RFID Tag Antenna Design Using Flexible Double-Layer Strip Dipole Antenna

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Abstract

This paper presents the RFID tag antenna design for use on cylindrical object. Our proposed Double-Layer antenna has physical change itself for better performance than modern antenna. An importance concept of the design is each layer of antenna can freely change to make a physical tuning.

Keywords : RFID Tag Antenna

1. Introduction

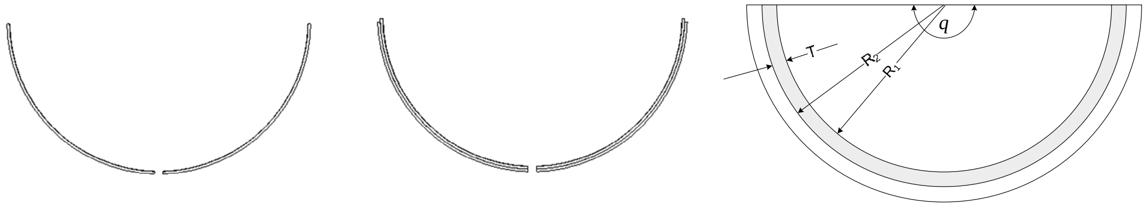
The advancement of radio frequency identification (RFID) systems has made them attractive for various applications including logistics, inventory management and human monitoring [1]. The non-line-of sight operation, longer read range, capability and ability to store information make these RFID systems ideal candidates to replace barcode technology.

In supply chain system, many RFID antennas designed for different types and shape of products. One problem when using RFID antennas on the product is various shapes and sizes. The flexible surfaces of the tag antenna has effected by various distortions such as bending when the product is attached to flexible package (Such as plastic and paper). Structural distortion changes the performance of the tag antenna and the performance decline especially when operating in microwave frequencies. By the way, the most used for tag RFID is dipole antenna [2, 3]. This paper will discuss the optimization reduced by simulating curving the RFID tag antenna models by using a double-layer antenna. The result of curving will change the resonance frequency of antenna. Double-layer antenna will reduce the effect of curving based on relative changes in length on each layers. Caused by curving of the antenna is not the same for both layer of antenna. Result of changes to compensate for the resonance frequency which allows the antenna performance increasing. So result of this a little length will be prove a resonance frequency on antenna and make it has better efficiency compares to modern antenna.

This paper is organized as follows. In the next section, the proposed antenna design structure and discussed for both single-layer and double-layer antennas. In section 3, simulations of the reflection coefficient in various radius of curved antenna are presented. The measurement results of the single-layer and double-layer prototype antennas with strength and curved are presented in section 4. Section 5 concludes the paper.

2. Proposed Antenna Design Structure

In this section, a brief review of single layer antenna model is given. Then, the proposed double layer model of Strip Dipole with the effect of curving antenna is discussed.



a) Single-layer strip dipole b) Double-layer strip dipole c) Diagram of purpose antenna

Figure 1: Schematic of the flexible strip dipole antenna

In Fig. 1, show structure of single-layer strip dipole compare to double-layer strip dipole antenna. Each layer has the same length but when it curving, the inner layer will be little shorter than outer layer because of radius of each layer not the same, as show in Fig 1c. An inner layer has length equal to $(2pq/360)R_1$ where q is an angle of each layer in degree and R1 is inner radius of curving antenna. The difference length of each layer is equal to $(2pq/360)(R_2-R_1)$.So, we can use this physical change for tuning it own properties of antenna. Normally, when a strip dipole has more length it's resonance frequency will change to a lower frequency [3]. In opposite way, if it length shorter than the original, it will shift to a higher resonance frequency. From this behavior, we design a model for study effect of double-layer strip dipole antenna with two difference type. Double-layer type-I used an inner layer shorter than outer layer and Double-layer type-II is used an outer layer shorter than inner layer as show in Fig.2.

a) Double-layer strip dipole type I b) Double-layer strip dipole type II

Figure 2: Structure of Double-layer strip dipole with curving radius used in simulation

a) Double-layer strip dipole type I straight b) Double-layer strip dipole type-I curved

c) Double-layer strip dipole type-II straight d) Double-layer strip dipole type-II curved

Figure 3: Diagram of double-layer strip dipole for calculate effective length

In Fig.3, it is a demonstrate diagram to show how we can calculate effective length of antenna when it straight and curved without overlap length as

$$L_{eff} = L_{ant} = 2*(A+B+T) = 2*(C+D+T) \tag{1}$$

The effective length (L_{eff}) of antenna from equation (1) is the same for both types. However, the effective length has change when antenna has curved. We can write the effective length of double-layer strip dipole type-I and double-layer strip dipole type–II as

$$L_{eff,TypeI} = 2*\left(A+D+T-\Delta L\right) \tag{3}$$

$$L_{eff,TypeII} = 2*\left(C+B+T+\Delta L\right) \tag{4}$$

From equation (3) and Fig. 3(b), length of section **C** was fixed by physical structure. So, it makes length of section **A** is reduce cause of curved. The same result for equation (4) and Fig. 3(d), where length of section **A** was fixed by physical structure. So, it makes section **C** will be extended. A difference length for both types can calculate by

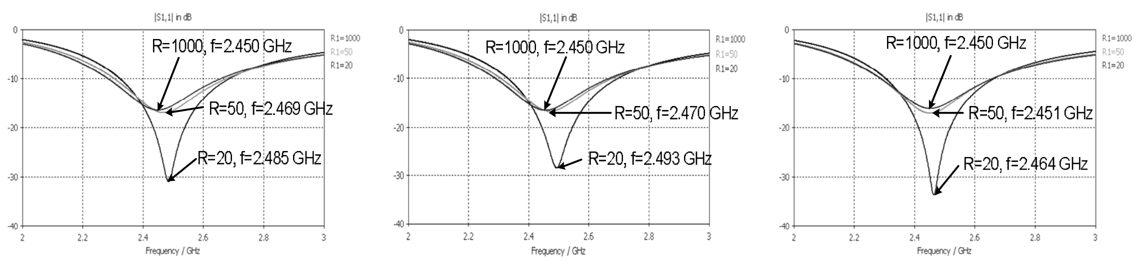
$$\Delta L = \frac{2pq}{360}\left(R_2 - R_1\right) \tag{5}$$

A negative sign in equation (3) mean to an effective length is decrease from normally length and positive sign in equation (4) mean to it extended from normally length of the first section of antenna's center.

However, Fig. 2 show that section **A** and **C** in both type of antenna must have some extended length to cover a difference length that occurred from curved effect for make both layer contacted to each other.

3. Simulation Results

In Fig. 2, a structure of the double-layer strip dipole antenna simulated by using CST [4]. All tag antenna lie on XY–plane and curving in XZ-plane. We curve it for radius 20, 50 and 1000 mm. From Fig. 3, length of section **A** and **C** is 10 mm., 18 mm. for section **B** and **D**, 1 mm. for overlap on each layer, 4mm. for a strip width and thickness is 0.3 mm. We changed the radius and observe result of reflective coefficient (S11) and resonance frequency. Result from simulation show in Fig. 4.



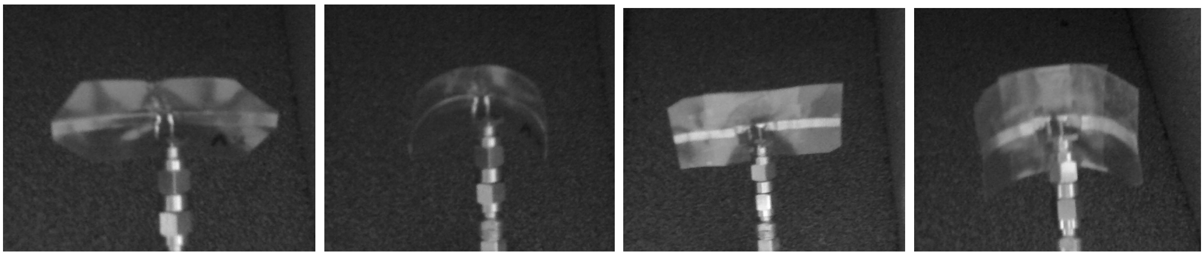
a) single-layer strip dipole b) double-layer strip dipole type-I c) double-layer strip dipole type II

Figure 4: Reflection coefficient (S11) for difference radius of curving

From Fig. 4(a), Single-layer strip dipole has resonance frequency at 2.450 GHz, 2.469 GHZ and 2.485 GHz when curving radius was 1000, 50 and 20 mm. respectively. A frequency shift to higher resonance frequency when it curved was report in [5]. So, a double-layer strips dipole type I has resonance frequency at 2.450 GHz, 2.470 GHZ and 2.493 GHz in Fig. 4(b). Finally, double-layer strips dipole type II in Fig 4(c) has resonance frequency at 2.450 GHz, 2.451 GHZ and 2.464 GHz when curving radius was 1000, 50 and 20 mm. respectively. All of this shows that a double-layer strip dipole type II has most stable resonance frequency than the others. For single layer strip dipole antenna, it shifts resonance frequency with 19MHz and 35MH compare to straight antenna. Next, a double-layer strip dipole antenna type-I change it resonance frequency for 20MHz and 43MHz. Then, a double-layer strip dipole antenna type-II change it resonance frequency for 1MHz and 14MHz.

4. Measurement Results

The prototype antenna is fabricated from copper sheet thickness 0.3 mm. and other size is same as simulation model. A network analyzer HP8722D used for measurement S11 result in anechoic chamber. From measurement results, double-layer antenna must have a structural supported sheet cover on front and back of antenna. We used a thin PVC film for this purpose. Property of PVC dielectric constant is 3 and thickness around 0.1 mm. So, it makes a small frequency shift when we compare to an original antenna without PVC cover. However, we can adjust it length for matching in the same resonance frequency. For single-layer antenna with PVC cover as show in Fig. 5(a) has a frequency resonance at 2.45 GHz. After curved, a resonance frequency has shift to 2.69 GHz with curving radius 20 mm. For double-layer strip dipole antenna type-II, a resonance frequency is 2.45 GHz for straight antenna. Next, the resonance frequency shift to 2.49 GHz when it curved at radius 20 mm. This result agree with simulation result in section 3 that double-layer strip dipole has improve resonance frequency shifted cause by curved antenna.



a) single-layer straight b) single-layer curved c) double-layer straight d) double-layer curved

Figure 5: Prototype antennas used for measurement

5. Conclusion

We have shown a design of double-layer strip dipole antenna can improve the performance of RFID tag when the antenna was curved. Result of improvement can be achieved when the RFID tag has curving characteristic. We have shown that double-layer strip dipole antenna type-II are more attractive than double-layer strip dipole antenna type-I for improvement because of resonance frequency was more stable when curving. Hence, the antenna has to be design to match specific object surface so that the RFID performance is improved.

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Acknowledgments

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