# REPORT ON
# RADIOFREQUENCY AND MICROWAVE RADIATION MEASUREMENTS AROUND TELECOMMUNICATION TOWER, KG TAROM, JOHOR BHARU, JOHOR

*A report prepared for*

**D'HARMONI**
**TELCO INFRA SDN. BHD.**

**By**

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## EXECUTIVE SUMMARY

D'Harmoni Telco Infra Sdn. Bhd. requested Malaysian Nuclear Agency Malaysia) to conduct a radiofrequency (RF) and microwave (MW) radiation measurement around the tower base stations (BTS) located at Kg. Tarom, 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 tower.

Nuclear Agency's Non-Ionising Radiation (NIR) Group carried out the measurement on 30th 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 based on 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 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.

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 highest broadband radiation level observed was found about 1.00μWatts/cm$^2$ (1.93 V/m) of which the level corresponds to about 0.16% or over 625x lower than 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 at the tower 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 Malaysia) to conduct a radiofrequency (RF) and microwave (MW) radiation measurement around the tower base stations (BTS) located at Kg. Tarom, 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 tower.

Nuclear Agency's Non-Ionising Radiation (NIR) Group carried out the measurement on 30$^{th}$ October 2008. In carrying out the work, the Group was assisted by personals from the company.

## 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 tower and
b) to assist the company on outcomes of the measurement based on local and international recommendations of standard 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 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 the measurement. The measurement was arranged to include both the electric field strength and power density at identified 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 tower base station (BTS) located next to the water reservoir on a small hill at Kg. Tarom, Johor Bharu, Johor. The tower, made of monopole metal of 30 metres high, which is surrounded by local residential houses.

Geographically, the condition of the measurement site and its immediate surrounding areas is hilly. Most of the residential houses are located on flat ground areas, at the level of very much lower than the base of the tower. Such situation provides an advantage in term of minimising chances for public exposure to the radiation.

It was assumed that the radiation level of the measurement are only from the sources of the antennas located at the tower. At the time of the measurement, there were 6 rectangular antennas and 1 point-to-point parabolic antennas (installed at 26.9 metres to 30 metres from the ground) that belong to Maxis.

The biggest dimension of the antennas was 2.08 metres for rectangular antennas and 0.6 metres (2 ft) diameter for the parabolic antennas respectively.

The rectangular antennas are mounted almost at the top of the tower and are fixed into three different direction (sectors) to ensure that there are always good uplink and downlink signals being transmitted and received from users living in areas within those sectors. The radiofrequency radiations are transmitted within the frequency range of 950 MHz to 2155 MHz with the highest transmitted power of 20 Watts. The parabolic antennas are, on the other hand, used for point-to-point communication of the mobile and they are mounted at about 28 metres above the ground. 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 the parabolic antenna is usually projected out horizontally way above the ground and in collimated manner, we can anticipate that this radiation would never touch the ground at any locations close to the tower along its projected direction and this is confirmed from the previous measurement made by Nuclear Malaysia around the similar type of towers elsewhere. Similarly, since the rectangular antennas are positioned vertically with a small tilt angle toward the ground, their radiations can, therefore, hardly be seen at locations below or within immediate vicinity of the tower. However, in reality, one can still find some radiation present in these areas. Our past experience indicates that this is often caused by low frequency radio and TV signals and very high frequency signals produced by other microwave and mobile telephone systems present in areas close to the site. In view of the orientation and special design of the antennas, which allows for the radiation beam to cut across only in a small section of the air, it is expected that the scattered radiation by air to places on the ground around the tower is minimal. The radiation on the ground is also expected to be very small in view of the fact that there are no high-rise buildings or structures present in immediate vicinity of the tower that can significantly reflect the beams to the ground.

## 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 Maxis antennas at the tower (950 MHz), which give the limits for workers are 3167μWatts/cm$^2$ or 107V/m of electric fields strength and 0.29A/m of magnetic fields strength while for members of the public are 633μWatts/cm$^2$ or 50V/m of electric fields strength and 0.13 A/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 Commissions 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 (see Figure 1).

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 (see Figure 1) 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<br>PMM HP-102<br>PMM EP-330<br>PMM EP-33M | <br>30MHz - 1GHZ<br>100kHz - 3GHz<br>700MHz - 3GHz | <br>25 Jan. 2008<br>18 Jan. 2008<br>14 Dec. 2006<br>17 Jan. 2008 |
| PMM instrument Model 8055S attach with<br>PMM EP-33M | 700MHz - 3GHz | 9 Jan. 2008<br>17 Jan. 2008 |
| Advantest Spectrum Analyzer<br>Horn antenna<br>Log Periodic Antenna | 300MHz -18GHz | - |

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

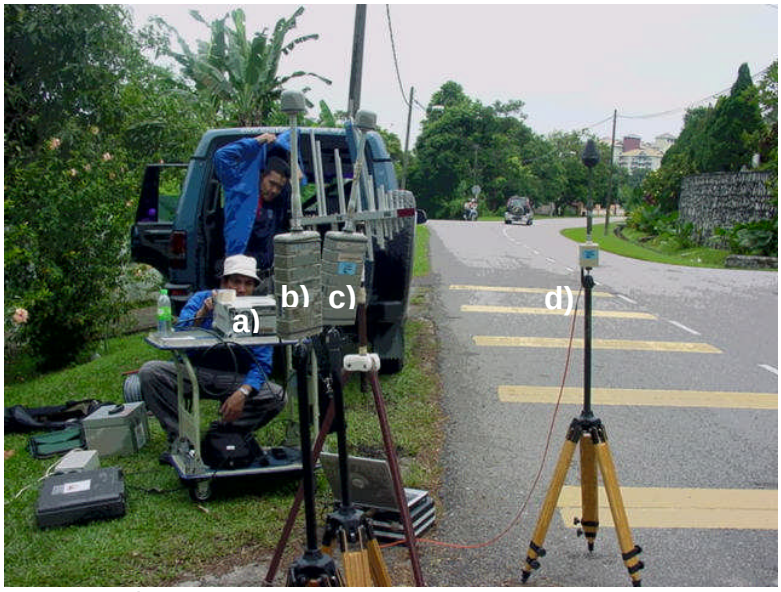


Figure 1: Measurement equipment,

a) spectrum analyzer attached with radiofrequency antenna.
b) PMM instrument Model 8053 with probe model PMM EP-330,
c) PMM instrument Model 8053 with probe Model PMM EP-33M,
d) Holaday instrument with probe model HI4455

Figure 2. 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 accessible locations around the tower and locations at the nearby housing area. There were 14 measurement locations. All measurements were performed about 1.5meter above the ground. The points 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 ($\mu$Watts/cm$^2$) and electrical field strength (V/m).

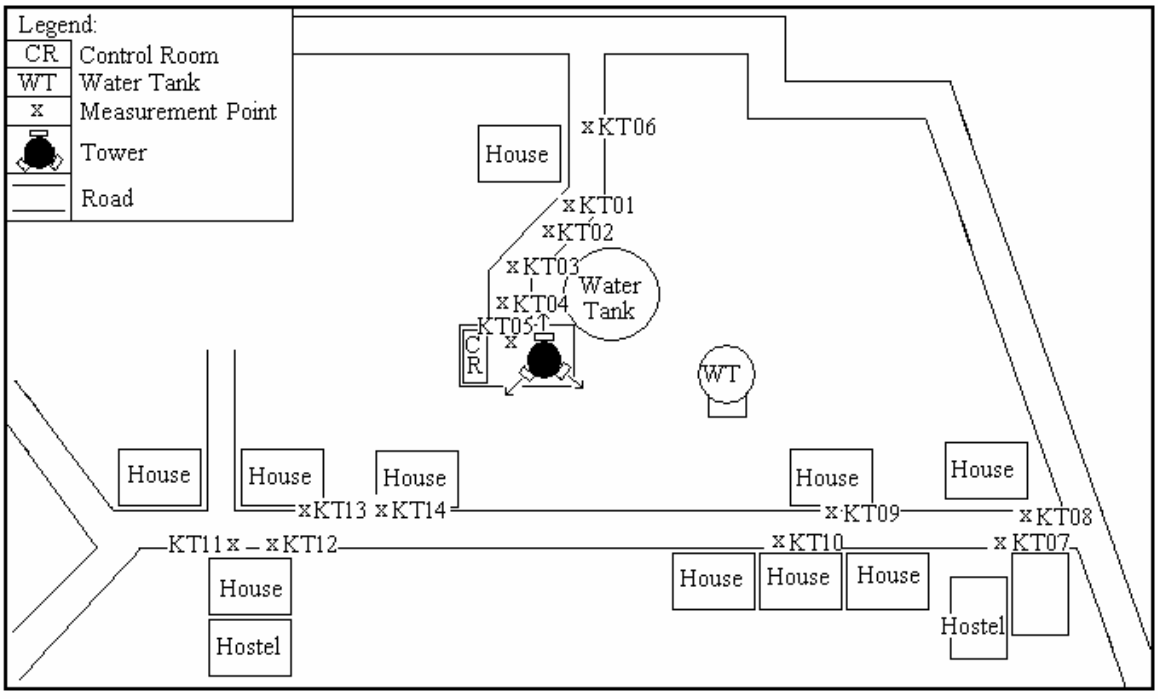


Figure 3: Layout of the measurement locations on the ground around the site

Figure 4. Photograph of the Mobile Telephone Base Station Tower at Kg.Tarom

## 8. RESULTS AND DISCUSSION

Results of the measurement carried out around the tower 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 below 1.00μWatts/$cm^2$ and 1.00μWatts/$cm^2$ (1.49V/m and 1.93 V/m) of which the highest level corresponds to about 0.16% or over 625x lower than 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 detection limit of the instrument; 0.02μW/$cm^2$ (0.25V/m) and 0.23μW/$cm^2$ (0.92V/m) of which the highest level corresponds to about 0.04% or over 2500x lower than the MCMC exposure limit for public.

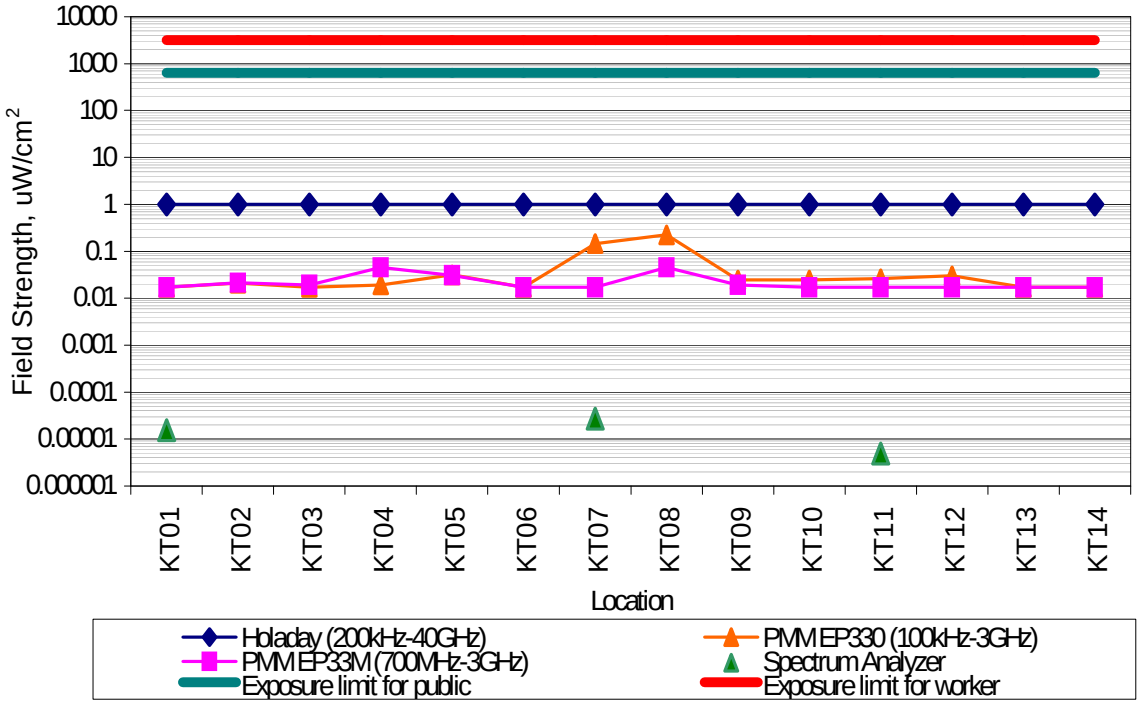


Figure 5: A plot of radiation levels in microwatts perunit area (μW/cm$^2$ ) against location of measurement (and their comparison with MCMC exposure limit for public)

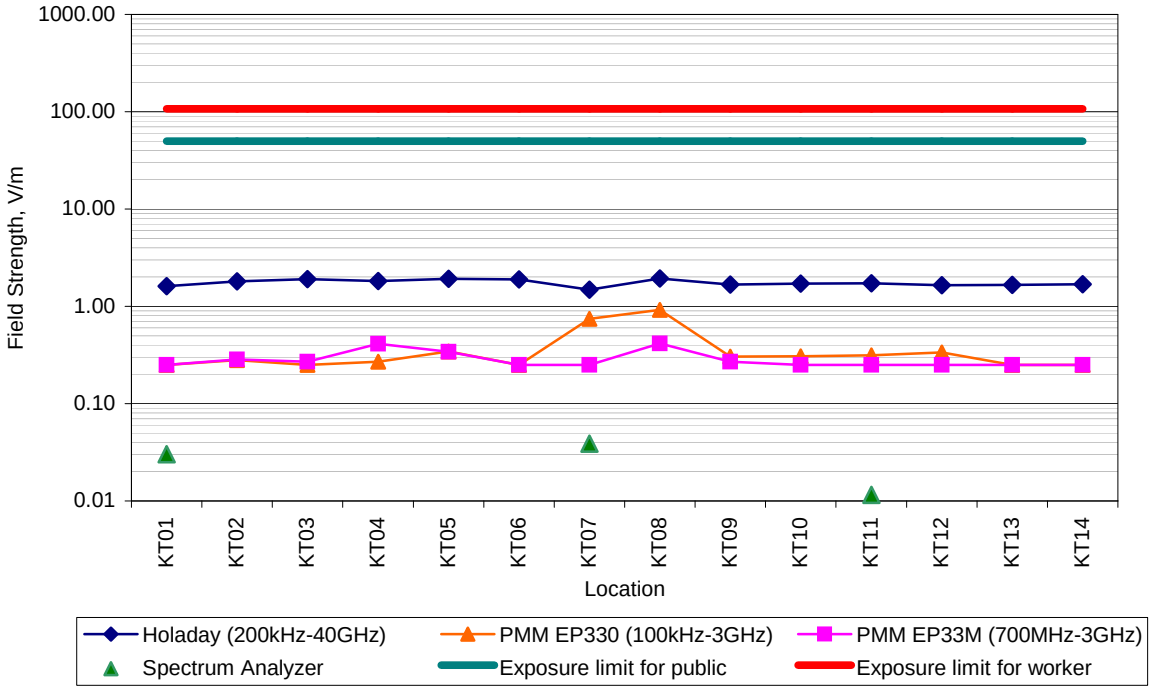


Figure 6: A plot of radiation levels in V/m against location of measurement (and their comparison with MCMC exposure limit for public)

The electrical field strength (V/m) pattern measured by continuous measurement for over than 24 hours was selected at point near the location KT01. The radiation level from the continuous measurement shown that the radiations over a period of 24 hours were below than the detection limit of instrument (<0.25V/m).

The magnetic field strength measured at about 1.5m above the 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 ( KT01, KT07 and KT11) 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, the reading recorded by the instrument were, therefore, always lower when compared with the broadband equipment. Measurement at KT07 (see Figure 8b)) indicates total average radiation measured around the site that was only 0.0000275 $\mu W/cm^2$ (0.039V/m). This radiation level is about 0.000004% or about 25million 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.

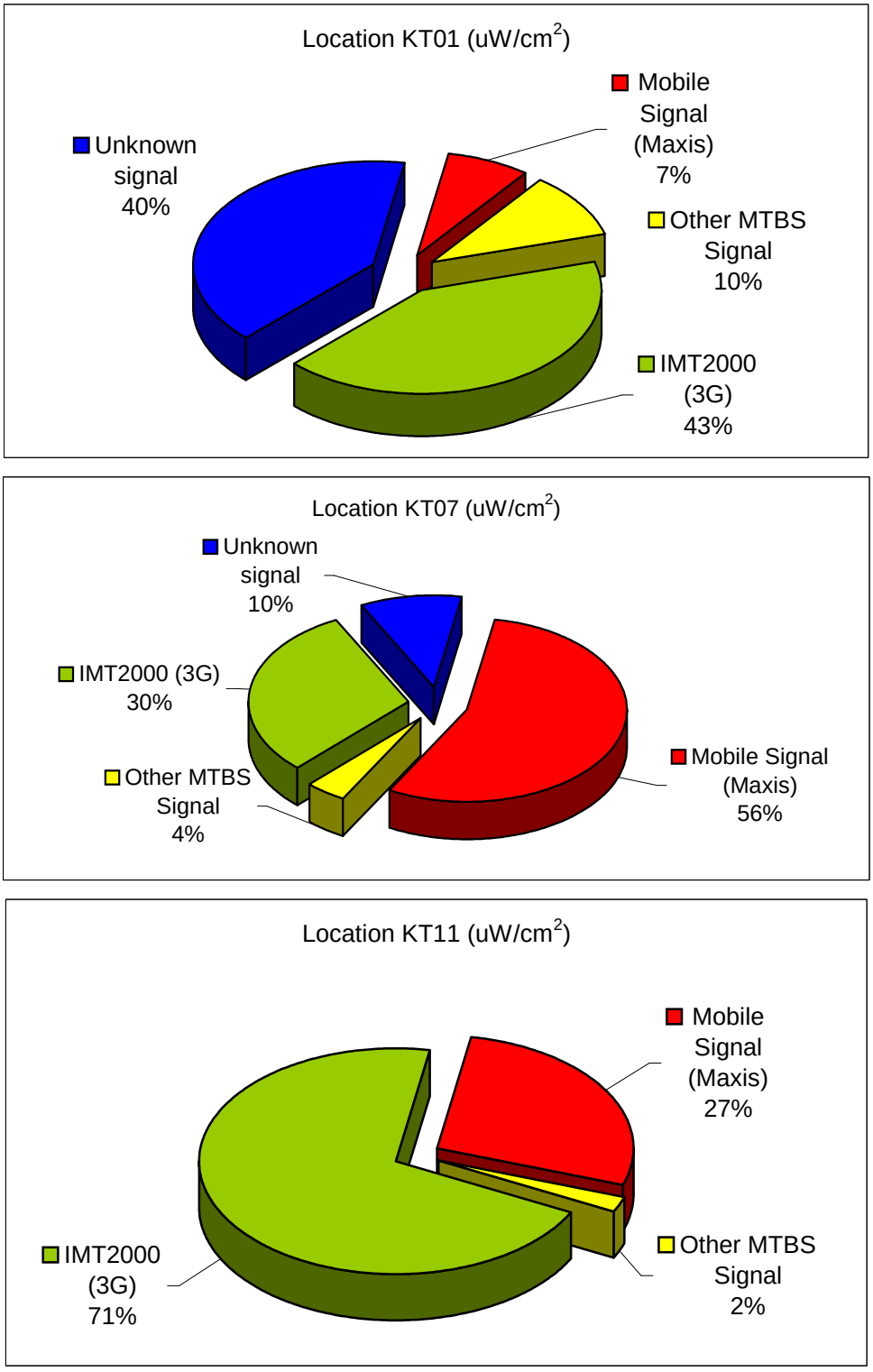


Figure 7: Percentage of radiations present at the three selected locations within the measurement site.

## 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 highest broadband radiation level observed was found at 1.00μWatts/cm$^2$ (1.93 V/m) of which the highest level corresponds to about 0.16% or over 625x lower than 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 at the tower 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

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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 |
| KT01 | 69.00 | 1.53 | 1.72 | 1.61 | 0.04 | 1.000 | 1.000 | 1.000 | 0.000 |
| KT02 | 55.00 | 1.72 | 1.89 | 1.81 | 0.03 | 1.000 | 1.000 | 1.000 | 0.000 |
| KT03 | 45.00 | 1.83 | 2.00 | 1.91 | 0.04 | 1.000 | 1.000 | 1.000 | 0.000 |
| KT04 | 39.00 | 1.72 | 1.94 | 1.82 | 0.05 | 1.000 | 1.000 | 1.000 | 0.000 |
| KT05 | 32.00 | 1.83 | 2.01 | 1.92 | 0.03 | 1.000 | 1.000 | 1.000 | 0.000 |
| KT06 | 100.00 | 1.79 | 1.98 | 1.88 | 0.04 | 1.000 | 1.000 | 1.000 | 0.000 |
| KT07 | 173.00 | 1.28 | 1.80 | 1.49 | 0.08 | 1.000 | 1.000 | 1.000 | 0.000 |
| KT08 | 180.00 | 1.59 | 2.09 | 1.93 | 0.08 | 1.000 | 1.000 | 1.000 | 0.000 |
| KT09 | 150.00 | 1.41 | 1.88 | 1.68 | 0.11 | 1.000 | 1.000 | 1.000 | 0.000 |
| KT10 | 138.00 | 1.57 | 1.82 | 1.71 | 0.06 | 1.000 | 1.000 | 1.000 | 0.000 |
| KT11 | 160.00 | 1.40 | 1.93 | 1.72 | 0.07 | <1.000 | 1.000 | 1.000 | 0.000 |
| KT12 | 151.00 | 1.52 | 1.77 | 1.65 | 0.05 | <1.000 | 1.000 | 1.000 | 0.000 |
| KT13 | 149.00 | 1.26 | 1.81 | 1.66 | 0.08 | 1.000 | 1.000 | 1.000 | 0.000 |
| KT14 | 132.00 | 1.35 | 1.81 | 1.69 | 0.06 | 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 ($\mu W/cm^2$) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Min | Max | Ave | Stdev | Min | Max | Ave | Stdev |
| KT01 | 69.00 | <0.25 | <0.25 | <0.25 | 0.00 | <0.017 | <0.017 | <0.017 | 0.000 |
| KT02 | 55.00 | 0.25 | 0.35 | 0.28 | 0.02 | 0.017 | 0.032 | 0.021 | 0.000 |
| KT03 | 45.00 | <0.25 | <0.25 | <0.25 | 0.00 | <0.017 | <0.017 | <0.017 | 0.000 |
| KT04 | 39.00 | <0.25 | 0.34 | 0.27 | 0.02 | <0.017 | 0.031 | 0.019 | 0.000 |
| KT05 | 32.00 | 0.28 | 0.42 | 0.34 | 0.03 | 0.021 | 0.047 | 0.032 | 0.000 |
| KT06 | 100.00 | <0.25 | <0.25 | <0.25 | 0.00 | <0.017 | <0.017 | <0.017 | 0.000 |
| KT07 | 173.00 | 0.63 | 0.89 | 0.74 | 0.03 | 0.105 | 0.210 | 0.146 | 0.000 |
| KT08 | 180.00 | 0.74 | 1.05 | 0.92 | 0.04 | 0.145 | 0.292 | 0.225 | 0.000 |
| KT09 | 150.00 | <0.25 | 0.41 | 0.30 | 0.04 | <0.017 | 0.045 | 0.025 | 0.000 |
| KT10 | 138.00 | 0.25 | 0.34 | 0.31 | 0.02 | 0.017 | 0.031 | 0.025 | 0.000 |
| KT11 | 160.00 | <0.25 | 0.35 | 0.31 | 0.03 | <0.017 | 0.032 | 0.026 | 0.000 |
| KT12 | 151.00 | 0.31 | 0.36 | 0.34 | 0.01 | 0.025 | 0.034 | 0.030 | 0.000 |
| KT13 | 149.00 | <0.25 | <0.25 | <0.25 | 0.00 | <0.017 | <0.017 | <0.017 | 0.000 |
| KT14 | 132.00 | <0.25 | <0.25 | <0.25 | 0.00 | <0.017 | <0.017 | <0.017 | 0.000 |

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 ($\mu W/cm^2$) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Min | Max | Ave | Stdev | Min | Max | Ave | Stdev |
| KT01 | 69.00 | <0.25 | <0.25 | <0.25 | 0.00 | <0.017 | <0.017 | <0.017 | 0.000 |
| KT02 | 55.00 | 0.25 | 0.38 | 0.28 | 0.02 | 0.017 | 0.038 | 0.021 | 0.000 |
| KT03 | 45.00 | <0.25 | 0.30 | 0.27 | 0.01 | <0.017 | 0.024 | 0.019 | 0.000 |
| KT04 | 39.00 | 0.34 | 0.47 | 0.41 | 0.02 | 0.031 | 0.059 | 0.045 | 0.000 |
| KT05 | 32.00 | <0.25 | 0.43 | 0.34 | 0.06 | <0.017 | 0.049 | 0.031 | 0.001 |
| KT06 | 100.00 | <0.25 | <0.25 | <0.25 | 0.00 | <0.017 | <0.017 | <0.017 | 0.000 |
| KT07 | 173.00 | <0.25 | <0.25 | <0.25 | 0.00 | <0.017 | <0.017 | <0.017 | 0.000 |
| KT08 | 180.00 | <0.25 | 0.60 | 0.41 | 0.05 | <0.017 | 0.095 | 0.046 | 0.001 |
| KT09 | 150.00 | <0.25 | 0.59 | 0.27 | 0.06 | <0.017 | 0.092 | 0.019 | 0.001 |
| KT10 | 138.00 | <0.25 | <0.25 | <0.25 | 0.00 | <0.017 | <0.017 | <0.017 | 0.000 |
| KT11 | 160.00 | <0.25 | <0.25 | <0.25 | 0.00 | <0.017 | <0.017 | <0.017 | 0.000 |
| KT12 | 151.00 | <0.25 | <0.25 | <0.25 | 0.00 | <0.017 | <0.017 | <0.017 | 0.000 |
| KT13 | 149.00 | <0.25 | <0.25 | <0.25 | 0.00 | <0.017 | <0.017 | <0.017 | 0.000 |
| KT14 | 132.00 | <0.25 | <0.25 | <0.25 | 0.00 | <0.017 | <0.017 | <0.017 | 0.000 |

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

| Location | Distance (m) | Magnetic field (A/m) | | | |
|---|---|---|---|---|---|
| | | Min | Max | Ave | Stdev |
| KT01 | 69.00 | <0.010 | <0.010 | <0.010 | 0.000 |
| KT02 | 55.00 | <0.010 | <0.010 | <0.010 | 0.000 |
| KT03 | 45.00 | <0.010 | <0.010 | <0.010 | 0.000 |
| KT04 | 39.00 | <0.010 | <0.010 | <0.010 | 0.000 |
| KT05 | 32.00 | <0.010 | <0.010 | <0.010 | 0.000 |
| KT06 | 100.00 | <0.010 | <0.010 | <0.010 | 0.000 |
| KT07 | 173.00 | <0.010 | <0.010 | <0.010 | 0.000 |
| KT08 | 180.00 | <0.010 | <0.010 | <0.010 | 0.000 |
| KT09 | 150.00 | <0.010 | <0.010 | <0.010 | 0.000 |
| KT10 | 138.00 | <0.010 | <0.010 | <0.010 | 0.000 |
| KT11 | 160.00 | <0.010 | <0.010 | <0.010 | 0.000 |
| KT12 | 151.00 | <0.010 | <0.010 | <0.010 | 0.000 |
| KT13 | 149.00 | <0.010 | <0.010 | <0.010 | 0.000 |
| KT14 | 132.00 | <0.010 | <0.010 | <0.010 | 0.000 |

Table A5:Results of total radiofrequency and microwave radiation measurements (electric fields) using spectrum analyzer

| | Field Strength (mV/m) | | | Power Density ($\mu W/cm^2 \times 10^{-6}$) @ $x10^{-12} W/cm^2$ | | |
|---|---|---|---|---|---|---|
| Location / Signal | KT01 | KT07 | KT11 | KT01 | KT07 | KT11 |
| Mobile Signal (Maxis) | 6.83 | 12.07 | 3.71 | 1.147 | 15.240 | 1.346 |
| Other MTBS Signal | 6.47 | 5.71 | 0.64 | 1.610 | 1.123 | 0.109 |
| IMT2000(3G) | 12.05 | 16.43 | 7.21 | 6.485 | 8.378 | 3.454 |
| Unknown signal | 4.85 | 4.54 | - | 6.232 | 2.805 | - |
| **Total** | **30.197** | **38.739** | **11.567** | **15.474** | **27.546** | **4.910** |

## ATTACHMENT B

Table B1:Results of radiofrequency and microwave radiation measurements (electric fields) at location KT01 using spectrum analyser.

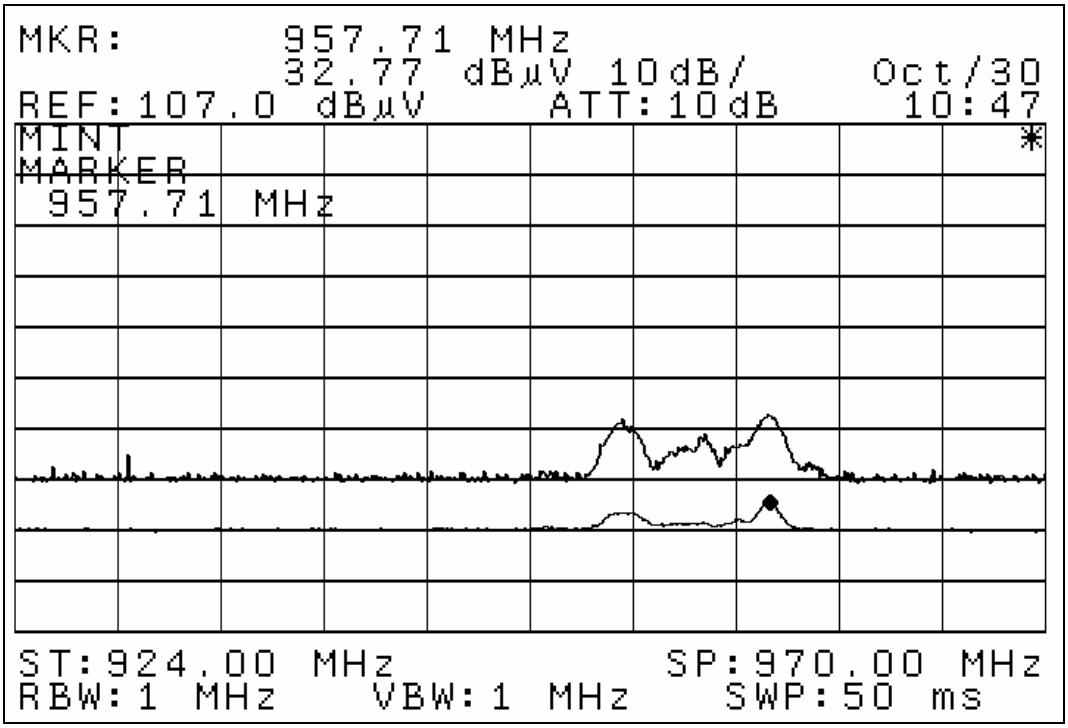
| Frequency (MHz) | Field Strength (mV/m) Ave | Calculated Field Strength ($\mu W/cm^2$ x $10^{-6}$) @ x$10^{-12}$W/$cm^2$ Ave | Remark |
|---|---|---|---|
| 950.81 | 0.621 | 0.102 | Mobile Signal (Maxis) |
| 951.00 | 0.656 | 0.114 | Mobile Signal (Maxis) |
| 951.01 | 0.634 | 0.107 | Mobile Signal (Maxis) |
| 951.14 | 0.400 | 0.042 | Mobile Signal (Maxis) |
| 951.27 | 0.632 | 0.106 | Mobile Signal (Maxis) |
| 951.34 | 0.640 | 0.109 | Mobile Signal (Maxis) |
| 951.47 | 0.640 | 0.109 | Mobile Signal (Maxis) |
| 951.53 | 0.629 | 0.105 | Mobile Signal (Maxis) |
| 951.67 | 0.624 | 0.103 | Mobile Signal (Maxis) |
| 956.20 | 0.545 | 0.079 | Mobile Signal (Maxis) |
| 957.71 | 0.804 | 0.171 | Mobile Signal (Maxis) |
| 1832.27 | 0.835 | 0.185 | Other MTBS Signal |
| 1836.00 | 0.852 | 0.193 | Other MTBS Signal |
| 1840.11 | 0.814 | 0.176 | Other MTBS Signal |
| 1846.93 | 0.967 | 0.248 | Other MTBS Signal |
| 1855.29 | 0.860 | 0.196 | Other MTBS Signal |
| 1857.34 | 1.019 | 0.275 | Other MTBS Signal |
| 1863.51 | 1.127 | 0.337 | Other MTBS Signal |
| 2126.70 | 1.712 | 0.777 | IMT2000(3G) |
| 2127.90 | 2.054 | 1.119 | IMT2000(3G) |
| 2128.70 | 2.097 | 1.166 | IMT2000(3G) |
| 2129.30 | 2.254 | 1.348 | IMT2000(3G) |
| 2129.70 | 2.170 | 1.249 | IMT2000(3G) |
| 2130.10 | 1.764 | 0.825 | IMT2000(3G) |
| 2165.70 | 4.847 | 6.232 | Unknown Signal |
| **Total** | **30.197** | **15.474** | |

Table B2: Results of radiofrequency and microwave radiation measurements (electric fields) at location KT11 using spectrum analyzer.

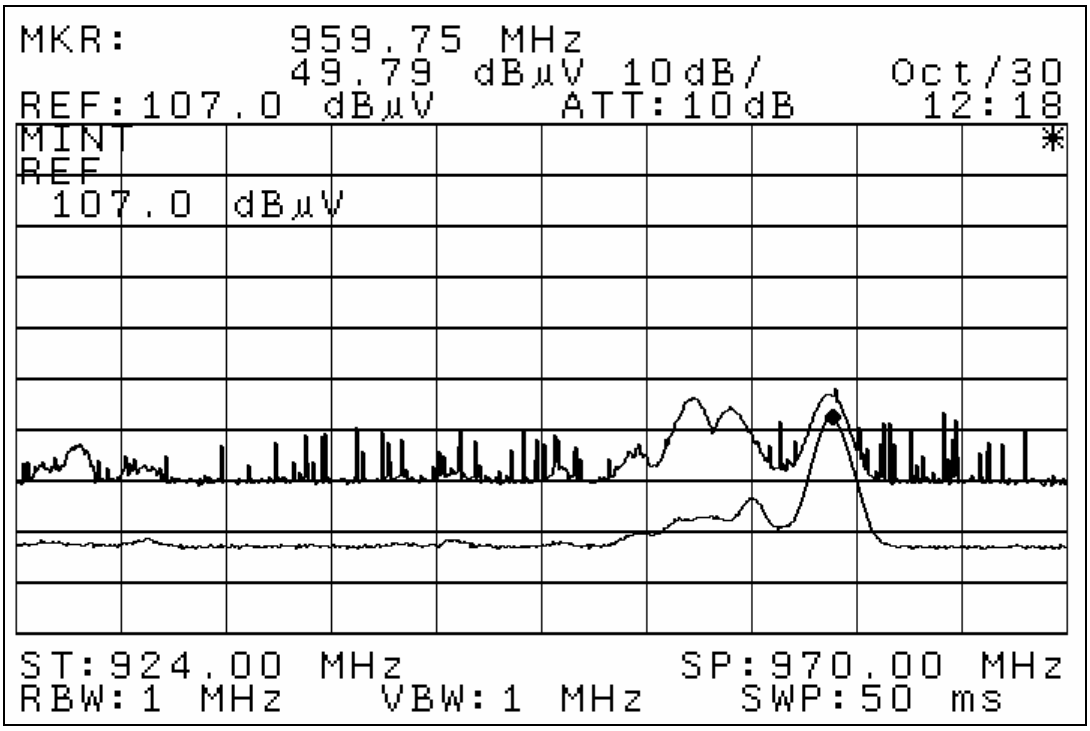
| Frequency (MHz) | Field Strength (mV/m) Ave | Calculated Field Strength ($\mu W/cm^2 \times 10^{-6}$) @ $x10^{-12} W/cm^2$ Ave | Remark |
|---|---|---|---|
| 855.00 | 0.553 | 0.081 | Other MTBS Signal |
| 952.85 | 0.561 | 0.083 | Mobile Signal (Maxis) |
| 956.27 | 0.928 | 0.228 | Mobile Signal (Maxis) |
| 959.75 | 5.702 | 8.624 | Mobile Signal (Maxis) |
| 960.00 | 4.875 | 6.304 | Mobile Signal (Maxis) |
| 1000.00 | 1.886 | 0.944 | Unknown Signal |
| 1832.01 | 0.678 | 0.122 | Other MTBS Signal |
| 1835.87 | 0.675 | 0.121 | Other MTBS Signal |
| 1839.99 | 0.661 | 0.116 | Other MTBS Signal |
| 1846.93 | 1.053 | 0.294 | Other MTBS Signal |
| 1855.41 | 0.653 | 0.113 | Other MTBS Signal |
| 1863.51 | 0.786 | 0.164 | Other MTBS Signal |
| 1877.91 | 0.650 | 0.112 | Other MTBS Signal |
| 2126.10 | 1.986 | 1.046 | IMT2000(3G) |
| 2126.90 | 2.352 | 1.467 | IMT2000(3G) |
| 2127.70 | 2.331 | 1.441 | IMT2000(3G) |
| 2128.30 | 2.236 | 1.326 | IMT2000(3G) |
| 2129.40 | 2.028 | 1.091 | IMT2000(3G) |
| 2150.60 | 1.344 | 0.479 | IMT2000(3G) |
| 2151.30 | 1.464 | 0.569 | IMT2000(3G) |
| 2152.10 | 1.361 | 0.491 | IMT2000(3G) |
| 2153.10 | 1.327 | 0.467 | IMT2000(3G) |
| 2165.70 | 2.649 | 1.861 | Unknown Signal |
| **Total** | **38.739** | **27.546** | |

Table B3: Results of radiofrequency and microwave radiation measurements (electric fields) at location KT11 using spectrum analyser (continue).

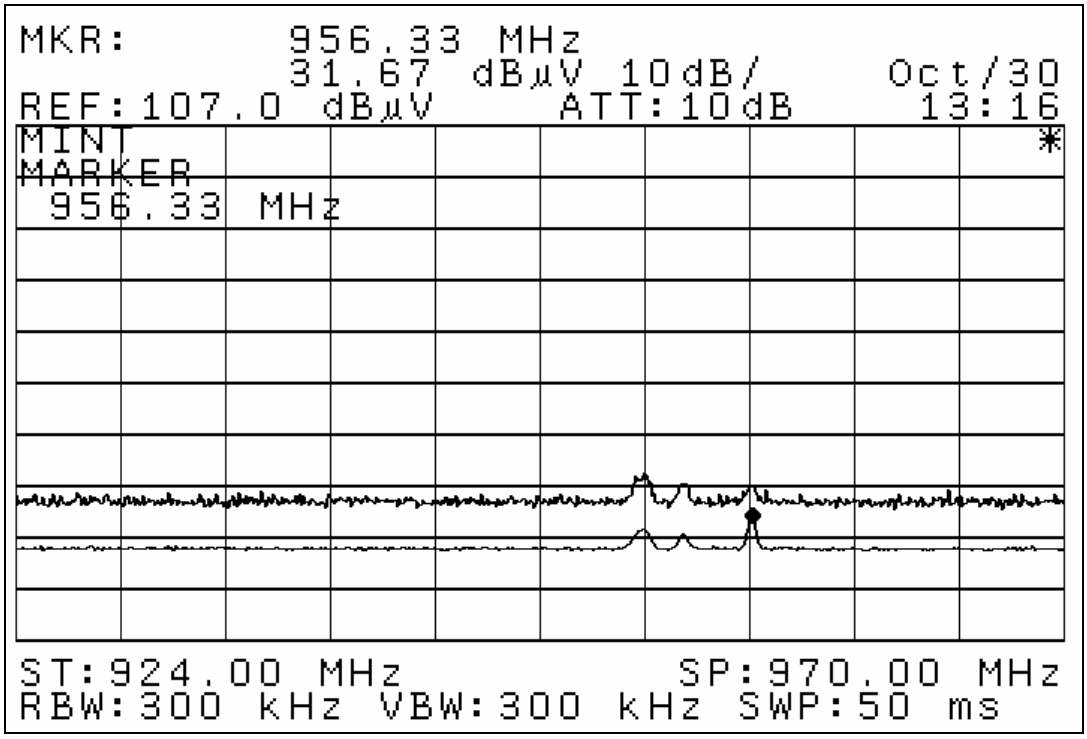
| Frequency (MHz) | Field Strength (mV/m) Ave | Calculated Field Strength ($\mu W/cm^2 \times 10^{-6}$) @ $x10^{-12} W/cm^2$ Ave | Remark |
|---|---|---|---|
| 956.00 | 2.023 | 1.086 | Mobile Signal (Maxis) |
| 956.33 | 0.708 | 0.133 | Mobile Signal (Maxis) |
| 953.31 | 0.462 | 0.057 | Mobile Signal (Maxis) |
| 951.53 | 0.518 | 0.071 | Mobile Signal (Maxis) |
| 1863.77 | 0.642 | 0.109 | Other MTBS Signal |
| 2127.60 | 1.886 | 0.944 | IMT2000(3G) |
| 2126.90 | 1.756 | 0.818 | IMT2000(3G) |
| 2128.10 | 1.816 | 0.875 | IMT2000(3G) |
| 2129.10 | 1.756 | 0.818 | IMT2000(3G) |
| **Total** | **11.567** | **4.910** | |




a) Location KT01




b) Location KT07




c) Location KT11

Figure 8: Mobile phone signal (GSM 900) captured by spectrum analyzer at locations KT01, KT07 and KT11.