

High Stability Thin Film Flat Chip Resistors



TNPW e3 precision thin film flat chip resistors are the perfect choice for most fields of modern electronics where highest reliability and stability is of major concern. Typical applications include test and measuring equipment, medical equipment, industrial, and automotive.

FEATURES

- Superior moisture resistivity (85 °C; 85 % RH)
- Excellent overall stability at different environmental conditions ≤ 0.05 % (1000 h rated power at 70 °C)
- AEC-Q200 qualified (sizes 0402 to 1206)
- Single lot date code (optional)
- Sulfur resistance verified according to ASTM B 809
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

 AUTOMOTIVE
GRADE

RoHS
COMPLIANT
HALOGEN
FREE

APPLICATIONS

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

TECHNICAL SPECIFICATIONS					
DESCRIPTION	TNPW0402 e3	TNPW0603 e3	TNPW0805 e3	TNPW1206 e3	TNPW1210 e3 ⁽¹⁾
Imperial size	0402	0603	0805	1206	1210
Metric size code	RR1005M	RR1608M	RR2012M	RR3216M	RR3225M
Resistance range	10 Ω to 100 k Ω	4.7 Ω to 332 k Ω	4.7 Ω to 1 M Ω	4.7 Ω to 2 M Ω	10 Ω to 3.01 M Ω
Resistance tolerance	± 1 %; ± 0.5 %; ± 0.1 %				
Temperature coefficient	± 50 ppm/K; ± 25 ppm/K; ± 15 ppm/K; ± 10 ppm/K				
Rated dissipation, P_{70} ⁽²⁾	0.100 W	0.125 W	0.200 W	0.400 W	0.500 W
Operating voltage, U_{max} . AC _{RMS} or DC	50 V	75 V	150 V	200 V	200 V
Permissible film temperature, ϑ_{Fmax} . ⁽²⁾	155 °C				
Operating temperature range	-55 °C to 155 °C				
Permissible voltage against ambient (insulation): 1 min; U_{ins}	75 V	100 V	200 V	300 V	300 V
Failure rate: FIT _{observed}	$\leq 0.1 \times 10^{-9}/h$				

Notes

- ⁽¹⁾ The detail specification EN 140401-801 does not cover this product size.
⁽²⁾ Please refer to APPLICATION INFORMATION, see next page.

APPLICATION INFORMATION

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

These resistors do not feature a limited lifetime when operated within the permissible limits. However, resistance value drift increasing over operating time may result in exceeding a limit acceptable to the specific application, thereby establishing a functional lifetime.



MAXIMUM RESISTANCE CHANGE AT RATED DISSIPATION			
OPERATION MODE		STANDARD	POWER
Rated dissipation, P_{70}	TNPW0402 e3	0.063 W	0.100 W
	TNPW0603 e3	0.100 W	0.125 W
	TNPW0805 e3	0.125 W	0.200 W
	TNPW1206 e3	0.250 W	0.400 W
	TNPW1210 e3	0.330 W	0.500 W
Operating temperature range		-55 °C to 125 °C	-55 °C to 155 °C
Permissible film temperature, θ_F max.		125 °C	155 °C
Max. resistance change at P_{70} for resistance range, $ \Delta R/R $ after:	TNPW0402 e3	10 Ω to 100 k Ω	10 Ω to 100 k Ω
	TNPW0603 e3	4.7 Ω to 332 k Ω	4.7 Ω to 332 k Ω
	TNPW0805 e3	4.7 Ω to 1 M Ω	4.7 Ω to 1 M Ω
	TNPW1206 e3	4.7 Ω to 2 M Ω	4.7 Ω to 2 M Ω
	TNPW1210 e3	10 Ω to 3.01 M Ω	10 Ω to 3.01 M Ω
	1000 h	≤ 0.05 %	≤ 0.10 %
	8000 h	≤ 0.10 %	≤ 0.20 %
	225 000 h	≤ 0.30 %	≤ 0.60 %

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) for information on the general nature of thermal resistance.



TEMPERATURE COEFFICIENT AND RESISTANCE RANGE				
TYPE / SIZE	TCR	TOLERANCE	RESISTANCE	E-SERIES
TNPW0402 e3	± 50 ppm/K	± 1 %	10 Ω to 100 kΩ	E24; E96
		± 0.5 %	10 Ω to 100 kΩ	E24; E192
		± 0.1 %	47 Ω to 100 kΩ	
	± 25 ppm/K	± 1 %	10 Ω to 100 kΩ	E24; E96
		± 0.5 %	10 Ω to 100 kΩ	E24; E192
		± 0.1 %	47 Ω to 100 kΩ	
		± 15 ppm/K		
± 10 ppm/K	± 0.1 %			
TNPW0603 e3	± 50 ppm/K	± 1 %	4.7 Ω to 332 kΩ	E24; E96
		± 0.5 %	4.7 Ω to 332 kΩ	E24; E192
		± 0.1 %		
	± 25 ppm/K	± 1 %	4.7 Ω to 332 kΩ	E24; E96
		± 0.5 %	4.7 Ω to 332 kΩ	E24; E192
		± 0.1 %		
		± 15 ppm/K	± 0.1 %	
± 10 ppm/K	± 0.1 %			
TNPW0805 e3	± 50 ppm/K	± 1 %	4.7 Ω to 1 MΩ	E24; E96
		± 0.5 %	4.7 Ω to 1 MΩ	E24; E192
		± 0.1 %		
	± 25 ppm/K	± 1 %	4.7 Ω to 1 MΩ	E24; E96
		± 0.5 %	4.7 Ω to 1 MΩ	E24; E192
		± 0.1 %		
		± 15 ppm/K	± 0.1 %	
± 10 ppm/K	± 0.1 %			
TNPW1206 e3	± 50 ppm/K	± 1 %	4.7 Ω to 2 MΩ	E24; E96
		± 0.5 %	4.7 Ω to 2 MΩ	E24; E192
		± 0.1 %		
	± 25 ppm/K	± 1 %	4.7 Ω to 2 MΩ	E24; E96
		± 0.5 %	4.7 Ω to 2 MΩ	E24; E192
		± 0.1 %		
		± 15 ppm/K	± 0.1 %	
± 10 ppm/K	± 0.1 %			
TNPW1210 e3	± 50 ppm/K	± 1 %	10 Ω to 3.01 MΩ	E24; E96
		± 0.5 %	10 Ω to 3.01 MΩ	E24; E192
		± 0.1 %	47 Ω to 2.13 MΩ	
	± 25 ppm/K	± 1 %	10 Ω to 3.01 MΩ	E24; E96
		± 0.5 %	10 Ω to 3.01 MΩ	E24; E192
		± 0.1 %	47 Ω to 2.13 MΩ	
		± 15 ppm/K		
± 10 ppm/K	± 0.1 %			



PACKAGING						
TYPE / SIZE	CODE	QUANTITY	PACKAGING STYLE	WIDTH	PITCH	PACKAGING DIMENSIONS
TNPW0402 e3	EP1 = EP	1000 ⁽¹⁾	Paper tape acc. IEC 60286-3, Type 1a	8 mm	2 mm	Ø 180 mm/7"
	ET2 = EI	5000				
	ET7 = ED	10 000				
TNPW0603 e3 TNPW0805 e3 TNPW1206 e3 TNPW1210 e3	E52 = EN	1000 ⁽¹⁾			4 mm	Ø 180 mm/7"
	ET1 = EA	5000				
	ET6 = EC ⁽²⁾	20 000				

Notes

- ⁽¹⁾ 1000 pieces packaging is available only for precision resistors with tolerance $\pm 0.1\%$ and temperature coefficient $\leq \pm 25$ ppm/K.
- ⁽²⁾ 20 000 pieces packaging is available only for resistors with TCR ± 25 ppm/K and ± 50 ppm/K.

PART NUMBER AND PRODUCT DESCRIPTION																	
Part Number: TNPW12061K32DEEA																	
T	N	P	W	1	2	0	6	1	K	3	2	D	E	E	A		
TYPE/SIZE	RESISTANCE	TOLERANCE	TCR	PACKAGING	SPECIAL												
TNPW0402 TNPW0603 TNPW0805 TNPW1206 TNPW1210	R = decimal K = thousand M = million (4 digits)	B = $\pm 0.1\%$ D = $\pm 0.5\%$ F = $\pm 1.0\%$	H = ± 50 ppm/K E = ± 25 ppm/K X = ± 15 ppm/K Y = ± 10 ppm/K	EI EP EA EC ED EN (E.. = lead-free)	Up to 2 digits Blank = standard 0H = single lot date code												
Product Description: TNPW1206 1K32 0.5 % T-9 ET1 e3																	
TNPW1206	1K32	0.5 %	T-9	ET1	e3												
TYPE/SIZE	RESISTANCE	TOLERANCE	TCR	PACKAGING	LEAD (Pb)-FREE												
TNPW0402 TNPW0603 TNPW0805 TNPW1206 TNPW1210	Examples: 54R1 = 54.1 Ω 1K32 = 1320 Ω	$\pm 0.1\%$ $\pm 0.5\%$ $\pm 1.0\%$	T-2 = ± 50 ppm/K T-9 = ± 25 ppm/K T-10 = ± 15 ppm/K T-13 = ± 10 ppm/K	EP1 ET1 ET2 ET6 ET7 E52	e3 = pure tin termination finish BV 20545 = single lot date code												

Note

- The product 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 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 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 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.

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>.

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

The TNPW with SnPb termination plating is designed for those applications, where lead bearing terminations are mandatory. For ordering TNPW with SnPb terminations please refer to latest edition of datasheet TNPW (www.vishay.com/doc?31006).

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 (www.vishay.com/doc?28779).

TNPS ESCC high-reliability thin film chip resistors are the premium choice for design and manufacture of equipment, where matured technology and proven reliability are of utmost importance. They are regularly used in communication and research satellites and fit equally well into aircraft and military electronic systems.

Approval of the TNPS ESCC products is granted by the European Space Components Coordination and registered in the ESCC Qualified Parts List, REP005 (www.vishay.com/doc?28789).

TNPV e3 High Voltage Thin Film Flat Chip Resistors are designed for most fields of modern electronics where precision, reliability and stability at high operating voltage are primary concerns (www.vishay.com/doc?28881).



FUNCTIONAL PERFORMANCE



Non-Linearity



Current Noise



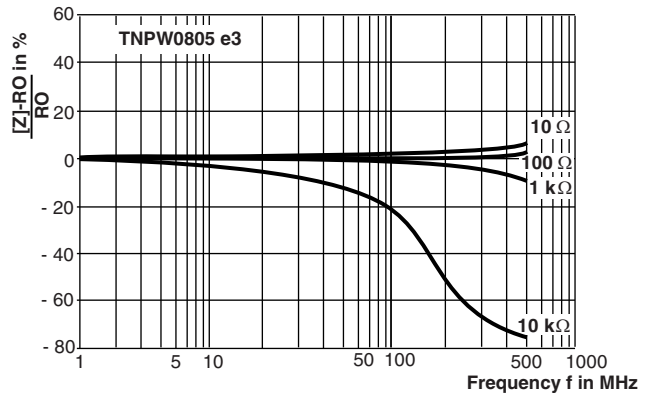
HF Performance (1)



HF Performance (1)



HF Performance (1)



HF Performance (1)

Note

(1) Typical figures. HF-characteristic also depends on termination and circuit design.



FUNCTIONAL PERFORMANCE



Derating - Standard Operation



Derating - Power Operation

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).



FUNCTIONAL PERFORMANCE



Single-Pulse High Voltage Overload
Test 1.2/50 μ s EN140000 4.27



Single-Pulse High Voltage Overload
Test 10/700 μ s EN140000 4.27



Maximum Pulse Load $P_{i,max}$
for Single Pulses



Maximum Pulse Load $P_{i,max}$
for Continuous Pulses



Maximum Pulse Voltage $U_{i,max}$



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 (ΔR)
			Stability for product types: TNPW0402 e3 TNPW0603 e3 TNPW0805 e3 TNPW1206 e3 TNPW1210 e3	
4.5	-	Resistance	-	$\pm 1 \%$; $\pm 0.5 \%$; $\pm 0.1 \%$
4.8	-	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: standard operation mode	$U = \sqrt{P_{70} \times R}$ or $U = U_{max.}$; whichever is the less severe; 1.5 h on; 0.5 h off; 70 °C; 1000 h 70 °C; 8000 h	$\pm (0.05 \% R + 0.01 \Omega)$ $\pm (0.1 \% R + 0.02 \Omega)$
		Endurance at 70 °C: power operation mode	$U = \sqrt{P_{70} \times R}$ or $U = U_{max.}$; whichever is the less severe; 1.5 h on; 0.5 h off; 70 °C; 1000 h 70 °C; 8000 h	$\pm (0.1 \% R + 0.01 \Omega)$ $\pm (0.2 \% R + 0.02 \Omega)$
4.25.3	-	Endurance at upper category temperature	125 °C; 1000 h	$\pm (0.05 \% R + 0.01 \Omega)$
			155 °C; 1000 h	$\pm (0.1 \% R + 0.02 \Omega)$
4.24	78 (Cab)	Damp heat, steady state	(40 \pm 2) °C; 56 days; (93 \pm 3) % RH	$\pm (0.1 \% R + 0.01 \Omega)$
4.37	67 (Cy)	Damp heat, steady state accelerated: Standard operation mode	(85 \pm 2) °C (85 \pm 5) % RH $U = \sqrt{0.1 \times P_{70} \times R}$; $U \leq 0.3 \times U_{max.}$; 1000 h	$\pm (0.25 \% R + 0.05 \Omega)$
-	1 (Ab)	Cold	- 55 °C; 2 h	$\pm (0.05 \% R + 0.01 \Omega)$



TEST PROCEDURES AND REQUIREMENTS				
EN 60115-1 CLAUSE	IEC 60068-2 (1) TEST METHOD	TEST	PROCEDURE	REQUIREMENTS PERMISSIBLE CHANGE (ΔR)
			Stability for product types: TNPW0402 e3 TNPW0603 e3 TNPW0805 e3 TNPW1206 e3 TNPW1210 e3	
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	$\pm (0.1 \% R + 0.01 \Omega)$
4.13	-	Short time overload: standard operation mode	$U = 2.5 \times \sqrt{P_{70} \times R}$ or $U = 2 \times U_{max.}$; whichever is the less severe; 5 s	$\pm (0.05 \% R + 0.01 \Omega)$
		Short time overload: power operation mode	$U = 2.5 \times \sqrt{P_{70} \times R}$ or $U = 2 \times U_{max.}$; whichever is the less severe; 5 s	$\pm (0.1 \% R + 0.01 \Omega)$
4.27	-	Single pulse high voltage overload: standard operation mode	Severity no. 4: $U = 10 \times \sqrt{P_{70} \times R}$ or $U = 2 \times U_{max.}$; whichever is the less severe; 10 pulses 10 μ s/700 μ s	$\pm (0.5 \% R + 0.02 \Omega)$ no visible damage
		Single pulse high voltage overload: power operation mode	Severity no. 4: $U = 10 \times \sqrt{P_{70} \times R}$ or $U = 2 \times U_{max.}$; whichever is the less severe; 10 pulses 10 μ s/700 μ s	$\pm (1 \% R + 0.02 \Omega)$ no visible damage
4.39	-	Periodic electric overload: standard operation mode	$U = \sqrt{15 \times P_{70} \times R}$ or $U = 2 \times U_{max.}$; 0.1 s on; 2.5 s off; whichever is the less severe; 1000 cycles	$\pm (0.5 \% R + 0.05 \Omega)$ no visible damage
		Periodic electric overload: power operation mode	$U = \sqrt{15 \times P_{70} \times R}$ or $U = 2 \times U_{max.}$; 0.1 s on; 2.5 s off; whichever is the less severe; 1000 cycles	$\pm (1 \% R + 0.05 \Omega)$ no visible damage
4.38	-	Electro static discharge (human body model)	IEC 61340-3-1 (1); 3 pos. + 3 neg. (equivalent to MIL-STD-883, method 3015) TNPW0402 e3: 400 V TNPW0603 e3: 1000 V TNPW0805 e3: 1500 V TNPW 1206 e3: 2000 V	$\pm (0.5 \% R + 0.05 \Omega)$
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	$\pm (0.05 \% R + 0.01 \Omega)$ no visible damage

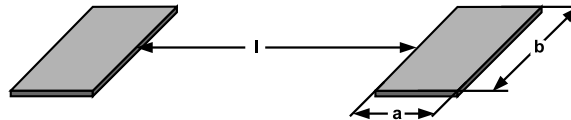
TEST PROCEDURES AND REQUIREMENTS				
EN 60115-1 CLAUSE	IEC 60068-2 ⁽¹⁾ TEST METHOD	TEST	PROCEDURE	REQUIREMENTS PERMISSIBLE CHANGE (ΔR)
			Stability for product types: TNPW0402 e3 TNPW0603 e3 TNPW0805 e3 TNPW1206 e3 TNPW1210 e3	
4.17	58 (Td)	Solderability	Solder bath method; SnPb40; non-activated flux (215 ± 3) °C; (3 ± 0.3) s Solder bath method; SnAg3Cu0.5 or SnAg3.5; non-activated flux (235 ± 3) °C; (2 ± 0.2) s	Good tinning (≥ 95 % covered); no visible damage
4.18	58 (Td)	Resistance to soldering heat	Solder bath method; (260 ± 5) °C; (10 ± 1) s	± (0.02 % <i>R</i> + 0.01 Ω)
4.29	45 (XA)	Component solvent resistance	Isopropyl alcohol + 50 °C; method 2	No visible damage
4.32	21 (Ue ₃)	Shear (adhesion)	TNPW0402 e3 and TNPW0603 e3: 9 N TNPW0805 e3 and TNPW1206 e3: 45 N	No visible damage
4.33	21 (Ue ₁)	Substrate bending	Depth 2 mm, 3 times	± (0.05 % <i>R</i> + 0.01 Ω) no visible damage, no open circuit in bent position
4.7	-	Voltage proof	$U_{RMS} = U_{ins}$; 60 ± 5 s	No flashover or breakdown
4.35	-	Flammability	IEC 60695-11-5 ⁽¹⁾ , needle flame test; 10 s	No burning after 30 s

Note

⁽¹⁾ 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 _t /T _b (mm)	MASS (mg)
TNPW0402 e3	1.0 ± 0.05	0.5 ± 0.05	0.35 ± 0.05	0.2 ± 0.10	0.65
TNPW0603 e3	1.55 ± 0.05	0.85 ± 0.10	0.45 ± 0.10	0.3 ± 0.20	2
TNPW0805 e3	2.0 ± 0.1	1.25 ± 0.15	0.45 ± 0.10	0.4 ± 0.20	5.5
TNPW1206 e3	3.2 + 0.1 / - 0.2	1.6 ± 0.15	0.55 ± 0.10	0.5 ± 0.25	10
TNPW1210 e3	3.2 + 0.1 / - 0.2	2.45 ± 0.15	0.60 ± 0.15	0.5 ± 0.25	16

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)
TNPW0402 e3	0.4	0.6	0.5	-	-	-
TNPW0603 e3	0.5	0.9	1.0	0.9	0.9	1.0
TNPW0805 e3	0.7	1.3	1.2	0.9	1.3	1.3
TNPW1206 e3	0.9	1.7	2.0	1.1	1.7	2.3
TNPW1210 e3	0.9	2.5	2.0	1.1	2.5	2.3



Disclaimer

ALL PRODUCT, PRODUCT SPECIFICATIONS AND DATA ARE SUBJECT TO CHANGE WITHOUT NOTICE TO IMPROVE RELIABILITY, FUNCTION OR DESIGN OR OTHERWISE.

Vishay Intertechnology, Inc., its affiliates, agents, and employees, and all persons acting on its or their behalf (collectively, "Vishay"), disclaim any and all liability for any errors, inaccuracies or incompleteness contained in any datasheet or in any other disclosure relating to any product.

Vishay makes no warranty, representation or guarantee regarding the suitability of the products for any particular purpose or the continuing production of any product. To the maximum extent permitted by applicable law, Vishay disclaims (i) any and all liability arising out of the application or use of any product, (ii) any and all liability, including without limitation special, consequential or incidental damages, and (iii) any and all implied warranties, including warranties of fitness for particular purpose, non-infringement and merchantability.

Statements regarding the suitability of products for certain types of applications are based on Vishay's knowledge of typical requirements that are often placed on Vishay products in generic applications. Such statements are not binding statements about the suitability of products for a particular application. It is the customer's responsibility to validate that a particular product with the properties described in the product specification is suitable for use in a particular application. Parameters provided in datasheets and / or specifications may vary in different applications and performance may vary over time. All operating parameters, including typical parameters, must be validated for each customer application by the customer's technical experts. Product specifications do not expand or otherwise modify Vishay's terms and conditions of purchase, including but not limited to the warranty expressed therein.

Except as expressly indicated in writing, Vishay products are not designed for use in medical, life-saving, or life-sustaining applications or for any other application in which the failure of the Vishay product could result in personal injury or death. Customers using or selling Vishay products not expressly indicated for use in such applications do so at their own risk. Please contact authorized Vishay personnel to obtain written terms and conditions regarding products designed for such applications.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted by this document or by any conduct of Vishay. Product names and markings noted herein may be trademarks of their respective owners.