Low Profile Modified Loop Antenna for Wearable Applications

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***Abstract* – A compact modified loop antenna resonating in a wireless medical telemetry service (WMTS) band for wearable application is presented. The proposed wearable antenna achieves the bandwidth of 45 MHz (1364–1409 MHz) at the WMTS band. The proposed antenna provides compactness with dimensions of 34 mm × 34 mm × 0.27 mm. The proposed antenna is designed using CST Microwave Studio. The return loss obtained for the proposed antenna is about 20 dB. The directional radiation pattern obtained from the antenna is highly suitable for long distance communication. The gain and efficiency obtained from the antenna is about 4.26 dBi and total efficiency of 73 %. The Simulated SAR is less than 1.6 W/Kg suitable for wearable applications.**

Keywords: *WMTS Band, Low profile, Modified Loop antenna, Wearable antenna,*

I. INTRODUCTION

Rapid development of wearable electronics leads to the increasing requirement of compact antenna design with low profile. Recent research has begun to contribute wearable antenna for all the modern applications with light weight, low cost, almost maintenance-free and no installation. Microstrip patch antenna is most commonly used especially for its cheap realization, minimal back radiation providing high directivity.

There are number of specialized occupation segments that apply body centric communication systems, such as paramedics, fire fighters, and military. Besides, wearable antennas also can be applied for youngsters, the aged, and athletes for the purpose of monitoring their health conditions. WMTS spectrum is commonly utilized for health monitoring of a patient in a remote place. Health monitoring is an indeniable right for every human being which should never be considered as a previledge to only a certain class.Wireless medical telemetry systems include devices to measure patients' vital signs and other important health parameters (e.g., pulse and respiration rates). Then it transports the data via a radio link to a remote location, such as a medical base station, equipped with a specialized radio receiver. For example, wireless cardiac monitors are often used to monitor patients following surgery.

The microstrip yagi array antenna presented in [1], operates at 2.45 GHz used for WBAN and telemedicine applications. This antenna produces semidirectional radiation pattern. In [2], a dual band textile antenna at 2.45 GHz and 5.8 GHz for ISM bands is presented. In [3], design and SAR analysis of a wearable antenna operating at 2.45 GHz is illustrated. It has a larger antenna dimension of about 113mm × 96.4 mm. In [4], a tri-band textile antenna resonating at 0.9 GHz, 2.45 GHz and 5.8 GHz. Due to the coupling body effect, the antenna produces the frequency shift when placed on the body tissue. In [5], a wearable antenna is designed using different textile materials. The dimensions of the patch is about 65.80 mm x 55.41 mm having low gain of about 2.93 dBi A wearable antenna is fabricated on a plaster substrate (3mm thickness) in [6], which operates at 2.45 GHz for on-body communication. It provides low efficiency of 60%. A zeroth-order resonant antenna placed on a wrist for wireless body area network (WBAN) applications (2.4 GHz) is presented in [7]. It provides resonating frequency 2.4 GHz with reduced bandwidth. In [8], the ultraminiature coaxial fed antenna has a compact dimension, designed to operate at 1.4 GHz. The On-Body Adhesive-Bandage-Like Antenna described in [9] has a low profile design and operates at the WMTS Band (1.429 GHz to 1.4315 GHz) with a gain of 4.19 dBi. This antenna operates at the higher WMTS band.

In this paper, a compact wearable antenna for wireless medical telemetry service application is reported. The proposed antenna provides the bandwidth from 1364 MHz to 1409 MHz at Wireless Medical Telemetry Service (WMTS) band with a center frequency of 1.39 GHz. The modified loop antenna is fabricated on 0.2 mm thickness RogersRO4003C substrate providing low profile, thus making it highly preferrable for wearable applications. The simulated SAR analysis is also performed to ensure that the antenna doesn't affect human tissues.

Rest of the paper is organized as follows: Section II describes the design part of the proposed antenna. Results and discussion is explained in Section III. Conclusion and references is attached finally.

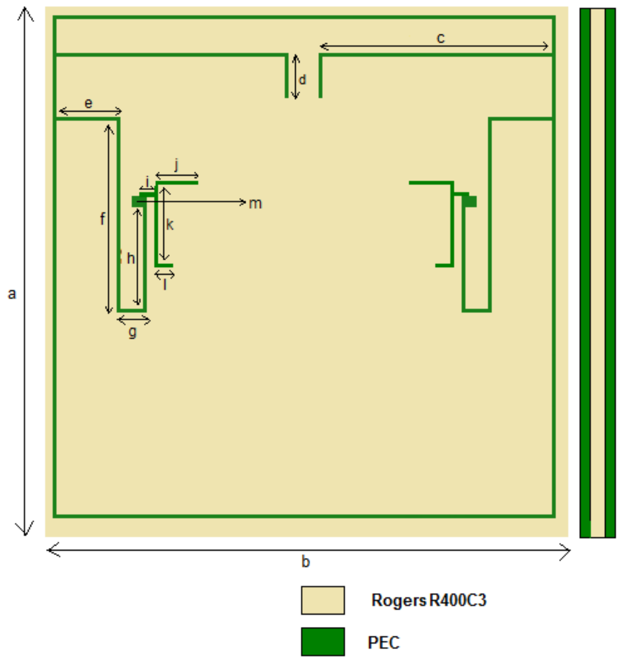


Figure 1: Final Design of the proposed Antenna (Top and Side View)

The dimension of the proposed antenna design is given as below:

PARAMETER	DIMENSION (mm)
a	34
b	34
c	13.25
d	3
e	4.25
f	12.75
g	2
h	6
i	1
j	3
k	5.25
l	1.25
m	1

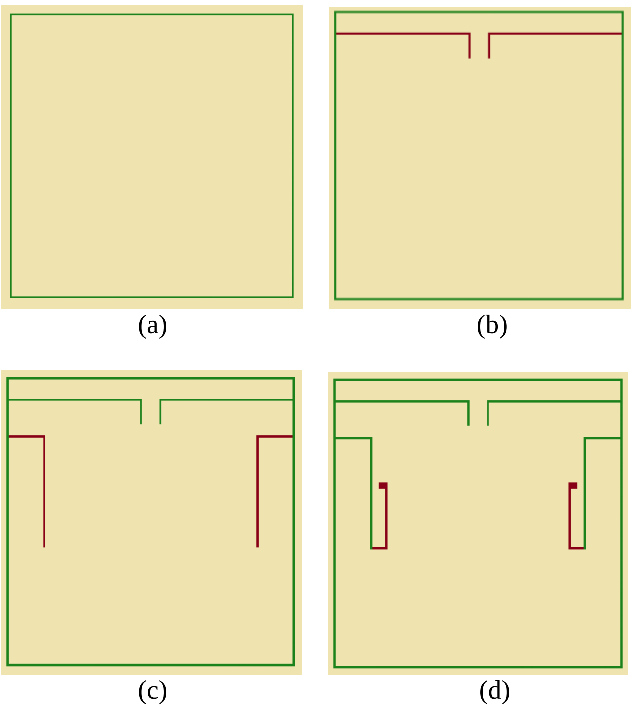
II.DESIGN OF THE PROPOSED ANTENNA

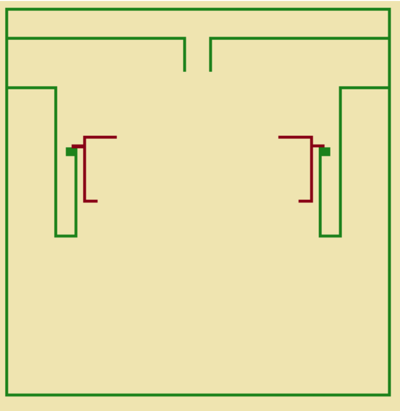
The proposed antenna for WMTS application band is prospected in Figure 1. The dimensions of the proposed antenna is 34 x 34 mm^2 . It consists of three layers: Radiating part , Rogers RO4003C substrate and ground plane. The radiating part is footprinted on a low cost thin Rogers substrate with a thickness of 0.2 mm and relative permittivity of 3.55. The proposed antenna is fed using a coaxial feed with 50 ohm impedance matching.

A. *Evolution of proposed antenna*

The evolution of different stages of the proposed antenna and its simulated reflection characteristics is presented in Figure 1 and 2 respectively.The proposed antenna initiates with a rectangular loop resonating at the frequency of 5.2 GHz with improper impedance matching. (Figure 2(a)). In the next stage, two inverted L-shaped stub is added at the upper part of the antenna providing a frequency shift to 5 GHz (Figure 2(b)). When a vertical inverted L-shape is added to the arms of the rectangular loop, impedance matcing is improved to 17 dB (Figure 2(c)).

Because of this improvement, at the same position, another mirrored L-shape is adhered to provide the frequency shift to 2 GHz(Figure 2(d)). Finally, to obtain the resonating frequency at WMTS band, the electrical length of the antenna is increased by attaching a C-shaped arm.This achieves the required resonance band at 1.39 GHz (WMTS Band) with an impedance matching of 20 dB (Figure 2(e)). The simulated reflection characteristics of each stage of the proposed antenna is shown in Figure 3.





(e)

Figure 2: Evolution of the wearable antenna (a)Rectangular outer loop (b)Inverted L Shaped patch on the upper sidearm (c)Inverted L Shaped Patch on the left and right sidearm (d)Mirrored L Shaped Patch (e) C Shaped Patch

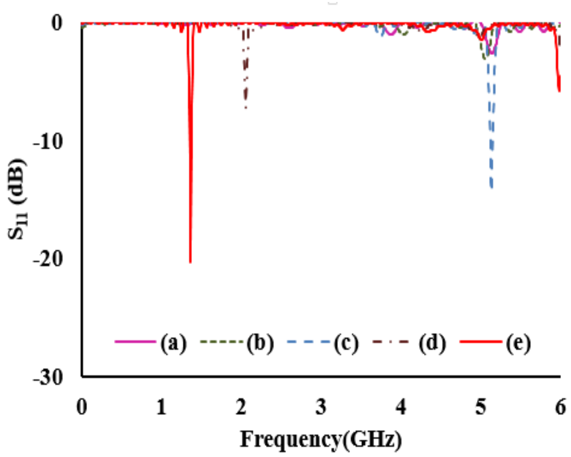


Figure 3: Simulated Reflection characteristics of the proposed antenna

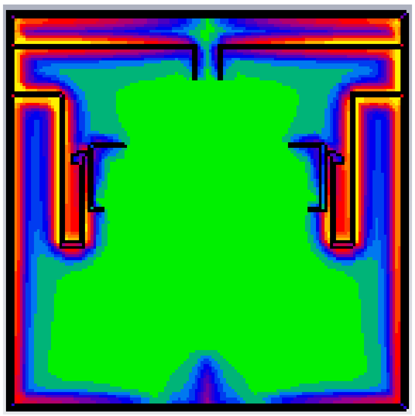


Figure 4: Surface current distribution for the proposed antenna

B. *Surface Current Distribution*

The propagation of electromagnetic coupling at the operating frequency of 1.39 GHz is observed in the Figure 4. From the figure, it is clear that there is high proliferation of electric and magnetic field distribution throughout the proposed modified loop antenna. As the proposed antennna is symmetric, it shows an evenly distributed surface current..

III.RESULTS AND DISCUSSION

The proposed antenna is designed and simulated using CST Microwave studio 2010.

A. *Simulation Results*

The simulated reflection characteristics is shown in Figure 5. The 10 dB impedance bandwidth of the proposed antenna is found to be 45 MHz (from 1364 MHz to 1409 MHz).The return loss is found to be about 20 dB at the operating WMTS band.

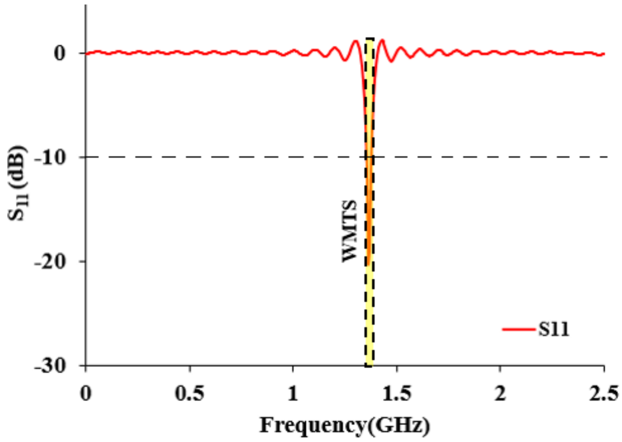
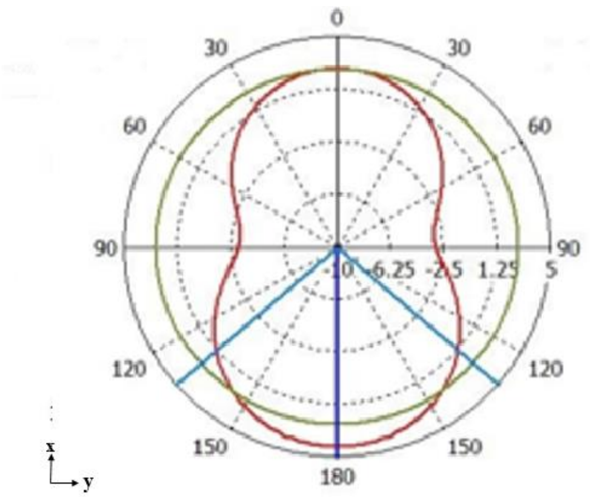


Figure 5: Reflection characteristics for the proposed antenna

B. *Radiation pattern*

The radiation pattern observed is bidirectional in both x-y plane and x-z plane as viewed in Figure 6. The gain is obtained at 1.39 GHz as 4.26 dBi and a total efficiency of 73.9 % . Thus the proposed wearable antenna with high gain and efficiency is more suitable for practical applications.

XY Plane Far Field Plot (Phi=0)



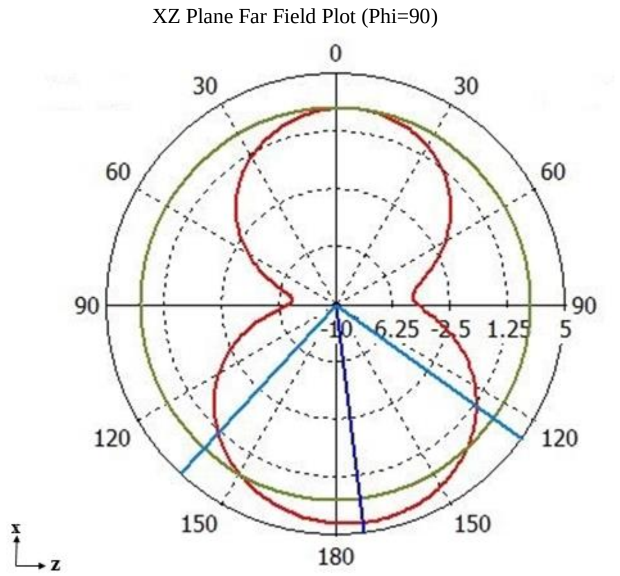


Figure 6: Radiation pattern for the proposed antenna .

C. SAR analysis.

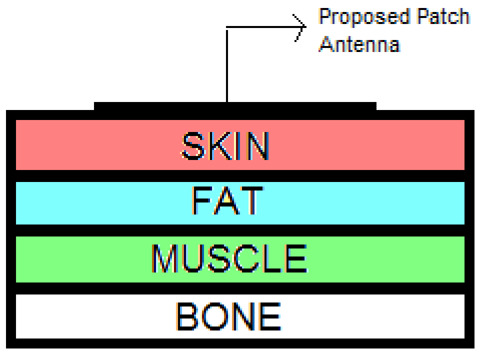


Figure 7:Simulated SAR Analysis performed on a human body model

The analysis of specific absorption rate in case of wearable antennas is very important as the antenna is to be operated close to the body tissue (Refer Figure 7). When a human tissue is exposed to electromagnetic radiation, the amount of power absorbed by the biological tissue is defined by the value of SAR. The minimum acceptable SAR value for any wearable antenna is limited to 1.6 W/Kg as specified by the Federal Communications Commission(FCC). For the proposed antenna, the simulated SAR value is about 0.765 W/Kg which is within the FCC limitation.

IV.CONCLUSION

The conception of wearable modified loop antenna for Wireless Medical Telemetry Service application band is elaborated in detail. The whole configuration is fabricated on a low cost, thin substrate providing low profile and cost effective. The 10 dB impedance bandwidth of 45 MHz (1.36-1.41 GHz) is observed in the operating frequency of WMTS band.The return loss obtained at the resonating frequency is about 20 dB. The proposed configuration provides high gain of 4.26 dBi and efficiency of 73%.The full ground plane reduces the back radiation and provides SAR value less than 1.6 W/Kg. Thus the proposed low profile modified loop antenna makes it satisfactory for practical wearable applications.

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