

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⁾ |
| DIN size | 0402 | 0603 | 0805 | 1206 | 1210 |
| Metric size code | RR 1005M | RR 1608M | RR 2012M | RR 3216M | RR 3225M |
| Resistance range | 10 Ω to 100 k Ω | 10 Ω to 332 k Ω | 10 Ω to 1 M Ω | 10 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⁾ | 0.063 W | 0.1 W | 0.125 W | 0.25 W | 0.33 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 125 °C (155 °C) | | | | |
| Insulation voltage: | | | | | |
| 1 min; U_{ins} | 75 V | 100 V | 200 V | 300 V | 300 V |
| Continuous | 75 V | 75 V | 75 V | 75 V | 75 V |
| Failure rate: FIT _{observed} | $\leq 0.1 \times 10^{-9}/h$ | | | | |

Notes

⁽¹⁾ Size not specified in EN 140401-801.

⁽²⁾ Please refer to APPLICATION INFORMATION below.



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.

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. 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.

| MAXIMUM RESISTANCE CHANGE AT RATED DISSIPATION | | |
|---|-------------|--------------------------------|
| OPERATION MODE | | STANDARD |
| Rated dissipation | TNPW0402 e3 | 0.063 W |
| | TNPW0603 e3 | 0.1 W |
| | TNPW0805 e3 | 0.125 W |
| | TNPW1206 e3 | 0.25 W |
| | TNPW1210 e3 | 0.33 W |
| Film temperature, $\vartheta_{F \max}$. | | 125 °C |
| Max. resistance change at rated dissipation for resistance range: | TNPW0402 e3 | 10 Ω to 100 k Ω |
| | TNPW0603 e3 | 10 Ω to 332 k Ω |
| | TNPW0805 e3 | 10 Ω to 1 M Ω |
| | TNPW1206 e3 | 10 Ω to 2 M Ω |
| | TNPW1210 e3 | 10 Ω to 3.01 M Ω |
| $\Delta R/R$ max., after: | | |
| | 1000 h | ≤ 0.05 % |
| | 8000 h | ≤ 0.10 % |
| | 225 000 h | ≤ 0.30 % |



| TEMPERATURE COEFFICIENT AND RESISTANCE RANGE | | | | |
|--|------------|------------|-----------------|-----------|
| TYPE | 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 % | 10 Ω to 332 kΩ | E24; E96 |
| | | ± 0.5 % | 10 Ω to 332 kΩ | E24; E192 |
| | | ± 0.1 % | | |
| | ± 25 ppm/K | ± 1 % | 10 Ω to 332 kΩ | E24; E96 |
| | | ± 0.5 % | 10 Ω to 332 kΩ | E24; E192 |
| | | ± 0.1 % | | |
| | ± 15 ppm/K | ± 0.1 % | 47 Ω to 332 kΩ | |
| ± 10 ppm/K | ± 0.1 % | | | |
| TNPW0805 e3 | ± 50 ppm/K | ± 1 % | 10 Ω to 1 MΩ | E24; E96 |
| | | ± 0.5 % | 10 Ω to 1 MΩ | E24; E192 |
| | | ± 0.1 % | | |
| | ± 25 ppm/K | ± 1 % | 10 Ω to 1 MΩ | E24; E96 |
| | | ± 0.5 % | 10 Ω to 1 MΩ | E24; E192 |
| | | ± 0.1 % | | |
| | ± 15 ppm/K | ± 0.1 % | 47 Ω to 1 MΩ | |
| ± 10 ppm/K | ± 0.1 % | | | |
| TNPW1206 e3 | ± 50 ppm/K | ± 1 % | 10 Ω to 2 MΩ | E24; E96 |
| | | ± 0.5 % | 10 Ω to 2 MΩ | E24; E192 |
| | | ± 0.1 % | | |
| | ± 25 ppm/K | ± 1 % | 10 Ω to 2 MΩ | E24; E96 |
| | | ± 0.5 % | 10 Ω to 2 MΩ | E24; E192 |
| | | ± 0.1 % | | |
| | ± 15 ppm/K | ± 0.1 % | 47 Ω to 2 MΩ | |
| ± 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 % | | |
| | ± 15 ppm/K | ± 0.1 % | 47 Ω to 2.13 MΩ | |
| ± 10 ppm/K | ± 0.1 % | | | |



| PACKAGING | | | | | | |
|--|----------|---------------------|--|-------|-------|---------------|
| TYPE | CODE | QUANTITY | CARRIER TAPE | WIDTH | PITCH | REEL DIAMETER |
| TNPW0402 e3 | ET7 = ED | 10 000 | Paper tape acc. IEC 60286-3 Type I | 8 mm | 2 mm | 180 mm/7" |
| TNPW0603 e3 TNPW0805 e3 TNPW1206 e3 TNPW1210 e3 | E52 = EN | 1000 ⁽¹⁾ | | | 4 mm | 180 mm/7" |
| | ET1 = EA | 5000 | | | 4 mm | 330 mm/13" |
| | ET6 = EC | 20 000 | | | | |

Note

(1) 1000 pieces packaging is available only for precision resistors with tolerance $\pm 0.1\%$ and temperature coefficient $\leq \pm 25$ 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 | | EA EC ED EN | | 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 | | ET1 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 (Al₂O₃) ceramic substrate 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. This includes full screening for the elimination of products with a potential risk of early life failures according to EN 140401-801, 2.1.2.2. Only accepted products are laid directly into the tape in accordance with **EN 60286-3**.

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**. 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, 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.

All products comply with the **JIG 101** list of legal restrictions on hazardous substances.

This includes full compliance 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)
- 2002/96/EC Waste Electrical and Electronic Equipment Directive (WEEE)

The resistors are Halogen-free according to JEDEC JS709A definition.

Solderability is specified for 2 years after production or re-qualification. The permitted storage time is 20 years.

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, document number 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, document number 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, document number 28789.



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



Temperature Rise



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).



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

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



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

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

FUNCTIONAL PERFORMANCE

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 (includes tests)

EN 140400, sectional specification (includes schedule for qualification approval)

EN 140401-801, detail specification (includes schedule for conformance inspection)

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, 5.3. A climate category is applied, defined by the lower category temperature (LCT), the upper category

temperature (UCT), and the number of days of the damp heat, steady-state test (56).

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45 % to 75 %

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

The components are mounted for testing on boards in accordance with EN 60115-1, 4.31 unless otherwise specified. The parameters stated in the Test Procedures and Requirements table are based on the required tests and permitted limits of EN 140401-801.

| TEST PROCEDURES AND REQUIREMENTS | | | | |
|----------------------------------|----------------------------|---|---|---|
| EN 60115-1 CLAUSE | IEC 60068-2 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 | - | $\pm 1 \%$; $\pm 0.5 \%$; $\pm 0.1 \%$ |
| 4.8.4.2 | - | 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 | $U = \sqrt{P_{70} \times R}$ 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 | $\pm (0.05 \% R + 0.01 \Omega)$ $\pm (0.1 \% R + 0.02 \Omega)$ |
| 4.25.3 | - | Endurance at upper category temperature | 125 °C; 1000 h 155 °C; 1000 h | $\pm (0.05 \% R + 0.01 \Omega)$ $\pm (0.1 \% R + 0.02 \Omega)$ |
| 4.24 | 78 (Cab) | Damp heat, steady state | (40 \pm 2) °C; 56 days; (93 \pm 3) % RH | $\pm (0.1 \% R + 0.01 \Omega)$ |

| TEST PROCEDURES AND REQUIREMENTS | | | | |
|----------------------------------|----------------------------|-------------------------------------|--|--|
| EN 60115-1 CLAUSE | IEC 60068-2 TEST METHOD | TEST | PROCEDURE | REQUIREMENTS PERMISSIBLE CHANGE (ΔR) |
| | | | Stability for product types: TNPW0402 e3 TNPW0603 e3 TNPW0805 e3 TNPW1206 e3 TNPW1210 e3 | |
| 4.23 | | Climatic sequence: | | |
| 4.23.2 | 2 (Bb) | Dry heat | UCT; 16 h | |
| 4.23.3 | 30 (Db) | Damp | 55 °C; 24 h; ≥ 90 % RH; 1 cycle | |
| 4.23.4 | 1 (Ab) | Cold | LCT; 2 h | |
| 4.23.5 | 13 (M) | Low air pressure | 8.5 kPa; 2 h; 25 ± 10 °C | $\pm (0.1 \% R + 0.02 \Omega)$ |
| 4.23.6 | 30 (Db) | Damp heat, cyclic | 55 °C; 5 days; ≥ 90 % RH; 5 cycles | |
| 4.23.7 | - | DC load | $U = \sqrt{P_{70} \times R} \leq U_{max.}$; 1 min LCT = - 55 °C UCT = 125 °C | |
| - | 1 (Ab) | Cold | - 55 °C; 2 h | $\pm (0.05 \% R + 0.01 \Omega)$ |
| 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 | $U = 2.5 \times \sqrt{P_{70} \times R}$ or $U = 2 \times U_{max.}$; whichever is the less severe; 5 s | $\pm (0.05 \% R + 0.01 \Omega)$ |
| 4.27 | - | Single pulse high voltage overload | 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 |
| 4.37 | - | Periodic electric overload | $U = \sqrt{15 \times P_{70} \times R}$ or $U = 2 \times U_{max.}$; whichever is the less severe; 0.1 s on; 2.5 s off; 1000 cycles | $\pm (0.5 \% R + 0.05 \Omega)$ no visible damage |
| 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 |
| 4.17.2 | 58 (Td) | Solderability | Solder bath method; SnPb40; non-activated flux (215 \pm 3) °C; (3 \pm 0.3) s Solder bath method; SnAg3Cu0.5 or SnAg3.5; non-activated flux (235 \pm 3) °C; (2 \pm 0.2) s | Good tinning (≥ 95 % covered); no visible damage |
| 4.18.2 | 58 (Td) | Resistance to soldering heat | Solder bath method; (260 \pm 5) °C; (10 \pm 1) s | $\pm (0.02 \% R + 0.01 \Omega)$ |
| 4.29 | 45 (XA) | Component solvent resistance | Isopropyl alcohol + 50 °C; method 2 | No visible damage |
| 4.32 | 21 (Ue ₃) | Shear (adhesion) | RR 1005M and RR 1608M; 9 N RR 2012M and RR 3216M; 45 N | No visible damage |
| 4.33 | 21 (Ue ₁) | Substrate bending | Depth 2 mm, 3 times | $\pm (0.05 \% R + 0.01 \Omega)$ 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, needle flame test; 10 s | No burning after 30 s |
| - | - | Damp heat, steady state accelerated | (85 \pm 5) °C; 56 days (85 \pm 5) % RH | $\pm (0.25 R + 0.05 \Omega)$ |

DIMENSIONS


| DIMENSIONS AND MASS | | | | | |
|----------------------------|------------|-------------|-------------|-------------------------------------|-----------|
| TYPE | 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 | 1.6 ± 0.10 | 0.85 ± 0.10 | 0.45 ± 0.10 | 0.3 ± 0.20 | 2 |
| TNPW0805 e3 | 2.0 ± 0.15 | 1.25 ± 0.15 | 0.45 ± 0.10 | 0.4 ± 0.20 | 5.5 |
| TNPW1206 e3 | 3.2 ± 0.15 | 1.6 ± 0.15 | 0.55 ± 0.10 | 0.5 ± 0.25 | 10 |
| TNPW1210 e3 | 3.2 ± 0.15 | 2.45 ± 0.15 | 0.60 ± 0.15 | 0.5 ± 0.25 | 16 |

SOLDER PAD DIMENSIONS


| SOLDER PAD DIMENSIONS | | | | | | |
|------------------------------|------------------|--------|--------|----------------|--------|--------|
| TYPE | 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 |



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Material Category Policy

Vishay Intertechnology, Inc. hereby certifies that all its products that are identified as RoHS-Compliant fulfill the definitions and restrictions defined under Directive 2011/65/EU of The European Parliament and of the Council of June 8, 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (EEE) - recast, unless otherwise specified as non-compliant.

Please note that some Vishay documentation may still make reference to RoHS Directive 2002/95/EC. We confirm that all the products identified as being compliant to Directive 2002/95/EC conform to Directive 2011/65/EU.

Vishay Intertechnology, Inc. hereby certifies that all its products that are identified as Halogen-Free follow Halogen-Free requirements as per JEDEC JS709A standards. Please note that some Vishay documentation may still make reference to the IEC 61249-2-21 definition. We confirm that all the products identified as being compliant to IEC 61249-2-21 conform to JEDEC JS709A standards.



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- Поставка более 17-ти миллионов наименований электронных компонентов;
- Поставка сложных, дефицитных, либо снятых с производства позиций;
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- Поставка специализированных компонентов (Xilinx, Altera, Analog Devices, Intersil, Interpoint, Microsemi, Aeroflex, Peregrine, Syfer, Eurofarad, Texas Instrument, Miteq, Cobham, E2V, MA-COM, Hittite, Mini-Circuits, General Dynamics и др.);

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- Подбор аналогов;
- Консультации по применению компонента;
- Поставка образцов и прототипов;
- Техническая поддержка проекта;
- Защита от снятия компонента с производства.



Как с нами связаться

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