Aluminum Capacitors
Power Economic Printed Wiring

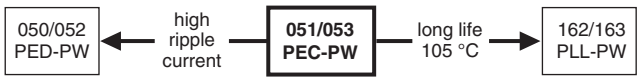


Fig. 1

FEATURES

- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Large types with reduced dimensions, cylindrical aluminum case, insulated with a blue sleeve
- Provided with keyed polarity
- Long useful life: 12 000 h at 85 °C
- High ripple current capability
- High resistance to shock and vibration
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

Pb-free
RoHS COMPLIANT

APPLICATIONS

- General purpose, industrial, medical and audio/video systems
- Standard and switched mode power supplies
- Energy storage in pulse systems

MARKING

The capacitors are marked (where possible) with the following information:

- Rated capacitance (in µF)
- Tolerance on rated capacitance, code letter in accordance with IEC 60062 (M for ± 20 %)
- Rated voltage (in V)
- Date code (YYMM)
- Name of manufacturer
- Code for factory of origin
- Polarity of the terminals and "-" sign to indicate the negative terminal, visible from the top and/or side of the capacitor
- Code number
- Climatic category in accordance with IEC 60068

QUICK REFERENCE DATA

DESCRIPTION	VALUE	
	051	053
Nominal case size (Ø D x L in mm)	25 x 30 to 40 x 100	
Rated capacitance range (E6 series), C_R	680 µF to 150 000 µF	68 µF to 2200 µF
Tolerance on C_R	± 20 %	
Rated voltage range, U_R	10 V to 100 V	200 V to 400 V
Category temperature range	-40 °C to +85 °C	
Endurance test at 85 °C	5000 h	
Useful life at 85 °C	12 000 h	
Useful life at 40 °C, 1.4 x I_R applied	200 000 h	
Shelf life at 0 V, 85 °C	500 h	
Based on sectional specification	IEC 60384-4/EN130300	
Climatic category IEC 60068	40/085/56	

SELECTION CHART FOR C_R, U_R, AND RELEVANT NOMINAL CASE SIZES (Ø D x L in mm)

C_R (µF)	U_R (V)								
	10	16	25	40	63	100	200	385	400
68	-	-	-	-	-	-	-	25 x 30	25 x 30
100	-	-	-	-	-	-	-	25 x 40	25 x 40
150	-	-	-	-	-	-	25 x 30	30 x 40	30 x 40
220	-	-	-	-	-	-	25 x 40	35 x 40	35 x 40
330	-	-	-	-	-	-	30 x 40	35 x 50	35 x 50
	-	-	-	-	-	-	-	40 x 40	40 x 40
470	-	-	-	-	-	-	35 x 40	40 x 50	40 x 50
680	-	-	-	-	-	25 x 30	35 x 50	40 x 70	40 x 70
	-	-	-	-	-	-	40 x 40	-	-
1000	-	-	-	-	-	25 x 40	40 x 50	40 x 100	40 x 100
1500	-	-	-	-	-	30 x 40	40 x 70	-	-
2200	-	-	-	-	25 x 30	35 x 40	40 x 100	-	-
3300	-	-	-	25 x 30	25 x 40	35 x 50	-	-	-
	-	-	-	-	-	40 x 40	-	-	-
4700	-	-	25 x 30	25 x 40	30 x 40	40 x 50	-	-	-

SELECTION CHART FOR C_R, U_R, AND RELEVANT NOMINAL CASE SIZES (Ø D x L in mm)									
C_R (µF)	U_R (V)								
	10	16	25	40	63	100	200	385	400
6800	-	25 x 30	25 x 40	30 x 40	35 x 40	40 x 70	-	-	-
10 000	25 x 30	25 x 40	30 x 40	35 x 40	35 x 50	40 x 100	-	-	-
	-	-	-	-	40 x 40	-	-	-	-
15 000	25 x 40	30 x 40	35 x 40	35 x 50	40 x 70	-	-	-	-
	-	-	-	40 x 40	-	-	-	-	-
22 000	30 x 40	35 x 40	35 x 50	40 x 50	40 x 100	-	-	-	-
	-	-	40 x 40	-	-	-	-	-	-
33 000	35 x 40	35 x 50	40 x 50	40 x 70	-	-	-	-	-
	-	40 x 40	-	-	-	-	-	-	-
47 000	35 x 50	40 x 50	40 x 70	40 x 100	-	-	-	-	-
	40 x 40	-	-	-	-	-	-	-	-
68 000	40 x 50	40 x 70	40 x 100	-	-	-	-	-	-
100 000	40 x 70	40 x 100	-	-	-	-	-	-	-
150 000	40 x 100	-	-	-	-	-	-	-	-

DIMENSIONS in millimeters AND AVAILABLE FORMS

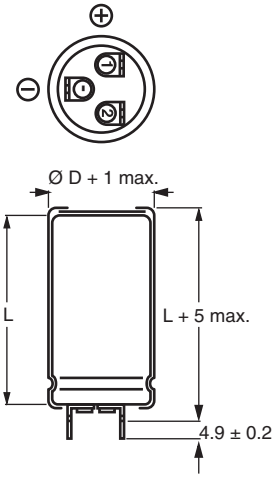


Fig. 1 - Printed wiring pin version
(case Ø D = 25 mm)

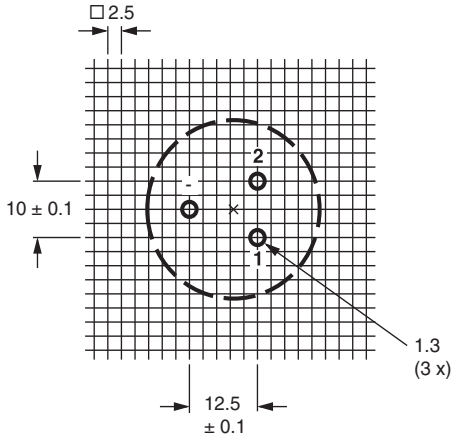


Fig. 2 - Mounting hole diagram viewed from component side
(case Ø D = 25 mm)

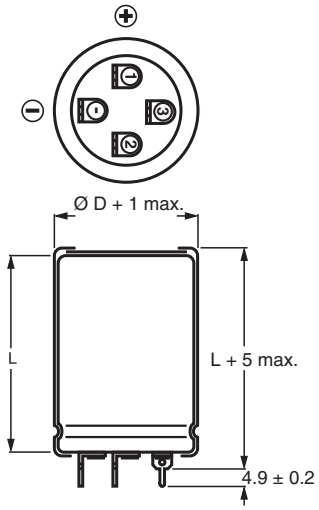


Fig. 3 - Printed wiring pin version
(case Ø D = 30 mm)

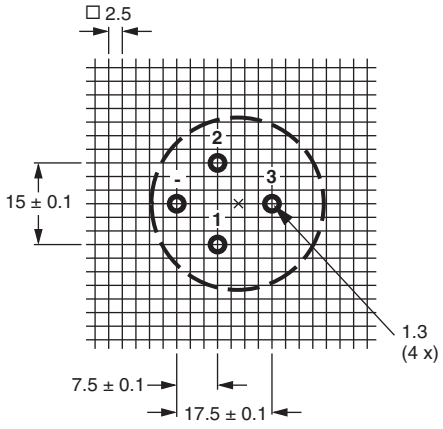


Fig. 4 - Mounting hole diagram viewed from component side
(case Ø D = 30 mm)

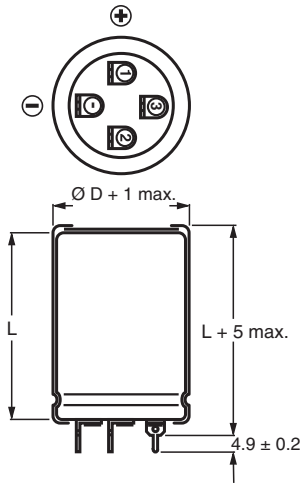


Fig. 5 - Printed wiring pin version
(case Ø D = 35 mm)

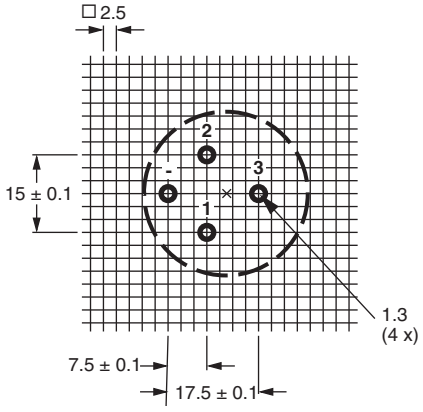


Fig. 6 - Mounting hole diagram viewed from component side
(case Ø D = 35 mm)

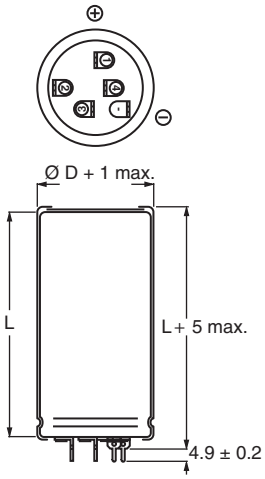


Fig. 7 - Printed wiring pin version
(case Ø D = 40 mm)

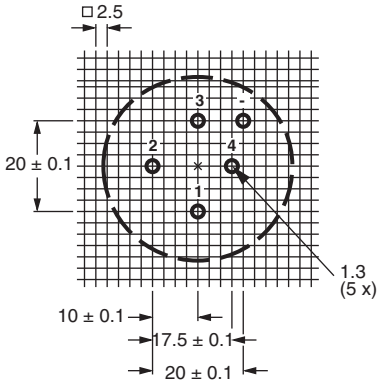


Fig. 8 - Mounting hole diagram viewed from component side
(case Ø D = 40 mm)

MOUNTING

When a number of capacitors are connected in a bank, they must not be closer together than 15 mm, when no derating of ripple current and/or temperature is applied.

Pin number 1 is the positive terminal. Pin "-" is the negative terminal.
Pin numbers 2, 3 and 4 (if present) should be free from the electrical circuit or connected to the minus terminal.

Table 1

DIMENSIONS in millimeters, **MASS, AND PACKAGING QUANTITIES**					
NOMINAL CASE SIZE Ø D x L	**Ø $D_{max.}$**	**$L_{max.}$**	**MASS (g)**	**PACKAGING QUANTITIES (units per box)**	**CARDBOARD BOX DIMENSIONS L x W x H**
25 x 30	26	35	≈ 24	100	290 x 280 x 50
25 x 40	26	45	≈ 28	100	290 x 280 x 60
30 x 40	31	45	≈ 38	100	340 x 330 x 60
35 x 40	36	45	≈ 51	50	390 x 198 x 60
35 x 50	36	55	≈ 66	50	390 x 198 x 70
40 x 40	41	45	≈ 78	50	440 x 223 x 60
40 x 50	41	55	≈ 82	50	440 x 223 x 70
40 x 70	41	75	≈ 110	25	230 x 230 x 90
40 x 100	41	105	≈ 176	25	230 x 230 x 120

ELECTRICAL DATA	
SYMBOL	DESCRIPTION
C_R	Rated capacitance at 100 Hz
I_R	Rated RMS ripple current at 100 Hz, 85 °C or at 20 kHz, 70 °C
I_{L1}	Max. leakage current after 1 min at U_R
I_{L5}	Max. leakage current after 5 min at U_R
ESR	Max. equivalent series resistance at 100 Hz
Z	Max. impedance at 10 kHz

Note

- Unless otherwise specified, all electrical values in tables 2 and 3 apply at T_{amb} = 20 °C, P = 86 kPa to 106 kPa, RH = 45 % to 75 %

ORDERING EXAMPLE

Electrolytic capacitor 051 series
10 000 µF/25 V; ± 20 %

Nominal case size: Ø 30 mm x 40 mm

Ordering code: MAL2 051 56103 E3
Former 12NC: 2222 051 56103

Table 2

ELECTRICAL DATA AND ORDERING INFORMATION 051 SERIES

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE Ø D x L (mm)	I_R 100 Hz 85 °C (A)	I_R 20 kHz 70 °C (A)	I_{L1} 1 min (mA)	I_{L5} 5 min (mA)	ESR 100 Hz (mΩ)	Z 10 kHz (mΩ)	ORDERING CODE MAL2051.....
10	10 000	25 x 30	3.1	5.9	0.60	0.20	51	40	54103E3
	15 000	25 x 40	4.1	7.8	0.90	0.30	37	30	54153E3
	22 000	30 x 40	5.0	9.5	1.32	0.44	30	25	54223E3
	33 000	35 x 40	5.5	10.4	1.98	0.66	28	24	54333E3
	47 000	35 x 50	6.8	12.9	2.82	0.94	23	20	54473E3
	47 000	40 x 40	5.8	10.4	2.82	0.94	29	22	44473E3
	68 000	40 x 50	7.1	13.5	4.08	1.36	24	20	54683E3
	100 000	40 x 70	9.2	17.4	6.00	2.00	19	16	54104E3
	150 000	40 x 100	12.0	22.7	9.00	3.00	16	14	54154E3
16	6800	25 x 30	3.1	5.9	0.65	0.22	53	42	55682E3
	10 000	25 x 40	4.0	7.6	0.96	0.32	39	34	55103E3
	15 000	30 x 40	5.0	9.5	1.44	0.48	31	27	55153E3
	22 000	35 x 40	5.5	10.4	2.12	0.71	29	26	55223E3
	33 000	35 x 50	6.7	12.7	3.17	1.06	23	21	55333E3
	33 000	40 x 40	5.7	10.8	3.17	1.06	30	24	45333E3
	47 000	40 x 50	7.0	13.3	4.52	1.51	24	20	55473E3
	68 000	40 x 70	9.2	17.4	6.53	2.18	19	16	55683E3
	100 000	40 x 100	12.0	22.7	9.60	3.20	16	14	55104E3
25	4700	25 x 30	2.9	5.5	0.71	0.24	60	42	56472E3
	6800	25 x 40	3.9	7.4	1.02	0.34	42	34	56682E3
	10 000	30 x 40	4.8	9.1	1.50	0.50	34	27	56103E3
	15 000	35 x 40	5.3	10.0	2.25	0.75	30	26	56153E3
	22 000	35 x 50	6.5	12.3	3.30	1.10	24	21	56223E3
	22 000	40 x 40	5.7	10.8	3.30	1.10	31	24	46223E3
	33 000	40 x 50	7.0	13.3	4.95	1.65	25	20	56333E3
	47 000	40 x 70	9.2	17.4	7.05	2.35	19	16	56473E3
	68 000	40 x 100	12.0	22.7	10.20	3.40	16	14	56683E3
40	3300	25 x 30	2.9	5.5	0.80	0.27	87	63	57332E3
	4700	25 x 40	3.8	7.2	1.13	0.38	62	47	57472E3
	6800	30 x 40	4.7	8.9	1.64	0.55	49	38	57682E3
	10 000	35 x 40	5.2	9.8	2.40	0.80	48	37	57103E3
	15 000	35 x 50	6.3	11.9	3.60	1.20	37	28	57153E3
	15 000	40 x 40	5.6	10.6	3.60	1.20	50	35	47153E3
	22 000	40 x 50	5.8	11.0	5.28	1.76	39	28	57223E3
	33 000	40 x 70	7.8	14.8	7.92	2.64	28	21	57333E3
	47 000	40 x 100	10.4	19.7	11.28	3.76	22	17	57473E3

ELECTRICAL DATA AND ORDERING INFORMATION 051 SERIES									
U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE Ø D x L (mm)	I_R 100 Hz 85 °C (A)	I_R 20 kHz 70 °C (A)	I_{L1} 1 min (mA)	I_{L5} 5 min (mA)	ESR 100 Hz (mΩ)	Z 10 kHz (mΩ)	ORDERING CODE MAL2051.....
63	2200	25 x 30	2.5	4.7	0.84	0.28	83	62	58222E3
	3300	25 x 40	3.3	6.2	1.25	0.42	58	42	58332E3
	4700	30 x 40	4.1	7.8	1.78	0.60	49	38	58472E3
	6800	35 x 40	4.5	8.5	2.57	0.86	48	37	58682E3
	10 000	35 x 50	5.4	10.2	3.78	1.26	37	28	58103E3
	10 000	40 x 40	4.6	8.7	3.78	1.26	52	37	48103E3
	15 000	40 x 70	7.5	14.2	5.67	1.89	29	24	58153E3
	22 000	40 x 100	10.0	19.0	8.32	2.77	22	19	58223E3
100	680	25 x 30	1.74	3.30	0.41	0.14	190	130	59681E3
	1000	25 x 40	2.34	4.44	0.60	0.20	130	90	59102E3
	1500	30 x 40	2.95	5.59	0.90	0.30	95	67	59152E3
	2200	35 x 40	3.69	7.00	1.32	0.44	71	53	59222E3
	3300	35 x 50	4.37	8.29	1.98	0.66	55	41	59332E3
	3300	40 x 40	4.16	7.89	1.98	0.66	64	48	49332E3
	4700	40 x 50	5.21	9.88	2.82	0.94	49	38	59472E3
	6800	40 x 70	6.97	13.22	4.08	1.36	35	28	59682E3
	10 000	40 x 100	9.50	18.00	6.00	2.00	26	21	59103E3

Table 3

ELECTRICAL DATA AND ORDERING INFORMATION 053 SERIES									
U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE Ø D x L (mm)	I_R 100 Hz 85 °C (A)	I_R 20 kHz 70 °C (A)	I_{L1} 1 min (mA)	I_{L5} 5 min (mA)	ESR 100 Hz (mΩ)	Z 10 kHz (mΩ)	ORDERING CODE MAL2053.....
200	150	25 x 30	0.70	1.33	0.18	0.06	1000	770	52151E3
	220	25 x 40	0.94	1.78	0.26	0.09	680	525	52221E3
	330	30 x 40	1.27	2.41	0.40	0.14	460	360	52331E3
	470	35 x 40	1.66	3.15	0.57	0.19	320	250	52471E3
	680	35 x 50	2.19	4.15	0.82	0.28	220	170	52681E3
	680	40 x 40	2.17	4.11	0.82	0.28	220	170	42681E3
	1000	40 x 50	2.86	5.42	1.20	0.40	150	115	52102E3
	1500	40 x 70	3.81	7.22	1.80	0.60	110	85	52152E3
	2200	40 x 100	5.20	9.86	2.64	0.88	80	60	52222E3
385	68	25 x 30	0.47	0.89	0.16	0.06	2200	1480	58689E3
	100	25 x 40	0.64	1.21	0.23	0.08	1500	1020	58101E3
	150	30 x 40	0.90	1.71	0.35	0.12	1000	700	58151E3
	220	35 x 40	1.15	2.18	0.51	0.17	680	480	58221E3
	330	35 x 50	1.53	2.90	0.77	0.26	450	340	58331E3
	330	40 x 40	1.52	2.88	0.77	0.26	450	340	48331E3
	470	40 x 50	1.96	3.72	1.09	0.36	320	260	58471E3
	680	40 x 70	2.70	5.12	1.58	0.53	220	190	58681E3
	1000	40 x 100	3.70	7.02	2.31	0.78	180	140	58102E3
400	68	25 x 30	0.54	1.02	0.16	0.06	2100	1000	56689E3
	100	25 x 40	0.73	1.38	0.24	0.08	1400	780	56101E3
	150	30 x 40	0.98	1.86	0.36	0.12	950	520	56151E3
	220	35 x 40	1.28	2.43	0.52	0.17	650	400	56221E3
	330	35 x 50	1.67	3.17	0.79	0.26	480	280	56331E3
	330	40 x 40	1.67	3.17	0.79	0.26	480	280	46331E3
	470	40 x 50	2.12	4.02	1.12	0.37	340	220	56471E3
	680	40 x 70	2.90	5.50	1.63	0.54	235	155	56681E3
	1000	40 x 100	4.05	7.68	2.40	0.80	160	110	56102E3

ADDITIONAL ELECTRICAL DATA		
PARAMETER	**CONDITIONS**	**VALUE**
Voltage		
Surge voltage	≤ 250 V versions	$U_s = 1.15 \times U_R$
	≥ 385 V versions	$U_s = 1.1 \times U_R$
Reverse voltage		$U_{rev} \leq 1$ V
Current		
Leakage current	After 1 min at U_R	$I_{L1} \leq 0.006\ C_R \times U_R + 4\ \mu A$
	After 5 min at U_R	$I_{L5} \leq 0.002\ C_R \times U_R + 4\ \mu A$
Inductance		
Equivalent series inductance (ESL)	Case Ø D = 25 mm	Max. 25 nH
	Case Ø D = 30 mm and 35 mm	Max. 30 nH
	Case Ø D = 40 mm	Max. 35 nH

CAPACITANCE (C)

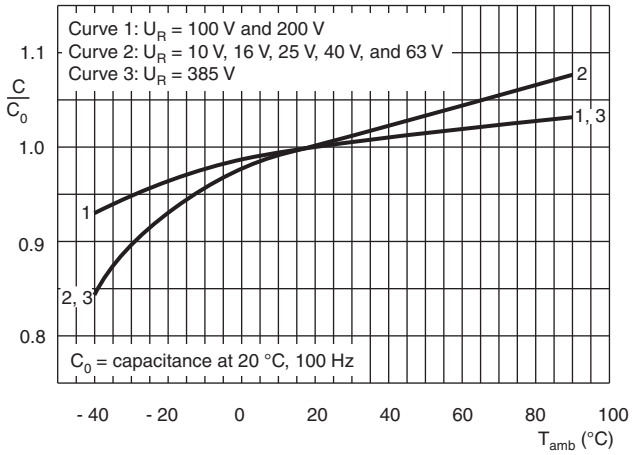


Fig. 9 - Typical multiplier of capacitance as a function of ambient temperature

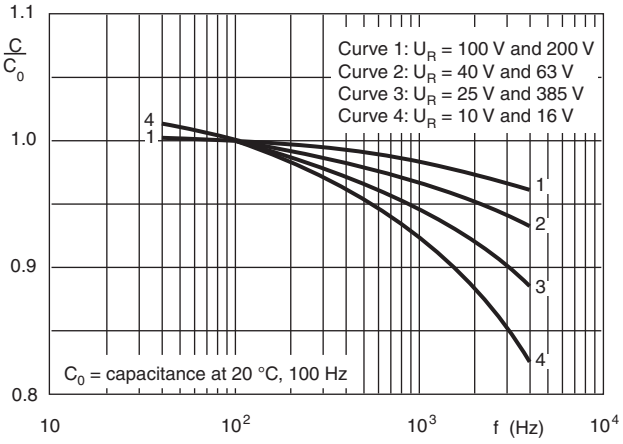


Fig. 10 - Typical multiplier of capacitance as a function of frequency

EQUIVALENT SERIES RESISTANCE (ESR)

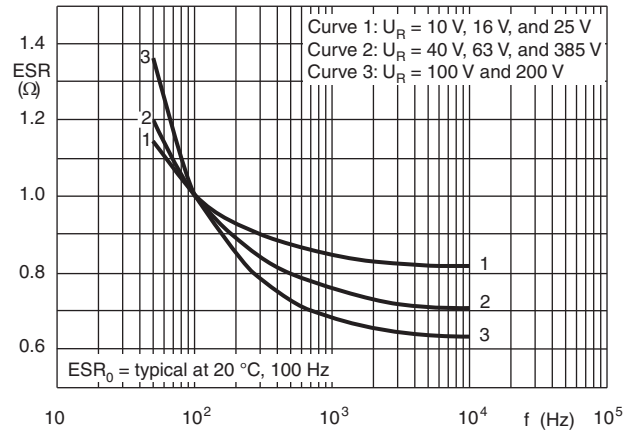


Fig. 11 - Typical multiplier of typical ESR as a function of frequency

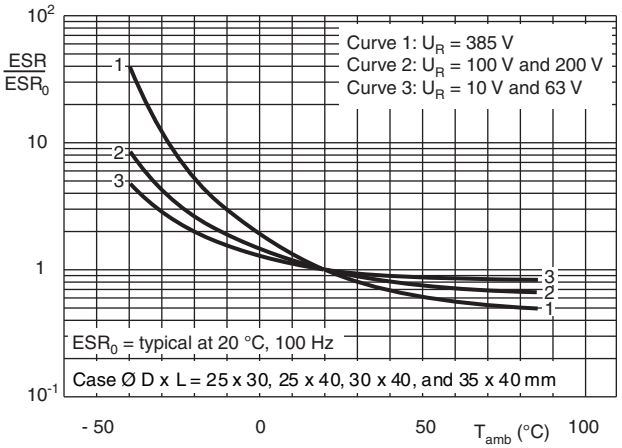


Fig. 12 - Typical multiplier of ESR as a function of ambient temperature

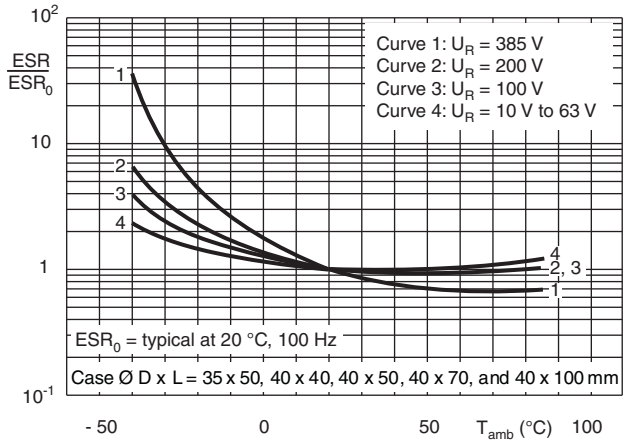


Fig. 13 - Typical multiplier of ESR as a function of ambient temperature

IMPEDANCE (Z)

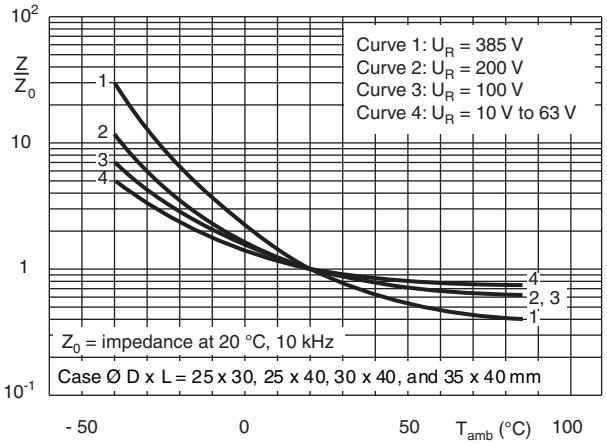


Fig. 14 - Typical multiplier of impedance as a function of ambient temperature

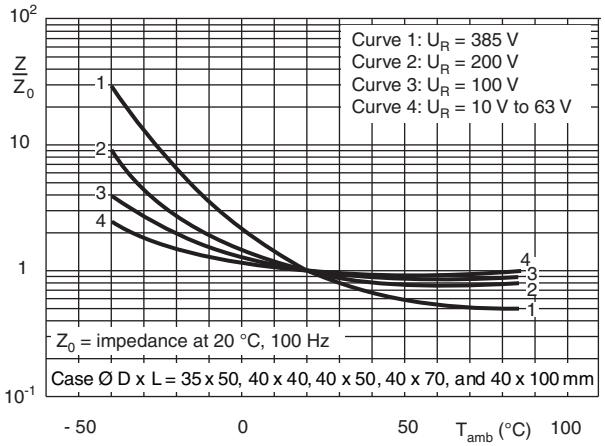


Fig. 15 - Typical multiplier of impedance as a function of ambient temperature

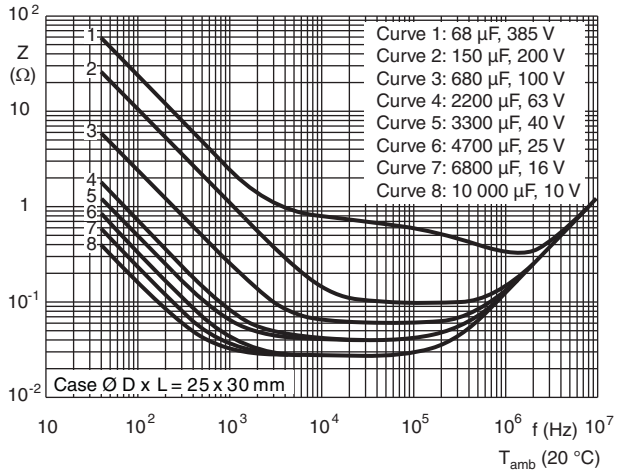


Fig. 16 - Typical impedance as a function of frequency

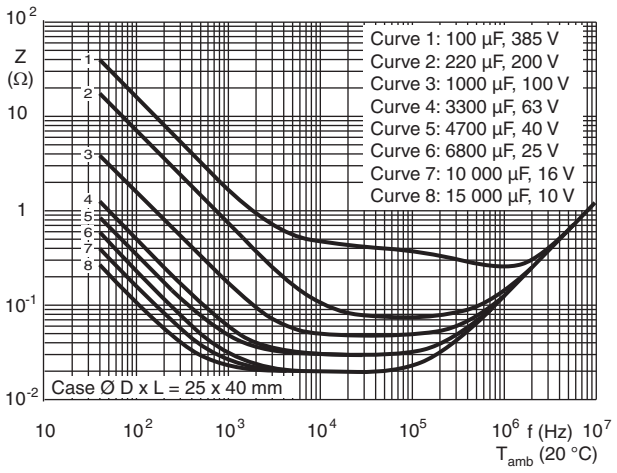


Fig. 17 - Typical impedance as a function of frequency

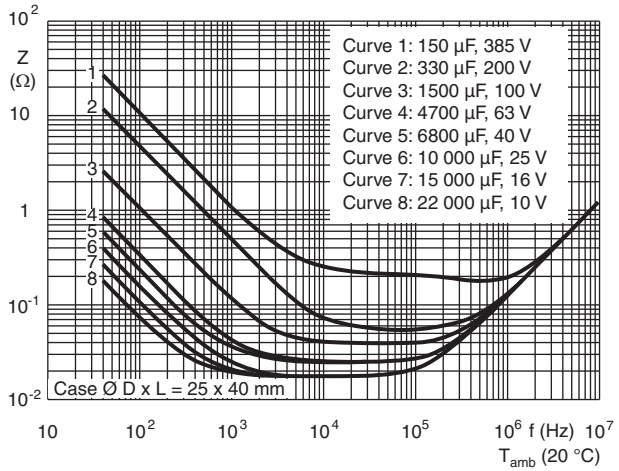


Fig. 18 - Typical impedance as a function of frequency

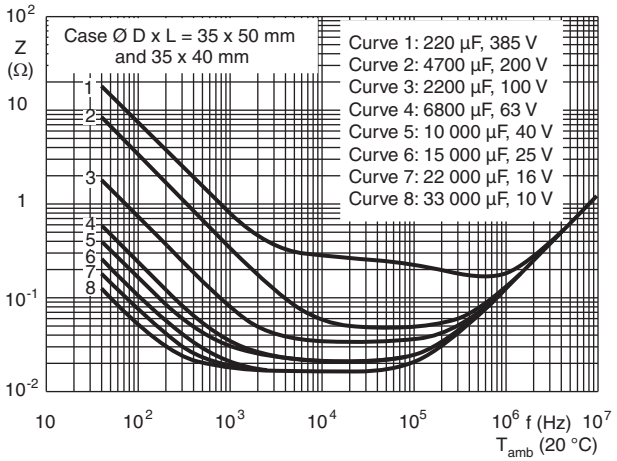


Fig. 19 - Typical impedance as a function of frequency

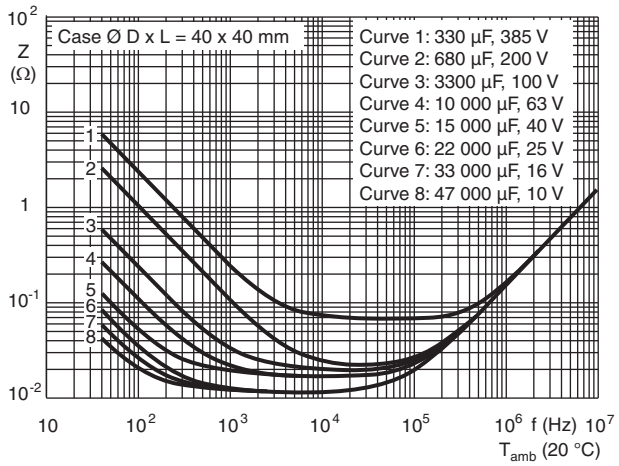


Fig. 20 - Typical impedance as a function of frequency

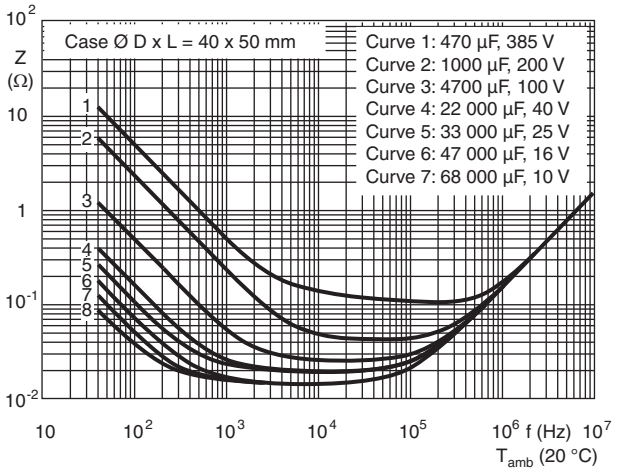


Fig. 21 - Typical impedance as a function of frequency

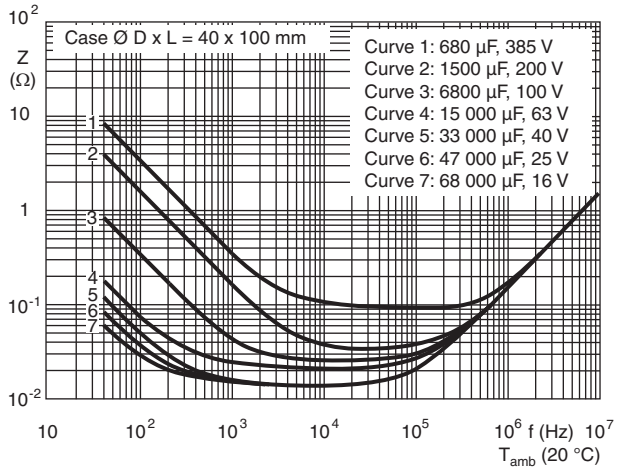


Fig. 22 - Typical impedance as a function of frequency

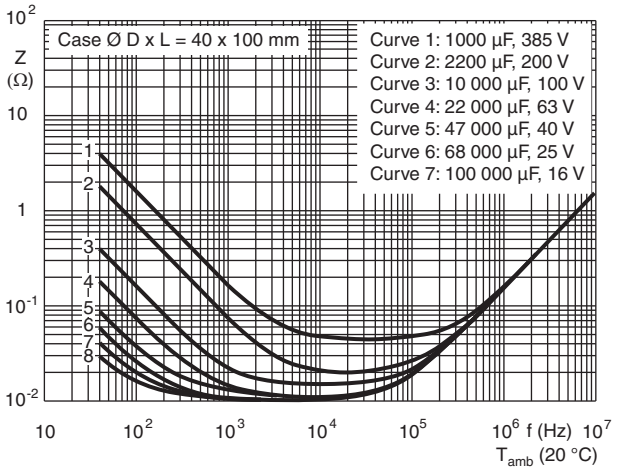
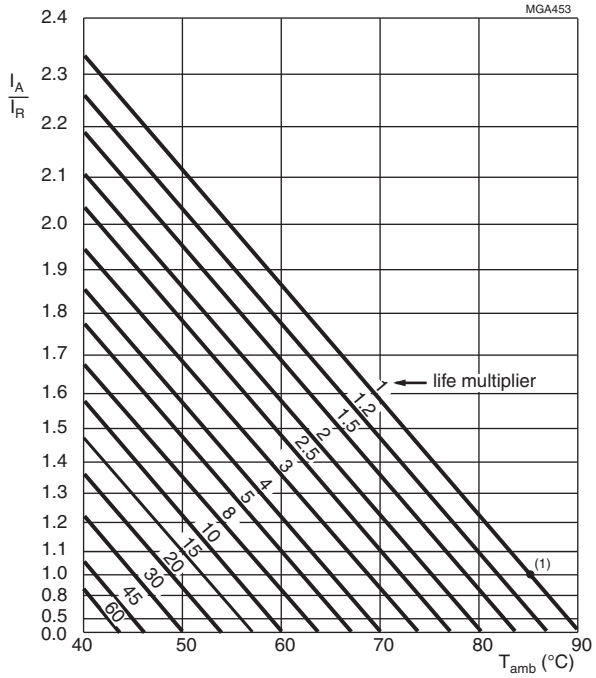


Fig. 23 - Typical impedance as a function of frequency

RIPPLE CURRENT AND USEFUL LIFE



I_A = Actual ripple current at 100 Hz
I_R = Rated ripple current at 100 Hz and 85 °C
(1) Useful life at 85 °C and I_R applied: 12 000 h

Fig. 24 - Multiplier of useful life as a function of ambient temperature and ripple current load

Table 4

MULTIPLIER OF RIPPLE CURRENT (I_R) AS A FUNCTION OF FREQUENCY	
FREQUENCY (Hz)	I_R MULTIPLIER
50	0.83
100	1.00
200	1.10
400	1.15
1000	1.19
≥ 2000	1.20

Table 5

TEST PROCEDURES AND REQUIREMENTS			
TEST		PROCEDURE (quick reference)	REQUIREMENTS
NAME OF TEST	REFERENCE		
Endurance	IEC 60384-4/ EN130300 subclause 4.13	T_{amb} = 85 °C; U_R applied; 5000 h	$U_R \leq$ 100 V; ΔC/C: ± 15 % $U_R >$ 100 V; ΔC/C: ± 10 % ESR ≤ 1.3 x spec. limit Z ≤ 2 x spec. limit $I_{L5} \leq$ spec. limit
Useful life	CECC 30301 subclause 1.8.1	T_{amb} = 85 °C; U_R and I_R applied; 12 000 h	$U_R \leq$ 100 V; ΔC/C: ± 45 % $U_R >$ 100 V; ΔC/C: ± 30 % ESR ≤ 3 x spec. limit Z ≤ 3 x spec. limit $I_{L5} \leq$ spec. limit no short or open circuit, no visible damage total failure percentage: $U_R \leq$ 100 V: ≤ 1 %; $U_R >$ 100 V: ≤ 3 %
Shelf life (storage at high temperature)	IEC 60384-4/ EN130300 subclause 4.17	T_{amb} = 85 °C; no voltage applied; 500 h after test: U_R to be applied for 30 min, 24 h to 48 h before measurement	ΔC/C: ± 10 % ESR ≤ 1.2 x spec. limit $I_{L5} \leq$ 2 x spec. limit

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