# Murata's New ESR Capacitors Tackle Anti-Resonance

As consumers continue to seek out more innovative and attractive products, manufacturers keep coming up with more advanced electronic equipment. High-performance LSIs play a central role in those electronic products, starting from the communication equipment underpinning our lifestyles, and extending to end-user devices, such as personal computers, TVs, and mobile phones. Monolithic ceramic capacitors provide vital support for these high-performance LSIs. A number of these monolithic ceramic capacitors are placed near LSIs as decoupling devices for eliminating noise and absorbing load fluctuations during operation.

Basic noise suppression measures have usually been based on the idea of reducing the impedance of a target line. Monolithic ceramic capacitors, which have a low resistive component called equivalent series resistance (ESR), are the best noise suppression device for this purpose, which is why many circuits employ these capacitors. However, nowadays, in some circuits, the concept of reducing the impedance no longer applies. When the ESR value is too low, an impedance peak known as anti-resonance is generated and the decoupling performance in the peak frequency region declines.

To resolve this problem, Murata Manufacturing Co., Ltd. developed low-ESL controlled ESR capacitors with ESR values that have been purposely increased. These are Murata's LLR Series capacitors.

## Selectable ESR in LLR Capacitors

The main feature of the LLR capacitors is that their ESR values have been purposely increased. The ESR is selectable among four values from 100mΩ to 1,000mΩ. (Table 1)

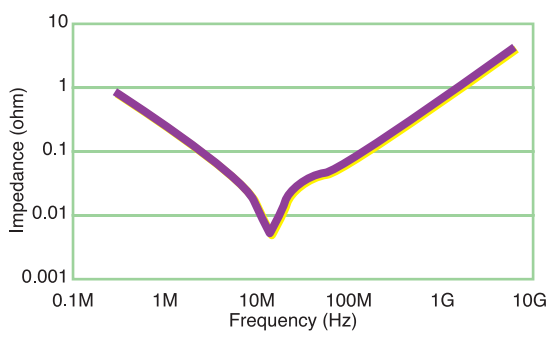


**Fig. 1: Impedance curve of capacitor**

**Table 1: LLR series product lineup**

| Type | | Thickness (mm max) | Capacitance (μF) | ESL (pH) | ESR (mohm) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | 100 | 220 | 470 | 1000 |
|  | 0816 size (mm) | 0.55 | 1 | 120 | X7S <1μF> (4V) | X7S <1μF> (4V) | X7S <1μF> (4V) | X7S <1μF> (4V) |

Significant reduction of anti-resonance!

Ideally, the electrical characteristics of a capacitor are quoted only by equivalent series capacitance (ESC), which indicates capacitance. In reality, however, dielectric (material) loss and internal electrode loss produce a coil component called equivalent series inductance (ESL), and a resistive component called ESR. For this reason, the impedance characteristics express a dipping curve (Fig. 1). Although monolithic ceramic capacitors have the advantage of a low ESR value (high Q value), this low ESR in some cases causes anti-resonance with capacitors of different capacitances or with the capacitance component of LSI packages. The advantage of the LLR Series is its bath-tub-curve impedance characteristics, which is achieved by increasing the ESR value of the capacitor (by reducing the Q value) to prevent anti-resonance. An ideal way to control the load fluctuations of an LSI is to reduce the ESL value of the capacitor and improve the charge and discharge characteristics. However, the conventional ESR control method, which changes the internal electrode patterns of a monolithic ceramic capacitor, has a downside because it causes the ESL value to increase at the same time. Murata has adopted its own design to successfully control the ESR value while the ESL value remains the same. In this way, Murata's new LLR Series achieves the capacitor performance for operating in the broadband region.

## Using LLR Capacitors

Anti-resonance can be generated when the ESR value of a capacitor is too low. In the case of a standard circuit configuration, various capacitors are placed between a high-performance LSI and a DC-DC converter that supplies power to this LSI (Fig. 2). The on-package capacitors, or capacitors mounted on an LSI package board, (shown as C01 in Fig. 2) are used as decoupling devices for high-frequency range support, whereas the high-capacitance ceramic capacitors and aluminum electrolytic capacitor with a capacitance of more than 100μF (shown as C02 and C03, respectively) are used as decoupling devices for low- and mid-frequency range support.

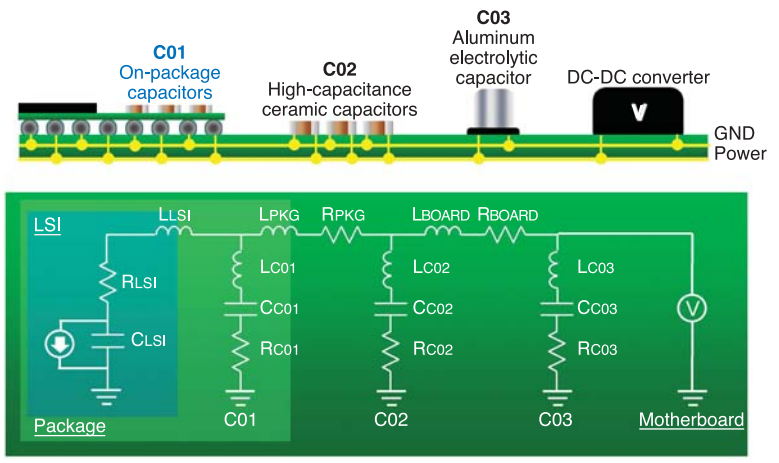


**Fig. 2: Circuit configuration of circuit board mounted with LSI**

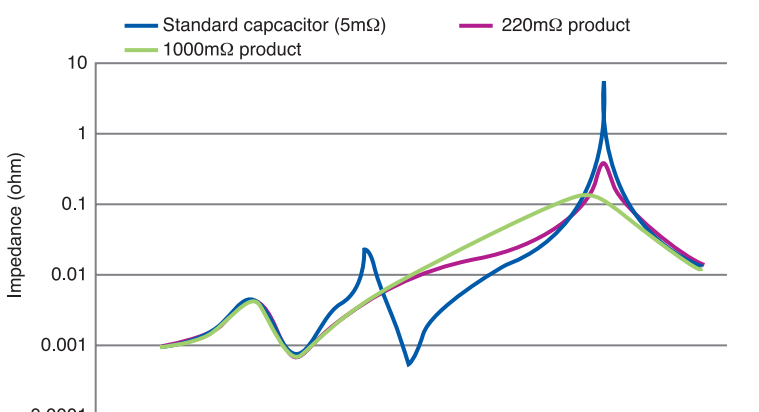


**Fig. 3: Circuit impedance simulation data**

In a circuit configuration, such as the one in this figure, the area between the LSI package and the on-package capacitors (C01) is susceptible to anti-resonance. Anti-resonance is generated there because of LC resonance caused by an extremely small capacitance component of an LSI package and an ESL component of a capacitor (C01) mounted on the package.

Three methods are available to control this anti-resonance. One is to increase the capacitance contained in an LSI package. Another method is to reduce the ESL value of the capacitor. The third is to increase the ESR value of the capacitor. The values for the first and second methods are determined by the components selected during the equipment design phase. Therefore, the third method, which increases the ESR value, is the easiest way to control anti-resonance. The LLR Series has been developed to achieve this purpose.

Fig. 3 shows simulation data of the circuit impedance profile when all capacitors (C01) mounted on the LSI package are replaced with the LLR Series capacitors. This graph shows that the higher the resistance value, the lower the anti-resonance peak. In this simulation, the peak value of the LLR series is reduced by a factor of one-fiftieth. Therefore, noise reduction in a target frequency range can be expected.

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## Preventing DC-DC Converter Oscillation

A capacitor is used at the output side of the step-down DC-DC converter to control the output voltage fluctuations (ripple voltage fluctuations). An LC low-pass filter is also provided at the output side to smooth the voltage output from the DC-DC converter (Fig. 4). When a monolithic ceramic capacitor with a low ESR value is used for the corresponding location, oscillation occurs. To prevent the oscillation, the ESR value of a capacitor is increased to provide a phase margin. This function can be achieved by using the LLR Series, which can resolve the oscillation problem stemming from a low ESR value of a monolithic ceramic capacitor. Murata believes that the LLR Series can give circuit designers more options.

## Emergence of ESR Control

In the past, the only requirements for monolithic ceramic capacitors have been large-capacitance and low-ESR characteristics for maintaining the power supply line and I/O line at low impedance. As more functions are added to electronic equipment, the new idea of ESR control has emerged. Murata believes that the value of monolithic ceramic capacitors as an easy-to-use passive component can be further improved through flexible responses to such new needs.

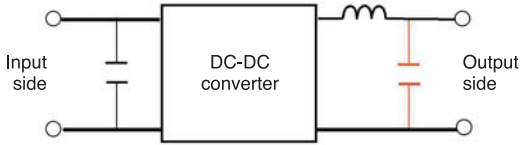


**Fig. 4: Step-down type DC-DC converter**

Murata intends to further develop the LLR Series and extend the lineup featuring this product. ❑

**About this Article**

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