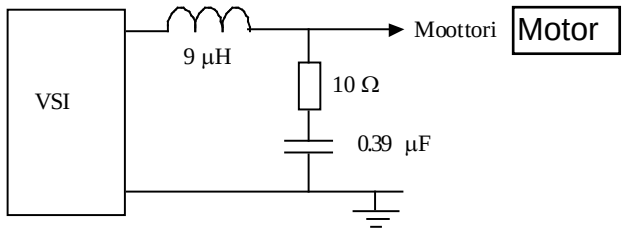
ELEC-E8421 Tehoelektroniikan komponentit

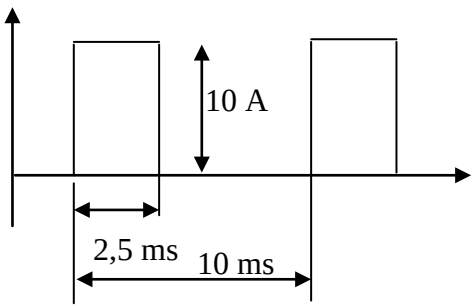
Harjoitus 7.

1. Variable frequency drive output voltage du/dt will be limited to reduce overvoltage due to voltage reflections. Figure shows configuration for a single phase.
In the worst case (earth fault on the other phase) the output voltage is 2 kHz square wave with height of 540 V. Environment ambient is 50 C. Choose a proper snubber resistor using following datasheet when the resistor surface temperature should be less than 300 C at all times, even in during earth fault. Motor current is considered to be constant during voltage transients.

   Tip: Circuit losses are similar to RC-snubber

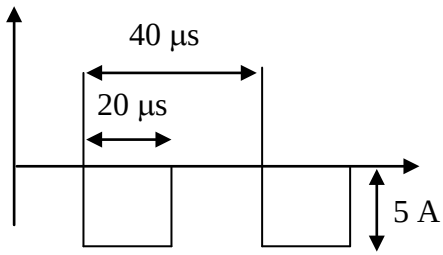


2. Switch mode power supply is fed with single phase full bridge rectifier. Rectified voltage has a nominal value of 300 V. Rectifier output filter is two paraller connected 330 uF / 385 V capacitors. Their ripple current is the sum of the harmonics from two current sources, rectifier input and power supply output (approximative figure below). Calculate whether the capacitors can withstand this ripple current load. The air temperature is 60˚C.



Tasasuuntaaja

Rectifier



Hakkuri

SMPS

Wirewound Vitreous Enamelled Resistors

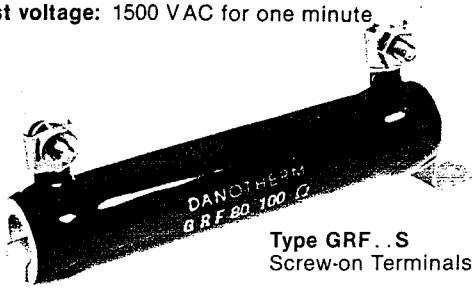
Resistors for use in all situations requiring reliability and stability. All resistors can be used with AC or DC at high voltage.

Materials: Tube: Steatite, non-hygroscopic
Winding: CrNi, CrAlFe or CuNi
Coating: Special non-hygroscopic enamel
Terminals: FeNi

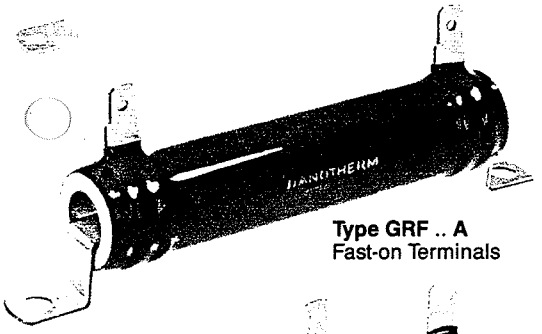
Temperature coefficient: + 20 ppm + 150 ppm
Below 1 R: 400 ppm

Insulation resistance: >10²M at 500 V DC

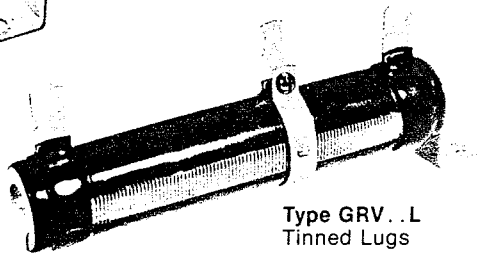
Test voltage: 1500 V AC for one minute



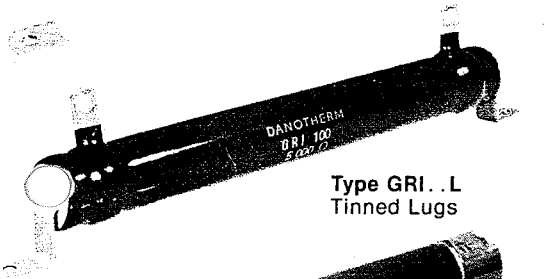
Type GRF . . S
Screw-on Terminals



Type GRF .. A
Fast-on Terminals

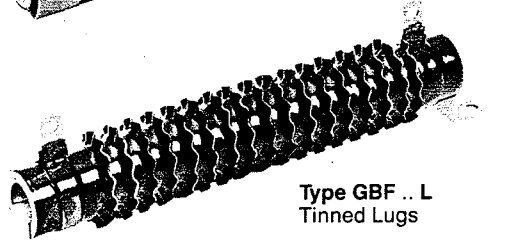


Type GRV . . L
Tinned Lugs

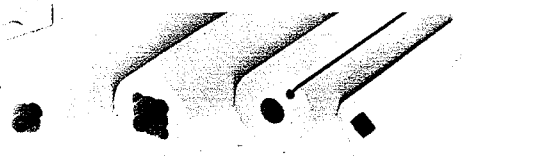


Type GRI . . L
Tinned Lugs

Type GKF
with ferrules



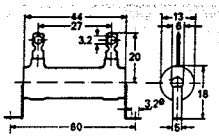
Type GBF .. L
Tinned Lugs



Where special profiles are necessary, some may be available, others can be made in a few weeks.

15 WATT

TYPE
GRF 10/44 GRV 10/44

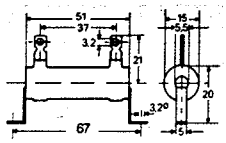


GRF15 S GRV15 S

ohm	max. amp.
2,2	2,60
3,3	2,13
4,7	1,79
6,8	1,49
10	1,22
15	1,00
22	0,83
33	0,67
47	0,56
68	0,47
100	0,39
150	0,32
220	0,26
330	0,21
470	0,18
680	0,15
1000	0,12
1500	0,10
2200	0,083
3300	0,067
4700	0,056

22 WATT

TYPE
GRF 12/51 GRV 12/51

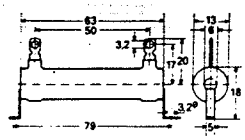


GRF22 S GRV22 S

ohm	max. amp.
4,7	2,17
6,8	1,82
10	1,48
15	1,21
22	1,00
33	0,82
47	0,69
68	0,57
100	0,47
150	0,38
220	0,32
330	0,26
470	0,22
680	0,18
1000	0,15
1500	0,12
2200	0,10
3300	0,082
4700	0,069
6800	0,057
10000	0,047

25 WATT

TYPE
GRF 10/63 GRV 10/63



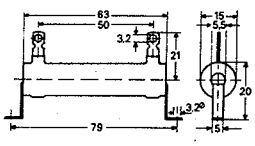
GRF25 S GRV25 S

ohm	max. amp.
3,3	2,75
4,7	2,30
6,8	1,91
10	1,59
15	1,29
22	1,06
33	0,87
47	0,72
68	0,61
100	0,50
150	0,41
220	0,34
330	0,28
470	0,23
680	0,19
1000	0,16
1500	0,13
2200	0,11
3300	0,087
4700	0,072
6800	0,061
10000	0,050

Lists are extended, please see page 6-7.

30 WATT

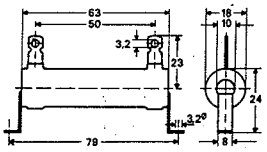
TYPE
GRF 12/63 GRV 12/63



ohm	max. amp.
4,7	2,54
6,8	2,10
10	1,73
15	1,41
22	1,17
33	0,95
47	0,80
68	0,66
100	0,54
150	0,44
220	0,37
330	0,30
470	0,25
680	0,21
1000	0,17
1500	0,14
2200	0,12
3300	0,095
4700	0,080
6800	0,066
10000	0,054

35 WATT

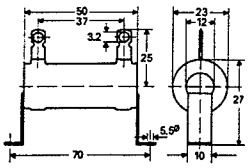
TYPE
GRF 15/63 GRV 15/63



ohm	max. amp.
4,7	2,72
6,8	2,27
10	1,87
15	1,52
22	1,26
33	1,03
47	0,86
68	0,72
100	0,59
150	0,48
220	0,40
330	0,32
470	0,27
680	0,23
1000	0,19
1500	0,15
2200	0,13
3300	0,10
4700	0,086
6800	0,072
10000	0,059
15000	0,048

40 WATT

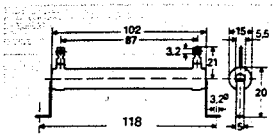
TYPE
GRF 20/50 GRV 20/50



ohm	max. amp.
4,7	2,91
6,8	2,42
10	2,00
15	1,61
22	1,34
33	1,10
47	0,92
68	0,77
100	0,63
150	0,52
220	0,43
330	0,35
470	0,29
680	0,24
1000	0,20
1500	0,16
2200	0,13
3300	0,11
4700	0,092
6800	0,077
10000	0,063

50 WATT

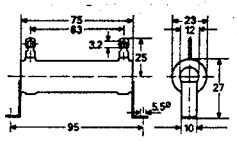
TYPE
GRF 12/102 GRV 12/102



ohm	max. amp.
6,8	2,71
10	2,23
15	1,82
22	1,51
33	1,23
47	1,03
68	0,86
100	0,71
150	0,57
220	0,47
330	0,39
470	0,32
680	0,27
1000	0,22
1500	0,18
2200	0,15
3300	0,12
4700	0,10
6800	0,086
10000	0,071
15000	0,057
22000	0,048

55 WATT

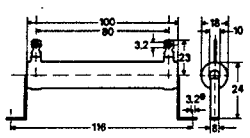
TYPE
GRF 20/75 GRV 20/75



ohm	max. amp.
6,8	2,84
10	2,34
15	1,91
22	1,58
33	1,29
47	1,08
68	0,90
100	0,74
150	0,61
220	0,50
330	0,41
470	0,34
680	0,28
1000	0,23
1500	0,19
2200	0,16
3300	0,13
4700	0,11
6800	0,090
10000	0,074
15000	0,061
22000	0,050

60 WATT

TYPE
GRF 15/100 GRV 15/100

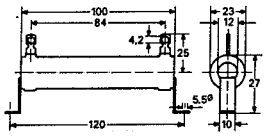


ohm	max. amp.
6,8	2,97
10	2,45
15	2,00
22	1,65
33	1,35
47	1,13
68	0,94
100	0,78
150	0,64
220	0,52
330	0,43
470	0,36
680	0,29
1000	0,24
1500	0,20
2200	0,16
3300	0,13
4700	0,11
6800	0,094
10000	0,078
15000	0,064
22000	0,052

Lists are extended, please see page 6-7.

80 WATT

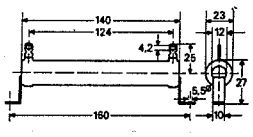
TYPE
GRF 20/100 GRV 20/100



ohm	max. amp.
6,8	3,42
10	2,83
15	2,30
22	1,91
33	1,55
47	1,30
68	1,08
100	0,89
150	0,73
220	0,61
330	0,49
470	0,41
680	0,34
1000	0,28
1500	0,23
2200	0,19
3300	0,15
4700	0,13
6800	0,11
10000	0,089
15000	0,073
22000	0,061
33000	0,050

100 WATT

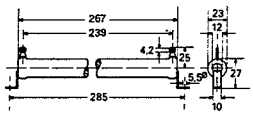
TYPE
GRF 20/140 GRV 20/140



ohm	max. amp.
10	3,16
15	2,57
22	2,13
33	1,74
47	1,46
68	1,21
100	1,00
150	0,82
220	0,67
330	0,55
470	0,46
680	0,38
1000	0,32
1500	0,26
2200	0,21
3300	0,17
4700	0,15
6800	0,12
10000	0,10
15000	0,082
22000	0,067
33000	0,055
47000	0,046

200 WATT

TYPE
GRF 20/267 GRV 20/267



ohm	max. amp.
15	3,65
22	3,00
33	2,46
47	2,06
68	1,71
100	1,41
150	1,15
220	0,95
330	0,78
470	0,65
680	0,54
1000	0,45
1500	0,37
2200	0,30
3300	0,25
4700	0,21
6800	0,17
10000	0,14
15000	0,115
22000	0,095
33000	0,078
47000	0,065
68000	0,054

GRF

Wirewound, vitreous enamelled, fixed resistors with end bands.
For alternating and direct current.
Standard Tolerance ± 10%, but can be ± 5% if requested. Can be supplied with fixing feet as shown on the illustrations. Intermediate bands can be included when required.

GRV

Wirewound, vitreous enamelled, variable resistors with adjustable band.
Standard Tolerance ± 10%, but can be ± 5% if requested. It is recommended that the adjustable band is removed when the current is cut off.

GRI

Wirewound, vitreous enamelled, fixed resistors having end bands and with low inductance coefficient.
Type GRI is supplied with a crossed winding (two coils superimposed in opposite directions).
Watts dissipation for the GRI types should be reduced by 50%.

GBF GBV

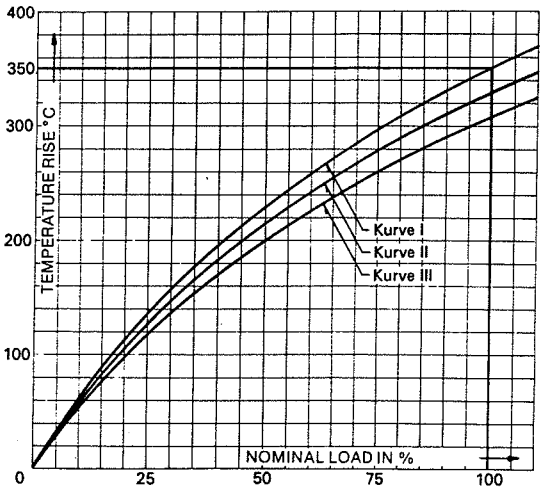
Type GBF is especially suited for high load at low ohmic values.
The resistors can be loaded 30% higher than the corresponding GRF types, as they are wound with corrugated resistance tape on edge.
In this way the resistance material provides cooling fins and the active surface area is increased. Material alloys are equivalent to GRF type resistors. Normal ohmic tolerance is ± 10% and max. diameters are 3-10 mm greater than GRF types.
Resistors can be supplied Type GBF - Fixed Value, or Type GBV - Variable.

All types can be delivered with tinned lugs (L), screw-on terminals (S) or A-MP tabs (A).

More types and extended range of ohmic values please see page 6-7.

Temperature Curves

Temperature increase is dependent on the watts dissipation. Resistors are measured at 25°C ambient temperature and when mounted vertically. If the resistors are in an enclosing housing without air circulation, the watts dissipation should be reduced by 50% (Typical).

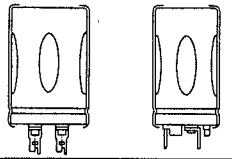


Curve I: 30, 50, 80, 200 W
Curve II: 22, 25, 35, 40, 55, 60, 100 W
Curve III: 15 W

The curves are equally applicable to Types GRV. and GRF

ALUMINIUM ELECTROLYTIC CAPACITORS

- Large type with solder tags or printed-wiring pins
- Long life
- Industrial applications



QUICK REFERENCE DATA

Nominal capacitance range (E6 series)	47 to 68 000 μF
Tolerance on nominal capacitance	−10 to + 30%
Rated voltage, U_R	10 to 385 V
Category temperature range	−40 to + 85 °C
Endurance test at 85 °C, at U_R	2000 h
Shelf life at 0 V, 85 °C	500 h
Basic specification	IEC 384-4, long-life grade; DIN 41240
Dimensional specification	DIN 41238
Climatic category, IEC 68 DIN 40040	40/085/56 GPF (56 days)
Approval	CECC 30 301-033

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

C_{nom}	U_R (V)							
μF	10	16	25	40	63	100	250	385
47								1
68								2
100							1	3
150							2	4
220							3	5/6
330							4	7
470						1	5/6	8
680						2	7	
1 000					1	3	8	
1 500				1	2	4		
2 200			1	2	3	5/6		
3 300		1	2	3	4	7		
4 700	1	2	3	4	5/6	8		
6 800	2	3	4	5/6	7	9		
10 000	3	4	5/6	7	8			
15 000	4	5/6	7	8	9			
22 000	5/6	7	8	9				
33 000	7	8	9					
47 000	8	9						
68 000	9							

case size	nominal dimensions (mm)	
	versions with solder tags	versions with printed-wiring pins
1	ϕ 25 x 35	ϕ 25 x 35
2	ϕ 25 x 45	ϕ 25 x 45
3	ϕ 30 x 45	ϕ 30 x 45
4	ϕ 35 x 45	ϕ 35 x 45
5	ϕ 35 x 55	ϕ 35 x 55
6		ϕ 40 x 45
7	ϕ 40 x 55	ϕ 40 x 55
8	ϕ 40 x 75	ϕ 40 x 75
9	ϕ 40 x 105	ϕ 40 x 105

APPLICATION

These capacitors have low ESR and ESL values and a high resistance to shock and vibration which render them suitable for application such as:

- switched-mode power supplies;
- power supplies in digital equipment;
- energy storage in pulse systems;
- filters in measuring and control apparatus.

DESCRIPTION

The resistance to shock and vibration is achieved by a special internal construction.
The capacitors are completely cold welded and charge/discharge proof. The aluminium case is fully insulated. The solder tag versions have a safety vent in the discs, the printed-wiring versions have a safety vent in the case bottom.

MECHANICAL DATA

Dimensions in mm

Capacitors with solder tags

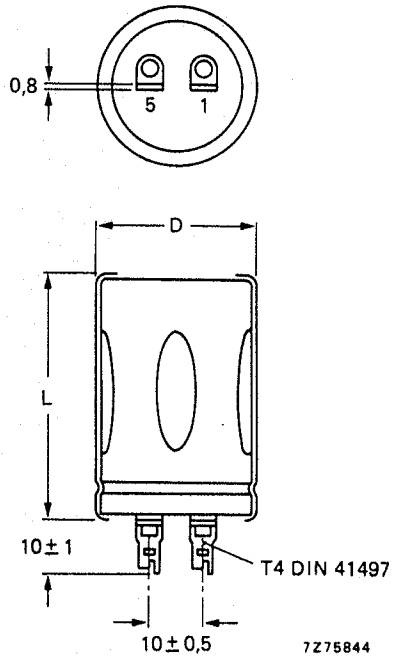


Fig. 1.

1 = positive terminal;
5 = negative terminal.

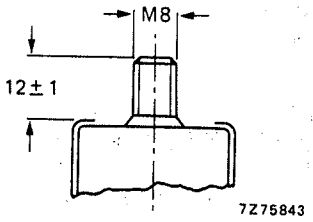


Fig. 2 Bolt version.

Table 1a

case size	D		L		mass approx. g
1	25	+ 0,6	35	+ 1,3	25
2	25		45		30
3	30		45		40
4	35		45		55
5	35		55		65
7	40		55		85
8	40		75		115
9	40		105		160

Capacitors with printed-wiring pins

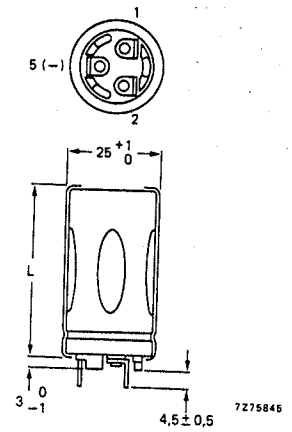


Fig. 3a.

1 = positive terminal;
5 = negative terminal.

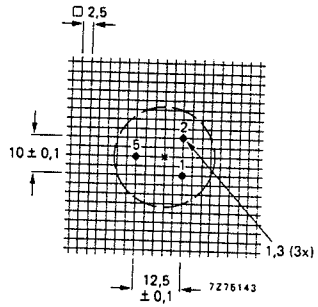


Fig. 3b Piercing diagram viewed from component side.

Table 1b

case size	L		mass approx. g
1	35	+ 1,3	25
2	45		30

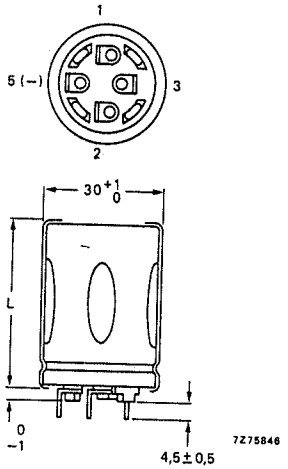


Fig. 4a.

1 = positive terminal;
5 = negative terminal.

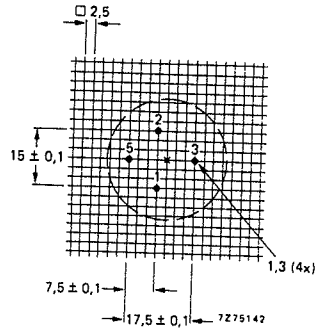


Fig. 4b Piercing diagram viewed from component side.

Table 1c

case size	L		mass approx. g
3	45	+ 1,3	40

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of 20 °C, a frequency of 100 Hz, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75%.

Table 2 (note is at the end of the table)

U_R V	nom. cap. µF	max. r.m.s. ripple current (A) at 100 Hz, 85 °C	20 kHz, 70 °C	max. d.c. leakage current at U_R after 1 min (mA)	typ. tan δ	max. ESR mΩ	max. impedance at 10 kHz mΩ	case size	catalogue number* 2222 followed by
10	4 700	2,4	4,6	0,28	0,19	74	50	1	050 . 4472
	6 800	3,2	6,1	0,41	0,18	51	37	2	. 4682
	10 000	3,8	7,2	0,60	0,24	39	29	3	. 4103
	15 000	4,1	7,8	0,90	0,33	35	26	4	. 4153
	22 000	5,0	9,5	1,32	0,37	27	21	5	. 4223
	22 000	4,2	8,0	1,32	0,48	36	27	6	. 4223
	33 000	5,0	9,5	1,98	0,58	29	22	7	. 4333
	47 000	6,8	12,9	2,82	0,58	20	17	8	. 4473
	68 000	9,2	17,5	4,08	0,62	15	14	9	. 4683
16	3 300	2,4	4,6	0,32	0,13	75	50	1	. 5332
	4 700	3,1	5,9	0,45	0,14	52	37	2	. 5472
	6 800	3,7	7,0	0,65	0,17	40	30	3	. 5682
	10 000	4,1	7,8	0,96	0,22	36	27	4	. 5103
	15 000	5,0	9,5	1,44	0,25	28	21	5	. 5153
	15 000	4,2	8,0	1,44	0,33	36	27	6	. 5153
	22 000	5,0	9,5	2,12	0,38	29	22	7	. 5223
	33 000	6,7	12,7	3,17	0,41	20	17	8	. 5333
	47 000	9,1	17,3	4,51	0,42	15	14	9	. 5473
25	2 200	2,3	4,4	0,33	0,10	78	52	1	. 6222
	3 300	3,1	5,9	0,49	0,11	53	38	2	. 6332
	4 700	3,7	7,0	0,70	0,12	42	31	3	. 6472
	6 800	4,1	7,8	1,02	0,15	37	28	4	. 6682
	10 000	5,0	9,5	1,50	0,17	28	21	5	. 6103
	10 000	4,2	8,0	1,50	0,22	36	27	6	. 6103
	15 000	5,0	9,5	2,25	0,26	29	22	7	. 6153
	22 000	6,8	12,9	3,30	0,27	20	17	8	. 6223
	33 000	9,2	17,5	4,95	0,30	15	14	9	. 6333
40	1 500	2,0	3,8	0,36	0,085	112	68	1	. 7152
	2 200	2,7	5,1	0,53	0,087	76	51	2	. 7222
	3 300	3,3	6,3	0,79	0,10	57	41	3	. 7332
	4 700	3,8	7,2	1,13	0,12	48	35	4	. 7472
	6 800	4,7	8,9	1,64	0,13	36	27	5	. 7682
	6 800	4,1	7,8	1,64	0,17	45	33	6	. 7682
	10 000	4,9	9,3	2,40	0,19	35	27	7	. 7103
	15 000	6,6	12,5	3,60	0,21	25	20	8	. 7153
	22 000	9,0	17,1	5,28	0,22	18	16	9	. 7223

Table 2 (continued)

U_R V	nom cap. µF	max. r.m.s. ripple current (A) at 100 Hz, 85 °C	20 kHz, 70 °C	max. d.c. leakage current at U_R after 1 min (mA)	typ. tan δ	max. ESR mΩ	max. impedance at 10 kHz mΩ	case size	catalogue number* 2222 followed by
63	1 000	1,8	3,4	0,38	0,064	122	74	1	050 . 8102
	1 500	2,5	4,7	0,57	0,065	83	54	2	. 8152
	2 200	3,1	5,9	0,83	0,076	57	41	3	. 8222
	3 300	3,6	6,8	1,25	0,094	48	35	4	. 8332
	4 700	4,4	8,3	1,78	0,10	36	27	5	. 8472
	4 700	3,8	7,2	1,78	0,13	45	33	6	. 8472
	6 800	4,7	8,9	2,57	0,14	35	27	7	. 8682
	10 000	6,2	11,8	3,78	0,15	25	20	8	. 8103
	15 000	8,5	16,1	5,67	0,16	18	16	9	. 8153
100	470	1,2	2,3	0,28	0,086	429	300	1	. 9471
	680	1,7	3,2	0,41	0,087	297	210	2	. 9681
	1 000	2,2	4,2	0,60	0,092	208	150	3	. 9102
	1 500	2,6	4,9	0,90	0,10	152	120	4	. 9152
	2 200	3,2	6,1	1,32	0,11	109	90	5	. 9222
	2 200	3,0	5,7	1,32	0,12	124	110	6	. 9222
	3 300	3,6	6,8	1,98	0,14	91	75	7	. 9332
	4 700	5,0	9,5	2,82	0,13	63	55	8	. 9472
	6 800	6,9	13,1	4,08	0,14	44	40	9	. 9682
250	100	0,6	1,15	0,15	0,085	1800	1300	1	052 . 3101
	150	0,8	1,5	0,23	0,08	1100	850	2	. 3151
	220	1,0	1,9	0,33	0,08	750	550	3	. 3221
	330	1,4	2,65	0,49	0,08	500	400	4	. 3331
	470	1,8	3,4	0,70	0,08	360	290	5	. 3471
	470	1,8	3,4	0,70	0,095	420	350	6	. 3471
	680	2,3	4,4	1,02	0,08	250	190	7	. 3681
	1 000	3,0	5,7	1,50	0,08	170	140	8	. 3102
385	47	0,4	0,75	0,11	0,065	2800	2200	1	. 8479
	68	0,6	1,15	0,16	0,055	1700	1350	2	. 8689
	100	0,8	1,5	0,23	0,055	1100	850	3	. 8101
	150	1,0	1,9	0,34	0,055	725	525	4	. 8151
	220	1,3	2,45	0,50	0,055	500	350	5	. 8221
	220	1,3	2,45	0,50	0,065	600	420	6	. 8221
	330	1,7	3,2	0,75	0,055	340	230	7	. 8331
	470	2,8	5,3	1,06	0,055	240	160	8	. 8471

* To complete the catalogue number, replace dot (8th digit) by:
1 = solder tag version;
4 = printed-wiring version, case size 6 only;
5 = printed-wiring version, except case size 6;
6 = solder tag, bolt version.

Capacitance

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

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

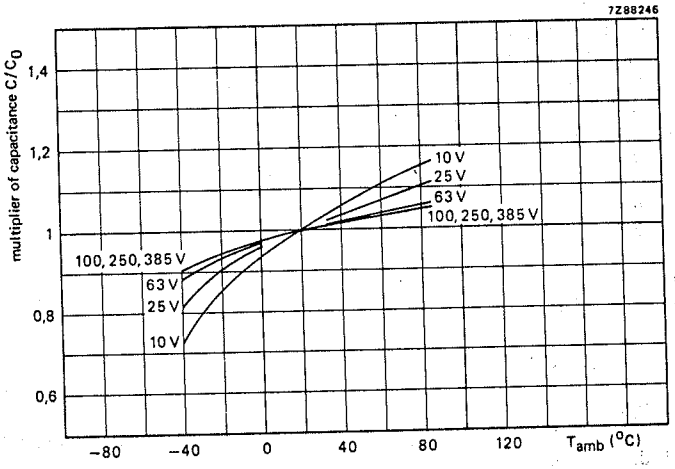


Fig. 7 Multiplier of capacitance as a function of ambient temperature; C_0 = capacitance at 25 °C, 100 Hz.

Voltage

	core temperature ▲ < 60 °C	core temperature ▲ 60 to 95 °C
Rated voltage = max. permissible voltage	1,1 x U_R	U_R
Ripple voltage* = max. permissible a.c. voltage providing the following conditions are met: (a) max. positive voltage on anode (d.c. + peak a.c.) (b) max. positive voltage on cathode (reverse voltage)	⩽ 1,1 x U_R	⩽ U_R
	2 V	
Surge voltage = max. permissible voltage at the maximum category temperature for short periods		
10 to 100 V versions	1,25 x U_R	1,15 x U_R
250 V version	1,15 x U_R	1,15 x U_R
385 V version	1,1 x U_R	1,1 x U_R
Reverse voltage = max. d.c. voltage applied in the reverse polarity at the maximum category temperature for short periods	2 V	

▲ See Introduction, section 5, "Ripple current".

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

Ripple current*

Maximum permissible r.m.s. ripple current

at 100 Hz and T_{amb} = 85 °C	see Table 2
at 20 kHz and T_{amb} = 70 °C	see Table 2
at 100 Hz and other temperatures	see Table 3
at other frequencies and T_{amb} = 85 °C	see Table 4

Table 3

ambient temperature °C	multiplier of max. ripple current
85	1,00
80	1,22
75	1,41
70	1,58
65	1,73
60	1,87
55	2,00
50	2,12
45	2,24
⩽ 40	2,35

Table 4

frequency Hz	multiplier of max. ripple current, $\sqrt{r}$
50	0,83
100	1,00
200	1,10
400	1,15
1000	1,19
⩾ 2000	1,20

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

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

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

I_n = ripple current at a certain frequency

$\sqrt{r_n}$ = multiplying factor at same frequency (Table 4).

Charge and discharge current

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

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