View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by Universiti Teknikal Malaysia Melaka (UTeM) Repository

Proceedings of the International Conference on Computer and Communication Engineering 2010 May 13-15, 2010 Kuala Lumpur, Malaysia

A Triple-band Dipole Antenna with 0.92 GHz AMC-HIS

Maisarah Abu[1], M. K. A. Rahim[1], M. K. Suaidi[2], I. M. Ibrahim[2], N. M. Nor[2]
[1]Radio and Communication Engineering Department, Faculty of Electrical Engineering, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia.
[2]Telecommunication Eng. Department, Faculty of Electronic and Computer Engineering, Universiti Teknikal Malaysia Melaka (UTeM), Karung Berkunci No. 1752, Pejabat Pos Durian Tunggal, 76109, Durian Tunggal, Melaka, Malaysia.
maisarah@utem.edu.my

Abstract

A triple-band dipole antenna integrated with 0.92 GHz Artificial Magnetic Conductor (AMC) is presented. The AMC structure is called a high-impedance surface (HIS) structure and is useful as a ground plane to the dipole antenna. This structure can be used to prevent the degradation of tag and antenna performance caused by the conductive materials (metal objects) and to increase the antenna gain. This paper begins by investigating the parameters in AMC design such as a patch and gap size. The AMC is characterized by the frequency where the phase of the reflection coefficient is zero degrees and has reflected wave in-phase with the incident wave.

I. Introduction

Radio Frequency Identification (RFID) is rapidly becoming an accepted automatic identification technology in many industries. RFID technology has been implemented in various sectors, including transportation, retail, health care and supply chain management. The RFID systems consist of RFID reader (interogrator), RFID antenna, RFID tag (transponder) and host computer. In many applications of RFID, the metallic objects need to be identified. However, the generally used label-fabricated RFID tags do not work attached to metal. The electromagnetic wave is reflected almost entirely by the metallic surface and a 180° phase shift is occurred. This causes poor radiation efficiency and return loss of the tag antenna [1-5]. The ability of RFID system to read near metal is become worst at higher RFID frequencies. Therefore the new tag antenna designs that can be mounted on metallic objects need to be developed.

High-impedance surface has been studied extensively over past few years. Artificial Magnetic Conductor (AMC) is an artificial structure showing high impedance property in a certain frequency range. An ideal AMC also known as a Perfect Magnetic Conductor. It is understood as a prominent candidate for a ground plane of low-profile antennas. Having high surface impedance (Z_s), it reflects the external electromagnetic waves without the phase reversal [6, 7]. There are two main advantages when AMC is used as a ground plane. Severe degradation of tag performance caused by the conductive materials can be prevented and the antenna gain also can be increased [8].

II. A Triple-band Dipole Antenna

A triple-band dipole antenna operating at 0.92 GHz, 2.45 GHz and 5.8 GHz was proposed in [9]. The proposed antenna was fabricated on one side of the substrate with substrate permittivity of 3.5 and thickness of 0.508mm respectively. As shown in Figure 1, the antenna consists of two branch elements to radiate at 2.45 GHz and 5.8 GHz connected to the prime dipole element (0.92 GHz). The input return loss of the proposed structure is plotted in Figure 2.

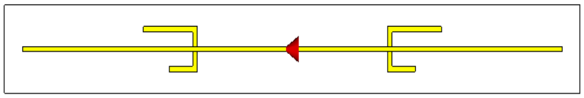


Figure 1. A triple-band dipole antenna

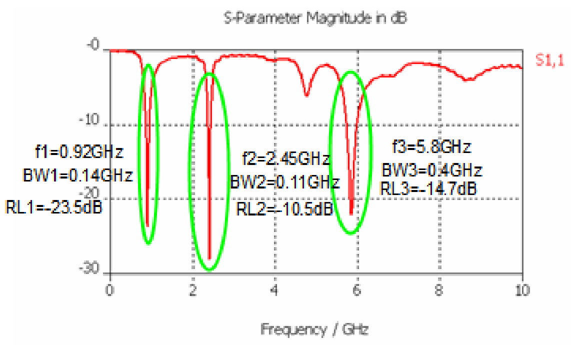


Figure 2. The input return loss of triple-band dipole antenna

III. 0.92 GHz AMC-HIS DESIGN

The designed AMC-HIS as shown in Figure 3 is a square patch structure printed on the substrate which has a permittivity of 3.2 and substrate thickness of 6.35mm and backed by a Perfect Electric Conductor (PEC) with 0.035mm thickness. A unit cell of this structure has a patch size of 67.5mm x 67.5mm and gap, *g* of 1.25mm. Figure 4 plots a reflection phase diagram of a unit cell of the designed AMC structure. The obtained bandwidth of this AMC-HIS structure is 12.12% (0.8743 GHz – 0.9803 GHz) where it is given by a ± 90° of the reflection phase graph. As can be seen in this figure, when the gap between the unit cells is increased, the resonant frequency (where the reflection phase is zero) and bandwidth will increase. While Figure 5 demonstrates the reflection phase of AMC-HIS with different patch sizes. When the patch size is increased, the resonant frequency and bandwidth will decrease. Referring to Figure 6, the impedance of the designed structure is very high at 0.92 GHz. This structure is simulated with a time-domain solver of Computer Simulation Technology (CST) software. The detail about simulation of a unit cell of high impedance structure is explained in [10].

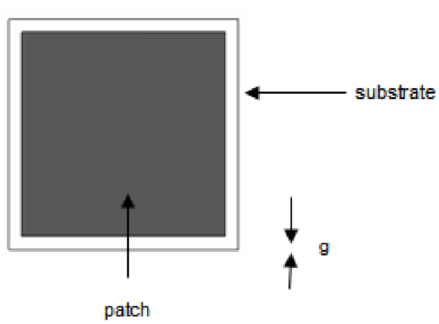


Figure 3. A unit cell of 0.92 GHz AMC-HIS

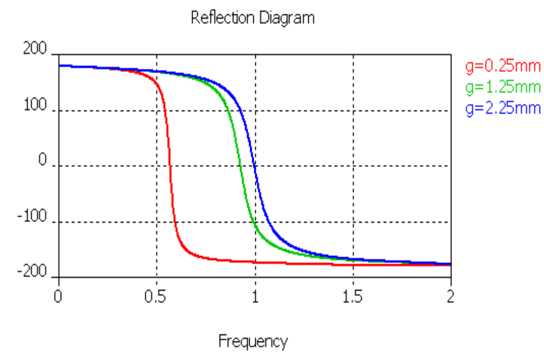


Figure 4. A reflection phase diagram of AMC-HIS with different gap sizes

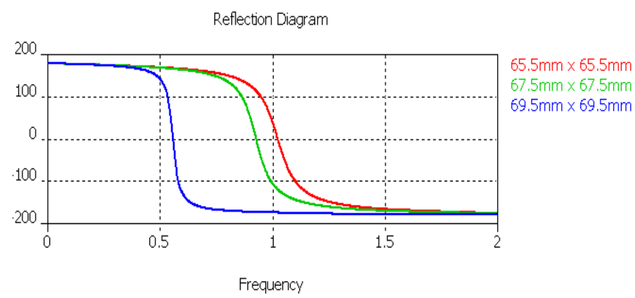


Figure 5. A reflection phase diagram of AMC-HIS with different patch sizes

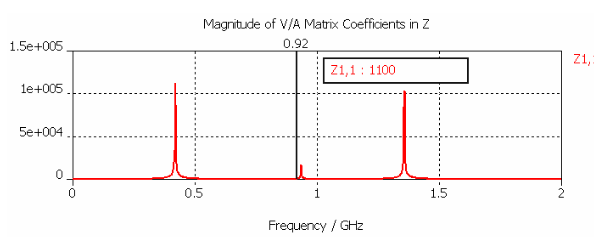
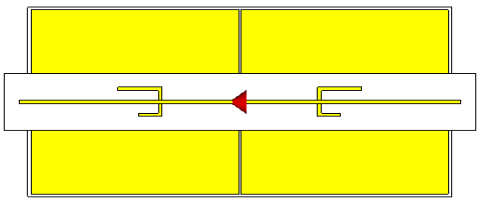


Figure 6. The simulated impedance of 0.92 GHz AMC-HIS

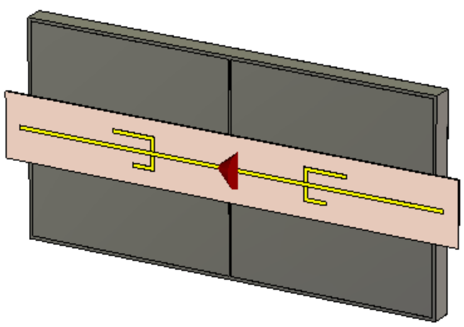
IV. THE PERFORMANCE OF TRIPLE-BAND DIPOLE ANTENNA WITH 0.92 GHZ AMC-HIS AND PEC GROUND PLANE

Figure 7 (a) and (b) show the proposed antenna in [9] is attached to the designed 0.92 GHz AMC-HIS and PEC structure. The performances of the antenna with 0.92 GHz and PEC ground plane are studied including the input return loss, radiation efficiency, directivity and gain. Figure 8 plots the input return loss of the antenna with AMC-HIS and PEC ground plane. It shows that, poor return loss and poor radiation efficiency are found when the antenna is attached directly to the PEC structure. But the advantage is the antenna directivity is increased. Here, the PEC is act as a reflector. The radiation pattern of the dipole antenna, dipole antenna with AMC GP and dipole antenna with PEC GP is plotted in Figure 9. As can be seen in this figure, the radiation pattern is changed from omni to directional pattern. The realized gain of the antenna is given as a multiplication of total radiation efficiency and the directivity. Very poor realized gain is obtained because the total radiation efficiency is very low.

$$RG = \mu_{tot}\, x\ Directivity \quad (1)$$



(a)



(b)

Figure 7. The triple-band dipole antenna attached to the: (a) 0.92 GHz AMC-HIS (front view) and (b) PEC structure (perspective view)

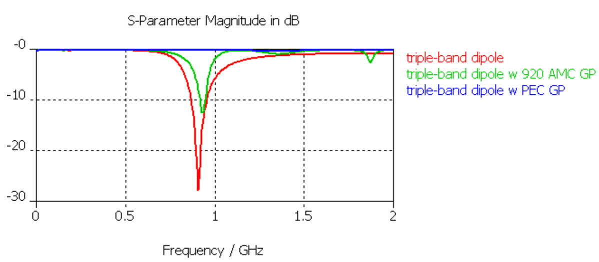


Figure 8. The input return loss of triple-band dipole antenna, triple-band dipole antenna with 0.92 GHz AMC-HIS and triple-band dipole antenna with PEC GP

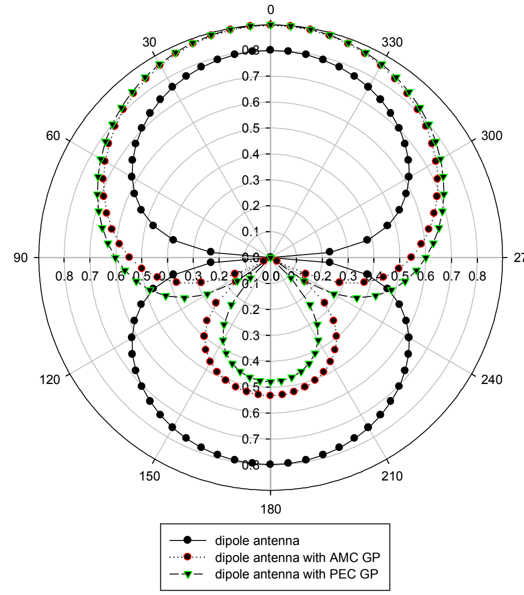


Figure 9. The radiation pattern of the dipole antenna, dipole antenna with 0.92 GHz AMC GP and dipole antenna with PEC GP

Table 1 tabulates the performance of triple-band dipole antenna, triple-band dipole antenna with 0.92 GHz AMC-HIS ground plane (GP) and triple-band dipole antenna with PEC GP. As a conclusion, with AMC ground plane, the performances of the antenna are improved. The simulated input return loss is -10.16 dB with high gain and radiation efficiency of 5.20 dB and 86.66% respectively.

TABLE I. THE PERFORMANCE OF TRIPLE-BAND DIPOLE ANTENNA, TRIPLE-BAND DIPOLE ANTENNA WITH 0.92 GHz AMC-HIS GP AND TRIPLE-BAND DIPOLE ANTENNA WITH PEC GP AT 0.92 GHz

	Return loss (dB)	Realized Gain (dB)	Radiation Efficiency (%)	Directivity (dBi)
Triple-band dipole antenna	-23.50	1.90	99.46	1.95
Triple-band dipole antenna with PEC GP	-0.06	-25.54	5.71	5.91
Triple-band dipole antenna with 0.92 GHz AMC-HIS GP	-10.16	5.20	86.66	5.82

V. CONCLUSION

The great majority of commercial UHF RFID tags are based on dipole antennas and it is well-known that the tag performance will degrade significantly when placed near a conducting surface. But, with introducing the Artificial Magnetic Conductor as a ground plane to the tag or antenna, return loss, radiation efficiency and gain of the tag or antenna can be improved. This is because the AMC structure provides in-phase image currents or it does not cancel the antenna current. Hence it enhances the radiation efficiency and gain of the antenna.

REFERENCES

[1] Elaine M. Cooney, *"RFID+: The Complete Review of Radio Frequency Identification"*, *Thomson Delmar Learning*, pp. 97-109, 2006.

[2] Zhi Ning Chen, "*Antenna for Portable Devices*", *John Wiley & Sons*, pp. 71-72, 2007

[3] P. R. Foster, R.A. Burberry, "Antenna Problems in RFID systems*"*, *IEE Colloquium on RFID Technology* (Ref. No. 1999/123), Pages: 3/1 - 3/5, 25 Oct. 1999.

[4] Leena Ukkonen, Lauri Sydanheimo, Markku Kivikoski, "Patch Antenna with EBG Ground Plane and Two-layer Substrate for passive RFID of Metallic Objects", *Proc 2004 IEEE AP-S*, Vol. 1, pp. 93-96, 2004.

[5] Leena Ukkonen, Member, IEEE, Lauri Sydänheimo, Member, IEEE, and Markku Kivikoski, "Effects of Metallic Plate Size on the Performance of Microstrip Patch-Type Tag Antennas for Passive RFID"*, IEEE Antennas and Wireless Propagation Letters*, Vol. 4, 2005.

[6] Sievenpiper D., Lijun Zhang, Broas, R.F. J., Alexopolous, N.G., Yablonovitch, E, "High-Impedance Electromagnetic Surfaces with a Forbidden Frequency Band", *IEEE Trans. Microwave Theory Tech*., 47, pp. 2059 – 2074, 1999.

[7] Fan Yang and Rahmat Samii, "*Electromagnetic Band Gap Structures in Antenna Engineering",* Cambridge University Press, pp.156 – 201, 2009.

[8] Dongho Kim and Junho Yeo, "Low Profile RFID tag Antenna using Compact AMC substrate for Metallic Object", *IEEE Antennas and Wireless Propagation Letters*, Vol. 7, 2008.

[9] M. Abu and M. K. A. Rahim, *"Triple-Band Printed Dipole Tag Antenna For RFID",* Progress In Electromagnetics Research C, Vol. 9, 145–153, 2009.

[10] Xiaoxia Zhou, Franz Hirtenfelder, Zhiyuan Yu and Min Zhang, "Fast Simulation of High Impedance Surface Using Time Domain Solver"*, 2004 4th International Conference on Microwave and Millimeter Wave Technology Proceedings*, pp. 731-734, 2004.