# §17. Study on EM Coupling between EM Fields and Electronic Circuits in Plasma Experimental Environment

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**Introduction**

In the experimental fusion facility, in addition to static magnetic fields for confining plasma, many devices such as plasma heating and discharge cleaning may also leak electromagnetic (EM) fields ranged from several MHz to several hundred GHz. The complex EM environment may yield a malfunction or misreading of the electronic personal dosimeter for radiation monitoring. The mobile phones may also become a reason for the misreading. The present study aims to model the EM environment in the fusion facility and derive a circuit model for the personal dosimeter from the view-point of EM coupling in order to clarify the mechanism of malfunction.

**Susceptibility Measurement of Personal Dosimeter**

The susceptibility of a personal dosimeter (ALOKA PDM-111) on radiated EM fields has been measured at the ICRF (Ion Cyclotron Range of Frequencies) band (35 MHz) and the mobile phone frequency band (900 MHz), respectively, in an anechoic chamber (Fig. 1). The used antenna produces horizontally or vertically polarized field. The exposure to the dosimeter continues 5 minutes and then the reading of the dosimeter is checked. At ICRF band, 1) no misreading is found up to an electric field of 30 V/m. On the other hand, at 900 MHz band, a misreading of 0.07 μSv occurs when the electric field exceeds 60 V/m for the horizontal polarization. Such a field level is possible in the neighbor of a cellular phone. For the vertical polarization, however, no misreading occurs even if the electric field reaches 100 V/m.

**Modeling of EM Coupling**

The EM coupling of leaked EM fields with the internal circuit of personal dosimeter is considered as a major reason of the misreading. A model of flip/flop circuit mounted on a micro-scrip line has been proposed to model the above-mentioned susceptibility phenomena. Both a magnetic-field coupling (corresponding to the horizontal polarization) and an electric-field coupling (corresponding to the vertical polarization) have been investigated by using a full-wave electromagnetic field simulation tool (HFSS) and a circuit simulation tool (SPICE). The simulation results show that the horizontal polarization indeed induces larger interference voltage, up to 4 times, at the IC pins compared to the vertical polarization. That is to say, the digital IC exhibits a higher susceptibility for the magnetic field coupling. The reason for this phenomenon is considered as follows. In the case of the electric field coupling, the equivalent current source is a parallel connection to the IC, while in the case of the magnetic field coupling the equivalent voltage source is a series connection to the IC. Due to the high input impedance of digital IC, the interference voltage induced at the IC pin should be larger in the latter case. The finding qualitatively supports the measurement result, and suggests that the proposed coupling model may be useful for explaining the mechanism of misreading of the personal dosimeter, although further quantitative analysis is required.

**Conclusion**

In this study, the susceptibility of personal dosimeters for radiated ICRF and cellular phone frequency bands has been measured and classified according to the polarization or the coupling mechanism. It is found that the digital IC exhibits a higher susceptibility for the magnetic field coupling compared to the electric field coupling. Attenuation should be therefore paid to this phenomenon in the use of personal dosimeters, and the countermeasure in the fusion facility should be taken in view of this finding.

1) J. Wang and K. Kuwabara, IEICE Trans. Commun. (Japanese Edition) J90-B (2007) 1213.

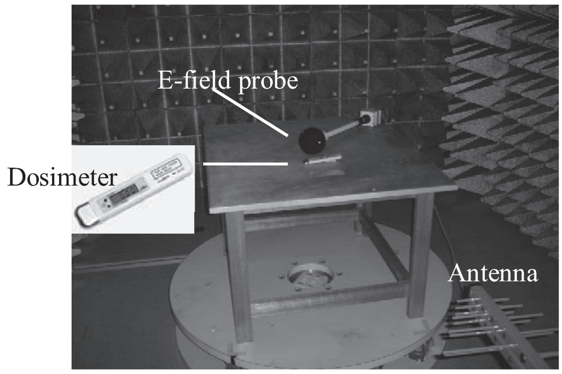


Fig. 1 View of measurement for susceptibility of personal dosimeter