Multi-band Dipole Antenna Incorporated with Single-band Square-patch AMC

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1. Introduction

Recently, there has been increasing interest in investigating metamaterial structures that exhibit novel electromagnetic properties not found in nature. The metamaterial structures include the Artificial Magnetic Conductor (AMC) which is known as Perfect Magnetic Conductor (PMC). AMC has high impedance surface exhibits a reflectivity of +1 oppose to a perfect electric conductor (PEC) which has a reflectivity of -1 [1, 2]. The AMC condition is characterized by the frequency or frequencies where the phase of the reflection coefficient is zero degrees. The important characteristic of the AMC is this structure has a reflected wave in phase with the incident wave.

Generally, a meandered or folded dipole film tag antenna has been popular for Radio Frequency Identification (RFID) tag antenna structure. When the antenna is attached to a metallic object, the dipole tag antenna cannot be powered up by the field strength emitted by the reader since the metallic object reflects RF wave. The impedance of the tag antenna, resonant frequency of the antenna and radiation efficiency will be changed due to the parasitic capacitance between the tag antenna and the metallic object [3, 4]. To minimize effects of the parasitic capacitor between the dipole antenna and metallic object and the effect of the reflection of the RF wave by metallic object, a gap between tag antenna and the metallic object is placed and dielectric material between them is added [5]. But in [6], they stated that the tag performance mainly due to various kinds of platform materials can be prevented and the antenna gain also can be increased when AMC is used as a ground plane to the low-profile antenna. The AMC structure was studied in [7] to make a low-profile passive RFID tag whose performance is tolerant to metallic objects.

In this paper, the design and performance of printed dipole antenna with high impedance surface (HIS) ground plane using Artificial Magnetic Conductor (AMC) is presented. The dipole antenna with straight and meandered structure is proposed to cover three RFID frequencies; 0.92GHz, 2.45GHz and 5.8GHz. Then, the dipole antenna is incorporated with single-band 5.8GHz AMC which is square-patch frequency selective surface backed by a ground plane. The performance of the antenna with and without the AMC layer is discussed including the input return loss, realized gain and radiation efficiency.

2. Multi-band Printed Dipole Antenna Design

Multi-band printed dipole antennas proposed in [8] are applied and then these antennas are incorporated with single-band 5.8GHz AMC ground plane (GP). The fabricated antennas are shown in Figure 1. In order to achieve multi-band operation, the prime dipole antenna (0.92GHz) is connected to the two branch elements which act as an additional resonator to resonate at 2.45GHz and 5.8GHz. The length of the prime dipole is meandered to reduce the antenna's size. So, by using the meandering technique, the overall size of the antenna is reduced up to 27%. The radiating elements of the antenna are printed on one side of the dielectric substrate that has a permittivity of 3.5 and thickness of 0.508mm. The simulated and measured return loss of the dipole antennas are shown in Figure 2.

3. AMC Design at 5.8GHz

As shown in Figure 3, the presented AMC structure composed the square-patch capacitive frequency selective surface (FSS) backed by a ground plane or PEC with thickness of 0.035mm. The equation involved in this HIS design is given in (1) – (4). From the equation given, there are four important parameters in AMC design. They are gap between a unit cell or lattice (*g*), patch size (*w*), substrate permittivity (ε_r) and substrate thickness (*d*).

Resonant frequency, $$f_r = \frac{1}{2\pi\sqrt{LC}} \quad (1)$$

Capacitance, $$C = \frac{\varepsilon_0 (1+\varepsilon_r) w}{\pi} \cosh^{-1}\left(\frac{2w+g}{g}\right) \quad (2)$$

Inductance, $$L = \mu_0 d \quad (3)$$

Bandwidth, $$BW = \frac{f_u - f_L}{fr} \quad (4)$$

where ε_0 and μ_0 are permittivity and permeability of the free space, f_u is the upper frequency when the reflection phase equals -90°, f_L is the lower frequency when the reflection phase equals +90° and f_r is the centre frequency when the reflection phase equals 0°.

4. Dipole Antenna with AMC structure

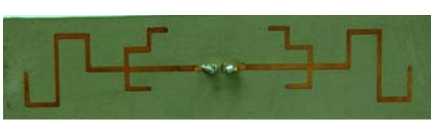
Referring to Figure 4, the printed dipole antennas are placed just above the AMC layer. The overall dimension for Figure 4(a) is 145mm x 20mm x 6.963mm and Figure 4(b) is 105mm x 20mm x 6.963mm. The simulated realized gain of straight and meandered dipole antenna with and without 5.8GHz AMC GP are plotted in Figure 5. For straight and meandered dipole antenna with AMC structure, the increment of 4.6dB and 3.4dB is recorded in gain (see Figure 5). Furthermore, from Figure 6, it shows that the measured power received of dipole antenna with AMC GP is higher than power received of dipole antenna with absent of AMC GP. The data in Table 1 shows that the simulated and measured return loss of the antenna with AMC layer. The measured and simulated return loss is matched.

5. Conclusion

The square-patch single-band 5.8GHz AMC is presented here and the performances of the dipole antenna with and without AMC structure are discussed. From the obtained results, it can be concluded that, when the AMC is introduced as a ground plane to the dipole antenna, the radiation properties of the antenna can be improved. This is due to the AMC characteristic that has in-phase image current with the incident current. So it enhances the radiation efficiency of the antenna and thus it improves the antenna's gain. Hence, the results of this research will be useful to RFID applications with metal environment.

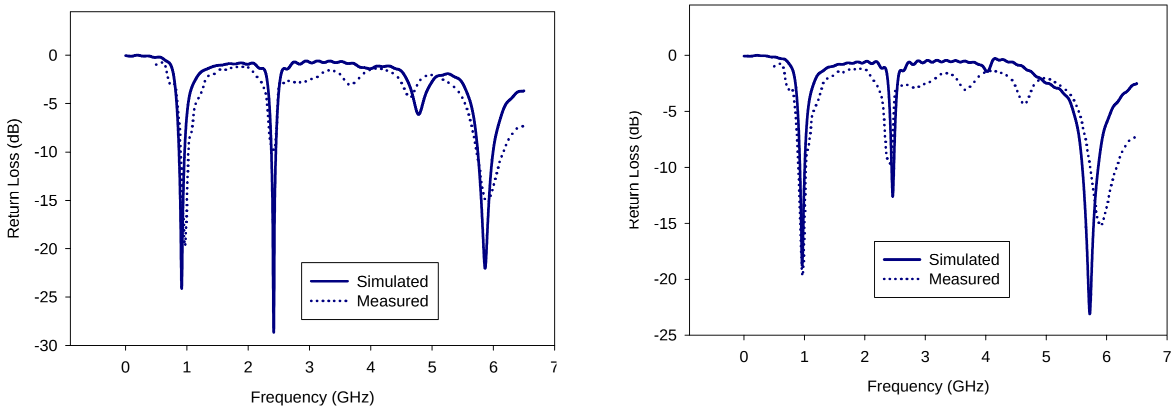
6. Figures and Tables

(a)



(b)

Figure 1: The Fabricated Multi-band Dipole Antennas: (a) Straight and (b) Meandered



(a) (b)

Figure 2: The Simulated and Measured Return Loss of Multi-band Printed Dipole Antennas: (a) Straight and (b) Meandered

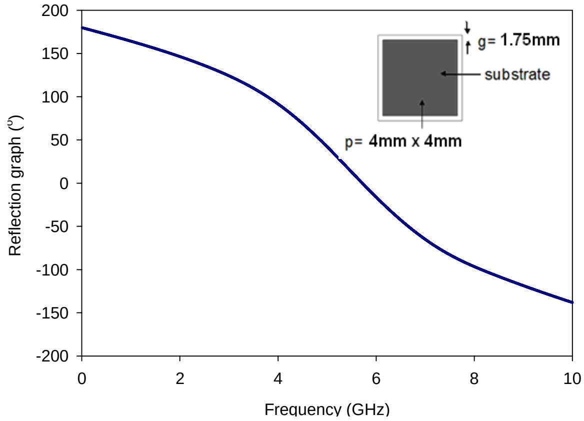
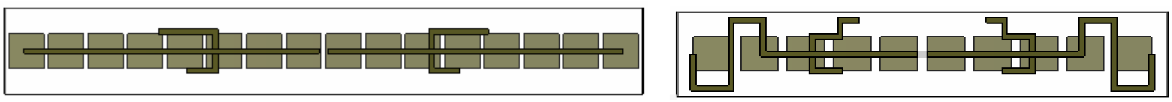
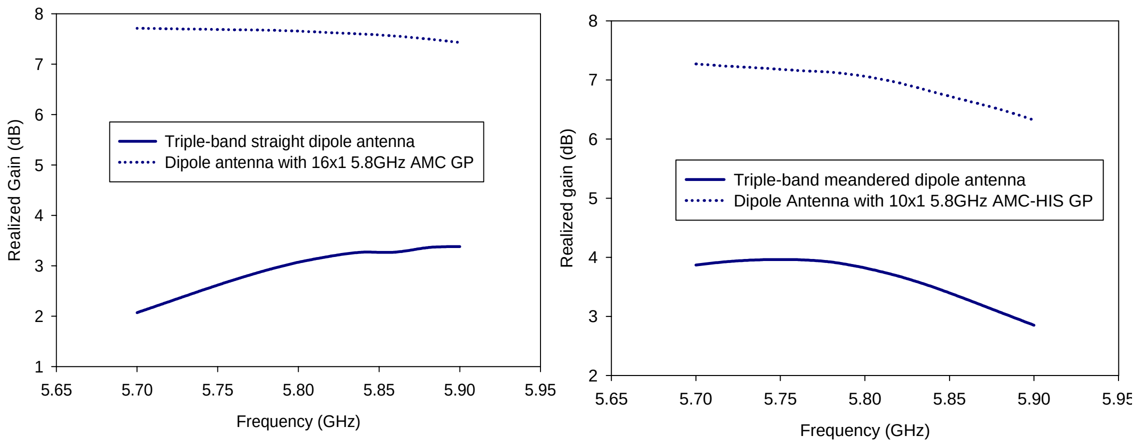


Figure 3: Reflection Graph of Single-band 5.8GHz AMC



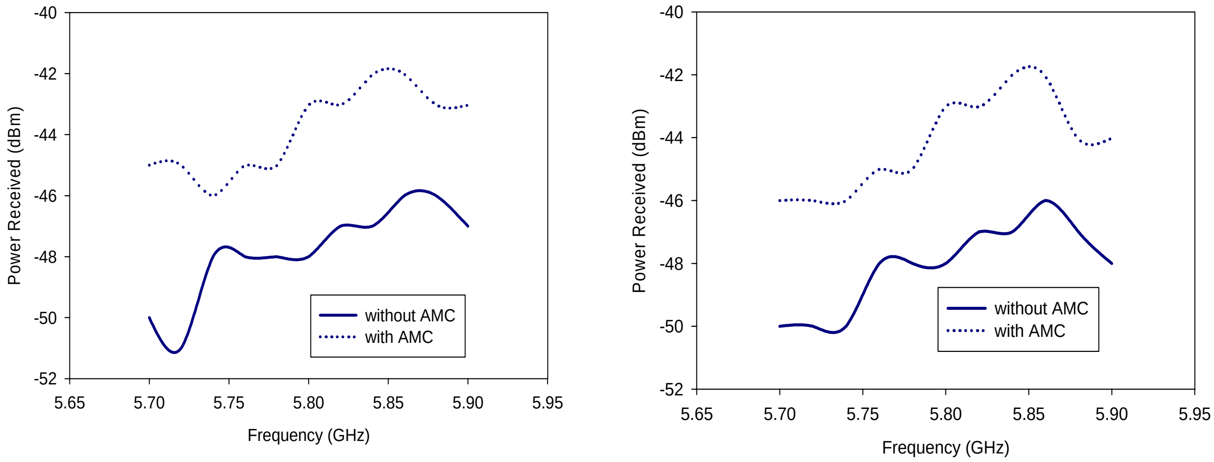
(a) (b)

Figure 4: (a) Multi-band Straight Dipole Antenna Incorporated with 16x1 5.8GHz AMC GP and (b) Multi-band Meandered Dipole Antenna Incorporated with 10x1 5.8GHz AMC GP



(a) (b)

Figure 5: The Simulated Realized Gain of: (a) Straight and (b) Meandered Dipole Antenna with and without 5.8GHz AMC GP



(a) (b)

Figure 6: The Measured Power Received of: (a) Straight and (b) Meandered Dipole Antenna with and without 5.8GHz AMC GP

Table 1: Simulated and Measured Return Loss of Multi-band Dipole Antennas with 5.8GHz AMC

	Return Loss (dB)	
	Simulated	**Measured**
Multi-band straight dipole antenna with 5.8GHz AMC	-17.79	-14.38
Multi-band meandered dipole antenna with 5.8GHz AMC	-13.91	-16.95

Acknowledgments

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