Vol. 1, No. 1, pp. 43-46, December 2002

INTERNATIONAL JOURNAL OF SAFETY
www.kiis.or.kr

Design of Mobile Phone for Minimization of the Impact of Electromagnetic Wave on Human Body

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(Received September 2, 2002; Accepted December 3, 2002)

Abstract : In this study, we adopt the strength variation ($\frac{1}{r}$) of electromagnetic waves by their distance. The location of antenna emitting electromagnetic waves is moved to its opposite side and the distance between human body and antenna is secured more. Therefore, the cellular phone designed in this study can reduce the impact of electromagnetic waves absorbed in local part of human body (in particular, head) and then can have competitiveness in the world market facing the regulations.

Key words : telecommunication, electromagnetic wave, cellular phone

1. Introduction

Recently, the applied technology of wireless telecommunication overcomes the space and time, ensures the mobility at maximum and then positions itself in the advanced core technology of modern society. But the anxiety and doubts as to whether the electromagnetic waves produced from these applications influences badly on human body are raised.

All the vital signals in human body and living creatures are realized by electric action. Thus the specialist argued that the electromagnetic waves might impact human body. And various reports, locally or internationally, were published that the physiological action including increase in temperature, excitement of nerves and muscles might be produced by energy of electromagnetic waves upon exposing to human body [1].

It was around 1950 that the general publics attention to electromagnetic waves had been raised. The population residing near highly charged lines began to complain about headache, tiredness and loss of memory. And the full-scale study of impact of electromagnetic waves on human body has been commenced from the beginning of 1980s.

In particular, the public concerns about cellular phone using low electricity and high frequency was originated the lawsuit in 1992 that the plaintiff, wife of deceased Reynard alleged the death of his husband, H. David Reynard was caused by brain cancer due to longtime use of cellular phone [2, 3].

The alleged death-producing cellular phone in question is very essential for social life but the exposure to microwave of wireless telecommunication threatens human life. The cellular phone radiates directly and indirectly the electromagnetic waves from its antenna in receptor forward human brain. The radiating energy is under 1 Watt but under consideration of the direct exposure to human head, the amount radiated is higher than that of pylon. Furthermore this radiation causes cancers in the cells of brain.

In this study, in use of cellular mobile phone (hereunder referred to as cellular phone) examine the impact of electromagnetic waves radiated from cellular phone on human body and propose the design of cellular phone minimizing its impact.

2. Definition of Electromagnetic Waves

Electromagnetic waves are the waves consisting of electric field and magnetic field. When electric field in space changes along the time, the magnetic field is created around. And when the magnetic field changes along the time, the electric field is created around. They are waves transmitting in the space at the speed of light. The light, X-ray or electric waves for broadcast-

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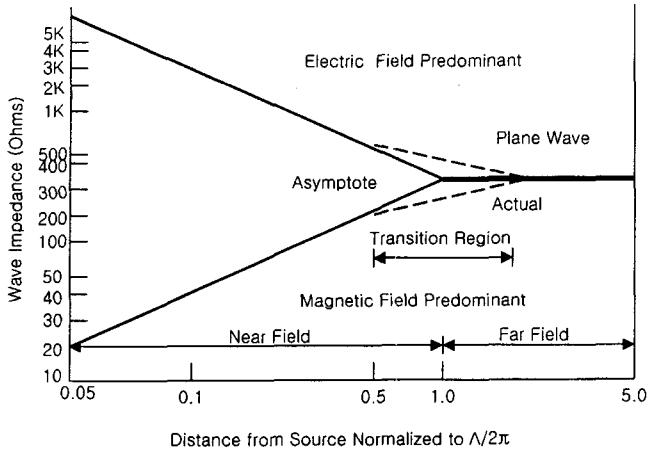

Fig. 1. Near Field & Far Field.

ing or wireless telecommunication are all electromagnetic waves [4].

Fig. 1 shows the wave impedance of near field and far field. The intensity of electromagnetic waves is reduced rapidly along the distance from their source and reflectedly bent their electricity as forwarding in free space or is reduced in inverse proportion to the square of distance. The electricity of diffracted electromagnetic waves is also reduced in inverse proportion to the square of distance.

In the near range from the source of AC electric and magnetic fields, their intensity is directly proportional to distance but in range of some distance, they are related proportionally (electric field is 377 times as strong as magnetic one) and transmitted in form of flat electromagnetic wave.

The range in proportional relation between electric and magnetic fields is called as far field range and not near field range. One of the criteria judging far field range is to examine the distance enough from the source, selecting the bigger one among two values of the waves and the result of two times of maximum diameter of source wave divided by wavelength.

$$\gamma >> \max\left(\frac{2D^2}{\lambda}, \lambda\right) \text{ (far field range) [5]}$$

$*r$: distance from electromagnetic wave source to a certain point
D : diameter of source
λ : wave numbers

Thus, in case of 60 Hz of frequency of power line or home appliances, the wavelength is 5000 km and our position is located largely in near field and the transmission of broadcasting or wireless telecommunication are positioned in far field from power line or base station. But, in case of cellular phone, we use them in contact with our head and its position is in near field.

3. Problems of Electromagnetic Waves of Cellular Phone and Regulations

When using cellular phone, its output is feeble with several hundreds mW but the local exposure, centered in the part of our head may influence harmfully on human body. So, the international trends to restrict directly the absorption of energy instead of regulation of intensity of electromagnetic waves prevails. This restriction value is the standards of specific absorption rate (SAR) and the absorption rate of electromagnetic waves is the rate of energy absorbed in unit mass of vital tissue (W/kg) and is the index largely adopted that is measuring the exposure amount against over 100 kHz of frequency. In case of cellular phone, the same standards are applied to general public and professionals. As the standard of absorption rate of electromagnetic waves, Table 1 shows the maximum value of average absorption rate against 1 g of a certain tissue of human body.

The SAR representing the thermal action is adopted as the basis of exposure restriction but FCC (Federal Communications Commission) recommends the safety limit as 1.6 W/kg for SAR value per 1 g and ICNIRP (International Commission on Nonioninzing Radiation Protection) recommends not to exceed the safety limit of 2.0 W/kg for SAR value of average 10 g [6, 7].

Korea plans to regulate the absorption rate against cellular phones as foreign countries from 2002 and reflect it for the form registration of cellular phone by measuring SAR within standards. The individual notice of the relevant value is assigned to each companys autonomy.

4. Design of Cellular Phone

The conclusion of impact of electromagnetic waves on human body is not clarified and continuous study

Table 1. SAR Average value (1 gram)

Frequency Range	Specific absorption rate (W/kg)
100 kHz~10 GHz	1.6

thereon is progressed.

When we are not clearly sure that the electromagnetic waves give harmfulness to human body, the best one we choose is to take the safety action under the presumption of their harmfulness.

To reduce the exposure to electromagnetic waves, the distance between antenna and users head is as far as possible since the intensity of electromagnetic waves in inverse proportion to distance and short call is better.

4-1. Location of Antenna

Distance between antenna and users head (Average value, cm)

Table 2 shows the linear distance measured between antenna installed in receptor/sender and users head.

In theoretically speaking, the changed location of antenna is doubled the distance between them. Therefore, the characteristic of inverse proportional to square of distance reduces the intensity of electromagnetic waves by one fourth.

Table 2. Distance between antenna and users head according to location of antenna

Receptor	2.75
Sender	4.5

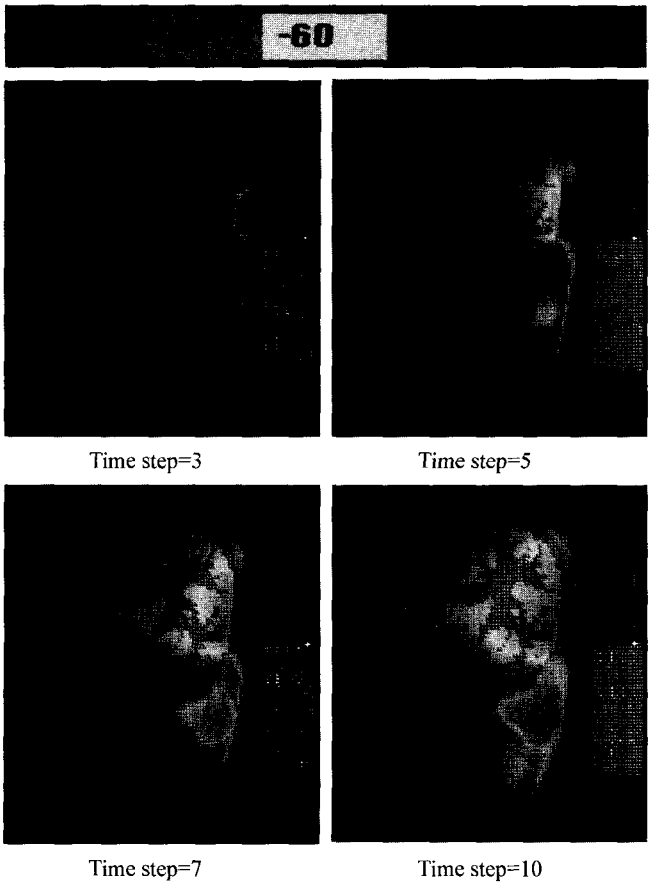

Fig. 2. SAR level at 800 MHz near head (original).

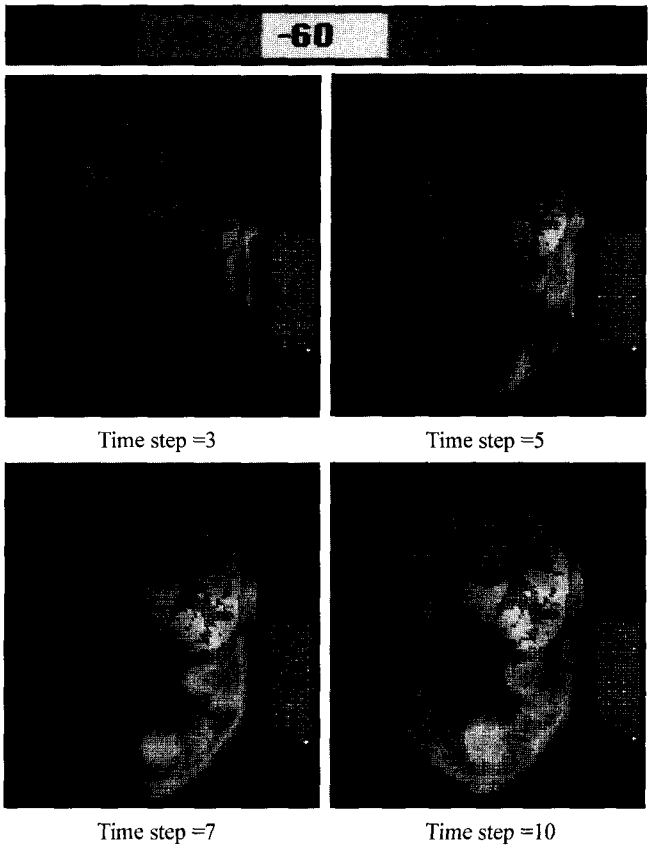

Fig. 3. SAR level at 800 MHz near head (deformation).

Fig. 2 and Fig. 3 show the specific absorption rate level from antenna installed in receptor and sender.

The cellular phone used in this simulation is the general type of flip. 2 GHz is adopted in the frequency range [8].

In this study, we tested the radiation in consideration of pattern and amount.

Therefore, as the result of the study above, we utilize the characteristics of electromagnetic waves showing the minimized impact by the distance.

In this study, we design the cellular phone (Fig. 4) with antenna located in sender (micro) instead of existing one in consideration of Monopole Antenna [9] radiating electromagnetic waves in circular during use of cellular phone.

With characteristics of Monopole Antenna, the change of location of antenna gives no impact of communication quality of cellular phone. Furthermore there is no difficulty in designing due to no additional modification of existing cellular phone.

5. Conclusion

Subscribers using cellular phone has increased gradually from actual 3 million persons (as of March 2002).

1) The applied frequency will adopt 1.8 GHz band instead existing 900 MHz for cellular phone and 2 GHz for next-generation service of IMT 2000.

2) Most of the countries provide the standards of safety limit of electromagnetic waves for their people with relevant regulations against radiation of the electric/magnetic field.

3) Therefore, the cellular phone designed in this study can reduce the impact of electromagnetic waves absorbed in local part of human body (in particular, head) and then can have competitiveness in the world market facing the regulations.

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