Multilayer Ceramic Capacitors
Series: **ECJ, ECY, ECD**

Handling Precautions

⚠Safety Precautions

Multilayer Ceramic Chip Capacitors (hereafter referred to as "Capacitors") should be used for general purpose applications found in consumer electronics (audio/visual, home, office, information & communication) equipment. When subjected to severe electrical, environmental, and/or mechanical stress beyond the specifications, as noted in the Ratings and Specified Conditions section, the capacitor may fail in a short circuit mode or in an open-circuit mode. This case results in a burn-out, smoke or flaming.

For products which require high safety levels, please carefully consider how a single malfunction can affect your product. In order to ensure the safety in the case of a single malfunction, please design products with fail-safe, such as setting up protecting circuits, etc.

● For the following applications and conditions, please contact us for additional specifications not found in this document.
·When your application may have difficulty complying with the safety or handling precautions specified below.
·For any applications where a malfunction with this product may directly or indirectly cause hazardous conditions which could result in death or injury;

① Aircraft and Aerospace Equipment (artificial satellite, rocket, etc.)
② Submarine Equipment (submarine repeating equipment, etc.)
③ Transportation Equipment (motor vehicles, airplanes, trains, ship, traffic signal controllers, etc.)
④ Power Generation Control Equipment (atomic power, hydroelectric power, thermal power plant control system, etc.)
⑤ Medical Equipment (life-support equipment, pacemakers, dialysis controllers, etc.)
⑥ Information Processing Equipment (large scale computer systems, etc.)
⑦ Electric Heating Appliances, Combustion devices (gas fan heaters, oil fan heaters, etc.)
⑧ Rotary Motion Equipment
⑨ Security Systems
⑩ And any similar types of equipment

■Operating Conditions and Circuit Design

1. Circuit Design

1.1 Operating Temperature and Storage Temperature

The specified "Operating Temperature Range" found in the specifications is the absolute maximum and minimum temperature rating. Every Capacitor shall be operated within the specified "Operating Temperature Range".
The capacitors mounted on PCB shall be stored without operating within the specified "Storage Temperature Range" in the Specifications.

1.2 Design of Voltage Application

Capacitors shall not be operated in excess of the specified "Rated Voltage" in the Specification.
If voltage ratings are exceeded, the Capacitors could result in failure or damage. The designed peak DC and AC voltages applied to the Capacitors, shall be within the specified "Rated Voltage".
In case of AC of pulse voltage, the peak voltage shall be within the specified "Rated Voltage". If high frequency voltage or fast rising pulse voltages are continuously applied, even when within the "Rated Voltage", consider that the reliability of the Capacitor may change. Continuous application of those types of voltages can affects the life of the Capacitors.

1.3 Charging and Discharging Current

The Capacitors shall not be operated beyond the specified "Maximum Charging/Discharging Current Ratings" in the specifications. For safety reasons Panasonic does not recommend use in applications with low impedance circuitry such as "secondary power circuits".

1.4 Temperature Rise due to Dielectric Loss of the Capacitors

The "Operating Temperature Range" mentioned above shall include a maximum surface temperature rise of 20 °C, which is caused by the Dielectric loss of the Capacitor and applied electrical stresses such as voltage, frequency and wave form. It is recommended to measure and check the "Surface Temperature of the Capacitor" in the application at room temperature (up to 25 °C).

1.5 Environmental Restrictions

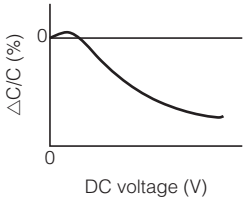
The Capacitors shall not be operated and/or stored under the following conditions.
(1) Environmental conditions
(a) Under direct exposure to water or salt water
(b) Under conditions where water can condense and/or dew can form
(c) Under conditions containing corrosive gases such as hydrogen sulfide, sulfurous acid, chlorine and ammonia
(2) Mechanical conditions
Under severe conditions of vibration or impact beyond the specified conditions found in the Specifications

1.6 DC Voltage Characteristics

The Capacitors (Class 2) employ dielectric ceramics with dielectric constant having voltage dependency, and if the applied DC voltage is high, capacitance may broadly change. For the specified capacitance, the following should be confirmed.

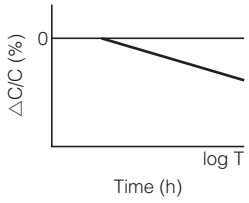
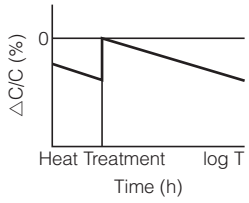
(1) If capacitance change caused by the applied voltage is within the allowable range, or if its application allows unlimited capacitance change.
(2) DC voltage characteristics demonstrate that even if the applied voltage is under the rated voltage, the capacitance change rate increases with higher voltage (Capacitance down). Accordingly, when the Capacitors are used for circuits with a narrow allowable capacitance range such as time constant circuits, we recommend applying a lower voltage after taking capacitance aging and the above into account.

Capacitance change - DC voltage



1.7 Capacitance Aging

The ceramic dielectrics of the Capacitors (Class 2) have capacitance aging. Accordingly, when the Capacitors are used for circuits which require a narrow allowable capacitance range, such as time constant circuits, pay special attention to capacitance aging before use.

Under Ordinary Temperature	Before and After Heat treatment
	

1.8 Piezoelectricity

Dielectrics used for the Capacitors (Class 2) may cause the following Piezoelectricity (or Electrostriction).
(1) If the signal of a specific frequency is applied to the Capacitors, electric and acoustic noise may be generated by resonating the characteristic frequency, which is determined by the dimensions of the Capacitor.
As a measure to prevent this phenomenon, changing the size of the Capacitor is effective in changing its resonance frequency.
In addition, changing the materials of the Capacitors to the Low-loss type, which has no (or less) piezoelectricity, or to use Class 1 dielectrics which have no (or less) piezoelectricity.
(2) Vibration or impact applied to the Capacitors may cause noise because mechanical force is converted to electrical signals (Especially to circuitry around an amplifier unit).
As a measure to prevent this phenomenon, changing the materials of the Capacitor to the Low-loss type, which has no (or less) piezoelectricity, or to Class1 is also available.
(3) If a "whining sound" is generated it does not indicate a problem with product performance and reliability, however, check if this undesirable phenomenon generates noise in your application. To prevent this phenomenon, changing the Capacitor's characteristics, such as size and shape, as shown in (1) & (2) above can be effective.
In addition, changing the mounting direction of the Capacitors may be effective in getting the resonance under control with other equipment such as printed circuit boards. Attaching the Capacitors to the printed circuit board by an adhesive may also be effective.

2. Design of Printed Circuit Board

2.1 Selection of Printed Circuit Board

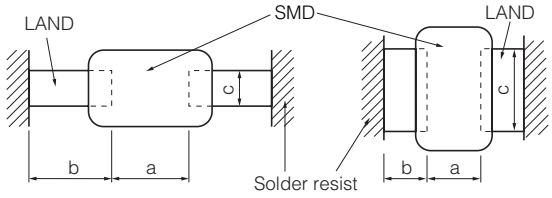
When the Capacitors are mounted and soldered on an "Alumina Substrate", the substrate influences the Capacitors' reliability against "Temperature Cycles" and "Heat shock" due to the difference in the thermal expansion coefficient between them. Confirm that the actual board used does not deteriorate the characteristics of the Capacitors.

2.2 Design of Land Pattern

(1) Recommended land dimensions are shown below. Use the proper amount of solder in order to prevent cracking. Using too much solder places excessive stress on the Capacitors.

Recommended land dimensions (Ex.)

〈 High Capacitance, For General Electronic Equipment, Low ProfileType, Wide-width Type, 100V·200V series, 630V series, High-Q capacitors 〉

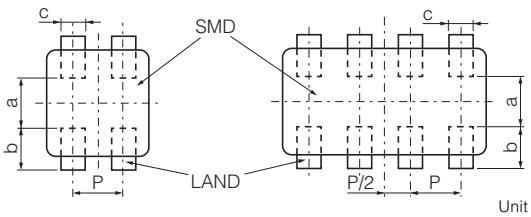


Unit (mm)

Size	Component Dimensions			a	b	c
	L	W	T			
0201	0.6	0.3	0.3	0.2 to 0.3	0.25 to 0.3	0.2 to 0.3
0402	1.0	0.5	0.5	0.4 to 0.5	0.4 to 0.5	0.4 to 0.5
0402*1	1.0	0.5	0.5	0.5 to 0.6	0.4 to 0.5	0.5 to 0.6
0603	1.6	0.8	0.45 to 0.8	0.8 to 1.0	0.6 to 0.8	0.6 to 0.8
0805	2.0	1.25	0.6 to 1.25	0.8 to 1.2	0.8 to 1.0	0.8 to 1.0
1206	3.2	1.6	0.6 to 1.6	1.8 to 2.2	1.0 to 1.2	1.0 to 1.3
1210	3.2	2.5	0.85 to 2.5	1.8 to 2.2	1.0 to 1.2	1.8 to 2.3
0508	1.25	2.0	0.85	0.5 to 0.7	0.5 to 0.6	1.4 to 1.9
0612	1.6	3.2	0.85	0.8 to 1.0	0.6 to 0.7	2.5 to 3.0

*1 The following value is applied as a dimensional tolerance : +0.15/-0.05 mm (L, W and T).

<2Array type, 4 Array type>



Unit (mm)

Size	Component Dimensions			a	b	c	P
	L	W	T				
0504 2 Array	1.37	1.0	0.6	0.3 to 0.4	0.45 to 0.55	0.3 to 0.4	0.54 to 0.74
			0.8	0.3 to 0.6	0.4 to 0.7	0.46 to 0.56	0.71 to 0.91
0805 4 Array	2.0	1.25	0.85	0.55 to 0.75	0.5 to 0.6	0.2 to 0.3	0.4 to 0.6
1206 4 Array	3.2	1.6	0.85	0.9 to 1.1	0.7 to 0.9	0.35 to 0.45	0.7 to 0.9

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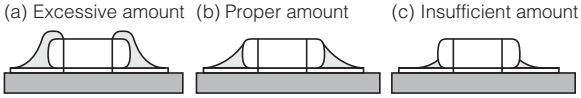
(2) The size of lands shall be designed to have equal spacing between the right and left sides. If the amount of solder on the right land is different from that on the left land, the component may be cracked by stress since the side with a larger amount of solder solidifies later during cooling.

Recommended Amount of Solder

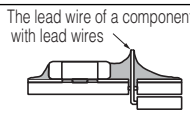
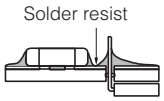
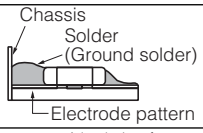
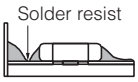
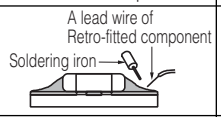
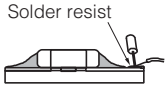
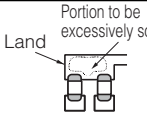
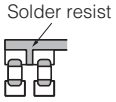


2.3 Applications of Solder Resist

(1) Solder resist shall be utilized to equalize the amounts of solder on both sides.
(2) Solder resist shall be used to divide the pattern for the following cases;
- ·Components are arranged closely.
- ·The Capacitor is mounted near a component with lead wires.
- ·The Capacitor is placed near a chassis.

See the table below.

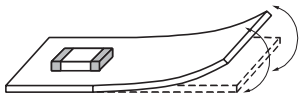
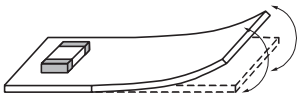
Prohibited Applications and Recommended Applications

Item	Prohibited applications	Improved applications by pattern division
Mixed mounting with a component with lead wires		
Arrangement near chassis		
Retro-fitting of component with lead wires		
Lateral arrangement		

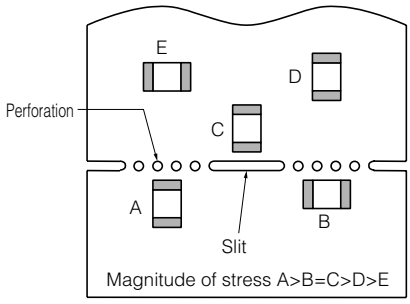
2.4 Component Layout

The Capacitors/components shall be placed on the PC board so as to have both electrodes subjected to uniform stresses, or to position the component electrodes at right angles to the grid glove or bending line. This should be done to avoid cracking the Capacitors from bending of the PC board after or during placing/mounting on the PC board.

(1) To minimize mechanical stress caused by warp or bending of a PC board, please follow the recommended Capacitors' layout below.

Prohibited layout	Recommended layout
	 Layout the Capacitor sideways against the stressing direction

(2) The following drawing is for reference since mechanical stress near the dividing/breaking position of a PC board varies depending on the mounting position of the Capacitors.



(3) The magnitude of mechanical stress applied to the Capacitors when the circuit board is divided is in the order of push back < slit < V-groove < perforation. Also take into account the layout of the Capacitors and the dividing/breaking method.

2.5 Mounting Density and Spaces

If components are arranged in too narrow a space, the components can be affected by solder bridges and solder balls. The space between components should be carefully determined.

■ Precautions for Assembly

1. Storage

(1) The Capacitors shall be stored between 5 - 40 °C and 20 - 70 % RH, not under severe conditions of high temperature and humidity.
(2) If stored in a place that is humid, dusty, or contains corrosive gasses (hydrogen sulfide, sulfurous acid, hydrogen chloride and ammonia, etc.), the solderability of the terminal electrodes may deteriorate.
In addition, storage in a place subjected to heating and/or exposure to direct sunlight will causes deformed tapes and reels, and component sticking to tapes, both of which can result in mounting problems.
(3) Do not store components longer than 6 months.
Check the solderability of products that have been stored for more than 6 months before use.
(4) High dielectric constant capacitors (Class 2, characteristic B, X7R, X5R and F, Y5V) change in capacitance with the passage of time, (Capacitance aging), due to the inherent characteristics of ceramic dielectric materials.
The capacitance change can be reversed to the initial value at the time of shipping by heat treatment (See 1. Circuit Design, 1-7. Capacitance aging)
(5) When the initial capacitance is measured, the Capacitors shall be heat-treated at 150 +0/-10 °C for 1 hour and then subjected to ordinary temperature and humidity for 48±4 hours before measuring the initial values.

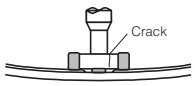
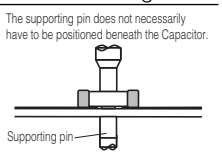
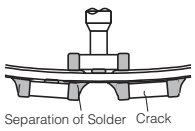
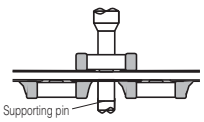
2. Adhesives for Mounting

(1) The amount and viscosity of an adhesive for mounting shall be such that the adhesive shall not flow off on the land during its curing.
(2) If the amount of adhesive is insufficient for mounting, the Capacitor may fall off after or during soldering.
(3) If the adhesive is too low in its viscosity, the Capacitors may be out of alignment after or during soldering.
(4) Adhesives for mounting can be cured by ultraviolet or infrared radiation. In order to prevent the terminal electrodes of the Capacitors from oxidizing, curing shall be done under the following conditions: 160 °C max., for 2 minutes max.

(5) Insufficient curing may cause the Capacitor to fall off after or during soldering. In addition, insulation resistance between terminal electrodes may deteriorate due to moisture absorption. In order to prevent these problems, please observe proper curing conditions.

3. Chip Mounting Consideration

(1) When mounting the Capacitors/components on a PC board, the Capacitor bodies shall be free from excessive impact loads such as mechanical impact or stress due to the positioning, pushing force and displacement of vacuum nozzles during mounting.
(2) Maintenance and inspection of the Chip Mounter must be performed regularly.
(3) If the bottom dead center of the vacuum nozzle is too low, the Capacitor will crack from excessive force during mounting.
The following precautions and recommendations are for your reference.
(a) Set and adjust the bottom dead center of the vacuum nozzles to the upper surface of the PC board after correcting the warp of the PC board.
(b) Set the pushing force of the vacuum nozzle during mounting to 1 to 3 N in static load.
(c) For double surface mounting, apply a supporting pin on the rear surface of the PC board to suppress the bending of the PC board in order to minimize the impact of the vacuum nozzles. Typical examples are shown in the table below.

Item	Prohibited mounting	Recommended mounting
Single surface mouting		
Double surface mounting		

(d) Adjust the vacuum nozzles so that their bottom dead center during mounting is not too low.
(4) The closing dimensions of the positioning chucks shall be controlled. Maintenance and replacement of positioning chucks shall be performed regularly to prevent chipping or cracking of the Capacitors caused by mechanical impact during positioning due to worn positioning chucks.
(5) Maximum stroke of the nozzle shall be adjusted so that the maximum bending of PC board does not exceed 0.5 mm at 90 mm span. The PC board shall be supported by an adequate number of supporting pins.

4. Selection of Soldering Flux

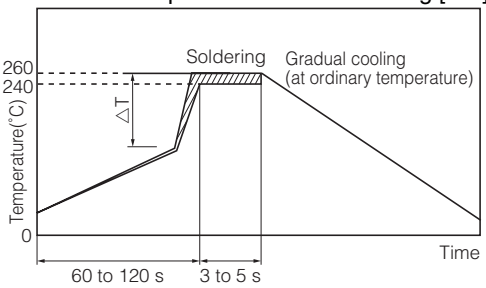
Soldering flux may seriously affect the performance of the Capacitors. The following shall be confirmed before use.
(1) The soldering flux should have a halogen based content of 0.1 wt. % (converted to chlorine) or below. Do not use soldering flux with strong acid.
(2) When applying water-soluble soldering flux, wash the Capacitors sufficiently because the soldering flux residue on the surface of PC boards may deteriorate the insulation resistance on the Capacitors surface.

5. Soldering

5.1 Flow Soldering

For flow soldering, abnormal and large thermal and mechanical stress, caused by the "Temperature Gradient" between the mounted Capacitors and melted solder in a soldering bath may be applied directly to the Capacitors, resulting in failure and damage of the Capacitors.
Therefore it is essential that soldering process follow these recommended conditions.
(1) Application of Soldering flux:
The soldering flux shall be applied to the mounted Capacitors thinly and uniformly by foaming method.
(2) Preheating:
The mounted Capacitors/Components shall be pre-heated sufficiently so that the "Temperature Gradient" between the Capacitors/Components and the melted solder shall be 150 °C max. (100 to 130 °C)
(3) Immersion into Soldering Bath:
The Capacitors shall be immersed into a soldering bath of 240 to 260 °C for 3 to 5 seconds.
(4) Gradual Cooling:
The Capacitors shall be cooled gradually to room ambient temperature at cooling temperature rates of 8 °C/s max. from 250 °C to 170 °C and 4 °C/s max. from 170 °C to 130 °C.
(5) Flux Cleaning:
When the Capacitors are immersed into a cleaning solvent, be sure that the surface temperatures of the devices do not exceed 100 °C.
(6) Performing flow soldering once under the conditions shown in the figure below [Recommended profile of Flow soldering (Ex)] will not cause any problems.
However, pay attention to the possible warp and bending of the PC board.

Recommended profile for Flow soldering [Ex.]



<Allowable temperature difference △T>

Size	Temp. Tol
0603 to 1206, 0508, 0612	△T ≦ 150 °C

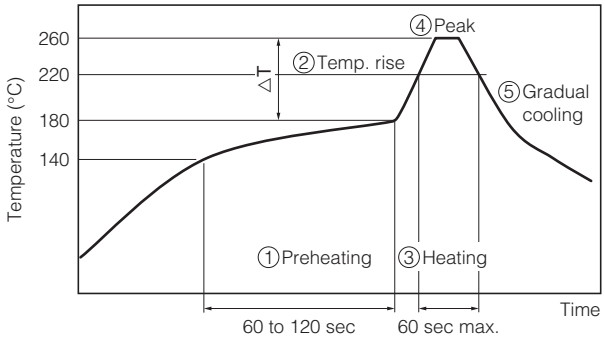
For products specified in individual specifications, avoid flow soldering.

5.2 Reflow Soldering

The reflow soldering temperature conditions are each temperature curves of Preheating, Temp. rise, Heating, Peak and Gradual cooling. Large temperature difference caused by rapid heat application to the Capacitors may lead to excessive thermal stresses, contributing to the thermal cracks. The Preheating temperature requires controlling with great care so that tombstone phenomenon may be prevented.

Item	Temperature	Period or Speed
①Preheating	140 to 180 °C	60 to 120 sec
②Temp. rise	Preheating temp to Peak temp.	2 to 5 °C/sec
③Heating	220 °C min.	60 sec max.
④Peak	260 °C max.	10 sec max.
⑤Gradual cooling	Peak temp. to 140 °C	1 to 4 °C/sec

Recommended profile of Reflow soldering [Ex.]



<Allowable temperature difference △T>

Size	Temp. Tol
0201 to 1206, 0508, 0612, 0504	△T ≦ 150 °C
1210	△T ≦ 130 °C

The rapid cooling (forced cooling) during Gradual cooling part should be avoided, because this may cause defects such as the thermal cracks, etc.
When the Capacitors are immersed into a cleaning solvent, confirm that the surface temperatures of the devices do not exceed 100 °C.
Performing reflow soldering twice under the conditions shown in the figure above [Recommended profile of Reflow soldering (EX)] will not cause any problems. However, pay attention to the possible warp and bending of the PC board.

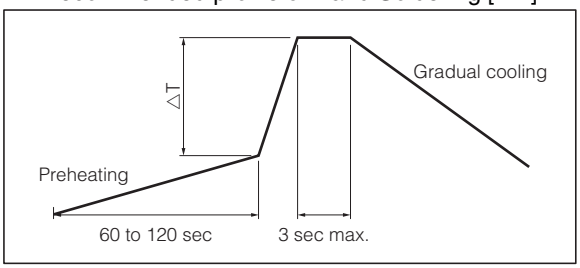
5.3 Hand Soldering

Hand soldering typically causes significant temperature change, which may induce excessive thermal stresses inside the Capacitors, resulting in the thermal cracks, etc.
In order to prevent any defects, the following should be observed.

- ·The temperature of the soldering tips should be controlled with special care.
- ·The direct contact of soldering tips with the Capacitors and/or terminal electrodes should be avoided.
- ·Dismounted Capacitors shall not be reused.

(1) Condition 1 (with preheating)
(a) Soldering:
ϕ1.0 mm or below Thread eutectic solder with soldering flux* in the core.
*Rosin-based and non-activated flux is recommended.
(b) Preheating:
The Capacitors shall be preheated so that the "Temperature Gradient" between the devices and the tip of soldering iron is 150 °C or below.
(c) Temperature of Iron tip: 300 °C max.
(The required amount of solder shall be melted in advance on the soldering tip.)
(d) Gradual Cooling:
After soldering, the Capacitors shall be cooled gradually at room temperature.

Recommended profile of Hand Soldering [Ex.]



<Allowable temperature difference △T>

Size	Temp. Tol.
0201 to 1206, 0508, 0612, 0504	△T ≦ 150 °C
1210	△T ≦ 130 °C

(2) Condition 2 (without preheating)
Hand soldering can be performed without preheating, by following the conditions below:
(a) Soldering iron tip shall never directly touch the ceramic and terminal electrodes of the Capacitors.
(b) The lands are sufficiently preheated with a soldering iron tip before sliding the soldering iron tip to the terminal electrodes of the Capacitor for soldering.

<Conditions of Hand soldering without preheating>

Item	Condition	
Size	0201 to 0805, 0508, 0504	1206, 1210, 0612
Temperature of Iron tip	270 °C max.	250 °C max.
Wattage	20 W max.	
Shape of Iron tip	ϕ3 mm max.	
Soldering time with a soldering iron	3 sec max.	

6. Post Soldering Cleaning

6.1 Cleaning Solvent

Soldering flux residue may remain on the PC board if cleaned with an inappropriate solvent. This may deteriorate the electrical characteristics and reliability of the Capacitors.

6.2 Cleaning Conditions

Insufficient cleaning or excessive cleaning may impair the electrical characteristics and reliability of the Capacitors.
(1) Insufficient cleaning can lead to:
(a) The halogen substance found in the residue of soldering flux may cause the metal of terminal electrodes to corrode.
(b) The halogen substance found in the residue of soldering flux on the surface of the Capacitors may change resistance values.
(c) Water-soluble soldering flux may have more remarkable tendencies of (a) and (b) above compared to those of rosin soldering flux.
(2) Excessive cleaning can lead to:
(a) Overuse of ultrasonic cleaning may deteriorate the strength of the terminal electrodes or cause cracking in the solder and /or ceramic bodies of the Capacitors due to vibration of the PC boards.
Please follow these conditions for Ultrasonic cleaning:
Ultrasonic wave output : 20 W/L max.
Ultrasonic wave frequency : 40 kHz max.
Ultrasonic wave cleaning time : 5 min max.

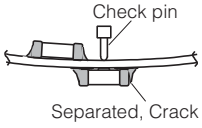
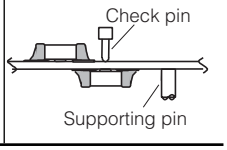
6.3 Contamination of Cleaning Solvent

Cleaning with contaminated cleaning solvent may cause the same results as insufficient cleaning due to the high density of liberated halogen.

7. Inspection Process

When mounted PC boards are inspected with measuring terminal pins, abnormal and excess mechanical stress shall not be applied to the PC board or mounted components, to prevent failure or damage to the devices.
(1) Mounted PC boards shall be supported by an adequate number of supporting pins with bend settings of 90 mm span 0.5 mm max.

(2) Confirm that the measuring pins have the right tip shape, are equal in height and are set in the correct positions.
The following figures are for your reference to avoid bending the PC board.

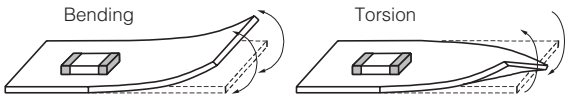
Item	Prohibited setting	Recommended setting
Bending of PC board		

8. Protective Coat

When the surface of a PC board on which the Capacitors have been mounted is coated with resin to protect against moisture and dust, it shall be confirmed that the protective coating which is corrosive or chemically active is not used, in order that the reliability of the Capacitors in the actual equipment may not be influenced. Coating materials that expand or shrink also may lead to damage to the Capacitors during the curing process.

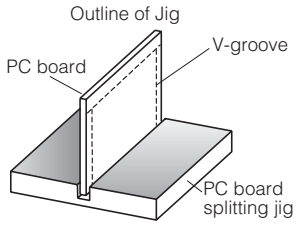
9. Dividing/Breaking of PC Boards

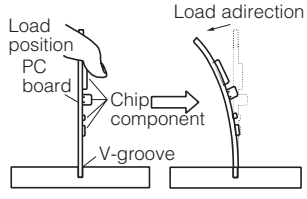
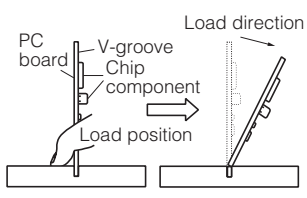
(1) Abnormal and excessive mechanical stress such as bending or torsion shown below can cause cracking in the Capacitors.



(2) Dividing/Breaking of the PC boards shall be done carefully at moderate speed by using a jig or apparatus to prevent the Capacitors on the boards from mechanical damage.

(3) Examples of PCB dividing/breaking jigs:
The outline of a PC board breaking jig is shown below. When PC boards are broken or divided, loading points should be close to the jig to minimize the extent of the bending
Also, planes with no parts mounted on should be used as plane of loading, which generates a compressive stress on the mounted plane, in order to prevent tensile stress induced by the bending, which may cause cracks of the Capacitors or other parts mounted on the PC boards.

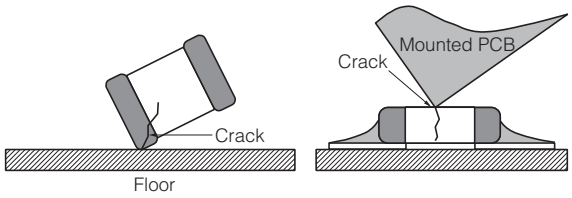


Prohibited dividing	Recommended dividing
	

10. Mechanical Impact

(1) The Capacitors shall be free from any excessive mechanical impact.
The Capacitor body is made of ceramics and may be damaged or cracked if dropped.
Never use a Capacitor which has been dropped; their quality may be impaired and failure rate increased.

(2) When handling PC boards with Capacitors mounted on them, do not allow the Capacitors to collide with another PC board.
When mounted PC boards are handled or stored in a stacked state, impact between the corner of a PC board and the Capacitor may cause damage or cracking and can deteriorate the withstand voltage and insulation resistance of the Capacitor.



■ Other

For special mounting conditions, please contact us.

Precautions for Use above are from

The Technical Report EIAJ RCR-2335 Caution Guide Line for Operation of Fixed Multilayer Ceramic Capacitors for Electronic Equipment by Japan Electronics and Information Technology Industries Association (March 2002 issued)

Please refer to above technical report for details.