*Research Journal of Recent Sciences* _______________________________________________ ISSN 2277-2502
Vol. **4(1),** 51-54, January **(2015)** *Res.J.Recent Sci.*

# A Study of SAR in Human Head Due to Radiofrequency Radiation from Personal Data Assistant Device with Hands-Free Kits

**Muhammad Irfan Khattak[1], J. Ma[2], Muhammad Shafi[1] and Mohammad Saleem[3]**
[1]University of Engineering and Technology Peshawar, PAKISTAN
[2]School of Electronic, Electrical and Systems Engineering, Loughborough University, UK
[3]Faculty of Computer Science and Engineering, GIKI Topi, PAKISTAN

**Available online at: www.isca.in, www.isca.me**
Received 28th December 2013, revised 24th February 2014, accepted 13th May 2014

## Abstract

*This paper deals with the absorption of RFenergy in human head caused by hands-free accessories compared to the handset alone. It was reported by others that hands-free kit may bring different influences to the SAR value in human head. The results of this study show the measurements results taken by the DASY4 system. The operating frequency is 1.8 GHZ and a particular designed SIM card is used. Two different mobile phones includingiphone 3GS are used in the measurements. Results presented here are useful in defining the radiation rate caused by adding hands-free close to human body. Research also indicates that using PDAs in front of human head can decrease the SAR value in human head.*

**Keywords:** Personal Data Assistant, SAR, Human Head, Hands-free.

## Introduction

Hands free accessories for mobile phones are very popularly used consumer products[1-3]. In the past decades, questions had been raised on the safety of using this equipment[4-6]. The UK Consumers' Association (CA) issued a technical report describing tests performed by ERA Technology in the UK to find out how the use of hands-free accessories for mobile phones affects the deposition of radiofrequency (RF) energy in human head [7]. The main conclusion of the study was that the use of hands-free accessories with mobile telephones increases the deposition of RF energy in the head by up to three times compared to a mobile phone alone held close to human head [7].

However, Bit-Babik et al.give different conclusions[8]. In their study, it shows that hands-free kits used with radio communication devices do not increase the SAR in the user's head compared to the same devices used near the head. And in some particular situations, the SAR in the user's head is reduced significantly. Also their results show that although the attenuation effect of the body may vary depending on the position of the wire relative to the body, the SAR in the ear region may be more than 10 dB lower than that from the handset alone when placed near the head[8].

Both of the above measurements were performed decades ago. With new developments in electronics and communications, there has been a merger between mobile communications and Personal Data Assistant (PDA) type devices. This trend suggests a different way of use mobile phones. These PDAs are intended to deliver multimedia applications, 3G video calls, internet browsing and email access among others, all of these functions require the device to be held in front of the face rather than to the side of the head. Previous researches are based on the side of the head use and all measurement were performed accordingly[7,8]. According to this trend, researchers should also bring the SAR value of using mobiles in front of face into the comparison.

This paper uses the DASY4 SAR measurement kit and a SAM head phantom to perform the measurement. Previously, the authors have modified a SAM head phantom for use in a DASY4 SAR measurement kit[9,10]. The rear of the head has been removed and the phantom fixed face down, allowing the E-field probe to scan the area behind the face.

The measurement system has been successfully validated against FDTD simulations[10]. In this study, we use the latest equipment and popular communications enabled PDAS to find the possible influence of using hands-free kit.

## Methodology

**Model Description:** ***A: Equipment Used*** SAR measurements in this paper were carried out using the modified SAM head, the SAM twin phantom and DASY4 system as shown in figure 1. The DASY4 system is the most popular equipment used in measuring specific absorption rate (SAR) of human, both in the body and the head. The SAM twin phantom is a fiberglass shell phantom with 2mm shell thickness. SAM Head phantom as shown in figure-2 has been designed for dosimetric assessment of transmitter held in front of the face position. One base station as long as a particular made SIM card was used to simulate the working status of the mobile. The mobile station test set used in this experiment is the Agilent 8922M. It is a powerful GSM radio frequency test Set designed for high volume manufacturing. Flexible, but easy to use all the measurements were performed at 1800 MHZ and CW dipoles were used. Two different PDAs were involved in this study, one is the LG KE850 while the other is the IPHONE 3GS (shown in figure-3). A random hands-free kit was used with the mobiles as this can make the results easier to compare. A rectangular phantom was used to simulate the hip of human body.

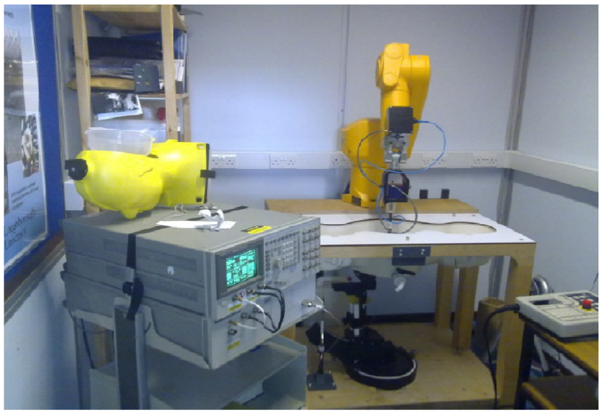

**Figure-1**
**Experimental Setup**

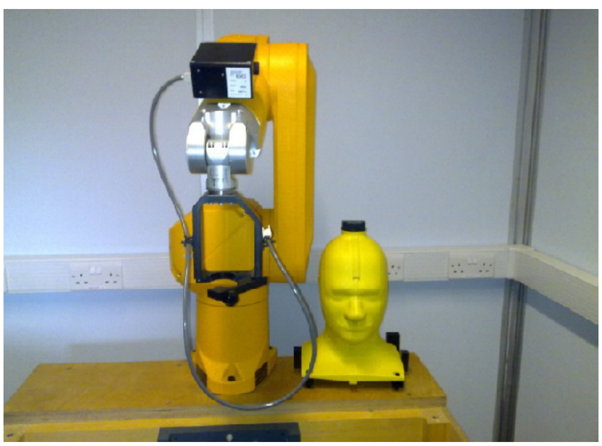

**Figure-2**
**SAM head phantom**

***B. Torso Phantom with a Tissue Simulating Liquid:*** A 2mm thick phantom made of glass fiber was used in the experiments. The approximate dimensions of the rectangular phantom were 2.4λ (400mm) long, 1.9λ (320mm) wide and 1.3λ (210mm) high for the mobile communication frequency of 1.8GHz. The dimensions for the phantom were so chosen to closely represent a human male torso. It is important to mention here that the use of glass fiber in microwave measurements is an accepted practice (Koyanagi et. al., Schmidand Partner, Mat et. al.)[11-14]. Table 1 shows the dielectric properties of phantom and muscle simulating liquid. The recipe for the filling fluid can be found in [12]. The slow filling and settling, procedure of the phantom with muscle simulating liquid ensured minimum chance of air pockets inside the phantom. When full the phantom approximately held 10liters of liquid and had an approximate weight of 26.8Kg.

**Figure-3**
**Communication Enabled PDAs**

***C. Experimental Model:*** For the start of the measurement, researchers need to make sure that the DASY4 system is working properly to get reliable results. The first set of measurements were designed to compare the highest SAR value generated by the PDAs with the official data, and it is called status 1 as shown in figure 5 in this paper. Under this status, the PDAs were put to the right bottom of the SAM twin phantom with no gap in between in order to get the highest SAR value. During the measurement, the PDAs kept nonstop communications with the base station.

**Table-1**
**Dielectric Properties of Muscle Simulating Liquid and FR4 Board**

| | $\varepsilon_r$ | σ ( S/m) |
|---|---|---|
| Muscle Simulating Liquid | 55.16 | 1.46 |
| FR4 Board | 4.5 | 0 |
| PVC (Spacer Material) | 4.0 | 10e(-6) |

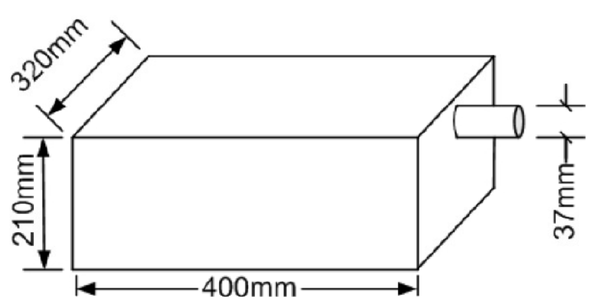


**Figure-4**
**A Line Drawing of Torso Simulating Phantom (Not to Scale)**

For status 2 and status 3, the flat section of the SAM twin phantom was considered as human hip. The PDAs in these two situations were put under the flat section of the SAM twin phantom. In status 2, the PDAs were tested alone without hands-free kit. While in status 3, one end of the hands-free kit was worn on the SAM head phantom which was full filled with simulation liquid and the other end was connected to the PDAs.

A further set of measurements as shown in figure 5 are status 4 and status 5. These measurements measure the SAR value inside human head. The SAM head phantom was used in these measurements instead of the SAM twin phantom. PDAs were put in front of the human head and positioned 80mm from the head phantom in status 4 without the hands-free kit. And in status 5, the hands-free kit were connect to the SAM head phantom while the PDAs were put on top of the Torso Simulating Phantom as shown in figure 6.

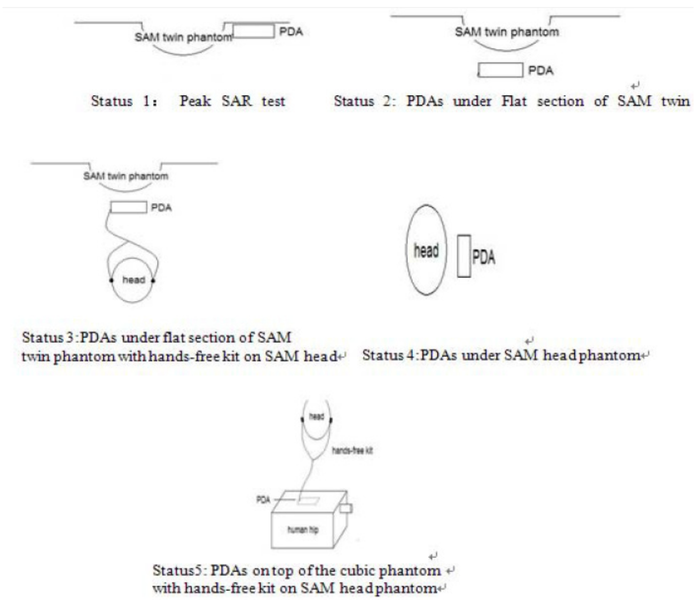


**Figure-5**
**Different Measurement Setup**

**Figure-6**
**Measurement of Status 5**

## Results and Discussion

Figure 7 shows the measured SAR values inside human body for LG KE850 for 4 different statuses. In status 1, the measured highest SAR value is basically consistent with the official data. This result indicates that the testing system works properly. Status 2 and status 3 was designed to compare the SAR inside human hip when putting the mobile in trouser pocket. In reality, status 2 will not happen as nobody will make calls in that position, so this measurement is just one reference for status 3. According to the results shown in figure 7, SAR value in status 3 is slightly higher than status 2. This shows that mobiles may need to generate more power to transfer signals to the hands-free kit. When the PDAs were put in front of the SAM head, SAR value was much less than the peak value as shown in status 4. However, this result was measured by locating the PDA 80mm from the head. If the position changed, the SAR value will change accordingly. The results of status 5 was not shown in the figure because in this situation the SAR value was very close to 0 so there is no need to put it in the figure. Comparing status 1 to status 3, it is easily shown that using hands-free kit can decrease the SAR value inside the human body. For status 1, the SAR was measured inside human head. In status 3, the SAR value was measured inside human body. However, by checking results from status 5, it is shown that using the hands-free kit will generate almost nothing inside human head.

Results in figure-8 give the same trend compared to figure 7. And the SAR radiated from IPHONE 3GS is much less than LG KE850 in all status. This might be caused by better design of the manufacture.

## Conclusions

The modified SAM head as well as the SAM twin phantom has been used to study the effects of hands-free kiton the SAR inside human body at 1.8GHz. The highest SAR value measured from both PDAs gave good agreement with the official data. It is shown from the results that by using hands-free kit, SAR value inside human body is decreased compared to when the PDAs alone are near human head. From status 4, it is shown that using PDAs in front of human head can also decrease the SAR value in human head and this may suggest that people use speakers to make phone call if it is convenient.

Compared to the previous work, the measurement equipment used in this study are much advanced and phantoms used are more accurate. Although this study is not able to measure all types of PDAs, the trend shows that for people who want to decrease the SAR value inside the head, using hands-free kit or making phone calls in front of the head are the two efficient ways.

Future work will involve developing a full body model and make the model more similar to human body.

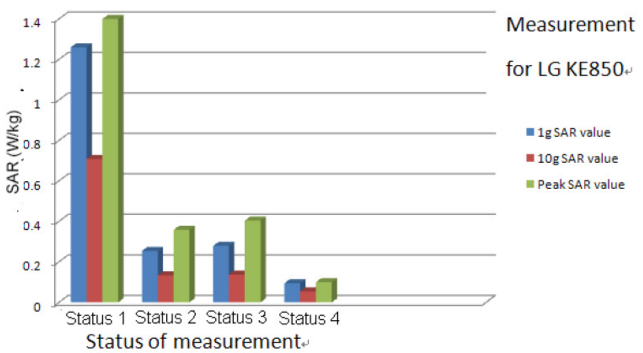


**Figure-7**
**SAR measured inside human radiated by LG KE850**

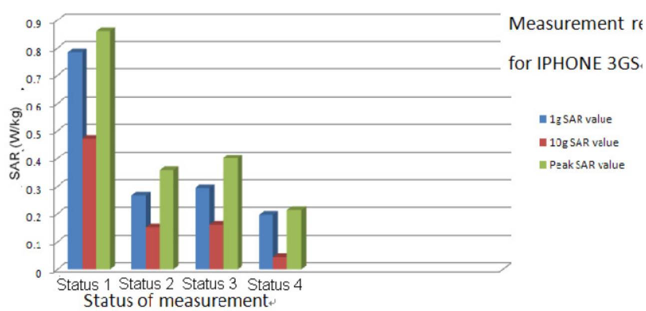


**Figure-8**
**SAR measured inside human radiated by iPhone 3GS**

## References


**1.** Nagadeepa N, Enhanced Bluetooth Technology to Assist the High Way Vehicle Drivers. *Research Journal of Recent Science*, **1(8),** 82-85 **(2012)**

**2.** Iqbal R.S., Alshmari M., Khan S.A., Zafar N.A. and Islam S.A., Mobile Agent-Based Algorithm for Prediction of Inundation Area, *Research Journal of Recent Science*, **3(1),** 72-77 **(2013)**

**3.** Haider W., Sharif M., Raza M., Wahab A., Hussain J., Khan I.A. and Zia U., The Realization of Personalized E-Learning platform based on 3G Mobile phone and NGN control frame work for SIP based IP Networks, *Research Journal of Recent Science*, **2(2),** 85-89 **(2013)**

**4.** Manning M.I. and Gabriel C.H.B., SAR tests on mobile phones used with and without personal hands-free kits. *Newdigate: SARTest,* **(2000)**

**5.** Troulis S.E., Scanlon W.G. and Evans N.E., Effect of'hands-free'leads and spectacles on SAR for a 1.8 GHz cellular handset, In *1st Joint IEI/IEE Symposium on Telecommunications Systems Research*, 1675-1684, **(2001)**

**6.** Troulis S.E., Scanlon W.G. and Evans N.E., Effect of a hands-free wire on specific absorption rate for a waist-mounted 1.8 GHz cellular telephone handset, *Physics in Medicine and Biology,* **48(12),** 1675 **(2003)**

**7.** Assessment of hands-free kits for mobile telephones: Technical summary, Consumers Association Technical Report, *Special report*. 11-17, **(2000)**

**8.** Bit-Babik G., Chou C.K., Faraone A., Gessner A., Kanda M. and Balzano Q., Estimation of the SAR in the Human Head and Body due to Radiofrequency Radiation Exposure from Handheld Mobile phones with Hands-Free Accessories, *Radiation Research,* **159**, 550-557 **(2003)**

**9.** Panagamuwa C.J., Whittow W., Ewards R., Vardaxoglou J.C. and McEvoy P., A study of the validation of RF energy Specific Absorption Rates for simulations of anatomically correct head FDTD simulations and truncated DASY4 standard equipment measurements, T*he First European Conference on Antennas and Propagation (EuCAP 2006),* Nice, France, **(2006)**

**10.** Panagamuwa C.J., Whittow W., Ewards R. and Vardaxoglou J.C., Experimental verification of a modified specific anthropomorphic mannequin (SAM) head used for SAR measurements, *Loughborough Antennas and Propagation Conference*, Loughborough, UK, 261-264 **(2007)**

**11.** Koyanagi Y., Kawai H., Ogawa K. and Ito K., Consideration of the Local SAR and Radiation Characteristics of aHelical Antenna Using a Cylindroid Whole Body Phantom at 150 MHz, *Electronics and Communications in Japan*, Part 1, 87(1) **(2004)**

**12.** Schmidand Partner Engineering AG, DASY4 Manual V4.1, **(2003)**

**13.** Mat M.H. et al., A comparative study of simple geometrical head phantoms on specific absorption rates for simulations and measurements at 900MHz. *2012IEEE International Conference on Biomedical Engineering (ICoBE),*.IEEE, **(2012)**

**14.** Mat M.H., Malek M.F.B.A., Omar A., Zulkefli M.S. and Ronald S.H., Analysis of the correlation between antenna gain and SAR Levels inside the human head model at 900MHz. In *IEEE Asia-Pacific Symposium onElectromagnetic Compatibility (APEMC),* 513-516 **(2012)**