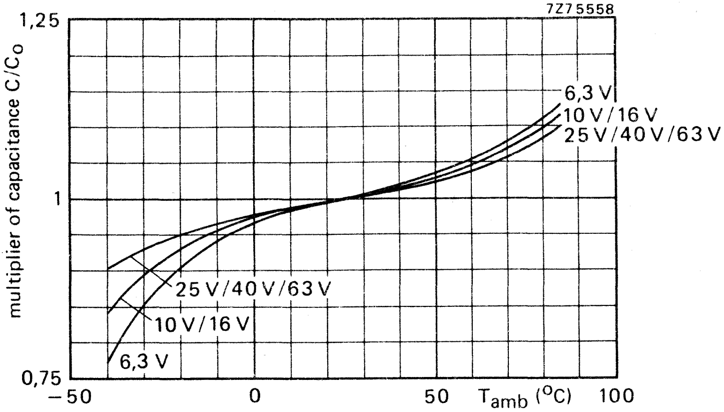


Fig. 5 Typical capacitance as a function of ambient temperature; C_0 = capacitance at 25 °C, 100 Hz.

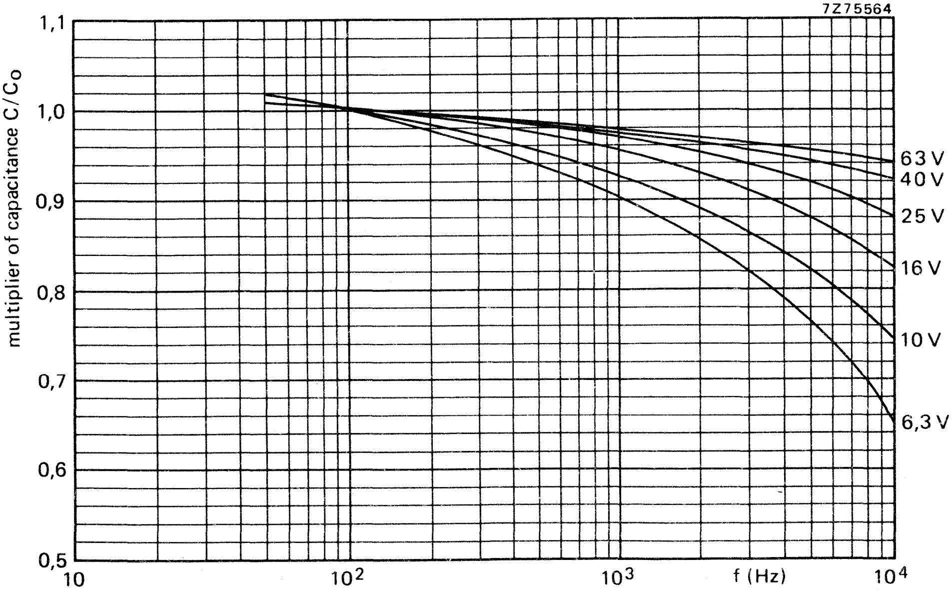


Fig. 6 Typical capacitance as a function of frequency; C_0 = capacitance at 25 °C, 100 Hz.

Voltage

	< 40 °C	40 to 85 °C
Rated voltage = max. permissible voltage	1,1 x U_R	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	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} = 85 °C	see Table 2

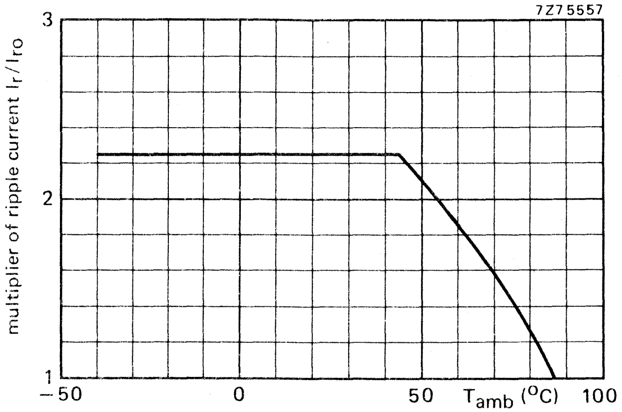


Fig. 7 Typical ripple current as a function of ambient temperature; I_{ro} = ripple current at 25 °C, 100 Hz.

---

* 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.

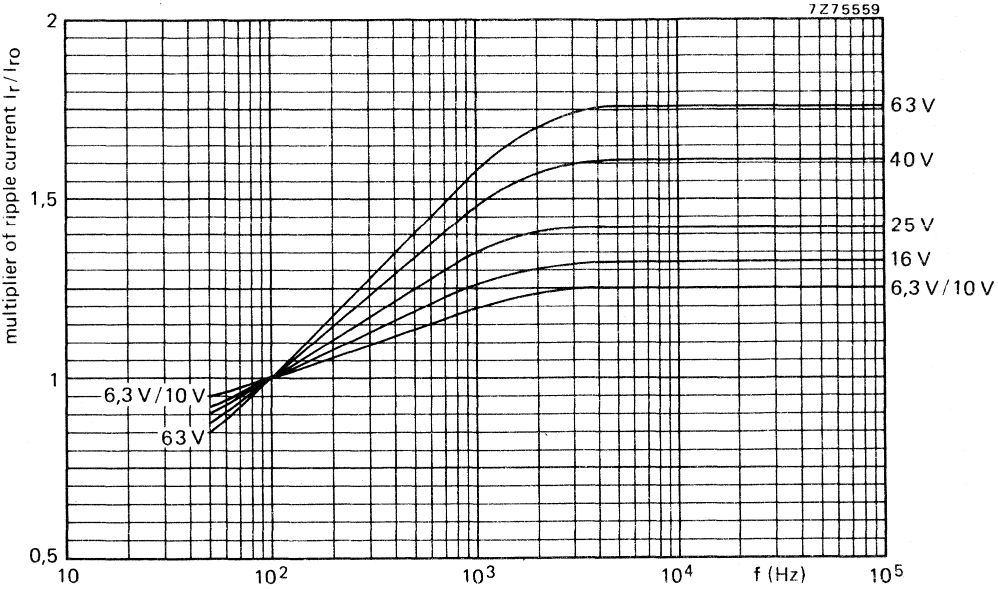


Fig. 8 Typical ripple current as a function of frequency; I_{ro} = ripple current at 25 °C, 100 Hz.

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

$$\sum_n \frac{I_n{}^2}{r_n} \leqslant I_{r\,max}{}^2$$

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

I_n = ripple current at a certain frequency;

$r_n = I_r/I_{ro}$ = multiplying factor at a same frequency.

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} = 25 °C	see Table 2 (0,006 CU + 4 μA)
Leakage current during continuous operation at U_R, at T_{amb} = 25 °C	approx. 0,01 of value stated in Table 2
at T_{amb} = 85 °C	⩽ 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.

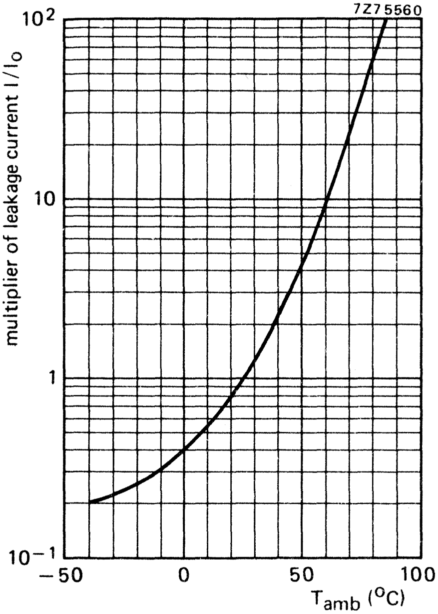


Fig. 9 Typical leakage current as a function of ambient temperature; I_o = leakage current during continuous operation at 25 °C and U_R.

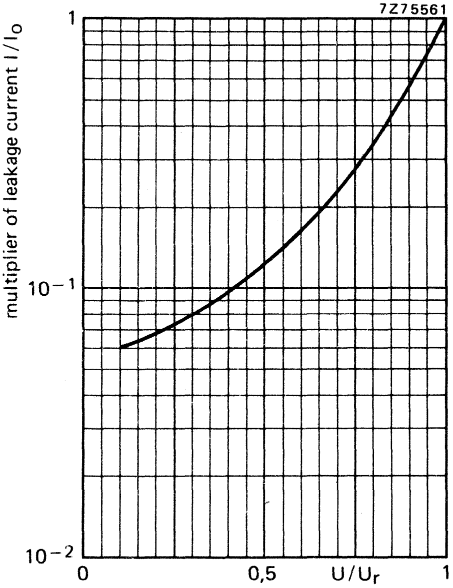


Fig. 10 Typical leakage current as a function of U/U_R; I_o = leakage current during continuous operation at 25 °C and U_R.

Equivalent series resistance (ESR)

ESR at 100 Hz and T_{amb} = 25 °C, measured by means of a four-terminal circuit (Thomson Circuit)

see Table 2

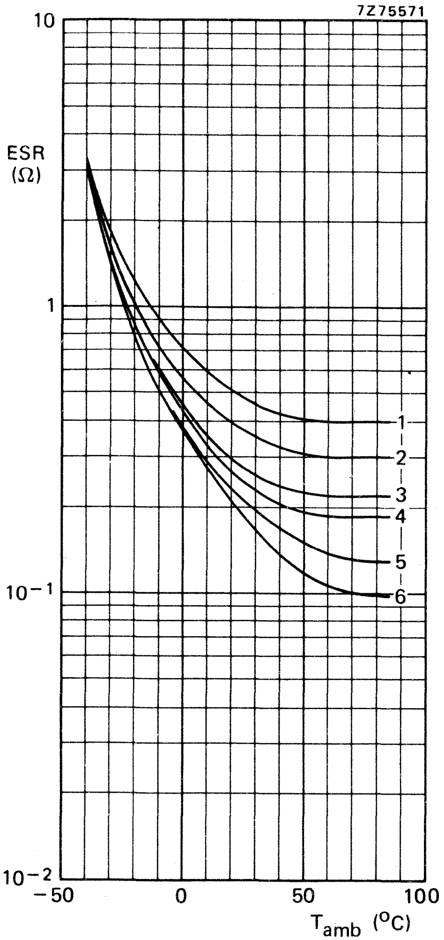


Fig. 11 Typical ESR as a function of ambient temperature at 100 Hz
Case size 00:
curve 1 = 150 μF, 63 V;
curve 2 = 220 μF, 40 V;
curve 3 = 470 μF, 25 V;
curve 4 = 680 μF, 16 V;
cueve 5 = 1000 μF, 10 V;
curve 6 = 1500 μF, 6,3 V.

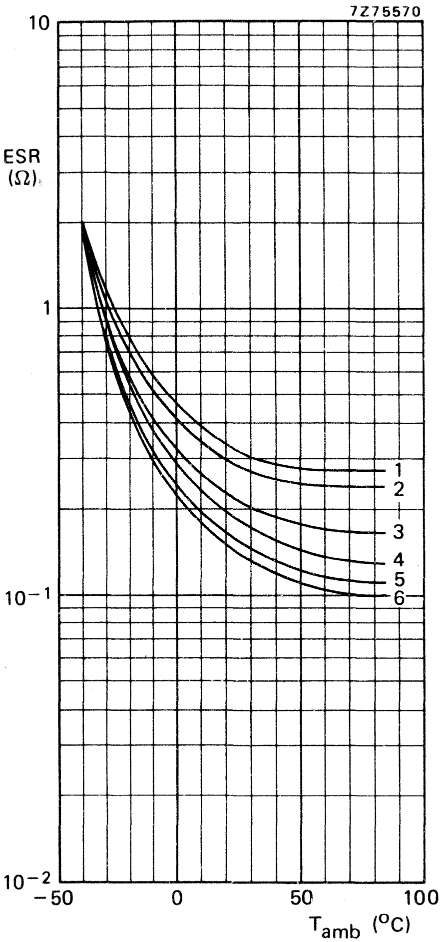


Fig. 12 Typical ESR as a function of ambient temperature at 100 Hz
Case size 01:
curve 1 = 220 μF, 63 V;
curve 2 = 330 μF, 40 V;
curve 3 = 470 μF, 40 V;
curve 4 = 680 μF, 25 V;
curve 5 = 1000 μF, 16 V;
curve 6 = 1500 μF, 10 V and 2200 μF, 6,3 V.

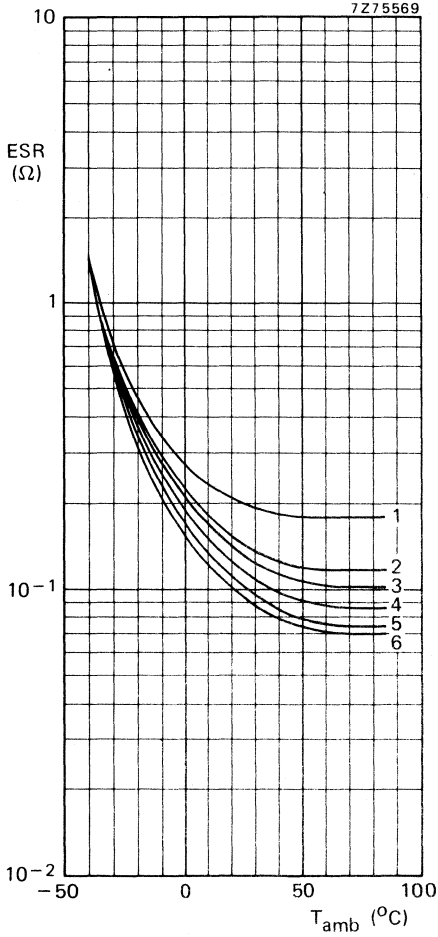


Fig. 13 Typical ESR as a function of ambient temperature at 100 Hz.
Case size 02:
curve 1 = 330 μF, 63 V;
curve 2 = 470 μF; 63 V;
curve 3 = 680 μF; 40 V;
curve 4 = 1000 μF, 25 V;
curve 5 = 1500 μF, 16 V;
curve 6 = 2200 μF, 10 V and 3300 μF, 6,3 V.

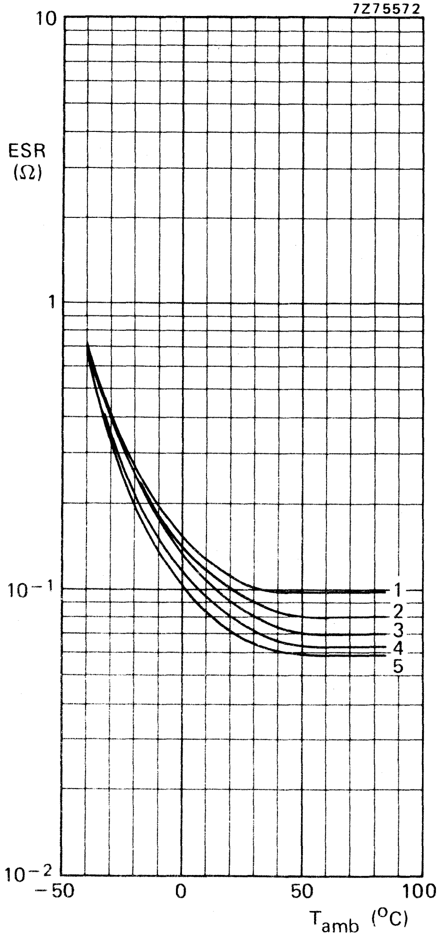


Fig. 14 Typical ESR as a function of ambient temperature at 100 Hz.
Case size 03:
curve 1 = 680 μF, 63 V;
curve 2 = 1000 μF, 40 V;
curve 3 = 1500 μF, 25 V;
curve 4 = 2200 μF, 16 V;
curve 5 = 3300 μF, 10 V and 4700 μF, 6,3 V.

Fig. 15 (opposite) Typical ESR as a function of frequency at 25 °C. **Case size 00:**
curve 1 = 150 μF, 63 V;
curve 2 = 220 μF, 40 V;
curve 3 = 470 μF; 25 V;
curve 4 = 680 μF, 16 V;
curve 5 = 1000 μF, 10 V;
curve 6 = 1500 μF, 6,3 V.

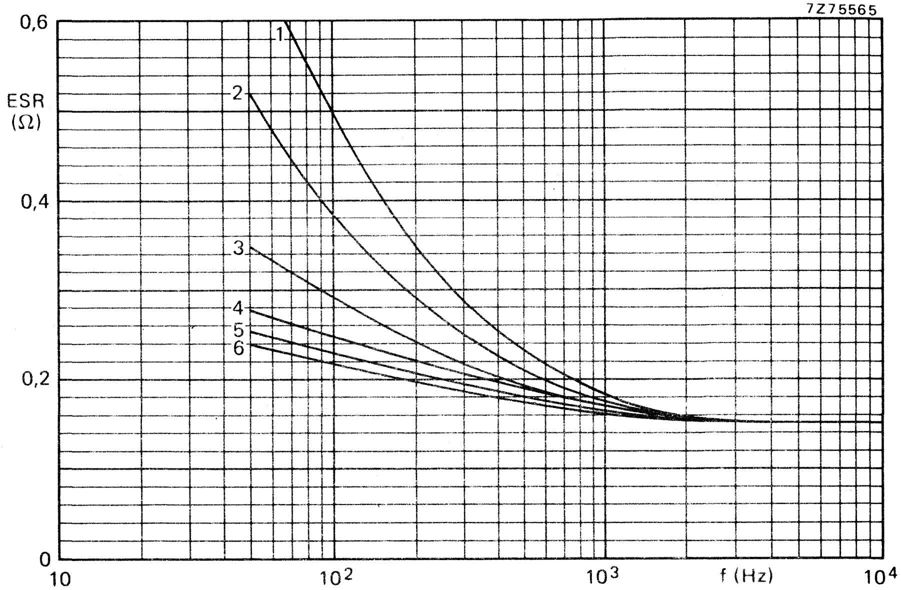


Fig. 15.

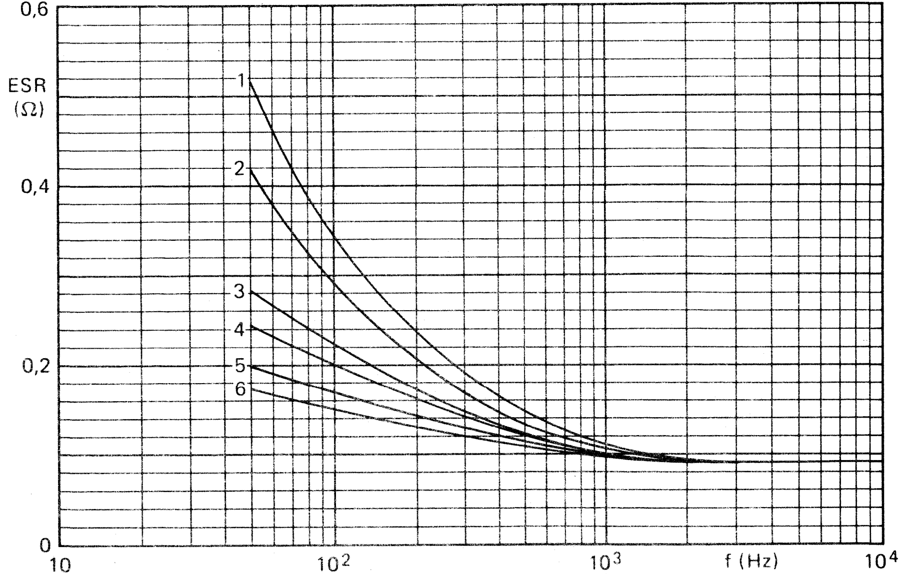


Fig. 16 Typical ESR as a function of frequency at 25 °C. **Case size 01:**

curve 1 = 220 μF, 63 V;
curve 2 = 330 μF, 40 V;
curve 3 = 470 μF, 40 V;
curve 4 = 680 μF, 25 V;
curve 5 = 1000 μF, 16 V;
curve 6 = 1500 μF, 10 V;
and 2200 μF, 6,3 V.

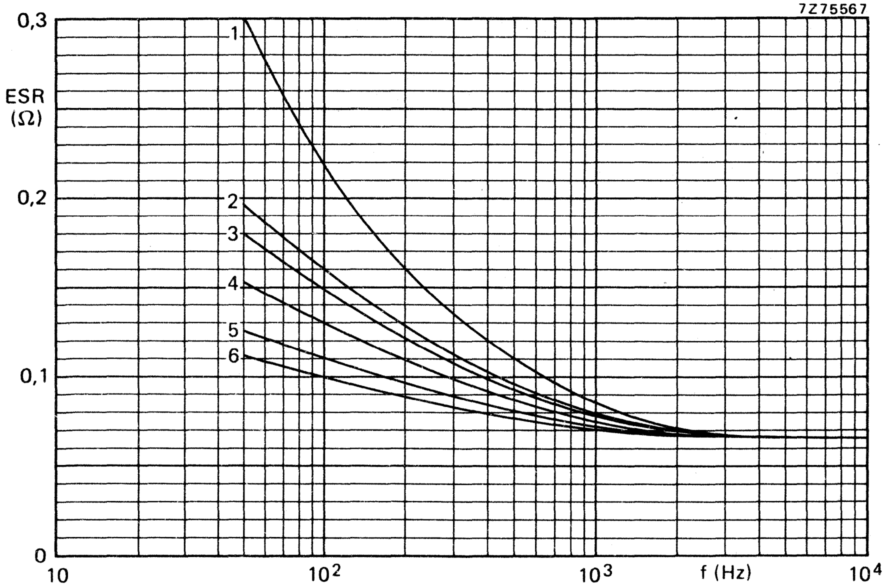


Fig. 17 Typical ESR as a function of frequency at 25 °C. **Case size 02:**

curve 1 = 330 μF, 63 V;
curve 2 = 470 μF, 63 V;
curve 3 = 680 μF, 40 V;
curve 4 = 1000 μF, 25 V;
curve 5 = 1500 μF, 16 V;
curve 6 = 2200 μF, 10 V;
and 3300 μF, 6,3 V;

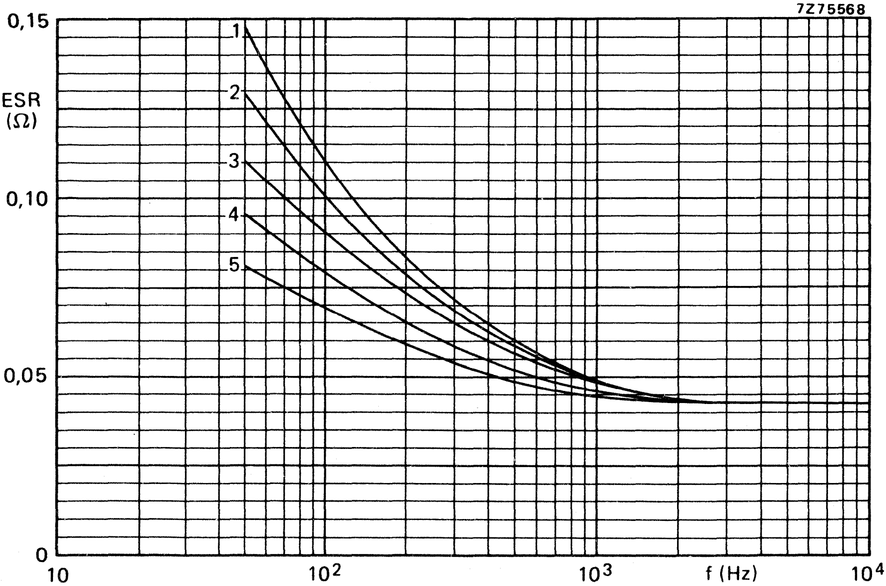


Fig. 18.

Fig. 18 (opposite) Typical ESR as a function of frequency at 25 °C. **Case size 03:**

curve 1 = 680 μF, 63 V; curve 2 = 1000 μF, 40 V; curve 3 = 1500 μF, 25 V; curve 4 = 2200 μF, 16 V; curve 5 = 3300 μF, 10 V; and 4700 μF, 6,3 V.

Tan δ (dissipation factor)

Tan δ = ESR x ωC

Impedance

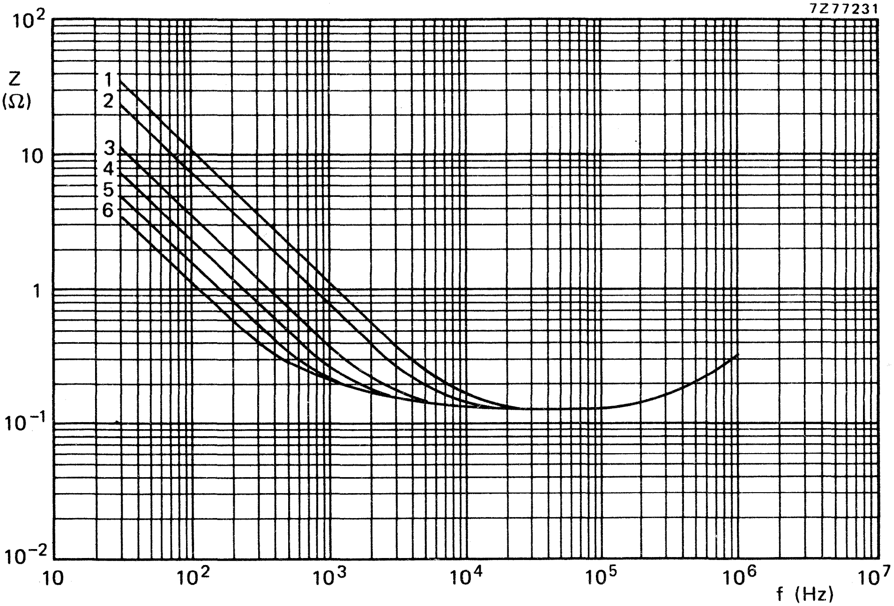


Fig. 19 Typical impedance as a function of frequency at 25 °C. **Case size 00:**

curve 1 = 150 μF, 63 V; curve 2 = 220 μF, 40 V; curve 3 = 470 μF, 25 V; curve 4 = 680 μF, 16 V; curve 5 = 1000 μF, 10 V; curve 6 = 1500 μF, 6,3 V.

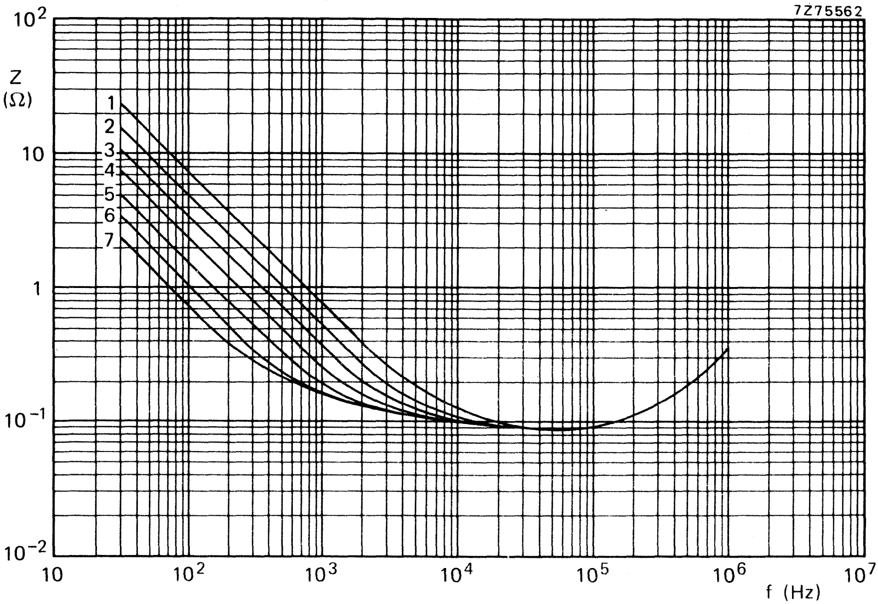

7Z75562
Z
(Ω)
10^2
10
1
10^{-1}
10^{-2}
1
2
3
4
5
6
7
10
10^2
10^3
10^4
10^5
10^6
10^7
f (Hz)

Fig. 20.

Fig. 21.

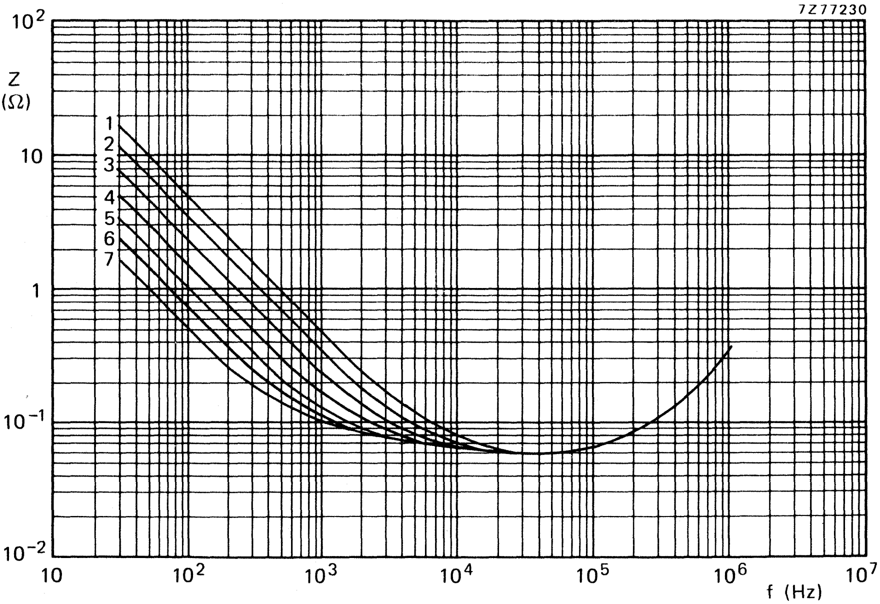

7Z77230
Z
(Ω)
10^2
10
1
10^{-1}
10^{-2}
1
2
3
4
5
6
7
10
10^2
10^3
10^4
10^5
10^6
10^7
f (Hz)

Fig. 20 (opposite) Typical impedance as a function of frequency at 25 °C. **Case size 01:**

curve 1 = 220 μF, 63 V; curve 2 = 330 μF, 40 V; curve 3 = 470 μF, 40 V; curve 4 = 680 μF, 25 V; curve 5 = 1000 μF, 16 V; curve 6 = 1500 μF, 10 V; curve 7 = 2200 μF, 6,3 V.

Fig. 21 (opposite) Typical impedance as a function of frequency at 25 °C. **Case size 02:**

curve 1 = 330 μF, 63 V; curve 2 = 470 μF, 63 V; curve 3 = 680 μF, 40 V; curve 4 = 1000 μF; 25 V; curve 5 = 1500 μF, 16 V; curve 7 = 2200 μF, 10 V; curve 7 = 3300 μF, 6,3 V.

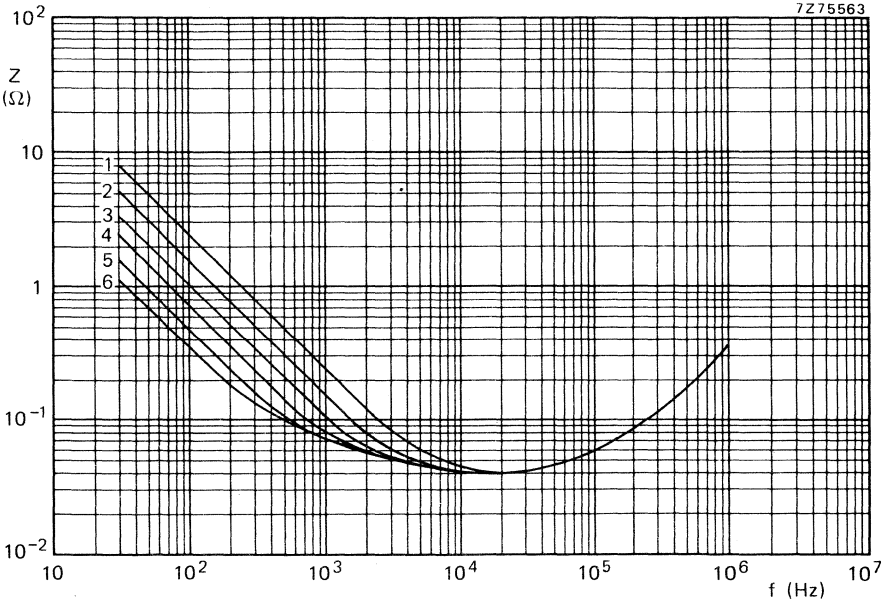


Fig. 22 Typical impedance as a function of frequency at 25 °C. **Case size 03:**

curve 1 = 680 μF, 63 V; curve 2 = 1000 μF, 40 V; curve 3 = 1500 μF, 25 V; curve 4 = 2200 μF, 16 V; curve 5 = 3300 μF, 10 V; curve 6 = 4700 μF, 6,3 V.

OPERATIONAL DATA

Category temperature range	–40 to + 85 °C

PACKING

The capacitors are packed in boxes containing 200 pieces.

TESTS AND REQUIREMENTS

See Introduction, section 9, under aluminium electrolytic capacitors.

Note: Capacitors 2222 032 belong to the small types, long-life grade.

ALUMINIUM ELECTROLYTIC CAPACITORS

- **Small type**
- **Bipolar**
- **Long life**
- **General applications**

QUICK REFERENCE DATA

Nominal capacitance range (E6 series)	3,3 to 47 μF
Tolerance on nominal capacitance	−20 to +20%
Rated voltage U_R (a.c.), frequency >15 Hz	63 V peak (40 V r.m.s.), provided ripple current remains within specified limits ←
Rated voltage U_R (d.c.)	63 V (in both directions) ←
Category temperature range	−40 to +85 °C
Endurance test at 85 °C	2000 h
Basic specification	IEC 384-4, long-life grade ←
Climatic category, IEC 68	40/085/56

Selection chart for C-U_R and relevant case sizes.

U_R V	C_{nom} μF	case size	nom. dimensions mm
63	3,3	00	ϕ 10 x 30
	4,7	00	ϕ 10 x 30
	6,8	00	ϕ 10 x 30
	10	01	ϕ 12,5 x 30
	15	01	ϕ 12,5 x 30
	22	02	ϕ 15 x 30
	33	02	ϕ 15 x 30
	47	03	ϕ 18 x 30

APPLICATION

These capacitors are especially designed for those applications where a low impedance, small dissipation and an excellent temperature constancy over the audio frequency range is required such as crossover filters in loudspeaker boxes and intercom systems.

DESCRIPTION

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

The capacitor is available in 3 styles, all with soldered-copper leads.

Style 1: axial leads; case insulated with a blue plastic sleeve.

Style 2: single ended, with self-locking lead; case insulated with a blue plastic sleeve.

Style 3: single ended; case insulated with a blue plastic sleeve.

MECHANICAL DATA

Dimensions in mm

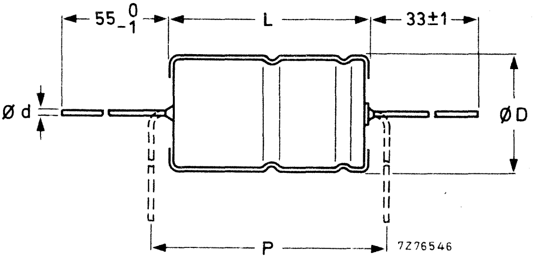


Fig.1 Style 1; see Table 1 for dimensions d, D, L and P.

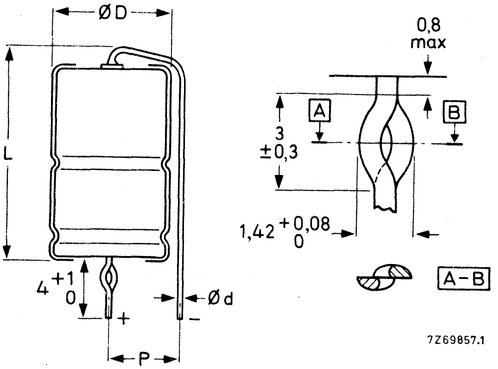


Fig.2 Style 2; see Table 1 for dimensions d, D, L and P.

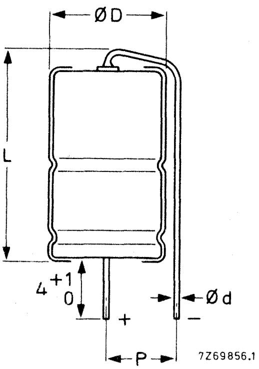


Fig.3 Style 3; see Table 1 for dimensions d, D, L and P.

Table 1

case size	d	style 1					styles 2 and 3			mass approx. g
		D_{nom}	l_{nom}	D_{max}	L_{max}	P_{min}	D_{max}	L_{max}	P	
00	0,8	10	30	10,5	30,5	35	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	6,3
02	0,8	15	30	15,5	30,5	35	15,5	34	10 -15	8,2
03	0,8	18	30	18,5	30,5	35	18,5	34	10 -15	10,9

Marking

The capacitors are marked with:
nominal capacitance;
tolerance on nominal capacitance;
rated voltage
group number 039;
name of manufacturer;
date code (year and month) according to IEC62;
bipolar.

Mounting

The diameter of the mounting holes in the printed-wiring board is 1 + 0,1 mm, except that of the hole for the anode lead of style 2 capacitors: 1,3 + 0,1 mm.

PACKING

The capacitors are packed in boxes containing 200 pieces.

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 930 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*	max leakage current at U_R after 5 min μA*	typ ESR Ω*	max ESR Ω*	case size	catalogue number**
63	3,3	35	10	38	85	00	2222 039 .8338
	4,7	42	15	26	59	00	.8478
	6,8	51	21	18	41	00	.8688
	10	70	31	12	28	01	.8109
	15	84	47	8,5	19	01	.8159
	22	121	61	5	11	02	.8229
	33	147	82	3,1	7	02	.8339
	47	213	109	1,9	4,3	03	.8479

Capacitance

The nominal capacitance values at 100 Hz are given in Table 2. The tolerance on nominal capacitance at 100 Hz is −20 to +20%.

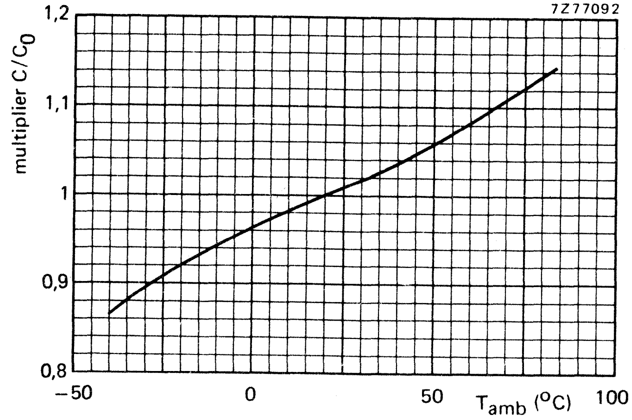


Fig.4 Typical capacitance as a function of ambient temperature; C_0 = capacitance at 20 °C and 100 Hz.

---

* See also corresponding paragraph.

** Replace dot in catalogue number by 1 for style 1, 7 for style 2, 8 for style 3.

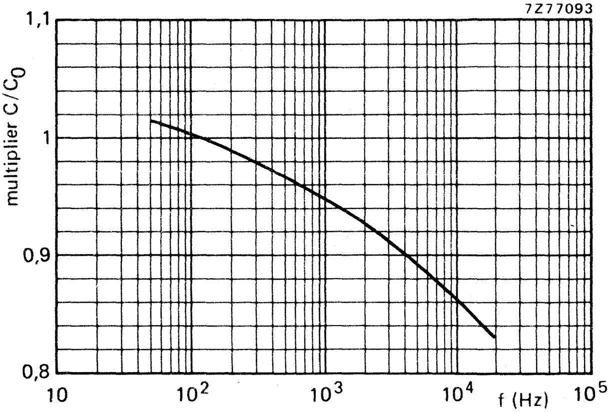


Fig.5 Typical capacitance as a function of frequency; C_0 = capacitance at 20 °C and 100 Hz.

Voltage

The rated voltage U_R (a.c.) in the temperature range --40 to +85 °C is 63 V peak (40 V r.m.s.), provided the ripple current remains below the specified values in Table 2.

The rated voltage U_R (d.c.) in the temperature range --40 to +85 °C is 63 V, independent of polarity.

Ripple current

The maximum permissible r.m.s. ripple current at 100 Hz and T_{amb} = 85 °C is given in Table 2.

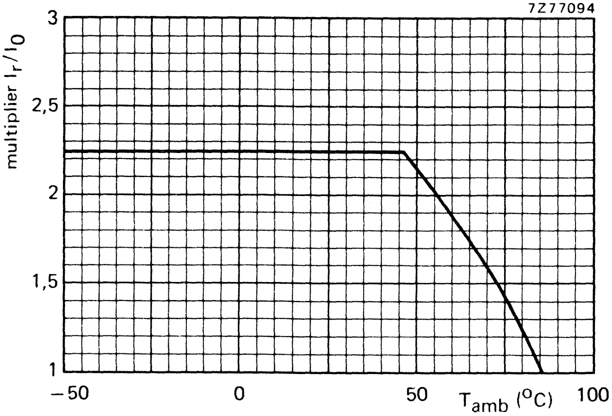


Fig.6 Typical ripple current as a function of ambient temperature; I_0 = ripple current at 85 °C and 100 Hz.

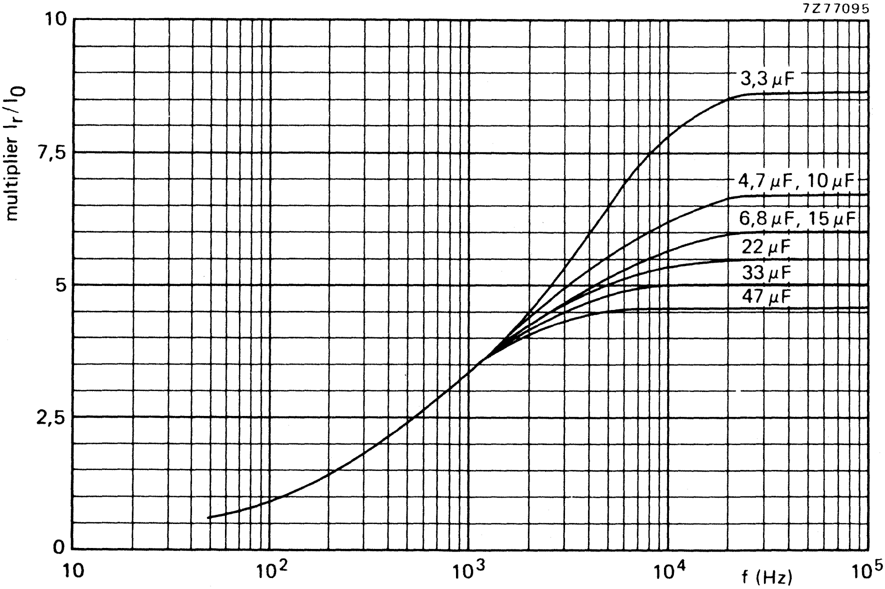


Fig.7 Typical ripple current as a function of frequency; I_0 = ripple current at 85 °C and 100 Hz.

Leakage current

The maximum leakage current in both directions 5 min after application of the rated voltage at T_{amb} = 20 to 25 °C is given in Table 2.

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

Equivalent series resistance (ESR)

The ESR at 100 Hz and T_{amb} = 25 °C, measured by means of a four-terminal circuit (Thomson circuit) is given in Table 2.

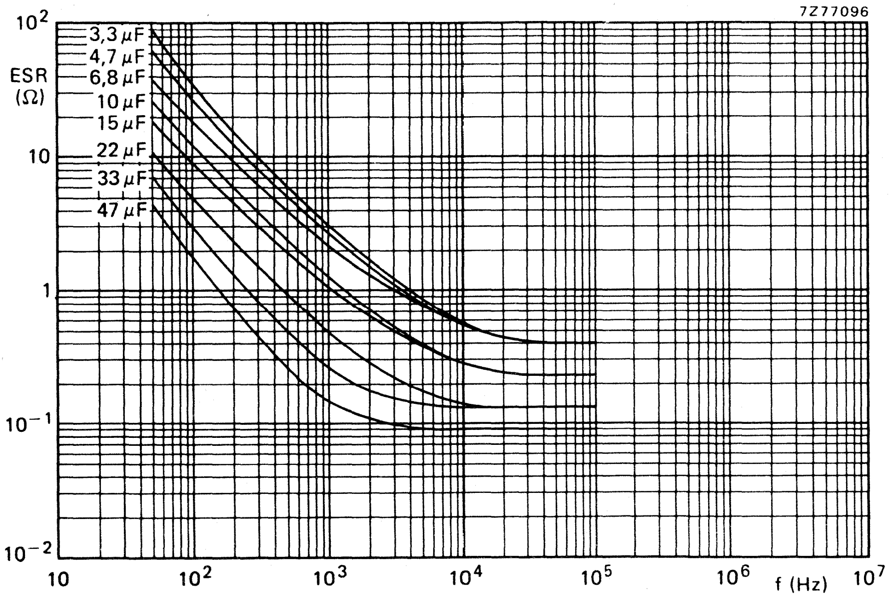


Fig.8 Typical ESR as a function of frequency at 25 °C.

Impedance

Impedance at T_{amb} = 25 °C measured by means of a four-terminal circuit (Thomson circuit), see graphs on the next page.

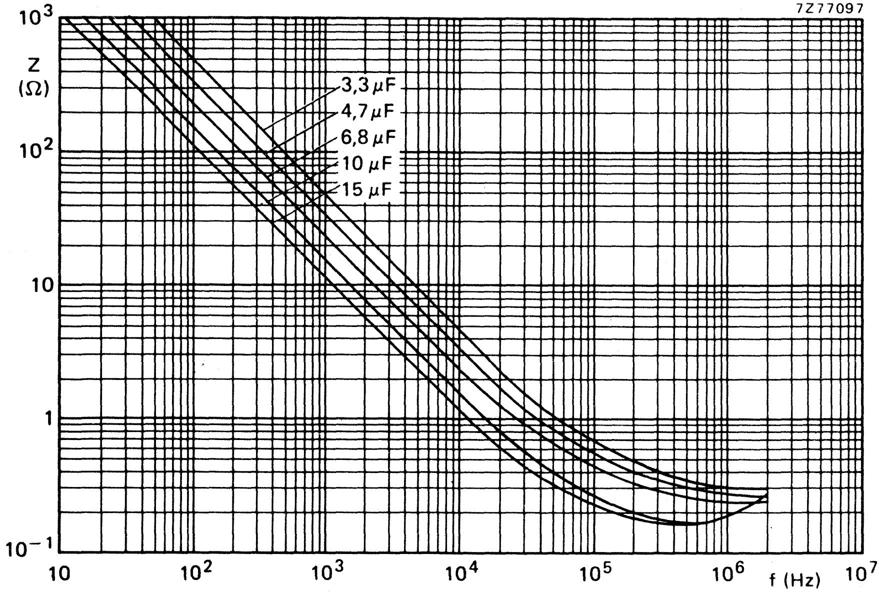


Fig.9 Typical impedance as a function of frequency at 25 °C.

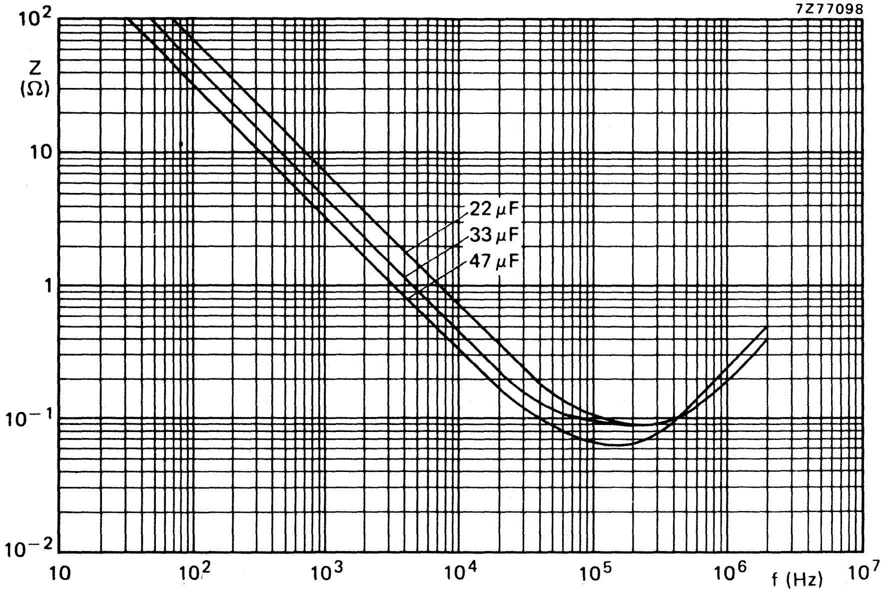


Fig.10 Typical impedance as a function of frequency at 25 °C.

TESTS AND REQUIREMENTS

See Introduction, section 9, under aluminium electrolytic capacitors, with the exception of IEC 384-4 sub clause 9.14, and the figures of tan δ, for which the following is valid.

IEC 384-4 sub clause 9.14.
IEC 68-2 test method: no reference.
Name of test: Endurance

Procedure a:	2000 h at 85 $^{\circ}$C, rated d.c. voltage applied in any direction.
Requirements:	no visible damage, no leakage of electrolyte, leakage current at applied d.c. voltage in applied direction $\leqslant$ stated limit, ESR $\leqslant$ 1,3 x stated limit, $\Delta C/C \leqslant 15\%$, ratio of impedances at 10 kHz before and after test $\leqslant 2$, insulation resistance > 100 MΩ, no breakdown or flashover.
Procedure b:	2000 h at 85 $^{\circ}$C, rated ripple current applied, no d.c. voltage applied.
Requirements:	no visible damage, no leakage of electrolyte, ESR $\leqslant$ 2 x stated limit, $\Delta C/C \leqslant 15\%$, ratio of impedances at 10 kHz before and after test $\leqslant 2$, insulation resistance > 100 MΩ, no breakdown or flashover.

In this data sheet no value is given for tan δ; where in the tests and requirements tan δ is mentioned, ESR must be read instead.

Note: Capacitors 2222 039 belong to the small types, long-life grade.

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

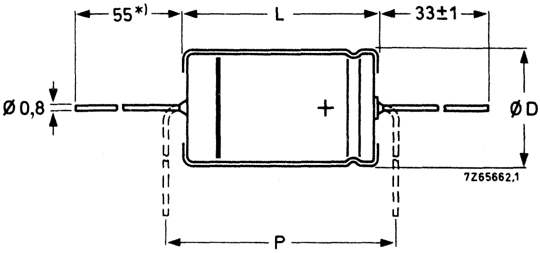
For smoothing, coupling and decoupling purposes in circuits where a high voltage is required.

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.

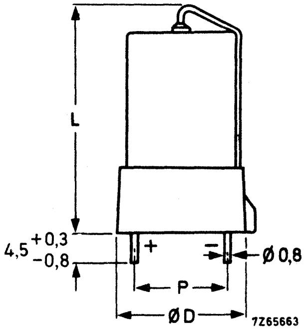
MECHANICAL DATA

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 $T_{amb} = 20\ ^{o}C$	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

$T_{amb} = 70\ ^{o}C$	see Table 2
at $T_{amb} = 60\ ^{o}C$	1,7 x value of Table 2
at $T_{amb} \leq 50\ ^{o}C$	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 (0,03CU + 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 ^{o}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 ^{o}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 ^{o}C recovery time ≥16 h (temp. see IEC 103)	Leakage current and tan δ ≤ stated limit; ΔC ≤ 10%; No visible damage

ALUMINIUM ELECTROLYTIC CAPACITORS

- **Large type**
- **Long life**
- **Industrial applications**

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 h at 85 °C
Basic specification	IEC 384-4, long-life grade DIN 41238 (only version with printed-wiring pins)
Climatic category, IEC 68	40/085/56
Approval	U.K. Post Office D2186 (only version with solder tags)

Selection chart for C_{nom}-U_R and relevant case sizes.

C_{nom} µF	U_R (V)					
	6,3	10	16	25	40	63
680						5/6a
1000					5/6a	6
1500						7/8a
2200				5/6a	6	8/9a
3300			5/6a	6	7/8a	9
4700		5/6a	6	7/8a	8/9a	10
6800		6	7/8a	8/9a	9	
10 000	6	7/8a	8/9a	9	10	
15 000	7/8a	8/9a	9	10		
22 000	8/9a	9	10			
33 000	9	10				
47 000	10					

case size	nominal dimensions (mm)	
	versions with solder tags	versions with printed-wiring pins
5	ϕ 21 x 50	
6a	ϕ 25 x 40	ϕ 25 x 45,5
6	ϕ 25 x 50	ϕ 25 x 55,5
7	ϕ 25 x 80	
8a	ϕ 30 x 50	ϕ 30 x 55,8
8	ϕ 30 x 80	ϕ 30 x 84,7
9a	ϕ 35 x 50	ϕ 35 x 55,8
9	ϕ 35 x 80	ϕ 35 x 84,7
10	ϕ 40 x 80	ϕ 40 x 84,7

APPLICATION

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

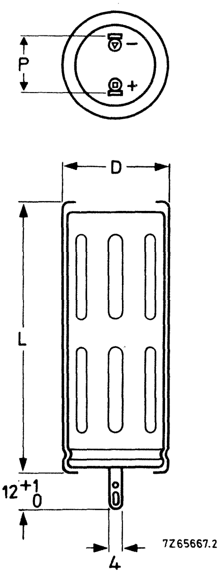
DESCRIPTION

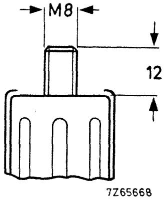
The capacitor winding is housed in an aluminium case, sealed with a rubber-faced paper laminate disc. The electrolyte used is of a special composition to ensure good characteristics at high and low temperatures. The case, which has no electrical function, is covered with a blue synthetic sleeve. The capacitors are available with solder tags or with printed-wiring pins. Each capacitor is provided with a safety vent to release gas pressure under overload conditions.

MECHANICAL DATA

Dimensions in mm

Capacitors with solder tags





Bolt version

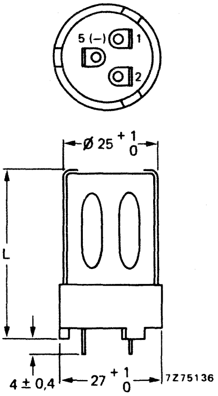
See Table 1 for dimensions D, L and P.

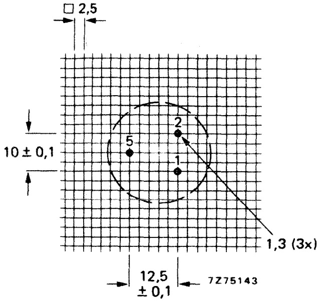
Table 1

case size	D		L		P *		mass approx. g
5	21	+0,6	50	+1,3	13	±0,1	20
6a	25		40		13		25
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

* P at emergence of terminals.

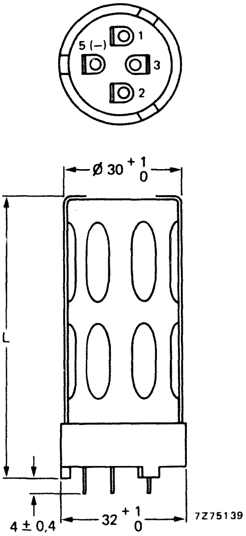
Capacitors with printed-wiring pins

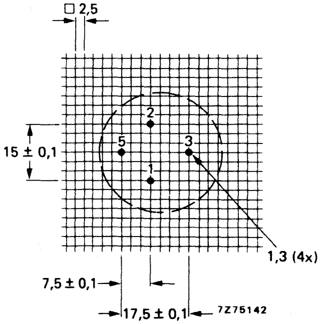




Piercing diagram viewed from component side.

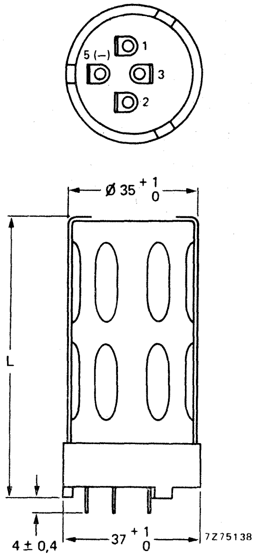
case size	L		mass approx. (g)
6a	45,5	± 0,8	20
6	55,5		30

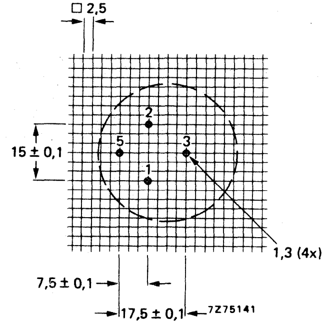




Piercing diagram viewed from component side.

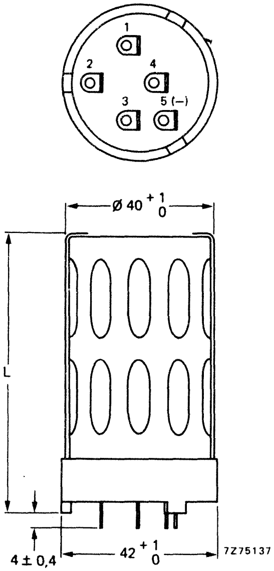
case size	L		mass approx. (g)
8a	55,8	± 0,8	40
8	84,7		70

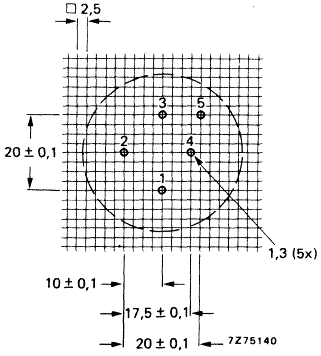




Piercing diagram viewed from component side.

case size	L	mass approx. (g)
9a	55, 8 } ± 0, 8	60
9	84, 7	100





Piercing diagram viewed from component side.

case size	L	mass approx. (g)
10	84, 7 ± 0, 8	130

Marking

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

The terminals are marked as shown in the dimensional figures; the negative terminal is also indicated by a hole in the insulation sleeve. ←

Mounting

The capacitors 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)

ELECTRICAL DATA

Table 2a; capacitors with solder tags

Unless otherwise specified all electrical values in Table 2a 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
	4700	1,1	280	0,35	80	6a	073 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
	3300	1,1	320	0,25	80	6a	073 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
	2200	1,0	330	0,20	80	6a	073 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
	1000	1,0	240	0,15	125	6a	073 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
	680	0,8	260	0,10	125	6a	073 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

---

1) See also corresponding paragraph.

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

Table 2b; capacitors with printed-wiring pins

Unless otherwise specified all electrical values in Table 2b 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%.

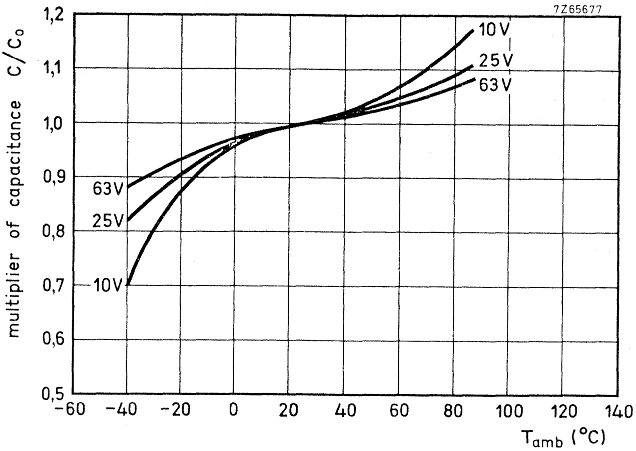
U_R (V)	nominal capacitance (µF) 1)	max. r.m.s. ripple current at T_{amb} = 85 °C (A) 1)	max. leakage current at U_R after 5 min (µA) 1)	max. tan δ 1)	maximum impedance at 100 kHz (mΩ) 1)	case size	catalogue number 2)
6,3	10000	1,8	380	0,50	60	6	2222 071 53103
	15000	2,5	570	0,50	50	8a	073 53153
	22000	3,7	840	0,50	50	8	071 53223
	22000	3,3	840	0,50	30	9a	073 53223
	33000	4,9	1250	0,50	25	9	071 53333
	47000	6,3	1780	0,50	25	10	071 53473
10	4700	1,1	280	0,35	80	6a	073 54472
	6800	1,8	410	0,35	60	6	071 54682
	10000	2.4	600	0,35	50	8a	073 54103
	15000	3,7	900	0,35	50	8	071 54153
	15000	3,3	900	0,35	30	9a	073 54153
	22000	4,8	1320	0,35	25	9	071 54223
	33000	6,0	1980	0,35	25	10	071 54333
16	3300	1,1	320	0,25	80	6a	073 55332
	4700	1,7	450	0,25	60	6	071 55472
	6800	2,4	655	0,25	50	8a	073 55682
	10000	3,5	960	0,25	50	8	071 55103
	10000	3.2	960	0.25	30	9a	073 55103
	15000	4,7	1440	0,25	25	9	071 55153
	22000	6,1	2120	0,25	25	10	071 55223
25	2200	1,0	330	0,20	80	6a	073 56222
	3300	1,7	495	0,20	60	6	071 56332
	4700	2,2	705	0,20	50	8a	073 56472
	6800	3,3	1020	0,20	50	8	071 56682
	6800	2,9	1020	0,20	30	9a	073 56682
	10000	4,3	1500	0,20	25	9	071 56103
	15000	5,7	2250	0,20	25	10	071 56153
40	1000	1,0	240	0,15	125	6a	073 57102
	2200	1,3	530	0,15	100	6	071 57222
	3300	1,7	795	0,15	80	8a	073 57332
	4700	3,1	1130	0,15	80	8	071 57472
	4700	2,4	1130	0,15	50	9a	073 57472
	6800	4,1	1640	0,15	40	9	071 57682
	10000	5,3	2400	0,15	40	10	071 57103
63	680	0,8	260	0,10	125	6a	073 58681
	1000	1,3	380	0,10	100	6	071 58102
	1500	1,7	570	0,10	80	8a	073 58152
	2200	2,6	835	0,10	80	8	071 58222
	2200	2,4	835	0,10	50	9a	073 58222
	3300	3,5	1250	0,10	40	9	071 58332
	4700	4,5	1780	0,10	40	10	071 58472

---

1) See also corresponding paragraph.

Capacitance

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



Typical capacitance as a function of ambient temperature
C_0 = 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

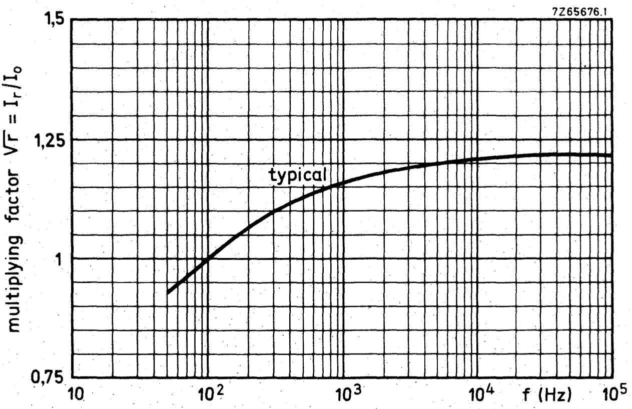
---

*) 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 2a or 2b
at T_{amb} = 80 °C	1,4 x values of Table 2a and 2b
at T_{amb} = 75 °C	1,7 x values of Table 2a and 2b
at T_{amb} ≤ 65 °C	2,2 x values of Table 2a and 2b



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 2a or 2b (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 2a or 2b
at T_{amb} = 85 °C	≤ value stated in Table 2a or 2b

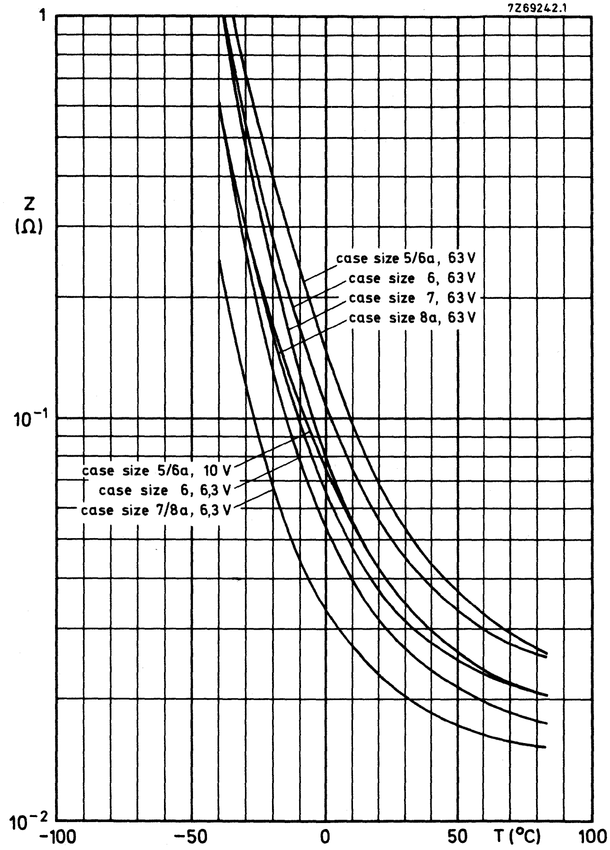
If owing to prolonged storage and/or storage at an excessive temperature the leakage current is too high, application of the rated voltage for some hours will cause the leakage current to fall to a value lower than specified in Table 2.

Tan δ (dissipation factor)

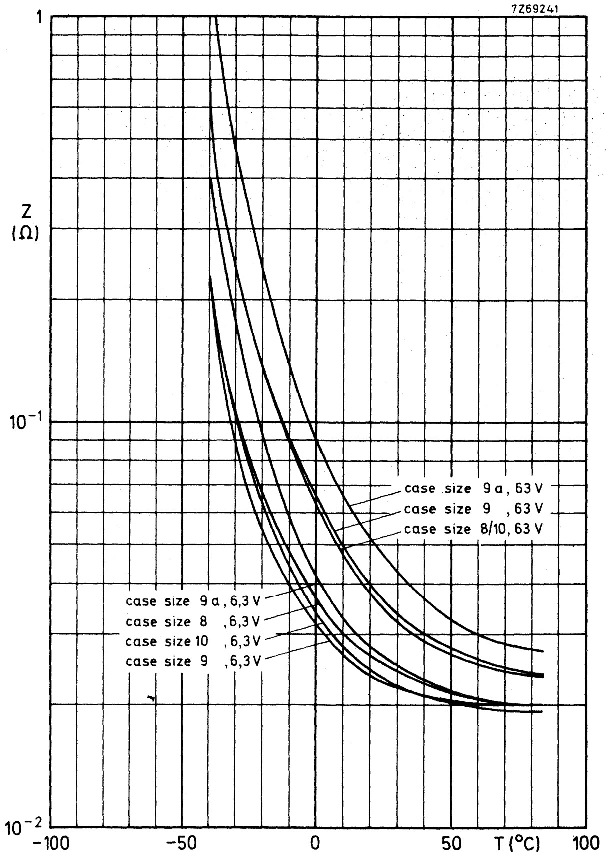
Tan δ at 100 Hz and 20 °C, measured by means of a four-terminal circuit (Thomson circuit)	see Table 2a or 2b

Impedance

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

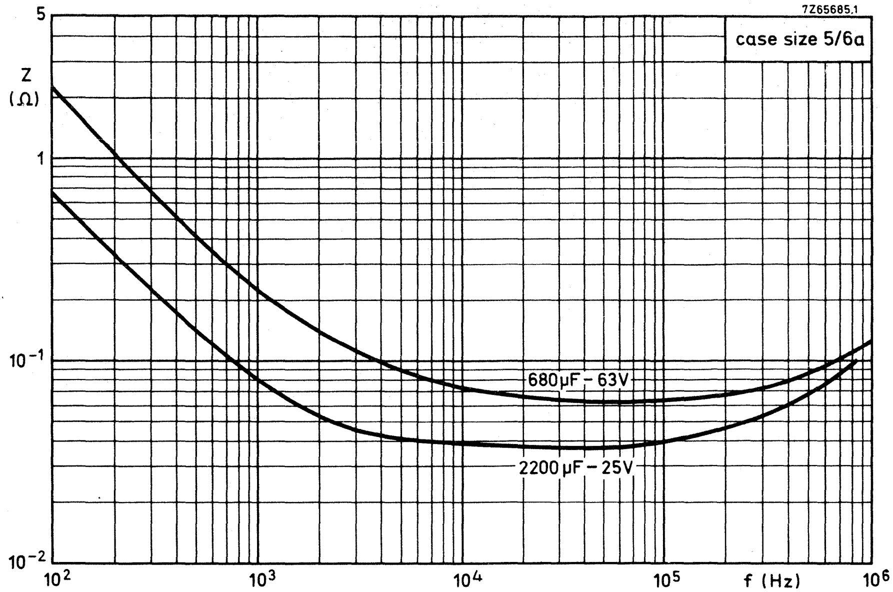


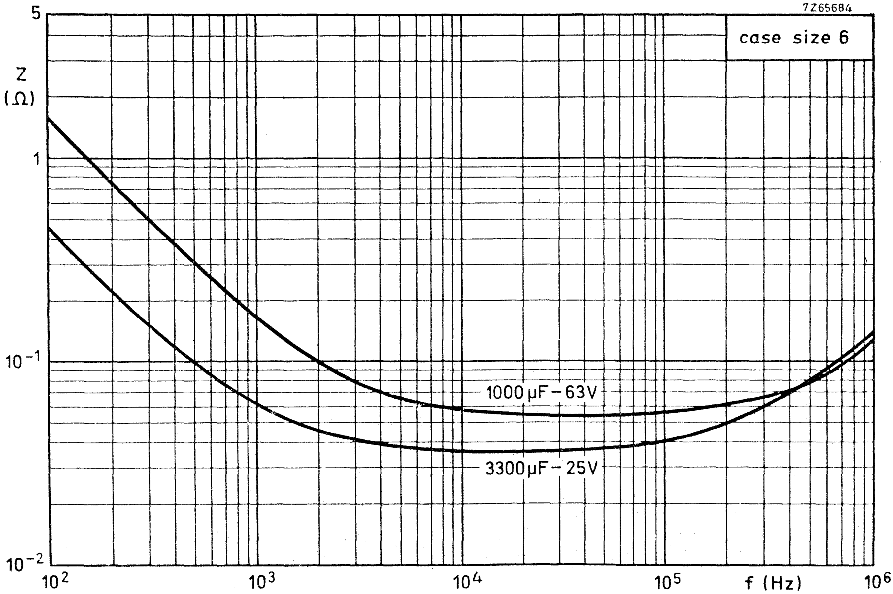
Typical impedance as a function of temperature at 100 kHz.



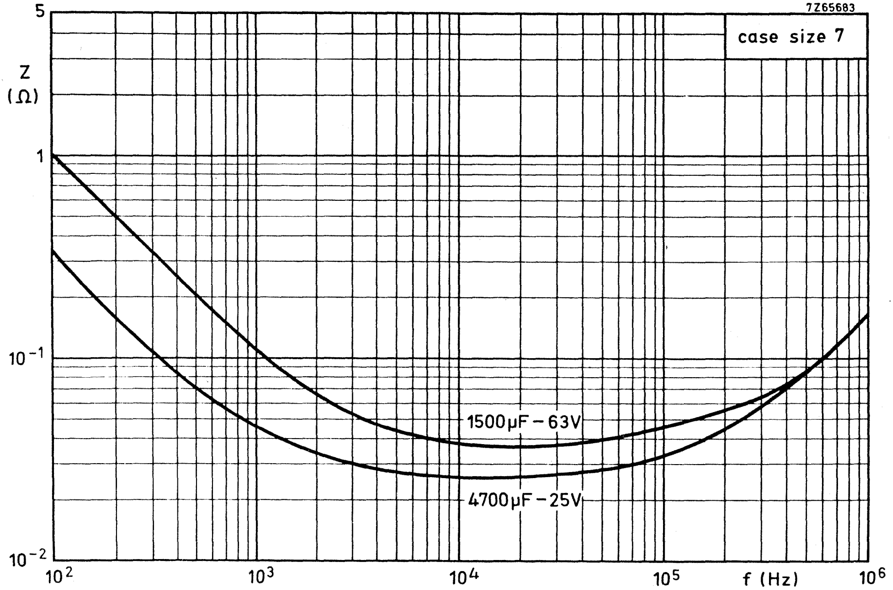
Typical impedance as a function of temperature at 100 kHz.

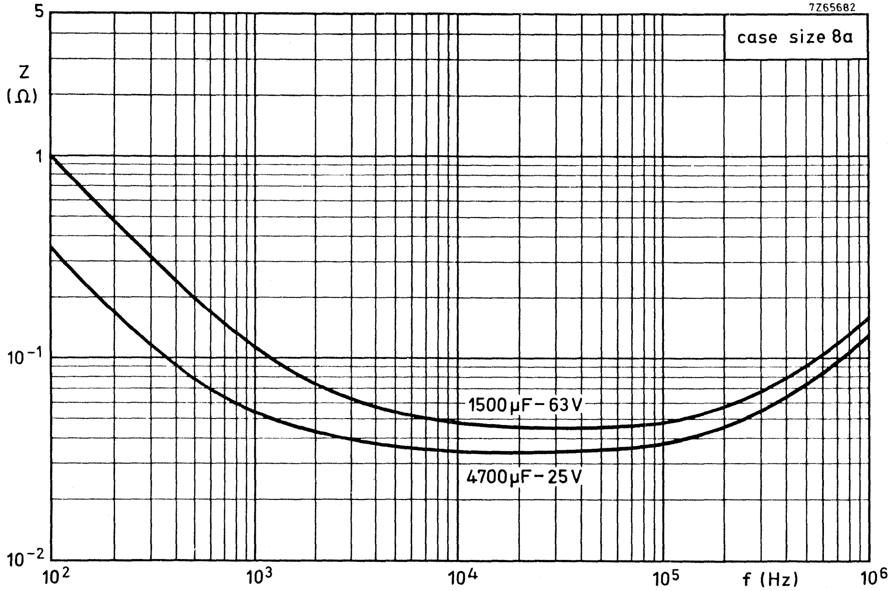
Typical impedance as a function of frequency at different voltages and $T_{amb} = +20\ ^{o}C$.



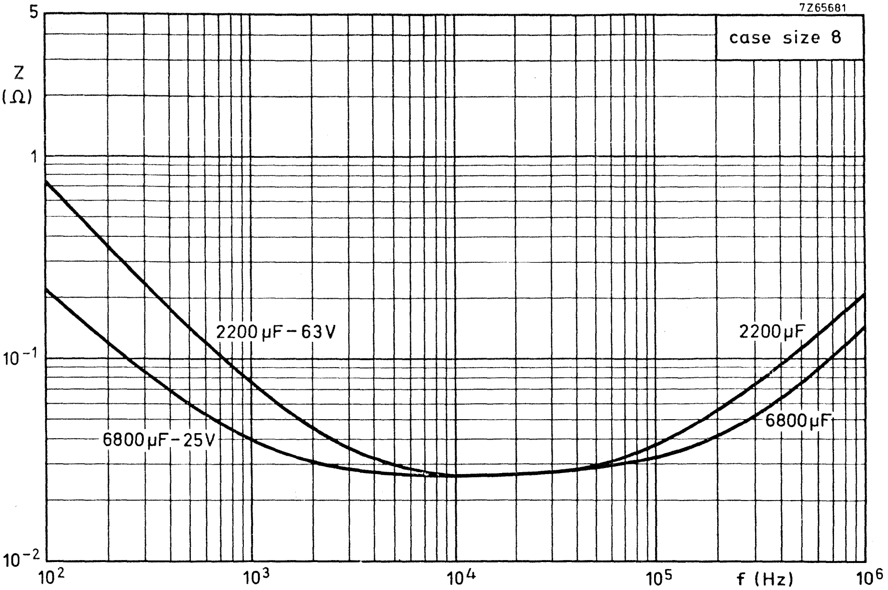


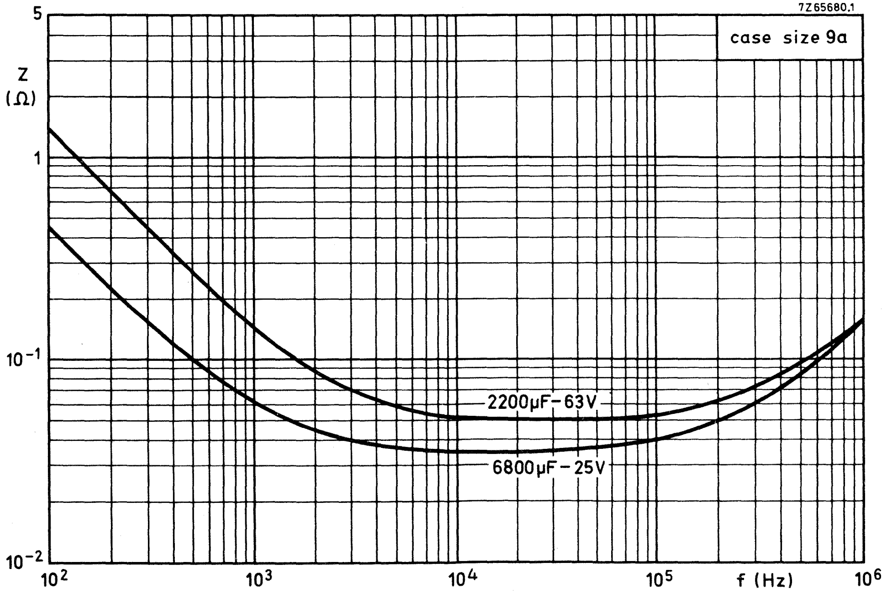
Typical impedance as a function of frequency at different voltages and $T_{amb} = +20\ ^{o}C$.



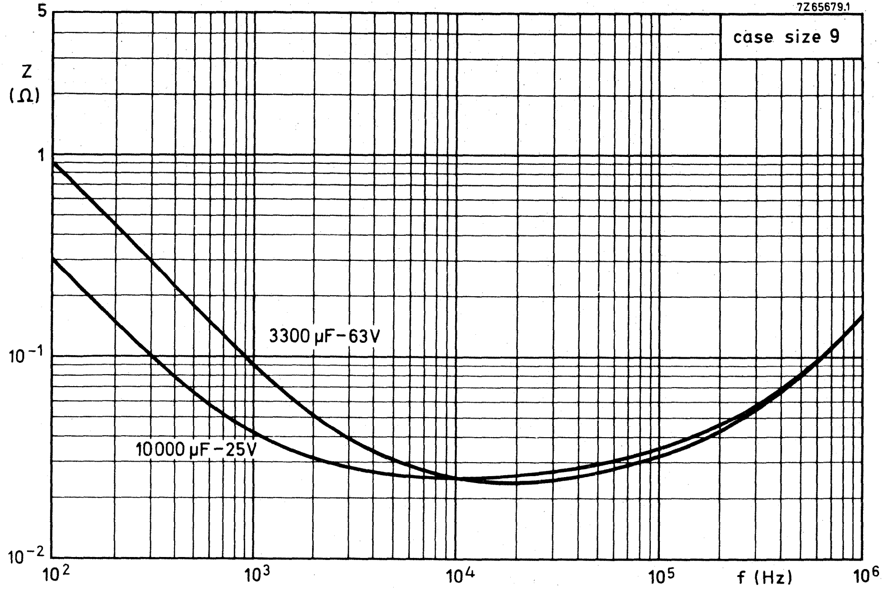


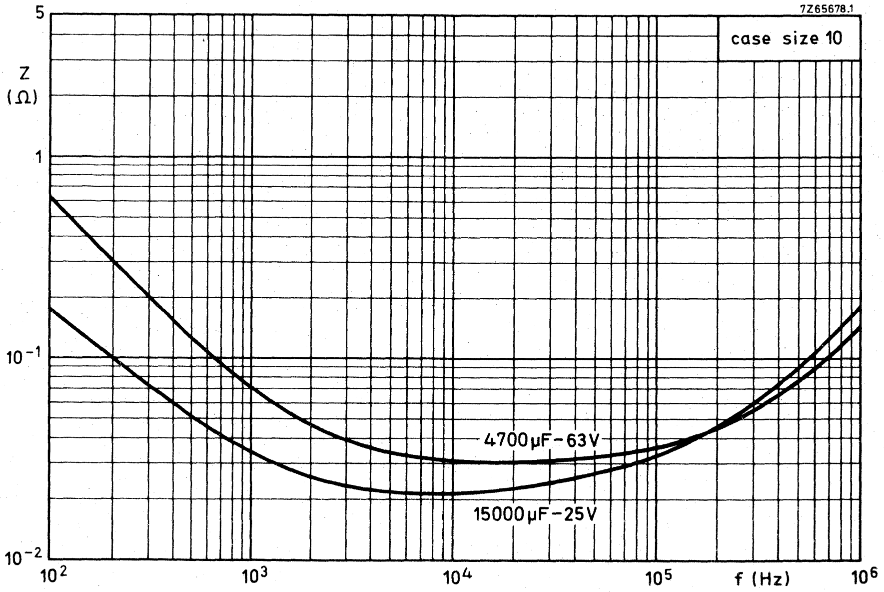
Typical impedance as a function of frequency at different voltages and $T_{amb} = +20\ ^{o}C$.





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





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

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 lifetime	
at T_{amb} = 85 °C	$>$5000 h
at T_{amb} = 25 °C	$>$15 years

PACKING

100 pieces per box.

TESTS AND REQUIREMENTS

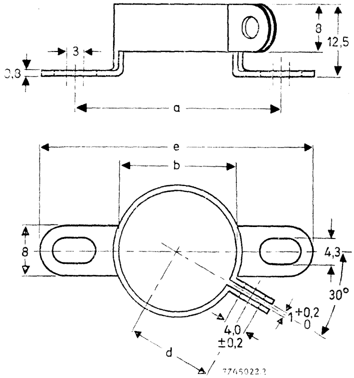
See Introduction, section 9, under aluminium electrolytic capacitors.

Note: Capacitors 2222 071 and 2222 073 belong to the large types, long-life grade.

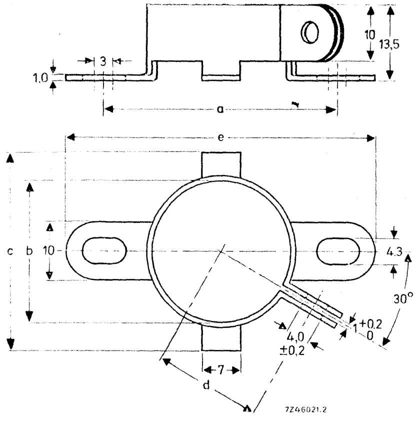
MOUNTING ACCESSORIES

Clamps

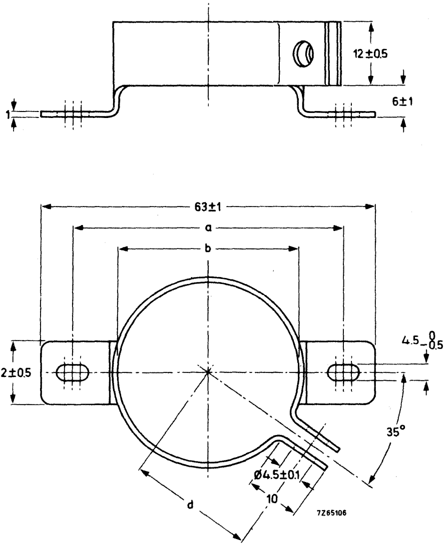
To facilitate vertical mounting, a series of rigid clamps made of cadmium-plated steel are available. They can easily be slid over the capacitor and then fixed to it with a nut and bolt. They are provided with two mounting lugs.
Five types are available, one for each case diameter of the capacitor range.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



For case size 5 and 6a.



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



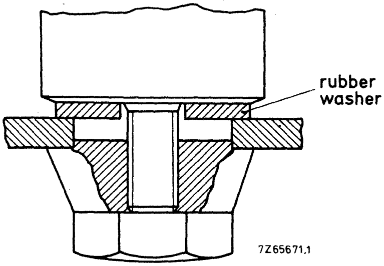
For case size 9 and 9a.

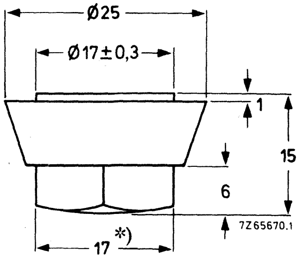
case size	dimensions in mm					catalogue number
	a	b	c	d	e	
5, 6a	37,0 ± 0,2	21	-	15,5	49	4322 043 03291
6, 7	41,5 ± 0,2	25	35	18,5	56	03301
8, 8a	46,5 ± 0,2	30	40	21	61	03311
9, 9a	51,5 ± 0,2	35	-	23,5	63	04272
10	56,5 ± 0,2	40	50	26	71	03331

Bolt/nut

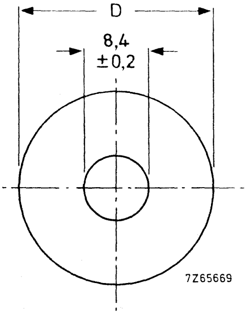
When mounting by means of the bolt, which is an integral part of the case, normal metal M8 nuts and washers can be used.
If an insulated mounting is required a synthetic nut and rubber washers are available.

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.

---

*) Dimension 17 measured across flats.

ALUMINIUM ELECTROLYTIC CAPACITORS

- **Large type with screw terminals**
- **Long life**
- **Industrial applications**

QUICK REFERENCE DATA

Nominal capacitance range (E6 series)	220 to 1000 μF
Tolerance on nominal capacitance	−10 to +30%
Rated voltage, U_R, at <60 °C	400 V
Derated voltage, 0,94 x U_R, at 60 to 85 °C	375 V
Category temperature range	−25 to +85 °C
Endurance test at 85 °C	2000 h
Basic specification	IEC 384-4, long-life grade ◄—
Climatic category, IEC 68,	
at U_R	25/060/56
at 0,94 x U_R	25/085/56

U_R V	C_{nom} μF	case size	nom dimensions mm
400	220	11	Ø 35 x 80
	330	12	Ø 35 x 112
	470	14	Ø 50 x 80
	680	15	Ø 50 x 112
	1000	16	Ø 65 x 112

APPLICATION

These capacitors are especially designed for those applications where the rectified mains is directly coupled to the smoothing capacitor, e.g. switched-mode power supplies.

DESCRIPTION

The high capacitance values are obtained by using special anode foil. High reliability at high ambient temperatures is guaranteed by a large safety factor between working and forming voltage.

The capacitors are cold-welded and charge/discharge proof. The aluminium cases are fully insulated and sealed by a glass-fibre reinforced nylon 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

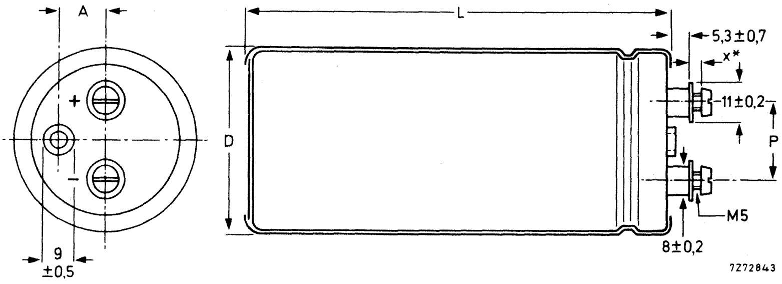


Fig.1 See Table 1 for dimensions D, L, P and A.

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

x	max permissible torque (Nm)
2	1,5
4	1
6	0,5

Table 1

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

Marking

The capacitors are marked with: name of manufacturer, nominal capacitance, tolerance on nominal capacitance, rated voltage and temperature, derated voltage and temperature, 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.

Minimum atmospheric pressure 85 mbar

ELECTRICAL DATA

Table 2

Unless otherwise specified all electrical values in Table 2 apply at an ambient temperature of 20 °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} = 60 °C A*	max leakage current at U_R after 5 min mA*	typ ESR Ω*	max tan δ *	impedance at 20 kHz Ω*		case size	catalogue number 2222 105 followed by
						typ	max		
400	220	1,8	0,53	0,90	0,21	0,60	0,90	11	16221
	330	2,5	0,79	0,60	0,21	0,40	0,60	12	16331
	470	3,1	1,13	0,42	0,21	0,28	0,42	14	16471
	680	4,4	1,63	0,29	0,21	0,19	0,29	15	16681
	1000	6,2	2,40	0,20	0,21	0,13	0,19	16	16102

Capacitance

Nominal capacitance values at 100 Hz — see Table 2

Tolerance on nominal capacitance at 100 Hz — −10 to +30%

Voltage

Rated voltage = max. permissible voltage at < 60 °C — U_R

Derated voltage = max. permissible voltage at 60 to 85 °C — $0,94 \times U_R$

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

	< 60 °C	60 to 85 °C
a) max. positive voltage on anode (d.c. + peak a.c.)	$\leqslant U_R$	$\leqslant 0,94 \times U_R$
b) max. positive voltage on cathode (reverse voltage)	2 V	
c) max. ripple current is not exceeded		

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

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} = 60 °C — see Table 2

---

* See also corresponding paragraph.

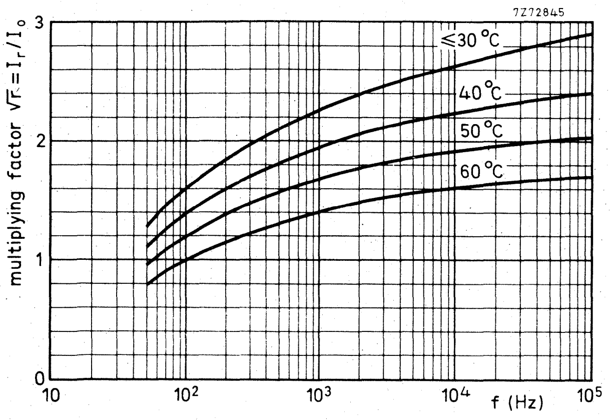


Fig.2 Multiplying factor as a function of frequency, for calculation of max. ripple current. I_o = maximum ripple current at 60 °C, 100 Hz.

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

$$\sum_n \frac{I_n^2}{r_n} \leqslant I_r^2{}_{max}.$$

$I_{r\ max}$ = 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.

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. (See also "Tests and requirements".)

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 x 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} = 20 °C, measured by means of a four-terminal circuit (Thomson circuit)	see Table 2

Impedance

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

Impedance as a function of frequency — see Fig.3

Equivalent series resistance (ESR = tan δ /ωC)

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

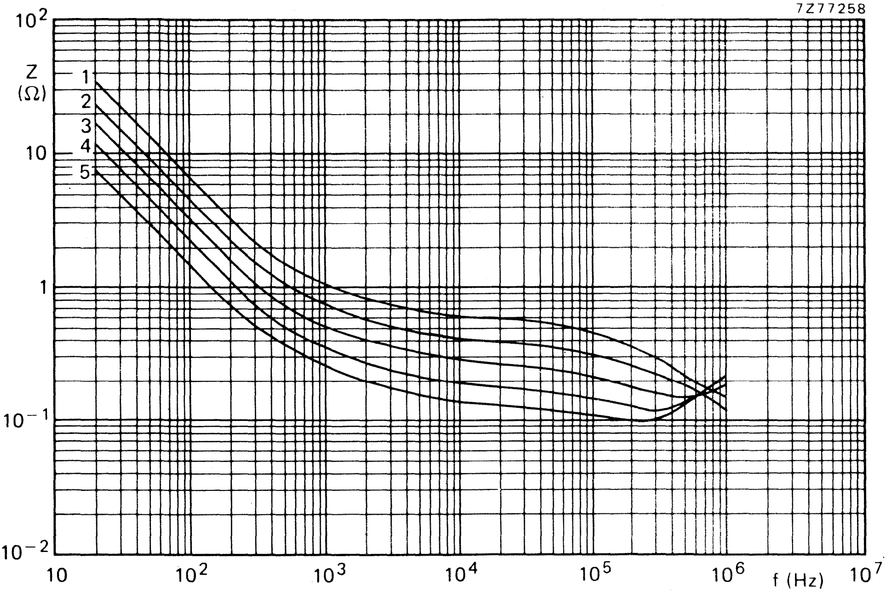


Fig.3 Typical impedance as a function of frequency at T_{amb} = 20 °C.
Curve 1 = 220 μF; 2 = 330 μF; 3 = 470 μF; 4 = 680 μF; 5 = 1000 μF.

OPERATIONAL DATA

Category temperature range

for rated voltage	–25 to +60 °C
for derated voltage	–25 to +85 °C

Life expectancy

Typical life time

at T_{amb} = 60 °C	> 10 000 h
at T_{amb} = 85 °C	> 2000 h

PACKING

Cases sizes 11, 12, 14 and 15: 50 pieces per box; case 16: 25 pieces per box.

TESTS AND REQUIREMENTS

See Introduction, section 9, under aluminium electrolytic capacitors.

Note: Capacitors 2222 105 belong to the large types with screw terminals, long-life grade.

ALUMINIUM ELECTROLYTIC CAPACITORS

- **Large type with screw terminals**
- **Long life**

QUICK REFERENCE DATA

Nominal capacitance range (E6 series)		1500 to 150 000 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 at 85 °C		>5000 h
Basic specification		IEC 384-4, long-life grade
Climatic 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	GPF (56 days)
NF C93-001	2222 107	654
Approvals		U.K. Post Office D 2186 Ministry of Defence (Navy) DEF5134-1 FOA/FTL (Sweden)

Selection chart for C_{nom}-U_R and relevant case sizes.

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	
10 000			11	12	14		16
15 000		11	12	14	15	16	
22 000	11	12	14	15			
33 000	12	14	15		16		
47 000	14	15		16			
68 000	15		16				
100 000		16					
150 000	16						

case size	nominal dimensions (mm)
11	Ø 35 x 80
12	Ø 35 x 112
14	Ø 50 x 80
15	Ø 50 x 112
16	Ø 65 x 112

APPLICATION

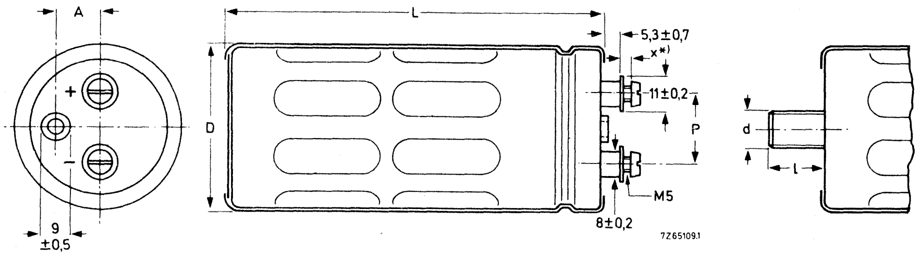
Because of their high reliability and long service life these capacitors are recommended not only for industrial but also for military applications. Their extremely low resistance and inductance values and high resistance to shock and vibration render them very suitable for applications such as : switched-mode 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.

---

*) 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 1	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

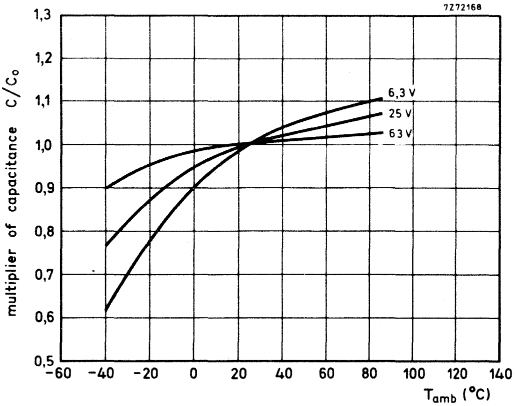
---

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 — $1,1 \times U_R$
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	$\leq 1,1 \times U_R$	$\leq U_R$
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") — $1,15 \times U_R$

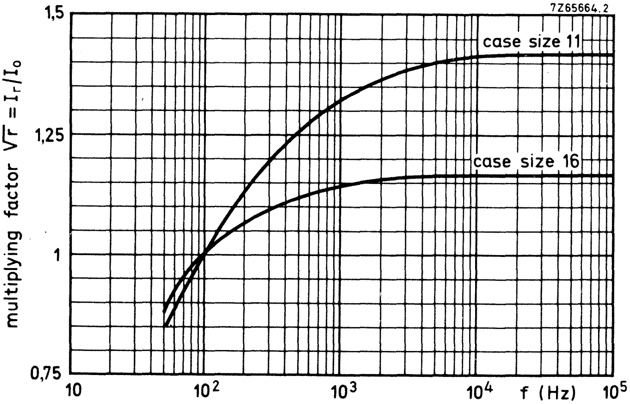
Reverse voltage = max. d.c. voltage applied in the reverse polarity at the maximum category temperature (for short periods) — 1 V

---

*) Ripple 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} ≤ 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

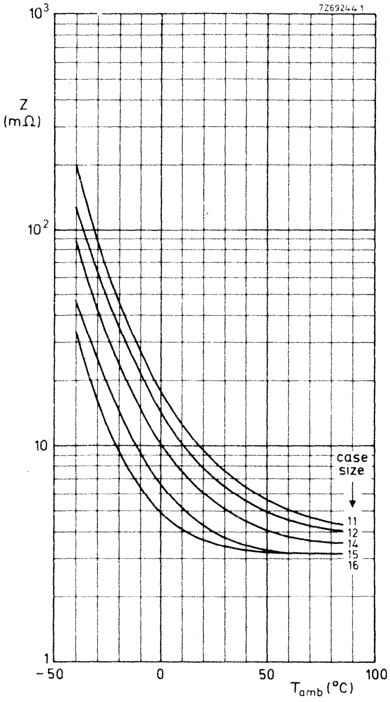
If owing to prolonged storage and/or storage at an excessive temperature the leakage current is too high, application of the rated voltage for some hours will cause the leakage current to fall to a value lower than specified in Table 2.

Tan δ (dissipation factor)

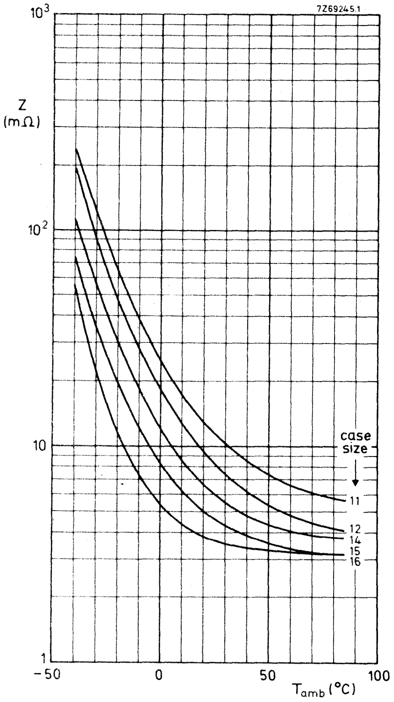
Tan δ at 100 Hz and $T_{amb} = 25$ °C, measured by means of a four-terminal circuit (Thomson circuit)	see Table 2

Impedance

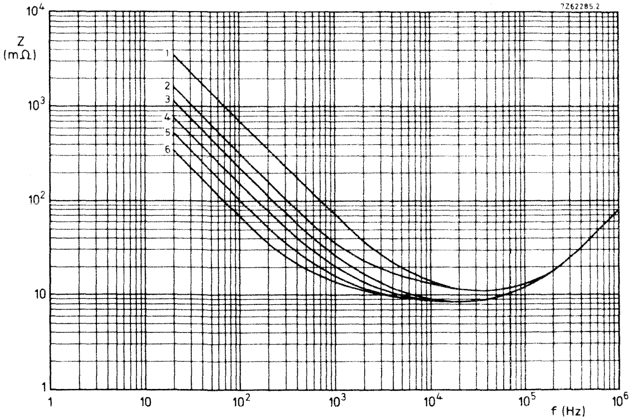
Impedance at 20 kHz and $T_{amb} = 25$ °C, measured by means of a four-terminal circuit (Thomson circuit)	see Table 2



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



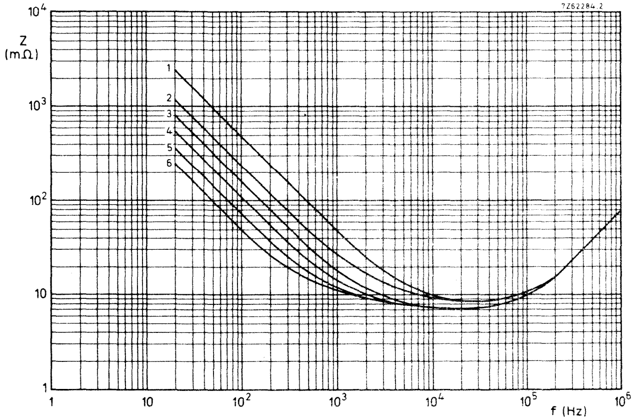
Typical impedance as a function of temperature at 20 kHz for 40 V and 63 V types.



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

case size 11

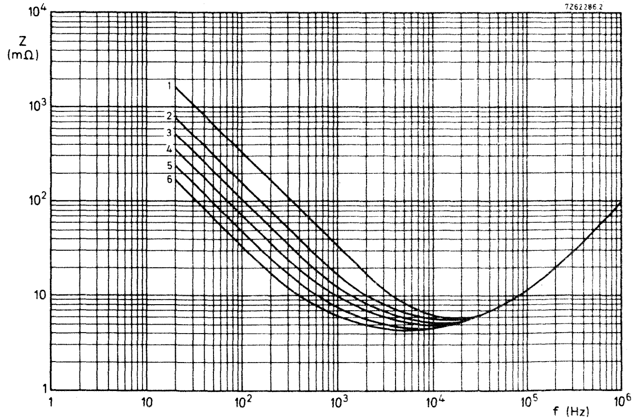
curve 1 = 2200 μF, 63 V
2 = 4700 μF, 40 V
3 = 6800 μF, 25 V
4 = 10 000 μF, 16 V
5 = 15 000 μF, 10 V
6 = 22 000 μF, 6,3 V



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

case size 12

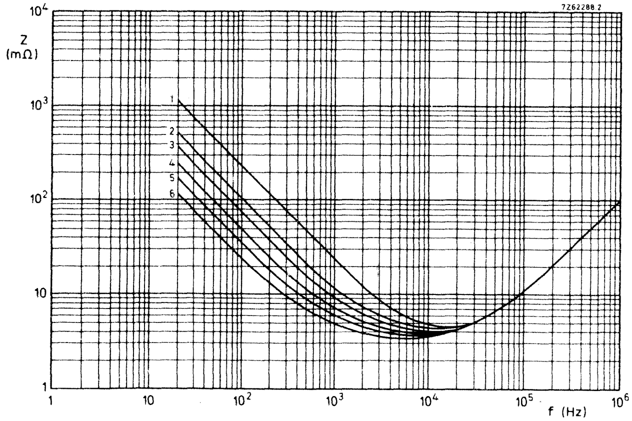
curve 1 = 3300 μF, 63 V
2 = 6800 μF, 40 V
3 = 10 000 μF, 25 V
4 = 15 000 μF, 16 V
5 = 22 000 μF, 10 V
6 = 33 000 μF, 6,3 V



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

case size 14

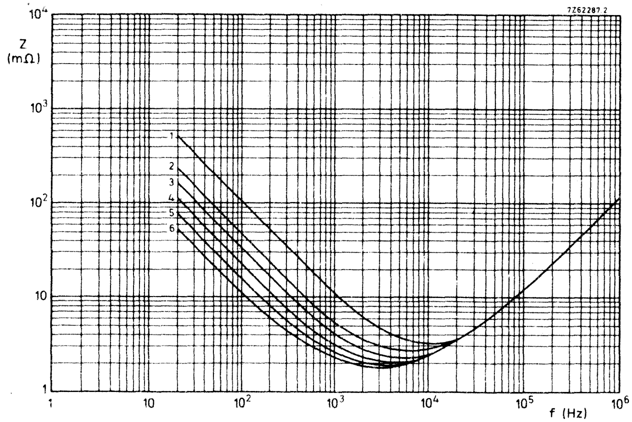
curve 1 = 4700 μF, 63 V
2 = 10 000 μF, 40 V
3 = 15 000 μF, 25 V
4 = 22 000 μF, 16 V
5 = 33 000 μF, 10 V
6 = 47 000 μF, 6,3 V



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



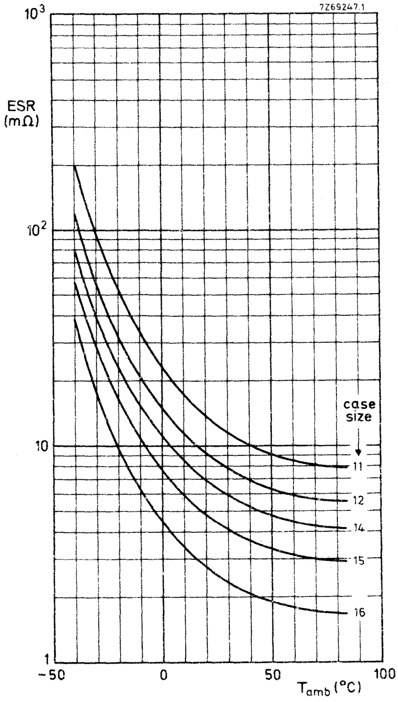
Typical impedance as a function of frequency at T_{amb} = 25 °C.

case size 16

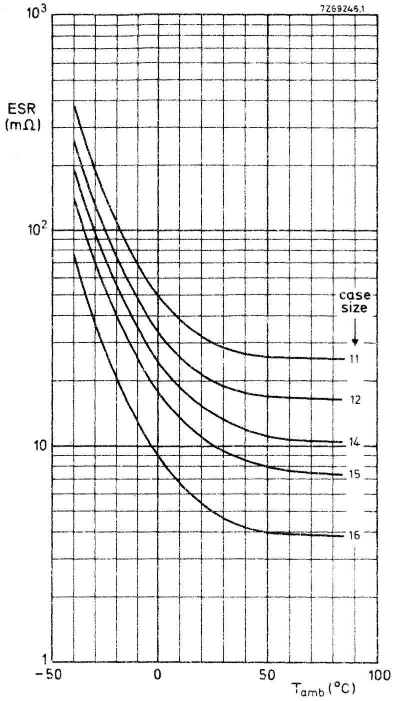
curve 1 = 15 000 μF, 63 V
2 = 33 000 μF, 40 V
3 = 47 000 μF, 25 V
4 = 68 000 μF, 16 V
5 = 100 000 μF, 10 V
6 = 150 000 μF, 6,3 V

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

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
for rated voltage, 2222 107	–25 to +85 °C

Life expectancy

Typical lifetime	
at T_{amb} = 85 °C	>5000 h
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

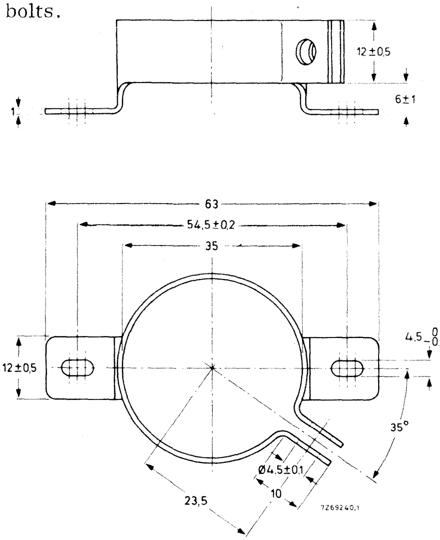
See Introduction, section 9, under aluminium electrolytic capacitors.

Note: Capacitors 2222 106 and 2222 107 belong to the large types with screw terminals, long-life grade.

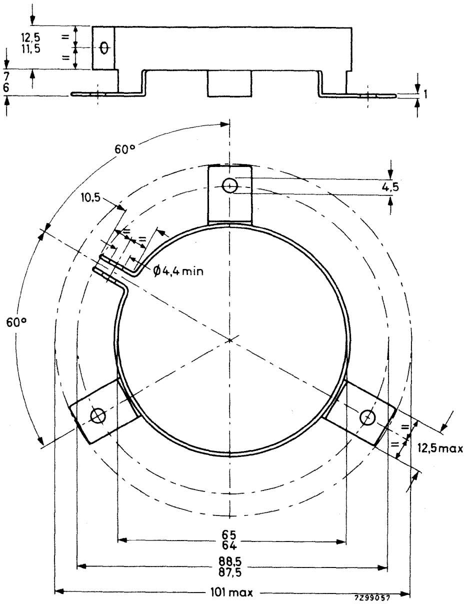
MOUNTING ACCESSORIES

Clamps

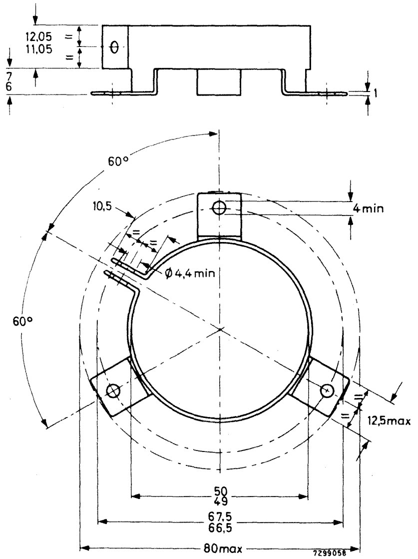
To facilitate vertical mounting, a series of rigid clamps made of cadmium-plated steel are available. They can easily be slid over the capacitor and then fixed to it with a nut and bolt. They are provided with two or three mounting lugs. Three types are available, one for each case diameter of the capacitor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



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



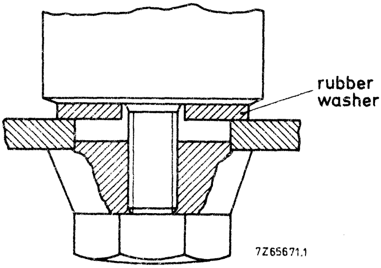
Clamp for case diameter of 65 mm.
Catalogue number 4322 043 04291.

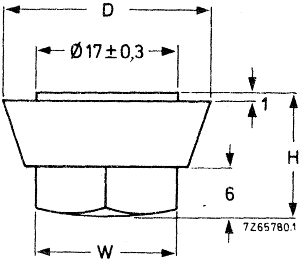


Clamp for case diameter of 50 mm.
Catalogue number 4322 043 04281.

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.

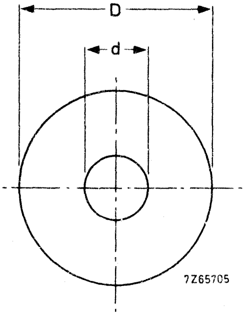




Synthetic cap nut

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



Rubber washer with thickness of 2 mm

dimensions in mm

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

---

*) W measured across flats.

ALUMINIUM ELECTROLYTIC CAPACITORS

- **Small type**
- **Long life**
- **Industrial 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 h	> 10 000 h
Basic specification	IEC 384–4, long-life grade DIN41240 (IA) DEF5134–1 NF C93–110 (type 1)	
Climatic category		
IEC 68	40/085/56	
DIN40040	GPF (56 days)	
NF C93–001	554	

Selection chart for C–U_R and relevant case sizes.

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					

case size	nominal dimensions (mm)
5	Ø 8 x 22
6	Ø 10 x 22
00	Ø 10 x 30
01	Ø 12,5 x 30
02	Ø 15 x 30
03	Ø 18 x 30

APPLICATION

These axial-type capacitors are especially designed for those applications where extreme requirements have to be met concerning reliability and long lifetime 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 a 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

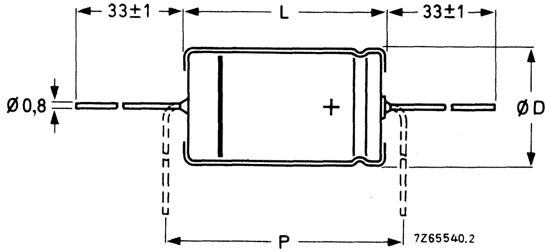


Fig. 1 Case sizes 5 and 6. For dimensions D, L and P, see Table 1.

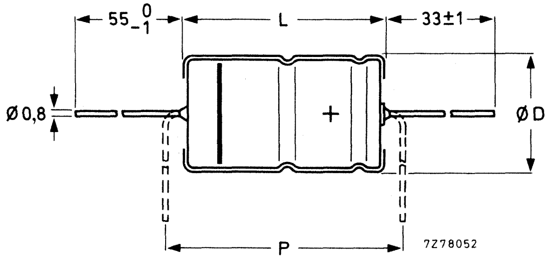


Fig. 2 Case sizes 00, 01, 02 and 03. For dimensions D, L and P, see Table 1.

Table 1

case size	dimensions					approx. mass g
	D		L		P_{min}	
5	8,0	+ 0,5	22,0	+ 0,5	28	1,8
6	10,0		22,0		28	2,5
00	10,0		30,0		35	4,3
01	12,5		30,0		35	6,6
02	15,0		30,0		35	8,5
03	18,0		30,0		35	11,2

Marking

Stamped on the case are: nominal capacitance, rated voltage, tolerance on capacitance, group number 108 (for case sizes 5 and 6) or 108.3 (for case sizes 00 to 03), 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 in the Introduction).

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) *	max. leakage current at U_R after 5 min µA	max. tan δ *	typ. ESR * Ω	impedance at 100 kHz Ω		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	33471
	1000	470	42	0,20	0,16	0,30	0,13	01	33102
	1500	630	60	0,20	0,11	0,22	0,10	02	33152
	2200	920	85	0,20	0,09	0,19	0,09	03	33222
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	34331
	680	470	45	0,15	0,19	0,30	0,13	01	34681
	1000	630	65	0,15	0,13	0,22	0,10	02	34102
	1500	920	95	0,15	0,09	0,19	0,09	03	34152
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	35221
	470	360	50	0,12	0,21	0,30	0,13	01	35471
	680	500	70	0,12	0,14	0,22	0,10	02	35681
	1000	650	100	0,12	0,10	0,19	0,09	03	35102
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	36151
	220	360	37	0,10	0,36	0,30	0,13	01	36221
	470	500	75	0,10	0,17	0,22	0,10	02	36471
	680	650	105	0,10	0,12	0,19	0,09	03	36681
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	37689
	100	245	28	0,08	0,63	0,30	0,13	01	37101
	150	280	40	0,08	0,43	0,30	0,13	01	37151
	220	360	55	0,08	0,34	0,22	0,10	02	37221
	330	495	85	0,08	0,20	0,19	0,09	03	37331
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	38339
	47	150	22	0,08	1,36	0,42	0,18	00	38479
	68	195	30	0,08	0,93	0,30	0,13	01	38689
	100	275	42	0,08	0,63	0,22	0,10	02	38101
	150	355	60	0,08	0,43	0,19	0,09	03	38151

---

* 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%

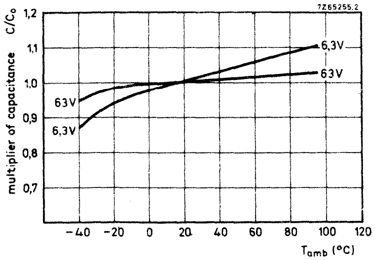


Fig. 3 Typical capacitance as a function of temperature; C_0 = capacitance at 20 °C, 100 Hz.

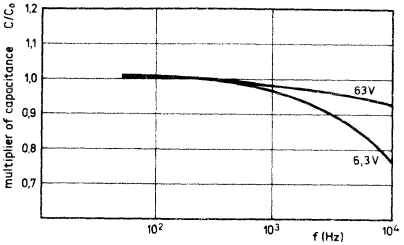


Fig. 4 Typical capacitance as a function of frequency; C_0 = capacitance at 20 °C, 100 Hz.

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 in the Introduction)	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

---

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

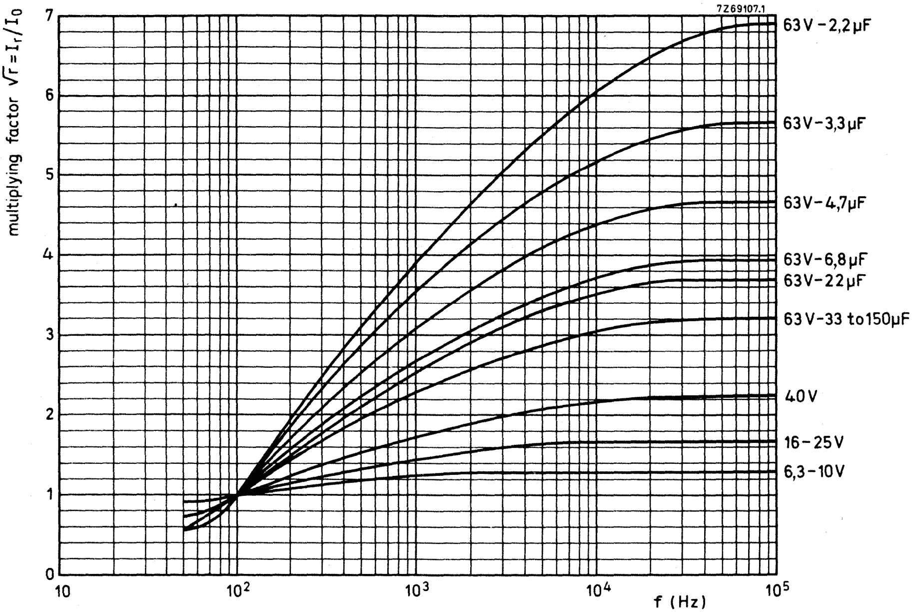


Fig. 5 Multiplying factor as a function of frequency. I_0 = maximum ripple current at 85 °C, 100 Hz.

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:

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

$I_{r\ max}$ = 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 Ripple voltage).

Charge and discharge current

The capacitors may be charged from a source with a source impedance of 0 Ω, 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	$\leqslant$ value stated in Table 2

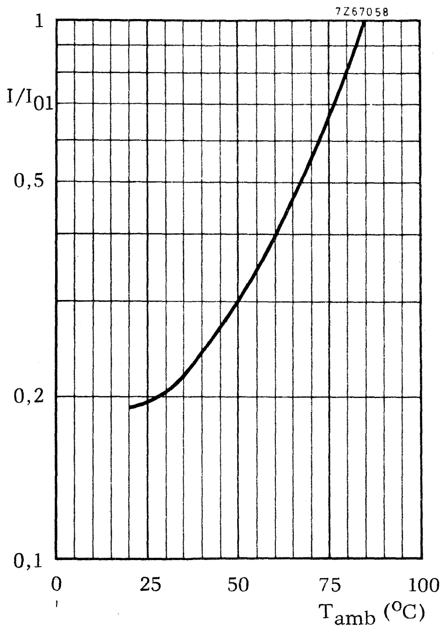


Fig. 6 Multiplier I/I_{01} as a function of temperature. I_{01} = leakage current during continuous operation at T_{amb} = 85 °C at U_R.

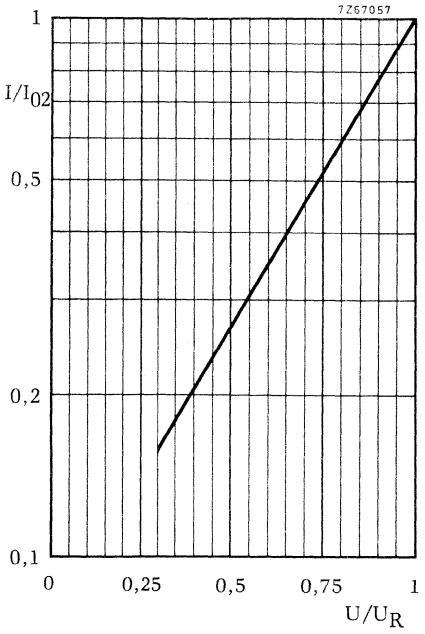


Fig. 7 Multiplier I/I_{02} as a function of U/U_R. I_{02} = leakage current at U_R at a discrete constant temperature within category temperature range.

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

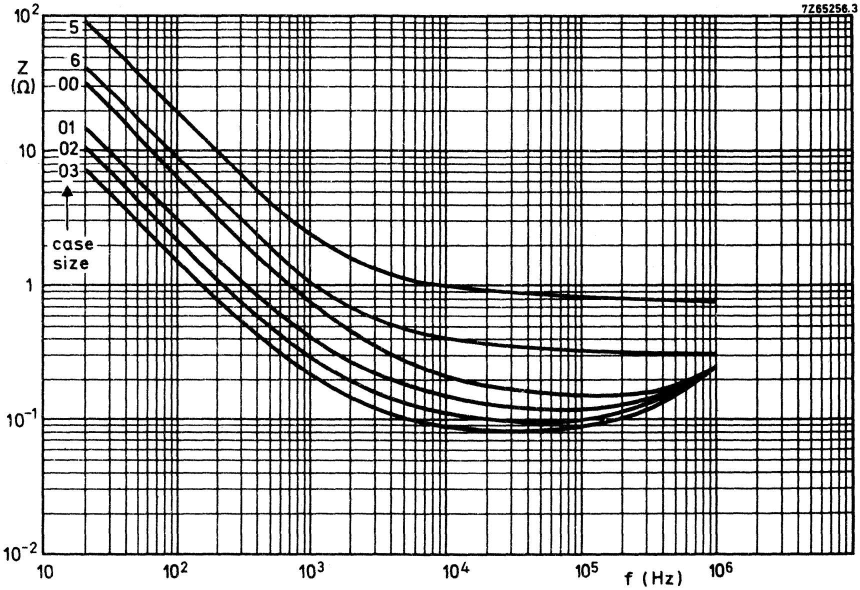


Fig. 8 Typical impedance as a function of frequency measured at 16 V and at 20 °C.

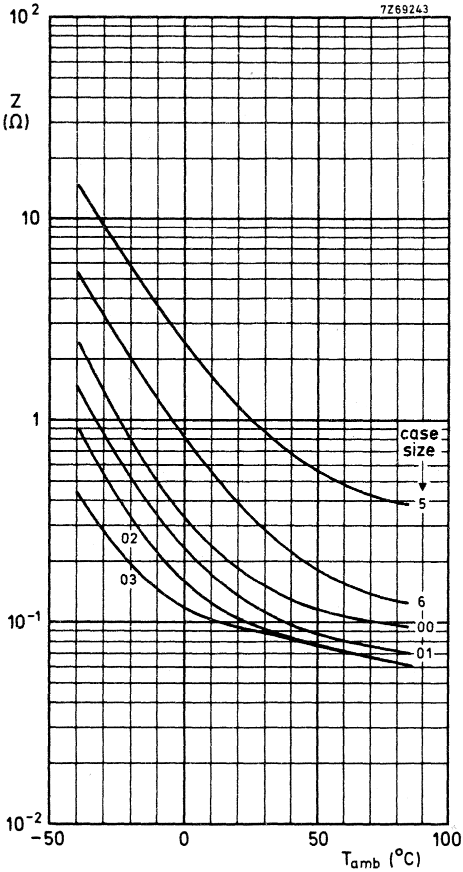


Fig. 9 Typical impedance as a function of temperature at 100 kHz.

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

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

Inductance — $\leqslant$ 40 nH

OPERATIONAL DATA

Category temperature range

for rated voltage —40 to + 85 °C

Life expectancy

	case sizes 5 and 6	case sizes 00 to 03
Guaranteed lifetime at + 85 °C	5000 h	
Typical lifetime at + 85 °C	> 7 500 h	> 10 000 h
Typical lifetime 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

See Introduction, section 9, under aluminium electrolytic capacitors, with the exception of IEC 384—4 sub clause 9.14, for which the following is valid.

IEC 384—4 sub clause 9.14.
IEC 68—2 test method: no reference.
Name of test: Endurance.
Procedure: 5000 h at 85 °C, rated voltage and ripple current applied.
Requirements: No visible damage, no leakage of electrolyte, insulation resistance > 100 MΩ, no breakdown or flashover, leakage current $\leqslant$ stated limit, tan $\delta \leqslant 1{,}3$ x stated limit, impedance at 100 kHz $\leqslant$ 2 x stated limit, $\Delta C/C \leqslant 15\%$.

Note
Capacitors 2222 108 belong to the small types, long-life grade.

SOLID ALUMINIUM CAPACITORS

- **Small type**
- **Long life**
- **Industrial applications**

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 at 125 °C	5000 h
Basic specification	IEC 384−4, long-life grade
Climatic 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)

Selection chart for C_{nom}−U_R and relevant case sizes.

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

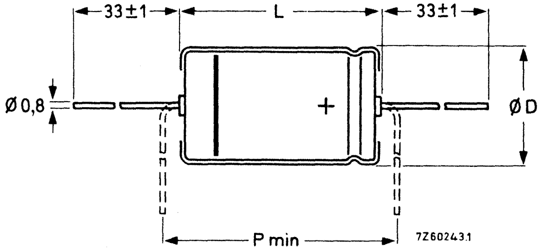


Table 1

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

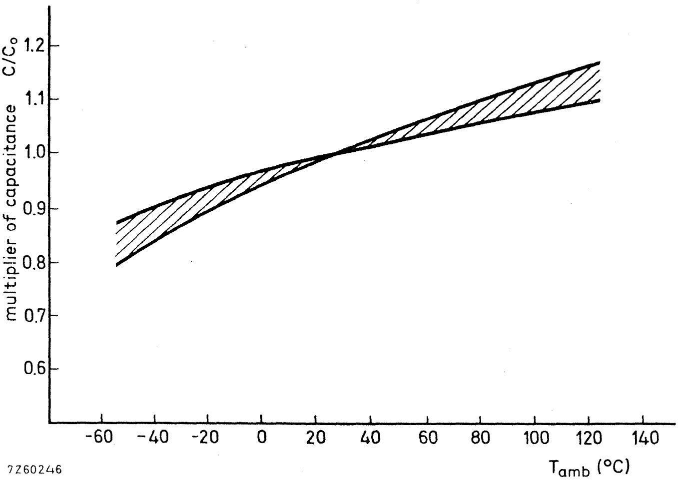
---

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 = $(I_{r0})^2R_{s0}$

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).

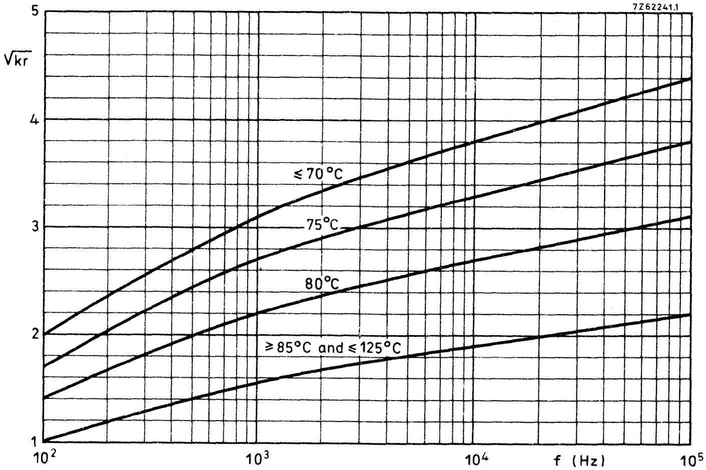
The formula is derived as follows:

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

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.

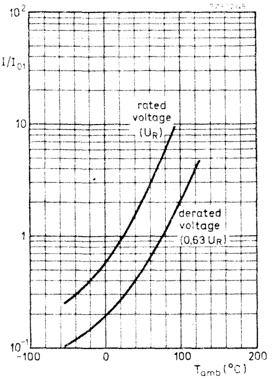
Leakage current

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

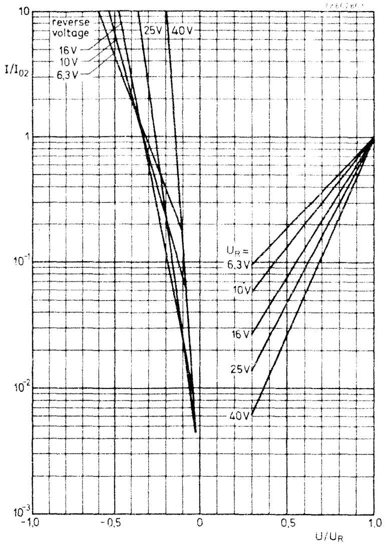
Leakage current during continuous operation at U_R,

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



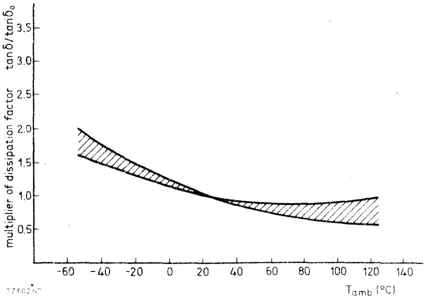
Multiplier I/I_{01} as a function of temperature
I_{01} = leakage current during continuous operation at T_{amb} = 25 °C at U_R



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

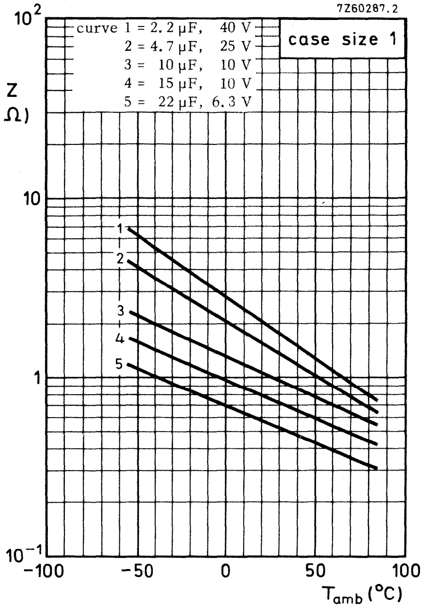


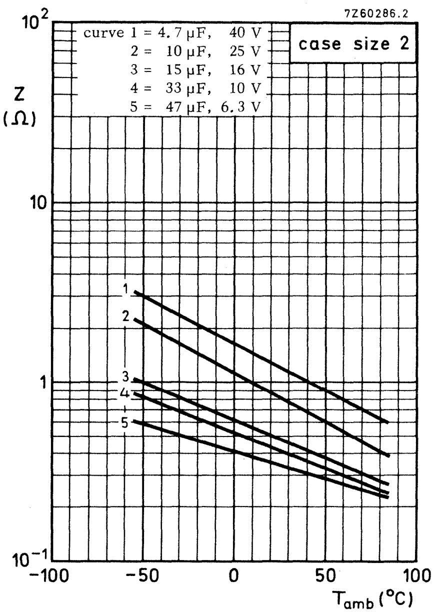
Typical dissipation factor as a function of temperature
Tan δ_0 = dissipation factor at 25 °C, 100 Hz

Impedance

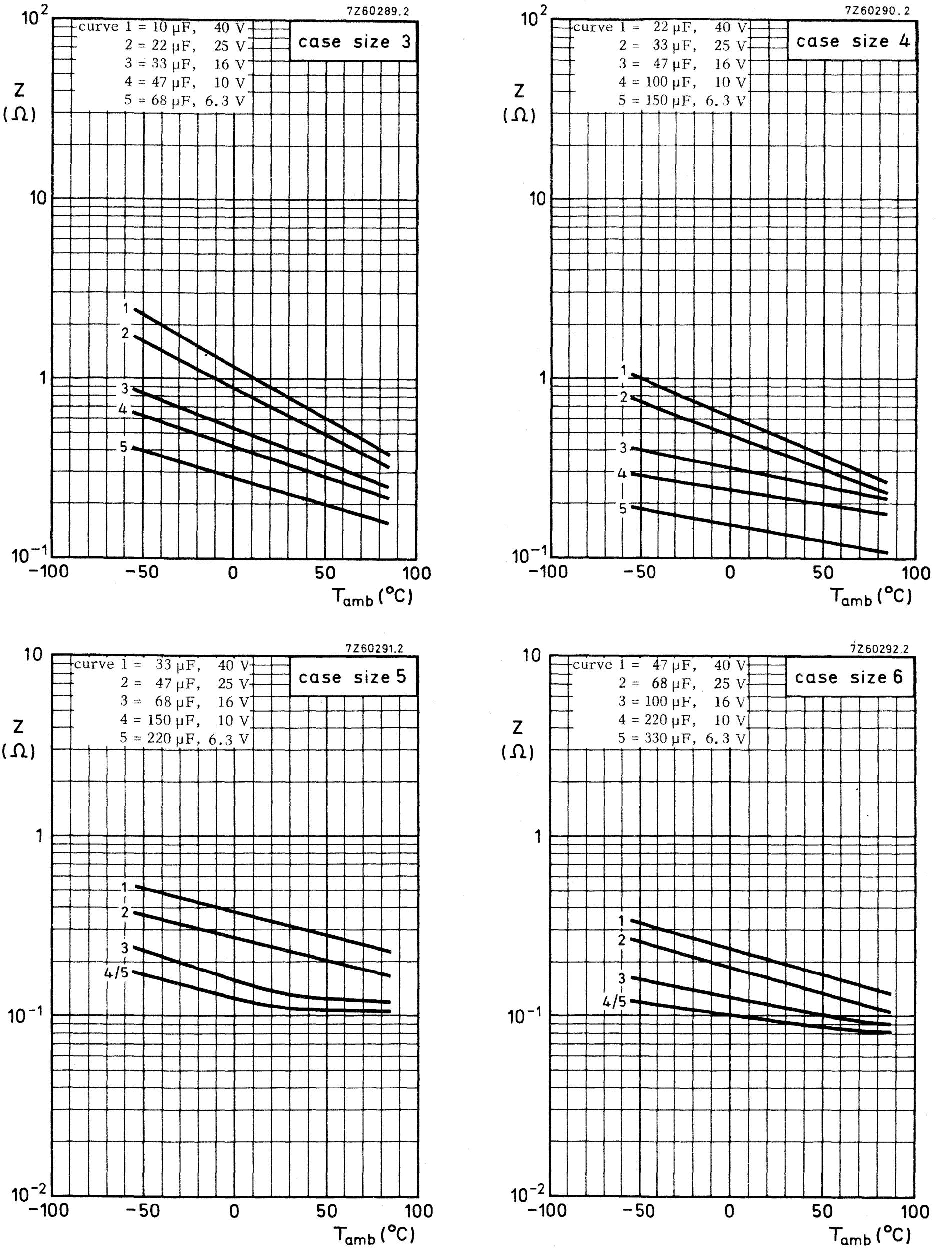
Impedance at 100 kHz, measured by means of a four-terminal circuit (Thomson circuit) (max. values) see Table 2

Typical impedance as a function of temperature at 100 kHz

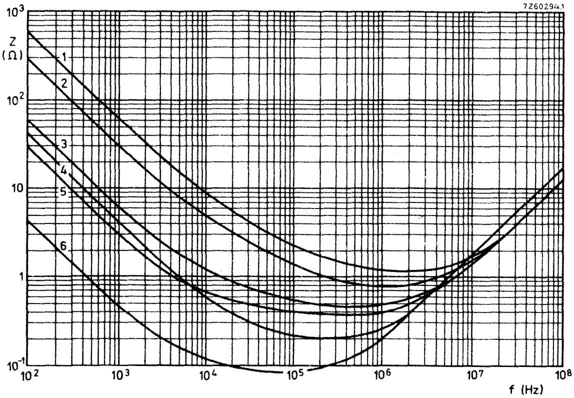




Typical impedance as a function of temperature at 100 kHz

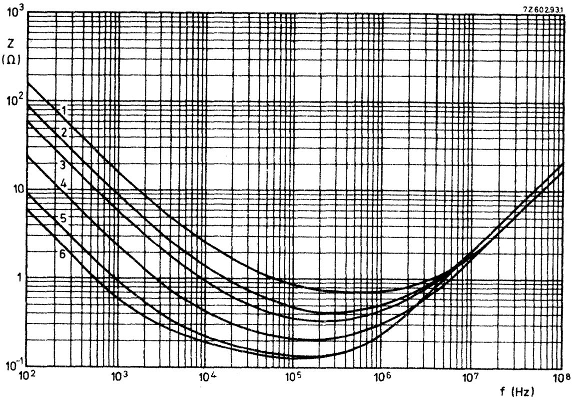


Typical impedance as a function of frequency at 25 °C



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

←

See Introduction, section 9, under solid aluminium capacitors.

SOLID ALUMINIUM CAPACITORS

- **Miniature type**
- **Single ended**
- **Resin dipped**
- **Long life**
- **General and industrial applications**

QUICK REFERENCE DATA

Nominal capacitance range (E6 series)	0,1 to 68 µF
Tolerance on nominal capacitance	–20 to + 40% (± 20% on request)
Rated voltage range, U_R (R5 series)	6,3 to 40 V
Category temperature range	–55 to + 125 °C
Endurance test	
at 85 °C	5000 h
at 125 °C	2000 h
Basic specification	IEC 384–4, long-life grade
Climatic category, IEC 68	55/125/56

Selection chart for C_{nom} – U_R and relevant case sizes.

C_{nom} µF	U_R (V)				
	6,3	10	16	25	40 *
0,1					1
0,15					1
0,22					1
0,33					1
0,47					2
0,68				1	2
1				1	3
1,5				1	4
2,2			1	2	
3,3			1	2	
4,7		1	2	3	
6,8		1	2	4	
10	1	2	3		
15	1	2	4		
22	2	3			
33	3	4			
47	4				
68	4				

case size	maximum dimensions (mm)
1	12,5 x 8 x 3,5
2	12,5 x 8 x 4,5
3	12,5 x 8 x 5
4	12,5 x 8 x 6

* Up to 85 °C, from 85 to 125 °C this value is 25 V.

APPLICATION

Especially for filtering, smoothing, coupling and decoupling purposes in general and industrial applications. These capacitors utilize advanced technology to achieve long life, high reliability, high stability and low temperature dependence.

The capacitors have a very low and stable leakage current, small dimensions and a fixed pitch of 5 mm.

DESCRIPTION

This capacitor is of a construction with a highly etched aluminium plate anode, aluminium oxide as a dielectric and a solid cathode. The capacitor is coated with an orange synthetic resin. The terminal wires are brought out on one side.

MECHANICAL DATA

Dimensions in mm

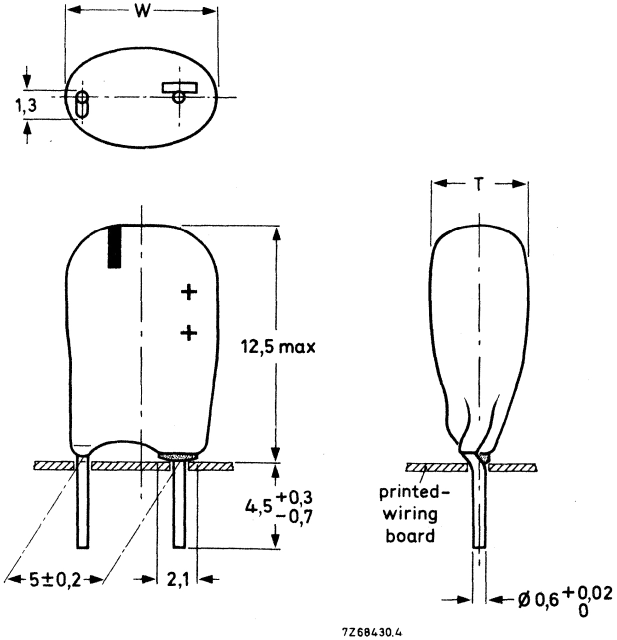


Fig.1 See Table 1 for dimensions T and W.

Table 1

case size	T_{max}	W_{max}
1	3,5	8
2	4,5	8
3	5	8
4	6	8

Note: A kink in the cathode wire avoids solder wetting problems of the lacquer dipped leads. The lacquer is so applied that it cannot pass beyond the centre of the kink, thus ensuring a clean surface of the part of the lead in the printed-wiring board hole. (Also suitable for use in plated-through holes.)

Marking

Stamped on the capacitor are: nominal capacitance, rated voltage, "+" signs to identify the anode terminal and a black stroke on the top to identify the cathode terminal.

Mounting

When bending, cutting or straightening the leads, ensure that the capacitor body is relieved of stress.

ELECTRICAL DATA

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 930 to 1060 mbar and a relative humidity of 45 to 75%.

Table 2

U_R V	nom. cap. µF	max r.m.s. ripple current at 1 kHz, T_{amb} = 85 °C mA *	max leakage current at U_R after 5 min µA *	max tan δ *	case size	catalogue number
6,3	10	60	3	0,15	1	2222 122 53109
	15	70	5	0,15	1	53159
	22	90	7	0,15	2	53229
	33	110	11	0,15	3	53339
	47	140	15	0,15	4	53479
	68	180	22	0,15	4	53689
10	4,7	40	3	0,15	1	54478
	6,8	50	4	0,15	1	54688
	10	60	5	0,15	2	54109
	15	75	8	0,15	2	54159
	22	95	11	0,15	3	54229
	33	125	17	0,15	4	54339
16	2,2	35	2	0,10	1	55228
	3,3	40	3	0,10	1	55338
	4,7	50	4	0,10	2	55478
	6,8	60	6	0,10	2	55688
	10	80	8	0,10	3	55109
	15	100	12	0,10	4	55159
25	0,68	20	2	0,10	1	56687
	1,0	25	2	0,10	1	56108
	1,5	30	2	0,10	1	56158
	2,2	35	3	0,10	2	56228
	3,3	45	4	0,10	2	56338
	4,7	55	6	0,10	3	56478
	6,8	70	9	0,10	4	56688
40**	0,1	7,5	2	0,10	1	57107
	0,15	10	2	0,10	1	57157
	0,22	12,5	2	0,10	1	57227
	0,33	15	2	0,10	1	57337
	0,47	17,5	2	0,10	2	57477
	0,68	20	2	0,10	2	57687
	1,0	25	2	0,10	3	57108
	1,5	30	3	0,10	4	57158

* See also corresponding paragraph.

** Up to 85 °C; from 85 to 125 °C this value is 25 V.

Capacitance

Nominal capacitance values at 100 Hz and $T_{amb} = 25\ ^{o}C$	see Table 2
Tolerance on nominal capacitance at 100 Hz	−20 to +40%; ± 20% on request

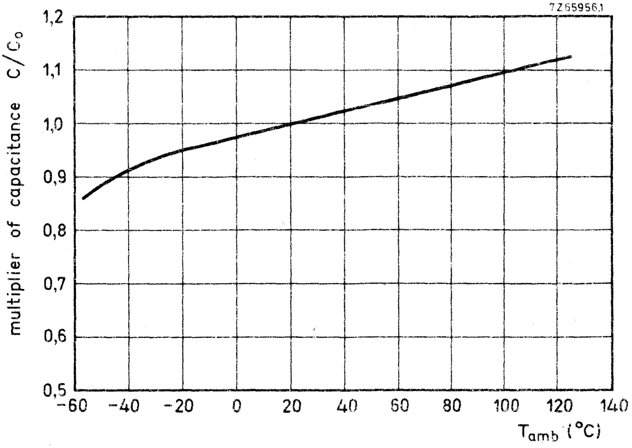


Fig.2 Typical capacitance as a function of temperature; C_0 = capacitance at 25 °C, 100 Hz.

Voltage

Rated voltage	= max permissible voltage at $\leqslant$ 85 °C	see Table 2, U_R
Derated voltage	= max permissible voltage at > 85 °C up to +125 °C	0,63 x U_R for 40 V version, U_R for other versions
Surge voltage	= max permissible voltage for short periods (see also Tests and requirements)	1,15 x U_R
Ripple voltage *	= max permissible a.c. voltage providing the following conditions are met:	
	a) if a.c. + d.c. voltage is applied:	
	● max (d.c. + peak a.c.) voltage	$\leqslant U_R$
	● max peak a.c voltage	$\leqslant$ applied d.c. voltage +0,3 U_R
	b) if only a.c. voltage is applied:	
	● max peak a.c. voltage	$\leqslant 0{,}3\ U_R$
Reverse voltage	= max d.c. voltage applied in the reverse polarity at the maximum category temperature for short periods (see also Tests and requirements)	0,30 x 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 *

The maximum permissible r.m.s. ripple current at 1 kHz and 85 °C (I_{ro}) is given in Table 2. The values in this table are based upon the maximum permissible heat dissipation, which is the dominating limiting factor at frequencies above 1 kHz. From 1 kHz onwards the maximum permissible ripple current can be found from the formula: $I_{r\,max} = \alpha . I_{ro}$; α is given in Fig.3. In this graph the curves below 1 kHz are omitted, because at these frequencies the ripple voltage (see under Voltage) is the dominating limiting factor. For frequencies below 1 kHz $I_{r\,max}$ can be calculated from the formula:
$I_{r\,max} = ½\pi\sqrt{2}.10^{-3}\ (U_R + 0{,}3\ U_R).f.C$ mA,
in which: U_R is rated voltage in V, f is frequency in Hz, C is minimum capacitance (0,8 C_{nom}) in μF.

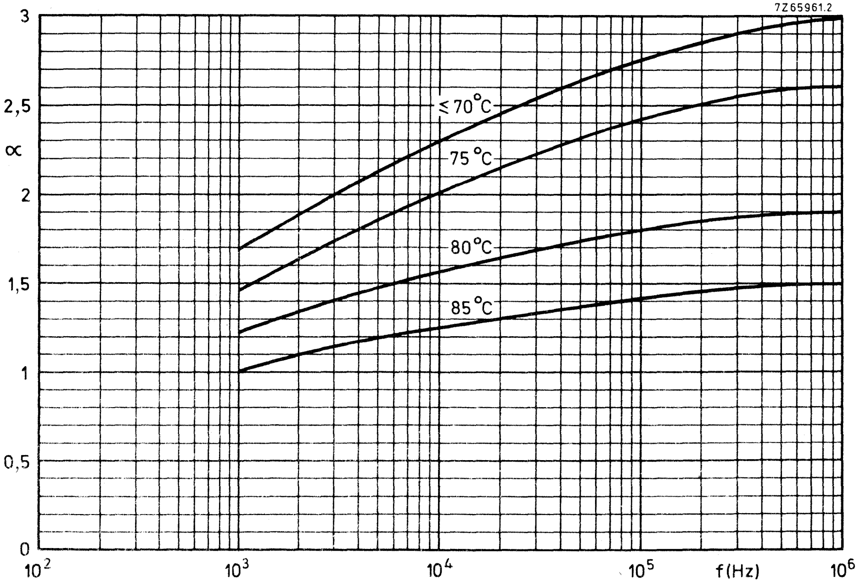


Fig.3 Multiplying factor α as a function of frequency.

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. (See also Tests and requirements.)

---

* 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, at T_{amb} = 25 °C	see Table 2 (0,05 CU or 2 μA whichever is greater)
Leakage current during continuous operation at U_R	
at 25 °C	approx. 0,02 x value stated in Table 2
at 85 °C	approx. 0,1 x value stated in Table 2

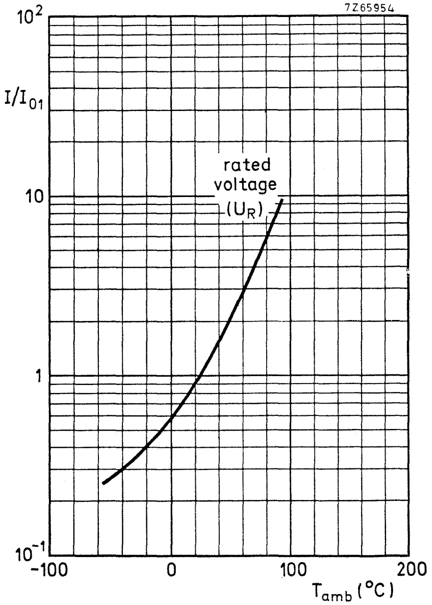


Fig. 4 Multiplier I/I_{01} as a function of temperature; I_{01} = leakage current during continuous operation at U_R, T_{amb} = 25 °C.

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

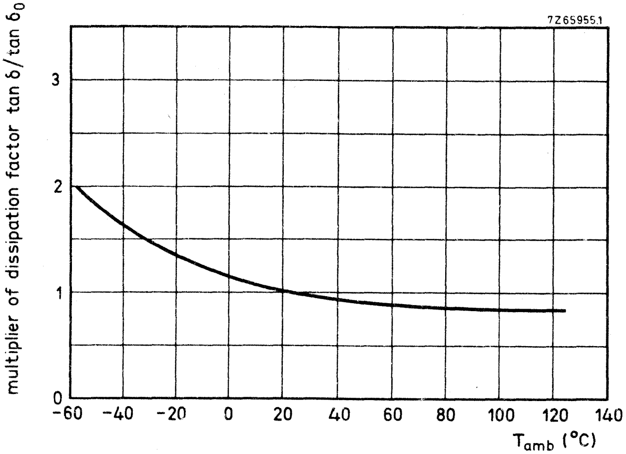


Fig.5 Multiplier of dissipation factor as a function of temperature; tan δ_0 = dissipation factor at 25 °C, 100 Hz.

Impedance

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

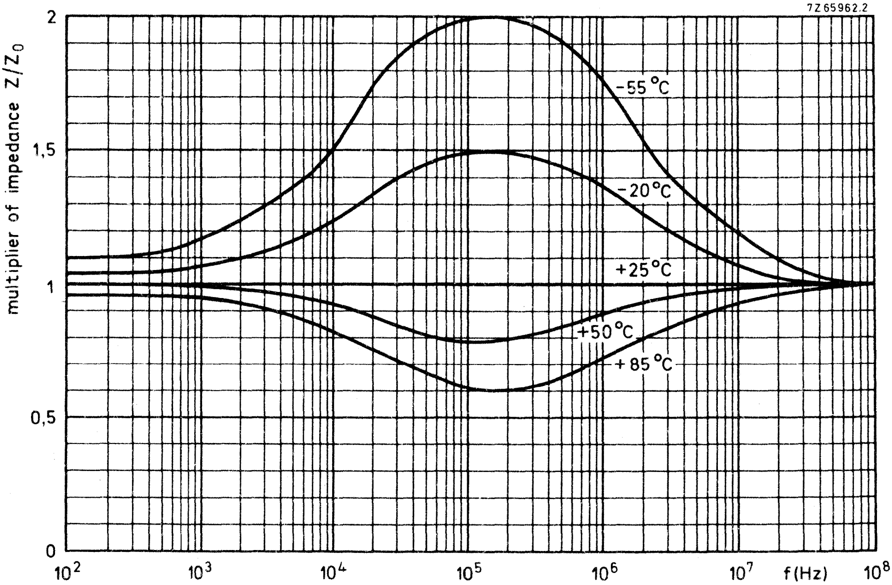


Fig.6 Multiplier of impedance Z/Z_0 as a function of frequency at different temperatures; Z_0 = impedance initial value at 25 °C.

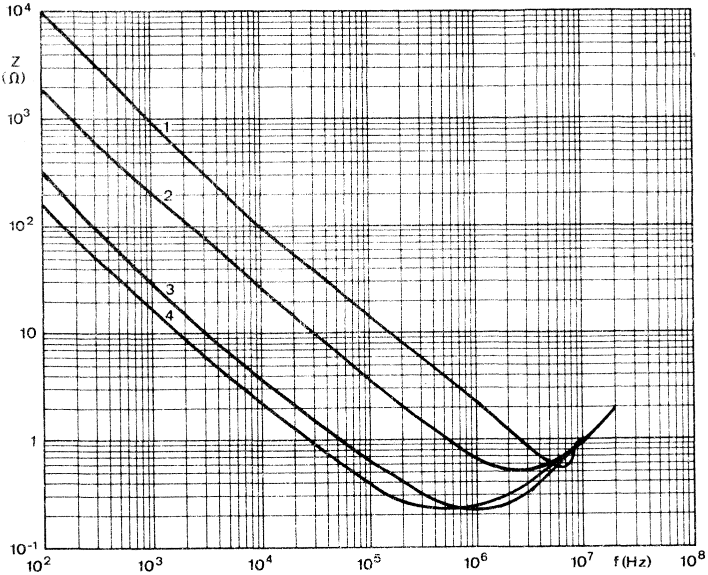


Fig.7 Typical impedance as a function of frequency at 25 °C, **case size 1.** Curve 1 = 0,15 μF, 40 V; curve 2 = 0,68 μF, 25 V; curve 3 = 4,7 μF, 10 V; curve 4 = 10 μF, 6,3 V.

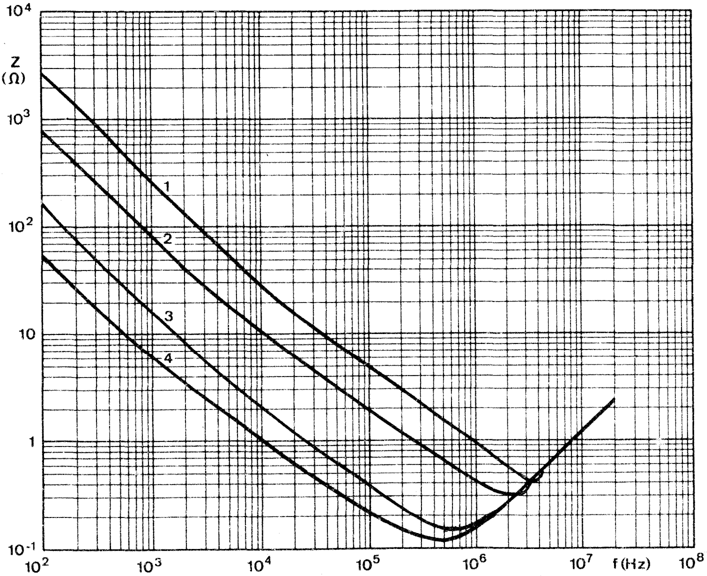


Fig.8 Typical impedance as a function of frequency at 25 °C; **case size 2.** Curve 1 = 0,47 μF, 40 V; curve 2 = 2,2 μF, 25 V; curve 3 = 10 μF, 10 V; curve 4 = 22 μF, 6,3 V.

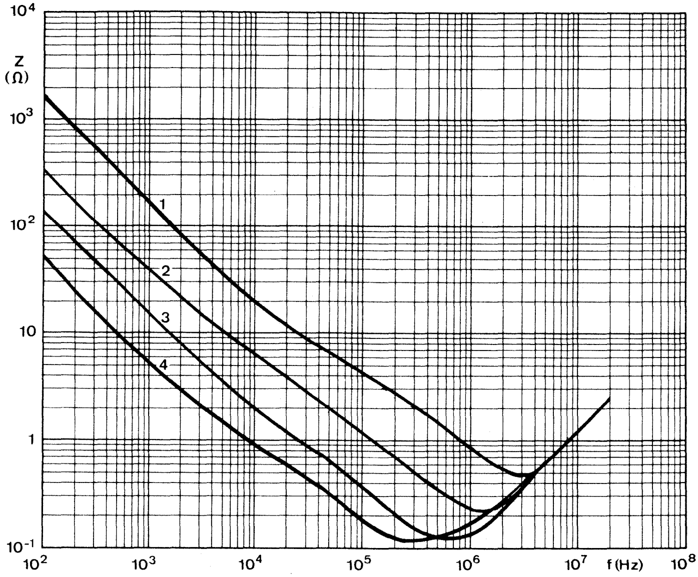


Fig.9 Typical impedance as a function of frequency at 25 °C; **case size 3.** Curve 1 = 1 μF, 40 V; curve 2 = 4,7 μF, 25 V; curve 3 = 10 μF, 16 V; curve 4 = 33 μF, 6,3 V.

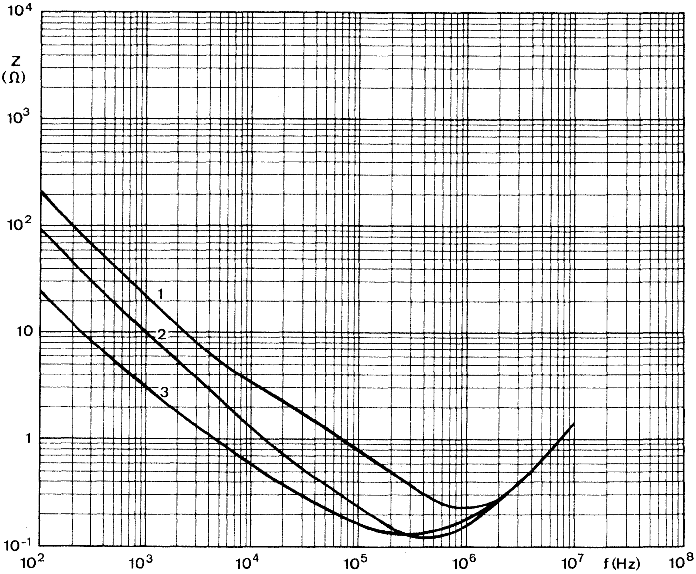


Fig.10 Typical impedance as a function of frequency at 25 °C; **case size 4.** Curve 1 = 6,8 μF, 25 V; curve 2 = 15 μF, 16 V; curve 3 = 68 μF, 6,3 V.

Equivalent series resistance (ESR) at 100 Hz

$$ESR = \frac{\tan \delta}{\omega C}$$

Tan δ and C at 100 Hz	see Table 2

OPERATIONAL DATA

Category temperature range

for rated voltage	−55 to +85 °C
for derated voltage	−55 to +125 °C

PACKING

1000 pieces per box: 200 pieces per plastic bag, 5 bags per box.

TESTS AND REQUIREMENTS

See Introduction, section 9, under solid aluminium capacitors.

SOLID TANTALUM CAPACITORS
hermetic seal tubular case, axial leads
style CSR13 according to MIL-C-39003/01; established reliability

QUICK REFERENCE DATA

Nominal capacitance range (E12 series)	0,1 to 330 μF
Tolerance on nominal capacitance	±20% and ±10% (±5% on request)
Rated voltage range, U_R	6 to 75 V (100 V on request)
Category temperature range	
at U_R	−55 to +85 °C
at 0,67 U_R	−55 to +125 °C
Basic specification	MIL-C-39003/01, style CSR13
Climatic category, IEC68	
at U_R	55/085/56
at 0,67 U_R	55/125/56

Selection chart for C-U_R and relevant case sizes

C_{nom} μF	U_R (V)					
	10	15	20	35	50	75
0,1					A	A
0,12					A	A
0,15					A	A
0,18					A	A
0,22					A	A
0,27					A	A
0,33					A	A
0,39					A	A
0,47					A	A
0,56					A	A
0,68					A	A
0,82					A	B
1					A	B
1,2			A		B	B
1,5			A		B	B
1,8			A		B	B
2,2			A		B	B
2,7		A			B	B
3,3		A			B	B
3,9	A				B	B
4,7	A				B	C

C_{nom} μF	U_R (V)						
	6	10	15	20	35	50	75
5,6	A				B	C	C
6,8	A				B	C	C
8,2				B		C	C
10				B		C	C
12				B		C	D
15				B		C	D
18			B			C	
22			B		C	D	
27		B		C	D		
33		B		C	D		
39		B		C	D		
47	B			C	D		
56	B		C	D			
68			C	D			
82		C		D			
100		C		D			
120		C	D				
150	C		D				
180	C	D					
220		D					
270	D						
330	D						

APPLICATION

These capacitors are designed for circuit functions such as:

- bypassing;
- coupling and decoupling;
- filtering;
- blocking;
- timing.

They are intended for use in polarized or d.c. biased circuits where the a.c. component is small compared to the d.c. rated voltage.

DESCRIPTION

The capacitors consist of a highly purified sintered tantalum anode body utilizing an electrolytically formed oxide dielectric, and a solid electrolyte, enclosed in a hermetically sealed insulated metal case with axial leads. Standard construction includes tin-lead plated leads.

MECHANICAL DATA

Dimensions in mm (including insulation)

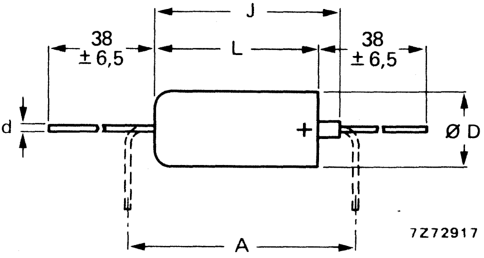


Fig.1.

Table 1

case size	A	D		L		J_{max}	d		approx. mass g
A	12,7	3,43	+0,41 −0,38	7,26	±0,79	10,72	0,51	±0,05	0,7
B	17,8	4,70		12,04		15,49	0,51		1,6
C	25,4	7,34		17,42		20,88	0,64		4,9
D	27,9	8,92		19,96		23,42	0,64		8,8

Marking

The capacitors are marked as follows:

1st line, all case sizes : military specification number;
2nd line, case sizes A and B : specification sheet number and trade mark;
2nd line, case sizes C and D : specification sheet number, dash number and J (for JAN) *;
3rd line, case sizes A and B : dash number and J (for JAN) *;
3rd line, case sizes C and D : polarity, date code (year and week) and lot code;
4th line, case sizes A and B : polarity, date code (year and week) and lot code;
4th line, case sizes C and D : polarity and nominal capacitance;
5th line, case size B : source code number of manufacturer;
5th line, case sizes C and D : tolerance on nominal capacitance and rated voltage;
6th line, case size B : nominal capacitance, tolerance on nominal capacitance and rated voltage;
6th line, case sizes C and D : source code number of manufacturer.

Marking examples of capacitors with different case sizes:

case size A	case size B	case size C and D
39003	M 39003	M 39003/
01–N	01–N	01–2261 J
2001 J	2246 J	+ 7626 C
+ 7626 A	+ 7626 B	+ 100 μF
	26769	10% 10 V
	56 K 6 V **	26769

---

* Not for failure rate level L.
** K = ±10%, M = ±20%, J = ±5%.

ELECTRICAL DATA

Table 2

Unless otherwise specified all electrical values apply at an ambient temperature of 20 to 25 ^{o}C, a frequency of 100 Hz, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%. Notes are at the end of the table.

MIL type designation (note 1)	U_R	nom. cap.	cap. tol.	max. leakage current at U_R after 5 min (μA) at			tan δ (%) at		case size	cat. no. 2222 141 ..... for failure rate level (% per 1000 h) (note 2)				
	V	μF	%	+25 ^{o}C	+85 ^{o}C	+125 ^{o}C	−55 ^{o}C +25 ^{o}C	+85 ^{o}C +125 ^{o}C		2,0 L	1,0 M	0,1 P	0,01 R	0,001 S
CSR13B565K	6	5,6	10	0,3	6	7,5	4	4	A	20011	22411	24811	27211	29611
CSR13B685K	6	6,8	10	0,3	6	7,5	6	6	A	20021	22421	24821	27221	29621
CSR13B685M	6	6,8	20	0,3	6	7,5	6	6	A	20031	22431	24831	27231	29631
CSR13B476K	6	47	10	1,5	24	30	6	6	B	20042	22442	24842	27242	29642
CSR13B476M	6	47	20	1,5	24	30	6	6	B	20052	22452	24852	27252	29652
CSR13B566K	6	56	10	1,5	24	30	6	6	B	20062	22462	24862	27262	29662
CSR13B157K	6	150	10	4,5	90	113	8	8	C	20073	22473	24873	27273	29673
CSR13B157M	6	150	20	4,5	90	113	8	8	C	20083	22483	24883	27283	29683
CSR13B187K	6	180	10	5,5	110	138	8	8	C	20093	22493	24893	27293	29693
CSR13B277K	6	270	10	6,5	130	163	8	8	D	20104	22504	24904	27304	29704
CSR13B337K	6	330	10	7,5	150	188	8	8	D	20114	22514	24914	27314	29714
CSR13B337M	6	330	20	7,5	150	188	8	8	D	20124	22524	24924	27324	29724
CSR13C395K	10	3,9	10	0,3	6	7,5	4	4	A	20131	22531	24931	27331	29731
CSR13C475K	10	4,7	10	0,4	7	8,6	4	4	A	20141	22541	24941	27341	29741
CSR13C475M	10	4,7	20	0,4	7	8,8	4	4	A	20151	22551	24951	27351	29751
CSR13C276K	10	27	10	2	40	50	6	6	B	20162	22562	24962	27362	29762
CSR13C336K	10	33	10	2,5	50	63	6	6	B	20172	22572	24972	27372	29772
CSR13C336M	10	33	20	2,5	50	63	6	6	B	20182	22582	24982	27382	29782
CSR13C396K	10	39	10	2,5	50	63	6	6	B	20192	22592	24992	27392	29792
CSR13C826K	10	82	10	4	80	100	6	6	C	20203	22603	25003	27403	29803
CSR13C107K	10	100	10	5	100	125	8	8	C	20213	22613	25013	27413	29813
CSR13C107M	10	100	20	5	100	125	8	8	C	20223	22623	25023	27423	29823
CSR13C127K	10	120	10	6	120	150	8	8	C	20233	22633	25033	27433	29833
CSR13C187K	10	180	10	9	180	226	8	8	D	20244	22644	25044	27444	29844

CSR13C227K	10	220	10	10	200	250	8	8	D	20254	22654	25054	27454	29854
CSR13C227M	10	220	10	20	200	250	8	8	D	20264	22664	25064	27464	29864
CSR13D275K	15	2,7	10	0,3	6	7,5	4	4	A	20271	22671	25071	27471	29871
CSR13D335K	15	3,3	10	0,4	8	10	4	4	A	20281	22681	25081	27481	29881
CSR13D335M	15	3,3	20	0,4	8	10	4	4	A	20291	22691	25091	27491	29891
CSR13D186K	15	18	10	2	35	44	6	6	B	20302	22702	25102	27502	29902
CSR13D226K	15	22	10	2	40	50	6	6	B	20312	22712	25112	27512	29912
CSR13D226M	15	22	20	2	40	50	6	6	B	20322	22722	25122	27522	29922
CSR13D566K	15	56	10	4	80	100	6	6	C	20333	22733	25133	27533	29933
CSR13D686K	15	68	10	5	100	125	6	6	C	20343	22743	25143	27543	29943
CSR13D686M	15	68	20	5	100	125	6	6	C	20353	22753	25153	27553	29953
CSR13D127K	15	120	10	9	180	226	8	8	D	20364	22764	25164	27564	29964
CSR13D157K	15	150	10	10	200	250	8	8	D	20374	22774	25174	27574	29974
CSR13D157M	15	150	20	10	200	250	8	8	D	20384	22784	25184	27584	29984
CSR13E125K	20	1,2	10	0,3	6	7,5	4	4	A	20391	22791	25191	27591	29991
CSR13E155K	20	1,5	10	0,3	6	7,5	4	4	A	20401	22801	25201	27601	30001
CSR13E155M	20	1,5	20	0,3	6	7,5	4	4	A	20411	22811	25211	27611	30011
CSR13E185K	20	1,8	10	0,3	6	7,5	4	4	A	20421	22821	25221	27621	30021
CSR13E225K	20	2,2	10	0,4	8	10	4	4	A	20431	22831	25231	27631	30031
CSR13E225M	20	2,2	20	0,4	8	10	4	4	A	20441	22841	25241	27641	30041
CSR13E825K	20	8,2	10	1	20	25	6	6	B	20452	22852	25252	27652	30052
CSR13E106K	20	10	10	1,5	30	38	6	6	B	20462	22862	25262	27662	30062
CSR13E106M	20	10	20	1,5	30	38	6	6	B	20472	22872	25272	27672	30072
CSR13E126K	20	12	10	1,8	35	44	6	6	B	20482	22882	25282	27682	30082
CSR13E156K	20	15	10	2	40	50	6	6	B	20492	22892	25292	27692	30092
CSR13E156M	20	15	20	2	40	50	6	6	B	20502	22902	25302	27702	30102
CSR13E276K	20	27	10	2,5	50	63	6	6	C	20513	22913	25313	27713	30113
CSR13E336K	20	33	10	3,5	70	88	6	6	C	20523	22923	25323	27723	30123
CSR13E336M	20	33	20	3,5	70	88	6	6	C	20533	22933	25333	27733	30133
CSR13E396K	20	39	10	4	80	100	6	6	C	20543	22943	25343	27743	30143
CSR13E476K	20	47	10	4,5	90	113	6	6	C	20553	22953	25353	27753	30153
CSR13E476M	20	47	20	4,5	90	113	6	6	C	20563	22963	25363	27763	30163
CSR13E566K	20	56	10	5,5	110	138	6	6	D	20574	22974	25374	27774	30174
CSR13E686K	20	68	10	7	140	175	6	6	D	20584	22984	25384	27784	30184
CSR13E686M	20	68	20	7	140	175	6	6	D	20594	22994	25394	27794	30194
CSR13E826K	20	82	10	8	160	200	6	6	D	20604	23004	25404	27804	30204

Table 2 (continued)

MIL type designation (note 1)	U_R	nom. cap.	cap. tol.	max. leakage current at U_R after 5 min (μA) at			tan δ (%) at		case size	cat. no. 2222 141 ..... for failure rate level (% per 1000 h) (note 2)				
	V	μF	%	+25 °C	+85 °C	+125 °C	−55 °C +25 °C	+85 °C +125 °C		2,0 L	1,0 M	0,1 P	0,01 R	0,001 S
CSR13E107K	20	100	10	10	200	250	8	8	D	20614	23014	25414	27814	30214
CSR13E107M	20	100	20	10	200	250	8	8	D	20624	23024	25424	27824	30224
CSR13F565K	35	5,6	10	1,3	25	32	4	4	B	20632	23032	25432	27832	30232
CSR13F685K	35	6,8	10	1,5	30	38	6	6	B	20642	23042	25442	27842	30242
CSR13F685M	35	6,8	20	1,5	30	38	6	6	B	20652	23052	25452	27852	30252
CSR13F226K	35	22	10	4	80	100	6	6	C	20663	23063	25463	27863	30263
CSR13F226M	35	22	20	4	80	100	6	6	C	20673	23073	25473	27873	30273
CSR13F276K	35	27	10	4,5	90	113	6	6	D	20684	23084	25484	27884	30284
CSR13F336K	35	33	10	5,5	110	138	6	6	D	20694	23094	25494	27894	30294
CSR13F336M	35	33	20	5,5	110	138	6	6	D	20704	23104	25504	27904	30304
CSR13F396K	35	39	10	7	140	175	6	6	D	20714	23114	25514	27914	30314
CSR13F476K	35	47	10	8	160	200	6	6	D	20724	23124	25524	27924	30324
CSR13F476M	35	47	20	8	160	200	6	6	D	20734	23134	25534	27934	30334
CSR13G104K	50	0,1	10	0,3	5	6,3	2	4	A	20981	23381	25781	28181	30581
CSR13G104M	50	0,1	20	0,3	5	6,3	2	4	A	20991	23391	25791	28191	30591
CSR13G124K	50	0,12	10	0,3	5	6,3	2	4	A	21001	23401	25801	28201	30601
CSR13G154K	50	0,15	10	0,3	5	6,3	2	4	A	21011	23411	25811	28211	30611
CSR13G154M	50	0,15	20	0,3	5	6,3	2	4	A	21021	23421	25821	28221	30621
CSR13G184K	50	0,18	10	0,3	5	6,3	2	4	A	21031	23431	25831	28231	30631
CSR13G224K	50	0,22	10	0,3	5	6,3	2	4	A	21041	23441	25841	28241	30641
CSR13G224M	50	0,22	20	0,3	5	6,3	2	4	A	21051	23451	25851	28251	30651
CSR13G274K	50	0,27	10	0,3	5	6,3	2	4	A	21061	23461	25861	28261	30661
CSR13G334K	50	0,33	10	0,3	5	6,3	2	4	A	21071	23471	25871	28271	30671
CSR13G334M	50	0,33	20	0,3	5	6,3	2	4	A	21081	23481	25881	28281	30681
CSR13G394K	50	0,39	10	0,3	5	6,3	2	4	A	21091	23491	25891	28291	30691
CSR13G474K	50	0,47	10	0,3	5	6,3	2	4	A	21101	23501	25901	28301	30701
CSR13G474M	50	0,47	20	0,3	5	6,3	2	4	A	21111	23511	25911	28311	30711
CSR13G564K	50	0,56	10	0,3	5	6,3	2	4	A	21121	23521	25921	28321	30721

CSR13G684K	50	0,68	10	0,3	5	6,3	2	4	A	21131	23531	25931	28331	30731
CSR13G684M	50	0,68	20	0,3	5	6,3	2	4	A	21141	23541	25941	28341	30741
CSR13G824K	50	0,82	10	0,3	5	6,3	2	4	A	21151	23551	25951	28351	30751
CSR13G105K	50	1	10	0,4	8	10	2	4	A	21161	23561	25961	28361	30761
CSR13G105M	50	1	20	0,4	8	10	2	4	A	21171	23571	25971	28371	30771
CSR13G125K	50	1,2	10	0,4	9	11	4	4	B	21182	23582	25982	28382	30782
CSR13G155K	50	1,5	10	0,6	12	15	4	4	B	21192	23592	25992	28392	30792
CSR13G155M	50	1,5	20	0,6	12	15	4	4	B	21202	23602	26002	28402	30802
CSR13G185K	50	1,8	10	0,7	14	18	4	4	B	21212	23612	26012	28412	30812
CSR13G225K	50	2,2	10	0,8	17	22	4	4	B	21222	23622	26022	28422	30822
CSR13G225M	50	2,2	20	0,8	17	22	4	4	B	21232	23632	26032	28432	30832
CSR13G275K	50	2,7	10	1	20	25	4	4	B	21242	23642	26042	28442	30842
CSR13G335K	50	3,3	10	1,2	25	32	4	4	B	21252	23652	26052	28452	30852
CSR13G335M	50	3,3	20	1,2	25	32	4	4	B	21262	23662	26062	28462	30862
CSR13G395K	50	3,9	10	1,5	30	38	4	4	B	21272	23672	26072	28472	30872
CSR13G475K	50	4,7	10	1,7	35	44	4	4	B	21282	23682	26082	28482	30882
CSR13G475M	50	4,7	20	1,7	35	44	4	4	B	21292	23692	26092	28492	30892
CSR13G565K	50	5,6	10	2,2	45	56	6	6	C	21303	23703	26103	28503	30903
CSR13G685K	50	6,8	10	2,2	45	56	6	6	C	21313	23713	26113	28513	30913
CSR13G685M	50	6,8	20	2,2	45	56	6	6	C	21323	23723	26123	28523	30923
CSR13G825K	50	8,2	10	2,5	50	63	6	6	C	21333	23733	26133	28533	30933
CSR13G106K	50	10	10	2,5	50	63	6	6	C	21343	23743	26143	28543	30943
CSR13G106M	50	10	20	2,5	50	63	6	6	C	21353	23753	26153	28553	30953
CSR13G126K	50	12	10	3	60	75	6	6	C	21363	23763	26163	28563	30963
CSR13G156K	50	15	10	4	80	100	6	6	C	21373	23773	26173	28573	30973
CSR13G156M	50	15	20	4	80	100	6	6	C	21383	23783	26183	28583	30983
CSR13G186K	50	18	10	4,5	90	113	6	6	C	21393	23793	26193	28593	30993
CSR13G226K	50	22	10	5,5	110	138	6	6	D	21404	23804	26204	28604	31004
CSR13G226M	50	22	20	5,5	110	138	6	6	D	21414	23814	26214	28614	31014
CSR13H104K	75	0,1	10	0,3	5	6,3	2	4	A	21421	23821	26221	28621	31021
CSR13H104M	75	0,1	20	0,3	5	6,3	2	4	A	21431	23831	26231	28631	31031
CSR13H124K	75	0,12	10	0,3	5	6,3	2	4	A	21441	23841	26241	28641	31041
CSR13H154K	75	0,15	10	0,3	5	6,3	2	4	A	21451	23851	26251	28651	31051
CSR13H154M	75	0,15	20	0,3	5	6,3	2	4	A	21461	23861	26261	28661	31061
CSR13H184K	75	0,18	10	0,3	5	6,3	2	4	A	21471	23871	26271	28671	31071
CSR13H224K	75	0,22	10	0,3	5	6,3	2	4	A	21481	23881	26281	28681	31081
CSR13H224M	75	0,22	20	0,3	5	6,3	2	4	A	21491	23891	26291	28691	31091

Table 2 (continued)

MIL type designation (note 1)	U_R	nom. cap.	cap. tol.	max. leakage current at U_R after 5 min (μA) at			tan δ (%) at		case size	cat. no. 2222 141 ..... for failure rate level (% per 1000 h) (note 2)				
	V	μF	%	+25 °C	+85 °C	+125 °C	−55 °C +25 °C	+85 °C +125 °C		2,0 L	1,0 M	0,1 P	0,01 R	0,001 S
CSR13H274K	75	0,27	10	0,3	5	6,3	2	4	A	21501	23901	26301	28701	31101
CSR13H334K	75	0,33	10	0,3	5	6,3	2	4	A	21511	23911	26311	28711	31111
CSR13H334M	75	0,33	20	0,3	5	6,3	2	4	A	21521	23921	26321	28721	31121
CSR13H394K	75	0,39	10	0,3	5	6,3	2	4	A	21531	23931	26331	28731	31131
CSR13H474K	75	0,47	10	0,3	5	6,3	2	4	A	21541	23941	26341	28741	31141
CSR13H474M	75	0,47	20	0,3	5	6,3	2	4	A	21551	23951	26351	28751	31151
CSR13H564K	75	0,56	10	0,3	5	6,3	2	4	A	21561	23961	26361	28761	31161
CSR13H684K	75	0,68	10	0,3	5	6,3	2	4	A	21571	23971	26371	28771	31171
CSR13H684M	75	0,68	20	0,3	5	6,3	2	4	A	21581	23981	26381	28781	31181
CSR13H824K	75	0,82	10	0,3	5	6,3	2	4	B	21592	23992	26392	28792	31192
CSR13H105K	75	1	10	0,3	5	6,3	2	4	B	21602	24002	26402	28802	31202
CSR13H105M	75	1	20	0,3	5	6,3	4	4	B	21612	24012	26412	28812	31212
CSR13H125K	75	1,2	10	0,3	5	6,3	4	4	B	21622	24022	26422	28822	31222
CSR13H155K	75	1,5	10	0,5	10	13	4	4	B	21632	24032	26432	28832	31232
CSR13H155M	75	1,5	20	0,5	10	13	4	4	B	21642	24042	26442	28842	31242
CSR13H185K	75	1,8	10	0,5	10	13	4	4	B	21652	24052	26452	28852	31252
CSR13H225K	75	2,2	10	0,7	10	19	4	4	B	21662	24062	26462	28862	31262
CSR13H225M	75	2,2	20	0,7	15	19	4	4	B	21672	24072	26472	28872	31272
CSR13H275K	75	2,7	10	0,7	15	19	4	4	B	21682	24082	26482	28882	31282
CSR13H335K	75	3,3	10	1	20	25	4	4	B	21692	24092	26492	28892	31292
CSR13H335M	75	3,3	20	1	20	25	4	4	B	21702	24102	26502	28902	31302
CSR13H395K	75	3,9	10	1	20	25	4	4	B	21712	24112	26512	28912	31312
CSR13H475K	75	4,7	10	3	60	75	4	4	C	21723	24123	26523	28923	31323
CSR13H475M	75	4,7	20	3	60	75	4	4	C	21733	24133	26533	28933	31333
CSR13H565K	75	5,6	10	3	60	75	4	4	C	21743	24143	26543	28943	31343
CSR13H685K	75	6,8	10	5	100	125	6	6	C	21753	24153	26553	28953	31353
CSR13H685M	75	6,8	20	5	100	125	6	6	C	21763	24163	26563	28963	31363
CSR13H825K	75	8,2	10	5	100	125	6	6	C	21773	24173	26573	28973	31373
CSR13H106K	75	10	10	5	100	125	6	6	C	21783	24183	26583	28983	31383

CSR13H106M	75	10	20	5	100	125	6	6	C	21793	24193	26593	28993	31393
CSR13H126K	75	12	10	5	100	125	6	6	D	21804	24204	26604	29004	31404
CSR13H156K	75	15	10	7	140	175	6	6	D	21814	24214	26614	29014	31414
CSR13H156M	75	15	20	7	140	175	6	6	D	21824	24224	26624	29024	31424

Note 1: Complete MIL type designation will include an additional symbol to indicate failure rate level; see also MIL coding system.

Note 2: Failure rate level L (2%) has been made obsolete by MIL-C-39003/1E. It is available for purchase but cannot carry a JAN marking.

Note 3: The following capacitor versions are available on request:

U_R = 75 V: 0,0047 to 0,82 μF (E12 series), case size A;

U_R = 100 V: 0,0047 to 0,56 μF (E12 series), case size A and 0,68 to 2,7 μF (E12 series), case size B.

On request the above-mentioned capacitance values, and all capacitance values in Table 2, are available with a tolerance of ±5%.

Military coding system

CSR13. . . . . .

style: established reliability sintered tantalum anode solid electrolyte capacitor. Insulated case only.

rated voltage U_R

B = 6 V   E = 20 V   G = 50 V
C = 10 V   F = 35 V   H = 75 V
D = 15 V

failure rate level in % per 1000 h

L = 2%   P = 0,1%   S = 0,001%
M = 1%   R = 0,01%

capacitance tolerance

K = ±10%   M = ±20%   J = ±5%

nominal capacitance in pF; first two digits are significant figure, third figure is number of zeros to follow.

Ordering coding system

2222 141 . . . . .

dash number of failure rate level according to MIL-C-39003/1E

case size

1 = case size A
2 = case size B
3 = case size C
4 = case size D

Capacitance

The nominal capacitance values at 100 Hz are given in Table 2. The tolerance on nominal capacitance at 100 Hz is ±20% and ±10% (±5% on request).

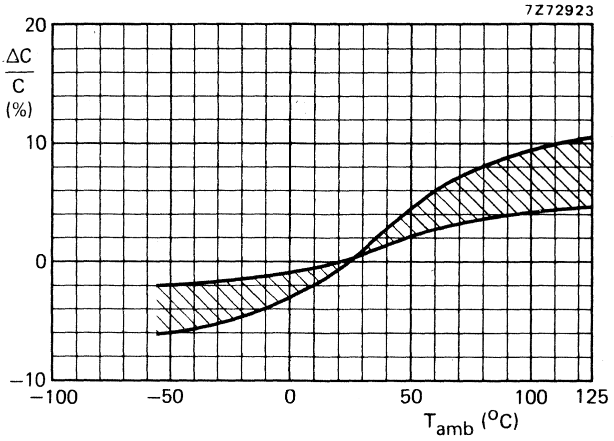


Fig.2 Typical capacitance as a function of ambient temperature.

The change in capacitance from the initial value measured at 25 °C shall not exceed the following percentages:

10% at −55 °C;
8% at +85 °C;
12% at +125 °C.

Voltage

Rated voltage

The rated voltage, U_R in Table 2, is the maximum permissible voltage at −55 to +85 °C. The capacitors may be operated up to 125 °C by derating the rated voltage in accordance with Fig.3.

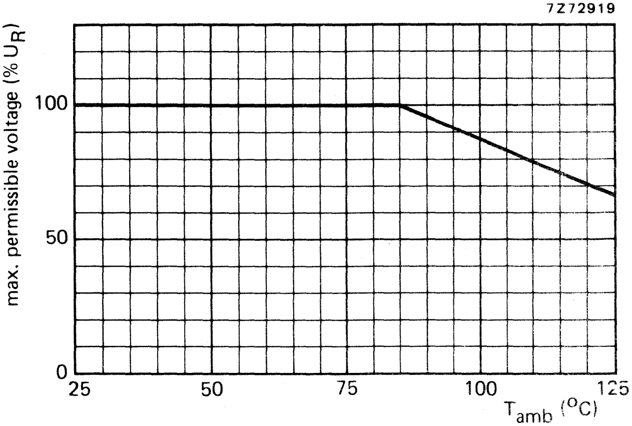


Fig.3 Maximum permissible voltage as a function of ambient temperature.

Surge voltage

The surge voltage (see Table 3) is the maximum short duration voltage which may be applied to the capacitor; i.e. turn-on transients, peak a.c. voltage, or any other voltage pulses which may be superimposed on the rated voltage. In no case may the sum of the a.c. voltage and the applied rated voltage exceed the rated d.c. surge voltage.

Table 3

U_R V	surge voltage (V)	
	at ⩽ 85 °C	at 85 to 125 °C
6	8	5
10	13	9
15	20	12
20	26	16
35	46	28
50	65	40
75	97	64
100	130	86

Surge voltage test

The appropriate surge voltage shall be applied to the test capacitors via a 1000 Ω series limiting resistor for 30 s. The test capacitors shall then be discharged via the 1000 Ω resistor for 5½ min. This charge-discharge cycle shall be repeated 2000 times.
Following the surge test the following requirements must be met:

- capacitance shall not change more than ±5%;
- dissipation factor shall meet initial requirements;
- d.c. leakage current shall meet initial requirements.

Reverse voltage

The reverse voltage is the maximum d.c. voltage applied in the reverse polarity at the maximum category temperature; its value is 0,5 V.

Ripple voltage

As in all electrical equipment the temperature rise in a capacitor must be controlled. The temperature rise is a result of the I^2 R loss in the equivalent series resistance (ESR) of the capacitor when the capacitor is subjected to an a.c. ripple current. To insure safe operating conditions the sum of the applied d.c. voltage and peak a.c. voltage should not exceed the rated voltage of the capacitor.

The maximum permissible a.c. voltage (r.m.s. value) at 60 Hz and 25 °C is shown in Fig.4. For the maximum permissible a.c. voltage at other operating conditions multiply the maximum permissible a.c. voltage found in Fig.4 by the appropriate temperature derating factor from Fig.5 and frequency derating factor from Fig.6.

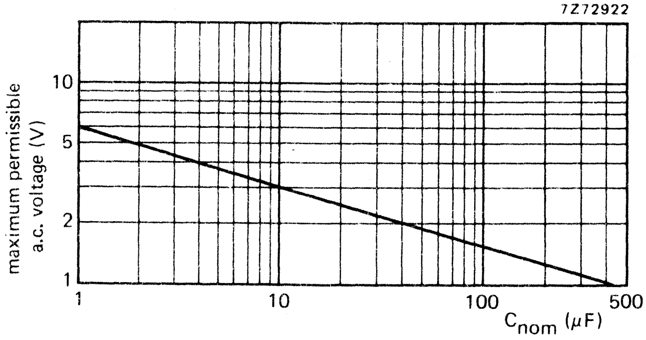


Fig.4 Maximum permissible a.c. voltage at 25 °C and 60 Hz as a function of nominal capacitance.

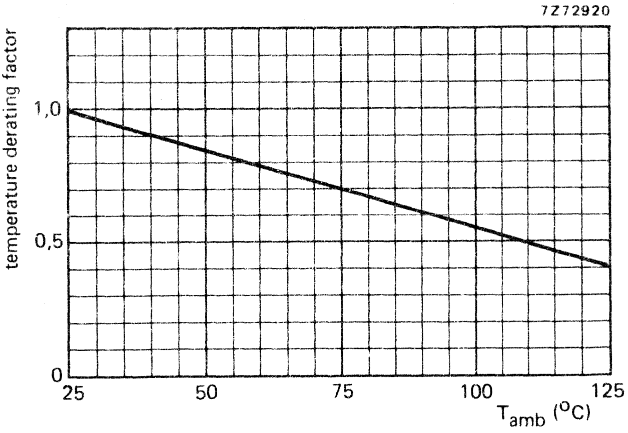


Fig.5 Effect of temperature on maximum permissible a.c. voltage.

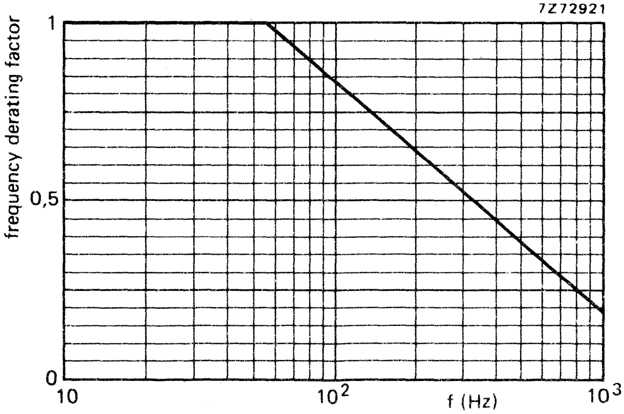


Fig.6 Effect of frequency on maximum permissible a.c. voltage.

Example

At 125 °C the maximum permissible ripple voltage of 400 Hz that can be applied to a capacitor of 10 μF is found in the following way. Fig.4 shows 2,7 V at 25 °C and 60 Hz; from Fig.5 the temperature derating factor at 125 °C is 0,4, from Fig.6 the frequency derating factor at 400 Hz is 0,45.
At the stated conditions the maximum permissible ripple voltage is 2,7 x 0,4 x 0,45 = 0,486 V.

Leakage current

The maximum leakage current 5 min after application of the rated voltage U_R is given in Table 2.

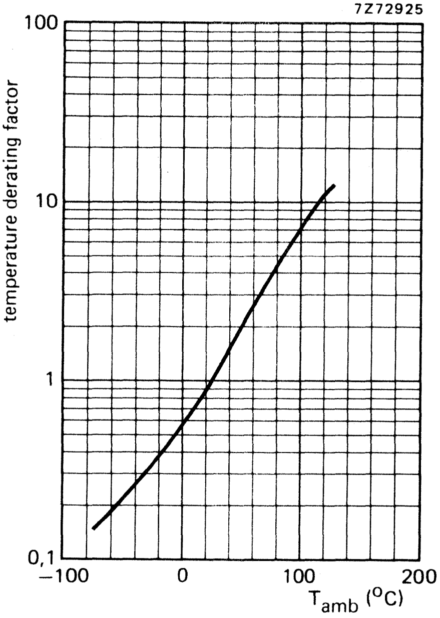


Fig.7 Typical effect of ambient temperature on leakage current.

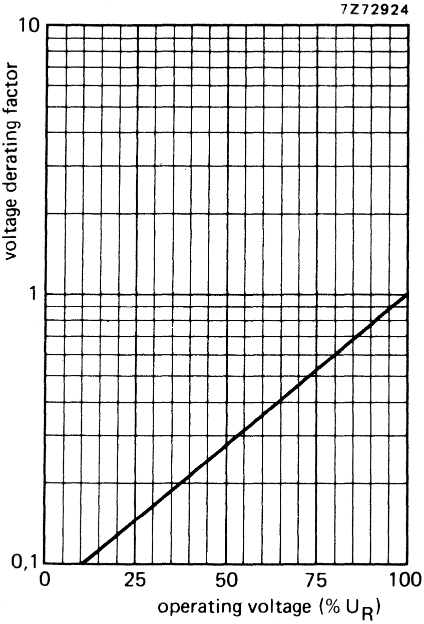


Fig.8 Typical effect of operating voltage on leakage current.

Tan δ (dissipation factor)

Tan δ at 100 Hz at −55 to +85 °C, measured by means of a four-terminal circuit (Thomson circuit), is given in Table 2.

Impedance

The impedance is measured by means of a four-terminal circuit (Thomson circuit).
See graphs on the following pages.

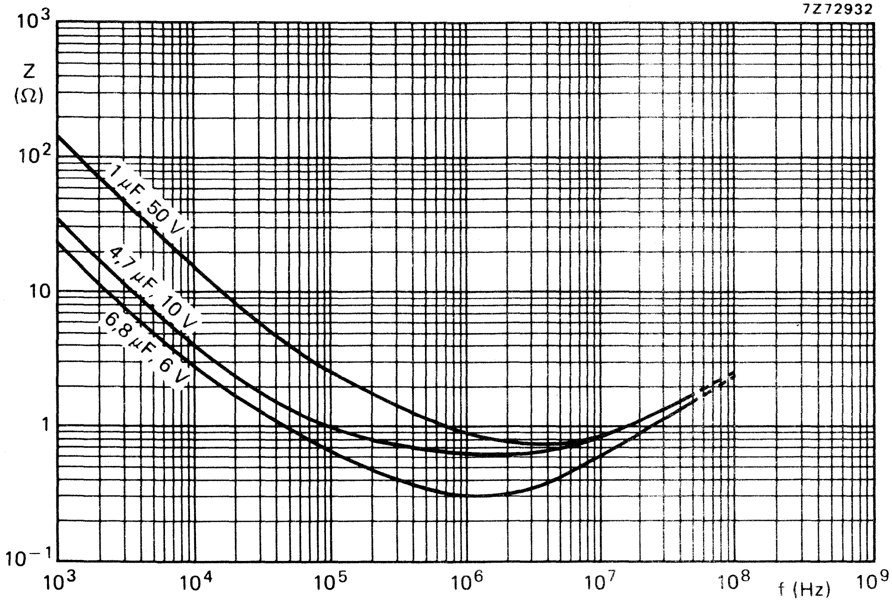


Fig.9 Typical impedance as a function of frequency at 25 °C; case size A.

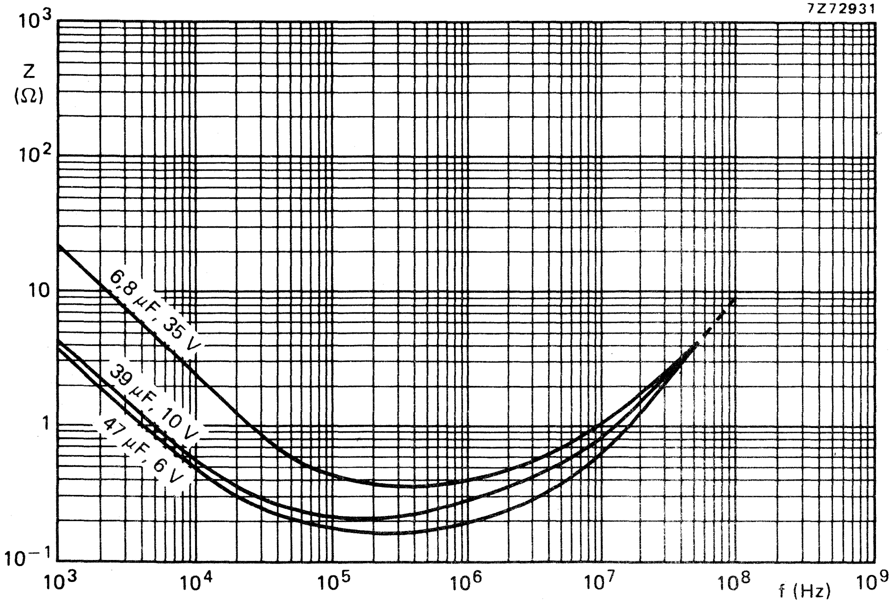


Fig.10 Typical impedance as a function of frequency at 25 °C; case size B.

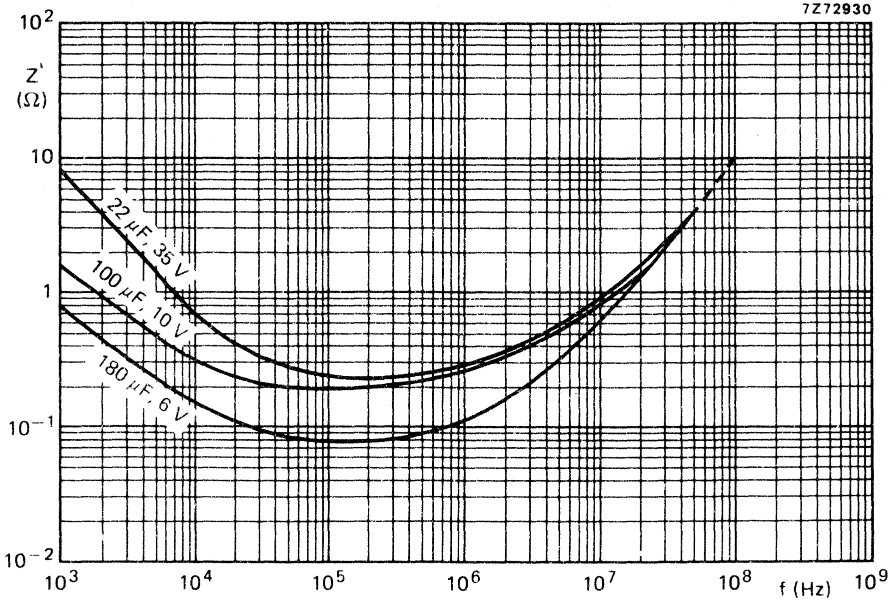


Fig.11 Typical impedance as a function of frequency at 25 °C; case size C.

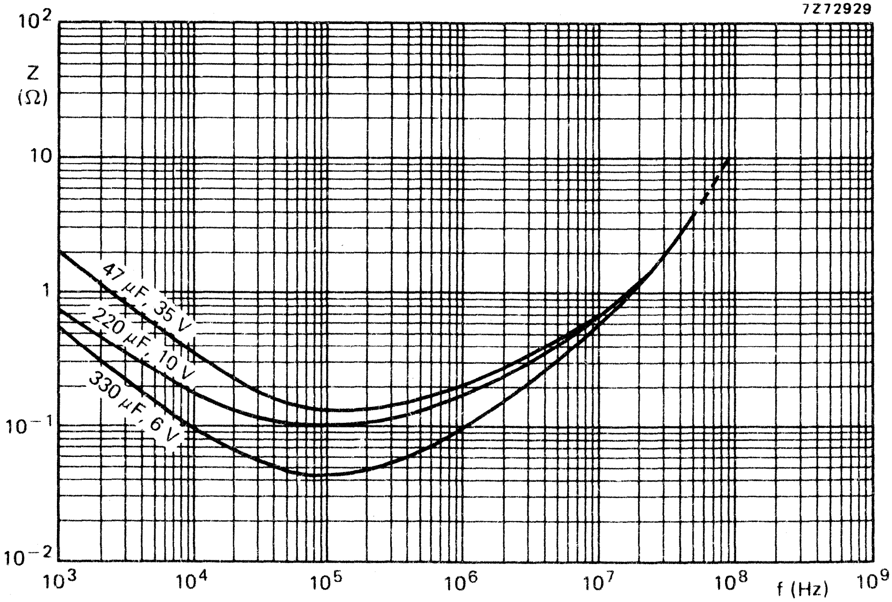


Fig.12 Typical impedance as a function of frequency at 25 °C; case size D.

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

Tan δ and C at 100 Hz are given in Table 2.

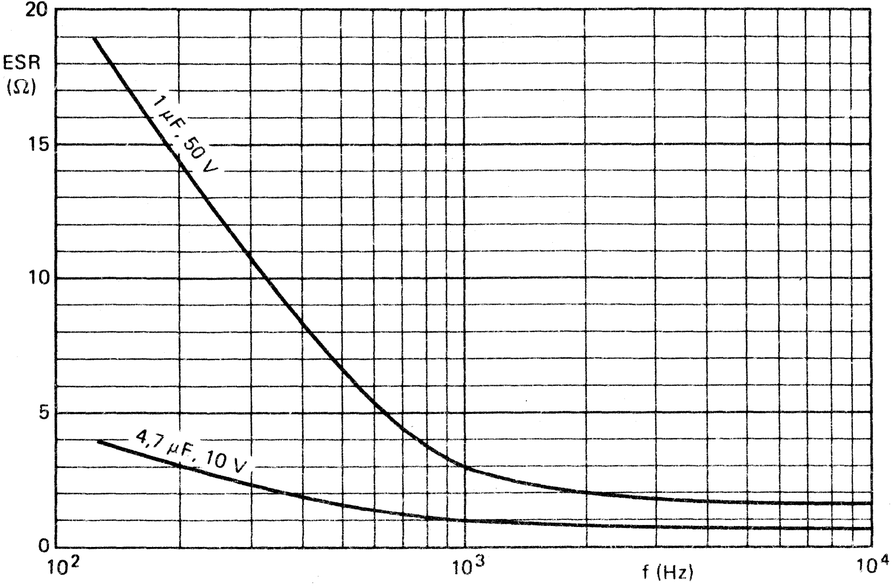


Fig.13 Typical ESR as a function of frequency; case size A.

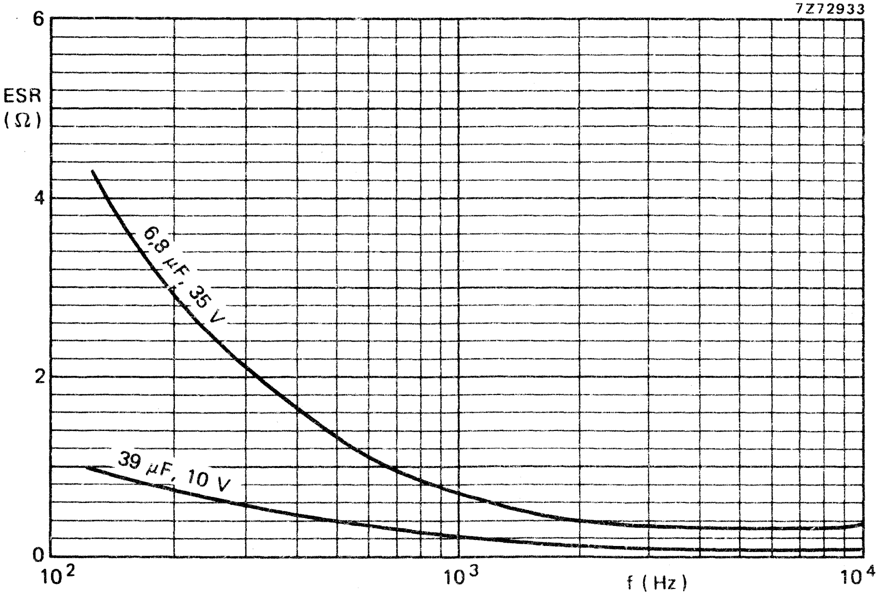


Fig.14 Typical ESR as a function of frequency; case size B.

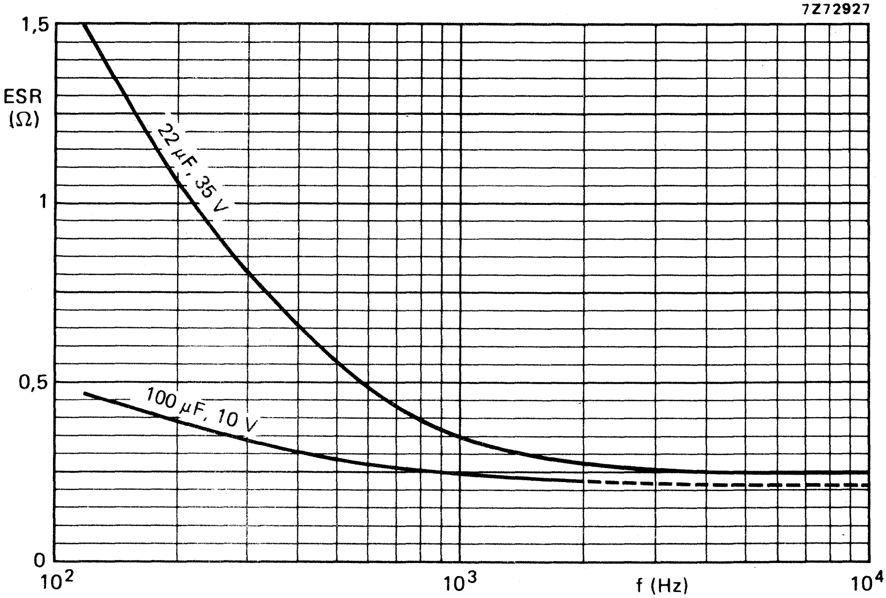


Fig.15 Typical ESR as a function of frequency; case size C.

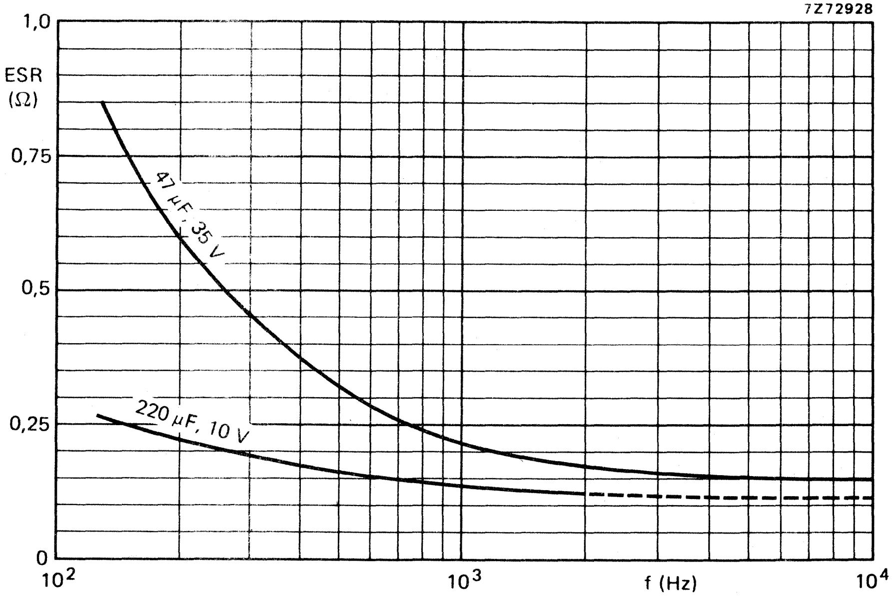


Fig.16 Typical ESR as a function of frequency; case size D.

OPERATIONAL DATA

Category temperature range

Category temperature range	
at U_R	−55 to +85 °C
at 0,67 U_R	−55 to +125 °C

Low-impedance applications

A word of caution concerning the use of solid electrolyte tantalum capacitors in low impedance circuits. Solid electrolyte tantalum capacitors do not have the self-healing characteristics of the liquid electrolyte types, nor do the solids have the ability to dampen or disperse current surges in the manner of the liquid electrolyte types. Both of these characteristics of solid electrolyte capacitors result in increased failure rates as the circuit impedance, as seen by the capacitor, is reduced. Experience has shown that a circuit resistance of 3 Ω per volt is desirable to limit possible surge damage to the dielectric.

Reliability

The reliability of the solid tantalum capacitor is dependent upon the operating voltage and temperature. This relationship is clearly defined in the reliability alignment chart (Fig.17). The designer may use this nomogram as an aid in predicting failure rate under conditions of voltage and temperature which are different to those for which the failure rate is known.

Note
The failure rates are normally established at maximum rated conditions (85 °C, rated voltage, maximum circuit impedance 3 Ω). The alignment chart will then give expected failure rate under actual operating conditions. For example, if a particular batch of capacitors has a failure rate of 0,5%/1000 h at 85 °C, rated voltage, and if these capacitors are operated at 70% of rated voltage and 83 °C, the failure rate will improve by about 2 orders of magnitude to 0,005%/1000 h.
The increase in circuit impedance provides additional improvement in failure rate as shown in Table 4.

Table 4

circuit impedance Ω/V	failure rate improvement (multiplying factors)
0,1	1,0
0,2	0,8
0,4	0,6
0,6	0,4
0,8	0,3
1,0	0,2
2,0	0,1
3 or greater	0,07

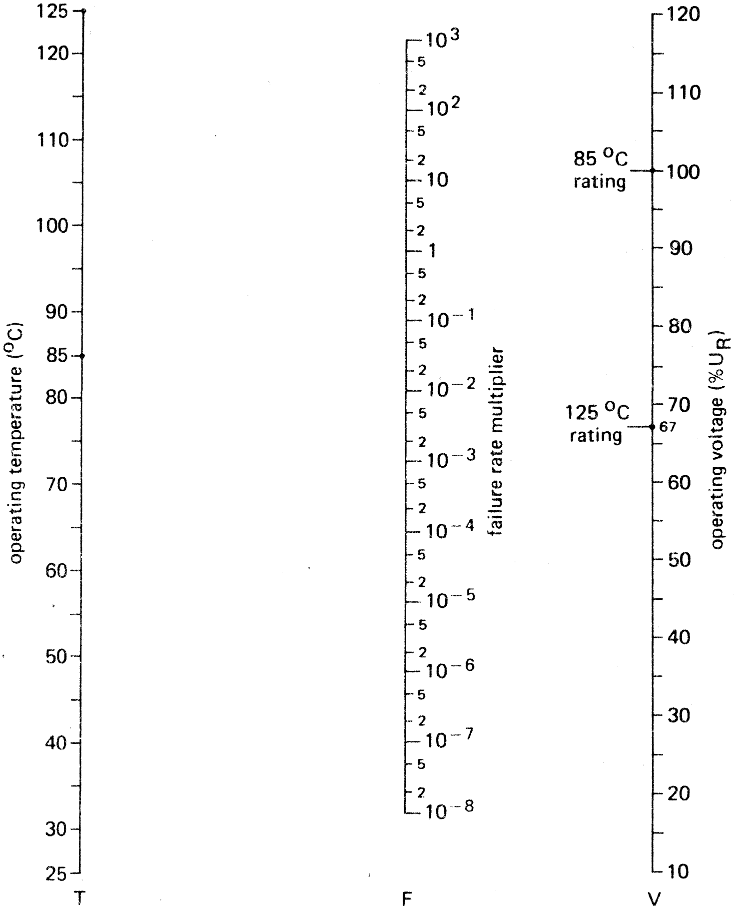


Fig.17 Reliability alignment chart. Connect the temperature and applied voltage of interest with a straight edge. The multiplier of rated failure is given at the intersection of this line with the model scale.

PACKING

Case size A: 1000 pieces per box.
Case size B: 1000 pieces per box.
Case size C: 400 pieces per box.
Case size D: 300 pieces per box.

SOLID TANTALUM CAPACITORS

hermetic seal tubular case, axial leads

QUICK REFERENCE DATA	
Nominal capacitance range (E12 series)	0,1 to 330 μF
Tolerance on nominal capacitance	±20% and ±10% (±5% on request)
Rated voltage range, U_R	6 to 50 V
Category temperature range at U_R at 0,67 U_R	−55 to +85 °C −55 to +125 °C
Endurance test at 85 °C, at U_R at 125 °C, at 0,67 U_R	2000 h 2000 h
Basic specification	MIL-STD-C-39003
Climatic category, IEC 68, at U_R at 0,67 U_R	55/085/56 55/125/56

Selection chart for C-U_R and relevant case sizes.

C_{nom} (μF)	U_R (V)					
	6	10	15	20	35	50
0,1					A	A
0,12					A	A
0,15					A	A
0,18					A	A
0,22					A	A
0,27					A	A
0,33					A	A
0,39					A	A
0,47					A	A
0,56					A	A
0,68					A	A
0,82					A	A
1					A	A
1,2				A	B	B
1,5				A	B	B
1,8				A	B	B
2,2				A	B	B
2,7			A		B	B
3,3			A		B	B
3,9		A			B	B
4,7		A			B	B
5,6	A				B	C

C_{nom} (μF)	U_R (V)					
	6	10	15	20	35	50
6,8	A				B	C
8,2				B	C	C
10				B	C	C
12				B	C	C
15				B	C	C
18			B		C	C
22			B		C	D
27		B		C	D	
33		B		C	D	
39		B		C	D	
47	B			C	D	
56	B		C	D		
68			C	D		
82		C		D		
100		C		D		
120		C	D			
150	C		D			
180	C	D				
220		D				
270	D					
330	D					

APPLICATION

These capacitors are designed for use as :

- bypass capacitors;
- coupling capacitors (decoupling);
- filter capacitors;
- blocking capacitors;
- timing capacitors.

They are intended for use in polarized or d.c. biased circuits where the a.c. component is small compared to the d.c. rated voltage.

DESCRIPTION

The capacitors consist of a highly purified sintered tantalum anode body utilizing an electrolytically formed oxide dielectric, and a solid electrolyte, enclosed in a hermetically sealed insulated metal case with axial leads. Standard construction includes tin-lead plated leads.

MECHANICAL DATA

Dimensions in mm (including insulation)

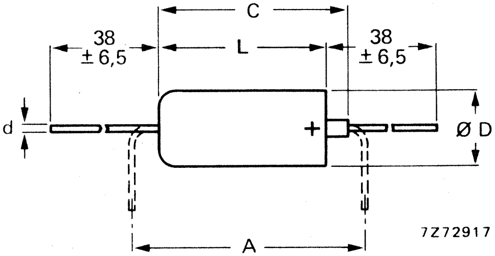


Fig. 1

Table 1

case size	A	D		L		C_{max}	d		approx. mass (g)
A	12,7	3,43	+0,41 −0,38	7,26	± 0,79	10,72	0,51	± 0,05	0,7
B	17,8	4,70		12,04		15,49	0,51		1,6
C	25,4	7,34		17,42		20,88	0,64		4,9
D	27,9	8,92		19,96		23,42	0,64		8,8

Marking

The capacitors are marked as follows :

1st line : polarity and company logo;
2nd line : nominal capacitance and tolerance on nominal capacitance;
3rd line : polarity and rated voltage;
4th line : date code (year and week).

Marking examples of capacitors with different case sizes :

case size A	case size B	case size C and D
+NCI	+NCI	+NCI
1.0K 1)	6.8M 1)	100 ± 10%
+ 35 V	+ 25 VDC	+ 10 VDC
7626	7626	7626

---

1) K = ± 10%; M = ± 20%.

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 1)	nom. cap. (μF) 1)	max. leakage current at U_R after 5 min at T_{amb} = 25 °C (μA) 1)	max. tan δ 1)	case size	catalogue number 2)
6	5,6	0,6	0,06	A	2222 143 .3568
	6,8	0,6	0,06	A	.3688
	47	4	0,06	B	.3479
	56	5	0,06	B	.3569
	150	9	0,08	C	.3151
	180	11	0,08	C	.3181
	270	16	0,08	D	.3271
	330	20	0,08	D	.3331
10	3,9	0,6	0,06	A	2222 143 .4398
	4,7	0,7	0,06	A	.4478
	27	4	0,06	B	.4279
	33	5	0,06	B	.4339
	39	5	0,06	B	.4399
	82	8	0,06	C	.4829
	100	10	0,08	C	.4101
	120	12	0,08	C	.4121
	180	18	0,08	D	.4181
	220	20	0,08	D	.4221
15	2,7	0,6	0,06	A	2222 143 .5278
	3,3	0,8	0,06	A	.5338
	18	4	0,06	B	.5189
	22	5	0,06	B	.5229
	56	7	0,06	C	.5569
	68	9	0,06	C	.5689
	120	13	0,08	D	.5121
	150	15	0,08	D	.5151
20	1,2	0,6	0,04	A	2222 143 .6128
	1,5	0,6	0,04	A	.6158
	1,8	0,6	0,04	A	.6188
	2,2	0,7	0,04	A	.6228
	8,2	2,5	0,06	B	.6828

---

1) See also corresponding paragraph.

2) Replace dot in catalogue number by: 1 for capacitance tolerance ±20%;
8 for capacitance tolerance ± 10%.

Table 2 (continued)

U_R (V) 1)	nom. cap. (μF) 1)	max. leakage current at U_R after 5 min at T_{amb} = 25 °C (μA) 1)	max. tan δ 1)	case size	catalogue number 2)
20	10	3,0	0,06	B	2222 143 .6109
	12	3,5	0,06	B	.6129
	15	5	0,06	B	.6159
	27	5	0,06	C	.6279
	33	6	0,06	C	.6339
	39	6	0,06	C	.6399
	47	7	0,06	C	.6479
	56	8,5	0,06	D	.6569
	68	10	0,06	D	.6689
	82	12	0,06	D	.6829
	100	15	0,06	D	.6101
35	0,1	0,6	0,04	A	2222 143 .7107
	0,12	0,6	0,04	A	.7127
	0,15	0,6	0,04	A	.7157
	0,18	0,6	0,04	A	.7187
	0,22	0,6	0,04	A	.7227
	0,27	0,6	0,04	A	.7277
	0,33	0,6	0,04	A	.7337
	0,39	0,6	0,04	A	.7397
	0,47	0,6	0,04	A	.7477
	0,56	0,6	0,04	A	.7567
	0,68	0,6	0,04	A	.7687
	0,82	0,6	0,04	A	.7827
	1,0	0,6	0,04	A	.7108
	1,2	0,6	0,04	B	.7128
	1,5	0,8	0,04	B	.7158
	1,8	1	0,04	B	.7188
	2,2	1,2	0,04	B	.7228
	2,7	1,4	0,04	B	.7278
	3,3	1,7	0,04	B	.7338
	3,9	2	0,04	B	.7398
	4,7	2,5	0,04	B	.7478
	5,6	3	0,06	B	.7568
	6,8	3,5	0,06	B	.7688
	8,2	3,5	0,06	C	.7828
	10	4	0,06	C	.7109
	12	4	0,06	C	.7129

---

1) See also corresponding paragraph.

2) Replace dot in catalogue number by: 1 for capacitance tolerance ± 20%;
8 for capacitance tolerance ± 10%.

Table 2 (continued)

U_R (V) 1)	nom. cap. (μF) 1)	max. leakage current at U_R after 5 min at T_{amb} = 25 °C (μA) 1)	max. tan δ 1)	case size	catalogue number 2)
35	15	6	0,06	C	2222 143 .7159
	18	6	0,06	C	.7189
	22	7	0,06	C	.7229
	27	7	0,06	D	.7279
	33	8	0,06	D	.7339
	39	10	0,06	D	.7399
	47	10	0,06	D	.7479
50	0,1	0,6	0,04	A	2222 143 .8107
	0,12	0,6	0,04	A	.8127
	0,15	0,6	0,04	A	.8157
	0,18	0,6	0,04	A	.8187
	0,22	0,6	0,04	A	.8227
	0,27	0,6	0,04	A	.8277
	0,33	0,6	0,04	A	.8337
	0,39	0,6	0,04	A	.8397
	0,47	0,6	0,04	A	.8477
	0,56	0,6	0,04	A	.8567
	0,68	0,6	0,04	A	.8687
	0,82	0,7	0,04	A	.8827
	1,0	0,8	0,04	A	.8108
	1,2	0,9	0,04	B	.8128
	1,5	1,2	0,04	B	.8158
	1,8	1,4	0,04	B	.8188
	2,2	1,7	0,04	B	.8228
	2,7	2	0,04	B	.8278
	3,3	2,5	0,04	B	.8338
	3,9	3	0,04	B	.8398
	4,7	3,5	0,04	B	.8478
	5,6	4,5	0,04	C	.8568
	6,8	5	0,06	C	.8688
	8,2	5	0,06	C	.8828
	10	5	0,06	C	.8109
	12	6	0,06	C	.8129
	15	6	0,06	C	.8159
	18	7	0,06	C	.8189
	22	8	0,06	D	.8229

---

1) See also corresponding paragraph.

2) Replace dot in catalogue number by: 1 for capacitance tolerance ±20%;
8 for capacitance tolerance ± 10%.

Note : The following versions are available on request :
U_R = 35 V;
capacitance range (E 12 series) : 0,0047 to 0,082 µF; case size A.

U_R = 75 V;
capacitance range (E 12 series) : 0,0047 to 0,68 µF; case size A;
0,82 to 3,9 µF; case size B;
4,7 to 10 µF; case size C;
12 to 15 µF; case size D.

U_R = 100 V;
capacitance range (E 12 series) : 0,0047 to 0,56 µF; case size A;
0,68 to 2,7 µF; case size B.

On request the above-mentioned capacitance values, and all capacitance values in Table 2, are available with a tolerance of ±5%.

Capacitance

Nominal capacitance values at 100 Hz	see Table 2
Tolerance on nominal capacitance at 100 Hz	±20% and ± 10%

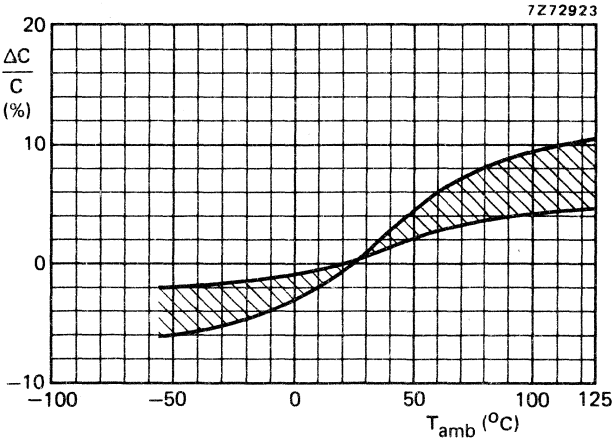


Fig. 2. Typical capacitance as a function of ambient temperature.

The change in capacitance from initial 25 °C measured capacitance shall not exceed the following percentages :
10% at −55 °C;
8% at + 85 °C;
12% at + 125 °C.

Voltage

Rated voltage

Rated voltage = maximum permissible voltage at −55 to +85 °C U_R, see Table 2

The capacitors may be further operated up to 125 °C by derating the rated voltage in accordance with the following graph.

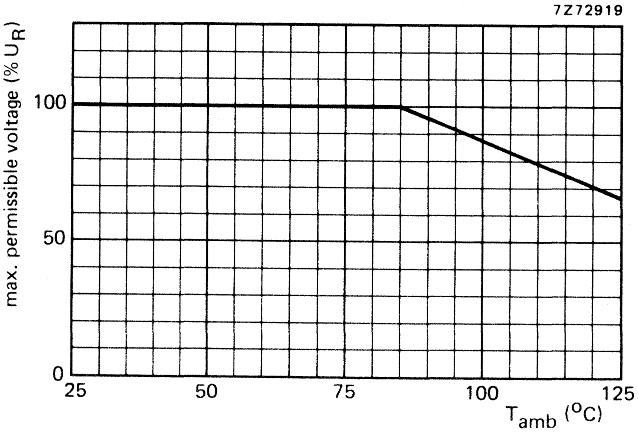


Fig. 3. Maximum permissible voltage as a function of ambient temperature.

Surge voltage

The surge voltage (see Table 3) is the maximum short duration voltage which may be applied to the capacitor; i.e. turn-on transients, peak a.c. voltage, or any other voltage pulses which may be superimposed on the rated voltage. In no case may the sum of the a.c. voltage and the applied rated voltage exceed the rated d.c. surge voltage.

Table 3

U_R (V)	surge voltage (V)	
	at ≤ 85 °C	at 85 to 125 °C
6	8	5
10	13	9
15	20	12
20	26	16
35	46	28
50	65	40
75	97	64
100	130	86

Surge voltage test

The appropriate surge voltage shall be applied to the test capacitors via a 1000 Ω series limiting resistor for 30 s. The test capacitors shall then be discharged via the 1000 Ω resistor for $5\frac{1}{2}$ min. This charge-discharge cycle shall be repeated 2000 times.
Following the surge test the following requirements must be met:

- capacitance shall not change more than ± 5%;
- dissipation factor shall meet initial requirements;
- d.c. leakage current shall meet initial requirements.

Reverse voltage

Reverse voltage	= maximum d.c. voltage applied in the reverse polarity at the maximum category temperature	0,5 V

Ripple voltage

As in all electrical equipment the temperature rise in a capacitor must be controlled. The temperature rise is a result of the I^2R loss in the Equivalent Series Resistance (ESR) of the capacitor when the capacitor is subjected to an a.c. ripple current.
To insure safe operating conditions the sum of the applied d.c. voltage and peak a.c. voltage should not exceed the rated voltage of the capacitor.

The maximum permissible a.c. voltage (r.m.s. value) at 60 Hz and 25 °C is shown in Fig. 4. For the maximum permissible a.c. voltage at other operating conditions multiply the maximum permissible a.c. voltage found in Fig. 4 by the appropriate temperature derating factor from Fig. 5 and frequency derating factor from Fig. 6.

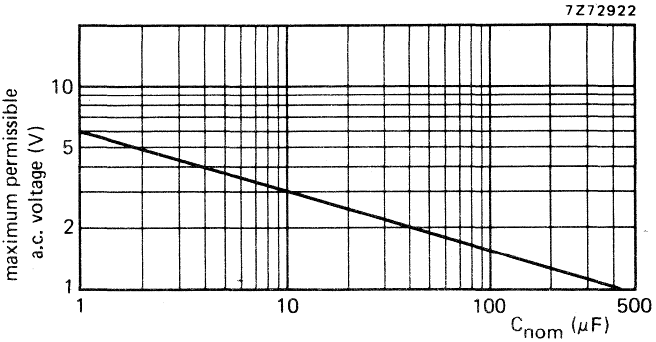


Fig. 4. Maximum permissible a.c. voltage at 25 °C and 60 Hz as a function of nominal capacitance.

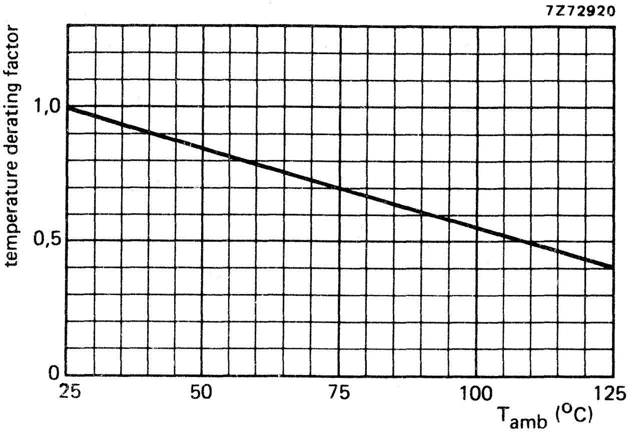


Fig. 5. Effect of temperature on maximum permissible a.c. voltage.

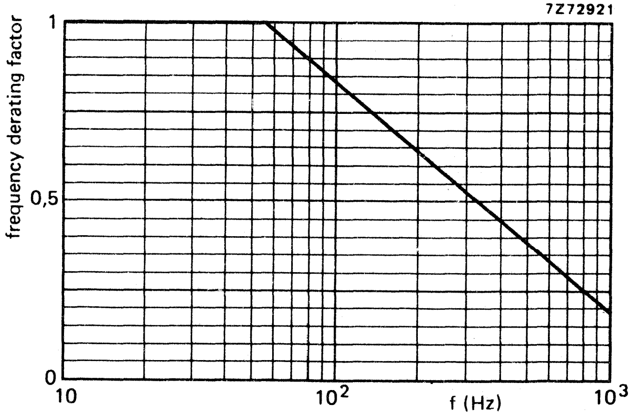


Fig. 6. Effect of frequency on maximum permissible a.c. voltage.

Example: At 125 °C the maximum permissible ripple voltage of 400 Hz that can be applied to a capacitor of 10 µF is found in the following way. Fig. 4 shows 2,7 V at 25 °C and 60 Hz; from Fig. 5 the temperature derating factor at 125 °C is 0,4, from Fig. 6 the frequency derating factor at 400 Hz is 0,45.
At the stated conditions the maximum permissible ripple voltage is
2,7 x 0,4 x 0,45 = 0,486 V.

Leakage current

Maximum leakage current 5 min after application of the rated voltage U_R at 25 °C	see Table 2
at 85 °C	10 x value stated in Table 2
at 125 °C	12 x value stated in Table 2

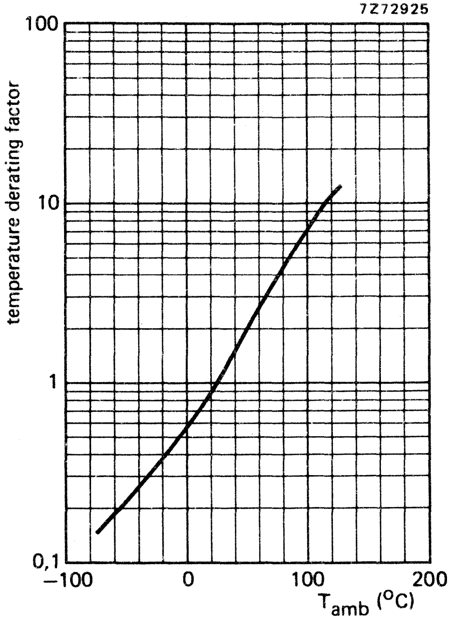


Fig. 7. Typical effect of ambient temperature on leakage current.

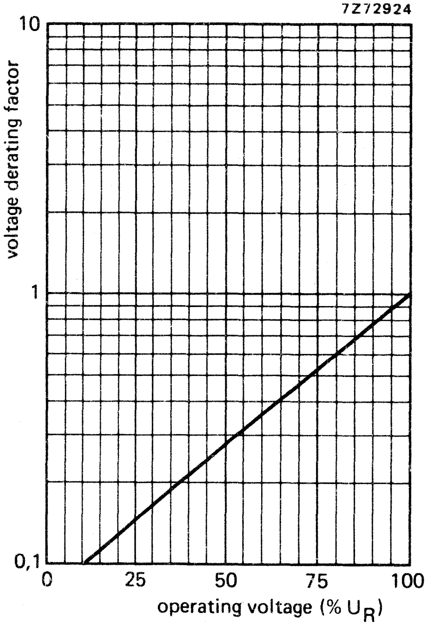


Fig. 8. Typical effect of operating voltage on leakage current.

Tan δ (dissipation factor)

Tan δ at 100 Hz at −55 to + 85 °C, measured by means of a four-terminal circuit (Thomson circuit)	see Table 2

Impedance

The impedance is measured by means of a four-terminal circuit (Thomson circuit). See graphs on the following pages.

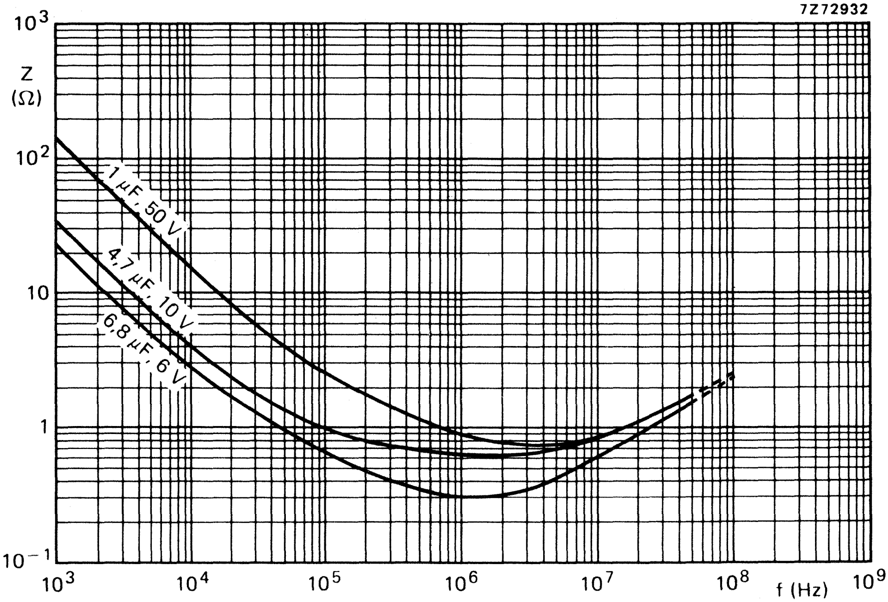


Fig. 9. Typical impedance as a function of frequency at 25 °C; case size A.

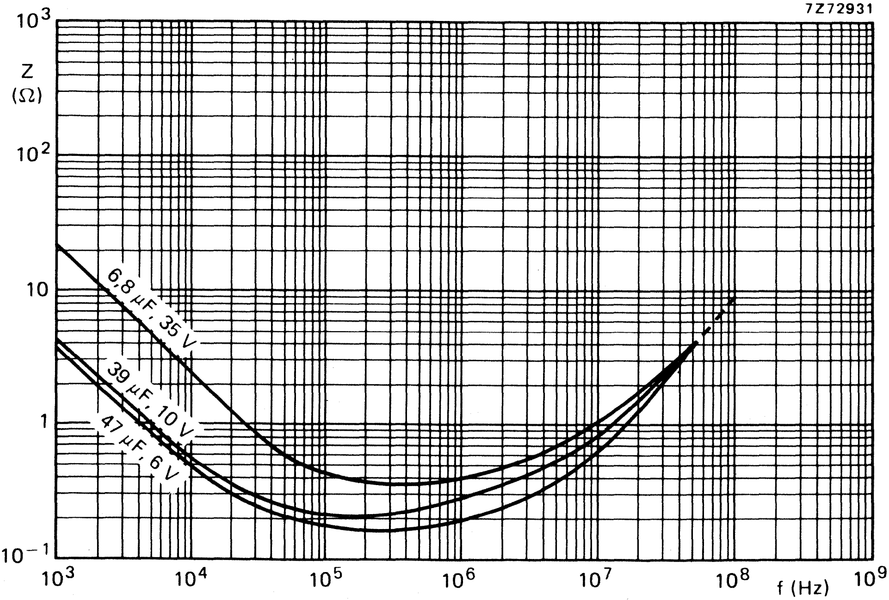


Fig. 10. Typical impedance as a function of frequency at 25 °C; case size B.

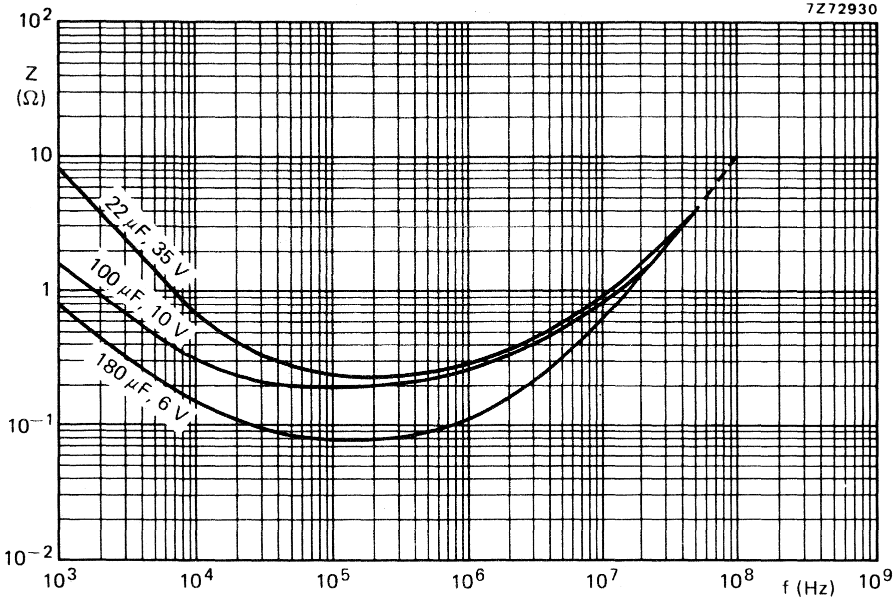


Fig. 11. Typical impedance as a function of frequency at 25 °C; case size C.

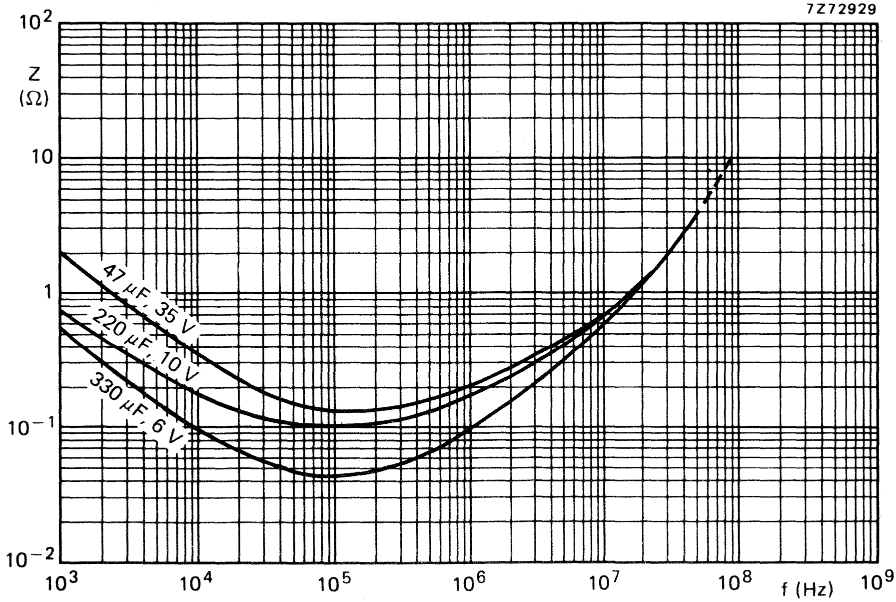


Fig. 12. Typical impedance as a function of frequency at 25 °C; case size D.

Equivalent series resistance (ESR = tan δ/ωC)

Tan δ and C at 100 Hz see Table 2

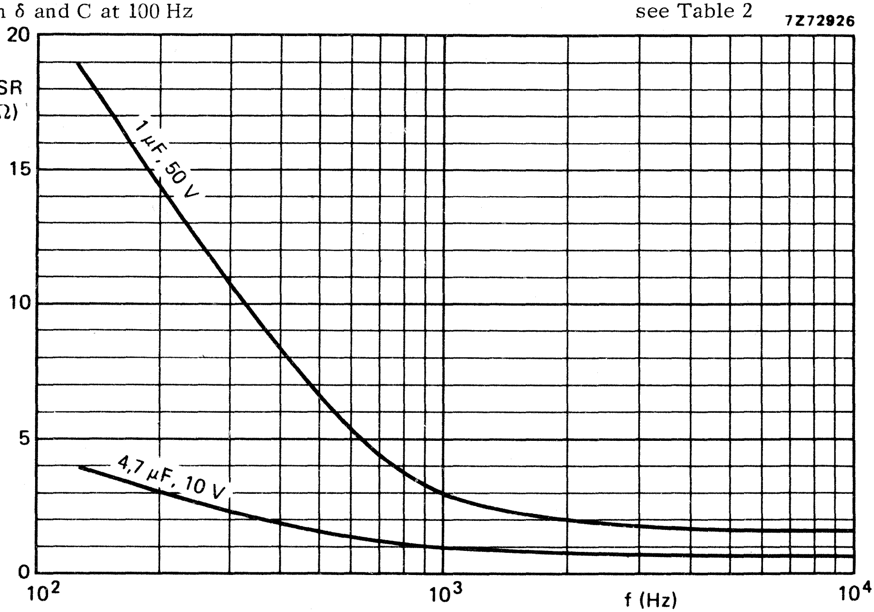


Fig. 13. Typical ESR as a function of frequency; case size A.

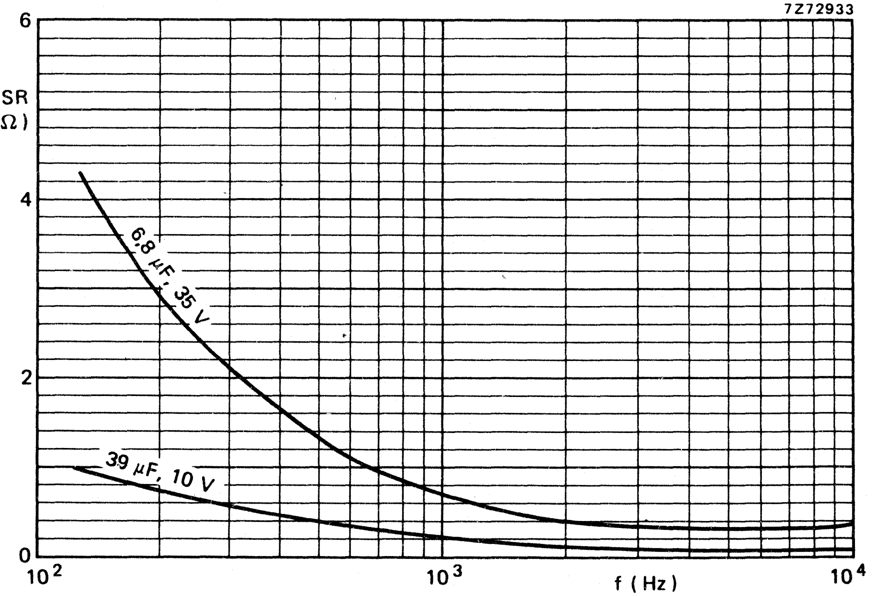


Fig. 14. Typical ESR as a function of frequency; case size B.

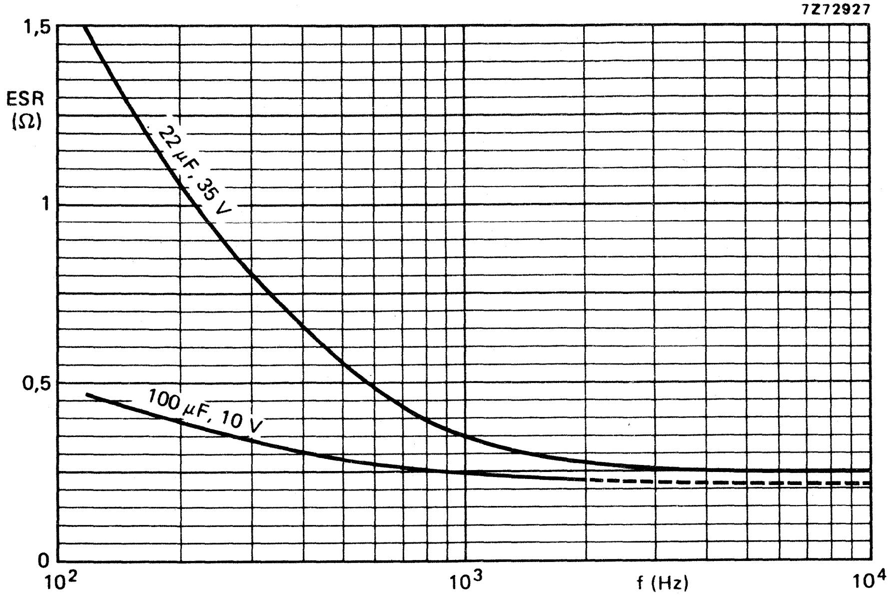


Fig. 15. Typical ESR as a function of frequency; case size C.

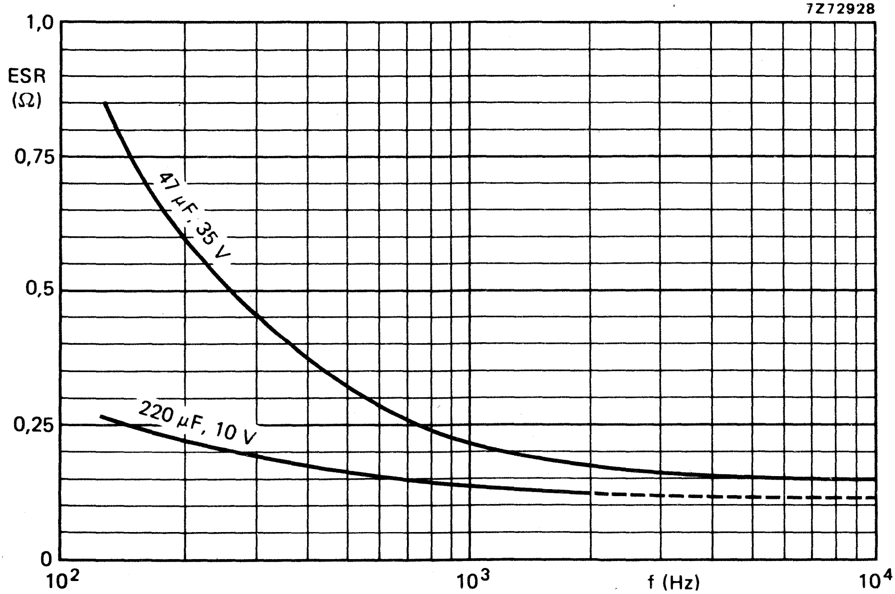


Fig. 16. Typical ESR as a function of frequency; case size D.

OPERATIONAL DATA

Category temperature range

Category temperature range at U_R	−55 to +85 °C
at 0,67 U_R	−55 to +125 °C

Low-impedance applications

A word of caution concerning the use of solid electrolyte tantalum capacitors in low impedance circuits. Solid electrolyte tantalum capacitors do not have the "self-healing" characteristics of the liquid electrolyte types, nor do the solids have the ability to dampen or disperse current surges in the manner of the liquid electrolyte types. Both of these characteristics of solid electrolyte capacitors result in increased failure rates as the circuit impedance, as seen by the capacitor, is reduced. Experience has shown that a circuit resistance of 3 Ω per volt is desirable to limit possible surge damage to the dielectric.

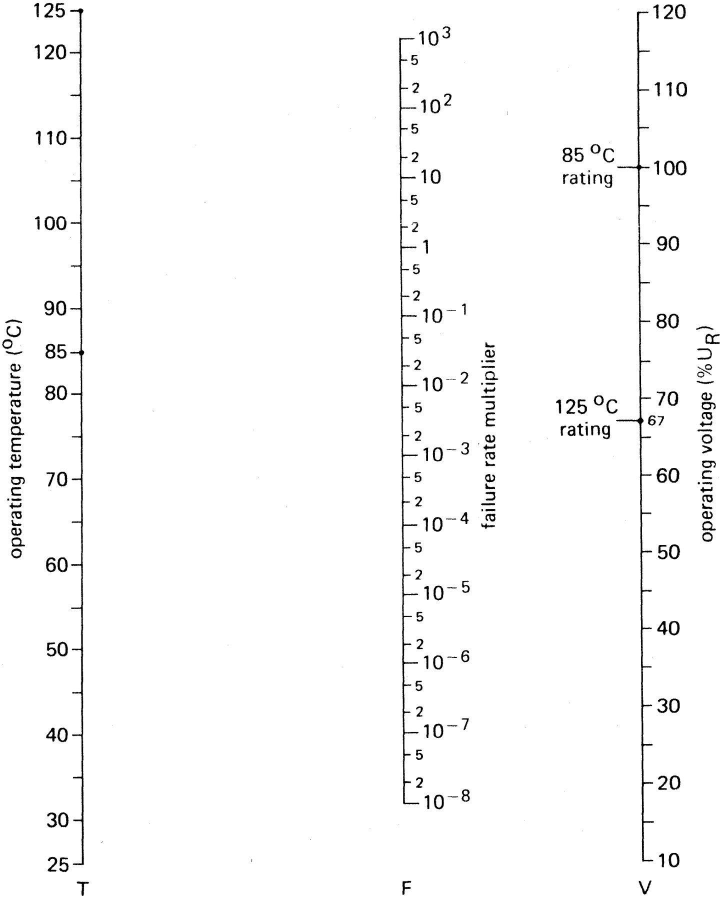
Reliability

The reliability of the solid tantalum capacitor is dependent upon the operating voltage and temperature. This relationship is clearly defined in the reliability alignment chart (Fig. 17). The designer may use this nomogram as an aid in predicting failure rate under conditions of voltage and temperature which are different than those for which the failure rate is known.

Note: The failure rates are normally established at maximum rated conditions (85 °C, rated voltage, maximum circuit impedance 3 Ω). The alignment chart will then give expected failure rate under actual operating conditions. For example, if a particular batch of capacitors has a failure rate of 0,5%/1000 h at 85 °C, rated voltage and if these capacitors are operated at 70% of rated voltage and 83 °C, the failure rate will improve by about 2 orders of magnitude to 0,005%/1000 h.
The increase in circuit impedance provides additional improvement in failure rate as shown in Table 4.

Table 4 - Failure rate improvement with circuit impedance.

Circuit impedance (Ω/V)	Failure rate improvement (multiplying factors)
0,1	1,0
0,2	0,8
0,4	0,6
0,6	0,4
0,8	0,3
1,0	0,2
2,0	0,1
3 or greater	0,07



7Z72918

Fig. 17. Reliability alignment chart.
Connect the temperature and applied voltage of interest with a straight edge. The multiplier of rated failure is given at the intersection of this line with the model scale.

PACKING

Capacitors with case size A : 1000 pieces per box;
case size B : 1000 pieces per box;
case size C : 400 pieces per box;
case size D : 300 pieces per box.

TESTS AND REQUIREMENTS

Life test

Capacitors shall be life tested for 2000 h at 85 °C or 125 °C with the appropriate rated voltage applied.
After life test when measured at 25 °C the dissipation factor shall meet the initial requirement. The leakage current shall not be more than 125% of the original requirements and capacitance shall not have changed more than ± 10% from the initial value.
Not more than 1 failure shall be permitted in 25 units tested.

Environmental tests

1. Low-frequency vibration

The capacitors shall be rigidly mounted by suitable case clamps and subjected to a simple harmonic motion having a maximum amplitude of 0,03 in. The frequency shall be varied uniformly over a frequency range of 10 to 55 Hz in approximately 1 min at a uniform rate for a total of 2 h. Rated voltage will be applied to the units during test. During the last $\frac{1}{2}$ hour of test, the test units will be monitored by an instrument capable of detecting intermittent open or short circuits with a duration of 0,5 ms or greater.
After vibration the capacitors shall meet the initial requirements of dissipation factor and leakage current. The capacitance shall not change more than ± 5% from the initial measured value.

1A. High-frequency vibration

The capacitors shall be rigidly mounted by suitable case clamps and subjected to a simple harmonic motion having a maximum amplitude of 0,03 in or 15 g in 2 mutually perpendicular directions (1 parallel and 1 perpendicular to the cylindrical axis).
Capacitors shall withstand vibration from 10 to 10 000 Hz at 15 g without internal damage.
The frequency shall be varied uniformly over a frequency range of 55 to 2000 Hz in approximately 20 min at a uniform rate for a total of 4 h. Rated voltage will be applied to the units during test. During the last $\frac{1}{2}$ hour of test the test units will be monitored by an instrument capable of detecting intermittent open or short circuits with a duration of 0,5 ms or greater.
After vibration the capacitors shall meet the initial requirements of dissipation factor and leakage current. The capacitance shall not change more than ± 5% from the initial measured value.

2. Lead strength

With the body of the capacitor secured, the leads shall withstand a 3 lb load applied in any direction for 30 s.

3. Lead bend

Each capacitor lead shall be capable of withstanding 5 bends. A bend shall be defined as follows:
With the capacitor vertical and 1 lb weight attached to the lead, the capacitor body shall be slowly rotated (in approximately 5 s) to a horizontal position and then rotated to the vertical position. The 4 succeeding bends shall then be made in the same manner but in alternate directions.

4. Moisture resistance

The capacitors shall be tested in accordance with method 106 of MIL Standard 202. The following details and exceptions shall apply:

a. Mounting: the capacitors shall be securely mounted by normal mounting means during the test. This does not apply during measurements.

b. Initial measurements are not applicable.

c. Polarization and loading voltages are not applicable during the test.

d. Final measurements: within 2 to 6 hours after the capacitors have been removed from the humidity chamber following the final cycle, the d.c. leakage, capacitance and dissipation factor shall be measured as specified.

e. Examinations after test: following the final measurements the capacitors shall be examined visually for evidence of corrosion, mechanical damage and obliteration of marking.

5. Insulation sleeves

For insulated capacitors, the insulating sleeves shall be tested as follows for dielectric strength and insulation resistance:
Two wire windings shall be placed around the insulating sleeves $\frac{1}{4}$ in apart. Each winding to consist of 2 close turns of 24 AWG bare copper wire.

5A. Dielectric strength

For dielectric strength a d.c. test potential of 2000 V shall be applied for 1 min between the 2 windings. There shall be no breakdown of case insulation.

5B. Insulation resistance

For insulation resistance a d.c. test potential of 100 V shall be applied for 2 min. The insulation resistance shall not be less than 100 MΩ.

6. Shelf life test

When the capacitors have been exposed to 5000 h shelf life test at 85 °C with no voltage applied, capacitance shall not change more than ±4% from the initial measured value. The dissipation factor shall not exceed 150% of the initial requirement and the leakage current shall meet the initial requirement.

7. Shock

The capacitors shall be tested for shock resistance in accordance with MIL Standard 202 method 213, with the following exceptions.

a. The capacitors shall be rigidly mounted by suitable body clamps.

b. The capacitors shall be subjected to 18 impacts of 100 g with a 6 ms duration, as described under condition I, method 213.

c. Rated voltage shall be applied to the capacitors during the shock test.

The test units shall be monitored during test by an instrument capable of detecting intermittent open and short circuits with a duration of 0, 5 ms or greater. After test the capacitors shall meet the initial requirements for capacitance, dissipation factor and leakage current.

8. Temperature and immersion cycling

After the capacitors are tested as specified in 8A and 8B, the leakage current shall meet the initial requirement. The capacitance change shall not exceed ± 5% of the value measured prior to test and the dissipation factor shall meet the initial requirement. When examined visually, at least 90% of all exposed metallic surfaces shall show no evidence of harmful corrosion. When examined internally, there shall be no evidence of dye penetration.

8A. Temperature shock

Capacitors shall be tested in accordance with method 107 of MIL Standard 202. The following exceptions and details shall apply :

a. Capacitors should be conditioned at a temperature of 25 ^{o}C for 15 min before the first cycle of test one.

b. The B test condition will be followed except that in the third step thereof, the capacitors will be subjected to a test at the highest applicable temperature.

c. Measurements before and after cycling may be omitted.

8B. Immersion cycling

After temperature cycling, a capacitor test should be made following Method 104 set down in MIL Standard 202. The following details and exceptions, however, shall apply:

a. A non-corrosive dye, Rhodamine B (tetraethylrhodamine), or its equivalent, shall be added in both baths in addition to steps provided in test condition B.

b. Measurements after final cycle.
Measurements of leakage current, capacitance and dissipation factor shall be made within 30 min after the capacitors are removed from the final immersion bath.

c. Examinations after test.
The capacitors shall be visually examined for traces of corrosion, mechanical damage, and obliteration of marking. Capacitors shall then be sectioned for evidence of dye penetration.

9. Reduced pressure

After the capacitors have been stabilized for 5 min in a vacuum of 22,53 Pa (= $1,69 \times 10^{-1}$ torr), rated voltage shall be applied for 1 min. There shall be no voltage flashover nor shall the end seals show evidence of damage by this test. The capacitance, dissipation factor, and leakage current shall meet the initial requirements.

SOLID TANTALUM CAPACITORS

- **Subminiature type**
- **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 25 V
Category temperature range	–55 to +85 °C
Endurance test	2000 hours at 85 °C
Climatic category, IEC 68	55/085/21

Selection chart for C-U_R and relevant sizes.

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

C nom µF	U_R (V)						
	1,6	2,5	4	6,3	10	16	25
1,0		1		2		3	4
1,5	1		2		3		4
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						

For sizes see Table 1 on next page.

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

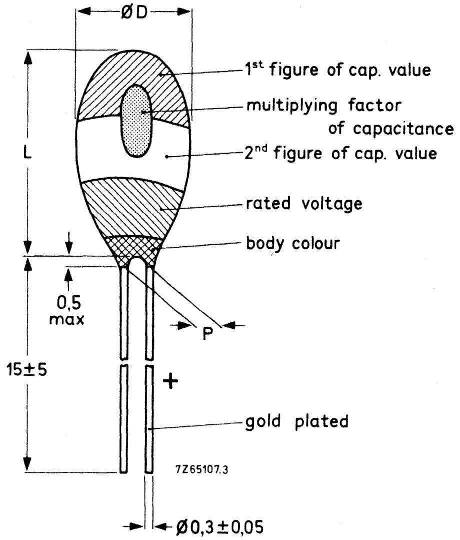


Table 1

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 2 and drawing.

Table 2

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	–	–
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 3

Unless otherwise specified all electrical values in Table 3 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 *	max. leakage current at U_R after 5 min. µA *	max. tan δ *	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

---

* See also corresponding paragraph.

Table 3 (continued)

U_R V	nom. cap. µF	max. r.m.s. ripple current at T_{amb} = 85 °C mA *	max. leakage current at U_R after 5 min. µA *	max. tan δ *	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	0,01	0,25	0,5	0,08	1	16106
	0,015	0,35	0,5	0,08	1	16156
	0,022	0,4	0,5	0,08	1	16226
	0,033	0,5	0,5	0,08	1	16336
	0,047	0,6	0,5	0,08	1	16476
	0,068	0,75	0,5	0,08	1	16686
	0,1	0,85	0,5	0,08	1	16107
	0,15	1,25	0,5	0,08	1	16157
	0,22	1,5	1	0,08	2	16227
	0,33	2	1	0,08	2	16337
	0,47	2,5	1	0,08	3	16477
	0,68	3,5	1	0,08	3	16687
	1	4,5	1,5	0,08	4	16108
	1,5	7,5	1,5	0,08	4	16158
	2,2	10	2,5	0,08	5	16228
	3,3	12,5	2,5	0,08	5	16338
	4,7	15	2,5	0,08	5	16478

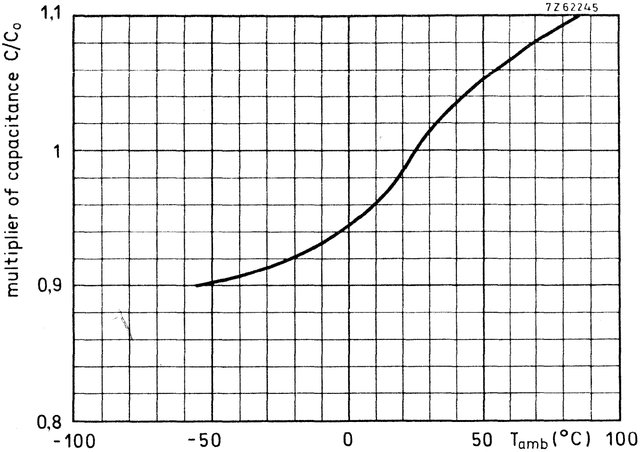
---

* 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	≤ 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 x U_R
Surge voltage	= max. permissible voltage for short periods at 85 °C (see also "Tests and requirements")	1,2 x 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 ^{o}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 ^{o}C = $(I_{r0})^2R_{s0}$

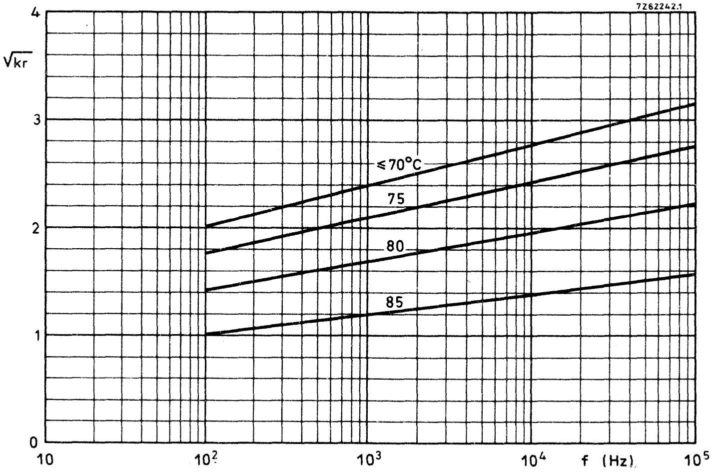
R_{s0} = series resistance at 100 Hz = $\frac{\tan\delta}{628\ C}$, C and tan δ to be read from Table 2

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

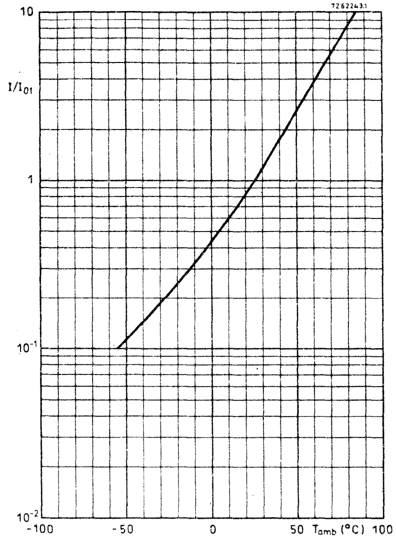
These ripple currents are not applicable if the maximum permissible ripple voltage is exceeded. In that case the ripple voltage is decisive.

Leakage current

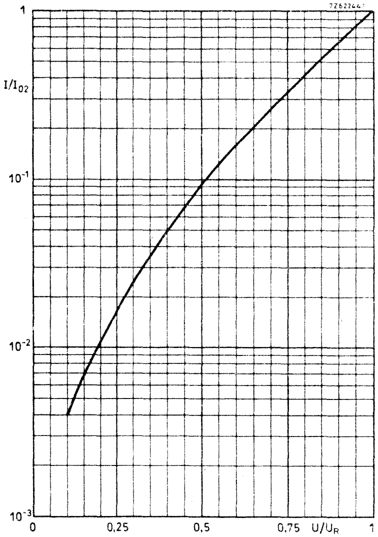
Maximum leakage current 5 min. after application of the rated voltage	see Table 2

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



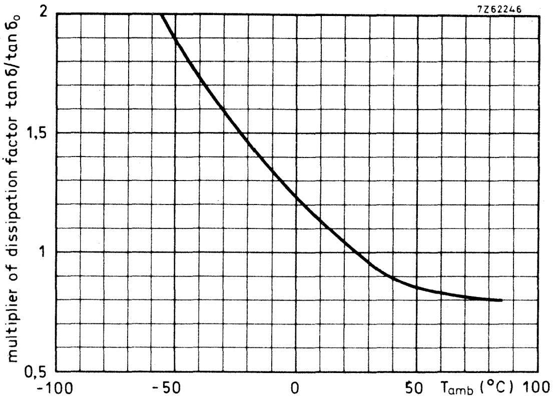
Multiplier I/I_{01} as a function of temperature
I_{01} = leakage current during continuous operation at $T_{amb} = 25\ ^oC$ at U_R



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 3

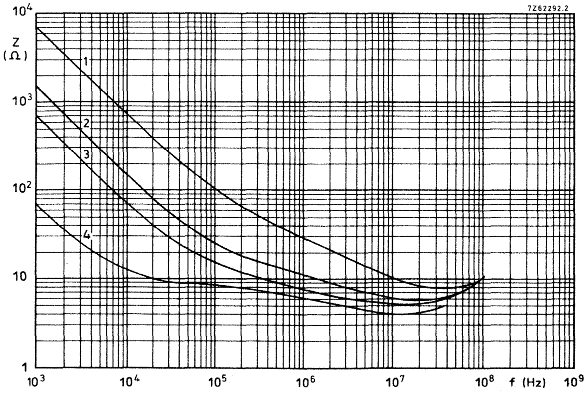


Typical dissipation factor as a function of temperature.
Tan δ_0 = dissipation factor at 25 °C, 100 Hz.

Impedance

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

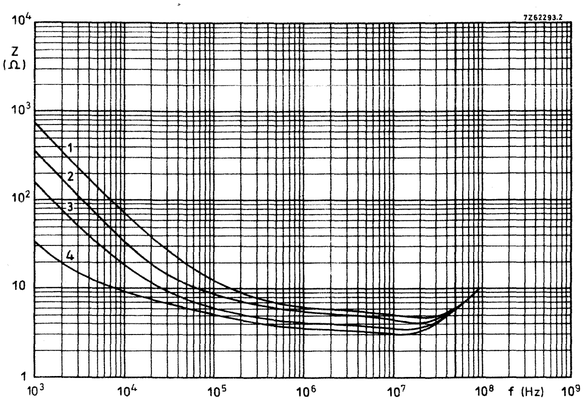
Typical impedance as a function of frequency at 25 °C



Size DTM1

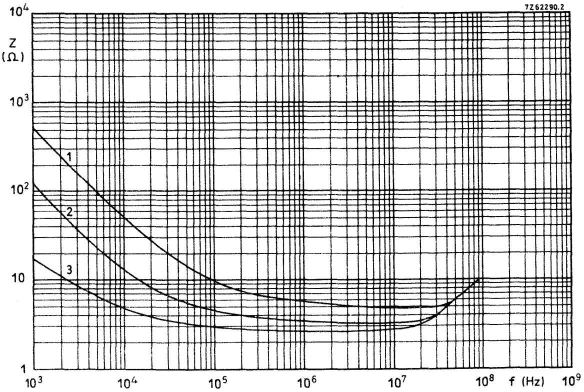
curve 1 = 0,022 μF, 25 V
2 = 0,1 μF, 25 V
3 = 0,22 μF, 16 V
4 = 2,2 μF, 1,6 V

Typical impedance as a function of frequency at 25 °C



Size DTM2

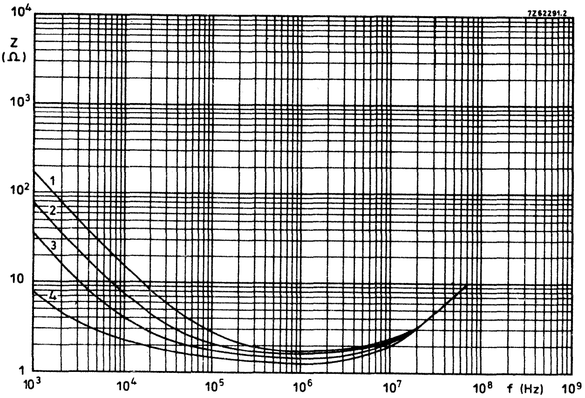
curve 1 = 0,22 μF, 25 V ←
2 = 0,47 μF, 16 V
3 = 1 μF, 6,3 V
4 = 4,7 μF, 1,6 V



Size DTM3

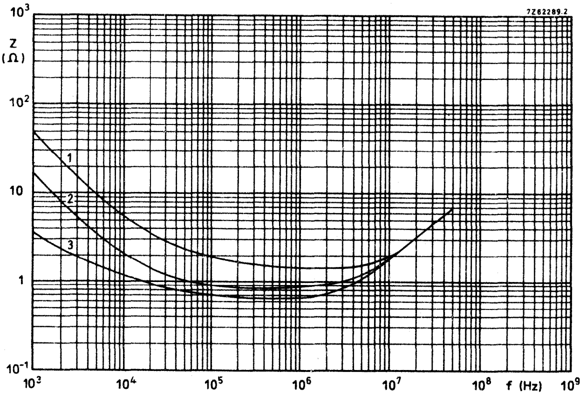
curve 1 = 0,47 μF, 25 V ←
2 = 1,5 μF, 10 V
3 = 10 μF, 1,6 V

Typical impedance as a function of frequency at 25 °C



Size DTM4

curve 1 = 1 μF, 25 V
2 = 2,2 μF, 16 V
3 = 4,7 μF, 6,3 V
4 = 22 μF, 1,6 V



Size DTM5

curve 1 = 3,3 μF, 25 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 3

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 $\leq$ stated limit tan $\delta \leq$ 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 $-55\pm3\,^{0}$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 ^{0}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 $55\pm2\,^{0}$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 Δ 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 $40\pm2\,^{0}$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 Δ C $\leq$ 10% Insulation resistances > 100 MΩ Breakdown voltage > 1000 V d.c.
III-1		Endurance	2000h at $85\pm1.5\,^{0}$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 Δ C $\leq$ 10% Breakdown voltage > 1000 V d.c.

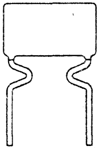
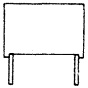
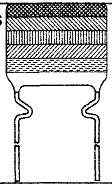
TESTS AND REQUIREMENTS (continued)

Group	IEC 68-2 Test method	Name of test	Procedure (Quick reference)	Requirements
IV-1	Ba	Characteristics at high temperature	16h at 85±2 °C with no voltage applied	After thermal stability at 85 °C leakage current ≤ 10 x stated limit tan δ ≤ 1.2 x stated limit Δ C < ± 10%
IV-2	Aa	Characteristics at low temperature	2h at −55±3 °C with no voltage applied	After thermal stability at −55 °C leakage current ≤ stated limit tan δ ≤ 2 x stated limit Δ C ≤ ± 10%
IV-3		Surge a. 85 °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 ≤ stated limit tan δ ≤ stated limit Δ C ≤ 10%
VI-1		Storage high temperature	96±4h at + 85 °C with no voltage applied	Leakage current ≤ stated limit tan δ ≤ stated limit Δ C ≤ 5%

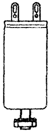
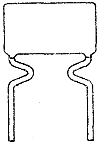
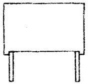
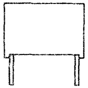
Film capacitors

SURVEY

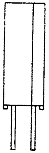
POLYESTER AND POLYCARBONATE CAPACITORS

type	series number 2222 . . .	main application	rated capacitance μF	rated voltage (U_R d.c.) V
Polyester film/foil capacitors (tubular foil); lacquered 	311	coupling, decoupling, high currents, steep pulses	0,01 to 1,0 0,001 to 0,47	160 400
Metallized polyester and polycarbonate film capacitors (mepolesco); moulded 	341	coupling, decoupling, timing and delay	0,10 to 6,8 0,047 to 2,2 0,010 to 1,0 0,010 to 0,47 0,010 to 0,15 0,001 to 0,068	100 250 400 630 } only metallized 1000 } polycarbonate 1600 } film
Polyester film/foil capacitors (p.p.c.); lacquered 	347	coupling, decoupling, high currents, steep pulses	0,015 to 1,0 0,010 to 0,68 0,0047 to 0,33 0,0010 to 0,15	100 250 400 630
Metallized polyester and polycarbonate film capacitors (nugget); potted 	344	coupling, decoupling, timing and delay	0,15 to 10 0,047 to 6,8 0,022 to 2,2 0,010 to 1,0 0,0047 to 0,47	63 (only metallized PETP film) 100 250 400 630 (only metallized polycarbonate film)
Metallized polyester film capacitors (f.f.c.); lacquered 	352	coupling, decoupling, timing and delay	0,047 to 6,8 0,001 to 2,2 0,010 to 1,0 0,010 to 0,47	100 250 400 630

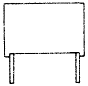
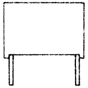
POLYPROPYLENE CAPACITORS

type	series number 2222 . . .	main application	rated capacitance µF	rated voltage (U_R d.c.) V
Metallized polypropylene film a.c. capacitors; sealed aluminium case 	328	power factor correction for discharge lighting	3,5 to 22,5	U_R (a.c.) = 250 V
Polypropylene film/foil capacitors (KP); lacquered 	357 4....	tv deflection, a.c. motor commutation, high currents, high voltages, steep pulses	0,039 to 0,68	250
Polypropylene film/foil capacitors (FP); potted 	357 5....		0,039 to 0,82	250
Polypropylene capcitors (KP/MKP); series construction 	357 6.... 357 7.... 357 8....		0,047 to 0,33 0,022 to 0,22 0,022 to 0,15	630 1000 1500

POLYSTYRENE CAPACITORS

type	series number 2222 . . .	main application	rated capacitance pF	rated voltage (U_R d.c.) V
Polystyrene film/foil capacitors (micropoco); sleeved 	424 to 431	tuning circuits, filter networks, applications with high stability, high precision, low losses	1 200 to 39 000 820 to 16 000 390 to 11 000 51 to 5 600	63 160 250 630
Polystyrene film/foil capacitors (wrapped end-filled) 	444 to 447		43 000 to 162 000 18 000 to 82 000 12 000 to 47 000 6 200 to 24 000	63 160 250 630
Polystyrene film/foil capacitors (p.f.c.); potted 	443	LC-filters, tuning circuits, applications with high precision, high stability, high reliability	100 to 34 000	63

DUAL DIELECTRIC CAPACITORS

type	series number 2222 . . .	main application	rated capacitance	rated voltage (U_R)
Paper/polyester, film/foil capacitors for radio interference suppression; potted 	276	general, industrial (safety capacitor in tv sets)	4,7 to 330 nF	U_R (a.c.) = 250 V
Paper/polypropylene, film/foil capacitors for flyback purposes; potted 	278	tuning in transistorized deflection circuits	10 to 27 nF 1,5 to 12 nF 1,5 to 10 nF	750 V_P 1500 V_P 2000 V_P max permissible peak voltage
Metallized polyester/paper film capacitors (MKT-P) for radio interference suppression; moulded 	330 00...	small household appliances, radio and tv	0,01 to 0,22 μF	U_R (a.c.) = 250 V
Metallized polyester/paper film capacitors (MKT-P) for radio interference suppression; potted 	330 40...		0,01 to 0,33 μF	U_R (a.c.) = 250 V
Metallized polycarbonate/paper film capacitors (MKC-P); moulded 	363 45... 363 46...	deflection circuits in tv receivers	0,91 to 1,5 μF	U_R (d.c.) = 210 V
Metallized polycarbonate/paper film capacitors (MKC-P); potted 	363 41... 363 42...		0,82 to 3,3 μF	U_R (d.c.) = 210 V

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

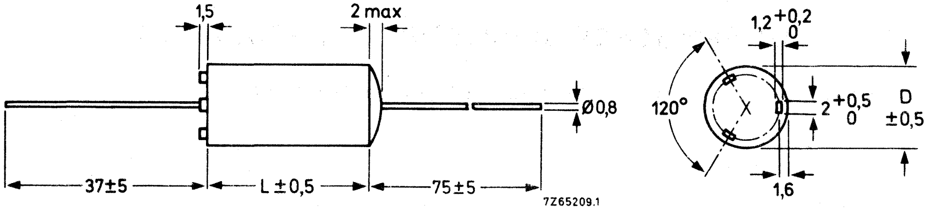


Fig. 1 For dimensions D and L see tables below.

AVAILABLE VERSIONS

nom. cap.	dimensions (mm)		class *)	catalogue number
(nF)	D	L		
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.	dimensions (mm)		class *)	catalogue number
(nF)	D	L		
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.

---

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

MECHANICAL DATA

Dimensions see Fig. 1

Marking

The marking is according to CEE10 (part 1):

1st line: manufacturer's identification symbol, nominal capacitance in nF and ASEV code;*
2nd line: catalogue number;
3rd line: rated voltage and class;
4th line: category according to IEC and DIN;
5th 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 PZ1
2222 276 60101
250 V~ Y
40/085/21 GPF

ASE 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.

---

* Only for safety capacitor.

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

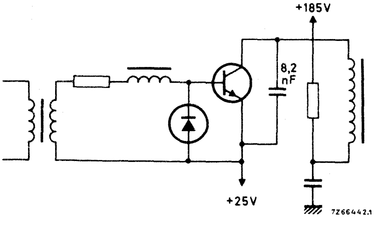
QUICK REFERENCE DATA

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		

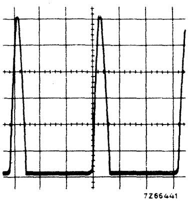
APPLICATION

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

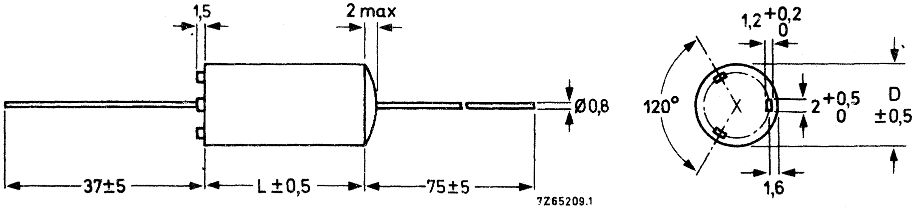


Fig. 1

AVAILABLE VERSIONS

750 V-range

nominal capacitance (nF)	dimensions (mm) D	dimensions (mm) L	marking of cap.	catalogue number
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	dimensions (mm)		marking of cap.	catalogue number
(nF)	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)		marking of cap.	catalogue number
	D	L		
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	≤ 30×10^{-4}
at 10 kHz	≤ 60×10^{-4}
at 100 kHz	≤ 150×10^{-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

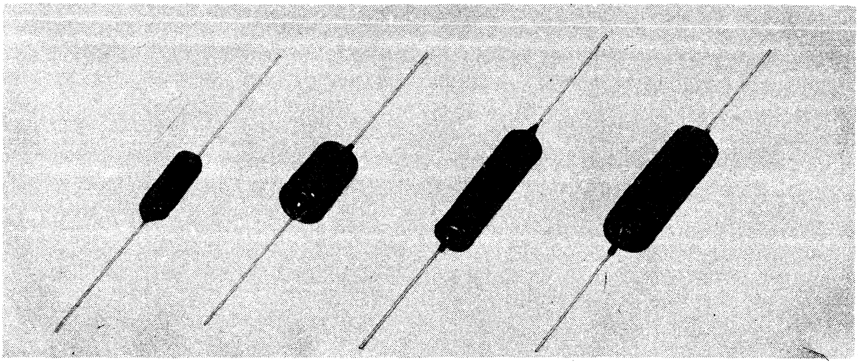
IEC 68, Test Ua: 10 N (1 kg) for 10 s in direction of leads.
Requirement: No damage.

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

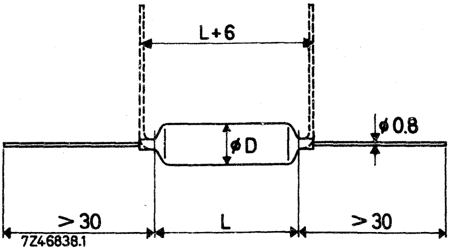
APPLICATION

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 %.

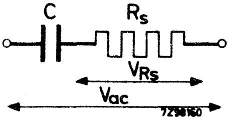
Working temperature range	-40/+85 °C
Maximum d.c. working voltage up to 85 °C	nominal voltage (V_{nom})
Maximum a.c voltage, 50-60 Hz (never to be exceeded at other frequencies)	160 V versions: 90 V 400 V versions: 150 V
Calculation of the dissipation	with the aid of Fig.1
Maximum dissipation	Fig.2
Test 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 $C \leq 0.33\ \mu F$	R > 50 000 MΩ
for $C > 0.33\ \mu F$	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.

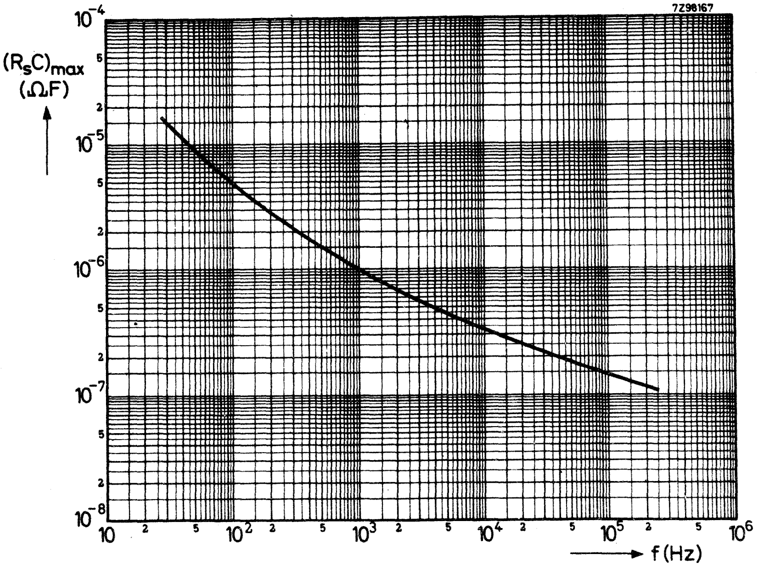
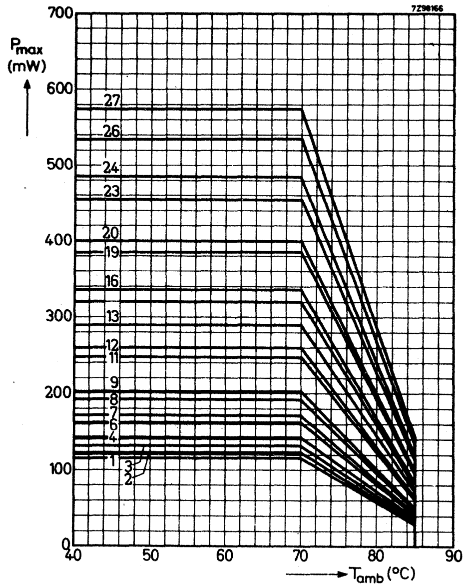


Fig.1. Maximum product of series resistance and capacitance as a function of the frequency



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

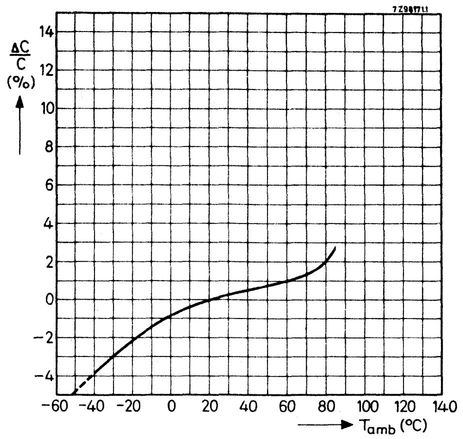


Fig.3. Capacitance as a function of the temperature

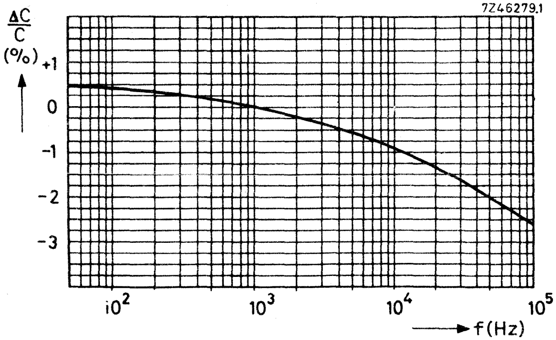


Fig.4. Capacitance as a function of the frequency

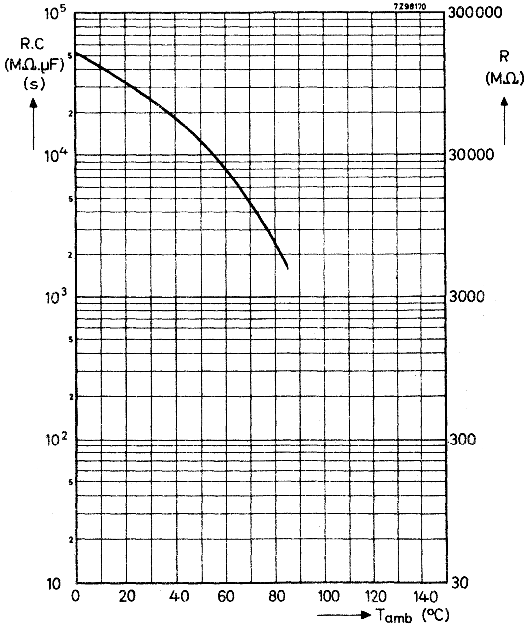


Fig.5. Insulation resistance as a function of the temperature

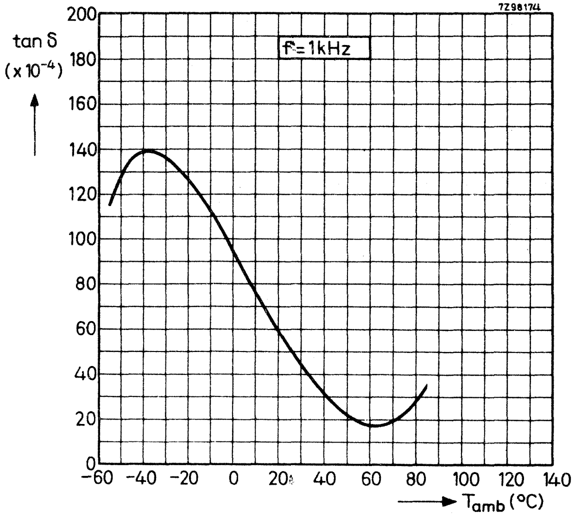


Fig.6. Losses at 1 kHz as a function of the temperature

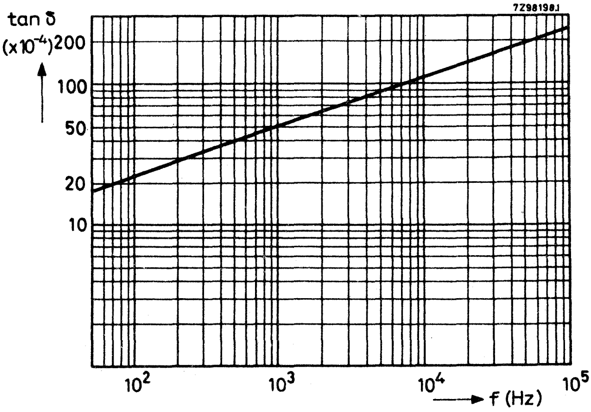


Fig.7. Losses as a function of the frequency

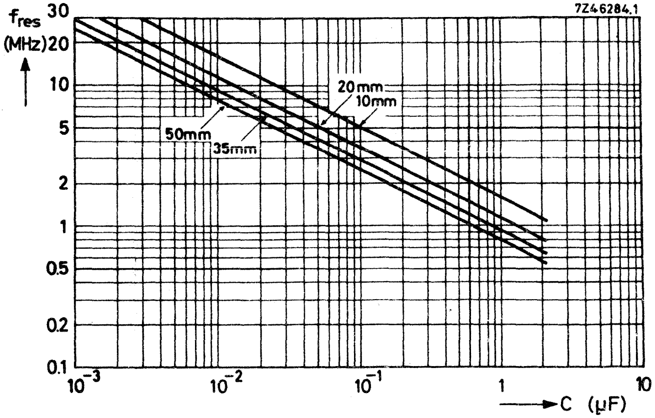


Fig.8. Resonance frequency as a function of the capacitance, at different total wire lengths

METALLIZED POLYPROPYLENE FILM CAPACITORS

for power factor correction of discharge lighting

QUICK REFERENCE DATA

Rated capacitance range	3,5 to 22,5 μF
Tolerance on rated capacitance	± 10%
Rated voltage U_R (a.c.), 50 to 60 Hz	250 V
Rated temperature	85 °C
Climatic category	
IEC 68	25/085/56
DIN 40040	HPF
Approvals	VDE, CEBEC, KEMA DEMKO, NEMKO*, SEMKO

APPLICATION

These capacitors are used for power factor correction in discharge lighting applications, such as fluorescent mercury and sodium vapour discharge lamp circuits.

DESCRIPTION

The capacitors consist of a non-inductive wound cell of metallized polypropylene film. The cell is housed in a cylindrical aluminium case which is end-sealed by a disc carrying two solder tags.

In the event of excessive pressure building up inside the case, a safety mechanism will cause the wire leads to the tags to be broken, whereby the risk of fire and explosion is prevented.

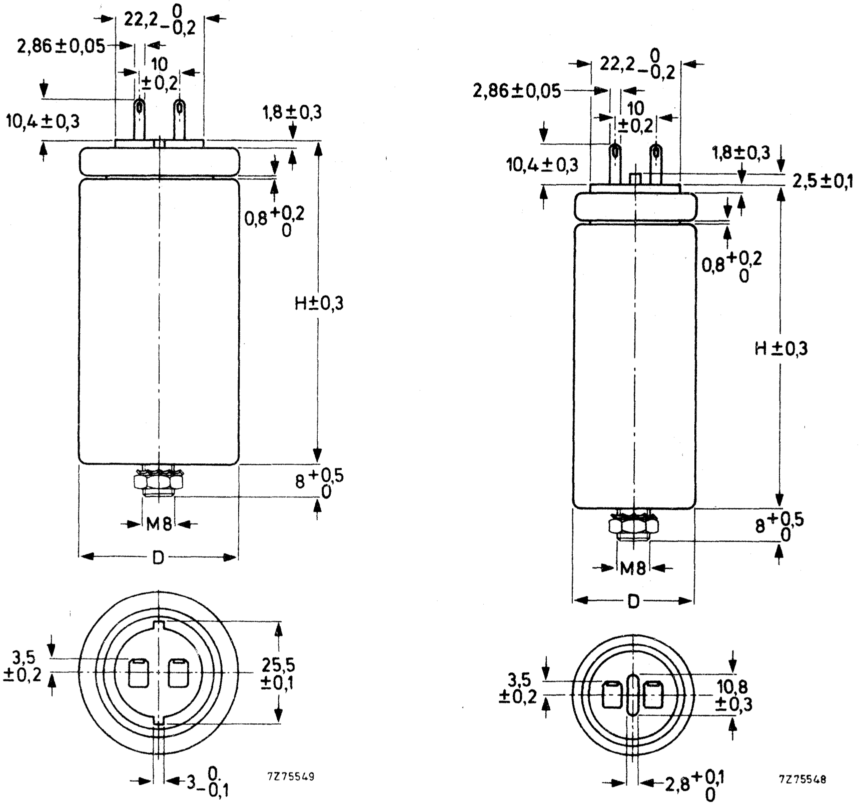
The capacitors comply with recommendations laid down in BS 4017 (1973), IEC 68, VDE 0560-6 (FP) and CEE 12.

---

* Approval has been sought.

MECHANICAL DATA

Dimensions in mm



a b

Fig. 1 For dimensions D and H see Table 1.

Marking

The capacitors are marked with:
1st line : catalogue number and manufacturers identification symbol;
2nd line: rated capacitance and tolerance;
3rd line: rated voltage (a.c.), 50 Hz and code for dielectric material (MK = metallized polypropylene film);
4th line: category temperature range and climatic category according to IEC and DIN;
5th line: approbation symbols;
6th line: month and year of manufacture.

Mounting

The capacitors are suited for horizontal or vertical mounting. Capacitors without stud can be fixed with a bracket. The tags are suited for soldering and also for accepting a snap-on connector which may include a discharge resistor.

The capacitors require a minimum clearance of 5 mm between the wall of the mounting space and the top end of the solder tags or snap-on connector. This is to allow for operation of the safety mechanism should there be an excess pressure build-up in the capacitor.

Table 1 U_R (a.c.) = 250 V

rated capacitance µF	D	H	Fig.	mass approx. g	catalogue number of capacitors	
					without stud	with stud
3	30	63,5	1a	35		2222 328 90016
3,5	30	63,5	1a	38	2222 328 51355	55355
4	30	63,5	1a	40	51405	55405
4,2	30	63,5	1a	41	51425	55425
4,5	30	63,5	1a	43	51455	55455
5	30	63,5	1a	45	51505	55505
5,1	35	63,5	1b	47	90014	
5,5	30	78	1a	47	51555	55555
6	30	78	1a	49	51605	55605
6,5	30	78	1a	51	51655	55655
6,9	35	63,5	1b	63	90015	
7	30	78	1a	53	51705	55705
7	35	63,5	1b	64	90011	90005
8	35	78	1b	67	51805	55805
8	40	63,5	1b	67	90001	90003
9	35	78	1b	70	51905	55905
10	35	78	1b	74	51106	55106
10	40	63,5	1b	71	90002	90004
12	40	78	1b	85	51126	55126
12,5	40	78	1b	89	90007	90006
14	40	78	1b	92	51146	55146
16	40	95	1b	100	51166	55166
18	40	95	1b	108	51186	55186
20	40	107	1b	114	51206	55206
22,5	40	107	1b	123	90009	90008

The capacitors have been approved by VDE, CEBEC, KEMA, DEMKO and SEMKO, see Table 2; NEMKO approval has been sought.

Table 2

catalogue number	approved by					
	VDE (FP) 0560-6 (1975)	CEBEC	KEMA	DEMKO	SEMKO	
2222 328 51106	x	x	x	x	x	
51355	x	x	x	x	x	
51405	x	x	x	x	x	
51425	x		x	x	x	
51455	x	x	x	x	x	
51505	x	x	x	x	x	
51555	x	x	x	x	x	
51605	x	x	x	x	x	
51655	x	x	x	x	x	
51705	x	x	x	x	x	
51755	x	x	x	x	x	
51805	x	x	x	x	x	
51855	x	x	x	x	x	
51905	x	x	x	x	x	
2222 328 55106	x	x		x		
55355	x	x		x		
55405	x	x		x		
55425	x		x	x	x	
55455	x	x		x		
55505	x	x		x		
55555	x	x		x		
55605	x	x		x		
55655	x	x		x		
55705	x	x		x		
55755	x	x		x		
55805	x	x		x		
55855	x	x		x		
55905	x	x		x		
2222 328 90001	x		x	x	x	
90002	x		x	x	x	
90003	x		x	x	x	
90004	x		x	x	x	
90005			x			
90011			x			
90014				x		
90015				x		
90016				x		

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of 25 ± 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 50 Hz	see Table 1
Tolerance on rated capacitance	± 10%

Voltage

Rated voltage U_R (a.c.), 50 to 60 Hz	250 V
Test voltage	
between terminals	1,5 x U_R (a.c.) for 10 s
between interconnected terminals and case	2500 V (a.c.) for 1 min

Insulation resistance

The insulation resistance is measured after a voltage of 100 ± 15 V has been applied for 1 min ± 5 s.

R between interconnected terminals and case at 23 °C	$>$ 12 500 MΩ
RC between terminals at 23 °C	$>$ 10 000 s

Tan δ (tangent of the loss angle)

Tan δ at 50 Hz	
$C_R \leqslant 10\ \mu F$	$\leqslant 5 \times 10^{-4}$
$C_R > 10\ \mu F$	$\leqslant 10 \times 10^{-4}$

Temperature

Rated temperature	85 °C
Category temperature range	−25 to + 85 °C
Storage temperature range	−40 to + 85 °C
Climatic category	
IEC 68	25/085/56
DIN 40040	HPF

PACKING

The capacitors are packed in boxes of 50 pieces.
Washers and nuts are supplied in plastic bags of 50 pieces.

TESTS AND REQUIREMENTS

IEC 68-2 test method	name of test	procedure (quick reference)	requirements
Ua1	Tensile strength of tags	Loading force 20 N in axial direction of the tags, 10 s.	No damage.
Ub2	Bending of tags	Two consecutive bends without load.	No damage.
Ud	Torque on threaded stud	Torque of 4 Nm one gradual application.	No damage.
Ta method 2	Solderability	Soldering iron: 350 ± 10 $^{\circ}$C, 10 s.	No damage, good tinning.
–	Resistance to soldering heat	Soldering iron: 350 ± 10 $^{\circ}$C, 10 s; bit sizes ϕ 8 mm x 32 mm. Solder: Pb/Sn 40/60 with non-activated flux.	Good tinning, no leakage or open circuit.
Na	Rapid change of temperature	5 cycles of 3 h at –25 $^{\circ}$C and 3 h at + 85 $^{\circ}$C.	No damage, no leakage, $\Delta C/C \leqslant 2\%$. Tan δ and insulation resistance shall meet initial requirements.
Fc	Vibration	10 to 55 Hz, 1,5 mm or 10g (whichever is less), 3 directions, 2 h per direction.	No damage, no open or short-circuit.
Eb	Bumping	40g, 1000 bumps.	No damage, no open or short-circuit.

Additional tests

test method	name of test	procedure (quick reference)	requirements
VDE 0560-6b para. 54C2	Sealing (gas leakage) of dry types	Capacitors in test chamber which accommodates a bath containing de-gassed oil with a viscosity of max. 25 cSt (25 x 10^{-6} m^2/s) at 20 °C; the oil maintained at 25 ± 5 °C. The air pressure shall be reduced within 1 min to 156 mbar (120 Torr) and maintained at this value for 1 min.	No leakage as evidenced by repetitive bubbling.
IEC 68-2, test Ca	Damp heat, steady state	56 days at 40 °C, R.H. 90 to 95%, no voltage applied.	Insulation resistance $>$ 0,5 x initial requirements, test voltage and tan δ shall meet initial requirements, $\Delta C/C \leqslant 2\%$.
	Endurance (cyclic)	Capacitors in oven, subjected to 84 cycles of 8 h; during first 6 h of each cycle 1,25 x U_R is applied, within 2 h the ambient temperature (25 ± 5 °C) is raised to 85 ± 2 °C. After 6 h period applied voltage is switched off, and capacitors are discharged for 2 h and subjected to forced cooling to 25 ± 5 °C inside oven.	Percentage of failures after 84 cycles shall not exceed 8%. Failure criteria: RC-product at 100 V (d.c.) for 1 min $<$ 5000 s; Δ tan δ at 50 Hz $\geqslant 10 \times 10^{-4}$; $\Delta C/C > 5\%$.
VDE 0560-6b, para. 49	Endurance	Test voltage 1,45 x U_R, for 1100 h, 85 ± 2 °C.	Percentage of failures after 1100 h shall not exceed 3%. Failure criteria: RC-product at 100 V (d.c.) for 1 min $<$ 5000 s; Δ tan δ at 50 Hz $\geqslant 10 \times 10^{-4}$; $\Delta C/C > 10\%$.
CEE 12	Endurance	Capacitors in oven with air circulation, for 500 h, 98 ± 2 °C, test voltage 1,3 x U_R.	No open or short-circuit.

test method	name of test	procedure (quick reference)	requirements
	Destruction	Samples: 15 capacitors having passed endurance test and 15 capacitors having passed initial measurements. Each capacitor enclosed by 4 layers of cotton, in oven heated to 100 ± 2 ^{o}C.	
		Step 1: U_R (a.c.) applied for 2 h.	No open or short-circuit.
		Step 2: D.C. voltage applied, which is increased; max. permissible current 50 mA.	Step 2 is terminated when permanent breakdown occurs.
		Step 3: 1,3 U_R (a.c.) applied, increased to 1,8 x U_R (a.c.) at a rate of 1 V/s; 1,8 x U_R (a.c.) maintained for 120 h.	No physical phenomena which could lead to catastrophic failure like fire or explosion; the safety mechanism has become operative (distortion of rill).
		Step 4: 2500 V (a.c.) applied between interconnected tags and case for 1 min.	No flashover over short-circuit.
		The test from step 2 shall be repeated until there is a total of 10 capacitors in which the safety mechanism has become operative.	

INTERFERENCE SUPPRESSION CAPACITORS

dual dielectric (MKT-P)

QUICK REFERENCE DATA

Rated capacitance range (E6 series)	
type with axial leads	0,01 to 0,22 μF
type with radial leads	0,01 to 0,33 μF
Tolerance on rated capacitance	±20%
Rated voltage U_R (a.c.), 50 to 60 Hz	250 V
Rated temperature	85 °C
Climatic category, IEC 68	40/085/21
Climatic category, DIN 40040	GPF
Approval	VDE 0560–7
Class	X

APPLICATION

For radio interference suppression in:
- small household appliances, e.g. coffee grinders, mixers;
- audio and tv circuits;
- general industrial applications, e.g. test and measuring equipment.

Thanks to the dual dielectric construction any active flammability under fault conditions is prevented.

DESCRIPTION

The capacitors consist of an impregnated low-inductive wound cell of metallized polyethyleneterephthalate (PETP) film and paper film. Two types are available: with axial leads and with radial leads.

The cell of the type with axial leads is moulded in yellow flame retardent polypropylene, that of the other type is potted with epoxy resin in a yellow flame retardent polypropylene case. The leads are solder-coated copper wire.

The capacitors are provided with stand-off ridges or pips to allow removal of solder flux etc., when cleaning the printed-wiring board.

Composition of the catalogue number (See also Tables 1 and 2)

2222 330 . . . . .

code for type —— code for capacitance

MECHANICAL DATA

Dimensions in mm

Type with axial leads

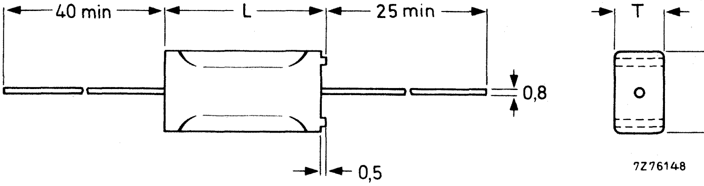


Fig.1 For dimensions T, L and H, see Table 1.

Table 1

rated capacitance µF	T_{max} mm	L_{max} mm	H_{max} mm	mass g	catalogue number
0,010	6,5	18	10,4	1,8	2222 330 00103
0,015					00153
0,022					00223
0,033					00333
0,047					00473
0,068	7,6	18	11,5	2,1	00683
0,10	7,4	23,5	11,5	2,7	00104
0,15	8,7	23,5	12,8	3,4	00154
0,22	10,4	23,5	14,4	4,2	00224

Marking

The capacitors are marked on one side as follows:
1st line: rated capacitance in µF, rated voltage and class;
2nd line: last eight digits of the catalogue number, and production date code.*
On the other side the capacitors are marked with manufacturer's identification symbol, category according to DIN, code for dielectric materials (MKT-P) and approbation symbols.

Mounting

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

---

* According to IEC 62, clause 5.

Type with radial leads

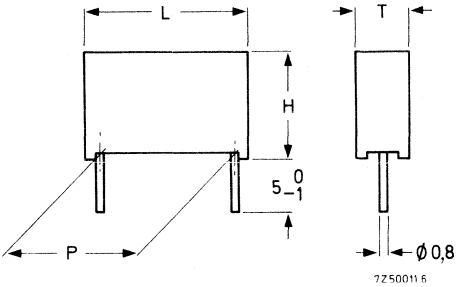


Fig. 2 For dimensions T, L, H and P, see Table 2.

Table 2

rated capacitance µF	T_{max} mm	L_{max} mm	H_{max} mm	P mm	mass g	catalogue number
0,010	5	17,5	11	15 ± 0,4	1,2	2222 330 40103
0,015						40153
0,022						40223
0,033						40333
0,047	6	17,5	11,5		1,4	40473
0,068	7	17,5	13		2,0	40683
0,10	8,5	17,5	14,5		2,6	40104
0,15	6,5	26	15,5	22,5 ± 0,4	3,0	40154
0,22	7,5	26	16,5		3,7	40224
0,33	9,5	26	19		5,4	40334

Marking

The capacitors are marked on the top face by embossed print, with:
1st line: rated capacitance in µF, rated voltage and class;
2nd line: 5th, 6th, 7th, 8th and 9th digits of the catalogue number and code for dielectric materials (MKT-P).
On the side the capacitors are marked with manufacturer's identification symbol, production date code*, category according to DIN and approbation symbols.

Mounting

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

---

* According to IEC 62, clause 5.

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of 15 to 35 °C, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

Capacitance

Rated capacitance values (C_R) at 1 kHz	see Tables 1 and 2
Tolerance on rated capacitance	±20%

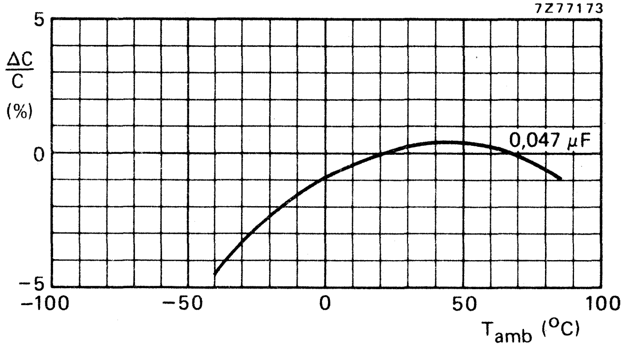


Fig.3 Capacitance as a function of temperature; typical curve, measured at 1 kHz, 0,3 V.

Voltage

Rated voltage U_R (a.c.), 50 to 60 Hz	250 V
Test voltage (d.c.) for 1 min between terminals	750 V
Test voltage (a.c.) for 1 min between interconnected terminals and coating	2000 V, 50 Hz

Insulation resistance

The insulation resistance is measured after a voltage of 100 ± 15 V has been applied for 1 min ± 5 s.

→ R between terminals at T_{amb} = 23 °C > 15 000 MΩ

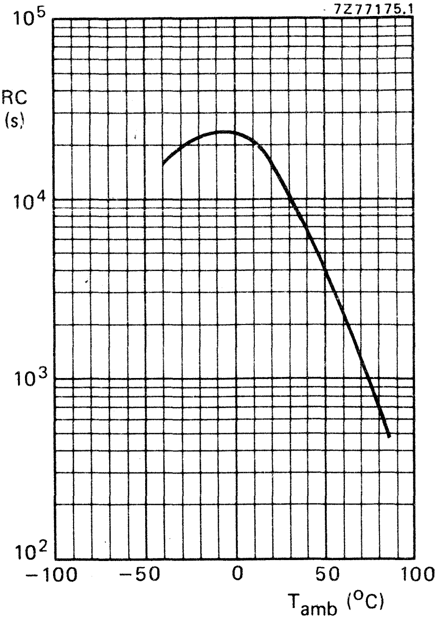


Fig.4 RC-product as a function of temperature; typical curve.

Tan δ (tangent of the loss angle)

Tan δ at 10 kHz $\leqslant 130 \times 10^{-4}$ (typ 90×10^{-4})

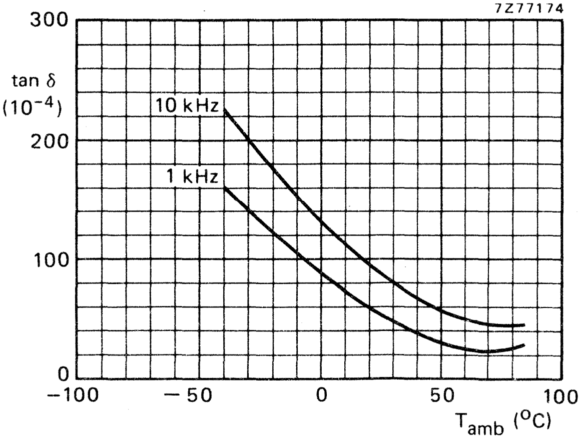


Fig.5 Tan δ as a function of temperature; typical curves, measured at 0,3 V.

Pulse steepness

Maximum pulse steepness	100 V/μs

See also Tests and requirements – charge and discharge test.

Resonant frequency

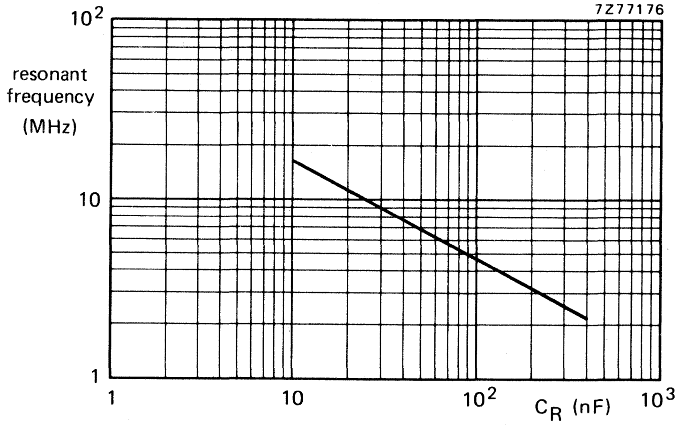


Fig.6 Resonant frequency as a function of rated capacitance.

Temperature

Rated temperature	85 °C
Category temperature range	–40 to +85 °C
Storage temperature range	–55 to +85 °C
Climatic category, IEC 68	40/085/21

PACKING

The capacitors are packed in boxes.

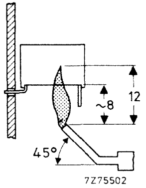
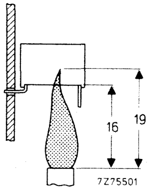
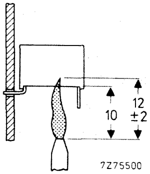
TESTS AND REQUIREMENTS

IEC 68-2 test method	name of test	procedure (quick reference)	requirements
Ua1	Tensile strength of terminations	Loading force 10 N in axial direction of the wires, 10 s.	No damage.
Ub method 1	Bending of terminations	Loading force 5 N, two consecutive bends.	No damage.
Uc (only for axial wires)	Torsion of terminations	Two successive rotations of 180° in opposite directions.	No damage.
Ta 1st part method 1	Solderability	Solder bath: 230 °C, 2 s.	No damage, good tinning.
Tb method 1B	Resistance to soldering heat	Solder bath: 350 °C, 3,5 s.	No damage.
Na	Rapid change of temperature	5 cycles of ½ h at −40 °C and ½ h at +85 °C.	No damage, no leakage; $\Delta C/C \leqslant 5\%$. Tan δ and insulation resistance shall meet initial requirements.
Fc	Vibration	10 to 55 Hz, 0,75 mm or 10g (whichever is less), 3 directions, 2 h per direction.	No damage, no open or short-circuit.
→ Eb	Bumping	40 g, 4000 bumps.	No damage, no open or short-circuit.

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, no leakage, $\Delta C/C \leqslant 5\%$.
	Db	Damp heat, cyclic	1 cycle of 24 h, upper temperature 55 ± 2 ^{o}C, R.H. 93 ± 3%; no voltage applied.	
	Aa	Cold	2 h at −40 ± 2 ^{o}C; no voltage applied.	
	M	Low air pressure	1 h at 25 ± 5 ^{o}C; at an atmospheric pressure of 85 mbar.	During and after the test there shall be no breakdown or flashover.
	Db	Damp heat, cyclic	1 cycle of 24 h, upper temperature 55 ± 2 ^{o}C, R.H. 93 ± 3%; no voltage applied.	
			Final measurement.	$\Delta C/C \leqslant 5\%$. Tan δ shall meet initial requirements. Insulation resistance > 7500 MΩ.
	Ca	Damp heat, steady state	21 days at 40 ^{o}C and R.H. 90 to 95%. a) No voltage applied. b) 250 V (d.c.) applied. Recovery 6 h at 55 ^{o}C and R.H. $\leqslant 20\%$, followed by 2 h recovery at 20 ^{o}C.	No damage, $\Delta C/C \leqslant 5\%$. Tan δ shall meet initial requirements. Insulation resistance > 7500 MΩ. After test voltage (750 V (d.c.), 1 min): no breakdown or interruption.
	–	Endurance	1000 h at 85 ^{o}C, 1,25 x rated a.c. voltage applied.	Percentage of rejects shall not exceed 5%. Failure criteria: – open or short-circuit; – $\Delta C/C > 10\%$; – insulation resistance < 7500 MΩ; – drops of impregnant.

name of test	procedure (quick reference)	requirements
Additional tests		
Storage	1000 h at 85 °C.	$\Delta C/C \leqslant 5\%$. Tan δ and insulation resistance shall meet initial requirements.
Damp heat, long term exposure	21 days at 40 °C, R.H. 90 to 95%. No voltage applied during the first 10 days; rated a.c. voltage applied for 16 h of every 24 h period during the next 11 days.	Percentage of rejects shall not exceed 5%. Failure criteria: – open or short-circuit; – insulation resistance < 7500 MΩ.
	21 days at 40 °C, R.H. 90 to 95%. Rated a.c. voltage applied for 16 h of every 24 h period.	
Charge and discharge	10 000 cycles of charge to 350 V (d.c.) and discharge via a resistor of value such that the pulse steepness is 1,5 x specified value. Cycle time: 1 to 150 cycles/s, temperature: 25 °C.	Δ tan $\delta \leqslant 20 \times 10^{-4}$ at 10 kHz.

→ For flammability tests see next page.

name of test	procedure (quick reference)	requirements
Flammability	 Bore of gas jet: ϕ 0,5 mm. Fuel: butane. Test duration: 20 s. One flame application.	After removing the test flame from the capacitor, the capacitor must not continue to burn for more than 15 s; no burning particles must drop from the sample.
	 Bore of gas jet: ϕ 10 mm. Fuel: natural gas. Test duration: 3 x 15 s. Time interval between each flame application: 15 s.	Extinguishing time ≤ 15 s after the first and second flame application, ≤ 60 s after the third flame application.
	 Bore of gas jet: ϕ 0,5 mm. Fuel: butane. Test duration: 3 x 15 s. Second and third flame application starts after extinguishing of the flame on the capacitor. Note: This test is not valid for capacitors with radial leads and 15 mm pitch.	Extinguishing time ≤ 10 s after each flame application; no burning particles must drop from the sample.

METALLIZED POLYESTER AND POLYCARBONATE FILM CAPACITORS

moulded type (mepolesco)

QUICK REFERENCE DATA

Rated capacitance range (E12-series)	0,82 nF to 6,8 μF
Tolerance on rated capacitance	± 5%, ± 10%, ± 20%
Rated voltage U_R (d.c.)	100 V, 250 V, 400 V, 630 V, 1000 V, 1600 V
Rated voltage U_R (a.c.), 50 to 60 Hz	63 V, 160 V, 220 V, 220 V, 250 V, 250 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

The capacitors consist of a low-inductive wound cell of metallized polyethyleneterephthalate (PETP) or polycarbonate film. The cell is moulded in yellow flame retardent polypropylene. The axial leads are solder coated copper wire. 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

metallized polycarbonate film:

23 = 100 V; ± 5%
28 = 100 V; ± 20%
29 = 100 V; ± 10%
47 = 250 V; ± 5%
48 = 250 V; ± 20%
49 = 250 V; ± 10%
57 = 400 V; ± 5%
58 = 400 V; ± 20%
59 = 400 V; ± 10%

60 = 630 V; ± 20%
61 = 630 V; ± 10%
62 = 630 V; ± 5%
70 = 1000 V; ± 20%
71 = 1000 V; ± 10%
80 = 1600 V; ± 20%
81 = 1600 V; ± 10%

metallized PETP film:

25 = 100 V; ± 5%
26 = 100 V; ± 20%
27 = 100 V; ± 10%
87 = 250 V; ± 5%
88 = 250 V; ± 20%
89 = 250 V; ± 10%
53 = 400 V; ± 5%
54 = 400 V; ± 20%
55 = 400 V; ± 10%

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

MECHANICAL DATA Dimensions in mm

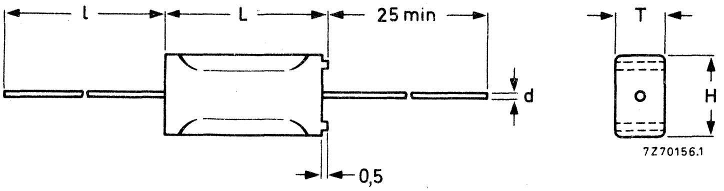


Fig. 1 For dimensions T, L, H, d and l, see tables below.

Table 1 U_R (d.c.) = 100 V; U_R (a.c.) = 63 V

Capacitors are available with either dielectric except where indicated ▲ (metallized PETP film dielectric only) or ■ (metallized polycarbonate film dielectric only).

rated capacitance* μF	T_{max}	L_{max}	H_{max}	d	l_{min}	mass g	capacitance code
0,10	4,7	14,5	8,7	0,8	40	1,0	104
0,15	4,7	14,5	8,7			1,0	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 ■	12,4	31	19,5			10,5	475
4,7 ▲	15	31	22			10,5	475
6,8 ■	15	31	22			10,5	685

---

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

Table 2 U_R (d.c.) = 250 V; U_R (a.c.) = 160 V
Dielectric: metallized polycarbonate film.

rated capacitance* μF	T_{max}	L_{max}	H_{max}	d	l_{min}	mass g	capacitance code
0,047	4,7	14,5	8,7	0,8	40	1,0	473
0,068	4,7	14,5	8,7			1,0	683
0,10	5,5	14,5	9,4			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

Table 3 U_R (d.c.) = 250 V; U_R (a.c.) = 160 V
Dielectric: metallized PETP film.

rated capacitance* μF	T_{max}	L_{max}	H_{max}	d	l_{max}	mass g	capacitance code
0,047	4,7	14,5	8,7	0,8	40	1,0	473
0,068	4,7	14,5	8,7			1,0	683
0,10	5,5	14,5	9,4			1,1	104
0,15	6,5	18	10,4			1,7	154
0,22	6,5	18	10,4			1,7	224
0,33	7,4	23,5	11,5			2,5	234
0,47	7,4	23,5	11,5			2,5	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	12,4	31	19,5			8,0	225

---

* 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 (d.c.) = 400 V; U_R (a.c.) = 220 V

Dielectric: metallized polycarbonate film or metallized PETP film.

rated capacitance* µF	T_{max}	L_{max}	H_{max}	d	l_{min}	mass g	capacitance code
0,010	4,7	14,5	8,7	0,8	40	1,0	103
0,015	4,7	14,5	8,7			1,0	153
0,022	4,7	14,5	8,7			1,0	223
→ 0,033	4,7	14,5	8,7			1,0	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

---

* 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 (d.c.) = 630 V; U_R (a.c.) = 220 V

Dielectric: metallized polycarbonate film.

rated capacitance* μF	T_{max}	L_{max}	H_{max}	d	l_{min}	mass 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 (d.c.) = 1000 V; U_R (a.c.) = 250 V

Dielectric: metallized polycarbonate film.

rated capacitance* μF	T_{max}	L_{max}	H_{max}	d	l_{min}	mass 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

---

* 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 (d.c.) = 1600 V; U_R (a.c.) = 250 V
Dielectric: metallized polycarbonate film.

rated capacitance* μF	T_{max}	L_{max}	H_{max}	d	l_{min}	mass 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	6,5	18	10,4			1,7	332
0,0047	7,6	18	11,5			2,0	472
0,0068	7,4	23,5	11,5			2,5	682
0,010	7,4	23,5	11,5			2,5	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, tolerance and rated d.c. voltage;
2nd line: 5th, 6th and 7th digits of the catalogue number, code for dielectric, code for factory of origin and production date code (trial and year).

The rated capacitance is marked in pF (without the pF unit symbol) for $C < 0{,}010$ μF, in μF (without the μF unit symbol) for $C \geqslant 0{,}010$ and < 1 μF, and in μF (with the μF unit symbol) for $C \geqslant 1$ μF.

Tolerance marking is 5 or J for ± 5%, 10 or K for ± 10%, and 20 or M for ± 20%.

The code for the dielectric is MA for metallized PETP, and MC for metallized polycarbonate.

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.

---

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

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of 15 to 35 °C, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

Capacitance

Rated capacitance values (C_R) at 1 kHz	see Tables 1 to 7
Tolerance on rated capacitance	± 5%*, ± 10% and ± 20%

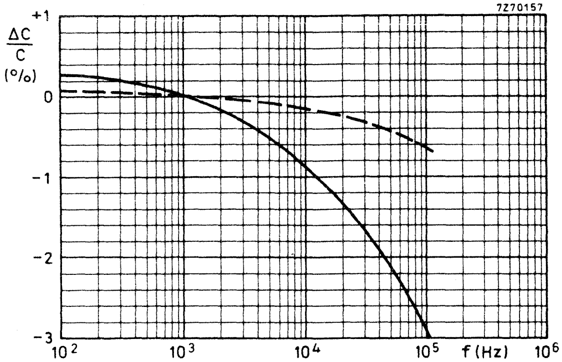


Fig. 2 Capacitance as a function of frequency; typical curves.

—— 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).

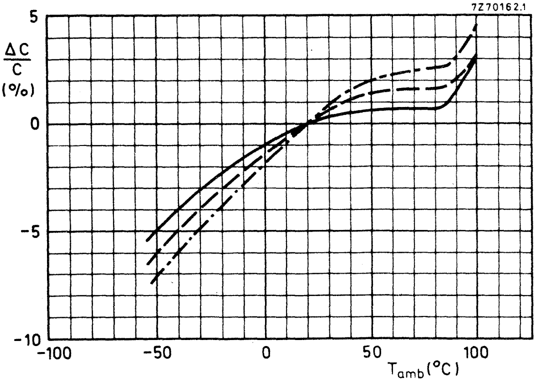


Fig. 3 Capacitance as a function of temperature; typical curves. Metallized PETP film dielectric.

—— 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.

---

* Only for 100 V, 250 V, 400 V and 630 V versions.

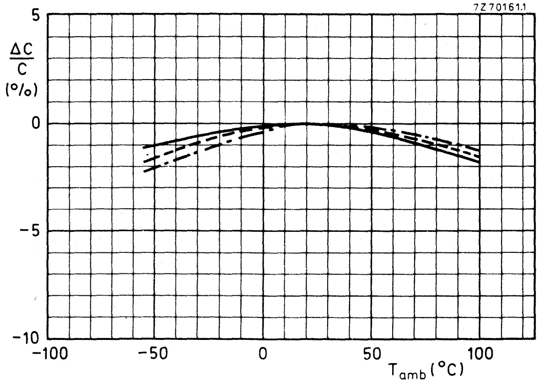


Fig. 4 Capacitance as a function of temperature; typical curves. Metallized polycarbonate film dielectric.
—— For all capacitance values, measured at 1 kHz, 1 V.
- - - For capacitance values ⩽ 1 μF, measured at 10 kHz, 1 V.
—.— For capacitance values ⩽ 0,1 μF, measured at 100 kHz, 0,3 V.

Voltage

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

Note

The sum of the d.c. voltage and the peak value of the superimposed a.c. voltage must be ⩽ U_R (d.c.).

---

* 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	
	23 °C	100 °C
R between terminations for $C_R \leqslant 0{,}33\ \mu F$		
100 V version	> 15 000 MΩ	> 50 MΩ
250 V to 1600 V versions	> 30 000 MΩ	> 100 MΩ
RC between terminations for $C_R > 0{,}33\ \mu F$		
100 V versions	> 5 000 s	> 16 s
250 V to 1600 V versions	> 10 000 s	> 33 s

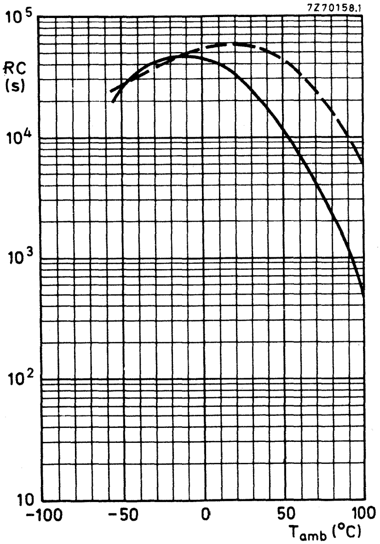


Fig. 5 RC-product as a function of temperature; typical curves.
—— Metallized PETP film dielectric.
- - - Metallized polycarbonate film dielectric.

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})

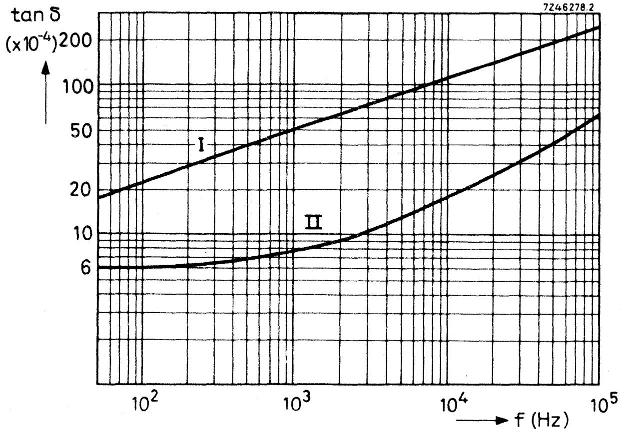


Fig. 6 Tan δ as a function of frequency; typical curves.
I = Metallized PETP film dielectric.
II = Metallized polycarbonate film dielectric.

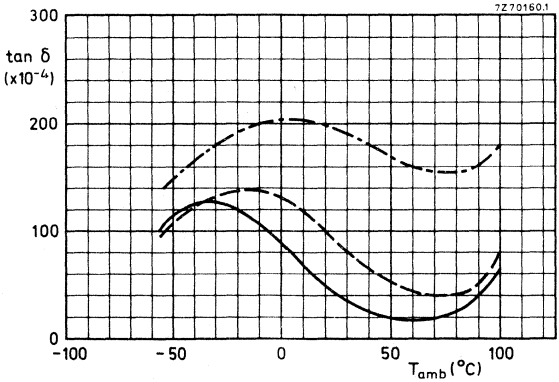


Fig. 7 Tan δ as a function of temperature; typical curves.
Metallized PETP film dielectric.
—— For all capacitance values, measured at 1 kHz, 1 V.
- - - For capacitance values ⩽ 1 μF, measured at 10 kHz, 1 V.
- . - For capacitance values ⩽ 0,1 μF, measured at 100 kHz, 0,3 V.

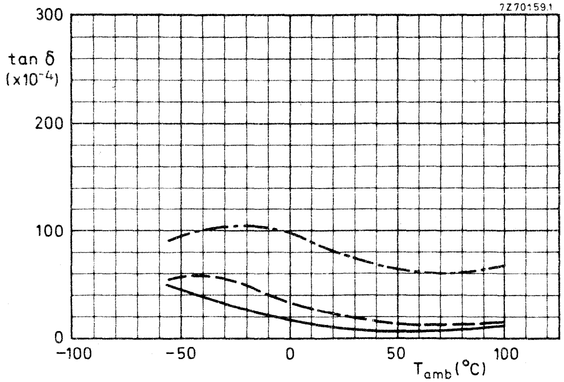


Fig. 8 Tan δ as a function of temperature; typical curves.
Metallized polycarbonate film dielectric.
—— For all capacitance values, measured at 1 kHz, 1 V.
- - - For capacitance values ⩽ 1 μF, measured at 10 kHz, 1 V.
- . - For capacitance values ⩽ 0,1 μF, measured at 100 kHz, 0,3 V.

Power dissipation

Maximum permissible power dissipation — see Additional information

Notes

In applications where voltages higher than 50 V are applied, it is recommended that the power in the capacitor is limited to 2,5 VA in case of capacitor failure.

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	max. pulse steepness (V/μs)			
	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

The maximum pulse steepness values in the table are valid for pulse voltages equal to the rated voltage. ←
For lower pulse voltages the given values may be multiplied by U_R/applied voltage.

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

TESTS AND REQUIREMENTS

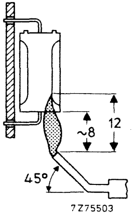
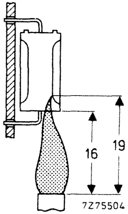
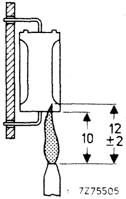
IEC 68-2 method	name of test	procedure (quick reference)	requirements
Ua1	Tensile strength of terminations	Loading force in axial direction of the wires: 10 N, 10 s for d = 0,8 mm; 20 N, 10 s for d = 1 mm.	No damage.
		Loading force in radial direction of the wires: 5 N, 10 s for d = 0,8 mm; 10 N, 10 s for d = 1 mm.	No damage.
Ub (method 1)	Bending of terminations	Loading force 5 N for d = 0,8 mm; 10 N for d = 1 mm; two consecutive bends.	No damage.
Ta	Soldering	Solder bath, non-activated colophony flux, solder temp. 235 °C, dwell time 2 s.	Good tinning.
Tb (method 1B)	Resistance to soldering heat	Solder bath: 350 °C, 3,5 s.	No damage; $\Delta C/C \leqslant 1\%$.
Na	Rapid change of temperature	5 cycles of ½ h at –55 °C and ½ h at + 100 °C	No damage; no leakage; $\Delta C/C \leqslant 2\%$. Tan δ and insulation resistance shall meet initial requirements.
Fc	Vibration	10 to 55 Hz, 0,75 mm or 10g (whichever is less), 3 directions, 2 h per direction.	No damage, no open or short-circuit. $\Delta C/C \leqslant 0,5\%$.
Eb	Bumping	40 g, 4000 bumps.	No damage, no open or short-circuit. $\Delta C/C \leqslant 0,5\%$.

	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; $\Delta C/C \leqslant 3\%$. (polycarbonate), $\leqslant 7\%$ (PETP) at 100 °C. Insulation resistance at 100 °C for $C_R \leqslant 0{,}33\ \mu F$: $> 50\ M\Omega$ (100 V version), $> 100\ M\Omega$ (other versions); for $C_R > 0{,}33\ \mu F$: $RC > 16$ s (100 V version), > 33 s (other versions).	
	Db	Damp heat, cyclic	1 cycle of 24 h, upper temperature 55 ± 2 °C, R.H. 93 ± 3%; no voltage applied.		
	Aa	Cold	2 h at −55 ± 3 °C; no voltage applied.	$\Delta C/C \leqslant -3\%$ (polycarbonate), $\leqslant -8\%$ (PETP) at −55 °C.	
	M	Low air pressure	1 h at 25 ± 5 °C; at an atmospheric pressure of 85 mbar.	During and after the test there shall be no breakdown or flashover.	
	Db	Damp heat, cyclic	5 cycles of 24 h, upper temperature 55 ± 2 °C, R.H. 93 ± 3%; no voltage applied.		
			Final measurement.	$\Delta C/C \leqslant 3\%$. Tan δ shall meet initial requirements. 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 (d.c.) applied continuously.	$\Delta C/C \leqslant 3\%$. Tan δ shall meet initial requirements. Insulation resistance $\geqslant 0{,}5$ x initial requirements.	
	–	Endurance	1000 h at 85 °C, 1,5 x U_R (d.c.) (U_R (d.c.) $\leqslant 630$ V) or 1,2 x U_R (d.c.) (U_R (d.c.) > 630 V) applied.	$\Delta C/C \leqslant 3\%$	$\Delta \tan \delta \leqslant 30 \times 10^{-4}$ at 10 kHz. Insulation resistance shall meet initial requirements.
			1000 h at 100 °C, 1,5 x U_c applied (U_R (d.c.) $\leqslant 630$ V) or 1,2 x U_c (U_R (d.c.) > 630 V).	$\Delta C/C \leqslant 5\%$	
			1000 h at 85 °C, U_R (a.c.), 50 Hz applied.	$\Delta C/C \leqslant 15\%$ (L = 14,5 mm) $\leqslant 10\%$ (L = 18 mm) $\leqslant 7\%$ (L = 23,5 mm) $\leqslant 5\%$ (L = 31 mm)	

Additional tests

name of test	procedure (quick reference)	requirements
Solvent resistance	According to MIL-STD-202 E, method 215.	No damage.
Storage	1000 h at 100 °C	$\Delta C/C \leqslant 3\%$. Tan δ and insulation resistance (at $\leqslant$ 10 V d.c.) shall meet initial requirements.
	10 000 h at 25 °C	$\Delta C/C \leqslant 1\%$. Tan δ and insulation resistance (at $\leqslant$ 10 V d.c.) shall meet initial requirements.
Charge and discharge	10 000 cycles of charge to U_R (d.c.) and discharge via a resistor of value such that the pulse steepness is 1,5 x specified value. Cycle time: 1 to 150 cycles/s, temperature: 25 °C.	$\Delta \tan \delta \leqslant 20 \times 10^{-4}$ at 10 kHz.

For flammability tests see next page.

name of test	procedure (quick reference)	requirements
Flammability	 Bore of gas jet: ϕ 0,5 mm. Fuel: butane. Test duration: 20 s. One flame application.	After removing the test flame from the capacitor, the capacitor must not continue to burn for more than 15 s; no burning particles must drop from the sample.
	 Bore of gas jet: ϕ 10 mm. Fuel: natural gas. Test duration: 3 x 15 s. Time interval between each flame application: 15 s.	Extinguishing time $\leqslant$ 15 s after the first and second flame application, $\leqslant$ 60 s after the third flame application.
	 Bore of gas jet: ϕ 0,5 mm. Fuel: butane. Test duration: 3 x 15 s. Second and third flame application starts after extinguishing of the flame on the capacitor.	Extinguishing time $\leqslant$ 10 s after each flame application; no burning particles must drop from the sample.

ADDITIONAL INFORMATION

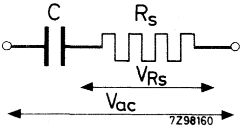
Power dissipation

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

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

The term $R_s C$ 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 $7,5 \times 10^{-7}\,\Omega F$ (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.

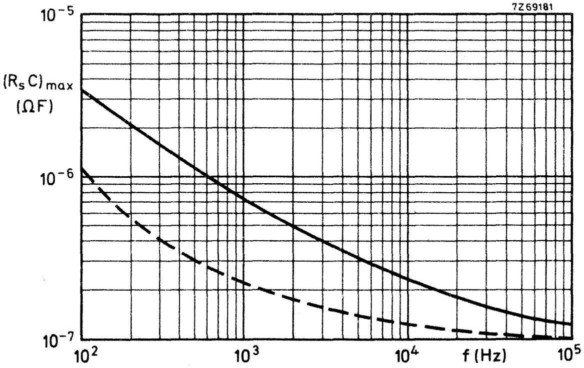


Fig. 9. Maximum product of series resistance and capacitance as a function of frequency
—— metallised PETP film dielectric
---- metallised polycarbonate film dielectric

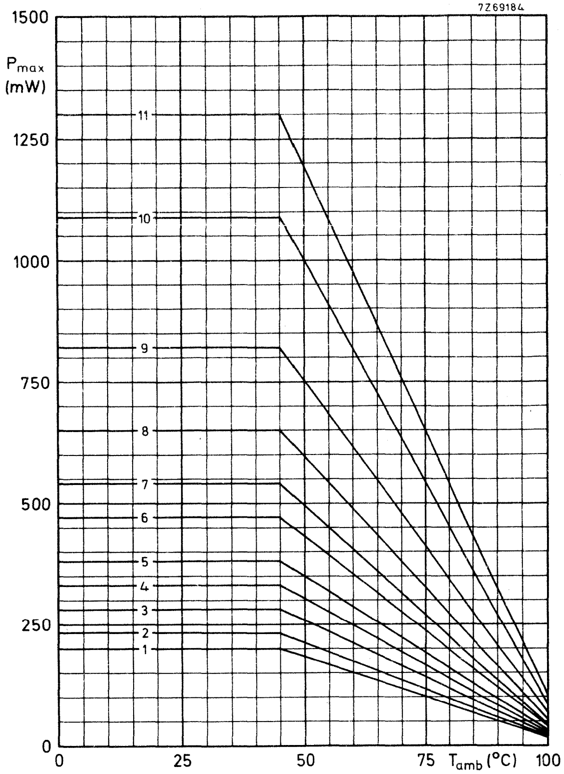


Fig. 10. Maximum permissible power dissipation as a function of temperature

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 OR POLYCARBONATE FILM CAPACITORS

potted type (nugget)

QUICK REFERENCE DATA

Rated capacitance range (E 12-series)	3900 pF to 10 μF				
Tolerance on rated capacitance	± 5%, ± 10%, ± 20%				
Rated voltage U_R (d.c.)	63 V	100 V	250 V	400 V	630 V
Rated voltage U_R (a.c.), 50 to 60 Hz	40 V	63 V	160 V	220 V	220 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

The capacitors consist of a low-inductive wound cell of metallized polyethyleneterephthalate (PETP) or polycarbonate film. The cell is potted with epoxy resin in a yellow flame retardent polypropylene case. The radial leads are solder-coated copper wire. The capacitors are provided with small pips to allow removal of solder flux etc., when cleaning the printed-wiring board. Miniature types are available for each rated voltage with metallized PETP film only.

Composition of the catalogue number

2222 344 . . . . .

code for rated voltage, capacitance tolerance and dielectric material

code for capacitance, see Tables 1 to 6

20 = 100 V; ± 20%
21 = 100 V; ± 10%
22 = 100 V; ± 5%
43 = 250 V; ± 5%
44 = 250 V; ± 20%
45 = 250 V; ± 10%
50 = 400 V; ± 20%
51 = 400 V; ± 10%
52 = 400 V; ± 5%
60 = 630 V; ± 20%
61 = 630 V; ± 10%
62 = 630 V; ± 5%

metallized polycarbonate film

16 = 63 V; ± 20%
17 = 63 V; ± 10%
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%

miniature types
metallized PETP film

14 = 63 V; ± 20%
15 = 63 V; ± 10%
23 = 100 V; ± 5%
24 = 100 V; ± 20%
25 = 100 V; ± 10%
40 = 250 V; ± 20%
41 = 250 V; ± 10%
42 = 250 V; ± 5%
53 = 400 V; ± 5%
54 = 400 V; ± 20%
55 = 400 V; ± 10%

metallized PETP film

MECHANICAL DATA

Dimensions in mm

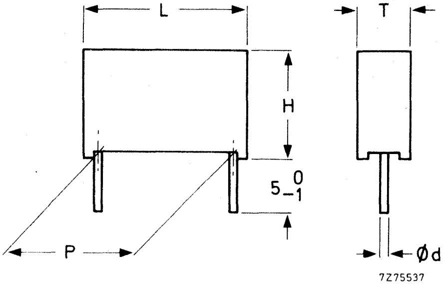


Fig. 1 For dimensions T, L, H, P and d, see tables below.

→ Table 1 U_R (d.c.) = 63 V; U_R (a.c.) = 40 V
Dielectric: metallized PETP film.

rated capacitance* μF	T_{max}	L_{max}	H_{max}	P	d	mass g	capacitance code
0,22	4,5	13	10	10 ± 0,4	0,8	0,7	224
0,33	5	13	11			0,9	334
0,47	6	13	12			1	474
0,68	6	17,5	11,5	15 ± 0,4		1,4	684
1,0	7	17,5	13			1,8	105
1,5	8,5	17,5	14,5			2,6	155
2,2	6,5	26	15,5	22,5 ± 0,4		2,8	225
3,3	8,5	26	18			4,3	335
4,7	9,5	26	19			5,1	475
6,8	11	30	20,5	27,5 ± 0,4		7,4	685
10	13,5	30	23			10,2	106
Miniature type 0,15	4,5	10,5	10	7,5 ± 0,4	0,6	0,8	154

---

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

Table 2 U_R (d.c.) = 100 V; U_R (a.c.) = 63 V ←

Capacitors are available with either dielectric except the miniature types, which are only available with metallized PETP film dielectric.

rated capacitance* μF	T_{max}	L_{max}	H_{max}	P	d	mass g	capacitance code
0,10	4,5	13	10	10 ± 0,4	0,8	0,7	104
0,15	4,5	13	10			0,7	154
0,22	5	13	11			0,9	224
0,33	5	17,5	11	15 ± 0,4		1,1	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			2,6	105
1,5	6,5	26	15,5	22,5 ± 0,4		2,8	155
2,2	8,5	26	18			4,3	255
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							
0,047	4,5	10,5	10	7,5 ± 0,4	0,6	0,8	473
0,068							683
0,10							104

---

* 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 (d.c.) = 250 V; U_R (a.c.) = 160 V
Dielectric: metallized polycarbonate film.

rated capacitance* µF	T_{max}	L_{max}	H_{max}	P	d	mass g	capacitance code
0,047	4,5	13	10	10 ± 0,4	0,8	0,7	473
0,068	4,5	13	10			0,7	683
0,10	5	17,5	11	15 ± 0,4		1,1	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			2,6	334
0,47	6,5	26	15,5	22,5 ± 0,4		2,8	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

→ Table 4 U_R (d.c.) = 250 V; U_R (a.c.) = 160 V
Dielectric: metallized PETP film.

rated capacitance* µF	T_{max}	L_{max}	H_{max}	P	d	mass g	capacitance code
0,047	4,5	13	10	10 ± 0,4	0,8	0,7	473
0,068	4,5	13	10			0,7	683
0,10	5	17,5	11	15 ± 0,4		1,1	104
0,15	5	17,5	11			1,1	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		2,8	474
0,68	6,5	26	15,5			2,8	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	11	30	20,5			7,4	225
Miniature types							
0,022 0,033	4,5	10,5	10	7,5 ± 0,4	0,6	0,8	223 333

* 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 (d.c.) = 400 V; U_R (a.c.) = 220 V

Capacitors are available with either dielectric except the miniature types; which are only available with metallized PETP film dielectric.

rated capacitance* μF	T_{max}	L_{max}	H_{max}	P	d	mass g	capacitance code
0,010	4,5	13	10	10 ± 0,4	0,8	0,7	103
0,015	4,5	13	10			0,7	153
0,022	4,5	13	10			0,7	223
0,033	4,5	13	10			0,7	333
0,047	5	17,5	11	15 ± 0,4		1,1	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			2,6	154
0,22	6,5	26	15,5	22,5 ± 0,4		2,8	334
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							
0,010	4,5	10,5	10	7,5 ± 0,4	0,6	0,8	103
0,015							153

---

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

Table 6 U_R (d.c.) = 630 V; U_R (a.c.) = 220 V

Capacitors are available with metallized polycarbonate film dielectric except the miniature types, which are only available with metallized PETP film dielectric.

rated capacitance* μF	T_{max}	L_{max}	H_{max}	P	d	mass g	capacitance code
0,010	4,5	13	10	10 ± 0,4	0,8	0,7	103
0,015	5	13	11			0,9	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			2,6	683
0,10	6,5	26	15,5	22,5 ± 0,4		2,8	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							
0,0047	4,5	10,5	10	7,5 ± 0,4	0,6	0,8	472
0,0068							682

Marking

The capacitors are marked on the top face by embossed print with:

1st line: rated capacitance in μF, tolerance and rated d.c. voltage;
2nd line: last eight digits of the catalogue number.

Miniature types are marked on the top face by embossed print with:

1st line: rated capacitance in pF or μF and tolerance;
2nd line: rated d.c. voltage, code for dielectric (MA = metallized PETP film) and code for factory of origin.

Mounting

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

---

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

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of 15 to 35 °C, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

Capacitance

Rated capacitance values (C_R) at 1 kHz	see Tables 1 to 6
Tolerance on rated capacitance	± 5%*, ± 10% and ± 20% ◄—

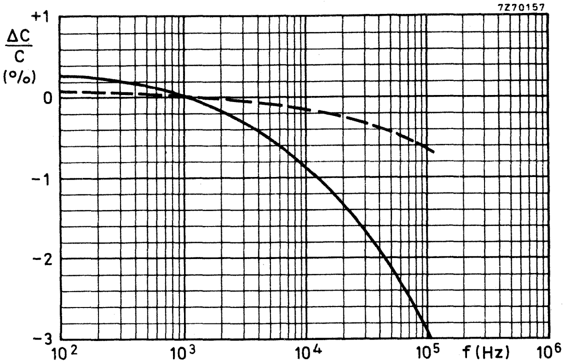


Fig. 2 Capacitance as a function of frequency; typical curves.
—— Metallized PETP film dielectric.
- - - - Metallized polycarbonate film dielectric.
From 100 Hz to 1 kHz the curve is valid for all capacitance values (measuring voltage 1 V). From 1 to 10 kHz the curve is valid for capacitance values ⩽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

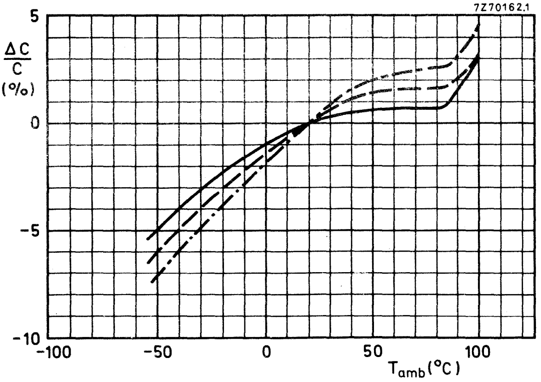


Fig. 3 Capacitance as a function of temperature; typical curves. Metallized PETP film dielectric.
—— For all capacitance values, measured at 1 kHz, 1 V.
- - - - For capacitance values ⩽ 1 μF, measured at 10 kHz, 1 V.
—.— For capacitance values ⩽ 0,1 μF, measured at 100 kHz, 0,3 V.

* Not for 63 V version.

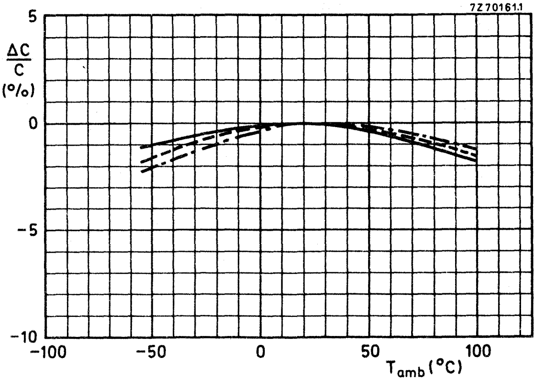


Fig. 4 Capacitance as a function of temperature; typical curves. Metallized polycarbonate film dielectric.
—— For all capacitance values, measured at 1 kHz, 1 V.
- - - For capacitance values ⩽ 1 μF, measured at 10 kHz, 1 V.
—.— For capacitance values ⩽ 0,1 μF, measured at 100 kHz, 0,3 V.

Voltage

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

Note

The sum of the d.c. voltage and the peak value of the superimposed a.c. voltage must be ⩽ U_R (d.c.).

---

* 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 63 V, 100 V, 250 V and 400 V versions and 500 ± 50 V for the 630 V version.

	ambient temperature	
	23 °C	100 °C
R between terminations for $C_R \leqslant 0{,}33\ \mu F$		
63 V and 100 V versions	> 15 000 MΩ	> 50 MΩ
250 V, 400 V and 630 V versions	> 30 000 MΩ	> 100 MΩ
RC between terminations for $C_R > 0{,}33\ \mu F$		
63 V and 100 V versions	> 5 000 s	> 16 s
250 V, 400 V and 630 V versions	> 10 000 s	> 33 s

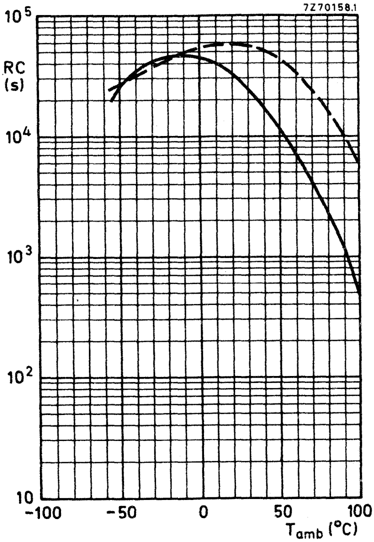


Fig. 5 RC-product as a function of temperature; typical curves.
—— Metallized PETP film dielectric.
- - - Metallized polycarbonate film dielectric.

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})

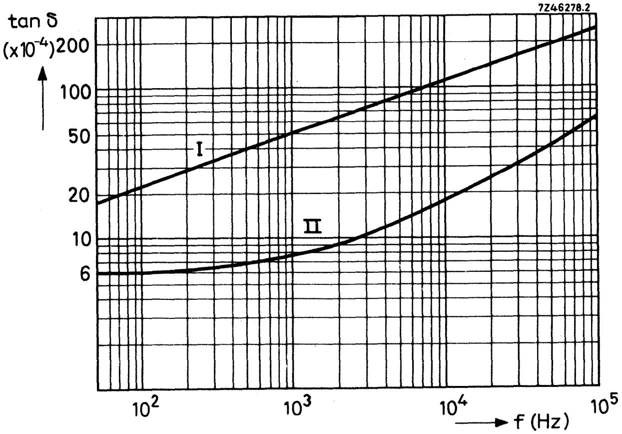


Fig. 6 Tan δ as a function of frequency; typical curves.
I = Metallized PETP film dielectric.
II = Metallized polycarbonate film dielectric.

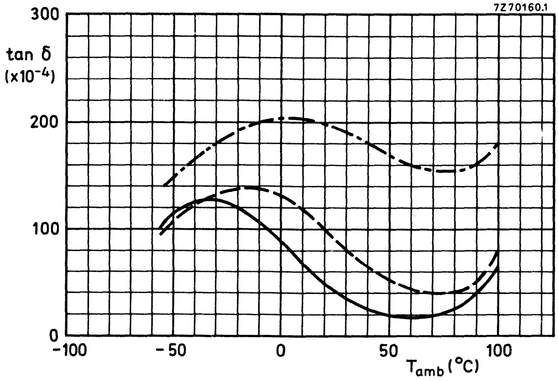


Fig. 7 Tan δ as a function of temperature; typical curves.
Metallized PETP film dielectric.
—— For all capacitance values, measured at 1 kHz, 1 V.
- - - For capacitance values ≤ 1 μF, measured at 10 kHz, 1 V.
-.- For capacitance values ≤ 0,1 μF, measured at 100 kHz, 0,3 V.

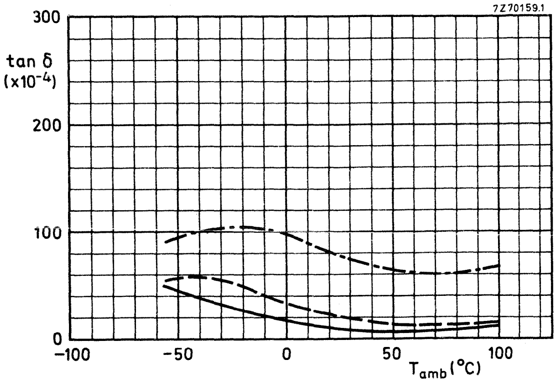


Fig. 8 Tan δ as a function of temperature; typical curves.
Metallized polycarbonate film dielectric.
—— For all capacitance values, measured at 1 kHz, 1 V.
- - - For capacitance values $\leqslant$ 1 μF, measured at 10 kHz, 1 V.
- . - For capacitance values $\leqslant$ 0,1 μF, measured at 100 kHz, 0,3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

Power dissipation

Maximum permissible power dissipation see Additional information

Notes

In applications where voltages higher than 50 V are applied, it is recommended that the power in the capacitor is limited to 2,5 VA in case of capacitor failure.

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
63	10	8	4	2	2
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

The maximum pulse steepness values in the table are valid for pulse voltages equal to the rated voltage. For lower pulse voltages the given values may be multiplied by U_R/applied voltage.

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, IEC68	55/100/56

→ PACKING

The capacitors are packed in boxes; the number per box is given in the table below.

capacitance values (μF)					number of capacitors per box
63 V version	100 V version	250 V version	400 V version	630 V version	
0,18 - 0,47	0,047 - 0,22	0,047 - 0,068	0,010 - 0,033	0,010 - 0,033	250
	0,27 - 0,33	0,082 - 0,15	0,039 - 0,047	0,039 - 0,047	200
0,56 - 0,68	0,39 - 0,47	0,18 - 0,22	0,056 - 0,068	0,056 - 0,068	150
0,82 - 1,0	0,56 - 0,68	0,27 - 0,33	0,082 - 0,1	0,082 - 1,0	125
1,2 - 1,5	0,82 - 1,0		0,12 - 0,15	0,12 - 0,15	100
1,8 - 4,7	1,2 - 3,3	0,39 - 1,0	0,18 - 0,47	0,18 - 0,47	200
5,6 - 10,0	3,9 - 6,8	1,2 - 2,2	0,56 - 1,0	0,56 - 1,0	100

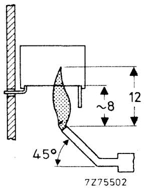
The miniature types are packed in boxes of 250 pieces.

TESTS AND REQUIREMENTS

IEC68-2 method	name of test	procedure (quick reference)	requirements
Ua1	Tensile strength of terminations	Loading force in axial direction of the wires: 10 N, 10 s.	No damage.
		Loading force in radial direction of the wires; 5 N, 10 s.	No damage.
Ub (method 1)	Bending of terminations	Loading force 5 N, two consecutive bends.	No damage.
Ta	Soldering	Solder bath, non-activated colophony flux, solder temp. 235 °C, dwell time 2 s.	Good tinning.
Tb (method 1B)	Resistance to soldering heat	Solder bath: 350 °C, 3,5 s.	No damage; $\Delta C/C \leqslant 1\%$.
Na	Rapid change of temperature	5 cycles of ½ h at −55 °C and ½ h at + 100 °C	No damage; no leakage; $\Delta C/C \leqslant 2\%$. Tan δ and insulation resistance shall meet initial requirements.
Fc	Vibration	10 to 55 Hz, 0,75 mm or 10g (whichever is less), 3 directions, 2 h per direction.	No damage, no open or short-circuit. $\Delta C/C \leqslant 0{,}5\%$.
Eb	Bumping	40g, 4000 bumps.	No damage, no open or short-circuit. $\Delta C/C \leqslant 0{,}5\%$.

IEC68-2 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; $\Delta C/C \leqslant -3\%$ (polycarbonate), $\leqslant +7\%$ (PETP) at 100 ^{o}C. Insulation resistance at 100 ^{o}C for $C_R \leqslant 0{,}33\ \mu F$: $> 50\ M\Omega$ (63 V and 100 V versions), $> 100\ M\Omega$ (other versions); for $C_R > 0{,}33\ \mu F$: $RC > 16$ s (63 V and 100 V versions), > 33 s (other versions).	
	Db	Damp heat, cyclic	1 cycle of 24 h, upper temperature 55 ± 2 ^{o}C, R.H. 93 ± 3%; no voltage applied.		
	Aa	Cold	2 h at −55 ± 3 ^{o}C; no voltage applied.	$\Delta C/C \leqslant -3\%$ (polycarbonate), $\leqslant -8\%$ (PETP) at −55 ^{o}C.	
	M	Low air pressure	1 h at 25 ± 5 ^{o}C; at an atmospheric pressure of 85 mbar.	During and after the test there shall be no breakdown or flashover.	
	Db	Damp heat, cyclic	5 cycles of 24 h, upper temperature 55 ± 2 ^{o}C, R.H. 93 ± 3%; no voltage applied.		
			Final measurement	$\Delta C/C \leqslant 3\%$. Tan δ shall meet initial requirements. Insulation resistance $> 0{,}5 \times$ initial requirements.	
	Ca	Damp heat, steady state	56 days at 40 ^{o}C and R.H. 90 to 95%; 6 V (d.c.) applied continuously.	$\Delta C/C \leqslant 3\%$. Tan δ shall meet initial requirements. Insulation resistance $\geqslant 0{,}5 \times$ initial requirements.	
	–	Endurance	1000 h at 85 ^{o}C, $1{,}5 \times U_R$ (d.c.) applied.	$\Delta C/C \leqslant 3\%$.	$\Delta \tan\delta \leqslant 30 \times 10^{-4}$ at 10 kHz. Insulation resistance shall meet initial requirements.
			1000 h at 100 ^{o}C, $1{,}5 \times U_c$ applied	$\Delta C/C \leqslant 5\%$	
			1000 h at 85 ^{o}C, U_R (a.c.), 50 Hz applied.	$\Delta C/C \leqslant 20\%$ (L = 10,5 mm) $\leqslant 15\%$ (L = 13 mm) $\leqslant 10\%$ (L = 17,5 mm) $\leqslant 7\%$ (L = 26 mm) $\leqslant 5\%$ (L = 30 mm)	

Additional tests

name of test	procedure (quick reference)	requirements
Solvent resistance	According to MIL-STD-202 E, method 215.	No damage.
Storage	1000 h at 100 °C	$\Delta C/C \leqslant 3\%$. Tan δ and insulation resistance (at $\leqslant$ 10 V d.c.) shall meet initial requirements.
	10 000 h at 25 °C	$\Delta C/C \leqslant 1\%$. Tan δ and insulation resistance (at $\leqslant$ 10 V d.c.) shall meet initial requirements.
Charge and discharge	10 000 cycles of charge to U_R (d.c.) and discharge via a resistor of value such that the pulse steepness is 1,5 x specified value. Cycle time: 1 to 150 cycles/s, temperature: 25 °C.	Δ tan $\delta \leqslant 20 \times 10^{-4}$ at 10 kHz.
Flammability	 Bore of gas jet: ϕ 0,5 mm. Fuel: butane. Test duration: 20s. One flame application.	After removing the test flame from the capacitor, the capacitor must not continue to burn for more than 15 s. No burning particles must drop from the sample.

ADDITIONAL INFORMATION

Power dissipation

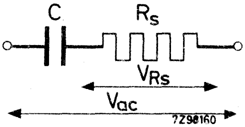
The rated a.c. voltage has been specified for 50 Hz and at 20 °C. This voltage value must also never be exceeded at other frequencies. This permissible a.c. voltage may further be limited by the following requirements:

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 $7,5 \times 10^{-7}$ 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.

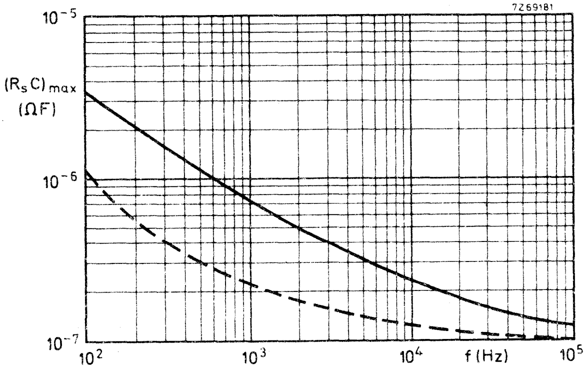


Fig. 9. Maximum product of series resistance and capacitance as a function of frequency
—— metallised PETP film dielectric
- - - - metallised polycarbonate film dielectric

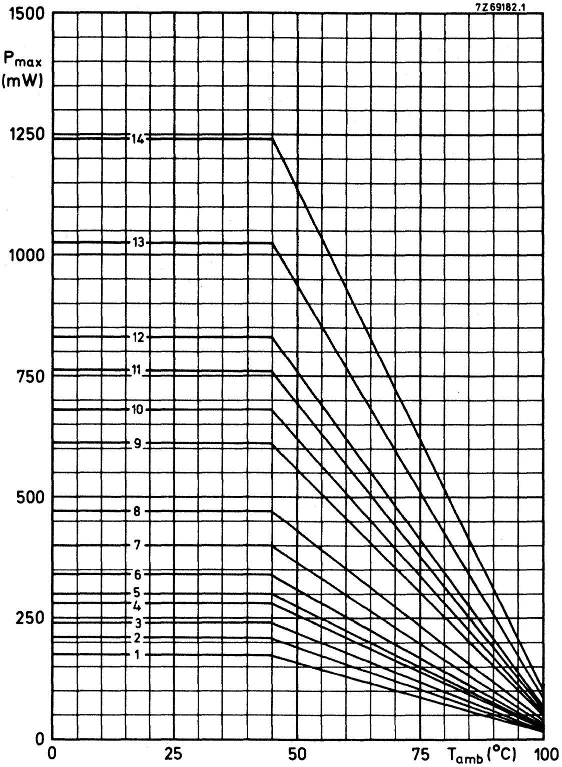


Fig. 10. Maximum permissible power dissipation as a function of temperature.

curve	dimensions (mm)		
	T_{max}	L_{max}	H_{max}
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 (E12-series)	1 nF to 1 µF	←
Tolerance on rated capacitance	± 10% and ± 20%	
Rated voltage U_R (d.c.)	100 V, 250 V, 400 V, 630 V	
Rated voltage U_R (a.c.), 50 to 60 Hz	50 V, 80 V, 125 V, 200 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. or 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

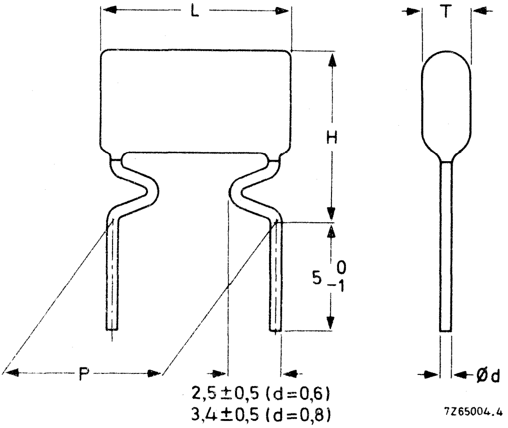


Fig. 1 For dimensions T, L, H, P and d, see tables below.

Table 1 U_R (d.c.) = 100 V; U_R (a.c.) = 50 V

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

---

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

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

Table 2 U_R (d.c.) = 250 V; U_R (a.c.) = 80 V

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

Table 3 U_R (d.c.) = 400 V; U_R (a.c.) = 125 V

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

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

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

Table 4 U_R (d.c.) = 630 V; U_R (a.c.) = 200 V

capacitance* μF	T_{max}	L_{max}	H_{max}	P	d	mass g	capacitance code
→ 0,0010	5,5	13,5	13	10,16 ± 0,3 (4e)**	0,6	0,5	102
→ 0,0015	5,5	13,5	13			0,6	152
0,0022	4,5	13,5	12			0,5	222
0,0033	5,5	13,5	13			0,6	332
0,0047	6	13,5	13,5			0,7	472
0,0068	7	13,5	14,5			0,9	682
0,010	6	19	14,5	15,24 ± 0,3 (6e)**	0,8	1,2	103
0,015	7	19	15,5			1,5	153
0,022	8	19	16,5			2,0	223
0,033	7	27	18,5	22,86 ± 0,3 (9e)**		2,8	333
0,047	8,5	27	20			3,4	473
0,068	10,5	27	22			4,4	683
0,10	11	32	22,5	27,94 ± 0,3 (11e)**		6,2	104
0,15	13,5	32	25			8,7	154

Marking

The capacitors are marked as follows:

1st line: rated capacitance and tolerance;
2nd line: rated voltage, code for dielectric (FA = non-metallized PETP film), code for factory of origin.

Mounting

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

---

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

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

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of 15 to 35 °C, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

Capacitance

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

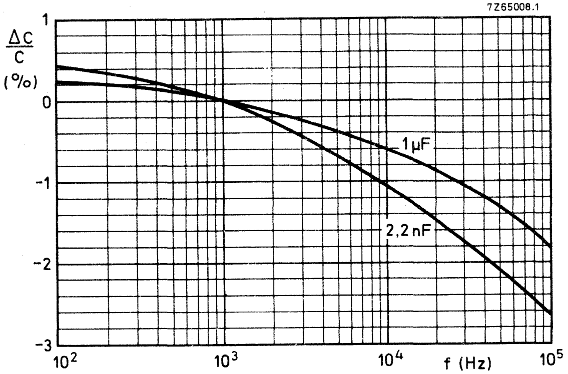


Fig. 2 Capacitance as a function of frequency; typical curves. Measuring voltage is 1 V for frequencies from 100 Hz to 10 kHz and 0,3 V for frequencies from 10 to 100 kHz.

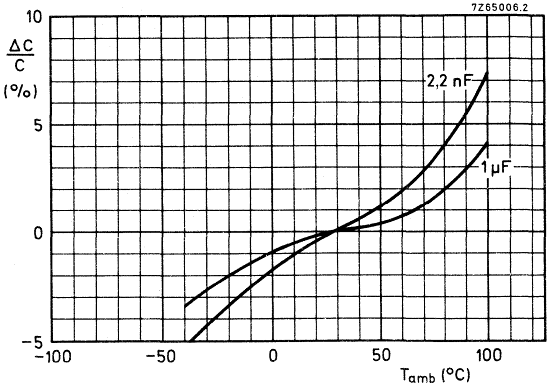


Fig. 3 Capacitance as a function of temperature; typical curves. Measuring frequencies from 1 to 100 kHz for capacitance values from 0,0022 to 0,1 μF and 1 to 10 kHz for capacitance values from 0,1 to 1 μF.

Voltage

Rated voltage U_R (d.c.)	100 V, 250 V, 400 V, 630 V
Rated voltage U_R (a.c.), 50 to 60 Hz *	
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 (d.c.) (derating of 1,25%/°C)
Test voltage for 1 min between terminals	2 x U_R (d.c.)

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	
	23 °C	100 °C
R between terminations, for $C_R \leqslant 0{,}33\ \mu F$	$>$ 50 000 MΩ	$>$ 200 MΩ
RC between terminations, for $C_R > 0{,}33\ \mu F$	$>$ 16 500 s	$>$ 65 s

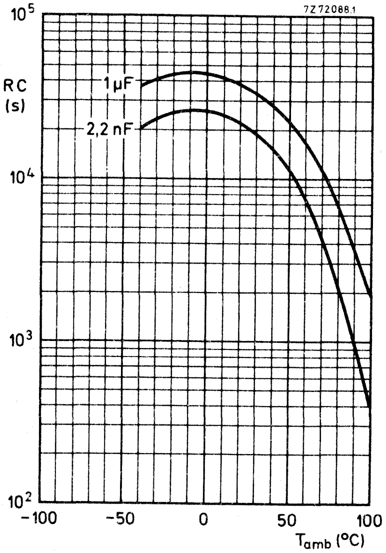


Fig. 4 RC-product as a function of temperature; typical curves.

---

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

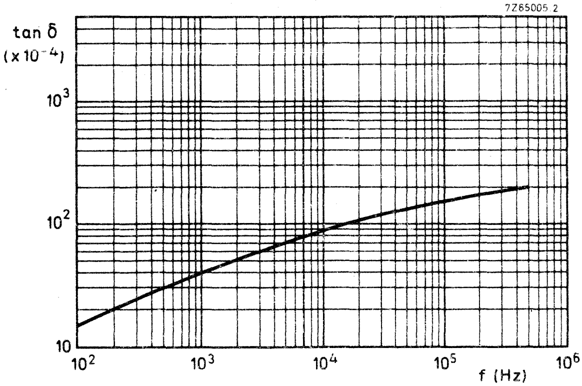


Fig. 5 Tan δ as a function of frequency; typical curve.

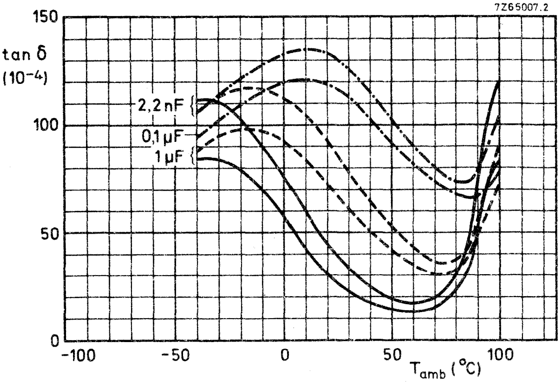


Fig. 6 Tan δ as a function of temperature; typical curves.

——— 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	limited by network conditions, not by capacitor construction
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

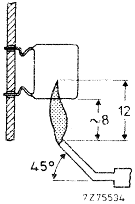
dimensions (mm) $T_{max} \times L_{max} \times H_{max}$	number of pieces per box
⩽ 5,5 x 13,5 x 13	2000 or 16000
> 5,5 x 13,5 x 13 and ⩽ 8 x 19 x 16,5	2000 or 8000
> 8 x 19 x 16,5 and ⩽ 8,5 x 27 x 20	1000 or 4000
> 8,5 x 27 x 20 and ⩽ 12 x 32 x 23,5	500 or 2000
> 12 x 32 x 23,5	250 or 1000

TESTS AND REQUIREMENTS

IEC 68-2 test method	name of test	procedure (quick reference)	requirements
Ua1	Tensile strength of terminations	Loading force 10 N in axial direction of the wires, 10 s.	No damage.
		Loading force 5 N in radial direction of the wires, 10 s.	No damage.
Ub (method 1)	Bending of terminations	Loading force 5 N, two consecutive bends.	No damage.
Ta	Soldering	Solder bath, non-activated colophony flux, solder temp. 235 °C, dwell time 2 s.	Good tinning.
Tb (method 1B)	Resistance to soldering heat	Solder bath: 350 °C, 3,5 s.	No damage; $\Delta C/C \leqslant 0{,}5\%$.
Na	Rapid change of temperature	5 cycles of ½ h at −40 °C and ½ h at +100 °C.	No damage; $\Delta C/C \leqslant 2\%$. 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 +100 ± 2 °C, no voltage applied.	No damage, $\Delta C/C \leqslant 5\%$ at 100 °C. For capacitors $\leqslant 0{,}33\ \mu F$, insulation resistance $> 500\ M\Omega$ at 100 °C; for capacitors $> 0{,}33\ \mu F$, $RC > 165$ s at 100 °C.
	Db	Damp heat, cyclic	1 cycle of 24 h, upper temperature 55 ± 2 °C, R.H. 93 ± 3%; no voltage applied.	
	Aa	Cold	2 h at –40 ± 3 °C; no voltage applied.	$\Delta C/C \leqslant 7\%$ at –40 °C.
	M	Low air pressure	1 h at 25 ± 5 °C; at an atmospheric pressure of 85 mbar.	During and after the test there shall be no breakdown or flashover.
	Db	Damp heat, cyclic	1 cycle of 24 h, upper temperature 55 ± 2 °C, R.H. 93 ± 3%; no voltage applied. Final measurement.	$\Delta C/C \leqslant 5\%$. Tan δ shall meet initial requirements. Insulation resistance $> 0{,}5 \times$ initial requirements.
Ca		Damp heat, steady state	21 days at 40 °C and R.H. 90 to 95%; no voltage applied.	$\Delta C/C \leqslant 5\%$. Tan δ shall meet initial requirements. Insulation resistance $> 0{,}5 \times$ initial requirements.
–		Endurance	1000 h at 85 °C, 1,5 x U_R (d.c.) applied.	No damage, no short circuit. $\Delta C/C \leqslant 5\%$; tan δ and insulation resistance shall meet initial requirements.
			1000 h at 85 °C, U_R (a.c.), 50 Hz applied.	
			1000 h at 100 °C, 1,5 x U_C applied.	

Additional tests

name of test	procedure (quick reference)	requirements
Solvent resistance	According to MIL-STD-202 E, method 215.	No damage.
Damp heat, long term exposure (IEC 68-2, test Ca)	21 days at 40 ± 2 °C, R.H. 90 to 95%; U_R (a.c.) applied for 16 h per 24 h.	No damage; $\Delta C/C \leqslant 5\%$. Tan δ shall not exceed initial requirements. Insulation resistance $\geqslant$ 50 % of initial requirements.
Flammability	 Bore of gas jet: ϕ 0,5 mm. Fuel: butane. Test duration: 20 s. One flame application.	After removing the test flame from the capacitor, the capacitor must not continue to burn for more than 15 s; no burning particles must drop from the sample.

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:

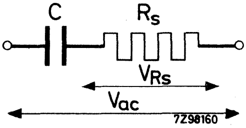
1) The power dissipation must not exceed the specified limit P_{max}.

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_sC 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 x 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.

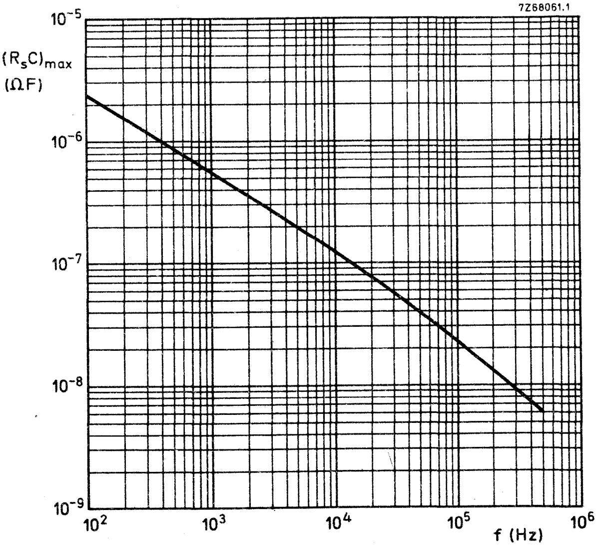


Fig. 7. Maximum product of series resistance and capacitance as a function of frequency.

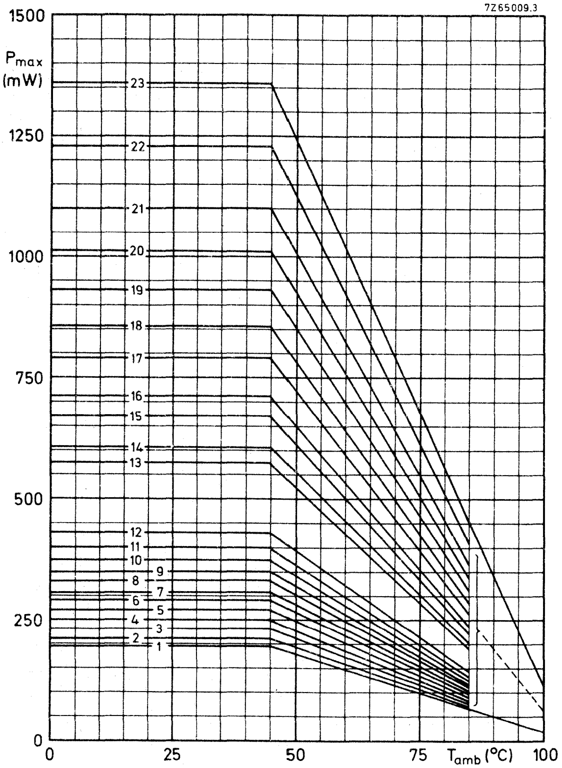


Fig. 8. Maximum permissible power dissipation as a function of temperature.

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
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

METALLIZED POLYESTER FILM CAPACITORS

lacquered type (f.f.c.)

QUICK REFERENCE DATA

Rated capacitance range (E12-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 voltage U_R (a.c.), 50 to 60 Hz	63 V, 160 V, 220 V, 220 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

The capacitors consist of a low-inductive wound cell of metallized polyethyleneterephthalate (PETP) film. The cell is protected by a hard, water repellent, solvent resistant lacquer. The radial leads are solder coated copper wire and are crimped to provide optimum soldering conditions. The capacitors are available with short or 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

Fig. 1 For dimensions T, L, H, P, d and l, see tables below.

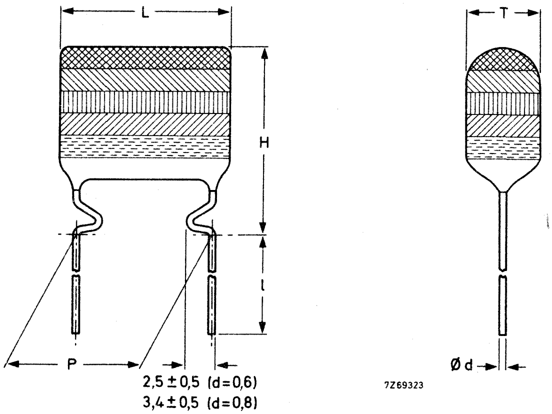


Table 1 U_R (d.c.) = 100 V; U_R (a.c.) = 63 V
The capacitors mentioned in this table are also available with lead length l = 5 − 1 mm.

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

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

Table 2 U_R (d.c.) = 250 V; U_R (a.c.) = 160 V

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}	mass g	capacitance code
0,0010	4,5	12,5	12,5	10,16 ± 0,3 (4e) *	0,6	13	0,5	102
0,0012	4,5		12,5				0,5	122
0,0015	4,5		12,5				0,5	152
0,0018	4,5		12,5				0,5	182
0,0022	4,5		12,5				0,5	222
0,0027	4,5		12,5				0,5	272
0,0033	4,5		12,5				0,5	332
0,0039	4,5		12,5				0,5	392
0,0047	4,5		12,5				0,5	472
0,0056	4,5		12,5				0,5	562
0,0068	4,5		12,5				0,5	682
0,0082	4,5		12,5				0,5	822
0,010	4		12				0,5	103
0,012	4		12				0,5	123
0,015	4		12				0,5	153
0,018	4		12				0,5	183
0,022	4		12				0,5	223
0,027	4		12				0,5	273
0,033	4		12				0,5	333
0,039	4		12				0,5	393
0,047	4		12				0,5	473
0,056	4,5		12,5				0,5	563
0,068	4,5		12,5				0,6	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) *	0,8		0,9	124
0,15	6		15				1,0	154
0,18	6,5		15,5				1,1	184
0,22	7		16				1,3	224
0,27	6	22,5	15	20,32 ± 0,3 (8e) *		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) *		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				5,0	155
1,8	10,5		22,5				5,7	185
2,2	11,5		23,5				6,5	225

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

Table 3 U_R (d.c.) = 400 V; U_R (a.c.) = 220 V

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}	mass g	capacitance code
0,010	4,5	12,5	12,5	10,16 ± 0,3 (4e) *	0,6	13	0,5	103
0,012	4,5		12,5				0,5	123
0,015	4,5		12,5				0,5	153
0,018	4,5		12,5				0,5	183
0,022	4,5		12,5				0,5	223
0,027	5		13				0,5	273
0,033	5,5		13,5				0,6	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) *	0,8		0,9	563
0,068	6		15				1,0	683
0,082	6,5		15,5				1,1	823
0,10	7		16				1,3	104
0,12	6	22,5	15	20,32 ± 0,3 (8e) *		21	1,4	124
0,15	6,5		15,5				1,6	154
0,18	7		16				1,9	184
0,22	7,5		16,5				2,2	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) *		19	3,2	394
0,47	9,5		18,5				3,7	474
0,56	9		21				4,3	564
0,68	10		22				5,0	684
0,82	11		23				5,7	824
1,0	12		24				6,5	105

---

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

Table 4 U_R (d.c.) = 630 V; U_R (a.c.) = 220 V

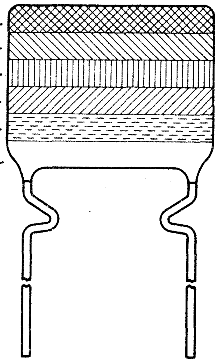
The capacitors mentioned in this table are also available with lead length l = 5 – 1 mm.

rated capacitance μF	T_{max}	L_{max}	H_{max}	P	d	l_{min}	mass g	capacitance code
0,010	4,5	12,5	12,5	10,16 ± 0,3 (4e) *	0,6	13	0,5	103
0,012	5		13				0,5	123
0,015	5,5		13,5				0,6	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) *	0,8		0,9	273
0,033	6		15				1,0	333
0,039	6,5		15,5				1,1	393
0,047	7		16				1,3	473
0,056	6	22,5	15	20,32 ± 0,3 (8e) *		21	1,4	563
0,068	6,5		15,5				1,6	683
0,082	7		16				1,9	823
0,10	7,5		16,5				2,2	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) *		19	3,2	184
0,22	9,5		18,5				3,7	224
0,27	9		21				4,3	274
0,33	10		22				5,0	334
0,39	11		23				5,7	394
0,47	12		24				6,5	474

---

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

Marking



colour	1st figure of capacitance value in pF	2nd figure of capacitance value in pF	multiplying factor	capacitance tolerance	rated voltage (d.c.)
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 15 to 35 °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%

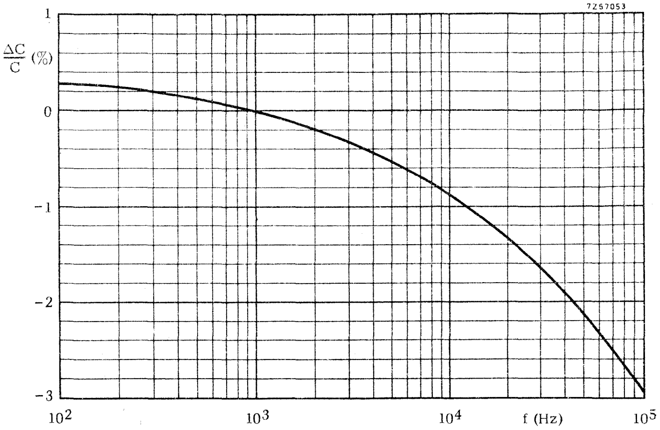


Fig. 2 Capacitance as a function of frequency; typical curve.

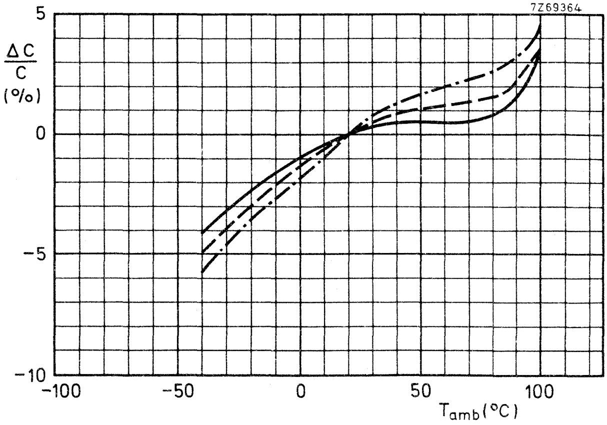


Fig. 3 Capacitance as a function of temperature; typical curves.
——— For all capacitance values, measured at 1 kHz, 1 V;
– – – For capacitance values ⩽ 1 μF, measured at 10 kHz, 1 V;
–.–.– For capacitance values ⩽ 0,1 μF, measured at 100 kHz, 0,3 V.

Voltage

Rated voltage U_R (d.c.)	100 V, 250 V, 400 V, 630 V
Rated voltage U_R (a.c.), 50 to 60 Hz	
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 (d.c.) (derating of 1,25%/°C)
Over-voltage for 1 min/h	
100 V and 250 V versions	$\leqslant$ 40% of U_R (d.c.)
400 V and 630 V versions	$\leqslant$ 25% of U_R (d.c.)
Test voltage for 1 min	
between terminals	1,6 x U_R (d.c.)
between interconnected terminals and coating	2 x U_R (d.c.) (minimum 1000 V)

Note
The sum of the d.c. voltage and the peak value of the superimposed a.c. voltage must be $\leqslant U_R$ (d.c.).

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	
	23 °C	100 °C
R between terminations for $C_R \leqslant 0{,}33\ \mu F$		
100 V version	> 15 000 MΩ	> 50 MΩ
250 V, 400 V, 630 V versions	> 30 000 MΩ	> 100 MΩ
RC between terminations for $C_R > 0{,}33\ \mu F$		
100 V version	> 5 000 s	> 16 s
250 V, 400 V, 630 V versions	> 10 000 s	> 33 s

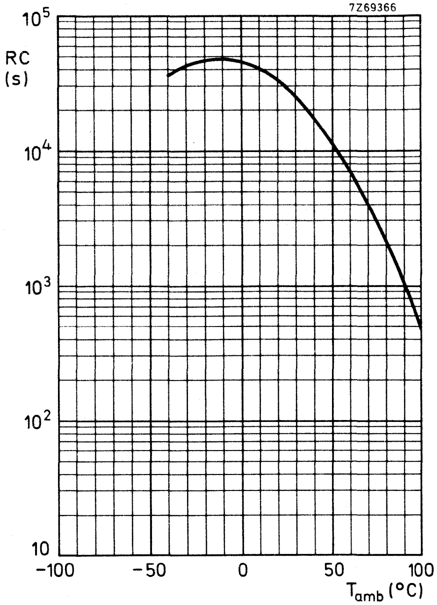


Fig. 4 RC-product as a function of temperature; typical curve.

Tan δ (tangent of the loss angle)

Tan δ at 10 kHz	⩽ 150 x 10^{-4} (typ. 90 x 10^{-4})

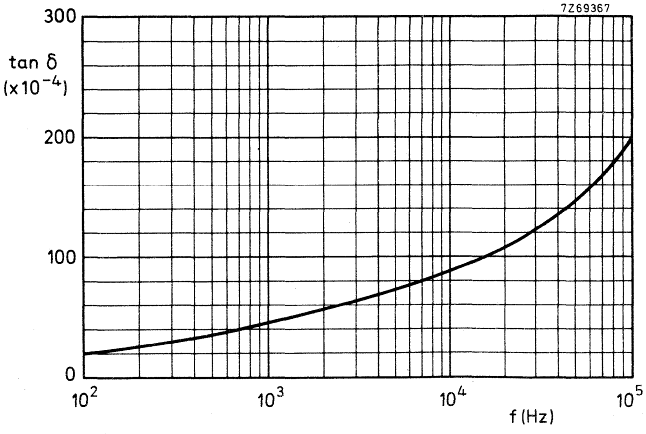


Fig. 5 Tan δ as a function of frequency; typical curve.

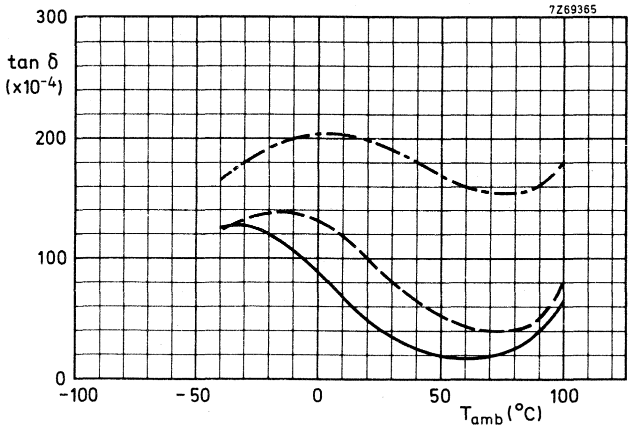


Fig. 6 Tan δ as a function of temperature; typical curves.

——— 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

Notes

→ In applications where voltages higher than 50 V are applied, it is recommended that the power in the capacitor is limited to 2,5 VA in case of capacitor failure.
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

→ The maximum pulse steepness values in the table are valid for pulse voltages equal to the rated voltage. For lower pulse voltages the given values may be multiplied by U_R/applied voltage.

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

IEC 384–2 clause	IEC 68–2 test method	name of test	procedure (quick reference)	requirements
17	Ua1	Tensile strength of terminations	Loading force 10 N in axial direction of the wires, 10 s.	No damage.
			Loading force 3,5 N (d = 0,6 mm) or 5 N (d = 0,8 mm) in radial direction of the wires, 10 s.	No damage.
	Ub (method 1)	Bending of terminations	Loading force 3,5 N (d = 0,6 mm) or 5 N (d = 0,8 mm), two consecutive bends.	No damage.
18	Ta	Soldering	Solder bath, non-activated colophony flux, solder temp. 235 °C, dwell time 2 s.	Good tinning.
	Tb (method 1B)	Resistance to soldering heat	Solder bath: 350 °C, 3,5 s.	No damage; $\Delta C/C \leqslant 1\%$.
19	Na	Rapid change of temperature	5 cycles of ½ h at –40 °C and ½ h at + 100 °C.	No damage, no leakage, $\Delta C/C \leqslant 2\%$. Tan δ and insulation resistance shall meet initial requirements.

IEC 384–2 clause	IEC 68–2 test method		name of test	procedure (quick reference)	requirements	
22.2	Climatic sequence	Ba	Dry heat	16 h at + 100 ± 2 °C, no voltage applied.	No damage, no leakage; $\Delta C/C \leqslant 7\%$ at 100 °C. Insulation resistance at 100 °C, for $C_R \leqslant 0{,}33\,\mu F$: > 50 MΩ (100 V version), > 100 MΩ (250 V, 400 V, 630 V versions); for $C_R > 0{,}33\,\mu F$: > 16 s (100 V version), > 33 s (250 V, 400 V, 630 V version).	
22.3		Db	Damp heat, cyclic	1 cycle of 24 h, upper temperature 55 ± 2 °C, R.H. 93 ± 3%; no voltage applied.		
22.4		Aa	Cold	2 h at −40 ± 3 °C; no voltage applied.	$\Delta C/C \leqslant -7\%$ at −40 °C.	
22.5		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.	
22.6		Db	Damp heat, cyclic	1 cycle of 24 h, upper temperature 55 ± 2 °C, R.H. 93 ± 3%; no voltage applied.		
				Final measurement.	$\Delta C/C \leqslant 5\%$. Tan δ shall meet initial requirements. Insulation resistance ⩾ 0,5 x initial requirements.	
23		Ca	Damp heat, steady state	21 days at 40 ± 2 °C, R.H. 90 to 95%; 6 V continuously applied.	$\Delta C/C \leqslant 5\%$. Tan δ shall meet initial requirements. Insulation resistance ⩾ 0,5 x initial requirements.	
24			Endurance	1000 h at 85 °C, 1,5 x U_R (d.c.) applied.	$\Delta C/C \leqslant 5\%$.	Tan δ and insulation resistance shall meet initial requirements.
				1000 h at 100 °C, 1,2 x U_R (d.c.) applied.	$\Delta C/C \leqslant 5\%$.	
				1000 h at 85 °C, U_R (a.c.), 50 Hz applied.	$\Delta C/C \leqslant 15\%$ (L = 12,5 mm) $\Delta C/C \leqslant 10\%$ (L = 17,5 mm) $\Delta C/C \leqslant 7\%$ (L = 22,5 mm) $\Delta C/C \leqslant 5\%$ (L = 30 mm)	

Additional tests

name of test	procedure (quick reference)	requirements
Solvent resistance	According to MIL-STD-202 E, method 215.	No damage.
Storage	1000 h at 100 °C.	$\Delta C/C \leqslant 3\%$. Tan δ and insulation resistance shall meet initial requirements.
Damp heat, long-term exposure	21 days at 40 ± 2 °C and R.H. 90 to 95%, U_R (a.c.) applied for 16 h per 24 h.	No damage.
Charge and discharge	10 000 cycles of charge to U_R (d.c.) and discharge via a resistor of value such that the pulse steepness is 1,5 x initial requirement. Cycle time: 1 to 150 cycles/s, temperature: 25 °C.	Δ tan $\delta \leqslant 20 \times 10^{-4}$ at 10 kHz.

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:

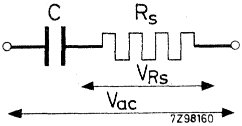
1) The power dissipation must not exceed the specified limit P_{max}.

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

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

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

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.

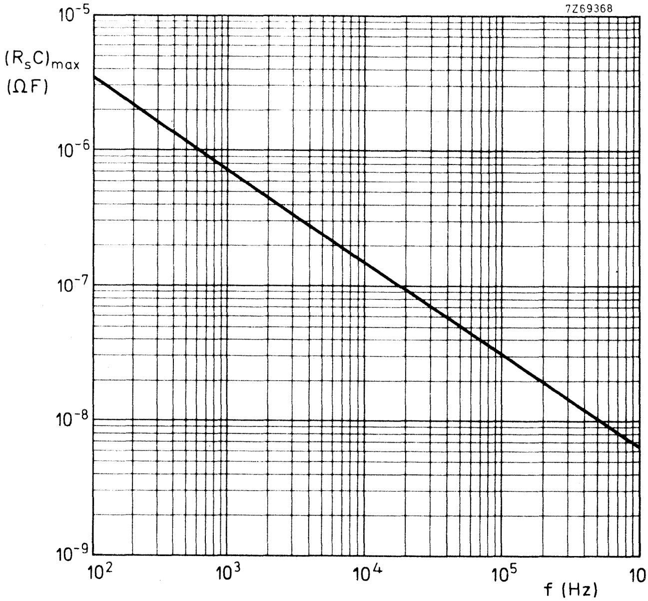
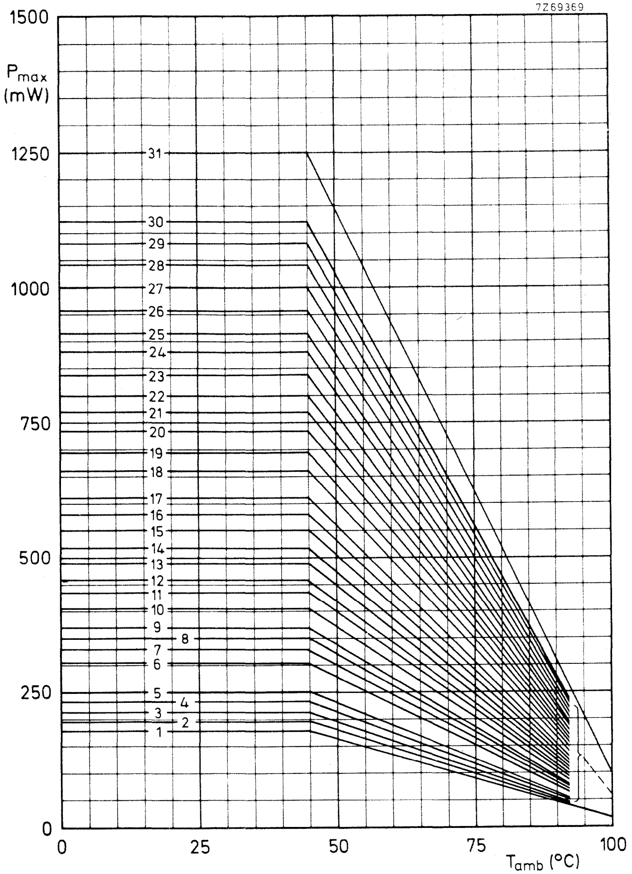


Fig. 7 Maximum product of series resistance and capacitance as a function frequency



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

lacquered type

QUICK REFERENCE DATA

Rated capacitance range (E 12 series)	0,039 to 0,68 μF
Tolerance on rated capacitance	± 5% and ± 10%
Rated voltage U_R (d.c.)	250 V
Rated voltage U_R (a.c.), 50 to 60 Hz	80 V
Rated temperature	85 ^{o}C
Climatic category, IEC 68	40/085/21

APPLICATION

These capacitors are intended for applications where high currents and steep pulses occur. They are mainly used for deflection circuits in television receivers, to operate at high peak currents at line frequency.

When requiring advice, please send oscillograms of current and voltage waveforms.

DESCRIPTION

The capacitors consist of an impregnated, low-inductive wound cell of aluminium foil and polypropylene film. The cell is protected by a hard, water repellent, solvent resistant lacquer. The radial leads are solder-coated copper wire, and are crimped to provide optimum soldering conditions.

Composition of the catalogue number

2222 357 4 . . . .

code for capacitance tolerance
8 = ± 10%
9 = ± 5%

code for capacitance,
see Table 1

MECHANICAL DATA

Dimensions in mm

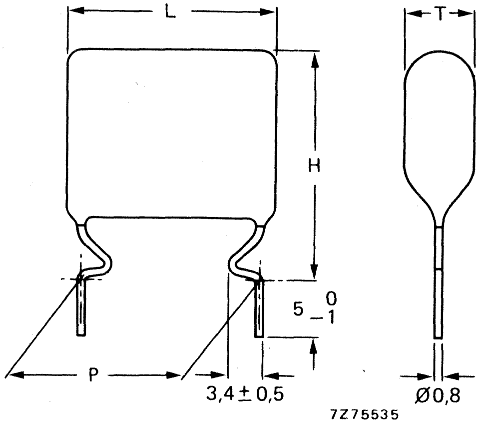


Fig. 1 For dimensions T, L, H and P, see Table 1.

Table 1 U_R (d.c.) = 250 V; U_R (a.c.) = 80 V

rated capacitance µF	T_{max}	L_{max}	H_{max}	P	mass g	catalogue number 2222 357	
						tol. ± 5%	tol. ± 10%
0,039	6	19,5	14,5	15,24 ± 0,3 (6 e)*	1,3	49393	48393
0,047	6,5	19,5	15		1,4	49473	48473
0,056	7,5	19,5	16		1,6	49563	48563
0,068	8	19,5	16,5		1,8	49683	48683
0,082	9	19,5	17,5	22,86 ± 0,3 (9 e)*	2,1	49823	48823
0,10	6	27	17,5		2,7	49104	48104
0,12	7	27	18,5		2,9	49124	48124
0,15	7,5	27	19		3,5	49154	48154
0,18	8,5	27	20		3,9	49184	48184
0,22	8	32	19,5	27,94 ± 0,3 (11 e)*	4,5	49224	48224
0,27	9	32	20,5		5,3	49274	48274
0,33	10	32	21,5		6,3	49334	48334
0,39	11	32	22,5		7,6	49394	48394
0,47	12,5	32	24		9,1	49474	48474
0,56	14	32	25,5		11	49564	48564
0,68	15,5	32	27		13	49684	48684

---

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

Marking

The capacitors are marked in ink on one side, with:
1 st line: rated capacitance in μF and tolerance, with unit symbols;
2nd line: rated d.c. voltage, with unit symbol, code for dielectric materials (KP) and code for factory of origin.

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 15 to 35 °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 1
Tolerance on rated capacitance	± 5% or ± 10%
Temperature coefficient at T_{amb} = 20 °C	–400 ± 100 ppm/°C

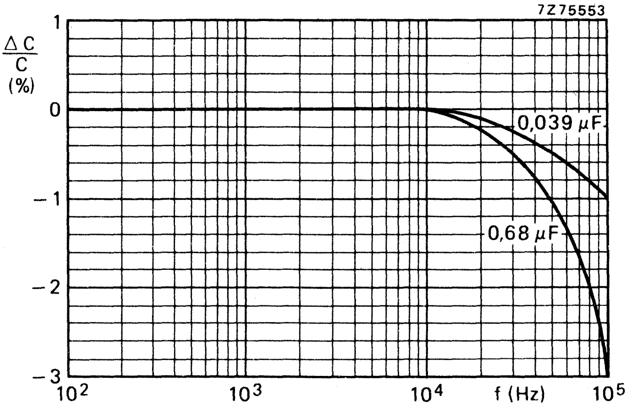


Fig. 2 Capacitance as a function of frequency; typical curves. Measuring voltage is 0,3 V.

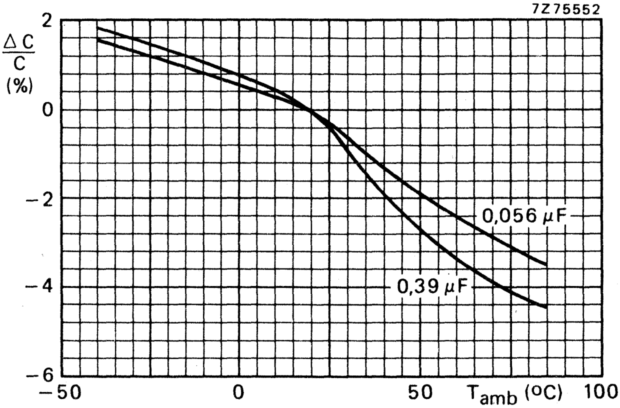


Fig. 3 Capacitance as a function of temperature; typical curves. Measuring voltage is 0,3 V, measuring frequency is 1 kHz.

Voltage

Rated voltage U_R (d.c.)	250 V
Rated voltage U_R (a.c.), 50 to 60 Hz	80 V*
Over-voltage (d.c.) for 1 min/h	$\leqslant$ 20% of U_R (d.c.)
Test voltage for 1 min	
between terminals	2 x U_R (d.c.)
between interconnected terminals and coating	1000 V (d.c.)

Note

The following two requirements must be satisfied:

the peak value of the a.c. voltage must be $\leqslant$ 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 $\leqslant$ rated d.c. voltage.

Insulation resistance

The insulation resistance is measured after a voltage of 100 ± 15 V has been applied for 1 min ± 5 s.

	ambient temperature	
	23 °C	85 °C
R between terminations, for $C_R \leqslant 0,1\ \mu F$	> 50 000 MΩ	> 500 MΩ
R_C between terminations, for $C_R > 0,1\ \mu F$	> 5 000 s	> 50 s

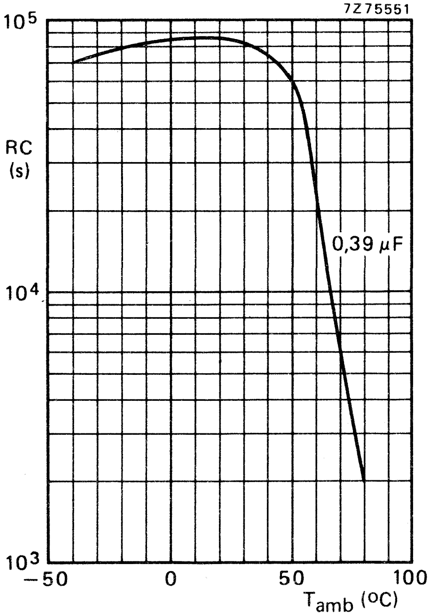


Fig. 4 RC-product as a function of temperature; typical curve.

---

* 200 $V_{p\text{-}p}$; no derating up to 20 kHz.

Tan δ (tangent of the loss angle)

Tan δ at 10 kHz	$\leqslant 10 \times 10^{-4}$ (typ. 2×10^{-4})

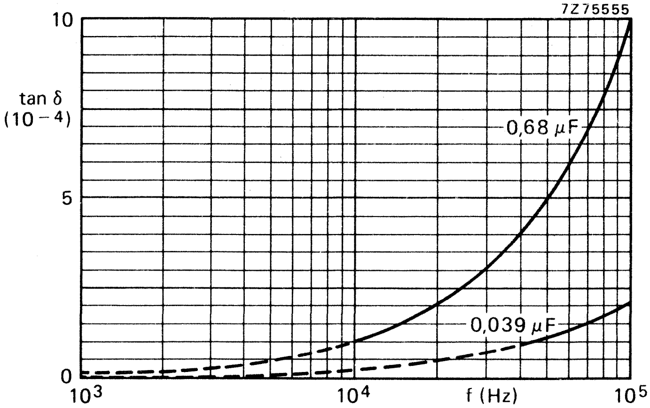


Fig. 5 Tan δ as a function of frequency; typical curves.

Temperature dependence at 100 Hz, 1 kHz, 10 kHz and 100 kHz	none

Power dissipation

Maximum permissible power dissipation	see Additional information
Pulse steepness	limited by network conditions not by capacitor construction

Temperature

Rated temperature	85 °C
Category temperature range	–40 to + 85 °C
Storage temperature range	–40 to + 85 °C
Climatic category, IEC 68	40/085/21

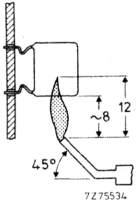
PACKING

The capacitors are packed in cardboard boxes.

TESTS AND REQUIREMENTS

IEC 68–2 test method	name of test	procedure (quick reference)	requirements
Ua1	Tensile strength of terminations	Loading force 10 N in axial direction of the wires, 10 s.	No damage.
		Loading force 5 N in radial direction of the wires, 10 s.	
Ub (method 1)	Bending of terminations	Loading force 5 N, two consecutive bends.	No damage.
Ta	Soldering	Solder bath, non-activated colophony flux, solder temp. 235 ^{o}C, dwell time 2 s.	Good tinning.
Tb (method 1B)	Resistance to soldering heat	Solder bath: 350 ^{o}C, 3,5 s.	No damage; $\Delta C/C \leqslant 1\%$.
Na	Rapid change of temperature	5 cycles of ½ h at –40 ^{o}C and ½ h at + 85 ^{o}C.	No damage, no leakage, $\Delta C/C \leqslant 2\%$. 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 °C, no voltage applied.	No damage, no leakage, $\Delta C/C \leqslant 5\%$ at 85 °C. Insulation resistance $> 500\ M\Omega$ at 85 °C.
	Db	Damp heat, cyclic	1 cycle of 24 h, upper temperature 55 ± 2 °C, R.H. 93 ± 3%; no voltage applied.	
	Aa	Cold	2 h at –40 ± 3 °C; no voltage applied	$\Delta C/C \leqslant 5\%$ at –40 °C.
	M	Low air pressure	1 h at 25 ± 5 °C, at atmospheric pressure of 85 mbar. During the last 5 min of the test U_R (d.c.) shall be applied.	During and after the test there shall be no breakdown or flashover.
	Db	Damp heat, cyclic.	1 cycle of 24 h, upper temperature 55 ± 2 °C, R.H. 93 ± 3%; no voltage applied. Within 15 min after the test U_R (d.c.) has to be applied for 1 min.	
			Final measurement.	$\Delta C/C \leqslant 1\%$. Tan δ shall meet initial requirements. Insulation resistance $\geqslant$ 0,5 x initial requirements.
	Ca	Damp heat, steady state	21 days at 40 ± 2 °C, R.H. 90 to 95%; no voltage applied. Within 15 min after the test U_R (d.c.) has to be applied for 1 min.	$\Delta C/C \leqslant 2\%$. Tan δ shall meet initial requirements. Insulation resistance $\geqslant$ 0,5 x initial requirements.

IEC 68–2 test method	name of test	procedure (quick reference)	requirements
–	Endurance	1000 h at 85 °C, 1,5 x U_R (d.c.) applied. 1000 h at 85 °C, U_R (a.c.) 50 Hz applied.	$\Delta C/C \leqslant 2\%$. Tan δ and insulation resistance shall meet initial requirements.
Additional tests			
	Solvent resistance	MIL-STD-202E, method 215.	No damage.
	Damp heat, long term exposure	21 days at 40 ± 2 °C, R.H. 90 to 95%. U_R (a.c.) applied for 16 h per 24 h.	$\Delta C/C \leqslant 2\%$. Tan δ shall meet initial requirements. Insulation resistance $\geqslant$ 0,5 x initial requirements.
	Discharge	10 000 cycles of charge to U_R (d.c.) via a resistor (RC $\leqslant$ 0,5 s) and discharge via a resistor of max. 10 mΩ at 25 °C. Cycle time: approx. 1 cycle/2 s.	Δ tan $\delta \leqslant 2 \times 10^{-4}$ at 10 kHz.
	Flammability	 Bore of gas jet: ϕ 0,5 mm. Fuel: butane Test duration: 20 s. One flame application.	After removing the test flame from the capacitor, the capacitor must not continue to burn for more than 15 s. No burning particles must drop from the sample.

ADDITIONAL INFORMATION

The rated a.c. voltage, which has been specified at 50 to 60 Hz requires no derating up to 20 kHz. However this voltage value may 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

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

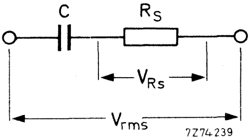


Fig. 6.

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

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

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

Thus

$$P = R_s\omega^2 C^2 V_{rms}{}^2 = (R_sC)C\omega^2 V_{rms}{}^2, \qquad (3)$$

in which $\omega = 2\pi f$; **the term (R_sC) is 1,59 x 10^{-8}.**

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 20 kHz and an ambient temperature of 75 °C. The R_sC-product at 20 kHz is 1,59 x 10^{-8} ΩF. The maximum permissible power dissipation at 75 °C is 525 mW (Fig. 7).

The maximum a.c. voltage can be calculated from Eq. (3):

$$V_{rms} = \sqrt{\left\{ \frac{P_{max}}{(R_sC)\,C\omega^2} \right\}}$$

$$= \sqrt{\left(\frac{0,525}{1,59 \times 10^{-8} \times 0,39 \times 10^{-6} \times 4\pi^2 \times 4 \times 10^8} \right)} = 73\ \text{V}.$$

	dimensions (mm)		
curve	T_{max}	L_{max}	H_{max}
1	6	19,5	14,5
2	6,5	19,5	15
3	7,5	19,5	16
4	8	19,5	16,5
5	9	19,5	17,5
6	6	27	17,5
7	7	27	18,5
8	7,5	27	19
9	8,5	27	20
10	8	32	19,5
11	9	32	20,5
12	10	32	21,5
13	11	32	22,5
14	12,5	32	24
15	14	32	25,5
16	15,5	32	27

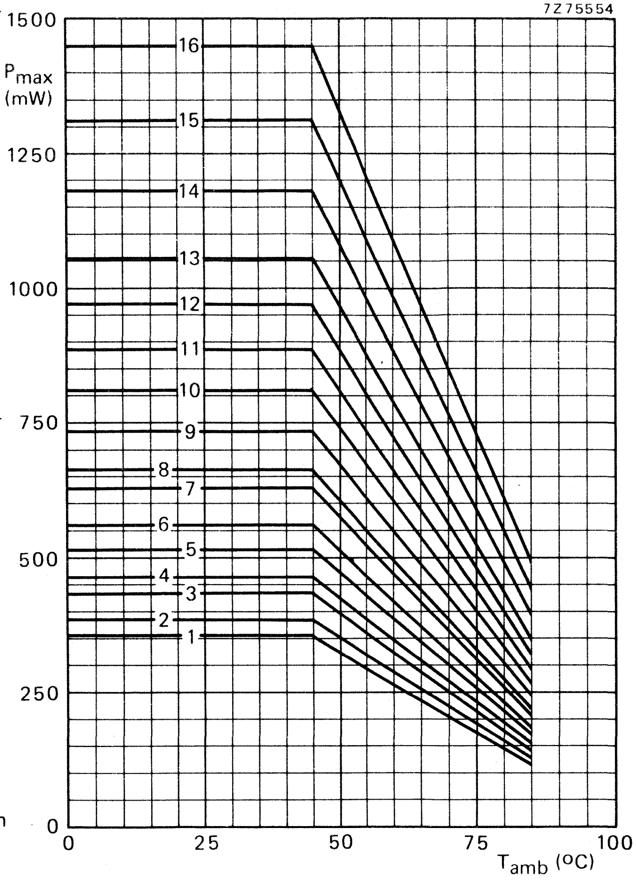


Fig. 7 Maximum permissible power dissipation as a function of temperature.

For a capacitor used with a half sine-wave pulse, the power dissipation as a function of the voltage over a resistance R is expressed by

$$P = \frac{T_1}{T_2} \frac{(½\, V_p\sqrt{2})^2}{R} = \left(V_p \sqrt{\frac{T_1}{2T_2}} \right)^2 \frac{1}{R} . \qquad (4)$$

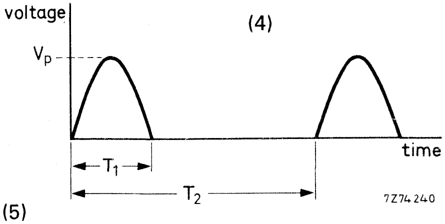


Fig. 8.

From the general expression $P = \frac{V_{rms}^2}{R}$ follows

$$V_{rms} = V_p \sqrt{\frac{T_1}{2T_2}} \qquad (5)$$

Substitution of Eq. (5) in Eq. (3) gives

$$P = (R_sC)\, C\omega^2 \left(V_p \sqrt{\frac{T_1}{2T_2}} \right)^2 , \qquad (6)$$

in which $\omega = 2\pi f = 2\pi \frac{1}{2T_1}$ **; the term (R_sC) is 1,59 x 10^{-8}.**
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 x 10^{-8}.

The maximum permissible power dissipation at 80 °C is 180 mW (Fig. 7).

The maximum peak voltage can be calculated from Eq. (6):

$$V_p = \sqrt{\left\{ \frac{P_{max}}{(R_sC)\, C\omega^2} \times \frac{2T_2}{T_1} \right\}}$$

$$= \sqrt{\left(\frac{0{,}18 \times 2 \times 64 \times 10^{-6}}{1{,}59 \times 10^{-8} \times 0{,}056 \times 10^{-6} \times 4\pi^2 \times 42^2 \times 10^6 \times 12 \times 10^{-6}} \right)}$$

$$= 176 \text{ V.}$$

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 $V_p \leqslant 80\sqrt{2} = 113$ V.

POLYPROPYLENE FILM/FOIL CAPACITORS

potted type

QUICK REFERENCE DATA

Rated capacitance range (E12 series)	0,039 to 0,82 μF
Tolerance on rated capacitance	± 5% and ± 10%
Rated voltage U_R (d.c.)	250 V
Rated voltage U_R (a.c.), 50 to 60 Hz	160 V
Rated temperature	85 °C
Climatic category, IEC 68	40/085/56

APPLICATION

These capacitors are intended for applications where high currents and steep pulses occur. They are mainly used for deflection circuits in television receivers, to operate at high peak currents at line frequency.

When requiring advice, please send oscillograms of current and voltage waveforms.

DESCRIPTION

The capacitors consist of an impregnated, low-inductive wound cell of aluminium foil and polypropylene film. The cell is potted with epoxy resin in a yellow flame-retardent 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 5 . . . .

code for capacitance tolerance
1 = ± 10%
2 = ± 5%

code for capacitance,
see Table 1

MECHANICAL DATA

Dimensions in mm

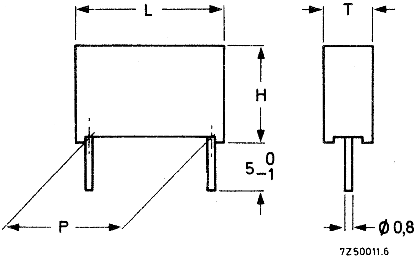


Fig. 1 For dimensions T, L, H and P, see Table 1.

Table 1 U_R (d.c.) = 250 V; U_R (a.c.) = 160 V

rated capacitance µF	T_{max}	L_{max}	H_{max}	P	mass g	catalogue number 2222 357	
						tol. ± 5%	tol. ± 10%
0,039	8	21,5	15	15 ± 0,4	3	52393	51393
0,047	8	21,5	15		3	52473	51473
0,056	8	21,5	15		3	52563	51563
0,068	10	21,5	17		4,5	52683	51683
0,082	10	21,5	17		4,5	52823	51823
0,10	8,5	29	18,5	22,5 ± 0,4	5,5	52104	51104
0,12	8,5	29	18,5		5,5	52124	51124
0,15	8,5	29	18,5		5,5	52154	51154
0,18	10	29	20		7,5	52184	51184
0,22	10	34	20	27,5 ± 0,4	8,5	52224	51224
0,27	10	34	20		8,5	52274	51274
0,33	12	34	22		11	52334	51334
0,39	12	34	22		11	52394	51394
0,47	15	34	25		16	52474	51474
0,56	15	34	25		16	52564	51564
0,68	18	34	28		22	52684	51684
0,82	18	34	28		22	52824	51824

Marking

The capacitors are marked on the top face by embossed print, with:
1st line: rated capacitance in µF, tolerance and rated d.c. voltage, without unit symbols;
2nd line: 5th, 6th and 7th digits of the catalogue number, code for dielectric materials (FP) 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, their mounting proximity should allow a free circulation of air.

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of 15 to 35 °C, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

Capacitance

Rated capacitance values (C_R) at 1 kHz	see Table 1
Tolerance on rated capacitance	± 5% or ± 10%
Temperature coefficient at T_{amb} = 20 °C	typ. –550 ± 50 ppm/°C

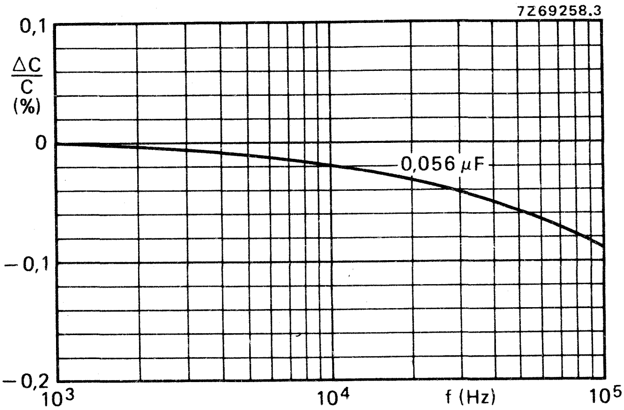


Fig. 2 Capacitance as a function of frequency; typical curve. Measuring voltage is 0,3 V.

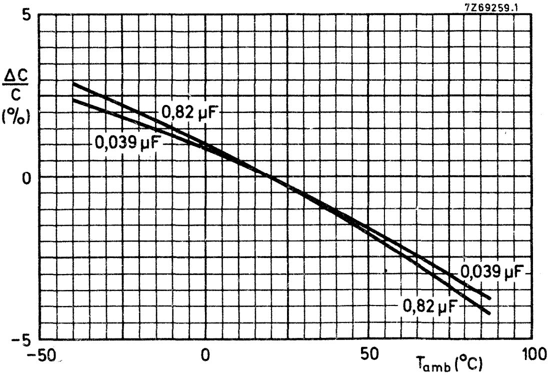


Fig. 3 Capacitance as a function of temperature; typical curves. Measuring voltage is 0,3 V, measuring frequency is 10 kHz.

Voltage

Rated voltage U_R (d.c.)	250 V
Rated voltage U_R (a.c.), 50 to 60 Hz	160 V
Over-voltage (d.c.) for 1 min/h	$\leqslant$ 20% of U_R (d.c.)
Test voltage for 1 min	
between terminals	2 x U_R (d.c.)
between interconnected terminals and case	1000 V (d.c.)

Note

The following two requirements must be satisfied:

the peak value of the a.c. voltage must be $\leqslant$ 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 $\leqslant$ rated d.c. voltage

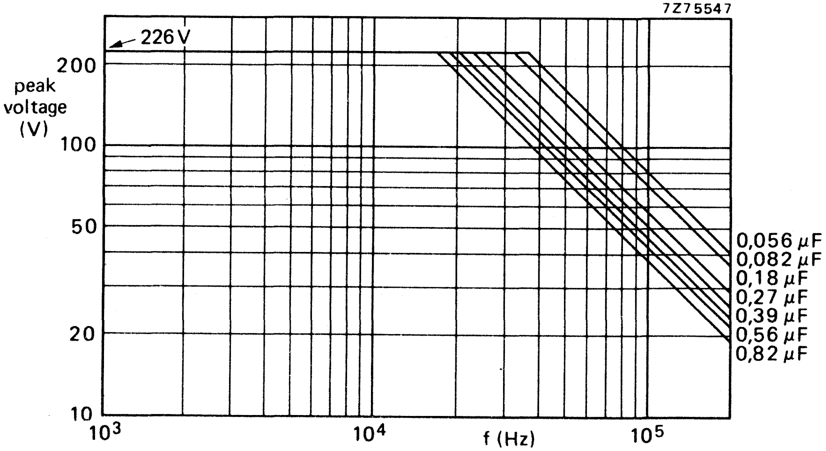


Fig. 4 Maximum permissible peak value of sinusoidal voltages as a function of frequency at $T_{amb} \leqslant 45$ °C.

Insulation resistance

The insulation resistance is measured after a voltage of 100 ± 15 V has been applied for 1 min ± 5 s.

	ambient temperature	
	23 °C	85 °C
R between terminations, for $C_R \leqslant 0,1$ μF	> 50 000 MΩ	> 500 MΩ
RC between terminations, for $C_R > 0,1$ μF	> 5 000 s	> 50 s

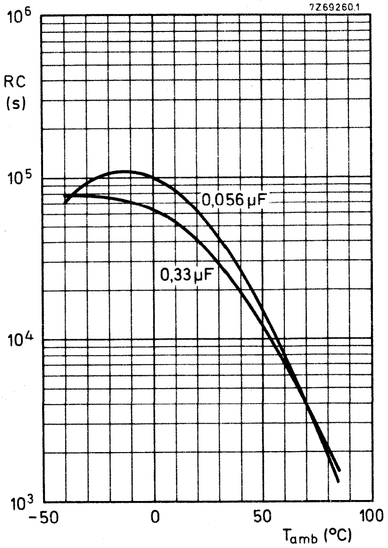


Fig. 5 RC-product as a function of temperature; typical curves.

Tan δ (tangent of the loss angle)

Tan δ at 10 kHz ⩽ 5 x 10^{-4} (typ. 1 x 10^{-4})

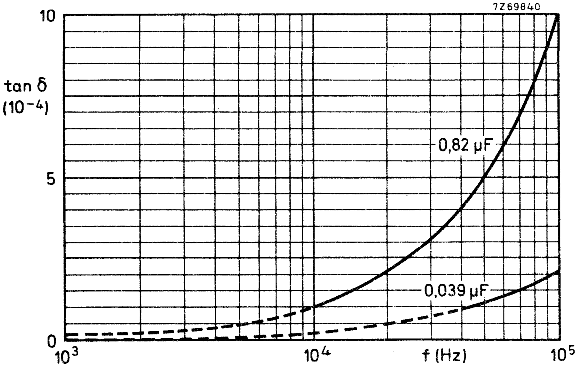


Fig. 6 Tan δ as a function of frequency; typical curves.

Temperature dependence at 100 Hz, 1 kHz, 10 kHz and 100 kHz none

Power dissipation	
Maximum permissible power dissipation	see Additional information
Pulse steepness	limited by network conditions not by capacitor construction
Temperature	
Rated temperature	85 °C
Category temperature range	−40 to + 85 °C
Storage temperature range	−55 to + 85 °C
Climatic category, IEC 68	40/085/56

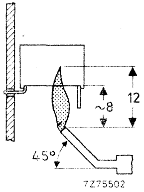
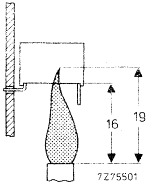
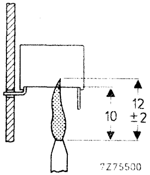
PACKING

The capacitors are packed in cardboard boxes. The number per box is 1000 for capacitors with L_{max} = 21,5 mm or 29 mm, and 500 for capacitors with L_{max} = 34 mm.

TESTS AND REQUIREMENTS

IEC 68--2 test method	name of test	procedure (quick reference)	requirements
Ua1	Tensile strength of terminations	Loading force 10 N in axial direction of the wires, 10 s.	No damage.
		Loading force 5 N in radial direction of the wires, 10 s.	
Ub (method 1)	Bending of terminations	Loading force 5 N, two consecutive bends.	No damage.
Ta	Soldering	Solder bath, non-activated colophony flux, solder temp. 235 ^{o}C, dwell time 2 s.	Good tinning.
Tb (method 1B)	Resistance to soldering heat	Solder bath: 350 ^{o}C, 3,5 s.	No damage; $\Delta C/C \leqslant 1\%$.
Na	Rapid change of temperature	5 cycles of ½ h at -40 ^{o}C and ½ h at + 85 ^{o}C.	No damage, no leakage, $\Delta C/C \leqslant 2\%$. Tan δ and insulation resistance shall meet initial requirements.
Fc	Vibration	10 to 55 Hz, 0,75 mm or 10g (whichever is less), 3 directions, 2 h per direction.	No damage, no open or short-circuit; $\Delta C/C \leqslant 0{,}5\%$.
Eb	Bumping	40g, 4000 bumps.	No damage, no open or short-circuit; $\Delta C/C \leqslant 0{,}5\%$.

IEC 68–2 test method		name of test	procedure (quick reference)	requirements
Climatic sequence	Ba	Dry heat	16 h at + 85 ± 2 °C, no voltage applied.	No damage, no leakage, $\Delta C/C \leqslant 5\%$ at 85 °C. Insulation resistance shall meet initial requirements.
	Db	Damp heat, cyclic	1 cycle of 24 h, upper temperature 55 ± 2 °C, R.H. 93 ± 3%; no voltage applied.	
	Aa	Cold	2 h at –40 ± 3 °C; no voltage applied.	$\Delta C/C \leqslant 5\%$ at –40 °C.
	M	Low air pressure	1 h at 25 ± 5 °C, at atmospheric pressure of 85 mbar. During the last 5 min. of the test U_R (d.c.) shall be applied.	During and after the test there shall be no breakdown or flashover.
	Db	Damp heat, cyclic	5 cycles of 24 h, upper temperature 55 ± 2 °C, R.H. 93 ± 3%; no voltage applied. Within 15 min. after the test U_R (d.c.) has to be applied for 1 min.	
			Final measurement.	$\Delta C/C \leqslant 1\%$. Tan δ shall meet initial requirements. Insulation resistance $\geqslant$ 0,5 x initial requirements.
	Ca	Damp heat, steady state	56 days at 40 ± 2 °C, R.H. 90 to 95%; no voltage applied. Within 15 min. after the test U_R (d.c.) has to be applied for 1 min.	No damage, $\Delta C/C \leqslant 2\%$. Tan δ shall meet initial requirements. Insulation resistance $\geqslant$ 0,5 x initial requirements.
	–	Endurance	1000 h at 85 °C, 1,5 x U_R (d.c.) applied.	$\Delta C/C \leqslant 1\%$. Tan δ shall meet initial requirements; insulation resistance $\geqslant$ 0,5 x initial requirements.
			1000 h at 85 °C, 1,5 x U_R (a.c.) 50 Hz applied	
			1000 h at 25 °C, 20 kHz voltage of 1,25 x max. permissible voltage (Fig. 4) applied.	

name of test	procedure (quick reference)	requirements
Additional tests		
Solvent resistance	MIL-STD-202E, method 215.	No damage.
Damp heat, long term exposure	56 days at 40 ± 2 °C, R.H. 90 to 95%; U_R (a.c.) applied for 16 h per 24 h.	$\Delta C/C \leqslant 2\%$. Tan δ shall meet initial requirements. Insulation resistance $\geqslant 0{,}5 \times$ initial requirements.
Discharge	10 000 cycles of charge to U_R (d.c.) via a resistor (RC $\leqslant$ 0,5 s) and discharge via a resistor of max. 10 mΩ at 25 °C. Cycle time: approx. 1 cycle/2 s.	Δ tan $\delta \leqslant 2 \times 10^{-4}$ at 10 kHz.
Flammability	 Bore of gas jet: ϕ5 mm. Fuel: butane. Test duration: 20 s. One flame application.	After removing the test flame from the capacitor, the capacitor must not continue to burn for more than 15 s. No burning particles must drop from the sample.
	 Bore of gas jet: ϕ10 mm. Fuel: natural gas. Test duration: 3 x 15 s. Time interval between each application: 15 s.	Extinguishing time $\leqslant$ 15 s after the first and second flame application, $\leqslant$ 60 s after the third flame application.
	 Bore of gas jet: ϕ0,5 mm. Fuel: butane. Test duration: 3 x 15 s. Second and third flame application start after extinguishing of the flame on the capacitor.	Extinguishing time $\leqslant$ 10 s after each flame application. No burning particles must drop from the sample.

ADDITIONAL INFORMATION

The rated a.c. voltage, which has been specified at 50 to 60 Hz 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

$$P = \frac{V_{Rs}^2}{R_S} = I^2 R_S \tag{1}$$

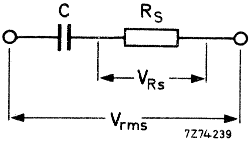


Fig. 7.

$$V_{Rs}^2 = \frac{R_S^2}{R_S^2 + 1/\omega^2 C^2} V_{rms}^2 \tag{2a}$$

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

$$V_{Rs}^2 = \frac{R_S^2}{1/\omega^2 C^2} V_{rms}^2 = R_S^2 \omega^2 C^2 V_{rms}^2 . \tag{2b}$$

Thus $$P = R_S \omega^2 C^2 V_{rms}^2 = (R_S C)\, C\omega^2 V_{rms}^2 , \tag{3}$$

in which $\omega = 2\pi f$; **the term ($R_S C$) is 7,96 x 10^{-9}.**

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. 8.

Example

A capacitor of 0,39 μF is to be used at 40 kHz and an ambient temperature of 75 °C. The R_SC-product at 40 kHz is 7,96 x 10^{-9} ΩF. The maximum permissible power dissipation at 75 °C is 630 mW (Fig. 8).

The maximum a.c. voltage can be calculated from Eq. (3):

$$V_{rms} = \sqrt{\left\{ \frac{P_{max}}{(R_S C)\, C\omega^2} \right\}}$$

$$= \sqrt{\left(\frac{0,63}{7,96 \times 10^{-9} \times 0,39 \times 10^{-6} \times 4\pi^2 \times 16 \times 10^8} \right)} = 57 \text{ V}.$$

---

* At $T_{amb} \leqslant 45$ °C the maximum permissible sinusoidal voltage can be found in Fig. 4.

curve	dimensions (mm)		
	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

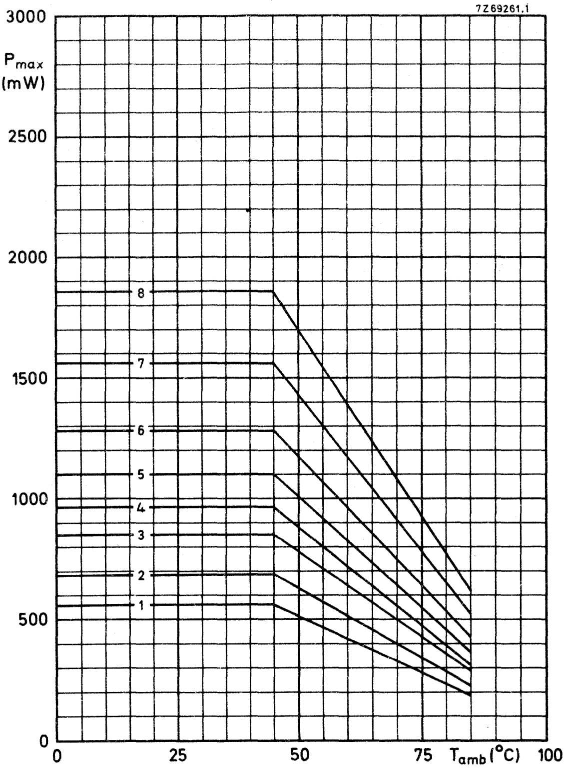


Fig. 8 Maximum permissible power dissipation as a function of temperature.

For a capacitor used with a half sine-wave pulse, the power dissipation as a function of the voltage over a resistance R is expressed by

$$P = \frac{T_1}{T_2}\ \frac{(\frac{1}{2} V_p \sqrt{2})^2}{R} = \left(V_p \sqrt{\frac{T_1}{2T_2}} \right)^2 \ \frac{1}{R}. \qquad (4)$$

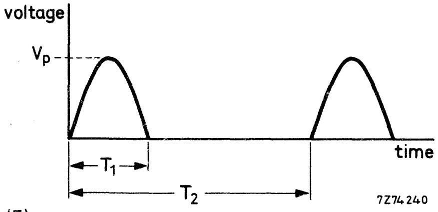


Fig. 9.

From the general expression $P = \frac{V_{rms}^2}{R}$ follows

$$V_{rms} = V_p \sqrt{\frac{T_1}{2T_2}}. \qquad (5)$$

Substitution of Eq. (5) in Eq. (3) gives

$$P = (R_sC)\,C\omega^2 \left(V_p \sqrt{\frac{T_1}{2T_2}} \right)^2 , \qquad (6)$$

in which $\omega = 2\pi f = 2\pi \frac{1}{2T_1}$; **the term ($R_sC$) is 7,96 x 10^{-9}.**

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. 8.

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 7,96 x 10^{-9} ΩF.

The maximum permissible power dissipation at 80 °C is 230 mW (Fig. 8).

The maximum peak voltage can be calculated from Eq. (6):

$$V_p = \sqrt{\left\{ \frac{P_{max}}{(R_sC)\,C\omega^2} \times \frac{2T_2}{T_1} \right\}}$$

$$= \sqrt{\left(\frac{0{,}23 \times 2 \times 64 \times 10^{-6}}{7{,}96 \times 10^{-9} \times 0{,}056 \times 10^{-6} \times 4\pi^2 \times 42^2 \times 10^6 \times 12 \times 10^{-6}} \right)}$$

$$= 281\ \text{V}.$$

However this voltage may not be applied because of the restriction that the peak value of the a.c. voltage must be $\leqslant$ rated a.c. voltage x $\sqrt{2}$. In this case $V_p \leqslant 160\sqrt{2} = 226$ V.

POLYPROPYLENE CAPACITORS

series construction (KP/MKP)

QUICK REFERENCE DATA

Rated capacitance range (E12 series)	0,022 to 0,33 μF *
Tolerance on rated capacitance	± 5% and ± 10%
Rated voltage U_R (d.c.)	630 V, 1000 V, 1500 V
Rated voltage U_R (a.c.), 50 to 60 Hz	300 V, 400 V, 600 V
Rated temperature	85 °C
Climatic category, IEC 68	40/085/56

APPLICATION

These capacitors are intended for applications where high currents, high voltages and steep pulses occur. They are mainly used for deflection circuits in television receivers, to operate at high peak currents at line frequency, and for commutation in motor control and pulse steepness suppression networks.

When requiring advice, please send oscillograms of current and voltage waveforms.

DESCRIPTION

The capacitors consist of an impregnated, series constructed, low-inductive wound cell of polypropylene film, aluminium foil and metallized polypropylene film. The cell is potted with epoxy resin in a yellow flame-retardent 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 . . . . .

code for rated voltage and capacitance tolerance ——— code for capacitance

61 = 630 V; ± 10%
62 = 630 V; ± 5%
71 = 1000 V; ± 10%
72 = 1000 V; ± 5%
81 = 1500 V; ± 10%
82 = 1500 V; ± 5%

---

* Lower values and values between E12 steps are available on request.

MECHANICAL DATA

Dimensions in mm

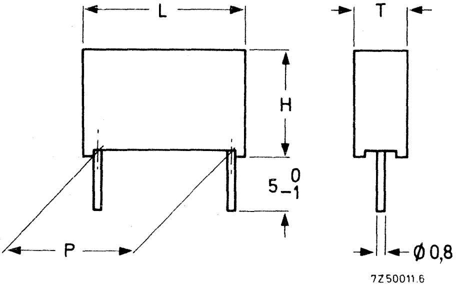


Fig. 1 For dimensions T, L, H and P, see Tables 1 to 3.

Table 1 U_R (d.c.) = 630 V; U_R (a.c.) = 300 V

rated capacitance * μF	T_{max}	L_{max}	H_{max}	P	mass g	catalogue number 2222 357	
						tol. ± 5%	tol. ± 10%
0,047	8,5	29	18,5	22,5 ± 0,4	6	62473	61473
0,056	8,5	29	18,5		6	62563	61563
0,068	10	29	20		9	62683	61683
0,082	10	29	20		9	62823	61823
0,10	10	29	20		9	62104	61104
0,12	10	34	20	27,5 ± 0,4	10	62124	61124
0,15	12	34	22		14	62154	61154
0,18	12	34	22		14	62184	61184
0,22	15	34	25		20	62224	61224
0,27	18	34	28		28	62274	61274
0,33	18	34	28		28	62334	61334

---

* Capacitance values of the E12 series as quoted are preferred; lower values and values between E12 steps, and other tolerances are available to special order.

Table 2 U_R (d.c.) = 1000 V; U_R (a.c.) = 400 V

rated capacitance * µF	T_{max}	L_{max}	H_{max}	P	mass g	catalogue number 2222 357	
						tol. ± 5%	tol. ± 10%
0,033	8,5	29	18,5	22,5 ± 0,4	6	72333	71333
0,039	8,5	29	18,5		6	72393	71393
0,047	10	29	20		9	72473	71473
0,056	10	29	20		9	72563	71563
0,068	10	34	20	27,5 ± 0,4	10	72683	71683
0,082	12	34	22		13	72823	71823
0,10	12	34	22		13	72104	71104
0,12	15	34	25		18	72124	71124
0,15	18	34	28		26	72154	71154
0,18	18	34	28		26	72184	71184
0,22	18	34	28		26	72224	71224

Table 3 U_R (d.c.) = 1500 V; U_R (a.c.) = 600 V

rated capacitance * µF	T_{max}	L_{max}	H_{max}	P	mass g	catalogue number 2222 357	
						tol. ± 5%	tol. ± 10%
0,022	8,5	29	18,5	22,5 ± 0,4	6	82223	81223
0,027	8,5	29	18,5		6	82273	81273
0,033	10	29	20		9	82333	81333
0,039	10	29	20		9	82393	81393
0,047	10	34	20	27,5 ± 0,4	10	82473	81473
0,056	12	34	22		13	82563	81563
0,068	12	34	22		13	82683	81683
0,082	15	34	25		18	82823	81823
0,10	15	34	25		18	82104	81104
0,12	18	34	28		26	82124	81124
0,15	18	34	28		26	82154	81154

Marking

The capacitors are marked on the top face by embossed print, with:
1st line: rated capacitance in µF, tolerance and rated d.c. voltage, without unit symbols;
2nd line: 5th, 6th and 7th digits of the catalogue number, code for dielectric materials (KP/MKP) 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, their mounting proximity should allow a free circulation of air.

---

* Capacitance values of the E12 series as quoted are preferred; lower values and values between E12 steps, and other tolerances are available to special order.

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of 15 to 35 °C, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

Capacitance

Rated capacitance values (C_R) at 1 kHz	see Tables 1, 2 and 3
Tolerance on rated capacitance	± 5% or ± 10%
Temperature coefficient at T_{amb} = 20 °C	–450 ± 50 ppm/°C

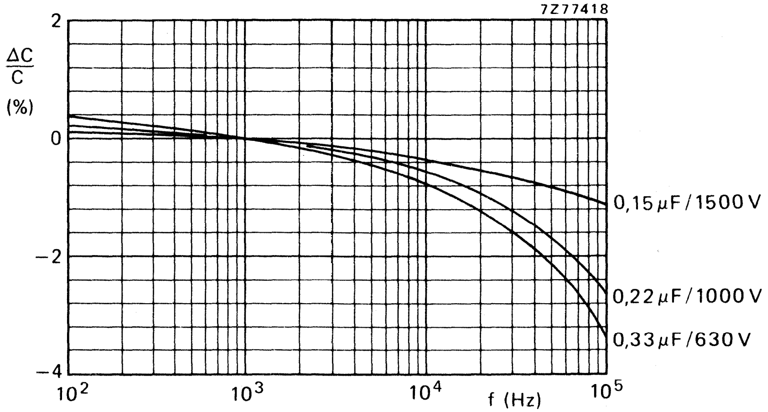


Fig. 2 Capacitance as a function of frequency; typical curves. Measuring voltage is 0,3 V.

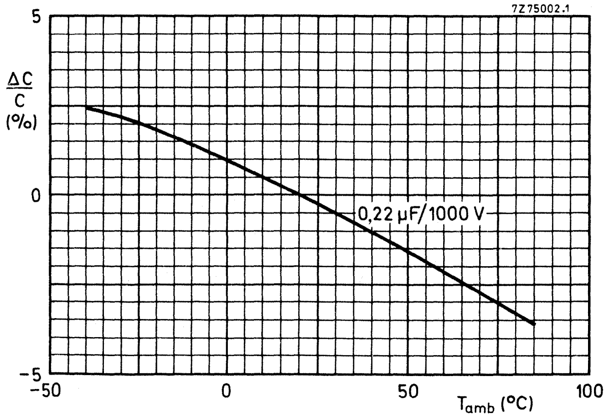


Fig. 3 Capacitance as a function of temperature; typical curve. Measuring voltage is 0,3 V, measuring frequency is 1 kHz.

Voltage

Rated voltage U_R (d.c.)	630 V, 1000 V, 1500 V
Rated voltage U_R (a.c.), 50 to 60 Hz	
630 V version	300 V
1000 V version	400 V
1500 V version	600 V
Over-voltage (d.c.) for 1 min/h	$\leqslant$ 20% of U_R (d.c.)
Test voltage for 1 min	
between terminals	1,6 x U_R (d.c.)
between interconnected terminals and case	2 x U_R (d.c.)

Note

The following two requirements must be satisfied:

the peak value of the a.c. voltage must be $\leqslant$ 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 $\leqslant$ rated d.c. voltage.

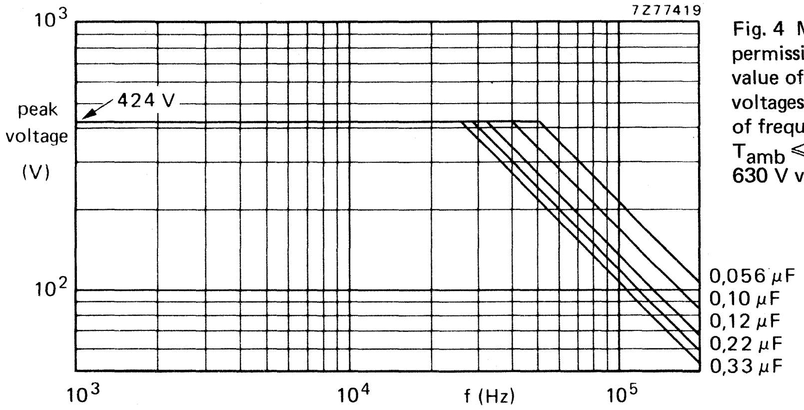


Fig. 4 Maximum permissible peak value of sinusoidal voltages as a function of frequency at $T_{amb} \leqslant 45\ ^oC$, for 630 V version.

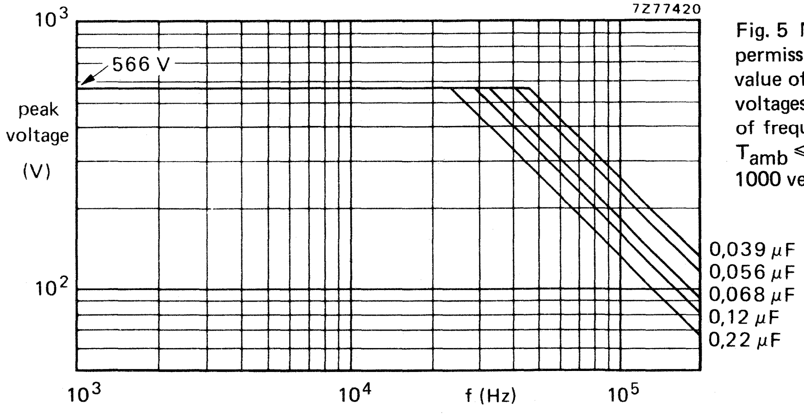


Fig. 5 Maximum permissible peak value of sinusoidal voltages as a function of frequency at $T_{amb} \leqslant 45\ ^oC$, for 1000 version.

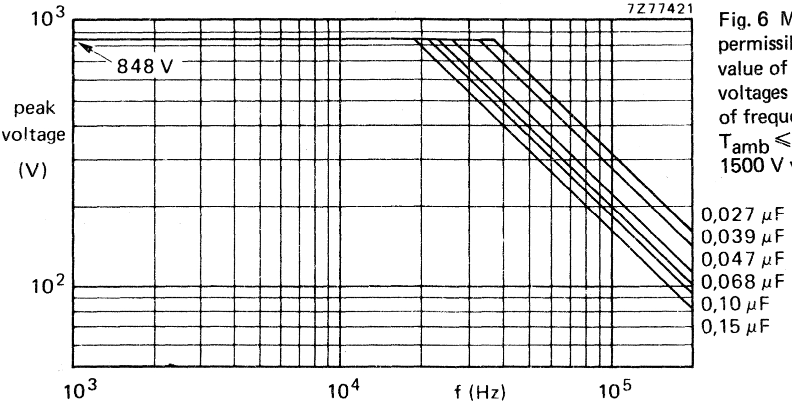


Fig. 6 Maximum permissible peak value of sinusoidal voltages as a function of frequency at $T_{amb} \leqslant 45$ °C, for 1500 V version.

Insulation resistance

The insulation resistance is measured after a voltage of 500 ± 50 V has been applied for 1 min ± 5 s.

	ambient temperature 23 °C	85 °C
R between terminations, for $C_R \leqslant 0{,}1$ μF	> 50 000 MΩ	> 500 MΩ
RC between terminations, for $C_R > 0{,}1$ μF	> 5 000 s	> 50 s

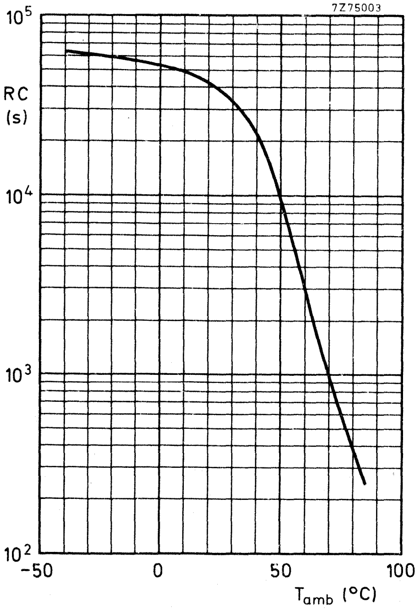


Fig. 7 RC-product as a function of temperature; typical curve.

Tan δ (tangent of the loss angle)

Tan δ at 100 kHz	
for capacitors with pitch P = 22,5 mm	≤ 10 x 10^{-4}
for capacitors with pitch P = 27,5 mm	≤ 15 x 10^{-4}

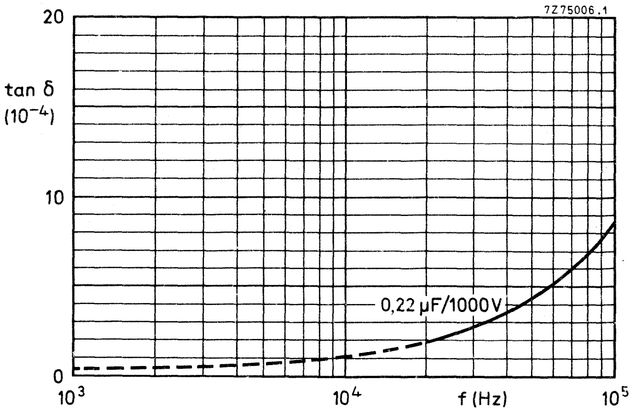


Fig. 8 Tan δ as a function of frequency; typical curve.

Temperature dependence at 100 Hz, 1 kHz, 10 kHz and 100 kHz	none

Power dissipation

Maximum permissible power dissipation	see Additional information
Pulse steepness	limited by network conditions not by capacitor construction

Temperature

Rated temperature	85 °C
Category temperature range	–40 to + 85 °C
Storage temperature range	–55 to + 85 °C
Climatic category, IEC 68	40/085/56

PACKING

The capacitors are packed in cardboard boxes. The number per box is 1000 for capacitors with L_{max} = 29 mm, and 500 for capacitors with L_{max} = 34 mm.

TESTS AND REQUIREMENTS

IEC 68–2 test method	name of test	procedure (quick reference)	requirements
Ua1	Tensile strength of terminations	Loading force 10 N in axial direction of the wires, 10 s.	No damage.
		Loading force 5 N in radial direction of the wires, 10 s.	
Ub (method 1)	Bending of terminations	Loading force 5 N, two consecutive bends.	No damage
Ta	Soldering	Solder bath, non-activated colophony flux, solder temp. 235 °C, dwell time 2 s.	Good tinning.
Tb (method 1A)	Resistance to soldering heat	Solder bath: 260 °C, 5 s.	No damage; $\Delta C/C \leqslant 1\%$.
Tb (method 1B)		Solder bath: 350 °C, 3,5 s.	
Na	Rapid change of temperature	5 cycles of ½ h at –40 °C and ½ h at + 85 °C.	No damage, no leakage, $\Delta C/C \leqslant 2\%$. Tan δ and insulation resistance shall meet initial requirements.
Fc	Vibration	10 to 55 Hz, 0,75 mm or 10g (whichever is less), 3 directions, 2 h per direction.	No damage, no open or short-circuit; $\Delta C/C \leqslant 0{,}5\%$.
Eb	Bumping	40g, 4000 bumps.	No damage, no open or short-circuit; $\Delta C/C \leqslant 0{,}5\%$.

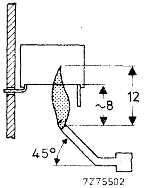
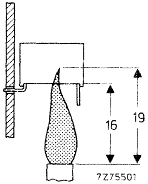
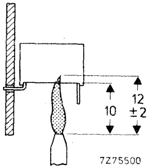
IEC 68–2 test method		name of test	procedure (quick reference)	requirements
Climatic sequence	Ba	Dry heat	16 h at + 85 ± 2 °C, no voltage applied.	No damage, no leakage, $\Delta C/C \leqslant 5\%$ at 85 °C. Insulation resistance shall meet initial requirements.
	Db	Damp heat, cyclic	1 cycle of 24 h, upper temperature 55 ± 2 °C, R.H. 93 ± 3%; no voltage applied.	
	Aa	Cold	2 h at −40 ± 3 °C; no voltage applied	$\Delta C/C \leqslant 5\%$ at −40 °C.
	M	Low air pressure	1 h at 25 ± 5 °C, at atmospheric pressure of 85 mbar. During the last 5 min of the test U_R (d.c.) shall be applied.	During and after the test there shall be no breakdown or flashover.
	Db	Damp heat, cyclic	5 cycles of 24 h, upper temperature 55 ± 2 °C, R.H. 93 ± 3%; no voltage applied. Within 15 min after the test U_R (d.c.) has to be applied for 1 min.	
			Final measurement.	$\Delta C/C \leqslant 1\%$. Tan δ shall meet initial requirements. Insulation resistance $\geqslant$ 0,5 x initial requirements.
	Ca	Damp heat, steady state	56 days at 40 ± 2 °C, R.H. 90 to 95%; no voltage applied. Within 15 min after the test U_R (d.c.) has to be applied for 1 min.	$\Delta C/C \leqslant 2\%$. Tan δ shall meet initial requirements. Insulation resistance $\geqslant$ 0,5 x initial requirements.

IEC 68–2 test method	name of test	procedure (quick reference)	requirements
–	Endurance	2000 h at 85 $^{\circ}$C, 1,5 x U_R (d.c.) applied.	$\Delta C/C \leqslant 2\%$. Tan δ and insulation resistance shall meet initial requirements.
		2000 h at 85 $^{\circ}$C, 1,25 x U_R (a.c.) 50 Hz applied.	
		1000 h at 25 $^{\circ}$C, 20 kHz voltage of 1,25 x max. permissible voltage (Figs 4, 5 and 6) applied.	

Additional tests

	Solvent resistance	MIL-STD-202E, method 215.	No damage.
	Damp heat, long term exposure	56 days at 40 ± 2 $^{\circ}$C, R.H. 90 to 95%; U_R (a.c.) applied for 16 h per 24 h.	$\Delta C/C \leqslant 2\%$. Tan δ shall meet initial requirements. Insulation resistance $\geqslant 0,5$ x initial requirements.
	Discharge	10 000 cycles of charge to U_R (d.c.) via a resistor ($RC \leqslant 0,5$ s) and discharge via a resistor of max. 10 mΩ at 25 $^{\circ}$C. Cycle time: approx. 1 cycle/2 s.	Δ tan $\delta \leqslant 2 \times 10^{-4}$ at 10 kHz.

For flammability tests, see next page.

name of test	procedure (quick reference)	requirements
Flammability	 Bore of gas jet: ϕ0,5 mm. Fual: butane. Test duration: 20 s. One flame application.	After removing the test flame from the capacitor, the capacitor must not continue to burn for more than 15 s. No burning particles must drop from the sample.
	 Bore of gas jet: ϕ10 mm. Fuel: natural gas. Test duration: 3 x 15 s. Time interval between each application: 15 s.	Extinguishing time ⩽ 15 s after the first and second flame application, ⩽ 60 s after the third flame application.
	 Bore of gas jet: ϕ0,5 mm. Fuel: butane. Test duration: 3 x 15 s. Second and third flame application start after extinguishing of the flame on the capacitor.	Extinguishing time ⩽ 10 s after each flame application. No burning particles must drop from the sample.

ADDITIONAL INFORMATION

The rated a.c. voltage, which has been specified at 50 to 60 Hz 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

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

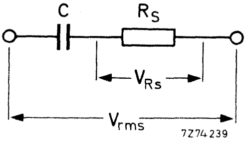


Fig. 9.

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

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

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

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 ($R_S C$) is 1,59 x 10^{-9} for capacitors with pitch P = 22,5 mm, and 2,39 x 10^{-9} for capacitors with pitch P = 27,5 mm.**

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. 10.

Example

A capacitor of 0,12 μF is to be used at a 20 kHz sinusoidal voltage of 300 V and an ambient temperature of 80 °C, The maximum R_SC-product at 20 kHz is 2,39 x 10^{-9} ΩF, so that the power to be dissipated is

$$P = (R_S C)\, C\omega^2 V_{rms}{}^2$$
$$= 2{,}39 \times 10^{-9} \times 0{,}12 \times 10^{-6} \times 4\pi^2 \times 20\,000^2 \times 300^2$$
$$P = 407 \text{ mW}.$$

Fig. 10 shows that at 80 °C capacitors with curve numbers 3 to 6 can be used, thus a minimum size of 10 mm x 34 mm x 20 mm. It can be seen from Tables 1 to 3 that a 0,12 μF/630 V, a 0,12 μF/1000 V or a 0,12 μF/1500 V capacitor can be chosen.

---

* At $T_{amb} \leqslant$ 45 °C the maximum permissible sinusoidal voltage can be found in Figs 4, 5 and 6.

curve	dimensions (mm)		
	T_{max}	L_{max}	H_{max}
1	8,5	29	18,5
2	10	29	20
3	10	34	20
4	12	34	22
5	15	34	25
6	18	34	28

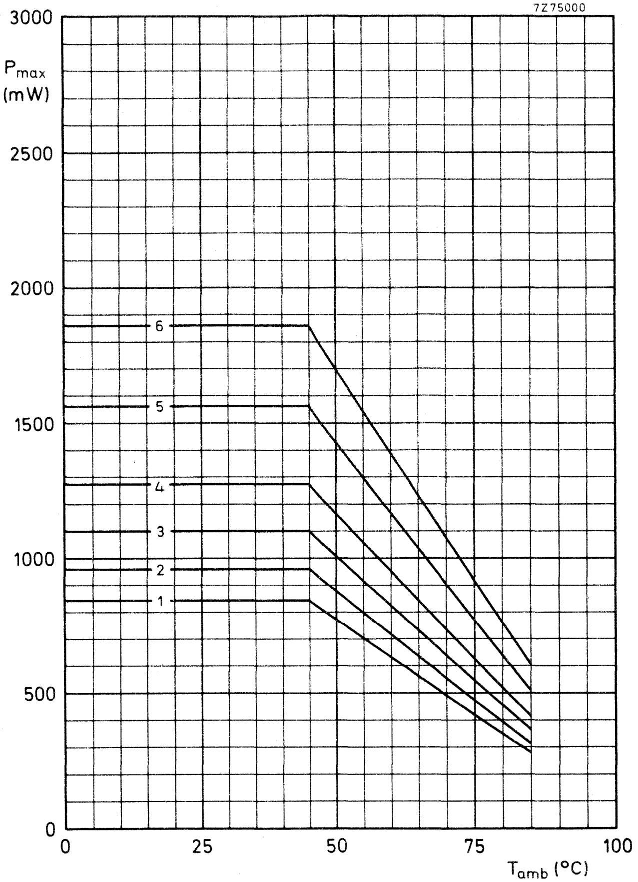


Fig. 10 Maximum permissible power dissipation as a function of temperature.

For a capacitor used with a half sine-wave pulse, the power dissipation as a function of the voltage over a resistance R is expressed by

$$P = \frac{T_1}{T_2}\,\frac{(\tfrac{1}{2}V_p\sqrt{2})^2}{R} = \left(V_p\sqrt{\frac{T_1}{2T_2}}\right)^2 \frac{1}{R}. \qquad (4)$$

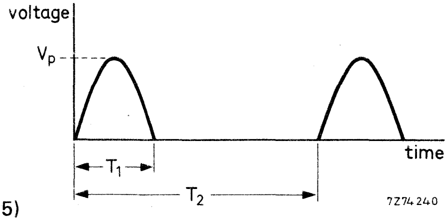


Fig. 11.

From the general expression $P = \frac{V_{rms}^2}{R}$ follows

$$V_{rms} = V_p\sqrt{\frac{T_1}{2T_2}}. \qquad (5)$$

Substitution of Eq. (5) in Eq. (3) gives

$$P = (R_sC)\,C\omega^2 \left(V_p \sqrt{\frac{T_1}{2T_2}} \right)^2 \qquad (6)$$

in which $\omega = 2\pi f = 2\pi \frac{1}{2T_1}$; **the term (R_sC) is 1,59 x 10^{-9} for capacitors with pitch P = 22,5 mm, and 2,39 x 10^{-9} for capacitors with pitch P = 27,5 mm.**

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. 10.

Example

A capacitor of 0,1 μF is to be used with a half sine-wave pulse (pulse duration 12 μs, repetition time 64 μs) at 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 maximum R_sC-product is 1,59 x 10^{-9} ΩF for a capacitor 0,1 μF/630 V, and 2,39 x 10^{-9} ΩF for capacitors 0,1 μF/1000 V and 0,1 μF/1500 V.

The maximum permissible power dissipation at 80 °C is 395 mW (630 V capacitor), 520 mW (1000 V capacitor), and 640 mW (1500 V capacitor), see Fig. 10.

The maximum peak voltage can be calculated from Eq. (6):

$$V_p = \sqrt{\left\{ \frac{P_{max}}{(R_sC)\,C\omega^2} \times \frac{2T_2}{T_1} \right\}}.$$

For 630 V capacitors: $$V_p = \sqrt{\left(\frac{0{,}395 \times 2 \times 64 \times 10^{-6}}{1{,}59 \times 10^{-9} \times 0{,}1 \times 10^{-6} \times 4\pi^2 \times 42^2 \times 10^6 \times 12 \times 10^{-6}} \right)} = 617 \text{ V.}$$

For 1000 V capacitors: $$V_p = \sqrt{\left(\frac{0{,}52 \times 2 \times 64 \times 10^{-6}}{2{,}39 \times 10^{-9} \times 0{,}1 \times 10^{-6} \times 4\pi^2 \times 42^2 \times 10^6 \times 12 \times 10^{-6}} \right)} = 578 \text{ V.}$$

For 1500 V capacitors: $$V_p = \sqrt{\left(\frac{0{,}64 \times 2 \times 64 \times 10^{-6}}{2{,}39 \times 10^{-9} \times 0{,}1 \times 10^{-6} \times 4\pi^2 \times 42^2 \times 10^6 \times 12 \times 10^{-6}} \right)} = 640 \text{ V.}$$

The peak voltage values found for 630 V and 1000 V capacitors may not be applied because of the restriction that the peak value of the a.c. voltage must be $\leqslant U_R$ (a.c.) x$\sqrt{2}$, i.e. 424 V and 566 V respectively. In this case only a 1500 V capacitor can be used.

METALLIZED POLYCARBONATE AND PAPER FILM CAPACITORS

dual dielectric (MKC-P)

QUICK REFERENCE DATA

Rated capacitance range	
type with axial leads	0,91 to 1,5 μF
type with radial leads	0,82 to 3,3 μF
Tolerance on rated capacitance	±5% and ±10%
Rated voltage U_R (d.c.)	210 V
Rated voltage U_R (a.c.), 50 to 60 Hz	100 V
Rated temperature	85 °C
Climatic category, IEC 68	40/085/56

APPLICATION

These capacitors are intended for applications where high currents occur. They are mainly used for deflection circuits in television receivers. Thanks to the dual dielectric construction any active flammability under fault conditions is prevented.

When requiring advice, please send oscillograms of current and voltage waveforms.

DESCRIPTION

The capacitors consist of an impregnated low-inductive wound cell of metallized polycarbonate film and paper film. Two types are available: with axial leads and with radial leads.

The cell of the type with axial leads is moulded in yellow flame retardent polypropylene, that of the other type is potted with epoxy resin in a yellow flame retardent polypropylene case. The leads are solder-coated copper wire.

The capacitors are provided with stand-off ridges or pips to allow removal of solder flux etc., when cleaning the printed-wiring board.

Composition of the catalogue number (See also Tables 1 and 2)

2222 363 4 . . . .

code for type and capacitance tolerance ——— code for capacitance

MECHANICAL DATA

Dimensions in mm

Type with axial leads

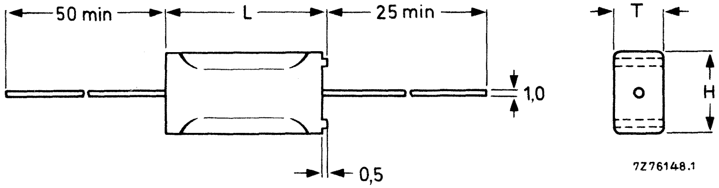


Fig.1 For dimensions T, L and H, see Table 1.

Table 1

rated capacitance μF	T_{max} mm	L_{max} mm	H_{max} mm	mass g	catalogue number 2222 363	
					tol. ±5%	tol. ±10%
0,91	12,4	31	19,5	8,5	46914	
1,0					46105	45105
1,2	15	31	22	11,7		45125
1,5						45155

Marking

The capacitors are marked on one side by embossed print, with:
1st line: rated capacitance in μF, tolerance and rated d.c. voltage;
2nd line: 5th, 6th and 7th digits of the catalogue number, code for dielectric materials (MKC-P), code for factory of origin and production date code.*

Mounting

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

---

* According to IEC 62, clause 5.

Type with radial leads

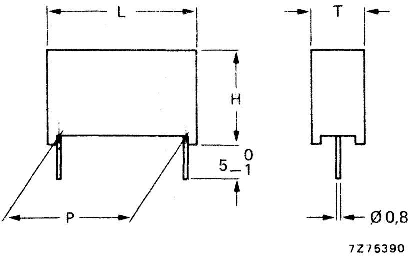


Fig.2a Capacitors of style 1; for dimensions T, L, H and P, see Table 2.

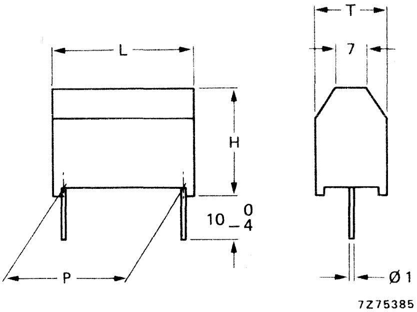


Fig.2b Capacitors of style 2; for dimensions T, L, H and P, see Table 2.

Table 2

	rated capacitance μF	T_{max} mm	L_{max} mm	H_{max} mm	P mm	mass g	catalogue number 2222 363	
							tol. ±5%	tol. ±10%
style 1	0,82	12	34	22	27,5 ± 0,4	10	42824	41824
	1,0						42105	41105
	1,2	15	34	25		15	42125	41125
	1,5						42155	41155
style 2	1,8	17	32	27,5		17	42185	41185
	2,2						42225	41225
	2,7	21	32	31,5		23	42275	41275
	3,3						42335	41335

Marking

The capacitors are marked on the top face by embossed print, with:

1 st line: rated capacitance in μF, tolerance and rated d.c. voltage;

2nd line: 5th, 6th and 7th digits of the catalogue number, code for dielectric materials (MKC-P) and code for factory of origin.

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 15 to 35 °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 and 2
Tolerance on rated capacitance at T_{amb} = 23 °C	±5% or ±10%

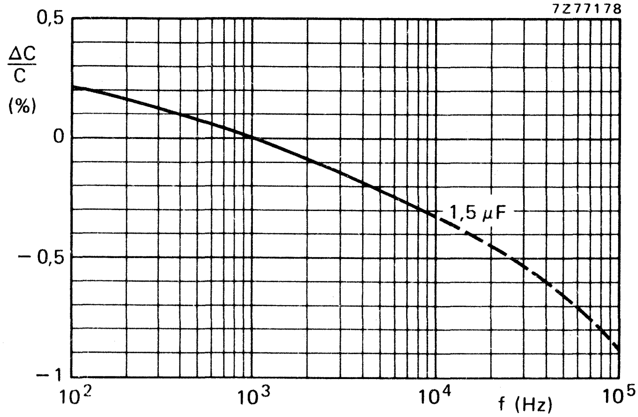


Fig.3 Capacitance as a function of frequency; typical curve, measured at 0,3 V.

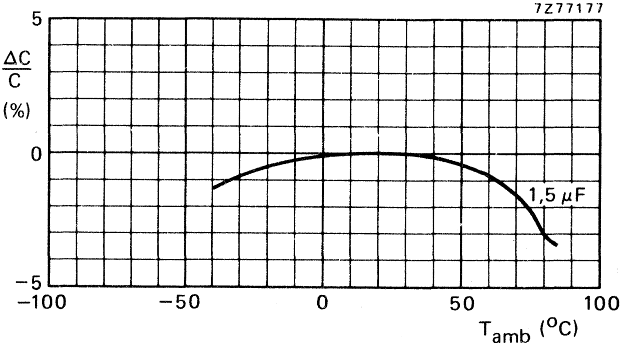


Fig.4 Capacitance as a function of temperature; typical curve, measured at 1 kHz, 0,3 V.

Voltage

Rated voltage U_R (d.c.)	210 V
Rated voltage U_R (a.c.), 50 to 60 Hz	100 V
Test voltage (d.c.) for 1 min	
between terminals	420 V
between interconnected terminals and case	1000 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.

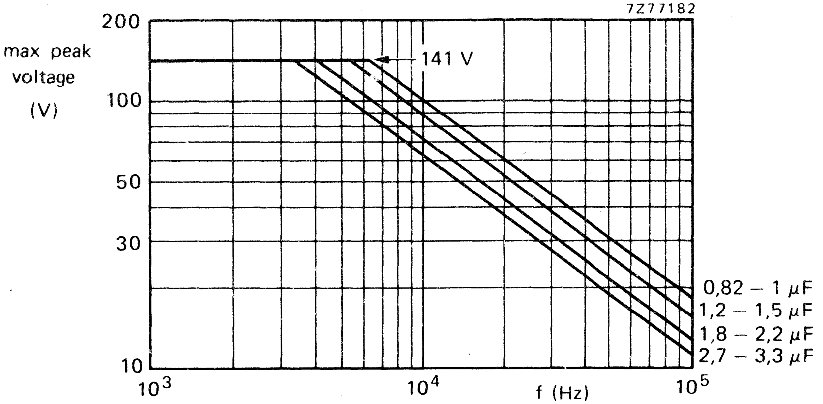


Fig.5 Maximum permissible peak value of sinusoidal voltages as a function of frequency at $T_{amb} \leqslant 45$ °C.

Insulation resistance

The insulation resistance is measured after a voltage of 100 ± 15 V has been applied for 1 min ± 5 s.

	ambient temperature	
	23 °C	85 °C
RC between terminations	> 10 000 s	> 100 s

See also graph (Fig.6) on the next page.

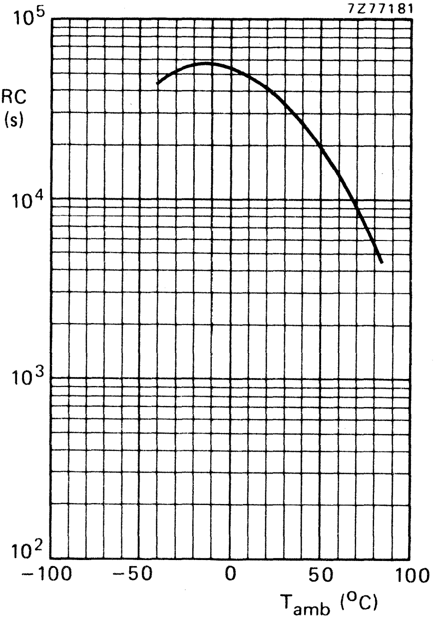


Fig.6 RC-product as a function of temperature; typical curve.

Tan δ (tangent of the loss angle)

Tan δ at 10 kHz	
for C ⩽ 1 μF	⩽ 55 x 10^{-4} (typ 35 x 10^{-4})
for C > 1 μF	⩽ 75 x 10^{-4} (typ 40 x 10^{-4})

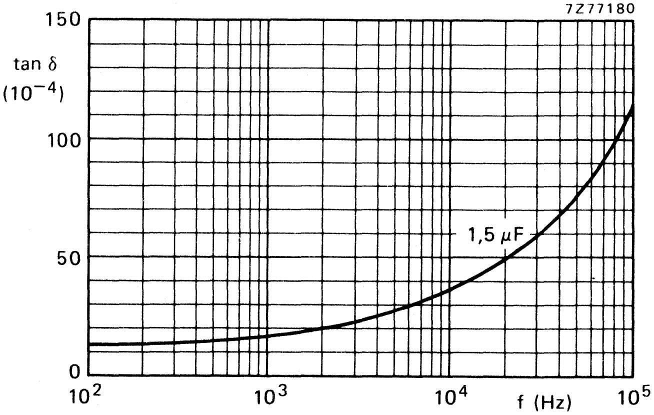


Fig.7 Tan δ as a function of frequency; typical curve.

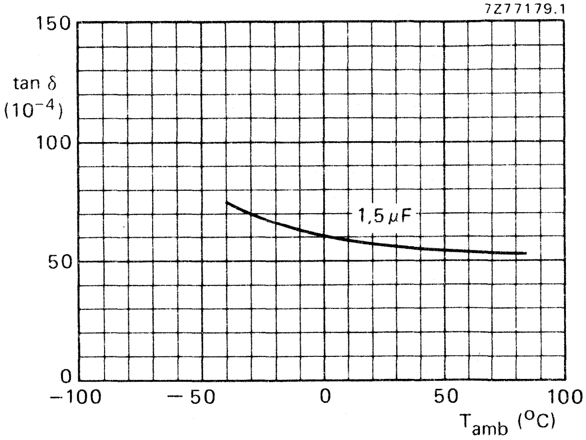


Fig.8 Tan δ as a function of temperature; typical curve, measured at 10 kHz, 0,3 V.

Power dissipation

Maximum permissible power dissipation	see Additional information

Pulse steepness

Maximum pulse steepness	10 V/μs

See also Tests and requirements – charge and discharge test.

Note
The maximum pulse steepness is valid for pulse voltages equal to the rated voltage.
For lower pulse voltages the given value may be multiplied by U_R/applied voltage.

Temperature

Rated temperature	85 °C
Category temperature range	−40 to +85 °C
Storage temperature range	−55 to +85 °C
Climatic category, IEC 68	40/085/56

PACKING

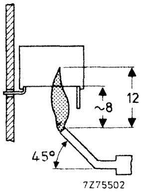
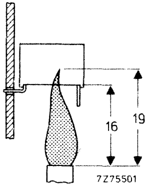
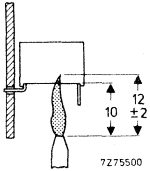
The capacitors are packed in cardboard boxes: type with axial leads 200 per box; type with radial leads 500 per box. Please order in multiples of these quantities.

TESTS AND REQUIREMENTS

IEC 68–2 test method	name of test	procedure (quick reference)	requirements
Ua1	Tensile strength of terminations	Loading force 10 N for d = 0,8 mm, 20 N for d = 1 mm in axial direction of the wires, 10 s.	No damage.
		Loading force 5 N for d = 0,8 mm, 10 N for d = 1 mm in radial direction of the wires, 10 s (only for radial type).	
Ub (method 1)	Bending of terminations	Loading force 5 N for d = 0,8 mm, 10 N for d = 1 mm; two consecutive bends.	No damage.
Ta	Soldering	Solder bath, non-activated colophony flux, solder temp. 235 °C, dwell time 2 s.	Good tinning.
Tb (method 1B)	Resistance to soldering heat	Solder bath: 350 °C, 3,5 s.	No damage; $\Delta C/C \leqslant 1\%$.
Na	Rapid change of temperature	5 cycles of ½ h at –40 °C and ½ h at +85 °C.	No damage, no leakage, $\Delta C/C \leqslant 2\%$. Tan δ and insulation resistance shall meet initial requirements.
Fc	Vibration	10 to 55 Hz, 0,75 mm or 10g (whichever is the less), 3 directions, 2 h per direction.	No damage, no open or short-circuit. $\Delta C/C \leqslant 0,5\%$.
Eb	Bumping	40g, 4000 bumps.	No damage, no open or short-circuit. $\Delta C/C \leqslant 0,5\%$.

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, no leakage, $\Delta C/C \leqslant 5\%$ at 85 ^{o}C. $RC \geqslant 100$ s at 85 ^{o}C.
	Db	Damp heat, cyclic	1 cycle of 24 h, upper temperature 55 ± 2 ^{o}C, R.H. 93 ± 3%; no voltage applied.	
	Aa	Cold	2 h at −40 ± 3 ^{o}C; no voltage applied	$\Delta C/C \leqslant 3\%$ 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.
	Db	Damp heat, cyclic	5 cycles of 24 h, upper temperature 55 ± 2 ^{o}C, R.H. 93 ± 3%; no voltage applied. Within 15 min after the test U_R (d.c.) has to be applied for 1 min.	
			Final measurement.	$\Delta C/C \leqslant 3\%$. Tan δ shall meet initial requirements. Insulation resistance $\geqslant$ 0,5 x initial requirements.
	Ca	Damp heat, steady state	56 days at 40 ± 2 ^{o}C, R.H. 90 to 95%; 6 V (d.c.) continuously applied.	$\Delta C/C \leqslant 3\%$. Tan δ shall meet initial requirements. Insulation resistance $\geqslant$ 0,5 x initial requirements.

IEC 68–2 test method	name of test	procedure (quick reference)	requirements	
–	Endurance	1000 h at 85 °C, 1,5 x U_R (d.c.) applied.	$\Delta C/C \leqslant 3\%$	Tan δ and insulation resistance shall meet initial requirements.
		1000 h at 85 °C, U_R (a.c.) 50 Hz applied.	$\Delta C/C \leqslant 3\%$	
		1000 h at 25 °C, 20 kHz voltage of 1,25 x max permissible voltage (Fig.5) applied.	$\Delta C/C \leqslant 1\%$ $\Delta \tan \delta \leqslant 30 \times 10^{-4}$ at 10 kHz	Insulation resistance shall meet initial requirements.
Additional tests				
	Solvent resistance	MIL-STD-202E, method 215.	No damage.	
	Storage	1000 h at 85 °C.	$\Delta C/C \leqslant 3\%$. Tan δ and insulation resistance shall meet initial requirements.	
		10 000 h at 25 °C.	$\Delta C/C \leqslant 1\%$. Tan δ and insulation resistance shall meet initial requirements.	
	Charge and discharge	10 000 cycles of charge to U_R (d.c.) and discharge via a resistor of value such that the pulse steepness is 1,5 x specified value. Cycle time: 1 to 150 cycles/s, temperature: 25 °C.	$\Delta \tan \delta \leqslant 20 \times 10^{-4}$ at 10 kHz.	

name of test	procedure (quick reference)	requirements
Flammability	 Bore of gas jet: ϕ 0,5 mm. Fuel: butane. Test duration: 20 s. One flame application.	After removing the test flame from the capacitor, the capacitor must not continue to burn for more than 15 s; no burning particles must drop from the sample.
	 Bore of gas jet: ϕ 10 mm. Fuel: natural gas. Test duration: 3 x 15 s. Time interval between each flame application: 15 s.	Extinguishing time ⩽ 15 s after the first and second flame application, ⩽ 60 s after the third flame application.
	 Bore of gas jet: ϕ 0,5 mm. Fuel: butane. Test duration: 3 x 15 s. Second and third flame application starts after extinguishing of the flame on the capacitor.	Extinguishing time ⩽ 10 s after each flame application; no burning particles must drop from the sample.

ADDITIONAL INFORMATION

The rated a.c. voltage, which has been specified at 50 to 60 Hz 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

$$P = \frac{V_{Rs}{}^2}{R_s} = I^2 R_s \tag{1}$$

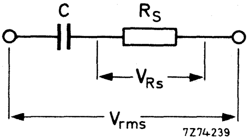


Fig. 9.

$$V_{Rs}{}^2 = \frac{R_s{}^2}{R_s{}^2 + 1/\omega^2 C^2} V_{rms}{}^2 \tag{2a}$$

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

$$V_{Rs}{}^2 = \frac{R_s{}^2}{1/\omega^2 C^2} V_{rms}{}^2 = R_s{}^2 \omega^2 C^2 V_{rms}{}^2. \tag{2b}$$

$$\text{Thus } P = R_S\omega^2 C^2 V_{rms}{}^2 = (R_SC)\, C\omega^2 V_{rms}{}^2, \tag{3}$$

in which $\omega = 2\,\pi f$, the term (R_SC) can be found from Fig. 10.

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.11.

Example

A capacitor with radial leads of 1 μF is to be used at 20 kHz and an ambient temperature of 65 °C. The R_SC-product at 20 kHz is 8 x 10^{-8} ΩF (Fig.10). The maximum permissible power dissipation at 65 °C is 850 mW (Fig.11).
The maximum a.c. voltage can be calculated from (3):

$$V_{rms} = \sqrt{\left\{\frac{P_{max}}{(R_SC)\, C\omega^2}\right\}}$$

$$= \sqrt{\left\{\frac{0{,}85}{8 \times 10^{-8} \times 1 \times 10^{-6} \times 4\pi^2 \times 4 \times 10^8}\right\}} = 25{,}9 \text{ V}$$

---

* At $T_{amb} \leqslant 45$ °C the maximum permissible sinusoidal voltage can be found in Fig.5.

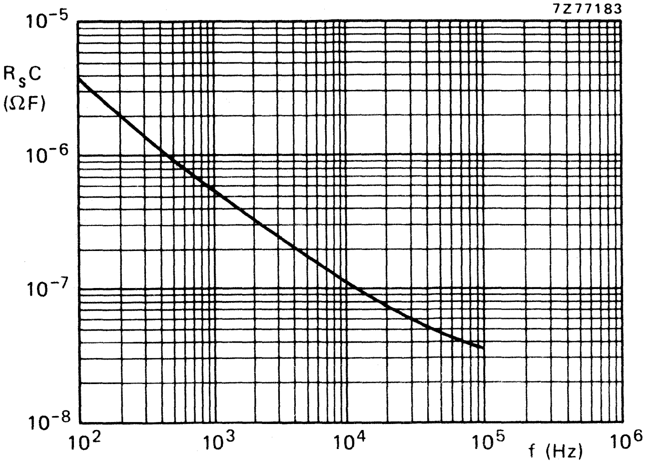


Fig.10 Maximum R_sC product as a function of frequency.

	dimensions in mm		
curve	T_{max}	L_{max}	H_{max}
1	12,4	31	19,5
2	12	34	22
3	15	31	22
4	15	34	25
5	17	32	27,5
6	21	32	31,5

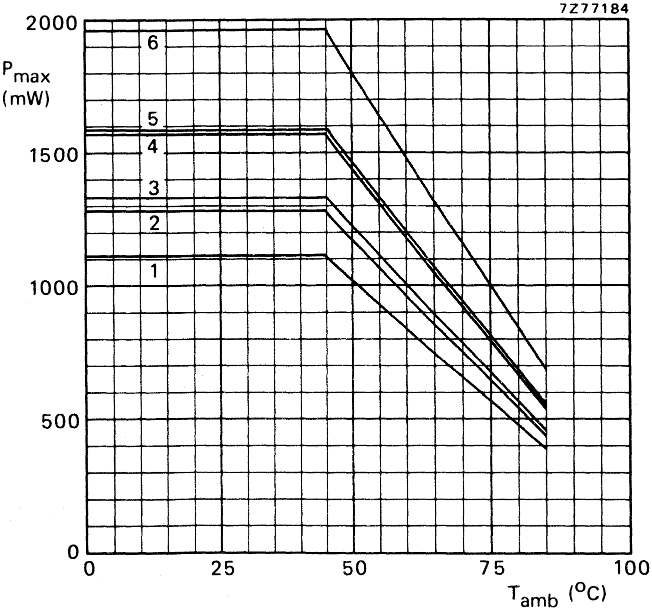


Fig.11 Maximum permissible power dissipation as a function of temperature.

For a capacitor used with a half sine-wave pulse, the power dissipation as a function of the voltage over a resistance R is expressed by

$$P = \frac{T_1}{T_2}\frac{(\frac{1}{2} V_p\sqrt{2})^2}{R} = \left(V_p \sqrt{\frac{T_1}{2T_2}}\right)^2 \frac{1}{R}. \qquad (4)$$

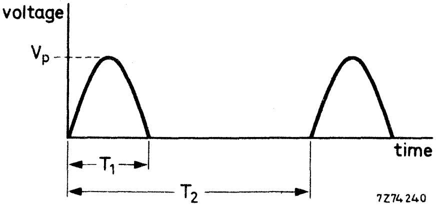


Fig. 12.

From the general expression $P = \frac{V_{rms}^2}{R}$ follows

$$V_{rms} = V_p \sqrt{\frac{T_1}{2T_2}}. \qquad (5)$$

Substitution of (5) into (3) gives

$$P = (R_sC)\, C\omega^2 \left(V_p \sqrt{\frac{T_1}{2T_2}}\right)^2, \text{ in which} \qquad (6)$$

$$\omega = 2\pi f = 2\pi \frac{1}{2T_1}$$; the term (R_sC) can be found from Fig.10.

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.11.

Example

A capacitor with radial leads of 1 μF is to be used with a half sine-wave pulse (pulse duration 25 μs, repetition time 64 μs) at an ambient temperature of 60 °C.

As the half period time is 25 μs, the pulse frequency is $\frac{1}{2 \times 25 \times 10^{-6}}$ Hz is 20 kHz.

The maximum R_sC-product at 20 kHz is 8×10^{-8} ΩF (Fig.10).

The maximum permissible power dissipation at 60 °C is 950 mW.

The maximum peak voltage can be calculated from (6):

$$V_p = \sqrt{\left\{\frac{P_{max}}{(R_sC)\, C\omega^2} \times \frac{2T_2}{T_1}\right\}}$$

$$V_p = \sqrt{\left(\frac{0{,}95 \times 2 \times 64 \times 10^{-6}}{8 \times 10^{-8} \times 1 \times 10^{-6} \times 4\pi^2 \times 4 \times 10^8 \times 25 \times 10^{-6}}\right)} = 62 \text{ V}.$$

POLYSTYRENE FILM/FOIL CAPACITORS

axial type (micropoco)

QUICK REFERENCE DATA

Rated capacitance range	51 to 39 000 pF
Tolerance on rated capacitance	± 5% (E24-series) ± 2% (E48-series) ± 1% (E96-series)
Rated voltage U_R (d.c.)	63 V, 160 V, 250 V, 630 V
Rated voltage U_R (a.c.), 50 to 60 Hz	25 V, 63 V, 125 V, 250 V
Rated temperature	
63 V version	70 °C
160 V, 250 V, 630 V versions	85 °C
Climatic category, IEC 68	
63 V version	40/070/21
160 V, 250 V, 630 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

The 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 . . . .

424 = 63 V 425 = 160 V 426 = 250 V 427 = 630 V	packed in boxes	2 = ± 5% 3 = ± 2% 4 = ± 1%	code for capacitance, see Tables 1 to 4
428 = 63 V 429 = 160 V 430 = 250 V 431 = 630 V	packed on bandoliers on reels	6 = ± 5% 7 = ± 2% 8 = ± 1%	

MECHANICAL DATA Dimensions in mm

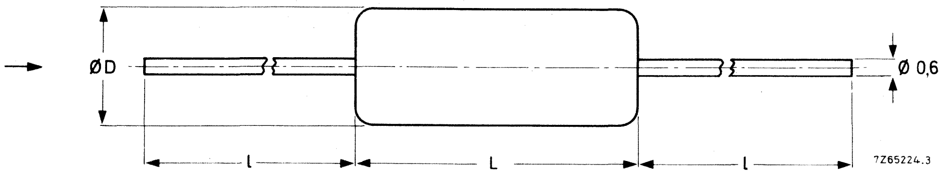


Fig. 1 For dimensions D, L and l see tables below.

Table 1 U_R (d.c.) = 63 V; U_R (a.c.) = 25 V

rated capacitance (E24-series, tol. ± 5%) * pF	D_{max}	L_{max}	l_{min}	approx. mass g	catalogue number (capacitors packed in boxes)
1 200	3,5	10,9	28	0,3	2222 424 21202
1 300					21302
1 500					21502
1 600					21602
1 800					21802
2 000					22002
2 200				0,4	22202
2 400					22402
2 700	4,0				22702
3 000					23002
3 300					23302
3 600					23602
3 900					23902
4 300	4,5			0,5	24302
4 700					24702
5 100					25102
5 600				0,6	25602
6 200	5,0				26202
6 800					26802
7 500		15	25,5		27502
8 200					28202
9 100				0,7	29102
10 000					21003
11 000	5,5			0,8	21103
12 000					21203
13 000				0,9	21303
15 000				1,1	21503

---

* Besides the values of the E24-series as quoted (with a tolerance ± 5%), intermediate values of the E48-series (with a tolerance ± 2%) and of the E96-series (with a tolerance ± 1%) are available.

Table 1 U_R (d.c.) = 63 V; U_R (a.c.) = 25 V (continued)

rated capacitance (E24-series, tol. ± 5%) * pF	D_{max}	L_{max}	l_{min}	approx. mass g	catalogue number (capacitors packed in boxes)
16 000	6,0	15	25,5	1,1	2222 424 21603
18 000					21803
20 000				1,3	22003
22 000	6,5				22203
24 000				1,4	22403
27 000	7,0			1,5	22703
30 000				1,7	23003
33 000	7,5			1,9	23303
36 000					23603
39 000	8,0			2,0	23903

Table 2 U_R (d.c.) = 160 V; U_R (a.c.) = 63 V

rated capacitance (E24-series, tol. ± 5%) * pF	D_{max}	L_{max}	l_{min}	approx. mass g	catalogue number (capacitors packed in boxes)
820	3,5	10,9	28	0,3	2222 425 28201
910					29101
1 000					21002
1 100					21102
1 200	4,0				21202
1 300					21302
1 500				0,4	21502
1 600					21602
1 800	4,5				21802
2 000					22002
2 200					22202
2 400				0,5	22402
2 700					22702
3 000	5,0				23002
3 300					23302
3 600				0,6	23602
3 900					23902
4 300		15	25,5		24302
4 700					24702
5 100					25102
5 600				0,7	25602
6 200					26202

---

* Besides the values of the E24-series as quoted (with a tolerance ± 5%), intermediate values of the E48-series (with a tolerance ± 2%) and of the E96-series (with a tolerance ± 1%) are available.

Table 2 U_R (d.c.) = 160 V; U_R (a.c.) = 63 V (continued)

rated capacitance (E24-series, tol. ± 5%) * pF	D_{max}	L_{max}	l_{min}	approx. mass g	catalogue number (capacitors packed in boxes)
6 800	5,5	15	25,5	0,8	2222 425 26802
7 500					27502
8 200	6,0			0,9	28202
9 100					29102
10 000				1,1	21003
11 000	6,5				21103
12 000				1,2	21203
13 000				1,3	21303
15 000	7,0			1,4	21503
16 000				1,5	21603

Table 3 U_R (d.c.) = 250 V; U_R (a.c.) = 125 V

rated capacitance (E24-series, tol. ± 5%) * pF	D_{max}	L_{max}	l_{min}	approx. mass g	catalogue number (capacitors packed in boxes)
390	3,5	10,9	28	0,3	2222 426 23901
430					24301
470					24701
510					25101
560					25601
620					26201
680					26801
750					27501
820	4,0			0,4	28201
910					29101
1 000					21002
1 100	4,5				21102
1 200				0,5	21202
1 300					21302
1 500					21502
1 600	5,0				21602
1 800					21802
2 000				0,6	22002
2 200					22202
2 400		15	25,5	0,5	22402
2 700				0,6	22702
3 000					23002
3 300					23302
3 600				0,7	23602
3 900					23902
4 300					24302

---

* Besides the values of the E24-series as quoted (with a tolerance ± 5%), intermediate values of the E48-series (with a tolerance ± 2%) and of the E96-series (with a tolerance ± 1%) are available.

Table 3 U_R (d.c.) = 250 V; U_R (a.c.) = 125 V (continued)

rated capacitance (E24-series, tol. ± 5%) * pF	D_{max}	L_{max}	l_{min}	approx. mass g	catalogue number (capacitors packed in boxes)
4 700	5,5	15	25,5	0,8	2222 426 24702
5 100					25102
5 600	6,0			0,9	25602
6 200					26202
6 800	6,5			1,1	26802
7 500					27502
8 200	7,0			1,3	28202
9 100	7,5				29102
10 000				1,5	21003
11 000				1,6	21103

Table 4 U_R (d.c.) = 630 V; U_R (a.c.) = 250 V

rated capacitance (E24-series, tol. ± 5%) * pF	D_{max}	L_{max}	l_{min}	approx. mass g	catalogue number (capacitors packed in boxes)
51	3,5	10,9	28	0,2	2222 427 25109
56					25609
62					26209
68					26809
75					27509
82					28209
91					29109
100					21001
110					21101
120					21201
130					21301
150					21501
160					21601
180					21801
200					22001
220					22201
240				0,3	22401
270					22701
300					23001
330	4,0				23301
360					23601
390					23901
430					24301
470	4,5				24701
510				0,4	25101
560					25601

* Besides the values of the E24-series as quoted (with a tolerance ± 5%), intermediate values of the E48-series (with a tolerance ± 2%) and of the E96-series (with a tolerance ± 1%) are available.

Table 4 U_R (d.c.) = 630 V; U_R (a.c.) = 250 V (continued)

rated capacitance (E24-series, tol. ± 5%) * pF	D_{max}	L_{max}	l_{min}	approx. mass g	catalogue number (capacitors packed in boxes)
620	4,5	10,9	28	0,4	2222 427 26201
680					26801
750	5,0				27501
820					28201
910				0,5	29101
1 000					21002
1 100					21102
1 200					21202
1 300		15	25,5	0,6	21302
1 500					21502
1 600	5,5			0,7	21602
1 800				0,8	21802
2 000					22002
2 200				0,9	22202
2 400				1,1	22402
2 700	6,0				22702
3 000	6,5				23002
3 300				1,4	23302
3 600	7,0				23602
3 900					23902
4 300	7,5			1,7	24302
4 700	8,0				24702
5 100					25102
5 600				2,0	25602

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 (d.c.);
3rd line: production date code (according to IEC 62, clause 5).

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).

---

* Besides the values of the E24-series as quoted (with a tolerance ± 5%), intermediate values of the E48-series (with a tolerance ± 2%) and of the E96-series (with a tolerance ± 1%) are available.

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_R) at 1 kHz	see Tables 1 to 4
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 voltage U_R (d.c.)	63 V, 160 V, 250 V, 630 V
Rated voltage U_R (a.c.), 50 to 60 Hz	
63 V version	25 V
160 V version	63 V
250 V version	125 V
630 V version	250 V
Category voltage U_C	1 x U_R (d.c.)
Test voltage for 1 min	
between terminals	2 x U_R (d.c.)
between interconnected terminals and coating	2 x U_R (d.c.) (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 160 V and 250 V versions, and 500 ± 15 V for the 630 V version.

	ambient temperature	
	23 °C	70 °C
R between terminals	> 100 000 MΩ	> 100 000 MΩ

Tan δ (tangent of the loss angle)

Tan δ at 10 kHz, for $C > 20\,000$ pF	$\leqslant 5 \times 10^{-4}$
Tan δ at 100 kHz, for 1000 pF $< C \leqslant 20\,000$ pF	$\leqslant 5 \times 10^{-4}$
Tan δ at 1 MHz, for $C \leqslant 1000$ pF	$\leqslant 10 \times 10^{-4}$

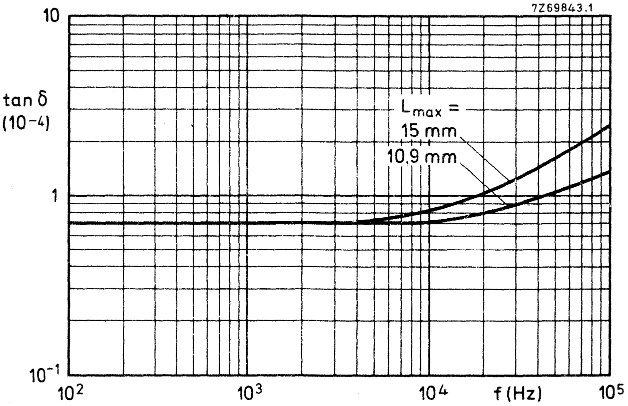


Fig. 2 Tan δ as a function of frequency; typical curves.

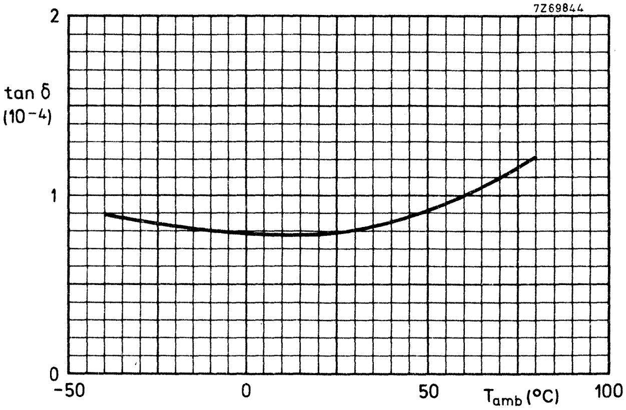


Fig. 3 Tan δ as a function of temperature; typical curve.

Resonant frequency

Resonant frequency		
length between soldering points 20 mm	$1126/\sqrt{C}$ MHz	C in pF
length between soldering points 30 mm	$919/\sqrt{C}$ MHz	
length between soldering points 40 mm	$796/\sqrt{C}$ MHz	

Temperature

Rated temperature	
63 V version	70 °C
160 V, 250 V and 630 V versions	85 °C
Category temperature range	
63 V version	−40 to + 70 °C
160 V, 250 V and 630 V versions	−40 to + 85 °C
Storage temperature range	
63 V version	−55 to + 70 °C
160 V, 250 V and 630 V versions	−55 to + 85 °C
Climatic category, IEC 68	
63 V version	40/070/21
160 V, 250 V and 630 V versions	40/085/21

PACKING

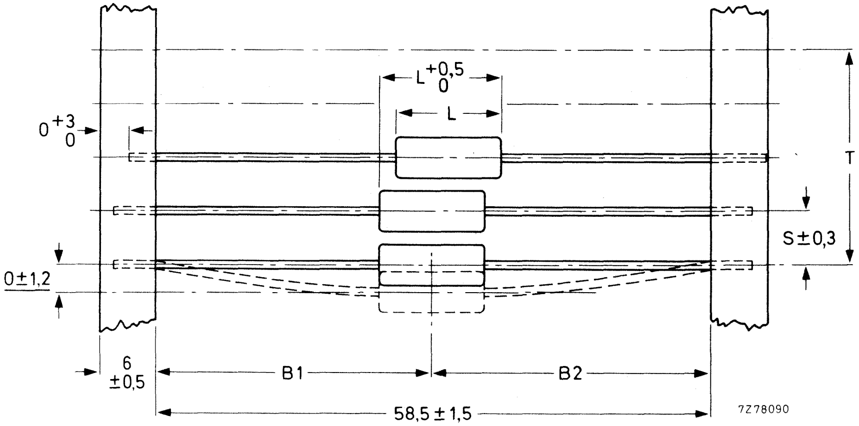
The capacitors are supplied in cardboard boxes or on bandoliers on reels.

Packing in cardboard boxes

capacitance values (pF) of				number of capacitors per box
63 V version	160 V version	250 V version	630 V version	
1 200– 2 400	820– 1 100	390– 750	51– 300	500
2 700– 3 900	1 200– 1 600	820– 1 000	330– 430	400
4 300– 5 600	1 800– 2 700	1 100– 1 500	470– 680	300
6 200– 6 800	3 000– 3 900	1 600– 2 200	750–1 200	250
7 500–10 000	4 300– 6 200	2 400– 4 300	1 300–1 500	300
11 000–20 000	6 800–10 000	4 700– 6 200	1 600–2 700	250
22 000–24 000	11 000–13 000	6 800– 7 500	3 000–3 300	200
27 000–39 000	15 000–16 000	8 200–11 000	3 600–5 600	150

Packing on bandoliers on reels

Dimensions in mm



|B1-B2| = max. 1,2

Fig. 4 For dimension L, see Tables 1 to 4.

capacitance values (pF) of				S	T for number (n) of capacitors	
63 V version	160 V version	250 V version	630 V version		n < 50	50 < n < 100
1 200– 5 600	820– 2 700	390– 1 500	51– 680	5	5(n - 1) ± 2	5(n - 1) ± 4
6 200–39 000	3 000–16 000	1 600–11 000	750–5 600	10	10(n - 1) ± 2	10(n - 1) ± 4

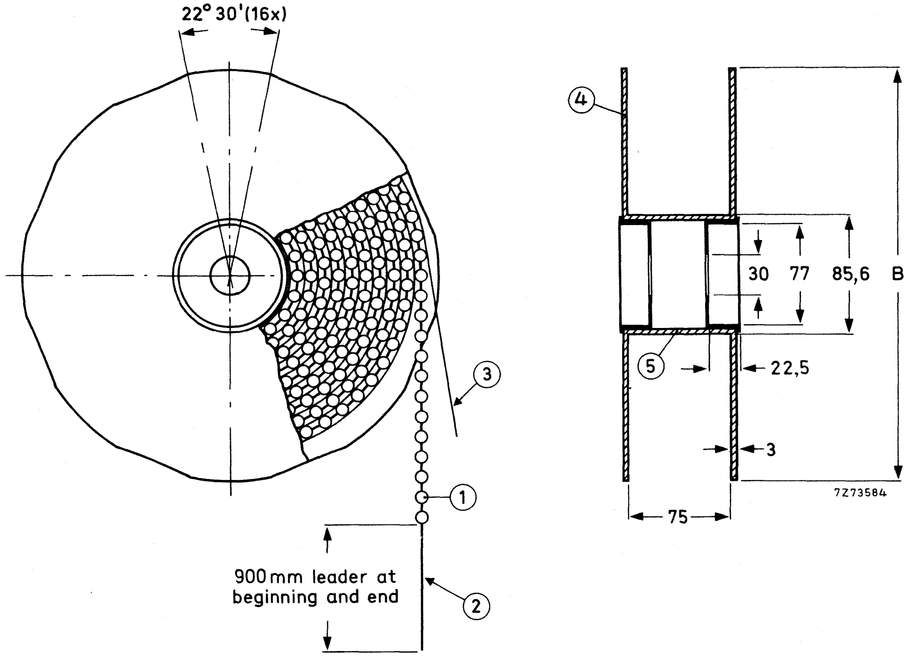


Fig. 5.

1: capacitor
2: bandolier
3: paper
4: flange
5: cylinder

capacitance values (pF) of				B	number of capacitors on one reel
63 V version	160 V version	250 V version	630 V version		
1 200– 2 400	820– 1 100	390– 750	51– 300	305	3 500
2 700– 5 600	1 200– 2 700	820– 1 500	330– 680	305	2 500
6 200–20 000	3 000–10 000	1 600– 6 200	750–2 700	356	1 500
22 000–39 000	11 000–16 000	6 800–11 000	3 000–5 600	356	1 000

TESTS AND REQUIREMENTS

IEC 275 clause	IEC 68–2 test method	name of test	procedure (quick reference)	requirements
15.1	Ua1	Tensile strength of terminations	Loading force 10 N in axial direction of the wires, 10 s.	No damage.
15.2	Ub (method 1)	Bending of terminations	Loading force 5 N, two consecutive bends.	No damage.
15.3	Uc	Torsion of terminations	Two successive rotations of 180^{o} in opposite directions.	No damage.
	Ta	Soldering	Solder bath, non-activated colophony flux, solder temp. 235 ^{o}C, dwell time 2 s.	Good tinning.
17	Na	Rapid change of temperature	5 cycles of ½ h at -40 ^{o}C and ½ h at $+70$ ^{o}C (63 V version) or $+85$ ^{o}C (other versions).	No damage, no leakage; $\Delta C/C \leqslant 0{,}5\% + 0{,}5$ pF. Tan δ and insulation resistance shall meet initial requirements.
18	Fc	Vibration	10 to 55 Hz, 0,75 mm or 10g (whichever is the less), 3 directions, 2 h per direction.	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 (160 V, 250 V, 630 V versions); no voltage applied.	No damage, no leakage.
		Db	Damp heat, cyclic	1 cycle of 24 h, upper temperature 55 ± 2 °C, R.H. 93 ± 3%; 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	Damp heat, cyclic	1 cycle of 24 h, upper temperature 55 ± 2 °C, R.H. 93 ± 3%; no voltage applied.	
				Final measurement.	$\Delta C/C \leqslant 1\%$ ($C \geqslant 500$ pF), $\leqslant 1{,}5\%$ or 1 pF, whichever is greater ($C < 500$ pF). Tan $\delta \leqslant 2$ x initial requirements; insulation resistance $>$ 0,5 x initial requirements.
21		Ca	Damp heat, steady state	21 days at 40 ± 2 °C and R.H. 90 to 95%; 6 V applied continuously.	$\Delta C/C \leqslant 1\%$ ($C \geqslant 500$ pF), $\leqslant 1{,}5\%$ or 1 pF, whichever is greater ($C < 500$ pF). Tan $\delta \leqslant 2$ 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
		Endurance	1000 h at 70 °C (63 V version) or at 85 °C (160 V, 250 V, 630 V versions); 1,5 x U_R (d.c.) applied.	ΔC/C ⩽ 0,3% (63 V version), ⩽ 0,5% + 0,5 pF (other versions). Tan δ ⩽ initial requirements or ⩽ 1,4 x initial measurements. Insulation resistance meets initial requirements.
23	Hb	Storage at low temperature	72 h at –55 °C.	No breakdown; ΔC/C ⩽ 0,25% (C > 500 pF), ⩽ 0,4% (C ⩽ 500 pF).
15.5		Temperature cycling drift	1 cycle of +25 °C/–40 °C/+70 °C/+25 °C.	ΔC/C ⩽ 0,1%.

Additional tests

Solderability of leads (globule method, IEC 68, test T3.2)	16 h at 155 ± 2 °C.	Good tinning, 4 s yield point.
Soldering test for mounting on printed-wiring boards	Capacitors mounted vertically on a board without plated-through holes; bodies rest on the board; without forced cooling.	
	Bath temp. 260 °C, dip-solder time 2 s;	ΔC/C ⩽ 1%.
	bath temp. 260 °C, dip-solder time 3 s;	ΔC/C ⩽ 2%.
	bath temp. 240 °C, dip-solder time 3 s;	ΔC/C ⩽ 1%.
	bath temp. 240 °C, dip-solder time 5 s.	ΔC/C ⩽ 2%.
	Capacitors mounted horizontally on a board with plated-through holes; bodies at least 1 mm from the board; max. permissible body temperature for 1 min is 100 °C.	ΔC/C ⩽ 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 34 000 pF
Tolerance on rated capacitance	± 1%
Rated voltage U_R (d.c.)	63 V
Rated voltage U_R (a.c.), 50 to 60 Hz	25 V
Rated temperature	70 ^oC
Climatic category, IEC 68	40/070/56
Basic specification	IEC 275

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

The capacitors consist of a low-inductive wound cell of polystyrene film and tin/lead foil. The cell is potted with epoxy resin in a yellow flame retardent 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 ⩽ 3 920 pF, according to Fig. 1, or
capacitors > 3 920 pF, according to Fig. 2, or
capacitors > 15 000 pF, according to Fig. 3
8 = capacitors ⩽ 3 920 pF, according to Fig. 2

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 4750 pF should be ordered as 2222 443 44752.
A capacitor of 121 pF according to Fig. 2, should be ordered as 2222 443 81211.
A capacitor of 12 100 pF should be ordered as 2222 443 41213.

MECHANICAL DATA

Dimensions in mm

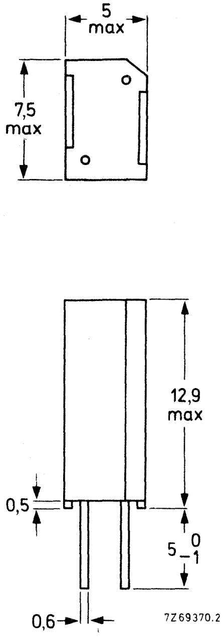


Fig. 1 Capacitors of rated capacitance range 100 to 3920 pF.

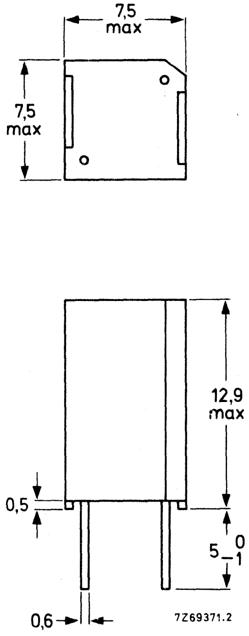


Fig. 2 Capacitors of rated capacitance range 100 to 15 000 pF.

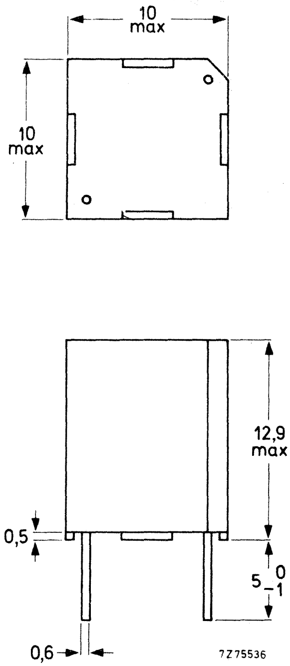


Fig. 3 Capacitors of rated capacitance range 15 400 to 34 000 pF.

Marking

Capacitors according to Fig. 1 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%) and rated voltage (d.c.);
3rd line: production date code according to IEC 62, clause 5, and code for dielectric (KS = polystyrene).

Note
The earth side is indicated by a vertical line to the left of the 2nd and 3rd lines of marking, and by the bevelled corner.

Capacitors according to Figs 2 and 3 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%) and rated voltage (d.c.);
3rd line: 5th, 6th and 7th digits of the catalogue number;
4th line: production date code according to IEC 62, clause 5, and code for dielectric (KS = polystyrene).

The manufacturer's identification symbol is indicated to the left of the 2nd and 3rd lines of marking.

Note
The earth side is indicated by a vertical line to the left of the 2nd, 3rd and 4th lines of marking, and by the bevelled corner.

Mounting

The capacitors are designed for mounting on printed-wiring boards. The required space on the printed-wiring board for a hole diameter of 1 mm is given in Figs 4, 5 and 6.

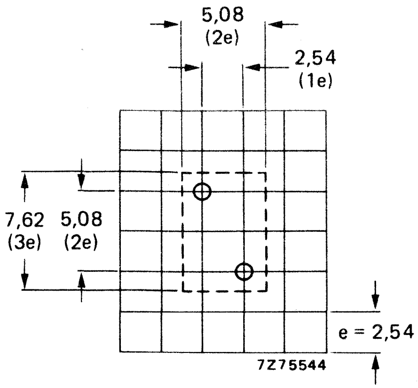


Fig. 4 Required space for capacitors according to Fig. 1.

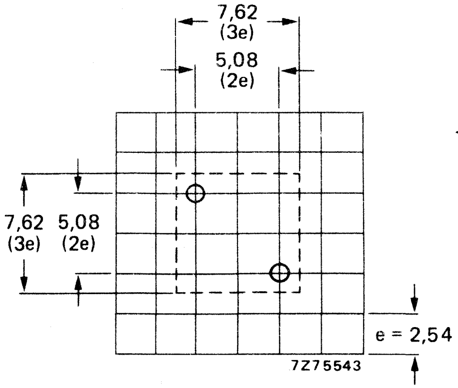


Fig. 5 Required space for capacitors according to Fig. 2.

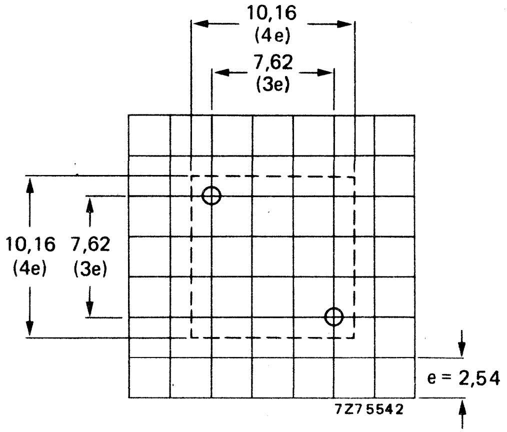


Fig. 6 Required space for capacitors according to Fig. 3.

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_R) at 1 kHz, $C_R > 1000$ pF and at 1 MHz, $C_R \leqslant 1000$ pF	100 to 34 000 pF (E96-series)
Tolerance on rated capacitance	± 1%
Temperature coefficient	
$C_R \leqslant 6000$ pF	−(95 to 155) ppm/°C
→ $C_R > 6000$ pF	−(120 to 185) ppm/°C
Frequency dependence between 100 Hz and 1 MHz	none

Voltage

Rated voltage U_R (d.c.)	63 V
Rated voltage U_R (a.c.), 50 to 60 Hz	25 V
Test voltage for 1 min	
between terminals	2 x U_R (d.c.)
between interconnected terminals and case	400 V (d.c.)

Insulation resistance

The insulation resistance is measured after a voltage of 10 ± 1 V has been applied for 1 min ± 5 s.

	ambient temperature	
	23 °C	70 °C
R between terminals	> 500 000 MΩ	> 100 000 MΩ
R between interconnected terminals and case	> 500 000 MΩ	> 100 000 MΩ

Tan δ (tangent of the loss angle)

Tan δ	
at 1 MHz, $C_R \leqslant 500$ pF	$\leqslant 5 \times 10^{-4}$
at 1 MHz, 500 pF $< C_R \leqslant 1000$ pF	$\leqslant 10 \times 10^{-4}$
at 1 kHz, $C_R > 1000$ pF	$\leqslant 2 \times 10^{-4}$

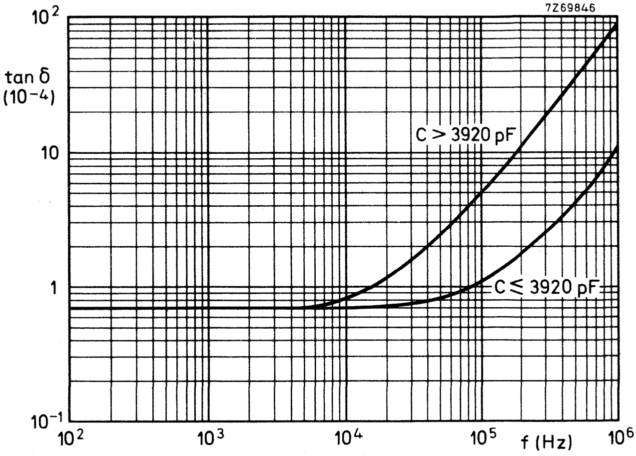


Fig. 7 Tan δ as a function of frequency; typical curves.

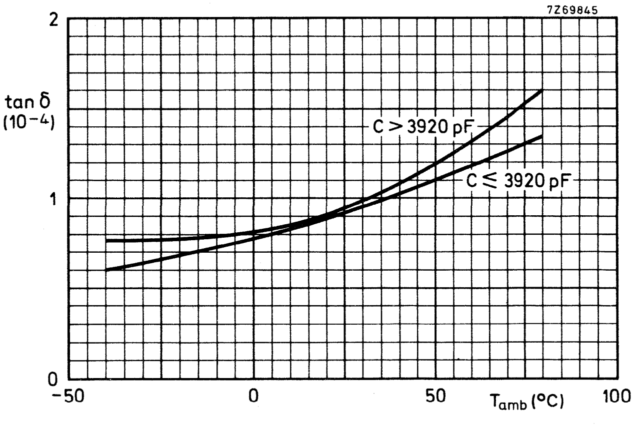


Fig. 8 Tan δ as a function of temperature; typical curves.

Resonant frequency

Resonant frequency, total lead length 2 x 1 mm $\geqslant \frac{8,5 \times 10^2}{\sqrt{C}}$ 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, IEC 68	40/070/56

→ PACKING

The capacitors are packed in boxes: capacitance values $\leqslant$ 15 000 pF (Figs 1 and 2) 200 pieces per box; capacitance values $>$ 15 000 pF (Fig. 3) 100 pieces per box.

TESTS AND REQUIREMENTS

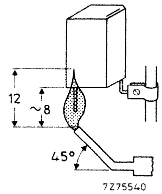
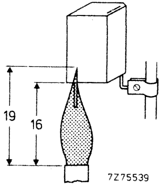
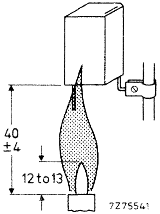
IEC 275 clause	IEC 68–2 test method	name of test	procedure (quick reference)	requirements
15,1	Ua1	Tensile strength of terminations	Loading force 10 N in axial direction of the wires, 10 s.	No damage.
	Ta	Soldering	Solder bath, non-activated colophony flux, solder temp. 235 °C, dwell time 2 s.	Good tinning.
17	Na	Rapid change of temperature	5 cycles of ½ h at −40 °C and ½ h at + 70 °C.	No damage, no leakage; $\Delta C/C \leqslant 0{,}2\%$. Tan δ and insulation resistance shall meet initial requirements.
18	Fc	Vibration	10 to 55 Hz, 0,75 mm or 10g (whichever is the less), 3 direction, 2 h per direction.	No damage, no open or short-circuit; $\Delta\ C/C \leqslant 0{,}1\%$.
19	Eb	Bumping	40g, 4000 bumps.	No damage, no open or short-circuit; $\Delta C/C \leqslant 0{,}1\%$.

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 ± 3 °C, no voltage applied.	No damage, no leakage
		Db	Damp heat, cyclic	1 cycle of 24 h, upper temperature 55 ± 2 °C, R.H. 93 ± 3%; 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.
		Db	Damp heat, cyclic	5 cycles of 24 h, upper temperature 55 ± 2 °C, R.H. 93 ± 3%; no voltage applied.	
				Final measurement.	$\Delta C/C \leqslant 0{,}5\% + 0{,}5$ pF. Tan δ at 1 kHz $\leqslant 2{,}4 \times 10^{-4}$ ($C > 1000$ pF); at 1 MHz $\leqslant 6 \times 10^{-4}$ ($C \leqslant 500$ pF); at 1 MHz $\leqslant 12 \times 10^{-4}$ (500 pF $< C \leqslant 1000$ pF). Insulation resistance $> 5 \times 10^5$ MΩ.
21		Ca	Damp heat, steady state	56 days at 40 ± 2 °C and R.H. 90 to 95%; 6 V applied continuously.	$\Delta C/C \leqslant 0{,}75\% + 0{,}5$ pF. Tan δ at 1 kHz $\leqslant 2{,}4 \times 10^{-4}$ ($C > 1000$ pF); at 1 MHz $\leqslant 6 \times 10^{-4}$ ($C \leqslant 500$ pF); at 1 MHz $\leqslant 12 \times 10^{-4}$ (500 pF $< C \leqslant 1000$ pF). Insulation resistance $> 5 \times 10^5$ MΩ.

IEC 275 clause	IEC 68–2 test method	name of test	procedure (quick reference)	requirements
		Endurance	1000 h at 70 ^{o}C, 1,5 x U_R (d.c.) applied.	$\Delta C/C \leqslant 0{,}3\% + 0{,}3$ pF. Tan δ at 1 kHz $2{,}8 \times 10^{-4}$ (C > 1000 pF); at 1 MHz 7×10^{-4} (C $\leqslant$ 500 pF); at 1 MHz 14×10^{-4} (500 pF < C $\leqslant$ 1000 pF). Insulation resistance shall meet initial requirement.
23	Hb	Storage at low temperature	72 h at –55 ^{o}C.	No breakdown; $\Delta C/C \leqslant 0{,}25\%$ or 1 pF, whichever is greater.

Additional tests

		Long term stability	10 000 h at 55 ^{o}C, 25 V (d.c.) applied.	$\Delta C/C \leqslant 0{,}3\% + 0{,}3$ pF.
		Endurance	2000 h at 70 ^{o}C, 1,5 x U_R (d.c.) applied.	$\Delta C/C \leqslant 0{,}3\% + 0{,}3$ pF.
		Solderability of leads (solder bath method, IEC 68, test Ta)	16 h at 155 ± 2 ^{o}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 ^{o}C; dip-solder time: 5 ± 0,5 s. Bath temp.: 260 ± 10 ^{o}C; dip-solder time: 3 ± 0,5 s.	$\Delta C/C \leqslant 0{,}25\%$ or 1 pF whichever is greater.
		Voltage test (destructive test)	5 x U_R (d.c.) between terminals for 1 s.	No breakdown.

name of test	procedure (quick reference)	requirements
Flammability	 Bore of gas jet: ϕ0,5 mm. Fuel: butane. Test duration: 20 s. One flame application.	After removing the test flame from the capacitor, the capacitor must not continue to burn for more than 10 s. No burning particles must drop from the sample.
	 Bore of gas jet: ϕ10 mm. Fuel: natural gas. Test duration: 3 x 15 s. Time interval between each application: 15 s.	Extinguishing time $\leqslant$ 15 s after the first and second flame application, $\leqslant$ 60 s after the third flame application.
	 Bore of gas jet: ϕ14 to ϕ15 mm. Fuel: propane. Test duration: 15 s. One flame application.	After removing the test flame from the capacitor, the capacitor must not continue to burn for more than 5 s. No burning particles must drop from the sampie.

POLYSTYRENE FILM/FOIL CAPACITORS

wrapped end-filled type

QUICK REFERENCE DATA

Rated capacitance range	6200 to 162 000 pF
Tolerance on rated capacitance	±5% (E24-series) ±2% (E48-series) ±1% (E96-series)
Rated voltage U_R (d.c.)	63 V, 160 V, 250 V and 630 V
Rated voltage U_R (a.c.), 50 to 60 Hz	25 V, 63 V, 125 V and 250 V
Rated temperature	
63 V version	70 °C
160 V, 250 V, 630 V versions	85 °C
Climatic category, IEC 68	
63 V version	40/070/56
160 V, 250 V, 630 V versions	40/085/56
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 wrapped in a polyester film, the ends are filled with epoxy resin. The axial leads are solder-coated.

Composition of the catalogue number

2222 . . . .

code for rated voltage, see Tables 1 to 4

code for capacitance, see Tables 1 to 4

code for tolerance
2 = ±5%
3 = ±2%
4 = ±1%

MECHANICAL DATA

Dimensions in mm

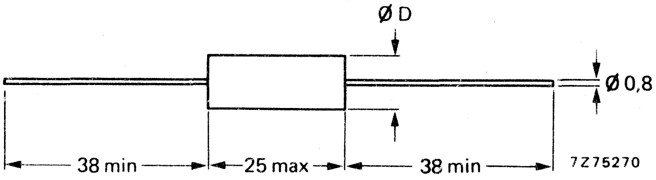


Fig.1 For dimension D see tables below.

Table 1 - U_R (d.c.) = 63 V; U_R (a.c.) = 25 V

rated capacitance (E24-series, tol. ±5%)* pF	D_{max} mm	approx. mass g	catalogue number
43000	7,0	3,1	2222 444 24303
47000	7,5	3,2	24703
51000	7,5	3,4	25103
56000	8,0	3,7	25603
62000	8,5	4,0	26203
68000	8,5	4,4	26803
75000	9,0	4,7	27503
82000	9,5	5,1	28203
91000	9,5	5,5	29103
100000	10,0	5,9	21004
110000	10,5	6,4	21104
120000	11,0	6,9	21204
130000	11,5	7,5	21304
150000	12,0	8,2	21504
160000	12,5	9,0	21604
162000	12,5	9,1	21624

---

* Besides the values of the E24 series as quoted (with a tolerance ±5%), intermediate values of the E48 series (with a tolerance ±2%) and of the E96 series (with a tolerance ±1%) are available.

Table 2 U_R (d.c.) = 160 V; U_R (a.c.) = 63 V

rated capacitance (E24-series, tol. ±5%)* pF	D_{max} mm	approx. mass g	catalogue number
18000	6,5	2,3	2222 445 21803
20000	7,0	2,4	22003
22000	7,0	2,5	22203
24000	7,5	2,6	22403
27000	7,5	2,8	22703
30000	8,0	3,1	23003
33000	8,5	3,4	23303
36000	8,5	3,8	23603
39000	9,0	4,1	23903
43000	9,5	4,4	24303
47000	9,5	4,7	24703
51000	10,0	5,1	25103
56000	10,5	5,5	25603
62000	11,0	5,9	26203
68000	11,5	6,4	26803
75000	12,0	7,0	27503
82000	12,5	7,6	28203

Table 3 U_R (d.c.) = 250 V; U_R (a.c.) = 125 V

rated capacitance (E24-series, tol. ±5%)* pF	D_{max} mm	approx. mass g	catalogue number
12000	7,0	2,1	2222 446 21203
13000	7,0	2,2	21303
15000	7,5	2,4	21503
16000	7,5	2,5	21603
18000	8,0	2,7	21803
20000	8,5	2,9	22003
22000	8,5	3,2	22203
24000	9,0	3,5	22403
27000	9,5	3,7	22703
30000	10,0	4,0	23003
33000	10,5	4,4	23303
36000	10,5	4,7	23603
39000	11,0	5,1	23903
43000	11,5	5,5	24303
47000	12,0	5,9	24703

---

* Besides the values of the E24 series as quoted (with a tolerance ±5%), intermediate values of the E48 series (with a tolerance ±2%) and of the E96 series (with a tolerance ±1%) are available.

Table 4 U_R (d.c.) = 630 V; U_R (a.c.) = 250 V

rated capacitance (E24-series, tol. ±5%)* pF	D_{max} mm	approx. mass g	catalogue number
6200	7,5	2,1	2222 447 26202
6800	7,5	2,2	26802
7500	8,0	2,4	27502
8200	8,0	2,6	28202
9100	8,5	2,8	29102
10000	9,0	3,0	21003
11000	9,0	3,3	21103
12000	9,5	3,6	21203
13000	10,0	3,9	21303
15000	10,5	4,2	21503
16000	11,0	4,6	21603
18000	11,5	4,9	21803
20000	12,0	5,3	22003
22000	12,5	5,8	22203
24000	12,5	6,2	22403

Marking

The capacitors are marked in ink as follows:
1st line: rated capacitance in pF or nF and tolerance;
2nd line: rated voltage (d.c.) and code for dielectric material (KS = polystyrene);
→ 3rd line: 5th, 6th and 7th digits of catalogue number and production date code. **
The outer film connection is identified with a stroke.

Mounting

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

---

* Besides the values of the E24 series as quoted (with a tolerance ± 5%), intermediate values of the E48 series (with a tolerance ± 2%) and of the E96 series (with a tolerance ± 1%) are available.

** According to IEC 62, clause 5.

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_R) at 1 kHz	see Table 1 to 4
Tolerance on rated capacitance	±5%, ±2% and ±1%
Temperature coefficient	−125 ± 60 ppm/°C
Frequency dependence between 100 Hz and 1 MHz	none

Voltage

Rated voltage U_R (d.c.)	63 V, 160 V, 250 V, 630 V
Rated voltage U_R (a.c.), 50 to 60 Hz	
63 V version	25 V
160 V version	63 V
250 V version	125 V
630 V version	250 V
Category voltage U_C	1 x U_R (d.c.)
Test voltage for 1 min	
between terminals	2 x U_R (d.c.)
between interconnected terminals and case	2 x U_R (d.c.) (minimum 400 V)

Insulation resistance

The insulation resistance is measured after a voltage has been applied for 1 min ±5 s, the voltage being 50 ± 5 V for the 63 V version, 100 ± 15 V for the 160 V and 250 V versions, and 500 ± 15 V for the 630 V version.

	ambient temperature	
	23 °C	85 °C *
R between terminals, for C ⩽ 100 000 pF	> 500 000 MΩ	> 100 000 MΩ
RC between terminals, for C > 100 000 pF	> 50 000 s	> 10 000 s
R between interconnected terminals and case	> 500 000 MΩ	> 100 000 MΩ

---

* 70 °C for 63 V version.

Tan δ (tangent of the loss angle)

Tan δ at 10 kHz, for $C_R > 20\,000$ pF	$\leqslant 5 \times 10^{-4}$
Tan δ at 100 kHz, for $C \leqslant 20\,000$ pF	$\leqslant 5 \times 10^{-4}$

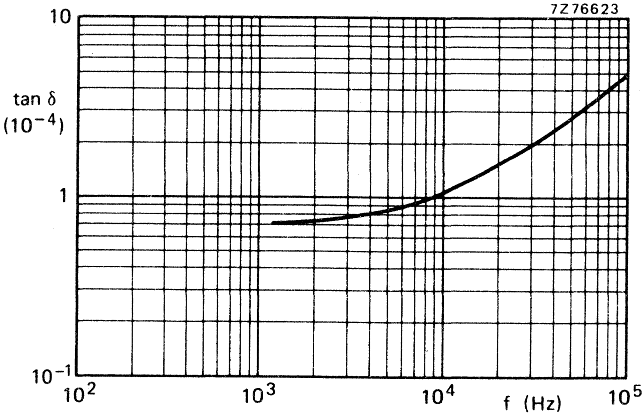


Fig.2 Tan δ as a function of frequency; typical curve.

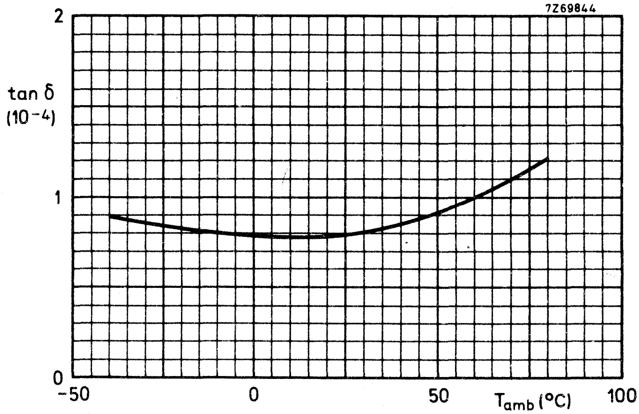


Fig.3 Tan δ as a function of temperature; typical curve.

Resonant frequency

Resonant frequency length between soldering points 30 mm	$\frac{919}{\sqrt{C}}$ MHz	C in pF
length between soldering points 40 mm	$\frac{796}{\sqrt{C}}$ MHz	

Temperature

Rated temperature	
63 V version	70 °C
160 V, 250 V and 630 V versions	85 °C
Category temperature range	
63 V version	−40 to +70 °C
160 V, 250 V and 630 V versions	−40 to +85 °C
Storage temperature range	
63 V version	−55 to +70 °C
160 V, 250 V and 630 V versions	−55 to +85 °C
Climatic category, IEC 68	
63 V version	40/070/56
160 V, 250 V and 630 V versions	40/085/56

PACKING

The capacitors are supplied in cardboard boxes; the number of capacitors per box is given in Table 5.

Table 5

capacitance values (pF) of				number of capacitors per box
63 V version	160 V version	250 V version	630 V version	
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

TESTS AND REQUIREMENTS

IEC 275 clause	IEC 68–2 test method	name of test	procedure (quick reference)	requirements
15.1	Ua1	Tensile strength	Loading force 10 N in axial direction of the wires, 10 s.	No damage. Tan δ shall meet initial requirements.
15.2	Ub (method 1)	Bending of terminations	Loading force 5 N, two consecutive bends.	
15.3	Uc	Torsion of terminations	Two successive rotations of 180° in opposite directions.	
	Ta	Soldering	Solder bath, non-activated colophony flux, solder temp. 235 °C, dwell time 2 s.	Good tinning.
	Tb method 1A	Resistance to soldering heat	Solder bath: 260 °C, 10 s.	$\Delta C/C \leqslant 0{,}5\%$; tan δ shall meet initial requirements.
17	Na	Rapid change of temperature	5 cycles of ½ h at –40 °C and ½ h at +70 °C (63 V version) or +85 °C (other versions).	No damage; $\Delta C/C \leqslant 0{,}5\%$. Tan δ shall meet initial requirements.
18	Fc	Vibration	10 to 55 Hz, 0,75 mm or 10g (whichever is the less), 3 directions, 2 h per direction.	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 (160 V, 250 V, 630 V versions); no voltage applied.	No damage.
		Db	Damp heat, cyclic	1 cycle of 24 h, upper temperature 55 ± 2 °C, R.H. 93 ± 3%; 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.
		Db	Damp heat, cyclic	5 cycles of 24 h, upper temperature 55 ± 2 °C, R.H. 93 ± 3%; no voltage applied. Within 15 min after removal from the test, the rated voltage shall be applied for 1 min.	
				Final measurement.	$\Delta C/C \leqslant 0{,}5\%$. Tan $\delta \leqslant 2$ x initial requirements. Insulation resistance $> 0{,}2$ x initial requirements.
21		Ca	Damp heat, steady state	56 days at 40 ± 2 °C and R.H. 90 to 95%; no voltage applied. Within 15 min after removal from the test, the rated voltage shall be applied for 1 min.	$\Delta C/C \leqslant 0{,}75\%$. Tan $\delta \leqslant 2$ x initial requirements. Insulation resistance $> 0{,}2$ x initial requirements.

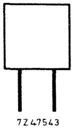
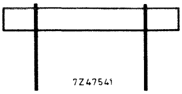
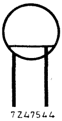
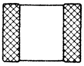
IEC 275 clause	IEC 68–2 test method	name of test	procedure (quick reference)	requirements
		Endurance	1000 h at 70 ^{o}C (63 V version) or at 85 ^{o}C (160 V, 250 V, 630 V versions); 1,5 x U_R (d.c.) applied.	$\Delta C/C \leqslant 0{,}3\%$ (63 V version), $\leqslant 0{,}5\%$ (other versions). Tan $\delta \leqslant$ initial requirements or $\leqslant$ 1,4 x initial measurements. Insulation resistance meets initial requirements.
23	Hb	Storage at low temperature	72 h at –55 ^{o}C.	No breakdown; $\Delta C/C \leqslant 0{,}25\%$.
		Temperature cycling drift	1 cycle of +25 ^{o}C/–40 ^{o}C/+85 ^{o}C/+25 ^{o}C.	$\Delta C/C \leqslant 0{,}1\%$.

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  7Z47543	1	0,56– 560	63/100	2222 631–632 2222 638 2222 641–643	67
		0,47– 270	500	2222 650	83
	2	1 000– 22 000	63	2222 629	
		180– 4 700	100	2222 630	
		1 000– 10 000	100	2222 640	55
		100– 2 700	500	2222 655	93
	3	22 000–100 000	6	2222 675 *	101
tubular  7Z47541	1	1– 560	500	2222 555	43
	2	680– 10 000	500	2222 552	39
	safety	22– 4 700	400 (a.c.)	2212 619	9
disc  7Z47544	1	0,47– 47	400	2222 625 2222 626	47
	2	100– 3 300	400	2222 627	51
		33– 2 700	500	2212 657	15
		33– 560	2 000	2222 659	15
		220– 2 200	250 (a.c.)	2212 660	27
	safety	33– 1 000	400 (a.c.)	2212 661	33
feed-through  7Z47545  7Z47546	2	2,5– 2 200	350	2222 700 *	
		2,5– 4 700	350	2222 702 *	107
chip 	1	10– 10 000	50	2222 851–856	111
	2	100–470 000	50		

* 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					

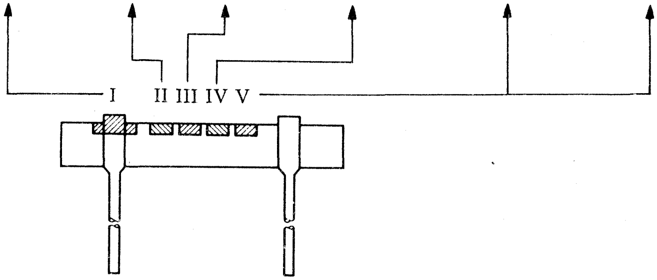
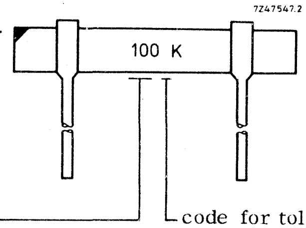


Figure code



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 ϵ_r = 6 up to 250 T.C. types			TYPE 2 ϵ_r > 250 high-K types	
P100	(+100 ppm/°C)	$MgTiO_3$, Mg_2SiO_4	ϵ_r = 2000	$BaTiO_3$
NP0	(0 ,, ,,)	$MgTiO_3$	ϵ_r = 5000	(Ba, Ca)(Ti, Zr)O_3 + add.
N075	(-75 ,, ,,)	$Ba_2Ti_9O_{20}+TiO_2$	ϵ_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:

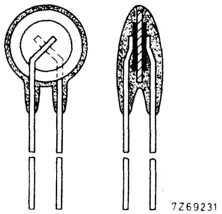


Fig. 1 Disc capacitor.

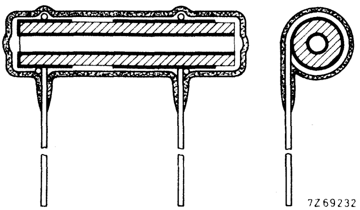


Fig. 2 Tubular capacitor.

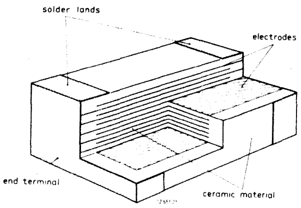


Fig. 3 Cross-section of a chip capacitor.

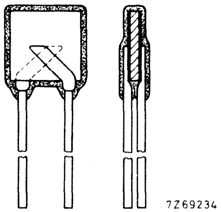


Fig. 4 Plate capacitor.

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 carrefully 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.

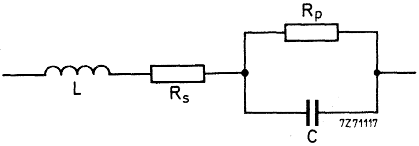


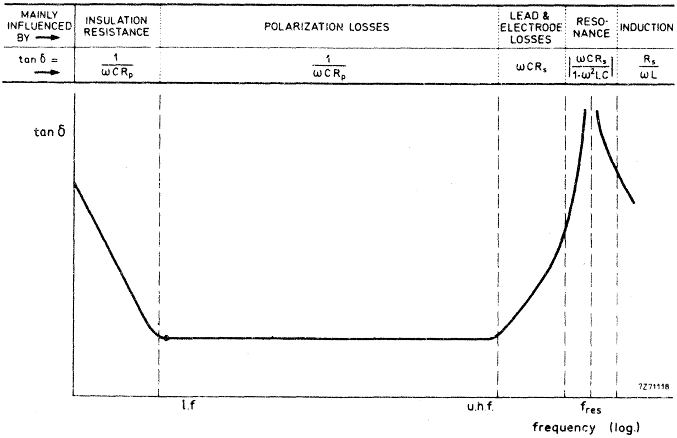
Fig. 5

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:

$$\tan\delta = \left|\frac{R}{X}\right| = \frac{R_p + R_s\ \{1+(\omega CR_p)^2\}}{\omega CR_p^2 - \omega L\ \{1+(\omega CR_p)^2\}}$$

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
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
$\tan\delta > 2$ x requirement after 1000 h
$R_{ins} < 0,1$ x requirement after 1000 h

The Failure Rate has a confidence level of 60%.

---

*) Detailed information is given in our Product Informations 30 and 39.

TUBULAR CERAMIC CAPACITORS

safety

QUICK REFERENCE DATA

Capacitance range	
in type 1B	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 1B, type 2
Climatic category, IEC 68	25/085/21
Basic specification	IEC 65
Approvals	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.

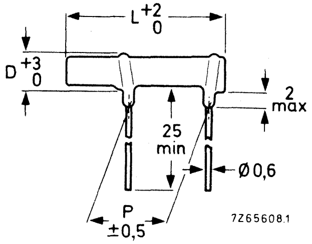
DESCRIPTION

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.

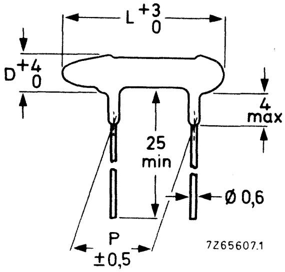
MECHANICAL DATA

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	+ L
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 ^{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	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^{o}	no damage
15	T	Soldering (solder bath)	solderability: 4 s 235 ^{o}C, non activating flux applied	good tinning
19.2	B	Climatic sequence Dry heat	16 h + 85 ^{o}C	no visible damage
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 followed by cold test
19.4	A	Cold	2 h −25 ^{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; $R_{ins} \geq 1500\,M\Omega$ after 24 h $\frac{\Delta C}{C} \leq 5\%$
20.1	Ca	Damp heat (long term)	21 days +40 ^{o}C, 90 to 95% 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 $\frac{\Delta C}{C} \leq 5\%$
21.3	–	Endurance	1500 h +85 ^{o}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 ^{o}C no breakdown or flash-over; after supply of 2500 V a.c. for 2 s: $R_{ins} \geq$ 1500 MΩ, after 24 h $\frac{\Delta C}{C} \leq 10\%$

▮▮▮▮▮▮▮

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 ^{o}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

QUICK REFERENCE DATA

Capacitance range	33 to 2700 pF (E12 series)
Rated d.c. voltage	500 V
Tolerance on capacitance	
33 to 2700 pF	±20%
1000 to 2700 pF	+50 to −20%
Basic specification	IEC 187
Category, IEC 68	40/085/21

APPLICATION

These 500 volt capacitors are made of high-K dielectric materials. They are suitable for by-pass and coupling purposes in all kinds of equipment where small dimensions are of importance and the losses need not to be minimized.

DESCRIPTION

The capacitors consist of a ceramic disc, both sides being metallized and provided with long or short connecting leads. The greater part of the capacitor body is insulated with a tan lacquer, which is solvent resistant according to MIL-STD-202E, test 215 and uninflammable according to MIL-STD-202E, test 111A. The whole capacitor is protected against atmospheric influences by a coating of material which permits soldering of the leads.

MECHANICAL DATA

Dimensions in mm

Outlines

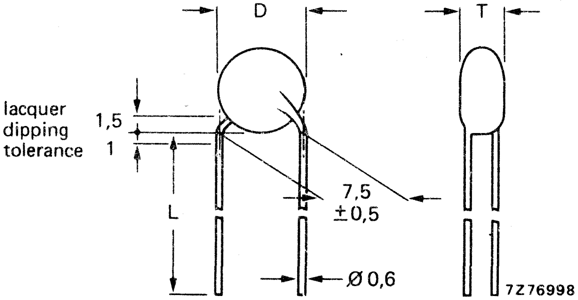


Fig. 1 For dimensions D, T and L see Tables 1 and 2.

Marking

The body of the capacitors is tan coloured. On the body is indicated in black script the capacitance value and a letter indicating the tolerance (see Tables 1 and 2).

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 2700 pF (E12 series)
Tolerance on capacitance	±20%, +50 to −20%
Rated a.c. voltage	500 V
Test voltage (a.c.) for 1 min, at 85 °C	1250 V (type test)
Insulation resistance at 500 V (d.c.) after 1 min	⩾ 10 000 MΩ
Tan δ at 1 kHz, ⩽ 1,5 V	
33 to 150 pF	⩽ 2%
180 to 2700 pF	⩾ 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 2700 pF (2C4 material)	see Fig. 2
for 1000 to 2700 pF (2E4 material)	see Fig. 3

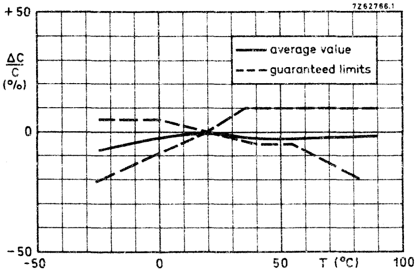


Fig. 2 Capacitance change with respect to the capacitance value at 20 °C as a function of temperature for capacitors of 33 to 2700 pF, tolerance ± 20%.

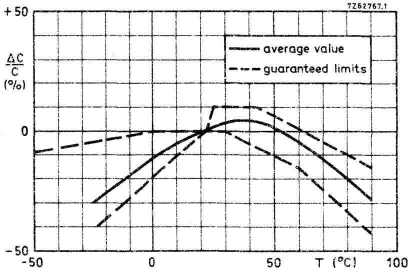


Fig. 3 Capacitance change with respect to the capacitance value at 20 °C as a function of temperature for capacitors of 1000 to 2700 pF, tolerance +50 to −20%.

Table 1 Tolerance on capacitance ± 20% (2C4 material)

cap. pF	max. D mm	max. T mm	marking		catalogue number	
			capacitance	tolerance	L = 5 to 6 mm	L ⩾ 20 mm
33	7	4,5	33p	M	2212 657 01339	2212 657 03339
39	7	4	39p	M	01399	03339
47	8	4,5	47p	M	01479	03479
56	8	4	56p	M	01569	03569
68	7	4,5	68p	M	01689	03689
82	7	4,5	82p	M	01829	03829
100	7	4	100p	M	01101	03101
120	8	4,5	120p	M	01121	03121
150	8	4	150p	M	01151	03151
180	7	5	180p	M	01181	03181
220	7	4,5	220p	M	01221	03221
270	7	4,5	270p	M	01271	03271
330	7	5	330p	M	01331	03331
390	7	5	390p	M	01391	03391
470	7	4,5	470p	M	01471	03471
560	7	4,5	560p	M	01561	03561
680	7	4	680p	M	01681	03681
820	8	4,5	820p	M	01821	03821
1000	8	4,5	1n0	M	01102	03102
1200	10	4,5	1n2	M	01122	03122
1500	10	4	1n5	M	01152	03152
1800	10	4	1n8	M	01182	03182
2200	11	4	2n2	M	01222	03222
2700	11	4	2n7	M	01272	03272

Table 2 Tolerance on capacitance + 50 to −20% (2E4 material)

cap. pF	max. D mm	max. T mm	marking		catalogue number	
			capacitance	tolerance	L = 5 to 6 mm	L ⩾ 20 mm
1000	8	4	1n0	S	2212 657 02102	2212 657 04102
1200	10	4,5	1n2	S	02122	04122
1500	10	4	1n5	S	02152	04152
1800	10	4	1n8	S	02182	04182
2200	11	4	2n2	S	02222	04222
2700	11	4	2n7	S	02272	04272

TESTS AND REQUIREMENTS

Essentially all tests mentioned in the schedule of IEC publication 187, 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 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°	no damage
15	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	3 x 1 min immersion benzene, chloroethane, freon, TMC and trichloroethane	no damage of tan coating
		Climate sequence		
19.2	B	Dry heat	16 h +85 °C	no visible damage, $R_{ins} \geqslant 6000\ M\Omega$
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: $R_{ins} \geqslant 1500\ M\Omega$; after 24 h $\frac{\Delta C}{C} \leqslant 5\%$

TESTS AND REQUIREMENTS (continued)

IEC 187 clause	IEC 68 test method	tests	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, $\leqslant$ 20% R.H. and 1-2 h recovery: $R_{ins} \geqslant 1500$ MΩ, after 24 h $\frac{\Delta C}{C} \leqslant 5\%$
21.3	–	Endurance	1000 h +85 °C, 750 V d.c.	$R_{ins} > 1500$ MΩ, after 24 h $\frac{\Delta C}{C} \leqslant 10\%$

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

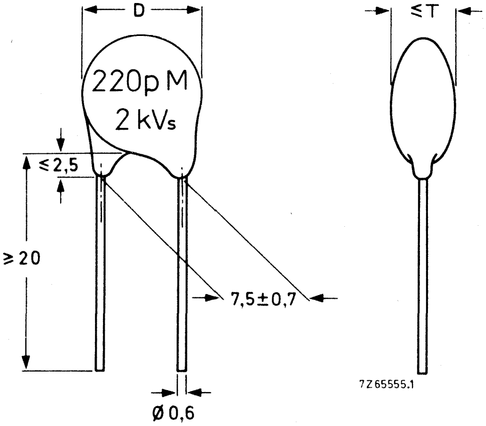


Fig. 1. For dimensions D and T see Tables 1 and 2.

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

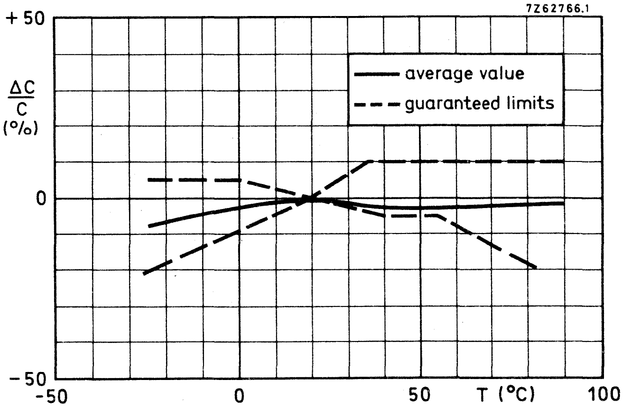


Fig. 2 Capacitance change with respect to the capacitance value at 20 °C as a function of temperature.

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 °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 °C ≤ 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 °C with pulse change 1,5 x rated voltage pulse time 13 μs pulse frequency 16 kHz	after cooling down to 20 °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 (E12-series)
Rated a.c. voltage	250 V
Tolerance on capacitance	± 20%
Basic specification	IEC 161
Approval	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 202D test 215 and MIL 202C test 111).

MECHANICAL DATA

Dimensions in mm

Outlines

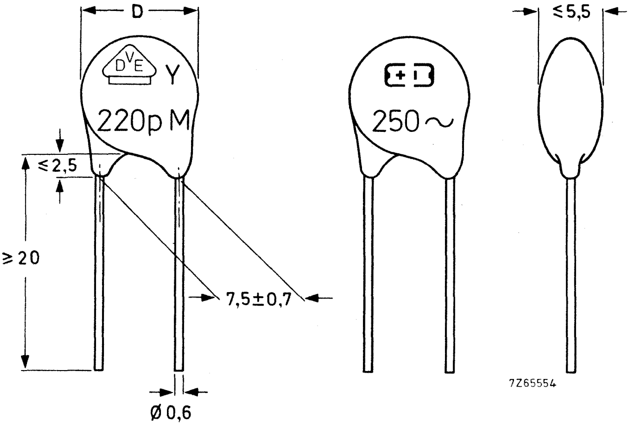


Fig. 1 For dimension D, see Table 1.

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), 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

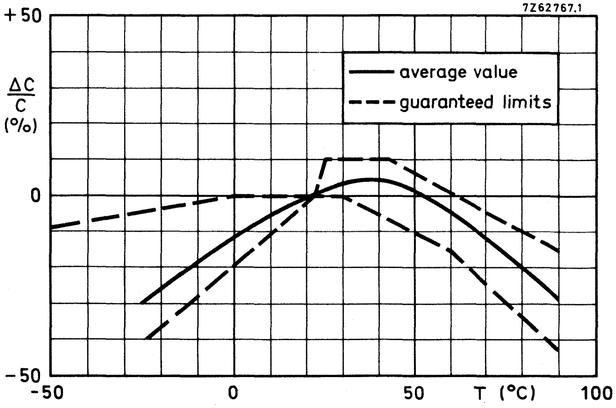


Fig. 2 Capacitance change with respect to the capacitance value at 20 °C as a function of temperature.

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, $R_{ins} \geq 6000$ MΩ
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: $R_{ins} \geq 1500$ MΩ; 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 $^{\circ}$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 $^{\circ}$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 $^{\circ}$C, 425 V a.c.	after cooling down to 20 $^{\circ}$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.

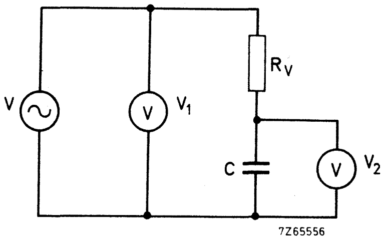


Fig. 3

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 $f_r = \frac{1}{1,2\sqrt{C_N}}$.

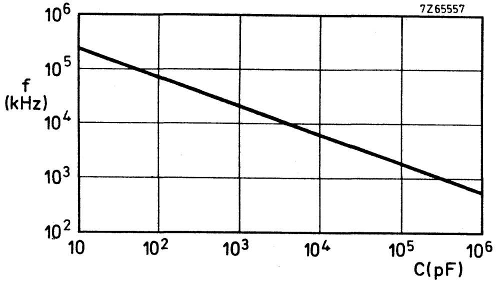


Fig. 4

PACKAGING

Multiples of 250 pieces.

CERAMIC DISC CAPACITORS

type 2, safety

QUICK REFERENCE DATA

Capacitance range	33 to 1000 pF (E12-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 202D test 215 and MIL 202C 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.	U.L. 1270/1410, file E55811 at 125 V (a.c.) ←
VDE	Germany	0560 part 2/5. 70

MECHANICAL DATA

Dimensions in mm

Outlines

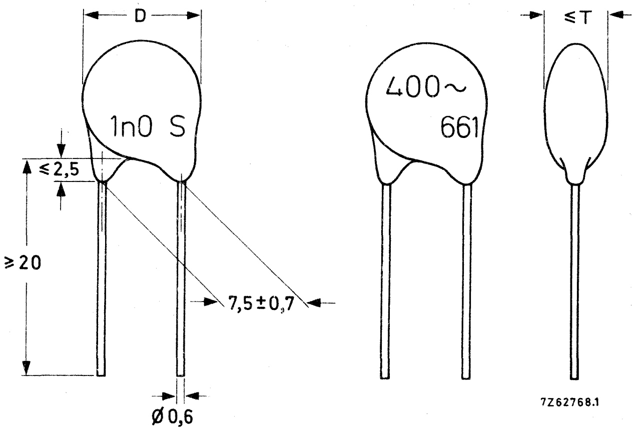
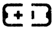


Fig. 1 For dimensions D and T, see table.

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	
VDE mark (Germany)	
SEMKO mark (Sweden)	
SEV mark (Switzerland) for 33–220 pF only	

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

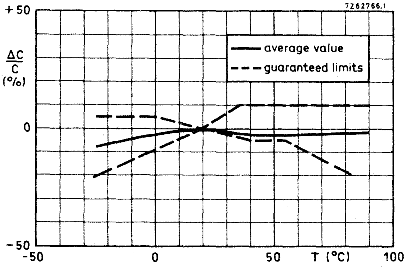


Fig. 2. Capacitance change with respect to the capacitance value at 20 °C as a function of temperature for capacitors of 33 to 220 pF.

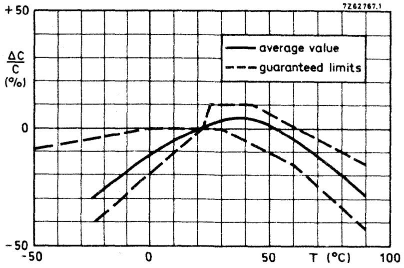


Fig. 3. Capacitance change with respect to the capacitance value at 20 °C as a function of temperature for capacitors of 270 to 1000 pF.

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 °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	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°	no damage
15	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	3 x 1 min immersion benzene, chloroethane, freon, TMC and trichloroethane	no damage
19.2	B	Climatic sequence Dry heat	16 h +85 °C	no visible damage, $R_{ins} \geq 6000\ \mathrm{M\Omega}$
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: $R_{ins} \geq 1500\ \mathrm{M\Omega}$; 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 ^{0}C, 90 to 95% R.H.	after drying 6 h at 55 ^{0}C ≤ 20% R.H. and 1 - 2 h recovery: R_{ins} ≥ 1500 MΩ, after 24 h $\frac{\Delta C}{C}$ ≤ 5%
21.3	-	Endurance	1500 h +85 ^{0}C, 800 V a.c.	after cooling down to 20 ^{0}C no breakdown or flash over after supply of 2500 V a.c. for 2 s, R_{ins} ≥ 1500 MΩ, after 24 h $\frac{\Delta C}{C}$ ≤ 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 ^{0}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 10 000 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.

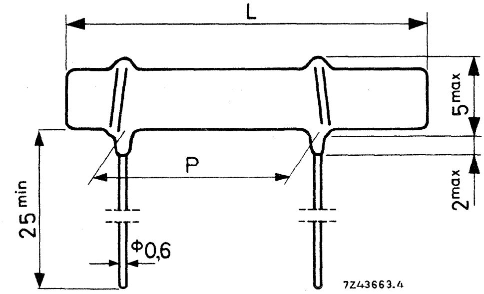
DESCRIPTION

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 against 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.

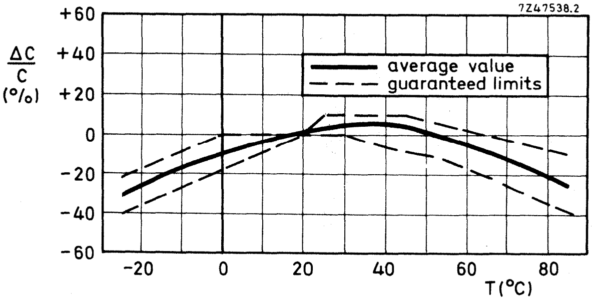
Mounting

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 10 000 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	> 10 000 MΩ
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.

capacitance * pF	L mm	P mm	catalogue number	
			insulated	non-insulated **
680	10	5	2222 552 04681	2222 552 03681
1 000	10	5	04102	03102
1 500	10	5	04152	03152
2 200	10	5	04222	03222
3 300	12	7,6	04332	03332
4 700	16	10,2	04472	03472
6 800	20	15,2	04682	03682
10 000	22	17,7	04103	03103

* Capacitance values out of the E12 series are subject to minimum order release requirements.

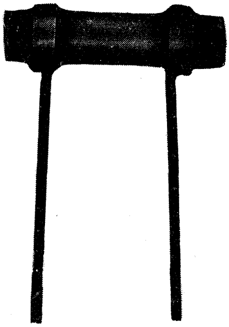
** Available on request.

TUBULAR CERAMIC CAPACITORS

type 1B

QUICK REFERENCE DATA

Capacitance range	1 to 560 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.

2222 555

TUBULER CERAMIC CAPACITORS
TYPE 1B

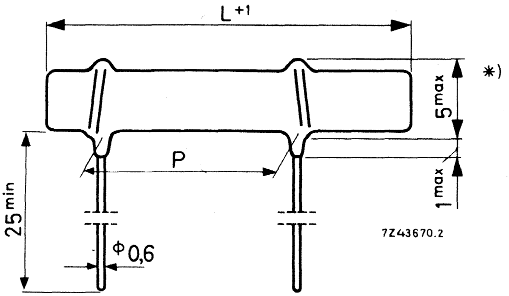
DESCRIPTION

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

---

*) 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.

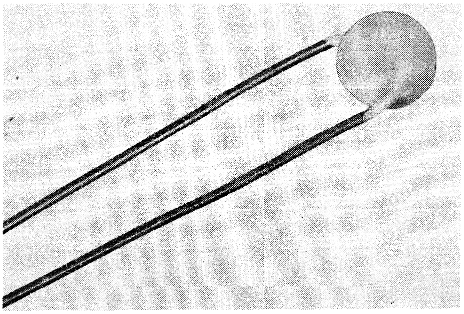
Table II

capacitance		temperature coefficient								
		NP0			N150			N750		
nom. pF	tol. ±	L mm	P mm	suffix	L mm	P mm	suffix	L mm	P mm	suffix
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

CATALOGUE NUMBER (for ordering) 2222 555 . . . . . , for suffix see Table II.

DISC TYPE CERAMIC CAPACITORS

type 1B



RZ 22070-9

Capacitance range	0,47 to 47 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.

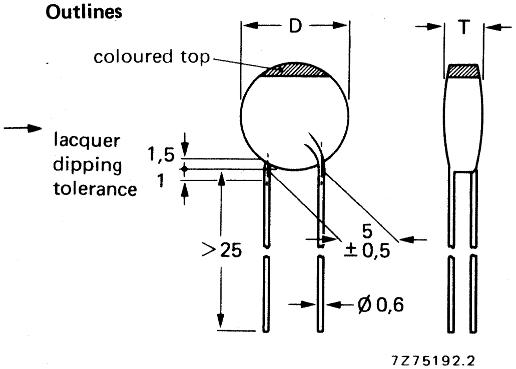
DESCRIPTION

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.

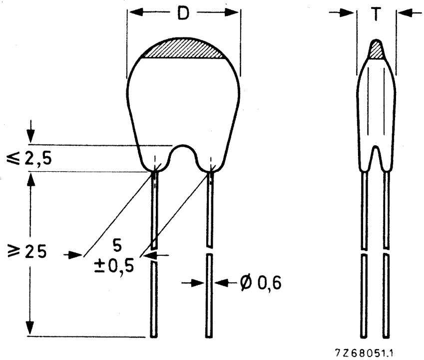
MECHANICAL DATA

Dimensions in mm

Outlines



2222 625
partly insulated



2222 626
insulated

For D and T see Table 2.

Marking

Figure code for capacitance value (see Survey Ceramic Capacitors), colour code for temperature coefficient (see Table I).

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 d.c. voltage	400 V
Test voltage (d.c.) for 1 min	1100 V
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, IEC 68	40/085/21
Capacitances and tolerances	see Table 2

Table 1 Temperature coefficients

temp. coeff. $10^{-6}/^{\circ}C$	tolerance $10^{-6}/^{\circ}C$	t.c. marking colour
P100: +100	−40 to +120	red/violet
NP0: 0	for C ⩽ 20 pF: −40 to +120 for C > 20 pF: −40 to +40	black
N150: −150	for C ⩽ 20 pF: −40 to +60 for C > 20 pF: −40 to +40	orange
N750: −750	for C ⩽ 20 pF: −120 to +250 for C > 20 pF: −120 to +120	violet

Capacitors with temperature coefficients N075, N220, N470 and N1500 can be supplied, provided acceptable quantities are ordered.

Composition of the catalogue number

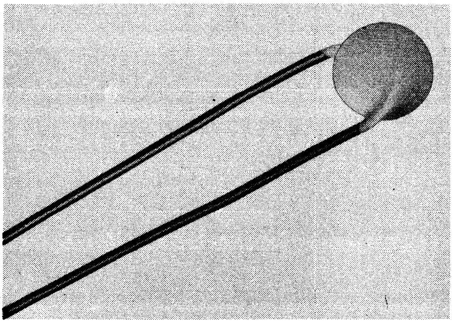
Partly insulated version: 2222 625 . . . . . } for suffix, see Table 2
Insulated version: 2222 626 . . . . . }

Capacitances and tolerances (Table 2)

capacitance		temperature coefficient												nom. cap.
		P100			NPO			N150			N750			
nom. pF	tol. ±	D_{max} mm	T_{max} mm	cat. no. suffix	D_{max} mm	T_{max} mm	cat. no. suffix	D_{max} mm	T_{max} mm	cat. no. suffix	D_{max} mm	T_{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	6	5	09108							1,0
1,2	0,25 pF	5	4	03128	6	4,5	09128							1,2
1,5	0,25 pF	5	3,5	03158	6	4	09158							1,5
1,8	0,25 pF	5	3,5	03188	5	3,5	09188	6	6	33188	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				6	3	08109	6	3	32109	5	3	56109	10
12	5 %				8	3	08129	6	3	32129	6	3,5	56129	12
15	5 %				8	3	08159	8	3	32159	6	3	56159	15
18	5 %				8	3	08189	8	3	32189	6	3	56189	18
22	5 %										6	3	56229	22
27	5 %										8	3	56279	27
33	5 %										8	3	56339	33
39	5 %										8	3	56399	39
47	5 %										8	3	56479	47

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.

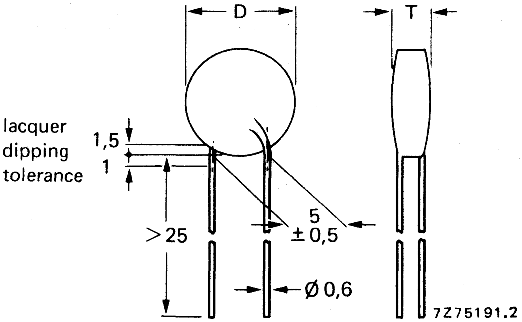
DESCRIPTION

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

Outlines



For D and T see table.

Marking

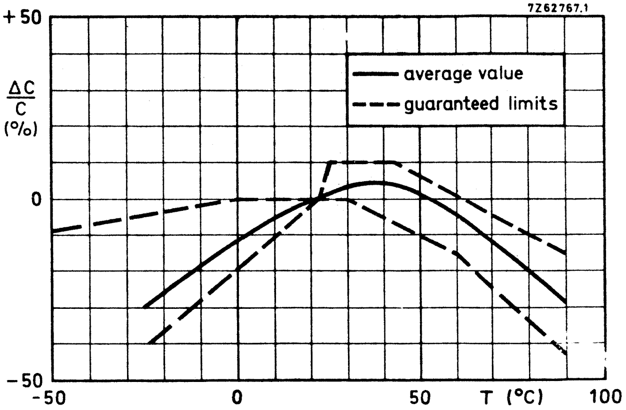
The capacitors are figure coded, see Survey Ceramic Capacitors. They are provided with a blue mark at the top for the applied ceramic material.

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 d.c. voltage	400 V
Test voltage (d.c.) for 1 min	1250 V
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, IEC 68	40/085/21

capacitance pF	tolerance %	max. D mm	max. T mm	catalogue number
100	–20/+ 50	5	4,5	2222 627 14101
150		5	3,5	14151
220		6	3,5	14221
330		6	3,5	14331
470		6	3	14471
680		6	3	14681
1 000		8	3	14102
1 500		9	3	14152
2 200		8	3	14222
3 300		9	3	14332

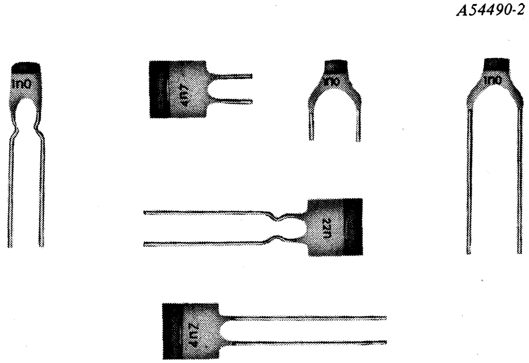


Capacitance change with respect to the capacitance value at 20 °C as a function of temperature.

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
	E 3 series	E 12 series	E 6 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 diameter	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

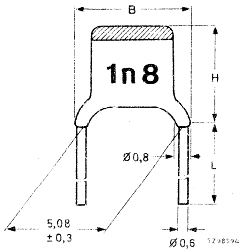


Fig. 1.

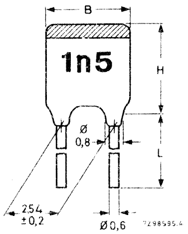


Fig. 2.

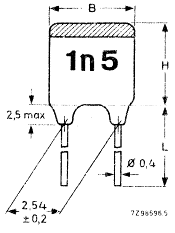


Fig. 3.

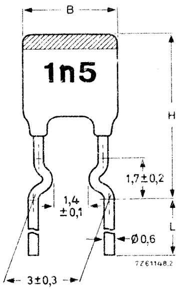


Fig. 4.

---

* 3 dots to be replaced by code for capacitance value, see Tables 3, 4 and 5.

** Flexible leads.

Table 2

size	max. B x max. H mm			approx. mass g
	Fig. 1	Figs. 2 and 3	Fig. 4	
I	6,5 x 6	3,5 x 4,5	3,5 x 8	0,14
II	6,5 x 7	4,5 x 5,5	3,5 x 9	0,15
III	6,5 x 8	5,5 x 6,5	3,5 x 10	0,17
IV	6,5 x 9	6,5 x 7,5	3,5 x 11	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 3 and 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 if 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	1000–22 000 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
1 000 *	I	1n0	102
2 200	I	2n2	222
4 700	I	4n7	472
10 000	II	10n	103
22 000	IV	22n	223

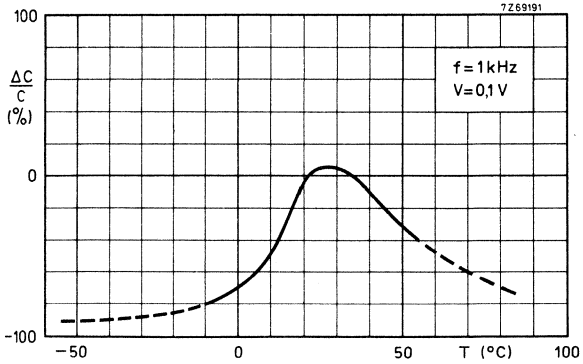


Fig. 5.

Typical 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.

---

* Maximum thickness 2,5 mm (0,1 in).

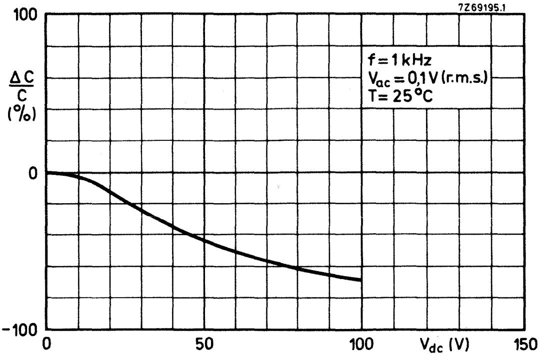


Fig. 6
Typical capacitance change with respect to the capacitance value at 0 V, as a function of d.c. voltage.

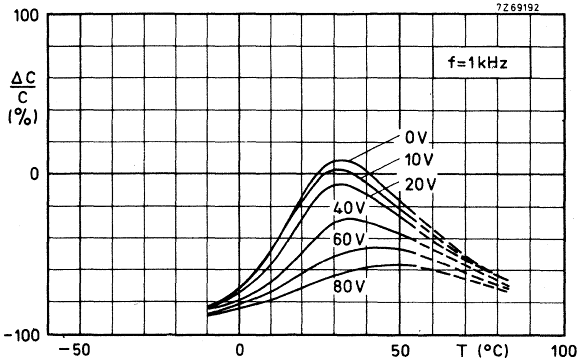


Fig. 7
Typical capacitance change with respect to the capacitance value at 0 V and 25 °C, as a function of temperature at different d.c. voltages.

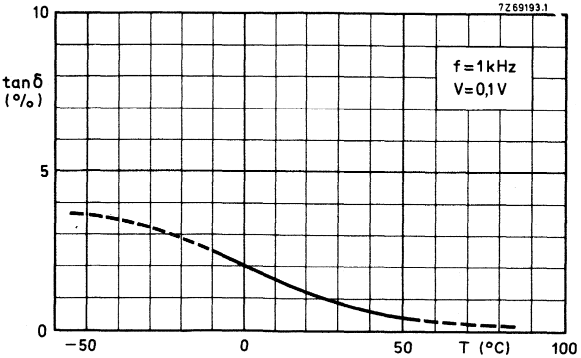


Fig. 8
Typical tan δ as a function of temperature.

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, E 12 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	cap. (pF)	size see Table 2	marking	code in catalogue number see Table 1
180 *)	I	n18	181	1000	II	1n0	102
220 *)	I	n22	221	1200	II	1n2	122
270	I	n27	271	1500	II	1n5	152
330	I	n33	331	1800	II	1n8	182
390	I	n39	391	2200	III	2n2	222
470	I	n47	471	2700	III	2n7	272
560	I	n56	561	3300	IV	3n3	332
680	I	n68	681	3900	IV	3n9	392
820	I	n82	821	4700	IV	4n7	472

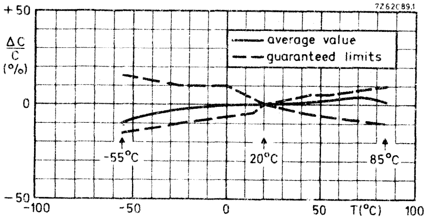


Fig. 9. ΔC with respect to C at 20 °C, as a function of temperature.

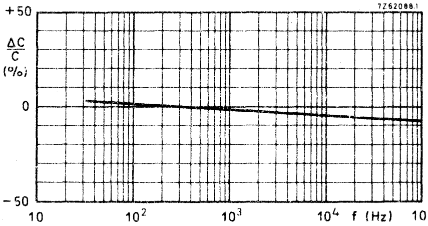


Fig. 10. Typ. ΔC with respect to C at 300 Hz, as a function of frequency.

---

*) Maximum thickness 2,5 mm (0,1 in).

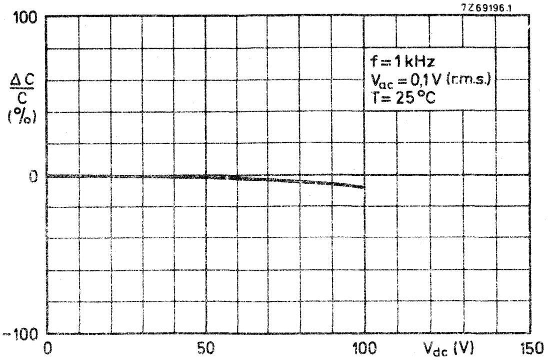


Fig. 11
Typical capacitance change with respect to the capacitance value at 0 V, as a function of d.c. voltage.

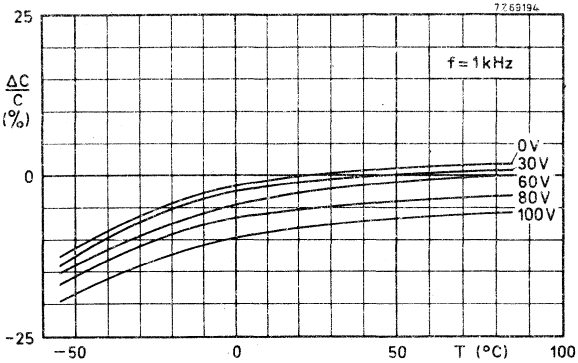


Fig. 12
Typical capacitance change with respect to the capacitance value at 0 V and 25 °C, as a function of temperature at different d.c. voltages.

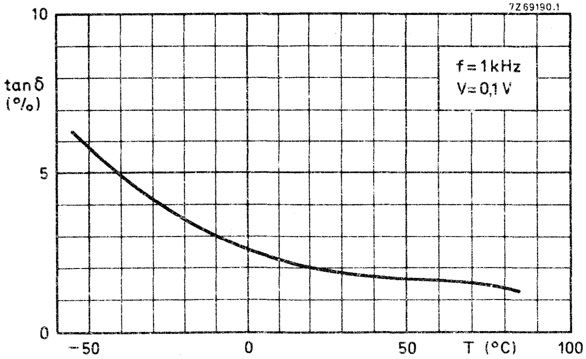


Fig. 13
Typical tan δ as a function of temperature.

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, ≤ 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	≥ 3000 MΩ
Tan δ at 1 kHz, ≤ 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

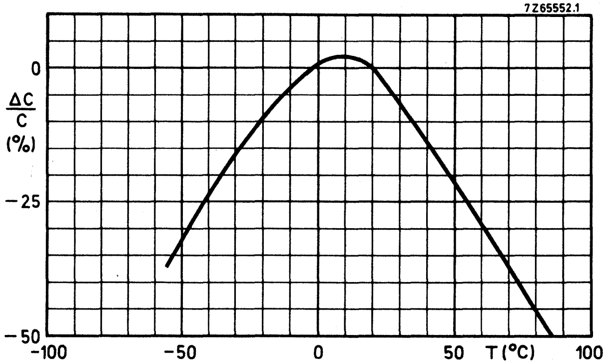


Fig. 14. Typical capacitance change versus temperature.

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

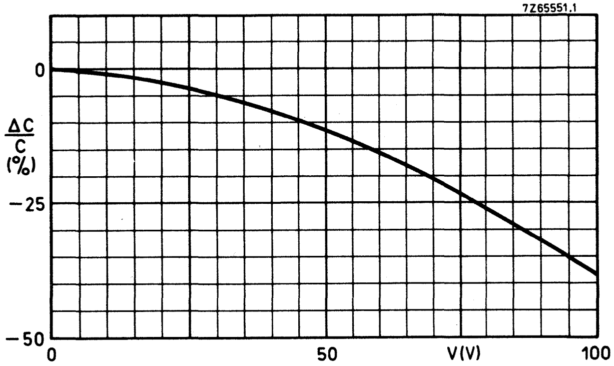


Fig. 15. Typical capacitance change with respect to the capacitance at 20 °C versus temperature.

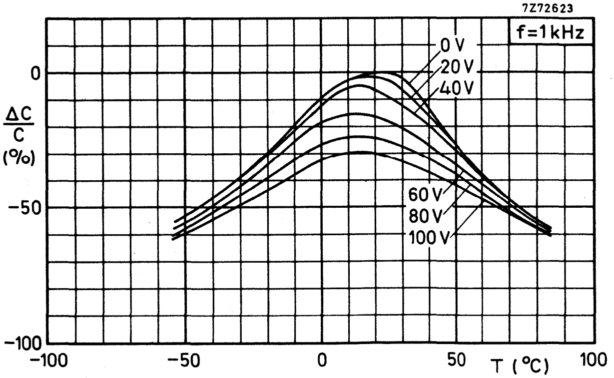
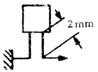


Fig. 16. Typical capacitance change with respect to the capacitance value of 0 V and 25 °C, as a function of temperature at different voltages.

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 ± < 10% 2222 629, 2222 640 ± < 20% tan δ < 7% R_{ins} > 100 MΩ

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: ΔC/C, 2222 630 ± < 10% 2222 629, 2222 640: ± < 20% tan δ < 7% R_{ins} > 100 MΩ
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: ΔC/C, 2222 630 ± < 10% 2222 629, 2222 640 ± < 20% tan δ < 5,25% R_{ins} > 300 MΩ
-	H	Storage	72 h −65 °C, recovery 1-2 h	electr. parameters within specification

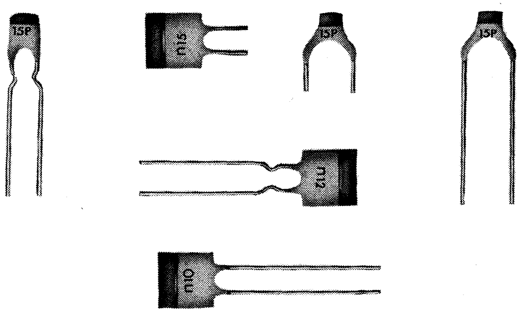
PACKAGING 1000 pieces per box.

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.

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

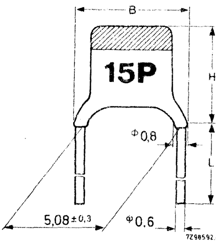


Fig. 1.

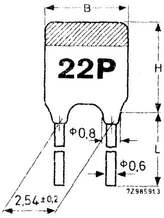


Fig. 2.

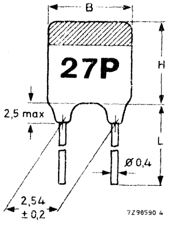


Fig. 3.

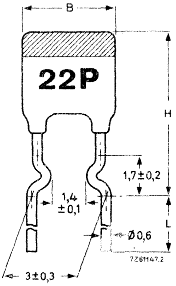


Fig. 4.

---

* 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	max. B x max. H mm			approx. mass g
	Fig. 1	Figs. 2 and 3	Fig. 4	
I	6,5 x 6	3,5 x 4,5	3,5 x 8	0,14
II	6,5 x 7	4,5 x 5,5	4,5 x 9	0,15
III	6,5 x 8	5,5 x 6,5	5,5 x 10	0,17
IV	6,5 x 9	6,5 x 7,5	6,5 x 11	0,20
V	6,5 x 12	6,5 x 10,5	6,5 x 14	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 10 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	$\leqslant 15\ (\frac{15}{C} + 0{,}7)\ 10^{-4}$; max. 55.10^{-4}
for $C > 50$ pF	$\leqslant 15.10^{-4}$
Category temperature range	−55 to + 85 °C
Climatic category, IEC 68	55/085/21

---

* 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

---

*) 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/°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	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

---

*) 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/^{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		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

---

*) 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

---

*) 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

---

*) 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	I	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

---

*) 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/^{o}C
Tolerance on the temperature coefficient for C < 20 pF	-90 to $+250$ ppm/^{o}C
for C > 20 pF	± 90 ppm/^{o}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

---

*) 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/°C
Tolerance on the temperature coefficient	
for C < 20 pF	−120 to + 250 ppm/°C
for C > 20 pF	± 120 ppm/°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
39	± 2%	I	39p	58399
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

* 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

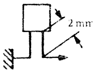
---

*) 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.

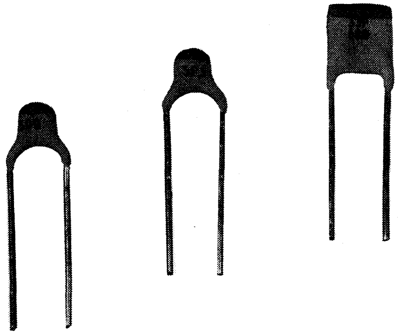
Table 12

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°	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 $\tan\delta < 2$ x 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 $\tan\delta \leq 2$ x 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 $\tan\delta \leq 1,5$ x 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.

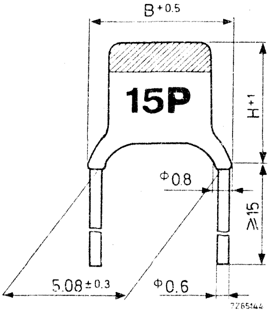
MECHANICAL DATA

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.

---

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	$\leq 15(\frac{15}{C} + 0,7).10^{-4}$, $(max. 55. 10^{-4})$
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

---

*) 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/$^{\circ}$C
Tolerance on the temperature coefficient for C < 20 pF	−40 to +120 ppm/$^{\circ}$C
for C > 20 pF	± 40 ppm/$^{\circ}$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

---

*) 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	$\pm$ 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

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

---

*) 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 $\leq$ 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

---

*) 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

---

*) 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

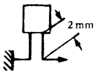
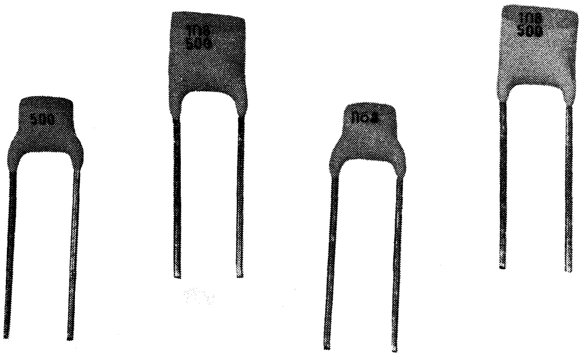
IEC 108 clause	IEC 68 test method	test	procedure	requirements
-	-	Robustness of terminations Pull-off	pull velocity 15 cm/min max. load 5 N 	no wire breakage or complete damage of capacitor
15.1	Ua	Tensile strength of leads	axial force 10 N	
15.2	Ub	Bending -	load 5 N, 4 x 90°	no wire breakage
16	T	Soldering	solderability: 5 s 250 °C, 3,5 mm from the body: non-activating flux applied	good tinning, ΔC/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, ΔC/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 ^{o}C	within tolerance as specified for each particular material
		Climatic sequence		
20.2	B	Dry heat	16 h +85 ^{o}C	no visible damage
20.3	Da	Damp heat (accel.) 1^{st} cycle	1 day +55 ^{o}C, 100 % R.H.	after recovery of 1-2 h immediately followed by cold test
20.4	A	Cold	2 h −55 ^{o}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 ^{o}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 ^{o}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 ^{o}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



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.

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.

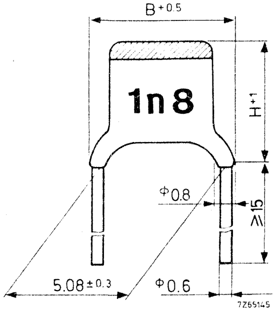
MECHANICAL DATA

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

---

*) Maximum thickness 2,5 mm.

TESTS AND REQUIREMENTS

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, see Table 3 below.

Table 3

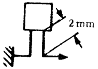
IEC 187 clause	IEC 68 test method	test	procedure	requirements
–	–	Robustness of terminations Pull-off	pull velocity 15 cm/min load 5 N 	no wire breakage or complete damage of capacitor
14.1	Ua	Tensile strength	lead dia 0,6 mm; axial force 10 N lead dia 0,4 mm; axial force 5 N	
14.2	Ub	Bending	load 5 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 ^{o}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 ^{o}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 ^{o}C, 750 V d.c.	$\Delta C/C \leq 10\%$ $\tan\delta < 525.10^{-4}$ $R_{ins} > 1000\ M\Omega$ after 24 h

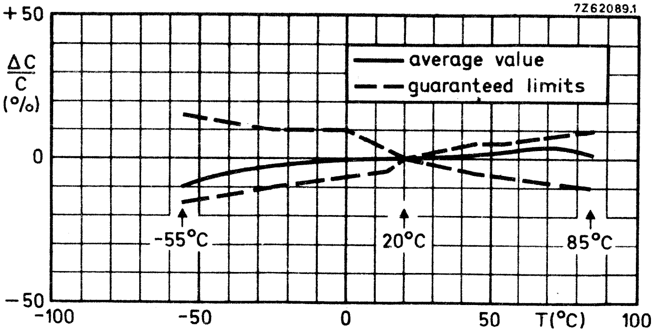


Fig. 2

Capacitance change with respect to the capacitance at 20 °C as a function of temperature.

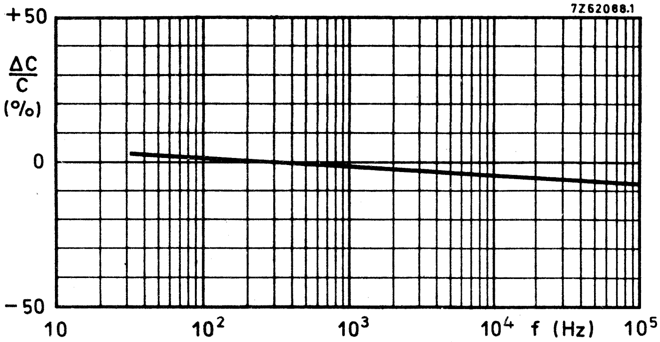


Fig. 3

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.

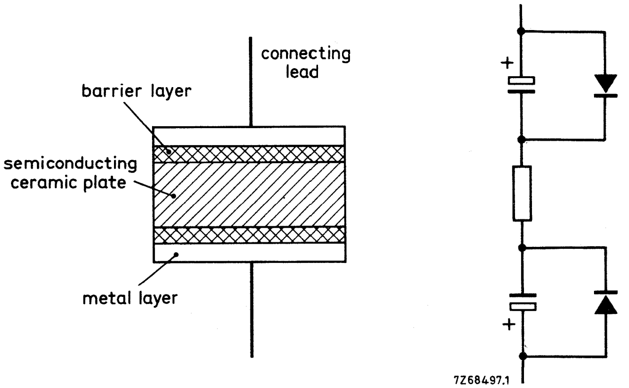


Fig. 1

MECHANICAL DATA

Dimensions (mm)

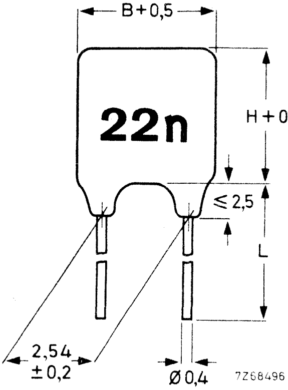


Fig. 2 Type with flexible connecting leads; d = 0,4 mm

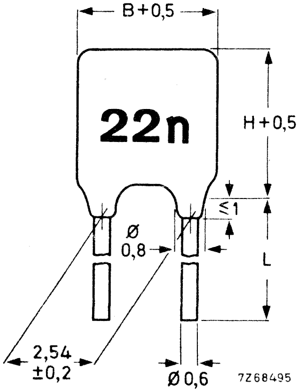


Fig. 3 Type with rigid connecting leads; d = 0,6 mm

For maximum thickness, T_{max}, see Table.

nominal capacitance (pF)	dimensions (mm) B	H	T_{max}	L	marking	catalogue number 2222 675 ..... 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 6 V (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

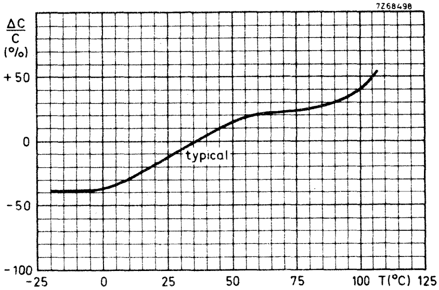


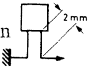
Fig. 4. Typical capacitance change as a function of temperature.

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

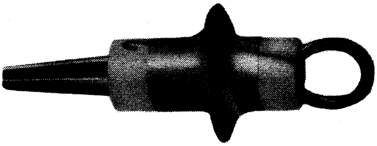
15.1		Soldering (solder bath)	solderability: 5 s, 250 °C, 3, 5 mm from the body; non-activated flux applied	good tinning $\Delta C/C \leq -10/+20\,\%$ after 24 h
		(mounting test)	capacitors mounted on p.w. board immersed in solder bath 250 °C load of 1 N pulled in direction of leads	no damage within 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

IIIIIII

IEC 324 clause	IEC 68 test method	test	procedure	requirements
19.3	Da	Damp heat (accel.) 1st cycle	1 day +55 ^{o}C 95 to 100 % R.H.	no visible damage
19.4	Aa	Cold	after 1 - 2 h recovery 2 h at −25 ^{o}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 ^{o}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 ^{o}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 ^{o}C reference measurement after 24 h	
21.3		Endurance	IEC 1000 h at + 85 ^{o}C at 6 V (d.c.) EIA 250 h at +85 ^{o}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 ^{o}C	after recovery within 1 - 4 h at +20 ^{o}C electrical parameters within stated 0 h limits (dry capacitors)

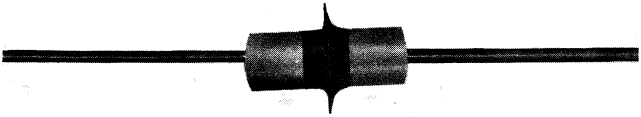
CERAMIC FEED-THROUGH CAPACITORS
TYPE 2

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

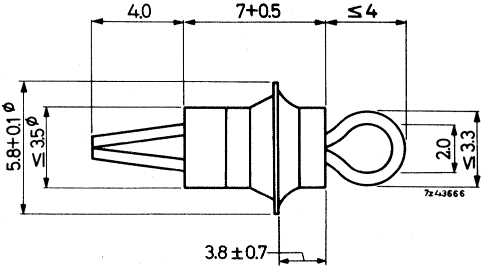
Ceramic feed-through capacitors are designed for decoupling the supply leads of high-frequency equipment, for instance in TV tuners. However, due to their extremely low inductances, they might also be used in frequency-determining circuits in similar equipment.

CONSTRUCTION

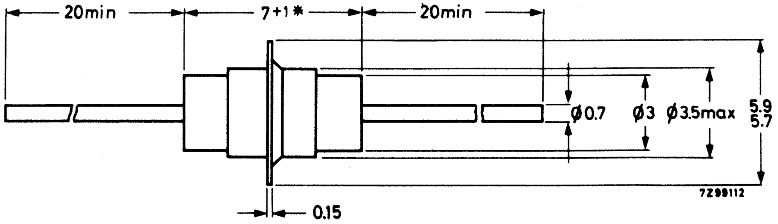
The capacitors consist of a ceramic tube provided with silver electrodes. The outer connection is formed by a flange, and the inner one by a split pen (700-series) or an axial lead (702-series). Both types are provided with sufficient soldering tin to facilitate mounting.
The split pen capacitors are 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

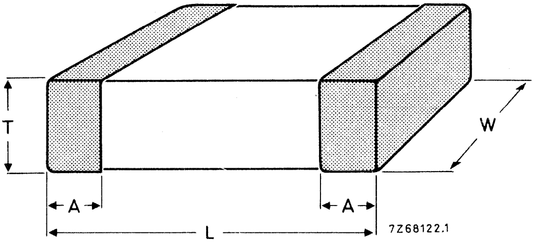


Fig. 1.

Table 1

size	L	W	T		A	
			min.	max.	min.	max.
0805	2,0 ± 0,2	1,25 ± 0,2	0,51	1,27	0,25	0,75
1210	3,2 ± 0,3	2,5 ± 0,2	0,51	1,90	0,3	1,0
1808	4,5 ± 0,3	2,0 ± 0,2	0,51	1,90	0,3	1,0
1812	4,5 ± 0,3	3,2 ± 0,3	0,51	1,90	0,3	1,0
2220	5,7 ± 0,4	5,0 ± 0,4	0,51	1,90	0,3	1,0

Soldering

Limiting conditions	min.	220 °C, 3 s
	max.	250 °C, 60 s

PACKAGING

Multiples of 100 pieces.

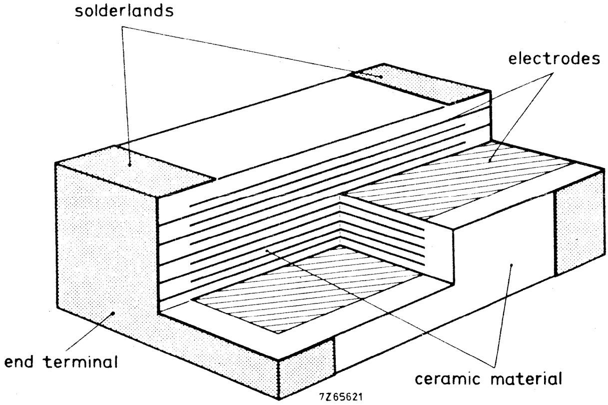


Fig. 2

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 E 12 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

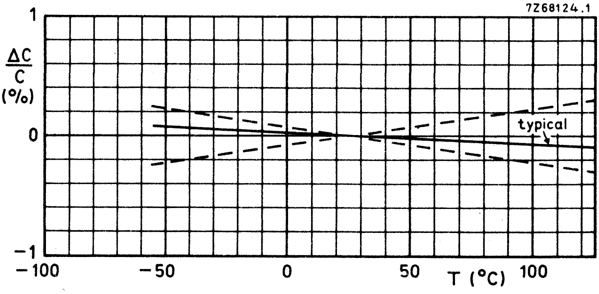


Fig. 3. Typical capacitance change as a function of temperature.
Dotted lines indicate the limits.

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	$< 300 . 10^{-4}$
Insulation resistance, $C \leq 10\,000$ 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

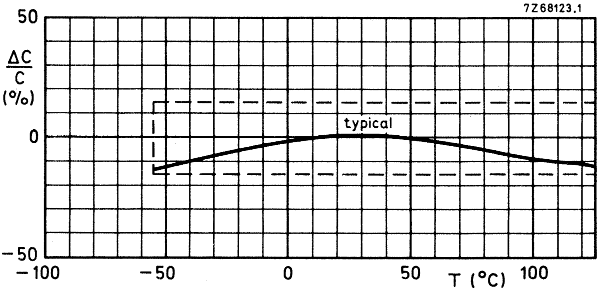


Fig. 4. Typical capacitance change as a function of temperature. Dotted lines indicate the limits.

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

sampling group	number of samples	IEC 384-1 par.	IEC 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 ≤ 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		test	procedure	requirements
		384-1 par.	draft 40(C.O.) 343 par.			
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 $\Delta C/C$, 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

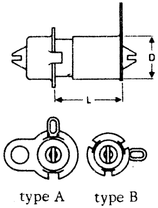
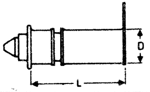
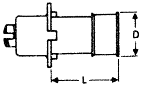
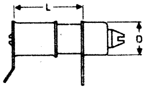
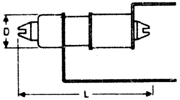
sampling group	number of samples	EIA RS 198/B test	EIA RS 198/B par.	test	procedure	requirements
1	50		4.4	Construction and appearance	any applicable method	chips shall be in accordance with specification
		1.6.1	1.5.2	Capacitance	C0G, C ≤ 1000 pF at 1 MHz C > 1000 pF at 1 kHz X7R at 1 kHz; measuring 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%

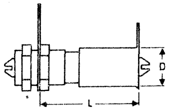
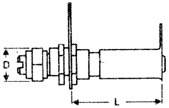
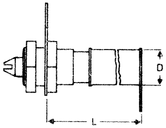
TESTS AND REQUIREMENTS–EIA (continued)

sam-pling group	number of samples	EIA RS 198/B test	EIA RS 198/B 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 2.5.7	1.5.8 2.4.8	Endurance Preconditioning	1 h at max. temperature	
				Capacitance	see group 1	in accordance with specification
				Test	250 h at max. temperature with 2 x U_R applied	see group 3

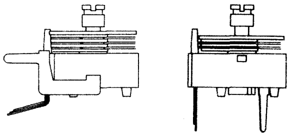
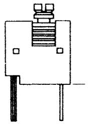
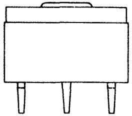
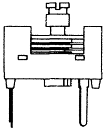
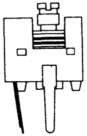
Variable capacitors

SURVEY

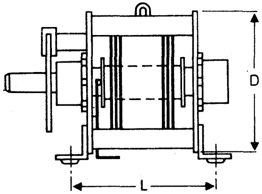
model		capacitance max. C_{min}/ min. C_{max} (pF)	rated voltage (d.c.) (V)	temperature coefficient (ppm/°C)	temperature range (°C)	dimensions L x D (mm)	catalogue number 2222 followed by
TUBULAR CERAMIC TRIMMERS							
	type A	0, 8/3	500	−200 ± 200	−50 to +100	5, 5 x 6	801 20001
		0, 8/6				8, 5 x 6	20002
		0, 9/9				11, 5 x 6	20003
		1/12				14, 5 x 6	20004
	type B	0, 8/3				5, 5 x 6	20005
		0, 8/6				8, 5 x 6	20006
		0, 9/9				11, 5 x 6	20007
		1/12				14, 5 x 6	20008
		0, 8/3	400	−200 ± 200	−50 to +100	8 x 4	801 20051
		0, 8/6		−300 ± 200		11 x 4	20052
		0, 7/6	500	+150 ± 100	−50 to +100	8, 5 x 6	801 96002
		0, 5/3		+150 ± 150			96003
		0, 3/1, 5	400	+50 ± 100	−50 to +100	13 x 4	801 96124
		0, 5/3, 5		−200 ± 200		13 x 4	96127
		1, 0/6, 0		−300 ± 300		13 x 4	96135
		0, 5/3, 0	400	+150 ± 200	−50 to +100	5 x 4	801 96138
		1, 0/5, 5		+100 ± 300		5 x 4	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, 5/2, 8 0, 6/4, 2 0, 7/5, 7 0, 9/8, 6 1, 0/11, 5	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 or −40 to +85	7, 5 ⌀ 10 ⌀ 13, 5 ⌀	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	16-250	100-640	100-500	1	L = 45	L = 67	2222 805 .....
	split 1 -4 gangs	10-64	25-125	25-125	2	L = 76,5	L = 117,5	
					3	L = 108	L = 168	
	differential 1 gang	64-160	–	–	4	L = 139,5	L = 218,5	

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.

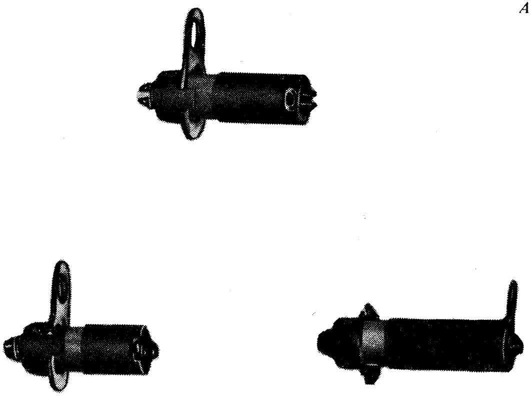
---

1) Top and bottom adjustment
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

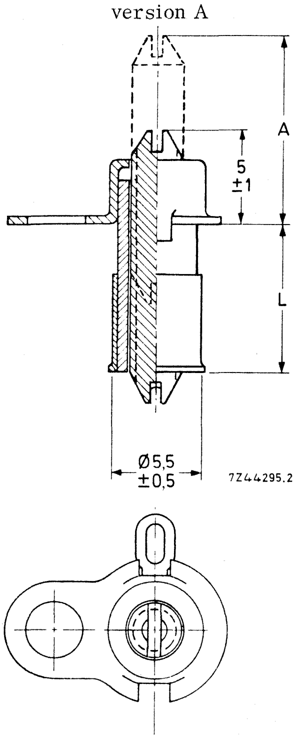
The trimmers have been designed for v.h.f. applications in radio and television receivers. For many applications the negative temperature coefficient results in a favourable compensation at varying temperatures. The two modes of mounting increase the universal applicability.

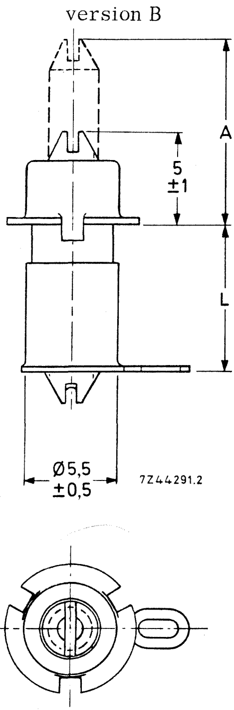
DESCRIPTION

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)



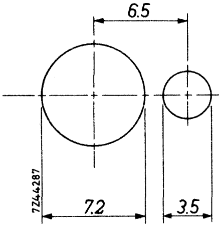


capacitance swing (pF)	dimensions (mm)		catalogue number	
	L	A	version A	version B
3	5, 5 ± 1	13, 5 ± 1	2222 801 20001	2222 801 20005
6	8, 5 ± 1	16, 5 ± 1	20002	20006
9	11, 5 ± 1	19, 5 ± 1	20003	20007
12	14, 5 ± 1	22, 5 ± 1	20004	20008

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°	5x360°	7x360°	9x360°
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			

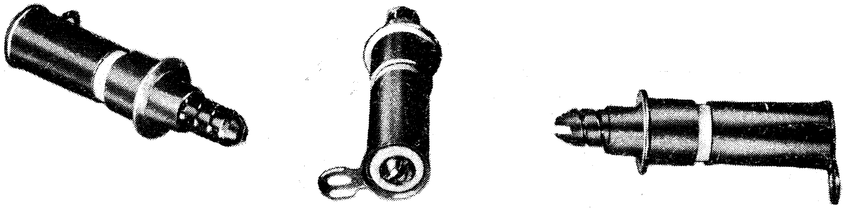
---

[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

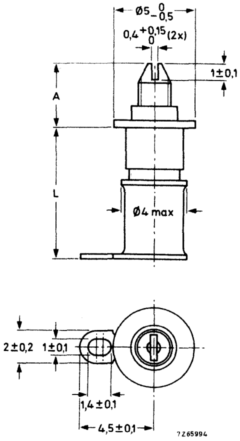
These trimmers have been developed for v.h.f. application in radio and television sets, especially in miniaturised equipment.

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

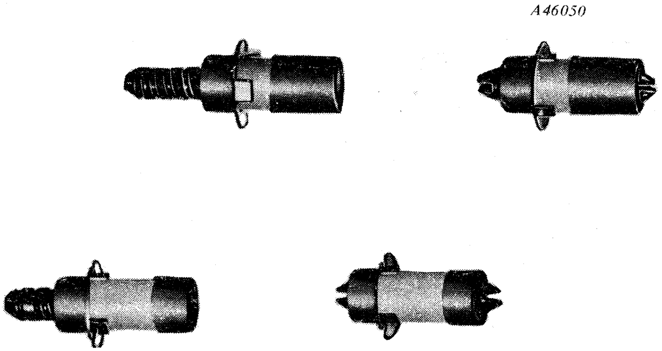
See also Note under Survey of variable capacitors (General section).

2222 801 96002
2222 801 96003

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



APPLICATION

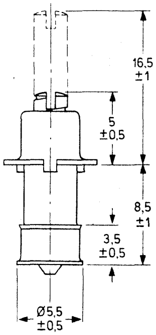
These trimmers have been designed for v.h.f. applications and are particularly suitable for u.h.f. tuners and other electronic circuits operating in the higher frequency ranges.

DESCRIPTION

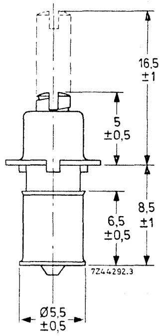
Since a brass rotor is used, the series resistance of the trimmers is low and the Q value quite acceptable, even at very high frequencies ; see the graph in which Q has been plotted as a function of working frequency.
Because, rather than wire leads, connecting strips being an integral part of the circuit 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

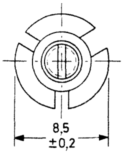
Dimensions (mm)



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

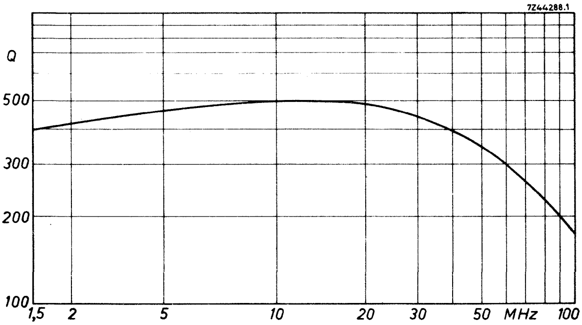
The mounting hole should have a diameter of 6, 5 mm.

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

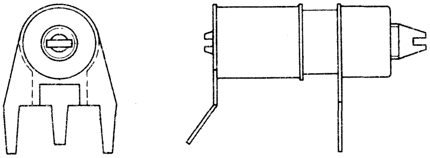
Sampling and data evaluation for quality level in accordance with MIL-STD-105D and IEC410

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)

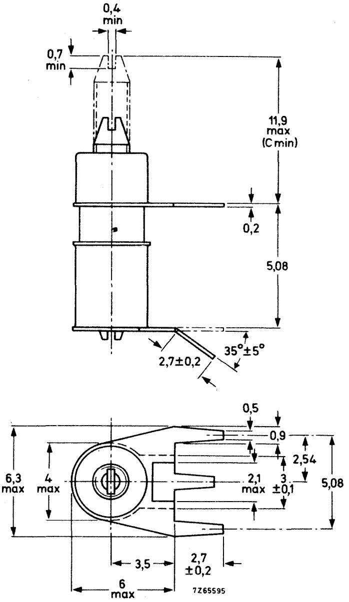


Fig. 1

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 ^{o}C, 10 s
Bending of the tags	may be bent by 90 ^{o}

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.

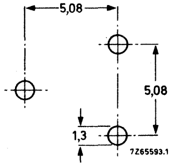


Fig. 2

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/°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	(°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

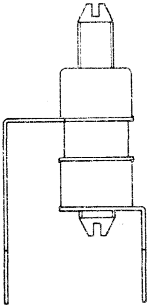
See also Note under Survey of variable capacitors (General section).

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)

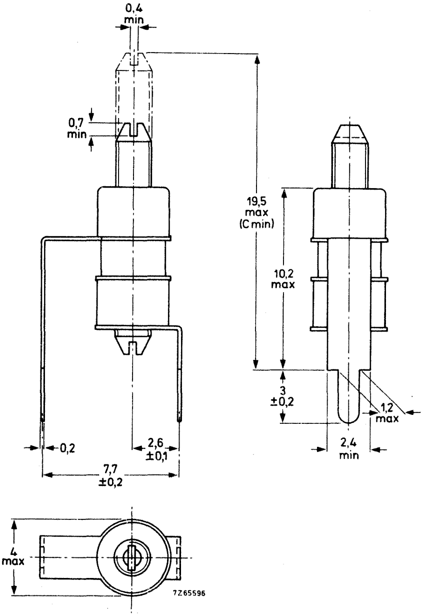


Fig. 1

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 °C, 10 s
Bending of the tags	may be bent by 90 °

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.

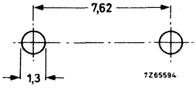


Fig. 2

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).

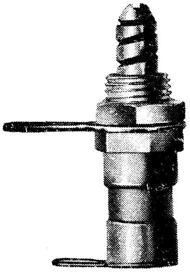
PACKAGING

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

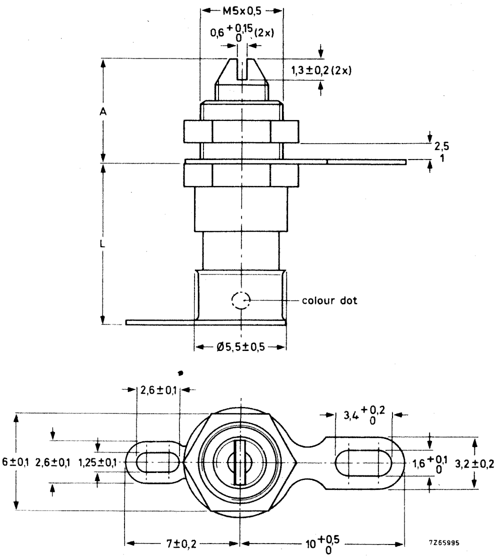
These capacitors have been disigned for the precision trimming of industrial equipment which operate at the higher frequencies.
Their simple form of construction guarantees high reliability and facilitates, moreover, a high breakdown voltage, good stability and high adjustment accuracy.
For many applications 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.

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

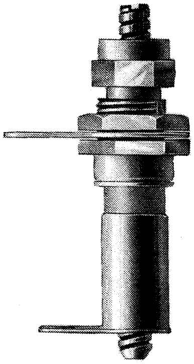
See also Note under Survey of variable capacitors (General section).

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	2, 8; 4, 2; 5, 7; 8, 6; 11, 5 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.

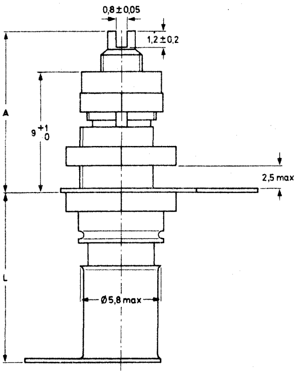
DESCRIPTION

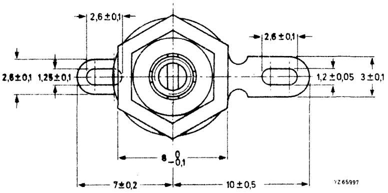
The trimmers consist of a low-k ceramic tube (for the values 2, 8; 4, 2; 5, 7 pF and a higher-k ceramic tube for 8, 6 and 11, 5 pF), internally ground, in which an invar rotor is guided by a threaded cap. This invar rotor has a copper coating which is nickel-plated*), one end is provided with a slot for screw-driver operation. By means of a locking nut the rotor can be locked after adjustment.

---

*) Silver-plated rotor can be delivered on request.

Dimensions (mm)



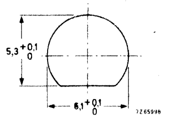


capacitance swing (pF)	zero capacitance (pF)	temperature coefficient (ppm/°C)	angle of rotation a° (approx.)	dimensions (mm)		catalogue number
				L	A at C_{min}	
≥ 2,8	≤ 0,5	− 10 ± 60	8 x 360	12,7 ±0,5	22,5 ± 1	2222 802 20011
≥ 4,2	≤ 0,6	− 10 ± 60	10 x 360	15,7 ±0,5	25,5 ± 1	20012
≥ 5,7	≤ 0,7	− 10 ± 60	11 x 360	18,2 ±0,5	28 ± 1	20013
≤ 8,6	≤ 0,9	− 250 ± 250	10 x 360	15,7 ±0,5	25,5 ± 1	20014
≤ 11,5	≤ 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 axial 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).

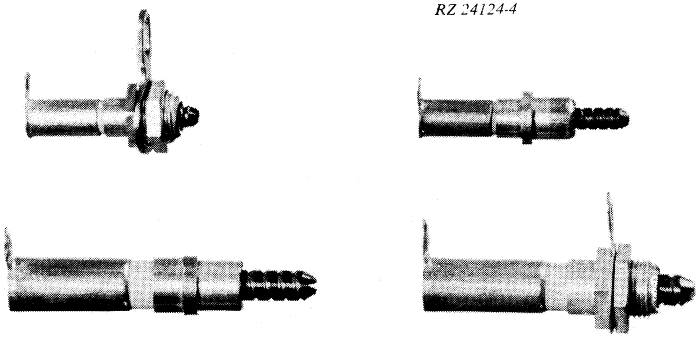
PACKAGING

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)

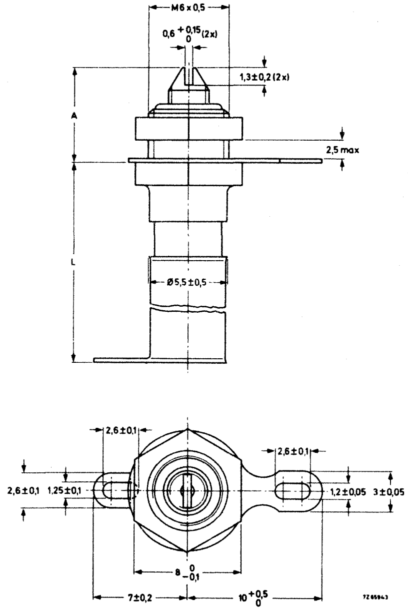


Fig.1 Screw mounting type.

Mounting hole diameter is
6, 2 + 0, 2 mm.

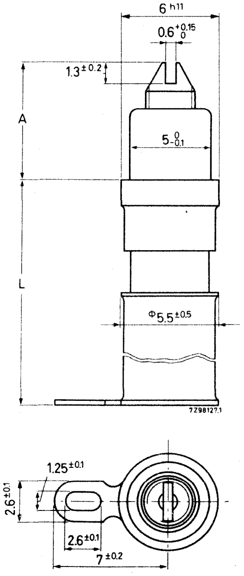


Fig.2 Solder mounting type.

Mounting hole diameter is
5, 1 + 0, 2 mm.

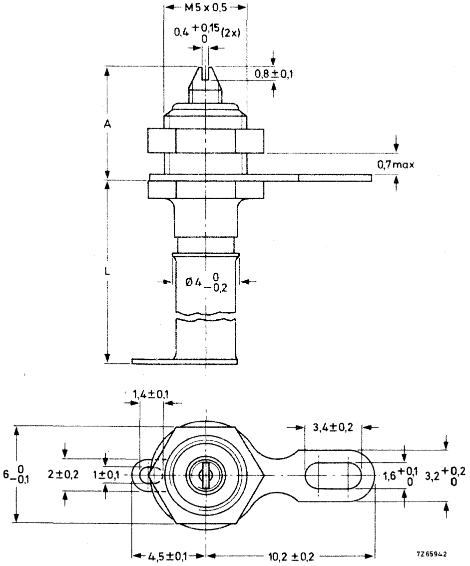


Fig. 3 Screw mounting type.

Mounting hole diameter is
5, 2 + 0, 2 mm.

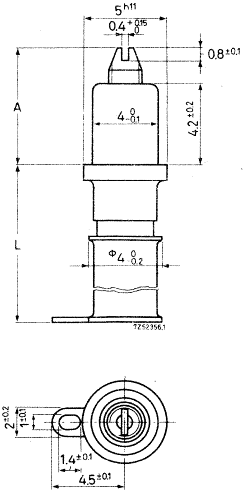


Fig. 4 Solder mounting type.

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

<u>Soldering</u>

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/°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	°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).

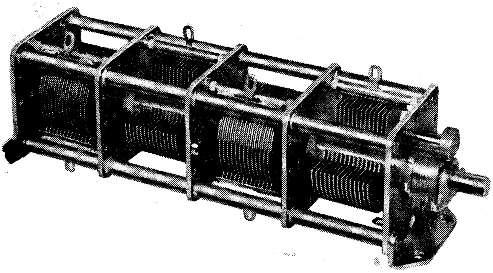
PACKAGING

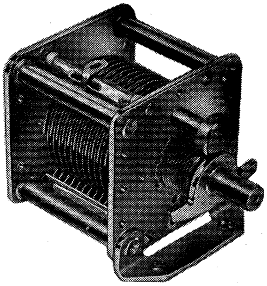
Blister packs of 50 pieces each. Smallest order quantity is one pack.

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


6486/19

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.

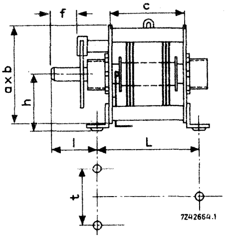
Single capacitors of the (40x40 mm) version for direct drive operation have the spindle end slotted for screwdriver adjustment.

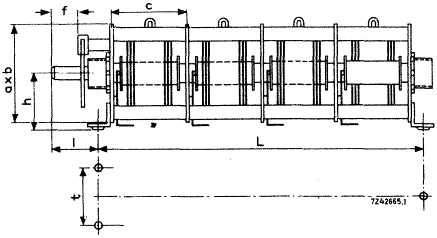
The capacitors are built entirely of basic parts with symmetrically placed stator and rotor packs. Non-listed combinations having non-standard capacitances, extra compartments, longer spindle ends (protruding up to 50 mm from both faces) and different connections, can be obtained on customers specification.

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 60 x 60	45 67	76,5 117,5	108 168	139,5 218,5
	t	40 x 40 60 x 60	22 35			
compartment length (±0.2)	c	40 x 40 60 x 60	31,5 50,5			
spindle length (±0.5)	l	40 x 40 60 x 60	16 18			
spindle height (±0.5)	h	40 x 40 60 x 60	22,5 32,5			
free spindle length	f	40 x 40 60 x 60	10 14,5			
weight (g)		40 x 40 60 x 60	120 400	200 700	300 1000	400 1300

Direction of rotation for increase in capacitance	clockwise
Effective angle of rotation, linear capacitor	360°
logarithmic capacitor	180°
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^o	see C_0 in table I
Test voltage	see V_{test} in table I
Rated voltage	$\frac{1}{2}$ 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^o) in ppm/^{o}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
Category 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)	$C_0 \pm 1$ pF[1] (pF)	V_{test}[2] (V d.c.)	$C_0 \pm 1$pF (pF)	V_{test}[3] (Vd.c.)	$C_0 \pm 1$pF (pF)	V_{test}[3] (Vd.c.)	$C_0 \pm 1$pF (pF)	V_{test}[3] (Vd.c.)	$C_0 \pm 1$pF (pF)	V_{test}[3] (Vd.c.)	$C_0 \pm 1$pF) (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		
250					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	2x10			194		
	2x16	138		195		
	2x25	139		196		
	2x40	141		197		
	2x64	142		198		
	2x100	143				
	2x160	144				
	2x250	145				
3 gangs	3x10					
	3x16	146		201		
	3x25	147		202		
	3x40	148		203		
	3x64	149		204		
	3x100	151		205		
	3x160	152				
	3x250	153				
4 gangs	4x10			207		
	4x16	154		208		
	4x25	155		209		
	4x40	156		211		
	4x64	157		212		
	4x100	158				
	4x160	159				
	4x250	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	40	65	80	100	120	pF
Max. C_{min}	1,4	2	2	2	3	2	3	5,5	5,5	5,5	6	11	pF
Diameter	7,5 mm, 10 mm, 13,5 mm												
Rated voltage (d.c.)	250 V and 150 V												
Basic specification	IEC 418-4												
Climatic category (IEC 68)	40/070/21 or 40/085/21												

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 polyethylene, 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 trichloroethane and trichloroethylene.

The 808 series comprises many versions which are grouped by diameter as in Table 1. For complete catalogue numbers refer to Tables 3, 5 and 7.

Table 1 Versions

diameter	position of spindle	angle between 2 rotor tags	adjustment			Fig.	catalogue number
			top	bottom			
7,5 mm	vertical	180°	screwdriver	key	see also Fig. 1	2	2222 808 11 . . .
	horizontal		screwdriver	key		3	57 . . .
10 mm	vertical	90° **	screwdriver	key		6	32 . . .
	vertical	180°	screwdriver	key		7	31 . . .
	vertical	180°	spanner	key		7	34 . . .
	horizontal		screwdriver	key		8	61 . . .
	horizontal		spanner	key		8	64 . . .
13,5 mm	vertical	180°	screwdriver	screwdriver		11	41 . . .
	vertical	180°	spanner	screwdriver		11	44 . . .
	horizontal		screwdriver	screwdriver		12	71 . . .
	horizontal		spanner	screwdriver		12	74 . . .

---

* 7,5 mm and 10 mm versions also available with P.T.F.E. dielectric in min. C_{max} values of 9 and 18 pF, and 50 pF respectively.

** Non-preferred.

Spanner adjustment

The hexagonal spindle head 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. It also allows a large axial tolerance.
The connection tags are arranged to fit a grid of 2,50 mm or 2,54 mm (0,1 inch).

Key for adjustment

The dimensions essential for the design of a key are given in Fig. 1.

A key (catalogue number 7122 347 21600) and the associated handle (catalogue number 7122 005 47910) can be supplied on request.

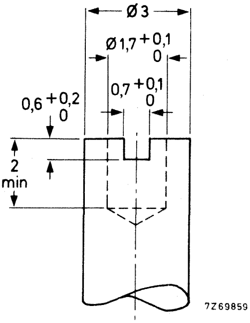


Fig. 1.

COMPOSITION OF CATALOGUE NUMBER

2222 808 . . . . .

code for angle between 2 rotor tags, and adjustment (see Table 1)

code for diameter and position of spindle (see Table 1)

code for capacitance:

multiplying factor
8 is 0,1 x
9 is 1 x
1 is 10 x

first two figures of C_{max} value.
(see Tables 3, 5 and 7)

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.

7,5 mm VERSION

MECHANICAL DATA

Dimensions in mm

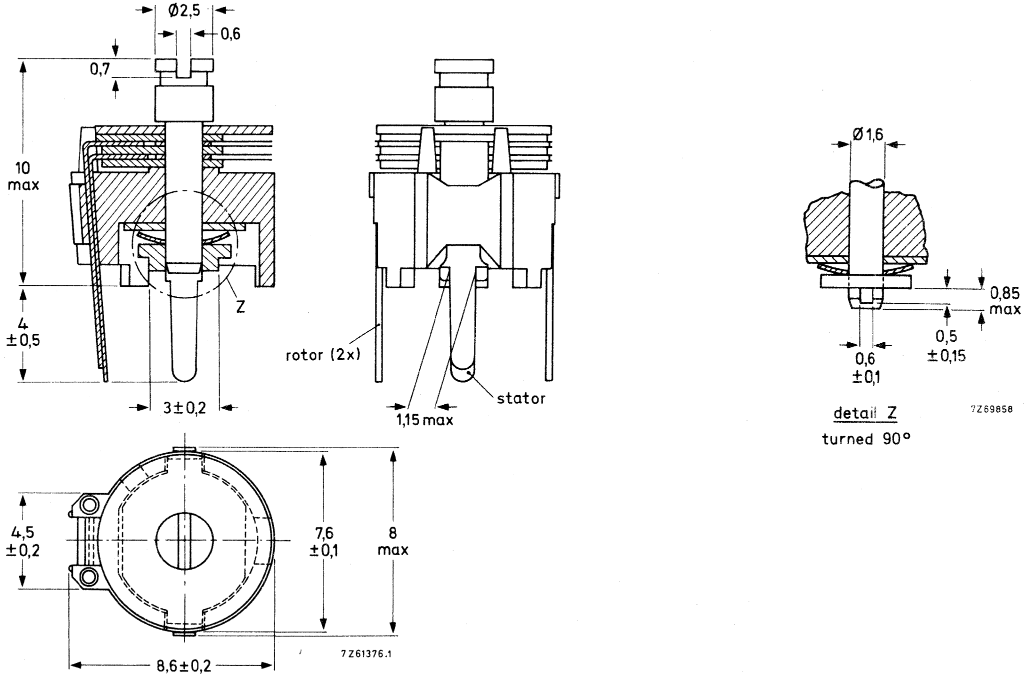


Fig. 2 Outlines of the capacitors 2222 808 11 . . . (see Tables 1 and 3).

7,5 mm version continued

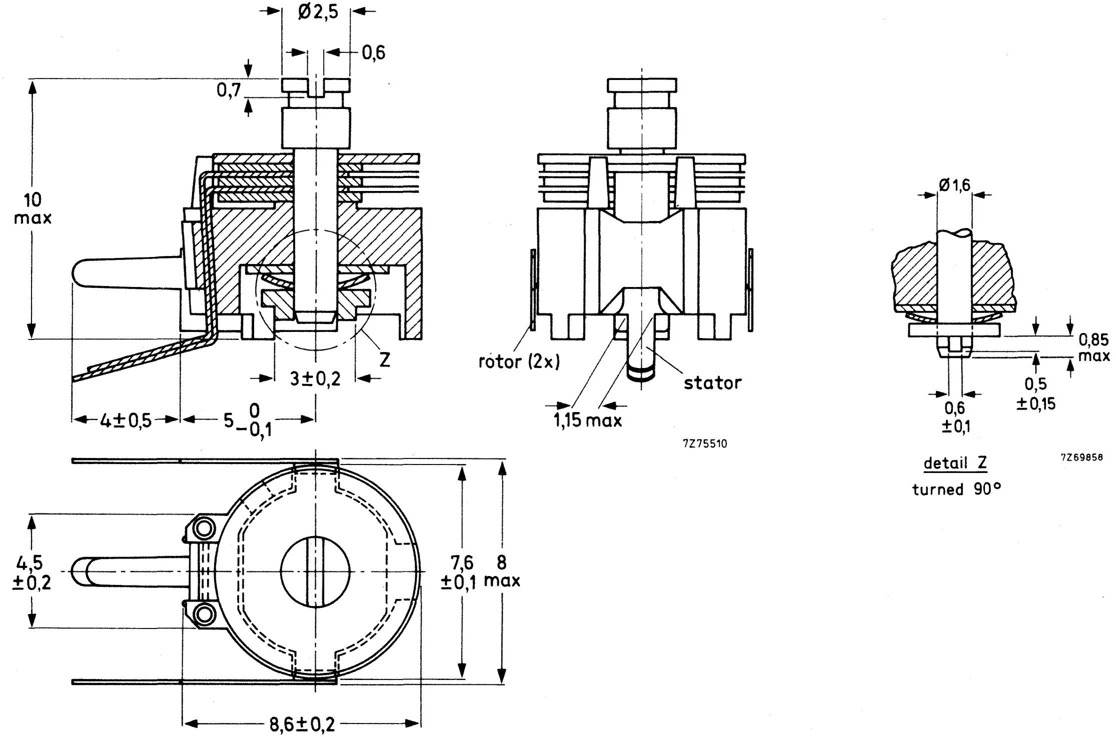


Fig. 3 Outlines of the capacitors 2222 808 51 . . . (see Tables 1 and 3).

Table 2

Effective angle of rotation	180°
Operating torque	1 - 15 mNm
Maximum axial thrust	2 N
Mass (approximately)	0,8 g

Marking

The different capacitance values 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 (R = rotor; S = stator).

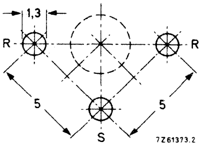


Fig. 4 For types of Fig. 2.

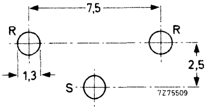


Fig. 5 For types of Fig. 3.

Note

The large hole is necessary for bottom adjustment of the vertical types. Diameter determined by the user's requirements.

7,5 mm version continued

ELECTRICAL DATA

Table 3

reference C_{min}/C_{max} (note 1) pF	guaranteed max. C_{min} min. C_{max} (note 2) pF	tan δ at C_{max} x 10^{-4}		temperature coefficient (note 3) ppm/°C	min. f_{res} at C_{max} MHz	colour of base	Fig.	catalogue number
		1 MHz	100 MHz					
1,2/6	1,4/5,5	⩽ 10	⩽ 25	−400 ± 300	850	grey	2	2222 808 11558
1,4/10	2/10	⩽ 10	⩽ 25	−200 ± 300	480	yellow	2	2222 808 11109
1,6/15	2/15	⩽ 10	⩽ 25	−200 ± 350	450	blue	2	2222 808 11159
1,8/22	2/22	⩽ 10	⩽ 25	−250 ± 350	350	green	2	2222 808 11229
2/30	2/27	⩽ 50		−250 ± 300	350	red	2	2222 808 11279
2/40	3/40	⩽ 50		−250 ± 300	300	violet	2	2222 808 11409
1,4/10	2/10	⩽ 10	⩽ 25	−200 ± 300	480	yellow	3	2222 808 51109
1,8/22	2/22	⩽ 10	⩽ 25	−250 ± 350	350	green	3	2222 808 51229
1,8/27	2/27	⩽ 50		−250 ± 300	350	red	3	2222 808 51279

Rated voltage (d.c.)	250 V
Test voltage (d.c.) for 1 minute	500 V
Category temperature range	
C_{max} = 10, 15, 22 pF	−40 to + 70 °C
C_{max} = 5,5; 27; 40 pF	−40 to + 85 °C
Contact resistance	max. 10 mΩ
Insulation resistance	min. 10 000 MΩ
Climatic category (IEC 68)	
C_{max} = 10, 15, 22 pF	40/070/21
C_{max} = 5,5; 27; 40 pF	40/085/21

Notes

1. This column indicates the reference values of the capacitance ranges currently available on the market which are equivalent to our range.
2. Measured at 200 kHz.
3. C at 60 to 80% of C_{max}; T from + 20 to upper category temperature.

10 mm VERSION

MECHANICAL DATA

Dimensions in mm

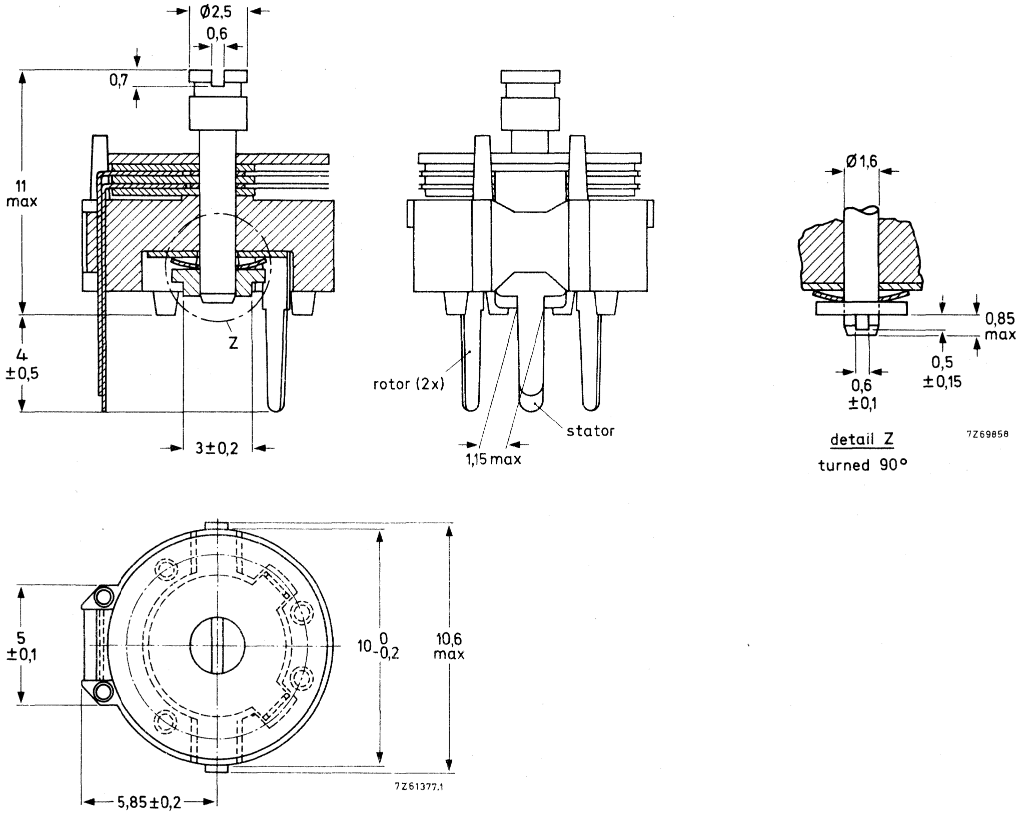
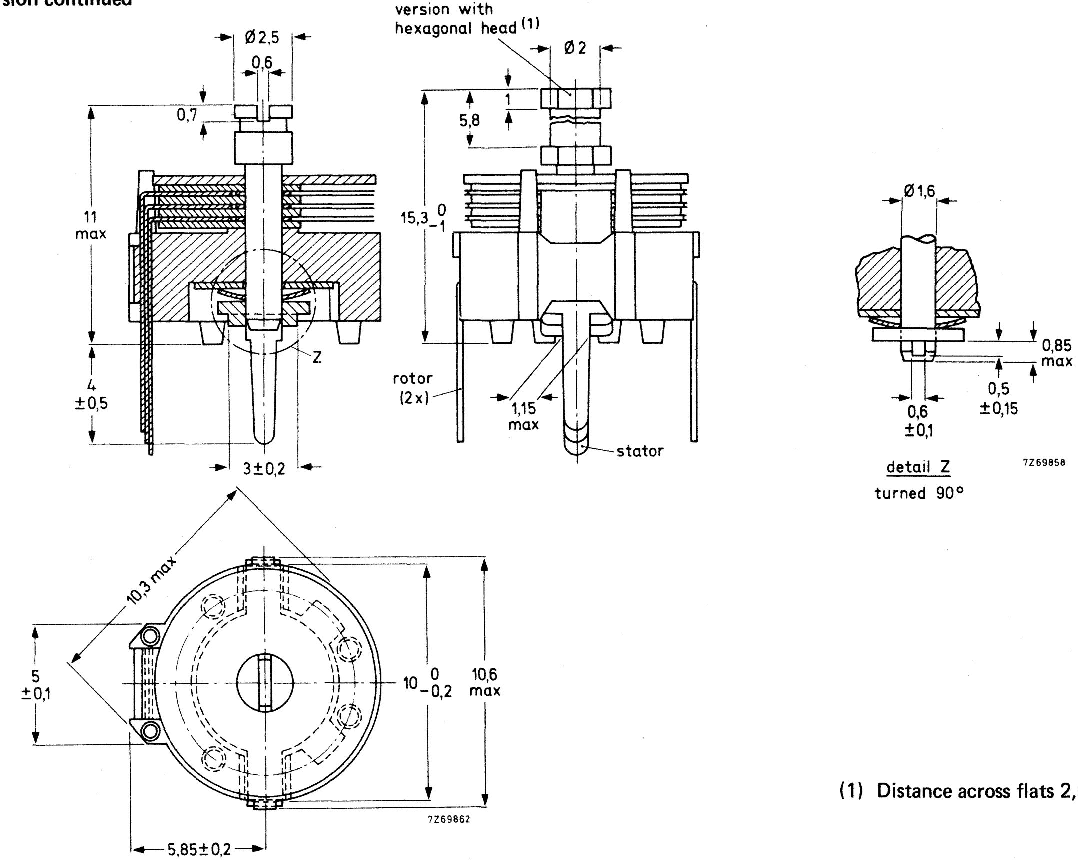


Fig. 6 Outlines of the capacitors 2222 808 32 . . . (see Tables 1 and 5).

10 mm version continued



(1) Distance across flats 2,5 – 0,06 mm.

Fig. 7 Outlines of the capacitors 2222 808 31 . . . and 2222 808 34 . . . (see Tables 1 and 5).

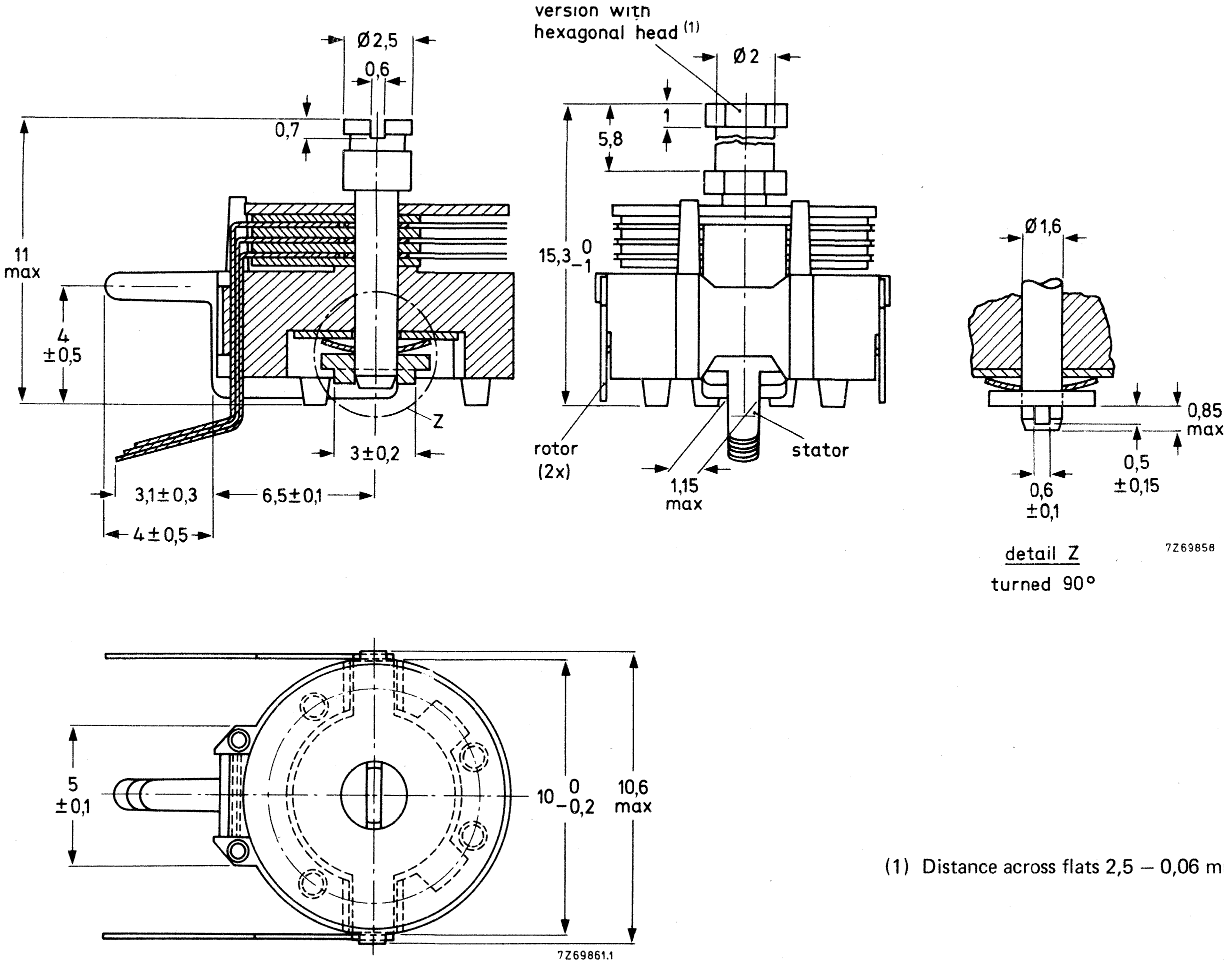


Fig. 8 Outlines of the capacitors 2222 808 61 . . . and 2222 808 64 . . . (see Tables 1 and 5).

(1) Distance across flats 2,5 – 0,06 mm.

10 mm version continued

Table 4

Effective angle of rotation	180°
Operating torque	2,5 - 35 mNm
Maximum axial thrust	2 N
Mass (approximately)	1,3 g

Marking

The different capacitance values 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 (R = rotor; S = stator).

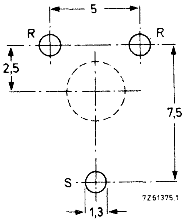


Fig. 9 For types of Fig. 6.

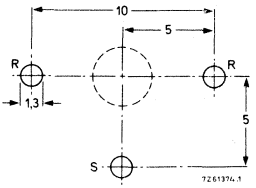


Fig. 10 For types of Figs 7 and 8.

Note

The large hole is necessary for bottom adjustment of the vertical types. Diameter determined by the user's requirements.

ELECTRICAL DATA

Table 5

reference C_{min}/C_{max} (note 1) pF	guaranteed max. C_{min} min. C_{max} (note 2) pF	tan δ at C_{max} x 10^{-4}		temperature coefficient (note 3) ppm/°C	min. f_{res} at C_{max} MHz	colour of base	Fig.	catalogue number
		1 MHz	100 MHz					
1,8/15	2,5/15	⩽ 10	⩽ 25	0 ± 400	420	blue	6	2222 808 32159
2,5/25	3/22,5	⩽ 10	⩽ 25	0 ± 400	200	green	6	2222 808 32229
4/40	5,5/40	⩽ 10	⩽ 25	−150 ± 350	200	grey	6	2222 808 32409
4,5/70	5,5/65	⩽ 10	⩽ 25	−200 ± 300	170	yellow	6	2222 808 32659
5/90	6/80	⩽ 50		−100 ± 300	170	red	6	2222 808 32809
6/105	6/100	⩽ 50		−100 ± 300	150	violet	6	2222 808 32101
1,8/15	2,5/15	⩽ 10	⩽ 25	0 ± 400	420	blue	7	2222 808 31159
2,5/25	3/22,5	⩽ 10	⩽ 25	0 ± 400	200	green	7	2222 808 31229
4/40	5,5/40	⩽ 10	⩽ 25	−150 ± 350	200	grey	7	2222 808 31409
4,5/70	5,5/65	⩽ 10	⩽ 25	−200 ± 300	170	yellow	7	2222 808 31659
5/90	6/80	⩽ 50		−100 ± 300	170	red	7	2222 808 31809
5/105	6/100	⩽ 50		−100 ± 300	150	violet	7	2222 808 31101
5/90	6/80	⩽ 50		−100 ± 300	170	red	7	2222 808 34809
1,8/15	2,5/15	⩽ 10	⩽ 25	0 ± 400	420	blue	8	2222 808 61159
2,5/25	3/22,5	⩽ 10	⩽ 25	0 ± 400	200	green	8	2222 808 61229
4/40	5,5/40	⩽ 10	⩽ 25	−150 ± 350	200	grey	8	2222 808 61409
4,5/70	5,5/65	⩽ 10	⩽ 25	−200 ± 300	170	yellow	8	2222 808 61659
5/90	6/80	⩽ 50		−100 ± 300	170	red	8	2222 808 61809
4,5/70	5,5/65	⩽ 50		−200 ± 300	170	yellow	8	2222 808 64659
5/90	6/80	⩽ 50		−100 ± 300	170	red	8	2222 808 64809
5/105	6/100	⩽ 50		−100 ± 300	150	violet	8	2222 808 64101

Rated voltage (d.c.)	250 V
Test voltage (d.c.) for 1 minute	500 V
Category temperature range,	
$C_{max} \leqslant 65$ pF	−40 to + 70 °C
$C_{max} > 65$ pF	−40 to + 85 °C
Contact resistance	max. 10 mΩ
Insulation resistance	min. 10 000 MΩ
Climatic category (IEC 68),	
$C_{max} \leqslant 65$ pF	40/070/21
$C_{max} > 65$ pF	40/085/21

Notes

1. This column indicates the reference values of the capacitance ranges currently available on the market which are equivalent to our range.
2. Measured at 200 kHz.
3. C at 60 to 80% of C_{max}; T from + 20 °C to upper category temperature.

13,5 mm VERSION

MECHANICAL DATA

Dimensions in mm

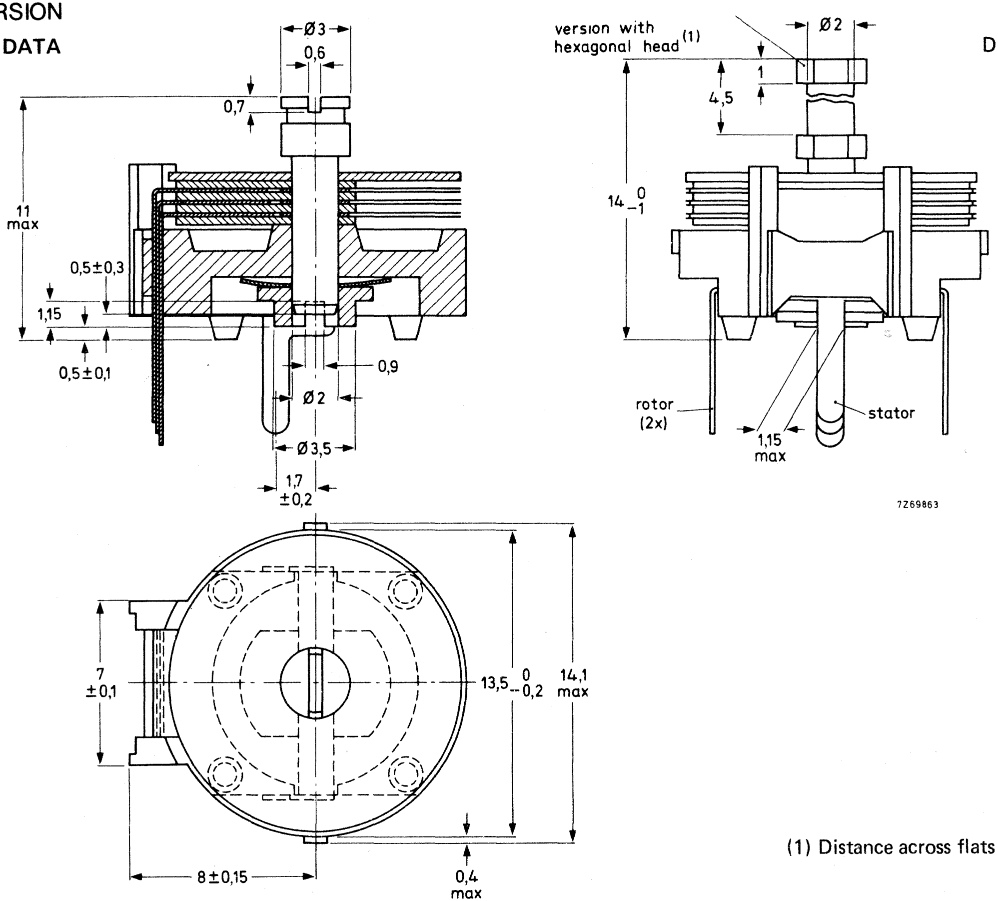
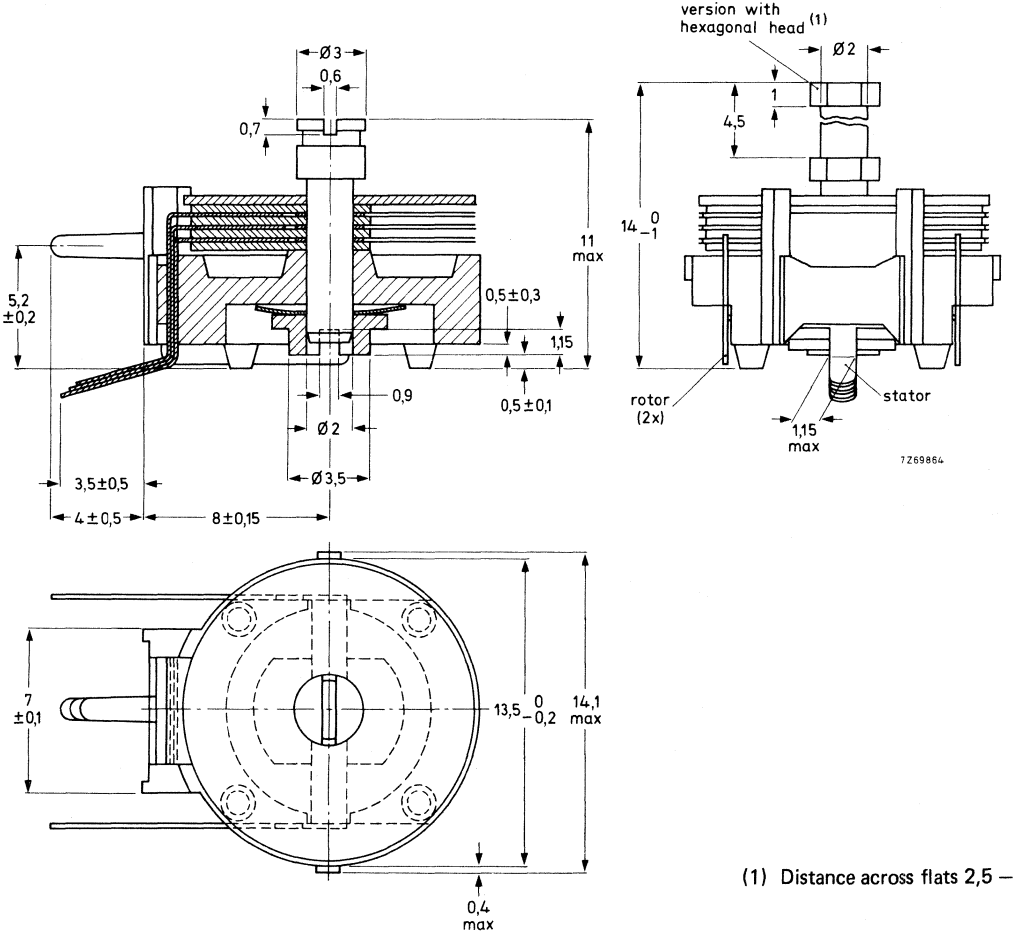


Fig. 11 Outlines of the capacitors 2222 808 41 . . . and 2222 808 44 . . . (see Tables 1 and 7).

(1) Distance across flats 2,5 – 0,06 mm.



(1) Distance across flats 2,5 – 0,06 mm.

Fig. 12 Outlines of the capacitors 2222 808 71 . . . and 2222 808 74 . . . (see Tables 1 and 7).

13,5 mm version continued

Table 6

Effective angle of rotation	180°
Operating torque	2 - 35 mNm
Maximum axial thrust	2 N
Mass (approximately)	2 g

Marking

The colour of the base is green.

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 figure below (R = rotor; S = stator).

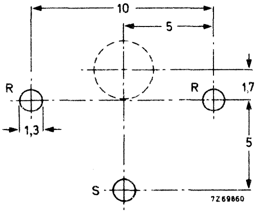


Fig. 13 For types of Fig. 11 and 12.

Note

The large hole is necessary for bottom adjustment of the vertical types. Diameter determined by the user's requirements.

ELECTRICAL DATA

Table 7

reference C_{min}/C_{max} (note 1) pF	guaranteed max. C_{min} min. C_{max} (note 2) pF	tan δ at C_{max} at 1 MHz x 10^{-4}	temperature coefficient (note 3) ppm/°C	f_{res} at C_{max} MHz	colour of base	Fig.	catalogue number
8/130	11/120	$\leqslant 50$	0 ± 200	> 150	green	11	2222 808 41121
8/130	11/120	$\leqslant 50$	0 ± 200	> 150	green	11	2222 808 44121
8/130	11/120	$\leqslant 50$	–200 ± 200	> 150	green	12	2222 808 71121
8/130	11/120	$\leqslant 50$	–200 ± 200	> 150	green	12	2222 808 74121

Rated voltage (d.c.)	150 V
Test voltage (d.c.) for 1 minute	300 V
Category temperature range	–40 to + 85 °C
Contact resistance	max. 10 mΩ
Insulation resistance	min. 10 000 MΩ
Climatic category (IEC 68)	40/085/21

Notes

1. This colomn indicates the reference values of the capacitance ranges currently available on the market which are equivalent to our range.
2. Measured at 200 kHz.
3. C at 60 to 80 % of C_{max}, T from + 20 to + 85 °C.

TESTS AND REQUIREMENTS

IEC 418-1 clause	IEC 68 test method	test	procedure
4.2		method of mounting	method A
14		cap. drift	
19		thrust	axial thrust of 2N
21		robustness of terminations:	
21.1	Ua	tensile	1N
21.2	Ub	bending	1 cycle
22	Na	rapid change of temperature	1 cycle: ½ h at the lower and ½ h at the upper category temperature
23	T	soldering	
	Ta	solderability	solder bath, immersion 3 mm, 235 °C, 2 s
	Tb	resistance to heat	solder bath 260 °C, 10 s
24		impact	
	Eb	bump	4000 ± 10 bumps, 40g, 6 ms
25	Fc	vibration	freq. 10 to 55 Hz, amplitude 0,35 mm, 1½ h
26		climatic sequence	
26.1	B	dry heat	16 h at the upper category temperature
26.2	D	damp heat accelerated, first cycle	1 cycle, 24 h + 40 °C, 95 to 100 % R.H.
26.3	Aa	cold	16 h –40 °C
26.5		damp heat accelerated, remaining cycles	1 cycle 24 h + 40 °C, 95 to 100 % R.H.

	requirements		
	7,5 mm version	10 mm version	13,5 mm version
$\Delta C/C$	$\leqslant$ 1%	$\leqslant$ 1,5%; $\leqslant$ 1% for $C_{max} >$ 40 pF	$\leqslant$ 1%
$\Delta C/C$	$\leqslant$ 0,3%	$\leqslant$ 0,3%	$\leqslant$ 0,3%
	no damage	no damage	no damage
$\Delta C/C$	$\leqslant$ 2%	$\leqslant$ 1,5%	$\leqslant$ 2%
	good wetting	good wetting	good wetting
	no mech. damage	no mech. damage	no mech. damage
	no mech. damage	no mech. damage	no mech. damage
$\Delta C/C$	$\leqslant$ 0,6% no mech. damage	$\leqslant$ 0,4% no mech. damage	$\leqslant$ 0,6% no mech. damage
$\Delta C/C$	$\leqslant$ 0,6% no mech. damage	$\leqslant$ 0,2% no mech. damage	$\leqslant$ 0,6% no mech. damage
$\Delta C/C$	$\leqslant$ 4%	$\leqslant$ 3% $\leqslant$ 6% for $C_{max} >$ 65 pF	$\leqslant$ 3,5%
tan δ	$\leqslant 10.10^{-4}$ $\leqslant 70.10^{-4}$ for $C_{max} >$ 22 pF	$\leqslant 15.10^{-4}$ $\leqslant 85.10^{-4}$ for $C_{max} >$ 65 pF	$\leqslant 70.10^{-4}$
R_{ins}	$\geqslant$ 10 000 MΩ	$\geqslant$ 10 000 MΩ	$\geqslant$ 10 000 MΩ
Rotor contact R	$\leqslant$ 10 mΩ	$\leqslant$ 10 mΩ	$\leqslant$ 10 mΩ
Voltage proof	as specified	as specified	as specified
Visual examination	no mech. damage	no mech. damage	no mech. damage
Operating torque	1 - 15 mNm	2 - 35 mNm	2 to 35 mNm

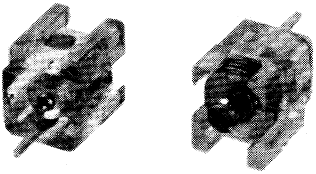
IEC 418-1 clause	IEC 68 test method	test	procedure
27	C	damp heat steady state	21 days + 40 °C, 90 to 95% R.H.
29 29.1		endurance mechanical	10 cycles

	requirements		
	7,5 mm version	10 mm version	13,5 mm version
$\Delta C/C$	$\leqslant 5\%$	$\leqslant 3\%$	$\leqslant 3\%$
tan δ	$\leqslant 30 \times 10^{-4}$	$\leqslant 20 \times 10^{-4}$	$\leqslant 50 \times 10^{-4}$
	70×10^{-4} for $C_{max} > 22$ pF	$\leqslant 70 \times 10^{-4}$ for $C_{max} > 65$ pF	
R_{ins}	$\geqslant 10\,000$ MΩ	$\geqslant 10\,000$ MΩ	$\geqslant 10\,000$ MΩ
rotor contact R	$\leqslant 10$ mΩ	$\leqslant 10$ mΩ	$\leqslant 10$ mΩ
voltage proof	table	table	table
visual examination	no mech. damage	no mech. damage	no mech. damage
operating torque	1 - 15 mNm	2 - 35 mNm	2 - 35 mNm
$\Delta C/C$	$\leqslant 1\%$	$\leqslant 0,3\%$	$\leqslant 0,3\%$
rotor contact R	$\leqslant 10$ mΩ	$\leqslant 10$ mΩ	$\leqslant 10$ mΩ
voltage proof	as specified	as specified	as specified
$\Delta C/C$ after axial thrust	$\leqslant 0,3\%$	$\leqslant 0,4\%$	$\leqslant 0,3\%$
visual examination	no mech. damage	no mech. damage	no mech. damage
operating torque	1 - 15 mNm	1,5 - 37 mNm	1,5 - 30 mNm

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.

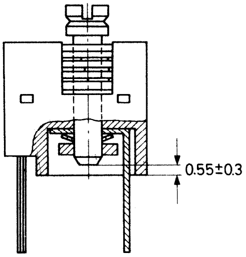
DESCRIPTION

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.

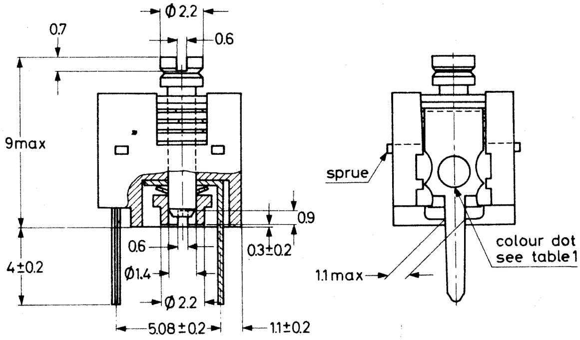
MECHANICAL DATA

Dimensions in mm

type with
top adjustment



type with
top and
bottom adjustment



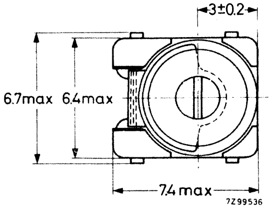


Table 1

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

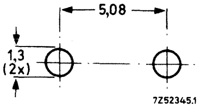
Bump	IEC68, test Eb - 4000 bumps of 40 g
Vibration	IEC68, test F - 10 - 55 Hz, acceleration 5g for 1,5 h

Marking

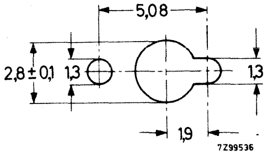
The capacitors are marked with a colour dot, see Table 1.

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

C_{max} (pF)	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.

---

*) Between +20 and +70 °C at C_{max}.

TESTS AND REQUIREMENTS

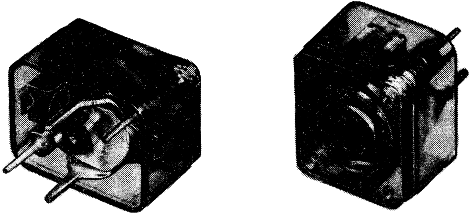
	IEC 68 test method	Test	Procedure
		Robustness of terminations	
	Ua	Tensile	load 2, 5 N; 10 s
	Ub	Bending	clause 2. 3, 1 bend
	T	Soldering	
		Solderability	clause3. 2: solder bath method, 240 °C
		Resistance to heat	clause 3. 2. 4, 350 °C, 3 s
	Na	Rapid change of temperature	30 min −40 °C/30 min +125 °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

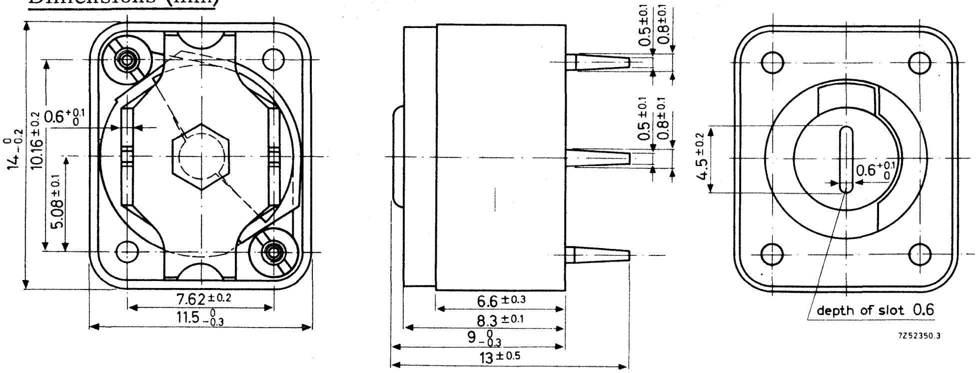
For use in miniaturised measuring and telecommunication equipment, specially where high temperatures occur and a low temperature coefficient is important, e.g. single-stator trimmers are suitable for fine adjustment of h.f. tuned circuits, split-stator trimmers for symmetrically built h.f. circuits and 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 have top adjustment 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

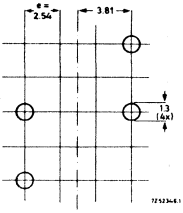
Bump	IEC68, test Eb - 4000 bumps of 40 g
Vibration	IEC68, test F - 10 - 55 Hz, acceleration 5g for 1, 5 h

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	C_{max} (pF)	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.

---

*) Preferred versions.

**) Between +20 and +125 °C at C_{max}.

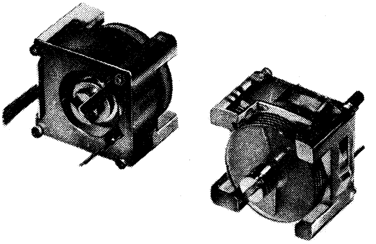
FILM DIELECTRIC TRIMMERS

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

A55374-1



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 P.T.F.E. 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

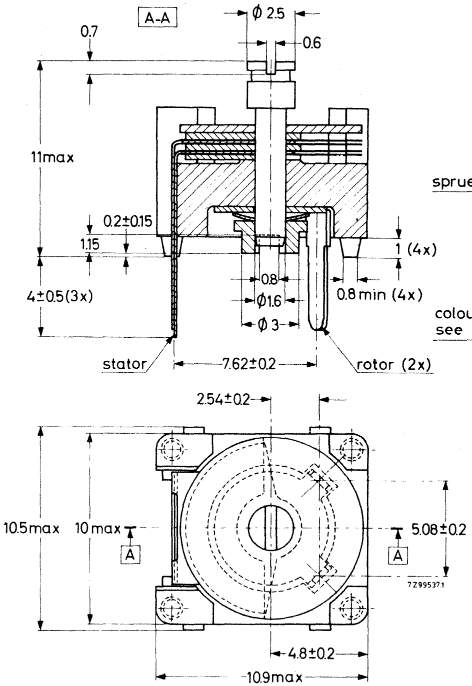


Table 1

max. capacitance	40 pF	60 pF
effective angle of rotation	180^o	180^o
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

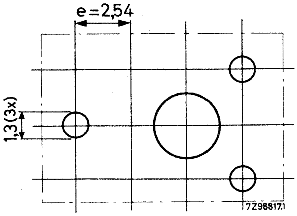
Bump	IEC68, test Eb - 4000 bumps of 40 g
Vibration	IEC68, test F - 10 - 55 Hz, acceleration 5g for 1,5 h

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

C_{max} (pF)	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).

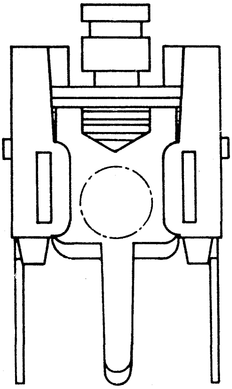
PACKAGING

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.

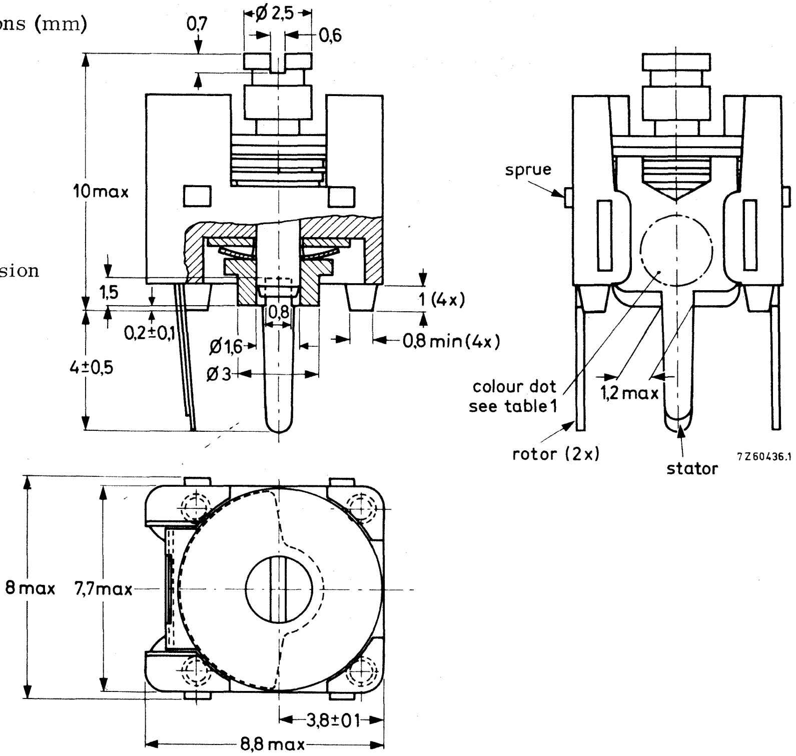
DESCRIPTION

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

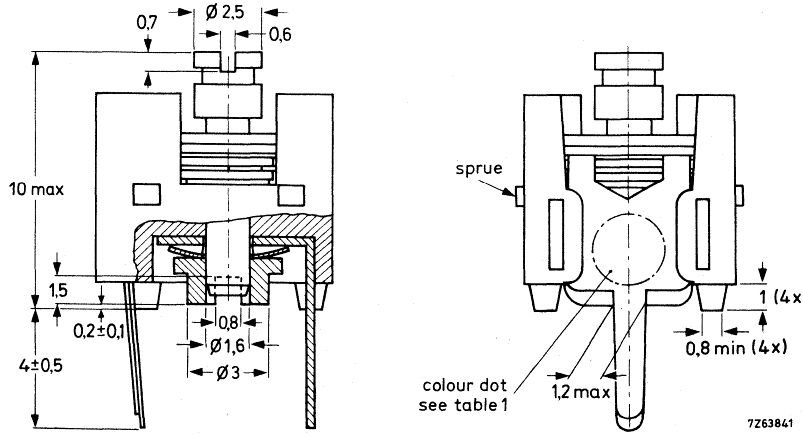


Table 1

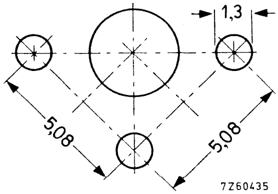
max. capacitance	5,5 pF	9 pF	18 pF
effective angle of rotation	180°	180°	180°
operating torque	1 to 15 mNm	2,5 to 20 mNm	2,5 to 20 mNm
maximum axial thrust	2 N	2 N	2 N
weight approx.	0,8 g	0,8 g	0,9 g
colour dot	green	white	red

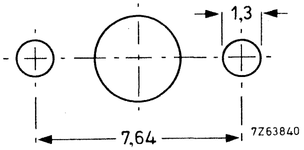
Marking

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.





Soldering conditions max. 260 °C, max. 10 s

Bending the tags by 90 degrees is permitted.

ELECTRICAL DATA

Cmax (pF)	Cmin (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).

Contents

DATA HANDBOOK SYSTEM

ELECTROLYTIC AND SOLID CAPACITORS

		page
Survey		2
Introduction		5
Aluminium electrolytic capacitors	2222 015- 2222 017	25
	2222 030 2222 031	41
	2222 032	55
	2222 039	71
	2222 040	81
	2222 071 2222 073	91
	2222 105	111
	2222 106 2222 107	117
	2222 108	131
Solid aluminium capacitors	2222 121	141
	2222 122	153
Solid tantalum capacitors	2222 141	165
	2222 143	185
	2222 146	205

FILM CAPACITORS

Survey		2
Interference suppression capacitors	2222 276	7
Dual dielectric capacitors	2222 278	13
Polyester foil capacitors	2222 311	19
Metallized polypropylene film capacitors	2222 328	29
Interference suppression capacitors	2222 330	37
Metallized polyester or polycarbonate film capacitors	2222 341	47
Metallized polyester or polycarbonate film capacitors	2222 344	67
Polyester film/foil capacitors	2222 347	85
Metallized polyester film capacitors	2222 352	99
Polypropylene film/foil capacitors	2222 357 4	117
Polypropylene film/foil capacitors	2222 357 5	129
Polypropylene capacitors	2222 357 6 . . . . 2222 357 7 . . . . 2222 357 8	141
Metallized polycarbonate and paper film capacitors	2222 663	155
Polystyrene film/foil capacitors	2222 424- 2222 431	169
Polystyrene film/foil capacitors	2222 443	183
Polystyrene film/foil capacitors	2222 444- 2222 447	193

CERAMIC CAPACITORS

		page
Survey		3
Introduction		5
Tubular ceramic capacitors, safety	2212 619	9
Ceramic disc capacitors		
type 2	2212 657	15
type 2, high voltage	2212 659	21
type 2, interference suppression	2212 660	27
type 2, safety	2212 661	33
Tubular ceramic capacitors		
type 2	2222 552	39
type 1B	2222 555	43
Disc type ceramic capacitors		
type 1B	2222 625 2222 626	47
type 2	2222 627	51
Miniature ceramic plate capacitors		
type 2, high-K types	2222 629 2222 630 2222 640	55
type 1B, temperature compensating types	2222 631-632 2222 638 2222 641-643	67
type 1B, 500 V (d.c.), temperature compensating types	2222 650	83
type 2A, 500 V (d.c.), high-K type	2222 655	93
Ceramic barrier layer capacitors, type 3	2222 675	101
Ceramic feed-through capacitors, type 2	2222 700 2222 702	107
Multilayer ceramic chip capacitors	2222 851- 2222 856	111

VARIABLE CAPACITORS

Survey		2
Tubular ceramic trimmers	2222 801 200 . .	7
	2222 801 20051 2222 801 20052	11
	2222 801 96002 2222 801 96003	15
	2222 801 96124 2222 801 96127 2222 801 96135	19
	2222 801 96138 2222 801 96139	23
	2222 802 20001- 2222 802 20005	27

		page
Tubular ceramic trimmers	2222 802 20011- 2222 802 20015	31
	2222 802 960 . .	35
Precision tuning capacitors	2222 805	39
Film dielectric trimmers	2222 808 SERIES	49
	2222 809 050 . .	69
	2222 809 070 . .	75
	2222 809 080 . .	79
	2222 809 090 . .	83

Electrolytic and solid capacitors

Film capacitors

Ceramic capacitors

Variable capacitors

Contents list

STANDARD SERIES OF VALUES IN A DECADE
for resistances and capacitances
according to I.E.C. publication 63

E192	E96	E48	E192	E96	E48	E192	E96	E48	E192	E96	E48	E192	E96	E48
100	100	100	169	169	169	284			481			816		
101			172			287	287	287	487	487	487	825	825	825
102	102		174	174		291			493			835		
104			176			294	294		499	499		845	845	
105	105	105	178	178	178	298			505			856		
106			180			301	301	301	511	511	511	866	866	866
107	107		182	182		305			517			876		
109			184			309	309		523	523		887	887	
110	110	110	187	187	187	312			530			898		
111			189			316	316	316	536	536	536	909	909	909
113	113		191	191		320			542			920		
114			193			324	324		549	549		931	931	
115	115	115	196	196	196	328			556			942		
117			198			332	332	332	562	562	562	953	953	953
118	118		200	200		336			569			965		
120			203			340	340		576	576		976	976	
121	121	121	205	205	205	344			583			988		
123			208			348	348	348	590	590	590			
124	124		210	210		352			597					
126			213			357	357		604	604				
127	127	127	215	215	215	361			612					
129			218			365	365	365	619	619	619			
130	130					370			626					
132			221	221		374	374		634	634				
133	133	133	223			379			642					
135			226	226	226	383	383	383	649	649	649			
137	137		229			388			657					
138			232	232		392	392		665	665				
140	140	140	234			397			673					
142			237	237	237	402	402	402	681	681	681			
143	143		240			407			690					
145			243	243		412	412		698	698				
147	147	147	246			417			706					
149			249	249	249	422	422	422	715	715	715			
150	150		252			427			723					
152			255	255		432	432		732	732				
154	154	154	258			437			741					
156			261	261	261	442	442	442	750	750	750			
158	158		264			448			759					
160			267	267		453	453		768	768				
162	162	162	271			459			777					
164			274	274	274	464	464	464	787	787	787			
165	165		277			470			796					
167			280	280		475	475		806	806				

E24	E12	E6	E3
10	10	10	10
11			
12	12		
13			
15	15	15	
16			
18	18		
20			
22	22	22	22
24			
27	27		
30			
33	33	33	
36			
39	39		
43			
47	47	47	47
51			
56	56		
62			
68	68	68	
75			
82	82		
91			

Electronic components and materials for professional, industrial and consumer uses from the world-wide Philips Group of Companies

Argentina: FAPESA i.y.C., Av. Crovara 2550, Tablada, Prov. de BUENOS AIRES, Tel. 652-7438/7478.
Australia: PHILIPS INDUSTRIES HOLDINGS LTD., Elcoma Division, 67 Mars Road, LANE COVE, 2066, N.S.W., Tel. 427 08 88.
Austria: ÖSTERREICHISCHE PHILIPS BAUELEMENTE Industrie G.m.b.H., Triester Str. 64, A-1101 WIEN, Tel. 62 91 11.
Belgium: M.B.L.E., 80, rue des Deux Gares, B-1070 BRUXELLES, Tel 523 00 00.
Brazil: IBRAPE, Caixa Postal 7383, Av. Paulista 2073-S/Loja, SAO PAULO, SP, Tel. 284-4511.
Canada: PHILIPS ELECTRONICS LTD., Electron Devices Div., 601 Milner Ave., SCARBOROUGH, Ontario, M1B 1M8, Tel. 292-5161.
Chile: PHILIPS CHILENA S.A., Av. Santa Maria 0760, SANTIAGO, Tel. 39-40 01.
Colombia: SADAPE S.A., P.O. Box 9805, Calle 13, No. 51 + 39, BOGOTA D.E. 1., Tel. 600 600.
Denmark: MINIWATT A/S, Emdrupvej 115A, DK-2400 KØBENHAVN NV., Tel. (01) 69 16 22.
Finland: OY PHILIPS AB, Elcoma Division, Kaivokatu 8, SF-00100 HELSINKI 10, Tel. 1 72 71.
France: R.T.C. LA RADIOTECHNIQUE-COMPELEC, 130 Avenue Ledru Rollin, F-75540 PARIS 11, Tel. 355-44-99.
Germany: VALVO, UB Bauelemente der Philips G.m.b.H., Valvo Haus, Burchardstrasse 19, D-2 HAMBURG 1, Tel. (040) 3296-1.
Greece: PHILIPS S.A. HELLENIQUE, Elcoma Division, 52, Av. Syngrou, ATHENS, Tel. 915 311.
Hong Kong: PHILIPS HONG KONG LTD., Comp. Dept., Philips Ind. Bldg., Kung Yip St., K.C.T.L. 289, KWAI CHUNG, N.T. Tel. 12-24 51 21.
India: PHILIPS INDIA LTD., Elcoma Div., Band Box House, 254-D, Dr. Annie Besant Rd., Prabhadevi, BOMBAY-25-DD, Tel. 457 311-5.
Indonesia: P.T. PHILIPS-RALIN ELECTRONICS, Elcoma Division, 'Timah' Building, Jl. Jen. Gatot Subroto, JAKARTA, Tel. 44 163.
Ireland: PHILIPS ELECTRICAL (IRELAND) LTD., Newstead, Clonskeagh, DUBLIN 14, Tel. 69 33 55.
Italy: PHILIPS S.p.A., Sezione Elcoma, Piazza IV Novembre 3, I-20124 MILANO, Tel. 2-6994.
Japan: NIHON PHILIPS CORP., Shuwa Shinagawa Bldg., 26-33 Takanawa 3-chome, Minato-ku, TOKYO (108), Tel. 448-5611.
(IC Products) SIGNETICS JAPAN, LTD., TOKYO, Tel. (03) 230-1521.
Korea: PHILIPS ELECTRONICS (KOREA) LTD., Philips House, 260-199 Itaewon-dong, Yongsan-ku, C.P.O. Box 3680, SEOUL, Tel. 44-4202.
Mexico: ELECTRONICA S.A. de C.V., Varsovia No. 36, MEXICO 6, D.F., Tel. 5-33-11-80.
Netherlands: PHILIPS NEDERLAND B.V., Afd. Elonco, Boschdijk 525, NL-4510 EINDHOVEN, Tel. (040) 79 33 33.
New Zealand: Philips Electrical Ind. Ltd., Elcoma Division, 2 Wagener Place, St. Lukes, AUCKLAND, Tel. 867 119.
Norway: ELECTRONICA A/S., Vitaminveien 11, P.O. Box 29, Grefsen, OSLO 4, Tel. (02) 15 05 90.
Peru: CADESA, Jr. Ilo, No. 216, Apartado 10132, LIMA, Tel. 27 73 17.
Philippines: ELDAC, Philips Industrial Dev. Inc., 2246 Pasong Tamo, MAKATI-RIZAL, Tel. 86-89-51 to 59.
Portugal PHILIPS PORTUGESA S.A.R.L., Av. Eng. Duharte Pacheco 6, LISBOA 1, Tel. 68 31 21.
Singapore: PHILIPS SINGAPORE PTE LTD., Elcoma Div., POB 340, Toa Payoh CPO, Lorong 1, Toa Payoh, SINGAPORE 12, Tel. 53 88 11.
South Africa: EDAC (Pty.) Ltd., South Park Lane, New Doornfontein, JOHANNESBURG 2001, Tel. 24/6701.
Spain: COPRESA S.A., Balmes 22, BARCELONA 7, Tel. 301 63 12.
Sweden: A.B. ELCOMA, Lidingövägen 50, S-10 250 STOCKHOLM 27, Tel. 08/67 97 80.
Switzerland: PHILIPS A.G., Elcoma Dept., Edenstrasse 20, CH-8027 ZÜRICH, Tel. 01/44 22 11.
Taiwan: PHILIPS TAIWAN LTD., 3rd Fl., San Min Building, 57-1, Chung Shan N. Rd, Section 2, P.O. Box 22978, TAIPEI, Tel. 5513101-5.
Turkey: TÜRK PHILIPS TICARET A.S., EMET Department, Inonu Cad. No. 78-80, ISTANBUL, Tel. 43 59 10.
United Kingdom: MULLARD LTD., Mullard House, Torrington Place, LONDON WC1E 7HD, Tel. 01-580 6633.
United States: (Active devices & Materials) AMPEREX SALES CORP., Providence Pike, SLATERSVILLE, R.I. 02876, Tel. (401) 762-9000.
(Passive devices) MEPCO/ELECTRA INC., Columbia Rd., MORRISTOWN, N.J. 07960, Tel. (201) 539-2000.
(IC Products) SIGNETICS CORPORATION, 811 East Arques Avenue, SUNNYVALE, California 94086, Tel. (408) 739-7700.
Uruguay: LUZILECTRON S.A., Rondeau 1567, piso 5, MONTEVIDEO, Tel. 9 43 21.
Venezuela: IND. VENEZOLANAS PHILIPS S.A., Elcoma Dept., A. Ppal de los Ruices, Edif. Centro Colgate, Apdo 1167, CARACAS, Tel. 36 05 11.

A5

Printed in The Netherlands

9399 261 31401