The role of capacitors and inductors

Looking at the circuit diagram shown in Figure 1, the DC/DC converter is labeled "IC-1," the output inductor is labeled "L-1," the output capacitor is labeled "C-1," the load input inductor is labeled "L-2," the input capacitor is labeled "C-2," and the load device is labeled "IC-2."

(Fig. 1) Circuit diagram showing power supply IC, inductors and capacitors

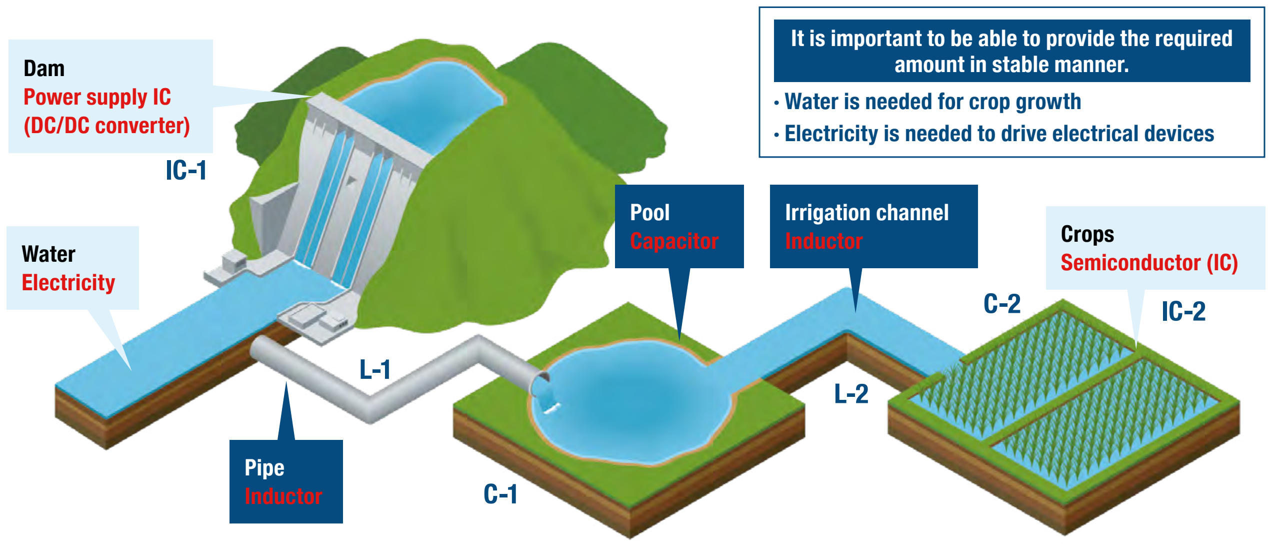
Figure 2 shows by analogy of the different roles of these devices.

The functions of the capacitors and inductors can be compared to the roles pipes and pools of water play in an irrigation system. The pipes and pools are used to control the flow of water from a dam and ensure a stable supply of irrigation water for the crops. If the electric power is thought of as "water," then the DC/DC converter (IC-1) is the "dam," the output inductor (L-1) is a "pipe," the output capacitor (C-1) is a "retention pool," the load input inductor (L-2) is an "irrigation channel," the input capacitor (C-2) is a "field," and the load device (IC-2) is the "crops." To ensure a stable flow of water, the "pipe," i.e. the output inductor (L-1), is used to regulate the flow, and the "retention pool," i.e. the output capacitor (C-1), is used to store water and filter out "impurities" (i.e. eliminating noise through grounding).

Then, the "irrigation channel," i.e. the input inductor (L-2), which leads directly to the "field," adjusts the flow of water so that the "field," i.e. the input capacitor (C-2), obtains a stable supply of water.

* The "irrigation channel" may also act as ferrite beads inductor for removing noise.

(Fig. 2) Analogical diagram showing the roles played by passive components and power supply IC



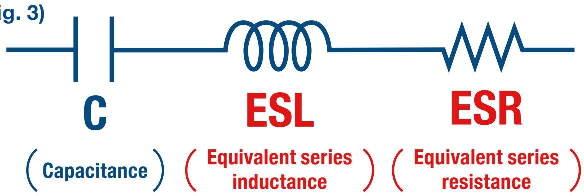
Why MLCCs have low ESL and low ESR

An equivalent circuit for a capacitor can be represented as a series circuit consisting of a capacitance component (C), an equivalent series inductance (ESL) component, and an equivalent series resistance (ESR) component (Figure 3). Figure 4 shows the impedance (Z) frequency characteristics. The basic form is a V-shaped curve, but the shape may change due to variation in capacitance, ESR and ESL between different types of capacitor.

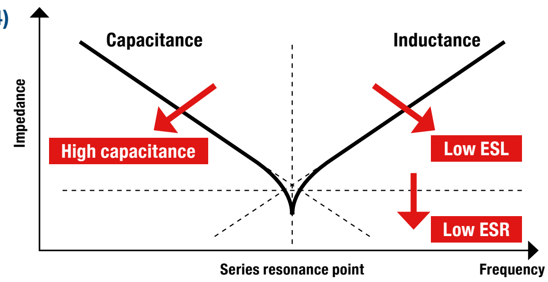
Aluminum electrolytic capacitors are constructed by winding aluminum foil and electrolytic paper into the form of a cylinder. This type of capacitor can be compared to a beer bottle, with a long (representing high ESL) but thin (representing high ESR) neck; the capacitor has large capacitance, but it is difficult for electrical charge to get in or out.

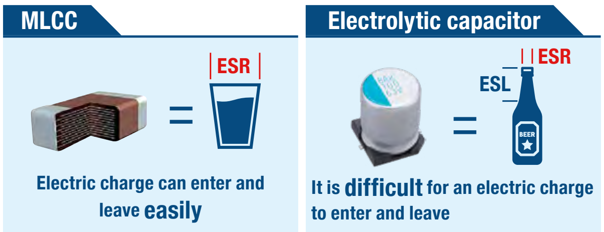
By contrast, a multilayer ceramic capacitor (MLCC) is formed by layering dielectrics and internal electrodes in parallel, with many (several hundred, at least) connections between the internal and external electrodes, so that the structure of the MLCC ensures reduced ESR and ESL. Rather than a beer bottle, the MLCC can be compared to a cup, with a wide mouth, which enables electric charge to enter and leave easily.

(Fig. 3)



(Fig. 4)



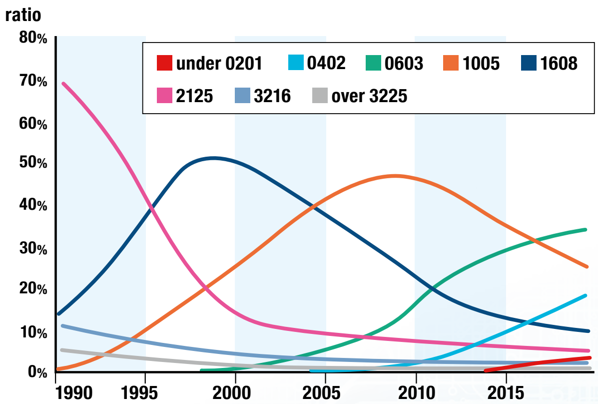


Key points to note in relation to MLCC miniaturization

[Trends in capacitor size]

The market expansion of mobile communication devices has been a major driving force behind the demand to miniaturize components. The increase in the number of electronic components associated with the shift toward the miniaturization and high functionality of electronic devices has led to the downsizing of MLCCs and the current popularity of the 0603 (0201 inch) size.

Trends in MLCC size



[Precautions regarding MLCC miniaturization]

Miniaturization tends to cause a significant increase in the rate of change of the DC bias characteristic. The DC bias characteristic is a phenomenon in which the static capacitance changes (decreases) from the “nominal value” when a DC voltage is applied to a ceramic capacitor with a high dielectric constant.

The diagram below compares the bias characteristic of different sizes of MLCCs that have the same capacitance and the same breakdown voltage. There is a difference in the amount of variation.

For more information about the DC bias characteristic of individual products, see P.14 of TY-COMPAS.