



Aluminum Capacitors Solid Axial

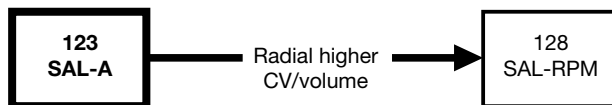


Fig. 1

| 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

- Polarized aluminum electrolytic capacitors, solid electrolyte MnO₂
- 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:

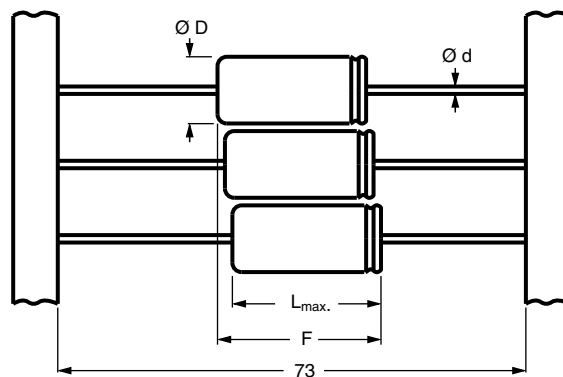
- Rated capacitance (in µF)
- Tolerance code on rated capacitance, code letter in accordance with IEC 60062 (M = ± 20 %, K = ± 10 %)
- Rated voltage (in V) at corresponding maximum temperature
- Date code in accordance with IEC 60062
- Name of manufacturer
- Code for factory of origin
- Band to indicate 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 ($\varnothing D \times L$ in mm) | | | | | | |
|-------------------------------------------------------------------------------------------------------|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| C_R (μF) | U_R (V) AT $T_{amb} = 85^\circ C$ | | | | | |
| | 6.3 | 10 | 16 | 25 | 35 | 40 |
| | U_C (V) AT $T_{amb} = 125^\circ C$ | | | | | |
| | 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 | | $F_{max.}$ | $\varnothing d$ | MASS ⁽²⁾ (g) | PACKAGING QUANTITIES | |
| MAXIMUM SIZE $\varnothing D \times L$ ⁽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 |
| $\tan \delta$ | 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 %.

Table 2

| ELECTRICAL DATA AND ORDERING INFORMATION for 123 series | | | | | | | | | | | | | | | |
|---------------------------------------------------------|--------------|-------------------------------------------|----------------------------------------------------------|-------------------------------------------|----------------------------------|----------------------------------------------------------------------|---------------------------------|-----------------------------------------------------------|---------------------------------------|---------------------------------------|------------------------------|---------------------------------|-------|-------|-------|
| U_C (V) | U_R (V) | C_R 100 Hz (μ F) | MAX. CASE SIZE $\varnothing D \times L$ (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 (μ A) | $\tan \delta$ 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 | | $\leq 2 V$ |
| Maximum peak AC voltage, without reverse voltage applied | $T_{amb} \leq 85 \text{ °C}$ 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 x U _R 0.45 x U _R 0.60 x U _R 0.65 x U _R 0.80 x U _R |
| | $85 \text{ °C} < T_{amb} \leq 125 \text{ °C}$ 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 x U _R 0.22 x U _R 0.30 x U _R 0.32 x U _R 0.40 x 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

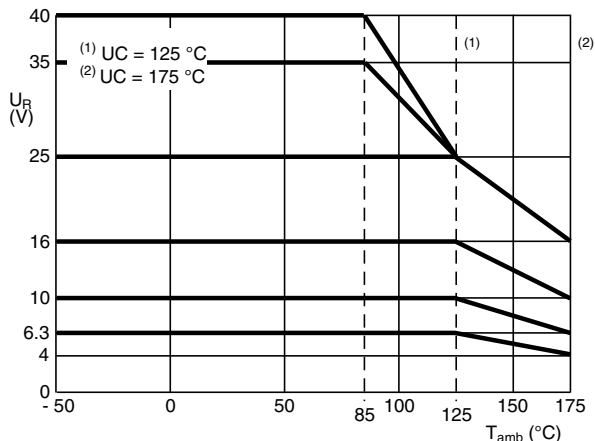


Fig. 3 - Maximum permissible voltage up to 175 °C

| 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

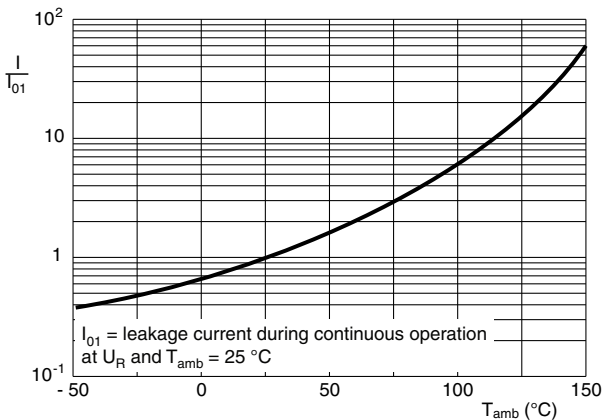


Fig. 4 - Typical multiplier of leakage current as a function of ambient temperature

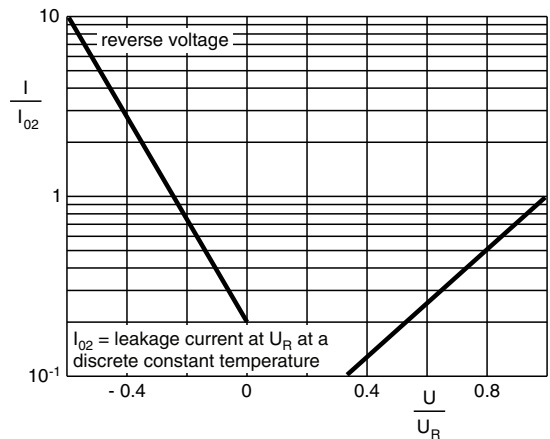


Fig. 5 - Typical multiplier of leakage current as a function of U/UR

CAPACITANCE (C)

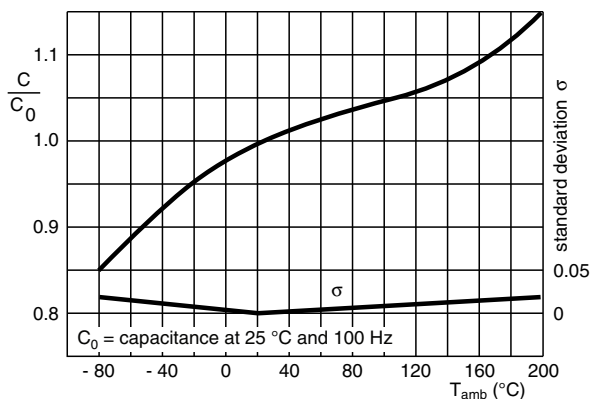


Fig. 6 - Typical multiplier of capacitance as a function of ambient temperature

DISSIPATION FACTOR (tan δ)

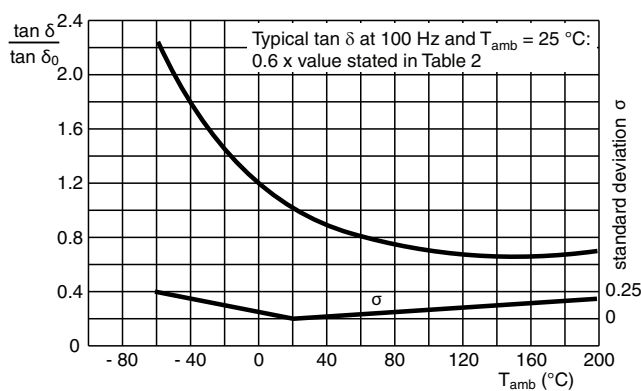


Fig. 7 - Typical multiplier of dissipation factor as a function of ambient temperature

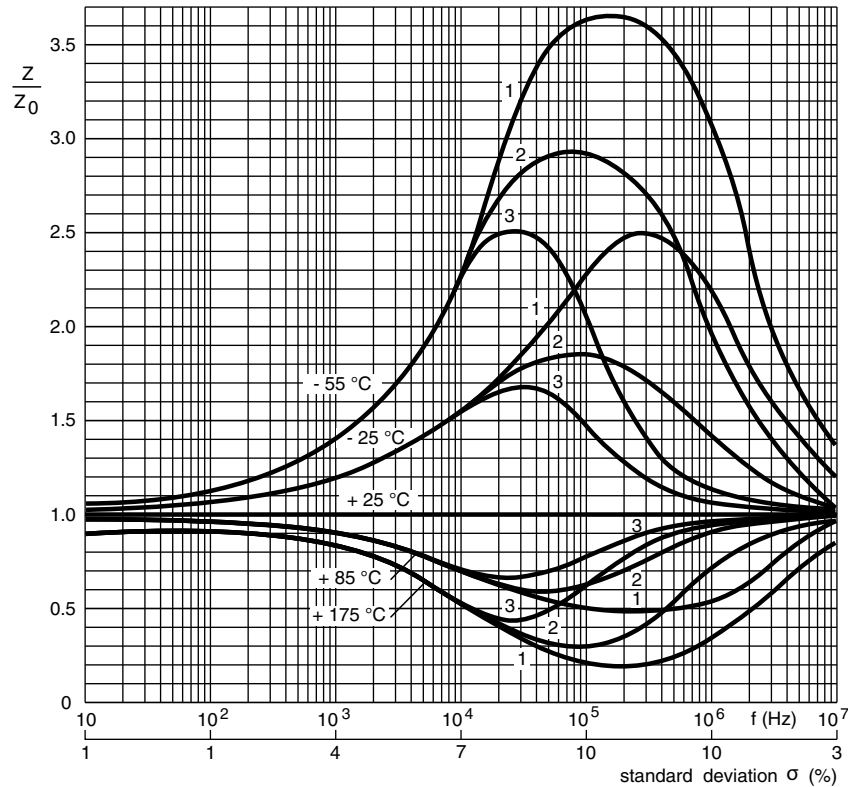


| MAXIMUM POWER DISSIPATION | |
|--------------------------------------|-----------------------------|
| MAXIMUM CASE SIZE Ø D x L (mm) | $P_{max.} = P_{125}$ (W) |
| 6.7 x 15.3 | 0.13 |
| 7.6 x 20.4 | 0.16 |
| 9.4 x 23.3 | 0.21 |
| 10.3 x 32.0 | 0.26 |
| 12.9 x 32.0 | 0.32 |

| 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 $T_{amb} = 25\text{ }^{\circ}\text{C}$: 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 $T_{amb} = 25\text{ }^{\circ}\text{C}$

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



IMPEDANCE (Z)

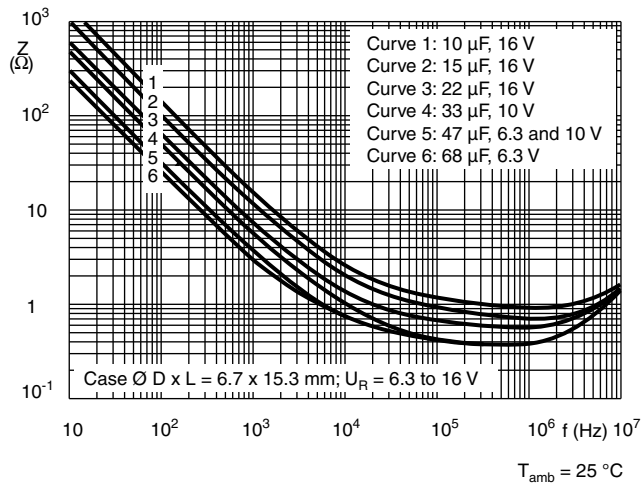


Fig. 9 - Typical impedance as a function of frequency

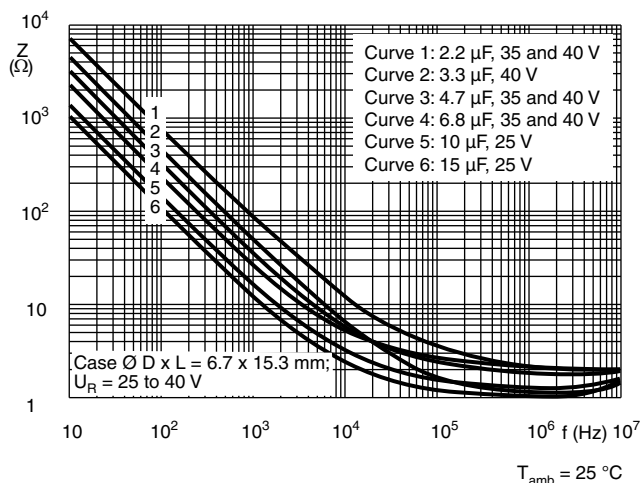


Fig. 10 - Typical impedance as a function of frequency

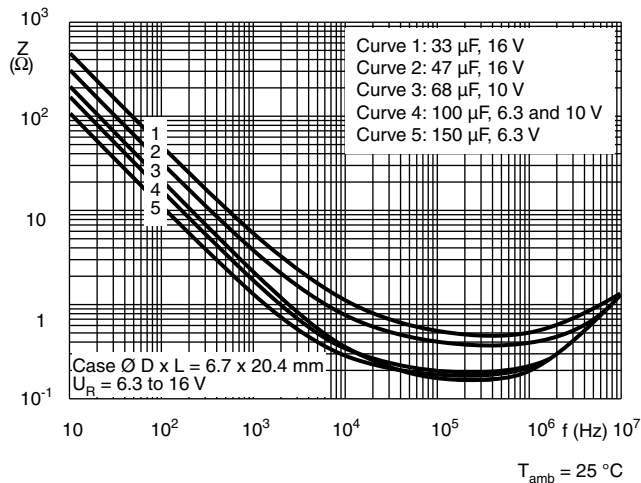


Fig. 11 - Typical impedance as a function of frequency

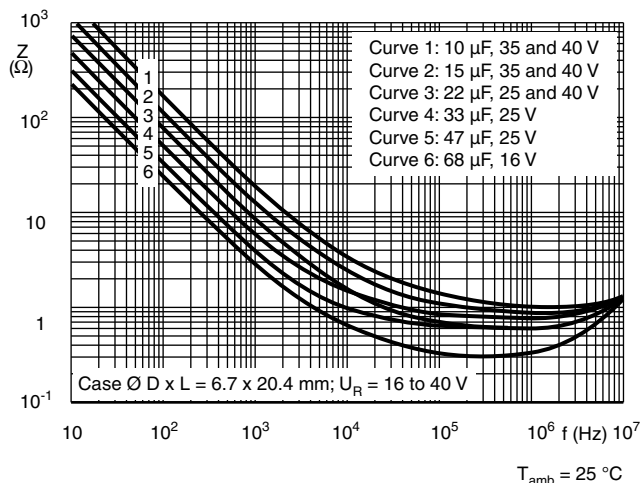


Fig. 12 - Typical impedance as a function of frequency

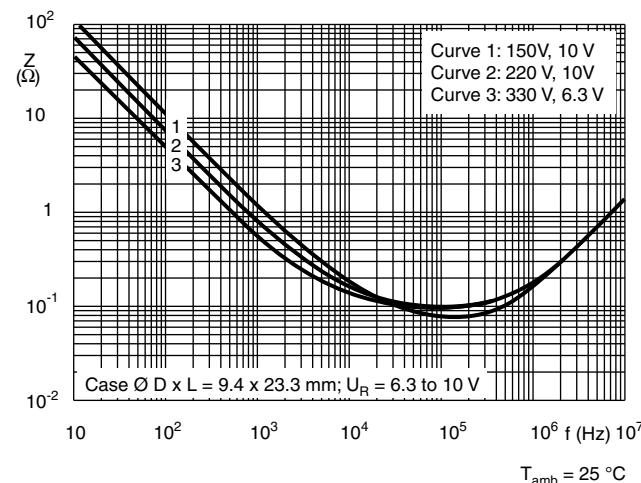


Fig. 13 - Typical impedance as a function of frequency

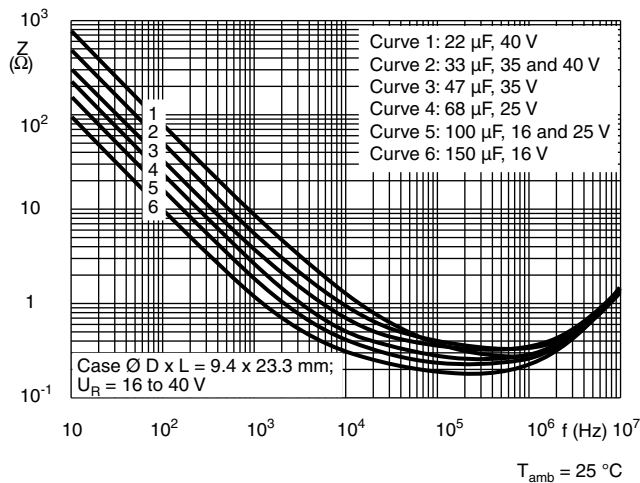


Fig. 14 - Typical impedance as a function of frequency



IMPEDANCE (Z)

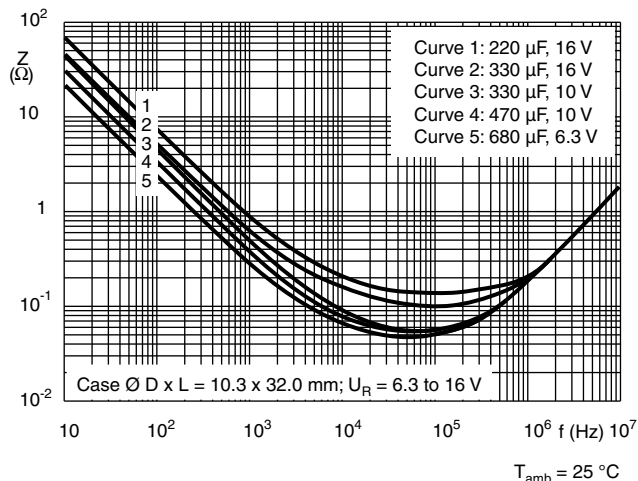


Fig. 15 - Typical impedance as a function of frequency

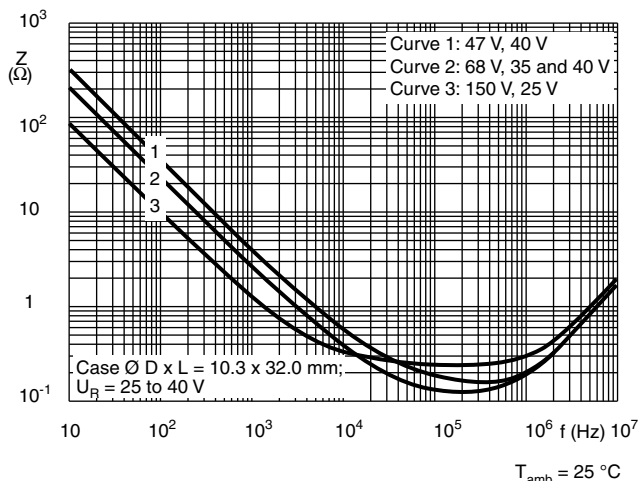


Fig. 16 - Typical impedance as a function of frequency

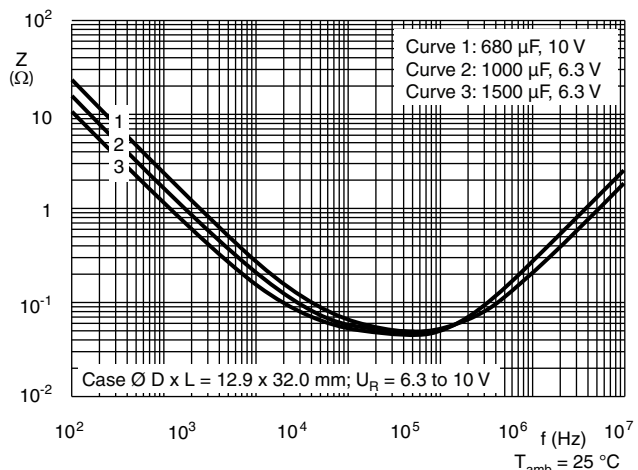


Fig. 17 - Typical impedance as a function of frequency

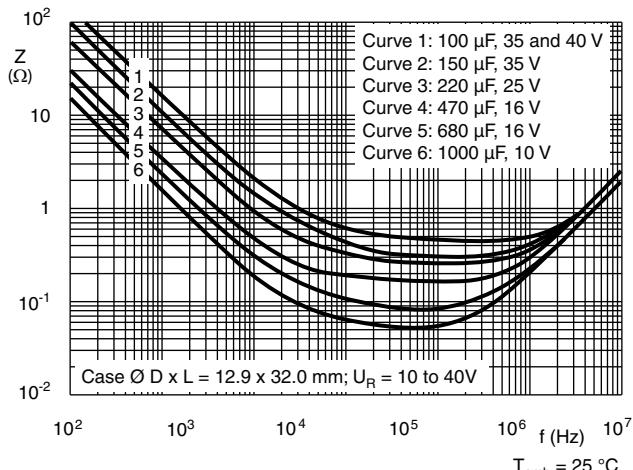


Fig. 18 - Typical impedance as a function of frequency

EQUIVALENT SERIES RESISTANCE (ESR)

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

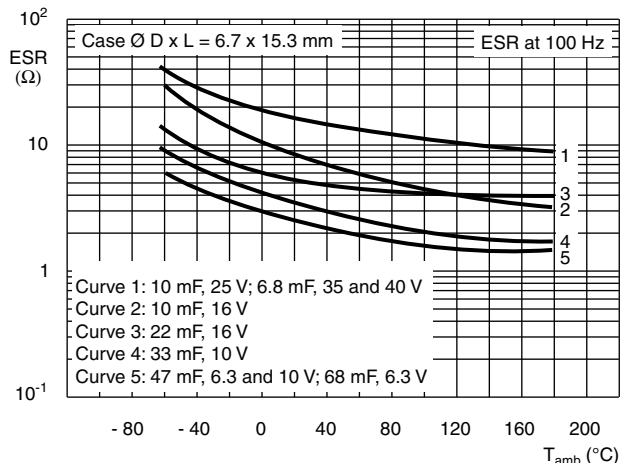


Fig. 19 - Typical ESR as a function of ambient temperature

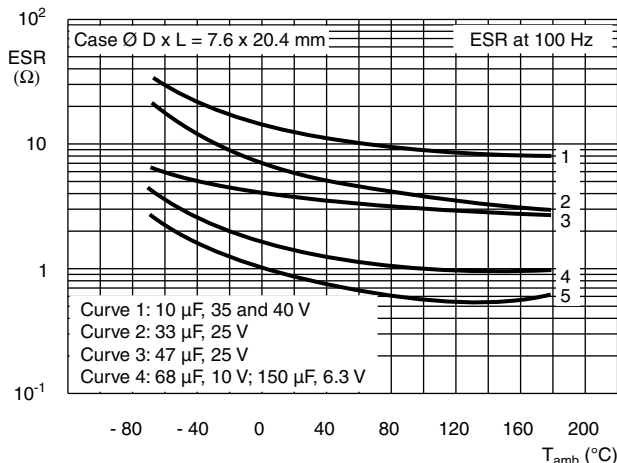


Fig. 20 - Typical ESR as a function of ambient temperature



EQUIVALENT SERIES RESISTANCE (ESR)

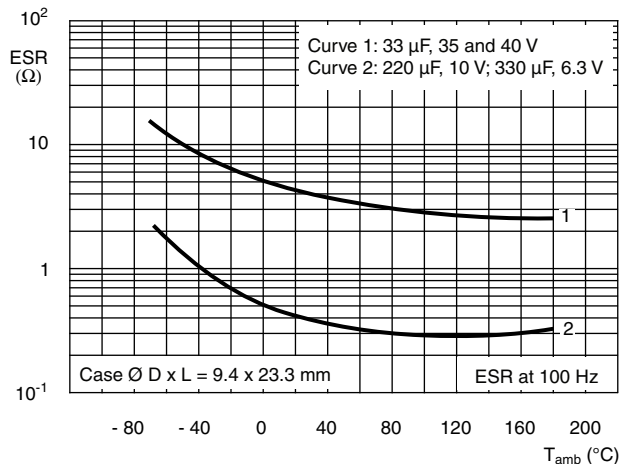


Fig. 21 - Typical ESR as a function of ambient temperature

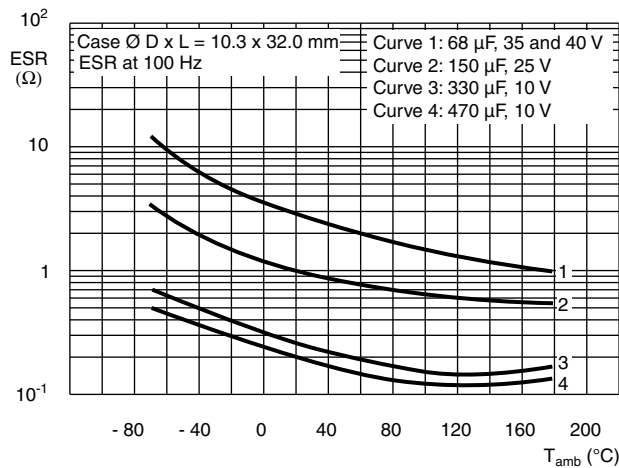


Fig. 22 - Typical ESR as a function of ambient temperature

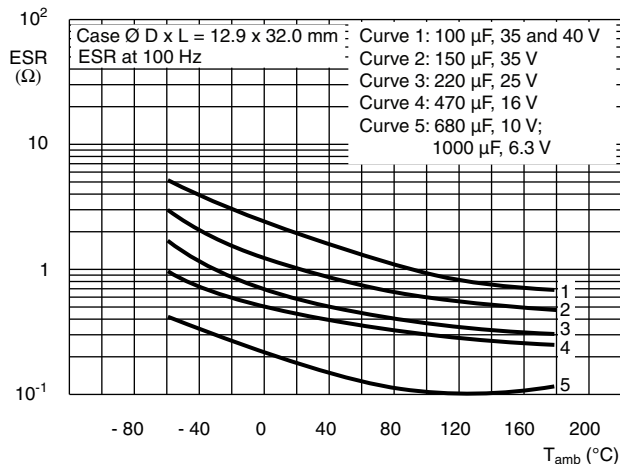


Fig. 23 - Typical ESR as a function of ambient temperature

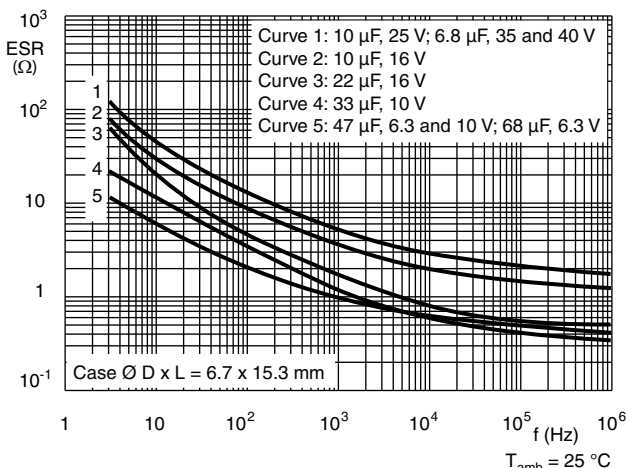


Fig. 25 - Typical ESR as a function of frequency

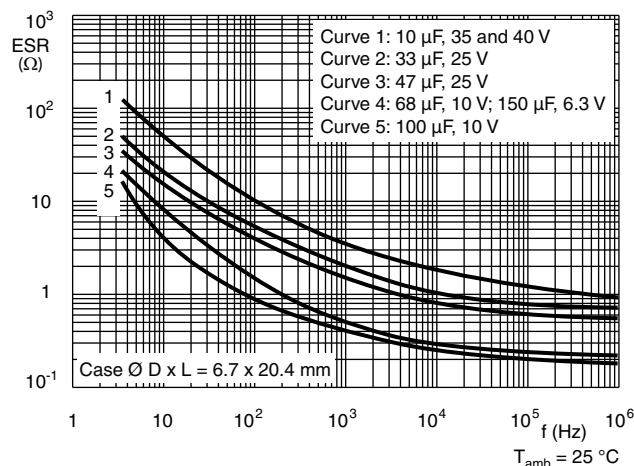


Fig. 24 - Typical ESR as a function of frequency

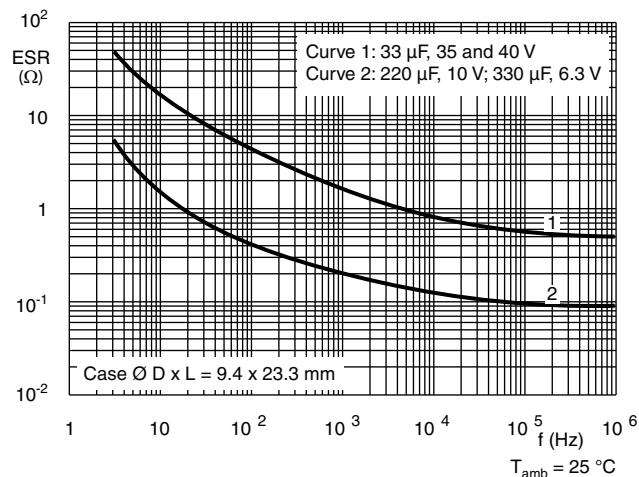


Fig. 26 - Typical ESR as a function of frequency



EQUIVALENT SERIES RESISTANCE (ESR)

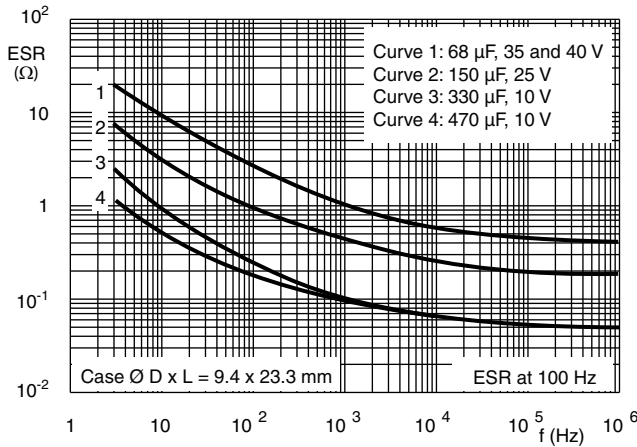


Fig. 27 - Typical ESR as a function of ambient temperature

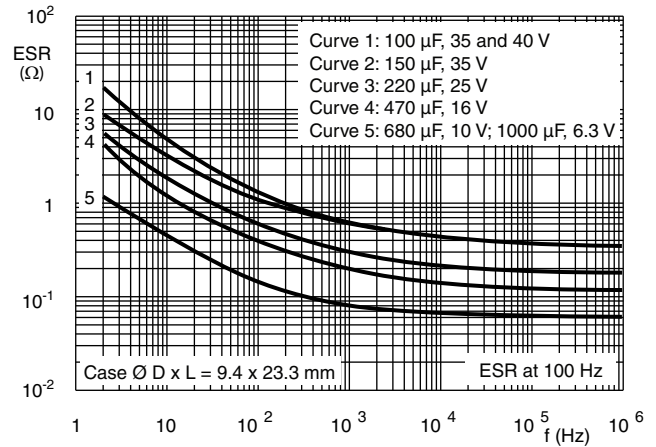


Fig. 28 - Typical ESR as a function of ambient temperature

Table 3

| TEST PROCEDURES AND REQUIREMENTS | | | |
|------------------------------------------------|--------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TEST | | PROCEDURE (quick reference) | REQUIREMENTS |
| NAME OF TEST | REFERENCE | | |
| Endurance | IEC 60384-4/ EN130300 subclause 4.13 | $T_{amb} = 125\text{ }^{\circ}\text{C}$; $U_R = 6.3\text{ V}$ to 25 V with U_R applied; $U_R = 35\text{ V}$ and 40 V with U_C applied; 10 000 h | $\Delta C/C: \pm 10\%$ $\tan \delta \leq 1.2 \times \text{spec. limit}$ $Z \leq 1.2 \times \text{spec. limit}$ $I_{L5} \leq \text{spec. limit}$ |
| Useful life | CECC 30302 subclause 1.8.1 | $T_{amb} = 125\text{ }^{\circ}\text{C}$; I_R applied and $U_R = 6.3\text{ V}$ to 25 V with U_R applied; $U_R = 35\text{ V}$ and 40 V with U_C applied; 20 000 h | $\Delta C/C: \pm 15\%$ $\tan \delta \leq 1.5 \times \text{spec. limit}$ $Z \leq 1.5 \times \text{spec. limit}$ $I_{L5} \leq \text{spec. limit}$ 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 | $T_{amb} = 125\text{ }^{\circ}\text{C}$; no voltage applied; 500 h | $\Delta C/C: \pm 10\%$ $\tan \delta \leq 1.2 \times \text{spec. limit}$ $I_{L5} \leq 1 \times \text{spec. limit}$ |
| 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 | $\Delta C/C: \pm 5\%$ 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 $\Delta C/C: \pm 5\%$ $\tan \delta \leq 1.2 \times \text{spec. limit}$ $Z \leq 1.2 \times \text{spec. limit}$ $I_{L5} \leq 1.5 \times \text{spec. limit}$ |
| Severe rapid change of temperature | | 100 cycles of 1 h duration, each with 30 min at $-40\text{ }^{\circ}\text{C}$ and $+125\text{ }^{\circ}\text{C}$ | $\Delta C/C: \pm 25\%$ $\tan \delta \leq 1.5 \times \text{spec. limit}$ $Z \leq 2.0 \times \text{spec. limit}$ $I_{L5} \leq 1 \times \text{spec. limit}$ |
| Solvent resistance | IEC 60068-2-45, test XA IEC 60653 | Immersion: 5 min ± 0.5 min with or without ultrasonic at $55\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ 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; $T_{amb} = 20\text{ }^{\circ}\text{C}$ to $25\text{ }^{\circ}\text{C}$; 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: | Clamping both body and leads | $\Delta C/C: \pm 10 \%$ $\tan \delta \leq 1.2 \times \text{stated limit}$ $Z \leq 1.4 \times \text{stated limit}$ DC leakage current: \leq stated limit no intermittent contacts no indication of breakdown no open circuiting no evidence of mechanical damage |
| Severity 1 | Frequency range temperature 10 Hz to 3000 Hz; 20 °C to 25 °C | |
| Severity 2 | Frequency range temperature 50 Hz to 2000 Hz; 125 °C | |
| Severity 1 and 2 | vibration amplitude: 50 g or 3.5 mm, whichever is less | |
| Direction and duration of motion: | | |
| Severity 1 | 1 octave/min; 3 directions (mutually perpendicular); 20 sweeps per direction (total 60 sweeps or 18 h) | |
| Severity 2 | 1 octave/min; 2 directions (longitudinal and transversal); 3 sweeps per direction (total 6 sweeps or 1 h) | |
| Functioning: | | |
| Severity 1 | Rated voltage applied | |
| Severity 2 | 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 | $\Delta C/C: \pm 10 \%$ $\tan \delta \leq 1.2 \times \text{stated limit}$ $Z \leq 1.4 \times \text{stated limit}$ DC leakage current: \leq stated limit no intermittent contacts no indication of breakdown no open circuiting no evidence of mechanical damage |
| Pulse shape: | Half-sine or sawtooth | |
| Severity 1 | 1500 g; 0.5 ms ("MIL STD-202", method 213, letter F) | |
| Severity 2 | 3000 g; 0.2 ms | |
| Severity 3 | 10 000 g; 0.1 ms | |
| Direction and number of shocks: | | |
| Severity 1 and 2 | 3 successive shocks in each direction of 3 mutually perpendicular axes (total 18 shocks) | |
| Severity 3 | 1 shock in any direction | |
| Functioning | Rated voltage applied | |



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