Dual-Loop NFC Chip Antenna Based on Z-Shaped Coil

Anping Zhao, Fuqiang Ai, and Yu Xu
Shenzhen Sunway Communication Co. Ltd., Shenzhen 518057, China

Abstract – **In this paper, a novel dual-loop NFC chip antenna is proposed. In particular, the dual-loop antenna contains a Z-shaped coil and an additional coil that is parallel to the ground plane. The antenna system based on the dual-loop antenna will have better performance since both the Z-shaped coil and the additional coil can generate magnetic field components perpendicular to the ground plane.**

Index Terms — **NFC Chip Antennas, dual-loop.**

1. Introduction

Near Field Communication (NFC) technology working at 13.56MHz can provide short range communication between portable devices [1]. In the past, NFC antennas that are suitable for the portable devices with the plastic back cover [2, 3] and the metal back cover [4, 5] have been developed. One drawback of these NFC antennas is their size; and the way to reduce the antenna size was studied [6]. Very recently, to increase the applicability of NFC antenna and further reduce the NFC antenna size, a new type of NFC chip antenna that can be soldered on PCB by SMT (surface mount technology) has been developed by Murata [7]. In this paper, to further enhance the chip antenna performance, a novel dual-loop NFC chip antenna is proposed. Especially, the dual-loop antenna has a Z-shaped coil and an additional coil that is parallel to the ground plane. Because both the Z-shaped coil and the additional coil can create magnetic field components perpendicular to the ground plane, so the dual-loop NFC chip antenna will have better interaction with the ground plane and thus can enhance the performance of the antenna system.

2. Dual-Loop NFC Chip Antenna

Fig. 1 shows the NFC chip antenna containing separately the Z-shape coil (left figure) and the additional coil (right figure), where the coils wind on the surfaces of a cubical ferrite with a dimension of 6mm (X) × 3mm (Y) × 1mm (Z). The current directions of the two coils are also illustrated in Fig. 1. The Z-shaped coil means that its projection in XZ-plane is Z-shaped. From Fig. 1 one can see that the Z-shaped coil will generate two magnetic field components: *B1* along Z direction and *A* along -X direction; whereas the additional coil will create one magnetic field component *B2* along Z direction. The coil configuration of the proposed dual-loop NFC antenna is shown in Fig. 2, which has two soldering pads at the bottom side (not shown). The two pads are used to feed the antenna and solder (SMT) the antenna on PCB. The two different coils are connected in series. The first end of the Z-shaped coil connects to the first pad and its other end connects to the first end of the additional coil, while the other end of the additional coil connects to the second pad. The manner for connecting the coils and pads makes the currents (i.e., *a* and *b*) of the coils flow the way as illustrated in Fig. 2. The dual-loop antenna will generate magnetic field that have components *A* along -X direction and (*B1*+*B2*) along Z direction.

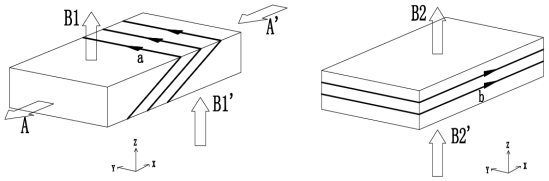

Fig. 1. NFC chip antenna coil configuration of Z-shaped coil (left) and additional coil (right).

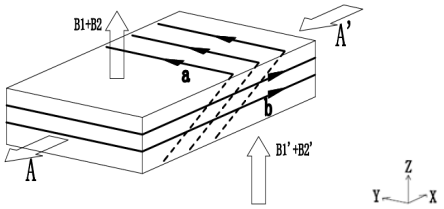

Fig. 2. Proposed dual-loop NFC chip antenna.

The Z-shaped and the additional coils generate different magnetic field profiles in space. As shown in Fig. 3, the Z-shaped coil forms a profile having one positive mode and one negative mode; while the additional coil creates a profile containing one positive mode only. Finally, a new profile is formed when these two profiles are combined together. This property can also be seen as the working principle of the (individual) dual-loop antenna. Because the amplitude of the positive mode of the final profile is bigger than that of any other modes, so one can say that the dual-loop antenna has better performance. In other words, the performance of the antenna containing only Z-shaped coil can be enhanced significantly while the additional coil is added. In addition, the dual-loop antenna has magnetic field components *B1*+*B2* and *A*. In contrast, the antenna in [7] has magnetic field component *A* only; this is because this antenna has only one coil winding spirally along X axis.

In practice, the dual-loop antenna should work together with PCB. Fig. 4 illustrates how the dual-loop chip antenna combines with the PCB that consists of substrate and metal

plate. To distinguish with the individual antenna, we name the combination of the antenna and the PCB as an antenna system. According to the near field coupling theory [6], the part of the Z-shaped coil locating at the bottom of the antenna can generate an eddy current loop *C* on the metal plate, which will form a magnetic field component *B3* along Z direction. Because the NFC signal of the antenna system is normally detected at Z plane, so the strength or magnitude of magnetic field component along Z direction plays a very important role. Hence, the combination of three magnetic field components (*B1, B2* and *B3*) along Z direction ensures a better performance for the dual-loop antenna system. In contrast, the antenna system developed in [7] has only one magnetic field component (*B3*) along Z direction since this antenna itself does not have any magnetic field components that are similar to *B1* and *B2*. Certainly, lack of the magnetic field components *B1* and *B2* worsens the performance of the antenna system.

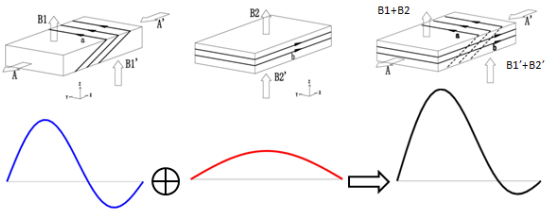

Fig. 3. Working principle of the proposed antenna.

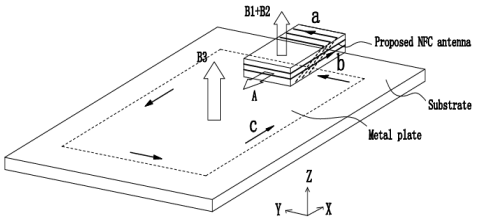

Fig. 4. Working principle of the proposed antenna system.

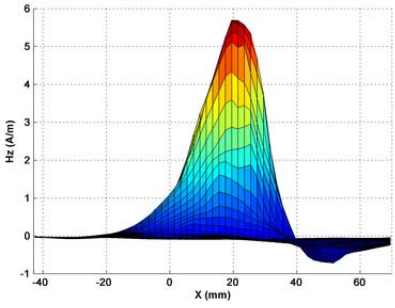

Fig. 5. Hz field component recorded at Z = 25 mm above the antenna system that has the dual-loop coil.

Fig. 5 shows the Hz field component distribution recorded at Z = 25mm above the antenna system shown in Fig. 4, while the number of turns of the Z-shaped and additional coils are 5 and 2, respectively. One can see from Fig. 5 that the dual-loop antenna system performs very well.

To demonstrate the importance of the additional coil, the recorded Hz field component for the case when the antenna system has the Z-shaped coil only is plotted in Fig. 6. The difference between the Hz field component distributions shown in Figs. 5 and 6 indicates that the performance of the can be improved very significantly (about 34%) while the additional coil is adopted for the proposed antenna.

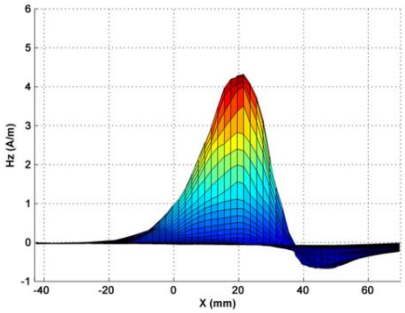

Fig. 6. Hz field component recorded at Z = 25 mm above the antenna system that has the Z-shaped coil only.

3. Conclusion

A dual-loop NFC chip antenna that has better antenna performance is developed. The dual-loop antenna can generate not only the magnetic field component (*A*) along X direction but also the field component (*B1+B2*) along Z direction. When combined with PCB, the antenna results in better performance for the antenna system. The dual-loop antenna proposed in this paper would be very useful for portable devices that require small size NFC antenna.

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