



## Aluminum Capacitors Solid Axial

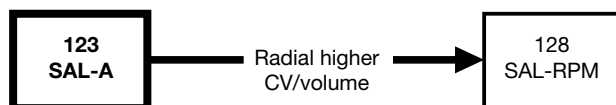


Fig. 1

### QUICK REFERENCE DATA

| DESCRIPTION                                            | VALUE                     |
|--------------------------------------------------------|---------------------------|
| Maximum case size<br>(Ø D x L in mm)                   | 6.7 x 15.3 to 12.9 x 32.0 |
| Rated capacitance range<br>(E6 series), C <sub>R</sub> | 1.0 µF to 1000 µF         |
| Tolerance on C <sub>R</sub>                            | ± 20 %; ± 10 % on request |
| Rated voltage range, U <sub>R</sub>                    | 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<br>and 125 °C                 | 5000 h and 8000 h         |
| Useful life at 125 °C                                  | 20 000 h                  |
| Useful life at 40 °C, I <sub>R</sub> 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 MnO<sub>2</sub>
- 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<sub>R</sub> allowed
- AC voltage up to 0.8 x U<sub>R</sub> allowed
- Advanced technology to achieve high reliability and high stability
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)



**RoHS\***  
Available

### 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:

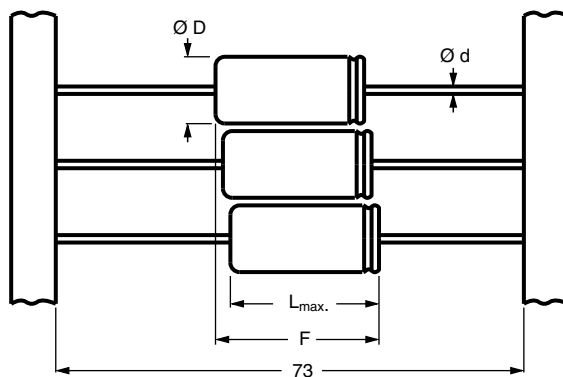
- Rated capacitance (in µF)
- Tolerance code on rated capacitance, code letter in accordance with IEC 60062 (M = ± 20 %, K = ± 10 %)
- Rated voltage (in V) at corresponding maximum temperature
- Date code in accordance with IEC 60062
- Name of manufacturer
- Code for factory of origin
- Band to indicate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

### SELECTION CHART FOR C<sub>R</sub>, U<sub>R</sub>, AND RELEVANT MAXIMUM CASE SIZES (Ø D x L in mm)

| C <sub>R</sub><br>(µF) | U <sub>R</sub> (V) AT T <sub>amb</sub> = 85 °C  |    |            |            |            |            |
|------------------------|-------------------------------------------------|----|------------|------------|------------|------------|
|                        | 6.3                                             | 10 | 16         | 25         | 35         | 40         |
|                        | U <sub>C</sub> (V) AT T <sub>amb</sub> = 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)**

| $C_R$<br>( $\mu F$ ) | $U_R$ (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

| <b>DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES</b> |      |            |                 |                            |                      |         |
|-----------------------------------------------------------------|------|------------|-----------------|----------------------------|----------------------|---------|
| CASE                                                            |      | $F_{max.}$ | $\varnothing d$ | MASS <sup>(2)</sup><br>(g) | PACKAGING QUANTITIES |         |
| MAXIMUM SIZE $\varnothing D \times L$ <sup>(1)</sup>            | 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**

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

| <b>CARDBOARD BOX DIMENSIONS, L x W x H (mm)</b> |                 |
|-------------------------------------------------|-----------------|
| 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  $25^\circ\text{C}$ ,  $P = 86$  to  $106$  kPa,  $RH = 45$  to  $75\%$ .

Table 2

| ELECTRICAL DATA AND ORDERING INFORMATION for 123 series |                       |                                  |                                         |                                            |                                           |                                            |                                  |                 |                              |                              |                     |                                                                                    |                                       |                                                                  |                                                       |
|---------------------------------------------------------|-----------------------|----------------------------------|-----------------------------------------|--------------------------------------------|-------------------------------------------|--------------------------------------------|----------------------------------|-----------------|------------------------------|------------------------------|---------------------|------------------------------------------------------------------------------------|---------------------------------------|------------------------------------------------------------------|-------------------------------------------------------|
| U <sub>C</sub><br>(V)                                   | U <sub>R</sub><br>(V) | C <sub>R</sub><br>100 Hz<br>(μF) | MAX.<br>CASE<br>SIZE<br>Ø D x L<br>(mm) | I <sub>R</sub><br>100 Hz<br>125 °C<br>(mA) | I <sub>R</sub><br>10 kHz<br>85 °C<br>(mA) | I <sub>R</sub><br>100 kHz<br>40 °C<br>(mA) | I <sub>L5</sub><br>5 min<br>(μA) | tan δ<br>100 Hz | MAX.<br>ESR<br>100 Hz<br>(Ω) | TYP.<br>ESR<br>100 Hz<br>(Ω) | Z<br>100 kHz<br>(Ω) | ORDERING CODE<br>MAL2123.....E3 LEAD (Pb)-FREE<br>MAL2123 ..... NON LEAD (Pb)-FREE |                                       |                                                                  |                                                       |
|                                                         |                       |                                  |                                         |                                            |                                           |                                            |                                  |                 |                              |                              |                     | SAL-A<br>FORM<br>BA<br>TOL.<br>± 20 %                                              | SAL-A<br>FORM<br>BR<br>TOL.<br>± 20 % | SAL-AG <sup>(1)</sup><br>FORM<br>BA<br>TOL.<br>± 10 %<br>LEVEL S | SAL-AG <sup>(1)</sup><br>FORM<br>BA<br>TOL.<br>± 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                                                 |

**ORDERING EXAMPLE**

Electrolytic capacitors 123 series

10  $\mu\text{F}/16\text{ V}$ ;  $\pm 20\%$ Maximum case size:  $\varnothing 6.7 \times 15.3$  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

**ELECTRICAL DATA AND ORDERING INFORMATION** for 123 series

| U <sub>C</sub><br>(V) | U <sub>R</sub><br>(V) | C <sub>R</sub><br>100 Hz<br>(μF) | MAX.<br>CASE<br>SIZE<br>Ø D x L<br>(mm) | I <sub>R</sub><br>100 Hz<br>125 °C<br>(mA) | I <sub>R</sub><br>10 kHz<br>85 °C<br>(mA) | I <sub>R</sub><br>100 kHz<br>40 °C<br>(mA) | I <sub>L5</sub><br>5 min<br>(μA) | tan δ<br>100 Hz | MAX.<br>ESR<br>100 Hz<br>(Ω) | TYP.<br>ESR<br>100 Hz<br>(Ω) | Z<br>100 kHz<br>(Ω) | ORDERING CODE                         |                                       |                                                                  |                                                       |
|-----------------------|-----------------------|----------------------------------|-----------------------------------------|--------------------------------------------|-------------------------------------------|--------------------------------------------|----------------------------------|-----------------|------------------------------|------------------------------|---------------------|---------------------------------------|---------------------------------------|------------------------------------------------------------------|-------------------------------------------------------|
|                       |                       |                                  |                                         |                                            |                                           |                                            |                                  |                 |                              |                              |                     | MAL2123.....E3 LEAD (Pb)-FREE         |                                       |                                                                  |                                                       |
|                       |                       |                                  |                                         |                                            |                                           |                                            |                                  |                 |                              |                              |                     | MAL2123 ..... NON LEAD (Pb)-FREE      |                                       |                                                                  |                                                       |
|                       |                       |                                  |                                         |                                            |                                           |                                            |                                  |                 |                              |                              |                     | SAL-A<br>FORM<br>BA<br>TOL.<br>± 20 % | SAL-A<br>FORM<br>BR<br>TOL.<br>± 20 % | SAL-AG <sup>(1)</sup><br>FORM<br>BA<br>TOL.<br>± 10 %<br>LEVEL S | SAL-AG <sup>(1)</sup><br>FORM<br>BA<br>TOL.<br>± 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                                                                                                 |
|----------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|
| <b>Voltage</b>                                           |                                                                                                                                                                                                                                  |                                                                                                       |
| 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         |                                                                                                                                                                                                                                  | $\leq 2 \text{ V}$                                                                                    |
| Maximum peak AC voltage, without reverse voltage applied | $T_{amb} \leq 85 \text{ °C at:}$<br>$f \leq 0.1 \text{ Hz}$<br>$0.1 \text{ Hz} < f \leq 1 \text{ Hz}$<br>$1 \text{ Hz} < f \leq 10 \text{ Hz}$<br>$10 \text{ Hz} < f \leq 50 \text{ Hz}$<br>$f > 50 \text{ Hz}$                  | $0.30 \times U_R$<br>$0.45 \times U_R$<br>$0.60 \times U_R$<br>$0.65 \times U_R$<br>$0.80 \times U_R$ |
|                                                          | $85 \text{ °C} < T_{amb} \leq 125 \text{ °C at:}$<br>$f \leq 0.1 \text{ Hz}$<br>$0.1 \text{ Hz} < f \leq 1 \text{ Hz}$<br>$1 \text{ Hz} < f \leq 10 \text{ Hz}$<br>$10 \text{ Hz} < f \leq 50 \text{ Hz}$<br>$f > 50 \text{ Hz}$ | $0.15 \times U_R$<br>$0.22 \times U_R$<br>$0.30 \times U_R$<br>$0.32 \times U_R$<br>$0.40 \times U_R$ |
| <b>Current</b>                                           |                                                                                                                                                                                                                                  |                                                                                                       |
| Maximum leakage current                                  | After 5 min at $U_R$ and $T_{amb} = 25 \text{ °C}$                                                                                                                                                                               | $I_{L5} \leq 0.05 C_R \times U_R$ or 2 μA, whichever is greater; see Table 2                          |
| Typical leakage current                                  | After 15 s at $U_R$ and $T_{amb} = 25 \text{ °C:}$<br>$U_R = 6.3 \text{ V to } 16 \text{ V}$                                                                                                                                     | $\approx 0.2 \times \text{value stated in Table 2}$                                                   |
|                                                          | $U_R = 25 \text{ V to } 40 \text{ V}$                                                                                                                                                                                            | $\approx 0.1 \times \text{value stated in Table 2}$                                                   |

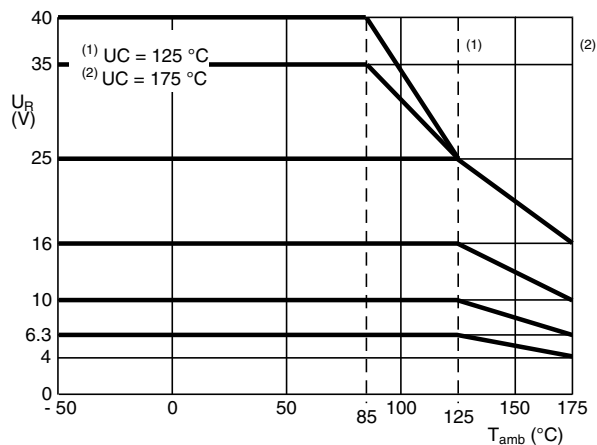
**VOLTAGE**

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

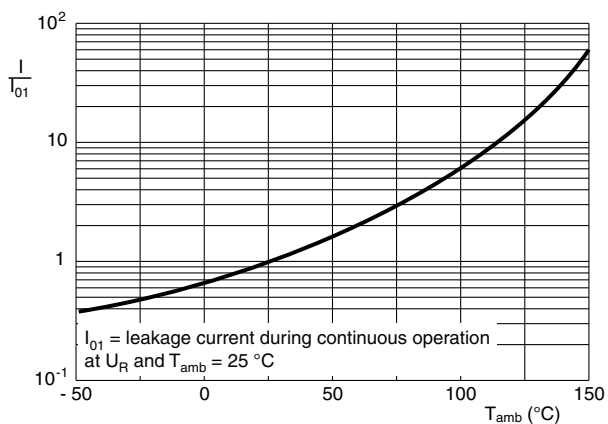
**LEAKAGE CURRENT**

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

**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.

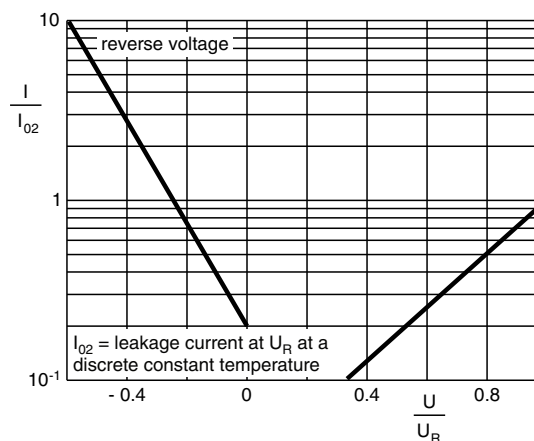
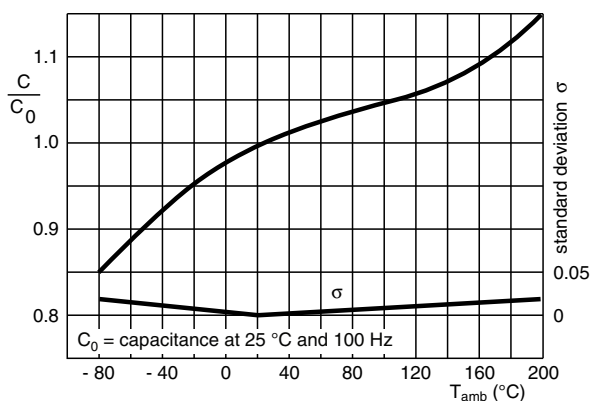
Fig. 5 - Typical multiplier of leakage current as a function of  $U/U_R$ **CAPACITANCE (C)**

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

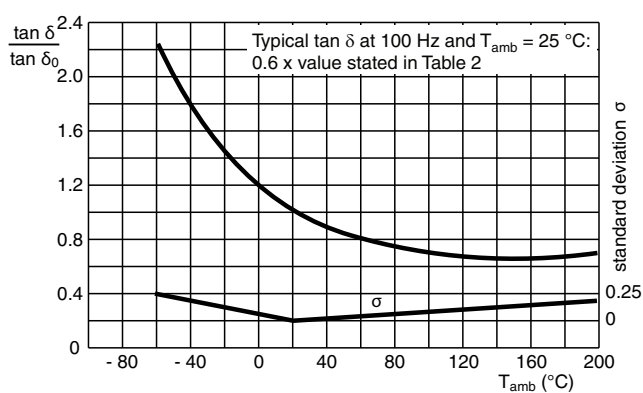
**DISSIPATION FACTOR ( $\tan \delta$ )**

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

**MAXIMUM POWER DISSIPATION**

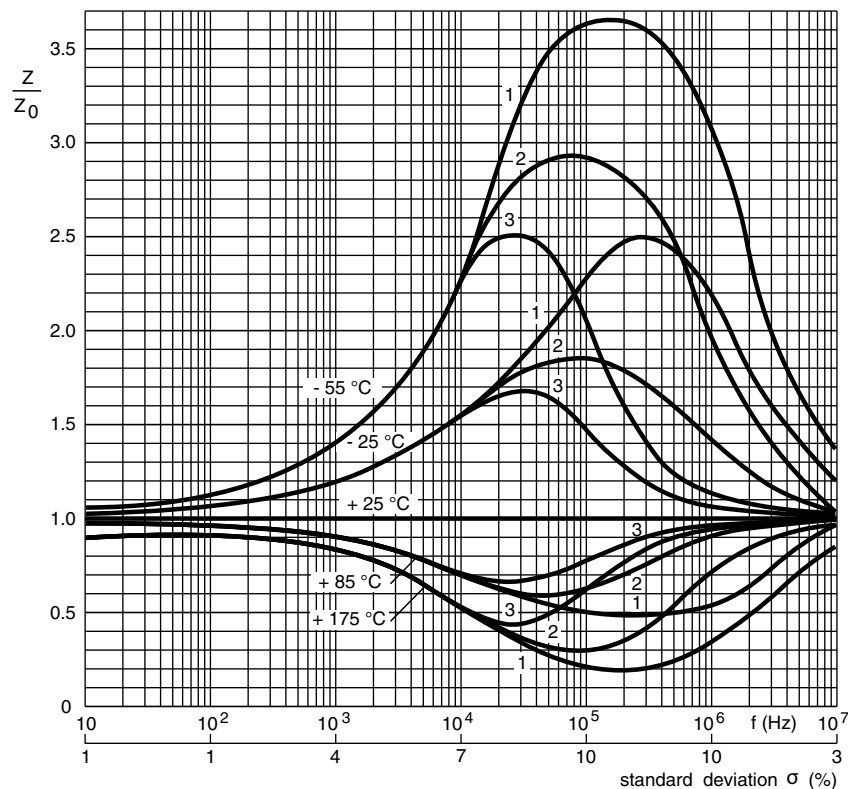
| MAXIMUM CASE SIZE<br>Ø D x L<br>(mm) | $P_{\max.} = P_{125}$<br>(W) |
|--------------------------------------|------------------------------|
| 6.7 x 15.3                           | 0.13                         |
| 7.6 x 20.4                           | 0.16                         |
| 9.4 x 23.3                           | 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<br>Ø D x L<br>(mm) | PITCH<br>(mm) | MAX. ESL<br>(nH) | TYP. ESL<br>(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  $T_{\text{amb}} = 25^\circ\text{C}$ : 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  $T_{\text{amb}} = 25^\circ\text{C}$

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

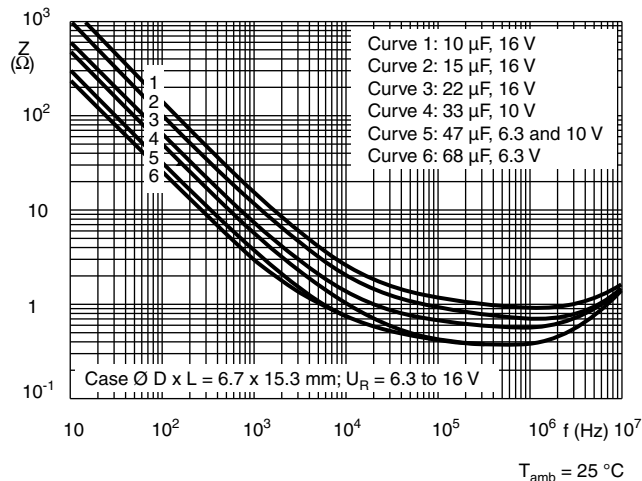
**IMPEDANCE (Z)**

Fig. 9 - Typical impedance as a function of frequency

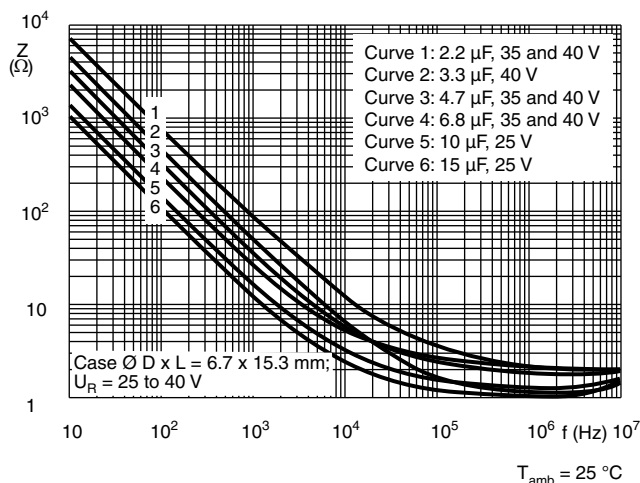


Fig. 10 - Typical impedance as a function of frequency

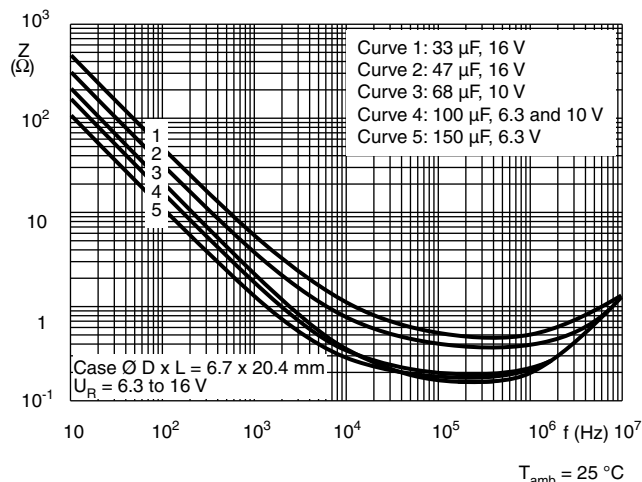


Fig. 11 - Typical impedance as a function of frequency

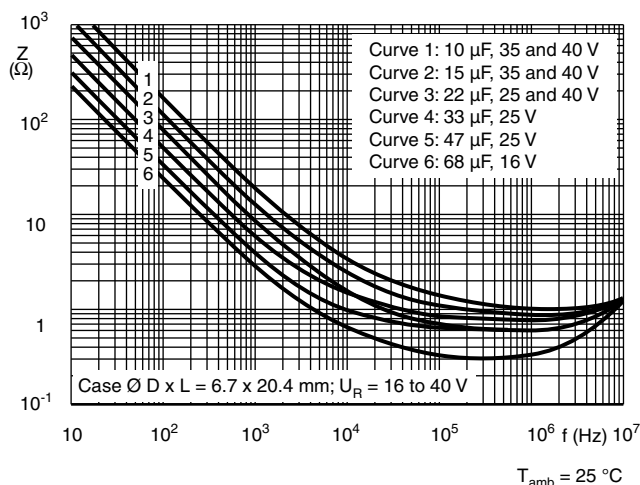


Fig. 12 - Typical impedance as a function of frequency

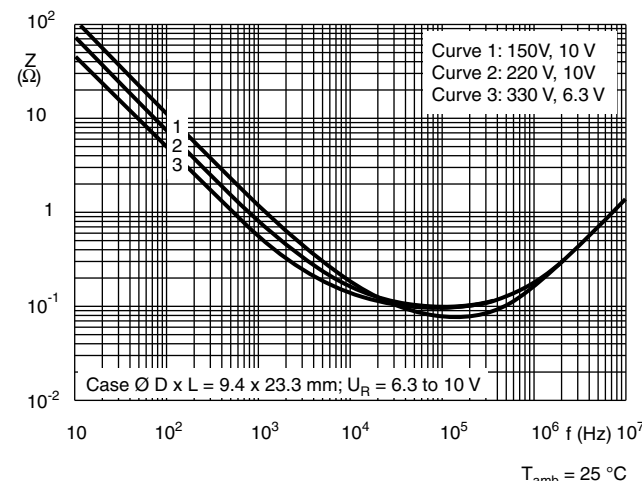


Fig. 13 - Typical impedance as a function of frequency

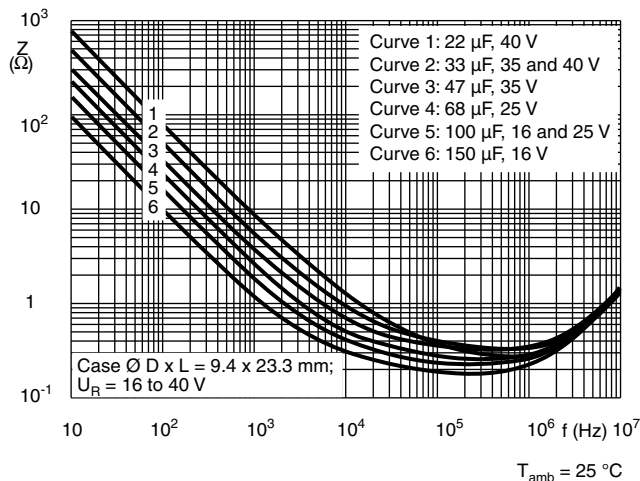


Fig. 14 - Typical impedance as a function of frequency



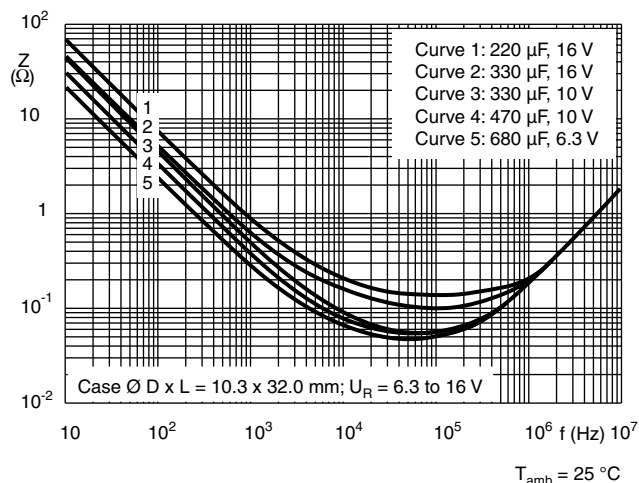
**IMPEDANCE (Z)**

Fig. 15 - Typical impedance as a function of frequency

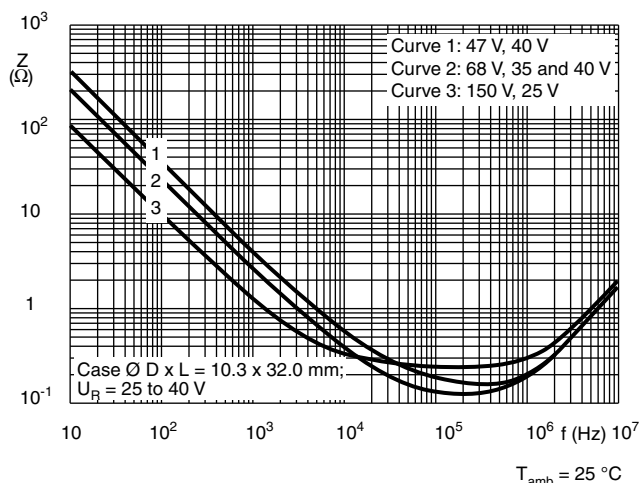


Fig. 16 - Typical impedance as a function of frequency

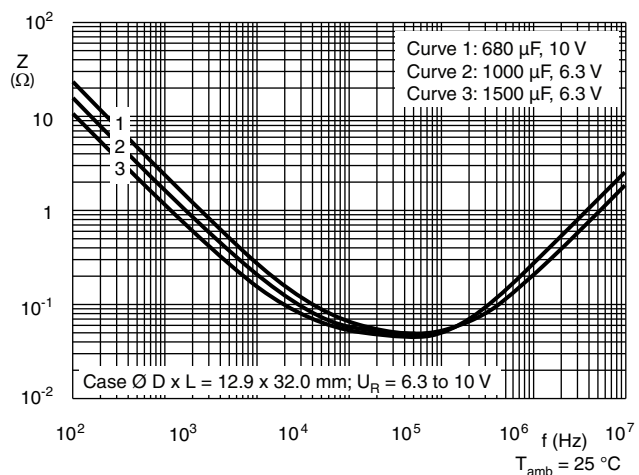


Fig. 17 - Typical impedance as a function of frequency

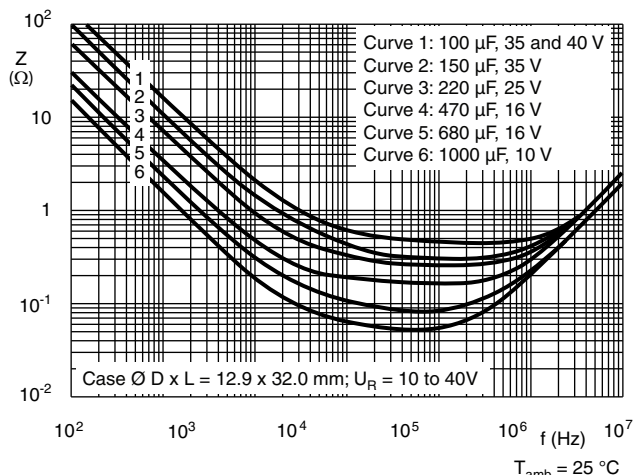


Fig. 18 - Typical impedance as a function of frequency

**EQUIVALENT SERIES RESISTANCE (ESR)**

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

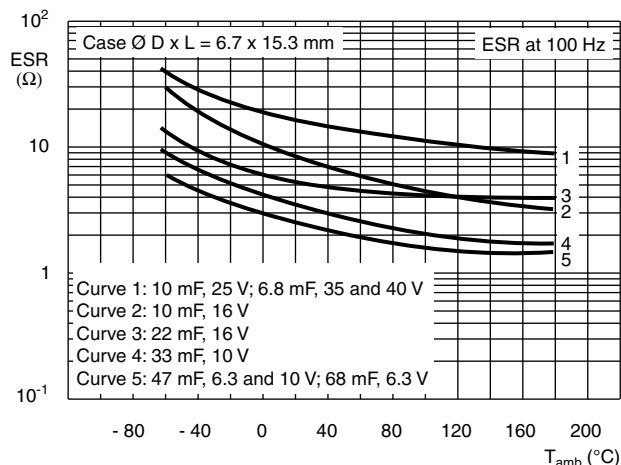


Fig. 19 - Typical ESR as a function of ambient temperature

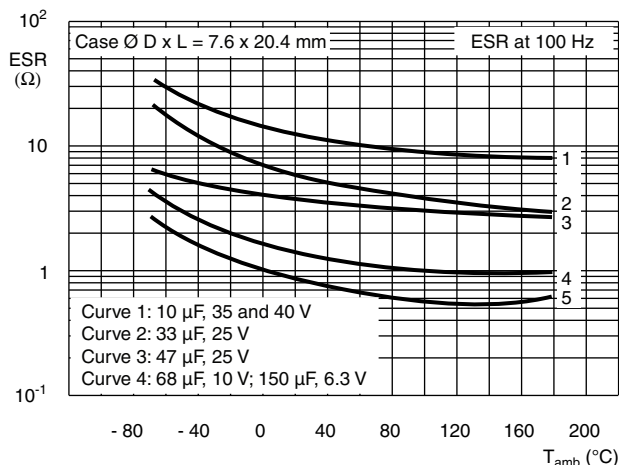


Fig. 20 - Typical ESR as a function of ambient temperature



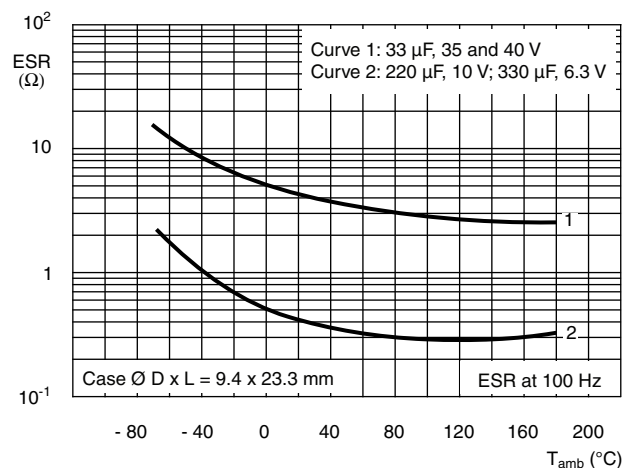
**EQUIVALENT SERIES RESISTANCE (ESR)**

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

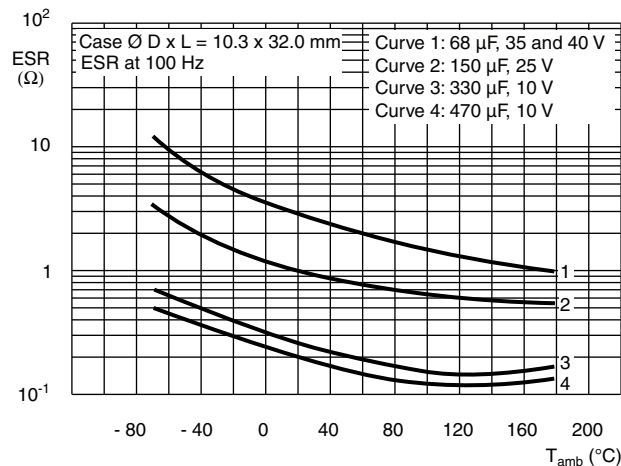


Fig. 22 - Typical ESR as a function of ambient temperature

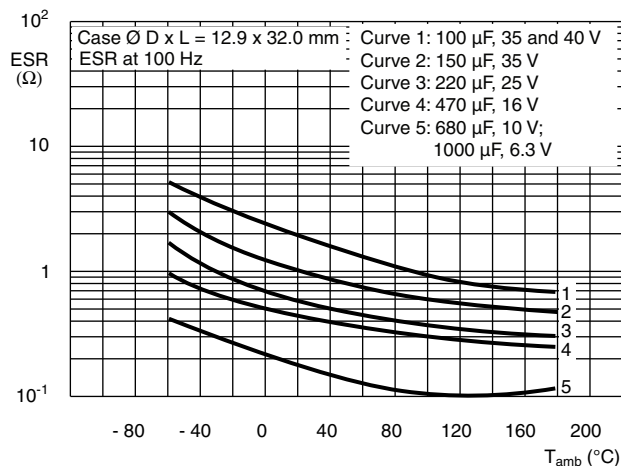


Fig. 23 - Typical ESR as a function of ambient temperature

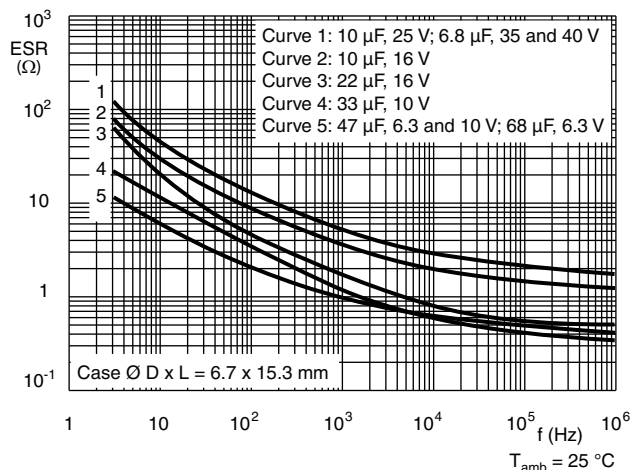


Fig. 25 - Typical ESR as a function of frequency

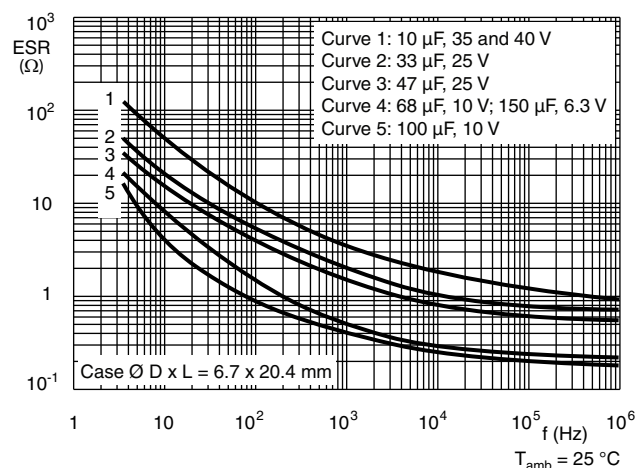


Fig. 24 - Typical ESR as a function of frequency

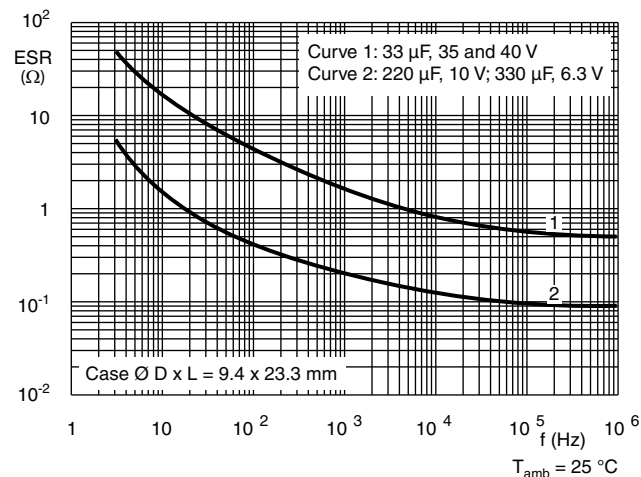


Fig. 26 - Typical ESR as a function of frequency

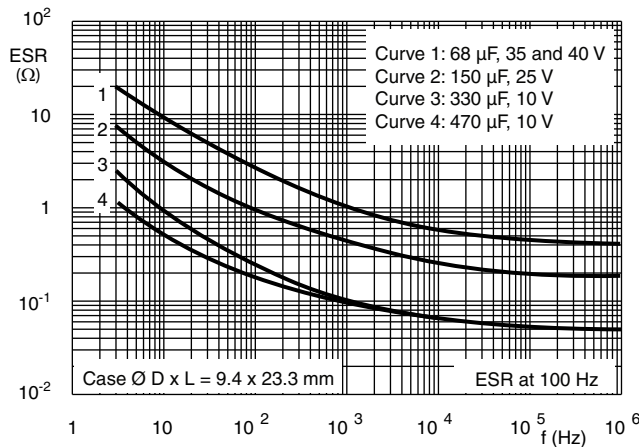
**EQUIVALENT SERIES RESISTANCE (ESR)**

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

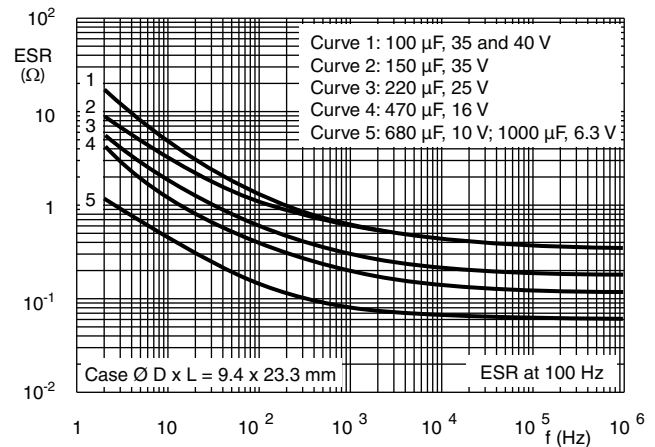


Fig. 28 - Typical ESR as a function of ambient temperature

**Table 3**

| <b>TEST PROCEDURES AND REQUIREMENTS</b>        |                                            |                                                                                                                                                                                           |                                                                                                                                                                                                                                                              |
|------------------------------------------------|--------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>TEST</b>                                    |                                            | <b>PROCEDURE<br/>(quick reference)</b>                                                                                                                                                    | <b>REQUIREMENTS</b>                                                                                                                                                                                                                                          |
| <b>NAME OF TEST</b>                            | <b>REFERENCE</b>                           |                                                                                                                                                                                           |                                                                                                                                                                                                                                                              |
| Endurance                                      | IEC 60384-4/<br>EN130300<br>subclause 4.13 | $T_{amb} = 125^{\circ}\text{C}$ ;<br>$U_R = 6.3\text{ V}$ to $25\text{ V}$ with $U_R$ applied;<br>$U_R = 35\text{ V}$ and $40\text{ V}$ with $U_C$ applied;<br>10 000 h                   | $\Delta C/C: \pm 10\%$<br>$\tan \delta \leq 1.2 \times \text{spec. limit}$<br>$Z \leq 1.2 \times \text{spec. limit}$<br>$I_{L5} \leq \text{spec. limit}$                                                                                                     |
| Useful life                                    | CECC 30302<br>subclause 1.8.1              | $T_{amb} = 125^{\circ}\text{C}$ ; $I_R$ applied and<br>$U_R = 6.3\text{ V}$ to $25\text{ V}$ with $U_R$ applied;<br>$U_R = 35\text{ V}$ and $40\text{ V}$ with $U_C$ applied;<br>20 000 h | $\Delta C/C: \pm 15\%$<br>$\tan \delta \leq 1.5 \times \text{spec. limit}$<br>$Z \leq 1.5 \times \text{spec. limit}$<br>$I_{L5} \leq \text{spec. limit}$<br>no short or open circuit,<br>no visible damage<br>total failure percentage: $< 1\%$              |
| Shelf life<br>(storage at high<br>temperature) | IEC 60384-4/<br>EN130300<br>subclause 4.17 | $T_{amb} = 125^{\circ}\text{C}$ ; no voltage applied;<br>500 h                                                                                                                            | $\Delta C/C: \pm 10\%$<br>$\tan \delta \leq 1.2 \times \text{spec. limit}$<br>$I_{L5} \leq 1 \times \text{spec. limit}$                                                                                                                                      |
| Charge and<br>discharge                        | IEC 60384-4-2<br>subclause 9.21            | $10^6$ cycles without series resistance:<br>0.5 s to $U_R$ ;<br>0.5 s to ground                                                                                                           | $\Delta C/C: \pm 5\%$<br>no short or open circuit,<br>no visible damage                                                                                                                                                                                      |
| Shock                                          | IEC 60068-2-27<br>test Ea                  | Half-sine or saw tooth pulse shape; 50 g; 11 ms;<br>3 successive shocks in each direction of<br>3 mutually perpendicular axes;<br>no voltage applied                                      | no intermittent contacts<br>no breakdown<br>no open circuiting<br>no mechanical damage<br>$\Delta C/C: \pm 5\%$<br>$\tan \delta \leq 1.2 \times \text{spec. limit}$<br>$Z \leq 1.2 \times \text{spec. limit}$<br>$I_{L5} \leq 1.5 \times \text{spec. limit}$ |
| Severe rapid change<br>of temperature          |                                            | 100 cycles of 1 h duration, each with<br>30 min at $-40^{\circ}\text{C}$ and $+125^{\circ}\text{C}$                                                                                       | $\Delta C/C: \pm 25\%$<br>$\tan \delta \leq 1.5 \times \text{spec. limit}$<br>$Z \leq 2.0 \times \text{spec. limit}$<br>$I_{L5} \leq 1 \times \text{spec. limit}$                                                                                            |
| Solvent resistance                             | IEC 60068-2-45,<br>test XA<br>IEC 60653    | Immersion:<br>5 min $\pm 0.5$ min with or without ultrasonic<br>at $55^{\circ}\text{C} \pm 5^{\circ}\text{C}$<br>Solvents: demineralized water and/or calgonite<br>solution (20 g/l)      | Visual appearance not affected                                                                                                                                                                                                                               |
| Passive flammability                           | IEC 60695-2-2                              | Capacitor mounted to a vertical printed-circuit<br>board, one flame on capacitor body;<br>$T_{amb} = 20^{\circ}\text{C}$ to $25^{\circ}\text{C}$ ;<br>test duration = 20 s                | After removing the test flame from the<br>capacitor, the capacitor must not<br>continue to burn for more than 15 s;<br>no burning particles must drop from<br>the sample                                                                                     |

**ADDITIONAL TESTS AND REQUIREMENTS FOR EPOXY-FILLED VERSIONS SAL-AG**2281 123 8.... Form BA  $\pm 10\%$ , level S, lead (Pb)-free2222 123 8.... Form BA  $\pm 10\%$ , 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:<br>Severity 1<br><br>Severity 2<br>Severity 1 and 2                                                                     | Clamping both body and leads<br><br>Frequency range temperature 10 Hz to 3000 Hz;<br>20 °C to 25 °C<br><br>Frequency range temperature 50 Hz to 2000 Hz; 125 °C<br><br>vibration amplitude: 50 g or 3.5 mm, whichever is less | ΔC/C: ± 10 %<br>tan δ ≤ 1.2 x stated limit<br>Z ≤ 1.4 x stated limit<br>DC leakage current: ≤ stated limit<br>no intermittent contacts<br>no indication of breakdown<br>no open circuiting<br>no evidence of mechanical damage |                                                                                                                                                                                                                                |
| Direction and duration of motion:<br>Severity 1<br><br>Severity 2                                                                           | 1 octave/min; 3 directions (mutually perpendicular);<br>20 sweeps per direction (total 60 sweeps or 18 h)<br><br>1 octave/min; 2 directions (longitudinal and transversal);<br>3 sweeps per direction (total 6 sweeps or 1 h) |                                                                                                                                                                                                                                |                                                                                                                                                                                                                                |
| Functioning:<br>Severity 1<br>Severity 2                                                                                                    | Rated voltage applied<br><br>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 %<br>tan δ ≤ 1.2 x stated limit<br>Z ≤ 1.4 x stated limit<br>DC leakage current: ≤ stated limit<br>no intermittent contacts<br>no indication of breakdown<br>no open circuiting<br>no evidence of mechanical damage |
| Pulse shape:<br>Severity 1<br>Severity 2<br>Severity 3                                                                                      | Half-sine or sawtooth<br><br>1500 g; 0.5 ms (“MIL STD-202”, method 213, letter F)<br><br>3000 g; 0.2 ms<br><br>10 000 g; 0.1 ms                                                                                               |                                                                                                                                                                                                                                |                                                                                                                                                                                                                                |
| Direction and number of shocks:<br>Severity 1 and 2<br><br>Severity 3                                                                       | 3 successive shocks in each direction of 3 mutually<br>perpendicular axes (total 18 shocks)<br><br>1 shock in any direction                                                                                                   |                                                                                                                                                                                                                                |                                                                                                                                                                                                                                |
| Functioning                                                                                                                                 | Rated voltage applied                                                                                                                                                                                                         |                                                                                                                                                                                                                                |                                                                                                                                                                                                                                |



## Disclaimer

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