

Aluminum Capacitors

Axial Long Life, DIN-Based

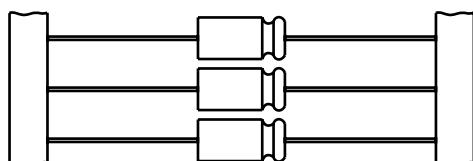
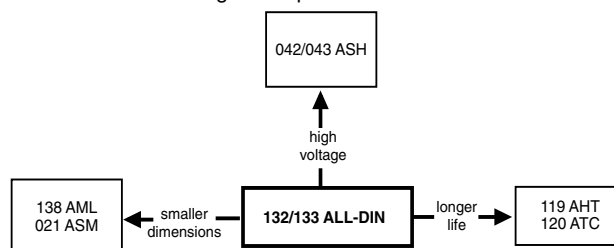


Fig.1 Component outlines


RoHS
COMPLIANT

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 Ø 15 x 30 mm available for automatic insertion
- Charge and discharge proof
- Long useful life: up to 10 000 to 15 000 hours at 85 °C, high reliability
- Lead (Pb)-free versions are RoHS compliant

APPLICATIONS

- General industrial, power supplies, telecommunication, EDP
- Coupling, decoupling, timing; smoothing, filtering and buffering in SMPS
- For use where low mounting height is important
- 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 for factory of origin
- Name of manufacturer
- Band to indicate the negative terminal
- '+' sign to identify the positive terminal
- Series number (132 or 133)

QUICK REFERENCE DATA

DESCRIPTION	VALUE		
Nominal case sizes (Ø D x L in mm)	6.5 x 18 and 8 x 18	10 x 18 and 10 x 25	10 x 30 to 21 x 38
Rated capacitance range, C _R	1 to 4700 µF		
Tolerance on C _R	- 10 to + 50 %		
Rated voltage range, U _R	10 to 350 V		
Category temperature range	- 40 to + 85 °C		
Endurance test at 105 °C	2000 hours	2000 hours	-
Endurance test at 85 °C	6000 hours	8000 hours	8000 hours
Useful life at 105 °C	3000 hours	3000 hours	-
Useful life at 85 °C	10 000 hours	15 000 hours	15 000 hours
Useful life at 40 °C, 1.8 x I _R applied	160 000 hours	240 000 hours	240 000 hours
Shelf life at 0 V, 85 °C	500 hours		
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	160	250	350
1.0	-	-	-	-	-	6.5 x 18	-	-	6.5 x 18
2.2	-	-	-	-	-	6.5 x 18	6.5 x 18	8 x 18	8 x 18
4.7	-	-	-	-	6.5 x 18	6.5 x 18	8 x 18	10 x 18	8 x 18
10	-	-	-	-	6.5 x 18	8 x 18	10 x 18	10 x 25	12.5 x 30 ⁽¹⁾
	-	-	-	-	-	-	-	10 x 30 ⁽¹⁾	-
22	-	-	6.5 x 18	-	8 x 18	10 x 18	10 x 25	12.5 x 30 ⁽¹⁾	-
	-	-	-	-	-	-	10 x 30 ⁽¹⁾	-	-

Note

⁽¹⁾ For these CV-values see data sheet 041 - 043 ASH.

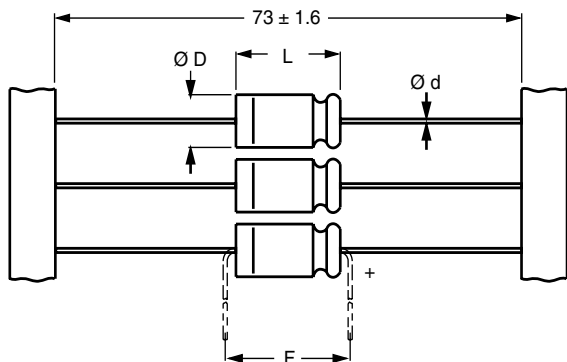
SELECTION CHART FOR C_R , U_R AND RELEVANT NOMINAL CASE SIZES ($\varnothing D \times L$ in mm)

C_R (μF)	U_R (V)								
	10	16	25	40	63	100	160	250	350
47	-	6.5 x 18	-	8 x 18	10 x 18	10 x 25	15 x 30 ⁽¹⁾	18 x 30 ⁽¹⁾	18 x 38 ⁽¹⁾
68	-	-	-	-	-	10 x 30	-	-	-
100	-	8 x 18	-	10 x 18	10 x 30	12.5 x 30	15 x 30 ⁽¹⁾	18 x 38 ⁽¹⁾	21 x 38 ⁽¹⁾
150	-	-	-	12.5 x 30	15 x 30	18 x 30	18 x 38 ⁽¹⁾	-	-
220	8 x 18	10 x 18	10 x 25	12.5 x 30	15 x 30	18 x 38	21 x 38 ⁽¹⁾	-	-
330	-	-	12.5 x 30	-	-	-	-	-	-
470	-	10 x 25	12.5 x 30	15 x 30	18 x 30	18 x 38	-	-	-
680	-	12.5 x 30	-	-	-	-	-	-	-
1000	12.5 x 30	10 x 25	12.5 x 30	15 x 30	18 x 38	21 x 38	-	-	-
1500	-	12.5 x 30	-	-	-	-	-	-	-
2200	12.5 x 30	15 x 30	18 x 30	18 x 30	21 x 38	-	-	-	-
3300	15 x 30	15 x 30	18 x 30	18 x 38	21 x 38	-	-	-	-
4700	18 x 30	18 x 30	18 x 38	21 x 38	-	-	-	-	-
	18 x 30	18 x 38	21 x 38	21 x 38	-	-	-	-	-
	18 x 38	21 x 38	-	-	-	-	-	-	-
	21 x 38	21 x 38	-	-	-	-	-	-	-

Note

⁽¹⁾ For these CV-values see data sheet 041-043 ASH.

DIMENSIONS IN MILLIMETERS AND AVAILABLE FORMS



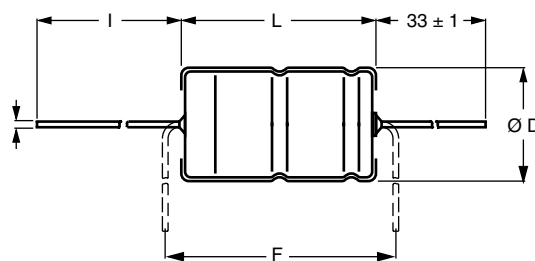
Form BR: Taped on reel

case $\varnothing D \times L = 6.5 \times 18$ to 15×30 mm

Form BA: Taped in box (ammopack)

case $\varnothing D \times L = 6.5 \times 18$ to 10×25 mm

Fig.2 Forms BA and BR



Form AA: Axial in box

case $\varnothing D \times L = 10 \times 30$ to 21×38 mm

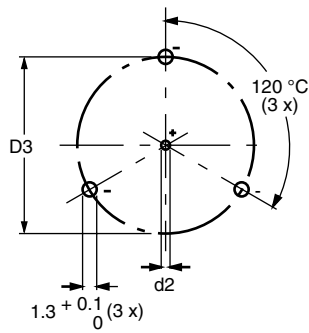
Fig.3 Form AA

Table 1

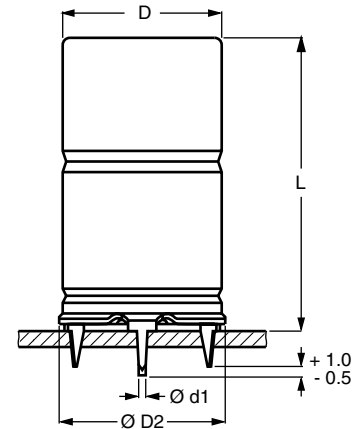
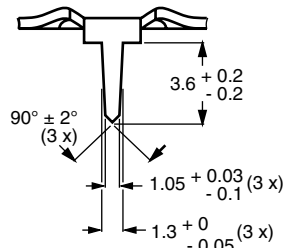
AXIAL; DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES										
NOMINAL CASE SIZE $\varnothing D \times L$	CASE CODE	AXIAL FORM AA, BA, and BR					MASS (g)	PACKAGING QUANTITIES		
		$\varnothing d$	l	$\varnothing D_{max.}$	$L_{max.}$	$F_{min.}$		FORM AA	FORM BA	FORM BR
6.5 x 18	4	0.8	-	6.9	18.5	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

Detailed tape dimensions see section 'PACKAGING'.



Mounting holes

Case $\varnothing D \times L = 15 \times 30$ to 21×38 mm

Case not insulated (insulation on request)

Especially for applications with severe shocks and vibrations

Fig.4 Mounting hole digram and outline; **Form MR:** With mounting ring and pins

Table 2

MOUNTING RING; DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES									
NOMINAL CASE SIZE $\varnothing D \times L$	CASE CODE	MOUNTING RING: FORM MR						MASS (g)	PACKAGING QUANTITIES
		$\varnothing d1$	$\varnothing d2$	$\varnothing D_{max.}$	$\varnothing D2_{max.}$	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/+ 50 %
I_R	rated RMS ripple current at 100 Hz, 85 °C
I_{L5}	max. leakage current after 5 minutes at U_R
$\tan \delta$	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, $P = 86$ to 106 kPa, $RH = 45$ to 75 %.

ORDERING EXAMPLE

Electrolytic capacitor 132 series

100 $\mu F/40$ V; - 10/+ 50 %Nominal case size: $\varnothing 10 \times 18$ mm; Form BR

Ordering code: MAL213227101E3

Former 12NC: 2222 132 27101

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Vishay BCcomponents

Table 3

ELECTRICAL DATA AND ORDERING INFORMATION												
U _R (V)	C _R 100 Hz (μF)	NOMINAL CASE SIZE Ø D x L (mm)	I _R 100 Hz 85 °C (mA)	I _{L5} 5 min (μA)	tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)	Z 100 kHz (Ω)	ORDERING CODE MAL2.....			
									IN BOX FORM AA	TAPED ON REEL FORM BR	TAPED IN BOX FORM BA	MOUNTING RING FORM MR
10	220	8 x 18	190	8.4	0.18	1.3	0.73	0.70	-	13224221E3	13234221E3	-
	470	12.5 x 30	350	9.4	0.18	0.61	0.26	0.60	13214471E3	13224471E3	-	-
	680	12.5 x 30	460	13.6	0.18	0.42	0.20	0.40	13214681E3	13224681E3	-	-
	1000	15 x 30	640	20	0.18	0.28	0.12	-	13214102E3	13224102E3	-	13244102E3
	1500	18 x 30	800	30	0.22	0.23	0.10	-	13214152E3	-	-	13244152E3
	2200	18 x 30	1100	44	0.22	0.16	0.09	-	13214222E3	-	-	13244222E3
	3300	18 x 38	1300	66	0.27	0.13	0.05	-	13214332E3	-	-	13244332E3
	4700	21 x 38	1800	94	0.27	0.09	0.05	-	13214472E3	-	-	13244472E3
16	47	6.5 x 18	95	5.5	0.14	4.7	2.6	2.2	-	13225479E3	13235479E3	-
	100	8 x 18	150	7.2	0.14	2.2	1.2	1.1	-	13225101E3	13235101E3	-
	220	10 x 18	250	11	0.14	1.0	0.55	0.55	-	13225221E3	13235221E3	-
	330	10 x 25	320	14.6	0.14	0.67	0.36	0.36	-	13290508E3	13290509E3	-
	330	12.5 x 30	320	10.6	0.14	0.67	0.36	0.60	13215331E3	13225331E3	-	-
	470	10 x 25	450	19	0.14	0.47	0.26	0.26	-	13290507E3	13290502E3	-
	470	12.5 x 30	450	15	0.14	0.47	0.26	0.40	13215471E3	13225471E3	-	-
	680	15 x 30	550	22	0.14	0.33	0.14	-	13215681E3	13225681E3	-	13245681E3
	1000	15 x 30	780	32	0.14	0.22	0.12	-	13215102E3	13225102E3	-	13245102E3
	1500	18 x 30	950	48	0.15	0.16	0.10	-	13215152E3	-	-	13245152E3
	2200	18 x 38	1300	70	0.15	0.11	0.06	-	13215222E3	-	-	13245222E3
	3300	21 x 38	1600	110	0.15	0.07	0.05	-	13215332E3	-	-	13245332E3
25	4700	21 x 38	2300	150	0.15	0.05	0.05	-	13215472E3	-	-	13245472E3
	22	6.5 x 18	60	5.1	0.11	8.0	4.1	2.9	-	13226229E3	13236229E3	-
	220	10 x 25	340	15	0.11	0.8	0.40	0.40	-	13290503E3	13290504E3	-
	220	12.5 x 30	340	11	0.11	0.8	0.40	0.60	13216221E3	13226221E3	-	-
	330	12.5 x 30	410	16.5	0.11	0.53	0.30	0.40	13216331E3	13226331E3	-	-
	470	12.5 x 30	560	24	0.11	0.37	0.20	-	13216471E3	13226471E3	-	-
	680	18 x 30	700	34	0.11	0.26	0.10	-	13216681E3	-	-	13246681E3
	1000	18 x 30	1000	50	0.11	0.17	0.10	-	13216102E3	-	-	13246102E3
40	1500	18 x 38	1100	75	0.12	0.13	0.06	-	13216152E3	-	-	13246152E3
	2200	21 x 38	1850	110	0.13	0.09	0.05	-	13216222E3	-	-	13246222E3
	47	8 x 18	120	7.8	0.09	3.0	1.6	1.4	-	13227479E3	13237479E3	-
	100	10 x 18	210	12	0.09	1.4	0.75	0.75	-	13227101E3	13237101E3	-
	150	10 x 25	310	16	0.09	0.95	0.50	0.50	-	13290511E3	13290512E3	-
	150	12.5 x 30	310	12	0.09	0.95	0.50	0.60	13217151E3	13227151E3	-	-
	220	12.5 x 30	410	17.5	0.09	0.65	0.34	0.40	13217221E3	13227221E3	-	-
	330	15 x 30	550	26	0.09	0.43	0.20	-	13217331E3	13227331E3	-	13247331E3
63	470	15 x 30	700	38	0.09	0.30	0.16	-	13217471E3	13227471E3	-	13247471E3
	680	18 x 30	900	54	0.09	0.21	0.10	-	13217681E3	-	-	13247681E3
	1000	18 x 38	1200	80	0.09	0.14	0.08	-	13217102E3	-	-	13247102E3
	1500	21 x 38	1500	120	0.10	0.10	0.06	-	13217152E3	-	-	13247152E3
	2200	21 x 38	1900	180	0.10	0.07	0.05	-	13217222E3	-	-	13247222E3
	4.7	6.5 x 18	38	4.6	0.07	24	12	5	-	13228478E3	13238478E3	-
	10	6.5 x 18	64	5.3	0.07	11	5.5	3.3	-	13228109E3	13238109E3	-
	22	8 x 18	100	6.8	0.07	5.1	2.5	2.1	-	13228229E3	13238229E3	-
63	47	10 x 18	170	9.9	0.07	2.4	1.2	1.2	-	13228479E3	13238479E3	-
	68	10 x 25	210	12.6	0.07	1.6	0.81	0.60	-	13290513E3	13290514E3	-
	68	10 x 30	210	8.6	0.07	1.6	0.80	0.60	13218689E3	13228689E3	-	-
	100	10 x 30	300	12.6	0.07	1.1	0.60	0.40	13218101E3	13228101E3	-	-
	150	15 x 30	350	19	0.07	0.74	0.37	-	13218151E3	13228151E3	-	13248151E3
	220	15 x 30	520	28	0.07	0.50	0.25	-	13218221E3	13228221E3	-	13248221E3
	330	18 x 30	600	42	0.07	0.34	0.15	-	13218331E3	-	-	13248331E3
	470	18 x 38	970	59	0.07	0.24	0.12	-	13218471E3	-	-	13248471E3
	680	21 x 38	1000	86	0.07	0.16	0.08	-	13218681E3	-	-	13248681E3
	1000	21 x 38	1600	130	0.07	0.11	0.06	-	13218102E3	-	-	13248102E3

ELECTRICAL DATA AND ORDERING INFORMATION

U _R (V)	C _R 100 Hz (μF)	NOMINAL CASE SIZE Ø D x L (mm)	I _R 100 Hz 85 °C (mA)	I _{L5} 5 min (μA)	tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)	Z 100 kHz (Ω)	ORDERING CODE MAL2.....			
									IN BOX FORM AA	TAPED ON REEL FORM BR	TAPED IN BOX FORM BA	MOUNTING RING FORM MR
100	1	6.5 x 18	20	4.0	0.06	95	45	6	-	13229108E3	13239108E3	-
	2.2	6.5 x 18	30	4.4	0.06	43	20	5	-	13229228E3	13239228E3	-
	4.7	6.5 x 18	48	4.9	0.06	20	9.6	4	-	13229478E3	13239478E3	-
	10	8 x 18	73	6	0.06	9.5	4.5	2.8	-	13229109E3	13239109E3	-
	22	10 x 18	130	8.4	0.06	4.3	2	1.3	-	13229229E3	13239229E3	-
	47	10 x 25	220	13.4	0.06	2.0	1	0.90	-	13290505E3	13290506E3	-
	47	10 x 30	220	9.4	0.06	2.0	1	0.90	13219479E3	13229479E3	-	-
	68	12.5 x 30	250	13.5	0.06	1.4	0.80	-	13219689E3	13229689E3	-	-
	100	15 x 30	380	20	0.06	0.95	0.50	-	13219101E3	13229101E3	-	13249101E3
	150	18 x 30	400	30	0.06	0.64	0.35	-	13219151E3	-	-	13249151E3
	220	18 x 38	660	44	0.06	0.43	0.20	-	13219221E3	-	-	13249221E3
	330	18 x 38	700	66	0.06	0.29	0.15	-	13219331E3	-	-	13249331E3
	470	21 x 38	1200	94	0.06	0.20	0.10	-	13219471E3	-	-	13249471E3
160	2.2	6.5 x 18	22	20	0.10	72	55	30	-	13321228E3	13331228E3	-
	4.7	8 x 18	37	20	0.10	34	26	20	-	13321478E3	13331478E3	-
	10	10 x 18	61	20	0.10	16	12	10	-	13321109E3	13331109E3	-
	22	10 x 25	120	20	0.10	7.2	5.5	2.5	-	13390502E3	13390503E3	-
250	2.2	8 x 18	25	20	0.10	72	50	30	-	13323228E3	13333228E3	-
	4.7	10 x 18	37	20	0.10	34	23	16	-	13323478E3	13333478E3	-
	10	10 x 25	66	20	0.10	16	11	9	-	13323109E3	13333109E3	-
350	1	6.5 x 18	15	20	0.10	160	100	40	-	13325108E3	13335108E3	-
	2.2	8 x 18	25	20	0.10	72	45	28	-	13325228E3	13335228E3	-
	4.7	8 x 18	43	20	0.10	34	21	15	-	13390511E3	13390509E3	-

ADDITIONAL ELECTRICAL DATA

PARAMETER	CONDITIONS	VALUE	
		AXIAL	MOUNTING RING
Voltage			
Surge voltage	$U_R = 10 \text{ to } 250 \text{ V}$	$U_s \leq 1.15 \times U_R$	
	$U_R = 350 \text{ V}$	$U_s \leq 1.1 \times U_R$	
Reverse voltage		$U_{rev} \leq 1 \text{ V}$	
Current			
Leakage current	After 1 minute: Case $\varnothing D \times L = 6.5 \times 18 \text{ to } 10 \times 25 \text{ mm}$: $U_R = 10 \text{ to } 100 \text{ V}$ $U_R = 160 \text{ to } 350 \text{ V}$ Case $\varnothing D \times L = 10 \times 30 \text{ to } 21 \times 38 \text{ mm}$: $U_R = 10 \text{ to } 100 \text{ V}$	$I_{L1} \leq 0.01 C_R \times U_R + 3$ $I_{L1} \leq 50 \mu A$ $I_{L1} \leq 0.006 C_R \times U_R + 3$	
	After 5 minutes: Case $\varnothing D \times L = 6.5 \times 18 \text{ to } 10 \times 25 \text{ mm}$: $U_R = 10 \text{ to } 100 \text{ V}$ $U_R = 160 \text{ to } 350 \text{ V}$ Case $\varnothing D \times L = 10 \times 30 \text{ to } 21 \times 38 \text{ mm}$: $U_R = 10 \text{ to } 100 \text{ V}$	$I_{L5} \leq 0.002 C_R \times U_R + 4$ $I_{L5} \leq 20 \mu A$ $I_{L5} \leq 0.002 C_R \times U_R + 4 \mu A$	
Inductance			
Equivalent series inductance (ESL)	Case $\varnothing D \times L \text{ mm}$:		
	6.5 x 18	typ. 15 nH	-
	8 x 18	typ. 35 nH	-
	10 x 18	typ. 69 nH	-
	10 x 25	typ. 38 nH	-
	10 x 30	typ. 38 nH	-
	12.5 x 30	typ. 46 nH	-
	15 x 30	typ. 48 nH	typ. 39 nH
	18 x 30	typ. 50 nH	typ. 39 nH
	18 x 38	typ. 54 nH	typ. 39 nH
	21 x 38	typ. 59 nH	typ. 39 nH

CAPACITANCE (C)

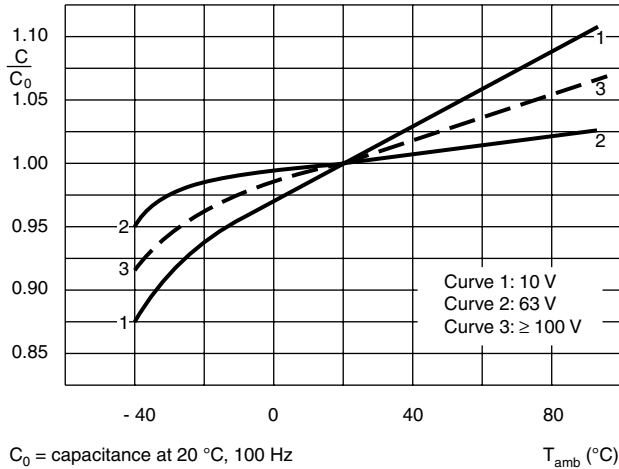


Fig.5 Typical multiplier of capacitance as a function of ambient temperature at 10 kHz

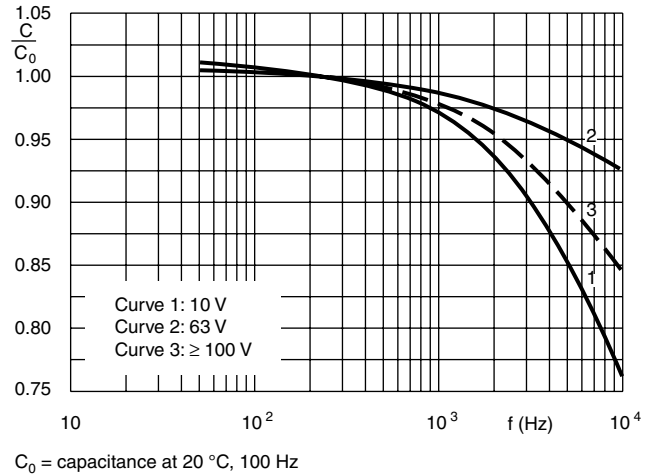


Fig.6 Typical multiplier of capacitance as a function of frequency

DISSIPATION FACTOR ($\tan \delta$)

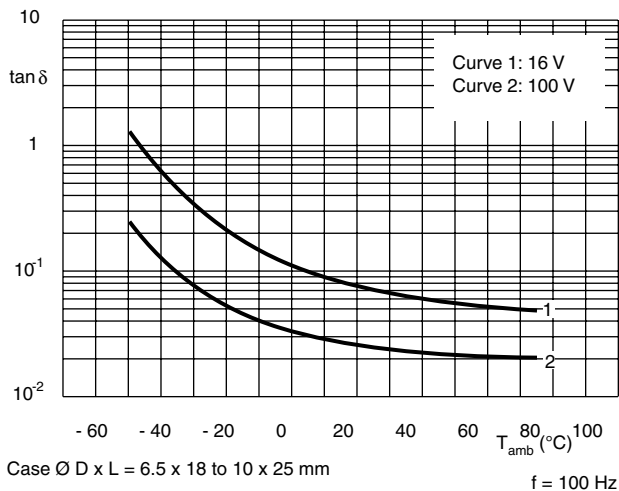


Fig.7 Typical $\tan \delta$ as a function of ambient temperature

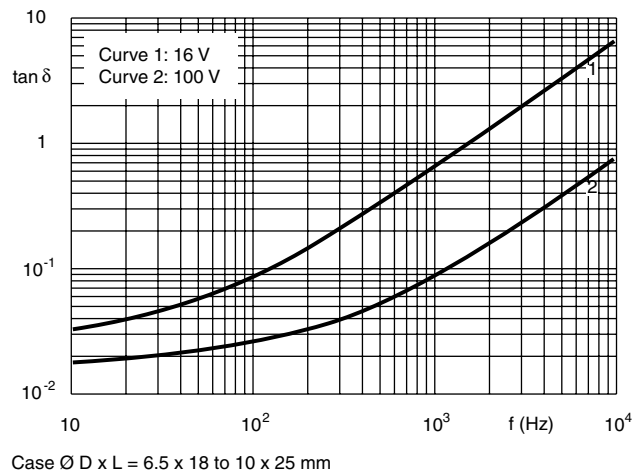


Fig.8 Typical $\tan \delta$ as a function of frequency

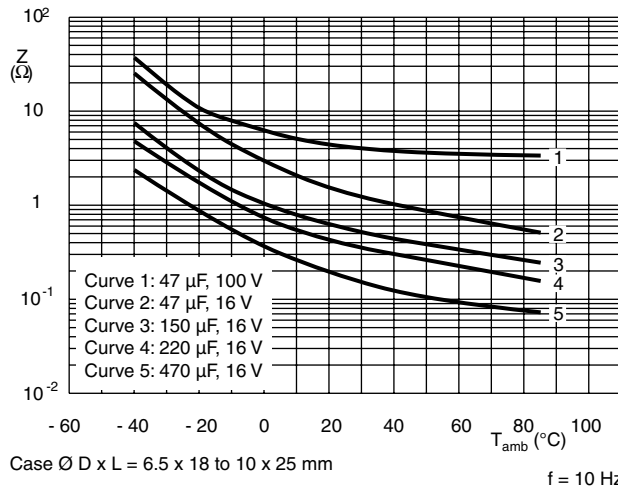
IMPEDANCE (Z)

Fig.9 Typical impedance as a function of ambient temperature

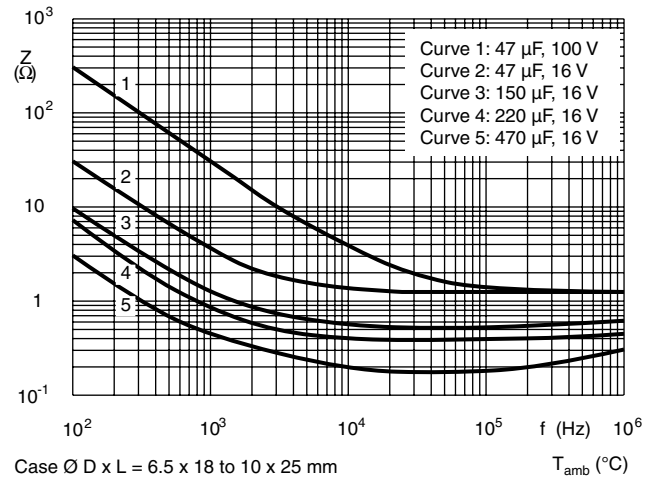


Fig.10 Typical impedance as a function of frequency

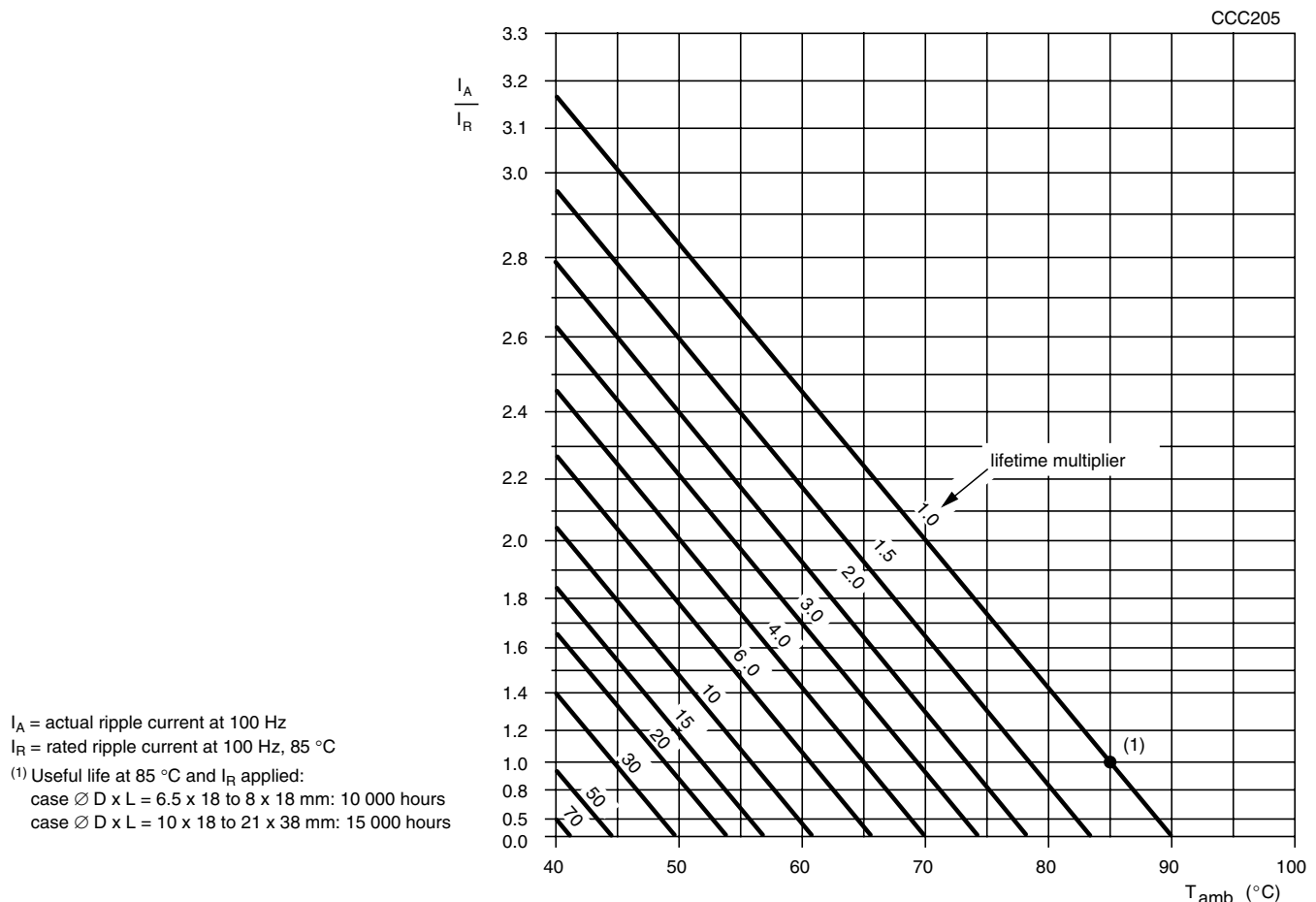
RIPPLE CURRENT AND USEFUL LIFE

Fig.11 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		
	$U_R = 10$ and 16 V	$U_R = 25$ and 63 V	$U_R = 100$ to 350 V
50	0.95	0.90	0.85
100	1.00	1.00	1.00
300	1.07	1.12	1.20
1000	1.12	1.20	1.30
3000	1.15	1.25	1.35
$\geq 10\,000$	1.20	1.30	1.40

Table 5

TEST PROCEDURES AND REQUIREMENTS			
TEST		PROCEDURE (quick reference)	REQUIREMENTS
NAME OF TEST	REFERENCE		
Endurance	IEC 60384-4/ EN130300 subclause 4.13	$T_{amb} = 85\text{ }^{\circ}\text{C}$; U_R applied; Case $\varnothing D \times L = 6.5 \times 18$ to 8×18 mm: 6000 hours; Case $\varnothing D \times L = 10 \times 18$ to 21×38 mm: 8000 hours	$U_R = 10$ to 160 V; $\Delta C/C: \pm 15\%$ $U_R = 250$ to 350 V; $\Delta C/C: \pm 10\%$ $\tan \delta \leq 1.3 \times \text{spec. limit}$ $Z \leq 2 \times \text{spec. limit}$ $I_{L5} \leq \text{spec. limit}$
Useful life	CECC 30301 subclause 1.8.1	$T_{amb} = 85\text{ }^{\circ}\text{C}$; U_R and I_R applied; Case $\varnothing D \times L = 6.5 \times 18$ to 8×18 mm: 10 000 hours; Case $\varnothing D \times L = 10 \times 18$ to 21×38 mm: 15 000 hours	$U_R = 10$ to 160 V; $\Delta C/C: \pm 45\%$ $U_R = 250$ to 350 V; $\Delta C/C: \pm 30\%$ $\tan \delta \leq 3 \times \text{spec. limit}$ $Z \leq 3 \times \text{spec. limit}$ $I_{L5} \leq \text{spec. limit}$ no short or open circuit total failure percentage: $\leq 1\%$
Shelf life (storage at high temperature)	IEC 60384-4/ EN130300 subclause 4.17	$T_{amb} = 85\text{ }^{\circ}\text{C}$; no voltage applied; 500 hours; After test: U_R to be applied for 30 minutes, 24 to 48 hours before measurement	$\Delta C/C$, $\tan \delta$, Z : for requirements see 'Endurance test' above $I_{L5} \leq 2 \times \text{spec. limit}$



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