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PDMS-Based U-Slotted Patch and Meander Line Antennas for Search and Rescue Applications

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***Abstract* - This study focuses on the development of a low-profile meander line-based antenna as well as a U-slotted patch antenna that was built specifically for the requirements of search and rescue operations. Both of these antennas serve as the primary focus of this investigation. Both the meander line antenna and the U-slotted patch antenna that are being considered are planned to be constructed on a substrate that is made of polydimethylsiloxane (PDMS). PDMS is selected because of its desired features, which include its durability, flexibility, resistance to water, and adaptability for deployment in demanding environmental circumstances. The usage of the search and rescue application necessitates the operation at a relatively lower frequency of 406 MHz, which in turn necessitates the utilization of antennas that have a longer electrical length. As a consequence of this, these antennas have a propensity to have larger physical dimensions. In order to circumvent the problem, it is possible to make use of U-Slotted Patch and Meander Line Antennas, which will result in a smaller dimension. This was proved by the results of the simulation, which showed that the antenna functioned at a central frequency of 406 MHz, displaying a bandwidth of 40.5 MHz for the U-slotted patch antenna and 67.49 MHz for the meander line antenna, respectively. Concerning the two antennas, these bandwidths were equivalent to a fractional bandwidth percentage of 9.9% and 16.55%, respectively, when evaluated at -10 dB of the reflection coefficient.**

Keywords: wearable antennas; flexible antennas; compact antennas; search and rescue; Cospas-Sarsat.

I. INTRODUCTION

A worldwide collaborative satellite-based radiolocation system is comprised of a number of essential components, including COSPAS, which is an acronym for Cosmicheskaya Systyema Poiska Aariynyich Sudov, and SARSAT, which is an acronym for Search and Rescue Satellite technology, aided Tracking System. Individuals that are in need of aid during search and rescue operations, such as aviators, seafarers, and land travelers, can receive assistance via this system, which is meant to give assistance. France, Canada, and the United States of America all worked together to build SARSAT at the same time. In the context of humanitarian aid, the acronym COSPAS-SARSAT refers to a network of satellites deployed by many governments to provide emergency rescue services. The collaborative endeavor, which was initially launched in 1979 by Canada, France, the United States of America, and the Soviet Union, is currently being carried out by 45 different nations. To enable the transmission of SAR (Search and Rescue) data, which includes information on the location of emergency situations, to the appropriate authorities of the 45 nations that have signed the agreement, the COSPAS-SARSAT system has been developed. The sharing of information makes it possible to effectively coordinate and carry out activities involving search and rescue. Presently, the program is comprised of a total of 62 satellites that are currently operational [1]–[5].

Researchers from a wide range of academic institutions have made significant contributions to the subject by providing research that concentrate on the development of antennas that are tailored especially for certain applications. These studies have taken into consideration the essential necessity of maintaining the antennas' robustness under harsh environmental circumstances by utilizing a variety of materials that are long-lasting. In [6], the presentation of two different designs of meandering dipole antennas that operate at a frequency of 406 MHz has been the subject of an investigation that has been carried out. A non-conductive textile material is one of the two materials that are being considered for use in the textile industry. With a permittivity (ε_r) of 1.44 and a loss tangent (tanδ) of 0.044, the first textile material demonstrates its characteristics. 3 millimeters is the thickness of it. The shield is the name given to the second type of textile material there is. There are conductive components included in the design of the antennas that have been suggested. The conductivity of the layer is determined to be 1.18 x 10^5 S/m, while the thickness of the layer is measured to be 0.17 millimeters. The antenna being considered has a fractional bandwidth of 10.05%. The recommended antenna has dimensions of 200 x 75 x 3 mm3, which may alternatively be represented as $0.271\lambda_0 \times 0.102\lambda_0 \times 0.0041\lambda_0$.

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The antenna mentioned in reference [3] is a patch antenna of the type that functions at a frequency of 406 MHz [4], [7] . The substrate of this product is made of a low-loss foam substance, while the conductive components are created using an inkjet-printing technology. The antenna has dimensions of 283 x 65 x 17.5 mm^3 ($0.383\lambda_0 \times 0.088\lambda_0 \times 0.024\lambda_0$) when it operates at a frequency of 406 MHz. The antenna was aligned parallel to the human body model, and the distance between the antenna and the model was systematically varied between 0 and 200 mm. An experiment was conducted to examine the effect of water on the return loss of an antenna. This was done by varying the gap distance between the water and the antenna, ranging from 0 to 120 mm. In a recent study, researchers presented a unique device comprising of two antennas that may be worn on a life vest [8].

One antenna is connected to the buoyant components on the chest region, while the other is linked to the buoyant components on the neck region. In the context of life-saving equipment, a traditional life vest is used, where the antenna is attached to both the chest and neck areas of the buoyant part of the vest, providing their respective functions. Both antennas examined in this investigation are meandering dipole antennas that are folded and employ a Rohacell substrate. The antennas demonstrate resonance at a frequency of 406 MHz. The antenna has dimensions of 300 × 150 × 1 mm^3 ($0.406\lambda_0 \times 0.203\lambda_0 \times 0.0014\lambda_0$) and operates at a frequency of 406 MHz. The proposed antenna demonstrates a fractional bandwidth of 4%. The experiment resulted in a simulated increase of 7 dB when the antenna was placed on the chest; however this number reduced to 1 dB when the antenna was moved to the head position.

In this paper two different types of flexible antennas are presented for the first time. The first antenna is a U-Slotted Patch, while the second antenna is a Meander Line Antenna, which will result in a lower dimension. Both of these antennas have a maximum gain at 0 degrees elevation (looking to the sky), and they both have a resonance frequency of 406 MHz. In this article, we suggest two alternative types of antennas that share these characteristics. The results of the simulation demonstrated that the antenna operated at a central frequency of 406 MHz, exhibiting a bandwidth of 40.5 MHz for the U-slotted patch antenna and 67.49 MHz for the meander line antenna, respectively. This was demonstrated by the fact that the antenna functioned at a fundamental frequency of 406 MHz. These bandwidths were comparable to a fractional bandwidth percentage of 9.9% and 16.55%, respectively, when evaluated at -10 dB of the reflection coefficient. This was the case concerning the two antennas.

II. ANTENNA DESIGN

2.1 Materials

The study will utilize two different types of materials in the design of the antenna. The ShieldIt Super ™, developed by LessEMF Inc., is one of the conductive textiles used to create the conductive components of the antenna, such as the radiator and ground plane. The material has an electrical conductivity of 1.18 x 10^5 S/m, and has a thickness of 0.17 mm. The polydimethylsiloxane (PDMS) substrate used in this investigation has a permittivity (ε_r) of 2.7, a loss tangent (tanδ) of 0.02, and a thickness of 3 mm. ShieldIt Super and PDMS have been utilized for satellite communications antennas and polarizing converter surfaces presented by Hidayath *et al* and Hossain *et al*[9]–[11].

2.2 Rectangular patch with U-slot antenna topology

When it comes to the microwave frequency spectrum, microstrip antennas, which are also frequently referred to as patch antennas, have gained a substantial amount of appeal due to the inherent simplicity of the technology and its smooth integration with printed circuit board processes. As a microstrip antenna, the pin-fed rectangular patch is applied extensively in a wide variety of applications.

Patch antennas have a comparatively narrow bandwidth, which is one of the primary limitations connected with them. There are a number of methods that can be utilized in order to increase bandwidth. Some of these methods include increasing the patch height, decreasing the relative permittivity, utilizing stacked patches, employing a coplanar parasitic subarray, inserting shorting pins, or integrating slots.

When compared to the U-slot patch, which exhibits a much greater bandwidth that may reach up to 40.5 MHz, the rectangular U-slot patch that is shown in Figure 1 (a) to Figure 1 (d) has a bandwidth that is roughly 9.9%. A rectangular patch that is placed on a dielectric substrate and has a ground plane placed beneath it is what is meant by the term "U-slot patch antenna." The patch is removed by removing a slit in the shape of a U. It may be observed that the parallel arms of the slot are parallel to the side of the patch that is the length.

A coaxial feedline is used to supply the antenna with the necessary amount of power. An electrical connection is made between the patch and the center conductor through the use of a hole in both the substrate and the ground plane. The outside conductor is connected to the ground plane, and the center conductor is connected to the patch. A list of the antenna parameters that were used in the simulation is provided in Table 1.

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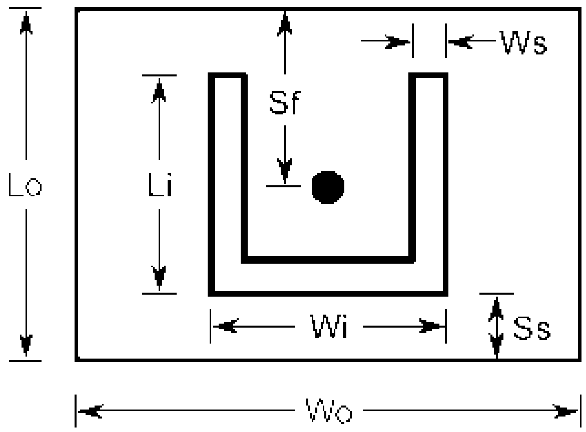

Figure 1(a): Antenna with slotted patch front view

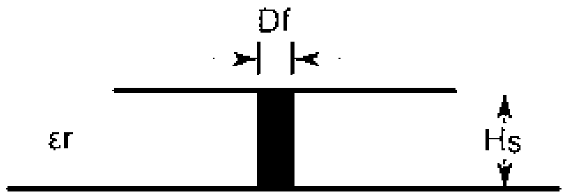

Figure 1(b): Slotted patch antenna side view

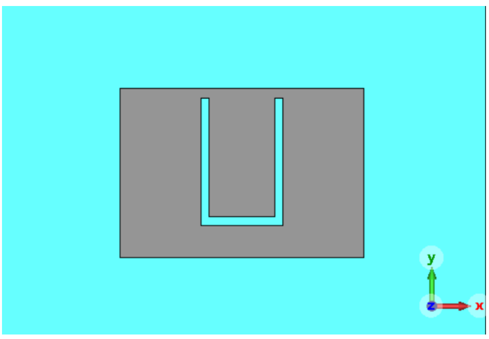

Figure 1(c): Front View and, (d): side view of Slotted Patch antenna in CST

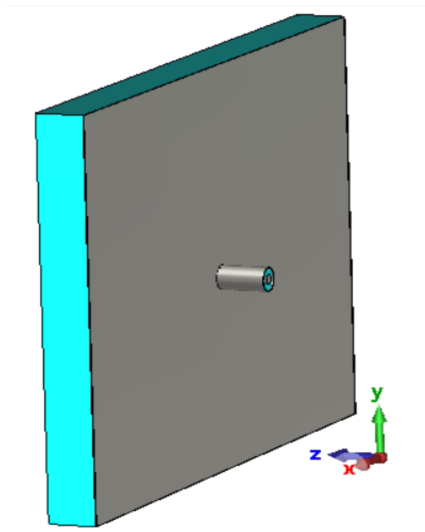

Figure 1(d): Side view of Slotted Patch antenna in CST

Table 1: Parameters for antenna design

Parameter	Value (mm)	Parameter	Value (mm)
ε_r	2.7	**Lo**	176.1
Hs	40.18	**Wo**	253.2
Ss	33.75	**Li**	131.6
Df	8.618	**Wi**	85.74
Ws	9.042	**Sf**	96.18

Kin-Fai Tong et al. has used "U" shaped slot to get broadband and circular polarization[12]. The resonance behavior of of using the U-slot patch antenna with single and dual slit in the patch has been discussed in [13]Weigand *et al.* [13], [14] . U-slot has also been implemented in textile PIFA antenna to enhance the bandwidth and control the resonant frequency by Pink Jack et al.[15].It has been found that the U-slot patch displays four different resonance frequencies.

In accordance with the findings of Weigand *et al.*, the first resonant frequency, which is represented by the symbol fres1, displayed a linear connection with the overall slot length. However, because of the existence of a high input impedance, its radiation efficiency is restricted to a certain extent.

There is a considerable association between the patch's TM01 mode and the second resonant frequency, which is denoted by the symbol fres2. The current trajectory is directed in the *y*-direction, which indicates that the dimensions of the patch as well as the slot will have a substantial impact on fres2. According to Weigand *et al.*, this occurrence takes place as a result of the influence of the measured distance that exists between the feed point and the two principal radiating horizontal edges.

The third resonant frequency, which is indicated by the symbol fres3, possesses a greater degree of complexity. There is a correlation between an increase in the width of the inner element and an increase in fres3 for particular values of the amount of length of the inner element. It is reasonable to anticipate a reduction in the Fresnel zone clearance, which is symbolized by the symbol fres3, given that the distance between the feed-point and the bottom radiating edge has risen. In accordance with the findings of Weigand and colleagues, the occurrence of an increase is indicative of the existence of a current route in the *x*-direction. The fact that the only paths that considerably shorten the distance between the feed point and the two vertical edges are the ones that are specified lends credence to this assertion.

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Establishing the relationship between the slot and the small "pseudopatch" is the first step in determining the relationship between the fourth resonant frequency, fres4. In the context of this discussion, the term "pseudopatch" refers to a device that possesses a number of different features, such as an effective permittivity and an effective patch width. In accordance with the methodology presented by Weigand *et al*., these parameters are utilized in the calculation of fres4.

In order to determine the operational bandwidth of the antenna, the second, third, and fourth resonant frequencies are taken into consideration.

2.3 Antenna Topology Meander Line Antenna (MLA)

Meander line antennas have a wide range of uses, including RFID tag usage at frequencies of 911 MHz and 13.56 MHz. Radio frequency identification (RFID) tags that are passive (meaning they do not require a power supply) are stimulated by an induced voltage that is produced by an incoming inquiry signal that is delivered by the reader antenna. The voltage that is produced at the terminals of the tag antenna serves as the voltage source. The quantity of voltage that is generated is sufficient for activating the chip, and it also serves as the energy source for charging a capacitor that has a big capacity. Following the protocols that have been set, the chip will alter its input impedance such that it is in accordance with the complex conjugate impedance of the tag[16], [17]. This will result in the transmission of a back-scattered signal, which will then be identified by the reader antenna.

For the Search and Rescue application operating at 406 MHz, the MLA is now being presented. With a bandwidth of 67.49 MHz and a -10 dB Axial ratio bandwidth of 16.55%, the antenna that is being provided includes a frequency range that extends from 0.37394 GHz to 0.44143 GHz.

Figure 1 (a) and Table 2 both show that a normal T-match arrangement is made up of a lengthy dipole with a length that is designated as L_1. In addition to this dipole, there is a folded dipole, which is also referred to as a *T-stub*, and its length is given by the symbol L_2. A particular distance, denoted by the letter ***d***, is the point at which the *T-stub* is connected to the long dipole. To fulfill the requirements, it is necessary that the length L_1 is longer than the length L_2, and it is frequently observed that the widths W_1 and W_2 of the corresponding strips are not the same. In the study conducted by [18]–[20], by altering the diameter of the arms of the *T-stub* so that it was different from the diameter of the feed terminals, the T-match arrangement was modified from its original state. Consequently, the region where the long dipole is coupled to the folded dipole has a higher width of the strip of the long dipole than the rest of the region. The occurrence of these phenomena is responsible for the decreased resistance and increased bandwidth that this technology is able to achieve. The findings of the simulation reveal that the optimization method makes it easier to blend two resonances that are adjacent to one another, which ultimately results in a broader bandwidth to be achieved. Both the L_P and W_P ends of the uniform meander dipole are provided with rectangular patches. These patches are located at both ends of the dipole. According to what was expected, the length of the patch has an effect on the resonant frequency, whilst the breadth of the patch has an effect on the impedance of the structure and the bandwidth of the structure.

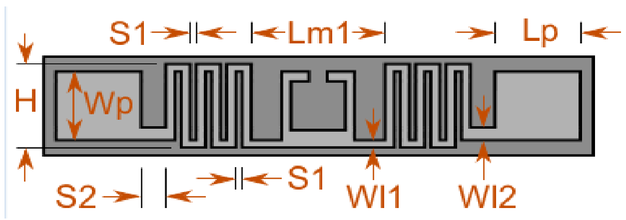

Figure 2(a): Meander line antenna front view

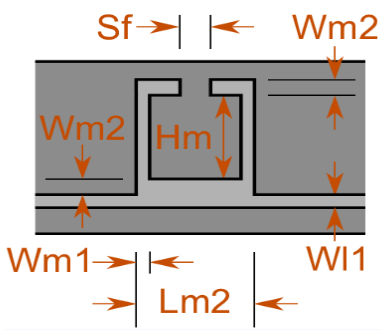

Figure 2(b): Detail front of meander line antenna

Figure 2(c): View of meander-line antenna from the side

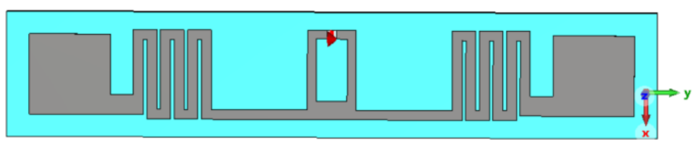

Figure 2(d): Simulated front view of the antenna in CST

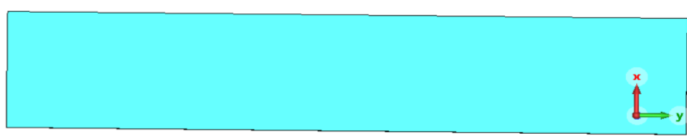

Figure 2(e): Simulated back view of the antenna in CST

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Table 2: Design parameters for meander line antenna

Parameter	Value (mm)	Parameter	Value (mm)
ε_r	2.70	Wl_2	6.65
L_P	26.97	S_1	1.22
W_P	27.22	S_2	7.56
H	30.26	H_M	85.74
Wl_1	3.28	LM_1	96.18
LM_2	16.10	WM_1	2.94
H_S	3		

III. RESULTS AND DISCUSSIONS

Both of the antennas, a slotted patch antenna and a meander line antenna; have their reflection coefficients displayed in Figure 3 (a) and Figure 3 (b), respectively. These figures show the findings of the reflection coefficient for both of the antennas. Through the use of the figure, it becomes apparent that both antennas display resonance at a frequency of 406 MHz. With a bandwidth of 40.5 MHz and 67.4 MHz, respectively, this finding reveals that the antenna demonstrates optimum impedance matching for the frequency that is intended to be used.

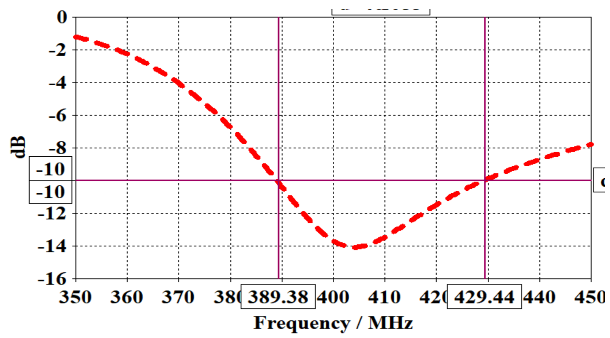

Figure 3(a): Reflection coefficient slotted patch antenna with a -10 dB performance

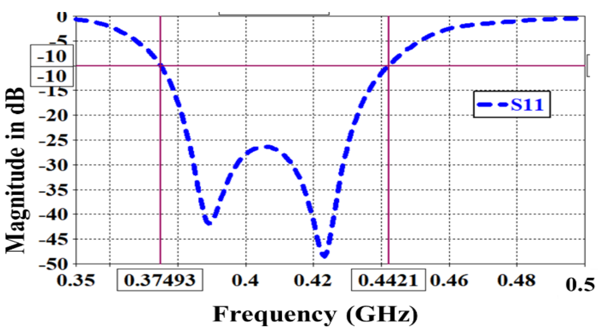

Figure 3(b): -10 dB meander line antenna reflection

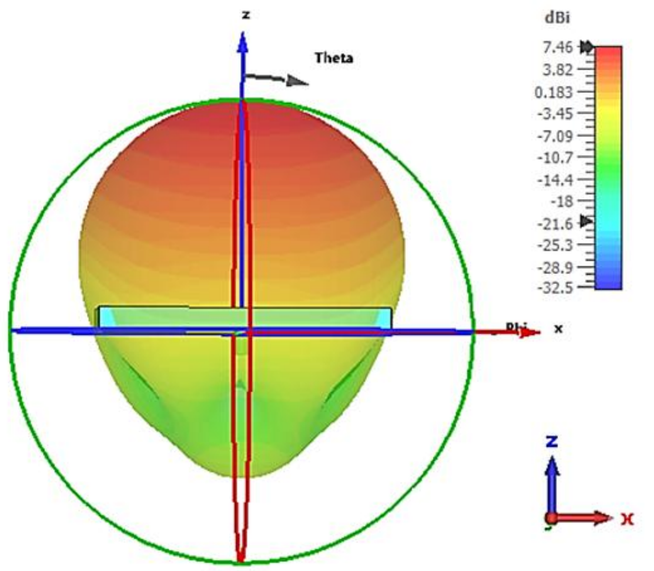

Figure 4(a): 3D radiation pattern with slotted patch antenna in middle

Both the slotted patch and the meander line antenna have achieved gain 3D radiation patterns, which are displayed in Figure 4(a) and Figure 4(b), respectively, along with their respective antenna structures. The maximum gain of both antennas can be seen to be in the *z*-direction, which is easy to see and confirm because the antenna will be positioned or placed on the beacon, and it will be facing upwards toward the sky, this attribute is highly significant because the antenna will be put on the beacon. In the event that the antenna has a null at 0^0or in the z-direction. If this is the case, the antenna will not be able to send a signal to the satellite.

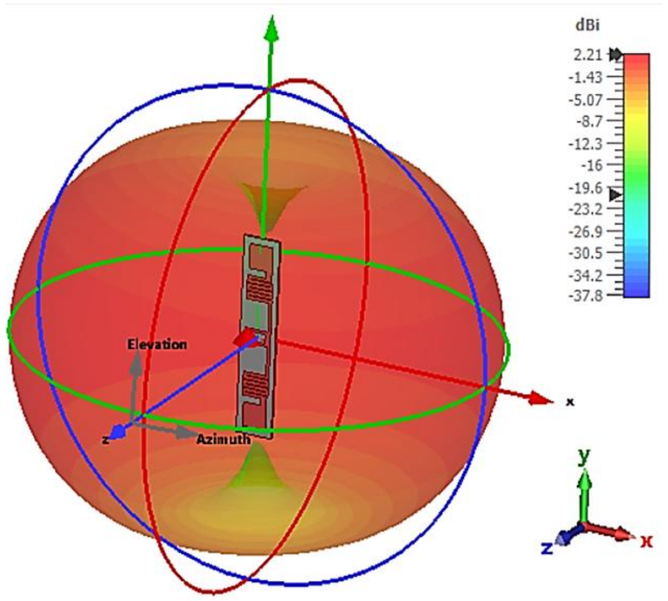

Figure 4(b): Meander line antenna 3D radiation pattern with antenna at center

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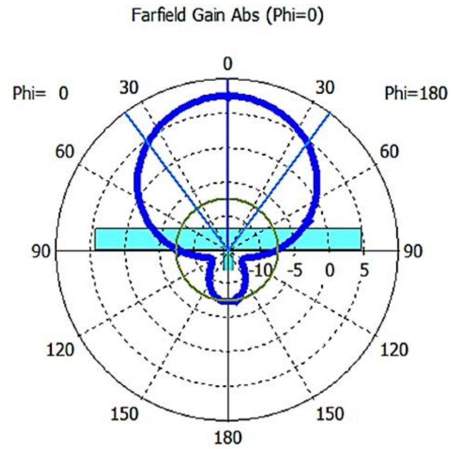
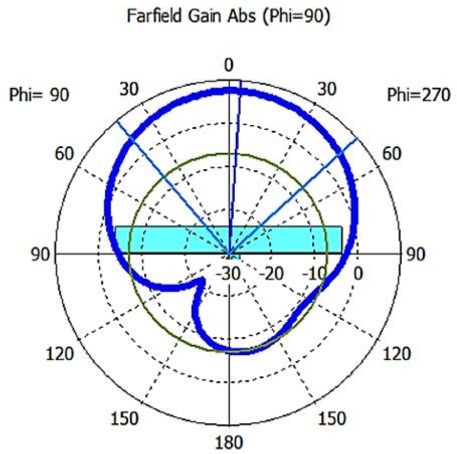


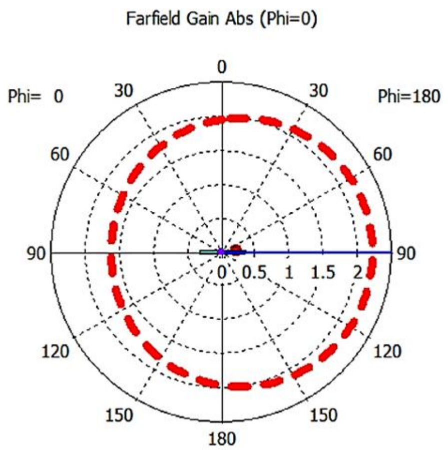
(a)



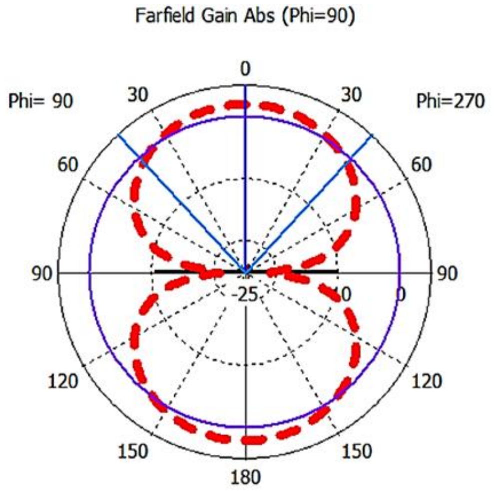
(b)

Figure 5: Simulations of slotted patch antenna radiation in free space: (a) Eφ (φ =0^0), and (b) Eφ (φ=90^0)

The Fig. 5 (a), (b) and Fig. 6(a), (b) presents the magnitude of gain in form of radiation patterns for φ =0^0 and φ=90^0. It can be observed that the antenna does not have nulls at 0^0.



(a)



(b)

Figure 6: Free-space meander line antenna radiation simulations: (a) Eφ (φ=0^0) and (b) Eφ (φ=90^0)

IV. CONCLUSION

A novel flexible COSPAS-SARSAT beacon antenna is now the focus of research that is being carried out. This study is being carried out at the moment. The operational frequency of the system is 0.406 GHz, and it is specifically designed to be used in the Mission Control Centers of COSPAS-SARSAT. The two antennas demonstrated here successfully achieve the two essential objectives in the following manner: The primary purpose of the first function is to optimize impedance matching at a frequency of 0.406 GHz, while the second function is to maximize gain at an angle of 0 degrees. Both of these functions are mutually exclusive. In the overall design of the structure, the conducting element is ShieldIt Super, while the substrate is PDMS. The entire building was constructed using a foundation that allows for total adaptability. The examination of the two antennas revealed that the predicted -10dB Fractional bandwidth was 9.9% for the slotted patch antenna under planar conditions, and 16.55% for the meander line antenna.

REFERENCES

[1] S. M. Catalogue and U. States, "COSPAS-SARSAT," pp. 1–85, 2012.

[2] H. Mirza, P. J. Soh, R. A. Sheikh, A. A. Al-Hadi, T. M. Hossain, and S. Yan, "A Flexible Wearable Linear-to-Circular Polarizer for GNSS Application," *ICEICT 2020 - IEEE 3rd Int. Conf. Electron. Inf. Commun. Technol.*, pp. 337–340, 2020.

[3] H. Mirza *et al.*, "Swastika-Shaped Flexible Linear to Circular Polarizer using Textiles," vol. 100, no. 1, pp. 2–4.

[4] G. Kumar, V. K. Singh, and M. B. Mahajan, "Broadband blade antenna operating in UHF band for ELT application," *2nd International Conference on*

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ISSN (online): 2581-3048
Volume 8, Issue 1, pp 81-87, January-2024
https://doi.org/10.47001/IRJIET/2024.801011

Wireless, Antenna and Microwave Symposium, WAMS 2023. 2023.

[5] J. V King, "Overview of the Cospas-Sarsat Satellite System for Search and Rescue."

[6] E. Faridah *et al.*, "A Wearable Textile Dipole for Search and Rescue Application," vol. 1, pp. 1–4, 2016.

[7] A. A. Corner, "Body-Worn Antennas Making a Splash : Lifejacket-Integrated Antennas for Global Search and Rescue Satellite System," vol. 55, no. 2, 2013.

[8] A. A. Serra, P. Nepa, and G. Manara, "A Wearable Two-Antenna System on a Life Jacket for Cospas-Sarsat Personal Locator Beacons," vol. 60, no. 2, pp. 1035–1042, 2012.

[9] H. Mirza *et al.*, "Deployable Linear-to-Circular Polarizer Using PDMS Based on Unloaded and Loaded Circular FSS Arrays for Pico-Satellites," *IEEE Access*, vol. 7, pp. 2034–2041, 2019.

[10] T. Hossain *et al.*, "Broadband Single-Layered , Single-Sided Flexible Linear-to-Circular Polarizer Using Square Loop Array for S-Band Pico-Satellites," *IEEE Access*, vol. 7, pp. 149262–149272, 2019.

[11] H. Mirza *et al.*, "A crossed dodecagonal deployable polarizer on textile and polydimethylsiloxane (PDMS) substrates," *Appl. Phys. A Mater. Sci. Process.*, vol. 124, no. 2, p. 178, 2018.

[12] K. F. Tong and T. P. Wong, "Circularly polarized U-slot antenna," *IEEE Trans. Antennas Propag.*, vol. 55, no. 8, pp. 2382–2385, 2007.

[13] R. Behavior, S. U-slot, and D. U. Antenna, "DUAL U-SLOT ANTENNA," pp. 14–17.

[14] S. Weigand, G. H. Huff, K. H. Pan, and J. T. Bernhard, "Analysis and design of broad-band single-layer rectangular U-slot microstrip patch antennas," *IEEE Trans. Antennas Propag.*, vol. 51, no. 3, pp. 457–468, 2003.

[15] P. J. Soh, G. A. E. Vandenbosch, S. L. Ooi, and N. H. M. Rais, "Design of a broadband all-textile slotted PIFA," *IEEE Trans. Antennas Propag.*, 2012.

[16] T. Althobaiti, A. Sharif, J. Ouyang, N. Ramzan, and Q. H. Abbasi, "Planar Pyramid Shaped UHF RFID Tag Antenna with Polarisation Diversity for IoT Applications Using Characteristics Mode Analysis," *IEEE Access*, vol. 8, pp. 103684–103696, 2020.

[17] N. W. Hlaing, K. Kamardin, Y. Yamada, T. Arima, M. Takahashi, and N. Michishita, "Analytical Equations for Designing Meander Line Antennas," *IEEE Open J. Antennas Propag.*, vol. PP, p. 1, 2024.

[18] H. Mirza and M. F. Elahi, "A UHF-RFID tag antenna for commercial applications," *Proc. ICECE 2008 - 5th Int. Conf. Electr. Comput. Eng.*, vol. 00, no. December 2008, pp. 764–767, 2008.

[19] H. Mirza, M. I. Ahmed, and M. F. Elahi, "Circularly polarized compact passive RFID tag antenna," in *Proceedings of ICECE 2008 - 5th International Conference on Electrical and Computer Engineering*, 2008.

[20] R. A. Sheikh *et al.*, "Design of a Compact Meander-Based Antenna for Search and Rescue using PDMS," *Proc. - CAMA 2019 IEEE Int. Conf. Antenna Meas. Appl.*, pp. 258–260, 2019.

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