



Frequently asked questions regarding:

## **MLCC Voltage Strength**

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### *Abstract*

*Industry practice and “rules of thumb” will vary when considering the proper voltage rating of a capacitor. There is a significant difference in derating rules between competing capacitor technologies. This FAQ addresses some common questions related to voltage strength of TDK MLCCs. Based on reliability and performance needs, the design engineers must decide component selections based on the acceptable reliability factors. This FAQ will answer some questions to assist in determining voltage rating selection.*

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## Q1. What is voltage strength?

A1. Voltage strength refers to how much voltage a part can withstand. This discussion will focus on TDK capacitors. There are different voltage strength thresholds depending on the application or stress conditions.

Typically voltage strength represents the maximum level of continuous voltage that can be applied across a capacitor. Voltage strength is just one factor used to determine the manufacturer's voltage rating. Different capacitor technologies may require derating of the rated voltage in actual use conditions.

## Q2. What is derating?

A2. Some technologies recommend a voltage derating to ensure safe operation of the component in circuit. This means that the maximum application voltage should be some level less than the manufacturer's rated voltage. Typically, electrolytics such as tantalum and aluminum capacitors recommend a 2 times (or greater) derating. For example, if the circuit voltage is 10V, then a 20V rated electrolytic should be selected. Since MLCCs have higher voltage strength and can withstand stress beyond its rated voltage, they do not require any voltage derating.

## Q3. How can voltage strength be measured?

A3. Voltage strength can be measured using a test called voltage breakdown (Vbd). This is a destructive test where DC voltage is applied at a controlled ramp rate until the part fails. The ramp rate can be any rate but 50 volts per second is often used. When comparing Vbd results, it is important to ensure all parts were tested under the same conditions. Once the maximum voltage is applied, the dielectric will begin to breakdown and cause the part to fail. Typical Vbd for MLCCs are much greater than the rated voltage while Vbd for electrolytics are much lower. (Table 1)

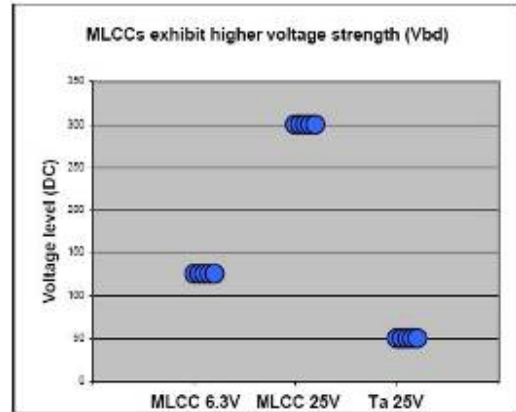


Table 1: Vbd comparison

## Q4. What is the typical result of voltage breakdown failure?

A4. Voltage breakdown is an event where the capacitor has seen voltage stress beyond its threshold. Failures typically result in short circuits caused by decreasing insulation resistance and increased current.

For a MLCC, the internal construction is compromised in the form of an electrical overstress (EOS) crack. (Figure 1)

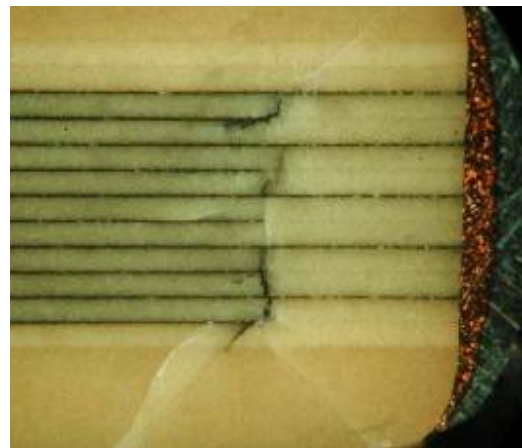


Figure 1: EOS of MLCC

**Q5. How does TDK determine rated voltage?**

A5. Since MLCCs are required to meet high reliability requirements, they must meet a number of electrical and environmental test conditions. There are several industry and customer specific test specifications and many are based on Mil-STD-202. Some examples of environmental tests include operating life and HALT tests which both include acceleration factors for temperature and voltage over some time period. The voltage is typically greater than rated voltage.

The post reliability test results are verified by measuring key performance parametrics: capacitance, dissipation factor, & insulation resistance. A part failure or wear out is determined by these parametric tests. During wear out, it is common to see degradation or “leaky” performance of the insulation resistance (IR).

Rated voltage is determined based on the reliability performance of environmental and electrical tests. TDK will further validate voltage performance on a 100% production level.

Since MLCCs are designed to meet industry required reliability tests, no further voltage derating is required by the customer.

**Q6. How does TDK verify their MLCCs will meet the voltage rating?**

A6. TDK incorporates an exhaustive battery of inspection and testing criteria for all products from raw material development through final packaging. Many of these tests are proprietary and are the reason why TDK products are well known for high quality.

Within our process flow, one step that is very important to mention is our 100% electrical testing and sorting. As the name implies, the 100% testing process is performed on every capacitor, from every lot, for every shipment. 100% testing includes a battery of electrical tests and measurements.

This 100% testing includes a unique and proprietary pulse waveform that subjects the part to a very high, short duty cycle voltage spike. The voltage spike level is much greater than the rated voltage of the part.

**Q7. What voltage ratings does TDK offer?**

A7. TDK offers a wide range of voltage ratings. The MLCCs are available in general application up to 50V, mid voltage family up to 630V, and high voltage family up to 3000V.

Series	Voltage Code	Rated Voltage	Withstand V Class 1	Withstand V Class 2
Standard Voltage	0G	4	12	10
	0J	6.3	18.9	15.75
	1A	10	30	25
	1C	16	48	40
	1E	25	75	62.5
	1V	35	105	87.5
	1H	50	150	125
Mid Voltage	2A	100	300	250
	2D	200	600	500
	2E	250	750	625
	2W	450	1350	1125
	2H	500	1500	1250
	2J	630	1890	1575
High Voltage	3A	1000	3000	2500
	3D	2000	6000	5000
	3F	3000	9000	7500

Table 2: Common voltage codes and values

Beyond this, TDK does offer some special application and new product voltage levels based on customer application. Some examples include product rated below 6.3 V for IC applications and 350V rated product targeted for lighting applications.

TDK also offers a family of leaded ceramic capacitors as well as UL rated safety caps. Examples of other capacitor product families include:

Series	Rated Voltage	Description
FK	6.3 to 630Vdc	Conformal radial-leaded
CC45	1 to 6KVdc	High voltage leaded disc, high frequency, Class I
CK45	1 to 3KVdc	High voltage leaded disc, general, Class II
CK45-RR	1 to 3KVdc	High voltage leaded disc, high frequency, low DF
CD	250Vac	AC Safety standard approved (X1,Y1), reinforced insulation, 4KVac withstand voltage
CS	250Vac	AC Safety standard approved (X1,Y2), basic insulation leaded, 2.6KVac withstand voltage
GA	10KVac	Ultra high AC voltage, non-insulated, metal terminals
FD	10 to 25KVac	Ultra high AC voltage, molded insulation, metal terminals
UHV/FHV	15 to 50KVdc	Ultra high voltage, molded insulation, metal terminals
HFC	10KVac	Ultra high voltage, molded insulation, feed-thru type

Table 3: Leaded and high voltage capacitor examples

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This *example list* of our product line is subject to change. Your local TDK representative can provide you a list of current available products.

**Q8. How do I derate for AC voltage?**

A8. TDK recommended operating voltage refers to total applied voltage. This can be full DC voltage, full AC voltage, or a combination of AC and DC. In the case of AC voltage, the complete peak to peak voltage in addition to any DC voltage should not exceed the rated voltage of the capacitor. Examples of acceptable voltage waveforms are shown in figure 2.

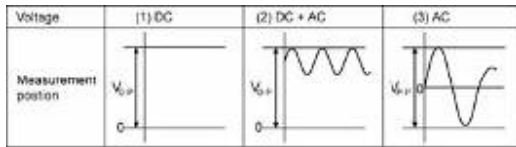


Figure 2: Example voltage measurement

Even if below the rated voltage, if repetitive high frequency AC is applied, the reliability of the capacitor may be reduced. This high frequency is near the self-resonant frequency and may result in high heating of the capacitor.

**Q9. How do I select the proper rated voltage MLCC?**

A9. The first step is to determine the maximum sustained voltage (AC and DC) the circuit will see. Then choose the rated voltage value item that meets or exceeds the voltage needs.

Some applications involve a transient surge or battery load dump. These are typically short bursts that are greater than the typical operating voltage level. In these cases, it is common to see a capacitor rated for the typical operating voltage used.

An example would be using a 50V rated MLCC on a 48 V line that may see an occasional 108V battery dump. The designer has determined that the overall voltage strength of the MLCC is sufficient to absorb the occasional surge voltage.

The MLCC appears to be strong enough to withstand this usage condition but the circuit designer must make the reliability assessment. As mentioned earlier, voltage strength and life are some factors for consideration. The manufacturer typically will not guarantee performance beyond its rated conditions.

In addition to the reliability considerations of rated voltage, the designer should verify the effective capacitance of the MLCC under the circuit conditions.

# End of Report

Contact TDK for further information or visit our website @[www.component.tdk.com](http://www.component.tdk.com), or [www.tdk.com](http://www.tdk.com).

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