THREE-DIMENSIONAL MAGNETIC FIELD ANALYSIS OF THIN-FILM HEAD USING TRANSMISSION LINE MODEL

Jung-Pyo Hong
Dept. of Electrical Engineering, Changwon Nat'l University, Changwon 641-773, Korea.

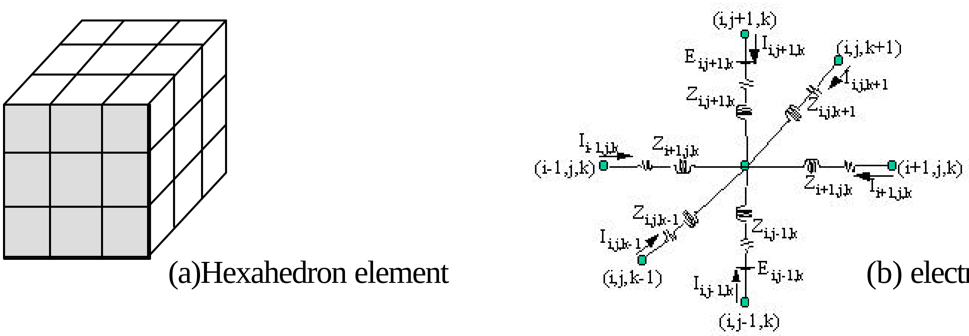
Abstract – The magnetic field distribution in thin-film recording head considering the skin-effect has been studied using three-dimensional transmission line model(TLM). In this model, the thin-film recording head is divided into small region, element, and the node is placed at the center of element. Each nodes are connected by electric impedance. R/L series network is composed and magnetic field distribution according to various frequency can be calculated by solving the network equation applying KCL and boundary condition.

Introduction

Accurate simulation of the thin-film recording head is complicated and difficult because electromagnetic induction causing by the conductivity of the head material. For the prediction of head performance, the simple approach using an equivalent circuit with lumped parameters is not sufficient, especially for the model having skin-effect. Use of numerical method, such as Finite Element Method(FEM), provides accurate results, but FEM is very hard to modeling and time consuming for the three-dimensional eddy current problems like as thin-film head. In this paper, we present another method, three-dimensional TLM. In this approach, we use electric impedance network to analyze the magnetic field of thin-film head[1]. Analysis region is divided into small hexahedrons, element, and the node is placed at the center of element. Each nodes are connected by inductive and resistive electric impedance which calculated using measured anisotropic complex permeability. Proposed method, three-dimensional TLM, has been verified by comparison with results obtained from three-dimensional FEM.

Magnetic Circuit Model

Hexahedron element and electric circuit network is shown is shown in Fig.1.



(a)Hexahedron element (b) electric circuit network

Fig. 1 Hexahedron element and electric circuit network

1. Youg-Su Kim
SAMSUNG Advanced Institute of Technology
P.O. Box 111, Suwon 440-600, KOREA
Tel : 82-331-280-9227
FAX : 82-331-280-6955
E-mail : yskim@saitgw.sait.samsung.co.kr
2. Subject Category :
3. Preference for Presentation : Poster

The presence of eddy current in magnetic circuit can be calculated using complex permeability and the node equation is given by [2]

$$F_{i-1,j,k} = \boldsymbol{Y}_{i-1,j,k}(\boldsymbol{U}_{i-1,j,k} - \boldsymbol{U}_{i,j,k} - \boldsymbol{E}_{i-1,j,k}) \qquad (1)$$

where $\boldsymbol{U}$ is magneto-motive force, F is flux, $\boldsymbol{E}$ is exiting magneto-motive force, and $\boldsymbol{Y}$ is admittance of magnetic circuit. The values for the resistance and inductance are represented in terms of complex permeability by [1]

$$\boldsymbol{R}_{ij} = \frac{m_r \times \boldsymbol{l}_{ij}}{(m_r^2 + m_i^2)\boldsymbol{A}_{ij}} \qquad (2) \qquad\qquad \boldsymbol{L}_{ij} = \frac{m_i \times \boldsymbol{l}_{ij}}{2pf \times (m_r^2 + m_i^2)\boldsymbol{A}_{ij}} \qquad (3)$$

where $\boldsymbol{l}_{ij}$ is the distance between the nodes and $\boldsymbol{A}_{ij}$ is the cross area.

Analysis Result

The analysis model for TLM has 4329 emements and 111 nodes. Fig.2 compares the 3D TLM and 3D FEM results of the flux density according to the frequency. Flux density distribution along head surface at 100[mHz] is also shown in Fig. 3. Fig.2 gives evidence of the utility of the 3D TLM.

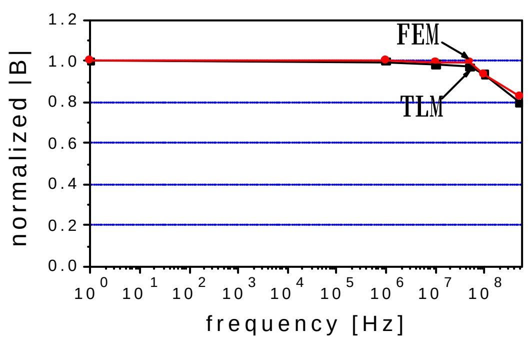


Fig. 2 flux density vs. frequency by TLM and FEM

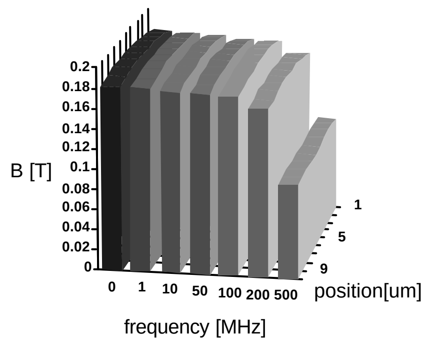


Fig. 3 flux density distribution along head surface

Conclusion

Three-dimensional transmission line model technique was presented and we have shown that it enable us to compute reliable flux density distribution comparing with the results obtained 3D FEM. In spite of the simplicity of the concept, if we know the complex permeability of the material, this method is useful to the thin-film head analysis having eddy current. These results will be checked experimentally in future work.

References

[1] M.Mallary, A.Torabi, and S.Batra, "Three-dimensional transmission line model for flux conduction in thin-film recording heads", J. Appl. Phys., Vol.67, No.9, pp.4863-4865, May, 1990

[2] Dal-Ho Im and Jung-Pyo Hong, "Magnetic Field Analysis of Permanent Magnet Motor by 3D Equivalent Magnet Circuit Network Method", J. of KIEE, Vol.43, No.9, pp.1432-1439, 1994.