

## Aluminum Electrolytic Capacitors Radial Standard Ultra Miniature

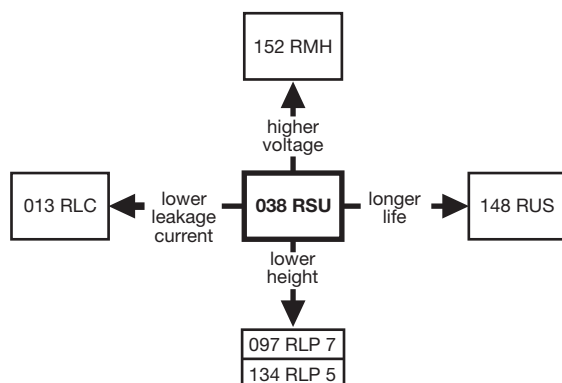
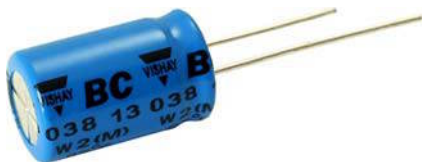


Fig. 1


**RoHS**  
COMPLIANT

### FEATURES

- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Radial leads, cylindrical aluminum case, insulated with a blue sleeve
- Pressure relief for case  $\varnothing D \geq 6.3$  mm
- Charge and discharge proof
- Miniaturized, high CV-product per unit volume
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)

### APPLICATIONS

- General purpose, industrial, automotive, consumer, and audio-video
- Coupling, decoupling, timing, smoothing, filtering, buffering in SMPS
- Portable and mobile equipment (small size, low mass)

### MARKING

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

- Rated capacitance (in  $\mu\text{F}$ )
- Tolerance on rated capacitance, code letter in accordance with IEC 60062 (M for  $\pm 20\%$ )
- Rated voltage (in V)
- Date code, in accordance with IEC 60062
- Code indicating factory of origin
- Name of manufacturer
- Negative terminal identification
- Series number (038)

| QUICK REFERENCE DATA                                 |                                           |
|------------------------------------------------------|-------------------------------------------|
| DESCRIPTION                                          | VALUE                                     |
| Nominal case sizes ( $\varnothing D \times L$ in mm) | 5 x 11 to 18 x 40                         |
| Rated capacitance range, $C_R$                       | 2.2 $\mu\text{F}$ to 22 000 $\mu\text{F}$ |
| Tolerance on $C_R$                                   | $\pm 20\%$                                |
| Rated voltage range, $U_R$                           | 6.3 V to 100 V                            |
| Category temperature range                           | -40 °C to +85 °C                          |
| Endurance test at 85 °C:                             |                                           |
| Case size $\varnothing D \leq 8$ mm                  | 2000 h                                    |
| Case size $\varnothing D \geq 10$ mm                 | 3000 h                                    |
| Useful life at 85 °C:                                |                                           |
| Case size $\varnothing D \leq 8$ mm                  | 2500 h                                    |
| Case size $\varnothing D \geq 10$ mm                 | 3500 h                                    |
| Useful life at 40 °C, 1.4 x $I_R$ applied:           |                                           |
| Case size $\varnothing D \leq 8$ mm                  | 60 000 h                                  |
| Case size $\varnothing D \geq 10$ mm                 | 90 000 h                                  |
| Shelf life at 0 V, 85 °C                             | 1000 h                                    |
| Based on sectional specification                     | IEC 60384-4 / EN130300                    |
| Climatic category IEC 60068                          | 40 / 085 / 56                             |

**SELECTION CHART FOR  $C_R$ ,  $U_R$ , AND RELEVANT NOMINAL CASE SIZES ( $\varnothing D \times L$  in mm)**

| $C_R$<br>( $\mu F$ ) | $U_R$ (V) |          |          |          |          |          |          |          |
|----------------------|-----------|----------|----------|----------|----------|----------|----------|----------|
|                      | 6.3       | 10       | 16       | 25       | 35       | 50       | 63       | 100      |
| 2.2                  | –         | –        | –        | –        | –        | –        | 5 x 11   | 5 x 11   |
| 3.3                  | –         | –        | –        | –        | –        | –        | 5 x 11   | 5 x 11   |
| 4.7                  | –         | –        | –        | –        | –        | –        | 5 x 11   | 5 x 11   |
| 10                   | –         | –        | –        | –        | –        | –        | 5 x 11   | 6.3 x 11 |
| 22                   | –         | –        | –        | –        | –        | 5 x 11   | 5 x 11   | 6.3 x 11 |
| 33                   | –         | –        | –        | –        | –        | 5 x 11   | 6.3 x 11 | 8 x 11.5 |
| 47                   | –         | –        | –        | –        | 5 x 11   | 6.3 x 11 | 6.3 x 11 | 10 x 12  |
| 100                  | –         | 5 x 11   | 5 x 11   | 6.3 x 11 | 6.3 x 11 | 8 x 11.5 | 10 x 12  | 10 x 20  |
| 220                  | 5 x 11    | 5 x 11   | 6.3 x 11 | 8 x 11.5 | 8 x 11.5 | 10 x 12  | 10 x 16  | 13 x 25  |
| 330                  | 6.3 x 11  | 6.3 x 11 | 8 x 11.5 | 8 x 11.5 | 10 x 12  | 10 x 16  | 10 x 20  | 13 x 25  |
| 470                  | 6.3 x 11  | 6.3 x 11 | 8 x 11.5 | 10 x 12  | 10 x 16  | 10 x 20  | 13 x 20  | 16 x 25  |
| 1000                 | 8 x 11.5  | 10 x 12  | 10 x 16  | 10 x 20  | 13 x 20  | 13 x 25  | 16 x 25  | 18 x 40  |
| 2200                 | 10 x 16   | 10 x 20  | 13 x 20  | 13 x 25  | 6 x 25   | 16 x 31  | 18 x 35  | –        |
| 3300                 | 10 x 20   | 13 x 20  | 13 x 25  | 16 x 25  | 16 x 35  | 18 x 35  | –        | –        |
| 4700                 | 13 x 20   | 13 x 25  | 16 x 25  | 16 x 31  | 18 x 35  | –        | –        | –        |
| 6800                 | 13 x 25   | 16 x 25  | 16 x 31  | 18 x 35  | –        | –        | –        | –        |
| 10 000               | 16 x 25   | 16 x 35  | 18 x 35  | –        | –        | –        | –        | –        |
| 22 000               | 18 x 40   | –        | –        | –        | –        | –        | –        | –        |

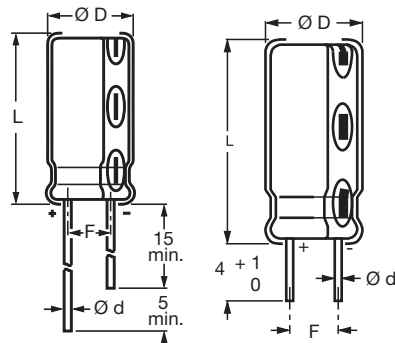
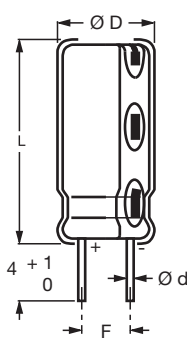
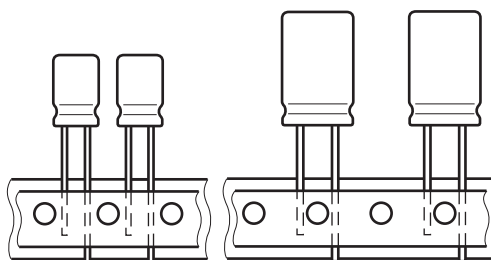
**DIMENSIONS in millimeters AND AVAILABLE FORMS**


Fig. 2 - Form CA


Fig. 3 - Form CB:  
Cut leads


Dimensions of pitch F see Table 1 and Table 2

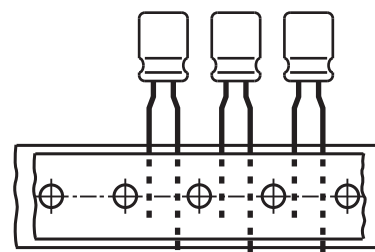
Fig. 4 - Form TNA, Form TFA:  
Taped in box (ammopack), straight leads

Case  $\varnothing D = 5$  mm to 8 mm; pitch F is 5 mm

Fig. 5 - Form TFA:  
Taped in box (ammopack), formed leads

Table 1

| <b>DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES</b> |              |                 |                        |            |               |                |                      |            |                  |
|-----------------------------------------------------------------|--------------|-----------------|------------------------|------------|---------------|----------------|----------------------|------------|------------------|
| NOMINAL<br>CASE SIZE<br>$\varnothing D \times L$                | CASE<br>CODE | $\varnothing d$ | $\varnothing D_{max.}$ | $L_{max.}$ | F             | MASS<br>(g)    | PACKAGING QUANTITIES |            |                  |
|                                                                 |              |                 |                        |            |               |                | FORM<br>CA           | FORM<br>CB | FORM<br>TFA, TNA |
| 5 x 11                                                          | 11           | 0.5             | 5.5                    | 12.5       | $2.0 \pm 0.5$ | $\approx 0.4$  | 5000                 | –          | 2000             |
| 6.3 x 11                                                        | 12           | 0.5             | 6.8                    | 12.5       | $2.5 \pm 0.5$ | $\approx 0.6$  | 5000                 | –          | 2000             |
| 8 x 11.5                                                        | 13           | 0.6             | 8.5                    | 12.5       | $3.5 \pm 0.5$ | $\approx 1.1$  | 5000                 | –          | 1000             |
| 10 x 12                                                         | 14           | 0.6             | 10.5                   | 13.5       | $5.0 \pm 0.5$ | $\approx 1.6$  | 3000                 | 1000       | 500              |
| 10 x 16                                                         | 15           | 0.6             | 10.5                   | 17.5       | $5.0 \pm 0.5$ | $\approx 1.9$  | 2500                 | 1000       | 500              |
| 10 x 20                                                         | 16           | 0.6             | 10.5                   | 22.0       | $5.0 \pm 0.5$ | $\approx 2.2$  | 2000                 | 800        | 500              |
| 13 x 20                                                         | 17           | 0.6             | 13.5                   | 22.0       | $5.0 \pm 0.5$ | $\approx 4.0$  | 1500                 | 400        | 300              |
| 13 x 25                                                         | 18           | 0.6             | 13.5                   | 27.0       | $5.0 \pm 0.5$ | $\approx 5.0$  | 1000                 | 400        | 300              |
| 16 x 25                                                         | 19           | 0.8             | 16.5                   | 27.0       | $7.5 \pm 0.5$ | $\approx 8.0$  | 750                  | 200        | 200              |
| 16 x 31                                                         | 20           | 0.8             | 16.5                   | 33.5       | $7.5 \pm 0.5$ | $\approx 9.0$  | 600                  | 200        | 200              |
| 16 x 35                                                         | 21           | 0.8             | 16.5                   | 37.5       | $7.5 \pm 0.5$ | $\approx 11.0$ | 500                  | 200        | –                |
| 18 x 35                                                         | 22           | 0.8             | 18.5                   | 37.5       | $7.5 \pm 0.5$ | $\approx 14.5$ | 400                  | 150        | –                |
| 18 x 40                                                         | 23           | 0.8             | 18.5                   | 42.0       | $7.5 \pm 0.5$ | $\approx 16.0$ | 400                  | 150        | –                |

**Note**

- Detailed tape dimensions see section “Packaging”.



| ELECTRICAL DATA |                                                   |
|-----------------|---------------------------------------------------|
| SYMBOL          | DESCRIPTION                                       |
| $C_R$           | Rated capacitance at 100 Hz, tolerance $\pm 20\%$ |
| $I_R$           | Rated RMS ripple current at 100 Hz, 85 °C         |
| $I_{L2}$        | Max. leakage current after 2 min at $U_R$         |
| $\tan \delta$   | Max. dissipation factor at 100 Hz                 |

**Note**

- Unless otherwise specified, all electrical values in Table 2 apply at  $T_{amb} = 20\text{ °C}$ ,  $P = 86\text{ kPa}$  to  $106\text{ kPa}$ ,  $RH = 45\%$  to  $75\%$ .

**Table 2**

| ELECTRICAL DATA AND ORDERING INFORMATION |                                  |                                         |                                           |                                  |                 |                              |                             |           |            |           |                |           |             |           |
|------------------------------------------|----------------------------------|-----------------------------------------|-------------------------------------------|----------------------------------|-----------------|------------------------------|-----------------------------|-----------|------------|-----------|----------------|-----------|-------------|-----------|
| U <sub>R</sub><br>(V)                    | C <sub>R</sub><br>100 Hz<br>(μF) | NOMINAL<br>CASE SIZE<br>Ø D x L<br>(mm) | I <sub>R</sub><br>100 Hz<br>85 °C<br>(mA) | I <sub>L2</sub><br>2 min<br>(μA) | tan δ<br>100 Hz | FREQ.<br>CODE <sup>(1)</sup> | ORDERING CODE MAL2038 ..... |           |            |           |                |           |             |           |
|                                          |                                  |                                         |                                           |                                  |                 |                              | BULK PACKAGING              |           |            |           | TAPED AMMOPACK |           |             |           |
|                                          |                                  |                                         |                                           |                                  |                 |                              | LONG LEADS                  |           | CUT LEADS  |           |                |           |             |           |
|                                          |                                  |                                         |                                           |                                  |                 |                              | FORM<br>CA                  | F<br>(mm) | FORM<br>CB | F<br>(mm) | FORM<br>TFA    | F<br>(mm) | FORM<br>TNA | F<br>(mm) |
| 6.3                                      | 220                              | 5 x 11                                  | 200                                       | 14                               | 0.23            | MF2                          | 53221E3                     | 2.0       | -          | -         | 33221E3        | 5.0       | 73221E3     | 2.5       |
|                                          | 330                              | 6.3 x 11                                | 270                                       | 21                               | 0.23            | MF2                          | 53331E3                     | 2.5       | -          | -         | 33331E3        | 5.0       | 73331E3     | 2.5       |
|                                          | 470                              | 6.3 x 11                                | 320                                       | 30                               | 0.23            | MF2                          | 53471E3                     | 2.5       | -          | -         | 33471E3        | 5.0       | 73471E3     | 2.5       |
|                                          | 1000                             | 8 x 11.5                                | 540                                       | 63                               | 0.23            | MF2                          | 53102E3                     | 3.5       | -          | -         | 33102E3        | 5.0       | 73102E3     | 3.5       |
|                                          | 2200                             | 10 x 16                                 | 785                                       | 139                              | 0.25            | MF3                          | 53222E3                     | 5.0       | 63222E3    | 5.0       | 33222E3        | 5.0       | -           | -         |
|                                          | 3300                             | 10 x 20                                 | 1185                                      | 208                              | 0.27            | MF3                          | 53332E3                     | 5.0       | 63332E3    | 5.0       | 33332E3        | 5.0       | -           | -         |
|                                          | 4700                             | 13 x 20                                 | 1545                                      | 296                              | 0.29            | MF3                          | 53472E3                     | 5.0       | 63472E3    | 5.0       | 33472E3        | 5.0       | -           | -         |
|                                          | 6800                             | 13 x 25                                 | 1880                                      | 428                              | 0.33            | MF3                          | 53682E3                     | 5.0       | 63682E3    | 5.0       | 33682E3        | 5.0       | -           | -         |
|                                          | 10 000                           | 16 x 25                                 | 2330                                      | 630                              | 0.41            | MF3                          | 53103E3                     | 7.5       | 63103E3    | 7.5       | 33103E3        | 7.5       | -           | -         |
|                                          | 22 000                           | 18 x 40                                 | 3320                                      | 1386                             | 0.65            | MF3                          | 53223E3                     | 7.5       | 63223E3    | 7.5       | -              | -         | -           | -         |
| 10                                       | 100                              | 5 x 11                                  | 145                                       | 10                               | 0.20            | MF2                          | 54101E3                     | 2.0       | -          | -         | 34101E3        | 5.0       | 74101E3     | 2.5       |
|                                          | 220                              | 5 x 11                                  | 160                                       | 22                               | 0.20            | MF2                          | 54221E3                     | 2.0       | -          | -         | 34221E3        | 5.0       | 74221E3     | 2.5       |
|                                          | 330                              | 6.3 x 11                                | 290                                       | 33                               | 0.20            | MF2                          | 54331E3                     | 2.5       | -          | -         | 34331E3        | 5.0       | 74331E3     | 2.5       |
|                                          | 470                              | 6.3 x 11                                | 350                                       | 47                               | 0.20            | MF2                          | 54471E3                     | 2.5       | -          | -         | 34471E3        | 5.0       | 74471E3     | 2.5       |
|                                          | 1000                             | 10 x 12                                 | 650                                       | 100                              | 0.20            | MF2                          | 54102E3                     | 5.0       | 64102E3    | 5.0       | 34102E3        | 5.0       | -           | -         |
|                                          | 2200                             | 10 x 20                                 | 1070                                      | 220                              | 0.22            | MF3                          | 54222E3                     | 5.0       | 64222E3    | 5.0       | 34222E3        | 5.0       | -           | -         |
|                                          | 3300                             | 13 x 20                                 | 1420                                      | 330                              | 0.24            | MF3                          | 54332E3                     | 5.0       | 64332E3    | 5.0       | 34332E3        | 5.0       | -           | -         |
|                                          | 4700                             | 13 x 25                                 | 1780                                      | 470                              | 0.26            | MF3                          | 54472E3                     | 5.0       | 64472E3    | 5.0       | 34472E3        | 5.0       | -           | -         |
|                                          | 6800                             | 16 x 25                                 | 2220                                      | 680                              | 0.30            | MF3                          | 54682E3                     | 7.5       | 64682E3    | 7.5       | 34682E3        | 7.5       | -           | -         |
|                                          | 10 000                           | 16 x 35                                 | 2760                                      | 1000                             | 0.38            | MF3                          | 54103E3                     | 7.5       | 64103E3    | 7.5       | -              | -         | -           | -         |
| 16                                       | 100                              | 5 x 11                                  | 160                                       | 16                               | 0.16            | MF2                          | 55101E3                     | 2.0       | -          | -         | 35101E3        | 5.0       | 75101E3     | 2.5       |
|                                          | 220                              | 6.3 x 11                                | 260                                       | 35                               | 0.16            | MF2                          | 55221E3                     | 2.5       | -          | -         | 35221E3        | 5.0       | 75221E3     | 2.5       |
|                                          | 330                              | 8 x 11.5                                | 370                                       | 53                               | 0.16            | MF2                          | 55331E3                     | 3.5       | -          | -         | 35331E3        | 5.0       | 75331E3     | 3.5       |
|                                          | 470                              | 8 x 11.5                                | 440                                       | 75                               | 0.16            | MF2                          | 55471E3                     | 3.5       | -          | -         | 35471E3        | 5.0       | 75471E3     | 3.5       |
|                                          | 1000                             | 10 x 16                                 | 785                                       | 160                              | 0.16            | MF2                          | 55102E3                     | 5.0       | 65102E3    | 5.0       | 35102E3        | 5.0       | -           | -         |
|                                          | 2200                             | 13 x 20                                 | 1295                                      | 352                              | 0.18            | MF3                          | 55222E3                     | 5.0       | 65222E3    | 5.0       | 35222E3        | 5.0       | -           | -         |
|                                          | 3300                             | 13 x 25                                 | 1655                                      | 528                              | 0.20            | MF3                          | 55332E3                     | 5.0       | 65332E3    | 5.0       | 35332E3        | 5.0       | -           | -         |
|                                          | 4700                             | 16 x 25                                 | 2090                                      | 752                              | 0.22            | MF3                          | 55472E3                     | 7.5       | 65472E3    | 7.5       | 35472E3        | 7.5       | -           | -         |
|                                          | 6800                             | 16 x 31                                 | 2520                                      | 1088                             | 0.26            | MF3                          | 55682E3                     | 7.5       | 65682E3    | 7.5       | 35682E3        | 7.5       | -           | -         |
|                                          | 10 000                           | 18 x 35                                 | 2920                                      | 1600                             | 0.34            | MF3                          | 55103E3                     | 7.5       | 65103E3    | 7.5       | -              | -         | -           | -         |



| ELECTRICAL DATA AND ORDERING INFORMATION |                                  |                                         |                                           |                                  |                 |                              |                             |           |            |           |                |           |             |           |
|------------------------------------------|----------------------------------|-----------------------------------------|-------------------------------------------|----------------------------------|-----------------|------------------------------|-----------------------------|-----------|------------|-----------|----------------|-----------|-------------|-----------|
| U <sub>R</sub><br>(V)                    | C <sub>R</sub><br>100 Hz<br>(μF) | NOMINAL<br>CASE SIZE<br>Ø D x L<br>(mm) | I <sub>R</sub><br>100 Hz<br>85 °C<br>(mA) | I <sub>L2</sub><br>2 min<br>(μA) | tan δ<br>100 Hz | FREQ.<br>CODE <sup>(1)</sup> | ORDERING CODE MAL2038 ..... |           |            |           |                |           |             |           |
|                                          |                                  |                                         |                                           |                                  |                 |                              | BULK PACKAGING              |           |            |           | TAPED AMMOPACK |           |             |           |
|                                          |                                  |                                         |                                           |                                  |                 |                              | LONG LEADS                  |           | CUT LEADS  |           |                |           |             |           |
|                                          |                                  |                                         |                                           |                                  |                 |                              | FORM<br>CA                  | F<br>(mm) | FORM<br>CB | F<br>(mm) | FORM<br>TFA    | F<br>(mm) | FORM<br>TNA | F<br>(mm) |
| 25                                       | 100                              | 6.3 x 11                                | 190                                       | 25                               | 0.14            | MF2                          | 56101E3                     | 2.5       | -          | -         | 36101E3        | 5.0       | 76101E3     | 2.5       |
|                                          | 220                              | 8 x 11.5                                | 320                                       | 55                               | 0.14            | MF2                          | 56221E3                     | 3.5       | -          | -         | 36221E3        | 5.0       | 76221E3     | 3.5       |
|                                          | 330                              | 8 x 11.5                                | 440                                       | 83                               | 0.14            | MF2                          | 56331E3                     | 3.5       | -          | -         | 36331E3        | 5.0       | 76331E3     | 3.5       |
|                                          | 470                              | 10 x 12                                 | 545                                       | 118                              | 0.14            | MF2                          | 56471E3                     | 5.0       | 66471E3    | 5.0       | 36471E3        | 5.0       | -           | -         |
|                                          | 1000                             | 10 x 20                                 | 955                                       | 250                              | 0.14            | MF2                          | 56102E3                     | 5.0       | 66102E3    | 5.0       | 36102E3        | 5.0       | -           | -         |
|                                          | 2200                             | 13 x 25                                 | 1540                                      | 550                              | 0.16            | MF3                          | 56222E3                     | 5.0       | 66222E3    | 5.0       | 36222E3        | 5.0       | -           | -         |
|                                          | 3300                             | 16 x 25                                 | 1975                                      | 825                              | 0.18            | MF3                          | 56332E3                     | 7.5       | 66332E3    | 7.5       | 36332E3        | 7.5       | -           | -         |
|                                          | 4700                             | 16 x 31                                 | 2420                                      | 1175                             | 0.20            | MF3                          | 56472E3                     | 7.5       | 66472E3    | 7.5       | 36472E3        | 7.5       | -           | -         |
|                                          | 6800                             | 18 x 35                                 | 2880                                      | 1700                             | 0.24            | MF3                          | 56682E3                     | 7.5       | 66682E3    | 7.5       | -              | -         | -           | -         |
| 35                                       | 47                               | 5 x 11                                  | 130                                       | 17                               | 0.12            | MF1                          | 50479E3                     | 2.0       | -          | -         | 30479E3        | 5.0       | 70479E3     | 2.5       |
|                                          | 100                              | 6.3 x 11                                | 210                                       | 35                               | 0.12            | MF2                          | 50101E3                     | 2.5       | -          | -         | 30101E3        | 5.0       | 70101E3     | 2.5       |
|                                          | 220                              | 8 x 11.5                                | 385                                       | 77                               | 0.12            | MF2                          | 50221E3                     | 3.5       | -          | -         | 30221E3        | 5.0       | 70221E3     | 3.5       |
|                                          | 330                              | 10 x 12                                 | 490                                       | 116                              | 0.12            | MF2                          | 50331E3                     | 5.0       | 60331E3    | 5.0       | 30331E3        | 5.0       | -           | -         |
|                                          | 470                              | 10 x 16                                 | 740                                       | 165                              | 0.12            | MF2                          | 50471E3                     | 5.0       | 60471E3    | 5.0       | 30471E3        | 5.0       | -           | -         |
|                                          | 1000                             | 13 x 20                                 | 1145                                      | 350                              | 0.12            | MF2                          | 50102E3                     | 5.0       | 60102E3    | 5.0       | 30102E3        | 5.0       | -           | -         |
|                                          | 2200                             | 16 x 25                                 | 1785                                      | 770                              | 0.14            | MF3                          | 50222E3                     | 7.5       | 60222E3    | 7.5       | 30222E3        | 7.5       | -           | -         |
|                                          | 3300                             | 16 x 35                                 | 2275                                      | 1155                             | 0.16            | MF3                          | 50332E3                     | 7.5       | 60332E3    | 7.5       | -              | -         | -           | -         |
|                                          | 4700                             | 18 x 35                                 | 2700                                      | 1645                             | 0.18            | MF3                          | 50472E3                     | 7.5       | 60472E3    | 7.5       | -              | -         | -           | -         |
| 50                                       | 22                               | 5 x 11                                  | 95                                        | 11                               | 0.10            | MF1                          | 51229E3                     | 2.0       | -          | -         | 31229E3        | 5.0       | 71229E3     | 2.5       |
|                                          | 33                               | 5 x 11                                  | 125                                       | 17                               | 0.10            | MF1                          | 51339E3                     | 2.0       | -          | -         | 31339E3        | 5.0       | 71339E3     | 2.5       |
|                                          | 47                               | 6.3 x 11                                | 165                                       | 24                               | 0.10            | MF1                          | 51479E3                     | 2.5       | -          | -         | 31479E3        | 5.0       | 71479E3     | 2.5       |
|                                          | 100                              | 8 x 11.5                                | 260                                       | 50                               | 0.10            | MF2                          | 51101E3                     | 3.5       | -          | -         | 31101E3        | 5.0       | 71101E3     | 3.5       |
|                                          | 220                              | 10 x 12                                 | 455                                       | 110                              | 0.10            | MF2                          | 51221E3                     | 5.0       | 61221E3    | 5.0       | 31221E3        | 5.0       | -           | -         |
|                                          | 330                              | 10 x 16                                 | 585                                       | 165                              | 0.10            | MF2                          | 51331E3                     | 5.0       | 61331E3    | 5.0       | 31331E3        | 5.0       | -           | -         |
|                                          | 470                              | 10 x 20                                 | 755                                       | 235                              | 0.10            | MF2                          | 51471E3                     | 5.0       | 61471E3    | 5.0       | 31471E3        | 5.0       | -           | -         |
|                                          | 1000                             | 13 x 25                                 | 1340                                      | 500                              | 0.10            | MF2                          | 51102E3                     | 5.0       | 61102E3    | 5.0       | 31102E3        | 5.0       | -           | -         |
|                                          | 2200                             | 16 x 31                                 | 1885                                      | 1100                             | 0.12            | MF3                          | 51222E3                     | 7.5       | 61222E3    | 7.5       | 31222E3        | 7.5       | -           | -         |
| 3300                                     | 18 x 35                          | 2500                                    | 1650                                      | 0.14                             | MF3             | 51332E3                      | 7.5                         | 61332E3   | 7.5        | -         | -              | -         | -           |           |
| 63                                       | 2.2                              | 5 x 11                                  | 28                                        | 3.0                              | 0.09            | MF1                          | 58228E3                     | 2.0       | -          | -         | 38228E3        | 5.0       | 78228E3     | 2.5       |
|                                          | 3.3                              | 5 x 11                                  | 34                                        | 3.0                              | 0.09            | MF1                          | 58338E3                     | 2.0       | -          | -         | 38338E3        | 5.0       | 78338E3     | 2.5       |
|                                          | 4.7                              | 5 x 11                                  | 45                                        | 3.0                              | 0.09            | MF1                          | 58478E3                     | 2.0       | -          | -         | 38478E3        | 5.0       | 78478E3     | 2.5       |
|                                          | 10                               | 5 x 11                                  | 70                                        | 6.3                              | 0.09            | MF1                          | 58109E3                     | 2.0       | -          | -         | 38109E3        | 5.0       | 78109E3     | 2.5       |
|                                          | 22                               | 5 x 11                                  | 105                                       | 14                               | 0.09            | MF1                          | 58229E3                     | 2.0       | -          | -         | 38229E3        | 5.0       | 78229E3     | 2.5       |
|                                          | 33                               | 6.3 x 11                                | 140                                       | 21                               | 0.09            | MF1                          | 58339E3                     | 2.5       | -          | -         | 38339E3        | 5.0       | 78339E3     | 2.5       |
|                                          | 47                               | 6.3 x 11                                | 170                                       | 30                               | 0.09            | MF1                          | 58479E3                     | 2.5       | -          | -         | 38479E3        | 5.0       | 78479E3     | 2.5       |
|                                          | 100                              | 10 x 12                                 | 320                                       | 63                               | 0.09            | MF2                          | 58101E3                     | 5.0       | 68101E3    | 5.0       | 38101E3        | 5.0       | -           | -         |
|                                          | 220                              | 10 x 16                                 | 490                                       | 139                              | 0.09            | MF2                          | 58221E3                     | 5.0       | 68221E3    | 5.0       | 38221E3        | 5.0       | -           | -         |
|                                          | 330                              | 10 x 20                                 | 710                                       | 208                              | 0.09            | MF2                          | 58331E3                     | 5.0       | 68331E3    | 5.0       | 38331E3        | 5.0       | -           | -         |
|                                          | 470                              | 13 x 20                                 | 900                                       | 296                              | 0.09            | MF2                          | 58471E3                     | 5.0       | 68471E3    | 5.0       | 38471E3        | 5.0       | -           | -         |
|                                          | 1000                             | 16 x 25                                 | 1560                                      | 630                              | 0.09            | MF2                          | 58102E3                     | 7.5       | 68102E3    | 7.5       | 38102E3        | 7.5       | -           | -         |
|                                          | 2200                             | 18 x 35                                 | 1950                                      | 1386                             | 0.11            | MF3                          | 58222E3                     | 7.5       | 68222E3    | 7.5       | -              | -         | -           | -         |

**ELECTRICAL DATA AND ORDERING INFORMATION**

| $U_R$<br>(V) | $C_R$<br>100 Hz<br>( $\mu$ F) | NOMINAL<br>CASE SIZE<br>$\varnothing$ D x L<br>(mm) | $I_R$<br>100 Hz<br>85 °C<br>(mA) | $I_{L2}$<br>2 min<br>( $\mu$ A) | $\tan \delta$<br>100 Hz | FREQ.<br>CODE <sup>(1)</sup> | ORDERING CODE MAL2038 ..... |           |            |           |                |           |             |           |
|--------------|-------------------------------|-----------------------------------------------------|----------------------------------|---------------------------------|-------------------------|------------------------------|-----------------------------|-----------|------------|-----------|----------------|-----------|-------------|-----------|
|              |                               |                                                     |                                  |                                 |                         |                              | BULK PACKAGING              |           |            |           | TAPED AMMOPACK |           |             |           |
|              |                               |                                                     |                                  |                                 |                         |                              | LONG LEADS                  |           | CUT LEADS  |           |                |           |             |           |
|              |                               |                                                     |                                  |                                 |                         |                              | FORM<br>CA                  | F<br>(mm) | FORM<br>CB | F<br>(mm) | FORM<br>TFA    | F<br>(mm) | FORM<br>TNA | F<br>(mm) |
| 100          | 2.2                           | 5 x 11                                              | 33                               | 3.0                             | 0.08                    | MF1                          | 59228E3                     | 2.0       | -          | -         | 39228E3        | 5.0       | 79228E3     | 2.5       |
|              | 3.3                           | 5 x 11                                              | 40                               | 3.3                             | 0.08                    | MF1                          | 59338E3                     | 2.0       | -          | -         | 39338E3        | 5.0       | 79338E3     | 2.5       |
|              | 4.7                           | 5 x 11                                              | 48                               | 4.7                             | 0.08                    | MF1                          | 59478E3                     | 2.0       | -          | -         | 39478E3        | 5.0       | 79478E3     | 2.5       |
|              | 10                            | 6.3 x 11                                            | 80                               | 10                              | 0.08                    | MF1                          | 59109E3                     | 2.5       | -          | -         | 39109E3        | 5.0       | 79109E3     | 2.5       |
|              | 22                            | 6.3 x 11                                            | 115                              | 22                              | 0.08                    | MF1                          | 59229E3                     | 2.5       | -          | -         | 39229E3        | 5.0       | 79229E3     | 2.5       |
|              | 33                            | 8 x 11.5                                            | 145                              | 33                              | 0.08                    | MF1                          | 59339E3                     | 3.5       | -          | -         | 39339E3        | 5.0       | 79339E3     | 3.5       |
|              | 47                            | 10 x 12                                             | 235                              | 47                              | 0.08                    | MF1                          | 59479E3                     | 5.0       | 69479E3    | 5.0       | 39479E3        | 5.0       | -           | -         |
|              | 100                           | 10 x 20                                             | 370                              | 100                             | 0.08                    | MF2                          | 59101E3                     | 5.0       | 69101E3    | 5.0       | 39101E3        | 5.0       | -           | -         |
|              | 220                           | 13 x 25                                             | 675                              | 220                             | 0.08                    | MF2                          | 59221E3                     | 5.0       | 69221E3    | 5.0       | 39221E3        | 5.0       | -           | -         |
|              | 330                           | 13 x 25                                             | 825                              | 330                             | 0.08                    | MF2                          | 59331E3                     | 5.0       | 69331E3    | 5.0       | 39331E3        | 5.0       | -           | -         |
|              | 470                           | 16 x 25                                             | 1070                             | 470                             | 0.08                    | MF2                          | 59471E3                     | 7.5       | 69471E3    | 7.5       | 39471E3        | 7.5       | -           | -         |
|              | 1000                          | 18 x 40                                             | 2410                             | 1000                            | 0.08                    | MF2                          | 59102E3                     | 7.5       | 69102E3    | 7.5       | -              | -         | -           | -         |

**Note**
<sup>(1)</sup> Determines the applicable row in the table "Multiplier of Ripple Current ( $I_R$ ) as a Function of Frequency"

**ADDITIONAL ELECTRICAL DATA**

| PARAMETER                          | CONDITIONS                                                   | VALUE                                                                   |
|------------------------------------|--------------------------------------------------------------|-------------------------------------------------------------------------|
| <b>Voltage</b>                     |                                                              |                                                                         |
| Surge voltage                      |                                                              | $U_S \leq 1.15 \times U_R$                                              |
| Reverse voltage                    |                                                              | $U_{REV} \leq 1 \text{ V}$                                              |
| <b>Current</b>                     |                                                              |                                                                         |
| Leakage current                    | After 2 min at $U_R$                                         | $I_{L2} \leq 0.01 C_R \times U_R$ or 3 $\mu$ A,<br>whichever is greater |
|                                    | After 5 min at $U_R$                                         | $I_{L5} \leq 0.002 C_R \times U_R + 3 \mu\text{A}$                      |
| <b>Inductance</b>                  |                                                              |                                                                         |
| Equivalent series inductance (ESL) | Case $\varnothing$ D $\leq$ 8 mm                             | Typ. 13 nH                                                              |
|                                    | Case $\varnothing$ D = 10 mm                                 | Typ. 16 nH                                                              |
|                                    | Case $\varnothing$ D $\geq$ 12.5 mm                          | Typ. 18 nH                                                              |
| <b>Resistance</b>                  |                                                              |                                                                         |
| Equivalent series resistance (ESR) | Calculated from $\tan \delta_{\max}$ and $C_R$ (see Table 2) | $\text{ESR} = \tan \delta / 2 \pi f C_R$                                |

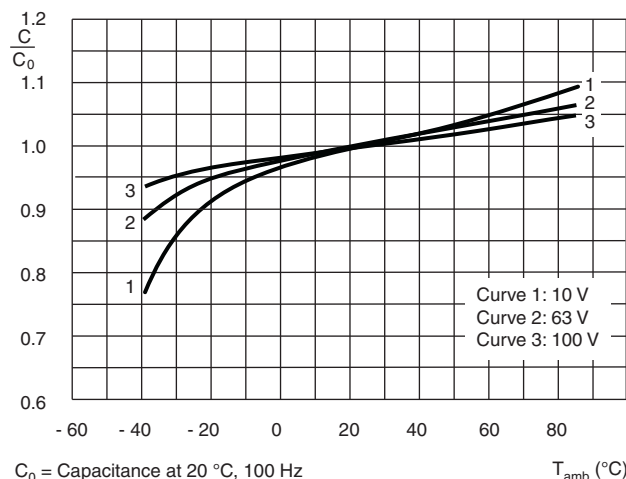
**CAPACITANCE (C)**


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

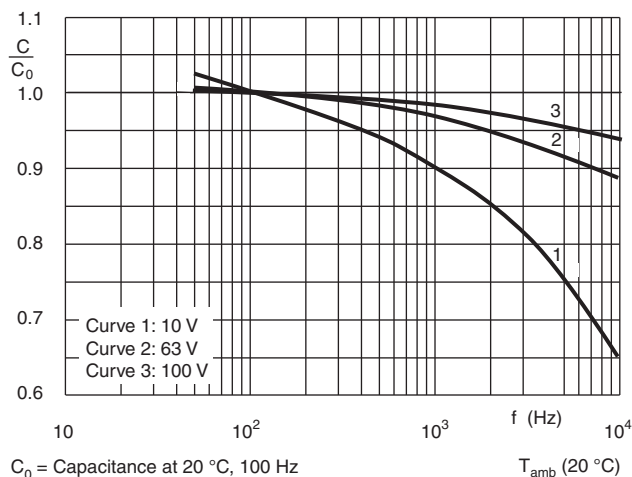


Fig. 7 - Typical multiplier of capacitance as a function of frequency

# RIPPLE CURRENT AND USEFUL LIFE

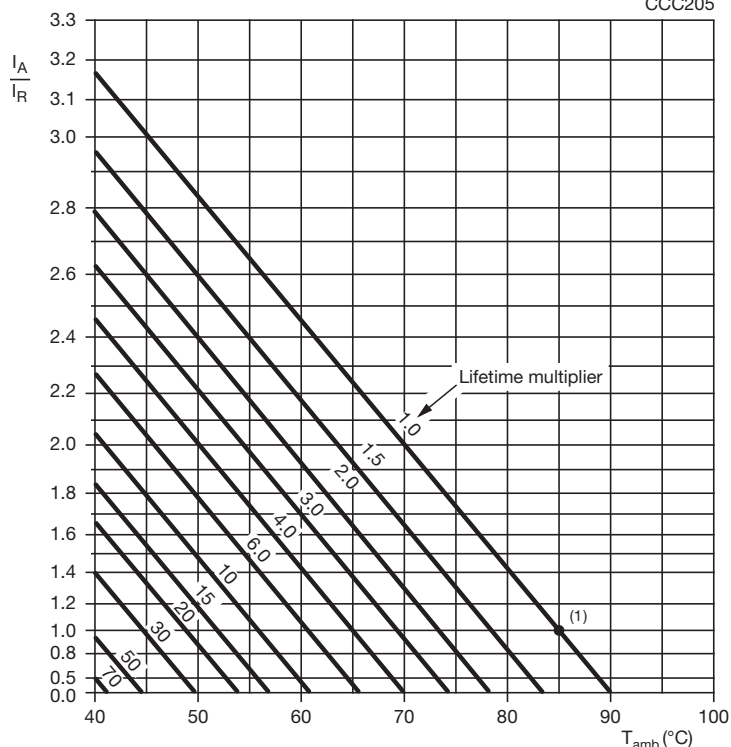
Table 3

| ENDURANCE TEST DURATION AND USEFUL LIFE |                              |                                |
|-----------------------------------------|------------------------------|--------------------------------|
| NOMINAL CASE SIZE<br>Ø D x L<br>(mm)    | ENDURANCE<br>AT 85 °C<br>(h) | USEFUL LIFE<br>AT 85 °C<br>(h) |
| 5 x 11                                  | 2000                         | 2500                           |
| 6.3 x 11                                | 2000                         | 2500                           |
| 8 x 11.5                                | 2000                         | 2500                           |
| 10 x 12                                 | 3000                         | 3500                           |
| 10 x 16                                 | 3000                         | 3500                           |
| 10 x 20                                 | 3000                         | 3500                           |
| 13 x 20                                 | 3000                         | 3500                           |
| 13 x 25                                 | 3000                         | 3500                           |
| 16 x 25                                 | 3000                         | 3500                           |
| 16 x 31                                 | 3000                         | 3500                           |
| 16 x 35                                 | 3000                         | 3500                           |
| 18 x 35                                 | 3000                         | 3500                           |
| 18 x 40                                 | 3000                         | 3500                           |

## Note

- Multiplier of useful life code: CCC205

CCC205



$I_A$  = Actual ripple current at 100 Hz  
 $I_R$  = Rated ripple current at 100 Hz, 85 °C  
 Useful life at 85 °C and  $I_R$  applied:  
 Case Ø D ≤ 8 mm: 2500 h  
 Case Ø D ≥ 10 mm: 3500 h

Fig. 8 - Multiplier of useful life as a function of ambient temperature and ripple current load

Table 4

| MULTIPLIER OF RIPPLE CURRENT ( $I_R$ ) AS A FUNCTION OF FREQUENCY |                  |      |      |      |                |
|-------------------------------------------------------------------|------------------|------|------|------|----------------|
| FREQ.<br>CODE                                                     | FREQUENCY (Hz)   |      |      |      |                |
|                                                                   | 50               | 100  | 500  | 1000 | $\geq 10\ 000$ |
|                                                                   | $I_R$ MULTIPLIER |      |      |      |                |
| MF1                                                               | 0.70             | 1.00 | 1.30 | 1.40 | 1.50           |
| MF2                                                               | 0.75             | 1.00 | 1.20 | 1.30 | 1.35           |
| MF3                                                               | 0.80             | 1.00 | 1.10 | 1.12 | 1.15           |

Table 5

| TEST PROCEDURES AND REQUIREMENTS               |                                              |                                                                                                                                                              |                                                                                                                                                                                      |
|------------------------------------------------|----------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TEST                                           |                                              | PROCEDURE<br>(quick reference)                                                                                                                               | REQUIREMENTS                                                                                                                                                                         |
| NAME OF TEST                                   | REFERENCE                                    |                                                                                                                                                              |                                                                                                                                                                                      |
| Endurance                                      | IEC 60384-4 /<br>EN 130300<br>subclause 4.13 | $T_{amb} = 85\ ^\circ\text{C}$ ; $U_R$ applied;<br>Case $\varnothing \leq 8\ \text{mm}$ : 2000 h<br>Case $\varnothing \geq 10\ \text{mm}$ : 3000 h           | $\Delta C/C: \pm 20\ \%$<br>$\tan \delta \leq 2 \times \text{spec. limit}$<br>$I_{L5} \leq \text{spec. limit}$                                                                       |
| Useful life                                    | CECC 30301<br>subclause 1.8.1                | $T_{amb} = 85\ ^\circ\text{C}$ ; $U_R$ and $I_R$ applied;<br>Case $\varnothing \leq 8\ \text{mm}$ : 2500 h<br>Case $\varnothing \geq 10\ \text{mm}$ : 3500 h | $\Delta C/C: \pm 50\ \%$<br>$\tan \delta \leq 3 \times \text{spec. limit}$<br>$I_{L5} \leq \text{spec. limit}$<br>no short or open circuit<br>total failure percentage: $\leq 1\ \%$ |
| Shelf life<br>(storage at high<br>temperature) | IEC 60384-4 /<br>EN 130300<br>subclause 4.17 | $T_{amb} = 85\ ^\circ\text{C}$ ; no voltage applied; 1000 h<br>after test: $U_R$ to be applied for 30 min, 24 h to 48 h<br>before measurement                | $\Delta C/C: \pm 20\ \%$<br>$\tan \delta \leq 2 \times \text{spec. limit}$<br>$I_{L5} \leq 3 \times \text{spec. limit}$                                                              |
| Surge                                          | IEC 60384-4 /<br>EN 130300<br>subclause 4.14 | From source of $1.15 \times U_R$ ;<br>$RC = 0.1\ \text{s} \pm 0.05\ \text{s}$ ;<br>1000 cycles of 30 s on,<br>330 s off, at $85\ ^\circ\text{C}$             | $\Delta C/C: \pm 25\ \%$<br>$\tan \delta \leq 1.5 \times \text{spec. limit}$<br>$I_{L5} \leq \text{spec. limit}$                                                                     |

Statements about product lifetime are based on calculations and internal testing. They should only be interpreted as estimations. Also due to external factors, the lifetime in the field application may deviate from the calculated lifetime. In general, nothing stated herein shall be construed as a guarantee of durability.



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