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A Compact Dual Band Microstrip Antenna for GPS L1/GS Applications

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ABSTRACT: A miniaturized dual band antenna is presented for using GPS L1/GS communication systems. This antenna structure consists of a radiating patch with four mender line resonant elements, and a modified ground plane which provides a dual band covering from 1.55 GHz to 1.64 GHz frequency. The inductances and capacitances developed due to the ground plane and patterned radiating patch leads to the behavior of the metamaterial. The proposed antenna designed on Rogers's 4350 material substrate with dimension of 25.4 mm × 25.4 mm× 0.762 mm. The proposed antenna shows good Omni directional radiation pattern, considerable gain level, and reasonable S_{11} for using in the GPS L1/GS communication systems.

KEYWORDS: Breast cancer, Omni-directional radiation pattern, microwave imaging, ultra-wideband.

I. INTRODUCTION

Owing to the rapid growth of wireless communication technology, miniature antenna plays a significant role for small size multifunctional devices. In recent days, all communication devices need to be small in size, compact, lightweight, in short should be portable. Moreover, portable devices obligatory to operate dual frequency band applications to use in different areas or countries.

Recently, demand of satellite based portable communication devices are increasing noticeably, especially vehicle tracking, mobile communication portable satellite station, weather forecasting etc. A considerable number of patch antenna have been developed targeting better performance for multiple frequency band applications due to lower performance of wired antennas. A low profile, compact, Antenna size reduction with multiband operation capability is still interesting topic for communication engineering researchers. A considerable research effort is given to antenna miniaturization to integrate with small form factor multi frequency devices without compromising the overall performance. There are several techniques have extensively studied by many researchers, such as using reactive impedance substrate [1], artificial magnetic conductor [2], EBG substrate [3], Metamaterials [4-7], Multilayer dielectric substrates [8], etc. Use of ceramic material substrate is one of the effective techniques for antenna miniaturization. Due to higher dielectric constant of the ceramic material substrate, the overall size of antenna can be reduced significantly without compromising the overall performance [9]. Many antenna technology researchers have comprehensively examined the use of ceramic material substrate for miniature antenna design in their article. A miniature antenna was designed using thick truncated textured Ceramic Substrate with the dimension of 14 mm×13.6 mm at 1.88 GHz resonant frequency and obtained 3.5 MHz of bandwidth [10]. A 25 mm×10 mm ×4 mm multiband dielectric resonator antenna designed for multi-standard mobile handheld devices [11]. A miniaturized patch antenna designed with 25.4 mm × 25.4 mm × 6.35 mm dimension using low temperature co-fired-ceramic (LTCC) substrates [12]. On the other hand, Metamaterial-inspired electrically small antennas were proposed in [13] and further developments in the corresponding electric monopole-based electrically small antenna designs have been obtained and confirmed experimentally. Although there is no bulk metamaterial involved in the performance enhancements of these antennas, their radiating elements represent a single unit cell of a metamaterial structure, which leads to the metamaterial-inspired terminology [14, 15]. However, in terms of antenna size reduction or bandwidth enhancement there are still needs to put more research effort for miniaturization with better performance to meet the ever increasing demand for dual band applications.

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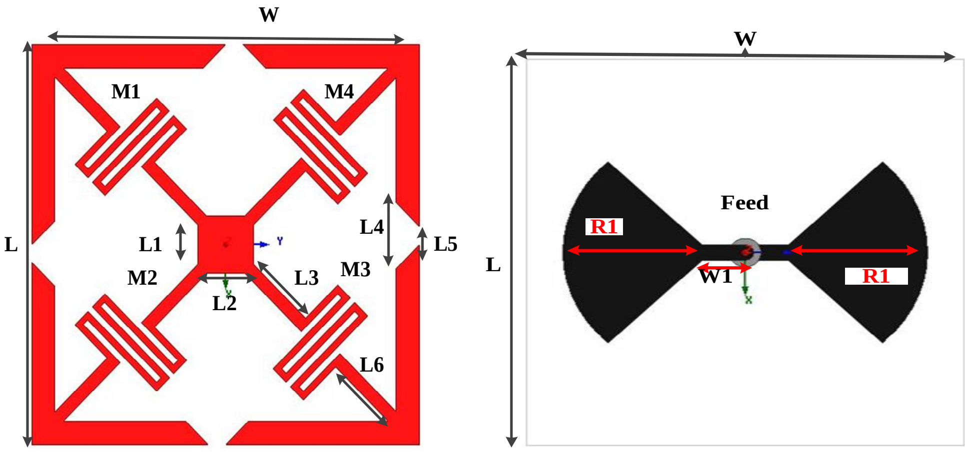
In this article, a compact (25.4 mm × 25.4 mm×0.762 mm) electrically small, low profile dual band antenna is presented. Multifunctional compact planar versions are introduced by appropriately four meander line elements. These antenna can be used for dual band [GPS L1 and Global star (GS)] linear polarization application. The performance characteristics of the proposed dual band antenna is investigated by Finite Element Method based 3D electromagnetic simulator ANSYS Ansoft High Frequency Structure Simulator (HFSS).

II ANTENNA DESIGN

Due to the popularity of satellite positioning and communications, a highly compact, multifunctional antenna that can communicate with satellites to accommodate both voice and data exchanges, while providing GPS functionality, is of great interest for portable communication device applications. For this perspective, a dual-band GPS L1 (1575.42 MHz) and Global Star (GS, 1610–1621 MHz) electrically small, planar antenna was designed and developed. The proposed dual band antennas geometric layout is presented in Figure 1 (a) top and (b) bottom which is printed on an Rogers 4350 dielectric substrate material with thickness 0.762 mm, dielectric constant 3.66, loss tangent 0.004 and 0.017 copper thickness. The basic architecture of the proposed dual band antenna consists of the radiating patch, a partial ground plane and a coaxial feed-line.



(a) (b)

Fig. 1: The configuration of the proposed antenna (a) top view (b) bottom view

The proposed dual band antenna is ported to a 50 Ω SMA connector for signal transmission. To achieve dual band characteristics, the radiating patch consists of some slotted structure with four meander line structure where M1 and M3 meander line elements are responsible for lower band 1.575 (GPS L1 1.575) and M2 and M4 elements is responsible for GS band (1.615 GHz). This can be clearly understand from the surface current distribution of the radiating patch shown in Figure 2 where M1 and M3 are more exciting for the lower band and M2 and M4 are exciting for upper band. The ground plane of the proposed antenna is consists of two near field parasitic elements which is act as single driven elements in the other side of the substrate. By exciting top and bottom driven elements through coaxial fed, both dipoles are the same except for the gaps between the capacitive loads, i.e., the capacitances formed by the gaps between the ends of the arrows. Because of the differences in the resulting capacitances, two independent resonant frequencies were obtained. However, to avoid any unnecessary structural overlaps and to keep the parasitic elements in a one-layer layout, the meander lines were introduced on their legs to increase the overall inductance while allowing a decrease in the requisite capacitances provided by their gaps and still maintaining the desired operating frequency. The choices of the dimensions of the elements were varied according to the usual principles, e.g., thinner traces and longer meander-line segments produce more inductance, and smaller gaps produce more capacitance. A square copper elements also introduced in the centre of the radiating patch for widening the total bandwidth. Their final values were optimized with HFSS by studying multiple design iterations and their behaviours. The dimensions of the proposed antenna structure are then optimized using the HFSS simulation software. The final dimensions are: L=25.4 mm, W=25.4 mm, L1= 2.86 mm, L2=2.86 mm, L3=4.57 mm, L4=4.18mm, L5= 1.18 mm, L6=5.23 mm, W1=2.5 mm, R1=8.1 mm.

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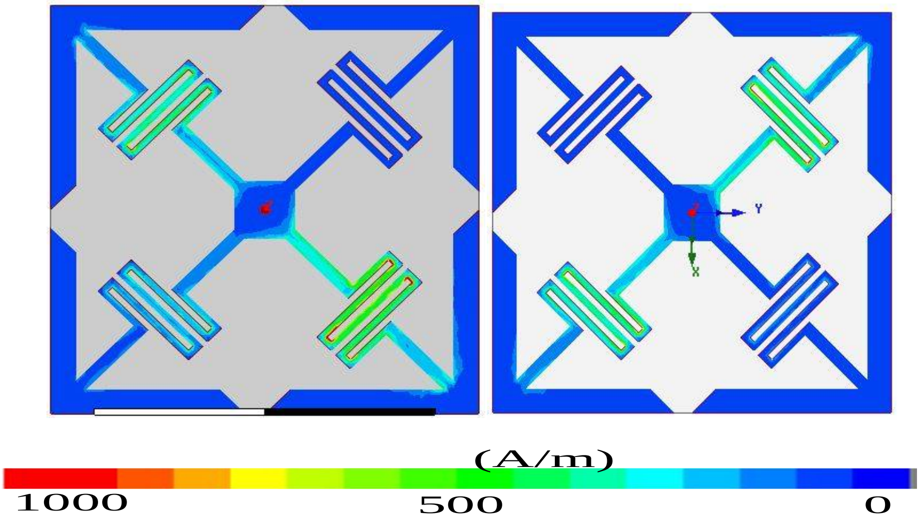
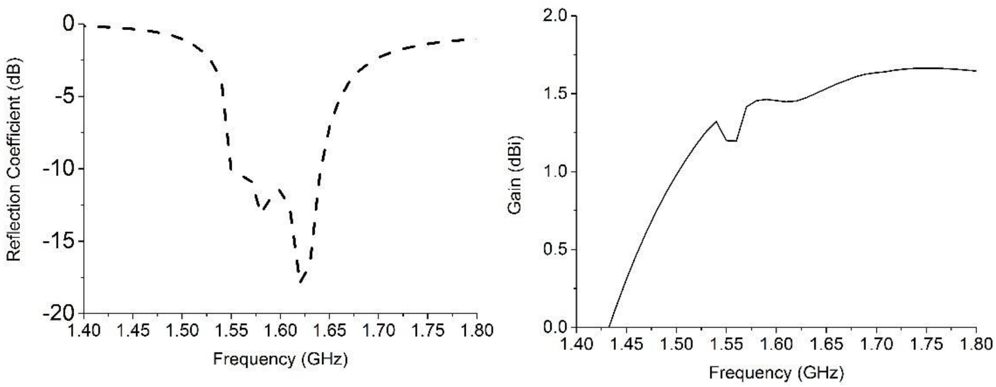


(a) (b)

Fig. 2: Surface current distribution of the proposed antenna (a) 1.575 GHz, (b) 1.615 GHz

III. RESULT AND DISCUSSION

Fig. 3(a) shows the simulated reflection coefficient of the proposed dual band antenna. It can be observed from the figure that the proposed antenna achieve -10dB S_{11} (Reflection coefficient) bandwidth from 1.55 GHz to 1.65 GHz which is totally cover the GPS L1 band (1.575 GHz) and GS band (1.615 GHz). The simulated gains and radiation efficiency of the proposed antenna against frequency are shown in Fig. 3(b). And Fig. 4(a). At GPS L1 frequency, the corresponding peak gain and radiation efficiencies were 1.44 dB and 92 % respectively. On the other hand, at the GS frequency, the peak gain and radiation efficiencies values were 1.45 dB and 93% respectively. Fig. 5 illustrates the far-field radiation pattern of the proposed antenna at 1.575 GHz and 1.615 GHz, including the xz plane (H-plane) and yz planes (E-plane). It can be seen that omnidirectional radiation pattern can be observed on xz plane and nearly omnidirectional radiation pattern on the yz plane can be observed over the whole operating frequency bands Figure 4(b) illustrates the 3D radiation pattern of the proposed antenna of the GPS and GS band frequency. The maximum directivity values were 1.72 dB at GPS L1 band and 1.73dB at GS band, respectively.



(a) (b)

Fig. 3: (a)Simulated reflection coefficient of the proposed antenna. (b) Peak gain of the proposed antenna.

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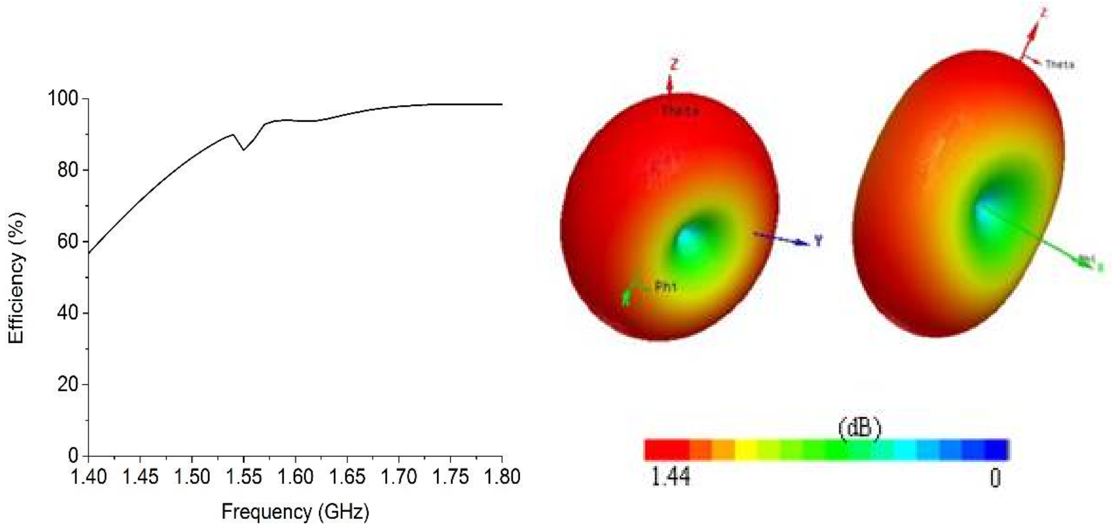
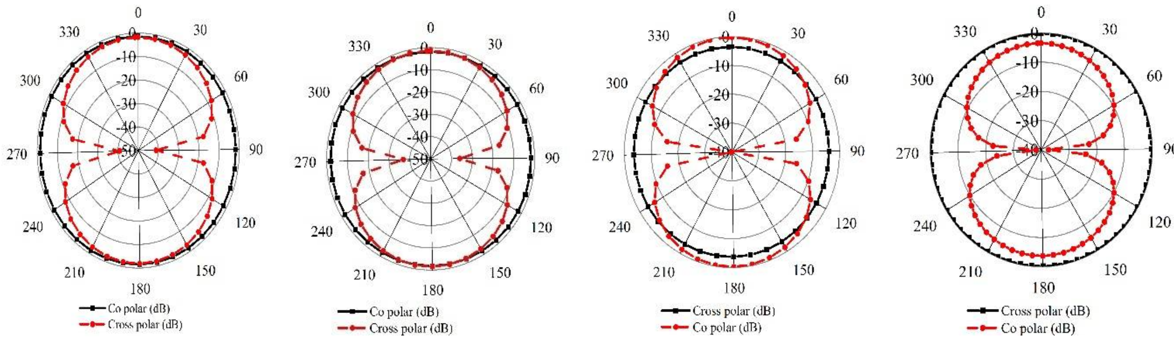


(a) (b)

Fig. 4(a) Radiation efficiency of the proposed antenna. (b)3D Radiation pattern of the proposed antenna, (i)1.575 GHz, (ii)1.62 GHz



(a) (b)

Fig.5 Radiation pattern of the proposed antenna, (a) 1.575 GHz, (b) 1.62 GHz

IV. CONCLUSION

An Omni-directional antenna with dual band characteristic for used in GPS and GS system has been proposed. The designed antenna consists of a radiating patch with four meander line parasitic elements and two Egyptian axe like dipoles to create required dual band frequency. The design antenna faces the -10dB reflection coefficient requirement from 1.55 GHz to 1.64 GHz. The overall antenna dimension is 0.133λ × 0.133λ × 0.004λ at 1.575 GHz. From the simulated results, it can be shown that the proposed antenna exhibits the dual band characteristic for the GPS L1 and GS band frequency. Reflection coefficient, Gain, radiation pattern and radiation efficiency, directivity of the proposed antenna are analysed and optimized by using finite element method based 3D-fullwave electromagnetic simulator HFSS. The proposed antenna can be a competitive solution for the current needs to be adopted with small multi technology wireless devices compare to other available dual band antennas.

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BIOGRAPHY

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