Progress In Electromagnetics Research C, Vol. 9, 145–153, 2009

TRIPLE-BAND PRINTED DIPOLE TAG ANTENNA FOR RFID

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Abstract—In this paper, a triple-band printed dipole tag antenna is proposed for Radio Frequency Identification (RFID). The triple-band printed dipole antenna is designed to operate at 0.92 GHz, 2.45 GHz and 5.8 GHz using Computer Simulation Technology (CST) software. In order to achieve triple-band operation, the proposed antenna contains two branch elements, which act as an additional resonator. The designed antenna is fabricated using Taconic RF-35 substrate with a dielectric constant (ε_r) of 3.5 and thickness (d) of 0.508 mm. The antenna's parameters for triple-band operation are investigated and discussed. Then, this fabricated antenna is integrated with a UHF microchip to become a passive UHF tag. This tag is tested by measuring the reading distance and it is found that the proposed tag can be used for RFID application.

1. INTRODUCTION

Passive Ultra High Frequency (UHF) Radio Frequency Identification (RFID) technology has become increasingly popular in various areas of automatic identification of objects such as access control, animal tracking, inventory management, asset identification and manufacturing industry. Basic passive UHF and Microwave Frequencies (MWF) RFID systems consist of a passive tag or transponder with stored information that is attached to an object and a reader that transmits commands and energy to activate the tag using electromagnetic waves [1, 2]. The communication from tag to reader is based on electromagnetic wave backscattering modulation by the data stored on tag. Generally, a RFID tag consists of an Application Specific Integrated Circuit (ASIC) microchip connected to an antenna.

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Printed dipole antennas have been actively studied since they are simple, easy to fabricate, and easy to integrate with the ASIC microchip. In recent years, several triple-band printed dipole antennas were reported. A triple-band printed dipole antenna using parasitic elements was proposed in [3]. The proposed antenna contains two parasitic elements as additional resonators by coupling from the driving dipole antenna. The antenna was designed and analyzed at the bands of PCS (Personal Communication Service: 1750 $\sim$ 1870 MHz), IMT-2000 (International Mobile Telecommunication-2000: 1920 $\sim$ 2170 MHz), and ISM (Industrial Scientific and Medical: 2400 $\sim$ 2483.5 MHz). In [4], a triple-band omni-directional antenna which comprises three pairs of dipoles placed back to back and printed on a dielectric substrate was presented for WLAN applications (2.4 GHz, 5.2 GHz and 5.8 GHz). A printed folded dipole antenna already been proposed for UHF reader in [6]. However, the stacked and planar triple-band microstrip antennas were presented in [8–10].

In this paper, a straight and meandered triple-band printed dipole antennas are constructed based on a printed triple-band monopole antenna that was proposed in [5]. The developed antenna is then integrated with the 902–928 MHz ASIC microchip to become a passive UHF tag. In order to validate the performance of the fabricated tag, the measuring distance of the tag is recorded. Thus, a passive UHF reader is required for this purpose.

2. ANTENNA DESIGN

The triple-band dipole is printed on one side of the Taconic substrate (dielectric constant, $\varepsilon_r = 3.5$, thickness, $d = 0.508$ mm and tangent loss, $\delta = 0.0019$) with a substrate size of 145 mm $\times$ 20 mm for the straight dipole (design 1) and 105 mm $\times$ 20 mm for the meandered dipole (design 2). In order to achieve a triple-band operation, the prime dipole antenna is connected to the two branch elements (l_2 and l_3), which act as an additional resonator to resonate at 2.45 GHz and 5.8 GHz. In the second design, the length of the prime dipole, l_1 is meandered to reduce the antenna size. The structure of the designed antenna is shown in Figure 1. A 2.0 mm gap at the centre of the antenna is connected by a discrete port of 50 Ω. In order to achieve matching impedance of 50 Ω, the width of the antenna elements, w equal to 1.2 mm is applied. Figure 1 also shows the surface current at 0.92 GHz for both triple-band printed dipoles.

The effects of the parameters on the frequency shift and the input impedance are investigated. It is found that the length of the prime dipole and length of the branch elements have a significant effect on resonant frequency or input impedance of the antenna.

Figures 2 and 3 show optimized simulated return loss and input impedance of the antenna. Referring to Figure 2, there are three resonant frequencies. For Figure 2(a), they are 0.92 GHz with very good return loss of −23.5 dB, 2.45 GHz with return loss of −10.5 dB and followed by 5.8 GHz with return loss of −14.7 dB. The input impedances at these three frequencies are 56.9 Ω, 50.8 Ω and 51.0 Ω respectively. For Figure 2(b), the return loss is −8.8 dB at 0.92 GHz, 11.5 dB at 2.45 GHz and −13.7 dB at 5.8 GHz. While the simulated

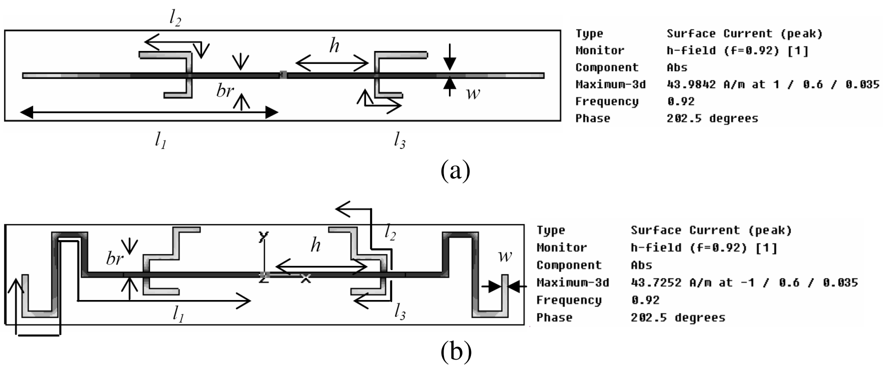


Figure 1. The structure of the designed triple-band printed dipole antenna and surface current at 0.92 GHz (a) straight (design 1) and (b) meandered (design 2).

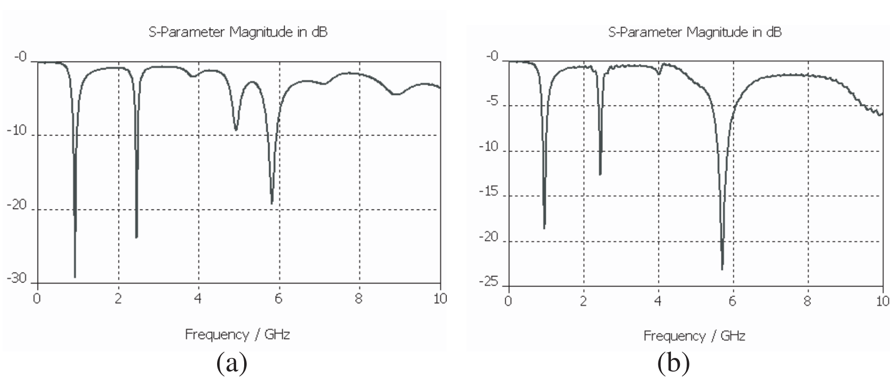
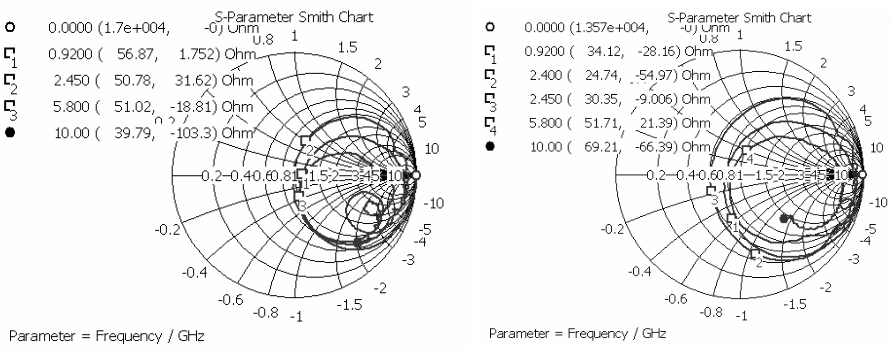
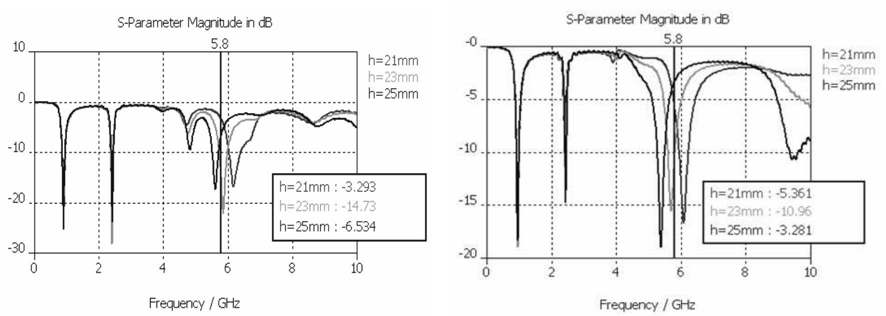


Figure 2. The simulated return loss of triple-band printed dipole antenna (a) design 1 (l_1 = 67.0 mm, l_2 = 18.1 mm, l_3 = 11.6 mm, br = 4.5 mm and h = 23.0 mm) and (b) design 2 (l_1 = 77.3 mm, l_2 = 18.1 mm and l_3 = 10.6 mm, br = 3.5 mm and h = 23.0 mm).



(a) (b)

Figure 3. The simulated input impedance of triple-band printed dipole antenna for (a) straight and (b) meandered.



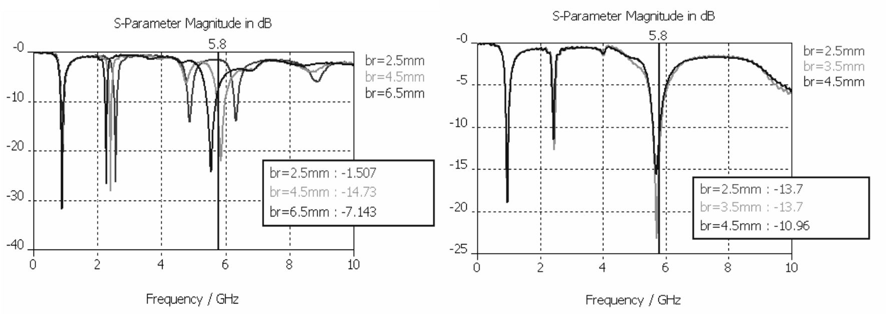
(a) (b)

Figure 4. The simulated return loss with different values of h (a) straight dipole and (b) meandered dipole.

input impedances at these three frequencies are $34.1\,\Omega$, $30.4\,\Omega$ and $51.7\,\Omega$ respectively.

The parameter that only affects the highest resonant frequency for both these antennas is the distance between port and the branch elements (h). Figure 4 shows the simulated return loss for straight and meandered dipole with different values of h.

Figure 5(a) shows that the middle and the highest resonant frequencies will be shifted to the left when the length of the branch (br) is increased. Based on this figure, the unwanted resonant frequency around 5 GHz is also introduced for the smallest value of br. But in Figure 5(b), it shows that the three resonant frequencies are generally



(a) (b)

Figure 5. The simulated return loss with different values of br (a) straight dipole and (b) meandered dipole.

remain constant. It only shows that the value of input return loss at the highest frequencies is deeper when the length of the branch (br) is decreased from 4.5 mm to 3.5 mm.

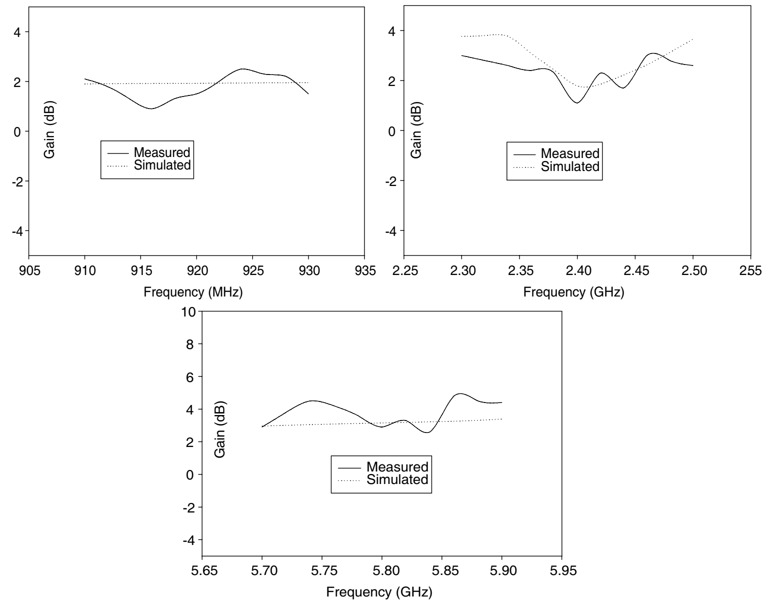
3. COMPARISON BETWEEN SIMULATION AND MEASUREMENT RESULTS

The measurement of return loss is done using Agilent 720ES S-parameter network analyzer (50 MHz–20 GHz). Results obtained indicates that both proposed antennas provide triple operating frequencies of 0.92 GHz, 2.45 GHz and 5.8 GHz for VSWR $<$ 2.6. The measured results are quite similar to those of the simulated results. The slightly different readings are obtained from the simulation due to the fabrication and measurement error.

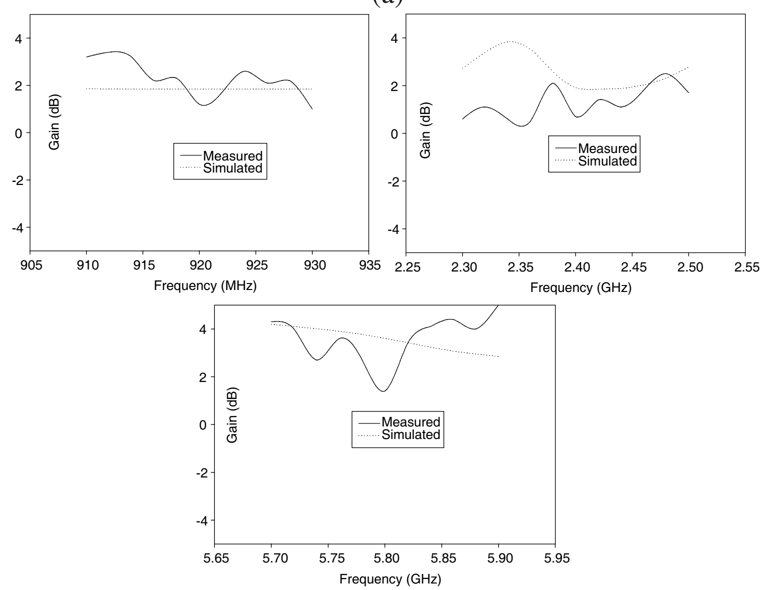
Table 1 tabulates the simulated and measured results of triple-band printed dipole antenna in term of input return loss, bandwidth and gain. The measured bandwidth is recorded for VSWR $<$ 2.6 and the developed antennas are considered narrowband antennas. For triple-band printed straight dipole antenna, the differences between the simulated and measured gain of the antenna are 0.4 dB, 0.7 dB and 0.2 dB at 0.92 GHz, 2.45 GHz and 5.8 GHz respectively. Differences of 0.6 dB, 0.4 dB and 2.2 dB at 0.92 GHz, 2.45 GHz and 5.8 GHz are obtained for triple-band printed meandered dipole antenna.

Graphs of measured and simulated gain versus frequency for straight and meandered triple-band printed dipole antennas are plotted in Figure 6.

The radiation patterns of the fabricated antenna are measured in anechoic chamber. The measured E-plane radiation pattern at



(a)



(b)

Figure 6. The simulated and measured gain of triple-band printed dipole antenna (a) straight and (b) meandered.

Table 1. The simulated and measured results of triple-band printed dipole antenna (a) straight and (b) meandered.

	Frequency (GHz)					
	0.92		2.45		5.8	
	Sim	Mea	Sim	Mea	Sim	Mea
Return Loss (dB)	−23.5	−15.3	−10.5	−7.7	−14.7	−7.9
Bandwidth (GHz)	0.14	0.14	0.11	0.15	0.4	0.1
Gain (dB)	1.9	1.5	2.4	1.7	3.1	2.9

(a)

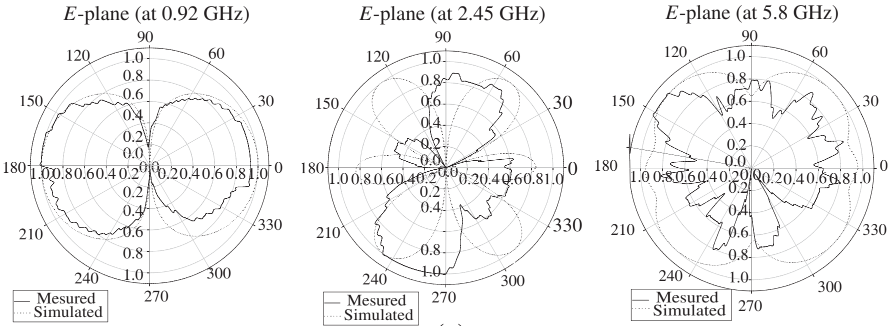
	Frequency (GHz)					
	0.92		2.45		5.8	
	Sim	Mea	Sim	Mea	Sim	Mea
Return Loss (dB)	−8.8	−10.9	−11.5	−9.0	−13.7	−12.7
Bandwidth (GHz)	0.12	0.12	0.07	0.1	0.4	0.4
Gain (dB)	1.8	1.2	1.9	1.5	3.6	1.4

(b)

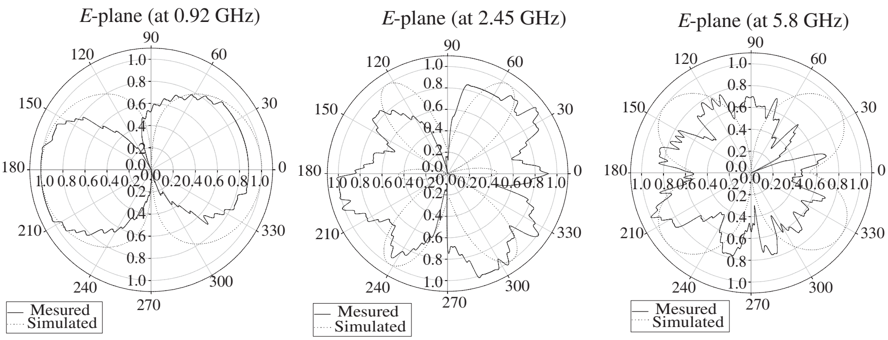
0.92 GHz, 2.45 GHz and 5.8 GHz is presented in Figure 7. The patterns exhibit 8-shaped omni-directional pattern at 0.92 GHz. Circular radiation patterns are observed for H-plane for these triple-band antennas.

4. MEASUREMENT ON TRI-BAND PRINTED DIPOLE ANTENNA

Then, the fabricated antenna is integrated with the ASIC microchip (902–928 MHz) to become a passive UHF tag. The developed passive UHF straight and meandered triple-band printed dipole tag antenna is shown in Figure 8. So, the port at the middle of the antenna is replaced by the microchip. It is required to connect the chip to the radiating element by soldering it carefully. Then, the performance of the tag is tested by measuring the reading distance. The reading distance of 3.5 m and 2.5 m is measured for straight and meandered dipole. The measurement is taken using UHF Gen2 SDK Module. Hence, it indicates that the developed tags can be used for UHF RFID system.



(a)



(b)

Figure 7. The simulated and measured radiation pattern of triple-band printed dipole antenna at 0.92 GHz, at 2.45 GHz and at 5.8 GHz (a) straight and (b) meandered.

(a)

(b)

Figure 8. Fabricated passive UHF tri-band printed dipole tag antenna (a) straight and (b) meandered.

5. CONCLUSION

A straight and meandered printed triple-band dipole antenna resonated at 0.92 GHz, 2.45 GHz and 5.8 GHz have been presented in this paper. The performance of the antenna is investigated and analyzed. With this antenna, it will become a passive triple-band dipole tag when it is integrated with the ASIC microchip. The tested reading distance shows that the passive tag can be used for UHF system.

6. FUTURE WORK

For future work, this triple-band printed dipole antenna will be integrated with the 2.45 GHz and 5.8 GHz microchip. So that it can be used for passive Microwave Frequencies RFID system. The reading distance of this passive tag then must be recorded to verify its performance.

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