Characteristics of Loop Antenna Structure of RFID Tag Antenna

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Abstract - A loop RFID tag antenna and a dipole RFID antenna with a T-matching method have been designed. The characteristic of loop and dipole with T-matching antenna structures of RFID tag antennas have been studied. The impedance of different sizes of loop and dipole antenna structures are found. This paper shows parametric research of loop RFID antenna structure and RFID dipole antenna with T-matching method to match the impedance of commercially available RFID chips.

Keywords: RFID tag Antenna, T matching method

1 Introduction

Radio Frequency Identification (RFID) has been popular in many applications; logistics, security systems, animal tracking, transportation, manufacturing process control, and etc. An RFID system consists of a reader, a transponder (tag) and a computer connected to the reader. Several frequency bands have been internationally assigned to the RFID applications, LF(125kHz, 135kHz), HF(13.56MHz), UHF(433.92MHz, 860~960MHz), and Microwave band (2.45GHz). Recently, the UHF band (860~960MHz) using backscattering method is more popular than other bands [1].

A passive tag receives the energy from the RF energy of the reader, while an active tag has a battery for a power source [2-4]. The tag sends a signal back to the reader using the tag antenna. The tag has an antenna and a microchip attached to the feeding point of the antenna. A commercial tag chip has been miniaturized already, but it is difficult for antenna to miniaturize, because the size of antenna is proportional to the wavelength. A tag antenna should have following characteristics; long recognition distance, omni directional beam pattern, and low price, miniaturization, and high gain to communicate with the reader.

The closed loop antenna structure is important impedance matching method for the early version of a RFID chip, since it protects the chip from a strong ESD (electrical static discharge). Because of several commercial RFID chips have different impedance, the size of a tag antenna and T matching parameters are different [5, 6].

The proposed tag can be easily designed to match any specific RFID chip impedance. To achieve the characteristics of the tag antenna, the impedance of antenna should be conjugate of the impedance of the RFID chip.

This paper presents the characteristics of loop antenna and dipole antenna using T-matching method, and shows method to match the antenna impedance to the various commercially available RFID chips. The design and characteristics of loop antenna and T matching dipole antenna are shown in the following sections.

2 Loop antenna

In this section, the characteristics of impedance for loop antenna are described, as shown in Figure.1. A loop antenna should have the conjugate of the RFID chip impedance (19-282j) at 910 MHz to mach the antenna impedance to the impedance of IC chip. The chip is manufactured by EM Microelectronic inc. Since the UHF RFID frequency band is 860~960MHz, the center frequency is at fc=910MHz. The parametric researches of the antenna shown in Figure 1 have been done in this section. The size of the impedance matched antenna to the RFID chip given above is shown in Table 1. The parameters are gap (G), width (W), length (L) and height (H).

Figure 2 shows the S11 of the design in Figure 1 with G(gap)=2mm, W(width)=1mm, L(length)=7.5mm and H(height)=15mm. In Figure 1, the bandwidth is about 760MHz, which covers whole UHF RFID frequency band (860~960MHz).

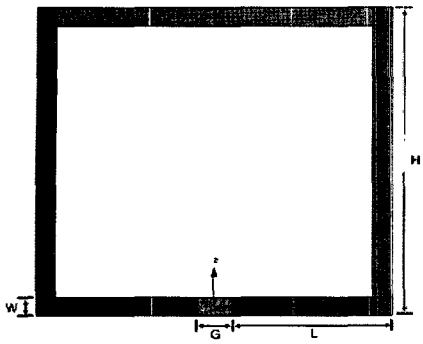

Figure 1. A sample of loop antenna

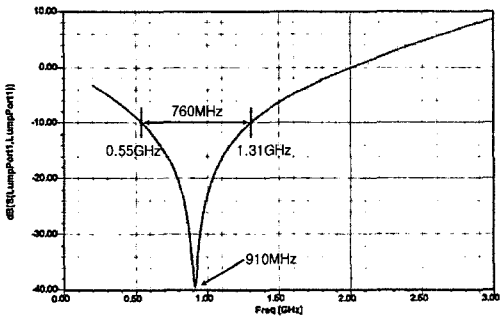

Figure 2. The S11 of RFID antenna matched to RFID chip 19-282j by EM Microelectronics G=2mm, W=1mm, L=7.5mm and H=15mm

The parametric study of the design in Figure 1 has been done. The range of H (height) and L (length) is from 4mm to 48mm for the standard size of 2 inches x 2 inches tag requested by WalMart. The increment of L and H is 4mm. Table 1 shows the real and imaginary parts of the impedance and the center frequency corresponding to the different lengths and heights of the loop antenna. The real part varies from 1.8 to 2556 ohm, and the imaginary part varies from 80 to 617 ohm. Also small loop antenna has small value of real and imaginary parts of impedance as shown in Table 1.

Table 1 and Figure 3 show the best size of the antenna is close to the L=1.2cm and H=1.2cm. Figure 3 shows the relationship between the resistance and height (4mm~48mm) when length = 1.2 cm. Figure 4 shows the relationship between the reactance of the loop antenna and height when the length is 1.2cm. These graphs in Figures 3 and 4 show the size L=1.2cm and H=1.2cm matched with the impedance of the RFID chip. Therefore, with these parameters of impedance shown in Table 1, an RFID antenna can be easily designed for any commercially available RFID chip. For example, RFID chip impedance is 16-j350 at 910 MHz (Philips' EPC 1.19), the table shows the matching dimension is L=12mm and H=12mm.

Table 1. The impedance table of dipole antenna with parameter L and H, (matched to 16-j350 at 910 MHz Philips' EPC 1.19.

	L=4cm			L=8cm			L=12cm			...	L=44cm			L=48cm		
H(cm)	Re	Im	fc	Re	Im	fc	Re	Im	fc		Re	Im	fc	Re	Im	fc
4	1.8	80.6	2.95	1.7	123.7	1.69	2.9	170.0	1.29		444.9	357.2	0.47	563.8	330.7	0.41
8	6.3	127.8	1.64	6.3	173.7	1.25	8.1	244.2	1.00		1268.0	-545.9	0.35	913.7	-347.7	0.34
12	16.9	193.4	1.15	20.5	259.4	0.95	16.2	306.7	0.83		961.9	-986.7	0.30	656.9	-668.3	0.30
16	24.9	237.7	0.99	33.4	308.2	0.86	31.2	403.2	0.74		509.0	-802.1	0.30	494.5	-684.1	0.24
20	45.5	323.3	0.82	53.2	395.0	0.73	65.3	507.4	0.63		406.6	-921.7	0.24	340.0	-627.6	0.25
24	271.0	656.5	0.64	111.1	526.2	0.64	148.4	701.5	0.56		322.9	-734.0	0.25	268.8	-591.1	0.21
28	128.0	534.5	0.65	258.3	689.4	0.59	190.1	793.1	0.50		262.6	-653.0	0.21	236.4	-541.9	0.20
32	224.5	736.3	0.54	287.9	801.3	0.52	388.1	1072.2	0.47		225.3	-626.9	0.20	210.5	-487.7	0.20
36	441.7	998.7	0.48	807.5	1072.4	0.47	733.9	1326.4	0.41		205.6	-531.4	0.20	198.6	-430.2	0.20
40	1197.8	1225.8	0.45	561.6	1195.9	0.42	1212.5	1539.5	0.38		198.4	-491.1	0.20	188.3	-393.3	0.20
44	1236.2	1339.5	0.41	2313.7	95.0	0.40	2606.0	1017.6	0.35		188.0	-432.9	0.20	183.0	-359.4	0.20
48	2556.5	-81.3	0.37	2313.2	444.6	0.37	2555.0	-617.2	0.33		181.0	-384.0	0.20	180.2	-331.3	0.20

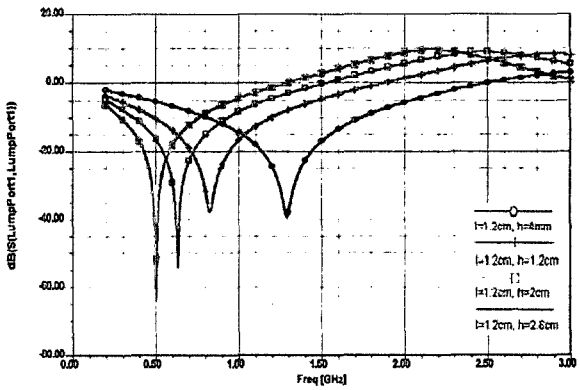

Figure 3. S11 of different heights with Length=12mm

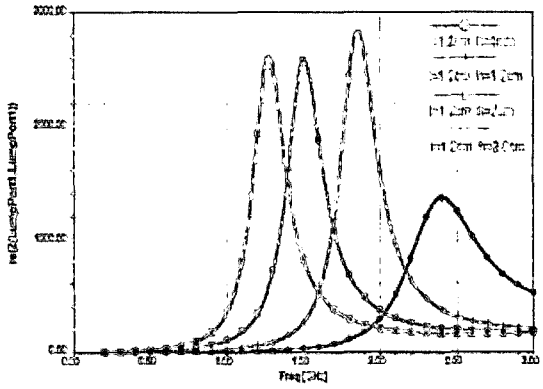

Figure 4. Real value of impedance of the Loop antenna with different Height with Length=12mm

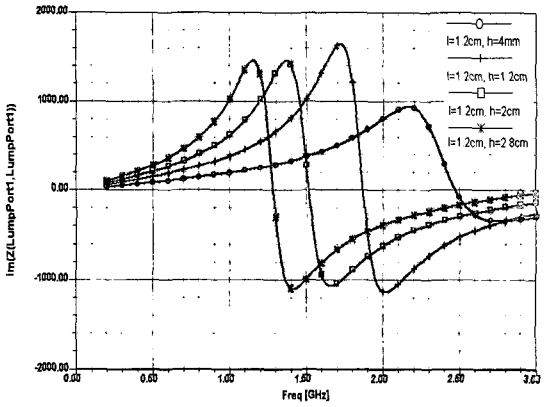

Figure 5. Imaginary value of impedance of the Loop antenna with different Height with Length=12mm

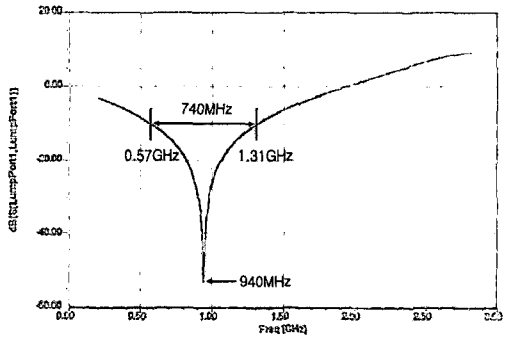

Figure 6. S11 of RFID antenna matched to RFID chip with 16-350j (Philips' EPC 1.19), L=12mm, H=12mm

Figure 6 shows the return loss of the matched antenna to Philips's RFID chip impedance 16-350j. In Figure 6, the bandwidth is 740MHz which can cover whole UHF band, and fc = 940MHz. The center frequency, fc, is 30MHz higher than 910MHz. The matching can be improved by finding exact matching size of H ranging from 12mm to 16mm.

3 Dipole antenna. with T-matching

Dipole antenna structure is basic shape on RFID tag antenna. Since the shape of basic dipole antenna is difficult to match to the complex value of the RFID chip impedance, a dipole antenna structure requires a T matching method. Figure 7 shows a dipole antenna with T matching method. The parametric research has been done with various lengths and heights of the parameters of the structure. Table 2 shows real and imaginary parts of the impedance of the antenna using a T matching. The range of parameter H and S is from 4mm to 48mm with every increment of 4mm.

Table 2 can give matching size of the antenna for a commercially available RFID chip by changing parameter S and H to match the impedance of RFID chip (19-282j) of EM Microelectronic inc. The parameters matched to the RFID chip are G(gap)=2mm, W(width)=1mm, L(length)=24mm, H(height)=15mm, A=8.4mm, and S=18.8mm. Figure 8 shows S11 of the design with the bandwidth of 540MHz. Table 2 shows impedance of the different parameters of S and H while other parameters G(gap)=2mm, W(width)=1mm, L(length)=24mm, and A=8.4mm. The total size is less than 2 inches x 2 inches. With Table 2, we can find parameter values to match impedance of other RFID chips. For example, the impedance of RFID chip is about 8-100j at 910MHz. We can find S=20mm and H=4mm are suitable to match. Figure 8 is return loss of the antenna matched to 19-282j, with S=20mm and H=4mm. The bandwidth is 840MHz, enough to cover whole UHF band 860~960.

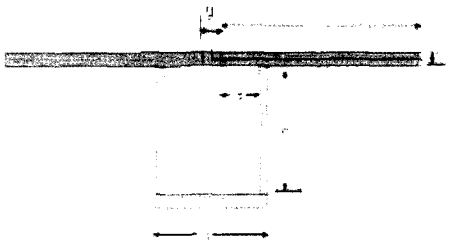

Figure 7. A dipole antenna using a T-matching method.

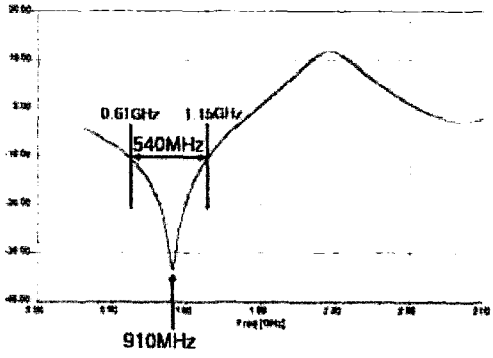

Figure 8. The S11 of a matched dipole antenna to 19-282j by EM Microelectronics W=1mm, L=24mm, H=15mm, A=8.4mm, S=18.8mm)

	s=4mm		s=12mm		s=18.8mm		s=20mm		s=28mm		s=36mm	
h	im	re	im	re	im	re	im	re	im	re	im	re
4mm	22.14	0.14	70.3	1.49	106.18	3.17	[illegible]	[illegible]	165.17	7.39	223.84	12
12mm	61.69	0.36	127.64	2.12	214.11	5.04	218.69	6.59	344.83	12.24	424.35	26.18
15mm	63.81	0.65	178.16	2 36	284.53	6.67	273.74	5.68	372.23	18.09	544.62	52.82
20mm	118.29	0.65	237.71	3 29	351.1	10.92	370.79	11.19	501.76	26.03	794.14	125.96
28mm	82.38	0.89	389.67	15.66	554.81	31.55	557.76	29.08	828.02	89.51	1235.1	214.74
36mm	276.26	5.44	560.55	26.7	846.69	82.24	1019.5	115.24	1570.2	334.15	2980.6	1653

Table 2. The impedance table of a dipole antenna with variation of S and H.

There are two more antennas matched to commercially available RFID chips with the impedance of 16-350j and 8-100j. The matched sizes are carefully found with the simulation results with Table 2. The S11 of the two antennas are shown in Figures 9 and 10. The bandwidth antennas are sufficient for RFID UHF 860~960MHz band.

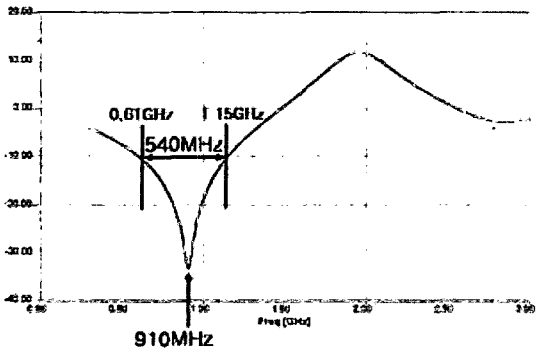

Figure 9. The S11 of the antenna matched to 16-350j

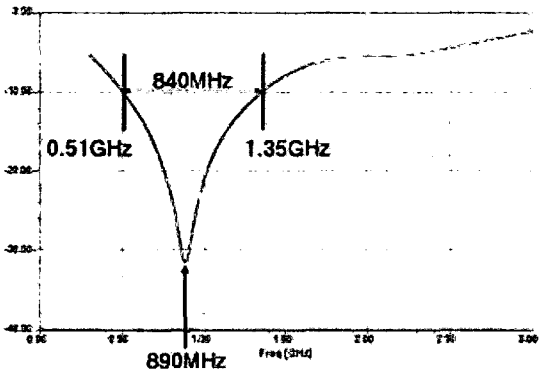

Figure 10. The S11 graph matched to 8-100j

4 Conclusions

This paper introduces a design of a loop antenna and a dipole antenna using T-matching method for the commercially available three RFID chips. The parametric studies of these two antennas have been done. Based on the variation of each parameter, the antenna impedance tables of a loop and a dipole antenna using T-matching are found. With the impedance values of different sizes of antennas in these Tables 1 and 2, the impedance matched antenna to any commercially available chip can be found easily. The 3 different impedance of commercially available RFID chips, 19-282j (EM microelectronic Inc.), 16-j350 and 8-100j, are used. After finding rough size of the antenna matched to any RFID chip from the Tables, we can find a perfect matching size of antenna by using a small variation of parameters around matching size. The future work is programming a optimizing program which can searches a perfect matching size of an antenna based on two Tables with trial errors and measurements.

5 References

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