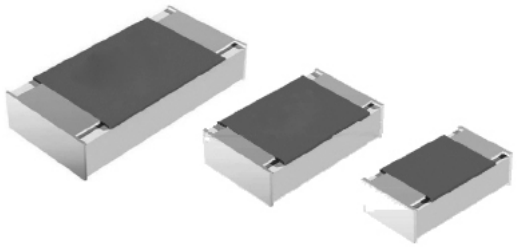
## Trimmable Flat Chip Resistors



### FEATURES

- Designed for state of the art laser trimming
- Enables economical functional circuit adjustment
- Low TCR ± 50 ppm/K available
- Excellent stability ≤ ± 0.25 % (1000 h rated power at 70 °C)
- Wide ohmic range: 10 Ω to 1 MΩ
- Lead (Pb)-free solder contacts
- Compliant to RoHS directive 2002/95/EC

RoHS COMPLIANT

TCT 0603, TCU 0805 and TCA 1206 trimmable flat chip resistors are best suited whenever stable circuit adjustment is required and potentiometers will be either too expensive, too unstable or too large. The trimming is done directly on the printed-circuit board (PCB) using a state of the art laser trimming system e.g. with YAG or $CO_2$ laser source. Typical applications include any type of electronic sensors, oscillators or electronic circuits which have to be trimmed to certain functional parameters after PCB assembly.

### APPLICATIONS

- Electronic sensors
- Oscillators
- Electronic circuits

| METRIC SIZE | | | |
|---|---|---|---|
| **INCH:** | 0603 | 0805 | 1206 |
| **METRIC:** | RR 1608M | RR 2012M | RR 3216M |

### TECHNICAL SPECIFICATIONS

| DESCRIPTION | TCT 0603 | | TCU 0805 | | TCA 1206 |
|---|---|---|---|---|---|
| Metric size | RR 1608M | | RR 2012M | | RR 3216M |
| Resistance range | 10 Ω to 1 MΩ | | 10 Ω to 1 MΩ | | 10 Ω to 1 MΩ |
| Resistance tolerance | + 0/- 30 %; + 0/- 20 %; + 0/- 10 % | | | | + 0/- 20 % |
| Temperature coefficient | ± 100 ppm/K; ± 50 ppm/K | | | | ± 100 ppm/K |
| Operation mode | Standard | Power | Standard | Power | Standard |
| Climatic category (LCT/UCT/days) | 55/125/56 | 55/155/56 | 55/125/56 | 55/155/56 | 55/125/56 |
| Rated dissipation, $P_{70}$ (1) | 0.1 W | 0.125 W | 0.125 W | 0.2 W | 0.25 W |
| Operating voltage, $U_{max.}$ AC/DC | 75 V | | 150 V | | 200 V |
| Film temperature | 125 °C | 155 °C | 125 °C | 155 °C | 125 °C |
| Max. resistance change at $P_{70}$ for resistance range, $\lvert\Delta R/R\rvert$ max., after: | 10 Ω to 1 MΩ | | 10 Ω to 1 MΩ | | 10 Ω to 1 MΩ |
| 1000 h | ≤ 0.25 % | ≤ 0.5 % | ≤ 0.25 % | ≤ 0.5 % | ≤ 0.25 % |
| 8000 h | ≤ 0.5 % | ≤ 1.0 % | ≤ 0.5 % | ≤ 1.0 % | ≤ 0.5 % |
| 225 000 h | ≤ 1.5 % | - | ≤ 1.5 % | - | ≤ 1.5 % |
| Insulation voltage: | | | | | |
| 1 min; $U_{ins}$ | 100 V | | 200 V | | 300 V |
| Continuous | 75 V | | 75 V | | 75 V |
| Failure rate: $FIT_{observed}$ | ≤ 0.1 x $10^{-9}$/h | | | | |

**Notes**

(1) The power dissipation on the resistor generates a temperature rise against the local ambient, depending on the heat flow support of the printed-circuit board (thermal resistance). The rated dissipation applies only if the permitted film temperature is not exceeded.

(2) All given figures are valid for the untrimmed resistor

- These resistors do not feature a limited lifetime when operated within the permissible limits. However, resistance value drift increasing over operating time may result in exceeding a limit acceptable to the specific application, thereby establishing a functional lifetime.

## PART NUMBER AND PRODUCT DESCRIPTION (1)

**PART NUMBER: TCT06030C4702XP500**

| T | C | T | 0 | 6 | 0 | 3 | 0 | C | 4 | 7 | 0 | 2 | X | P | 5 | 0 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| MODEL/SIZE | SPECIAL CHARACTER | TCR | VALUE | TOLERANCE | PACKAGING | SPECIAL |
|---|---|---|---|---|---|---|
| **TCT0603**<br>**TCU0805**<br>**TCA1206** | **0** = Neutral | **C** = ± 50 ppm/K<br>**B** = ± 100 ppm/K | **3 digit value**<br>**1 digit multiplier**<br>MULTIPLIER<br>**9** = $*10^{-1}$<br>**0** = $*10^{0}$<br>**1** = $*10^{1}$<br>**2** = $*10^{2}$<br>**3** = $*10^{3}$<br>**4** = $*10^{4}$<br>**5** = $*10^{5}$ | **W** = + 0/- 30 %<br>**X** = + 0/- 20 %<br>**Y** = + 0/- 10 % | **P5**<br>**PW** | Up to 2 digits<br>**00** = Standard |

**PRODUCT DESCRIPTION: TCT 0603 - 50 - 20 % P5 47K**

| TCT | 0603 | - 50 | - 20 % | P5 | 47K |
|---|---|---|---|---|---|
| MODEL | SIZE | TCR (2) | TOLERANCE | PACKAGING | RESISTANCE VALUE |
| **TCT**<br>**TCU**<br>**TCA** | **0603**<br>**0805**<br>**1206** | ± **50** ppm/K<br>± **100** ppm/K | **- 10 %** = + 0/- 10 %<br>**- 20 %** = + 0/- 20 %<br>**- 30 %** = + 0/- 30 % | **P5**<br>**PW** | **47K** = 47 kΩ<br>**1M** = 1 MΩ |

**Notes**

(1) Products can be ordered using either the PRODUCT DESCRIPTION or the PART NUMBER

(2) A temperature coefficient ± 100 ppm/K is marked -00

## TEMPERATURE COEFFICIENT AND RESISTANCE RANGE

| DESCRIPTION | | RESISTANCE VALUE (3) | | |
|---|---|---|---|---|
| **TCR** | **TOLERANCE** | **TCT 0603** | **TCU 0805** | **TCA 1206** |
| ± 100 ppm/K | + 0/- 30 % | 10 Ω to 1 MΩ | 10 Ω to 1 MΩ | – |
| | + 0/- 20 % | **10 Ω to 1 MΩ** | **10 Ω to 1 MΩ** | 10 Ω to 1 MΩ |
| | + 0/- 10 % | 10 Ω to 1 MΩ | 10 Ω to 1 MΩ | – |
| ± 50 ppm/K | + 0/- 30 % | 100 Ω to 1 MΩ | 100 Ω to 1 MΩ | – |
| | + 0/- 20 % | **100 Ω to 1 MΩ** | **100 Ω to 1 MΩ** | – |
| | + 0/- 10 % | 100 Ω to 1 MΩ | 100 Ω to 1 MΩ | – |

**Note**

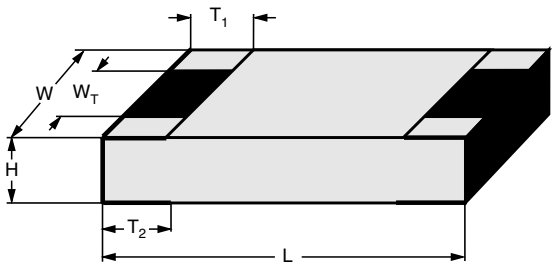
(3) Resistance values to be selected from E12 (preferred) or E24 series

**Resistance ranges printed in bold are preferred TCR/tolerance combinations with optimized availability.**

## PACKAGING

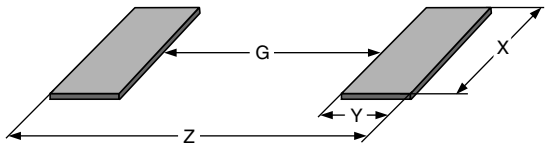
| MODEL | REEL | |
|---|---|---|
| | **PIECES/PAPER TAPE ON REEL** | **CODE** |
| TCT 0603 | 5000 | P5 |
| | 20 000 | PW |
| TCU 0805 | 5000 | P5 |
| | 20 000 | PW |
| TCA 1206 | 5000 | P5 |

## DIMENSIONS




| DIMENSIONS AND MASS | | | | | | | |
|---|---|---|---|---|---|---|---|
| TYPE | H (mm) | L (mm) | W (mm) | $W_T$ (mm) | $T_1$ (mm) | $T_2$ (mm) | MASS (mg) |
| TCT 0603 | 0.45 + 0.1/- 0.05 | 1.55 ± 0.05 | 0.85 ± 0.1 | > 75 % of W | 0.3 + 0.15/- 0.2 | 0.3 + 0.15/- 0.2 | 1.9 |
| TCU 0805 | 0.45 + 0.1/- 0.05 | 2.0 ± 0.1 | 1.25 ± 0.15 | > 75 % of W | 0.4 + 0.1/- 0.2 | 0.4 + 0.1/- 0.2 | 4.6 |
| TCA 1206 | 0.45 + 0.1/- 0.05 | 3.2 + 0.1/- 0.2 | 1.6 ± 0.15 | > 75 % of W | 0.5 ± 0.25 | 0.5 ± 0.25 | 9.2 |

## SOLDER PAD DIMENSIONS




| RECOMMENDED SOLDER PAD DIMENSIONS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| TYPE | WAVE SOLDERING | | | | REFLOW SOLDERING | | | |
| | G (mm) | Y (mm) | X (mm) | Z (mm) | G (mm) | Y (mm) | X (mm) | Z (mm) |
| TCT 0603 | 0.55 | 1.10 | 1.10 | 2.75 | 0.65 | 0.70 | 0.95 | 2.05 |
| TCU 0805 | 0.80 | 1.25 | 1.50 | 3.30 | 0.90 | 0.90 | 1.40 | 2.70 |
| TCA 1206 | 1.40 | 1.50 | 1.90 | 4.40 | 1.50 | 1.15 | 1.75 | 3.80 |

**Note**

- The rated dissipation applies only if the permitted film temperature is not exceeded. Furthermore, a high level of ambient temperature or of power dissipation may raise the temperature of the solder joint, hence special solder alloys or board materials may be required to maintain the reliability of the assembly.
  Specified power rating above 125 °C requires dedicated heat-sink pads, which depend on board materials.
  The given solder pad dimensions reflect the considerations for board design and assembly as outlined e.g. in standards IEC 61188-5-x, or in publication IPC-7351. They do not guarantee any supposed thermal properties, particularly as these are also strongly influenced by many other parameters.
  Still, the given solder pad dimensions will be found adequate for most general applications, e.g. those referring to “standard operation mode”. Please note however that applications for “power operation mode” require special considerations for the design of solder pads and adjacent conductor areas.

## DESCRIPTION

Production is strictly controlled and follows an extensive set of instructions established for reproducibility. A newly developed cermet layer is deposited onto a high-grade ($Al_2O_3$) ceramic substrate and conditioned to achieve the desired temperature coefficient. Pre-contacts are built on both sides of the substrate. The resistor elements are covered by glass for superior electrical, mechanical and climatic protection. The terminations receive a final pure tin-on-nickel plating.

The result of the determined production is verified by an extensive testing procedure performed on 100 % of the individual chip resistors. Only accepted products are laid directly into the paper tape in accordance with **IEC 60286-3** [3].

## ASSEMBLY

The resistors are suitable for processing on automatic SMD assembly systems. They are suitable for automatic soldering using wave, reflow or vapour phase as shown in **IEC 61760-1** [3]. The encapsulation is resistant to all cleaning solvents commonly used in the electronics industry, including alcohols, esters and aqueous solutions. The suitability of conformal coatings, if applied, shall be qualified by appropriate means to ensure the long-term stability of the whole system.

The resistors are RoHS compliant; the pure tin plating provides compatibility with lead (Pb)-free and lead-containing soldering processes. Solderability is specified for 2 years after production or requalification. The permitted storage time is 20 years. The immunity of the plating against tin whisker growth has been proven under extensive testing.

All products comply with the **GADSL** [1] and the **CEFIC-EECA-EICTA** [2] list of legal restrictions on hazardous substances. This includes full compliance with the following directives:

- 2000/53/EC End of Vehicle life Directive (ELV) and Annex II (ELV II)
- 2002/95/EC Restriction of the use of Hazardous Substances directive (RoHS)
- 2002/96/EC Waste Electrical and Electronic Equipment Directive (WEEE)

## APPROVALS

The resistors are tested in accordance with **EN 140401-802** which refers to **EN 60115-1** and **EN 140400**. The detail specification refers to the climatic category 55/125/56, which relates to the “Standard operation mode” of this datasheet.

Vishay BEYSCHLAG has achieved **“Approval of Manufacturer”** in accordance with **EN 100114-1**.

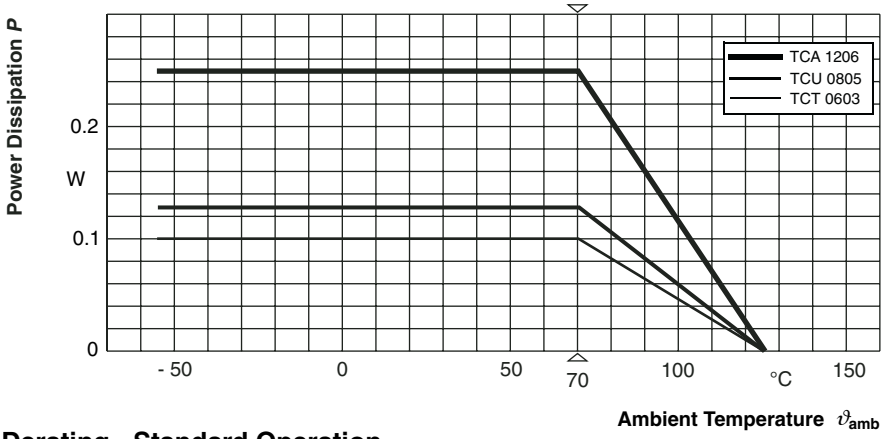
**Notes**

(1) Global Automotive Declarable Substance List, see www.gadsl.org

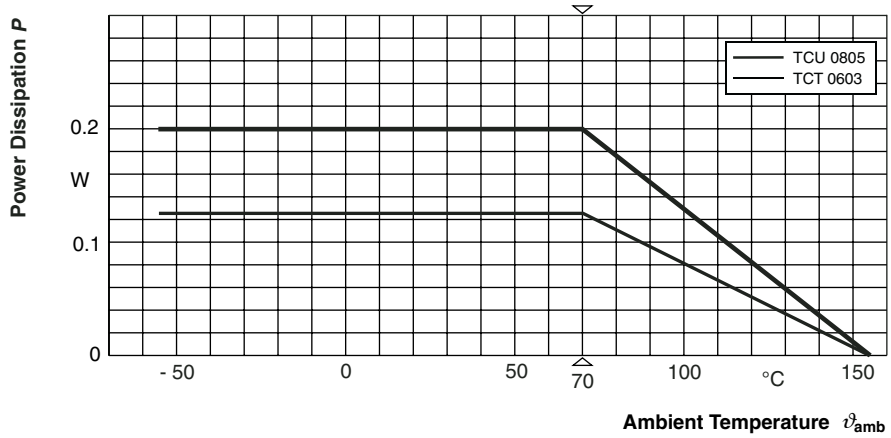
(2) CEFIC (European Chemical Industry Council), EECA (European Electronic Component Manufacturers Association), EICTA (European trade organisation representing the information and communications technology and consumer electronics), see www.eicta.org/index.php?id=995 → issue → environment policy → chemicals → chemicals for electronics

(3) The quoted IEC standards marked with an asterisk (*) are also released as EN standards with the same number and identical contents

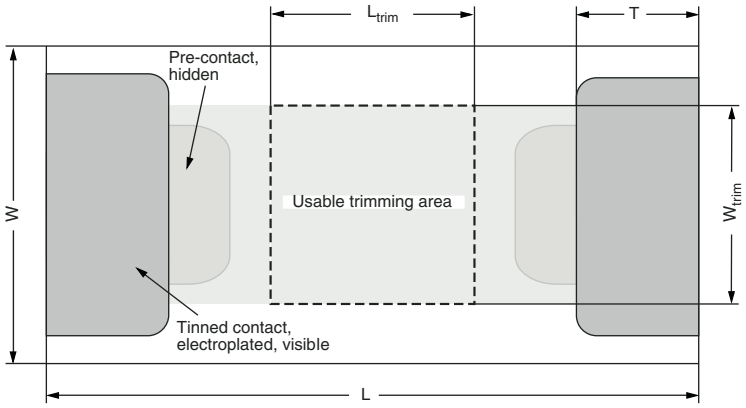
## FUNCTIONAL PERFORMANCE




**Derating - Standard Operation**




**Derating - Power Operation**




**Permissible Trimming Area**

| DIMENSIONS OF THE PERMISSIBLE TRIMMING AREA IN MILLIMETERS | | | | | |
|---|---|---|---|---|---|
| **TYPE** | **L** | **W** | **T** | **$L_{trim}$** | **$W_{trim}$** |
| TCT 0603 | 1.6 | 0.8 | 0.3 | 0.5 | 0.5 |
| TCU 0805 | 2.0 | 1.2 | 0.3 | 0.8 | 0.8 |
| TCA 1206 | 3.2 | 1.6 | 0.4 | 1.4 | 1.0 |

## TESTS AND REQUIREMENTS

All tests are carried out in accordance with the following specifications:

EN 60115-1, generic specification (includes tests)

EN 140400, sectional specification (includes schedule for qualification approval)

EN 140401-802, detail specification (includes schedule for conformance inspection)

The components are approved in accordance with the European CECC-system, where applicable. The following table contains only the most important tests. For the full test schedule refer to the documents listed above. The testing also covers most of the requirements specified by EIA/IS-703 and JIS-C-5202.

The tests are carried out in accordance with IEC 60068 and under standard atmospheric conditions in accordance with IEC 60068-1, 5.3. Climatic category LCT/UCT/56 (rated temperature range: Lower category temperature, upper category temperature; damp heat, long term, 56 days) is valid.

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45 % to 75 %

Air pressure: 86 kPa to 106 kPa (860 mbar to 1060 mbar).

The components are mounted for testing on boards in accordance with EN 60115-1, 4.31 unless otherwise specified.

The requirements stated in the Test Procedures and Requirements table are based on the required tests and permitted limits of EN 140401-802. However, some additional tests and a number of improvements against those minimum requirements have been included.

**TEST PROCEDURES AND REQUIREMENTS (1)**

| EN 60115-1 CLAUSE | IEC 60068-2 TEST METHOD | TEST | PROCEDURE | REQUIREMENTS PERMISSIBLE CHANGE ($\Delta R$) |
|---|---|---|---|---|
| | | | Stability for product types: | |
| | | | **TCT 0603** | 10 Ω to 1 MΩ |
| | | | **TCU 0805** | 10 Ω to 1 MΩ |
| | | | **TCA 1206** | 10 Ω to 1 MΩ |
| 4.5 | - | Resistance | | + 0/- 30 % $R$;<br>+ 0/- 20 % $R$;<br>+ 0/- 10 % $R$ |
| 4.8.4.2 | - | Temperature coefficient | At (20/- 55/20) °C and (20/125/20) °C | ± 100 ppm/K;<br>± 50 ppm/K |
| 4.25.1 | - | Endurance at 70 °C: Standard operation mode | $U = \sqrt{P_{70} \times R}$ or $U = U_{max.}$; whichever is the less severe; 1.5 h on; 0.5 h off;<br>70 °C; 1000 h<br>70 °C; 8000 h | <br><br>± (0.25 % $R$ + 0.05 Ω)<br>± (0.5 % $R$ + 0.05 Ω) |
| | - | Endurance at 70 °C: Power operation mode | $U = \sqrt{P_{70} \times R}$ or $U = U_{max.}$; whichever is the less severe; 1.5 h on; 0.5 h off;<br>70 °C; 1000 h<br>70 °C; 8000 h | <br><br>± (0.5 % $R$ + 0.05 Ω)<br>± (1 % $R$ + 0.05 Ω) |
| 4.25.3 | – | Endurance at upper category temperature | 125 °C; 1000 h<br>155 °C; 1000 h | ± (0.25 % $R$ + 0.05 Ω)<br>± (0.5 % $R$ + 0.05 Ω) |

## TEST PROCEDURES AND REQUIREMENTS (1)

| EN 60115-1 CLAUSE | IEC 60068-2 TEST METHOD | TEST | PROCEDURE | REQUIREMENTS PERMISSIBLE CHANGE ($\Delta R$) |
|---|---|---|---|---|
| | | | Stability for product types: | |
| | | | **TCT 0603** | 10 Ω to 1 MΩ |
| | | | **TCU 0805** | 10 Ω to 1 MΩ |
| | | | **TCA 1206** | 10 Ω to 1 MΩ |
| 4.24 | 78 (Cab) | Damp heat, steady state | (40 ± 2) °C;<br>56 days;<br>(93 ± 3) % RH | ± (0.25 % $R$ + 0.05 Ω) |
| 4.23 | | Climatic sequence: | | |
| 4.23.2 | 2 (Ba) | dry heat | UCT; 16 h | |
| 4.23.3 | 30 (Db) | damp heat, cyclic | 55 °C; 24 h;<br>> 90 % RH;<br>1 cycle | |
| 4.23.4 | 1 (Aa) | cold | LCT; 2 h | |
| 4.23.5 | 13 (M) | low air pressure | 8.5 kPa;<br>2 h;<br>25 ± 10 °C | |
| 4.23.6 | 30 (Db) | damp heat, cyclic | 55 °C; 5 days;<br>> 95 % to 100 % RH;<br>5 cycles<br>LCT = - 55 °C;<br>UCT = 125 °C | ± (0.25 % $R$ + 0.05 Ω) |
| - | 1 (Aa) | Cold | - 55 °C; 2 h | ± (0.25 % $R$ + 0.05 Ω) |
| 4.19 | 14 (Na) | Rapid change of temperature | 30 min at LCT and 30 min at UCT;<br>LCT = - 55 °C;<br>UCT = 125 °C;<br>5 cycles | ± (0.25 % $R$ + 0.05 Ω)<br>no visible damage |
| | | | LCT = - 55 °C;<br>UCT = 125 °C;<br>1000 cycles | ± (0.5 % $R$ + 0.05 Ω)<br>no visible damage |
| 4.13 | - | Short time overload; standard operation mode | $U = 2.5 \times \sqrt{P_{70} \times R}$ or<br>$U = 2 \times U_{max.}$;<br>whichever is the less severe;<br>5 s | ± (0.25 % $R$ + 0.05 Ω) |
| | | Short time overload; power operation mode | | ± (0.5 % $R$ + 0.05 Ω) |
| 4.22 | 6 (Fc) | Vibration | Endurance by sweeping;<br>10 Hz to 2000 Hz;<br>no resonance;<br>amplitude ≤ 1.5 mm or ≤ 200 m/s$^2$; 6 h | ± (0.25 % $R$ + 0.05 Ω);<br>no visible damage |
| 4.17.2 | 58 (Td) | Solderability | Solder bath method;<br>SnPb40;<br>non-activated flux<br>(215 ± 3) °C; (3 ± 0.3) s | Good tinning<br>(≥ 95 % covered);<br>no visible damage |
| | | | Solder bath method;<br>SnAg3Cu0.5 or SnAg3.5;<br>non-activated flux<br>(235 ± 3) °C; (2 ± 0.2) s | |
| 4.18.2 | 58 (Td) | Resistance to soldering heat | Solder bath method;<br>(260 ± 5) °C; (10 ± 1) s | ± (0.25 % $R$ + 0.05 Ω);<br>no visible damage |
| 4.29 | 45 (XA) | Component solvent resistance | Isopropyl alcohol + 50 °C;<br>method 2 | No visible damage |

| TEST PROCEDURES AND REQUIREMENTS (1) | | | | |
|---|---|---|---|---|
| **EN 60115-1 CLAUSE** | **IEC 60068-2 TEST METHOD** | **TEST** | **PROCEDURE** | **REQUIREMENTS PERMISSIBLE CHANGE ($\Delta R$)** |
| | | | Stability for product types: | |
| | | | **TCT 0603** | 10 Ω to 1 MΩ |
| | | | **TCU 0805** | 10 Ω to 1 MΩ |
| | | | **TCA 1206** | 10 Ω to 1 MΩ |
| 4.32 | 21 ($Ue_3$) | Shear (adhesion) | RR 1608M; 9 N | No visible damage |
| | | | RR 2012M and RR 3216M; 45 N | |
| 4.33 | 21 ($Ue_1$) | Substrate bending | Depth 2 mm, 3 times | ± (0.25 % $R$ + 0.05 Ω) no visible damage, no open circuit in bent position |
| 4.7 | - | Voltage proof | $U_{RMS} = U_{ins}$; (60 ± 5) s | No flashover or breakdown |
| 4.35 | - | Flammability | IEC 60695-2-2, needle flame test; 10 s | No burning after 30 s |

**Note**

(1) All given figures are valid for the untrimmed resistor

## 12NC INFORMATION FOR HISTORICAL CODING REFERENCE ONLY

- The resistors have a 12 digit numeric code starting with 2312.
- The subsequent 4 digits indicate the resistor type, specification and packaging; see the 12NC table.
- The remaining 4 digits indicate the resistance value:
  - The first 3 digits indicate the resistance value.
  - The last digit indicates the resistance decade. in accordance with the 12NC indicating resistance decade table.

**Last digit of 12NC indicating resistance decade**

| RESISTANCE DECADE | LAST DIGIT |
|---|---|
| 10 Ω to 99.9 Ω | 9 |
| 100 Ω to 999 Ω | 1 |
| 1 kΩ to 9.99 kΩ | 2 |
| 10 kΩ to 99.9 kΩ | 3 |
| 100 kΩ to 999 kΩ | 4 |
| 1 MΩ to 9.99 MΩ | 5 |

**12NC example**

The 12NC of a TCT 0603 resistor, value 47 kΩ and TCR 50 with + 0/- 20 % tolerance, supplied in cardboard tape of 5000 units per reel is: 2312 300 64703.

| **12NC** - Resistor type and packaging | | | | |
|---|---|---|---|---|
| **DESCRIPTION** | | | **CODE 2312 ... .....** | |
| | | | **CARDBOARD TAPE ON REEL** | |
| **TYPE** | **TCR** | **TOL.** | **P5 5000 UNITS** | **PW 20 000 UNITS** |
| TCT 0603 | ± 100 ppm/K | + 0/- 30 % | 300 1.... | 305 1.... |
| | | + 0/- 20 % | **300 2....** | **305 2....** |
| | | + 0/- 10 % | 300 3.... | 305 3.... |
| | ± 50 ppm/K | + 0/- 30 % | 300 5.... | 305 5.... |
| | | + 0/- 20 % | **300 6....** | **305 6....** |
| | | + 0/- 10 % | 300 7.... | 305 7.... |
| TCU 0805 | ± 100 ppm/K | + 0/- 30 % | 320 1.... | 325 1.... |
| | | + 0/- 20 % | **320 2....** | **325 2....** |
| | | + 0/- 10 % | 320 3.... | 325 3.... |
| | ± 50 ppm/K | + 0/- 30 % | 320 5.... | 325 5.... |
| | | + 0/- 20 % | **320 6....** | **325 6....** |
| | | + 0/- 10 % | 320 7.... | 325 7.... |
| TCA 1206 | ± 100 ppm/K | + 0/- 20 % | 340 2.... | 345 2.... |

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**Vishay Intertechnology, Inc. hereby certifies that all its products that are identified as RoHS-Compliant fulfill the definitions and restrictions defined under Directive 2011/65/EU of The European Parliament and of the Council of June 8, 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (EEE) - recast, unless otherwise specified as non-compliant.**

**Please note that some Vishay documentation may still make reference to RoHS Directive 2002/95/EC. We confirm that all the products identified as being compliant to Directive 2002/95/EC conform to Directive 2011/65/EU.**

**Vishay Intertechnology, Inc. hereby certifies that all its products that are identified as Halogen-Free follow Halogen-Free requirements as per JEDEC JS709A standards. Please note that some Vishay documentation may still make reference to the IEC 61249-2-21 definition. We confirm that all the products identified as being compliant to IEC 61249-2-21 conform to JEDEC JS709A standards.**