Effect of Hands Free Kit on SAR when using a Smart Phone at 1800MHz

O. A. Ojerinde[1], C. J. Panagamuwa[2], R.M. Edwards[3]
Department of Electronic and Electrical Engineering
Loughborough University
Loughborough, UK
O.A.Ojerinde@lboro.ac.uk, C.J.Panagamuwa@lboro.ac.uk, R.M.Edwards@lboro.ac.uk

Abstract— **This paper investigates the effects of a wired Hands free kit on the SAR inside the head when using a Smart phone in front of the face. SAR measurements are carried out in the GSM 1800 frequency band using a DASY twin phantom and the Loughborough phantom. Results indicate that energy is coupled onto the wire in certain scenarios and this can increase the SAR at the ear when the Smart phone is in front of the face. However, all results indicate that the maximum SAR in the head is obtained when the Smart phone is used in its standard talk position at the side of the head.**

Keywords-component; Hands free kit; SAR; Loughborough phantom; Smart phone

I. INTRODUCTION

Mobile phones are now widely used in many societies. According to the International Telecommunications Union, the number of mobile phone subscribers was due to reach 4.6 billion worldwide by the end of 2009 [1]. The heating caused by radio frequency radiation absorption has been widely investigated in the past [15] and is limited by strict regulations and measurement standards. All mobile phones are required to be tested for their Specific Absorption Rate (SAR), which is the rate at which energy is absorbed by a unit mass of tissue. In Europe, the SAR limit is 2 W/kg averaged over 10g of tissue.

A mobile phone conversation generally requires the phone to be held at the side of the head next to the ear. As technology advanced, hands free kits (HFK) were developed that enabled the user to move the phone off-body or to a different part of the body (for example, a trouser pocket or a shirt pocket). The basic HFK would link the earpiece speaker to the mobile phone through a wired link. The length of the wire varied between phone manufacturers. Although Bluetooth HFKs have been available for many years and provide a more convenient wireless solution, some manufacturers still ship wired HFKs as part of their phone packages.

A number of studies have been conducted in the past to investigate the effects of the wire on the SAR inside the head. The hypothesis put forward was that fields from the mobile phone may couple/induce currents on the HFK wire and cause radiation at the earpiece. In [2], various possible HFK and phone positions relative to the body were investigated. An IndexSAR SARA2 suite was used to measure the SAR inside the head at 888MHz and 1750MHz. It was concluded that higher SAR is obtained from a phone held next to the head at 888MHz. At 1750MHz, the SAR was almost two times lower when the phone was held to the head. In [3], SAR in the head was measured while using a HFK with a phone by the waist. Simulation studies were carried out using an adult male body model from Remcom Inc and a perfectly electrically conducting (PEC) box was used to model the phone with a PEC wire as the HFK. It concluded that the use of HFK with phones degrades the efficiency of the phone system, increases the power that is absorbed by the body and increases the peak and average SAR values. However, it was noted that the increased SAR values were still within the international guidelines.

A procedure for assessing the SAR in the head due to HFKs is outlined in the IEC international standard 62209-2 [4]. It stresses the importance of including the body when testing HFKs because of the attenuation of the energy coupled to the cable caused by the body. An example of the recommended setup was used to test a phone placed on the chest and connected to a HFK. Results showed that when the torso is filled with body simulating liquid, the SAR at the ear was 13dB lower than when the phone was tested directly at the side of the head.

To check the effect of HFKs and other shielding accessories, a consumer association called Which? conducted experiments using 2 HFKs. The measured results showed that these HFKs were able to triple the SAR value in the head [5]. Similar tests were carried out by SARTEST at 900MHz and 1800MHz. The result showed the SAR value in the head reduced substantially when using a HFK compared to when the phone is held to the ear [6].

Over recent years, Smart phones have appeared on the market with ever increasing functionality. With large touch-enabled screens, these devices are often used in front of the face. A subscriber can now hold a voice call using the HFK whilst simultaneously accessing an application holding the phone in front of the face (and thus away from the ear). In these situations, the positioning of the HFK wire will be significantly different to what has been studied previously. Wires could fall away from the body and so the attenuation normally caused by the torso would be negligible. This study therefore investigates the effects on SAR of holding a Smart phone in front of the face and using a HFK.

II. Description of Experiment

The series of measurements conducted in this study were carried out using the DASY kit with the Loughborough SAM head [16][17] and the twin phantom. The Loughborough SAM head allows the smart phone to be placed in front of the face and the SAR to be measured in the facial area. The twin phantom was used for all SAR measurements at the ear. A Samsung SGH-i600 smart phone was used in the experiment with its factory HFK. The experiments were carried out in the GSM 1800 frequency band with the phantoms filled with head simulating liquid. An Anritsu test SIM card was used in the smart phone. An Agilent 8922M was used in simulating the base station with a dipole antenna connected to it for communication with the smart phone. The experiment setup is shown in the figure below.

Figure1: Experimental setup for SAR measurement.

Figure 2: Samsung SGH-i600 smart phone used in the experiment.

Figure 2 shows a photograph of the Smart phone and HFK used in this experiment.

III. Methodology

This study is concerned with the use of smart phones in front of the face, with and without HFKs. For completeness, the effect of placing the smart phone at the waist was also studied. The following five experimental setups were investigated

1. Smart phone in front of the Loughborough phantom and the facial area scanned for maximum SAR

2. Smart phone in front of the left head nose on the twin phantom and HFK extending to the left ear (see figure 3 and 4). The phone was positioned with the keypad touching the tip of the nose in order to represent the worst case scenario. 10 different random cable positions were investigated. The area around the ear of the left head phantom was scanned for maximum SAR.

3. Smart phone placed at the flat section of the twin phantom and the HFK extending to the left ear. The area around the ear of the left head phantom was scanned for maximum SAR

4. Smart phone placed at the flat section of the twin phantom without the HFK connected. The flat section was scanned for maximum SAR

5. Smart phone placed in the standard talk position at the left ear of the twin phantom. The area around the ear of the left head phantom was scanned for maximum SAR

In test 2, the ten random positions used for the HFK are listed below:

1. HFK wire left freely.
2. HFK wire folded together.
3. HFK wire placed by the side of the HFK microphone.
4. HFK wire held by the side of the smart phone.
5. HFK wire held under the smart phone.
6. HFK wire left to dangle.
7. HFK wire dangling to the chest.
8. HFK wire dangling far from the chest.
9. HFK wire dangling to the back of the ear.
10. HFK wire to the back of the smart phone.

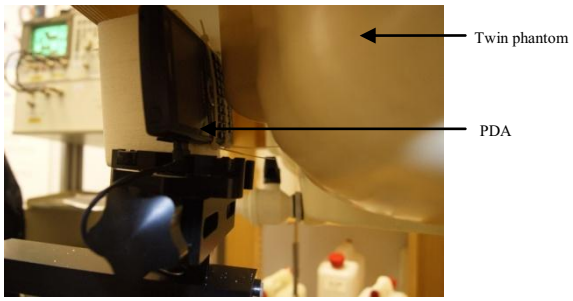

Figure 3: The smart phone placed in front of the face for the twin phantom.

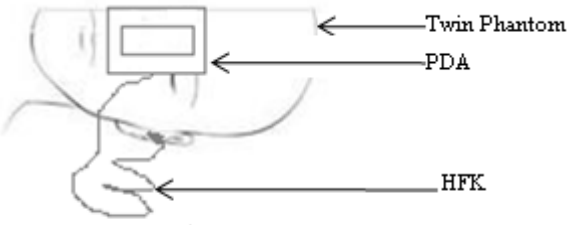

Figure 4: Smart phone-Head orientation during actual experiment [14].

When using the Loughborough SAM head to measure facial SAR, it is not possible to measure inside the nose because of the steep walls [16]. For absolute measurements peak SAR values, it is recommended that the electric field probe and the liquid are kept in calibration. Since the equipment is out of calibration, all graphs are plotted by normalizing the data to the maximum recorded value. This allows all measurements to

be compared to each other because any errors in the system would apply to all measurements equally. These experiments were carried out with the smart phone in continuous communication with the base station simulator.

IV. RESULTS

The normalized SAR results from placing the smart phone (without the HFK) at the flat section, the left head of the twin phantom and in front of the face of the Loughborough phantom are given in the Figure 5.

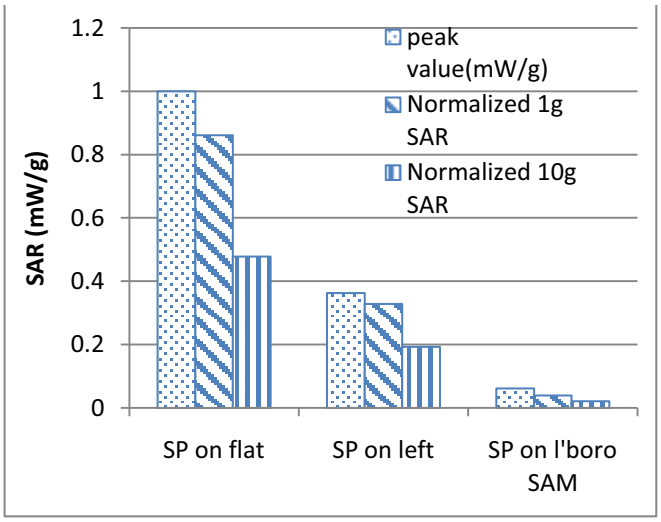

Figure 5: Graph of the smart phone (SP) in different positions on the phantoms without the HFK.

The SAR at the flat section is more than double that at the side of the head. This is in keeping with the current understanding that the flat section overestimates the SAR inside the head. When the smart phone is held in front of the face, the maximum SAR in the facial area is much smaller than when the phone is held at the side of the head. This is most likely due to the increased distance between the phone and head phantom.

When the smart phone is placed at the flat section and the HFK is taken to the left ear, the SAR measured at the left ear was in the noise floor of the equipment. Therefore, in this configuration at least, the HFK dramatically reduces the SAR inside the head.

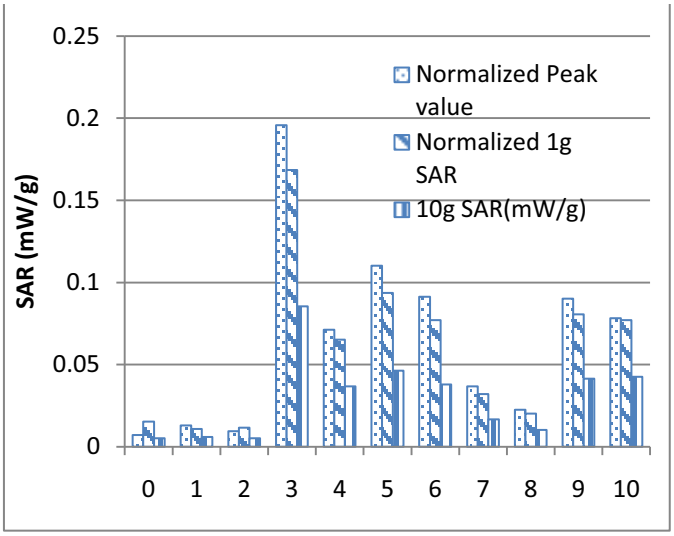

Figure 6: The SAR values in the ear when the HFK wire was placed in random positions (1-10) and smart phone without HFK.

In test 2 where the smart phone was placed in front of the left head nose, the SAR results from 10 different random positions of the HFK wire were record. All the SAR values are from the ear region and are normalized to the maximum value obtained in the previous experiment (smart phone placed at the flat section).

The first graph labeled '0' in Figure 6 indicates a situation where the smart phone is without the HFK. As would be expected, the SAR at the side of the head is very low when the phone is radiating from in front of the face.

When the HFK is in position 3, the SAR at the side of the head increases by about a factor of 20. In this scenario the wire is placed by the side of the HKF microphone. Figure 7 shows the configuration of the wire. The experiment was repeated a second time in order to check if the results were reproducible. The SAR comparisons are made in Figure 8. The results are again normalized to the maximum value in Figure 5. The graph highlights the difficulty in repositioning the cable in exactly the same orientation but both measurements indicate a large (greater than x15) increase.

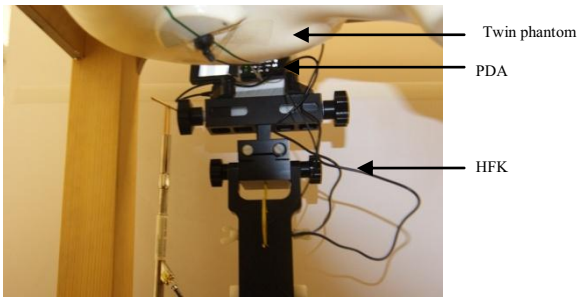

Figure 7: Picture of wire position for third HFK wire scenario.

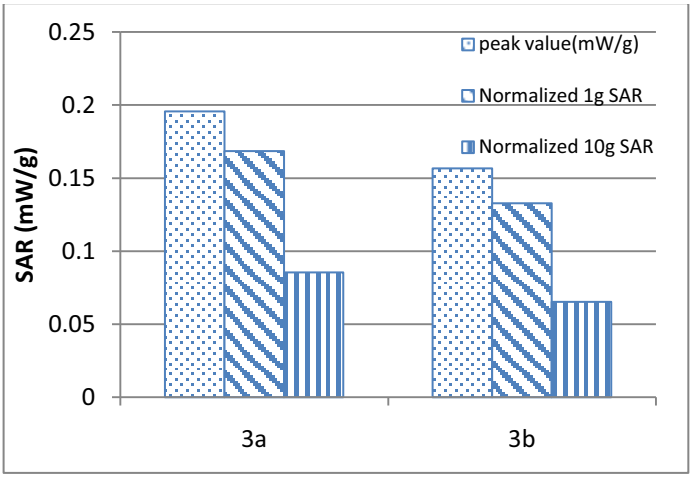

Figure 8: 3rd scenario of HFK wire done twice to confirm results.

Cable positions 4 to 10 also seem to increase the SAR by the ear, although not by as much as position 3. Therefore, there is obvious coupling from the smart phone in front of the face to the cable.

V. CONCLUSION

This paper has presented the results of an initial study looking at the effects of a HFK on SAR inside the head when a Smart phone is used in front of the face. Results show that without the HFK, the SAR from the phone when in front of the face is much lower than when used at the side of the head.

When comparing the SAR at the side of the head with and without the HFK when the phone is radiating from in front of the face, there are a number of scenarios where the SAR at the side of the head is increased by the wire. In the worst case, the SAR is increased by a factor of nearly 20. In this particular scenario where the phone was radiating the face, the SAR at the ear was greater than the SAR in the face. However, when comparing all these results to the SAR obtained by placing the phone directly at the side of the head, it seems that the standard talk position still provides the highest SAR inside the head. This work has only commented on the relative increases and decreases in SAR and does not draw any conclusions regarding the absolute values.

These is clear coupling between the Smart phone and the cable which is causing SAR to change near the ear. A robust study looking at realistic cable positions is clearly needed.

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