Chip Beads that Reflect and Absorb Noise

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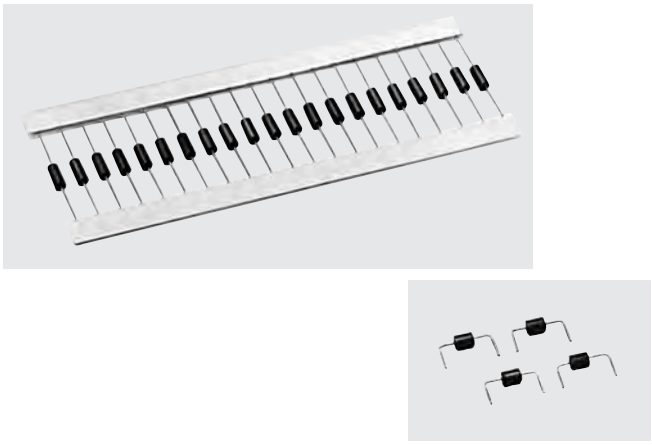
1 Chip Beads that Can Easily be Used by Series Insertion into Circuits

Chip beads can be used in either signal circuits or power supply circuits. They are convenient components, which exert effects as noise suppression measures by simply being inserted into circuits in series. Unlike bypass capacitors, they are not affected by the conditions of ground patterns.

As is shown in Photo 1, a chip bead has a structure in which a conductive wire is passed through a toroidal ferrite magnetic body. It is an inductance element with the simplest structure, in which a conductive wire is wound once around a toroidal core.

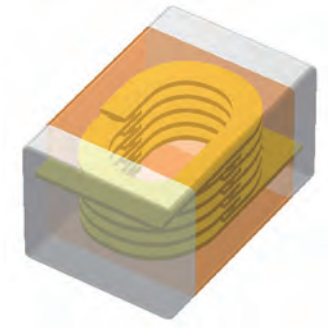
They are called “beads” since their appearance is similar to beads used for accessories such as necklaces.

Photo 1 External Appearance of General Chip Beads BH and BT Series



At present, multilayer chip beads, in which ferrite sheets or ferrite paste and conductive paste are layered, are commonly used. An image of the internal structure of a multilayer chip bead is shown in Figure 1. As is shown in the figure, the conductor forms a coil.

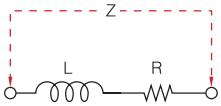
Figure 1 Diagram of the Internal Structure of a Multilayer Chip Bead-1



2 Different Though Having the Same Nominal Impedance

As is shown in Figure 2, the equivalent circuit of a chip bead is denoted by the reactance component X and the resistance component R, and its static characteristics are expressed by the frequency characteristics of the impedance Z, which is the combined impedance of X and R. Generally, the nominal value of the static characteristics of a chip bead is the impedance value at 100 MHz.

Figure 2 Equivalent Circuit of a Chip Bead



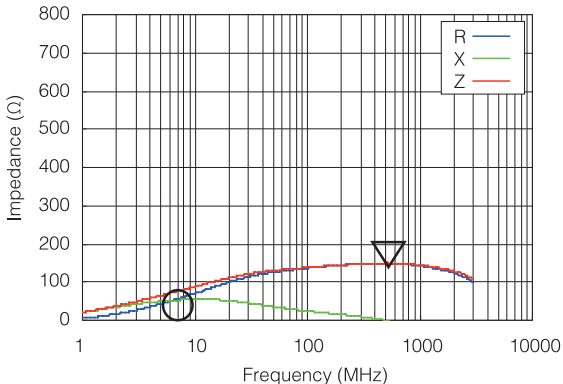
$X = \omega L = 2\pi fL$ f: Frequency

The impedance characteristics of five typical multilayer chip beads with different ferrite compositions are shown in Figure 3. Their impedance values at 100 MHz are approximately the same. Although their impedance values are the same, their frequency characteristics vary; therefore, it is necessary to select a bead that is suitable for the circuit to be used.

In addition, even among chip beads using ferrite bodies with a ferrite composition, some of them have different frequency characteristics depending on their internal conductor structures. The frequency characteristics of two chip beads are shown in Figure 4. The chip bead in Figure 4 (a) has the structure described in Figure 1, whereas the chip bead in Figure 4 (b) has the structure shown in Figure 5, causing the peak point of the impedance to become higher and to shift toward the high frequency side.

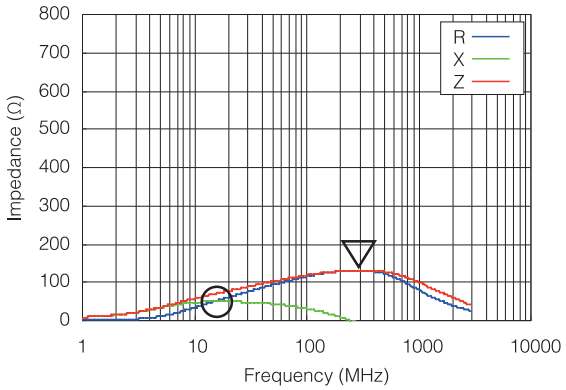
Figure 3 Comparison of Impedance Frequency Characteristics (Uniform impedance at 100 MHz)

(a) MMZ1608B121C

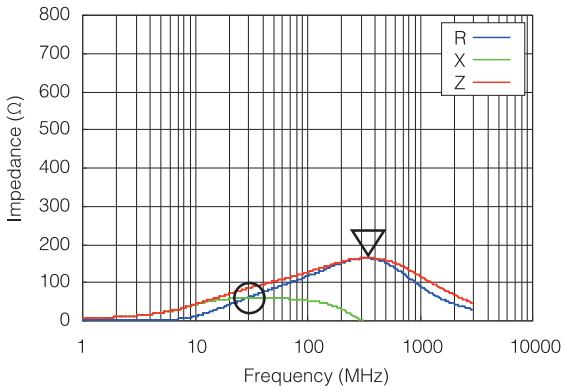


○ : Intersection of R and X
▽ : Peak point of R

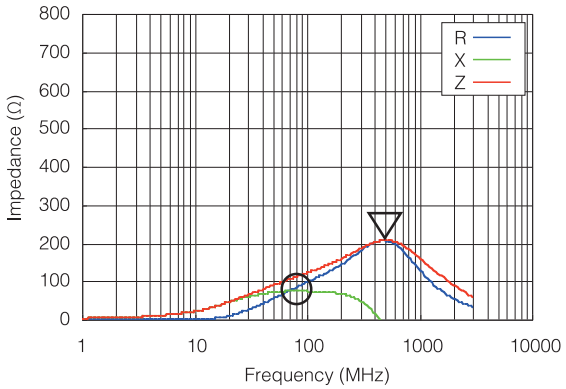
(b) MMZ1608R121A



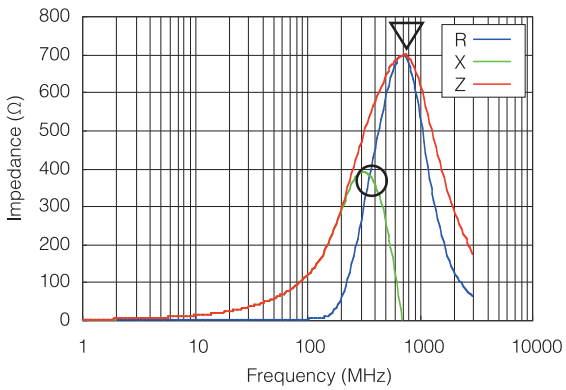
(c) MMZ1608S121A



(d) MMZ1608Y121B



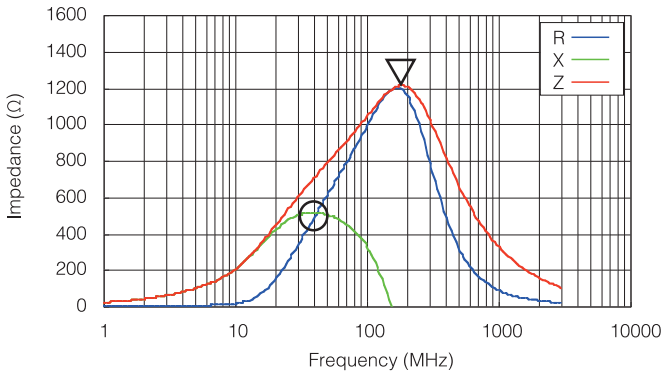
(e) MMZ1608D121C



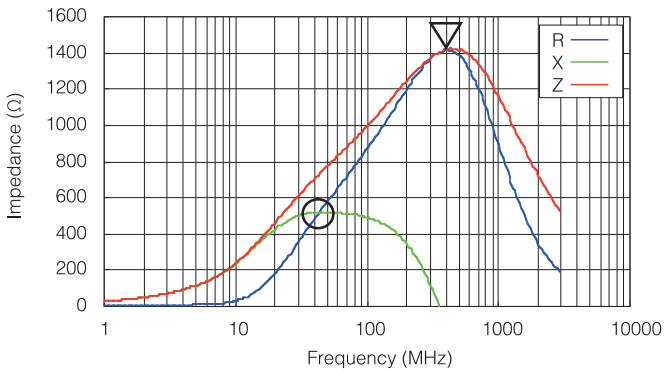
◯ : Intersection of R and X
▽ : Peak point of R

Figure 4 Comparison of Impedance Frequency Characteristics (Uniform impedance at 100 MHz)

(a) MMZ1608R121A

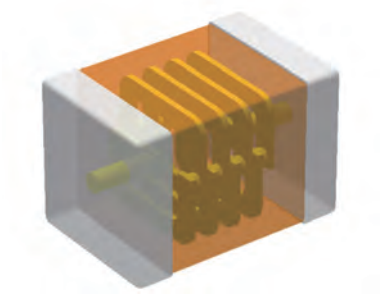


(b) MMZ1608R121A



◯ : Intersection of R and X
▽ : Peak point of R

Figure 5 Diagram of the Internal Structure of a Multilayer Chip Bead-2



3 | Reflection and Absorption

Let us look into the frequency characteristics of chip beads in a greater detail. The X component is dominant in the low frequency range, and the bead functions as an inductor that reflects noise. In the high frequency range, the R component becomes dominant, and the bead functions as resistance that converts noise into heat (absorbs noise). These functions switch at the frequency where the R component and X component become equal. This frequency is called the R – X cross point.

As the frequency becomes higher, the impedance becomes higher; however, when the frequency reaches a certain point, the impedance suddenly begins to decrease. This frequency is called the self-resonance frequency. Self-resonance is a phenomenon that occurs because the bead functions as a capacitor at frequencies higher than the self-resonance

frequency. Based on these factors, in order to select a proper chip bead, the frequency of the noise that needs to be suppressed should be between the R – X cross point and the self-resonance frequency, and the impedance of the bead should be low at frequencies of signals that are necessary.

4 Additional Role of Chip Beads

Chip beads have an effect of improving pulse waveforms.

The effect of chip beads on pulse waveforms was examined using the test circuit shown in Figure 6. The five beads shown in Figure 3 were used in the test.

The test results are shown in Figure 7. As is clear in the figure, less ringing and waveform distortion were observed when the R – X cross point frequency of the beads was lower.

Waveform distortion can become a cause for malfunctions of a digital circuit. Although it depends on the frequency of the digital circuit, using a chip bead that has as low R – X cross point as possible will lead to the prevention of malfunctions.

5 Consideration of DC Resistance Levels

DC resistance is another important characteristic. If DC resistance is high, the power consumption will become greater, and the signal levels will also decrease. It is desirable that DC resistance be as low as possible.

By selecting chip beads that are suitable for the circuits to be used based on an understanding of these characteristics, more effective EMC countermeasures will become possible.

Figure 6 Chip Bead Operation Test Circuit

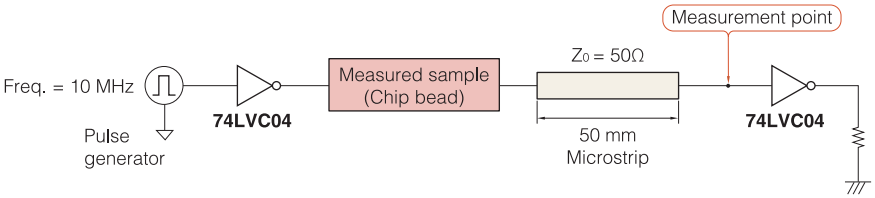
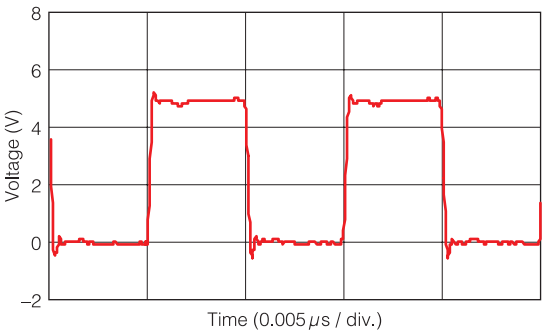
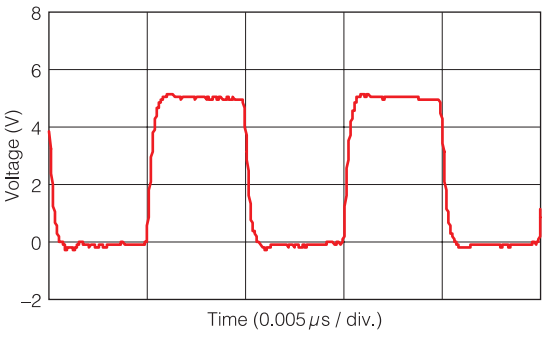


Figure 7 Chip Bead Operation Test Results

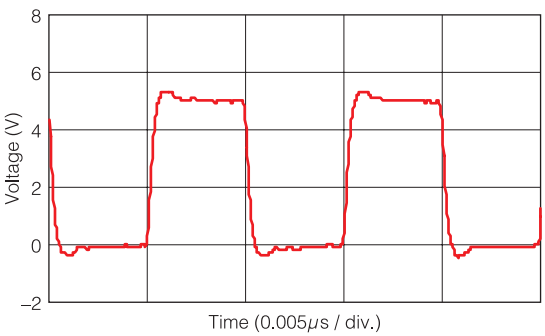
(a) No beads (through)



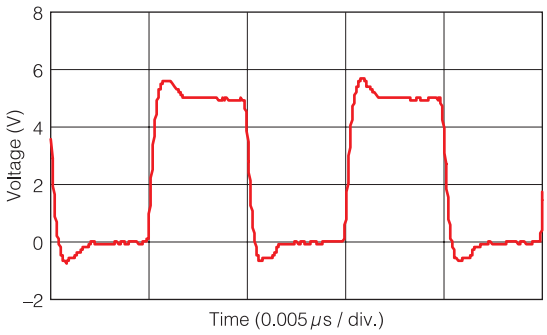
(b) MMZ1608B121 (Cross point : 5MHz)



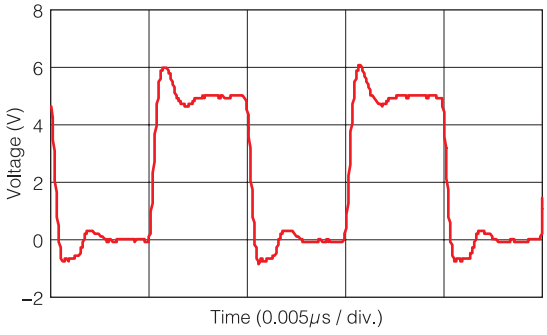
(C) MMZ1608B121 (Cross point : 15MHz)



(d) MMZ1608B121 (Cross point : 25MHz)



(e) MMZ1608B121 (Cross point : 80MHz)



(f) MMZ1608B121 (Cross point : 400MHz)