Effects of residual magnetism due to minor loop on magnetic property of permanent magnet type of MRI

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EV 02

EFFECTS OF RESIDUAL MAGNETISM DUE TO MINOR LOOP ON MAGNETIC PROPERTY OF PERMANENT MAGNET TYPE OF MRI

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The flux distribution of a permanent magnet type of MRI[1] shown in Fig.1 is affected by the hysteresis (minor loop) and eddy current in pole piece and yoke due to the pulse current (Fig.2) of the gradient coil. In this paper, the effects of the hysteresis and the eddy current in the yoke on residual flux density of probe coil are investigated. It can be assumed that the eddy current does not flow in the pole piece because it is divided into pieces. The eddy current flows in the yoke. Fig.3 shows the change of residual flux density ΔB_z at the point S(0,0) in Fig.1. ΔB_z is given by

$$\Delta B_z = B_{zi} - B_{z0} \quad (1)$$

where B_{z0} is the flux density at the instant t=0(I=0A). B_{zi} is the flux density at the instant t=i(I=0A). The instant of 1,2,3,··· in Fig.2 corresponds to 1,2,3,··· in Fig.3. Fig.3 shows that the hysteresis in the pole piece and yoke should be taken into account. The effect of eddy current in the yoke on the residual flux density ΔB_z is not negligible. These results suggests that the reduction of the amplitudes of minor loop and eddy current is important in order to improve the operating characteristics of the permanent magnet type of MRI.

Reference

[1] N.Takahashi, T.Kayano, K.Miyata, and K.Ohashi : IEEE Trans. Magn., vol.35, no.3, pp.1893-1896,1999.

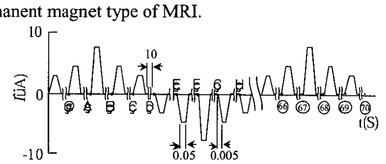

Fig.2. Current of gradient coil.

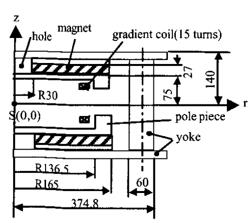

Fig.1. Model of permanent magnet assembly for MRI device.

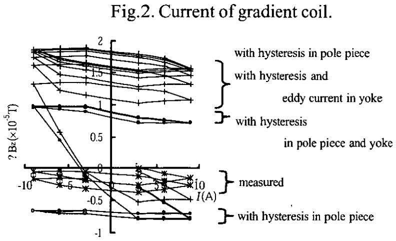

Fig.3. Change of residual flux density.

EV 03

LOCAL EMI IN THE MONOLITHIC DC-DC CONVERTER WITH ON-CHIP PLANAR INDUCTOR

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1. Introduction

A one-chip DC-DC converter IC with an on-chip planar inductor was developed [1]. The planar inductor was placed on the LSI module with BiCMOS control circuit and power MOS-FETs. Therefore it is important to investigate the local EMI effect of the leakage magnetic field from the on-chip planar inductor on the lower LSI circuit. In this study, the local EMI problem in the monolithic DC-DC converter is discussed on the basis of the simulation of the magnetic field distribution.

2. Simulation model

The model under investigation, composed of a spiral coil type planar inductor on the Si-substrate, is shown in Fig.1,this figure is illustrated as the 1/2 model.The planar inductor had a 50μm thick copper spiral coil with 12 coil turns and its surrounding ferromagnetic material. To apply the ferromagnetic material to the LSI process, the fabrication temperature should be as low as possible below 400 degrees Centigrade. For example, when the ferrite paste is used for the on-chip planar inductor, it should be fired at low temperature below 400 degrees Centigrade. However, its relative permeability degrades below 100. Therefore the local EMI problem becomes serious. To discuss the above mentioned local EMI problem, the two-dimensional magnetic field analysis including eddy current calculation was done. The relative permeability of the ferromagnetic material was assumed to be 30. In addition, the effect of the insertion of the conductive shield layer between the on-chip planar inductor and lower Si-substrate was also investigated.

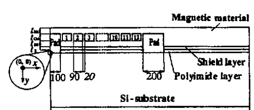
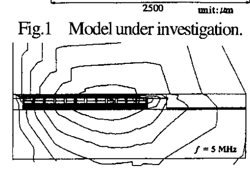
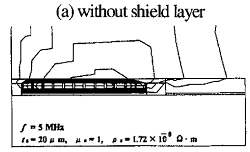


Fig.1 Model under investigation.



(a) without shield layer



(b) with 20μ m thick copper shield layer

Fig.2 Magnetic field distribution.

3. Results and discussion

Fig.2 shows the magnetic field distributions with and without copper shield layer, These results were calculated under 5MHz in frequency. When the shield layer was not used, the leakage magnetic field of the on-chip planar inductor passed through the lower Si-substrate. On the other hand, the leakage magnetic field through the Si-substrate was markedly decreased by using 20μ m thick copper shield layer. The induced EMI noise in the LSI circuit was also estimated. The EMI noise due to the on-chip planar inductor was suppressed very well by using the copper shield layer, but its result is not shown here.

[1] Y.Katayama, et al., *IEEE Power Electorn. Specialists Conf. 2000*, pp.1485-1490 (2000).