

Aluminum Electrolytic Capacitors Radial Miniature, High Voltage

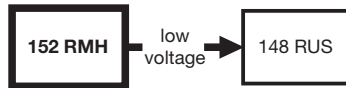


Fig. 1

 AUTOMOTIVE
GRADE

RoHS
COMPLIANT

FEATURES

- Long useful life: 3000 h to 4000 h at 105 °C
- AEC-Q200 qualified
- Miniaturized, ultra high CV-product per unit volume
- High reliability
- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Radial leads, cylindrical aluminum case, insulated with a blue sleeve
- Pressure relief
- Charge and discharge proof
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

APPLICATIONS

- Automotive
- High-reliability and professional applications
- Lighting, monitors, consumer electronics, general industrial
- Filtering of high voltages in power supplies

MARKING

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

- Rated capacitance value (in μF)
- 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
- Upper category temperature (105 °C)
- Negative terminal identification
- Series number (152)

| QUICK REFERENCE DATA | |
|---|--|
| DESCRIPTION | VALUE |
| Nominal case sizes (\varnothing D x L in mm) | 10 x 12 to 18 x 35 |
| Rated capacitance range, C_R | 1.5 μF to 220 μF |
| Tolerance on C_R | $\pm 20\%$ |
| Rated voltage range, U_R | 200 V to 450 V |
| Category temperature range | -40 °C to +105 °C |
| Endurance test at 105 °C | 2000 h |
| Useful life at 105 °C: | |
| Case \varnothing D = 10 mm and 12.5 mm | 3000 h |
| Case \varnothing D = 16 mm and 18 mm | 4000 h |
| Useful life at 40 °C, $1.6 \times I_R$ applied: | |
| Case \varnothing D = 10 mm and 12.5 mm | 200 000 h |
| Case \varnothing D = 16 mm and 18 mm | 260 000 h |
| Shelf life at 0 V, 105 °C | 1000 h |
| Based on sectional specification | IEC 60384-4 / EN 130300 |
| Climatic category IEC 60068 | 40 / 105 / 56 |

| SELECTION CHART FOR C_R , U_R , AND RELEVANT NOMINAL CASE SIZES (\varnothing D x L in mm) | | | | |
|--|-----------|-----------|-----------|-----------|
| C_R (μF) | U_R (V) | | | |
| | 200 | 250 | 400 | 450 |
| 1.5 | - | - | - | 10 x 12 |
| 2.2 | - | - | 10 x 12 | 10 x 16 |
| 4.7 | - | - | 10 x 16 | 10 x 20 |
| | - | - | 10 x 12 | - |
| 6.8 | - | - | 10 x 16 | 12.5 x 20 |
| 10 | 10 x 12 | 10 x 16 | 10 x 20 | 12.5 x 20 |
| | 10 x 16 | 12.5 x 20 | 12.5 x 25 | 16 x 25 |
| 22 | - | - | 16 x 20 | 18 x 20 |
| | 10 x 20 | 12.5 x 20 | 16 x 20 | 16 x 35 |
| 33 | - | - | - | 18 x 25 |
| | 12.5 x 20 | 12.5 x 25 | 16 x 25 | 18 x 35 |
| 47 | - | 16 x 20 | - | - |
| | 12.5 x 25 | - | 16 x 35 | - |
| 100 | 16 x 20 | 16 x 25 | 18 x 35 | - |
| 220 | 16 x 35 | - | - | - |

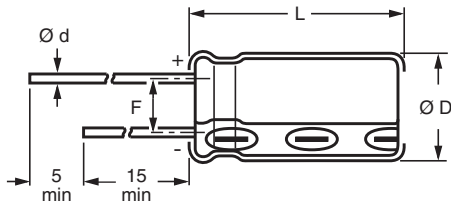
DIMENSIONS in millimeters AND AVAILABLE FORMS


Fig. 2 - Form CA: Long leads

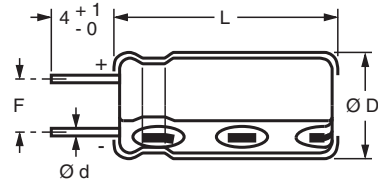


Fig. 3 - Form CB: Cut leads

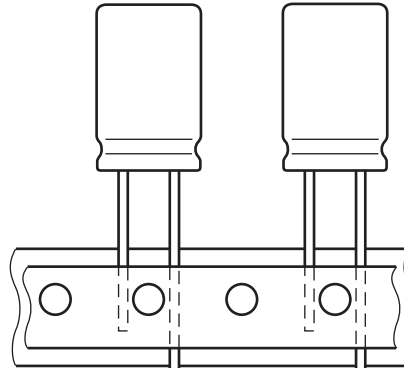


Fig. 4 - Form TFA: Taped in box (ammopack)

Table 1

| DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES | | | | | | | | | |
|--|-----------|-----------------|------------------------|------------|---------------|----------------|----------------------|---------|----------|
| NOMINAL CASE SIZE $\varnothing D \times L$ | CASE CODE | $\varnothing d$ | $\varnothing D_{max.}$ | $L_{max.}$ | F | MASS (g) | PACKAGING QUANTITIES | | |
| | | | | | | | FORM CA | FORM CB | FORM TFA |
| 10 x 12 | 14 | 0.6 | 10.5 | 13.5 | 5.0 ± 0.5 | ≈ 1.6 | 1000 | 500 | 800 |
| 10 x 16 | 15 | 0.6 | 10.5 | 17.5 | 5.0 ± 0.5 | ≈ 1.9 | 500 | 500 | 800 |
| 10 x 20 | 16 | 0.6 | 10.5 | 22.0 | 5.0 ± 0.5 | ≈ 2.2 | 500 | 500 | 800 |
| 12.5 x 20 | 17 | 0.6 | 13.0 | 22.0 | 5.0 ± 0.5 | ≈ 4.0 | 500 | 500 | 500 |
| 12.5 x 25 | 18 | 0.6 | 13.0 | 27.0 | 5.0 ± 0.5 | ≈ 5.0 | 250 | 250 | 500 |
| 16 x 20 | 19a | 0.8 | 16.5 | 22.0 | 7.5 ± 0.5 | ≈ 6.0 | 250 | 250 | 250 |
| 16 x 25 | 19 | 0.8 | 16.5 | 27.0 | 7.5 ± 0.5 | ≈ 8.0 | 250 | 250 | 250 |
| 16 x 35 | 21 | 0.8 | 16.5 | 37.5 | 7.5 ± 0.5 | ≈ 11.0 | 100 | 100 | - |
| 18 x 20 | 1820 | 0.8 | 18.5 | 22.0 | 7.5 ± 0.5 | ≈ 8.0 | 100 | 100 | - |
| 18 x 25 | 1825 | 0.8 | 18.5 | 27.0 | 7.5 ± 0.5 | ≈ 10.0 | 100 | 100 | - |
| 18 x 35 | 22 | 0.8 | 18.5 | 37.5 | 7.5 ± 0.5 | ≈ 14.5 | 100 | 100 | - |

Note

- For detailed tape dimensions please see www.vishay.com/doc?28360

| ELECTRICAL DATA | |
|-----------------|---|
| SYMBOL | DESCRIPTION |
| C_R | Rated capacitance at 100 Hz, tolerance $\pm 20 \%$ |
| I_R | Rated RMS ripple current at 100 Hz, 105°C |
| I_{L1} | Max. leakage current after 1 min at U_R |
| $\tan \delta$ | Max. dissipation factor at 100 Hz |
| Z | Max. impedance at 10 kHz |

Note

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

ORDERING EXAMPLE

Electrolytic capacitor 152 series

 4.7 μF / 400 V; $\pm 20 \%$

 Nominal case size: $\varnothing 10 \text{ mm} \times 16 \text{ mm}$; form TFA

Ordering code: MAL215236478E3

Former 12NC: 2222 152 36478



Table 2

| ELECTRICAL DATA AND ORDERING INFORMATION | | | | | | | | | |
|--|----------------------------------|---|--|----------------------------------|-----------------|--------------------|-----------------------------|---------|----------|
| U _R (V) | C _R 100 Hz (μF) | NOMINAL CASE SIZE Ø D x L (mm) | I _R 100 Hz 105 °C (mA) | I _{L1} 1 min (μA) | tan δ 100 Hz | Z 10 kHz (Ω) | ORDERING CODE MAL2152 | | |
| | | | | | | | BULK PACKAGING | | TAPED |
| | | | | | | | FORM CA | FORM CB | FORM TFA |
| 200 | 10 | 10 x 12 | 85 | 130 | 0.12 | 6.3 | 52109E3 | 62109E3 | 32109E3 |
| | 22 | 10 x 16 | 120 | 202 | 0.12 | 3.2 | 52229E3 | 62229E3 | 32229E3 |
| | 33 | 10 x 20 | 150 | 268 | 0.12 | 2.3 | 52339E3 | 62339E3 | 32339E3 |
| | 47 | 12.5 x 20 | 240 | 352 | 0.12 | 0.9 | 52479E3 | 62479E3 | 32479E3 |
| | 68 | 12.5 x 25 | 310 | 478 | 0.12 | 0.6 | 52689E3 | 62689E3 | 32689E3 |
| | 100 | 16 x 20 | 340 | 670 | 0.12 | 0.4 | 52101E3 | 62101E3 | 32101E3 |
| | 220 | 16 x 35 | 630 | 1390 | 0.12 | 0.2 | 52221E3 | 62221E3 | - |
| 250 | 10 | 10 x 16 | 105 | 145 | 0.12 | 6.3 | 53109E3 | 63109E3 | 33109E3 |
| | 22 | 12.5 x 20 | 180 | 235 | 0.12 | 2.3 | 53229E3 | 63229E3 | 33229E3 |
| | 33 | 12.5 x 20 | 180 | 318 | 0.12 | 1.5 | 53339E3 | 63339E3 | 33339E3 |
| | 47 | 12.5 x 25 | 310 | 423 | 0.12 | 0.9 | 53479E3 | 63479E3 | 33479E3 |
| | 47 | 16 x 20 | 310 | 423 | 0.12 | 0.9 | 93475E3 | 93476E3 | 93473E3 |
| | 100 | 16 x 25 | 340 | 820 | 0.12 | 0.4 | 53101E3 | 63101E3 | 33101E3 |
| 400 | 2.2 | 10 x 12 | 44 | 96 | 0.15 | 28.0 | 56228E3 | 66228E3 | 36228E3 |
| | 4.7 | 10 x 12 | 48 | 127 | 0.15 | 24.0 | 96475E3 | 96476E3 | 96473E3 |
| | 4.7 | 10 x 16 | 65 | 126 | 0.15 | 18.0 | 56478E3 | 66478E3 | 36478E3 |
| | 6.8 | 10 x 16 | 65 | 152 | 0.15 | 12.0 | 56688E3 | 66688E3 | 36688E3 |
| | 10 | 10 x 20 | 80 | 190 | 0.15 | 9.0 | 56109E3 | 66109E3 | 36109E3 |
| | 22 | 12.5 x 25 | 150 | 334 | 0.15 | 3.8 | 56229E3 | 66229E3 | 36229E3 |
| | 22 | 16 x 20 | 150 | 334 | 0.15 | 3.8 | 96225E3 | 96226E3 | 96223E3 |
| | 33 | 16 x 20 | 190 | 466 | 0.15 | 2.6 | 56339E3 | 66339E3 | 36339E3 |
| | 47 | 16 x 25 | 240 | 634 | 0.15 | 2.0 | 56479E3 | 66479E3 | 36479E3 |
| | 68 | 16 x 35 | 310 | 886 | 0.15 | 1.7 | 56689E3 | 66689E3 | - |
| 100 | 18 x 35 | 380 | 1270 | 0.15 | 0.9 | 56101E3 | 66101E3 | - | |
| 450 | 1.5 | 10 x 12 | 30 | 90 | 0.20 | 26.0 | 57158E3 | 67158E3 | 37158E3 |
| | 2.2 | 10 x 16 | 50 | 99 | 0.20 | 26.0 | 57228E3 | 67228E3 | 37228E3 |
| | 4.7 | 10 x 20 | 65 | 133 | 0.20 | 20.0 | 57478E3 | 67478E3 | 37478E3 |
| | 6.8 | 12.5 x 20 | 80 | 162 | 0.20 | 16.0 | 57688E3 | 67688E3 | 37688E3 |
| | 10 | 12.5 x 20 | 90 | 205 | 0.20 | 10.0 | 57109E3 | 67109E3 | 37109E3 |
| | 22 | 16 x 25 | 150 | 367 | 0.20 | 4.6 | 57229E3 | 67229E3 | 37229E3 |
| | 22 | 18 x 20 | 150 | 367 | 0.20 | 4.6 | 97225E3 | 97226E3 | - |
| | 33 | 16 x 35 | 200 | 516 | 0.20 | 3.4 | 57339E3 | 67339E3 | - |
| | 33 | 18 x 25 | 200 | 516 | 0.20 | 3.4 | 97335E3 | 97336E3 | - |
| 47 | 18 x 35 | 260 | 705 | 0.20 | 2.0 | 57479E3 | 67479E3 | - | |

| ADDITIONAL ELECTRICAL DATA | | |
|------------------------------------|--|---|
| PARAMETER | CONDITIONS | VALUE |
| Voltage | | |
| Surge voltage | U _R = 200 V to 250 V | U _S ≤ 1.15 x U _R |
| | U _R = 400 V to 450 V | U _S ≤ 1.10 x U _R |
| Reverse voltage | | U _{rev} ≤ 1 V |
| Current | | |
| Leakage current | After 1 min at U _R | I _{L1} ≤ 0.03 C _R x U _R + 70 μA |
| | After 5 min at U _R | I _{L5} ≤ 0.015 C _R x U _R + 30 μA |
| Inductance | | |
| Equivalent series inductance (ESL) | Case Ø D = 10 mm | Typ. 16 nH |
| | Case Ø D ≥ 12.5 mm | Typ. 18 nH |
| Resistance | | |
| Equivalent series resistance (ESR) | Calculated from tan δ _{max.} and C _R (see Table 2) | ESR = tan δ/2 π f C _R |

RIPPLE CURRENT AND USEFUL LIFE

Table 3

| ENDURANCE TEST DURATION AND USEFUL LIFE | | | |
|---|-------------------------------|---------------------------------|--|
| NOMINAL CASE SIZE Ø D x L (mm) | ENDURANCE AT 105 °C (h) | USEFUL LIFE AT 105 °C (h) | USEFUL LIFE AT 40 °C 1.6 x I _R APPLIED (h) |
| 10 x 12 | 2000 | 3000 | 200 000 |
| 10 x 16 | 2000 | 3000 | 200 000 |
| 10 x 20 | 2000 | 3000 | 200 000 |
| 12.5 x 20 | 2000 | 3000 | 200 000 |
| 12.5 x 25 | 2000 | 3000 | 200 000 |
| 16 x 20 | 2000 | 4000 | 260 000 |
| 16 x 25 | 2000 | 4000 | 260 000 |
| 16 x 35 | 2000 | 4000 | 260 000 |
| 18 x 20 | 2000 | 4000 | 260 000 |
| 18 x 25 | 2000 | 4000 | 260 000 |
| 18 x 35 | 2000 | 4000 | 260 000 |

Note

- Multiplier of useful life code: CCC206

I_A = Actual ripple current at 100 Hz
 I_R = Rated ripple current at 100 Hz, 105 °C

⁽¹⁾ Useful life at 105 °C and I_R applied
 Case Ø D = 10 mm and 12.5 mm: 3000 h
 Case Ø D = 16 mm and 18 mm: 4000 h

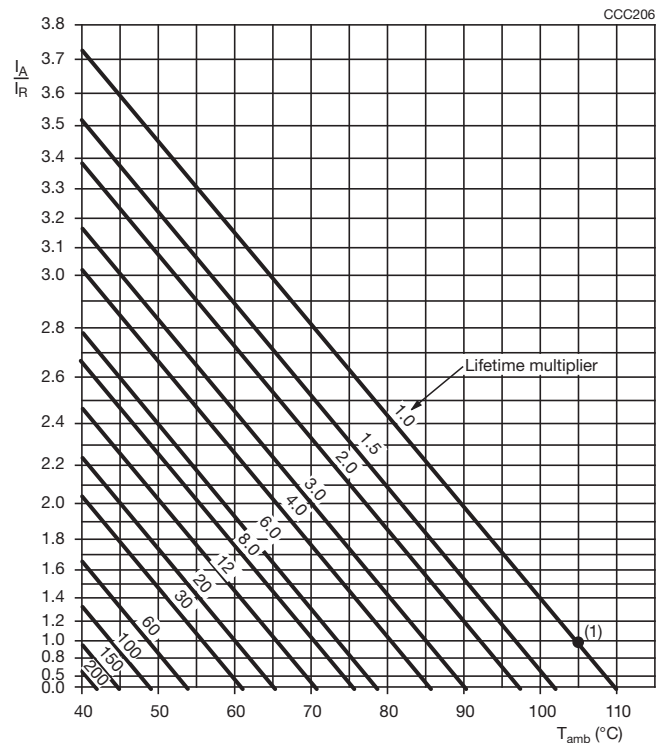


Fig. 5 - Multiplier of useful life as a function of ambient temperature and ripple current load

Table 4

| MULTIPLIER OF RIPPLE CURRENT (I_R) AS A FUNCTION OF FREQUENCY | | | | | | | |
|---|------------------|------|------|------|------|--------|-----------------|
| U_R (V) | FREQUENCY (Hz) | | | | | | |
| | 50 | 100 | 300 | 1000 | 3000 | 10 000 | $\geq 100\ 000$ |
| | I_R MULTIPLIER | | | | | | |
| 200 | 0.75 | 1.00 | 1.50 | 2.00 | 2.20 | 2.50 | 3.00 |
| 250 | 0.75 | 1.00 | 1.50 | 2.00 | 2.20 | 2.50 | 3.00 |
| 400 | 0.75 | 1.00 | 1.30 | 1.60 | 1.90 | 2.20 | 2.50 |
| 450 | 0.75 | 1.00 | 1.30 | 1.60 | 1.90 | 2.20 | 2.50 |

Table 5

| TEST PROCEDURES AND REQUIREMENTS | | | |
|--|--|--|--|
| TEST | | PROCEDURE (quick reference) | REQUIREMENTS |
| NAME OF TEST | REFERENCE | | |
| Endurance | IEC 60384-4 / EN 130300 subclause 4.13 | $T_{amb} = 105\ ^\circ\text{C}$; U_R applied; 2000 h | $\Delta C/C: \pm 20\ \%$ $\tan \delta \leq 2 \times \text{spec. limit}$ $Z \leq 2 \times \text{spec. limit}$ $I_{L5} \leq \text{spec. limit}$ |
| Useful life | CECC 30301 subclause 1.8.1 | $T_{amb} = 105\ ^\circ\text{C}$; U_R and I_R applied; Case $\varnothing D = 10\ \text{mm}$ and $12.5\ \text{mm}$: 3000 h Case $\varnothing D = 16\ \text{mm}$ and $18\ \text{mm}$: 4000 h | $\Delta C/C: \pm 50\ \%$ $\tan \delta \leq 3 \times \text{spec. limit}$ $Z \leq 3 \times \text{spec. limit}$ $I_{L5} \leq \text{spec. limit}$ no short or open circuit total failure percentage: $\leq 1\ \%$ |
| Shelf life (storage at high temperature) | IEC 60384-4 / EN 130300 subclause 4.17 | $T_{amb} = 105\ ^\circ\text{C}$; no voltage applied; 1000 h After test: U_R to be applied for 30 min, 24 h to 48 h before measurement | $\Delta C/C: \pm 20\ \%$ $\tan \delta \leq 2 \times \text{spec. limit}$ $Z \leq 2 \times \text{spec. limit}$ $I_{L5} \leq 2 \times \text{spec. limit}$ |
| Reverse voltage | IEC 60384-4 / EN 130300 subclause 4.15 | $T_{amb} = 105\ ^\circ\text{C}$: 125 h at $U = -1\ \text{V}$, followed by 125 h at U_R | $\Delta C/C: \pm 15\ \%$ $I_{L5} \leq \text{spec. limit}$ $\tan \delta \leq \text{spec. limit}$ |

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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