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

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Abstract: The tremendous growth of telecommunication industry results 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].

Fig. 1: TS-EMF equipments

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

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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	Electric field (v/m)	Magnetic field (a/m)	Power density (mw/cm^2)
USA /ANSI/	100MHz – 1 GHz	61.4(f/100)	0.163(f/100)	f/100
IEEE	1GHz – 300 GHz	194.16	0.515	10
MALAYSIA	300MHz- 1.5 GHz	1.616 $f^{0.5}$	0.00433 $f^{0.5}$	f / 1500
(MCMC)	1.5GHz- 300 GHz	62	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

Table3: Specification of tri-axis probe

Frequency range	80 MHz to 2.5 GHz
VSWR	≤ 2.0 (f > 800 MHz)
Measurement range	about 1mV/m up to 100 V/m
Isotropic deviation	± 1.0 dB (900 MHz), ± 1.7 dB (1800 MHz)
Temperature range	-10° C to 50° C
Humidity	85%
Current consumption	500 mA max.

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.

In this project, the portable EMF measurement system¸ TS-EMF from Rohde and Schwarz is used to measure the electric field and power density from mobile base station. The equipment consists of 3 main components, which are the tri-axis probe, portable spectrum analyzer FSH3 and the RFEX software, which installed in a laptop. The equipment is shown in Fig. 1.

The equipment has wide frequency range which from 300kHz to 3 GHz covering all common radio services as Mobile radio (GSM, CDMA and UMTS), DECT, Bluetooth™, WLAN (802.11b), Sound broadcasting and TV broadcasting. The portable EMF Measurement System TS-EMF is designed for short-term and long-term measurements of the electromagnetic field (EMF)[3]. The tri-axis probe has an isotropic characteristic, so the measurement is done independent from direction or polarization of the emitter. In contrast to directional antennas, it is no longer necessary to move the antenna for covering all directions and polarization. The specification of the probe[3] is shown in Table 3.

The portable spectrum analyzer is designed for mobile and outdoor measurement. It is needed by the RFEX software to analyze the input signal. The RFEX software has 3-measurement mode, which are single measurement (2 minutes average), average and peak (6 minutes average) and long term (determination of time variations in the signals). The probe was connected to the spectrum analyzer and notebook computer which was set for about six minutes[3].

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.

$$SAR = \left(\partial W_C / \partial t\right) / \rho_m \quad (1)$$

where ρ_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[4,5]:

$$SAR = P/\rho_m = \sigma \left|E\right|^2 / \rho_m = \omega\varepsilon_0\varepsilon' \left|E\right|^2 / \rho_m \quad (2)$$

where P is the absorbed power density
σ is the conductivity
ε 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

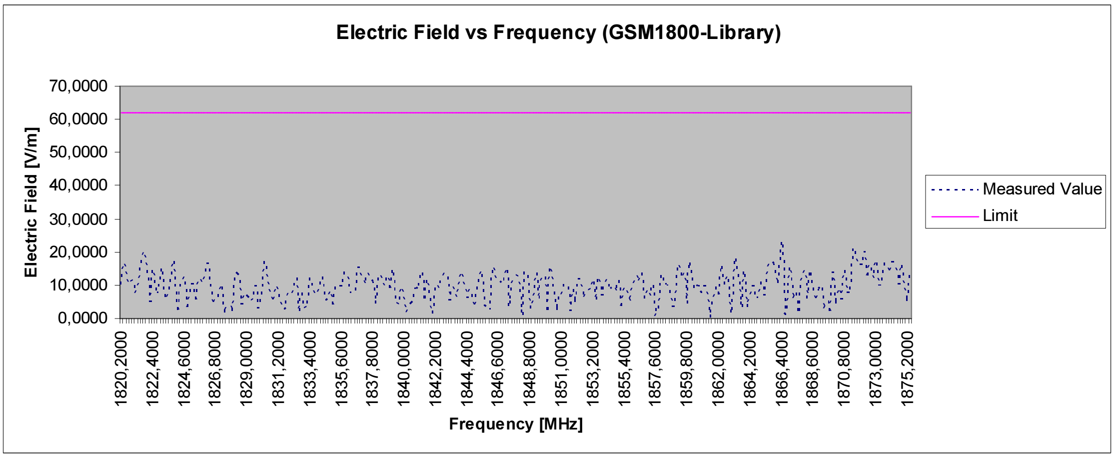

Fig. 2: Electric field intensity measured at central library for GSM1800 signals

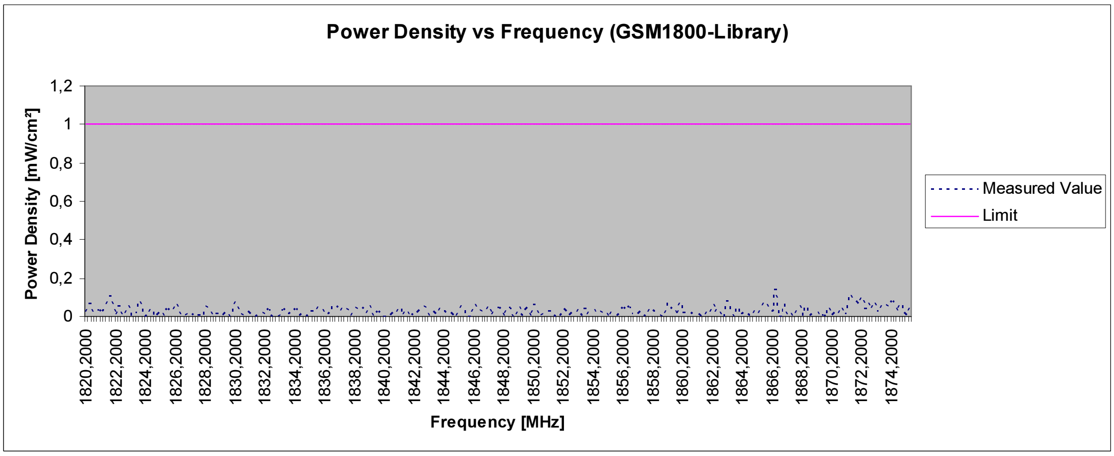

Fig. 3: Power density measured at central library for GSM1800 signals

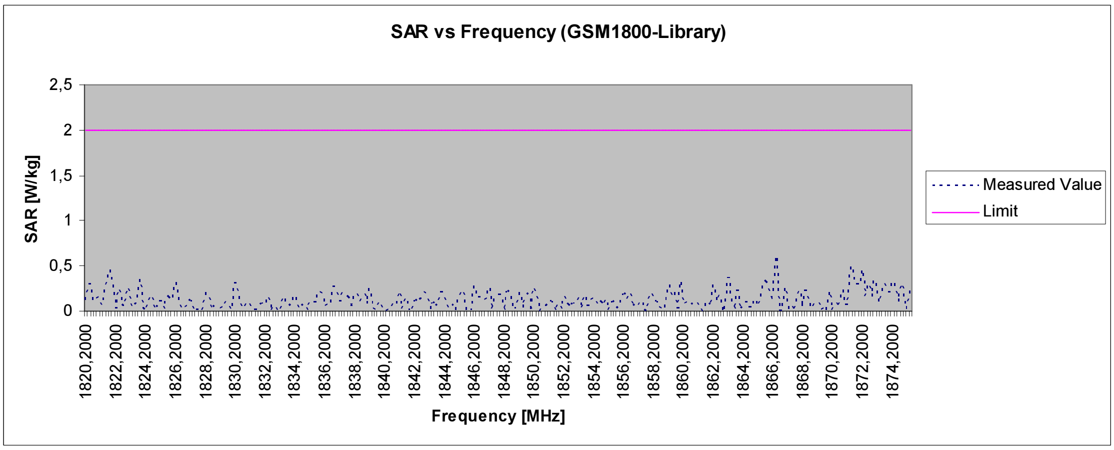

Fig. 4: Specific absorption rate measured at central library for GSM1800 signals

location over limit that was given by ICNIRP[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.

Table 4: Tissue dielectric properties for human brain

Frequency (MHz)	Relative Permittivity	Conductivity ($\Omega^{-1}m^{-1}$)	Mass Density (kg/m^3)
900	45.8055	0.7665	1030.0
1800	43.5449	1.1531	1030.0

Table 5: Percentage for highest peak measured values over limits for GSM900

Measurement Locations	Electric Field (%)	Power Density (%)	SAR (%)
Central Library	20.44	4.34	3.88
Hostel3	18.91	3.72	3.32
Artificial Tree	18.91	3.71	3.28
Hostel2	17.72	3.26	2.93
Hostel1	17.14	3.05	2.72
Hostel4	17.06	3.02	2.70
Rector Office	16.67	2.90	2.58
Faculty of Economics	15.81	2.60	2.27

Table 6: Percentage for highest peak measured values over limits for GSM1800

Measurement Locations	Electric Field (%)	Power Density (%)	SAR (%)
Central Library	34.38	12.05	25.43
Hostel3	32.8	10.1	23
Artificial Tree	33.8	11.7	24.95
Hostel2	32.3	11	22.4
Hostel1	34.05	11.9	24.8
Hostel4	32.16	10.55	22.26
Rector Office	33.2	11.6	24.0
Faculty of Economics	33.4	11.0	24.8

For GSM1800 system, the readings produced by the RFEX indicated that the highest reading of electric field and power density are at the library. The value for electric field is 21.3133 V/m, which is 34.38% of the limit. . On the other hand, the reading for power density is 0.1205 mW/cm^2, which is 12.05 % of the limit. The calculation for SAR gives the value of 0.5085 W/kg, which is 25.43 % of the limit.

The lowest value was at student hostel 4 with reading for electric field is 19.9388 V/m, which is 32.16 % of the limit. The value for power density is 0.1055 mW/cm^2, which is 10.55 % of the limit. The calculation of SAR gives the value of 0.4451W/kg, which is 22.26 % of the limit.

The preliminary results indicate that all the values for electric field, power density and the calculated SAR inside IIUM campus were very low compared to the limit given by ICNIRP, MCMC, IEEE and other recognized bodies. Therefore it is not considered to be hazardous to the people in the surrounding area of the cellular base stations inside IIUM campus.

But it is very important to mention here that electric fields had been observed in all eight locations at 2.4 GHz. At Central Library this field had been measured to 37.8 V/m, which is 62% of ICNIRP limit. At student hostel1, the measured field at 2.4 GHz was 38.4 V/m, which is 63% of safety limit. At theses levels of electric field intensities, estimated SAR values exceed 80% of limit. The sources of these signals are unknown but it seems that the signals at 2.4 GHz and around transmit from Wireless LAN. Therefore, it is very urgent to investigate the radiations from Wireless LAN, which is increasing rapidly in indoor environments.

CONCLUSION

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 GH z 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 it's population.

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