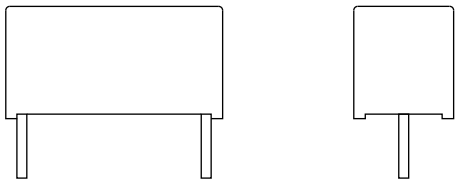
# AC and Pulse Double Metallized Polypropylene Film Capacitors MMKP Radial Potted Type



## FEATURES

- 7.5 mm to 37.5 mm lead pitch
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

Pb-free
RoHS COMPLIANT
HALOGEN FREE
GREEN (5-2008)

## APPLICATIONS

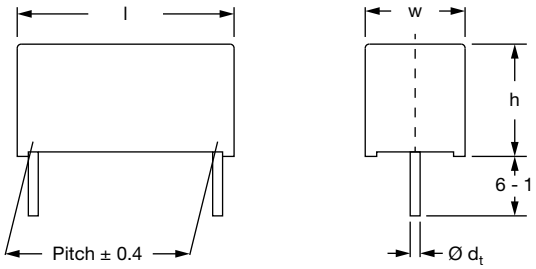
- High voltage, high current and high pulse operations
- Protection circuits in SMPS's, snubber and electronic ballast circuits

| QUICK REFERENCE DATA | |
|---|---|
| Rated DC voltage | 250 $V_{DC}$; 400 $V_{DC}$; 630 $V_{DC}$; 1000 $V_{DC}$; 1600 $V_{DC}$; 2000 $V_{DC}$ |
| Rated AC voltage | 160 $V_{AC}$; 220 $V_{AC}$; 250 $V_{AC}$; 400 $V_{AC}$; 600 $V_{AC}$; 650 $V_{AC}$; 700 $V_{AC}$ |
| Capacitance range | 470 pF to 4.7 µF |
| Capacitance tolerance | ± 5 % |
| Climatic testing class according to EN 60068-1 | 55/100/56 |
| Maximum application temperature | 100 °C |
| Reference standards | IEC 60384-16 |
| Dielectric | Polypropylene film |
| Electrodes | Metallized |
| Construction | Internal series construction |
| Encapsulation | Plastic case, epoxy resin sealed, flame retardant, UL-class 94 V-0 |
| Leads | Tinned wire |
| Marking | C-value; tolerance; rated voltage; manufacturer's type; code for dielectric material; manufacturer location; manufacturer's logo; year and week |

**Note**

- For more detailed data and test requirements, contact dc-film@vishay.com

**DIMENSIONS** in millimeters




| PITCH | w | Ø $d_t$ |
|---|---|---|
| 7.5 | - | 0.5 ± 0.05 |
| 10 | - | 0.6 ± 0.06 |
| 15 | ≤ 6 | 0.6 ± 0.06 |
| 15 | > 6 | 0.8 ± 0.08 |
| 22.5 to 27.5 | - | 0.8 ± 0.08 |
| 37.5 | < 16.0 | 0.8 ± 0.08 |
| 37.5 | ≥ 16.0 | 1.0 ± 0.1 |

## COMPOSITION OF CATALOG NUMBER

| MULTIPLIER (nF) | |
|---|---|
| 0.1 | 2 |
| 1 | 3 |
| 10 | 4 |
| 100 | 5 |

| CAPACITANCE (numerically) |
|---|
| Example: |
| 410 = 100 nF |

| MKP | 1841 | X | XX | 40 | 4 | M | X |
|---|---|---|---|---|---|---|---|

METALLIZED POLYPROPYLENE

TYPE CONSTRUCTION

| VOLTAGE ($V_{DC}$) |
|---|
| 25 = 250 $V_{DC}$ |
| 40 = 400 $V_{DC}$ |
| 63 = 630 $V_{DC}$ |
| 10 = 1000 $V_{DC}$ |
| 13 = 1600 $V_{DC}$ |
| 20 = 2000 $V_{DC}$ |

| TOLERANCE | |
|---|---|
| 4 | ± 5 % |

MINI VERSION

| PACKAGING | |
|---|---|
| | Bulk |
| G | Ammopack |
| W | Reel (Ø 350 mm) |
| V | Reel (Ø 500 mm) |

**Note**

- For detailed tape specifications refer to "Packaging Information" www.vishay.com/doc?28139 or end of catalog

## SPECIFIC REFERENCE DATA

| DESCRIPTION | VALUE | | |
|---|---|---|---|
| Tangent of loss angle: | at 1 kHz | at 10 kHz | at 100 kHz |
| C ≤ 0.1 µF | ≤ 10 x $10^{-4}$ | ≤ 10 x $10^{-4}$ | ≤ 20 x $10^{-4}$ |
| 0.1 µF < C ≤ 1.0 µF | ≤ 10 x $10^{-4}$ | ≤ 10 x $10^{-4}$ | - |
| C ≥ 1.0 µF | ≤ 10 x $10^{-4}$ | - | - |

| PITCH (mm) | MAXIMUM PULSE RISE TIME $(dU/dt)_R$ [V/µs] | | | | | | |
|---|---|---|---|---|---|---|---|
| | 250 $V_{DC}$ | 400 $V_{DC}$ | 630 $V_{DC}$ / 250 $V_{AC}$ | 630 $V_{DC}$ / 400 $V_{AC}$ | 1000 $V_{DC}$ | 1600 $V_{DC}$ | 2000 $V_{DC}$ |
| 7.5 | 1730 | - | - | - | - | - | - |
| 10 | 865 | 1297 | 2162 | - | - | - | - |
| 15 | 432 | 649 | - | 2703 | 3784 | 6683 | 9610 |
| 22.5 | 247 | 360 | - | 1441 | 2018 | 2827 | 3326 |
| 27.5 | 192 | 282 | - | 1081 | 1514 | 2042 | 2544 |
| 37.5 | 133 | 200 | - | - | 1044 | 1313 | 1602 |

| | |
|---|---|
| R between leads, for C ≤ 0.33 µF at 100 V; 1 min | > 100 000 MΩ |
| RC between leads; for C > 0.33 µF at 100 V; 1 min | > 30 000 s |
| R between leads and case: 100 V; 1 min | > 30 000 MΩ |
| Withstanding (DC) voltage (cut off current 10 mA) (1); rise time ≤ 1000 V/s | 1.6 x $U_{RDC}$, 1 min |
| Withstanding (DC) voltage between leads and case | 2840 V; 1 min |
| Maximum application temperature | 100 °C |

**Note**

(1) See "Voltage Proof Test for Metalized Film Capacitors": www.vishay.com/doc?28169

## ELECTRICAL DATA

| $U_{RDC}$ (V) | CAP. (µF) | CAPACITANCE CODE | VOLTAGE CODE | $V_{AC}$ | DIMENSIONS (w x h x l) | PCM |
|---|---|---|---|---|---|---|
| 250 | 0.010 | 310 | 25 | 160 | 4.0 x 9.0 x 10.0 | 7.5 |
| | 0.015 | 315 | | | 4.0 x 9.0 x 10.0 | 7.5 |
| | 0.022 | 322 | | | 4.0 x 10.0 x 12.5 | 10 |
| | 0.033 | 333 | | | 4.0 x 10.0 x 12.5 | 10 |
| | 0.047 | 347 | | | 5.0 x 11.0 x 12.5 | 10 |
| | 0.068 | 368 | | | 6.0 x 12.0 x 12.5 | 10 |
| | 0.10 | 410 | | | 5.0 x 11.0 x 17.5 | 15 |
| | 0.15 | 415 | | | 6.0 x 12.0 x 17.5 | 15 |
| | 0.22 | 422 | | | 7.0 x 13.5 x 17.5 | 15 |
| | 0.33 | 433 | | | 8.5 x 15.0 x 17.5 | 15 |
| | 0.47 | 447 | | | 8.5 x 18.0 x 26.0 | 22.5 |
| | 0.68 | 468 | | | 10.0 x 19.5 x 26.0 | 22.5 |
| | 1.0 | 510 | | | 10.0 x 19.5 x 26.0 | 22.5 |
| | 1.5 | 515 | | | 13.0 x 23.0 x 31.0 | 27.5 |
| | 2.2 | 522 | | | 15.0 x 25.0 x 31.0 | 27.5 |
| | 3.3 | 533 | | | 21.0 x 31.0 x 31.0 | 27.5 |
| | 4.7 | 547 | | | 18.0 x 32.5 x 41.5 | 37.5 |
| 400 | 0.010 | 310 | 40 | 220 | 4.0 x 10.0 x 12.5 | 10 |
| | 0.015 | 315 | | | 4.0 x 10.0 x 12.5 | 10 |
| | 0.022 | 322 | | | 4.0 x 10.0 x 12.5 | 10 |
| | 0.033 | 333 | | | 5.0 x 11.0 x 17.5 | 15 |
| | 0.047 | 347 | | | 5.0 x 11.0 x 17.5 | 15 |
| | 0.068 | 368 | | | 6.0 x 12.0 x 17.5 | 15 |
| | 0.10 | 410 | | | 7.0 x 13.5 x 17.5 | 15 |
| | 0.15 | 415 | | | 8.5 x 15.0 x 17.5 | 15 |
| | 0.22 | 422 | | | 7.0 x 16.5 x 26.0 | 22.5 |
| | 0.33 | 433 | | | 8.5 x 18.0 x 26.0 | 22.5 |
| | 0.47 | 447 | | | 10.0 x 19.5 x 26.0 | 22.5 |
| | 0.68 | 468 | | | 11.0 x 21.0 x 31.0 | 27.5 |
| | 1.0 | 510 | | | 13.0 x 23.0 x 31.0 | 27.5 |
| | 1.5 | 515 | | | 15.0 x 25.0 x 31.0 | 27.5 |
| | 2.2 | 522 | | | 16.0 x 28.5 x 41.5 | 37.5 |
| 630 | 0.00068 | 168 | 63 | 250 | 4.0 x 10.0 x 12.5 | 10 |
| | 0.00082 | 182 | | | 4.0 x 10.0 x 12.5 | 10 |
| | 0.0010 | 210 | | | 4.0 x 10.0 x 12.5 | 10 |
| | 0.0015 | 215 | | | 4.0 x 10.0 x 12.5 | 10 |
| | 0.0022 | 222 | | | 4.0 x 10.0 x 12.5 | 10 |
| | 0.0033 | 233 | | | 4.0 x 10.0 x 12.5 | 10 |
| | 0.0047 | 247 | | | 4.0 x 10.0 x 12.5 | 10 |
| | 0.0068 | 268 | | | 4.0 x 10.0 x 12.5 | 10 |
| | 0.010 | 310 | | | 5.0 x 11.0 x 12.5 | 10 |
| | 0.015 | 315 | | | 6.0 x 12.0 x 12.5 | 10 |
| | 0.022 | 322 | | | 6.0 x 12.0 x 12.5 | 10 |
| 630 | 0.015 | 315 | 63 | 400 | 5.0 x 11.0 x 17.5 | 15 (1) |
| | 0.022 | 322 | | | 6.0 x 12.0 x 17.5 | 15 (1) |
| | 0.033 | 333 | | | 7.0 x 13.5 x 17.5 | 15 (1) |
| | 0.047 | 347 | | | 8.5 x 15.0 x 17.5 | 15 (1) |
| | 0.068 | 368 | | | 7.0 x 16.5 x 26.0 | 22.5 |
| | 0.10 | 410 | | | 8.5 x 18.0 x 26.0 | 22.5 |
| | 0.15 | 415 | | | 10.0 x 19.5 x 26.0 | 22.5 |
| | 0.22 | 422 | | | 11.0 x 21.0 x 31.0 | 27.5 |
| | 0.33 | 433 | | | 13.0 x 23.0 x 31.0 | 27.5 |
| | 0.47 | 447 | | | 18.0 x 28.0 x 31.0 | 27.5 |
| | 0.68 | 468 | | | 21.0 x 31.0 x 31.0 | 27.5 |

| ELECTRICAL DATA | | | | | | |
|---|---|---|---|---|---|---|
| $U_{RDC}$ (V) | CAP. (µF) | CAPACITANCE CODE | VOLTAGE CODE | $V_{AC}$ | DIMENSIONS (w x h x l) | PCM |
| 1000 | 0.0047 | 247 | 10 | 600 | 5.0 x 11.0 x 17.5 | 15 |
| | 0.0068 | 268 | | | 5.0 x 11.0 x 17.5 | 15 |
| | 0.010 | 310 | | | 6.0 x 12.0 x 17.5 | 15 |
| | 0.015 | 315 | | | 7.0 x 13.5 x 17.5 | 15 |
| | 0.022 | 322 | | | 8.5 x 15.0 x 17.5 | 15 |
| | 0.033 | 333 | | | 7.0 x 16.5 x 26.0 | 22.5 |
| | 0.047 | 347 | | | 8.5 x 18.0 x 26.0 | 22.5 |
| | 0.068 | 368 | | | 10.0 x 19.5 x 26.0 | 22.5 |
| | 0.10 | 410 | | | 12.0 x 22.0 x 26.0 | 22.5 |
| | 0.15 | 415 | | | 13.0 x 23.0 x 31.0 | 27.5 |
| | 0.22 | 422 | | | 15.0 x 25.0 x 31.0 | 27.5 |
| | 0.33 | 433 | | | 18.0 x 28.0 x 31.0 | 27.5 |
| 1600 | 0.0033 | 233 | 13 | 650 | 5.0 x 11.0 x 17.5 | 15 |
| | 0.0047 | 247 | | | 6.0 x 12.0 x 17.5 | 15 |
| | 0.0068 | 268 | | | 7.0 x 13.5 x 17.5 | 15 |
| | 0.010 | 310 | | | 8.5 x 15.0 x 17.5 | 15 |
| | 0.015 | 315 | | | 10.0 x 16.5 x 17.5 | 15 |
| | 0.022 | 322 | | | 8.5 x 18.0 x 26.0 | 22.5 |
| | 0.033 | 333 | | | 8.5 x 18.0 x 26.0 | 22.5 |
| | 0.047 | 347 | | | 10.0 x 19.5 x 26.0 | 22.5 |
| | 0.068 | 368 | | | 12.5 x 20.0 x 26.5 | 22.5 |
| | 0.10 | 410 | | | 13.0 x 23.0 x 31.0 | 27.5 |
| | 0.15 | 415 | | | 15.0 x 25.0 x 31.0 | 27.5 |
| | 0.22 | 422 | | | 16.0 x 28.5 x 41.5 | 37.5 |
| 2000 | 0.00047 | 147 | 20 | 700 | 5.0 x 11.0 x 17.5 | 15 |
| | 0.00068 | 168 | | | 5.0 x 11.0 x 17.5 | 15 |
| | 0.00082 | 182 | | | 5.0 x 11.0 x 17.5 | 15 |
| | 0.0010 | 210 | | | 5.0 x 11.0 x 17.5 | 15 |
| | 0.0015 | 215 | | | 5.0 x 11.0 x 17.5 | 15 |
| | 0.0022 | 222 | | | 5.0 x 11.0 x 17.5 | 15 |
| | 0.0033 | 233 | | | 6.0 x 12.0 x 17.5 | 15 |
| | 0.0047 | 247 | | | 6.0 x 12.0 x 17.5 | 15 |
| | 0.0068 | 268 | | | 6.0 x 15.5 x 26.0 | 22.5 |
| | 0.010 | 310 | | | 6.0 x 15.5 x 26.0 | 22.5 |
| | 0.015 | 315 | | | 7.0 x 16.5 x 26.0 | 22.5 |
| | 0.022 | 322 | | | 8.5 x 18.0 x 26.0 | 22.5 |
| | 0.033 | 333 | | | 9.0 x 19.0 x 31.0 | 27.5 |
| | 0.047 | 347 | | | 11.0 x 21.0 x 31.0 | 27.5 |
| | 0.068 | 368 | | | 13.0 x 23.0 x 31.0 | 27.5 |
| | 0.10 | 410 | | | 14.5 x 24.5 x 41.5 | 37.5 |
| | 0.15 | 415 | | | 16.0 x 28.5 x 41.5 | 37.5 |
| | 0.22 | 422 | | | 18.0 x 32.5 x 41.5 | 37.5 |

**Note**

(1) Ordering code -2M for pitch 15 (e.g. MKP18413226342M)

| RECOMMENDED PACKAGING | | | | | | | |
|---|---|---|---|---|---|---|---|
| LETTER CODE | TYPE OF PACKAGING | HEIGHT (H) (mm) | REEL DIAMETER (mm) | ORDERING CODE EXAMPLES | PITCH ≤ 15 | PITCH 22.5 TO 27.5 | PITCH 37.5 |
| G | Ammo | 18.5 | - | MKP1841-310/404-MG | X | - | - |
| W | Reel | 18.5 | 350 | MKP1841-310/404-MW | X | - | - |
| V | Reel | 18.5 | 500 | MKP1841-410/634-MV | - | X | - |
| G | Ammo | 18.5 | - | MKP1841-410/634-MG | - | X | - |
| - | Bulk | - | - | MKP1841-410/634-M | X | X | X |

## MOUNTING

### Normal Use

The capacitors are designed for mounting on printed-circuit boards. The capacitors packed in bandoliers are designed for mounting in printed-circuit boards by means of automatic insertion machines.

For detailed tape specifications refer to “Packaging Information” www.vishay.com/doc?28139.

### Specific Method of Mounting to Withstand Vibration and Shock

In order to withstand vibration and shock tests, it must be ensure that the stand-off pips are in good contact with the printed-circuit board:

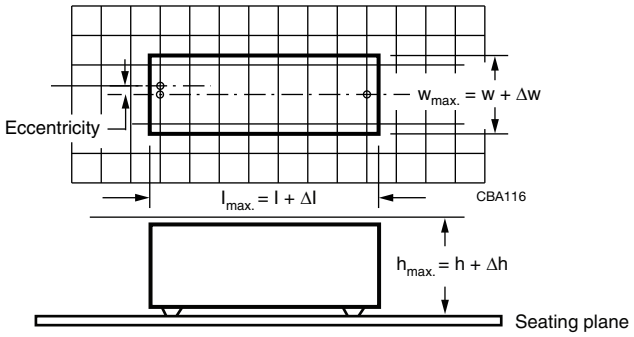
- For pitches = 15 mm capacitors shall be mechanically fixed by the leads
- For larger pitches the capacitors shall be mounted in the same way and the body clamped

### Space Requirements on Printed Circuit Board

The maximum space for length ($l_{max.}$), width ($w_{max.}$) and height ($h_{max.}$) of film capacitors to take in account on the printed circuit board is shown in the drawings.

- For products with pitch ≤ 15 mm, $\Delta w = \Delta l = 0.3$ mm; $\Delta h = 0.1$ mm
- For products with 15 mm < pitch ≤ 27.5 mm, $\Delta w = \Delta l = 0.5$ mm; $\Delta h = 0.1$ mm
- For products with pitch = 37.5 mm, $\Delta w = \Delta l = 0.7$ mm and $\Delta h = 0.5$ mm

Eccentricity defined as in drawing. The maximum eccentricity is smaller than or equal to the lead diameter of the product concerned.




## SOLDERING CONDITIONS

For general soldering conditions and wave soldering profile, we refer to the application note:
**“Soldering Guidelines for Film Capacitors”**: www.vishay.com/doc?28171

### Storage Temperature

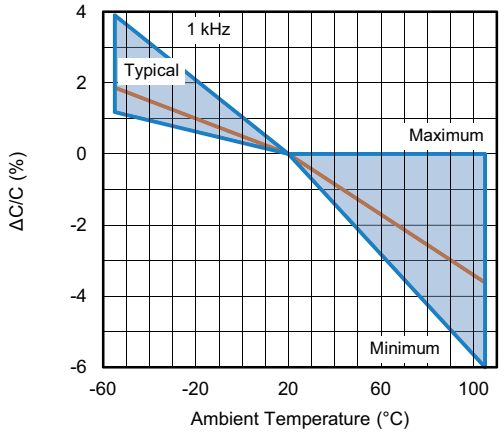
$T_{stg}$ = -25 °C to +35 °C with RH maximum 75 % without condensation

### Ratings and Characteristics Reference Conditions

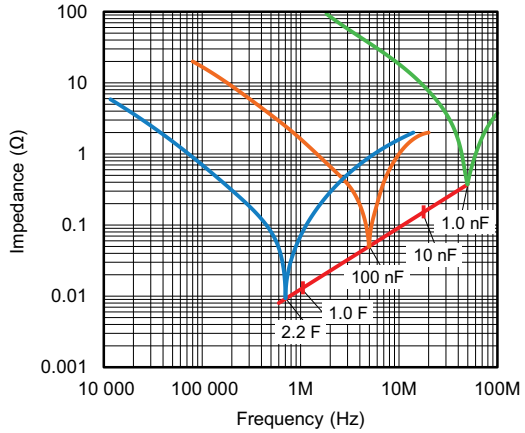
Unless otherwise specified, all electrical values apply to an ambient free temperature of 23 °C ± 1 °C, an atmospheric pressure of 86 kPa to 106 kPa and a relative humidity of 50 % ± 2 %.

For reference testing, a conditioning period shall be applied over 96 h ± 4 h by heating the products in a circulating air oven at the rated temperature and a relative humidity not exceeding 20 %.

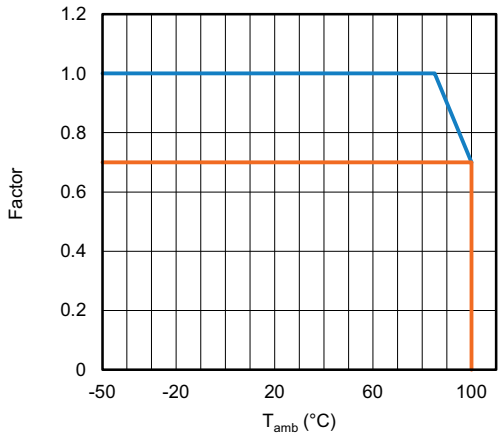
## CHARACTERISTICS



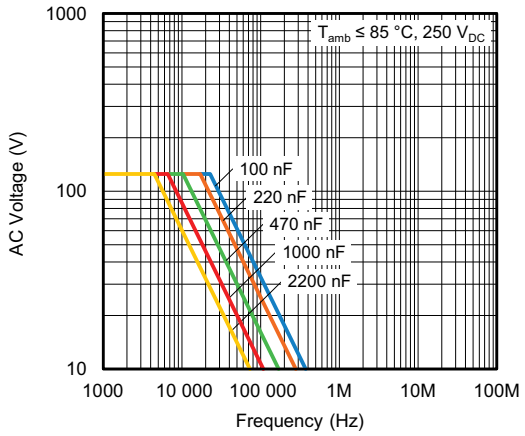

Capacitance as a function of ambient temperature
(typical curve - 1 kHz)



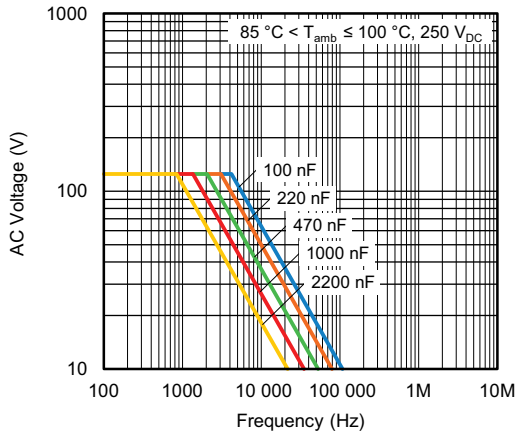

Impedance as a function of frequency
(typical curve)




Max. DC and AC voltage as function of temperature

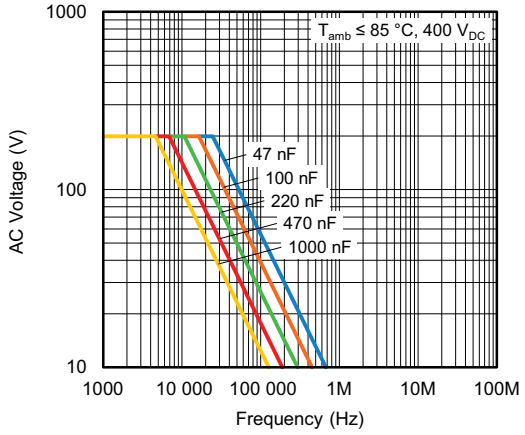



Maximum RMS voltage as a function of frequency

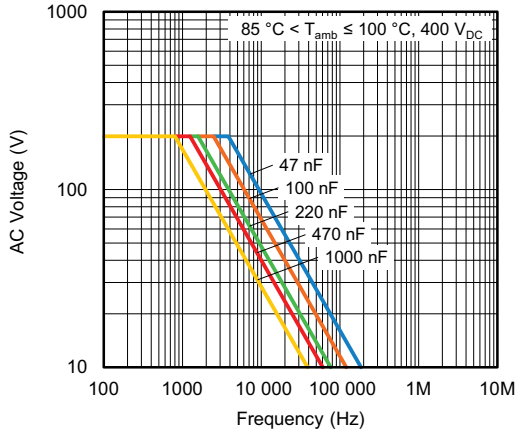



Maximum RMS voltage as a function of frequency

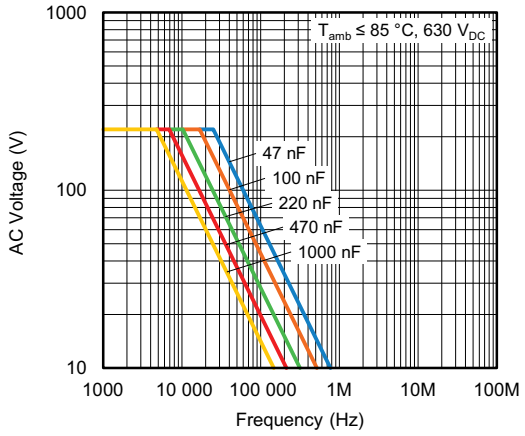
## CHARACTERISTICS



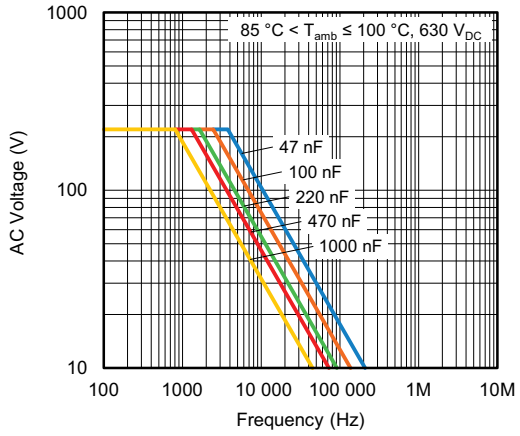

Maximum RMS voltage as a function of frequency



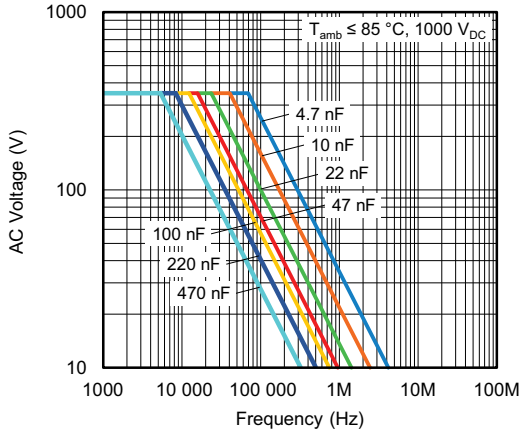

Maximum RMS voltage as a function of frequency



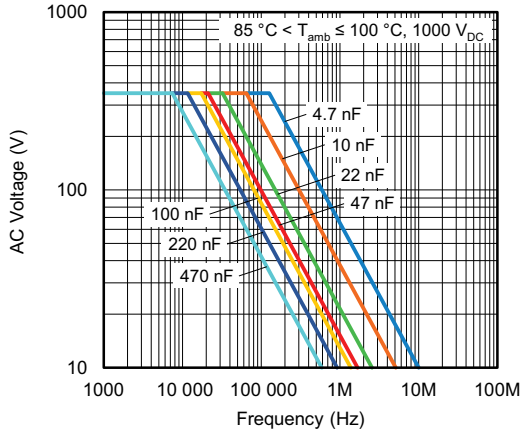

Maximum RMS voltage as a function of frequency




Maximum RMS voltage as a function of frequency

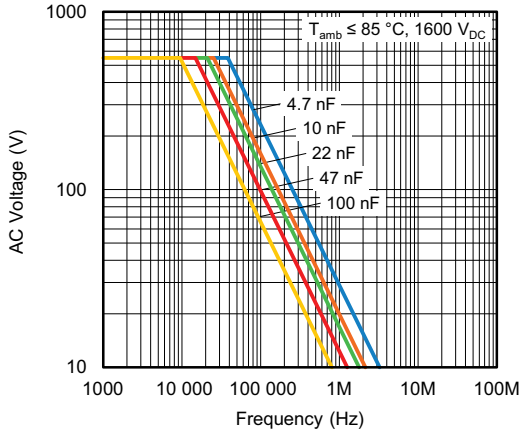



Maximum RMS voltage as a function of frequency

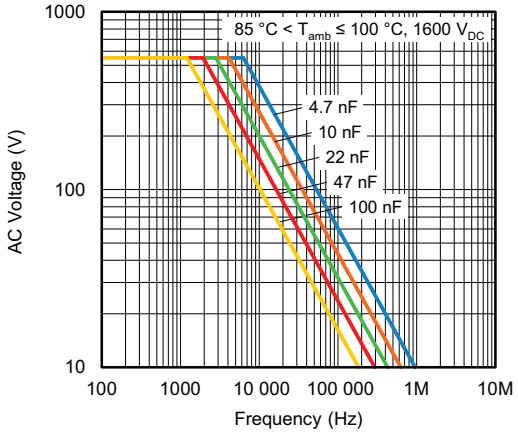



Maximum RMS voltage as a function of frequency

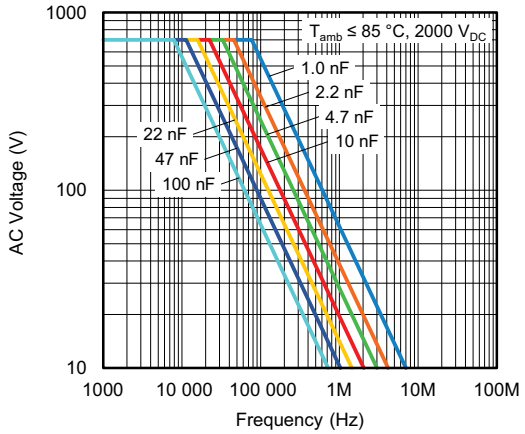
## CHARACTERISTICS



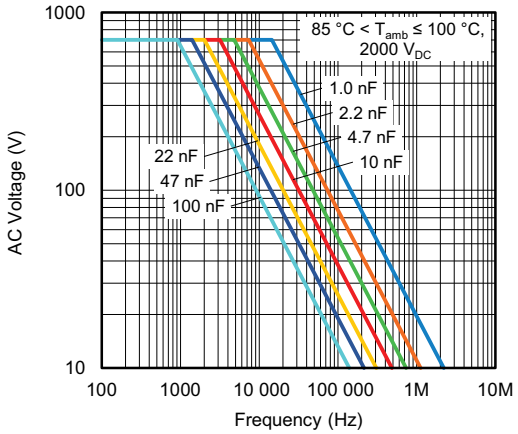

Maximum RMS voltage as a function of frequency



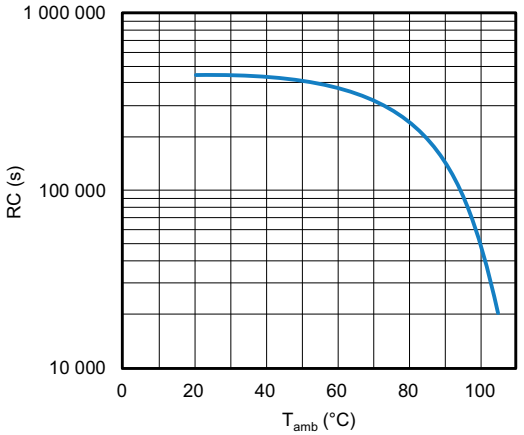

Maximum RMS voltage as a function of frequency



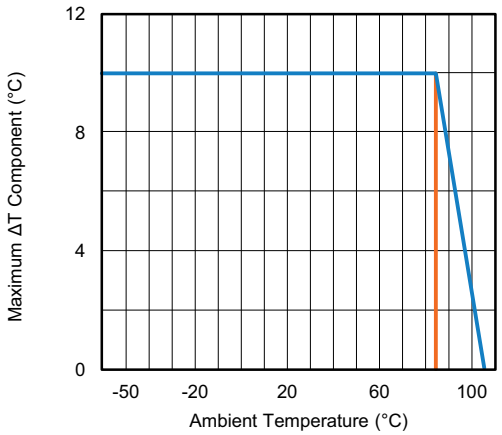

Maximum RMS voltage as a function of frequency




Maximum RMS voltage as a function of frequency

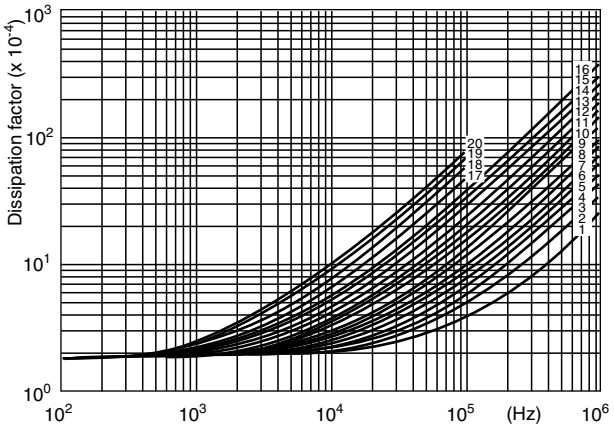



Insulation resistance as a function of ambient temperature




Maximum allowed component temperature rise (ΔT) as a function of the ambient temperature ($T_{amb}$)

## CHARACTERISTICS




Tangent of loss angle as a function of frequency
(typical curve)

| 250 V | 400 V | 630 V | 1000 V | 1600 V | 2000 V |
|---|---|---|---|---|---|
| C ≤ 0.091 µF, curve 8 | C ≤ 0.047 µF, curve 5 | C ≤ 0.033 µF, curve 4 | C ≤ 0.01 µF, curve 2 | C ≤ 0.0047 µF, curve 3 | C ≤ 0.0047 µF, curve 2 |
| C ≤ 0.015 µF, curve 9 | C ≤ 0.068 µF, curve 6 | C ≤ 0.068 µF, curve 5 | C ≤ 0.027 µF, curve 3 | C ≤ 0.0091 µF, curve 4 | C ≤ 0.033 µF, curve 3 |
| C ≤ 0.022 µF, curve 10 | C ≤ 0.1 µF, curve 7 | C ≤ 0.1 µF, curve 6 | C ≤ 0.047 µF, curve 4 | C ≤ 0.068 µF, curve 5 | C ≤ 0.1 µF, curve 4 |
| C ≤ 0.027 µF, curve 11 | C ≤ 0.2 µF, curve 8 | C ≤ 0.15 µF, curve 7 | C ≤ 0.062 µF, curve 5 | C ≤ 0.01 µF, curve 6 | |
| C ≤ 0.033 µF, curve 12 | C ≤ 0.24 µF, curve 12 | C ≤ 0.22 µF, curve 11 | C ≤ 0.075 µF, curve 6 | C ≤ 0.15 µF, curve 7 | |
| C ≤ 0.056 µF, curve 15 | C ≤ 0.36 µF, curve 13 | C ≤ 0.27 µF, curve 12 | C ≤ 0.1 µF, curve 7 | | |
| C ≤ 0.082 µF, curve 16 | C ≤ 0.47 µF, curve 14 | C ≤ 0.47 µF, curve 15 | C ≤ 0.15 µF, curve 8 | | |
| C ≤ 1.2 µF, curve 18 | C ≤ 0.56 µF, curve 16 | C ≤ 0.68 µF, curve 16 | C ≤ 0.22 µF, curve 9 | | |
| C ≤ 1.6 µF, curve 19 | C ≤ 1.1 µF, curve 17 | | C ≤ 0.3 µF, curve 10 | | |
| C ≤ 2.2 µF, curve 20 | | | C ≤ 0.39 µF, curve 11 | | |

### HEAT CONDUCTIVITY (G) AS A FUNCTION OF (ORIGINAL) PITCH AND CAPACITOR BODY THICKNESS IN mW/°C

| $W_{max.}$ (mm) | HEAT CONDUCTIVITY (mW/°C) | | | | | |
|---|---|---|---|---|---|---|
| | PITCH 7.5 mm | PITCH 10 mm | PITCH 15 mm | PITCH 22.5 mm | PITCH 27.5 mm | PITCH 37.5 mm |
| 4.0 | - | 6.5 | - | - | - | - |
| 4.5 | 5 | - | - | - | - | - |
| 5.0 | - | 7.5 | 10 | - | - | - |
| 6.0 | - | 9.0 | 11 | - | - | - |
| 7.0 | - | - | 12 | 21 | - | - |
| 8.5 | - | - | 16 | 25 | - | - |
| 10.0 | - | - | 18 | 28 | - | - |
| 11.0 | - | - | - | - | 36 | - |
| 12.0 | - | - | - | 34 | - | - |
| 13.0 | - | - | - | - | 42 | - |
| 14.5 | - | - | - | - | - | 59 |
| 15.0 | | - | - | - | 48 | - |
| 16.0 | - | - | - | - | - | 68 |
| 18.0 | - | - | - | - | 57 | - |
| 18.5 | - | - | - | - | - | 89 |
| 21.0 | - | - | - | - | 68 | - |
| 30.0 | - | - | - | - | - | 134 |

## POWER DISSIPATION AND MAXIMUM COMPONENT TEMPERATURE RISE

The power dissipation must be limited in order not to exceed the maximum allowed component temperature rise as a function of the free air ambient temperature.

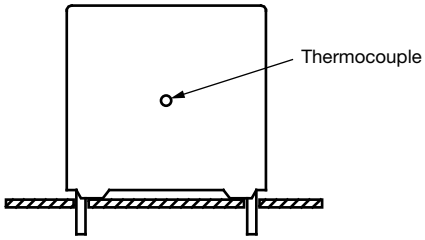
The power dissipation can be calculated according type detail specification “HQN-384-01/101: Technical Information Film Capacitors”.

The component temperature rise ($\Delta T$) can be measured (see section “Measuring the component temperature” for more details) or calculated by $\Delta T = P/G$:

- $\Delta T$ = component temperature rise (°C)
- P = power dissipation of the component (mW)
- G = heat conductivity of the component (mW/°C)

## MEASURING THE COMPONENT TEMPERATURE

A thermocouple must be attached to the capacitor body as in:




The temperature is measured in unloaded ($T_{amb}$) and maximum loaded condition ($T_C$).

The temperature rise is given by $\Delta T = T_C - T_{amb}$.

To avoid radiation or convection, the capacitor should be tested in a wind-free box.

## APPLICATION NOTE AND LIMITING CONDITIONS

These capacitors are not suitable for mains applications as across-the-line capacitors without additional protection, as described hereunder. These mains applications are strictly regulated in safety standards and therefore electromagnetic interference suppression capacitors conforming the standards must be used.

To select the capacitor for a certain application, the following conditions must be checked:

1. The peak voltage ($U_P$) shall not be greater than the rated DC voltage ($U_{RDC}$)
2. The peak-to-peak voltage ($U_{P-P}$) shall not be greater than the maximum ($U_{P-P}$)to avoid the ionization inception level
3. The voltage pulse slope (dU/dt) shall not exceed the rated voltage pulse slope in an RC-circuit at rated voltage and without ringing. If the pulse voltage is lower than the rated DC voltage, the rated voltage pulse slope may be multiplied by $U_{RDC}$ and divided by the applied voltage.
   For all other pulses following equation must be fulfilled:
   $$2 \times \int_0^T \left(\frac{dU}{dt}\right)^2 \times dt < U_{RDC} \times \left(\frac{dU}{dt}\right)_{rated}$$
   T is the pulse duration.
4. The maximum component surface temperature rise must be lower than the limits (see graph “Max. allowed component temperature rise”).
5. Since in circuits used at voltages over 280 V peak-to-peak the risk for an intrinsically active flammability after a capacitor breakdown (short circuit) increases, it is recommended that the power to the component is limited to 100 times the values mentioned in the table: “Heat Conductivity”
6. When using these capacitors as across-the-line capacitor in the input filter for mains applications or as series connected with an impedance to the mains the applicant must guarantee that the following conditions are fulfilled in any case (spikes and surge voltages from the mains included).

**VOLTAGE CONDITIONS FOR 6 ABOVE**

| ALLOWED VOLTAGES | $T_{amb} \leq 85$ °C | 85 °C < $T_{amb} \leq 100$ °C |
|---|---|---|
| Maximum continuous RMS voltage | $U_{RAC}$ | $U_{RAC}$ |
| Maximum temperature RMS-overvoltage (< 24 h) | 1.25 x $U_{RAC}$ | 0.875 x $U_{RAC}$ |
| Maximum peak voltage ($V_{O-P}$) (< 2 s) | 1.6 x $U_{RDC}$ | 1.1 x $U_{RDC}$ |

## INSPECTION REQUIREMENTS

### General Notes

Sub-clause numbers of tests and performance requirements refer to the “Sectional Specification, Publication IEC 60384-16 and Specific Reference Data”.

| GROUP C INSPECTION REQUIREMENTS | | |
|---|---|---|
| **SUB-CLAUSE NUMBER AND TEST** | **CONDITIONS** | **PERFORMANCE REQUIREMENTS** |
| **SUB-GROUP C1A PART OF SAMPLE OF SUB-GROUP C1** | | |
| 4.1 Dimensions (detail) | | As specified in chapters “General Data” of this specification |
| 4.3.1 Initial measurements | Capacitance<br>Tangent of loss angle:<br>for C ≤ 0.1 µF at 100 kHz or<br>for C > 0.1 µF at 10 kHz<br>Tensile and bending | |
| 4.3 Robustness of terminations | | No visible damage |
| 4.4 Resistance to soldering heat | Method: 1A<br>Solder bath: 280 °C ± 5 °C<br>Duration: 5 s | |
| 4.14 Component solvent resistance | Isopropylalcohol at room temperature<br>Method: 2<br>Immersion time: 5 min ± 0.5 min<br>Recovery time: min. 1 h, max. 2 h | |
| 4.4.2 Final measurements | Visual examination | No visible damage<br>Legible marking |
| | Capacitance | \|ΔC/C\| ≤ 2 % of the value measured initially |
| | Tangent of loss angle | Increase of tan δ: ≤ 0.002<br>Compared to values measured in 4.3.1 |
| **SUB-GROUP C1B OTHER PART OF SAMPLE OF SUB-GROUP C1** | | |
| 4.6.1 Initial measurements | Capacitance<br>Tangent of loss angle:<br>for C ≤ 0.1 µF at 100 kHz or<br>for C > 0.1 µF at 10 kHz | |
| 4.15 Solvent resistance of the marking | Isopropylalcohol at room temperature<br>Method: 1<br>Rubbing material: cotton wool | No visible damage<br>Legible marking |
| 4.6 Rapid change of temperature | Immersion time: 5.0 min ± 0.5 min<br>θA = lower category temperature<br>θB = upper category temperature<br>5 cycles<br>Duration t = 30 min | |
| 4.7 Vibration | Visual examination<br>Mounting: see section “Mounting” for more information<br>Procedure B4<br>Frequency range: 10 Hz to 55 Hz<br>Amplitude: 0.75 mm or<br>Acceleration 98 m/s²<br>(whichever is less severe)<br>Total duration 6 h | No visible damage |

| GROUP C INSPECTION REQUIREMENTS | | |
|---|---|---|
| **SUB-CLAUSE NUMBER AND TEST** | **CONDITIONS** | **PERFORMANCE REQUIREMENTS** |
| **SUB-GROUP C1B OTHER PART OF SAMPLE OF SUB-GROUP C1** | | |
| 4.7.2 Final inspection | Visual examination | No visible damage |
| 4.9 Shock | Mounting:<br>see section “Mounting” for more information<br>Pulse shape: half sine<br>Acceleration: 490 m/s²<br>Duration of pulse: 11 ms | |
| 4.9.3 Final measurements | Visual examination | No visible damage |
| | Capacitance | $\lvert\Delta C/C\rvert \leq 2$ % of the value measured in 4.6.1 |
| | Tangent of loss angle | Increase of tan $\delta \leq 0.002$<br>Compared to values measured in 4.6.1 |
| | Insulation resistance | $\geq 50$ % of values specified in section “Insulation Resistance” of this specification |
| **SUB-GROUP C1 COMBINED SAMPLE OF SPECIMENS OF SUB-GROUPS C1A AND C1B** | | |
| 4.10 Climatic sequence | | |
| 4.10.2 Dry heat | Temperature: +105 °C<br>Duration: 16 h | |
| 4.10.3 Damp heat cyclic<br>Test Db, first cycle | | |
| 4.10.4 Cold | Temperature: -55 °C<br>Duration: 2 h | |
| 4.10.6 Damp heat cyclic<br>Test Db, remaining cycles | | |
| 4.10.6.2 Final measurements | Voltage proof = $U_{RDC}$ for 1 min within 15 min after removal from test chamber | No breakdown or flashover |
| | Visual examination | No visible damage<br>Legible marking |
| | Capacitance | $\lvert\Delta C/C\rvert \leq 3$ % of the value measured initially 4.11.1 |
| | Tangent of loss angle | Increase of tan $\delta$: $\leq 0.003$<br>Compared to values measured in 4.3.1. or 4.6.1 |
| | Insulation resistance | $\geq 50$ % of values specified in section “Insulation Resistance” of this specification |
| **SUB-GROUP C2** | | |
| 4.11 Damp heat steady state | 56 days; 40 °C; 90 % to 95 % RH, no load | |
| 4.11.1 Initial measurements | Capacitance<br>Tangent of loss angle at 1 kHz | |
| 4.11.3 Final measurements | Voltage proof = $U_{RDC}$ for 1 min within 15 min after removal from test chamber | No breakdown or flashover |
| | Visual examination | No visible damage<br>Legible marking |
| | Capacitance | $\lvert\Delta C/C\rvert \leq 3$ % of the value measured in 4.11.1. |
| | Tangent of loss angle | Increase of tan $\delta$: $\leq 0.002$<br>Compared to values measured in 4.11.1 |
| | Insulation resistance | $\geq 50$ % of values specified in section “Insulation Resistance” of this specification |

| GROUP C INSPECTION REQUIREMENTS | | |
|---|---|---|
| **SUB-CLAUSE NUMBER AND TEST** | **CONDITIONS** | **PERFORMANCE REQUIREMENTS** |
| **SUB-GROUP C3** | | |
| 4.12.1 Endurance test at 50 Hz alternating voltage | Duration: 2000 h | |
| 4.12.1.1 Initial measurements | Voltage: 1 x $U_{RAC}$ at 100 °C<br>Capacitance<br>Tangent of loss angle: at 10 kHz | |
| 4.12.1.3 Final measurements | Visual examination | No visible damage<br>Legible marking |
| | Capacitance | $\lvert\Delta C/C\rvert \leq 5$ % compared to values measured in 4.12.1.1 |
| | Tangent of loss angle | Increase of tan $\delta$: $\leq 0.004$<br>Compared to values measured in 4.12.1 |
| | Insulation resistance | $\geq 50$ % of values specified in section "Insulation Resistance" of this specification |
| **SUB-GROUP C4** | | |
| 4.2.6 Temperature characteristics | | |
| Initial measurements | Capacitance | For -55 °C to +20 °C |
| Intermediate measurements | Capacitance at -55 °C<br>Capacitance at 20 °C<br>Capacitance at 100 °C | +1 % $\leq \lvert\Delta C/C\rvert \leq 3.75$ %<br>or<br>For 20 °C to 105 °C:<br>-6 % $\leq \lvert\Delta C/C\rvert \leq 0$ % |
| Final measurements | Capacitance | As specified in section "Capacitance" of this specification. |
| | Insulation resistance | As specified in section "Insulation Resistance" of this specification |
| 4.13 Charge and discharge | 10 000 cycles<br>Charged to $U_{RDC}$<br>Discharge resistance:<br>$R = \frac{U_{RDC}}{1.5 \times C(dU/dt)}$ | |
| 4.13.1 Initial measurements | Capacitance<br>Tangent of loss angle:<br>for C $\leq$ 1 µF at 100 kHz or<br>for C > 1 µF at 10 kHz | |
| 4.13.3 Final measurements | Capacitance | $\lvert\Delta C/C\rvert \leq 3$ % compared to values measured in 4.13.1 |
| | Tangent of loss angle | Increase of tan $\delta$: $\leq 0.005$<br>compared to values measured in 4.13.1 |
| | Insulation resistance | $\geq 50$ % of values specified in section "Insulation Resistance" of this specification |

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