Revised in August 2022

Code of Practice for the Protection of Workers and Members of Public Against Non-Ionising Radiation Hazards from Radio Transmitting Equipment

1. Introduction

1.1 This Code of Practice (hereinafter referred to as the "CoP") has been prepared for those who design or operate radio systems and for those who work at radio sites. The CoP gives guidance for the protection of workers and the general public from exposure to radiofrequency electromagnetic fields so as to provide a safe and healthy working or living environment under all normal conditions. Radio system designers and radio site operators (collectively referred to as "radio operators") as well as occupational personnel should observe the CoP in the design, construction, installation, maintenance and operation of radio systems.

1.2 This CoP cannot be so detailed as to deal adequately with every set of circumstances that may arise, and it may well be necessary for radio operators to obtain more specialist advice.

2. General Principles

2.1 The radio operator should be responsible for ensuring that the radio systems operated by it complies with this CoP, taking into consideration the combined effects of its own present/future transmissions and other present/future transmissions from the same site or sites in the vicinity.

2.2 The radio operator of a new radio system or a modified radio system should be responsible in ensuring that paragraph 2.1 is complied with, and should take whatever measure that is necessary to achieve such compliance prior to operation.

2.3 A radio system should be so designed, constructed, installed, maintained and operated to meet the health protection standards specified in this CoP.

2.4 Compliance with the health protection standards specified in this CoP should be achieved, as far as possible, through restrictions in the technical parameters of the transmitting equipment, and appropriate sitting of the antennas and ancillary equipment.

2.5 In case safety cannot be sufficiently guaranteed by the measures stated in paragraph 2.4, appropriate operational protection measures should be applied in order to comply with the health protection standards.

3. Health Protection Standard

3.1 The health protection standards specified in this CoP are those laid down in the "*Guidelines for Limiting Exposure to Electromagnetic Fields (100 kHz to 300 GHz)*" published by the International Commission on Non-Ionizing Radiation Protection ("ICNIRP") in 2020 (the "2020 ICNIRP Guidelines"). The radio operator should ensure that the electric and magnetic fields as well as the power density radiated from the antennas at the site operated by it do not cause exposure to occupational personnel and members of the general public in excess of the limits specified in Annex 1 which are extracted from the 2020 ICNIRP Guidelines. References should be made to the full Guidelines for the protection limits for pulsed fields, localised exposure, protection against RF shocks and burns.

3.2 In the case of multiple simultaneous exposure, the combined effect of such exposure should be assessed in accordance with the 2020 ICNIRP Guidelines.

4. Basic Guidelines

4.1 Safety Management

Radio operators are required to properly train their occupational personnel and keep them fully aware of the possible hazards in the working areas. A written procedure for safety management should be documented and may include the following points,

4.1.1 Safety policy

4.1.2 Training

4.1.3 Identification of potential hazards

4.1.4 Measuring equipment calibration

4.1.5 Non-ionising radiation (“NIR”) incident investigation

4.1.6 Record keeping

4.2 Equipment Performance Standards

4.2.1 The equipment should deliver the minimum radiofrequency output power necessary to meet operational requirements.

4.2.2 The antennas should be so designed and sited as to avoid, as far as possible, unnecessary radiation of radiofrequency energy.

4.2.3 The secondary radiation (scattered or leakage radiation) should be reduced to a negligible value or even prevented in the proximity of the equipment.

4.2.4 The equipment should be type-approved by the Communications Authority (“CA”) or conform to specifications prescribed by the CA.

4.2.5 The manufacturer's guidance on the conditions for use and necessary precautions to be taken should be observed for all equipment not having the intrinsic safety.

4.3 Design of radio sites

4.3.1 Radio operators may jointly develop and share facilities of a radio site for establishing their radio systems. For new radio sites, radio operators will be required to submit to the Office of the Communications Authority (“OFCA”) the relevant details necessary to set up a database to assess the potential of NIR hazards at a radio site. For existing radio sites, radio operators may be required to submit to OFCA the relevant details necessary to set up a database to assess the potential of NIR hazards at a radio site. The database can only be accessed by radio operators on a need-to-know basis. Confidential information of the radio operators will not be contained in the database. The required details of the database will be,

I Site plan.
II Present and future allowable number of services and transmitters at the radio site.
III Antenna location, height and direction.
IV Worst case effective radiated power.
V Antenna model and radiation pattern.
VI Position of antenna and antenna mast for maintenance. Current paging antenna masts are lowered for the maintenance of antennas, therefore it is important that its position for maintenance does not fall directly in front of another transmitting antenna.

4.3.2 Radio operators should select the appropriate site and mounting for the antennas of transmitting equipment to reduce NIR levels to a negligible value at easily accessible areas for the general public, and minimised at easily accessible areas for workers. In any case, the power density at public areas should not exceed the ICNIRP exposure limit for the general public.

4.3.3 NIR levels should as far as possible be calculated first by the radio operator, taking into account the combined effects of its own present/future transmissions and other present/future transmissions from the same sites or sites in the vicinity. This can be done by consultation with the site manager or the database of OFCA. If necessary, verification should be performed with a NIR site survey and, non-hazardous/hazardous areas established and documented. The measurement should be carried out based on the recommendations stipulated in the IEEE standard, C95.3-2021 [1] or equivalent standards.

4.3.4 Where the conditions given in paragraph 4.3.2 may not be practically achieved in radio sites, under such conditions the NIR levels for the general public and workers should not exceed the exposure limits given in Annex 1.

4.4 Operational protection measures

4.4.1 Occupational personnel working at radio sites should keep alert and avoid any unnecessary exposure to NIR.

4.4.2 Areas in which the electromagnetic fields exceed the exposure limits given in Annex 1 should, as far as practicable, be made inaccessible to the general public.

4.4.3 If the measures stated in paragraph 4.4.2 are impractical, the radio operator should delineate and identify these areas by warning symbols. For high power radio sites where the power density in the working area exceeds 10 times of the ICNIRP occupational exposure limit, lights are required at the radio sites to alert the occupational personnel for the possible hazard.

4.4.4 The warning symbol for identifying potential areas of NIR hazards should follow the British Standard BS5378[2]. The sign is based around black wavefronts radiating from a stylised point source antenna on a yellow background and is enclosed in a black triangle as shown in Figure 1. The actual dimensions used depends on the prominence required, a typical size for the triangle would be approximately 150mm or 200mm across the base. The warning sign should be made of reliable material. Fading should be avoided in outdoor environment. The warning sign should not carry sharp edges that may cause any potential danger to the general public. It should be securely mounted on appropriate positions such as ladders leading to the top of water tank where the antennas are mounted.

Figure 1 Non-ionising radiation warning symbol.

4.4.5 If the installation of new radio system or a modified radio system results in the power density at the site exceeding the ICNIRP exposure limit for general public, the radio operator of that system will be responsible to put up the warning signs and carry out routine maintenance to ensure that the signs are in their proper positions and in good conditions. For existing sites where the power density at the site already exceeds the ICNIRP exposure limit for the general public, the major user of the radio site should be responsible to put up the warning signs and carry out routine maintenance to ensure that the signs are in their proper position and in good conditions.

4.4.6 Waveguides that carry power levels high enough to cause radiated power to reach dangerous levels, if cut, should be identified. Prominent warning notices should be displayed in rooms where such waveguides are present to stress the danger of looking into open ended waveguides. All flanged joints in high power waveguides should be checked periodically for RF leakage.

4.4.7 Wherever practicable, the radio operator should use protective features such as wire screens, automatic safety devices, etc. to physically restrict personnel from gaining access to transmitting equipment or antenna structures when dangerous fields may exist.

4.4.8 Wherever practicable, access to elevated platforms, maintenance towers, etc. if the power density exceeds 10 times of the ICNIRP occupational exposure limit should be controlled by interlocked mechanism.

4.4.9 For steerable antennas, hazardous NIR may be avoided by using sector blanking or automatic restriction of power whenever the antenna beam is below a pre-determined angle.

4.4.10 The radio operator should develop and implement safety instructions for the protection against excessive exposure to NIR at the various working places.

4.4.11 As a last resort, occupational personnel should use individual protection equipment such as protective clothing, glasses etc. when working under the exposure in excess of the limits specified in the health protection standards. The protective equipment should be regularly inspected to ensure its effectiveness. A personnel wearing a damaged piece of protective clothing which allows the coupling of electromagnetic radiation, may be subjected to an even greater hazard than without wearing the protective clothing.

5. Generic Guidelines

5.1 General

NIR levels can be reduced at any radio site by placing the antennas higher or locating them further away, but in some cases this may not be practical. Under these circumstances, access to areas where NIR hazards exist should be restricted by physical means and warning signs placed at all access points. Wherever practicable, protective features such as locked doors, locked ladders or barriers can be used to restrict personnel from gaining access to transmitting equipment or antenna structures when dangerous fields may exist. If access is required when NIR hazard exists, the exposure time should be limited according to the 2020 ICNIRP Guidelines. Other measures could include lowering the transmitter power if a complete shutdown cannot be avoided. Metal supporting masts or other metallic structure must be grounded if dangerous RF-voltages due to induction are anticipated. Radio sites should be kept clear of flammable atmospheres according to the British Standard BS6656: 2002[3] or equivalent standards.

5.2 Paging and Private Mobile

Paging/private mobile transmitters are normally mounted on roof-tops using antennas that are mainly omni-directional. The antennas should be mounted high enough to eliminate NIR hazard at easily accessible areas in an uncontrolled environment. The height needed to avoid NIR hazard in an uncontrolled environment can be calculated using the model found in Annex 2, section 1. An absolute minimum height of 2.5m from the bottom of the antenna is recommended to avoid easy accessibility which may cause RF shocks or burns. Because the antennas used are mainly omni-directional, the position of the antennas should ideally be located at the centre of the roof top, this may not be critical and therefore should not be binding. If directional antennas are used, it would be preferable to mount the antenna near the edge of the building with the main beam pointing away from the roof top. Consideration should also be given to NIR radiated into adjacent buildings or adjacent roof-tops, again possible hazards can be calculated using equation (1) which can be found in Annex 2, section 1. If a minimum height of 2.5m is not practical then a NIR survey will need to be performed using spatial as well as time averaging to assess the hazard. Due to the possibility of future installation of additional transmitters, OFCA should be consulted on the expected maximum number of transmitters that are likely to be installed.

5.3 Public Mobile Radio

As far as practicable, the transmitting antennas should be mounted either on towers or poles of suitable height at the edge of the building and facing away from the building. To ensure that there is no possibility of NIR hazard, the transmitting antennas should be mounted at least 2.5m high in easily accessible areas. If the transmitting antennas have to be mounted on walls, water tanks or street furniture where the general public can walk underneath, it should be mounted at a suitable height. The suitable height to avoid

NIR hazards can be calculated using equations (1) and (5) which can be found in Annex 2, section 1 and 2. If a minimum height of 2.5m is not practical then a NIR survey will need to be performed using spatial as well as time averaging to assess the hazard.

5.4 AM Broadcasting

AM broadcasting radio sites are generally well restricted, as an additional precaution contractors for AM broadcasting transmitters should take into consideration the exposure limits in the 2020 ICNIRP Guidelines. Consideration should also be given for access to the towers during maintenance, even with the main transmitter switched off. The back up transmitters are usually located close to the main transmitter and can radiate significantly into the main tower. The same is true for the main transmitter radiating into the tower of the back up transmitter. The radio site should be kept clear of debris, especially metallic poles which is a common source of RF burns. Due to the high power levels involved the NIR hazardous area should be determined and restricted for either the occupational population and/or the general population. Calculation can be performed in the near field using equations (6-9) for AM transmitters using monopole antennas and can be found in Annex 2, section 3. A guide to expected field strengths can be found in reference [4].

5.5 FM/TV Broadcasting

While FM/TV broadcasting radio sites are generally well restricted from access with antennas mounted quite high on towers, as an additional precaution, contractors for FM broadcasting transmitters should take into consideration the exposure limits in the 2020 ICNIRP Guidelines. Consideration should be given for NIR hazard when using the back up transmitter antennas, which are normally positioned lower than the main transmitter antennas thus producing a larger power density at ground level. Consideration should also be given for personnel which may need to climb up the tower for maintenance with the active transmitters. NIR radiation levels can be reduced in the tower by the use of shielding materials and it is recommended that reference [5] be consulted on any implementation. Far field NIR levels can be calculated using equation (1) and near field calculation can be calculated using equation (5) for antenna arrays which can be found in Annex 2, section 1. NIR occurring in masts have been found to be the highest at the top [6] and by the antenna spacing, with a coupling factor in the order of 10 dB. This coupling factor can be used as a guide to the possibility of NIR hazard for personnel intending to climb up the tower to gain access for maintenance.

5.6 MMDS

MMDS operates at microwave frequencies, using either arrays or reflector antennas. The NIR levels can be calculated according to equation (1) in the far field and equation (10) for the near field which can be found in Annex 2, section 1 and 4. Further information can be found in reference [l] or equivalent standards for near field power density in the axial direction. It is recommended that antennas are located on masts in order to restrict access by the general public. If the antennas are mounted on roof-tops where the use of towers are impractical, NIR radiation hazards can be minimised by positioning the antenna away from the centre of the roof-top with the main beam pointing away from the roof-top and any access points. Access to the antenna should be restricted physically for the general population and for the occupational population when power is present. Reference should be made to section 5.7 on additional safety practices.

5.7 Satellite Earth Station

Satellite earth stations can transmit power in the order of kW and can be a cause for concern regarding NIR hazards. It is recommended that reference [7, 8] be consulted on the assessment of exposure to NIR near the satellite antennas. The safety precautions can be summarised as,

- I Access to the reflection surface must be avoided.
- II Access to the tubular beam must be avoided.
- III Exposure to NIR hazards must be controlled.
- IV Restrictions are necessary as regards masking of the site by obstacles.
- V Restrictions are necessary as regards the height of the station buildings.
- VI Consideration must be given to potential NIR hazards at collimation and other towers.

5.8 Point to Point Fixed Links

The guidelines for point to point have actually been covered in section 5.6 for microwave frequencies and section 5.2 for the lower frequencies.

5.9 RADAR

Although the average power for radar is usually small in comparison with the peak power, there is a danger of considering only the average power whereas letting the peak power increase without limit. The peak power density can be calculated according to equation (1) which can be found in Annex 2, and the average power density can be calculated according to Annex 3. The permissible level can then be determined according to the ICNIRP standard taking note of the conditions for pulsed fields. A major concern regarding radar is the possible large increase in NIR due to the failure of the rotating scanning mechanism, which can be minimised by the use of an interlock mechanism.

6. Enquires

6.1 Any enquires on this document should be made to –

Senior Telecommunications Engineer (Spectrum Planning 2)
Office of the Communications Authority
29/F, Wu Chung House
213 Queen's Road East
Wan Chai
Hong Kong
Fax No.: 2803 5113
Email: spenq@ofca.gov.hk

References

[1] "IEEE Recommended Practice for Measurements and Computations of Electric, Magnetic, and Electromagnetic Fields with Respect to Human Exposure to Such Fields with Respect to Human Exposure to Such Fields, 0 Hz to 300 GHz" " IEEE Std C95.3-2021, Published by the Institute of Electrical and Electronics Engineers, Inc.

[2] "Safety Signs and Colours", British Standard BS5378, Part 1 1980, Part 3 1982.

[3] "Assessment of inadvertent ignition of flammable atmospheres by radio-frequency radiation. Guide", British Standard, BS 6656: 2002.

[4] "Radiation Levels and Protection Near Broadcasting Antennas", by G. E. Hatfield, International Broadcasting Convention 1988, pp125-128.

[5] "Antenna Shielding for the Protection of Engineering Personnel", by G. E. Hatfield and A. J. McCarthy, International Broadcasting Convention 1992, pp98-102.

[6] "Health and Safety with RF Broadcast Stations", by P. Shelswell, R. D. C. Thoday and S. Wakeling, Intemational Broadcasting Convention 1988, pp120-124.

[7] "Evaluating Fields from Terrestrial Broadcasting Transmitting Systems Operating in any Frequency Band for Assessing Exposure to Non-ionizing Radiation", Recommendation ITU-R BS.1698.

[8] "Safety Aspects of Radio-Frequency Radiation from Fixed Earth-Station Antenna Systems", Recommendations and Reports of the CCIR, 1986, Volume IV, Part 1, Annex IV, pp176-177.

Office of the Communications Authority
August 2022

2020 ICNIRP Guidelines on Reference Levels for Exposure to Electromagnetic Fields

Table 1
Reference levels for occupational exposure to electromagnetic fields from 100 kHz to 300 GHz (unperturbed rms values)

Frequency range f (MHz)	E-field strength (V/m)	H-field strength (A/m)	Power density (W/m^2)
0.1 – 30	$660/f^{0.7}$	4.9/f	-
>30 – 400	61	0.16	10
>400 – 2,000	$3\sqrt{f}$	$0.008\sqrt{f}$	f/40
>2,000 – 300,000	-	-	50

Table 2
Reference levels for general public exposure to electromagnetic fields from
100 kHz to 300 GHz (unperturbed rms values)

Frequency range f (MHz)	E-field strength (V/m)	H-field strength (A/m)	Power density (W/m^2)
0.1 – 30	$300/f^{0.7}$	2.2/f	-
>30 – 400	27.7	0.073	2
>400 – 2,000	$1.375\sqrt{f}$	$0.0037\sqrt{f}$	f/200
>2,000 – 300,000	-	-	10

Occupationally-exposed individuals are defined as adults who are exposed under controlled conditions associated with their occupational duties, trained to be aware of potential radiofrequency electromagnetic field (“EMF”) risks and to employ appropriate harm-mitigation measures, and who have the sensory and behavioural capacity for such awareness and harm-mitigation response. An occupationally-exposed worker must also be subject to an appropriate health and safety program that provides the above information and protection. The general public is defined as individuals of all ages and of differing health statuses, which includes more vulnerable groups or individuals, and who may have no knowledge of or control over their exposure to EMFs. These differences suggest the need to include more stringent restrictions for the general public, as members of the general public would not be suitably trained to mitigate harm, or may not have the capacity to do so.

Calculation of Plane Wave Power Density

1 Far-Field Approximation

In the Fraunhofer region, the gain can be assumed to be independent of the distance and the power density can be approximated by [1]:

$$S(r,\theta,\emptyset) = \frac{R(\theta,\emptyset)G_0 P}{4\pi r^2} \quad (1)$$

where

P = input power of the antenna
G_0 = antenna gain
R = radiation pattern
(normalised to unity in the direction of maximum radiation)
r = distance from the observation point to the antenna

For more conservative safety calculations [2], the far-field approximation, equation (1), can be used when

$$r > r_n = \frac{2h^2}{\lambda} \quad (2)$$

where

h = the maximum dimension of the antenna
λ = operating wavelength

For the antennas: PD10204, PD128 and PD207, the observation points are mainly within the far-field zone. These antennas have omni-directional horizontal radiation patterns. Referring to Figure 1, the power density at point P(x, z) can be calculated using the following equation:

$$S(x,z) = \frac{R\left(\pi - \tan^{-1}\left(\frac{x - x_0}{H + \frac{h}{2} - z}\right)\right)G_0P}{4\pi\left(\frac{x - x_0}{\sin\left(\tan^{-1}\left(\frac{x - x_0}{H + \frac{h}{2} - z}\right)\right)}\right)^2} \qquad (3)$$

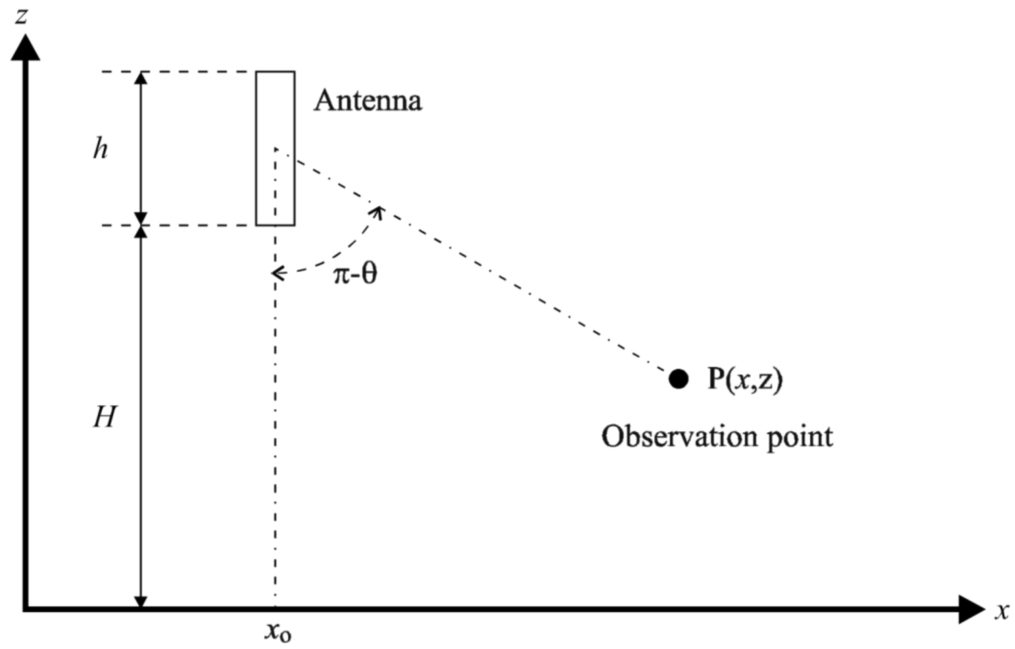

Figure 1

For the case of multi-channel transmission by one or several antennas installed in a particular site, the effective power density may be defined as:

$$S_e(x,z) = \sum_{i=1}^{M}\sum_{j=1}^{N} S_{ij}(x,z) \qquad (4)$$

where S_{ij} is the power density contributed by channel j of antenna i.

2 Near-Field Approximation for Antenna Arrays

For an antenna array such as the collinear antenna used in many paging networks or dipole arrays found in many cellular radio networks, the power density at locations where $r \leq r_n$ may be approximated by [3]:

$$S_n(r,\theta) = \frac{S(r_n,\theta)r_n}{r} \qquad (5)$$

where $S(r,\theta)$ is the power density obtained by equation (1). Effectively, we provide a correction factor r_n/r to the far-field formula when calculating the near-field. Note that this approximation is valid only if the power is uniformly distributed between the elements of the array. For the case when the power falls off at the end of the array, we may replace the physical length of the array by an effective length.

3 Near-Field Approximation for Monopole Antennas

For an electrically small monopole antenna such as the antennas used for AM broadcasting, the power level at locations with $r \ll \lambda_0$ can be estimated by the following near-zone expressions for the electromagnetic field [4]:

$$E_r = -j\frac{Ih_\lambda Z_0 \cos\theta}{2\pi^2 \lambda r_\lambda^3} \qquad (6)$$

$$E_\theta = -j\frac{Ih_\lambda Z_0 \sin\theta}{4\pi^2 \lambda r_\lambda^3} \qquad (7)$$

$$H_\emptyset = \frac{Ih_\lambda \sin\theta}{2\pi \lambda r_\lambda^2} \qquad (8)$$

where

I	=	current at the fed-point of the antenna
Z_0	=	377Ω
h_λ	=	electrical length of the antenna (h/λ_0)
r_λ	=	distance between the observation point and the fed-point of the antenna (r/λ_0)
λ_0	=	wavelength in free space

The magnitude of the electric field intensity can be determined by,

$$|E| = \sqrt{|E_r|^2 + |E_\theta|^2} \tag{9}$$

4 Reflector Antennas

At distances less than $0.5a^2/\lambda$ where a is the largest aperture dimension, the maximum power density S_m may be approximated by [5],

$$S_m = \frac{4P}{A} \tag{10}$$

where
P = Net power delivered to antenna
A = Physical aperture of antenna

This equation will give an accuracy within ±3 dB (in the absence of reflections) for square apertures with uniform, cosine and cosine^2 amplitude tapers, and for circular apertures with tapers ranging from uniform up to $(1 - q^2)^3$ [6].

References

[1] "Antennas and Radiowave Propagation", by Collin, R. E., McGraw-Hill, 1985.
[2] "Avoidance of Radiation Hazards from Microwave Antennas", by Shinn, D. H., The Marconi Review, vol.39, pp.61-80, 1976.
[3] "Theoretical and Measured Power Density in Front of VHF/UHF Broadcasting Antennas", by Jokela, K., Health Physics, vol.54, no.5, pp.533-543, 1988.
[4] "Antennas", by Krauss J. D., 2nd edition, McGraw-Hill, 1988.
[5] "IEEE Recommended Practice for Measurements and Computations of Electric, Magnetic, and Electromagnetic Fields with Respect to Human Exposure to Such Fields with Respect to Human Exposure to Such Fields, 0 Hz to 300 GHz" ", IEEE Std C95.3-2021, Published by the Institute of Electrical and Electronics Engineers, Inc..
[6] "Some Technical Aspects of Microwave Radiation Hazards", by Mumford, W. W., IRE Proceedings, no. 49, pp.427-447, Feb. 1961.

Rotating Beams

1 General

For rotating beams with a constant rotational velocity the average power density at a fixed point is reduced by the effective antenna-pattern beamwidth divided by the scanning angle.

2 Far Field

In the far field the reduction in the average power is simply given by,

$$Reduction\ factor = \frac{Beamwidth}{Scanning\ angle} \qquad (1)$$

3 Near Field

In the near field, the effective beamwidth will vary with distance, the power density can be approximated [1] by,

$$S = \left(\frac{4P}{A}\right)\left(\frac{a}{2\pi r}\right)\left(\frac{360^0}{q}\right) \qquad q > \left(\frac{a}{2\pi r}\right)360^0 \qquad (2)$$

$$S = \left(\frac{4P}{A}\right) \qquad q < \left(\frac{a}{2\pi r}\right)360^0 \qquad (3)$$

where,

q	=	the scanned angle, in degrees
P	=	the average power transmitted
A	=	the effective area of the antenna
a	=	antenna diameter or width
r	=	distance from the antenna

[1] "IEEE Recommended Practice for Measurements and Computations of Electric, Magnetic, and Electromagnetic Fields with Respect to Human Exposure to Such Fields with Respect to Human Exposure to Such Fields, 0 Hz to 300 GHz" ", IEEE Std C95.3-2021, Published by the Institute of Electrical and Electronics Engineers, Inc.

Determination of Maximum Allowable Transmitters on Roof-Tops

1 Introduction.

It is assumed here that the maximum allowable number of transmitters are limited by NIR and not other factors such as roof-top size or other structural restrictions. Under such conditions then the maximum number of allowable transmitters are determined by the NIR level observed at,

1.1 Adjacent buildings or roof-tops.

1.2 Roof-top where the transmitters are located.

The maximum number is only a guide and should not be binding, under implementation the actual number could be larger but would require verification with a survey.

2 Number Limited by Adjacent Buildings or Roof-Tops.

If the number of transmitters are likely to be limited by the NIR level observed in adjacent buildings, it must first be determined where the transmitter antennas are to be located. There are generally two most likely positions where the antennas will be located, either at the edge of the building or cluttered around the building. With the distance of the adjacent buildings known, the NIR limit known and the transmitter effective radiated power per transmitter known, the number of transmitters can be calculated according to equation 1, Annex 2. The non-ionising limit chosen, should be for the general public, since adjacent buildings or roof-tops will be under an uncontrolled environment.

3 Number Limited by Roof-top where the Transmitters are Located.

If the roof-top is large or if the transmitter antennas are mounted low then the number of transmitters will most likely be limited by the NIR level at the roof-top. In order to determine the number, the maximum allowable antenna height will be required. Assuming that the NIR level at the roof-top has an equal contribution from each transmitter, then the number can be determined from equation 1, Annex 2, taking into account a factor of 6 dB for a cluttered roof-top. The non-ionising limit chosen, should be for the general public in easily accessible areas and can be the occupational limit in areas that are not easily accessible but will be restricted.

4 Simplification to Determine the Approximate Transmitter Number.

In order to use equation 1 in Annex 2 some simplifications will be required such as assuming that all antennas are omni-directional with a gain of 3 dB and that each transmitter has an effective radiated power of 100 W. To simplify things further, all the transmitters can be assumed to be located at the same point, either at the centre of the building or under worst case conditions, at the edge.