Monopole Flexible Antenna for Wi-Fi and 4G Long Term Evolution Applications

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Abstract: *A coplanar waveguide-fed planar monopole flexible antenna with operations for Wi-Fi and 4G LTE applications is proposed. The geometry of the proposed antenna is simple consisting of a circular radiating patch with a crescent slot and it occupies a thin substrate of flexible material. The operating band around 2.4 GHz is achieved by optimizing the design parameters. The proposed antenna exhibits omnidirectional pattern and appreciable gain across the desired band, making it acceptable for Wi-Fi and 4G LTE applications along with its flexible capability to be used in wearable systems.*

Keywords: *Monopole, Coplanar Waveguide-fed, Flexible Antenna, Wearable System, Wi-Fi, 4G LTE*

I. INTRODUCTION

Wireless technology is one of the main areas of research in communication system today. A wireless communication system has a number of advantages over a wired communication system, not only in the mobility of devices within the environment but also the simplicity to relocate a communicating device and absence of any additional cost and rewiring and excessive downtime associated with such a move. The study of wireless communication systems is incomplete without an understanding of the operation and fabrication of antennas. Nowadays antennas' design for wireless communication system have some key requirements in addition to the low cost, these are simple structure and miniaturised size [1]. The additional compelling property of flexibility finds great applications in the wearable systems used in personal and defence communications.

Advantage of a monopole antenna over a dipole antenna is that, only one radiating element is present making the antenna reduced in length.

Planar monopole antennas [5] are suitable for our desired functions because of their simple structure, low profile, light weight and omnidirectional radiation patterns.

Coplanar waveguide (CPW) [6-8], [3], [4] fed antennas are easy to fabricate and integrate in the system exhibiting wide bandwidth. The coupling in the CPW antennas is accomplished via a slot either in the ground plane [10] or in the patch. Because the polarizabilities depend on the shape of slot as well as the size, it is desirable to improve the antenna performance by optimising the shape and size of coupling slot for given antenna dimensions[1].

In our proposed work, we have taken into account both the suitability of planar monopole antennas and the advantages of CPW feed in addition to the simple geometry, well suited for Wi-Fi and 4G LTE applications. In the design of our antenna we have selected commercial, cost friendly and flexible substrate over which a circular radiating patch is placed. A crescent slot is etched on the circular radiating patch so that we can achieve the intended band feature of Wi-Fi band (2.4-2.484 GHz) and also of 4G LTE band (2.5-2.69 GHz). Our antenna is designed in the HFSS [9] and it is characterised in terms of return loss and radiation patterns.

II. ANTENNA DESIGN

The aim of this paper is to design an antenna that independently controls the two intended frequency bands i.e. Wi-Fi and 4G LTE [1]. The proposed antenna is implemented in a low cost, low thickness and flexible commercial dielectric substrate that can be easily integrated with other components in wireless communication. The breakthrough property of the proposed antenna is its flexibility and an appreciative gain. Moreover this antenna can be realized and adjusted

to operate in other frequency bands based on our resulting design.

A slot has been introduced in the circular patch over the substrate to achieve an optimized antenna performance. The substrate used is Rogers RT/Duroid 5880™ which differs from the TACONIC TLX in having an extra property of flexibility with low dielectric constant and loss.

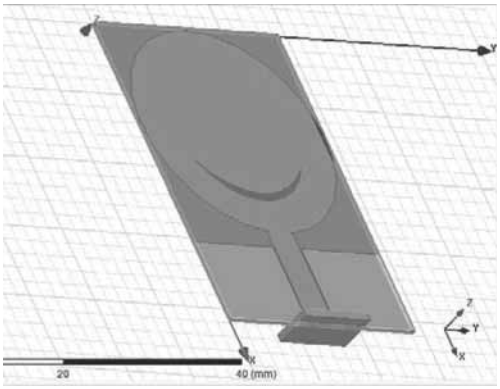

Fig. 1. Proposed Model Structure in HFSS

Table 1. Dimensions of CPW-fed Monopole Flexible Antenna (mm)

W	L	Wf	Lf	Wg	Lg
28.38	41.6	4	13	12	10.8
d	**r**	**rs**	**rp**	**g**	
2.2	14.2	9.1	10.15	0.9	

The antenna is excited by a 50 ohm CPW line with a length L of 41.6mm, a width W of 28.38 mm and a gap g of 0.19mm between the feed line and ground plane [1]. The substrate used is Rogers RT/Duroid 5880™ with a thickness of h=0.32 mm, relative dielectric permittivity ε_r = 2.2 and loss tangent of 0.009. The length Lf and the width Wf of the feedline is 13mm and 4 mm respectively. The printed circular patch mainly determines the lower resonance frequency and for this, it is adjusted approximately at 2.4 GHz. The crescent slot introduced, whose size is controlled by the radii rb, rs enables the antenna to operate optimally at the resonance frequency. The two ground planes are placed on either sides of the CPW feed line having dimensions Lg and Wg which serve as an impedance matching circuit.

To check the effect of each variable dimensions to the proposed antenna's resonances and bandwidth characteristics, the frequency response of return loss for our antenna has been performed by simulation. All the simulation performances are done in Ansoft HFSS [9] which is common antenna simulation software. The setup configuration uses driven modal solution type. The antenna is given waveport excitation with a surrounding radiation box with radiation boundary conditions atleast ¼ wavelengths away from antenna [1]. The distance d between the circular patch and the ground plane is responsible for the frequency matching. The advantage achieved with our proposed antenna is that it exhibits band operation which controls the resonance frequencies of both Wi-Fi and 4G LTE with very favorable gain in addition to its flexible property which makes it an advantageous antenna in the wearable systems.

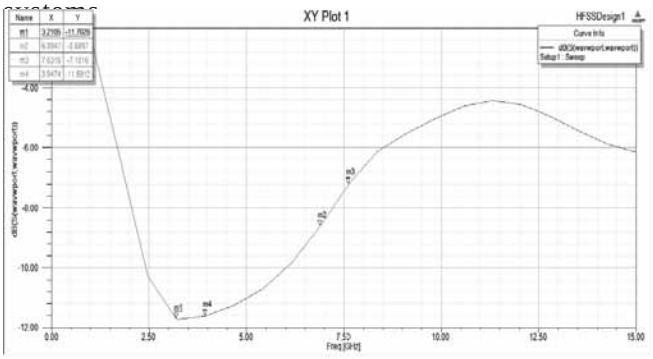

Fig. 2. Simulated return loss of the monopole flexible antenna against frequency.

From the simulation's results obtained of returned loss of the antenna, it is observed that the designed antenna covers from 2.5 to 2.65 GHz resonating at 2.5 GHz in the lower frequency band. Although the return loss (Fig 2) obtained is not appreciable but it is compensated by the very high favorable gain because of high beamwidth. Thus, according to the obtained simulation results, the proposed CPW- fed a crescent monopole flexible antenna optimally covers the intended Wi-Fi and 4G LTE frequency bands. The proposed antenna can be easily tuned to operate in other frequency bands for other intended applications with its flexible property, which makes it an important antenna to be used in wearable systems in the field of defense as well as personal applications.

III. CHARACTERISTIC RESULTS

The antenna proposed optimally covers the lower Wi-Fi band (2.4-2.484 GHz) UHF and 4G LTE band (2.5-2.69 GHz). The striking point of the antenna is its favorable and appreciative gain of 15.2 dB depicted at Fig. 3 which is a very high value. Fig. 4 shows the far field radiation pattern at 2.4 GHz which is an omnidirectional one. Thus it is observed that the antenna shows omnidirectional property at the operating frequency.

Comparing our antenna with some recently published antenna designs for the 2.4 GHz band, the monopole flexible antenna exhibits numerous advantages which are: A very thin and smaller in size than the previously proposed ones. The dielectric permittivity of the substrate used is relatively low which is [r = 2.2 compared to [r = 2.55 used in [1] and [r = 4.4 used in [3-6, 9]. It exhibits a very high gain than showed by the [1, 3, 4] and [6] while covering the band for the targeted applications.

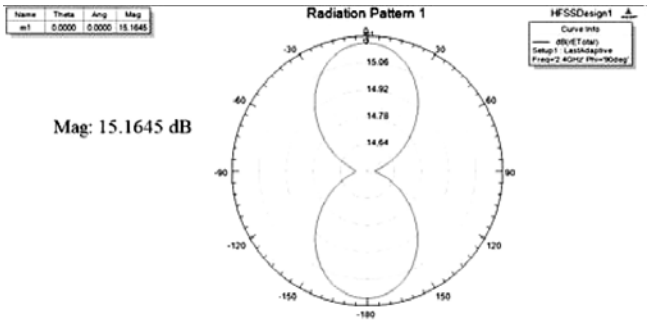

Fig. 3: Radiation pattern for the monopole flexible antenna at 2.4 GHz.

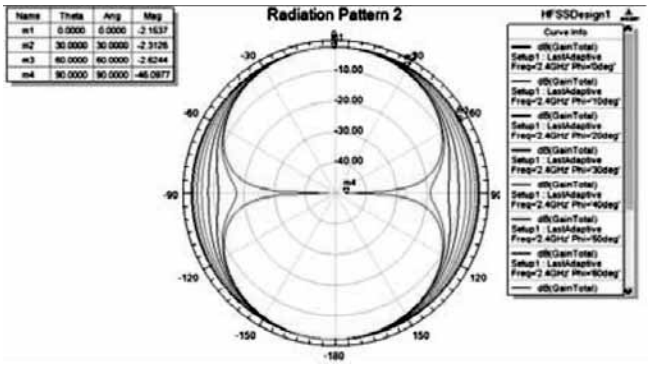

Fig. 4: Radiation pattern cuts at different values of theta and phi in space.

Table 2: Comparison of monopole flexible antenna with some recently published antennas

Antenna	Thickness	[r	Gain dB (2.4 GHz)
This paper	0.32	2.2	15.16
[1]	1.52	2.55	1.6
[2]	1.59	4.4	1.73
[3]	1.6	4.4	3.25
[4]	1.6	4.4	1.4

The very high gain comes with the compensation of return loss because of a high beamwidth.

IV. CONCLUSION

The monopole flexible CPW-fed antenna presented covers the 2.4 GHz (2.4-2.484 GHz) Wi-Fi band and also (2.5-2.69 GHz) 4G LTE band.

In addition to that, the presented antenna has numerous advantages like very low thickness, miniaturized size, low cost, showcasing proper radiation pattern and very high gain making it acceptable for Wi-Fi and 4G LTE communication systems. The applications of wearable antennas include electronic tags, intelligent smart cards, finger print scanners and photo voltaic etc.

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