a YAGEO company

What Makes Ceramic Dielectrics Different

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About the Speaker

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Today's Agenda

1. 30k Foot MLCC View
2. Alpha-Numeric Designations
3. Two Materials, Multiple Functions
4. Time, Temp, and Piezoelectric Effects
5. Open Q&A

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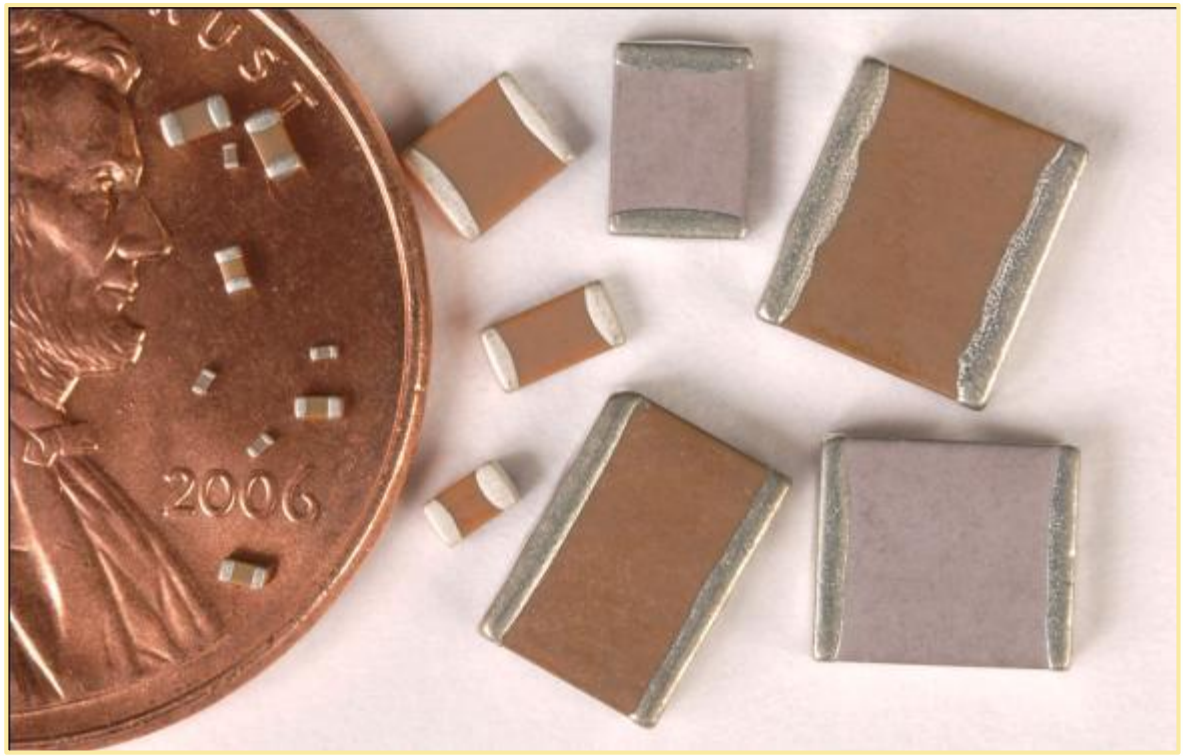
Form Factor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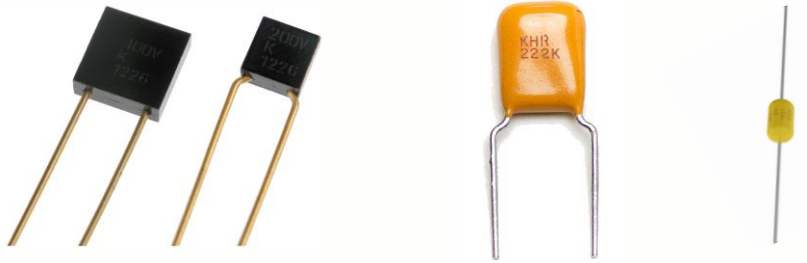

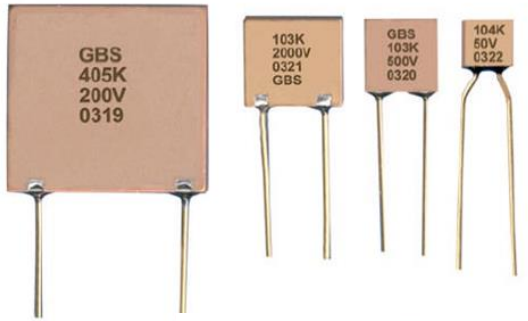
GBS
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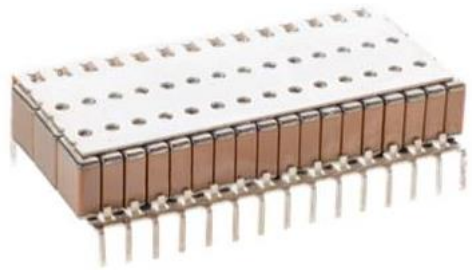
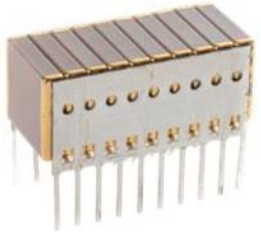
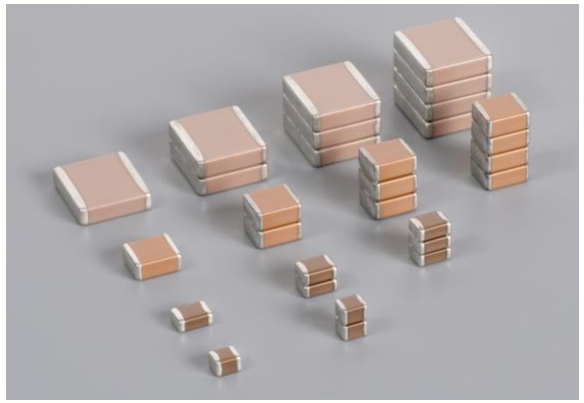
200V
0319
103K
2000V
0321
GBS
GBS
103K
500V
0320
104K
50V
0322



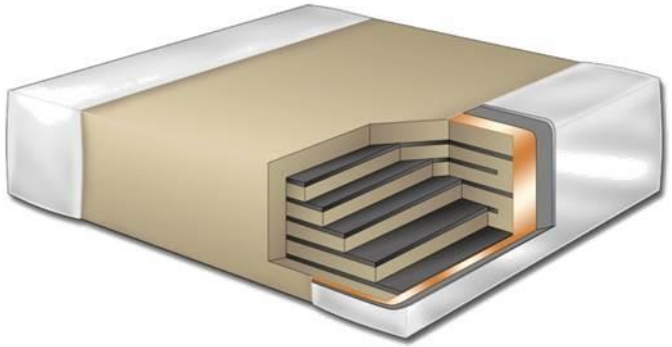


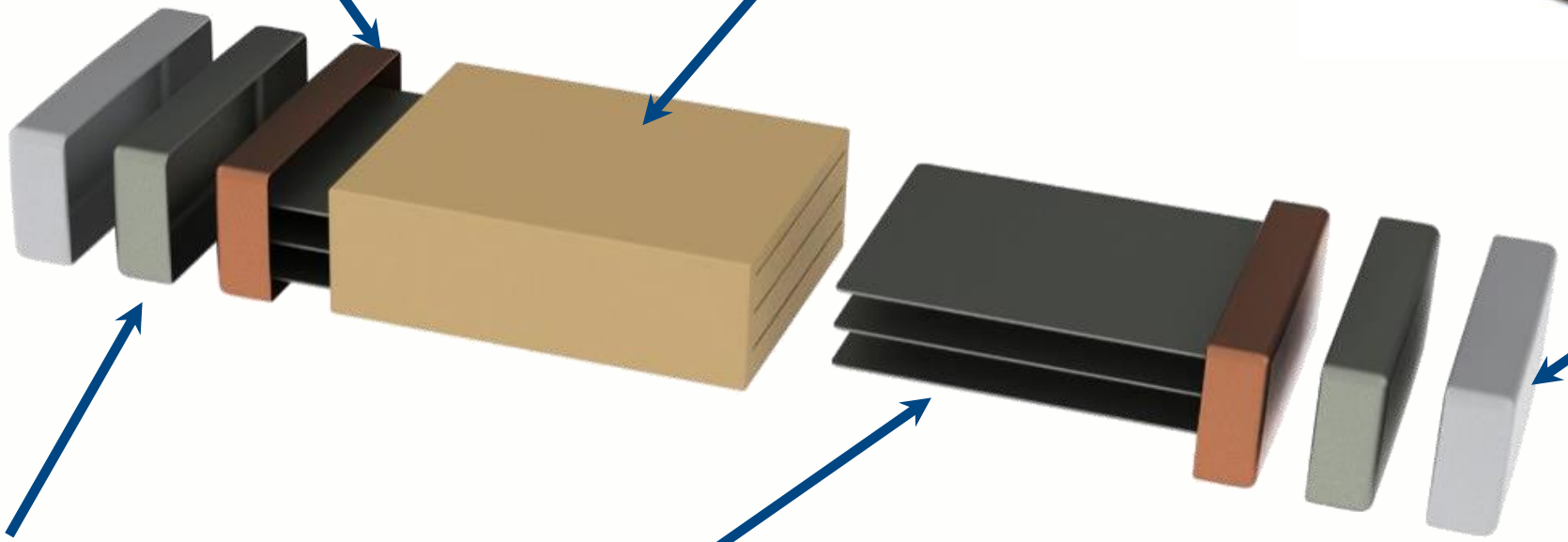


Typical Construction

Termination (External Electrode, Cu for BME, Ag for PME)

Ceramic Dielectric





Plated Sn finish for Solderability

Barrier Layer (Plated Ni)

Internal Electrode (Ni for BME, Ag/Pd for PME)

Dielectric Technology

Commercial & Automotive Grade Dielectric Materials

Class 1

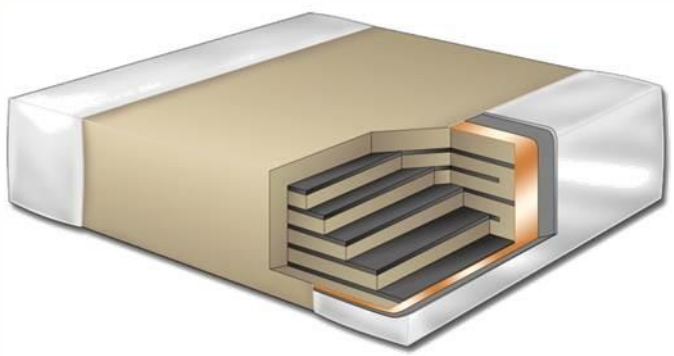
- X8G
  - BME
  - 150C
- C0G
  - PME & BME
  - 200ºC
- U2J
  - BME

Class 2

- X8R
  - BME
- X8L
  - BME
- X7R
  - PME & BME
  - 175ºC
- X5R
  - BME

Class 3

- Y5V
  - BME
- Z5U
  - BME



Military & Hi-Rel Dielectric Materials

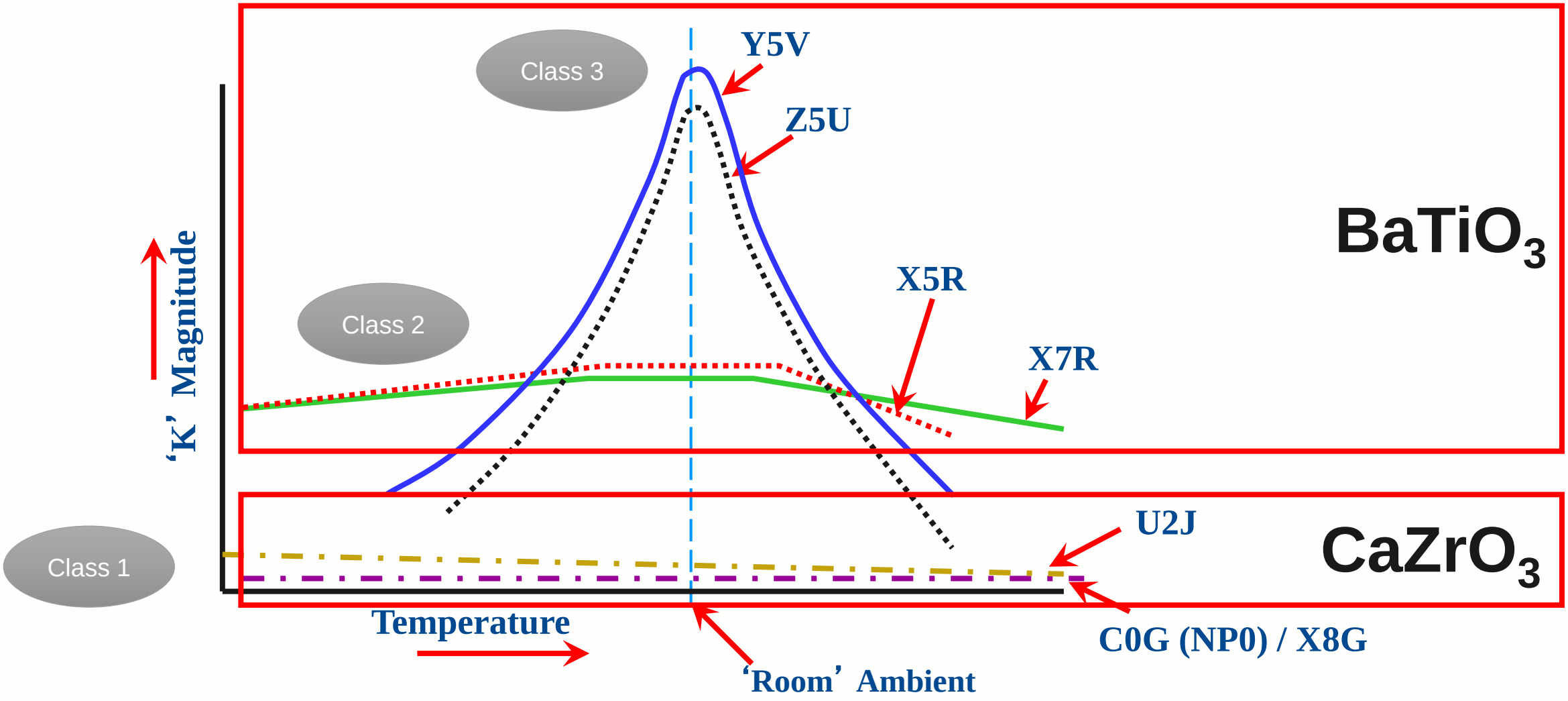
Class 1

- BP
  - PME
  - C0G @ Rated V

Class 2

- BX
  - PME
  - X7R +15/25% @ Rated V
- BR
  - PME
  - X7R & +15/-40% @ Rated V

Relative Capacitance vs. Temperature (TCC)



Dielectric Classification

Class 1 (Per EIA – 198)

C0G Example

U2J Example

Class I Dielectrics

Alpha Symbol	Significant Figure of Temp Coefficient ppm/°C	Numerical Symbol	Multiplier to significant figure	Alpha Symbol	Tolerance of Temp Coefficient ± ppm/°C
C	0	0	-1	G	30
B	0.3	1	-10	H	60
L	0.8	2	-100	J	120
A	0.9	3	-1000	K	250
M	1.0	4	-10000	L	500
P	1.5	5	+1	M	1000
R	2.2	6	+10	N	2500
S	3.3	7	+100		
T	4.7	8	+1000		
U	7.5	9	+10000		

Operating Temperature -55°C to +125°C

Dielectric Classification

Class 2 and 3 (per EIA-198)

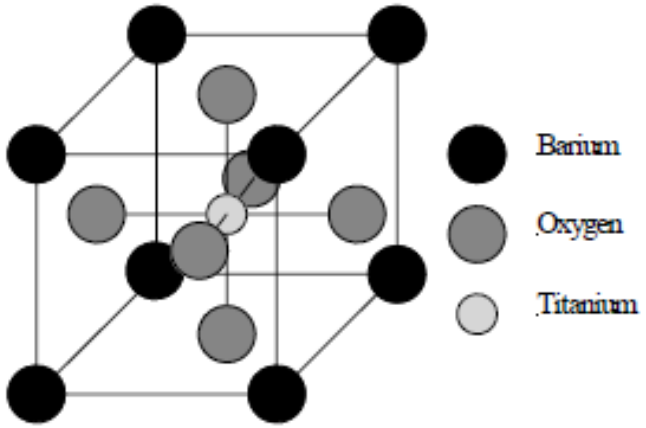
Alpha Symbol	Low Temperature (ºC)	Numerical Symbol	High Temperature (ºC)	Alpha Symbol	Max cap change over temp. range (%)	
Z	+10	2	+45	G	±30 ppm/ºC	CLASS 1+
Y	-30	4	+65	A	±1.0	
X	-55	5	+85	B	±1.5	
		6	+105	C	±2.2	
		7	+125	D	±3.3	CLASS 2
		8	+150	E	±4.7	
		9	+200	F	±7.5	
				P	±10	
				R	±15	
				S	±22	
				* L	+15 to - 40	
				T	+22 to - 33	
				U	+22 to - 56	CLASS 3
				V	+22 to - 82	

* Industry Classification (Non EIA-198)

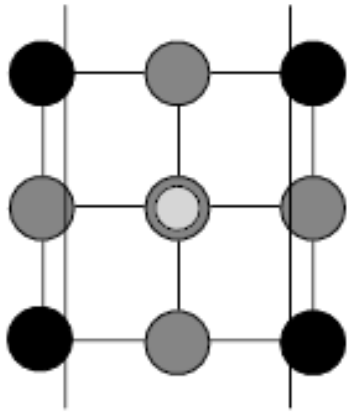
+ Class 1 is an exception to the EIA-198 table. Example: X8G

Voltage Coefficient (Class 2 and 3)

DC Bias

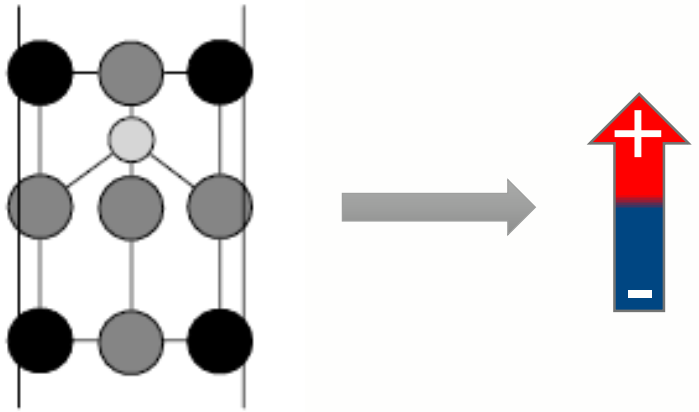


Face Centered Cubic Crystal Structure



$BaTiO_3$ above Curie point

- **Cubic**
- **No Dipole**



$BaTiO_3$ below Curie point

- **Tetragonal**
- **Creates Dipole**

Voltage Coefficient (Class 2 and 3)

DC Bias

VDC

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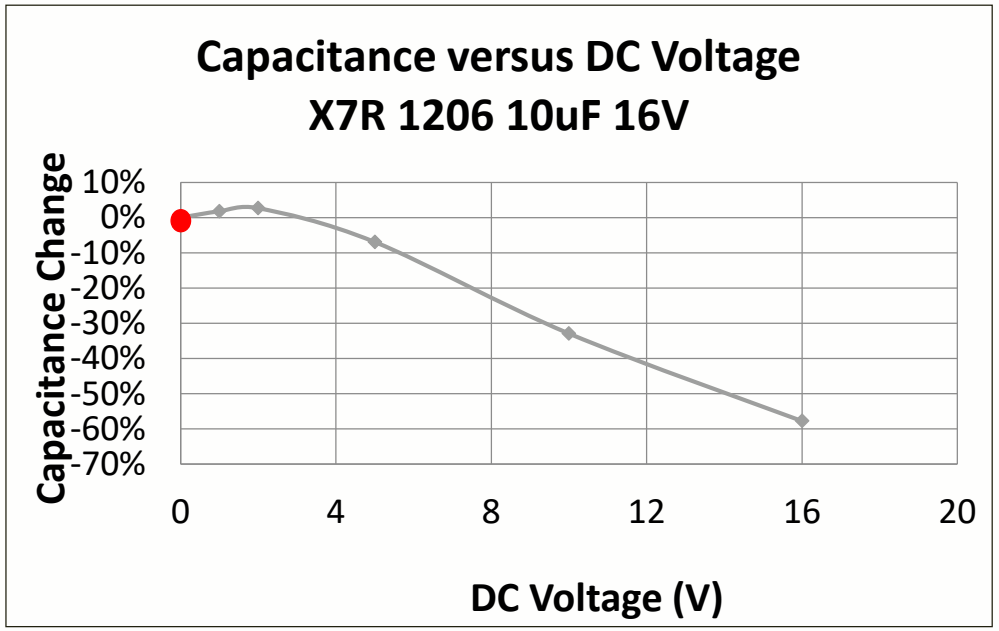
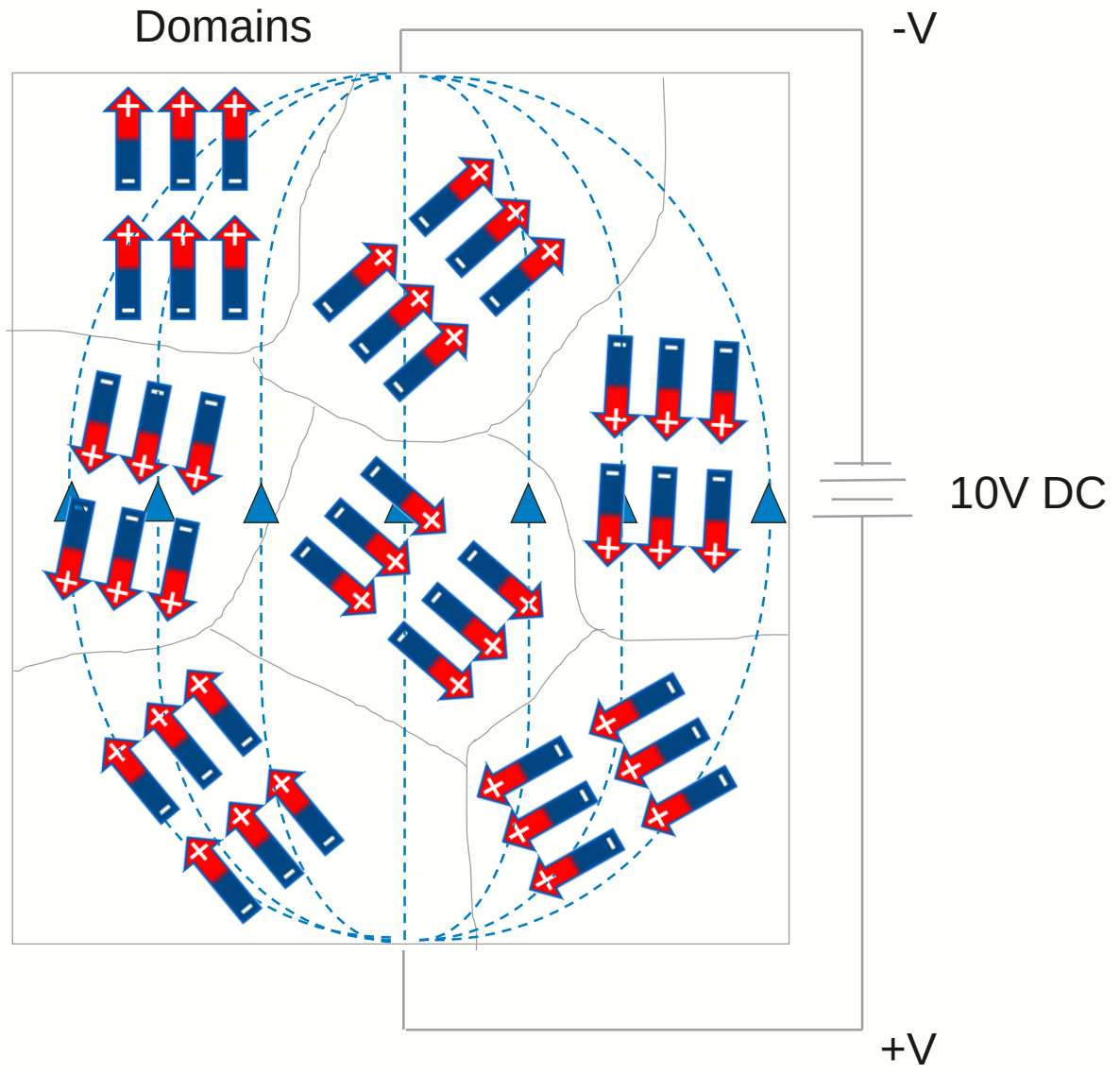
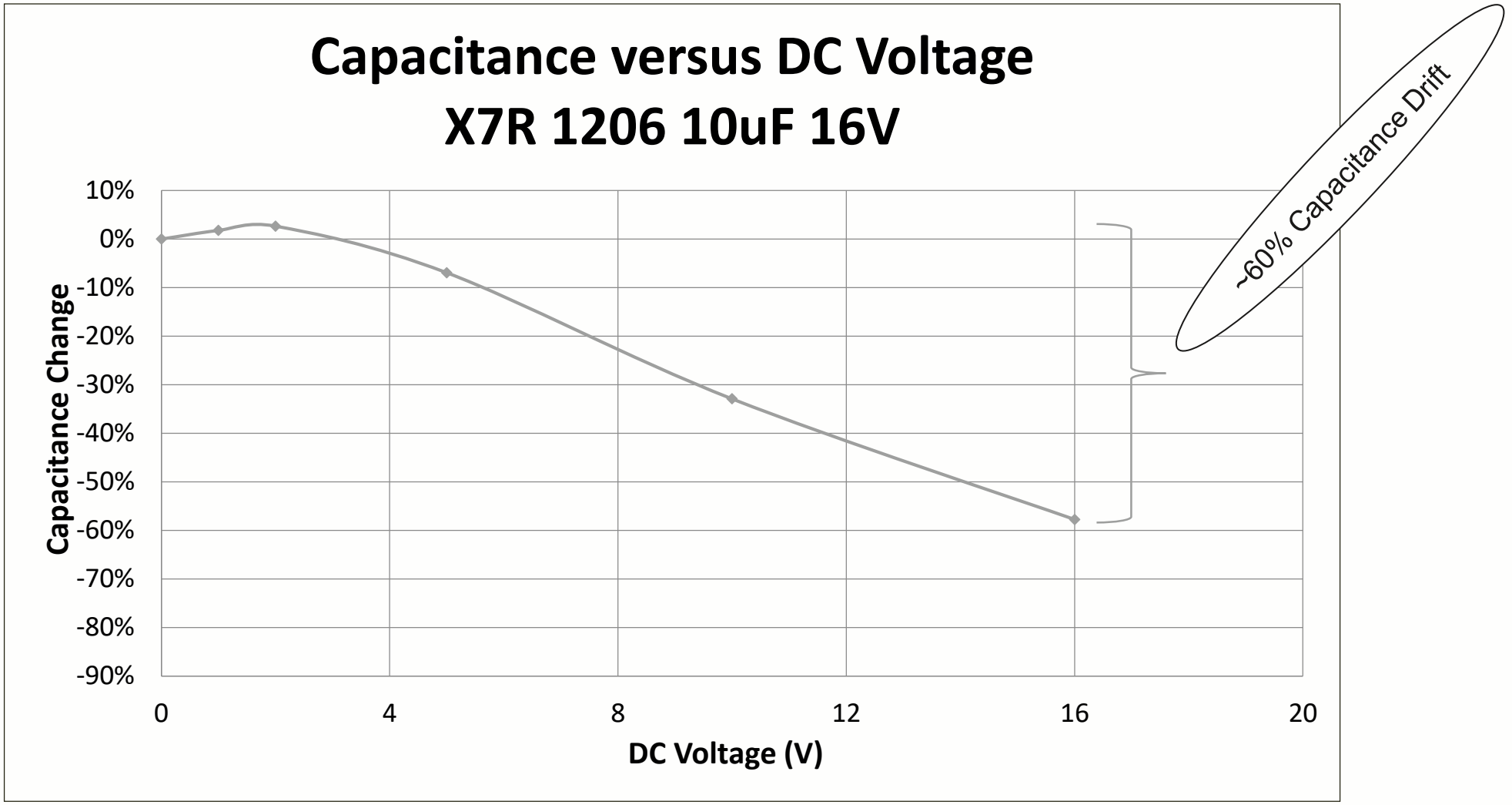




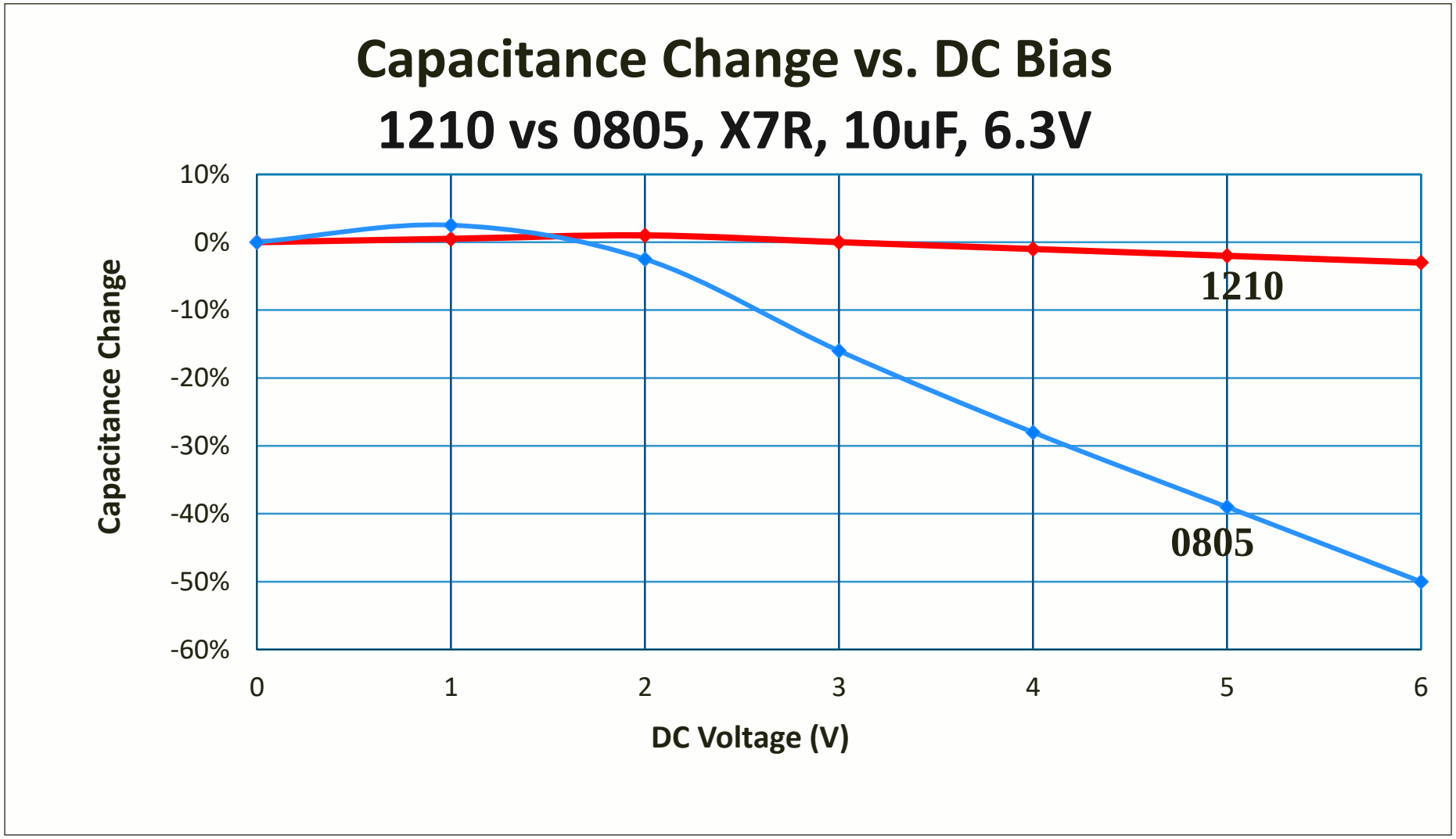
Capacitance Stability

Versus DC Voltage – Class 2 and Class 3



Capacitance Stability

Versus DC Voltage – Class 2 and Class 3



Class 1 MLCCs

Ultra Stable versus Voltage

VAC

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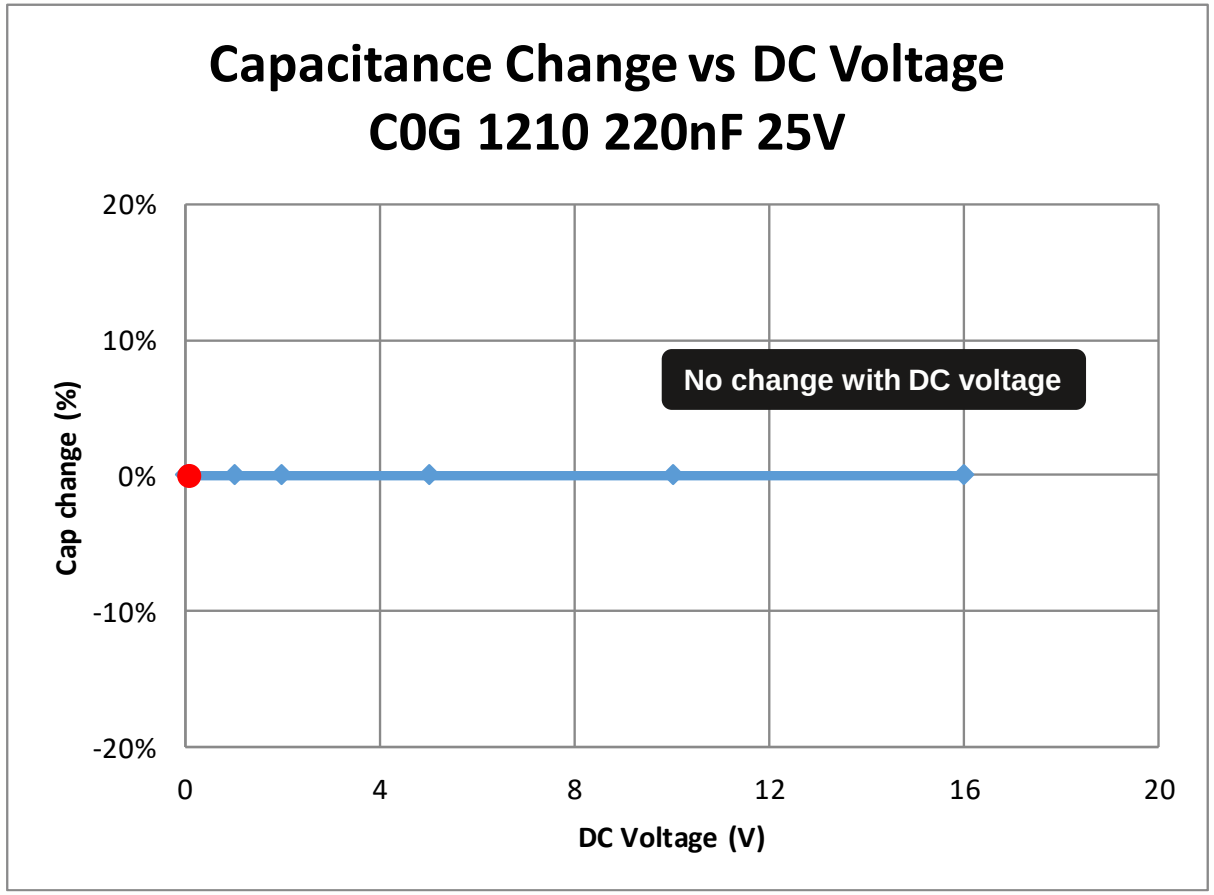
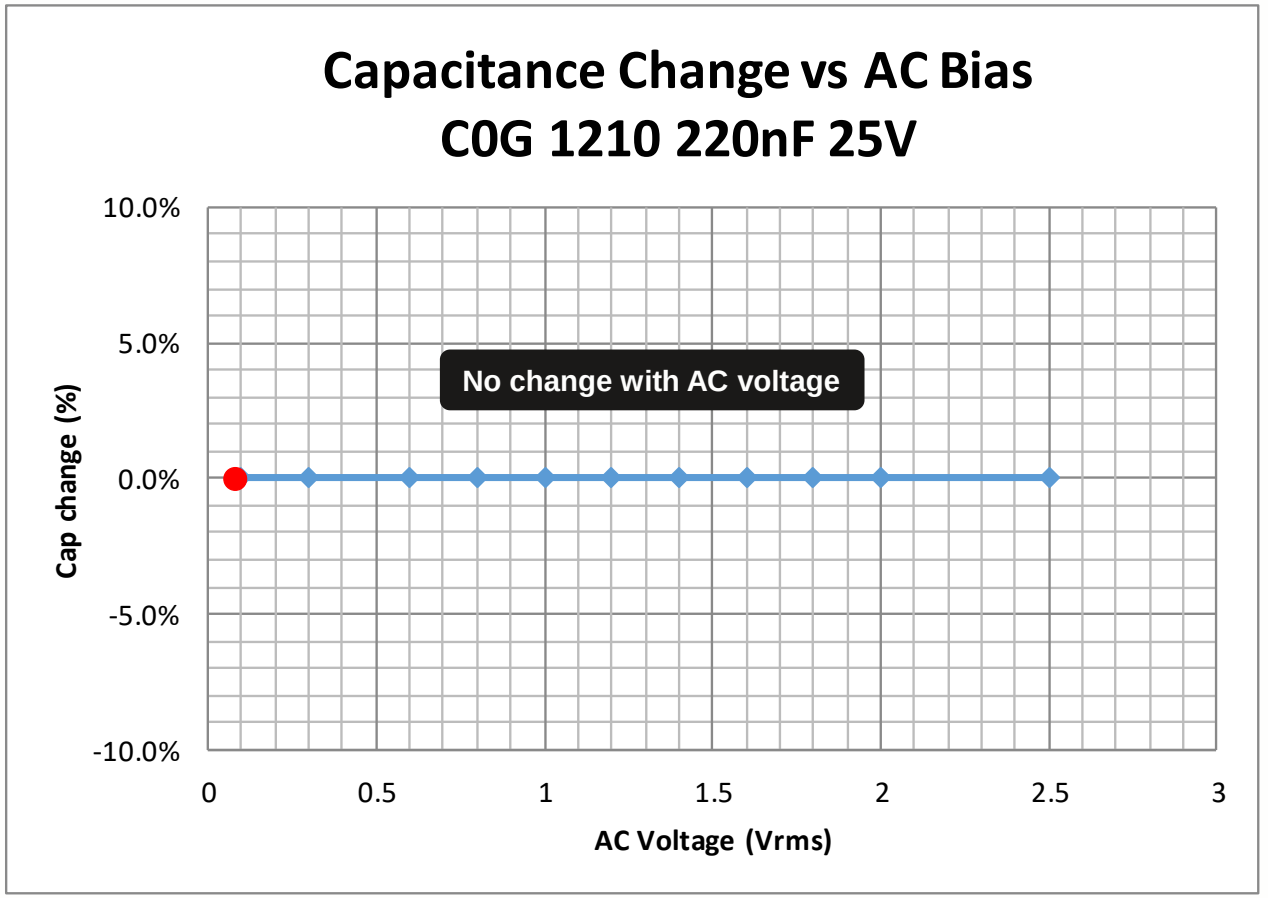


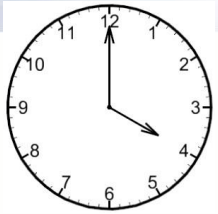
DC Voltage

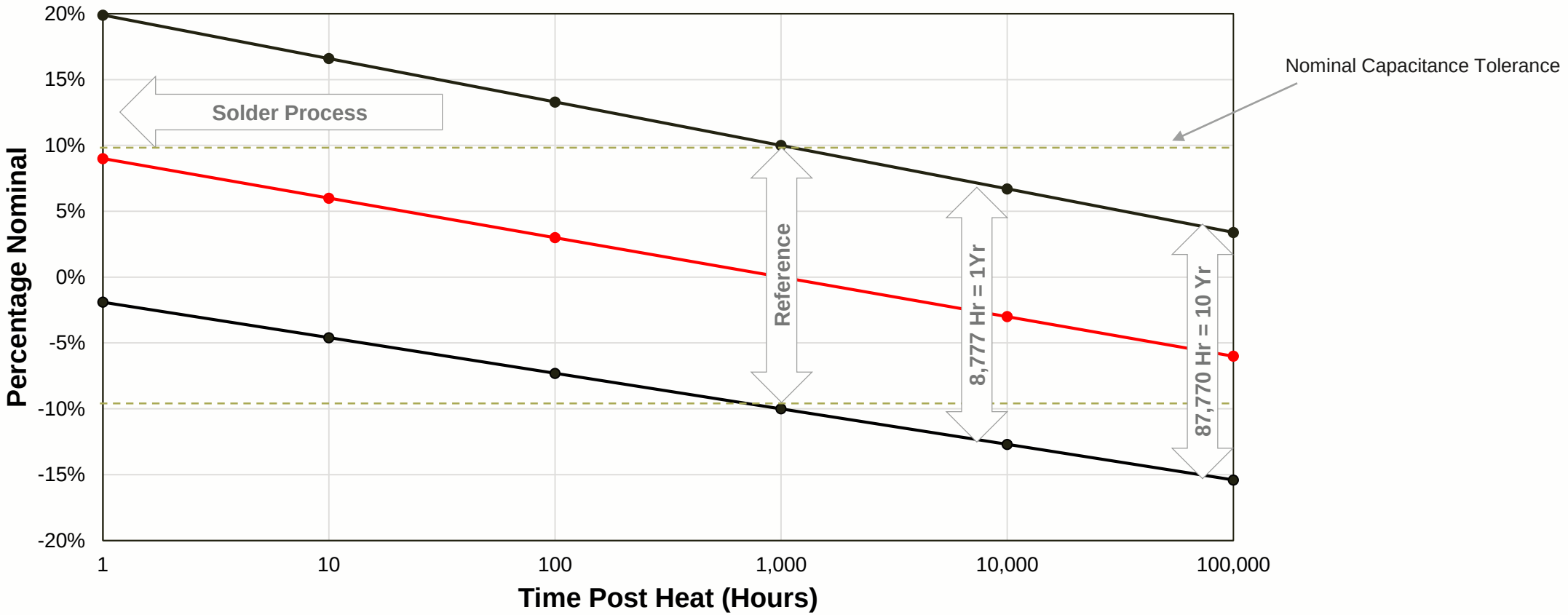


AC Voltage

Capacitance Stability

Versus Time (Aging) Class 2

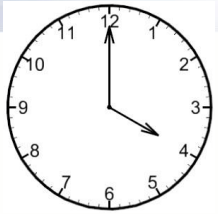


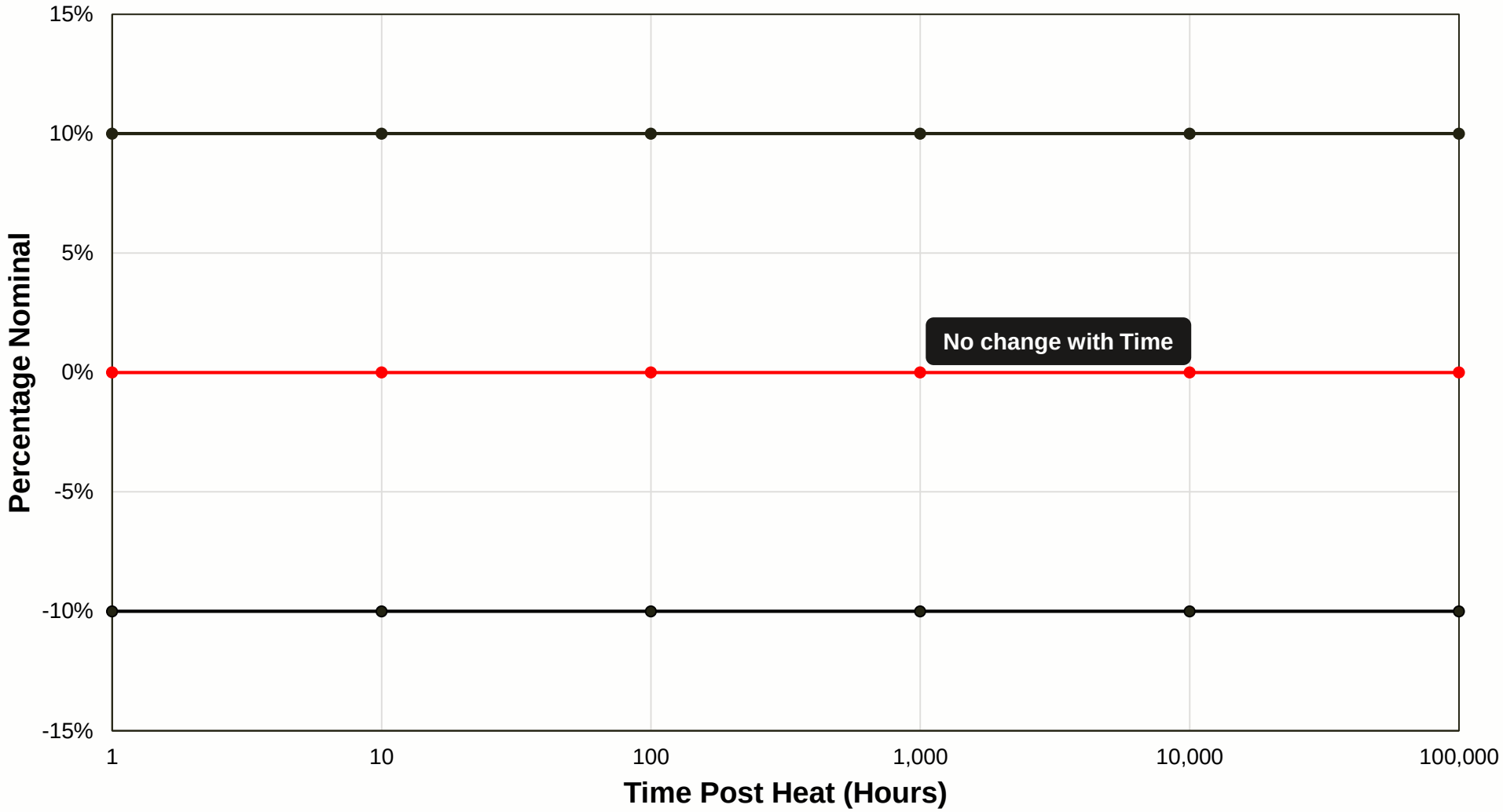


https://ec.kemet.com/design-tools/aging-calculator-for-ceramics

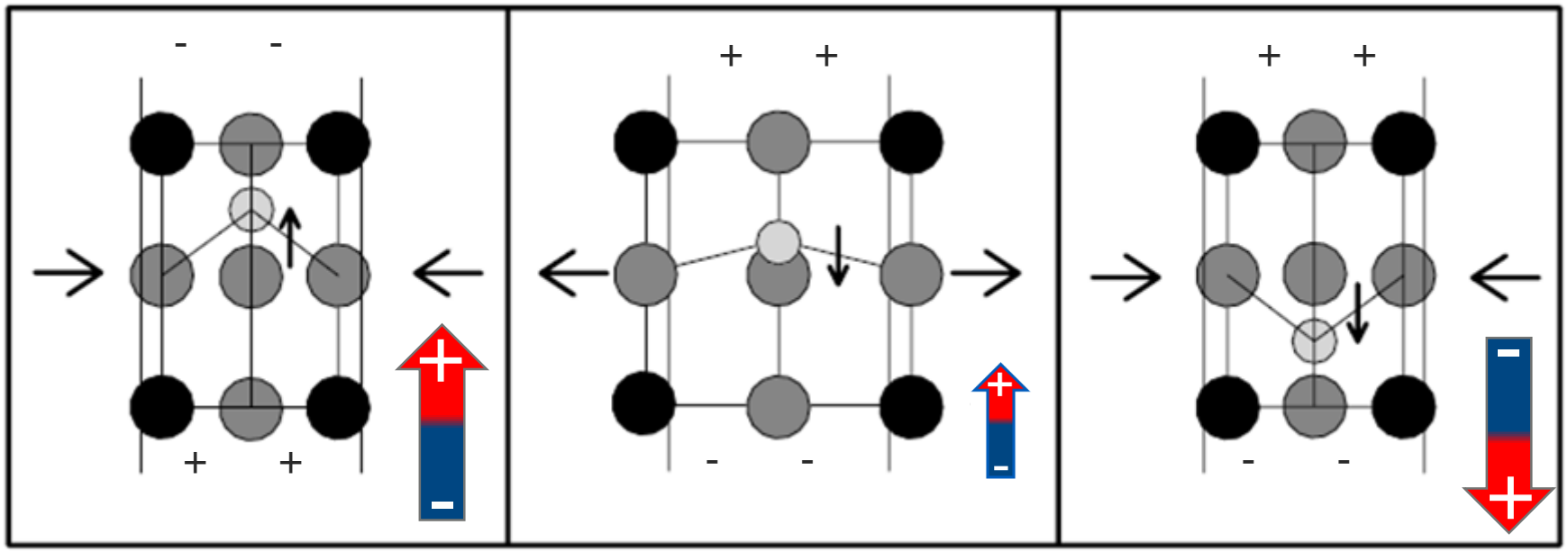
Capacitance Stability

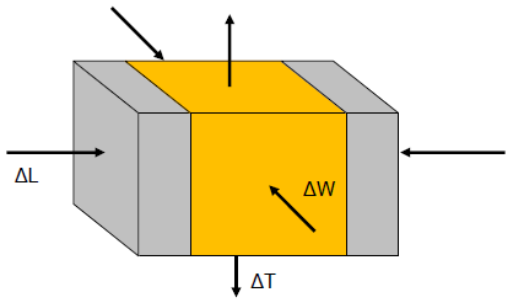
Versus Time (Aging) Class 1





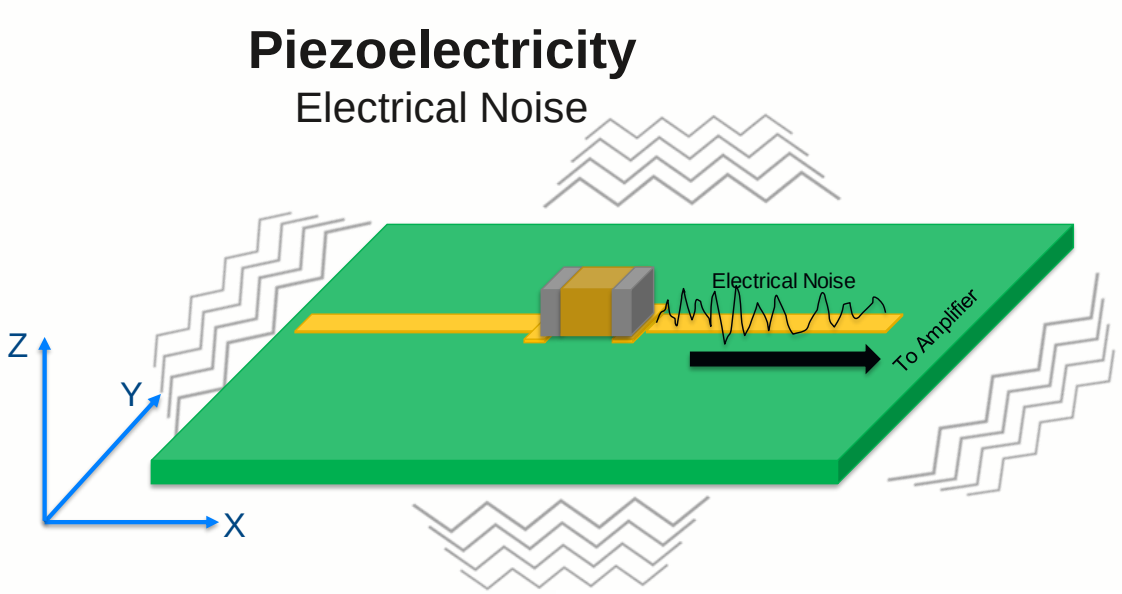
Piezoelectricity and Electrostriction

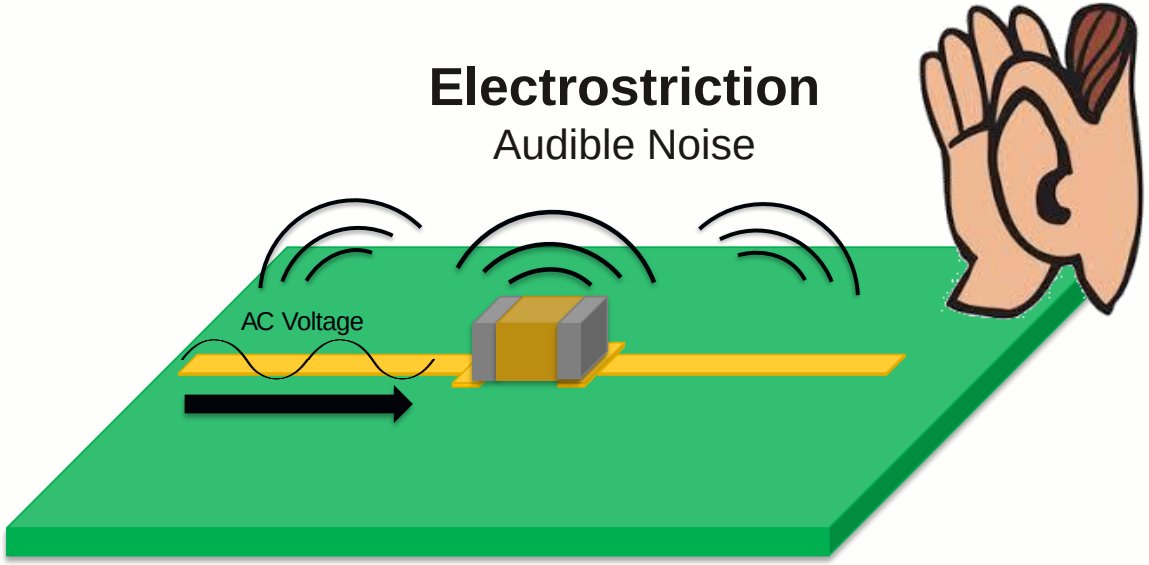


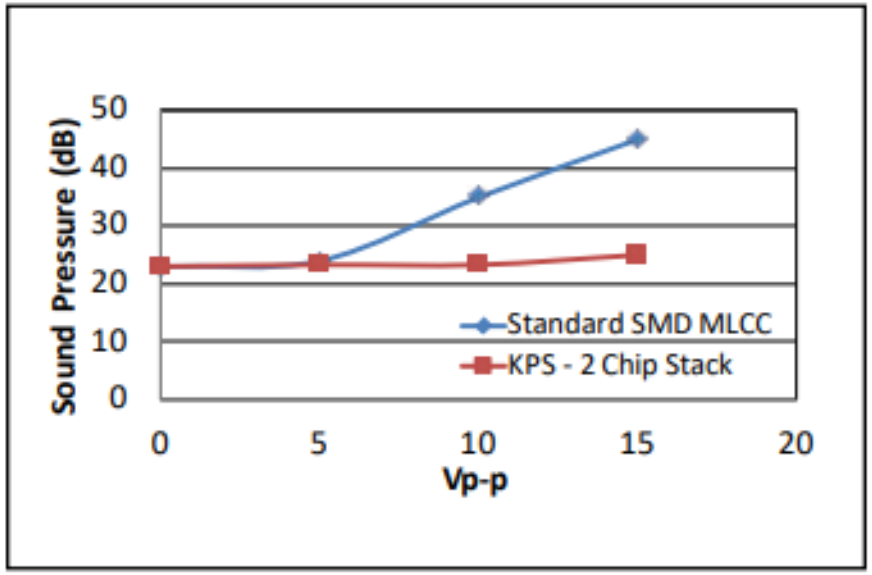


Mechanical Distortion

Piezoelectricity and Electrostriction







Thank You