Retraction

Retraction: SAR measurement for different antenna configurations (J. Phys.: Conf. Ser. 1916 012044)

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This article (and all articles in the proceedings volume relating to the same conference) has been retracted by IOP Publishing following an extensive investigation in line with the COPE guidelines. This investigation has uncovered evidence of systematic manipulation of the publication process and considerable citation manipulation.

IOP Publishing respectfully requests that readers consider all work within this volume potentially unreliable, as the volume has not been through a credible peer review process.

IOP Publishing regrets that our usual quality checks did not identify these issues before publication, and have since put additional measures in place to try to prevent these issues from reoccurring. IOP Publishing wishes to credit anonymous whistleblowers and the Problematic Paper Screener [1] for bringing some of the above issues to our attention, prompting us to investigate further.

[1] Cabanac G, Labbé C and Magazinov A 2021 arXiv:2107.06751v1

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SAR measurement for different antenna configurations

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Abstract. Specific Absorption Rate (SAR) is a measure of radiation absorbed by the human body. SAR is expressed either as an average value of SAR in a cell of 1 gram or an average value in a cell of 10 grams. The aim of the paper is to study the average SAR value in human head due to the usage of mobile phones. The SAR values are measured and studied using a simulation software. In addition to calculating the SAR value, four different antenna configurations were designed with quarter-wave antennas to obtain the optimal design that has the least SAR value. The Specific Anthropomorphic Mannequin (SAM) phantom was used to simulate the human head and the simulation software was used to design the antennas and mobile phone.

1. Introduction
All mobile phones undergo a number of tests to check if they are safe to use by the general public. One of the tests the phones undergo is the estimation of their Specific Absorption Rate (SAR). SAR is a measure of the rate at which energy is absorbed by the human body when exposed to radio frequency (RF) and electromagnetic field. The measurement of SAR value should meet certain standards set by the country in which the mobile phone is used. If these standards are not met then the mobile phone poses a risk of increased absorption of radiation by the body, which could prove fatal for the user [1]. The standards specify a certain minimum value up to which the radiation absorbed by the human being is harmless [2]. In India, SAR measurements are done regularly and independently by the government-run Telecom Engineering Centre (TEC) on handsets and towers. All handsets must have a hand-free mode. However, the SAR limits set by the government does not limit the effects it has on our bodies.

2. SAR Measurement
The SAR value is a measure of the amount of power that is absorbed by biological tissue when the body is exposed to an electromagnetic field. The formula for measurement of SAR is

\[
\text{SAR} = \frac{1}{V} \int_{\text{sample}} \frac{\sigma(r) |E(r)|^2}{\rho(r)} \, dr
\]

In equation (1), \( \sigma \) represents electrical conductivity, \( E \) is the RMS electric field, \( \rho \) is the sample density and \( V \) is the volume of the sample. The Finite Difference Time Domain (FDTD) method is used to measure the SAR. It is a popular computational electro-dynamic method to perform numerical simulation using a specific anthropomorphic mannequin (SAM) phantom. Since it is a time-domain method, different frequency values can be used in a single simulation run. SAR is generally measured for the
human head, more specifically, the brain tissue. The average SAR over 1g must not exceed 1.6 W/kg, according to the FCC recommendations. The whole-body mass averaged SAR should not exceed 0.08 W/kg. The average SAR in the head over a 10g cube must not exceed 2 W/kg, according to the ICNIRP’s guidelines.

3. Radiation Pattern
The monopole and dipole antennas contain one or two straight metal rods along a standard axis. These antennas are axially symmetric, and therefore have radiation patterns called omnidirectional patterns i.e., they radiate equal power, perpendicular to the antenna, in all directions, with the power varying only with the angle to the axis, dropping off to zero on the antenna’s axis. Therefore, the radiation pattern of an antenna will have an equivalent symmetry if the shape of the antenna is symmetrical.

In most antennas, the radiation from the various parts of the antenna interferes at certain angles. Angles where the radio waves arrive out of phase results in zero radiation, and other angles where the radio wave are in phase, results in the local maxima of radiation. The pattern of maxima at various angles in the radiation plot of antennas are called "lobes", which are separated by "nulls", the angles at which the radiation is zero.

As the size of the antenna increases with respect to the wavelength, the number of lobes increases [3]. In a directive antenna, the goal is to direct the radio waves in one particular direction wherein the lobe is larger than the others; this is the "main lobe". The "beam axis" or "boresight axis" is the axis along the maximum radiation that passes through the centre of the main lobe. In split-beam antennas, for example, there exists more than one main lobe. A minor lobe is any lobe other than the main lobe.

Unwanted radiation in directions, other than that of the main lobe, are called "side lobes". The "back lobe" is the lobe that is in opposite direction (180°) to that of the most lobe. Minor lobes are generally radiations in undesired directions, which must be minimized. Side lobes are normally the largest of the minor lobes. The side lobe ratio or sidelobe level is the ratio of the power density in a particular lobe to that of the main lobe. This is used to express the level of the minor lobes. Sidelobe levels of −20 dB or lesser are undesirable in most applications. Careful design and construction are needed to attain side lobe levels of −30 dB or smaller.

4. Proposed SAR Estimation Models
4.1 Estimation of SAR in the simulation software

4.1.1 SAT interface. Upon opening the software, we choose the template for specifying the background and the frequencies upon which our simulation is tested. Upon choosing the required template design we proceed further with the simulation of the objects. The set of options leads us to produce a folder from which we can import objects which are necessary for our simulation. The SAT is an interface that allows us to import objects from CAD or similar design software. We will be selecting two objects from this step, namely the SAM phantom and the Generic Mobile Phone.

4.1.2 SAM Phantom. SAM phantom which is expanded as the Specific Anthropomorphic Mannequin is modeled as an object to simulate the human head for all its functions. It has been modeled after a US soldier. It consists of two parts viz. an outer shell and a liquid shell within it. The liquid shell is used to simulate all the various liquids in a human body such as blood. It has a predefined set of values that can be suitable for any experiments. However, we will be using the SAM phantom for all our simulations.

4.2 Generic Mobile Phone
The generic mobile phone is imported and the appropriate values are specified for the mobile phone such as the material properties etc. The mobile phone is moved within close proximity of the human head. Now we can see that the phone being simulated here consists of a helical antenna. It is connected to the body part of the mobile phone using a port. The port is of two types a discrete face port and a
waveguide port. The port is a tool that produces the excitation signals that are necessary to begin the simulation. The simulation can be brought about only if at least a single port is available.

4.2.1 Transient Solver and SAR Calculation. The Transient Solver performs the calculation for the field in which the generated models are produced. It is a time domain solver that calculates the development of fields \[4\] through time at discrete locations and at discrete samples. The simulation is produced by the excitation of the port present among the objects at the appropriate position. We can now begin the solver by pressing the Transient solver icon in the taskbar or access the action through the following action

Solve → Transient Solver

The field is calculated step by step through time by the LeapFrog updating scheme. The Navigation tree on the left-hand side produces the tabulation of the different results. The solver however takes a considerable amount of time to complete the transient analysis.

Upon completion we can perform SAR calculation by choosing the following option from the Task bar

Results → SAR Calculation

It opens the SAR Special properties dialog box. In this dialog box we can specify the calculation to be taken for either 1g or 10g per mass of the head. In order to study the radiation pattern in the simulation, choose the option of 2D and 3D results from the Navigation tree window. The radiation pattern is displayed on the window as shown in Figure 1. It also shows the peak SAR values and a separate table for the various levels of SAR.

![Figure 1. Radiation Pattern and SAR values](image)

5. SAR estimation for different types of Antennas and their positions in a Mobile phone

Different antenna configurations were experimented with, to obtain an antenna that produces the minimum possible SAR value. Quarter-wave antennas viz., helical antenna and telescopic antenna were used in the simulation. Four different simulations were done viz., with the helical antenna on the left-hand side of the phone, the helical antenna on the right-hand side of the phone, the helical antenna and the telescopic antenna combined together with an open-end facing outside and an open-end facing inside. The SAM phantom was imported for SAT interface.
5.1 Creation of the Model Phones and Simulation

5.1.1 Mobile Phone Simulation for Antenna Positions. New mobile phones were designed instead of importing a design using the SAT interfaces. The Brick tool was used to create the body of the mobile phone. The procedure is illustrated as follows. The Brick tool is accessed by clicking on the Brick icon or from the options in the taskbar

Objects → Brick

Now in the working window we will be able to create the shape we need using the mouse button. Upon creation of the brick, we will be able to specify the name of the object along with the type of its material and define the properties. Figure 2 shows the various properties being entered during the design of the brick. The vertices should be specified to help locate the body of the phone near the ear of the head model.

Figure 2. Brick Design

Once the properties are defined, we must create the antenna by generating the shapes for a helical antenna. This is achieved as follows:

Macros → Construct → Coils → Linear Spiral Coil

The vertices need to be specified to position it near the body part of the phone [5]. Alternatively, the Transform option can be used to move the helical structure using the mouse pointer in the working area to the required position. Similarly, the antenna on the RHS position was obtained for the second simulation. Now the ports are created and they are connected to the body and antenna by using a feature called dots. They enable the formation of ports at required positions. Figure 3 shows the dots and faces that are used for the port connection.
Figure 3. Dot options for connecting ports

The objects are simulated by defining power loss density and running the Transient solver. Figure 4 shows the design models of the quarter-wave helix antenna in the LHS positions.

Figure 4. Helix antenna in the LHS position

5.1.2 Mobile Phone Simulation for Antenna combinations. The next part of the object creation involves the capacitive coupling of the helical and telescopic antenna in the inside and outside positions for open end. This coupling is done on the previously created model (LHS-positioned helical antenna mobile phone). The telescopic antenna is constructed using the cylinder icon or through the option. Upon creation of the cylinder, we need to specify the radius of both ends of the antenna appropriately to create the open and closed ends of the antenna. The objects are shown in Figure 5 and Figure 6.
They are then connected to the helical antenna using the Transform option and the ports. Upon specifying the power density loss, we can simulate the model by providing the excitation at the ports.

Figure 5. Telescopic antenna (outside)

Figure 6. Telescopic Antenna (inside)

Figure 7. SAR Radiation pattern for Telescopic antenna facing outside
5.1.3 Observation. A variety of conclusions can be made from the results of the 4 simulated models. The LHS positioned helical antenna mobile phone shows less SAR value compared to the RHS positioned helical antenna mobile phone. Thus, the SAR value increases with greater proximity of the antenna to the human head. The antenna with the telescope on the outside of the helical structure has been found to have the least SAR value. However, the construction of this particular antenna is difficult to implement mechanically. Figure 7 shows the SAR radiation pattern for an antenna with telescope facing outside.

6. Conclusion
The average SAR value was found to be 0.5 W/Kg. Quarter-wave antennas (LHS and RHS helix) with half-wave antennas were studied and the SAR value is found to be higher when the antenna was placed on the right-hand side of the phone than when the antenna is placed on the left-hand side, as the antenna is closer to the head when placed on the right-hand side. The SAR is found to be lower when the telescope antenna was used unlike when an ordinary helical antenna was used.

In this paper, a simulation software was used to obtain new insights into the radiation patterns of a mobile phone and its influence on the human body. The calculations have been performed for four various antenna designs on the cell phone. The SAM phantom, required by IEEE standards, has been simulated along with a generic phone.

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