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## A STUDY ON THE EFFECT OF A METALLIC RING WORN ON HUMAN FINGERS USING A SIMPLE SCANNABLE BLOCK HAND PHANTOM

N. A. Samsuri, J. A. Flint

*Department of Electronics and Electrical Engineering  
Loughborough University, United Kingdom  
Email: N.A.Samsuri@lboro.ac.uk, J.A.Flint@lboro.ac.uk*

**Abstract:** A simple geometrical representation of a human hand has been constructed which allow a metallic ring to be placed on the finger. The electric field magnitude within an isolated finger is measured and compared with the cases when the ring is worn. The ring has been found to significantly alter the electric field magnitude within the finger at 1800 MHz. This effect can also be found within the adjacent fingers at both 900 MHz and 1800 MHz.

### 1. Introduction

The use of mobile phones is increasing day by day as well as the increase in concern for possible health effects due to the electromagnetic field radiated by the antenna. Conventionally, the mobile phone is placed close to the face and partially masked by human fingers (within near-field zone) where a certain amount of the electromagnetic energy is absorbed rather than directly radiated. Numerous studies have examined the interaction between the electromagnetic fields radiated by the mobile handset, the human head, the hand [1-4], additional conductors such as external objects (wire-framed spectacles, hands-free) [5-6] and metallic implants (surgical pins, jewellery) [7-9] that may also have effects on the amount of the electromagnetic field radiated by the antenna. The results seem to suggest that metallic earrings, metallic loops and rings could increase the SAR. In the current paper, a simple geometrical representation of a human hand has been employed which allow a metallic ring to be worn on the finger. The electric field distribution within the finger (without ring) is measured and compared with the cases when the ring is worn in an isolated finger. The measurement results are then compared with the simulation results that also include different properties of the simulating liquid used within the hand model.

### 2. Methodology

The geometrical configurations employed in the measurement and the simulation studies are shown in Fig. 1, 2 and 3. The handset was modelled as a metallic box (90×16×44 mm) with a  $\lambda/4$  monopole antenna on top of it.

#### (i) Measurement study

Measurements were carried out using a DASY 4 system. The hand phantom was constructed from ABS plastic (3mm thick) and filled with head tissue simulating liquid (HSL) for 900 MHz and 1800 MHz (see Table 1). Body simulating liquid cannot be employed in this measurement due to the probe conversion factor (of the current available probe) is not enabled to be used with the body simulating liquid. The field distribution within Finger 1, 2 and 3 were measured along Z-direction in X and Y plane. Due to the size of the probe body, only about 4 mm distance can be measured in the X and Y plane within each finger (refer to the solid-black dots in Fig. 3). A metallic ring was introduced into the measurement set-up (worn on Finger 2) in order to examine any change in the electric field magnitude within the fingers. In each case the excitation was provided by means of a CW source at 900 MHz and 1800 MHz. All results in this paper are normalized to 0.25 W input power.

#### (ii) Simulation study

The same geometrical configurations as the measurement are then used in the simulations. The effects of a ring worn on human hand were simulated using Microstripes TLM. The ABS plastic relative permittivity was set to 3 with a conductivity of  $\sim 0$  S/m. The ring investigated was modelled as a conducting object with a radius of 16 mm, 2 mm thick and 5 mm wide. The simulation results were then compared with the measurements. Further

study on the effect brought about by the ring is performed by extending the measurement points closer enough to the edge of the inner finger diameter (refer to the lined-dots in Fig. 3). Those points are not reachable by the probe in the measurements. Three scenarios are then considered in simulations: (i) set the inner hand with the head liquid properties, (ii) set the inner hand with muscle properties (named ‘muscle’ in the result) and (iii) reduce the thickness of the ABS to 0.1 mm and then set the inner hand with muscle properties (named ‘homo’ in the results). The muscle properties ( $\epsilon$ ,  $\sigma$ ) used in the hand model were the same as those for the standard tissue equivalent liquids recommended by the IEEE and FCC [10].

Table 1: Head tissue simulating liquid (HSL) parameters filled in the hand phantom

HSL	Permittivity, $\epsilon_r$	Conductivity (S/m)
900 MHz	41.28	0.96
1800 MHz	40.48	1.37

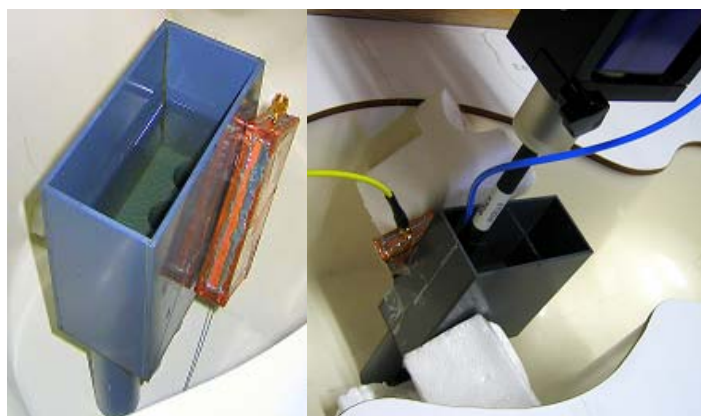


Figure 1: Measurement setup: A hand phantom filled with head tissue simulating liquid, excited by means of CW source at 900 MHz and 1800 MHz

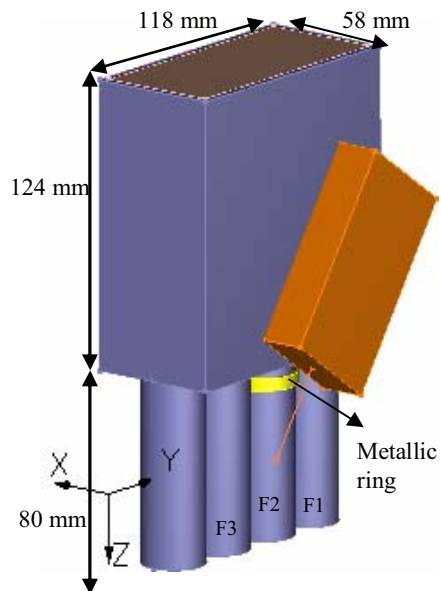


Figure 2: Simulation setup: A hand phantom filled with head/muscle properties, with ring worn on Finger 2

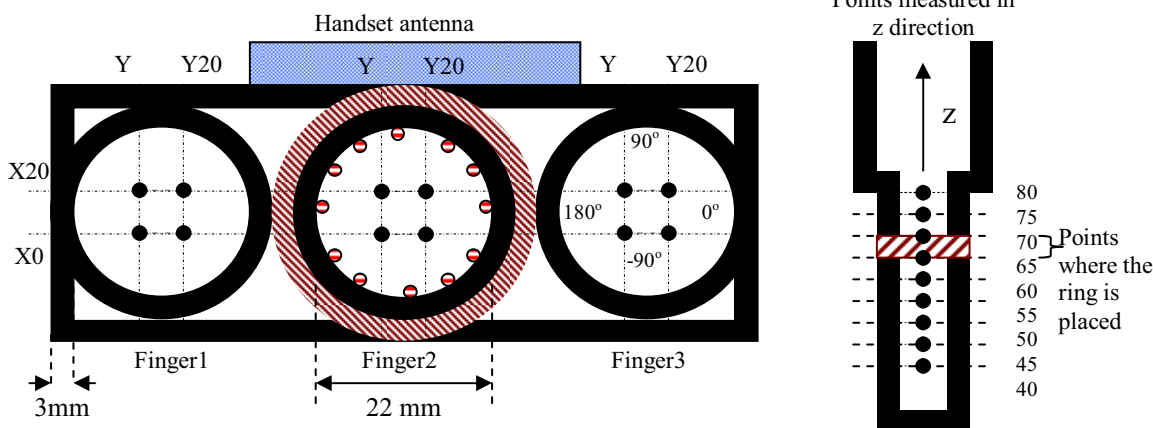


Figure 3: Points measured in the measurement and simulations (●) and the extended points set in the latter simulations (⊙)

### 3. Simulation and measurement results

In order to study the changes brought about by the ring inclusion, a series of plots were obtained for the electric field magnitude inside the fingers. Fig. 4 illustrates the electric field magnitude changes by the ring within Finger2 at 900 MHz and 1800 MHz. Good agreement is obtained between simulations and measurements at both frequencies. The black vertical lines represent the position where the ring is placed. The ring appears to give only a minor effect on the E-field magnitude along z-direction at 900 MHz but significantly increases from the bottom (point 65) to the top (point 70) of the ring at 1800 MHz. However, the hand phantom shell is quite thick and the

points measured were far in the center, the ring effects are expected to be more noticeable when the measured points are placed closer to the edge of the inner finger.

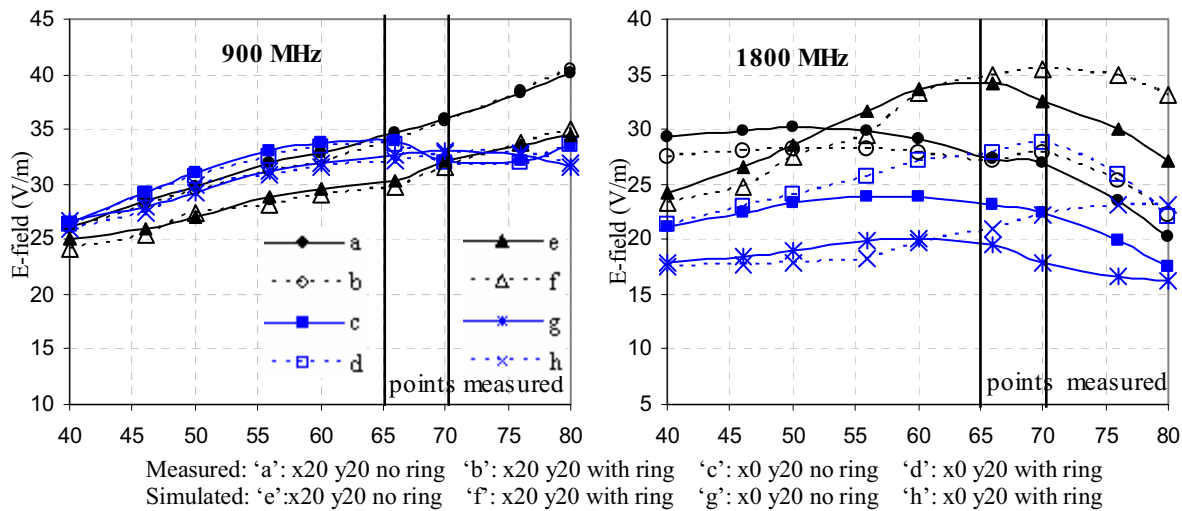


Figure 4: E-field (V/m) along z-axis in finger 2 at 900 MHz and 1800 MHz, both simulation and measurement

The latter results present the extended simulation studies with the measured points placed closer to the edge of the inner finger (see Fig. 3). Due to the geometrical symmetry it was convenient to use the polar coordinate system and to plot the E-field magnitude as a function of theta for  $-180^\circ \leq \theta \leq 180^\circ$ . The results shown in Fig. 5 are for the E-field magnitude around the ring at point 65 within Finger2. The ring does significantly alter the E-field magnitude especially at the points that were very close to the antenna ( $0^\circ < \theta < 180^\circ$ ). The same phenomenon was observed for the hand phantom filled with 'muscle' and 'homo' properties. In addition, the ring that was worn on Finger2 can also affect the E-field magnitude within the adjacent fingers. The E-field magnitudes within the adjacent fingers (Finger1 and 3) are shown in Fig. 6. The results shown are for the points along z-direction at  $\theta = 0^\circ$  within Finger1 and  $\theta = 180^\circ$  within Finger3 at both 900 MHz and 1800 MHz. The 1g and 10g SAR within the hand with different tissue properties at 900 MHz and 1800 MHz are also shown in Fig. 7

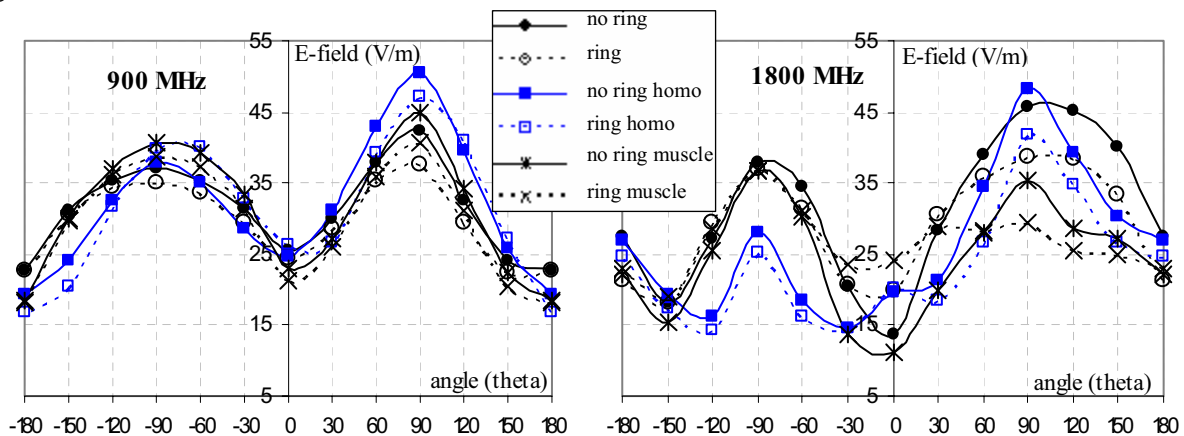


Figure 5: E-field (V/m) inside the finger 2, around the points where the ring is worn at 900 MHz and 1800 MHz

#### 4. Conclusions

The simulation results prove that the presence of jewellery ring when worn on the human hand could influence the SAR although the effect is quite small. The metallic ring only slightly affects the E-field magnitude within the finger at 900 MHz but the effect is more noticeable at 1800 MHz. The metallic ring worn on one finger can also affect the adjacent fingers at both 900 MHz and 1800 MHz. The influence on the result is affected by the proximity of the ring to the handset antenna and also the coupling effect between the antenna and the dielectric

within the hand model. The ring could potentially exhibit resonance effects and also experience local enhancement of the electromagnetic field near the metallic object. As the metallic ring worn on human hand does cause noticeable changes on the E-field distribution within the hand, it could also affect the SAR. Hence it is worth considering the metallic jewellery worn on human hand when measuring the SAR. The fact that the higher frequency has a greater influence may be important with the current trends in personal mobile communications.

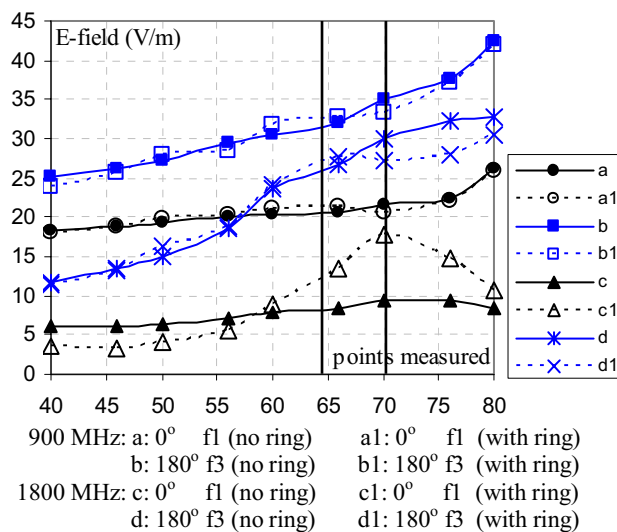


Figure 6: The E-field magnitude changes in Finger1 and Finger3 due to the ring that worn on Finger2

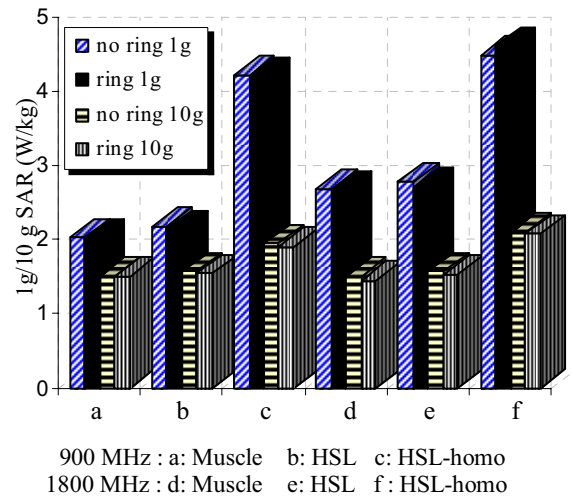


Figure 7: The 1g and 10g SAR within the hand at 900 MHz and 1800 MHz with different tissue properties

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