Aluminum Capacitors
Power Eurodin Printed Wiring

Fig. 1

FEATURES

- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Large types, cylindrical aluminum case, insulated with a blue sleeve
- Provided with keyed polarity
- 050 series also available in solder-lug (SL) versions
- Very long useful life: 15 000 h at 85 °C
- Low ESR, high ripple current capability
- High resistance to shock and vibration
- Compliant to RoHS Directive 2002/95/EC

Pb-free
RoHS
COMPLIANT

APPLICATIONS

- Computer, telecommunication, and industrial systems
- Smoothing and filtering
- 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 (Q for - 10 %/+ 30 %)
- 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	
	050	052
Nominal case size (Ø D x L in mm)	25 x 30 to 40 x 100	
Rated capacitance range (E6 series), C_R	470 µF to 68 000 µF	47 µF to 1000 µF
Tolerance on C_R	- 10 % to + 30 %	
Rated voltage range, U_R	10 V to 100 V	250 V to 400 V
Category temperature range	- 40 °C to + 85 °C	
Endurance test at 85 °C	5000 h	
Useful life at 85 °C	15 000 h	
Useful life at 40 °C, 1.4 x I_R applied	250 000 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 FOR 050 SERIES (Ø D x L in mm)

C_R (µF)	U_R (V)					
	10	16	25	40	63	100
470	-	-	-	-	-	25 x 30
680	-	-	-	-	-	25 x 40
1000	-	-	-	-	25 x 30	30 x 40
1500	-	-	-	25 x 30	25 x 40	35 x 40
2200	-	-	25 x 30	25 x 40	30 x 40	35 x 50
	-	-	-	-	-	40 x 40
3300	-	25 x 30	25 x 40	30 x 40	35 x 40	40 x 50
4700	25 x 30	25 x 40	30 x 40	35 x 40	35 x 50	40 x 70
	-	-	-	-	40 x 40	-
6800	25 x 40	30 x 40	35 x 40	35 x 50	40 x 50	40 x 100
	-	-	-	40 x 40	-	-
10 000	30 x 40	35 x 40	35 x 50	40 x 50	40 x 70	-
	-	-	40 x 40	-	-	-
15 000	35 x 40	35 x 50	40 x 50	40 x 70	40 x 100	-
	-	40 x 40	-	-	-	-
22 000	35 x 50	40 x 50	40 x 70	40 x 100	-	-
	40 x 40	-	-	-	-	-
33 000	40 x 50	40 x 70	40 x 100	-	-	-
47 000	40 x 70	40 x 100	-	-	-	-
68 000	40 x 100	-	-	-	-	-

SELECTION CHART FOR C_R, U_R, AND RELEVANT NOMINAL CASE SIZES FOR 052 SERIES (Ø D x L in mm)			
C_R (µF)	U_R (V)		
	250	385	400
47	-	25 x 30	25 x 30
68	-	25 x 40	25 x 40
100	25 x 30	30 x 40	30 x 40
150	25 x 40	35 x 40	35 x 40
220	30 x 40	35 x 50	35 x 50
	-	40 x 40	40 x 40
330	35 x 40	40 x 50	40 x 50
470	35 x 50	40 x 70	40 x 70
	40 x 40	-	-
680	40 x 50	-	40 x 100
1000	40 x 70	-	-

DIMENSIONS in millimeters AND AVAILABLE FORMS

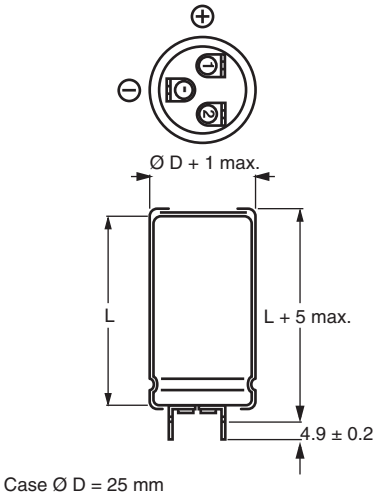


Fig. 2 - Printed wiring pin version

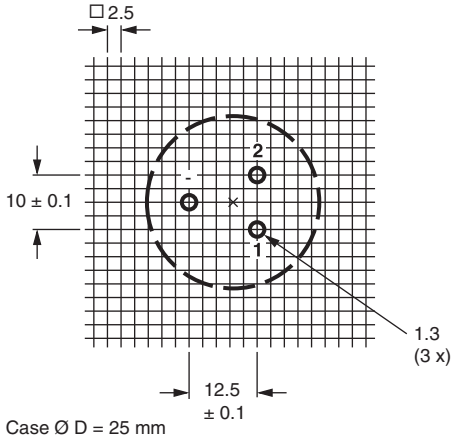


Fig. 3 - Mounting hole diagram viewed from component side

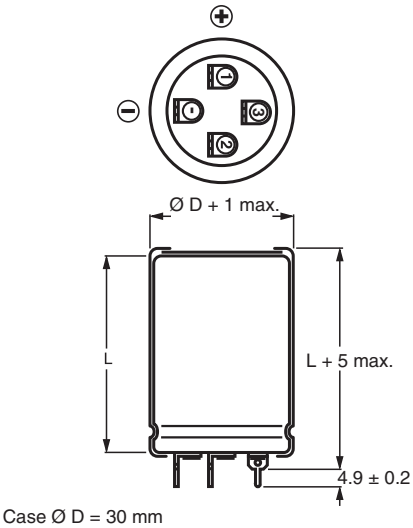


Fig. 4 - Printed wiring pin version

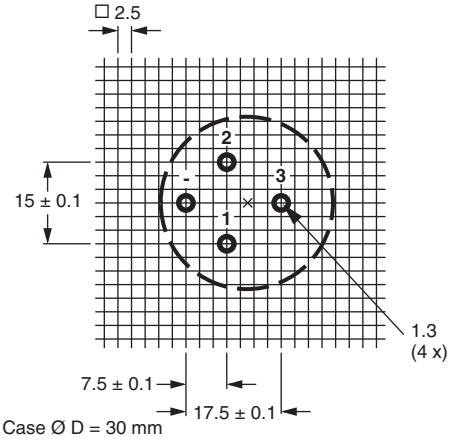


Fig. 5 - Mounting hole diagram viewed from component side

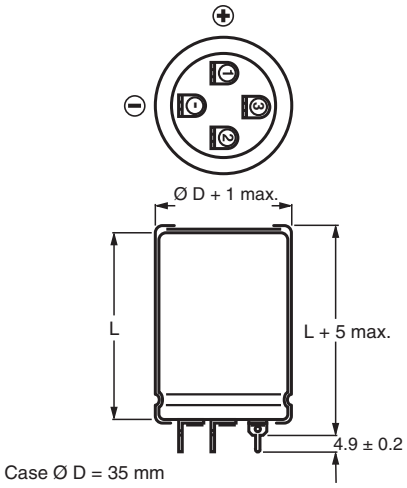


Fig. 6 - Printed wiring pin version

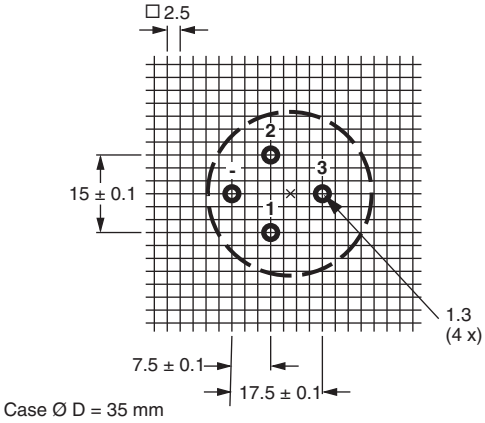


Fig. 7 - Mounting hole diagram viewed from component side

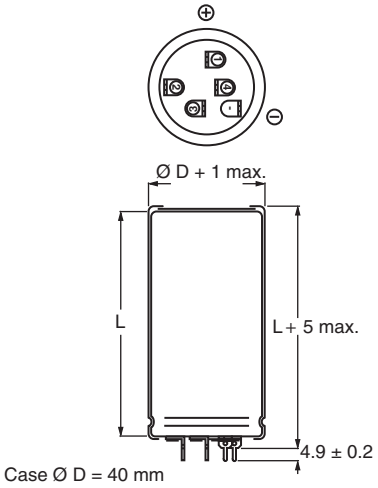


Fig. 8 - Printed wiring pin version

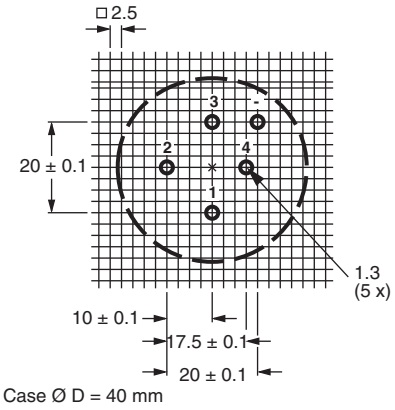


Fig. 9 - Mounting hole diagram viewed from component side

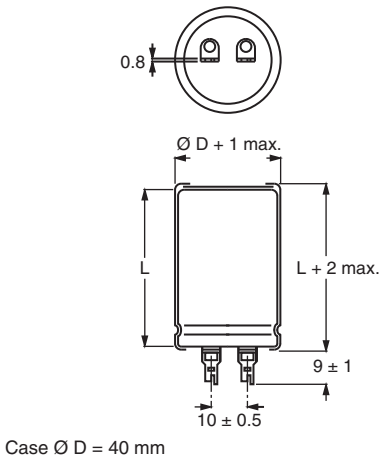


Fig. 10 - Solder-lug version (SL): only available in 050 series

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 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 $D_{max.}$	$L_{max.}$ SL VERSIONS	$L_{max.}$ PW VERSIONS	MASS (g)	PACKAGING QUANTITIES (units per box)	CARDBOARD BOX DIMENSIONS L x W x H
25 x 30	26	32	35	≈ 24	100	290 x 280 x 50
25 x 40	26	42	45	≈ 28	100	290 x 280 x 60
30 x 40	31	42	45	≈ 38	100	340 x 330 x 60
35 x 40	36	42	45	≈ 51	50	390 x 198 x 60
35 x 50	36	52	55	≈ 66	50	390 x 198 x 70
40 x 40 (1)	41	-	45	≈ 78	50	440 x 223 x 60
40 x 50	41	52	55	≈ 82	50	440 x 223 x 70
40 x 70	41	72	75	≈ 110	25	230 x 230 x 90
40 x 100	41	102	105	≈ 176	25	230 x 230 x 120

Note

(1) Not available in SL versions

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 050 series
10 000 µF/25 V; - 10 %/+ 30 %
Nominal case size:Ø 35 mm x 50 mm; PW version
Ordering code: MAL2 050 56103 E3
Former 12NC: 2222 050 56103

Table 2

ELECTRICAL DATA AND ORDERING INFORMATION FOR 050 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 SL MAL2050.....	ORDERING CODE PW MAL2050.....
10	4700	25 x 30	2.4	4.6	0.28	0.10	74	50	14472E3	54472E3
	6800	25 x 40	3.2	6.1	0.41	0.14	51	37	14682E3	54682E3
	10 000	30 x 40	3.8	7.2	0.60	0.20	39	29	14103E3	54103E3
	15 000	35 x 40	4.1	7.8	0.90	0.30	35	26	14153E3	54153E3
	22 000	35 x 50	5.0	9.5	1.32	0.44	27	21	14223E3	54223E3
	22 000	40 x 40	4.2	8.0	1.32	0.44	36	27	n/a	44223E3
	33 000	40 x 50	5.0	9.5	1.98	0.66	29	22	14333E3	54333E3
	47 000	40 x 70	6.8	12.9	2.82	0.94	20	17	14473E3	54473E3
	68 000	40 x 100	9.2	17.5	4.08	1.36	15	14	14683E3	54683E3

ELECTRICAL DATA AND ORDERING INFORMATION FOR 050 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 SL MAL2050.....	ORDERING CODE PW MAL2050.....
	3300	25 x 30	2.4	4.6	0.32	0.11	75	50	15332E3	55332E3
	4700	25 x 40	3.1	5.9	0.45	0.15	52	37	15472E3	55472E3
	6800	30 x 40	3.7	7.0	0.65	0.22	40	30	15682E3	55682E3
	10 000	35 x 40	4.1	7.8	0.96	0.32	36	27	15103E3	55103E3
16	15 000	35 x 50	5.0	9.5	1.44	0.48	28	21	15153E3	55153E3
	15 000	40 x 40	4.2	8.0	1.44	0.48	36	27	n/a	45153E3
	22 000	40 x 50	5.0	9.5	2.12	0.71	29	22	15223E3	55223E3
	33 000	40 x 70	6.7	12.7	3.17	1.06	20	17	15333E3	55333E3
	47 000	40 x 100	9.1	17.3	4.51	1.51	15	14	15473E3	55473E3
	2200	25 x 30	2.3	4.4	0.33	0.11	78	52	16222E3	56222E3
	3300	25 x 40	3.1	5.9	0.49	0.17	53	38	16332E3	56332E3
	4700	30 x 40	3.7	7.0	0.70	0.24	42	31	16472E3	56472E3
	6800	35 x 40	4.1	7.8	1.02	0.34	37	28	16682E3	56682E3
25	10 000	35 x 50	5.0	9.5	1.50	0.50	28	21	16103E3	56103E3
	10 000	40 x 40	4.2	8.0	1.50	0.50	36	27	n/a	46103E3
	15 000	40 x 50	5.0	9.5	2.25	0.75	29	22	16153E3	56153E3
	22 000	40 x 70	6.8	12.9	3.30	1.10	20	17	16223E3	56223E3
	33 000	40 x 100	9.2	17.5	4.95	1.65	15	14	16333E3	56333E3
	1500	25 x 30	2.0	3.8	0.36	0.12	112	68	17152E3	57152E3
	2200	25 x 40	2.7	5.1	0.53	0.18	76	51	17222E3	57222E3
	3300	30 x 40	3.3	6.3	0.79	0.27	57	41	17332E3	57332E3
	4700	35 x 40	3.8	7.2	1.13	0.38	48	35	17472E3	57472E3
40	6800	35 x 50	4.7	8.9	1.64	0.55	36	27	17682E3	57682E3
	6800	40 x 40	4.1	7.8	1.64	0.55	45	33	n/a	47682E3
	10 000	40 x 50	4.9	9.3	2.40	0.80	35	27	17103E3	57103E3
	15 000	40 x 70	6.6	12.5	3.60	1.20	25	20	17153E3	57153E3
	22 000	40 x 100	9.0	17.1	5.28	1.76	18	16	17223E3	57223E3
	1000	25 x 30	1.8	3.4	0.38	0.13	122	74	18102E3	58102E3
	1500	25 x 40	2.5	4.7	0.57	0.19	83	54	18152E3	58152E3
	2200	30 x 40	3.1	5.9	0.83	0.28	57	41	18222E3	58222E3
	3300	35 x 40	3.6	6.8	1.25	0.42	48	35	18332E3	58332E3
63	4700	35 x 50	4.4	8.3	1.78	0.60	36	27	18472E3	58472E3
	4700	40 x 40	3.8	7.2	1.78	0.60	45	33	n/a	48472E3
	6800	40 x 50	4.7	8.9	2.57	0.86	35	27	18682E3	58682E3
	10 000	40 x 70	6.2	11.8	3.78	1.26	25	20	18103E3	58103E3
	15 000	40 x 100	8.5	16.1	5.67	1.89	18	16	18153E3	58153E3
	470	25 x 30	1.4	2.7	0.28	0.10	247	172	19471E3	59471E3
	680	25 x 40	1.9	3.6	0.41	0.14	170	116	19681E3	59681E3
	1000	30 x 40	2.5	4.7	0.60	0.20	123	88	19102E3	59102E3
	1500	35 x 40	3.1	5.8	0.90	0.30	94	71	19152E3	59152E3
100	2200	35 x 50	3.9	7.4	1.32	0.44	69	55	19222E3	59222E3
	2200	40 x 40	3.6	6.8	1.32	0.44	81	65	n/a	49222E3
	3300	40 x 50	4.6	8.7	1.98	0.66	59	48	19332E3	59332E3
	4700	40 x 70	6.2	11.7	2.82	0.94	42	36	19472E3	59472E3
	6800	40 x 100	8.2	15.5	4.08	1.36	32	28	19682E3	59682E3

Table 3

ELECTRICAL DATA AND ORDERING INFORMATION FOR 052 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 MAL2052.....
250	100	25 x 30	0.6	1.15	0.15	0.05	1800	1300	53101E3
	150	25 x 40	0.8	1.5	0.23	0.08	1100	850	53151E3
	220	30 x 40	1.0	1.9	0.33	0.11	750	550	53221E3
	330	35 x 40	1.4	2.65	0.49	0.17	500	400	53331E3
	470	35 x 50	1.8	3.4	0.70	0.24	360	290	53471E3
	470	40 x 40	1.8	3.4	0.70	0.24	420	350	43471E3
	680	40 x 50	2.3	4.4	1.02	0.34	250	190	53681E3
	1000	40 x 70	3.0	5.7	1.50	0.50	170	140	53102E3
385	47	25 x 30	0.5	0.94	0.11	0.04	2370	1550	58479E3
	68	25 x 40	0.67	1.27	0.16	0.06	1640	1100	58689E3
	100	30 x 40	0.84	1.59	0.23	0.08	1275	950	58101E3
	150	35 x 40	1.13	2.14	0.34	0.11	850	635	58151E3
	220	35 x 50	1.48	2.8	0.50	0.17	580	430	58221E3
	220	40 x 40	1.48	2.8	0.50	0.17	580	430	48221E3
	330	40 x 50	1.97	3.73	0.75	0.25	385	300	58331E3
	470	40 x 70	2.7	5.11	1.06	0.36	270	215	58471E3
400	47	25 x 30	0.47	0.89	0.11	0.04	2700	2125	56479E3
	68	25 x 40	0.63	1.29	0.16	0.06	1875	1470	56689E3
	100	30 x 40	0.84	1.59	0.24	0.08	1275	1000	56101E3
	150	35 x 40	1.13	2.14	0.36	0.12	850	665	56151E3
	220	35 x 50	1.41	2.67	0.52	0.17	650	450	56221E3
	220	40 x 40	1.41	2.67	0.52	0.17	650	450	46221E3
	330	40 x 50	1.86	3.52	0.79	0.26	435	315	56331E3
	470	40 x 70	2.54	4.81	1.12	0.37	305	225	56471E3
	680	40 x 100	3.56	6.75	1.63	0.54	210	155	56681E3

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	$I_{L1} \leq 0.006\ C_R \times U_R + 4$ µA
	After 5 min at U_R	$I_{L5} \leq 0.002\ C_R \times U_R + 4$ µA
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)

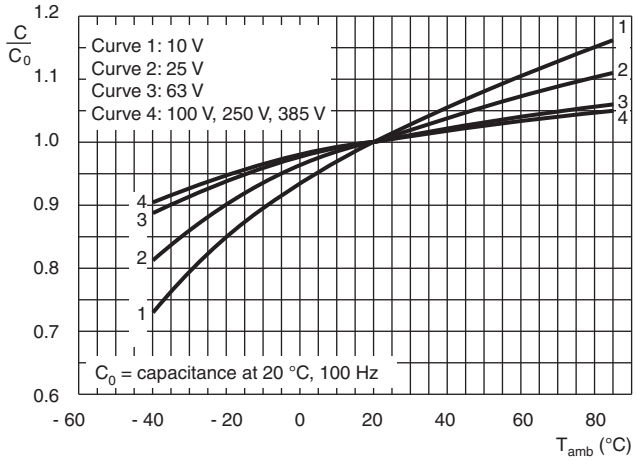


Fig. 11 - Typical multiplier of capacitance as a function of ambient temperature

EQUIVALENT SERIES RESISTANCE (ESR)

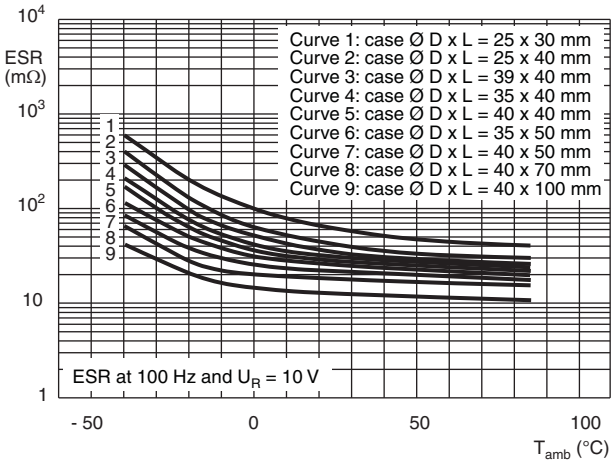


Fig. 12 - Typical ESR as a function of temperature

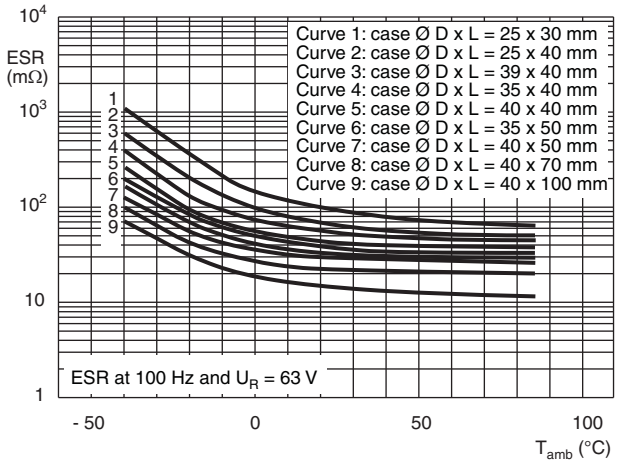


Fig. 13 - Typical ESR as a function of temperature

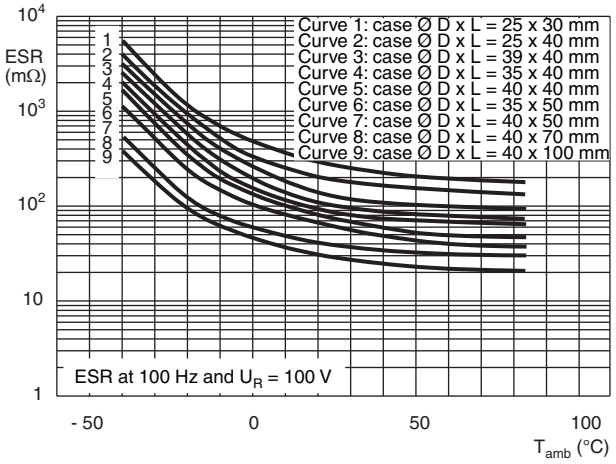


Fig. 14 - Typical ESR as a function of temperature

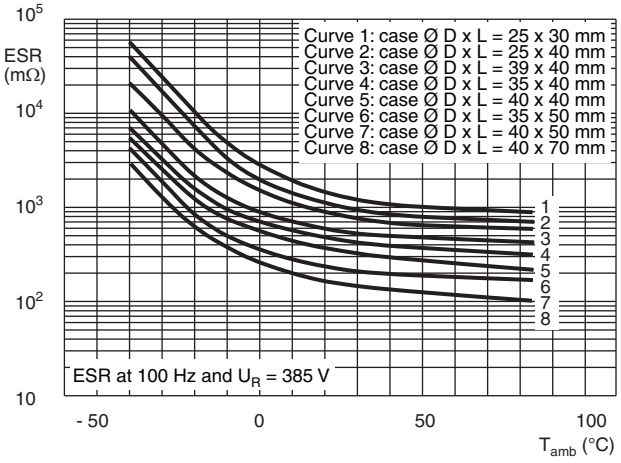


Fig. 15 - Typical ESR as a function of temperature

IMPEDANCE (Z)

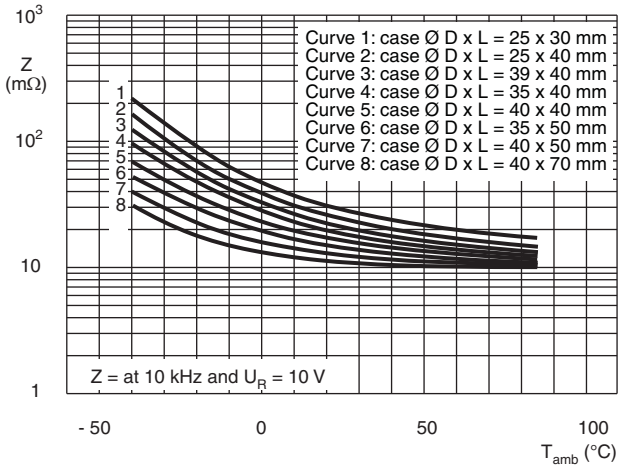


Fig. 16 - Typical impedance as a function of temperature

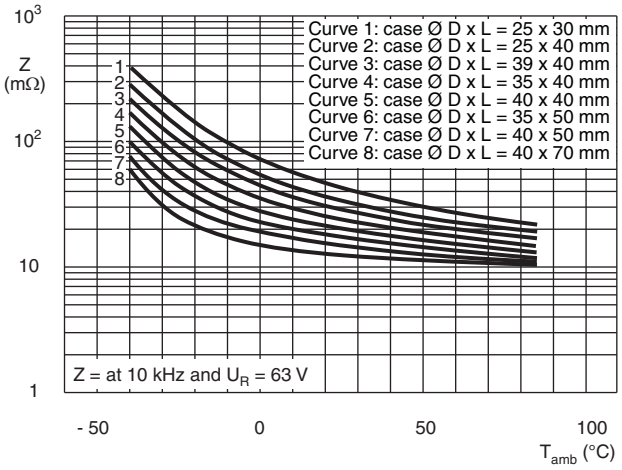


Fig. 17 - Typical impedance as a function of temperature

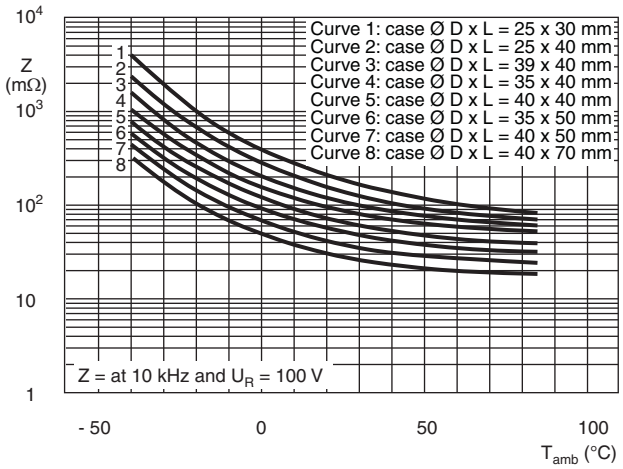


Fig. 18 - Typical impedance as a function of temperature

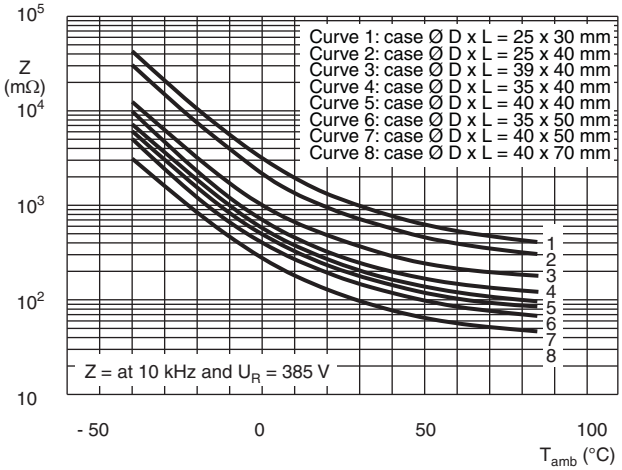


Fig. 19 - Typical impedance as a function of temperature

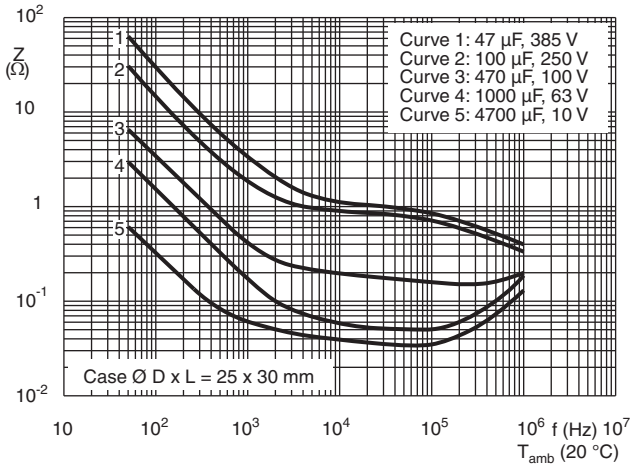


Fig. 20 - Typical impedance as a function of temperature

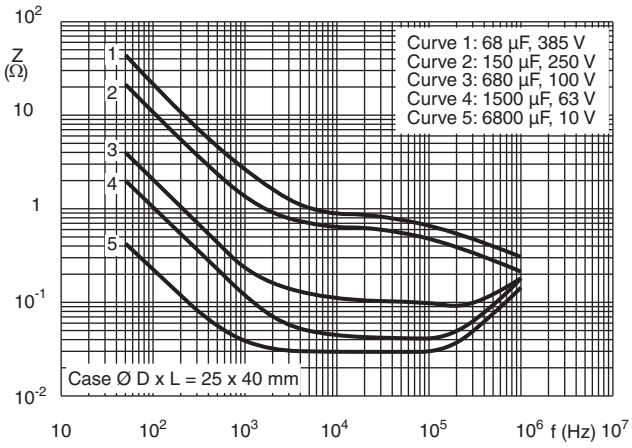


Fig. 21 - Typical impedance as a function of temperature

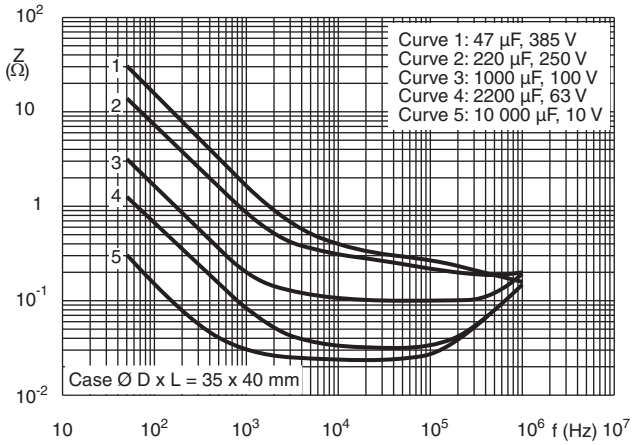


Fig. 22 - Typical impedance as a function of frequency

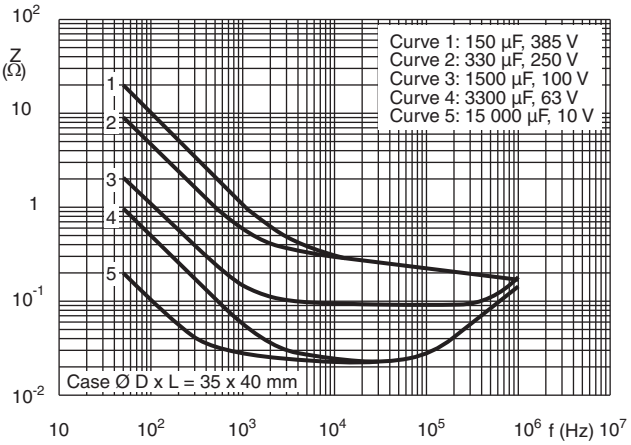


Fig. 23 - Typical impedance as a function of frequency

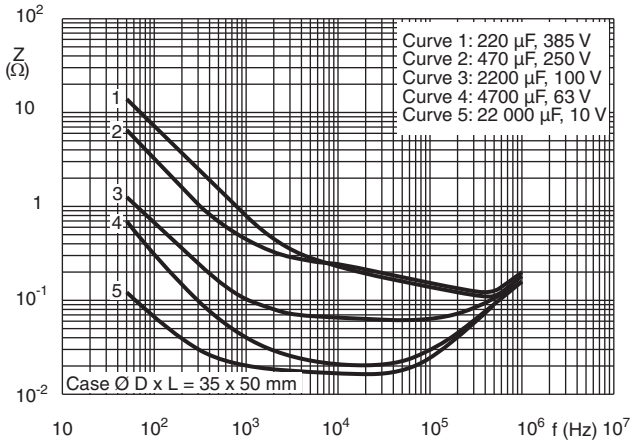


Fig. 24 - Typical impedance as a function of frequency

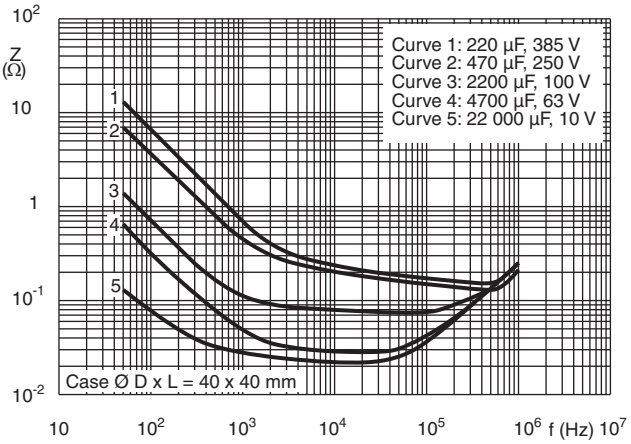


Fig. 25 - Typical impedance as a function of frequency

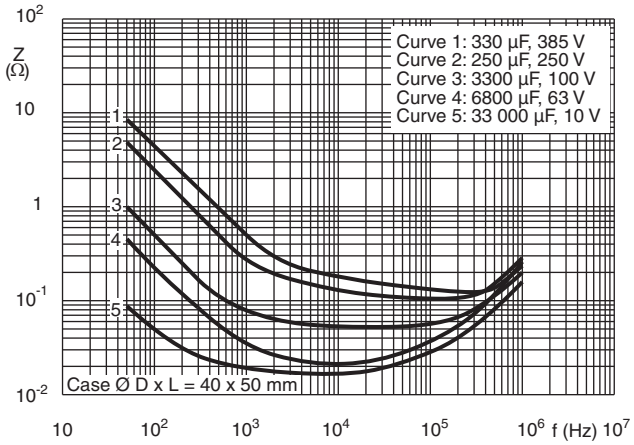


Fig. 26 - Typical impedance as a function of frequency

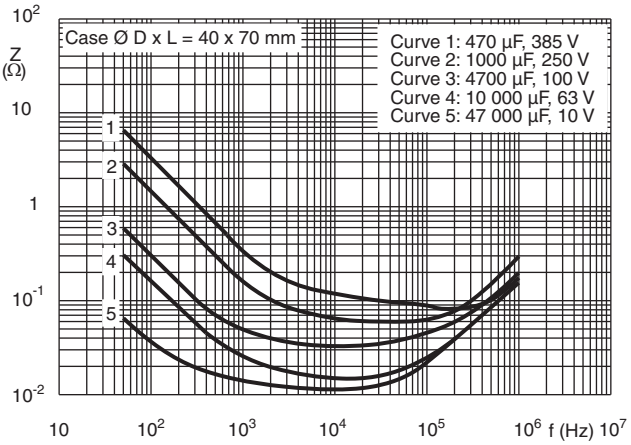


Fig. 27 - Typical impedance as a function of frequency

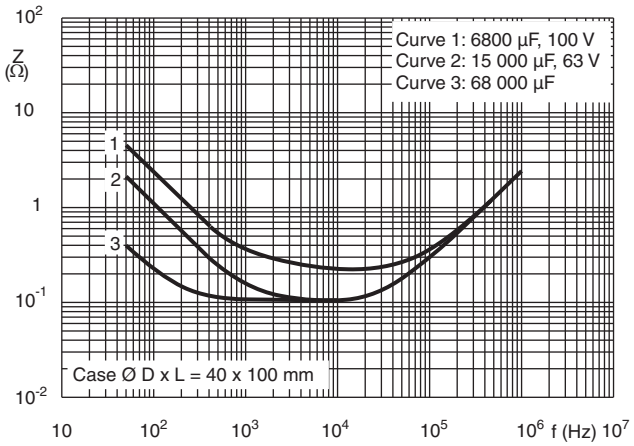
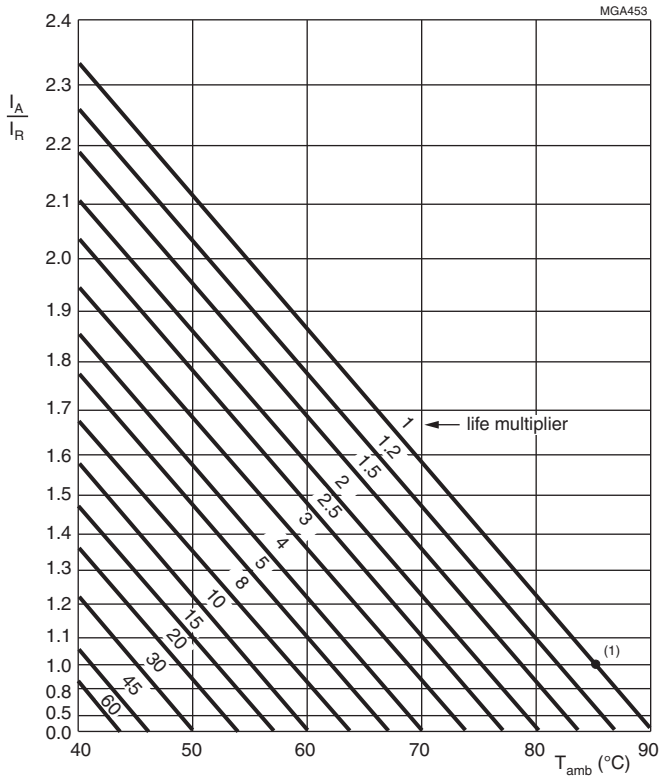


Fig. 28 - Typical impedance as a function of frequency

RIPPLE CURRENT AND USEFUL LIFE



I_A = Actual ripple current
I_R = Rated ripple current at 100 Hz and 85 °C
(1) Useful life at 85 °C and I_R applied: 15 000 h

Fig. 29 - 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 ≤ x 2 spec. limit I_{L5} ≤ spec. limit
Useful life	CECC 30301 subclause 1.8.1	T_{amb} = 85 °C; U_R and I_R applied; 15 000 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} ≤ 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} ≤ 2 x spec. limit

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