# A DUAL-BAND CIRCULAR SLOT ANTENNA WITH AN OFFSET MICROSTRIP-FED LINE FOR PCS, UMTS, IMT-2000, ISM, BLUETOOTH, RFID AND WLAN APPLICATIONS

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**Abstract**—In this paper, a circular slot antenna fed by an offset microstrip-fed line is proposed. The antenna exhibits dual-band characteristics. The two operating frequency bands are: 1.83–2.73 GHz and 5.36–7.63 GHz, which are of impedance bandwidth 39.5% and 34.9% respectively. The bands are suitable for PCS, UMTS, IMT-2000, ISM, Bluetooth, RFID and WLAN applications. A parametric study has been carried out by varying the location of the feedline to investigate its effect on the resonant frequency. Impedance, radiation and gain characteristics of the proposed antenna are also presented and discussed.

## 1. INTRODUCTION

Printed slot antennas have been well-known in the past decades for its attractive merits such as wider bandwidth, less interaction via surface waves, better isolation and negligible radiation from feed networks [1]. In addition, they are low cost, low profile, light weight and easy to integrate with other planar circuits. Therefore, printed slot antennas have been investigated by many researchers all over the world [1–11].

Sze and Wong [2] proposed printed wide slot antenna fed by a microstrip line with a fork-like tuning stub operates from 1.82–2.4 GHz with the size of 110 mm × 110 mm. In [3, 4], square and rhombus-like slot antennas fed by mircostrip line have been reported. A printed

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elliptical/circular slot antenna for ultra-wideband applications has been studied by Li et al. [5]. The antenna is fed by a U-shaped tuning stub which increases the design procedures. A circular slot antenna of size 10 cm × 10 cm fed by a circular open-ended microstrip line is reported in [6].

In this paper, a simple circular slot antenna fed by a microstrip line is proposed and discussed. The microstrip line is dislocated from the centre of the antenna. This proposed antenna exhibits dual-band characteristics. The two operating bands (1.83–2.73 GHz and 5.36–7.63 GHz) are suitable for Personal Communication System (PCS 1.85–1.99 GHz), Universal Mobile Telecommunication System (UMTS 1.92–2.17 GHz), International Mobile Telecommunications-2000 (IMT 1.9–2.2 GHz), Industrial Scientific Medical (ISM 2.4–2.484 GHz), Bluetooth (2.3–2.55 GHz), Radio Frequency Identification (RFID 2.45 GHz) and Wireless Local-Area Network (WLAN 2.4–2.484 and 5.725–5.825 GHz) wireless applications. The antenna features a small size compared with those published in [1–9]. This work has been centred on some specific goals: wide bandwidth, simple design and low cost.

## 2. ANTENNA DESIGN

Figure 1 shows the geometry and dimensions of the proposed circular slot microstrip-line-fed antenna. Fig. 1(a) shows the front view of the antenna which comprises a circular slot of radius 20 mm at the centre of the substrate. The antenna is fed by a 50 Ω microstrip line of length 30 mm and width 3.064 mm, which is located 7.5 mm away from the centre of the antenna at the back of the slot, as shown in Fig. 1(b). The proposed antenna is printed on an economical FR4 substrate of thickness 1.6 mm and a dielectric constant of 4.4. The total area of the antenna is 50 mm × 50 mm. The prototype of the antenna is fabricated using photolithographic printing circuit technology following the dimensions given in Table 1. A photograph of the fabricated prototype is shown in Fig. 2.

**Table 1.** Dimensions of the proposed antenna.

| *Parameter* | *Value* (mm) |
|---|---|
| $r$ | 20 |
| $h$ | 30 |
| $f$ | 3.064 |
| $d$ | 7.5 |
| $W$ | 50 |
| $L$ | 50 |

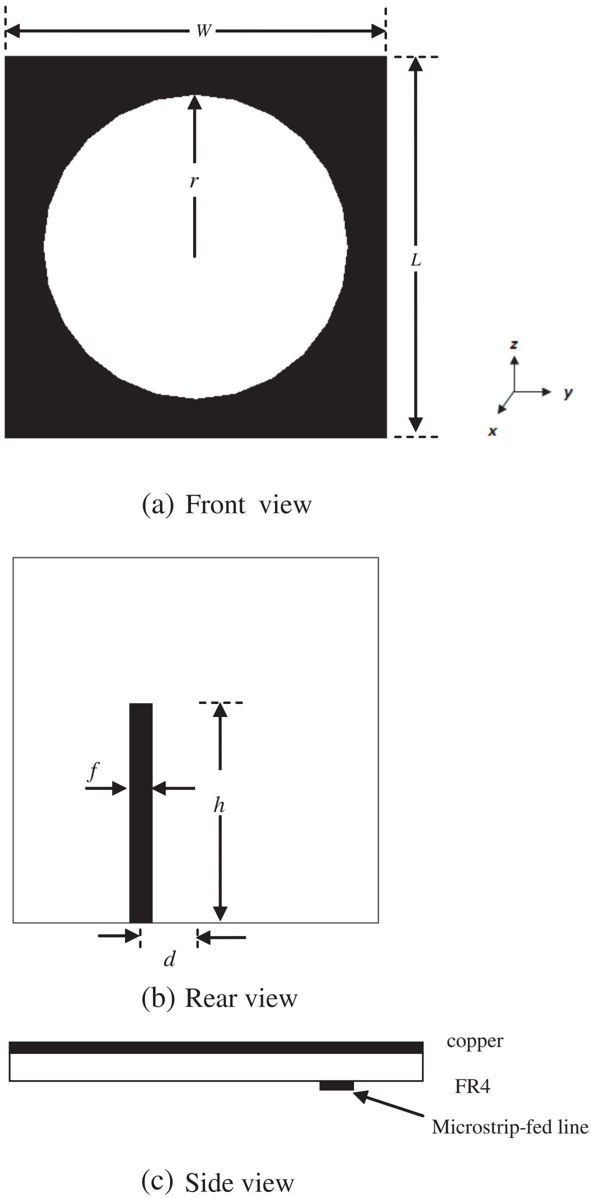



**Figure 1.** Structure of the proposed antenna: (a) Front view, (b) rear view, and (c) side view.

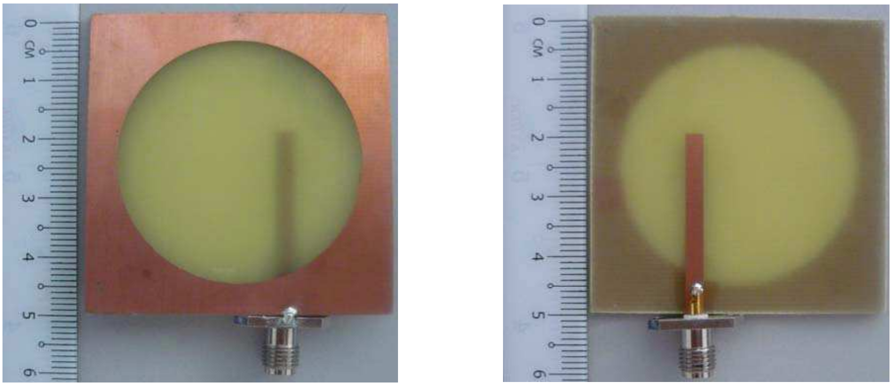


**Figure 2.** Photograph of the antenna prototype.

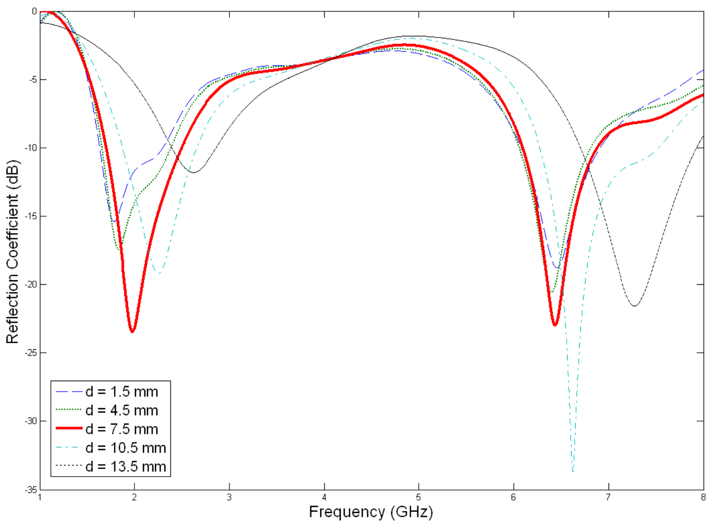



**Figure 3.** Simulated reflection coefficients for different $d$.

## 3. THE EFFECT OF THE FEEDLINE LOCATION

This section presents the parametric study of the feedline location $d$ (the distance between the antenna centre and the feedline centre) in Fig. 1(b) of the proposed antenna. The distance has been varied from 1.5 mm to 13.5 mm. The observed reflection coefficients are shown in Fig. 3. As $d$ increases from 1.5 mm to 13.5 mm, it can be clearly observed that both the resonant frequencies centred at 2 GHz and 6.3 GHz increase. This shows that the further the feedline away from the centre of the antenna, the higher the resonant frequency. For both the resonant frequencies, as the distance between the feedline and the centre of the antenna increases, the reflection coefficient improves. However, when the distance is further increased, the reflection coefficient worsens. Fig. 3 illustrates the simulated reflection coefficients for various $d$. The parametric study shows that by a proper choice of the parameter $d$, the desired location of the centre frequencies could be obtained.

## 4. SIMULATION AND EXPERIMENTAL RESULTS

The antenna is simulated using a commercial software package CST Microwave Studio. The reflection coefficient is also measured using an Agilent 8757D Scalar Network Analyzer. Using a VSWR $\leq$ 2 (reflection coefficient $\leq -9.5$ dB) as benchmark, the measured result shows that the antenna covers 1.83 GHz to 2.73 GHz and 5.36 GHz to 7.63 GHz frequency ranges; thus the impedance bandwidths are 39.5% and 34.9% respectively. The frequency bands that are covered by this antenna is suitable for PCS 1.85–1.99 GHz, UMTS 1.92–2.17 GHz, IMT 1.9–2.2 GHz, ISM 2.4–2.484 GHz, Bluetooth 2.3–2.55 GHz, RFID 2.45 GHz and WLAN 2.4–2.484 and 5.725–5.825 GHz

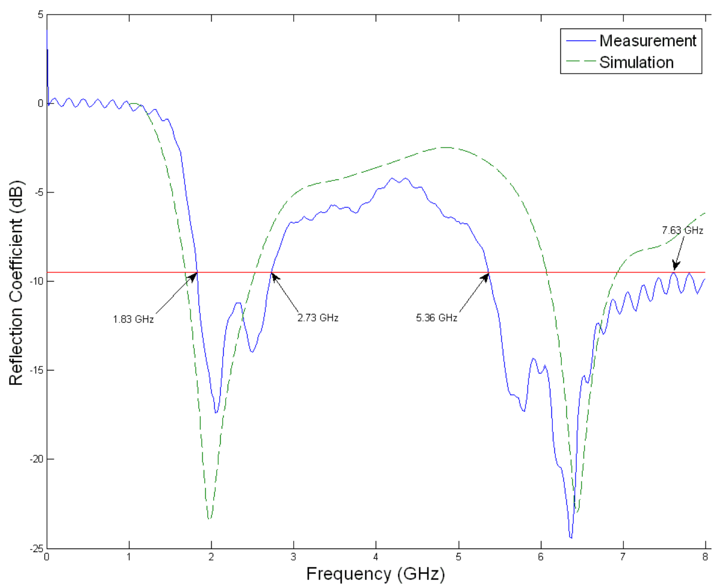
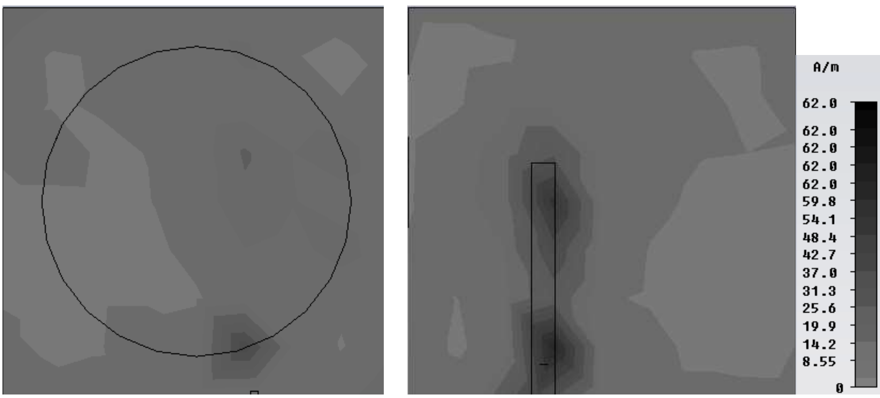


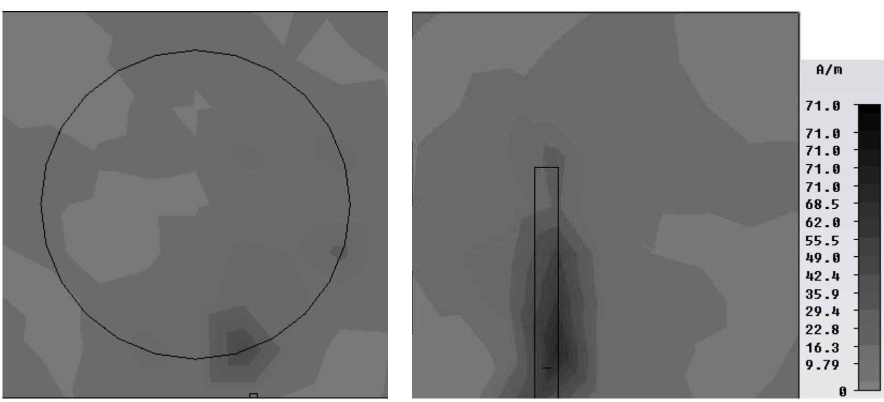

**Figure 4.** Simulated and measured reflection coefficients against frequency.

wireless applications. Fig. 4 shows the measured and simulated reflection coefficients versus frequency graph. It could be observed that there is an acceptable agreement between the calculated and measured results.

The surface current distribution has been studied using simulation tool and is illustrated in Fig. 5. On the ground plane, the current is mainly concentrated at the slot edge exactly opposite the feedline at both 2 GHz and 6.3 GHz. It is observed that the current is concentrated at the top and bottom portions of the feedline at lower frequency band centred at 2 GHz and mainly concentrated at the lower half of the feedline at higher frequency band centred at 6.3 GHz.

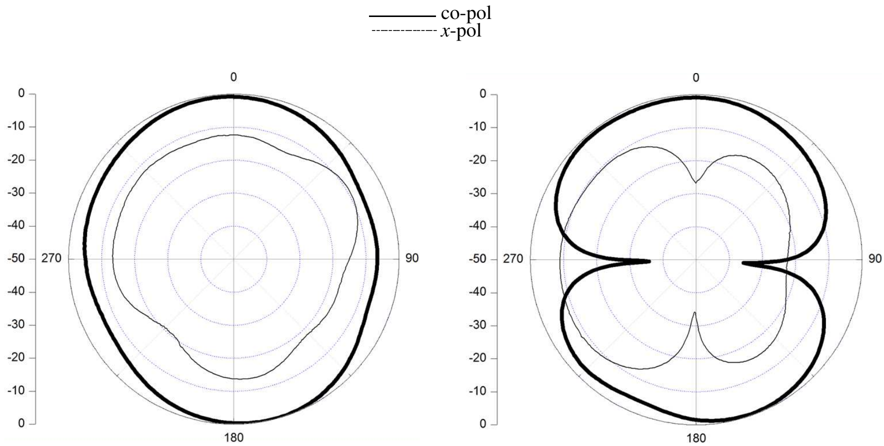



(a)



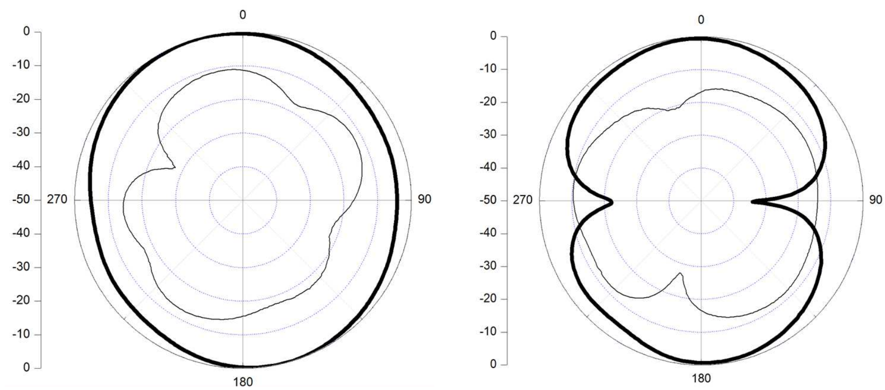

(b)

**Figure 5.** Simulated surface current distribution at (a) 2 GHz and (b) 6.3 GHz.




(a) *X-Y* Plane (b) *X-Z* Plane

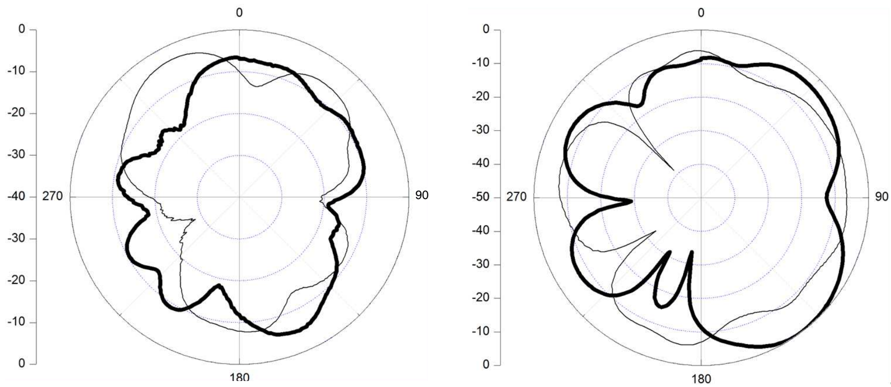
**Figure 6.** Measured radiation patterns at 2 GHz.




(a) *X-Y* Plane (b) *X-Z* Plane

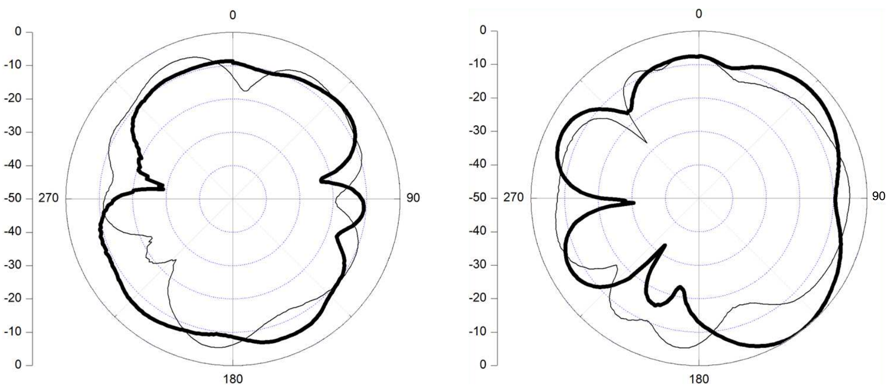
**Figure 7.** Measured radiation patterns at 2.4 GHz.

Figures 6 to 9 show the measured radiation patterns in the $x$-$y$ plane and $x$-$z$ plane that include co-polarization (co-pol) and cross-polarization ($x$-pol) for the proposed antenna at 2, 2.4, 5.5 and 5.8 GHz, respectively. At both 2 GHz and 2.4 GHz, very close to omnidirectional pattern is obtained for the $x$-$y$ plane. For the $x$-$z$ plane, close to a figure-8 pattern is observed at both the frequencies. At higher frequencies, which are at 5.5 GHz and 5.8 GHz, the patterns are




(a) *X*-*Y* Plane (b) *X*-*Z* Plane

**Figure 8.** Measured radiation patterns at 5.5 GHz.




(a) *X*-*Y* Plane (b) *X*-*Z* Plane

**Figure 9.** Measured radiation patterns at 5.8 GHz.

seem to be deteriorated at both $x$-$y$ and $x$-$z$ planes. The deterioration might be due to the feedline itself acts as a radiator and its effect becomes more prominent at higher frequencies.

The maximum gains of the proposed antenna in the operating frequency range are simulated, as shown in Figs. 10 and 11. At low frequency band, the gain ranges from 3.3 dBi to 3.7 dBi, whereas, at high frequency band, the gain ranges from 5.3 dBi to 6.1 dBi. The gain variation for both operating bandwidths is less than 1 dBi.

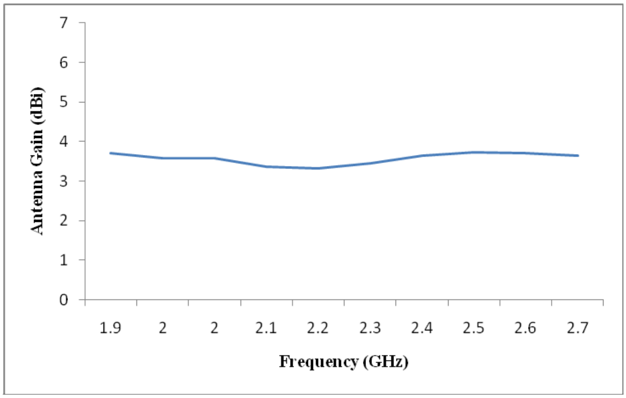



**Figure 10.** Simulated peak gain from 1.9 GHz to 2.7 GHz.

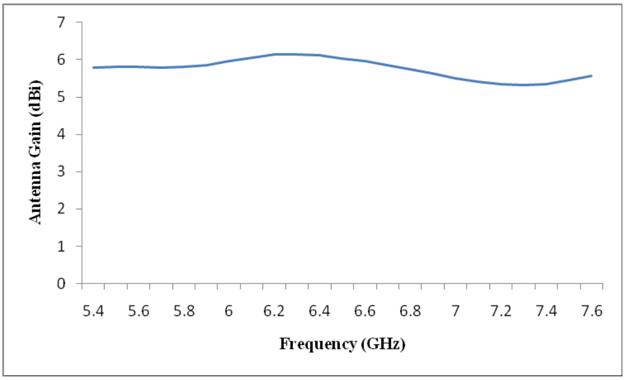



**Figure 11.** Simulated peak gain from 5.4 GHz to 7.6 GHz.

## 5. CONCLUSIONS

A circular slot printed antenna fed by an offset microstrip line is proposed. The proposed antenna covers dual bands for PCS, UMTS, IMT-2000, ISM, Bluetooth, RFID and WLAN operations. In spite of the low cost, the simple antenna demonstrates acceptable reflection coefficient, close to omnidirectional patterns and gain variation of less than 1 dBi over the two operation bands. The nearly omnidirectional radiation is suitable for wireless communication applications.

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