Design and analysis of Jeans based Wearable monopole antenna with enhanced gain using AMC backing

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Abstract - A monopole antenna with enhanced gain, low Specific Absorption Rate (SAR) and low profile backed with an artificial magnetic conductor (AMC) for wireless communications is designed and presented in this article. This antenna presents AMC design, which is applicable to reduce the SAR for the portion of the EM waves where electromagnetic pollution is commonly observed. To reduce the radiation of the back lobe and to improve the antenna gain, AMC is designed and backed under the monopole antenna. The antenna resonates in a single band which is from 2.38GHz to 2.44GHz with the reflection coefficient of 2.41Ghz. With the obtained band, the proposed model can be utilised for wearable applications.

Keywords- monopole antenna, AMC, SAR, Wearable antenna.

1. Introduction:
In recent years, many are concentrated on wearable antennas due to massive features like low cost, lightweight, portable and flexible. Such models have to be conformal by applying on different parts of the body, thus there is a necessity to implement with low profile structure using flexible materials. The wearable antenna can be used up by the human anywhere around the wrist, thigh, arm, over the body, on the chest etc [1-5]. When monitoring the user’s conditions and their health remotely on regular basis, vital decisions have been made for saving the human’s life.

The user’s data can be sent by using two forms of communication. One is the on-body, where communication is done through wearable devices closely. The second one is off-body communication, where data analysis is done by physicians and experts remotely. To obtain recognition for an antenna in the wearable industry, it exhibits high efficiency, acceptable gain, flexibility and low Specific Absorption Rate (SAR) which depends on different applications [6,7]. However, within the body, the performance of the designed antenna needs to be evaluated essentially. The absorption level of EM waves by the human is observed with the help of SAR analysis.

To minimize the SAR different types of methodologies have been adopted in the literature through a lot of effort in research. Some of the common techniques is incorporating Artificial Magnetic Conductors (AMCs), Electromagnetic Band Gap structures (EBGs) [8,9] and High Impedance Surfaces (HISs), to the antennas as backing shield. With that being used, surface waves and absorption of EM waves are reduced to great extent [10]. Subsequently, the lowered radiation is obtained towards the body surface and the model exhibits an enhancement in its Front-to-Back Ratio and overall gain [11]. The experimentation for the patch antenna design is carried out by the formulae [12]. The Patch antenna structure [13] also plays a key role along with AMC backing.
In this work, initially designed an AMC surface and integrated with a compact monopole patch antenna at a specific gap to upgrade and observe the radiation parameters significantly. The periodic AMC has contributed negative refractive index along with negative permeability and permittivity, which has increased the gain of antenna.

2. Antenna Design:

The patch antenna has a thin metallic patch above the ground plane. The patch is held up by a dielectric substrate with a thickness of 1.5mm. Thus, microstrip patch is also known as “printed antenna” and its performance depends on size and shape of the patch. The microstrip transmission line is used to fed the antenna. The most commonly designed patch is rectangular shape with its dimensions and structure are shown in table 1 and figure 1 below.

| Parameters | Size(mm) |
|------------|----------|
| l          | 80       |
| w          | 80       |
| Lp         | 47       |
| Wp         | 30.2     |
| Fl         | 32       |
| Fw         | 2.98     |
| Fg         | 1.5      |

The patch length, patch width, feed length, feed width and feed gap of the proposed antenna are calculated from the formulae given in [12]. The s11 of the proposed antenna is observed in figure2(a), the gain of rectangular patch antenna is observed as 6.62dBi which is shown in figure2(b) as far field plot. The patch antenna simulation is carried out at a frequency of 2.4GHz with -45dB as return loss.
2.1. Design of AMC Unit Cell:

The unit cell with AMC backing is proposed by using the Jeans material as the substrate with a thickness of 0.5mm which is very low as compared to various literature surveys. The copper patch is designed with a thickness of 0.035mm. The dimensions of the unit cell with its structure is also shown below in figure 3.

![Figure 3 Proposed Unit Cell with its Parameters](image)

The simulated model is mainly constructed using CST microwave studio as floquet boundary conditions. The placed magnetic conductor acts as a perfect AMC in the respective proposed frequency band.

2.2. AMC Structure and Antenna Design:

At 2.4GHz, the proposed design offers zero phase reflection. The antenna size is designed, so it resonates at required frequency bands and the structure nullifies the phase reflection because within +90 and -90-degrees phase owed to the individual surface. Themonopole antenna isdesigned in a manner with which it provides robust performance and enhances the radiation gain when incorporated with the AMC. The patch antenna is placed at a distance to the ground plane and designed using jeans substrate of thickness as 1.5 mm. The patch antenna is placed above to the AMC surface with a 10 mm of air gap to ensure low profile, in phase reflection and also good impedance matching at the required frequency band. The AMC structure next to antenna design of the designed model is shown in figure 4.
The design has been noticed that, simulated S11 and gain are similar for different sizes of array when simulated. So, to achieve the smallest possible size, it has designed a $2 \times 2$ array of slotted cells. The entire structure is formulated using CST Studio.

![Image](image_url)

**Figure 4** Rectangular patch with AMC backing

The boundary conditions performed for the design are electric and magnetic on respective x-axis and y-axis with z-axis as open-end space. With all these results, the simulated values of the integrated design enhance the gain when compared with a normal patch antenna. So, the proposed model is utilized by integrating the AMC as a backing by maintaining its frequency to produce better gain at a separation of 10mm.

3. **Conclusion:**

This paper presents a simple monopole antenna designed to operate at a frequency of 2.4GHz, later it was proposed with AMC backing as jeans as a substrate surface of thickness 0.5mm which is very small, compared to other substrates, jeans produce best results with the designed frequency. Improved results were obtained with a separation of 10mm connecting the patch antenna and AMC backing surface. The proposed and designed method produces improved gain as compared with simple monopole antenna results. Here, observe that by designing and proposing the AMC as a backing reflector, the efficiency also improved to great extent along with gain. This reduces the backward EM Wave radiation and also
for future work, the miniaturized antenna is designed with backing for several other applications such as WLAN, WI-FI etc.

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