

## Thin Film Chip Fuse



MFU AT thin film chip fuses are the perfect choice for automotive electronics. The highly controlled manufacturing thin film process guarantees an outstanding stability of fusing characteristics. Typical automotive applications include electro vehicle and hybrid electro vehicle, battery management and circuit protection for small loads.

### FEATURES

- Advanced thin film technology
- AEC-Q200 qualified <sup>(1)</sup>
- Very quick acting fuse characteristics
- Outstanding stability of fusing characteristics
- 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)



### APPLICATIONS

- Electro vehicle
- Hybrid electro vehicle
- Battery management
- Circuit protection of small loads

| TECHNICAL SPECIFICATIONS                                           |                             |
|--------------------------------------------------------------------|-----------------------------|
| DESCRIPTION                                                        | MFU 0603-FF AT              |
| Imperial size                                                      | 0603                        |
| Metric size code                                                   | RR1608M                     |
| Rated current range $I_R$                                          | 0.5 A to 5.0 A              |
| Rated voltage, $U_{max}$ DC                                        | 32 V up to 63 V             |
| Breaking capacity, $I_{max}$ at $U_{max}$ DC                       | 50 A at $U_{max}$ DC        |
| Voltage drop at $1 \times I_R$                                     | 85 mV to 361 mV             |
| Cold resistance at $0.1 \times I_R$                                | 13 mΩ to 500 mΩ             |
| Permissible film temperature, $\vartheta_{F max}$                  | 125 °C                      |
| Operating temperature range                                        | -55 °C to 125 °C            |
| Permissible continuous current rating at $\vartheta_{amb} = 23$ °C | $0.7 \times I_R$            |
| Approval UL / CSA recognition file                                 | E253806                     |
| Failure rate: FIT <sub>observed</sub>                              | $\leq 0.2 \times 10^{-9}/h$ |

#### Note

<sup>(1)</sup> According to Vishay's automotive chip fuse qualification requirements



| PACKAGING   |      |          |                                        |       |       |                      |
|-------------|------|----------|----------------------------------------|-------|-------|----------------------|
| TYPE / SIZE | CODE | QUANTITY | PACKAGING STYLE                        | WIDTH | PITCH | PACKAGING DIMENSIONS |
| MFU 0603 AT | P1   | 1000     | Paper tape acc.<br>IEC 60286-3 Type 1a | 8 mm  | 4 mm  | 180 mm / 7"          |
|             | P5   | 5000     |                                        |       |       | 330 mm / 13"         |
|             | PW   | 20 000   |                                        |       |       |                      |

| PART NUMBER AND PRODUCT DESCRIPTION          |   |                        |   |                        |   |                                             |   |                |                |                                         |   |                                   |   |   |   |   |   |
|----------------------------------------------|---|------------------------|---|------------------------|---|---------------------------------------------|---|----------------|----------------|-----------------------------------------|---|-----------------------------------|---|---|---|---|---|
| Part Number: MFU0603FF01000P5AT              |   |                        |   |                        |   |                                             |   |                |                |                                         |   |                                   |   |   |   |   |   |
| M                                            | F | U                      | 0 | 6                      | 0 | 3                                           | F | F              | 0              | 1                                       | 0 | 0                                 | 0 | P | 5 | A | T |
| TYPE / SIZE                                  |   | FUSING CHARACTERISTIC  |   |                        |   | RATED CURRENT                               |   |                | PACKAGING      |                                         |   | SPECIAL                           |   |   |   |   |   |
| MFU0603                                      |   | FF = very quick acting |   |                        |   | Examples:<br>0.5 A = 00500<br>1.0 A = 01000 |   |                | P1<br>P5<br>PW |                                         |   | Up to 2 digits<br>AT = automotive |   |   |   |   |   |
| Product Description: MFU 0603 - FF AT P5 1A0 |   |                        |   |                        |   |                                             |   |                |                |                                         |   |                                   |   |   |   |   |   |
| MFU                                          |   | 0603                   |   | - FF                   |   | AT                                          |   | P5             |                | 1A0                                     |   |                                   |   |   |   |   |   |
| TYPE                                         |   | SIZE                   |   | FUSING                 |   | VERSION                                     |   | PACKAGING      |                | RATED CURRENT                           |   |                                   |   |   |   |   |   |
| MFU                                          |   | 0603                   |   | FF = very quick acting |   | AT = automotive                             |   | P1<br>P5<br>PW |                | Examples:<br>0.5 A = 0A5<br>1.0 A = 1A0 |   |                                   |   |   |   |   |   |

**Note**

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

| MFU 0603 AT RATING - Very quick acting (FF) |            |               |               |                                      |                                             |                                                |                      |       |          |                               |
|---------------------------------------------|------------|---------------|---------------|--------------------------------------|---------------------------------------------|------------------------------------------------|----------------------|-------|----------|-------------------------------|
| SIZE                                        | FUSE CHAR. | RATED CURRENT | RATED VOLTAGE | PRE-ARCING $I^2t$ at $10 \times I_R$ | VOLT. DROP <sup>(1)</sup> at $1 \times I_R$ | COLD RESIS. <sup>(1)</sup> at $0.1 \times I_R$ | BREAKING CAPACITY DC | MARK. | APPROVAL | PART NUMBER <sup>(2)(3)</sup> |
| 0603                                        | FF         | 500 mA        | 63 V          | 0.0009 A <sup>2</sup> s              | 361 mV                                      | 500 mΩ                                         | 50 A at 63 V         | F     | UL / CSA | MFU0603FF00500P5AT            |
|                                             |            | 750 mA        | 50 V          | 0.0020 A <sup>2</sup> s              | 258 mV                                      | 262 mΩ                                         | 50 A at 50 V         | G     | UL / CSA | MFU0603FF00750P5AT            |
|                                             |            | 1.0 A         | 50 V          | 0.0028 A <sup>2</sup> s              | 223 mV                                      | 170 mΩ                                         | 50 A at 50 V         | H     | UL / CSA | MFU0603FF01000P5AT            |
|                                             |            | 1.5 A         | 50 V          | 0.0059 A <sup>2</sup> s              | 155 mV                                      | 79 mΩ                                          | 50 A at 50 V         | K     | UL / CSA | MFU0603FF01500P5AT            |
|                                             |            | 2.0 A         | 50 V          | 0.0101 A <sup>2</sup> s              | 150 mV                                      | 57 mΩ                                          | 50 A at 50 V         | N     | UL / CSA | MFU0603FF02000P5AT            |
|                                             |            | 2.5 A         | 50 V          | 0.0157 A <sup>2</sup> s              | 121 mV                                      | 37 mΩ                                          | 50 A at 50 V         | O     | UL / CSA | MFU0603FF02500P5AT            |
|                                             |            | 3.0 A         | 50 V          | 0.0227 A <sup>2</sup> s              | 126 mV                                      | 32 mΩ                                          | 50 A at 50 V         | P     | UL / CSA | MFU0603FF03000P5AT            |
|                                             |            | 3.5 A         | 32 V          | 0.0308 A <sup>2</sup> s              | 106 mV                                      | 23 mΩ                                          | 50 A at 32 V         | R     | UL / CSA | MFU0603FF03500P5AT            |
|                                             |            | 4.0 A         | 32 V          | 0.0403 A <sup>2</sup> s              | 100 mV                                      | 19 mΩ                                          | 50 A at 32 V         | S     | UL / CSA | MFU0603FF04000P5AT            |
|                                             |            | 5.0 A         | 32 V          | 0.2275 A <sup>2</sup> s              | 85 mV                                       | 13 mΩ                                          | 50 A at 32 V         | T     | UL / CSA | MFU0603FF05000P5AT            |

**Notes**

- (1) Typical values
- (2) For packages with 1000 pieces, please use for packaging P1 instead of P5
- (3) For packages with 20 000 pieces, please use for packaging PW instead of P5



## 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 (Al<sub>2</sub>O<sub>3</sub>). The fuse elements are covered by a 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 performed on 100 % of the individual fuses. Only accepted products are laid directly into the paper tape in accordance with **IEC 60286-3, Type 1a** <sup>(1)</sup>.

## ASSEMBLY

The fuses are suitable for processing on automatic SMD assembly systems. They are suitable for automatic soldering using wave, reflow or vapor phase as shown in **IEC 61760-1**. 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 fuses 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

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 fuses are tested in accordance with the following standards:

- UL 248-14

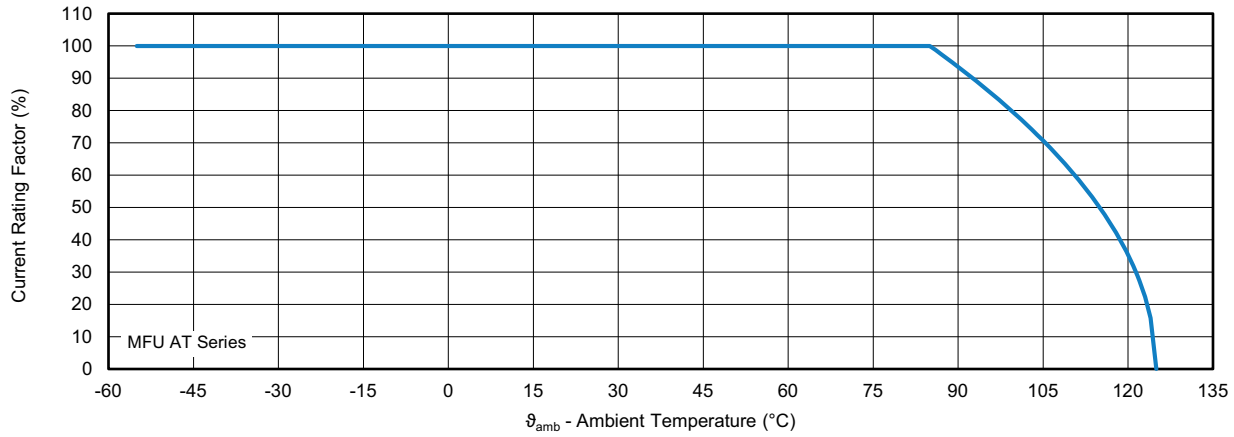
Approval of recognition by Underwriter Laboratories Inc. is indicated by the CSA / UL logo on the package label.

## Notes

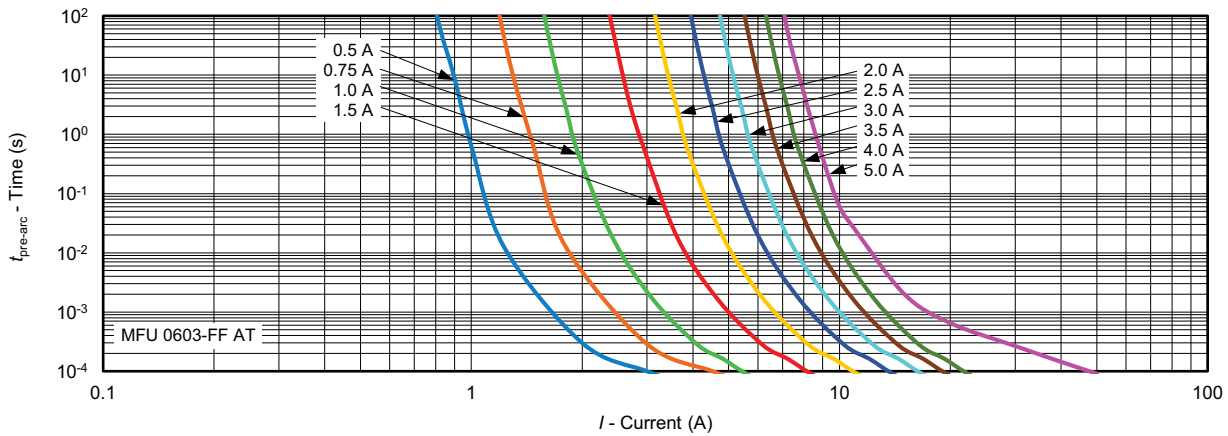
- <sup>(1)</sup> The quoted IEC standards are also released as EN standards with the same number and identical contents
- <sup>(2)</sup> The IEC 62474 list of declarable substances is maintained in a dedicated database, which is available at <http://std.iec.ch/iec62474>
- <sup>(3)</sup> The Global Automotive 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>



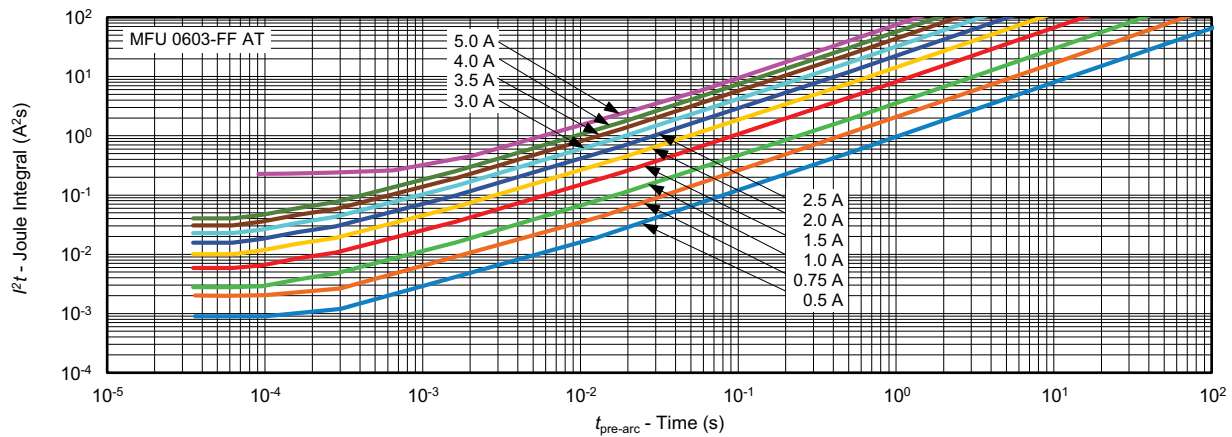
## FUNCTIONAL PERFORMANCE



Current Rating Factor (1) vs. Ambient Temperature  $\vartheta_{amb}$



Typical  $t_{pre-arc}$  vs.  $I$  Characteristic of MFU 0603 AT (2)



Typical  $I^2t$  vs.  $t_{pre-arc}$  Characteristic of MFU 0603 AT (2)

### Notes

- (1) Current rating factor is in addition to the given permissible continuous current rating of 0.7
- (2) Fuses mounted on a test board according to IEC 60127-4



**TEST AND REQUIREMENTS**

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

IEC 60127-1, Miniature fuse - Part 1: definitions for miniature fuses and general requirements for miniature fuse-links

IEC 60127-4, Universal Modular Fuse Links (UMF)

UL 248-14, Low voltage fuses - Part 14: supplemental fuses  
AEC-Q200, Rev D June 1, 2010 according to Table 7 wherever applicable

For the full test schedule refer to the documents listed above. The testing also covers most of the requirements specified by METI and CCC.

The tests are carried out under standard atmospheric conditions in accordance with IEC 60068-1, 4.3. Climatic category LCT/UCT/56 (rated temperature range: lower category temperature, upper category temperature; damp heat, long term, 56 days) is valid.

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 25 % to 75 %

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

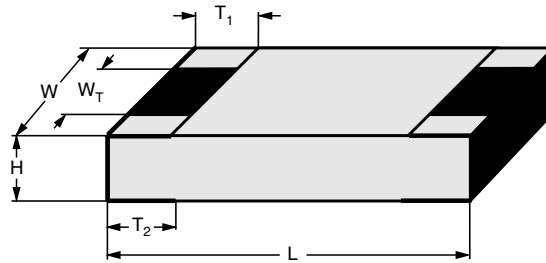
The components are mounted for testing on printed-circuit boards in accordance with IEC 60127-4, unless otherwise specified.

The requirements stated in the Test Procedures and Requirements table are based on the required tests and permitted limits of IEC 60127-1 and IEC 60127-4 respectively. Where applicable some additional tests required by AEC-Q200 Table 7 Table of Methods referenced Resistors and its equivalent IEC 60068-2 environmental tests have been included.

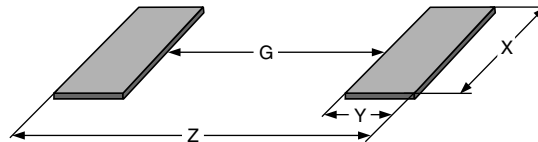
| TEST PROCEDURES AND REQUIREMENTS |                         |                                                     |                                                                                                            |                    |                        |                                                                                                                                                                           |
|----------------------------------|-------------------------|-----------------------------------------------------|------------------------------------------------------------------------------------------------------------|--------------------|------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| IEC 60127-4 CLAUSE               | IEC 60068-2 TEST METHOD | TEST                                                | PROCEDURE                                                                                                  |                    |                        | REQUIREMENTS PERMISSIBLE CHANGE                                                                                                                                           |
| 8.3.2                            | 21 (U <sub>e1</sub> )   | Substrate bending                                   | Depth 3 mm;<br>rate 1 mm/s<br>1 times                                                                      |                    |                        | No visible damage<br>$\Delta R/R \leq \pm 15 \%$                                                                                                                          |
| 8.6.2                            | 58 (Td)                 | Solderability                                       | Solder bath method; SnPb40;<br>non-activated flux;<br>(215 ± 3) °C; (3 ± 0.3) s                            |                    |                        | Good tinning (≥ 95 % covered);<br>no visible damage                                                                                                                       |
|                                  |                         |                                                     | Solder bath method; SnAg3Cu0.5 or SnAg3.5;<br>non-activated flux;<br>(235 ± 3) °C; (2 ± 0.2) s             |                    |                        |                                                                                                                                                                           |
| 8.7.2                            | 58 (Td)                 | Resistance to soldering heat                        | Solder bath method;<br>(260 ± 5) °C; (10 ± 1) s                                                            |                    |                        | No visible damage<br>$\Delta R/R \leq \pm 15 \%$                                                                                                                          |
|                                  |                         |                                                     | Reflow method 2<br>(IR/forced gas convection);<br>(260 ± 5) °C; (10 ± 1) s                                 |                    |                        |                                                                                                                                                                           |
| 9.2.1                            | -                       | Time/current characteristics at nominal temperature | Cold resistance at 0.1 x I <sub>R</sub> ;<br>destructive testing under overcurrent conditions (DC-current) | <b>MFU 0603 AT</b> | I <sub>R</sub> ≤ 5.0 A | At 1.25 x I <sub>R</sub> , t <sub>pre-arc</sub> > 1 h<br>at 2.0 x I <sub>R</sub> , t <sub>pre-arc</sub> < 10 s<br>at 10 x I <sub>R</sub> , t <sub>pre-arc</sub> < 0.001 s |
| 9.3.2                            | -                       | Breaking capacity                                   | 50 A at rated voltage<br>acc. to UL 248-14                                                                 |                    |                        | Optical inspection with naked eye<br>no visible damage                                                                                                                    |
| 9.3.3                            | -                       | Residual resistance                                 | 50 A at rated voltage<br>acc. to UL 248-14                                                                 |                    |                        | Insulation resistance<br>at 2.0 x U <sub>R</sub> (DC)<br>higher than 0.1 MΩ                                                                                               |
| 9.4                              | -                       | Endurance test<br>acc. to IEC 60127-1               | a) I = 1.0 x I <sub>R</sub> (DC)<br>1.0 h on; 0.25 h off;<br>23 °C; 100 times                              | <b>MFU 0603 AT</b> | I <sub>R</sub> ≤ 5.0 A | No visible damage<br>$\Delta R/R \leq \pm 15 \%$                                                                                                                          |
|                                  |                         |                                                     | b) I = 1.25 x I <sub>R</sub> (DC)<br>1.0 h on<br>23 °C; 1 time                                             |                    |                        |                                                                                                                                                                           |



| TEST PROCEDURES AND REQUIREMENTS |                         |                                                                                               |                                                                                                                       |                    |                          |                                                                    |
|----------------------------------|-------------------------|-----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|--------------------|--------------------------|--------------------------------------------------------------------|
| IEC 60127-4 CLAUSE               | IEC 60068-2 TEST METHOD | TEST                                                                                          | PROCEDURE                                                                                                             |                    |                          | REQUIREMENTS PERMISSIBLE CHANGE                                    |
| 9.5                              | -                       | Maximum sustained dissipation acc. to IEC 60127-1                                             | Calculation in accordance with results of clause 9.4 b)                                                               |                    |                          | Dissipation ≤ acc. to IEC 60127-4 table 2                          |
| 9.7                              | -                       | Fuse-link temperature                                                                         | The test is performed during the final 5 min of clause 9.4 b)                                                         | <b>MFU 0603 AT</b> | $I_R \leq 5.0 \text{ A}$ | Temperature rise of terminals ≤ 95 K                               |
| -                                | -                       | Verification of temperature rise and current-carrying capacity acc. to UL 248-14 clause 8.2.3 | $I = 1.0 \times I_R \text{ (DC)}$                                                                                     | <b>MFU 0603 AT</b> | $I_R \leq 5.0 \text{ A}$ | Temperature rise of hot spot ≤ 75 K acc. to UL 248-14 clause 8.2.4 |
| -                                | 78 (Cab)                | Damp heat, steady state                                                                       | (40 ± 2) °C; 56 days;<br>(93 ± 3) % RH                                                                                |                    |                          | $\Delta R/R \leq \pm 15 \%$<br>I-t characteristic                  |
| -                                | 67 (Cy)                 | Damp heat, steady state, accelerated                                                          | (85 ± 2) °C;<br>(85 ± 5) % RH;<br>1000 h                                                                              |                    |                          | $\Delta R/R \leq \pm 15 \%$                                        |
| -                                | 14 (Na)                 | Rapid change of temperature                                                                   | 30 min at LCT;<br>30 min at UCT;<br>LCT = -55 °C;<br>UCT = 125 °C;<br>1000 cycles                                     |                    |                          | $\Delta R/R \leq \pm 15 \%$                                        |
| -                                | 6 (Fc)                  | Vibration                                                                                     | Endurance by sweeping;<br>10 Hz to 2000 Hz;<br>no resonance;<br>amplitude ≤ 1.5 mm or<br>≤ 200 m/s <sup>2</sup> ; 6 h |                    |                          | $\Delta R/R \leq \pm 15 \%$                                        |
| -                                | 45 (XA)                 | Component solvent resistance                                                                  | Isopropyl alcohol;<br>50 °C; method 2                                                                                 |                    |                          | No visible damage                                                  |
| -                                | 45 (XA)                 | Solvent resistance of marking                                                                 | Isopropyl alcohol;<br>50 °C; method 1, toothbrush                                                                     |                    |                          | Marking legible,<br>no visible damage                              |
| -                                | 21 (Ue <sub>3</sub> )   | Shear (adhesion)                                                                              | 9 N                                                                                                                   |                    |                          | No visible damage                                                  |
| -                                | -                       | Flammability                                                                                  | IEC 60695-11-5,<br>needle flame test; 10 s                                                                            |                    |                          | No burning after 30 s                                              |

**DIMENSIONS**


| DIMENSIONS AND MASS |                     |             |            |             |                     |                     |           |
|---------------------|---------------------|-------------|------------|-------------|---------------------|---------------------|-----------|
| TYPE / SIZE         | H (mm)              | L (mm)      | W (mm)     | WT (mm)     | T <sub>1</sub> (mm) | T <sub>2</sub> (mm) | MASS (mg) |
| MFU 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       |

**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) |
| MFU 0603 AT                       | 0.55           | 1.10   | 1.10   | 2.75   | 0.65             | 0.70   | 0.95   | 2.05   |

**Note**

- The given solder pad dimensions reflect the considerations for board design and assembly as outlined e.g. in standards IEC 61188-5-x or in publication IPC-7351. They do not guarantee any supposed thermal properties, particularly as these are also strongly influenced by many other parameters



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