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# Performance Analysis of Mobile Phone Radiation Minimization Through Characteristic Impedance Measurement

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## ABSTRACT

As mobile phones have become more essential and necessary handheld devices in present world generation. Because of the cost reduction and simplicity of mobile phones, the number of mobile users, particularly children, increases drastically within few years. But the effect of mobile Electro Magnetic (EM) radiation on children is more severe than adults. This paper investigates a method to limit radiation of mobile antenna using impedance matching technique by varying the length of antenna. We make use of simulation tool called Computer Simulation Technology (CST) Microwave Studio. The characteristics of impedance of antenna placed inside the TEM (Transverse Electro Magnetic) cell are measured.

**Keywords:** *Antenna Measurements, Antenna Radiation Pattern, Electromagnetic Wave Absorption, Mobile Antennas, Specific Absorption Rate.*

## 1. INTRODUCTION

Within a short period of time, mobile phone has created a great impact on people all over the world. According to the report of World Health Organization (WHO) about 4.6 billion of people around the world are using mobile phones. The radiation emitted from the mobile phone is transmitted in all the directions. A part of the energy will incident on human head. The electromagnetic radiation interacts with human head and produce heat. This heat will be absorbed by the skin and by some other special tissues within our head. Therefore, it can cause incurable diseases to human like brain tumor, cancer, etc. The objective of this paper is to limit the radiation level being emitted by the Planar Inverted F-Antenna (PIFA) by varying the antenna length placed inside the TEM cell using trial and error method. The simulation tool we are going to use is CTS Microwave Studio from which we can find the characteristic impedance.

## 2. EXISTING SYSTEM

Already a huge number of studies have been carried out for limiting the hazardous EM radiation from mobile antenna. But, still now no method has been proposed for completely eliminating the SAR. The methods so far proposed have significantly limited the SAR within a specific value. EBG structure can act as a perfect magnetic conductor surface which will reduce the radiation from mobile antenna by reducing the surface wave [1]. Metamaterials can be used to study the SAR reduction using finite-difference time-domain (FDTD) method. By placing the Metamaterials between the human head and mobile antenna the SAR can be reduced [7]. Our work in this paper is to limit the EM radiation emitted from mobile antenna by varying the antenna length.

## 3. PROBLEM FORMULATED

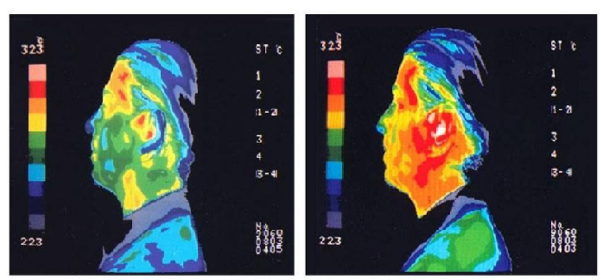
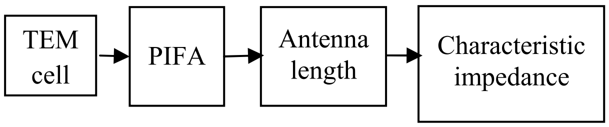


Fig. 1(a) Before using mobile phone
Fig. 1(b) After using mobile phone for 15 minutes

Fig. 1(a) shows the scan image of a common human head before the usage of mobile phone. From this image we can observe that the temperature of this human is within the range of standard temperature. Fig. 1(b) shows the scan image of a common human after the usage of mobile phone for 15 minutes. From this we can observe that heat generated inside the head is massive when compared to the previous image. This clearly shows that the interaction of EM radiation with human head is the fact behind the cause for this massive increase in temperature.

## 4. PROPOSED WORK FLOW




### 4.1 TEM (Transverse Electro Magnetic) CELL

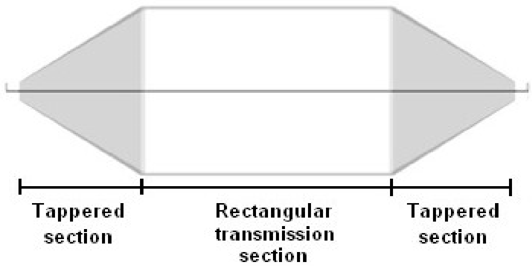



Fig. 2 The rectangular TEM cell

The rectangular TEM is broadly used for testing of emission from electronic devices. The TEM cell is made up of a rectangular coaxial transmission section which is tapered at both sides with coaxial connector, as shown in Fig. 2. It consists of two conductors. The inner conductor which is also called as septum acts as the positive conductor or hot line. The outer conductor acts as a ground.

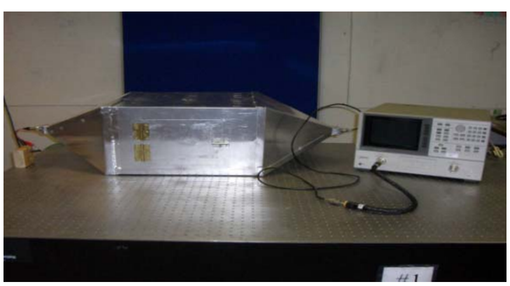


Fig. 3 Experimental setup for characterizing the impedance of PIFA.

This Fig. 3 shows the experimental setup for characterizing the PIFA's impedance measurement. To measure the characteristic impedance of PIFA we have to place the PIFA inside the TEM cell. The one end of TEM cell is connected with a load of 50Ω. The other end is connected to a HP 8791A network analyzer.

### 4.2 PLANAR INVERTED F-ANTENNA

Planar Inverted Fractal Antenna (PIFA) is a type of linear Inverted F-Antenna (IFA). PIFA is the widely used mobile antenna structure as it is widely used in most type of mobile phones due to its characteristics like low profile, small size, built-in structure, easy fabrication, low manufacturing cost and simple structure.

### 4.3 ANTENNA LENGTH

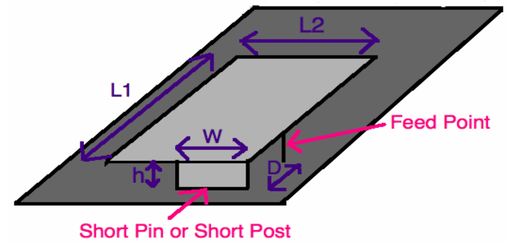



Fig. 4 Planar Inverted-F Antenna, with a sorting plane

Where, $L_1$ – length of PIFA; $L_2$ – width of PIFA;W – width of shorting pin or shorting post; D –distance of feed from shorting pin; h –height of PIFA from ground plane. In this paper we have chosen length of PIFA ($L_1$) as the parameter which is to be varied in order to limit the SAR

### 4.4 CHARACTERISTIC IMPEDANCE

There are large numbers of simulation tools available for designing mobile antenna. We have decided to use CTS Microwave Studio due to its advantages such as multi-technology co design, high speed data link and easy integration to other components. From the simulation result, we can observe the characteristic impedance of PIFA.

## 5. RESULTS AND DISCUSSION

### 5.1 NUMERICAL ANALYSIS

The SAR rating for various mobile phones can be defined using number of standards. Here we have concentrated on American standard of SAR rating as it is being followed in many foreign countries as well as accepted by wide range of people all over the world.

Table 1 : ICNIRP guidelines adopted by India

| | **Whole-body average SAR (W/kg)** | **Localized SAR head and trunk (W/kg)** | **Localized SAR limbs (W/kg)** |
|---|---|---|---|
| General Public Exposure | 0.08 | 2 | 4 |

The ICNIRP (International Commission on Non-Ionizing Radiation Protection) guidelines have been adopted as standard by India for limiting the exposure to the radio frequency energy produced by mobile phones as in Table 1. The SAR value from the above Table 1 has been averaged using 10g of average mass over period of 6 minutes.
From this Table 2 we can infer about various R.F sources existing in India and their operating

frequency range, transmission power as well as the availability of these sources.

The EM radiation emitted from sources like AM/FM Tower, Cell Towers and Mobile Phones has risen exponentially by rapid growth of wireless technology such as cell phones, Wi-Fi (Wireless Fidelity), Wi-max and other wireless devices.

Table : 2 Radio Frequency (RF) sources in India

| R. F Source | Operating Frequency | Transmission Power | Availability in numbers |
|---|---|---|---|
| AM/FM Tower | 540 KHz-108 MHz | 1 - 300 KW | 380 |
| Wi-Fi | 2.4 – 2.5 GHz | 10-100 mW | -- |
| Cell Towers | 800, 900, 1800, 2450 MHz | 20 W | 5.4 Lacs |
| Mobile Phones | GSM-900 | 2 W | 700+Million |

## 6. SIMULATION RESULTS

### 6.1 Characteristic Impedance Measurement

Using trial and error method we have calculated characteristic impendence by varying the length of PIFA using CTS Microwave Studio tool.

Table 3: Measurement of characteristic impedance by varying the length of PIFA

| S.no | Length of PIFA(cm) | Characteristics impedance(Ω) |
|---|---|---|
| 1. | 9.4 | 52.6819 |
| 2. | 8.5 | 52.4350 |
| 3. | 7.3 | 52.0189 |
| 4. | 6.8 | 51.7998 |
| 5. | 5.4 | 51.4668 |
| 6. | 4.6 | 51.1421 |
| 7. | 3.5 | 51.0214 |
| 8. | 2.6 | 50.9273 |
| 9. | 1.0 | 50.7180 |

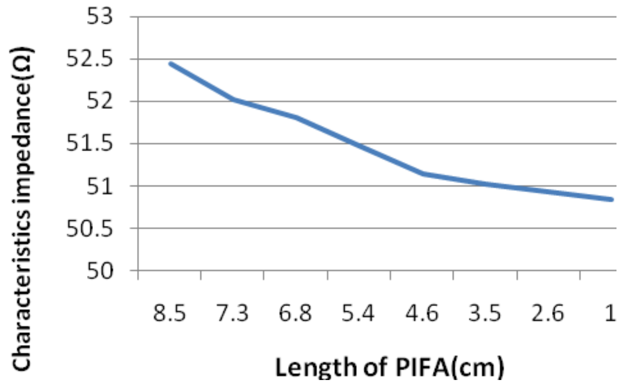



Fig. 1 Length of PIFA vs Characteristic impedance

The following Fig. 6 shows the characteristics impedance of the PIFA of length 1 cm which is placed inside the TEM cell.

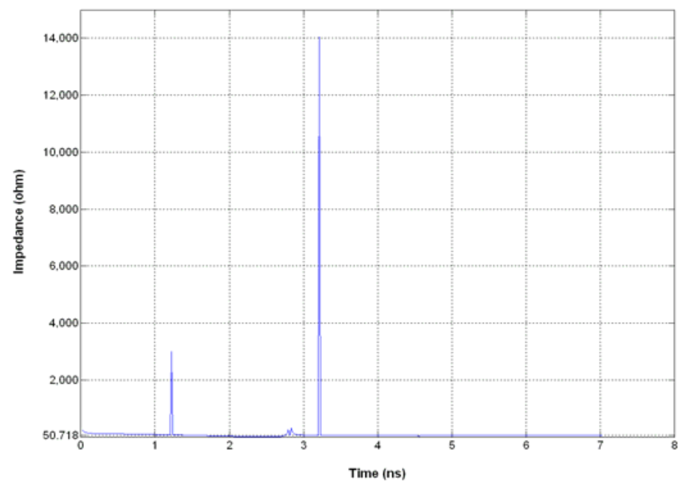



Fig. 6 Characteristic impedance of the PIFA of length 1 cm placed witihin TEM cell

The characteristics impendence of PIFA is 50.7180 Ω. From the result, we can observe two peaks which occurs due to reflection within the TEM cell. The first peak indicates reflection at the tapered section. The second peak shows the refection from the rectangular transmission section. From this characteristic impedance of PIFA we can find the reflection coefficient which is caused due to reflection within the TEM cell. The reflection coefficient can be calculated using the relation

$$|\Gamma| = (Z_L - Z_O) / (Z_L + Z_O)$$

Where,

$Z_O$-source impedance

$Z_L$-load impedance

The reflection coefficient calculated for PIFA of length 1 cm using the above formula is found as 0.0072. Thus the value of reflection coefficient is found to be low for PIFA. Therefore using 1 cm PIFA we can effectively reduce the SAR.

## 7. CONCLUSION

The progress in science and technology is a nonstop process. New things and new technology are being developed every now and then. The proposed work is based on investigating PIFA which is more reliable, compact and fewer complexes. Using the simulation tool the feasibility of the design has been studied. In future, this simulation result can be used to design low SAR PIFA.

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