REPORT ON
RADIOFREQUENCY AND MICROWAVE RADIATION MEASUREMENTS AROUND TELECOMMUNICATION TOWERS, TAMAN DAYA, JOHOR BHARU, JOHOR

A report prepared for

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By

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EXECUTIVE SUMMARY

D'Harmoni Telco Infra Sdn. Bhd. requested Malaysian Nuclear Agency (Nuclear Malaysia) to conduct a radiofrequency (RF) and microwave (MW) radiation measurement around the two tower base stations (BTS) located at Taman Daya, Johor Bharu, Johor. The measurement was requested by the company with aims to know the level of RF and MW radiations emitted by antennas of the towers.

Nuclear Agency's Non-Ionising Radiation (NIR) Group carried out the measurement on 29th October 2008. In carrying out the work, the Group was assisted by personals from the company.

The main objectives of the measurement were to determine and assess radiofrequency and microwave radiation present in all accessible places within and around the tower and, to assist the company on outcomes of the measurement data in compliance with the local and international recommendations of standard and guidelines issued by the Malaysian Communications and Multimedia Commission (MCMC) and the International Commission on Non-Ionising Radiation Protection (ICNIRP).

The measurement was encompassed only on the assessment of the RF and MW radiation generated by the antennas from the tower present at the ground level (about 1.5meter from the ground). It was not intended to cover other safety aspects, which might also present at the site during measurement. The measurement was arranged to include both the electric field strength and power density at identified measurement locations around the BTS. Measured radiations were assessed and evaluated against the exposure limits and the recommendations of standard guidelines issued by the MCMC and ICNIRP.

The radiofrequency and microwave radiation present at the tower area were measurable but of low levels. The electrical field strengths were well below the exposure limits stipulated by the MCMC and ICNIRP guidelines for workers and members of the public. The broadband radiation levels observed were found to vary between 1.00μWatts/cm^2 and 2.00μWatts/cm^2 (0.97V/m and 2.80V/m) of which the highest level corresponds to about 0.32% or over than 300x lower than of the MCMC exposure limit for public.

Based on the findings of these measurement, we strongly believe that the presence of the radiofrequency and microwave radiation emitted by the antennas from the BTSs with the present loads would not lead to any significant radiation exposure received by residence or workers in the areas around the facility.

It should be noted that with adding in new antennas at the tower or increasing the transmitted power of the existing antennas is likely to enhance the radiation levels and if this is occurred it may require a new assessment to be carried out on site.

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1. INTRODUCTION

D'Harmoni Telco Infra Sdn. Bhd. requested Malaysian Nuclear Agency (Nuclear Malaysia) to conduct a radiofrequency (RF) and microwave (MW) radiation measurement around the two tower base stations (BTS) located at Taman Daya, Johor Bharu, Johor. The measurement was requested by the company with aims to know the level of RF and MW radiations emitted by antennas of the towers.

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2. OBJECTIVE

The main objectives of the measurement were

a) to determine and assess RF and microwave radiation present in all accessible places within and around the towers and
b) to assist the company on outcomes of the measurement data in compliance with the local and international recommendations of standard and guidelines issued by the Malaysian Communications and Multimedia Commission (MCMC) and the International Commission on Non-Ionising Radiation Protection (ICNIRP).

3. SCOPE OF THE MEASUREMENT

The measurement was encompassed only on the assessment of the RF and microwave radiation generated by the antennas from the towers present at the ground level (about 1.5meter from the ground). It was not intended to cover other safety aspects, which might also present at the site during the measurement. The measurement was arranged to include both the electric field strength and power density at identified measurement locations around the BTS. Measured radiations were assessed and evaluated against the exposure limits and the recommendations of standard guidelines issued by the MCMC and the ICNIRP. A conclusion and recommendations were elaborated base only on results of the measurements.

4. DESCRIPTION OF SURVEY SITE AND RADIATION SOURCE

The site involved in this measurement is around the towers base station (BTS) located next to the water reservoir on a small hill. The site was near to residential areas in Taman Daya, Johor Bharu. Geographically, the condition of the survey site and its immediate surrounding areas is hilly. Most of the residential houses are on flat ground areas, of levels lower than the base of the tower. Such situation provides an advantage in minimising public exposure to the radiation.

There are two BTS towers at the site. The first tower (monopole) of 30 meters height occupied by DiGi and Maxis antennas, while the second tower are occupied by Celcom antennas. It was assumed that the radiation level during the measurement were only from the sources of the antennas at the towers. At the time of the measurement, the first tower consist of 9 rectangular antennas, and 4 units of point-to-point parabolic antennas, while the second tower are occupied by 9 rectangular antennas and two point-to-point parabolic antenna.

For the first tower, biggest sizes of the rectangular antennas are 2.080 meter that owned by Maxis, 1.2 metre owned by Digi and parabolic antennas of about 0.61 meter (2ft) diameter.

For the second tower, the biggest sizes of Celcom rectangular antennas is 1.3 meter and the 1.22 meter (4ft) for parabolic antennas. The rectangular antennas which belongs to Maxis are fixed at 30 and 18 metres from the ground, while DiGi and Celcom antennas at 23 metres and 22 meter height respectively. Rectangular antennas are fixed in different direction (sectors) to ensure that there are always good uplink and downlink signals being transmitted and received from users in areas within those sectors. The RF radiations are transmitted within the frequency range of 925MHz to 2155MHz. The parabolic antennas are, on the other hand, used for point-to-point communication and they are mounted at various heights. The parabolic antennas used by mobile systems normally transmit microwave radiation at frequencies within the range of 4 GHz to 19 GHz.

Since the primary radiation beam produced by parabolic antenna is usually projected out horizontally way above the ground and in collimated manner, this condition would never made the primary radiation touch the ground at any points along its projected direction. This was confirmed from the previous measurement made by Nuclear Malaysia around the similar type of tower loads elsewhere. Similarly, since the rectangular antennas were positioned vertically with a small tilt angle toward the ground, their low radiations can, therefore, hardly be detected at locations below or within immediate vicinity of the tower. However, in reality, one can still find some radiation present in these areas that contributed by low frequency radio and TV signals and very high frequency signals from other microwave and mobile telephone systems. In view of the orientation and special design of the antennas, which allows only radiation beam to cut across a small section in air, and no high-rise buildings or structures present in immediate vicinity, it is expected that the scattered radiation is very small.

5. SAFETY GUIDELINES AND EXPOSURE LIMITS

For the purpose of this measurement, relevant safety guidelines and standards produced by local and international organisations, namely Malaysian Communications and Multimedia Commission (MCMC) and ICNIRP (ICNIRP 1998) were referred.

The most relevant local guidelines available at the moment are the one issued by Jabatan Telekomunikasi Malaysia (JTM) entitled 'Regulatory Framework on the Sharing of Radiocommunications Infrastructure (REG – R 002)', which was published in 1998 (JTM 1999) and have since been adopted and used by MCMC as standard guidelines for regulating radio communication industry in the country. These guidelines were established based on ICNIRP standard guidelines. The permissible exposure limits for both workers and members of the public excerpted from these guidelines are given in Tables 1 and 2.

Table 1: Radiofrequency and microwave radiation exposure limits for workers as recommended by MCMC and ICNIRP (For the purpose of comparison and easy reference, the exposure limits adopted by other countries are also included).

COUNTRY/ ORGANIZATION	RADIOFREQUENCY AND MICROWAVES			
	FREQ.	ELECTRIC FIELD (V/m)	MAGNETIC FIELD (A/m)	POWER DENSITY ($\mu W/cm^2$)
UK	30MHz-400MHz	61.4	0.163	1000
	400MHz-2GHz	$97.1(f/1000)^{0.5}$	$0.258(f/1000)^{0.5}$	f/0.4
	2GHz-300GHz	137	0.364	5000
IRPA/ ICNIRP	10MHz-400MHz	61	0.16	1000
	400MHz-2GHz	$3f^{0.5}$	$0.008f^{0.5}$	f/0.4
	2GHz-300GHz	137	0.36	5000
AUSTRALIA	100 kHz – 1 MHz	614	1.63/f	-
	1 MHz – 10 MHz	614/f	1.63/f	$10,000/f^2$
	10 MHz – 400 MHz	61.4	0.163	1000
	400 MHz- 2GHz	$3.07 \times f^{0.5}$	$0.00814f^{0.5}$	f/0.4
	2 GHz – 300 GHz	137	0.364	5000
CENELEC	10MHz-400MHz	61.4	0.16	NAV
	400MHz-1.5GHz	61.4-137	0.16-0.364	NAV
	1.5GHz-150GHz	137	0.364	NAV
MALAYSIA (MCMC)	30MHz – 300MHz	60	0.163	1000
	300MHz – 1.5GHz	$3.46f^{0.5}$	$0.0093f^{0.5}$	f/0.3
	1.5GHz – 300GHz	140	0.36	5000

Note: Frequency (f) in MHz
NAV – Not Available

Table 1: Radiofrequency and microwave radiation exposure limits for workers as recommended by MCMC and ICNIRP (continue).

COUNTRY/ ORGANIZATION	RADIOFREQUENCY AND MICROWAVES			
	FREQ.	ELECTRIC FIELD (V/m)	MAGNETIC FIELD (A/m)	POWER DENSITY ($\mu W/cm^2$)
USA/ ACGIH	30MHz-100MHz	61.4	0.163	1000
	100MHz-1GHz	61.4(f/100)	0.163(f/100)	f/0.1
	1GHz-300GHz	194.16	0.515	10,000
USA/ANSI/ IEEE	30MHz-100MHz	61.4	16.3/f	1000
	100MHz-300MHz	61.4	0.163	1000
	300MHz-3GHz	NAP	NAP	f/0.3
	3GHz-15GHz	NAP	NAP	10,000
	15GHz-300GHz	NAP	NAP	10,000
CANADA	30MHz - 300MHz	60	0.163	1000
	300MHz-1.5GHz	$3.54f^{0.5}$	$0.0094f^{0.5}$	f/0.3
	1.5GHz-15GHz	137	0.364	5000
	15GHz – 150GHz	137	0.364	5000
	15GHz – 300GHz	$0.354f^{0.5}$	$9.4x10^{-4} f^{0.5}$	$3.33 \times 10^{-2} f$

Note: Frequency (f) in MHz

Table 2: Radiofrequency and microwave radiation exposure limits for members of the public as recommended by MCMC and ICNIRP (For the purpose of comparison and easy reference, the exposure limits adopted by other countries are also included).

COUNTRY/ ORGANIZATION	RADIOFREQUENCY AND MICROWAVES			
	FREQ.	ELECTRIC FIELD (V/m)	MAGNETIC FIELD (A/m)	POWER DENSITY ($\mu W/cm^2$)
IRPA/ ICNIRP	10MHz-400MHz	27.5	0.073	200
	400MHz-2GHz	$1.375f^{0.5}$	$0.0037f^{0.5}$	f/2
	2GHz-300GHz	61	0.16	1000
AUSTRALIA	100 kHz – 150 kHz	86.8	4.86	-
	150 kHz – 1 MHz	86.8	0.729/f	-
	1 MHz – 10 MHz	$86.8/f^{0.5}$	0.729/f	-
	10 MHz-400GHz	27.4	0.0729	200
	400 MHz – 2 GHz	$1.37f^{0.5}$	$0.00364f^{0.5}$	f/2
	2 GHz - 300 GHz	61.4	0.163	1000
MALAYSIA (MCMC)	30MHz – 300MHz	28	0.073	200
	300MHz – 1.5GHz	$1.616f^{0.5}$	$0.00433f^{0.5}$	f/1.5
	1.5GHz – 300GHz	62	0.16	1000

Note: Frequency (f) in MHz

Table 2: Radiofrequency and microwave radiation exposure limits for members of the public as recommended by MCMC and ICNIRP (continue).

COUNTRY/ ORGANIZATION	RADIOFREQUENCY AND MICROWAVES			
	FREQ.	ELECTRIC FIELD (V/m)	MAGNETIC FIELD (A/m)	POWER DENSITY ($\mu W/cm^2$)
USA/ANSI /IEEE	30MHz-100MHz	27.5	$158.3/f^{1.668}$	200
	100MHz-300MHz	27.5	0.0729	200
	300MHz-3GHz	NAP	NAP	f/1.5
	3GHz-15GHz	NAP	NAP	f/1.5
	15GHz-300GHz	NAP	NAP	10,000
CANADA	30MHz - 300MHz	28	0.073	200
	300MHz-1.5GHz	$1.585f^{0.5}$	$0.0042f^{0.5}$	f/1.5
	1.5GHz-15GHz	61.4	0.163	1000
	15GHz – 150GHz	61.4	0.163	1000
	150GHz – 300GHz	$0.158f^{0.5}$	$4.21 \times 10^{-4} f^{0.5}$	$6.67 \times 10^{-3} f$
UK	30MHz-400MHz	61.4	0.163	1000
	400MHz-2GHz	$97.1(f/1000)^{0.5}$	$0.258(f/1000)^{0.5}$	f/0.4
	2GHz-300GHz	137	0.364	5000

Note: Frequency (f) in MHz

As indicated from Tables 1 and 2, the exposure limits are referred to RF and microwave radiation frequency involved and are set differently for workers and members of the public. Public being more critical to radiation because of longer exposure time involves, unknown exposure situation and more diverse in term of health status and age groups represented, has had the limits established at much lower levels (by 2 to 5 times) than the workers.

As clearly shown in Tables 1 and 2, the permissible limits for occupational and public exposure appear to be more stringent at the lower frequencies of the radiofrequency and microwave radiations. For the lowest frequency radiation expected to be transmitted by the antennas at the towers (925 MHz), the limits for workers are 3083μWatts/cm^2 or 105V/m of electric fields strength and 0.28A/m of magnetic fields strength, while for members of the public are 617μWatts/cm^2 or 49V/m of electric fields strength and 0.13A/m of magnetic fields strength. For comparison and easy reference, the exposure limits adopted by other countries are also included in the tables.

The permissible exposure limits were established to protect workers and the general population from adverse effects of exposure to radiofrequency and microwave radiation. The limits were based on the findings of extensive scientific researches carried out by over than 15,000 scientific groups in different parts of the world. The international scientific committees and agencies else where, such as, ICNIRP (ICNIRP 1998), IEEE (IEEE 1991), World Health Organisation (WHO 1998) and regulatory authority in many countries in the world (USFCC 1997, HWC 1999, NRPB 1988, ARPANSA 2002) believe that, based on validated scientific evidences available and our present knowledge on the subject, prolonged exposure at or below these limits are considered as safe and acceptable for the purpose of protection of human health.

6. STANDARD MEASUREMENT EQUIPMENT

The measurement was carried out using Holaday instrument attached with an isotropic electric field broadband probe model HI4455 (200kHz – 40GHz) and PMM instrument Model 8053 with an isotropic probe model PMM EP-330 (100kHz – 3GHz). The PMM instrument Model 8053 attached with an isotropic electric field probe Model PMM EP-33M was also used to measure the radiation contribution at the narrow range frequencies from 700MHz – 3GHz.

Additionally, the level of magnetic field was measured using an isotropic probe Model PMM HP-102 (30MHz – 1GHz) attached with the PMM instrument Model 8053.

Monitoring of radiation level for over 24 hour was conducted using PMM instrument Model 8055S with an isotropic probe model PMM EP-330 (100kHz – 3GHz). The above measurement equipment set-up is shown in Figure 2.

For details analysis of radiations involved, measurements were made using an Advantest Spectrum Analyser Model U3361 attached with two types of antenna which measure radiofrequency and microwave electric field strength from 300MHz up to 18GHz (Antennas Model 3146 from EMCO and Horn Antenna Model AH-118 from Com-Power Corporation).

To maintain the reliability and accuracy of the measurement, probes and instrument were calibrated at the recognized standard laboratory for every three years. Last calibration date for probes and equipment use in this measurement is given in Table 3. In addition to the calibration at standard laboratory each probe and instrument are routinely checked prior use for performance test in the GTEM5407 at the Non-ionizing Radiation Laboratory, Nuclear Malaysia.

Table 3: Type of probes and instrument use in the measurement.

Probe Type and Antenna	Frequency Range	Last Date of Calibration*
Holaday Isotropic Probe Model HI4455	200kHz – 40GHz	-
PMM instrument Model 8053 attach with PMM HP-102 PMM EP-330 PMM EP-33M	 30MHz - 1GHZ 100kHz - 3GHz 700MHz - 3GHz	 25 Jan. 2008 18 Jan. 2008 14 Dec. 2006 17 Jan. 2008
PMM instrument Model 8055S attach with PMM EP-33M	700MHz - 3GHz	9 Jan. 2008 17 Jan. 2008
Advantest Spectrum Analyzer Horn antenna Log Periodic Antenna	300MHz -18GHz	-

**Calibrated at Narda Safety Test Solutions S.r.l*

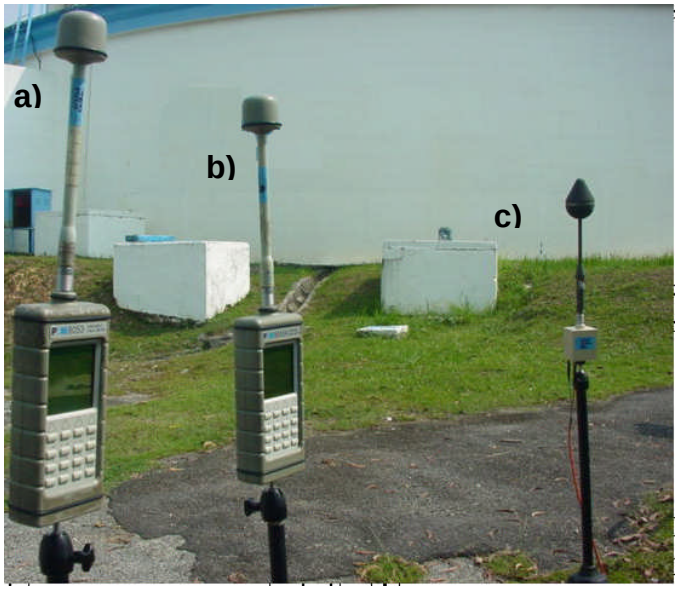


Figure 1: Measurement equipment, a) PMM instrument Model 8053 with probe model PMM EP-330, b) PMM instrument Model 8053 with probe Model PMM EP-33M, c) Holaday instrument with probe model HI4455

Figure 2. Set-up of PMM instrument Model 8055 with probe model PMM EP-33M for 24 hours monitoring.

7. METHOD OF MEASUREMENTS

The level of electromagnetic radiation were carried out in an accessible points within the tower compound and points at the nearby housing area. There were 15 measurement locations selected which included 7 locations at the tower compound and 8 locations around the site. All measurements were performed about 1.5meter above the ground. The locations of measurement selected was based on the worst-case situation i.e. those which were potential to present the higher radiation exposure to people living around the stations. Schematic of the measurement locations is shown in Figure 3, while Figure 4 shown the photograph of the tower taken from one of the selected measurement location.

The probes were mounted on a wooden tripod to minimize radiation interference and set at the height of about 1.5 metre from the ground to minimize ground reflection. Each measurement data was set for six minutes, this standard procedures are recommended by ICNIRP, IEEE, Canadian Safety Code 6 and Australia Standard (ICNIRP 1998, IEEE 1991, HWC 1999 AND ARPANSA 2002). Results of the measurements were recorded and presented as RF power density (μWatts/cm^2) and electrical field strength (V/m).

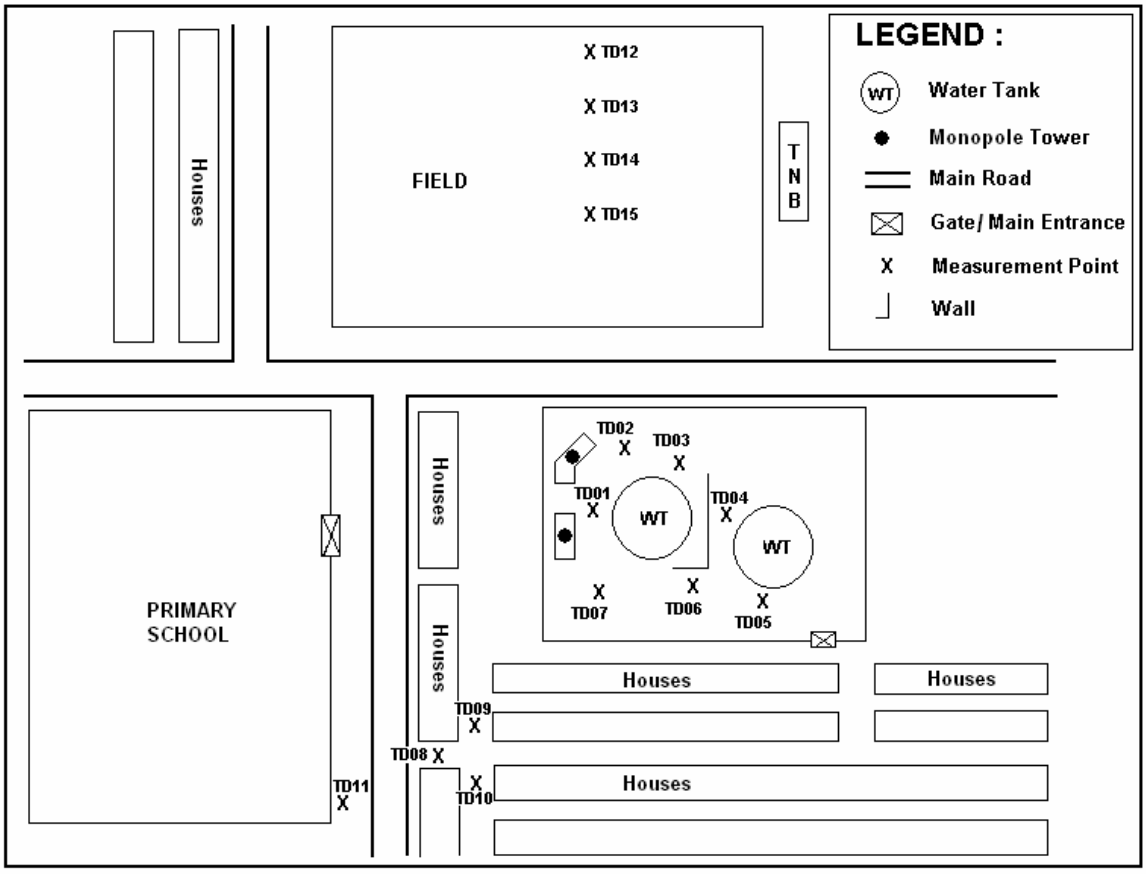


Figure 3: Layout of the measurement locations on the ground around the site

Figure 4. Photograph of Mobile Telephone Base Station Tower at Taman Daya a) left picture shows Celcom tower and b) right picture shows sharing DiGi and Maxis tower

8. RESULTS AND DISCUSSION

Results of the measurement carried out around the towers using different equipments are shown in Figures 5 and 6 . Details are given in Attachment A of Tables A1 to A5. The plots of Figure 5 and Figure 6 indicate the absolute radiation levels at measurement location and compared with the exposure limit recommended by the MCMC for workers and members of the public. The unit of measurements for all selected locations are given in power density (μWatts/cm^2) and electric fields strength (V/m).

Generally, the results indicate that radiation levels present at all measurement locations around the tower were very low and in compliance with the current exposure limit recommended by the MCMC (JTM Guidelines 1998) and the ICNIRP for workers and members of the public. The power density profiles do not show decreases with increasing distance from the tower but it were steady with little fluctuation. These were due to the measurement taken at off axis of the primary RF or microwave beams and other interference object from building structures and trees.

Broad band frequency measured by Holaday and PMM instruments indicate the overall (total) radiations present at the site during the measurement, which contributed by all RF and microwave sources including those emitted from antennas located at the tower. These electromagnetic radiations may lead to the exposure received by people whose living or working in the areas onsite. The averaged radiation levels measured over six minutes were found to vary between 1.00μWatts/cm^2 and 2.00μWatts/cm^2 (0.97V/m and 2.80V/m) of which the highest level corresponds to about 0.32% or over than 300x lower than of the MCMC exposure limit for public.

The readings of PMM instrument indicate the total RF radiations present onsite during measurement which including those emitted from antennas located at the tower. At all of measurement locations, the averaged radiation levels were found

to vary between 0.02μW/cm^2 (0.28V/m) and 0.38μW/cm^2 (1.20V/m) of which the highest level corresponds to about 0.06% or over than 1600x lower than of the MCMC exposure limit for public.

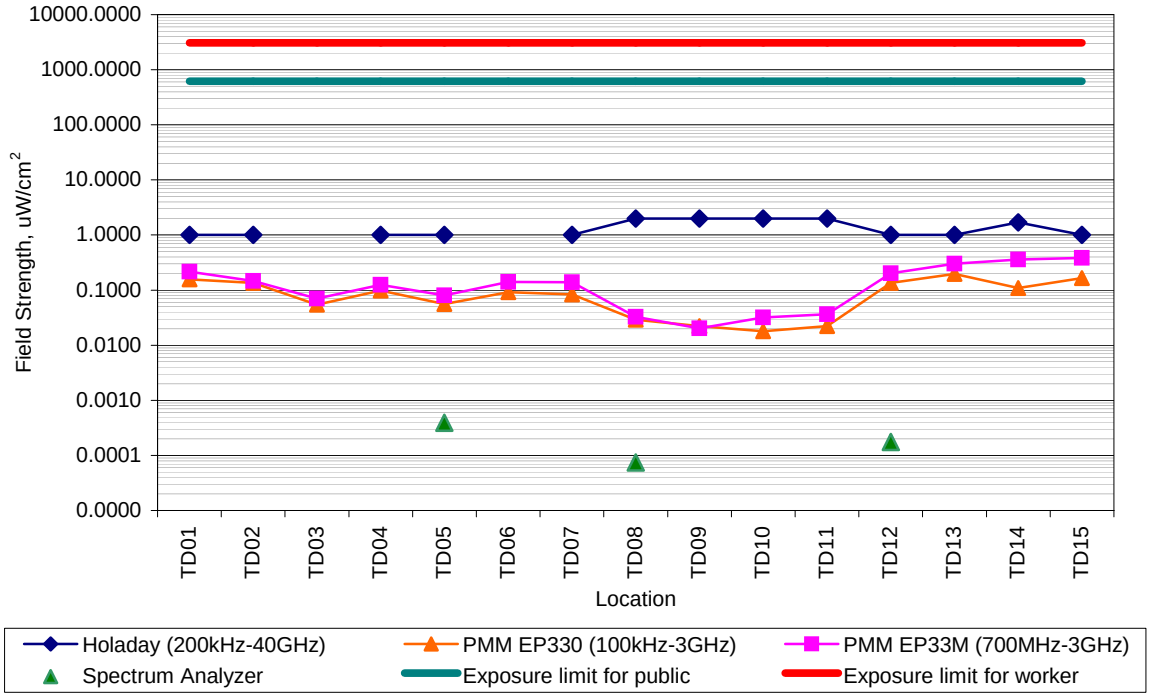


Figure 5: A plot of radiation levels in microwatts perunit area (μW/cm^2) against location of measurement (and their comparison with MCMC exposure limit for public)

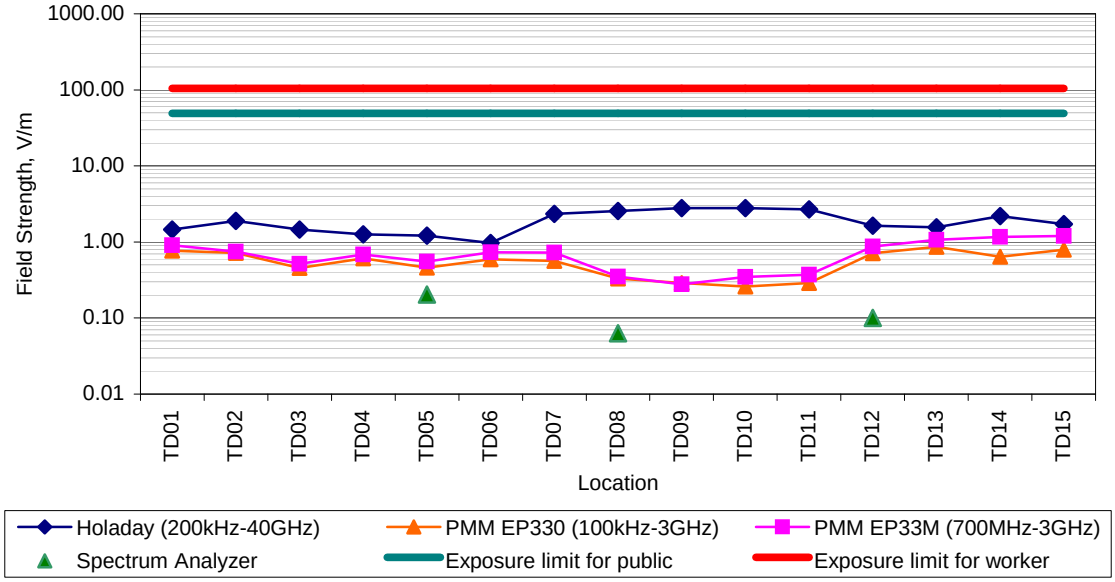


Figure 6: A plot of radiation levels in V/m against location of measurement (and their comparison with MCMC exposure limit for public)

The electrical field strength (V/m) pattern measured continuously for over than 24 hours was selected at location near TD05 (near fence). The results of continuous measurement over a period of 24 hours shown that the radiation levels were below than 2.6V/m.

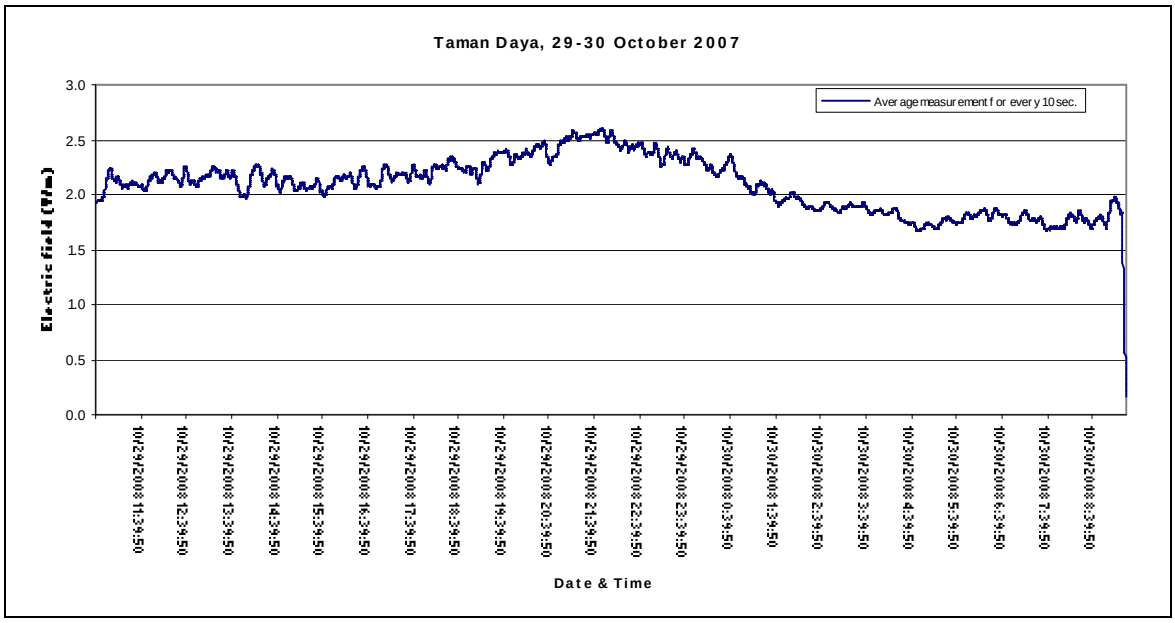


Figure 7: The 24 hours measurement of electric field strength at location near TD05

The magnetic field strength measured at about 1.5m above the floor/ground were also very low. The averaged readings measured at most of the time were below than the detection limit of the instrument (<0.01A/m).

Details of the radiation spectrums at three locations (TD05, TD08 and TD12) using spectrum analyser are given in Table B1 to B3 in Attachment B and their summarized result in Table A5. The contribution of each radiations involved and its comparison with the total radiation measured on the ground is shown in Figure 7. Since the spectrum analyser is very sensitive and its resolution is down to the individual frequency of radiations, the reading recorded by the instrument were, therefore, always lower when compared with the broadband results recorded by the former instruments. The result of spectrum analyzer at location TD05 indicates total average radiation measured around the site that was only 0.0004μW/cm^2 (0.204V/m). This radiation level is about 0.00006% or 1.5million times lower than

of the MCMC and ICNIRP exposure limit for public. The result also indicate that the radiation were contributed by other sources in the vicinity during the measurement.

In view of this situation, there is very low possibility of antenna may lead to any enhancement of the radiation within the area. It is, therefore, very unlikely that the site is potential to cause significant radiation exposure received by members of the public living or staying in the areas around the site.

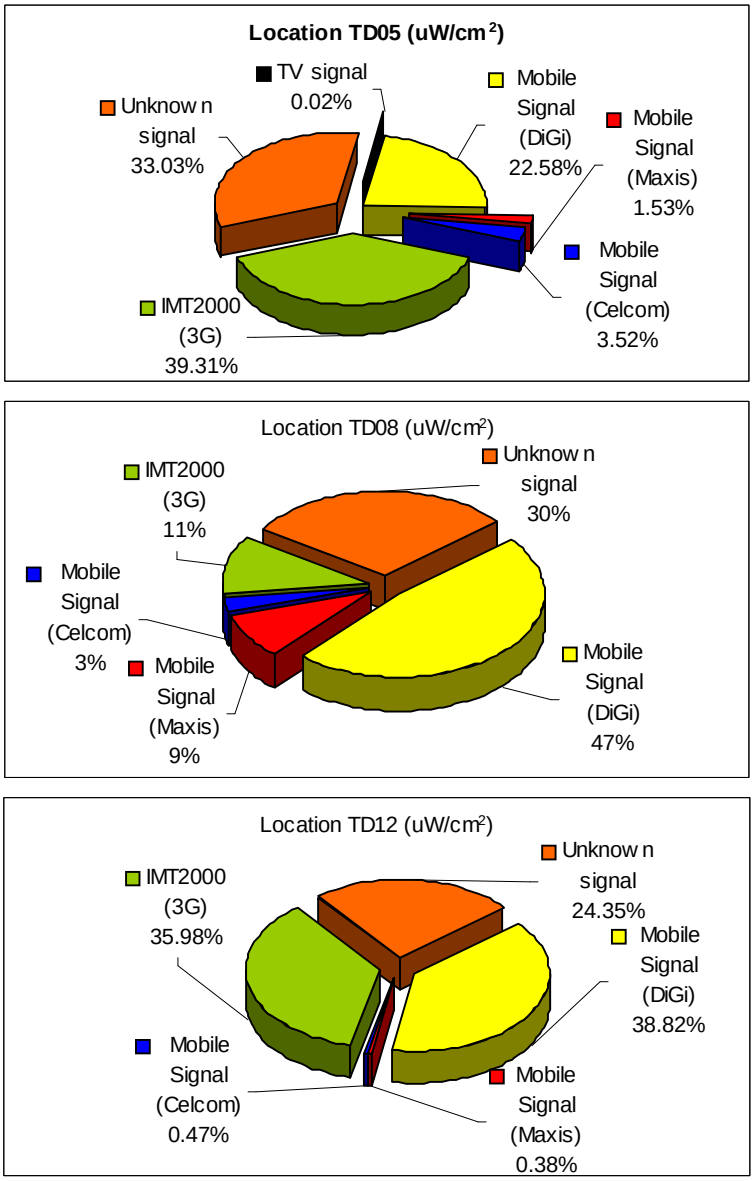


Figure 8: Percentage of radiations present at the three selected locations within the measurement site.

9. CONCLUSIONS

The radiofrequency and microwave radiation present at the tower area were measurable but of low levels. The electrical field strengths were well below the exposure limits stipulated by the MCMC and ICNIRP guidelines for workers and members of the public. The average broadband radiation levels observed were found to vary between 1.00μWatts/cm^2 and 2.00μWatts/cm^2 (0.97V/m and 2.80V/m) of which the highest level corresponds to about 0.32% or over than 300x lower than of the MCMC exposure limit for public.

Based on the findings of these measurement, we strongly believe that the presence of the radiofrequency and microwave radiation emitted by the antennas from the BTSs with the present loads would not lead to any significant radiation exposure received by residence or workers in the areas around the facility.

It should be noted that with adding in new antennas at the tower or increasing the transmitted power of the existing antennas is likely to enhance the radiation levels and if this is occurred it may require a new assessment to be carried out on site.

10. REFERENCES

1. ACGIH; Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices, 1990 – 1991
2. Australian Radiation Protection and Nuclear Safety (ARPANSA): Radiation Protection Standard; Maximum Exposure Levels to Radiofrequency Fields – 3 kHz to 300 GHz, Radiation Protection Series Publication No. 3, May 2002
3. Australian Standard (AS); Radiofrequency radiation Part 1 – Maximum exposure levels – 100 kHz to 300 GHz, AS 2772.1 1990.
4. CENELEC pr ENV 50166-2 (9/94).
5. Health and Welfare Canada (HWC); Limits of Human Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 3kHz – 300 GHz: Safety Code 6, 1999.
6. International Commission on Non-Ionising Radiation Protection (ICNIRP); Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300GHz); ICNIRP Guidelines Health Physics No.4, Vol. 74, pp. 115-123, 1998.
7. Institute of Electrical and Electronic Engineers (IEEE); Standard for Safety Levels with Respect to Human Exposure to Radiofrequency Electromagnetic Fields, 3 kHz to 300 GHz, IEEE C95.3-1991/ANSI, 1991
8. Jabatan Telekomunikasi Malaysia (JTM); Regulatory Framework on the Sharing of Radiocommunications Infrastructure (REG – R002), 1998.
9. Mohd Yusof Mohd Ali, MINT Internal report 2004.
10. National Radiological Protection Board (NRPB); Guidance as to Restrictions on Exposures to Time Varying Electromagnetic Fields and the 1988 Recommendations of the International Non-Ionising Radiation Committee; Guidance on Standards, NRPB-GS11, November 1988.
11. National Council on Radiation Protection and Measurements (NRPB); A Practical Guide to the Determination of Human Exposure to Radiofrequency Fields, NCRP Report No. 119, 1993.
12. US Federal Communication Commission Office of Engineering and Technology; Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields, OET Bulletin 65, Supplement A, Edition 97-01, August 1997.
13. World Health Organization; Electromagnetic Fields and Public Health, Fact Sheet No 193, May 1998.

ATTACHMENT A

Table A1: Results of radiofrequency and microwave radiation measurements (electric fields) taken around the tower using broadband Holaday instrument.

Location	Distance (m)	Electric field (V/m)				Power Density (μW/cm^2)			
		Min	Max	Ave	Stdev	Min	Max	Ave	Stdev
TD01	20	1.01	1.75	1.46	0.16	1.000	1.000	1.000	0.000
TD02	20	1.07	2.14	1.89	0.14	1.000	1.000	1.000	0.000
TD03	30	1.13	1.69	1.45	0.13	<1.000	<1.000	<1.000	0.000
TD04	40	0.66	2.01	1.26	0.33	1.000	1.000	1.000	0.000
TD05	73	1.02	1.42	1.21	0.09	1.000	1.000	1.000	0.000
TD06	56	0.13	1.46	0.97	0.25	<1.000	<1.000	<1.000	0.000
TD07	38	2.12	2.48	2.34	0.10	1.000	1.000	1.000	0.000
TD08	169	2.42	2.67	2.56	0.06	2.000	2.000	2.000	0.000
TD09	148	2.73	2.85	2.80	0.02	2.000	2.000	2.000	0.000
TD10	170	2.73	2.83	2.78	0.02	2.000	3.000	2.003	0.059
TD11	201	2.59	2.76	2.69	0.03	2.000	2.000	2.000	0.000
TD12	225	1.32	1.87	1.63	0.14	1.000	1.000	1.000	0.000
TD13	196	1.29	1.82	1.56	0.11	1.000	1.000	1.000	0.000
TD14	173	2.06	2.41	2.19	0.07	1.000	2.000	1.696	0.461
TD15	151	1.50	2.05	1.72	0.10	1.000	1.000	1.000	0.000

Table A2: Results of radiofrequency and microwave radiation measurements (electric fields) taken around the tower using broadband PMM instrument (EP330).

Location	Distance (m)	Electric field (V/m)				Power Density (μW/cm^2)			
		Min	Max	Ave	Stdev	Min	Max	Ave	Stdev
TD01	20	0.69	0.92	0.77	0.03	0.126	0.224	0.157	0.000
TD02	20	0.65	0.78	0.71	0.02	0.112	0.161	0.136	0.000
TD03	30	0.41	0.60	0.45	0.02	0.045	0.095	0.055	0.000
TD04	40	0.55	0.70	0.61	0.03	0.080	0.130	0.098	0.000
TD05	73	0.40	0.64	0.46	0.03	0.042	0.109	0.056	0.000
TD06	56	0.48	0.72	0.59	0.05	0.061	0.137	0.092	0.001
TD07	38	0.49	0.63	0.56	0.02	0.064	0.105	0.084	0.000
TD08	169	<0.25	0.53	0.33	0.03	<0.017	0.074	0.029	0.000
TD09	148	<0.25	0.47	0.29	0.07	<0.017	0.059	0.022	0.001
TD10	170	<0.25	0.54	0.26	0.02	<0.017	0.077	0.018	0.000
TD11	201	<0.25	0.48	0.29	0.03	<0.017	0.061	0.022	0.000
TD12	225	0.54	0.91	0.71	0.07	0.077	0.220	0.135	0.001
TD13	196	0.65	1.10	0.86	0.09	0.112	0.321	0.197	0.002
TD14	173	0.51	0.81	0.64	0.06	0.069	0.174	0.109	0.001
TD15	151	0.60	1.00	0.79	0.07	0.095	0.265	0.166	0.001

Table A3: Results of radiofrequency and microwave radiation measurements (electric fields) taken around the tower using narrowband PMM instrument (EP33M).

Location	Distance (m)	Electric field (V/m)				Power Density (μW/cm^2)			
		Min	Max	Ave	Stdev	Min	Max	Ave	Stdev
TD01	20	0.84	0.99	0.90	0.02	0.187	0.260	0.216	0.000
TD02	20	0.68	0.80	0.74	0.02	0.123	0.170	0.147	0.000
TD03	30	0.44	0.67	0.52	0.03	0.051	0.119	0.071	0.000
TD04	40	0.62	0.78	0.68	0.03	0.102	0.161	0.124	0.000
TD05	73	0.47	0.69	0.55	0.04	0.059	0.126	0.080	0.000
TD06	56	0.57	0.90	0.73	0.06	0.086	0.215	0.141	0.001
TD07	38	0.64	0.94	0.72	0.04	0.109	0.234	0.139	0.000
TD08	169	0.30	0.40	0.35	0.02	0.024	0.042	0.033	0.000
TD09	148	<0.25	0.45	0.28	0.07	<0.017	0.054	0.020	0.001
TD10	170	0.31	0.95	0.35	0.07	0.025	0.239	0.032	0.001
TD11	201	0.29	0.94	0.37	0.05	0.022	0.234	0.037	0.001
TD12	225	0.69	0.98	0.87	0.04	0.126	0.255	0.201	0.001
TD13	196	0.74	1.42	1.06	0.10	0.145	0.535	0.300	0.002
TD14	173	0.97	1.38	1.17	0.07	0.250	0.505	0.360	0.001
TD15	151	1.03	1.43	1.20	0.07	0.281	0.542	0.383	0.001

Table A4: Results of radiofrequency and microwave radiation measurements (magnetic fields) taken around the tower using narrowband PMM instrument (HP102).

Locations	Distance (m)	Magnetic field (A/m)			
		Min	Max	Ave	Stdev
TD01	20	<0.010	<0.010	<0.010	0.000
TD02	20	<0.010	<0.010	<0.010	0.000
TD03	30	<0.010	<0.010	<0.010	0.000
TD04	40	<0.010	<0.010	<0.010	0.000
TD05	73	<0.010	<0.010	<0.010	0.000
TD06	56	<0.010	<0.010	<0.010	0.000
TD07	38	<0.010	<0.010	<0.010	0.000
TD08	169	<0.010	<0.010	<0.010	0.000
TD09	148	<0.010	<0.010	<0.010	0.000
TD10	170	<0.010	<0.010	<0.010	0.000
TD11	201	<0.010	<0.010	<0.010	0.000
TD12	225	<0.010	<0.010	<0.010	0.000
TD13	196	<0.010	<0.010	<0.010	0.000
TD14	173	<0.010	<0.010	<0.010	0.000
TD15	151	<0.010	<0.010	<0.010	0.000

Table A5: Summarized results of total radiofrequency and microwave radiation measurements (electric fields) using spectrum analyser.

	Field Strength (mV/m)			**Power Density ($\mu W/cm^2$ x 10^{-6}) @ x10^{-12}W/cm^2**		
Location / **Signal**	TD05	TD08	TD12	TD05	TD08	TD12
TV signal	0.57	-	-	0.09	-	-
Mobile Signal (DiGi)	83.55	19.42	32.67	88.46	35.24	68.00
Mobile Signal (Maxis)	9.14	9.60	1.57	5.99	6.64	0.66
Mobile Signal (Celcom)	20.05	5.92	3.84	13.81	2.08	0.83
IMT2000 (3G)	63.32	17.25	46.97	153.98	8.15	63.03
Unknown signal	27.27	11.06	15.15	129.36	22.07	42.66
Total	**203.90**	**63.24**	**100.20**	**391.69**	**74.18**	**175.17**

ATTACHMENT B

Table B1: Results of radiofrequency and microwave radiation measurements (electric fields) at location TD05 using spectrum analyser.

Frequency (MHz)	Field Strength (mV/m) Ave	Calculated Field Strength ($\mu W/cm^2 \times 10^{-6}$) @ $\times 10^{-12} W/cm^2$ Ave	Remark
680.00	0.573	0.087	TV Signal
925.51	0.356	0.034	Mobile Signal (Maxis)
936.00	1.578	0.661	Mobile Signal (Celcom)
937.00	1.578	0.661	Mobile Signal (Celcom)
937.21	0.356	0.034	Mobile Signal (Celcom)
945.00	3.483	3.218	Mobile Signal (Celcom)
945.49	2.535	1.705	Mobile Signal (Celcom)
958.04	0.500	0.066	Mobile Signal (Maxis)
959.00	1.265	0.424	Mobile Signal (Maxis)
959.62	0.774	0.159	Mobile Signal (Maxis)
1000.00	2.421	1.555	Unknown Signal
1810.67	4.241	4.771	Mobile Signal (Maxis)
1813.89	0.889	0.210	Mobile Signal (Maxis)
1823.14	1.117	0.331	Mobile Signal (Maxis)
1832.27	2.228	1.317	Mobile Signal (Celcom)
1836.00	3.112	2.569	Mobile Signal (Celcom)
1847.06	2.200	1.284	Mobile Signal (Celcom)
1851.43	2.982	2.359	Mobile Signal (Celcom)
1855.80	13.630	49.279	Mobile Signal (DiGi)
1862.87	0.804	0.171	Mobile Signal (DiGi)
1867.24	0.905	0.217	Mobile Signal (DiGi)
1872.77	1.795	0.855	Mobile Signal (DiGi)
1874.50	1.656	0.727	Mobile Signal (DiGi)
1875.34	2.385	1.509	Mobile Signal (DiGi)
1875.47	2.363	1.481	Mobile Signal (DiGi)
1875.60	2.415	1.547	Mobile Signal (DiGi)
1875.73	2.404	1.533	Mobile Signal (DiGi)
1875.86	2.435	1.573	Mobile Signal (DiGi)
1875.99	2.304	1.408	Mobile Signal (DiGi)
1876.11	2.208	1.293	Mobile Signal (DiGi)
1876.24	2.200	1.284	Mobile Signal (DiGi)
1876.37	2.118	1.190	Mobile Signal (DiGi)
1876.50	2.136	1.210	Mobile Signal (DiGi)
1876.63	2.118	1.190	Mobile Signal (DiGi)
1876.76	2.082	1.150	Mobile Signal (DiGi)
1876.89	2.056	1.121	Mobile Signal (DiGi)
1877.01	2.092	1.161	Mobile Signal (DiGi)
1877.14	2.046	1.110	Mobile Signal (DiGi)
1877.27	2.030	1.093	Mobile Signal (DiGi)
1877.40	2.021	1.083	Mobile Signal (DiGi)
1877.53	1.961	1.020	Mobile Signal (DiGi)

Table B1: Results of radiofrequency and microwave radiation measurements (electric fields) at location TD05 using spectrum analyser (continue).

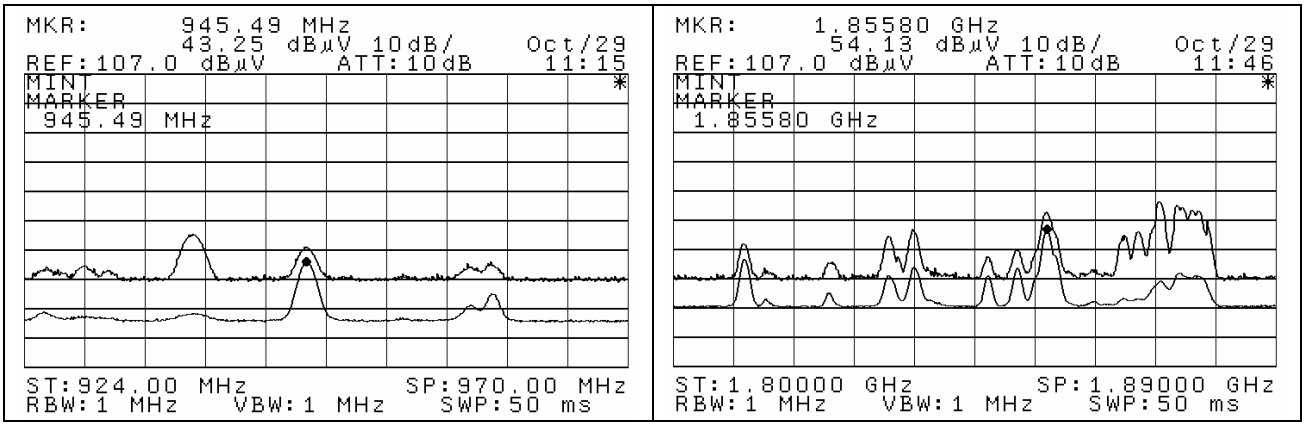
Frequency (MHz)	Field Strength (mV/m) Ave	Calculated Field Strength ($\mu W/cm^2 \times 10^{-6}$) @ $x10^{-12} W/cm^2$ Ave	Remark
1877.66	2.046	1.110	Mobile Signal (DiGi)
1877.79	2.143	1.218	Mobile Signal (DiGi)
1877.91	2.173	1.253	Mobile Signal (DiGi)
1878.04	2.190	1.272	Mobile Signal (DiGi)
1878.17	2.082	1.150	Mobile Signal (DiGi)
1878.30	2.173	1.253	Mobile Signal (DiGi)
1878.43	2.126	1.199	Mobile Signal (DiGi)
1878.56	2.163	1.241	Mobile Signal (DiGi)
1878.69	2.163	1.241	Mobile Signal (DiGi)
1878.81	2.073	1.140	Mobile Signal (DiGi)
1878.94	2.065	1.131	Mobile Signal (DiGi)
1879.07	1.986	1.046	Mobile Signal (DiGi)
1898.60	21.727	125.219	Unknown Signal
2126.80	2.670	1.891	IMT2000(3G)
2127.50	2.894	2.222	IMT2000(3G)
2128.60	3.020	2.419	IMT2000(3G)
2129.70	2.570	1.752	IMT2000(3G)
2151.10	9.183	22.369	IMT2000(3G)
2151.90	10.471	29.083	IMT2000(3G)
2152.90	11.259	33.626	IMT2000(3G)
2153.80	11.790	36.872	IMT2000(3G)
2154.40	9.462	23.748	IMT2000(3G)
2190.00	3.122	2.585	Unknown Signal
Total	**203.903**	**391.690**	

Table B2: Results of radiofrequency and microwave radiation measurements (electric fields) at location TD08 using spectrum analyser.

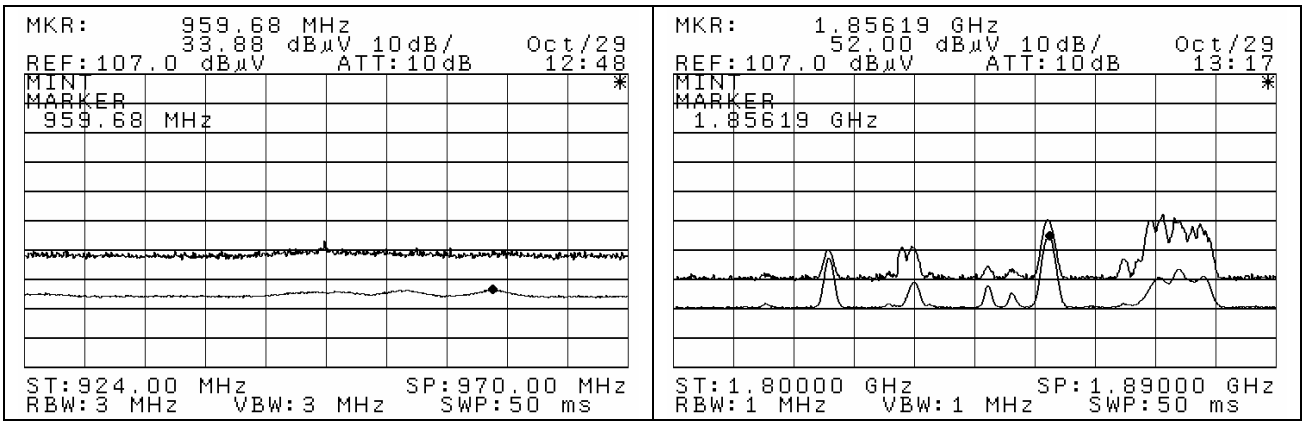
Frequency (MHz)	Field Strength (mV/m) Ave	Calculated Field Strength ($\mu W/cm^2 \times 10^{-6}$) @ $x10^{-12} W/cm^2$ Ave	Remark
926.00	0.734	0.143	Mobile Signal (Maxis)
945.00	0.724	0.139	Mobile Signal (Celcom)
953.00	0.811	0.174	Mobile Signal (Maxis)
953.31	0.878	0.204	Mobile Signal (Maxis)
959.68	0.913	0.221	Mobile Signal (Maxis)
960.00	0.948	0.238	Mobile Signal (Maxis)
1000.00	2.205	1.290	Unknown Signal
1813.27	0.760	0.153	Mobile Signal (Maxis)
1823.27	4.555	5.504	Mobile Signal (Maxis)
1832.27	0.757	0.152	Mobile Signal (Celcom)
1836.00	1.750	0.812	Mobile Signal (Celcom)
1847.06	1.529	0.620	Mobile Signal (Celcom)
1850.53	1.156	0.354	Mobile Signal (Celcom)
1856.19	10.666	30.177	Mobile Signal (DiGi)
1862.74	0.696	0.128	Mobile Signal (DiGi)
1867.24	0.776	0.160	Mobile Signal (DiGi)
1872.39	2.136	1.210	Mobile Signal (DiGi)
1875.60	2.907	2.242	Mobile Signal (DiGi)
1879.20	2.236	1.326	Mobile Signal (DiGi)
1898.60	8.851	20.780	Unknown Signal
2127.10	1.414	0.530	IMT2000(3G)
2127.90	1.427	0.540	IMT2000(3G)
2128.40	1.501	0.598	IMT2000(3G)
2129.10	1.547	0.635	IMT2000(3G)
2130.00	1.344	0.479	IMT2000(3G)
2150.70	1.698	0.765	IMT2000(3G)
2151.90	2.063	1.129	IMT2000(3G)
2152.30	2.178	1.258	IMT2000(3G)
2153.30	2.205	1.290	IMT2000(3G)
2154.10	1.871	0.929	IMT2000(3G)
Total	**63.236**	**74.182**	

Table B3: Results of radiofrequency and microwave radiation measurements (electric fields) at location TD12 using spectrum analyser.

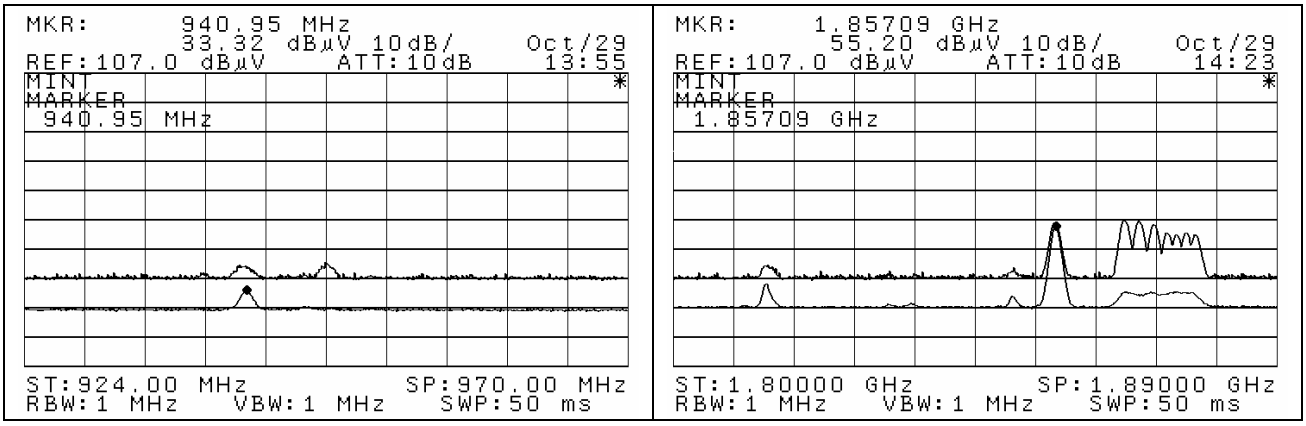
Frequency (MHz)	Field Strength (mV/m) Ave	Calculated Field Strength ($\mu W/cm^2 \times 10^{-6}$) @ $x10^{-12} W/cm^2$ Ave	Remark
940.95	0.808	0.173	Mobile Signal (Celcom)
941.00	0.869	0.200	Mobile Signal (Celcom)
945.42	0.425	0.048	Mobile Signal (Celcom)
947.00	0.772	0.158	Mobile Signal (Celcom)
1813.89	1.574	0.657	Mobile Signal (Maxis)
1850.53	0.964	0.247	Mobile Signal (Celcom)
1857.09	15.417	63.048	Mobile Signal (DiGi)
1866.73	0.964	0.247	Mobile Signal (DiGi)
1866.86	1.074	0.306	Mobile Signal (DiGi)
1866.99	1.075	0.307	Mobile Signal (DiGi)
1867.11	1.136	0.342	Mobile Signal (DiGi)
1867.24	1.117	0.331	Mobile Signal (DiGi)
1868.27	1.089	0.315	Mobile Signal (DiGi)
1869.04	1.062	0.299	Mobile Signal (DiGi)
1870.20	1.019	0.275	Mobile Signal (DiGi)
1871.23	1.161	0.358	Mobile Signal (DiGi)
1872.13	1.048	0.291	Mobile Signal (DiGi)
1873.16	1.032	0.283	Mobile Signal (DiGi)
1874.06	1.103	0.323	Mobile Signal (DiGi)
1875.34	1.136	0.342	Mobile Signal (DiGi)
1876.24	1.131	0.339	Mobile Signal (DiGi)
1877.27	1.117	0.331	Mobile Signal (DiGi)
1878.04	0.989	0.259	Mobile Signal (DiGi)
1898.60	12.374	40.615	Unknown Signal
2125.90	3.681	3.594	IMT2000(3G)
2126.60	6.223	10.272	IMT2000(3G)
2127.90	6.887	12.581	IMT2000(3G)
2128.90	6.524	11.290	IMT2000(3G)
2130.00	4.360	5.042	IMT2000(3G)
2150.60	2.831	2.126	IMT2000(3G)
2151.30	4.041	4.332	IMT2000(3G)
2152.40	4.592	5.593	IMT2000(3G)
2153.10	4.271	4.839	IMT2000(3G)
2154.40	3.560	3.362	IMT2000(3G)
2165.70	2.773	2.040	Unknown Signal
Total	**100.199**	**175.166**	



a) Location TD05



b) Location TD08



c) Location TD12

Figure 9: Mobile phone signal (GSM 900 and GSM 1800) signal captured by spectrum analyzer at locations TD05, TD08 and TD12.