The History of TDK Capacitors

1951 Production of standard-size cylindrical ceramic capacitors (barium titanate capacitors) begins at the Hirasawa Plant.
1952 Research on high-dielectric type ceramic capacitor manufacturing methods begins.
1953 Kotoura Plant constructed in Hirasawa-cho, Akita Prefecture to manufacture ceramic capacitors.
1955 Sales of Ulcon disk capacitors begin.
1961 Sales of cylindrical pass-through ceramic capacitors begin.
1964 Compact ceramic capacitors received certification from Underwriters Laboratories in the United States.
1968 Development of multilayer chip capacitors begins.
1969 Sales of high-voltage disk ceramic capacitors for television use begin.
1971 TDK-ACI Co. Ltd. established as a joint venture with American Components Incorporated (ACI) of the United States to manufacture multilayer ceramic capacitors. Sales of multilayer ceramic chip capacitors (palladium internal electrode) begin.
1980 TDK acquires ACI’s holdings of TDK-ACI, cancels the joint venture agreement, and changes TDK-ACI’s name to TDK-MCC Corporation.
1985 Sales of large-capacitance multilayer ceramic capacitors (F temperature characteristics; palladium internal electrode) begin.
1998 Sales of nickel internal electrode multilayer ceramic chip capacitors (F temperature characteristics) begin.
1992 Sales of nickel internal electrode multilayer ceramic chip capacitors (B and X7R temperature characteristics) begin.
1993 Sales of nickel internal electrode ceramic chip capacitors for high-temperature use (X6R temperature characteristics) begin.
1998 TDK wins the Okochi Memorial Technology Prize for its high-reliability nickel internal electrode multilayer ceramic capacitors.
1999 Sales of nickel internal electrode high-capacitance COG multilayer ceramic chip capacitors with Ni electrodes begin.
2001 Construction of TDK-MCC Kitakami Plant completed. Multilayer chip capacitor manufacturing and sales company established in Suzhou City, China.
2008 Construction of TDK-MCC Honjo Plant completed.
Welcome to TDK Capacitor World!

Contents
- Origins and History of Capacitors ........................................1
- What Is a Capacitor? .........................................................3
- Basic Properties of Capacitors .........................................4
- The Workings of Capacitors in Circuits .................................5
- The Capacitor Family .........................................................7
- Capacitances and Frequencies of Various Capacitors ...............8
- Characteristics and Types of Ceramic Capacitors ....................9
- TDK’s Extensive Lineup of Capacitors ..................................10
- TDK’s Multilayer Ceramic Chip Capacitor Technologies ............11
- Core Technologies Supporting Miniaturization and Higher Capacitance .........................................................12
- Electronic Devices and Capacitors Part 1: Digital Television Sets 13
- Electronic Devices and Capacitors Part 2: Mobile Devices ..........15
- Electronic Devices and Capacitors Part 3: PCs .........................17
- Electronic Devices and Capacitors Part 4: Automotive Electronics ....19
- Manufacturing Processes: How TDK’s Multilayer Ceramic Chip Capacitors Are Made 21

Origins and History of Capacitors
- About 600 BC
  - Records of amber (fossilized resin) attracting dust and ashes, a frictional electric phenomenon
- 1600s
  - Galvani’s friction generator
  - Ball of sulfur
- 1700s
  - Advances in electric science
  - Distinction between glass electricity (+) and resin electricity (-)
  - Invention of the Leyden jar
  - "Elekter," a hand-operated generator, created
  - Franklin’s kite experiment
  - Volta’s electrophorus
- 1800s
  - Volta cell
  - Birth and advance of electromagnetism
  - Mica capacitor
  - Paper capacitor
  - Early ceramic capacitors
  - Aluminum electrolytic capacitor
- 1900s
  - Birth of electronics
  - Film capacitor
  - Titanium oxide and barium titanate ceramic capacitors
- Since 1945
  - Multilayer ceramic chip capacitor
  - Tantalum electrolytic capacitor
What is a Capacitor?

If you rub a plastic board, it attracts your hair. The friction causes positive and negative electric charges, and they attract each other. This is the basic principle of a capacitor. The capacitor, which is a type of electronic component, does not use friction, but is electrified (charged) by applying voltage.

Instead of friction, voltage is applied to a capacitor to electrify (charge) it.

The ability of a capacitor to store an electric charge is known as capacitance. The larger the surface area of the electrodes and the smaller the distance between the electrodes, the higher the capacitance. The capacitance also changes greatly depending on the properties of the insulator (air or a dielectric material) between the electrodes. This is indicated by relative permittivity.

<table>
<thead>
<tr>
<th>Dielectric Material</th>
<th>Relative Permittivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air</td>
<td>1</td>
</tr>
<tr>
<td>Plastic films</td>
<td>2-3</td>
</tr>
<tr>
<td>Mica</td>
<td>6-8</td>
</tr>
<tr>
<td>Aluminum oxide</td>
<td>8-10</td>
</tr>
<tr>
<td>Ceramic (low-permittivity)</td>
<td>10-100</td>
</tr>
<tr>
<td>Ceramic (high-permittivity)</td>
<td>10000-20000</td>
</tr>
</tbody>
</table>

Called a condenser in Japanese and a capacitor in English.

Basic Properties of Capacitors

Capacitors were originally created as devices for storing electricity (charge). In Japan they are called condensers because they condense electricity, but in the English-speaking world they are referred to as capacitors. Let’s learn the two basic properties of capacitors.

① Store charge.

Electric current flows through a wire for a short time until the capacitor is charged.

When voltage is applied, the dielectric material causes electric polarization.

② Stop Direct Current, Allow Alternating Current to Flow.

Capacitors stop direct current electricity. When alternating current is applied, however, alternating charging occurs and the direction of the electric field reverses repeatedly. This has the same effect as alternating current flowing through the dielectric material in the middle.
The Workings of Capacitors in Circuits

The basic properties of capacitors—storing charge, stopping direct current and allowing alternating current to flow—are used in many ways in circuits found every-day electronics.

**Storing Electricity**

Using a Stored Charge

- Reusable Camera Strobe Light-Generating Circuit
- DC-DC converters
- Electrical switches
- Dry cells
- Boosting circuits
- Aluminum electrolytic capacitors
- Trigger transformers
- Shutter button
- Multi-layer ceramic chip capacitors
- Xenon lamps
- Generation of light
- Camera strobes use the electricity storage properties of capacitors.

**Smoothing**

Smoothing Changes in Voltage

- Role of Smoothing Circuits in AC Adaptors
- AC adaptors
- Transformer
- Bridge diode
- Smoothing electrolytic capacitor
- AC input
- Voltage conversion
- Rectification
- DC output
- DC segment → AC segment
- 100 V (AC) power from an outlet is converted to DC for storage in the battery of an electronic device.

**Coupling**

Block Direct Current But Allow Signals (AC) to Pass

- DC segment → AC segment
- AC segment
- DC segment
- Coupling capacitor
- Capacitors block DC passage and allow only the signal, which is AC, to pass through, so they are used to isolate and combine (couple) circuits blocks.

**Decoupling**

Bypass High-Frequency Noise

- Decoupling capacitors are also called bypass capacitors.
- Noise segment
- Power supply line
- Noise is sent to a ground
- IC
- Noise is sent to a ground
- Decoupling capacitors send (bypass) AC segment such as noise to a ground. They are also called bypass capacitors.

**Important**

Capacitors allow higher-frequency AC to pass more easily, and the higher the capacitance the more easily the current can pass through.

- Higher frequencies pass through more easily.
- Low frequencies cannot pass through.
- When capacitance is high, current can pass through.
The Capacitor Family

Capacitors together with resistors and inductors (coils) are referred to as the “Big Three Passive Electronic Components,” and many different types of capacitors have been developed. In terms of external configuration, capacitors are divided into those with leads and those without, which are known as surface mount devices (SMDs). Multi-layer ceramic chip capacitors have made substantial contributions to the miniaturization of electronic devices and are the most common type of capacitor used today.

Capacitors with Leads

- Axial Leads
- Radial Leads

Capacitor shapes are highly varied and include cylinders, disks, square plates, and chip types.

Mica capacitors have layers of thin mica and electrode plates. Paper capacitors have a structure with a paper insulator and metallic foil rolled together.

Surface Mount Device (SMD) Capacitors

- SMD Type Electrolytic Capacitors
- Multilayer Ceramic Chip Capacitors

They have no leads (legal), so they are compact and save space.

We make up 80% of the capacitors in use around the world today.

Capacitances and Frequencies of Various Capacitors

The capacitance is the most fundamental property of a capacitor. Multilayer ceramic chip capacitors are compact but are available in a wide range of capacitances.

Range of Capacitances of Different Capacitor Types

<table>
<thead>
<tr>
<th>Capacitor Type</th>
<th>1pF</th>
<th>10pF</th>
<th>100pF</th>
<th>1nF</th>
<th>0.1μF</th>
<th>1μF</th>
<th>10μF</th>
<th>100μF</th>
<th>1000μF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multilayer Ceramic Capacitors</td>
<td>0.001 μF</td>
<td>0.01 μF</td>
<td>0.1 μF</td>
<td>1 μF</td>
<td>10 μF</td>
<td>100 μF</td>
<td>1000 μF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aluminum Electrolytic Capacitors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tantalum Electrolytic Capacitors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Film Capacitors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The capacitances of common capacitors are shown above.

Different Uses of Capacitors According to Frequency

- Audio
- AM Radio
- Short Wave
- FM/TV/Mobile Phone/Broadcast Satellite

High-frequency refers to alternating current or radio waves with extremely high frequencies.
Characteristics and Types of Ceramic Capacitors

General-purpose ceramic capacitors are broadly divided into low-permittivity types (type I) and high-permittivity types (type II). They are further divided by their temperature characteristics. Temperature characteristics are defined according to EIA and JIS standards. Examples are shown in the tables below.

**Types and Temperature Characteristics by Dielectric Type**

**Low Permittivity (Type I)**
- Dielectric: Titanium oxide, etc.

**High Permittivity (Type II)**
- Dielectric: Barium titanate

### Examples of Type I Symbols and Characteristics

<table>
<thead>
<tr>
<th>Standard</th>
<th>Characteristic</th>
<th>Temperature range</th>
<th>Capacitance change</th>
</tr>
</thead>
<tbody>
<tr>
<td>JIS</td>
<td>CH</td>
<td>-25 to +85°C</td>
<td>±60ppm/°C</td>
</tr>
<tr>
<td></td>
<td>UJ</td>
<td>-25 to +85°C</td>
<td>-750±120ppm/°C</td>
</tr>
<tr>
<td></td>
<td>SL</td>
<td>-20 to +85°C</td>
<td>350-1000ppm/°C</td>
</tr>
<tr>
<td>EIA</td>
<td>COG</td>
<td>-55 to +125°C</td>
<td>±30ppm/°C</td>
</tr>
</tbody>
</table>

**Advantage:** Small capacitance change from temperature.

**Disadvantage:** Permittivity is low, so capacitance is small.

### Examples of Type II Symbols and Characteristics

<table>
<thead>
<tr>
<th>Standard</th>
<th>Characteristic</th>
<th>Temperature range</th>
<th>Capacitance change</th>
</tr>
</thead>
<tbody>
<tr>
<td>JIS</td>
<td>JB (B)</td>
<td>-25 to +85°C</td>
<td>±10%</td>
</tr>
<tr>
<td></td>
<td>JF (F)</td>
<td>-25 to +85°C</td>
<td>+30%, -80%</td>
</tr>
<tr>
<td>EIA</td>
<td>X5R</td>
<td>-55 to +85°C</td>
<td>±15%</td>
</tr>
<tr>
<td></td>
<td>X7R</td>
<td>-55 to +125°C</td>
<td>±15%</td>
</tr>
<tr>
<td></td>
<td>X8R</td>
<td>-55 to +150°C</td>
<td>±15%</td>
</tr>
<tr>
<td></td>
<td>Y5V</td>
<td>-30 to +85°C</td>
<td>+22%, -82%</td>
</tr>
</tbody>
</table>

**Advantage:** Permittivity is high, so capacitance is high.

**Disadvantage:** Large capacitance change from temperature.

---

TDK’s Extensive and Varied Lineup of Capacitors

- **General-Purpose Capacitors**
  - Extensive lineup from ultra-compact 0402 size to high- and large-capacitance types.

- **Capacitor Arrays**
  - A multi-unit capacitor made from several capacitor elements formed in a single chip.

- **Low-ESL Flip Type**
  - ESL is reduced by reversing (flipping) the direction of the electrode terminals. Optimal for IC decoupling and other applications.

- **Low-ESL Three-Terminal Pass-Through Capacitors**
  - A low ESL capacitor created by multilayering a pass-through capacitor.

- **Ultra-Low ESL ULI Capacitors**
  - A multi-terminal type that uses an original internal structure to greatly reduce ESL, CPU decoupling and other applications.

- **Medium- to High-Voltage Disk Capacitors with Leads**
  - Low-loss, high-pressure resistance, high reliability.

- **Ultra-High Voltage Capacitors**
  - Circuit breakers, distribution lines, laser devices, etc.

- **High-Voltage Pass-Through Capacitors**
  - Magnetron applications such as microwave ovens.

- **High-Temperature Guaranteed X8R Capacitors**
  - Optimal X8R characteristics (-55 to +150°C) for use in automotive and other devices.

- **Multilayered Capacitors with Leads**
  - High-reliability products with outstanding frequency characteristics.

---

It is important to use the proper ceramic capacitor according to its temperature characteristics.

TDK has an extensive lineup of application products from general-purpose to special-purpose capacitors.
TDK's Multilayer Ceramic Chip Capacitor Technologies

Basic Technologies for Increasing Capacitance

- Make Dielectric Layers Thinner
- Increase the Number of Layers

Capacitance

$$C = \varepsilon_r \varepsilon_0 \frac{S}{d} N$$

- $C$: Capacitance
- $\varepsilon_r$: Permittivity in a vacuum
- $\varepsilon_0$: Relative permittivity of a dielectric
- $S$: Electrode area
- $d$: Dimensions of the dielectric layer
- $N$: Number of layers

When $d$ is decreased and $N$ increased, the capacitance increases.

TDK's multilayer ceramic chip capacitors achieve amazing miniaturization and increases in capacitance.

(Comparison of 3216 sizes with the same configuration)

- Capacitance has been increased from $0.1 \mu F$ to $100 \mu F$.
- Capacitance 1000 times higher!

(Comparison of capacitors with $0.1 \mu F$ capacitance)

- One 3216 size capacitor (actual size)
- 3216 size components have been miniaturized to 0603 size.
- Volume 100 times smaller!

Core Technologies Supporting Miniaturization and Higher Capacitance

- Technologies for Pulverizing and Dispersing Materials
  - Beads (grinding media)
  - Subject material
  - Dielectric and internal electrode materials (nickel) are precisely pulverized and dispersed on the nano-meter order.
  - Average particle diameter: 0.2 µm or less
  - Nano-powder

- Advanced Application and Thick-Film Printing Techniques
  - Special ultra-precise mesh screens are used for printing internal electrodes.
  - Application of Dielectric Material
  - Screen Printing of Electrode Paste
  - PET film, Doctor blade, Ni paste

Focus on Materials
Focus on Thinness
Focus on Layering
Focus on Sintering

Miniaturization Higher Capacitance

Thin-Film and Multilayering Technologies Are Approaching Extremes.

- Dielectric layers are less than 1 micron (1/1000 mm) and the maximum number of layers can exceed 1000.

Computer managed, high-precision temperature and atmosphere control

Components are sintered while temperature and atmosphere are precisely controlled.

Materials, thin-film, and multilayering technologies support miniaturization and increases in capacitance.
Electronic Devices and Capacitors Part 1

Digital Television Sets

In 2011, all television broadcasts in Japan will be digital. Numerous multilayer ceramic chip capacitors are used in LCD and plasma televisions, contributing to making the sets thinner and lighter.

Basic Circuit Structure of a Digital Television

- **Antenna**
- **Tuner Block** (video and voice signal processor, digital signal processor, CPU)
- **DSP Block** (video and voice signal processor, digital signal processor, CPU)
- **Interface Block**
- **Power Supply Block**
  - **AC-DC Converter**
  - **DC-DC Converter**

AC-DC Converter

- Converts AC to DC.
- High-capacitance multilayer ceramic chip capacitors and Mega Cap capacitors are used as primary and secondary smoothing capacitors.

DC-DC Converter

- The input DC voltage is stepped up or down to the required voltage.

Capacitors Used in DC-DC Converters

- **Smoothing Circuits**
  - High- and large-capacitance chip capacitors
  - Medium- and high-voltage capacitors
  - Three-terminal pass-through capacitors, etc.

- **Snubber Circuits**
  - High and large-capacitance chip capacitors
  - Medium- and high-voltage capacitors
  - Three-terminal pass-through capacitors, etc.

- **Circuit Elements That Combine Capacitors and Resistors**

  - **Filter Circuits**
    - Capacitors hinder direct current and low-frequency alternating current, but allow high-frequency alternating current to pass easily. Filter circuits use these properties (filters that combine inductors and capacitors are known as LC filters).

  - **Low-Pass Filter (LPF)**
    - The high-frequency portion is passed to the ground and the low-frequency portion is output.

  - **High-Pass Filter (HPF)**
    - The low-frequency portion is passed and only the high-frequency portion passes through and is output.

Most noise is concentrated in the high-frequency portion (high-frequency AC).
Mobile phone functions are rapidly increasing including digital cameras, electronic money, and reception of One Segment digital television broadcasts. Compact electronic components and devices that can save power and support high-density mounting are essential.

**Basic Circuit Structure of a Mobile Phone**

- Keypad
- Logic circuit
- Speaker
- Camera unit
- Power supply unit
- Vibration
- LCD driver
- LCD panel
- High-frequency circuit
- Antenna

- Ultra-compact capacitors
- Capacitor arrays
- Three-terminal pass-through capacitors, etc.

**Capacitor Arrays**

A capacitor array is a component that combines multiple capacitors on a single chip. They are effective in reducing mounting costs.

**Low-ESL Three-Terminal Pass-Through Capacitors**

Three-terminal pass-through capacitors are low ESL capacitors that have an internal structure different from other capacitors. They are highly effective as mobile device noise countermeasures.

- Internal electrodes for conducting current and internal electrodes for ground are layered with dielectric material between them.
- Internal electrodes for conducting current and internal electrodes for ground are placed in alternating layers.
- When a pass-through structure is used, the smaller the distance between the capacitor and the ground, the lower the ESL. This reduces a lot of noise.

See page 18 for an explanation of ESL.

Multilayer ceramic chip capacitors make important contributions to making mobile phones smaller and lighter.

Array type components are effective at decreasing the number of components and reducing mounting costs.
In conjunction with faster computer speeds, capacitors must be able to provide outstanding high-frequency characteristics.

**What are ESR and ESL?**

In high-frequency application, the equivalent series resistance (ESR) and equivalent series inductance (ESL) of a capacitor’s internal electrodes and terminal electrodes become apparent.

**ESR:** Equivalent series resistance

**ESL:** Equivalent series inductance

The ESL of components with leads is higher than chip components because of the inductance of the leads. That is why they are not suitable for high frequencies.

A capacitor circuit diagram is this:

But an equivalent circuit is shown like this:

ESL acts as a hindrance, reflecting the signal current.

**PC CPUs Also Use Low ESL Capacitors**

The semiconductor CPU is the brain of a PC, and the CPU power supply also uses low ESL capacitors to rapidly provide the electric power that the CPU needs to operate.

The CPU requires a lot of power to perform high-speed calculations. The energy stored in capacitors can provide power to the CPU quickly.

**Low ESR Capacitors**

- Low ESR flip chip capacitor
- Low ESR three-terminal pass-through capacitor
- Ultra-low ESR ULI capacitor

ESL is lowered by reversing the terminal electrode length and width and making the current route short and fat.

The internal electrode and ground electrode are layered alternately to reduce the ESL (see page 16 for more information).

Ultra-low ESL is created by alternating the flow of current so the magnetic fields cancel out. Effective for miniaturization and high capacitance.

ESL is the inductor (coil) portion of the capacitor’s internal electrodes, etc.
Modern automobiles are electronics devices that can be driven. High-reliability capacitors are essential for safe and comfortable driving.

**High-Temperature Guarantee X8R Capacitors**
- Wide-Ranging Temperature Characteristics That Can Withstand Severe Cold and Engine Compartment Heat
- Characteristic Multilayer Ceramic Chip Capacitors
- Temperatures That Automotive Capacitors Must Withstand

Automotive electrical systems are controlled by many electronic control units (ECUs), which are linked by various in-vehicle LANs including body, power train, safety, and multimedia networks.

**Introduction of Networks Using In-vehicle LANs**
- Structure of automotive electrical systems linking in-vehicle LANs
- Body Network: CAN, LIN
- Power Train Network: FlexRay
- Safety Network: Gate-by-wire (ASIS), DSI, DCT
- Multimedia Network: MOST, DAB, IDA-1394
- Gateway
- Lights, Mirrors, Key
- ABS, Transmission, Brakes, Engine Control
- Airbags, Sensors
- Car Navigation System
- Speakers, Television, Audio, Video Camera

**Future automobiles will require even higher-performance, higher-reliability electronic components.**

Automotive electrical systems use 20,000 to 30,000 electronic components, of which more than 1,000 are multilayer ceramic chip capacitors.

**Mega Cap**
- Original Structure with Metal Cap Doubles Capacitance
- Metal cap
- Lead-free high temperature solder layer
- Nickel & tin plating layer
- Terminal electrode
- Since the unit has a metal cap, they are safe to use even on aluminum boards. They resist board warping after mounting.

Absorbs Heat and Mechanical Shock
- The metal caps absorb stress from heat and mechanical shocks, raising reliability. Used in power supply smoothing circuits for outdoor communications equipment and automotive devices. Twice the capacitance is achieved in the space of a single capacitor, contributing to space saving.

More than 1,000 multilayer ceramic chip capacitors are used in cars.

Automotive electronic components require high reliability above all else.
Manufacturing Processes: How TDK’s Multilayer Ceramic Chip Capacitors are Made

1. Manufacture of Dielectric Paste
   - Powdered dielectric material and resin are mixed to make a dielectric paste.

2. Sheet Formation
   - Dielectric Paste
   - Carrier Film
   - The dielectric paste is made into a thin sheet.

3. Internal Electrode Printing
   - Screen
   - Electrodes are printed on the dielectric paste.
   - Printed Electrodes

4. Sheet Layering and Pressing
   - Multiple sheets of dielectric paste with printed electrodes are layered and pressure is applied.

5. Cutting Multilayer Sheets and Chip Formation
   - The sheets are cut to specified sizes.

6. Sintering
   - The chips are placed in a furnace for sintering (firing).
   - After sintering, they become hard ceramic.

7. Application of Terminal Electrode Paste, Baking, and Plating
   - Electrode Paste
   - Barrel
   - Ni Plating
   - Sn Plating
   - After baking, the chips are electroplated.

8. Inspection and Packaging
   - After the characteristics are inspected, the chips are packaged and shipped.
   - Taping, Bulk Case, etc.
The History of TDK Capacitors

1951 Production of standard-size cylindrical ceramic capacitors (barium titanate capacitors) begins at the Hirasawa Plant.
1952 Research on high-dielectric type ceramic capacitor manufacturing methods begins.
1953 Kotoura Plant constructed in Hirasawa-cho, Akita Prefecture to manufacture ceramic capacitors.
1955 Sales of Ulcon disk capacitors begin.
1961 Sales of cylindrical pass-through ceramic capacitors begin.
1964 Compact ceramic capacitors received certification from Underwriters Laboratories in the United States.
1968 Development of multilayer chip capacitors begins.
1969 Sales of high-voltage disk ceramic capacitors for television use begin.
1971 TDK-ACI Co. Ltd. established as a joint venture with American Components Incorporated (ACI) of the United States to manufacture multilayer ceramic capacitors.
Sales of multilayer ceramic chip capacitors (palladium internal electrode) begin.
1980 TDK acquires ACI’s holdings of TDK-ACI, cancels the joint venture agreement, and changes TDK-ACI’s name to TDK-MCC Corporation.
1985 Sales of large-capacitance multilayer ceramic capacitors (F temperature characteristics; palladium internal electrode) begin.
1998 Sales of nickel internal electrode multilayer ceramic chip capacitors (F temperature characteristics) begin.
1992 Sales of nickel internal electrode multilayer ceramic chip capacitors (B and X7R temperature characteristics) begin.
Sales of nickel internal electrode ceramic chip capacitors for high-temperature use (X6R temperature characteristics) begin.
1993 Sales of nickel internal electrode, medium- and high-voltage ceramic chip capacitors (X7R temperature characteristics) begin.
1998 TDK wins the Okochi Memorial Technology Prize for its high-reliability nickel internal electrode multilayer ceramic capacitors.
1999 Sales of nickel internal electrode high-capacitance COG multilayer ceramic chip capacitors with Ni electrodes begin.
2001 Construction of TDK-MCC Kitakami Plant completed.
Multilayer chip capacitor manufacturing and sales company established in Suzhou City, China.
2008 Construction of TDK-MCC Honjo Plant completed.