MCMC MTSFB TC G033:2021

TECHNICAL CODE

PREDICTION AND MEASUREMENT OF RF EMF EXPOSURE FROM TERRESTRIAL RADIO AND TELEVISION BROADCASTING TRANSMITTER STATION

Developed by

Malaysian Technical Standards Forum Bhd

Registered by

MCMC

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Development of technical codes

The Communications and Multimedia Act 1998 ('the Act') provides for Technical Standards Forum designated under section 184 of the Act or the Malaysian Communications and Multimedia Commission ('the Commission') to prepare a technical code. The technical code prepared pursuant to section 185 of the Act shall consist of, at least, the requirement for network interoperability and the promotion of safety of network facilities.

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Maxis Broadband Sdn Bhd

Measat Broadcast Network System Sdn Bhd

Media Prima Berhad

MYTV Broadcasting Sdn Bhd

Panasonic AVC Networks Kuala Lumpur Malaysia Sdn Bhd

Sharp Electronics (M) Sdn Bhd

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Sony EMCS Malaysia Sdn Bhd

Telekom Malaysia Berhad

Universiti Teknikal Malaysia Melaka

Universiti Teknologi Malaysia

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Wideminds Pte Ltd

Foreword

This technical code for Prediction and Measurement of RF EMF Exposure from Terrestrial Radio and Television Broadcasting Transmitter Station ('this Technical Code') was developed pursuant to the section 95 and section 185 of the Act 588 by the Malaysian Technical Standards Forum Bhd (MTSFB) via its Broadcast Technology Working Group.

This Technical Code shall continue to be valid and effective from the date of its registration until it is replaced or revoked.

PREDICTION AND MEASUREMENTS OF RF EMF EXPOSURE FROM TERRESTRIAL RADIO AND TELEVISION BROADCASTING TRANSMITTER STATION

1. Scope

This Technical Code describes the prediction and measurement methods for the determination of Radio Frequency (RF) field strength and power density in the vicinity of terrestrial radio and television broadcasting transmitter station for the purpose of evaluating Electromagnetic Fields (EMF) exposure to humans.

The method of evaluating EMF exposure for EMF Compliance Assessment shall be as specified in the **Commission Determination on the Mandatory Standard for Electromagnetic Field Emission from Radiocommunications Infrastructure*,* Determination No. 5 of 2021** ('Mandatory Standard').

2. Normative reference

The following normative reference is indispensable for the application of this Technical Code. For dated reference, only the edition cited applies. For undated reference, the latest edition of the normative reference (including any amendments) applies.

MCMC Determination No. 5 of 2021, *Commission determination on the mandatory standard for electromagnetic field emission from radiocommunications infrastructure.*

MCMC Spectrum Plan Issued 2017

Recommendation ITU-R-REC-BS.1698-0 (02/2005), *Evaluating fields from terrestrial broadcasting transmitting systems for assessing exposure to non-ionizing radiation*

Recommendation ITU-T K.100 (07/2019), *Measurement of radio frequency electromagnetic fields to determine compliance with human exposure limits when a base station is put into service*

Recommendation ITU-T K.70 (01/2018), *Mitigation techniques to limit human exposure to EMFs in the vicinity of radiocommunication stations*

Recommendation ITU-T K.61 (01/2018), *Guidance on measurement and numerical prediction of electromagnetic fields for compliance with human exposure limits for telecommunication installations*

Recommendation ITU-T K.52 (01/2018), *Guidance on complying with limits for human exposure to electromagnetic fields*

IEC 62232:2019, *Determination of RF field strength, power density and Specific Energy Absorption Rate (SAR) in the vicinity of radiocommunication base stations for the purpose of evaluating human exposure*

ICNIRP Guidelines, Health Phys. 118(5):483–524; 2020; *Guidelines for limiting exposure to electromagnetic fields (100 kHz to 300 GHz)*

3. Abbreviations

For the purposes of this Technical Code, the following abbreviations apply.

AF	Antenna Factor
AM	Amplitude Modulation
CASP	Content Applications Services Provider
CIIP	Common Integrated Infrastructure Provider
CF	Calibration Factor
DTT	Digital Terrestrial Television
E-field	Electric field
EIRP	Equivalent Isotropic Radiated Power
EMF	Electromagnetic Fields
ERP	Effective Radiated Power
FDTD	Finite-Difference Time-Domain
FF	Far-field
FM	Frequency Modulation
HF	High Frequency
H-field	Magnetic field
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IEC	International Electrotechnical Commission
ITU	International Telecommunication Union
MOM	Method of Moments
MR	Multiple-Region
MR-FDTD	Multiple-Region Finite-Difference Time
MW	Medium Wave
NEC	Numeric Electromagnetic Code
NF	Near-field
RCI	Radiocommunications Infrastructure
RF	Radio Frequency
SAR	Specific Energy Absorption Rate
SI	International System of Units
SW	Short Wave
UHF	Ultra High Frequency
VHF	Very High Frequency
WHO	World Health Organisation

4. Terms and definitions

For the purposes of this Technical Code, the following terms and definitions apply.

4.1 Antenna Factor (AF)

Ratio of the electromagnetic field strength incident upon an antenna to the voltage that is produced across a specified impedance (e.g., 50 Ω) terminating the line connection of the antenna.

4.2 Averaging time

Appropriate time over which exposure is averaged for purposes of determining compliance.

4.3 Compliance zone

In the compliance zone, potential exposure to EMF is below the applicable limits for both controlled/occupational exposure and uncontrolled/general public exposure.

4.4 Directivity

Ratio of the radiation intensity produced by an antenna in a given direction to the value of the radiation intensities averaged across all directions in space.

4.5 Effective Radiated Power (ERP)

Product of the power supplied to the antenna and the maximum antenna gain relative to a half-wave dipole.

4.6 Electric field (E-field) strength

Vector field quantity, E which exerts on any charged particle at rest a force, F equal to the product of E and the electric charge, Q of the particle.

4.7 Effective Isotropic Radiated Power (EIRP)

Product of the power supplied to the antenna and the maximum antenna gain relative to an isotropic antenna.

4.8 Exceedance zone

In the exceedance zone, potential exposure to EMF exceeds the applicable limits for both controlled/occupational exposure and uncontrolled/general public exposure.

4.9 Exclusion zone

Areas around an antenna or antennas where the RF field values emanating from the antennas exceed the International Commission on Non-Ionizing Radiation Protection (ICNIRP) public guidelines (public exclusion zone) or the ICNIRP occupational guidelines (occupational exclusion zone).

4.10 Exposure

Exposure occurs wherever a person is subjected to electric, magnetic or electromagnetic fields or to contact currents other than those originating from physiological processes in the body or other natural phenomena.

4.11 Exposure level

Value given in the appropriate quantity used when to express the degree of exposure of a person to electromagnetic fields or contact currents.

4.12 Exposure limits

Values of the basic restrictions or reference levels acknowledged, according to obligatory regulations, as the limits for the permissible maximum level of the human exposure to the electromagnetic fields.

4.13 Far-field (FF) region

Region of the field of an antenna where the radial field distribution is essentially dependent inversely on the distance from the antenna. In this region, the field has a predominantly plane-wave character, i.e. locally uniform distribution of electric field and magnetic field in planes transverse to the direction of propagation.

4.14 Magnetic field (H-field) strength

Vector quantity obtained at a given point by subtracting the magnetisation, M from the magnetic flux density, B divided by the magnetic constant, μ_0.

4.15 Near-field (NF) region

Region generally in proximity to an antenna or other radiating structure, in which the electric and magnetic fields do not have a substantially plane-wave character, but vary considerably from point to point. The Near-field (NF) region is further subdivided into the reactive NF region, which is closest to the radiating structure and that contains most or nearly all of the stored energy, and the radiating NF region where the radiation field predominates over the reactive field, but lacks substantial plane-wave character and is complex in structure.

4.16 Occupational zone

In the occupational zone, potential exposure to EMF is below the applicable limits for controlled/occupational exposure but exceeds the applicable limits for uncontrolled/general public exposure.

4.17 Shared sites

Multiple services or systems on the same or different radiocommunications infrastructure within a particular location.

4.18 Transmitter station

Fixed equipment including the radio frequency transmitter and associated antennas as used in terrestrial radio and television broadcasting.

5. Exposure limits

All service providers have to comply with the EMF exposure limits determined according to the Mandatory Standard for general public and occupational workers, individually and jointly. Basic restriction and reference level units are shown in Table 1.

Table 1. Quantities and corresponding International System of Units (SI) units used

Quantity	Symbol	Unit
Incident power density	S_{inc}	Watt per square meter, W m^{-2}
Incident electric field strength	E_{inc}	Volt per meter, V m^{-1}
Induced magnetic field strength	H_{ind}	Ampere per meter, A m^{-1}
Incident magnetic field strength	H_{inc}	Ampere per meter, A m^{-1}
Specific energy absorption rate	*SAR*	Watt per kilogram, W kg^{-1}
Electric current	*I*	Ampere, A
Frequency	*f*	Hertz, Hz
Time	*t*	Second, s

The limit of EMF exposure from a transmitter station for public and occupational workers shall not exceed the specified values as shown in Table 2. In the event of any inconsistency with the Mandatory Standard, the limits specified by the Mandatory Standard shall prevail. The averaging and integrating time of the relevant exposure quantities are specified to determine whether personal exposure level is compliant with the guidelines. The averaging time is not necessarily the same as the measurement time needed to estimate field strengths or other exposure quantities.

Table 2. Reference levels for exposure from 100 kHz to 300 GHz (unperturbed root mean square (rms) values)

Exposure scenario	Frequency range	Incident E-field strength, E_{inc} (V m^{-1})	Incident H-field strength, H_{inc} (A m^{-1})	Incident power density, S_{inc} (W m^{-2})
Occupational workers	0.1 MHz - 30 MHz	$660/f_M^{0.7}$	$4.9/f_M$	N/A
	> 30 MHz - 400 MHz	61	0.16	10
	> 400 MHz - 2 000 MHz	$3f_M^{0.5}$	$0.008f_M^{0.5}$	$f_M/40$
	> 2 GHz - 300 GHz	N/A	N/A	50
Public	0.1 MHz - 30 MHz	$300/f_M^{0.7}$	$2.2/f_M$	N/A
	> 30 MHz - 400 MHz	27.7	0.073	2
	> 400 MHz - 2 000 MHz	$1.375f_M^{0.5}$	$0.0037f_M^{0.5}$	$f_M/200$
	> 2 GHz - 300 GHz	N/A	N/A	10

NOTES:

1. N/A signifies not applicable and does not need to be taken into account when determining compliance.
2. f_M is frequency in MHz.

Table 2. Reference levels for exposure from 100 kHz to 300 GHz (unperturbed root mean square (rms) values) *(continued)*

3. S_{inc}, E_{inc}, and H_{inc} are to be averaged over 30 min, over the whole-body space. Temporal and spatial averaging of each of E_{inc} and H_{inc} must be conducted by averaging over the relevant square values.

4. For frequencies of 100 kHz to 30 MHz, regardless of the Far-field (FF)/NF zone distinctions, compliance is demonstrated if neither E_{inc} or H_{inc} exceeds the above reference level values.

5. For frequencies of > 30 MHz to 2 GHz:

    a. within the FF zone, compliance is demonstrated if either S_{inc}, E_{inc} or H_{inc}, does not exceed the above reference level values (only one is required), S_{eq} may be substituted for S_{inc};

    b. within the radiative NF zone, compliance is demonstrated if either S_{inc}, or both E_{inc} and H_{inc}, does not exceed the above reference level values; and

    c. within the reactive NF zone, compliance is demonstrated if both E_{inc} and H_{inc} do not exceed the above reference level values, S_{inc} cannot be used to demonstrate compliance, and so basic restrictions must be assessed.

6. For frequencies of > 2 GHz to 300 GHz:

    a. within the FF zone, compliance is demonstrated if S_{inc} does not exceed the above reference level values, S_{eq} may be substituted for S_{inc};

    b. within the radiative NF zone, compliance is demonstrated if S_{inc} does not exceed the above reference level values; and

    c. within the reactive NF zone, reference levels cannot be used to determine compliance, and so basic restrictions must be assessed.

(Source: ICNIRP Guidelines)

Exposure limits for occupational workers are higher than for the general public because workers are adults who are generally exposed under known conditions and are trained to be aware of potential risks and to take appropriate precautions. Anyone who is not at work would be regarded as a member of the public and the public exposure limits apply.

6. Shared site

Shared site refers to a multiple broadcast transmitter or terrestrial systems, which are installed within the same tower or structure. For the purpose to determine the RF owner for a shared site, the following methods shall be applied. Figure 1 shows an example of a shared site for a broadcast transmitter.

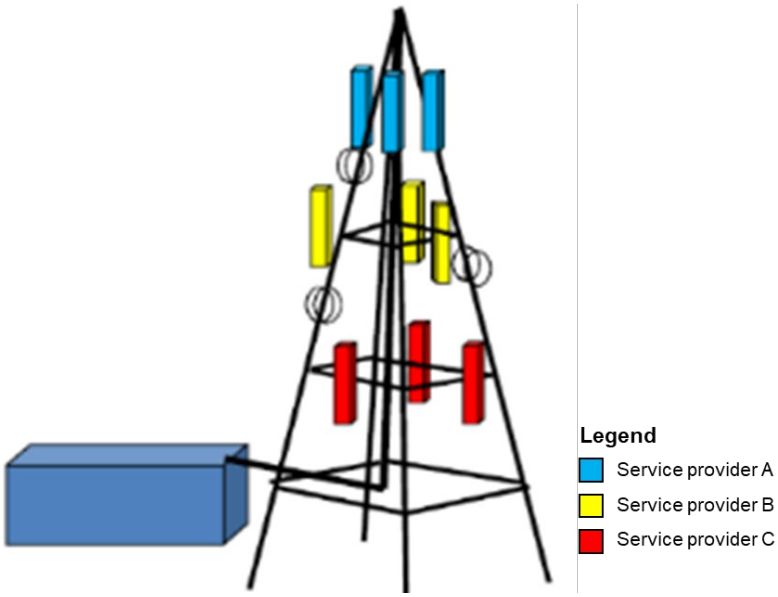

Figure 1. 4-legged tower

6.1 Determination of Radio Frequency (RF) owner at shared site

In view of the existence of multiple service providers at a particular site, RF owner shall be appointed to ease EMF compliance activities, such as generating and submitting the latest EMF Compliance Report according to Mandatory Standard. Nevertheless, the compliance with EMF exposure limit is the responsibility of all sharing parties, whereby any non-compliance should be resolved amicably.

6.2 Principles of determining RF owner for a shared site

The RF owner for each shared site should be decided by the relevant service providers sharing the same tower. The list below stipulates the principles of determining an RF owner for a shared site depending on the ownership of the site:

6.2.1 Site owned by Content Applications Services Provider (CASP) or Common Integrated Infrastructure Provider (CIIP)

Site structure owner is designated as the RF owner. However, the role will be relinquished to the subsequent service provider that comes on board. Ownership will also change to the service provider who performs an upgrade with additional antennas or transmitters. Even so, the site structure owner is responsible to inform all existing service providers that are currently operating at the site of any new tenants or changes made to transmitters or antennas. This is to allow the current RF owner to handover the responsibility to the new RF owner.

6.2.2 Site not owned by the CASP or CIIP

The first service provider on board is designated as the RF owner. However, the role will be relinquished to the subsequent service provider that comes on board. Ownership will also change to the service provider who performs an upgrade with additional antennas or transmitters. Even so, the site structure owner is responsible to inform all existing service providers that are currently operating at the site of any new tenants or changes made to transmitters or antennas. This is to allow the current RF owner to hand over the responsibility to the new RF owner.

NOTES:

1. While the principles highlighted above are applicable to new sites that are on-air subsequent to the issuance date of this document, it is encouraged for relevant service providers to deliberate on the RF ownership amicably for existing sites that are already on-air.

2. The candidate for RF owner shall be from the service providers that operate the spectrum assigned to it to provide network service. Parties that do not operate the RCI/ spectrum are excluded.

3. The role will be relinquished to the previous RF owner should the current RF owner left the site.

6.3 EMF measurement responsibility for a shared site

For EMF measurement activities involving other service provider(s) but not the RF owner, the responsibility for the said activities lies with the respective service provider(s). For EMF measurement activities involving other service provider(s) including the RF owner, the RF owner will be the coordinator for the said activities in collaboration with the other service provider(s).

7. Exclusion zones

The methods for determining the limit of EMF levels and exclusion zones shall be in accordance with the calculations as described in the ITU-T K.100, ITU-R BS.1698 and IEC 62232.

7.1 Theoretical calculation for single station

The theoretical calculation for determining the exclusion zone derived from NF and FF zones formula and FF zone formula.

7.1.1 NF zone

The NF zone formula is used to estimate the power density for distances less than the FF zone.

The formula is shown as below:

$$S_m = \frac{4PE}{A}$$

where,

S_m the maximum power density, in watt per square metre, *W/m²*;
E antenna efficiency (in number 0 to 1);
P the power output of the system; and
A the physical aperture area, in square metres, *m²*.

7.1.2 FF zone

The FF zone formula is used to estimate the incident power density for FF zone distance.

The formula is shown as below:

$$S_{inc} = \frac{PG_{\theta,\varphi}}{(4\pi d^2)}$$

where,

S_{inc}	the incident power density;
P	transmitted power;
$G_{\theta,\varphi}$	gain of the antenna in the direction (θ,$\boldsymbol{\varphi}$); and
d	distance from the antenna to the evaluation point.

The associated incident electric field strength, E_{inc}, and incident magnetic field strength, H_{inc}, can be evaluated as follows:

$$E_{inc} = \sqrt{\frac{30PG_{\theta,\varphi}}{d}}$$

$$H_{inc} = \frac{E}{\eta_0}$$

where, $\eta_0 \approx 377\ \Omega$.

If the power density is evaluated in the direction of maximum antenna gain:

$$S_{inc} = \frac{EIRP}{(4\pi d^2)}$$

where, Equivalent Isotropic Radiated Power (EIRP) is $PG_{\theta,\varphi}$.

The equation is rearranged to calculate the minimum safe distance from the antenna, d_{min} or also known as exclusion zone distance is as follows:

$$d_{min} = \sqrt{\frac{EIRP}{4\pi S_{inc}}} \qquad \text{or} \qquad d_{min} = \sqrt{\frac{1.64ERP}{4\pi S_{inc}}}$$

If the electric field strength is evaluated in the direction of maximum antenna gain, the equation for the minimum safe distance from the antenna, d_{min} or also known as exclusion zone distance is as follows:

$$d_{min} = \frac{5.5\sqrt{\mathrm{EIRP}}}{\mathrm{E}} \qquad \text{or} \qquad d_{min} = \frac{5.5\sqrt{1.64\mathrm{ERP}}}{\mathrm{E}}$$

7.2 Exclusion zone distances for terrestrial radio and television broadcasting transmitters

Based on the method described in section 7.1.2, the exclusion zone distances at an antenna main lobe for terrestrial radio and television transmitter stations are calculated as in Table 3 and Table 4. The list of spectrum frequency bands in these tables are in accordance with the MCMC Spectrum Plan Issued 2017, which specify the frequency bands for terrestrial radio and television broadcasting services in Malaysia.

Table 3. Exclusion zone distances for terrestrial radio broadcasting transmissions

Band	Frequency (MHz)	Transmit power at antenna / Highest ERP (dBW)	ICNIRP limit for public	ICNIRP limit for occupational exposure	Exclusion zone distance for public (m)	Exclusion zone distance for workers (m)
Medium Wave (MW)	0.525 - 1.605	N/A*	470.99 V/m	1036.17 V/m	N/A*	N/A*
Short Wave (SW)	5.9 - 6.2	59	86.60 V/m	190.52 V/m	72.50	32.95
	7.2 - 7.45	59	75.33 V/m	165.73 V/m	83.34	37.88
	9.4 - 9.9	59	62.51 V/m	137.52 V/m	100.45	45.66
	11.6 - 12.1	59	53.95 V/m	118.69 V/m	116.38	52.90
	13.57 - 13.87	59	48.34 V/m	106.35 V/m	129.88	59.04
	15.1 - 15.8	59	44.86 V/m	98.69 V/m	139.97	63.62
	17.48 - 17.9	59	40.49 V/m	89.08 V/m	155.07	70.49
	18.9 - 19.02	59	38.34 V/m	84.34 V/m	163.78	74.45
	21.45 - 21.85	59	35.09 V/m	77.19 V/m	178.95	81.34
	25.67 - 26.1	59	30.94 V/m	68.07 V/m	178.95	92.24
Frequency Modulation (FM)	87.5 - 108	43.39	2 W/m^2	10 W/m^2	37.74	16.88
Very High Frequency (VHF)	174 - 230	N/A*	2 W/m^2	10 W/m^2	N/A*	N/A*

NOTES:

1. No MW and VHF radio or television broadcasting service available as of November 2020.
2. The highest ERP value stated in Table 3 has made reference to the common operation of radio broadcasting in Malaysia.
3. The calculation for exclusion zones of MW and SW band are based on the lowest frequency band while the ICNIRP limit level refers to electric field strength (V m-1). However, for FM and VHF bands, the calculation of exclusion zone is based on the lowest frequency band and ICNIRP limit level refers to power density (W m-2).
4. The exclusion zone for other than the main lobe direction will be smaller than the value determined in Table 3.

Table 4. Exclusion zone distances for terrestrial television broadcasting transmissions

UHF channel	Frequency (MHz)	Transmit power at antenna / Highest ERP (dBW)	ICNIRP limit for public, S_{inc} (W m^{-2})	ICNIRP limit for occupational exposure, S_{inc} (W m^{-2})	Exclusion zone distance for public (m)	Exclusion zone distance for workers (m)
21	470 - 478	51	2.35	11.75	83.61	37.39
22	478 - 486	51	2.39	11.95	82.91	37.08
23	486 - 494	51	2.43	12.15	82.23	36.77
24	494 - 502	51	2.47	12.35	81.56	36.47
25	502 - 510	51	2.51	12.55	80.90	36.18
26	510 - 518	51	2.55	12.75	80.27	35.90
27	518 - 526	51	2.59	12.95	79.64	35.62
28	526 - 534	51	2.63	13.15	79.04	35.35
29	534 - 542	51	2.67	13.35	78.44	35.08
30	542 - 550	51	2,71	13.55	77.86	34.82
31	550 - 558	51	2.75	13.75	77.29	34.57
32	558 - 566	51	2.79	13.95	76.74	34.32
33	566 - 574	51	2.83	14.15	76.19	34.07
34	574 - 582	51	2.87	14.35	75.66	33.84
35	582 - 590	51	2.91	14.55	75.14	33.60
36	590 - 598	51	2.95	14.75	74.63	33.37
37	598 - 606	51	2.99	14.95	74.13	33.15
38	606 - 614	51	3.03	15.15	73.64	32.93
39	614 - 622	51	3.07	15.35	73.15	32.72
40	622 - 630	51	3.11	15.55	72.68	32.50
41	630 - 638	51	3.15	15.75	72.22	32.30
42	638 - 646	51	3.19	15.95	71.76	32.09
43	646 - 654	51	3.23	16.15	71.32	31.89
44	654 - 662	51	3.27	16.35	70.88	31.70
45	662 - 670	51	3.31	16.55	70.45	31.51
46	670 - 678	51	3.35	16.75	70.03	31.32
47	678 - 686	51	3.39	16.95	69.62	31.13
48	686 - 694	51	3.43	17.15	69.21	30.95

Table 4. Exclusion zone distances for terrestrial television broadcasting *(continued)*

NOTES:

1. The highest ERP value stated in Table 4 has made reference to the common operation of Digital Terrestrial Television (DTT) broadcasting in Malaysia.

2. The calculation for the exclusion zone of the UHF band is based on the lowest frequency band and ICNIRP limit level refers to power density (W m-2).

3. The exclusion zone for other than the main lobe direction will be smaller than the value determined in Table 4.

It shall be noted that the exclusion zone distances in Table 3 and Table 4 are only examples based on practical ERP and antenna data, which are determined by common operation values used by local broadcasters.

The calculation for exclusion zone distances of other broadcasting frequency spectrum bands as specified in Annex A shall be based on actual transmitter station specifications. It shall also be based on the proper usage of the formulas and the ERP values.

However, in real condition, the guidelines in Figure 2 and examples of simple EMF exposure evaluation for various situations shown in ITU-T K.52 shall be referred to.

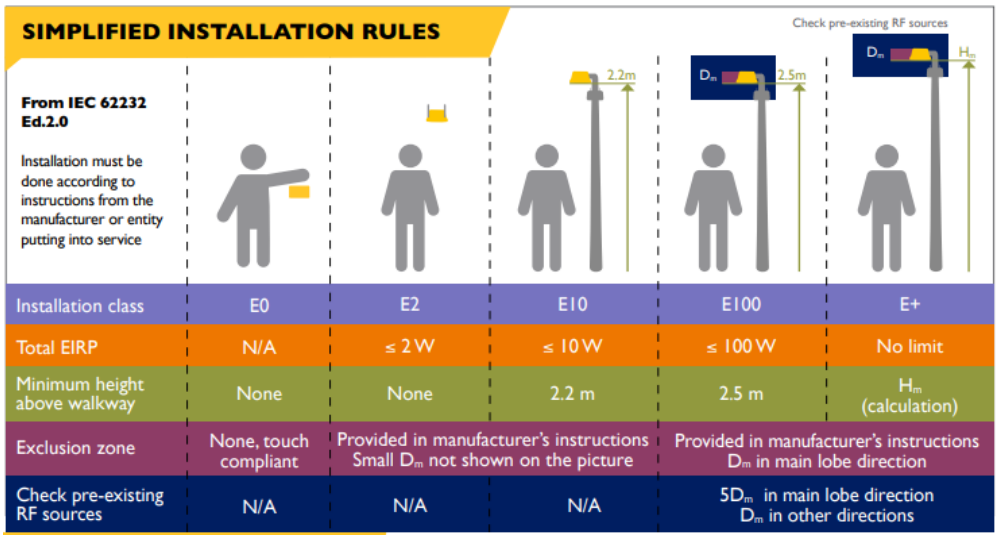

Figure 2. Simplified installation rules and total EIRP determination

8. Prediction methods for EMF exposure

This section describes the calculation and computation methods to evaluate EMF exposure. The selection of numerical methods suitable for EMF exposure prediction in various situations are provided in ITU-T K.61 and IEC 62232.

The evaluation procedure is divided into:

a) evaluation by calculation for single transmitter station; and

b) evaluation by advanced computation using a simulation software, for complex transmitter station (where there are 2 or more antennas/transmitters).

In the event of any configuration changes on the station, the EMF exposure should be re-evaluated with the updated configuration parameters.

8.1 Evaluation by calculation

In the case of a single transmitter station (including directional or omni-directional for coverage in all directions), the basic calculation of EMF exposure is as stipulated in Clause 7 in accordance with ITU-T K.52. The evaluation of the EMF exposure is to be made at various publicly accessible points in the environment surrounding the station. The EMF exposure calculation report shall consist of the data and technical parameters as shown in Table 5.

Table 5. EMF exposure calculation information

Type	Descriptions
Station information	a) station ID; b) station address; c) Global Positioning System (GPS) coordinates; and d) date of commission.
Technical parameters	a) station location; b) station height in metre; c) tower height; d) antenna height; e) electrical tilt and mechanical tilt in degree; f) antenna gain in dB; g) antenna vertical bandwidth beam in degree; h) antenna side lobe attenuation in dB; i) antenna type, model and manufacturer; and j) transmitter power output in W.
Other technical parameters	Uncertainty estimation analysis, which consist of: a) cable, connector and combiner loss in dB; b) scattering from nearby object and ground in dB; c) mismatch between antenna and its feed in dB; and d) antenna radiation pattern data.
Calculation tool's information	a) version, model and manufacturer (if any); b) operator name and designation; and c) date and time of calculation report.

8.2 Evaluation by advanced computation

Advanced computational electromagnetic mapping using a simulation software is required for complex sites where there are 2 or more transmitters or antennas. The simulation results are to be presented in the form of field strength or power densities that are calculated according to the plane of interest, and expressed in terms of numerical values and percentage of the exposure limit. Based on the simulated results, it is required for the EMF measurements to be performed if the power density values are found to exceed the stipulated exposure limit.

8.2.1 Advanced computation methods

For a complex scattering environment, exclusion zones for multiple antennas in close proximity are drawn by software simulation based on methodologies as proposed in IEC 62232, ITU-T K.52 and ITU-T K.61.

There are several methods useful for determining compliance with exposure limits, namely:

a) Finite-Difference Time-Domain (FDTD);

b) Multiple-Region Finite-Difference Time-Domain (MR/FDTD);

c) ray tracing model;

d) hybrid ray tracing/FDTD methods; and

e) NF antenna models such as Method of Moments (MOM) and the Numeric Electromagnetic Code (NEC).

The guidance in selecting appropriate computation methods to assess compliance with EMF levels is shown in Table 6 which shall depend on the following factors:

a) the field zone where the exposure evaluation is required;

b) the quantities being evaluated; and

c) the topology of the environment where the exposure occurs.

Table 6. Selection of numerical techniques

Field zone	Topology	Evaluated quantity	Suitable numerical technique
NF	Open	Field	FDTD, MOM
NF	Closed, multiple scatterers	Field	FDTD, MOM
FF	Open	Field	Ray tracing, MOM
FF	Multiple scatterers (complex urban environment)	Field	Ray tracing
NOTE: More detailed information on numerical techniques can be found in IEC 62232.			

8.2.2 Software estimation of uncertainty

All methods require an uncertainty analysis report to be included with the simulation report. Detailed information can be found in IEC 62232 and ITU-T K.100. The software estimation of uncertainty involves the following tasks:

a) identification of all sources of uncertainty that may reasonably be expected to cause significant variation or uncertainty in the evaluation;

b) for each source of uncertainty, an estimation of the probability distribution type and parameter;

c) specification of how the sources of uncertainty are combined to provide a total uncertainty value (a mathematical model which defines how the influence quantities are combined or added); and

d) determine the best estimate of the evaluation and expanded uncertainty for a 95 % confidence interval.

8.2.3 Validation of EMF simulation software

The simulation software shall be validated with a reference sample stated in IEC 62232 depending on the choice of computational method used. If the maximum deviation from the reference results is within ± 3 dB, the simulation package has passed the validation. The latest simulation software validation is required for the updated version or/and model.

Simulation software operators shall be trained and a training certificate shall be provided for verification purpose. Software operator name and designation shall be available in the simulation report. A simulation software (EMF estimator) as described in ITU-T K.70 should be used.

8.2.4 Exclusion zone indicators

The simulation report shall provide clear information on zoning as defined in ITU K.52 that classifies potential exposure to EMF as belonging to one of the three following zones; compliance zone, occupational zone and exceedance zone.

In the examples shown in Figure 3, the red zone indicates the exceedance zone, where no person is allowed into this area without following the appropriate shut-down, power-down or safe pass-through procedures. The yellow zone indicates the occupational zone, where only the RF-trained personnel are allowed, on the condition that they follow the relevant site access procedures. The area outside the yellow zone (white zone) is open for public access.

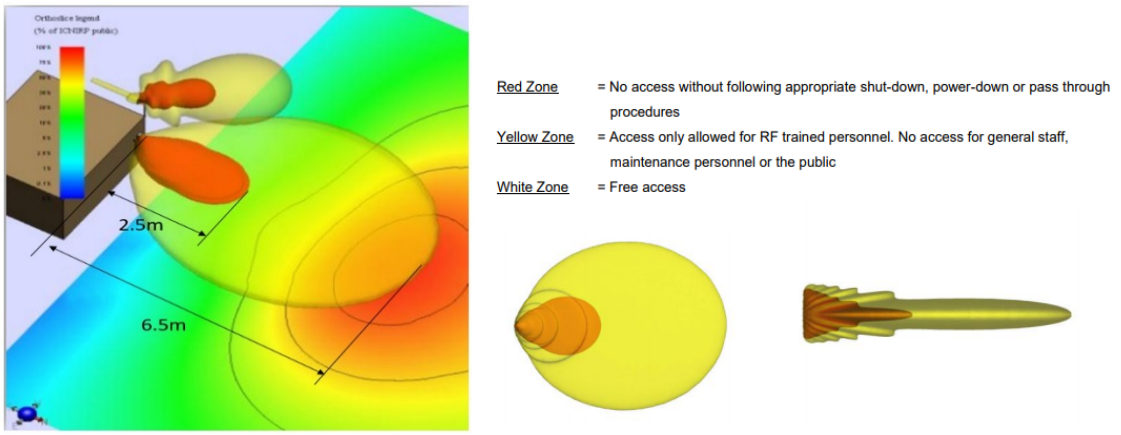

Figure 3. An example of simulated exclusion zone

The examples of simulation models illustrating the exclusion zones for various antenna structures are shown in Figure 4.

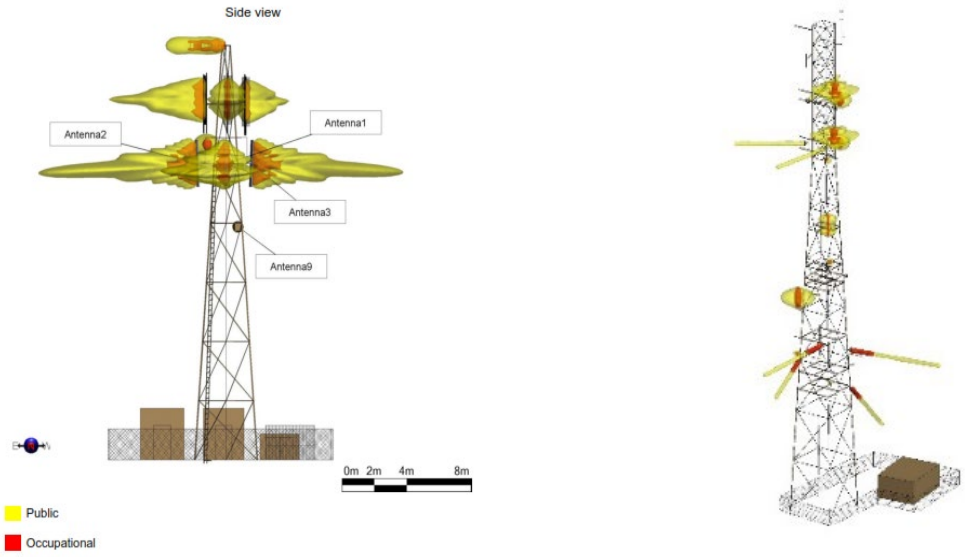

Figure 4. Examples of computed exclusion zone

8.2.5 EMF simulation report

The simulation report should include the following data and technical parameters as elaborated and explained in Annex B:

a) broadcast transmitter information;

b) technical parameters;

c) cut-plane figures;

d) simulation software information; and

e) blueprint to scale.

The computations and assessments of the exposure level shall consider the following conditions:

a) the maximum emission conditions (e.g. maximum EIRP, gain and beamwidth of the antenna system;

b) the simultaneous presence of several EMF sources, even at different frequencies; and

c) various characteristics of the installation, such as the antenna location, antenna height, beam direction and beam tilt.

Sample of the simulation report is shown in Annex D.

9. On-site measurement for EMF exposure

On-site measurement shall be performed to analyse and confirm the actual EMF exposure at particular site and its surrounding areas. The measurement shall comply with the EMF exposure limits as stated

in the Mandatory Standard. This clause specifies the techniques and instrumentation for the on-site EMF measurement.

9.1 In-situ EMF measurement

In-situ measurement is a measurement of the RF exposure level in the vicinity of the station. Measurement or evaluation shall be made in the areas, which are known to be accessible by public and workers, and shall be performed at one location or area, known as the measurement area. The in-situ measurement method shall be in accordance with the IEC 62232.

9.1.1 NF measurement

NF measurement is conducted to determine the EMF exposure level for workers. For NF measurement, both E-field and H-field intensities shall be measured and compared to the EMF exposure limits as specified in the Mandatory Standard.

9.1.2 FF measurement

FF measurement is conducted to determine the EMF exposure for the public. For FF measurement, only electric field strength (E-field) or power density shall be measured and compared to the EMF exposure limits, and shall be in accordance to the Mandatory Standard.

FF region can be determined by the following formula:

If the dimension D, of the antenna is much longer as compared to the wavelength, it can be determined by the following formula:

$$FF = \frac{2D^2}{\lambda}$$

where,

FF the distance which indicates the beginning of the FF region;
D the biggest dimension of the antenna in metre, m; and
λ wavelength of the transmitted radiation in metre, m.

a) However, for the onset of the FF zone, the maximum phase difference of the electromagnetic waves coming from different points on the antenna is 22.5º. To estimate the field strength (worst case scenario), a realistic practical distance from a large antenna (parabolic) at the FF zone begins at:

$$FF = \frac{0.5D^2}{\lambda}$$

b) For small antenna size (e.g. rod/dipole), the FF can be determined using the following formula.

$$FF = \frac{\lambda}{2\pi}$$

The NF and FF regions are illustrated in Figure 5.

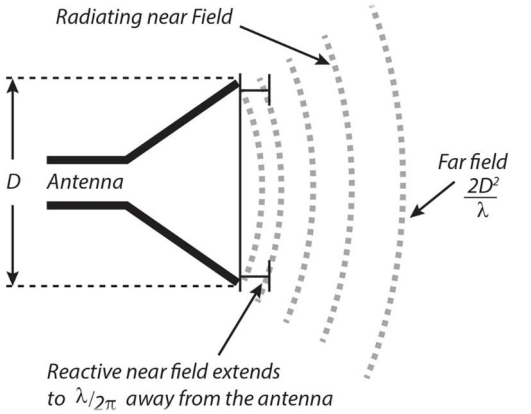

Figure 5. NF and FF region

9.1.3 Measurement instrumentations

Measurement shall be performed using the most appropriate measuring equipment to obtain the information of transmit electromagnetic fields emitted on-site. According to the ITU-T K.61, there are several considerations in selecting the measurement devices as follows:

a) frequency range

There are 2 frequency ranges, which are the broadband and narrowband frequency range. Broadband devices will measure the overall frequency available around the site. This measurement will not indicate the individual frequency spectrum, but this is very appropriate for measurement at the public area, to show the overall EMF emission as indication of the public exposure. Measurement devices are generally antennas with a big frequency range. Narrowband measurement devices are generally antennas with flat antenna factors over limited spectrum ranges and can be used for selective frequency measurement.

b) antenna directivity

The antenna response may be isotropic or directional. For the isotropic devices, the response is expected to be dependent on the direction of the incident EMF. Directional devices are generally polarised and have an axial symmetry in the radiation pattern.

c) quantity measured

The majority of the devices measure either the electric field or the magnetic field. In the FF region, measurement devices for the electric field component are preferred. The equivalent power density within the FF region is obtained from the measured field by calculation shown in Table 1 of the ITU-T K.61, which is based on the following equation:

$$Power\ density, S = \frac{E^2}{Z_0} = Z_0 \cdot H^2$$

where,

E	Electric field
Z_0	Intrinsic impedance
H	Magnetic field

d) device selection

The selection for EMF measurement devices is determined by some factors, for instance:

i) The equipment and device shall comply to the following recommendations:

1) The device shall measure electric field (V/m), magnetic field (A/m) and power density ($\mu W/cm^2$) and comply to the existing standard by ICNIRP; and

2) The equipment should be suitable for the frequency range; i.e. narrowband or broadband measurement to comply with the characteristics of the EMF source.

ii) For NF measurement, the EMF personal monitor is required.

iii) The number and the characteristics of EMF sources (which meet the measurement objective) are also considered.

iv) Equipment or device shall be calibrated and has a valid calibration certificate.

v) The field region (i.e. reactive NF, radiating NF or FF) in which the measurement is made should be determined.

The accuracy of measurement results depends on the measurement procedures, as well as on the characteristics of the measurement instrument used. An expanded measurement uncertainty with a 95 % confidence interval less than or equal to 4 dB is deemed sufficient to show compliance.

9.1.4 Calibration requirements

Calibration is very important to ensure the reliability of the equipment used. The objective of the calibration is to minimise any measurement uncertainty by ensuring the accuracy of the test equipment by quantifying and controlling errors within measurement processes to an acceptable level. The calibration requirements shall comply with the ITU-T K.61 and IEC 62232.

a) Calibration Factor (CF)

For the broadband probes, the CF is defined by the following formula:

$$CF = \frac{E_{ref}}{E_{meas}}$$

It is the ratio between the expected electric field reference field strength, E_{ref} and the measured value, E_{meas} is displayed on the dedicated receiver unit. This factor is mainly a function of frequency and in the presence of non-linearity error or field strength. The CF is determined as a frequency function. For each frequency, the CF value shall be known with uncertainty less than 1 dB. Errors due to frequency interpolation are included in the tolerable uncertainty on CF.

b) Antenna Factor (AF)

The AF is defined for antennas and frequency selective probe as the ratio of the following formula:

$$AF = \frac{E_{ref}}{V}[m^{-1}]$$

where,

E_{ref} the E-field strength on the probe; and
V the voltage measured on the spectrum analyser.

This factor is primarily a function of frequency but in presence of non-linearity errors, it may depend on field strength as well. The AF is determined as a frequency function. For each frequency, the AF value shall be known with an expanded uncertainty (i.e. 95 % statistical confidence) of less than 2 dB. The maximum tolerable uncertainty includes the error due to the frequency interpolation.

c) isotropy

An isotropic probe is needed for compliance measurement of EMF emission. The isotropic response is usually achieved by a three-axial antenna system, where the three axes are arranged to be orthogonal. The deviation from an ideal isotropic response is called isotropic error and in general, it is a function of the incident wave direction. It can be evaluated by measuring the difference from a cosine response of each axis if they are spatially identified and a signal from each axis is available, or by checking the whole probe response (if it is not possible to clearly define the position of each axis, or a single axis signal is not available). The mean deviation from the isotropic response should be less than 1 dB.

d) linearity

A linear response versus the field amplitude is required; a linearity error would mean that the antenna and the calibration factors are functions of the test field strength. Thus, the linearity test should be the starting point of the whole characterisation process of the probe.

9.1.5 Probe selection

General consideration in probe selection is the frequency range. It can be a broadband probe or a narrowband probe. This depends on the EMF sources intended to be measured (single source or multiple EMF sources). Broadband measurement will provide one set of field strength measurement for all frequency range and sources at the measurement area, while narrowband measurement requires separate sets of field strength values of each source and frequencies at the measurement area. The choice of the measurement type depends on the objective of the in-situ evaluation as stated in the IEC 62232.

The dimension of the probe sensor should be less than a wavelength at the highest operating frequency. According to ITU-T K.61, a non-directional probe is preferred in conducting EMF measurement.

9.1.6 Measurement method

The details of the measurement method which comply in accordance with IEC 62232, ITU-T K.61 and ITU-T K.100 are as follows:

a) measurements shall be conducted by qualified personnel with specific training on EMF instrumentations and techniques;

b) visual inspection shall be conducted before the measurement starts;

c) physical condition of the EMF source at the site must be recorded (number of antenna, height of the structure and type of the antenna) and a photo of the site must be taken for record on the day of the measurement;

d) the parameters that shall be considered during the assessment are as follows:

   i) frequency range;

   ii) type of antenna;

   iii) transmitting power;

iv) dimension of the antenna; and

v) distance.

e) identification of RF source and measurement points;

f) the locations of measurement selected shall be based on the worst-case situation (nearest accessible location facing the antenna beam) and popular public places (residential area, playground, bus stops, etc.).

Distance from the EMF source to the measurement point must be recorded as reference. The NF or FF region shall be determined before selecting the measurement point. EMF measurement shall be conducted at various location points and should be mapped with the exact location (with longitude and latitude coordinates). The EMF mapping process will show the EMF exposure level variations over the distance and at the selected measurement points. The layout plan must be sketched for any measurement conducted in the building;

g) EMF measurement instruments shall match with the EMF sources frequency range and suit the FF or NF region, in which appropriate equipment and probes shall be selected based on the intended frequency range;

h) the measurement shall be carried out at 1.5 m to 2 m from the ground/floor which the measurement probe should be mounted on a wooden tripod;

i) inspection or measurement point shall be selected at least the length of 3 probe or 0.2 m away from any conducting or reflecting objects;

j) for each point, measurement shall be taken for 6 min by using broadband and selective spectrum analyser with appropriate probe (according to the frequency used by each telco service); and

k) results shall be recorded in power density ($\mu W/cm^2$) to represent the EMF exposure.

Measurements for the shared site shall consider the number of RF sources available at the site. Information on the individual frequency of the RF source used by each service provider shall be obtained before the measurement. The broadband measurement is required to determine the total electromagnetic field around the site. Individual frequency measurement using the selective spectrum analyser can be conducted if needed. The EMF exposure limits calculation for the shared sites shall be determined by using the lowest frequency used by the shared service provider as a consideration of the worst-case scenario.

9.1.7 Measurement report

A sample of the measurement report is as per Annex E. A measurement report shall consists of the following information:

a) introduction;

b) objective;

c) scope of the measurement;

d) description of survey site and radiation source;

e) safety guidelines and exposure limit;

f) standard measurement equipment;

g) method of measurement;

h) results and discussion;

i) conclusion;

j) attachment; and

k) report verification.

Annex A
(informative)

Frequency spectrum allocation for broadcasting services

The list of frequency spectrum allocation for broadcasting services as specified in ITU Region 3 and MCMC Spectrum Plan Issued 2017 are tabulated in Table A.1

Table A.1. Frequency spectrum allocation for broadcasting services

ITU Region 3 frequency band (MHz)	Allocation service	Malaysia footnotes
0.5265 - 0.535	Broadcasting Mobile	MLA3 MLA11 MLA93
0.535 - 1.6065	Broadcasting	MLA3 MLA11 MLA93
2.30 - 2.495	Fixed Mobile Broadcasting	MLA13
3.20 - 3.23	Fixed Mobile (except aeronautical mobile) Broadcasting	MLA3 MLA13 MLA93
3.23 - 3.40	Fixed Mobile (except aeronautical mobile) Broadcasting	MLA3 MLA13 MLA93
3.90 - 3.95	Aeronautical mobile Broadcasting	MLA3 MLA13 MLA83 MLA93
3.95 - 4.00	Broadcasting	MLA3 MLA13 MLA83 MLA93
4.75 - 4.85	Fixed Broadcasting Land mobile	MLA3 MLA13 MLA93
4.85 - 4.995	Fixed Broadcasting Land mobile	MLA3 MLA13 MLA93
5.005 - 5.06	Fixed Broadcasting	MLA3 MLA13 MLA93
5.90 - 5.95	Broadcasting	MLA13 MLA93
5.95 - 6.20	Broadcasting	MLA3 MLA93
7.20 - 7.30	Broadcasting	MLA3 MLA93
7.30 - 7.40	Broadcasting	MLA3 MLA93
7.40 - 7.45	Broadcasting	MLA3 MLA93
9.40 - 9.50	Broadcasting	MLA3 MLA93
9.50 - 9.90	Broadcasting	MLA3 MLA93
11.60 - 11.65	Broadcasting	MLA3 MLA93
11.65 - 12.05	Broadcasting	MLA3 MLA93

Table A.1. Frequency spectrum allocation for broadcasting services *(continued)*

ITU Region 3 frequency band (MHz)	Allocation service	Malaysia footnotes
12.05 - 12.10	Broadcasting	MLA3 MLA93
13.57 - 13.60	Broadcasting	MLA3 MLA93
13.60 - 13.80	Broadcasting	MLA3 MLA93
13.80 - 13.87	Broadcasting	MLA3 MLA93
15.10 - 15.60	Broadcasting	MLA3 MLA93
15.60 - 15.80	Broadcasting	MLA3 MLA93
17.48 - 17.55	Broadcasting	MLA3 MLA93
17.55 - 17.90	Broadcasting	MLA3 MLA93
18.90 - 19.02	Broadcasting	MLA3 MLA93
21.45 - 21.85	Broadcasting	MLA3 MLA93
2.567 - 2.61	Broadcasting	MLA3 MLA93
47 - 50	Fixed Mobile Broadcasting	MLA3 MLA14 MLA90 MLA94 MLA102
54 - 68	Fixed Mobile Broadcasting	MLA3 MLA102
87 - 100	Fixed Mobile Broadcasting	MLA3 MLA94 MLA102
100 - 108	Broadcasting	MLA3 MLA94 MLA102
174 - 223	Fixed Mobile Broadcasting	MLA3 MLA29 MLA31 MLA86 MLA94 MLA95 MLA102
223 - 230	Fixed Mobile Broadcasting Aeronautical radionavigation Radiolocation	MLA29 MLA31 MLA32 MLA86 MLA87 MLA94 MLA95 MLA102
470 - 585	Fixed Mobile Broadcasting	MLA3 MLA29 MLA 85 MLA86 MLA93 MLA94 MLA95 MLA102
585 - 610	Fixed Mobile Broadcasting Radionavigation	MLA3 MLA29 MLA86 MLA94 MLA95 MLA102
610 - 698	Fixed Mobile Broadcasting	MLA3 MLA29 MLA86 MLA94 MLA95 MLA102
698 - 790	Fixed Mobile Broadcasting	MLA3 MLA29 MLA86 MLA94 MLA95 MLA102

Table A.1. Frequency spectrum allocation for broadcasting services *(continued)*

ITU Region 3 frequency band (MHz)	Allocation service	Malaysia footnotes
1 452 - 1 492	Fixed Mobile Broadcasting Broadcasting-satellite	MLA48 MLA106
2 520 - 2 535	Fixed Fixed-satellite Mobile (except aeronautical mobile) Broadcasting-satellite	MLA3 MLA89 MLA102
2 535 - 2 655	Fixed Mobile (except aeronautical mobile) Broadcasting-satellite	MLA3 MLA89 MLA102
2 655 - 2 670	Fixed Fixed-satellite Mobile (except aeronautical mobile) Broadcasting-satellite Earth exploration-satellite (passive) Radio astronomy Space research (passive)	MLA3 MLA89 MLA102
11 700 - 12 200	Fixed Mobile (except aeronautical mobile) Broadcasting Broadcasting-satellite	MLA96 MLA97
12 200 - 12 500	Fixed Fixed-satellite Mobile (except aeronautical mobile) Broadcasting	MLA58 MLA96 MLA97
12 500 - 12 750	Fixed Fixed-satellite Mobile (except aeronautical mobile) Broadcasting-satellite	MLA3 MLA58 MLA96 MLA97
21 400 - 22 000	Fixed Mobile Broadcasting-satellite	MLA3 MLA74 MLA102
40 500 - 41 000	Fixed Fixed-satellite Broadcasting Broadcasting-satellite Mobile	
41 000 - 42 500	Fixed Fixed-satellite Broadcasting Broadcasting-satellite Mobile	

Table A.1. Frequency spectrum allocation for broadcasting services *(concluded)*

ITU Region 3 frequency band (MHz)	Allocation service	Malaysia footnotes
74 000 - 76 000	Fixed Fixed-satellite Mobile Broadcasting Broadcasting-satellite Space research	

NOTES:

1. MLA3 - Class assignment.
2. MLA11 - The band from 526.5 kHz to 1 606.5 kHz is being used by stations for transmitting analogue broadcasting service and may be reserved for digital broadcasting service.
3. MLA13 - Part of the bands may be used for Digital Broadcasting Service.
4. MLA14 - Specific frequency bands exclusively for the Government of Malaysia.
5. MLA29 - Standard Radio System Plan 536: Requirements for Digital Terrestrial Television (including digital terrestrial sound) (DTT) Service Operating in the Frequency Bands from 174 MHz to 230 MHz and 470 MHz to 742 MHz.
6. MLA31 - The use of the band from 174 MHz to 230 MHz by the Fixed and Mobile Services shall not cause harmful interference to the Broadcasting Service.
7. MLA32 - The stations in the Aeronautical Radionavigation Service in the band from 225 MHz to 235 MHz shall not cause harmful interference to and shall not claim protection from broadcasting stations.
8. MLA48 - Standard Radio System Plan 520: Requirements for Digital Multimedia Service (DMS) Operating in the Frequency Band from 1 452 MHz to 1 492 MHz.
9. MLA83 - Some frequencies in HF band have been identified as common Public Protection and Disaster Relief (PPDR) use in Brunei Darussalam, Malaysia and Singapore.
10. MLA86 - Analogue TV broadcasting stations are allowed to operate in the bands from 174 MHz to 230 MHz and from 470 MHz to 790 MHz until Analogue Switch-Off (ASO) targeted in June 2018. Analogue TV broadcasting stations shall cease operation after ASO.
11. MLA87 - Use of frequency band from 223 MHz to 230 MHz for Airport Tower operation in the Aeronautical Radionavigation Service is allowed until 31 December 2020.
12. MLA90 - Technical Specification for Cordless Telephone System (SKMM WTS CTS).
13. MLA93 - Specification for Land Mobile Radio Equipment (MCMC MTSFB TC T012).
14. MLA94 - Specification for Short Range Devices (MCMC MTSFB TC T007).
15. MLA95 - Specification for Digital Terrestrial Television Broadcast Receiver (SKMM MTSFB TC T004).
16. MLA102 - Standard Radio System Plan 549: Requirements for Fixed Service Line-Of-Sight Radio-Relay Systems Operating in the Frequency Bands from 71 GHz to 76 GHz and 81 GHz to 86 GHz.
17. MLA106 - No new assignment in the frequency band 1 452 MHz to 1 492 MHz shall be considered. Existing stations are allowed to operate until 31 December 2020.

Annex B
(normative)

Technical requirements in EMF compliance report (simulation)

The following data and technical details should be included in the EMF compliance report (simulation):

a) station information consists of the following data;
   i) RCI ID;
   ii) RCI address;
   iii) GPS coordinate;
   iv) RCI type (e.g. tower/pole);
   v) geographical classification (e.g. dense urban/urban/sub-urban/rural);
   vi) date of commission;
   vii) RCI owner;
   viii) RF owner;
   ix) service providers;
   x) frequency available/maximum limit; and
   xi) simulation software.

b) technical parameters consist of the following data;
   i) RCI height in meter;
   ii) electrical tilt and mechanical tilt in degree;
   iii) antenna transmit gain in dBi;
   iv) antenna vertical bandwidth beam in degree;
   v) antenna side lobe attenuation in dB;
   vi) antenna type, model and make;
   vii) antenna GPS position;
   viii) transmitter power output in Watt;
   ix) frequency of operation; and
   x) Technology (e.g. FM/DTT)

c) other technical parameters for uncertainty estimation analysis

i) cable, connector and combiner loss in dB;

ii) scattering from nearby objects and ground in dB;

iii) mismatch between antenna and its feed in dB; and

iv) antenna radiation pattern data.

d) cut-plane figures for the following items below, as described in Table B.1 in reference to;

i) orthoslice at ground level as Figure B.1;

ii) exclusion zone crossover with adjacent building as Figure B.2.

Table B.1. The description of the required cut-plane figures

Cut-plane type	Description
Orthoslice at ground level	Horizontal plane 2 m above ground level in terms of power density or emission percentage against exposure limits. Legend with logarithmic rainbow colour scale shall be marked clearly.
Exclusion zone crossover with adjacent building:	At antenna height level to analyse the crossover within adjacent nearby buildings in close vicinity, in terms of power density or emission percentage against exposure limits. Legend with logarithmic rainbow colour scale shall be marked clearly.
NOTE: Public, occupational, and exceedance exposure limits shall be marked clearly.	

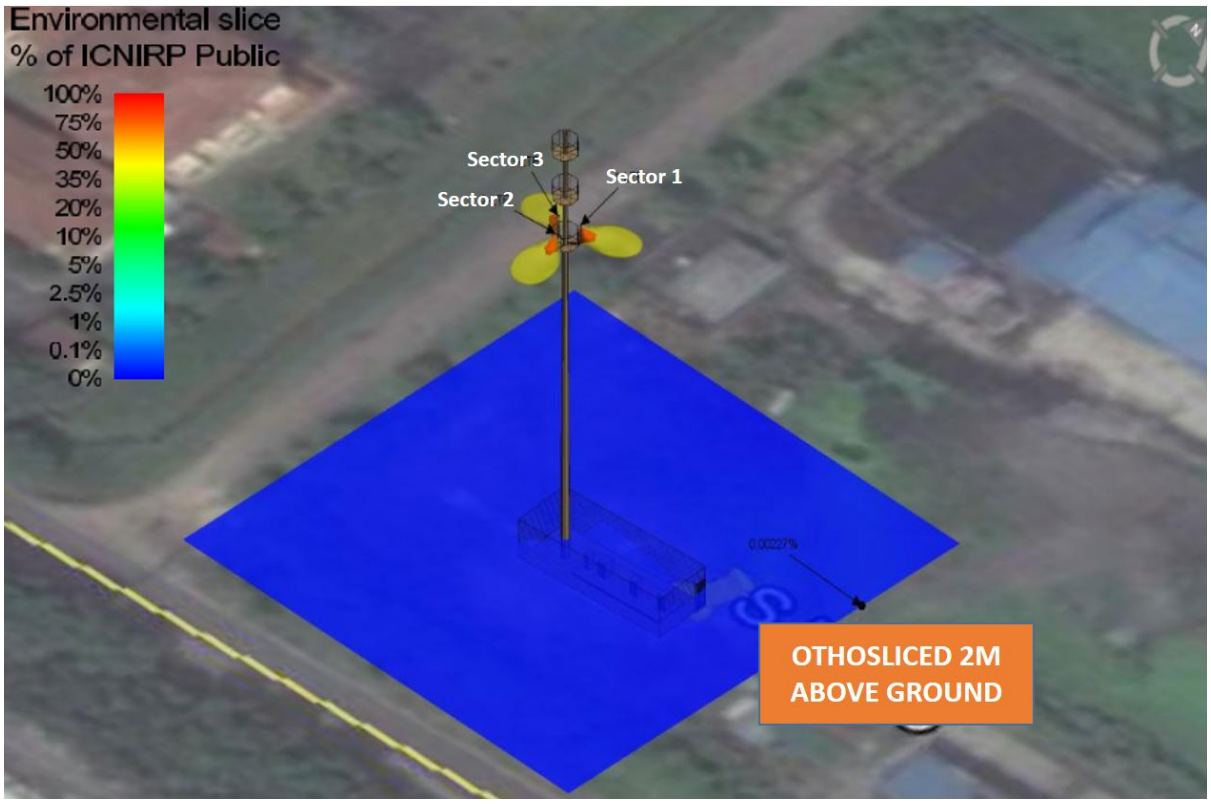

Figure B.1. Orthoslice method (2 meter above ground level)

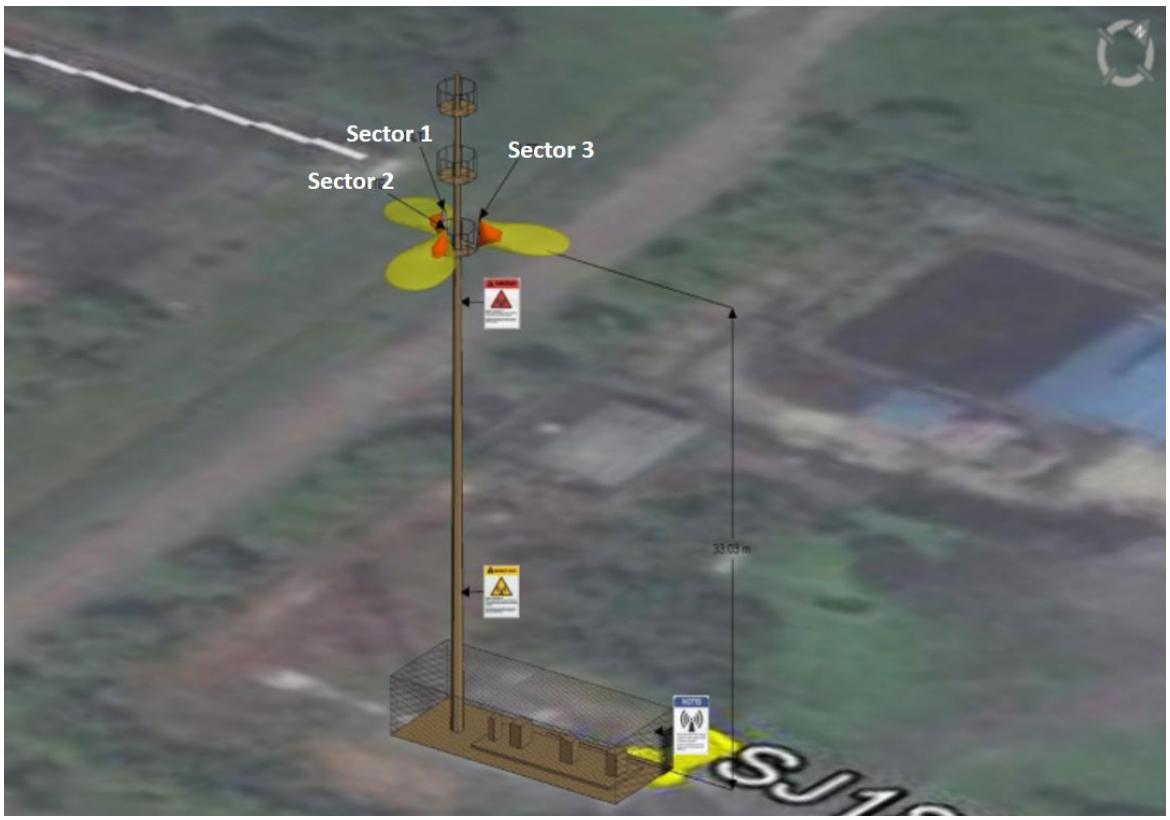

Figure B.2. Orthoslice method (exclusion zone with adjacent)

e) simulation software information consists of the following information; and

   i) simulation software's version, model and manufacturer;

   ii) simulation software operator's name and designation; and

   iii) date and time of the simulation report.

f) following requirements for blueprint to scale as the sample of blueprint to be imported as shown in Figure B.2:

   i) simulation must be based on the actual size of the building and area; and

   ii) the actual size of blueprints and aerial pictures either in any format (JPEG, PDF, PNG and BMP) must be imported.

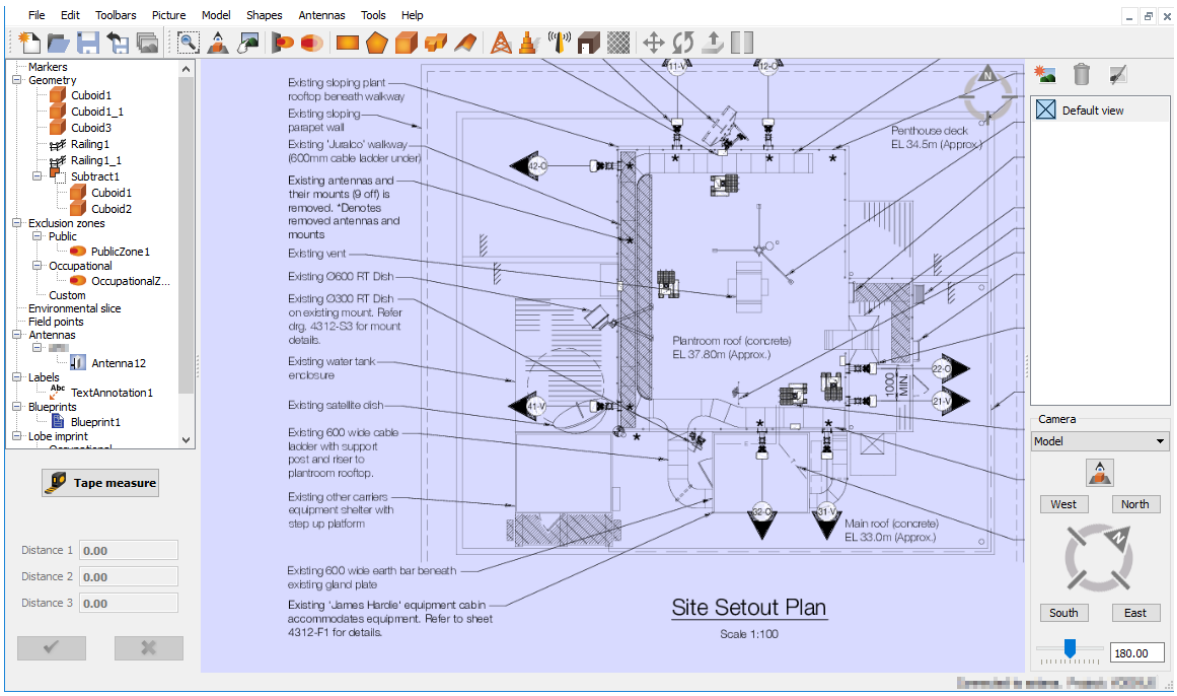

Figure B.3. Blueprint sample

Annex C
(normative)

Technical requirements in EMF compliance report (measurement)

The following data and technical details should be included in the EMF compliance report (measurement):

a) station information

   i) RCI ID;

   ii) RCI address;

   iii) GPS coordinate;

   iv) RCI type (e.g. tower/pole);

   v) geographical classification (e.g. dense urban/urban/sub-urban/rural);

   vi) date of commission;

   vii) RCI owner;

   viii) RF owner;

   ix) service providers;

   x) frequency available/maximum limit; and

   xi) measurement equipment.

b) RCI technical parameters

   i) RCI height in meter;

   ii) electrical tilt and mechanical tilt in degree;

   iii) antenna transmit gain in dBi;

   iv) antenna vertical bandwidth beam in degree;

   v) antenna side lobe attenuation in dB;

   vi) antenna type, model and make;

   vii) antenna GPS position;

   viii) transmitter power output in Watt;

   ix) frequency of operation; and

   x) technology (e.g. FM/DTT).

c) measurement assessment

i) measurement site;

ii) measurement points; and

iii) measurement data.

d) measurement equipment information

i) measurement equipment model and manufacturer;

ii) frequency range and calibration date;

iii) measurement equipment operator's name and designation; and

iv) date and time of measurement report.

e) blueprint to scale as shown in Figure C.1.

i) simulation must be based on actual size of the building and area; and

ii) the actual size of blueprints and aerial pictures in any format (JPEG, PDF, PNG and BMP) must be imported.

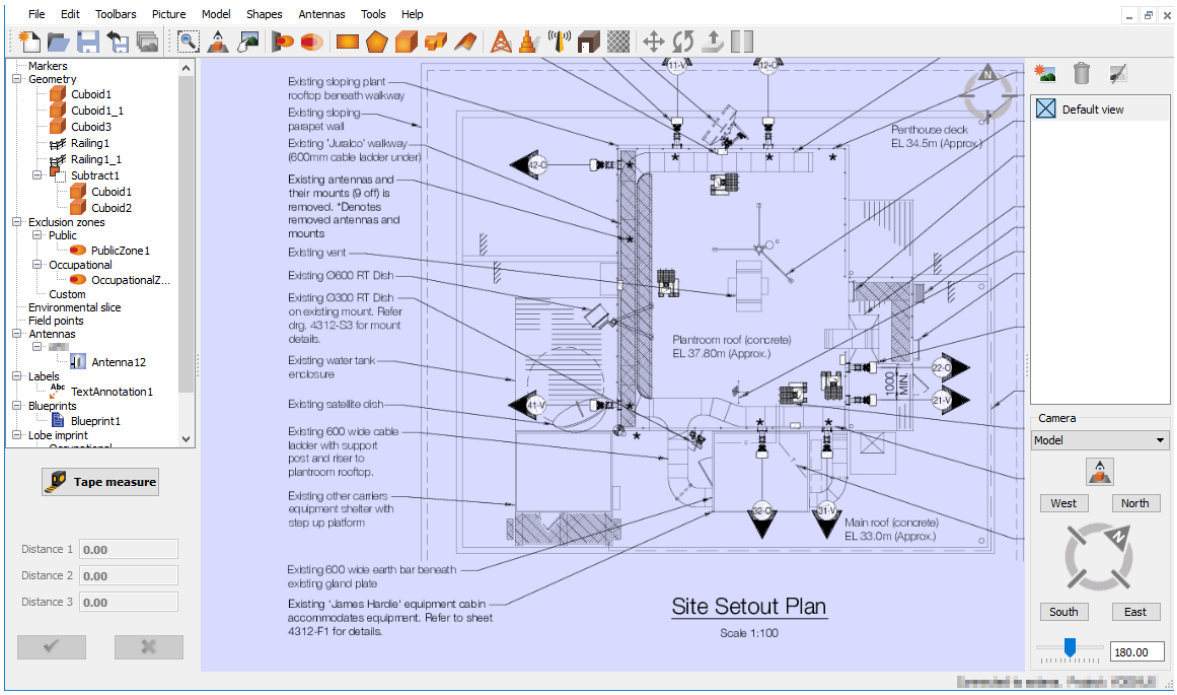

Figure C.1. Blueprint sample

Annex D
(informative)

EMF compliance report (simulation) sample

The EMF simulation report sample is as follows.

EMF COMPLIANCE REPORT (SIMULATION)

Report ID: **R04-000900/S/2021/1**

Compliance Method	Simulation Measurement
RCI ID	R04-000900
RF Owner	Telco A Sdn Bhd
RCI Address	42, Jalan Tun Sri Lanang, Kampung Durian Daun, 75100 Melaka.

RF Owner

Company Logo	Company Name and Address
	Telco A Sdn Bhd, Ground Floor, Block A, Shaftsbury Square, 63000 Cyberjaya, Malaysia.

Revision History

Issue No.	Issue Date	Validation Date	Reason for Amendment
1.0	17 August 2021	25 August 2021	Original

TABLE OF CONTENT

R04-000900/S/2021/1

1. EMF SIMULATION REPORT APPROVAL

This radio frequency electromagnetic field (RF EMF) simulation assessment has been performed in accordance with the Malaysian Communications and Multimedia Commission (MCMC) Mandatory Standard for Electromagnetic Field Emission from Radiocommunications Infrastructure ('MS EMF') and Malaysian Technical Standard Forum Bhd. (MTSFB) Technical Codes on EMF ('TC on EMF'):

- MCMC MTSFB TC G032:2021 - Prediction and Measurement of EMF Exposure from Base Station; or
- MCMC MTSFB TC G033:2021 - Prediction and Measurement of EMF Exposure from Terrestrial Radio and Television Broadcast Transmitter Station.

The assessment were conducted based on technical information provided by the client in the Technical Site Survey Report (TSSR) document.

Performed by:

Name	Address
Ultimate Communications Sdn. Bhd.	Unit 543, Jalan 51A/243, 46100 Petaling Jaya, Selangor Darul Ehsan, Malaysia.

Prepared by:

Name & Position	Date	Sign
Mohd Fadli Ahmad System Engineer	10 August 2021	*Fadli*

[To be completed by personnel who conducted simulation and prepared report]

Approved by:

Name & Position	Date	Sign
Alan Tan Technical Director	10 August 2021	*Alan T.*

[To be completed by company representative who approved the simulation result]

2. SUMMARY OF SIMULATION ASSESSMENT

[To provide the objective, summarised data and result of compliance to MS EMF based on assessment results and findings.]

The purpose of this assessment was to determine whether the RF EMF strength at this site was in compliance with the MS EMF for the general public. This assessment was done in accordance to the TC on EMF.

The highest RF EMF reading point of interest in public area were simulated with the technical parameters stated in Section 3.

Site Information

Report ID	R04-000900/S/2021/1		
RCI ID / Name	R04-000900 / Durian Daun		
GPS Coordinate	Lat 2.20458°, Long 102.25322°		
RCI Type	Mini Monopole (Rooftop)		
Geographical Classification	Rural		
Date of Commission	10 September 2013		
RCI Owner	Telco A Sdn Bhd		
RF Owner	Telco A Sdn Bhd		
Service Providers	Telco A 900MHz - 2G/3G 1800MHz - 2G	Telco B 1800MHz - 4G 2100MHz - 3G 2600MHz - 4G	Telco C 1800MHz - 4G 2100MHz - 3G 2600MHz - 4G
Frequency Available / Maximum Limit	900MHz/41 Vm^{-1}, 1800MHz/58 Vm^{-1}, 2100MHz/61 Vm^{-1}		
Simulation Software	IXUS EMF Compliance Software		

Simulation Result (Orthoslice) Power Density:

Level	Simulation Value		Compliance Status
2m above ground	6.57%	2.69 V/m	PASS
2m above rooftop	57.49%	23.57 V/m	PASS

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The simulation result at 2m above ground indicated that the highest point for RF EMF emission at public area was 2.69V/m or at 6.57% of the limit.

In comparison to the allowable exposure limit of 41V/m, this *value was well below the exposure limits* recommended by the MS EMF for the general public.

The actual RF EMF exposure levels will generally be significantly less than the simulated values, due to automatic power control used by cellular base stations as well as reduction in exposure levels due to environmental factors such as the presence of buildings, trees and other objects. The simulated values were aimed towards the analytic of **worst-case scenario** for the peak traffic conditions.

RESULT OF ASSESSMENT	**2.69V/m , 6.57%**
COMPLIANCE TO MS EMF	**PASS**

3. TECHNICAL REQUIREMENTS

[Refer to TC on EMF for the technical requirements for simulation. Include the data for all service providers at the same site.]

3.1 TECHNICAL PARAMETERS

ITEM	UNITS	TELCO A			TELCO A			TELCO A		
BUILDING HEIGHT AGL	(m)	22	22	22	22	22	22	22	22	22
RCI HEIGHT (GBT) AGL	(m)	7	7	7	7	7	7	7	7	7
RTT / GBT		Rooftop			Rooftop			Rooftop		
ANTENNA HEIGHT AGL	(m)	27	27	27	27	27	27	27	27	27
SYSTEM TYPE		3G	3G	3G	2G	2G	2G	2G	2G	2G
FREQUENCY OF OPERATION	(MHz)	900			1800			900		
MAKE AND MODEL OF ANTENNA	Ant-1	Agisson ATR451606			Agisson ATR451606			Agisson ATR451606		
	Ant-2	Agisson ATR451606			Agisson ATR451606			Agisson ATR451606		
	Ant-3	Agisson ATR451606			Agisson ATR451606			Agisson ATR451606		
ANTENNA GAIN	(dBi)	2	2	2	2	2	2	2	2	2
ELECTRICAL TILT	(Deg)	7	7	7	7	7	7	7	7	7
MECHANICAL / TOTAL TILT	(Deg)	3	3	3	3	3	3	3	3	3
AZIMUTH	(Deg)	120	230	320	120	230	320	120	230	320
TX POWER	(Watts)	80	80	80	80	80	80	80	80	80

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ITEM	UNITS	TELCO B			TELCO B			TELCO B		
BUILDING HEIGHT AGL	(m)	22	22	22	22	22	22	22	22	22
RCI HEIGHT (GBT) AGL	(m)	7	7	7	7	7	7	7	7	7
RTT / GBT		Rooftop			Rooftop			Rooftop		
ANTENNA HEIGHT AGL	(m)	27	27	27	27	27	27	27	27	27
SYSTEM TYPE		LTE	LTE	LTE	LTE	LTE	LTE	3G	3G	3G
FREQUENCY OF OPERATION	(MHz)	2600			1800			2100		
MAKE AND MODEL OF ANTENNA	Ant-1	Agisson ATR451607			Agisson ATR451606			Agisson ATR451607		
	Ant-2	Agisson ATR451607			Agisson ATR451606			Agisson ATR451607		
	Ant-3	Agisson ATR451607			Agisson ATR451606			Agisson ATR451607		
ANTENNA GAIN	(dBi)	3	3	3	3	3	3	3	3	3
ELECTRICAL TILT	(Deg)	7	7	7	7	7	7	7	7	7
MECHANICAL / TOTAL TILT	(Deg)	3	3	3	3	3	3	3	3	3
AZIMUTH	(Deg)	120	230	320	120	230	320	120	230	320
TX POWER	(Watts)	80	80	80	80	80	80	80	80	80

ITEM	UNITS	TELCO C			TELCO C			TELCO C		
BUILDING HEIGHT AGL	(m)	22	22	22	22	22	22	22	22	22
RCI HEIGHT (GBT) AGL	(m)	7	7	7	7	7	7	7	7	7
RTT / GBT		Rooftop			Rooftop			Rooftop		
ANTENNA HEIGHT AGL	(m)	27	27	27	27	27	27	27	27	27
SYSTEM TYPE		LTE	LTE	LTE	LTE	LTE	LTE	3G	3G	3G
FREQUENCY OF OPERATION	(MHz)	2600			1800			2100		
MAKE AND MODEL OF ANTENNA	Ant-1	Agisson ATR451607			Agisson ATR451606			Agisson ATR451607		
	Ant-2	Agisson ATR451607			Agisson ATR451606			Agisson ATR451607		
	Ant-3	Agisson ATR451607			Agisson ATR451606			Agisson ATR451607		
ANTENNA GAIN	(dBi)	3	3	3	3	3	3	3	3	3
ELECTRICAL TILT	(Deg)	7	7	7	7	7	7	7	7	7
MECHANICAL / TOTAL TILT	(Deg)	3	3	3	3	3	3	3	3	3
AZIMUTH	(Deg)	120	230	320	120	230	320	120	230	320
TX POWER	(Watts)	80	80	80	80	80	80	80	80	80

3.2 BLUEPRINT TO SCALE

[To provide the actual size of blueprints of the structure and aerial pictures of site in any format (JPEG, PDF, PNG and BMP).]

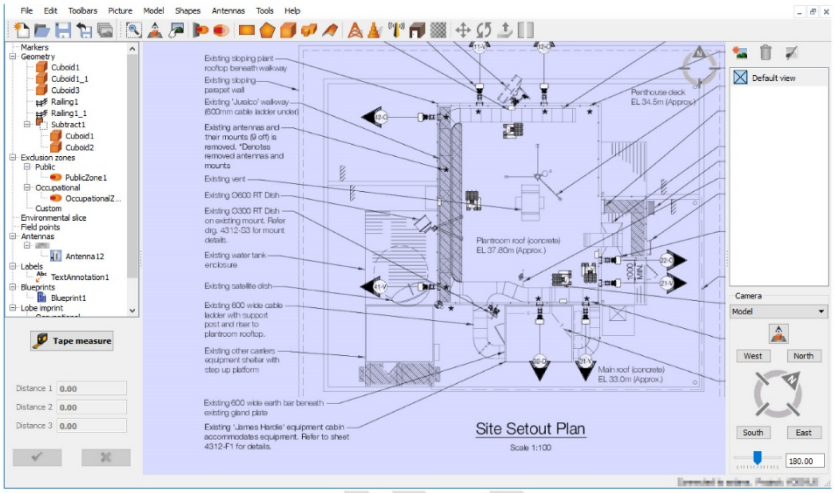

Figure 1: Blueprint of Structure

The site is located at **LAT 2.20458° LONG 102.25322°** shown in Figure 2.

Figure 2: Site location (Top View)

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4. UNCERTAINTY ESTIMATION ANALYSIS

[To identify all sources of uncertainty that may reasonably be expected to cause significant variation or uncertainty in the evaluation. Refer to TC on EMF. Table below is a sample template.]

Source of uncertainty	Unit	Prob. distrib. type	Uncertainty or semi span *a*	Divisor *d*	Sens. couff. *c*	Standard uncertainty *u=a/d*	Corr. fact *t*	c^2u^2
System								
Variation in the power of the RF transmitter from its nominal level	dB	rect.			1			
Cable/connector losses	dB	normal			1			
Mismatch between antenna and its feed	dB	U			1			
Antenna radiation pattern data (NOTE 2)	dB	normal			1			
Antenna positioning, mounting & support structure	dB	rect.			1			
Technique Uncertainties								
Inherent uncertainties associated with the approximate numerical model used to represent the antenna	dB	rect.			1			
Null-filling of antenna patterns (if applied)	dB	Depends on algoritm			1			
Environmental Uncertainties								
Scattering from nearby objects and the ground	dB	rect.			1			
Uncertainty in using electric field strength evaluations to estimate magnetic field strength or vice versa	dB	rect.			1			
Combined correction factor, $t_C = \sum_{i=1}^{N} t_i$								N/A
Combined standard uncertainty, $u_C = \sqrt{\sum_{i=1}^{N} (c_i^2 u_i^2)}$								
Expanded uncertainty, $U=k \times u_C$								

Note 1: The value of divisor d for normal probability distribution is for 95% confidence.

Note 2: The normalized radiation pattern uncertainty can be different inside the HPBW (very small); outside the main beam (larger); and in the side lobes.

5. SIMULATION ASSESSMENT

[Refer to Section 8 in TC on EMF for the simulation assessment methodology.]

5.1 SIMULATION RESULT OF ORTHOSLICE AT 2M ABOVE GROUND LEVEL (3D ELEVATION)

[To provide simulation data on whether the area is safe in Places of Interest in the Electromagnetic Field for General Public at 2m above ground level and the radiation emitted to the adjacent building, if any. Examples below in Figures 3-5.]

In this section, orthoslice at 2m above ground level were simulated.

i. Figures 3 and 4 showed the simulation data that reflected the area is safe in Places of Interest in the Electromagnetic Field for General Public. The simulation value with the highest point is 6.57% of the limit for public.

Description	Value %	Value V/m
The highest point of 2 meter above ground level	6.57	2.69

ii. Figure 5 is the top view simulation, showing no radiation emitted to the adjacent building.

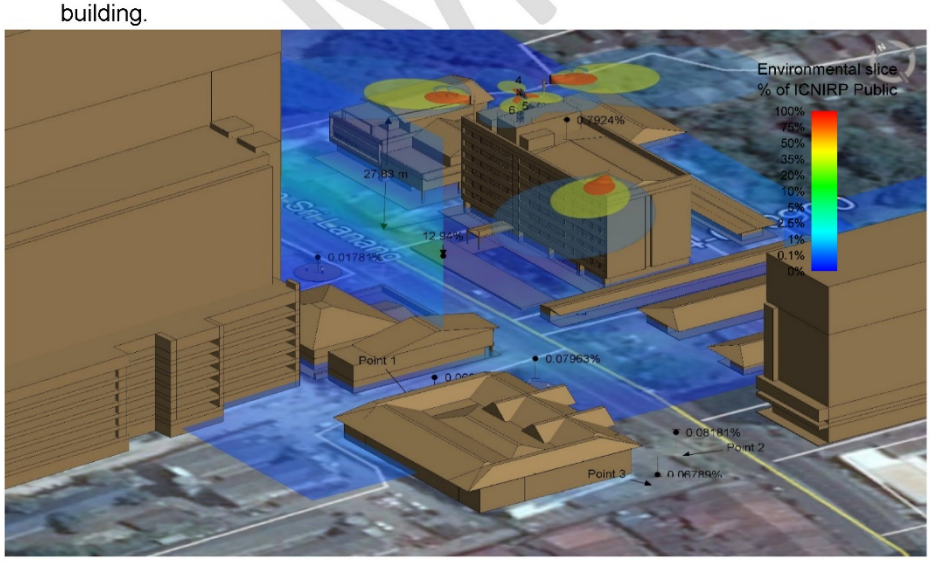


Figure 3: Power density at 2m above the ground level (3D Overview North or South View Elevation)

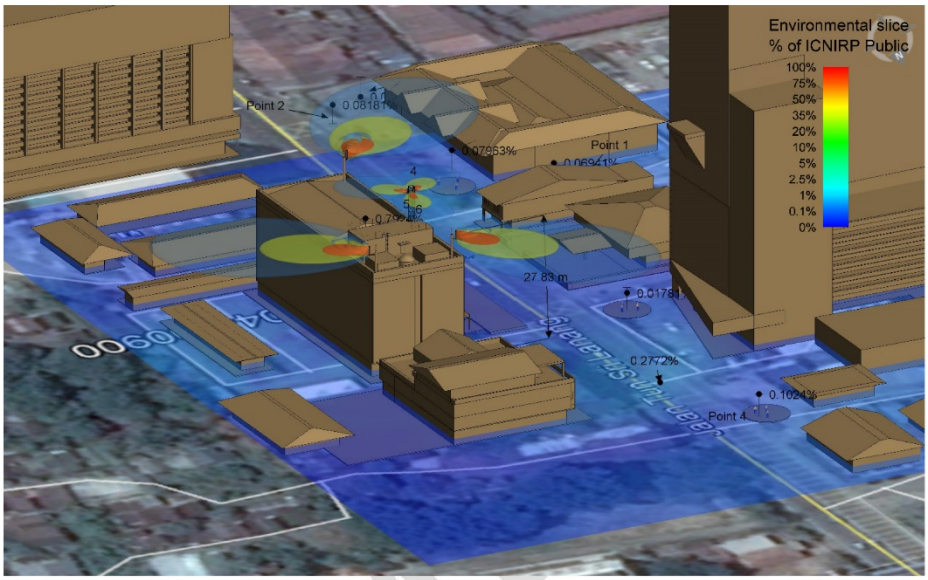


Figure 4: Power density at 2m above the ground level (3D Overview Top View Elevation)

Figure 5: Power density at 2m above the ground level (Top View 2D Elevation)

5.2 SIMULATION RESULT OF ORTHOSLICE AT 2M ABOVE ROOF TOP (3D ELEVATION)

[To provide simulation data on whether the area is safe in Places of Interest in the Electromagnetic Field for General Public at 2m above roof top level and the radiation emitted to the adjacent building, if any. Examples below in Figures 6-8.]

In this section, orthoslice at 2 meters above roof top level were simulated.

i. Figures 6 and 7 showed that the highest simulated emission reading was 57.49% of the limit. The exposure rate was still below the permissible limit for public, but it was recommended that only qualified workers were allowed to enter the building's roof top.

ii. Figure 8 showed the simulation for the top view of the radiation exposure to several adjacent buildings.

Description	Value %	Value V/m
The highest point of 2 meter above roof top	57.49	23.57

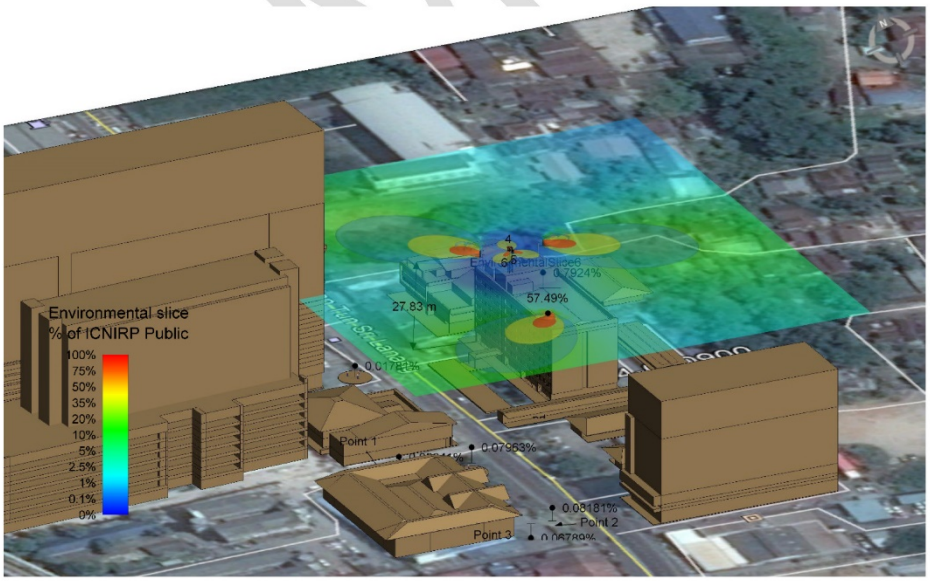


Figure 6: Orthoslice at 2m above roof top (North 3D View Elevation)

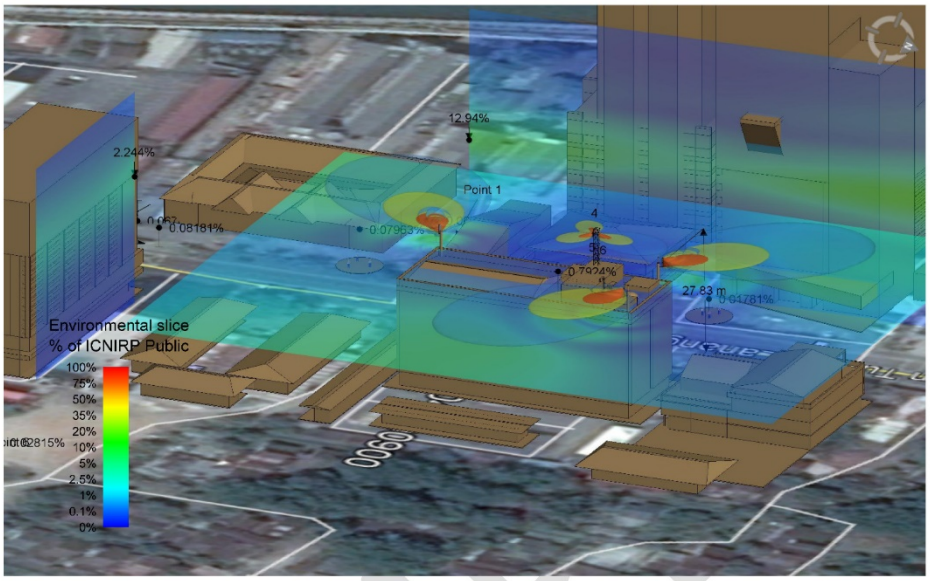


Figure 7: Orthoslice vertical & horizontal at 2m above roof top (South 3D View Elevation)

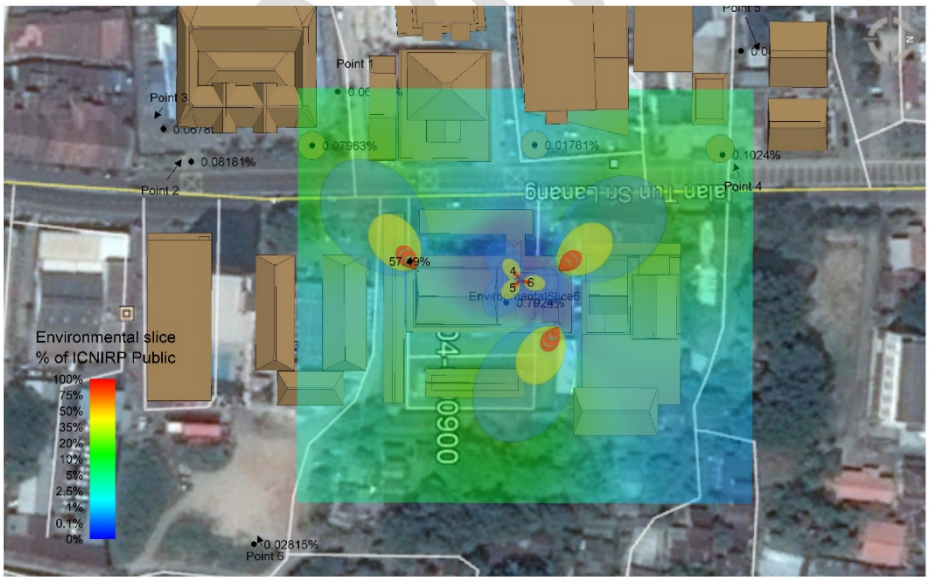


Figure 8: Power density at 2m above roof top (Top View)

5.3 SIMULATION RESULT OF EXCLUSION ZONE WITH ADJACENT BUILDING (3D ELEVATION)

[To provide simulation and lope imprint data on the exclusion zone with adjacent buildings (3D Elevations) below antenna, including the distance (meter) for Near Field and Far Field. Refer to Section 7 in TC on EMF. Examples below in Figures 9-11.]

Near Fields (Fresnel) Exclusion Zone		Far Fields Region (Fraunhofer)
Reactive Region	Radiation Region	
9.52 meters	22.89 meters	Above 23 meter

i. In Figures 9 and 10, the simulated data showed the distance of 2 regions, near field and far fields between the antennas to the adjacent Building. The simulated distance were 23 meters Near Field consist of Reactive & Radiating Region (Near Field) where the distance setting of this antenna beam should not be facing towards adjacent buildings within **23 meters**.

ii. Figure 11 is a top view simulated data showing the Far Field distances of the antennas to the adjacent building. Far Fields distance started from 23 meters from the antenna.

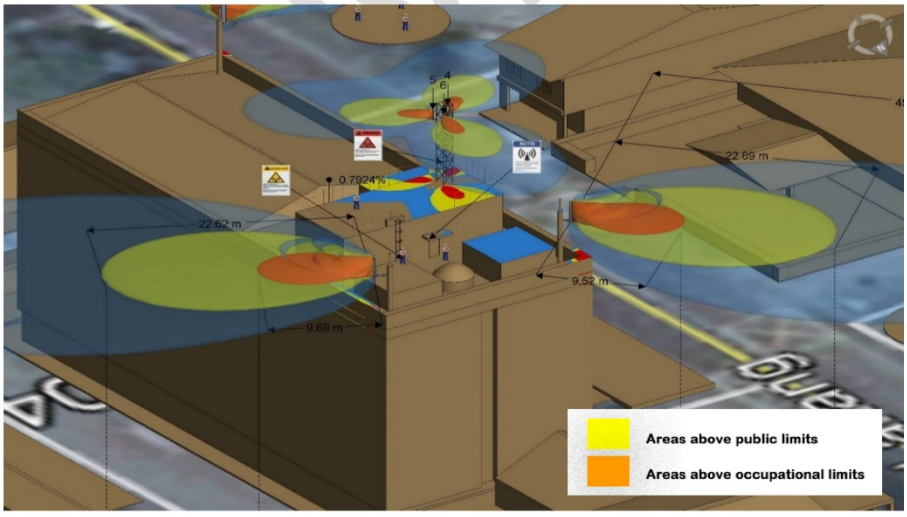


Figure 9: Zoom in view on the exclusion zone lope imprint the limit for public and occupational in 3d elevations for tower/rooftop/dual-function

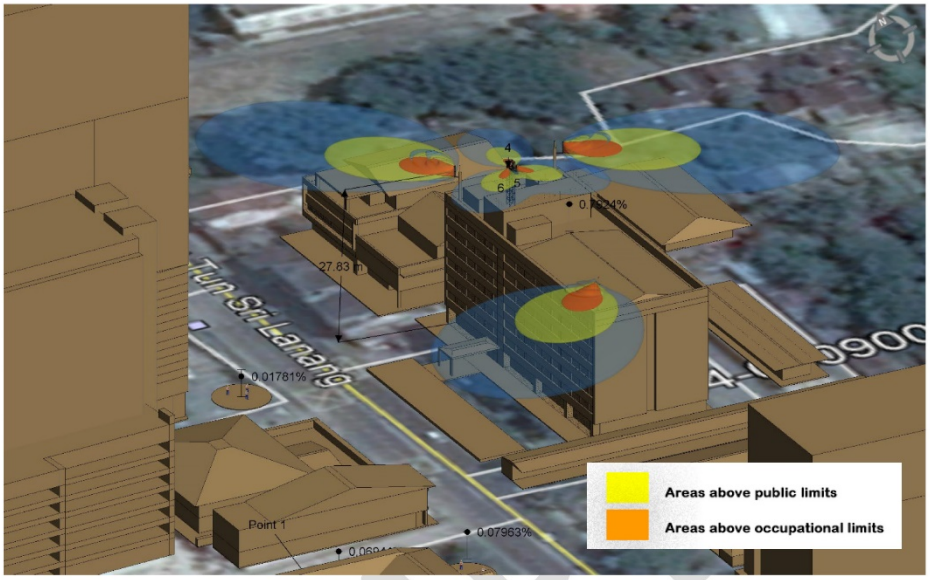


Figure 10: Exclusion zone with adjacent building near fields and far fields (3D View Elevation)

Figure 11: Exclusion zone with adjacent building near fields and far fields (2D Top View)

5.4 SIMULATION RESULT FOR SIGNAGE PLACEMENTS

[To provide simulation on the placement of 3 types of signage, including the distance (meter). Refer to Section 7 in TC on EMF. Examples below in Figures 12 and 13.]

Base on the simulated data, there should be 3 types of signage to be displayed at designated area as shown in Figures 12 and 13.

Signage Type	Description	Distance from the Antenna
WARNING	Near Field-Reactive Region	6 meters from the antenna
CAUTION	Near Field - Radiating Region	22.62 meters from the antenna
NOTICE	Far field	Signage must be placed at the entrance on the Base station area.

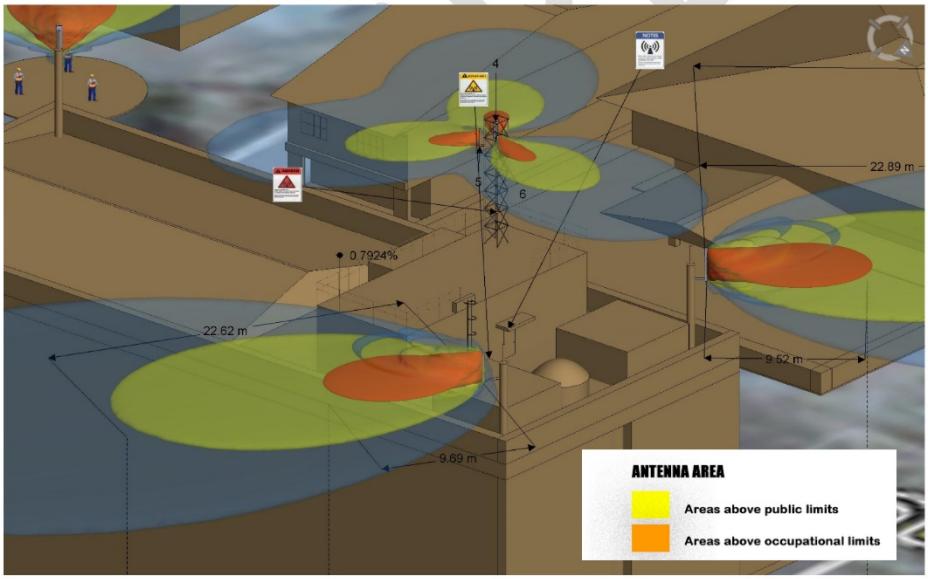


Figure 12: Zoom in View on the Exclusion Zone for Signage placement in 3D Elevations

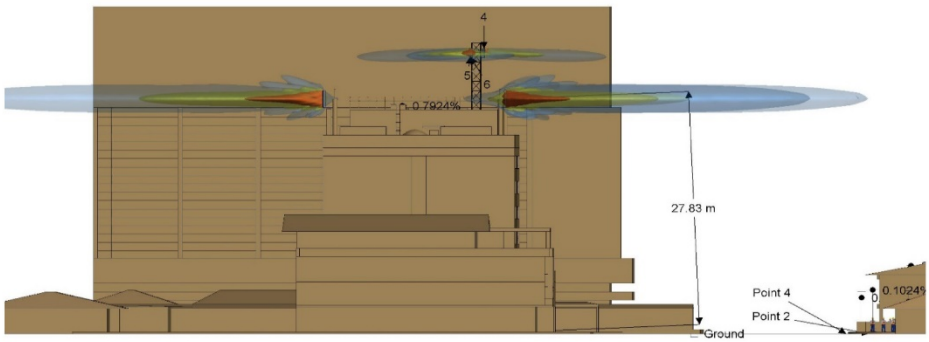


Figure 13: Signage placement in side view Elevations

5.5 SIMULATION SOFTWARE

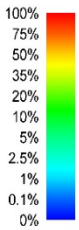
[To provide information on the software used for this simulation.]

Model & Version	IXUS EMF Compliance Software
Manufacturer	Alphawave Mobile Network Products
Operator Name & Designation	Mohd Fadli Ahmad, System Engineer
Simulation Date / Time	10 August 2021 / 3.40 PM

The algorithms implemented and used in IXUS are an implementation of the ray tracing synthetic model as detailed in ITU-T K.61, CENELEC 50383, and IEC62232.

Numerical modelling assessments in IXUS Modeller include the combined exposure from multi-band and multi-operator transmissions as specified in the EU directive. IXUS Modeller calculates the occupational and public exclusion zones established by ICNIRP.

6. CONCLUSION

Environmental Slice % of MS EMF Exposure Limit for Public  	The scale for Environmental Slice % of MS EMF Exposure Limit for Public describes the value of the simulation performed, where 100% is the value of a predefined standard level of MS EMF. Exposure limit used for this simulation was **41 V/m**. **Current Value of Simulated Data:** 2m above ground = **2.69 V/m (6.57%)** The simulated value was less than 7%, and referring to the scale it was in the green area. 2m above rooftop = **23.57 V/m (57.49%)** The simulated value was less than 60%, and referring to the scale it was in the orange area. The exposure rate is still below the permissible limit for public. However, due to the high value, it was recommended that area on the building's roof top is not safe for the public and only qualified workers were allowed to enter.

In conclusion, the simulation assessment has confirmed that the electric field strength simulated at this site was well below the RF EMF exposure limits recommended by the MS EMF for the general public.

This was in compliance with MS EMF exposure for the general public.

Based on the findings of the simulated data, we strongly believe that the presence of the RF EMF emitted by the antennas installed on the telecommunication structure at this site, with its current load and the background condition, would not lead to any significant radiation exposure received by members of the public living or working in this area.

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7. CERTIFICATE OF COMPLIANCE

MALAYSIAN NUCLEAR AGENCY (NUKLEAR MALAYSIA)
Ministry of Science, Technology and Innovation
Bangi, 43000 Kajang, Selangor

Certificate of Radio Frequency (RF) Radiation Safety Assessment

[Certificate Reference Number : CISSPT_XXXX]

Title	EMF SIMULATION AND ASSESSMENT
Conducted by	EMF SIMULATION SDN BHD
Location	42, Jalan Tun Sri Lanang, Kampung Durian Daun, 75100 Melaka.
Coordinate	L[illegible]
Simulation Date	10th Aug 2021
Report number	R04-000900/S/2021/1
Results	PASS

Field strength / Measurement range	Highest RF radiation level ($\mu W/cm^2$)	Permissible exposure limit ($\mu W/cm^2$)	Comparison with permissible exposure limit (%) *
Broadband (100kHz – 6 GHz)			

**Malaysian Communications And Multimedia Commission (MCMC) Mandatory Standard for Electromagnetic Field Emission from Radiocommunications Instructructure, Determination No 1 of 2010 (Communication and Multimedia Act 1998)*
**International Commission on Non Ionising Radiation Protection (ICNIRP)*

The Radio Frequency (RF) radiation emitted from the antenna(s) of this telecommunication structure complies with the permissible exposure limits issued by the MCMC and ICNIRP.
The results are valid only to the current specification and configuration of the antenna(s).
Reassessment will be required if there are any changes to the current antenna(s) structure.

Verified by:

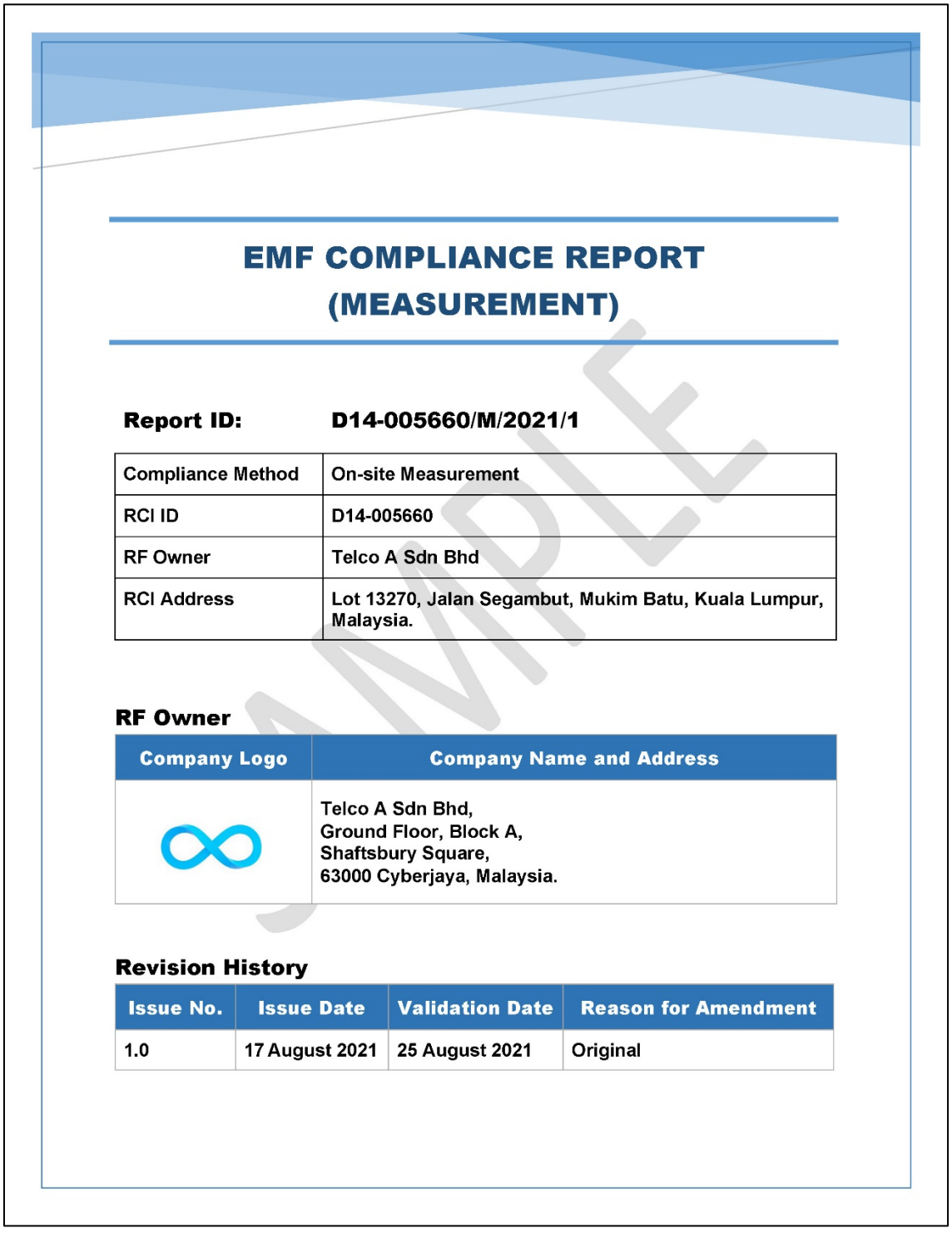
.....

Radiation Health and Safety Division.
Malaysian Nuclear Agency (Nuklear Malaysia)

Annex E
(informative)

EMF compliance report (measurement) sample

The EMF measurement report sample is as follows.



EMF COMPLIANCE REPORT
(MEASUREMENT)

Report ID: **D14-005660/M/2021/1**

Compliance Method	On-site Measurement
RCI ID	D14-005660
RF Owner	Telco A Sdn Bhd
RCI Address	Lot 13270, Jalan Segambut, Mukim Batu, Kuala Lumpur, Malaysia.

RF Owner

Company Logo	Company Name and Address
	Telco A Sdn Bhd, Ground Floor, Block A, Shaftsbury Square, 63000 Cyberjaya, Malaysia.

Revision History

Issue No.	Issue Date	Validation Date	Reason for Amendment
1.0	17 August 2021	25 August 2021	Original

D14-005660/M/2021/1

TABLE OF CONTENT

D14-005660/M/2021/1

1. EMF MEASUREMENT REPORT APPROVAL

This radio frequency electromagnetic field (RF EMF) measurement assessment has been performed in accordance with the Malaysian Communications and Multimedia Commission (MCMC) Mandatory Standard for Electromagnetic Field Emission from Radiocommunications Infrastructure ('MS EMF') and Malaysian Technical Standard Forum Bhd. (MTSFB) Technical Codes on EMF ('TC on EMF'):

- MCMC MTSFB TC G032:2021 - Prediction and Measurement of EMF Exposure from Base Station; or
- MCMC MTSFB TC G033:2021 - Prediction and Measurement of EMF Exposure from Terrestrial Radio and Television Broadcast Transmitter Station.

The assessment were conducted based on technical information provided by the client in the Technical Site Survey Report (TSSR) document.

Performed by:

Company Name	Address
Ultimate Communications Sdn. Bhd.	Unit 543, Jalan 51A/243, 46100 Petaling Jaya, Selangor Darul Ehsan, Malaysia.

Prepared by:

Name & Position	Date	Signature
Ahmad Shahir System Engineer	10 August 2021	*A Shahir*

[To be completed by personnel who conducted simulation and prepared report.]

Approved by:

Name & Position	Date	Signature
Alan Tan Manager	17 August 2021	*Alan T.*

[To be completed by company representative who approved the measurement result.]

2. SUMMARY OF MEASUREMENT ASSESSMENT

[To provide the objective, summarised data and result of compliance to MS EMF based on assessment results and findings.]

The purpose of this assessment was to determine whether the electromagnetic field strength at this site was in compliance with the MS EMF for the general public. This assessment was done in accordance to the TC on EMF.

The scope of this assessment covers the on-site measurement of electromagnetic fields emitted by radiation sources in the 900 MHz – 2.6 GHz frequencies used by mobile service providers in Malaysia. The site under assessment is shown below.

Site Information

Report ID	D14-005660/M/2021/1	
RCI ID / Name	D14-005660 / Jalan Segambut	
GPS Coordinate	Lat 3.18484414°, Long 101.6691854°	
RCI Type	Lamp Pole	
Geographical Classification	Urban	
Date of Commission	10 September 2017	
RCI Owner	Telco A Sdn. Bhd.	
RF Owner	Telco A Sdn. Bhd.	
Service Providers	Telco A 900MHz - 2G/4G 1800MHz - 4G	Telco B 900MHz - 2G/4G 1800MHz - 4G
Frequency Available / Maximum Limit	900MHz/41 Vm^{-1}, 1800MHz/58 Vm^{-1}	
Measurement Equipment	Narda SRM-3006, Antenna-3502/01	

A total of 5 test points were selected for assessment in the areas surrounding the antenna structure. Based on measured data obtained during this assessment, the electrical field strength was found to be *well below the EMF exposure limits of 41V/m*. This is in compliance with MS EMF on EMF exposure for the general public.

RESULT OF ASSESSMENT	**3.04V/m , 7.34%**
COMPLIANCE TO MS EMF	**PASS**

3. TECHNICAL REQUIREMENTS

[Refer to TC on EMF for the technical requirements for measurement. Include the data for all service providers at the same site.]

3.1 TECHNICAL PARAMETERS

ITEM	UNITS	TELCO A			TELCO A			TELCO A		
BUILDING HEIGHT AGL	(m)	22	22	22	22	22	22	22	22	22
RCI HEIGHT (GBT) AGL	(m)	7	7	7	7	7	7	7	7	7
RTT / GBT		Lamp Pole			Lamp Pole			Lamp Pole		
ANTENNA HEIGHT AGL	(m)	27	27	27	27	27	27	27	27	27
SYSTEM TYPE		4G	4G	4G	4G	4G	4G	2G	2G	2G
FREQUENCY OF OPERATION	(MHz)	900			1800			900		
MAKE AND MODEL OF ANTENNA	Ant-1	Agisson ATR451606			Agisson ATR451606			Agisson ATR451606		
	Ant-2	Agisson ATR451606			Agisson ATR451606			Agisson ATR451606		
	Ant-3	Agisson ATR451606			Agisson ATR451606			Agisson ATR451606		
ANTENNA GAIN	(dBi)	2	2	2	2	2	2	2	2	2
ELECTRICAL TILT	(Deg)	7	7	7	7	7	7	7	7	7
MECHANICAL / TOTAL TILT	(Deg)	3	3	3	3	3	3	3	3	3
AZIMUTH	(Deg)	120	230	320	120	230	320	120	230	320
TX POWER	(Watts)	80	80	80	80	80	80	80	80	80

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ITEM	UNITS	TELCO B			TELCO B			TELCO B		
BUILDING HEIGHT AGL	(m)	22	22	22	22	22	22	22	22	22
RCI HEIGHT (GBT) AGL	(m)	7	7	7	7	7	7	7	7	7
RTT / GBT		Lamp Pole			Lamp Pole			Lamp Pole		
ANTENNA HEIGHT AGL	(m)	27	27	27	27	27	27	27	27	27
SYSTEM TYPE		4G	4G	4G	4G	4G	4G	2G	2G	2G
FREQUENCY OF OPERATION	(MHz)	900			1800			900		
MAKE AND MODEL OF ANTENNA	Ant-1	Agisson ATR451606			Agisson ATR451606			Agisson ATR451606		
	Ant-2	Agisson ATR451606			Agisson ATR451606			Agisson ATR451606		
	Ant-3	Agisson ATR451606			Agisson ATR451606			Agisson ATR451606		
ANTENNA GAIN	(dBi)	2	2	2	2	2	2	2	2	2
ELECTRICAL TILT	(Deg)	7	7	7	7	7	7	7	7	7
MECHANICAL / TOTAL TILT	(Deg)	3	3	3	3	3	3	3	3	3
AZIMUTH	(Deg)	120	230	320	120	230	320	120	230	320
TX POWER	(Watts)	80	80	80	80	80	80	80	80	80

3.2 BLUEPRINT TO SCALE

[To provide the actual size of blueprints and aerial pictures in any format (JPEG, PDF, PNG and BMP).]

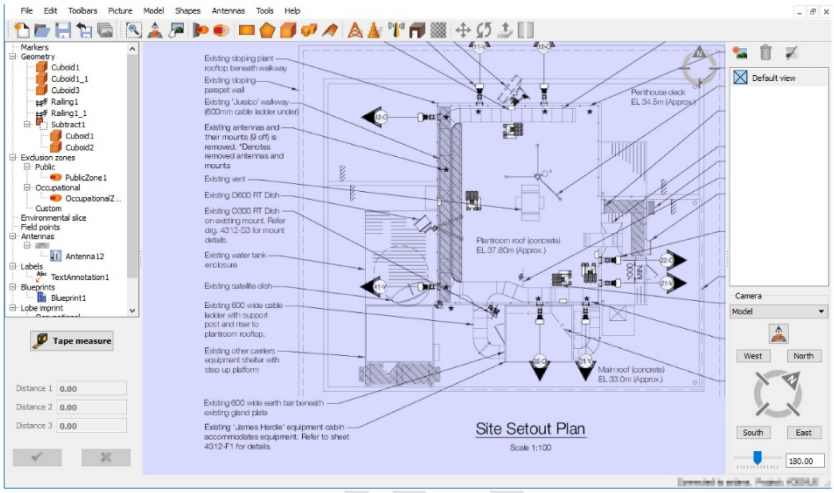


Figure 1: Blueprint of Structure

The site is located at **LAT 3.18484414°, LONG 101.6691854°** shown in Figure 12.

Figure 2: Site location (Top View)

4 MEASUREMENT ASSESSMENT

[Refer to Section 9 in TC on EMF for the measurement assessment methodology]

4.1 MEASUREMENT SITE

[To provide details on measurement site. Example below in Figure 3.]

The site involved in this assessment was located at Lot 13720, Jalan Segambut, Mukim Batu, Kuala Lumpur, next to Condominium Savio at Ria Dutamas in the middle of a busy area with combination of residential, shops and school.

The Structure ID for this structure was D14-005660.

The radiation source for this assessment were the telecommunication antennas installed on a lamp pole structure as shown in Figure 1 below.

Figure 3: Measurement Site Picture and Radiation Source.

4.2 MEASUREMENT POINTS

[To provide the details on measurement points. The number of measurement points depends on the location selected and shall be based on the worst-case situation (nearest accessible location facing the antenna beam and public area). Recommended measurement points were 5 or more. Examples below in Figures 4 and 5.]

A total of 5 test points were selected for measurements. They were all outdoor locations in areas surrounding the antenna structure where the public go about their daily lives, such as schools, shop lots, residential homes, pedestrian bridge, and etc. Refer to Figure 4 below.

Figure 4: Measurement Points

Test Points	Coordinates (Lat, Long)	Location	Level
1 – S01	3.184417, 101.669354	Residential - Behind Savio Condo	Ground
2 – S02	3.1851267, 101.6695605	Shoplot - Ho Leong Tractor	Ground
3 – S03	3.185563, 101.669029	Shoplot - Home Deco	Ground
4 – S04	3.185437, 101.669582	School - SRJK Khai Chee	Ground
5 – S05	3.185370, 101.669711	Pedestrian Crossing - Jejantas	Ground

Figure 5: Site Pictures of Measurement Points

4.3 MEASUREMENT DATA

[To provide details on the results and findings of measurement assessment. Example below in Table 1.]

During assessment, the electric field (E) at each test point was measured, recorded and compared to the worst case MS EMF limit of 41V/m as the Pass/Fail Criteria for the general public.

Table 1 below showed a summary of Electric Field Exposure Levels measured relative to the MS EMF safety limit for the general public.

Test Points	Electric Field (V/m)	ICNIRP Limit (V/m)	Percent Of Limit (%)	Result
1 – S01	1.24	41	3.02	Pass
2 – S02	2.07	41	5.04	Pass
3 – S03	0.93	41	2.27	Pass
4 – S04	2.25	41	5.49	Pass
5 – S05	**3.01**	**41**	**7.34**	**Pass**

Table 1: Summary of Electric Field Levels (V/m) Measured On-site.

The highest Electric Field measured in this assessment was found to be at **Test Point S05**, **showing 3.01V/m or 7.34% of the limit.**

In comparison to the allowable exposure limit of 41V/m, this *value was well below the exposure limits* recommended by the MS EMF for the general public.

4.4 MEASUREMENT EQUIPMENT

[To provide details on the equipment used for measurement assessment; including model, frequency range and calibration information. Examples below in Table 2 and Figure 6.]

Measurements were taken using calibrated and specialized equipment designed specifically for broadband electromagnetic field test and measurement. It was conducted on 10 August 2021 by our System Engineer, Ahmad Shahir.

Refer to equipment list below.

Equipment	Frequency Range	Calibration Due Date
Narda SRM-3006, Antenna-3502/01	100kHz – 6GHz	5th July, 2022

Table 2: Equipment Used and Calibration Information.

Figure 6: Equipment Used for Testing.

5. EXTRAPOLATION FACTOR ANALYSIS

[To provide estimation/calculation of the worst-case EMF exposure at the site using extrapolation factor. Refer to TC on EMF. Table below is a sample data.]

1	2	3	4	5	6	7	8	9	10	11
f (MHz)/Code(UMTS)/ Cell-ID+no of MIMO path (LTE)	Service Provider	Limit (V/m)	E (Meas.) (dBµV/m)	Meas. Uncert (dB)	Max. Immission Factor	Emax (dBµV/m)	Emax (V/m)	Emax limit (%)	Smax (mW/m²)	Service Type
Point No.	S01									
939.0	Telco A	41.7	105.1	0.0	2.0	108.1	0.25	0.61	0.17	GSM-900
944.6	Telco A	41.7	130.8	0.0	2.0	133.8	4.90	11.76	63.78	GSM-900
953.8	Telco B	41.7	118.8	0.0	2.0	121.8	1.23	2.95	4.02	GSM-900
936.8	Telco B	41.7	116.4	0.0	4.0	122.4	1.32	3.17	4.63	GSM-900
946.6	Telco B	41.7	105.3	0.0	4.0	111.3	0.37	0.88	0.36	GSM-900
948.6	Telco B	41.7	113.9	0.0	4.0	119.9	0.99	2.38	2.60	GSM-900
1860.0	Telco B	58.4	109.9	0.0	4.0	115.8	0.62	1.06	1.01	GSM-1800
1863.8	Telco A	58.4	105.4	0.0	4.0	111.4	0.37	0.64	0.37	GSM-1800
1864.6	Telco A	58.4	116.4	0.0	4.0	122.4	1.32	2.26	4.63	GSM-1800
2132.6/23	Telco A	61.0	103.4	0.0	20.0	116.4	0.66	1.08	1.16	UMTS
2132.6/301	Telco A	61.0	117.3	0.0	20.0	130.3	3.28	5.37	28.49	UMTS
2132.6/413	Telco B	61.0	101.0	0.0	20.0	114.0	0.50	0.82	0.67	UMTS
2167.2/154	Telco B	61.0	121.8	0.0	20.0	134.8	5.50	9.02	80.30	UMTS
2167.2/157	Telco A	61.0	100.5	0.0	20.0	113.5	0.47	0.78	0.60	UMTS
2167.2/159	Telco A	61.0	102.7	0.0	20.0	115.7	0.61	1.00	0.99	UMTS
816.0/131-0	Telco A	39.2	100.5	0.0	600.0	128.3	2.59	6.62	17.86	LTE-800
816.0/131-1	Telco A	39.2	100.1	0.0	600.0	127.9	2.48	6.32	16.29	LTE-800
816.0/132-0	Telco B	39.2	105.6	0.0	600.0	133.4	4.67	11.91	57.78	LTE-800
816.0/132-1	Telco B	39.2	105.0	0.0	600.0	132.8	4.36	11.11	50.33	LTE-800
816.0/133-0	Telco A	39.2	84.1	0.0	600.0	111.9	0.39	1.00	0.41	LTE-800
816.0/133-1	Telco A	39.2	84.3	0.0	600.0	112.1	0.40	1.03	0.43	LTE-800
						Sum	11.3	25.2	336.88	

Total summation of extrapolated values over all operators are highlighted in the table. The values represented the worst-case EMF exposure scenario.

6. CONCLUSION

In conclusion, this assessment has confirmed that the electric field strength measured at this site was well below the EMF exposure limits.

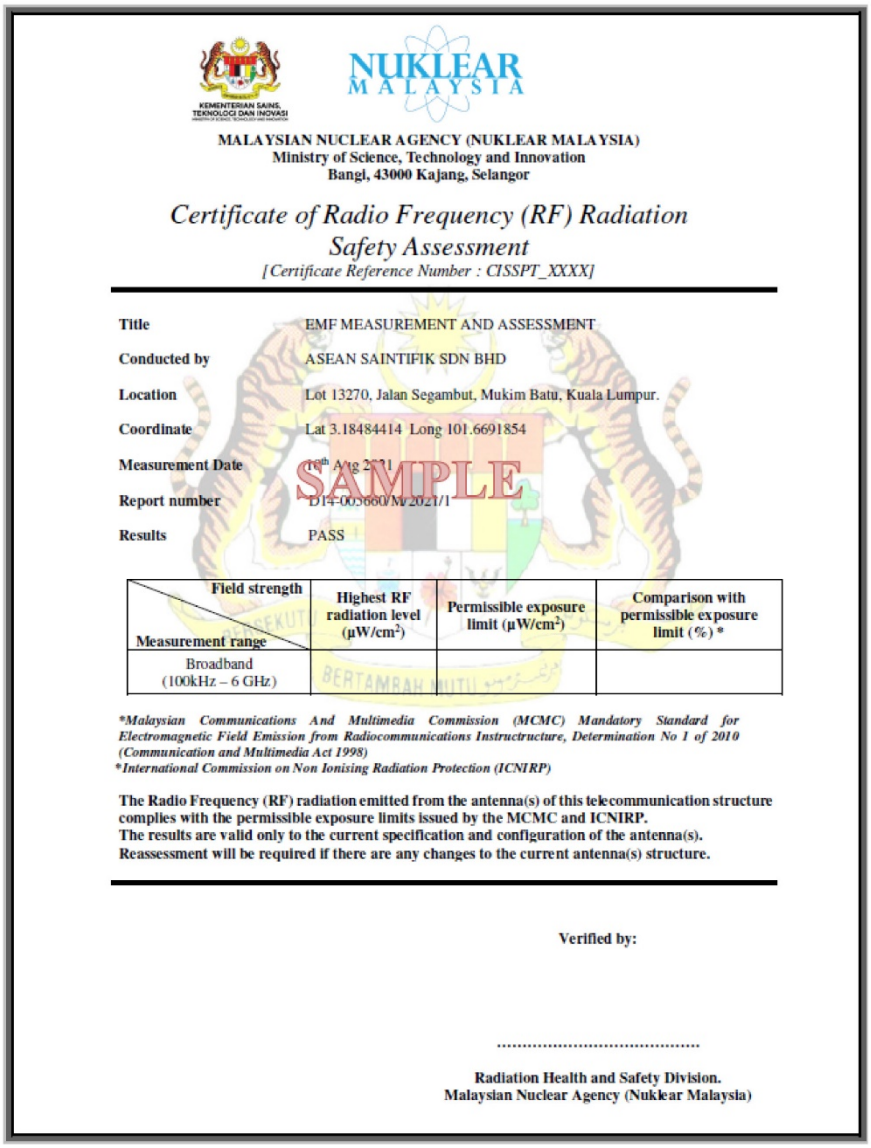
This was in compliance with MS EMF exposure for the general public.

Based on the findings of this on-site measurement assessment, we strongly believe that the presence of the RF EMF emitted by the antennas installed on the telecommunication structure at this site, with its current load and the background condition, would not lead to any significant radiation exposure received by members of the public living or working in this area.

Re-assessment must be performed if there is any modification of the equipment.

D14-005660/M/2021/1

7. CERTIFICATE OF COMPLIANCE



MALAYSIAN NUCLEAR AGENCY (NUKLEAR MALAYSIA)
Ministry of Science, Technology and Innovation
Bangi, 43000 Kajang, Selangor

Certificate of Radio Frequency (RF) Radiation Safety Assessment

[Certificate Reference Number : CISSPT_XXXX]

Title	EMF MEASUREMENT AND ASSESSMENT
Conducted by	ASEAN SAINTIFIK SDN BHD
Location	Lot 13270, Jalan Segambut, Mukim Batu, Kuala Lumpur.
Coordinate	Lat 3.18484414 Long 101.6691854
Measurement Date	16th Aug 2021
Report number	D14-005660/M/2021/1
Results	PASS

SAMPLE

Field strength / Measurement range	Highest RF radiation level ($\mu W/cm^2$)	Permissible exposure limit ($\mu W/cm^2$)	Comparison with permissible exposure limit (%) *
Broadband (100kHz – 6 GHz)			

**Malaysian Communications And Multimedia Commission (MCMC) Mandatory Standard for Electromagnetic Field Emission from Radiocommunications Instructructure, Determination No 1 of 2010 (Communication and Multimedia Act 1998)*
**International Commission on Non Ionising Radiation Protection (ICNIRP)*

The Radio Frequency (RF) radiation emitted from the antenna(s) of this telecommunication structure complies with the permissible exposure limits issued by the MCMC and ICNIRP.
The results are valid only to the current specification and configuration of the antenna(s).
Reassessment will be required if there are any changes to the current antenna(s) structure.

Verified by:

.....

Radiation Health and Safety Division.
Malaysian Nuclear Agency (Nuklear Malaysia)

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Acknowledgements

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