 ISSN 1023-862X

THE REDUCTION OF SPECIFIC ABSORPTION RATE AT DIFFERENT FREQUENCIES

Sahib Khan*, Abdur Rehman*, Nasir Ahmad**, Muhammad Naeem***

ABSTRACT

This Paper is about the reduction of specific absorption rate (SAR) of wearable rectangular patch antenna for 1.8GHz and 2.45GHz wireless applications. Antenna is designated on a 3mm X 3mm X 3mm resolution truncated Hugo body model in Computer simulation technology software. The ramification reveals the specific absorption rate simulated value that were reduced by 89% compared to previously achieved SAR reduction of 83.5%. A reduction of power absorption was also noticed as the space of patch antenna increased. The SAR of Patch antennas are reduced from 0.0005 to 0.00041 SAR Avg (mW/g) at frequencies of 1.8GHZ & 2.45GHZ respectively resulting in a significant improvement in antenna performance. The improvement in directivity & gain has been observed and bandwidth of about 65% has achieved with Specific absorption rate reduction.

KEY WORDS: *Textile Antennas, Rectangular Patch Antenna, Wearable Antenna, Specific Absorption Rate*

INTRODUCTION

Antenna have always remained a key component of any wireless system used to transfer radio frequency signals of a guided media i.e. transmission line into free space in the form of electromagnetic wave. Antennas are resonating devices that operate efficiently over a relative narrow frequency band. A universal demand of antennas for wireless communication applications made it a hot area of research and various types of antennas were designed to meet the need of newly emerging technologies including RFIDs, phones, wearable computing devices, monitoring devices, health care and military applications[1-8].

One of the most significant applications of the antennas is the body centric communication among the various electronic devices used on the body[3], due to which the research on the wearable antennas has attracted the interest of many researchers in the recent times. The design of Antennas is driven mainly by three types of operations, namely, the on-body channels, in-body links and body-centric communication[2-3]. Body-centric communication or off-body links work in existence of human being having outward body radiation. While the on-body performance pledge the endorse link different parts of body. In-body links antennas are worn for healthcare implantation[3]. Significant candidates for structures of wearable antennas to be used for body-centric communication are textile and patch antennas. It has become promising factor due to pliability to be concatenated into clothing which has embossed health risks alertness from EM fields. Therefore, The Specific absorption rate is employed in disposition to mark the venture of health manipulated to human body by wearable devices. Most of the international manifestation guidelines and standards deploy Specific absorption rate as a Dosimetric consignment for frequencies up to 10 GHZ[9-10]. Specific absorption rate is an important criterion which is used to quantify EM energy subsumed by biological tissue mass when exposed to radiating devices. The intensity level of electric field, E in V/m characterize a directly measurable consignment criterion corresponding to basic restrictions[11]. Specific absorption rate is calculated as,

$$SAR = \frac{\sigma |E|^2}{\rho} \tag{1}$$

Where is the electrical conductivity of the tissue in Siemens per meter, |E| is the rms of induced electric field and is tissue density in kg per cubic meter. The unit of SAR is Watt per kg. The ANSI/IEEE and ICNIRP, for the US, manifest the limitation of SAR for hands which is equivalent to 4 Watt per Kilogram for this manoeuvre latitude[1]. It is exigent to analyze the suggested antenna in term of specific absorption rate values, as the wearable patch antenna is erected and employed in the proximity of human body[12,13]. The on-body link antenna's has to have a reduction in Specific absorption rate values[4]. In[14-16] various antennas for WLAN, WBAN, Bluetooth and Zigbee significance were feigned. However, a very

* *Department of Electrical Engineering, University of Engineering and Technology, Peshawar, Pakistan*
** *Department of Computer Systems Engineering, University of Engineering and Technology, Peshawar, Pakistan*
*** *Department of Computer Science, University of Peshawar Peshawar, Pakistan*

limited researcher analyzed the SAR effect on the human body in their papers[9,12].

Therefore this paper is aimed to reduce SAR values of patch antenna on skin effect. The Hugo body model using CST is employed to signify the above effect by using a delivered power of 1W..

Antenna Modeling

To analyze the SAR an E-Shape patch antenna is designed. A selection of suitable conducting and non-conducting materials are required to reduce SAR. Conducting material is applied to both the ground plane and the patch, while non-conducting textile is applied as substrate layer of the antenna. For the substrate of antenna, skin fabric is chosen due to its high thickness and a low permittivity of 1.48, which are considered suitable for patch and antenna designing. The substrate has a thickness of 4.5mm and provides an adequate antenna bandwidth. The conducting material is self-adhesive copper foil tape, which has a thickness of 0.1mm and provides low surface resistivity. The self-adhesive side makes it easy to fasten the copper tape to the substrate. Besides this the self-adhesive copper is easy in handling such as cutting and sewing. The designed antenna is shown in Fig. 1.

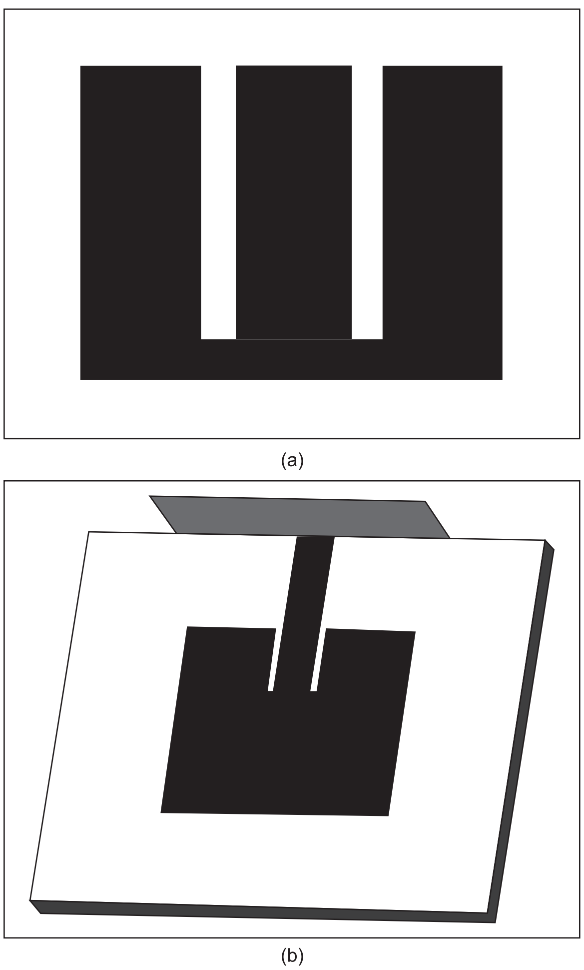


Fig.1. CST Simulation design models. (a) E-Shaped antenna (b) port creation

The antenna is analyzed for a band of 3GHz of frequencies i.e. form 0-3GHz. The return loss parameter is measured over this band of frequencies for the designed antenna. A return loss less than -10dB has been observed at 1.8GHz and 2.45GHz for different parameters of antenna. The two resonant frequencies are still visible at 1.8GHz and 2.45GHz in return loss vs. frequency graph as displayed in Figure. 2(a) and 2(b) accordingly.

The polar plot of S-Parameter for both 1.8GHz and 2.45GHz resonant frequencies is also shown here in Fig. 3(a) and 3(b) respectively.

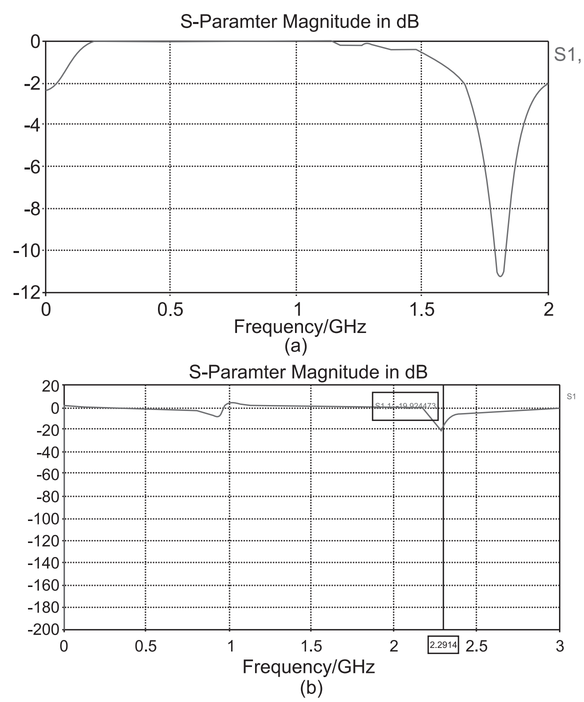


Fig.2. Characteristics of return loss S11 of E-Shape MPA (a) 1.8GHz (b) 2.45GHz

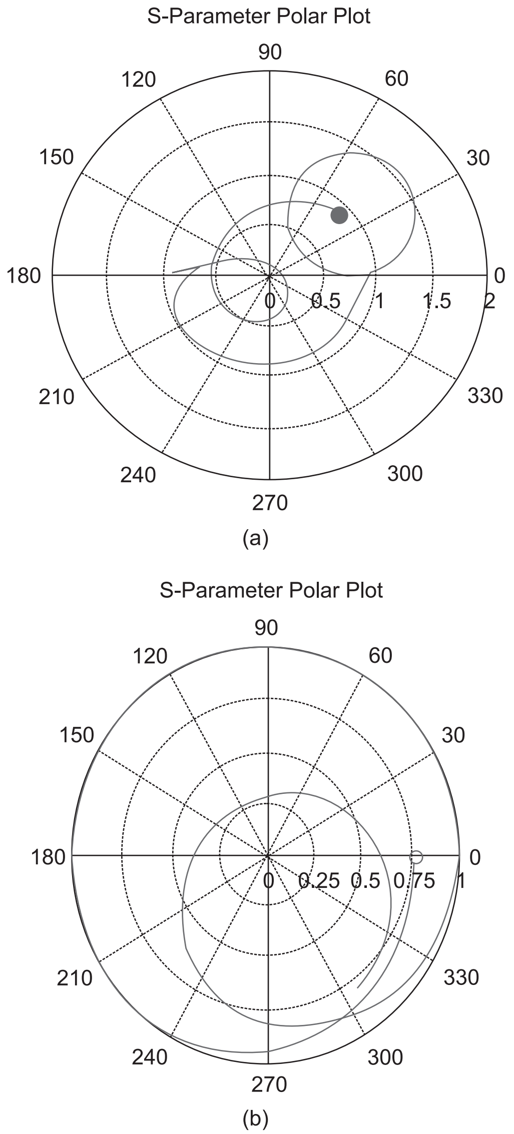


Fig.2. Characteristics of S-Parameter of E-Shape MPA (a) 1.8GHz (b) 2.45GHz

SAR Modeling and Reduction Results

Having investigation of EM characteristics of microstrip patch antenna, focusing turn to the power loss density as clearly characterized by SAR, which helps in the mathematical absorption issues & power losses study. Therefore, the MPA is re-scaled for two different frequencies 1.8GHZ and 2.45GHZ. A truncated model constructed for MRI & CT iconic mental representation of actual human body have been put to use in specific absorption rate implementation and modeling. Its size of cell is 3 mm × 3 mm × 3 mm containing detailed models of different organ. The anatomy related expressions of body of human being can be desiccated to set the conductivity and permittivity to various body cell tissues within the pertaining grid. Therefore, this model is used to give careful consideration to the performance of antenna where the antenna is placed on the above portion of human body. The parameters of electrical related to body cell tissues about the working frequencies 1.8GHZ and 2.45GHZ have been taken from available data [6]. In SAR calculations, the average specific absorption rate came into possession by computing it over six relative cells. The previous work and current result are listed here in Table 1 and Table 2 respectively for comparison and a clear improvement in SAR has been achieved.

Table 2 shows the maximum SAR, absorbed power and (1g - 10g) average specific absorption rate for E Shape MPA. Distributions of SAR for both 1.8GHz and 2.45GHz are shown in Fig.4. The SAR is given in 1 Watt delivered power and the bar indicates the relative SAR strength in decibel.

Comparison

The result reveals that the recreated particular retention rate qualities were decreased by 89% contrasted with already accomplished SAR lessening of 83.5%. Comparing to previous result, the SAR Avg(mW/g) for two different frequencies 1.8GHZ & 2.45GHZ not only diminished but also incurred it's relative SAR values .

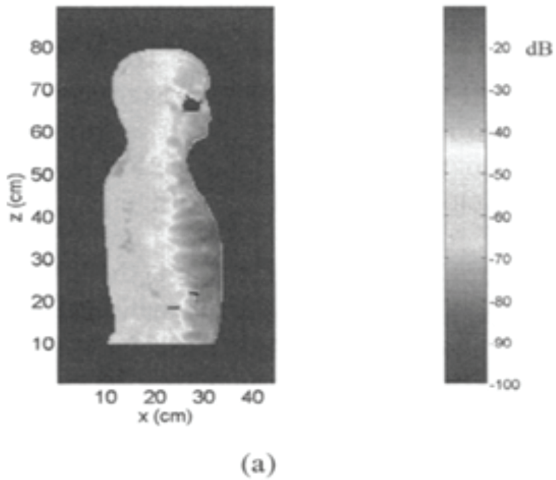
In case of 2.45 GHZ, it decreased from 0.0005 (mW/g) to 0.00041(MW/G) using microstrip line feeding technique in which microstrip was elongated using transition line. This due to the high impedance nature

Table 1. SAR previous Value for 1W delivered power

Frequency (MHz)	Pabs (mW)	SAR peak (mW/g)	SARAvg (mW/g)
1850	63	0.54	0.0012
2450	24	0.35	0.0005

Table 2. SAR current Value for 1W delivered power

Frequency (MHz)	Pabs (mW)	SAR peak (mW/g)	SARavg (mW/g)
1800	57	0.55	0.0013
2450	24	0.19	0.00041



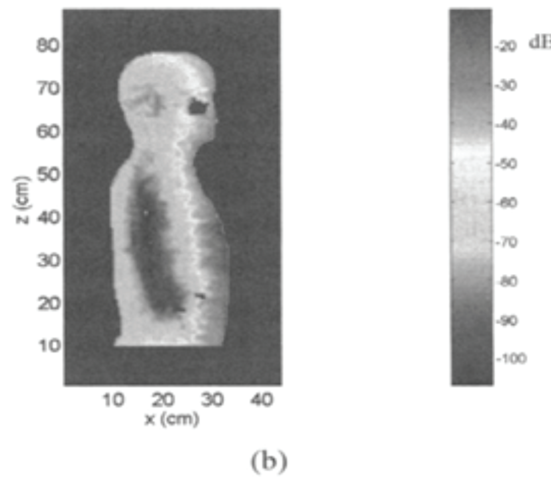


Fig.4. Computed Specific absorption rate (SAR) distribution) (a) Freq =1.8GHz (b) Freq=2.45GHz

Table 3. Comparison of SAR for 1W delivered power

Frequency (MHz)	Pabs (mW)		SAR peak (mW/g)		SARAvg (mW/g)	
	Previous	Improved	Previous	Improved	Previous	Improved
1850	63	57	0.54	0.52	0.0012	0.0011
2450	24	21.72	0.35	0.19	0.0005	0.00041

of the transition based surface used as a ground plane, which electromagnetically isolate the antenna from the body, thereby not only controlled the value of SAR below the safe level (2W/Kg (Eurpean Standard)) but also approached to experimental test prospective. So comparing to other papers, this paper reduces SAR to detune from its destined frequencies. The improvement can be clearly seen from the values listed in Table 3. The SAR has been reduced significantly for both operating frequencies.

CONCLUSIONS

Prospect act of using elegant fabrication will capacitate multi-frequency and multi-function textile antennas applications. This work has reviewed the improvements of microstrip patch antenna for SAR reduction and different wearable applications. This work has taken skin as fabric to model wearable antenna for 1.8GHz and 2.45GHz frequencies. Furthermore, the antenna radiation characteristics and input match have been fixed into scope by CST measurements and simulation. Numerical modeling of SAR is also performed. The results of SAR were found better than the tuned limit of Specific absorption rate result. The agreement of simulated and measured results shows that the analysis method and experimental results are accurate and effective. The antenna not only has good properties, but also is easy to manufacture. It satisfies communication requirements, even when bent on human arm and placed on human chest. In addition, the antenna provides required antenna gain to be applied in a body-centric wireless communications.

REFERENCES

1. *Kwak, S. I., Sim, D. U., Kwon, J. H. and Choi, H. D., 2010. Design of wearable communication device for body protection from EM wave using the EBG structure," in Proc. of 40th European Microwave Conf. (EuMC), pp. 1433-1436.*

2. *Liu, Z, G., and Guo, Y. X., 2015. Compact Low-Profile Dual Band Metamaterial Antenna for Body Centric Communications," Antennas and Wireless Propagation Letters, IEEE, 14, pp. 863-866.*

3. *Khan S., Ahmad N., Wahid, M., Naem, M., and Baloch B., 2016. Design of Circular Stud Antenna*

and Parametric Analysis," Sindh University Research Journal-SURJ (Science Series) 47, no. 2, pp:231-236.

4. *Hall, P. S., Ricci M., and Hee T. W., 2002. Characterization of on-body communication channels," In IEEE Proceedings of 3rd International Conference on Microwave and Millimeter Wave Technology (ICMMT) 2002, pp. 770-772.*

5. *Khan, S., Ahmad, N., Wahid, M., Baloch, B., and Naem M., 2015. Design and Characterization of Rectangular Stud Antenna." Sindh University Research Journal (Science Series) 47, no. 1.*

6. *Chen J., Ye, Y., and Pahlavan, K., 2012. UWB characteristics of creeping wave for RF localization around the human body," In IEEE 23rd International Symposium on Personal Indoor and Mobile Radio Communications (PIMRC), pp. 1290-1294.*

7. *Tuovinen, T., Berg, M., Yazdandoost, K. Y., and Salonen, E., 2012. Radiation properties of the planar UWB dipole antenna in the proximity of dispersive body models," In Proceedings of the 7th International Conference on Body Area Networks, ICST , pp. 82-88.*

8. *Khouri, R., Ratajczak P., Brachat P., and Staraj R., 2010. A thin surface-wave antenna using a via-less EBG structure for 2.45 Ghz on-body communication systems," In IEEE Proceedings of the Fourth European Conference on Antennas and Propagation (EuCAP), pp. 1-4.*

9. *Salonen, P., Kim, J. and Rahmat-Samii Y., 2005. Dual-band E-shaped patch wearable textile antenna," in Proc. of 2005 IEEE Antennas and Prop. Int. Symp., vol. 1A, pp. 466-469.*

10. *Wang, Q., and Wang, J., 2009. Performance of on-body chest-to-waist UWB communication link," Microwave and Wireless Components Letters, IEEE, 19(2), PP. 119-121.*

11. *Mat M. H., Malek M. F., Ronald S. H., and Zulkefli, M. S., 2011. Effects of the metallic spectacles with braces added on specific absorption rate (SAR) exposed to frontal radiation sources," In Antennas and Propagation Conference (LAPC), Loughborough, pp. 1-4.*

12. *Khan, S., Ahmad, N., Wahid, M., Baloch, B., and Naeem, M., 2015. "Design and Characterization of Rectangular Stud Antenna," Sindh Univ. Res. Jour. (Sci. Ser.) Vol.47 (1), 29-34.*

13. *Khan, S., Ahmad, N., Wahid, M., Naem, M. and Baloch B., 2015. Design of Circular Stud Antenna and Parametric Analysis," Sindh Univ. Res. Jour. (Sci. Ser.) Vol.47 (2), 231-236.*

14. *Chahat, N., Zhadobov, M., Sauleau, R. and Mahdjoubi, K., 2011. Parametric analysis of on-body dual-band antenna performance: Dependence on the human body morphology," In IEEE Proceedings of the 5th European Conference on Antennas and Propagation (EUCAP), pp. 437-440.*

15. *Salonen, P., Rahmat-Samii, Y., Schaffrath, M., and Kivikoski, M., 2004. Effect of textile materials on wearable antenna performance: a case study of GPS antennas," In Antennas and Propagation Society International Symposium, 2004. IEEE, vol. 1, pp. 459-462.*

16. *Soh, P. J., Boyes, S. J., Vandenbosch, D. A., Huang, Y., and Ooi, S. L., 2012. On-body characterization of dual-band all-textile PIFA," Progress In Electromagnetics Research, 129, pp. 517-539,.*