Aluminum Capacitors Solid Axial

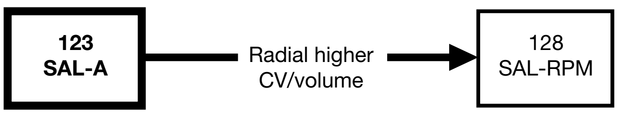


Fig. 1

QUICK REFERENCE DATA	
DESCRIPTION	**VALUE**
Maximum case size (Ø D x L in mm)	6.7 x 15.3 to 12.9 x 32.0
Rated capacitance range (E6 series), C_R	1.0 µF to 1000 µF
Tolerance on C_R	± 20 %; ± 10 % on request
Rated voltage range, U_R	6.3 V to 40 V
Category temperature range	- 55 °C to + 125 °C
Useable temperature range	- 80 °C to + 200 °C
Endurance test at 155 °C and 125 °C	5000 h and 8000 h
Useful life at 125 °C	20 000 h
Useful life at 40 °C, I_R applied	450 000 h
Shelf life at 0 V, 125 °C	500 h
Based on sectional specification	IEC 60384-4/EN130300
Climatic category IEC 60068	55/125/56

FEATURES

Pb-free Available

RoHS* Available

- Polarized aluminum electrolytic capacitors, solid electrolyte MnO_2
- Axial leads, aluminum case, ceramic seal, blue insulation sleeve
- SAL-A: standard version
- SAL-AG: epoxy filled shock-proof version up to 10 000 g
- Extremely long useful life: 20 000 h at 125 °C
- Extended high temperature range up to 200 °C
- Excellent low temperature impedance and ESR behavior
- Charge and discharge proof, application with 0 Ω resistance allowed
- Reverse DC voltage up to 0.3 x U_R allowed
- AC voltage up to 0.8 x U_R allowed
- Advanced technology to achieve high reliability and high stability
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

Note

* This datasheet provides information about parts that are RoHS-compliant and / or parts that are non-RoHS-compliant. For example, parts with lead (Pb) terminations are not RoHS-compliant. Please see the information / tables in this datasheet for details.

APPLICATIONS

- EDP, telecommunication, industrial high temperature, automotive, military and space
- Smoothing, filtering, buffering, timing
- For power supplies, DC/DC converters

MARKING

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

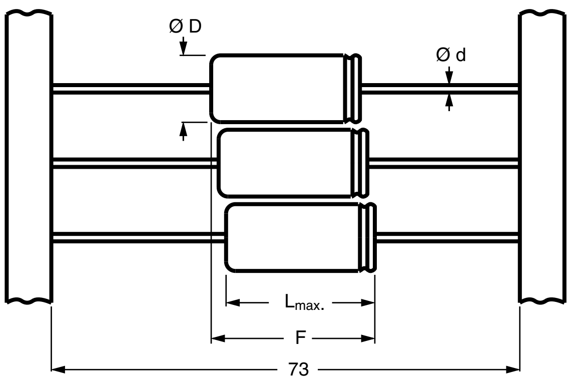
- Rated capacitance (in µF)
- Tolerance code on rated capacitance, code letter in accordance with IEC 60062 (M = ± 20 %, K = ± 10 %)
- Rated voltage (in V) at corresponding maximum temperature
- Date code in accordance with IEC 60062
- Name of manufacturer
- Code for factory of origin
- Band to indicate the negative terminal
- "+" sign to identify the positive terminal
- Series number

SELECTION CHART FOR C_R, U_R, AND RELEVANT MAXIMUM CASE SIZES (Ø D x L 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**
1.0	-	-	-	-	6.7 x 15.3	-
1.5	-	-	-	-	6.7 x 15.3	-
2.2	-	-	-	-	6.7 x 15.3	6.7 x 15.3
3.3	-	-	-	-	6.7 x 15.3	6.7 x 15.3
4.7	-	-	-	-	6.7 x 15.3	6.7 x 15.3
6.8	-	-	-	-	6.7 x 15.3	6.7 x 15.3
10	-	-	6.7 x 15.3	6.7 x 15.3	7.6 x 20.4	7.6 x 20.4
15	-	-	6.7 x 15.3	6.7 x 15.3	7.6 x 20.4	7.6 x 20.4

SELECTION CHART FOR C_R, U_R, AND RELEVANT MAXIMUM CASE SIZES (Ø D x L 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
22	-	-	6.7 x 15.3	7.6 x 20.4	7.6 x 20.4	9.4 x 23.3
33	-	6.7 x 15.3	7.6 x 20.4	7.6 x 20.4	9.4 x 23.3	9.4 x 23.3
47	6.7 x 15.3	6.7 x 15.3	7.6 x 20.4	7.6 x 20.4	9.4 x 23.3	10.3 x 32.0
68	6.7 x 15.3	7.6 x 20.4	7.6 x 20.4	9.4 x 23.3	10.3 x 32.0	10.3 x 32.0
100	-	7.6 x 20.4	9.4 x 23.3	9.4 x 23.3	12.9 x 32.0	12.9 x 32.0
150	7.6 x 20.4	9.4 x 23.3	9.4 x 23.3	10.3 x 32.0	12.9 x 32.0	-
220	-	9.4 x 23.3	10.3 x 32.0	12.9 x 32.0	-	-
330	9.4 x 23.3	10.3 x 32.0	10.3 x 32.0	-	-	-
470	-	10.3 x 32.0	12.9 x 32.0	-	-	-
680	10.3 x 32.0	12.9 x 32.0	-	-	-	-
1000	12.9 x 32.0	12.9 x 32.0	-	-	-	-

DIMENSIONS in millimeters AND AVAILABLE FORMS



BA: taped in box (ammopack)
BR: taped on reel

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

Table 1

DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES						
CASE		$F_{max.}$	Ø d	MASS (2) (g)	PACKAGING QUANTITIES	
MAXIMUM SIZE Ø D x L (1)	CODE				FORM BA	FORM BR
6.7 x 15.3	1	20.0	0.6	≈ 1.05	100	800
7.6 x 20.4	2A	22.5	0.6	≈ 1.55	100	800
9.4 x 23.3	4	25.0	0.6	≈ 2.60	100	500
10.3 x 32.0	5	35.0	0.8	≈ 4.20	100	500
12.9 x 32.0	6	35.0	0.8	≈ 7.00	100	400

Notes
(1) For epoxy-filled versions add 1 mm to stated $L_{max.}$.
(2) Add 10 % for SAL-AG epoxy-filled versions.
- Detailed tape dimensions see www.vishay.com/doc?28361.

CARDBOARD BOX DIMENSIONS, L x W x H (mm)	
SOLID TYPES FORM BA	
6.7 x 15.3	110 x 95 x 70
7.6 x 20.4	110 x 95 x 70
9.4 x 23.3	110 x 95 x 85
10.3 x 32.0	160 x 95 x 85
12.9 x 32.0	160 x 95 x 120
SOLID TYPES FORM BR	
all	370 x 370 x 115

ELECTRICAL DATA	
SYMBOL	DESCRIPTION
C_R	Rated capacitance at 100 Hz
I_R	Max. RMS ripple current, no necessary DC voltage applied
I_{L5}	Max. leakage current after 5 min at U_R
tan δ	Max. dissipation factor at 100 Hz
ESR	Max./typ. equivalent series resistance at 100 Hz
Z	Max. impedance at 100 kHz

Note

- 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 123 series

10 µF/16 V; ± 20 %

Maximum case size: Ø 6.7 x 15.3 mm; form BR

for lead (Pb)-free:

Ordering code: MAL2 123 25109 E3
Former 12NC: 2281 123 25109

for non lead (Pb)-free:

Ordering code: MAL2 123 25109
Former 12NC: 2222 123 25109

Table 2

ELECTRICAL DATA AND ORDERING INFORMATION for 123 series

U_C (V)	U_R (V)	C_R 100 Hz (µF)	MAX. CASE SIZE Ø D x L (mm)	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	MAX. ESR 100 Hz (Ω)	TYP. ESR 100 Hz (Ω)	Z 100 kHz (Ω)	ORDERING CODE MAL2123.....E3 LEAD (Pb)-FREE MAL2123 ..... NON LEAD (Pb)-FREE			
												SAL-A FORM BA TOL. ± 20 %	SAL-A FORM BR TOL. ± 20 %	SAL-AG (1) FORM BA TOL. ± 10 % LEVEL S	SAL-AG (1) FORM BA TOL. ± 20 %
6.3	6.3	47	6.7 x 15.3	58	440	640	15	0.18	7.6	3.0	1.2	13479	23479	83479	63479
		68	6.7 x 15.3	83	520	760	21	0.18	5.3	2.6	1.2	13689	23689	83689	63689
		150	7.6 x 20.4	160	870	1270	47	0.18	2.4	1.5	1.0	13151	23151	83151	63151
		330	9.4 x 23.3	330	1470	2140	104	0.18	1.1	0.55	0.4	13331	23331	83331	63331
		680	10.3 x 32.0	680	2340	3410	214	0.18	0.55	0.28	0.3	13681	23681	83681	63681
		1000	12.9 x 32.0	940	3180	4640	315	0.18	0.36	0.19	0.2	13102	23102	83102	63102
10	10	33	6.7 x 15.3	63	360	530	17	0.18	11	3.8	1.2	14339	24339	84339	64339
		47	6.7 x 15.3	83	440	640	24	0.18	7.6	4.0	1.2	14479	24479	84479	64479
		68	7.6 x 20.4	110	590	850	34	0.18	5.3	2.5	1.0	14689	24689	84689	64689
		100	7.6 x 20.4	160	710	1040	50	0.18	3.6	1.8	1.0	14101	24101	84101	64101
		150	9.4 x 23.3	240	990	1450	75	0.18	2.4	0.9	0.4	14151	24151	84151	64151
		220	9.4 x 23.3	350	1180	1720	110	0.18	1.7	0.6	0.4	14221	24221	84221	64221
		330	10.3 x 32.0	490	1650	2410	165	0.18	1.1	0.45	0.3	14331	24331	84331	64331
		470	10.3 x 32.0	570	1940	2830	235	0.18	0.8	0.35	0.3	14471	24471	84471	64471
		680	12.9 x 32.0	760	2580	3750	340	0.18	0.55	0.25	0.2	14681	24681	84681	64681
		1000	12.9 x 32.0	1000	3380	4920	500	0.18	0.36	0.18	0.2	14102	24102	84102	64102
16	16	10	6.7 x 15.3	31	230	330	16	0.14	28	8.0	2.5	15109	25109	85109	65109
		15	6.7 x 15.3	47	280	400	24	0.14	19	5.5	2.5	15159	25159	85159	65159
		22	6.7 x 15.3	63	340	490	35	0.14	13	5.5	2.5	15229	25229	85229	65229
		33	7.6 x 20.4	89	470	680	55	0.14	8.4	3.0	2.0	15339	25339	85339	65339
		47	7.6 x 20.4	120	560	810	75	0.14	5.9	2.6	2.0	15479	25479	85479	65479
		68	7.6 x 20.4	180	670	970	110	0.14	4.1	2.5	2.0	15689	25689	85689	65689
		100	9.4 x 23.3	260	920	1340	160	0.14	2.8	1.5	0.8	15101	25101	85101	65101
		150	9.4 x 23.3	310	1060	1550	240	0.16	2.1	0.7	0.8	15151	25151	85151	65151
		220	10.3 x 32.0	420	1420	2060	350	0.16	1.5	0.55	0.6	15221	25221	85221	65221
		330	10.3 x 32.0	510	1740	2530	500	0.16	1.0	0.35	0.6	15331	25331	85331	65331
		470	12.9 x 32.0	680	2280	3330	750	0.16	0.7	0.25	0.4	15471	25471	85471	65471
25	25	10	6.7 x 15.3	43	230	330	25	0.14	28	13.0	5	16109	26109	86109	66109
		15	6.7 x 15.3	60	280	400	35	0.14	19	10.0	5.0	16159	26159	86159	66159
		22	7.6 x 20.4	88	370	550	55	0.14	13	7	2.5	16229	26229	86229	66229
		33	7.6 x 20.4	130	470	680	85	0.14	8.4	5	2.5	16339	26339	86339	66339
		47	7.6 x 20.4	160	560	810	100	0.14	5.9	3.5	2.5	16479	26479	86479	66479
		68	9.4 x 23.3	230	760	1110	170	0.14	4.1	1.8	1.0	16689	26689	86689	66689
		100	9.4 x 23.3	250	860	1250	250	0.16	3.2	1.0	1.0	16101	26101	86101	66101
		150	10.3 x 32.0	350	1200	1740	400	0.16	2.1	1.2	0.8	16151	26151	86151	66151
		220	12.9 x 32.0	460	1560	2270	550	0.16	1.5	0.85	0.6	16221	26221	86221	66221

ELECTRICAL DATA AND ORDERING INFORMATION for 123 series

U_C (V)	U_R (V)	C_R 100 Hz (µF)	MAX. CASE SIZE Ø D x L (mm)	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	MAX. ESR 100 Hz (Ω)	TYP. ESR 100 Hz (Ω)	Z 100 kHz (Ω)	ORDERING CODE MAL2123.....E3 LEAD (Pb)-FREE MAL2123 ..... NON LEAD (Pb)-FREE			
												SAL-A FORM BA TOL. ± 20 %	SAL-A FORM BR TOL. ± 20 %	SAL-AG (1) FORM BA TOL. ± 10 % LEVEL S	SAL-AG (1) FORM BA TOL. ± 20 %
25	35	1.0	6.7 x 15.3	4	55	80	5	0.12	240	105	16.5	10108	20108	80108	60108
		1.5	6.7 x 15.3	7	68	98	5	0.12	160	40.60	11.0	10158	20158	80158	60158
		2.2	6.7 x 15.3	10	82	120	5	0.12	109	30	7.5	10228	20228	80228	60228
		3.3	6.7 x 15.3	14	100	150	7	0.12	73	28	7.5	10338	20338	80338	60338
		4.7	6.7 x 15.3	20	120	170	10	0.12	51	20	7.5	10478	20478	80478	60478
		6.8	6.7 x 15.3	27	140	210	15	0.12	35	16	7.5	10688	20688	80688	60688
		10	7.6 x 20.4	37	200	280	20	0.12	24	10	2.5	10109	20109	80109	60109
		15	7.6 x 20.4	53	240	350	30	0.12	16	8	2.5	10159	20159	80159	60159
		22	7.6 x 20.4	78	290	420	45	0.12	11	7	2.5	10229	20229	80229	60229
		33	9.4 x 23.3	120	410	590	65	0.12	7.2	3	1.0	10339	20339	80339	60339
		47	9.4 x 23.3	140	480	700	95	0.12	5.1	2.9	1.0	10479	20479	80479	60479
		68	10.3 x 32.0	170	570	820	135	0.16	4.7	2.1	0.8	10689	20689	80689	60689
		100	12.9 x 32.0	220	760	1100	200	0.16	3.2	1.7	0.6	10101	20101	80101	60101
		150	12.9 x 32.0	290	990	1440	300	0.16	2.1	1.0	0.6	10151	20151	80151	60151
25	40	2.2	6.7 x 15.3	11	82	120	9	0.12	109	38	7.5	17228	27228	87228	67228
		3.3	6.7 x 15.3	16	100	150	13	0.12	73	25	7.5	17338	27338	87338	67338
		4.7	6.7 x 15.3	22	120	170	19	0.12	51	20	7.5	17478	27478	87478	67478
		6.8	6.7 x 15.3	28	140	210	27	0.12	35	15	7.5	17688	27688	87688	67688
		10	7.6 x 20.4	41	200	280	40	0.12	24	11	2.5	17109	27109	87109	67109
		15	7.6 x 20.4	61	240	350	60	0.12	16	7	2.5	17159	27159	87159	67159
		22	9.4 x 23.3	89	330	480	90	0.12	11	4	1.5	17229	27229	87229	67229
		33	9.4 x 23.3	120	410	590	130	0.12	7.2	2.9	1.0	17339	27339	87339	67339
		47	10.3 x 32.0	160	540	790	190	0.12	5.1	2.7	1.0	17479	27479	87479	67479
		68	10.3 x 32.0	170	570	820	270	0.16	4.7	2.3	0.8	17689	27689	87689	67689
		100	12.9 x 32.0	220	760	1100	400	0.16	3.2	1.6	0.6	17101	27101	87101	67101

Note

(1) SAL-AG types are epoxy-filled.

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 ≤ 0.1 Hz 0.1 Hz < f ≤ 1 Hz 1 Hz < f ≤ 10 Hz 10 Hz < f ≤ 50 Hz f > 50 Hz	 $0.30 \times U_R$ $0.45 \times U_R$ $0.60 \times U_R$ $0.65 \times U_R$ $0.80 \times U_R$
	85 °C < $T_{amb} \leq 125$ °C at: f ≤ 0.1 Hz 0.1 Hz < f ≤ 1 Hz 1 Hz < f ≤ 10 Hz 10 Hz < f ≤ 50 Hz f > 50 Hz	 $0.15 \times U_R$ $0.22 \times U_R$ $0.30 \times U_R$ $0.32 \times U_R$ $0.40 \times U_R$
Current		
Maximum leakage current	After 5 min 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 V to 16 V U_R = 25 V to 40 V	 ≈ 0.2 x value stated in Table 2 ≈ 0.1 x value stated in Table 2

VOLTAGE

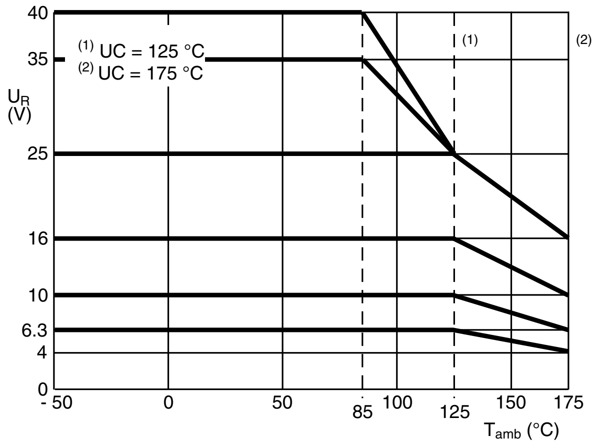


Fig. 3 - Maximum permissible voltage up to 175 °C

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

Notes

(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.

LEAKAGE CURRENT

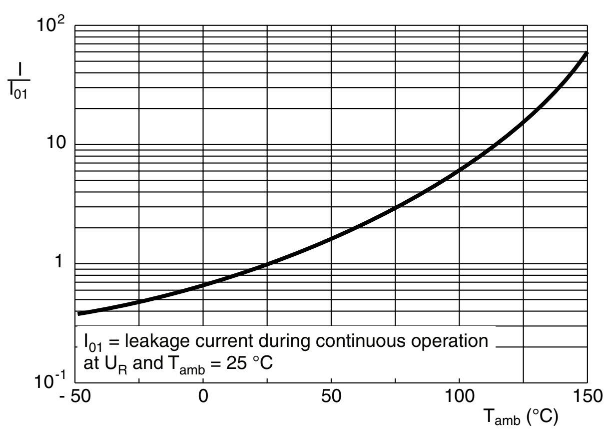


Fig. 4 - Typical multiplier of leakage current as a function of ambient temperature

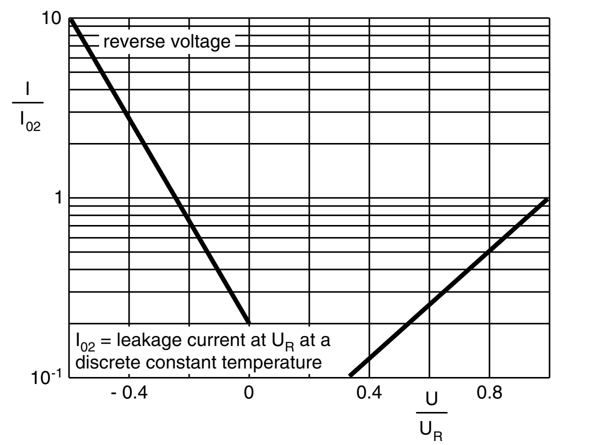


Fig. 5 - Typical multiplier of leakage current as a function of U/U_R

CAPACITANCE (C)

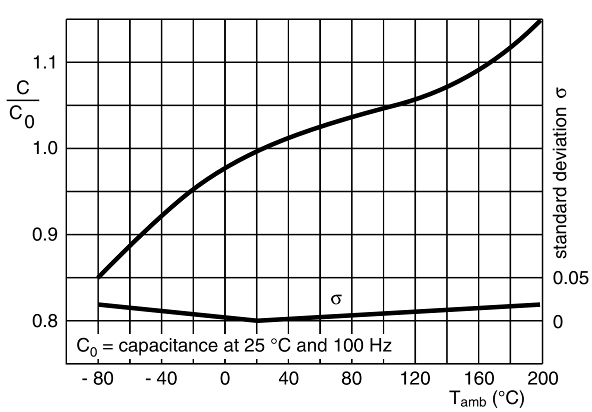


Fig. 6 - Typical multiplier of capacitance as a function of ambient temperature

DISSIPATION FACTOR (tan δ)

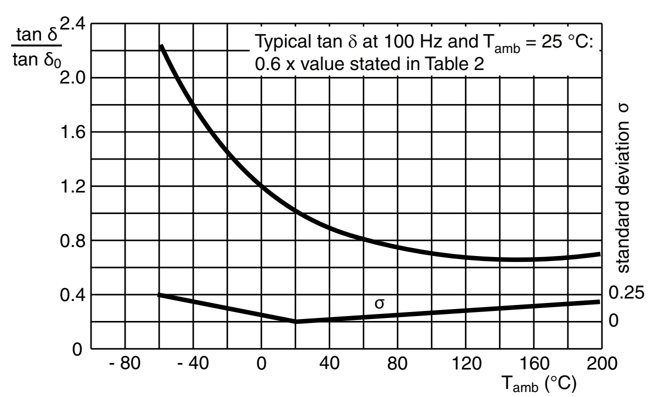


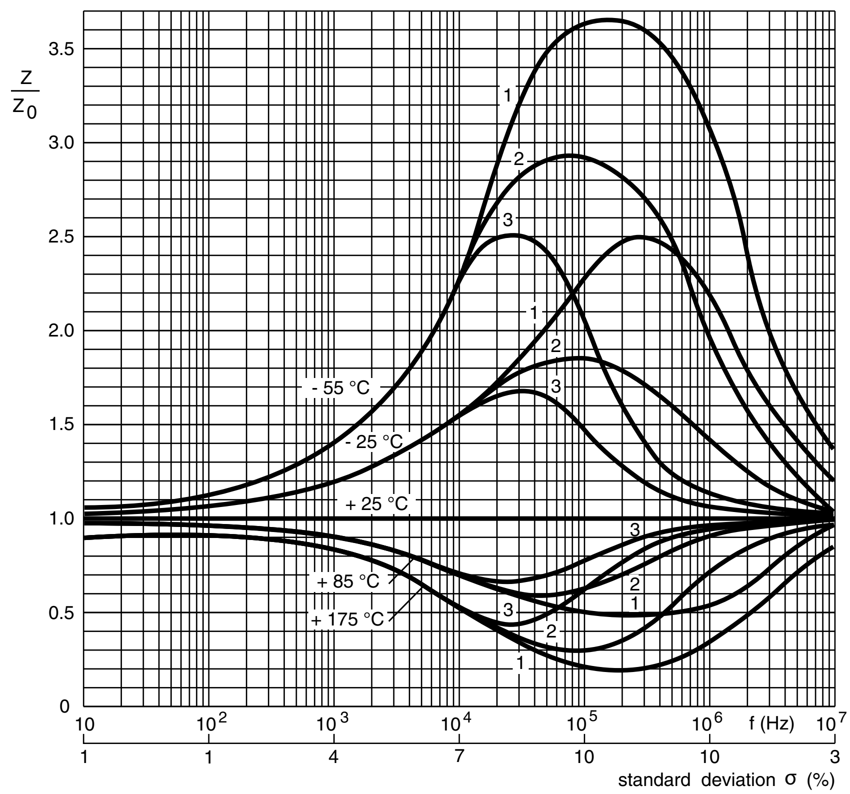
Fig. 7 - Typical multiplier of dissipation factor as a function of ambient temperature

MAXIMUM POWER DISSIPATION	
MAXIMUM CASE SIZE Ø D x L (mm)	$P_{max.} = P_{125}$ (W)
6.7 x 15.3	0.13
7.6 x 20.4	0.16
9.4 x 23.3	0.21
10.3 x 32.0	0.26
12.9 x 32.0	0.32

EQUIVALENT SERIES INDUCTANCE (ESL), f = 10 MHz			
MAXIMUM CASE SIZE Ø D x L (mm)	PITCH (mm)	MAX. ESL (nH)	TYP. ESL (nH)
6.7 x 15.3	20.3	30	15 to 23
7.6 x 20.4	25.4	30	16 to 24
9.4 x 23.3	27.9	35	20 to 27
10.3 x 32.0	35.6	40	26 to 33
12.9 x 32.0	35.6	55	32 to 49

IMPEDANCE (Z)

Typical impedance at 100 kHz and T_{amb} = 25 °C: 0.5 x value stated in Table 2.



Curve 1: Case Ø D x L = 6.7 mm x 15.3 mm and 7.6 mm x 20.4 mm; 16 V to 40 V
Curve 2: Case Ø D x L = 6.7 mm x 15.3 mm and 7.6 mm x 20.4 mm; 6.3 V to 10 V
Curve 3: Case Ø D x L = 9.4 mm x 32.0 mm, 10.3 mm x 32.0 mm and 12.9 mm x 32.0 mm
Z_0 = Initial impedance value at any frequency and T_{amb} = 25 °C

Fig. 8 - Typical multiplier of impedance as a function of frequency at different ambient temperatures

IMPEDANCE (Z)

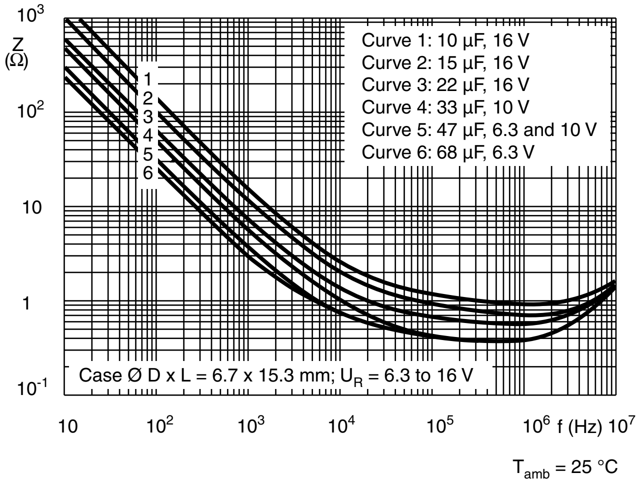


Fig. 9 - Typical impedance as a function of frequency

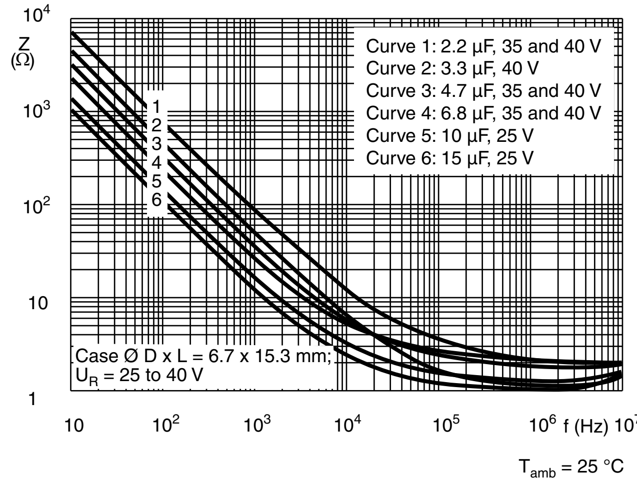


Fig. 10 - Typical impedance as a function of frequency

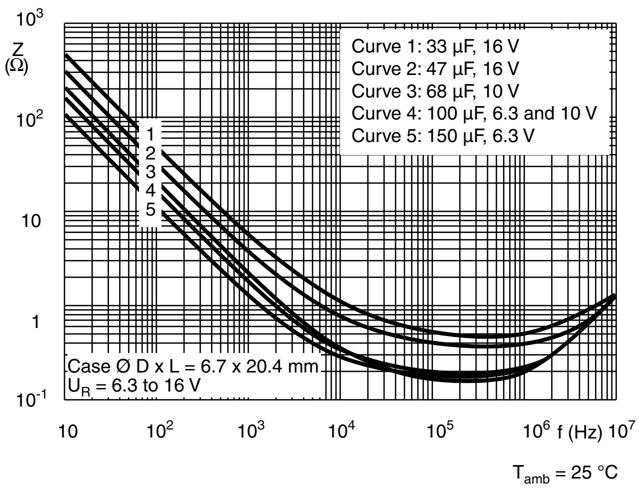


Fig. 11 - Typical impedance as a function of frequency

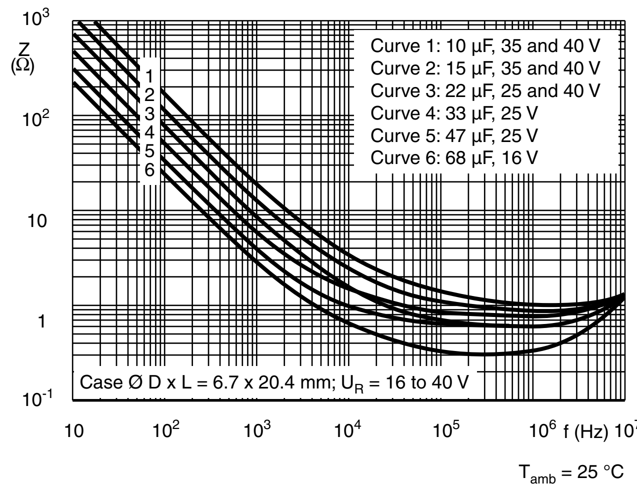


Fig. 12 - Typical impedance as a function of frequency

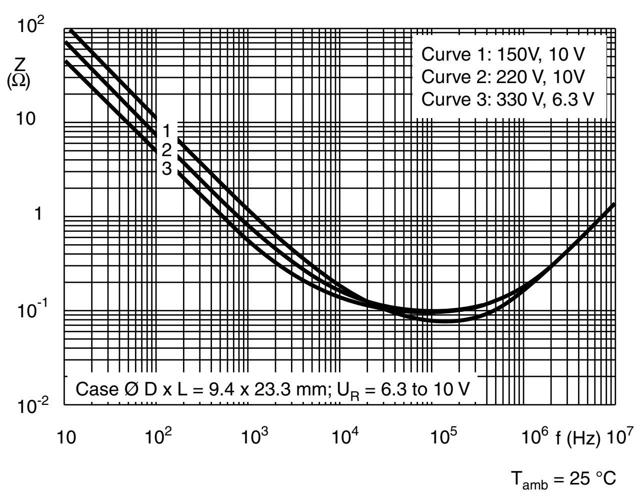


Fig. 13 - Typical impedance as a function of frequency

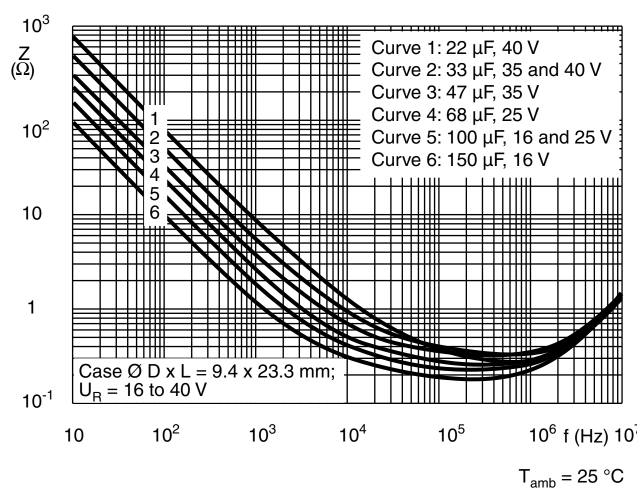


Fig. 14 - Typical impedance as a function of frequency

IMPEDANCE (Z)

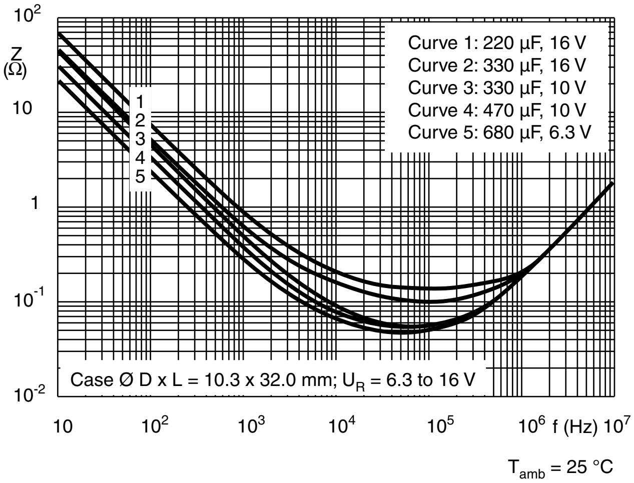


Fig. 15 - Typical impedance as a function of frequency

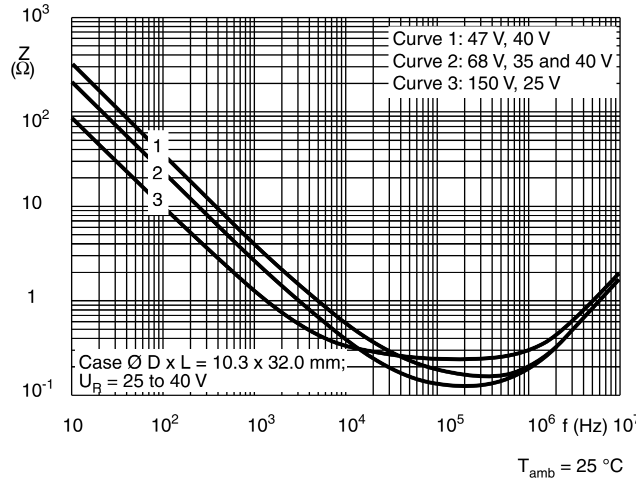


Fig. 16 - Typical impedance as a function of frequency

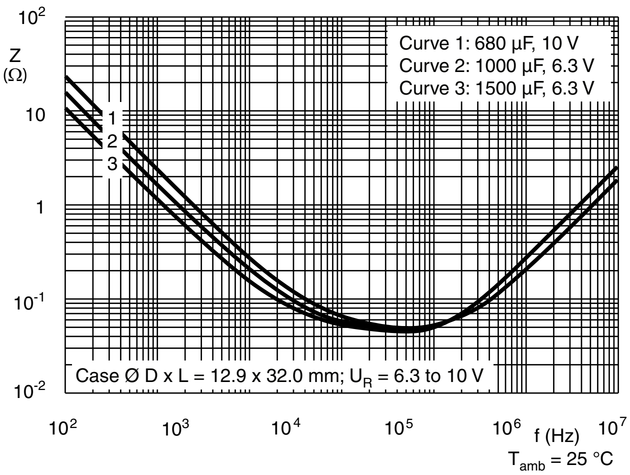


Fig. 17 - Typical impedance as a function of frequency

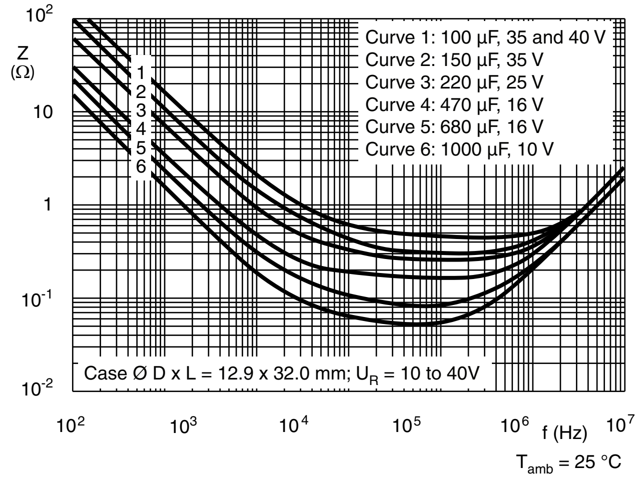


Fig. 18 - Typical impedance as a function of frequency

EQUIVALENT SERIES RESISTANCE (ESR)

Typical ESR: see Figures 20 to 28; the standard deviation is 20 % of each value.

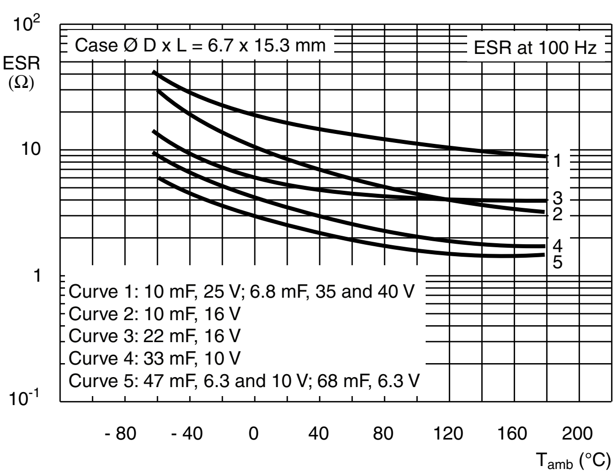


Fig. 19 - Typical ESR as a function of ambient temperature

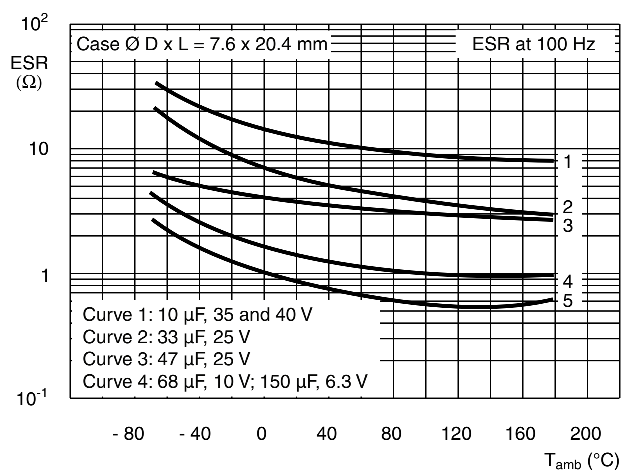


Fig. 20 - Typical ESR as a function of ambient temperature

EQUIVALENT SERIES RESISTANCE (ESR)

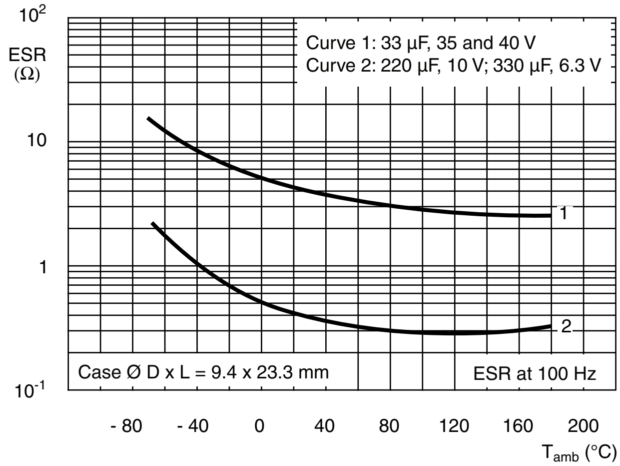


Fig. 21 - Typical ESR as a function of ambient temperature

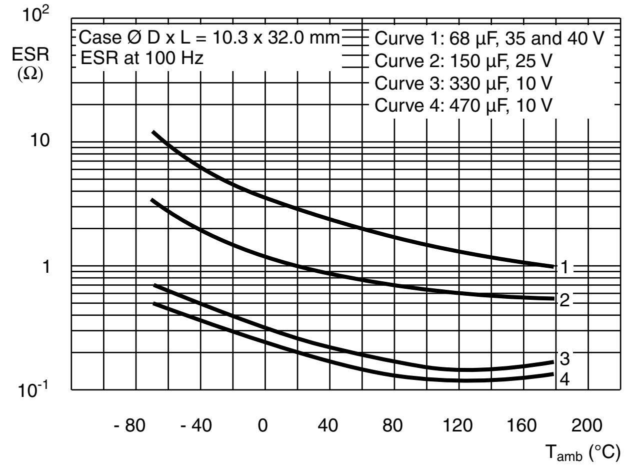


Fig. 22 - Typical ESR as a function of ambient temperature

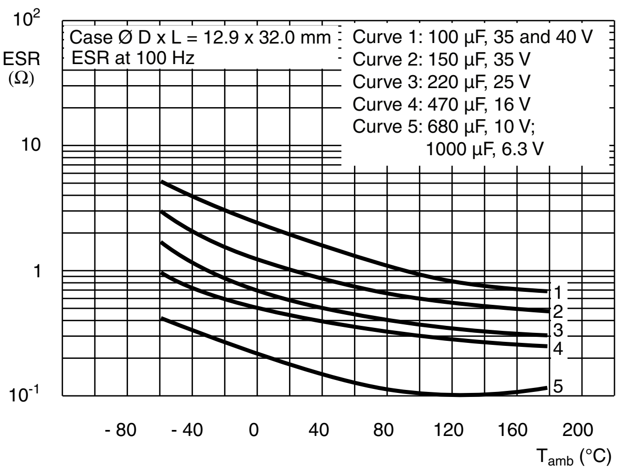


Fig. 23 - Typical ESR as a function of ambient temperature

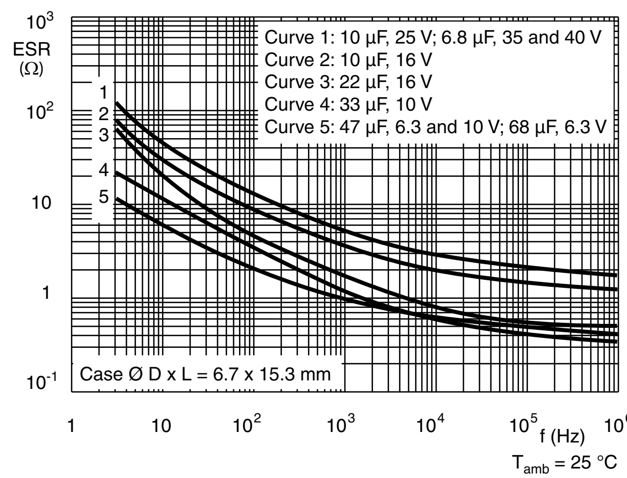


Fig. 25 - Typical ESR as a function of frequency

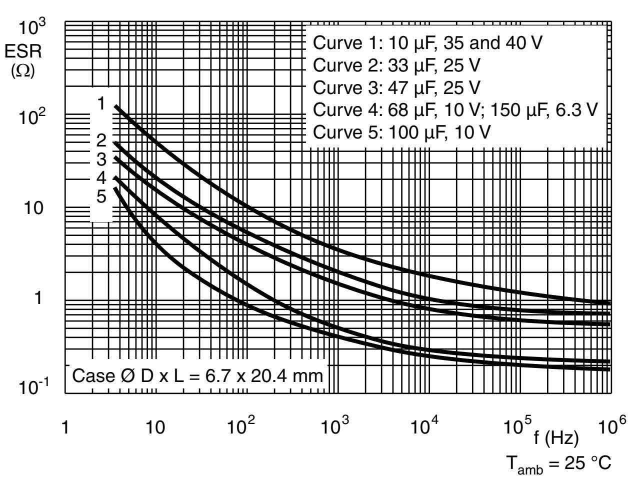


Fig. 24 - Typical ESR as a function of frequency

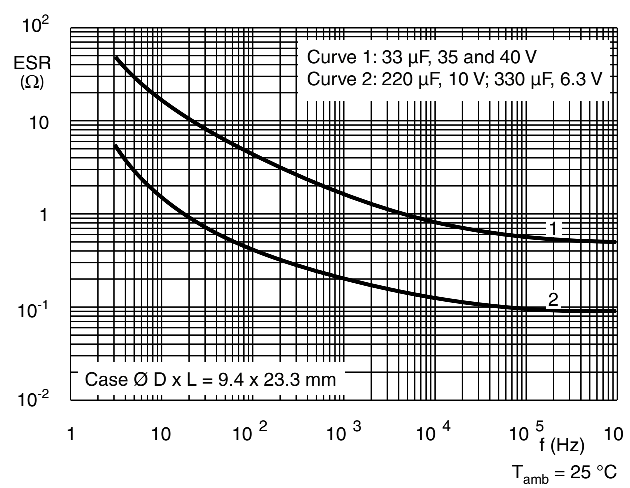


Fig. 26 - Typical ESR as a function of frequency

EQUIVALENT SERIES RESISTANCE (ESR)

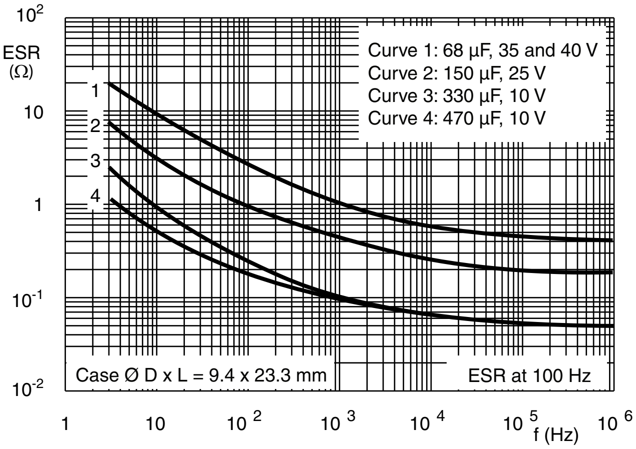


Fig. 27 - Typical ESR as a function of ambient temperature

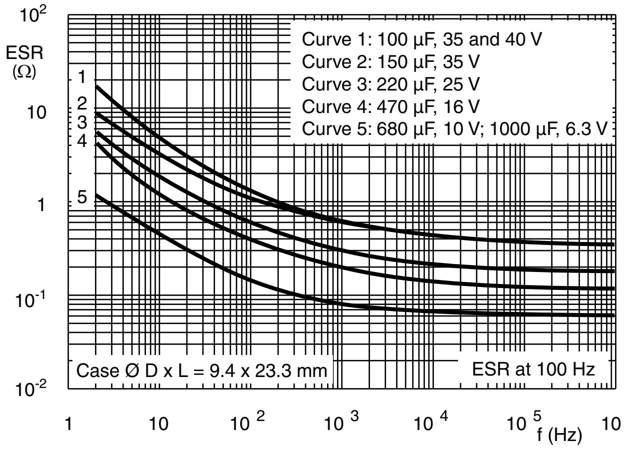


Fig. 28 - Typical ESR as a function of ambient temperature

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 V to 25 V with U_R applied; U_R = 35 V and 40 V with U_C applied; 10 000 h	ΔC/C: ± 10 % tan δ ≤ 1.2 x spec. limit Z ≤ 1.2 x spec. limit I_{L5} ≤ spec. limit
Useful life	CECC 30302 subclause 1.8.1	T_{amb} = 125 °C; I_R applied and U_R = 6.3 V to 25 V with U_R applied; U_R = 35 V and 40 V with U_C applied; 20 000 h	ΔC/C: ± 15 % tan δ ≤ 1.5 x spec. limit Z ≤ 1.5 x spec. limit I_{L5} ≤ 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 h	ΔC/C: ± 10 % tan δ ≤ 1.2 x spec. limit I_{L5} ≤ 1 x 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	ΔC/C: ± 5 % no short or open circuit, no visible damage
Shock	IEC 60068-2-27 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 ΔC/C: ± 5 % tan δ ≤ 1.2 x spec. limit Z ≤ 1.2 x spec. limit I_{L5} ≤ 1.5 x spec. limit
Severe rapid change of temperature		100 cycles of 1 h duration, each with 30 min at - 40 °C and + 125 °C	ΔC/C: ± 25 % tan δ ≤ 1.5 x spec. limit Z ≤ 2.0 x spec. limit I_{L5} ≤ 1 x spec.limit
Solvent resistance	IEC 60068-2-45, test XA IEC 60653	Immersion: 5 min ± 0.5 min with or without ultrasonic at 55 °C ± 5 °C Solvents: demineralized water and/or calgonite solution (20 g/l)	Visual appearance not affected
Passive flammability	IEC 60695-2-2	Capacitor mounted to a vertical printed-circuit board, one flame on capacitor body; T_{amb} = 20 °C 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

ADDITIONAL TESTS AND REQUIREMENTS FOR EPOXY-FILLED VERSIONS SAL-AG

2281 123 8.... Form BA ± 10 %, level S, lead (Pb)-free

2222 123 8.... Form BA ± 10 %, level S, non lead (Pb)-free

Table 4

TEST PROCEDURES AND REQUIREMENTS		
TEST	**PROCEDURE**	**REQUIREMENTS**
Severe vibration tests in accordance with *"IEC 60068-2-6"* **and** *"MIL STD-202"***, method 204, letter E, with the following details and additions**		
Method of mounting: Severity 1 Severity 2 Severity 1 and 2	Clamping both body and leads Frequency range temperature 10 Hz to 3000 Hz; 20 °C to 25 °C Frequency range temperature 50 Hz to 2000 Hz; 125 °C vibration amplitude: 50 *g* or 3.5 mm, whichever is less	ΔC/C: ± 10 % tan δ ≤ 1.2 x stated limit Z ≤ 1.4 x stated limit DC leakage current: ≤ stated limit no intermittent contacts no indication of breakdown no open circuiting no evidence of mechanical damage
Direction and duration of motion: Severity 1 Severity 2	1 octave/min; 3 directions (mutually perpendicular); 20 sweeps per direction (total 60 sweeps or 18 h) 1 octave/min; 2 directions (longitudinal and transversal); 3 sweeps per direction (total 6 sweeps or 1 h)	
Functioning: Severity 1 Severity 2	Rated voltage applied No voltage applied	
Typical capability	> 80 g at 10 Hz to 3000 Hz (also at 125 °C)	
Severe shock tests in accordance with *"IEC 60068-2-27"* **and** *"MIL STD-202"***, method 213, letter F, with the following details and additions**		
Method of mounting	Clamping both body and leads	ΔC/C: ± 10 % tan δ ≤ 1.2 x stated limit Z ≤ 1.4 x stated limit DC leakage current: ≤ stated limit no intermittent contacts no indication of breakdown no open circuiting no evidence of mechanical damage
Pulse shape: Severity 1 Severity 2 Severity 3	Half-sine or sawtooth 1500 *g*; 0.5 ms ("MIL STD-202", method 213, letter F) 3000 *g*; 0.2 ms 10 000 *g*; 0.1 ms	
Direction and number of shocks: Severity 1 and 2 Severity 3	3 successive shocks in each direction of 3 mutually perpendicular axes (total 18 shocks) 1 shock in any direction	
Functioning	Rated voltage applied	

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