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REGULAR ARTICLE

Multiresonant Artificial Magnetic Conductor Impacted Monopole Antenna for WBAN Applications

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A wearable, small, and effective antenna that incorporates artificial magnetic conductor (AMC) is suggested. In addition to the band notches used as the front end and the square and circular ring array pattern used as the back end, the rectangular monopole patch antenna's inclusion of slots as well as bevels/cuts creates a wide bandwidth. The middle paper serves as an isolator to prevent interference between the AMC's ends. The AMC Meta surface that supports the specified antenna reduces a Specific Absorption Ratio (SAR) considerably and transforms its bidirectional radiation pattern into a unidirectional one. The proposed antenna is outside its Ultra-Wideband (UWB) region of 3.1 through 10.6 GHz, with a frequency range of 3.8 to 13.3 GHz. Band notches have been cut out of the emitting patch using slots within the subbands spanning 5.8 through 6.2 GHz along with 6.6 to 9.1 GHz. The overall dimensions of the building are $29 \times 28 \times 3.624$ mm^2. The AMC layer greatly enhanced this antenna's transmission effectiveness. We used the paper material to produce the suggested antenna compatible with WBAN purposes because it is a flexible and affordable substrate. This offered antenna serves as a suitable option for a range of UWB wearable body area network (WBAN) devices because of its simple structure, thin profile, minimal SAR, wide operational bands, as well as several band notches.

Keywords: Array antenna, Far field pattern, Window method, Array tapering, Side lobe level, Radar applications.

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1. INTRODUCTION

Using a front-to-back configuration revealed generates 13 dB has a peak gain about 3.54 dB, the study in [1] showed that this antenna had considerable coverage emitted away from the human body and displays decreasing radiation towards the human being. The suggested design functions all through a broad frequency range of 2.9 to 12 GHz, which is outside the declared Ultra-Wideband (UWB) spectrum of 3.1-10.6 GHz. Slots were set up within the radiated region that encompassed the 5.50 to 5.67 GHz and 7.16 to 7.74 GHz sub-bands in order to form the band notches. The primary goal of this project [2] has been to layout, model, and construct an implantable antenna which can support mobile wireless local area network implementations by using a coplanar waveguide which is completely integrated into textile materials and operates at 2.45/5.8 GHz.

Given the fact that it is supposed to be positioned in close proximity to the human body, this antenna has to be tiny and effective. A adaptable, small antenna device for telemedicine purposes is based on an M-shaped printed monopole antenna [3]. It operates in 2.45 GHz Industrial, Scientific, and Medical (ISM) band that have a small slotted Jerusalem Crossing (JC) Artificial Magnetic Conductor (AMC) surfaces plane incorporated

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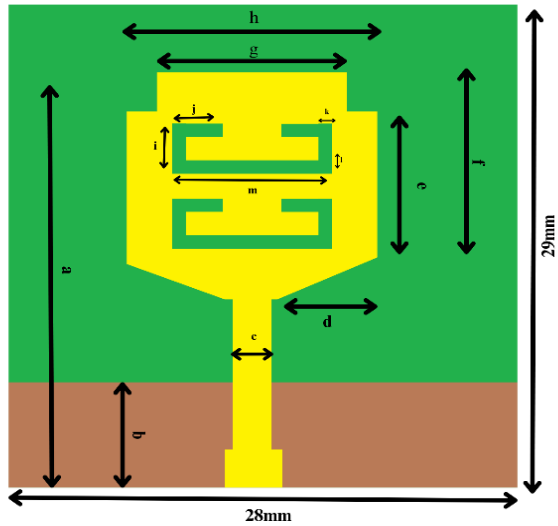
into it. A metamaterial which replicates the characteristics of a perfect magnetic conductor (PMC) is called an artificial magnetic conductor (AMC). Its phase reflection angles are near zero because its magnetic permeability was minus. AMCs function well at certain frequencies and are lossless reactive surfaces.

In [4], a dual-band antenna that utilizes metamaterial construction is presented. The polyimide used to create the antenna's base is what gives it its portable and adaptable shape. A clothing antenna which employs a near-end fire artificial magnetic conductor (AMC) [5] is ideal for body-area network communications which use the 2.4-GHz industrial, scientific, and medical (ISM) radio spectrum. [6] suggests a quarter-mode substrate embedded waveguide design for an implantable antenna which made completely of fabrics and explains how fabrics can be used to create an adaptable, discrete, dual-band AMC antenna which functions at 2.45/5.6 GHz enabling local area network (also known as WLAN) installations that employ on-body antennas. In [8], an invisible antenna that integrates an artificial magnetic conductor (AMC) with a monopole via a ground plane is proposed. Its profile is modest and small. [9] provides a dual-band, dual-polarized antenna with a frequency range of 2.45 GHz with circular polarization and 5.8 GHz with vertical polarization for both on-and off-body wirelessly body area networking (WBAN) operations. In [10], a tapered patch square ring-shaped ground antenna supporting double mode, on-body, as well as off-body telecommunication is analyzed. Specific frequency bands are restricted by UWB systems. To achieve this, several methods are proposed, including multilayered resonant structures, matched networks with frequency-selective characteristics, and antenna designs with built-in low-pass filtering.

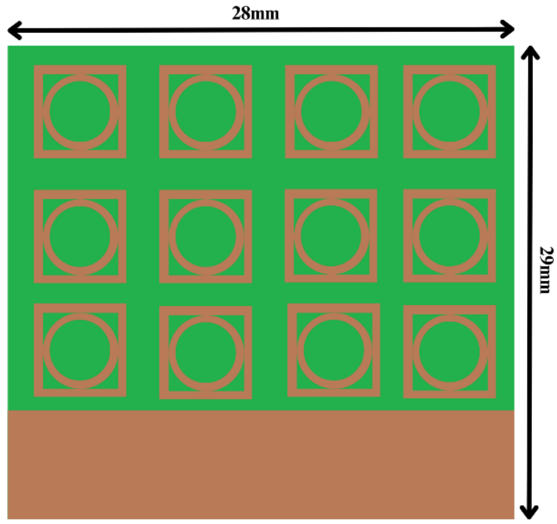
When UWB systems use match networks with frequency-selecting features, the size, complexity, and cost of the antenna are increased. The system is kept small by using multilayered antennas with notch filters built in; this can be accomplished by adding radiating patches or slots [5]. The use of various geometric shapes of radiating structures, such as bouquet-like [14], spiral parasite elements [13], inverted C-shaped [12], and *L*-shaped [11], are additional techniques. This work offers a small AMC-layered monopole patch antenna. It offers a strong gain while handling UWB along with blocks disturbance by using band notches. To achieve the full UWB spectrum, the antenna's emitting patch is altered via square as well as triangular edges, cuts, in addition slits in addition to the necessary band notches. At the bottom of the antenna, AMC is applied. Produce detuning effects to boost gain because change the omnidirectional emission pattern into a unidirectional one.

2. PROPOSED STRUCTURE DESIGN

The dimensions of a basic rectangular monopole antenna that incorporates an artificial magnetic conductor (AMC) are compiled in a table.1. Rectangle monopole antennas with patching are modified with slots enabling bevels/cuts to produce band notches and also a broad frequency. The suggested antenna uses an AMC meta-surface across the opposite side to convert a bidirectional radiating pattern to become unilateral version. Simple design, a minimal SAR, compact profile, together having wide functional regions with numerous bands is all features of the suggested design.



(a)



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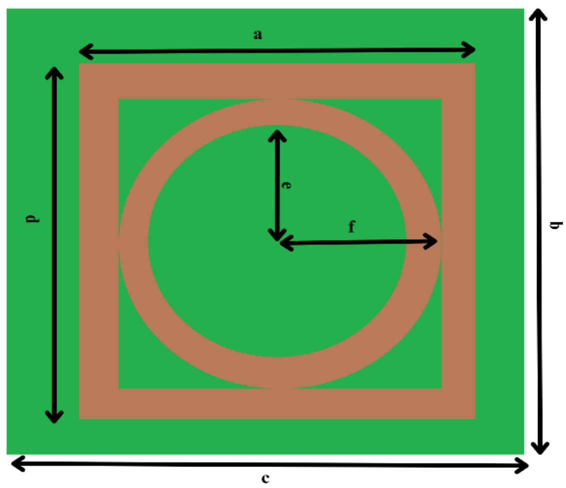

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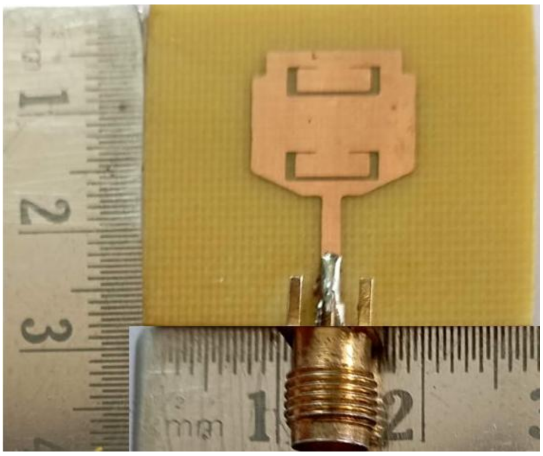


(d)

Fig. 1 – Proposed structure (a) Antenna with slots (b) 4 × 4 array unit cell for AMC (c) UWB unit cell (d) Prototyping of proposal

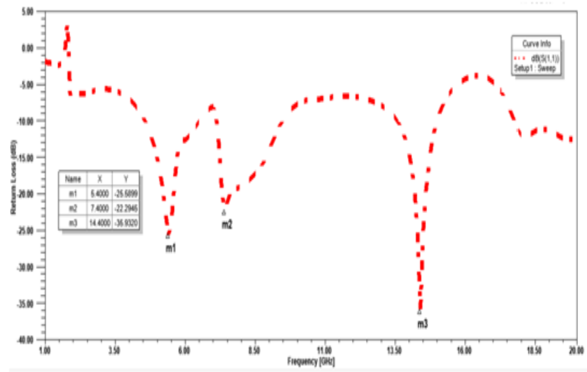
Table 1 – Dimension of the proposed UWB antenna

Name	Values (mm)	Name	Values (mm)
Antenna a with slots			
a	27	h	13
b	7	i	3.8
c	2.5	j	2.5
d	5	k	0.8
e	9	l	0.3
f	11	m	7
g	12		
Unit cell			
a	5	c	8
b	8	d	6
e	2	f	2.5

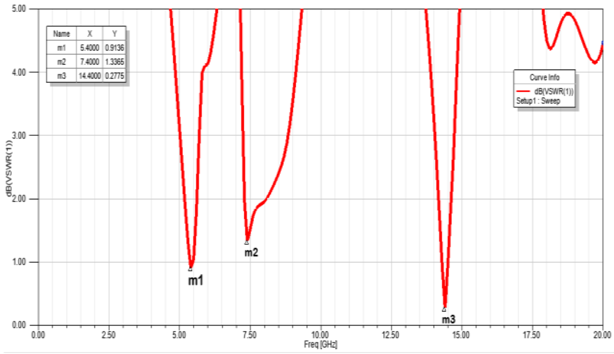
The antenna's is in the form of 4 × 3 array, which lowers the Specific Absorption Ratio (SAR) significantly and converts the two-way radiation back into a one-way form. This is supported by an AMC meta-surface and consists of a circular ring and a square loop unit cell structure. To keep the system small, multilayered structures or antennas with built-in notch filters are used, which can be accomplished by incorporating radiating patches or slots. The monopole antenna differs from conventional patch antennas due to its half-cut ground.

3. RESULTS & DISCUSSIONS

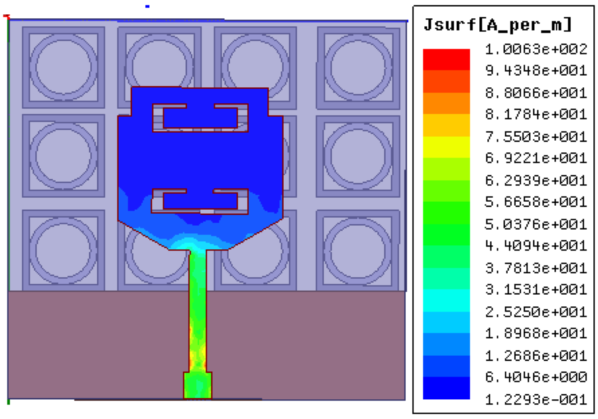
The return loss map shows the performance of the antenna across a range of frequencies. The resultant frequencies for 5.4, 7.4, and 14.40 GHz are shown in Fig. 2(a) below. VSWR, or voltage standing wave ratio in Fig. 2(b) illustrates the antenna's performance in relation to the ratio for the greatest to minimum voltage standing waves across the transmission line. Over the majority of the frequency band, the plot displays a VSWR of lower than 2:1, indicating effective power transfer and acceptable impedance matching. At the frequency notches, where the antenna is intended to reject specific frequency bands, the VSWR rises. Overall, the VSWR of plot demonstrates how well the improved UWB antenna performs. Figure 2(c) shows



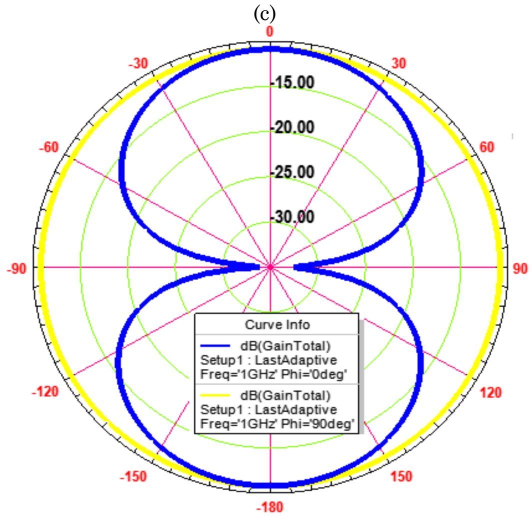
(a)



(b)



(c)



(d)

Fig. 2 – Characteristics of proposed structure (a) Return loss (b) VSWR (c) Current distribution (d) Radiation pattern

the surface current spread graph, which shows the dispersion of electric current over the antenna's surface.

It facilitates better performance and comprehension of the antenna's behavior. By modeling the antenna then measuring the electrical energy flowing on its surface, the plot is produced. Along with areas of varied current density, it offers information about the current's route and direction. Antenna designers can determine which parts of the antenna could require adjustment to enhance performance by examining the surface current spread map. The plane of the electromagnetic wave's electric field vector is known as the *E*-plane.

The magnetic field's vector plane for electromagnetic waves is known to be called, *H*-plane. Crucially, antenna orientation is determined by the *E*-plane in addition *H*-plane. An antenna's spectrum will typically diverge across the *E*-plane from that along the *H*-plane. To properly recognize an antenna's effectiveness and improve its construction for a specific use, practical antenna conception and assessment must take into account both the *E*-plane and *H*-plane radiation patterns. Figure 2(d) displays the electromagnetic pattern of the suggested configuration. A diagram of an antenna's radiating energy on a 2-dimensional space is commonly referred to as this 2D radiation pattern. Typically shown in polar coordinates, it displays the pattern for radiation power as an indicator of direction. The highest radiation in a direction perpendicular to the antenna direction is demonstrated by the "figure-eight" shape.

Table 2 – Performance of proposed structure for different substrate materials

Parameter	**Polyethy lene**	**Polyes-ter**	**Cotton**	**Paper**
Operating frequency (GHz)	6.3, 7.3, 10.6	7.3	7.9	5.4, 7.4, 14.4
Return Loss(dB)	– 10.2, – 11.3, – 15.3, – 18.1	– 12.64	– 17.13	– 25.5, – 22.2, – 35.9
VSWR (dB)	4.8, 3, 2.52	4,12	2.43	0.91, 1.33, 0.27
Operating Bands	3	1	1	3
Ease of Fabrication	Difficult	Difficult	Difficult	Difficult

4. CONCLUSION

For healthcare antenna purposes, a very low-profile patch antenna having an antenna size of 0.2 mm (only about 0.λ at 2 GHz) was proposed. The recommended antenna used in the 2/2.4 GHz WLAN frequency was successfully evaluated along modeled. The computational forecast and the experimental results are largely in agreement. Placing the manufactured antenna directly on the human wrists causes slight variations in impedance. The suggested antenna should work well for on-body medical antenna applications.

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Багаторезонансна штучна магнітна провідна ударна монопольна антена для WBAN застосувань

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Запропоновано носиму, невелику та ефективну антену, яка містить штучний магнітний провідник (ШМП). Окрім вирізів для смуг, що використовуються на передньому кінці, та квадратної та круглої діаграми розташування кільцевих решіток, що використовується на задньому кінці, наявність прорізів, а також скосів/вирізів у прямокутній монопольній патч-антені створює широку смугу пропускання. Середній папір служить ізолятором для запобігання перешкодам між кінцями ШМП. Поверхня Мета ШМП, яка підтримує зазначену антену, значно зменшує питомий коефіцієнт поглинання (SAR) та перетворює її двонаправлену діаграму спрямованості на односпрямовану. Запропонована антена знаходиться поза межами своєї надширокосмугової (UWB) області від 3,1 до 10,6 ГГц, з діапазоном частот від 3,8 до 13,3 ГГц. Вирізи для смуг були вирізані з випромінювальної плями з використанням прорізів у піддіапазонах, що охоплюють від 5,8 до 6,2 ГГц, а також від 6,6 до 9,1 ГГц. Загальні розміри будівлі становлять 29 × 28 × 3,624 мм². Шар AMC значно підвищив ефективність передачі цієї антени. Ми використали паперовий матеріал для виготовлення запропонованої антени, сумісної з цілями WBAN, оскільки це гнучка та доступна підкладка. Ця запропонована антена є підходящим варіантом для ряду пристроїв, що носяться на тілі (UWB), завдяки своїй простій структурі, тонкому профілю, мінімальному коефіцієнту поглинання, широким робочим діапазонам, а також кільком смугам виїмок.

Ключові слова: Антенна решітка, Діаграма спрямованості дальнього поля, Метод вікна, Звуження решітки, Рівень бічних пелюсток, Застосування в радіолокації.