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# Printed Circular Patch Wideband Antenna for Wireless Communication

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**Abstract:** This letter presents a new wideband, printed, microstrip-fed, circular patch antenna for multifunctional wireless communication applications. The commercially available CST Microwave Studio software package, which is based on finite difference time-domain (FDTD) analyses, has been adopted in this study. The experimentally determined impedance bandwidths are 2.2 GHz (1.75 GHz to 4 GHz) and 750 MHz (4.15GHz to 4.90 GHz), which cover the GSM-1800, GSM-1900, UMTS, Bluetooth (2400-2800) MHz, WLAN (2400-2485) MHz, WiMAX (2500-2690) MHz and WiMAX (3400-3600) MHz frequency bands. The experimental measurements taken using the proposed antenna are in good agreement with the computational results.

**Keywords:** Antenna, circular patch, wideband, wireless communication.

# Tiskana krožna krpičasta širokopasovna antena za brezvrvične zveze

**Izvleček:** Članek opisuje novo širokopasovno tiskano mikro trakasto krpično krožno anteno za večfunkcijsko brezžično komunikacijo. Za potrebe študije je bilo predelano komercialno programsko orodje CST Microwave Studio, ki temelji na metodi končnih razlik v časovnem prostoru. Eksperimentalno določene impedančne pasovne širine so 2.2 GHz (od 1.75 GHz do 4 GHz) in 750 MHz (od 4.15GHz do 4.90 GHz), ki pokrivajo frekvenčne pasove GSM-1800, GSM-1900, UMTS, Bluetooth (2400-2800) MHz, WLAN (2400-2485) MHz, WiMAX (2500-2690) MHz in WiMAX (3400-3600) MHz. Eksperimentalni rezultati so v dobrem ujemanju s simulacijami.

**Ključne besede:** Antena, krožna krpičasta antena, široki pas, brezžična povezava

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## 1 Introduction

In recent years, microstrip-fed circular patch antennas have become popular in antenna researcher because of their numerous benefits such as cost effectiveness, wideband abilities, simple fabrication and improved performance. Moreover, Improvements in wireless communications have introduced tremendous demands in the antenna technology. .It's withal the paved the way for extensive utilization of mobile phones in modern society resulting in mounting concerns circumventing its inimical radiation [1-3]. Furthermore, this type of antenna satisfies the challenges of connectivity with both mobile and fixed devices with greater user experience and also overcomes the limitation of narrow impedance and axial ratio bandwidth.

Researchers have analysed various types of circular antennas for different operating frequencies [4-7]. Various techniques, such as the annular ring microstrip patch antenna using a prolonged ear [8], have been used to obtain the desired operating frequency. Moreover, to achieve wideband abilities, a number of additional techniques were studied. For example, a dual rectangular wire loop configuration above an infinite ground plane was designed in [9]; an L-probe patch antenna was proposed in [10]; a magneto-dielectric resonator antenna was proposed in [11] and electromagnetically coupled, two-layer substrate was used in [12].

Furthermore, by adding one or more parasitic elements, a wide bandwidth of up to 40% axial-ratio bandwidth was achieved in [13]. A fan-shaped, parasitic patch with an annular-ring patch antenna was investigated in [14], where a bandwidth of 2.3% was achieved, and the effect of parasitic elements was investigated in [15-18].

A number of studies have been conducted on slot antennas as well [19-24], where CP antennas have achieved 4% to 25% axial-ratio bandwidths.

In this article, a new wideband, circular polarized, printed monopole antenna is proposed that can be operated in the GSM, UMTS, WLAN and WiMAX frequency bands with improved gains. The concept of adding a parasitic element and cutting slot are investigated and compared. The experimental results of the antenna exhibit continuous wide bands from 1.75 GHz to 4 GHz and from 4.15 GHz to 4.9 GHz.

## 2 Antenna geometry

The geometries of the proposed and fabricated antenna prototype are shown in Fig. 1 and Fig. 2, respectively. The length of the printed circuit board is Lg = 50 mm and the width is Wg = 62.9 mm. The antenna consists of two main parts: the circular patch with parasitic elements and the defected ground. The radius of the circular radiator is 12.5 mm. The width and length of the feed line are Wf and Lf, respectively, which has an input impedance of 50 Ω. A parasitic element is attached to the patch to change the surface current's path. The dimensions of the proposed antenna are shown in Table I.

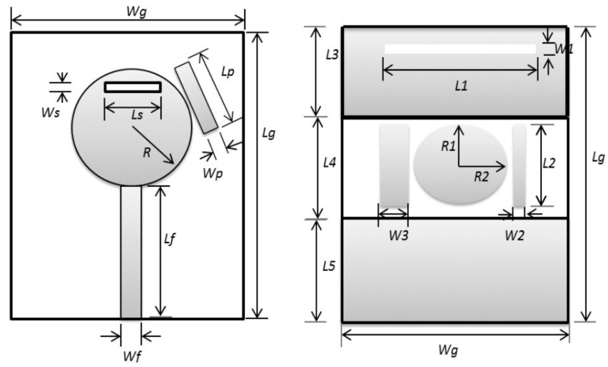
**Table. 1:** The proposed antenna specifications (in mm).

| Parameters | Values (mm) | Parameters | Values (mm) |
|---|---|---|---|
| **Wg** | 50.00 | **L1** | 28 |
| **Lg** | 62.9 | **L2** | 15 |
| **Lf** | 25.5 | **W1** | 1.06 |
| **Wf** | 2.89 | **W2** | 6.5 |
| **R** | 12.5 | **L3** | 15 |
| **Ls** | 12.3 | **L4** | 21.4 |
| **Ws** | 1.06 | **R1** | 10 |
| **Lp** | 14.5 | **R2** | 11 |
| **Wp** | 2.00 | | |

## 3 Parametric studies

### 3.1 Effect of parasitic elements and slots

The best performances of the proposed antenna are obtained by adding different types of parasitic elements and cutting slots. Parasitic elements and cut-




(a) (b)

**Figure 1:** Design layout of the proposed antenna: (a) Top View and (b) Bottom view.

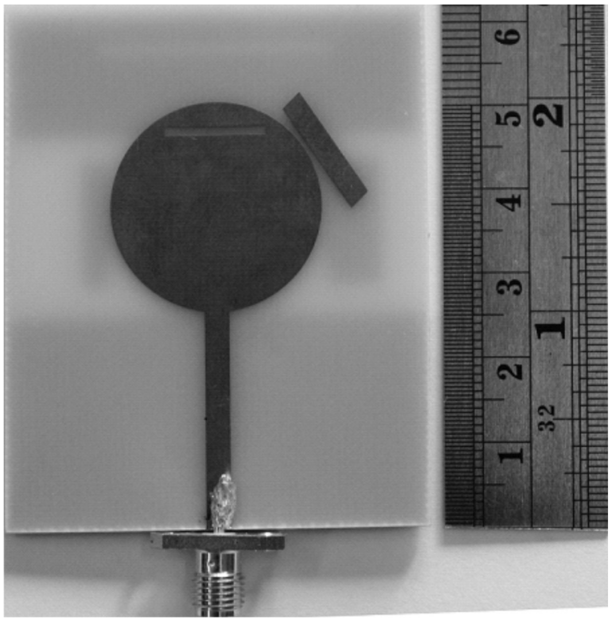


**Figure 2:** Photograph of the fabricated proposed antenna.

ting slots are added to change the current flow and attain better radiation profiles. The proposed antenna has been designed using optimally sized parasitic elements. Initially, analyses were performed with one conventional, circular patch microstrip monopole antenna. Several steps were subsequently followed. In the first step, a 15 mm × 3 mm copper element was added to the ground plane, which resulted in a smaller reflection coefficient. In the second step, a 15 mm × 6.5 mm copper element and an ellipse were added to the ground plane together with first element and analysed. In the third step, the 15 mm × 50 mm copper elements were added in the upper side of the ground plane, which resulted in improved results relative to the previous step. In the fourth step, a slot was cut from the upper portion of the ground. In the fifth step, a parasitic element was added to the patch, which resulted in improved results. Finally, a slot was cut from the patch, which resulted in the desired results. The reflection coefficient values of the different slots are compared in Fig. 3.

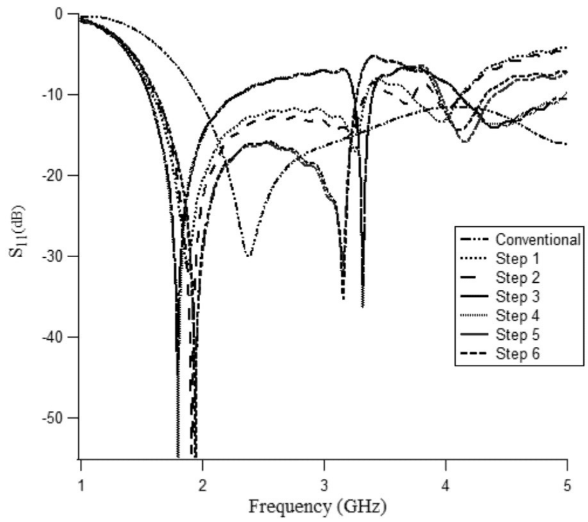



**Figure 3:** Effect on the reflection coefficient from adding parasitic elements and slotting.

### *3.2 Substrate Height*

Fig. 4 shows the simulation result of the reflection coefficient of the proposed antenna for FR4 substrate thicknesses of 0.254 mm, 0.500 mm, 1 mm and 1.6 mm. From Fig. 4, it is clearly observed that the best performance of the proposed antenna was found using a thickness of 1.6 mm. Because the thicker substrate increases the radiated power and improve impedance bandwidth.

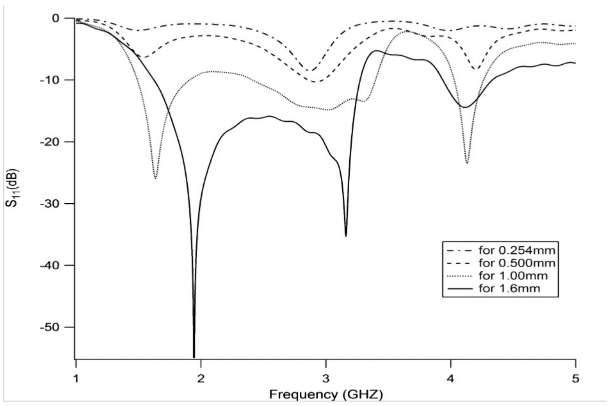



**Figure 4:** Reflection coefficient for different values of substrate thickness.

### *3.3 Different Substrates*

The reflection coefficients of the antenna using different types of substrate materials are shown in Fig. 5. From Fig. 5, we see that the substrate material is an important parameter for the antenna design. The different materials properties are shown in Table II.

**Table. 2:** Material properties of different materials

| Substrate Name | Permittivity | Loss Tangent | Substrate thickness |
|---|---|---|---|
| RT 5880 | 2.2 | 0.0015 | 1.6 |
| RT 5870 | 2.33 | 0.0012 | 1.6 |
| RT 6010 | 10.2 | 0.002 | 1.6 |
| FR4 | 4.6 | 0.02 | 1.6 |
| Bio plastic | 15 | 0.002 | 1.6 |

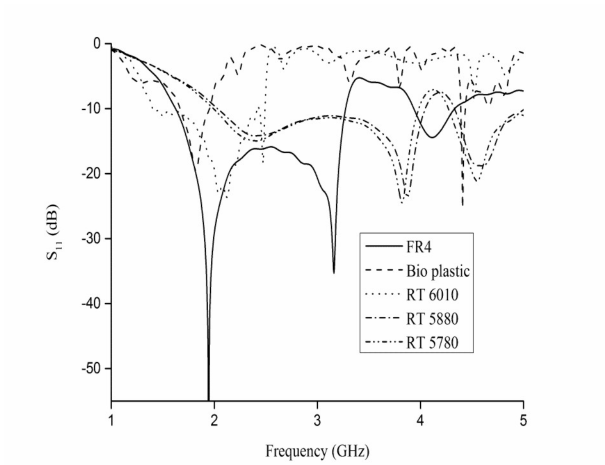



**Figure 5:** Reflection coefficient for different types of substrates.

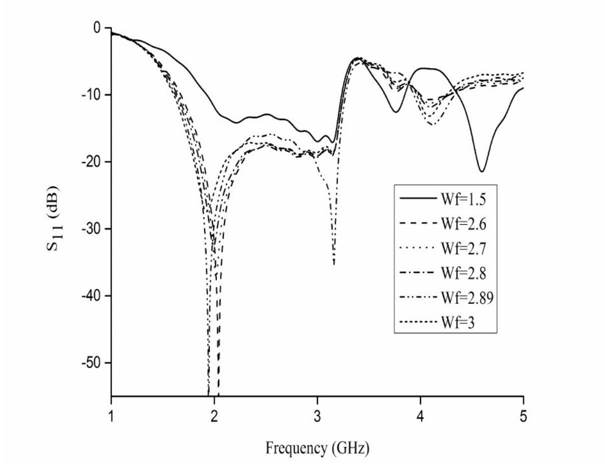



**Figure 6:** Reflection coefficient for different values of the feed line width

### *3.4 Feed Line Width*

Fig. 6 shows the simulated reflection coefficient values of the proposed antenna for different feed line widths (Wf). The optimum value of Wf for the desired frequency band was determined to be 2.89 mm. which indicates that the input impedance matches smoothly at 2.89 mm feed line width.

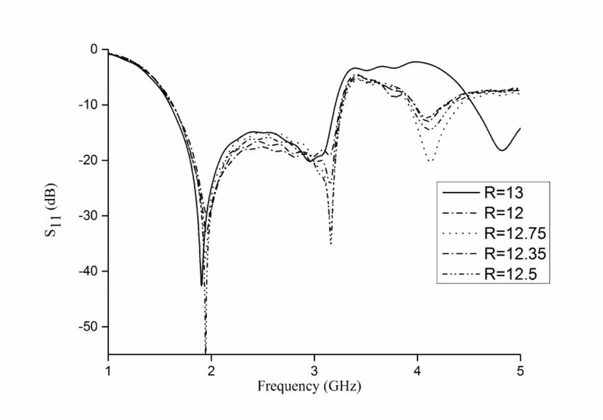



**Figure 7:** Reflection coefficient for different values of patch radius .

### 3.5 Patch Radius

The optimized patch radius for the proposed antenna is 12.5 mm as seen in Fig. 7. The frequency band from 3.9 GHz to 4.5 GHz can be controlled by regulating the patch radius as seen in Fig. 7.

## 4 Results and discussions

The design and simulation of the proposed antenna have been performed using the commercially available CST Microwave Studio and High Frequency Structural Simulator (HFSS) software package. The prototype of the proposed antenna has been fabricated and measured. The reflection coefficient measurement has been performed using an Agilent TE8362C network analyzer. The simulated and the experimental reflection coefficients were compared as seen in Fig. 8. It is seen from Fig. 8 that the simulated peak resonant was achieved at 1.95 GHz and 3.16 GHz. Moreover, two wide bandwidths of 1.65 GHz and 550 MHz were seen from 1.62 GHZ to 4.45 GHz. In the experiment, two wide bandwidths of 2.2 GHz from 1.75 GHz to 4 GHz and 750 MHz from 4.15 GHz to 4.9 GHz were found. The surface current distribution was observed for different frequencies as seen in Fig. 9.

In addition, the simulated E-plane and H-plane radiation pattern at 1.8 GHz, 2.1 GHz, 2.4 GHz, 2.7 GHz, and 4.5 GHz are shown in Fig. 10. From Fig. 10, it is observed that the proposed antenna shows a directional radiation pattern for E-plane and H-plane radiation pattern. At higher frequency there are some distortion in the radiation pattern.The main reason of this distortion is the excitation of higher-order current mode.

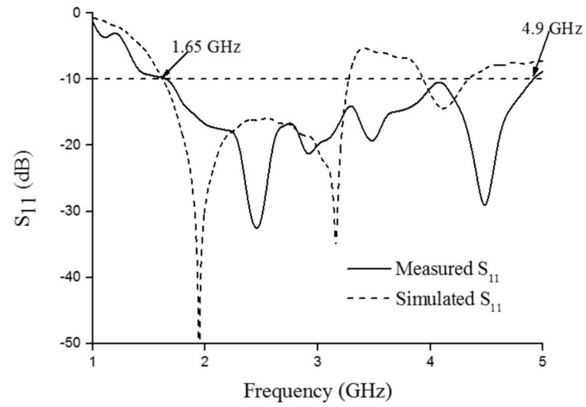



**Figure 8:** Simulated and measured reflection coefficient value of the proposed antenna.

The dimensions of the wideband wireless antenna to cover the GSM 1800, GSM 1900, GSM 2100, UMTS, Bluetooth (2400-2800 MHz), WLAN (2400-2485 MHz), WiMAX (2500-2690 MHz), and WiMAX (3400-3600 MHz) frequency bands are quiet larger. In [25], the authors achieved a wide bandwidth of 1.37 GHz from 1.04 to 2.41 GHz, and the antenna ground plane dimension was 300 mm × 300 mm. In [26], the authors presented a wideband, circularly polarized antenna; however, their antenna ground plane radius is larger than the proposed antenna, which is 150 mm. Conversely, the dimensions of the proposed antenna were 50 mm × 62.9 mm, which achieved a wide bandwidth of 2.2 GHz and 750 MHz from 1.75 GHz to 4 GHz and from 4.15 GHz to 4.9 GHz, respectively.

## 5 Conclusion

A simple, low-cost, wideband, circular patch microstrip-fed monopole antenna was presented. The presented antenna has a wide bandwidth of 2.2 GHz from 1.75 GHz to 4 GHz and 750 MHz from 4.15 GHz to 4.9 GHz, respectively. The proposed antenna can cover the GSM 1800, GSM 1900, UMTS, Bluetooth, WLAN and WiMAX frequency bands. In this study, it was observed that the proposed antenna can play an important role in current wireless communication systems.

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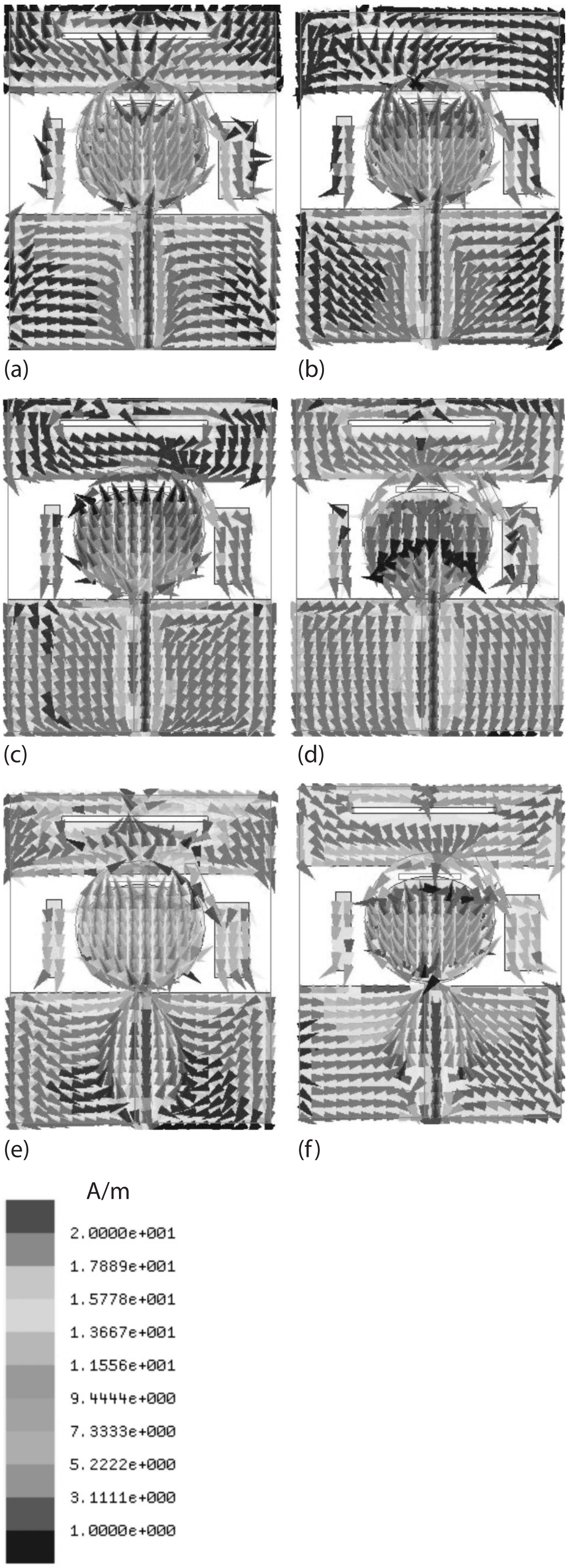


**Figure 9:** Simulated surface current at (a) 1.8 GHz, (b) 1.9 GHz, (c) 2.1 GHz, (d) 2.4 GHz, (e) 3.6 GHz and (f) 4.5 GHz

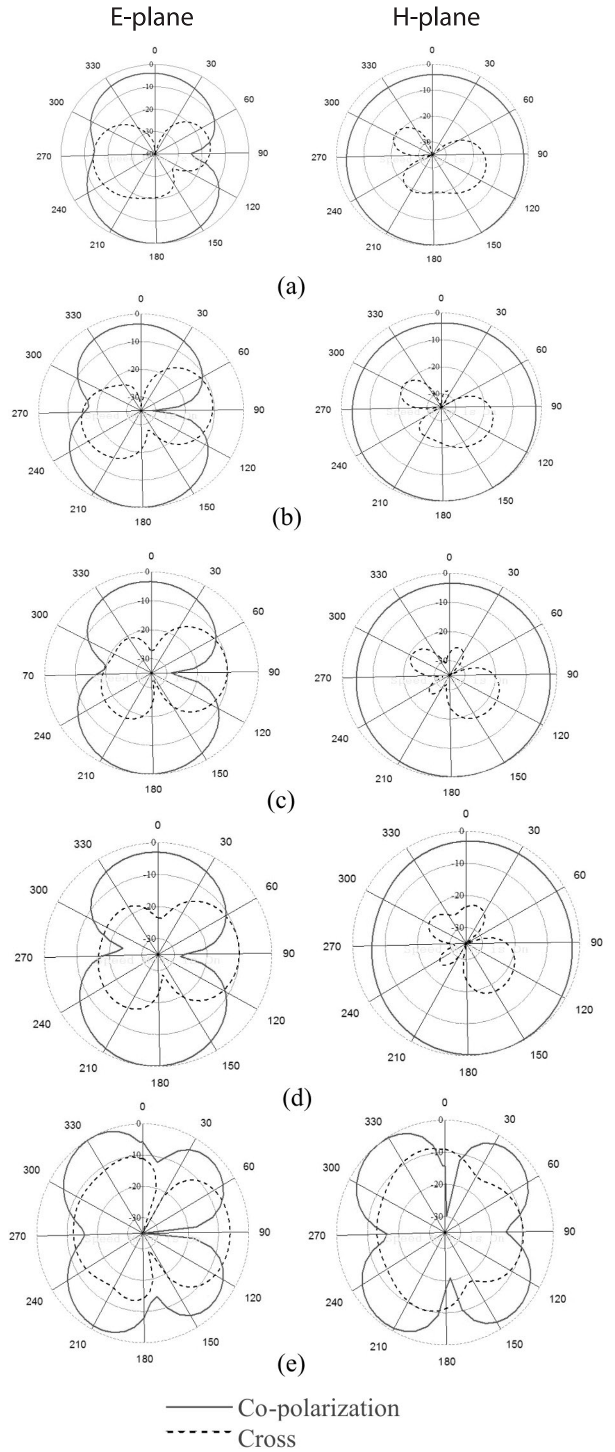


**Figure 10:** Radiation Pattern (a) at 1.8 GHz, (b) 2.1 GHz, (c) 2.4 GHz, (d) 2.7 GHz and (e) 4.5 GHz

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