Development of high frequency multilayer device using ferrite

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Introduction

As notebook PCs and similar electronic equipment have in recent years become getting faster and smaller, the noise-controlled electronic components for controlling noise are accordingly also required to be faster and smaller. To attain a superior EMI cutting effect there is a need for degree of high common mode impedance even at high frequencies. Hence, by varying the permittivity of a non-magnetic material used in a coil have been enhanced, we have prepared a low-permittivity ferrite in which high-frequency characteristics. By optimizing firing and printing conditions at a tune of using this material, we have succeeded in developing a small, lightweight, thin and low-direct current resistance laminated common mode choke coil. Moreover, by varying also the permittivity of the low-permittivity ferrite, we have been able to a obtain superior degree of impedance that facilitates matching with various interface differential characteristics impedance standards such as USB2.0, IEEE1394, and HDMI.

Experimental Procedure

We built a simulation model of the laminated common mode choke coil and calculated the common-mode and normal-mode impedances by determining, on the basis of magnetic field analysis, the inductance, stray capacity, and direct current resistance. This analysis assumed that the non-magnetic portion had a permittivity of zinc ferrite ($\varepsilon = 8$ or 13).

To prepare a magnetic paste, we mixed Fe_2O_3, NiO, CuO, and ZnO as the starter raw materials to a given molar ratio and, after temporarily firing and crushing the mixure, ground it into NiCuZn ferrite powder. Then, mixing a binder and additives into the powder, we processed it into a paste with the aid of a 3-roll rolling mill.

To prepare a non-magnetic paste, we measured and mixed to a determined molar ratio Fe_2O_3 and ZnO as the starter materials and after temporarily firing and crushin g the mixure, we ground it into a zinc ferrite powder. Then, by mixing a binder and additives into the powder, we transformed it into a paste by means of 3-roll rolling mill. At this stage we verified the shrinkage rate and shrinkage behavior by means of TMA, and we adjusted the mixing ratio to one which permitted firing of the magnetic material at the same time.

By means of using the magnetic and non-magnetic pastes thus obtained, and a silver paste used for coil patterns, we repeated lamination by screen printing, we cut the product to a detemined size and we fired the pieces that have been cut. To evaluate the characteristics, by use of an impedance analyzer we measured the common-mode and normal-mode impedances over a range of bandwidths extending from 1 MHz to 1.8 GHz. By use of a network analyzer we measured the transmission characteristics over a ragen of bandwidths extending from 40 MHz to 8 GHz.

Results and Discussion

Fig. 1 illustrates the impedance measurement results, along with simulation results, when zinc ferrite was used for the non-magnetic portion. Fig. 2 illustrates the impedance measurement results, along with simulation results, when low-permittivity zinc ferrite was used for the non-magnetic portion. These results indicate that when zinc ferrite is used, the resonant frequency in the normal mode was around 1.3 GHz, whereas when low-permittivity zinc ferrite was used, the increase resonant frewuency to 1.8 GHz or higher. Since the magnetic material was the same for both samples, inductance was uniform. The reason for the diffenerece is the shift of the resonant frequency toward the higher frequency side as the degree of permittivity of the non-magnetic portion was reduced, and the level of stray capacity lowered. These coincide results very well with simulation results. It could also be verified by simulation that the degree of permittivity of the low-permittivity zinc ferrite had decreased to 8 or so. The common mode impedance had also risen to a high-frequency range, a fact which enables us to expect an adequate EMI cutting effect.

Fig. 3 illustrates the results of measurement of the transmission characteristics. In both samples signals were transmitted without a loss in a low-frequency range, a result which indicates that impedance matching has been successful. The cutoff frequency was 800 MHz in the zinc ferrite, whereas it was 1670 Hz in the low-permittivity zinc ferrite, a fact which indicates that signals were being transmitted at a considerably high frequency.

These results demonstrate that, simply by varying the permittivity of the non-magnetic portion, a laminated common mode choke coil can be obtained without difficulty that is capable of operating at a high frequency.

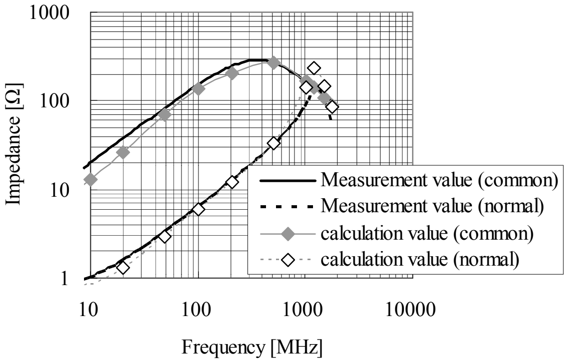


Fig1. Impedance characteristics of zinc ferrite.

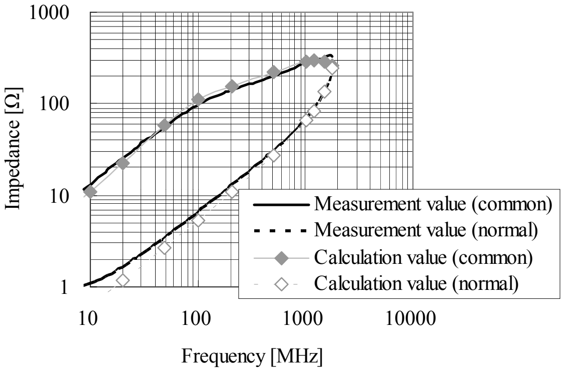


Fig.2 Impedance characteristics of low-permittivity zinc ferrite.

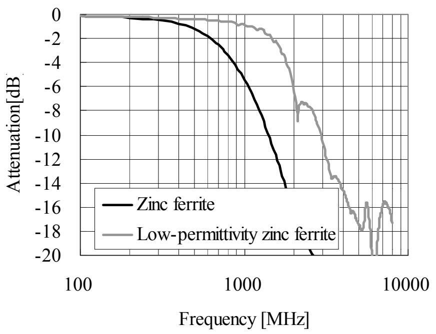
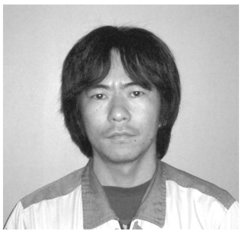


Fig.3 transmission characteristics

Biographical Sketch



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