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APPLICATION ARTICLE

Technology Focus

Small Ceramic Capacitors Address Temperature Compensation Issue

Technical innovations in chip monolithic ceramic capacitors are being accelerated to meet the needs of small and high performance electronics devices. In the area of capacitors for temperature compensation, small-sized and high capacitance capacitors have been developed. These products are now used in markets that were previously monopolized by film capacitors as they can now compete with film capacitors in terms of performance and cost.

This article discusses the technology for high capacitance capacitors for temperature compensation, which maintain the high frequency and high reliability characteristics of monolithic ceramic capacitors, and which use dielectric materials with excellent temperature and voltage characteristics.

Ceramic Capacitor for Temperature Compensation

Monolithic ceramic capacitors are classified into two classes – those for temperature compensation (class I) and high dielectric constant products (class II) – according to the materials used (Fig. 1). High dielectric constant products use as their main material ferrodielectric material represented mainly by barium titanate, and are characterized by a dielectric constant of 1,000 or more. These capacitors are available as small-sized high capacitance products and are extensively used in ordinary electronic devices for bypass,

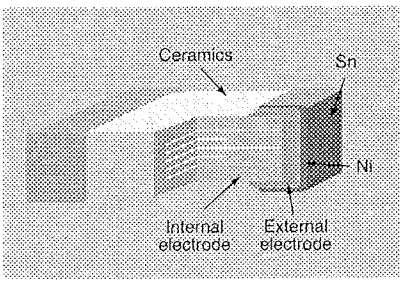
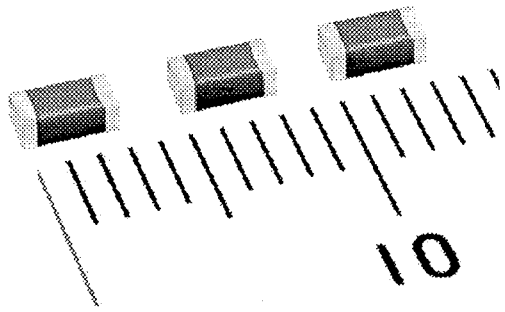


Fig. 1: Structural diagram of monolithic ceramic capacitor



High capacitance temperature compensation capacitors

coupling and decoupling uses. On the other hand, their shortcoming is that their change in capacitance due to temperature is relatively large and that their capacitance and dielectric loss also change to a great extent when DC or AC current passes through them.

In contrast to high dielectric constant type capacitors, those for temperature compensation whose specific dielectric constant is relatively small use electrically stable paraelectric material. Paraelectric material is limited in temperature and voltage dependence and their dielectric loss is very small at 0.05 percent. Viewed from the standpoint of electric characteristics, it may be said that they are close to an ideal temperature compensation capacitor. With a low loss characteristic, temperature compensation capacitors have been used widely for oscillation, tuning, filter and other circuits.

Higher Capacitance Products

Temperature compensation capacitors can obtain a lower capacitance because of their low specific dielectric constant compared with high dielectric constant type capacitors. Thus, according to conventional technology, the highest capacitance that can be obtained from a 1206 size product is low at 0.01μF, so that it needs size reduction and increase in capacitance to meet current market needs.

On the other hand, the shortcomings of high dielectric constant type capacitors is that they generate shock noise because of their piezoelectric characteristic and has an effect on passing signals to distort them. Because of these characteristic defects, there is a restriction on expanding their market.

To solve this problem, Murata Manufacturing Co., Ltd. pioneered in the industry in introducing to the market a high capacitance series of temperature compensation capacitors. Thus, in May 2002, the company introduced a series with a C0G characteristic – 1) 1206/0.1μF/25V – and in November of the same year another series with a U2J characteristic -- 2) 1206/0.1μF/50V.

Particularly, the U2J characteristic products represented a series made smaller and lower in cost than the C0G characteristic series, reducing the number of layers of dielectric devices by designing materials higher in specific dielectric constant, compared with the C0G series.

In developing these series, thin multilayer, super-fine powder, and high distribution technologies for already marketed high dielectric constant type capacitor were used. At the same time, the development of these series represented an expanded use of base metal (nickel) to internal electrodes -- the previous use of precious metal for internal electrodes was impossible for a marketable product because of its high cost.

1) C0G:-55°C~+125°C 0+/-30ppm/°C
2) U2J:-55°C~85°C -750+/-120ppm/°C

Temperature Compensation Capacitors

Capacitors of this type, which use paraelectric ceramic material, are excellent in capacitance-temperature characteristic and distortion, and suffer little change in capacitance after application of DC bias voltage, exhibiting stable voltage dependence.

In the following, general-purpose high dielectric constant type capacitors, C0G

characteristic temperature compensation capacitors, U2J characteristic temperature compensation capacitors and chip type film capacitors are compared as to their representative electric characteristics.

I. Lock-Up Time (LUT)

The results of comparison among the LUT levels of the loop filters for PLLs (Phase Locked Loops) for VCOs (Voltage-Controlled Oscillators) -- filters mounted with different types of capacitors, respectively, are illustrated (Fig. 1).

The LUT is one of the important operating characteristics of PLL circuits, and the shorter the LUT is, the better the modulation precision of a set is, so that a short LUT contributes to faster channel switchover time. There is no difference among them in C0G or U2J characteristics. This is due to the fact that the loss (ESR) of temperature compensation capacitors is very small and that they depend very little on voltage (Figs. 2 and 3).

Capacitors of this type are most suitable for mobile phones and tuners that use PLL circuits.

Table 1: Comparison of LUT

Capacitance: 0.01μF
Output frequencies: 1,742MHz to 1,769.5MHz

	LUT
MLCC U2J characteristic product	1.1ms
MLCC C0G characteristic product	1.1ms
Film capacitor	1.4ms
MLCC X7R characteristic product	6.0ms

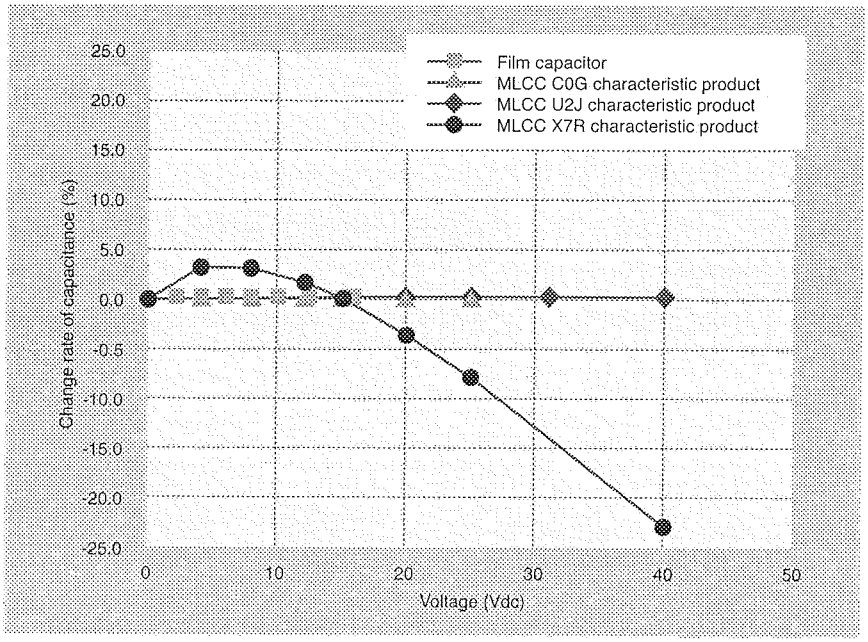


Fig. 3: DC bias characteristic (Tester: HP4284A, measuring condition: 1kHz, 1.0Vrms, 60sec)

II. Shock Noise

For filter, oscillation and other circuits, it is important that no malfunctions occur that are caused by external mechanical shocks or vibration. The results of a comparison under the test conditions mentioned below showed that shock noise caused in C0G/U2J characteristic temperature compensation capacitors are less than the normally acceptable level. This means they have excellent anti-shock noise characteristics.

This is because temperature compensation types use paraelectric material and do not have a piezoelectric characteristic such as seen in high dielectric type capacitors (Fig. 4). Temperature compensation types are particularly suitable for the preamplifier circuits of audio systems that process very small signals and are liable to be affected by shock noise and also for car electronics, which are liable to be exposed to vibration during startup and when the car is running.

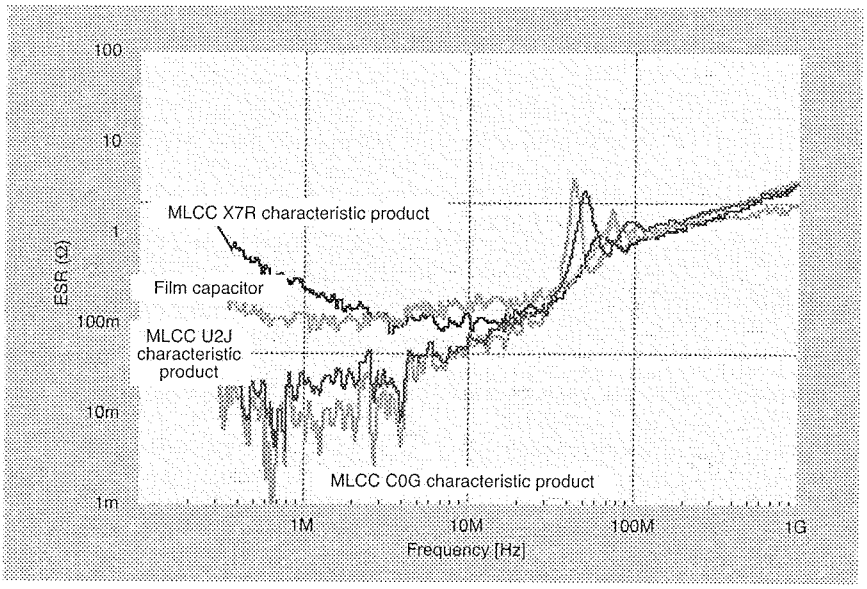


Fig. 2: ESR (Tester: HP8753D)

III. 3rd Harmonic Distortion

The 3rd harmonic distortion means an index of distortion given passing signals in audio and other systems. Illustrated here are the results of comparison of the occurrence rate of 3rd harmonic components (30kHz) in case a reference signal voltage of 10kHz is applied. It may be said that the lower the distortion rate is, the smaller is the effect on signal waveforms. In this respect, too, temperature compensation types excel the other types. This shows their differences in dielectric loss and voltage dependence (Fig. 5).

This type of capacitors is most suitable for audio circuits, which are especially important because of their effect on sound quality. As explained earlier, high capacitance temperature compensation types are excellent in capacitance stability and response, and can be used sufficiently for the circuits for which film capacitors were previously used.

Furthermore, chip film capacitors, which use organic film as their dielectric material, are not characteristically resistant to heat, whereas it is an important characteristic of chip monolithic capacitors that they are highly resistant to heat. Particularly, because of environmental conservation considerations, lead-free devices that require high soldering temperature were introduced. Ceramic capacitors can respond to a demand for high soldering temperature for electronic devices.

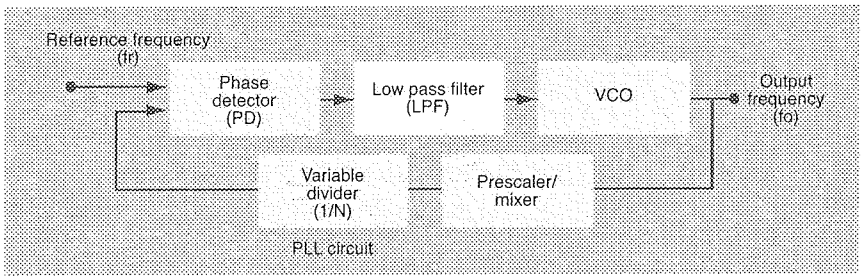


Fig. 6: Application to loop filters

Circuits Used

The following are the main applications of high capacitance temperature compensation type: Loop filters of PLL circuits of VCOs (Voltage Controlled Oscillators); Preamplifier circuits, tone control circuits and coupling circuits of audio systems; Integrating circuits; Peak hold circuits; Filter circuits; Resonance capacitors in inverter circuits for backlights; and Snubber circuits for power supplies.

These devices are extensively used for ordinary electronic equipment, including mobile phones, tuners, audio systems, panel systems and communication modems, and the market for these applications is expected to grow steadily in the future. At present, capacitors of this type are being adopted for the PLL circuits of mobile phones and equipment using LCD panels.

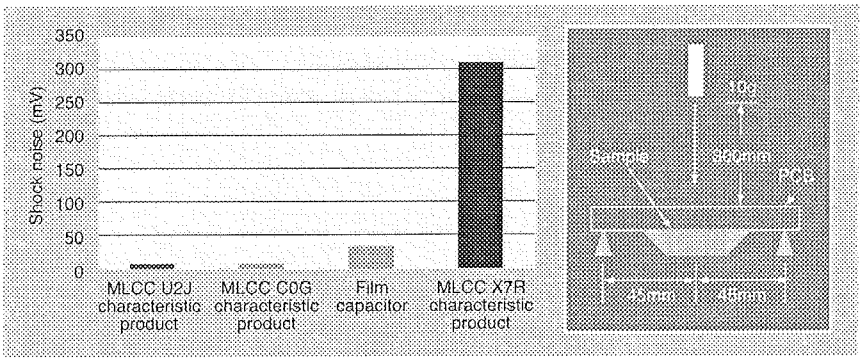


Fig. 4: Shock noise comparison (when 50Vdc is impressed)

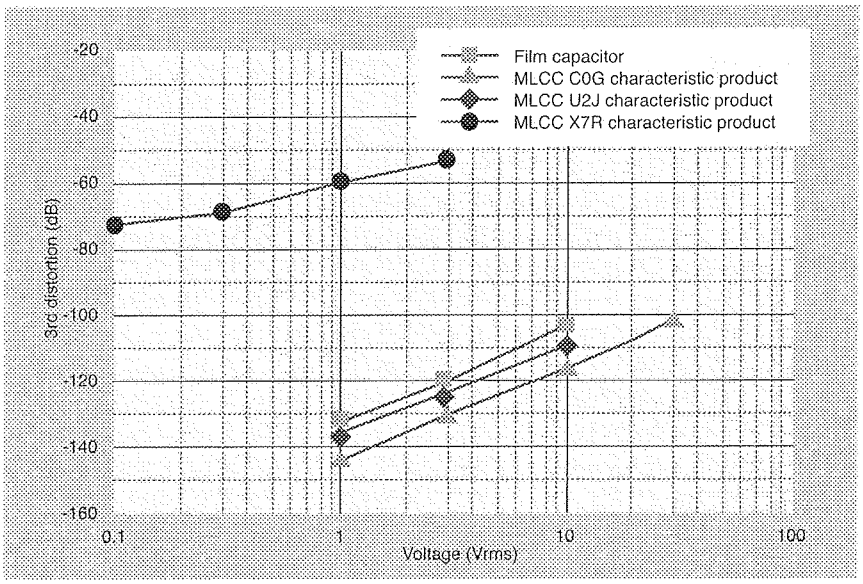


Fig. 5: Measurement results of 3rd harmonic distortion
Tester: CLT-1 (manufactured by Radio Meter, measurement conditions: 10kHz, 1.0Vrms)

Line-Up of Products (only maximum capacitance levels are shown)

U2J characteristic products

- GRM1887U1H103JA01 0603 size/0.01μF/50V
- GRM21B7U1H473JA01 0805 size/0.047μF/50V
- GRM31M7U1H104JA01 1206 size /0.1μF/50V

C0G characteristic products

- GRM1885C1H272JA01 0603 size/0.0027μF/50V
- GRM21B5C1H223JA01 0805 size/0.022μF/50V
- GRM31C5C1E104JA01 1206 size/0.1μF/25V

Electronic systems will tend toward high speed and high frequency in the future as is seen in telecommunication circuits. This is due to the fact that, together with the development of near-next-generation communication networks such as Bluetooth, FTTH (Fiber-To-The-Home), FWA (Fixed Wireless Access) and other networks, communication-information systems are increasingly required to process higher speed signals. In this situation, there will be an increased market need for capacitors that have more excellent capacitance stability and high-speed response.

Murata Manufacturing Co., Ltd. will endeavor to develop products that meet market needs by developing new materials and utilizing more advanced production technologies.

About This Article

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