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CPW-Fed Circular Antenna with Arc-Shaped Tuning Stub for Wi-MAX/WLAN Applications

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ABSTRACT
By using a coplanar waveguide (CPW) fed circular slot with arc-shaped tuning stub antenna for broadband operation is presented. The proposed antenna can be obtained an operating bandwidth is 2.8 GHz from 2.85 to 5.65 GHz for Wi-MAX/WLAN applications. The specified spectrum for Wi-MAX is centered at 3.5 GHz and for WLAN is centered at 5.2 GHz. The antenna occupies a small volume 70(L) X 70(W) X 0.8(H) mm^3 and printed on FR-4 substrate. The Simulation results are show that the impedance matching for the proposed antenna strongly depends on the location of the tuning stub in the circular slot, and the impedance bandwidth is mainly determined by the width and length of the tuning stub. The antenna is simulated using CST simulator and performance of the antenna is measured in terms of return loss, VSWR, gain and radiation pattern. The simulated results confirm the successful design using 50Ω CPW-fed antenna for broadband applications.

Key words: CPW, Wi-MAX, WLAN, MMICs, FCC, VSWR

1. INTRODUCTION

The microstrip wideband antennas have attracted much attention owing to their advantages such as simple structure, low profile, high data rate, easy integration with monolithic microwave integrated circuits (MMICs), and ease of fabrication. Thus, the wideband antenna has become the most promising solution for future short-range high-data wireless communication applications.

With the significant advancements in the wireless communications, there is a constant need to investigate and develop novel antennas and components to support modern communication systems, targeted for range of applications in satellite and mobile communications, personal communication, healthcare, defence, sports and public security. The antenna is a vital front-end component in any wireless system. Mobile devices, such as hand-held computers and smart phones, are widely using wireless local area network (WLAN) and worldwide interoperability for microwave access (Wi-MAX) for internet access. The Wi-MAX/WLAN module, used to avail of these environments, is capable of operating at multiple frequency bands. The federal communication commission (FCC), specified spectrum for Wi-MAX is centered at 2.5/3.5/5.5 GHz and for WLAN is centered at 2.4/5.2/5.8 GHz respectively. However, a number of microstrip antennas with different geometries have been experimentally characterized to reduce the size and enhance the bandwidth for Wi-MAX/WLAN applications [1-5].

Table 1: FCC, Specified Spectrum for Wi-MAX/WLAN [5]

Wireless Operating Bands	Centre Frequency (f_C, GHz)	Frequency Band (GHz)	Bandwidth (MHz)
Wi-MAX	f_{C1} = 2.5	2.500 – 2.690	190
	f_{C2} = 3.5	3.400 – 3.690	290
	f_{C3} = 5.5	5.250 – 5.850	600
WLAN	f_{C1} = 2.4	2.400 – 2.484	84
	f_{C2} = 5.2	5.150 – 5.350	200
	f_{C3} = 5.8	5.725 – 5.825	100

In order to overcome the disadvantage of narrow bandwidth, several techniques have been employed [6-11]. The impedance bandwidth is mainly determined by the width and length of the tuning stub. By properly choosing the location and the size of the tuning stub, a wide impedance bandwidth can be obtained. Multiple frequencies operation is necessary to wireless communication for application such as GSM/UMTS/DCS/PCS/IMT, Bluetooth, ISM, Wi-MAX, and WLAN etc. The proposed antenna can be achieved an operating bandwidth is Wi-MAX/WLAN applications.

2. DUAL-BAND ANTENNA DESIGN AND RESULT ANALYSIS

2.1 Antenna Design and Configuration

Fig. 1(a) shows the structure of dual-band conventional antenna (Ref. antenna-2) on the 0.8 mm FR-4 substrate by using the CPW feeding with the arc-shaped tuning stub [3]. The ground and substrate plane is chosen to be square, and the outer and inner radii of the annular slot are denoted by R_1 and R_2, respectively. The physical dimension of reference design antenna-2 is 70 (L) × 70 (W) mm^2. The others dimensions are fed-line width W_f, W_s, and W_t, and heights l_f, l_s, and l_t, respectively, as shown in Fig. 1(b). The feeding structure consists of the two tuning sections, which are the arc-shaped tuning stub and 50-Ω transformer fed-line [3].

As shown in Fig. 1(b), the arc-shaped tuning stub with the extended angle (α) and width (t) is linked a 50-Ω transformer, which is connected to the extremity of the CPW fed-line, achieving the dual-band impedance matching. Furthermore, the angle (α) of the arc-shaped tuning stub is used to control the movable high-band to make dual or broad-band design and the width of the tuning section (W_t) is used to match the dual-band input impedance [3].

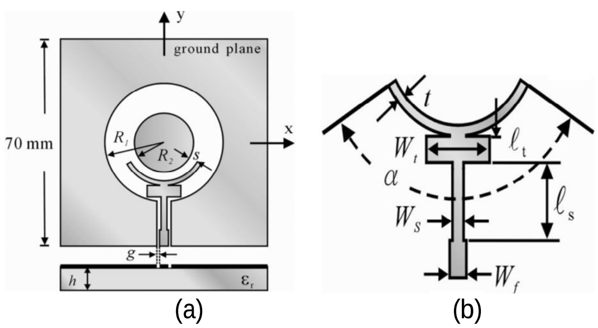


Figure 1: (a) Structure of reference annular-ring slot antenna.
(b) Feeding structure of reference antenna.

Table 2: Detailed dimensions of reference design antenna-2 [3]

Parameters	Unit (mm)	Parameters	Unit (mm)
W_f	4.2	R_1	19.5
W_s	3.0	R_2	11
W_t	11.2	S	0.1
l_f	7.5	t	0.2
l_s	9.2	Angle (α)	60°
l_t	7.0	g	0.3

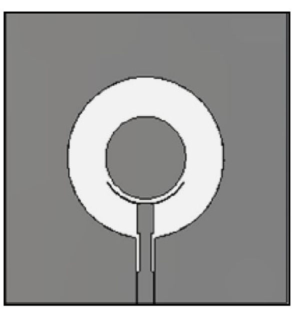


Figure 2: Geometry of proposed antenna

The built-in antenna mounted in square shaped (L=W=70 mm) on the printed circuit board is shown in Fig. 2. Main PCB layer has a FR- 4 epoxy substrate, dielectric constant (ε_r) 4.4 and thickness 0.8 mm. The geometry of the proposed patch antenna has design for broadband applications, which have operating in Wi-MAX and WLAN bands.

Table 3: Optimal parameter values are given of the proposed antenna

Parameter	R_1	R_2	W_s	S	t	W_f	W_t
Unit (mm)	19.5	11	3.0	0.2	0.1	4.2	4.2

There are good agreement of simulated results return loss, VSWR, radiation pattern, and gain with optimal parameter values to each other in given Table 3. Return loss and VSWR of the proposed antenna are shown in Fig. 2 (a) and (b) respectively with different fed-line widths (W_t). The wide impedence bandwidth is to be obtained, when W_t = W_f = 4.2 mm, at dual resonant frequencies 3.60 and 5.25 GHz respectively. In Fig. 3 (a) and (b) are shown radiation pattern and gain of proposed antenna respectively.

2.2 Return Loss and VSWR

The simulated return loss (S1, 1_1) of the proposed antenna has wider bandwidth is shown in Fig. 2(a), which indicates that the impedance bandwidth of the antenna have 2.80 GHz from 2.85 to 5.65 GHz at less than -10dB. The resonant frequencies (f_{R1}=3.6 GHz and f_{R2}=5.2 GHz) resonate at -23 dB respectively for Wi-MAX and WLAN applications.

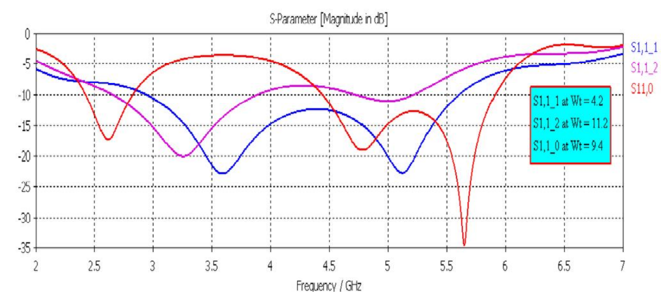


Figure 2(a): Return loss at optimal parameter values, at W_t = 4.2 mm (S1,1_1), W_t = 11.2 mm (S1,1_2), and W_t = 9.4 mm (S1,1_0) respectively.

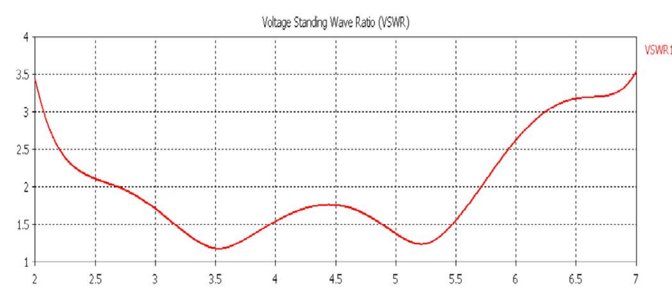
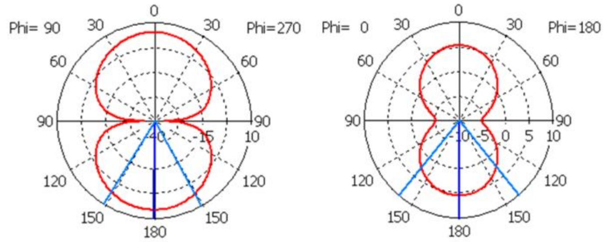


Figure 2(b): VSWR of proposed antenna, at W_t =W_f = 4.2mm.

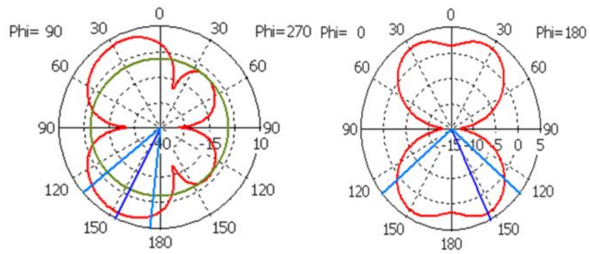
VSWR is a function of reflection coefficient which describes the power reflected from the antenna. The simulated VSWR of proposed antenna is shown in Fig. 2(b). It is clearly shows that the VSWR is less than 2 dB for wide band range and at resonant frequencies (f_{R1}=3.5 GHz and f_{R2}=5.2 GHz) have less then 1.5dB respectively.

2.3 Radiation Pattern and Gain

The simulated radiation patterns of the proposed antenna at 3.5 GHz, and 5.2 GHz along both y-z plane (E-plane) and x-z plane (H-plane) are illustrated in Fig. 3(a). The both resonant frequencies, it is seen that our proposed design exhibits a broadside radiation antenna and with the increase of frequency, the proposed antenna becomes more directive.



E/H – plane at 3.5 MHz



E/H – plane at 5.2 MHz

Figure 3(a): Farfield radiation pattern of proposed antenna at 3.5 and 5.3 GHz.

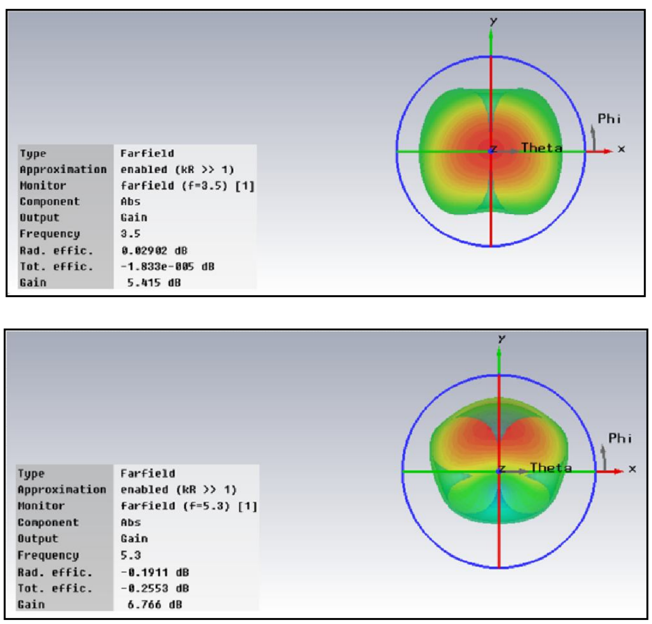


Figure 3(b): Gain of proposed antenna at 3.5 and 5.3 GHz.

Table 4: Compare the performance of proposed antenna with reference antennas, [3]

Antenna	W_f (mm)	W_s (mm)	W_t (mm)	α (°)	BW (GHz)	Gain (dB)	
Ref. Ant. 1	4.2	3.0	12	10	1.83	-	-
Ref. Ant.2	4.2	3.0	11.2	60	2.06	-	-
Proposed	4.2	3.0	4.2	60	2.80	5.42 at 3.5MHz	6.77 at 5.2MHz

3. CONCLUSION

The proposed CPW-fed broadband antenna has achieved 2.8 GHz impedance bandwidth and suitable for worldwide interoperability for microwave access (Wi-MAX), wireless local area network (WLAN) bands respectively. The various simulated parameters of the proposed antenna show a good agreement in term of the return loss, VSWR, radiation pattern, and gain. It can be concluded from the results that the designed antenna is well suited to be integrated within various portable devices for Wi-MAX/WLAN systems.

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