SYSTEMATIC REVIEW OF SAR REDUCTION TECHNIQUES FOR MINIMIZING MOBILE PHONE RADIATION

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ABSTRACT

In this mobile digital world cellular handsets and tablet pc’s have become the common used devices. These devices use the Electromagnetic Frequency (EMF) Spectrum which is widespread in our atmosphere. Electromagnetic fields of all frequencies represent one of the most common and fastest growing environmental influences, about which anxiety and speculation are spreading. All populations are now exposed to varying degrees of EMF, and the levels will continue to increase as technology advances. The World Health Organization (WHO) established the International EMF Project in 1996 to assess the scientific evidence of possible health effects of EMF in the frequency range from 0 to 300 GHz and possibly reducing the effects caused by them. Our project aims in limiting the hazardous EM radiation emitted from the mobile phones. This can be achieved by using the PIFA antenna in the Transfer electromagnetic (TEM) cell experimental setup.

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 [3]. 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 [5]. 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 [7]. 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 computer simulation technology(CST) microwave studio software from which we can find the characteristic impedance and VSWR.

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 [9]. The methods so far proposed have significantly limited the SAR within a specific value [10-13]. 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 [8]. By placing the Metamaterials between the human head and mobile antenna the SAR can be reduced [6]. Our work in this paper is to limit the EM radiation emitted from mobile antenna by varying the antenna length.

3. PROBLEM FORMULATED

Figure: 1(a) shows the scan image of a common human head before the usage of mobile phone [15]. From this image we can observe that the temperature of this human is within the range of standard temperature [17]. Figure: 1(b) shows the scan image of a common human after the usage of mobile phone for 15 minutes [19-21]. 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

The rectangular TEM is broadly used for testing of emission from electronic devices [2]. The TEM cell is made up of a rectangular coaxial transmission section which is tapered at both sides with coaxial connector, as shown in Figure 2. It consists of two conductors. The inner conductor which is also called as septum acts as the positive conductor or hot line [4]. The outer conductor acts as a ground.

The experimental setup for characterizing the impedance of PIFA

This Figure 3 shows the experimental setup for characterizing the PIFA’s impedance and VSWR 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 [8]. The other end is connected to a HP 8791A network analyzer. The same experimental setup is used to measure VSWR.

4.2 Planar Inverted F-Antenna

Figure 4 shows that the Planar Inverted Fractal Antenna (PIFA) which is a type of linear Inverted F-Antenna (IFA) [14]. 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 [16].

4.3 Antenna Length

![Short Pin or Short Post](image)

Figure 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 [6].

4.4 Characteristic Impedance and VSWR

There are large numbers of simulation tools available for designing mobile antenna. We have decided to use computer simulation technology (CST) microwave studio software due to its advantages such as multi-technology co design, high speed data link and easy integration to other components [18]. From the simulation result, we can observe the characteristic impedance and VSWR of PIFA.

5. RESULTS AND DISCUSSION

5.1 Numerical Analysis

The SAR rating for various mobile phones can be defined using number of standards [25]. 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: Comparison of SAR for various mobile phones

| S.No. | Product name | SAR Rating (American standard) [1.6 W/kg] | SAR Rating (European standard) [2 W/kg] |
|-------|--------------|------------------------------------------|------------------------------------------|
| 1.    | Apple        | 1.19                                     | 1.10                                     |
| 2.    | Nokia        | 1.40                                     | 1.38                                     |
| 3.    | Samsung      | 1.28                                     | 1.32                                     |
| 4.    | G-Five       | -                                        | 1.78                                     |
| 5.    | Karbonn      | -                                        | 1.97                                     |
| 6.    | Micromax     | -                                        | 1.94                                     |

From this Table :1 we can infer that Mobile phones manufactured by international branded companies have average SAR rating. But the mobile manufactured by some unbranded companies have high SAR rating [22-24].
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            |

From these 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 [27]. The major sources of radio frequency in India are the transmitting towers such as AM/FM Tower, Cell Towers, Mobile Phones etc. emit EM radiation continuously. The EM radiation emitted from these sources has risen exponentially by rapid growth of wireless technology such as cell phones, Wireless Fidelity, Wi-max and other wireless devices [26].

Table 3: Reference levels for general public at 900MHz

| Country or Organization | Document | 900 MHz |
|-------------------------|----------|---------|
|                         |          | Electric field (V/m) | Power density (W/m²) |
| International health based guidelines | | | |
| International commission of non ionizing radiation protection | ICNIRP 1998 | 41.25 | 4.5 |
| International Institute of Electrical and Electronics Engineer | IEEE, 1999 USA | 47.6 | 6.0 |
| European/ European Committee for Electro technical Standardization (Technical committee) | CENELEC, 1995 | 41.1 | 4.5 |
| National health based guidelines | | | |
| Australia/ Standard Association of Australia | AS/NSZ, 1998 | 27.5 | 2.0 |
| East European health based guidelines | | | |
| Hungary/ Hungarian Standard Institution | Hungary, 1986 | 6.1 | 0.1 |
| National guidelines based on precautionary approaches | | | |
| Belgium | 20.6 | 1.1 |
| Italy/ Ministry of Environment | Italy 1, 1998b | 20 | 1.0 |
| Italy/ Ministry of Environment | Italy 2, 1998b | 6 | 0.1 |
| Switzerland/Schweizer Bunndesrat | NISV, 1999 | 4 | 0.04 |
| Local recommendations, based on precautionary approaches | | | |
| Austria Local | S vorGW 1998 | 0.6 | 0.001 |

This Table 3 shows the various reference levels for the general public which are guidelines based at 900MHz.
The following ICNIRP guidelines have been adopted as standard by India for limiting the exposure to radio frequency energy produced by mobile phones. The SAR value from the Table 4 has been averaged using 10g of average mass over a period of 6 minutes.

Table 4: ICNIRP guidelines adopted by India

| General Public Exposure [25] | Whole-body average SAR (W/kg) | Localized SAR head and trunk (W/kg) | Localized SAR limbs (W/kg) |
|-----------------------------|------------------------------|-----------------------------------|---------------------------|
|                             | 0.08                         | 2                                 | 4                         |

5.2 Numerical Results

5.2.1 VSWR Measurement

The reduction in the length of PIFA will results in a very complicated structure. The length of PIFA is varied between 9.4 cm and 1 cm using trial and error method and the VSWR readings are summarized as follows. From the following Table 5, we can infer that if the length of PIFA is reduced then the VSWR is also reduced considerably. This shows that VSWR is directly proportional to the length of PIFA.

Table 5: Various VSWR measured by significantly varying the length of PIFA

| S.No | Length of PIFA (cm) | VSWR  |
|------|---------------------|-------|
| 1.   | 9.4                 | 53.28 |
| 2.   | 8.5                 | 52.64 |
| 3.   | 7.3                 | 52.19 |
| 4.   | 6.8                 | 51.94 |
| 5.   | 5.4                 | 51.53 |
| 6.   | 4.6                 | 51.11 |
| 7.   | 3.5                 | 50.85 |
| 8.   | 2.6                 | 50.31 |
| 9.   | 1.0                 | 49.92 |
Figure 5 : Statistical analysis of VSWR by varying the length of VSWR

From the numerical and the graphical results plotted in Figure : 5, it shows as the length of the PIFA antenna decreases the VSWR also decreases and they are proportional to other.

5.2.2 Characteristic Impedance Measurement

Using trial and error method we have calculated characteristic impedance by varying the length of PIFA. From the following Table : 6 we can infer that if the length of PIFA is reduced then the Characteristics impedance(Ω) is also reduced considerably. Figure : 6 shows that Characteristics impedance (Ω) is directly proportional to the length of PIFA.

Table 6 : 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                | 50.8427                     |

Figure 6 : Length of PIFA versus Characteristic impedance

The reflection coefficient can be calculated using the relation
6. 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, computer simulation technology (CST) microwave studio software the feasibility of the design has been studied. In future, this simulation result can be used to design low SAR PIFA.

REFERENCES

[1] Sang Il Kwak, Dong-Uk Sim, Jong Hwa Kwon, "Design of Optimized Multilayer PIFA With the EBG Structure for SAR Reduction in Mobile Applications", Electromagnetic Compatibility, IEEE Transactions, Volume: 53 Issue: 2, On page(s): 325 – 331, May 2011.

[2] S.Palanivel Rajan, "A Significant and Vital Glance on "Stress and Fitness Monitoring Embedded on a Modern Telematics Platform", Telemedicine and e-Health Journal, ISSN: 1530-5627 (Online ISSN: 1556-3669), Vol. No.: 20, Issue No.: 8, pages: 757-758, 2014.

[3] Islam, M.R. Ali, M, " Ground Current Modification of Mobile Terminal Antennas and Its Effects", Antennas and Wireless Propagation Letters, IEEE, Volume: 10 , On page(s): 438 – 441, May 2011.

[4] S.Palanivel Rajan, K.Sheik Davood, "Performance Evaluation on Automatic Follicles Detection in the Ovary", International Journal of Applied Engineering Research, ISSN No.: 0973-4562, Vol. 10, Issue 55, pp. 1-5, 2015.

[5] Pascaud, R. Gillard, R. Loison, R. Wiant, J. Man-Fal Wong," Exposure Assessment Using the Dual-Grid Finite-Difference Time-Domain Method ", Microwave and Wireless Components Letters, IEEE, Volume: 18 Issue: 10, page(s): 656–658, 2014.

[6] S.Vijayprasad, R.Sukanesh, S.Palanivel Rajan, "Assessment of relationship between heart rate variability and drowsiness of post operative patients in driving conditions", JoKULL Journal, ISSN : 0449-0576, Vol. 63, Issue 11, pp.107–121, 2013.

[7] Kwak, S.I. Sim, D.U. Kwon, J.H. Choi, H.D," Experimental tests of SAR reduction on mobile phone using EBG structures",Electronics Letters, Volume: 44 Issue: 9, On page(s): 568 - 569 , April 2008 .

[8] S.Palanivel Rajan, R.Sukanesh, "Viable Investigations and Real Time Recitation of Enhanced ECG Based Cardiac Tele-Monitoring System for Home-Care Applications: A Systematic Evaluation", Telemedicine and e-Health Journal, ISSN: 1530-5627 (Online ISSN: 1556-3669), Vol. No.: 19, Issue No.: 4, pp. 278-286, 2013.

[9] Hamblin, D.L. Anderson, V. McIntosh, R.J, "Wideband reduced size electromagnetic band gap structure", Electromagnetic Compatibility, IEEE Transactions, Volume: 54 Issue: 5, On page(s): 914 – 920, May 2007.

[10] Dr.C.Vivek, S.Palanivel Rajan, "Z-TCAM : An Efficient Memory Architecture Based TCAM", Asian Journal of Information Technology, ISSN No.: 1682-3915, Vol. No.: 15, Issue : 3, pp. 448-454, 2016.

[11] Jiunn-Nan Hwang; Fu-Chiann Chen, "Reduction of the Peak SAR in the Human Head With Metamaterials", Antennas and Propagation, IEEE Transactions, Volume: 54 Issue:12, On page(s): 3763 – 3770, Dec. 2006.

[12] Folayan, O. Langley, R.J, "Wideband reduced size electromagnetic band gap structure", Electromagnetic Compatibility, IEEE Transactions, Volume: 41 issue:20 ,On page(s): 1099 - 1100, Sept. 2005.

[13] S.Palanivel Rajan, Sukanesh, R, et.al., "Performance Analysis Of Mobile Phone Radiation Minimization Through Characteristic Impedance Measurement", International Journal of Computer Science Issues, Vol. 9, Issue 2, p540, 2012

[14] S.Palanivel Rajan, R Sukanesh, S, Vijayprasath, "Performance Evaluation of Mobile Phone Radiation Minimization through Characteristic Impedance Measurement for Health-care Applications", IEEE International Conference on Advanced Communication Control and Computing Technologies (iCACCCT), ISBN 978-1-4673-2048-1/12, IEEE 2012

[15] S.Palanivel Rajan, T.Dinesh, "A Systematic Review on Wearable Driver Vigilance System with Future Research Directions", International Journal of Applied Engineering Research, ISSN No.: 0973-4562, Vol. 10, Issue No.1, pp. 627-632, 2015.

[16] Beard, B.B.; Kainz, W.; Onishi, T.; Iyama, T.; Watanabe, S.; Fujiwara, O.; Jiangqing Wang; Bit-Babik, G.; Faraone, A.; Wiant, J.; Christ, A.; Kuster, N, "Comparisons of computed mobile phone induced SAR in the SAM phantom to that in anatomically correct models of the human head ",Electromagnetic Compatibility, IEEE Transactions , Volume: 48 Issue:2 , On page(s): 397 – 407, May 2006.

[17] S.Palanivel Rajan, R.Sukanesh, "Experimental Studies on Intelligent, Wearable and Automated Wireless Mobile Tele-Alert System for Continuous Cardiac Surveillance", Journal of Applied Research and Technology, ISSN No.:
1665–6423, Vol. No. 11, Issue No.: 1, pp.133 - 143, 2013.

[18] S.Palanivel Rajan, “Review and Investigations on Future Research Directions of Mobile Based Telecare System for Cardiac Surveillance”, Journal of Applied Research and Technology, ISSN: 1665–6423, Vol.13, Issue.4, pp.454-460, 2015.

[19] S.Palanivel Rajan, T.Dinesh, “Analysis of Human Brain Disorders for Effectual Hippocampus Surveillance”, International Journal of Modern Sciences and Engineering Technology, ISSN 2349-3755, Vol. No.: 2, Issue No.: 2, pages: 38-45, 2015.

[20] Chang Yong Rhee, Jea Hak Kim, Woo Jae Jung, Taejoon Park, Byungje Lee and Chang Won Jung “Frequency-Reconfigurable Antenna for Broadband Airborne Applications” IEEE Antenna and wireless propagation letters., vol. 13, pp. 189–192, 2014.

[21] S.Palanivel Rajan, R.Sukanesh, S.Vijayprasath, “Design and Development of Mobile Based Smart Tele-Health Care System for Remote Patients”, European Journal of Scientific Research, ISSN No.: 1450-216X/1450-202X, Vol. No. 70, Issue 1, pp. 148-158, 2012.

[22] S.Palanivel Rajan, R.Sukanesh, S.Vijayprasath, “Analysis and Effective Implementation of Mobile Based Tele-Alert System for Enhancing Remote Health-Care Scenario”, HealthMED Journal, ISSN No.: 1840-2291, Vol. No. 6, Issue 7, pp. 2370–2377, 2012.

[23] S.Vijayprasath, S.Palanivel Rajan, “Performance Investigation of an Implicit Instrumentation Tool for Deadened Patients Using Common Eye Developments as a Paradigm”, International Journal of Applied Engineering Research, ISSN No.: 0973-4562, Vol. 10, Issue No.1, pp. 925-929, 2015.

[24] Angus C. K. Mak, Corbett R. Rowell, Ross D. Murch, and Chi-Lun Mak "Reconfigurable Multiband Antenna Designs for Wireless Communication Devices", IEEE Trans. Antennas Propag., Vol. 55, NO. 7, Jul 2007 pp.1919-1929.

[25] A. Mansoul, F. Ghanem, Member, IEEE, Mohamad Rijal Hamid, Member, IEEE, and Mohamed Trabelsi "A Selective Frequency-Reconfigurable Antenna for Cognitive Radio Applicatione" IEEE Antenna and wireless propagation letters., Vol. 13, 2014 pp.315-318.

[26] S.Palanivel Rajan, S.Vijayprasath, Performance Analysis on Web based Traffic Control for DDoS Attacks, International Journal of Engineering Research and General Sciences, ISSN: 2091 - 2730, Volume 3, Issue 1, 2015.

[27] R.Sukanesh, S.Palanivel Rajan, “Cellular Phone based Biomedical System for Health Care”, Proceedings of the IEEE, International Conference on Communication Control and Computing Technologies, INSPEC Accession Number: 11746436, ISBN No.: 978-1- 4244-7769-2, pp. 550-553, 2010.

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