PHILIPS

Data handbook

PHILIPS

Electronic
components
and materials

Components and materials

Part 15 September 1982

Film capacitors

Ceramic capacitors

COMPONENTS AND MATERIALS

PART 15 - SEPTEMBER 1982

FILM AND CERAMIC CAPACITORS

METALLIZED POLYESTER FILM CAPACITORS MKT A

METALLIZED POLYCARBONATE FILM CAPACITORS MKC B

POLYESTER FILM/FOIL CAPACITORS KT C

POLYSTYRENE FILM/FOIL CAPACITORS KS D

POLYPROPYLENE FILM/FOIL CAPACITORS KP, KP/MKP E

INTERFERENCE SUPPRESSION CAPACITORS MKT-P F

CERAMIC CAPACITORS G

DATA HANDBOOK SYSTEM

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

ELECTRON TUBES	BLUE
SEMICONDUCTORS	RED
INTEGRATED CIRCUITS	PURPLE
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)

The blue series of data handbooks is comprised of the following parts:

T1	**Tubes for r.f. heating**
T2	**Transmitting tubes for communications**
T3	**Klystrons, travelling-wave tubes, microwave diodes**
ET3	**Special Quality tubes, miscellaneous devices** (will not be reprinted)
T4	**Magnetrons**
T5	**Cathode-ray tubes** Instrument tubes, monitor and display tubes, C.R. tubes for special applications
T6	**Geiger-Müller tubes**
T7	**Gas-filled tubes** Segment indicator tubes, indicator tubes, dry reed contact units, thyratrons, industrial rectifying tubes, ignitrons, high-voltage rectifying tubes, associated accessories
T8	**Picture tubes and components** Colour TV picture tubes, black and white TV picture tubes, colour monitor tubes for data graphic display, monochrome monitor tubes for data graphic display, components for colour television, components for black and white television and monochrome data graphic display
T9	**Photo and electron multipliers** Photomultiplier tubes, phototubes, single channel electron multipliers, channel electron multiplier plates
T10	**Camera tubes and accessories, image intensifiers**
T11*	**Microwave components and assemblies**

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* Will become available in the course of 1982.

SEMICONDUCTORS (RED SERIES)

The red series of data handbooks is comprised of the following parts:

S1	**Diodes** Small-signal germanium diodes, small-signal silicon diodes, voltage regulator diodes(< 1,5 W), voltage reference diodes, tuner diodes, rectifier diodes
S2	**Power diodes, thyristors, triacs** Rectifier diodes, voltage regulator diodes (> 1,5 W), rectifier stacks, thyristors, triacs
S3	**Small-signal transistors**
S4	**Low-frequency power transistors and hybrid IC modules**
S5	**Field-effect transistors**
S6	**R.F. power transistors and modules**
S7	**Microminiature semiconductors for hybrid circuits**
S8	**Devices for optoelectronics** Photosensitive diodes and transistors, light-emitting diodes, displays, photocouplers, infrared sensitive devices, photoconductive devices.
S9	Taken into handbook T11 of the blue series
S10	**Wideband transistors and wideband hybrid IC modules**

INTEGRATED CIRCUITS (PURPLE SERIES)

The purple series of data handbooks is comprised of the following parts:

IC1	**Bipolar ICs for radio and audio equipment**
IC2	**Bipolar ICs for video equipment**
IC3*	**Digital ICs for radio, audio and video equipment**
IC4	**Digital integrated circuits** LOCMOS HE4000B family
IC5	**Digital integrated circuits – ECL** ECL10 000 (GX family), ECL100 000 (HX family), dedicated designs
IC6*	**Professional analogue integrated circuits**
IC7	**Signetics bipolar memories**
IC8	**Signetics analogue circuits**
IC9*	**Signetics TTL circuits**

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* These handbooks will be available in the course of 1982.

COMPONENTS AND MATERIALS (GREEN SERIES)

The green series of data handbooks is comprised of the following parts:

C1	**Assemblies for industrial use** PLC modules, PC20 modules, HNIL FZ/30 series, NORbits 60-, 61-, 90-series, input devices, hybrid ICs, peripheral devices
C2	**FM tuners, television tuners, video modulators, surface acoustic wave filters**
C3	**Loudspeakers**
C4	**Ferroxcube potcores, square cores and cross cores**
C5	**Ferroxcube for power, audio/video and accelerators**
C6	**Electric motors and accessories** Permanent magnet synchronous motors, stepping motors, direct current motors
C7	**Variable capacitors***
C8	**Variable mains transformers**
C9	**Piezoelectric quartz devices** Quartz crystal units, temperature compensated crystal oscillators, compact integrated oscillators, quartz crystal cuts for temperature measurements
C10	**Connectors**
C11	**Non-linear resistors** Voltage dependent resistors (VDR), light dependent resistors (LDR), negative temperature coefficient thermistors (NTC), positive temperature coefficient thermistors (PTC)
C12	**Variable resistors and test switches**
C13	**Fixed resistors**
C14	**Electrolytic and solid capacitors**
C15	**Film capacitors, ceramic capacitors***
C16	**Piezoelectric ceramics, permanent magnet materials**

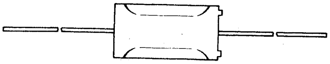
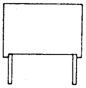
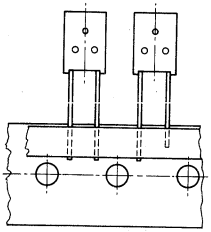
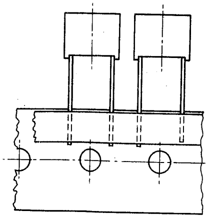
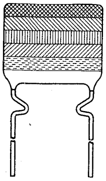
* C7 is in preparation. Retain C15 05-80 for information on variable capacitors until C7 becomes available.

METALLIZED POLYESTER FILM CAPACITORS MKT

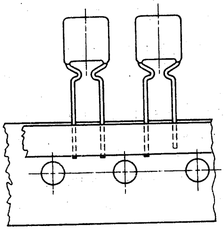
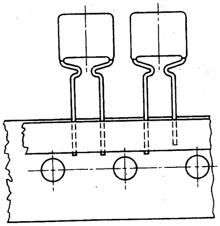
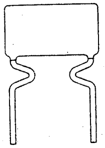
A

SURVEY

Main applications: coupling, decoupling, timing, delay.

type	series number	pitch e = 2,54 mm	rated capacitance µF	rated d.c. voltage V	page
	2222 341		0,082 – 6,8 0,039 – 2,2 0,0082 – 1,0	100 250 400	A17
	2222 344	4e, 6e 9e, 11e	0,18 – 10 0,082 – 10 0,039 – 2,2 0,010 – 1,0	63 100 250 400	A29
	2222 370*	2e	0,047 – 0,47 0,010 – 0,10	63 100	A89
	2222 371	3e	0,039 – 0,15 0,012 – 0,047 0,0039 – 0,015	100 250 400	A95
	2222 352 not for new design	4e, 6e 8e, 11e	0,047 – 6,8 0,001 – 2,2 0,10 – 1,0 0,010 – 0,47	100 250 400 630	A41

* Development Sample Data.

type	series number	pitch e = 2,54 mm	rated capacitance µF	rated d.c. voltage V	page
	2222 365*	2e	0,047 – 0,47 0,010 – 0,10	63 100	A55
	2222 365	2e (3e)	0,12 – 0,47 0,039 – 0,27 0,018 – 0,033 0,0039 – 0,015	63 100 250 400	A55
	2222 366*	2e	0,047 – 0,47 0,010 – 0,10	63 100	A65
	2222 366	3e	0,12 – 0,47 0,039 – 0,27 0,018 – 0,033 0,0039 – 0,015	63 100 250 400	A65
	2222 368	4e, 6e 9e, 11e	0,056 – 5,6 0,027 – 1,8 0,001 – 0,82	100 250 400	A75

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* Development Sample Data.

TESTS AND REQUIREMENTS

Standard atmospheric conditions for reference tests: ambient temperature + 23 ± 1 °C, atmospheric pressure 86 to 106 kPa, relative humidity 50 ± 2%.

IEC 384-2 clause	IEC 68-2 test method	name of test	procedure (quick reference)
4.3.1			Initial measurements C at 1 kHz, tan δ at 1 kHz, 10 kHz, 100 kHz
4.3	Ua1	Tensile strength of terminations	Loading force in axial direction for 10 s: ϕ 0,6 and 0,8 mm 10 N, ϕ 1,0 mm 20 N
	Ub (method 1)	Bending of terminations	Loading force 5 N for ϕ = 0,6 and 0,8 mm 10 N for ϕ = 1,0 mm, 2 consecutive bends
	Uc	Torsion of terminations	2 successive rotations of 180° for lead length of 25 mm only
4.4	Tb (method 1A)	Resistance to soldering heat	Solder bath 260 °C, 10 s
4.4.2			Final measurements
4.5	Ta	Soldering	Solder bath, non-activated colophony flux, solder temp. 235 °C, dwell time 2 s
4.6.1			Initial measurements C at 1 kHz, tan δ at 1 kHz, 10 kHz, 100 kHz
4.6	Na	Rapid change of temperature	5 cycles of ½ h at lower category temp. and ½ h at upper category temp. Recovery for 1 to 2 h
4.7	Fc	Vibration	10 to 55 Hz, 0,75 mm or 10g (whichever is the less), 3 directions, 2 h per direction. Capacitors mounted on printed-wiring boards
4.8	Eb	Bumping	40g, 6 ms, 4000 bumps. Capacitors mounted on printed-wiring boards.
4.8.3			Final measurements

n.a. = not applicable

	requirements							
2222 . . .	341	344	352	365	366	368	370	371
Visual examination	no damage							
Visual examination	no damage							
	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	no damage	n.a.
Visual examination	no damage							
$\Delta C/C$	$\leqslant 1\%$	$\leqslant 1\%$	$\leqslant 1\%$	$\leqslant 2\%$	$\leqslant 2\%$	$\leqslant 2\%$	$\leqslant 1\%$	$\leqslant 1\%$
$\Delta \tan \delta$ (x 10^{-4}) at 1 kHz, $C > 1\ \mu F$ at 10 kHz, $C \leqslant 1\ \mu F$ at 100 kHz, $C \leqslant 0{,}1\ \mu F$				$\leqslant 30$ $\leqslant 50$	$\leqslant 30$ $\leqslant 50$	$\leqslant 20$ $\leqslant 30$ $\leqslant 50$	$\leqslant 30$ $\leqslant 50$	$\leqslant 30$ $\leqslant 50$
Visual examination	good tinning							
Visual examination	no damage							
Visual examination	no damage		n.a.	no damage				
			n.a.					
Visual examination	no damage		n.a.	no damage				
$\Delta C/C$	$\leqslant 2\%$	$\leqslant 2\%$	$\leqslant 2\%$	$\leqslant 3\%$	$\leqslant 3\%$	$\leqslant 3\%$	$\leqslant 3\%$	$\leqslant 3\%$
$\Delta \tan \delta$ (x 10^{-4}) at 1 kHz, $C > 1\ \mu F$ at 10 kHz, $C \leqslant 1\ \mu F$ at 100 kHz, $C \leqslant 0{,}1\ \mu F$	meet initial requirements			$\leqslant 30$ $\leqslant 50$	$\leqslant 30$ $\leqslant 50$	$\leqslant 20$ $\leqslant 30$ $\leqslant 50$	$\leqslant 30$ $\leqslant 50$	$\leqslant 30$ $\leqslant 50$
R_{ins}	meet initial requirements							

IEC 384-2 clause	IEC 68-2 test method		name of test	procedure (quick reference)
4.10.2	CLIMATIC SEQUENCE	Ba	Dry heat	16 h at upper category temp., no voltage applied
4.10.3		Db	Damp heat, cyclic	1 cycle of 24 h, upper temp. 55 ± 2 °C, R.H. 93 ± 3%; no voltage applied
4.10.4		Aa	Cold	2 h at lower category temp., no voltage applied
4.10.6		Db	Damp heat, cyclic	n cycles of 24 h at 55 °C, R.H. 93 ± 3%. Within 15 min after removal from the test, U_R shall be applied for 1 min
				Final measurements
4.11.1			Damp heat, steady state	Initial measurements C at 1 kHz, $\tan\delta$ at 1 kHz, 10 kHz, 100 kHz
4.11	Ca			40 ± 2 °C for the time period given in the climatic category; R.H. 90 to 95%; no voltage applied
4.11.3				Final measurements

	requirements							
2222 . . .	341	344	352	365	366	368	370	371
ΔC/C at upper category temp.	⩽ 5%	⩽ 5%	⩽ 5%	⩽ 5%	⩽ 5%	⩽ 5%	⩽ 5%	⩽ 5%
R_{ins}	meet initial requirements							
ΔC/C at lower category temp.	⩽ 7%	⩽ 7%	⩽ 7%	⩽ 7%	⩽ 7%	⩽ 7%	⩽ 7%	⩽ 7%
	n = 5	n = 5	n = 1	2e(3e) 63 V, and 2e version n = 1; remaining versions n = 5		n = 5		n = 5
Visual examination	no damage							
ΔC/C	⩽ 3%	⩽ 3%	⩽ 5%	⩽ 5%	⩽ 5%	⩽ 5%	⩽ 3%	⩽ 3%
Δ tan δ (x 10^{-4}) at 1 kHz, C > 1 μF at 10 kHz, C ⩽ 1 μF at 100 kHz, C ⩽ 0,1 μF	⩽ 50	⩽ 50	⩽ 50	⩽ 50 ⩽ 70	⩽ 50 ⩽ 70	⩽ 30 ⩽ 50 ⩽ 70	⩽ 50 ⩽ 70	⩽ 50 ⩽ 70
R_{ins}	⩾ 0,5 x initial requirements							
Visual examination	no damage							
ΔC/C	⩽ 5%	⩽ 5%	⩽ 5%	⩽ 5%	⩽ 5%	⩽ 5%	⩽ 5%	⩽ 5%
Δ tan δ (x 10^{-4}) at 1 kHz, C > 1 μF at 10 kHz, C ⩽ 1 μF at 100 kHz, C ⩽ 0,1 μF	⩽ 50	⩽ 50	⩽ 50	⩽ 50 ⩽ 70	⩽ 50 ⩽ 70	⩽ 30 ⩽ 50 ⩽ 70	⩽ 50 ⩽ 70	⩽ 50 ⩽ 70
R_{ins}	⩾ 0,5 x initial requirements							

IEC 384-2 clause	IEC 68-2 test method	name of test	procedure (quick reference)	
4.12.1		Endurance	Initial measurements C at 1 kHz, tan δ at 1 kHz, 10 kHz, 100 kHz	
4.12.2			Grade 1 capacitors (long life)	2000 h at 85 °C; 1,25 x U_R (d.c.) applied 2000 h at 100 °C; 1,25 x U_C applied
4.12.5				Final measurements
4.12.2			Grade 2 capacitors (general purpose	1000 h at 85 °C; 1,25 x U_R (d.c.) applied 1000 h at 100 °C; 1,25 x U_C applied
4.12.5				Final measurements
4.13.1		Charge and discharge	Initial measurements C at 1 kHz, tan δ at 1 kHz, 10 kHz, 100 kHz	
4.13.2			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.	
4.13.3			Final measurements	

	requirements							
2222 . . .	341	344	352	365	366	368	370	371
			n.a.					
Visual examination	no damage			no damage				
$\Delta C/C$	≤ 3%	≤ 3%		≤ 5%	≤ 5%	≤ 5%	≤ 3%	≤ 3%
$\Delta \tan\delta$ (x 10^{-4}) at 1 kHz, $C > 1\ \mu F$ at 10 kHz, $C \leq 1\ \mu F$ at 100 kHz, $C \leq 0{,}1\ \mu F$	≤ 30	≤ 30		≤ 30 ≤ 50	≤ 30 ≤ 50	≤ 30 ≤ 50	≤ 30 ≤ 50	≤ 30 ≤ 50
R_{ins}	≥ 0,5 x initial requirements			≥ 0,5 x initial requirements				
	n.a.	n.a.		n.a.	n.a.	n.a.	n.a.	n.a.
Visual examination			no damage					
$\Delta C/C$			≤ 5%					
$\Delta \tan\delta$ (x 10^{-4}) at 10 kHz			≤ 30					
R_{ins}			≥ 0,5 x in. req.					
$\Delta C/C$	≤ 3%	≤ 3%	≤ 3%	≤ 3%	≤ 3%	≤ 3%	≤ 3%	≤ 3%
$\Delta \tan\delta$ (x 10^{-4}) at 1 kHz, $C > 1\ \mu F$ at 10 kHz, $C \leq 1\ \mu F$ at 100 kHz, $C \leq 0{,}1\ \mu F$	≤ 30	≤ 30	≤ 30	≤ 30 ≤ 50	≤ 30 ≤ 50	≤ 20 ≤ 30 ≤ 50	≤ 30 ≤ 50	≤ 30 ≤ 50
R_{ins}	≥ 0,5 x initial requirements							

n.a. = not applicable.

Additional tests

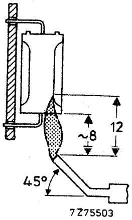
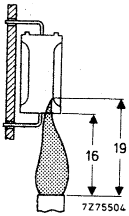
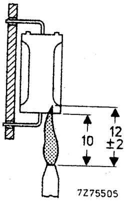
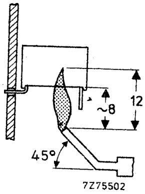
name of test	procedure (quick reference)
Solvent resistance	According to MIL-STD-202E method 215; recovery for 2 h.
	Detergent test: 20g/l dish washer detergent, 70 °C, 3 min; followed by rinsing in clean water for 1 min; recovery time min. 2 h.
	Final measurements
Endurance	1000 h at 85 °C; 1,25 x U_R (a.c.) 50 Hz applied
Storage	1000 h at 100 °C
Tensile strength of terminations	Loading force in radial direction of wire for 10 s:ϕ 0,6 mm 7,5 N
	Loading force in radial direction of wire for 10 s: ϕ 0,6 and 0,8 mm 5 N ϕ 1,0 mm 10 N
	ϕ 0,6 mm and 0,8 mm 10 N

n.a. = not applicable

	requirements							
2222 . . .	341	344	352	365	366	368	370	371
			n.a.					
	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.		
Visual examination	no damage			no damage				
$\Delta C/C$	$\leqslant$ 1%	$\leqslant$ 1%		$\leqslant$ 1%	$\leqslant$ 1%	$\leqslant$ 1%	$\leqslant$ 1%	$\leqslant$ 1%
$\Delta \tan \delta$ ($\times 10^{-4}$) at 1 kHz, $C > 1\ \mu F$ at 10 kHz, $C \leqslant 1\ \mu F$ at 100 kHz, $C < 0{,}1\ \mu F$	$\leqslant$ 30	$\leqslant$ 30		$\leqslant$ 30 $\leqslant$ 50	$\leqslant$ 30 $\leqslant$ 50	$\leqslant$ 20 $\leqslant$ 30 $\leqslant$ 50	$\leqslant$ 30 $\leqslant$ 50	$\leqslant$ 30 $\leqslant$ 50
R_{ins}	$\geqslant$ 0,5 x initial requirements			$\geqslant$ 0,5 x initial requirements				
$\Delta C/C$	see ***			$\leqslant$ 10%	$\leqslant$ 10%	$\leqslant$ 10%	$\leqslant$ 10%	$\leqslant$ 10%
$\Delta \tan \delta$ ($\times 10^{-4}$) at 1 kHz, $C > 1\ \mu F$ at 10 kHz, $C \leqslant 1\ \mu F$ at 100 kHz, $C < 0{,}1\ \mu F$	$\leqslant$ 30	$\leqslant$ 30	$\leqslant$ 30	$\leqslant$ 20 $\leqslant$ 50	$\leqslant$ 20 $\leqslant$ 50	$\leqslant$ 20 $\leqslant$ 30 $\leqslant$ 50	$\leqslant$ 30 $\leqslant$ 50	$\leqslant$ 30 $\leqslant$ 50
R_{ins}	meet initial requirements							
$\Delta C/C$	$\leqslant$ 3%	$\leqslant$ 3%	$\leqslant$ 3%	$\leqslant$ 3%	$\leqslant$ 3%	$\leqslant$ 3%	$\leqslant$ 3%	$\leqslant$ 3%
$\Delta \tan \delta$ ($\times 10^{-4}$) at 1 kHz, $C > 1\ \mu F$ at 10 kHz, $C \leqslant 1\ \mu F$ at 100 kHz, $C \leqslant 0{,}1\ \mu F$	$\leqslant$ 20 $\leqslant$ 30	$\leqslant$ 20 $\leqslant$ 30	$\leqslant$ 20 $\leqslant$ 30	$\leqslant$ 30 $\leqslant$ 50	$\leqslant$ 30 $\leqslant$ 50	$\leqslant$ 20 $\leqslant$ 30 $\leqslant$ 50	$\leqslant$ 30 $\leqslant$ 50	$\leqslant$ 30 $\leqslant$ 50
R_{ins}	meet initial requirements							
	n.a.	n.a.	n.a.			n.a.	n.a.	n.a.
				n.a.	n.a.	n.a.	n.a.	n.a.
	n.a.	n.a.	n.a.	n.a.	n.a.		n.a.	n.a.
Visual examination	no damage							

***	341	344	352
$\Delta C/C$	for L = 14,5 mm: $\leqslant$ 15% 18 mm: $\leqslant$ 10% 23,5 mm: $\leqslant$ 7% 31 mm: $\leqslant$ 5%	for L = 13 mm: $\leqslant$ 15% 17,5 mm: $\leqslant$ 10% 26 mm: $\leqslant$ 7% 30 mm: $\leqslant$ 5%	for L = 12,5 mm: $\leqslant$ 15% 17,5 mm: $\leqslant$ 10% 22,5 mm: $\leqslant$ 7% 30 mm: $\leqslant$ 5%

Additional tests

name of test	procedure (quick reference)
Flammability	 Bore of gas jet: ϕ 0,5 mm. Fuel: butane. Test duration: 20 s. One flame application.
	 Test according to UL1414. Bore of gas jet: ϕ 10 mm. Fuel: natural gas. Test duration: 3 x 15 s. Time interval between each flame application: 15 s.
	 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.
	 Bore of gas jet: ϕ 0,5 mm. Fuel: butane. Test duration: 20 s. One flame application.

	requirements							
2222 . . .	341	344	352	365	366	368	370	371
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.		n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Extinguishing time ⩽ 15 s after the first and second flame application, ⩽ 60 s after the third flame application.		n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Extinguishing time ⩽ 10 s after each flame application; no burning particles must drop from the sample.		n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
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.	n.a.		n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

n.a. = not applicable.

Tests concerning tape specification

name of test	procedure (quick reference)
Pull-out force of the component	
Pull-off force of adhesive tape	
Tearing force of tape	
Climatic test	250 h at 40 ± 2 °C, R.H. 90 to 95%; recovery time 24 h.
Storage	max. temperature + 40 °C, min. temperature −25 °C, max. R.H. 80%, time: 18 months.

requirements								
2222 . . .	341	344	352	365	366	368	370	371
⩾ 5 N	n.a.	n.a.	n.a.		n.a.	n.a.		
⩾ 6 N								
⩾ 15 N								
Change in position of lead hole: ⩽ 0,05 mm. Angle of component ⩽ 4°.								
Taping must be within specification. Tapes must not stick together.								

n.a. = not applicable.

METALLIZED POLYESTER FILM CAPACITORS

moulded type

QUICK REFERENCE DATA

Rated capacitance range (E 12-series)	0,01 to 6,8 μF
Tolerance on rated capacitance	± 5%, ± 10%, ± 20%
Rated voltage U_R (d.c.)	100 V, 250 V, 400 V
Rated voltage U_R (a.c.), 50 to 60 Hz	63 V, 160 V, 220 V
Rated temperature	85 °C
Climatic category, IEC 68	55/100/56
Basic specification	IEC 384-2

APPLICATION

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

DESCRIPTION

The capacitors consist of a low-inductance wound cell of metallized polyethyleneterephthalate (PETP) 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.

MECHANICAL DATA

Dimensions in mm

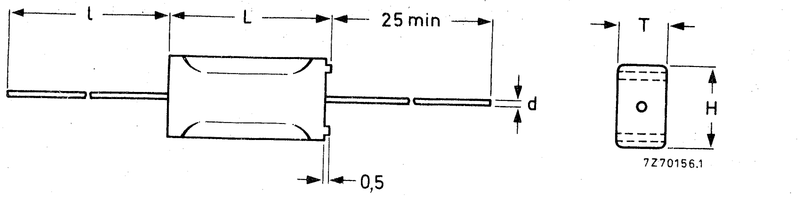


Fig. 1 For dimensions T, L, H, d and l, see tables below.

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

rated capacitance* µF	T_{max}	L_{max}	H_{max}	d	l_{min}	mass g	catalogue number 2222 341		
							tol. ±5%	tol. ±10%	tol. ±20%
0,10	4,9	14,5	8,7	0,8	40	1,0	25104	27104	26104
0,15	4,9	14,5	8,7			1,0	25154	27154	26154
0,22	6,5	14,5	10,4			1,4	25224	27224	26224
0,33	6,7	18	10,4			1,7	25334	27334	26334
0,47	7,9	18,1	11,5			2,0	25474	27474	26474
0,68	7,8	23,8	11,7			2,5	25684	27684	26684
1,0	9,2	23,5	12,8			3,2	25105	27105	26105
1,5	10,4	23,5	14,4			4,0	25155	27155	26155
2,2	10,4	31	14,6	1	50	5,5	25225	27225	26225
3,3	12,4	31	19,5			8,0	25335	27335	26335
4,7	12,4	31	19,5			10,5	25475	27475	26475
6,8	15	31	22			10,5	25685	27685	26685

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* 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

rated capacitance* µF	T_{max}	L_{max}	H_{max}	d	l_{min}	mass g	catalogue number 2222 341		
							tol. ±5%	tol. ±10%	tol. ±20%
0,047	4,9	14,5	8,7	0,8	40	1,0	87473	89473	88473
0,068	4,9	14,5	8,7			1,0	87683	89683	88683
0,10	5,5	14,5	9,4			1,1	87104	89104	88104
0,15	6,7	18	10,4			1,7	87154	89154	88154
0,22	6,5	18	10,4			1,7	87224	89224	88224
0,33	7,8	23,8	11,7			2,5	87334	89334	88334
0,47	7,4	23,5	11,5			2,5	87474	89474	88474
0,68	9,2	23,5	12,8			3,2	87684	89684	88684
1,0	10,4	31	14,6	1	50	5,5	87105	89105	88105
1,5	12,4	31	19,5			8,0	87155	89155	88155
2,2	12,4	31	19,5			8,0	87225	89225	88225

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

rated capacitance* µF	T_{max}	L_{max}	H_{max}	d	l_{min}	mass g	catalogue number 2222 341		
							tol. ±5%	tol. ±10%	tol. ±20%
0,010	4,9	14,5	8,7	0,8	40	1,0	53103	55103	54103
0,015	4,9	14,5	8,7			1,0	53153	55153	54153
0,022	4,9	14,5	8,7			1,0	53223	55223	54223
0,033	4,9	14,5	8,7			1,0	53333	55333	54333
0,047	6,5	14,5	10,4			1,4	53473	55473	54473
0,068	6,7	18	10,4			1,7	53683	55683	54683
0,10	7,9	18,1	11,5			2,0	53104	55104	54104
0,15	7,8	23,8	11,7			2,5	53154	55154	54154
0,22	9,2	23,5	12,8			3,2	53224	55224	54224
0,33	10,4	23,5	14,4			4,0	53334	55334	54334
0,47	10,4	31	14,6	1,0	50	5,5	53474	55474	54474
0,68	12,4	31	19,5			8,0	53684	55684	54684
1,0	15	31	22			10,5	53105	55105	54105

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

→ Marking

The marking is impressed on one side:

1st line: rated capacitance, tolerance and rated d.c. voltage;
2nd line: 341, MKT, production date code (three-month period and year).
The outer film connection is marked with a stroke on the body.

On the other side is impressed:
1st line: name of manufacturer;
2nd line: code for factory of origin.

Mounting

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

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of 23 ± 1 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 50 ± 2%.

Capacitance

Rated capacitance values (C_R) at 1 kHz	see Tables 1 to 3
Tolerance on rated capacitance	± 5%*, ± 10% and ± 20%

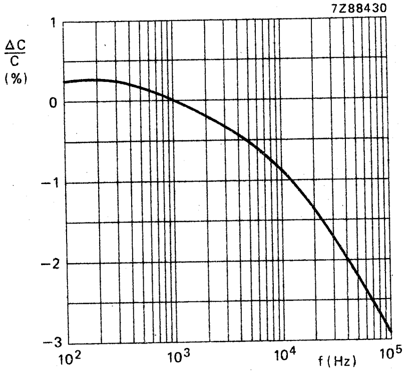

Fig. 2 Capacitance as a function of frequency; typical curve.
From 100 Hz to 1 kHz the curve is valid for all capacitance values (measuring voltage 1 V). From 1 to 10 kHz the curve is valid for capacitance values ≤ 1 μF (measuring voltage 1 V). From 10 to 100 kHz the cuve is valid for capacitance values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

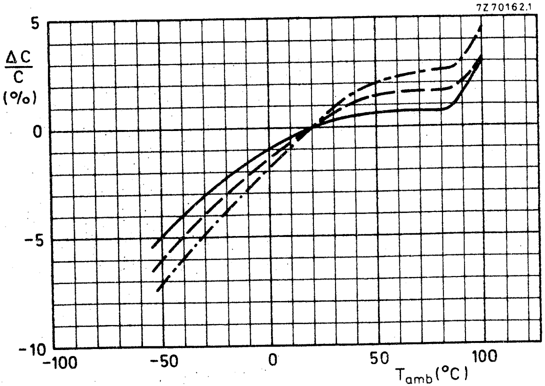

Fig. 3 Capacitance as a function of temperature; typical curves.
—— For all capacitance values, measured at 1 kHz, 1 V.
- - - - For capacitance values ≤ 1 μF, measured at 10 kHz, 1 V.
—.—. For capacitance values ≤ 0,1 μF, measured at 100 kHz, 0,3 V.

Voltage

Rated voltage U_R (d.c.)	100 V, 250 V, 400 V
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
Category voltage U_C	0,8 x U_R (d.c.)
Test voltage for 1 min	
between terminals	1,6 x U_R (d.c.)
between interconnected terminals and coating	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 of 100 ± 15 V has been applied for 1 min ± 5 s.

	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 and 400 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 and 400 V versions	> 10 000 s	> 33 s

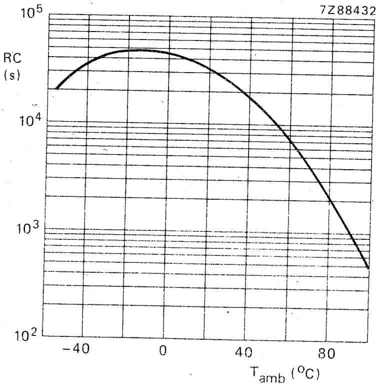

Fig. 4 RC-product as a function of temperature; typical curves.

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* For higher frequencies see Additional information.

Tan δ (tangent of the loss angle)

Tan δ at 10 kHz	$\leqslant 150 \times 10^{-4}$ (typ. 100×10^{-4})

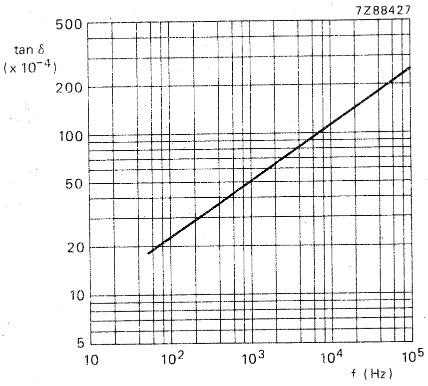

Fig. 5 Tan δ as a function of frequency; typical curve.

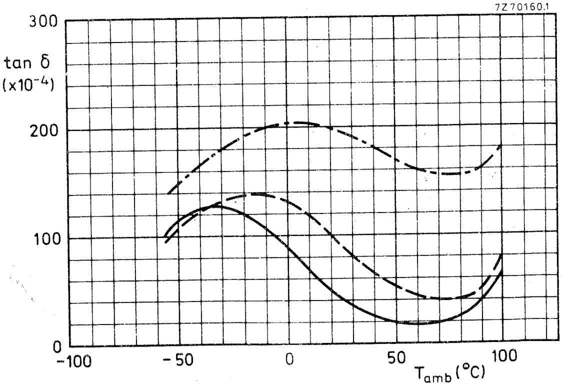

Fig. 6 Tan δ as a function of temperature; typical curves.

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

- - - - For capacitance values $\leqslant 1$ 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 disspation is satisfied, a check must be made to ascertain that the maximum permissible pulse steepness is not exceeded.

Pulse steepness

rated voltage	max. pulse steepness (V/μs)			
V	L = 14,5 mm	L = 18 mm	L = 23,5 mm	L = 31 mm
100	9	5,6	4	3
250	25	14	10	7,5
400	40	22	16	12

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

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.

ADDITIONAL INFORMATION

Power dissipation

The rated a.c. voltage has been specified for 50 to 60 Hz, at 23 °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.

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

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

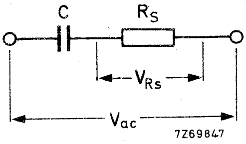

Fig. 7.

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

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

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

Thus

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

or

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

The term R_sC can be found from Fig. 8. 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. 9. Thus, when the actual power has been calculated with equation (3b), Fig. 9 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. 8 and Fig. 9

A capacitor with a value of 1 μF should be used at an a.c. voltage of 130 V, a frequency of 1 kHz and an ambient temperature of 50 °C. The R_sC- product is 7,5 x 10^{-7} s (from Fig. 8), so that the power to be dissipated

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

Figure 9 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.

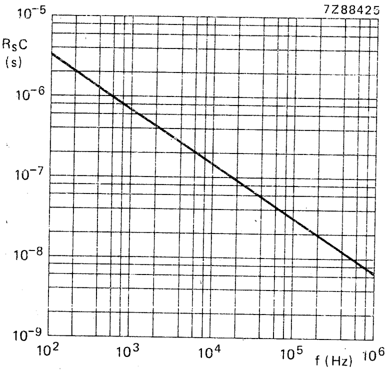

Fig. 8 Maximum product of series resistance and capacitance as a function of frequency.

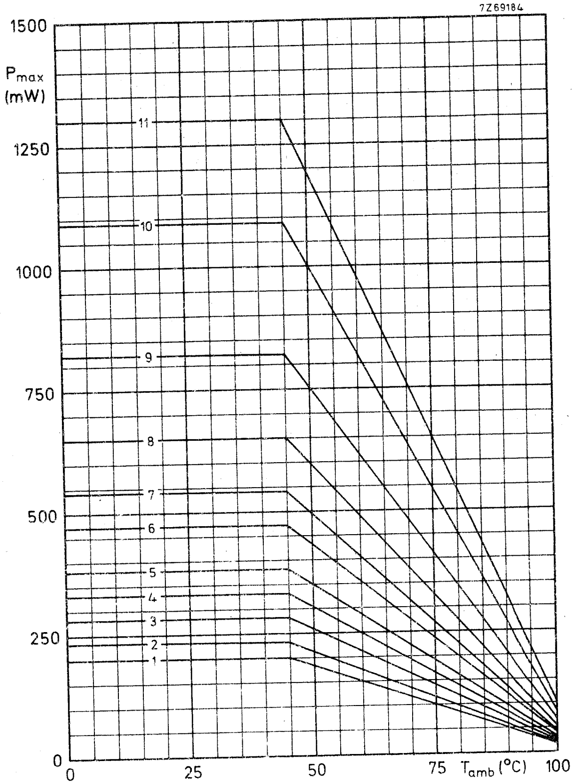

Fig. 9 Maximum permissible power dissipation as a function of temperature.

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 FILM CAPACITORS

potted type

QUICK REFERENCE DATA

Rated capacitance range (E 12-series)	0,01 to 10 μF			
Tolerance on rated capacitance	± 5%, ± 10%, ± 20%			
Rated voltage U_R (d.c.)	63 V	100 V	250 V	400 V
Rated voltage U_R (a.c.), 50 to 60 Hz	40 V	63 V	160 V	220 V
Rated temperature	85 °C			
Climatic category, IEC 68	55/100/56			
Basic specification	IEC 384-2			
Approval	CECC 30 401-039*			

APPLICATION

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

DESCRIPTION

The capacitors consist of a low-inductance wound cell of metallized polyethyleneterephthalate (PETP) 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.

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* For rated d.c. voltages of 100 V, 250 V and 400 V, and capacitance values according to the E 12-series.

MECHANICAL DATA

Dimensions in mm

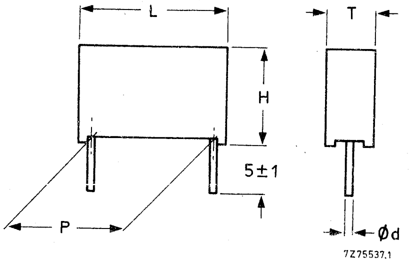

Fig. 1 For dimensions T, L, H, P and d, see tables below.

Table 1 U_R (d.c.) = 63 V; U_R (a.c.) = 40 V

rated capacitance* µF	T_{max}	L_{max}	H_{max}	P	d	mass g	catalogue number 2222 344	
							tol. ± 10%	tol. ± 20%
0,22	4,5	13	10	10 ± 0,4	0,8	0,7	15224	14224
0,33	5	13	11			0,9	15334	14334
0,47	6	13	12			1	15474	14474
0,68	6	17,5	11,5	15 ± 0,4		1,4	15684	14684
1,0	7	17,5	13			1,8	15105	14105
1,5	8,5	17,5	14,5			2,6	15155	14155
2,2	6,5	26	15,5	22,5 ± 0,4		2,8	15225	14225
3,3	8,5	26	18			4,3	15335	14335
4,7	9,5	26	19			5,1	15475	14475
6,8	11	30	20,5	27,5 ± 0,4		7,4	15685	14685
10	13,5	30	23			10,2	15106	14106

---

* 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

rated capacitance* µF	T_{max}	L_{max}	H_{max}	P	d	mass g	catalogue number 2222 344		
							tol. ± 5%	tol. ± 10%	tol. ± 20%
0,10	4,5	13	10	10 ± 0,4	0,8	0,7	23104	25104	24104
0,15	4,5	13	10			0,7	23154	25154	24154
0,22	5	13	11			0,9	23224	25224	24224
0,33	5	17,5	11	15 ± 0,4		1,1	23334	25334	24334
0,47	6	17,5	11,5			1,4	23474	25474	24474
0,68	7	17,5	13			1,8	23684	25684	24684
1,0	8,5	17,5	14,5			2,6	23105	25105	24105
1,5	6,5	26	15,5	22,5 ± 0,4		2,8	23155	25155	24155
2,2	8,5	26	18			4,3	23225	25225	24225
3,3	9,5	26	19			5,1	23335	25335	24335
4,7	11	30	20	27,5 ± 0,4		7,4	23475	25475	24475
6,8	13,5	31	22,5			10,2	23685	25685	24685
10	15	31	25		1,0	12,8	23106	25106	24106

Table 3 U_R (d.c.) = 250 V; U_R (a.c.) = 160 V

rated capacitance* µF	T_{max}	L_{max}	H_{max}	P	d	mass g	catalogue number 2222 344		
							tol. ± 5%	tol. ± 10%	tol. ± 20%
0,047	4,5	13	10	10 ± 0,4	0,8	0,7	42473	41473	40473
0,068	4,5	13	10			0,7	42683	41683	40683
0,10	5	17,5	11	15 ± 0,4		1,1	42104	41104	40104
0,15	5	17,5	11			1,1	42154	41154	40154
0,22	6	17,5	11,5			1,4	42224	41224	40224
0,33	7	17,5	13			1,8	42334	41334	40334
0,47	6,5	26	15,5	22,5 ± 0,4		2,8	42474	41474	40474
0,68	6,5	26	15,5			2,8	42684	41684	40684
1,0	8,5	26	18			4,4	42105	41105	40105
1,5	11	31	20	27,5 ± 0,4		7,4	42155	41155	40155
2,2	11	31	20			7,4	42225	41225	40225

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* 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

rated capacitance* μF	T_{max}	L_{max}	H_{max}	P	d	mass g	catalogue number 2222 344		
							tol. ± 5%	tol. ± 10%	tol. ± 20%
0,010	4,5	13	10	10 ± 0,4	0,8	0,7	53103	55103	54103
0,015	4,5	13	10			0,7	53153	55153	54153
0,022	4,5	13	10			0,7	53223	55223	54223
0,033	4,5	13	10			0,7	53333	55333	54333
0,047	5	17,5	11	15 ± 0,4		1,1	53473	55473	54473
0,068	6	17,5	11,5			1,4	53683	55683	54683
0,10	7	17,5	13			1,8	53104	55104	54104
0,15	8,5	17,5	14,5			2,6	53154	55154	54154
0,22	6,5	26	15,5	22,5 ± 0,4		2,8	53224	55224	54224
0,33	7,5	26	16,5			3,5	53334	55334	54334
0,47	9,5	26	19			5,1	53474	55474	54474
0,68	11	31	20	27,5 ± 0,4		7,4	53684	55684	54684
1,0	13,5	31	22,5			10,2	53105	55105	54105

Marking

The capacitors are marked on the top by embossed printed:

1st line: rated capacitance in μF, tolerance and rated d.c. voltage;
2nd line: MKT, 344, code for factory of origin.
Manufacturer's identification symbol at the left of this marking.

Mounting

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

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* 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 23 ± 1 °C, an atmospheric pressure of 86 to 106 kPa 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%*, ± 10% and ± 20%

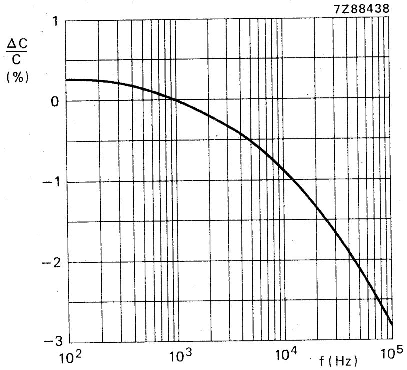

Fig. 2 Capacitance as a function of frequency; typical curve.
From 100 Hz to 1 kHz the curve is valid for all capacitance values (measuring voltage 1 V). From 1 to 10 kHz the curve is valid for capacitance values ⩽ 1 μF (measuring voltage 1 V). From 10 to 100 kHz the curve is valid for capacitance values ⩽ 0,1 μF (measuring voltage 0,3 V).

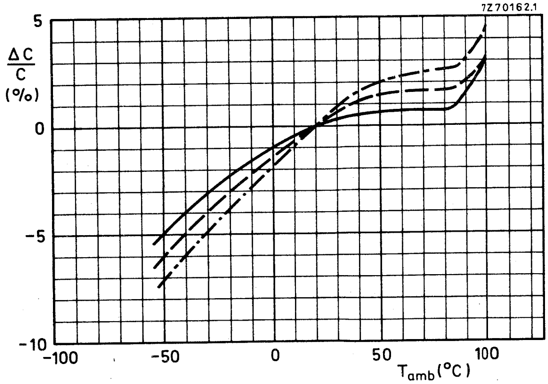

Fig. 3 Capacitance as a function of temperature; typical curves.
—— For all capacitance values, measured at 1 kHz, 1 V.
- - - - For capacitance values ⩽ 1 μF, measured at 10 kHz, 1 V.
—.—. For capacitance values ⩽ 0,1 μF, measured at 100 kHz, 0,3 V.

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* Not for 63 V version.

Voltage

Rated voltage U_R (d.c.)	63 V, 100 V, 250 V, 400 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 version	220 V
Category voltage U_C	0,8 x U_R (d.c.)
Test voltage for 1 min	
between terminals	1,6 x U_R (d.c.)
between interconnected terminals and coating	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.

	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 and 400 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 and 400 V versions	> 10 000 s	> 33 s

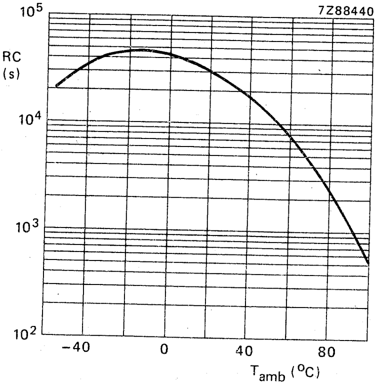

Fig. 4. RC-product as a function of temperature; typical curve.

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* For higher frequencies see Additional information.

Tan δ (tangent of the loss angle)

Tan δ at 10 kHz	⩽ 150 x 10^{-4} (typ. 100 x 10^{-4})

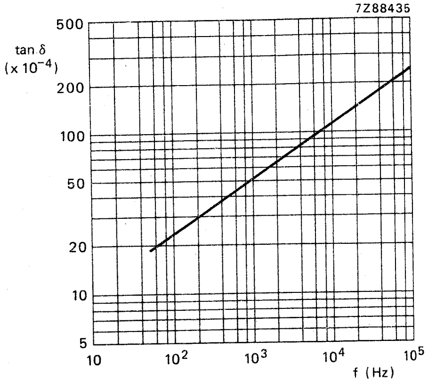

Fig. 5 Tan δ as a function of frequency; typical curve.

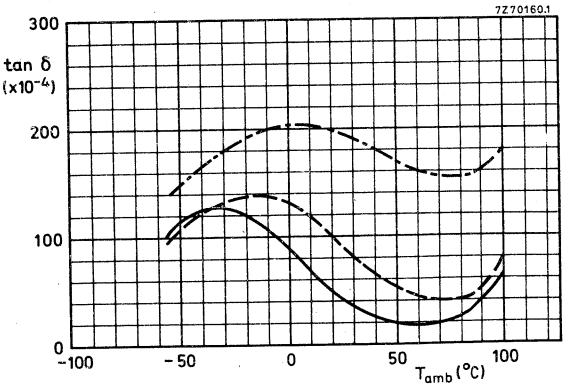

Fig. 6 Tan δ as a function of temperature; typical curves.

—— 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 Additonal 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 = 13 mm	L = 17,5 mm	L = 26 mm	L = 30 mm
63	4,2	2,6	1,7	1,4
100	9	5,6	3,5	3
250	25	14	9	7,5
400	40	22	14	12

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

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	
0,18 - 1,0	0,082 - 0,68	0,039 - 0,33	0,010 - 0,1	1000
1,2 - 1,5	0,82 - 1,0		0,12 - 0,15	500
1,8 - 4,7	1,2 - 3,3	0,39 - 1,0	0,18 - 0,47	200
5,6 - 10,0	3,9 - 10	1,2 - 2,2	0,56 - 1,0	100

ADDITIONAL INFORMATION

Power dissipation

The rated a.c. voltage has been specified for 50 to 60 Hz and at 23 °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.

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

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

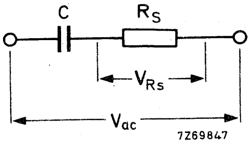

Fig. 7.

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

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

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

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. 8; 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. 9. Thus, when the actual power has been calculated with equation (3b), Fig. 9 gives the minimum size of capacitor which can dissipate this power.

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

Example of using Fig. 8 and Fig. 9

A capacitor with a dielectric of metallized PETP film and a value of 1 μF should be used at an a.c. voltage of 130 V, a frequency of 1 kHz and an ambient temperature of 50 °C. The R_sC-product is 7,5 x 10^{-7}s (from Fig. 8), 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. 9 shows that at 50 °C capacitors with curve numbers 8 to 13 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.

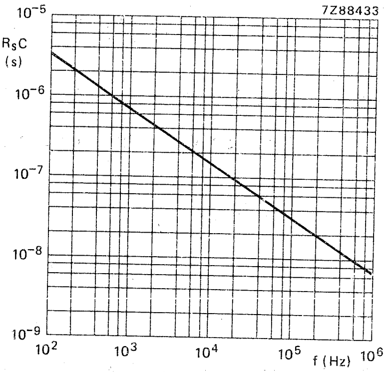

Fig. 8 Maximum product of series resistance and capacitance as a function of frequency.

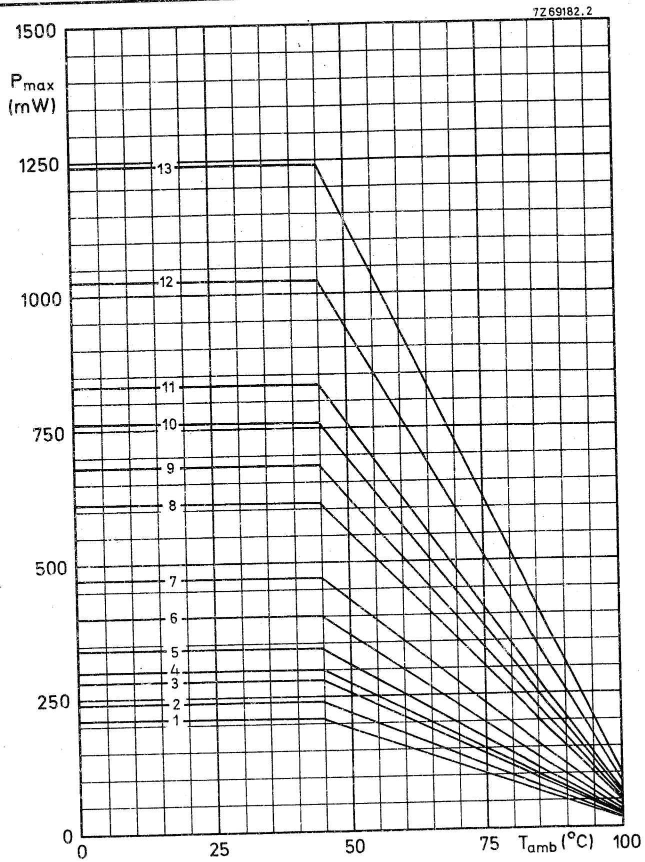

Fig. 9 Maximum permissible power dissipation as a function of temperature.

curve	dimensions (mm)		
	T_{max}	L_{max}	H_{max}
1	4,5	13	10
2	5	13	11
3	6	13	12
4	5	17,5	11
5	6	17,5	11,5
6	7	17,5	13
7	8,5	17,5	14,5
8	6,5	26	15,5
9	7,5	26	16,5
10	8,5	26	18
11	9,5	26	19
12	11	31	20
13	13,5	31	22,5

METALLIZED POLYESTER FILM CAPACITORS

lacquered type

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 384-2, grade 2

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 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.

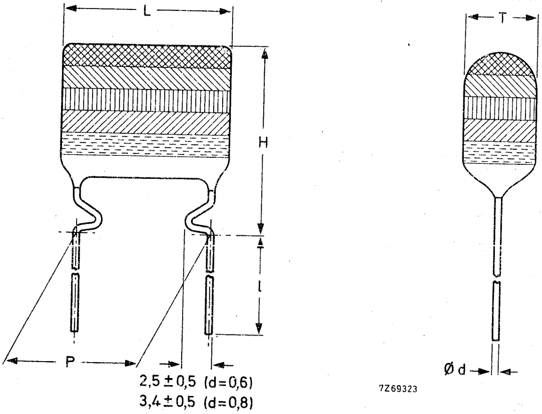

Table 1 U_R (d.c.) = 100 V; U_R (a.c.) = 63 V
The capacitors mentioned in this table are also available with lead length l = 5 – 1 mm.

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

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* 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

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* 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

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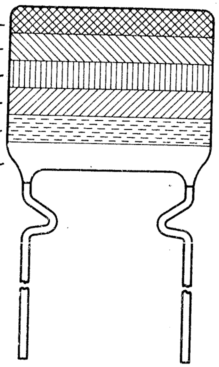
* e = 2,54 mm (0,1 in).

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 23 ± 1 °C, an atmospheric pressure of 86 to 106 kPa 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	± 10% and ± 20%

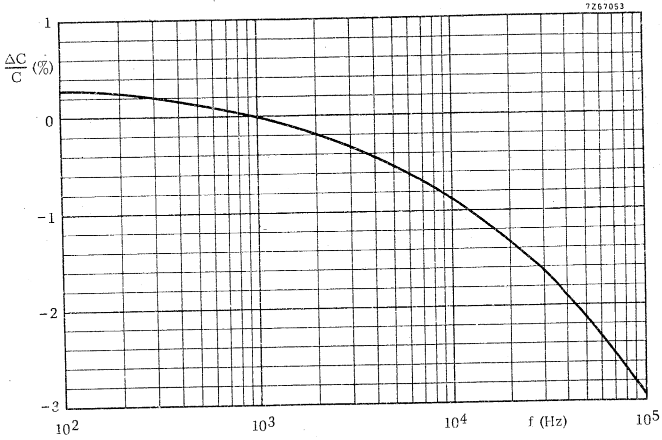


Fig. 2 Capacitance as a function of frequency; typical curve.

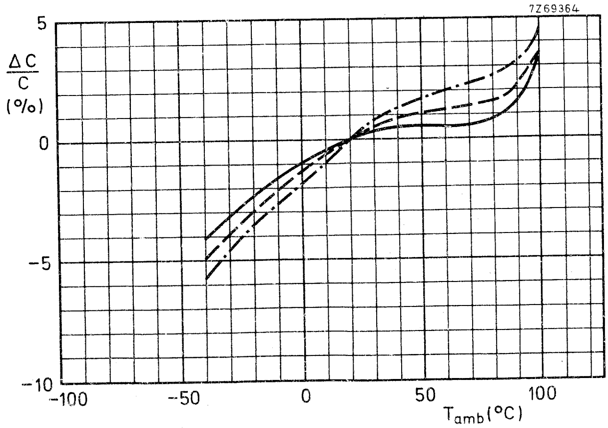


Fig. 3 Capacitance as a function of temperature; typical curves.
——— For all capacitance values, measured at 1 kHz, 1 V;
— — — For capacitance values ⩽ 1 μF, measured at 10 kHz, 1 V;
—.—.— For capacitance values ⩽ 0,1 μF, measured at 100 kHz, 0,3 V.

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.)
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 200 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

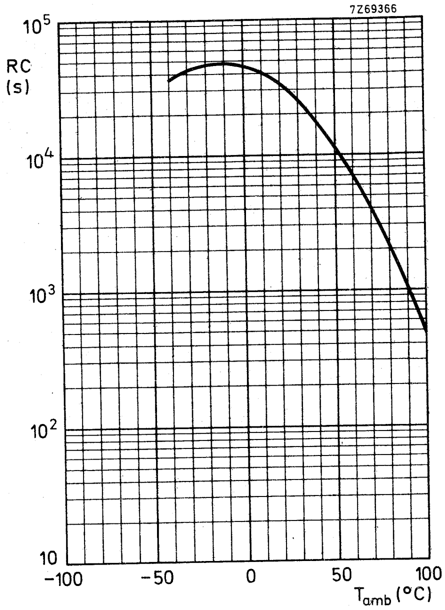


Fig. 4 RC-product as a function of temperature; typical curve.

Tan δ (tangent of the loss angle)

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

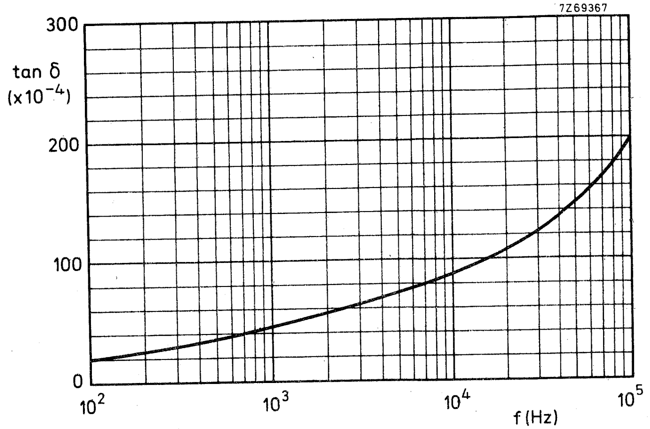


Fig. 5 Tan δ as a function of frequency; typical curve.

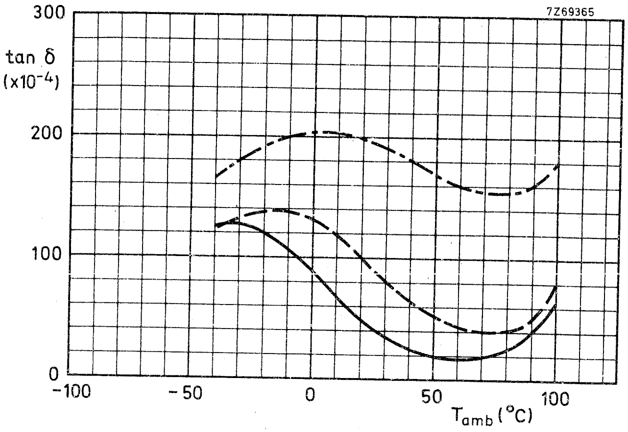


Fig. 6 Tan δ as a function of temperature; typical curves.
——— For all capacitance values, measured at 1 kHz, 1 V;
– – – For capacitance values ⩽ 1 μF, measured at 10 kHz, 1 V;
–.–.– For capacitance values ⩽ 0,1 μF, measured at 100 kHz, 0,3 V.

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	9	5,6	4	3
250	25	14	10	7,5
400	40	22	16	12
630	70	37	26	19

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

ADDITIONAL INFORMATION

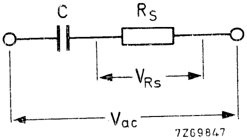
Power dissipation

The rated a.c. voltage has been specified for 50 to 60 Hz and at 23 °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.

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

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



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

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

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

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 equation (3b), Fig. 8 gives the minimum size of capacitor which can dissipate this power.

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

Example of using Fig. 7 and Fig. 8

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

$$P = (R_sC)\ C\omega^2 V_{ac}{}^2$$
$$= 7{,}1 \times 10^{-7} \times 0{,}68 \times 10^{-6} \times 4\,\pi^2 \times 1000^2 \times 130^2 = 322\ \text{mW}$$

Figure 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.

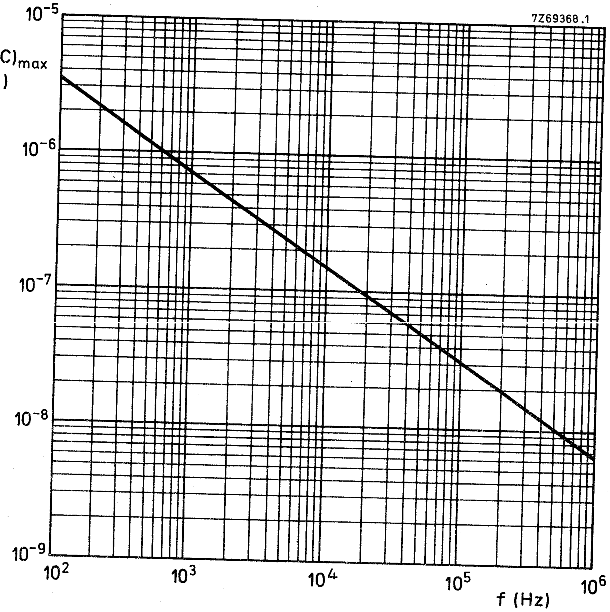
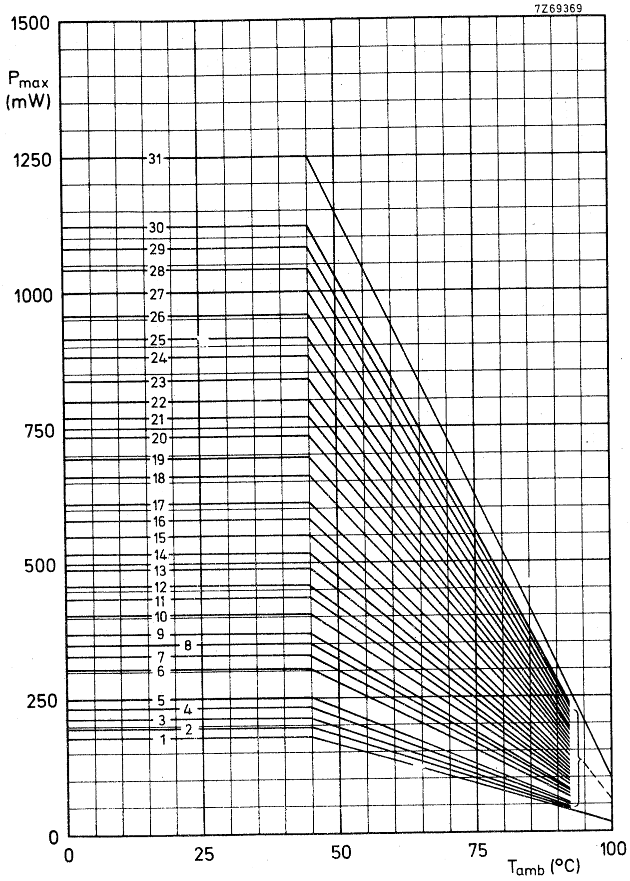


Fig. 7 Maximum product of series resistance and capacitance as a function frequency.



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.

METALLIZED POLYESTER FILM CAPACITORS

- Epoxy lacquered type; radial leads
- 5,08 mm pitch
- Supplied on reeled tape or on tape in ammunition pack

QUICK REFERENCE DATA

Rated capacitance range (E12-series)	0,0039 to 0,47 μF
Tolerance on rated capacitance	± 10% and ± 20%*
Rated voltage U_R (d.c.)	63 V, 100 V, 250 V, 400 V
Rated voltage U_R (a.c.), 50 to 60 Hz	40 V, 63 V, 160 V, 220 V
Rated temperature	85 °C
Climatic category, IEC 68	
2e (3e) version: 100 V, 250 V, 400 V	40/100/56
2e (3e) version: 63 V	40/100/21
2e version (Development Sample Data)	40/100/21
Basic specification	IEC 384-2, general-purpose grade

APPLICATION

For coupling and decoupling, especially where miniaturization is required.

DESCRIPTION

The capacitors consist of a low-inductance wound cell of metallized polyethyleneterephthalate (PETP) film. The cell is protected by a hard, water repellent, solvent resistant orange epoxy lacquer. The radial leads are tinned.

A 2e version and a 2e (3e) version are available. The former has a lead pitch of 2e (5,08 mm) and a natural body length for this pitch. The latter has a body length natural for a 3e lead pitch, but the pitch is reduced to 2e by bending the leads.

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* ± 5% on request except for the (natural) 2e version.

MECHANICAL DATA

Dimensions in mm

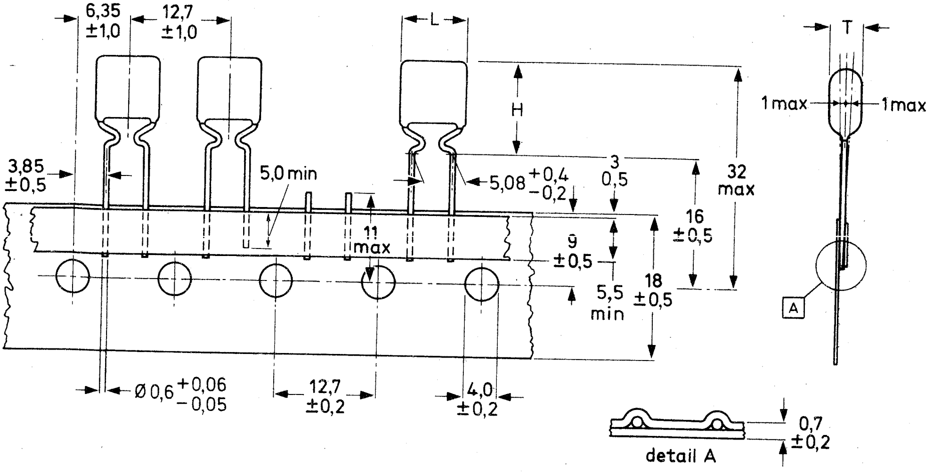

Fig. 1 For dimensions T, L and H, see Tables 1 to 4.

Cumulative feed-hole pitch error: 1,0 mm/20 pitches.
Maximum 0,25% of the total number of capacitors per reel may be missing, but no more than 2 consecutive positions will be vacant.

Table 1A U_R (d.c.) = 63 V; U_R (a.c.) = 40 V; 2e (3e) version

rated capacitance µF	T_{max}	H_{max}	L_{max}	mass g	catalogue number 2222 365			
					reel packing		ammunition packing	
					tol. ± 10%	tol. ± 20%	tol. ± 10%	tol. ± 20%
0,12	4	13,5	10	0,4	11124	10124	15124	14124
0,15	4	13,5	10	0,4	11154	10154	15154	14154
0,18	4	13,5	10	0,4	11184	10184	15184	14184
0,22	4,5	14	10,5	0,5	11224	10224	15224	14224
0,27	4,5	14	10,5	0,5	11274	10274	15274	14274
0,33	5	14,5	10,5	0,5	11334	10334	15334	14334
0,39	5,5	15	10,5	0,6	11394	10394	15394	14394
0,47	6	15,5	10,5	0,7	11474	10474	15474	14474

Table 1B U_R **(d.c.) = 63 V;** U_R **(a.c.) = 40 V; 2e version** *(Development Sample Data)*

rated capacitance µF	T_{max}	H_{max}	L_{max}	mass g	catalogue number 2222 365			
					reel packing		ammunition packing	
					tol. ± 10%	tol. ± 20%	tol. ± 10%	tol. ± 20%
0,047	4	11	7,5	0,30	71473	70473	75473	74473
0,056	4	11	7,5	0,30	71563	70563	75563	74563
0,068	4	11	7,5	0,30	71683	70683	75683	74683
0,082	4	11	7,5	0,30	71823	70823	75823	74823
0,10	4	11	7,5	0,30	71104	70104	75104	74104
0,12	4	11	7,5	0,30	71124	70124	75124	74124
0,15	4,5	11,5	8	0,35	71154	70154	75154	74154
0,18	4,5	11,5	8	0,35	71184	70184	75184	74184
0,22	5	12	8	0,40	71224	70224	75224	74224
0,27	5	12	8	0,40	71274	70274	75274	74274
0,33	5,5	12,5	8	0,45	71334	70334	75334	74334
0,39	5,5	12,5	8	0,45	71394	70394	75394	74394
0,47	6	13	8	0,50	71474	70474	75474	74474

Table 2A U_R **(d.c.) = 100 V;** U_R **(a.c.) = 63 V; 2e (3e) version**

rated capacitance µF	T_{max}	H_{max}	L_{max}	mass g	catalogue number 2222 365			
					reel packing		ammunition packing	
					tol. ± 10%	tol. ± 20%	tol. ± 10%	tol. ± 20%
0,039	4	13,5	10	0,4	21393	20393	25393	24393
0,047					21473	20473	25473	24473
0,056					21563	20563	25563	24563
0,068					21683	20683	25683	24683
0,082					21823	20823	25823	24823
0,10					21104	20104	25104	24104
0,12	4,5	14	10,5	0,5	21124	20124	25124	24124
0,15	5	14,5		0,5	21154	20154	25154	24154
0,18	5,5	15		0,6	21184	20184	25184	24184
0,22	6	15,5		0,7	21224	20224	25224	24224
0,27	6	15,5		0,7	21274	20274	25274	24274

Table 2B U_R **(d.c.) = 100 V;** U_R **(a.c.) = 63 V; 2e version** *(Development Sample Data)*

rated capacitance µF	T_{max}	H_{max}	L_{max}	mass g	catalogue number 2222 365			
					reel packing		ammunition packing	
					tol. ± 10%	tol. ± 20%	tol. ± 10%	tol. ± 20%
0,010	4	11	7,5	0,30	81103	80103	85103	84103
0,012	4	11	7,5	0,30	81123	80123	85123	84123
0,015	4	11	7,5	0,30	81153	80153	85153	84153
0,018	4	11	7,5	0,30	81183	80183	85183	84183
0,022	4	11	7,5	0,30	81223	80223	85223	84223
0,027	4	11	7,5	0,30	81273	80273	85273	84273
0,033	4	11	7,5	0,30	81333	80333	85333	84333
0,039	4	11	7,5	0,30	81393	80393	85393	84393
0,047	5	12	8	0,40	81473	80473	85473	84473
0,056	5	12	8	0,40	81563	80563	85563	84563
0,068	5	12	8	0,40	81683	80683	85683	84683
0,082	5	12	8	0,40	81823	80823	85823	84823
0,10	5,5	12,5	8	0,45	81104	80104	85104	84104

Table 3 U_R **(d.c.) = 250 V;** U_R **(a.c.) = 160 V; 2e (3e) version**

rated capacitance µF	T_{max}	H_{max}	L_{max}	mass g	catalogue number 2222 365			
					reel packing		ammunition packing	
					tol. ± 10%	tol. ± 20%	tol. ± 10%	tol. ± 20%
0,018	4	13,5	10	0,4	41183	40183	45183	44183
0,022					41223	40223	45223	44223
0,027					41273	40273	45273	44273
0,033					41333	40333	45333	44333

Table 4 U_R **(d.c.) = 400 V;** U_R **(a.c.) = 220 V; 2e (3e) version**

rated capacitance µF	T_{max}	H_{max}	L_{max}	mass g	catalogue number 2222 365			
					reel packing		ammunition packing	
					tol. ± 10%	tol. ± 20%	tol. ± 10%	tol. ± 20%
0,0039	4	13,5	10	0,4	51392	50392	55392	54392
0,0047					51472	50472	55472	54472
0,0056					51562	50562	55562	54562
0,0068					51682	50682	55682	54682
0,0082					51822	50822	55822	54822
0,010					51103	50103	55103	54103
0,012					51123	50123	55123	54123
0,015					51153	50153	55153	54153

Marking

The capacitors of the 2e (3e) version are marked in ink on the top as follows:
1st line: rated capacitance in pF or μF, and tolerance code (K = ± 10%, M = ± 20%);
2nd line: rated voltage (d.c.) and code for dielectric material (MKT = metallized PETP film).

The capacitors of the 2e version are marked in black ink on the top as follows:
1st line: rated capacitance in μF without unit symbol;
2nd line: tolerance code (± 10% identified by K, and ± 20% by M), and rated voltage (d.c.) without unit symbol.

Mounting

The capacitors are suitable for mounting on printed-wiring boards by means of automatic insertion machines.

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of 23 ± 1 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 50 ± 2%.

Capacitance

Rated capacitance (C_R) at 1 kHz	see Tables 1 to 4
Tolerance on rated capacitance	± 10% and ± 20% ± 5% on request (except for the 2e version)

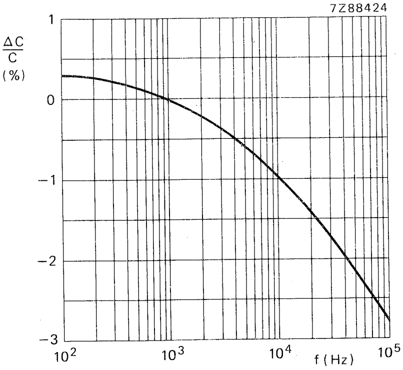

Fig. 2 Capacitance as a function of frequency; typical curve.

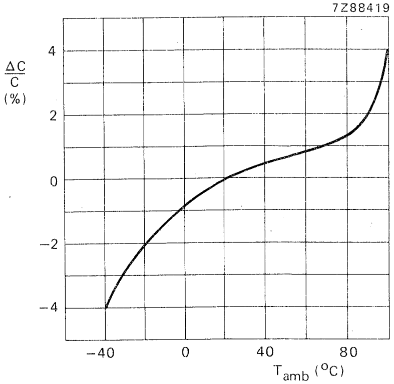

Fig. 3 Capacitance as a function of temperature; typical curve.

Voltage

Rated voltage U_R (d.c.)	63 V, 100 V, 250 V, 400 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 version	220 V
Category voltage U_C	0,8 x 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 200 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 10 ± 1 V for the 63 V version, and 100 ± 15 V for the 100 V, 250 V and 400 V versions.

	ambient temperature 20 °C	100 °C
R between terminals, 63 and 100 V capacitors (except $C_R > 0{,}33$ μF of the 2e version)	$>$ 15 000 MΩ	$>$ 75 MΩ
250 V and 400 V capacitors	$>$ 30 000 MΩ	$>$ 150 MΩ
RC between terminals, for $C_R > 0{,}33$ μF, 2e version	$>$ 5 000 s	$\geqslant$ 25 s
R between interconnected terminals and coating	$>$ 30 000 MΩ	

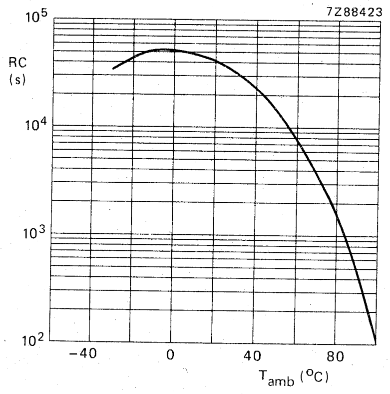

Fig. 4 RC product as a function of temperature; typical curve.

Tan δ (tangent of the loss angle)

Tan δ at 1 kHz	$\leqslant 75 \times 10^{-4}$
Tan δ at 10 kHz	$\leqslant 130 \times 10^{-4}$; typ. 90×10^{-4}
Tan δ at 100 kHz	$\leqslant 300 \times 10^{-4}$; typ. 150×10^{-4}

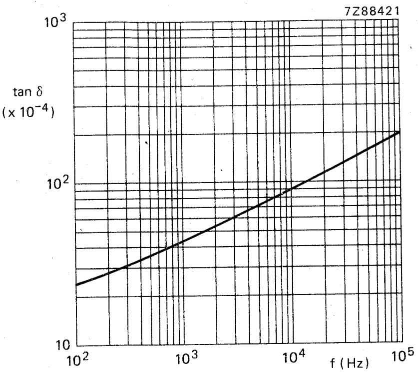

Fig. 5 Tan δ as a function of frequency; typical curve.

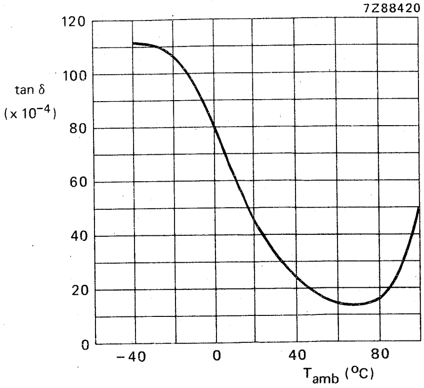

Fig. 6 Tan δ as a function of temperature; typical curve.

Power dissipation

Maximum permissible power dissipation	see Additional information

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

If the maximum permissible power dissipation is not exceeded check that the maximum permissible pulse steepness is not exceeded.

Pulse steepness

rated voltage V	maximum pulse steepness (V/μs)	
	2e (3e) version	2e version
63	6,3	10
100	12,5	19
250	42	
400	67	

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 is not exceeded, check 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	
2e (3e) version: 100 V, 250 V, 400 V	40/100/56
2e (3e) version: 63 V	40/100/21
2e version	40/100/21

PACKING

The capacitors are supplied on reeled tape or on tape in ammunition pack. The number of capacitors per reel and per pack is given in the table below.

thickness (T) of capacitors	number of capacitors per reel or per ammunition pack
4 mm	1500
4,5 or 5 mm	1300
5,5 or 6 mm	1100

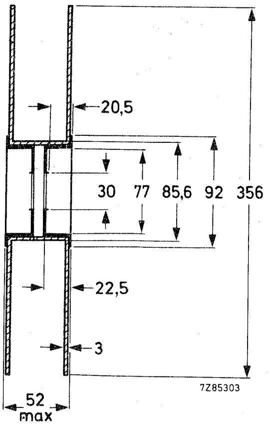

Fig. 7 Reel.

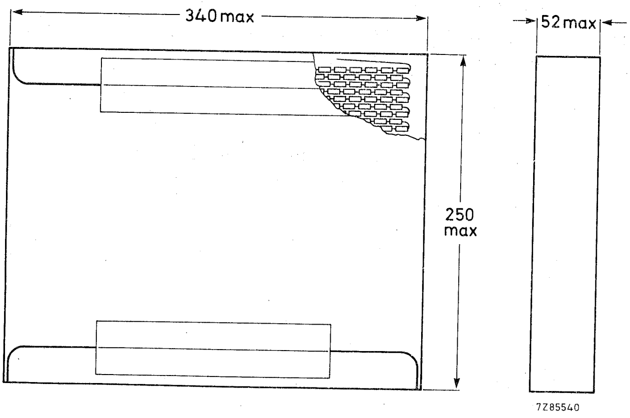

Fig. 8 Capacitors on tape in ammunition pack.

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.

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

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

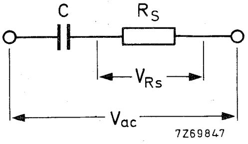

Fig. 9.

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

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

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

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. 10; 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. 11. Thus, when the actual power has been calculated with equation (3b), Fig.11 gives the minimum size of capacitor which can dissipate this power.

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

Example of using Fig. 10 and Fig. 11

A capacitor of 0,1 μF should be used at an a.c. voltage of 10 V, a frequency of 10 kHz and an ambient temperature of 50 °C.
The $R_S C$-product is $2{,}0 \times 10^{-7}$ s (from Fig. 10), so that the power to be dissipated is

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

$$= 2{,}0 \times 10^{-7} \times 0{,}1 \times 10^{-6} \times (2\pi)^2 \times 10^8 \times 10^2 = 7{,}9 \text{ mW}.$$

For use with 10 V, a capacitor of the 63 V range, 2e version, can be applied. Figure 11a shows that a capacitor of 0,1 μF/63 V is suitable because of its dimensions, 4 mm x 11 mm x 7,5 mm and its maximum permissible power dissipation of 73 mW at 50 °C. If a 2e (3e) version capacitor is desired, a suitable item can be found in the 100 V range (see Fig. 11b).

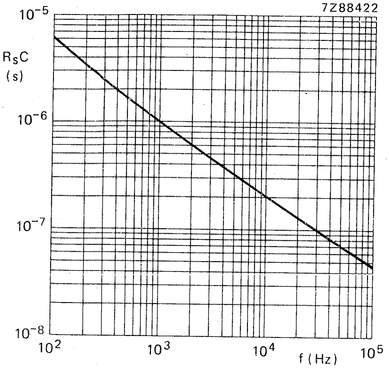

Fig. 10 R_sC-product as a function of frequency; typical curve.

Maximum permissible power dissipation as a function of temperature.

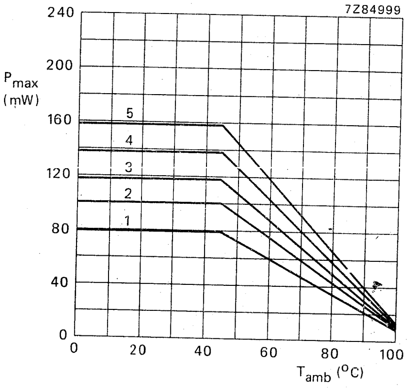

Fig. 11a.
2e version

curve	dimensions (mm)		
	T_{max}	H_{max}	L_{max}
1	4	11	7,5
2	4,5	11,5	8
3	5	12	8
4	5,5	12,5	8
5	6	13	8

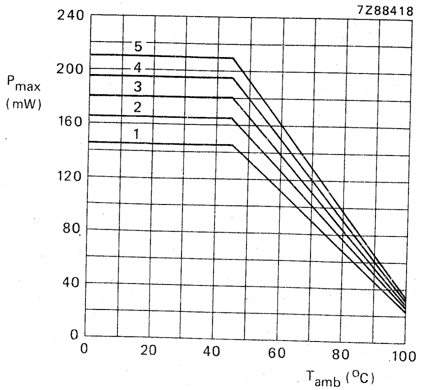

Fig. 11b.
2e (3e) version

curve	dimensions (mm)		
	T_{max}	H_{max}	L_{max}
1	4	13,5	10
2	4,5	14	10,5
3	5	14,5	10,5
4	5,5	15	10,5
5	6	15,5	10,5

METALLIZED POLYESTER FILM CAPACITORS

- Epoxy lacquered type; radial leads
- 7,62 mm and 5,08 mm pitch

QUICK REFERENCE DATA

Rated capacitance range (E12-series)	0,0039 to 0,47 μF
Tolerance on rated capacitance	± 10% and ± 20%*
Rated voltage U_R (d.c.)	63 V, 100 V, 250 V, 400 V
Rated voltage U_R (a.c.), 50 to 60 Hz	40 V, 63 V, 160 V, 220 V
Rated temperature	85 °C
Climatic category IEC 68	
lead pitch 7,62 mm: 100 V, 250 V, 400 V	40/100/56
lead pitch 7,62 mm: 63 V	40/100/21
lead pitch 5,08 mm (Development Sample Data)	40/100/21
Basic specification	IEC 384-2, G.P. grade

APPLICATION

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

DESCRIPTION

The capacitors consist of a low-inductance wound cell of metallized polyethyleneterephthalate (PETP) film. The cell is protected by a hard water repellent, solvent resistant orange epoxy lacquer. The radial leads are tinned.

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* Capacitors with a pitch of 7,62 mm available with ± 5% tol. on request.

MECHANICAL DATA

Dimensions in mm

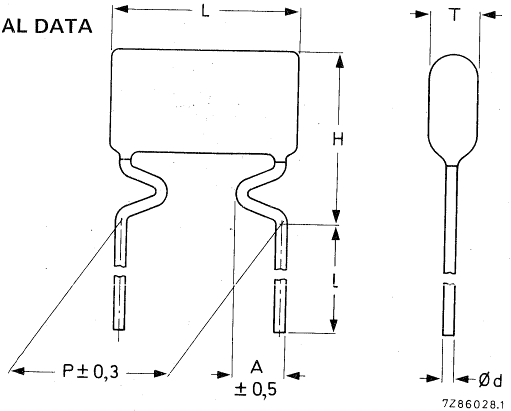

Fig. 1 For dimensions T, H, L, d, A and l see Tables 1 to 4.

Table 1A U_R (d.c.) = 63 V; U_R (a.c.) = 40 V, pitch P = 7,62 mm

rated capacitance μF	T_{max}	H_{max}	L_{max}	d	A	mass g	catalogue number 2222 366			
							l = 5–1		l = 17 ± 4	
							tol. ± 10%	tol. ± 20%	tol. ± 10%	tol. ± 20%
0,12	4	11	10	0,6	2,0	0,4	15124	14124	11124	10124
0,15	4	11	10			0,4	15154	14154	11154	10154
0,18	4	11	10			0,4	15184	14184	11184	10184
0,22	4,5	11,5	10,5			0,5	15224	14224	11224	10224
0,27	4,5	11,5	10,5			0,5	15274	14274	11274	10274
0,33	5	12	10,5			0,6	15334	14334	11334	10334
0,39	5,5	12,5	10,5			0,7	15394	14394	11394	10394
0,47	6	13	10,5			0,7	15474	14474	11474	10474

Table 1B U_R (d.c.) = 63 V; U_R (a.c.) = 40 V, pitch P = 5,08 mm *(Development Sample Data)*

rated capacitance μF	T_{max}	H_{max}	L_{max}	d	A	mass g	catalogue number 2222 366			
							l = 5–1		l = 17 ± 4	
							tol. ± 10%	tol. ± 20%	tol. ± 10%	tol. ± 20%
0,047	4	11	7,5	0,6	1,5	0,30	75473	74473	71473	70473
0,056	4	11	7,5			0,30	75563	74563	71563	70563
0,068	4	11	7,5			0,30	75683	74683	71683	70683
0,082	4	11	7,5			0,30	75823	74823	71823	70823
0,10	4	11	7,5			0,30	75104	74104	71104	70104
0,12	4	11	7,5			0,30	75124	74124	71124	70124
0,15	4,5	11,5	8			0,35	75154	74154	71154	70154
0,18	4,5	11,5	8			0,35	75184	74184	71184	70184
0,22	5	12	8			0,40	75224	74224	71224	70224
0,27	5	12	8			0,40	75274	74274	71274	70274
0,33	5,5	12,5	8			0,45	75334	74334	71334	70334
0,39	5,5	12,5	8			0,45	75394	74394	71394	70394
0,47	6	13	8			0,50	75474	74474	71474	70474

Table 2A U_R (d.c.) = 100 V; U_R (a.c.) = 63 V, pitch P = 7,62 mm

rated capacitance µF	T_{max}	H_{max}	L_{max}	d	A	mass g	catalogue number 2222 366			
							l = 5–1		l = 17 ± 4	
							tol. ± 10%	tol. ± 20%	tol. ± 10%	tol. ± 20%
0,039	4	11	10	0,6	2,0	0,4	25393	24393	21393	20393
0,047	4	11	10			0,4	25473	24473	21473	20473
0,056	4	11	10			0,4	25563	24563	21563	20563
0,068	4	11	10			0,4	25683	24683	21683	20683
0,082	4	11	10			0,4	25823	24823	21823	20823
0,10	4	11	10			0,4	25104	24104	21104	20104
0,12	4,5	11,5	10,5			0,5	25124	24124	21124	20124
0,15	5	12	10,5			0,5	25154	24154	21154	20154
0,18	5,5	12,5	10,5			0,6	25184	24184	21184	20184
0,22	6	13	10,5			0,7	25224	24224	21224	20224
0,27	6	13	10,5			0,7	25274	24274	21274	20274

Table 2B U_R (d.c.) = 100 V; U_R (a.c.) = 63 V, pitch P = 5,08 mm *(Development Sample Data)*

rated capacitance µF	T_{max}	H_{max}	L_{max}	d	A	mass g	catalogue number 2222 366			
							l = 5–1		l = 17 ± 4	
							tol. ± 10%	tol. ± 20%	tol. ± 10%	tol. ± 20%
0,010	4	11	7,5	0,6	1,5	0,30	85103	84103	81103	80103
0,012	4	11	7,5			0,30	85123	84123	81123	80123
0,015	4	11	7,5			0,30	85153	84153	81153	80153
0,018	4	11	7,5			0,30	85183	84183	81183	80183
0,022	4	11	7,5			0,30	85223	84223	81223	80223
0,027	4	11	7,5			0,30	85273	84273	81273	80273
0,033	4	11	7,5			0,30	85333	84333	81333	80333
0,039	4	11	7,5			0,40	85393	84393	81393	80393
0,047	5	12	8			0,40	85473	84473	81473	80473
0,056	5	12	8			0,40	85563	84563	81563	80563
0,068	5	12	8			0,40	85683	84683	81683	80683
0,082	5	12	8			0,40	85823	84823	81823	80823
0,10	5,5	12,5	8			0,45	85104	84104	81104	80104

Table 3 U_R (d.c.) = 250 V; U_R (a.c.) = 160 V, pitch P = 7,62 mm

rated capaci-tance μF	T_{max}	H_{max}	L_{max}	d	A	mass g	catalogue number 2222 366			
							l = 5–1		l = 17 ± 4	
							tol. ± 10%	tol. ± 20%	tol. ± 10%	tol. ± 20%
0,018	4	11	10	0,6	2,0	0,4	45183	44183	41183	40183
0,022							45223	44223	41223	40223
0,027							45273	44273	41273	40273
0,033							45333	44333	41333	40333

Table 4 U_R (d.c.) = 400 V; U_R (a.c.) = 220 V, pitch P = 7,62 mm

rated capaci-tance μF	T_{max}	H_{max}	L_{max}	d	A	mass g	catalogue number 2222 366			
							l = 5–1		l = 17 ± 4	
							tol. ± 10%	tol. ± 20%	tol. ± 10%	tol. ± 20%
0,0039	4	11	10	0,6	2,0	0,4	55392	54392	51392	50392
0,0047							55472	54472	51472	50472
0,0056							55562	54562	51562	50562
0,0068							55682	54682	51682	50682
0,0082							55822	54822	51822	50822
0,010							55103	54103	51103	50103
0,012							55123	54123	51123	50123
0,015							55153	54153	51153	50153

Marking

The capacitors with a pitch of 7,62 mm are marked in black ink on the top as follows:
1st line: rated capacitance in pF or μF, and tolerance code (± 10% identified by K, and ± 20% by M).
2nd line: rated voltage (d.c.) and code for dielectric material (MKT = metallized PETP film).

The capacitors with a pitch of 5,08 mm are marked in black ink on the top as follows:
1st line: rated capacitance in μF without unit symbol;
2nd line: tolerance code (± 10% identified by K, and ± 20% by M), and rated voltage (d.c.) without unit symbol.

Mounting

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

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of 23 ± 1 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 50 ± 2%.

Capacitance

Rated capacitance (C_R) at 1 kHz	see Tables 1 to 4
Tolerance on rated capacitance	± 10% and ± 20% ± 5% on request (except for capacitors with a lead pitch of 5,08 mm)

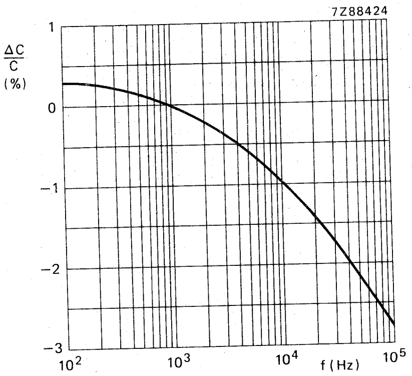

Fig. 2 Capacitance as a function of frequency; typical curve.

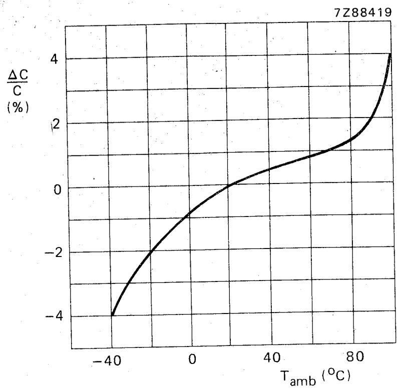

Fig. 3 Capacitance as a function of temperature; typical curve.

Voltage

Rated voltage U_R (d.c.)	63 V, 100 V, 250 V, 400 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 version	220 V
Category voltage U_C	0,8 x 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.)

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 10 ± 1 V for the 63 V version, and 100 ± 15 V for the 100 V, 250 V and 400 V versions.

	ambient temperature	
	20 °C	100 °C
R between terminals, 63 and 100 V capacitors (except $C_R > 0{,}33\ \mu F$ with 5,08 mm pitch)	$> 15\,000\ M\Omega$	$> 75\ M\Omega$
250 V and 400 V capacitors	$> 30\,000\ M\Omega$	$> 150\ M\Omega$
RC between terminals, for $C_R > 0{,}33\ \mu F$; 5,08 mm pitch	$> 5\,000$ s	$\geqslant 25$ s
R between interconnected terminals and coating	$> 30\,000\ M\Omega$	

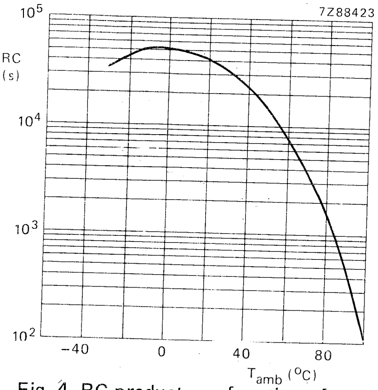

Fig. 4 RC product as a function of temperature; typical curve.

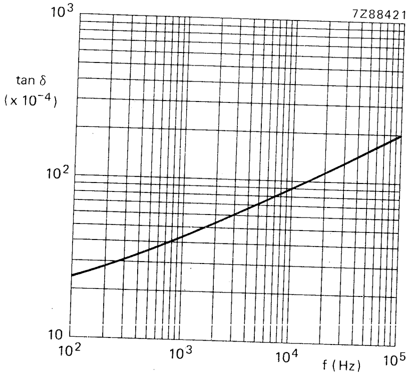

Fig. 5 Tan δ as a function of frequency; typical curve.

Tan δ (tangent of the loss angle)

Tan δ at 1 kHz	$\leqslant 75 \times 10^{-4}$
Tan δ at 10 kHz	$\leqslant 130 \times 10^{-4}$; typ. 90×10^{-4}
Tan δ at 100 kHz	$\leqslant 300 \times 10^{-4}$; typ. 150×10^{-4}

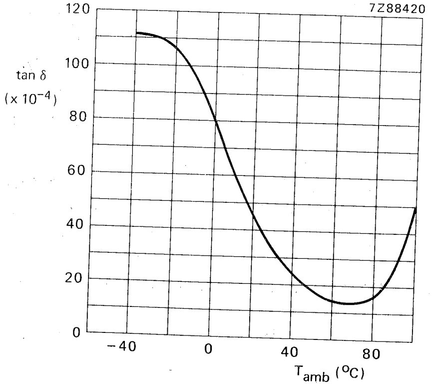

Fig. 6 Tan δ as a function of temperature; typical curve.

Power dissipation

Maximum permissible power dissipation — see Additional information

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

If the maximum permissible power dissipation is not exceeded, check that the maximum permissible pulse steepness is not exceeded.

Pulse steepness

rated voltage V	maximum pulse steepness (V/μs) lead pitch 7,62 mm	 lead pitch 5,08 mm
63	6,3	10
100	12,5	19
250	42	
400	67	

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	
lead pitch 7,62 mm: 100 V, 250 V, 400 V	40/100/56
lead pitch 7,62 mm: 63 V	40/100/21
lead pitch 5,08 mm	40/100/21

PACKING

The capacitors are supplied in boxes. For the number of capacitors per box see table below.

thickness (T) of capacitors	number of capacitors per box pitch 5,08 mm l = 5−1 mm	 l = 17 ± 4 mm	 pitch 7,62 mm l = 5−1 mm	 l = 17 ± 4 mm
4 mm	5000	2500	1500	1500
4,5 or 5 mm	3000	1500	1300	1300
5,5 or 6 mm	3000	1500	1100	1100

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.

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

$$P = \frac{V_{Rs}^2}{R_s} = I^2 R_s \tag{1}$$

$$V_{Rs}^2 = \frac{R_s^2}{R_s^2 + 1/\omega^2 C^2} V_{ac}^2 \tag{2a}$$

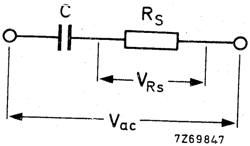

Fig. 7.

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

$$V_{Rs}^2 = \frac{R_s^2}{1/\omega^2 C^2} V_{ac}^2 = R_s^2 \omega^2 C^2 V_{ac}^2 \tag{2b}$$

Thus $$P = R_s\omega^2 C^2 V_{ac}^2 \tag{3a}$$

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

The term R_sC can be found from Fig. 8; 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. 9. Thus, when the actual power has been calculated with equation (3b), Fig. 9 gives the minimum size of capacitor which can dissipate this power.

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

Example of using Fig. 8 and Fig. 9

A capacitor of 0,1 μF should be used at an a.c. voltage of 10 V, a frequency of 10 kHz and an ambient temperature of 50 °C.
The R_sC-product is $2{,}0 \times 10^{-7}$ s (from Fig. 8), so that the power to be dissipated is

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

$$= 2{,}0 \times 10^{-7} \times 0{,}1 \times 10^{-6} \times (2\pi)^2 \times 10^8 \times 10^2 = 7{,}9 \text{ mW}.$$

For use with 10 V, a capacitor of the 63 V range, 2e version, can be applied. Figure 9a shows that a capacitor of 0,1 μF/63 V is suitable because of its dimensions, 4 mm x 11 mm x 7,5 mm and its maximum permissible power dissipation of 73 mW at 50 °C. If a 2e (3e) version capacitor is desired, a suitable item can be found in the 100 V range (see Fig. 9b).

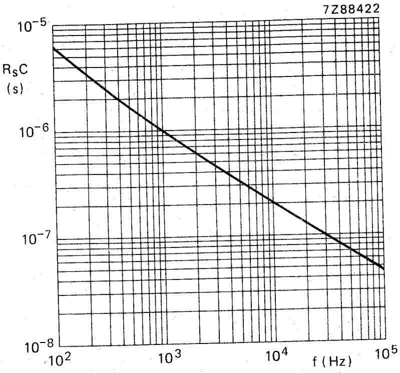

Fig. 8 R_sC-product as a function of temperature; typical curve.

Maximum permissible power dissipation as a function of temperature

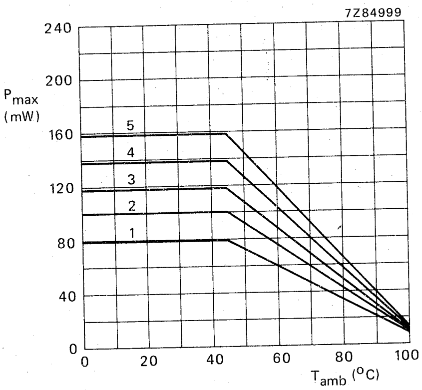

Fig. 9a.
Lead pitch 5,08 mm

curve	dimensions (mm)		
	T_{max}	H_{max}	L_{max}
1	4	11	7,5
2	4,5	11,5	8
3	5	12	8
4	5,5	12,5	8
5	6	13	8

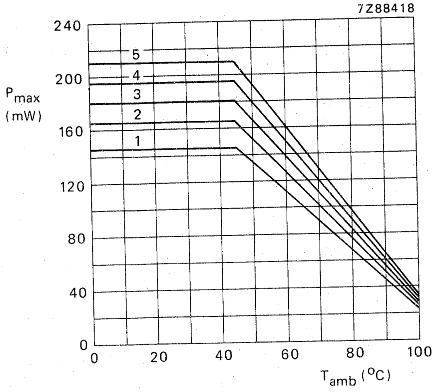

Fig. 9b.
Lead pitch 7,62 mm

curve	dimensions (mm)		
	T_{max}	H_{max}	L_{max}
1	4	13,5	10
2	4,5	14	10,5
3	5	14,5	10,5
4	5,5	15	10,5
5	6	15,5	10,5

METALLIZED POLYESTER FILM CAPACITORS

- Epoxy lacquered
- 10,16 mm, 15,24 mm, 22,86 mm and 27,94 mm pitch

QUICK REFERENCE DATA

Rated capacitance range (E12-series)	0,001 to 5,6 μF
Tolerance on rated capacitance	± 10% and ± 20%*
Rated voltage U_R (d.c.)	100 V, 250 V, 400 V
Rated voltage U_R (a.c.), 50 to 60 Hz	63 V, 160 V, 220 V
Rated temperature	85 °C
Climatic category IEC 68	40/100/56
Basic specification	IEC 384-2, long-life grade

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 orange epoxy lacquer. The radial leads are solder coated copper wire.

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* ± 5% to special order.

MECHANICAL DATA

Dimensions in mm

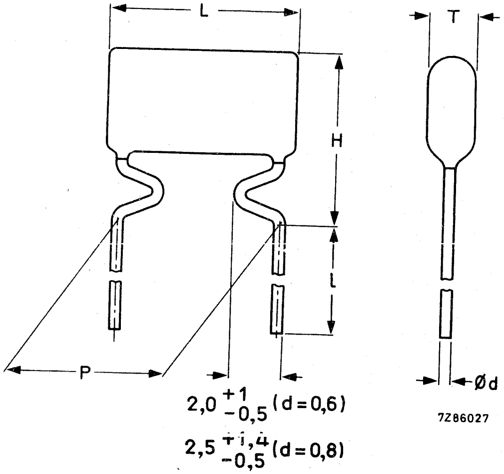


Fig. 1 For dimensions T, L, H, P, d and l, see Tables 1 to 3.

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

rated capacitance μF	T_{max}	H_{max}	L_{max}	d	P	mass	catalogue number 2222 368			
							l = 5−1		l = 17 ± 4	
						g	tol. ± 10%	tol. ± 20%	tol. ± 10%	tol. ± 20%
0,056	4	12	12,5	0,6	10,16 ± 0,3	0,4	25563	24563	21563	20563
0,068	4	12	12,5			0,4	25683	24683	21683	20683
0,082	4	12	12,5			0,4	25823	24823	21823	20823
0,10	4	12	12,5			0,4	25104	24104	21104	20104
0,12	4,5	12,5	12,5			0,4	25124	24124	21124	20124
0,15	4,5	12,5	12,5			0,45	25154	24154	21154	20154
0,18	5	13	12,5			0,5	25184	24184	21184	20184
0,22	5,5	13,5	12,5			0,55	25224	24224	21224	20224
0,27	5	14	17,5	0,8	15,24 ± 0,3	0,5	25274	24274	21274	20274
0,33	5	14	17,5			0,6	25334	24334	21334	20334
0,39	5,5	14,5	17,5			0,65	25394	24394	21394	20394
0,47	6	15	17,5			0,75	25474	24474	21474	20474
0,56	6,5	15,5	17,5			0,85	25564	24564	21564	20564
0,68	7	16	17,5			1,0	25684	24684	21684	20684
0,82	7,5	16,5	17,5			1,2	25824	24824	21824	20824
1,0	8,5	17,5	17,5			1,4	25105	24105	21105	20105

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

rated capacitance µF	T_{max}	H_{max}	L_{max}	d	P	mass g	catalogue number 2222 368			
							l = 5–1		l = 17 ± 4	
							tol. ± 10%	tol. ± 20%	tol. ± 10%	tol. ± 20%
1,2	6	18	26	0,8	22,86 ± 0,3	1,8	25125	24125	21125	20125
1,5	6,5	18,5	26			2,0	25155	24155	21155	20155
1,8	7	19	26			2,3	25185	24185	21185	20185
2,2	8	20	26			2,8	25225	24225	21225	20225
2,7	8,5	20,5	26			3,2	25275	24275	21275	20275
3,3	9,5	21,5	26			4,0	25335	24335	21335	20335
3,9	10	22	30	0,8	27,94 ± 0,3	4,5	25395	24395	21395	20395
4,7	11	23	30			5,2	25475	24475	21475	20475
5,6	12	24	30			6,0	22565	24565	21565	20565

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

rated capacitance µF	T_{max}	H_{max}	L_{max}	d	P	mass g	catalogue number 2222 368			
							l = 5–1		l = 17 ± 4	
							tol. ± 10%	tol. ± 20%	tol. ± 10%	tol. ± 20%
0,027	4	12	12,5	0,6	10,16 ± 0,3	0,4	45273	44273	41273	40273
0,033	4	12	12,5			0,4	45333	44333	41333	40333
0,039	4	12	12,5			0,4	45393	44393	41393	40393
0,047	4	12	12,5			0,4	45473	44473	41473	40473
0,056	4,5	12,5	12,5			0,4	45563	44563	41563	40563
0,068	4,5	12,5	12,5			0,45	45683	44683	41683	40683
0,082	5	13	12,5			0,5	45823	44823	41823	40823
0,10	5	13	12,5			0,55	45104	44104	41104	40104
0,12	5	14	17,5	0,8	15,24 ± 0,3	0,65	45124	44124	41124	40124
0,15	5	14	17,5			0,7	45154	44154	41154	40154
0,18	5,5	14,5	17,5			0,8	45184	44184	41184	40184
0,22	6	15	17,5			0,9	45224	44224	41224	40224
0,27	6,5	15,5	17,5			1,1	45274	44274	41274	40274
0,33	7	16	17,5			1,3	45334	44334	41334	40334
0,39	5	17	26	0,8	22,86 ± 0,3	1,8	45394	44394	41394	40394
0,47	5,5	17,5	26			2,1	45474	44474	41474	40474
0,56	6	18	26			2,5	45564	44564	41564	40564
0,68	6,5	18,5	26			2,9	45684	44684	41684	40684
0,82	7	19	26			3,3	45824	44824	41824	40824
1,0	7,5	19,5	26			3,6	45105	44105	41105	40105
1,2	7,5	19,5	30	0,8	27,94 ± 0,3	4,0	45125	44125	41125	40125
1,5	8,5	20,5	30			5,1	45155	44155	41155	40155
1,8	9,5	21,5	30			5,9	45185	44185	41185	40185

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

rated capacitance µF	T_{max}	H_{max}	L_{max}	d	P	mass g	catalogue number 2222 368			
							l = 5−1		l = 17 ± 4	
							tol. ± 10%	tol. ± 20%	tol. ± 10%	tol. ± 20%
0,0010	4	12	12,5	0,6	10,16 ± 0,3	0,4	55102	54102	51102	50102
0,0012	4	12	12,5			0,4	55122	54122	51122	50122
0,0015	4	12	12,5			0,4	55152	54152	51152	50152
0,0018	4	12	12,5			0,4	55182	54182	51182	50182
0,0022	4	12	12,5			0,4	55222	54222	51222	50222
0,0027	4	12	12,5			0,4	55272	54272	51272	50272
0,0033	4	12	12,5			0,4	55332	54332	51332	50332
0,0039	4	12	12,5			0,4	55392	54392	51392	50392
0,0047	4	12	12,5			0,4	55472	54472	51472	50472
0,0056	4	12	12,5			0,4	55562	54562	51562	50562
0,0068	4	12	12,5			0,4	55682	54682	51682	50682
0,0082	4	12	12,5			0,4	55822	54822	51822	50822
0,010	4	12	12,5			0,4	55103	54103	51103	50103
0,012	4	12	12,5			0,4	55123	54123	51123	50123
0,015	4	12	12,5			0,4	55153	54153	51153	50153
0,018	4	12	12,5			0,4	55183	54183	51183	50183
0,022	4	12	12,5			0,4	55223	54223	51223	50223
0,027	4,5	12,5	12,5			0,45	55273	54273	51273	50273
0,033	4,5	12,5	12,5			0,45	55333	54333	51333	50333
0,039	5	14	17,5	0,8	15,24 ± 0,3	0,6	55393	54393	51393	50393
0,047	5	14	17,5			0,6	55473	54473	51473	50473
0,056	5	14	17,5			0,65	55563	54563	51563	50563
0,068	5	14	17,5			0,7	55683	54683	51683	50683
0,082	5,5	14,5	17,5			0,8	55823	54823	51823	50823
0,10	6	15	17,5			0,9	55104	54104	51104	50104
0,12	6,5	15,5	17,5			1,1	55124	54124	51124	50124
0,15	7	16	17,5			1,3	55154	54154	51154	50154
0,18	5	17	26	0,8	22,86 ± 0,3	1,6	55184	54184	51184	50184
0,22	5,5	17,5	26			1,9	55224	54224	51224	50224
0,27	6	18	26			2,3	55274	54274	51274	50274
0,33	6,5	18,5	26			2,6	55334	54334	51334	50334
0,39	7	19	26			3,0	55394	54394	51394	50394
0,47	8	20	26			3,4	55474	54474	51474	50474
0,56	8	20	30	0,8	27,94 ± 0,3	3,5	55564	54564	51564	50564
0,68	8,5	20,5	30			4,0	55684	54684	51684	50684
0,82	9,5	21,5	30			4,5	55824	54824	51824	50824

Marking

The capacitors are marked in black ink on the top as follows:
1st line: rated capacitance in pF or μF, and tolerance (± 10% identified by K or 10%, ± 20% by M or 20%).
2nd line: rated voltage (d.c.) and code for dielectric material (MKT = metallized PETP film).
The manufacturer's name is at the left and code for factory of origin is indicated to the right of this marking.

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 23 ± 1 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 50 ± 2%.

Capacitance

Rated capacitance values (C_R) at 1 kHz	see Tables 1 to 3
Tolerance on rated capacitance	± 10% and ± 20% ± 5% to special order

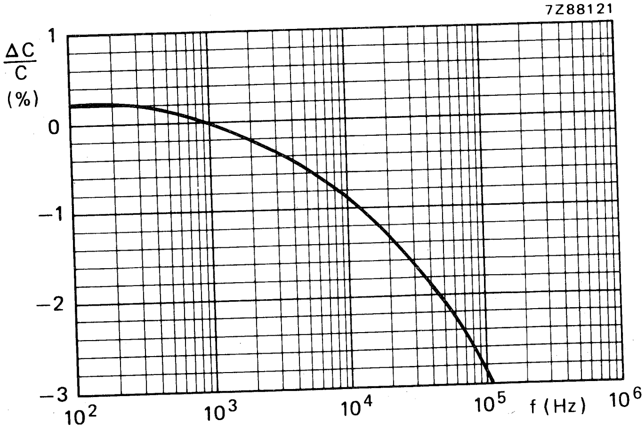


Fig. 2 Capacitance as a function of frequency; typical curve.

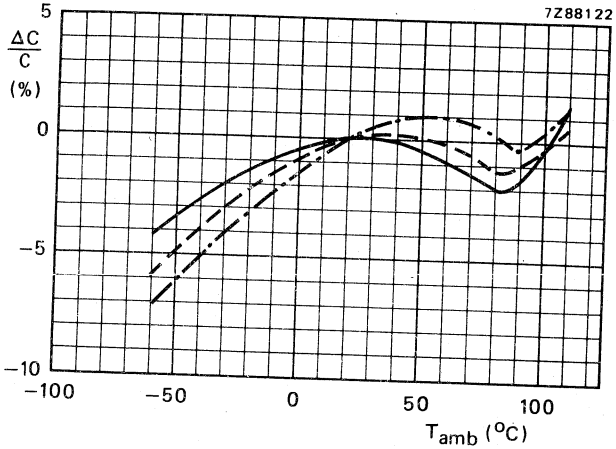


Fig. 3 Capacitance as a function of temperature; typical curves.
———— For all capacitance values, measured at 1 kHz, 1 V.
– – – – For capacitance values ⩽ 1 μF, measured at 10 kHz, 1 V.
– · – · – For capacitance values ⩽ 0,1 μF, measured at 100 kHz, 0,3 V.

Voltage

Rated voltage U_R (d.c.)	100 V, 250 V, 400 V
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
Category voltage U_C	0,8 x 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.)

Note

The sum of the d.c. voltage and the peak value of the superimposed a.c. voltage must be ⩽ U_R (d.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	
	20 °C	100 °C
R between terminals, for $C_R \leqslant 0,33\ \mu F$		
100 V version	> 15 000 MΩ	> 75 MΩ
250 V and 400 V versions	> 30 000 MΩ	> 150 MΩ
RC between terminals, for $C_R > 0,33\ \mu F$		
100 V version	> 5 000 s	> 25 s
250 V and 400 V versions	> 10 000 s	> 50 s
R between interconnected terminals and coating	> 30 000 MΩ	

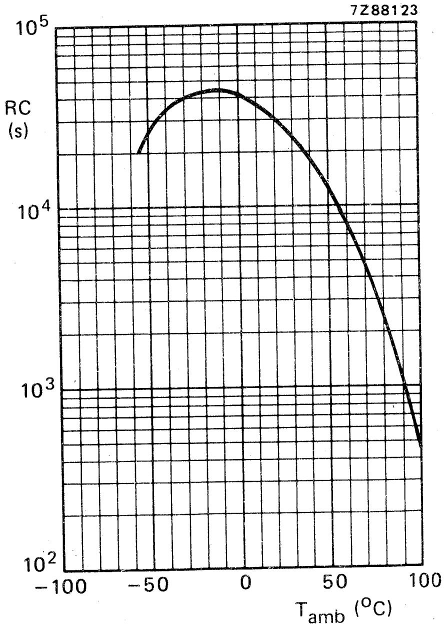


Fig. 4 RC product as a function of temperature; typical curve.

Tan δ (tangent of the loss angle)

Tan δ at 1 kHz	$\leqslant$ 75 x 10^{-4}
Tan δ at 10 kHz	$\leqslant$ 150 x 10^{-4}

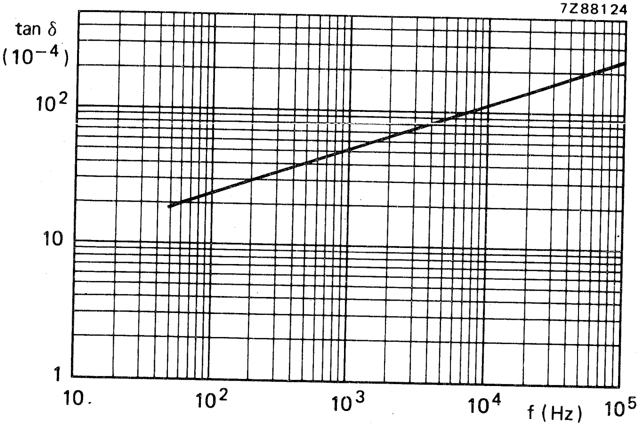


Fig. 5 Tan δ as a function of frequency; typical curve.

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 = 26 mm	L = 30 mm
100	9	5,6	4	3
250	25	14	10	7,5
400	40	22	16	12

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 $\hat{U}_R$/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	40/100/56

PACKING

The capacitors are packed in boxes. For the number of capacitors per box see table below.

L_{max}	T_{max}	number of capacitors per box	
		l = 5−1 mm	l = 17 ± 4 mm
12,5 mm 17,5 mm		2000	1000
26 mm	⩽ 7 mm	2000	1000
	> 7 mm	1000	1000
30 mm	⩽ 9,5 mm	1000	500
	> 9,5 mm	500	500

ADDITIONAL INFORMATION

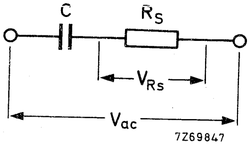
Power dissipation

The rated a.c. voltage has been specified for 50 to 60 Hz and at 23 °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.

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

$$P = \frac{V_{Rs}^2}{R_s} = I^2 R_s \tag{1}$$



$$V_{Rs}^2 = \frac{R_s^2}{R_s^2 + 1/\omega^2 C^2} V_{ac}^2 \tag{2a}$$

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

$$V_{Rs}^2 = \frac{R_s^2}{1/\omega^2 C^2} V_{ac}^2 = R_s^2 \omega^2 C^2 V_{ac}^2 \tag{2b}$$

Thus $$P = R_s \omega^2 C^2 V_{ac}^2 \tag{3a}$$

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

The term R_sC can be found from Fig. 6; 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. 7. Thus, when the actual power has been calculated with equation (3b), Fig. 7 gives the minimum size of capacitor which can dissipate this power.

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

Example of using Fig. 6 and Fig. 7

A capacitor of 0,15 μF should be used at an a.c. voltage of 130 V, a frequency of 1 kHz and an ambient temperature of 60 °C.
The R_sC-product is 7,0 x 10^{-7} s (from Fig. 6), so that the power to be dissipated is

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

$$= 7{,}0 \times 10^{-7} \times 0{,}15 \times 10^{-6} \times (2\pi)^2 \times 10^6 \times 130^2 = 70 \text{ mW}.$$

For use with 130 V, a capacitor of at least the 250 V range is required. Figure 7 shows that a capacitor 0,15 μF/250 V can be used because of its dimensions, 5 mm x 14 mm x 17,5 mm and its maximum permissible power dissipation of 210 mW at 60 °C.

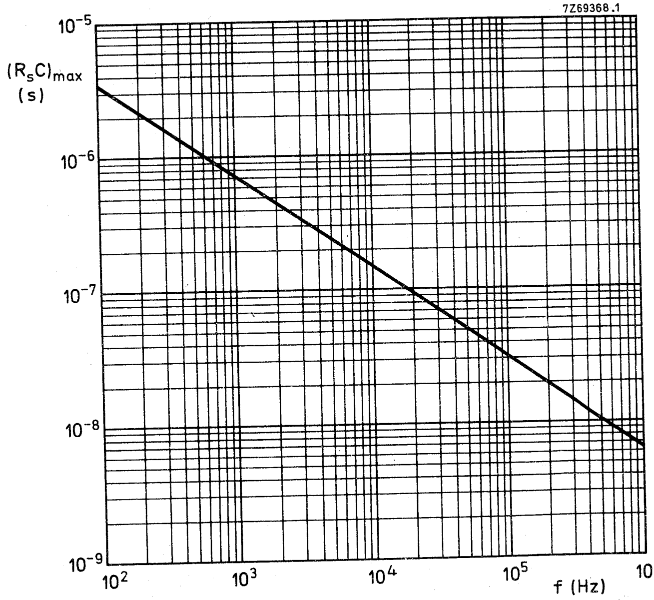


Fig. 6 R_sC-product as a function of frequency; typical curve.

curve	dimensions (mm)		
	T_{max}	H_{max}	L_{max}
1	4	12	12,5
2	4,5	12,5	12,5
3	5	13	12,5
4	5,5	13,5	12,5
5	5	14	17,5
6	5,5	14,5	17,5
7	6	15	17,5
8	6,5	15,5	17,5
9	7	16	17,5
10	7,5	16,5	17,5
11	8,5	17,5	17,5

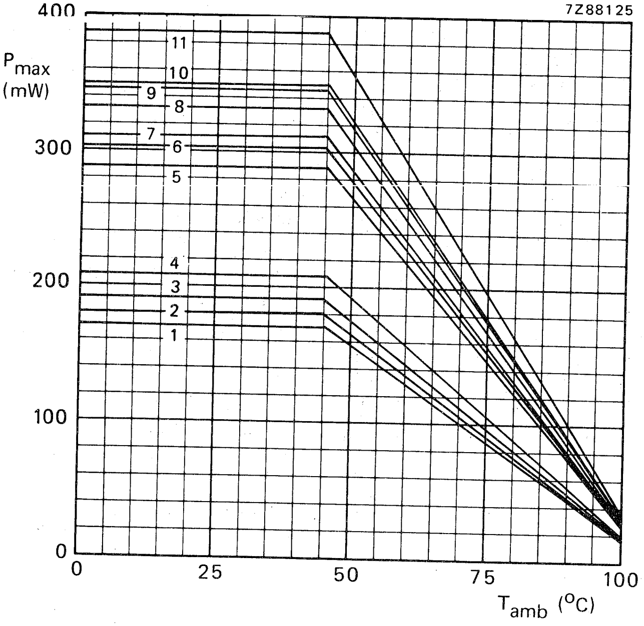


Fig. 7 Maximum permissible power dissipation as a function of temperature, for capacitors with L_{max} = 12,5 and 17,5 mm.

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

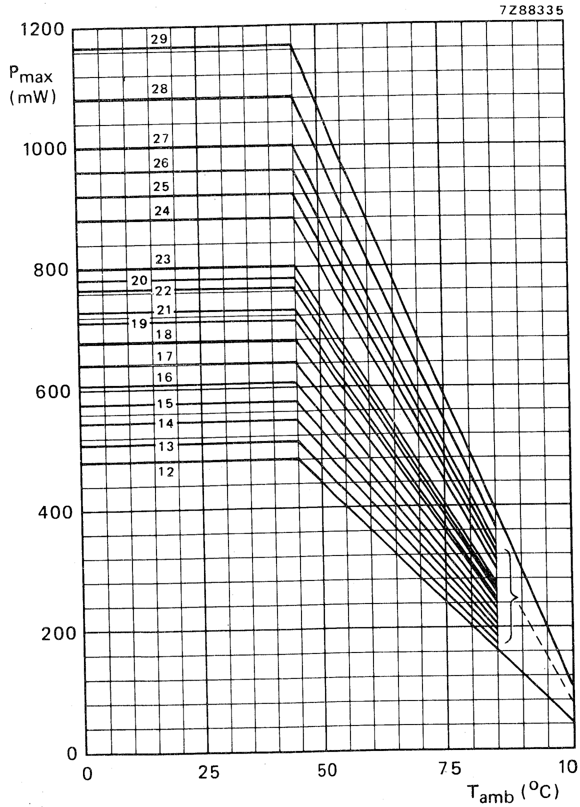


Fig. 8 Maximum permissible power dissipation as a function of temperature, for capacitors with L = 26 and 30 mm.

METALLIZED POLYESTER FILM CAPACITORS

- Potted type; radial leads
- 5,08 mm pitch
- Supplied on tape and in boxes

QUICK REFERENCE DATA

Rated capacitance range (E 12-series)	0,01 to 0,47 μF
Tolerance on rated capacitance	± 10% and ± 20%
Rated voltage U_R (d.c.)	63 V, 100 V
Rated voltage U_R (a.c.), 50 Hz	40 V, 63 V
Rated temperature	85 ^{o}C
Climatic category IEC 68 (CECC 30400)	55/100/56
Basic specification	IEC 384-2, long-life grade

APPLICATION

For general purpose and industrial use in electronic equipment, e.g. for coupling and decoupling applications, especially where high package density is required.

DESCRIPTION

The capacitors consist of a low-inductive wound cell of metallized polyethyleneterephthalate (PETP) film. The cell is potted with epoxy resin in a flame retardent polypropylene case. The radial leads are solder-coated wire. The capacitors can withstand solvents and rinsing liquids without damage. They are provided with small pips to allow removal of solder flux etc., when cleaning the printed-wiring board.

MECHANICAL DATA

Dimensions in mm

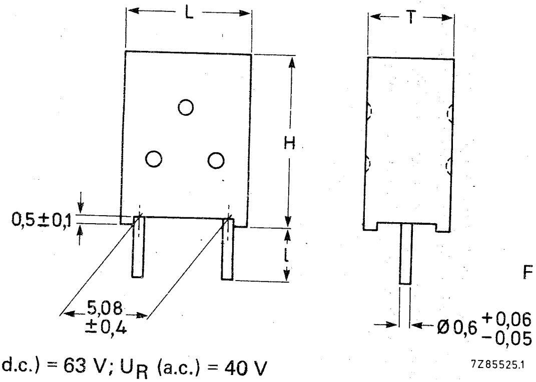


Fig. 1 For dimensions T, H, L and l, see tables below.

Table 1 U_R (d.c.) = 63 V; U_R (a.c.) = 40 V

rated capaci- tance µF	T	H_{max}	L	mass g	catalogue number 2222 370							
					packed in boxes				on tape on reel		on tape in ammunition pack	
					l = 4 + 2		l = 25 + 2					
					tol. ± 10%	tol. ± 20%	tol. ± 10%	tol. ± 20%	tol. ± 10%	tol. ± 20%	tol. ± 10%	tol. ± 20%
0,047	3	8	7,2	to be established	11473	10473	15473	14473	18473	17473	78473	77473
0,056					11563	10563	15563	14563	18563	17563	78563	77563
0,068					11683	10683	15683	14683	18683	17683	78683	77683
0,082					11823	10823	15823	14823	18823	17823	78823	77823
0,10					11104	10104	15104	14104	18104	17104	78104	77104
0,12	4	9	7,2		11124	10124	15124	14124	18124	17124	78124	77124
0,15					11154	10154	15154	14154	18154	17154	78154	77154
0,18					11184	10184	15184	14184	18184	17184	78184	77184
0,22					11224	10224	15224	14224	18224	17224	78224	77224
0,27	5	10	7,2		11274	10274	15274	14274	18274	17274	78274	77274
0,33					11334	10334	15334	14334	18334	17334	78334	77334
0,39					11394	10394	15394	14394	18394	17394	78394	77394
0,47					11474	10474	15474	14474	18474	17474	78474	77474

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

rated capaci-tance	T	H_{max}	L	mass	catalogue number 2222 370							
					packed in boxes				on tape on reel		on tape in ammunition pack	
					l = 4 + 2		l = 25 + 2					
μF				g	tol. ± 10%	tol. ± 20%	tol. ± 10%	tol. ± 20%	tol. ± 10%	tol. ± 20%	tol. ± 10%	tol. ± 20%
0,010	3	8	7,2	to be established	21103	20103	25103	24103	28103	27103	88103	87103
0,012					21123	20123	25123	24123	28123	27123	88123	87123
0,015					21153	20153	25153	24153	28153	27153	88153	87153
0,018					21183	20183	25183	24183	28183	27183	88183	87183
0,022					21223	20223	25223	24223	28223	27223	88223	87223
0,027					21273	20273	25273	24273	28273	27273	88273	87273
0,033					21333	20333	25333	24333	28333	27333	88333	87333
0,039					21393	20393	25393	24393	28393	27393	88393	87393
0,047	4	9	7,2		21473	20473	25473	24473	28473	27473	88473	87473
0,056					21563	20563	25563	24563	28563	27563	88563	87563
0,068					21683	20683	25683	24683	28683	27683	88683	87683
0,082	5	10	7,2		21823	20823	25823	24823	28823	27823	88823	87823
0,10					21104	20104	25104	24104	28104	27104	88104	87104

Marking

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

1st line: rated capacitance in pF or μF, tolerance code (K = ± 10%, M = ± 20%), and rated d.c. voltage, without unit symbols;

2nd line: code for dielectric material (MKT), 5th, 6th and 7th digits of the catalogue number, and code for factory of origin.

Mounting

The capacitors are suited for mounting on printed-wiring boards. The required space on the board is shown in Fig. 2.

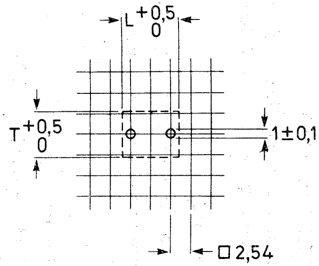


Fig. 2 For dimensions T and L see tables above.

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of 23 ± 1 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 50 ± 2%.

Capacitance

Rated capacitance values (C_R) at 1 kHz	see Tables 1 and 2
Tolerance on rated capacitance	± 10% and ± 20%

Voltage

Rated voltage U_R (d.c.)	63 V, 100 V
Rated voltage U_R (a.c.), 50 Hz	
63 V version	40 V
100 V version	63 V
Category voltage U_C	0,8 x 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.); min. 200 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 10 ± 1 V for the 63 V version, and 100 ± 15 V for the 100 V version.

	ambient temperature	
	20 °C	100 °C
R between terminals, for $C_R \leqslant 0,33\ \mu F$	> 15 000 MΩ	> 75 MΩ
RC between terminals, for $C_R > 0,33\ \mu F$	> 5000 s	> 25 s
R between interconnected terminals and case	> 30 000 MΩ	

Tan δ (tangent of the loss angle)

Tan δ at 1 kHz	$\leqslant 75 \times 10^{-4}$
Tan δ at 10 kHz	$\leqslant 130 \times 10^{-4}$
Tan δ at 100 kHz	$\leqslant 300 \times 10^{-4}$

Power dissipation

Maximum permissible power dissipation	to be established

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
63	10
100	19

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.

DEVELOPMENT SAMPLE DATA

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

The capacitors are supplied in boxes, on tape on reel, and in ammunition pack.
The number of capacitors per box is 2000 for l = 4 mm and 1000 for l = 25 mm.

The number of capacitors per reel and per ammunition packing is 1500 for $T \leqslant 4$ mm, and 1300 for T = 5 mm.

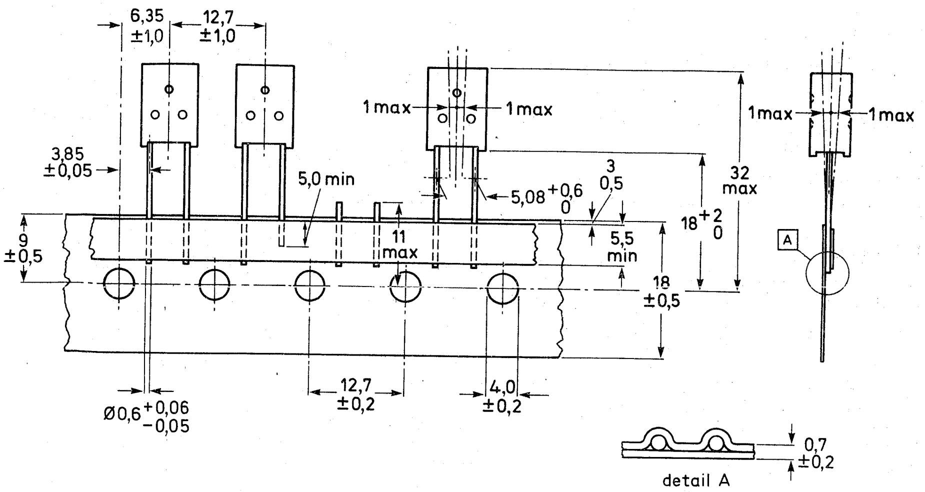


Fig. 3 Capacitors on tape.

Cumulative pitch error: 1,0 mm/20 pitches.
Maximum 0,25% of the total number of capacitors per reel may be missing, but no more than 2 consecutive positions will be vacant.

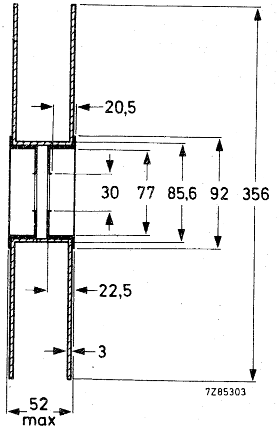


Fig. 4 Reel.

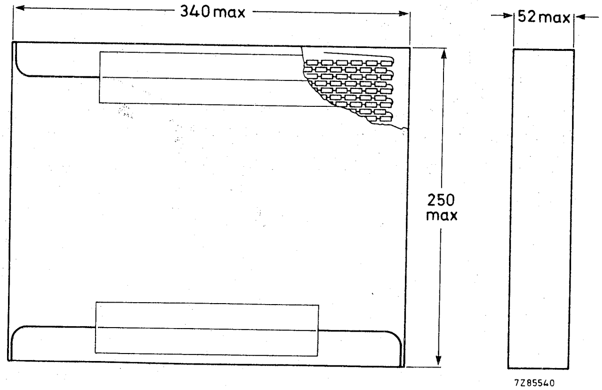


Fig. 5 Capacitors on tape in ammunition packing.

METALLIZED POLYESTER FILM CAPACITORS

- Potted type; radial leads
- 7,62 mm pitch
- Supplied in bulk or on tape on reel.

QUICK REFERENCE DATA

Rated capacitance range (E 12-series)	0,0039 to 0,15 μF
Tolerance on rated capacitance	± 10% and ± 20%*
Rated voltage U_R (d.c.)	100 V, 250 V, 400 V
Rated voltage U_R (a.c.), 50 to 60 Hz	63 V, 160 V, 220 V
Rated temperature	85 °C
Climatic category IEC 68 (CECC 30400)	55/100/56
Basic specification	IEC 384-2, long-life grade

APPLICATION

For general purpose and industrial use in electronic equipment, e.g. for coupling and decoupling applications, especially where high package density is required.

DESCRIPTION

The capacitors consist of a low-inductive wound cell of metallized polyethyleneterephthalate (PETP) film. The cell is potted with epoxy resin in a flame retardent polypropylene case. The radial leads are solder-coated wire. The capacitors can withstand solvents and rinsing liquids without damage.
They are provided with small pips to allow removal of solder flux etc., when cleaning the printed-wiring board.

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* ± 5% available on request.

MECHANICAL DATA

Dimensions in mm

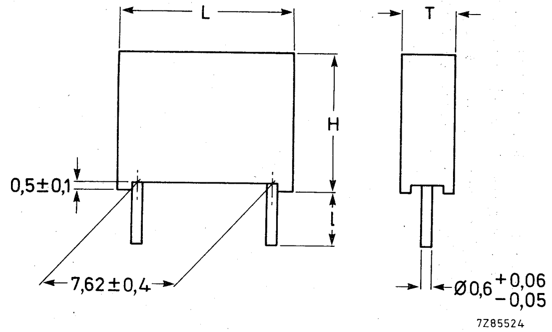


Fig. 1 For dimensions T, L, H and I, see tables below.

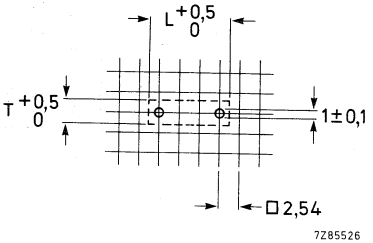


Fig. 2 For dimensions T and L, see tables below.

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

rated capacitance μF	T	H_{max}	L	mass g	catalogue number 2222 371					
					l = 4 + 2		l = 10 + 5		version on tape on reel	
					tol. ± 10%	tol. ± 20%	tol. ± 10%	tol. ± 20%	tol. ± 10%	tol. ± 20%
0,039	3	8	10	0,4	21393	20393	25393	24393	28393	27393
0,047					21473	20473	25473	24473	28473	27473
0,056					21563	20563	25563	24563	28563	27563
0,068					21683	20683	25683	24683	28683	27683
0,082					21823	20823	25823	24823	28823	27823
0,10					21104	20104	25104	24104	28104	27104
0,12	4	9	10	0,5	21124	20124	25124	24124	28124	27124
0,15					21154	20154	25154	24154	28154	27154

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

rated capacitance µF	T	H_{max}	L	mass g	catalogue number 2222 371					
					l = 4 + 2		l = 10 + 5		version on tape on reel	
					tol. ± 10%	tol. ± 20%	tol. ± 10%	tol. ± 20%	tol. ± 10%	tol. ± 20%
0,012	3	8	10	0,4	41123	40123	45123	44123	48123	47123
0,015					41153	40153	45153	44153	48153	47153
0,018					41183	40183	45183	44183	48183	47183
0,022					41223	40223	45223	44223	48223	47223
0,027					41273	40273	45273	44273	48273	47273
0,033					41333	40333	45333	44333	48333	47333
0,039	4	9	10	0,5	41393	40393	45393	44393	48393	47393
0,047					41473	40473	45473	44473	48473	47473

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

rated capacitance µF	T	H_{max}	L	mass g	catalogue number 222 371					
					l = 4 + 2		l = 10 + 5		version on tape on reel	
					tol. ± 10%	tol. ± 20%	tol. ± 10%	tol. ± 20%	tol. ± 10%	tol. ± 20%
0,0039	3	8	10	0,4	51392	50392	55392	54392	58392	57392
0,0047					51472	50472	55472	54472	58472	57472
0,0056					51562	50562	55562	54562	58562	57562
0,0068					51682	50682	55682	54682	58682	57682
0,0082					51822	50822	55822	54822	58822	57822
0,010					51103	50103	55103	54103	58103	57103
0,012	4	9	10	0,5	51123	50123	55123	54123	58123	57123
0,015					51153	50153	55153	54153	58153	57153

Marking

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

1st line: rated capacitance in pF or µF, tolerance and rated d.c. voltage, without unit symbols;
2nd line: code for dielectric material (MKT), 5th, 6th and 7th digits of the catalogue number, and code for factory of origin.

Mounting

The capacitors are suited for mounting on printed-wiring boards. The required space on the board is shown in Fig. 2.

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of 23 ± 1 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 50 ± 2%.

Capacitance

Rated capacitance values (C_R) at 1 kHz	see Tables 1 to 3
Tolerance on rated capacitance	± 10% and ± 20% (± 5% available on request)

Voltage

Rated voltage U_R (d.c.)	100 V, 250 V, 400 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
Category voltage U_C	0,75 x U_R (d.c.)
Test voltage for 1 min	
between terminals	1,6 U_R (d.c.)
between interconnected terminals and case	2 x U_R (d.c.)

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 of 100 ± 15 V has been applied for 1 min ± 5 s.

	ambient temperature 20 °C	ambient temperature 100 °C
R between terminals		
100 V version	> 15 000 MΩ	> 75 MΩ
250 V and 400 V versions	> 30 000 MΩ	> 150 MΩ
R between interconnected terminals and case	> 30 000 MΩ	

Tan δ (tangent of the loss angle)

Tan δ at 1 kHz	$\leqslant 75 \times 10^{-4}$
Tan δ at 10 kHz	$\leqslant 130 \times 10^{-4}$
Tan δ at 100 kHz	$\leqslant 300 \times 10^{-4}$

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
100	30
250	45
400	75

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

The capacitors are packed in boxes of 500 or on tape on reel with 1500, see Figs 3 and 4.

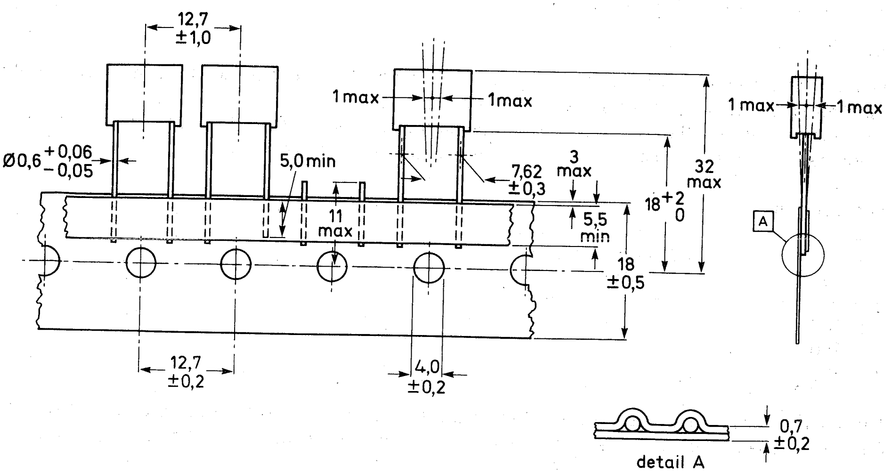


Fig. 3 Capacitors on tape.

Cumulative pitch error: 1,0 mm/20 pitches.
Maximum 0,25% of the total number of capacitors per reel may be missing, but no more than 2 consecutive positions will be vacant.

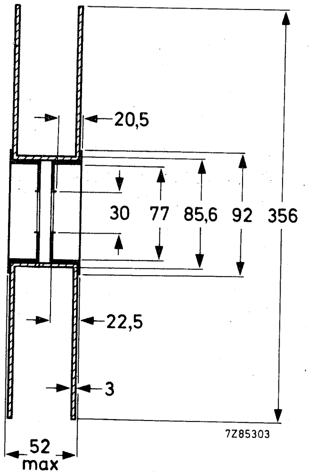


Fig. 4 Reel.

ADDITIONAL INFORMATION

Power dissipation

The rated a.c. voltage has been specified for 50 to 60 Hz at 23 °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.

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

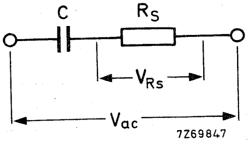


Fig. 5.

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

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

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

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

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. 6; 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. 7. Thus, when the actual power has been calculated with equation (3b), Fig. 7 gives the minimum size of capacitor which can dissipate this power.

Example of using Fig. 6 and Fig. 7

A capacitor of 0,1 µF should be used at an a.c. voltage of 20 V, a frequency of 10 kHz and an ambient temperature of 50 °C.

The R_sC-product is $2 \times 10^{-7}\ \Omega F$ (from Fig. 6), so that the power to be dissipated is

$$\begin{aligned} P &= (R_s C)\, C \omega^2 V_{ac}^2 \\ &= 2 \times 10^{-7} \times 0{,}1 \times 10^{-6} \times (2\pi)^2 \times 10^8 \times 20^2 = 32 \text{ mW.} \end{aligned}$$

For use with 20 V, a capacitor of at least the 100 V range is required. Figure 7 shows that a capacitor 0,1 µF/100 V can be used because of its dimensions, 3 mm x 8 mm x 10 mm and its maximum permissible power dissipation of 100 mW at 50 °C.

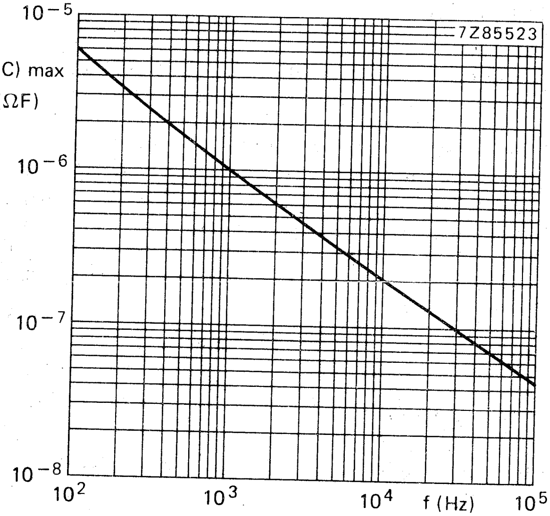
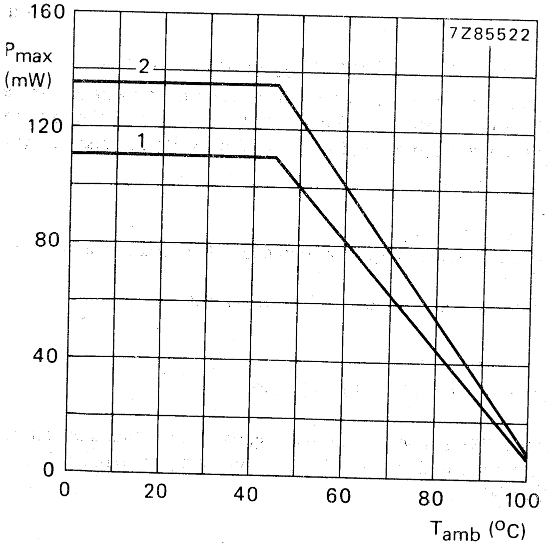


Fig. 6 R_sC-product as a function of frequency; typical curve.



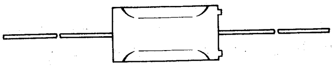
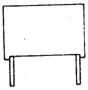
curve	dimensions (mm)		
	T	H_{max}	L
1	3	8	10
2	4	9	10

Fig. 7 Maximum permissible power dissipation as a function of temperature.

METALLIZED POLYCARBONATE FILM CAPACITORS MKC

SURVEY

Main applications: coupling, decoupling, timing, delay.

type	series number	pitch e = 2,54 mm	rated capacitance µF	rated d.c. voltage V	page
	2222 341		0,10 – 6,8 0,047 – 2,2 0,010 – 1,0 0,010 – 0,47 0,010 – 0,15	100 250 400 630 1000	B15
	2222 344	4e, 6e 9e, 11e	0,10 – 6,8 0,047 – 2,2 0,010 – 1,0 0,010 – 0,47	100 250 400 630	B27

TESTS AND REQUIREMENTS

Standard atmospheric conditions for reference tests: ambient temperature + 23 ± 1 °C, atmospheric pressure 86 to 106 kPa, relative humidity 50 ± 2%.

IEC 384-1 clause	IEC 68-2 test method	name of test	procedure (quick reference)
4.3.1			Initial measurements C at 1 kHz, tan δ at 10 kHz
4.3	Ua1	Tensile strength of terminations	Loading force in axial direction for 10 s: ϕ 0,8 mm 10 N, ϕ 1,0 mm 20 N
	Ub (method 1)	Bending of terminations	Loading force 5 N for ϕ 0,8 mm, 10 N for ϕ = 1,0 mm, 2 consecutive bends
4.4	Tb (method 1A)	Resistance to soldering heat	Solder bath 260 °C, 10 s
4.4.2			Final measurements
4.5	Ta	Soldering	Solder bath, non-activated colophony flux, solder temp. 235 °C, dwell time 2 s
4.6.1			Initial measurements C at 1 kHz, tan δ at 10 kHz
4.6	Na	Rapid change of temperature	5 cycles of ½ h at −55 °C, and ½ h at + 100 °C. Recovery for 1 to 2 h
4.7	Fc	Vibration	10 to 55 Hz, 0,75 mm or 10g (whichever is the less), 3 directions, 2 h per direction. Capacitors mounted on printed-wiring boards
4.8	Eb	Bumping	40g, 6 ms, 4000 bumps. Capacitors mounted on printed-wiring boards.
4.8.3			Final measurements

requirements		
2222 . . .	341	344
Visual examination	no damage	
Visual examination	no damage	
Visual examination	no damage	
$\Delta C/C$	$\leqslant 1\%$	$\leqslant 1\%$
$\Delta \tan \delta$ at 10 kHz	$\leqslant 30 \times 10^{-4}$	$\leqslant 30 \times 10^{-4}$
Visual examination	good tinning	
Visual examination	no damage	
Visual examination	no damage	
Visual examination	no damage	
$\Delta C/C$	$\leqslant 2\%$	$\leqslant 2\%$
$\Delta \tan \delta$ at 10 kHz	$\leqslant 30 \times 10^{-4}$	$\leqslant 30 \times 10^{-4}$
R_{ins}	meet intial requirements	

IEC 384-1 clause	IEC 68-2 test method		name of test	procedure (quick reference)
4.10.2	CLIMATIC SEQUENCE	Ba	Dry heat	16 h at + 100 ± 2 °C, no voltage applied
4.10.3		Db	Damp heat, cyclic	1 cycle of 24 h, upper temp. 55 ± 2 °C, R.H. 93 ± 3%; no voltage applied
4.10.4		Aa	Cold	2 h at lower category temp., no voltage applied
		M	Low air pressure	1 h at 25 ± 5 °C; at an atmospheric pressure of 8,5 kPa
4.10.6		Db	Damp heat, cyclic	5 cycles of 24 h at 55 ± 2 °C, R.H. 93 ± 3%; no voltage applied
				Final measurements
4.11.1			Damp heat, steady state	Initial measurements C at 1 kHz, tan δ at 10 kHz
4.11	Ca			40 ± 2 °C for 56 days; R.H. 90 to 95%; no voltage applied
4.11.3				Final measurements

	requirements	
2222 . . .	341	344
Visual examination	no damage, no leakage	
ΔC/C at 100 °C	$\leqslant$ 3%	$\leqslant$ 3%
R_{ins}, $C_R \leqslant 0{,}33\ \mu F$	100 V version > 50 MΩ, other versions > 100 MΩ	
RC, $C_R > 0{,}33\ \mu F$	100 V version > 16 s, other versions > 33 s	
ΔC/C at lower category temp.	$\leqslant$ 3%	$\leqslant$ 3%
During and after the test	no breakdown or flashover	
Visual examination	no damage	
ΔC/C	$\leqslant$ 3%	$\leqslant$ 3%
Δ tan δ at 10 kHz	$\leqslant 50 \times 10^{-4}$	$\leqslant 50 \times 10^{-4}$
R_{ins}	$\geqslant$ 0,5 x initial requirements	
Visual examination	no damage	
ΔC/C	$\leqslant$ 3%	$\leqslant$ 3%
Δ tan δ at 10 kHz	$\leqslant 50 \times 10^{-4}$	$\leqslant 50 \times 10^{-4}$
R_{ins}	$\geqslant$ 0,5 x initial requirements	

IEC 384-1 clause	IEC 68-2 test method	name of test	procedure (quick reference)	
4.12.1		Endurance	Initial measurements C at 1 kHz, tan δ at 10 kHz	
4.12.2			Grade 1 capacitors (long life)	2000 h at 85 °C; 1,25 x U_R (d.c.) applied 2000 h at 100 °C; 1,25 x U_C applied
4.12.5				Final measurements
4.13.1		Charge and discharge	Initial measurements C at 1 kHz, tan δ at 10 kHz	
4.13.2			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.	
4.13.3			Final measurements	

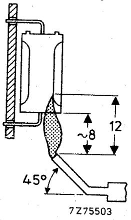
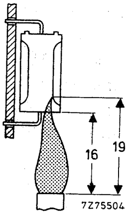
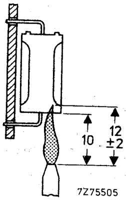
requirements		
2222 . . .	341	344
Visual examination	no damage	
$\Delta C/C$	$\leqslant 3\%$	$\leqslant 3\%$
$\Delta \tan \delta$ at 10 kHz	$\leqslant 30 \times 10^{-4}$	$\leqslant 30 \times 10^{-4}$
R_{ins}	$\geqslant 0{,}5$ x initial requirements	
$\Delta C/C$	$\leqslant 3\%$	$\leqslant 3\%$
$\Delta \tan \delta$ at 10 kHz	$\leqslant 20 \times 10^{-4}$	$\leqslant 20 \times 10^{-4}$
R_{ins}	$\geqslant 0{,}5$ x initial requirements	

Additional tests

name of test	procedure (quick reference)
Solvent resistance	According to MIL-STD-202E method 215; recovery for 2 h.
	Final measurements
Endurance	1000 h at 85 °C; 1,25 x U_R (a.c.) 50 Hz applied
Storage	1000 h at 100 °C
Tensile strength of terminations	Loading force in radial direction of wire for 10 s: 10 N

	requirements	
2222 . . .	341	344
Visual examination	no damage	
$\Delta C/C$	$\leqslant 1\%$	$\leqslant 1\%$
$\Delta \tan \delta$ at 10 kHz	$\leqslant 30 \times 10^{-4}$	$\leqslant 30 \times 10^{-4}$
R_{ins}	$\geqslant 0{,}5 \times$ initial requirements	
$\Delta C/C$	for L = 14,5 mm: $\leqslant 15\%$ 18 mm: $\leqslant 10\%$ 23,5 mm: $\leqslant 7\%$ 31 mm: $\leqslant 5\%$	for L = 13 mm: $\leqslant 15\%$ 17,5 mm: $\leqslant 10\%$ 26 mm: $\leqslant 7\%$ 30 mm: $\leqslant 5\%$
$\Delta \tan \delta$ at 10 kHz	$\leqslant 30 \times 10^{-4}$	$\leqslant 30 \times 10^{-4}$
R_{ins}	meet initial requirements	
$\Delta C/C$	$\leqslant 3\%$	$\leqslant 3\%$
$\Delta \tan \delta$ at 10 kHz	$\leqslant 30 \times 10^{-4}$	$\leqslant 30 \times 10^{-4}$
R_{ins} at < 10 V (d.c.)	meet initial requirements	
Visual examination	no damage	

Additional tests

name of test	procedure (quick reference)
Flammability	 Bore of gas jet: ϕ 0,5 mm. Fuel: butane. Test duration: 20 s. One flame application.
	 Test according to UL1414. Bore of gas jet: ϕ 10 mm. Fuel: natural gas. Test duration: 3 x 15 s. Time interval between each flame application: 15 s.
	 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.

requirements		
2222 . . .	341	344
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.		
Extinguishing time ⩽ 15 s after the first and second flame application, ⩽ 60 s after the third flame application.		n.a.
Extinguishing time ⩽ 10 s after each flame application; no burning particles must drop from the sample.		n.a.

n.a. = not applicable.

METALLIZED POLYCARBONATE FILM CAPACITORS

moulded type

QUICK REFERENCE DATA

Rated capacitance range (E12-series)	0,01 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
Rated voltage U_R (a.c.), 50 to 60 Hz	63 V, 160 V, 220 V, 220 V, 250 V
Rated temperature	85 °C
Climatic category, IEC 68	55/100/56
Basic specification	IEC 384-1

APPLICATION

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

DESCRIPTION

The capacitors consist of a low-inductance wound cell of metallized 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.

MECHANICAL DATA

Dimensions in mm

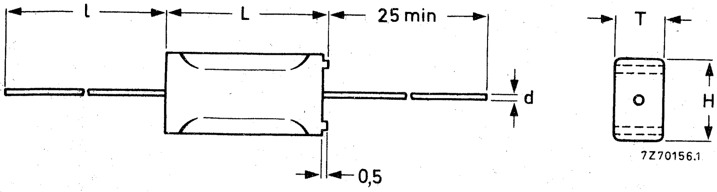


Fig. 1 For dimensions T, L, H, d and l, see tables below.

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

rated capacitance* μF	T_{max}	L_{max}	H_{max}	d	l_{min}	mass g	catalogue number 2222 341		
							tol. ± 5%	tol. ± 10%	tol. ± 20%
0,10	4,9	14,5	8,7	0,8	40	1,0	23104	29104	28104
0,15	4,9	14,5	8,7			1,0	23154	29154	28154
0,22	6,5	14,5	10,4			1,4	23224	29224	28224
0,33	6,7	18	10,4			1,7	23334	29334	28334
0,47	7,9	18,1	11,5			2,0	23474	29474	28474
0,68	7,8	23,8	11,7			2,5	23684	29684	28684
1,0	9,2	23,5	12,8			3,2	23105	29105	28105
1,5	10,4	23,5	14,4			4,0	23155	29155	28155
2,2	10,4	31	14,6	1	50	5,5	23225	29225	28225
3,3	12,4	31	19,5			8,0	23335	29335	28335
4,7	12,4	31	19,5			10,5	23475	29475	28475
6,8	15	31	22			10,5	23685	29685	28685

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* 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

rated capacitance* μF	T_{max}	L_{max}	H_{max}	d	l_{min}	mass g	catalogue number 2222 341		
							tol. ± 5%	tol. ± 10%	tol. ± 20%
0,047	4,9	14,5	8,7	0,8	40	1,0	47473	49473	48473
0,068	4,9	14,5	8,7			1,0	47683	49683	48683
0,10	5,5	14,5	9,4			1,4	47104	49104	48104
0,15	6,7	18	10,4			1,7	47154	49154	48154
0,22	7,9	18,1	11,5			2,0	47224	49224	48224
0,33	7,8	23,8	11,7			2,5	47334	49334	48334
0,47	9,2	23,5	12,8			3,2	47474	49474	48474
0,68	10,4	23,5	14,4			4,0	47684	49684	48684
1,0	10,4	31	14,6	1	50	5,5	47105	49105	48105
1,5	12,4	31	19,5			8,0	47155	49155	48155
2,2	15	31	22			10,5	47225	49225	48225

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

rated capacitance* μF	T_{max}	L_{max}	H_{max}	d	l_{min}	mass g	catalogue number 2222 341		
							tol. ± 5%	tol. ± 10%	tol. ± 20%
0,010	4,9	14,5	8,7	0,8	40	1,0	57103	59103	58103
0,015	4,9	14,5	8,7			1,0	57153	59153	58153
0,022	4,9	14,5	8,7			1,0	57223	59223	58223
0,033	5,5	14,5	9,4			1,1	57333	59333	58333
0,047	6,5	14,5	10,4			1,4	57473	59473	58473
0,068	6,7	18	10,4			1,7	57683	59683	58683
0,10	7,9	18,1	11,5			2,0	57104	59104	58104
0,15	7,8	23,8	11,7			2,5	57154	59154	58154
0,22	9,2	23,5	12,8			3,2	57224	59224	58224
0,33	10,4	23,5	14,4			4,0	57334	59334	58334
0,47	10,4	31	14,6	1,0	50	5,5	57474	59474	58474
0,68	12,4	31	19,5			8,0	57684	59684	58684
1,0	15	31	22			10,5	57105	59105	58105

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

rated capacitance* µF	T_{max}	L_{max}	H_{max}	d	l_{min}	mass g	catalogue number 2222 341		
							tol. ± 5%	tol. ± 10%	tol. ± 20%
0,010	4,9	14,5	8,7	0,8	40	1,0	62103	61103	60103
0,015	5,5	14,5	9,4			1,1	62153	61153	60153
0,022	6,5	14,5	10,4			1,4	62223	61223	60223
0,033	6,7	18	10,4			1,7	62333	61333	60333
0,047	7,9	18,1	11,5			2,0	62473	61473	60473
0,068	7,8	23,8	11,7			2,5	62683	61683	60683
0,10	9,2	23,5	12,8			3,2	62104	61104	60104
0,15	10,4	23,5	14,4			4,0	62154	61154	60154
0,22	10,4	31	14,6	1,0	50	5,5	62224	61224	60224
0,33	12,4	31	19,5			8,0	62334	61334	60334
0,47	15	31	22			10,5	62474	61474	60474

Table 5 U_R (d.c.) = 1000 V; U_R (a.c.) = 250 V

rated capacitance* µF	T_{max}	L_{max}	H_{max}	d	l_{min}	mass g	catalogue number 2222 341	
							tol. ± 10%	tol. ± 20%
0,010	6,7	18	10,4	0,8	40	1,7	71103	70103
0,015	7,9	18,1	11,5			2,0	71153	70153
0,022	7,8	23,8	11,7			2,5	71223	70223
0,033	9,2	23,5	12,8			3,2	71333	70333
0,047	10,4	23,5	14,4			4,0	71473	70473
0,068	10,4	31	14,6	1,0	50	5,5	71683	70683
0,10	12,4	31	19,5			8,0	71104	70104
0,15	15	31	22			10,5	71154	70154

Marking

The marking is impressed as follows:

1st line: rated capacitance, tolerance and rated d.c. voltage;
2nd line: 341, MKC, production date code (three-month period and year).
The outer film connection is marked with a stroke on the body.

On the other side is impressed:
1st line: name of manufacturer;
2nd line: code for factory of origin.

Mounting

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

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* 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 23 ± 1 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 50 ± 2%.

Capacitance

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

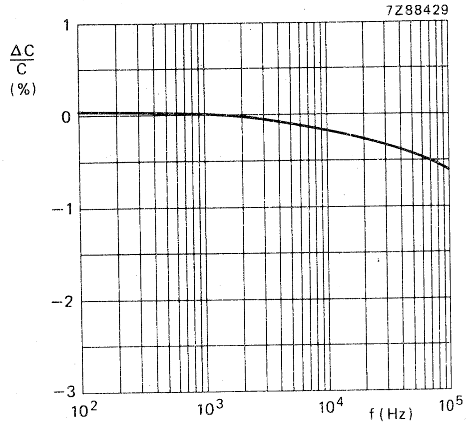

Fig. 2 Capacitance as a function of frequency; typical curve.
From 100 Hz to 1 kHz the curve is valid for all capacitance values (measuring voltage 1 V). From 1 to 10 kHz the curve is valid for capacitance values ⩽ 1 μF (measuring voltage 1 V). From 10 to 100 kHz the curve is valid for capacitance values ⩽ 0,1 μF (measuring voltage 0,3 V).

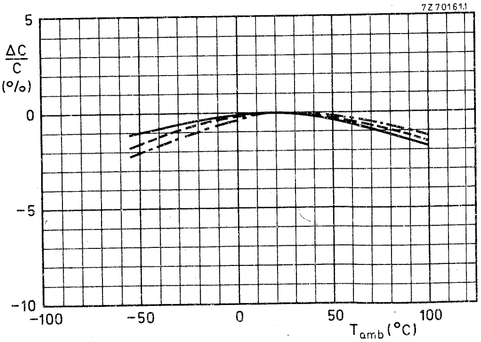

Fig. 3 Capacitance as a function of temperature; typical curves.
——— For all capacitance values, measured at 1 kHz, 1 V.
– – – – For capacitance values ⩽ 1 μF, measured at 10 kHz, 1 V
–.–.– For capacitance values ⩽ 0,1 μF, measured at 100 kHz, 0,3 V.

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

Voltage

Rated voltage U_R (d.c.)	100 V, 250 V, 400 V, 630 V, 1000 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 version	250 V
Category voltage U_C	0,8 x 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 and 1000 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 1000 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 to 1000 V versions	> 10 000 s	> 33 s

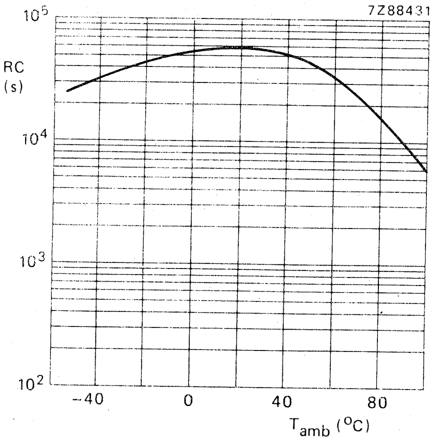

Fig. 4 RC-product as a function of temperature; typical curve.

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* For higher frequencies see Additional Information.

Tan δ (tangent of the loss angle)

Tan δ at 10 kHz	⩽ 75 x 10^{-4} (typ. 20 x 10^{-4})

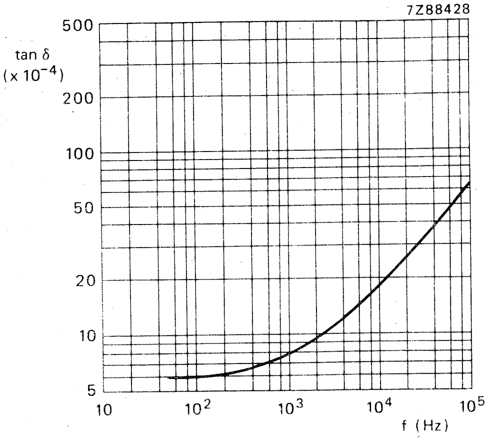

Fig. 5 Tan δ as a function of frequency; typical curve.

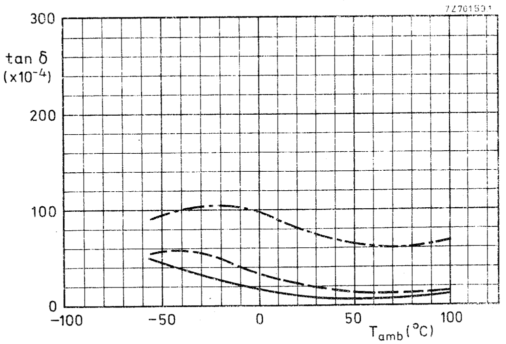

Fig. 6 Tan δ as a function of temperature; typical curves.

——— 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	max. pulse steepness (V/μs)			
	L = 14,5 mm	L = 18 mm	L = 23,5 mm	L = 31 mm
100	9	5,6	4	3
250	25	14	10	7,5
400	40	22	16	12
630	70	37	26	19
1000		50	40	35

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.

ADDITIONAL INFORMATION

Power dissipation

The rated a.c. voltage has been specified for 50 to 60 Hz, at 23 °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.

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

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

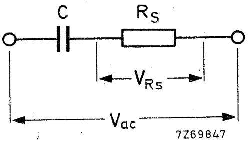

Fig. 7.

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

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

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

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. 8. 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. 9. Thus, when the actual power has been calculated with equation (3b), Fig. 9 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. 8 and Fig. 9

A capacitor with a value of 1 μF should be used at an a.c. voltage of 130 V, a frequency of 1 kHz and an ambient temperature of 50 °C. The R_sC-product is 7,5 x 10^{-7} s (from Fig. 8), so that the power to be dissipated

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

Figure 9 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.

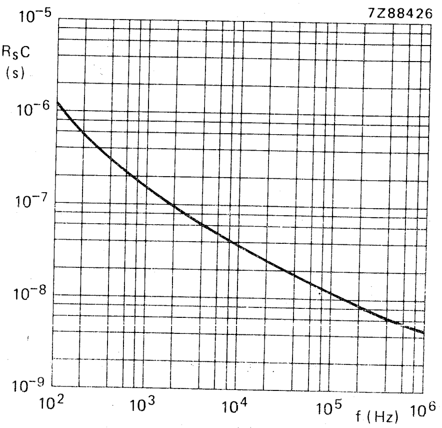

Fig. 8 Maximum product of series resistance and capacitance as a function of frequency.

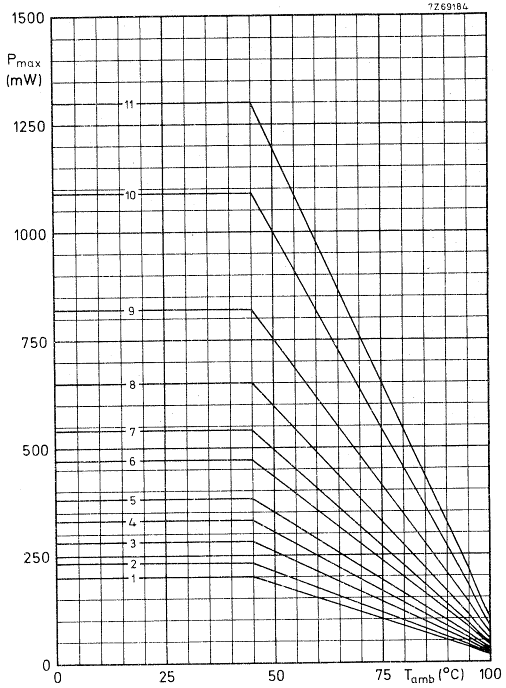

Fig. 9 Maximum permissible power dissipation as a function of temperature.

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 POLYCARBONATE FILM CAPACITORS

potted type

QUICK REFERENCE DATA

Rated capacitance range (E 12-series)	0,01 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
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	55/100/56
Basic specification	IEC 384-1

APPLICATION

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

DESCRIPTION

The capacitors consist of a low-inductance wound cell of metallized 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.

MECHANICAL DATA

Dimensions in mm

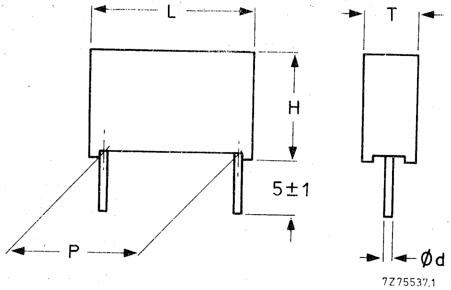

Fig. 1 For dimensions T, L, H, P and d, see tables below.

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

rated capacitance* μF	T_{max}	L_{max}	H_{max}	P	d	mass g	catalogue number 2222 344		
							tol. ± 5%	tol. ± 10%	tol. ± 20%
0,10	4,5	13	10	10 ± 0,4	0,8	0,7	22104	21104	20104
0,15	4,5	13	10			0,7	22154	21154	20154
0,22	5	13	11			0,9	22224	21224	20224
0,33	5	17,5	11	15 ± 0,4		1,1	22334	21334	20334
0,47	6	17,5	11,5			1,4	22474	21474	20474
0,68	7	17,5	13			1,8	22684	21684	20684
1,0	8,5	17,5	14,5			2,6	22105	21105	20105
1,5	6,5	26	15,5	22,5 ± 0,4		2,8	22155	21155	20155
2,2	8,5	26	18			4,3	22225	21225	20225
3,3	9,5	26	19			5,1	22335	21335	20335
4,7	11	31	20	27,5 ± 0,4		7,4	22475	21475	20475
6,8	13,5	31	22,5			10,2	22685	21685	20685

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* 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

rated capacitance* µF	T_{max}	L_{max}	H_{max}	P	d	mass g	catalogue number 2222 344		
							tol. ± 5%	tol. ± 10%	tol. ± 20%
0,047	4,5	13	10	10 ± 0,4	0,8	0,7	43473	45473	44473
0,068	4,5	13	10			0,7	43683	45683	44683
0,10	5	17,5	11	15 ± 0,4		1,1	43104	45104	44104
0,15	6	17,5	11,5			1,4	43154	45154	44154
0,22	7	17,5	13			1,8	43224	45224	44224
0,33	8,5	17,5	14,5			2,6	43334	45334	44334
0,47	6,5	26	15,5	22,5 ± 0,4		2,8	43474	45474	44474
0,68	7,5	26	16,5			3,5	43684	45684	44684
1,0	9,5	26	19			5,1	43105	45105	44105
1,5	11	31	20	27,5 ± 0,4		7,4	43155	45155	44155
2,2	13,5	31	22,5			10,2	43225	45225	44225

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

rated capacitance* µF	T_{max}	L_{max}	H_{max}	P	d	mass g	catalogue number 2222 344		
							tol. ± 5%	tol. ± 10%	tol. ± 20%
0,010	4,5	13	10	10 ± 0,4	0,8	0,7	52103	51103	50103
0,015	4,5	13	10			0,7	52153	51153	50153
0,022	4,5	13	10			0,7	52223	51223	50223
0,033	4,5	13	10			0,7	52333	51333	50333
0,047	5	17,5	11	15 ± 0,4		1,1	52473	51473	50473
0,068	6	17,5	11,5			1,4	52683	51683	50683
0,10	7	17,5	13			1,8	52104	51104	50104
0,15	8,5	17,5	14,5			2,6	52154	51154	50154
0,22	6,5	26	15,5	22,5 ± 0,4		2,8	52224	51224	50224
0,33	7,5	26	16,5			3,5	52334	51334	50334
0,47	9,5	26	19			5,1	52474	51474	50474
0,68	11	31	20	27,5 ± 0,4		7,4	52684	51684	50684
1,0	13,5	31	22,5			10,2	52105	51105	50105

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

rated capacitance* µF	T_{max}	L_{max}	H_{max}	P	d	mass g	catalogue number 2222 344		
							tol. ± 5%	tol. ± 10%	tol. ± 20%
0,010	4,5	13	10	10 ± 0,4	0,8	0,7	62103	61103	60103
0,015	5	13	11			0,9	62153	61153	60153
0,022	6	13	12			1,0	62223	61223	60223
0,033	6	17,5	11,5	15 ± 0,4		1,4	62333	61333	60333
0,047	7	17,5	13			1,8	62473	61473	60473
0,068	8,5	17,5	14,5			2,6	62683	61683	60683
0,10	6,5	26	15,5	22,5 ± 0,4		2,8	62104	61104	60104
0,15	7,5	26	16,5			3,5	62154	61154	60154
0,22	9,5	26	19			5,1	62224	61224	60224
0,33	11	31	20	27,5 ± 0,4		7,4	62334	61334	60334
0,47	13,5	31	22,5			10,2	62474	61474	60474

Marking

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

1st line: rated capacitance in µF, tolerance and rated d.c. voltage;
2nd line; last eight digits of the catalogue number.
The outer film connection is marked with a stroke.

Mounting

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

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* 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 23 ± 1 °C, an atmospheric pressure of 86 to 106 kPa 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%, ± 10% and ± 20%

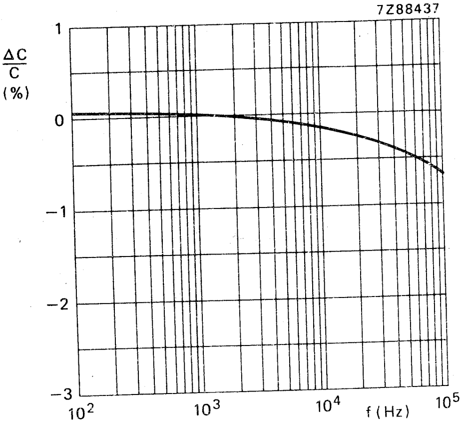

Fig. 2 Capacitance as a function of frequency; typical curves.
From 100 Hz to 1 kHz the curve is valid for all capacitance values (measuring voltage 1 V). From 1 to 10 kHz the curve is valid for capacitance values ≤ 1 μF (measuring voltage 1 V). From 10 to 100 kHz the curve is valid for capacitance values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

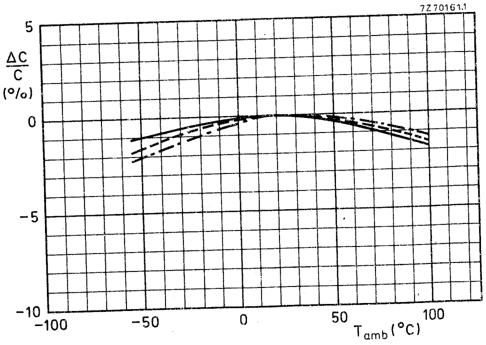

Fig. 3 Capacitance as a function of temperature; typical curves.
———— For all capacitance values, measured at 1 kHz, 1 V.
– – – – – For capacitance values ≤ 1 μF, measured at 10 kHz, 1 V.
—.—.—.—. For capacitance values ≤ 0,1 μF, measured at 100 kHz, 0,3 V.

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 and 630 V versions	220 V
Category voltage U_C	0,8 x 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; 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 and 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 and 630 V versions	> 10 000 s	> 33 s

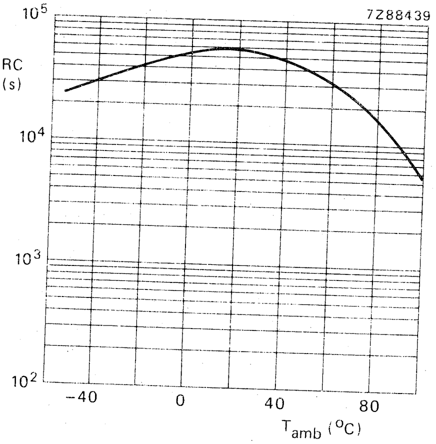

Fig. 4 RC-product as a function of temperature; typical curve.

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* For higher frequencies see Additional information.

Tan δ (tangent of the loss angle)

Tan δ at 10 kHz	≤ 75 x 10^{-4} (typ. 20 x 10^{-4})

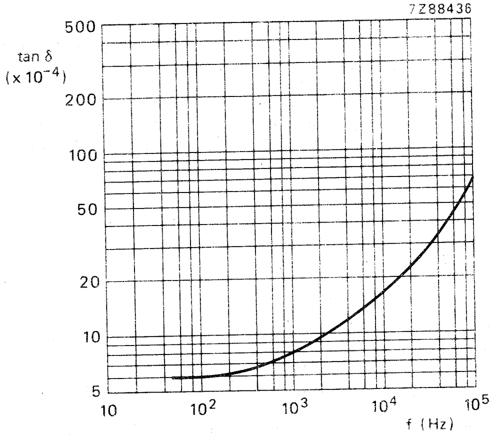


Fig. 5 Tan δ as a function of frequency; typical curve.

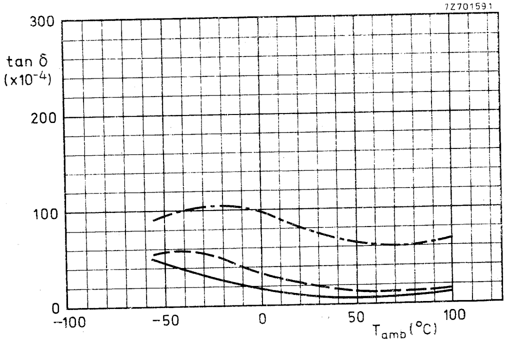


Fig. 6 Tan δ as a function of temperature; typical curves.

——— 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	max. pulse steepness (V/μs)			
	L = 13 mm	L = 17,5 mm	L = 26 mm	L = 30 mm
100	9	5,6	3,5	3
250	25	14	9	7,5
400	40	22	14	12
630	70	37	23	19

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

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

capacitance values (μF)				number of capacitors per box
100 V version	250 V version	400 V version	630 V version	
0,082 – 0,68	0,039 – 0,22	0,010 – 0,10	0,010 – 0,047	1000
0,82 – 1,0	0,27 – 0,33	0,12 – 0,15	0,056 – 0,068	500
1,2 – 3,3	0,39 – 1,0	0,18 – 0,47	0,082 – 0,22	200
3,9 – 6,8	1,2 – 2,2	0,56 – 1,0	0,27 – 0,47	100

ADDITIONAL INFORMATION

Power dissipation

The rated a.c. voltage has been specified for 50 to 60 Hz and at 23 °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.

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

$$P = \frac{V_{Rs}^2}{R_s} = I^2 R_s \tag{1}$$

$$V_{Rs}^2 = \frac{R_s^2}{R_s^2 + 1/\omega^2 C^2} V_{ac}^2 \tag{2a}$$

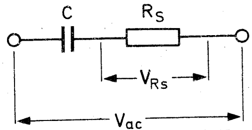


Fig. 7.

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

$$V_{Rs}^2 = \frac{R_s^2}{1/\omega^2 C^2} V_{ac}^2 = R_s^2 \omega^2 C^2 V_{ac}^2 \tag{2b}$$

Thus

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

or

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

The term $R_s C$ can be found from Fig. 8; 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. 9. Thus, when the actual power has been calculated with equation (3b), Fig. 9 gives the minimum size of capacitor which can dissipate this power.

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

Example of using Fig. 8 and Fig. 9

A capacitor with 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 $7{,}5 \times 10^{-7}$ s (from Fig. 8), so that the power to be dissipated

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

Figure 9 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.

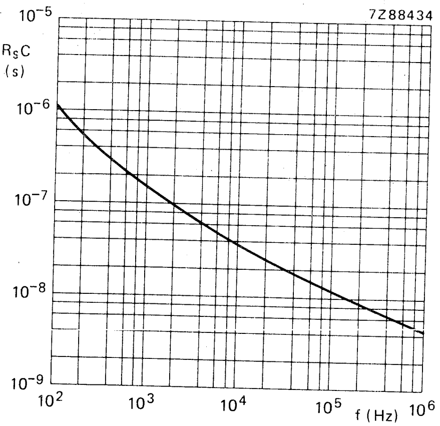


Fig. 8 Maximum product of series resistance and capacitance as a function of frequency.

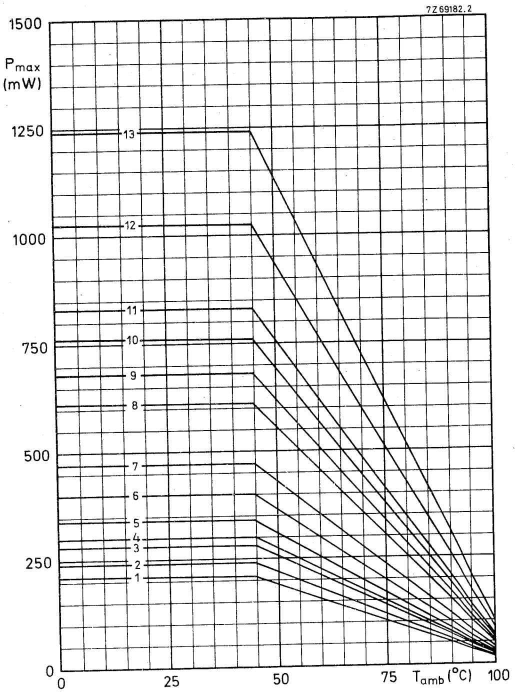


Fig. 9 Maximum permissible power dissipation as a function of temperature.

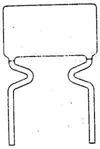
curve	dimensions (mm)		
	T_{max}	L_{max}	H_{max}
1	4,5	13	10
2	5	13	11
3	6	13	12
4	5	17,5	11
5	6	17,5	11,5
6	7	17,5	13
7	8,5	17,5	14,5
8	6,5	26	15,5
9	7,5	26	16,5
10	8,5	26	18
11	9,5	26	19
12	11	31	20
13	13,5	31	22,5

POLYESTER FILM/FOIL CAPACITORS KT

C

SURVEY

Main applications: coupling, decoupling, high currents, steep pulses.

type	series number	pitch e = 2,54 mm	rated capacitance μF	rated d.c. voltage V	page
	2222 347	4e, 6e	0,015 – 1,0	100	
		9e, 11e	0,010 – 0,68	250	
			0,0047 – 0,33	400	
			0,0010 – 0,15	630	C11

TESTS AND REQUIREMENTS

Standard atmospheric conditions for reference tests: ambient temperature + 23 ± 1 °C, atmospheric pressure 86 to 106 kPa, relative humidity 50 ± 2%.

IEC 384-11 clause	IEC 68-2 test method	name of test	procedure (quick reference)
			Initial measurements, C at 1 kHz, tan δ at 10 kHz
12.1	Ua1	Tensile strength of terminations	Loading force in axial direction for 10 s: 10 N
	Ub (method 1)	Bending of terminations	Loading force 5 N, 2 consecutive bends
12.21	Tb (method 1A)	Resistance to soldering heat	Solder bath 260 °C, 10 s
			Final measurements
12.2.2	Ta	Soldering	Solder bath, non-activated colophony flux, solder temp. 235 °C, dwell time 2 s
			Initial measurements, C at 1 kHz, tan δ at 10 kHz
12.3	Na	Rapid change of temperature	5 cycles of ½ h at −40 °C and ½ h at + 100 °C. Recovery for 1 to 2 h

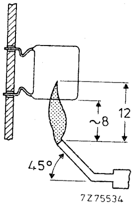
requirements

Visual examination	no damage
Visual examination	no damage
Visual examination	no damage
$\Delta C/C$ tan δ at 10 kHz	$\leqslant$ 0,5% meets initial requirements
Visual examination	good tinning
Visual examination	no damage

IEC 384-11 clause	IEC 68-2 test method	name of test	procedure (quick reference)
12.7.2	CLIMATIC SEQUENCE Ba	Dry heat	16 h at + 100 ± 2 °C, no voltage applied
12.7.3	Db	Damp heat, cyclic	1 cycle of 24 h, upper temp. 55 ± 2 °C, R.H. 93 ± 3%; no voltage applied
12.7.4	Aa	Cold	2 h at –40 ± 3 °C, no voltage applied
12.7.5	Db	Damp heat, cyclic	1 cycle of 24 h at 55 ± 2 °C, R.H. 93 ± 3%, no voltage applied
			Final measurements
		Damp heat, steady state	Initial measurements, C at 1 kHz, $\tan \delta$ at 10 kHz
12.8	Ca		40 ± 2 °C for 21 days; R.H. 90 to 95%; no voltage applied
			Final measurements
12.9		Endurance	Initial measurements, C at 1 kHz, $\tan \delta$ at 10 kHz
			1000 h at 85 °C; 1,5 x U_R (d.c.) applied 1000 h at 100 °C; 1,5 x U_C applied 1000 h at 85 °C; U_R (a.c.) 50 Hz applied
			Final measurements

requirements	
at 100 °C: $\Delta C/C$ R_{ins}, $C \leqslant 0{,}33\ \mu F$ RC, $C > 0{,}33\ \mu F$	$\leqslant 5\%$ $> 500\ M\Omega$ $> 165\ s$
$\Delta C/C$ at $-40\ ^{\circ}C$	$\leqslant 7\%$
Visual examination	no damage
$\Delta C/C$ tan δ at 10 kHz R_{ins}	$\leqslant 5\%$ meets initial requirements $\geqslant 0{,}5$ x initial requirements
Visual examination	no damage
$\Delta C/C$ tan δ at 10 kHz R_{ins}	$\leqslant 5\%$ meets initial requirements meets initial requirements
Visual examination	no damage
$\Delta C/C$ tan δ at 10 kHz R_{ins}	$\leqslant 5\%$ meets initial requirements meets initial requirements

Additional tests

name of test	procedure (quick reference)
Solvent resistance	According to MIL-STD-202 E, method 215.
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.
Flammability	 Bore of gas jet: ϕ 0,5 mm. Fuel: butane. Test duration: 20 s. One flame application.

requirements
No damage.
No damage; $\Delta C/C \leqslant 5\%$. Tan δ shall not exceed initial requirements. Insulation resistance $\geqslant 50\ \%$ of initial requirements.
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.

POLYESTER FILM/FOIL CAPACITORS

flat type

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
Basic specification	IEC 384-11

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

MECHANICAL DATA

Dimensions in mm

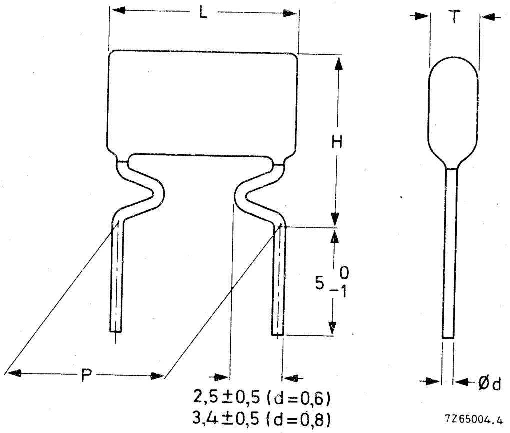


Fig. 1 For dimensions T, L, H, P and d, see tables below.

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	catalogue number 2222 347	
							tol. ±10%	tol. ±20%
0,015	4,5	13,5	12	10,16 ± 0,3 (4e)**	0,6	0,4	21153	20153
0,022	5,5	13,5	13			0,6	21223	20223
0,033	6	13,5	13,5			0,7	21333	20333
0,047	7	13,5	14,5			0,9	21473	20473
0,068	6	19	14,5	15,24 ± 0,3 (6e)**	0,8	1,3	21683	20683
0,10	7	19	15,5			1,7	21104	20104
0,15	8	19	16,5			2,3	21154	20154
0,22	7	27	18,5	22,86 ± 0,3 (9e)**		3,2	21224	20224
0,33	8,5	27	20			4,4	21334	20334
0,47	10,5	27	22			6,0	21474	20474
0,68	11	32	22,5	27,94 ± 0,3 (11e)**		8,4	21684	20684
1,0	13,5	32	25			12,5	21105	20105

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* Capacitances of the E6 series as quoted are preferred; intermediate capacitances 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	catalogue number 2222 347	
							tol. ±10%	tol. ±20%
0,010	5	13,5	12,5	10,16 ± 0,3 (4e)**	0,6	0,5	41103	40103
0,015	5,5	13,5	13			0,6	41153	40153
0,022	6,5	13,5	14			0,8	41223	40223
0,033	5,5	19	14	15,24 ± 0,3 (6e)**	0,8	1,1	41333	40333
0,047	6,5	19	15			1,4	41473	40473
0,068	7,5	19	16			1,8	41683	40683
0,10	6,5	27	18	22,86 ± 0,3 (9e)**		2,7	41104	40104
0,15	8	27	19,5			3,5	41154	40154
0,22	9,5	27	21			4,5	41224	40224
0,33	10	32	21,5	27,94 ± 0,3 (11e)**		6,3	41334	40334
0,47	12	32	23,5			9,1	41474	40474
0,68	15	32	26,5			13,1	41684	40684

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	catalogue number 2222 347	
							tol. ±10%	tol. ±20%
0,0047	4,5	13,5	12	10,16 ± 0,3 (4e)**	0,6	0,4	51472	50472
0,0068	5,5	13,5	13			0,5	51682	50682
0,010	6	13,5	13,5			0,7	51103	50103
0,015	7	13,5	14,5			0,9	51153	50153
0,022	6	19	14,5	15,24 ± 0,3 (6e)**	0,8	1,2	51223	50223
0,033	7	19	15,5			1,6	51333	50333
0,047	8	19	16,5			2,1	51473	50473
0,068	7	27	18,5	22,86 ± 0,3 (9e)**		2,9	51683	50683
0,10	8,5	27	20			3,8	51104	50104
0,15	10,5	27	22			5,2	51154	50154
0,22	11	32	22,5	27,94 ± 0,3 (11e)**		6,9	51224	50224
0,33	13,5	32	25			9,5	51334	50334

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* 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	catalogue number 2222 347	
							tol. ±10%	tol. ±20%
0,0010	5,5	13,5	13	10,16 ± 0,3 (4e)**	0,6	0,5	61102	60102
0,0015	5,5	13,5	13			0,6	61152	60152
0,0022	4,5	13,5	12			0,5	61222	60222
0,0033	5,5	13,5	13			0,6	61332	60332
0,0047	6	13,5	13,5			0,7	61472	60472
0,0068	7	13,5	14,5			0,9	61682	60682
0,010	6	19	14,5	15,24 ± 0,3 (6e)**	0,8	1,2	61103	60103
0,015	7	19	15,5			1,5	61153	60153
0,022	8	19	16,5			2,0	61223	60223
0,033	7	27	18,5	22,86 ± 0,3 (9e)**		2,8	61333	60333
0,047	8,5	27	20			3,4	61473	60473
0,068	10,5	27	22			4,4	61683	60683
0,10	11	32	22,5	27,94 ± 0,3 (11e)**		6,2	61104	60104
0,15	13,5	32	25			8,7	61154	60154

→ **Marking**

The capacitors are marked as follows:

1st line: rated capacitance and tolerance (± 10% indicated by 10 or K, ± 20% indicated by 20 or M);
2nd line: rated voltage, code for dielectric (KT = non-metallized PETP film), code for factory of origin.
The manufacturer's name is at the left and code for factory of origin is indicated to the right of this marking.

Mounting

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

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* Capacitances of the E6 series as quoted are preferred; intermediate capacitances 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 23 ± 1 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 50 ± 2%.

Capacitance

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

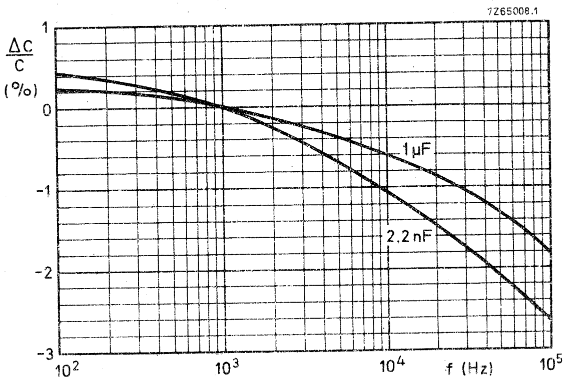

Fig. 2 Capacitance as a function of frequency; typical curves. Measuring voltage is 1 V for frequencies from 100 Hz to 10 kHz and 0,3 V for frequencies from 10 to 100 kHz.

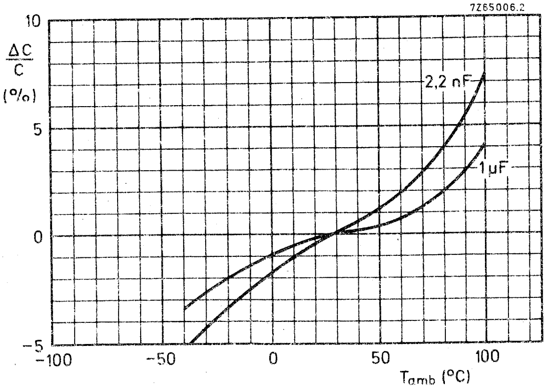

Fig. 3 Capacitance as a function of temperature; typical curves. Measuring frequencies from 1 to 100 kHz for capacitance values from 0,0022 to 0,1 μF and 1 to 10 kHz for capacitance values from 0,1 to 1 μF.

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
Test voltage for 1 min between terminals	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 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

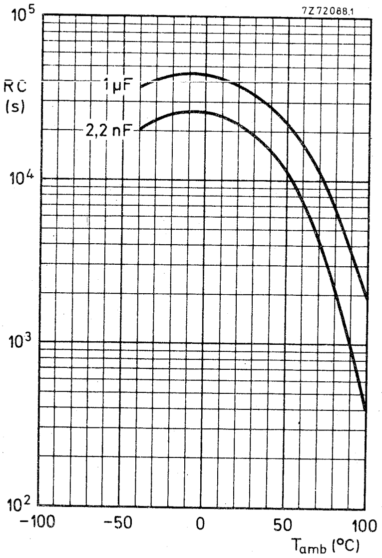

Fig. 4 RC-product as a function of temperature; typical curves.

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* 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})

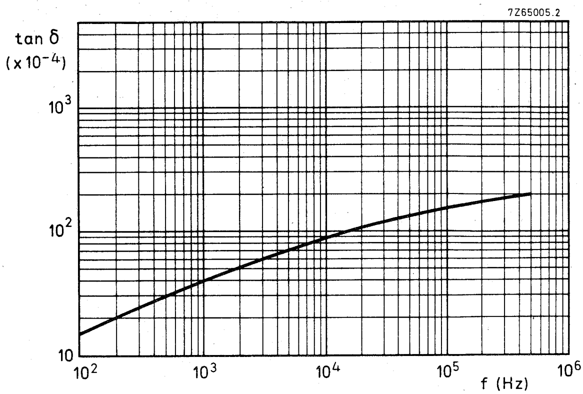


Fig. 5 Tan δ as a function of frequency; typical curve.

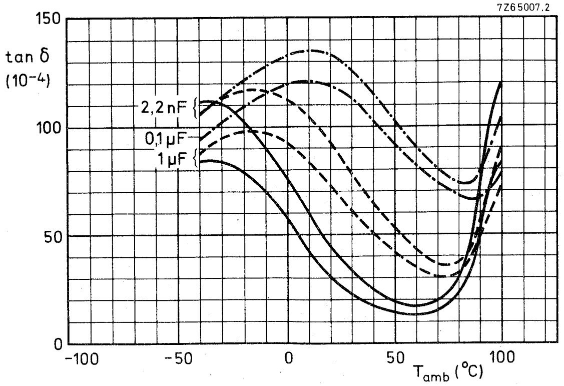


Fig. 6 Tan δ as a function of temperature; typical curves.

———— 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
$\leqslant$ 7,5 x 19 x 16	2000
$>$ 7,5 x 19 x 16 and $\leqslant$ 7 x 27 x 18,5	1000
$>$ 7 x 27 x 18,5 and $\leqslant$ 11 x 32 x 22,5	500
$>$ 11 x 32 x 22,5	250

ADDITIONAL INFORMATION

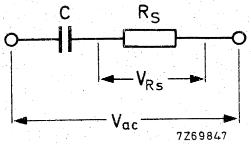
Power dissipation

The rated a.c. voltage has been specified for 50 to 60 Hz and at 23 °C. This voltage 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.

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

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



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

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

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

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

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

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 equation (3b), Fig. 8 gives the minimum size of capacitor which can dissipate this power.

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

Example of using Fig. 7 and Fig. 8

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

$$P = (R_sC)\, C\omega^2\ V_{ac}^2$$
$$= 1,35 \times 10^{-7} \times 0,047 \times 10^{-6} \times 4\pi^2 \times 10^8 \times 10^4 = 250 \text{ mW}$$

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.

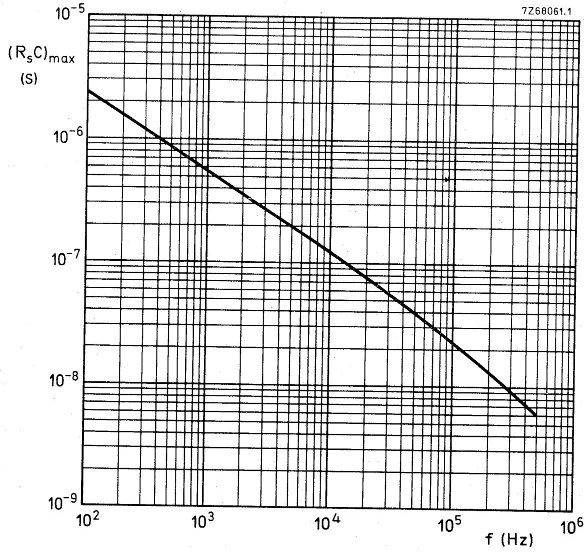


Fig. 7 Maximum product of series resistance and capacitance as a function of frequency.

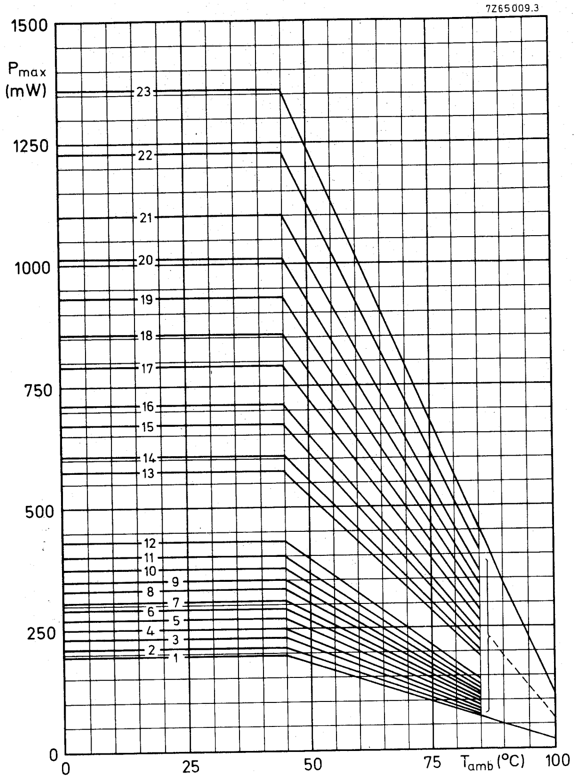


Fig. 8 Maximum permissible power dissipation as a function of temperature, with case size as a parameter.

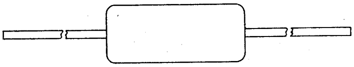
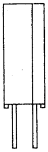
curve	dimensions in mm		
	T_{max}	L_{max}	H_{max}
1	4,5	13,5	12
2	5	13,5	12,5
3	5,5	13,5	13
4	6	13,5	13,5
5	6,5	13,5	14
6	7	13,5	14,5
7	5,5	19	14
8	6	19	14,5
9	6,5	19	15
10	7	19	15,5
11	7,5	19	16

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

POLYSTYRENE FILM/FOIL CAPACITORS KS

SURVEY

Main applications: tuning circuits, filter networks requiring high stability, high precision, low losses, high reliability.

type	series number 2222 . . .	rated capacitance pF	rated voltage (U_R d.c.) V	page
sleeved 	424 to 431	2000 to 39 000	63	
		1100 to 16 000	160	
		560 to 11 000	250	
		51 to 5 600	630	D15
wrapped end-filled 	444 to 447	43 000 to 162 000	63	
		18 000 to 82 000	160	
		12 000 to 47 000	250	
		6 200 to 24 000	630	D33
potted 	443	100 to 34 000	63	D27

TESTS AND REQUIREMENTS

Standard atmospheric conditions for reference tests: ambient temperature + 23 ± 1 °C, atmospheric pressure 86 to 106 kPa, relative humidity 50 ± 2%.

IEC 384-7 clause	IEC 68-2 test method	name of test	procedure (quick reference)
12.1	Ua1	Tensile strength of terminations	Loading force in axial direction for 10 s: 10 N
	Ub (method 1)	Bending of terminations	Loading force 5 N, 2 consecutive bends
	Uc	Torsion of terminations	2 successive rotations of 180° in opposite directions
12.2	Ta	Soldering	Solder bath, non-activated colophony flux, solder temp. 235 °C, dwell time 2 s
	Tb (method 1B)	Resistance to soldering heat	Solder bath 260 °C, 10 s
12.3	Na	Rapid change of temperature	5 cycles of ½ h at –40 °C and ½ h at + 70 °C
			5 cycles of ½ h at –40 °C and ½ h at + 85 °C
12.4	Fc	Vibration	10 to 55 Hz, 0,75 mm or 10g (whichever is the less), 3 directions, 2 h per direction.
12.5	Eb	Bumping	40g, 6 ms, 4000 bumps.

n.a. = not applicable.

	requirements		
	2222 424 – 2222 431	2222 443	2222 444 – 2222 447
Visual examination	no damage		
Tan δ			meet initial requirements
Visual examination	no damage	n.a.	no damage
Tan δ			meet initial requirements
Visual examination	no damage	n.a.	no damage
Tan δ			meet initial requirements
Visual examination	good tinning		
Visual examination	no damage		
$\Delta C/C$	$\leqslant$ 1%	$\leqslant$ 0,5%	$\leqslant$ 0,5%
Tan δ	meet initial requirements		
Visual examination	only 63 V version		only 63 V version
	no damage		
$\Delta C/C$	$\leqslant$ 0,5% + 0,5 pF	$\leqslant$ 0,2%	$\leqslant$ 0,5%
Tan δ and R_{ins}	meet initial requirements		
Visual examination	160 V,250 V,630 V versions		160 V,250 V,630 V versions
	no damage		
$\Delta C/C$	$\leqslant$ 0,5% + 0,5 pF	$\leqslant$ 0,5%	$\leqslant$ 0,5%
Tan δ and R_{ins}	meet initial requirements		
Visual examination	no damage		
$\Delta C/C$		$\leqslant$ 0,1% no open or short circuit	
Visual examination	n.a.	no damage	n.a.
$\Delta C/C$		$\leqslant$ 0,1% no open or short circuit	

IEC 384-7 clause		IEC 68-2 test method	name of test	procedure (quick reference)
CLIMATIC SEQUENCE	12.7	Ba	Dry heat	16 h at + 70 ± 2 °C, no voltage applied
				16 h at + 85 ± 2 °C, no voltage applied
		Db	Damp heat, cyclic	1 cycle of 24 h, upper temp. 55 ± 2 °C, R.H. 93 ± 3%; no voltage applied
		Aa	Cold	2 h at –40 ± 3 °C, no voltage applied
		Db	Damp heat, cyclic	n cycles of 24 h at 55 °C, R.H. 93 ± 3%, no voltage applied Within 15 min after removal from the test, U_R shall be applied for 1 min
				Final measurements
12.8		Ca	Damp heat, steady state	40 ± 2 °C for the time period given in the climatic category; R.H. 90 to 95%; 6 V applied continuously
				As above but: within 15 min after removal from the test, the rated voltage is applied for 1 min

	requirements		
	2222 424 – 2222 431	2222 443	2222 444 – 2222 447
Visual examination	63 V version no damage, no leakage	n.a.	63 V version no damage, no leakage
	160 V,250 V,630 V versions	all versions	160 V,250 V,630 V versions
	no damage, no leakage		
	n = 1	n = 5	n = 5
	n.a.	n.a.	
$\Delta C/C$, $C < 500$ pF	$\leqslant 1{,}5\%$ or 1 pF*		
$C \geqslant 500$ pF	$\leqslant 1\%$		
$\Delta C/C$		$\leqslant 0{,}5\% + 0{,}5$ pF	$\leqslant 0{,}5\%$
Tan δ	$\leqslant 2$ x initial requirements	$\leqslant 1{,}2$ x initial requirements	$\leqslant 2$ x initial requirements
R_{ins}	$> 0{,}5$ x initial requirements	$> 5 \times 10^5$ MΩ	$> 0{,}2$ x initial requirements
$\Delta C/C$, $C < 500$ pF	$\leqslant 1{,}5\%$ or 1 pF*		
$C \geqslant 500$ pF	$\leqslant 1\%$		
$\Delta C/C$		$\leqslant 0{,}75\% + 0{,}5$ pF	
Tan δ	$\leqslant 2$ x initial requirements	$\leqslant 1{,}2$ x initial requirements	
R_{ins}	$> 0{,}5$ x initial requirements	$> 5 \times 10^5$ MΩ	
$\Delta C/C$			$\leqslant 0{,}5\%$
Tan δ			$\leqslant 2$ x initial requirements
R_{ins}			$> 0{,}2$ x initial requirements

n.a = not applicable

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* Whichever is greater.

IEC 384-7 clause	IEC 68-2 test method	name of test	procedure (quick reference)
12.9		Endurance	1000 h at + 70 °C 1,5 x U_R (d.c.) applied
			1000 h at + 85 °C 1,5 x U_R (d.c.) applied
12.10		Storage at low temperature	72 h at –55 °C

	requirements		
	2222 424 – 2222 431	2222 443	2222 444 – 2222 447
	63 V version:		63 V version:
$\Delta C/C$	$\leqslant$ 0,3%	$\leqslant$ 0,3% + 0,3 pF	$\leqslant$ 0,3%
Tan δ	$\leqslant$ initial requirements	$\leqslant$ 1,4 x initial requirements	$\leqslant$ initial requirements
R_{ins}	meet initial requirements	$>$ 5 x 10^5 MΩ	meet initial requirements
	160 V, 250 V, 630 V versions:		160 V, 250 V, 630 V versions:
$\Delta C/C$	$\leqslant$ 0,5% + 0,5 pF	$\leqslant$ 0,75% + 0,75 pF	$\leqslant$ 0,5%
R_{ins}	meet initial requirements	$>$ 5 x 10^5 MΩ	meet initial requirements
Tan δ	$\leqslant$ 1,4 x initial requirements		
$\Delta C/C$, $C < 500$ pF	$\leqslant$ 0,4%		
$C \geqslant 500$ pF	$\leqslant$ 0,25%		
$\Delta C/C$		$\leqslant$ 0,25% or 1 pF* no breakdown	$\leqslant$ 0,25% no breakdown

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* Whichever is greater.

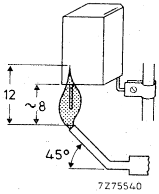
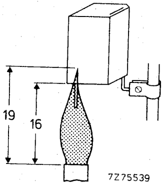
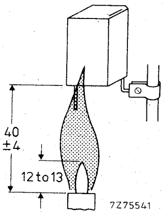
Additional tests

name of test	procedure (quick reference)
Long term stability	10 000 h at + 55 °C, 25 V (d.c.) applied
Endurance	2000 h at + 70 °C; 1,5 x U_R (d.c.) applied
Solderability of leads – globule method (IEC68, test T3.2)	16 h at + 155 ± 2 °C
– solder bath method (IEC68, test Ta)	16 h at + 155 ± 2 °C
Soldering test on printed-wiring boards	Capacitors mounted vertically on a board without plated-through holes; bodies rest on the board; board thickness: 1,6 mm, hole diameter: 0,8 mm. Bath temperature 250 °C, dip-solder time 7,5 s bath temperature 260 °C, dip-solder time 5 s Capacitors mounted horizontally on a board with plated-through holes; bodies at least 1 mm from the board. Bath temperature 260 °C, dip-solder time 5 s
	Board thickness: 1,6 mm, hole diameter: 0,8 mm; plated-through holes. Bath temperature: 250 ± 10 °C; dip-solder time: 7,5 ± 0,5 s. Bath temperature: 260 ± 10 °C; dip-solder time: 5 ± 0,5 s.

	requirements	
	2222 424 – 2222 431	2222 443
ΔC/C	n.a.	≤ 0,3% + 0,3 pF
ΔC/C	n.a.	≤ 0,3% + 0,3 pF
	good tinning, 4 s yield point	n.a.
	n.a.	good tinning
		n.a.
ΔC/C	≤ 1%	
ΔC/C	≤ 0,75%	
ΔC/C	≤ 1%. Forced cooling of the component side of the board gives less capacitance drift.	n.a.
ΔC/C	n.a.	≤ 0,5% or 1 pF whichever is greater

n.a. = not applicable

Additional tests

name of test	procedure (quick reference)
Flammability	 Bore of gas jet: ϕ 0,5 mm. Fuel: butane. Test duration: 20 s. One flame application.
	 Test according to UL1414 Bore of gas jet: ϕ 10 mm. Fuel: natural gas. Test duration: 3 x 15 s. Time interval between each application: 15 s.
	 Bore of gas jet: ϕ 14 to ϕ 15 mm. Fuel: propane. Test duration: 15 s. One flame application.

requirements		
	2222 424 – 2222 431	2222 443
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.	n.a.	
Extinguishing time ⩽ 15 s after the first and second flame application, ⩽ 60 s after the third flame application.	n.a.	
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 sample	n.a.	

POLYSTYRENE FILM/FOIL CAPACITORS

axial type

QUICK REFERENCE DATA

Rated capacitance range	51 to 39 000 pF
Tolerance on rated capacitance	± 5% (E24-series) ± 2% (E24, E48-series) ± 1% (E24, E48, 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 384-7

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-inductance 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

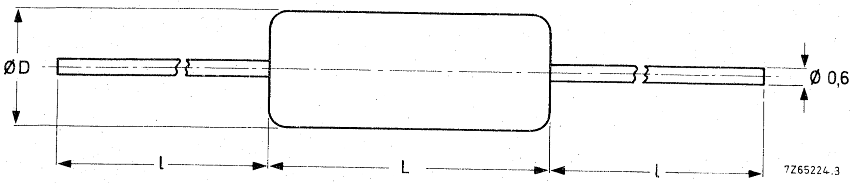


Fig. 1 For dimensions D, L and l see tables below.

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)
2 000	3,8	10,9	30	0,3	2222 424 22002
2 200					22202
2 400				0,4	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					25602
6 200	5,0			0,6	26202
6 800					26802
7 500		15	28		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

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* The capacitance values quoted are also available with a tolerance ± 1% or ± 2%.
Besides the values of the E24-series as quoted, intermediate values of the E48-series (with a tolerance ± 1% or ± 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	28	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)
1 100	3,8	10,9	30	0,3	2222 425 21102
1 200	4,0				21202
1 300					21302
1 500				0,4	21502
1 600					21602
1 800					21802
2 000	4,5				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		15	28		23902
4 300					24302
4 700					24702
5 100					25102
5 600				0,7	25602
6 200					26202

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* The capacitance values quoted are also available with a tolerance ± 1% or ± 2%.
Besides the values of the E24-series as quoted, intermediate values of the E48-series (with a tolerance ± 1% or ± 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	28	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)
560	3,8	10,9	30	0,3	2222 426 25601
620					26201
680					26801
750	4,0				27501
820				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	28	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

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* The capacitance values quoted are also available with a tolerance ± 1% or ± 2%.
Besides the values of the E24-series as quoted, intermediate values of the E48-series (with a tolerance ± 1% or ± 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	28	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	3,8	10,9	30	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

* The capacitance values quoted are also available with a tolerance ± 1% or ± 2%.
Besides the values of the E24-series as quoted, intermediate values of the E48-series (with a tolerance ± 1% or ± 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	30	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	28	0,6	21302
1 500					21502
1 600				0,7	21602
1 800	5,5			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) and code for dielectric material (KS = polystyrene film/foil).

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.

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* The capacitance values quoted are also available with a tolerance ± 1% or ± 2%.
Besides the values of the E24-series as quoted, intermediate values of the E48-series (with a tolerance ± 1% or ± 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 86 to 106 kPa and a relative humidity of 50 ± 2%.

Capacitance

Rated capacitance (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	$-(125 \pm 60) \times 10^{-6}$/K
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
R between interconnected terminals and coating	> 500 000 MΩ	> 100 000 MΩ

Tan δ (tangent of the loss angle)

Tan δ at 10 kHz, for $C > 20\,000$ pF	$\leqslant 10 \times 10^{-4}$
Tan δ at 100 kHz, for $10\,000\ \text{pF} < C \leqslant 20\,000$ pF	$\leqslant 15 \times 10^{-4}$
Tan δ at 100 kHz, for $1000\ \text{pF} < C \leqslant 10\,000$ pF	$\leqslant 10 \times 10^{-4}$
Tan δ at 1 MHz, for $C \leqslant 1000$ pF	$\leqslant 10 \times 10^{-4}$

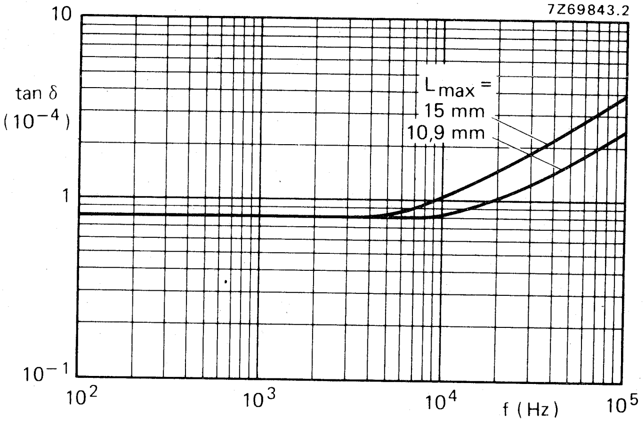

Fig. 2 Tan δ as a function of frequency; typical curves.

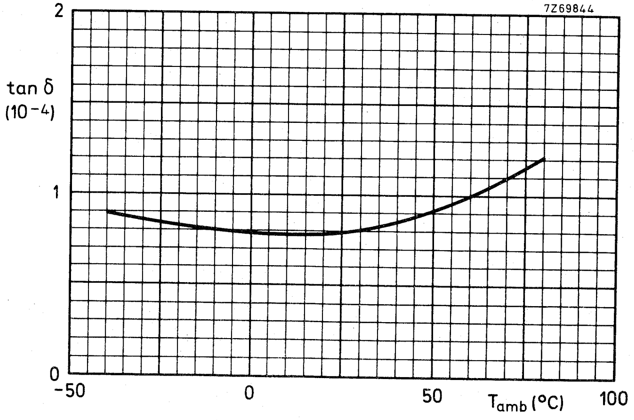

Fig. 3 Tan δ as a function of temperature; typical curve.

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	
2 000– 3 900	1 100– 1 800	560– 1 000	51– 430	400
4 300– 5 600	2 000– 2 700	1 100– 1 500	470– 680	300
6 200– 6 800	3 000– 3 900	1 600– 2 200	750–1 000	250
			1 100–1 200	200
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

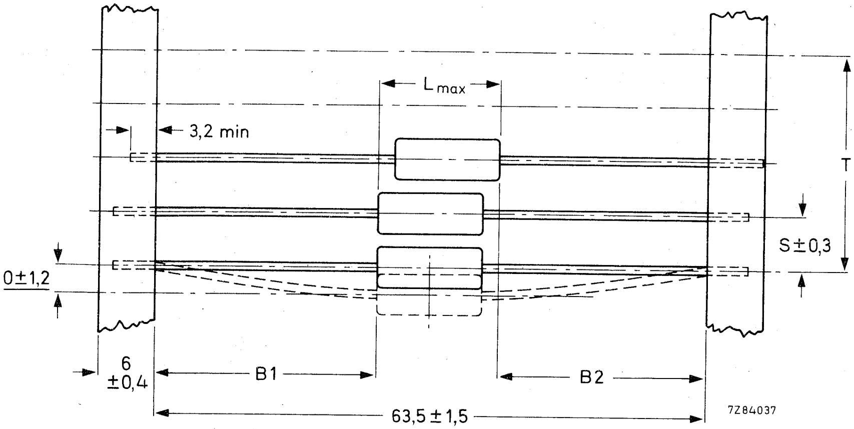

Fig. 4 | B1-B2 | = max. 1,4 mm; for dimension L max, see Tables 1 to 4.

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
2 000– 5 600	1 100– 2 700	560– 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

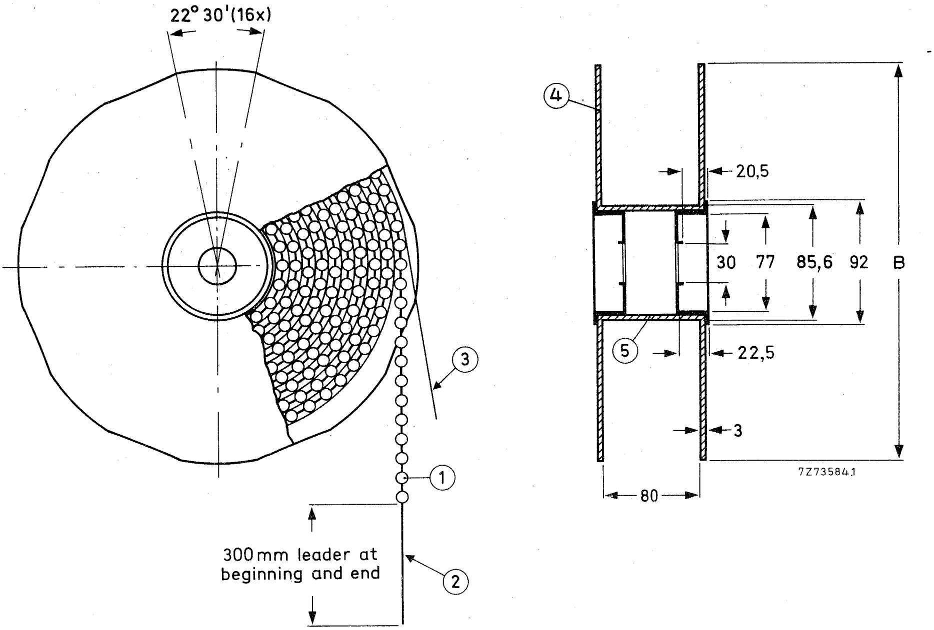

Fig. 5.

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		
2 000– 2 400	1 100	560– 680	51– 300	305	3 000
2 700– 5 600	1 200– 2 700	750– 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

POLYSTYRENE FILM/FOIL CAPACITORS

potted type

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 °C (class 1*) 85 °C (class 3*)
Climatic category, IEC 68	40/070/56 (class 1*) 55/085/56 (class 3*)
Basic specification	IEC 384–7

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-inductance 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

first three figures of capacitance value in pF

multiplying factor
1 = 1x
2 = 10x
3 = 100x

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.

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* According to IEC 384–7.

MECHANICAL DATA

Dimensions in mm

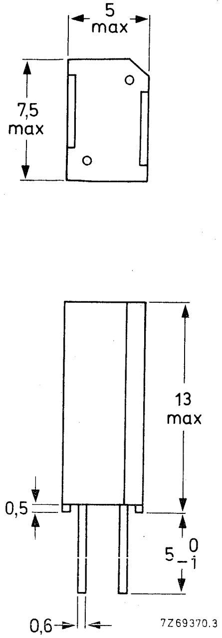


Fig. 1 Capacitors of rated capacitance range 100 to 3920 pF.

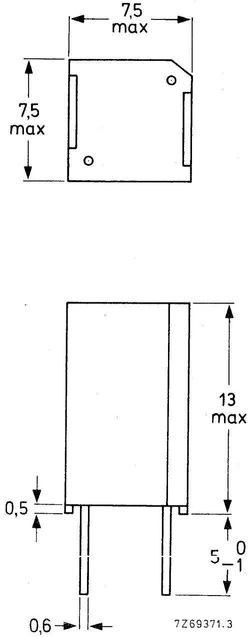


Fig. 2 Capacitors of rated capacitance range 100 to 15 000 pF.

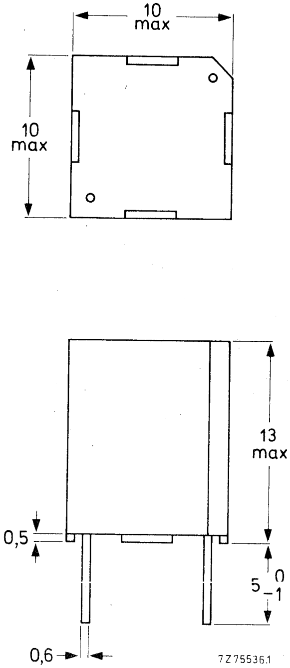


Fig. 3 Capacitors of rated capacitance range 15 400 to 34 000 pF.

Marking

Capacitors according to Fig. 1 are marked in ink on the top with:
1st line: rated capacitance in pF (without the pF unit symbol);
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 (without the pF unit symbol);
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.

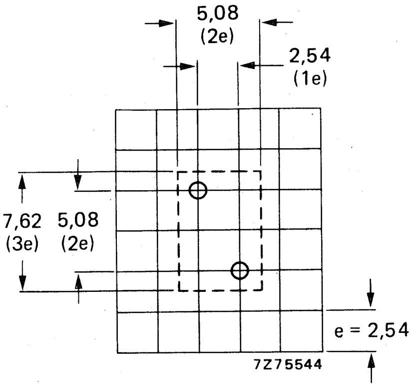


Fig. 4 Required space for capacitors according to Fig. 1.

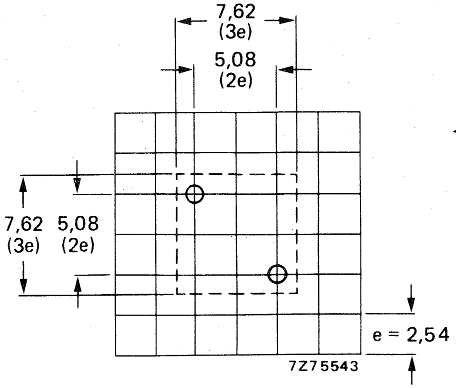


Fig. 5 Required space for capacitors according to Fig. 2.

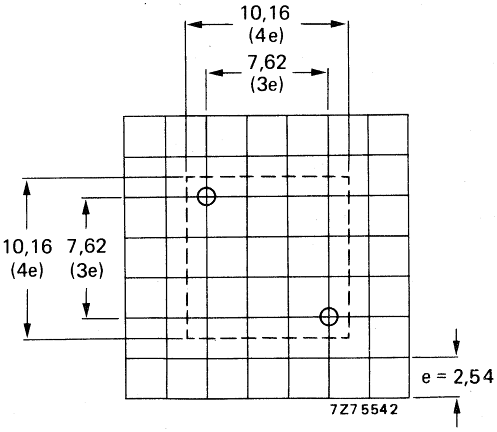


Fig. 6 Required space for capacitors according to Fig. 3.

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of 23 ± 1 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 50 ± 2%.

Capacitance

Rated capacitance (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	$-(95 \text{ to } 155) \times 10^{-6}$/K
$C_R > 6000$ pF	$-(120 \text{ to } 185) \times 10^{-6}$/K
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	$2 \times U_R$ (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, $500 \text{ pF} < C_R \leqslant 1000$ pF	$\leqslant 10 \times 10^{-4}$
at 100 kHz, for $1000 \text{ pF} < C \leqslant 10\,000$ pF	$\leqslant 10 \times 10^{-4}$
at 100 kHz, for $10\,000 \text{ pF} < C \leqslant 15\,000$ pF	$\leqslant 15 \times 10^{-4}$
at 10 kHz, for $C > 15\,000$ pF	$\leqslant 10 \times 10^{-4}$

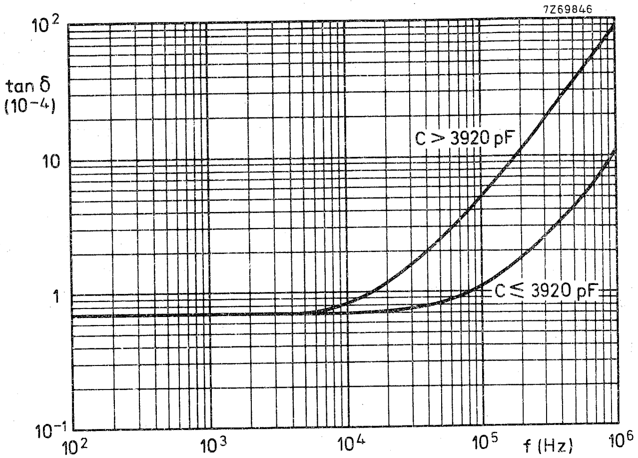


Fig. 7 Tan δ as a function of frequency; typical curves.

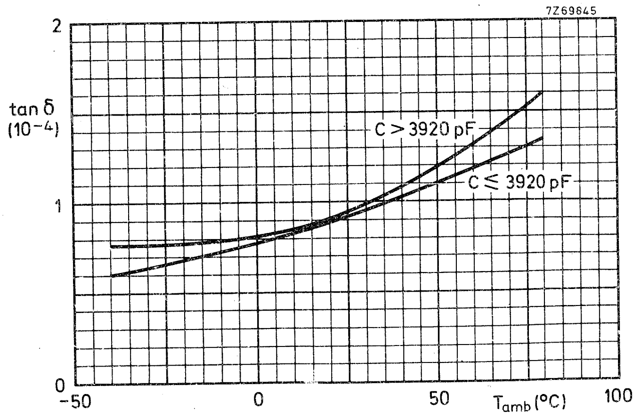


Fig. 8 Tan δ as a function of temperature; typical curves.

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

For general applications

Rated temperature	85 °C (IEC 384–7, class 3)
Category temperature range	–55 to + 85 °C
Storage temperature range	–55 to + 85 °C
Climatic category, IEC 68	55/085/56

For long-life applications

Rated temperature	70 °C (IEC 384–7, class 1)
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.
Capacitors according to Figs 1 and 2: 200 pieces per box;
Capacitors according to Fig. 3: 100 pieces per box.

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 384-7

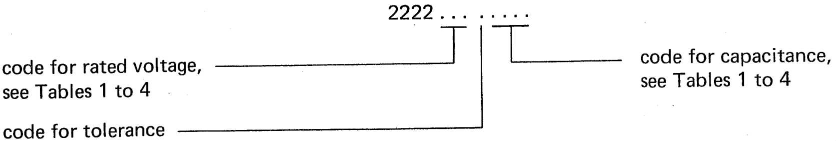
APPLICATION

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-inductance 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



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

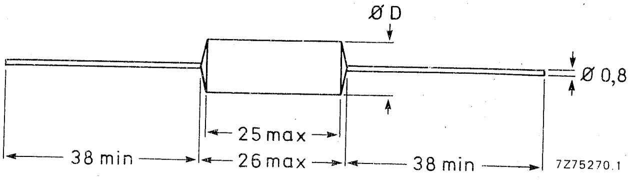


Fig. 1 For dimension D see tables below.

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

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* 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

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* 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.

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* 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 86 to 106 kPa 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	$-(125 \pm 60) \times 10^{-6}$/K
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

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* 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	$\leqslant 5 \times 10^{-4}$

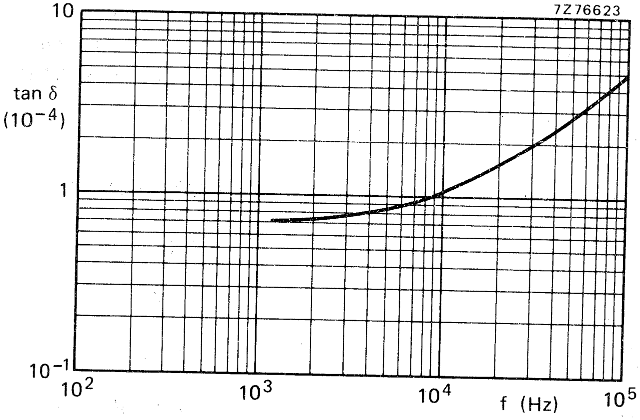


Fig.2 Tan δ as a function of frequency; typical curve.

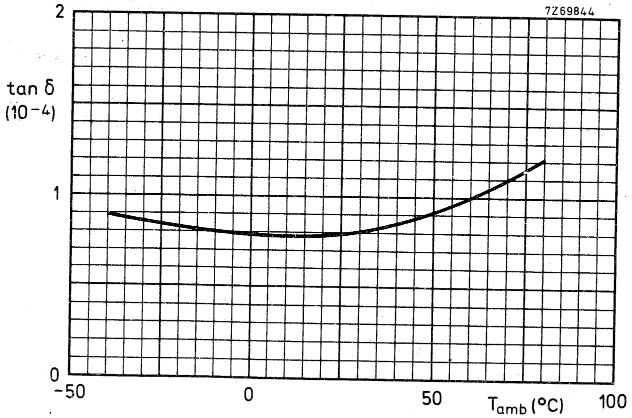


Fig.3 Tan δ as a function of temperature; typical curve.

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

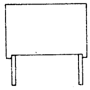
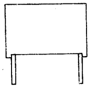
The capacitors are supplied in cardboard boxes; the number of capacitors per box is given in Table 5.

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

POLYPROPYLENE FILM/FOIL CAPACITORS
KP, KP/MKP

SURVEY

type	series number 2222 . . .	main application	rated capacitance	rated voltage (U_R d.c.) V	page
KP potted 	357 5....	tv deflection, a.c. motor commutation, high currents, high voltages, steep pulses	0,039 to 0,82 μF	250	E15
KP/MKP series construction 	357 6.... 357 7.... 357 8.... 357 9....		0,047 to 0,33 μF 0,018 to 0,22 μF 0,0082 to 0,15 μF 0,001 to 0,013 μF	630 1000 1500 2000	E23
KP axial type 	455 ..... 456 ..... 457	tuning circuits, filter networks, applications with high stability, high precision, low losses	3300 to 56 000 pF 1800 to 36 000 pF 47 to 20 000 pF	63 160 250	E33

TESTS AND REQUIREMENTS

Standard atmospheric conditions for reference tests: ambient temperature + 23 ± 1 °C, atmospheric pressure 86 to 106 kPa, relative humidity 50 ± 2%.

IEC 68-2 test method	name of test	procedure (quick reference)
Ua1	Tensile strength of terminations	Loading force in axial direction of the wires 10 N for 10 s
		Loading force in radial direction of the wires 5 N for 10 s
Ub (method 1)	Bending of terminations	Loading force 5 N, 2 consecutive bends
Uc	Torsion of terminations	2 successive rotations of 180° in opposite directions
Ta	Soldering	Solder bath, non-activated colophony flux, solder temperature 235 °C, dwell time 2 s
Tb method 1B	Resistance to soldering heat	Solder bath 260 °C, 10 s
method 1A		
Na	Rapid change of temperature	5 cycles of ½ h at −40 °C and ½ h at + 85 °C
		5 cycles of ½ h at −40 °C and ½ h at + 100 °C
Fc	Vibration	10 to 55 Hz, 0,75 mm or 10g (whichever is the less), 3 directions, 2 h per direction.
Eb	Bumping	40g, 6 ms, 4000 bumps.

n.a. = not applicable.

	requirements		
	2222 357 5	2222 357 6/9	2222 455 – 2222 457
Visual examination	no damage		
Visual examination	no damage		n.a.
Visual examination	no damage		
Visual examination	n.a.	n.a.	no damage
Visual examination	good tinning		
Visual examination	no damage		n.a.
$\Delta C/C$	$\leqslant 1\%$	$\leqslant 1\%$	
Visual examination	n.a.	n.a.	no damage
$\Delta C/C$			$\leqslant 1\% + 1$ pF
Visual examination	no damage, no leakage		
$\Delta C/C$	$\leqslant 2\%$	$\leqslant 2\%$	$\leqslant 1\% + 1$ pF
Tan δ	meet initial requirements		
R_{ins}	meet initial requirements		
$\Delta C/C$	n.a.	n.a.	$\leqslant 1{,}5\% + 1$ pF
Tan δ			meet initial requirements
R_{ins}			
Visual examination	no damage, no open or short circuit		
$\Delta C/C$	$\leqslant 0{,}5\%$	$\leqslant 0{,}5\%$	
Visual examination	no damage, no open or short circuit		
$\Delta C/C$	$\leqslant 0{,}5\%$	$\leqslant 0{,}5\%$	

IEC68-2 test method		name of test	procedure (quick reference)
Ba	CLIMATIC SEQUENCE	Dry heat	16 h at + 85 ± 2 °C, no voltage applied
Db		Damp heat, cyclic	1 cycle of 24 h, upper temp. 55 ± 2 °C, R.H. 93 ± 3%; no voltage applied
Aa		Cold	2 h at −40 ± 3 °C, no voltage applied
M		Low air pressure	1 h at 25 ± 5 °C, and an atmospheric pressure of 8,5 kPa During the last 5 min of the test U_R (d.c.) is applied
Db		Damp heat, cyclic	n cycles of 24 h at 55 °C, R.H. 93 ± 3%, no voltage applied Within 15 min after removal from the test, U_R (d.c.) is applied for 1 min
			Final measurements
Ca		Damp heat, steady state	56 days at 40 ± 2 °C, R.H. 90 to 95%; no voltage applied Within 15 min after test U_R (d.c.) is applied for 1 min
			21 days at 40 ± 2 °C, R.H. 90 to 95% 6 V applied continuously

	requirements		
	2222 357 5	2222 357 6/9	2222 455 – 2222 457
Visual examination	no damage, no leakage		
$\Delta C/C$ at 85 °C	⩽ 5%	⩽ 5%	
R_{ins}	meet initial requirements		
$\Delta C/C$ at −40 °C	⩽ 5%	⩽ 5%	
	no damage, no flashover during and after test		
	n = 5	n = 5	n = 1
			n.a.
Visual examination			no damage no leakage
$\Delta C/C$	⩽ 1%	⩽ 1%	⩽ 0,5% + 0,5 pF
Tan δ	meet initial requirements		⩽ 1,4 x initial requirements
R_{ins}	⩾ 0,5 x initial requirements		
Visual examination	no damage		n.a.
$\Delta C/C$	⩽ 2%	⩽ 2%	
Tan δ	meet initial requirements		
R_{ins}	⩾ 0,5 x initial requirements		
$\Delta C/C$	n.a.	n.a.	⩽ 0,5% + 0,5 pF
Tan δ			⩽ 1,4 x initial requirements
R_{ins}			⩾ 0,5 x initial requirements

n.a. = not applicable.

IEC 68-2 test method	name of test	procedure (quick reference)
	Endurance	1000 h at + 85 °C; 1,5 x U_R (d.c.) applied 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 at 20 kHz applied
		2000 h at + 85 °C; 1,5 x U_R (d.c.) applied 2000 h at + 85 °C; 1,25 x U_R (a.c.) 50 Hz applied 1000 h at + 25 °C; 20 kHz voltage of 1,25 x max. permissible voltage at 20 kHz applied
		1000 h at + 85 °C; 1,5 x U_R (d.c.) applied 1000 h at + 85 °C; 1,25 x U_R (a.c.) 50 Hz applied
		1000 h at + 100 °C; 1,5 x U_C (d.c.) applied
	Storage	72 h at −55 °C 1000 h at + 100 °C

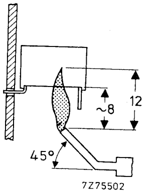
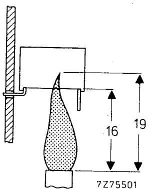
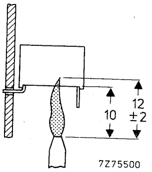
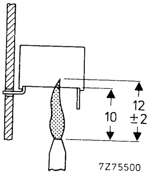
	requirements		
	2222 357 5	2222 357 6/9	2222 455 – 2222 457
$\Delta C/C$ Tan δ R_{ins}	$\leqslant$ 1% meet initial requirements $\geqslant$ 0,5 x initial requirements	n.a.	n.a.
$\Delta C/C$ Tan δ R_{ins}	n.a.	$\leqslant$ 2% meet initial requirements	n.a.
$\Delta C/C$	n.a.	n.a.	$\leqslant$ 0,5% + 0,5 pF
$\Delta C/C$ Tan δ R_{ins}	n.a.	n.a.	$\leqslant$ 1% + 1 pF $\leqslant$ 1,4 x initial requirements $\geqslant$ initial requirements
$\Delta C/C$ $\Delta C/C$	n.a.	n.a.	$\leqslant$ 0,5% + 0,5 pF $\leqslant$ 1% + 1 pF

Additional tests

name of test	procedure (quick reference)
Solvent resistance	MIL-STD-202E, method 215
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
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
Endurance (only for capacitors suited for fly-back purposes)	1000 h at + 25 °C 800 V (d.c.) + 500 V (a.c.) applied for 1000 V version 1200 V (d.c.) + 800 V (a.c.) applied for 1500 V version 1500 V (d.c.) + 1000 V (a.c.) applied for 2000 V version
	1000 h at + 85 °C, same voltages applied as above
Soldering test for mounting on printed-wiring boards	Capacitors mounted horizontally on a board, thickness 1,6 mm, with non-plated-through holes. Bodies rest on the board without forced cooling. Body temperature 70 ± 5 °C, bath temperature 250 ± 10 °C, dwell time 5 ± 0,5 s.

	requirements		
	2222 357 5	2222 357 6/9	2222 455 – 2222 457
Visual examination	no damage		n.a.
R_{ins}		meet initial requirements	
$\Delta C/C$	$\leqslant 2\%$	$\leqslant 2\%$	n.a.
Tan δ	meet initial requirements		
R_{ins}	$\geqslant 0{,}5$ x initial requirements		
Δ tan δ at 10 kHz	$\leqslant 2 \times 10^{-4}$	$\leqslant 2 \times 10^{-4}$	n.a.
	n.a.	no short circuit no interruption	n.a.
	n.a.	no short circuit no interruption	n.a.
Visual examination $\Delta C/C$	n.a.	n.a.	no damage $\leqslant 1\% + 1$ pF

Additional tests

name of test	procedure (quick reference)
Flammability	 Bore of gas jet: ϕ 5 mm. Fuel: butane. Test duration: 20 s. One flame application.
	 Test according to UL1414 Bore of gas jet: ϕ 10 mm. Fuel: natural gas. Test duration: 3 x 15 s. Time interval between each application: 15 s.
	 Bore of gas jet: ϕ 0,5 mm. Fuel: butane. Test duration: 3 x 15 s. Second and third flame application start after extinguishing of the flame on the capacitor.
	 Test according to VDE0860, part 1. Bore of gas jet: ϕ 0,5 mm. Fuel: butane. Before testing the capacitors are stored for 2 h at 100 ± 2 °C. Test duration 1st cycle: 10 s, 2nd cycle: 1 min, 3rd cycle: 2 min. Second and third flame application start directly after extinguishing of the flame on the capacitor.

requirements
2222 357
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.
Extinguishing time ⩽ 15 s after the first and second flame application, ⩽ 60 s after the third flame application.
Extinguishing time ⩽ 10 s after each flame application. No burning particles must drop from the sample.
Extinguishing time ⩽ 30 s after each flame application. No burning particles must drop from the sample.

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-inductance 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.

MECHANICAL DATA

Dimensions in mm

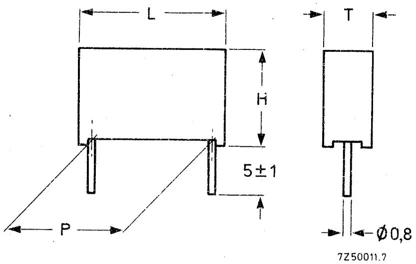


Fig. 1 For dimensions T, L, H and P, see Table 1.

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%	catalogue number 2222 357 . . . . . 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:

- rated capacitance in µF, tolerance and rated d.c. voltage, without unit symbols;
- code for dielectric materials (KP), 5th, 6th and 7th digits of the catalogue number, code for factory of origin and production date code (according to IEC 62, clause 5);
- manufacturer's identification symbol.

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 ait.

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of 23 ± 1 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 50 ± 2%.

Capacitance

Rated capacitance (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) x 10^{-6}/K

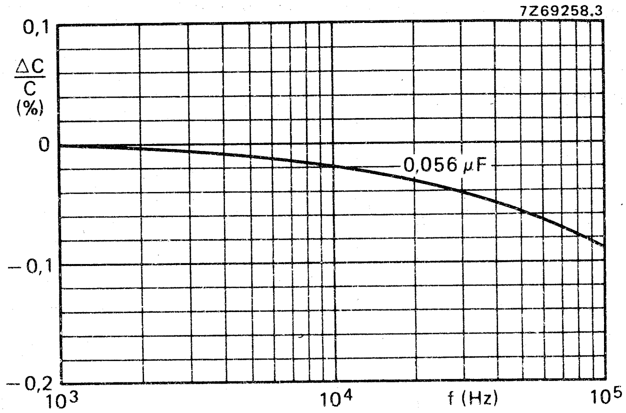


Fig. 2 Capacitance as a function of frequency; typical curve. Measuring voltage is 0,3 V.

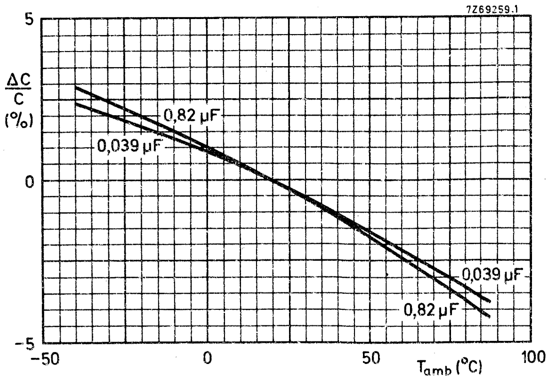


Fig. 3 Capacitance as a function of temperature; typical curves. Measuring voltage is 0,3 V, measuring frequency is 10 kHz.

Voltage

Rated voltage U_R (d.c.)	250 V
Rated voltage U_R (a.c.), 50 to 60 Hz	160 V
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 ≤ 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

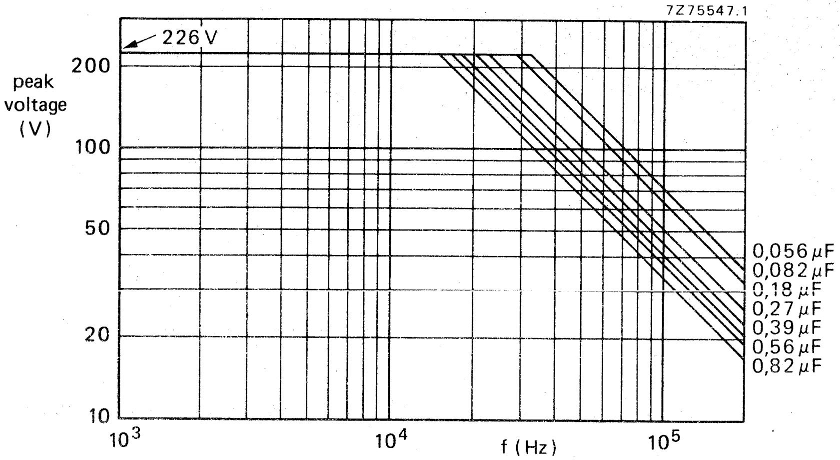


Fig. 4 Maximum permissible peak value of sinusoidal voltages as a function of frequency at $T_{amb} \leq 45$ °C.

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 $C_R \leq 0,1$ μF	> 50 000 MΩ	> 500 MΩ
RC between terminations, for $C_R > 0,1$ μF	> 5 000 s	> 50 s

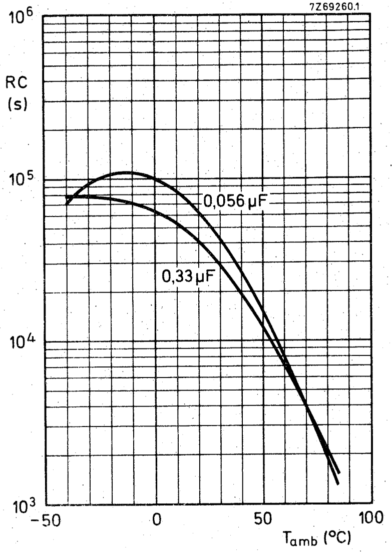


Fig. 5 RC-product as a function of temperature; typical curves.

Tan δ (tangent of the loss angle)

Tan δ at 100 kHz	
for capacitors with pitch P = 15 or 22,5 mm	$\leqslant 10 \times 10^{-4}$
for capacitors with pitch P = 27,5 mm	
$C_R \leqslant 0{,}33\ \mu F$	$\leqslant 15 \times 10^{-4}$
$0{,}33\ \mu F < C_R \leqslant 0{,}47\ \mu F$	$\leqslant 20 \times 10^{-4}$
$C_R > 0{,}47\ \mu F$	$\leqslant 25 \times 10^{-4}$

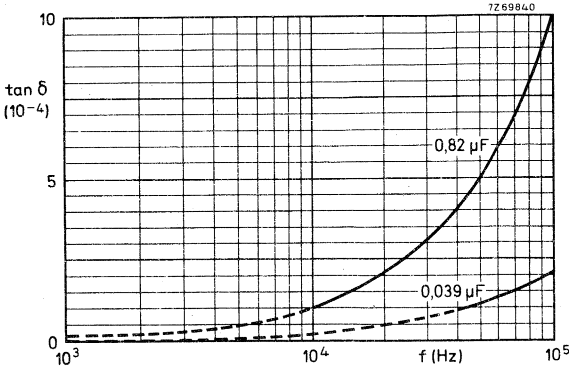


Fig. 6 Tan δ as a function of frequency; typical curves.

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.

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}).

For a capacitor used with a sinusoidal voltage, the power dissipation is expressed by:

$$P = V_{rms} I_{rms} \cos \varphi. \qquad (1)$$

As $I_{rms} = \omega C V_{rms}$, and $\cos \varphi \approx \tan \delta$, equation (1) can be rewritten as:

$$P = V_{rms}^2 \omega C \tan \delta = V_{rms}^2\ 2\pi f C \tan \delta. \qquad (2)$$

For capacitors of the 357 series, tan δ is about proportional to the frequency, thus:

$$\tan \delta = \frac{f}{10^5} \tan \delta_{100\ kHz}. \qquad (3)$$

Substituting equation (3) in equation (2) gives:

$$P = 2\pi.10^{-5}\ V_{rms}^2 f^2 C \tan \delta_{100\ kHz}. \qquad (4)$$

For capacitors with a pitch of 15 or 22,5 mm the maximum tan δ at 100 kHz is 10^{-3}, thus:

$$P = 2\pi.10^{-8} V_{rms}^2 f^2 C. \qquad (5)$$

For capacitors with a pitch of 27,5 mm the maximum tan δ at 100 kHz is:

$1{,}5 \times 10^{-3}$ for $C \leqslant 0{,}33\ \mu F$ thus $P = 3\pi.10^{-8} V_{rms}^2 f^2 C$, (6)
$2{,}0 \times 10^{-3}$ for $0{,}33\ \mu F < C \leqslant 0{,}47\ \mu F$, thus $P = 4\pi.10^{-8}\ V_{rms}^2 f^2 C$, (7)
$2{,}5 \times 10^{-3}$ for $C > 0{,}47\ \mu F$, thus $P = 5\pi.10^{-8} V_{rms}^2 f^2 C$. (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.

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

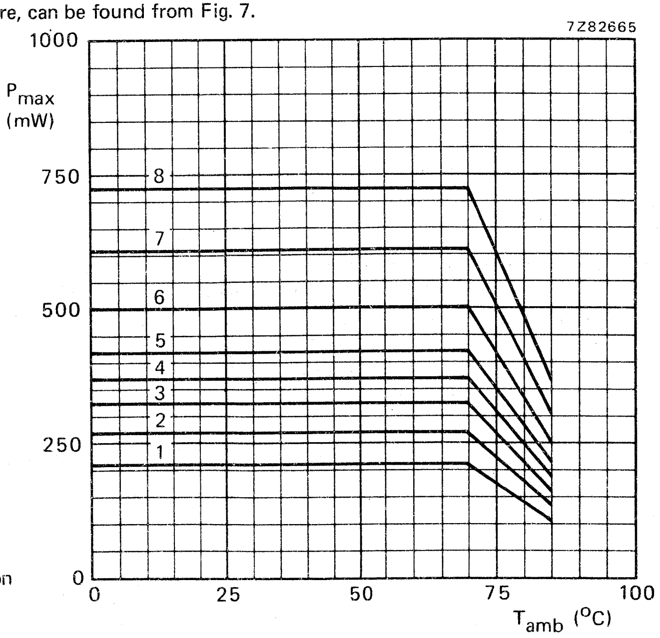


Fig. 7 Maximum permissible power dissipation as a function of temperature.

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* At $T_{amb} \leqslant 45$ °C the maximum permissible sinusoidal voltage can be found in Fig. 4.

Example 1

A capacitor of 0,82 μF (27,5 mm pitch) is to be used at a 20 kHz sinusoidal voltage of 100 V and an ambient temperature of 75 °C. The power to be dissipated is

$$\begin{aligned} P &= 5\pi.10^{-8}\ V_{rms}^2 f^2 C \\ &= 5 \times 3,14 \times 10^{-8} \times 100^2 \times 20\,000^2 \times 0,82 \times 10^{-6}\ \mathrm{W} \\ P &= 515\ \mathrm{mW}. \end{aligned}$$

Fig. 7 shows that at 75 °C, capacitors with curve number 8 can be used, thus a size of 18 mm x 34 mm x 28 mm.

Example 2

For a capacitor used with a half sinewave pulse, (Fig. 8), V_{rms} can be expressed by

$$V_{rms}^2 = \frac{1}{2} V_p^2 \frac{T1}{T2} . \tag{9}$$

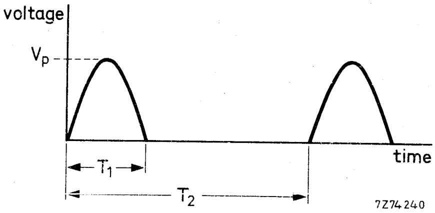

Fig. 8.

With $f = \frac{1}{2T_1}$, and substitution of equation (9) in equation (5), the maximum power dissipation for a capacitor with a pitch of 22,5 mm is

$$P = \frac{\pi}{4} .10^{-8} V_p^2 \frac{1}{T_1.T_2} C. \tag{8}$$

A capacitor of 0,056 μF is to be used with a half sinewave pulse (pulse duration 12 μs, repetition time 60 μs), peak value 200 V at an ambient temperature of 80 °C.

The maximum dissipated power is

$$P = \frac{\pi}{4} \times 10^{-8} \times 200^2 \times \frac{1}{12 \times 60 \times 10^{-12}} \times 0,056 \times 10^{-6}\ \mathrm{W}$$

$$P = 24,4\ \mathrm{mW}.$$

From Fig. 7 it can be seen that this power value is permitted for all capacitor sizes.

POLYPROPYLENE CAPACITORS

series construction

QUICK REFERENCE DATA

Rated capacitance range (E12 series)	1000 pF to 0,33 μF ←
Tolerance on rated capacitance	± 5% and ± 10%
Rated voltage U_R (d.c.)	630 V, 1000 V, 1500 V, 2000 V
Rated voltage U_R (a.c.), 50 to 60 Hz	300 V, 400 V, 600 V, 700 V
Rated temperature	85 °C
Climatic catagory, IEC 68	40/085/56

APPLICATION

For applications where high currents, high voltages and steep pulses occur.
They are mainly used for deflection circuits in television receivers (e.g. flyback), for commutation in thyristor circuits (e.g. 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-inductance wound cell of polypropylene film, aluminium foil and metallized polypropylene film. The cell is potted with epoxy resin in a yellow polypropylene case. The radial leads are solder-coated copper wire.

The capacitors are flame retardent and can withstand solvents and rinsing liquids without damage. They are provided with small stand-off pips to allow removalof solder flux etc., when cleaning the printed-wiring board.

MECHANICAL DATA

Dimensions in mm

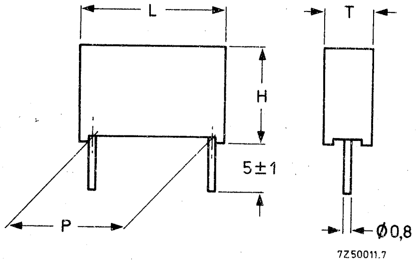

Fig. 1 For dimensions T, L, H and P, see Tables 1 to 4.

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

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* Besides the values of the E12 series as quoted, intermediate values of the E24 series (with a tolerance ± 5%) are available. Other capacitance values and 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%
0,018**	8,5	29	18,5	22,5 ± 0,4	6	72183	
0,022**	8,5	29	18,5		6	72223	
0,027**	8,5	29	18,5		6	72273	
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%
0,0082**	8,5	29	18,5	22,5 ± 0,4	6	82822	
0,010**	8,5	29	18,5		6	82103	
0,012**	8,5	29	18,5		6	82123	
0,015**	8,5	29	18,5		6	82153	
0,018	8,5	29	18,5	22,5 ± 0,4	6	82183	81183
0,022	8,5	29	18,5		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

* Besides the values of the E12 series as quoted, intermediate values of the E24 series (with a tolerance ± 5%) are available. Other capacitance values and tolerances are available to special order.

** Especially suited for fly-back purposes.

Table 4 U_R (d.c.) = 2000 V; U_R (a.c.) = 700 V **Especially suited for flyback purposes**

rated capacitance* µF	T_{max}	L_{max}	H_{max}	P	mass g	catalogue number 2222 357	
						tol. ± 5%	tol. ± 10%
0,0010	8,5	29	18,5	22,5 ± 0,4	6	92102	
0,0012						92122	
0,0013						92132	
0,0014						92142	
0,0015						92152	
0,0018						92182	
0,0022						92222	
0,0027						92272	
0,0033						92332	
0,0039						92392	
0,0047						92472	
0,0056						92562	
0,0068						92682	
0,0075						92752	
0,0082	10		20		9	92822	
0,010						92103	
0,012						92123	
0,013						92133	

Marking

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

- rated capacitance in pF or µF, tolerance and rated d.c. voltage, without unit symbols;
- code for dielectric materials (KP/MKP); 5th, 6th and 7th digits of the catalogue number; code for factory of origin and production date code (according to IEC62, clause 5);
- manufacturer's identification symbol at the left of this marking.

The capacitors which are especially suited for flyback purposes are also marked with peak-to-peak voltage and repetition frequency (16 kHz).

Mounting

The capacitors are suited for mounting on printed-wiring boards. When a number of capacitors are connected to form a capacitor bank, and considerable power dissipation is expected, their mounting proximity should allow a free circulation of air.

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* Besides the values quoted, intermediate values of the E24 series (with a tolerance ± 5%) are available. Other capacitance values and tolerances are available to special order.

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of 23 ± 1 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 50 ± 2%.

Capacitance

Rated capacitance (C_R) at 1 kHz	see Tables 1 to 4
Tolerance on rated capacitance	± 5% or ± 10%
Temperature coefficient at T_{amb} = 20 °C	$-(400 \pm 50) \times 10^{-6}$/K
Frequency dependence between 100 Hz and 100 kHz	negligible

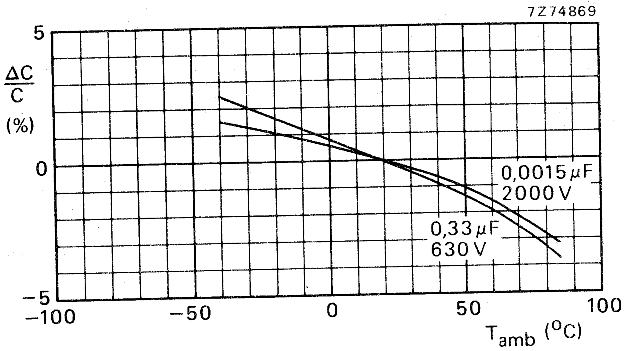

Fig. 2 Capacitance as a function of temperature; typical curves. Measuring voltage is 0,3 V, measuring frequency is 1 kHz.

Voltage

Rated voltage U_R (d.c.)	630 V, 1000 V, 1500 V, 2000 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
2000 V version	700 V
Maximum permissible peak-to-peak voltage for flyback capacitors, pulse duration 10 to 14 μs, repetition frequency 15 to 20 kHz	
1000 V version	1000 V (p-p)
1500 V version	1500 V (p-p)
2000 V version	2000 V (p-p)
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.)

Notes

The following requirements must be satisfied:

- the sum of the d.c. voltage and the peak value of the superimposed a.c. voltage must be ⩽ rated d.c. voltage;
- the peak-to-peak value of the a.c. voltage must be ⩽ maximum permissible a.c. voltage x 2V2;
- for other than sinusoidal waveforms, the maximum permissible dissipation must not be exceeded.

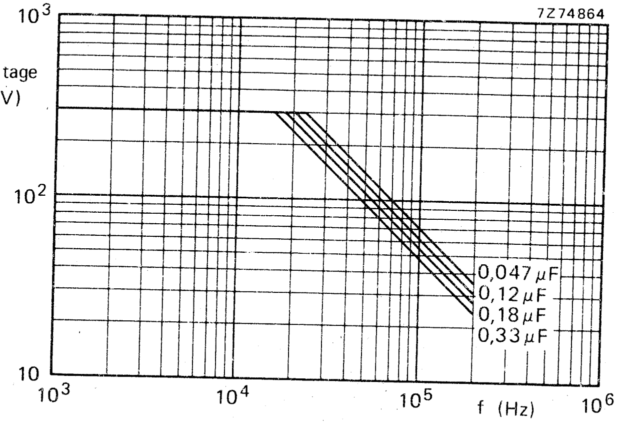

Fig. 3 Maximum permissible r.m.s. value of sinusoidal voltages as a function of frequency at $T_{amb} \leqslant 70\ ^oC$, for 630 V version.

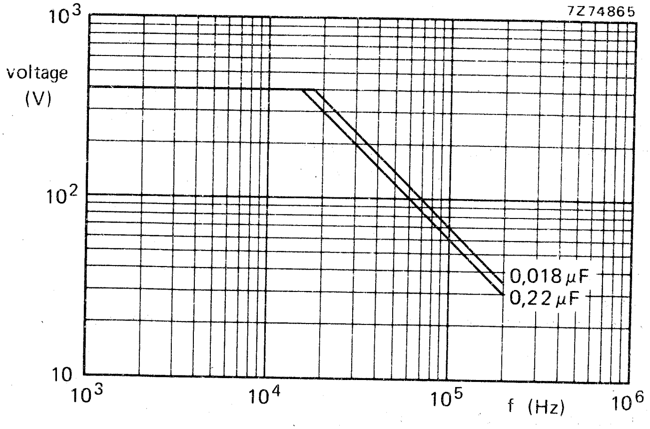

Fig. 4 Maximum permissible r.m.s. value of sinusoidal voltages as a function of frequency at $T_{amb} \leqslant 70\ ^oC$, for 1000 V version.

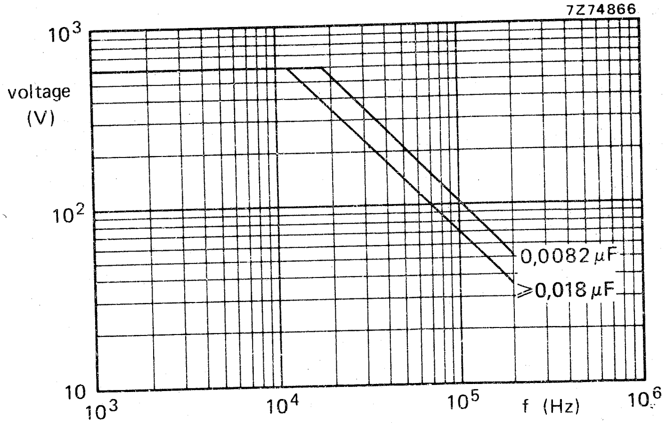

Fig. 5 Maximum permissible r.m.s. value of sinusoidal voltages as a function of frequency at $T_{amb} \leqslant 70\ ^{o}C$, for 1500 V version.

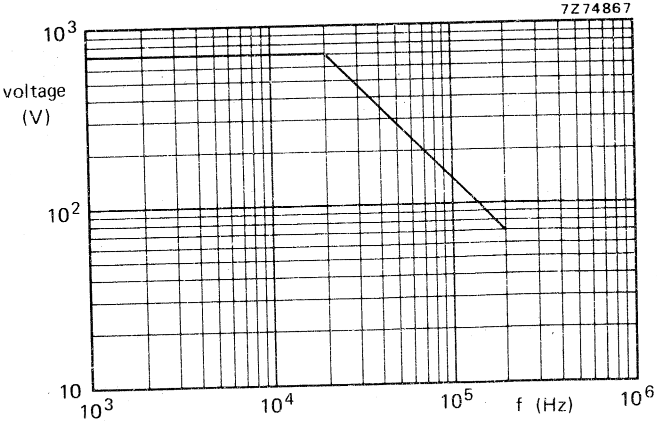

Fig. 6 Maximum permissible r.m.s. value of sinusoidal voltages as a function of frequency at $T_{amb} \leqslant 70\ ^{o}C$, for 2000 V version.

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 $C_R \leqslant 0,1\ \mu F$	$> 50\ 000\ M\Omega$	$> 500\ M\Omega$
RC between terminations, for $C_R > 0,1\ \mu F$	$> 5\ 000$ s	> 50 s

Tan δ (tangent of the loss angle)

Tan δ at 100 kHz	
for capacitors with pitch P = 22,5 mm	$\leqslant 10 \times 10^{-4}$
for capacitors with pitch P = 27,5 mm	$\leqslant 15 \times 10^{-4}$

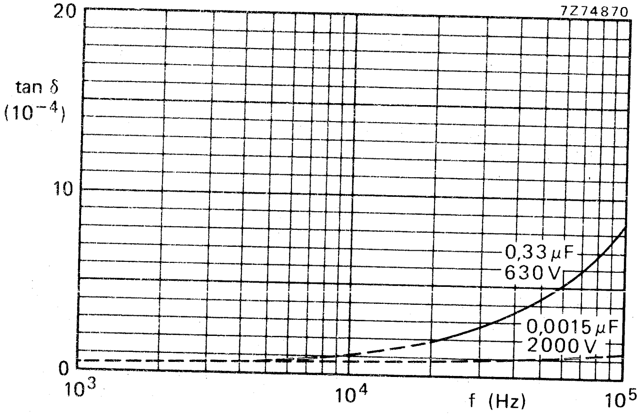

Fig. 7 Tan δ as a function of frequency; typical curves.

Temperature dependence at 100 Hz, 1 kHz, 10 kHz and 100 kHz	negligible

Power dissipation

Maximum permissible power dissipation	see Additional information

Pulse steepness	limited by network conditions

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.

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}).

For a capacitor used with a sinusoidal voltage, the power dissipation is expressed by:

$$P = V_{rms} I_{rms} \cos \varphi. \qquad (1)$$

As $I_{rms} = \omega C V_{rms}$, and $\cos \varphi \approx \tan \delta$, equation (1) can be rewritten as :

$$P = V^2{}_{rms} \omega C \tan \delta = V^2{}_{rms}\, 2\pi f C \tan \delta. \qquad (2)$$

For capacitors of the 357 series, tan δ is about proportional to the frequency, thus:

$$\tan \delta = \frac{f}{10^5} \tan \delta_{100kHz}. \qquad (3)$$

Substituting equation (3) in equation (2) gives:

$$P = 2\pi . 10^{-5}\ V^2{}_{rms} f^2 C \tan \delta_{100kHz}. \qquad (4)$$

For capacitors with a pitch of 22,5 mm the maximum tan δ at 100 kHz is 10^{-3}, thus:

$$P = 2\pi . 10^{-8} V^2{}_{rms} f^2 C. \qquad (5)$$

For capacitors with a pitch of 27,5 mm the maximum tan δ at 100 kHz is $1{,}5 \times 10^{-3}$, thus:

$$P = 3\pi . 10^{-8} V^2{}_{rms} f^2 C. \qquad (6)$$

The maximum permissible power dissipation (P_{max}), which depends on the dimensions of the capacitor and on the ambient temperature, can be found from Fig. 8.

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

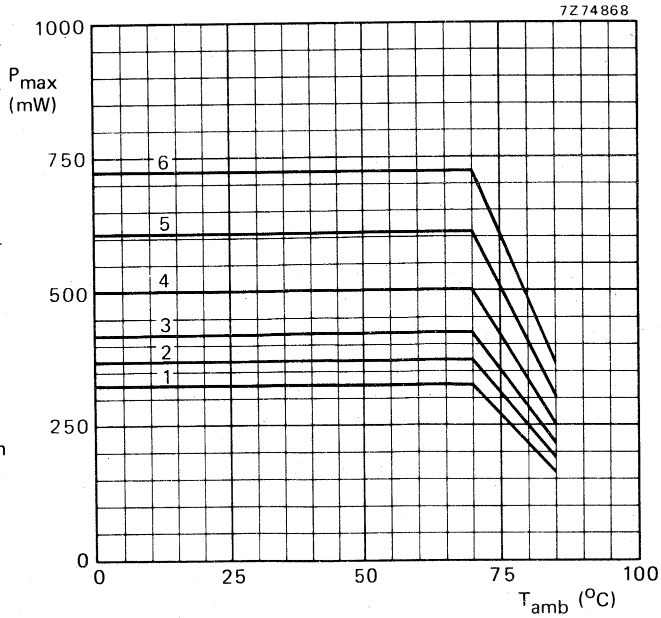

Fig. 8 Maximum permissible power dissipation as a function of temperature with case size as a parameter.

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* At $T_{amb} \leqslant 70$ °C the maximum permissible sinusoidal voltage can be found in Figs 3 to 6.

Example 1

A capacitor of 0,12 μF (27,5 mm pitch) is to be used at a 20 kHz sinusoidal voltage of 300 V and an ambient temperature of 80 °C. The power to be dissipated is

$$P = 3\pi.10^{-8}\ V_{rms}{}^2 f^2 C$$
$$= 3 \times 3{,}14 \times 10^{-8} \times 300^2 \times 20\,000^2 \times 0{,}12 \times 10^{-6}\text{W}$$
$$P = 407 \text{ mW.}$$

Fig. 8 shows that at 80 °C, capacitors with curve number 5 can be used, thus a size of 15 mm x 34 mm x 25 mm. It can be seen from Tables 1 to 4 that a 0,12 μF/1000 V capacitor must be chosen.

Example 2

For a capacitor used with a half sinewave pulse, (Fig. 9), V_{rms} can be expressed by

$$V_{rms}{}^2 = \frac{1}{2} V_p{}^2 \frac{T1}{T2}. \qquad (7)$$

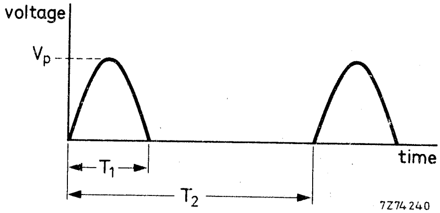

Fig. 9.

With $f = \frac{1}{2T_1}$, and substitution of equation (7) in equation (5), the maximum power dissipation for a capacitor with a pitch of 22,5 mm is

$$P = \frac{\pi}{4}.10^{-8} V_p{}^2 \frac{1}{T_1.T_2} C. \qquad (8)$$

A capacitor of 0,0075 μF is to be used with a half sinewave pulse (pulse duration 12 μs, repetition time 60 μs), peak value 1500 V at an ambient temperature of 80 °C.

The maximum dissipated power is

$$P = \frac{\pi}{4} \times 10^{-8} \times 1500^2 \times \frac{1}{12 \times 60 \times 10^{-12}} \times 0{,}0075 \times 10^{-6} \text{ W}$$
$$P = 184 \text{ mW}$$

From Fig. 8 it can be seen that this power value is permitted for all capacitor sizes.

POLYPROPYLENE FILM/FOIL CAPACITORS

axial type

QUICK REFERENCE DATA

Rated capacitance range	47 to 56 000 pF*
Tolerance on rated capacitance	± 5% (E24-series) ± 2% (E24-series and E48-series)
Rated voltage U_R (d.c.)	63 V, 160 V, 250 V
Rated voltage U_R (a.c.), 50 to 60 Hz	40 V, 63 V, 100 V
Rated temperature	85 °C
Climatic category, IEC 68	40/100/21
Basic specification	IEC 384-13

APPLICATION

For use in circuits where close tolerance, reliability and low losses are of prime importance, e.g. tuned circuits, filter networks, timing networks, etc.

DESCRIPTION

The capacitors consist of a low-inductance wound cell of aluminium foil and a polypropylene film. The cell is covered with a blue plastic film. The long, axial leads of solder-coated wire make the capacitor suitable for vertical or horizontal mounting on printed-wiring boards.

Composition of the catalogue number

2222 . . . .

455 = 63 V
456 = 160 V
457 = 250 V

6 = ± 5% } packed on bandoliers on reels
7 = ± 2% }

2 = ± 5% } packed in boxes
3 = ± 2% }

code for capacitance, see Tables 1 to 4

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* A part of the range is still under development; please refer to the Tables 1 to 3 on the following pages.

MECHANICAL DATA

Dimensions in mm

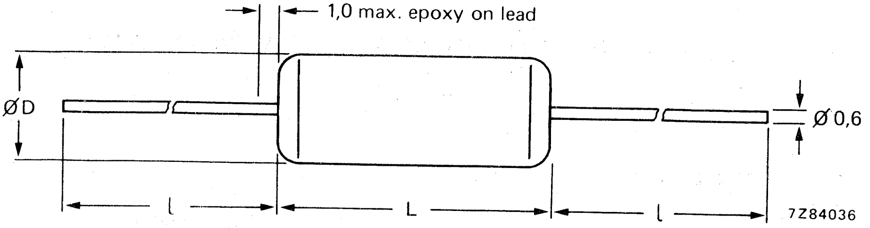

Fig. 1 For dimensions D, L and l see tables below.

Table 1 U_R (d.c.) = 63 V; U_R (a.c.) = 40 V

rated capacitance (E24-series, tol. ± 5%)* pF	D_{max}	L_{max}	l_{min}	approx. mass g	catalogue number (packed on bandoliers on reels)
3 300	4,0	11,0	30	0,3	2222 455 63302
3 600					63602
3 900					63902
4 300					64302
4 700	4,5				64702
5 100					65102
5 600					65602
6 200					66202
6 800	5,0			0,4	66802
7 500					67502
8 200					68202
9 100					69102
10 000	4,5	15,0	28	0,5	61003
11 000					61103
12 000					61203
13 000	5,0				61303
15 000					61503
16 000					61603
18 000	5,5			0,6	61803
20 000					62003
22 000					62203
24 000	6,0				62403
27 000					62703
30 000	6,5			0,7	63003
33 000					63303
36 000	7,0			0,8	63603
39 000					63903
43 000	7,5			0,9	64303
47 000					64703
51 000	8,0			1,0	65103
56 000					65603

For these values the data given in this data sheet are provisional

---

* Besides the values of the E24-series with a tolerance ± 5% as quoted, these values and intermediate values of the E48-series are available with a tolerance ± 2%.

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 (packed on bandoliers on reels)
1 800	4,0	11,0	30	0,3	2222 456 61802
2 000					62002
2 200					62202
2 400					62402
2 700					62702
3 000	4,5				63002
3 300					63302
3 600					63602
3 900					63902
4 300	5,0			0,4	64302
4 700					64702
5 100					65102
5 600					65602
6 200	4,5	15,0	28	0,5	66202
6 800					66802
7 500					67502
8 200	5,0				68202
9 100					69102
10 000					61003
11 000	5,5			0,6	61103
12 000					61203
13 000					61303
15 000 For these values the data given in this data sheet are provisional	6,0				61503
16 000					61603
18 000	6,5			0,7	61803
20 000					62003
22 000	7,0			0,8	62203
24 000					62403
27 000	7,5			0,9	62703
30 000					63003
33 000	8,0			1,0	63303
36 000					63603

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* Besides the values of the E24-series with a tolerance ± 5% as quoted, these values and intermediate values of the E48-series are available with a tolerance ± 2%.

Table 3 U_R (d.c.) = 250 V; U_R (a.c.) = 100 V

rated capacitance (E24-series, tol. ± 5%)* pF	D_{max}	L_{max}	l_{min}	approx. mass g	catalogue number (packed on bandoliers on reels)
47	4,0	11,0	30	0,3	2222 457 64709
51					65109
56					65609
62					66209
68					66809
75					67509
82					68209
91					69109
100					61001
110					61101
120					61201
130					61301
150					61501
160					61601
180					61801
200					62001
220					62201
240					62401
270					62701
300					63001
330					63301
360					63601
390					63901
430					64301
470	4,5				64701
510					65101
560					65601
620					66201
680					66801
750					67501
820					68201
910					69101
1 000					61002
1 100					61102
1 200					61202
1 300					61302
1 500					61502
1 600					61602
1 800					61802
2 000					62002
2 200					62202
2 400	5,0			0,4	62402
2 700					62702
3 000					63002

* Besides the values of the E24-series with a tolerance ± 5% as quoted, these values and intermediate values of the E48-series are available with a tolerance ± 2%.

Table 3 U_R (d.c.) = 250 V; U_R (a.c.) = 100 V (continued)

rated capacitance (E24-series, tol. ± 5%)* pF		D_{max}	L_{max}	l_{min}	approx. mass g	catalogue number (packed on bandoliers on reels)
3 300		4,5	15,0	28	0,4	2222 457 63302
3 600						63602
3 900						63902
4 300						64302
4 700		5,0				64702
5 100						65102
5 600						65602
6 200		5,5			0,5	66202
6 800						66802
7 500						67502
8 200	For these values the data given in this data sheet are provisional	6,0				68202
9 100						69102
10 000		6,5			0,6	61003
11 000						61103
12 000		7,0			0,7	61203
13 000						61303
15 000		7,5			0,8	61503
16 000						61603
18 000		8,0			0,9	61803
20 000						62003

Marking

The capacitors are marked as follows:
1st line: rated capacitance code;
2nd line: tolerance code (G = ± 2%, J = ± 5%) and rated voltage (d.c.);
3rd line: production date code and code for dielectric material (KP = polypropylene film/foil);
4th line: name of manufacturer.

Note: rated capacitance, tolerance, and production date code are according to IEC 62, clause 5.

Mounting

The capacitors are suited for horizontal or vertical mounting on printed-wiring boards. When mounting vertically on boards with plated-through holes, the capacitors must be mounted at least 1 mm above the board.

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* Besides the values of the E24-series with a tolerance ± 5% as quoted, these values and intermediate values of the E48-series are available with a tolerance ± 2%.

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of 23 ± 1 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 50 ± 2%.

Capacitance

Rated capacitance values (C_R) at 1 kHz	see Tables 1 to 3
Tolerance on rated capacitance	± 5% and ± 2%
Temperature coefficient	$-(65 \pm 60) \times 10^{-6}$/K

Voltage

Rated voltage U_R (d.c.)	63 V, 160 V, 250 V
Rated voltage U_R (a.c.), 50 to 60 Hz	
63 V version	40 V
160 V version	63 V
250 V version	100 V
Category voltage U_C	0,75 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)

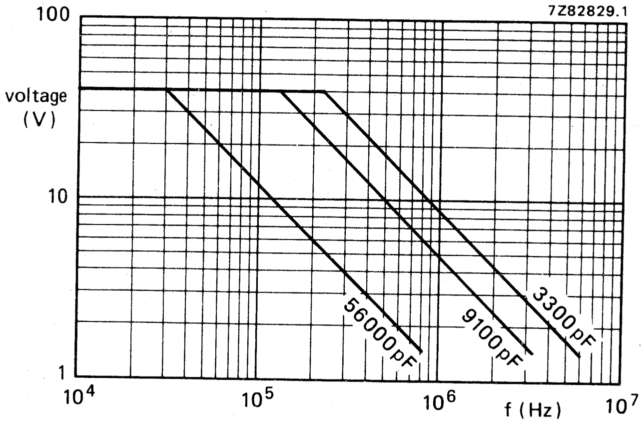


Fig. 2 Maximum permissible r.m.s. value of sinusoidal voltages as a function of frequency at $T_{amb} \leq 70$ °C, for 63 V version.

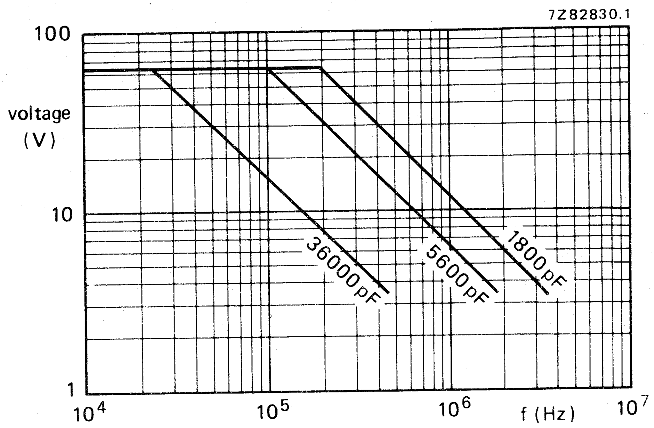


Fig. 3 Maximum permissible r.m.s. value of sinusoidal voltages as a function of frequency at $T_{amb} \leqslant 70$ °C, for 160 V version.

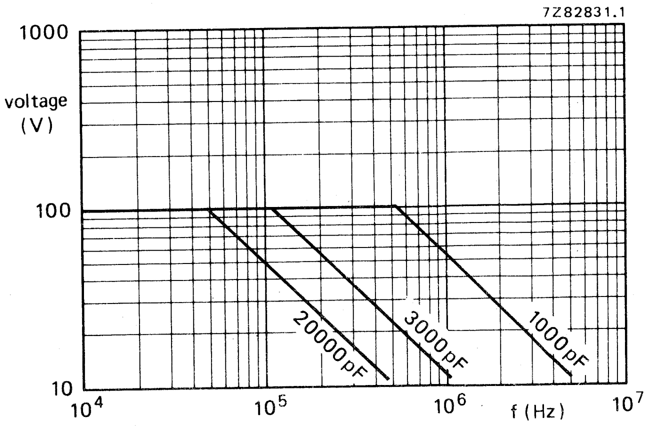


Fig. 4 Maximum permissible r.m.s. value of sinusoidal voltages as a function of frequency at $T_{amb} \leqslant 70$ °C, for 250 V version.

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 and 100 ± 15 V for the 160 V and 250 V versions.

	ambient temperature	
	20 °C	100 °C
R between terminals	$> 100\,000$ MΩ	$> 10\,000$ MΩ

Tan δ (tangent of the loss angle)

Tan δ at 1 MHz, for $C_R \leqslant 1000$ pF	$\leqslant 10 \times 10^{-4}$
Tan δ at 100 kHz,	
for $1000 \text{ pF} < C_R \leqslant 5000$ pF	$\leqslant 10 \times 10^{-4}$
for $5000 \text{ pF} < C_R \leqslant 20\,000$ pF	$\leqslant 15 \times 10^{-4}$
Tan δ at 10 kHz for $C_R > 20\,000$ pF	$\leqslant 10 \times 10^{-4}$

Inductance

Maximum inductance	10 nH/cm lead and capacitor length

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

Life expectancy

Typical life time at $T_{amb} = 100$ °C	> 4000 h

PACKING

The capacitors are supplied on bandoliers on reels or in cardboard boxes.

Packing on bandoliers on reels

Dimensions in mm

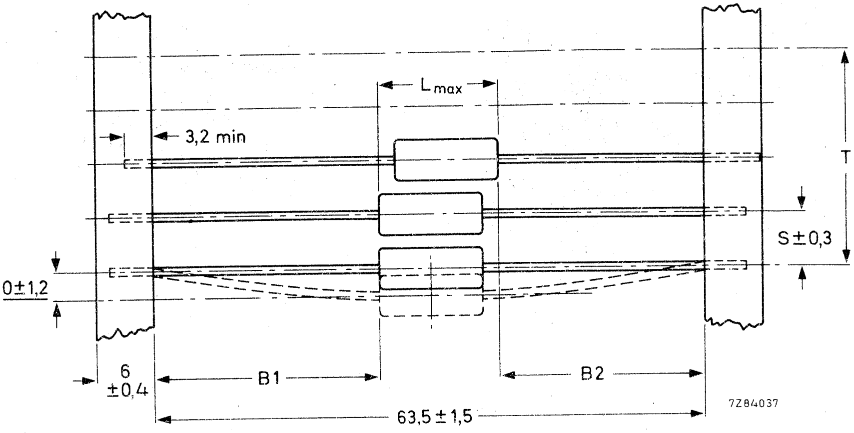
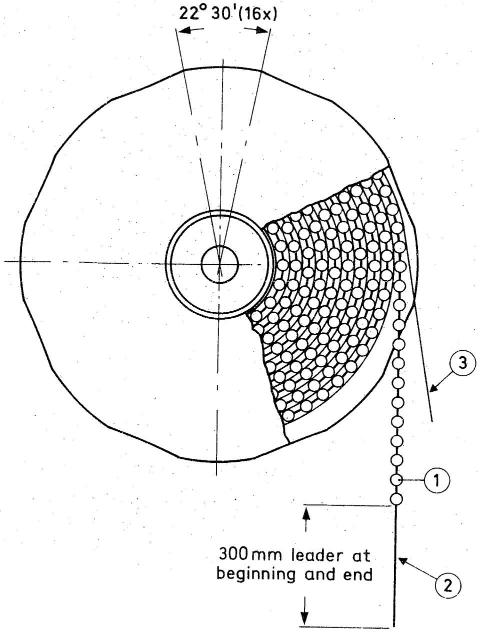


Fig. 5 $|B1-B2|$ = max. 1,4; for dimension L_{max} see Tables 1 to 3.

capacitance values (pF) of			S	T for number (n) of capacitors	
63 V version	160 V version	250 V version		$n < 50$	$50 < n < 100$
3 300– 6 200	1 800– 3 900	47– 2 200	5	5(n - 1) ± 2	5(n - 1) ± 4
6 800– 9 100	4 300– 5 600	2 400– 3 000	10	10(n - 1) ± 2	10(n - 1) ± 4
10 000–12 000	6 200– 7 500	3 300– 4 300	5	5(n - 1) ± 2	5(n - 1) ± 4
13 000–56 000	8 200–36 000	4 700–20 000	10	10(n - 1) ± 2	10(n - 1) ± 4



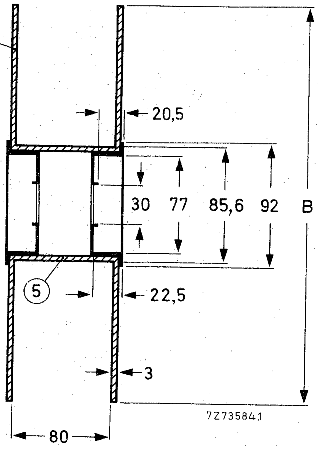


Fig. 6 1: capacitor 4: flange
2: bandolier 5: cylinder
3: paper

capacitance values (pF) of 63 V version	 160 V version	 250 V version	B	number of capacitors on one reel
3 300– 6 200	1 800– 3 900	47– 2 200	305	2500
6 800– 9 100	4 300– 5 600	2 400– 3 000	356	1500
10 000–12 000	6 200– 7 500	3 300– 4 300	305	2500
13 000–27 000	8 200–16 000	4 700– 9 100	356	1500
30 000–56 000	18 000–36 000	10 000–20 000	356	1000

Packing in cardboard boxes

capacitance values (pF) of 63 V version	 160 V version	 250 V version	number of capacitors per box
3 300– 4 300	1 800– 2 700	47– 620	400
4 700– 6 200	3 000– 3 900	680– 2 200	300
6 800– 9 100	4 300– 5 600	2 400– 3 000	250
10 000–12 000	6 200– 7 500	3 300– 4 300	400
13 000–16 000	8 200–10 000	4 700– 5 600	300
18 000–27 000	11 000–16 000	6 200– 9 100	250
30 000–33 000	18 000–20 000	10 000–11 000	200
36 000–56 000	22 000–36 000	12 000–20 000	150

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 may further be limited by the maximum permissible power dissipation (P_{max}).

For a capacitor used with a sinusoidal voltage, the power dissipation is expressed by:

$$P = V_{rms}\, I_{rms} \cos \varphi. \qquad (1)$$

As $I_{rms} = \omega C V_{rms}$, and $\cos \varphi \approx \tan \delta$, equation (1) can be rewritten as:

$$P = V_{rms}{}^{2} \omega C \tan \delta = V_{rms}{}^{2}\; 2\pi f C \tan \delta. \qquad (2)$$

For capacitors of the 455 to 457 series, tan δ is about proportional to the frequency, thus:

$$\tan \delta = \frac{f}{10^5} \tan \delta_{ref}. \qquad (3)$$

→ Tan δ_{ref} is the maximum tan δ at 100 kHz value given under Electrical Data.

Substituting equation (3) in equation (2) gives:

$$P = 2\pi . 10^{-5}\; V_{rms}{}^{2} f^{2} C \tan \delta_{ref}. \qquad (4)$$

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.

curve	dimensions (mm)	
	D_{max}	L_{max}
1	4,0	11,0
2	4,5	11,0
3	5,0	11,0
4	4,5	15,0
5	5,0	15,0
6	5,5	15,0
7	6,0	15,0
8	6,5	15,0
9	7,0	15,0
10	7,5	15,0
11	8,0	15,0

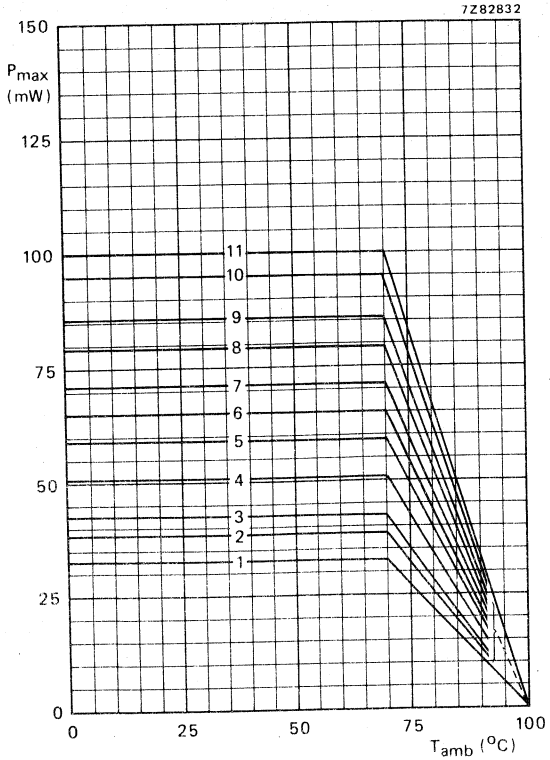


Fig. 7 Maximum permissible power dissipation as a function of temperature.

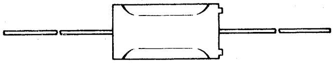
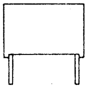
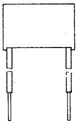
→ * At $T_{amb} \leqslant 70$ °C the maximum permissible sinusoidal voltage can be found in Figs 2,3 and 4.

INTERFERENCE SUPPRESSION CAPACITORS MKT-P

F

SURVEY

Main applications: interference suppression in small household appliances, radio and tv.

	series number	rated capacitance μF	rated voltage (U_R a.c.) V	page
	2222 330 0....	0,01 to 0,47	250	F15
	2222 330 4....	0,01 to 1,0	250	F15
	2222 330 8....	0,01 to 0,1	250	F15

TESTS AND REQUIREMENTS

Standard atmospheric conditions for reference tests: ambient temperature + 23 ± 1 °C, atmospheric pressure 86 to 106 kPa, relative humidity 50 ± 2%.

IEC 384-14 clause	IEC 68-2 test method	name of test	procedure (quick reference)
12.1	Robustness of terminations		
	Ua1	Tensile strength of terminations	Loading force in axial direction for 10 s: ϕ 0,8 mm 10 N, ϕ 1,0 mm 20 N
	Ub (method 1)	Bending of terminations	Loading force 5 N for ϕ 0,8 mm, 10 N for ϕ = 1,0 mm, 2 consecutive bends
	Uc	Torsion of terminations	2 successive rotations of 180° in opposite directions
12.2	Tb (method 1A)	Resistance to soldering heat	Solder bath 260 °C, 10 s
12.2.2			Final measurements
12.3	Ta	Solderability	Solder bath, solder temp. 235 °C, dwell time 2 s
12.4	Na	Rapid change of temperature	5 cycles of ½ h at −40 °C and ½ h at + 85 °C
12.5	Fc	Vibration	10 to 55 Hz, 0,75 mm or 10g (whichever is the less), 3 directions, 2 h per direction.
12.6	Eb	Bumping	40g, 6 ms, 4000 bumps.
			Final measurements

	requirements		
	2222 330 0....	2222 330 4....	2222 330 8....
Visual examination	no damage		
Visual examination	no damage		
Visual examination	no damage	n.a.	n.a.
Visual examination	no damage	no damage	n.a.
$\Delta C/C$ $\Delta \tan \delta$ at 10 kHz	$\leqslant 2\%$ $\leqslant 30 \times 10^{-4}$	$\leqslant 2\%$ $\leqslant 30 \times 10^{-4}$	$\leqslant 2\%$ $\leqslant 30 \times 10^{-4}$
Visual examination	no damage, good tinning		n.a.
Visual examination	no leakage, no damage		n.a.
Visual examination	no damage		n.a.
Visual examination	no damage		n.a.
$\Delta C/C$ $\Delta \tan \delta$ at 10 kHz	$\leqslant 2\%$ $\leqslant 30 \times 10^{-4}$	$\leqslant 2\%$ $\leqslant 30 \times 10^{-4}$	
R_{ins}	meet initial requirements		

n.a. = not applicable.

IEC 384-14 clause	IEC 68-2 test method		name of test	procedure (quick reference)
12.9.1				Initial measurements
12.9.2	CLIMATIC SEQUENCE	Ba	Dry heat	16 h at + 85 ± 2 °C, no voltage applied
12.9.3		Db	Damp heat, cyclic	1 cycle of 24 h, upper temp. 55 ± 2 °C, R.H. 93 ± 3%; no voltage applied
12.9.4		Aa	Cold	2 h at –40 ± 2 °C, no voltage applied
12.9.6		Db	Damp heat, cyclic	1 cycle of 24 h at 55 ± 2 °C, R.H.93 ± 3%, no voltage applied
12.9.7				Final measurements
12.10.1				Initial measurements
12.10.2		Ca	Damp heat, steady state	40 ± 2 °C for 21 days; R.H. 90 to 95%; a: no voltage applied; b: 250 V (a.c.) applied. Recovery for 6 h at 55 °C and R.H. ≤ 20%, followed by 2 h recovery at 20 °C
12.10.3				Final measurements

	requirements		
	2222 330 0....	2222 330 4....	2222 330 8....
C, tan δ, R_{ins}			
Visual examination	no damage, no leakage		
$\Delta C/C$	$\leqslant 5\%$	$\leqslant 5\%$	$\leqslant 5\%$
$\Delta C/C$	$\leqslant 7\%$	$\leqslant 7\%$	$\leqslant 7\%$
Visual examination	no damage		
$\Delta C/C$	$\leqslant 5\%$	$\leqslant 5\%$	$\leqslant 5\%$
Tan δ at 10 kHz	$\leqslant 50 \times 10^{-4}$	$\leqslant 50 \times 10^{-4}$	$\leqslant 50 \times 10^{-4}$
Voltage proof 725 V (d.c.), 1 min	no permanent breakdown or flashover		
R_{ins}	$\geqslant$ 0,5 x initial requirements		
C, tan δ, R_{ins}			
Visual examination	no damage		
$\Delta C/C$	$\leqslant 5\%$	$\leqslant 5\%$	$\leqslant 5\%$
Tan δ at 10 kHz	$\leqslant 50 \times 10^{-4}$	$\leqslant 50 \times 10^{-4}$	$\leqslant 50 \times 10^{-4}$
Voltage proof 725 V (d.c.), 1 min	no breakdown or flashover		
R_{ins}	$\geqslant$ 0,5 x initial requirements		$>$ 7500 MΩ

IEC 384-14 clause	IEC 68-2 test method	name of test	procedure (quick reference)
12.11.1		Endurance	Initial measurements
12.11.2			1000 h at 85 °C; 1,25 x U_R (a.c.) applied; once in each hour the voltage is increased to 1000 V (r.m.s.) for 0,1 s via a resistor of 220 Ω ± 10%
			Final measurements

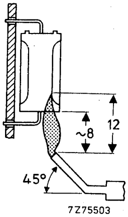
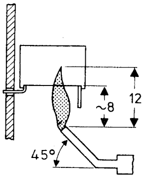
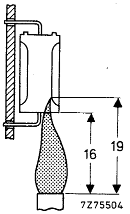
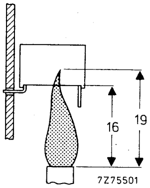
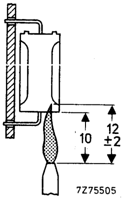
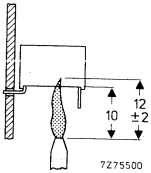
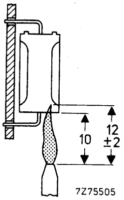
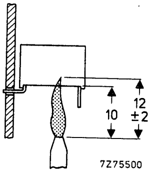
	requirements		
	2222 330 0....	2222 330 4....	2222 330 8....
C, R_{ins}			
	no open or short-circuit		
$\Delta C/C$	$\leqslant 10\%$	$\leqslant 10\%$	$\leqslant 10\%$
Δ tan δ at 10 kHz	$\leqslant 30 \times 10^{-4}$	$\leqslant 30 \times 10^{-4}$	$\leqslant 30 \times 10^{-4}$
R_{ins}	$\geqslant$ 0,5 x initial requirements		$>$ 7500 MΩ
Voltage proof 725 V (d.c.), 1 min	no drops of impregnant percentage of rejects $\leqslant 5\%$		

Additional tests

name of test	procedure (quick reference)
Charge and discharge	Initial measurements: tan δ $C \leqslant 1\ \mu F$ (10 kHz), 1 V (r.m.s.) 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 initial requirement. Cycle time: 1 to 150 cycles/s, temperature: 25 °C. Final measurements
Storage	1000 h at 85 °C
Damp heat, long term exposure	21 days at 40 °C, R.H. 90 to 95%. Rated a.c. voltage applied for 16 h in every 24 h period.
Solvent resistance	MIL-STD 202E, method 215

requirements

	2222 330 0....	2222 330 4....	2222 330 8....
Δ tan δ at 10 kHz	$\leqslant 20 \times 10^{-4}$	$\leqslant 20 \times 10^{-4}$	$\leqslant 20 \times 10^{-4}$
$\Delta C/C$	$\leqslant 5\%$	$\leqslant 5\%$	$\leqslant 5\%$
Tan δ and R_{ins}	meet initial requirements		
Percentage of rejects	$\leqslant 5\%$	$\leqslant 5\%$	$\leqslant 5\%$
Failure criterions	no open or short circuit		
R_{ins}	$\geqslant 0{,}5$ x initial requirements		$> 7500\ M\Omega$
Visual examination	no damage		
$\Delta C/C$	$\leqslant 5\%$	$\leqslant 5\%$	$\leqslant 5\%$
Δ tan δ at 10 kHz	$\leqslant 50 \times 10^{-4}$	$\leqslant 50 \times 10^{-4}$	$\leqslant 50 \times 10^{-4}$
R_{ins}	$> 0{,}5$ x initial requirements		

name of test	procedure (quick reference)	
Flammability IEC 50C	 7Z75503  7Z75502	Bore of gas jet: ϕ 0,5 mm. Fuel: butane. Test duration: 20 s. One flame application.
UL 1414	 7Z75504  7Z75501	Bore of gas jet: ϕ 10 mm. Fuel: natural gas. Test duration: 3 x 15 s. Time interval between each flame application: 15 s.
BRC	 7Z75505  7Z75500	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.
VDE 0860, part 1	 7Z75505  7Z75500	Bore of gas jet: ϕ 0,5 mm. Fuel: butane. Before testing the capacitors are stored for 2 h at 100 ± 2 °C. Test duration 1st cycle: 10 s, 2nd cycle: 1 min, 3rd cycle: 2 min.

requirements 2222 330
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.
Extinguishing time ⩽ 15 s after the first and second flame application, ⩽ 60 s after the third flame application.
Extinguishing time ⩽ 10 s after each flame application; no burning particles must drop from the sample.
Extinguishing time ⩽ 30 s after each flame application. No burning particles must drop from the sample.

INTERFERENCE SUPPRESSION CAPACITORS

dual dielectric

QUICK REFERENCE DATA

Rated capacitance range (E6 series)	
type with axial leads	0,01 to 0,47 μF
type with radial leads	0,01 to 1 μF
Tolerance on rated capacitance	± 10% and ± 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
Approvals	
type with axial leads	VDE0565, part 1
type with radial leads	VDE0565, part 1 and SEMKO
Class	X2

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-inductance 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. A version with insulated radial leads is available.

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

MECHANICAL DATA

Type with axial leads

Dimensions in mm

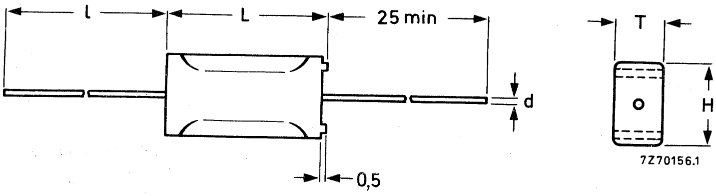


Fig. 1 For dimensions T, L, H, d and l, see Table 1.

Table 1

rated capacitance μF	T_{max}	H_{max}	L_{max}	d	l_{min}	mass g	catalogue number 2222 330 . . . . . tol. ± 10%	tol. ± 20%
0,010	6,7	10,4	18	0,8	40	1,8	01103	00103
0,015							01153	00153
0,022							01223	00223
0,033							01333	00333
0,047							01473	00473
0,068	7,9	11,5	18,1			2,1	01683	00683
0,10	7,8	11,7	23,8			2,7	01104	00104
0,15	9,2	12,8	23,5			3,4	01154	00154
0,22	10,4	14,4	23,5			4,2	01224	00224
0,33	12,4	19,5	31	1,0	50	8,0	01334	00334
0,47						8,0	01474	00474

Marking

The capacitors are marked on one side as follows:
1st line: rated capacitance in μF, tolerance (± 10% identified by K, ± 20% not identified), 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 VDE approbation symbol.**

Mounting

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

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* According to IEC 62, clause 5.

** VDE approval has been sought for 0,33 μF and 0,47 μF capacitors.

Type with radial leads

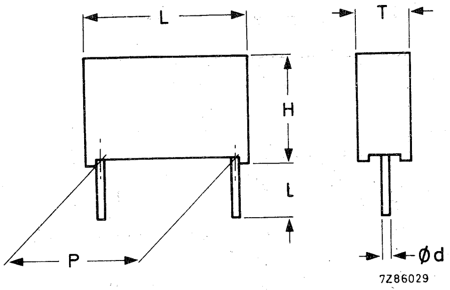

Fig. 2 For dimensions T, L, H, P, d and l, see Table 2.

Table 2

rated capacitance µF	T_{max}	H_{max}	L_{max}	P	d	mass g	catalogue number 2222 330 . . . . . l = 5 ± 1		l = 25 + 2	
							tol. ± 10%	tol. ± 20%	tol. ± 10%	tol. ± 20%
0,010	5	11	17,5	15 ± 0,4	0,8	1,2	41103	40103	45103	44103
0,015							41153	40153	45153	44153
0,022							41223	40223	45223	44223
0,033							41333	40333	45333	44333
0,047	6	11,5	17,5			1,4	41473	40473	45473	44473
0,068	7	13	17,5			2,0	41683	40683	45683	44683
0,10	8,5	14,5	17,5			2,6	41104	40104	45104	44104
0,15	7	16	26	22,5 ± 0,4		3,0	41154	40154	45154	44154
0,22	8,5	17,5	26			3,7	41224	40224	45224	44224
0,33	10	18,5	26			5,4	41334	40334	45334	44334
0,47	13,5	22,5	31	27,5 ± 0,4		10,8	41474	40474	45474	44474
0,68	15	25	31			12,9	41684	40684	45684	44684
1,0	18	28	31		1,0	18,2	41105	40105	45105	44105

Marking

The capacitors are marked on the top face by embossed print, with:
1st line: rated capacitance in µF, tolerance (± 10% identified by K or 10, ± 20% not identified), rated voltage and class;
2nd line: 5th, 6th, 7th, 8th and 9th digits of the catalogue number and code for dielectric materials (MKT-P);
3rd line: production date code,* SEMKO approbation symbol,** and category according to DIN.
Manufacturer's identification symbol and VDE approbation symbol** are to the left and to the right respectively of the three lines of marking.

Mounting

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

* According to IEC 62, clause 5.
** VDE and SEMKO approval have been sought for 0,47 to 1 µF capacitors.

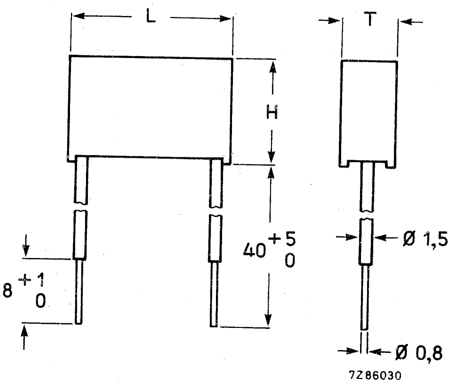

Fig. 3 Version with insulated radial leads. For dimensions T, L and H, see Table 3.

Table 3

rated capacitance µF	T_{max}	H_{max}	L_{max}	mass g	catalogue number 2222 330	
					tol. ± 10%	tol. ± 20%
0,010	6	12	17,5	1,8	85103	84103
0,015					85153	84153
→ 0,022					85223	84223
0,033					85333	84333
→ 0,047				2,0	85473	84473
→ 0,068	7	13	17,5	2,5	85683	84683
→ 0,10	8,5	14,5	17,5	3,0	85104	84104

Marking

The capacitors are marked on the top face by embossed print, with:
1st line: rated capacitance in µF, tolerance (± 10% identified by K or 10, ± 20% not identified), rated voltage and class;
2nd line: 5th, 6th, 7th, 8th and 9th digits of the catalogue number and code for dielectric materials (MKT-P);
3rd line: production date code,* SEMKO approbation symbol, and category according to DIN.
→ Manufacturer's identification symbol and VDE approbation symbol are to the left and to the right respectively of the three lines of marking.

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* 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 86 to 106 kPa and a relative humidity of 50 ± 2%.

Capacitance

Rated capacitance values (C_R) at 1 kHz	see Tables 1, 2 and 3
Tolerance on rated capacitance	± 10% and ± 20%

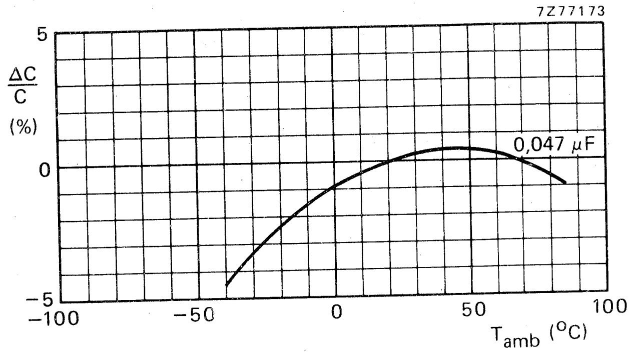


Fig. 4 Capacitance as a function of temperature; typical curve, measured at 1 kHz, 0,3 V.

Voltage

Rated voltage U_R (a.c.), 50 to 60 Hz	250 V
Test voltage (d.c.) for 1 min, between terminals	
type with axial leads	750 V
type with radial leads	1075 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

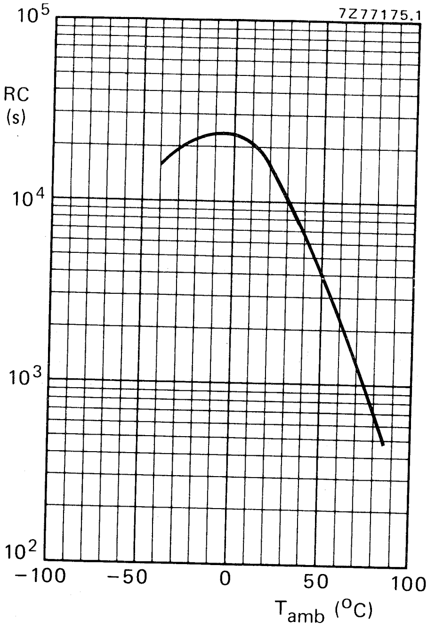


Fig. 5 RC-product as a function of temperature; typical curve.

Tan δ (tangent of the loss angle)

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

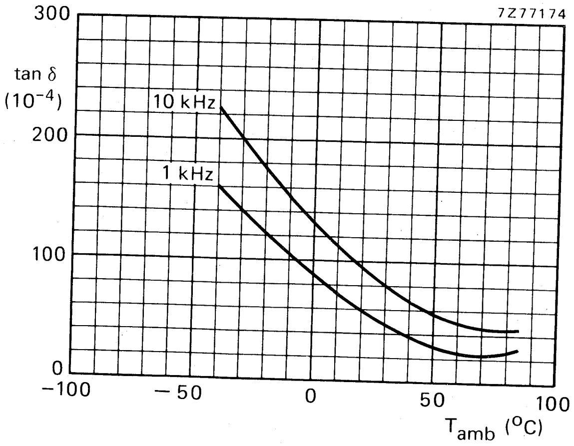


Fig. 6 Tan δ as a function of temperature; typical curves, measured at 0,3 V.

Pulse steepness

Maximum pulse steepness 100 V/μs

See also Tests and requirements – charge and discharge test.

Resonant frequency

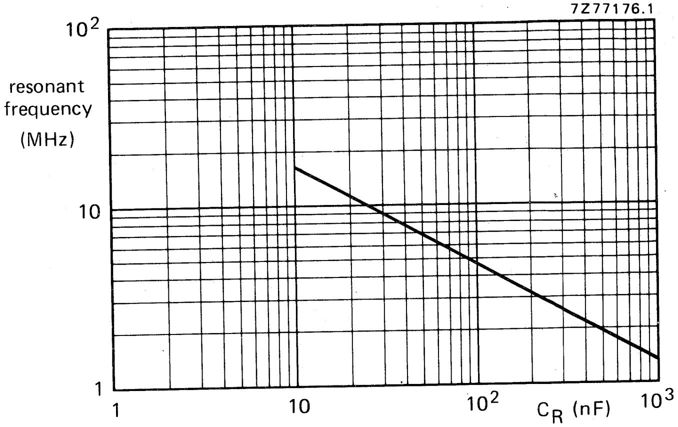


Fig. 7 Resonant frequency as a function of rated capacitance.

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

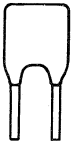
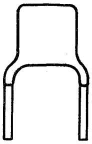
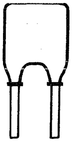
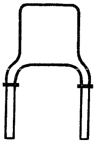
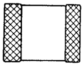
The capacitors are packed in boxes; the number per box is given in the table below.

capacitance value μF	number of capacitors per box
0,010 – 0,068	1000
0,10	500
0,15 – 0,33	200
0,47 – 1,0	100

CERAMIC CAPACITORS G

SURVEY

Application class 1 – for tuning and other applications where low losses and a linear temperature dependence are required.
Application class 2 – for all coupling and decoupling purposes.

version	application	capacitance range pF	rated d.c. voltage V	capacitor series	page
plate; not for new design	class 1	0,56– 560	100	2222 631, 632	
 				2222 638,	
				2222 641, 642	G33
	class 1	0,47– 270	500	2222 650	G49
	class 2	1 000– 22 000	63	2222 629	
		180– 4 700	100	2222 630	
		1 000– 10 000	100	2222 640	G7
	class 2	100– 2 700	500	2222 655 03	G71
plate; leads with flange	class 1	0,56– 560	100	2222 679-	
 				2222 683	G85
	class 1	0,47– 270	500	2222 652	
				2222 654	G59
	class 2	1 000– 22 000	63	2222 629	
		180– 4 700	100	2222 630	
		1 000– 10 000	100	2222 640	G19
	class 2	100– 2 700	500	2222 655 09	
				2222 655 53	G77
chip	class 1	0,47– 10 000	50	2222 590, 591	
				2222 851–856	
	class 2	180–1 000 000	50	2222 861, 863	G103

INTRODUCTION

Ceramic capacitors are widely used in electronic circuitry for coupling and decoupling, and in filters. These different functions require specific capacitor properties.

Ceramic capacitors can be divided into two classes:

Class 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.

Class 2 These capacitors have higher losses and have non-linear temperature characteristics ($\epsilon_r > 250$). They are used for coupling and decoupling.

The survey below shows the various materials we use and their basic chemical composition.

class 1 ϵ_r = 6 up to 250, T.C. types			colour code
P100	(+100 x 10^{-6}/K)	$MgTiO_3$, Mg_2SiO_4	red/violet
NP0	(0 x 10^{-6}/K)	$MgTiO_3$	black
N075	(–75 x 10^{-6}/K)	$Ba_2Ti_9O_{20} + TiO_2$	red
N150	(–150 x 10^{-6}/K)		orange
N220	(–220 x 10^{-6}/K)		yellow
N330	(–330 x 10^{-6}/K)		green
N470	(–470 x 10^{-6}/K)		blue
N750	(–750 x 10^{-6}/K)	TiO_2 + additions	violet
N1500	(–1500 x 10^{-6}/K)	$CaTiO_3$ + additions	orange/orange
class 2 $\epsilon_r > 250$, high-K types			
ϵ_r = 2000	$BaTiO_3$		
ϵ_r = 5000	(Ba, Ca) (Ti, Zr) O_3 + add.		
ϵ_r = 16000	(Ba, Ca) (Ti, Zr) O_3 + add.		

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 strength.

Two constructions are shown in the figures below:

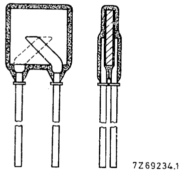


Fig. 1 Plate capacitor.

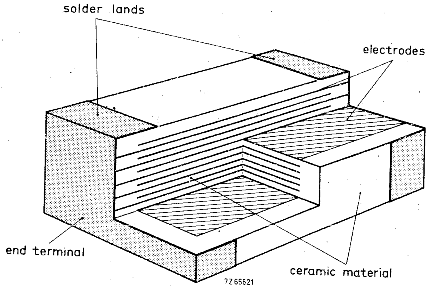


Fig. 2 Cross-section of a chip capacitor.

The electrodes are normally silver or some other good electrical conductor. For multilayer capacitors palladium or platinum is used since the electrodes are applied before the ceramic is fired at a temperature where silver would oxidize.

The dielectric material

The raw materials are finely ground and carefully mixed. After calcining at a temperature below the dissociation or melting point, the resultant mass is reground. The calcined, finely ground material is mixed with, for instance, water and binding matter. The shapes are obtained by extruding or rolling. A carefully controlled drying sequence follows before 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 is marked on the body of the plate capacitors. The temperature coefficient or temperature dependence are indicated by colour coding in accordance with international standards (see page G3).

EQUIVALENT CIRCUIT

Figure 3 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 is 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 is 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.

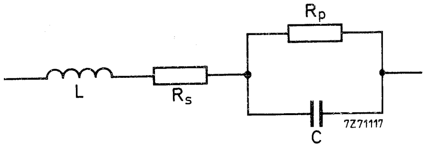


Fig. 3.

TANGENT OF THE LOSS ANGLE

The losses of a capacitor are expressed in terms of tan δ which is the relationship between the resistive and reactive parts of the impedance, specified as follows:

$$\tan\delta = \left|\frac{R}{X}\right| = \frac{R_p + R_s\left\{1 + (\omega C R_p)^2\right\}}{\omega C R_p^2 - \omega L\left\{1 + (\omega C R_p)^2\right\}}$$

From this formula, tan δ can be derived for different frequency ranges as shown diagrammatically in the graph of Fig. 4.

MAINLY INFLUENCED BY ⟶	INSULATION RESISTANCE	POLARIZATION LOSSES	LEAD & ELECTRODE LOSSES	RESO-NANCE	INDUCTION
$\tan\delta =$ ⟶	$\frac{1}{\omega C R_p}$	$\frac{1}{\omega C R_p}$	$\omega C R_s$	$\left\lvert\frac{\omega C R_s}{1-\omega^2 LC}\right\rvert$	$\frac{R_s}{\omega L}$

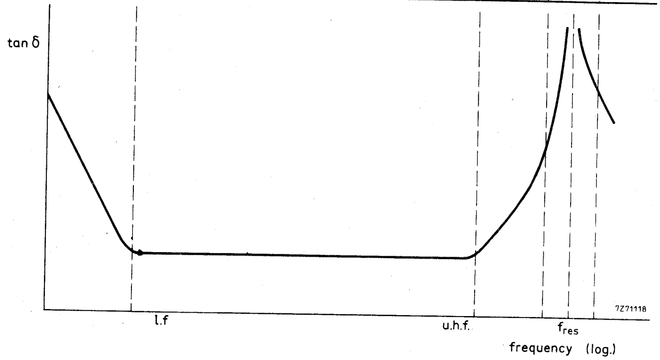


Fig. 4.

RELIABILITY *

		F.R. in 10^{-6}/h			
		catastrophic + degradation		catastrophic	
		test	normalized	test	normalized
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 642	2	0,04	1,4	0,03
	2222 650				
	2222 652				
	2222 654	0,96	0,02	0,37	0,01
	2222 655	1,2	0,03	1,2	0,03
	2222 679- 2222 683	2	0,04	1,4	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%.

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* Detailed information is given in our Product Informations 30 and 39.

MINIATURE CERAMIC PLATE CAPACITORS

class 2

QUICK REFERENCE DATA

	2222 629-series	2222 630-series	2222 640-series
Capacitance range	1000-22000 pF	180-4700 pF	1000-10000 pF
	E3 series	E12 series	E6 series
Rated d.c. voltage	63 V	100 V	100 V
Tolerance on capacitance	−20/+ 80%	± 10%	−20/+ 50%
Basic specification	IEC 384-9	IEC 384-9 (2C2)	IEC 384-9 (2E2)
Climatic 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 capacitance with 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 commonly used cleaning solvents. They are tan coloured.
No silver migration can occur.

MECHANICAL DATA

Dimensions in mm

The capacitors are available in the following 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 flexible	0,4 (0,016 in)	3	2222 629 02 . . . 2222 630 02 . . . 2222 640 02 . . .

Outlines

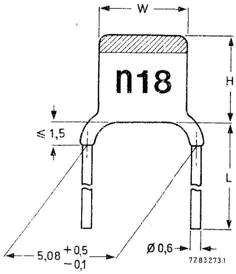

Fig. 1.

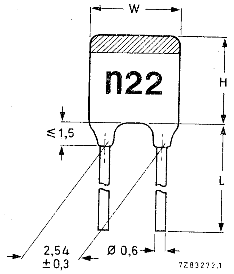

Fig. 2.

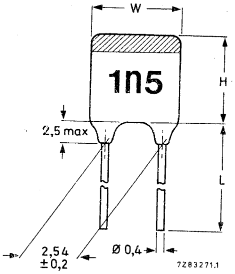

Fig. 3.

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* 3 dots to be replaced by code for capacitance value, see Tables 3, 4 and 5.

Table 2

size	W mm	H mm	approx. mass g
I	3,6(−1,5)	3,7(−1,6)	0,14
IIA	3,9(−1,2)	4,0(−1,3)	0,15
IIB	4,5(−1,1)	4,7(−1,3)	0,16
III	5,1(−1,1)	5,3(−1,3)	0,17
IV	6,2(−1,1)	6,4(−1,2)	0,20

Tolerance between brackets.

The thickness of the capacitors does not exceed 2,3 mm (0,09 in), except for a few types as is indicated in Tables 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. For those capacitance values indicated with asterisks in Tables 3 and 4, and lead pitch of 5,08 mm, the lacquer on the leads is less than 2 mm.

Marking

The body of the capacitors is tan coloured. The capacitors also have a colour mark on top indicating the temperature dependence of the capacitance; green for type 2222 629, yellow for type 2222 630, and blue for type 2222 640. The capacitance value is indicated on the body by figures according to Tables 3, 4 and 5 in a contrasting colour.

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. 10 s

PACKING

The capacitors are supplied in boxes of 1000.

ELECTRICAL DATA

Capacitors 2222 629 (colour mark green)

The capacitors are in conformity with IEC 384-9.
Unless otherwise specified all electrical values apply a at a temperature of 20 ± 1 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 63 to 67%.

Capacitance values measured at 1 kHz, 1 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 V	⩽ 6,5%
Category temperature range	−10 to + 55 °C
Storage temperature range	−55 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	IIB	10n	103
22 000	IV	22n	223

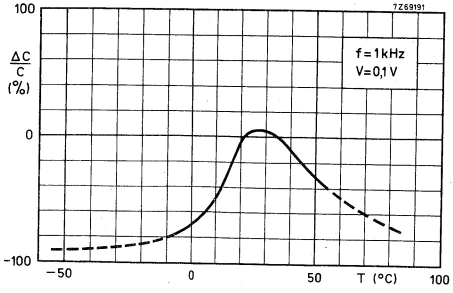

Fig. 4 Typical capacitance change as a function of temperature for capacitance values 2200 pF to 22 000 pF; dotted lines give an indication of the behaviour at higher and lower temperatures.

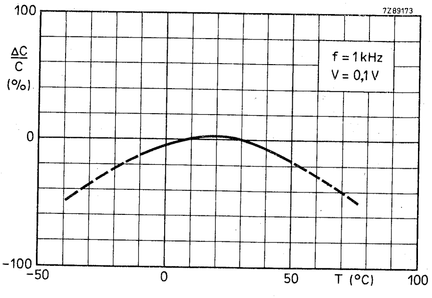

Fig. 5 Typical capacitance change as a function of temperature for capacitance value 1000 pF; dotted lines give an indication of the behaviour at higher and lower temperatures.

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* Maximum thickness 2,5 mm (0,1 in), H_{max} = 4,5 mm.

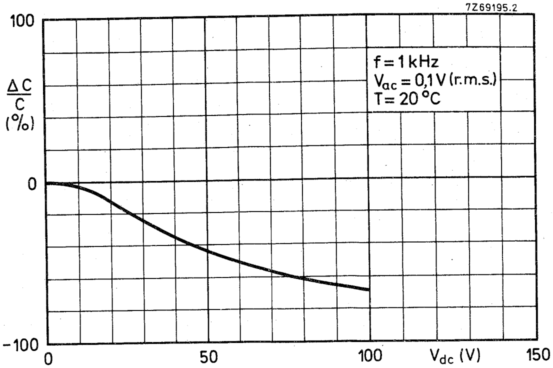


Fig. 6 Typical capacitance change with respect to the capacitance value at 0 V, as a function of d.c. voltage, for capacitance values 2200 to 22 000 pF.

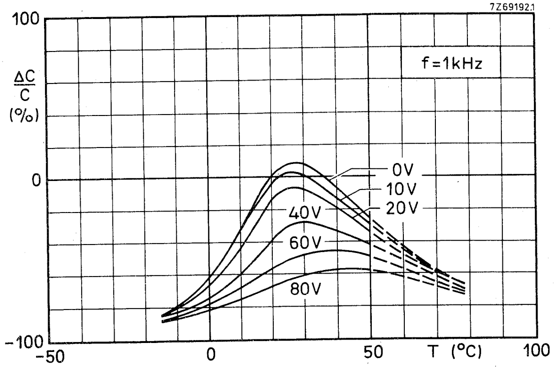


Fig. 7 Typical capacitance change with respect to the capacitance value at 0 V and 20 °C, as a function of temperature at different d.c. voltages, for capacitance values 2200 to 22 000 pF; V_{ac} = 0,1 V (r.m.s.).

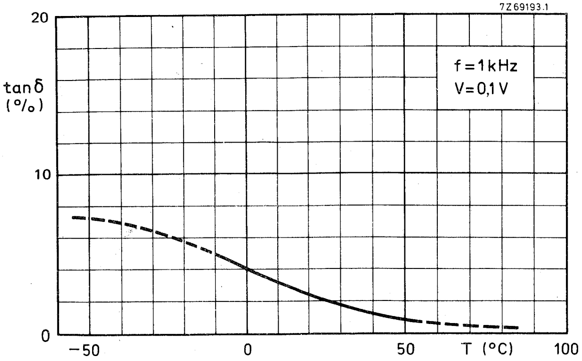


Fig. 8 Typical tan δ as a function of temperature, for capacitance values 2200 to 22 000 pF.

ELECTRICAL DATA (continued)

Capacitors 2222 630 (colour mark yellow)

The capacitors are in conformity with IEC 384-9 (2C2).
Unless otherwise specified all electrical values apply at a temperature of 20 ± 1 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 63 to 67%.

Capacitance values, measured at 1 kHz, 1 V	180 – 4700 pF, E12 series (see Table 4)
Tolerance on the capacitance	± 10%
Rated d.c. voltage	100 V
Test voltage (d.c.) for 1 min	300 V
Test voltage (d.c.) of coating for 1 min	300 V
Insulation resistance at 100 V (d.c.) after 1 min	⩾ 4000 MΩ
Tan δ at 1 kHz, 1 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 in catalogue number see Table 1
180*	I	n18	181
220**	I	n22	221
270	I	n27	271
330	I	n33	331
390	I	n39	391
470	I	n47	471
560	I	n56	561
680	I	n68	681
820	I	n82	821
1000	IIA	1n0	102
1200	IIA	1n2	122
1500	IIB	1n5	152
1800	IIB	1n8	182
2200	III	2n2	222
2700	III	2n7	272
3300	IV	3n3	332
3900	IV	3n9	392
4700	IV	4n7	472

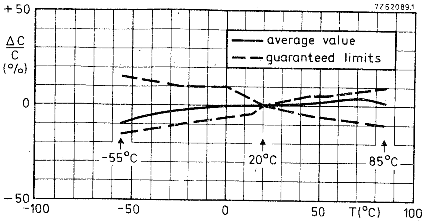


Fig. 9 ΔC with respect to C at 20 °C as a function of temperature. V = 0,1 V; f = 1 kHz.

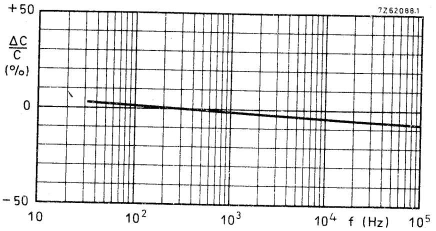


Fig. 10 Typ. ΔC with respect to C at 300 Hz, as a function of frequency. V = 0,1 V.

* Maximum thickness 2,7 mm, H_{max} = 4,5 mm.

** Maximum thickness 2,5 mm, H_{max} = 4,5 mm.

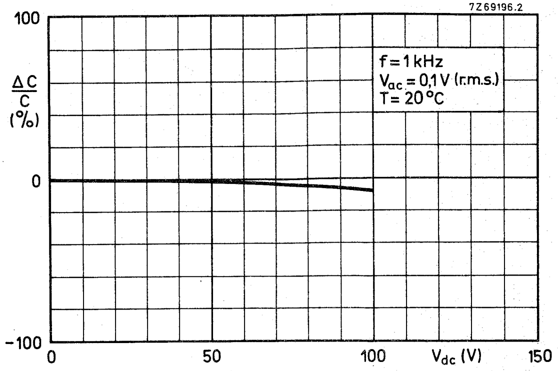


Fig. 11 Typical capacitance change with respect to the capacitance value at 0 V, as a function of d.c. voltage.

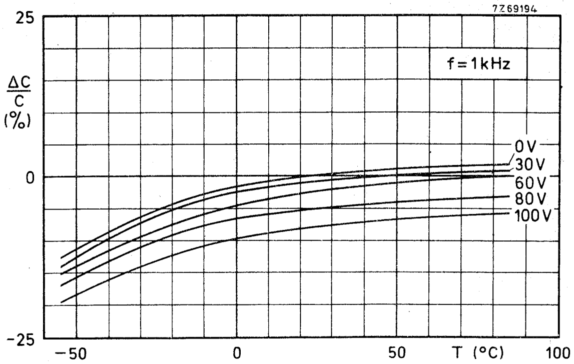


Fig. 12 Typical capacitance change with respect to the capacitance value at 0 V and 20 °C, as a function of temperature at different d.c. voltages. V_{ac} = 0,1 V (r.m.s.).

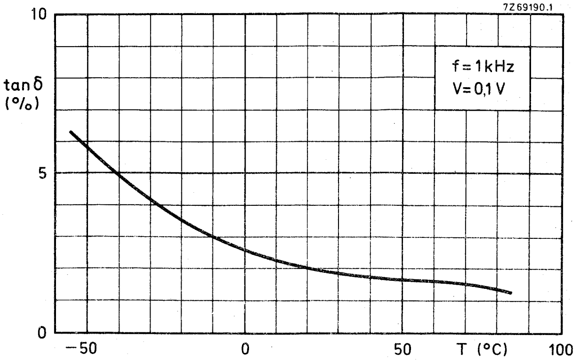


Fig. 13 Typical tan δ as a function of temperature.

ELECTRICAL DATA (continued)

Capacitors 2222 640 (colour mark blue)

The capacitors meet the essential requirements of IEC 384-9 (2E2).
Unless otherwise specified all electrical values apply at a temperature of 20 ± 1 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 63 to 67%.

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

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	IIA	3n3	332
4700	IIB	4n7	472
6800	III	6n8	682
10000	IV	10n	103

Graphs

measured at
V_{ac} = 1 V (r.m.s.),
f = 1 kHz.

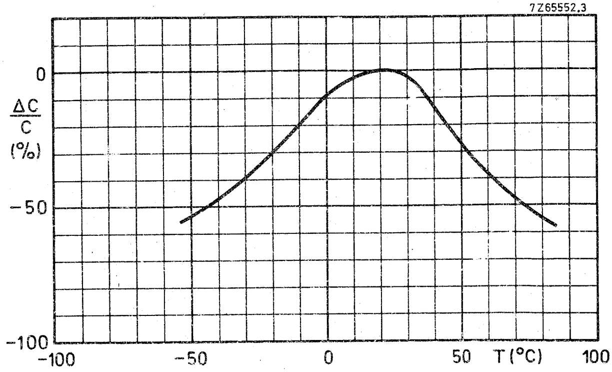


Fig. 14 Typical capacitance change versus temperature at 0 V (d.c.).

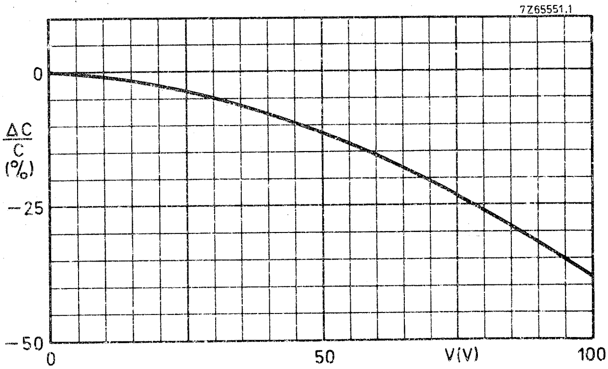


Fig. 15 Typical capacitance change with respect to the capacitance at 20 °C versus d.c. voltage.

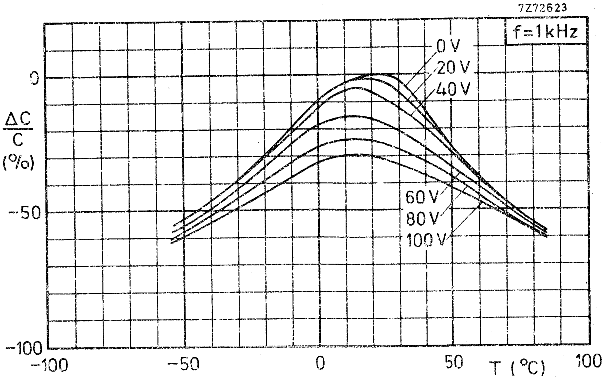
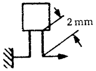


Fig. 16 Typical capacitance change with respect to the capacitance value at 0 V and 20 °C, as a function of temperature at different voltages.

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 384-9, 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.

IEC 384-9 clause	IEC 68 test method	Test	Procedure	Requirements
– 10.1	– 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: aixal force 5 N	no wire breakage or complete damage of capacitor
10.1	Ub	Bending (half number of samples)	load 5 N, 4 x 90°	no wire breakage
10.2	T	Soldering (solder bath)	solderability: 2 s at 235 °C	good tinning, ΔC/C after 24 h, 2222 630: ± < 10% 2222 629, 2222 640: ± < 20%
	–	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	
10.3	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%

10.4	Fb	Vibration	10-55-10 Hz 0,75 mm displacement 3 directions, 6 h	no visible damage
10.5	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
–	–	Resistance to solvents	3 min ultrasonic washing in trichloroethylene 1 min drying, 30 ^{o}C 10 brush strokes	marking and colour coding must remain legible and not discoloured; no mechanical or electrical damage or deterioration of the material
10.6.1	–	Climatic sequence Pre-conditioning	2222 630, 2222 640: 1 h + 85 ^{o}C 2222 629: 1 h + 55 ^{o}C reference measurements after 24 h	
10.6.2	B	Dry heat	16 h + 85 ^{o}C and + 55 ^{o}C respectively	no visible damage
10.6.3	Db	Damp heat (accel.) 1st cycle	12 h + 25 ^{o}C, 95 to 100% R.H.	no visible damage; after recovery of 1 - 2 h immediately followed by cold test
10.6.4	A	Cold	2222 630, 2222 640: 2 h –55 ^{o}C 2222 629: 2 h –10 ^{o}C	no visible damage
10.6.5	M	Low air pressure	1 h at 8,5 kPa last 2 min rated voltage applied	no breakdown or flashover
10.6.6	Db	Damp heat (accel.) remaining cycles	1 day + 55 ^{o}C, 95 to 100% R.H.	after 24 h recovery: $\Delta C/C$, 2222 630 $\pm < 10\%$ 2222 629, 2222 640 $\pm < 20\%$ $\tan \delta < 7\%$ $R_{ins} > 100\ M\Omega$

IEC 384-9 clause	IEC 68 test method	Test	Procedure	Requirements
10.7	Ca	Damp heat (steady state)	21 days + 40 °C, 90 to 95% R.H. half number of samples 100 V (d.c.), half number of samples no voltage applied	no visible damage; after 1 - 2 h: $\Delta C/C$, 2222 630 $\pm < 10\%$ 2222 629, 2222 640: $\pm < 20\%$ $\tan \delta < 7\%$ $R_{ins} > 100\ M\Omega$
10.9.1	–	Endurance Pre-conditioning	2222 630, 2222 640: 1 h + 85 °C 2222 629: 1 h + 55 °C reference measurements after 24 h	
10.9.3	–	Endurance	1000 h (IEC) 2222 630, 2222 640: + 85 °C, 150 V (d.c.) 2222 629: + 55 °C, 100 V (d.c.)	after 24 h at 20 °C: $\Delta C/C$, 2222 630 $\pm < 10\%$ 2222 629, 2222 640 $\pm < 20\%$ $\tan \delta < 5\%$ (2222 629 $< 6{,}5\%$) $R_{ins} > 300\ M\Omega$
–	H	Storage	72 h –65 °C, recovery 1 - 2 h	electr. parameters within specification

FLANGE VERSION

MINIATURE CERAMIC PLATE CAPACITORS
class 2

QUICK REFERENCE DATA

	2222 629-series	2222 630-series	2222 640-series
Capacitance range	1000-22000 pF	180-4700 pF	1000-10000 pF
	E3 series	E12 series	E6 series
Rated d.c. voltage	63 V	100 V	100 V
Tolerance on capacitance	−20/+ 80%	± 10%	−20/+ 50%
Basic specification	IEC 384-9	IEC 384-9 (2C2)	IEC 384-9 (2E2)
Climatic category (IEC 68)	10/055/21	55/085/21	55/085/21

APPLICATION

Electronic circuits where a non-linear change of capacitance with temperature is permissible and very low losses are not essential, e.g. coupling and decoupling.
Because of their small size and their availability with a pitch of 2,54 mm over the whole range, the capacitors are ideal for circuitry with a high component density.

DESCRIPTION

The capacitors consist of a thin rectangular ceramic plate, both sides of which are metallized. The tinned connecting leads are secured with a high melting point solder. The leads are provided with a flange the guarantees leads without lacquer, making these capacitors perfectly suited for automatic insertion.
The capacitors are protected by several layers of tan lacquer that ensures a good behaviour under humid conditions and is resistant to all commonly used cleaning solvents.
No silver migration can occur.

MECHANICAL DATA

Dimensions in mm

The capacitors are available in the following versions.

Table 1

lead spacing	lead length L	lead diameter	Fig.	catalogue number (1)
bulk packed capacitors				
5,08 (0,2 in)	⩾ 13	0,6 (0,024 in)	1	2222 629 09 . . . 2222 630 09 . . . 2222 640 09 . . .
5,08 (0,2 in)	4 ± 0,5	0,6 (0,024 in)	1	2222 629 19 . . . 2222 630 19 . . . 2222 640 19 . . .
2,54 (0,1 in)	⩾ 13	0,6 (0,024 in)	2	2222 629 08 . . . 2222 630 08 . . . 2222 640 08 . . .
2,54 (0,1 in)	4 ± 0,5	0,6 (0,024 in)	2	2222 629 18 . . . 2222 630 18 . . . 2222 640 18 . . .
capacitors on tape				
–	–	0,6 (0,024 in)	18 (2)	2222 629 53 . . . 2222 630 53 . . . 2222 640 53 . . .

Outlines

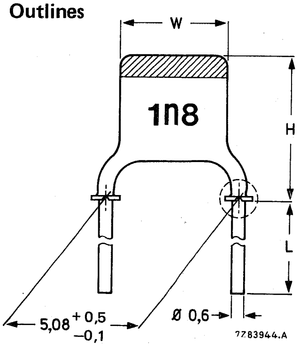


Fig. 1.

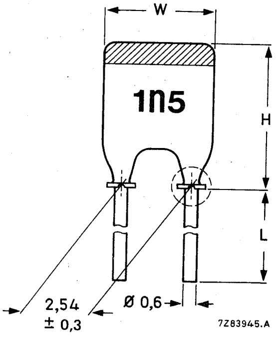
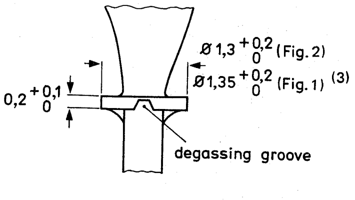


Fig. 2.



DETAIL

(1) 3 dots to be replaced by code for capacitance value, see Tables 3, 4 and 5.
(2) Capacitors are according to Fig. 1 except for the lead length. Fig. 18 is found under "Packing".
(3) The longest axis of the possible ellips has a minimum length of 1,4 mm.

Table 2

size	W(mm)	H(mm)		approx. mass g
		Fig. 1	Fig. 2	
I	3,6(−1,5)	6,3(−1,8)	5,0(−1,5)	0,14
IIA	3,9(−1,2)	6,7(−1,8)	5,3(−1,5)	0,15
IIB	4,5(−1,1)	7,3(−1,8)	6,0(−1,5)	0,15
III	5,1(−1,1)	7,9(−1,7)	6,6(−1,4)	0,17
IV	6,2(−1,1)	9,0(−1,7)	7,7(−1,4)	0,20

Tolerance between brackets.

The thickness of the capacitors does not exceed 2,3 mm (0,08 in), except for a few types as is indicated in Table 3.

Marking

The body of the capacitors is tan coloured. The capacitors also have a colour mark on top indicating the temperature dependence of the capacitance; green for type 2222 629, yellow for type 2222 630, and blue for type 2222 640. The capacitance value is indicated on the body by figures according to Tables 3, 4 and 5 in a contrasting colour.

Mounting

When bending and cutting or flattening the leads, one should relieve them of the applied load at the capacitor body.

Soldering conditions max. 270 °C, max. 10 s

The capacitors are mounted on printed-wiring boards (hand mounting or automatic insertion). Due to the flange on the leads solder connections are free from lacquer. The flange is provided with a degassing groove.

ELECTRICAL DATA

Capacitors 2222 629 (colour mark green)

The capacitors conform to IEC 384-9.
Unless otherwise specified all electrical values apply a at a temperature of 20 ± 1 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 63 to 67%.

Capacitance values measured at 1 kHz, 1 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 V	⩽ 6,5%
Category temperature range	−10 to + 55 °C
Storage temperature range	−55 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	IIB	10n	103
22 000	IV	22n	223

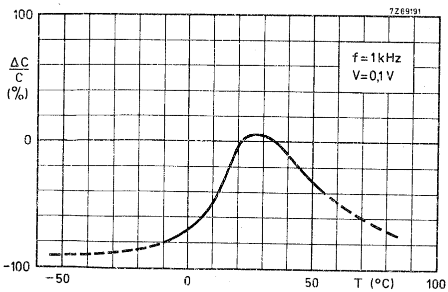


Fig. 3 Typical capacitance change as a function of temperature for capacitance values 2200 pF to 22 000 pF; dotted lines give an indication of the behaviour at higher and lower temperatures.

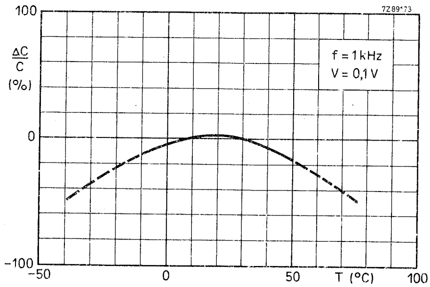


Fig. 4 Typical capacitance change as a function of temperature for capacitance value 1000 pF; dotted lines give an indication of the behaviour at higher and lower temperatures.

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* Maximum thickness 2,5 mm (0,1 in), H_{max} = 4,5 mm.

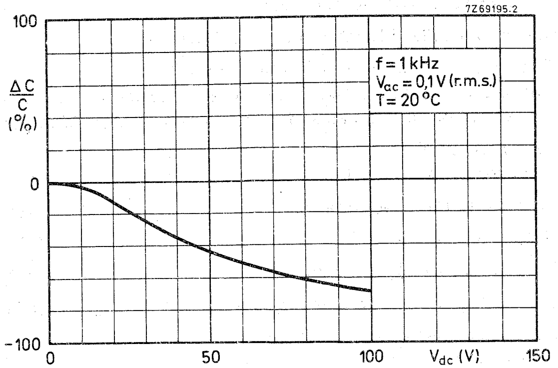


Fig. 5 Typical capacitance change with respect to the capacitance value at 0 V, as a function of d.c. voltage, for capacitance values 2200 to 22 000 pF.

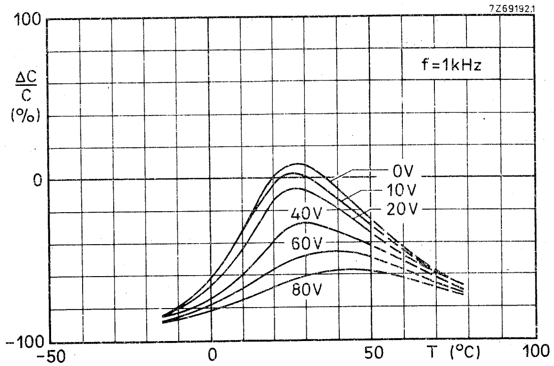


Fig. 6 Typical capacitance change with respect to the capacitance value at 0 V and 20 °C, as a function of temperature at different d.c. voltages, for capacitance values 2200 to 22 000 pF; V_{ac} = 0,1 V (r.m.s.).

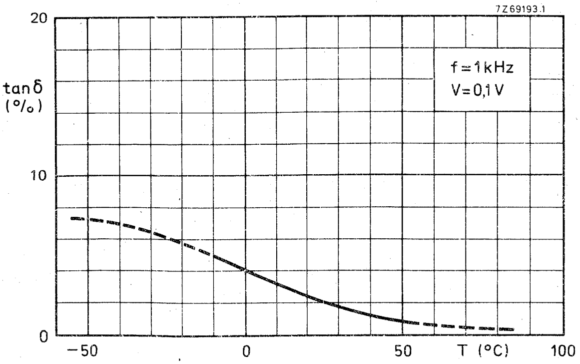


Fig. 7 Typical tan δ as a function of temperature, for capacitance values 2200 to 22 000 pF.

ELECTRICAL DATA (continued)

Capacitors 2222 630 (colour mark yellow)

The capacitors conform to IEC 384-9 (2C2).

Unless otherwise specified all electrical values apply at a temperature of 20 ± 1 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 63 to 67%.

Capacitance values, measured at 1 kHz, 1 V	180 – 4700 pF, E12 series (see Table 4)
Tolerance on the capacitance	± 10%
Rated d.c. voltage	100 V
Test voltage (d.c.) for 1 min	300 V
Test voltage (d.c.) of coating for 1 min	300 V
Insulation resistance at 100 V (d.c.) after 1 min	$\geqslant$ 4000 MΩ
Tan δ at 1 kHz, 1 V	$\leqslant$ 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 in catalogue number see Table 1	cap. pF	size see Table 2	marking	code in catalogue number see Table 1
180*	I	n18	181	1000	IIA	1n0	102
220**	I	n22	221	1200	IIA	1n2	122
270	I	n27	271	1500	IIB	1n5	152
330	I	n33	331	1800	IIB	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

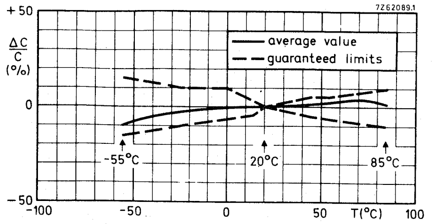


Fig. 8 ΔC with respect to C at 20 °C as a function of temperature. V = 0,1 V, f = 1 kHz.

* Maximum thickness 2,7 mm, H_{max} = 4,5 mm.
** Maximum thickness 2,5 mm, H_{max} = 4,5 mm.

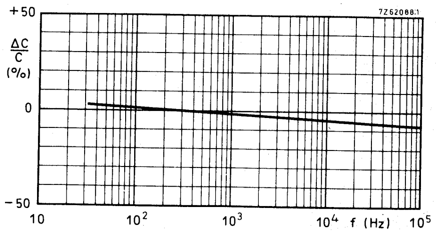


Fig. 9 Typ. ΔC with respect to C at 300 Hz, as a function of frequency. V = 0,1 V.

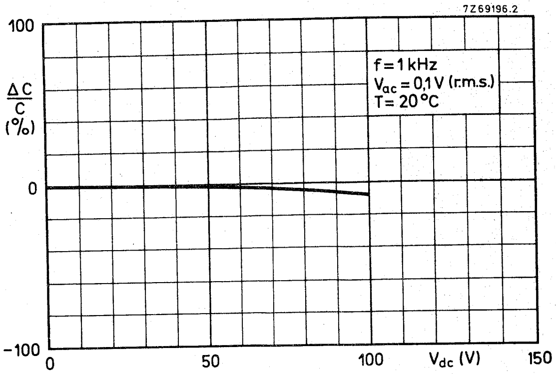


Fig. 10 Typical capacitance change with respect to the capacitance value at 0 V, as a function of d.c. voltage.

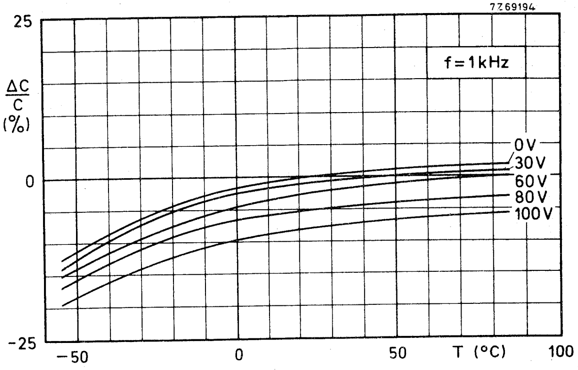


Fig. 11 Typical capacitance change with respect to the capacitance value at 0 V and 20 °C, as a function of temperature at different d.c. voltages. V_{ac} = 0,1 V (r.m.s.).

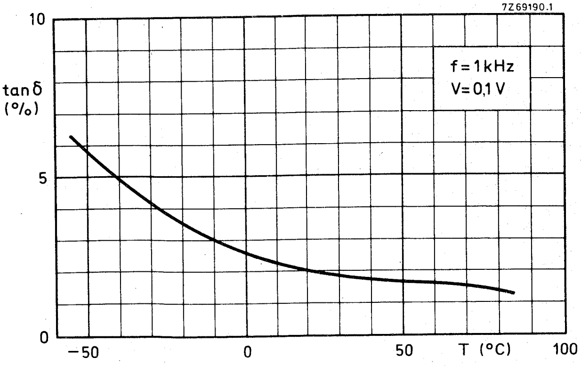


Fig. 12 Typical tan δ as a function of temperature.

ELECTRICAL DATA (continued)

Capacitors 2222 640 (colour mark blue)

The capacitors meet the essential requirements of IEC 384-9 (2E2).
Unless otherwise specified all electrical values apply at a temperature of 20 ± 1 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 63 to 67%.

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	$\geqslant$ 3000 MΩ
Tan δ at 1 kHz, 1 V	$\leqslant$ 3,5%
Category temperature range	−55 to + 85 °C
Storage temperature range	−55 to + 85 °C
Climatic category (IEC 68)	55/085/21

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	IIA	3n3	332
4700	IIB	4n7	472
6800	III	6n8	682
10000	IV	10n	103

Graphs,
measured at
V_{ac} = 1 V (r.m.s.)
f = 1 kHz.

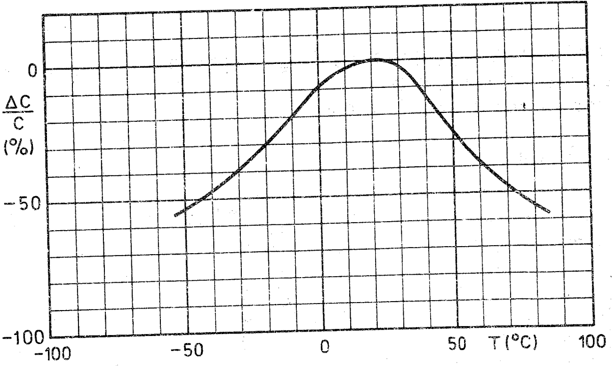


Fig. 13 Typical capacitance change versus temperature at 0 V (d.c.).

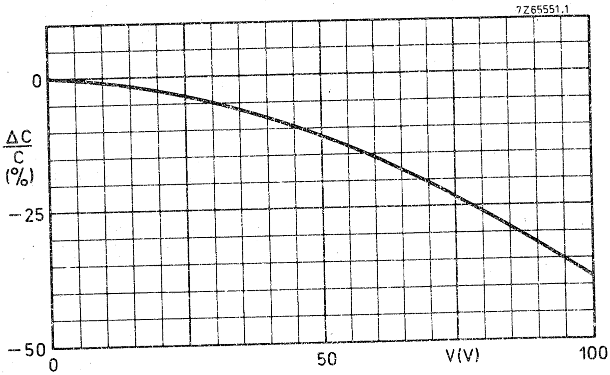


Fig. 14 Typical capacitance change with respect to the capacitance at 20 °C versus d.c. voltage.

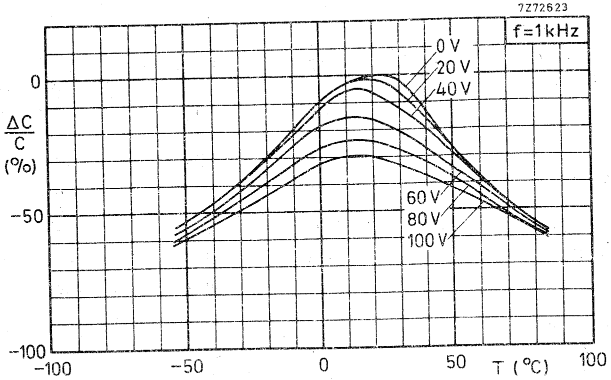


Fig. 15 Typical capacitance change with respect to the capacitance value at 0 V and 20 °C, as a function of temperature at different voltages.

→ PACKING

The capacitors 2222 629 53 . . ., 2222 630 53 . . . and 2222 640 53 . . . are supplied on tape on reels, 4000 capacitors per reel (Figs 18, 19, 20).
All other versions are supplied in boxes of 1000.

Capacitors on tape on reels

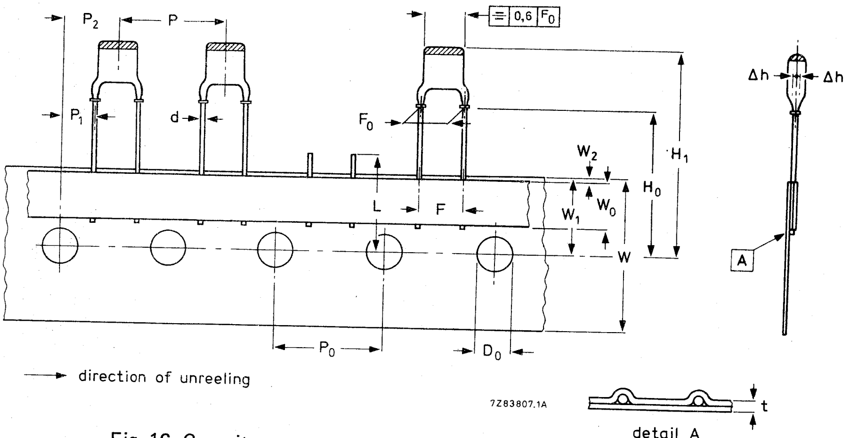


Fig. 16 Capacitors on tape; see Table 6 for dimensions of versions 2222 629 53 . . ., 2222 630 53 . . . and 2222 640 53 . . .

Table 6

	symbol	dimensions	
		nominal	tolerance
Lead diameter	d	0,6	+0,06/−0,05
Pitch between capacitors	P	12,7	± 1,0
Feed-hole pitch	P_0	12,7	± 0,2*
Feed-hole centre to lead centre	P_1	3,85	± 0,7
Feed hole centre to component centre	P_2	6,35	± 1,0
Lead-to-lead distance	F	5,0	+ 0,8/−0,2
	F_0	5,08	+ 0,5/−0,1
Component alignment	Δh	0	± 1,0
Tape width	W	18,0	−0,5
Hold-down tape width	W_0	6,0	± 0,5
Hole position	W_1	9,0	± 0,5
Hold-down tape position	W_2	0	+ 2
Flange to tape centre	H_0	18,25	+ 1,5/−0,5
Component height	H_1	30,5 23	max. min.
Length of snipped lead	L	11	max.
Feed-hole diameter	D_0	4,0	± 0,2
Total tape thickness	t	0,5	± 0,2

Note: See Tables 1 and 2 for dimensions of capacitors.

* Cumulative pitch error: ± ⩽ 1 mm/20 pitches.

Extraxtion force for component in the tape plane, vertically to direction of unreeling	min.	5 N
Break force of tape	min.	15 N
Pull-off force main tape — reel	max.	2,5 N

Maximum 0,5% of the total number of capacitors per reel may be missing. A maximum of 3 consecutive vacant positions is followed by at least 6 consecutive components. The tape begins and ends with 5 empty positions.

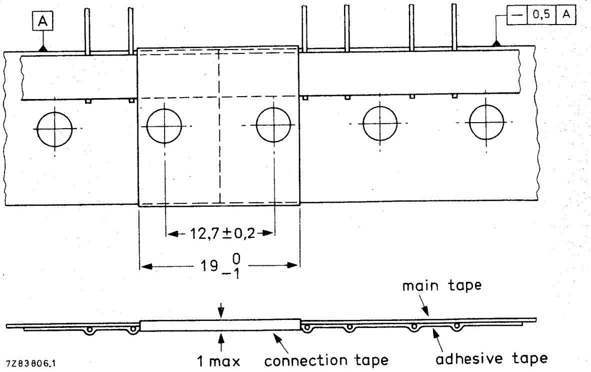


Fig. 17 Connection of tapes.

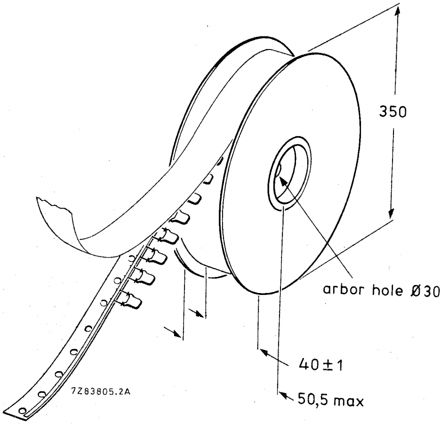
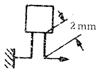


Fig. 18 Reel with capacitors on tape.

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 384-9, 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.

IEC 384-9 clause	IEC 68 test method	test	procedure	requirements
— 10.1	— 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
10.1	Ub	Bending (half number of samples)	load 5 N, 4 x 90°	no wire breakage
10.2.1	Ta method 1	Soldering (solder bath)	solderability: 2 s at 235 °C	good tinning,
		Pre-conditioning	2222 629 : 1 h + 55 °C 2222 630, 2222 640 : 1 h + 85 °C reference measurements after 24 h	
10.2.2	Tb method 1A	Resistance to soldering heat	270 °C, 10 s	no visible damage, ΔC/C after 24 h, 2222 630: ± < 10% 2222 629, 2222 640: ± < 20%
		Pre-conditioning		
10.3	Na		5 cycles 2222 630: ½ h −55 °C/½ h + 85 °C 2222 640: ½ h −55 °C/½ h + 85 °C 2222 629: ½ h −10 °C/½ h + 55 °C	no damage, ΔC/C after 24 h, 2222 630: ± < 10% 2222 629, 2222 640: ± < 20%

10.4	Fb	Vibration	10-55-10 Hz 0,75 mm displacement 3 directions, 6 h	no visible damage
10.5	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
–	–	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
10.6.1	–	Climatic sequence Pre-conditioning	2222 630, 2222 640: 1 h + 85 °C 2222 629: 1 h + 55 °C reference measurements after 24 h	
10.6.2	B	Dry heat	16 h + 85 °C and + 55 °C respectively	no visible damage
10.6.3	Db	Damp heat (accel.) 1st cycle	12 h + 25 °C, 95 to 100% R.H.	no visible damage; after recovery of 1 - 2 h immediately followed by cold test
10.6.4	A	Cold	2222 630, 2222 640: 2 h –55 °C 2222 629: 2 h –10 °C	no visible damage
10.6.5	M	Low air pressure	1 h at 8,5 kPa last 2 min rated voltage applied	no breakdown or flashover
10.6.6	Db	Damp heat (accel.) remaining cycles	1 day + 55 °C, 95 to 100% R.H.	after 24 h recovery: $\Delta C/C$, 2222 630 $\pm < 10\%$ 2222 629, 2222 640 $\pm < 20\%$ tan $\delta < 7\%$ $R_{ins} > 100$ MΩ

IEC 384-9 clause	IEC 68 test method	test	procedure	requirements
		Pre-conditioning		
10.7	Ca	Damp heat (steady state) half number of samples rated voltage, half number of samples no voltage applied	21 days + 40 °C, 90 to 95% R.H.	no visible damage; after 24 h: ΔC/C, 2222 630 ± < 10% 2222 629, 2222 640: ± < 20% tan δ < 7% R_{ins} >100 MΩ
		Pre-conditioning		
10.9.3	–	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% (2222 629 < 6,5%) R_{ins} > 300 MΩ
		Pre-conditioning		
–	H	Storage	72 h –65 °C, recovery 1 - 2 h	electr. parameters within specification

MINIATURE CERAMIC PLATE CAPACITORS

class 1, temperature compensating types

QUICK REFERENCE DATA

Capacitance range	0,56 to 560 pF (E12 series)
Rated d.c. voltage	100 V
Tolerance on capacitance	± 2% or ± 0,25 pF
Temperature coefficients	P100, NP0, N075, N150, N220 N330, N470, N750, N1500
Basic specification	IEC 384-8, sub-class 1B
Climatic category (IEC 68)	55/085/21

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

Dimensions in mm

The capacitors are available in the following 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 . . . . .

Outlines

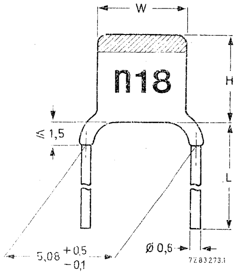


Fig. 1.

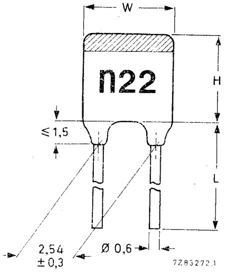


Fig. 2.

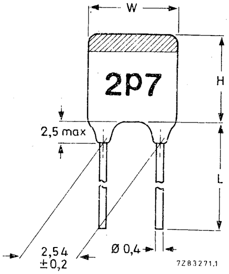


Fig. 3.

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* Capacitors with silver electrodes suffer from the "silver migration" effect. Silver particles move from one electrode to the other under the influence of a d.c. voltage and moisture. Capacitors with silver electrodes are considerably larger.

** Flexible leads.

*** For suffix see Tables 3 to 11.

Table 2

size	W mm	H mm	approx. mass g
I	3,6 (−1,5)	3,7 (−1,6)	0,14
IIA	3,9 (−1,2)	4,0 (−1,3)	0,15
IIB	4,5 (−1,1)	4,7 (−1,3)	0,15
III	5,1 (−1,1)	5,3 (−1,3)	0,17
IV	6,2 (−1,1)	6,4 (−1,2)	0,20
V	6,2 (−1,1)	8,4 (−1,6)	0,20

Tolerance between brackets.

The thickness of the capacitors does not exceed 2,3 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.

For those capacitance values indicated with asterisks in Tables 3 to 10, and lead pitch of 5,08 mm, the lacquer on the leads is less than 2 mm.

Marking

The temperature coefficient is indicated by a colour code as per IEC and EIA recommendations.
The capacitance value is indicated on the body by figures in a contrasting colour.

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. 10 s

PACKING

1000 capacitors per box, size V in boxes of 500.

ELECTRICAL DATA

The capacitors meet the essential requirements of IEC 384-8. Unless stated otherwise all electrical values apply at an ambient temperature of 20 ± 1 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 63 to 67%.

Capacitance values* and tolerances, measured at 1 MHz, $\leqslant$ 5 V	see Tables 3 to 11
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 after 1 min at 100 V (d.c.)	$\geqslant$ 10 000 MΩ
Tan δ* at 1 MHz, $\leqslant$ 5 V	
for $C \leqslant 50$ pF	$\leqslant 15 \left(\frac{15}{C} + 0{,}7\right) \times 10^{-4}$; max. 55×10^{-4}
for $C > 50$ pF	$\leqslant 15 \times 10^{-4}$
Category temperature range	−55 to + 85 °C
Storage temperature range	−55 to + 85 °C
Climatic category, IEC 68	55/085/21

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* Including 2 mm per connecting lead.

Capacitors with a temperature coefficient P100, rated voltage 100 V (d.c.)

Capacitance range	0,56 to 47 pF (E12 series)
Temperature coefficient of the capacitance $(\frac{\Delta C}{C.\Delta T})$	$+ 100 \times 10^{-6}$/K
Tolerance on the temperature coefficient	
for $C < 22$ pF	$(-40$ to $+ 120) \times 10^{-6}$/K
for $C \geqslant 22$ pF	$\pm 40 \times 10^{-6}$/K
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	IIA	8p2	03828
10	± 2%	IIA	10p	04109
12	± 2%	IIB	12p	04129
15	± 2%	IIB	15p	04159
18	± 2%	III	18p	04189
22	± 2%	III	22p	04229
27	± 2%	IV	27p	04279
33	± 2%	IV	33p	04339
39	± 2%	V	39p	04399
47	± 2%	V	47p	04479

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* Maximum thickness 2,7 mm, $H_{max} = 4,5$ mm.

** Maximum thickness 2,5 mm, $H_{max} = 4,5$ mm.

Capacitors with a temperature coefficient NPO, rated voltage 100 V (d.c.)

Capacitance range	1,8 to 120 pF (E12 series)
Temperature coefficient of the capacitance ($\frac{\Delta C}{C.\Delta T}$)	0×10^{-6}/K
Tolerance on the temperature coefficient	
for $C < 22$ pF	$(-40$ to $+120) \times 10^{-6}$/K
for $C \geqslant 22$ pF	$\pm 30 \times 10^{-6}$/K
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%	I	22p	10229
27	± 2%	I	27p	10279
33	± 2%	I	33p	10339
39	± 2%	IIA	39p	10399
47	± 2%	IIA	47p	10479
56	± 2%	IIB	56p	10569
68	± 2%	IIB	68p	10689
82	± 2%	IIB	82p	10829
100	± 2%	III	n10	10101
120	± 2%	III	n12	10121

---

* Maximum thickness 2,5 mm, $H_{max} = 4,5$ mm.

Capacitors with a temperature coefficient N075, rated voltage 100 V (d.c.)

Capacitance range	3,9 to 120 pF (E12 series)
Temperature coefficient of the capacitance ($\frac{\Delta C}{C.\Delta T}$)	-75×10^{-6}/K
Tolerance on the temperature coefficient	
for C $<$ 22 pF	$(-40 \text{ to } +60) \times 10^{-6}$/K
for C $\geqslant$ 22 pF	$\pm 30 \times 10^{-6}$/K
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%	IIA	22p	28229
27	± 2%	IIA	27p	28279
33	± 2%	IIB	33p	28339
39	± 2%	IIB	39p	28399
47	± 2%	III	47p	28479
56	± 2%	III	56p	28569
68	± 2%	IV	68p	28689
82	± 2%	IV	82p	28829
100	± 2%	V	n10	28101
120	± 2%	V	n12	28121

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* Maximum thickness 2,5 mm, H_{max} = 4,5 mm.

Capacitors with a temperature coefficient N150, rated voltage 100 V (d.c.)

Capacitance range	3,9 to 150 pF (E12 series)
Temperature coefficient of the capacitance $(\frac{\Delta C}{C.\Delta T})$	-150×10^{-6}/K
Tolerance on the temperature coefficient	
for $C < 22$ pF	$(-40 \text{ to } +60) \times 10^{-6}$/K
for $C \geqslant 22$ pF	$\pm 40 \times 10^{-6}$/K
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%	I	27p	34279
33	± 2%	I	33p	34339
39	± 2%	IIA	39p	34399
47	± 2%	IIA	47p	34479
56	± 2%	IIB	56p	34569
68	± 2%	IIB	68p	34689
82	± 2%	III	82p	34829
100	± 2%	III	n10	34101
120	± 2%	IV	n12	34121
150	± 2%	IV	n15	34151

* Maximum thickness 2,7 mm, H_{max} = 4,5 mm.
** Maximum thickness 2,5 mm, H_{max} = 4,5 mm.

Capacitors with a temperature coefficient N220, rated voltage 100 V (d.c.)

Capacitance range	3,9 to 150 pF (E12 series)
Temperature coefficient of the capacitance $(\frac{\Delta C}{C.\Delta T})$	-220×10^{-6}/K
Tolerance on the temperature coefficient	
for $C < 22$ pF	$(-40 \text{ to } +60) \times 10^{-6}$/K
for $C \geqslant 22$ pF	$\pm 40 \times 10^{-6}$/K
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%	IIA	27p	40279
33	± 2%	IIA	33p	40339
39	± 2%	IIB	39p	40399
47	± 2%	IIB	47p	40479
56	± 2%	III	56p	40569
68	± 2%	III	68p	40689
82	± 2%	IV	82p	40829
100	± 2%	IV	n10	40101
120	± 2%	V	n12	40121
150	± 2%	V	n15	40151

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* Maximum thickness 2,7 mm, H_{max} = 4,5 mm.
** Maximum thickness 2,5 mm, H_{max} = 4,5 mm.

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 ($\frac{\Delta C}{C.\Delta T}$)	-330×10^{-6}/K
Tolerance on the temperature coefficient	$\pm 60 \times 10^{-6}$/K
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%	IIA	33p	46339
39	± 2%	IIA	39p	46399
47	± 2%	IIB	47p	46479
56	± 2%	IIB	56p	46569
68	± 2%	III	68p	46689
82	± 2%	III	82p	46829
100	± 2%	IV	n10	46101
120	± 2%	IV	n12	46121
150	± 2%	V	n15	46151
180	± 2%	V	n18	46181

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* Maximum thickness 2,7 mm, H_{max} = 4,5 mm.
** Maximum thickness 2,5 mm, H_{max} = 4,5 mm.

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 $(\frac{\Delta C}{C.\Delta T})$	-470×10^{-6}/K
Tolerance on the temperature coefficient	
for $C < 22$ pF	$(-90$ to $+250) \times 10^{-6}$/K
for $C \geqslant 22$ pF	$\pm 60 \times 10^{-6}$/K
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%	IIA	39p	52399
47	± 2%	IIA	47p	52479
56	± 2%	IIB	56p	52569
68	± 2%	IIB	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, $H_{max} = 4,5$ mm.

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 $(\frac{\Delta C}{C.\Delta T})$	-750×10^{-6}/K
Tolerance on the temperature coefficient	
for C < 22 pF	$(-120 \text{ to } +250) \times 10^{-6}$/K
for C ⩾ 22 pF	$\pm 120 \times 10^{-6}$/K
Marking colour of the temperature coefficient	violet

Table 10

cap. pF	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%	IIA	56p	58569
68	± 2%	IIA	68p	58689
82	± 2%	IIB	82p	58829
100	± 2%	IIB	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, $H_{max} = 4,5$ mm.

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 $(\frac{\Delta C}{C.\Delta T})$	-1500×10^{-6}/K
Tolerance on the temperature coefficient	$(0 \text{ to } +500) \times 10^{-6}$/K
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%	IIA	n10	70101
120	± 2%	IIA	n12	70121
150	± 2%	IIB	n15	70151
180	± 2%	IIB	n18	70181
220	± 2%	III	n22	70221
270	± 2%	III	n27	70271
330	± 2%	IV	n33	70331
390	± 2%	IV	n39	70391
470	± 2%	V	n47	70471
560	± 2%	V	n56	70561

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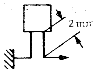
* Maximum thickness 2,5 mm, H_{max} = 4,5 mm.

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 384-8, 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 below.

IEC 384-8 clause	IEC 68 test method	test	procedure	requirements
—	—	Robustness of terminations Pull-off	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
10.1	Ua	Tensile strength		
10.1	Ub	Bending	load 5 N, 4 x 90°	no wire breakage
10.2	T	Soldering (solder bath)	solderability: 2 s 235 °C	good tinning
10.3	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
10.4	F	Vibration	10-55-10 Hz 0,75 mm displacement 3 directions, 6 h	no visible damage
10.5	E	Bump	4000 bumps in 2 directions, 40 g; 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
9,5	—	Temperature coefficient	between + 20 and + 85 °C	within tolerance as specified for each particular material

		Climatic sequence		
10.6.2	B	Dry heat	16 h + 85 °C	no visible damage
10.6.3	Db	Damp heat (accel.) 1st cycle	12 h + 55 °C, 12 h + 25 °C, 100% R.H.	after recovery of 1-2 h immediately followed by cold test
10.6.4	A	Cold	2 h –55 °C	no visible damage
10.6.5	M	Low air pressure	1 h 8,5 kPa, last 2 min rated voltage	no breakdown or flashover
10.6.6	Db	Damp heat (accel.)	12 h + 55 °C, 12 h + 25 °C, 100% R.H.	$\Delta C/C \pm \leqslant 1\%$ or 1 pF $\tan\delta < 2$ x specified $\tan\delta$ R_{ins} after 1-2 h > 100 MΩ
10.7	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.	$\Delta C/C \pm \leqslant 1\%$ or 1 pF $\tan\delta \leqslant 2$ x specified $\tan\delta$ R_{ins} after 1-2 h > 100 MΩ
10.8	–	Endurance	1000 h at +85 °C, 150 V (d.c.)	$\Delta C/C \pm \leqslant 1\%$ or 1 pF $\tan\delta \leqslant 1{,}5$ x specified $\tan\delta$ $R_{ins} > 300$ MΩ
–	–	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.
–	H	Storage	72 h –65 °C, recovery 1 - 2 h	electrical parameters within specification

MINIATURE CERAMIC PLATE CAPACITORS

class 1, 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 384-8, sub-class 1B
Category (IEC 68)	55/085/21

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 size the capacitors are very suitable for circuitry with high componenet density.

DESCRIPTION

The capacitors consist of a thin rectangular ceramic plate, both sides of which are metallized and provided with connecting leads. They are insulated by a coating that ensures a good behaviour under humid conditions. The colour of the capacitor body is grey. The capacitors distinguish themselves by small dimensions and narrow tolerances on the lead spacing.
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

Dimensions in mm

Table 1

size	W	H	approx. mass g
I	3,6(−1,5)	3,7(−1,6)	0,15
IIA	3,9(−1,2)	4,0(−1,3)	0,15
IIB	4,5(−1,1)	4,7(−1,3)	0,16
III	5,1(−1,1)	5,3(−1,3)	0,17
IV	6,2(−1,1)	6,4(−1,2)	0,21
V	6,2(−1,1)	8,4(−1,6)	0,23

Tolerance between brackets.

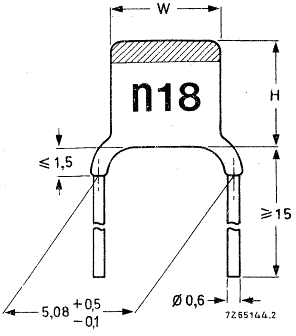


Fig. 1.

Except for the types indicated in Tables 2 to 6, the thickness of the capacitor does not exceed 2,3 mm.

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. For those capacitance values indicated with asterisks in Tables 2 to 6, the lacquer on the leads is less than 2 mm.

Marking

The temperature coefficient is indicated by a colour code as per IEC and EIA recommendations. The capacitance value and the voltage are indicated on the body by figures in a contrasting colour, see Tables 2 to 6.

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. 10 s

The capacitors are mounted on printed-wiring boards (hand mounting or automatic insertion). Due to the flange on the leads solder connections are free from lacquer. The flange is provided with a degassing groove.

PACKAGING

1000 items per box, size V in boxes of 500.

ELECTRICAL DATA

The capacitors meet the essential requirements of IEC 384-8. Unless stated otherwise all electrical values apply at an ambient temperature of 20 ± 1 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 63 to 67%.

Capacitance values and tolerances, measured at 1 MHz, $\leqslant 5$ 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, $\leqslant 5$ V*	
for $C < 50$ pF	$\leqslant 15\,(\frac{15}{C} + 0{,}7).10^{-4}$
for $C > 50$ pF	$\leqslant 15.10^{-4}$
Category temperature range	−55 to + 85 °C
Storage temperature range	−55 to + 85 °C
Climatic category (IEC 68)	55/085/21

Capacitors with temperature coefficient P100

Capacitance range	0,47 to 33 pF (E12 series)
Temperature coefficient of the capacitance $(\frac{\Delta C}{C.\Delta T})$	$+ 100 \times 10^{-6}$/K
Tolerance on the temperature coefficient	
for C < 22 pF	$(-40 \text{ to } + 120) \times 10^{-6}$/K
for C ⩾ 22 pF	$\pm 40 \times 10^{-6}$/K
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	IIA	4P7	500	03478
5,6	± 0,25 pF	IIA	5P6	500	03568
6,8	± 0,25 pF	IIB	6P8	500	03688
8,2	± 0,25 pF	IIB	8P2	500	03828
10	± 2%	III	10P	500	04109
12	± 2%	III	12P	500	04129
15	± 2%	III	15P	500	04159
18	± 2%	IV	18P	500	04189
22	± 2%	IV	22P	500	04229
27	± 2%	V	27P	500	04279
33	± 2%	V	33P	500	04339

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* Maximum thickness 2,5 mm.

Capacitors with a temperature coefficient NP0

Capacitance range	0,82 to 47 pF (E12 series)
Temperature coefficient of the capacitance ($\frac{\Delta C}{C.\Delta T}$)	0 x 10^{-6}/K
Tolerance on the temperature coefficient	
for C < 22 pF	(−40 +120) x 10^{-6}/K
for C ⩾ 22 pF	± 30 x 10^{-6}/K
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	IIA	6P8	500	09688
8,2	± 0,25 pF	IIA	8P2	500	09828
10	± 2%	IIB	10P	500	10109
12	± 2%	IIB	12P	500	10129
15	± 2%	IIB	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%	IV	39P	500	10399
47	± 2%	V	47P	500	10479

* Maximum thickness 2,7 mm.

** 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}/K
Tolerance on the temperature coefficient	
for $C < 22$ pF	$(-40 + 60) \times 10^{-6}$/K
for $C \geqslant 22$ pF	$\pm 30 \times 10^{-6}$/K
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	IIA	8P2	500	33828
10	± 2%	IIA	10P	500	34109
12	± 2%	IIB	12P	500	34129
15	± 2%	IIB	15P	500	34159
18	± 2%	IIB	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%	IV	47P	500	34479
56	± 2%	V	56P	500	34569

* Maximum thickness 2,7 mm.

** 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 $(\frac{\Delta C}{C.\Delta T})$	-750×10^{-6}/K
Tolerance on the temperature coefficient	
for $C < 22$ pF	$(-120 + 250) \times 10^{-6}$/K
for $C \geqslant 22$ pF	$\pm 120 \times 10^{-6}$/K
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%	IIA	18P	500	58189
22	± 2%	IIA	22P	500	58229
27	± 2%	IIB	27P	500	58279
33	± 2%	IIB	33P	500	58339
39	± 2%	IIB	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%	IV	n10	500	58101
120	± 2%	V	n12	500	58121

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* Maximum thickness 2,7 mm.

** 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 ($\frac{\Delta C}{C.\Delta T}$)	-1500×10^{-6}/K
Tolerance on the temperature coefficient	$(-0 + 500) \times 10^{-6}$/K
Marking colour of the temperature coefficient	orange/orange

Table 6

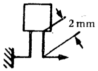
capacitance pF	tolerance	size	marking		catalogue number
8,2*	± 0,25 pF	I	8P2	500	2222 650 69828
10 *	± 2%	I	10P	500	70109
12 **	± 2%	I	12P	500	70129
15 **	± 2%	I	15P	500	70159
18	± 2%	I	18P	500	70189
22	± 2%	I	22P	500	70229
27	± 2%	I	27P	500	70279
33	± 2%	IIA	33P	500	70339
39	± 2%	IIA	39P	500	70399
47	± 2%	IIA	47P	500	70479
56	± 2%	IIB	56P	500	70569
68	± 2%	IIB	68P	500	70689
82	± 2%	IIB	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%	IV	n22	500	70221
270	± 2%	V	n27	500	70271

* Maximum thickness 2,7 mm.
** Maximum thickness 2,5 mm.

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 384-8, 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 8 below.

Table 8

IEC 384-8 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
10.1	Ua	Tensile strength	axial force 10 N	
10.1	Ub	Bending	load 5 N, 4 x 90°	no wire breakage
10.2.1	Ta method 1	Soldering	solderability: 2 s 235 °C	good tinning
10.2.2	Tb method 1A	Resistance to soldering heat	270 °C, 10 s	no visible damage $\Delta C/C \pm \leqslant 0,5\%$ or 0,5 pF after 1 h to 2 h
10.3	Na	Rapid change of temperature	30 min −55 °C/30 min + 85 °C, 5 cycles	no damage, after 24 h $\Delta C/C \pm \leqslant 0,5\%$ or 0,5 pF
10.4	Fc	Vibration	10-55-10 Hz 0,75 mm displacement 3 directions, 6 h	no visible damage
10.5	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
9.5	—	Temperature coefficient	between + 20 and + 85 °C	within tolerance as specified for each particular material

		Climatic sequence		
10.6.2	B	Dry heat	16 h + 85 $^{\circ}$C	no visible damage
10.6.3	Db	Damp heat (accel.) 1st cycle	12 h + 55 $^{\circ}$C, 12 h + 25 $^{\circ}$C, 100% R.H.	after recovery of 1-2 h immediately followed by cold test
10.6.4	A	Cold	2 h − 55 $^{\circ}$C	no visible damage
10.6.5	M	Low air pressure	1 h 8,5 kPa, last 2 min rated voltage	no breakdown or flashover
10.6.6	Db	Damp heat (accel.)	1 day + 55 $^{\circ}$C, 100% R.H.	$\Delta C/C \pm \leqslant 1\%$ or 1 pF $\tan \delta < 2 \times$ specified $\tan \delta$ R_{ins} after 1-2 h > 5000 MΩ
10.7	Ca	Damp heat, steady state (half number of the lot at rated voltage, other half at zero voltage)	21 days + 40 $^{\circ}$C 90 to 95% R.H.	$\Delta C/C \pm \leqslant 1\%$ or 1 pF $\tan \delta \leqslant 2 \times$ specified $\tan \delta$ R_{ins} after 1-2 h > 5000 MΩ
10.8	–	Endurance	1000 h at + 85 $^{\circ}$C, 750 V (d.c.)	$\Delta C/C \pm \leqslant 1\%$ or 1 pF $\tan \delta \leqslant 1{,}5 \times$ specified $\tan \delta$ $R_{ins} > 3000$ MΩ
–	–	Resistance to solvents	3 min ultrasonic washing in trichloroethylene 1 min drying, 30 $^{\circ}$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
–	H	Storage	72 h −65 $^{\circ}$C, recovery 1-2 h	electrical parameters within specification

MINIATURE CERAMIC PLATE CAPACITORS

class 1, 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 384-8, sub-class 1B
Category (IEC 68)	55/085/21

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 size the capacitors are very suitable for circuitry with high component density.

DESCRIPTION

The capacitors consist of a thin rectangular ceramic plate, both sides of which are metallized and provided with connecting leads. They are insulated by a coating that ensures a good behaviour under humid conditions. The colour of the capacitor body is grey. The capacitors distinguish themselves by small dimensions and narrow tolerances on the lead spacing. The leads are provided with a flange, that guarantees leads without lacquer, making them perfectly suited for automatic insertion.
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

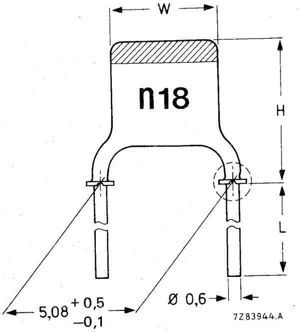
Table 1

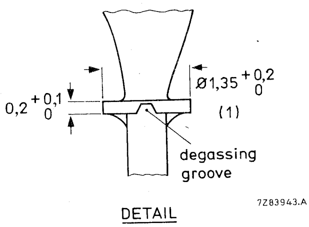
size	W	H	approx. mass g
I	3,6(−1,5)	6,3(−1,8)	0,15
IIA	3,9(−1,2)	6,7(−1,8)	0,15
IIB	4,5(−1,1)	7,3(−1,8)	0,16
III	5,1(−1,1)	7,9(−1,7)	0,17
IV	6,2(−1,1)	9,0(−1,7)	0,21
V	6,2(−1,1)	11,2(−2,1)	0,23

Tolerance between brackets.

Dimensions in mm

Fig. 1 L ≥ 13 mm.





DETAIL

Except for the types indicated in Tables 2 to 6, the thickness of the capacitor does not exceed 2,3 mm.

(1) The longest axis of the possible ellipse has a minimum length of 1,4 mm.

Marking

The temperature coefficient is indicated by a colour code as per IEC and EIA recommendations. The capacitance value and the voltage are indicated on the body by figures in a contrasting colour, see Tables 2 to 6.

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. 10 s

The capacitors are mounted on printed-wiring boards (hand mounting or automatic insertion). Due to the flange on the leads solder connections are free from lacquer. The flange is provided with a degassing groove.

ELECTRICAL DATA

The capacitors meet the essential requirements of IEC 384-8. Unless stated otherwise all electrical values apply at an ambient temperature of 20 ± 1 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 63 to 67%.

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	$\leqslant 15 (\frac{15}{C} + 0{,}7).10^{-4})$
for C > 50 pF	$\leqslant 15.10^{-4}$
Category temperature range	−55 to + 85 °C
Storage temperature range	−55 to + 85 °C
Climatic category (IEC 68)	55/085/21

Capacitors with temperature coefficient P100

Capacitance range	0,47 to 33 pF (E12 series)
Temperature coefficient of the capacitance $(\frac{\Delta C}{C.\Delta T})$	$+ 100 \times 10^{-6}$/K
Tolerance on the temperature coefficient	
for $C < 22$ pF	$(-40 \text{ to } + 120) \times 10^{-6}$/K
for $C \geqslant 22$ pF	$\pm 40 \times 10^{-6}$/K
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 XXX 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	IIA	4P7	500	03478
5,6	± 0,25 pF	IIA	5P6	500	03568
6,8	± 0,25 pF	IIB	6P8	500	03688
8,2	± 0,25 pF	IIB	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

XXX in catalogue number must be replaced by:
652 for bulk packed capacitors.
654 for capacitors on tape on reel.
See also Packing.

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* Maximum thickness 2,5 mm.

Capacitors with a temperature coefficient NP0

Capacitance range	0,82 to 47 pF (E12 series)
Temperature coefficient of the capacitance ($\frac{\Delta C}{C.\Delta T}$)	0×10^{-6}/K
Tolerance on the temperature coefficient	
for C < 22 pF	$(-40 +120) \times 10^{-6}$/K
for C ⩾ 22 pF	$\pm 30 \times 10^{-6}$/K
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 XXX 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	IIA	6P8	500	09688
8,2	± 0,25 pF	IIA	8P2	500	09828
10	± 2%	IIB	10P	500	10109
12	± 2%	IIB	12P	500	10129
15	± 2%	IIB	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%	IV	39P	500	10399
47	± 2%	V	47P	500	10479

XXX in catalogue number must be replaced by:
652 for bulk packed capacitors.
654 for capacitors on tape on reel.
See also Packing.

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* Maximum thickness 2,7 mm.
** 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}/K
Tolerance on the temperature coefficient	
for $C < 22$ pF	$(-40 + 60) \times 10^{-6}$/K
for $C \geqslant 22$ pF	$\pm 30 \times 10^{-6}$/K
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 XXX 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	IIA	8P2	500	33828
10	± 2%	IIA	10P	500	34109
12	± 2%	IIB	12P	500	34129
15	± 2%	IIB	15P	500	34159
18	± 2%	IIB	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%	IV	47P	500	34479
56	± 2%	V	56P	500	34569

XXX in catalogue number must be replaced by:
652 for bulk packed capacitors.
654 for capacitors on tape on reel.
See also Packing.

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* Maximum thickness 2,7 mm.
** 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 $(\frac{\Delta C}{C.\Delta T})$	-750×10^{-6}/K
Tolerance on the temperature coefficient	
for $C < 22$ pF	$(-120 + 250) \times 10^{-6}$/K
for $C \geqslant 22$ pF	$\pm 120 \times 10^{-6}$/K
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 XXX 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%	IIA	18P	500	58189
22	± 2%	IIA	22P	500	58229
27	± 2%	IIB	27P	500	58279
33	± 2%	IIB	33P	500	58339
39	± 2%	IIB	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%	IV	n10	500	58101
120	± 2%	V	n12	500	58121

XXX in catalogue number must be replaced by:
652 for bulk packed capacitors.
654 for capacitors on tape on reel.
See also Packing.

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* Maximum thickness 2,7 mm.
** 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 $\left(\frac{\Delta C}{C.\Delta T}\right)$	-1500×10^{-6}/K
Tolerance on the temperature coefficient	$(-0 + 500) \times 10^{-6}$/K
Marking colour of the temperature coefficient	orange/orange

Table 6

capacitance pF	tolerance	size	marking		catalogue number
8,2*	± 0,25 pF	I	8P2	500	2222 XXX 69828
10 *	± 2%	I	10P	500	70109
12 **	± 2%	I	12P	500	70129
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%	IIA	33P	500	70339
39	± 2%	IIA	39P	500	70399
47	± 2%	IIA	47P	500	70479
56	± 2%	IIB	56P	500	70569
68	± 2%	IIB	68P	500	70689
82	± 2%	IIB	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%	IV	n22	500	70221
270	± 2%	V	n27	500	70271

XXX in catalogue number must be replaced by:
652 for bulk packed capacitors.
654 for capacitors on tape on reel.
See also Packing.

* Maximum thickness 2,7 mm.
** Maximum thickness 2,5 mm.

PACKING

Dimensions in mm

The capacitors 2222 654 are supplied on tape on reels with 4000 capacitors per reel (Figs 2, 3, 4). The capacitors 2222 652 are supplied in boxes of 1000, except those in size V, which are supplied in boxes of 500.

Capacitors on tape on reels

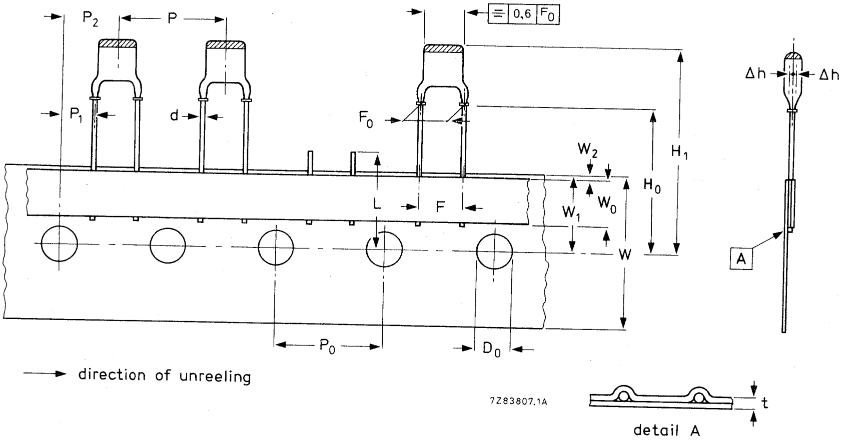


Fig. 2 Capacitors 2222 654 on tape; see Table 7 for dimensions.

Table 7

	symbol	dimensions	
		nominal	tolerance
Lead diameter	d	0,6	+ 0,06/−0,05
Pitch between capacitors	P	12,7	± 1,0
Feed-hole pitch	P_0	12,7	± 0,2*
Feed-hole centre to lead centre	P_1	3,85	± 0,7
Feed-hole centre to component centre	P_2	6,35	± 1,0
Lead-to-lead distance	F	5,0	+ 0,8/−0,2
	F_0	5,08	+ 0,5/−0,1
Component alignment	Δh	0	± 1,0
Tape width	W	18,0	−0,5
Hold-down tape width	W_0	6,0	± 0,5
Hole position	W_1	9,0	± 0,5
Hold-down tape position	W_2	0	+ 2
Flange to tape centre	H_0	18,25	+ 1,5/−0,5
Component height	H_1	30,5	max.
		23	min.
Length of snipped lead	L	11	max.
Feed-hole diameter	D_0	4,0	± 0,2
Total tape thickness	t	0,5	± 0,2

Note: See Table 1 for dimensions of capacitors.

* Cumulative pitch error: ± ⩽ 1 mm/20 pitches.

Extraction force for component in the tape plane, vertically to direction of unreeling	min. 5 N
Break force of tape	min. 15 N
Pull-off force main tape — reel	max. 2,5 N

Maximum 0,5% of the total number of capacitors per reel may be missing. A maximum of 3 consecutive vacant positions is followed by at least 6 consecutive components. The tape begins and ends with 5 empty positions.

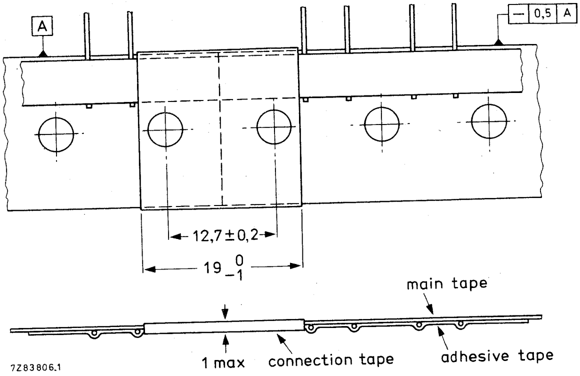


Fig. 3 Connection of tapes.

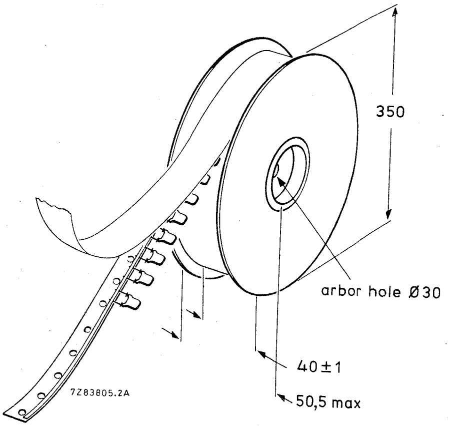


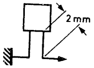
Fig. 4 Reel with capacitors on tape.

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 384-8, 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 8 below.

Table 8

IEC 384-8 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
10.1	Ua	Tensile strength	axial force 10 N	
10.1	Ub	Bending	load 5 N, 4 x 90°	no wire breakage
10.2.1	Ta method 1	Soldering (solder bath)	solderability: 2 s 235 °C	good tinning
10.2.2	Tb method 1A	Resistance to soldering heat	270 °C, 10 s	no visible damage $\Delta C/C \pm \leqslant 0{,}5\%$ or 0,5 pF after 1 h to 2 h
10.3	Na	Rapid change of temperature	30 min −55 °C/30 min + 85 °C, 5 cycles	no damage, after 24 h $\Delta C/C \pm \leqslant 0{,}5\%$ or 0,5 pF
10.4	Fc	Vibration	10-55-10 Hz 0,75 mm displacement 3 directions, 6 h	no visible damage
10.5	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
9.5	—	Temperature coefficient	between + 20 and + 85 °C	within tolerance as specified for each particular material

		Climatic sequence		
10.6.2	B	Dry heat	16 h + 85 ^{o}C	no visible damage
10.6.3	Db	Damp heat (accel.) 1st cycle	12 h + 55 ^{o}C, 12 h + 25 ^{o}C, 100% R.H.	after recovery of 1-2 h immediately followed by cold test
10.6.4	A	Cold	2 h –55 ^{o}C	no visible damage
10.6.5	M	Low air pressure	1 h 8,5 kPa, last 2 min rated voltage	no breakdown or flashover
10.6.6	Db	Damp heat (accel.)	1 day + 55 ^{o}C, 100% R.H.	$\Delta C/C \pm \leqslant 1\%$ or 1 pF $\tan \delta < 2$ x specified $\tan \delta$ R_{ins} after 1-2 h > 5000 MΩ
10.7	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.	$\Delta C/C \pm \leqslant 1\%$ or 1 pF $\tan \delta \leqslant 2$ x specified $\tan \delta$ R_{ins} after 1-2 h > 5000 MΩ
10.8	–	Endurance	1000 h at + 85 ^{o}C, 750 V (d.c.)	$\Delta C/C \pm \leqslant 1\%$ or 1 pF $\tan \delta \leqslant 1{,}5$ x specified $\tan \delta$ $R_{ins} > 3000$ MΩ
–	–	Resistance to solvents	3 min ultrasonic washing in trichloroethylene 1 min drying, 30 ^{o}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
–	H	Storage	72 h –65 ^{o}C, recovery 1 - 2 h	electrical parameters within specification

MINIATURE CERAMIC PLATE CAPACITORS

class 2, 500 V (d.c.)

QUICK REFERENCE DATA

Capacitance range	100 - 2700 pF (E12 series)
Rated d.c. voltage	500 V
Tolerance on capacitance	± 10%
Basic specification	IEC 384-9 (2C2)
Category (IEC 68)	55/085/21

APPLICATION

Electronic circuits where a non-linear change of capacitance with temperature is permissible and very low losses are not essential, e.g. coupling and decoupling.
Because of their small size the capacitors are ideal for circuitry with a high component density.

DESCRIPTION

The capacitors consist of a thin rectangular ceramic plate, both sides of which are metallized. The tinned connecting leads are secured with a high melting point solder.

The capacitors are protected by several layers of tan lacquer that ensures a good behaviour under humid conditions and is resistant to all commonly used cleaning solvents.
No silver migration can occur.

MECHANICAL DATA

Dimensions in mm

Table 1

size	W	H	approx. mass g
I	3,6 (−1,5)	3,7 (−1,6)	0,15
IIA	3,9 (−1,2)	4,0 (−1,3)	0,15
IIB	4,5 (−1,1)	4,7 (−1,3)	0,15
III	5,1 (−1,1)	5,3 (−1,3)	0,17
IV	6,2 (−1,1)	6,4 (−1,2)	0,21
V	6,2 (−1,1)	8,4 (−1,6)	0,23

Tolerance between brackets.

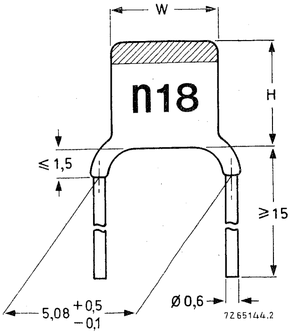


Fig. 1.

Except for a few types as indicated in Table 2, the thickness of the capacitor does not exceed 2,3 mm.

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. For those capacitance values indicated with asterisks in Table 2, the lacquer on the leads is less than 2 mm.

Marking

The body of the capacitors is tan coloured.
The temperature dependence is indicated by a yellow colour cap. Capacitance value and voltage are indicated on the body by figures according to Table 2 in a contrasting colour.

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. 10 s

The capacitors are mounted on printed-wiring boards (hand mounting or automatic insertion). Due to the flange on the leads solder connections are free from lacquer. The flange is provided with a degassing groove.

PACKAGING: 1000 items per box, size V in boxes of 500.

ELECTRICAL DATA

The capacitors meet the essential requirements of IEC 384-9. Unless stated otherwise all electrical values apply at an ambient temperature of 20 ± 1 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 63 to 67%.

Capacitance values, measured at 1 kHz ± 10% $\leqslant$ 1 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 a 1 kHz, $\leqslant$ 1 V	$<$ 3,5%
Category temperature range	−55 to + 85 °C
Climatic category	55/085/21
Storage temperature range	−55 to + 85 °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	121
150 *	I	n15	500	151
180 **	I	n18	500	181
220 **	I	n22	500	221
270	I	n27	500	271
330	I	n33	500	331
390	IIA	n39	500	391
470	IIA	n47	500	471
560	IIB	n56	500	561
680	IIB	n68	500	681
820	IIB	n82	500	821
1000	III	1n0	500	102
1200	III	1n2	500	122
1500	IV	1n5	500	152
1800	IV	1n8	500	182
2200	IV	2n2	500	222
2700	V	2n7	500	272

* Maximum thickness 2,7 mm.

** Maximum thickness 2,5 mm.

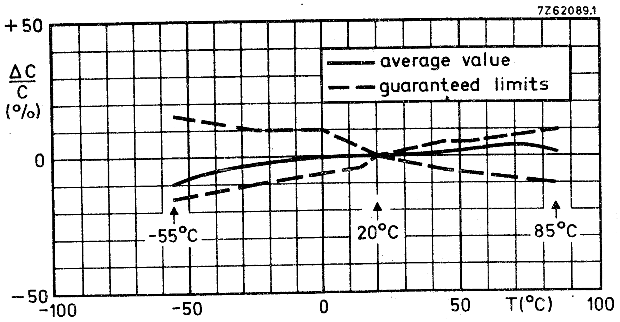


Fig. 2 Capacitance change with respect to the capacitance at 20 °C as a function of temperature.

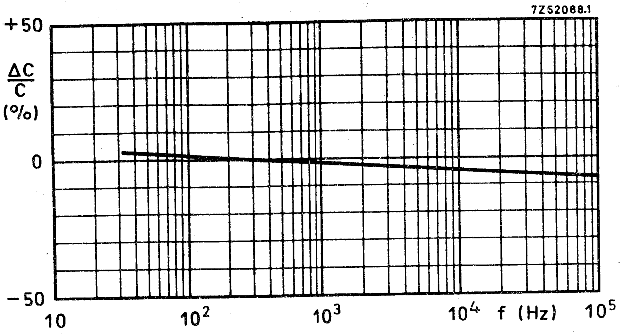


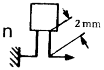
Fig. 3 Typical capacitance change with respect to the capacitance at 300 Hz as a function of frequency.

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 394-9, 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 4 below.

Table 4

IEC 384-9 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
10.1	Ua	Tensile strength	axial force 10 N	
10.1	Ub	Bending (half number of samples)	load 5 N, 4 x 90°	no wire breakage
10.2.1	Ta method 1	Soldering (solder bath)	solderability: 2 s at 235 °C	good tinning
		Pre-conditioning	1 h + 85 °C, reference measurements after 24 h	
10.2.2	Tb method 1A	Resistance to soldering heat	270 °C, 10 s	no visible damage, ΔC/C after 24 h between + 20% and –10%
		Pre-conditioning		
10.3	Na	Rapid change of temperature	½ h –55 °C/½ h + 85 °C 5 cycles	no damage ΔC/C after 24 h ± ⩽ 10%
10.4	Fb	Vibration	10-55-10 Hz 0,75 mm displacement 3 directions, 6 h	no visible damage
10.5	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
–	–	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
10.6.1	–	Climatic sequence Pre-conditioning	1 h + 85 °C reference measurements after 24 h	
10.6.2	B	Dry heat	16 h + 85 °C	no visible damage
10.6.3	Db	Damp heat (accel.) 1st cycle	12 h + 25 °C, 95 to 100% R.H.	no visible damage; after recovery of 1 - 2 h immediately followed by cold test
10.6.4	A	Cold	2 h –55 °C	no visible damage
10.6.5	M	Low air pressure	1 h at 8,5 kPa last 5 min rated voltage applied	no breakdown or flashover
10.6.6	Db	Damp heat (accel.) remaining cycles	1 day + 55 °C, 95 to 100% R.H.	after recovery of 24 h $\Delta C/C < 10\%$ $\tan \delta < 7\%$ $R_{ins} > 1000\ M\Omega$
		Pre-conditioning		
10.7	Ca	Damp heat (steady state) half number of samples rated voltage, half number of samples no voltage applied	21 days + 40 °C, 90 to 95% R.H.	$\Delta C/C \leqslant 10\%$ $\tan \delta \leqslant 7\%$ R_{ins} after 1 - 2 h $> 1500\ M\Omega$
		Pre-conditioning		
10.9.3	–	Endurance	1000 h + 85 °C, 750 V (d.c.)	$\Delta C/C \leqslant 10\%$ $\tan \delta < 5\%$ $R_{ins} > 1000\ M\Omega$
		Pre-conditioning		
	H	Storage	72 h –65 °C, recovery 1 - 2 h	electrical parameters within specification

MINIATURE CERAMIC PLATE CAPACITORS

class 2, 500 V (d.c.)

QUICK REFERENCE DATA

Capacitance range	100 - 2700 pF (E12 series)
Rated d.c. voltage	500 V
Tolerance on capacitance	± 10%
Basic specification	IEC 384-9 (2C2)
Category (IEC 68)	55/085/21

APPLICATION

Electronic circuits where a non-linear change of capacitance with temperature is permissible and very low losses are not essential, e.g. coupling and decoupling.

Because of their small size the capacitors are ideal for circuitry with a high component density.

DESCRIPTION

The capacitors consist of a thin rectangular ceramic plate, both sides of which are metallized. The tinned connecting leads are secured with a high melting point solder. The leads are provided with a flange that guarantees leads without lacquer, making these capacitors perfectly suited for automatic insertion.

The capacitors are protected by several layers of tan lacquer that ensures a good behaviour under humid conditions and is resistant to all commonly used cleaning solvents.

No silver migration can occur.

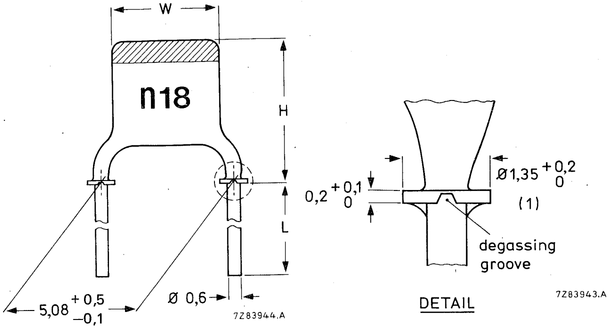
MECHANICAL DATA

Dimensions in mm

Table 1

size	W	H	approx. mass g
I	3,6(−1,5)	6,3(−1,8)	0,15
IIA	3,9(−1,2)	6,7(−1,8)	0,15
IIB	4,5(−1,1)	7,3(−1,8)	0,15
III	5,1(−1,1)	7,9(−1,7)	0,17
IV	6,2(−1,1)	9,0(−1,7)	0,21
V	6,2(−1,1)	11,2(−2,1)	0,23

Tolerance between brackets.



DETAIL

Fig. 1 L ⩾ 13 mm

Except for a few types as indicated in Table 2, the thickness of the capacitor does not exceed 2,3 mm.

(1) The longest axis of the possible ellipse has a minimum length of 1,4 mm.

Marking

The body of the capacitors is tan coloured.
The temperature dependence is indicated by a yellow colour cap. Capacitance value and voltage are indicated on the body by figures according to Table 2 in a contrasting colour.

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. 10 s

The capacitors are mounted on printed-wiring boards (hand mounting or automatic insertion). Due to the flange on the leads solder connections are free from lacquer. The flange is provided with a degassing groove.

ELECTRICAL DATA

The capacitors meet the essential requirements of IEC 384-9. Unless stated otherwise all electrical values apply at an ambient temperature of 20 ± 1 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 63 to 67%.

Capacitance values, measured at 1 kHz ± 10% $\leqslant$ 1 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 a 1 kHz, $\leqslant$ 1 V	$<$ 3,5%
Category temperature range	−55 to + 85 °C
Climatic category	55/085/21
Storage temperature range	−55 to + 85 °C
Capacitance change versus temperature	see Fig. 2
Capacitance change versus frequency	see Fig. 3

In Table 2 the catalogue number must be completed as follows:
XX must be replaced by **09** for bulk packed capacitors.
XX must be replaced by **53** for capacitors on tape on reel.
See also Packing.

Table 2

capacitance pF	size	marking		catalogue number***
100 *	I	n10	500	2222 655 XX101
120 *	I	n12	500	121
150 *	I	n15	500	151
180 **	I	n18	500	181
220 **	I	n22	500	221
270	I	n27	500	271
330	I	n33	500	331
390	IIA	n39	500	391
470	IIA	n47	500	471
560	IIB	n56	500	561
680	IIB	n68	500	681
820	IIB	n82	500	821
1000	III	1n0	500	102
1200	III	1n2	500	122
1500	IV	1n5	500	152
1800	IV	1n8	500	182
2200	IV	2n2	500	222
2700	V	2n7	500	272

* Maximum thickness 2,7 mm. ** Maximum thickness 2,5 mm.

*** See former page at the bottom for complete number.

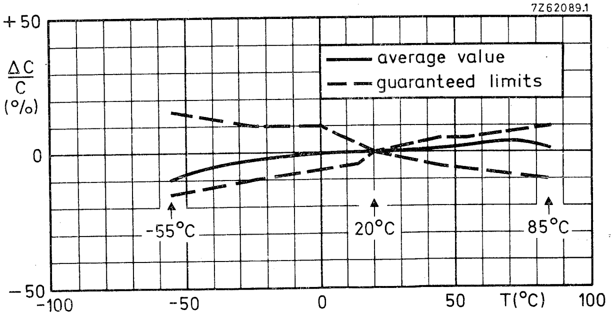


Fig. 2 Capacitance change with respect to the capacitance at 20 °C as a function of temperature.

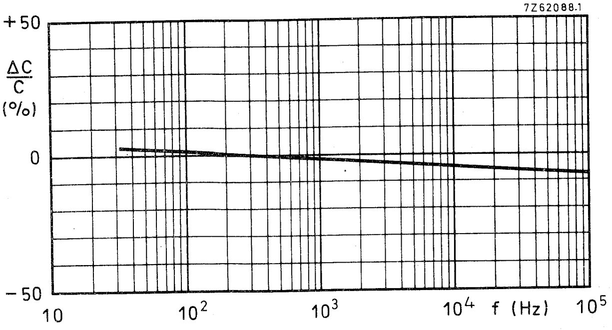


Fig. 3 Typical capacitance change with respect to the capacitance at 300 Hz as a function of frequency.

PACKING

The capacitors 2222 655 53 . . . are supplied on tape on reels, 4000 capacitors per reel (Figs 4, 5, 6). The capacitors 2222 655 09 . . . are supplied in boxes of 1000, except those in size V, which are supplied in boxes of 500.

Capacitors on tape on reels

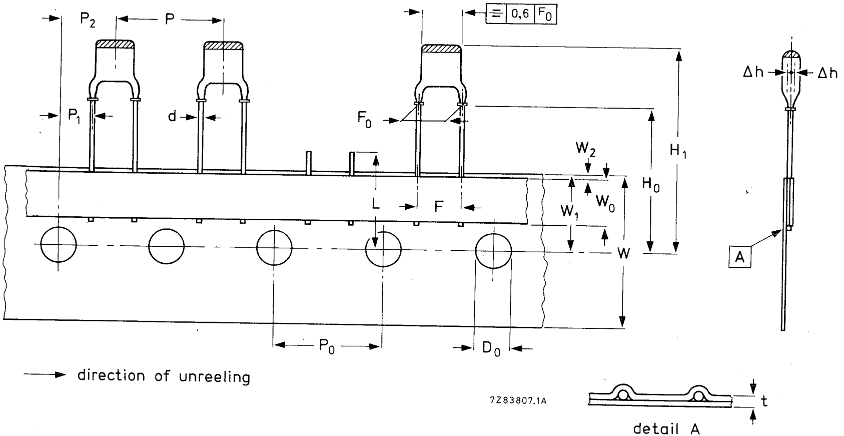


Fig. 4 Capacitors on tape; see Table 3 for dimensions of version 2222 655 53 . . .

Table 3

	symbol	dimensions	
		nominal	tolerance
Lead diameter	d	0,6	+ 0,06/–0,05
Pitch between capacitors	P	12,7	± 1,0
Feed-hole pitch	P_0	12,7	± 0,2*
Feed-hole centre to lead centre	P_1	3,85	± 0,7
Feed-hole centre to component centre	P_2	6,35	± 1,0
Lead-to-lead distance	F	5,0	+ 0,8/–0,2
	F_0	5,08	+ 0,5/–0,1
Component alignment	Δh	0	± 1,0
Tape width	W	18,0	–0,5
Hold-down tape width	W_0	6,0	± 0,5
Hole position	W_1	9,0	± 0,5
Hold-down tape position	W_2	0	+ 2
Flange to tape centre	H_0	18,25	+ 1,5/–0,5
Component height	H_1	30,5	max.
		23	min.
Length of snipped lead	L	11	max.
Feed-hole diameter	D_0	4,0	± 0,2
Total tape thickness	t	0,5	± 0,2

Note: See Table 1 for dimensions of capacitors.
* Cumulative pitch error: ± ⩽ 1 mm/20 pitches.

Extraction force for component in the tape plane, vertically to direction of unreeling	min.	5	N
Break force of tape	min.	15	N
Pull-off force main tape — reel	max.	2,5	N

Maximum 0,5% of the total number of capacitors per reel may be missing. A maximum of 3 consecutive vacant positions is followed by at least 6 consecutive components. The tape begins and ends with 5 empty positions.

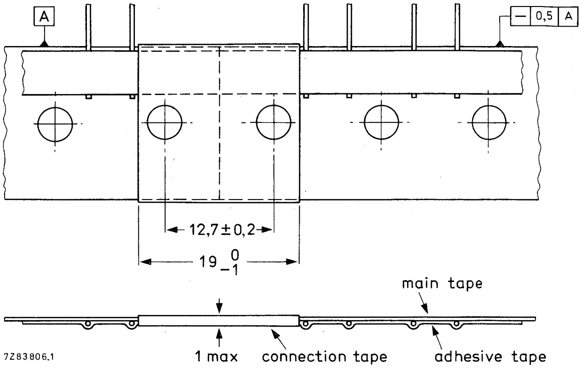


Fig. 5 Connection of tapes.

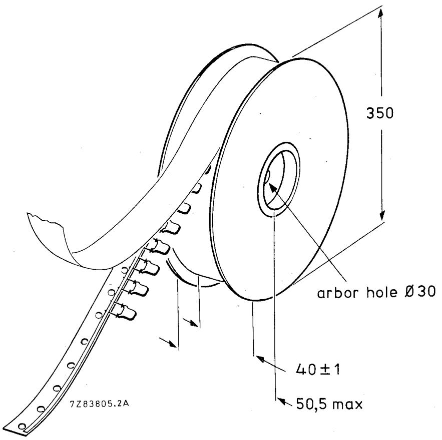


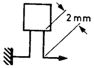
Fig. 6 Reel with capacitors on tape.

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 394-9, 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 4 below.

Table 4

IEC 384-9 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
10.1	Ua	Tensile strength	axial force 10 N	
10.1	Ub	Bending (half number of samples)	load 5 N, 4 x 90°	no wire breakage
10.2.1	Ta method 1	Soldering (solder bath)	solderability: 2 s ar 235 °C	good tinning
		Pre-conditioning	1 h + 85 °C, reference measurements after 24 h	
10.2.2	Tb method 1A	Resistance to soldering heat	270 °C, 10 s	no visible damage, ΔC/C after 24 h between + 20% and −10%
		Pre-conditioning		
10.3	Na	Rapid change of temperature	½ h −55 °C/½ h + 85 °C 5 cycles	no damage ΔC/C after 24 h ± ⩽ 10%
10.4	Fb	Vibration	10-55-10 Hz 0,75 mm displacement 3 directions, 6 h	no visible damage
10.5	Eb	Bump	4000 bumps in 2 directions, 40g; pulse time 6 ms	no visible damage

			bunsen burner with flame-height 40-60 mm	after removal of bunsen burner
–	–	Resistance to solvents	3 min ultrasonic washing in trichloroethylene 1 min drying, 30 ^{o}C 10 brush strokes	marking and colour coding must remain legible and not discoloured; no mechanical or electrical damage or deterioration of the material
10.6.1	–	Climatic sequence Pre-conditioning	1 h + 85 ^{o}C reference measurements after 24 h	
10.6.2	B	Dry heat	16 h + 85 ^{o}C	no visible damage
10.6.3	Db	Damp heat (accel.) 1st cycle	12 h + 25 ^{o}C, 95 to 100% R.H.	no visible damage; after recovery of 1 - 2 h immediately followed by cold test
10.6.4	A	Cold	2 h – 55 ^{o}C	no visible damage
10.6.5	M	Low air pressure	1 h at 8,5 kPa last 5 min rated voltage applied	no breakdown or flashover
10.6.6	Db	Damp heat (accel.) remaining cycles	1 day + 55 ^{o}C, 95 to 100% R.H.	after recovery of 24 h $\Delta C/C < 10\%$ $\tan\delta < 7\%$ $R_{ins} > 1000\ M\Omega$
		Pre-conditioning		
10.7	Ca	Damp heat (steady state) half number of samples rated voltage, half number of samples no voltage applied	21 days + 40 ^{o}C, 90 to 95% R.H.	$\Delta C/C \leqslant 10\%$ $\tan\delta \leqslant 7\%$ R_{ins} after 1 - 2 h $> 1500\ M\Omega$
		Pre-conditioning		
10.9.3	–	Endurance	1000 h + 85 ^{o}C, 750 V (d.c.)	$\Delta C/C \leqslant 10\%$ $\tan\delta < 5\%$ $R_{ins} > 1000\ M\Omega$
		Pre-conditioning		
	H	Storage	72 h –65 ^{o}C, recovery 1 - 2 h	electrical parameters within specification

MINIATURE CERAMIC PLATE CAPACITORS

class 1, temperature compensating types

QUICK REFERENCE DATA

Capacitance range	0,56 to 560 pF (E12 series)
Rated d.c. voltage	100 V
Tolerance on capacitance	± 2% or ± 0,25 pF
Temperature coefficients	P100, NP0, N075, N150, N220 N330, N470, N750, N1500
Basic specification	IEC 384-8, sub-class 1B ←
Climatic category (IEC 68)	55/085/21

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.
Because of their small size and their availability with a pitch of 2,54 mm over the whole range, the capacitors are ideal for circuitry with a high component density.

DESCRIPTION

The capacitors consist of a thin rectangular ceramic plate, both sides of which are metallized and provided with connecting leads. They are insulated by a coating that ensures a good behaviour under humid conditions. The colour of the capacitor body is grey. The capacitors distinguish themselves by small dimensions and narrow tolerances on the lead spacing. They are available with different lead shapes. The leads are provided with a flange, that guarantees leads without lacquer, making them perfectly suited for automatic insertion.

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 (1).

MECHANICAL DATA

Dimensions in mm

The capacitors are available in the following versions.

Table 1

lead spacing	lead length L	lead diameter	Fig.	catalogue number (2)
bulk packed capacitors				
5,08 (0,2 in)	⩾ 13	0,6 (0,024 in)	1	2222 681 . . . . .
5,08 (0,2 in)	4 ± 0,5	0,6 (0,024 in)	1	2222 683 . . . . .
2,54 (0,1 in)	⩾ 13	0,6 (0,024 in)	2	2222 680 . . . . .
2,54 (0,1 in)	4 ± 0,5	0,6 (0,024 in)	2	2222 682 . . . . .
capacitors on tape				
–	–	0,6 (0,024 in)	5 (3)	2222 679 . . . . .

Outlines

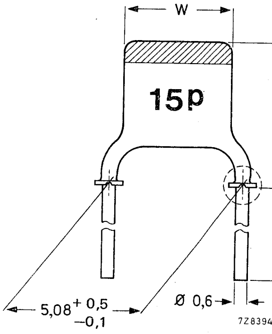


Fig. 1.

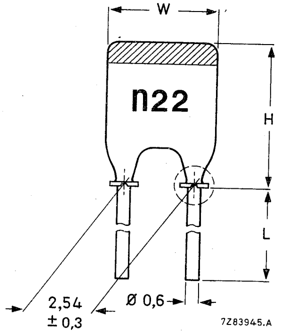
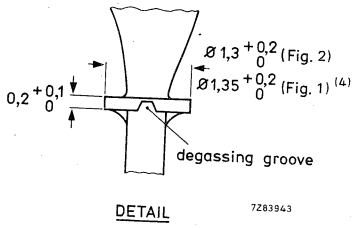


Fig. 2.



DETAIL

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(1) 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.

(2) For suffix see Tables 3 to 11.

(3) Capacitors are according to Fig. 1 except for the lead length. Fig. 5 is found under "Packing".

(4) The longest axis of the possible ellips has a minimum length of 1,4 mm.

Table 2

size	W (mm)	H (mm)		approx. mass g
		Fig. 1	Fig. 2	
I	3,6(−1,5)	6,3(−1,8)	5,0(−1,5)	0,14
IIA	3,9(−1,2)	6,7(−1,8)	5,3(−1,5)	0,15
IIB	4,5(−1,1)	7,3(−1,8)	6,0(−1,5)	0,15
III	5,1(−1,1)	7,9(−1,7)	6,6(−1,4)	0,17
IV	6,2(−1,1)	9,0(−1,7)	7,7(−1,4)	0,20
V	6,2(−1,1)	11,2(−2,1)	9,9(−1,8)	0,20

Tolerance between brackets.

The thickness of the capacitors does not exceed 2,3 mm (0,08 in), except for a few types as is indicated in Tables 3 to 11.

Marking

The temperature coefficient is indicated by a colour code as per IEC and EIA recommendations.
The capacitance value is indicated on the body by figures in a contrasting colour.

Mounting

When bending, cutting or flattening the leads, they should be relieved of the applied load of the capacitor body,

Soldering conditions max. 270 °C, max. 10 s

The capacitors are mounted on printed-wiring boards (hand mounting or automatic insertion). Due to the flange on the leads solder connections are free from lacquer. The flange is provided with a degassing groove.

ELECTRICAL DATA

The capacitors meet the essential requirements of IEC 384-8. Unless stated otherwise all electrical values apply at an ambient temperature of 20 ± 1 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 63 to 67%.

Capacitance values* and tolerances, measured at 1 MHz, $\leqslant$ 5 V	see Tables 3 to 11
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 after 1 min at 100 V (d.c.)	$\geqslant$ 10 000 MΩ
Tan δ* at 1 MHz, $\leqslant$ 5 V	
for C $\leqslant$ 50 pF	$\leqslant 15\ (\frac{15}{C} + 0{,}7) \times 10^{-4}$; max. 55×10^{-4}
for C > 50 pF	$\leqslant 15 \times 10^{-4}$
Category temperature range	−55 to + 85 °C
Storage temperature range	−55 to + 85 °C
Climatic category, IEC 68	55/085/21

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* Including 2 mm per connecting lead.

Capacitors with a temperature coefficient P100, rated voltage 100 V (d.c.)

Capacitance range	0,56 to 47 pF (E12 series)
Temperature coefficient of the capacitance ($\frac{\Delta C}{C.\Delta T}$)	+ 100 x 10^{-6}/K
Tolerance on the temperature coefficient	
for $C < 22$ pF	(–40 to + 120) x 10^{-6}/K
for $C \geqslant 22$ pF	± 40 x 10^{-6}/K
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	IIA	8p2	03828
10	± 2%	IIA	10p	04109
12	± 2%	IIB	12p	04129
15	± 2%	IIB	15p	04159
18	± 2%	III	18p	04189
22	± 2%	III	22p	04229
27	± 2%	IV	27p	04279
33	± 2%	IV	33p	04339
39	± 2%	V	39p	04399
47	± 2%	V	47p	04479

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* Maximum thickness 2,7 mm.
** Maximum thickness 2,5 mm.

Capacitors with a temperature coefficient NP0, rated voltage 100 V (d.c.)

Capacitance range	1,8 to 120 pF (E12 series)
Temperature coefficient of the capacitance $(\frac{\Delta C}{C.\Delta T})$	0×10^{-6}/K
Tolerance on the temperature coefficient	
for $C < 22$ pF	$(-40 \text{ to } + 120) \times 10^{-6}$/K
for $C \geqslant 22$ pF	$\pm 30 \times 10^{-6}$/K
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%	I	22p	10229
27	± 2%	I	27p	10279
33	± 2%	I	33p	10339
39	± 2%	IIA	39p	10399
47	± 2%	IIA	47p	10479
56	± 2%	IIB	56p	10569
68	± 2%	IIB	68p	10689
82	± 2%	IIB	82p	10829
100	± 2%	III	n10	10101
120	± 2%	III	n12	10121

---

* Maximum thickness 2,5 mm.

Capacitors with a temperature coefficient N075, rated voltage 100 V (d.c.)

Capacitance range	3,9 to 120 pF (E12 series)
Temperature coefficient of the capacitance ($\frac{\Delta C}{C.\Delta T}$)	-75×10^{-6}/K
Tolerance on the temperature coefficient	
for $C < 22$ pF	$(-40 \text{ to } +60) \times 10^{-6}$/K
for $C \geqslant 22$ pF	$\pm 30 \times 10^{-6}$/K
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%	IIA	22p	28229
27	± 2%	IIA	27p	28279
33	± 2%	IIB	33p	28339
39	± 2%	IIB	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.

Capacitors with a temperature coefficient N150, rated voltage 100 V (d.c.)

Capacitance range	3,9 to 150 pF (E12 series)
Temperature coefficient of the capacitance ($\frac{\Delta C}{C.\Delta T}$)	-150×10^{-6}/K
Tolerance on the temperature coefficient	
for $C < 22$ pF	$(-40 \text{ to } +60) \times 10^{-6}$/K
for $C \geqslant 22$ pF	$\pm 40 \times 10^{-6}$/K
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%	I	27p	34279
33	± 2%	I	33p	34339
39	± 2%	IIA	39p	34399
47	± 2%	IIA	47p	34479
56	± 2%	IIB	56p	34569
68	± 2%	IIB	68p	34689
82	± 2%	III	82p	34829
100	± 2%	III	n10	34101
120	± 2%	IV	n12	34121
150	± 2%	IV	n15	34151

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* Maximum thickness 2,7 mm.
** Maximum thickness 2,5 mm.

Capacitors with a temperature coefficient N220, rated voltage 100 V (d.c.)

Capacitance range	3,9 to 150 pF (E12 series)
Temperature coefficient of the capacitance $(\frac{\Delta C}{C.\Delta T})$	-220×10^{-6}/K
Tolerance on the temperature coefficient	
for $C < 22$ pF	$(-40 \text{ to } +60) \times 10^{-6}$/K
for $C \geqslant 22$ pF	$\pm 40 \times 10^{-6}$/K
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%	IIA	27p	40279
33	± 2%	IIA	33p	40339
39	± 2%	IIB	39p	40399
47	± 2%	IIB	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 2,7 mm.
** Maximum thickness 2,5 mm.

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 $(\frac{\Delta C}{C.\Delta T})$	-330×10^{-6}/K
Tolerance on the temperature coefficient	$\pm 60 \times 10^{-6}$/K
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%	IIA	33p	46339
39	± 2%	IIA	39p	46399
47	± 2%	IIB	47p	46479
56	± 2%	IIB	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 2,7 mm.
** Maximum thickness 2,5 mm.

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 $(\frac{\Delta C}{C.\Delta T})$	-470×10^{-6}/K
Tolerance on the temperature coefficient	
for C < 22 pF	$(-90$ to $+250) \times 10^{-6}$/K
for C ≥ 22 pF	$\pm 60 \times 10^{-6}$/K
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%	IIA	39p	52399
47	± 2%	IIA	47p	52479
56	± 2%	IIB	56p	52569
68	± 2%	IIB	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.

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 $(\frac{\Delta C}{C.\Delta T})$	-750×10^{-6}/K
Tolerance on the temperature coefficient	
for $C < 22$ pF	$(-120$ to $+250) \times 10^{-6}$/K
for $C \geqslant 22$ pF	$\pm 120 \times 10^{-6}$/K
Marking colour of the temperature coefficient	violet

Table 10

cap. pF	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%	IIA	56p	58569
68	± 2%	IIA	68p	58689
82	± 2%	IIB	82p	58829
100	± 2%	IIB	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.

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 $(\frac{\Delta C}{C.\Delta T})$	-1500×10^{-6}/K
Tolerance on the temperature coefficient	$(0 \text{ to } +500) \times 10^{-6}$/K
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%	IIA	n10	70101
120	± 2%	IIA	n12	70121
150	± 2%	IIB	n15	70151
180	± 2%	IIB	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.

PACKING

Dimensions in mm

The capacitors 2222 679 are supplied on tape on reels with 4000 capacitors per reel (Figs 3, 4, 5). All other versions are supplied in boxes of 1000, except 2222 681 size V, which are supplied in boxes of 500.

Capacitors on tape on reels

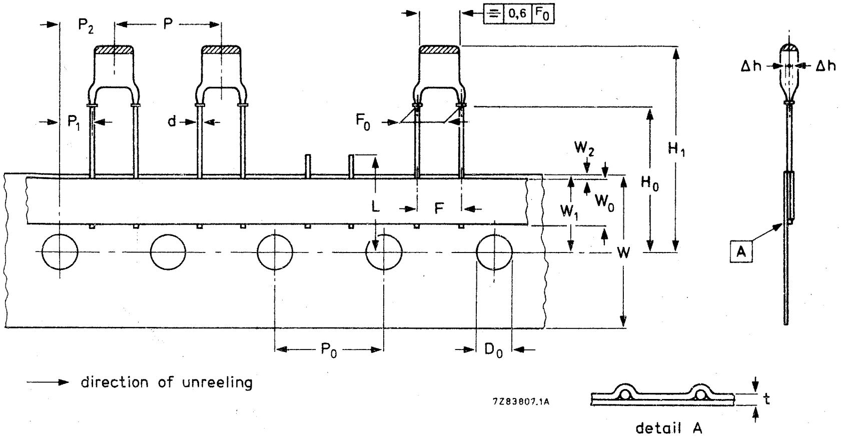


Fig. 3 Capacitors 2222 679 on tape; see Table 12 for dimensions.

Table 12

	symbol	dimensions	
		nominal	tolerance
Lead diameter	d	0,6	+0,06/–0,05
Pitch between capacitors	P	12,7	± 1,0
Feed-hole pitch	P_0	12,7	± 0,2*
Feed-hole centre to lead centre	P_1	3,85	± 0,7
Feed hole centre to component centre	P_2	6,35	± 1,0
Lead-to-lead distance	F	5,0	+ 0,8/–0,2
	F_0	5,08	+ 0,5/–0,1
Component alignment	Δh	0	± 1,0
Tape width	W	18,0	–0,5
Hold-down tape width	W_0	6,0	± 0,5
Hole position	W_1	9,0	± 0,5
Hold-down tape position	W_2	0	+ 2
Flange to tape centre	H_0	18,25	+ 1,5/–0,5
Component height	H_1	30,5 23	max. min.
Length of snipped lead	L	11	max.
Feed-hole diameter	D_0	4,0	± 0,2
Total tape thickness	t	0,5	± 0,2

Note; See Tables 1 and 2 for dimensions of capacitors.

* Cumulative pitch error: ± ≤ 1 mm/20 pitches.

Extraction force for component in the tape plane, vertically to direction of unreeling	min.	5	N
Break force of tape	min.	15	N
Pull-off force main tape – reel	max.	2,5	N

Maximum 0,5% of the total number of capacitors per reel may be missing. A maximum of 3 consecutive vacant positions is followed by at least 6 consecutive components. The tape begins and ends with 5 empty positions.

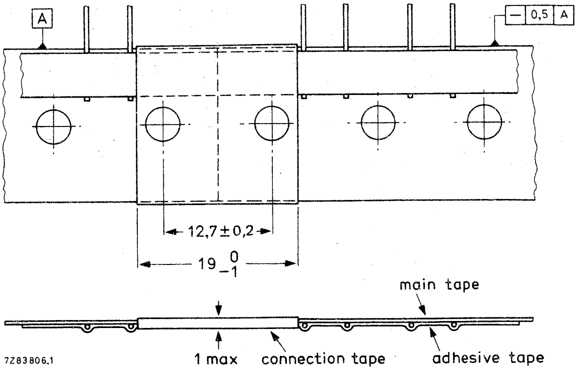


Fig. 4 Connection of tapes.

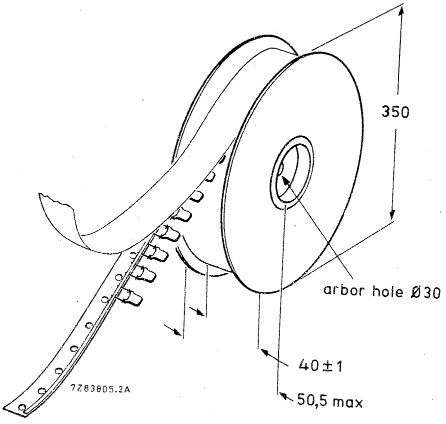
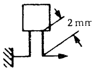


Fig. 5 Reel with capacitors on tape.

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 384-8, 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 below.

IEC 384-8 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
10.1	Ua	Tensile strength	lead dia. 0,6 mm, axial force 10 N lead dia. 0,4 mm, axial force 5 N	
10.1	Ub	Bending	load 5 N, 4 x 90°	no wire breakage
10.2.1	Ta	Soldering (solder bath)	solderability: 2 s 235 °C	good tinning
10.2.2	Tb	Resistance to soldering heat	270 °C, 10 s	no visible damage $\Delta C/C \pm \leqslant 0{,}5\%$ or 0,5 pF after 1 to 2 h
10.3	Na	Rapid change of temperature	3 hours −55 °C/3 hours + 85 °C, 1 cycle	no damage, $\Delta C/C \pm \leqslant 0{,}5\%$ or 0,5 pF
10.4	F	Vibration	10-55-10 Hz 0,75 mm displacement 3 directions, 6 h	no visible damage
10.5	E	Bump	4000 bumps in 2 directions, 40 g; 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
9,5	—	Temperature coefficient	between + 20 and + 85 °C	within tolerance as specified for each particular material

		Climatic sequence		
10.6.2	B	Dry heat	16 h + 85 °C	no visible damage
10.6.3	Db	Damp heat (accel.) 1st cycle	12 h + 55 °C, 12 h + 25 °C, 100% R.H.	after recovery of 1-2 h immediately followed by cold test
10.6.4	A	Cold	2 h –55 °C	no visible damage
10.6.5	M	Low air pressure	1 h 8,5 kPa, last 2 min rated voltage	no breakdown or flashover
10.6.6	Db	Damp heat (accel.)	12 h + 55 °C, 12 h + 25 °C, 100% R.H.	$\Delta C/C \pm \leqslant 1\%$ or 1 pF $\tan \delta < 2 \times$ specified $\tan \delta$ R_{ins} after 1-2 h > 100 MΩ
10.7	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.	$\Delta C/C \pm \leqslant 1\%$ or 1 pF $\tan \delta \leqslant 2 \times$ specified $\tan \delta$ R_{ins} after 1-2 h > 100 MΩ
10.8	–	Endurance	1000 h at + 85 °C, 150 V (d.c.)	$\Delta C/C \pm \leqslant 1\%$ or 1 pF $\tan \delta \leqslant 1{,}5 \times$ specified $\tan \delta$ $R_{ins} > 300$ MΩ
–	–	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.
–	H	Storage	72 h –65 °C, recovery 1 - 2 h	electrical parameters within specification

MULTILAYER CERAMIC CHIP CAPACITORS

QUICK REFERENCE DATA

Capacitance range		
class 1 (NP0, N220, N750 dielectric)	0,47 to 10 000 pF	(E12 series)
X7R dielectric	180 to 470 000 pF	(E12 series)
Z5U (Y5V) dielectric	2200 to 1 000 000 pF	(E6 series)
Rated d.c. voltage	50 V (EIA), 63 V (IEC)	
Tolerance on capacitance		
NP0, N220, N750	± 10%, ± 5%	
X7R	± 20%, ± 10%	
Z5U (Y5V)	–20/+ 80%, ± 20%	
Basic specification	IEC 384-10 (EIA RS198/B)	
Climatic category (IEC 68)		
NP0, N220, N750	55/125/56	
X7R	55/125/56	
Z5U, incl. Y5V	30/085/56	

APPLICATION

These multilayer ceramic capacitors have a very high capacitance per unit volume which, together with size and performance, makes them very suitable for use in hybrid and other microcircuitry. These small components can perform 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. They are Pd Ag metallized at the end terminal (see Fig. 4).

MECHANICAL DATA

Dimensions in mm

Outlines

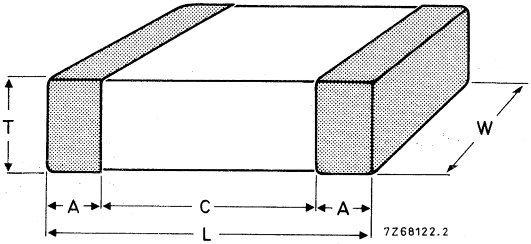


Fig. 1.

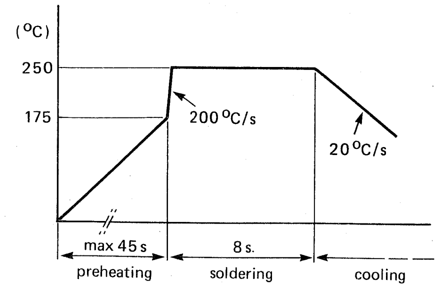
Table 1

size	L	W	T, see also Tables 2, 3, 4		A		C
			min.	max.	min.	max.	min.
0805	2,0 ± 0,15	1,25 ± 0,15	0,51	1,27	0,25	0,75	0,4
1206	3,2 ± 0,15	1,6 ± 0,15	0,51	1,60	0,25	0,75	
1210	3,2 ± 0,2	2,5 ± 0,2	0,51	1,90	0,3	1,0	
1808	4,5 ± 0,2	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. 230 °C, 2 s
max. 250 °C, 60 s

Worst-case solder conditions:



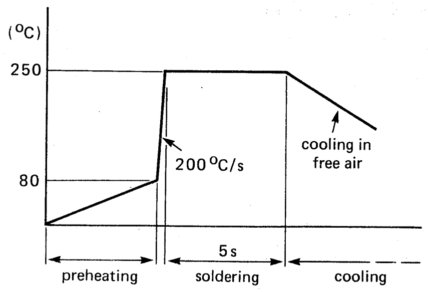


Fig. 2 Reflow soldering.

Fig. 3 Wave soldering.
The capacitors may be soldered twice according to this method if necessary.

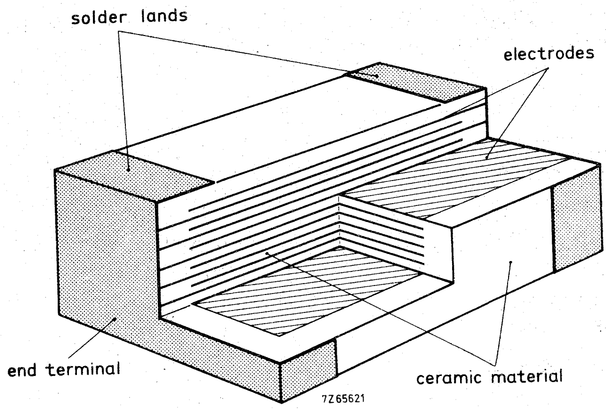

solder lands
electrodes
end terminal
ceramic material
7Z65621

Fig. 4.

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of 20 ± 1 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 63 to 67%.

Class 1

Capacitance range	
$\leqslant$ 1000 pF measured at 1 MHz, 1 V	
$>$ 1000 pF measured at 1 kHz, 1 V	see Table 2 to 6
Tolerance on capacitance	± 10%, ± 5%, ± 0,5 pF, ± 0,25 pF
Rated d.c. voltage (U_R)	50 V (EIA), 63 V (IEC)
D.C. test voltage for 1 min	200 V
Tan δ, measured at 1 V,	
1 MHz, $C \leqslant 30$ pF	$10\,(\frac{10}{C} + 0{,}7) \times 10^{-4}$, max. 27×10^{-4}
1 MHz, 30 pF $< C \leqslant$ 1000 pF	$< 10 \times 10^{-4}$
1 kHz, $C >$ 1000 pF	$< 10 \times 10^{-4}$
Insulation resistance	$>$ 100 000 MΩ
Category temperature range	−55 to + 125 °C

Temperature coefficient	NPO	N220	N750
0,47 – $<$ 5 pF	$(0 \pm 120) \times 10^{-6}$	$(-220 \pm 60) \times 10^{-6}$	
5 – $<$ 10 pF	$(0 \pm 120) \times 10^{-6}$	$(-220 \pm 60) \times 10^{-6}$	$(-750 \pm 120) \times 10^{-6}$
$\geqslant$ 10 pF	$(0 \pm 30) \times 10^{-6}$	$(-220 \pm 60) \times 10^{-6}$	$(-750 \pm 120) \times 10^{-6}$

Table 2: NP0

size	on tape on reel	bulk	cap. values from E12 series (1). pF	thickness T, see Fig. 1 mm	cap. tolerance %	catalogue number
0805	X		0,47 – 330	0,51 – 0,70	5	2222 861 12. . .
	X				10	2222 861 13. . .
	X		390 – 560	0,8 – 1,00	5	2222 861 12. . .
	X				10	2222 861 13. . .
		X	0,47 – 1000	0,51 – 1,27	5	2222 851 12. . .
		X			10	2222 851 13. . .
1206	X		0,47 – 1200	0,51 – 0,70	5	2222 863 12. . .
	X				10	2222 863 13. . .
	X		1500 – 1800	0,80 – 1,00	5	2222 863 12. . .
	X				10	2222 863 13. . .
		X	0,47 – 3300	0,51 – 1,60	5	2222 853 12. . .
		X			10	2222 853 13. . .
1210		X	47 – 4700	0,51 – 1,90	5	2222 852 12. . .
		X			10	2222 852 13. . .
1808		X	100 – 5600	0,51 – 1,90	5	2222 854 12. . .
		X			10	2222 854 13. . .
1812		X	330 – 5600	0,51 – 1,90	5	2222 855 12. . .
		X			10	2222 855 13. . .
2220		X	470 – 10 000	0,51 – 1,90	5	2222 856 12. . .
		X			10	2222 856 13. . .

code for capacitance value:
first two figures of capacitance value according to
E12 series followed by:
9 for 10 to 82 pF
1 for 100 to 820 pF
2 for 1 000 to 8 200 pF
3 for 10 000 pF
e.g.: fill in 272 for 2700 pF.

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(1) According to IEC 63.

Table 3: N220, Size 0805

Catalogue number:		
	bulk packing	2222 590 0 . . . .
	on tape on reel	2222 590 1 . . . .

capacitance value pF	tolerance	suffix of catalogue number	tolerance	suffix of catalogue number
3,9	0,25 pF	2473	–	–
4,7	0,25 pF	2475	–	–
5,6	0,5 pF	2477	–	–
6,8	0,5 pF	2479	–	–
8,2	0,5 pF	2482	–	–
10	5%	2484	10%	2618
12		2486		2621
15		2488		2623
18		2491		2625
22		2493		2627
27	5%	2495	10%	2629
33		2497		2632
39		2499		2634
47		2502		2636
56		2504		2638
68	5%	2506	10%	2641
82		2508		2643
100		2511		2645
120		2513		2647
150		2515		2649
180	5%	2517	10%	2652
220		2519		2654
270		2522		2656

Thickness T = 0,51 – 0,70 mm.

Table 4: N220, Size 1206

Catalogue number: bulk packing 2222 591 0 . . . .
on tape on reel 2222 591 1 . . . .

capacitance value pF	tolerance	suffix of catalogue number	tolerance	suffix of catalogue number
8,2	0,5 pF	2482	–	–
10	5%	2484	10%	2618
12		2486		2621
15		2488		2623
18		2491		2625
22		2493		2627
27	5%	2495	10%	2629
33		2497		2632
39		2499		2634
47		2502		2636
56		2504		2638
68	5%	2506	10%	2641
82		2508		2643
100		2511		2645
120		2513		2647
150		2515		2649
180	5%	2517	10%	2652
220		2519		2654
270		2522		2656
330		2524		2658
390		2526		2661
470	5%	2528	10%	2663
560		2531		2665
680		2533		2667
820		2535		2669

Thickness T = 0,51 – 0,70 mm.

Table 5: N750, Size 0805

Catalogue number: bulk packing 2222 590 0 . . . .
on tape on reel 2222 590 1 . . . .

capacitance value pF	tolerance	suffix of catalogue number	tolerance	suffix of catalogue number
6,8	0,5 pF	4099	–	–
8,2	0,5 pF	4102	–	–
10	5%	4104	10%	4238
12		4106		4241
15		4108		4243
18		4111		4245
22		4113		4247
27	5%	4115	10%	4249
33		4117		4252
39		4119		4254
47		4122		4256
56		4124		4258
68	5%	4126	10%	4261
82		4128		4263
100		4131		4265
120		4133		4267
150		4135		4269
180	5%	4137	10%	4272
220		4139		4274
270		4142		4276
330		4144		4278
390		4146		4281

Thickness T = 0,51 – 0,70 mm.

Table 6: N750, Size 1206

Catalogue number: bulk packing 2222 591 0 . . . .
on tape on reel 2222 591 1 . . . .

capacitance value pF	tolerance	suffix of catalogue number	tolerance	suffix of catalogue number
6,8	0,5 pF	4099	–	–
8,2	0,5 pF	4102	–	–
10	5%	4104	10%	4238
12		4106		4241
15		4108		4243
18		4111		4245
22		4113		4247
27	5%	4115	10%	4249
33		4117		4252
39		4119		4254
47		4122		4256
56		4124		4258
68	5%	4126	10%	4261
82		4128		4263
100		4131		4265
120		4133		4267
150		4135		4269
180	5%	4137	10%	4272
220		4139		4274
270		4142		4276
330		4144		4278
390		4146		4281
470	5%	4148	10%	4283
560		4151		4285
680		4153		4287
820		4155		4289
1000		4157		4292
1200		4159		4294

Thickness T = 0,51 – 0,70 mm.

Class 2, X7R

Capacitance range measured at 1 kHz, 1 V	see Table 7
Tolerance on capacitance	± 20%, ± 10%
Rated d.c. voltage (U_R)	50 V (EIA), 63 V (IEC)
D.C. test voltage for 1 min	200 V
Tan δ, measured at 1 kHz, 0,5 V	$< 3\%$
Insulation resistance	
$C \leqslant 10\,000$ pF	$> 100\,000$ MΩ
$C > 10\,000$ pF	$R_{ins} \times C > 1000$ s
Category temperature range	−55 to + 125 °C
Maximum capacitance variation as a function of temperature	± 15%, see Fig. 5
Ageing	typ. 1% per time decade

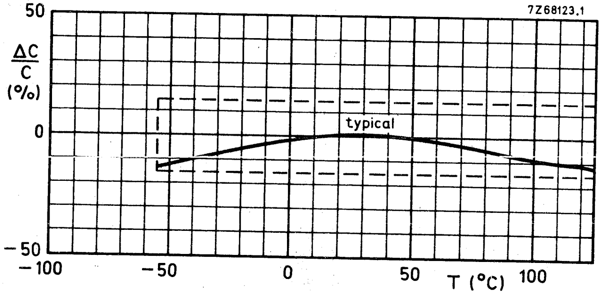

Fig. 5 Typical capacitance variation as a function of temperature. Dotted lines indicate the limits.

Table 7: X7R

size	on tape on reel	bulk	cap. values from E 12 series (1) pF	thickness T, see Fig. 1 mm	cap. tolerance %	catalogue number
0805	X		180 – 5600	0,51 – 0,70	10	2222 861 47. . .
	X				20	2222 861 48. . .
	X		6800 – 10 000	0,80 – 1,00	10	2222 861 47. . .
	X				20	2222 861 48. . .
		X	180 – 22 000	0,51 – 1,27	10	2222 851 47. . .
		X			20	2222 851 48. . .
1206	X		680 – 18 000	0,51 – 0,70	10	2222 863 47. . .
	X				20	2222 863 48. . .
	X		22 000, 27 000	0,80 – 1,00	10	2222 863 47. . .
	X				20	2222 863 48. . .
		X	680 – 56 000	0,51 – 1,60	10	2222 853 47. . .
		X			20	2222 853 48. . .
1210		X	2200 – 100 000	0,51 – 1,90	10	2222 852 47. . .
		X			20	2222 852 48. . .
1808		X	2200 – 150 000	0,51 – 1,90	10	2222 854 47. . .
		X			20	2222 854 48. . .
1812		X	4700 – 270 000	0,51 – 1,90	10	2222 855 47. . .
		X			20	2222 855 48. . .
2220		X	12 000 – 470 000	0,51 – 1,90	10	2222 856 47. . .
		X			20	2222 856 48. . .

code for capacitance value:
first two figures of capacitance value according to E 12 series followed by:

1 for 180 to 820 pF
2 for 1 000 to 8 200 pF
3 for 10 000 to 82 000 pF
4 for 100 000 to 470 000 pF

e.g.: fill in 683 for 68 000 pF.

---

(1) According to IEC 63.

Class 2, Z5U (Y5V)

Capacitance range measured at 1 kHz, 1 V	see Table 8
Tolerance on capacitance	−20/+ 80% and ± 20%
Rated d.c. voltage (U_R)	50 V (EIA), 63 V (IEC)
D.C. test voltage for 1 min	200 V
Tan δ, measured at 1 kHz, 1 V	< 2,5%
Insulation resistance	
C ⩽ 25 000 pF	> 4000 MΩ
C > 25 000 pF	$R_{ins} \times C > 100$ s
Category temperature range	−30 to + 85 °C
Maximum capacitance variation with respect	
to C at 20 °C (IEC)	+ 20/−55%, see Fig. 6
to C at 25 °C (EIA)	+ 22/−56%
Ageing	typ. 5% per time decade

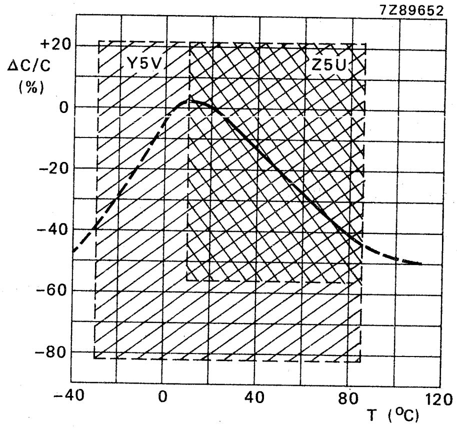

Fig. 6 Typical capacitance variation as a function of temperature.

Table 8: Z5U

size	on tape on reel	bulk	cap. values from E6 series (1) pF	thickness T, see Fig. 1 mm	cap. tolerance %	catalogue number
0805	X		2200 – 10 000	0,51 – 0,70	± 20	2222 861 58. . .
	X				–20/+ 80	2222 861 59. . .
	X		15 000, 22 000	0,80 – 1,00	± 20	2222 861 58. . .
	X				–20/+ 80	2222 861 59. . .
		X	2200 – 33 000	0,51 – 1,27	± 20	2222 851 58. . .
		X			–20/+ 80	2222 851 59. . .
1206	X		10 000 – 33 000	0,51 – 0,70	± 20	2222 863 58. . .
	X				–20/+ 80	2222 863 59. . .
	X		47 000, 68 000	0,80 – 1,00	± 20	2222 863 58. . .
	X				–20/+ 80	2222 863 59. . .
		X	10 000 – 100 000	0,51 – 1,60	± 20	2222 853 58. . .
		X			–20/+ 80	2222 853 59. . .
1210		X	100 000 – 220 000	0,51 – 1,90	± 20	2222 852 58. . .
		X			–20/+ 80	2222 852 59. . .
1808		X	100 000 – 330 000	0,51 – 1,90	± 20	2222 854 58. . .
		X			–20/+ 80	2222 854 59. . .
1812		X	100 000 – 470 000	0,51 – 1,90	± 20	2222 855 58. . .
		X			–20/+ 80	2222 855 59. . .
2220		X	100 000 – 1 000 000	0,51 – 1,90	± 20	2222 856 58. . .
		X			–20/+ 80	2222 856 59. . .

code for capacitance value: first two figures of capacitance value according to E12 series followed by:

2 for 2 200 to 6 800 pF
3 for 10 000 to 68 000 pF
4 for 100 000 to 680 000 pF
5 for 1 000 000 pF

e.g. fill in 683 for 68 000 pF.

---

(1) According to IEC 63.

STANDARD PACKAGING

Cardboard boxes containing 1000 capacitors in plastic bag.
Capacitors size 0805 and 1206 also available on tape on reel, 4000 capacitors per reel (see below).

Configuration of tape

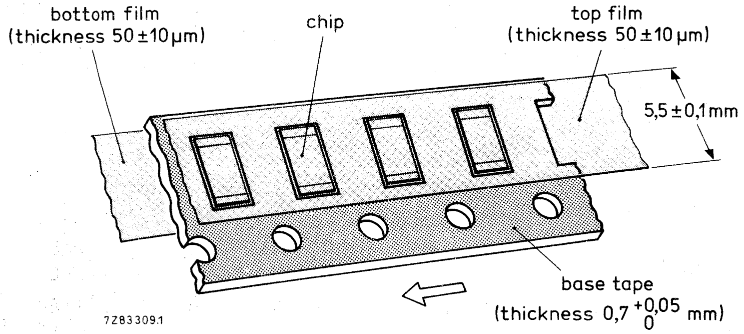

Fig. 7.

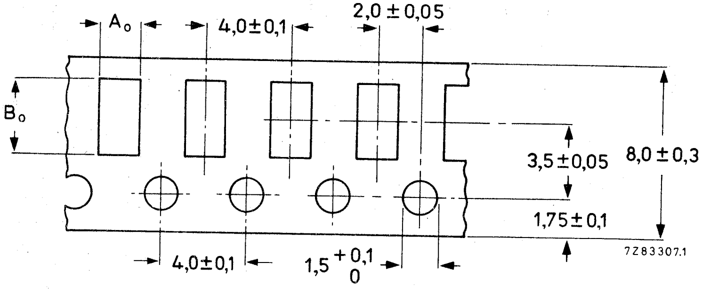

Fig. 8 Dimensions of base tape (mm).

	size	
	0805	1206
A_o	1,5 + 0,2	1,85 + 0,2
B_o	2,25 + 0,2	3,45 + 0,2

Reel dimensions (mm)

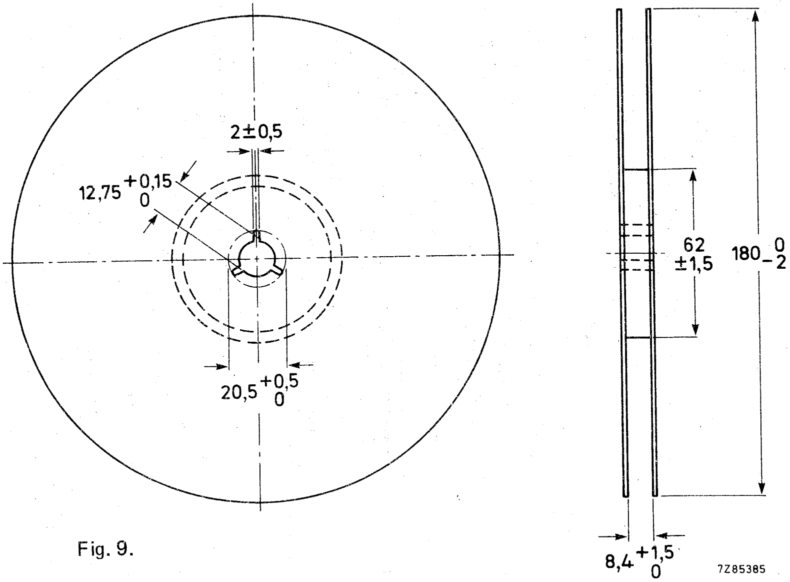

Fig. 9.

At least 10 positions at the beginning and end of the tape are not used. The tape has a 200 mm leader.

TESTS AND REQUIREMENTS—IEC

IEC		test	procedure	requirements
384-10 par.	68-2 par.			
8		Visual inspection and check of dimensions	any applicable method	in accordance with specification
9.1		Capacitance	$C \leqslant 1000$ pF f = 1 MHz $C > 1000$ pF f = 1 kHz measuring voltage 1 V, T = + 20 °C	within specified tolerance, class 2 1000 h after manufacturing date
9.2		Tan δ	see 9.1	in accordance with specification
9.3		Insulation resistance	at 10 V (d.c.), 1 min	in accordance with specification
9.4		Voltage proof	200 V (d.c.), 1 min	no breakdown or flashover
9.5.1		Temperature coefficient, type 1	between min. and max. temperature	in accordance with specification
9.5.2		Temperature characteristic, class 2	X7R and Z5U between min. and max. temperature	in accordance with specification
10.3	Ta	Solderability	unmounted chips completely immersed for 2 ± 0,5 s in a solder bath of 230 ± 10 °C	the terminations of the chip must be well tinned.
	Tb	Resistance to soldering heat	260 ± 5 °C, 10 ± 1 s	the terminations of the chip must be well tinned, after recovery $\Delta C/C$, class 1 : $\pm \leqslant 1\%$ or 1 pF X7R : $\pm \leqslant 10\%$ Z5U : $\pm \leqslant 20\%$
10.1		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.
10.2	Fc	Vibration	severity IV	no visible damage.
7.3.2		Pre-conditioning class 2	X7R and Z5U: 1 h at 150 °C, then 24 h recovery	

10.4	Na	Rapid change temperature	pre-conditioning class 2 $-55/+125\ ^{o}C$, 5 cycles	no visible damage; after 24 h recovery class 1: $\Delta C/C \pm \leqslant 1\%$ or 1 pF X7R : $\Delta C/C \pm \leqslant 10\%$ Z5U : $\Delta C/C \pm \leqslant 20\%$
10.5		Climatic sequence	pre-conditioning class 2	
10.5.3	Ba	Dry heat	16 h + 125 ^{o}C	no visible damage
10.5.4	Db	Damp heat accelerated, 1 cycle	24 h, R.H. 100% at + 55 ^{o}C	
10.5.5	Aa	Cold	2 h at $-55\ ^{o}C$	no visible damage
10.5.6	Db	Damp heat accelerated, remaining cycles	at 55 ^{o}C, R.H. 100% 5 cycles of 24 h	after recovery, class 1 1-2 h, class 2 24 h $\Delta C/C$, class 1: $\pm \leqslant 2\%$ or 2 pF X7R : $\pm \leqslant 10\%$, Z5U: $\pm \leqslant 20\%$ tan δ, class 1: $\leqslant 2$ x specified tan δ X7R : $\leqslant 5\%$ Z5U : $\leqslant 5\%$ R_{ins}, class 1: > 2500 MΩ or $R_iC_R > 25$ s X7R, Z5U : > 1000 MΩ or $R_iC_R > 25$ s
10.6	Ca	Damp heat, steady state	pre-conditioning class 2 56 days, R.H. 90-95% at 40 ^{o}C, no voltage applied	no visible damage. electrical: same as 10.5.6
10.7		Endurance	pre-conditioning class 2 1000 h at 1,5 x rated voltage at maximum temperature	no visible damage, after 24 h recovery $\Delta C/C$, class 1: $\pm \leqslant 2\%$ or 2 pF X7R : $\pm \leqslant 10\%$, Z5U: $\pm \leqslant 20\%$ tan δ, class 1: $\leqslant 1{,}5$ x specified tan δ X7R : $\leqslant 3{,}75\%$, Z5U: $\leqslant 5\%$ R_{ins}, class 1: $> 15.10^3$ MΩ X7R : 5.10^3 MΩ or $R_iC_R > 125$ s Z5U : 2.10^3 MΩ or $R_iC_R > 50$ s

TESTS AND REQUIREMENTS—EIA

EIA RS 198/B		test	procedure	requirements
test	par.			
2.5.5	2.4.6	Temperature characterisitc	X7R: + 25, −55, + 25, + 125 °C Z5U: + 25, + 10, + 25, + 85 °C	X7R: $\Delta C/C \pm \leqslant 15\%$ Z5U: $\Delta C/C + 22\%/-56\%$
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; $\Delta C/C$, class 1: $\pm \leqslant 2\%$ or 0,25 pF X7R : $\pm \leqslant 20\%$, Z5U: $\pm \leqslant 20\%$ tan δ, class 1: $\leqslant 2 \times$ specified tan δ X7R : $\leqslant 5\%$ Z5U : $\leqslant 5\%$ R_{ins}, class 1: $> 10^4$ MΩ X7R : $> 10^4$ MΩ or $R_iC_R > 100$ s Z5U : > 500 MΩ or $R_iC_R > 50$ s
1.6.7	1.5.8	Endurance	250 h at 2 x rated voltage at maximum temperature	same as under seal test.

DATE CODE SYSTEM

FOR CAPACITORS AND RESISTORS ACCORDING TO IEC PUBLICATION 62, CLAUSE 5.

Two-character code (year/month)

Where the marking of the year and month of manufacture is required, the following system is used.

year	letter
1979	L
1980	M
1981	N
1982	P
1983	R
1984	S
1985	T
1986	U
1987	V
1988	W
1989	X

month	character
January	1
February	2
March	3
April	4
May	5
June	6
July	7
August	8
September	9
October	0
November	N
December	D

Examples: November 1979 = LN
March 1980 = M3

Four-character code (year/week)

Where the marking of the year and week of manufacture is required, the code system uses four figures. The first two figures shall be the last two figures of the year, and the last two figures the numbering of the week; the numbering of the week shall be in accordance with ISO Recommendation R2015, Numbering of Weeks.

Example: Fifth week of 1980 = 8005.

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A	METALLIZED POLYESTER FILM CAPACITORS MKT
B	METALLIZED POLYCARBONATE FILM CAPACITORS MKC
C	POLYESTER FILM/FOIL CAPACITORS KT
D	POLYSTYRENE FILM/FOIL CAPACITORS KS
E	POLYPROPYLENE FILM/FOIL CAPACITORS KP, KP/MKP
F	INTERFERENCE SUPPRESSION CAPACITORS MKT-P
G	CERAMIC CAPACITORS

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for resistances and capacitances

according to IEC publication 63

E192	E96	E48	E192	E96	E48	E192	E96	E48	E192	E96	E48	E192	E96	E48
100	100	100	169	169	169	287	287	287	487	487	487	825	825	825
101			172			291			493			835		
102	102		174	174		294	294		499	499		845	845	
104			176			298			505			856		
105	105	105	178	178	178	301	301	301	511	511	511	866	866	866
106			180			305			517			876		
107	107		182	182		309	309		523	523		887	887	
109			184			312			530			898		
110	110	110	187	187	187	316	316	316	536	536	536	909	909	909
111			189			320			542			920		
113	113		191	191		324	324		549	549		931	931	
114			193			328			556			942		
115	115	115	196	196	196	332	332	332	562	562	562	953	953	953
117			198			336			569			965		
118	118		200	200		340	340		576	576		976	976	
120			203			344			583			988		
121	121	121	205	205	205	348	348	348	590	590	590			
123			208			352			597					
124	124		210	210		357	357		604	604				
126			213			361			612					
127	127	127	215	215	215	365	365	365	619	619	619			
129			218			370			626					
130	130		221	221		374	374		634	634				
132			223			379			642					
133	133	133	226	226	226	383	383	383	649	649	649			
135			229			388			657					
137	137		232	232		392	392		665	665				
138			234			397			673					
140	140	140	237	237	237	402	402	402	681	681	681			
142			240			407			690					
143	143		243	243		412	412		698	698				
145			246			417			706					
147	147	147	249	249	249	422	422	422	715	715	715			
149			252			427			723					
150	150		255	255		432	432		732	732				
152			258			437			741					
154	154	154	261	261	261	442	442	442	750	750	750			
156			264			448			759					
158	158		267	267		453	453		768	768				
160			271			459			777					
162	162	162	274	274	274	464	464	464	787	787	787			
164			277			470			796					
165	165		280	280		475	475		806	806				
167			284			481			816					

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			

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