

# Y1-Compliant Ceramic Capacitor Satisfies Tiny Power Devices

Murata Manufacturing Co., Ltd. has commercialized DK Series type EA ceramic capacitor, which is certified as IEC60384-14 X1/Y1 class compatible with surface mounting, and is suitable, in particular, for the power supply of thin devices. The appearance of this product is shown in Photo 1. The structural dimensions and the internal structure are shown in Figs. 1 and 2.

## Higher Need for Smaller Power Supplies

Demand is now growing for the reduction in the size and thickness of power supply equipment for audio-video instruments, such as flat-panel TV and LED lighting instruments, and equipment mounted on a 1U rack of a data center.

Power supplies are usually equipped with a Y capacitor connecting the commercial power line and the ground, and with a coupling capacitor connecting the primary part and secondary part as a countermeasure against noise. These capacitors are required to have high withstand voltage and high flame retardancy. In addition, products can be used only when they have acquired the certification of safety standard bodies,

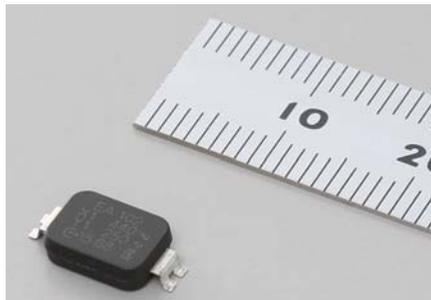
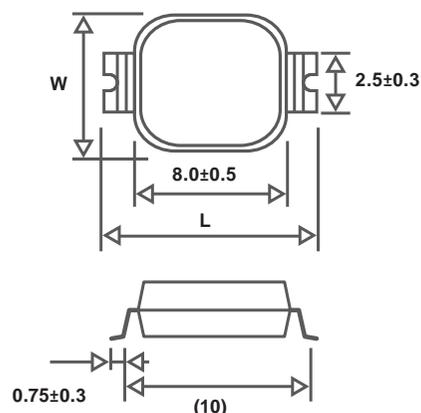
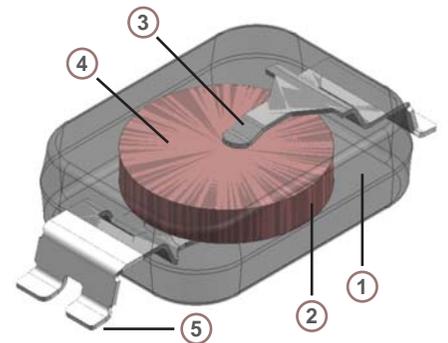


Photo 1: DK Series type EA capacitor of resin-mold and SMD type, certified as Y1 class



L: 11.4±0.5  
 W: 6.0±0.5  
 T: 2.5 or less  
 Unit: mm  
 Numbers in parentheses are reference values

Fig. 1: Dimensions of DK Series type EA ceramic capacitor



No.	Component material	Material name
①	Enclosure	Epoxy resin (UL94V-0 certified)
②	Dielectric element	Ceramics
③	Solder	Sn-Sb solder
④	Electrode	Copper
⑤	Metal terminal	Iron alloy (Sn/Ni plating)

Fig. 2: Internal structure of DK Series type EA ceramic capacitor

such as UL and CQC. Besides such safety standard certification, these capacitors are required to be small in size. Radial lead disc type ceramic capacitors, such as DE Series type KX manufactured by Murata, have contributed to the downsizing of power supply equipment in response to this demand. However, reducing the mounting height from the circuit board surface becomes less and less easy for devices with a radial lead, which sometimes limits the progress in reducing the thickness of the power supply unit.

Furthermore, in a component with a radial lead, the tip of the lead wire inserted into the circuit board comes out on the back side of the substrate. A certain distance (insulation distance) must be secured between the tip of the lead wire and the metal part of the power supply equipment, such as the chassis,

according to the requirement of the safety standard imposed on the power supply equipment. This may also become a limitation on further advancement in reducing the thickness of the power supply equipment.

In the DK Series type EA, a flat-type metal terminal was soldered to a disk type ceramic dielectric of the capacitor element, and then the resulting device is resin molded into a rectangular shape. This structure has enabled surface mounting of the Y capacitor. The SMD type makes it possible to reduce the height of the parts, and at the same time, eliminate the protrusion of the lead terminals to the back side of the circuit board. Thus, it may be no longer necessary to pay attention to the insulation distance between the tip of the lead terminal and the chassis of the equipment. Due to such improvement, this DK Series can make big contribution to the progress in reducing the thickness of the power supply equipment. Figure 3 shows an example schematic of an equipment height reduction due to surface mounting of Y capacitor.

**Product Lineup, Features**

Table 1 shows main product specifications of DK Series type EA.

**Low profile, SMD**

The DK Series type EA has a structure in which metal terminals are soldered to disk type ceramics of a capacitor element, and then the resulting device is resin molded into a rectangular shape. It ensures the high breakdown voltage required by the IEC60384-14 X1/Y1 class, and at the same time, realizes the small

**Table 1: Main product specifications**

Item	Specification
Range of operating temperature	-40 ~ +125 °C
Rated voltage	Y1: AC300V (r.m.s.), X1: AC440V (r.m.s.) or Y1: AC250V (r.m.s.), X1: AC440V (r.m.s.)
Range of available capacitance value	10 ~ 1500pF (Nominal capacitance value)
Certified safety standard	UL (UL 60384-14), ENEC (EN 60384-14), CQC (IEC 60384-14), KTC (KC 60384-14)

height of the part from the surface, less than 2.5mm.

Careful consideration was given to the selection of the solder type for joining the ceramic element and the metal terminal and also to the control of the solder quantity. This has made it possible to deal with the reflow soldering method, which exposes the device to high temperature atmosphere for a longer time than the usual method. In addition, Sn plating is applied to the surface of the metal terminal to ensure good solderability.

**High breakdown voltage**

For a long time, Murata has commercialized the disk-type ceramic capacitor DE Series with radial lead, satisfying the safety standard. For example, the DE Series type KX has been widely adopted as IEC60384-14 X1/Y1 class certified, which is satisfied by the present DK Series type EA. Disk type ceramics similar to the DE Series are also used for capacitor elements of the type EA, and the ceramic technology accumulated in the DE Series is also used in this DK Series. As a result, the type EA satisfies

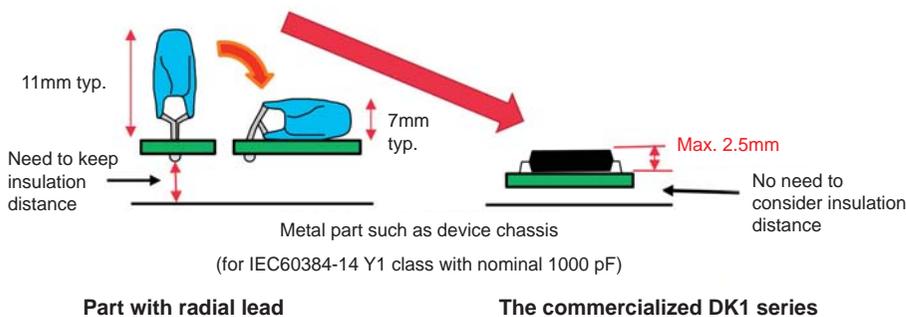
the high withstand voltage required for IEC60384-14 Y1 class products, typically represented by withstanding voltage between terminals: AC 4kV r.m.s. for 60 seconds, in spite of its smallness and low profile.

Figure 4 shows the comparison of the breakdown voltage between terminals of the DK Series type EA and the DE Series type KX, demonstrating their high withstand voltage. The minimum value of the dielectric breakdown voltage of the DK Series is equivalent to that of the DE Series and is sufficiently larger than AC 4kV, required by the safety standard for the withstanding voltage between terminals.

**High reliability**

In the case of composite parts of ceramics and resin, acquiring a match of their thermal-expansion coefficients, their good adhesion, among others is an important key point in securing reliability as a ceramic capacitor. For example, when the adhesion between ceramics and resin is not sufficient, there is a risk of lowering the performance of the withstand voltage and the moisture resistance. In addition, when the thermal expansion coefficients are significantly different between the ceramics and the enclosure, cracks may occur in the enclosure or the ceramic element due to mechanical stress caused by the difference in the amount of expansion and shrinkage during temperature cycling.

For reference, Figure 5 shows the change in the insulation resistance before and after the humidity resistance test (60°C, 95% RH, AC 440V applying, 1000h) of the DK Series and the corresponding DE Series type KX. Both the DK Series and the DE Series indicate no deterioration in moisture resistance performance, such as a remarkable decrease



**Fig. 3: An example schematic of an equipment height reduction by SMD type Y capacitor (for IEC60384-14 Y1 class with nominal 1000pF)**

in the insulation resistance before and after the test. Thus, the DK Series has a moisture resistance performance the same as the DE Series. Further, because of its structure, the DK Series is free of chip cracks caused by substrate bending occurring when chip MLCCs of large sizes are used, and of cracks of mounted solder after thermal cycling. This humidity resistance test gives additional information showing the reliability of the product.

**Compliance with safety standard requirements**

The safety standard for the Y capacitor connecting the grid power line and the ground has requirements on the distance (creepage) between the terminals and the flame retardant performance in addition to the withstand voltage between terminals. The requirement of the withstanding voltage has been already described under “High breakdown voltage.” Regarding the creepage, the structure of the capacitor body and the shape of the terminal have been designed so as to ensure the safety standard requirement of 8mm or more. In fact, this condition is satisfied even for the distance between the lands on which capacitors are mounted, which is considered to be the shortest creepage in the actual use, as well as the creepage of the main body of the product.

[Change of insulation resistance before and after humidity resistance test (reference values)]  
Condition: 60 °C, 90 ~ 95% RH, AC440V@60Hz, 1000h, n = 10

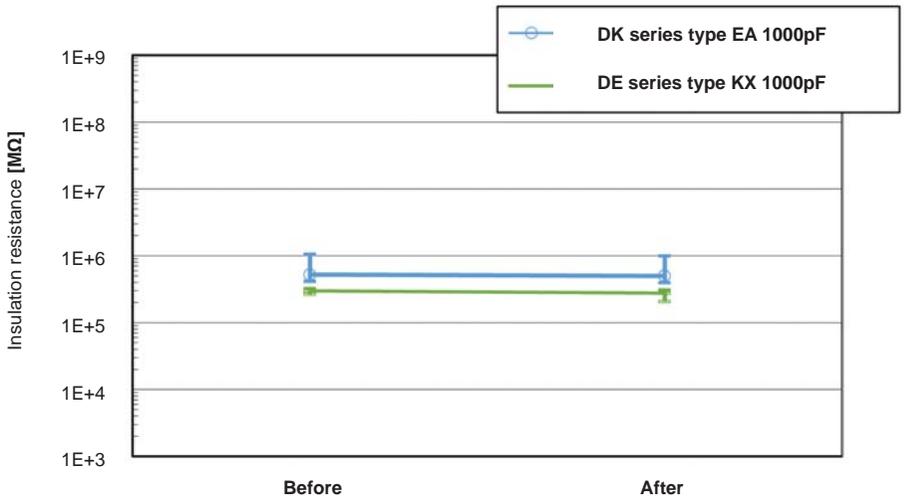


Fig. 5: Moisture resistance test (example)

The resin that molds the capacitor body conforms to UL94V-0, which is considered to be most severe under the flameproof test conditions, and therefore satisfies the required performance of the safety standard. In addition, the thickness of the enclosure is controlled such that the withstand resistance between the terminals and the enclosure satisfies the required safety standard.

These have resulted in obtaining certification of major safety standards in Europe, United States, and Asia, such as UL, CQC, KTC, etc. Details of the approved safety standards are shown in Table 1.

**Impact of DK Series type EA**

As shown in Fig. 4, by using the DK Series type EA, the mounting height from the substrate surface can be drastically reduced in comparison with conventional components with radial leads, and further thinning of the power supply units can be realized. Moreover, it is expected that DK Series type EA allow use of surface mounting technology and offers greater freedom of the power supply equipment design.

**Future Developments**

Mass production of this DK Series type EA started at Murata Electronics (Thailand), Ltd. from May 2017. The scale of the production will be gradually expanded in the future.

**About This Article:**

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[Measured breakdown voltage (between terminals, room temperature, in insulating oil, n = 10, reference values)]

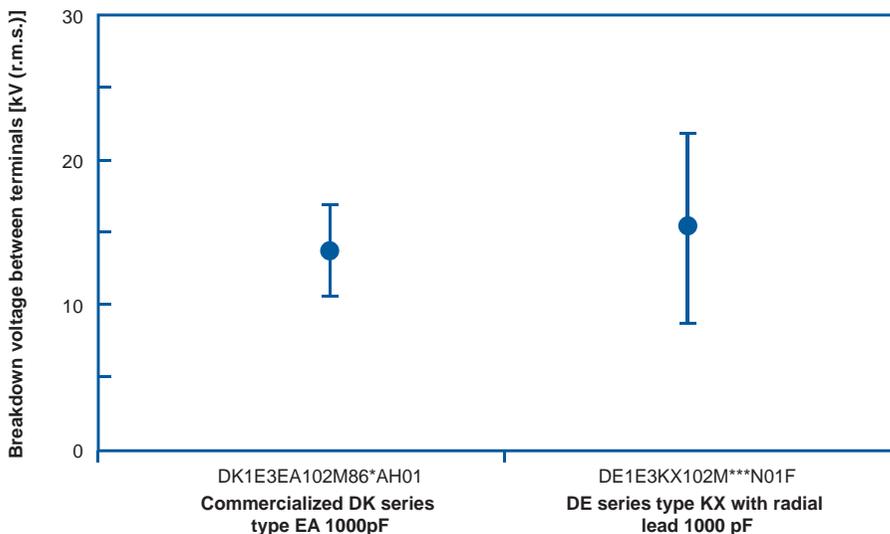


Fig. 4: Measured breakdown voltage (example)