Design of a Small Loop Antenna Operating in VLF band for Shielding Effectiveness Measurement

Eunjung Kang[1], Tae Heung Lim[1], Dae Heon Lee[2], Ki Baek Kim[2], Seung Kab Ryu[2] and Hosung Choo[1]
[1]School of Electronic and Electrical Engineering, Hongik University, 94 Seoul, Republic of Korea
[2]The affiliated Instituted of ETRI, Daejeon, Republic of Korea

***Abstract*- This paper proposes the design of a small printed loop antenna operating in the VLF band for obtaining improved AF properties. The proposed antenna is composed of a ring shape ferrite core and a printed loop antenna to reduce and simplify the antenna size. The ferrite core allows to concentrate the magnetic flux density on the ferrite surface of the antenna, which can decrease the antenna size. The results show that the antenna is suitable for accurate SE measurement of small shielded enclosures in the VLF band due to the small size and low AF level.**

Keywords — VLF antenna, Ferrite loop antenna, AF enhancement.

I. INTRODUCTION

As demands for small shield enclosures grow, the field of antenna engineering makes efforts to decrease the antenna factor (AF) of the loop antenna that enhance the precision of the shielding effectiveness (SE) measurement. Recently, studies on loop antennas have been conducted to improve the AF using a load resistor and a shielded semirigid coaxial cable [1]-[6]. Although these approaches have reduced the AF levels with the miniaturized antenna structure, such loop antennas still have difficulties in the SE measurement at the very low-frequency (VLF) band with a complicated fabrication process for the antenna structure.

In this paper, we propose the design of a small printed loop antenna operating in the VLF band for miniaturizing antenna size. The proposed antenna is composed of a ring shape ferrite core and a printed loop antenna to reduce the antenna size and simplify the antenna geometry. Due to the ferrite core, the magnetic flux density is concentrated on the upper surface of the antenna, which can decrease the AF levels. In addition, such behavior allows the proposed antenna to be miniaturized and operate in the frequency range from 10 kHz to 20 MHz. Therefore, this small loop antenna is suitable for accurate SE measurement of small shielded enclosures.

II. PROPOSED SMALL LOOP ANTENNA

Fig. 1 shows the geometry of a proposed small loop antenna for SE measurement in the VLF band. The proposed antenna is composed of a ring shape ferrite core (μ_r = 500) and a loop antenna printed on the lateral surface of the ferrite core. The ferrite core has inner and outer diameters (d, d_c) of 20 mm and 196 mm with a height (h) of 30 mm. The printed loop antenna fed by a single SMA connector has a width (w) of 6 mm and the same diameter of the ferrite core.

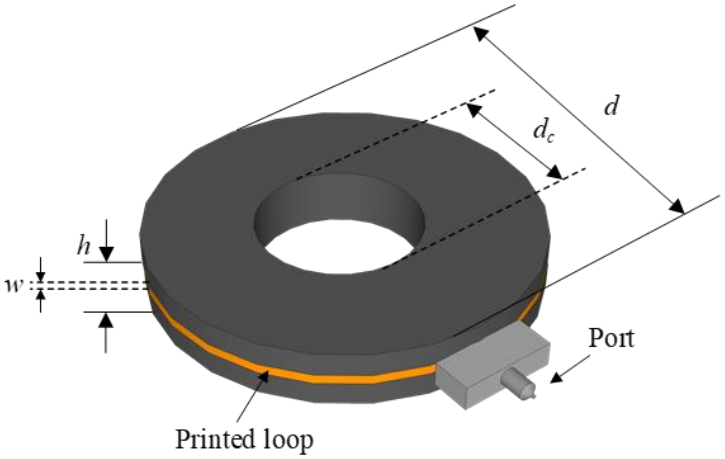

Fig. 1. Geometry of the proposed small loop antenna.

In the SE measurement, the loop antenna performance is often determined by AF (F_m), which is defined as follows [7]:

$$F_m = \frac{H(f)}{V_o(f)}, \quad (1)$$

where $H(f)$ is the magnetic flux density simulated at the center of the loop antenna, and $V_o(f)$ is the excited voltage level calculated with a load impedance of 50 Ω. From equation (1), when the incident plane wave is constant, the voltage induced at the load determines the AF level. In other words, a higher induced voltage value causes a lower AF level, which implies the loop antenna can have better performance in SE measurement. Therefore, we optimize the small loop antenna to miniaturize the antenna size and obtain a low AF level by changing the inner diameter of the ferrite core.

Fig. 2 presents the AF level in DB at an operating frequency of 10 kHz by varying d_c from 0 mm to 160 mm. The result shows that the AF is affected by d_c, and thus the loop antenna is designed with the inner ferrite diameter of 20 mm.

To verify the VLF antenna performance, the proposed antenna is compared to a conventional loop antenna by observing the AF levels in the operating frequency range from 10 kHz to 20 MHz, as illustrate in Fig. 3. The AF levels of the proposed antenna and conventional loop antenna are 49 dB and

46.2 dB at 10 kHz, respectively. The results demonstrate that the proposed antenna is suitable for SE measurements of small shielded enclosures in the VLF band due to the low AF levels and the miniaturized antenna size.

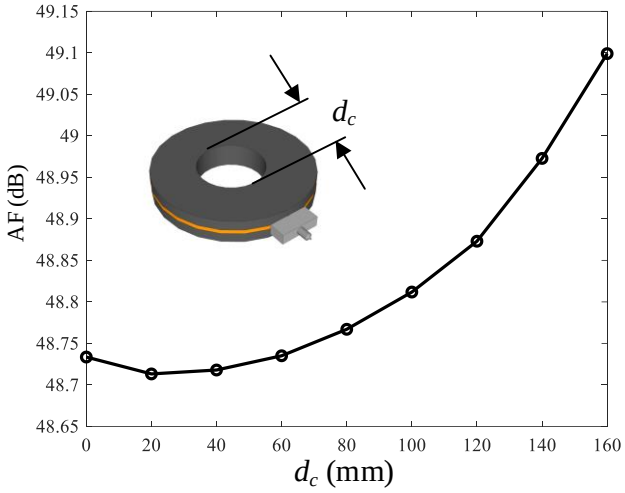

Fig. 2. AF according to d_c.

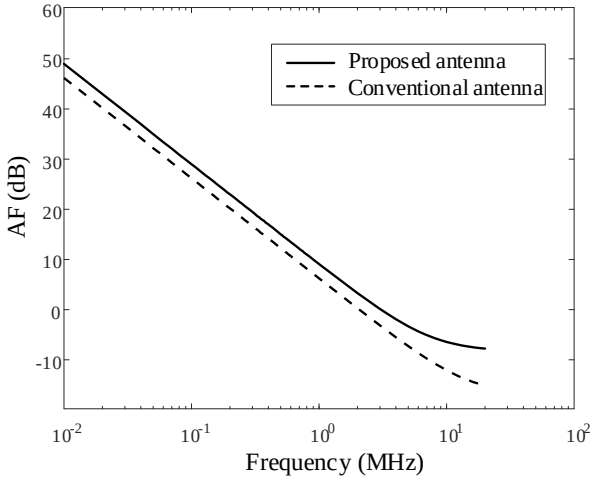

Fig.3. Comparisons of the AF properties.

III. Conclusion

We investigated the design of a small printed loop antenna with low AF properties to measure the SE in the VLF band. The low AF levels with the small antenna size were achieved by a ring shape ferrite core and a printed loop structure that can concentrate the magnetic flux density on the surface of the antenna. The proposed antenna had an AF level of 49 dB at 10 kHz and a miniaturized size compared to the conventional loop antenna. The results demonstrated that the proposed antenna is suitable for accurate SE measurement of small shielded enclosures in the VLF band due to the small size and the low AF level.

Acknowledgment

This paper is a result that was implemented as a research project by affiliated institute of ETRI

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