Aluminum Capacitors
Axial Standard, High Voltage

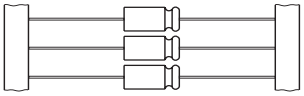
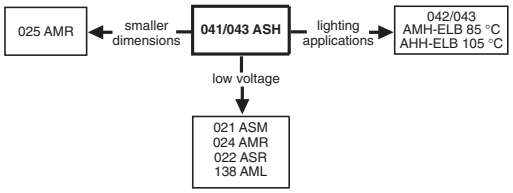


Fig.1 Component outlines



QUICK REFERENCE DATA		
DESCRIPTION	VALUE	
Nominal case sizes (∅D × L in mm)	6.5 × 18 to 10 × 25	10 × 30 to 21 × 38
Rated capacitance range, C_R	1 to 220 µF	
Tolerance on C_R	–10 to +50%	
Rated voltage range, U_R	160 to 450 V	
Category temperature range	–40 to +85 °C (450 V: –25 to +85 °C)	
Endurance test at 85 °C	2000 hours	8000 hours (450 V: 5000 hours)
Useful life at 85 °C	5000 hours	15000 hours (450 V: 10000 hours)
Useful life at 40 °C	1.4 × I_R applied: 120000 hours	1.8 × I_R applied: 240000 hours (450 V: 160000 hours)
Shelf life at 0 V, 85 °C	500 hours	500 hours
Based on sectional specification	IEC 60384-4/EN130300	
Climatic category IEC 60068	40/085/56 (450 V: 25/085/56)	

FEATURES

- Polarized aluminum electrolytic capacitors, non-solid electrolyte.
- Axial leads, cylindrical aluminum case, insulated with a blue sleeve.
- Mounting ring version not available in insulated form.
- Taped versions up to case ∅15 × 30 mm available for automatic insertion.
- Useful life: 5000 to 15000 hours at 85 °C.
- High rated voltage: up to 450 V.

APPLICATIONS

- General purpose, industrial, power supply, audio-video
- Smoothing, filtering, buffering at high voltages
- Boards with restricted mounting height, vibration and shock resistant.

MARKING

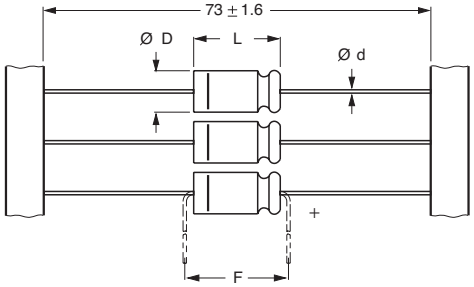
The capacitors are marked (where possible) with the following information:

- Rated capacitance (in µF).
- Tolerance on rated capacitance, code letter in accordance with IEC 60062 (T for -10 to +50%).
- Rated voltage (in V).
- Upper category temperature (85 ° C).
- Date code, in accordance with IEC 60062.
- Code indicating factory of origin.
- Name of manufacturer.
- Band to indicate the negative terminal.
- '+' sign to identify the positive terminal.
- Series number (041, 042 or 043).

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

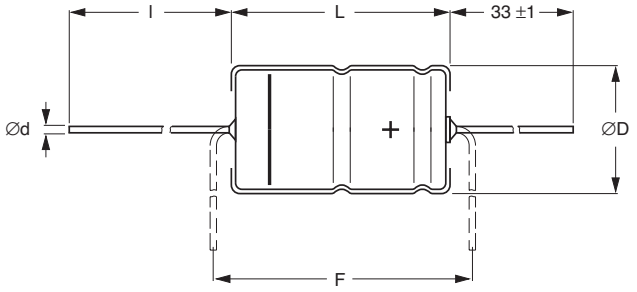
C_R (µF)	U_R (V)					
	160	250	350	385	400	450
1.0	–	–	–	6.5 × 18	–	–
2.2	–	6.5 × 18	–	8 × 18	–	–
4.7	6.5 × 18	8 × 18	10 × 18	10 × 25	–	–
6.8	–	–	10 × 30	10 × 30	10 × 30	10 × 30
10	8 × 18	10 × 25	12.5 × 30	12.5 × 30	12.5 × 30	12.5 × 30
	–	10 × 30	–	–	–	–
15	–	12.5 × 30	12.5 × 30	15 × 30	15 × 30	12.5 × 30
22	10 × 25	12.5 × 30	15 × 30	18 × 30	18 × 30	15 × 30
	10 × 30	–	–	–	–	–
33	12.5 × 30	15 × 30	18 × 30	18 × 38	18 × 38	18 × 30
47	15 × 30	18 × 30	18 × 38	18 × 38	18 × 38	18 × 38
68	15 × 30	18 × 38	21 × 38	21 × 38	21 × 38	21 × 38
100	18 × 30	21 × 38	–	–	–	–
150	18 × 38	–	–	–	–	–
220	21 × 38	–	–	–	–	–

DIMENSIONS in millimeters AND AVAILABLE FORMS



Form BR: Taped on reel,
case ∅D × L = 6.5 × 18 to 15 × 30 mm.
Form BA: Taped in box (ammopack),
case ∅D × L = 6.5 × 18 to 10 × 25 mm.

Fig.2 **Forms BA and BR**.



Form AA: Axial in box,
case ∅D × L = 10 × 30 to 21 × 38 mm

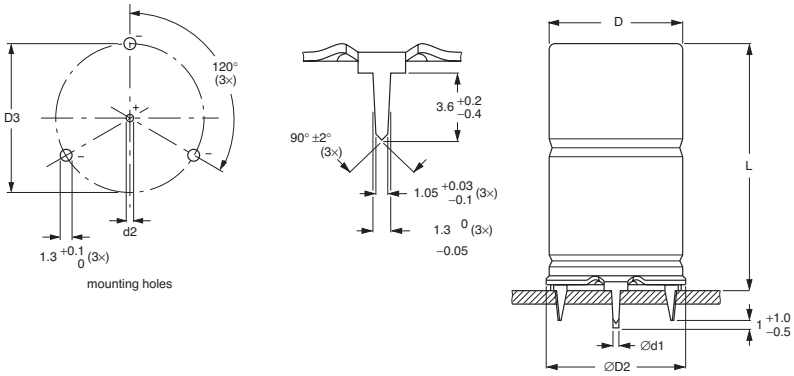
Fig.3 **Form AA.**

Table 1

AXIAL; DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES										
NOMINAL CASE SIZE ∅D × L	CASE CODE	AXIAL: FORM AA, BA, and BR					MASS (g)	PACKAGING QUANTITIES		
		∅d	l	$∅D_{max}$	L_{max}	F_{min}		FORM AA	FORM BA	FORM BR
6.5 × 18	4	0.8	–	6.9	18.5	25	≈1.3	–	1000	1000
8 × 18	5	0.8	–	8.5	18.5	25	≈1.7	–	500	500
10 × 18	6	0.8	–	10.5	18.5	25	≈2.5	–	500	500
10 × 25	7	0.8	–	10.5	25.0	30	≈3.3	–	500	500
10 × 30	00	0.8	55 ±1	10.5	30.5	35	≈4.8	340	–	500
12.5 × 30	01	0.8	55 ±1	13.0	30.5	35	≈7.4	260	–	400
15 × 30	02	0.8	55 ±1	15.5	30.5	35	≈11.7	300	–	250
18 × 30	03	0.8	55 ±1	18.5	30.5	35	≈12.9	200	–	–
18 × 38	04	0.8	34 ±1	18.5	39.0	44	≈19.0	125	–	–
21 × 38	05	0.8	34 ±1	21.5	39.0	44	≈24.0	100	–	–

Note
1. Detailed tape dimensions see section 'PACKAGING'.

Fig.4 Mounting hole diagram and outline; **Form MR;** mounting ring and pins.



Form MR: case ∅D × L = 15 × 30 to 21 × 38 mm.
Case not insulated (insulation on request).
Especially for applications with severe shocks and vibrations.

Table 2

MOUNTING RING; DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES									
NOMINAL CASE SIZE ∅D × L	CASE CODE	MOUNTING RING: FORM MR						MASS (g)	PACKAGING QUANTITIES
		∅d1	∅d2	$∅D_{max}$	$∅D2_{max}$	D3	L_{max}		
15 × 30	02	0.8	1.0 +0.4	15.5	17.5	16.5 ±0.2	33	≈11.7	200
18 × 30	03	0.8	1.0 +0.4	18.5	19.5	18.5 ±0.2	33	≈12.9	240
18 × 38	04	0.8	1.0 +0.4	18.5	19.5	18.5 ±0.2	42	≈19.0	100
21 × 38	05	0.8	1.0 +0.4	21.5	22.5	21.5 ±0.2	42	≈24.0	100

ELECTRICAL DATA	
SYMBOL	**DESCRIPTION**
C_R	rated capacitance at 100 Hz, tolerance –10 to +50%
I_R	rated RMS ripple current at 100 Hz, 85 °C
I_{L1}	max. leakage current after 1 minute at U_R
I_{L5}	max. leakage current after 5 minutes at U_R
Tan δ	max. dissipation factor at 100 Hz
ESR	equivalent series resistance at 100 Hz (calculated from tan δ_{max} and C_R)
Z	max. impedance at 10 kHz

Note

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

ORDERING EXAMPLE

Electrolytic capacitor 041 series

10 µF/250 V; -10/+50%

Nominal case size: ∅10 × 25 mm; Form BA

Catalog number: 2222 041 33109.

Table 3

ELECTRICAL DATA AND ORDERING INFORMATION

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅D × L (mm)	CASE CODE	I_R 100 Hz 85 °C (mA)	I_{L1} 1 min (µA)	I_{L5} 5 min (µA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)	CATALOG NUMBER 2222			
										IN BOX FORM AA	TAPED ON REEL FORM BR	TAPED IN BOX FORM BA	MOUNTING RING FORM MR
160	4.7	6.5 × 18	4	50	38	8	0.15	51	26	–	041 21478	041 31478	–
	10	8 × 18	5	70	68	14	0.15	24	12	–	041 21109	041 31109	–
	22	10 × 25	7	150	130	25	0.15	11	5.5	–	041 21229	041 31229	–
	22	10 × 30	00	190	42	25	0.10	6.8	5.5	042 11229	042 21229	–	–
	33	12.5 × 30	01	270	58	36	0.10	4.5	3.1	042 11339	042 21339	–	–
	47	15 × 30	02	350	78	49	0.10	3.2	2.1	042 11479	042 21479	–	042 41479
	68	15 × 30	02	420	110	69	0.10	2.2	1.4	042 11689	042 21689	–	042 41689
	100	18 × 30	03	580	150	100	0.10	1.5	1.0	042 11101	–	–	042 41101
	150	18 × 38	04	760	230	150	0.10	1.0	0.7	043 11151	–	–	043 41151
	220	21 × 38	05	940	330	220	0.10	0.7	0.5	043 11221	–	–	043 41221
250	2.2	6.5 × 18	4	35	28	6	0.10	72	50	–	041 23228	041 33228	–
	4.7	8 × 18	5	55	55	11	0.10	34	23	–	041 23478	041 33478	–
	10	10 × 25	7	90	95	19	0.10	16	11	–	041 23109	041 33109	–
	10	10 × 30	00	130	33	19	0.10	15	11	042 13109	042 23109	–	–
	15	12.5 × 30	01	180	44	27	0.10	10	7.4	042 13159	042 23159	–	–
	22	12.5 × 30	01	220	60	37	0.10	6.8	5.0	042 13229	042 23229	–	–
	33	15 × 30	02	290	84	54	0.10	4.5	3.4	042 13339	042 23339	–	042 43339
	47	18 × 30	03	400	120	75	0.10	3.2	2.3	042 13479	–	–	042 43479
	68	18 × 38	04	520	160	110	0.10	2.2	1.7	043 13689	–	–	043 43689
	100	21 × 38	05	650	240	150	0.10	1.5	1.1	043 13101	–	–	043 43101
350	4.7	10 × 18	6	60	69	14	0.10	34	22	–	041 25478	041 35478	–
	6.8	10 × 30	00	110	32	18	0.10	22	14	042 15688	042 25688	–	–
	10	12.5 × 30	01	150	42	25	0.10	15	10	042 15109	042 25109	–	–
	15	12.5 × 30	01	180	57	36	0.10	10	6.7	042 15159	042 25159	–	–
	22	15 × 30	02	250	79	50	0.10	6.8	4.5	042 15229	042 25229	–	042 45229
	33	18 × 30	03	350	110	73	0.10	4.5	3.1	042 15339	–	–	042 45339
	47	18 × 38	04	450	160	100	0.10	3.2	2.1	043 15479	–	–	043 45479
	68	21 × 38	05	560	220	150	0.10	2.2	1.4	043 15689	–	–	043 45689
385	1	6.5 × 18	4	20	19	4	0.10	160	100	–	041 28108	041 38108	–
	2.2	8 × 18	5	40	42	8	0.10	72	45	–	041 28228	041 38228	–
	4.7	10 × 25	7	70	71	15	0.10	34	22	–	041 28478	041 38478	–
	6.8	10 × 30	00	110	34	20	0.10	22	14	042 18688	042 28688	–	–
	10	12.5 × 30	01	150	45	27	0.10	15	10	042 18109	042 28109	–	–
	15	15 × 30	02	210	62	39	0.10	10	6.0	042 18159	042 28159	–	042 48159
	22	18 × 30	03	290	86	55	0.10	6.8	4.1	042 18229	–	–	042 48229
	33	18 × 38	04	380	120	80	0.10	4.5	2.7	043 18339	–	–	043 48339
	47	18 × 38	04	450	170	110	0.10	3.2	2.1	043 18479	–	–	043 48479
	68	21 × 38	05	570	250	160	0.10	2.2	1.4	043 18689	–	–	043 48689

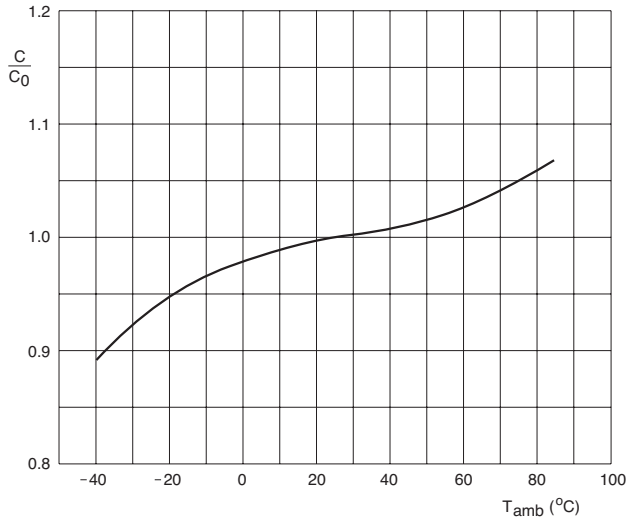
ELECTRICAL DATA AND ORDERING INFORMATION

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅D × L (mm)	CASE CODE	I_R 100 Hz 85 °C (mA)	I_{L1} 1 min (µA)	I_{L5} 5 min (µA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)	CATALOG NUMBER 2222			
										IN BOX FORM AA	TAPED ON REEL FORM BR	TAPED IN BOX FORM BA	MOUNTING RING FORM MR
400	6.8	10 × 30	00	110	220	110	0.055	11.5	7.3	042 16688	042 26688	–	–
	10	12.5 × 30	01	150	240	110	0.055	7.5	4.6	042 16109	042 26109	–	–
	15	15 × 30	02	210	250	110	0.055	5.0	3.1	042 16159	042 26159	–	042 46159
	22	18 × 30	03	290	280	120	0.055	3.5	2.1	042 16229	–	–	042 46229
	33	18 × 38	04	380	320	130	0.055	2.3	1.4	043 16339	–	–	043 46339
	47	18 × 38	04	450	370	140	0.055	1.7	1.1	043 16479	–	–	043 46479
	68	21 × 38	05	560	440	150	0.055	1.2	0.7	043 16689	–	–	043 46689
450	6.8	10 × 30	00	110	230	110	0.10	22	14	042 17688	042 27688	–	–
	10	12.5 × 30	01	150	240	110	0.10	15	10	042 17109	042 27109	–	–
	15	12.5 × 30	01	180	260	110	0.10	10	6	042 17159	042 27159	–	–
	22	15 × 30	02	240	290	120	0.10	6.8	4.1	042 17229	042 27229	–	042 47229
	33	18 × 30	03	350	330	130	0.10	4.5	2.7	042 17339	–	–	042 47339
	47	18 × 38	04	440	390	140	0.10	3.2	2.1	043 17479	–	–	043 47479
	68	21 × 38	05	550	460	160	0.10	2.2	1.4	043 17689	–	–	043 47689

ADDITIONAL ELECTRICAL DATA

PARAMETER	CONDITIONS	VALUE	
		AXIAL	MOUNTING RING
Voltage			
Surge voltage	U_R = 160 to 250 V	$U_s \leq 1.15 \times U_R$	
	U_R = 350 to 450 V	$U_s \leq 1.1 \times U_R$	
Reverse voltage		$U_{rev} \leq 1$ V	
Current			
Leakage current	after 1 minute:		
	case ∅D × L = 6.5 × 18 to 10 × 25 mm:		
	CV ≤ 1000 µC	$I_{L1} \leq 0.05\ C_R \times U_R$ or 5 µA, whichever is greater	
	CV > 1000 µC	$I_{L1} \leq 0.03\ C_R \times U_R + 20$ µA	
	case ∅D × L = 10 × 30 to 21 × 38 mm:		
	U_R = 160 to 385 V	$I_{L1} \leq 0.009\ C_R \times U_R + 10$ µA	
	U_R = 400 and 450 V	$I_{L1} \leq 0.009\ C_R \times U_R + 200$ µA	
	after 5 minutes:		
	U_R = 160 to 385 V:		
	CV ≤ 1000 µC	$I_{L5} \leq 0.01\ C_R \times U_R$ or 1 µA, whichever is greater	
	CV > 1000 µC	$I_{L5} \leq 0.006\ C_R \times U_R + 4$ µA	
	U_R = 400 and 450 V	$I_{L5} \leq 0.002\ C_R \times U_R + 100$ µA	
Inductance			
Equivalent series inductance (ESL)	case ∅D × L mm:		
	6.5 × 18	typ. 15 nH	–
	8 × 18	typ. 35 nH	–
	10 × 18	typ. 69 nH	–
	10 × 25	typ. 38 nH	–
	10 × 30	typ. 38 nH	–
	12.5 × 30	typ. 46 nH	–
	15 × 30	typ. 48 nH	typ. 39 nH
	18 × 30	typ. 50 nH	typ. 39 nH
	18 × 38	typ. 54 nH	typ. 39 nH
	21 × 38	typ. 59 nH	typ. 39 nH

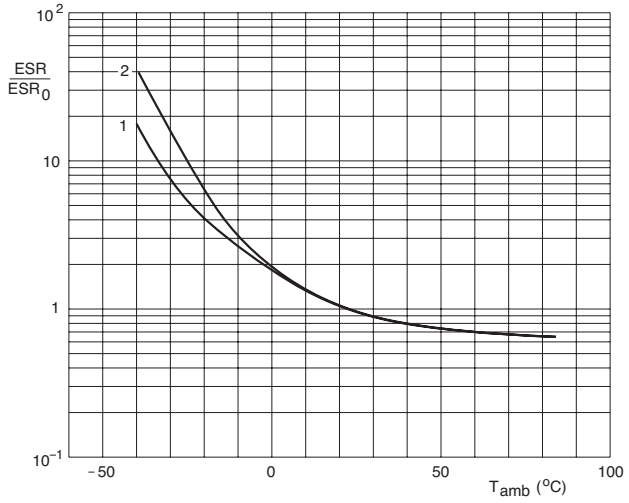
CAPACITANCE (C)



C_0 = capacitance at 20 °C, 100 Hz.

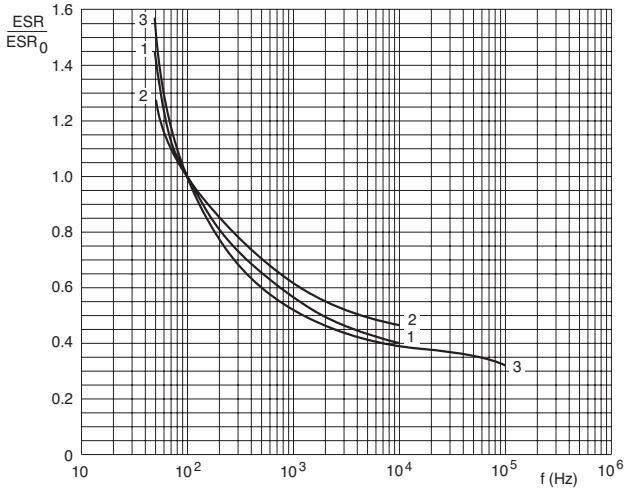
Fig.5 Typical multiplier of capacitance as a function of ambient temperature

EQUIVALENT SERIES RESISTANCE (ESR)



Curve 1: case ∅D × L = 10 × 30 to 21 × 38 mm.
Curve 2: case ∅D × L = 6.5 × 18 to 10 × 25 mm.
ESR_0 = typical at 20 °C, 100 Hz.

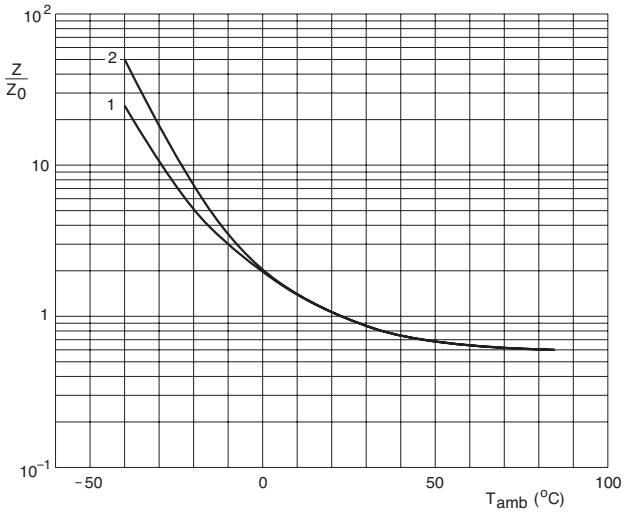
Fig.6 Typical multiplier of ESR as a function of ambient temperature.



Curve 1: case ∅D × L = 10 × 30 mm.
Curve 2: case ∅D × L = 21 × 38 mm.
Curve 3: case ∅D × L = 6.5 × 18 to 10 × 25 mm.
ESR_0 = typical at 20 °C, 100 Hz.

Fig.7 Typical multiplier of ESR as a function of frequency.

IMPEDANCE (Z)

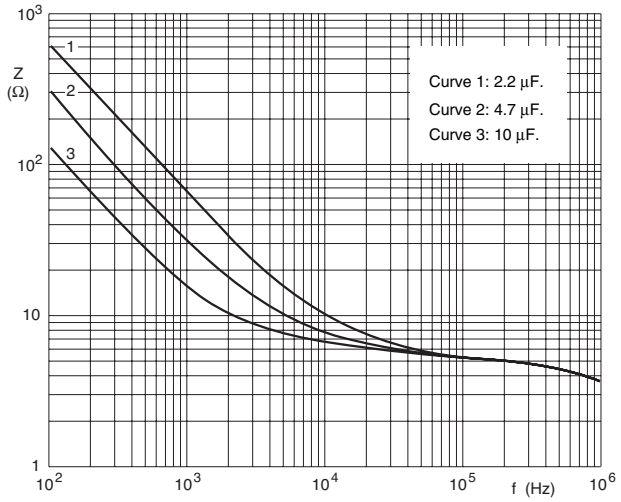


Curve 1: case ∅D × L = 10 × 30 to 21 × 38 mm.

Curve 2: case ∅D × L = 6.5 × 18 to 10 × 25 mm.

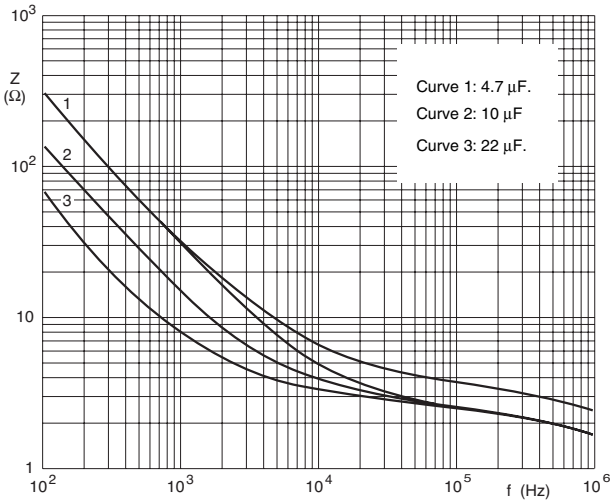
Z_0 = impedance at 20 °C, 10 kHz.

Fig.8 Typical multiplier of impedance as a function of ambient temperature.



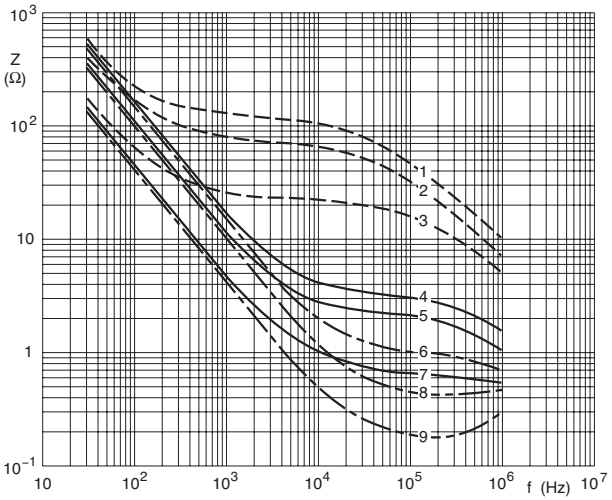
Case ∅D × L = 8 × 18 mm. T_{amb} = 20 °C.

Fig.9 Typical impedance as a function of frequency.



Case ∅D × L = 10 × 18 and 10 × 25 mm. T_{amb} = 20 °C.

Fig.10 Typical impedance as a function of frequency.



Case ∅D × L = 12.5 × 30 mm.

Curve 1: 10 µF, 350 and 385 V; −40 °C.

Curve 2: 15 µF, 250 V; −40 °C.

Curve 3: 33 µF, 160 V; −40 °C.

Curve 4: 10 µF, 350 and 385 V; 20 °C.

Curve 5: 15 µF, 250 V; 20 °C.

Curve 6: 33 µF, 160 V; 20 °C.

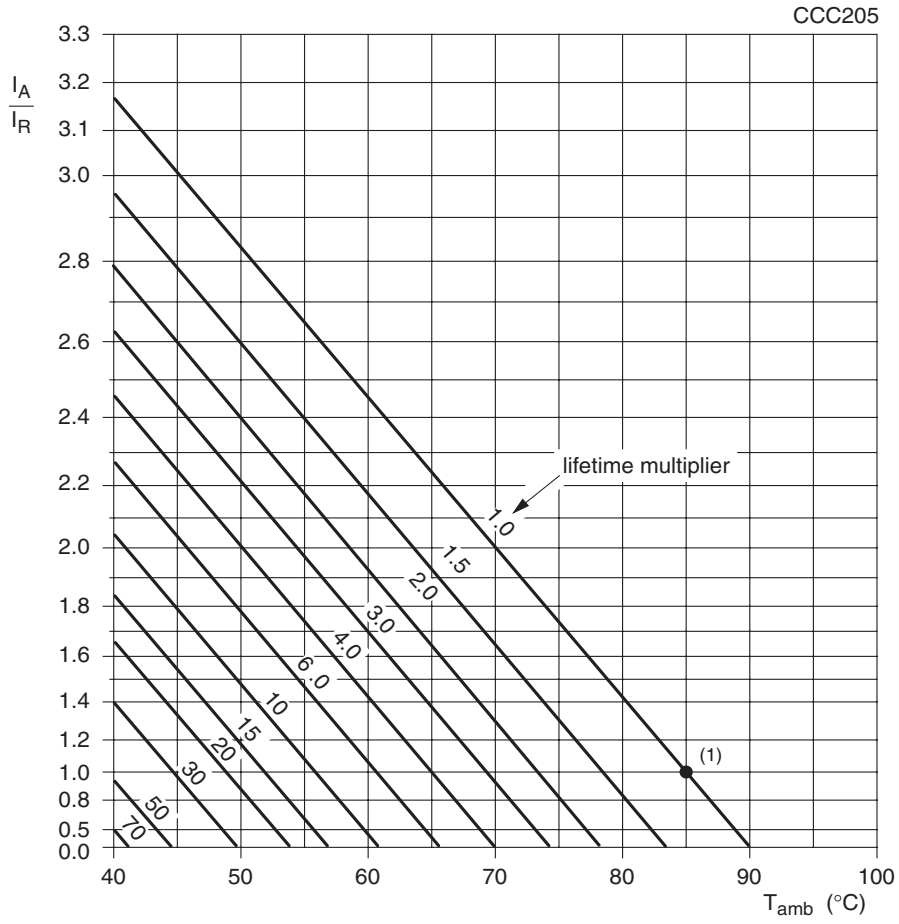
Curve 7: 10 µF, 350 and 385 V; 85 °C.

Curve 8: 15 µF, 250 V; 85 °C.

Curve 9: 33 µF, 160 V; 85 °C.

Fig.11 Typical impedance as a function of frequency at different ambient temperatures.

RIPPLE CURRENT AND USEFUL LIFE



I_A = actual ripple current at 100 Hz.

I_R = rated ripple current at 100 Hz, 85 °C.

(1) Useful life at 85 °C and I_R applied;
case ∅D × L = 6.5 × 18 to 10 × 25 mm: 5000 hours
case ∅D × L = 10 × 30 to 21 × 38 mm: 15000 hours (450 V: 10000 hours).

Fig.12 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	0.75
100	1.00
300	1.15
1000	1.30
3000	1.40
≥10000	1.50

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; case ∅D × L: 6.5 × 18 to 10 × 25 mm: 2000 hours; 10 × 30 to 21 × 38 mm 8000 hours (450 V: 5000 hours)	U_R = 160 V; ΔC/C: ±15% U_R = 250 to 450 V; ΔC/C: ±10% tan δ ≤ 1.3 × spec. limit Z ≤ 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; case ∅D × L: 6.5 × 18 to 10 × 25 mm: 5000 hours; 10 × 30 to 21 × 38 mm: 15000 hours (450 V: 10000 hours)	U_R = 160 V; ΔC/C: ±45% U_R = 250 to 450 V; ΔC/C: ±30% tan δ ≤ 3 × spec. limit Z ≤ 3 × spec. limit I_{L5} ≤ spec. limit no short or open circuit total failure percentage: ≤ 3%
Shelf life (storage at high temperature)	IEC 60384-4/ EN130300 subclause 4.17	T_{amb} = 85 °C; no voltage applied; 500 hours after test: U_R to be applied for 30 minutes, 24 to 48 hours before measurement	ΔC/C, tan δ, Z: for requirements see 'Endurance test' above I_{L5} ≤ 2 × spec. limit