Technical Report

Technology Trends of Multilayer Gigaspira Beads

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1. Introduction

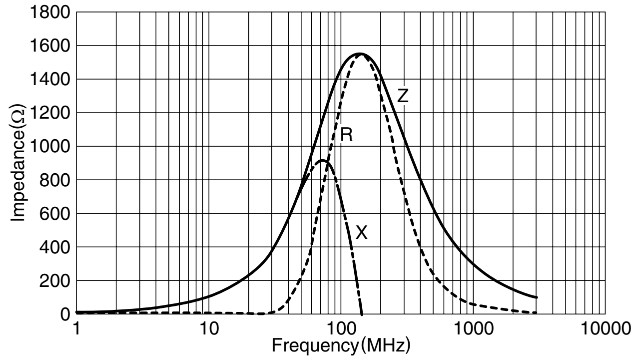
Digital mobile device functions such as in mobile phones and smartphones have greatly advanced. Basic camera functions have expanded and wireless communication functions have also advanced. Reception functions for FM radios, digital terrestrial TVs, and GPS have also been added. Transfer functions for wireless LANs and Bluetooth have improved. Because of this, various wireless communication systems are installed into one device, and the used frequency bands have expanded from over 10MHz to over 1GHz. These transfer functions are integrated into one terminal, but mobile terminal chassis are small, so the circuit density has increased to do these added functions. This situation means that multiple noise emission source circuits exist in close proximity. Therefore, self-jamming can easily occur with such devices, making it important to consider EMC management from the early stages of development. In recent years, signal frequencies for circuits have become higher, causing more cases where harmonic noise occurs up to the high frequency range. This makes it important to implement noise suppression in the GHz range.

Chip beads are one key to resolving such issues related to EMC. Chip beads can be installed in-line with transmission lines that become noise emission sources. These are widely used because they are convenient and easy to use for noise suppression. Here, multilayer chip gigaspira beads that are able to maintain high impedance characteristics in the GHz frequency range will be explained.

2. Chip beads

First of all, this will give an overview of noise suppression using chip beads. Figure 1 shows the representative frequency characteristics (Z, R, X) of multilayer chip beads. Impedance shows the characteristics of the chip beads. Impedance (Z) is the combined resistance of reactance (X) and resistance (R).

Figure 1 Multilayer chip bead frequency characteristics



As for chip bead frequency characteristics, reactance components are dominant in the low frequency range and function as inductors that reflect noise. At higher frequencies, the resistance components increase and function as resistance that converts noise to heat and absorbs it.

The cross point of these functions is the intersection point of the reactance curve and resistance curve referred to as the R-X cross point. When the frequency becomes higher, self-resonance occurs due to coil stray capacitance.

At the frequency range higher than the self-resonance point, impedance begins to decrease gradually.

To select the proper chip beads for absorbing noise, the frequency of the noise that needs to be suppressed must be within the absorption range (after the R-X cross point). Noise is absorbed by the resistance components, so the resistance component should be large; i.e. the impedance should be larger to achieve better noise suppression.

3. Gigaspira bead characteristics

There are structural difference between gigaspira beads and standard beads. Figure 2 shows a model of the internal configuration of gigaspira beads and standard beads. The configuration difference is the direction

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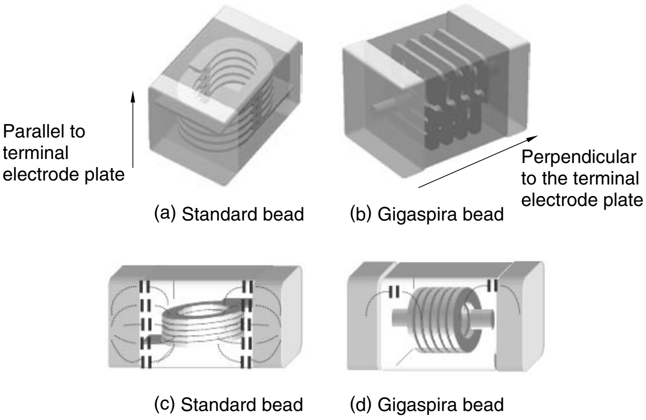
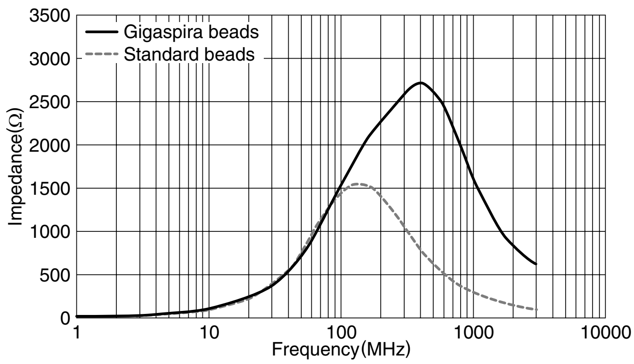
of the coil winding. Standard beads are wound in the direction parallel to the terminal electrode plane (Figure 2a), while gigaspira beads are wound perpendicular the terminal electrode plane (Figure 2b). Standard beads have a terminal electrode and stray capacitance in each internal conductor (Figure 2c), but gigaspira beads have controlled stray capacitance for terminal electrodes (Figure 2d).

Figure 2 Configuration model of multilayer chip beads



There is also a difference in the electrical characteristics between standard and gigaspira beads. Figure 3 shows the impedance frequency characteristics of standard beads and multilayer gigaspira beads, which have equivalent impedance at 100MHz and use the same ferrite material. There are two major characteristics when comparison is made with standard beads. First, the impedance peak occurs in the high frequency range.

Figure 3 Frequency characteristics of multilayer chip beads



This is because the configuration is designed to reduce stray capacitance, so the self-resonance frequency is shifted to a higher frequency, which causes the impedance to be stretched to the high frequency range. This shows that gigaspira beads are effective at removing noise in the high frequency range where standard beads are unable to be effective.

Second, gigaspira beads have higher impedance than standard beads. This indicates that gigaspira beads are better at noise suppression than standard beads. This is because the winding is longitudinal to the product in order to increase the number of coil winding resulting is higher impedance. The range where gigaspira beads can attenuate signals includes the FM range, cellular range, and GPS range. In the past, it was necessary to select the proper noise suppression components according to each frequency range. However, by using gigaspira beads, only one chip is needed to suppress noise over a wide frequency range. These are especially effective for mobile terminals that have multiple communication frequency ranges where self-jamming often occurs.

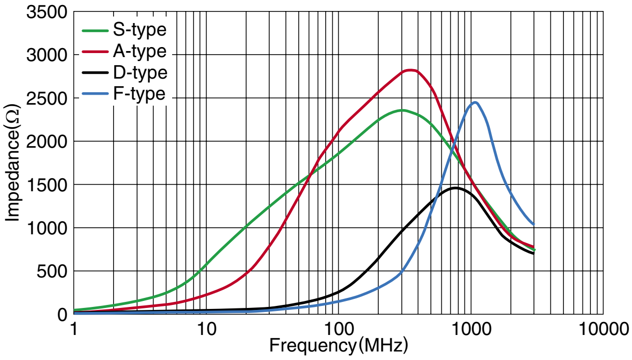
The advantage of gigaspira beads is that they can ensure high impedance, but the downside is that the number of windings of the inner coil is high, and DC resistance (Rdc) is higher than that of standard beads. The current trend is for devices to be smaller and more energy efficient. Therefore, lower resistance is a current requirement for SMD components. We implemented the latest element technologies to optimize internal configuration when developing the MMZ1005-E series of gigaspira beads compatible with a wide frequency range. As a result, we could achieve a product with the highest impedance characteristics in the industry at 100MHz while reducing DC resistance by over 20% of our conventional products. We began mass production of 13 gigaspira bead products with four materials with different characteristics using our various ferrite materials (Table 1).

Table 1 Lineup of multilayer chip gigaspira beads

Type	Part No.	Impedance(Ω)		DC resistance (Ω)max.
		[100MHz]	[1GHz]	
S-type	MMZ1005S601E	600	1000	0.70
	MMZ1005S102E	1000	1400	1.10
	MMZ1005S182E	1800	1800	1.65
A-type	MMZ1005A601E	600	1400	0.85
	MMZ1005A102E	1000	2000	1.25
	MMZ1005A152E	1500	2300	2.00
	MMZ1005A182E	1800	2700	2.20
	MMZ1005A222E	2200	3000	2.30
D-type	MMZ1005D121E	120	1000	0.70
	MMZ1005D221E	220	1700	1.00
F-type	MMZ1005F470E	47	800	0.70
	MMZ1005F750E	75	1500	1.00
	MMZ1005F121E	120	2300	1.50

Figure 4 shows the impedance frequency characteristics for each type. The following will explain the two major categories. First, there are S-type and A-type products for standard signals. Impedance is increased from 5 to 20MHz, and they have broad frequency characteristics with high impedance. They allow signals with low frequencies to pass while removing noise that can affect the FM range and cellular range. High impedance is maintained over a wide frequency bandwidth up to the GHz range. These products are best for removing noise at multiple frequency ranges propagated by audio line.

Figure 4 Frequency characteristics of multilayer chip beads



The other category includes the D-type and F-type products for high-speed signals. The impedance for these products suddenly increases at 100MHz, and high impedance is maintained into the GHz range. These are best for suppressing high-frequency noise, which is especially a problem in the cellular and GPS ranges. Our gigaspira beads allow for one chip to cover a wide area into the GHz range. TDK can provide various noise control methods that are compatible with various communication frequency ranges including high frequencies.

4. Future efforts

Recent market trends show that frequencies for communications are getting higher. WiMAX uses frequencies into the lower GHz range, and it is expected that the frequency will continue to increase. Because of the smaller size of electrical devices, SMD components must be smaller with lower DC resistance and have a larger current. In addition to meeting market needs quickly, TDK will continue to propose new product developments based on our unique technologies.

• Please note that the articles from the November 12, 2009 Edition of the Dempa Shimbun contained in this chapter have been edited by our company.