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Design of Microstrip Antenna in LTE Application and SAR Evaluation for Head Tissue

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Abstract: Microstrip patch antenna is designed at Long Term Evolution (LTE) bands (1.7-2.7) GHz for mobile phone connected to the last generation cellular networks. This antenna is modeled and numerically test by using CST micrwave studio 2014 and place the antenna close to the human head at distance 5 mm. Computation of the Specific Absorption Rate (SAR) over 1 and 10 g for adult human head model when design microstrip patch antenna at (1800, 2200, 2500 MHz) for LTE applications. The obtained results for the SAR level is smallest from the limtation value of SAR according to IEEE and FCC.

Key words: Microstrip patch antenna, Specific Absorption Rate (SAR), head tissues, Long Term Evolution (LTE), limtation value, cellular networks

INTRODUCTION

Advances in telecommunications technology recently because of the use of systems like cellular phones on a large scale, cellular phones are the main causes of Electromagnetic radiation (EM) that penetrates the tissues of the organism and causes many health risks. Radio frequency waves have be one of the main export of pollution that could pose a prospect manage to person validity, according to the World Health Organization (WHO). The level of radio waves beyond radiation can lead to several diseases, including brain tumor, cancer and other diseases. In addition, the energy soak up by the human being turns into heat in the person body which causes high fever and thermic effects. The Specific Absorption Rate (SAR) is the interaction between the organism body and the energy of radio waves and is immediately related to the distribution of electric and magnetic fields in organism tissue.

SAR is the absorption energy of each per unit mass of tissue, generally on a specific part of an body or the all body (usually 1 or 10 g of tissue). Safety basic have been developed to limit the exposition of mobile phone radiation by the International Commission on Radiation Protection and the Institute of Engineers Electricity and Electronics, these principles have been adopted as the basic limits on the SAR, to prevent harmful health effects related to the thermal stress of the whole body (Zhang and Alden, 2011).

SAR is a derivative of the time of increasing energy (dE) soak up by or wasted in an increasing mass (dk) content in size element (dv) of a given density and can be described by the Eq. 1:

$$SAR = \frac{d}{dt}\left(\frac{dE}{dk}\right) = \frac{d}{dt\left(\frac{dE}{pdk}\right)} \quad (1)$$

where, dE, dk and • represent increasing energy, increasing mass and density respectively. Generally, the units of SAR is Watt per kilogram (W/kg) or in milliwatt per gram (mW/g). It can be defined as the rate of radio frequency energy absorbed per unit mass to some portion of the whole body given by:

$$SAR = \sigma E^2/\rho \quad (2)$$

where, E, • and • represent the root mean square value of electric field strength (V/m), the conductivity of biological tissue (S/m) and expresses the density of biological tissue (kg/m^3) respectively (Zhang and Alden, 2011; Rajagopal and Rajasekaran, 2014). The maximum value of the SAR was set by the International Commission on on Non-Ionizing Radiation Protection and Federal Communication Commission of the United States. The maximum limit SAR is fixed at 2 W/kg regared to every 10 g of organsim tissues according IEEE. For FCC, the maximum level of SAR at 1.6 W/kg for every 1 g of organsim tissue (Hossain *et al*., 2015).

In previous study, the development of communications systems requires lower cost, lower weight and lower profile antenna in addition to being able to maintain rising execution on a broad range of frequencies. The future of personal communication devices which aims to provide a picture, voice and information at any time and anywhere in the world. The evolution of terminal communication antennas must meet broadband or broadband requirements to cover possible operating ranges sufficiently (Memon and Paliwal, 2013). Determining important parts of the structure of the antenna such as thickness, length, stretch between the human head and mobile on the performance of mobile antenna, impact of those parts on the bandwidth, SAR and efficiency of the antenna. And a comprehensive study of two models of phones that include the internal patch phones and the structure of the phone and put them next to the human head and the first model works at 900 MHz frequency and the second model in 1800 MHz (Kivekas *et al*., 2004). The CST microwave studio program has been used to simulated and numerical test of the several antennas widely used in cellular phones. These antennas include monopole, a helical, a patch and a PIFA antenna. These antennas were tested close to the human head and hand and the behavior of each antenna was studied at varying distances. The test results were used as benchmarks to compare the Specific Absorption Rate (SAR) and are within the specified health safety criteria (Faruque *et al*., 2010). Baligar *et al.* (2016) presented the design of an microstrip Patch antenna using CST program. The specific absorption rate of the microwave antenna which can be used in four generation mobile radio communications has been calculated. The antenna was placed at a space of the human head and the Specific Absorption Rate (SAR) was calculated within the FCC value. Design four generation antennas (700-960 MHz and 1.7-2.7 GHz) for eyeglass equipments to be linked to latest generation cell connections and wireless local area connections. Three types of conjugation antennas were used with connections when placing eyewear on the person head. The Specific Absorption Rate (SAR) was calculated when eyeglass were placed on a homogeneous SAM phantom and liken to limition value (Cihangir *et al*., 2015).

In this research present the design of microstrip patch antenna and implemented using CST microwave studio 2014. microstrip patch antenna can cover the bands (1800, 2200 and 2500 MHz) for LTE application when the distance between the antenna and the mobile at 5 mm. Specific Absorption Rate (SAR) values are calculated over 1 and 10 g mass of body for adult human head, according to the IEEE and ICNIRP standards. The conculsion of the results offer that the maximum SAR value on the human head model is smallest from the limitation value of the IEEE and FCC standards for head safety.

MATERIALS AND METHODS

Microstrip patch antenna: The great advanced in communications systems excess demand for integrated antennas, cost-effective and easy to simulated antennas. It is a requirement of the current time to invent patch antennas because it is lightweight, affordable and simple in the manufacturing and can be readily used in handheld devices (Ali *et al*., 2012). Microstrip patch antennas are more commonly used in mobile phones because they are light weight, less compact and easy to install on a rigid surface and less expensive. The unpretentious microstrip patch Antenna composed of a dielectric substrate having fixed dielectric constant. Radiating patch is existing on one side of a dielectric substrate and a ground plane is existing on other side of a substrate. A metal patch may take several geometrical forms and the dimensions of this patch are represented to the resonant frequency of the antenna (Baligar *et al*., 2016). The patch is composed of conducting material and the radiating patch and the feed lines are usually photo etched on the dielectric substrate.

The parameters which describe the structure of microstrip antenna are specified as follows: W is width of the patch, L indicate the length of the patch is usually between (0.3333$\bullet_0$- 0.5$\bullet$) where $\bullet$ is the free-space wavelength and h is represented the height of the dielectric substrate is usually between (0.003 $\bullet_0$<h<0.05 $\bullet_0$) and the dielectric constant of the substrate ($\bullet_r$) is typically in the range 2.2<$\bullet_r$<12 (Dular and Joshi, 2015). The microstrip patch antenna is depicted with Fig. 1.

In this research, the rectangular microstrip patch antenna is designed for LTE application (1.7-2.7 GHz). The rectangular patch reception apparatus is FR-4 substrate $\bullet_r$ = 4.3 which used for designed antenna. The dimensions of the rectangular patch antenna can be calculated as (Ramna and Sappa, 2013; Mahdi, 2010):

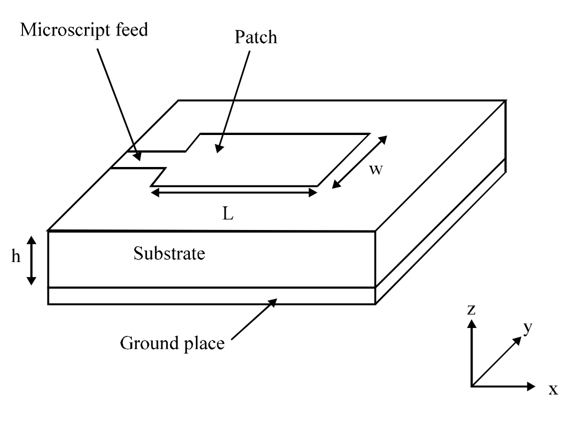

Fig 1: Basic structure of microstrip antenna

$$f_r = \frac{c}{2L\sqrt{\varepsilon_{reff}}}$$

where, c is the speed of light in a vacuum and f_r is the resonant frequency. Where the effective dielectric constant can be obtained from Eq. 4 and indicated in Fig.2:

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{-\frac{1}{2}} \quad (4)$$

the width of the antenna can be calculated by Eq. 5:

$$W = \frac{c}{2f_r\sqrt{\frac{\varepsilon_r + 1}{2}}} \quad (5)$$

from Balanis (2005) the actual length can obtain using:

$$L = L_{eff} - 2\Delta L \quad (6)$$

where L_{eff} is the effective length of the patch can be calculated by Eq. 7:

$$L_{eff} = \frac{c}{2f_r\sqrt{\varepsilon_{reff}}} \quad (7)$$

and • L is the extension in length and given by Dular and Joshi (2015):

$$\Delta L = 0.412h\frac{(\varepsilon_{reff} + 0.3)\left[\frac{w}{h} + 0.264\right]}{(\varepsilon_{reff} - 0.258)\left[\frac{w}{h} + 0.8\right]} \quad (8)$$

Finally, the dimensions of the ground plane can be calcuated as:

$$W_g = 6h + W \quad (9)$$

$$L_g = 6h + L \quad (10)$$

where W_g and L_g represents the width and length of the ground plane, recpectivily.

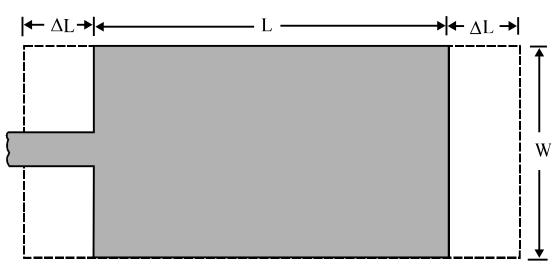

Fig. 2: Effective lengths of rectangular microstrip patch

RESULTS AND DISCUSSION

The rectangular microstrip patch antenna was simulated using the CST 2014. From the Eq. (4-10) is calculated of the dimensions of the rectangular patch antenna for the LTE bands (1.7 -2.7) GHz and the center frequencies were chosen (1.8, 2.2 and 2.5) GHz in antenna design as shown in Table 1.

The S-parameters and radiation pattern at 1.8, 2.2 and 2.5 GHz for adults human head are presented in Fig. 3-5 and the directivity calculated at azimuth angle. At 1.8 GHz, the value of return loss is (-17 dB) for microstrip patch antenna while in 2.5 GHz, the return loss is (-23 dB). The directivity of microstrip patch antenna in the (1.8) GHz is smallest than other frequencies (2.2 and 2.5 GHz) as shown in Table 2.

Table 1: Dimensions of the microstrip patch antenna

Parameters	f_r = 1.8 GHz	f_r = 2.2 GHz	f_r = 2.5 GHz
L	39.32	32.05	28.10
W	51.20	42.00	36.85
h	1.60	1.60	1.60
G	1.00	1.00	1.00
L_g	78.64	64.10	56.20
W_g	78.64	84.00	73.70

Table 2: Microstrip patch antenna characteristics

Frequency (GHz)	Return loss (dB)	VSWR	Directivity (dBi)
1.8	-17.0	2.02	7.33
2.2	-21.8	2.10	7.49
2.5	-23.0	3.00	7.60

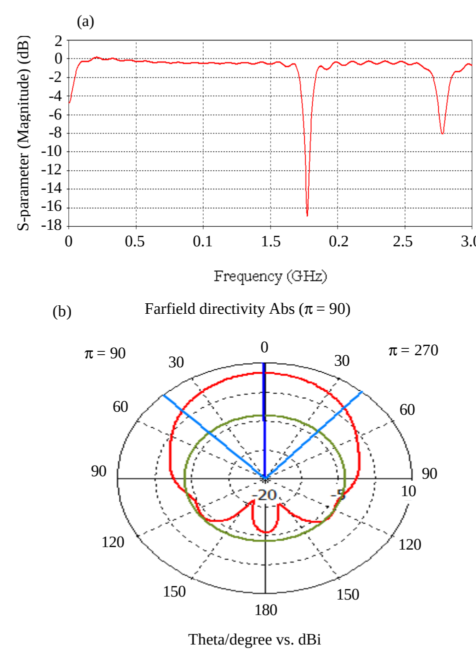

Fig. 3: a) Return loss and b) Directivity (dBi) for microstrip patch antenna at 1.8 GHz resonance frequency

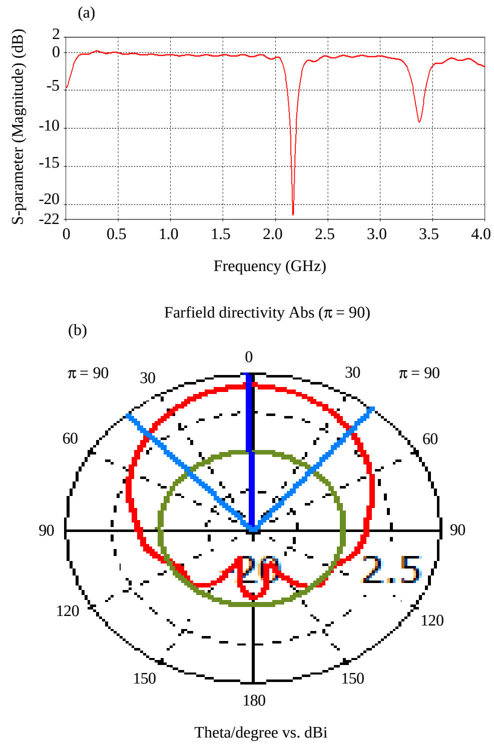

Fig. 4: a) Return loss and b) Directivity (f_r) for microstrip patch antenna at 2.2 GHz resonance frequency

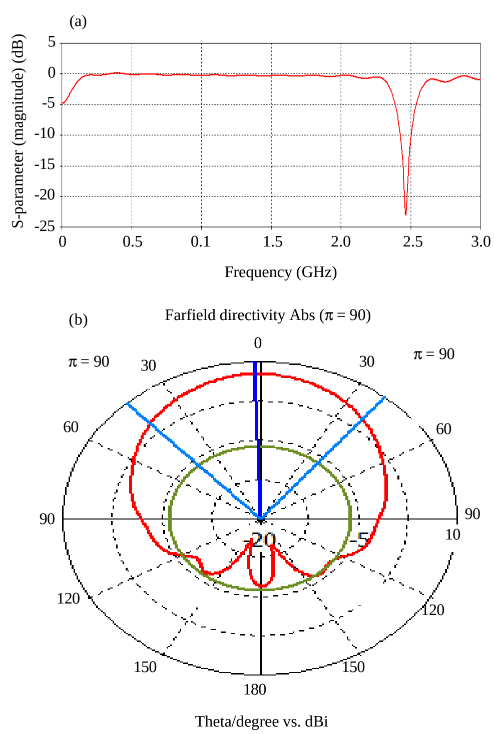

Fig. 5: a) Return loss and b) Directivity (f_r) for microstrip patch antenna at 2.5 GHz resonance frequency

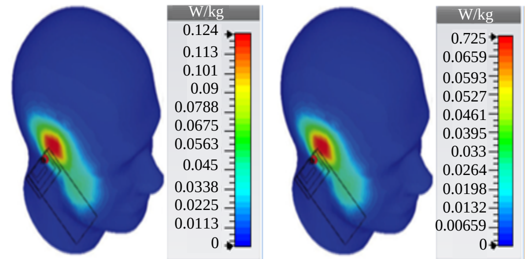

Fig. 6: Specific Absorbing Rate (SAR) at 1.8 GHz for adult human head: a) 1 g and b) 10 g

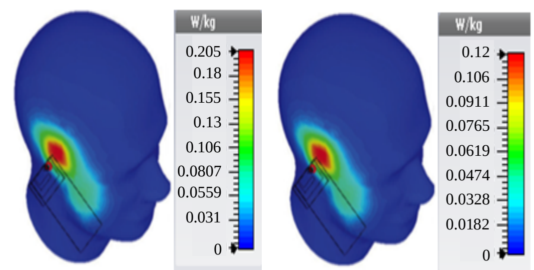

Fig. 7: Specific Absorbing Rate (SAR) at 2.2 GHz for adult human head a) 1 g and b) 10 g

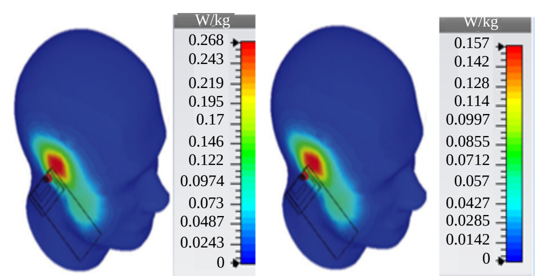

Fig. 8: Specific Absorbing Rate (SAR) at 2.5 GHz for adult human head: a) 1 g and b) 10 g

The value of the Specific Absorption Rate (SAR) was calculated at adult human head model. A distance of 5 mm is set between the head and mobile phone and SAR is calculated. The value of SAR according to FCC is greater than the value of SAR according to IEEE, the SAR value is 0.0725 W/kg for 10 g of tissue while for 1 g the maximum SAR value 0.124 W/kg at 1.8 GHz. Note that the values for each of the SAR value increased by increasing frequency at 1.8 GHz, the maximum value of the SAR is 0.124 W/kg while at 2.5 GHz, the maximum value of the SAR is 0.268 W/kg for 1 g of tissue. Figure 6-8 shows SAR value for human head model at covers the LTE bands (1.8, 2.2 and 2.5 GHz) for two standard limits.

CONCLUSION

Design of the rectangular microstrip patch antenna and its SAR value is tested for adult human head model. Specific absorption rates have been calculated in human head tissues exposed to LTE frequencies 1800, 2200 and 2500 MHz from cellular phones when the distance between the antenna and the mobile at 5 mm. The results indicated that the SAR values as averaged over 1 and 10 g on the human head obtained for all simulations are well below the limitation value which is recommended by FCC and IEEE.

REFERENCES

Ali, S.A., U. Rafique, U. Ahmad and M.A. Khan, 2012. Multiband microstrip patch antenna for microwave applications. IOSR. J. Electron. Commun. Eng., 3: 43-48.

Balanis, C.A., 2005. Antenna Theory Analysis and Design. 3rd Edn., John Wiley and Sons Inc., USA.

Baligar, S.M., R. Soloni and D.N. Chandrappa, 2016. Analysis of Specific Absorption Rate (SAR) of microstrip patch antenna for wireless applications. Intl. J. Adv. Res. Comput. Commun. Eng., 5: 230-232.

Cihangir, A., W. Whittow, C. Panagamuwa, G. Jacquemod and F. Gianesello *et al*., 2015. 4G antennas for wireless eyewear devices and related SAR. C. R. Phys., 16: 836-850.

Dular, M. and I. Joshi, 2015. Study of multiband patch antenna for x-band applications. Intl. J. Electr. Electron. Eng., 2: 35-38.

Faruque, M.I., M.T. Islam and N. Misran, 2010. SAR analysis in human head tissues for different types of antennas. World Appl. Sci. J., 11: 1089-1096.

Hossain, M.I., M.R.I. Faruque and M.T. Islam, 2015. Analysis on the effect of the distances and inclination angles between human head and mobile phone on SAR. Prog. Biophys. Mol. Biol., 119: 103-110.

Kivekas, O., J. Ollikainen, T. Lehtiniemi and P. Vainikainen, 2004. Bandwidth, SAR and efficiency of internal mobile phone antennas. IEEE. Trans. Electromagnet. Compat., 46: 71-86.

Mahdi, H.F., 2010. Simulation of rectangular microstrip antenna by integrating MATLAB in visual basic. Diyala J. Eng. Sci., 3: 16-24.

Memon, M.I. and A. Paliwal, 2013. Microstrip patch Antenna design calculator. Intl. J. Eng. Res. Technol., 2: 3080-3085.

Rajagopal, B. and L. Rajasekaran, 2014. SAR assessment on three layered spherical human head model irradiated by mobile phone antenna. Hum. Centric Comput. Inf. Sci., 4: 1-11.

Ramna and A.S. Sappa, 2013. Design of rectangular microstrip patch antenna using particle swarm optimization. Intl. J. Adv. Res. Comput. Commun. Eng., 2: 2918-2920.

Zhang, M. and A. Alden, 2011. Calculation of whole-body SAR from a 100 MHz dipole antenna. Prog. Electromagnet. Res., 119: 133-153.