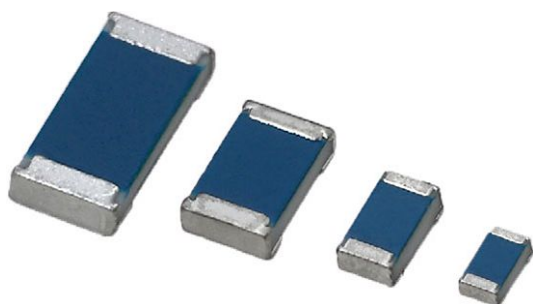




## High Stability Thin Film Flat Chip Resistors



## FEATURES

- Rated dissipation  $P_{70}$  up to 0.52 W for size 1206
- AEC-Q200 qualified
- IECQ-CECC approved to EN 140401-801
- Operating temperature up to 175 °C
- Superior temperature cycling robustness
- Superior moisture resistivity,  $|\Delta R/R| < 0.1 \%$  (85 °C; 85 % RH; 1000 h)
- Advanced 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)

RoHS  
COMPLIANT

Vishay Automotive Grade MC AT thin film chip resistors are the perfect choice for most fields of modern electronics where reliability and stability is of major concern. Typical applications include automotive, industrial, telecommunication and medical equipment, as well as precision test and measuring equipment.

## APPLICATIONS

- Automotive
- Industrial equipment with enhanced requirements
- Telecommunication
- Medical equipment

## TECHNICAL SPECIFICATIONS

| DESCRIPTION                                                           | MCS 0402 AT                                       | MCT 0603 AT                                                     | MCU 0805 AT                                       | MCA 1206 AT       |
|-----------------------------------------------------------------------|---------------------------------------------------|-----------------------------------------------------------------|---------------------------------------------------|-------------------|
| Imperial size                                                         | 0402                                              | 0603                                                            | 0805                                              | 1206              |
| Metric size code                                                      | RR1005M                                           | RR1608M                                                         | RR2012M                                           | RR3216M           |
| Resistance range                                                      | 1 Ω to 1 MΩ; 0 Ω                                  | 1 Ω to 2 MΩ; 0 Ω                                                | 1 Ω to 7.5 MΩ; 0 Ω                                | 1 Ω to 10 MΩ; 0 Ω |
| Resistance tolerance                                                  | ± 1 %; ± 0.5 %; ± 0.1 %                           | ± 1 %; ± 0.5 %; ± 0.1 %;<br>± 0.05 %                            | ± 1 %; ± 0.5 %; ± 0.1 %                           |                   |
| Temperature coefficient                                               | ± 50 ppm/K; ± 25 ppm/K;<br>± 15 ppm/K; ± 10 ppm/K | ± 50 ppm/K; ± 25 ppm/K;<br>± 15 ppm/K; ± 10 ppm/K;<br>± 5 ppm/K | ± 50 ppm/K; ± 25 ppm/K;<br>± 15 ppm/K; ± 10 ppm/K |                   |
| Rated dissipation $P_{70}$ <sup>(1)</sup>                             | 0.130 W                                           | 0.210 W                                                         | 0.260 W                                           | 0.520 W           |
| Operating voltage, $U_{max}$ AC <sub>RMS</sub> /DC                    | 50 V                                              | 75 V                                                            | 150 V                                             | 200 V             |
| Permissible film temperature, $\vartheta_{F max}$ <sup>(1)</sup>      | 175 °C                                            |                                                                 |                                                   |                   |
| Operating temperature range <sup>(2)</sup>                            | -55 °C to 175 °C                                  |                                                                 |                                                   |                   |
| Internal thermal resistance (typical) <sup>(1)</sup>                  | 90 K/W                                            | 63 K/W                                                          | 38 K/W                                            | 32 K/W            |
| Permissible voltage against ambient (insulation):<br>1 min; $U_{ins}$ | 75 V                                              | 100 V                                                           | 200 V                                             | 300 V             |
| Failure rate: FIT <sub>observed</sub>                                 | ≤ 0.1 x 10 <sup>-9</sup> /h                       |                                                                 |                                                   |                   |

## Notes

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

<sup>(2)</sup> Please refer to table MAXIMUM RESISTANCE CHANGE AT RATED DISSIPATION, see 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.

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.

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                                                                 |             | GENERAL                             |                                    | POWER                               |                                    | ADVANCED                            |                                    |
| Rated dissipation, $P_{70}$                                                    | MCS 0402 AT | 0.070 W                             |                                    | 0.105 W                             |                                    | 0.130 W                             |                                    |
|                                                                                | MCT 0603 AT | 0.110 W                             |                                    | 0.170 W                             |                                    | 0.210 W                             |                                    |
|                                                                                | MCU 0805 AT | 0.140 W                             |                                    | 0.220 W                             |                                    | 0.260 W                             |                                    |
|                                                                                | MCA 1206 AT | 0.270 W                             |                                    | 0.420 W                             |                                    | 0.520 W                             |                                    |
| Operating temperature range                                                    |             | -55 °C to 125 °C                    |                                    | -55 °C to 155 °C                    |                                    | -55 °C to 175 °C                    |                                    |
| Permissible film temperature, $\vartheta_F$ max.                               |             | 125 °C                              |                                    | 155 °C                              |                                    | 175 °C                              |                                    |
| Max. resistance change at $P_{70}$ for resistance range, $ \Delta R/R $ after: | MCS 0402 AT | 1 $\Omega$ to $\leq 47$ k $\Omega$  | > 47 k $\Omega$ to 1 M $\Omega$    | 1 $\Omega$ to $\leq 47$ k $\Omega$  | > 47 k $\Omega$ to 1 M $\Omega$    | 1 $\Omega$ to $\leq 47$ k $\Omega$  | > 47 k $\Omega$ to 1 M $\Omega$    |
|                                                                                | MCT 0603 AT | 1 $\Omega$ to $\leq 100$ k $\Omega$ | > 100 k $\Omega$ to 2 M $\Omega$   | 1 $\Omega$ to $\leq 100$ k $\Omega$ | > 100 k $\Omega$ to 2 M $\Omega$   | 1 $\Omega$ to $\leq 100$ k $\Omega$ | > 100 k $\Omega$ to 2 M $\Omega$   |
|                                                                                | MCU 0805 AT | 1 $\Omega$ to $\leq 100$ k $\Omega$ | > 100 k $\Omega$ to 7.5 M $\Omega$ | 1 $\Omega$ to $\leq 100$ k $\Omega$ | > 100 k $\Omega$ to 7.5 M $\Omega$ | 1 $\Omega$ to $\leq 100$ k $\Omega$ | > 100 k $\Omega$ to 7.5 M $\Omega$ |
|                                                                                | MCA 1206 AT | 1 $\Omega$ to $\leq 100$ k $\Omega$ | > 100 k $\Omega$ to 10 M $\Omega$  | 1 $\Omega$ to $\leq 100$ k $\Omega$ | > 100 k $\Omega$ to 10 M $\Omega$  | 1 $\Omega$ to $\leq 100$ k $\Omega$ | > 100 k $\Omega$ to 10 M $\Omega$  |
|                                                                                | 1000 h      | $\leq 0.05$ %                       | $\leq 0.1$ %                       | $\leq 0.1$ %                        | $\leq 0.2$ %                       | $\leq 0.2$ %                        | $\leq 0.5$ %                       |
|                                                                                | 8000 h      | $\leq 0.1$ %                        | $\leq 0.2$ %                       | $\leq 0.2$ %                        | $\leq 0.4$ %                       | -                                   | -                                  |
|                                                                                | 225 000 h   | $\leq 0.3$ %                        | $\leq 0.6$ %                       | $\leq 0.6$ %                        | -                                  | -                                   | -                                  |

## 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 (1) |                                 |                      |                                  |           |
|--------------------------------------------------|---------------------------------|----------------------|----------------------------------|-----------|
| TYPE / SIZE                                      | TCR                             | TOLERANCE            | RESISTANCE                       | E-SERIES  |
| MCS 0402 AT                                      | $\pm 50$ ppm/K                  | $\pm 1$ %            | 1 $\Omega$ to 221 k $\Omega$     | E24; E96  |
|                                                  | $\pm 25$ ppm/K                  | $\pm 0.5$ %          | 10 $\Omega$ to 221 k $\Omega$    | E24; E192 |
|                                                  | $\pm 25$ ppm/K                  | $\pm 0.1$ %          | 47 $\Omega$ to 1 M $\Omega$      | E24; E192 |
|                                                  | $\pm 15$ ppm/K                  |                      | 47 $\Omega$ to 100 k $\Omega$    |           |
|                                                  | $\pm 10$ ppm/K                  |                      | 47 $\Omega$ to 47 k $\Omega$     |           |
|                                                  | Jumper (2); $I_{max.} = 0.63$ A | $\leq 20$ m $\Omega$ | 0 $\Omega$                       | -         |
| MCT 0603 AT                                      | $\pm 50$ ppm/K                  | $\pm 1$ %            | 1 $\Omega$ to 511 k $\Omega$     | E24; E96  |
|                                                  | $\pm 25$ ppm/K                  | $\pm 0.5$ %          | 10 $\Omega$ to 511 k $\Omega$    | E24; E192 |
|                                                  | $\pm 25$ ppm/K                  | $\pm 0.1$ %          | 47 $\Omega$ to 2 M $\Omega$      | E24; E192 |
|                                                  | $\pm 15$ ppm/K                  |                      | 47 $\Omega$ to 221 k $\Omega$    |           |
|                                                  | $\pm 10$ ppm/K                  |                      | 47 $\Omega$ to 100 k $\Omega$    |           |
|                                                  | $\pm 5$ ppm/K                   |                      | 3.9 k $\Omega$ to 100 k $\Omega$ |           |
|                                                  | $\pm 5$ ppm/K                   | $\pm 0.05$ %         | 3.9 k $\Omega$ to 100 k $\Omega$ | -         |
|                                                  | Jumper (2); $I_{max.} = 1$ A    | $\leq 20$ m $\Omega$ | 0 $\Omega$                       | -         |
| MCU 0805 AT                                      | $\pm 50$ ppm/K                  | $\pm 1$ %            | 1 $\Omega$ to 1 M $\Omega$       | E24; E96  |
|                                                  | $\pm 25$ ppm/K                  | $\pm 0.5$ %          | 10 $\Omega$ to 1 M $\Omega$      | E24; E192 |
|                                                  | $\pm 25$ ppm/K                  | $\pm 0.1$ %          | 47 $\Omega$ to 7.5 M $\Omega$    | E24; E192 |
|                                                  | $\pm 15$ ppm/K                  |                      | 47 $\Omega$ to 332 k $\Omega$    |           |
|                                                  | $\pm 10$ ppm/K                  |                      | 47 $\Omega$ to 100 k $\Omega$    |           |
|                                                  | Jumper (2); $I_{max.} = 1.5$ A  | $\leq 20$ m $\Omega$ | 0 $\Omega$                       | -         |
| MCA 1206 AT                                      | $\pm 50$ ppm/K                  | $\pm 1$ %            | 1 $\Omega$ to 1 M $\Omega$       | E24; E96  |
|                                                  | $\pm 25$ ppm/K                  | $\pm 0.5$ %          | 10 $\Omega$ to 1 M $\Omega$      | E24; E192 |
|                                                  | $\pm 25$ ppm/K                  | $\pm 0.1$ %          | 47 $\Omega$ to 10 M $\Omega$     | E24; E192 |
|                                                  | $\pm 15$ ppm/K                  |                      | 47 $\Omega$ to 511 k $\Omega$    |           |
|                                                  | $\pm 10$ ppm/K                  |                      | 47 $\Omega$ to 100 k $\Omega$    |           |
|                                                  | Jumper (2); $I_{max.} = 2$ A    | $\leq 20$ m $\Omega$ | 0 $\Omega$                       | -         |

## Notes

- (1) For the approved IECQ-CECC resistance range, including stability class information, please refer to [www.vishay.com/doc?28945](http://www.vishay.com/doc?28945)
- (2) The temperature coefficient of resistance (TCR) is not specified for 0  $\Omega$  jumpers



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

| PART NUMBER AND PRODUCT DESCRIPTION                                                          |                              |                                                                                                     |                                                                                                                                                                                                                                                         |                                                                       |                      |                                 |
|----------------------------------------------------------------------------------------------|------------------------------|-----------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|----------------------|---------------------------------|
| Part Number: MCT0603MD4641DPW00<br>Part Number: MCT0603MZ0000ZP500                           |                              |                                                                                                     |                                                                                                                                                                                                                                                         |                                                                       |                      |                                 |
| M                                                                                            | C                            | T                                                                                                   | 0                                                                                                                                                                                                                                                       | 6                                                                     | 0                    | 3                               |
| M                                                                                            | D                            | 4                                                                                                   | 6                                                                                                                                                                                                                                                       | 4                                                                     | 1                    | D                               |
| P                                                                                            | W                            | 0                                                                                                   | 0                                                                                                                                                                                                                                                       |                                                                       |                      |                                 |
| TYPE / SIZE                                                                                  | VERSION                      | TCR                                                                                                 | RESISTANCE                                                                                                                                                                                                                                              | TOLERANCE                                                             | PACKAGING            | SPECIAL                         |
| MCS0402<br>MCT0603<br>MCU0805<br>MCA1206                                                     | M = AT<br>(automotive)       | G = ± 5 ppm/K<br>F = ± 10 ppm/K<br>E = ± 15 ppm/K<br>D = ± 25 ppm/K<br>C = ± 50 ppm/K<br>Z = jumper | 3 digit value<br>1 digit multiplier<br><br>Multiplier<br>8 = *10 <sup>-2</sup><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><br>5 = *10 <sup>5</sup> | A = ± 0.05 %<br>B = ± 0.1 %<br>D = ± 0.5 %<br>F = ± 1 %<br>Z = jumper | E5<br>E0<br>P5<br>PW | Up to 2 digits<br>00 = standard |
| Product Description: MCT 0603-25 0.5 % AT PW 4K64<br>Product Description: MCT 0603 AT P5 0R0 |                              |                                                                                                     |                                                                                                                                                                                                                                                         |                                                                       |                      |                                 |
| MCT                                                                                          | 0603                         | -25                                                                                                 | 0.5 %                                                                                                                                                                                                                                                   | AT                                                                    | PW                   | 4K64                            |
| TYPE                                                                                         | SIZE                         | TCR                                                                                                 | TOLERANCE                                                                                                                                                                                                                                               | VERSION                                                               | PACKAGING            | RESISTANCE                      |
| MCS<br>MCT<br>MCU<br>MCA                                                                     | 0402<br>0603<br>0805<br>1206 | ± 5 ppm/K<br>± 10 ppm/K<br>± 15 ppm/K<br>± 25 ppm/K<br>± 50 ppm/K                                   | ± 0.05 %<br>± 0.1 %<br>± 0.5 %<br>± 1 %                                                                                                                                                                                                                 | AT = automotive                                                       | E5<br>E0<br>P5<br>PW | 4K64 = 4.64 kΩ<br>0R0 = jumper  |

**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 special 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 cutting a meander groove in the resistive layer without damaging the ceramics. The resistor elements are covered by a unique protective coating designed for electrical, mechanical and climatic protection. The terminations receive a final pure matte 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 (feasible for  $R \geq 10 \Omega$ ). 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. They are suitable for automatic soldering using wave, reflow or vapour phase as shown in **IEC 61760-1** <sup>(1)</sup>. 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 matte 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>

<sup>(5)</sup> For the approved IECQ-CECC resistance range, please refer to [www.vishay.com/doc?28945](http://www.vishay.com/doc?28945)

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

Where applicable, 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** <sup>(5)</sup> 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.

The resistors are qualified according to AEC-Q200.

## RELATED PRODUCTS

**Chip resistor arrays** may be used in sensing applications or precision amplifiers where close matching between multiple resistors is necessary. Please refer to the **ACAS AT - Precision** datasheet ([www.vishay.com/doc?28770](http://www.vishay.com/doc?28770)).

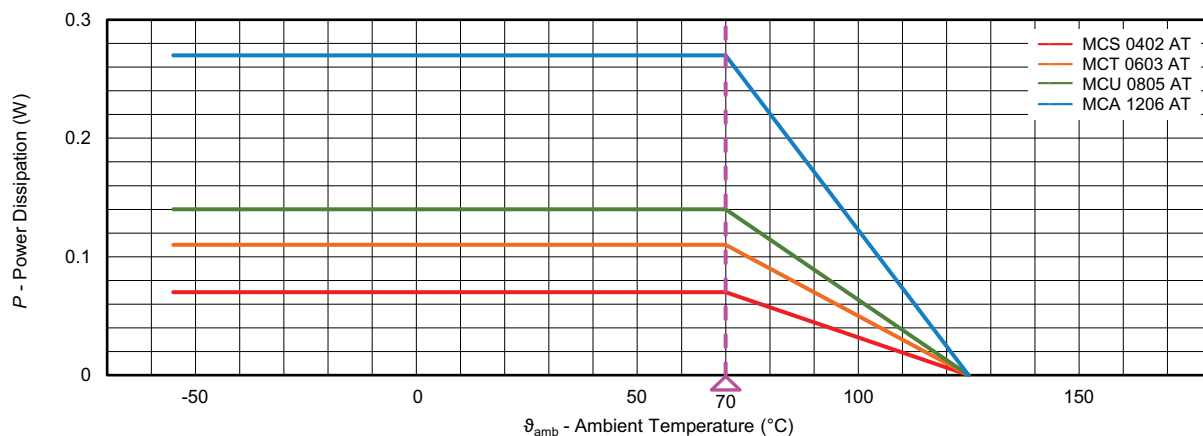
**MC AT** series is also available with gold termination for conductive gluing: **MC ATAU - Precision**. Please refer to the datasheet ([www.vishay.com/doc?28877](http://www.vishay.com/doc?28877)).

For high power and high temperature applications **MCW AT** wide terminal thin film chip resistors offer extremely high power ratings and extraordinary temperature cycling robustness. Please refer to the datasheets: [www.vishay.com/doc?28847](http://www.vishay.com/doc?28847) and [www.vishay.com/doc?28796](http://www.vishay.com/doc?28796).

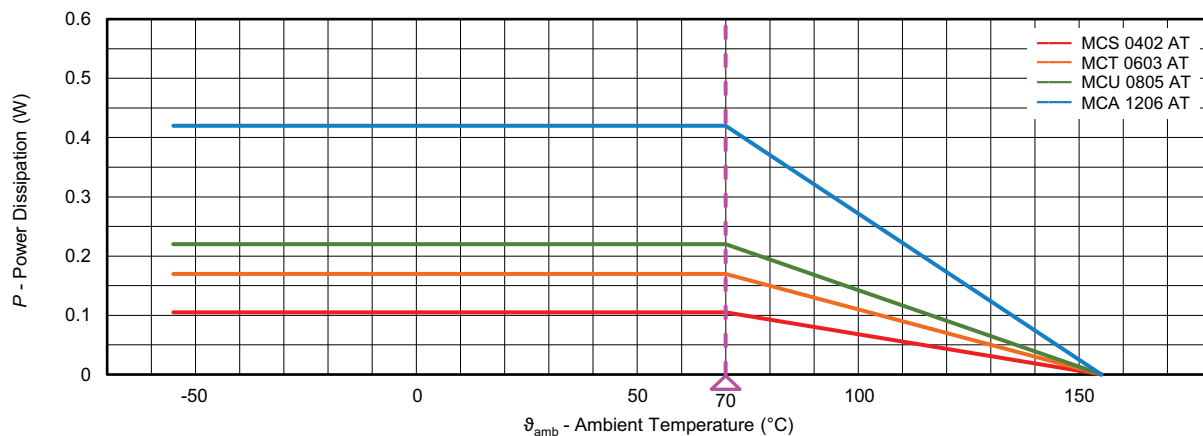
These wide-terminal products are also available in low-ohmic values, **NCW AT** ([www.vishay.com/doc?28849](http://www.vishay.com/doc?28849)).



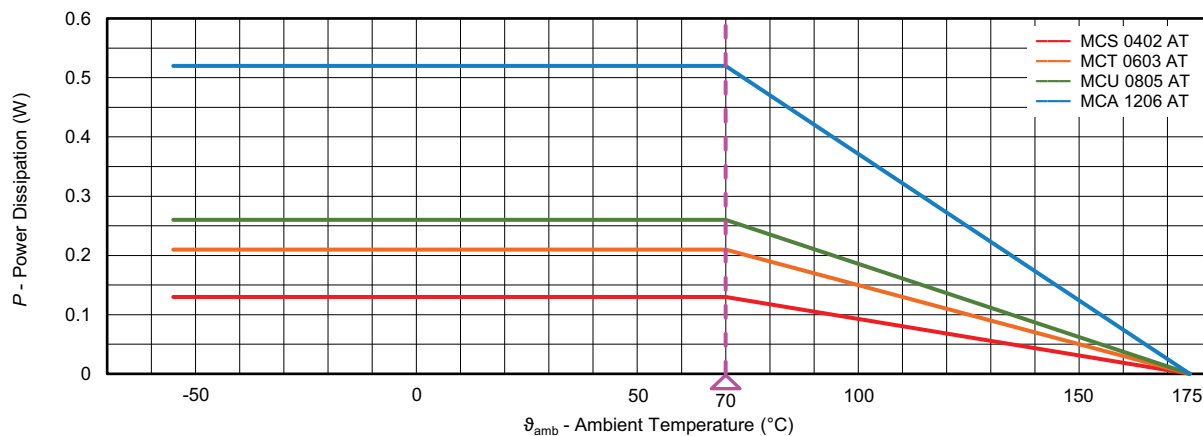
## FUNCTIONAL PERFORMANCE



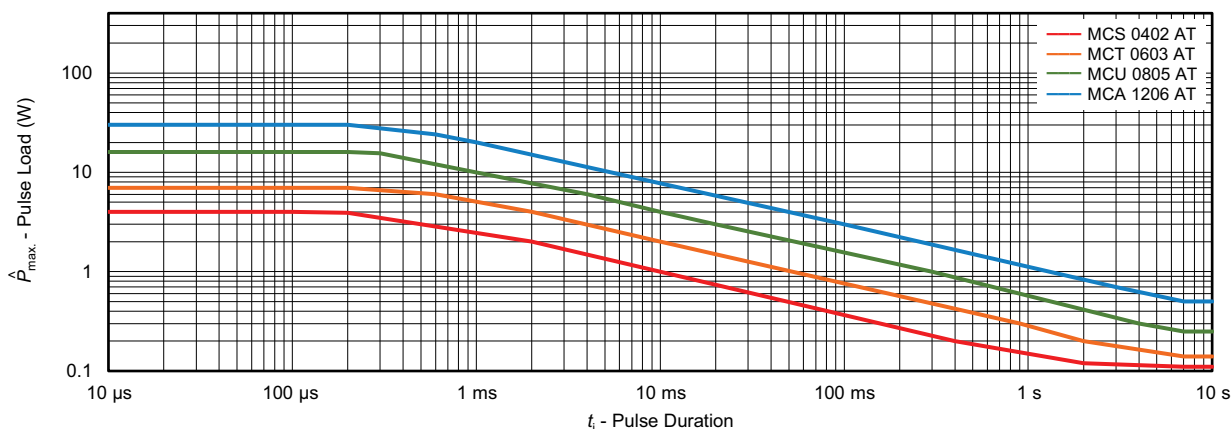
## Derating - General Operation



## Derating - Power Operation

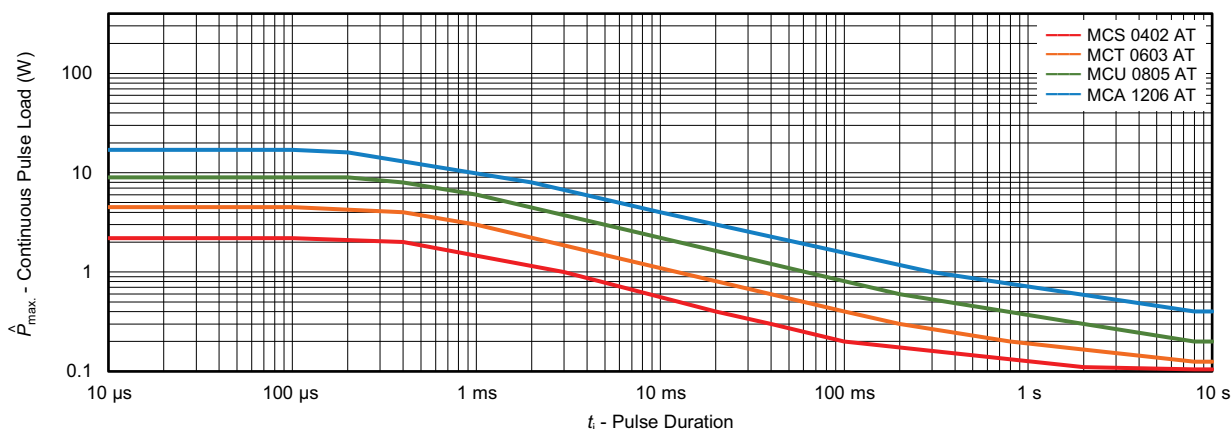


## Derating - Advanced Operation



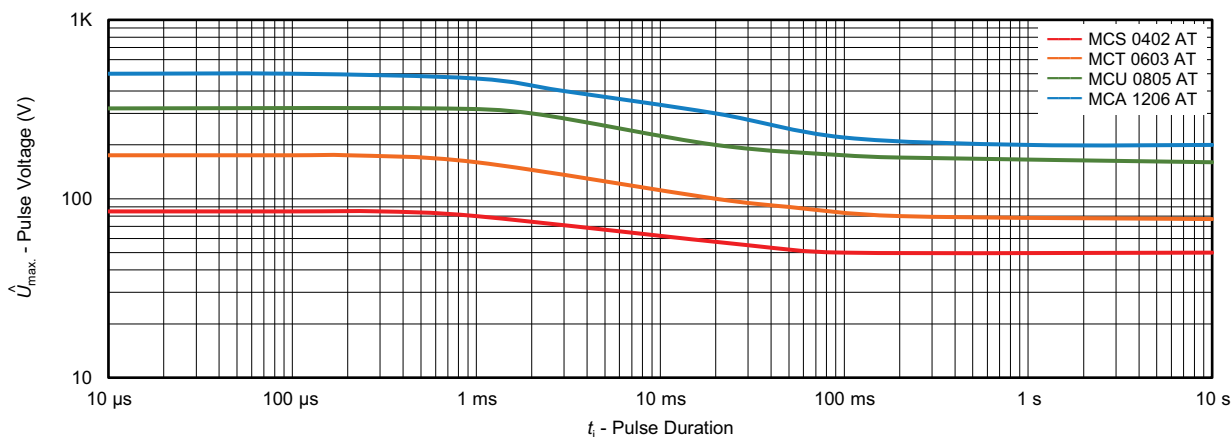
Maximum pulse load, single pulse; applicable if  $\bar{P} \rightarrow 0$  and  $n \leq 1000$  and  $\hat{U} \leq \hat{U}_{max}$ ; for permissible resistance change equivalent to 8000 h operation in standard operation mode

## Single Pulse <sup>(1)</sup>



Maximum pulse load, continuous pulses; applicable if  $\bar{P} \leq P(\vartheta_{amb})$  and  $\hat{U} \leq \hat{U}_{max}$ ; for permissible resistance change equivalent to 8000 h operation in standard operation mode

## Continuous Pulse <sup>(1)</sup>

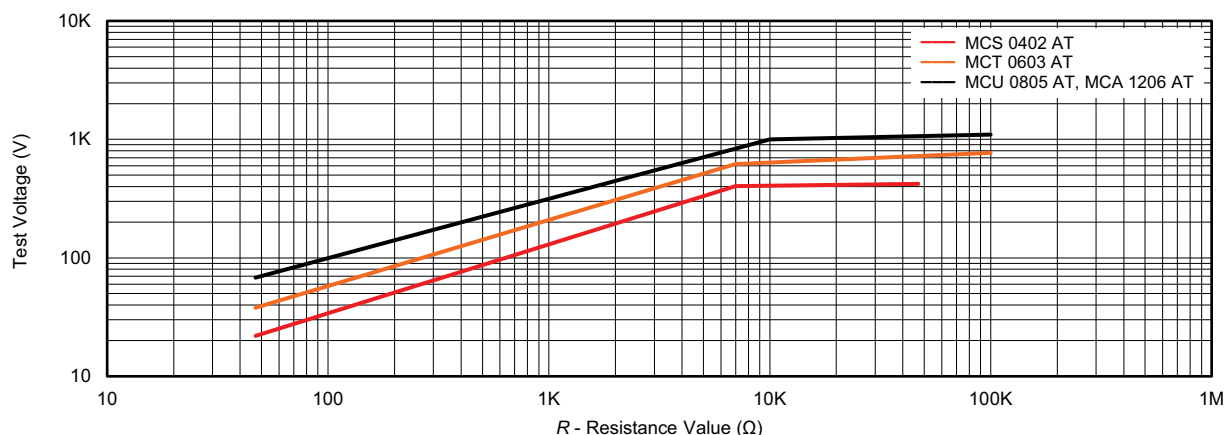


Maximum pulse voltage, single and continuous pulses; applicable if  $\hat{P} \leq \hat{P}_{max}$ ; for permissible resistance change equivalent to 8000 h operation in standard operation mode

## Pulse Voltage <sup>(1)</sup>

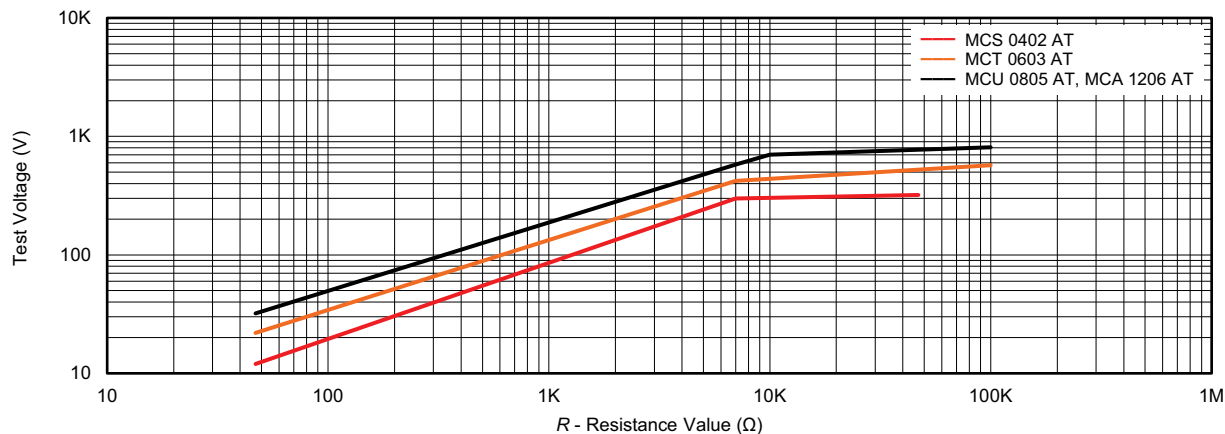
### Note

<sup>(1)</sup> Measured on components with  $\pm 0.5\%$  or  $\pm 1\%$  tolerance



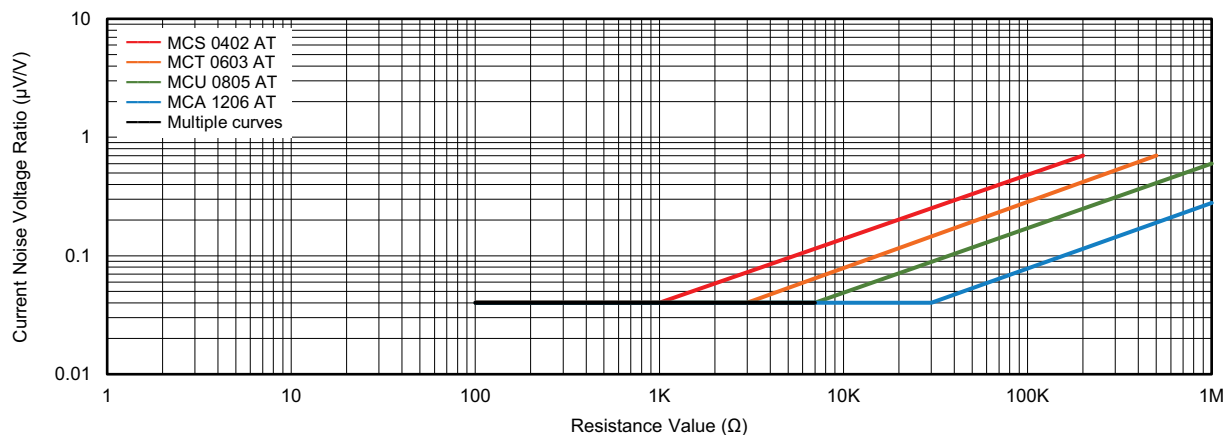
Pulse load rating in accordance with EN 60115-1 clause 4.27; 1.2  $\mu$ s/50  $\mu$ s;  
5 pulses at 12 s intervals; for permissible resistance change  $\pm (0.5 \% R + 0.05 \Omega)$

## 1.2/50 Pulse <sup>(1)</sup>



Pulse load rating in accordance with EN 60115-1 clause 4.27; 10  $\mu$ s/700  $\mu$ s;  
10 pulses at 1 minute intervals; for permissible resistance change  $\pm (0.5 \% R + 0.05 \Omega)$

## 10/700 Pulse <sup>(1)</sup>

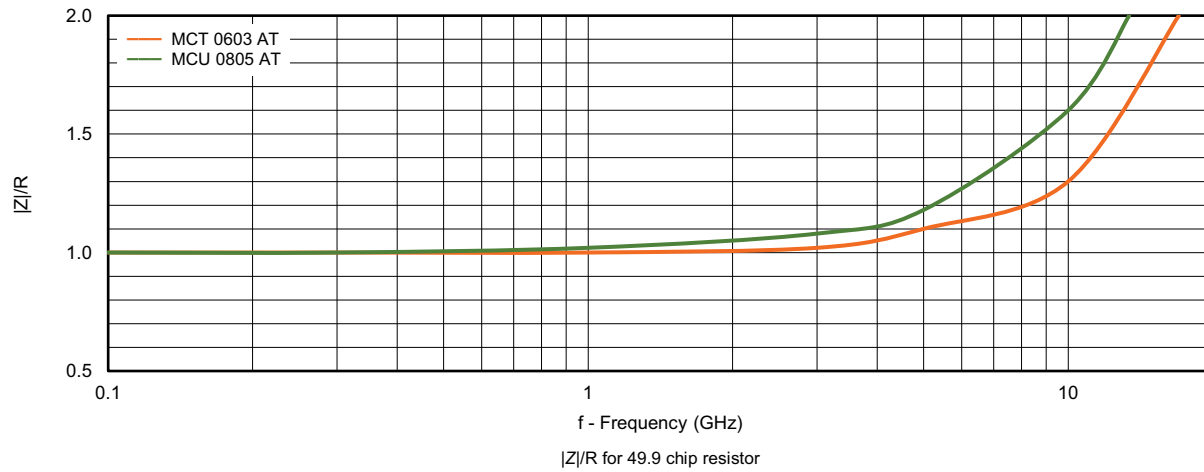


In accordance with IEC 60195

## Current Noise Voltage Ratio

### Note

<sup>(1)</sup> Measured on components with  $\pm 0.5 \%$  or  $\pm 1 \%$  tolerance



## RF-Behavior





## TESTS AND REQUIREMENTS

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

EN 60115-1, generic specification

EN 60115-8, sectional specification

EN 140401-801, detail specification

IEC 60068-2-xx, test methods

When applicable, 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 60115-1<br>CLAUSE             | IEC 60068-2 <sup>(1)</sup><br>TEST<br>METHOD | TEST                                                        | PROCEDURE                                                                                                                                                       | REQUIREMENTS<br>PERMISSIBLE CHANGE ( $\Delta R$ )                                                           |                                                                                                             |
|                                  |                                              |                                                             |                                                                                                                                                                 | HIGH ACCURACY                                                                                               | REGULAR ACCURACY                                                                                            |
|                                  |                                              |                                                             | Stability for product types:                                                                                                                                    |                                                                                                             |                                                                                                             |
|                                  |                                              |                                                             | MCS 0402 AT                                                                                                                                                     | 1 $\Omega$ to $\leq$ 47 k $\Omega$                                                                          | > 47 k $\Omega$ to 1 M $\Omega$                                                                             |
|                                  |                                              |                                                             | MCT 0603 AT                                                                                                                                                     | 1 $\Omega$ to $\leq$ 100 k $\Omega$                                                                         | > 100 k $\Omega$ to 2 M $\Omega$                                                                            |
|                                  |                                              |                                                             | MCU 0805 AT                                                                                                                                                     | 1 $\Omega$ to $\leq$ 100 k $\Omega$                                                                         | > 100 k $\Omega$ to 7.5 M $\Omega$                                                                          |
|                                  |                                              |                                                             | MCA 1206 AT                                                                                                                                                     | 1 $\Omega$ to $\leq$ 100 k $\Omega$                                                                         | > 100 k $\Omega$ to 10 M $\Omega$                                                                           |
| 4.5                              | -                                            | Resistance                                                  |                                                                                                                                                                 | $\pm 1\ \% R$ ; $\pm 0.5\ \% R$ ; $\pm 0.1\ \% R$ ; $\pm 0.05\ \% R$                                        |                                                                                                             |
| 4.8                              | -                                            | Temperature coefficient                                     | At (20 / -55 / 20) °C and (20 / 155 / 20) °C                                                                                                                    | $\pm 50$ ppm/K; $\pm 25$ ppm/K; $\pm 15$ ppm/K; $\pm 10$ ppm/K; $\pm 5$ ppm/K                               |                                                                                                             |
| 4.25.1                           | -                                            | Endurance at 70 °C:<br>general operation mode               | $U = \sqrt{P_{70} \times R}$ or $U = U_{max.}$ ;<br>whichever is the less severe;<br>1.5 h on; 0.5 h off;<br>70 °C; 1000 h<br>70 °C; 8000 h<br>70 °C; 225 000 h | $\pm (0.05\ \% R + 0.01\ \Omega)$<br>$\pm (0.10\ \% R + 0.02\ \Omega)$<br>$\pm (0.30\ \% R + 0.02\ \Omega)$ | $\pm (0.10\ \% R + 0.02\ \Omega)$<br>$\pm (0.20\ \% R + 0.02\ \Omega)$<br>$\pm (0.60\ \% R + 0.05\ \Omega)$ |
|                                  |                                              | Endurance at 70 °C:<br>power operation mode                 | $U = \sqrt{P_{70} \times R}$ or $U = U_{max.}$ ;<br>whichever is the less severe;<br>1.5 h on; 0.5 h off;<br>70 °C; 1000 h<br>70 °C; 8000 h<br>70 °C; 225 000 h | $\pm (0.10\ \% R + 0.01\ \Omega)$<br>$\pm (0.20\ \% R + 0.02\ \Omega)$<br>$\pm (0.60\ \% R + 0.05\ \Omega)$ | $\pm (0.20\ \% R + 0.02\ \Omega)$<br>$\pm (0.40\ \% R + 0.05\ \Omega)$                                      |
|                                  |                                              | Endurance at 70 °C:<br>advanced operation mode              | $U = \sqrt{P_{70} \times R}$ or $U = U_{max.}$ ;<br>whichever is the less severe;<br>1.5 h on; 0.5 h off;<br>70 °C; 1000 h                                      | $\pm (0.20\ \% R + 0.05\ \Omega)$                                                                           | $\pm (0.50\ \% R + 0.05\ \Omega)$                                                                           |
| 4.25.3                           | -                                            | Endurance at upper category temperature                     | 125 °C; 1000 h<br>155 °C; 1000 h<br>175 °C; 1000 h                                                                                                              | $\pm (0.05\ \% R + 0.01\ \Omega)$<br>$\pm (0.10\ \% R + 0.02\ \Omega)$<br>$\pm (0.50\ \% R + 0.05\ \Omega)$ | $\pm (0.15\ \% R + 0.02\ \Omega)$<br>$\pm (0.30\ \% R + 0.02\ \Omega)$<br>$\pm (0.50\ \% R + 0.05\ \Omega)$ |
| 4.24                             | 78 (Cab)                                     | Damp heat, steady state                                     | (40 $\pm$ 2) °C; (93 $\pm$ 3) % RH;<br>56 days                                                                                                                  | $\pm (0.10\ \% R + 0.01\ \Omega)$                                                                           | $\pm (0.10\ \% R + 0.02\ \Omega)$                                                                           |
| 4.37                             | 67 (Cy)                                      | Damp heat, steady state accelerated: general operation mode | (85 $\pm$ 2) °C<br>(85 $\pm$ 5) % RH<br>$U = \sqrt{0.1 \times P_{70} \times R}$ ;<br>$U \leq 0.3 \times U_{max.}$ ; 1000 h                                      | $\pm (0.10\ \% R + 0.05\ \Omega)$                                                                           | $\pm (0.50\ \% R + 0.05\ \Omega)$                                                                           |



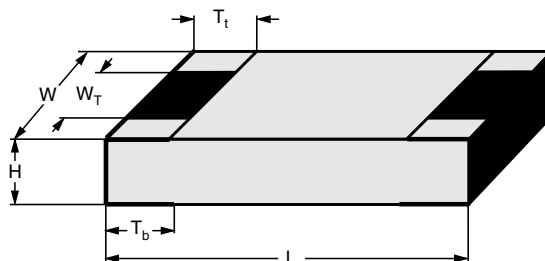
| TEST PROCEDURES AND REQUIREMENTS |                                              |                                                                  |                                                                                                                                                                       |                                                                                |                                    |
|----------------------------------|----------------------------------------------|------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|------------------------------------|
| EN 60115-1<br>CLAUSE             | IEC 60068-2 <sup>(1)</sup><br>TEST<br>METHOD | TEST                                                             | PROCEDURE                                                                                                                                                             | REQUIREMENTS<br>PERMISSIBLE CHANGE ( $\Delta R$ )                              |                                    |
|                                  |                                              |                                                                  |                                                                                                                                                                       | HIGH ACCURACY                                                                  | REGULAR ACCURACY                   |
|                                  |                                              |                                                                  | Stability for product types:                                                                                                                                          |                                                                                |                                    |
|                                  |                                              |                                                                  | MCS 0402 AT                                                                                                                                                           | 1 $\Omega$ to $\leq$ 47 k $\Omega$                                             | > 47 k $\Omega$ to 1 M $\Omega$    |
|                                  |                                              |                                                                  | MCT 0603 AT                                                                                                                                                           | 1 $\Omega$ to $\leq$ 100 k $\Omega$                                            | > 100 k $\Omega$ to 2 M $\Omega$   |
|                                  |                                              |                                                                  | MCU 0805 AT                                                                                                                                                           | 1 $\Omega$ to $\leq$ 100 k $\Omega$                                            | > 100 k $\Omega$ to 7.5 M $\Omega$ |
|                                  |                                              |                                                                  | MCA 1206 AT                                                                                                                                                           | 1 $\Omega$ to $\leq$ 100 k $\Omega$                                            | > 100 k $\Omega$ to 10 M $\Omega$  |
| 4.23                             | 2 (Bb)                                       | Climatic sequence:<br>general operation mode                     |                                                                                                                                                                       | $\pm (0.25 \% R + 0.02 \Omega)$                                                |                                    |
| 4.23.2                           |                                              | Dry heat                                                         | 125 °C; 16 h                                                                                                                                                          |                                                                                |                                    |
| 4.23.3                           |                                              | Damp heat, cyclic                                                | 55 °C; 24 h; $\geq 90 \% \text{ RH}$ ;<br>1 cycle                                                                                                                     |                                                                                |                                    |
| 4.23.4                           |                                              | Cold                                                             | -55 °C; 2 h                                                                                                                                                           |                                                                                |                                    |
| 4.23.5                           |                                              | Low air pressure                                                 | 8.5 kPa; 2 h; (25 $\pm$ 10) °C                                                                                                                                        |                                                                                |                                    |
| 4.23.6                           |                                              | Damp heat, cyclic                                                | 55 °C; 24 h; 90 % RH;<br>5 cycles                                                                                                                                     |                                                                                |                                    |
| 4.23.7                           |                                              | DC load                                                          | $U = \sqrt{P_{70}} \times \bar{R} \leq U_{\text{max.}}$ ; 1 min                                                                                                       |                                                                                |                                    |
| -                                | 1 (Aa)                                       | Cold / storage at low<br>temperature                             | -55 °C; 2 h                                                                                                                                                           | $\pm (0.05 \% R + 0.01 \Omega)$                                                |                                    |
| 4.19                             | 14 (Na)                                      | Rapid change of<br>temperature                                   | 30 min at -55 °C and<br>30 min at 155 °C;<br>1000 cycles                                                                                                              | $\pm (0.10 \% R + 0.01 \Omega)$<br>R < 47R:<br>$\pm (0.25 \% R + 0.05 \Omega)$ | $\pm (0.25 \% R + 0.02 \Omega)$    |
|                                  |                                              | Extended rapid change<br>of temperature                          | 30 min at -40 °C;<br>30 min at 125 °C;<br>MCS 0402 AT: 3000 cycles<br>MCT 0603 AT: 2000 cycles<br>MCU 0805 AT: 1500 cycles<br>MCA 1206 AT: 1000 cycles                | $\pm (0.25 \% R + 0.05 \Omega)$ ;<br>( $\geq 50 \%$ of initial shear force)    |                                    |
| 4.13                             | -                                            | Short time overload:<br>general operation mode                   | $U = 2.5 \times \sqrt{P_{70}} \times \bar{R}$ or<br>$U = 2 \times U_{\text{max.}}$ ;<br>whichever is the less severe;<br>5 s                                          | $\pm (0.05 \% R + 0.01 \Omega)$                                                |                                    |
|                                  |                                              | Short time overload:<br>power operation mode                     | $U = 2.5 \times \sqrt{P_{70}} \times \bar{R}$ or<br>$U = 2 \times U_{\text{max.}}$ ;<br>whichever is the less severe;<br>5 s                                          | $\pm (0.1 \% R + 0.01 \Omega)$                                                 | $\pm (0.25 \% R + 0.05 \Omega)$    |
| 4.27                             | -                                            | Single pulse high<br>voltage overload:<br>general operation mode | $U = 10 \times \sqrt{P_{70}} \times \bar{R}$ or<br>$U = 2 \times U_{\text{max.}}$ ;<br>whichever is the less severe;<br>10 pulses 10 $\mu\text{s}$ /700 $\mu\text{s}$ | $\pm (0.25 \% R + 0.05 \Omega)$                                                |                                    |
|                                  |                                              | Single pulse high<br>voltage overload:<br>power operation mode   | $U = 10 \times \sqrt{P_{70}} \times \bar{R}$ or<br>$U = 2 \times U_{\text{max.}}$ ;<br>whichever is the less severe;<br>10 pulses 10 $\mu\text{s}$ /700 $\mu\text{s}$ | $\pm (0.50 \% R + 0.05 \Omega)$                                                |                                    |
| 4.39                             | -                                            | Periodic electric<br>overload: general<br>operation mode         | $U = \sqrt{15 \times P_{70}} \times \bar{R}$ or<br>$U = 2 \times U_{\text{max.}}$ ;<br>whichever is the less severe;<br>0.1 s on; 2.5 s off;<br>1000 cycles           | $\pm (0.50 \% R + 0.05 \Omega)$                                                |                                    |
|                                  |                                              | Periodic electric<br>overload: power<br>operation mode           | $U = \sqrt{15 \times P_{70}} \times \bar{R}$ or<br>$U = 2 \times U_{\text{max.}}$ ;<br>whichever is the less severe;<br>0.1 s on; 2.5 s off;<br>1000 cycles           | $\pm (1.0 \% R + 0.05 \Omega)$                                                 |                                    |



| TEST PROCEDURES AND REQUIREMENTS |                                              |                                                |                                                                                                                                                          |                                                                                               |                                                                                                                                                                                                                                                                      |
|----------------------------------|----------------------------------------------|------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| EN 60115-1<br>CLAUSE             | IEC 60068-2 <sup>(1)</sup><br>TEST<br>METHOD | TEST                                           | PROCEDURE                                                                                                                                                | REQUIREMENTS<br>PERMISSIBLE CHANGE ( $\Delta R$ )                                             |                                                                                                                                                                                                                                                                      |
|                                  |                                              |                                                |                                                                                                                                                          | HIGH ACCURACY                                                                                 | REGULAR ACCURACY                                                                                                                                                                                                                                                     |
|                                  |                                              |                                                | Stability for product types:                                                                                                                             |                                                                                               |                                                                                                                                                                                                                                                                      |
|                                  |                                              |                                                | MCS 0402 AT                                                                                                                                              | 1 $\Omega$ to $\leq$ 47 k $\Omega$                                                            | > 47 k $\Omega$ to 1 M $\Omega$                                                                                                                                                                                                                                      |
|                                  |                                              |                                                | MCT 0603 AT                                                                                                                                              | 1 $\Omega$ to $\leq$ 100 k $\Omega$                                                           | > 100 k $\Omega$ to 2 M $\Omega$                                                                                                                                                                                                                                     |
|                                  |                                              |                                                | MCU 0805 AT                                                                                                                                              | 1 $\Omega$ to $\leq$ 100 k $\Omega$                                                           | > 100 k $\Omega$ to 7.5 M $\Omega$                                                                                                                                                                                                                                   |
|                                  |                                              |                                                | MCA 1206 AT                                                                                                                                              | 1 $\Omega$ to $\leq$ 100 k $\Omega$                                                           | > 100 k $\Omega$ to 10 M $\Omega$                                                                                                                                                                                                                                    |
| 4.38                             | -                                            | Electro static discharge<br>(human body model) | IEC 61340-3-1; 3 pos. + 3 neg.;<br>(MIL-STD-883, method 3015)<br>MCS 0402 AT: 500 V<br>MCT 0603 AT: 1000 V<br>MCU 0805 AT: 1500 V<br>MCA 1206 AT: 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;<br>amplitude 1.5 mm or<br>$\leq$ 200 m/s <sup>2</sup> ; 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 (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 (95 % covered);<br>no visible damage                                             |                                                                                                                                                                                                                                                                      |
| 4.18                             | 58 (Td)                                      | Resistance to<br>soldering heat                | Solder bath method;<br>(260 $\pm$ 5) °C; (10 $\pm$ 1) s                                                                                                  | $\pm$ (0.05 % $R$ + 0.01 $\Omega$ )                                                           | $\pm$ (0.05 % $R$ + 0.01 $\Omega$ )<br><br>$R$ > 221 k $\Omega$ in 0402:<br>$\pm$ (0.10 % $R$ + 0.01 $\Omega$ )<br>$R$ > 511 k $\Omega$ in 0603:<br>$\pm$ (0.10 % $R$ + 0.01 $\Omega$ )<br>$R$ > 1 M $\Omega$ in 0805 / 1206:<br>$\pm$ (0.10 % $R$ + 0.01 $\Omega$ ) |
| 4.29                             | 45 (XA)                                      | Component solvent<br>resistance                | Isopropyl alcohol +50 °C;<br>method 2                                                                                                                    | No visible damage                                                                             |                                                                                                                                                                                                                                                                      |
| 4.32                             | 21 (Ue <sub>3</sub> )                        | Shear (adhesion)                               | MCS 0402 AT and<br>MCT 0603 AT: 9 N                                                                                                                      | No visible damage                                                                             |                                                                                                                                                                                                                                                                      |
|                                  |                                              |                                                | MCU 0805 AT and<br>MCA 1206 AT: 45 N                                                                                                                     |                                                                                               |                                                                                                                                                                                                                                                                      |
| 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;<br>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,<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<br>(mm)           | L<br>(mm)         | W<br>(mm)   | W <sub>T</sub><br>(mm) | T <sub>t</sub><br>(mm) | T <sub>b</sub><br>(mm) | MASS<br>(mg) |
| MCS 0402 AT         | 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 AT         | 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 AT         | 0.52 ± 0.1          | 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 AT         | 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          |

**SOLDERING RECOMMENDATIONS**

For recommended solder pad dimensions please refer to [www.vishay.com/doc?28950](http://www.vishay.com/doc?28950).

For recommended soldering profiles please refer to [www.vishay.com/doc?31090](http://www.vishay.com/doc?31090).



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