Aluminum Capacitors
Solid Al, Radial Pearl Miniature

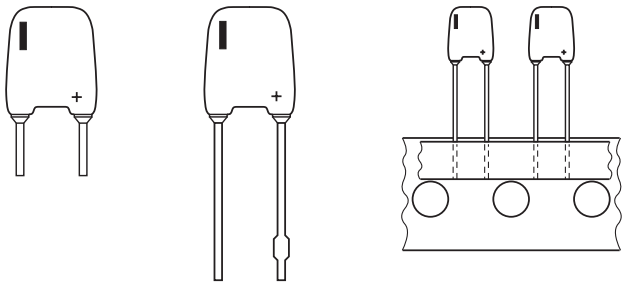
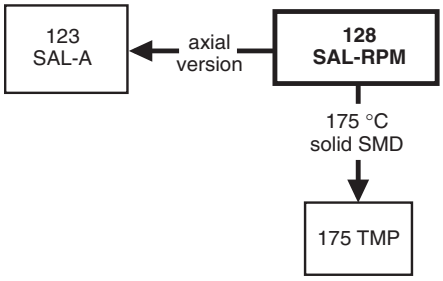


Fig.1 Component outlines.



FEATURES

- Polarized aluminum electrolytic capacitors, solid electrolyte MnO_2
- Radial leads, max. height 10 mm, resin dipped, orange coloured
- Extremely long useful life, 20000 hours/125 °C
- Extended usable temperature range up to 175 °C
- Excellent low temperature, impedance and ESR behaviour
- Charge and discharge proof, application with 0 Ω resistance allowed
- Reverse DC voltage up to $0.3 \times U_R$ allowed
- AC voltage up to $0.8 \times U_R$ allowed
- Advanced technology to achieve high reliability and high stability.

Pb-free Available

RoHS* COMPLIANT

APPLICATIONS

- EDP, telecommunication, general industrial, automotive and audio-video
- Smoothing, filtering and buffering
- For small power supplies, DC/DC converters.

QUICK REFERENCE DATA	
DESCRIPTION	**VALUE**
Maximum case sizes (H × W × T in mm)	10 × 7 × 3 to 10 × 8 × 6
Rated capacitance range (E6 series), C_R	0.1 to 68 µF
Tolerance on C_R	± 20 %
Rated voltage range, U_R	6.3 to 40 V
Category temperature range:	
U_R = 6.3 to 40 V	− 55 to + 85 °C
U_C = 6.3 to 25 V	− 55 to + 125 °C
Endurance test at 125 °C	10000 hours
Useful life at 125 °C	20000 hours
Useful life at 175 °C	2000 hours
Useful life at 40 °C, I_R applied	> 300000 hours
Shelf life at 0 V, 125 °C	500 hours
Based on sectional specification	IEC 60384-4/EN130300
Climatic category IEC 60068	55/125/56

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) and category voltage if applicable.
- Date code in accordance with IEC60062.
- Name of manufacturer.
- '**l**' sign to indicate the negative terminal.
- '+' sign to identify the positive terminal.
- Series Number.

MOUNTING

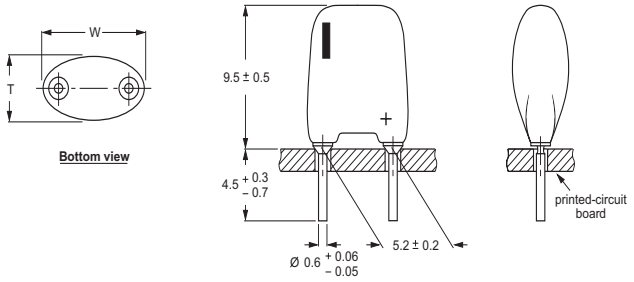
When bending, cutting or straightening the leads, ensure that the capacitor body is relieved of stress.

Bending after soldering must be avoided.

*Pb containing terminations are not RoHS compliant, exemptions may apply

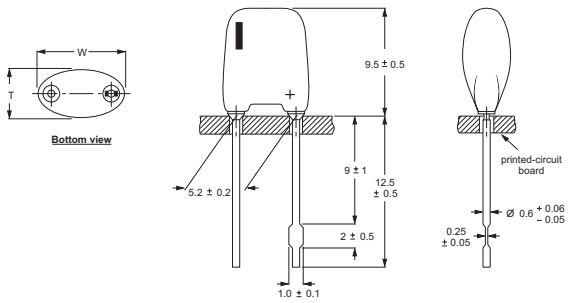
SELECTION CHART FOR C_R, U_R, U_C AND RELEVANT MAXIMUM CASE SIZES (H x W x T in mm)						
C_R (µF)	U_R (V) at T_{amb} = 85 °C					
	6.3	10	16	25	35	40
	U_C (V) at T_{amb} = 125 °C					
	6.3	10	16	25	25	25
0.1	-	-	-	-	-	10 x 7 x 3
0.15	-	-	-	-	-	10 x 7 x 3
0.22	-	-	-	-	-	10 x 7 x 3.5
0.33	-	-	-	-	10 x 7 x 3.5	10 x 7 x 4
0.47	-	-	-	-	10 x 7 x 4	10 x 7 x 5
0.68	-	-	-	10 x 7 x 3.5	10 x 7 x 4	10 x 7 x 5
1	-	-	-	10 x 7 x 3.5	10 x 7 x 5	10 x 8 x 5
1.5	-	-	-	10 x 7 x 3.5	10 x 8 x 5	10 x 8 x 6
2.2	-	-	10 x 7 x 3.5	10 x 7 x 4	10 x 8 x 6	10 x 8 x 6
3.3	-	-	10 x 7 x 3.5	10 x 7 x 5	10 x 8 x 6	-
4.7	-	10 x 7 x 3.5	10 x 7 x 4	10 x 8 x 5	-	-
6.8	-	10 x 7 x 3.5	10 x 7 x 4	10 x 8 x 6	-	-
10	10 x 7 x 3.5	10 x 7 x 4	10 x 7 x 5	10 x 8 x 6	-	-
15	-	10 x 7 x 4	10 x 8 x 5	-	-	-
22	10 x 7 x 4	10 x 7 x 5	10 x 8 x 6	-	-	-
33	10 x 7 x 5	10 x 8 x 5	-	-	-	-
47	10 x 8 x 5	10 x 8 x 6	-	-	-	-
68	10 x 8 x 6	-	-	-	-	-

DIMENSIONS in millimeters **AND AVAILABLE FORMS**



The diameter of the mounting holes in the printed-circuit board is 0.8 ± 0.1 mm.
Flanges are provided with degassing grooves.

Fig.2 **Form CB**: Short leads, in boxes.



The diameter of the mounting holes in the printed-circuit board is 0.8 ± 0.1 mm, except for the hole of the anode lead of Form CA capacitors: 1.3 − 0.2 mm.
Flanges are provided with degassing grooves.

Fig.3 **Form CA**: Long leads with keyed polarity, in boxes.

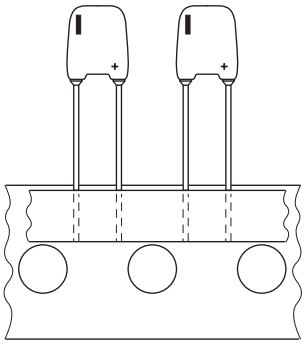
Table 1

DIMENSIONS in millimeters, **MASS AND PACKAGING QUANTITIES**						
MAXIMUM CASE SIZE H × W × T (mm)	**CASE CODE**	**MASS (g)**	**PACKAGING QUANTITIES**			
			FORM CA (note 1)	**FORM CB (note 1)**	**FORM TR+**	**FORM TFA**
10 × 7 × 3	10	≈ 0.22	1000	1000	2000	1000
10 × 7 × 3.5	20	≈ 0.25	1000	1000	2000	1000
10 × 7 × 4	30	≈ 0.30	1000	1000	2000	1000
10 × 7 × 5	40	≈ 0.35	1000	1000	1000	1000
10 × 8 × 5	50	≈ 0.50	1000	1000	1000	1000
10 × 8 × 6	60	≈ 0.60	1000	1000	1000	1000

Note

1. In plastic bags of 200 units each.
2. Detailed tape dimensions see section ‘PACKAGING’.

TAPED PRODUCTS



Form TR+: Taped on reel, positive leading.
Form TFA: Taped in ammopack.

Fig.4 Taped versions.

ELECTRICAL DATA	
C_R	rated capacitance at 100 Hz, tolerance ± 20 %
I_R	max. RMS ripple current no necessary DC applied
I_{L5}	max. leakage current after 5 minutes at U_R
Tan δ	max. dissipation factor at 100 Hz; note 1
ESR	max./typ. equivalent series resistance at 100 Hz
Z	max. impedance at 100 kHz

Note

1. Unless otherwise specified, all electrical values in Table 2 apply at T_{amb} = 20 to 25 °C, P = 86 to 106 kPa, RH = 45 to 75 %.

ORDERING EXAMPLE

Electrolytic capacitors 128 series 10 µF/16 V; ± 20 %
Maximum case size: 10 × 7 × 5 mm; Form CB;
Lead (Pb)-Free

Catalog number: 2281 128 55109

Table 2

ELECTRICAL DATA AND ORDERING INFORMATION

U_C (V)	U_R (V)	C_R 100 Hz (µF)	MAXIMUM CASE SIZE H × W × T (mm)	CASE CODE	I_R 100 Hz 125 °C (mA)	I_R 10 kHz 85 °C (mA)	I_R 100 kHz 40 °C (mA)	I_{L5} 5 min (µA)	MAX. ESR 100 Hz (Ω)	TYP. ESR 100 Hz (Ω)	Z 100 kHz (Ω)	CATALOG NUMBER 2281 128..... LEAD (Pb)-FREE [2]			
												FORM CB	FORM CA	FORM TR+ REEL	FORM TFA AMMO
6.3	6.3	10	10 × 7 × 3.5	20	22.4	320	595	2	20	8	2.0	53109	73109	23109	33109
		22	10 × 7 × 4	30	32.9	470	870	4	9	3.5	1.0	53229	73229	23229	33229
		33	10 × 7 × 5	40	65.4	595	1100	5	6.1	2	0.70	53339	73339	23339	33339
		47	10 × 8 × 5	50	118.4	740	1360	7	4.3	2	0.50	53479	73479	23479	33479
		68	10 × 8 × 6	60	153.0	800	1650	11	3.0	1.5	0.40	53689	73689	23689	33689
10	10	4.7	10 × 7 × 3.5	20	16.1	230	425	2	43	16	3.00	54478	74478	24478	34478
		6.8	10 × 7 × 3.5	20	18.9	270	500	2	30	12	2.20	54688	74688	24688	34688
		10	10 × 7 × 4	30	21.7	310	573	3	20	9	1.70	54109	74109	24109	34109
		15	10 × 7 × 4	30	27.3	390	720	4	14	7	1.20	54159	74159	24159	34159
		22	10 × 7 × 5	40	51.7	470	870	6	9	3.5	0.90	54229	74229	24229	34229
		33	10 × 8 × 5	50	81.6	510	940	8	6.1	2	0.60	54339	74339	24339	34339
		47	10 × 8 × 6	60	105.4	620	1140	12	4.3	1.5	0.40	54479	74479	24479	34479
16	16	2.2	10 × 7 × 3.5	20	14.0	200	370	2	91	25	4.50	55228	75228	25228	35228
		3.3	10 × 7 × 3.5	20	16.1	230	425	2	61	26	3.30	55338	75338	25338	35338
		4.7	10 × 7 × 4	30	18.9	270	500	2	43	14	2.30	55478	75478	25478	35478
		6.8	10 × 7 × 4	30	22.4	320	590	3	30	11	1.65	55688	75688	25688	35688
		10	10 × 7 × 5	40	42.9	390	720	4	20	6	1.10	55109	75109	25109	35109
		15	10 × 8 × 5	50	71.2	445	820	6	14	5	0.85	55159	75159	25159	35159
		22	10 × 8 × 6	60	86.7	510	940	9	9	3.5	0.65	55229	75229	25229	35229
25	25	0.68	10 × 7 × 3.5	20	7.7	110	200	2	295	85	17.00	56687	76687	26687	36687
		1	10 × 7 × 3.5	20	9.1	130	240	2	200	71	12.50	56108	76108	26108	36108
		1.5	10 × 7 × 3.5	20	10.8	155	285	2	135	48	10.00	56158	76158	26158	36158
		2.2	10 × 7 × 4	30	13.6	195	360	2	91	34	7.00	56228	76228	26228	36228
		3.3	10 × 7 × 5	40	16.1	230	425	2	61	19	5.20	56338	76338	26338	36338
		4.7	10 × 8 × 5	50	25.3	270	500	3	43	14	3.50	56478	76478	26478	36478
		6.8	10 × 8 × 6	60	52.7	310	570	4	30	11	2.70	56688	76688	26688	36688
		10	10 × 8 × 6	60	64.8	360	660	6	20	9	2.00	56109	76109	26109	36109
25	35	0.33	10 × 7 × 3.5	20	5.6	80	145	2	610	185	27.00	50337	70337	20337	30337
		0.47	10 × 7 × 4	30	6.3	90	165	2	430	130	20.00	50477	70477	20477	30477
		0.68	10 × 7 × 4	30	7.7	110	205	2	295	89	15.00	50687	70687	20687	30687
		1	10 × 7 × 5	40	13.7	125	230	2	200	49	10.00	50108	70108	20108	30108
		1.5	10 × 8 × 5	50	24.8	155	285	2	135	41	7.00	50158	70158	20158	30158
		2.2	10 × 8 × 6	60	33.1	195	360	2	91	28	4.50	50228	70228	20228	30228
		3.3	10 × 8 × 6	60	39.9	235	435	3	61	28	3.50	50338	70338	20338	30338
25	40	0.1	10 × 7 × 3	10	2.0	40	75	2	1990	950	45.00	57107	77107	27107	37107
		0.15	10 × 7 × 3	10	2.5	50	95	2	1330	400	35.00	57157	77157	27157	37157
		0.22	10 × 7 × 3.5	20	4.2	60	115	2	910	275	27.00	57227	77227	27227	37227
		0.33	10 × 7 × 4	30	5.3	75	140	2	610	172	20.00	57337	77337	27337	37337
		0.47	10 × 7 × 5	40	10.4	95	175	2	430	114	15.00	57477	77477	27477	37477
		0.68	10 × 7 × 5	40	12.1	110	205	2	295	89	10.00	57687	77687	27687	37687
		1	10 × 8 × 5	50	20.0	125	230	2	200	45	7.00	57108	77108	27108	37108
		1.5	10 × 8 × 6	60	25.5	150	280	2	135	35	5.50	57158	77158	27158	37158
		2.2	10 × 8 × 6	60	33.1	195	360	2	91	28	4.20	57228	77228	27228	37228

Note

1. Tan δ at 100 Hz for all types < 0.10.
2. Non Lead (Pb)-free version available on request.

ADDITIONAL ELECTRICAL DATA		
PARAMETER	**CONDITIONS**	**VALUE**
Voltage		
Surge voltage		$U_s \leq 1.15 \times U_R$
Reverse voltage		$U_{rev} < 0.3 \times U_R$
Maximum peak AC voltage	reverse voltage applied	≤ 2 V
Maximum peak AC voltage, without reverse voltage applied	$T_{amb} \leq 85$ °C:	
	at $f \leq 0.1$ Hz	$0.30 \times U_R$
	at $0.1 \text{ Hz} < f \leq 1$ Hz	$0.45 \times U_R$
	at $1 \text{ Hz} < f \leq 10$ Hz	$0.60 \times U_R$
	at $10 \text{ Hz} < f \leq 50$ Hz	$0.65 \times U_R$
	at $f > 50$ Hz	$0.80 \times U_R$
	$85 \text{ °C} < T_{amb} \leq 125$ °C:	
	at $f \leq 0.1$ Hz	$0.15 \times U_R$
	at $0.1 \text{ Hz} < f \leq 1$ Hz	$0.22 \times U_R$
	at $1 \text{ Hz} < f \leq 10$ Hz	$0.30 \times U_R$
	at $10 \text{ Hz} < f \leq 50$ Hz	$0.32 \times U_R$
	at $f > 50$ Hz	$0.40 \times U_R$
Inductance		
Equivalent series inductance (ESL)	case sizes 10 × 7 × 3 to 10 × 7 × 5 mm	typ. 9 to 14 nH
	case sizes 10 × 8 × 5 and 10 × 8 × 6 mm	typ. 11 to 16 nH
	all case sizes	max. 20 nH
Dissipation		
Maximum power dissipation	case sizes 10 × 7 × 3 to 10 × 7 × 5 mm	P_{125} = 88 mW
	case sizes 10 × 8 × 5 and 10 × 8 × 6 mm	P_{125} = 104 mW
Current		
Maximum leakage current	after 5 minutes at U_R and T_{amb} = 25 °C	$I_{L5} \leq 0.025\ C_R \times U_R$ or 2 μA whichever is greater; see Table 2
Typical leakage current	15 s at U_R and T_{amb} = 25 °C:	
	U_R = 6.3 to 16 V	≈ 0.2 × value stated in Table 2
	U_R = 25 to 40 V	≈ 0.1 × value stated in Table 2

VOLTAGE

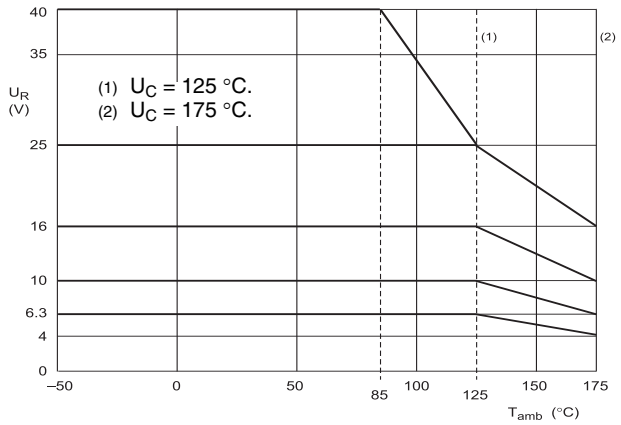


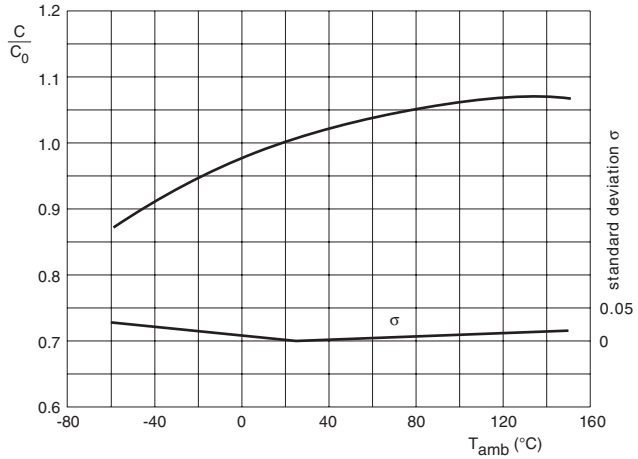
Fig.5 Maximum permissible voltage up to T_{amb} = 175 °C.

RIPPLE CURRENT (I_R)						
PARAMETER	**T_{amb}**					
	25 °C	**40 °C**	**65 °C**	**85 °C**	**105 °C**	**125 °C**
I_R multiplier	1.1	1.0	0.88	0.75	0.59	0.37

Note

1. Applying the maximum RMS ripple current given in Table 2 will cause a device temperature of 138 °C
2. The 100 kHz values in Table 2 for other temperatures are to be calculated with the above I_R multipliers:

CAPACITANCE (C)



C_0 = capacitance at 25 °C and 100 Hz.

Fig.6 Typical multiplier of capacitance and standard deviation as functions of ambient temperature.

TYPICAL CAPACITANCE CHANGE AFTER ENDURANCE TEST AT T_{AMB} = 125 °C

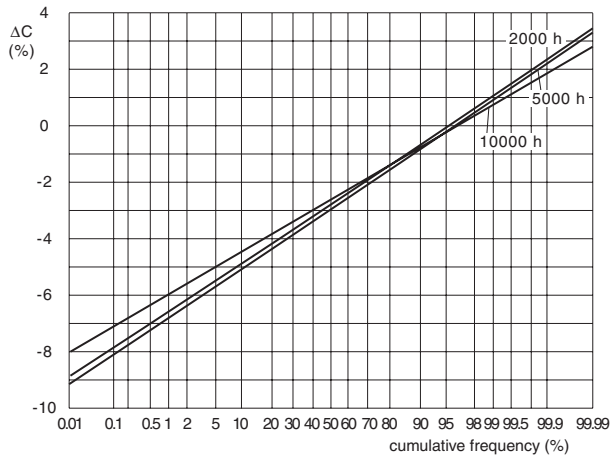
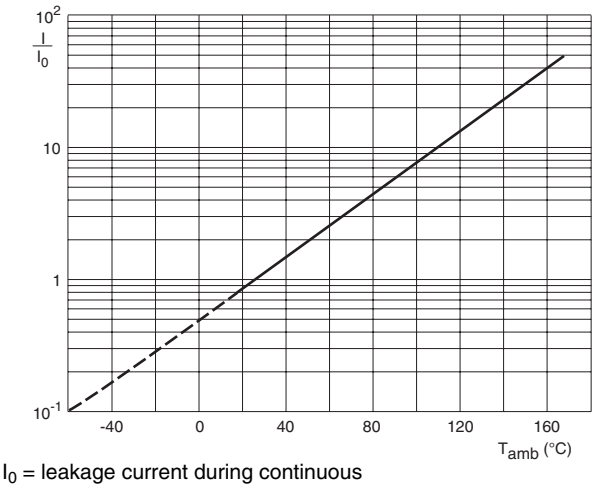


Fig.7 Change of capacitance as a function of cumulative frequency after endurance test.

LEAKAGE CURRENT



I_0 = leakage current during continuous operation at U_R and T_{amb} = 25 °C.

Fig.8 Typical multiplier of leakage current as a function of ambient temperature.

TYPICAL LEAKAGE CURRENT CHANGE AFTER ENDURANCE TEST AT T_{AMB} = 125 °C

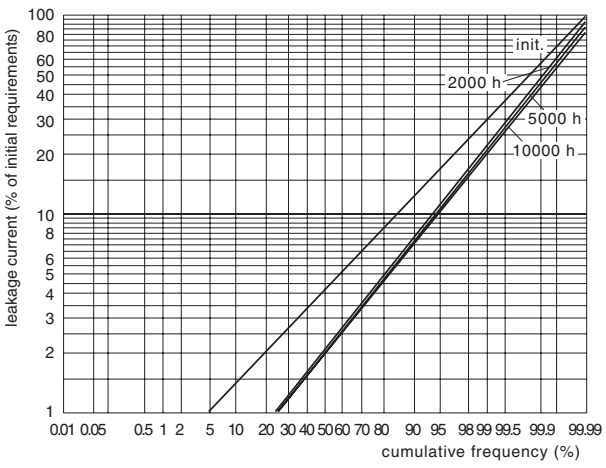
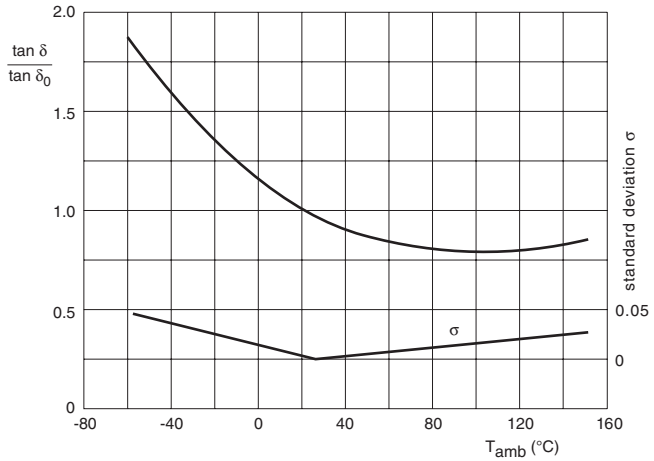


Fig.9 Leakage current change as a function of cumulative frequency after endurance test.

DISSIPATION FACTOR (tan δ)



$Tan\delta_0$ = dissipation factor at T_{amb} = 25 °C and 100 Hz.

Fig.10 Typical multiplier of dissipation factor and standard deviation as functions of ambient temperature.

TYPICAL tan δ CHANGE AFTER ENDURANCE TEST AT T_{AMB} = 125 °C

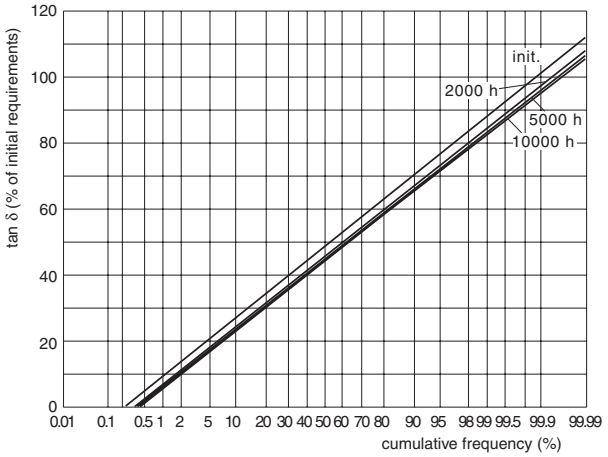
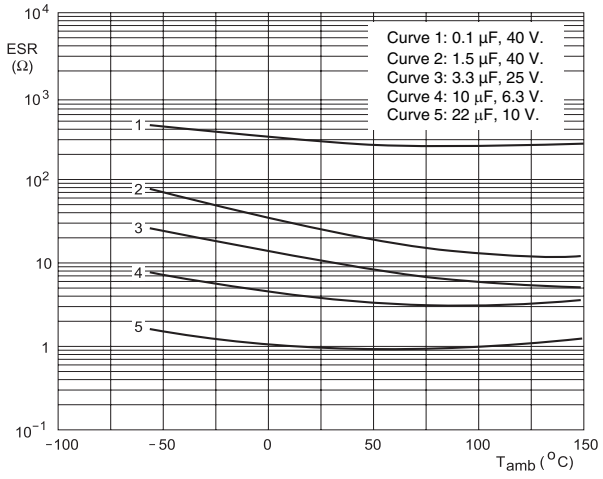


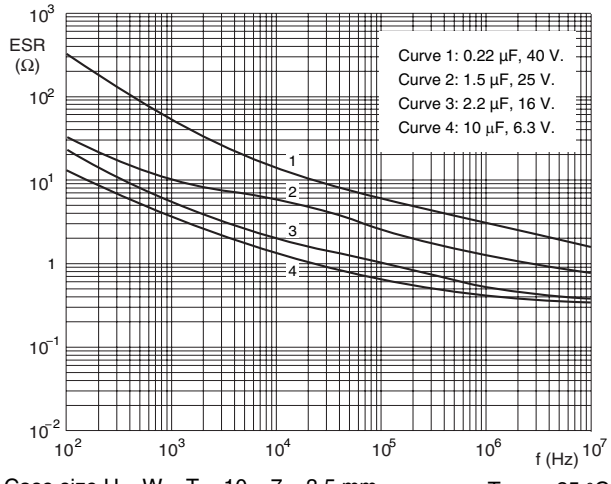
Fig.11 Tan δ change as a function of cumulative frequency after endurance test.

EQUIVALENT SERIES RESISTANCE (ESR)



ESR at 100 Hz.

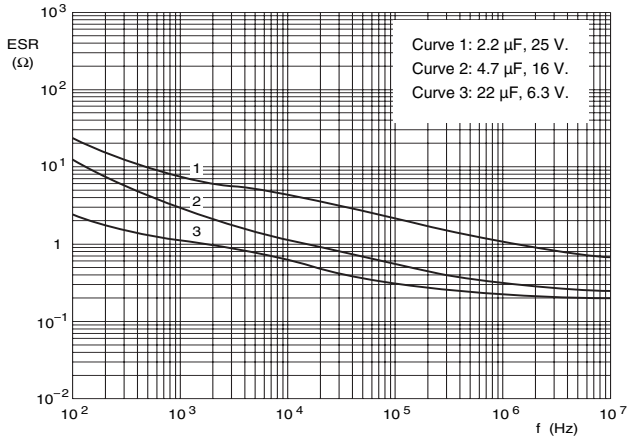
Fig.12 Typical ESR as a function of ambient temperature.



Case size H × W × T = 10 × 7 × 3.5 mm. T_{amb} = 25 °C.

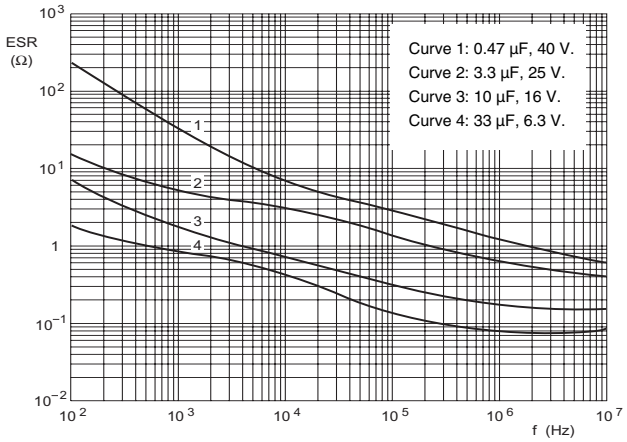
Fig.13 Typical ESR as a function of frequency.

EQUIVALENT SERIES RESISTANCE (ESR)



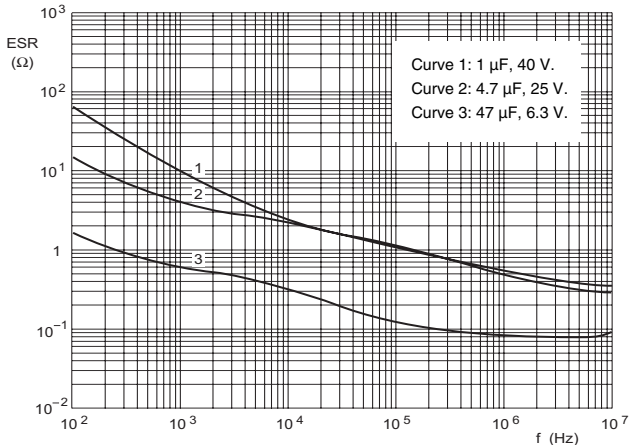
Case size H × W × T = 10 × 7 × 4 mm. T_{amb} = 25 °C.

Fig.14 Typical ESR as a function of frequency.



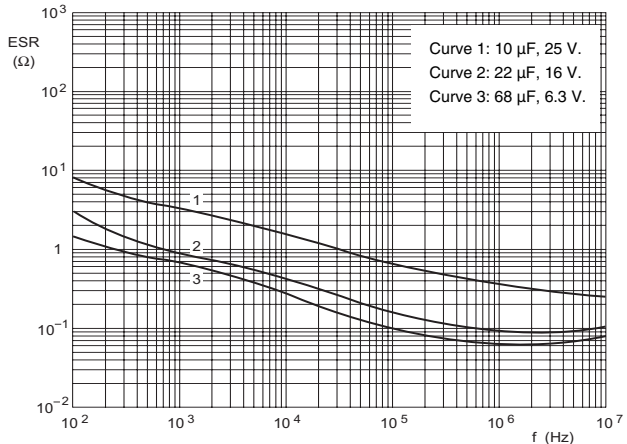
Case size H × W × T = 10 × 7 × 5 mm. T_{amb} = 25 °C.

Fig.15 Typical ESR as a function of frequency.



Case size H × W × T = 10 × 8 × 5 mm. T_{amb} = 25 °C.

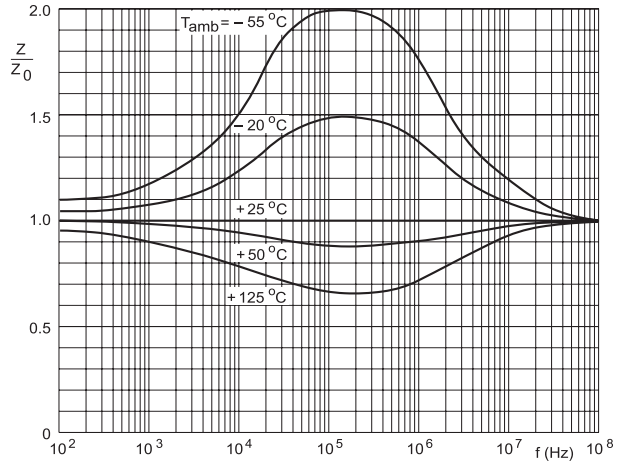
Fig.16 Typical ESR as a function of frequency.



Case size H × W × T = 10 × 8 × 6 mm. T_{amb} = 25 °C.

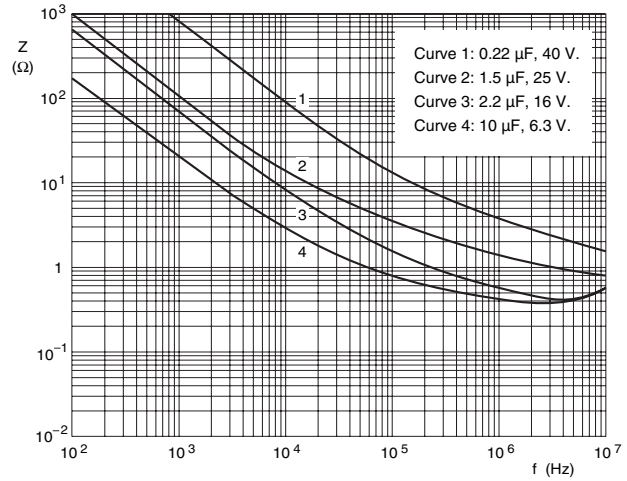
Fig.17 Typical ESR as a function of frequency.

IMPEDANCE (Z)



Z_0 = initial impedance value at T_{amb} = 25 °C.

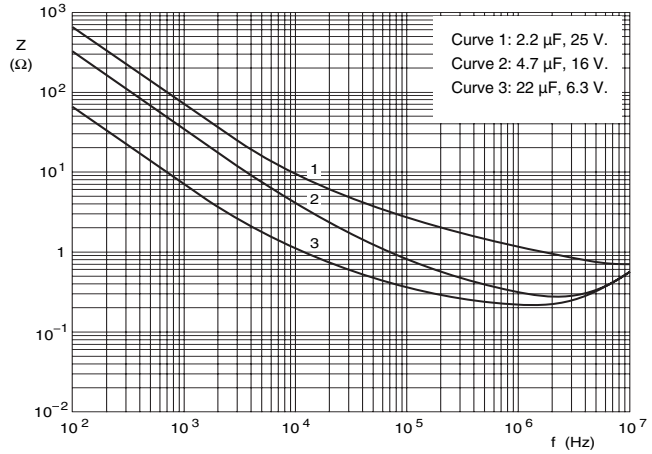
Fig.18 Typical multiplier of impedance as a function of frequency at different ambient temperatures.



Case size H × W × T = 10 × 7 × 3.5 mm. T_{amb} = 25 °C.

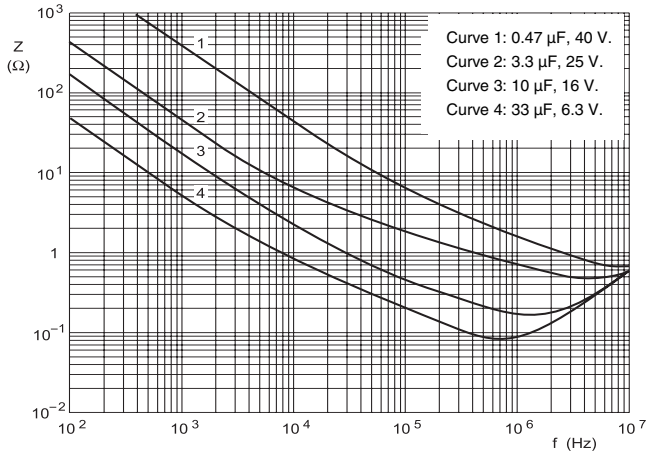
Fig.19 Typical impedance as a function of frequency.

IMPEDANCE (Z)



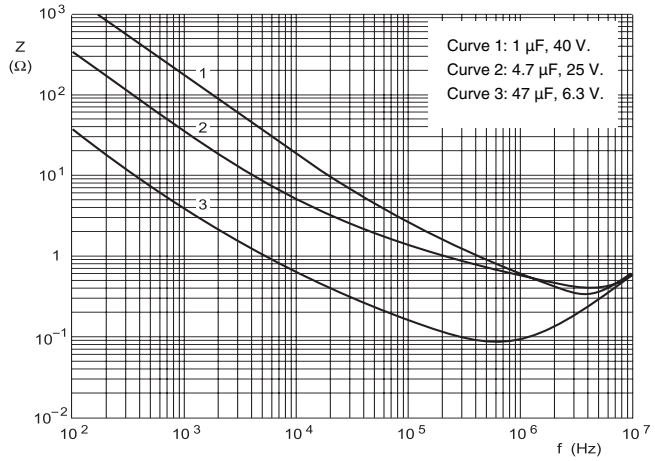
Case size H × W × T = 10 × 7 × 4 mm T_{amb} = 25 °C.

Fig.20 Typical impedance as a function of frequency.



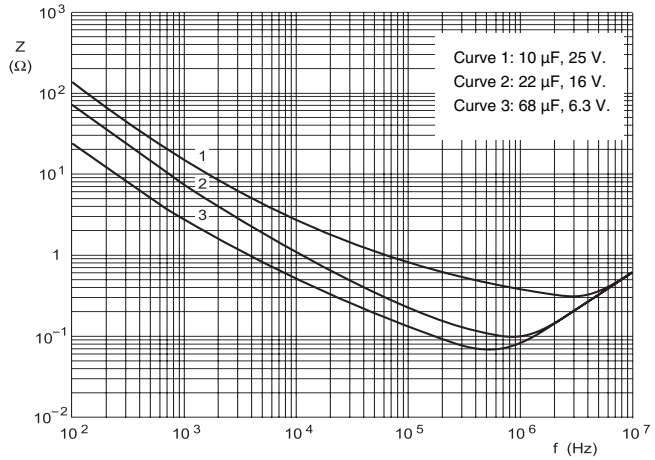
Case size H × W × T = 10 × 7 × 5 mm. T_{amb} = 25 °C.

Fig.21 Typical impedance as a function of frequency.



Case size H × W × T = 10 × 8 × 5 mm. T_{amb} = 25 °C.

Fig.22 Typical impedance as a function of frequency.



Case size H × W × T = 10 × 8 × 6 mm. T_{amb} = 25 °C.

Fig.23 Typical impedance as a function of frequency.

Table 3

TEST PROCEDURES AND REQUIREMENTS			
TEST		**PROCEDURE (quick reference)**	**REQUIREMENTS**
NAME OF TEST	**REFERENCE**		
Endurance	IEC 60384-4/ EN130300 subclause 4.13	T_{amb} = 125 °C; U_R = 6.3 to 25 V with U_R applied; U_R = 35 and 40 V with U_C applied; 10000 hours	$\Delta C/C$: ± 10 % tan $\delta \leq 1.2 \times$ spec. limit $Z \leq 1.2 \times$ spec. limit $I_L 5 \leq$ spec. limit
Useful life	CECC 30302 subclause 1.8.1	T_{amb} = 125 °C; I_R applied and: U_R = 6.3 to 25 V with U_R applied; U_R = 35 and 40 V with U_C applied; 20000 hours	$\Delta C/C$: ± 15 % tan $\delta \leq 1.5 \times$ spec. limit $Z \leq 1.5 \times$ spec. limit $I_L 5 \leq$ spec. limit no short or open circuit, no visible damage total failure percentage: < 1%
Shelf life (storage at high temperature)	IEC 60384-4/ EN130300 subclause 4.17	T_{amb} = 125 °C; no voltage applied; 500 hours	$\Delta C/C$: ± 10 % tan $\delta \leq 1.2 \times$ spec. limit $I_L 5 \leq 1 \times$ spec. limit
Charge and discharge	IEC 60384-4-2 subclause 9.21	10^6 cycles without series resistance: 0.5 s to U_R; 0.5 s to ground	$\Delta C/C$: ± 5 % no short or open circuit, no visible damage
Solvent resistance	IEC 60068-2-45, test XA IEC 60653	immersion: 5 ± 0.5 minutes with or without ultrasonic at 55 ± 5 °C solvents: demineralized water and/or calgonite solution (20 g/l)	visual appearance not affected
Extended vibration	IEC 60068-2-6 test Fc	10 to 2000 Hz; 1.5 mm or 20 g; 1 octave/minute; 3 directions; 1 sweep per direction; no voltage applied	no intermittent contacts no breakdown no open circuiting no mechanical damage $\Delta C/C$: ± 5 % tan $\delta \leq 1.2 \times$ spec. limit $Z \leq 1.2 \times$ spec. limit $I_L 5 \leq 1.5 \times$ spec. limit
Shock	IEC 60068-2-27 test Ea	half-sine or sawtooth pulse shape; 50 g; 11 ms; 3 successive shocks in each direction of 3 mutually perpendicular axes; no voltage applied	no intermittent contacts no breakdown no open circuiting no mechanical damage $\Delta C/C$: ± 5 % tan $\delta \leq 1.2 \times$ spec. limit $Z \leq 1.2 \times$ spec. limit $I_L 5 \leq 1.5 \times$ spec. limit
Passive flammability	IEC 60695-2-2	capacitor mounted to a vertical printed-circuit board, one flame on capacitor body; T_{amb} = 20 to 25 °C; test duration = 20 s	after removing the test flame from the capacitor, the capacitor must not continue to burn for more than 15 s; no burning particles must drop from the sample

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