

## Precision Thin Film Chip Resistors



Thin film flat chip resistors combine the proven reliability of the professional products with an advanced level of precision and stability. Therefore they are perfectly suited for applications in the fields of test and measurement equipment together with industrial and medical electronics.

### FEATURES

- Approved to EN 140401-801
- Low TCR:  $\pm 10$  ppm/K to  $\pm 25$  ppm/K
- Precision tolerance of resistance:  $\pm 0.1$  % and  $\pm 0.25$  %
- Superior overall stability: class 0.1 and 0.25
- Sulfur resistance verified according to ASTM B 809
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)



### APPLICATIONS

- Automotive
- Test and measuring equipment
- Medical equipment
- Industrial equipment

| TECHNICAL SPECIFICATIONS                                                  |                                                |                               |                               |                             |
|---------------------------------------------------------------------------|------------------------------------------------|-------------------------------|-------------------------------|-----------------------------|
| DESCRIPTION                                                               | MCS 0402                                       | MCT 0603                      | MCU 0805                      | MCA 1206                    |
| Imperial size                                                             | 0402                                           | 0603                          | 0805                          | 1206                        |
| Metric size code                                                          | RR1005M                                        | RR1608M                       | RR2012M                       | RR3216M                     |
| Resistance range                                                          | 100 $\Omega$ to 221 k $\Omega$                 | 39 $\Omega$ to 511 k $\Omega$ | 39 $\Omega$ to 1.5 M $\Omega$ | 39 $\Omega$ to 2 M $\Omega$ |
| Resistance tolerance                                                      | $\pm 0.25$ %; $\pm 0.1$ %                      |                               |                               |                             |
| Temperature coefficient                                                   | $\pm 25$ ppm/K; $\pm 15$ ppm/K; $\pm 10$ ppm/K |                               |                               |                             |
| Rated dissipation, $P_{70}^{(1)}$                                         | 0.063 W                                        | 0.100 W                       | 0.125 W                       | 0.250 W                     |
| Operating voltage, $U_{max}$ , AC <sub>RMS</sub> /DC                      | 50 V                                           | 75 V                          | 150 V                         | 200 V                       |
| Permissible film temperature, $\vartheta_{F max}^{(1)}$                   | 125 °C                                         |                               |                               |                             |
| Operating temperature range                                               | -55 °C to 125 °C                               |                               |                               |                             |
| Permissible voltage against ambient (insulation):<br><br>1 min; $U_{ins}$ | 75 V                                           | 100 V                         | 200 V                         | 300 V                       |
| Failure rate: FIT <sub>observed</sub>                                     | $\leq 0.1 \times 10^{-9}/h$                    |                               |                               |                             |

#### Note

<sup>(1)</sup> Please refer to APPLICATION INFORMATION below.

### APPLICATION INFORMATION

When the resistor dissipates power, a temperature rise above the ambient temperature occurs, dependent on the thermal resistance of the assembled resistor together with the printed circuit board. The rated dissipation applies only if the permitted film temperature is not exceeded.

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.



| MAXIMUM RESISTANCE CHANGE AT RATED DISSIPATION                                 |           |                                |                                |
|--------------------------------------------------------------------------------|-----------|--------------------------------|--------------------------------|
| OPERATION MODE                                                                 |           | PRECISION                      | STANDARD                       |
| Rated dissipation, $P_{70}$                                                    | MCS 0402  | 0.016 W                        | 0.063 W                        |
|                                                                                | MCT 0603  | 0.032 W                        | 0.100 W                        |
|                                                                                | MCU 0805  | 0.050 W                        | 0.125 W                        |
|                                                                                | MCA 1206  | 0.100 W                        | 0.250 W                        |
| Operating voltage, $U_{\max}$ . $AC_{RMS}/DC$                                  | MCS 0402  | 12.5 V                         | 50 V                           |
|                                                                                | MCT 0603  | 25 V                           | 75 V                           |
|                                                                                | MCU 0805  | 35 V                           | 150 V                          |
|                                                                                | MCA 1206  | 50 V                           | 200 V                          |
| Operating temperature range                                                    |           | -10 °C to 85 °C                | -55 °C to 125 °C               |
| Permissible film temperature, $\vartheta_F \max.$                              |           | 85 °C                          | 125 °C                         |
| Max. resistance change at $P_{70}$ for resistance range, $ \Delta R/R $ after: | MCS 0402  | 100 $\Omega$ to 221 k $\Omega$ | 100 $\Omega$ to 221 k $\Omega$ |
|                                                                                | MCT 0603  | 39 $\Omega$ to 511 k $\Omega$  | 39 $\Omega$ to 511 k $\Omega$  |
|                                                                                | MCU 0805  | 39 $\Omega$ to 1.5 M $\Omega$  | 39 $\Omega$ to 1.5 M $\Omega$  |
|                                                                                | MCA 1206  | 39 $\Omega$ to 2 M $\Omega$    | 39 $\Omega$ to 2 M $\Omega$    |
|                                                                                | 1000 h    | $\leq 0.05$ %                  | $\leq 0.1$ %                   |
|                                                                                | 8000 h    | $\leq 0.1$ %                   | $\leq 0.25$ %                  |
|                                                                                | 225 000 h | $\leq 0.25$ %                  | $\leq 0.5$ %                   |

## Note

- The presented operation modes do not refer to different types of resistors, but actually show examples of different loads, that lead to different film temperatures and different achievable load-life stability (drift) of the resistance value. A suitable low thermal resistance of the circuit board assembly must be safeguarded in order to maintain the film temperature of the resistors within the specified limits. Please consider the application note "Thermal Management in Surface-Mounted Resistor Applications" ([www.vishay.com/doc?28844](http://www.vishay.com/doc?28844)) for information on the general nature of thermal resistance.

| TEMPERATURE COEFFICIENT AND RESISTANCE RANGE |                |              |                                                            |           |
|----------------------------------------------|----------------|--------------|------------------------------------------------------------|-----------|
| TYPE / SIZE                                  | TCR            | TOLERANCE    | RESISTANCE                                                 | E-SERIES  |
| MCS 0402                                     | $\pm 25$ ppm/K | $\pm 0.25$ % | 100 $\Omega$ to 221 k $\Omega$                             | E24; E192 |
|                                              |                | $\pm 0.1$ %  | <b>100 <math>\Omega</math> to 221 k<math>\Omega</math></b> |           |
|                                              | $\pm 15$ ppm/K | $\pm 0.25$ % | 100 $\Omega$ to 150 k $\Omega$                             |           |
|                                              |                | $\pm 0.1$ %  | <b>100 <math>\Omega</math> to 150 k<math>\Omega</math></b> |           |
|                                              | $\pm 10$ ppm/K | $\pm 0.25$ % | 100 $\Omega$ to 130 k $\Omega$                             |           |
|                                              |                | $\pm 0.1$ %  | <b>100 <math>\Omega</math> to 130 k<math>\Omega</math></b> |           |
| MCT 0603                                     | $\pm 25$ ppm/K | $\pm 0.25$ % | 39 $\Omega$ to 511 k $\Omega$                              |           |
|                                              |                | $\pm 0.1$ %  | <b>47 <math>\Omega</math> to 511 k<math>\Omega</math></b>  |           |
|                                              | $\pm 15$ ppm/K | $\pm 0.25$ % | 39 $\Omega$ to 332 k $\Omega$                              |           |
|                                              |                | $\pm 0.1$ %  | <b>47 <math>\Omega</math> to 332 k<math>\Omega</math></b>  |           |
|                                              | $\pm 10$ ppm/K | $\pm 0.25$ % | 39 $\Omega$ to 221 k $\Omega$                              |           |
|                                              |                | $\pm 0.1$ %  | <b>47 <math>\Omega</math> to 221 k<math>\Omega</math></b>  |           |
| MCU 0805                                     | $\pm 25$ ppm/K | $\pm 0.25$ % | 39 $\Omega$ to 1.5 M $\Omega$                              |           |
|                                              |                | $\pm 0.1$ %  | <b>47 <math>\Omega</math> to 1.5 M<math>\Omega</math></b>  |           |
|                                              | $\pm 15$ ppm/K | $\pm 0.25$ % | 39 $\Omega$ to 1 M $\Omega$                                |           |
|                                              |                | $\pm 0.1$ %  | <b>47 <math>\Omega</math> to 1 M<math>\Omega</math></b>    |           |
|                                              | $\pm 10$ ppm/K | $\pm 0.25$ % | 39 $\Omega$ to 511 k $\Omega$                              |           |
|                                              |                | $\pm 0.1$ %  | <b>47 <math>\Omega</math> to 511 k<math>\Omega</math></b>  |           |
| MCA 1206                                     | $\pm 25$ ppm/K | $\pm 0.25$ % | 39 $\Omega$ to 2 M $\Omega$                                |           |
|                                              |                | $\pm 0.1$ %  | <b>47 <math>\Omega</math> to 2 M<math>\Omega</math></b>    |           |
|                                              | $\pm 15$ ppm/K | $\pm 0.25$ % | 39 $\Omega$ to 1.5 M $\Omega$                              |           |
|                                              |                | $\pm 0.1$ %  | <b>47 <math>\Omega</math> to 1.5 M<math>\Omega</math></b>  |           |
|                                              | $\pm 10$ ppm/K | $\pm 0.25$ % | 39 $\Omega$ to 1 M $\Omega$                                |           |
|                                              |                | $\pm 0.1$ %  | <b>47 <math>\Omega</math> to 1 M<math>\Omega</math></b>    |           |

## Note

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

**PACKAGING**

| TYPE / SIZE | CODE | QUANTITY | PACKAGING STYLE                            | WIDTH | PITCH | PACKAGING DIMENSIONS |
|-------------|------|----------|--------------------------------------------|-------|-------|----------------------|
| MCS 0402    | E1   | 1000     | Paper tape acc.<br>IEC 60286-3,<br>Type 1a | 8 mm  | 2 mm  | Ø 180 mm/7"          |
|             | E5   | 5000     |                                            |       |       |                      |
|             | E0   | 10 000   |                                            |       |       |                      |
| MCT 0603    | P1   | 1000     |                                            |       | 4 mm  | Ø 180 mm/7"          |
|             | P5   | 5000     |                                            |       |       | Ø 330 mm/13"         |
|             | PW   | 20 000   |                                            |       |       | Ø 330 mm/13"         |
| MCU 0805    | P1   | 1000     |                                            |       |       | Ø 180 mm/7"          |
|             | P5   | 5000     |                                            |       |       | Ø 330 mm/13"         |
|             | PW   | 20 000   |                                            |       |       | Ø 330 mm/13"         |
| MCA 1206    | P1   | 1000     |                                            |       |       | Ø 180 mm/7"          |
|             | P5   | 5000     |                                            |       |       |                      |

**PART NUMBER AND PRODUCT DESCRIPTION**

Part Number: MCT06030D4641BPW00

|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M | C | T | 0 | 6 | 0 | 3 | 0 | D | 4 | 6 | 4 | 1 | B | P | W | 0 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| TYPE / SIZE                              | VERSION     | TCR                                                | RESISTANCE                                                                                                                                                                                                    | TOLERANCE                   | PACKAGING                        |
|------------------------------------------|-------------|----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|----------------------------------|
| MCS0402<br>MCT0603<br>MCU0805<br>MCA1206 | 0 = neutral | F = ± 10 ppm/K<br>E = ± 15 ppm/K<br>D = ± 25 ppm/K | 3 digit value<br>1 digit multiplier<br><br><b>Multiplier</b><br>9 = *10 <sup>-1</sup><br>0 = *10 <sup>0</sup><br>1 = *10 <sup>1</sup><br>2 = *10 <sup>2</sup><br>3 = *10 <sup>3</sup><br>4 = *10 <sup>4</sup> | B = ± 0.1 %<br>C = ± 0.25 % | E1<br>E5<br>E0<br>P1<br>P5<br>PW |

Product Description: MCT 0603-25 0.1 % PW 4K64

| MCT                      | 0603                         | -25                                    | 0.1 %               | PW                               | 4K64                            |
|--------------------------|------------------------------|----------------------------------------|---------------------|----------------------------------|---------------------------------|
| TYPE                     | SIZE                         | TCR                                    | TOLERANCE           | PACKAGING                        | RESISTANCE                      |
| MCS<br>MCT<br>MCU<br>MCA | 0402<br>0603<br>0805<br>1206 | ± 10 ppm/K<br>± 15 ppm/K<br>± 25 ppm/K | ± 0.1 %<br>± 0.25 % | E1<br>E5<br>E0<br>P1<br>P5<br>PW | 4K64 = 4.64 kΩ<br>50R1 = 50.1 Ω |

**Note**

- Products can be ordered using either the PART NUMBER or PRODUCT DESCRIPTION.



## DESCRIPTION

Production is strictly controlled and follows an extensive set of instructions established for reproducibility. A homogeneous film of metal alloy is deposited on a high grade ceramic substrate ( $\text{Al}_2\text{O}_3$ ) and conditioned to achieve the desired temperature coefficient. Specially designed inner contacts are deposited on both sides. A special laser is used to achieve the target value by smoothly fine trimming the resistive layer without damaging the ceramics. A further conditioning is applied in order to stabilize the trimming result. The resistor elements are covered by a protective coating designed for 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 and optical inspection performed on 100 % of the individual chip resistors. This includes full screening for the elimination of products with potential risk of early field failures. Only accepted products are laid directly into the paper tape in accordance with **IEC 60286-3 Type 1a** <sup>(1)</sup>.

## ASSEMBLY

The resistors are suitable for processing on automatic SMD assembly systems and for automatic soldering using wave, reflow or vapor phase. 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, potting compounds and their processes, 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.

## MATERIALS

Vishay acknowledges the following systems for the regulation of hazardous substances:

- IEC 62474, Material Declaration for Products of and for the Electrotechnical Industry, with the list of declarable substances given therein <sup>(2)</sup>
- The Global Automotive Declarable Substance List (GADSL) <sup>(3)</sup>
- The REACH regulation (1907/2006/EC) and the related list of substances with very high concern (SVHC) <sup>(4)</sup> for its supply chain

## Notes

- <sup>(1)</sup> The quoted IEC standards are also released as EN standards with the same number and identical contents.
- <sup>(2)</sup> The IEC 62474 list of declarable substances is maintained in a dedicated database, which is available at <http://std.iec.ch/iec62474>.
- <sup>(3)</sup> The Global Automotive Declarable Substance List (GADSL) is maintained by the American Chemistry Council and available at [www.gadsl.org](http://www.gadsl.org).
- <sup>(4)</sup> The SVHC list is maintained by the European Chemical Agency (ECHA) and available at <http://echa.europa.eu/candidate-list-table>.

The products do not contain any of the banned substances as per IEC 62474, GADSL, or the SVHC list, see [www.vishay.com/how/leadfree](http://www.vishay.com/how/leadfree).

Hence the products fully comply with the following directives:

- 2000/53/EC End-of-Life Vehicle Directive (ELV) and Annex II (ELV II)
- 2011/65/EU Restriction of the Use of Hazardous Substances Directive (RoHS) with amendment 2015/863/EU
- 2012/19/EU Waste Electrical and Electronic Equipment Directive (WEEE)

Vishay pursues the elimination of conflict minerals from its supply chain, see the Conflict Minerals Policy at [www.vishay.com/doc?49037](http://www.vishay.com/doc?49037).

## APPROVALS

The resistors are approved within the IECQ-CECC Quality Assessment System for Electronic Components to the detail specification **EN 140401-801** which refers to **EN 60115-1**, **EN 60115-8** and the variety of environmental test procedures of the **IEC 60068** <sup>(1)</sup> series.

Conformity is attested by the use of the **CECC** logo () as the mark of conformity on the package label.

Vishay Beyschlag has achieved “**Approval of Manufacturer**” in accordance with **IECQ 03-1**. The release certificate for “**Technology Approval Schedule**” in accordance with **CECC 240001** based on **IECQ 03-3-1** is granted for the Vishay Beyschlag manufacturing process.

## RELATED PRODUCTS

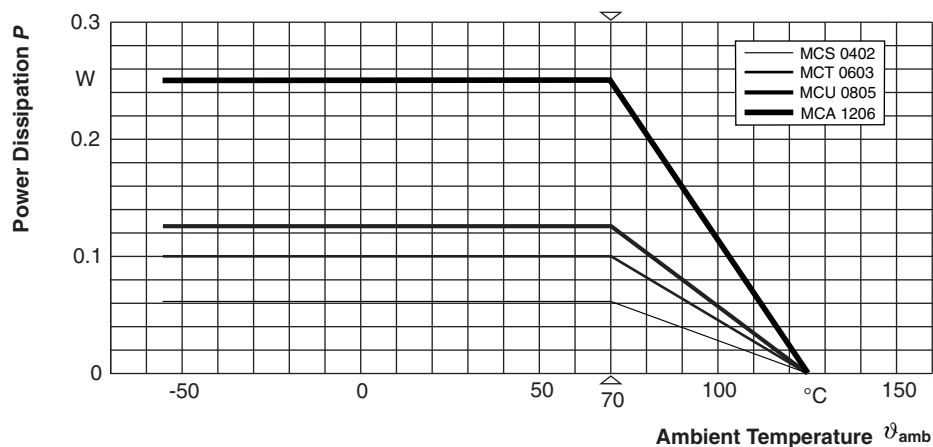
Resistors are available with established reliability in accordance with EN 140401-801 version E. Please refer to the special datasheet ([www.vishay.com/doc?28744](http://www.vishay.com/doc?28744)) for information on failure rate level, available resistance ranges and order codes.

For more information about products with higher rated power and higher operation temperature please refer to the Professional Thin Film Chip Resistor datasheet ([www.vishay.com/doc?28705](http://www.vishay.com/doc?28705)).

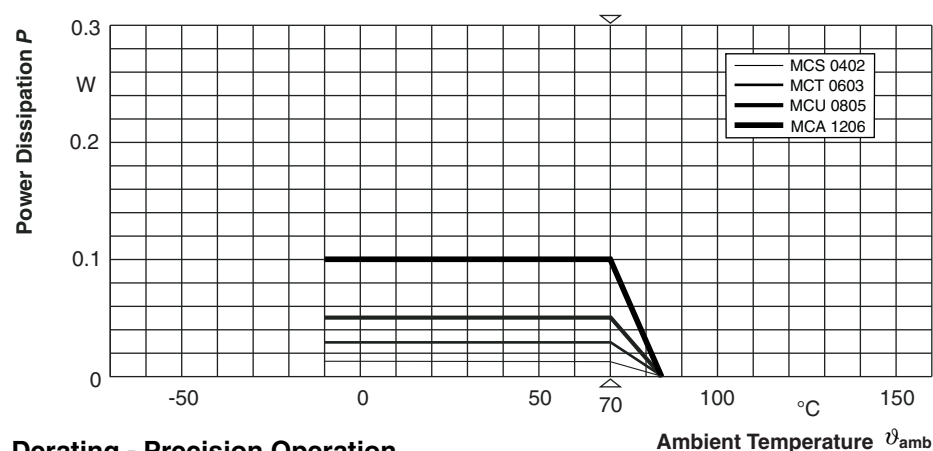
Precision chip resistor arrays may be used in voltage divider applications or precision amplifiers where close matching between multiple resistors is necessary. Please refer to the ACAS 0612 - Precision datasheet ([www.vishay.com/doc?28751](http://www.vishay.com/doc?28751)).



## FUNCTIONAL PERFORMANCE



Derating - Standard Operation



Derating - Precision Operation



In accordance with IEC 60195

## Current Noise Voltage Ratio



## TESTS AND REQUIREMENTS

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

EN 60115-1, generic specification

EN 60115-8 (successor of EN 140400), sectional specification

EN 140401-801, detail specification

IEC 60068-2-xx, test methods

The components are approved under the IECQ-CECC quality assessment system for electronic components.

The parameters stated in the Test Procedures and Requirements table are based on the required tests and permitted limits of EN 140401-801. The table presents only the most important tests, for the full test schedule refer to the documents listed above. However, some additional tests and a number of improvements against those minimum requirements have been included.

The testing also covers most of the requirements specified by EIA/ECA-703 and JIS-C-5201-1.

The tests are carried out under standard atmospheric conditions in accordance with IEC 60068-1, 4.3, whereupon the following values are applied:

Temperature: 15 °C to 35 °C

Relative humidity: 25 % to 75 %

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

A climatic category LCT / UCT / 56 is applied, defined by the lower category temperature (LCT), the upper category temperature (UCT), and the duration of exposure in the damp heat, steady state test (56 days).

The components are mounted for testing on printed circuit boards in accordance with EN 60115-8, 2.4.2, unless otherwise specified.

| TEST PROCEDURES AND REQUIREMENTS |                                      |                                                       |                                                                                                                                                |                                                                   |                                                                        |
|----------------------------------|--------------------------------------|-------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|------------------------------------------------------------------------|
| EN<br>60115-1<br>CLAUSE          | IEC<br>60068-2 (1)<br>TEST<br>METHOD | TEST                                                  | PROCEDURE                                                                                                                                      | REQUIREMENTS<br>PERMISSIBLE CHANGE ( $\Delta R$ )                 |                                                                        |
|                                  |                                      |                                                       |                                                                                                                                                | STABILITY CLASS 0.1                                               | STABILITY CLASS 0.25                                                   |
|                                  |                                      |                                                       | Stability for product types:                                                                                                                   |                                                                   |                                                                        |
|                                  |                                      |                                                       | <b>MCS 0402</b>                                                                                                                                | 100 $\Omega$ to 10 k $\Omega$                                     | > 10 k $\Omega$ to 221 k $\Omega$                                      |
|                                  |                                      |                                                       | <b>MCT 0603</b>                                                                                                                                | 100 $\Omega$ to 10 k $\Omega$                                     | 39 $\Omega$ to < 100 $\Omega$ ;<br>> 10 k $\Omega$ to 511 k $\Omega$   |
|                                  |                                      |                                                       | <b>MCU 0805</b>                                                                                                                                | 100 $\Omega$ to 47.5 k $\Omega$                                   | 39 $\Omega$ to < 100 $\Omega$ ;<br>> 47.5 k $\Omega$ to 1.5 M $\Omega$ |
|                                  |                                      |                                                       | <b>MCA 1206</b>                                                                                                                                | 47 $\Omega$ to 332 k $\Omega$                                     | 39 $\Omega$ to < 47 $\Omega$ ;<br>> 332 k $\Omega$ to 2 M $\Omega$     |
| 4.5                              | -                                    | Resistance                                            | -                                                                                                                                              | $\pm 0.1 \% R$ ; $\pm 0.25 \% R$                                  |                                                                        |
| 4.8                              | -                                    | Temperature<br>coefficient                            | At (20 / - 10 / 20) °C and<br>(20 / 85 / 20) °C                                                                                                | $\pm 25$ ppm/K; $\pm 15$ ppm/K;<br>$\pm 10$ ppm/K                 | -                                                                      |
|                                  |                                      |                                                       | At (20 / - 55 / 20) °C and<br>(20 / 125 / 20) °C                                                                                               | -                                                                 | $\pm 25$ ppm/K; $\pm 15$ ppm/K;<br>$\pm 10$ ppm/K                      |
| 4.25.1                           | -                                    | Endurance<br>at 70 °C:<br>precision<br>operation mode | $U = \sqrt{P_{70} \times R}$ or $U = U_{max.}$ ;<br>whichever is the less<br>severe;<br>1.5 h on; 0.5 h off;<br>70 °C; 1000 h<br>70 °C; 8000 h | $\pm (0.05 \% R + 0.02 \Omega)$<br>$\pm (0.1 \% R + 0.02 \Omega)$ |                                                                        |
|                                  |                                      | Endurance<br>at 70 °C:<br>standard<br>operation mode  | $U = \sqrt{P_{70} \times R}$ or $U = U_{max.}$ ;<br>whichever is the less<br>severe;<br>1.5 h on; 0.5 h off;<br>70 °C; 1000 h<br>70 °C; 8000 h | $\pm (0.1 \% R + 0.02 \Omega)$<br>$\pm (0.25 \% R + 0.05 \Omega)$ |                                                                        |
| 4.25.3                           | -                                    | Endurance at<br>upper category<br>temperature         | 85 °C; 1000 h                                                                                                                                  | $\pm (0.1 \% R + 0.02 \Omega)$                                    | $\pm (0.2 \% R + 0.02 \Omega)$                                         |
|                                  |                                      |                                                       | 125 °C; 1000 h                                                                                                                                 | $\pm (0.2 \% R + 0.02 \Omega)$                                    | $\pm (0.25 \% R + 0.05 \Omega)$                                        |
| 4.24                             | 78 (Cab)                             | Damp heat,<br>steady state                            | (40 $\pm$ 2) °C; 56 days;<br>(93 $\pm$ 3) % RH                                                                                                 | $\pm (0.1 \% R + 0.02 \Omega)$                                    | $\pm (0.25 \% R + 0.05 \Omega)$                                        |

| TEST PROCEDURES AND REQUIREMENTS |                                      |                                                                      |                                                                                                                                                               |                                                      |                                                                        |
|----------------------------------|--------------------------------------|----------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|------------------------------------------------------------------------|
| EN<br>60115-1<br>CLAUSE          | IEC<br>60068-2 (1)<br>TEST<br>METHOD | TEST                                                                 | PROCEDURE                                                                                                                                                     | REQUIREMENTS<br>PERMISSIBLE CHANGE ( $\Delta R$ )    |                                                                        |
|                                  |                                      |                                                                      |                                                                                                                                                               | STABILITY CLASS 0.1                                  | STABILITY CLASS 0.25                                                   |
|                                  |                                      |                                                                      | Stability for product types:                                                                                                                                  |                                                      |                                                                        |
|                                  |                                      |                                                                      | <b>MCS 0402</b>                                                                                                                                               | 100 $\Omega$ to 10 k $\Omega$                        | > 10 k $\Omega$ to 221 k $\Omega$                                      |
|                                  |                                      |                                                                      | <b>MCT 0603</b>                                                                                                                                               | 100 $\Omega$ to 10 k $\Omega$                        | 39 $\Omega$ to < 100 $\Omega$ ;<br>> 10 k $\Omega$ to 511 k $\Omega$   |
|                                  |                                      |                                                                      | <b>MCU 0805</b>                                                                                                                                               | 100 $\Omega$ to 47.5 k $\Omega$                      | 39 $\Omega$ to < 100 $\Omega$ ;<br>> 47.5 k $\Omega$ to 1.5 M $\Omega$ |
|                                  |                                      |                                                                      | <b>MCA 1206</b>                                                                                                                                               | 47 $\Omega$ to 332 k $\Omega$                        | 39 $\Omega$ to < 47 $\Omega$ ;<br>> 332 k $\Omega$ to 2 M $\Omega$     |
| 4.23                             |                                      | Climatic<br>sequence:<br>standard<br>operation mode:                 |                                                                                                                                                               |                                                      |                                                                        |
| 4.23.2                           | 2 (Bb)                               | Dry heat                                                             | 125 °C; 16 h                                                                                                                                                  |                                                      |                                                                        |
| 4.23.3                           | 30 (Db)                              | Damp heat,<br>cyclic                                                 | 55 °C; 24 h; > 90 % RH;<br>1 cycle                                                                                                                            |                                                      |                                                                        |
| 4.23.4                           | 1 (Ab)                               | Cold                                                                 | -55 °C; 2 h                                                                                                                                                   |                                                      |                                                                        |
| 4.23.5                           | 13 (M)                               | Low air pressure                                                     | 8.5 kPa; 2 h; (25 $\pm$ 10) °C                                                                                                                                | $\pm (0.1 \% R + 0.02 \Omega)$                       | $\pm (0.25 \% R + 0.05 \Omega)$                                        |
| 4.23.6                           | 30 (Db)                              | Damp heat,<br>cyclic                                                 | 55 °C; 24 h; > 90 % RH;<br>5 cycles                                                                                                                           |                                                      |                                                                        |
| 4.23.7                           | -                                    | DC load                                                              | $U = \sqrt{P_{70} \times R} \leq U_{max.};$<br>1 min.                                                                                                         |                                                      |                                                                        |
| -                                | 1 (Aa)                               | Cold                                                                 | -55 °C; 2 h                                                                                                                                                   | $\pm (0.05 \% R + 0.01 \Omega)$                      |                                                                        |
| 4.19                             | 14 (Na)                              | Rapid change<br>of temperature                                       | 30 min at LCT and<br>30 min at UCT;<br>LCT = -10 °C;<br>UCT = 85 °C;<br>5 cycles                                                                              | $\pm (0.05 \% R + 0.01 \Omega)$<br>no visible damage |                                                                        |
|                                  |                                      |                                                                      | LCT = -55 °C;<br>UCT = 125 °C;<br>1000 cycles                                                                                                                 | $\pm (0.25 \% R + 0.05 \Omega)$<br>no visible damage |                                                                        |
| 4.13                             | -                                    | Short time<br>overload:<br>precision<br>operation mode               | $U = 2.5 \times \sqrt{P_{70} \times R}$<br>or $U = 2 \times U_{max.};$<br>whichever is the less severe;<br>5 s                                                | $\pm (0.05 \% R + 0.01 \Omega)$                      |                                                                        |
|                                  |                                      | Short time<br>overload:<br>standard<br>operation mode                | $U = 2.5 \times \sqrt{P_{70} \times R}$<br>or $U = 2 \times U_{max.};$<br>whichever is the less severe;<br>5 s                                                | $\pm (0.05 \% R + 0.01 \Omega)$                      |                                                                        |
| 4.27                             | -                                    | Single pulse high<br>voltage overload:<br>standard<br>operation mode | Severity no. 4:<br>$U = 10 \times \sqrt{P_{70} \times R}$<br>or $U = 2 \times U_{max.};$<br>whichever is the less severe;<br>10 pulses 10 $\mu$ s/700 $\mu$ s | $\pm (0.5 \% R + 0.05 \Omega)$<br>no visible damage  |                                                                        |
| 4.39                             | -                                    | Periodic electric<br>overload:<br>standard<br>operation mode         | $U = \sqrt{15 \times P_{70} \times R}$<br>or $U = 2 \times U_{max.};$<br>whichever is the less severe;<br>0.1 s on; 2.5 s off;<br>1000 cycles                 | $\pm (0.5 \% R + 0.05 \Omega)$<br>no visible damage  |                                                                        |



| TEST PROCEDURES AND REQUIREMENTS |                                                 |                                                |                                                                                                                                                                                 |                                                                                        |                                                                        |
|----------------------------------|-------------------------------------------------|------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------------|
| EN<br>60115-1<br>CLAUSE          | IEC<br>60068-2 <sup>(1)</sup><br>TEST<br>METHOD | TEST                                           | PROCEDURE                                                                                                                                                                       | REQUIREMENTS<br>PERMISSIBLE CHANGE ( $\Delta R$ )                                      |                                                                        |
|                                  |                                                 |                                                |                                                                                                                                                                                 | STABILITY CLASS 0.1                                                                    | STABILITY CLASS 0.25                                                   |
|                                  |                                                 |                                                | Stability for product types:                                                                                                                                                    |                                                                                        |                                                                        |
|                                  |                                                 |                                                | <b>MCS 0402</b>                                                                                                                                                                 | 100 $\Omega$ to 10 k $\Omega$                                                          | > 10 k $\Omega$ to 221 k $\Omega$                                      |
|                                  |                                                 |                                                | <b>MCT 0603</b>                                                                                                                                                                 | 100 $\Omega$ to 10 k $\Omega$                                                          | 39 $\Omega$ to < 100 $\Omega$ ;<br>> 10 k $\Omega$ to 511 k $\Omega$   |
|                                  |                                                 |                                                | <b>MCU 0805</b>                                                                                                                                                                 | 100 $\Omega$ to 47.5 k $\Omega$                                                        | 39 $\Omega$ to < 100 $\Omega$ ;<br>> 47.5 k $\Omega$ to 1.5 M $\Omega$ |
|                                  |                                                 |                                                | <b>MCA 1206</b>                                                                                                                                                                 | 47 $\Omega$ to 332 k $\Omega$                                                          | 39 $\Omega$ to < 47 $\Omega$ ;<br>> 332 k $\Omega$ to 2 M $\Omega$     |
| 4.38                             | -                                               | Electro static discharge<br>(human body model) | IEC 61340-3-1 <sup>(1)</sup> ;<br>3 pos. + 3 neg.<br>(equivalent to MIL-STD-883,<br>method 3015)<br>MCS 0402: 500 V<br>MCT 0603: 1000 V<br>MCU 0805: 1500 V<br>MCA 1206: 2000 V | $\pm (0.5 \% R + 0.05 \Omega)$                                                         |                                                                        |
| 4.22                             | 6 (Fc)                                          | Vibration                                      | Endurance by sweeping;<br>10 Hz to 2000 Hz;<br>no resonance; amplitude<br>$\leq 1.5$ mm or $\leq 200$ m/s <sup>2</sup> ;<br>7.5 h                                               | $\pm (0.05 \% R + 0.01 \Omega)$<br>no visible damage                                   |                                                                        |
| 4.17                             | 58 (Td)                                         | Solderability                                  | Solder bath method;<br>SnPb40; non-activated flux;<br>(215 $\pm$ 3) °C; (3 $\pm$ 0.3) s                                                                                         | Good tinning ( $\geq 95$ % covered);<br>no visible damage                              |                                                                        |
|                                  |                                                 |                                                | Solder bath method;<br>SnAg3Cu0.5 or SnAg3.5;<br>non-activated flux;<br>(235 $\pm$ 3) °C; (2 $\pm$ 0.2) s                                                                       | Good tinning ( $\geq 95$ % covered);<br>no visible damage                              |                                                                        |
| 4.18                             | 58 (Td)                                         | Resistance to soldering heat                   | Solder bath method;<br>(260 $\pm$ 5) °C; (10 $\pm$ 1) s                                                                                                                         | $\pm (0.05 \% R + 0.01 \Omega)$                                                        |                                                                        |
| 4.29                             | 45 (XA)                                         | Component solvent resistance                   | Isopropyl alcohol; + 50 °C;<br>method 2                                                                                                                                         | No visible damage                                                                      |                                                                        |
| 4.32                             | 21 (Ue <sub>3</sub> )                           | Shear<br>(adhesion)                            | MCS 0402 and MCT 0603;<br>9 N                                                                                                                                                   | No visible damage                                                                      |                                                                        |
|                                  |                                                 |                                                | MCU 0805 and MCA 1206;<br>45 N                                                                                                                                                  | No visible damage                                                                      |                                                                        |
| 4.33                             | 21 (Ue <sub>1</sub> )                           | Substrate bending                              | Depth 2 mm, 3 times                                                                                                                                                             | $\pm (0.05 \% R + 0.01 \Omega)$<br>no visible damage, no open circuit in bent position |                                                                        |
| 4.7                              | -                                               | Voltage proof                                  | $U_{RMS} = U_{ins}$ ; (60 $\pm$ 5) s                                                                                                                                            | No flashover or breakdown                                                              |                                                                        |
| 4.35                             | -                                               | Flammability                                   | IEC 60695-11-5 <sup>(1)</sup> ,<br>needle flame test; 10 s                                                                                                                      | No burning after 30 s                                                                  |                                                                        |

## Note

<sup>(1)</sup> The quoted IEC standards are also released as EN standards with the same number and identical contents.

## DIMENSIONS



| DIMENSIONS AND MASS |                     |                   |             |                     |                     |                     |           |
|---------------------|---------------------|-------------------|-------------|---------------------|---------------------|---------------------|-----------|
| TYPE / SIZE         | H (mm)              | L (mm)            | W (mm)      | W <sub>T</sub> (mm) | T <sub>t</sub> (mm) | T <sub>b</sub> (mm) | MASS (mg) |
| MCS 0402            | 0.32 ± 0.05         | 1.0 ± 0.05        | 0.5 ± 0.05  | > 75 % of W         | 0.2 + 0.1 / - 0.15  | 0.2 ± 0.1           | 0.6       |
| MCT 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       |
| MCU 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       |
| MCA 1206            | 0.55 ± 0.1          | 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 / SIZE                       | WAVE SOLDERING |        |        |        | REFLOW SOLDERING |        |        |        |
|                                   | G (mm)         | Y (mm) | X (mm) | Z (mm) | G (mm)           | Y (mm) | X (mm) | Z (mm) |
| MCS 0402                          | -              | -      | -      | -      | 0.35             | 0.55   | 0.55   | 1.45   |
| MCT 0603                          | 0.55           | 1.10   | 1.10   | 2.75   | 0.65             | 0.70   | 0.95   | 2.05   |
| MCU 0805                          | 0.80           | 1.25   | 1.50   | 3.30   | 0.90             | 0.90   | 1.40   | 2.70   |
| MCA 1206                          | 1.40           | 1.50   | 1.90   | 4.40   | 1.50             | 1.15   | 1.75   | 3.80   |

### Notes

- The given solder pad dimensions reflect the considerations for board design and assembly as outlined e.g. in standards IEC 61188-5-x <sup>(1)</sup>, or in publication IPC-7351.

<sup>(1)</sup> The quoted IEC standards are also released as EN standards with the same number and identical contents.

**HISTORICAL 12NC INFORMATION**

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

**Last Digit of 12NC Indicating Resistance Decade**

| RESISTANCE DECADE                | LAST DIGIT |
|----------------------------------|------------|
| 10 $\Omega$ to 99.9 $\Omega$     | 9          |
| 100 $\Omega$ to 999 $\Omega$     | 1          |
| 1 k $\Omega$ to 9.99 k $\Omega$  | 2          |
| 10 k $\Omega$ to 99.9 k $\Omega$ | 3          |
| 100 k $\Omega$ to 999 k $\Omega$ | 4          |
| 1 M $\Omega$ to 9.99 M $\Omega$  | 5          |

**Historical 12NC example**

The 12NC of a MCT 0603 resistor, value 47 k $\Omega$  and TCR 25 with  $\pm 0.1$  % tolerance, supplied in cardboard tape of 5000 units per reel was: 2312 216 74703.

| <b>HISTORICAL 12NC - Resistors type and packaging</b> |                |              |                        |                  |                    |                  |                    |
|-------------------------------------------------------|----------------|--------------|------------------------|------------------|--------------------|------------------|--------------------|
| DESCRIPTION                                           |                |              | 2312... ..             |                  |                    |                  |                    |
|                                                       |                |              | CARDBOARD TAPE ON REEL |                  |                    |                  |                    |
| TYPE                                                  | TCR            | TOL.         | P1<br>1000 UNITS       | P5<br>5000 UNITS | PW<br>20 000 UNITS | E1<br>1000 UNITS | E0<br>10 000 UNITS |
| MCS 0402                                              | $\pm 25$ ppm/K | $\pm 0.25$ % | -                      | -                | -                  | 261 6....        | 276 6....          |
|                                                       |                | $\pm 0.1$ %  | -                      | -                | -                  | 261 7....        | 276 7....          |
|                                                       | $\pm 15$ ppm/K | $\pm 0.25$ % | -                      | -                | -                  | 262 6....        | 277 6....          |
|                                                       |                | $\pm 0.1$ %  | -                      | -                | -                  | 262 7....        | 277 7....          |
|                                                       | $\pm 10$ ppm/K | $\pm 0.25$ % | -                      | -                | -                  | 263 6....        | 278 6....          |
|                                                       |                | $\pm 0.1$ %  | -                      | -                | -                  | 263 7....        | 278 7....          |
| MCT 0603                                              | $\pm 25$ ppm/K | $\pm 0.25$ % | 201 6....              | 216 6....        | 206 6....          | -                | -                  |
|                                                       |                | $\pm 0.1$ %  | 201 7....              | 216 7....        | 206 7....          | -                | -                  |
|                                                       | $\pm 15$ ppm/K | $\pm 0.25$ % | 202 6....              | 217 6....        | 207 6....          | -                | -                  |
|                                                       |                | $\pm 0.1$ %  | 202 7....              | 217 7....        | 207 7....          | -                | -                  |
|                                                       | $\pm 10$ ppm/K | $\pm 0.25$ % | 203 6....              | 218 6....        | 208 6....          | -                | -                  |
|                                                       |                | $\pm 0.1$ %  | 203 7....              | 218 7....        | 208 7....          | -                | -                  |
| MCU 0805                                              | $\pm 25$ ppm/K | $\pm 0.25$ % | 241 6....              | 256 6....        | 246 6....          | -                | -                  |
|                                                       |                | $\pm 0.1$ %  | 241 7....              | 256 7....        | 246 7....          | -                | -                  |
|                                                       | $\pm 15$ ppm/K | $\pm 0.25$ % | 242 6....              | 257 6....        | 247 6....          | -                | -                  |
|                                                       |                | $\pm 0.1$ %  | 242 7....              | 257 7....        | 247 7....          | -                | -                  |
|                                                       | $\pm 10$ ppm/K | $\pm 0.25$ % | 243 6....              | 258 6....        | 248 6....          | -                | -                  |
|                                                       |                | $\pm 0.1$ %  | 243 7....              | 258 7....        | 248 7....          | -                | -                  |
| MCA 1206                                              | $\pm 25$ ppm/K | $\pm 0.25$ % | 381 6....              | 396 6....        | 386 6....          | -                | -                  |
|                                                       |                | $\pm 0.1$ %  | 381 7....              | 396 7....        | 386 7....          | -                | -                  |
|                                                       | $\pm 15$ ppm/K | $\pm 0.25$ % | 382 6....              | 397 6....        | 387 6....          | -                | -                  |
|                                                       |                | $\pm 0.1$ %  | 382 7....              | 397 7....        | 387 7....          | -                | -                  |
|                                                       | $\pm 10$ ppm/K | $\pm 0.25$ % | 383 6....              | 398 6....        | 388 6....          | -                | -                  |
|                                                       |                | $\pm 0.1$ %  | 383 7....              | 398 7....        | 388 7....          | -                | -                  |



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