

## Ultra Precision Thin Film Chip Resistors



TNPU e3 ultra precision thin film flat chip resistors combine the proven reliability of TNPW e3 products with a most advanced level of precision and stability. This unique combination makes the product perfectly suited for all applications with outstanding requirements towards size, reliable precision and stability.

### FEATURES

- Low temperature coefficients and tight tolerances
- Sulfur resistance verified according to ASTM B 809
- Superior moisture resistivity (85 °C; 85 % RH)
- Excellent overall stability at different environmental conditions  $\leq 0.05\%$  (1000 h rated power at 70 °C)
- AEC-Q200 qualified
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)

 AUTOMOTIVE  
GRADE

**RoHS**  
COMPLIANT

### APPLICATIONS

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

| TECHNICAL SPECIFICATIONS  |                                |   |                                |                                |
|---|--------------------------------|---|--------------------------------|--------------------------------|
| DESCRIPTION   | TNPU0402 e3                    | TNPU0603 e3                               | TNPU0805 e3                    | TNPU1206 e3                    |
| Imperial size   | 0402                           | 0603                                      | 0805                           | 1206                           |
| Metric size code  | RR1005M                        | RR1608M                                   | RR2012M                        | RR3216M                        |
| Resistance range  | 100 $\Omega$ to 100 k $\Omega$ | 100 $\Omega$ to 100 k $\Omega$            | 100 $\Omega$ to 332 k $\Omega$ | 100 $\Omega$ to 511 k $\Omega$ |
| Resistance tolerance  | $\pm 0.1\%$ ; $\pm 0.05\%$     | $\pm 0.1\%$ ; $\pm 0.05\%$ ; $\pm 0.02\%$ |                                |                                |
| Temperature coefficient   | $\pm 10$ ppm/K; $\pm 5$ ppm/K  |   |                                |                                |
| Rated dissipation, $P_{70}$ <sup>(1)</sup>                            | 0.063 W                        | 0.1 W                                     | 0.125 W                        | 0.25 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>      | 125 °C                         |   |                                |                                |
| Operating temperature range   | -55 °C to 125 °C               |   |                                |                                |
| Internal thermal resistance <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                          |
| FIT <sub>observed</sub>   | $\leq 0.1 \times 10^{-9}/h$    |   |                                |                                |

#### Note

<sup>(1)</sup> Please refer to APPLICATION INFORMATION, 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   |             | STANDARD                       |
| Rated dissipation, $P_{70}$  | TNPU0402 e3 | 0.063 W                        |
|  | TNPU0603 e3 | 0.100 W                        |
|  | TNPU0805 e3 | 0.125 W                        |
|  | TNPU1206 e3 | 0.250 W                        |
| Operating temperature range  |             | -55 °C to 125 °C               |
| Permissible film temperature, $\vartheta_{F \max}$ .                           |             | 125 °C                         |
| Max. resistance change at $P_{70}$ for resistance range, $ \Delta R/R $ after: | TNPU0402 e3 | 100 $\Omega$ to 100 k $\Omega$ |
|  | TNPU0603 e3 | 100 $\Omega$ to 100 k $\Omega$ |
|  | TNPU0805 e3 | 100 $\Omega$ to 332 k $\Omega$ |
|  | TNPU1206 e3 | 100 $\Omega$ to 511 k $\Omega$ |
|  | 1000 h      | $\leq 0.05$ %                  |
|  | 8000 h      | $\leq 0.1$ %                   |
|  | 225 000 h   | $\leq 0.3$ %                   |

| TEMPERATURE COEFFICIENT AND RESISTANCE RANGE |                |              |                                |           |
|--|----------------|--------------|--------------------------------|-----------|
| TYPE / SIZE                                  | TCR            | TOLERANCE    | RESISTANCE                     | E-SERIES  |
| TNPU0402 e3                                  | $\pm 10$ ppm/K | $\pm 0.05$ % | 100 $\Omega$ to 100 k $\Omega$ | E24; E192 |
|  | $\pm 5$ ppm/K  | $\pm 0.1$ %  |                                |           |
|  |                | $\pm 0.05$ % |                                |           |
| TNPU0603 e3                                  | $\pm 10$ ppm/K | $\pm 0.05$ % | 100 $\Omega$ to 100 k $\Omega$ |           |
|  | $\pm 5$ ppm/K  | $\pm 0.1$ %  |                                |           |
|  |                | $\pm 0.05$ % |                                |           |
|  |                | $\pm 0.02$ % |                                |           |
| TNPU0805 e3                                  | $\pm 10$ ppm/K | $\pm 0.05$ % | 100 $\Omega$ to 332 k $\Omega$ |           |
|  | $\pm 5$ ppm/K  | $\pm 0.1$ %  | 100 $\Omega$ to 200 k $\Omega$ |           |
|  |                | $\pm 0.05$ % |                                |           |
|  |                | $\pm 0.02$ % |                                |           |
| TNPU1206 e3                                  | $\pm 10$ ppm/K | $\pm 0.05$ % | 100 $\Omega$ to 511 k $\Omega$ |           |
|  | $\pm 5$ ppm/K  | $\pm 0.1$ %  |                                |           |
|  |                | $\pm 0.05$ % |                                |           |
|  |                | $\pm 0.02$ % | 100 $\Omega$ to 200 k $\Omega$ |           |



| PACKAGING                                 |          |          |   |       |       |                      |  |  |
|---|----------|----------|---|-------|-------|----------------------|--|--|
| TYPE / SIZE                               | CODE     | QUANTITY | PACKAGING STYLE                           | WIDTH | PITCH | PACKAGING DIMENSIONS |  |  |
| TNPU0402 e3                               | EP1 = EP | 1000     | Paper tape according IEC 60286-3, type 1a | 8 mm  | 2 mm  | Ø 180 mm / 7"        |  |  |
|   | ET2 = EI | 5000     |   |       | 4 mm  |                      |  |  |
| TNPU0603 e3<br>TNPU0805 e3<br>TNPU1206 e3 | E52 = EN | 1000     |   |       |       |                      |  |  |
|   | ET1 = EA | 5000     |   |       |       |                      |  |  |

| PART NUMBER AND PRODUCT DESCRIPTION                   |   |               |  |                                 |   |                                       |   |                          |   |                                  |   |                      |   |   |   |   |   |
|---|---|---------------|--|---------------------------------|---|---------------------------------------|---|--------------------------|---|----------------------------------|---|----------------------|---|---|---|---|---|
| Part Number: TNPU12061K32AZE00                        |   |               |  |                                 |   |                                       |   |                          |   |                                  |   |                      |   |   |   |   |   |
| T   | N | P             | U  | 1                               | 2 | 0                                     | 6   | 1                        | K | 3                                | 2 | A                    | Z | E | A | 0 | 0 |
| TYPE / SIZE   |   |               | RESISTANCE   |                                 |   |                                       | TOLERANCE                                   |                          |   | TCR                              |   | PACKAGING            |   |   |   |   |   |
| TNPU0402<br>TNPU0603<br>TNPU0805<br>TNPU1206          |   |               | R = decimal<br>K = thousand<br>M = million<br>(4 digits) |                                 |   |                                       | B = ± 0.1 %<br>A = ± 0.05 %<br>H = ± 0.02 % |                          |   | Y = ± 10 ppm/K<br>Z = ± 5 ppm/K  |   | EP<br>EI<br>EN<br>EA |   |   |   |   |   |
| Product Description: TNPU1206 1K32 0.05 % T-16 ET1 e3 |   |               |  |                                 |   |                                       |   |                          |   |                                  |   |                      |   |   |   |   |   |
| TNPU1206  |   | 1K32          |  | 0.05 %                          |   | T-16                                  |   | ET1                      |   | e3                               |   |                      |   |   |   |   |   |
| TYPE / SIZE   |   | RESISTANCE    |  | TOLERANCE                       |   | TCR                                   |   | PACKAGING                |   | LEAD (Pb)-FREE                   |   |                      |   |   |   |   |   |
| TNPU0402<br>TNPU0603<br>TNPU0805<br>TNPU1206          |   | 1K32 = 1320 Ω |  | ± 0.02 %<br>± 0.05 %<br>± 0.1 % |   | T-13 = ± 10 ppm/K<br>T-16 = ± 5 ppm/K |   | EP1<br>ET2<br>E52<br>ET1 |   | e3 = pure tin termination finish |   |                      |   |   |   |   |   |

**Note**

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



## DESCRIPTION

Production is strictly controlled and follows an extensive set of instructions established for reproducibility. A homogeneous film of metal alloy is deposited on a high grade ceramic substrate ( $Al_2O_3$ ) 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 tin on nickel plating. The result of the determined production is verified by an extensive testing procedure on 100 % of the individual chip resistors. Only accepted products are laid directly into the 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 tin plating provides compatibility with lead (Pb)-free and lead-containing soldering processes. 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).

## RELATED PRODUCTS

For products with precision specification see the datasheet:

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

## 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**





**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, 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 CLAUSE                | IEC 60068-2 (1) TEST METHOD | TEST                                    | PROCEDURE  | REQUIREMENTS PERMISSIBLE CHANGE ( $\delta R$ )                    |
|                                  |                             |   | <b>Stability for product types:</b><br>TNPU0402 e3<br>TNPU0603 e3<br>TNPU0805 e3<br>TNPU1206 e3  |   |
| 4.5                              | -                           | Resistance                              |  | $\pm 0.1 \%$ ; $\pm 0.05 \%$ ; $\pm 0.02 \%$                      |
| 4.8                              | -                           | Temperature coefficient                 | At (20 / -55 / 20) °C and (20 / 125 / 20) °C   | $\pm 10$ ppm/K; $\pm 5$ ppm/K                                     |
| 4.25.1                           | -                           | Endurance at 70 °C                      | $U = \sqrt{P_{70} \times R}$ or $U = U_{max.}$ ; whichever is the less severe;<br>1.5 h on; 0.5 h off;<br>70 °C; 1000 h<br>70 °C; 8000 h | $\pm (0.05 \% R + 0.01 \Omega)$<br>$\pm (0.1 \% R + 0.02 \Omega)$ |
| 4.25.3                           | -                           | Endurance at upper category temperature | 125 °C; 1000 h<br>125 °C; 8000 h   | $\pm (0.05 \% R + 0.01 \Omega)$<br>$\pm (0.1 \% R + 0.02 \Omega)$ |
| 4.24                             | 78 (Cab)                    | Damp heat, steady state                 | (40 $\pm$ 2) °C; 56 days;<br>(93 $\pm$ 3) % RH   | $\pm (0.1 \% R + 0.01 \Omega)$                                    |
| 4.23                             |                             | Climatic sequence:                      |  |   |
| 4.23.2                           | 2 (Bb)                      | Dry heat                                | UCT; 16 h  |   |
| 4.23.3                           | 30 (Db)                     | Damp heat, cyclic                       | 55 °C; 24 h;<br>> 90 % RH;<br>5 cycle  |   |
| 4.23.4                           | 1 (Ab)                      | Cold                                    | LCT; 2 h   |   |
| 4.23.5                           | 13 (M)                      | Low air pressure                        | 8.5 kPa; 2 h; (25 $\pm$ 10) °C   | $\pm (0.1 \% R + 0.02 \Omega)$                                    |
| 4.23.6                           | 30 (Db)                     | Damp heat, cyclic                       | 55 °C; 24 h;<br>> 90 % RH;<br>5 cycles   |   |
| 4.23.7                           | -                           | D.c. load                               | $U = \sqrt{P_{70} \times R} \leq U_{max.}$ ; 1 min<br>LCT = -55 °C<br>UCT = 125 °C   |   |
| -                                | 1 (Aa)                      | Cold                                    | -55 °C; 2 h  | $\pm (0.05 \% R + 0.01 \Omega)$                                   |

| TEST PROCEDURES AND REQUIREMENTS |   |  |  |  |
|----------------------------------|---|--|--|--|
| EN 60115-1<br>CLAUSE             | IEC 60068-2 <sup>(1)</sup><br>TEST METHOD | TEST   | PROCEDURE  | REQUIREMENTS<br>PERMISSIBLE CHANGE ( $\delta R$ )                                      |
|                                  |   |  | <b>Stability for product types:</b><br>TNPU0402 e3<br>TNPU0603 e3<br>TNPU0805 e3<br>TNPU1206 e3  |  |
| 4.19                             | 14 (Na)                                   | Rapid change of temperature                            | 30 min at LCT and 30 min at UCT;<br>LCT = -55 °C;<br>UCT = 125 °C;<br>1000 cycles  | $\pm (0.1 \% R + 0.01 \Omega)$   |
| 4.13                             | -   | Short time overload                                    | $U = 2.5 \times \sqrt{P_{70}} \times R$<br>or $U = 2 \times U_{max.}$ ;<br>whichever is the less severe;<br>5 s  | $\pm (0.05 \% R + 0.01 \Omega)$  |
| 4.22                             | 6 (Fc)                                    | Vibration  | Endurance by sweeping;<br>10 Hz to 2000 Hz;<br>no resonance;<br>amplitude $\leq 1.5$ mm or<br>$\leq 200$ m/s <sup>2</sup> ; 6 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<br>Solder bath method;<br>SnAg3Cu0,5 or SnAg3,5;<br>non-activated flux<br>(235 $\pm$ 3) °C; (2 $\pm$ 0.2) s | Good tinning ( $\geq 95$ % covered);<br>no visible damage                              |
| 4.18                             | 58 (Td)                                   | Resistance to soldering heat                           | Solder bath method;<br>(260 $\pm$ 5) °C; (10 $\pm$ 1) s  | $\pm (0.02 \% R + 0.01 \Omega)$  |
| 4.29                             | 45 (XA)                                   | Component solvent resistance                           | Isopropyl alcohol<br>+50 °C; method 2  | No visible damage  |
| 4.32                             | 21 (Ue <sub>3</sub> )                     | Shear (adhesion)                                       | RR 1005M and<br>RR 1608M; 9 N<br>RR 2012M and<br>RR 3216M; 45 N  | No visible damage  |
| 4.33                             | 21 (Ue <sub>1</sub> )                     | Substrate bending                                      | Depth 2 mm, 3 times  | $\pm (0.05 \% R + 0.01 \Omega)$<br>no visible damage, no open circuit in bent position |
| 4.7                              | -   | Voltage proof  | $U_{RMS} = U_{ins}$ ; 60 $\pm$ 5 s   | No flashover or breakdown  |
| 4.35                             | -   | Flammability   | IEC 60695-11-5 <sup>(1)</sup> ,<br>needle flame test; 10 s   | No burning after 30 s  |
| 4.39                             | -   | Periodic electric overload:<br>Standard operation mode | $U = \sqrt{15} \times P_{70} \times R$<br>or $U = 2 \times U_{max.}$ ;<br>whichever is the less severe;<br>0.1 s on; 2.5 s off;<br>1000 cycles   | $\pm (0.1 R + 0.02 \Omega)$  |
| 4.37                             | 67 (Cy)                                   | Damp heat, steady state, accelerated                   | (85 $\pm$ 5) °C; 56 days<br>(85 $\pm$ 5) % RH  | $\pm (0.25 R + 0.05 \Omega)$   |
| 4.38                             | -   | Electro static discharge<br>(Human Body Model)         | IEC 61340-3-1 <sup>(1)</sup> ;<br>3 pos. + 3 neg.<br>(equivalent to MIL-STD-883,<br>method 3015)<br>TNPU0402: 400 V<br>TNPU0603: 1000 V<br>TNPU0805: 1500 V<br>TNPU1206: 2000 V                    | $\pm (0.5 R + 0.05 \Omega)$  |

**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         | L (mm)     | W (mm)      | H (mm)      | T <sub>t</sub> / T <sub>b</sub> (mm) | MASS (mg) |
| TNPU0402 e3         | 1.0 ± 0.05 | 0.5 ± 0.05  | 0.35 ± 0.05 | 0.2 ± 0.10                           | 0.65      |
| TNPU0603 e3         | 1.6 ± 0.10 | 0.85 ± 0.10 | 0.45 ± 0.10 | 0.3 ± 0.20                           | 2         |
| TNPU0805 e3         | 2.0 ± 0.15 | 1.25 ± 0.15 | 0.45 ± 0.10 | 0.4 ± 0.20                           | 5.5       |
| TNPU1206 e3         | 3.2 ± 0.15 | 1.6 ± 0.15  | 0.55 ± 0.10 | 0.5 ± 0.25                           | 10        |

**SOLDER PAD DIMENSIONS**


| RECOMMENDED SOLDER PAD DIMENSIONS |                  |        |        |                |        |        |
|-----------------------------------|------------------|--------|--------|----------------|--------|--------|
| TYPE / SIZE                       | REFLOW SOLDERING |        |        | WAVE SOLDERING |        |        |
|                                   | a (mm)           | b (mm) | l (mm) | a (mm)         | b (mm) | l (mm) |
| TNPU0402 e3                       | 0.4              | 0.6    | 0.5    | -              | -      | -      |
| TNPU0603 e3                       | 0.5              | 0.9    | 1.0    | 0.9            | 0.9    | 1.0    |
| TNPU0805 e3                       | 0.7              | 1.3    | 1.2    | 0.9            | 1.3    | 1.3    |
| TNPU1206 e3                       | 0.9              | 1.7    | 2.0    | 1.1            | 1.7    | 2.3    |

**Notes**

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

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





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