Conductive Polymer Capacitors Frequently Asked Questions (FAQs)

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Q: What is Vishay's selection of capacitors with conductive polymer electrolyte?

A: T55 vPolyTan^{TM} conductive polymer surface-mount chip capacitors, molded case, high performance type
T56 vPolyTan^{TM} conductive polymer surface-mount chip capacitors, molded case, hi-rel COTS
T50 vPolyTan^{TM} conductive polymer surface-mount chip capacitors, molded case, high performance type
T59 vPolyTan^{TM} conductive polymer surface-mount chip capacitors, low ESR, leadframeless molded type
T52 vPolyTan^{TM} conductive polymer surface-mount chip capacitors, low profile, leadframeless molded type
T54 vPolyTan^{TM} conductive polymer surface-mount chip capacitors, low ESR, leadframeless molded type, hi-rel COTS
T58 vPolyTan^{TM} conductive polymer surface-mount chip capacitors, compact, leadframeless molded type

Q: What is the major difference between tantalum MnO_2 and conductive polymer capacitors?

A: The construction of conductive polymer capacitors is basically the same as of tantalum capacitors with MnO_2 solid electrolyte. The major difference is in the material used to create the solid electrolyte. For regular capacitors this is manganese dioxide (MnO_2), possessing the conductivity typical of semiconductors, while for conductive polymer capacitors, inherently conductive polymer (ICP) materials are used. Electrical conductivity of ICP is several orders of magnitude higher than that of MnO_2. As a result, conductive polymer capacitors have a much lower ESR. Conductive polymer capacitors require essentially lower level of DC voltage derating comparing to MnO_2. Another feature of conductive polymer capacitors is the absence of an ignition failure mode due to less oxygen content.

Q: Do conductive polymer capacitors have issues with out-gassing?

A: Conductive polymer capacitors are thoroughly dried and vacuum-sealed in aluminum foil bags so there will be no out-gassing when the parts are used properly. However, conductive polymer capacitors are rated to Moisture Sensitivity Level 3 [MSL 3] and they will slowly absorb moisture once unsealed and exposed to the environment. Out-gassing may occur during reflow mounting if the parts are handled in violation of MSL 3 required practices.

Q: Are conductive polymer capacitors susceptible to vibration?

A: No. Conductive polymer capacitors are solid-constructed. They have no inner parts that can move, and they are not affected by shock or vibration.

Q: How many reflows are allowed for conductive polymer capacitors?

A: Three reflows are allowed in accordance with the published specifications in the datasheet. In general, every reflow generates thermal mechanical stress that adversely affects electrical properties such as ESR and DCL. The more reflows, the greater the impact.

Q: Are conductive polymer capacitors process sensitive?

A: Yes, conductive polymer capacitors are process sensitive. PSL classification to JEDEC J-STD-075 for product series T50, T52, T55, T56 and T58: R4G; for product series T54 and T59: R6G.

Q: How does the capacitance of conductive polymer capacitors change with voltage and temperature?

A: Unlike ceramic and aluminum capacitors, the capacitance of conductive polymer capacitors is virtually unchanged with voltage load, but changes with temperature. Please refer to Performance Characteristics section of relevant datasheet for details.

Q: How does the ESR of conductive polymer capacitors change with voltage and temperature?

A: The ESR of conductive polymer capacitors is virtually unchanged with voltage load and virtually unchanged with temperature.

Q: How does the ESR and capacitance of conductive polymer capacitors change during long term endurance tests?

A: ESR tends to drift higher slowly over time while capacitance tends to drift lower, eventually reaching a plateau within the specifications published in the datasheet.

Q: How do conductive polymer capacitors behave under elevated temperature without a voltage load?

A: Unlike aluminum conductive polymer capacitors that show increased DCL, conductive polymer capacitors have stable properties under elevated temperatures without a voltage load. This can be attributed to the much higher stability of the tantalum pentoxide dielectric compared to dielectric in aluminum conductive polymer. Also, conductive polymer capacitors have a solid electrolyte, so they do not have the "dry-out" issue associated with wet aluminum capacitors that use a liquid electrolyte.

Q: How do conductive polymer capacitors perform in endurance tests in humid environments?

A: Typical performance specifications for Vishay's conductive polymer capacitors include performance at 60 °C / 90 % RH for 500 hours. Some special grades, like T50 and T56 series, can withstand highly accelerated test conditions of 85 °C / 85 % RH at full rated voltage applied for 500 hours.

Q: What is the operation temperature range of conductive polymer capacitors?

A: Conductive polymer capacitors are designed to operate at up to 105 °C in long term applications. Some special grades (like T50, T54) can operate at up to 125 °C.

Q: Do conductive polymer capacitors possess self-healing feature?

A: Yes, conductive polymer capacitors possess a highly efficient feature of self-healing dielectric defective spots. When current in a defective spot grows, it heats the spot locally to approximately 300°C, the conductive polymer converts to a highly resistant material and isolates the spot.

Q: Why do conductive polymer capacitors have higher DCL spec limits vs. their MnO_2 counterparts?

A: The conductive polymer capacitors have higher initial DCL due to their conductive polymer cathode construction. However, the higher DCL after reflow tends to be reduced significantly when a voltage is applied, as the result of self-healing.

Q: Are conductive polymer capacitors more tolerant to voltage surges and spikes than their MnO_2 counterparts are?

A: Yes. It is established that conductive polymer capacitors need only a 10 % voltage de-rating (or 20 % at higher voltages) vs. a 50 % de-rating for MnO_2 counterparts to ensure a good safety margin in applications. Refer to FAQ: "Why are voltage and temperature derating needed for tantalum capacitors?" or to relevant vPolyTan™ datasheet for recommended voltage derating.

Q: Are high-voltage conductive polymer capacitors reliable?

A: Yes. Extensive tests and simulations conclude that high-voltage conductive polymer capacitors are very reliable.

Q: Why do conductive polymer capacitors have much lower ESR than their MnO_2 counterparts?

A: The inherently conductive polymer used as the electrolyte (and part of cathode material) is orders of magnitude more conductive than MnO_2.

Q: What is the common failure mode of conductive polymer capacitors?

A: The common failure mode is high DCL or short and typically, it is not accompanied with ignition.

Q: What are your cage codes?

A: Vishay manufactures conductive polymer capacitors in two locations: Dimona, Israel (cage code 2800 A) and Miharu, Japan (cage code SXP61). Contact tantalum@vishay.com for information on a particular capacitor series.

Q: What is the shelf life of this part in the original packaging?

A: Conductive polymer capacitors have no known wear-out mechanism or shelf life limitations. However, solderability and cover-tape peel strength may be affected by storage conditions. See FAQ "What is the recommended storage conditions for conductive polymer capacitors?".

Q: Are all Vishay conductive polymer capacitors RoHS-compliant?

A: All commercial conductive polymer capacitors are offered with a RoHS-compliant material option.

Q: Where do I get RoHS, REACH, Green, halogen-free status, and material declaration documentation?

A: Send an email to VPECM.surveys@vishay.com. Include specific part number(s) in your request.

Q: Do you have a SPICE model for conductive polymer capacitors?

A: SPICE models are available for the following conductive polymer series: T50, T52, T54, T55, T56, T58, and T59

Q: What is the recommended storage conditions for conductive polymer capacitors?

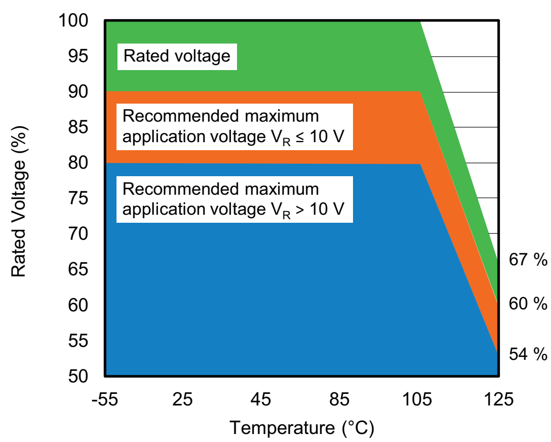
A: 40 °C (max.), 70 % RH (max.), re-certify for solderability after two years. Warranty period for moisture sensitive capacitors supplied as vacuum-sealed in moisture barrier bags is limited to one year from sealing date (as shown on the dedicated label).

Q: What is the moisture sensitivity of Vishay conductive polymer capacitors?

Moisture sensitivity levels (MSL) and test conditions to assure product capability were developed by the semiconductor industry for surface-mount devices that are susceptible to the “popcorn” phenomenon. Passive component manufacturers, including solid capacitors, use the J-STD-020 specification for MSL grading. Capacitors with conductive polymer electrolyte are classified as MSL 3 as a rule. For the MSL data of specific capacitors series, please refer to the product datasheet or the following document: www.vishay.com/doc?40135. All capacitors series classified as MSL 3 or higher are vacuum-packaged in metallized bags as specified in J-STD-033, with desiccant and a moisture strip (humidity indicator card). For the capacitor’s floor life and storage conditions after opening of the original bag, please follow the mentioned specifications. If excess moisture remains, the capacitors can be dried at 40 °C for 168 hours (standard “dry box” conditions).

Q: Why are voltage and temperature derating needed for conductive polymer capacitors?

A: Capacitors require voltage derating in order to operate properly within a customer's application. The voltage on the capacitor is equal to the sum of the DC and AC voltages. This sum should never exceed the category voltage. For conductive polymer capacitors at temperatures below or equal to 105 °C the category voltage is equal to the rated voltage and then it linearly decreases to the specified value at the maximum operating temperature (see relevant product datasheet for details). For reliable capacitor performance, it is recommended that the DC voltage applied to the capacitor not to exceed the recommended derated value, see chart below.



Note

- Part of the chart above 105 °C is relevant for product series with temperature range up to 125 °C only

As an example, if a conductive polymer capacitor is used without any derating, failure rates of 0.1 % to 1 % will occur. Conductive polymer capacitor manufacturers generally recommend that a minimum of 10 % voltage derating for ratings up to 10 V and 20 % voltage derating for ratings above 10 V should be applied (if not specified differently in a product datasheet).

Q: Why is there a difference in recommended voltage / temperature derating for conductive polymer capacitors comparatively to conventional MnO_2 capacitors?

A: Conductive polymer capacitors represent advanced version of conventional tantalum MnO_2 capacitors.

They use inherently conductive organic conductive polymer material as a part of counter electrode rather than traditional MnO_2 material. In addition to significantly lower ESR, the conductive polymer cathode features a benign failure mode. This relates to several factors, but mostly to the fact that the conductive polymer, contrary to MnO_2, does not release oxygen in case of occasional short circuit event. It allows for more generous derating recommendations. While 50 % to 60 % derating recommended for MnO_2 capacitors, following is applicable for conductive polymer capacitors:

- 10 % for products rated up to 10 V
- 20 % for products rated higher than 10 V

In order to better understand the reason for less derating, one needs to look into the self-healing mechanism of tantalum capacitors. It is a well-known feature, which relates to a sequence of events happening when the current passing through the defect in Ta_2O_5 dielectric and generates localized heat. In case of MnO_2 cathodes, the MnO_2 is thermally reduced to a lower oxide of manganese, which has a much higher resistance and effectively isolates the defect and may suppress elevated leakage current. The reduction occurs at about 500 °C: $MnO_2 \rightarrow Mn_2O_3 + O^+$. In addition, oxygen released from the MnO_2 "heals" the defective area of Ta_2O_5 dielectric. However, at high levels of applied voltage and elevated temperature this exothermic reaction may generate excessive heat. With additional heating, instead of "healing" the defective area may grow leading to irreversible dielectric breakdown. To prevent this situation from happening, 50 % to 60 % voltage derating is necessary for MnO_2 tantalum capacitors. For conductive polymer capacitors, the polymer material loses conductivity and isolates the defect at lower temperature of approximately 300 °C effectively suppressing leakage current. In this case, no oxygen is present to be released when the conductive polymer heats up, which explains its benign failure mode. For this reason, 10 % to 20 % derating is possible with conductive polymer capacitors.

Q: Are conductive polymer capacitors ESD-sensitive?

A: Conductive polymer capacitors are not ESD-sensitive. Vishay does offer ESD packaging as an option if customers need to store capacitors alongside ESD-sensitive components.

Q: Why is surge current testing done on conductive polymer capacitors and how is it performed?

A: During outgoing electrical testing, 100 % surge current testing (SCT) is performed by Vishay on most solid tantalum capacitors. Surge current testing ensures that the capacitor will perform under severe circuit application conditions. In applications where circuit resistance is low and there is a large available current from the power bus, high inrush currents to the capacitor may be experienced. For these reasons, many solid capacitors (especially those with low-ESR / high-capacitance, high-voltage ratings) are 100 % tested with at least three cycles of surge current and with at least rated voltage applied through a low-impedance circuit. Surge current testing ensures that potentially weak capacitors are eliminated by providing a level of inrush current that is higher than what would be found in even the most stressful applications.