Comments:

Welcome to this Murata product tutorial on high capacitance (Hi-Cap) MLCC products. Here the company will review a little basic theory and touch on some of the more important characteristics and applications for these capacitors. We hope you will find it enjoyable and educational.

Introduction

Purpose

- Provide basic information on Murata's High Capacitance Multilayer Ceramic Capacitors (MLCC)

Objectives

- Explain the function and features of a High Capacitance capacitor
- Discuss applications and performance details of a High Capacitance capacitor
- Examine Murata's current line-up of High Capacitance capacitor products

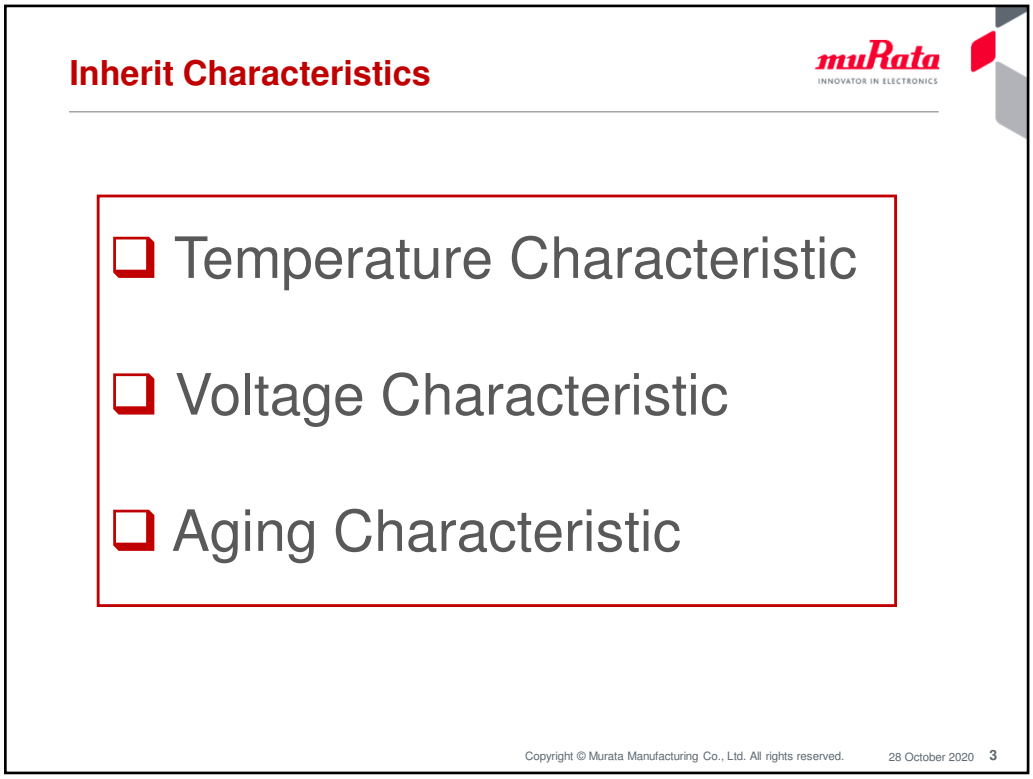
Contents

- 22_ pages

Learning Time

-___

Comments :
Here Murata provides a brief introduction as to what this product training module will cover.



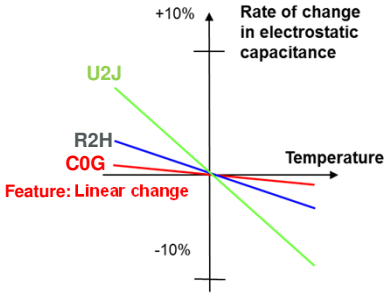
Comments:

When it comes to MLCC, specifically Hi-Cap, there are several inherit characteristics that a user must be aware of. These characteristics will have a direct effect on the capacitance of a Hi-Cap MLCC. Please refer to the following slides for details relating to:

1.) Temperature Characteristics
2.) Voltage Characteristics
3.) Aging

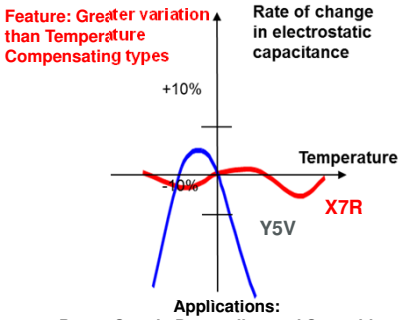
Temperature Characteristic

Example of change in capacitance for **Temperature Compensating types**



Applications:
Filters and High-Frequency circuit matching

Example of change in capacitance for **High Dielectric Constant types**



Applications:
Power Supply Decoupling and Smoothing

Comments:

The first inherit characteristic is the effect of Temperature. In general, capacitance value varies depending on ambient temperature (Temperature Characteristics). For MLCC, there are 2 classes of Temperature Characteristics:

a.) Class 1: Temperature Compensating type
b.) Class 2: High Dielectric Constant type (Hi-Caps)

Temperature Characteristic

Class II: High Dielectric (Hi-K) Type

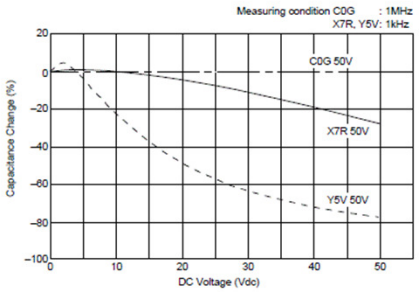
Temp. Char.	Specifications		
	Min Temp	Max Temp	Cap Change @
X5R	-55℃	85℃	±15%
X6S	-55℃	105℃	±22%
X6T	-55℃	105℃	±22/-33%
X7R	-55℃	125℃	±15%
X7S	-55℃	125℃	±22%
X7T	-55℃	125℃	±22/-33%
X7U	-55℃	125℃	±22/-56%
X8L	-55℃	150℃	+15% to -22%
X8R	-55℃	150℃	±15%

@: allowable change of capacitance within temperature range

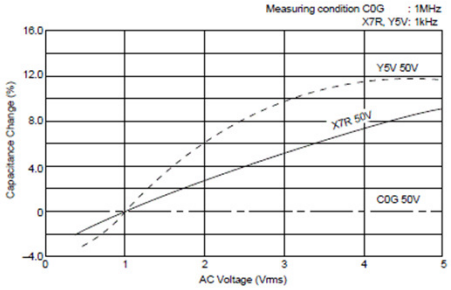
Comments:
Murata offers many Class II, High Dielectric types for their Hi-Caps. The actual choice of Temperature Characteristic depends upon factors like operating temperature range, capacitance range, allowable capacitance change, voltage rating, reliability and case size. The change in electrostatic capacitance due to temperature differs for each type, so they must be selected and used in accordance with their features.

Voltage Characteristic

■ Capacitance - DC Voltage Characteristics



■ Capacitance - AC Voltage Characteristics



- Class 2 dielectric materials (X5R, X7R, etc.) experience a change in capacitance when an AC or DC voltage is applied.
- Capacitance decreases when DC voltage is applied
- Capacitance increases slightly when an AC voltage is seen

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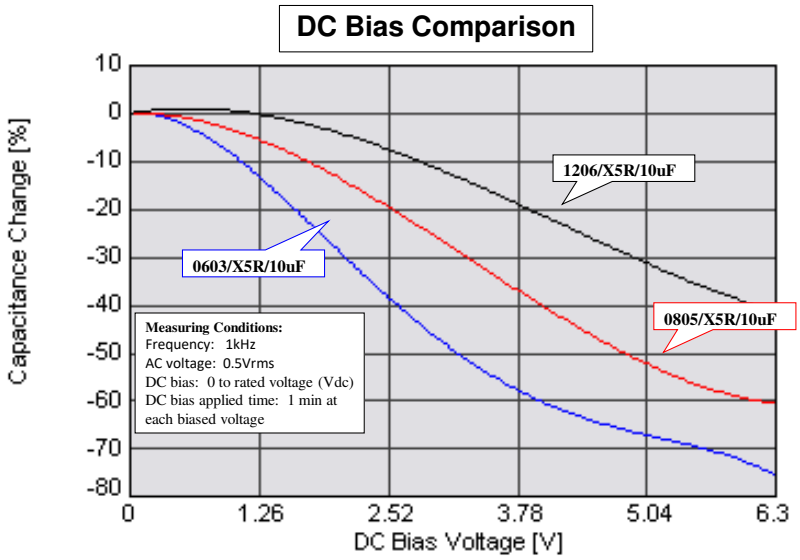
Comments:

The second inherent characteristic is the effect of Voltage. Though, Hi-Caps experience a change in capacitance when either AC or DC voltage is applied, the effect of DC voltage (DC Bias) is more substantial (thus more critical to designers) as shown in the above chart.

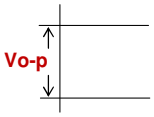
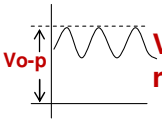
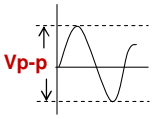
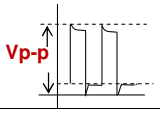
Voltage Characteristic



Comments:

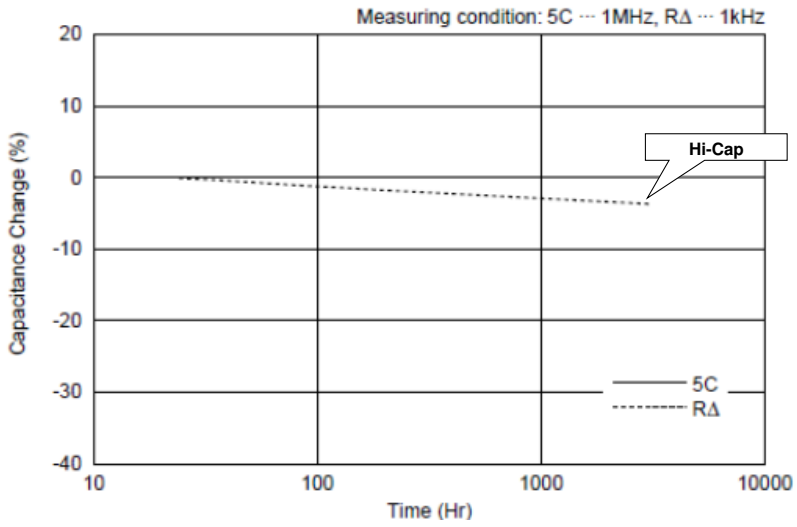
For Class II capacitors (X5R, X7R, etc.), the larger case size components have less capacitance change versus DC Bias voltage due to thicker dielectric layers and lower dielectric constant materials.

Voltage Characteristic

	Concept of Rated Working Voltage
DC	 Vo-p value is within rated working voltage.
DC + AC	 Vo-p value is within rated working voltage.
AC	 Vp-p value is within rated working voltage.
Pulse	 Vp-p value is within rated working voltage.

Comments:
When referring to applied voltages, it is also important to understand the Rated Working Voltage specification of a particular capacitor. Here the company provides this chart shows the various voltage conditions to consider.

Aging Characteristic



Comments:
The third inherent characteristic of Hi-Cap MLCC is Aging (capacitance decrease over time).
For example, as shown in the chart above, the longer the elapsed time, the more effective capacitance is reduced (it decreases almost linearly in a logarithmic time chart). The horizontal axis shows elapsed time (Hr), and the vertical axis shows the capacitance change ratio against the initial value.

The design must take operating temperature, voltage conditions, and Aging into consideration to ensure reliability and functionality of the capacitor.

Advantages of Hi-Cap MLCC

- Impedance/ESR of the MLCC are much lower, especially at high frequencies (above approx. 10kHz).
- The capacitance of the MLCC remains constant over a wide frequency range.
- Excellent noise absorption.
- Self-Heating of the MLCC due to ripple current is low because of lower ESR.
- Excellent breakdown voltage.
- MLCC has no polarity unlike other technology, which eliminates the risk of reverse biasing resulting in instant failures or worse case eventually leading to field failures.
- MLCC has a volumetric advantage as advances in ceramic technology make way for higher capacitances in smaller and smaller case sizes.

Comments:
Despite the disadvantages of the three inherit characteristics that we just described, Hi-Cap MLCC still has many advantages when compared to other capacitor technologies in the market as the company shows in this chart.

Function & Applications

•**Function** – Electrical signals contain various noise components such as EMI or equipment-generated noise. This noise can cause many problems such as crosstalk, false-triggering, or incorrect logic-levels. High Capacitance MLC capacitors can be used to reduce these noise signals and provide a more stable operating system.

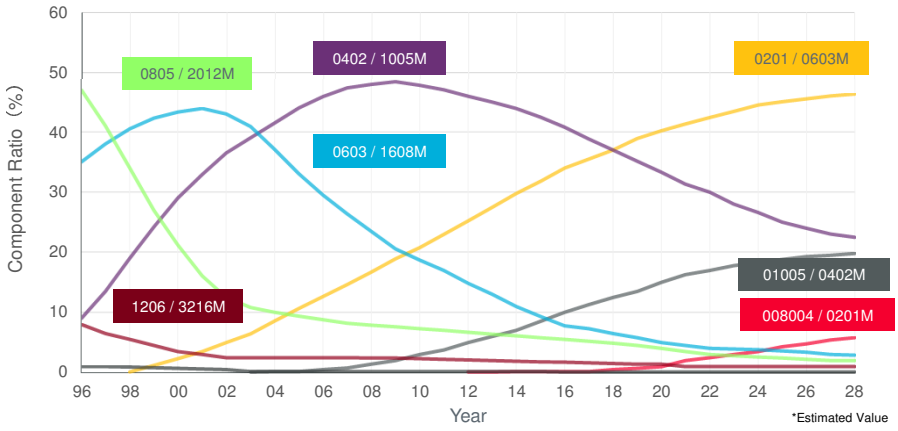
•**Decoupling** – In addition to noise reduction, the MLCC work to keep the voltage level from drifting between connected devices. Neighboring circuits with common voltage lines become independent of each other with the proper capacitor (low-pass) filtering the supply line. The capacitance should be large enough to absorb any load shift of a device.

•**Smoothing** – When AC signals are changed to DC signals, if the voltage waveform contains too much ripple then a capacitor is used to smooth (absorb) this voltage before being sent to other circuits. The capacitance should be large enough to absorb the ripple current.

Comments:
Typical applications for Hi-Cap MLCC are for filtering, decoupling, and smoothing applications. In this chart the company provides greater detail for each application .

MLCC Case Size Trend (General use)

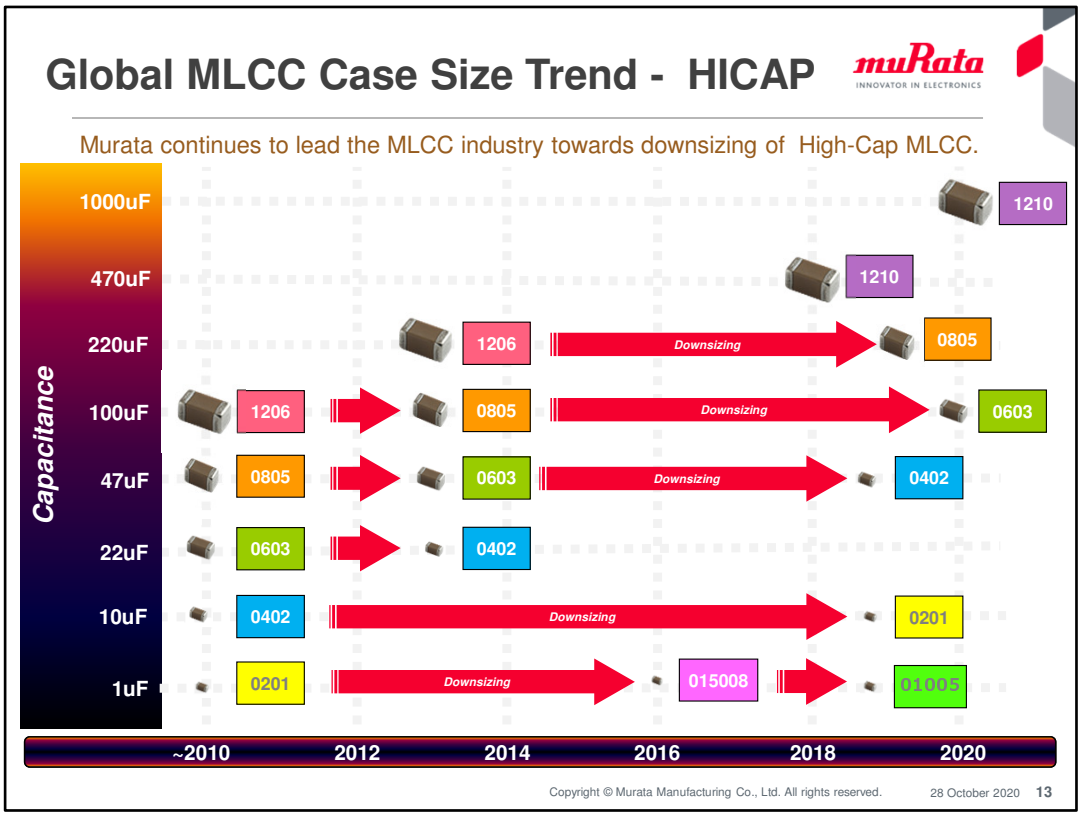
- In 2018, the 0201 inch size is became the leading case size due to the expansion of the ultra-compact product market.



Comments:

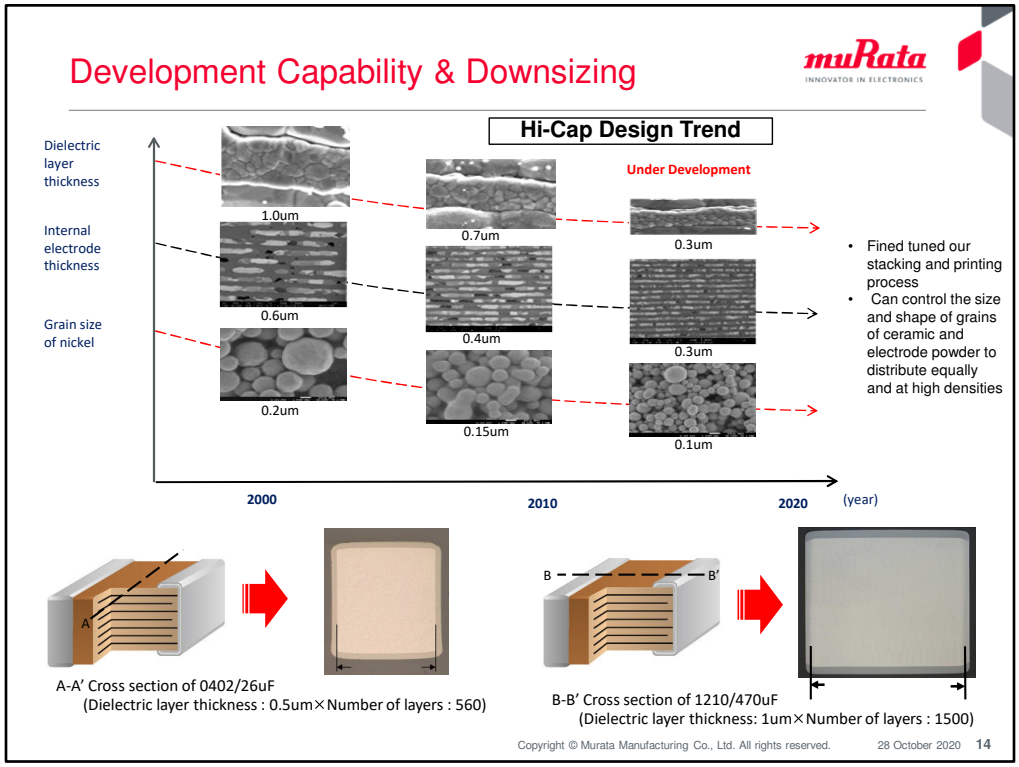
Murata's case size lineup allows design engineers to downsize designs with various package options.

The company estimates that the major case size after 2024 will be the EIA 0201 case size.



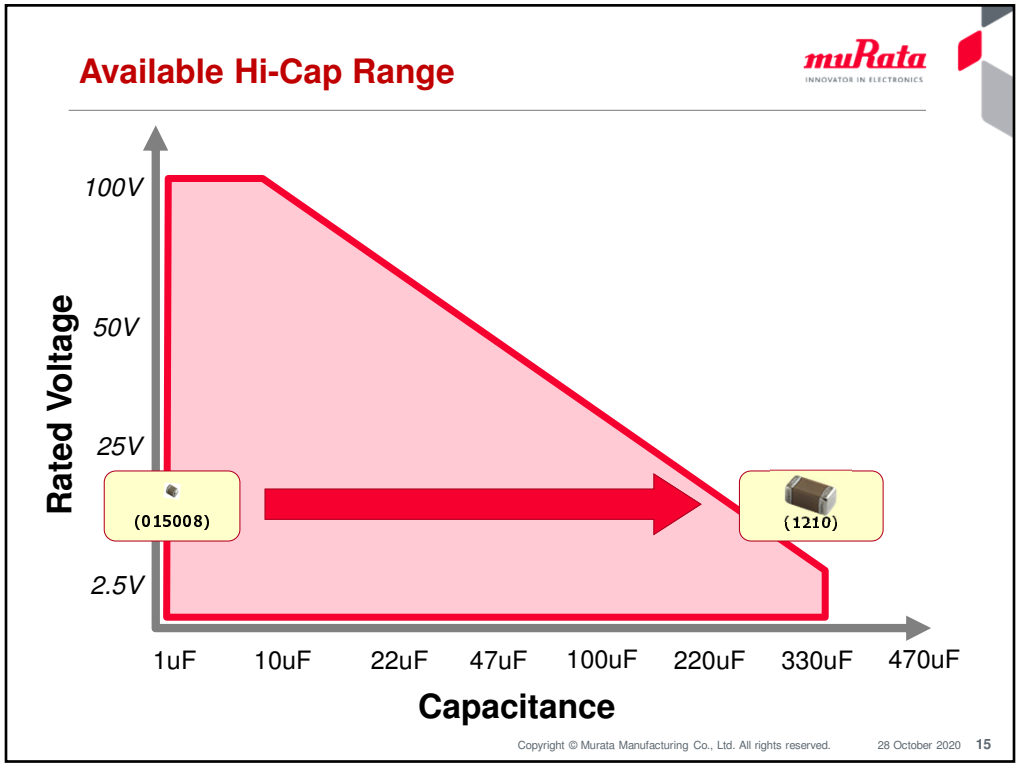
Comments:

The company provides historical trends highlighting MLCC Hi-Cap downsizing showing either increased capacitance in each given size or increased capacitance in newer downsized case sizes.



Comments:

Murata's thin dielectric layer technology is important to the development of their Hi-Cap product line-up. The company has established a processing technology to control the size and shape of the grains of the ceramic powder at high accuracy, and to distribute it equally at high density. Murata has already achieved 0.7um and thinner dielectric layer technology and is currently focused on increasing capacitance in smaller case sizes.



Comments:
Today, Murata offers a wide range of high capacitance, temperature characteristics, and rated voltage:

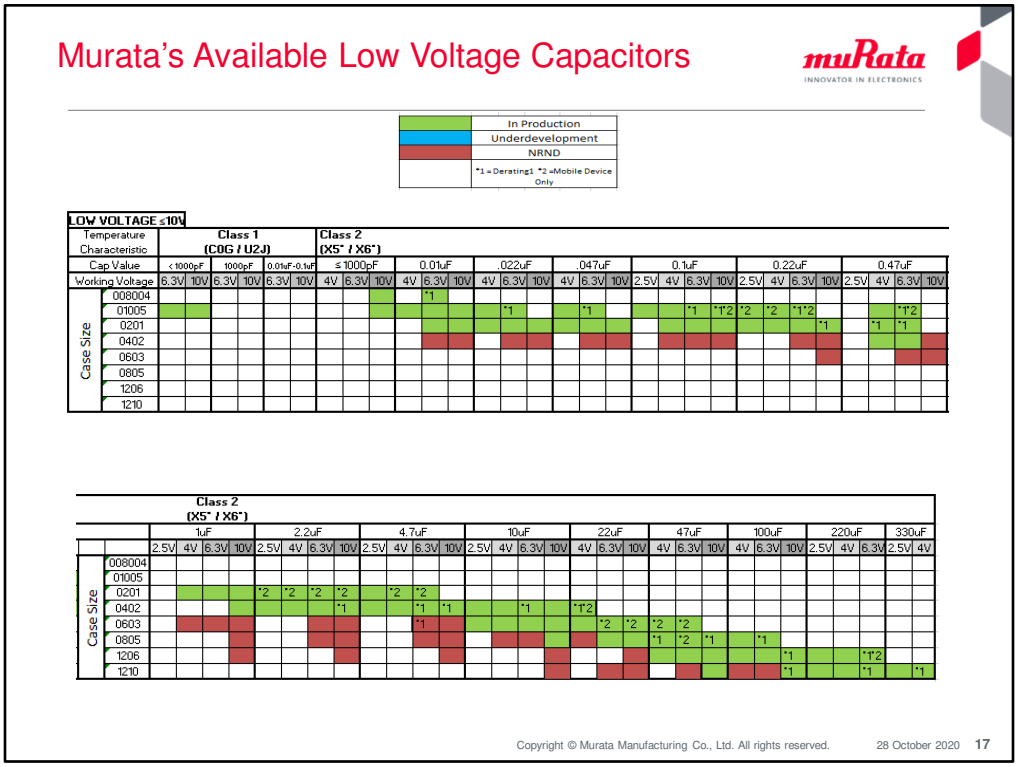
(a.) 1uF is available in the 015008 (new EIA) case size
(b.) 330uF is available in the 1210 case size

Available Hi-Cap Case Sizes (1uF and above)

EIA Size	L (mm)	W (mm)
015008	0.5 ± 0.025	0.25 ± 0.025
0201	0.6 ± 0.013	0.3 ± 0.03
0402	1.0 ± 0.05	0.5 ± 0.05
0603	1.6 ± 0.02	0.8 ± 0.2
0805	2.0 ± 0.1	1.25 ± 0.1
1206	3.2 ± 0.1	1.6 ± 0.15
1210	3.2 ± 0.3	2.5 ± 0.3

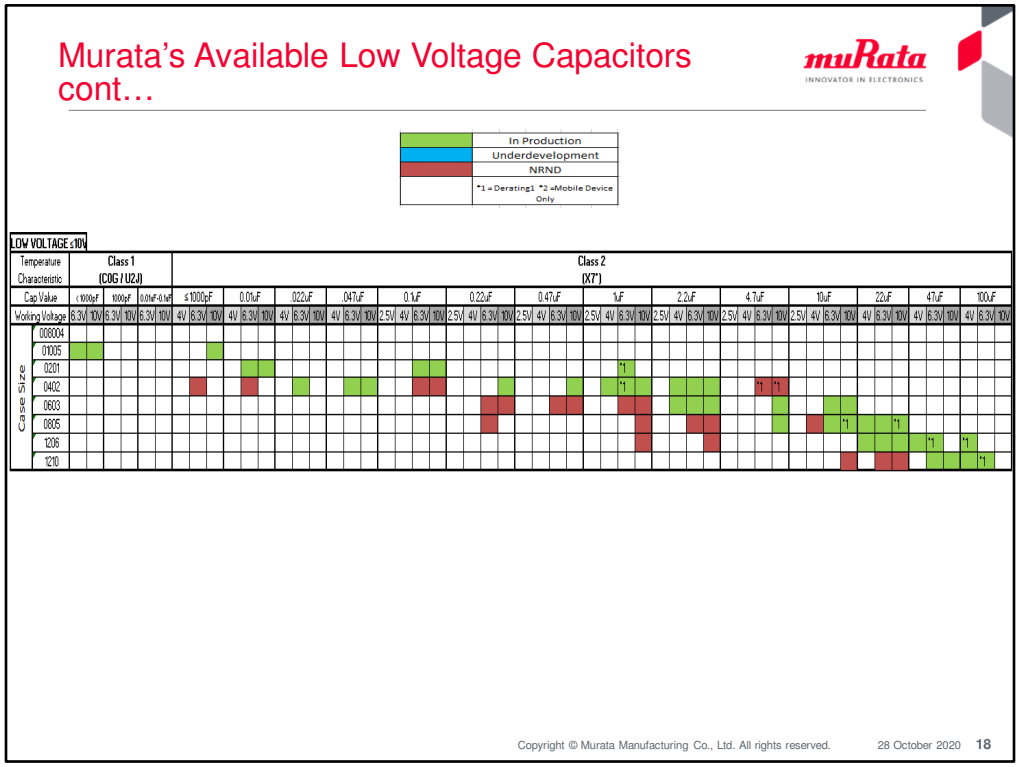
Comments:
Murata has a diverse case size line up to offer to their customers along with providing downsized versions for tomorrow's designs .

Murata's Available Low Voltage Capacitors



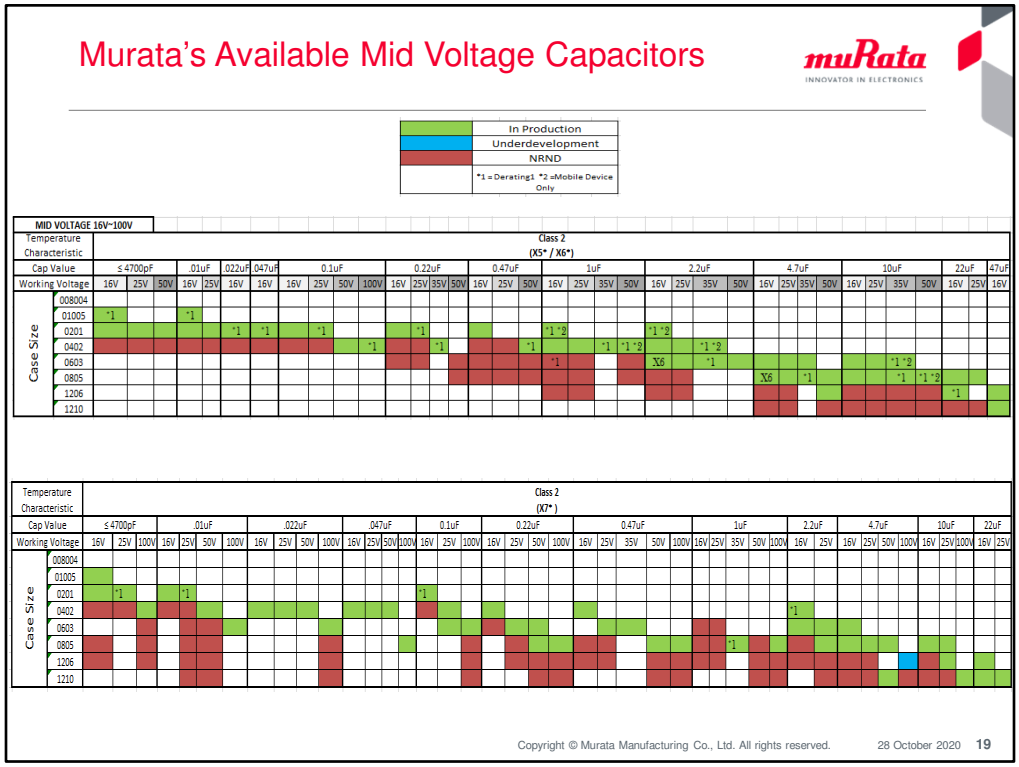
Comments :

The above charts are a summary of Murata's Low Voltage Class 1 and Class 2 GRM series, in case sizes from EIA 008004 to EIA 1210 and their product status at the time of this publication.



Comments:

The above charts are a summary of Murata's Low Voltage Class 1 and Class 2 , GRM series, from EIA 008004 to EIA 1210 sizes and their product status at the time of this publication.

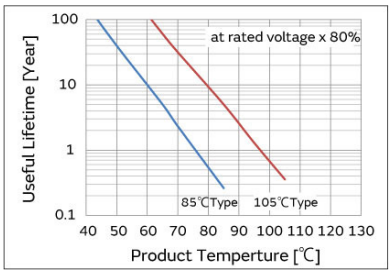


Comments :

The above charts are a summary of Murata's Mid Voltage Class 2 , GRM series, from EIA 008004 to EIA 1210 and their product status at the time of this publication.

Derating for Mobile Devices

- Mobile application specific MLCC products are designed for use in devices with a typical lifetime of less than 5 years.
  (Examples: Cellular phone, Smartphone, Tablet PC, Digital camera, Watch, Electronics dictionary, Small-scale server, IPC-9592B class1 equipment, etc.)
- Lifetime of MLCC can also be estimated from voltage acceleration and temperature acceleration factors.
- These MLCC products are designed so that the useful lifetime can be extended longer than 5 years under the following conditions:
  (80% of the rated voltage or less, Maximum operating temperature -20 degree C or less)
- Extended useful lifetime, under specific operating conditions, can be estimated from the following chart:



Comments :

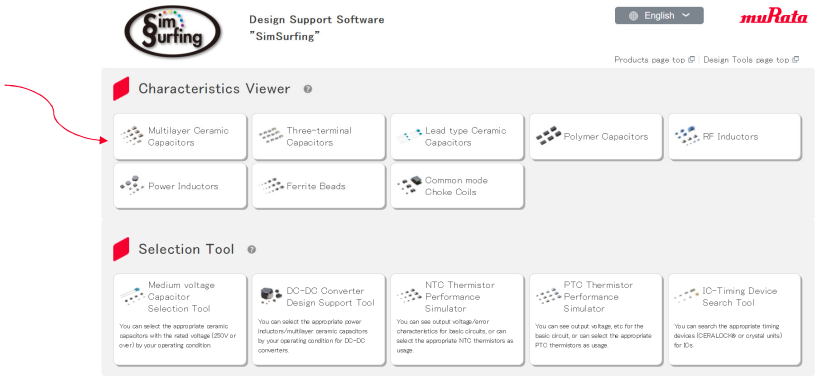
Here , the company provides information pertaining to Mobile Specific MLCC products and the affects of temperature and voltage on the life expectancy of the MLCC (i.e. derating) .

Software Design Tools

“SimSurfing”

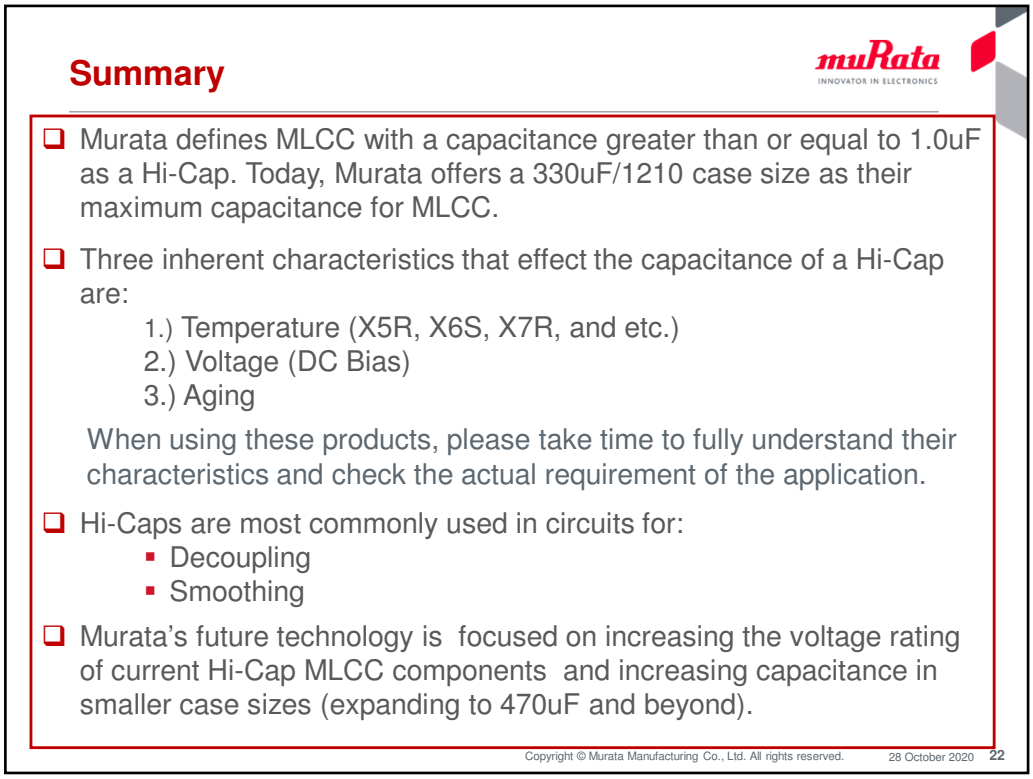
web-based design tool

http://ds.murata.co.jp/simsurfing/index.html?lcid=en-us



Comments:

The company’s SimSurfing software tool gives the user the option of pre-selecting a known part number from a list or by inputting the part based on characteristics such as case size, capacitance, rated voltage, and temperature characteristics. SimSurfing also allows users to plot various data for each selected part. It includes Capacitance vs. DC Bias, Capacitance vs. Temperature, and other Frequency Characteristics such as Impedance and ESR.



Comments:

Murata provides a complete range of MLCC Hi – Cap products suitable for a variety of electronic applications .

For a complete review of Murata's Hi-Cap MLCC, please refer to the Mouser website.