Rapid Building of a Low-Cost VLF Electromagnetic Field Antenna Based on Mature Printed Circuit Board Technology and Its Application

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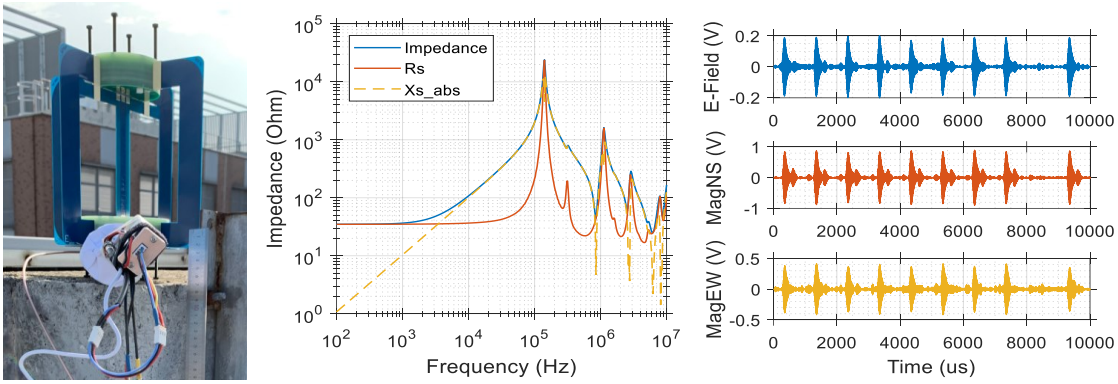
Naturally or artificially generated very-low-frequency (VLF) electromagnetic fields propagating in space are usually weak and difficult to detect. In this frequency band (300 - 300 kHz), large-sized air-core coils or coils with magnetic cores are usually used for electromagnetic field detection. However, both require manual or by means of a winding machine, winding of enameled wire around a prefabricated bobbin, and the resulting performance is difficult to maintain consistent due to differences in position and size of the crossover section [1]. To solve this problem, the method of using printed circuit board (PCB) technology to make coils has appeared in some fields to improve measurement consistency, such as PCB Rogowski coils [2].

In this study, we have designed and manufactured a set of antennas based on PCB technology for observing lightning electromagnetic pulses and Loran-C signals, which mainly included two orthogonal magnetic coils and a parallel plate antenna for measuring electric field. Shown in **Figure 1 (a)** is a photo of the antenna set, which consists of only six main components and a few screws. The PCB coil was manufactured using a conventional four-layer process, with a finished thickness of 1.6 mm and 0.195 mm prepregs used for bonding the top and bottom layers. In order to alleviate the contradiction caused by the increase of stray capacitance when using wide wires and the increase of the resistance and thermal noise when using narrow wires, the connection method of each layer of coils was adjusted as follows. Firstly, the thinnest wires consistent with the craft were used to build coils on each layer. Secondly, the coils on the top and second layers and the coils on the third and bottom layers were connected in parallel, respectively. Finally, the two paralleled coils are connected in series. While using this method to minimize the coil resistance, the use of a 1.2 mm PCB core effectively increases the distance between coils, reduces stray capacitance and increases resonant frequency. The curve of impedance changing with frequency is shown in **Figure 1 (b)**, which shows a DC resistance of 35 ohms, and a first resonant frequency of 141 kHz. **Figure 1 (c)** shows the Loran-C waveform received with this antenna, which demonstrates the feasibility of this PCB antenna design.



(a) (b) (c)

Figure 1. Electromagnetic field antennas built using PCB technology and its performance. (a) Antenna photo during field test, (b) Impedance curve of field coil, (c) Loran-C signal received using this antenna.

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References

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