

DATA SHEET

021 ASM
Aluminum electrolytic capacitors
Axial Standard Miniature

Product specification
Supersedes data of 12th June 2002
File under BCcomponents, BC01

2003 Feb 25

Aluminum electrolytic capacitors

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FEATURES

- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Axial leads, cylindrical aluminum case, insulated with a blue sleeve
- Mounting ring version not insulated
- Charge and discharge proof
- Taped versions up to case $\varnothing 15 \times 30$ mm available for automatic insertion
- Miniaturized, high CV-product per unit volume.

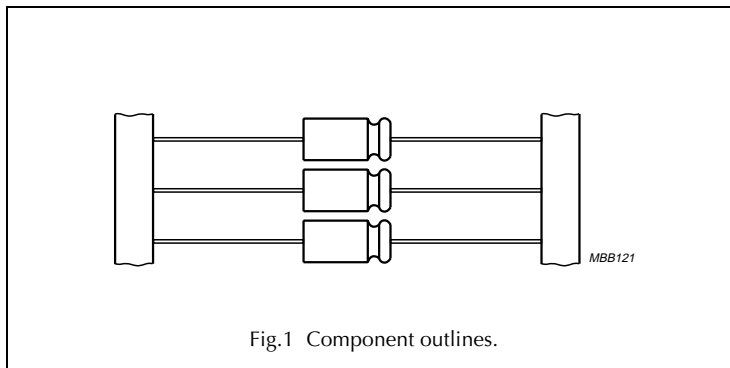
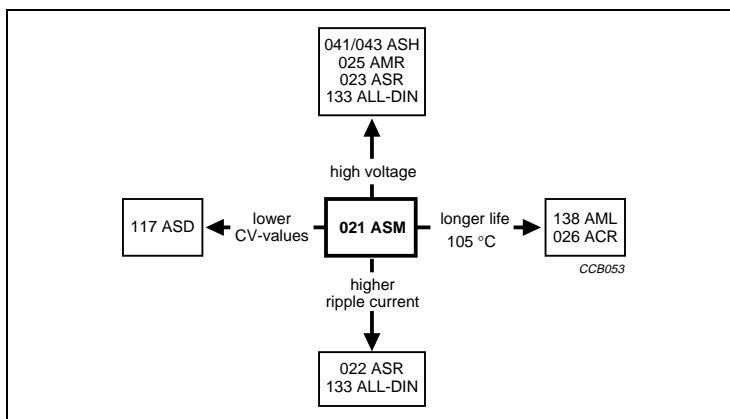


Fig.1 Component outlines.

APPLICATIONS

- General purpose, industrial, automotive, audio-video
- Coupling, decoupling, smoothing, filtering, buffering
- Portable and mobile equipment (small size, low mass)
- Low mounting height boards, vibration and shock resistant.



QUICK REFERENCE DATA

DESCRIPTION	VALUE	
Case sizes ($\varnothing D_{nom} \times L_{nom}$ in mm)	4.5 × 10 to 10 × 25	10 × 30 to 21 × 38
Rated capacitance range, C_R	0.47 to 15 000 μ F	
Tolerance on C_R	±20%	
Rated voltage range, U_R	6.3 to 100 V	
Category temperature range	-40 to +85 °C	
Endurance test at 85 °C:		
$U_R = 6.3$ to 25 V	1 000 hours	5 000 hours
$U_R = 40$ to 100 V	2 000 hours	5 000 hours
Endurance test at 105 °C	–	1 500 hours
Useful life at 85 °C	2 500 hours	8 000 hours
Useful life at 40 °C, $1.4 \times I_R$ applied	70 000 hours	200 000 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	

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Selection chart for C_R , U_R and relevant nominal case sizes ($\varnothing D \times L$ in mm)

 Preferred types in **bold**.

C_R (μF)	U_R (V)						
	6.3	10	16	25	40	63	100
0.47	–	–	–	–	–	4.5 × 10	–
1	–	–	–	–	–	4.5 × 10	4.5 × 10
2.2	–	–	–	–	–	4.5 × 10	4.5 × 10
3.3	–	–	–	–	–	4.5 × 10	–
4.7	–	–	–	–	–	4.5 × 10	4.5 × 10
10	–	–	–	–	–	4.5 × 10	6 × 10
15	–	–	–	–	–	4.5 × 10	8 × 11
	–	–	–	–	–	–	6.5 × 18
22	–	–	–	–	4.5 × 10	6 × 10	8 × 11
	–	–	–	–	–	–	6.5 × 18
33	–	–	–	–	–	6 × 10	6.5 × 18
47	–	–	–	4.5 × 10	6 × 10	8 × 11	8 × 18
	–	–	–	–	–	6.5 × 18	–
68	–	–	4.5 × 10	–	–	8 × 11	10 × 18
	–	–	–	–	–	6.5 × 18	–
100	–	4.5 × 10	–	6 × 10	8 × 11	8 × 18	10 × 25
	–	–	–	–	6.5 × 18	–	10 × 30
150	–	–	6 × 10	8 × 11	8 × 18	10 × 18	12.5 × 30
	–	–	–	6.5 × 18	–	–	–
220	–	6 × 10	8 × 11	6.5 × 18	10 × 18	10 × 25	12.5 × 30
	–	–	–	–	–	10 × 30	–
330	–	8 × 11	6.5 × 18	8 × 18	10 × 25	12.5 × 30	15 × 30
470	8 × 11	6.5 × 18	8 × 18	10 × 18	10 × 25	12.5 × 30	18 × 30
	–	–	–	–	10 × 30	–	–
680	–	8 × 18	10 × 18	10 × 25	12.5 × 30	15 × 30	18 × 38
	–	–	–	10 × 30	–	–	–
1000	8 × 18	10 × 18	10 × 25	12.5 × 30	12.5 × 30	18 × 30	21 × 38
	–	–	10 × 30	–	–	–	–
1500	–	10 × 25	12.5 × 30	12.5 × 30	15 × 30	18 × 38	–
	–	10 × 30	–	–	–	–	–
2200	10 × 25	12.5 × 30	12.5 × 30	15 × 30	18 × 30	21 × 38	–
3300	–	12.5 × 30	15 × 30	18 × 30	18 × 38	–	–
4700	–	15 × 30	18 × 30	18 × 38	21 × 38	–	–
6800	–	18 × 30	18 × 38	21 × 38	–	–	–
10000	–	18 × 38	21 × 38	–	–	–	–
15000	–	21 × 38	–	–	–	–	–

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MECHANICAL DATA, AVAILABLE FORMS AND PACKAGING QUANTITIES

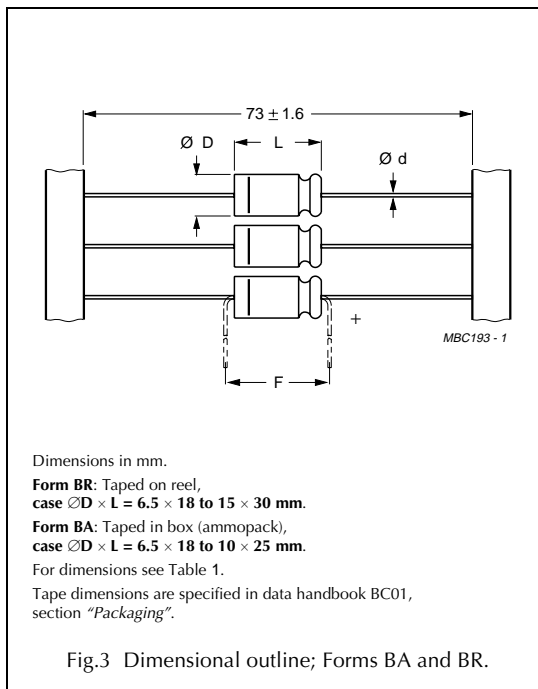
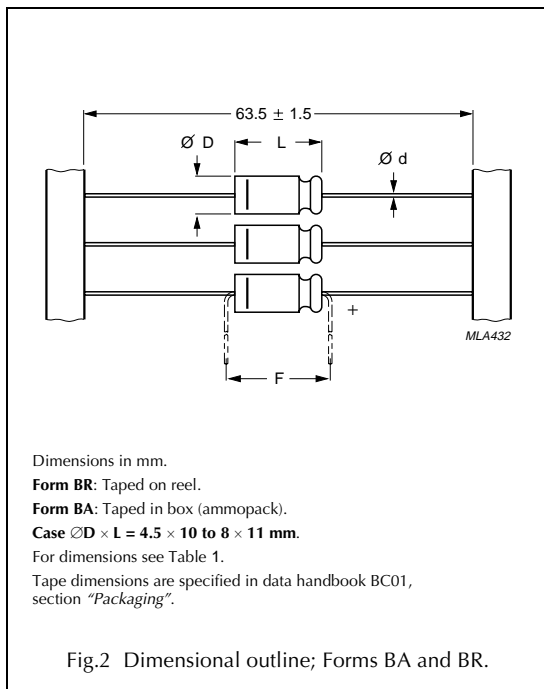


Table 1 Axial; physical dimensions, mass and packaging quantities; see Figs 2, 3 and 4

NOMINAL CASE SIZE $\varnothing D \times L$ (mm)	CASE CODE	AXIAL: FORM AA, BA, and BR					MASS (g)	PACKAGING QUANTITIES		
		$\varnothing d$	l	$\varnothing D_{max}$ (mm)	L_{max} (mm)	F_{min} (mm)		FORM AA	FORM BA	FORM BR
4.5 × 10	2	0.6	–	5.0	10.5	15	≈0.50	–	1000	3000
6 × 10	3	0.6	–	6.3	10.5	15	≈0.70	–	1000	1000
8 × 11	5a	0.6	–	8.5	11.5	15	≈1.1	–	500	500
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	–	–

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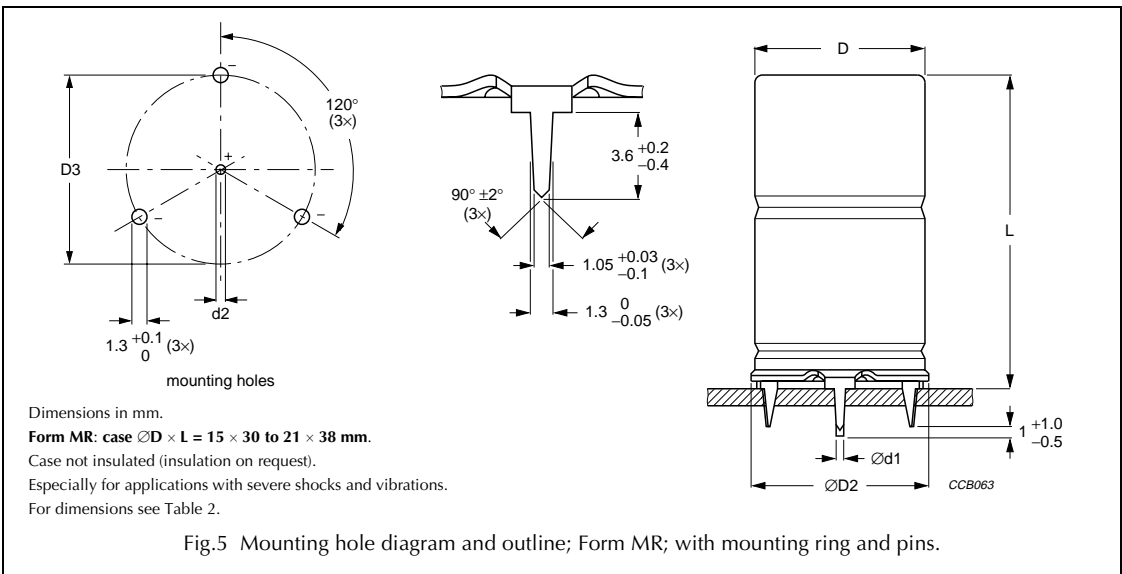
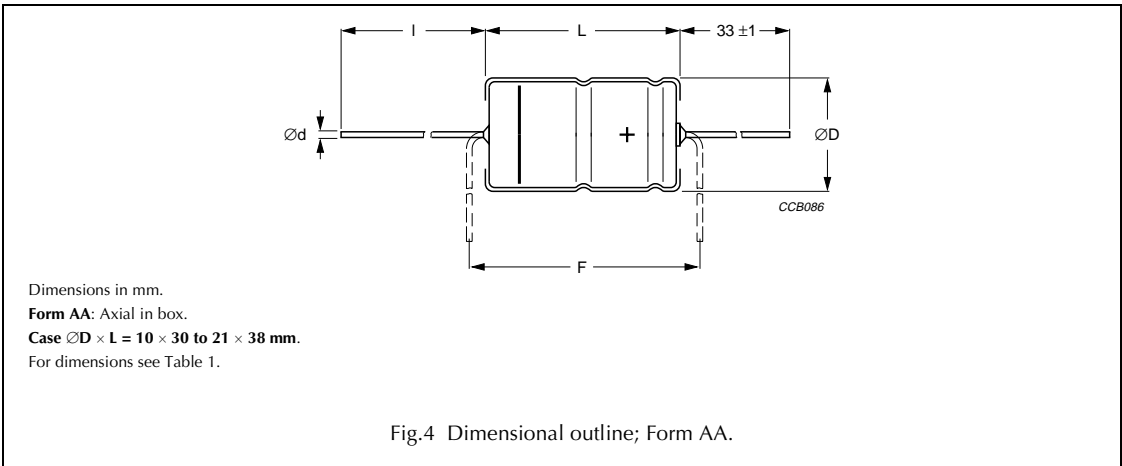


Table 2 Mounting ring; mass and packaging quantities; see Fig.5

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

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ELECTRICAL DATA AND ORDERING INFORMATION

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

SYMBOL	DESCRIPTION
C_R	rated capacitance at 100 Hz, tolerance $\pm 20\%$
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

Ordering example

Electrolytic capacitor 021 series

1000 $\mu\text{F}/16\text{ V}$; $\pm 20\%$

Nominal case size: $\varnothing 10 \times 25\text{ mm}$;
Form BA

Catalogue number: 2222 021 90518.

Table 3 Electrical data and ordering Information; preferred types in **bold**

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE $\varnothing D \times L$ (mm)	I_R 100 Hz 85 °C (mA)	I_{L5} 5 min (μA)	$\tan \delta$ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)	CATALOGUE NUMBER 2222 021			
								IN BOX FORM AA	TAPED ON REEL FORM BR	TAPED IN BOX FORM BA	MOUNTING RING FORM MR
6.3	470	8 × 11	260	10	0.25	0.85	0.64	–	23471	33471	–
	1000	8 × 18	440	17	0.25	0.4	0.5	–	23102	33102	–
	2200	10 × 25	710	32	0.29	0.21	0.16	–	90588	90589	–
10	100	4.5 × 10	100	6	0.20	3.2	2.0	–	24101	34101	–
	220	6 × 10	160	8.4	0.20	1.5	0.91	–	24221	34221	–
	330	8 × 11	230	11	0.20	1.0	0.61	–	24331	34331	–
	470	6.5 × 18	310	13	0.20	0.68	0.43	–	24471	34471	–
	680	8 × 18	400	18	0.20	0.47	0.29	–	24681	34681	–
	1000	10 × 18	550	24	0.20	0.32	0.20	–	24102	34102	–
	1500	10 × 25	690	34	0.23	0.25	0.18	–	90524	90525	–
	1500	10 × 30	740	34	0.23	0.245	0.18	14152	24152	–	–
	2200	12.5 × 30	980	48	0.25	0.177	0.095	14222	24222	–	–
	3300	12.5 × 30	1090	70	0.27	0.128	0.095	14332	24332	–	–
	4700	15 × 30	1320	98	0.29	0.100	0.07	14472	24472	–	44472
	6800	18 × 30	1590	140	0.34	0.079	0.065	14682	–	–	44682
10000	18 × 38	2090	204	0.40	0.064	0.04	14103	–	–	44103	
15000	21 × 38	2250	304	0.50	0.054	0.035	14153	–	–	44153	
16	68	4.5 × 10	90	6.2	0.16	3.8	2.4	–	25689	35689	–
	150	6 × 10	140	8.8	0.16	1.7	1.1	–	25151	35151	–
	220	8 × 11	210	11	0.16	1.2	0.73	–	25221	35221	–
	330	6.5 × 18	290	15	0.16	0.77	0.48	–	25331	35331	–
	470	8 × 18	380	19	0.16	0.55	0.34	–	25471	35471	–
	680	10 × 18	500	26	0.16	0.38	0.24	–	25681	35681	–
	1000	10 × 25	660	36	0.16	0.26	0.18	–	90517	90518	–
	1000	10 × 30	700	36	0.16	0.260	0.175	15102	25102	–	–
	1500	12.5 × 30	950	52	0.19	0.205	0.095	15152	25152	–	–

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U _R (V)	C _R 100 Hz (μF)	NOMINAL CASE SIZE ∅D × 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)	CATALOGUE NUMBER 2222 021			
								IN BOX FORM AA	TAPED ON REEL FORM BR	TAPED IN BOX FORM BA	MOUNTING RING FORM MR
16	2200	12.5 × 30	1040	74	0.21	0.150	0.095	15222	25222	–	–
	3300	15 × 30	1290	110	0.23	0.111	0.07	15332	25332	–	45332
	4700	18 × 30	1560	154	0.25	0.087	0.065	15472	–	–	45472
	6800	18 × 38	2040	222	0.30	0.070	0.04	15682	–	–	45682
	10000	21 × 38	2170	324	0.36	0.058	0.035	15103	–	–	45103
25	47	4.5 × 10	80	6.4	0.14	4.8	2.6	–	26479	36479	–
	100	6 × 10	150	9	0.14	2.3	1.2	–	26101	36101	–
	150	8 × 11	190	12	0.14	1.5	0.80	–	90534	90535	–
	150	6.5 × 18	210	12	0.14	1.5	0.80	–	26151	36151	–
	220	6.5 × 18	250	15	0.14	1.0	0.55	–	26221	36221	–
	330	8 × 18	340	21	0.14	0.68	0.36	–	26331	36331	–
	470	10 × 18	450	28	0.14	0.48	0.26	–	26471	36471	–
	680	10 × 25	560	38	0.14	0.33	0.18	–	90527	90528	–
	680	10 × 30	640	38	0.14	0.323	0.175	16681	26681	–	–
	1000	12.5 × 30	840	54	0.14	0.220	0.095	16102	26102	–	–
	1500	12.5 × 30	950	79	0.17	0.179	0.095	16152	26152	–	–
	2200	15 × 30	1180	114	0.19	0.132	0.07	16222	26222	–	46222
	3300	18 × 30	1470	169	0.21	0.099	0.065	16332	–	–	46332
	4700	18 × 38	1920	239	0.23	0.079	0.04	16472	–	–	46472
6800	21 × 38	2070	344	0.28	0.064	0.035	16682	–	–	46682	
40	22	4.5 × 10	60	5.8	0.11	8.0	3.2	–	27229	37229	–
	47	6 × 10	110	7.8	0.11	3.8	1.5	–	27479	37479	–
	100	8 × 11	170	12	0.11	1.8	0.70	–	90537	90538	–
	100	6.5 × 18	190	12	0.11	1.8	0.70	–	27101	37101	–
	150	8 × 18	250	16	0.11	1.1	0.47	–	27151	37151	–
	220	10 × 18	330	22	0.11	0.8	0.32	–	27221	37221	–
	330	10 × 25	430	30	0.11	0.53	0.21	–	27331	37331	–
	470	10 × 25	520	42	0.11	0.37	0.18	–	90514	90515	–
	470	10 × 30	590	42	0.12	0.404	0.175	17471	27471	–	–
	680	12.5 × 30	800	58	0.12	0.297	0.110	17681	27681	–	–
	1000	12.5 × 30	900	84	0.12	0.190	0.110	17102	27102	–	–
	1500	15 × 30	1120	124	0.15	0.159	0.07	17152	27152	–	47152
	2200	18 × 30	1390	180	0.17	0.118	0.065	17222	–	–	47222
	3300	18 × 38	1810	268	0.19	0.090	0.04	17332	–	–	47332
4700	21 × 38	1940	380	0.21	0.072	0.035	17472	–	–	47472	
63	0.47	4.5 × 10	8	4.1	0.09	310	120	–	28477	38477	–
	1	4.5 × 10	12	4.1	0.09	150	55	–	28108	38108	–
	2.2	4.5 × 10	21	4.3	0.09	65	25	–	28228	38228	–
	3.3	4.5 × 10	25	4.4	0.09	44	17	–	28338	38338	–
	4.7	4.5 × 10	31	4.6	0.09	31	12	–	28478	38478	–

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U _R (V)	C _R 100 Hz (μF)	NOMINAL CASE SIZE ∅D × 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)	CATALOGUE NUMBER 2222 021			
								IN BOX FORM AA	TAPED ON REEL FORM BR	TAPED IN BOX FORM BA	MOUNTING RING FORM MR
63	10	4.5 × 10	50	5.3	0.08	13	5.5	–	28109	38109	–
	15	4.5 × 10	55	5.9	0.08	8.5	3.7	–	28159	38159	–
	22	6 × 10	90	6.8	0.08	5.8	2.5	–	28229	38229	–
	33	6 × 10	100	8.2	0.08	3.9	1.7	–	28339	38339	–
	47	8 × 11	140	10	0.08	2.7	1.2	–	90541	90542	–
	47	6.5 × 18	150	10	0.08	2.7	1.2	–	28479	38479	–
	68	8 × 11	160	13	0.08	1.9	0.81	–	90544	90545	–
	68	6.5 × 18	170	13	0.08	1.9	0.81	–	28689	38689	–
	100	8 × 18	250	17	0.08	1.3	0.55	–	28101	38101	–
	150	10 × 18	320	23	0.08	0.85	0.37	–	28151	38151	–
	220	10 × 25	430	32	0.08	0.60	0.25	–	90511	90512	–
	220	10 × 30	480	32	0.08	0.614	0.26	18221	28221	–	–
	330	12.5 × 30	610	46	0.08	0.409	0.19	18331	28331	–	–
	470	12.5 × 30	700	63	0.08	0.287	0.13	18471	28471	–	–
	680	15 × 30	890	90	0.08	0.199	0.095	18681	28681	–	48681
	1000	18 × 30	1170	130	0.08	0.135	0.075	18102	–	–	48102
	1500	18 × 38	1530	193	0.11	0.122	0.045	18152	–	–	48152
	2200	21 × 38	1780	281	0.13	0.099	0.040	18222	–	–	48222
100	1	4.5 × 10	14	4.2	0.08	130	90	–	29108	39108	–
	2.2	4.5 × 10	20	4.4	0.08	58	41	–	29228	39228	–
	4.7	4.5 × 10	30	4.9	0.08	27	19	–	29478	39478	–
	10	6 × 10	65	6	0.08	13	9	–	29109	39109	–
	15	8 × 11	77	7	0.08	8.5	6	–	90547	90548	–
	15	6.5 × 18	85	7	0.08	8.5	6	–	29159	39159	–
	22	8 × 11	95	8.4	0.08	5.8	4.1	–	90551	90552	–
	22	6.5 × 18	100	8.4	0.08	5.8	4.1	–	29229	39229	–
	33	6.5 × 18	120	10.6	0.08	3.9	2.7	–	29339	39339	–
	47	8 × 18	160	13.4	0.08	2.7	1.9	–	29479	39479	–
	68	10 × 18	220	17.6	0.08	1.9	1.3	–	29689	39689	–
	100	10 × 25	300	24	0.08	1.3	0.9	–	90531	90532	–
	100	10 × 30	340	24	0.07	1.150	1.0	19101	29101	–	–
	150	12.5 × 30	490	34	0.07	0.645	0.61	19151	29151	–	–
	220	12.5 × 30	560	48	0.08	0.610	0.56	19221	29221	–	–
	330	15 × 30	740	70	0.09	0.420	0.40	19331	29331	–	49331
	470	18 × 30	980	98	0.09	0.310	0.29	19471	–	–	49471
	680	18 × 38	1260	140	0.09	0.195	0.18	19681	–	–	49681
1000	21 × 38	1470	204	0.10	0.160	0.15	19102	–	–	49102	

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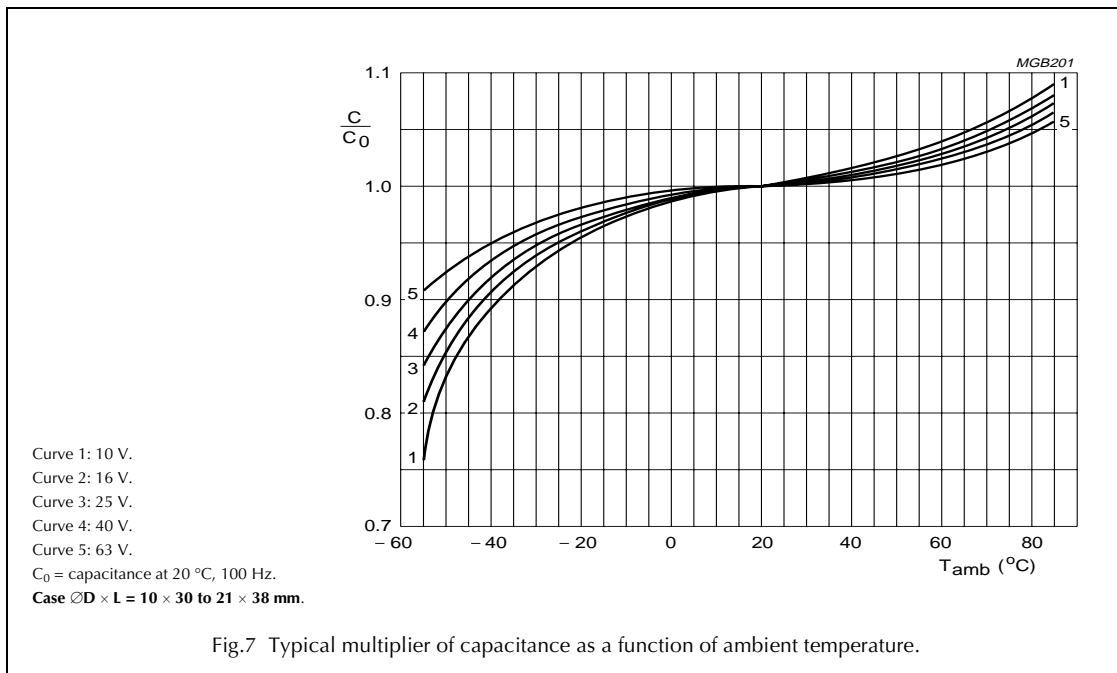
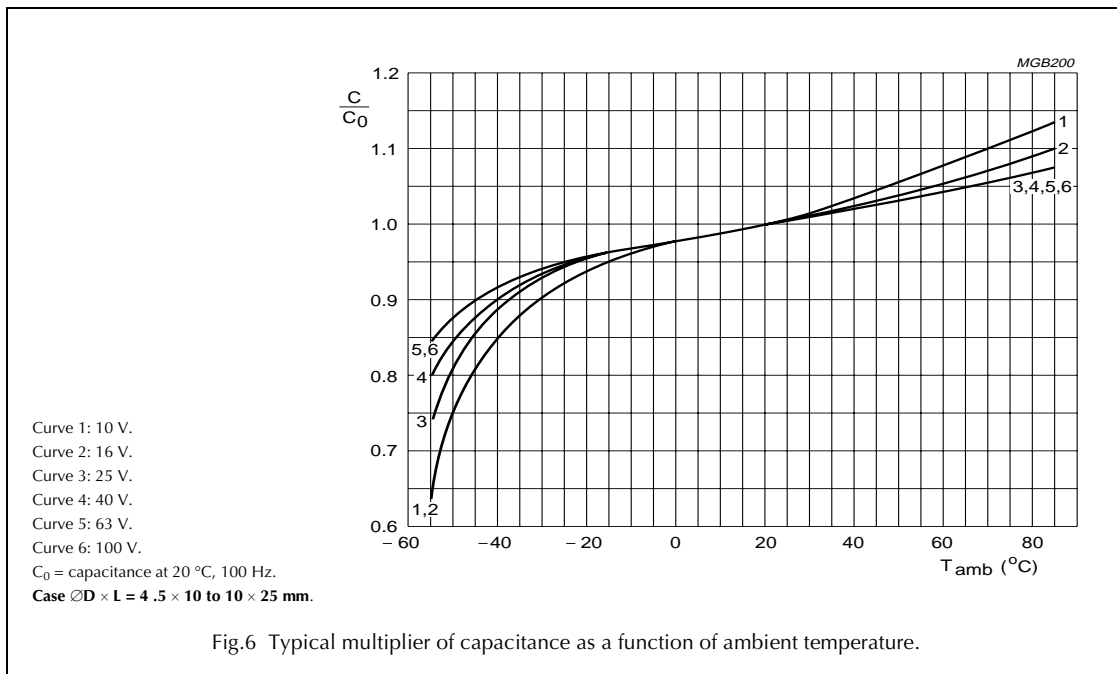
PARAMETER	CONDITIONS	VALUE	
		AXIAL	MOUNTING RING
Voltage			
Surge voltage		$U_s \leq 1.15 \times U_R$	
Reverse voltage		$U_{rev} \leq 1 \text{ V}$	
Current			
Leakage current	after 1 minute at U_R	$I_{L1} \leq 0.006C_R \times U_R + 4 \mu\text{A}$	
	after 5 minutes at U_R :	$I_{L5} \leq 0.002C_R \times U_R + 4 \mu\text{A}$	
Inductance			
Equivalent series inductance (ESL)	case $\varnothing D \times L$ mm:		
	4.5 × 10	typ. 10 nH	–
	6 × 10	typ. 22 nH	–
	8 × 11	typ. 85 nH	–
	6.5 × 18	typ. 25 nH	–
	8 × 18	typ. 40 nH	–
	10 × 18	typ. 61 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	

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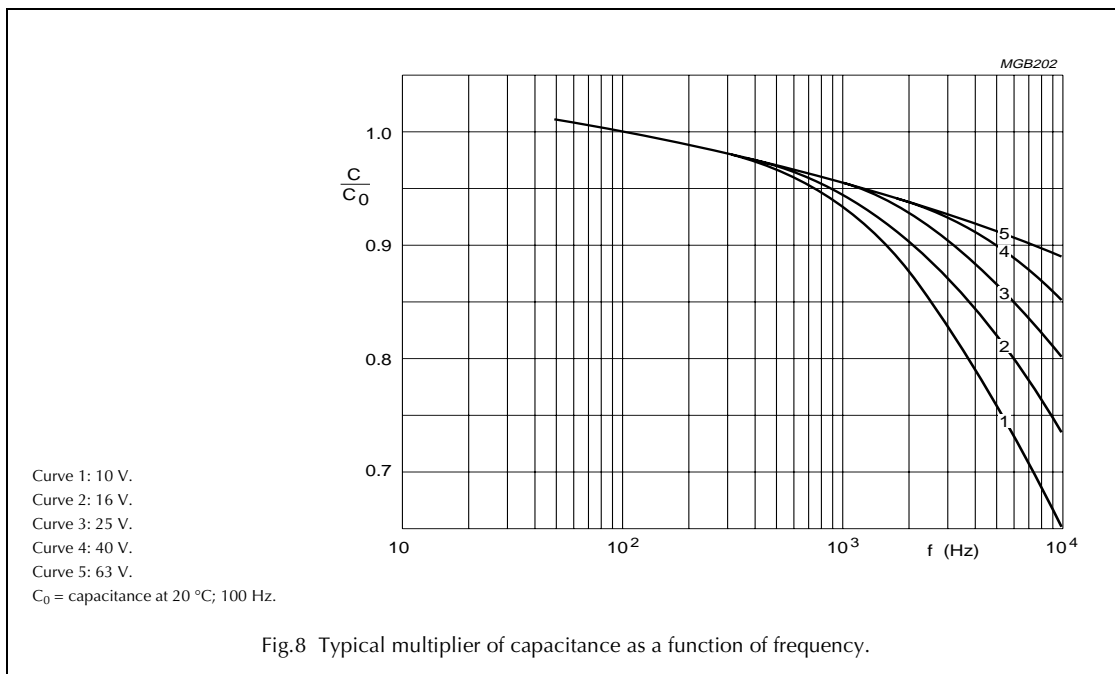
Capacitance (C)



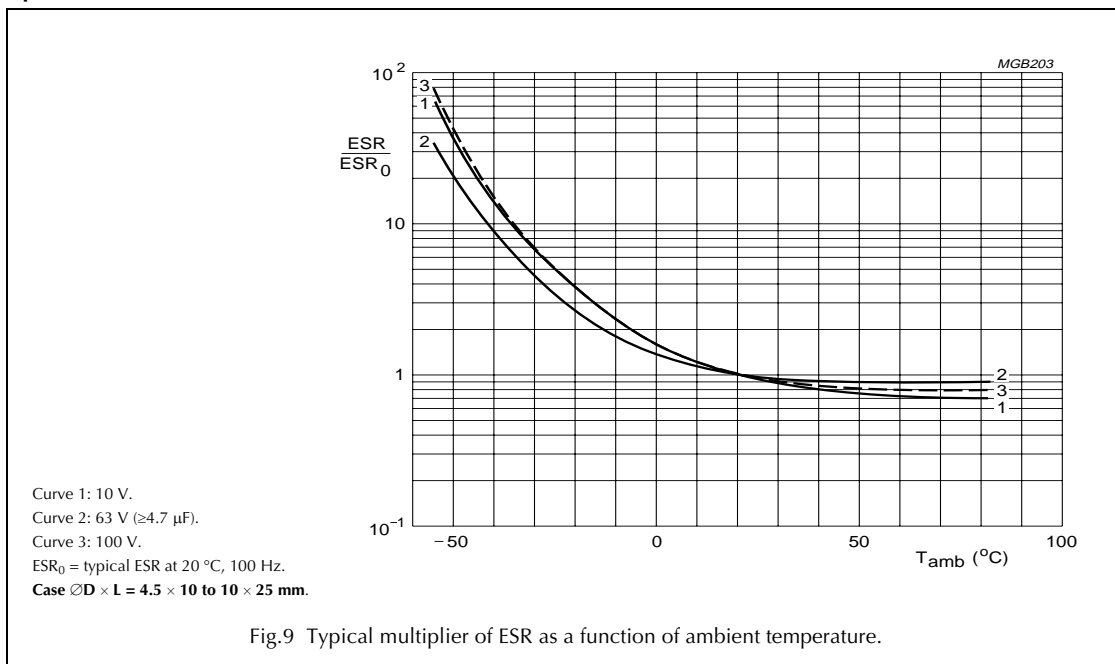
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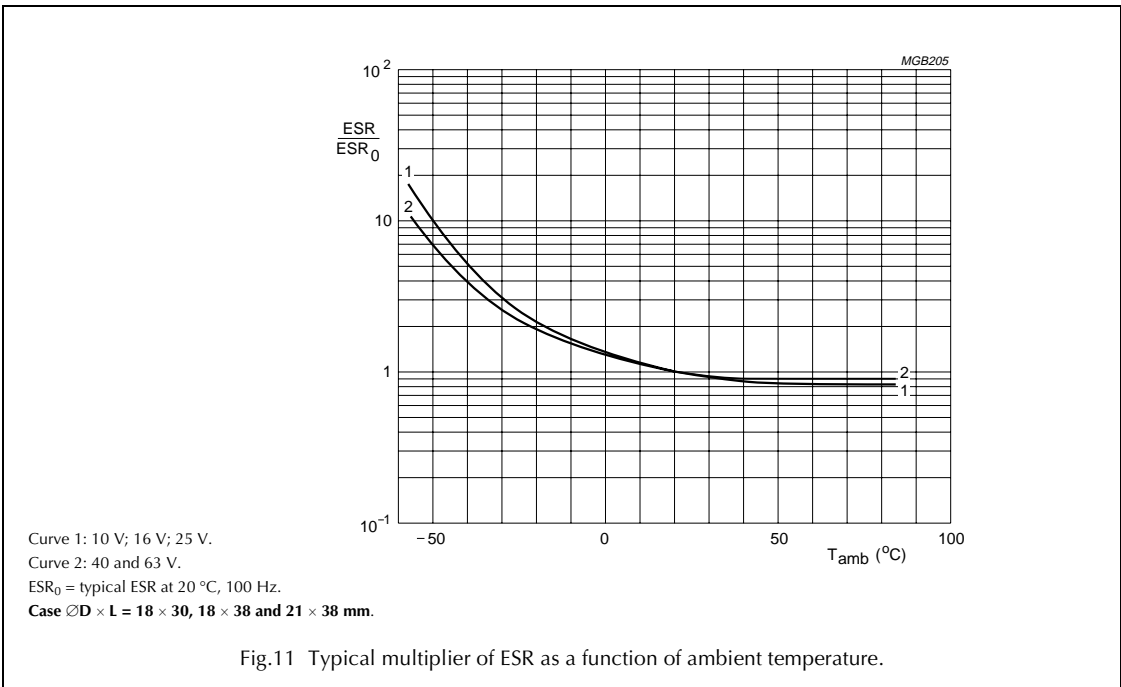
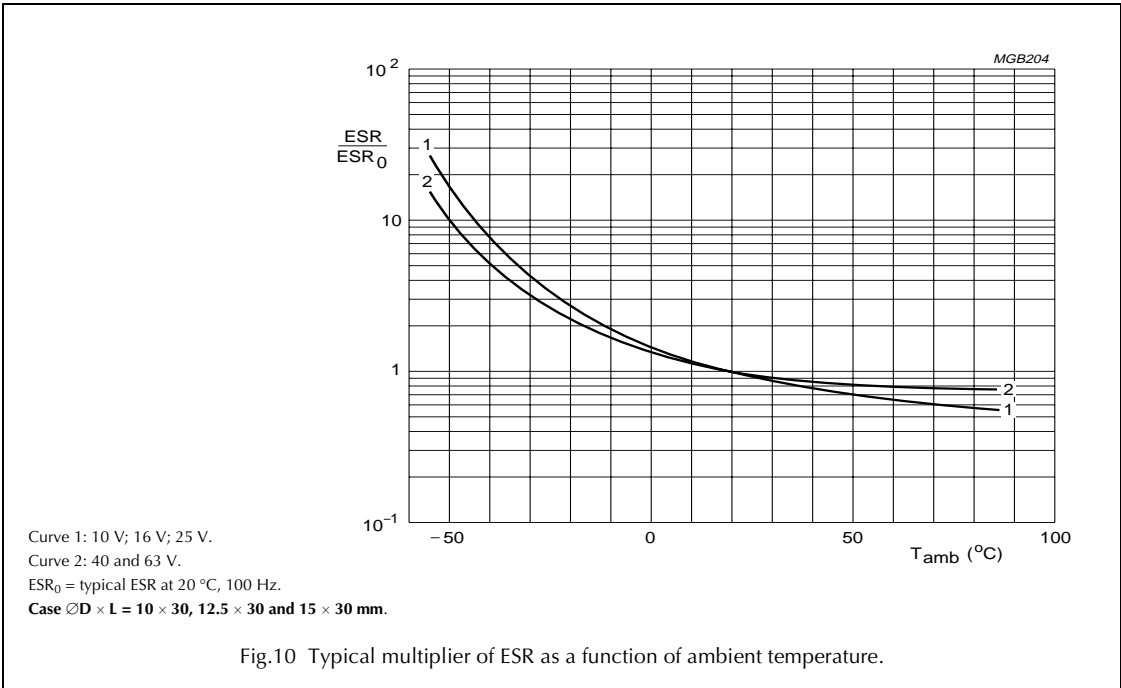
Equivalent series resistance (ESR)



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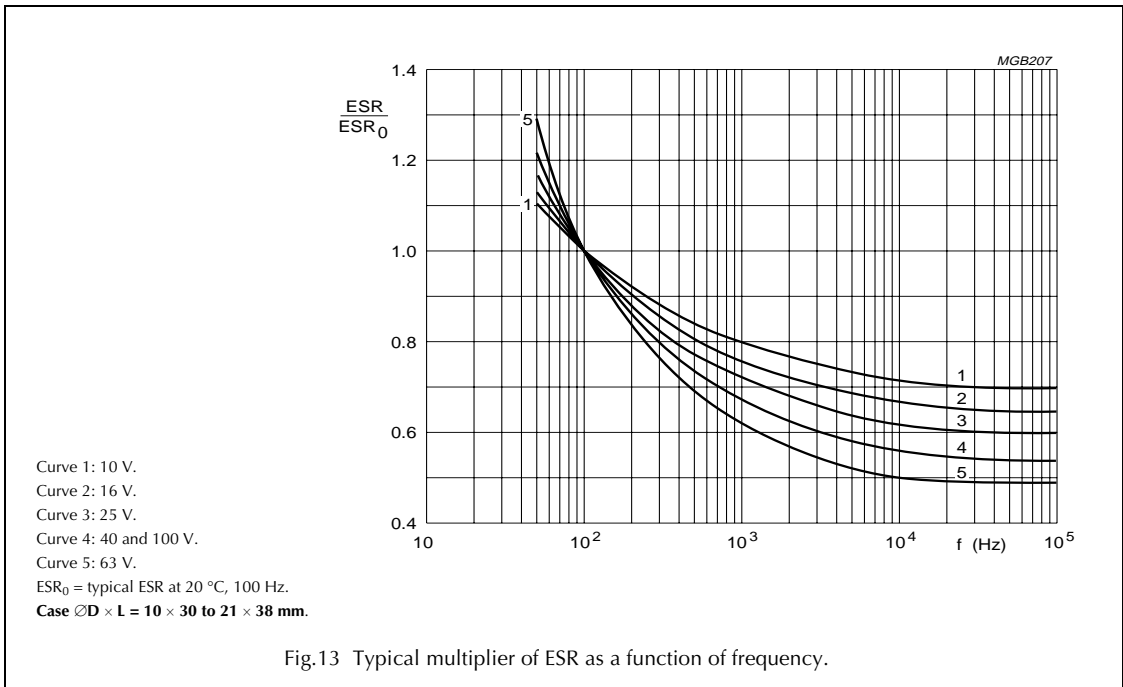
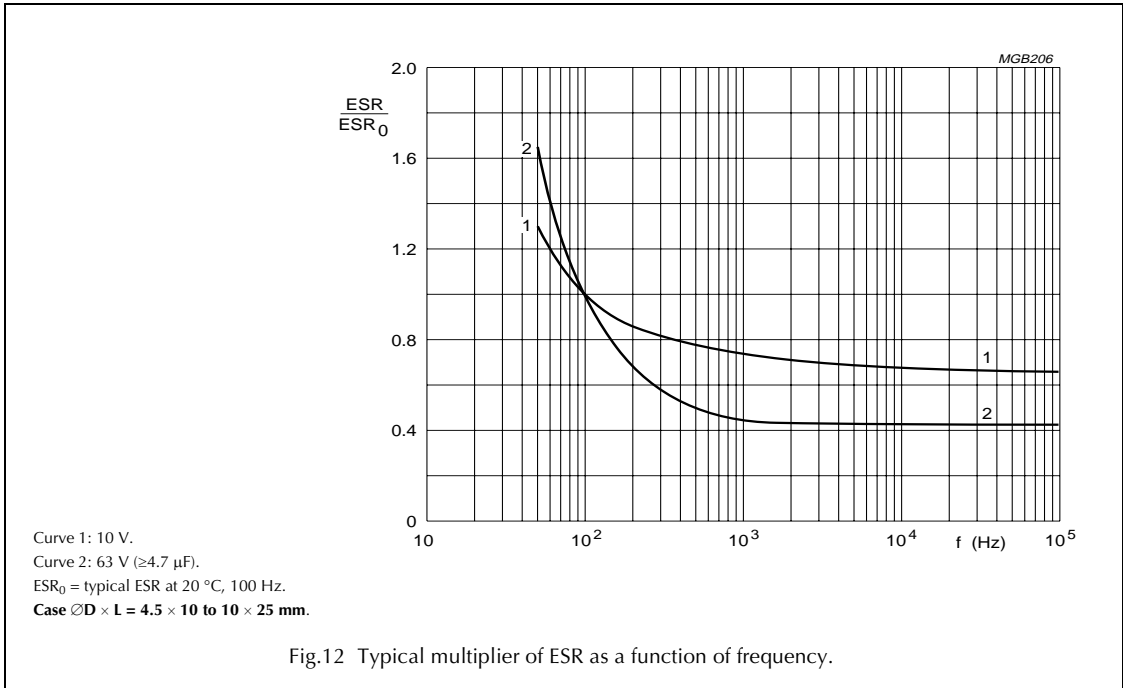
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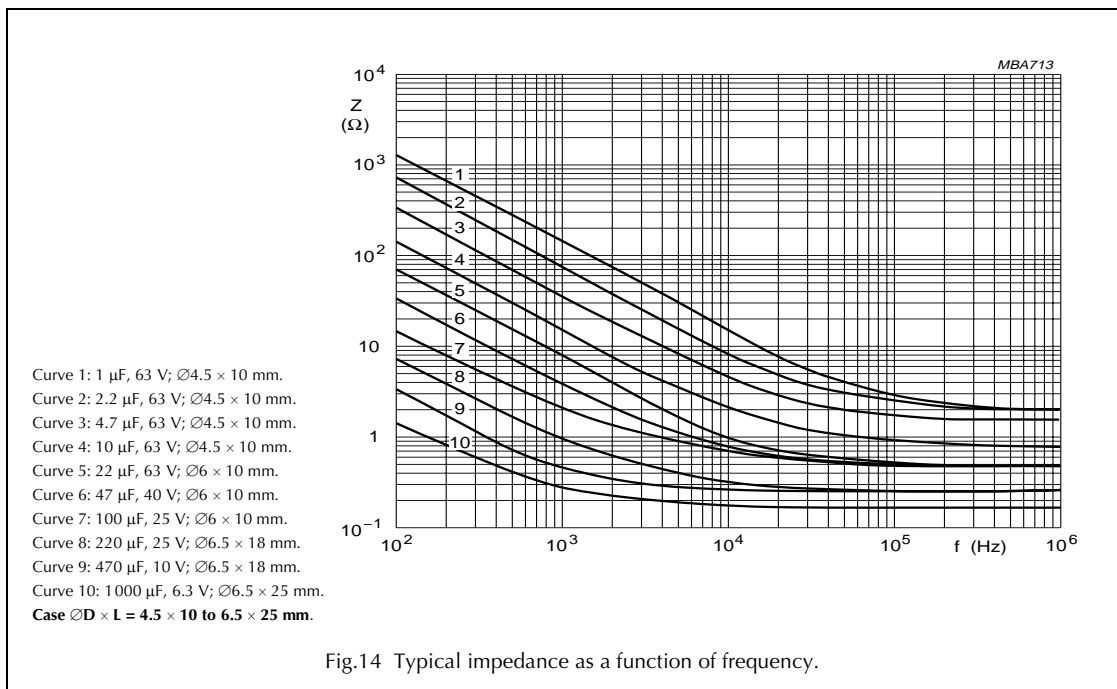
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Impedance (Z)

Table 4 Impedance × capacitance values (case $\varnothing D \times L = 4.5 \times 10$ to 10×25 mm)

T_{amb}	$Z \times C_R (\Omega \times \mu F)$ at 10 kHz						
	6.3 V	10 V	16 V	25 V	40 V	63 V	100 V
+20 °C	≤300	≤200	≤160	≤120	≤70	≤55	≤90
-25 °C	≤2000	≤1200	≤750	≤560	≤300	≤180	≤600
-40 °C	≤5500	≤3200	≤2000	≤1500	≤900	≤500	≤1600



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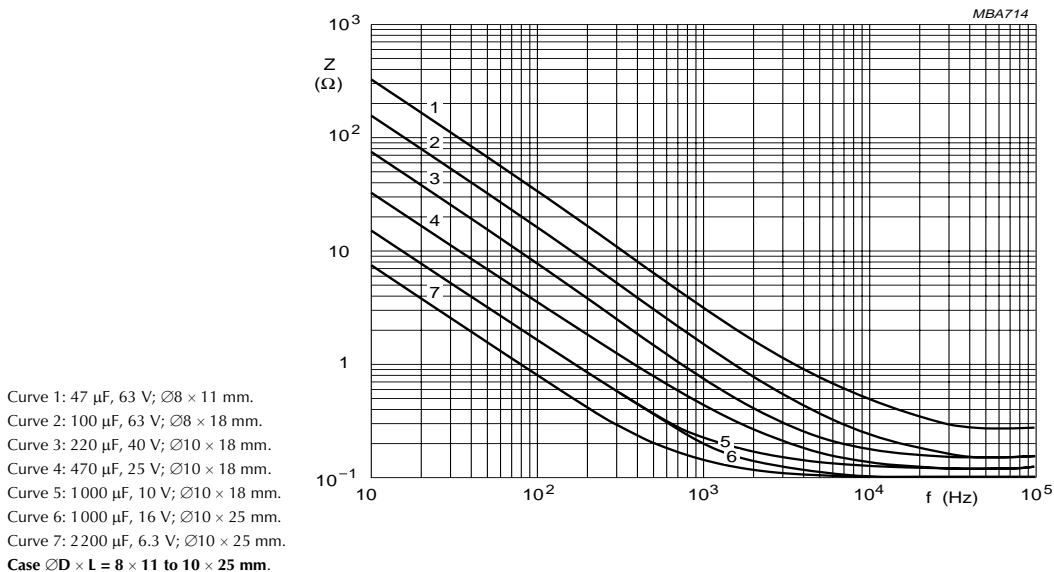


Fig.15 Typical impedance as a function of frequency.

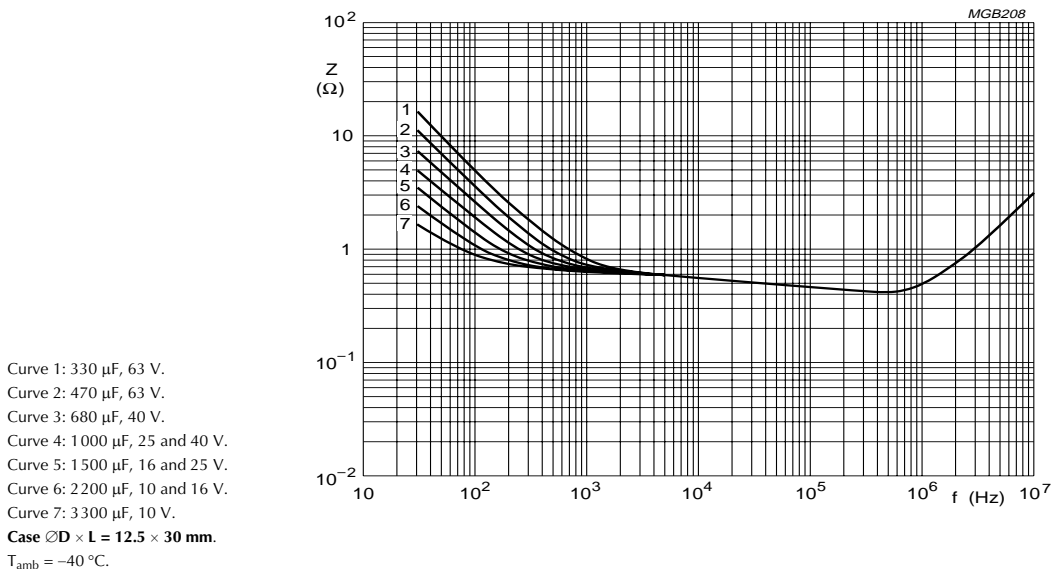
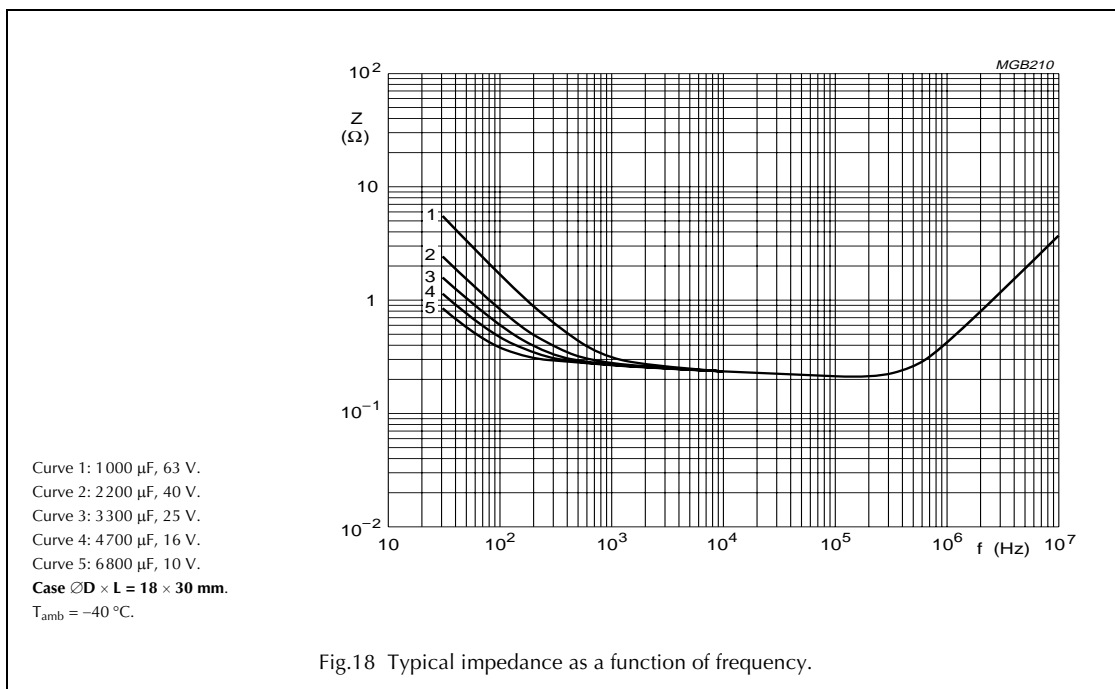
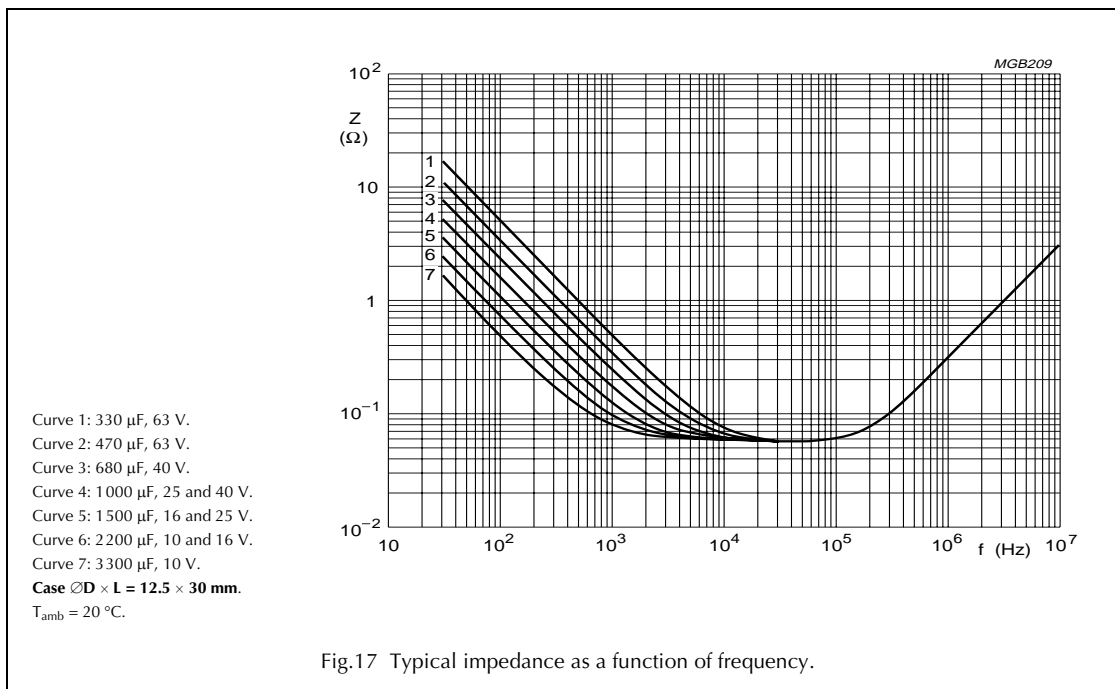


Fig.16 Typical impedance as a function of frequency.

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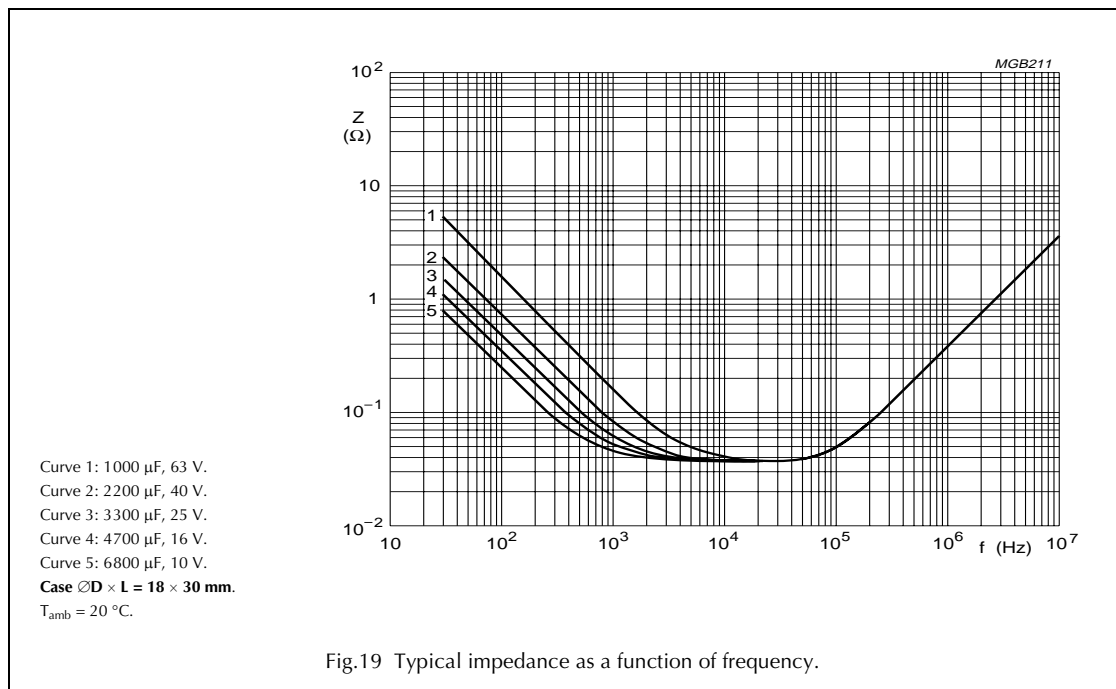
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MARKING

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

- Rated capacitance (in μF)
- Tolerance on nominal capacitance (in accordance with "IEC 60062")
- Rated voltage (in V)
- Group number (021)
- Name of manufacturer
- Date code in accordance with "IEC 60062"
- Code for factory of origin
- Band to indicate the negative terminal
- '+' sign to identify the positive terminal (not for case sizes $L < 18 \text{ mm}$).

Aluminum electrolytic capacitors

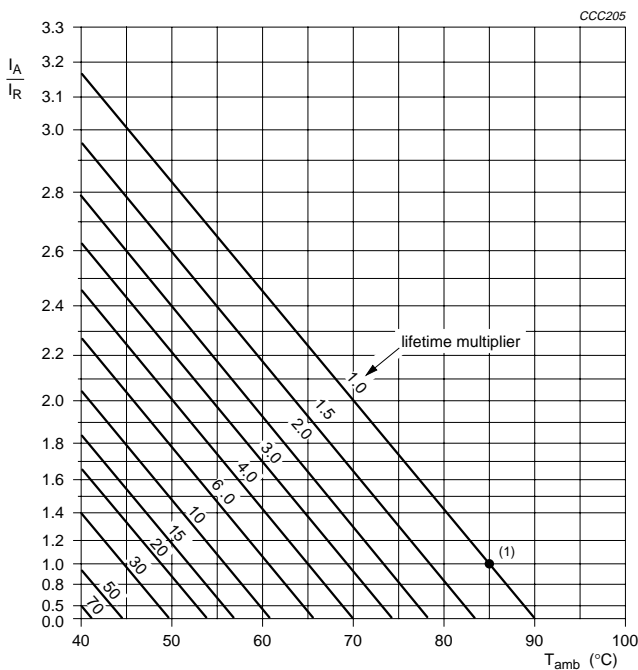
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RIPPLE CURRENT AND USEFUL LIFE

Table 5 Multiplier of ripple current (I_R) as a function of frequency

FREQUENCY (Hz)	I_R MULTIPLIER		
	$U_R = 6.3$ to 16 V	$U_R = 25$ to 40 V	$U_R = 63$ to 100 V
50	0.95	0.9	0.85
100	1	1	1
300	1.07	1.12	1.2
1000	1.12	1.2	1.3
3000	1.15	1.25	1.35
≥ 10000	1.2	1.3	1.4



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 $\varnothing D \times L = 4.5 \times 10$ to 10×25 mm: 2500 hours

case $\varnothing D \times L = 10 \times 30$ to 21×38 mm: 8000 hours.

Fig.20 Multiplier of useful life as a function of ambient temperature and ripple current load.

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SPECIFIC TESTS AND REQUIREMENTS

General tests and requirements are specified in data handbook BC01, section "Tests and Requirements".

Table 6 Test procedures and requirements

TEST		PROCEDURE (quick reference)	REQUIREMENTS
NAME OF TEST	REFERENCE		
Endurance	IEC 60384-4/ EN130300 subclause 4.13	$T_{amb} = 85\text{ °C}$; U_R applied; case $\varnothing D \times L = 4.5 \times 10$ to 10×25 mm: $U_R = 6.3$ to 25 V: 1000 hours; $U_R = 40$ to 100 V: 2000 hours; case $\varnothing D \times L = 10 \times 30$ to 21×38 mm: $U_R = 6.3$ to 100 V: 5000 hours	$U_R \leq 6.3$ V; $\Delta C/C$: +15/-30% $U_R > 6.3$ V; $\Delta C/C$: $\pm 15\%$ $\tan \delta \leq 1.3 \times$ spec. limit $Z \leq 2 \times$ spec. limit $I_{L5} \leq$ spec. limit
		$T_{amb} = 105\text{ °C}$; U_R applied; case $\varnothing D \times L = 10 \times 30$ to 21×38 mm: 1500 hours	$\Delta C/C$: $\leq \pm 15\%$ $\tan \delta \leq 1.6 \times$ spec. limit $Z \leq 2 \times$ spec. limit $I_{L5} \leq$ spec. limit
Useful life	CECC 30301 subclause 1.8.1	$T_{amb} = 85\text{ °C}$; U_R and I_R applied; case $\varnothing D \times L = 4.5 \times 10$ to 10×25 mm: 2500 hours; case $\varnothing D \times L = 10 \times 30$ to 21×38 mm: 8000 hours	$U_R \leq 6.3$ V; $\Delta C/C$: +45/-50% $U_R > 6.3$ V; $\Delta C/C$: $\pm 45\%$ $\tan \delta \leq 3 \times$ spec. limit $Z \leq 3 \times$ spec. limit $I_{L5} \leq$ 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	$T_{amb} = 85\text{ °C}$; 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 $I_{L5} \leq 2 \times$ spec. limit