



Radio Frequency Radiation Study

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The use of sophisticated wireless communications devices has been increasing exponentially over the past decades in line with the needs of high speed communication. These include the use of mobile phones as well as the unregulated installation of WLAN access points (AP) at home and public places. Figure 1.1 shows the cellular phones penetration rate in Malaysia from year 2000 until third quarter of year 2008. The penetration rate of cellular phones user has exceeded 100% by the end of 2009.

Other than the mobility offered by mobile phones, the plans and packages offered by the telecommunication companies (telcos) also play a major role in contributing to this growth. Telcos tend to lower the tariffs with respect to the competition pressure amongst them. This makes mobile phone services cheaper and affordable even for low-income groups, and hence increases the demand for the service.

In ensuring the quality of services to their customers and competitions from other service provider, the telcos have to build more base stations at very strategic locations. These locations, most of the times were located in highly populated areas such as on the roof top of the shop lots,

Telefon Selular di Malaysia
Cellular Phones in Malaysia

Tahun	Suku	Pasca bayar (000)	Pra bayar (000)	Jumlah langganan (000)	Kadar Penembusan (%)
2000		2,599	2,523	5,122	21.8
2001		3,069	4,316	7,385	30.8
2002		2,961	6,092	9,053	36.9
2003		2,566	8,558	11,124	43.9
2004		2,555	12,057	14,611	56.5
2005		2,925	16,620	19,545	74.1
2007	1	3,392	17,427	20,819	77.0
	2	3,485	17,734	21,219	78.2
	3	3,689	18,380	22,069	80.8
	4	3,905	19,442	23,347	85.1
2008	1	4,137	20,116	24,253	87.9
	2	4,451	20,635	25,086	90.6
	3	4,926	21,236	26,162	93.9
Year	Quarter	Postpaid ('000)	Prepaid ('000)	Total subscriptions ('000)	Penetration Rate (%)

Figure 1.1: Mobile Phone Penetration Rate in Malaysia (Source: SKMM)

apartments or the telcos would build their own base station towers at the edge of the open space such as playing field or parking lots of the shopping complexes. The number of base stations built by telcos in residential areas has raised concerns from the residents about possible radio wave effects caused by these base stations to them.

The communication between mobile phones and base stations involves the exchange of radio signals. The radio link from the phone to the base station is known as uplink, while the radio link from the base station to the phone is known as downlink. The level of these signals is carefully optimised for the network to perform satisfactorily. The areas covered by base stations are usually referred to as cells. However, transmitted signal strength falls off with distance from base stations, and mobile phones require certain minimum signal strength to ensure adequate reception. Due to this, the telcos install more mobile phone base stations to meet the rapidly increasing demand of mobile phone users. Along with the increment in the number of base stations is the public concern on health issues from it.

Several bodies were established internationally to address these issues. These bodies came out with guidelines and standards aiming to allay public fear on the effect of radio frequency radiation. These bodies include International Commission on Non-Ionizing Radiation Protection (ICNIRP), Institute of Electrical and Electronics Engineers (IEEE), the National Radiological Protection Board (NRPB) in the United Kingdom, Industrial Technology Research Institute (ITRI) of Taiwan, the Australian Radiation

Protection and Nuclear Safety Agency (ARPANSA) and many more.

Standardisation And Exposure Guideline

Different institutions have different standards in assessing the exposure levels. These institutions include ICNIRP and IEEE. Normally, countries will adopt the standards advised by these bodies. Figure 1.2 shows standards adopted by countries around the world. Most European and Asian countries adopt the standard set by ICNIRP. The International Telecommunications Union (ITU) recommends the adoption of ICNIRP standards for countries without such regulations.

ICNIRP Standards

ICNIRP standard is explained in “Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz)”, published in 1998 [5]. The document aims to establish guidelines for limiting electromagnetic field exposure that will provide protection against known adverse health effects.

Figure 1.3 shows the graph of ICNIRP standard for both occupational environment and general public exposure. The maximum exposure limit (MPE) varies according to the frequency.

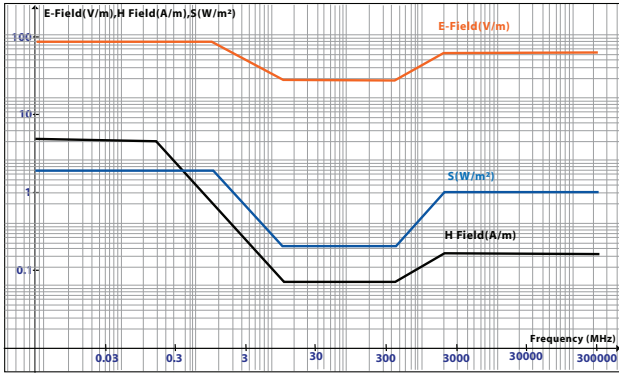
The black coloured line illustrates magnetic field limit in ampere per metre (A/m) and the red coloured line illustrates electric field limit in volt per metre (V/m). The blue coloured line illustrates the power density in milliwatts per square centimetre (mW/cm²).

IEEE Standards

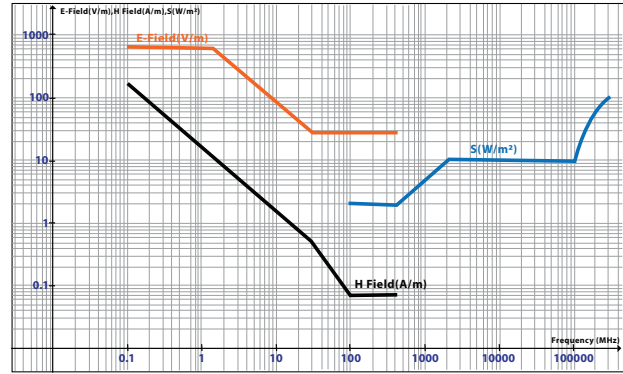
IEEE standards is explained in “IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz”, C95.1-2005 document. The document provides the recommendations to protect against harmful effects in human beings exposed to electromagnetic fields in the frequency range from 3 kHz to 300 GHz, for both the general public and occupational exposure. Figure 1.4 shows the graph of IEEE C95.1-2005 standard for general public exposure. The maximum exposure limit (MPE) also varies according to the frequency.

The black coloured line illustrates the magnetic field limit in Ampere per metre (A/m), while the red coloured line illustrates the electric field limit in Volt per metre (V/m); and where applicable, the power density limits in watts per square metre (W/m²) is illustrated in blue line.

IEEE C95.1-2005 standard is a revised version of IEEE C95.1-1991. Both ICNIRP and the new IEEE standards have



ICNIRP Standards for Occupational and General Public



IEEE C95.1-2005 Standards for General Public

relatively small difference, and are identical at frequencies used in mobile telecommunications systems. The revised C95.1 standard was harmonised with the ICNIRP standard in 2005. The process of global harmonisation of RF standards was supported by the Mobile Manufacturers Forum (MMF) which will benefit both the consumers and manufacturers of wireless devices and regulators.

RFR Study In Other Countries

A number of studies have been carried out to study the amount of Radio Frequency Radiation (RFR) emission from the Wireless Local Area Network (WLAN) and mobile phone base stations and to identify potential health risk caused by RFR from WLAN and mobile phone base stations. Result of the study carried out by the NRPB at 20 mobile phone base station sites selected in random from a group of 3000 that has a low antenna height and radiated low power in United Kingdom concluded that the members of public would not be exposed in excess of the ICNIRP guidelines whilst standing on the ground at any of the sites.

A study carried out by the ARPANSA on the RF electromagnetic emission (EME) levels in the vicinity of mobile phone base stations in 14 sites in Australia concluded that the average RF exposure level from mobile phone base station was considerably less at $0.0016 \mu\text{W}/\text{cm}^2$ as the limit of power flux density is $200 \mu\text{W}/\text{cm}^2$. In Poland, where the maximum permissible power density value is $0.01 \text{ mW}/\text{cm}^2$ at relevant base station frequencies, measurement of electromagnetic field (EMF) in the surrounds of 20 mobile phone base stations showed that admissible EMF intensities at the level of people's presence, in existing buildings, in surroundings of base stations and inside the buildings with antennas, were not exceeded.

A study carried out by the Somerset Scientific Services to assess the RF exposure level from two WLAN in use at county schools in the UK indicates that the exposures are well within the ICNIRP standard. The Office of the Telecommunications Authority (OFTA) of Hong Kong had carried out measurements to assess the RF exposure level emitted by WLAN Access Points (APs) from September 2007 until October 2008. The report states that the exposure level at

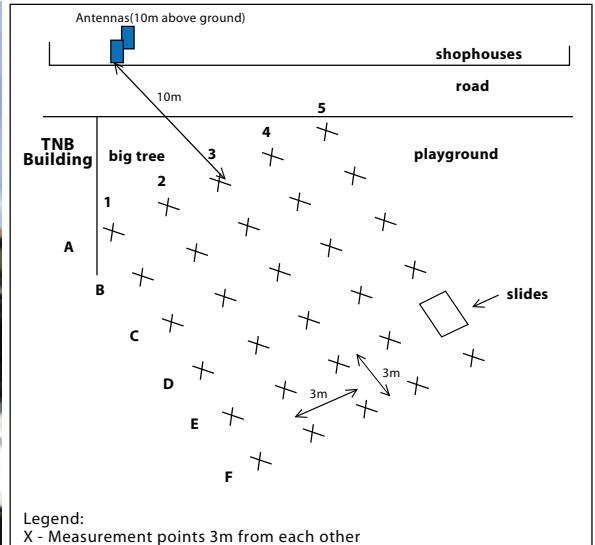
measured locations range from 0.03% to 0.3% of the limits recommended by ICNIRP.

RFR Study In Malaysia

In Malaysia, several measurements had been carried out for base stations by the Malaysian Institute of Nuclear Technology (MINT) and Universiti Islam Antarabangsa Malaysia (UIAM). This research complements the measurements with updated findings for the base station based on the measurements carried out in year 2008. The RFR emission for WLAN however, has not been investigated in Malaysia and our attempt will be the first of its kind.

WLAN Measurements in Kuala Lumpur and Johor Bahru

The methodology for measuring the RFR from WLAN was developed based on best practices in ICNIRP and IEEE. Field measurements were instrumented using broadband isotropic RF metres positioned at approximate heights of 1 metre and 1.5 metre. RF metre positioning is adjusted within the location to get the optimum reading. At the maximum reading spot, Wireless LAN spectrum analyser (WLAN SA) with antenna was used to span the frequency for WLAN, i.e. 2.4GHz – 2.5GHz and measurements were recorded for every 6 minutes up to 24 minutes. Generally, popular locations, whereby the concentration of Wi-Fi hotspots and users are high, were selected for RFR measurements. In Kuala Lumpur's Golden Triangle, the measurement sites identified were Suria, KLCC; SOGO, Kuala Lumpur; and Low Yat Plaza. Measurement sites selected at Johor Bahru were City Square Johor Bahru, McDonald's Jalan Skudai, Danga City Mall, Jaya Jusco Taman Universiti and also The Zon. Based on the broadband measurements made at the 8 sites, SOGO was found to have the highest recorded WLAN radiation in the area with electric field strength of $0.00303 \mu\text{W}/\text{cm}^2$ in Kuala Lumpur. Whereas, McDonald's Jalan Skudai was found to have the highest recorded WLAN radiation in the area with electric field strength of $1.015 \mu\text{W}/\text{cm}^2$ at Johor Bahru. When compared, the highest recorded reading made during the study was far below the MPE standard set by the international bodies like ICNIRP, i.e. $0.2 \text{ mW}/\text{cm}^2$.



One of the sites and measurement grid points made of the site

Base Station Measurements in Kuala Lumpur and Johor Bahru

RFR from base stations measurement methodology was also developed based on best practices from other countries and institutions such as ICNIRP and IEEE. Measurements were conducted using broadband isotropic RF metre at height of 1.5 m above ground level, which is about the height of an average human and the electric field strength metre was set to max-hold mode for six minutes. The results were then compared to the lowest maximum permissible exposure set by ICNIRP (0.2 mW/cm²) to emulate worst case scenario. Narrowband measurements were carried using Advantest U3741 spectrum analyser when the reading at a point exceeds 0.2 mW/cm² or at the point that gives the highest reading at the each site.

A total of ten sites, five located in Kuala Lumpur and another five in Johor Bahru, were selected for measurement. Base stations identified at Kuala Lumpur were at Wisma Lim Foo Yong, Lorong Datuk Sulaiman, Jalan Pandan Indah, Jalan Wangsa Murni and Jalan Pandan Ilmu. Base stations identified at Johor Bahru were at Jalan Kuching, Restoran Taat, Johor Tourist Information Center, Jalan Wong Ah Fook and Hotel A. The highest recorded reading using the broadband measurement was at Hotel A, which is 0.004331 mW/cm². The results show that the radiation levels for all 10 sites are below the maximum permissible exposure set by ICNIRP of 0.2mW/cm².

Health Concerns

New telecommunications technologies have been introduced without full provision of information about their nature and without prior discussion within the scientific community about possible consequences for health. The average output power from the antennas of digital mobile phones is lower than that from earlier analogue models, but the maximum powers are greater, the exact patterns of radiation are different and these differences might influence

their effects on people. As the costs of mobile phone technology have fallen, their use has increased dramatically and the overall levels of exposure of the population as a whole have therefore increased.

Radiofrequency radiation from wireless communications facilities has become a large public health concern in many countries of the world. People are not only concerned about the growing weight of scientific evidence linking health effects to mobile phone use, they are increasingly worried about chronic, low-level exposure to base stations or cell sites.

In the last 40 years, there are numerous studies on health effects caused by electromagnetic energy (EME) radiated by mobile phones, base stations and other RF transmitters. These health effects can be divided into two: thermal and non-thermal effects. Several factors have been taken into account in the studies on health effects by EME sources such as the level of exposure (i.e. power density), frequency and the duration of exposure (short and long term exposure).

Lab tests were carried out on animals such as rats, rabbits, dogs, guinea pigs, etc. The animals were exposed to various factors as stated above. Among the effects studied were hyperthermia and gross thermal effects, effects on the eyes, endocrine and nervous system, effects on reproduction and development and so forth.

As for the effects on human, studies were carried out on personnel involved in installing, maintaining and repairing RF devices. Among the effects studied were possible effects on the eyes, effects on reproduction and development and cardiovascular effects. Weak non-ionizing radiation, such as that from mobile phones, mobile phone base stations and Wi-Fi has been shown to have biological effects, ranging from changes in brain function to the exacerbation of allergies and the induction and promotion of cancer.

A number of scientific studies have investigated possible health effects of mobile phone radiations. These studies are collected and reviewed by scientific committees at the World Health Organisation (WHO), ICNIRP and other

similar bodies to assess the overall risks. Most of the assessments conclude that, from the available research, there are no significant health effects that have been demonstrated from mobile phone radiation at normal exposure levels. However, there are scientific evidence for mobile phone, mobile base stations and WLAN causing biological effects and potentially can become health hazards for the public.

In the year 2000, World Health Organization (WHO) recommended that the precautionary principle could be voluntarily adopted in this case. It follows the recommendations of the European Community for environmental risks. Precautionary principle is a risk management policy applied in circumstances with a high degree of scientific uncertainty, reflecting the need to take action for a potentially serious risk without awaiting the results of scientific research. Other less stringent recommended approaches are prudent avoidance principle and ALARA (As Low as Reasonably Achievable). Although all of these are problematic in application, due to the widespread use and economic importance of wireless telecommunication systems in modern civilisation, there is an increased popularity of such measures in the general public, though also evidence that such approaches may increase concern. Recommendations include minimisation of cellphone usage, the limitation of use by at-risk population (children), the adoption of cellphones and microcells with ALARA levels of radiation, the wider use of hands-free and earphone technologies such as Bluetooth headsets, the adoption of maximal standards of exposure, RF field intensity and distance of base stations antennas from human habitations.

After 10 years of surveillance and study, in May 2006, the World Health Organization (WHO) issued Fact Sheet No. 304 under the Electromagnetic Fields and Public Health, entitled Base Stations and Wireless Technologies. Among others, the fact sheet stated that:

- Recent surveys indicate that RF exposures from base stations are between 0.002% to 2% of the international standards.
- RF exposures from base stations are lower or comparable to RF exposures from radio and television broadcast transmitters.
- Because of the low frequency of radio (around 100 MHz) and television (300-400 MHz), human body absorbs up to 5 times more of these signal than from base stations. In addition, radio and television broadcast have been in operation for the past 50 or more years without any adverse health consequence being established.
- A common concern about base stations and local wireless network relates to the possible long-term health effects that whole body exposure may have.

As for the link to cancer, the fact sheet stated that geographically, cancers are unevenly distributed among any population. Given the widespread presence of base stations in the environment, it is expected that possible cancer clusters will occur near base stations by chance. Moreover, cancers cases reported in these clusters are often

a collection of different type of cancer with no common characteristics and hence are unlikely to have a common cause. Studies examining a potential relationship between RF transmitters and cancer published over the past 15 years have not provided evidence that RF exposures increase the risk of cancer. Likewise, long term animal studies have not established an increase risk of cancer from exposure to RF fields, even at values higher than those produced by base stations and wireless networks.

Studies have also been conducted on Electromagnetic Hypersensitivity (EHS) individuals as described in WHO Fact Sheet No 296 which was published in December 2005. EHS individuals are individuals who experience non-specific symptoms upon exposure to RF Fields emitted by base station and other wireless transmitters. The aim of these studies was to bring forth symptoms under controlled laboratory conditions. For example, a study involving fifteen EHS individuals and normal controls exposed to electric and magnetic fields in their homes or workplaces was conducted. The result shows that EHS individuals were no better than control subjects in identifying their exposure to electric or magnetic fields during the experiment.

Conclusions

The era of pervasive and ubiquitous communications is inevitably coming and is very much dependent on wireless communications through radio frequency radiation. It is recommended that random audits be done regularly to ensure that the wireless communications environment conforms to international safety levels. The radio frequency radiation readings recorded for selected WLAN and base stations sites in KL and JB in our study were found to be far below the international service safety level.

End Note: Md Zaini Jamaludin, Nagaletchumi Balasubramaniam, Aiman Ismail and Thahirah Syed Jalal were in the team that carried out the study

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