



# EMC SOCIETY of AUSTRALIA NEWSLETTER

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IEAust 11 National Circuit Barton ACT 2600

A SOCIETY OF THE INSTITUTION OF ENGINEERS AUSTRALIA

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## MESSAGE FROM THE CHAIRMAN

Debate on the possible health effects of exposure to Electromagnetic Radiation (EMR), particularly from mobile phones, continues to appear regularly in the media.

I have been involved in surveying sites for base stations for a mobile phone network, and have found that the issue of possible adverse health effects of transmissions from the base stations is a common concern for those living, working, and playing nearby. While involved in this industry I found myself wondering to what level should I get involved in discussions outside the technical design of the installations. Coming to the topic from an engineering background I did not claim special competence in assessing the biological effects of EMR. I decided I would leave that to my colleagues who worked in areas such as the biological sciences and biophysics.

However, I did claim competence in areas such as the measurement of electrical and magnetic fields, as they related to those biological effects, and the generation and control of those fields.

Recently the EMC Society was asked by the Electrical College of the Institution of Engineers to prepare a position paper on health effects of electromagnetic radiation. (The Society is affiliated with the Electrical College.)

Despite misgivings about being involved in a controversial area with a high profile and potential for media distortions and “beat-ups,” the Council decided that the preparation of such a paper should proceed.

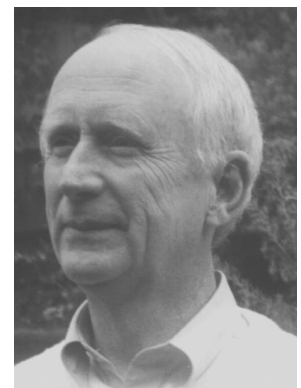
Although not a primary interest of some members, it is generally accepted that the study of biological effects of EMR is within the scope of the EMC Society. I believe it is the place of the Society to provide an independent and objective point of view on the topic.

This led me to think about the range of other topics that the EMC Society may regard as within the broad discipline of EMC. The IEEE EMC Society, for example, accepts papers for its EMC transactions on *EMC Standards, Measurement Technology, Undesired Sources, Cables and Grounding, Shielding and Filters, Equipment EMC, Systems EMC, Antennas and Propagation, Spectrum Utilization, EMP, Lightning, Radiation Hazards, and Walsh Functions*. Perhaps not all of these are of interest to us, but most are, and there may be others not listed.

There are members of the EMC Society who come from different educational and industry backgrounds, with different specialist interests but who have a common interest in the effects on man and machines of electromagnetic energy which we use so commonly in contemporary society. This diversity allows us to cover a range of topics and to bring a range of viewpoints to any one particular topic. Together, the members of the EMC Society should be well placed to provide that independent and objective point of view on EMC topics that is so necessary today. Let me encourage you as members to do so.

Nominations for councillors for 2001/2002 were called in late 2000. We received nine nominations for the nine vacancies and as no voting was required the nominees were elected unopposed. We also welcome Franz Schlagenhauer to the Council representing the West Australian Chapter.

John Hyne, MIEAust.,, CPEng.



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## LETTER FROM THE EDITOR

The controversial issue of the danger of exposure to magnetic fields from power lines continues to raise concerns around the world. The UK National Radiological Protection Board recently released a report on the risks of cancer at low levels of radiation. Following this report the Melbourne "Age" featured an article by David Elias on 10<sup>th</sup> March, 2001, discussing the statistics of the number of cases of leukaemia in young children in Australia. In this issue of the newsletter we include a statement by Dr. John Loy of the Australian Radiation Protection and Nuclear Safety Agency reviewing recent reports.

This newsletter includes a technical paper on research carried out in Germany by Professor Heyno Garbe and his associates on the influence of the measured electrical field strength by the rim and size of limited conducting planes.

We also include a contribution by Yajun Wang, Wee Jin Koh and Joo Huat Tan from Singapore on a study of hand phone radiation.

The EMC Society is currently calling for technical papers in the Student Paper Competition for Year 2001. This year the council has seen fit to lift the prize money to \$1000-00, so to all you students, please flood us with your entries.

I would like to thank our contributors for their articles and encourage more of our members to submit their articles of interest for publication.

Jack Pluck  
Editor



# TECHNICAL BRIEFS

## INFLUENCE ON THE MEASURED ELECTRICAL FIELD STRENGTH BY THE RIM AND SIZE OF LIMITED CONDUCTING PLANES

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### 1 Introduction

The measurement of electromagnetic interference from 30 to 1000 MHz requires a test site suited to the specifications of ANSI Std. C63.4 [1]. This could be an open area test site (OATS) for example. A parameter often used for qualifying an OATS is the normalized site attenuation (NSA). The radiation pattern and electrical characteristics of an antenna on an OATS can be influenced by objects, especially if the distance between the interfering object and the transmitting element is small. Part of the emitted power radiated towards the ground where it is reflected, and the degree of reflection depends on geometry and electrical characteristics of the ground. An ideal OATS consists of a flat homogeneous ground plane of perfect conductivity and infinite extension. No reflections from any objects except the transmitter occur above the plane. With these assumptions the electromagnetic field can easily be calculated by the method of mirroring. The reflection on the conducting plane can be modelled by an imaginary mirrored antenna below the ground plane ( see figure 1.1). The calculations for NSA in [1] are based on this method.

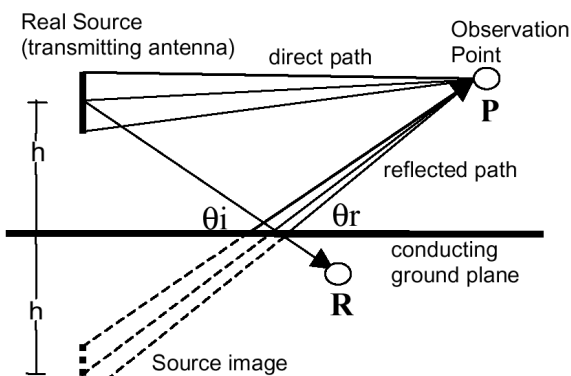


Fig. 1.1: Reflection of the radiated power

In this case we suppose a half-wave dipole antenna mounted at height  $h$  over an ideal ground plane. The power is radiated depending on radiation pattern of the transmitting dipole. For any point P in the hemisphere above the ground plane there is also a reflected wave beside the direct wave. If the reflected path is extended below the ground plane it seems, that an image source exists below the plane. This source has the same distance  $h$  to the ground plane like the real source. If the antenna consists of several elements, each element can be mirrored in this way. The reflection coefficient is determined by material parameters under and over the ground plane, which acts as a boundary. With an ideal conducting boundary the incident wave is reflected completely and the field under the boundary is zero. Corresponding to the border condition the tangential electrical fields have to vanish in all points on the boundary [2].

On a realistic OATS the characteristics of an infinite conducting plane can only be reproduced by a limited area with finite conductivity (e.g. wire mesh). The requirements for this plane are described in the standard CISPR 16 [6]. Because of the limited extension of the plane the method of mirroring cannot be used. In this report the influence of the rim and size of the ground plane on the electrical field strength is investigated. Especially the error caused by different shape and size of the plane is calculated. Furthermore a ground plane of special shape has been investigated in chapter 4 that was derived from the simulation results.

All calculations have been carried out with the software package CONCEPT II [5] for the discrete frequencies 50 and 100 MHz. This program is based on the Method of Moments and allows the simulation of surface currents and the calculation of electric and magnetic fields on arbitrary observations points, lines and planes.

### 2 Modelling of the ground plane

The electrical field strength measured over an infinite plane has been compared with the field over a plane of finite extension. A horizontally polarized half-wave dipole at a distance of 80 cm over the conducting plane has been used as EUT. The dipole has a radius of 1cm and infinite conductivity. The maximum dimension of the transmitting dipole is  $d = 3$  m (for 50 MHz) and the maximum dimension of the receiving dipole is  $a = 1$  m (fig. 2.2). The field strength at a horizontal distance of 10 m has been calculated at a measurement height of 1 m up to 4 m, to find the maximum value. With reference to the requirements of the ground plane, mentioned in CISPR 16 [6], two planes with different areas have been chosen. The area of the two planes depends on the horizontal measurement distance.

The first plane (Model 1) is an ellipse with a receiving antenna at the observation point and the above mentioned transmitting dipole (EUT), which are both placed at the apices.

The second plane (Model 2) has the minimal area with respect to CISPR 16. The plane should be extended at least 1m over the periphery of the EUT and the antenna. There are no interruptions of the ground plane between the EUT and the antenna allowed. This means, that the area of the plane depends on the size of the EUT and the antenna.

In order to investigate the influence of the limiting rim, two rectangular planes have been investigated also (see table 2.1). Both planes have a length of 1-m but Model 3 has a width of  $\sqrt{3}R$  (see ellipse) and Model 4 has the same area as the ellipse.

Model	Pattern	Sizes of the plane	Area	Figures
1	Ellipse	Horizontal distance $R = 10\text{ m}$ Dimension in X-direction is $2R$ Dimension in Y-direction is $\sqrt{3} R$	$272\text{ m}^2$	2.1
2	Minimal plane circle + rectangle	$d = 3\text{ m} / D = 5\text{ m} / a = 1\text{ m} / W = 3\text{ m}$ $d$ : max. dimension of the EUT $a$ : max. dimension of the receiving-antenna $D = d + 2\text{ m}; W = a + 2\text{ m}$	$110\text{ m}^2$	2.2
3	Rectangle	Horizontal distance $R = 10\text{ m}$ Dimension in x-direction $2 R$ Dimension in y-direction $\sqrt{3} R$	$346\text{ m}^2$	2.3
4	Rectangle	Horizontal distance $R = 10\text{ m}$ Dimension in x-direction is $2 R$ Dimension in y-direction is $13.6\text{ m}$	$272\text{ m}^2$	2.4

Table 2.1: Figures of the used models for the different planes

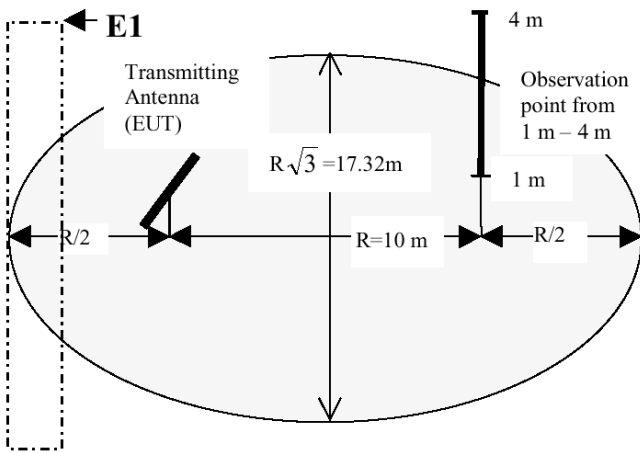


Fig. 2.1: Model 1, conducting ellipse,  $A=272\text{m}^2$

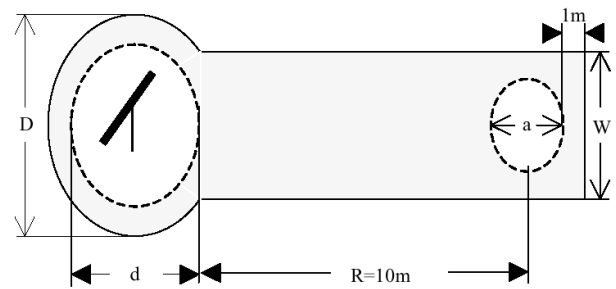


Fig. 2.2: Model 2, minimal plane,  $A=110\text{m}^2$

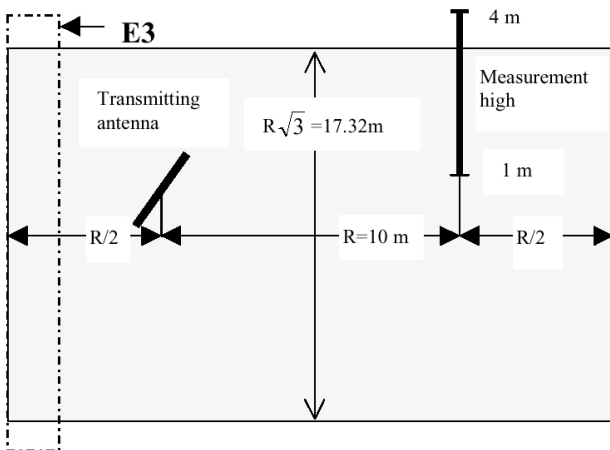


Fig. 2.3: Model 3, rectangular plane I,  $A=346\text{m}^2$

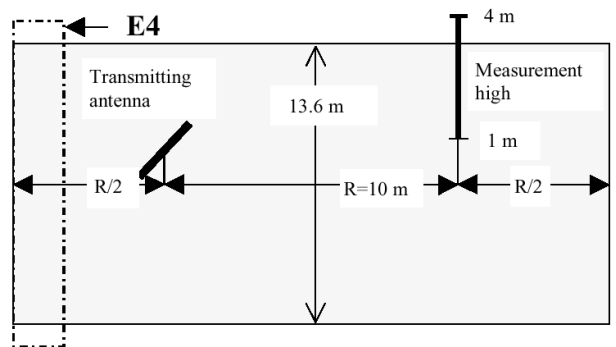


Fig. 2.4: Model 4, rectangular plane II,  $A=272\text{m}^2$

### 3 Simulation results

In this chapter the results of the numerical calculations are introduced, to determine the error that results from the use of different ground planes of finite size, instead of an infinite plane. Special attention is paid to the rim of the plane.

As a reference the electric field strength produced by a half wave dipole has been calculated along an observation line in a horizontal distance from the source of 10 m, the height varying from 1 m to 4 m. The transmitting dipole, representing an EUT, has been placed 0.8 m above a perfect conducting ground plane of infinite size. The results have been used as a basis for the estimation of the error due to the different size and shape of the ground planes under investigation.

The following assumptions have been made:

- The horizontal measurement distance is  $R = 10$  m (corresponding to CISPR16).
- The transmitting antenna (EUT) is a horizontal dipole, at a distance of 80 cm over the conducting plane.
- The calculations have been executed for two frequencies 50 and 100 MHz only.
- All ground planes have infinite conductivity and are infinitely thin.

In figure 3.1 and figure 3.2 the error in dB is presented that results from the limited size the ground plane:

The minimal plane has a large error in comparison with the other models, with more than -2.5 dB for  $f=50$  MHz and more than -4 dB for  $f=100$  MHz. The error of the rectangular plane (<.25 dB) is smaller than that of the ellipse (see table 3.1 left hand side).

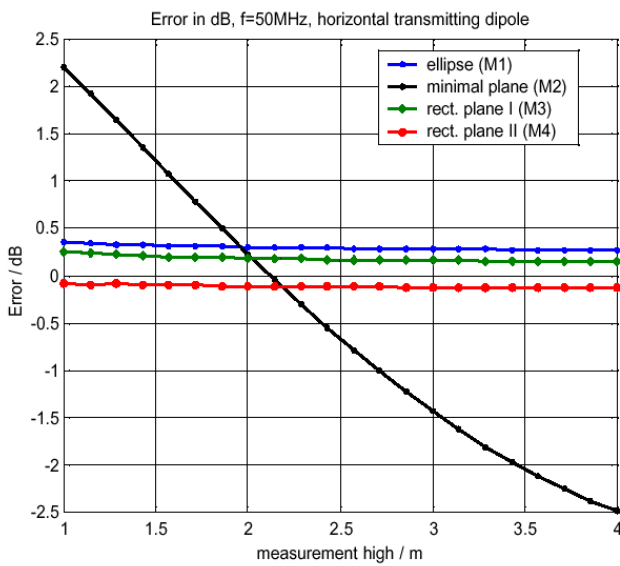


Fig. 3.1: Error in dB for  $f = 50$  MHz

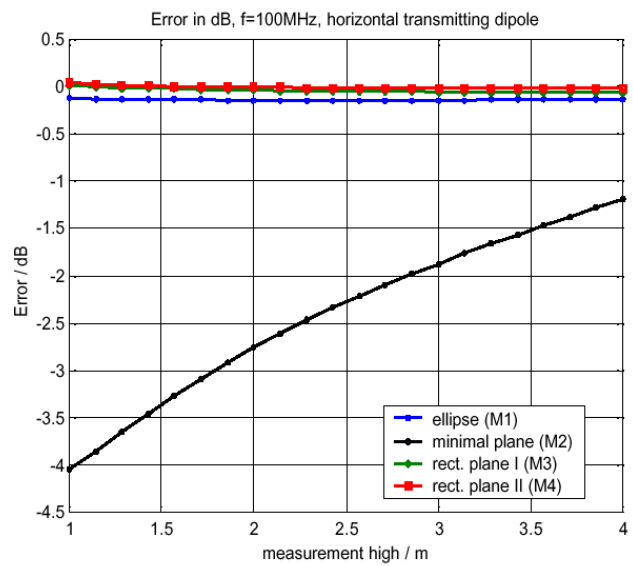


Fig. 3.2: Error in dB for  $f = 100$  MHz

Model	Error /dB 50 MHz	Error /dB 100 MHz	H-field distribution	Surface Current	Frequency / MHz
1	-0.4	-0.2	fig. 3.4	fig. 3.5	100
2	-2.5	-4	fig. 3.6 fig. 3.8	fig. 3.7 fig. 3.9	50 100
3	0.25	-0.05	fig. 3.10	fig. 3.11	100
4	-0.15	0	fig. 3.12	fig. 3.13	100

Table 3.1: Errors for 50 & 100 MHz (fig.3.1 + 3.2) and figures corresponding to the models

Comparing the elliptic plane and rectangular plane II, only the rim of the planes is different, their area is the same. It is obvious, that the difference of the error is depended on the pattern and area of the ground plane. Therefore the rim of the plane has a strong influence on the calculated field strength. Such an effect on the field can only be caused by a surface current at the rim of the plane, which simultaneously means a magnetic field strength.

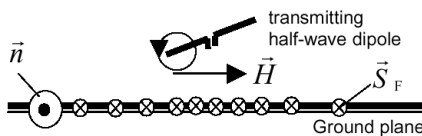


Fig. 3.3: Current Density and magnetic field strength

The incoming electromagnetic wave causes a surface current density  $\vec{S}_F$ . Using the first Maxwell's equation and applying Gauss's law results in [3], [4]:

$$\oint_c \vec{H} d\vec{s} = \iint_A \vec{S}_F n dA \quad (G1. 3.1)$$

$\vec{n}$  is a vector normal to the surface of an area, and the integration path  $c$  is the border of this area. The line integral and the curl -7 of the vector field are linked with a right-hand coordinate system (fig. 3.3).  $\vec{S}_F$  is the surface current density on the ground plane, which is equal to the curl of the magnetic field [2]. In a different mode of expression:

$$\text{rot } \vec{H} = \vec{S}_F \quad (\text{Gl. 3.2})$$

The surface current density on the plane, caused by the transmitting half-wave dipole, is calculated for all planes. Those areas of the plane, which have no significant surface current density, make no significant contribution to the field. Therefore they can be ignored and need not be covered by conducting material. It is obvious from fig. 3.14 and fig. 4.3, that the surface current density is concentrated around the EUT. Because of this, the area around the EUT must be covered by a wire mesh or other material with a high conductivity. For the remaining area of the plane a wire mesh or conducting material of lower quality could be used, without a strong influence on the field, which will be shown in chapter 5.

To treat this problem in some detail, the surface current distributions on the planes and the magnetic field strength distributions have been drawn in fig. 3.4- fig. 3.14.

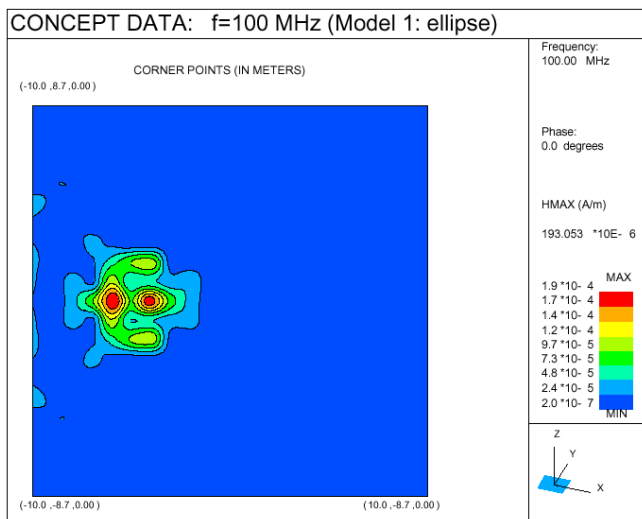


Fig. 3.4: H-field strength distribution  $f = 100$  MHz (M1)

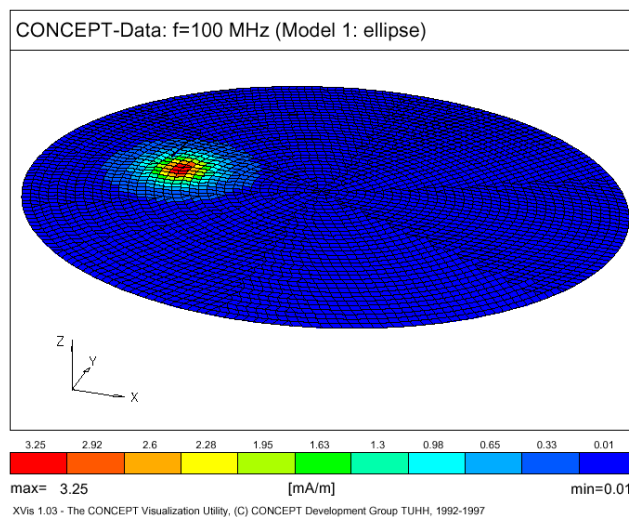


Fig. 3.5: Surface current distribution  $f = 100$  MHz (M1)

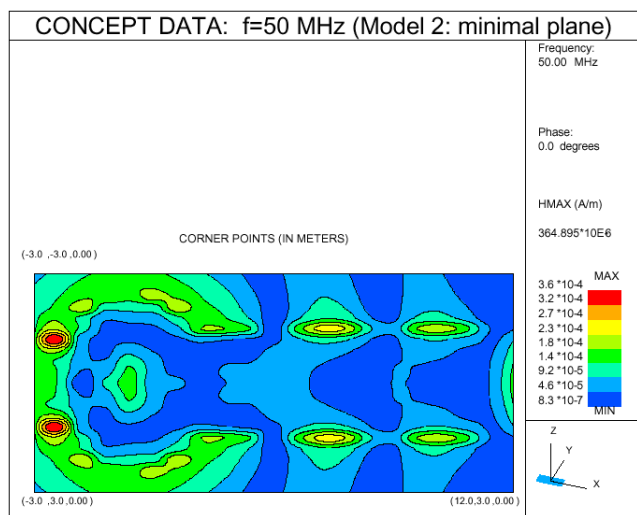


Fig. 3.6: H-field strength distribution  $f = 50$  MHz (M2)

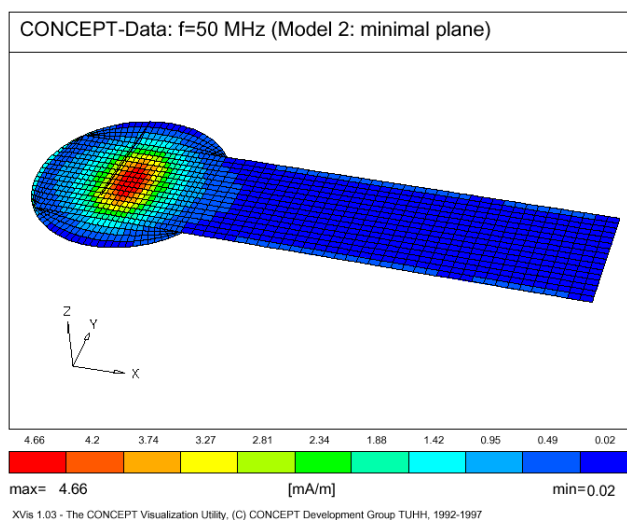


Fig. 3.7: Surface current distribution  $f = 50$  MHz (M2)

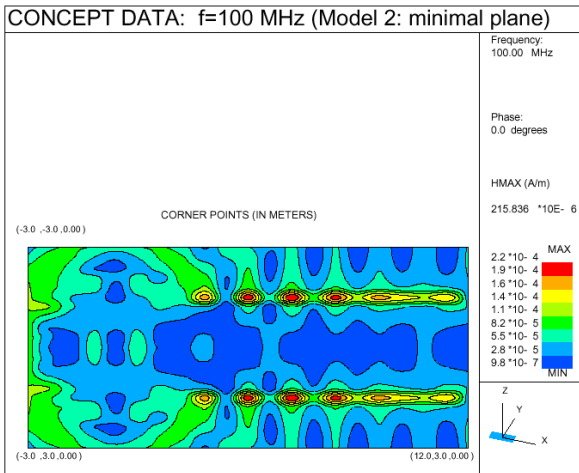


Fig. 3.8: H-field strength distribution  $f = 100$  MHz (M2)

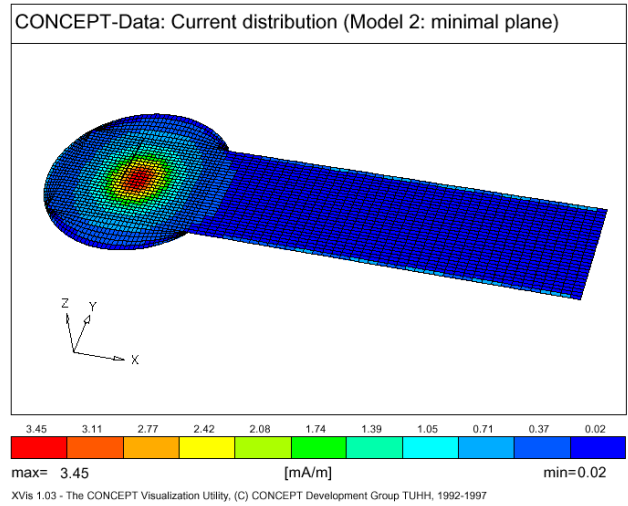


Fig. 3.9: Surface current distribution  $f = 100$  MHz (M2)

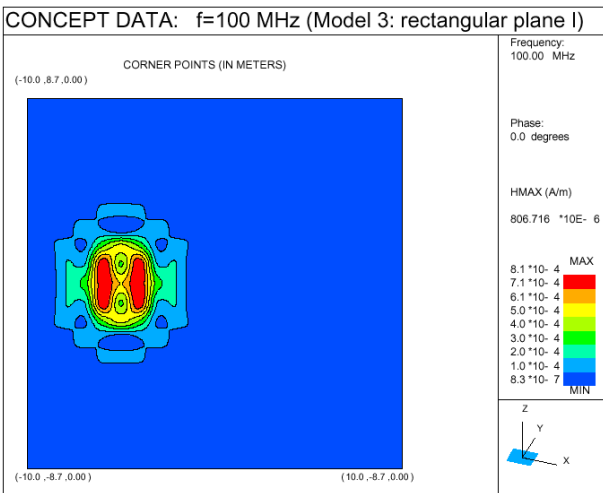


Fig. 3.10: H-field strength distribution  $f = 100$  MHz (M3)

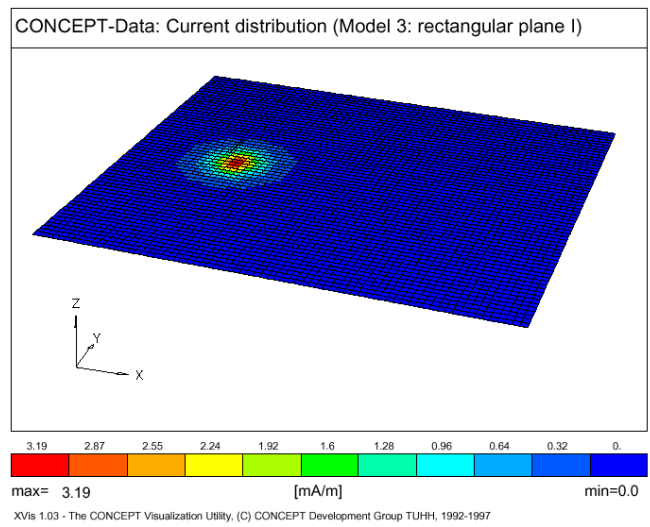


Fig. 3.11: Surface current distribution  $f = 100$  MHz (M3)

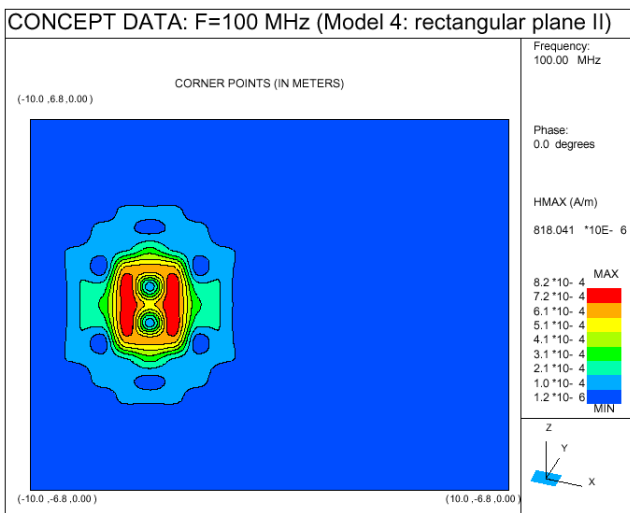


Fig. 3.12: H-field strength distr.  $f = 100$  MHz (M4)

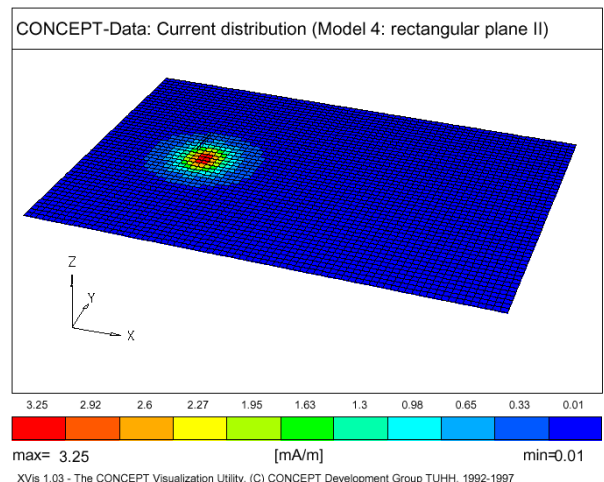


Fig. 3.13: Surface current distribution  $f = 100$  MHz (M4)

Figure 3.5 shows the surface current distribution on the conducting ellipse. The part of the plane, where the EUT is placed, has a high surface current density with the surface current spreading out in all directions. At the rim of the ellipse the surface current density is 0.003 normalized to the maximum surface current density. CONCEPT depicts the magnetic field strength distribution only in rectangular planes, therefore a plane, that encircles the ellipse, is shown in figure 3.4. At the left end of the plane, where the EUT is placed, the magnetic field is 0.17 normalized to the maximal magnetic field strength.

Figures 3.7 and 3.9 show the surface current distributions on the minimal plane (Model 2) for 50 MHz and 100 MHz. For 50 MHz the current density at the left hand side rim is 0.3 times the maximal current density, which appears at the centre of the circular part of the plane under the transmitting antenna (fig. 3.7). The same is valid for 100 MHz (fig. 3.9). The dimension of the EUT (half wave dipole) is 1.5 m for  $f=100$  MHz and the diameter of the circular plane is  $D=5$  m (fig. 2.2). Although the plane is larger than necessary according to CISPR 16 there exists still a considerable surface current density along the rim. To investigate the influence of the rim of the minimal plane the magnetic field distribution on the minimal plane has been shown in fig. 3.6 and 3.8. It is obvious, that the rim of the minimal plane has a high magnetic field strength, which is about  $125 \mu\text{A/m}$  for  $f=100$  MHz. The magnetic field at the rim is 0.58 normalized to maximal magnetic field strength. This is the reason, why the error is nearly 4 dB when using the minimal plane, compared to an infinite ground plane.

The H-field distribution and the surface current distribution have been depicted on the rectangular planes (Model 3 and 4). Corresponding to fig. 3.1 up to fig. 3.13 it is obvious, that hardly any surface current density exists at the rim of the planes. The current density (normalized to the maximum) is almost zero for Model 3 and 0.003 for Model 4. The magnetic field strength (normalized to the maximum) is about 0.081 for Model 3 and Model 4.

A comparison of fig. 3.4 to fig. 3.13 shows, that the rims of the ellipse and the minimal plane show the highest current density compared to the other planes. To depict the influence of the rim, magnetic field distributions are illustrated in more detail for the sections E1, E3 and E4, which are also shown in fig. 2.1, 2.2 and 2.4, respectively. These results are shown in fig. 3.14. The minimal plane shows the highest magnetic field at the rim, and an additional picture is not necessary (see fig. 3.6 and fig. 3.8).

Comparing the different models in figures 3.14 and 3.8 it is obvious, that the rim of the ellipse (E1, left hand side diagram) has a high magnetic field strength of  $34 \mu\text{A/m}$ . The minimal plane (E2) shows a considerably larger magnetic field strength of  $125 \mu\text{A/m}$ . The rectangular planes (E3, E4, centre and right hand side diagrams) have a magnetic field strength of  $65 \mu\text{A/m}$  and  $66 \mu\text{A/m}$ , respectively at the centre of the rim. These values, while in absolute terms larger than for Model 1, are lower if compared with the respective maximum field strength values.

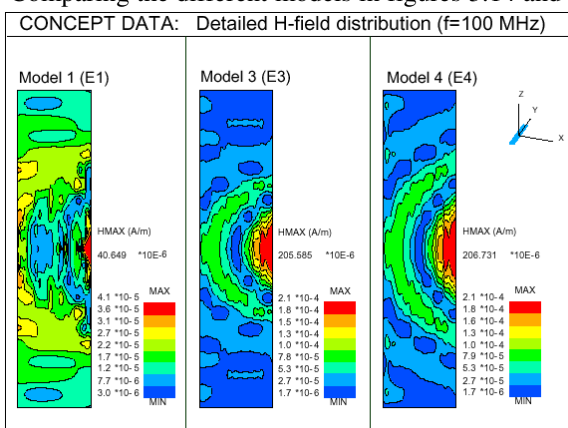


Fig. 3.14: Sectional illustration of H-field distribution

#### 4 Evaluation of the results

It can be seen that an extension of the plane naturally improves the performance as it comes closer to the ideal of an infinite plane. This shows that filling up the area around the radiating EUT with conducting material leads to better results. A new special plane (Model 5) is now created and simulated to demonstrate this (fig. 4.1). This plane consists of a square area of  $R^2$  around the EUT and a rectangular part with dimensions  $R \times R/2$  around the measurement point (table 4.1).

In order to determine the influence of the rim the surface current distribution and the magnetic field strength distribution have been calculated for Model 5 (fig. 4.2 - fig. 4.4). To depict especially the influence of the rim, the magnetic field distribution has been illustrated in the section E5 (fig. 4.3).

In figures 4.5 and 4.6 the error in dB is presented that results from the limited size of the ground plane. Compared with the results of figures 3.1 and 3.2 the error for the special plane according to Model 5 has been added.

Model	Pattern	Dimension	Area/m <sup>2</sup>	Figure
5	2 quadrilateral: 1. square 2. rectangle	1. side length R 2. dimension r x R/2	150m <sup>2</sup>	Fig 4.1

Table 4.1: Characteristics of the special plane

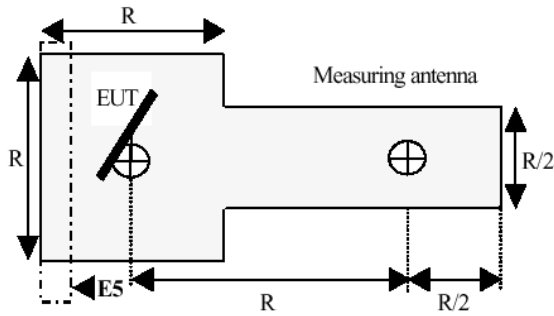


Fig. 4.1: Model 5, special plane,  $A=150m^2$

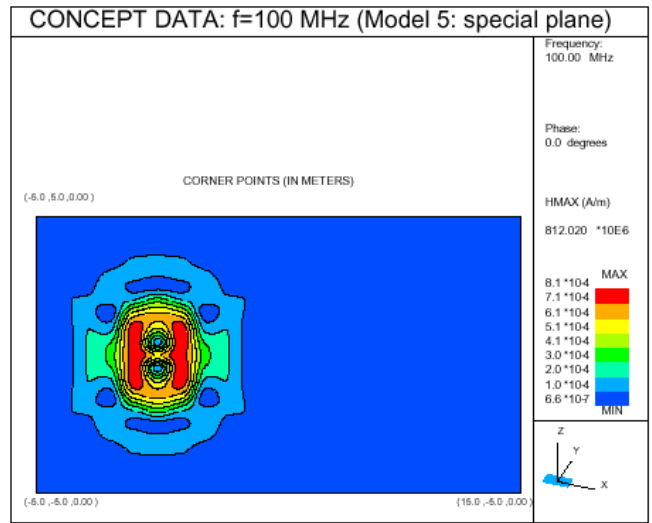


Fig. 4.2: H-field strength distribution  $f=100$  MHz (M5)

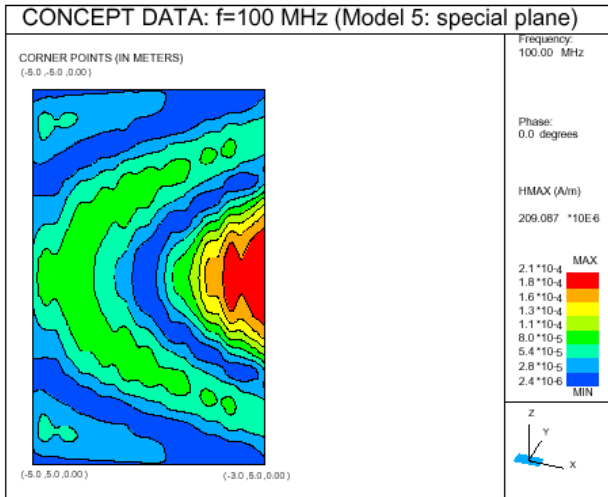


Fig. 4.3: Sectional illustration of H-field distribution (M5)

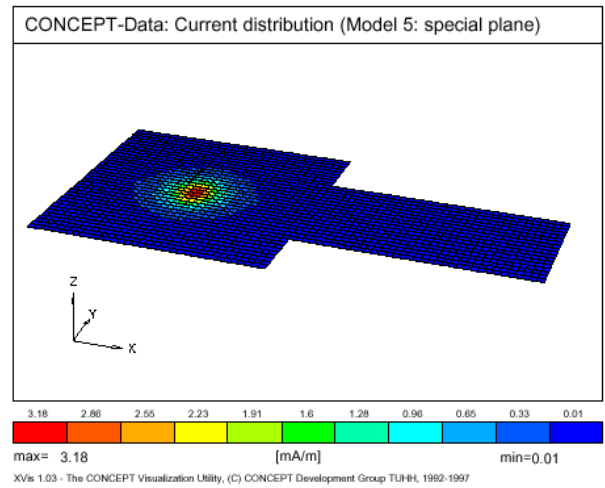


Fig. 4.4: Surface current distribution  $f=100$ MHz (M5)

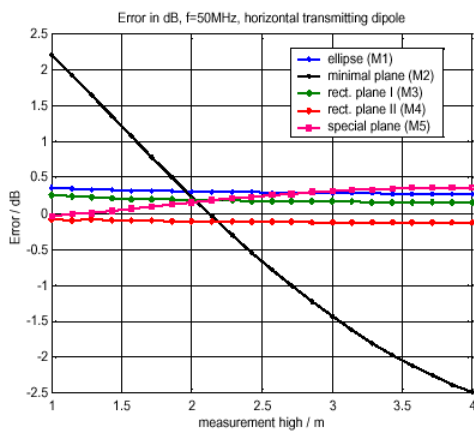


Fig. 4.5: Error in dB for  $f=50$  MHz

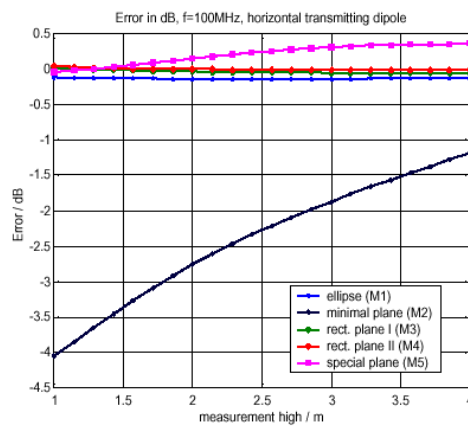


Fig. 4.6: Error in dB for  $f=100$  MHz

In figure 4.5 it is easy to recognize, that the error, when using the special plane (M5), is less than 0.4 dB for 50 MHz and 100 MHz, respectively. The error of the special plane is much smaller than that of the minimal plane (M2) although the surface area is only 150 m<sup>2</sup> compared to the 110 m<sup>2</sup>. Its area is only 55% of that of Model 1 and 4 and only 43% of that of Model 3. Thus a slight increase in the surface area improves the performance significantly (Model 2 -> Model 5), while an additional substantial amount of conducting material (Model 1, Model 3, Model 4) gives only a slight improvement.

The connection between the surface current, the magnetic field strength and area of the different models is also obvious in table 4.2.

Model	Maximum surface current at the rim of the plane (normalised to the maximum surface current on the whole plane)	Maximum magnetic field strength at the rim of the plane (normalised to the maximum magnetic field strength on the whole plane)	Area/m <sup>2</sup>
1. (ellipse)	0.003	0.17	272
2. (minimal plane)	0.3	0.58	110
3. (rectangular plane I)	0	0.081	346
4. (rectangular plane II)	0.003	0.081	272
5. (special plane)	0.003	0.08	150

Table 4.2: Maximum surface current and maximum magnetic field strength at rim of plane

## 5 Summary

The influence of the rim of different planes in OATS has been investigated. It has been shown that the rim has a very important influence to the field distribution, if the area of the metallic plane is small around the EUT. Use of an infinite perfect conducting plane results in an ideal condition. This ideal case can be approximated in reality only with a plane of limited size. Using rectangular planes (Model 3 and 4) cause a small error in comparison with the conducting ellipse (Model 1) or the minimal plane (Model 2), which has the biggest error. A special plane has been designed, as the error becomes smaller, if the metallic plane around the EUT becomes larger. Comparing the different areas and the errors of the planes, the special plane is a good compromise between the essential metallic plane area and the caused error (<.4 dB for 50/100 MHz). Moreover it has been shown, that the conducting ellipse, which is suggested by the standard, is not the best solution. This result is even more important for an OATS with low ground conductivity (dry sandy or stony soil), where the surface current density will have an abrupt transition at the rim from the metallic plane to the surrounding soil.

Concluding this paper it is possible to minimize the uncertainty for the NSA by limitation of the plane due to the fact that the metallic plane will be lined out around the EUT where high surface currents are expected. So the way and position of laying is more important than the absolute quantity of metal used for the ground plane.

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## CORRECTION

*The following e-mail was received from Gordana Felic (Competition winner) regarding her article in the February Newsletter. Unfortunately it was received too late to make the correction to her article.*

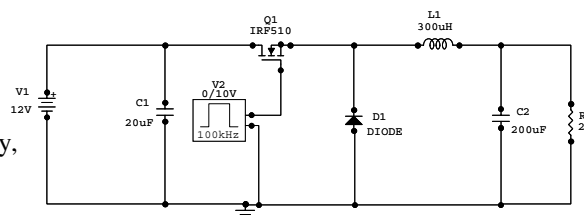
Hi

I have noticed a mistake in the circuit from Fig 7. The diode is up-side down, wrong direction.

This was due to the changes I had to do in order to save on memory, translated the circuit to CM and it did rotate the diode.

This should be changed, if too late then add the correction in the next edition.

Thanks, Gordana.



# Study of Headset Effect on Hand-phone Radiation

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**Abstract** The objective of the paper is to look into headset effect on power density or electric field strength radiated from a mobile hand-phone. The typical electromagnetic radiation measurement set-up, technique and results are presented. The comparison between two cases, with or without a headset when the mobile hand-phone is working, is addressed. Some suggestions on the practical headset use are also proposed.

**Introduction** The mobile telecommunications market has been evolving very quickly during the last decade. The third-generation (3G) and fourth-generation (4G) mobile systems have been in the process of intensive research recently. The wide spread use of the mobile communications in the last years raises the problem of the health risk connected with the high-frequency electromagnetic fields [1-3]. It is not easy to forecast the possible biological effects based on present technologies [4-5]. There are general fears, or sometimes even hysteria or electro-phobia, in the society from these effects [5]. However, the benefits can not be ignored as mobile telecommunications increase with an astonishing extent.

Furthermore, while the interest in the use of the headset (or hand free set / hand free kit) for some modern mobile hand-phones has been increasing rapidly, the radiation exposure of the user's head to the hand-phone via the headset merits investigation. This paper presents one solution to finding out the headset effect on electromagnetic radiation from the hand-phone based on measurement and comparison methods.

## Solution and Measurement Set-up

Because of the relatively short wavelength of GSM 900 compared to the size of the human body, only the electric field strength or power density measurement would be sufficient to assure that both electric and magnetic fields are investigated.

The GSM hand-phones always emit the maximum power within a few seconds during the process of connecting to the base station. The hand-phones send registering signals to the nearest base station every 5-10 minutes. The ringing starts only after the connection has been completed. During the conversation the power is usually smaller than the maximum, and the output power of the hand-phone is regulated down to the level which is just enough for the safe connection [6].

The peak field strength or power density measurements were conducted during this study, although it was reported that the whole-body specific absorption rate (SAR) [7] is related more to the average field strength over the body dimensions than to the peak value at one specific point. The peak value seems relatively perceptible compared to the average one in the case of comparison measurement.

Determination of the peak electric field strength may be determined by spatial measurements of the exposure fields over the plane surrounding the human body. Non-uniform fields will be commonly encountered in reflective conditions such as standing wave fields produced by reflection of fields from the earth or other surrounding reflective surfaces. Such measurement was accomplished through the use of real-time peak data-logging equipment (in this work, HP spectrum analyser 8564E was used).

A series of 60 points of received (peak) power, which are actually converted from electric field strength received by a receive antenna (in this work, a log periodic 3145DP with frequency range between 100MHz and 1100MHz) was applied. The measurements were performed in a horizontal plane with the tested hand-phone or headset close to the receive antenna. Co-polarisation direction between the antenna and the hand-phone or the headset is critical to maximise the measurement results.

The measurements should also take into account the fact that several factors will influence the response of the receive antenna to the radiation field of the hand-phone or the headset. These factors include the following,

- (1). Variation of the antenna impedance with proximity to nearby reflective surfaces,
- (2). Capacitive coupling between the antenna and the radiation field from the hand-phone or headset, and
- (3). Non-uniform illumination of the sensing elements that make up the receive antenna.

Two measurement methodologies were utilised: either a pure hand-phone without a headset or a hand-phone using a headset. In both cases, the relative position of the hand-phone without a headset to the receive antenna remained the same as that of the headset to the receive antenna. In the case with a headset, two extreme hand-phone positions were measured, i.e., close to the headset and farthest away from the headset. Two different situations, either the hand-phone is calling or receiving, were investigated.

For simplicity, only in-door measurement environment was chosen, while open-range measurement will be similar to the in-door case. Nearby stray electromagnetic fields (EMF) were minimised and the proper operation of the hand-phones was guaranteed during the measurements.

The major measurement facilities were the radiation exposure measurement system, inclusive of a log periodic dual-polarised antenna EMCO 3145DP with frequency range between 100MHz and 1100MHz and a HP spectrum analyser 8564E. The equipment under test (EUT) were two typical GSM900 hand-phones with specific headsets, hand-phone A (with an external antenna and a length of 1.15m headset cable) and hand-phone B (with an internal antenna and a length of 1.2m headset cable). Both hand-phones and headsets were in good condition, and the hand-phones were supplied with full-charged new batteries. The measurement set-ups for the two cases, with or without the headset, are shown in Fig. 1. It shall be noted that the log periodic antenna can be replaced by a suitable dipole antenna with a known antenna factor for simplicity.

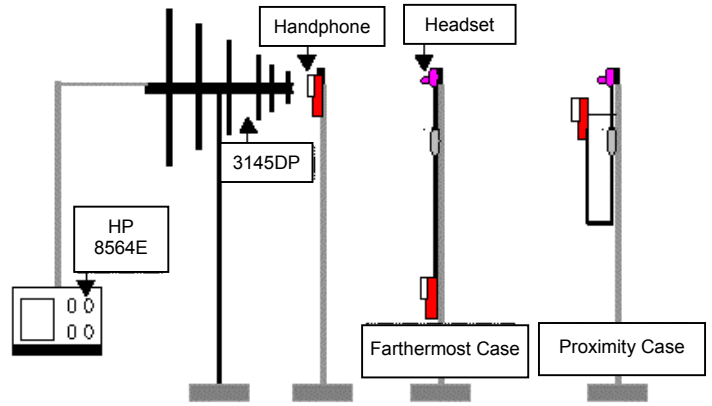


Fig. 1. Measurement set-up using a log periodic antenna to measure the headset effect

### Measurement Results

#### (1). In the case without a headset

The measured received (peak) power PdBm from the hand-phone A and the hand-phone B, without their headsets, are plotted in Fig. 2. Sixty samples were taken during the measurements. The calculated average received peak power was 10.59dBm and 7.09 dBm for hand-phones A and B, respectively. The measured received power can be converted to the desired electric field strength E and power density S by the following equations,

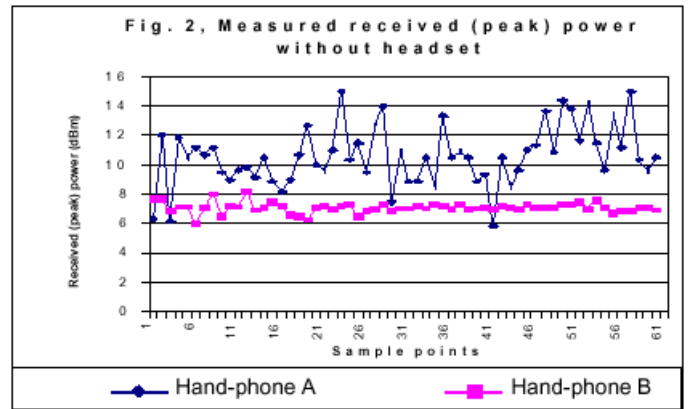
$$E_{dB\mu V/m} = AF_{dB} + P_{dBm} + 107dB$$

(for antenna impedance  $R = 50\Omega$ )

$$E_{V/m} = 10^{-6} \times 10^{\left\{ \frac{E_{dB\mu V/m}}{20} \right\}}$$

$$S_{mW/cm^2} = 0.1 \times S_{W/m^2} = 0.1 \times E_{V/m}^2 / 377$$

where  $AF_{dB}$  is the antenna factor of the log periodic antenna in dB (around 24dB in the GSM900 spectrum for this antenna) and  $E_{V/m}$  is the electric field strength in V/m.



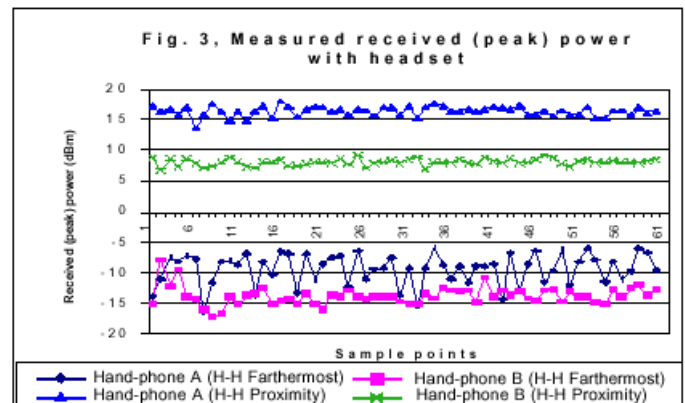
The calculated electric field strengths and the power densities S were 12.00 V/m and 8.03 V/m, 0.038  $cm/mW^2$  and 0.017  $mW/cm^2$  for hand-phones A and B, respectively. These results can be regarded safe for public users, since these power densities are lower than the maximum permissible exposure (MPE), 0.6  $mW/cm^2$ , recommended by IEEE Std C95.1-1999 [7] for uncontrolled environments.

#### (2). In the case with a headset

As the relative position between the hand-phone and the headset will affect the measurement results, two extreme cases were investigated. In the first case the hand-phone was put farthest away from the headset (H-H farthest) and in the second case the hand-phone was made to be very close to the headset (H-H proximity), which simulated the scenario that the user is dialling a hand-phone or receiving a call.

In the first case, the measured received (peak) power PdBm is plotted in Fig. 3. The calculated average received peak power was -9.38 dBm and -13.6 dBm for hand-phones A and B, respectively.

The calculated electric field strengths E and power densities S were 1.21 V/m and 0.74 V/m, 0.00039  $mW/cm^2$  and 0.00015  $mW/cm^2$  for hand-phones A and B, respectively, which are much less than the proposed MPE by IEEE Std C95.1-1999.



In the second case, the measured received power PdBm are also plotted in Fig. 3. The calculated average received peak power was 16.24 dBm and 8.13 dBm for hand-phones A and B, respectively. The calculated electric field strengths and power

densities  $S$  were 23.01 V/m and 9.05 V/m, 0.141 mW/cm<sup>2</sup> and 0.022 mW/cm<sup>2</sup> for hand-phones A and B, respectively, which are much higher than those without headset. In the case of hand-phone A, the electric field strength with headset was nearly twice of that without headset (23.01/12.00), while the power density with the headset was more than three times higher than that without the headset (0.141/0.038 > 3).

### Conclusions and Suggestions

The measured powers and calculated electric field strengths and power densities are tabulated in Table 1 for perceivable comparison. Based on the results of the measurement and calculation, the following observations may be drawn,

- a. Whether the use of the headset will increase or decrease the electric field strength or power density radiated from a mobile hand-phone depends on the way the user operates his hand-phone and headset. When the hand-phone is put farthest away from the headset, the power density is the lowest and much less than the case without using the headset. When the user puts the hand-phone very close to his headset during dialling or receiving a call, the power density becomes much higher, around 3 times, than that in the case without the headset.
- b. All the measurement results demonstrate that both mobile phones are safe for uncontrolled public users according to IEEE Std. C95.1-1999, while the hand-phone B with an internal antenna or microstrip patch antenna (MPA) is much preferable from the standpoint of radiation exposure.
- c. It is recommended that the user shall put his hand-phone and headset as far away from each other as possible to make or receive a call whenever the headset is applied.

**Table 1.** Comparison of typical parameters for hand-phone with or without a headset

Cases	Measured Received Power (dBm)		Calculated Electric Field Strength (V/m)		Calculated Power Density mW/cm <sup>2</sup>		
	Hand-phone A	Hand-phone B	Hand-phone A	Hand-phone B	Hand-phone A	Hand-phone B	
<b>Without a Headset</b>	10.59	7.09	12.00	8.03	0.038	0.017	
<b>With a Headset</b>	<b>H-H Farthermost</b>	-9.38	-13.6	1.21	0.74	0.00038	0.00015
	<b>H-H Proximity</b>	16.24	8.13	23.01	9.05	0.141	0.022

- Notes:
1. The antenna factor of the log periodic antenna is around 24 dB at GSM900 frequency spectra;
  2. “H-H Farthermost” and “H-H Proximity” stand for the two relative positions between the hand-phone and the headset;
  3. The receive antenna is regarded as a loss-less one.

It shall also be noted that the average electric field strength measurement method by the aid of a battery-operated broadband isotropic electric field probe (Holaday HI-4450 Probe) and fibre optic-connected data acquisition output (Holaday HI-4416 Readout) can be introduced alternatively. The measurement results in this way may be a little higher compared to those using the log periodic antenna due to the fact that it is relatively difficult for the antenna to detect the maximum co-polarisation direction throughout the measurements.

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- [7]. IEEE Std C95.1-1999, *IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 KHz to 300 GHz*.

# POWER FREQUENCY MAGNETIC FIELDS AND CANCER

There has been substantial community interest in 50Hz magnetic fields over many years. Recently the UK National Radiological Protection Board published a report on power frequency electromagnetic fields and the risk of cancer at levels above 0.4 micro tesla.

There has been widespread media 'analysis' of the UK report some of which has been misleading.

The Australian Radiation Protection and Nuclear Safety Agency has reviewed the UK report and the much less publicised US report (released 1999) and made recommendations on a way ahead for a protocol to be established for measurement in households.

The response from Dr John Loy of ARPANSA to the UK report is published in full in this newsletter. – Kingsley McRae

Media Release

5 March 2001

Media Statement on the NRPB (National Radiological Protection Board) Report Concerning Childhood Cancer and Powerlines

There is speculation today that a British Government-backed study by Sir Richard Doll, re-examining previous research, shows children who live near electricity pylons are more likely to develop leukaemia.

The CEO of ARPANSA, Dr John Loy, wishes to make the following statement about the report expected from the UK sometime this week:

"When the NRPB [National Radiological Protection Board] report is issued, ARPANSA will immediately examine its findings and make advice on them available to both the Commonwealth Government and the general public".

"ARPANSA will then refer the report to the Radiation Health and Safety Advisory Council to formally consider the health and safety implications".

Details on the function and membership of the Radiation Health and Safety Advisory Council can be seen on ARPANSA's web site.

Email: [arpansa@health.gov.au](mailto:arpansa@health.gov.au)

URL: [http://www.arpansa.gov.au/mr\\_pwr\\_lines.htm](http://www.arpansa.gov.au/mr_pwr_lines.htm)

Produced by Australian Radiation Protection and Nuclear Safety Agency, Commonwealth Department of Health and Aged Care.

Web page created March 2001; content last updated 5 March 2001 by Australian Radiation Protection and Nuclear Safety Agency.

Media Release

16 March 2001

British Radiation Protection Report Assessed

The CEO of ARPANSA, Dr John Loy, announced a number of commitments in Sydney today reflecting his assessment of last week's report by the Advisory Group on Non Ionising Radiation to the National Radiological Protection Board (NRPB) on extremely low frequency (ELF) electromagnetic fields and the risk of cancer.

Dr Loy said "I must stress that the extensive review of scientific research conducted by the Advisory Group found some epidemiological evidence that prolonged exposure to higher household levels of ELF electromagnetic fields is associated with a small risk of leukaemia in children. The evidence is not new and nor is it strong enough to justify a firm conclusion that such fields cause leukaemia in children, although that possibility remains".

Dr Loy added "It is precisely because that possibility remains that I now make the following observations and commitments:

1. Australians need clear and unambiguous information on ELF electromagnetic fields. ARPANSA will prepare a new fact sheet as a matter of urgency in consultation with the Radiation Health Committee and make it widely available through the Internet and other outlets. Additional support for widespread distribution of this fact sheet may be sought from the electricity supply industry.

2. A protocol should be prepared soon to ensure that measurements of adult and child exposures to ELF electromagnetic fields are done reliably and consistently, using a method suitable for the household setting. I recommend that ARPANSA prepare this measurement protocol in consultation with other expert organisations.

3. The percentage of Australian homes exposed to higher levels of ELF electromagnetic fields is not known for certain, though there is little reason to believe they will differ from homes in other advanced countries. However, I am putting the idea of a large-scale survey of average exposures across Australia to the Radiation Health Committee, for it to report to the Radiation Health and Safety Council.

4. The National Health and Medical Research Council published the Australian health standard for exposure to ELF fields in 1989, entitled "Interim guidelines on limits of exposure to 50/60Hz electric and magnetic fields". Current evidence provides no basis for re-writing these guidelines, but I will nonetheless ask the Radiation Health Committee to review them".

The many sources of ELF around us include high voltage powerlines on pylons, powerlines on telephone poles, electrical wiring in buildings and electric appliances. Most of the fields experienced in a day come from sources other than powerlines.

Another important difference between these sources is ELF electromagnetic fields from powerlines are continuous, whereas those from electric appliances are usually intermittent.

There is no laboratory or epidemiological evidence that electromagnetic fields cause cancer in general. It therefore does not appear that ELF magnetic fields are a broad carcinogen.

Epidemiological studies observe people's health and evaluate whether groups that have high or unusual EMF exposure have a greater chance of developing a disease like cancer than groups with more typical exposure.

A complete copy of Dr Loy's advice entitled "Does Electricity Cause Cancer?" is available on ARPANSA's web site. This web site also shows the membership and function of the Radiation Health and Safety Council and the Radiation Health Committee.

The main conclusions and recommendations of the NRPB Advisory Group on Non Ionising Radiation report can be found at the following web address: [www.nrpb.org.uk](http://www.nrpb.org.uk)

## **DOES ELECTRICITY<sup>1</sup> CAUSE CANCER?**

**Advice by the CEO of the Australian Radiation Protection and Nuclear Safety Agency – March 2001**

### **1. Introduction**

The Advisory Group on Non-Ionising Radiation (AGNIR) to the UK National Radiological Protection Board has published a report on power frequency electromagnetic fields and the risk of cancer (1).

Prior to the publication of this report, there was substantial media interest in Australia as to what had been suggested (misleadingly) to be its conclusions: that there was a link between high voltage power lines and cancer, especially childhood leukaemia. I undertook to provide early advice on the report as soon as it was released.

### **2. What Does the AGNIR Report Actually Say?**

The report reviews scientific research published since an earlier review by AGNIR of this topic in 1992-1994. It contains detailed reviews of:

- sources and measurements of electromagnetic fields
- biological studies on cells relevant to cancer induction
- animal and volunteer studies relevant to cancer induction
- epidemiological studies on domestic exposure to electromagnetic fields; and
- occupational exposures.

The overall main conclusion of the report deserves to be quoted in full:

*"Laboratory experiments have provided no good evidence that extremely low frequency electromagnetic fields are capable of producing cancer, nor do human epidemiological studies suggest that they cause cancer in general. There is, however, some epidemiological evidence that prolonged exposure to higher levels of power frequency magnetic fields is associated with a small risk of leukaemia in children. In practice, such levels of exposure are seldom encountered by the general public in the UK. In the absence of clear evidence of a carcinogenic effect in adults, or of a plausible explanation from experiments on animals or isolated cells, the epidemiological evidence is currently not strong enough to justify a firm conclusion that such fields cause leukaemia in children. Unless, however, further research indicates that the finding is due to chance or some currently unrecognised artifact, the possibility remains that intense and prolonged exposure to magnetic fields can increase the risk of leukaemia in children."*

The elements that make up this complex conclusion are worth drawing out:

- laboratory experiments have provided no good evidence that ELF EM fields are capable of producing cancer;
- human epidemiological studies do not suggest that such fields cause cancer in general;
- there is, however, some epidemiological evidence that prolonged exposure to higher levels of ELF magnetic fields is associated with a small risk of leukaemia in children;
- the evidence is not strong enough to justify a firm conclusion that such fields cause leukaemia in children;
- but that possibility remains.

Importantly, the report indicates that, in adults who are occupationally exposed, a causal relationship between EM field exposure and tumour incidence at any site is not established.

The Advisory Group notes that considerable advances have been made in methods for assessing exposure to electromagnetic fields, both in the case of experimental studies and in epidemiological investigations. It notes that this has provided a substantially improved basis for many of the epidemiological studies reviewed by the Group.

**With respect to studies at the cellular level, the report states that there is no clear evidence that such exposure, at levels that are likely to be encountered, can affect biological processes. There is no convincing evidence that exposure to these fields is directly genotoxic or can bring about the transformation of cells in culture and thus the fields are unlikely to initiate**

carcinogenesis. Many of the effects reported occurred with exposure to fields at high levels that are unlikely to be sustained in a residential situation.

Turning to animal and volunteer studies, the report concludes again that there is no convincing evidence from its review of a large number of animal studies to support the hypothesis that exposure to ELF EM fields increases the risk of cancer. Volunteer studies have focused on impacts on the hormone melatonin and its role as a possible natural tumour suppressor and on any possible inhibitory effect of power frequency magnetic field exposure on those aspects of immune system function relevant to tumour suppression.

The report then turns to evaluation of epidemiological studies<sup>2</sup> of residential exposure to ELF magnetic fields. The suggestion that there may be a link between exposure to such magnetic field and childhood cancer has been made for over 20 years and the subject has been extensively studied. The most recent evidence on which the AGNIR relies to a substantial extent for its conclusions is a pooled analysis of nine studies in a number of countries (2). Taken together, they suggest that prolonged exposure above 0.4 microtesla<sub>3</sub> is associated with a doubling of the risk of leukemia in children under 15 years of age.

The nine studies that were pooled included 3247 children with leukaemia and 10,400 control children. The positive result of a relative risk of two, with a confidence interval from 1.27 to 3.13, occurred in the group with exposure level above 0.4 microtesla. This group included just 44 children with leukaemia and 62 controls. The study adjusted for a number of potential confounding variables: socio-economic class, urbanization, type of dwelling, mobility, and level of traffic exhaust. These adjustments did not appreciably change the results.

It is illustrative of the complexity of the field to note that the single largest study included in the pooled analysis was the UK Childhood Cancer Study – at the time of its publication it was stated that it found no link between overhead power cables and childhood cancer.

The AGNIR report points out the limitations of the pooled analysis that make the evidence not conclusive. In the majority of the projects grouped together in the analysis, direct measurements were made of the magnetic field exposures but there is some doubt about whether the control groups in these studies were representative of children from low socio-economic backgrounds. A number of projects were carried out in the Nordic countries using population registers that avoided this issue of representativeness, but in these cases the fields were estimated, rather than measured.

### **3. What Do Other Authorities Say?**

In May 1999, the Director of the US *National Institute of Environmental Health Sciences* (NIEHS) brought forward a report on “Health Effects from Exposure to Power-line Frequency Electric and Magnetic Fields” (3). The preparation of this report had been required by an Act passed by the US Congress in 1992 and it drew upon a research and evaluation program (EMFRAPID) conducted by NIEHS with the support of other US agencies.

A conclusion of the NIEHS report was:

*“that ELF-EMF exposure cannot be recognised at this time as entirely safe because of weak scientific evidence that exposure may pose a leukemia hazard. In my opinion, the conclusion of this report is insufficient to warrant aggressive regulatory concerns. However, because everyone in the United States uses electricity and therefore is routinely exposed to ELF-EMF, passive regulatory action is warranted, such as a continued emphasis on educating both the public and the regulated community on means aimed at reducing exposure.”*

As did AGNIR, the NIEHS reached this conclusion on the basis of epidemiological studies:

*“While the support from individual studies is weak, the epidemiological studies demonstrate, for some methods of measuring exposure, a fairly consistent pattern of a small, increased risk with increasing exposure that is somewhat weaker for chronic lymphocytic leukemia than for childhood leukemia”.*

*“mechanistic studies and the animal toxicology literature, failed to demonstrate any consistent pattern across studies although sporadic findings of biological effects have been recorded. No indication of increased leukemias in experimental animals has been observed.”*

During the work of the NIEHS on the EMFRAPID program there was a working group formed to evaluate the evidence in relation to the carcinogenic effect of EMF fields using the criteria laid down by the International Agency for Research on Cancer (IARC). The majority of the working group concluded that ELF-EMF would be classified as “a possible human carcinogen”.

In 2000, the *Health Council of the Netherlands* issued a report prepared by a committee of the council on the issue (4). The committee also reported that:

*“some epidemiological data points to a reasonably consistent association, that is, a statistically significant relation, between residence in the vicinity of power lines and an, otherwise slight, increase in the incidence of childhood leukaemia.”*

The committee took the view that, in the light of the weakness of the association and the lack of evidence from experimental research, it has not been demonstrated that exposure to ELF EM fields at permitted levels “induces any kind of disease or abnormality”.

#### **4. Relevant Circumstances in Australia**

The evidence principally relied upon in the AGNIR report comes from advanced countries – Canada, Denmark, Finland, Germany, New Zealand, Norway, Sweden, USA and the UK. There is no reason to expect that Australian exposures to ELF EM fields will be significantly greater than exposures in those countries.

There have not been any large-scale epidemiological studies carried out in Australia on any link between ELF EM fields and cancer. As a consequence, there have been few systematic and recent studies of magnetic field exposures in Australian homes.

There are no Australian exposure standards applying to the general public or workers. The National Health and Medical Research Council published ‘Interim guidelines on limits of exposure to 50/60Hz electric and magnetic fields’ in 1989. These interim guidelines were those proposed under the auspices of the body that has now become the International Commission on Non Ionizing Radiation Protection (ICNIRP). The exposure levels permitted by these guidelines were set on the basis of preventing harmful levels of induced current in the tissues of the central nervous system. The magnetic field exposure at 50 Hz permitted by these guidelines on this basis is 100 microtesla.

#### **5. Position of the CEO of ARPANSA**

It is first worth noting what AGNIR, NIEHS and the Health Council of the Netherlands say in common – that there is no evidence, either laboratory or epidemiological, that fields generally cause cancer. That is it does not appear that ELF magnetic fields are a broad carcinogen.

There is, however, epidemiological evidence that there may be a link between ELF magnetic fields and childhood leukaemia. The evidence is that if this effect is real, it occurs at relatively high long-term residential exposure levels. It appears to involve a doubling of the risk at these higher exposure levels, noting that childhood leukaemia is, fortunately, a fairly rare disease.

There can always be discussion about the interpretation of epidemiological studies of weak effects. There are nearly always confounding factors - that is other factors which affect the incidence of the disease under study and are also correlated with the exposure under study - and these may be difficult to allow for properly in the analysis of the data. Studies of EM fields are also bedevilled by the difficulty of actually measuring exposures over a long period of time in domestic circumstances.

Nonetheless, as both the AGNIR report and the NIEHS report state, the epidemiological studies stand and have not been shown to be invalid or an alternative explanation established.

In thinking about how to deal with this issue, it is important to emphasise that, if the effect is real, it does seem only to occur at average levels of exposure at the high end of what is normally encountered on average in a residence. The level of 0.4 microtesla and above that provides a positive association in the pooled analysis applied to no more than 0.8% of the total population sampled in these studies. There is no reason to believe that Australia would have a vastly different proportion of people in this higher residential exposure range. There are some 175 cases of leukaemia diagnosed in Australia each year in children under 15. If no more than 1% of children are exposed above 0.4 microtesla and the risk factor were doubled for these children, this would result in 2 cases in Australia each year.

It is also important not to fixate on the location of external power lines, including high voltage transmission lines, as the prime cause of exposure. Exposure to ELF magnetic fields can arise from ground currents, internal household wiring and the use of electrical appliances as much as from exposure to the external power lines.

In my view, while noting all the qualifications on the AGNIR and NIEHS findings, it does behove public health authorities to consider what action should be taken now, in case the link with childhood leukaemia is real. In the final section of this report I have set out some actions that I believe should be considered and undertaken in this context. The actions that I have proposed are of an informative and precautionary nature. The weakness of the scientific evidence and the size of effect that is pointed to by the epidemiological studies do not in any way warrant a complete overturning of our approach to the use of electricity in industrialised countries. Furthermore, in terms of regulation, we have no certain basis on which to change our regulatory approach, because we do not know the mechanism that may be at work.

## 6. What Should Happen in Australia

It is important that the public are informed of the findings in a factual and direct way that enables people to make their own decisions about whether they need to limit exposures and how they might go about that should it be their wish. ARPANSA will prepare a new fact sheet as a matter of urgency in consultation with the Radiation Health Committee<sup>4</sup> and make it widely available through the Internet and through other outlets. Additional support for widespread distribution of this fact sheet could be sought from the electricity supply industry.

People will seek information about their personal exposures and that of their children. I believe that, as a matter of some urgency, a protocol should be drawn up to ensure that such measurements are done on a reliable and consistent basis, employing a methodology suitable for household measurement at modest cost. I propose that ARPANSA lead this work in consultation with other relevant bodies. The protocol should address what sensible advice can be given to people in residences with higher levels of fields present.

As noted above, there is a range of reasons why exposures may be at a certain level in a household or residential situation. The UK authorities have described the relatively small number of people likely to be exposed above 0.4 microtesla and such information that we have indicates that that would be similar around Australia. There may be value in a wider survey of exposures in Australian homes, using the techniques that would allow clear measurement of the average exposure levels. A significant survey would be expensive and preliminary estimates are that it could be in the order of \$500,000. Whether this is of value to recommend to the Government is a matter I intend to put to the Radiation Health Committee in the first instance for a report to the Radiation Health and Safety Advisory Council<sup>5</sup>

I would not see any value in an Australian epidemiological study as it is unlikely that there would be sufficient numbers to add to the current results. Researchers who formulate hypothesis-driven proposals to examine biological effects or to undertake animal experiments should be considered under the usual NHMRC and other funding arrangements.

As noted above, there is no formal exposure standard and the current health guidelines for exposure to ELF fields were released in 1989. At the relevant frequencies, the permitted exposure levels are the same as current ICNIRP guidelines, though the rationale for the exposure levels is dated. I will ask the RHC to place review of the interim guidelines and the need for an exposure standard on its agenda for early action. The issue of how such a standard might deal with precautionary approaches to limiting exposures of children clearly will be important.

John Loy  
CEO of ARPANSA  
15 March 2001

## References

- (1) Report of an Advisory Group on Non-Ionising Radiation. ELF Electromagnetic Fields and the Risk of Cancer. *Doc NRPB* 12(1), 3-179(2001) ISBN 0-85951-45609.
- (2) Ahlbom A, Day N, Feychting M et al. A pooled analysis of magnetic fields and childhood leukaemia *B J Cancer* **83** 692-8(2000).
- (3) Health Effects from Exposure to Power-Line Frequency Electric and Magnetic Fields. A report prepared in response to the 1992 Energy Policy Act. NIH Publication No. 99-4493 (1999).
- (4) Health Council of the Netherlands : ELF Electromagnetic Fields Committee. Exposure to electromagnetic fields (0 Hz – 10 MHz). Publication No. 2000/06E. (2000).

1 'Electricity' in this context means the varying electric and magnetic fields arising from the supply and use of electric power in homes and workplaces. The frequency of the fields is 50/60 Hz and they are called ELF (Extremely Low Frequency) EM (Electromagnetic) fields.

2 Epidemiology is the study of the possible causes of disease through the comparison of selected population groups.

3 A microtesla is a unit of measurement of magnetic field. By comparison, the earth's (static) magnetic field has a strength of around 50 microtesla.

4 The Radiation Health Committee is established by the ARPANS Act 1998 and includes State/Territory regulators of radiation and independent members.

The Radiation Health and Safety Advisory Council is established by the ARPANS Act 1998. It has a high level advisory role in issues of radiation protection and nuclear safety.

# TECHNICAL 2000 PRESENTATION

On the 26<sup>th</sup> February this year, Mr. James (Jim) Smith of Steward Incorporated, USA, gave a presentation to the EMC society “Practical EMC Prevention During Design”. The tutorial was presented in a workshop type session to 35 attendees at the Melbourne IE Aust Auditorium.

Steward Inc. is a leading manufacturer of Ferrite materials. As a simple introduction, ferrite material is a ceramic impregnated with iron oxide. When ferrite surrounds a current carrying conductor, the lossy material dissipates high frequency energy. This property is utilised widely to reduce radio frequency interference to meet applicable EMC specifications.

Ferrites today come in a multitude of shapes, sizes and material property. An informed choice, out of what may seem a bewildering array, is more likely to select an appropriate ferrite to succeed as an EMI suppressor. Mr. Smith’s presentation rationally discussed the necessary criteria: -



- Permeability: a key parameter of the material type, and suitability for the intended suppression frequency.
- Saturation: two heads may be better than one, but when it comes to common mode currents – one ferrite for both wires is better than two separate ferrites.
- Common and differential mode currents: Correct identification is crucial.
- Impedance curves: The ferrite resembles an AC coupled resistor. Due to the non-linear nature of soft magnetic materials, the DC bias current determines the value of this resistance and the frequency at which it occurs. Similar in concept to biasing a transistor.
- Ferrite geometry and volume: impact parasitic capacitances.

**As a technology, often with high expectations upon it, Mr. Smith presented the relevant facts backed up by data – to the appreciation of the audience. Ferrites are a useful complement to capacitive-inductive filtering, in the overall EMI-busting picture. Suffice to say that ferrites have the following enhancements.**

- Unwanted signals are dissipated rather than reflected.
- AC coupling ensures the wanted base-band signals are preserved.
- Long term environmental stability.

The tutorial was a great opportunity to review the excellent reference material contained in Steward publications.

It was interesting to note that ferrites are no longer limited to donut or tubular constructions. As an unwieldy last minute band-aid solution, these were often a hit or miss proposition. Availability is now extended to miniature surface mount, through hole, and connector footprints: just to name a few. Taking into account ferrite application guidelines and compatibility with automated assembly techniques, the circuit designer now has a new option in the quest to produce low emission boards economically.

The EMC Society of Australia, and the many visitors, who attended the tutorial, thanked Mr. Smith for taking time out of his working holiday to Australia.

Although Jim has returned to the U.S., any reader seeking further information about the role of ferrites in EMI suppression, the Steward contact point in Australia is Mr. Roger Farrell at RFI industries, contact on 041 491 2353.

Emile Barco.

## EMC PAPER COMPETITION

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All entrants will receive a one year membership to the EMC Society

The EMC Society of Australia, a Technical Society of the Institution of Engineers Australia, is inviting Tertiary students to prepare a paper on any aspect of EMC technology. All papers will be considered for publication in the Newsletter of the EMC Society.

### Conditions

- The entrant must be a student studying towards a recognised Award from an Australian Tertiary Institution.
- The paper must meet the publishing requirements defined on the EMC Society Website <http://azp.to/emc.society.au>.
- All papers must be received or postmarked by 6p.m. on the 1<sup>st</sup> of October 2001.
- Papers may be delivered by surface mail, facsimile or electronic mail. Papers delivered in electronic format must be in MS Word, Adobe Acrobat, Word Perfect, HTML or rich text formats. The EMC Society website has the detailed addresses.
- The National Committee of the EMC Society will be responsible for judging the papers, and the Committee's decision will be final. No correspondence will be entered into.

All entrants will receive a critique of their paper by mail on or before 12<sup>th</sup> November 2001.

## EMR standard to cover all radiocommunications licensees

by Leonie Tarnawski

The ACA is to make the electromagnetic radiation (EMR) human exposure standard mandatory for all radiocommunications transmitters by the end of this year. Not only will manufacturers and importers of certain devices have to comply with the standard, but it will also apply to all radiocommunications licensees.

To ease the burden of regulatory compliance on licensees, the ACA has developed a model that exempts licensees of transmitters that meet certain criteria from having to provide evidence of compliance to the ACA. However, licensees must still comply with the standard, Transmitters meeting the criteria cannot by their very nature exceed the limits of the EMR standard and are known as category I,

To date, criteria have been developed for four classes of transmitter only:

- . private land mobile base stations above 30 MHz-single transmitter installations;
- . private land mobile base stations above 30 MHz-multi transmitter installations;
- . point-to-point fixed services above about 12 GHz; and
- . low power broadcast stations above 30 MHz

**Transmitters for other types of services, or those that do not meet the category I criteria, are classed as category 2. All category 2 transmitters will require evaluation against the EMR standard and licensees will be required to make a declaration of conformity and hold supporting documentation.**

The ACA will allow evaluation of compliance with the standard through a range of means from self-assessment to assessment by an accredited laboratory. Licensees will be able to make a choice, depending on the level of in-house expertise, and their assessment of the risk of their transmitter not complying with the standard. Many licensees may make the decision that the highest level of confidence will only be achieved through on-site measurement by a body accredited by NATA.

A small number of licensees will be able to use some relatively simple charts and graphs provided by the ACA. These are available for the following services where there is a single antenna operating with no interference from adjacent transmitting antennas and no reflections from significant metal structures in front of the antenna:

- . fixed links operating above 30 MHz;
- . land mobile base stations operating between 3 MHz and 1000 MHz;
- . low power TV and radio broadcast operating above 30 MHz;
- . paging operating between 3 MHz and 1000 MHz;
- . amateur radio; and
- . general radio operating above 30 MHz.

Licensees who have transmitters in radiocommunications services that cannot be assessed using the ACA charts and graphs and who do not wish to engage a NATA-accredited body have other options including assessment by qualified personnel using appropriate software or on-site measurement.

### Trial of simple self-assessment materials

The ACA has been conducting a trial of the charts and graphs to gauge the ease of their use. To date, most interest in the trial has been from amateur radio operators and some broadcasting service operators who, in general, have found the materials easy to use.

Partly because of the lack of response by other groups of radiocommunications licensees who would be eligible to use the charts and graphs, the ACA will hold a series of seminars on the EMR regulatory arrangements and the various compliance options. These are planned for April-July 2001. Interested readers should watch for advertisements in industry magazines, major daily newspapers and on the ACA website.

For more Information on EMR policy and proposals see the ACA website at:

[www.aca.gov.au/standards/emr/Industry.htm](http://www.aca.gov.au/standards/emr/Industry.htm)



# CALENDAR OF EVENTS

- June 27 -29** Wireless & Optical Communications 2001  
Banff, Canada Contact IASTED Secretariat – WOC 2001  
Phone +403 288 1195 Fax +403 247 6851  
calgary@iasted.com <http://www.iasted.com>
- June 19 – 22** International Symposium on EMC  
Saint-Petersburg, Russia Contact Prof. Popov, 5, Saint-Petersburg, Russia  
Phone +7 812 346 4637 Fax +7 812 234 3795  
EMC2001@eltech.ru discone@vilan.spb.ru <http://www.eltech.ru/EMC2001>
- July 3 -6** Advances in Communications  
Rhodes, Greece Contact IASTED Secretariat – AIC 2001  
Phone +403 288 1195 Fax +403 247 6851  
calgary@iasted.com <http://www.iasted.com>
- July 8 – 13** 2001 IEEE AP-S URSIO  
International Symposium  
Boston, MA
- July 18 – 22** PIERS'01  
Osaka, Japan
- August 13 – 17** 2001 IEEE EMCS Symposium on Electromagnetic Capability  
Palais de Congres, Montreal, Canada Contact Benoit Nadeau  
Phone: +514 822 6000  
Fax: + 514 822 6275 e-mail bnadeau@ieee.org

## EMC ZURICH 2001

In February of every odd-numbered year many EMC experts go on a pilgrimage to the EMC Symposium in Zurich, Switzerland. This year about 600 participants gathered there to attend over 130 presentations, workshops, tutorials and industry forum and, equally important, discuss the current research activities and latest results during the coffee breaks or throughout the evenings in Zurich's restaurants and pubs. (After all, the word 'Symposium' originates from the Greek *συμποσιον* meaning 'having a drink together'.)

Since 1975 this EMC symposium is held biennially in Europe and since 1981 at the Federal Institute of Technology (Eidgenossische Technische Hochschule) in Zurich. An EMC event in Germany just 3 weeks later dropped the number of exhibitors in Zurich this time, however the quality of the presentations was not affected. The program committee rejected about 1/3 of the submitted papers, and this tough selection process ensured the high scientific standard of the symposium.

Participants and presenters came from all continents, with the exception of Antarctica, and most aspects of EMC were covered. In 19 sessions topics from Biological Effects to High Power Electromagnetics and Lightning, to Transients and Transmission Lines, to Measurements Techniques and EMC In Networks to Computer Codes And Validation were covered. Test Chambers and Cells and Reverberation Chambers were addressed in two sessions, as was EMC on chip-level.

EMC is not a new science, and many problems in achieving an electromagnetic compatible environment are quite well understood. The solution of these problems is however still a challenging task and there is plenty of work ahead.

Looking for the ultimate test site continues with OATS, Anechoic chamber, various Test Cells and Reverberation Chamber all having their place in EMC testing. Computer simulation has made enormous progress in the last decade and was the subject in several sessions. The trend here is the combination of different techniques in hybrid methods.

It was again a successful EMC event, enjoyed by all the experts interested in the more scientific aspects of the area. Many of them are certainly looking forward to February 2003, to the next pilgrimage to Zurich.

Franz Schlagenhauser

## NEW MEMBERS

For those who have not yet joined our EMC Society we would ask you to fill in our membership application form and encourage your colleagues to follow suit. If you have applied for membership but not yet received an invoice from IEAust, would you please fill in and submit a new application.

## MAILBOX

We invite all our members and readers to participate in our quarterly newsletter. In order to produce a better newsletter and provide our readers with the information and items of interest looked for, we welcome your comment, advice and criticism. Particularly, we would look forward to receiving technical articles, amusing anecdotes and items of general interest to the EMC community.

## CORPORATE MEMBERSHIP

The EMC Society offers corporate Membership to organisations who may wish to nominate up to three people for membership. It also provides an important source of funding to the Society and we would like to take this opportunity to recognise the 2001 corporate Members.

**ADVANTEC ELECTRONICS Pty Ltd** is a registered NATA test house with accreditations for testing to TS001, TS002, TS004, TS006 and TS008.

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**The EMC Society would like to express gratitude to Advantec, Department of Defence, Rittal, Robert Bosch, and Tenix for their support in 2001.**

## Institutional Listings

The IEAust Electromagnetic Compatibility Society is grateful for the assistance given by the firms listed and invites application for Institutional Listings from other firms interested in the electromagnetic compatibility field.

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An Institutional Listing recognises contributions to support the publication of **THE IE AUST ELECTROMAGNETIC COMPATIBILITY SOCIETY** newsletter. Minimum rates are \$200.00 for a listing in one issue. Larger contributions will be most welcome. No agency fee is granted for soliciting such contributions. Inquiries, or contributions made payable to the EMC Society, plus instructions on how you wish your Institutional Listing to appear, should be sent to the Editor, EMC Society Newsletter, IE Aust, 11 National Circuit, Barton, A.C.T. 2600.