Solid Al - electrolytic capacitors
Solid Al, Radial Pearl

SAL-RP 122

FEATURES

- Polarized aluminium electrolytic capacitors, solid electrolyte MnO_2
- Radial leads, max. height 12.5 mm, resin dipped, orange coloured
- Extremely long useful life, 20000 hours at 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.

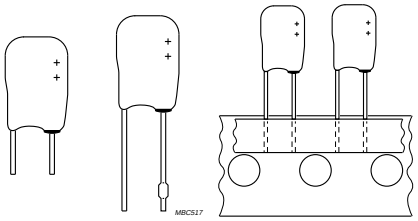


Fig.1 Component outlines.

APPLICATIONS

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

QUICK REFERENCE DATA

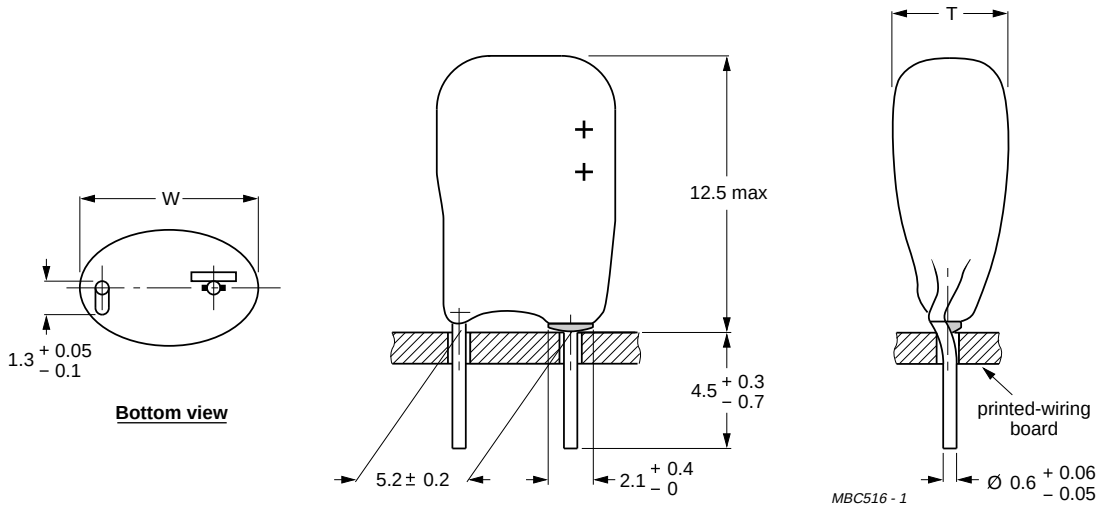
DESCRIPTION	VALUE
Case sizes ($H_{max} \times W_{max} \times T_{max}$ in mm)	$12.5 \times 8 \times 3.5$ to $12.5 \times 8 \times 6$
Rated capacitance range (E6 series), C_R	0.33 to 68 µF
Tolerance on C_R	±20%
Rated voltage range, U_R	6.3 to 40 V
Category temperature range: U_C = 6.3 to 25 V U_R = 6.3 to 40 V	 –55 to +125 °C –55 to +85 °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 384-4/CECC 30300
Detail specification	IEC 384-4-2/CECC 30302
Climatic category IEC 68 (DIN 40040; NF C20-600)	55/125/56 (FKD; 434)
Approvals	Liste LNZ 44-04 COS-B Gam-t-1

Selection chart for C_R, U_R, U_C and relevant maximum case sizes (H × W × T in mm)

Preferred types in **bold**.

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**	**35**	**40**
0.33	–	–	–	–	–	12.5 × 8 × 3.5
0.47	–	–	–	–	–	**12.5 × 8 × 4.5**
0.68	–	–	–	12.5 × 8 × 3.5	–	12.5 × 8 × 4.5
1.0	–	–	–	**12.5 × 8 × 3.5**	**12.5 × 8 × 4.5**	**12.5 × 8 × 5**
1.5	–	–	–	12.5 × 8 × 3.5	–	12.5 × 8 × 6
2.2	–	–	**12.5 × 8 × 3.5**	**12.5 × 8 × 4.5**	–	**12.5 × 8 × 6**
3.3	–	–	12.5 × 8 × 3.5	12.5 × 8 × 4.5	12.5 × 8 × 6	–
4.7	–	**12.5 × 8 × 3.5**	**12.5 × 8 × 4.5**	**12.5 × 8 × 5**	–	–
6.8	–	12.5 × 8 × 3.5	12.5 × 8 × 4.5	12.5 × 8 × 6	–	–
10	**12.5 × 8 × 3.5**	**12.5 × 8 × 4.5**	**12.5 × 8 × 5**	**12.5 × 8 × 6**	–	–
15	12.5 × 8 × 4.5	12.5 × 8 × 4.5	12.5 × 8 × 6	–	–	–
22	**12.5 × 8 × 4.5**	**12.5 × 8 × 5**	–	–	–	–
33	12.5 × 8 × 5	12.5 × 8 × 6	–	–	–	–
47	**12.5 × 8 × 6**	–	–	–	–	–
68	12.5 × 8 × 6	–	–	–	–	–

MECHANICAL DATA AVAILABLE FORMS AND PACKAGING QUANTITIES

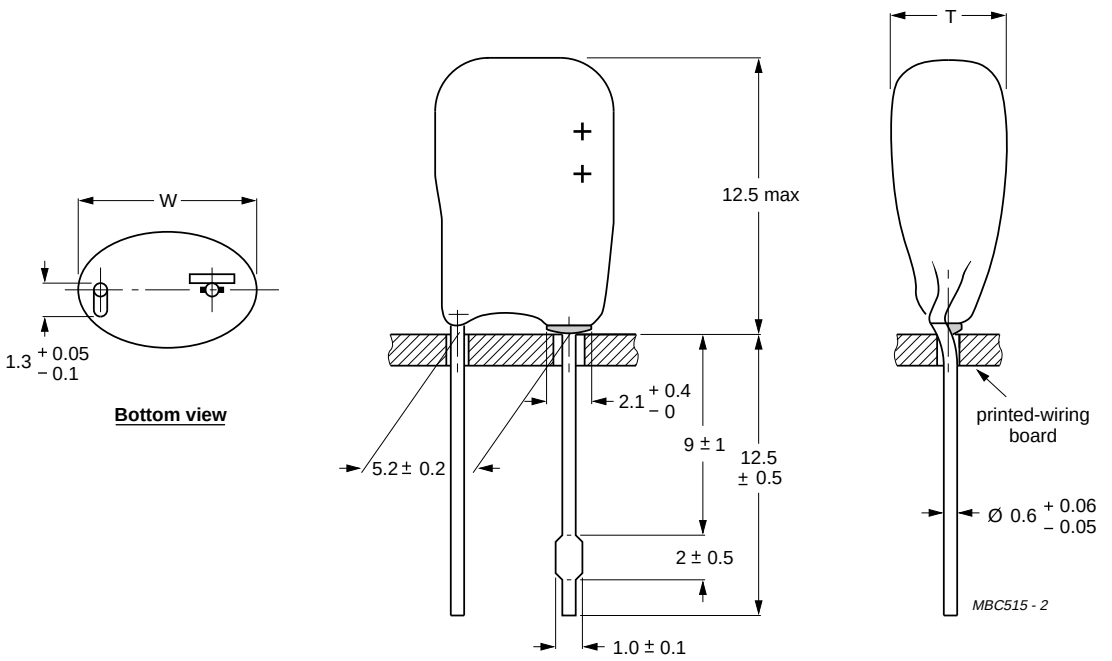


Dimensions in mm.

For dimensions see Table 1.

The diameter of the mounting holes in the printed-circuit board is 0.8 ±0.1 mm.

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



Dimensions in mm.

For dimensions see Table 1.

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.

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

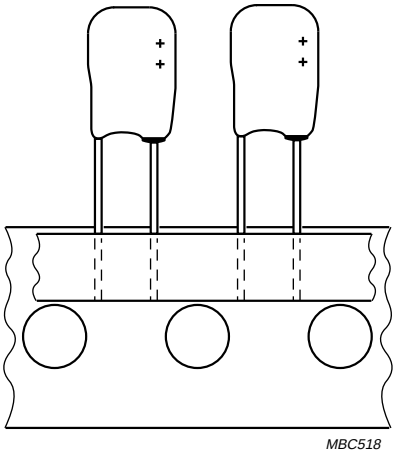
Table 1 Physical dimensions, mass and packaging quantities; see Figs 2 and 3

CASE		MASS (g)	PACKAGING QUANTITIES			
MAXIMUM SIZE H × W × T (mm)	CODE		FORM CA (note 1)	FORM CB (note 1)	FORM TR+	FORM TFA
12.5 × 8 × 3.5	1	≈0.35	1000	1000	2000	2000
12.5 × 8 × 4.5	2	≈0.38	1000	1000	2000	2000
12.5 × 8 × 5	3	≈0.45	1000	1000	1000	1000
12.5 × 8 × 6	4	≈0.58	800	1000	1000	1000

Note

1. In plastic bags of 200 units each.

Taped products



Form TR+: Taped on reel, positive leading.
Form TFA: Taped in ammopack.
Tape dimensions are specified in handbook, Section *"Packaging"*.

Fig.4 Taped versions.

Mounting

When bending, cutting or straightening the leads, ensure that the capacitor body is relieved of stress. Bending after soldering must be avoided.

ELECTRICAL DATA AND ORDERING INFORMATION

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%.

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

Ordering example

Electrolytic capacitors SAL-RP

10 µF/16 V; ±20%

Maximum case size: 12.5 × 8 × 5 mm, Form TFA

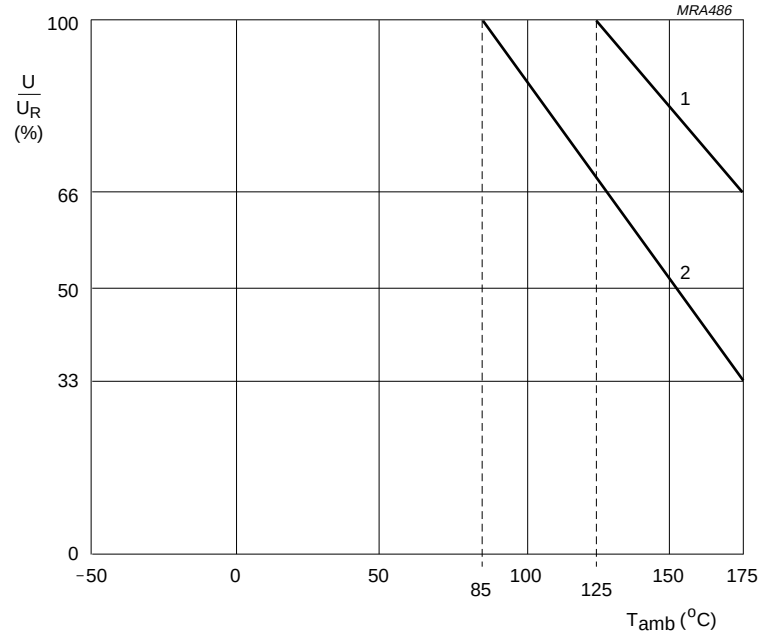
Catalogue number: 2222 122 35109.

Table 2 Electrical data and ordering information; preferred types in **bold**

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)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 100 kHz (Ω)	CATALOGUE NUMBER 2222 122			
												FORM CB	FORM CA	FORM TR+ REEL	FORM TFA AMMO
6.3	6.3	**10**	**12.5 × 8 × 3.5**	**1**	9	156	211	3	0.15	30	5	53109	73109	23109	**33109**
		15	12.5 × 8 × 4.5	2	13	195	264	5	0.15	20	3	53159	73159	23159	33159
		22	**12.5 × 8 × 4.5**	**2**	20	234	317	7	0.15	14	1.3	53229	73229	23229	**33229**
		33	12.5 × 8 × 5	3	30	293	396	11	0.15	9	0.9	53339	73339	23339	33339
		47	**12.5 × 8 × 6**	**4**	42	371	502	15	0.15	6.4	0.7	53479	73479	23479	**33479**
		68	12.5 × 8 × 6	4	61	449	607	22	0.15	4.4	0.5	53689	73689	23689	33689
10	10	**4.7**	**12.5 × 8 × 3.5**	1	7	117	158	3	0.15	64	7	54478	74478	24478	**34478**
		6.8	12.5 × 8 × 3.5	1	10	137	185	4	0.15	44	5	54688	74688	24688	34688
		10	**12.5 × 8 × 4.5**	**2**	14	156	211	5	0.15	30	1.5	54109	74109	24109	**34109**
		15	12.5 × 8 × 4.5	2	21	195	264	8	0.15	20	1	54159	74159	24159	34159
		22	**12.5 × 8 × 5**	**3**	31	234	317	11	0.15	14	0.7	54229	74229	24229	**34229**
		33	12.5 × 8 × 6	4	47	312	422	17	0.15	9	0.5	54339	74339	24339	34339
16	16	**2.2**	**12.5 × 8 × 3.5**	**1**	5	98	132	2	0.10	91	10	55228	75228	25228	**35228**
		3.3	12.5 × 8 × 3.5	1	8	117	158	3	0.10	61	7	55338	75338	25338	35338
		4.7	**12.5 × 8 × 4.5**	**2**	11	137	185	4	0.10	43	2	55478	75478	25478	**35478**
		6.8	12.5 × 8 × 4.5	2	16	156	211	6	0.10	29.5	1.5	55688	75688	25688	35688
		10	**12.5 × 8 × 5**	**3**	23	195	264	8	0.10	20	1	55109	75109	25109	**35109**
		15	12.5 × 8 × 6	4	34	254	343	12	0.10	13.5	0.7	55159	75159	25159	35159

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)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 100 kHz (Ω)	CATALOGUE NUMBER 2222 122			
												FORM CB	FORM CA	FORM TR+ REEL	FORM TFA AMMO
25	25	0.68	12.5 × 8 × 3.5	1	2	55	74	2	0.10	295	30	56687	76687	26687	36687
		1.0	**12.5 × 8 × 3.5**	**1**	4	62	85	2	0.10	200	20	56108	76108	26108	**36108**
		1.5	12.5 × 8 × 3.5	1	5	78	106	2	0.10	135	15	56158	76158	26158	36158
		2.2	**12.5 × 8 × 4.5**	**2**	8	98	132	3	0.10	91	10	56228	76228	26228	**36228**
		3.3	12.5 × 8 × 4.5	2	12	117	158	4	0.10	61	7	56338	76338	26338	36338
		4.7	**12.5 × 8 × 5**	**3**	17	137	185	6	0.10	43	5	56478	76478	26478	**36478**
		6.8	12.5 × 8 × 6	4	24	176	238	9	0.10	29.5	3	56688	76688	26688	36688
		10	**12.5 × 8 × 6**	**4**	35	200	238	13	0.15	20	2	56109	76109	26109	**36109**
25	35	**1.0**	**12.5 × 8 × 4.5**	**2**	3	62	85	2	0.10	200	15	50108	70108	20108	**30108**
		3.3	12.5 × 8 × 6	4	12	117	132	6	0.10	61	5	50338	70338	20338	30338
25	40	0.33	12.5 × 8 × 3.5	1	1	39	53	2	0.10	610	30	57337	77337	27337	37337
		0.47	**12.5 × 8 × 4.5**	**2**	2	47	63	2	0.10	430	20	57477	77477	27477	**37477**
		0.68	12.5 × 8 × 4.5	2	2	55	74	2	0.10	295	15	57687	77687	27687	37687
		1.0	**12.5 × 8 × 5**	**3**	4	62	85	2	0.10	200	10	57108	77108	27108	**37108**
		1.5	12.5 × 8 × 6	4	5	78	106	3	0.10	135	7	57158	77158	27158	37158
		2.2	**12.5 × 8 × 6**	**4**	8	98	132	5	0.10	91	5	57228	77228	27228	**37228**

Voltage



Curve 1: 6.3 V to 25 V.
Curve 2: 35 and 40 V.

Fig.5 Maximum permissible voltage up to 175 °C.

MARKING

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

- Rated capacitance (in μF)
- Tolerance code on rated capacitance (M = ±20%)
- Rated voltage (in V) and category voltage if applicable
- Date code in accordance with *"IEC 62"*
- Name of manufacturer
- "+" signs to identify the anode terminal.

ELECTRICAL DATA (continued)

Additional electrical data

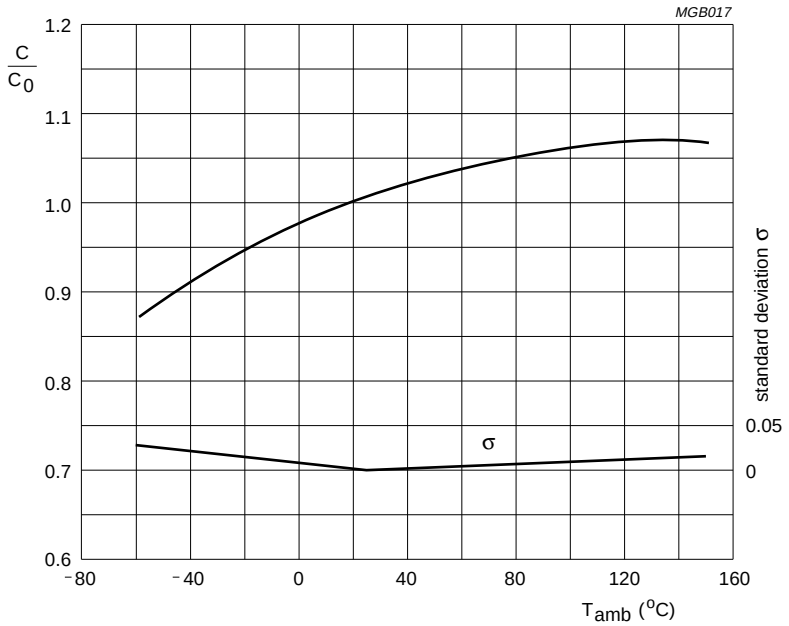
PARAMETER	CONDITIONS	VALUE
Voltage		
Surge voltage	for short periods	$U_S \leq 1.15 \times U_R$
Reverse voltage		$U_{rev} < 0.3 \times U_R$
Maximum peak AC voltage reverse voltage applied		≤2 V
Maximum peak AC voltage without reverse voltage applied	$T_{amb} \leq 85$ °C:	
	at $f \leq 0.1$ Hz	$0.30 \times U_R$
	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 °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 size $12.5 \times 8 \times 3.5$ to $12.5 \times 8 \times 4.5$ mm	typ. 9 to 14 nH
	case size $12.5 \times 8 \times 5$ and $12.5 \times 8 \times 6$ mm	typ. 11 to 16 nH
	all case sizes	max. 20 nH
Dissipation		
Maximum power dissipation	case sizes $12.5 \times 8 \times 3.5$ to $12.5 \times 8 \times 5$ mm	P_{125} = 88 mW
	case size $12.5 \times 8 \times 6$ mm	P_{125} = 104 mW
Current		
Maximum leakage current	after 5 minutes at U_R and T_{amb} = 25 °C	$I_{L5} \leq 0.05 C_R \times U_R$ or 2 µA whichever is greater; see Table 2
Typical leakage current	after 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

Ripple current (I_R)

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

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

Capacitance (C)



C_0 = capacitance at 25 °C and 100 Hz.

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

Typical parameter change after endurance test at T_{amb} = 125 °C

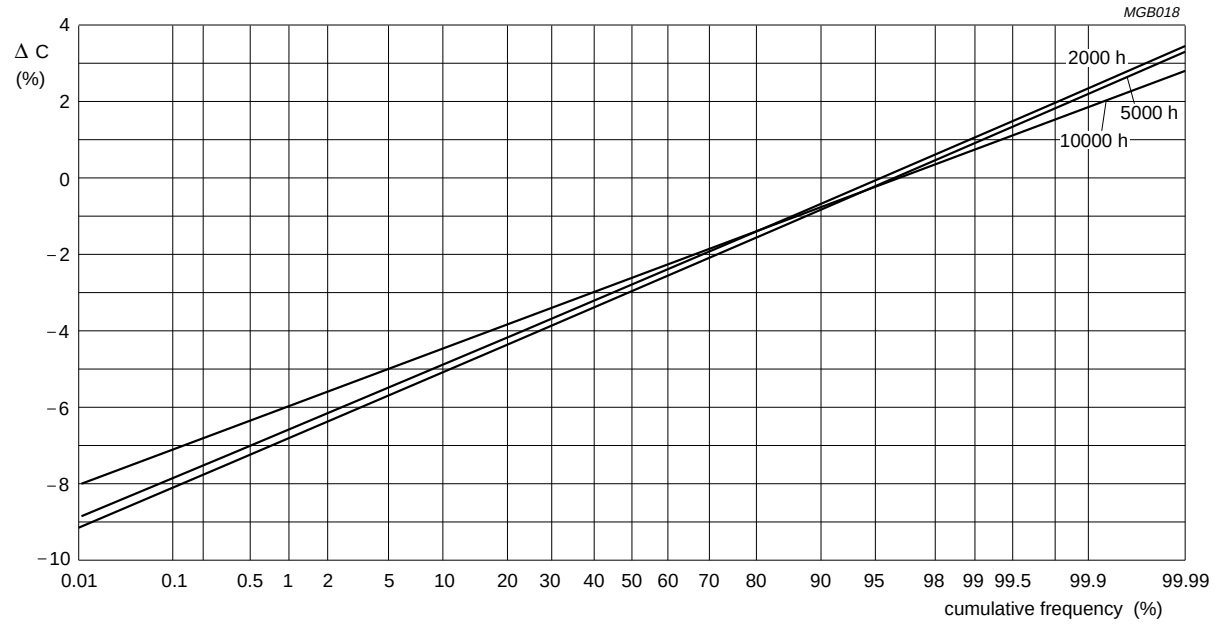
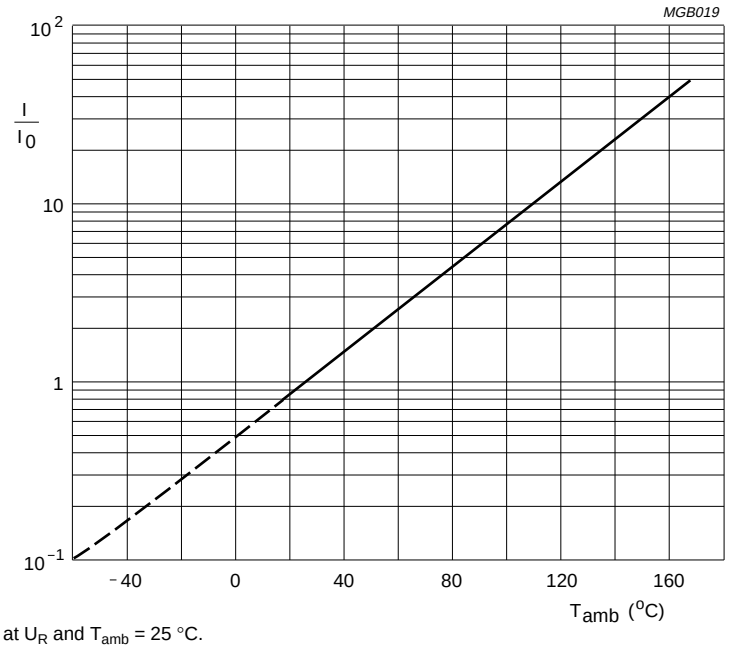


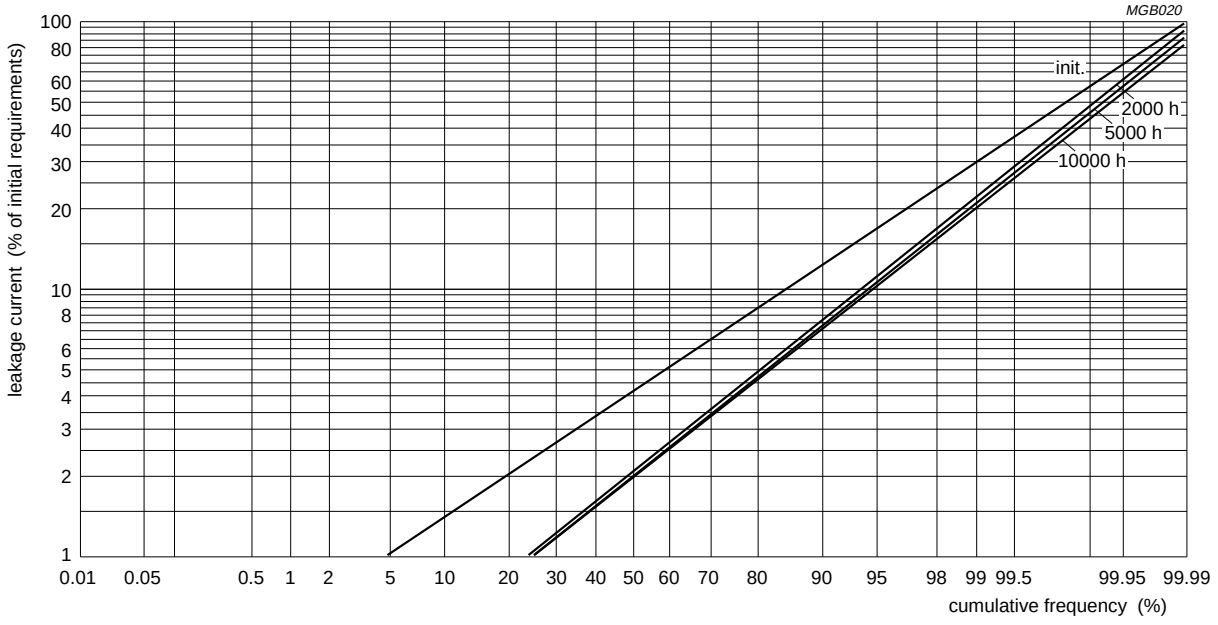
Fig.7 Change of capacitance after endurance test.



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.

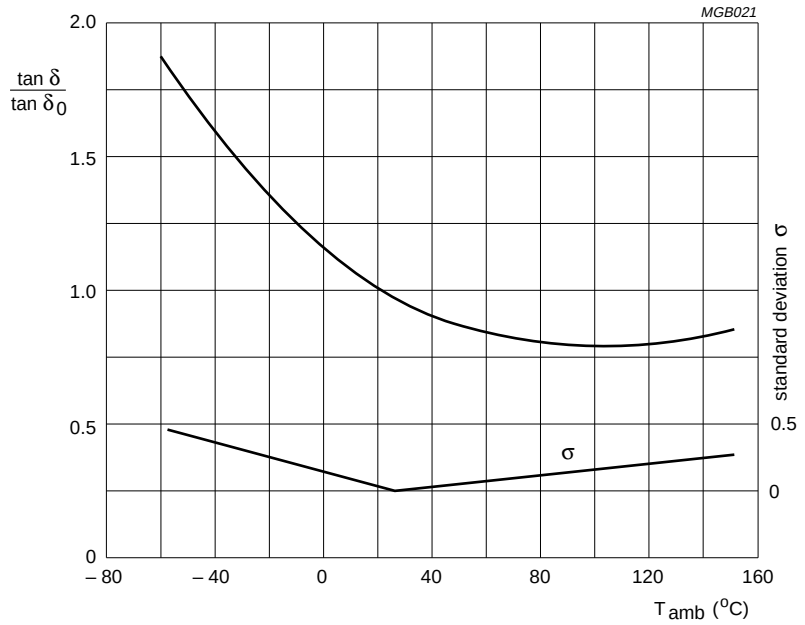
Typical parameter change after endurance test at T_{amb} = 125 °C



T_{amb} = 125 °C.

Fig.9 Leakage current after endurance test.

Dissipation factor (tan δ)



tan δ_0 = dissipation factor at T_{amb} = 25 °C and 100 Hz.

Fig.10 Typical multiplier of dissipation factor as a function of temperature.

Typical parameter change after endurance test at T_{amb} = 125 °C

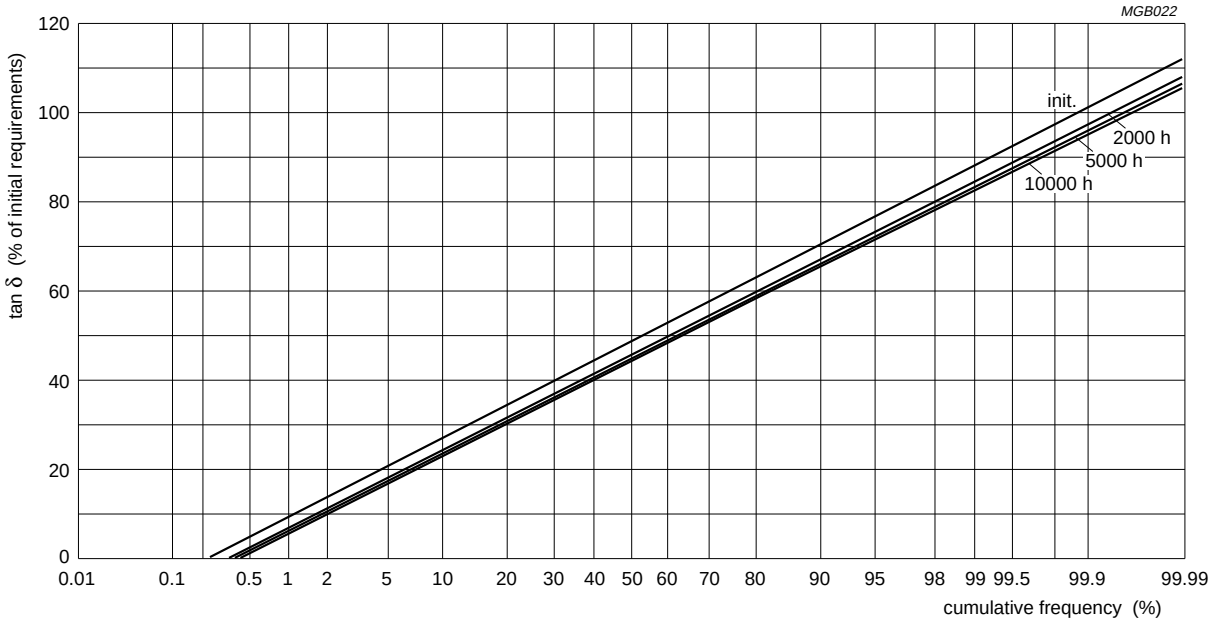
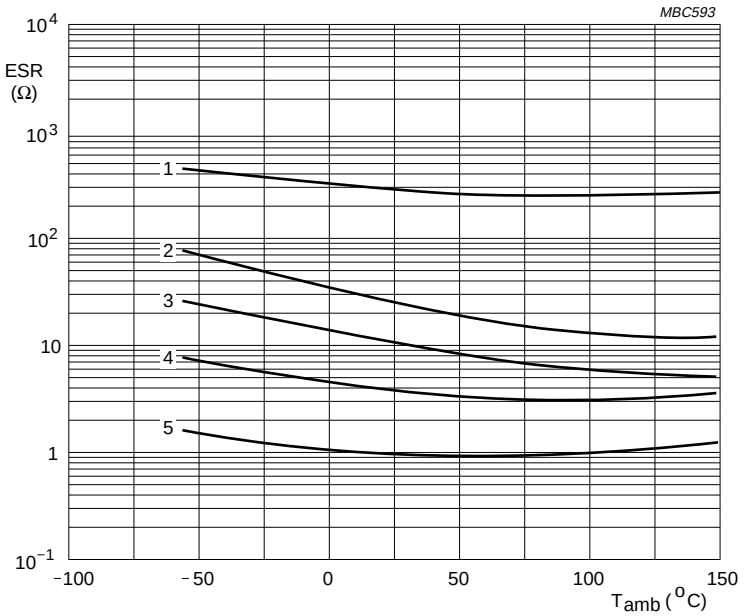


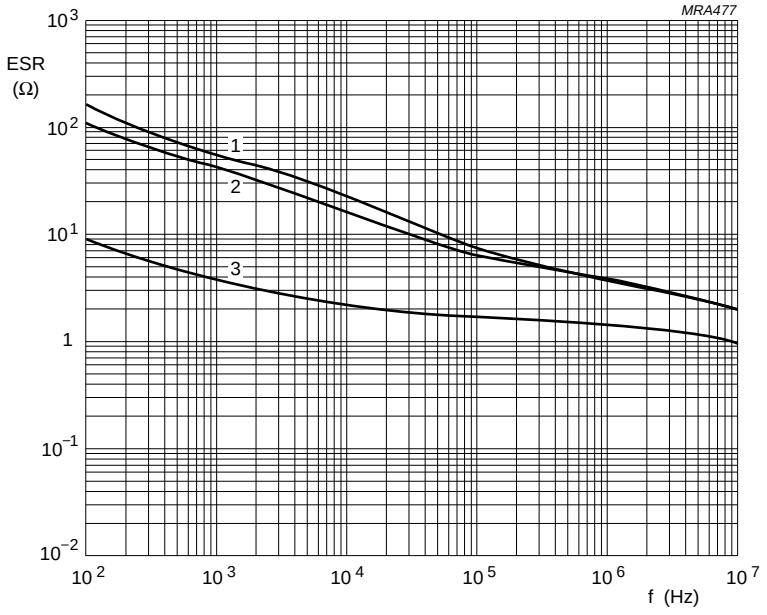
Fig.11 Tan δ after endurance test.

Equivalent series resistance (ESR)



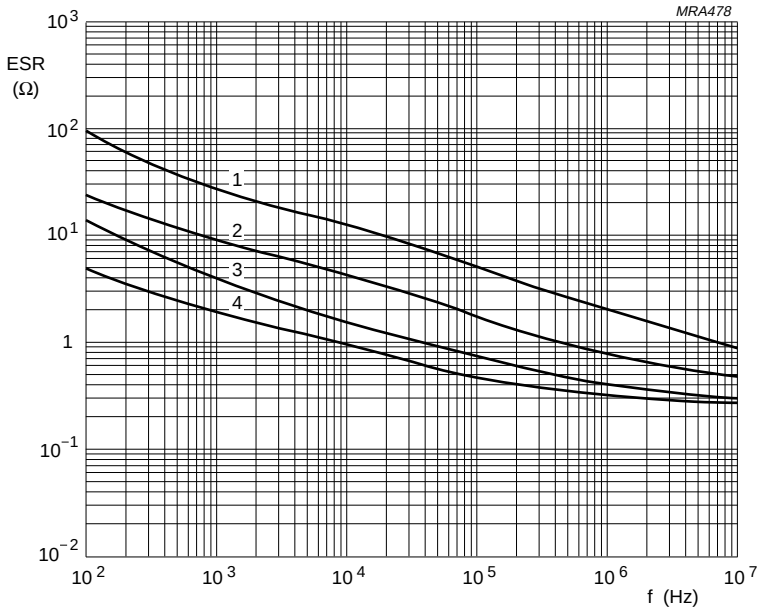
Curve 1: 0.1 μF, 40 V.
Curve 2: 1.5 μF, 40 V.
Curve 3: 3.3 μF, 25 V.
Curve 4: 10 μF, 6.3 V.
Curve 5: 22 μF, 10 V.
ESR at 100 Hz.

Fig.12 Typical ESR as a function of temperature.



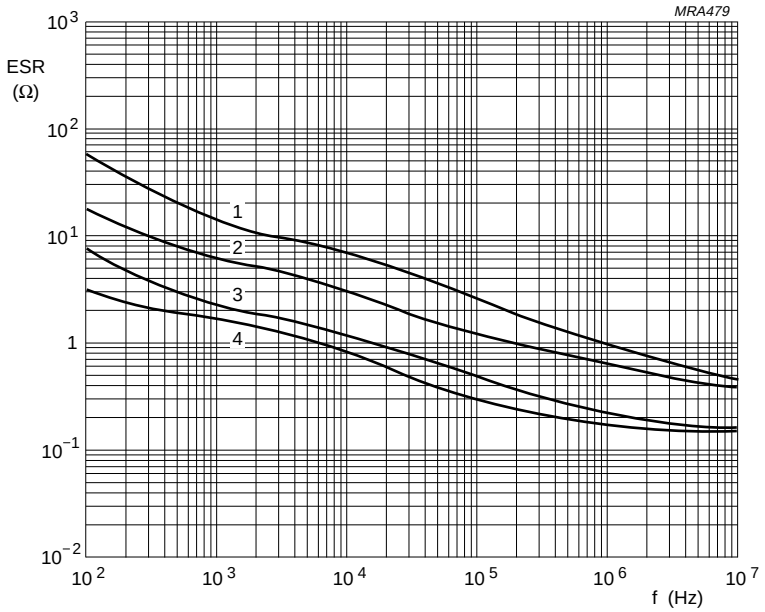
Curve 1: 0.33 μF, 40 V.
Curve 2: 0.68 μF, 25 V.
Curve 3: 10 μF, 6.3 V.
Case size H × W × T = 12.5 × 8 × 3.5 mm.
T_{amb} = 25 °C.

Fig.13 Typical ESR as a function of frequency.



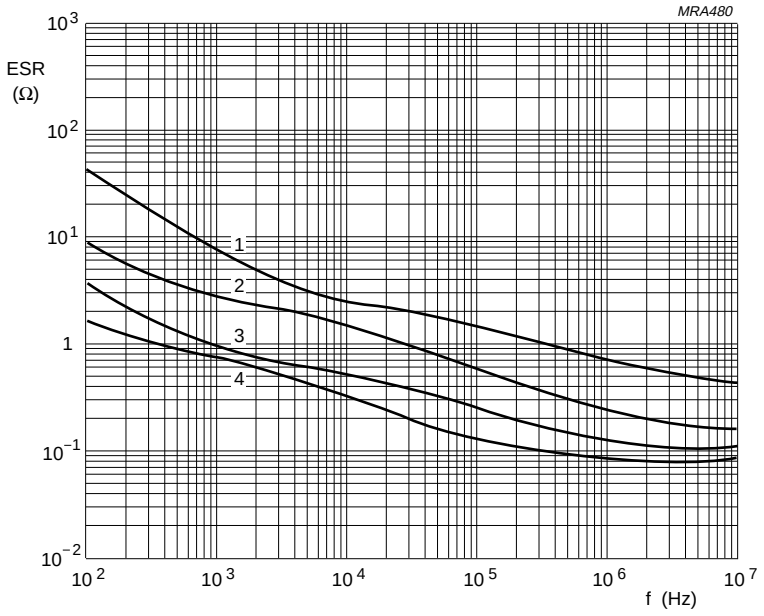
Curve 1: 0.47 µF, 25 V.
Curve 2: 2.2 µF, 25 V.
Curve 3: 4.7 µF, 16 V
Curve 4: 22 µF, 6.3 V.
Case size H × W × T = 12.5 × 8 × 4.5 mm.
T_{amb} = 25 °C.

Fig.14 Typical ESR as a function of frequency.



Curve 1: 1.0 µF, 40 V.
Curve 2: 4.7 µF, 25 V.
Curve 3: 10 µF, 16 V.
Curve 4: 33 µF, 6.3 V.
Case size H × W × T = 12.5 × 8 × 5 mm.
T_{amb} = 25 °C.

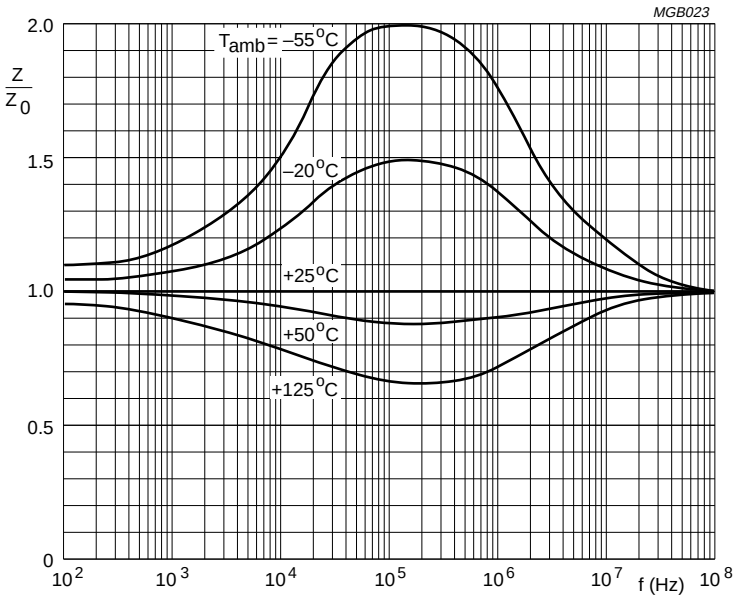
Fig.15 Typical ESR as a function of frequency.



Curve 1: 1.5 μF, 40 V.
Curve 2: 6.8 μF, 25 V.
Curve 3: 15 μF, 16 V.
Curve 4: 68 μF, 6.3 V.
Case size H × W × T = 12.5 × 8 × 6 mm.
T_{amb} = 25 °C.

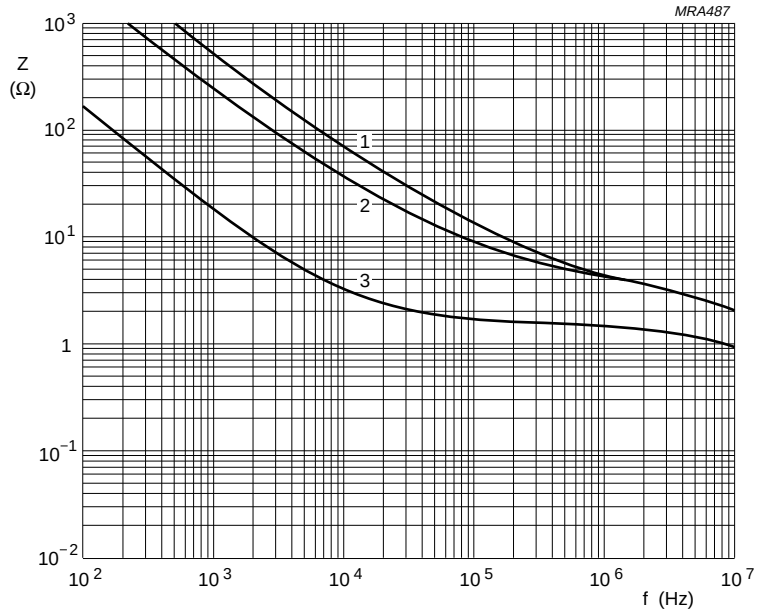
Fig.16 Typical ESR as a function of frequency.

Impedance (Z)



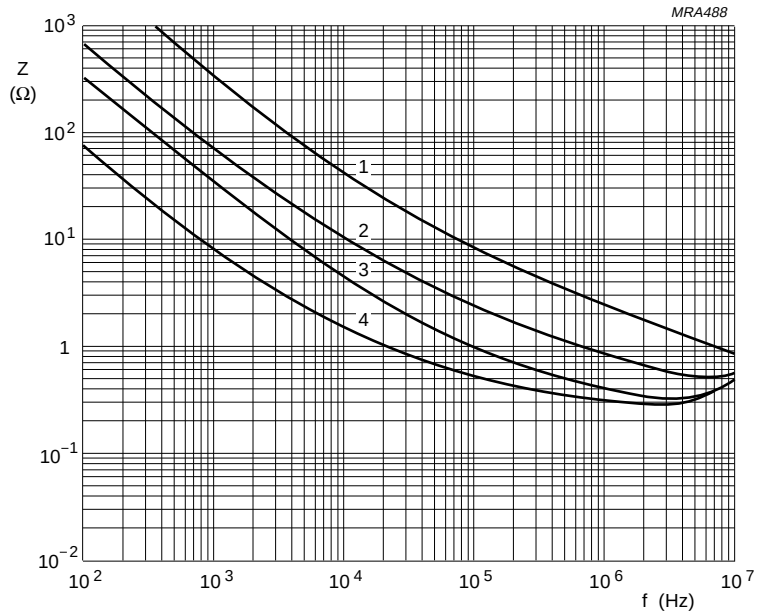
Z_0 = initial impedance value at T_{amb} = 25 °C.

Fig.17 Typical multiplier of impedance as a function of frequency at different temperatures.



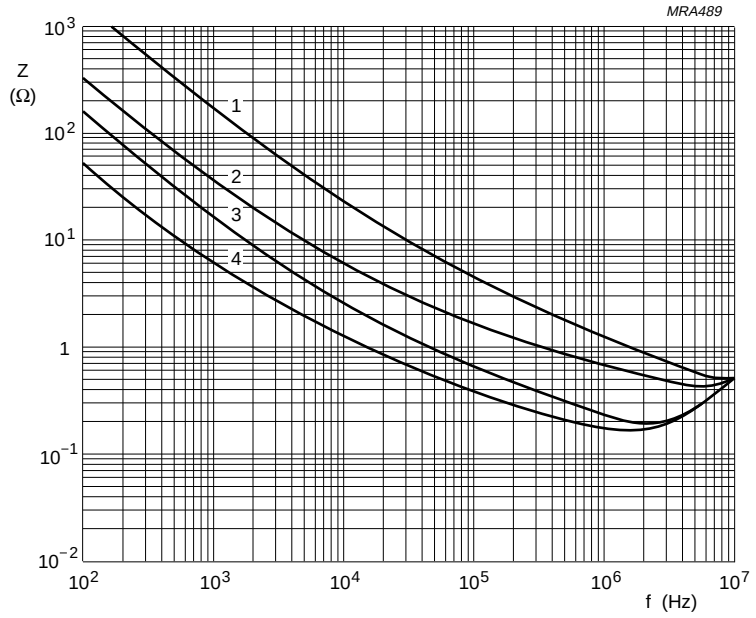
Curve 1: 0.33 μF, 40 V.
Curve 2: 0.68 μF, 25 V.
Curve 3: 10 μF, 6.3 V.
Case size H × W × T = 12.5 × 8 × 3.5 mm.
T_{amb} = 25 °C.

Fig.18 Typical impedance as a function of frequency



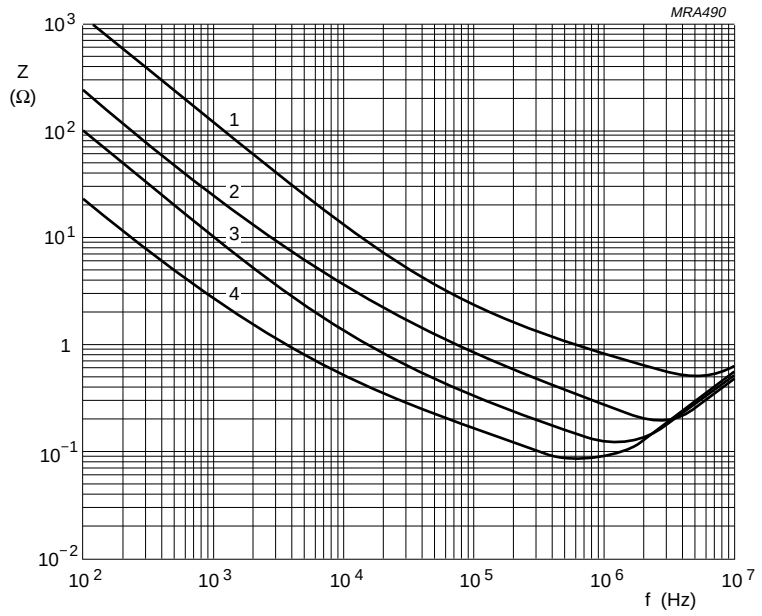
Curve 1: 0.47 μF, 25 V.
Curve 2: 2.2 μF, 25 V.
Curve 3: 4.7 μF, 16 V.
Curve 4: 22 μF, 6.3 V.
Case size H × W × T = 12.5 × 8 × 4.5 mm.
T_{amb} = 25 °C.

Fig.19 Typical impedance as a function of frequency.



Curve 1: 1.0 μF, 40 V.
Curve 2: 4.7 μF, 25 V.
Curve 3: 10 μF, 16 V.
Curve 4: 33 μF, 6.3 V.
Case size H × W × T = 12.5 × 8 × 5 mm.
T_{amb} = 25 °C.

Fig.20 Typical impedance as a function of frequency.



Curve 1: 1.5 μF, 40 V
Curve 2: 6.8 μF, 25 V
Curve 3: 15 μF, 16 V
Curve 4: 68 μF, 6.3 V.
Case size H × W × T = 12.5 × 8 × 6 mm.
T_{amb} = 25 °C.

Fig.21 Typical impedance as a function of frequency.

SPECIFIC TESTS AND REQUIREMENTS

General tests and requirements are specified in this handbook, Section *"Tests and Requirements"*.

Table 3 Test procedures and requirements

TEST		PROCEDURE (quick reference)	REQUIREMENTS
NAME OF TEST	**REFERENCE**		
Endurance	IEC 384-4/ CECC 30300 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 $I_{L5} \leq$ 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 $I_{L5} \leq$ spec. limit no short or open circuit, no visible damage total failure percentage: <1%
Shelf life (storage at high temperature)	IEC 384-4/ CECC 30300 subclause 4.17	T_{amb} = 125 °C; no voltage applied; 500 hours	$\Delta C/C$: ±10% tan $\delta \leq 1.2 \times$ spec. limit $I_{L5} \leq 1 \times$ spec. limit
Charge and discharge	IEC 384-4-2 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 68-2-45, test XA IEC 653	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

TEST		PROCEDURE (quick reference)	REQUIREMENTS
NAME OF TEST	REFERENCE		
Extended vibration	IEC 68-2-6 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 $I_{L5} \leq 1.5 \times$ spec. limit
Shock	IEC 68-2-27 test Ea	half-sine or saw tooth 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 $I_{L5} \leq 1.5 \times$ spec. limit
Passive flammability	IEC 695-2-2	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