# Aluminum Capacitors
# Power High Ripple Current Long Life Screw Terminals

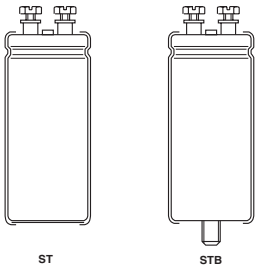
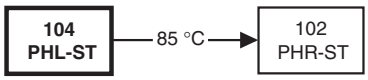



Fig.1 Component outlines.




## FEATURES

- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Large types, cylindrical aluminum case, insulated with a blue sleeve
- Also available in bolt version (104 PHL-STB)
- Pressure relief in the sealing
- Long useful life

Pb-free
RoHS COMPLIANT

## APPLICATIONS

- Telecommunications and industrial systems
- Smoothing and filtering
- Standard and switched mode power supplies
- Energy storage in pulse systems

## MARKING

The capacitors are marked with the following information:

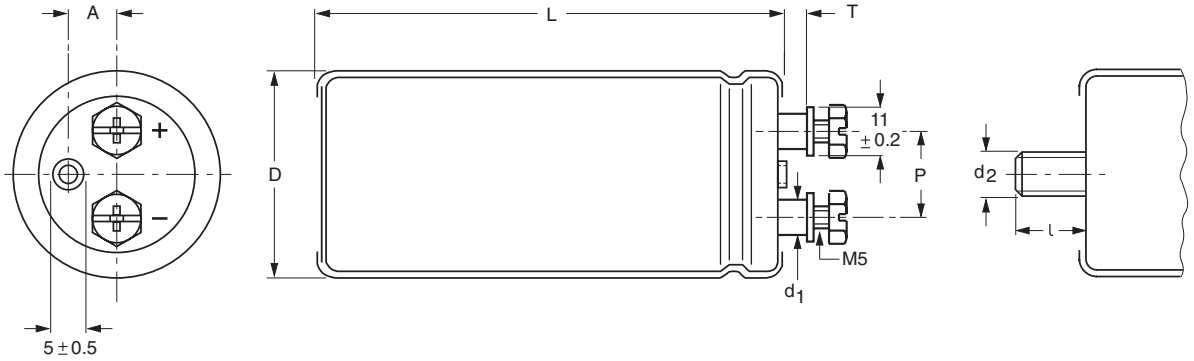
- Rated capacitance (in µF)
- Tolerance on rated capacitance, code letter in accordance with IEC 60062 (± 20 %)
- Rated voltage (in V)
- Date code (YYMM)
- Name of manufacturer.
- Code for factory of origin
- Code number
- Climatic category in accordance with IEC 60068
- “LL” for long life grade

| QUICK REFERENCE DATA | |
|---|---|
| DESCRIPTION | Value |
| Nominal case size (∅D × L in mm) | 35 × 60 to 76 × 146 |
| Rated capacitance range (E6 series), $C_R$ | 150 to 15000 µF |
| Tolerance on $C_R$ | ± 20 % |
| Rated voltage range, $U_R$ | 200 to 450 V |
| Category temperature range | - 40 to + 105 °C |
| Endurance test at 105 °C | 2000 hours |
| Useful life at 105 °C | 5000 hours |
| Shelf life at 0 V, 105 °C | 1000 hours |
| Based on sectional specification | IEC 60384-4/EN130300 |
| Climatic category IEC 60068 | 40/105/56 |

**SELECTION CHART FOR $C_R$, $U_R$ AND RELEVANT NOMINAL CASE SIZES** (∅D × L in mm)

| $C_R$ (µF) | $U_R$ (V) | | | | |
|---|---|---|---|---|---|
| | 200 | 250 | 350 | 400 | 450 |
| 150 | – | – | – | – | 35 × 60 |
| 220 | – | – | – | 35 × 60 | 35 × 80 |
| 330 | – | – | 35 × 60 | 35 × 80 | 35 × 105 |
| 470 | – | – | 35 × 80 | 35 × 80 | 50 × 80 |
| 680 | 35 × 60 | 35 × 60 | 35 × 105 | 50 × 80 | 50 × 105 |
| 1000 | 35 × 60<br>35 × 80 | 35 × 80<br>35 × 105 | 50 × 80 | 50 × 105 | 50 × 105<br>65 × 105 |
| 1500 | 35 × 80<br>35 × 105 | 35 × 105<br>50 × 80 | 50 × 105 | 50 × 105<br>65 × 105 | 65 × 105<br>76 × 105 |
| 2200 | 35 × 105<br>50 × 80 | 50 × 80<br>50 × 105 | 65 × 105 | 65 × 105<br>76 × 105 | 76 × 105<br>76 × 146 |
| 3300 | 50 × 80<br>50 × 105 | 50 × 105<br>65 × 105 | 65 × 105<br>76 × 105 | 76 × 105<br>76 × 146 | 76 × 146 |
| 4700 | 50 × 105<br>65 × 105 | 65 × 105<br>76 × 105 | 76 × 105<br>76 × 146 | 76 × 146 | – |
| 6800 | 65 × 105<br>76 × 105 | 76 × 105<br>76 × 146 | 76 × 146 | – | – |
| 10000 | 76 × 105<br>76 × 146 | 76 × 146 | – | – | – |
| 15000 | 76 × 146 | – | – | – | – |

## **DIMENSIONS** in millimeters **AND AVAILABLE FORMS**




Maximum permissible torque which may be applied to the termination screws: 2 Nm.

For accessories refer to data sheet *"Mounting Accessories"*.

The capacitors are delivered with screws and washers.

Fig.2 Screw terminal **(ST)**; screw terminal bolt **(STB)**.

**Table 1**

| **DIMENSIONS** in millimeters, **MASS AND PACKAGING QUANTITIES** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **NOMINAL CASE SIZE ∅D × L** | **∅$D_{max}$** | **$L_{max}$** | **P ± 0.3** | **A ± 0.5** | **$d_1$ ± 0.2** | **T ± 0.5** | **$d_2$ × l** | **MASS (g)** | **PACKAGING QUANTITIES (per box)** | **CARDBOARD BOX DIMENSIONS L × W × H** |
| 35 × 60 | 36 | 63 | 13 | 8 | 8 | 5.9 | M8 × 12 | 75 | 25 | 196 × 192 × 110 |
| 35 × 80 | 36 | 81 | 13 | 8 | 8 | 5.9 | M8 × 12 | 95 | 25 | 196 × 192 × 115 |
| 35 × 105 | 36 | 105 | 13 | 8 | 8 | 5.9 | M8 × 12 | 130 | 25 | 196 × 192 × 140 |
| 50 × 80 | 51.5 | 83 | 22 | 12 | 8 | 5.9 | M12 × 16 | 200 | 25 | 293 × 273 × 115 |
| 50 × 105 | 51.5 | 105 | 22 | 12 | 8 | 5.9 | M12 × 16 | 300 | 25 | 293 × 273 × 140 |
| 65 × 105 | 66 | 105 | 28.5 | 16 | 8* | 5.9* | M12 × 16 | 480 | 10 | 368 × 151 × 140 |
| 76 × 105 | 77 | 106 | 32 | 19 | 8* | 5.9* | M12 × 16 | 700 | 10 | 418 × 173 × 140 |
| 76 × 146 | 77 | 146 | 32 | 19 | 8* | 5.9* | M12 × 16 | 1000 | 10 | 418 × 173 × 180 |

* Terminals also available in High Current version. Contact manufacturer for mechanical dimensions.

| ELECTRICAL DATA | |
|---|---|
| **SYMBOL** | **DESCRIPTION** |
| $C_R$ | rated capacitance at 100 Hz, tolerance ± 20 % |
| $I_R$ | rated RMS ripple current at 100 Hz, 105 °C |
| $I_{L5}$ | max. leakage current after 5 minutes at $U_R$ |
| ESR | max. equivalent series resistance at 100 Hz |
| Z | impedance at 20 kHz |

**Note**

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

## ORDERING EXAMPLE

Electrolytic capacitor 104 PHL-ST series

4700 µF/250 V; ± 20 %

Nominal case size: ∅65 × 105 mm; ST version

Catalog number: 2222 104 13472.

**Table 2**

**ELECTRICAL DATA AND ORDERING INFORMATION**

| $U_R$ [V] | $C_R$ 100 Hz [µF] | NOMINAL CASE SIZE D x L [mm] | $I_R$ 100Hz 105 °C [A] | $I_{L5}$ 5 min [µA] | ESR max 100 Hz [mΩ] | Z MAX. 20 kHz [mΩ] | CATALOG NUMBER ST 2222 104 | CATALOG NUMBER STB 2222 104 |
|---|---|---|---|---|---|---|---|---|
| 200 | 680 | 35 × 60 | 2.9 | 276 | 197 | 117 | 12681 | 52681 |
| | 1000 | 35 × 60 | 3.3 | 404 | 148 | 94 | 12102 | 52102 |
| | 1000 | 35 × 80 | 3.7 | 404 | 137 | 83 | 22102 | 62102 |
| | 1500 | 35 × 80 | 4.1 | 604 | 102 | 66 | 12152 | 52152 |
| | 1500 | 35 × 105 | 4.6 | 604 | 95 | 59 | 22152 | 62152 |
| | 2200 | 35 × 105 | 5.0 | 884 | 74 | 49 | 12222 | 52222 |
| | 2200 | 50 ×80 | 6.7 | 884 | 63 | 39 | 22222 | 62222 |
| | 3300 | 50 ×80 | 8.2 | 1324 | 42 | 26 | 12332 | 52332 |
| | 3300 | 50 × 105 | 8.2 | 1324 | 44 | 28 | 22332 | 62332 |
| | 4700 | 50 × 105 | 9.9 | 1884 | 31 | 19 | 12472 | 52472 |
| | 4700 | 65 × 105 | 11.6 | 1884 | 31 | 19 | 22472 | 62472 |
| | 6800 | 65 × 105 | 13.7 | 2724 | 22 | 14 | 12682 | 52682 |
| | 6800 | 76 × 105 | 15.2 | 2724 | 22 | 14 | 22682 | 62682 |
| | 10000 | 76 × 105 | 16.4 | 4004 | 17 | 12 | 12103 | 52103 |
| | 10000 | 76 × 146 | 16.9 | 4004 | 17 | 12 | 22103 | 62103 |
| | 15000 | 76 × 146 | 19.9 | 6004 | 12 | 9 | 12153 | 52153 |
| 250 | 680 | 35 × 60 | 2.9 | 344 | 176 | 99 | 13681 | 53681 |
| | 1000 | 35 × 80 | 3.7 | 504 | 123 | 70 | 13102 | 53102 |
| | 1000 | 35 × 105 | 4.0 | 504 | 116 | 63 | 23102 | 63102 |
| | 1500 | 35 × 105 | 4.5 | 754 | 86 | 51 | 13152 | 53152 |
| | 1500 | 50 × 80 | 5.9 | 754 | 76 | 41 | 23152 | 63152 |
| | 2200 | 50 × 80 | 6.6 | 1104 | 58 | 34 | 13222 | 53222 |
| | 2200 | 50 × 105 | 7.3 | 1104 | 54 | 30 | 23222 | 63222 |
| | 3300 | 50 × 105 | 8.9 | 1654 | 36 | 20 | 13332 | 53332 |
| | 3300 | 65 × 105 | 10.4 | 1654 | 36 | 20 | 23332 | 63332 |
| | 4700 | 65 × 105 | 11.4 | 2354 | 28 | 17 | 13472 | 53472 |
| | 4700 | 76 × 105 | 12.7 | 2354 | 28 | 17 | 23472 | 63472 |
| | 6800 | 76 × 105 | 15.0 | 3404 | 20 | 12 | 13682 | 53682 |
| | 6800 | 76 × 146 | 15.4 | 3404 | 20 | 12 | 23682 | 63682 |
| | 10000 | 76 × 146 | 18.2 | 5004 | 14 | 9 | 13103 | 53103 |
| 350 | 330 | 35 × 60 | 2.1 | 235 | 396 | 243 | 15331 | 55331 |
| | 470 | 35 × 80 | 2.6 | 333 | 280 | 172 | 15471 | 55471 |
| | 680 | 35 × 105 | 3.2 | 480 | 197 | 122 | 15681 | 55681 |
| | 1000 | 50 × 80 | 4.7 | 704 | 132 | 82 | 15102 | 55102 |
| | 1500 | 50 × 105 | 5.9 | 1054 | 90 | 57 | 15152 | 55152 |
| | 2200 | 65 × 105 | 8.4 | 1544 | 61 | 38 | 15222 | 55222 |
| | 3300 | 65 × 105 | 10.1 | 2314 | 42 | 26 | 15332 | 55332 |
| | 3300 | 76 × 105 | 11.2 | 2314 | 42 | 26 | 25332 | 65332 |
| | 4700 | 76 × 105 | 12.6 | 3294 | 32 | 21 | 15472 | 55472 |
| | 4700 | 76 × 146 | 13.7 | 3294 | 30 | 19 | 25472 | 65472 |
| | 6800 | 76 × 146 | 15.4 | 4764 | 22 | 15 | 15682 | 55682 |

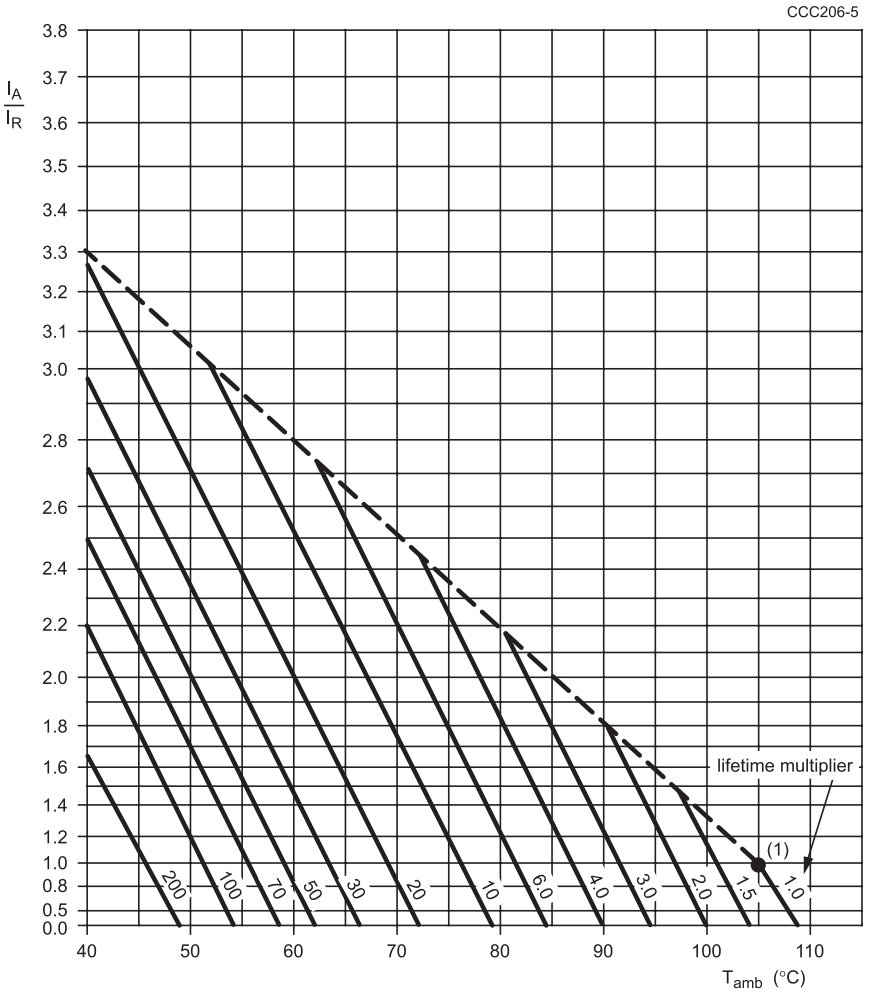
## ELECTRICAL DATA AND ORDERING INFORMATION

| $U_R$ [V] | $C_R$ 100 Hz [µF] | NOMINAL CASE SIZE D x L [mm] | $I_R$ 100Hz 105 °C [A] | $I_{L5}$ 5 min [µA] | ESR max 100 Hz [mΩ] | Z MAX. 20 kHz [mΩ] | CATALOG NUMBER ST 2222 104 | CATALOG NUMBER STB 2222 104 |
|---|---|---|---|---|---|---|---|---|
| 400 | 220 | 35 × 60 | 1.8 | 180 | 519 | 290 | 16221 | 56221 |
| | 330 | 35 × 80 | 2.3 | 268 | 349 | 196 | 16331 | 56331 |
| | 470 | 35 × 80 | 2.6 | 380 | 254 | 148 | 16471 | 56471 |
| | 680 | 50 × 80 | 4.1 | 548 | 170 | 96 | 26681 | 66681 |
| | 1000 | 50 × 105 | 5.1 | 804 | 117 | 67 | 16102 | 56102 |
| | 1500 | 50 × 105 | 6.0 | 1204 | 83 | 49 | 16152 | 56152 |
| | 1500 | 65 × 105 | 6.9 | 1204 | 83 | 49 | 26152 | 66152 |
| | 2200 | 65 × 105 | 8.4 | 1764 | 56 | 33 | 16222 | 56222 |
| | 2200 | 76 × 105 | 9.4 | 1764 | 56 | 33 | 26222 | 66222 |
| | 3300 | 76 × 105 | 11.3 | 2644 | 38 | 23 | 16332 | 56332 |
| | 3300 | 76 × 146 | 11.6 | 2644 | 38 | 23 | 26332 | 66332 |
| | 4700 | 76 × 146 | 13.8 | 3764 | 27 | 17 | 16472 | 56472 |
| 450 | 150 | 35 × 60 | 1.5 | 139 | 735 | 404 | 17151 | 57151 |
| | 220 | 35 × 80 | 1.9 | 202 | 503 | 278 | 17221 | 57221 |
| | 330 | 35 × 105 | 2.4 | 301 | 339 | 189 | 17331 | 57331 |
| | 470 | 50 × 80 | 3.3 | 427 | 253 | 148 | 17471 | 57471 |
| | 680 | 50 × 105 | 4.3 | 616 | 165 | 92 | 17681 | 57681 |
| | 1000 | 50 × 105 | 5.1 | 904 | 117 | 67 | 17102 | 57102 |
| | 1000 | 65 × 105 | 5.9 | 904 | 116 | 66 | 27102 | 67102 |
| | 1500 | 65 × 105 | 7.3 | 1354 | 77 | 44 | 17152 | 57152 |
| | 1500 | 76 × 105 | 8.1 | 1354 | 77 | 44 | 27152 | 67152 |
| | 2200 | 76 × 105 | 9.7 | 1984 | 53 | 31 | 17222 | 57222 |
| | 2200 | 76 × 146 | 10.0 | 1984 | 53 | 31 | 27222 | 67222 |
| | 3300 | 76 × 146 | 12.1 | 2974 | 36 | 21 | 17332 | 57332 |

## ADDITIONAL ELECTRICAL DATA

| PARAMETER | CONDITIONS | VALUE |
|---|---|---|
| **Voltage** | | |
| Surge voltage | ≤ 250 V versions | $U_s = 1.15 \times U_R$ |
| | ≥ 350 V versions | $U_s = 1.1 \times U_R$ |
| Reverse voltage | | $U_{rev} \leq 1$ V |
| **Current** | | |
| Leakage current | after 1 minute at $U_R$ | $I_{L1} \leq 0.006\ C_R \times U_R + 4$ µA |
| | after 5 minutes at $U_R$ | $I_{L5} \leq 0.002\ C_R \times U_R + 4$ µA |
| **Inductance** | | |
| Equivalent series inductance (ESL) | case ∅D = 35 mm | typ. 13 nH |
| | case ∅D = 50 mm | typ. 16 nH |
| | case ∅D = 65 mm | typ. 19 nH |
| | case ∅D = 76 mm | typ. 20 nH |

## RIPPLE CURRENT AND USEFUL LIFE




$I_A$ = actual ripple current at 100 Hz.

$I_R$ = actual ripple current at 100 Hz and 105 °C.

With an absolute maximum of 50 A at 105 °C.

(1) Useful life at 105 °C and $I_R$ applied: 5000 hours

Fig. 3 Multiplier of useful life as a function of ambient temperature and ripple current load.

**Table 3**

| MULTIPLIER OF RIPPLE CURRENT ($I_R$) AS A FUNCTION OF FREQUENCY | |
|---|---|
| **FREQUENCY (Hz)** | **$I_R$ MULTIPLIER** |
| 50 | 0.90 |
| 100 | 1.00 |
| 200 | 1.20 |
| 400 | 1.30 |
| 1000 | 1.40 |
| 10 000 | 1.50 |

**Table 4**

| TEST PROCEDURES AND REQUIREMENTS | | | |
|---|---|---|---|
| **TEST** | | **PROCEDURE (quick reference)** | **REQUIREMENTS** |
| **NAME OF TEST** | **REFERENCE** | | |
| Endurance | IEC 60384-4/ EN130300 subclause 4.13 | $T_{amb}$ = 105 °C; $U_R$ applied; 2000 hours | ΔC/C: ± 10 %<br>ESR ≤ 1.3 × spec. limit<br>Z ≤ 2 × spec. limit<br>$I_{L5}$ ≤ spec. limit |
| Useful life | CECC 30301 subclause 4.13 | $T_{amb}$ = 105 °C; $U_R$ and $I_R$ applied; 5000 hours | ΔC/C: ± 30 %<br>ESR ≤ 3 × spec. limit<br>Z ≤ 3 × spec. limit<br>$I_{L5}$ ≤ spec. limit<br>no short or open circuit, no visible damage<br>total failure percentage ≤ 3 % |
| Shelf life (storage at high temperature) | IEC 60384-4/ EN130300 subclause 4.17 | $T_{amb}$ = 105 °C; no voltage applied; 1000 hours<br>after test: $U_R$ to be applied for 30 minutes, 24 to 48 hours before measurement | ΔC/C: ± 10 %<br>ESR ≤ 1.2 × spec. limit<br>$I_{L5}$ ≤ 2 × spec. limit |