

Electromagnetic Fields: A Human EMC Problem?

Can low levels of electromagnetic field (EMF) exposure affect human and animal health? This is a topic that has been increasingly debated recently. In this article Alasdair Philips brings together some of the latest developments and offers a personal view of the issues that is intended to stimulate debate. In a subsequent article he discusses signal waveforms and offers some practical circuit ideas to help you investigate these issues.

Introduction

Bioelectromagnetics research is now seriously challenging conventional wisdom in biology, the physical sciences and engineering. Since the first reports of physiological responses to low levels of EMF exposure appeared over 35 years ago there has been ongoing fierce and dismissive opposition from scientists holding orthodox views and from industries fearing “unreasonable” restrictions being placed on their activities.

If we are ever to understand the complex way that electric and magnetic fields interact with living beings we need to know what to measure. It is interesting to note that the EMC susceptibility regulations for equipment mainly specify frequency, electric and magnetic signal strengths and not power densities. For RF susceptibility, equipment has to be tested at 3 volts/metre (V/m) (10V/m for life critical systems) at mobile phone frequencies, whereas we allow humans to be exposed to over 60V/m. Are we really that less susceptible to interference?

If your house isn't close to a radio transmitter (e.g. cellular phone base station) then an easy experiment to try is to turn off all the house electricity supply at the main switch. It is surprising how many people report feeling, after 10 to 30 minutes, that a “pressure” has lifted when all the power is off. I believe about 1 in 5 people notice a difference.

There is plenty of evidence that EMFs can affect living processes and adversely effect the well-being of some people – maybe some 5% of the population. Reported effects range from headaches, through chronic fatigue, to cancer. I am convinced that the modulated ‘electro-smog’ that we are increasingly submerged in is having a detrimental effect on the lives of many people.

Despite living in “the information age”, the official view of the interactions of EMFs with people is still based on a model that equates us to a dead slab of meat with a built-in cooling system (the circulating blood) exposed to a continuous wave (CW) signal. The latest bioelectromagnetics research shows this is incorrect.

In fact, even the old ionizing / non-ionizing argument is flawed when considering living beings. The argument is based on the energy to break a covalent or ionic bond, yet almost all the forces at work when DNA replicates or is repaired are about 100 times weaker - hydrogen bonds, Van der Waals and hydrophobic forces.

The challenge to conventional wisdom

It is often stated that there is “no known mechanism” whereby cells could detect and demodulate electromagnetic signals. In fact, conventional standard science cannot yet explain human and animal sensitivities to light, sound, taste or smell. For example, the auditory threshold of a healthy young person with good hearing involves a hair cell vibration of 10^{-11} meters, or about the diameter of a single hydrogen atom. The ear suppresses the vastly larger noise of its thermal atomic and molecular collisions, by an as yet unknown mechanism, functioning as an almost perfect amplifier close to 0°K .

Excitation in biological systems has been traditionally thought of in terms of equilibrium thermodynamics. This assumes that the potential effectiveness of an exciting agent could be assessed by its ability to transfer energy to the receptor in excess of its random thermal atomic and molecular collisions. Thus, the Boltzmann expression (kT) has been regarded as setting an immutable threshold below which an exciting agent would not be physiologically effective. Low-frequency magnetic fields, now proven to be able to act as effective physiological stimuli, would also fall below this thermal barrier. The complexity of living biological organisms demands our careful consideration and we are still a long way from knowing what “life energies” really are. From a scientific viewpoint, answers need to be sought in nonequilibrium thermodynamics and in multicellular cooperative states, as suggested by Herbert Fröhlich. [1]

The genome is like a recipe book that can both photocopy and read itself. It unwinds and winds up again in a ‘cosmic dance of life’ using very weak electromagnetic forces. It is transcribed into messenger RNA and then converted into strings of amino acids that fold up into proteins. Conformational changes in protein folding is one of the repeatedly reported effects of EMF exposure. Almost everything in our bodies is either made of proteins, or made by proteins. Every protein is a translated gene. Both single- and double-strand DNA breaks have been shown to become more common when living cells are exposed to quite low levels of man-made time-varying EMFs.

The recently published REFLEX project report [2] has made a substantial contribution to known biological effects of EMFs on *in-vitro* cellular systems. Twelve institutes in seven countries found genotoxic effects and modified expressions on numerous genes and proteins after low level exposure of living cells *in-vitro* to EMFs well below current international safety guidance. Gene mutations, deregulated cell proliferation and suppressed or exaggerated programmed cell death (apoptosis) that are caused by, or result in, altered gene and protein expression are such critical effects. They found that genotoxic effects and a modified expression of numerous genes and proteins after EMF exposure could be demonstrated with great certainty, while effects on cell proliferation, differentiation and apoptosis were much less conclusive. Since all these observations were made using *in-vitro* studies, the results neither preclude nor confirm a health risk due to EMF exposure, but they support such a possibility. The study concluded that *in-vitro* damage due to low-level EMF exposure is real and that it is important to carry out much more research, especially monitoring the long-term health of people.

Power-frequency guidance levels

Current UK maximum public exposure levels (PEL) for 50Hz are set at 100 microtesla (μT) and 5000 volts/metre (V/m) (see inset box). However there have been many calls for a much more precautionary stance to be taken. Switzerland currently requires a PEL of no more than $1\mu\text{T}$ for new installations. Some regions of Italy set guide levels around $0.4\mu\text{T}$ and 500V/m . Some large

multinational companies have been setting design guides for buildings at about $0.25\mu\text{T}$ and 100 V/m for about the last ten years.

Professor Michael Kundi (University of Vienna) recently compared the EMF regulation setting process with that used by WHO for controlling air pollution [3]. He derived a maximum magnetic flux guidance level of $0.21\mu\text{T}$. With good electrical design of wiring and appliances there is no reason why this should not be universally achievable at little cost apart from near to high-power lines and some electrical appliances.

The average 50Hz UK background magnetic flux level in houses is about $0.04\mu\text{T}$ and about double this in flats. The two main causes are (i) local electricity distribution system wiring and (ii) "ring" circuits within buildings. Common supply practice in the UK is to (a) connect electricity substations in parallel so that circuits share load and connectivity problems and this leads to fewer customer complaints and (b) Protective Multiple Earthing (PME) is used; this connects Neutral to physical Ground/Earth every few hundred metres. Both these practices lead to stray "net-error" currents, where outgoing current takes a different return route and this causes elevated magnetic fields over extensive areas from what effectively becomes a large single-turn transformer loop. Ring circuits are a problem, especially as they age and new sockets are added, etc. Any imbalance in loop impedances will result in an imbalance in current flows. $0.01\text{--}0.1\text{ ohm}$ is just as bad $0.1\text{--}1\text{ ohm}$ in causing the 'single-turn transformer effect'.

Power-frequency electric fields in buildings using earthed metal conduit are effectively zero, but this was abandoned years ago for houses. Lighting circuits are now the worst offender for generating high electric fields. Modern practice of looping Line (230V) around all lighting fittings and then taking this to and from the switch results in a live spiders web – with 230V on most cables even with all the lights switched off. This capacitively couples with wall and ceilings and causes typical E-field levels between 15 and 100V/m within the room.

Recent microwave & health reports

In September 2004 ICNIRP issued an epidemiology overview [4] that ignored most of the most relevant recent reports of ill health related to microwave exposure. In January 2005, the UK National Radiological Protection Board (NRPB) issued an update [5] of the original Stewart Report (2000) [6]. This expresses concern about a number of aspects of microwave emissions with regard to health [7].

A Israeli study [8] found a seven-fold increase in cancers in a population living within 350 metres of a small cell-phone base station compared to a similar population away from the mast. A report by German Doctors on a group of 1000 patients in the town of Naila showed a 3-fold increase risk of cancer in those living within 400m of a base station when compared to people living further away [9]. These are disturbing findings.

A 2004 paper reporting ill health in Spain near to a base station showed a 59-fold increase in depression, a 40-fold increase in fatigue and a 20-fold increase in concentration problems in people living in measured GSM field strengths between $0.25\text{--}1.3\text{V/m}$ when compare with people living in field strengths below 0.05V/m [10].

In December 2004, Microwave News brought out a special issue [11] on EMF and health setting out a wealth of evidence to justify more precautionary exposure policies.

A recent initiative

At power supply frequencies it is now increasingly being recognised that there is enough evidence of possible harm to start to actively reduce public exposure on the ALARA (as low as reasonably achievable) principle. In the UK there is now an advisory working group has been established under the secretariat of the UK Department of Health and with the support of the Health Minister, that brings together the main stakeholders - Industry, Academics, Government and others - to discuss ways of reducing the public's exposure to power-frequency electric and magnetic fields. This is from all sources: High-Voltage Overhead Transmission Lines, electricity substations, railways, distribution and building wiring and appliances. Hopefully the same will happen for cellular phone signals.

NRPB & ICNIRP Guidance

At mains electricity frequencies the only restrictions in most countries are based on the direct effects of induced currents in the body and on their effects on the central nervous system. The UK NRPB (National Radiological Protection Board) has recently reduced its guidance at 50Hz from 1600 μ T magnetic flux density and 12,000V/m electric field strength to the ICNIRP (International Committee on Non-Ionizing Radiation Protection) levels of 100 microtesla and 5,000V/m. However the ICNIRP levels are based on the same premise with an additional safety factor for the general public. They are suitable for acute exposure, however they do not take into account the vast array of published data showing long-term adverse health effects associated with chronic, long-term, low-level exposure.

The NRPB's "Advice on Limiting Exposure to Electromagnetic Fields" (Documents of the NRPB Vol 15 No 2 2004) noted that below the guidelines: *"an association between prolonged exposure to intense power frequency magnetic fields and a small raised risk of childhood leukaemia has, however, been found... .. the need for precautionary measures should be considered by Government."*

They fail to explain their curious choice of the word "intense" to refer to 0.4 μ T, when their own guidelines allow continuous exposure to 100 μ T, a level some 250 times higher. EMFs close to some electrical appliances are often up to 50 μ T and I have personally measured over 2000 μ T next to powerful electrical generating sets. The dictionary definition of "intense" includes "extreme in degree, strength or size".

At radio-frequencies, "If it doesn't heat you, it doesn't harm you" is the conventional view of that is still endorsed by the IEE (Institution of Electrical Engineers), the NRPB and ICNIRP. This may be acceptably correct for conventional CW and AM and FM modulated signals, but looks quite wrong in the light of recent research into the biological effects of modern TDMA and CDMA communication system signals [e.g. 2]. This is especially the case with 24-7 exposure from nearby cellular base stations that is qualitatively quite different from a number of short-term exposures.

References

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It is also available with an over-view and downloadable in sections from: <http://www.verum-foundation.de/cgi-bin/content.cgi?id=euprojekte01>

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Some thoughts about "life energies"

"A living organism . . . feeds upon negative entropy . . . Thus the device by which a living organism maintains itself stationary at a fairly high level of orderliness (fairly low level of entropy) really consists in continually sucking orderliness from its environment." [A, B]

Life on Earth is not a closed system, forming only one small part of the universe. Living organisms use highly ordered structures (such as DNA) to store vast amounts of information. A great deal of order is required to keep matter alive. An organism stays alive in its highly organized state by importing high quality energy from outside itself and degrading it to support the organizational structure of the system. Some of the defining aspects of the low-entropy state that characterize living beings are in genome-ecosystem relationships, which depend on internal structures, like brains and bladders, needed to establish them, as well as physical phenomena like sound waves, electrical signals and chemicals that mediate them[C].

Geneticist D.J.Pritchard has noted: "Gene expression is controlled directly or indirectly by the intra- and extra-cellular environments to which the DNA in which the genes are encoded is exposed, while components of the environment become incorporated into bodily structure as a feature of expression of the genes. Phenotype at all levels is thus the product of interaction between the genome and the environment and either can be limiting." [D]

[A] Erwin Schrödinger, 1887-1961 (Nobel Prize winner for discovering 'Schrödinger's Wave Equation' that gives the quantised energies of a wave in time and space)

[B] <http://hyperphysics.phy-astr.gsu.edu/hbase/quantum/schr.html>

[C] Schrödinger, Erwin, *What Is Life?*, Macmillan 1947

[D] Pritchard D.J., 1990. "The Missing Chapter in Evolution Theory," *Biologist*, vol. 37, no. 5, pp. 149-152.