Low-ESL Multilayer Ceramic Capacitors

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1 Effects of ESL

Decoupling capacitors or bypass capacitors are connected near power supply terminals of LSI (large-scale integration) circuits, and they supply the RF current necessary for operation. In many cases, multilayer ceramic capacitors (MLCCs) are used; however, since the operating frequencies of LSI circuits are getting higher, general-purpose MLCCs are becoming inadequate, since ESL (equivalent series inductance), a parasitic element of capacitors, affects the current supply capacity in high frequency regions (Figure 1). A pulse transient current is generated at the power source of an LSI circuit as it operates. A pulse current is high-frequency and wide-ranging, as it contains the operating frequency of the circuit and its harmonic components. If the ESL of a capacitor is large, much of the high-frequency current discharged from the capacitor will be reflected by ESL, and an insufficient high-frequency current will be conducted through the power supply or GND line, and will cause voltage fluctuations, generating logic errors or becoming common mode noise that is discharged outside the device, and will cause electromagnetic interference.

In order to suppress noise and to stabilize operations in an LSI circuit that operates at a high frequency, a capacitor with a low ESL is suitable. In this chapter, a low-ESL MLCC will be introduced.

Figure 1 Decoupling Capacitor

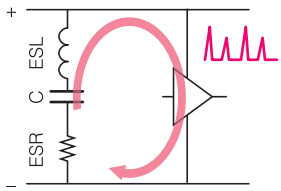


Figure 2 Low-ESL MLCCs

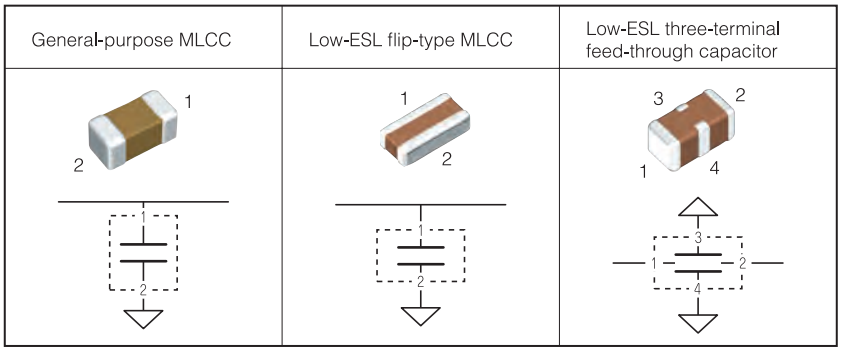
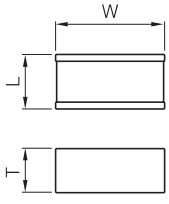


Table 1 Product Lineup of Flip-Type MLCCs

Type [EIA standard]	Dimensions (mm) L×W×T max.	Temperature characteristics	Rated voltage (V)	Capacitance (μF) 0.01 / 0.1 / 1 / 10
C0510 [0204]	0.5×1.0×0.35	X6S	4	0.22μF
		X7S	4	
C0816 [0306]	0.8×1.6×0.6	X7R	16	0.1μF
		X7R	6.3	0.22μF
		X7S	4	2.2μF
	0.8×1.6×0.35	X6S	4	0.47μF



2 | Low-ESL Multilayer Ceramic Capacitor

Flip (LW reverse) Type

By reversing the length and width dimensions of an MLCC, inductance of the internal conductor is reduced. The product lineup (Table 1) and frequency characteristics (Figure 3) are shown. Since characteristics that are equivalent to those of four general-purpose products mounted in parallel can be achieved, a reduction in the number of parts or mounting space will become possible. Additionally, products with a thickness of 0.3 mm have been made available as low-profile products.

A C0816 (0.8 × 1.6 mm) type product with a thickness of 0.35 mm (max.) is shown in Figure 4. These low-profile type products are effective for application as decoupling capacitors in ball grid array (BGA) packaging, as well as in low-profile electronic devices.

Figure 3 Frequency Characteristics of a Flip-Type Capacitor

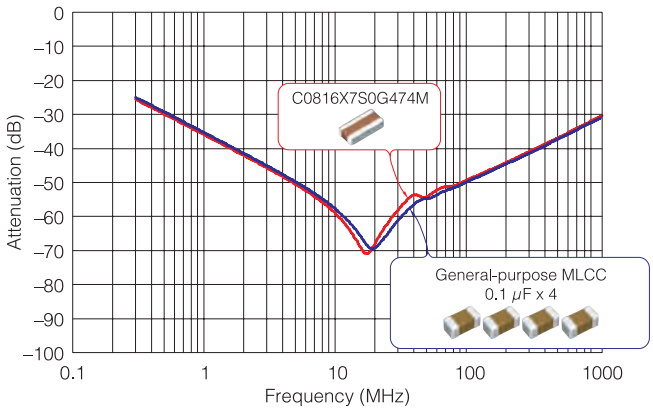


Figure 4 Low-Profile (t = 0.35 mm max.) Flip-Type Capacitor

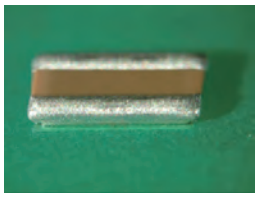
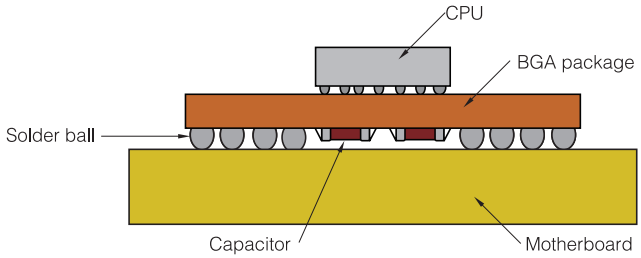


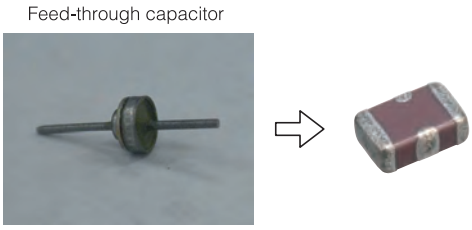
Figure 5 Applications Example of Low-Profile Flip-Type Capacitors



Three-Terminal Feed-Through Multilayer Ceramic Capacitors

The structure of a feed-through type capacitor was applied to MLCCs to reduce ESL (Figure 6). Three-terminal feed-through type products have smaller ESL and superior noise removal performance, compared to flip-type products, and are capable of reducing multiple noise suppression components.

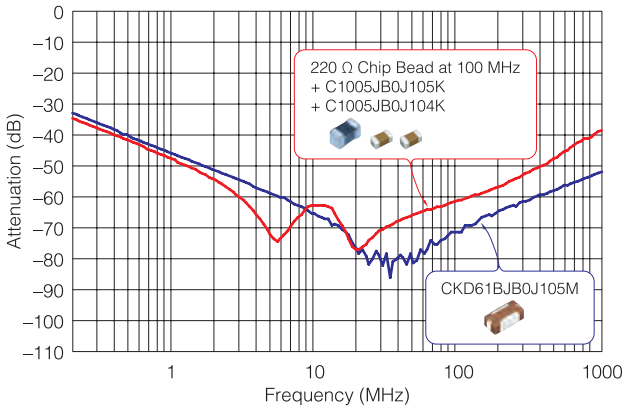
Figure 6 Feed-Through Capacitor and Three-Terminal Feed-Through MLCC



The attenuation characteristics of one CKD610JB0J105M element and of three elements: a 220 Ω chip bead, a 1 μF MLCC and a 0.1 μF MLCC, are shown in Figure7.

The figure indicates that the CKD610JB0J105M shows higher attenuation characteristics at frequencies over 30 MHz.

Figure 7 Frequency Characteristics of a Three-Terminal Feed-Through MLCC



An example of noise reduction effects is shown in Figure 8. A gate IC was driven at 40 MHz, and noise was superimposed on the power line, and the noise reduction effects were observed and compared when a single CKD610JB0J105M was used and when three elements, consisting of a 220 Ω chip bead, a 1 μF MLCC and a 0.1 μF MLCC, were used.

It was shown that a greater noise reduction effect was obtained when the CKD610JB0J105M was used. The product lineup of the three-terminal feed-through type capacitor is shown in Table. 2. A 22 μF large capacitance product is available, which is effective for application in output filters for switching regulators or as decoupling capacitors of high-power LSI circuits.

Figure 8 Example of Effects of a Three-Terminal Feed-Through Capacitor

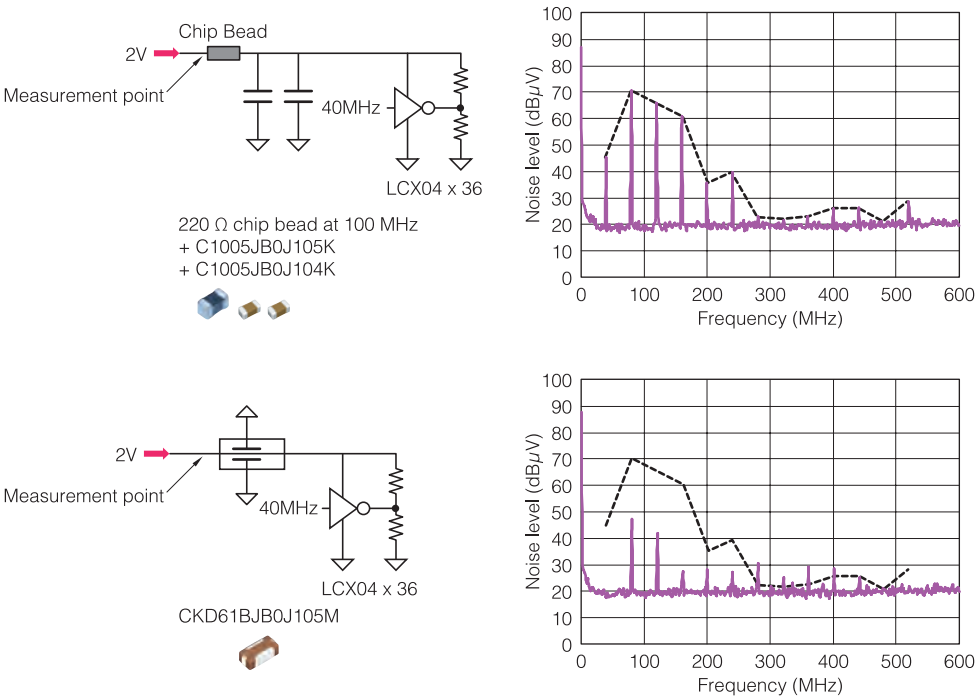


Table 2 Product Lineup of Three-terminal Feed-through MLCCs

Application	Series	Type [EIA standard]	Dimensions (mm) L×W×T	Capacitance
For signals	CKD510JB	2012 [0805]	2.0×1.25×0.85	0.01μF
For power supply	CKD610JB	1608 [0603]	1.6×0.8×0.8	2.2μF
	CKD510JB	2012 [0805]	2.0×1.25×0.85	4.7μF
	CKD310JB	3216 [1206]	3.2×1.6×1.3	22μF
	CKD61BJB	1608 [0603]	1.6×0.8×0.6	1.0μF
	CKD51BJB	2012 [0805]	2.0×1.25×0.85	4.7μF