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Design of Wide Band Low-profile Antenna for 5G Applications

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ABSTRACT

Increase in the demand of 5G technologies the demand for antennas capable of transmitting 5G signals has gone high. A wideband low-profile antenna for 5G applications is presented in this thesis. The proposed design comprises of a pair of vertically placed feeding structures and an Artificial Magnetic Conductor (AMC) surface. The antenna operates at the frequencies of 2.76 - 5.55GHz. The 4x4 AMC reflector surface is used to obtain a stable and unidirectional radiation pattern and also to obtain the low-profile characteristics. The maximum gain of 12.11 dB is achieved using the proposed antenna. Experimental results confirm the antenna meets the need for 5G communication.

Keywords: *Low-profile antenna; Artificial magnetic conductor (AMC) surface; Unidirectional radiation.*

1.0 Introduction

In cellular wireless communication system, dual-polarized base stations antennas are facing many stringent requirements such as wide impedance bandwidth to support multiple wireless communication with rapid development of various generations of mobile communication systems antenna with wide communication systems, antenna with wide frequency bandwidth are preferred in modern base station antenna applications [1-2].

The dual polarized antennas have been widely used to improve the traffic handling capability of the wireless communication channels it responds to both horizontally and vertically polarized radio waves simultaneously [3]. The other factors increased such as high isolation for coupling minimization, low cross-polarization to ensure good polarization performance and stable radiation pattern [4]. Artificial magnetic conductors (AMC) are introduced which are having the property such as no losses and exactly zero reflection plane. But in the practical, the reflection phase of AMC crosses zero at just one frequency but the frequency of useful bandwidth of an AMC is in general defined +90 to -90 on either side of central frequency[1].The design all achieved wide MBWS of 2.76-5.55GHz with the small height of 0.5. Meta materials inspired antenna has also attracted much attention recently because of its low profile, wide operation band width and high gain.

The advent of micro system technologies and nanotechnologies enabled break thoughts in many different areas of science and technology, offering functionalities well beyond the natural ones [5]. It enabled structuring of materials for electromagnetic and optical applications in manners previously unimaginable.

Here the technique use in this thesis is called meta materials (MTMs) structure approach to enhance the performance of the micro strip patch antenna .In recent years, there has been significant interest in investigating meta materials structures and its applications in electromagnetic and antennas community. To enhance the performance in terms of multiple resources, bandwidth and to reduce its size of the antenna, thus improving efficiency, the meta materials structures are used [6]. As some communication systems are operating in multiple frequency bands with increasing data rates. Such communication systems such as UMB.

With the development of wireless communications technologies it has become increasingly desirable for modern communication devices to integrate multiple communication

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standards, such as 2G/3G/4G/5G and WLAN /WIMAX into one single system. However, the development of wireless technology requires efficient antennas that meet the characteristics of these devices. In such a way micro strip antennas have been used in several commercial and military applications [7].

Micro strip patch antenna in its easiest configuration consists of a radiating patch on one side of a substrate filled with dielectric (ϵ r<10), which has a ground plane(metal) on the other side. The patch conductors are used normally of copper or gold, can assume virtually any shape i.e., circle, rectangular, square, triangle, but regular shapes are generally used to simplify analysis and performance prediction, Ideally, the relative permittivity of the substrate should be low(ϵr< 2.5), to enhance the fringing fields that account for the radiation [8]. However, other performance requirements may dictate the use of substrate materials whose dielectric constants can be greater than, say, four. Various types of substrates having a large range of dielectric constant and loss tangent values have been developed. Sometimes if we increase the dielectric constant or relative permittivity of the substrate there is chance to increase the performance of the antenna but high value of dielectric constant substrate may or may not be available to fabricate. The figure shown below is the basic structure of micro strip patch antenna in the centre of the figure there is a patch which is metal in nature which can be any shape, and bottom of the figure1 is ground plane which is metal in nature i.e. substrate is sandwiched between two metals, so micro strip patch antenna consists two metals and one substrate. To energies this structure you need to feed this antenna with different feeding techniques that are discussed in the next topic [9].

2.0 Basic Element of Antenna Design

This antenna consists of mainly three parts: AMC surface, two reconfigurable dipole antennas and two improved feeding structure and U-shaped structure.FR4 is used to print the feeding structure and equilateral triangle reconfigurable dipoles.FR4 is used to print the 16 units consists of AMC surface. Reconfigurable dipoles are used to feed the two cross feed structures. As shown in Fig.1 (a) and Fig.1 (b) the vertex of the bias circuit is connected to the positive pole of the voltage source and ground of the AMC is connected to the negative pole. Artificial Magnetic Conductor is a type of implemented Meta material in several antenna and microwave design applications and is also used for ground based material.

Figure 1(a): Proposed Antenna

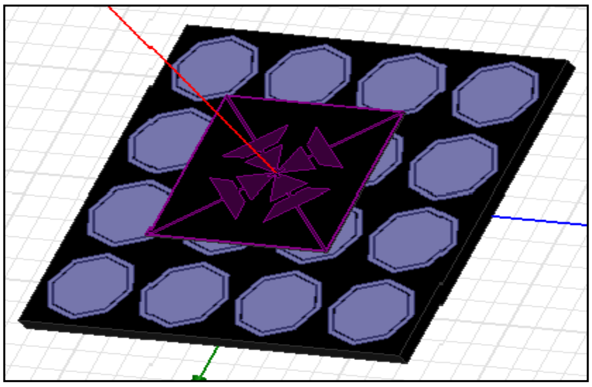


Figure 1(b): Antenna Patch

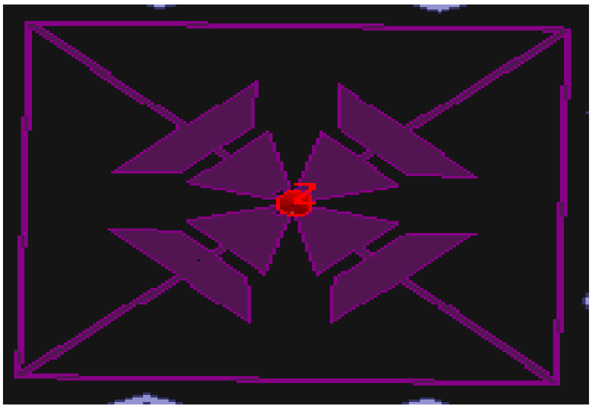
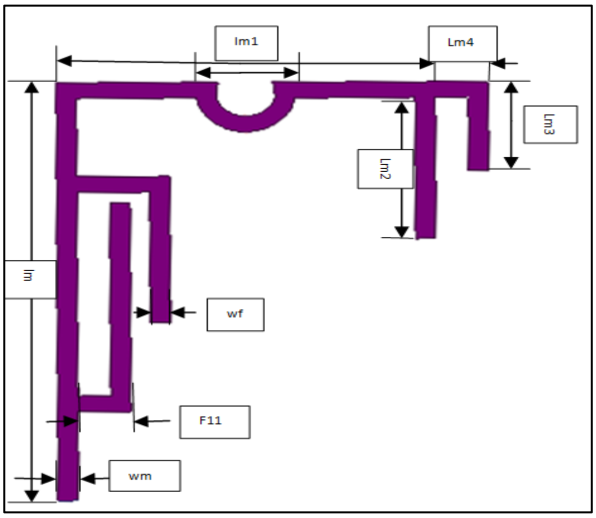
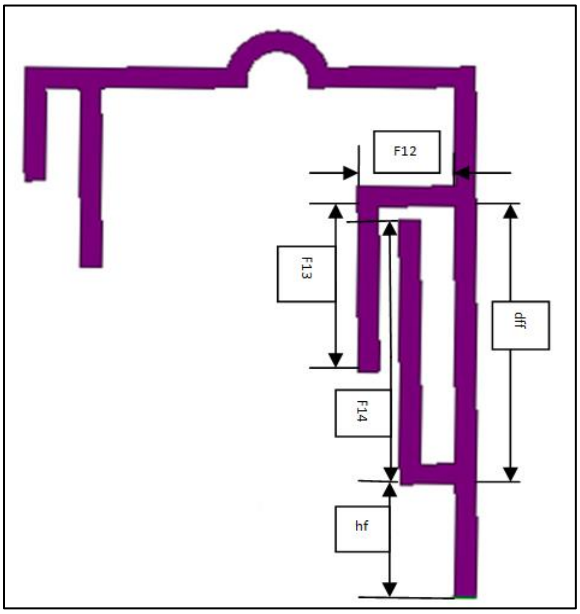


Figure 2: Feeding Structures of Antenna





AMC acts a reflector in a printed antenna is known to improve the antennas Fig.2, feeding structures contain the U-shaped structure. In addition the antenna has a good mechanical characteristics, low profile and good stability. In communication a system is wide band and the message bandwidth and the message bandwidth significantly exceeds the coherence bandwidth of the signal. A wideband antenna is one with approximately the same operating characteristics over a very wide pass band.

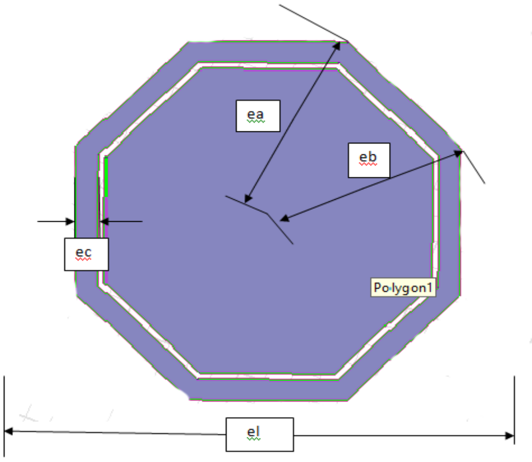
As shown in Figure 3, it needs 8 rectangles to form the feeding structure. Width of the rectangle is 0.3 for all the rectangles. Two feeding structure are used in the proposed antenna. The two feeding structures are used in the reverse direction. Height values are different for one feeding structure and are the same values for another feeding structure.

Table 3: Parameter of Proposed Antenna

Parameter	H1	H2	w	w1	WS	lm	el
Value(mm)	9	0.5	9	2	1.5	8	18
Parameter	lm1	lm2	lm3	lm4	r1	hf	ea
Value(mm)	5.7	3	1.7	0.8	0.75	1.7	8.1
Parameter	df1	fi1	fi2	fi3	fi4	wf	eb
Value(mm)	4.2	0.8	1.4	2.5	4	0.3	7.2
Parameter	a	b	wb	wp	ha	wm	ec
Value(mm)	7	6	0.5	34	3	0.3	0.3

Artificial magnetic conductor including hard and soft surfaces and dual-polarised high impedance surfaces are realized by printed dipole. A magnetically loaded AMC material providing enhanced bandwidth has been developed. The characteristics such as frequency selective surface and high impedance ground plane surface.

Figure 3: AMC Design



3.0 Results and Analysis

Figure 4(a): Simulated Result for Bandwidth of Proposed Antenna

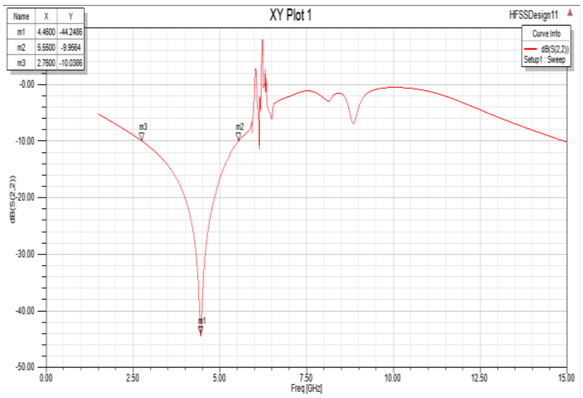
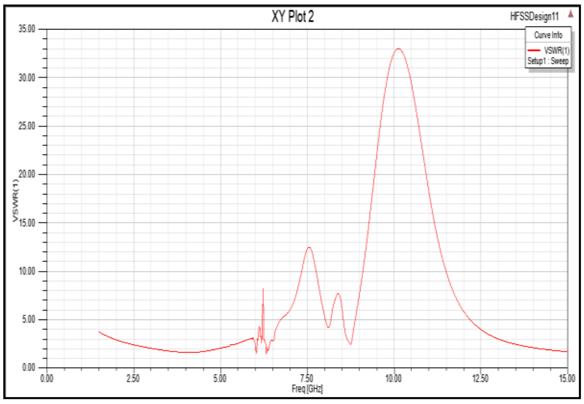


Figure 4(b): Simulated Result for VSWR for Proposed Antenna



As shown in fig. 4(a) and fig. 4(b), the antenna with the U-shaped structure can get great impedance matching and the antenna radiates from the frequencies of 2.76 – 5.55 GHz. The bandwidth of the proposed antenna according to the simulated results is 2.79GHz. This means the antenna is a wide band antenna. It operates at wide frequency spectrum which is a con as the antenna can be used for a wide range of applications, instead of a single application. High bandwidth represents high bit rate. This increases the importance of the antenna. The Voltage Standing Wave Ratio (VSWR) is measured in the fig. 4(b) the simulated results show that the antenna has the VSWR sweep of up to 33dB.

Figure 5(a): Gain of the Proposed Antenna

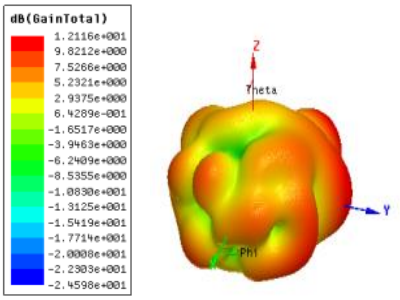
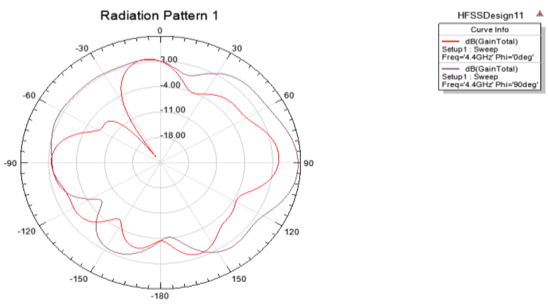


Figure 5(b): Radiation Pattern of the Proposed antenna



The fig. 5(a) and 5(b) represents the simulated results of the proposed antenna for the gain and radiation pattern respectively. The simulated results show that the maximum gain obtained by the antenna is 12.11dB. Also the fig 5(b) represents the radiation pattern of the proposed antenna. Three dimensional represents the antenna radiation patterns. In the field of the antenna design the termradiation pattern refers to the directional dependence of the strength of the radio waves from the antenna.

4.0 Conclusions

A low profile wide band antenna for 5G communication antenna is presented in this paper. The antenna radiates at the frequency range of 2.76 – 5.55GHz. The gain of the proposed antenna is 12.11db. Because of these excellent features, the antenna should possess wide applications in the modern wireless communication systems.

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