C-6

# Modeling & Fabrication of Multilayer Ferrite Chip Inductor

Korea Electronics Technology Institute C. S. Yoo*, W. Lim, H.M. C
W. S. Lee, N. K. Kang
Soonchunhyang Univ. S. H. Kim, D. Ah

## 1. Introduction

Ferrite is the material having useful magnetic properties. This material has advantages as follows. The resistance is lower than that of magnetic metals, so th due to the stray current is much smaller. Magnetic properties of ferrite can be adj for the purpose, and the cost of material is low.

In this paper, the inductance and magnetic field are analyzed in many situat using HFSS of Ansoft. And the one of the most important charateristics of inducto factor is predicted by simulation.

Finally, to verifythe results of simulation, some kinds of multilayer ferrite inductors are fabricated and measured.

## 2. Procedure

The size of 2012 (2.0mm×1.2mm×1.25mm) chip inductor is simulated and simulator, HFSS Ansoft 6.0 version is used. The frequency we get the characterist inductor varies with the inductance range. Not the loss of the conductor(Ag) but th ferrite is considered to get the value of Q factor near to that of real samples.

Multilayer process—from tape casting to plating—is used to fabricate ferrite inductor. We used Ni-Zn-Cu based ferrite of various permeability. HP 4194A LCR and HP 4291A impedance analyzer are used for measurement.

3. *Results and discussion*

In ferrite systems, the region magnetic field exists is limited inside of inductor in contrast with glass/ceramic inductor. To make sure this, the position of patter changed vertically from center to near to top(bottom) as follows.


Fig. 1. The side view of chip inductor

In case of (b) in Fig. 1, magnetic field is limited in the upper region of pattern inductance decreases from 0.82 to 0.55 $\mu$H.

To get the relation between height of pattern and thickness of inductor, for the s pattern, only the thickness of inductor is changed as Fig. 2.

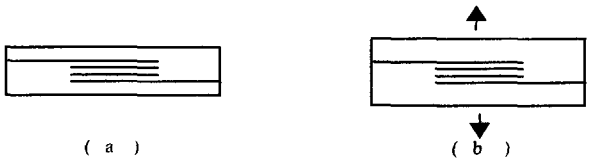



Fig. 2. The side view of chip inductor

As the thickness of inductor become larger, inductance increases. But over the sp thickness, inductance doesn't increase any more. Magnetic field is considered to be developed over specific thickness.

For the sample with the same conditions(#of turns, pattern shape etc.) but different permeability, the relation between L and permeability is examined. Induct is directly proportional to permeability of ferrite.

Inductance can be calculated by following equation.

$$L = Lo \cdot N^x$$

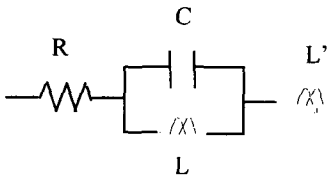
Lo : inductance of 1 turn

x : coupling coefficient

There are many factors affecting x, but distance between patterns is dominant

The effect of the distance on x is examined. As the distance between patterns decreases, coupling coefficient x increases linearly. In comparing this results with x of real samples, the difference between simulated and measured is smaller than 0.1. So we can predict the inductance of real samples with the results of simulations mentioned before.

SRF is affected by inductance and mutual parallel capacitance. The equivalent c of inductor is as follows.




L : inductance
C : mutual capacitance
L' : inductance of lead line
R : resistance of conductor line

Fig. 5. Equivalent circuit of inductor

Mutual capacitance is decided by pattern shape and permittivity of ferrite. To pr SRF correctly, we measured permittivity of ferrite. As a result of applying permittiv ferrite in simulation, SRF is almost same that of real samples.

One of the most important factors is Q factor. Q value can be calculated by follow equation.

$$Q = \frac{\omega L}{R}$$

R is the resistance of conductor line result from conductor loss and material los ferrite system, material loss is dominant. Q value changes widely in the variation $\tan\delta$ of ferrite.

To obtain precise Q value of ferrite inductor in simulation, the loss of ferrite u must be considered along.

## 4. Conclusion

The trends of multilayer ferrite inductor are examined by simulation and certified fabrication. A good simulation near to real samples can be performed by conside some dominant factors like the loss of material and conductor, coupling coeffic

permittivity of ferrite.

5. Reference

[1] Yu-Ting Huang ' The study of magnetic circuit design for multilayer ferrite inductors' TRANSACTIONS ON MAGNETICS, VOL. 31, NO. 6, NOVEMBER 1995

[2] D. A. Lowther, P. P. Silvester, 'Computer-Aided Design in Magnetics' Springer-