Radiation Measurement from Mobile Base Stations at a University Campus in Malaysia

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Abstract: The tremendous growth of telecommunication industry results in the number of hand phone users increases everyday. In order to support the growing number of users, the mobile base stations can be seen in almost everywhere. This scenario has created uncomfortable feelings to the people that they may be affected by the radiations from antennas. A measurement was done at student hostels and office premises near to base stations in International Islamic University Malaysia, Gombak campus. Measured values are compared with Malaysian Communication and Multimedia Commission (MCMC), IEEE and ANSI recommendations for safety guidelines. The results are presented in this study.

Key words: Mobile base stations, radiation measurement, measurement system, antennas radiations

INTRODUCTION

The number of hand phone users increases everyday and in order to support the growing number of users, the mobile base stations can be seen in almost everywhere. The locations vary from high rise tower to rooftop of buildings. Nine base stations operated by three mobile services provider in Malaysia as Celcom, Digi and Maxis are located in International Islamic University Malaysia (IIUM), Gombak campus. Few stations with multiple antennas transmit signals at 900 MHz and 1800 MHz bands. Radiation exposes to 15000 population of IIUM campus including students and staff. A measurement was done at student hostels and office premises near to base stations. Telekom Malaysia R & D unit and Wireless Communication Research Group jointly carried out the measurement. A tri-axis isotropic probe with portable spectrum analyzer FSH3 and RFEX software were used to measure electric field intensities and power densities for all existing signals ranging from 80 MHz to 2.5 GHz. Measured values are compared with Malaysian Communication and Multimedia Commission (MCMC) which adopted ICNIRP recommendations for safety guidelines.

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) was launched as an independent commission in May 1992. For the American National Standards Institute (ANSI), the RF safety sections now operate as part of the Institute of Electrical and Electronic Engineers (IEEE). Generally, the ICNIRP and ANSI/IEEE standards are the most widely accepted all over the world. Radio frequency and microwave radiation exposure limits as recommended by ICNIRP/IRPA and adopted by some countries are shown in Table 1[1]. Furthermore, the SAR limits recommended by the recognized bodies are also summarized in Table 2[1,2].

Experimental setup: All the mobile base stations in the university are located at the students hostels area. Most of them are at the rooftop of hostels. There is one artificial tree having 6 antennas and used by one operator. Eight different locations were chosen for the measurement of electric field and power density. The places are divided into the hostel area and center area. The sites of hostels area are at Hostel1 (Ali), Hostel2 (Bilal), Hostel3 (Halimah) and Hostel4 (Sumaiyyah). The center area comprises of faculty of Economics, Central Library, Rector Office and near the artificial tree. The places were selected due to its distance from the base station, the function of the place, the geographical condition and the level of density of the
Table 1: Radio frequency and microwave radiation exposure limits for member of the public as recommended by ICNIRP and adopted by some countries

| Country          | Radio frequency and Microwaves | Frequency range | Electric field (v/m) | Magnetic field (A/m) | Power density (mW/cm²) |
|------------------|---------------------------------|-----------------|----------------------|----------------------|------------------------|
| USA / ANSI       | 1.0 MHz – 3 GHz                 | 19.4 f/100      | 0.163 f/100          | f/100                |
| IEEE             | 1.0 Hz – 300 Hz                 | 194.16          | 0.515                | 10                   |
| MALAYSIA         | 300 MHz – 1.5 GHz               | 1.616 f¹⁰⁄³      | 0.00433 f¹⁰⁄³         | f/1500               |
| (MCMC)           | 1.5 GHz – 300 GHz               | 0.16            | 1                    |

Table 2: SAR limits recommended by ANSI/IEEE and ICNIRP

| Organizations | Exposure Characteristics | Frequency Range | Whole-body average SAR (W/Kg) | Localized SAR (Head) (W/Kg) | Localized SAR (Limbs) (W/Kg) |
|---------------|--------------------------|-----------------|--------------------------------|----------------------------|----------------------------|
| ANSI/IEEE     | Occupational            | 100KHz – 6 GHz  | 0.4                            | 8                          | 20                         |
|               | General Public          | 100KHz – 6 GHz  | 0.08                           | 1.6                        | 4                          |
| ICNIRP        | Occupational            | 100KHz – 10 GHz | 0.4                            | 10                         | 20                         |
|               | General Public          | 100KHz – 10 GHz | 0.08                           | 2                          | 4                          |

Table 3: Specification of tri-axis probe

| Frequency range | VSWR | Measurement range | Isotropic deviation | Temperature range | Humidity | Current consumption |
|-----------------|------|-------------------|---------------------|-------------------|----------|--------------------|
| 80 MHz to 2.5 GHz | ≤ 2.0 | about 1mV/m up to 100 V/m | ± 1.0 dB (900 MHz) | -10° C to 50° C   | 85%      | 500 mA max         |

RESULTS AND ANALYSIS

Specific Absorption Rate (SAR) is a measurement of the heat absorbed by the tissue. It is described as the transfer of energy from electric and magnetic fields to charged particles in an absorber. SAR is defined, at a point in the absorber, as the time rate of change of energy transferred to charged particles in an infinitesimal volume at that point, divided by the mass of the infinitesimal volume.

\[ \text{SAR} = \frac{(\varepsilon P / \sigma)}{\rho_m} \]  

where \( \rho_m \) is the mass density of the object at that point.

In this project, local SAR has been estimated at point on the brain as the absorber and not the whole average body of a human. The local SAR is related to the internal E-field through following equation:[3, 4]

\[ \text{SAR} = \frac{P}{\rho_m} = \varepsilon \frac{\varepsilon |E|}{\rho_m} = \frac{\varepsilon |E|^2}{\rho_m} \]  

where \( P \) is the absorbed power density \( \varepsilon \) is the conductivity \( \sigma \) is the permittivity

Thus, if the E-fields and the conductivity are known at a point inside the object, which is brain, the SAR at that point can easily be found. SAR is also called absorbed power density as the letter P in the equation is called absorbed-power density. All the information about the dielectric and permittivity of the brain were obtained from Federal Communications Commission (FCC) database on Tissue Dielectrics[6] and shown in Table 4.

The measured electric fields and power densities at central library for GSM1800 signals are shown in Fig. 2 and 3. The measured electric fields and dielectric properties presented in Table 4 have been used to estimate specific absorption rate (SAR) for human brain. The SAR for above site is also shown in Fig. 4.

The data that is shown in the Table 5 are the percentages of highest values of GSM900 for each

students in that particular area. Most of the antennas used at the base station are rectangular antenna and positioned vertically with zero tilt angle toward the ground. For that reason, their radiations are hardly being observed at location below or within immediate vicinity of the base station.

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The data that is shown in the Table 5 are the percentages of highest values of GSM900 for each
location over limit that was given by ICNIRP\cite{7}. The field intensity varied from 0 to 20.44\%, while power density varied from 0 to 4.34 and 0 to 3.88\% for SAR of the ICNIRP general public maximum permissible exposure limit. As shown in the table, the highest peak value was detected at library and the lowest detected peak value was at Faculty of Economics.

The data that is shown in the Table 6 are the percentages of highest values of GSM1800 for each location over limit that was given by ICNIRP.
A measurement on radiation from mobile base stations was conducted at eight locations in International Islamic University of Malaysia, Gombak campus. The measured electric field intensities, power densities and calculated specific absorption rate (SAR) values are compared with International Commission on Non-Ionizing Radiation Protection (ICNIRP) recommendations for safety guidelines. The results indicate that the microwave radiation for GSM900 and GSM1800 systems were approximately 34% lower than the recommended values in the campus. During measurement, it has been noticed that strong radiation was transmitting from Wireless LAN at 2.4 GHz bands, which is approximately 62% of the limit. Therefore it is highly recommended to investigate carefully the radiations from other sources before reaching to a decision that the campus is safe for its population.

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