

muRata

# **2021 KOREA MURATA WEBINAR**

# **Capacitor part**

생김새는 같지만 쓰임새가 다른 콘텐서



# 콘덴서의 종류와 특성



### What is Capacitor



#### **Structure of Capacitor**





#### Charge to capacitor

<Be in proportion>

>Active area

>Dielectric constant

(constant that is decided by material)

<Be in inverse proportion>

>Distance between electrodes





### **Capacitance Range by Material**









## What is Ceramic Capacitor?





#### Outer electrode

**3rd layer : Sn Barrier** 

2nd layer : Ni Barrier

1st layer : Cu

**Printed Electrode** 

**Ceramic Green sheet** 







### What is Polymer AL Capacitor?





## What is Silicon Capacitor & IPD ?



Silicon capacitor & IPD			
3D capacitor by using	Differentiation	Feature	Benefit
processes.	<b>Structure</b> Deep trench Tripod pillar	High cap density	Miniaturization
n+-polySi dielectric n+-Si	Dielectric Si dioxide / Si nitride	DC, AC, Temp, Aging stability	High stability of performance
n <sup>-</sup> -Si substrate	Product design Customization	Capacitor array. Binary capacitor. IPD including C, R.	Uniqueness & Competitiveness

### **Types of products**

	Standard Products		Customized Products
Solder mounting	Wire-bonding / Embedded	Wire-bonding	Capacitor array Binary capacitor IPD
2 terminal	2-4 terminal	Vertical	C+R+L

### What is Film Capacitor?







Metal evaporated plastic film



### Features and Benefits:

- 125 °C Temp Rating, 500V<sub>DC</sub> Voltage Rating
- \* 850V type is also available as A-sample
- Sizing: 10mF and 15mF in 35mm x 35.5mm x 14.5mm
  - 20mF Film Cap in 35mm x 37mm x 20mm

• High-Temp operation with reduced Cap size

### **Competitive Comparison**

Characteristic	PP Film Cap	HTFC			
Material	Thermo-plastic	Thermo-setting Resin			
Operating Temp	85 ºC ~ 105 ºC	125 ºC			
Size (same Film thickness)	100%	60% (40% reduction)			
I <sub>RIPPLE</sub> Rating (20kHz, 95 °C)	8 A <sub>RMS</sub>	11 A <sub>RMS</sub>			

### **Ceramic Material & Characteristic**



Class	Ceramic Material	Ceramic Character	Temp. Char	Capacitance	e Range	Recommended Circuit
Class 1	Temperature	Capacitance Accuracy	<eia></eia>	СНІР	0.1pF - 0.1uF	In Band Pass Filter Circuit
	Compensation	for temperature	C0G,U2J		(0R1 - 104)	
			<eia-j></eia-j>			In Coupling Circuit
	(TC系)		CH,UJ,SL	LEAD	1pF - 680nF	
					(010 - 683)	In Temp. Compensasion Circuit
Class2	High Dielectric	Hi Capacitance Value	<eia></eia>	СНІР	100pF - 100uF	In By-Pass Circuit
			X7R,Y5V,		(101 - 107)	
	(Hi-K <u>系</u> )		X5R,X6S			In Decoupling Circuit
			<eia-j></eia-j>	LEAD	220pF - 4.7uF	
			B, R, F		(221 - 475)	In Resonance Circuit

[ Classification by Temperature Characteristic ]

Class 1 : C0G, U2J,,,,,

Class 2 : X7R, X6S, X5R, Y5V,,,

Capacitance formula  $\boldsymbol{\mathcal{C}} = \frac{\boldsymbol{\varepsilon} \times \boldsymbol{\varepsilon}_0 \times \boldsymbol{S}_0 \times \boldsymbol{n}}{\boldsymbol{\varepsilon}_0 \times \boldsymbol{S}_0 \times \boldsymbol{n}}$ ε : Relative permittivity of dielectric ε<sub>0</sub> : Permittivity of vacuum 8.854×10-12 (F/m) So : Effective area per layer n : Number of dielectric layers t : Dielectric layer thickness

### **Extensive lineup and proposal**







# 고용량 콘덴서와 소형화



### **Frequency characteristic**





## **Frequency characteristic**





## **Design Support Software "SimSurfing"**

![](_page_15_Picture_1.jpeg)

![](_page_15_Picture_2.jpeg)

![](_page_15_Figure_3.jpeg)

Frequency Characteristic

10k

1mLL 100

1k

In Production - GRM033R60J105MEA2,R,DC0V,25degC

$$Z = R + \sqrt{2\pi f L^2 + \frac{1}{2\pi f c^2}}$$

![](_page_15_Figure_5.jpeg)

10k 100k 1M (10M) 100M 1G 10G Frequency

## **Design Support Software "SimSurfing"**

![](_page_16_Picture_1.jpeg)

![](_page_16_Picture_2.jpeg)

![](_page_16_Figure_3.jpeg)

### **Thinning of dielectric and inner electrodes**

![](_page_17_Picture_1.jpeg)

![](_page_17_Figure_2.jpeg)

## **High Precision Lamination Technology**

![](_page_18_Picture_1.jpeg)

Murata cutting edge High-Cap MLCCs have established highly accurate stacking and printing process technology.

![](_page_18_Figure_3.jpeg)

### Change in compact, large capacity products (6.3 V or less)

![](_page_19_Picture_1.jpeg)

Murata leads the industry in creating compact, large capacity products for the market.

![](_page_19_Figure_3.jpeg)

### X5R series; 85 degree C guarantee 008004 to 0603 size, 100nF~

![](_page_20_Picture_1.jpeg)

	Ci-o	Rated			ce						
Series	[inch/mm]	Voltage [V]	100nF (0.10uF)	0.22uF (220nF)	0.47uF (470nF)	1.0uF	2.2uF	4.7uF	10uF	22uF	47uF
GRM01	008004/0250125M	6.3	New!! *1*2								
		10	*1								
GRM02	01005/0402M	6.3	*2	*1*2	*1*2	2021					
		4		*1	*1	New!! *1*2		Taller type			
GRMMD	015008/05025M	6.3				*1*2		i andi cype			
	-	35	*2								
		25		*2	*2						
GRM03	0201/0603M	16		*2		*1	*1				
	0201/000514	10		*2	*2	*1	*1				
		6.3				*2	*1	*1			
		4					*1	*1			
		50			*2	*1*2				Т	aller type
		35				*2	*1*2				71
		25									
GRM15	0402/1005M	16						*2		M	
		10						*2	*2	*2 💆	
		6.3						*2	*1	*2	
		4								*2	
		50									
		35					*2		*1		
		25								Feasibility study	
GRM18	0603/1608M	16								21Q2*1	
		10								*2	
		6.3									*1
		4									*1

\*1:Mobile/PC application specific MLCC.

\*2:Recommended to use voltage / temperature derating condition.

### X5R series; 85 degree C guarantee 0704 to 1210 size, 1uF~

![](_page_21_Picture_1.jpeg)

	Sizo	Rated					Сарас	itance				
Series	[inch/mm]	Voltage [V]	1.0uF	2.2uF	4.7uF	10uF	22uF	47uF	100uF	220uF	330uF	470uF
GRMJN	0704/1810M	16				21Q4*1 (T=0.65Max)	(T=0.8Max)*1					
		6.3						43uF				
		50			*1*2	*1*2						
		35			*2	*2						
		25										
GRM21	0805/2012M	16										
		10						*2				
		6.3						*2	*2			
		4										
		50										
		25										
CDM21	1206/2216M	16										
GRM31	1200/32101	10							*2			
		6.3								*2		
		4										
		10							*2			
GRM32	1210/3225M	6.3										
	1210/322314	4								*2	*2	MP: TBD
		2.5										MP: TBD

\*1:Mobile/PC application specific MLCC.

\*2:Recommended to use voltage / temperature derating condition.

### **Polymer Al capacitor ECAS series**

![](_page_22_Picture_1.jpeg)

						Caj	oacitance	e Value (j	μ <b>F)</b>						
		6.8	10	15	22	33	47	68	100	150	22	20	330	47	70
	2 0D								D4 16	D4 9	D4 9		D4 4.5/6/9	D4*	D6 4.5
	2.5 0E												D4 4.5/6/9	D4*	D6 4.5
(dc)	4 0G							D4 20	D4 16	D4 16	D4 9	D6 10	D6 8		
tage (V	6.3 OJ		D4 55		D4 45	D4 25	D4 25	D4 15	D4 15	D4 15	D4 10	D6 10	D6 9		
ed Vol	10 1A		D4 55		D4 28	D4 25	D4 25	D6 15	D4 40	D6 10					
Rat	16 1C	D4 70	D4 60	D4 40	D6 30	D4 40	D4 40	D4 40	D6 12						
	20 1D					D3 40	D4 40								
	25 1E		D4 40	D4 40	D4 40	D4 40									

D4 6

Case Size Code MP ESR (mΩ)

![](_page_22_Picture_5.jpeg)

CQ4

Under Development standard type

![](_page_23_Picture_0.jpeg)

![](_page_23_Picture_1.jpeg)

### **Solution for Low ESL**

![](_page_24_Picture_1.jpeg)

![](_page_24_Figure_2.jpeg)

## **Effective utilizing method of Low ESL Cap**

![](_page_25_Picture_1.jpeg)

#### Optimization by using Low ESL Cap

![](_page_25_Figure_3.jpeg)

## **Murata MLCC Solution / 3T LowESL Proposal**

![](_page_26_Picture_1.jpeg)

Murata has **LowESL solution** to reduce Z and component space for best power integrity design.

![](_page_26_Figure_3.jpeg)

![](_page_27_Picture_0.jpeg)

![](_page_27_Picture_1.jpeg)

![](_page_27_Figure_2.jpeg)

![](_page_27_Picture_3.jpeg)

![](_page_27_Picture_4.jpeg)

![](_page_27_Picture_5.jpeg)

### **Three Terminal Capacitors – NFM series**

![](_page_28_Picture_1.jpeg)

Series	Dime	ension	Series	Dimension				
	[inch/mm]	L x W [mm]	Series	[inch/mm]	L x W [mm]			
NFM15PL	0402/1005M	1.00 × 0.50 mm	NFM18	0603/1608M	1.6 x 0.8 mm			
NFM15PC	0402/1005M	005M 1.00 × 0.50 mm		0805/2012M	2.00 x 1.25 mm			
NFMJMPC 05035/1209M		1.2 × 0.9 mm	NFM31	1206/3216M	3.2 x 1.6 mm			

![](_page_28_Picture_3.jpeg)

								Сарас	itance					
Series	[inch/mm]	Thickness (max.)	47nF	100nF (0.10uF)	0.22uF	0.47uF	1.0uF	2.2uF	4.3uF	7.5uF	9.1uF	14uF	15uF	22uF
NFM15PL	0402/1005M	0.22mm					85C/4V/2A							
		0.35mm				105C/4V/2A 85C/6.3V/2A	105C/4V/2A 85C/6.3V/2A							
NFM15PC	M15PC 0402/1005M	0.50mm	85C/16V/1A	85C/10V/2A	85C/10V/2A				105C/6.3V/2A 85C/4V/2A					
		0.65mm								105C/2.5V/2A 85C/4V/2A		85C/4V/2A *1		
		0.70mm									105C/2.5V/2A 85C/4V/2A			
		0.5mm												X5R/4V 2023
NFMJMPC	IPC 05035/1209M	0.65mm											105C/2.5V/2A 85C/6.3V/2A	X5R/4V New!!
		0.80mm												105C/2.5V/2A 85C/4V/2A

\*1:Mobile/PC application specific MLCC.

\*2:Recommended to use voltage / temperature derating condition.

### **Reverse Geometry Capacitors – LLL series**

![](_page_29_Picture_1.jpeg)

Series	Dimension							
Series	[inch/mm]	L x W [mm]						
LLL15	0204/0510M	0.5 x 1.0 mm						
LLL1U	02404/0610M	0.6 x 1.0 mm						

EIA	Temp. Cha	Operation				
Code	Temp. Range	Cap. Change	Temp. Range			
X5R	-55 to 85C	+/-15%	-55 to 85C			
X6S	-55 to 105C	+/-22%	-55 to 105C			
X6T	-55 to 105C	+22%, -33%	-55 to 105C			
X7R	-55 to 125C	+/-15%	-55 to 125C			
X7S	-55 to 125C	+/-22%	-55 to 125C			
X7T	-55 to 125C	+22%, -33%	-55 to 125C			

						Capacitano	ce value		
	Series	Size [inch/mm]	Thickness (max.)	100nF (0.10uF)	0.22uF	0.47uF	1.0uF	2.2uF	4.3uF
			0.22mm	X5R 6.3V X6S 4V	X5R 6.3V X6S 4V	X5R 6.3V X6S 4V X7S 2.5V	X5R 4V X6T 2.5V		
	LLL15	0204/0510M	0.35mm	X5R 10V X6S 6.3V X7S 4V	X5R 6.3V X6S 6.3V X7T 4V	X5R 4V X6S 4V X7S 4V	X6S 4V X7S 2.5V		
			0.60mm	X7R 10V	X7R 10V	X5R 6.3V X7S 4V			
J/	LLL1U	02404/0610M	0.45mm						X5R 4V

#### \*1:Mobile/PC application specific MLCC.

\*2:Recommended to use voltage / temperature derating condition.

# Si-cap vs. MLCC No Change of Impedance $\rightarrow$ Low IL

![](_page_30_Picture_1.jpeg)

![](_page_30_Figure_2.jpeg)

### Low ESL and ESR on Broadband

![](_page_31_Picture_1.jpeg)

![](_page_31_Figure_2.jpeg)

(P/N: 935 153 630 510-xxT)

![](_page_32_Picture_0.jpeg)

INNOVATOR IN ELECTRONICS

![](_page_33_Picture_1.jpeg)

### <Background>

The communication infrastructure market such as BTS for cell phone.

In this market, there is a need to realize lower power consumption and to reduce reflection loss.

### <Background>

- $\checkmark$  **RF circuit**
- ✓ High power circuit
- $\checkmark$  Low power consumption
- ✓ Reduction on reflection loss

![](_page_33_Picture_10.jpeg)

#### Requirement

- $\Rightarrow$   $\checkmark$  High SRF
- $\Rightarrow$   $\checkmark$  High rated voltage
- $\Rightarrow$   $\checkmark$  High Q/Low ESR
- $\Rightarrow$   $\checkmark$  Tight tolerance

![](_page_33_Figure_16.jpeg)

### Murata HiQ Capacitors and Applications

![](_page_34_Figure_1.jpeg)

> Semiconductor mfg.

1111

Equipment
Base station for

#### Cellular/Broadcasting

- Industrial transceiver
- Satellite system
- > Cell phone
- RF module

 $GQM/GJM \Rightarrow Cu$  inner electrode GRM ⇒ Ni inner electrode

#### GJM series for Module Solution

![](_page_34_Picture_14.jpeg)

Specifications									
Case Size	01005, 0201, 0402 inch								
Rated Voltage	6.3 to <u>100</u> Vdc								
Capacitance	0.1 to 47 pF								
Operating	C0G: -55 to 125°C,								
Temperature	X8G: -55 to 150℃								
Temperature	0.1.00								
Characteristic	0±30 ppm/10								

#### Features

- Higher Q Value  $\checkmark$
- Low ESR = High Current
- Smaller case size  $\checkmark$
- **Tighter Tolerance**  $\checkmark$

Cap range	Standard tol	Tight tol
≦0.9pF	±0.1pF	±0.05pF
1~5pF	±0.25pF	±0.05pF, ±0.1pF
5.1~9.9pF	±0.5pF	±0.05pF, ±0.1pF, ±0.25pF
>10pF	±5%	±2%

Please feel free to contact us when you need other tolerance.

Copyright @ Murata Manufacturing Co., Ltd. All rights reserved.

### GMA series Line-up

![](_page_34_Figure_25.jpeg)

#### For wire bonding mount $\checkmark$

![](_page_34_Picture_27.jpeg)

<Mounting Example>

#### Mass Production Under Development Capacitance Range [pF] Size Code Rated тс Capacitance Type inch (mm) Voltage GM A05 0202 (0505M) X7R GM A08 0303 (0808M) X 7 R

#### GQM series for High Power PA

![](_page_34_Picture_31.jpeg)

0201 to 1111 inch

COG: -55 to 125°C,

X8G: -55 to 150°C

up to 500 Vdc

0.1 to 150 pF

0±30 ppm/°C

#### Features

- ✓ High Temperature (up to 150°C)
- High Voltage (up to 500V)
- ~ **Higher Q Value**
- Low ESR = High Current

Cap range	Standard tol	Tight tol
≦0.9pF	±0.1pF	±0.05pF
1~5pF	±0.25pF	±0.05pF, ±0.1pF
5.1~9.9pF	±0.5pF	±0.05pF, ±0.1pF, ±0.25pF
>10pF	±5%	±2%

Please feel free to contact us when you need other tolerance.

Specifications

Rated Voltage Capacitance

Case Size

Operating

Temperature

Temperature

Characteristic

Copyric

35

тu

### For HPPAM (Sub-6GHz PA for Final Stage)

![](_page_35_Picture_1.jpeg)

![](_page_35_Figure_2.jpeg)

\*1 C11 is for High Power PAM only.

### **Resonant Capacitor – Target Application & Area**

![](_page_36_Picture_1.jpeg)

![](_page_36_Figure_2.jpeg)

## **Typical MLCC functions in EV**

![](_page_37_Picture_1.jpeg)

![](_page_37_Figure_2.jpeg)

### **Example of SWF trend of LLC converter**

![](_page_38_Picture_1.jpeg)

![](_page_38_Figure_2.jpeg)

SWF [ KHz ]

### **Murata MLCC products**

![](_page_39_Picture_1.jpeg)

Class 1 ceramic capacitor for resonance capacitor

#### **Resonance cap.**

![](_page_39_Figure_4.jpeg)

Optimize layout of resonance capacitor

supported by SimSurfing

https://ds.murata.co.jp/simsurfing/cst.html?lcid=en-us

Operation manual	-P	Capacitance of the resonant circuit	100.00	[nF]
Precautions for use		Frequency	200.00	[kHz]
Trecadions for use	5	Voltage applied to the resonant circuit	600.00	[V(p-p)] V
Calculation		Current of the resonant circuit	26.66	[A(r.m.s.)]
		Capacitor surface temperature	105.00	[℃]
Clear		Mounting interval in the L direction	1	[mm]
		Mounting interval in the W direction	1	[mm]

![](_page_39_Picture_9.jpeg)

**<u>GCM series</u>** Standard chip type Class 1 (C0G) ceramic capacitor Stable capacitance value in temperature range and DC bias voltage

Туре	TC	Rated/AC	Rated/DC	size	100	220	470	101	221	471	102	222	472	103	223	333
CCM21	COC		630Vdc	1206												
GCM31	CUG	-	1000Vdc	1206												
CCM22	COC		630Vdc	1210												
GCM32	CUG	-	1000Vdc	1210												

![](_page_39_Picture_12.jpeg)

**<u>KCM series</u>** Class 1 (C0G) ceramic capacitor with metal termination Stable capacitance value in temperature range and DC bias voltage

Туре	TC	Rated/AC	Rated/DC	structure	153	183	223	273	303	363	443	543	
			620)/dc	single									
VCMEE	COC		030700	double									Mass production
KCM55	CUG	-	1000\/dc	single									
			TOODAGC	double									

# Design Support Software "SimSurfing"

### Medium voltage Capacitor Selection Tool

![](_page_40_Picture_2.jpeg)

(

![](_page_40_Picture_3.jpeg)

![](_page_40_Figure_4.jpeg)

Surfing Medium voltage C	apacitor Selection	n Tool 🛛 🔻						En	giisn	¥					
Search/View Window	Help Link-Click	here for Products v	vith U2J tem	perature characteris	tics										
Selection															
Operation manual     4*       Precautions for use     4*       Calculation     Clear	Capacitance Frequency Voltage app Current of t Capacitor su Mounting in	of the resonant cir lied to the resonant he resonant circuit urface temperature terval in the L direc terval in the W dire	t circuit	100.00         [nF]           200.00         [kHz]           660.00         [V(P-p)]           26.66         [A(r.m.s.)           105.00         [°C]           1         [mm]	A () A () [(,	fission profile Irbitrary voltage wavef Select file Not : Upload Clear	iorm selected								
Search Function On/O	ff	Cours on COM		General		I				1.000		(Decelored De			
Select P/N :	11	Items 409		Automotive	Multiple Graphs	Allow. V(p-	o)-Freq.	Allow. A	r.m.s.)-Freq.	<u>∧∕</u> Te	mp.rise	Product De	tail <sub>t</sub>		
Part Number	Status	Capacitance	Rated	Maximum	Temperature	Size Code	Т	Capacitance	Allowable	Allowable	Number	Number	Total count	t Total	Mounting area
Part Number Search Clear Conditions	<ul> <li>✓ (Select All)</li> <li>✓ Under deveopment</li> <li>✓ inProduction</li> </ul>	≦ 54 nF = nF ≧ 0.01 nF	≤ 1000 = ≥ 250	V ≦ 125 V = V ≧ 125	<ul><li>✓ (Select All)</li><li>✓ COG</li></ul>	<ul> <li>✓ (Select All)</li> <li>✓ 1608M/0603</li> <li>✓ 2012M/0805</li> </ul>	≦ 6.2 = ≧ 0.8	≤ 5 % = % ≥ 5 %	≦ 0 '' ='' ≧ 0 ''	/ ≦ 0 . / = / ≧ 0 .	A ≦ 0 A = A ≧ 0	≦ 0 = ≥ 0	≦ 0 = ≥ 0	≦ 0 = ≧ 0	
Part Number	Status ?	Capacitance [nF](Nominal value)	Rated voltage [V]	Maximum operating temperature[°C]	Temperature Characteristics	Size Code [mm]/[inch]	T size [mm]	Capacitance tolerance [%]	Allowable voltage [V(p-p)]	Allowable current [A(r.m.s.)]	Number of series	Number of parallel	Total count	Total capacity [nF]	Mounting area 4 [mm <sup>2</sup> ]
AKCM55V5C2J543JDL2	InProduction	54	630	125	COG	5750M/2220	6.2	5							
AKCM55V5C2J443JDL2	InProduction	44	630	125	COG	5750M/2220	6.2	5							
A KCM55T5C2J363JDL1	InProduction	36	630	125	COG	5750M/2220	4.8	5							
A KCM55T5C2J303JDL1	InProduction	30	630	125	C0G	5750M/2220	4.8	5							
A KCM55R5C2J273JDL1	In Production	27	630	125	COG	5750M/2220	3.6	5							
KCM55R5C2J223JDL1	InProduction	22	630	125	COG	5750M/2220	3.6	5							
A KCM55L5C2J183JDL1	InProduction	18	630	125	COG	5750M/2220	2.8	5							
A KCM55L5C2J153JDL1	InProduction	15	630	125	COG	5750M/2220	2.8	5							
A KCM55V5C3A543J	Under deveopment	54	1000	125	COG	5750M/2220	6.2	5							
A KCM55V5C3A443]	Under deveopment	44	1000	125	COG	5750M/2220	6.2	5							
A KCM55T5C3A363J	Under deveopment	36	1000	125	COG	5750M/2220	4.8	5							
A KCM55T5C3A303J	Under deveopment	30	1000	125	COG	5750M/2220	4.8	5							
A KCM55R5C3A273J	Under deveopment	27	1000	125	COG	5750M/2220	3.6	5							
A KCM55R5C3A223J	Under deveopment	22	1000	125	COG	5750M/2220	3.6	5							
合 KCM55L5C3A183J	Under	18	1000	125	COG	5750M/2220	2.8	5							

![](_page_41_Picture_1.jpeg)

#### MLCC : High allowable AC voltage

![](_page_41_Figure_3.jpeg)

Allowable AC voltage comparison

•V company Film-Cap.: 22nF/2kVdc •Murata MLCC: KRM55 22nF/630Vdc

![](_page_42_Picture_1.jpeg)

### Target Application ; Electric Compressor / Pump(Water/Oil)

![](_page_42_Figure_3.jpeg)

![](_page_43_Picture_1.jpeg)

![](_page_43_Picture_2.jpeg)

#### Target Application ; Inverter (Main system)

![](_page_43_Figure_4.jpeg)

# 세라믹 콘덴서의 성질로 인한 문제점 및 대책

![](_page_44_Picture_1.jpeg)

### **Solution for Acoustic Noise**

![](_page_45_Picture_1.jpeg)

### Acoustic Noise problem (Customer side)

![](_page_45_Figure_3.jpeg)

### **Mechanism of acoustic noise**

![](_page_46_Picture_1.jpeg)

- 1. High dielectric constant type vibrates when AC voltage and pulse voltage are applied. The piezoelectric effect contributes the vibration of the capacitor as following Fig1.
- Circuit board vibrates with capacitor as following Fig2. (Amplitude of circuit board vibration is around 1pm to 1nm)
- 3. When the vibration frequency becomes audiofrequency, acoustic noise happen around the capacitor. (20-20,000Hz)

![](_page_46_Figure_5.jpeg)

### **Murata Proposal for Acoustic noise issue**

![](_page_47_Picture_1.jpeg)

![](_page_47_Figure_2.jpeg)

![](_page_48_Picture_0.jpeg)

# 세라믹 콘덴서의 신뢰성 문제와 대책

![](_page_48_Picture_3.jpeg)

### **Solution for bending crack - Background**

![](_page_49_Picture_1.jpeg)

![](_page_49_Figure_2.jpeg)

![](_page_49_Picture_3.jpeg)

**Electric field concentration occurs at a crack.** 

Then capacitor will be short circuit.

### **Solution for bending crack - Murata Product**

![](_page_50_Picture_1.jpeg)

![](_page_50_Figure_2.jpeg)

### **Board Flex Test Result**

![](_page_51_Picture_1.jpeg)

![](_page_51_Figure_2.jpeg)

Metal T. Capacitor is high reliability compare than general MLCC.  $\checkmark$ 

Soft termination capacitor is high reliability compare than general MLCC.  $\checkmark$ 

8

![](_page_52_Picture_0.jpeg)

# Thank you 감사합니다.