Dual-Frequency Circular Patch Antenna for RFID Reader Application

Jun-Jiat Tiang[1,3], M. T. Islam[2], N. Misran[2, 3], and J. S. Mandeep[2, 3]
[1] Faculty of Engineering, Multimedia University
Persiaran Multimedia, 63100 Cyberjaya, Selangor, Malaysia
[2] Institute of Space Science (ANGKASA), Universiti Kebangsaan Malaysia
43600 Bangi, Selangor, Malaysia
[3]Department of Electrical, Electronic and Systems Engineering, Universiti Kebangsaan Malaysia
43600 Bangi, Selangor, Malaysia
jjtiang@mmu.edu.my[1], tariqul@ukm.my[2]

Abstract

This paper presents a new design of a dual-frequency circular patch antenna for RFID reader application. The dual-frequency is achieved by employing slot loading and meandering slits. By appropriately inserting the positions of slots and slits, the proposed RFID antenna exhibits dual operating frequencies at both the UHF band ranging from 850 MHz to 891 MHz and the microwave band frequency ranging from 2.44 GHz to 2.48 GHz. More importantly, it results in the size reduction for dual-frequency operation. The return loss and radiation pattern of the proposed antenna are presented.

Keywords : dual-frequency, microstrip antenna, RFID

1. Introduction

Microstrip patch antennas have been studied extensively due to their advantages such as small size, light weight, easy to integration with active device [1]. Much effort has been dedicated to the enhancement of multiband and miniaturization for the microstrip patch antennas. In [2-4], several designs of dual-band microstrip antenna have been reported. On the other hand, the microstrip antennas with miniaturization technologies have been studied in [5-6].

Radio frequency identification (RFID) is an automatic identification technology that uses principle of electromagnetic wave for data communication [7]. Passive RFID tag receives power from the RFID reader antenna for the identification of objects. In recent years, ultra high frequency (UHF) and microwave frequency bands attracts lots of attention in RFID application due to their long range and high data rate. Therefore, we have enough reason to include the UHF and microwave band in the dual-frequency operation of the proposed antenna.

In [8], dual-frequency is achieved by using slot loading and inserting slits to size of the microstrip antenna. In this paper, a new microstrip antenna is proposed by employing circular disk structure due to advantage of better impedance range and smaller size compared to rectangular patch antenna [9]. By appropriately inserting slots and slits to the circular patch antenna, the proposed antenna is optimized to meet the requirement of the dual-frequency for UHF and microwave frequency bands.

2. Antenna Structure

The geometry of the dual-frequency circular patch antenna is illustrated in Fig. 1. The proposed antenna is fabricated on an FR4 substrate of dielectric constant $\varepsilon_r = 4.55$ and loss tangent of 0.019. The proposed antenna is fed by a coaxial probe. It comprises a pair of slots which is placed close to the radiating edges. A use of five slits is applied to reduce the size of circular patch antenna. The dimension of the square ground plane is $a \times a$. Table 1 presents the proposed

dimensions of the dual-frequency printed circular patch antenna. The antenna parameters are simulated and optimized by CST Microwave Studio.

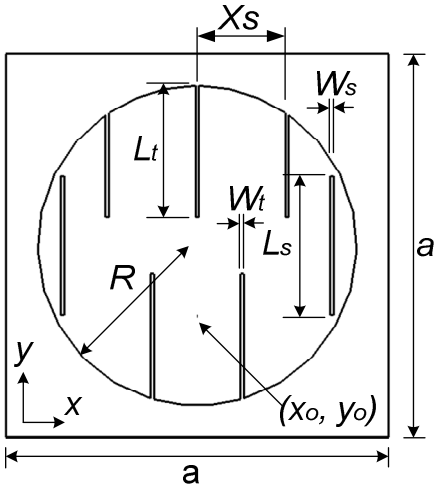


Figure 1: The geometry of the proposed antenna.

Table 1: Design specification of dual-frequency circular patch antenna

Substrate material	FR4
Relative permittivity of the substrate, ε_r	4.55
Thickness of the dielectric (h)	1.6 mm
Radius of the circular disk patch (R)	45 mm
Length of the slot, L_s	39 mm
Width of the slot, W_s	1 mm
Length of the slit, L_t	37 mm
Width of the slit, W_t	1 mm
Distance between the slits, X_s	25.333 mm
Feed location (x_o, y_o)	(0, -19.8 mm)
Square ground plane ($a \times a$)	(108 mm × 108 mm)

3. Results and Discussion

The return loss of the antenna with coaxial feed defined by the proposed parameters in Table 1 is simulated and the result is shown in Fig. 2.

The antenna bandwidth is characterized from 10 dB return loss. The simulation results for the UHF bandwidth of 41 MHz (from 850 MHz to 891 MHz) and the microwave bandwidth of 37.8 MHz (from 2.44 GHz to 2.48 GHz) are shown. Therefore, the potential of the dual-band operation for RFID reader application is covered.

Fig. 3 shows comparative plot of variation of return loss with three different antenna designs which consist of basic circular patch, slot loaded circular patch and circular patch with slot loading and meandering slits.

It is first found for the basic circular patch antenna, antenna resonates at 894 MHz and 2.5977 GHz. By loading a pair of slots to the radiating edges, the frequency ratio between UHF and microwave bands decreases. In order to reduce the size of the antenna the meandering slits are used by properly choosing the slit length. Therefore, the two operating frequencies are at UHF and microwave band region is achieved, which are suitable for RFID dual-frequency application.

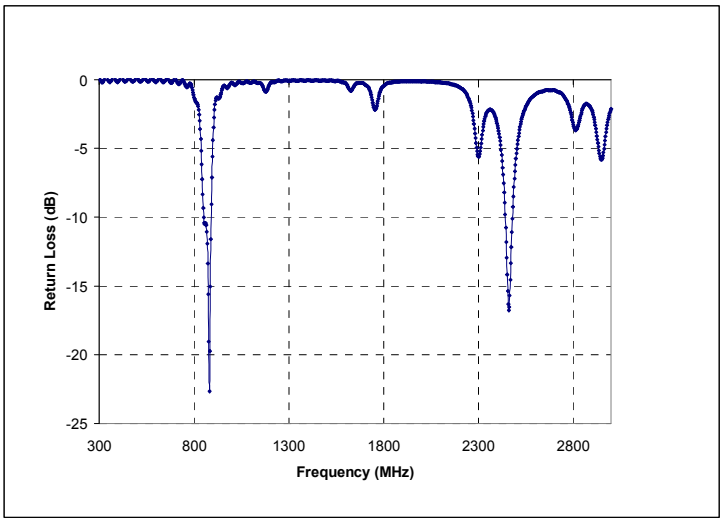


Figure 2: Magnitude of S11 versus frequency.

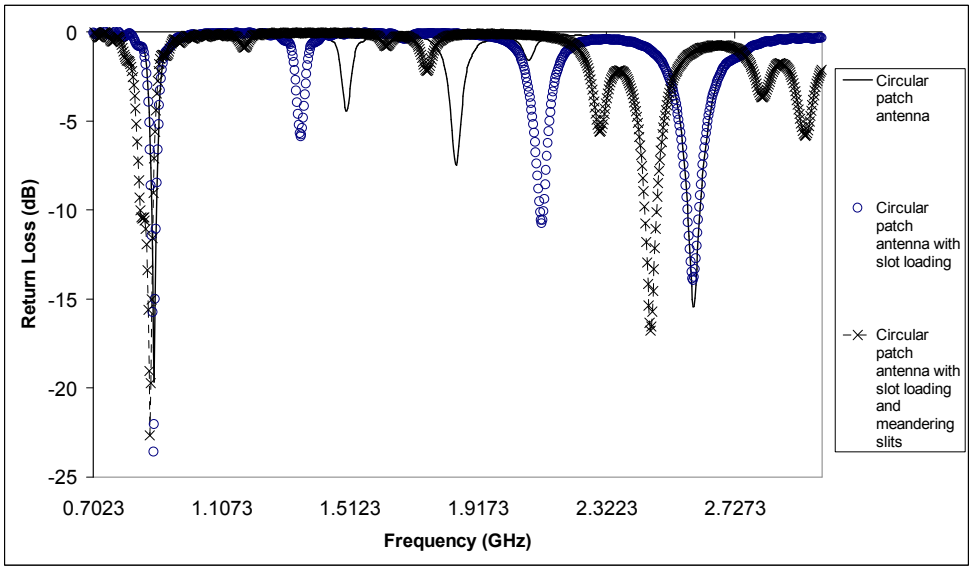
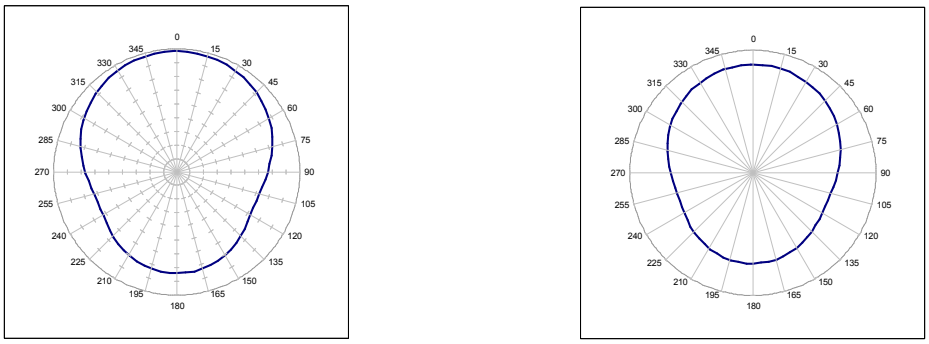


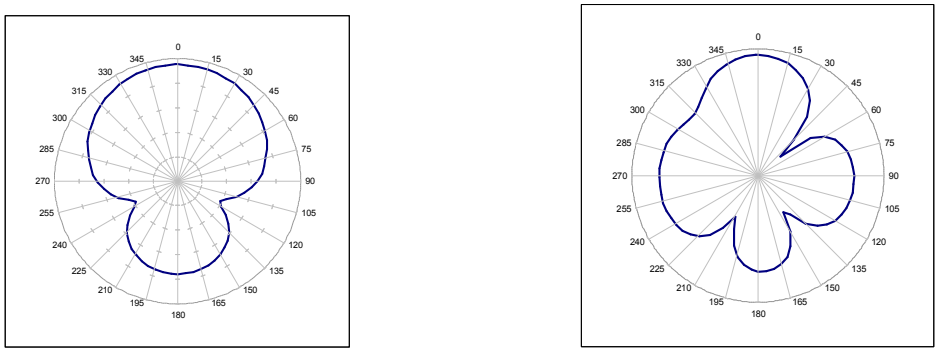
Figure 3: Effects of slot loading and meandering slits.

Fig. 4 and Fig. 5 show the radiation patterns for E-plane and H-plane of the proposed antenna in the operation bands. It is found that the unidirectional radiation pattern in both the UHF and microwave bands. At 870 MHz in UHF band, the antenna offers a gain of 5.355 dBi, at 2.45 GHz in microwave band, the antenna gain is 8.114 dBi.



(a) (b)

Figure 4: Simulated radiation patterns at 870 MHz (a) xz plane (b) yz plane.



(a) (b)

Figure 5: Simulated radiation patterns at 2.45 GHz (a) xz plane (b) yz plane.

4. Conclusions

A novel dual-frequency circular patch antenna fabricated on a single layer is presented. By applying slot loading and meandering slits, the proposed antenna provides two operating frequencies for the UHF and microwave RFID bands. The design results demonstrate the proposed circular patch antenna is feasible for RFID application with the advantages of low-profile, low-cost and dual-frequency characteristics.

References

[1] Y. T. Lo, D. Solomon, W. F. Richards, "Theory and Experiment on Microstrip Antennas," IEEE Transactions on Antennas and Propagation, vol. 27, no. 2, pp. 137 - 145, 1979.

[2] M. T. Islam, A. T. Mobashsher, and N. Misran, "A novel feeding technique for a dual band microstrip patch antenna," IEICE Transactions on Communications, vol.E93-B, No.9, pp.2455-2457, 2010.

[3] A. T. Mobashsher, M. T. Islam and N. Misran, "A Novel High Gain Dual Band Antenna for RFID Reader Applications," IEEE Antennas and Wireless Propagation Letters, vol. 9, pp. 653-656, 2010.

[4] M. T. Islam, A. T. Mobashsher, and N. Misran, "Design of a Microstrip Patch Antenna using a novel U-shaped Feeding Strip with Unequal Arm," Electronics Letters, vol. 46, No. 14, pp. 968-970, 2010.

[5] M. T. Islam, A. T. Mobashsher, and N. Misran, "Coplanar waveguide fed printed antenna with compact size for broadband wireless applications," Journal of Infrared, Millimeter, and Terahertz Waves (Springer US), vol.31, pp.1427–1437, 2010.

[6] M. N. Shakib, M. T. Islam and N. Misran, "Stacked Patch Antenna with Folded Patch Feed for Ultrawideband Application," IET Microwave, Antenna and Propagation, 4(10), pp. 1456-1461. ISSN 1751-8725,2010.

[7] J. Landt, "The History of RFID," IEEE Potentials, vol. 24 , no. 4, pp. 8 – 11, 2005.

[8] Jui-Han Lu, Kin-Lu Wong, "Slot-loaded, Meandered Rectangular Microstrip Antenna with Compact Dual Frequency Operation," Electronics Letters, vol. 34, no. 11, pp. 1048 – 1050, 1998.

[9] R. Garg, P. Bhartia, I. Bhal, A. Ittipiboon, Microstrip Antenna Design Handbook, Artech House, Norwood, MA, 2001.