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A low profile circularly polarized UWB antenna with integrated GSM band for wireless communication

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ABSTRACT

A novel monopole antenna with wide impedance bandwidth and axial ratio bandwidth (ARBW) is presented. The proposed structure is consisting of a wide slot hexagonal shape with an L-shaped radiator coupled inside the slot. Further, two inverted L-shaped strips are protruded on the opposite corners of the hexagonal patch for better radiation capability. The radiating patch is fed by a semi hexagonal ring feed mechanism followed by a tapered line coplanar waveguide (CPW) for improving antenna performance. The proposed structure is supported by a triangular shaped ground plane. An extremely wide -10 dB impedance bandwidth of around 195% and 3-dB axial ratio bandwidth of 32.5% is achieved. The designed antenna has stable radiation characteristics within the operating band. Proposed antenna is fabricated on FR4 epoxy substrate by means of standard photolithography process and measured results are found in a good match with simulated.

1. Introduction

Planar antennas are a major choice among all the radiating elements available for efficient wireless transmission due to their numerous advantages like low fabrication cost, small size, high flexibility, simple to design and easily integrable with other devices. The major limitation of planar antennas is their narrow bandwidth [1]. In the last decades, a number of design configurations have been proposed by various researchers across the globe for wide bandwidth. Monopole antennas are most popular among all those proposed design structures. Monopole antennas provide a wider impedance bandwidth, high radiation efficiency, omnidirectional radiation pattern and easier to fabricate. They can be easily employed for high resolution radars, wireless personal area networks, military communication, imaging systems, cognitive radio, etc. In the year 2002, the Federal Communication Commission (FCC) has assigned 3.1 GHz to 10.6 GHz bandwidth for unlicensed ultrawideband (UWB) communication [2]. The UWB monopole antennas find applications for wireless USB dongle, C band satellite communication, Bluetooth, WLAN, WiMAX and HIPERLAN/2. Due to this large bandwidth and a wide number of applications UWB antennas are in high demand.

A number of antennas with different shapes such as circular, elliptical, square, rectangular, trapezoidal, annular ring have been proposed with large bandwidth and high gain in the last decades [3–8]. Octagon shape structure with low temperature co-fired ceramic [9], U-shaped monopole [10], spline shaped monopole [11], a trident shaped feeding strip monopole antenna [12], monopole with Defected Ground Structure (DGS) [13] and half bowtie antenna with staircase shaped patch [14] have been proposed for various wireless applications with enhanced bandwidth. By means of cutting notches in the ground plane, a better impedance matching can be obtained and by varying the length and breadth of the inserted notches the impedance bandwidth of the antenna can be altered [15,16]. A rounded ground plane can also improve the bandwidth of the monopole [17], another good method is by using trapeziform ground and feeding the patch by CPW, this method improves the impedance bandwidth to a larger extent [18,19].

In the recent time, most of the portable devices are wireless so the problem of multipath fading has to be taken care. In the case of handheld mobile as the receiving terminal, there is no guarantee of a line of sight communication; in consequence, there will be an issue of

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Table 1
Comparison of proposed antenna in terms of impedance and axial ratio bandwidth with other related antennas.

Reference	Impedance band (GHz)	−10 dB fractional bandwidth	Circularly polarized band (GHz)	3-dB axial ratio bandwidth
[20]	2.25–2.35	4%	2.26–2.34	80 MHz
[21]	1.41–1.91	30%	1.5–1.9	400 MHz
[22]	2.32–8.88	117%	3.2–4.4	1.2 GHz
[23]	2.45–3.79	43%	2.88–3.65	770 MHz
[24]	2.18–3.92	57%	2.15–3.5	1.35 GHz
[25]	1.24–1.96	45%	1.56–1.64	80 MHz
[26]	5.19–7.08	31%	5.49–6.73	1.24 GHz
[27]	4.70–7.48	45.6%	4.9–6.2	1.3 GHz
[28]	3.75–7.0	60.5%	4.25–5.95	1.7 GHz
Proposed	0.17–13.5	195%	4.9–6.8	1.9 GHz

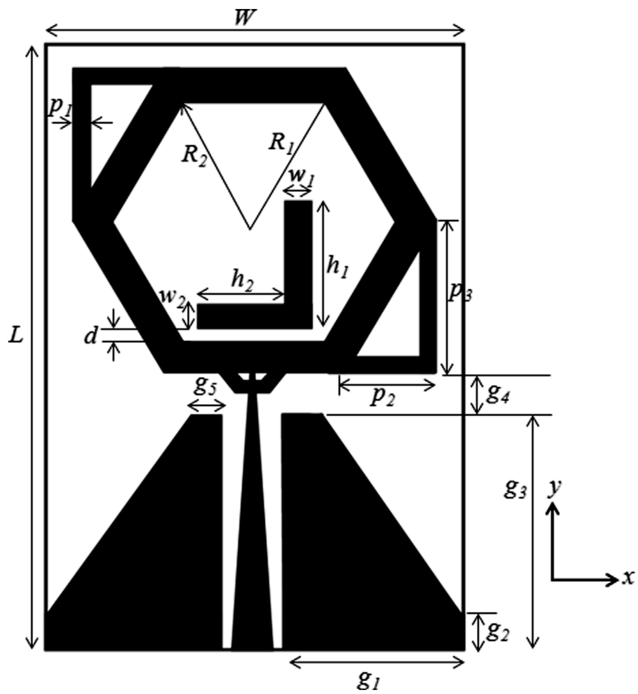

Fig. 1. Geometry of the proposed antenna.

multipath fading. The problem of multipath fading can be addressed by the help of polarization diversity via using circularly polarized (CP) antennas for both reception and transmission. The transmitting and receiving antennas must be aligned to each other for avoiding polarization mismatch in the case of linearly polarized systems; the problem of orientation mismatch can be solved using CP antennas. More, the CP antennas are able to reduce Faraday rotation effect occurring in the ionospheric layer of the atmosphere; the Faraday rotation effect causes a loss of more than 3 dB when linearly polarized waves are radiated. The CP transceiver systems are immune to this problem; therefore, they are widely employed for space applications. A few circularly polarized antennas in existence are an unequal arm monopole antenna with Y-shape [20], a monopole L-shape antenna [21], simple rectangular monopole antenna with asymmetric feed network [22], C-shaped monopole with several embedded arms in the radiator [23], circularly polarized antenna with back reflector [24], a linearly and circularly polarized monopole antenna [25], a broadband circularly polarized antenna with truncated main patch and parasitic stacked patch [26], truncated square patch antenna with metasurface [27] and a monopole antenna configured with lumped capacitor is presented in [28]. However, the main drawback of these circularly polarized antennas is their small impedance and axial ratio bandwidth, complex geometry as many of them requires a feed network or reflector, large size and less flexible design. Thus, designing a monopole antenna with wide impedance and axial ratio bandwidth with less design complexity is always a challenging task.

In this work, a novel design of monopole is proposed with extremely large −10 dB impedance and 3-dB axial ratio bandwidth. The proposed design will cover lower frequency bands also i.e. frequencies lower than 3.1 GHz. The proposed antenna has a hexagonal shaped patch loaded with a wide slot and L-shaped radiator embedded inside the slot. The L-shaped radiator coupled with the help of slotted hexagonal patch is responsible for circular polarization. The L-shaped parasitic element generates two orthogonal waves equal in amplitude and with 90° phase difference, thus exciting circularly polarized band within the impedance bandwidth range. Also, the hexagonal radiator with L-shaped parasitic element does not involve truncation of corners or any loading of active devices used for the function of circular polarization; therefore, making antenna design relatively simple. To improve the radiation characteristics two L-shaped strips are inserted on the two sides of the hexagonal patch. The ground plane of the proposed antenna is of trapeziform shape and the antenna patch is fed through tapered line CPW semi hexagonal ring feed mechanism. The design, analysis and optimization of the proposed monopole are done in Finite Element Method

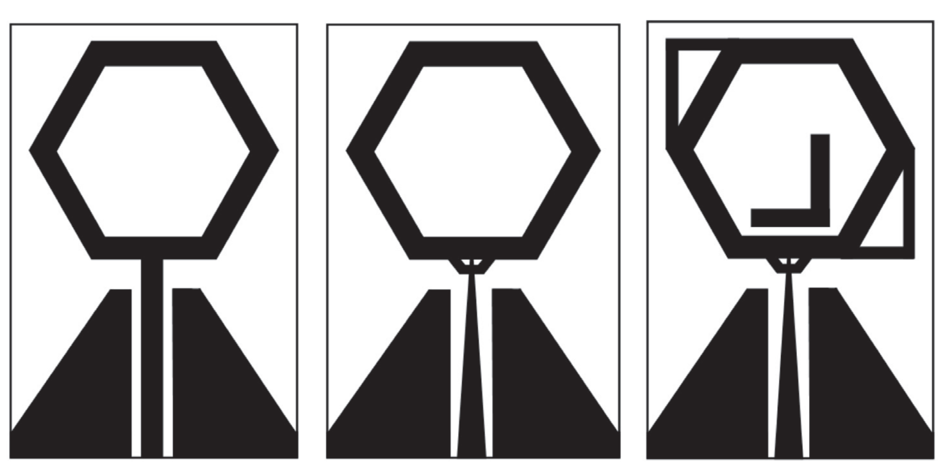

Fig. 2. Designing steps of the proposed antenna (a) CPW fed hexagonal ring patch with trapeziform shaped ground plane (b) Semi hexagonal ring CPW tapered line fed hexagonal ring patch (c) Proposed antenna design.