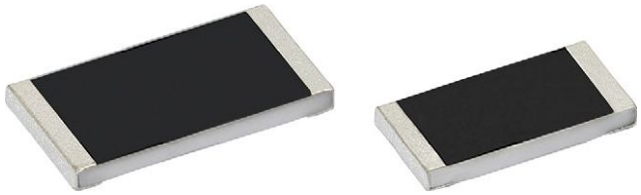
# High Voltage (Up to 3 kV) Thick Film Chip Resistors



The RCV e3 high voltage thick film chip resistors series are the perfect choice for modern electronics with high voltage requirements. Typical applications include automotive inverters for H(EV) cars, voltage measurement systems as implemented in on board chargers, and DC-DC converters.

## FEATURES

- High operating voltage (up to 3 kV)
- Low voltage coefficient of resistance (VCR): 25 ppm/V
- RCV-AT series AEC-Q200 qualified
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

RoHS COMPLIANT
HALOGEN FREE

## APPLICATIONS

- Inverters for (H)EV cars
- On board chargers
- DC-DC converters

| TECHNICAL SPECIFICATIONS | | |
|---|---|---|
| **DESCRIPTION** | **RCV2010-AT e3** | **RCV2512-AT e3** |
| Imperial size | 2010 | 2512 |
| Metric size code | RR5025M | RR6332M |
| Resistance range | 100 kΩ to 100 MΩ | |
| Resistance tolerance | ± 5 %; ± 1 % | |
| Temperature coefficient | ± 200 ppm/K; ± 100 ppm/K | |
| Voltage coefficient | 25 ppm/V | |
| Rated dissipation, $P_{70}$ (1) | 0.75 W | 1.0 W |
| Operating voltage, $U_{max.}$ $AC_{RMS}$/DC | 2000 V | 3000 V |
| Permissible film temperature, $\vartheta_{F\ max.}$ (1) | 155 °C | |
| Operating temperature range | -55 °C to +155 °C | |
| Max. resistance change at $P_{70}$ for resistance range, $\lvert\Delta R/R\rvert$ after: 1000 h | ≤ 2.0 % | ≤ 2.0 % |

**Note**

(1) Please refer to APPLICATION INFORMATION 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.

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.

## TEMPERATURE COEFFICIENT AND RESISTANCE RANGE

| TYPE / SIZE | TCR | TOLERANCE | RESISTANCE | E-SERIES |
|---|---|---|---|---|
| **RCV2010-AT e3** | ± 200 ppm/K | ± 5 % | 100 kΩ to 100 MΩ | E24 |
| | ± 100 ppm/K | ± 1 % | 100 kΩ to 10 MΩ | E24; E96 |
| **RCV2512-AT e3** | ± 200 ppm/K | ± 5 % | 100 kΩ to 100 MΩ | E24 |
| | ± 100 ppm/K | ± 1 % | 100 kΩ to 10 MΩ | E24; E96 |

## PACKAGING

| TYPE / SIZE | CODE | QUANTITY | PACKAGING STYLE | WIDTH | PITCH | PACKAGING DIMENSIONS |
|---|---|---|---|---|---|---|
| **RCV2010-AT e3** | EF = E02 | 4000 | Blister tape according to IEC 60286-3, type 2a | 12 mm | 4 mm | Ø 180 mm / 7" |
| **RCV2512-AT e3** | EG = E67 | 2000 | | 12 mm | 8 mm | Ø 180 mm / 7" |
| | ET = E82 | 4000 | | | 4 mm | |

## PART NUMBER AND PRODUCT DESCRIPTION

**Part Number: RCV2010100KFKEFAT**

| R | C | V | 2 | 0 | 1 | 0 | 1 | 0 | 0 | K | F | K | E | F | A | T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| TYPE / SIZE | RESISTANCE | TOLERANCE | TCR | PACKAGING | VERSION |
|---|---|---|---|---|---|
| **RCV2010**<br>**RCV2512** | **K** = thousand<br>**M** = million | **F** = ± 1 %<br>**J** = ± 5 % | **K** = ± 100 ppm/K<br>**N** = ± 200 ppm/K | **EF, EG, EH** | **AT** = automotive |

**Product Description: RCV2010-AT 100 100K 1 % E02 e3**

| RCV2010-AT | 100 | 100K | 1 % | E02 | e3 |
|---|---|---|---|---|---|
| TYPE / SIZE | TCR | RESISTANCE | TOLERANCE | PACKAGING | LEAD (Pb)-FREE |
| **RCV2010-AT**<br>**RCV2512-AT** | ± **100** ppm/K<br>± **200** ppm/K | **100K** = 100 kΩ<br>**1M** = 1 MΩ<br>**100M** = 100 MΩ | ± **1 %**<br>± **5 %** | **E02, E67, E82** | **e3** = pure tin termination finish |

## DESCRIPTION

Production is strictly controlled and follows an extensive set of instructions established for reproducibility. A cermet film layer and a glass-over are deposited on a high grade ($Al_2O_3$) ceramic substrate. 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. 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 and 2a** (1).

## ASSEMBLY

The resistors 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** (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.

## 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.

## APPROVALS

The resistors are qualified according to AEC-Q200.

Where applicable, the resistors are tested in accordance with **EN 140401-802** which refers to **EN 60115-1**, **EN 60115-8** and the variety of environmental test procedures of the **IEC 60068** (1) series.

## RELATED PRODUCTS

For high voltage thin film products, please refer to latest edition of TNPV e3, High Voltage Thin Film Chip Resistors datasheet, www.vishay.com/doc?28881.

**Notes**

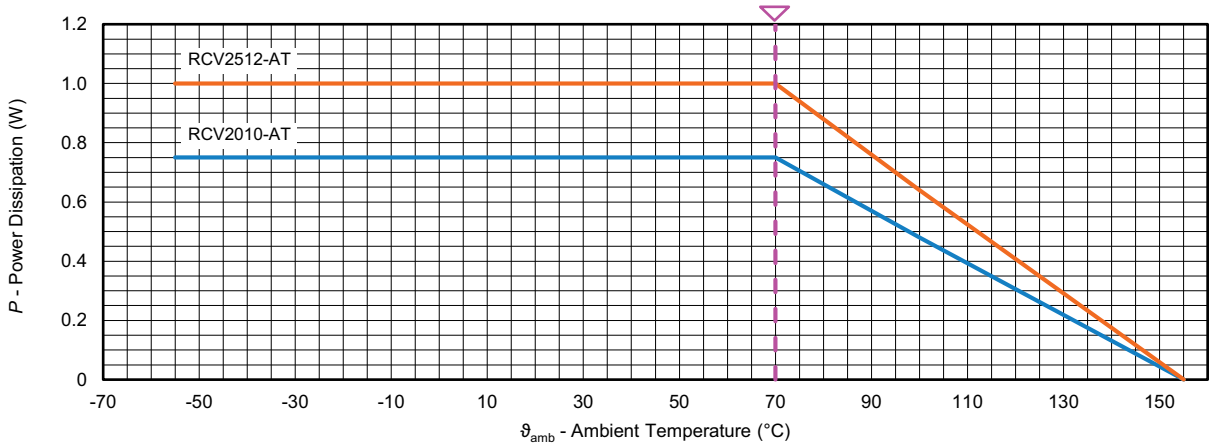
(1) The quoted IEC standards are also released as EN standards with the same number and identical contents

(2) The IEC 62474 list of declarable substances is maintained in a dedicated database, which is available at http://std.iec.ch/iec62474

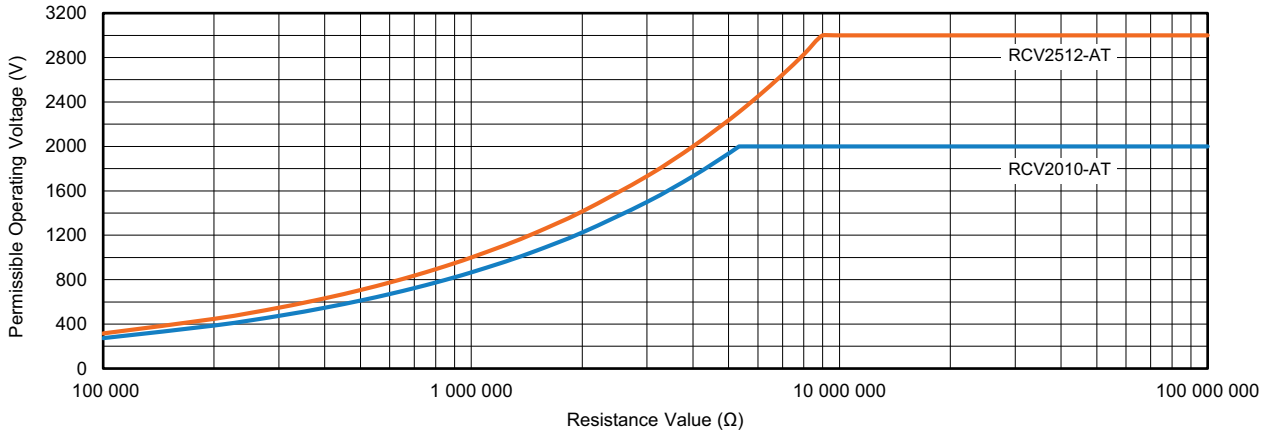
(3) The Global Automotive Declarable Substance List (GADSL) is maintained by the American Chemistry Council and available at www.gadsl.org

(4) The SVHC list is maintained by the European Chemical Agency (ECHA) and available at http://echa.europa.eu/candidate-list-table

## DERATING




## NOMINAL OPERATING VOLTAGE




**The permissible operating voltage $U_{max.}$ equals the rated voltage.**
**For ambient temperatures above 70 °C power derating must be considered**

## TESTS AND REQUIREMENTS

All executed 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 140401-802, 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 140401-802. 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/IS-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).

## TEST PROCEDURES AND REQUIREMENTS

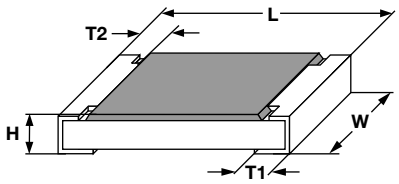
| EN 60115-1 CLAUSE | IEC 60082-2 (1) TEST METHOD | TEST | PROCEDURE | REQUIREMENTS PERMISSIBLE CHANGE ($\Delta R$) | |
|---|---|---|---|---|---|
| | | | | STABILITY CLASS 1 OR BETTER | STABILITY CLASS 2 OR BETTER |
| | | | Stability for product types: | 100 kΩ to 100 MΩ | |
| | | | RCV-AT e3 | | |
| 4.5 | - | Resistance | - | ± 1 % | ± 5 % |
| 4.8 | - | Temperature coefficient | At (20 / -55 / 20) °C and (20 / 155 / 20) °C | ± 100 ppm/K | ± 200 ppm/K |
| 4.25.1 | - | Endurance at 70 °C | $U = P_{70} \times R$ 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 | ± (2 % $R$ + 0.1 Ω) ± (4 % $R$ + 0.1 Ω) | |
| 4.25.3 | - | Endurance at upper category temperature | 155 °C; 1000 h | ± (2 % $R$ + 0.1 Ω) | |
| 4.24 | 78 (Cab) | Damp heat, steady state | (40 ± 2) °C; 56 days; (93 ± 3) % RH | ± (2 % $R$ + 0.1 Ω) | |
| 4.37 | 67 (Cy) | Damp heat, steady state, accelerated power operation mode | (85 ± 2) °C; (85 ± 5) % RH $U = (0.1 \times P_{85} \times R)^{1/2} \leq 0.3 \times U_{max.}$; 1000 h | ± (2 % $R$ + 0.1 Ω) | |
| 4.23 | - | Climatic sequence: | | ± (2 % $R$ + 0.1 Ω) | |
| 4.23.2 | 2 (Bb) | Dry heat | 125 °C; 16 h | | |
| 4.23.3 | 30 (Db) | Damp heat, cyclic | 55 °C; 24 h; ≥ 90 % RH; 1 cycle | | |
| 4.23.4 | 1 (Ab) | Cold | -55 °C; 2 h | | |
| 4.23.5 | 13 (M) | Low air pressure | 8.5 kPa; 2 h; (25 ± 10) °C | | |
| 4.23.6 | 30 (Db) | Damp heat, cyclic | 55 °C; 5 days; > 90 % RH; 5 cycles | | |
| 4.23.7 | - | DC load | $U = (P_{70} \times R)^{1/2} \leq U_{max.}$; 1 min | | |
| - | 1 (Aa) | Cold | -55 °C; 2 h | ± (0.5 % $R$ + 0.05 Ω) | |
| 4.19 | 14 (Na) | Rapid change of temperature | 30 min. at -55 °C and 30 min. at 125 °C; 1000 cycles | ± (1 % $R$ + 0.05 Ω) no visible damage | |
| 4.13 | - | Short time overload | $U = 2.5 \times (P_{70} \times R)^{1/2} \leq 2 \times U_{max.}$; whichever is the less severe; 5 s | ± (2 % $R$ + 0.05 Ω) | |
| | | | Style / Duration / Maximum $U_{OL}$ | | |
| | | | RCV2010-AT / 5 s / 3000 | | |
| | | | RCV2512-AT / 5 s / 4000 | | |
| 4.27 | - | Single pulse high voltage overload | Severity no. 4: $U = 10 \times (P_{70} \times R)^{1/2}$ or $U = 2 \times U_{max.}$; whichever is the less severe; 10 pulses 10 µs / 700 µs | ± (2 % $R$ + 0.1 Ω) no visible damage | |
| 4.39 | - | Periodic electric overload | $U = 15 \times P_{70} \times R$ or $U = 2 \times U_{max.}$; whichever is the less severe; 0.1 s on; 2.5 s off; 1000 cycles | ± (2 % $R$ + 0.05 Ω) | |
| 4.38 | - | Electrostatic discharge (human body model) | IEC 61340-3-1 (1); 3 positive + 3 negative discharges; RCV2010: 12 kV RCV2512: 25 kV | ± (1 % $R$ + 0.05 Ω) | |
| 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 | ± (0.25 % $R$ + 0.05 Ω) no visible damage | ± (0.5 % $R$ + 0.05 Ω) no visible damage |
| 4.17 | 58 (Td) | Solderability | Solder bath method, SnPb40; non-activated flux (235 ± 5) °C; (2 ± 0.2) s | Good tinning (≥ 95 % covered); no visible damage | |
| | | | Solder bath method, Sn96.5Ag3Cu0.5; non-activated flux (245 ± 5) °C; (3 ± 0.3) s | | |

| TEST PROCEDURES AND REQUIREMENTS | | | | | |
|---|---|---|---|---|---|
| EN 60115-1 CLAUSE | IEC 60082-2 [1] TEST METHOD | TEST | PROCEDURE | REQUIREMENTS PERMISSIBLE CHANGE ($\Delta R$) | |
| | | | | STABILITY CLASS 1 OR BETTER | STABILITY CLASS 2 OR BETTER |
| | | | Stability for product types: | 100 kΩ to 100 MΩ | |
| | | | RCV-AT e3 | | |
| 4.18 | 58 (Td) | Resistance to soldering heat | Soldering bath method; (260 ± 5) °C; (10 ± 1) s | ± (0.25 % $R$ + 0.05 Ω) | ± (0.5 % $R$ + 0.05 Ω) |
| 4.29 | 45 (XA) | Component solvent resistance | Isopropyl alcohol +50 °C; method 2 | No visible damage | |
| 4.32 | 21 ($Uu_3$) | Shear (adhesion) | 17.7 N | No visible damage | |
| 4.33 | 21 ($Uu_1$) | Substrate bending | Depth 2 mm; 3 times | ± (1 % $R$ + 0.05 Ω) no visible damage, no open circuit in bent position | |
| 4.7 | - | Voltage proof | $U$ = 1.4 x $U_{ins}$; 60 s | No flashover or breakdown | |
| 4.35 | - | Flammability, needle flame test | IEC 60695-11-5 [1]; 10 s | No burning after 30 s | |

**Note**

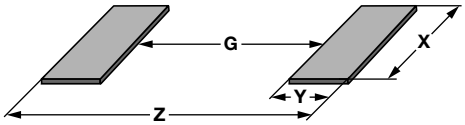
[1] The quoted IEC standards are also released as EN standards with the same number and identical contents

## DIMENSIONS




| DIMENSIONS AND MASS | | | | | | |
|---|---|---|---|---|---|---|
| TYPE / SIZE | L (mm) | W (mm) | H (mm) | T1 (mm) | T2 (mm) | MASS (mg) |
| RCV2010-AT e3 | 5.0 ± 0.15 | 2.5 ± 0.15 | 0.6 ± 0.10 | 0.6 ± 0.20 | 0.45 ± 0.20 | 25.5 |
| RCV2512-AT e3 | 6.3 ± 0.20 | 3.15 ± 0.15 | 0.6 ± 0.10 | 0.6 ± 0.20 | 0.45 ± 0.20 | 42 |

## 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) |
| RCV2010-AT e3 | 3.60 | 1.65 | 2.85 | 6.90 | 3.70 | 1.20 | 2.70 | 6.10 |
| RCV2512-AT e3 | 4.90 | 1.60 | 3.50 | 8.10 | 5.00 | 1.25 | 3.35 | 7.50 |

**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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