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# Computational Performances and EM Absorption Analysis of a Monopole Antenna for Portable Wireless Devices

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***Abstract*— *In this paper, a simple inverted L-shaped monopole antenna is presented* for *portable wireless devices. The designed antenna performances and specific absorption analysis is investigated. The antenna can operate at widely used GSM bands 850, 1800, 1900 and LTE 2100MHz. A relatively inexpensive dielectric substrate material FR4 is considered to design the antenna. The Specific absorption rate (SAR) analysis and antenna performances comply the antenna to apply in mobile communication systems.*

***Keywords*— *Antenna, Mobile Communication, GSM, SAR, Wireless.***

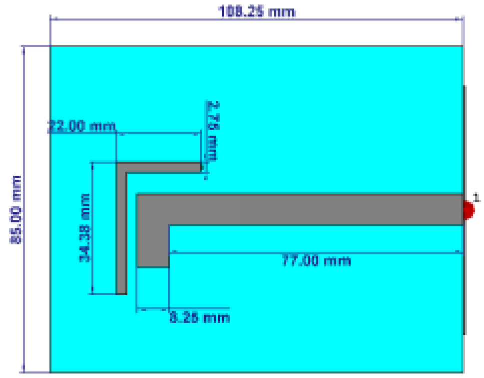
## I. INTRODUCTION

Printed microstrip patch antennas have been extensively used in mobile telephony system due to its compactness, cost effectiveness and simplicity characteristics. Several researches have been performed for GSM mobile applications [1-6]. The major lacking these works is covering GSM bands with wide impedance bandwidth. Besides this, Electromagnetic (EM) absorption from the mobile antenna is a major concern to the antenna researchers. Alam et al. proposed a low EM absorption mobile antenna for wireless antenna in [1,3], but the antenna didn't cover lower GSM band. In [2], Zhao et al. proposed segmented loop antenna for mobile applications, but this antenna failed to meet the GSM band requirements. Lee et al. proposed a multiband mobile for wireless communications, but the EM absorption analysis was not performed [4]. In [5], a broadband antenna with SAR analysis has been presented. This antenna also failed to cover lower GSM bands. A quarter-wavelength printed loop antenna is presented in [7], where lower and upper GSM bands has been covered. Moreover, the SAR values of the presented antenna was also investigated, where marginal level of SAR values is observed.

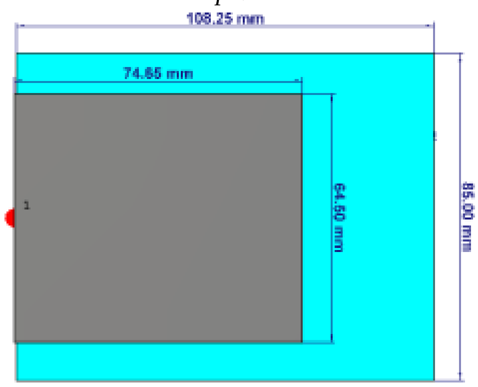
A multiband printed microstrip fed monopole antenna for portable devices has been presented. The proposed antenna has a simple structure and is easy to fabricate using low cost FR4 substrate material. EM absorption in terms of SAR is also investigated. The proposed antenna can operate within the existing wireless GSM standards, such as 850MHz, 1800MHz, 1900MHz and LTE 2100.

## II. ANTENNA DESIGN

The proposed antenna is designed using electromagnetic simulation software CST microwave studio. The antenna consists of an inverted L-shaped monopole and a shorted parasitic L-shaped radiating patch, shown in fig. 1. The antenna is designed on available dielectric substrate material FR4. The antenna is fed by 50 Ω microstrip feedline. A partial ground plane is used, which is shorted with parasitic patch.




*Top View*




*Bottom View*

*Fig.1: Proposed antenna design layout*

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## III. ANTENNA PERFORMANCES ANALYSIS

The reflection coefficient of the proposed antenna is investigated, which is shown in Fig. 1. The reflection coefficient curve shows that the antenna resonates at 850 MHz and 1800MHz, 1900MHz and 2100 MHz.

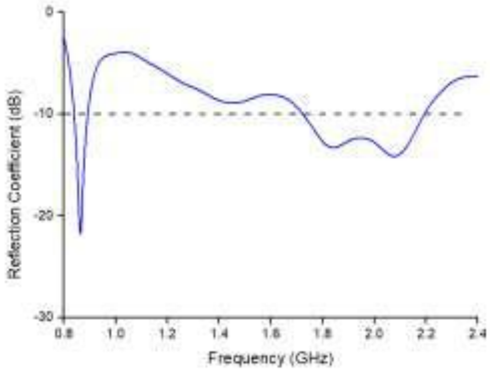
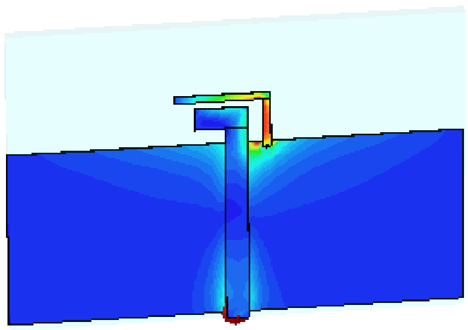
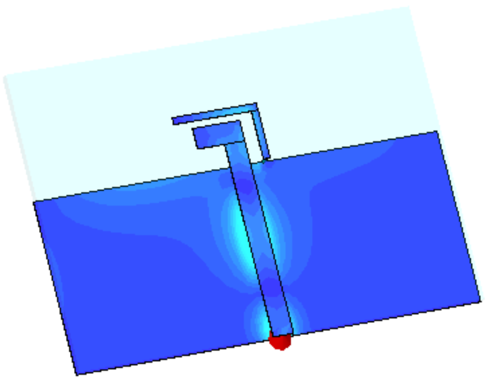



*Fig.2: Reflection Coefficient of the proposed antenna*

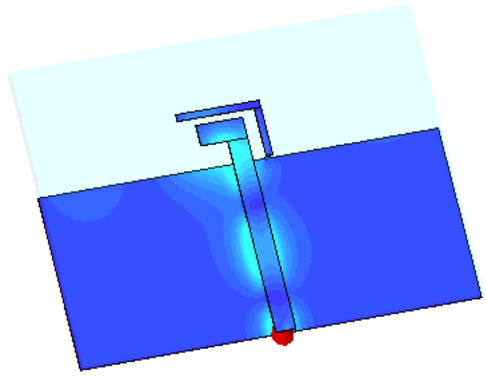
The surface current of the presented antenna is depicted in Fig. 3. Fig. 3 shows that the parasitic inverted L-shaped element is responsible to resonate at 850 MHz. Moreover, the second resonance is created for coupling between two patches. And the third resonance, 2100MHz is created due to third harmonic in microstrip line.



At 800MHz

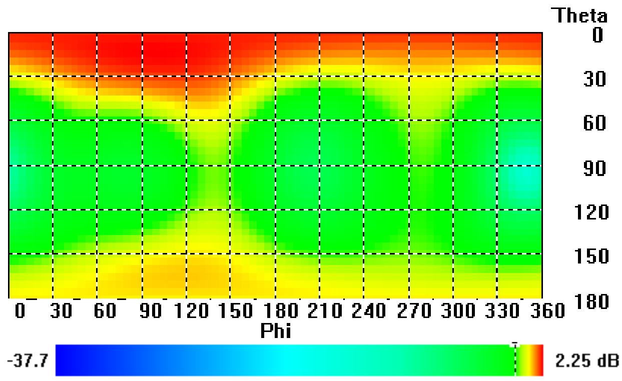


At 1800MHz

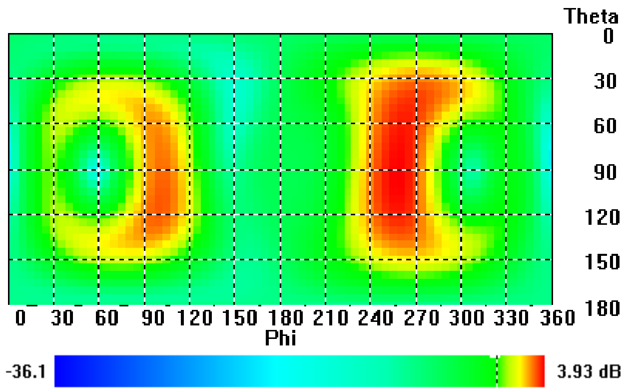


At 2100MHz

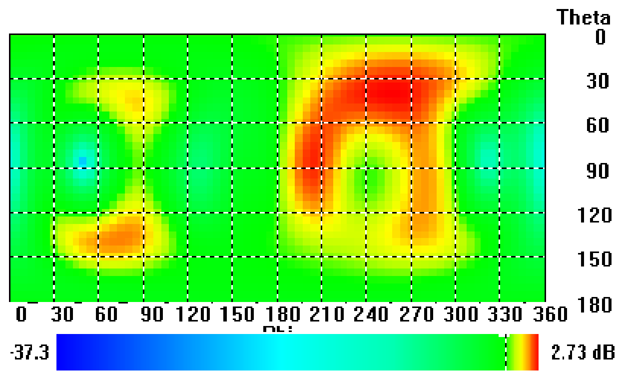
*Fig. 3: Surface current distribution of the proposed antenna*




(a) At 850 MHz




(b). at 1800MHz




(c). at 2100MHz

*Fig. 4: 2D radiation pattern of the proposed antenna*

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The radiatiion pattern of the proposed antenna is analysed, shown in Figure 4. From Fig. 4, it can be observed that the pattern shapes are not as good as a conventional monopole. But the antenna shows about 3.93 dB realized gain at 850 MHz, 2.73 dB at 1800 MHz and 2.729 dB at 2100 MHz. The radiation efficiency of the antenna is presented in Fig. 5. The total efficiency of the proposed antenna at 850, 1800 and 2100 MHz is 84.02%, 88.% and 88.6%, respectively.

*Table 1: Antenna performances*

| *Antenna Performances* | *Value* |
|---|---|
| *Polarisation* | *Linear* |
| *Radiation pattern* | *Multipath* |
| *Gain* | *Positive realized gain* |
| *Complexity* | *Simple* |
| *Impedance* | *50 Ω* |
| *Operating frequency bands* | *GSM 850, 1800, 2100MHz* |
| *Efficiency (%) at operating frequency* | *Above 84%* |
| *Application* | *GSM* |

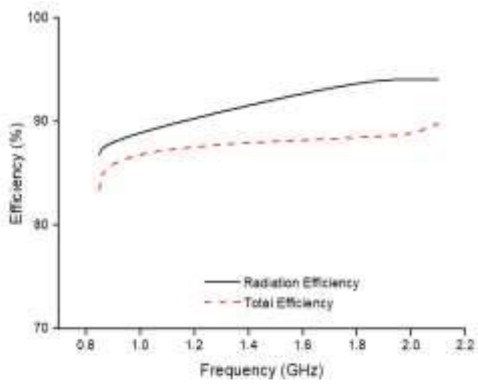
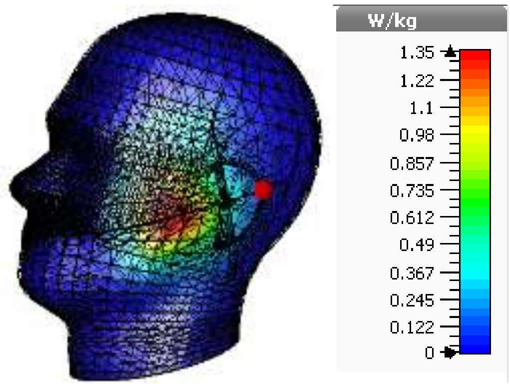


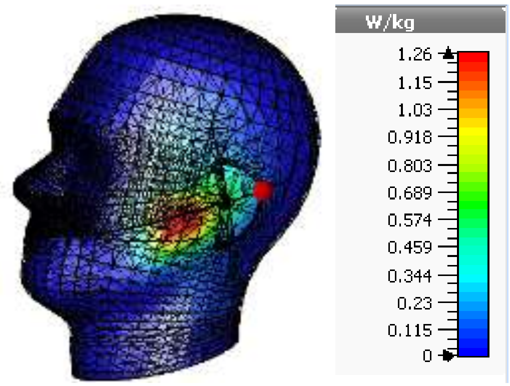

*Fig. 5: Efficiency of the proposed antenna*

## IV. SAR ANALYSIS

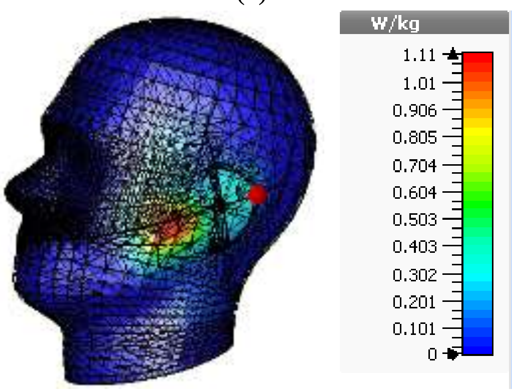
The mobile telephony in Bangladesh operated in Global System for Mobile Communication (GSM) network which works in the frequency exposure of 900MHz and 1800MHz. A mobile phone antenna can transmit and receives signal as electromagnetic waves. The EM waves in absorbed by human tissues and tissue temperature increased, which is harmful for human being. The EM absorption is measured in terms of Specific absorption rate (SAR). The SAR values is standardized by some established organizations, like IEEE, International Commission on Non-Ionizing Radiation Protection (ICNIRP), the Federal Communications Commission (FCC) etc. The electromagnetic absorption limit recommended by the ICNIRP and IEEE C95.1:2005 guideline is 1.6 W/kg averaged over 1 gram of tissue volume in the shape of a cube and 2.0 W/kg average over any 10 grams of continuous tissue [8-9]. The SAR value of the proposed antenna has been investigated and presented in Fig. 6. It is shown in Fig.6 that the antenna shows 10 g SAR values at 850 MHz, 1800MHz and 2100MHz of 1.35 W/Kg, 1.26 W/Kg and 1.11 W/Kg, respectively.




(a)




(b)




(c)

*Fig. 6: SAR values of the proposed antenna-(a). at 850MHz, (b). at 1800Mhz and (c). at 2100MHz.*

## V. CONCLUSION

A compact multifunctional monopole antenna is presented for mobile wireless communication. The proposed antenna is suitable for lower and upper GSM communication systems. In addition, a wide impedance

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band has also been achieved at about 1800 MHz for GSM, DCS/PCS/UMTS operation. Moreover, the proposed antenna complies the IEEE and ICNIRP requirement, which makes the antenna potential to be applied for wireless mobile telephony systems.

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