Aluminum Capacitors
Axial Miniature, Long-Life

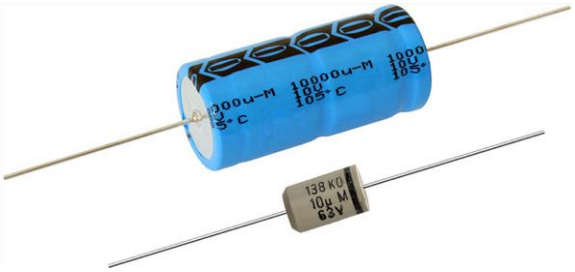

Fig. 1

QUICK REFERENCE DATA		
DESCRIPTION	**VALUE**	
Nominal case sizes (Ø D x L in mm)	6.3 x 12.7 to 10 x 25	10 x 30 to 21 x 38
Rated capacitance range, C_R	1.0 µF to 15 000 µF	
Tolerance on C_R	± 20 %	
Rated voltage range, U_R	6.3 V to 100 V	
Category temperature range	- 40 °C to + 105 °C	
Endurance test at 105 °C	1000 h	5000 h
Useful life at 105 °C	2000 h	10 000 h
Useful life at 40 °C, I_R applied	1.3 x I_R applied: 200 000 h	1.8 x I_R applied: 500 000 h
Shelf life at 0 V, 105 °C	500 h	
Based on sectional specification	IEC 60384-4/EN130 300	
Climatic category IEC 60068	40/105/56	

FEATURES

- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Axial leads, cylindrical aluminum case, insulated with a blue sleeve
  (case Ø 6.3 mm x 12.7 mm and 7.7 mm x 12.7 mm are molded with flame retardant plastic material)
- Mounting ring version not available in insulated form
- Taped versions up to case Ø 15 mm x 30 mm available for automatic insertion
- Charge and discharge proof
- Long useful life: 2000 h to 10 000 h at 105 °C, high reliability
- High ripple current capability
- Miniaturized, high CV-product per unit volume
- Material categorization: For definitions of compliance please see www.vishay.com/doc?99912

Pb-free

RoHS COMPLIANT

APPLICATIONS

- Industrial, automotive, EDP and telecommunication
- Smoothing, filtering, buffering in SMPS; coupling, decoupling, timing
- Portable and mobile equipment (small size, low mass)
- Stand-by applications
- Low mounting height boards, 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 (M for ± 20 %)
- Rated voltage (in V)
- Upper category temperature (105 °C)
- Date code, in accordance with IEC 60062
- Code for factory of origin
- Name of manufacturer
- Negative terminal identification
- Series number (138)

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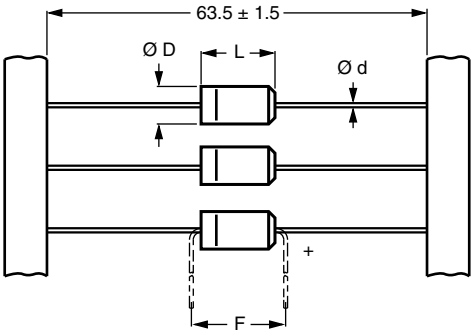
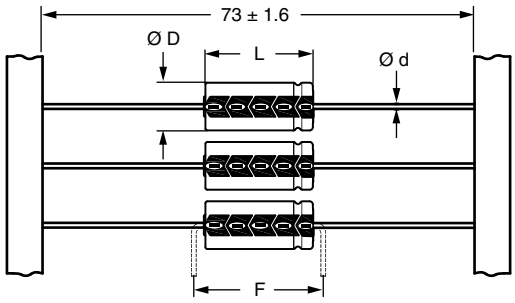
SELECTION CHART FOR C_R, U_R, AND RELEVANT NOMINAL CASE SIZES (Ø D x L in mm)								
C_R (µF)	U_R (V)							
	6.3	10	16	25	40	50	63	100
1.0	-	-	-	-	-	-	-	6.3 x 12.7
2.2	-	-	-	-	-	-	-	6.3 x 12.7
4.7	-	-	-	-	-	-	6.3 x 12.7	7.7 x 12.7
10	-	-	-	6.3 x 12.7	-	6.3 x 12.7	7.7 x 12.7	6.5 x 18
22	-	-	6.3 x 12.7	6.3 x 12.7	-	7.7 x 12.7	6.5 x 18	8 x 18
33	-	-	-	6.3 x 12.7	7.7 x 12.7	-	-	-
47	-	-	6.3 x 12.7	7.7 x 12.7	6.5 x 18	-	8 x 18	10 x 25
68	-	-	-	-	-	-	-	10 x 30
100	6.3 x 12.7	-	7.7 x 12.7	6.5 x 18	8 x 18	10 x 18	10 x 25	12.5 x 30
150	-	7.7 x 12.7	-	-	-	-	10 x 30	15 x 30
220	7.7 x 12.7	6.5 x 18	8 x 18	10 x 18	10 x 25	-	12.5 x 30	15 x 30
330	-	-	-	-	10 x 30	-	12.5 x 30	18 x 30
470	6.5 x 18	8 x 18	10 x 18	10 x 25	12.5 x 30	-	15 x 30	18 x 38
680	-	-	-	10 x 30	12.5 x 30	-	18 x 30	21 x 38
1000	10 x 18	10 x 25	10 x 30	12.5 x 30	15 x 30	-	18 x 38	-
1500	-	10 x 30	12.5 x 30	15 x 30	18 x 30	-	21 x 38	-
2200	10 x 25	12.5 x 30	15 x 30	18 x 30	18 x 38	-	-	-
3300	-	15 x 30	18 x 30	18 x 38	21 x 38	-	-	-
4700	-	18 x 30	18 x 30	18 x 38	-	-	-	-
6800	-	18 x 38	18 x 38	21 x 38	-	-	-	-
10 000	-	18 x 38	21 x 38	-	-	-	-	-
15 000	-	21 x 38	-	-	-	-	-	-

DIMENSIONS in millimeters AND AVAILABLE FORMS



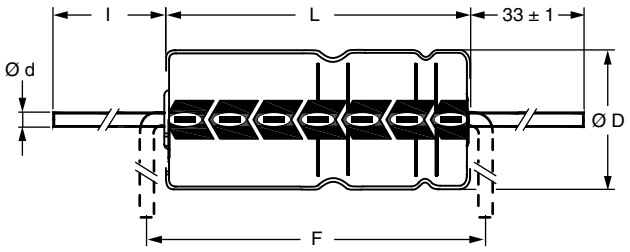
Form BR: Taped on reel
Form BA: Taped in box (ammopack)
Case Ø D x L = 6.3 mm x 12.7 mm to 7.7 mm x 12.7 mm

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



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. 3 - **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. 4 - **Form AA**

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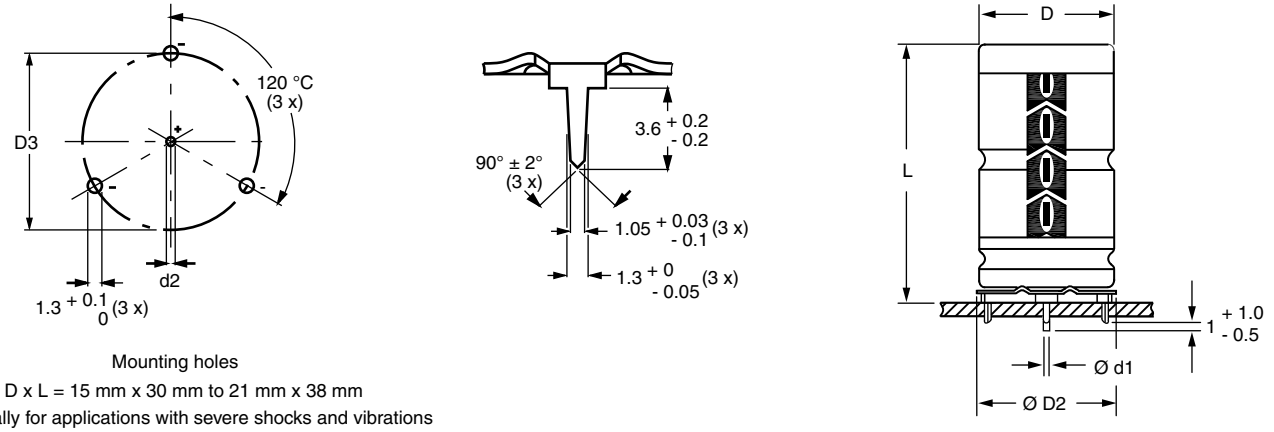
Table 1

AXIAL; DIMENSIONS in millimeters, **MASS AND PACKAGING QUANTITIES**										
NOMINAL CASE SIZE Ø D x L (mm)	**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**
6.3 x 12.7	(2)	0.6	-	6.5	12.9	17.5	≈ 1.1	-	1000	1000
7.7 x 12.7	(3)	0.6	-	7.9	12.9	17.5	≈ 1.3	-	500	500
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 refer to packaging information: www.vishay.com/doc?28361



Mounting holes

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. 5 - Mounting hole diagram 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**	**$D_{max.}$**	**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

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ELECTRICAL DATA	
SYMBOL	DESCRIPTION
C_R	Rated capacitance at 100 Hz, tolerance ± 20 %
I_R	Rated RMS ripple current at 100 Hz, 105 °C
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 or 100 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 138 series

470 µF/10 V; ± 20 %

Nominal case size: Ø 8 mm x 18 mm; Form BA

Ordering code: MAL213834471E3
Former 12 NC: 2222 138 34471

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 105 °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 MAL2138.....			
									IN BOX FORM AA	TAPED ON REEL FORM BR	TAPED IN BOX FORM BA	MOUNTING RING FORM MR
6.3	100	6.3 x 12.7	99	5.3	0.24	3.800	3.000	1.800	-	23101E3	33101E3	-
	220	7.7 x 12.7	160	6.8	0.24	1.700	1.400	0.950	-	23221E3	33221E3	-
	470	6.5 x 18	250	9.9	0.24	0.810	0.640	0.500	-	23471E3	33471E3	-
	1000	10 x 18	430	17	0.24	0.380	0.300	0.240	-	23102E3	33102E3	-
	2200	10 x 25	640	32	0.29	0.210	0.180	0.150	-	23222E3	33222E3	-
10	150	7.7 x 12.7	140	7.0	0.2	2.100	1.300	0.950	-	24151E3	34151E3	-
	220	6.5 x 18	190	8.4	0.2	1.400	0.910	0.500	-	24221E3	34221E3	-
	470	8 x 18	300	13	0.2	0.680	0.430	0.350	-	24471E3	34471E3	-
	1000	10 x 25	520	24	0.2	0.320	0.200	0.160	-	24102E3	34102E3	-
	1500	10 x 30	670	34	0.28	0.320	0.260	0.260	14152E3	24152E3	-	-
	2200	12.5 x 30	890	48	0.29	0.220	0.190	0.190	14222E3	24222E3	-	-
	3300	15 x 30	1140	70	0.30	0.160	0.130	0.150	14332E3	24332E3	-	44332E3
	4700	18 x 30	1450	98	0.33	0.120	0.110	0.130	14472E3	-	-	44472E3
	6800	18 x 38	1880	140	0.34	0.085	0.074	0.110	14682E3	-	-	44682E3
	10 000	18 x 38	1980	200	0.41	0.070	0.062	0.100	14103E3	-	-	44103E3
	15 000	21 x 38	2200	300	0.55	0.063	0.058	0.099	14153E3	-	-	44153E3
16	22	6.3 x 12.7	58	4.7	0.12	8.700	7.300	2.700	-	25229E3	35229E3	-
	47	6.3 x 12.7	83	5.5	0.16	5.400	3.400	1.900	-	25479E3	35479E3	-
	100	7.7 x 12.7	130	7.2	0.16	2.500	1.600	1.000	-	25101E3	35101E3	-
	220	8 x 18	230	11	0.16	1.200	0.730	0.350	-	25221E3	35221E3	-
	470	10 x 18	360	19	0.16	0.540	0.340	0.250	-	25471E3	35471E3	-
	1000	10 x 30	630	36	0.20	0.340	0.270	0.260	15102E3	25102E3	-	-
	1500	12.5 x 30	860	52	0.20	0.230	0.190	0.190	15152E3	25152E3	-	-
	2200	15 x 30	1090	74	0.21	0.170	0.140	0.150	15222E3	25222E3	-	45222E3
	3300	18 x 30	1420	110	0.24	0.120	0.100	0.130	15332E3	-	-	45332E3
	4700	18 x 30	1480	150	0.28	0.100	0.090	0.120	15472E3	-	-	45472E3
	6800	18 x 38	1930	220	0.28	0.072	0.062	0.100	15682E3	-	-	45682E3
	10 000	21 x 38	2100	320	0.38	0.065	0.057	0.098	15103E3	-	-	45103E3
25	10	6.3 x 12.7	46	4.5	0.09	14.000	12.000	2.800	-	26109E3	36109E3	-
	22	6.3 x 12.7	61	5.1	0.14	10.000	5.500	2.500	-	26229E3	36229E3	-
	33	6.3 x 12.7	74	5.7	0.14	6.800	3.600	1.900	-	26339E3	36339E3	-
	47	7.7 x 12.7	96	6.4	0.14	4.700	2.600	1.000	-	26479E3	36479E3	-

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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 105 °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 MAL2138.....			
									IN BOX FORM AA	TAPED ON REEL FORM BR	TAPED IN BOX FORM BA	MOUNTING RING FORM MR
25	100	6.5 x 18	160	9.0	0.13	2.100	1.200	0.550	-	26101E3	36101E3	-
	220	10 x 18	270	15	0.13	0.940	0.550	0.270	-	26221E3	36221E3	-
	470	10 x 25	440	28	0.13	0.440	0.260	0.170	-	26471E3	36471E3	-
	680	10 x 30	580	38	0.14	0.360	0.260	0.250	16681E3	26681E3	-	-
	1000	12.5 x 30	790	54	0.15	0.250	0.180	0.190	16102E3	26102E3	-	-
	1500	15 x 30	1020	79	0.15	0.170	0.130	0.150	16152E3	26152E3	-	46152E3
	2200	18 x 30	1320	110	0.17	0.130	0.100	0.130	16222E3	-	-	46222E3
	3300	18 x 38	1720	170	0.17	0.090	0.071	0.110	16332E3	-	-	46332E3
	4700	18 x 38	1840	240	0.21	0.076	0.063	0.100	16472E3	-	-	46472E3
	6800	21 x 38	2100	340	0.27	0.068	0.058	0.099	16682E3	-	-	46682E3
40	33	7.7 x 12.7	91	6.6	0.11	5.300	2.700	1.000	-	27339E3	37339E3	-
	47	6.5 x 18	120	7.8	0.10	3.400	1.900	0.650	-	27479E3	37479E3	-
	100	8 x 18	180	12	0.10	1.600	0.900	0.400	-	27101E3	37101E3	-
	220	10 x 25	350	22	0.10	0.720	0.410	0.200	-	27221E3	37221E3	-
	330	10 x 30	490	30	0.09	0.470	0.320	0.300	17331E3	27331E3	-	-
	470	12.5 x 30	650	42	0.09	0.340	0.230	0.220	17471E3	27471E3	-	-
	680	12.5 x 30	750	58	0.10	0.250	0.180	0.180	17681E3	27681E3	-	-
	1000	15 x 30	970	84	0.10	0.170	0.120	0.140	17102E3	27102E3	-	47102E3
	1500	18 x 30	1250	120	0.12	0.130	0.098	0.120	17152E3	-	-	47152E3
	2200	18 x 38	1640	180	0.12	0.093	0.069	0.100	17222E3	-	-	47222E3
	3300	21 x 38	1810	270	0.15	0.079	0.061	0.100	17332E3	-	-	47332E3
50	10	6.3 x 12.7	51	5.0	0.09	14.00	7.000	2.700	-	21109E3	31109E3	-
	22	7.7 x 12.7	82	6.2	0.09	6.500	3.002	1.100	-	21229E3	31229E3	-
	100	10 x 18	230	14	0.08	1.300	0.700	0.300	-	21101E3	31101E3	-
63	4.7	6.3 x 12.7	35	4.6	0.09	30.00	17.000	5.000	-	28478E3	38478E3	-
	10	7.7 x 12.7	59	5.3	0.08	13.00	8.000	1.800	-	28109E3	38109E3	-
	22	6.5 x 18	100	6.8	0.07	5.100	3.600	0.850	-	28229E3	38229E3	-
	47	8 x 18	150	9.9	0.07	2.400	1.700	0.500	-	28479E3	38479E3	-
	100	10 x 25	280	17	0.07	1.100	0.800	0.270	-	28101E3	38101E3	-
	150	10 x 30	410	23	0.11	0.730	0.440	0.400	18151E3	28151E3	-	-
	220	12.5 x 30	560	32	0.11	0.500	0.310	0.290	18221E3	28221E3	-	-
	330	12.5 x 30	660	46	0.12	0.370	0.230	0.220	18331E3	28331E3	-	-
	470	15 x 30	860	63	0.12	0.260	0.160	0.160	18471E3	28471E3	-	48471E3
	680	18 x 30	1130	90	0.12	0.190	0.120	0.140	18681E3	-	-	48681E3
	1000	18 x 38	1460	130	0.12	0.130	0.086	0.110	18102E3	-	-	48102E3
	1500	21 x 38	1680	190	0.13	0.100	0.072	0.110	18152E3	-	-	48152E3
100	1.0	6.3 x 12.7	16	4.2	0.09	140.0	55.000	10.00	-	29108E3	39108E3	-
	2.2	6.3 x 12.7	24	4.4	0.09	65.00	25.000	8.000	-	29228E3	39228E3	-
	4.7	7.7 x 12.7	40	4.9	0.08	27.00	17.000	5.000	-	29478E3	39478E3	-
	10	6.5 x 18	67	6.0	0.07	11.00	8.000	2.400	-	29109E3	39109E3	-
	22	8 x 18	100	8.4	0.07	5.100	3.600	1.400	-	29229E3	39229E3	-
	47	10 x 25	190	13	0.07	2.400	1.700	0.670	-	29479E3	39479E3	-
	68	10 x 30	300	18	0.07	1.700	1.100	0.970	19689E3	29689E3	-	-
	100	12.5 x 30	410	24	0.07	1.100	0.770	0.670	19101E3	29101E3	-	-
	150	15 x 30	550	34	0.07	0.780	0.520	0.460	19151E3	29151E3	-	49151E3
	220	15 x 30	650	48	0.07	0.540	0.370	0.330	19221E3	29221E3	-	49221E3
	330	18 x 30	880	70	0.08	0.380	0.270	0.240	19331E3	-	-	49331E3
	470	18 x 38	1130	98	0.08	0.270	0.190	0.170	19471E3	-	-	49471E3
	680	21 x 38	1330	140	0.09	0.210	0.140	0.140	19681E3	-	-	49681E3

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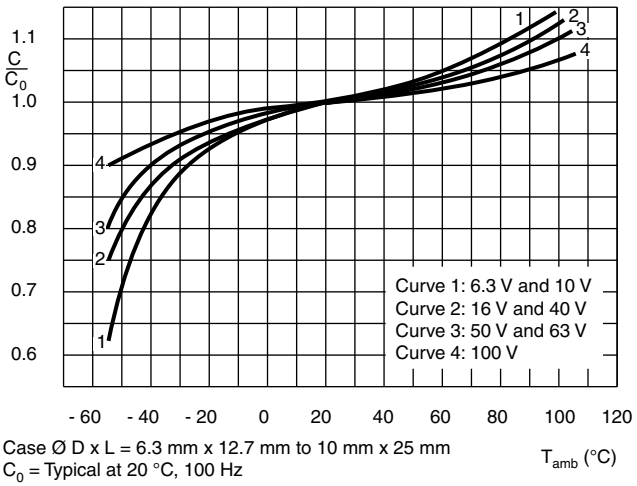
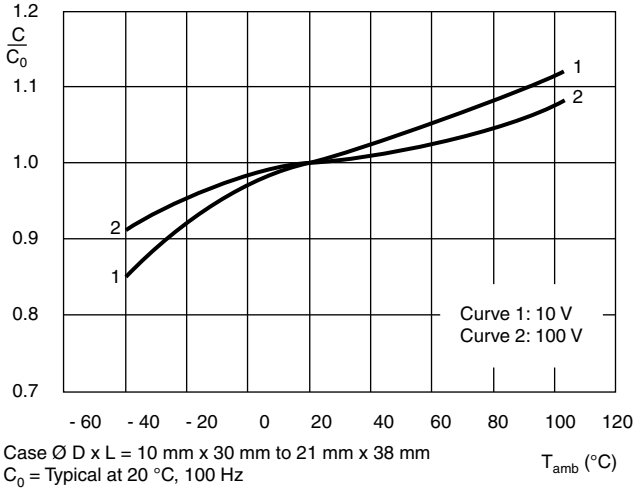
ADDITIONAL ELECTRICAL DATA			
PARAMETER	CONDITIONS	VALUE	
		AXIAL	MOUNTING RING
Voltage			
Surge voltage		$U_s \leq 1.15 \times U_R$	
Reverse voltage		$U_{rev} \leq 1$ V	
Current			
Leakage current	After 1 min at U_R: Case Ø D x L = 6.3 mm x 12.7 mm and 7.7 mm x 12.7 mm Case Ø D x L = 6.5 mm x 18 mm to 21 mm x 38 mm	$I_{L1} \leq 0.02\ C_R \times U_R + 3$ µA $I_{L1} \leq 0.006\ C_R \times U_R + 4$ 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 x L mm:		
	6.3 x 12.7	Typ. 20 nH	-
	7.7 x 12.7	Typ. 30 nH	-
	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)



Case Ø D x L = 6.3 mm x 12.7 mm to 10 mm x 25 mm
C_0 = Typical at 20 °C, 100 Hz

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



Case Ø D x L = 10 mm x 30 mm to 21 mm x 38 mm
C_0 = Typical at 20 °C, 100 Hz

Fig. 7 - Typical multiplier of capacitance as a function of ambient temperature

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EQUIVALENT SERIES RESISTANCE (ESR)

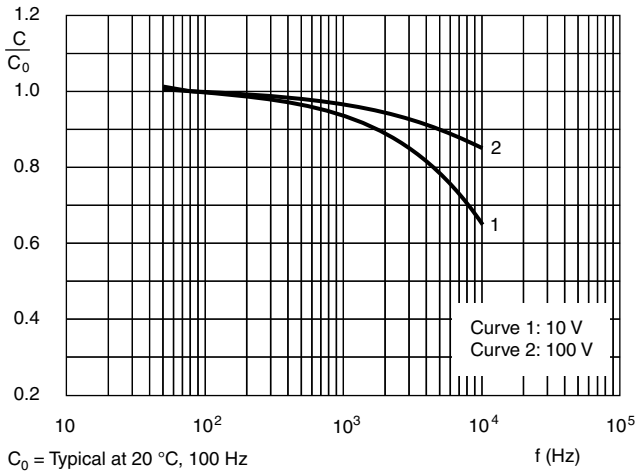

Fig. 8 - Typical multiplier of capacitance as a function of frequency

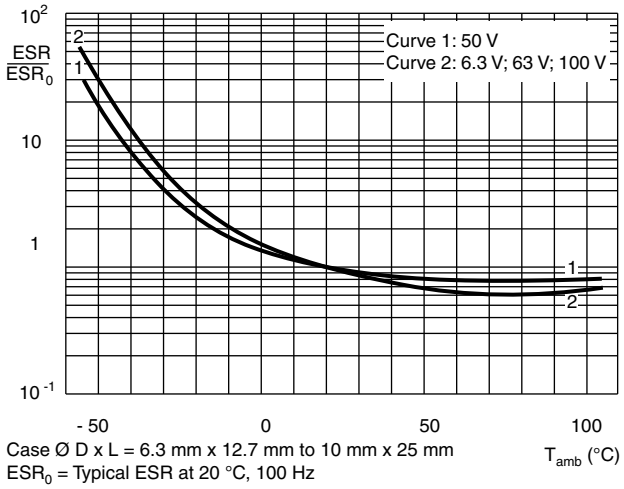

Fig. 9 - Typical multiplier of ESR as a function of ambient temperature

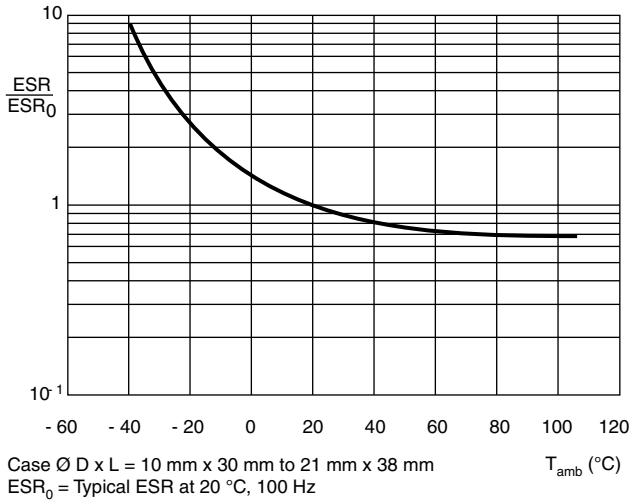

Fig. 10 - Typical multiplier of ESR as a function of ambient temperature

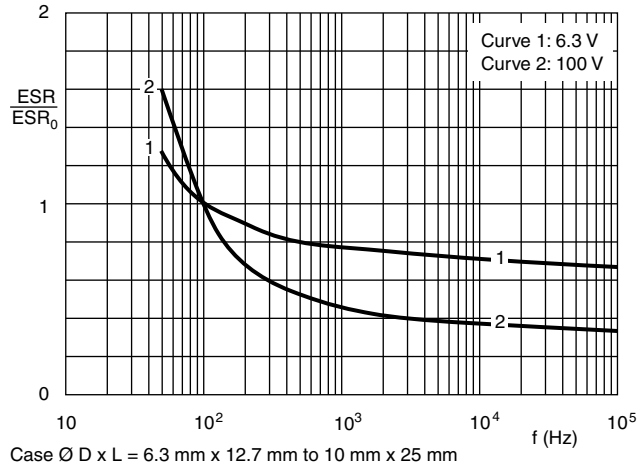

Fig. 11 - Typical multiplier ESR as a function of frequency

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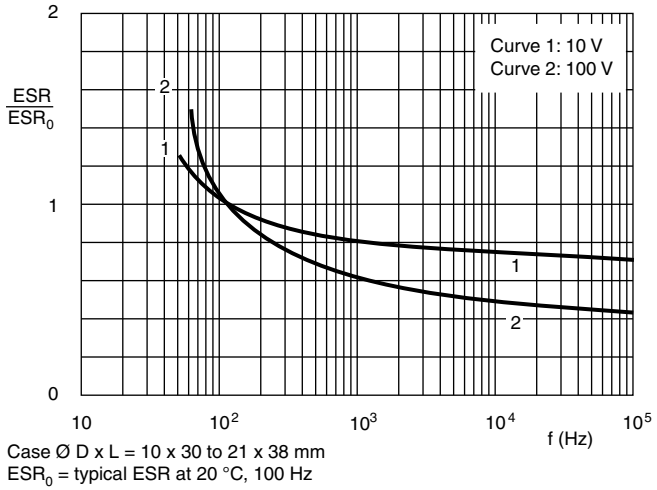
EQUIVALENT SERIES RESISTANCE (ESR)



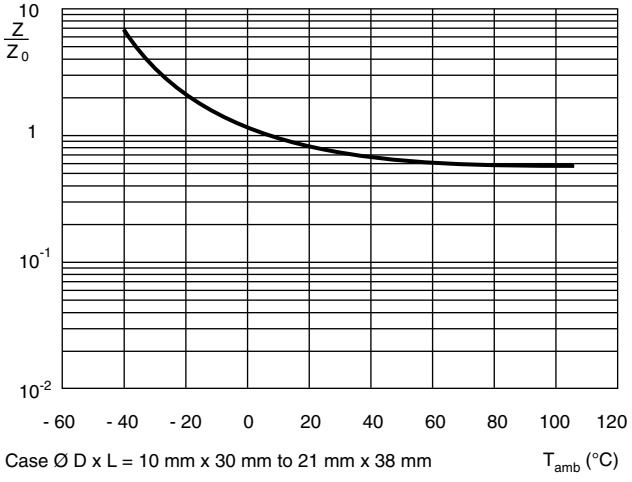
Case Ø D x L = 10 x 30 to 21 x 38 mm
ESR_0 = typical ESR at 20 °C, 100 Hz

Fig. 12 - Typical multiplier ESR as a function of frequency

IMPEDANCE (Z)

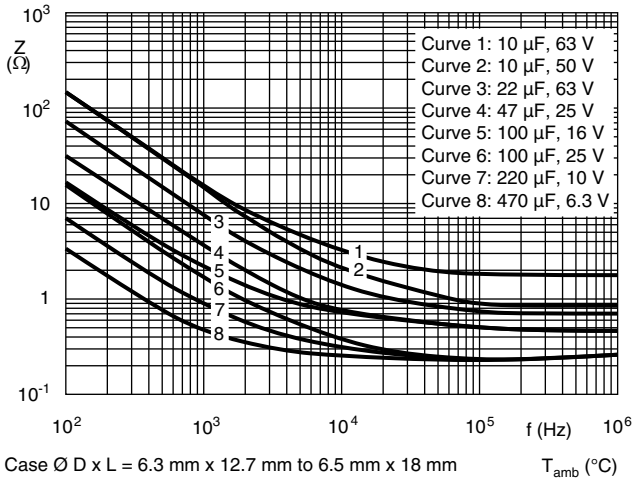
Table 4

IMPEDANCE VS. CAPACITANCE VALUES (Case Ø D x L = 6.3 mm x 12.7 mm to 10 mm x 25 mm)								
T_{amb}	**Z x C_R (Ω x µF) AT 10 kHz**							
	6.3 V	**10 V**	**16 V**	**25 V**	**40 V**	**50 V**	**63 V**	**100 V**
+ 20 °C	≤ 300	≤ 200	≤ 160	≤ 120	≤ 90	≤ 70	≤ 80	≤ 80
- 25 °C	≤ 2000	≤ 1200	≤ 750	≤ 560	≤ 450	≤ 300	≤ 550	≤ 550
- 40 °C	≤ 5500	≤ 3200	≤ 2000	≤ 1500	≤ 1200	≤ 900	≤ 1500	≤ 1500



Case Ø D x L = 10 mm x 30 mm to 21 mm x 38 mm

Fig. 13 - Typical multiplier of ESR as a function of ambient temperature at 10 kHz



Case Ø D x L = 6.3 mm x 12.7 mm to 6.5 mm x 18 mm

Fig. 14 - Typical impedance as a function of frequency

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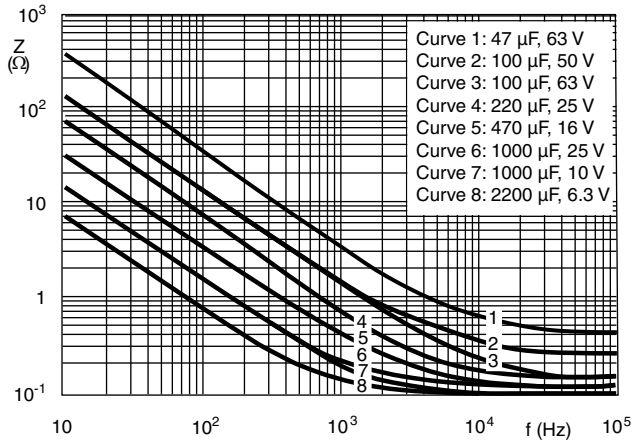

Fig. 15 - Typical impedance as a function of frequency

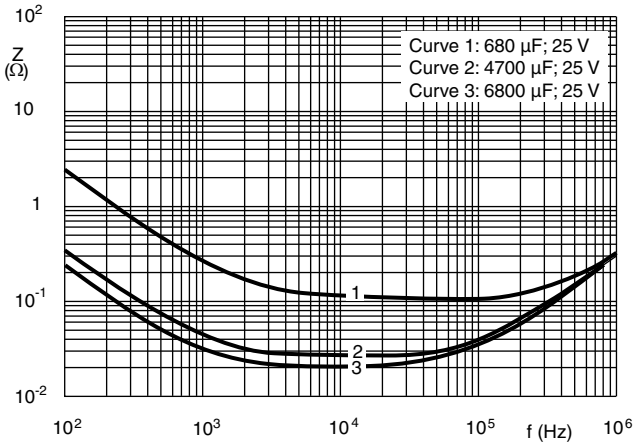

Fig. 16 - Typical impedance as a function of frequency

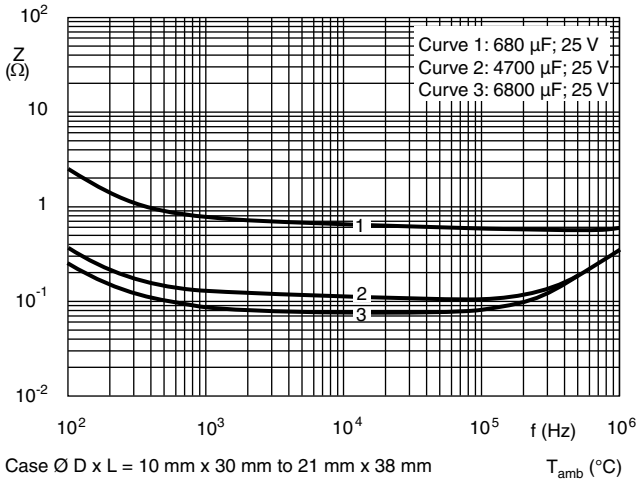

Fig. 17 - Typical impedance as a function of frequency

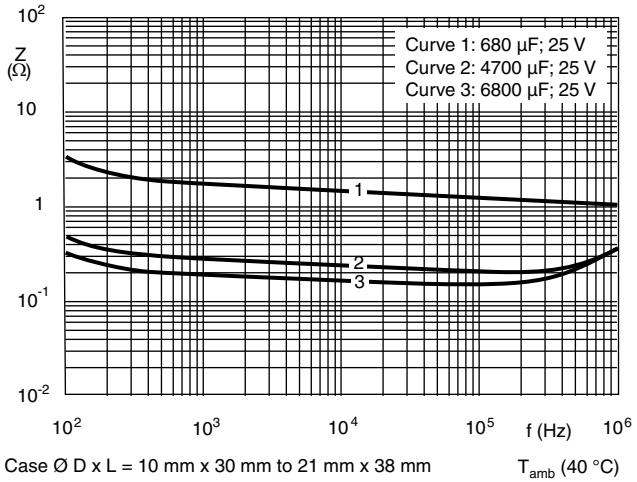

Fig. 18 - Typical impedance as a function of frequency

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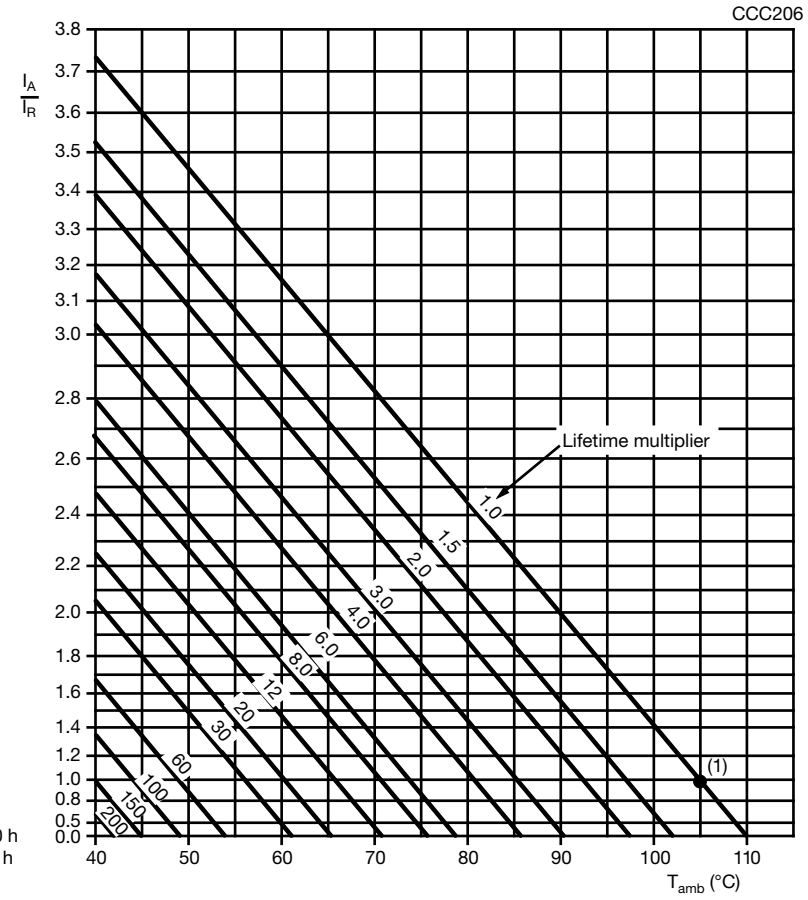
RIPPLE CURRENT AND USEFUL LIFE



I_A = Actual ripple current at 100 Hz
I_R = Rated ripple current at 100 Hz, 105 °C

(1) Useful life at 105 °C and I_R applied:
Case Ø D x L = 6.3 mm x 12.7 mm to 10 mm x 25 mm: 2000 h
Case Ø D x L = 10 mm x 30 mm to 21 mm x 38 mm: 10 000 h

Fig. 19 - Multiplier of useful life as a function of ambient temperature and ripple current load

Table 5

MULTIPLIER OF RIPPLE CURRENT (I_R) AS A FUNCTION OF FREQUENCY			
FREQUENCY (Hz)	I_R MULTIPLIER		
	U_R = 6.3 V TO 10 V	U_R = 16 V TO 25 V	U_R = 40 V TO 100 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
≥ 10 000	1.20	1.30	1.40

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Table 6

TEST PROCEDURES AND REQUIREMENTS			
TEST		PROCEDURE (quick reference)	REQUIREMENTS
NAME OF TEST	REFERENCE		
Endurance	IEC 60384-4/ EN130300 subclause 4.13	T_{amb} = 105 °C; U_R applied; Case Ø D x L: 6.3 mm x 12.7 mm to 10 mm x 25 mm: 1000 h; 10 mm x 30 mm to 21 mm x 38 mm: 5000 h	$U_R \leq$ 6.3 V; ΔC/C: + 15 %/- 30 % $U_R >$ 6.3 V; ΔC/C: ± 15 % tan δ ≤ 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} = 105 °C; U_R and I_R applied; Case Ø D x L: 6.3 mm x 12.7 mm to 10 mm x 25 mm: 2000 h; 10 mm x 30 mm to 21 mm x 38 mm: 10 000 h	$U_R \leq$ 6.3 V; ΔC/C: + 45 %/- 50 % $U_R >$ 6.3 V; ΔC/C: ± 45 % tan δ ≤ 3 x spec. limit Z ≤ 3 x spec. limit $I_{L5} \leq$ spec. limit no short open circuit total failure percentage: ≤ 1 %
Shelf life (storage at high temperature)	IEC 60384-4/ EN130300, subclause 4.17	T_{amb} = 105 °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 $I_{L5} \leq$ 2 x spec. limit

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