Aluminum Capacitors
Axial Standard, High Voltage

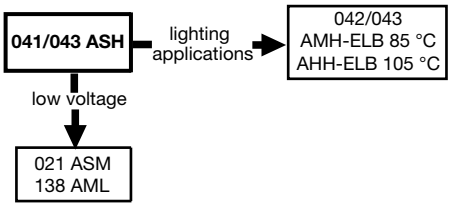


Fig. 1

FEATURES

- Useful life: 5000 h to 15 000 h at 85 °C
- High rated voltage: Up to 450 V
- Taped versions up to case Ø 15 mm x 30 mm available for automatic insertion
- 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
- Material categorization: For definitions of compliance please see www.vishay.com/doc?99912

Pb-free

RoHS COMPLIANT

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
- Negative terminal identification
- Series number (041, 042 or 043)

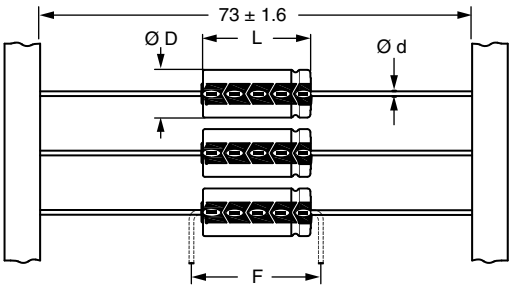
QUICK REFERENCE DATA

DESCRIPTION	VALUE	
Nominal case sizes (Ø D x L in mm)	6.5 x 18 to 10 x 25	10 x 30 to 21 x 38
Rated capacitance range, C_R	1 µF to 220 µF	
Tolerance on C_R	- 10 % to + 50 %	
Rated voltage range, U_R	160 V to 450 V	
Category temperature range	- 40 °C to + 85 °C (450 V: - 25 °C to + 85 °C)	
Endurance test at 85 °C	2000 h	8000 h (450 V: 5000 h)
Useful life at 85 °C	5000 h	15 000 h (450 V: 10 000 h)
Useful life at 40 °C	1.4 x I_R applied: 120 000 h	1.8 x I_R applied: 240 000 h (450 V: 160 000 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 (450 V: 25/085/56)	

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

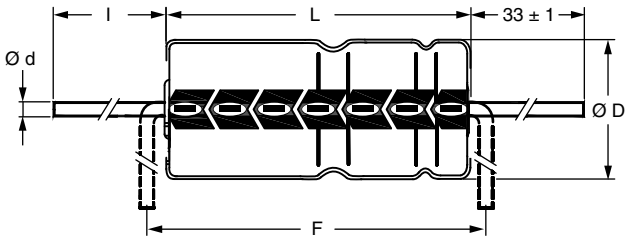
C_R (µF)	U_R (V)					
	160	250	350	385	400	450
1.0	-	-	-	6.5 x 18	-	-
2.2	-	6.5 x 18	-	8 x 18	-	-
4.7	6.5 x 18	8 x 18	10 x 18	10 x 25	-	-
6.8	-	-	10 x 30	10 x 30	10 x 30	10 x 30
10	8 x 18	10 x 25	12.5 x 30	12.5 x 30	12.5 x 30	12.5 x 30
	-	10 x 30	-	-	-	-
15	-	12.5 x 30	12.5 x 30	15 x 30	15 x 30	12.5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

DIMENSIONS in millimeters **AND AVAILABLE FORMS**



Form BR: Taped on reel
Case Ø D x L = 6.5 mm x 18 mm to 15 mm x 30 mm
Form BA: Taped in box (ammopack)
Case Ø D x L = 6.5 mm x 18 mm to 10 mm x 25 mm

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



Form AA: Axial in box
Case Ø D x L = 10 mm x 30 mm to 21 mm x 38 mm

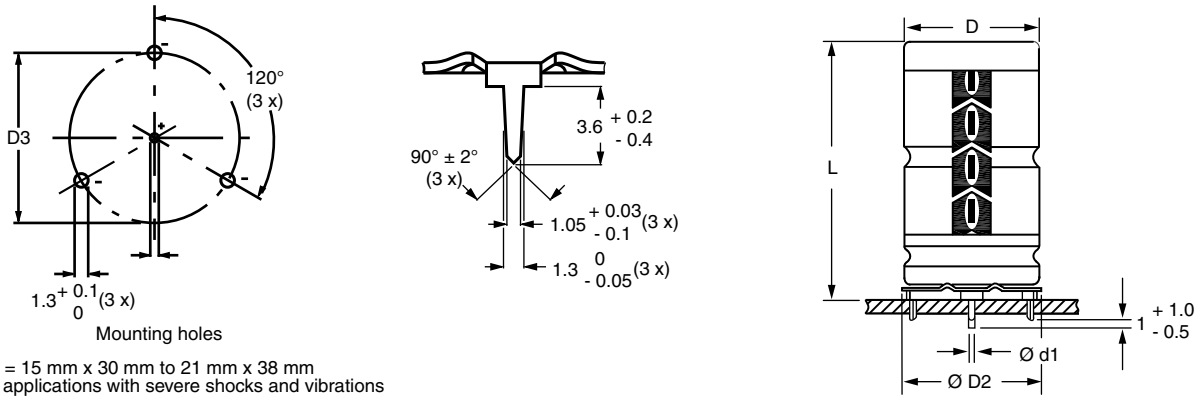
Fig. 3 - **Form AA**

Table 1

AXIAL; DIMENSIONS in millimeters, **MASS AND PACKAGING QUANTITIES**										
NOMINAL CASE SIZE Ø D x L	**CASE CODE**	**AXIAL: FORM AA, BA, AND BR**					**MASS (g)**	**PACKAGING QUANTITIES**		
		Ø d	**l**	**Ø $D_{max.}$**	**$L_{max.}$**	**$F_{min.}$**		**FORM AA**	**FORM BA**	**FORM BR**
6.5 x 18	4	0.8	-	6.9	18.5	25	≈ 1.3	-	1000	1000
8 x 18	5	0.8	-	8.5	18.5	25	≈ 1.7	-	500	500
10 x 18	6	0.8	-	10.5	18.5	25	≈ 2.5	-	500	500
10 x 25	7	0.8	-	10.5	25.5	30	≈ 3.3	-	500	500
10 x 30	00	0.8	55 ± 1	10.5	30.5	35	≈ 4.8	340	-	500
12.5 x 30	01	0.8	55 ± 1	13.0	30.5	35	≈ 7.4	260	-	400
15 x 30	02	0.8	55 ± 1	15.5	30.5	35	≈ 11.7	200	-	250
18 x 30	03	0.8	55 ± 1	18.5	30.5	35	≈ 12.9	120	-	-
18 x 38	04	0.8	34 ± 1	18.5	39.5	44	≈ 19.0	125	-	-
21 x 38	05	0.8	34 ± 1	21.5	39.5	44	≈ 24.0	100	-	-

Note

- For detailed tape dimensions please refer to packaging information: www.vishay.com/doc?28361



Form MR:
Case Ø D x L = 15 mm x 30 mm to 21 mm x 38 mm
Especially for applications with severe shocks and vibrations

Fig. 4 - Mounting hole diagramm and outline. **Form MR:** With mounting ring and pins

Table 2

MOUNTING RING; DIMENSIONS in millimeters, **MASS AND PACKAGING QUANTITIES**									
NOMINAL CASE SIZE Ø D x L	**CASE CODE**	**MOUNTING RING: FORM MR**						**MASS (g)**	**PACKAGING QUANTITIES**
		Ø d1	**Ø d2**	**Ø $D_{max.}$**	**Ø $D2_{max.}$**	**D3**	**$L_{max.}$**		
15 x 30	02	0.8	1.0 + 0.4	15.5	17.5	16.5 ± 0.2	33	≈ 11.7	200
18 x 30	03	0.8	1.0 + 0.4	18.5	19.5	18.5 ± 0.2	33	≈ 12.9	240
18 x 38	04	0.8	1.0 + 0.4	18.5	19.5	18.5 ± 0.2	42	≈ 19.0	100
21 x 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 min at U_R
I_{L5}	Max. leakage current after 5 min at U_R
tan δ	Max. dissipation factor at 100 Hz
ESR	Equivalent series resistance at 100 Hz (calculated from tan $\delta_{max.}$ and C_R)
Z	Max. impedance at 10 kHz

Note

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

ORDERING EXAMPLE

Electrolytic capacitor 041 series

10 µF/250 V; - 10 %/+ 50 %

Nominal case size: Ø 10 mm x 25 mm; Form BA

Ordering code: MAL204133109E3
Former 12NC: 2222 041 33109

ELECTRICAL DATA AND ORDERING INFORMATION

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE Ø D x 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)	ORDERING CODE MAL2..... IN BOX FORM AA	TAPED ON REEL FORM BR	TAPED IN BOX FORM BA	MOUNTING RING FORM MR
160	4.7	6.5 x 18	4	50	38	8	0.15	51	26	-	04121478E3	04131478E3	-
	10	8 x 18	5	70	68	14	0.15	24	12	-	04121109E3	04131109E3	-
	22	10 x 25	7	150	130	25	0.15	11	5.5	-	04121229E3	04131229E3	-
	22	10 x 30	00	190	42	25	0.10	6.8	5.5	04211229E3	04221229E3	-	-
	33	12.5 x 30	01	270	58	36	0.10	4.5	3.1	04211339E3	04221339E3	-	-
	47	15 x 30	02	350	78	49	0.10	3.2	2.1	04211479E3	04221479E3	-	04241479E3
	68	15 x 30	02	420	110	69	0.10	2.2	1.4	04211689E3	04221689E3	-	04241689E3
	100	18 x 30	03	580	150	100	0.10	1.5	1.0	04211101E3	-	-	04241101E3
	150	18 x 38	04	760	230	150	0.10	1.0	0.7	04311151E3	-	-	04341151E3
	220	21 x 38	05	940	330	220	0.10	0.7	0.5	04311221E3	-	-	04341221E3
250	2.2	6.5 x 18	4	35	28	6	0.10	72	50	-	04123228E3	04133228E3	-
	4.7	8 x 18	5	55	55	11	0.10	34	23	-	04123478E3	04133478E3	-
	10	10 x 25	7	90	95	19	0.10	16	11	-	04123109E3	04133109E3	-
	10	10 x 30	00	130	33	19	0.10	15	11	04213109E3	04223109E3	-	-
	15	12.5 x 30	01	180	44	27	0.10	10	7.4	04213159E3	04223159E3	-	-
	22	12.5 x 30	01	220	60	37	0.10	6.8	5.0	04213229E3	04223229E3	-	-
	33	15 x 30	02	290	84	54	0.10	4.5	3.4	04213339E3	04223339E3	-	04243339E3
	47	18 x 30	03	400	120	75	0.10	3.2	2.3	04213479E3	-	-	04243479E3
	68	18 x 38	04	520	160	110	0.10	2.2	1.7	04313689E3	-	-	04343689E3
	100	21 x 38	05	650	240	150	0.10	1.5	1.1	04313101E3	-	-	04343101E3
350	4.7	10 x 18	6	60	69	14	0.10	34	22	-	04125478E3	04135478E3	-
	6.8	10 x 30	00	110	32	18	0.10	22	14	04215688E3	04225688E3	-	-
	10	12.5 x 30	01	150	42	25	0.10	15	10	04215109E3	04225109E3	-	-
	15	12.5 x 30	01	180	57	36	0.10	10	6.7	04215159E3	04225159E3	-	-
	22	15 x 30	02	250	79	50	0.10	6.8	4.5	04215229E3	04225229E3	-	04245229E3
	33	18 x 30	03	350	110	73	0.10	4.5	3.1	04215339E3	-	-	04245339E3
	47	18 x 38	04	450	160	100	0.10	3.2	2.1	04315479E3	-	-	04345479E3
	68	21 x 38	05	560	220	150	0.10	2.2	1.4	04315689E3	-	-	04345689E3
385	1	6.5 x 18	4	20	19	4	0.10	160	100	-	04128108E3	04138108E3	-
	2.2	8 x 18	5	40	42	8	0.10	72	45	-	04128228E3	04138228E3	-
	4.7	10 x 25	7	70	71	15	0.10	34	22	-	04128478E3	04138478E3	-
	6.8	10 x 30	00	110	34	20	0.10	22	14	04218688E3	04228688E3	-	-
	10	12.5 x 30	01	150	45	27	0.10	15	10	04218109E3	04228109E3	-	-
	15	15 x 30	02	210	62	39	0.10	10	6.0	04218159E3	04228159E3	-	04248159E3
	22	18 x 30	03	290	86	55	0.10	6.8	4.1	04218229E3	-	-	04248229E3
	33	18 x 38	04	380	120	80	0.10	4.5	2.7	04318339E3	-	-	04348339E3
	47	18 x 38	04	450	170	110	0.10	3.2	2.1	04318479E3	-	-	04348479E3
	68	21 x 38	05	570	250	160	0.10	2.2	1.4	04318689E3	-	-	04348689E3

ELECTRICAL DATA AND ORDERING INFORMATION

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE Ø D x 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)	ORDERING CODE MAL2..... IN BOX FORM AA	TAPED ON REEL FORM BR	TAPED IN BOX FORM BA	MOUNTING RING FORM MR
400	6.8	10 x 30	00	110	220	110	0.055	11.5	7.3	04216688E3	04226688E3	-	-
	10	12.5 x 30	01	150	240	110	0.055	7.5	4.6	04216109E3	04226109E3	-	-
	15	15 x 30	02	210	250	110	0.055	5.0	3.1	04216159E3	04226159E3	-	04246159E3
	22	18 x 30	03	290	280	120	0.055	3.5	2.1	04216229E3	-	-	04246229E3
	33	18 x 38	04	380	320	130	0.055	2.3	1.4	04316339E3	-	-	04346339E3
	47	18 x 38	04	450	370	140	0.055	1.7	1.1	04316479E3	-	-	04346479E3
	68	21 x 38	05	560	440	150	0.055	1.2	0.7	04316689E3	-	-	04346689E3
450	6.8	10 x 30	00	110	230	110	0.10	22	14	04217688E3	04227688E3	-	-
	10	12.5 x 30	01	150	240	110	0.10	15	10	04217109E3	04227109E3	-	-
	15	12.5 x 30	01	180	260	110	0.10	10	6.0	04217159E3	04227159E3	-	-
	22	15 x 30	02	240	290	120	0.10	6.8	4.1	04217229E3	04227229E3	-	04247229E3
	33	18 x 30	03	350	330	130	0.10	4.5	2.7	04217339E3	-	-	04247339E3
	47	18 x 38	04	440	390	140	0.10	3.2	2.1	04317479E3	-	-	04347479E3
	68	21 x 38	05	550	460	160	0.10	2.2	1.4	04317689E3	-	-	04347689E3

ADDITIONAL ELECTRICAL DATA

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

CAPACITANCE (C)

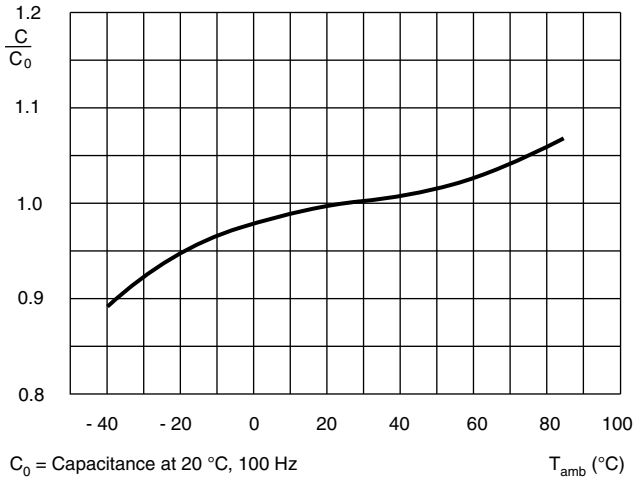


Fig. 5 - Typical multiplier of capacitance as a function of ambient temperature

EQUIVALENT SERIES RESISTANCE (ESR)

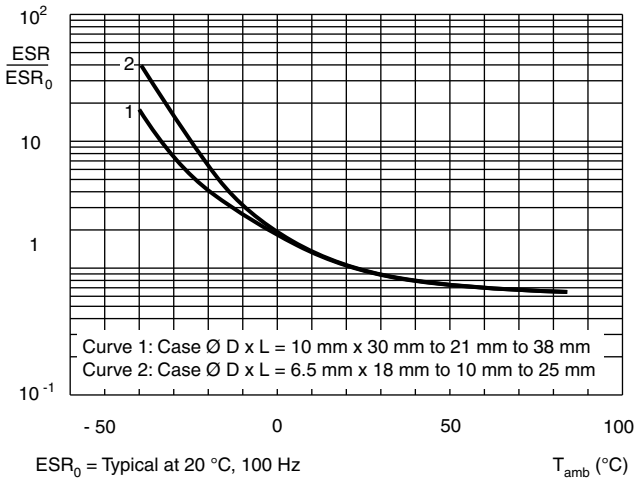


Fig. 6 - Typical multiplier of ESR
as a function of ambient temperature

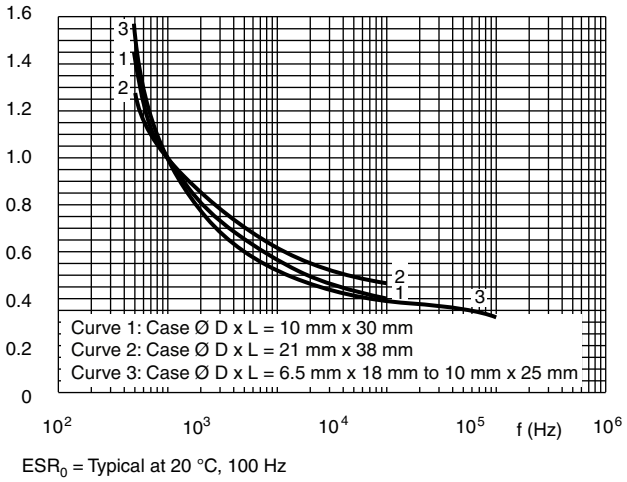


Fig. 7 - Typical multiplier of ESR as a function of frequency

IMPEDANCE (Z)

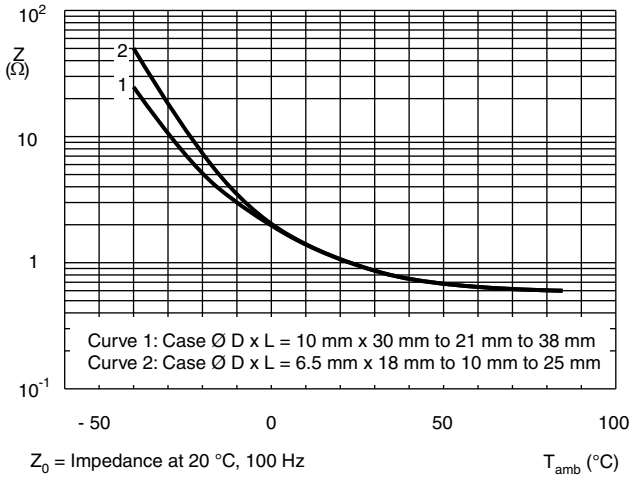


Fig. 8 - Typical impedance of capacitance as a function of ambient temperature

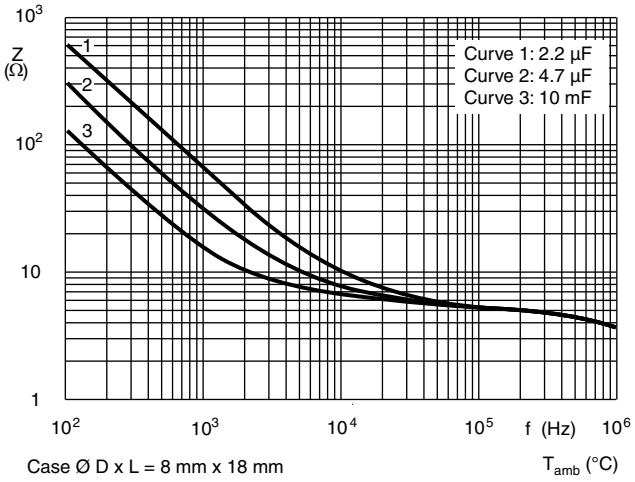


Fig. 9 - Typical impedance as a function of frequency

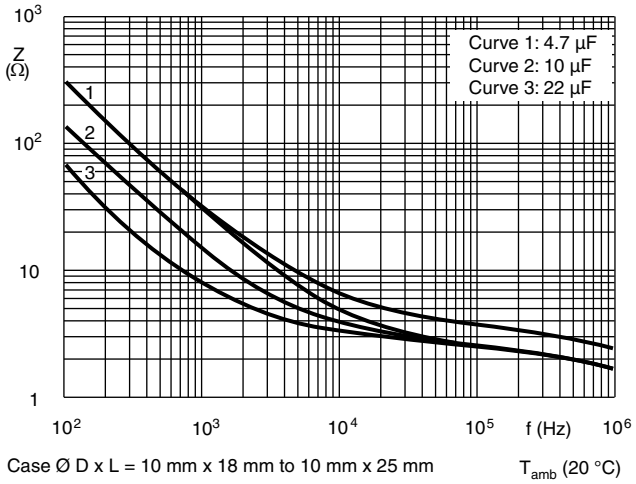


Fig. 10 - Typical impedance as a function of frequency

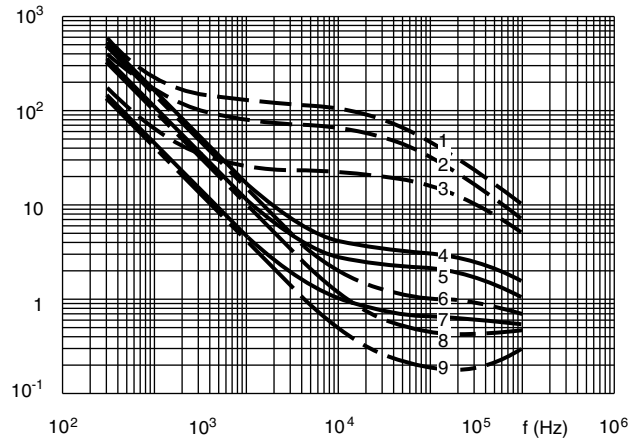
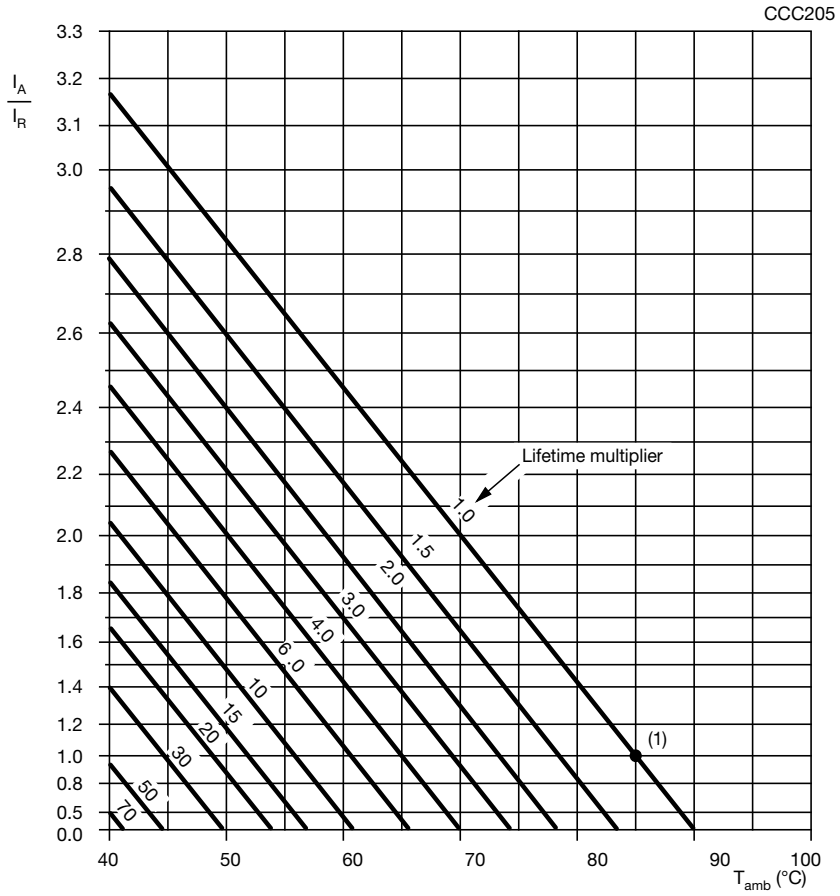


Fig. 11 - Typical impedance as a function of frequency at different ambient tempertures

Curve 1: 10 µF, 350 V 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 V 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 V and 385 V; 85 °C
Curve 8: 15 µF, 250 V; 85 °C
Curve 9: 33 µF, 160 V; 85 °C

RIPPLE CURRENT AND USEFUL LIFE



I_A = Actual ripple current at 100 Hz
I_R = Rated ripple at 100 Hz, 85 °C

(1) Useful life at 85 °C and I_R applied;
Case Ø D x L = 6.5 mm x 18 mm to 10 mm x 25 mm: 5000 h
Case Ø D x L = 6.5 mm x 18 mm to 10 mm x 25 mm: 5000 h (450 V: 10 000 h)

Fig. 12 - Multiplier of useful life as a function of ambient temperature and ripple current load

Table 3

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
≥ 10 000	1.50

Table 4

TEST PROCEDURE 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 Ø D x L: 6.5 mm x 18 mm to 10 mm x 25 mm: 2000 h; 10 mm x 30 mm to 21 mm x 38 mm: 8000 h (450 V: 5000 h)	U_R = 160 V; ΔC/C: ± 15 % U_R = 250 V to 450 V; ΔC/C: ± 10 % tan δ ≤ 1.3 x spec. limit Z ≤ 2 x 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 Ø D x L: 6.5 mm x 18 mm to 10 mm x 25 mm: 5000 h; 10 mm x 30 mm to 21 mm x 38 mm: 15 000 h (450 V: 10 000 h)	U_R = 160 V; ΔC/C: ± 45 % U_R = 250 V to 450 V; ΔC/C: ± 30 % tan δ ≤ 3 x spec. limit Z ≤ 3 x 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 h After test: U_R to be applied for 30 min, 24 h to 48 h before measurement	ΔC/C, tan δ, Z: For requirements see “Endurance test” above I_{L5} ≤ 2 x spec. limit

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