Triple-band Printed Dipole Tag Antenna for RFID Application

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1. Introduction

In this paper, a triple-band printed dipole tag antenna is proposed for RFID application. The tri-band printed dipole antenna is designed at 0.92 GHz, 2.45 GHz and 5.8 GHz using Computer Simulation Technology (CST). In order to achieve triple-band operation, the proposed antenna contains two branch elements, which acts as an additional resonator. The designed antenna was fabricated using Taconic RF-35 substrate with a dielectric constant of 3.5 and thickness of 0.508 mm. The antenna's parameters for triple-band operation are investigated and discussed. Then, this fabricated antenna is integrated with the UHF (902-928 MHz) 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.

2. Passive RFID System

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 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 tag by electromagnetic wave [1]. 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.

3. Triple-band Printed Dipole Antenna

Printed dipole antenna 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 by [2]. 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 ~ 1870 MHz), IMT-2000 (International Mobile Telecommunication-2000: 1920 ~ 2170 MHz), and ISM (Industrial Scientific and Medical: 2400 ~ 2483.5 MHz). Based on [3], 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). In this paper, a triple-band printed dipole antenna is constructed based on a printed triple-band monopole antenna that was proposed by [4]. Then, the developed antenna is 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.

4. Antenna Design

The triple-band dipole is printed on one side of Taconic substrate with substrate size of 145 mm x 20 mm. The substrate properties are (dielectric constant = 3.5, thickness = 0.508 mm and tangent loss = 0.0019). In order to achieve a triple-band operation, the prime dipole antenna is connected to the two branch elements, which acts as an additional resonator to resonate at 2.45 GHz and 5.8 GHz. The structure of the designed triple-band printed dipole antenna is shown in Figure 1. A 2.0 mm gap at the centre of the antenna is connected by a discrete port of 50Ω. Figure 1 also shows the surface current at 0.92 GHz.

The effects of the parameters on the frequency shift or the input impedance are also investigated. It is found that the length of the prime dipole and length of the branch elements give significant effect on resonant frequency or input impedance of the antenna. Figure 2 shows the graph of optimized simulated return loss and input impedance of the antenna for l_1 *= 67.0 mm,* l_2 *= 18.1 mm and* l_3 *= 11.6 mm* respectively. Referring to Figure 2 (a), the antenna is resonated at three resonant frequencies. 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. While the input impedances of these three frequencies are 56.9Ω, 50.8Ω and 51.0Ω respectively.

The parameter that affects only the highest resonant frequency is the distance between port and the branch elements (*h)*. Figure 3 (a) shows the simulated return loss with different value of *h*. But in Figure 3 (b), it shows that the middle and the highest frequencies will be shifted to the left when the length of the branch (*br*) is increased. Based on Figure 3 (b) also, the unwanted resonant frequency around 5 GHz is introduced with smallest value of *br*.

5. Comparison between Simulation and Measurement Results

The measurement of return loss is taken using Agilent 8720ES S-parameter network analyzer (50 MHz – 20 GHz). From the results obtained, it indicates that the proposed antenna provides triple operating frequencies of 920 MHz (880 - 1020 MHz), 2450 MHz (2350 - 2500 MHz), and 5800 MHz (5770 - 5870 MHz) for VSWR<2.6. The measured return loss is quite similar to those of the simulated return loss. Slightly different readings are obtained from the simulation due to the fabrication 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 antenna is considered a narrowband antenna. From this table, it shows that the different reading between the simulated and measured gain of the antenna is 0.4dB, 0.7dB and 0.2dB at 0.92 GHz, 2.45 GHz and 5.8 GHz respectively.

The radiation pattern of the fabricated antenna is measured in anechoic chamber. The measured E-plane radiation pattern at 0.92 GHz, 2.45 GHz and 5.8 GHz is presented in Figure 4. The patterns exhibit omni-directional pattern at 0.92 GHz. A circle radiation patterns are observed for H-plane for this triple-band antenna.

6. Measurement on Triple-band Printed Dipole Tag Antenna

Then, the fabricated antenna is integrated with the ASIC microchip (902-928 MHz) to become a passive UHF tag. The developed passive UHF triple-band printed dipole tag antenna is shown in Figure 5. 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. Thus, the measured reading distance of 3.5 mm is recorded by using UHF Gen2 SDK Module. Hence, it indicates that the developed tag can be used for UHF RFID system.

7. Conclusion

A printed triple-band dipole antenna resonated at 0.92 GHz, 2.45 GHz and 5.8 GHz has been presented in this paper. The performance of the antenna is investigated and analyzed. With this antenna, it becomes 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.

8. 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. This antenna also will be optimized to reduce the antenna's size.

9. Figures and Tables

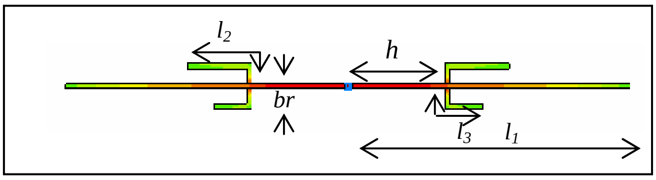

Figure 1: The Structure of the Designed Triple-Band Printed Dipole Antenna and Surface Current at 0.92 GHz

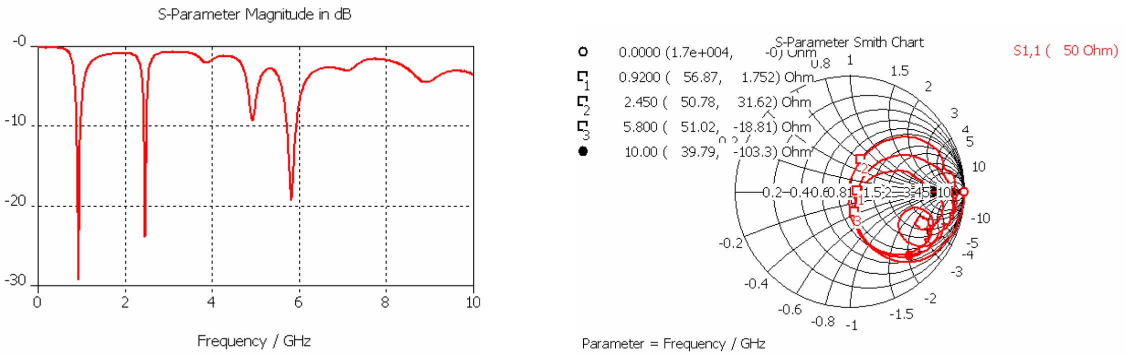

Figure 2: (a) Simulated Return Loss and (b) Simulated Input Impedance of Designed Triple-Band Printed Dipole Antenna

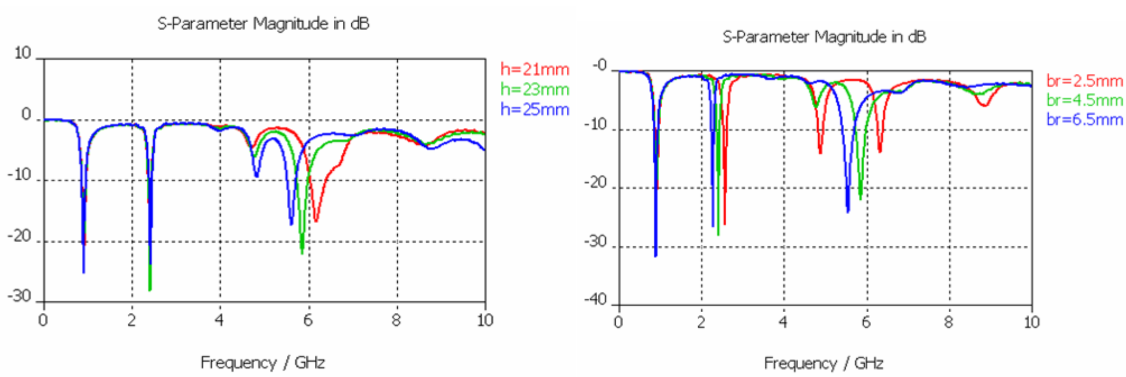

Figure 3: Simulated Return Loss with Different Value of (a) *h* and (b) *br*

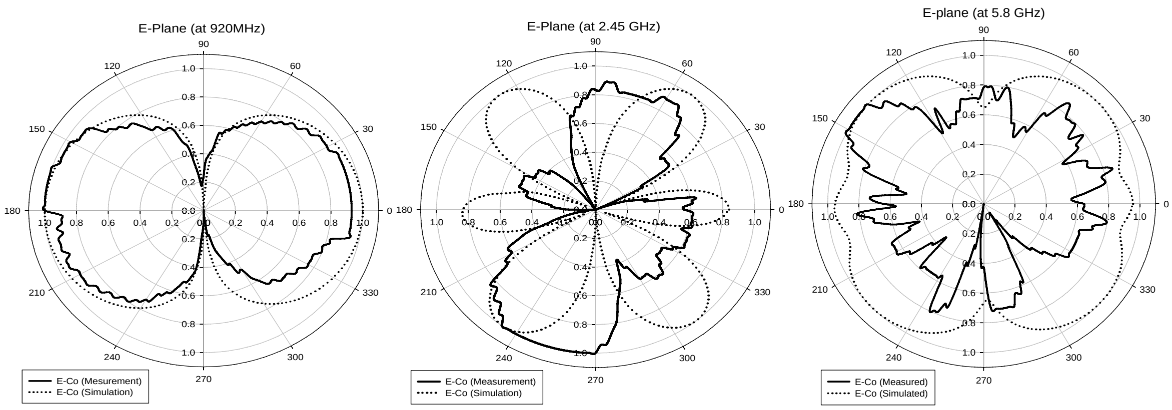

Figure 4: Simulated and Measured Radiation Pattern of Triple-Band Printed Dipole Antenna
(a) at 0.92 GHz, (b) at 2.45 GHz and (c) at 5.8 GHz

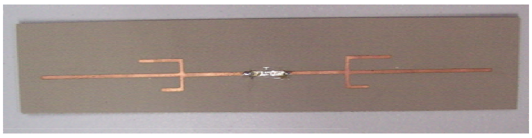

Figure 5: Fabricated Passive UHF Triple-Band Printed Dipole Tag Antenna.

Table 1: Simulated and Measured Results of Triple-band Printed Dipole Antenna

	Frequency (GHz)					
	0.92		**2.45**		**5.8**	
	Simulated	**Measured**	**Simulated**	**Measured**	**Simulated**	**Measured**
Return Loss (dB)	-23.5	-15.3	-10.5	-7.7	-14.7	-7.9
Bandwidth (MHz) (VSWR<2.6)	140	140	110	150	400	100
Gain (dB)	1.9	1.5	2.4	1.7	3.1	2.9

References

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[4]M. John and M. J. Ammann, "Integrated antenna for multiband multi-national wireless combined with GSM1800/PCS1900/IMT2000+Extension", Microwave and Optical Technology Letters, vol. 48, No. 3, pp. 613-615, March 2006.