Frequently asked questions regarding:

Ripple Current for MLCCs

Richard Tse
TDK Components USA, Inc.

Abstract
With the improvement in material development and manufacturing technology, MLCC capacitance range has increased into the tantalum and aluminum range. Design and Manufacturing Engineers are increasingly finding the advantages of using MLCCs over Ta and Al.

As engineers are switching over to MLCCs they find themselves trying to match power dissipation capabilities. This is most commonly represented as ripple current. Since these types of performance characteristics are not typically specified for MLCCs, this paper will address some of the fundamental questions.

July, 2006

Ripple Current for MLCCs

Richard Tse, Principal Engineer I

Q1. ***What is ripple current?***
A1. Ripple current refers to the effect of internal self heating within the capacitor. Once the capacitor reaches the maximum temperature, the associated current level is referred to as ripple current.

Ripple current rating does not directly apply to MLCCs.

Q2. ***Why are MLCCs not rated for ripple current?***
A2. MLCCs are not stressed by current. Instead, it is the temperature that is the critical factor here. Ripple current, in this case, would vary depending on the MLCC temperature.

Q3. ***Why would the ripple current rating for a MLCC vary?***
A3. Since MLCCs are dependant on temperature and not current, variation in this temperature will determine the max ripple current allowed.

This can be explained by looking at an example of a Class II (X7R) capacitor. The X7R capacitor has a maximum operating temperature is 125^{O}C. If the circuit was operating at a room temp of 25^{O}C then the MLCC could handle enough current until the part heated up to 125^{O}C. If the same circuit was initially in a 100^{O}C environment, the ripple current would be less since there is a lower temperature differential.

If the MLCC could be kept below the maximum rated temperature, it could handle more current. Due to this dependency on temperature, ripple current measurement on MLCCs are performed at room temperature.

Q4. ***How is ripple current measured?***
A4. Many MLCC suppliers measure ripple current differently. There really is no industry mandated method. Therefore when trying to compare ripple current data between suppliers or different test methods, it is important to understand the test conditions first before analyzing the results. There are direct and indirect methods to measure ripple current.

One direct method would involve gauging the amount of input current until the capacitor temperature rose to some delta T such as 10^{O}C. Often a thermocouple would also be placed physically on the capacitor to measure the temperature rise.

Indirect methods include using ESR measurements to obtain ripple current. This principal is based on a common power formula $P = i^2R$ where in this case R is the equivalent series resistance (ESR). The capacitor is typically at room temperature.

Q5. ***What are some of the factors that affect ripple current measurement?***
A5. There are many factors that affect ripple current. Factors such as frequency and temperature are more easily controlled.

Due to the ESR component, ripple current is directly related to ESR. Both are frequency dependant therefore since ESR is lowest at the self resonant frequency (SRF), the corresponding maximum ripple current is also at the SRF.

Q6. ***What happens if I exceed the maximum ripple current?***
A6. As with any performance parameter, the manufacture does not recommend exceed any specification parameters. Some heating beyond the maximum rated temperature may not necessarily cause immediate failure. If the MLCC is heated beyond the maximum rated temperature, waveform of the ripple current would contribute to reducing the life of the capacitor.

Some ripple current waveform factors include duration, intensity, and shape of the current.

Q7. ***Does polarity affect ripple current for MLCCs?***
A7. For a polarized capacitor such as an aluminum electrolytic, application of reverse voltage does accelerate the capacitor breakdown. MLCCs are not subject to this because they are not polarized.

This is another advantage to use MLCCs for both design and manufacturing engineers.

Q8. ***Does case size affect ripple?***
A8. From an electrical standpoint there are too many variations on design to generalize. Physically the larger case size MLCC does have greater volume and and thermal mass. Due to this, the larger case size can absorb more energy (i.e. ripple current) before reaching the maximum rated temperature when compared to the same component in a smaller size.

Contact one of the following TDK sales offices for further information or visit our website @www.component.tdk.com, or www.tdk.com.

TDK CORPORATION OF OF AMERICA
1221 Business Center Drive
Mount Prospect, IL 60056
Phone: 847-803-6100
Fax: 847-803-6296

ATLANTA Sales Office
2180 Satellite Boulevard
Building 400, Suite 300
Duluth, GA 30096
Phone: 678-584-2275
Fax: 678-584-2276

AUSTIN Sales Office
7000 N. Mopac Expressway
2nd Floor
Austin, TX 78731
Phone: 512-514-6308
Fax: 413-541-8329

CHICAGO District Office
1221 Business Center Drive
Mount Prospect, IL 60056
Phone: 847-803-6100
Fax: 847-390-4325

DALLAS District Office
511 E. Carpenter Freeway
Suite 690
Irving, TX 75062
Phone: 972-506-9800
Fax: 972-869-3353

DENVER Sales Office
357 South McCaslin Blvd
Suite 200
Louisville, CO 80027
Phone: 303-926-4996
Fax: 303-926-4997

DETROIT District Office
38701 Seven Mill Road
Suite 250
Livonia, MI 48152
Phone: 734-462-1210
Fax: 734-462-1193

FLORIDA District
800 Fairway Drive
Suite 291
Deerfield Beach, FL 33441
Phone: 954-425-0095
Fax: 954-425-8287

GREENSBORO District Office
600 Green Valley Road
Suite 207
Greensboro, NC 27408
Phone: 336-292-0012
Fax: 336-292-3831

HUNTSVILLE District Office
250 Finney Road
Huntsville, AL 35824
Phone: 256-464-0222
Fax: 256-464-9963

INDIANAPOLIS District Office
4015 West Vincennes Road
Indianapolis, IN 46268
Phone: 317-872-0370
Fax: 317-872-2978

LOS ANGELES Sales Office
11137 Warland Drive
Cypress, CA 90630
Phone: 562-596-1212
Fax: 562-596-4841

NEW ENGLAND District Office
264 South River Road
Suite 416
Bedford, NH 03110
Phone: 603-622-0003
Fax: 603-622-1196

NEW JERSEY District Office
99 Wood Ave. South
3rd Floor
Iselin, NJ 08830
Phone: 732-494-0100
Fax: 732-494-5306

SAN DIEGO District Office
6165 Greenwich Drive
Suite 110
San Diego, CA 92122
Phone: 858-554-0999
Fax: 858-554-1861

SAN JOSE District Office
1740 Technology Drive
Suite 510
San Jose, CA 95110
Phone: 408-437-9585
Fax: 408-437-9591