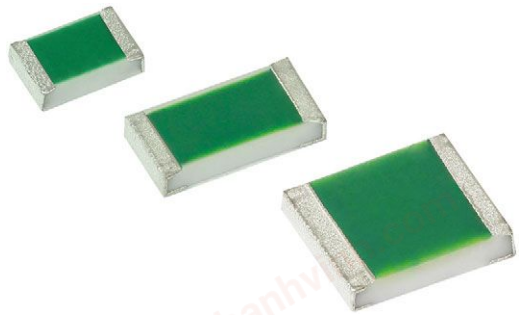
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# High Voltage Thin Film Flat Chip Resistors



TNPV e3 precision thin film flat chip resistors are the perfect choice for most fields of modern electronics where the highest reliability and stability at high operating voltages are of major concern. Typical applications include industrial and automotive inverters, voltage measurement systems as implemented in battery management systems, and test and measuring equipment.

## FEATURES

- High operating voltage $U_{max.}$ up to 1000 V
- Low voltage coefficient < 1 ppm/V
- Excellent overall stability at different environmental conditions ≤ 0.05 % (1000 h rated power at 70 °C)
- Superior moisture resistivity (85 °C; 85 % RH)
- AEC-Q200 qualified
- Sulfur resistance verified according to ASTM B 809
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

AUTOMOTIVE GRADE

Pb-free

RoHS COMPLIANT

HALOGEN FREE

## APPLICATIONS

- Industrial and automotive inverters
- Battery management system
- Test and measuring equipment

## TECHNICAL SPECIFICATIONS

| DESCRIPTION | TNPV0805 e3 | TNPV1206 e3 | TNPV1210 e3 |
|---|---|---|---|
| Imperial size | 0805 | 1206 | 1210 (1) |
| Metric size code | RR2012M | RR3216M | RR3225M (1) |
| Resistance range | 180 kΩ to 1 MΩ | 160 kΩ to 2 MΩ | 121 kΩ to 3.01 MΩ |
| Resistance tolerance | ± 1 %; ± 0.5 %; ± 0.1 % | | |
| Temperature coefficient | ± 50 ppm/K; ± 25 ppm/K; ± 15 ppm/K; ± 10 ppm/K | | |
| Voltage coefficient \|c\| | < 1 ppm/V | | |
| Rated dissipation, $P_{70}$ (2) | 0.20 W | 0.25 W | 0.33 W |
| Maximum operating voltage, $U_{max.}$ $AC_{RMS}$ or DC (3) | 450 V | 700 V | 1000 V |
| Permissible film temperature, $\vartheta_{F\ max.}$ (2) | 155 °C | | |
| Operating temperature range | -55 °C to 125 °C (155 °C) | | |
| Internal thermal resistance (2) | 38 K/W | 32 K/W | tbd |
| Failure rate: $FIT_{observed}$ | ≤ 0.1 x $10^{-9}$/h | | |

**Notes**

(1) Size not specified in EN 140401-801

(2) Please refer to APPLICATION INFORMATION below

(3) Application-specific safety requirements may set limitations to the applicability of the specified voltage

## APPLICATION INFORMATION

The power dissipation on the resistor generates a temperature rise against the local ambient, depending on the heat flow support of the printed circuit board (thermal resistance). The rated dissipation applies only if the permitted film temperature is not exceeded. Furthermore, a high level of ambient temperature or of power dissipation may raise the temperature of the solder joint, hence special solder alloys or board materials may be required to maintain the reliability of the assembly.

Please consider the application note “Thermal Management in Surface-Mounted Resistor Applications” (www.vishay.com/doc?28844) for information on the general nature of thermal resistance.

These resistors do not feature a lifetime limitation when operated within the limits of rated dissipation, permissible operating voltage, and permissible film temperature. However, the resistance typically increases due to the resistor's film temperature over operating time, generally known as drift. The drift may exceed the stability requirements of an individual application circuit and thereby limits the functional lifetime. The designer may estimate the performance of the particular resistor application or set certain load and temperature limits in order to maintain a desired stability.



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## MAXIMUM RESISTANCE CHANGE AT RATED DISSIPATION

| PARAMETER | | VALUE |
|---|---|---|
| Rated dissipation, $P_{70}$ | **TNPV0805 e3** | 0.20 W |
| | **TNPV1206 e3** | 0.25 W |
| | **TNPV1210 e3** | 0.33 W |
| Applied maximum film temperature, $\vartheta_F$ max. | | 125 °C |
| Max. resistance change at $P_{70}$ for resistance range $\Delta R/R$, after: | **TNPV0805 e3** | 180 kΩ to 1 MΩ |
| | **TNPV1206 e3** | 160 kΩ to 2 MΩ |
| | **TNPV1210 e3** | 121 kΩ to 3.01 MΩ |
| | 1000 h | ≤ 0.05 % |
| | 8000 h | ≤ 0.10 % |
| | 225 000 h | ≤ 0.30 % |

## TEMPERATURE COEFFICIENT AND RESISTANCE RANGE

| TYPE / SIZE | TCR | TOLERANCE | RESISTANCE | E-SERIES |
|---|---|---|---|---|
| **TNPV0805 e3** | ± 50 ppm/K | ± 1 % | 180 kΩ to 1.0 MΩ | E24; E96 |
| | ± 25 ppm/K | ± 0.5 % | | E24; E192 |
| | | ± 0.1 % | | |
| | ± 15 ppm/K | ± 0.1 % | | |
| | ± 10 ppm/K | ± 0.1 % | | |
| **TNPV1206 e3** | ± 50 ppm/K | ± 1 % | 160 kΩ to 2.0 MΩ | E24; E96 |
| | ± 25 ppm/K | ± 0.5 % | | E24; E192 |
| | | ± 0.1 % | | |
| | ± 15 ppm/K | ± 0.1 % | | |
| | ± 10 ppm/K | ± 0.1 % | | |
| **TNPV1210 e3** | ± 50 ppm/K | ± 1 % | 121 kΩ to 3.01 MΩ | E24; E96 |
| | ± 25 ppm/K | ± 0.5 % | | E24; E192 |
| | | ± 0.1 % | 121 kΩ to 2.13 MΩ | |
| | ± 15 ppm/K | ± 0.1 % | | |
| | ± 10 ppm/K | ± 0.1 % | | |

## PACKAGING

| TYPE / SIZE | CODE | QUANTITY | PACKAGING STYLE | WIDTH | PITCH | PACKAGING DIMENSIONS |
|---|---|---|---|---|---|---|
| **TNPV0805 e3**<br>**TNPV1206 e3**<br>**TNPV1210 e3** | E52 = EN | 1000 (1) | Paper tape according IEC 60286-3, Type 1a | 8 mm | 4 mm | Ø 180 mm / 7" |
| | ET1 = EA | 5000 | | | | |
| | ET6 = EC | 20 000 | | | | Ø 330 mm / 13" |

**Note**

(1) 1000 pieces packaging is available only for precision resistors with tolerance ± 0.1 %

## PART NUMBER AND PRODUCT DESCRIPTION

**Part Number: TNPV12061M24DEEA**

| T | N | P | V | 1 | 2 | 0 | 6 | 1 | M | 2 | 4 | D | E | E | A | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| TYPE / SIZE | RESISTANCE | TOLERANCE | TCR | PACKAGING | SPECIAL |
|---|---|---|---|---|---|
| **TNPV0805**<br>**TNPV1206**<br>**TNPV1210** | **R** = decimal<br>**K** = thousand<br>**M** = million<br>(4 digits) | **B** = ± 0.1 %<br>**D** = ± 0.5 %<br>**F** = ± 1.0 % | **H** = ± 50 ppm/K<br>**E** = ± 25 ppm/K<br>**X** = ± 15 ppm/K<br>**Y** = ± 10 ppm/K | **EA**<br>**EC**<br>**EN** | Up to 2 digits<br>Blank = standard |

**Product Description: TNPV1206 1M24 0.5 % T-9 ET1 e3**

| **TNPV1206** | **1M24** | **0.5 %** | **T-9** | **ET1** | **e3** |
|---|---|---|---|---|---|
| TYPE / SIZE | RESISTANCE | TOLERANCE | TCR | PACKAGING | LEAD (Pb)-FREE |
| **TNPV0805**<br>**TNPV1206**<br>**TNPV1210** | Examples:<br>**1M24** = 1.24 MΩ<br>**560K** = 560 kΩ | **± 0.1 %**<br>**± 0.5 %**<br>**± 1.0 %** | **T-2** = ± 50 ppm/K<br>**T-9** = ± 25 ppm/K<br>**T-10** = ± 15 ppm/K<br>**T-13** = ± 10 ppm/K | **ET1**<br>**ET6**<br>**E52** | **e3** = pure tin termination finish |

**Note**

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



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## 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 ($Al_2O_3$) and conditioned to achieve the desired temperature coefficient. Specially designed inner contacts are deposited on both sides. A special laser is used to achieve the target value by smoothly fine trimming the resistive layer without damaging the ceramics. A further conditioning is applied in order to stabilize the trimming result. The resistor elements are covered by a protective coating designed for electrical, mechanical and climatic protection. The terminations receive a final pure 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 a potential risk of early life failures (feasible for $R \geq 10\ \Omega$). Only accepted products are laid directly into the tape in accordance with **IEC 60286-3, Type 1a** [(1)].

## 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** [(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 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 [(2)]
- The Global Automotive Declarable Substance List (GADSL) [(3)]
- The REACH regulation (1907/2006/EC) and the related list of substances with very high concern (SVHC) [(4)] 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.

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.

## RELATED PRODUCTS

For products with ultra precision specification see the datasheet:

- TNPU e3 - Ultra Precision Thin Film Flat Chip Resistors (www.vishay.com/doc?28779)

For products with high stability specification see the datasheet:

- TNPW e3 - High Stability Thin Film Flat Chip Resistors (www.vishay.com/doc?28758)

**Notes**

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



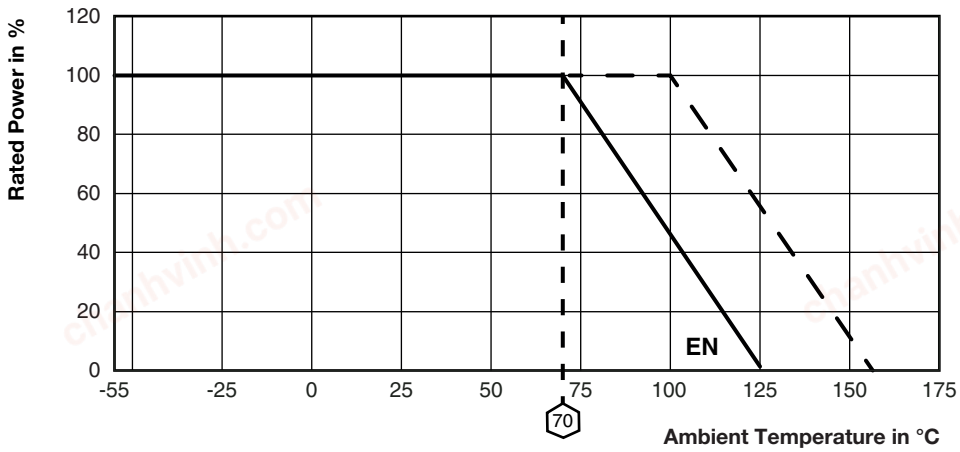
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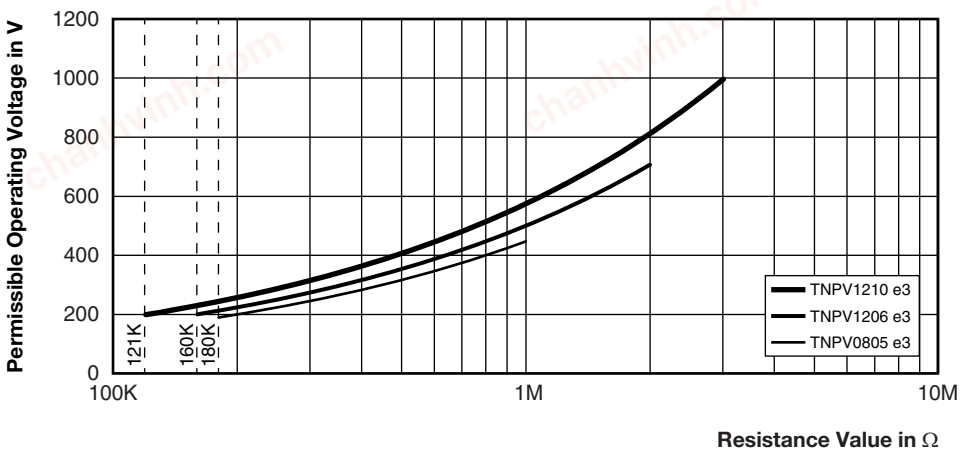
## FUNCTIONAL PERFORMANCE




### Derating

**Note**

- The solid line is based on IEC/EN reference test conditions which is considered as standard mode. However, above that the maximum permissible film temperature is 155 °C (dashed line)




### Nominal Operating Voltage

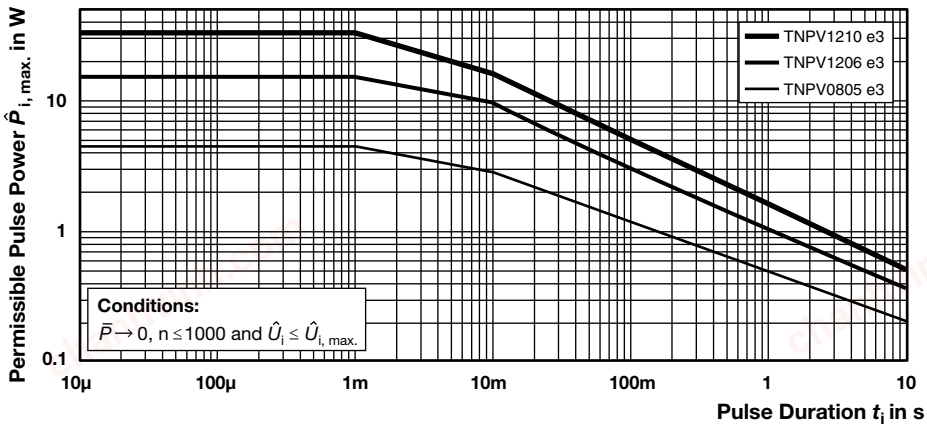
**Note**

- The permissible operating voltage equals the rated voltage $U_R = \sqrt{P_{70} \times R}$. For ambient temperatures above 70 °C power derating must be considered

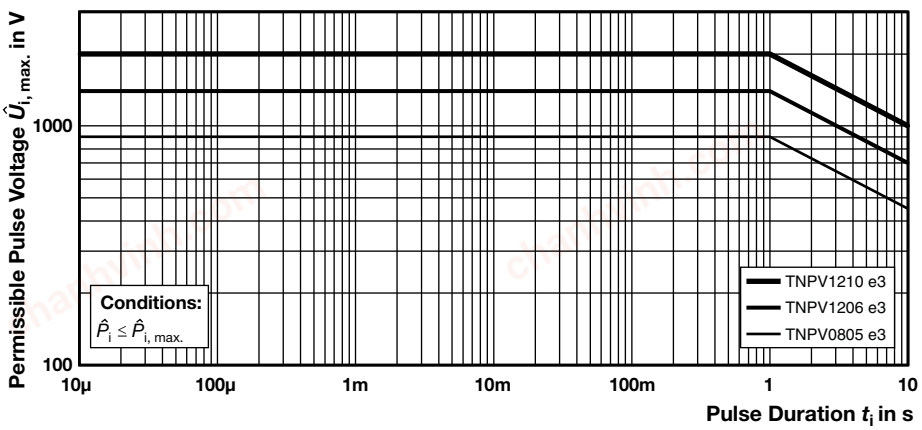

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**Maximum Pulse Load $\hat{P}_{i, max.}$ Single Pulses**




**Maximum Pulse Voltage $\hat{U}_{i, max.}$**


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## TEST AND REQUIREMENTS

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

EN 60115-1, generic specification

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

EN 140401-801, detail specification

IEC 60068-2-xx, test methods

The 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, where upon 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 CLAUSE | IEC 60068-2 (1) TEST METHOD | TEST | PROCEDURE | REQUIREMENTS PERMISSIBLE CHANGE ($\Delta R$) |
|---|---|---|---|---|
| | | | **Stability for product types:** | |
| | | | **TNPV0805 e3** | 180 kΩ to 1 MΩ |
| | | | **TNPV1206 e3** | 160 kΩ to 2 MΩ |
| | | | **TNPV1210 e3** | 121 kΩ to 3.01 MΩ |
| 4.5 | - | Resistance | - | ± 1 %; ± 0.5 %; ± 0.1 % |
| 4.8.4.2 | - | Temperature coefficient | At (20 / -55 / 20) °C and (20 / 125 / 20) °C | ± 50 ppm/K; ± 25 ppm/K; ± 15 ppm/K; ± 10 ppm/K |
| 4.25.1 | - | Endurance at 70 °C | $U = U_{max.}$; 1.5 h on; 0.5 h off;<br>70 °C; 1000 h<br>70 °C; 8000 h | <br>± (0.05 % $R$)<br>± (0.1 % $R$) |
| 4.25.3 | - | Endurance at upper category temperature | 125 °C; 1000 h<br>155 °C; 1000 h | ± (0.05 % $R$)<br>± (0.1 % $R$) |
| 4.24 | 78 (Cab) | Damp heat, steady state | (40 ± 2) °C; 56 days; (93 ± 3) % RH; $U = 0.1 \times U_{max.}$ | ± (0.1 % $R$) |
| 4.19 | 14 (Na) | Rapid change of temperature | 30 min at LCT and 30 min at UCT; LCT = -55 °C; UCT = 125 °C; 1000 cycles | ± (0.1 % $R$) |
| 4.13 | - | Short time overload | $U = 2 \times$ permissible operating voltage; 5 s | ± (0.05 % $R$) |
| 4.27 | - | Single pulse high voltage overload | Severity no. 4: $U = 2 \times U_{max.}$; 10 pulses 10 µs/700 µs | ± (0.1 % $R$) |
| 4.39 | - | Periodic electric overload | $U = 2 \times U_{max.}$; 0.1 s on; 2.5 s off; 1000 cycles | ± (0.1 % $R$) |
| 4.22 | 6 (Fc) | Vibration | Endurance by sweeping; 10 Hz to 2000 Hz; no resonance; amplitude ≤ 1.5 mm or ≤ 200 m/s$^2$; 7.5 h | ± (0.05 % $R$) |


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| TEST PROCEDURES AND REQUIREMENTS | | | | |
|---|---|---|---|---|
| **EN 60115-1 CLAUSE** | **IEC 60068-2 [1] TEST METHOD** | **TEST** | **PROCEDURE** | **REQUIREMENTS PERMISSIBLE CHANGE ($\Delta R$)** |
| | | | **Stability for product types:** | |
| | | | **TNPV0805 e3** | 180 kΩ to 1 MΩ |
| | | | **TNPV1206 e3** | 160 kΩ to 2 MΩ |
| | | | **TNPV1210 e3** | 121 kΩ to 3.01 MΩ |
| 4.38 | - | Electrostatic discharge (Human Body Model) | IEC 61340-3-1 [1]; 3 pos. + 3 neg. discharges; TNPV0805 e3: 2 kV TNPV1206 e3, TNPV1210 e3: 6 kV | ± (0.5 % $R$) |
| 4.17.2 | 58 (Td) | Solderability | Solder bath method; SnPb40; non-activated flux (215 ± 3) °C; (3 ± 0.3) s | Good tinning (≥ 95 % covered); no visible damage |
| | | | Solder bath method; SnAg3Cu0.5 or SnAg3.5; non-activated flux (235 ± 3) °C; (2 ± 0.2) s | |
| 4.18.2 | 58 (Td) | Resistance to soldering heat | Solder bath method; (260 ± 5) °C; (10 ± 1) s | ± (0.02 % $R$) |
| | | | Reflow method 2 (IR/forced gas convection); (260 ± 5) °C; (10 ± 1) s | |
| 4.29 | 45 (XA) | Component solvent resistance | Isopropyl alcohol; 50 °C; method 2 | No visible damage |
| 4.30 | 45 (XA) | Solvent resistance of marking | Isopropyl alcohol; 50 °C; method 1, toothbrush | No visible damage |
| 4.32 | 21 ($Ue_3$) | Shear (adhesion) | 45 N | No visible damage |
| 4.33 | 21 ($Ue_1$) | Substrate bending | Depth 2 mm, 3 times | ± (0.05 % $R$) no visible damage, no open circuit in bent position |
| 4.35 | - | Flammability | IEC 60695-11-5 [1], needle flame test; 10 s | No burning after 30 s |
| 4.37 | 67 (Cy) | Damp heat, steady state, accelerated | (85 ± 2) °C; (85 ± 5) % RH; $U$ = 0.3 x $U_{max.}$; 1000 h | ± (0.25 % $R$) |

**Note**

[1] The quoted IEC standards are also released as EN standards with the same number and identical contents

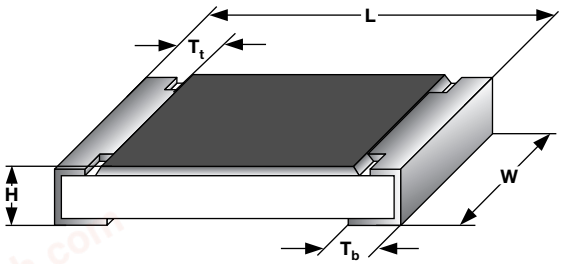


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## DIMENSIONS




| DIMENSIONS AND MASS | | | | | |
|---|---|---|---|---|---|
| TYPE / SIZE | H (mm) | L (mm) | W (mm) | $T_t$ / $T_b$ (mm) | MASS (mg) |
| TNPV0805 e3 | 0.45 ± 0.10 | 2.0 ± 0.1 | 1.25 ± 0.15 | 0.4 ± 0.20 | 5.5 |
| TNPV1206 e3 | 0.55 ± 0.10 | 3.2 + 0.1 / - 0.2 | 1.6 ± 0.15 | 0.5 ± 0.25 | 10 |
| TNPV1210 e3 | 0.60 ± 0.15 | 3.2 + 0.1 / - 0.2 | 2.45 ± 0.15 | 0.5 ± 0.25 | 16 |

## SOLDER PAD DIMENSIONS




| RECOMMENDED SOLDER PAD DIMENSIONS | | | | | | |
|---|---|---|---|---|---|---|
| TYPE / SIZE | REFLOW SOLDERING | | | WAVE SOLDERING | | |
| | Y (mm) | X (mm) | G (mm) | Y (mm) | X (mm) | G (mm) |
| TNPV0805 e3 | 0.7 | 1.3 | 1.2 | 0.9 | 1.3 | 1.3 |
| TNPV1206 e3 | 0.9 | 1.7 | 2.0 | 1.1 | 1.7 | 2.3 |
| TNPV1210 e3 | 0.9 | 2.5 | 2.0 | 1.1 | 2.5 | 2.3 |

**Note**

- Utilization of the full specified operating voltage may require special considerations on the creepage and clearance distance between conductors at different potential levels


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