



## Aluminum Capacitors Solid Axial

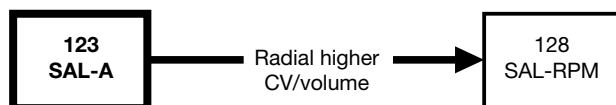


Fig. 1

### QUICK REFERENCE DATA

| DESCRIPTION                                       | VALUE                              |
|---------------------------------------------------|------------------------------------|
| Maximum case size<br>( $\varnothing$ D x L in mm) | 6.7 x 15.3 to 12.9 x 32.0          |
| Rated capacitance range<br>(E6 series), $C_R$     | 1.0 $\mu$ F to 1000 $\mu$ F        |
| Tolerance on $C_R$                                | $\pm 20\%$ ; $\pm 10\%$ 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<br>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  $MnO_2$
- Axial leads, aluminum case, ceramic seal, blue insulation sleeve
- SAL-A: standard version
- SAL-AG: epoxy filled shock-proof version up to 10 000 g
- Extremely long useful life: 20 000 h at 125 °C
- Extended high temperature range up to 200 °C
- Excellent low temperature impedance and ESR behavior
- Charge and discharge proof, application with 0  $\Omega$  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](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:

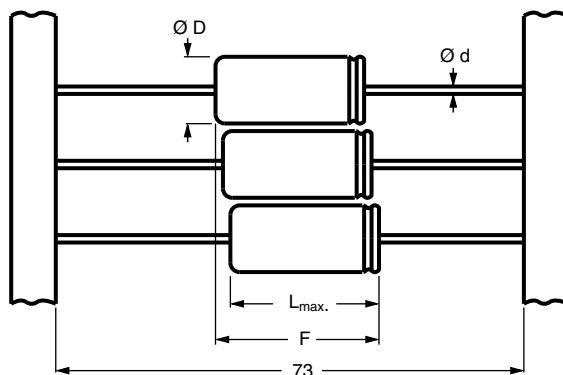
- Rated capacitance (in  $\mu$ F)
- Tolerance code on rated capacitance, code letter in accordance with IEC 60062 (M =  $\pm 20\%$ , K =  $\pm 10\%$ )
- Rated voltage (in V) at corresponding maximum temperature
- Date code in accordance with IEC 60062
- Name of manufacturer
- Code for factory of origin
- 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 ( $\varnothing$ D x L in mm)

| $C_R$<br>( $\mu$ F) | $U_R$ (V) AT $T_{amb} = 85\text{ °C}$  |    |            |            |            |            |
|---------------------|----------------------------------------|----|------------|------------|------------|------------|
|                     | 6.3                                    | 10 | 16         | 25         | 35         | 40         |
|                     | $U_C$ (V) AT $T_{amb} = 125\text{ °C}$ |    |            |            |            |            |
|                     | 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                                                 |
| 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 <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<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 % |
| 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 $2 \text{ μA}$ , whichever is greater; see Table 2               |
| Typical leakage current                                  | After 15 s at $U_R$ and $T_{amb} = 25 \text{ °C:}$<br>$U_R = 6.3 \text{ V to } 16 \text{ V}$                                                                                                                                     | $\approx 0.2 \times \text{value stated in Table 2}$                                                   |
|                                                          | $U_R = 25 \text{ V to } 40 \text{ V}$                                                                                                                                                                                            | $\approx 0.1 \times \text{value stated in Table 2}$                                                   |

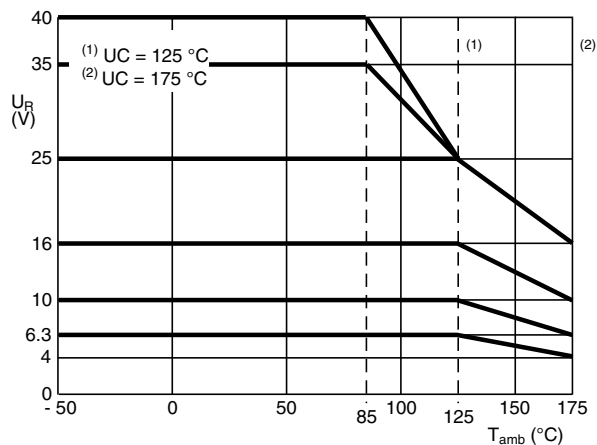
**VOLTAGE**

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

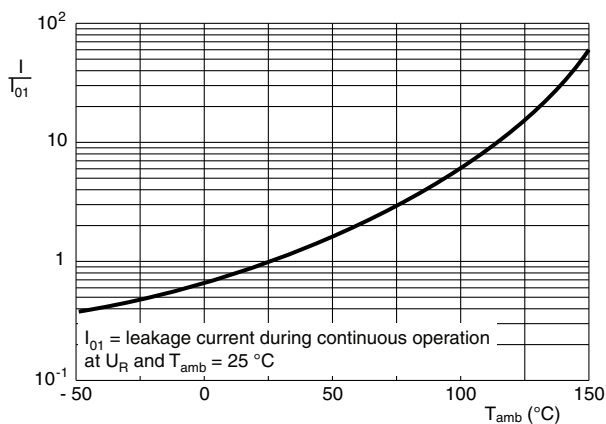
**LEAKAGE CURRENT**

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.

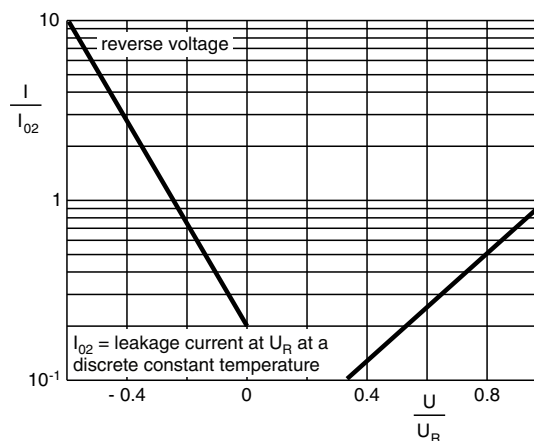
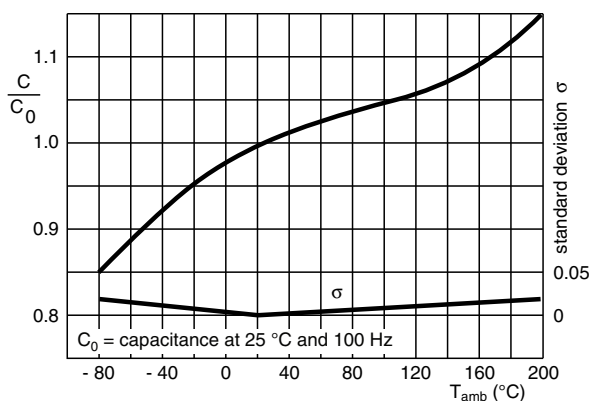
Fig. 5 - Typical multiplier of leakage current as a function of  $U/U_R$ **CAPACITANCE (C)**

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

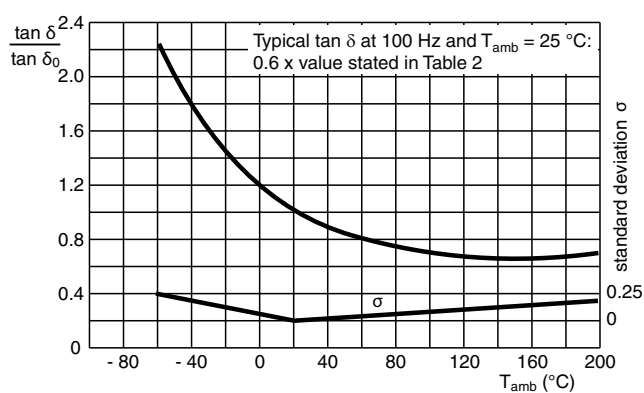
**DISSIPATION FACTOR ( $\tan \delta$ )**

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

**MAXIMUM POWER DISSIPATION**

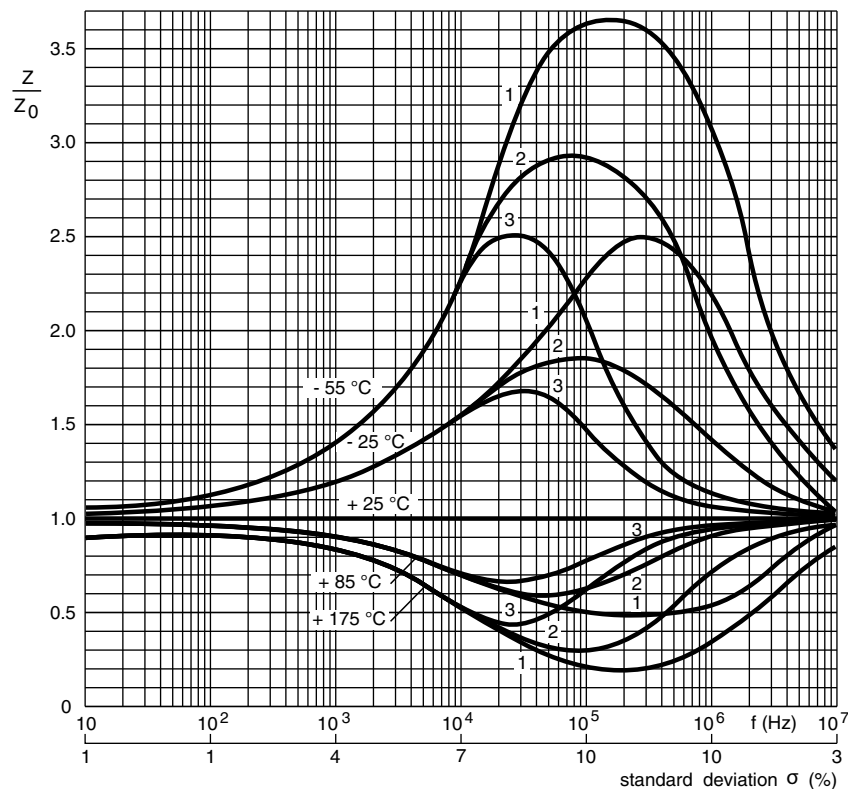
| MAXIMUM CASE SIZE<br>Ø D x L<br>(mm) | $P_{max.} = P_{125}$<br>(W) |
|--------------------------------------|-----------------------------|
| 6.7 x 15.3                           | 0.13                        |
| 7.6 x 20.4                           | 0.16                        |
| 9.4 x 23.3                           | 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  $T_{amb} = 25$  °C: 0.5 x value stated in Table 2.



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

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

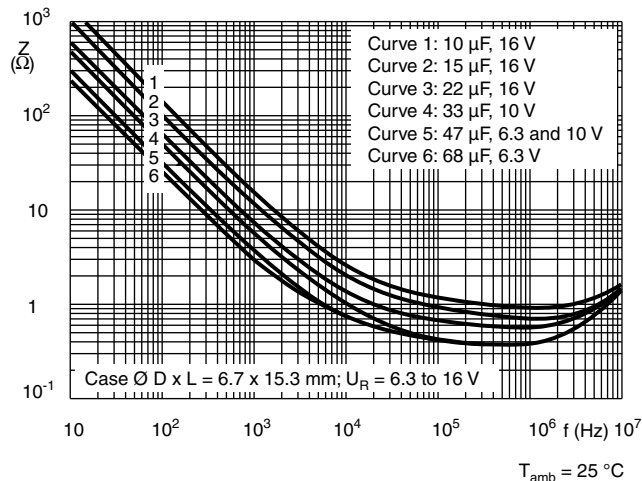
**IMPEDANCE (Z)**

Fig. 9 - Typical impedance as a function of frequency

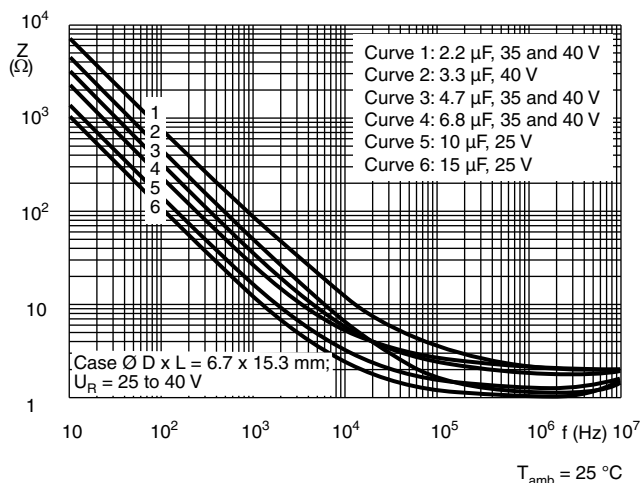


Fig. 10 - Typical impedance as a function of frequency

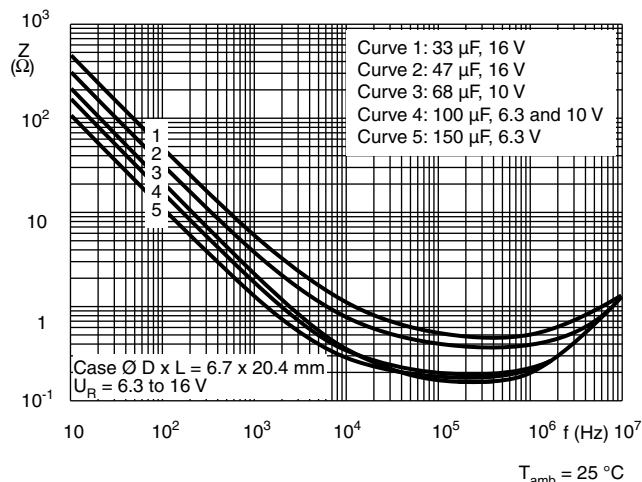


Fig. 11 - Typical impedance as a function of frequency

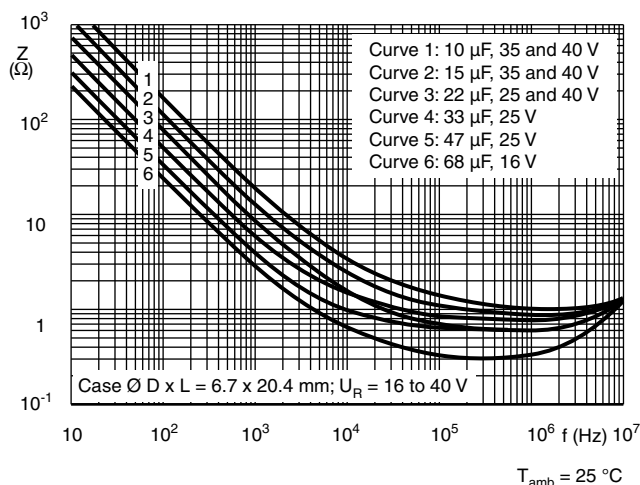


Fig. 12 - Typical impedance as a function of frequency

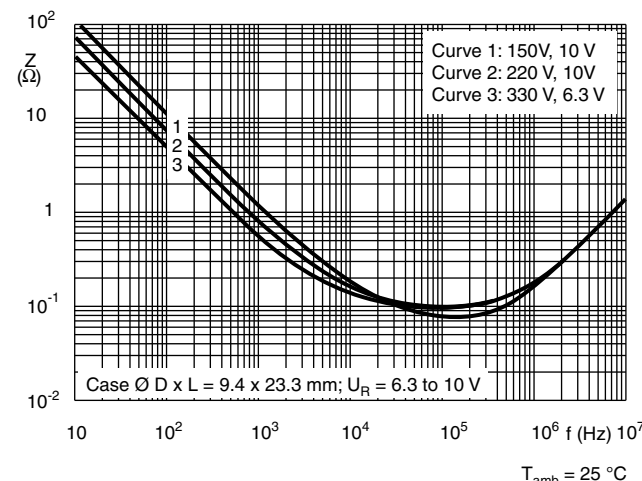


Fig. 13 - Typical impedance as a function of frequency

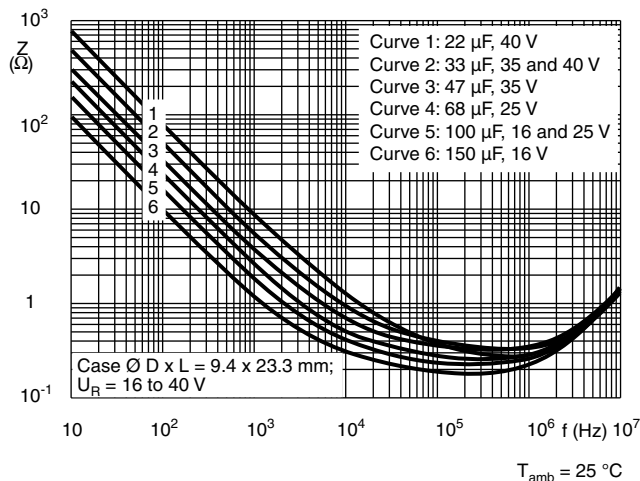


Fig. 14 - Typical impedance as a function of frequency

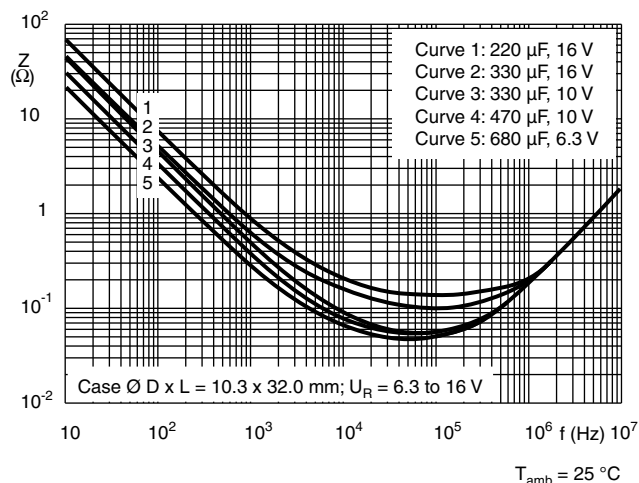
**IMPEDANCE (Z)**

Fig. 15 - Typical impedance as a function of frequency

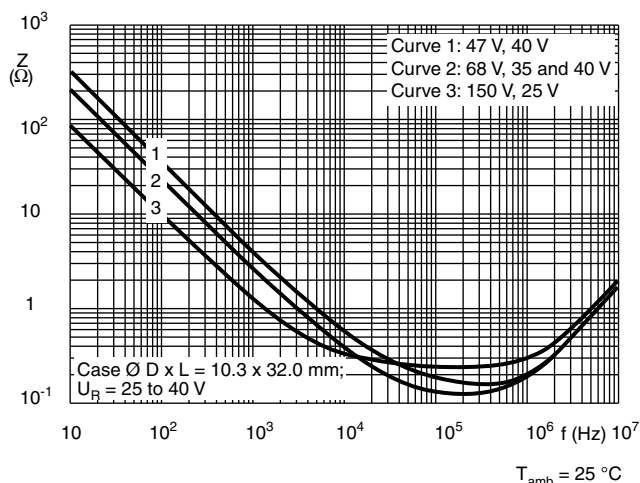


Fig. 16 - Typical impedance as a function of frequency

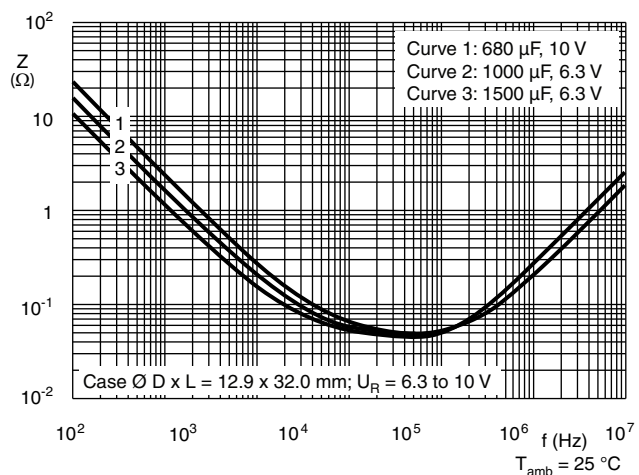


Fig. 17 - Typical impedance as a function of frequency

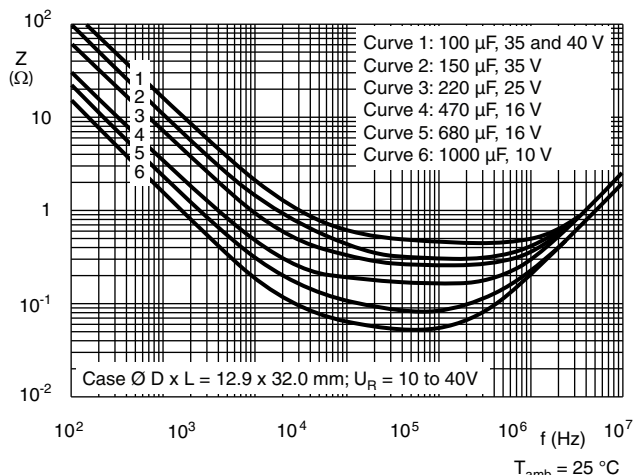


Fig. 18 - Typical impedance as a function of frequency

**EQUIVALENT SERIES RESISTANCE (ESR)**

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

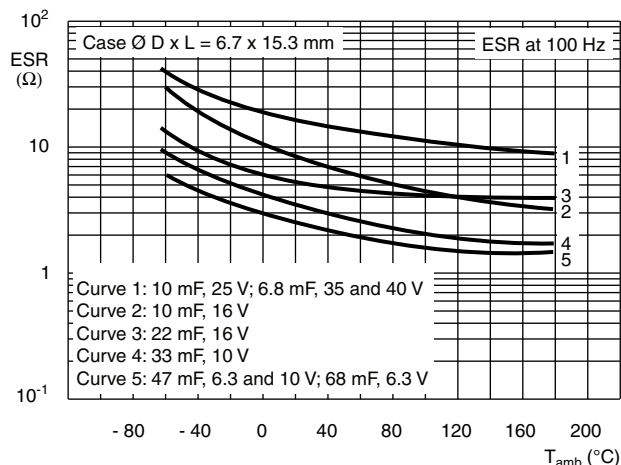


Fig. 19 - Typical ESR as a function of ambient temperature

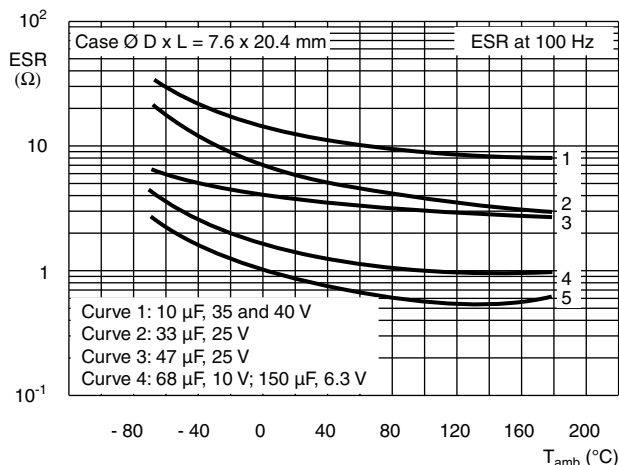


Fig. 20 - Typical ESR as a function of ambient temperature

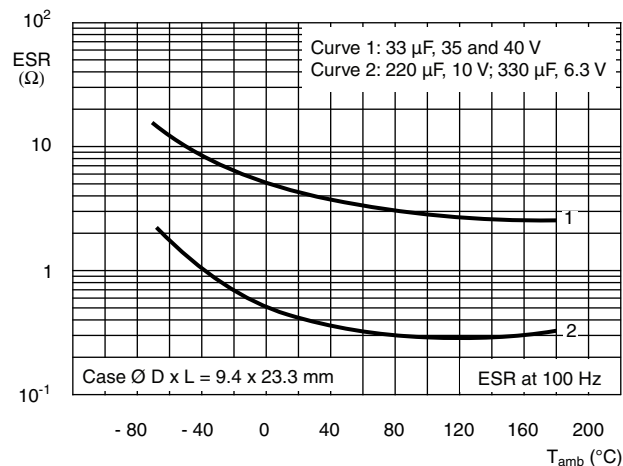
**EQUIVALENT SERIES RESISTANCE (ESR)**

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

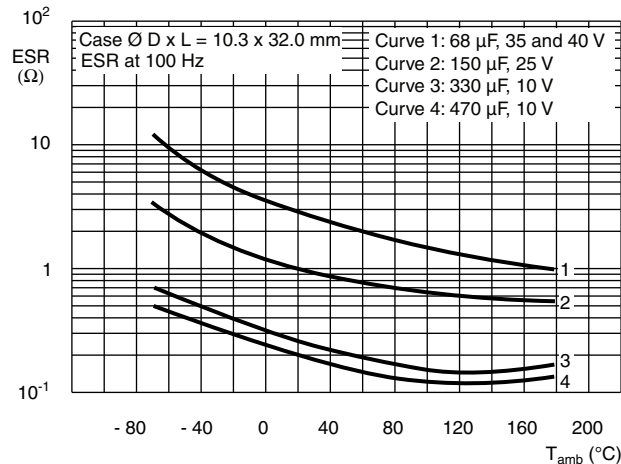


Fig. 22 - Typical ESR as a function of ambient temperature

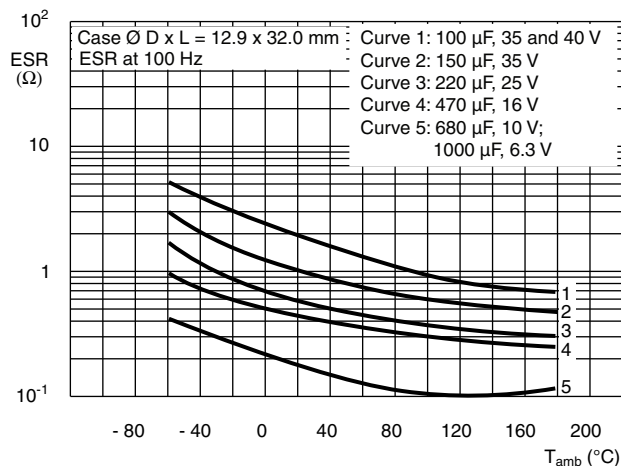


Fig. 23 - Typical ESR as a function of ambient temperature

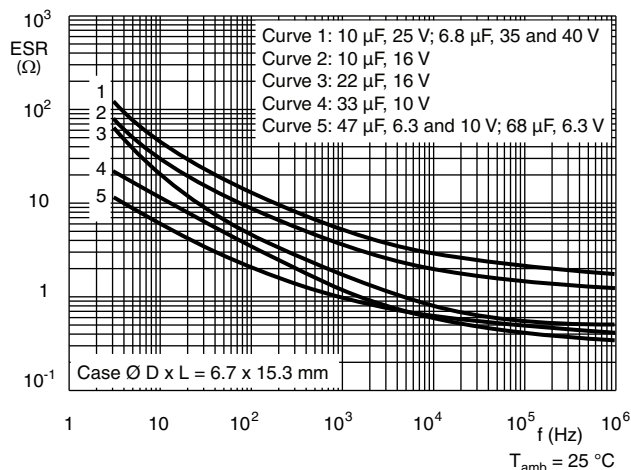


Fig. 25 - Typical ESR as a function of frequency

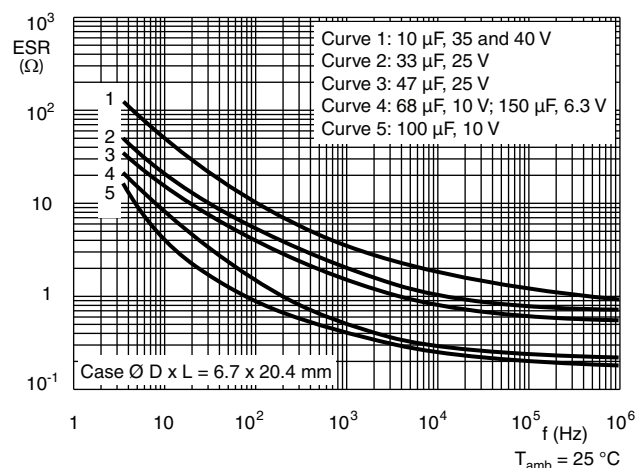


Fig. 24 - Typical ESR as a function of frequency

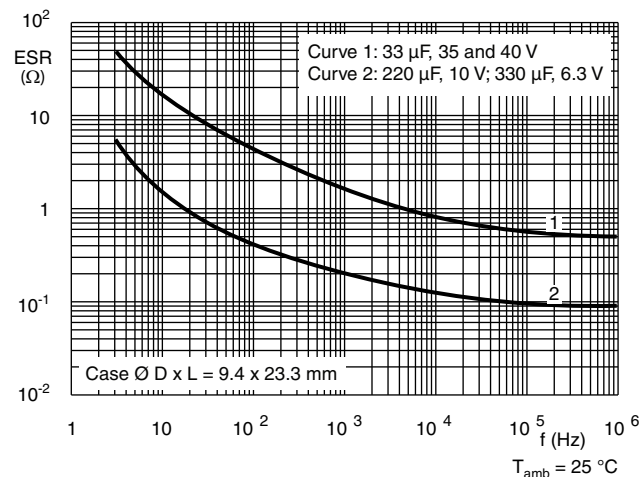


Fig. 26 - Typical ESR as a function of frequency

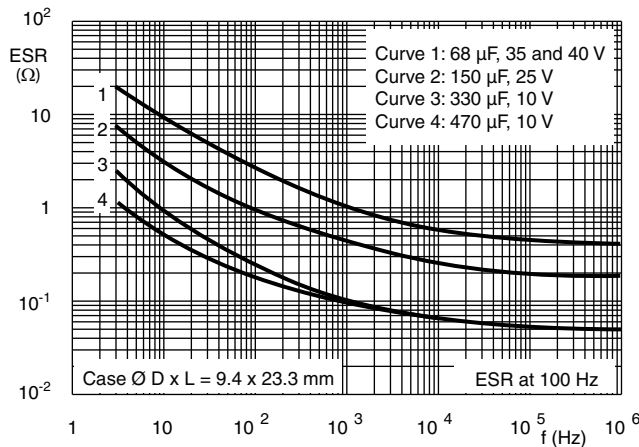
**EQUIVALENT SERIES RESISTANCE (ESR)**

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

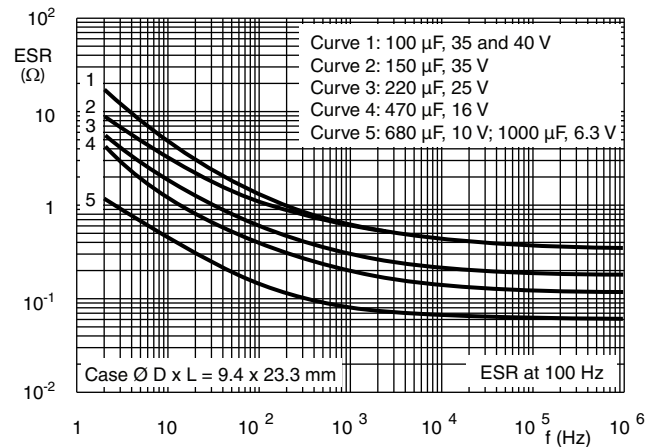


Fig. 28 - Typical ESR as a function of ambient temperature

**Table 3**

| <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 | $T_{amb} = 125\text{ °C}$ ;<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              | $T_{amb} = 125\text{ °C}$ ; $I_R$ 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 | $T_{amb} = 125\text{ °C}$ ; 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 $-40\text{ °C}$ and $+125\text{ °C}$                                                                                             | $\Delta C/C: \pm 25\%$<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 $55\text{ °C} \pm 5\text{ °C}$<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>$T_{amb} = 20\text{ °C}$ to $25\text{ °C}$ ;<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

ALL PRODUCT, PRODUCT SPECIFICATIONS AND DATA ARE SUBJECT TO CHANGE WITHOUT NOTICE TO IMPROVE RELIABILITY, FUNCTION OR DESIGN OR OTHERWISE.

Vishay Intertechnology, Inc., its affiliates, agents, and employees, and all persons acting on its or their behalf (collectively, "Vishay"), disclaim any and all liability for any errors, inaccuracies or incompleteness contained in any datasheet or in any other disclosure relating to any product.

Vishay makes no warranty, representation or guarantee regarding the suitability of the products for any particular purpose or the continuing production of any product. To the maximum extent permitted by applicable law, Vishay disclaims (i) any and all liability arising out of the application or use of any product, (ii) any and all liability, including without limitation special, consequential or incidental damages, and (iii) any and all implied warranties, including warranties of fitness for particular purpose, non-infringement and merchantability.

Statements regarding the suitability of products for certain types of applications are based on Vishay's knowledge of typical requirements that are often placed on Vishay products in generic applications. Such statements are not binding statements about the suitability of products for a particular application. It is the customer's responsibility to validate that a particular product with the properties described in the product specification is suitable for use in a particular application. Parameters provided in datasheets and / or specifications may vary in different applications and performance may vary over time. All operating parameters, including typical parameters, must be validated for each customer application by the customer's technical experts. Product specifications do not expand or otherwise modify Vishay's terms and conditions of purchase, including but not limited to the warranty expressed therein.

Except as expressly indicated in writing, Vishay products are not designed for use in medical, life-saving, or life-sustaining applications or for any other application in which the failure of the Vishay product could result in personal injury or death. Customers using or selling Vishay products not expressly indicated for use in such applications do so at their own risk. Please contact authorized Vishay personnel to obtain written terms and conditions regarding products designed for such applications.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted by this document or by any conduct of Vishay. Product names and markings noted herein may be trademarks of their respective owners.