

Letters

Comments on "Biological Effects of Radio-Frequency/Microwave Radiation"

Ronold W. P. King

The above paper¹ is important in that it well summarizes 50 years of research on the thermal effects of microwave radiation in the human body and the penetration of a plane-wave incident on a planar surface of that body.

The author would like to see the above paper supplemented with at least a reference to the possible biological effects of the axial electric current and electric field induced in the human body near its resonant length. This occurs near 53 MHz and is analyzed in [1], in which the normalized total axial current is derived together with the normalized current density and the electric field along the central axis. Since an important amateur radio band is 50–60 MHz, a study has been made of the electric field induced in the cells in the bodies of RF amateurs when operating their own transmitters. This is reported in [2]. The electric field in such a cell, near its surface, is found to be $E_z \sim 0.53E_z^{\text{inc}}$. Here, E_z^{inc} is the electric-field incident on the body from the transmitting antenna. There is some indication that a field of this magnitude may be biologically significant since there is statistical evidence that there is an increase in malignancies in many amateur radio operators over the general population.

Another study is of the electric field induced in the human body when exposed to electromagnetic fields at 1–30 MHz. This applies to personnel on shipboard and is carried out in [3]. In [3], the electric field induced in a man wearing rubber-soled shoes or standing barefoot on a metal deck is determined when the incident electric field is generated by one of the ship's transmitting antennas.

Since the advent of the cellular telephone, questions have been raised regarding their safety. Can the fields generated by such a phone in the transmit mode have a deleterious biological effect? In order to make a start toward providing a meaningful answer, a detailed study has been made of two common types of cellular telephones. This is carried out in [4]. The study is based on actual measurements of a telephone in use beside a human head. It takes full account of the skull and shape of the head. The calculated electric field in a cell in the brain is of the order of 25 V/m.

REFERENCES

- [1] R. W. P. King, "Electric current and electric field induced in the human body when exposed to an incident electric field near the resonant frequency," *IEEE Trans. Microwave Theory Tech.*, vol. 48, pp. 1537–1543, Sept. 2000.
- [2] —, "Electric fields induced in cells in the bodies of amateur radio operators by their transmitting antennas," *IEEE Trans. Microwave Theory Tech.*, vol. 48, pp. 2155–2158, Nov. 2000.
- [3] —, "The electric field induced in the human body when exposed to electromagnetic fields at 1–30 MHz on shipboard," *IEEE Trans. Biomed. Eng.*, vol. 46, pp. 747–751, June 1999.
- [4] —, "Electric currents and fields induced in cells in the human brain by radiation from hand-held cellular telephones," *J. Appl. Phys.*, vol. 87, pp. 893–900, 2000.

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Authors' Reply

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We acknowledge with thanks the King comments on the above paper.¹ King provides information from some of his recent publications concerning possible biological effects of induced electric fields and currents in the cells and tissues of the human body during exposure to certain radio frequencies (1–30 and 53 MHz). The potential for adverse health effects at cellular telephone frequencies was also addressed in his comments.

Although a large literature suggests that nonthermal interactions, such as those described by King, may have deleterious health effects, such possibilities have not yet been clearly demonstrated or confirmed. Indeed, many recent comprehensive reviews of this literature conclude that exposure to low level (considered nonthermal) RF energy cannot, and does not provide a hazard to cells or tissues in the human body. One extensive review of the literature provided the basis for the International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines, published in 1998 [1]. The following conclusion appears in that document: "Overall, the literature on athermal effects of AM electromagnetic fields is so complex, the validity of reported effects so poorly established, and the relevance of the effects to human health is so uncertain, that it is impossible to use this body of information as a basis for setting limits on human exposure to these fields."

A review chapter by Postow and Swicord in [2] indicates no hazardous effects either from exposure to low-level nonionizing electromagnetic fields from extremely low frequency (ELF) through millimeter waves, or from modulated RF fields. Recent reviews by the Health Council of The Netherlands conclude that there are no indications for radiation risks of mobile phones [3], Global System for Mobile Communications (GSM) base stations [4], or electromagnetic fields [5]. Moulder *et al.* [6], in an extensive review of the subject as it relates to exposure to the fields from cell phones, states clearly that the current "evidence for a causal relationship between RF radiation from cell phones and cancer is found to be weak to nonexistent." Finally, a panel of experts chaired by Doll [7] reviewed the extensive literature on "calcium efflux," one of the classic examples of a nonthermal effect. The panel concluded, "If the phenomenon is biologically significant, concomitant changes would be expected in the functions of nervous tissues that depend on the movement of calcium ions, but none has been shown unambiguously to occur."

More and more papers and statements will undoubtedly be published on the potential hazards to health of low-level or nonthermal RF/microwave (MW) fields. However, until there is independent and definitive replication of any such effect, those institutions that generate

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