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Dual Band Grounded Coplanar Waveguide Fed Antenna for WLAN on Body Application

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ABSTRACT

A very-low-profile grounded coplanar waveguide (GCPW)-fed slot antenna with an antenna thickness of 0.8 mm(about 0.0064λ at 2.4 GHz) and a compact size of 15 mm x 40 mm(about 0.12 λ x 0.32 λ at 2400 MHz) for 2.4/5.8 GHz dual-band wireless local area network (WLAN) on-body antenna application is presented. The GCPW slot antenna consists of a top ground with the GCPW feed line and radiating slot embedded thereon and a bottom ground spaced 0.8 mm to the top ground. The radiating slot is an asymmetric T-shape slot having a longer slot path for 2400~2500 MHz band and a shorter slot path for 5725~5875 MHz band. It is convenient to tune the dual-band operation by adjusting the lengths of the longer and shorter slot paths, respectively. Additionally, owing to the presence of the bottom ground, the GCPW slot antenna has decreased backward radiation. This causes antenna's impedance matching very slightly varied when it is in the proximity of human body. The very-low-profile GCPW slot antenna is presented.

Keywords- RF antenna, co-plannar waveguide, WLAN antennas, on-body antennas

I. INTRODUCTION

Antennas are the most critical components in modern age for wireless communications. The first wireless electromagnetic system was demonstrated by Hertz in 1886 [1] and in 1901, Marconi succeeded in sending signals over large distance from England to Newfoundland, Canada. In 1950, the idea of microstrip antenna was first introduced by G. A. Deschamps [2]; however, it took almost 20 years for researchers to practically realize the concept thanks to the development of printed circuit board (PCB) in 1970s [3]. The necessity for having antennas with low-profile, low-weight, low-cost, easy integrability into arrays and microwave integrated circuits, or polarization diversity, encouraged the researchers to develop of microstrip antennas [4, 5]. A wireless biomedical system attracts many designers to invent new gadgets. Likewise in this antenna for on body wearable applications, the antennas are operated in close range to the human body. These kinds of antennas play a vital and valuable part in the military, pharmacy and home care areas [6]. In this square antenna single feed is given via microstrip feeding technique for energy harvest. The proposed antenna was tested by varying the two parameters called thickness of substrate and number of port. To these adding the design must undergo FCC (federal communication commission) for human safety for this wearable communication device [7]. The most important part is to maintain the antenna performance.

The 2/2.45GHZ band is popular in communication frequencies as it is most common in commercial platforms [7]. All the simulations in this work are done in CST studio 2019 v1.2.8. This design is most sophisticated one to wear as the total thickness is 1.80mm (1.6 + 0.20).The proposed antenna is flexible but not fragile which is the most needed for wearable communication device. AMC (antenna magnetic conductor) technique decreases backward radiation which is needed for on body application. There are several antennas but in microstrip antenna yields a low profile construction, low cost and less complexity [8]. The concept of microstrip patch antenna took from utilizing PC technology (printed circuit) not only for the circuit component and transmission lines but also for the radiating elements of an electronic system [9]. The commonly used antenna is half wave dipole antenna in that only two conductors are used about ¼ waves long which is driven by a source from the centre.

The parameters that are usually noted in all cases are

- Gain
- Impedance bandwidth

Gain gives the directional property for the antenna and the impedance bandwidth shows about the range [10] of antenna frequency for the VSWR (voltage standing wave ratio). The common gain and bandwidth are given in below table 1.1.

Types of antenna and its block diagram is shown

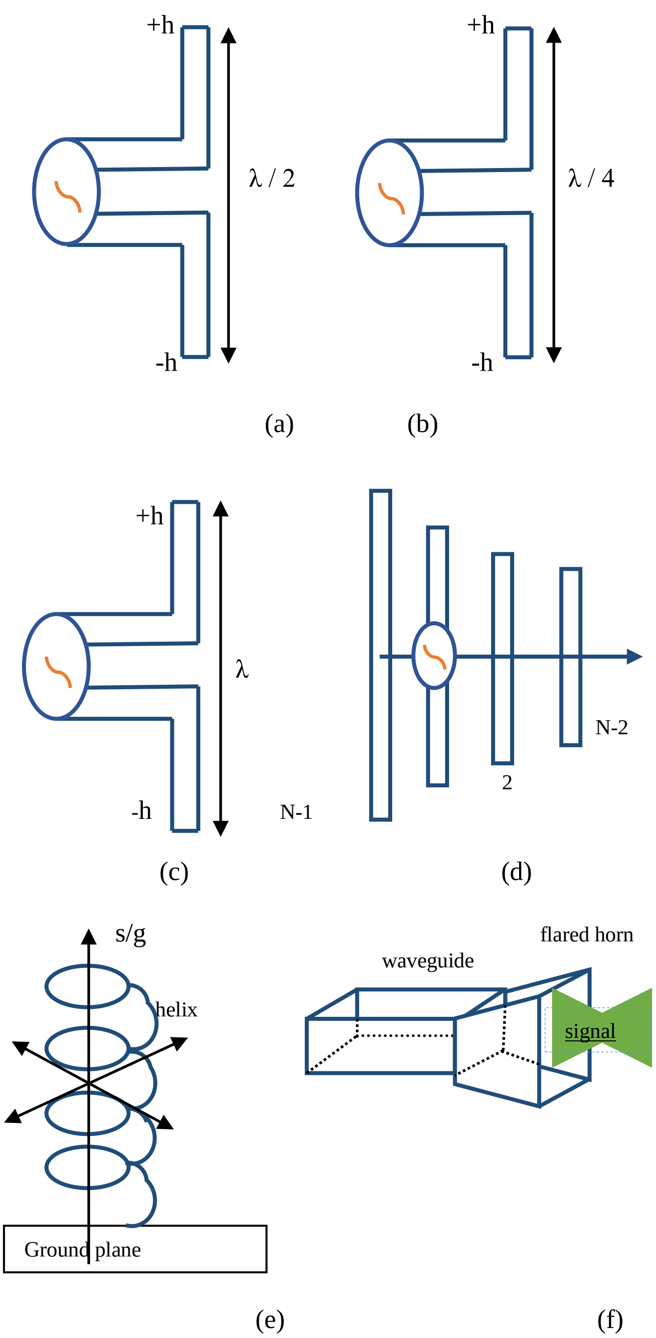


Fig 1. a) Half wave dipole antenna b) Quarter wave dipole antenna c) One wave length loop antenna d) Yagi antena e) Helical antenna f) Horn antenna

II. MICROSTRIP ANETNNAS

Micro strip also known as printed antenna generally means to an antenna fabricated which include photolithographic technique process. This antenna looks very low profile and contains multiple levels of layers. Basic structure is shown in fig 1.

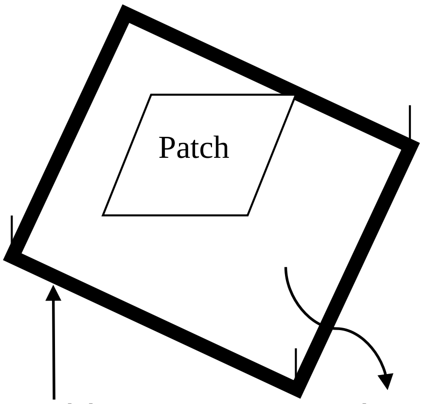


Fig 2 microstrip patch antenna

Microstrip patch was first established [11] by Deschamps but till 1970s [12] it was not came out. In late 70s (1975-1979), this type of antenna research [13] and its development has evolved to relater levels in IEEE journal [14]. After "Printed circuit antenna technology workshop" held in Nov-1979 several thousands of books, journals and article were made. Basic look of a patch antenna was shown in Fig 1.2. The patch shape can be varied with respect to the needs, flexibility and bandwidth. In patch the shapes used are shown in Fig .3.

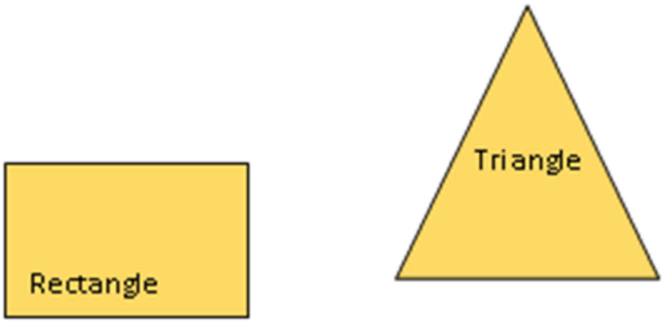


Fig.3 Basic structures used for radiating slot

In these patches different feeding techniques like Microstrip line, coaxial probe, Proximity, Aperture coupled feedings are used. The feedline in the patch resonates and leaks out some of energy into the space these results in an operating antenna. To enhance the level of correlation extra shapes will be added like hexagon in this proposed antenna. Separated ground plane is to reduce the mutual coupling . These antennas can be applicable for the areas of MIMO, Wearable, Medical, Wideband and multi band applications.

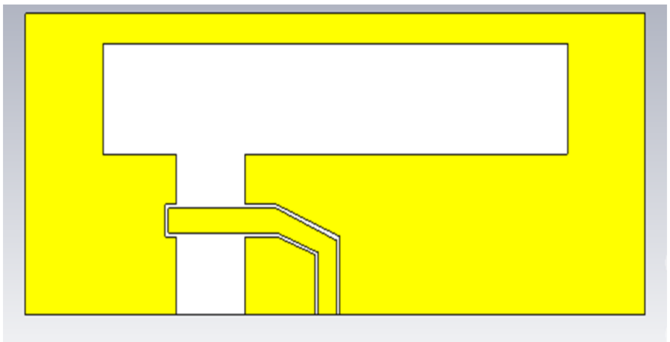
Table 1: Different types of antenna

Element	Gain	Bandwidth percentage
Half wave dipole	2 dB	8 to 16%
Quarter wave dipole	5 dB	8 to 16%
One wavelength loop	4 dB	8 to 16%
Yagi	12 dB	10%
Dipole + corner reflector	12 dB	5%
Dipole + corner reflector	16 dB	70%
Helical	20 dB	20%
Horn		

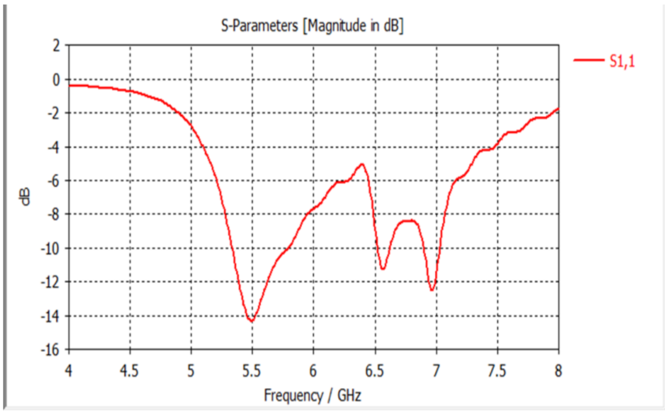
III. OUR PROPOSED ANETNNA & RESULTS

In this proposal, we design a very-low-profile grounded coplanar waveguide (GCPW)-fed slot antenna with an antenna thickness of 0.8 mm (about 0.0064 λ at 2.4 GHz) and a compact size of 15 mm x 40 mm (about 0.12 λ x 0.32 λ at 2400 MHz) for 2.4/5.8 GHz WLAN band operation. The proposed GCPW-fed slot antenna has a simple structure with both ground planes at its top and bottom surfaces. The top ground has the GCPW feed line and radiating slot embedded therein. The bottom ground is spaced 0.8 mm below the top ground to have decreased backward radiation. Although with an antenna thickness of only about 0.0064 λ at 2.4 GHz, good antenna performance of the proposed GCPW slot antenna is obtained for 2.4/5.8 GHz dual-band WLAN operation. This is because the radiating slot at the top ground can be considered as an effective magnetic current, whose image current with respect to a perfect electric conductor (bottom ground) has same amplitude and orientation. Therefore, when the radiating slot is very close to the bottom ground, good antenna efficiency can still be obtained. In addition, the bottom ground causes decreased backward radiation, thereby providing the attractive feature of very small impedance mismatching variations caused by the human body proximity. Details of the proposed GCPW slot antenna are presented and its possible on-body application is discussed.

The GCPW slot antenna has a small thickness of 0.8 mm and occupies an area of 15 mm x 40 mm. The radiating slot is an asymmetric T-shape slot embedded in the antenna's top ground and excited by a coplanar GCPW feed line. The radiating slot, the top ground, and the feed line are all printed on a 0.4 mm thick FR4 substrate (relative permittivity 4.4, loss tangent 0.02), which is spaced by a 0.4 mm thick air layer to the bottom ground. Note that since the FR4 substrate is a very lossy material, its thickness is limited to 0.4 mm in the present study. By using an additional 0.4 mm thick air layer between the FR4 substrate and bottom ground, which increases the antenna thickness to be 0.8 mm, the obtained antenna efficiency can be much better than 40% in the desired WLAN bands to be acceptable for practical communication application.



(a)



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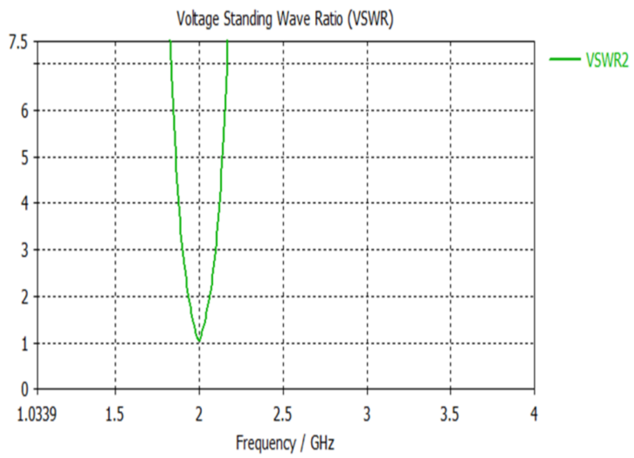
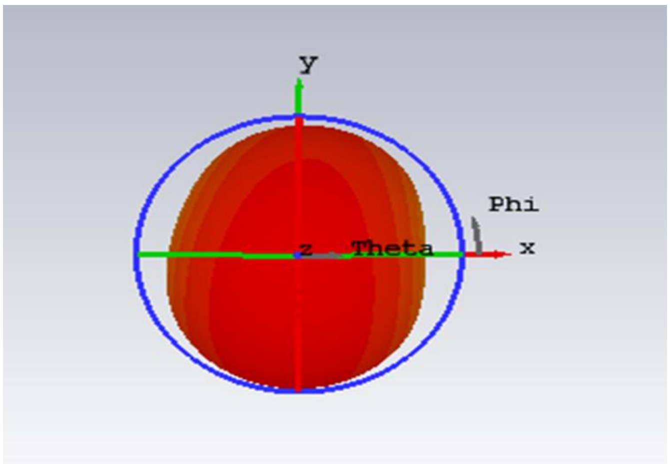
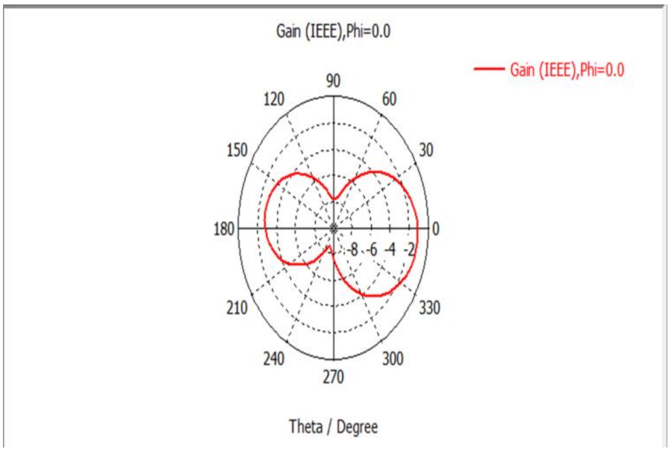


(c)



(d)



(e)

Fig.4.Our proposed antenna & its results (a) Structure of our proposal (b) Return Loss (c) VSWR (d) Far field radiation pattern (e) Gain of antenna

Return loss is an important parameter to describe the quality of the MPA and several studies can be found in this area [15 -16]. The return loss of a antenna can be given by the measure of how properly the devices or lines are matched. For a mismatched load the whole input power is not delivered to the load and a fraction of the power is returned which is termed as return loss. Return loss can also be defined as the logarithmic ratio of the antenna input power from the transmission line to the antenna reflected power. In our work the return loss archived is below -12 dB in both resonant frequency at 5.5 GHz and 7 GHz.

Here, SWR is the standing wave ratio. In radio engineering and telecommunications, standing wave ratio (SWR) is a measure of impedance matching of loads to the characteristic impedance of a transmission line or waveguide. Impedance mismatches result in standing waves along the transmission line, and SWR is defined as the ratio of the partial standing wave's amplitude at an antinode (maximum) to the amplitude at a node (minimum) along the line. The SWR is usually thought of in terms of the maximum and minimum AC voltages along the transmission line, thus called the voltage standing wave ratio or VSWR. For example, the VSWR value 1.2:1 means that an AC voltage, due to standing waves along the transmission line, will have a peak value 1.2 times that of the minimum AC voltage along that line, if the line is at least one half wavelength long. The SWR can be also defined as the ratio of the maximum amplitude to minimum amplitude of the transmission line's currents, electric field strength, or the magnetic field strength. Neglecting transmission line loss, these ratios are identical. In our work the VSWR archived is below 2 in both resonant frequency at 5.5 GHz and 7 GHz.

IV. CONCLUSION

A very-low-profile GCPW slot antenna having an antenna thickness of 0.8 mm (only about 0.0064 at 2.4 GHz) has been proposed for on-body antenna application. The proposed antenna covering 2.4/5.8 GHz WLAN bands has been fabricated and tested. The experimental results generally agree with the simulation prediction. Very small effects on the antenna's impedance matching are observed when the fabricated antenna is directly placed on the human wrist. It is expected that the proposed antenna is suitable for on-body antenna applications.

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