Commission for
Communications Regulation

Report

2008 Programme of Measurement of Non-Ionising Radiation Emissions

First Interim Report

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Contents

1. Executive Summary 3
2. Introduction 4
3. Measurement Results 6
3.1 Explanatory Note 6
3.2 Measurement Results by Site 10
3.1.1 Dublin 1: Custom House Quay - Jurys Inn Hotel 10
3.1.2 Dublin 3: East Wall Road 11
3.1.3 Dublin 4: Ballsbridge - Northumberland Road 12
3.1.4 Dublin 4: Ringsend - Shelbourne Park Greyhound Stadium 13
3.1.5 Dublin 8: Kilmainham - Junction Old Kilmainham Rd / South Circular Rd 14
3.1.6 Dublin 9: Santry - Crowne Plaza Hotel 15
3.1.7 Dublin 11: Finglas - just off the N2 (Near Permanent TSB) 16
3.1.8 Dublin 12: Fox & Geese - Killeen Rd (Junct. Nangor Rd) 17
3.1.9 Kildare: Celbridge - Dublin Road 18
3.1.10 Meath: Clonee - Bracetown Business Park 19
4. Conclusion 20
Annex 1 - NIR and Emissions Standards 21
Annex 2 – The ICNIRP Guidelines 23
Annex 3 – Survey Methodology 27
Annex 4 – Measurement of Electromagnetic Fields 29
Annex 5 – Derivation of Adjusted Levels 31
Annex 6 – Glossary 35

1. Executive Summary

The Commission for Communications Regulation (ComReg) currently arranges for Non-Ionising Radiation (NIR) surveys to be conducted near a sample of licensed transmitter sites nationwide. Each survey involves measurement of NIR emission levels at the point of highest emissions (in a public area), associated with the transmitter. Sites are surveyed in order to assess compliance on the part of transmitter operators with their licence conditions relating to NIR emissions.

This report forms part of an ongoing series of interim reports which outline ComReg's programme and presents the results of the first set of 10 site surveys undertaken in 2008.

In April 2008, ComReg engineers conducted measurements at 10 sites. On the basis of this work, ComReg have concluded that the NIR emissions measured from all of the 10 sites were below the relevant ICNIRP guideline limits for general public exposure[1]. The results of the measurements taken at all the sites are presented in this report.

[1] See Annex 2

2. Introduction

The Commission for Communications Regulation (ComReg) is the licensing authority for the use of the radio frequency spectrum in Ireland. The frequency spectrum is a valuable national resource which has been used for communications purposes for over 100 years. Applications which make use of the radio spectrum include a wide range of services such as radio and television broadcasting, mobile telephony and other telecommunications services such as internet connection.

It is a condition of various licences[2] issued by ComReg that licensees must ensure that non-ionising radiation[3] (NIR) emissions from each transmitter operated under the licence must be within the limits set down in the guidelines published by the International Commission on Non-Ionizing Radiation Protection (ICNIRP)[4]. Levels of NIR emissions from a licensed transmitter must not exceed the ICNIRP limits in any part of the site or surrounding area to which the general public has access.

In order to assess compliance on the part of transmitter operators with their licence conditions relating to NIR, ComReg currently arranges for NIR surveys to be conducted near a sample number of licensed transmitter sites nationwide. Each survey involves measurement of NIR emission levels at the point of highest emissions (in a public area), associated with the transmitter.

This report presents the results of measurements taken at the first set of 10 sites chosen as part of the 2008 Programme of Measurement of Non-Ionising Radiation emissions. All 10 site surveys were conducted by ComReg engineers.

[2] Issued pursuant to the Wireless Telegraphy Act, 1926 (No. 45 of 1926) e.g. for services such as GSM & UMTS Mobile Telephony, Radio & TV Broadcasting, MMDS, Wireless Broadband etc.

[3] Non-ionising radiation is that part of the electromagnetic spectrum below 3 x 10^{15} Hz (3000 million MHz). Radio waves, infrared radiation and visible light are examples of NIR. (see Annex 1)

[4] See Annexes 1& 2 for further details.

Abbreviated versions of the individual site survey reports are available on the ComReg website[5] as well as on Siteviewer[6], an on-line facility provided by ComReg, which allows the public to view details of GSM and 3G mobile telephony base stations throughout Ireland. Copies of the full site reports are available on request.

[5] www.comreg.ie
[6] www.siteviewer.ie

3. Measurement Results

3.1 Explanatory Note

At the point of highest emissions[7] associated with each site, the engineers measured the electric field strength (or electric field voltage)[8] of emissions in the relevant radio frequency bands.

The tables which follow in the next sub-section present the levels measured at each site. The sites are listed in order by county.

The tables show the measured levels alongside the relevant ICNIRP limits for general public exposure. They include levels measured in respect of emissions from the transmitter site, along with the levels for emissions from nearby sites, if particularly high at the location.

The tables present the measurements for each site under the following headings:

1. Frequency Range
2. Measured Level V/m
3. Adjusted Level V/m
4. ICNIRP guideline limit
5. Total Exposure Quotient

A brief explanation of each of the headings follows:-

[7] See Annex 3 for an outline of the site survey methodology.

[8] See Annex 4 for an outline of how electromagnetic fields are measured.

Frequency (MHz)

Various radio services are transmitted in predefined frequency ranges. For example 3G (or UMTS) mobile telephony base stations transmit signals on a frequency somewhere in the range 2110 – 2170 MHz. At each site transmitting a 3G signal, measurements were taken in that frequency range and the results of those measurements are presented in the tables. Other services such as GSM 900, GSM 1800, TETRA, Television etc. are presented in similar manner in the tables, if applicable.

Measured Level V/m

The tables show the electric field strength levels measured for each emission (signal) type from the designated site, along with the levels for emissions from nearby sites, if particularly high. In many instances more than one measured level is shown for each emission type. This is due to the fact that different mobile operators often transmit signals from the same site on different frequency channels.

Adjusted Level V/m

For some emission types an adjusted level has been calculated from the measured level for any or all of the following reasons:

- to compensate for the limited measurement resolution of the spectrum analyser[9]. For example, a measurement of a digital television signal performed with at a resolution of 5 MHz needs to be adjusted upwards using a correction factor in order to account for the energy present within the full 7.6 MHz bandwidth of the signal.

- to extrapolate to an estimate of the level under maximum traffic from the transmitter. For example, the base stations of mobile telephone networks produce emissions which vary according to the changing volume of calls or data traffic over the course of the day. The levels measured for the

[9] Spectrum analysers are used to measure individual emissions at specific frequencies (see Annex 4).

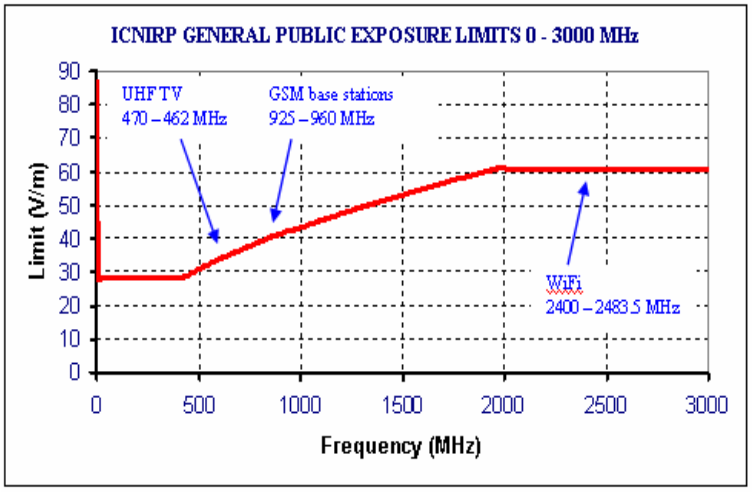
always-on pilot channels of the base stations can be used to extrapolate to a level which would be expected if all voice and data channels were in operation.

- to account for the characteristics of certain complex signal types (e.g. analogue PAL TV).

For further details concerning the calculation of Adjusted Levels, please refer to Annex 5.

ICNIRP guideline limit

For each site the table shows the measured and adjusted electric field strength levels in Volts per metre (V/m) alongside the relevant ICNIRP general public guideline limits. It should be noted that the ICNIRP guideline limits vary according to frequency as illustrated:



For example, for a GSM mobile signal on a frequency of 940.050 MHz, the relevant limit is 42.158 V/m, while for a 3G mobile signal on a frequency of 2147.2 MHz the relevant limit is 61 V/m. Thus the limits for the different measurements presented in the tables will vary as the measurements have been performed at different frequencies.

For further details concerning the ICNIRP Limits, please refer to Annex 2.

Total Exposure Quotient

For each site, Total Exposure Quotients are calculated, in accordance with mathematical formulas specified in the ICNIRP Guidelines in order assess the cumulative effect of emissions from multiple transmitters. The quotients in this report are calculated from the Adjusted Levels rather than from the Measured Levels, in order to account for total potential public exposure under maximum traffic conditions.

In order to satisfy the criteria of the ICNIRP Guidelines, the Quotients must be less than or equal to 1.

The two quotients are as follows:

Quotient for Electrical Stimulation Effects (1 Hz to 10 MHz)

This quotient is calculated only in a small number of cases where strong emissions in the frequency range between 1 Hz and 10 MHz are present at the survey location (e.g. near a long wave radio transmitter site).

Quotient for Thermal Effects (100 kHz and above)

The measurements of any emissions above 100 kHz are used to calculate a Quotient to assess any thermal (heat) effects.

Please refer to Annex 2 for further information concerning the calculation of the Quotients.

3.2 Measurement Results by Site

3.1.1 Dublin 1: Custom House Quay - Jurys Inn Hotel

Measurements

Signal Type	Frequency (MHz)	Measured Level (V/m)	Adjusted Level (V/m)	ICNIRP Limit (V/m)	Times below limit (of Adjusted Level)
GSM 900	955.450	1.90100	3.80200	42.50	11.18
GSM 900	938.530	0.10750	0.21500	42.12	195.92
GSM 900	948.217	0.05792	0.11584	42.34	365.51
GSM 900	946.817	0.06151	0.12302	42.31	343.92
GSM 1800	1841.000	0.11036	0.22072	59.00	267.29
GSM 1800	1857.000	0.11454	0.22908	59.25	258.66
GSM 1800	1862.500	0.10552	0.21104	59.34	281.18
UMTS	2113.900	0.85540	5.53161	61.00	11.03
UMTS	2127.400	0.43310	2.80073	61.00	21.78
UMTS	2147.500	0.88940	5.75148	61.00	10.61
UMTS	2167.900	0.34220	2.21290	61.00	27.57

Total Exposure Quotients (calculated from Adjusted Levels)

Quotient	Frequency Range	Calculated Quotient Value	Limit
Electrical Stimulation Effects	1 Hz to 10 MHz	n/a	1
Thermal Effects	100 kHz and above	0.02862311	1

3.1.2 Dublin 3: East Wall Road

Measurements

Signal Type	Frequency (MHz)	Measured Level (V/m)	Adjusted Level (V/m)	ICNIRP Limit (V/m)	Times below limit (of Adjusted Level)
GSM 900	939.817	0.95980	1.91960	42.15	21.96
GSM 900	938.067	0.16300	0.32600	42.11	129.18
GSM 900	940.983	0.09220	0.18440	42.18	228.74
GSM 900	948.217	0.17170	0.34340	42.34	123.30
GSM 1800	1867.000	0.65960	1.31920	59.41	45.04
GSM 1800	1860.750	0.20700	0.41400	59.31	143.27
GSM 1800	1832.250	0.11180	0.22360	58.86	263.22
UMTS	2113.000	3.25400	21.04263	61.00	2.90
UMTS	2126.500	0.51880	3.35492	61.00	18.18
UMTS	2145.700	1.66100	10.74119	61.00	5.68
UMTS	2168.800	0.03697	0.23907	61.00	255.15

Total Exposure Quotients (calculated from Adjusted Levels)

Quotient	Frequency Range	Calculated Quotient Value	Limit
Electrical Stimulation Effects	1 Hz to 10 MHz	n/a	1
Thermal Effects	100 kHz and above	0.15581923	1

3.1.3 Dublin 4: Ballsbridge - Northumberland Road

Measurements

Signal Type	Frequency (MHz)	Measured Level (V/m)	Adjusted Level (V/m)	ICNIRP Limit (V/m)	Times below limit (of Adjusted Level)
GSM 900	954.050	1.00600	2.01200	42.47	21.11
GSM 900	950.083	0.33140	0.66280	42.38	63.94
GSM 900	955.450	0.18280	0.36560	42.50	116.25
GSM 1800	1875.750	0.04578	0.09156	59.55	650.41
GSM 1800	1839.250	0.18890	0.37780	58.97	156.08
GSM 1800	1832.000	0.13600	0.27200	58.85	216.37
UMTS	2113.600	0.63090	4.07984	61.00	14.95
UMTS	2128.600	0.20280	1.31145	61.00	46.51
UMTS	2146.000	0.47080	3.04452	61.00	20.04
UMTS	2168.500	0.67310	4.35273	61.00	14.01

Total Exposure Quotients (calculated from Adjusted Levels)

Quotient	Frequency Range	Calculated Quotient Value	Limit
Electrical Stimulation Effects	1 Hz to 10 MHz	n/a	1
Thermal Effects	100 kHz and above	0.01514587	1

3.1.4 Dublin 4: Ringsend - Shelbourne Park Greyhound Stadium

Measurements

Signal Type	Frequency (MHz)	Measured Level (V/m)	Adjusted Level (V/m)	ICNIRP Limit (V/m)	Times below limit (of Adjusted Level)
GSM 900	953.467	1.22800	2.45600	42.46	17.29
GSM 900	954.867	0.36890	0.73780	42.49	57.59
GSM 900	938.883	0.06223	0.12446	42.13	338.52
GSM 900	947.750	0.04645	0.09290	42.33	455.65
GSM 1800	1854.500	0.63840	1.27680	59.21	46.38
GSM 1800	1862.000	0.22520	0.45040	59.33	131.73
GSM 1800	1866.750	0.08981	0.17962	59.41	330.74
UMTS	2111.800	1.20500	7.79237	61.00	7.83
UMTS	2127.600	0.04246	0.27458	61.00	222.16
UMTS	2146.600	0.09752	0.63063	61.00	96.73
UMTS	2169.000	0.71660	4.63404	61.00	13.16

Total Exposure Quotients (calculated from Adjusted Levels)

Quotient	Frequency Range	Calculated Quotient Value	Limit
Electrical Stimulation Effects	1 Hz to 10 MHz	n/a	1
Thermal Effects	100 kHz and above	0.02640967	1

3.1.5 Dublin 8: Kilmainham - Junction Old Kilmainham Rd / South Circular Rd

Measurements

Signal Type	Frequency (MHz)	Measured Level (V/m)	Adjusted Level (V/m)	ICNIRP Limit (V/m)	Times below limit (of Adjusted Level)
GSM 900	938.88	1.68100	3.36200	42.13	12.53
GSM 900	951.25	0.96150	1.92300	42.41	22.05
GSM 900	947.05	0.66610	1.33220	42.31	31.76
GSM 900	955.57	0.24750	0.49500	42.50	85.87
GSM 1800	1863.75	0.10510	0.21020	59.36	282.40
GSM 1800	1855.25	0.22030	0.44060	59.22	134.42
GSM 1800	1833.25	0.16150	0.32300	58.87	182.27
GSM 1800	1831.25	0.46370	0.92740	58.84	63.45
UMTS	2113.3	0.07569	0.48946	61.00	124.63
UMTS	2128.0	0.39730	2.56922	61.00	23.74
UMTS	2148.1	1.15900	7.49490	61.00	8.14
UMTS	2165.8	0.22020	1.42397	61.00	42.84

Total Exposure Quotients (calculated from Adjusted Levels)

Quotient	Frequency Range	Calculated Quotient Value	Limit
Electrical Stimulation Effects	1 Hz to 10 MHz	n/a	1
Thermal Effects	100 kHz and above	0.02737667	1

3.1.6 Dublin 9: Santry - Crowne Plaza Hotel

Measurements

Signal Type	Frequency (MHz)	Measured Level (V/m)	Adjusted Level (V/m)	ICNIRP Limit (V/m)	Times below limit (of Adjusted Level)
GSM 900	938.53	0.04561	0.09122	42.12	461.78
GSM 900	954.87	0.02561	0.05122	42.49	829.53
GSM 900	958.53	0.02444	0.04888	42.57	870.91
GSM 1800	1834.50	0.23110	0.46220	58.89	127.42
GSM 1800	1839.25	0.16750	0.33500	58.97	176.03
GSM 1800	1845.25	0.08637	0.17274	59.07	341.93
UMTS	2113.9	0.88900	5.74889	61.00	10.61
UMTS	2148.1	0.48720	3.15058	61.00	19.36
UMTS	2168.2	0.04490	0.29035	61.00	210.09

Total Exposure Quotients (calculated from Adjusted Levels)

Quotient	Frequency Range	Calculated Quotient Value	Limit
Electrical Stimulation Effects	1 Hz to 10 MHz	n/a	1
Thermal Effects	100 kHz and above	0.01168210	1

3.1.7 Dublin 11: Finglas - just off the N2 (Near Permanent TSB)

Measurements

Signal Type	Frequency (MHz)	Measured Level (V/m)	Adjusted Level (V/m)	ICNIRP Limit (V/m)	Times below limit (of Adjusted Level)
GSM 900	939.70	0.01770	0.03540	42.15	1190.68
GSM 900	953.70	0.02140	0.04280	42.46	992.12
GSM 900	954.87	0.04423	0.08846	42.49	480.32
GSM 900	945.42	0.01391	0.02782	42.28	1519.70
GSM 900	950.32	0.01861	0.03722	42.39	1138.83
GSM 1800	1837.25	0.09821	0.19642	58.94	300.06
GSM 1800	1841.25	0.02805	0.05610	59.00	1051.71
GSM 1800	1857.00	0.07104	0.14208	59.25	417.04
UMTS	2113.3	2.36900	15.31961	61.00	3.98
UMTS	2148.1	0.06833	0.44187	61.00	138.05

Total Exposure Quotients (calculated from Adjusted Levels)

Quotient	Frequency Range	Calculated Quotient Value	Limit
Electrical Stimulation Effects	1 Hz to 10 MHz	n/a	1
Thermal Effects	100 kHz and above	0.06314935	1

3.1.8 Dublin 12: Fox & Geese - Killeen Rd (Junct. Nangor Rd)

Measurements

Signal Type	Frequency (MHz)	Measured Level (V/m)	Adjusted Level (V/m)	ICNIRP Limit (V/m)	Times below limit (of Adjusted Level)
GSM 900	955.68	0.03992	0.07984	42.51	532.40
GSM 900	954.52	0.04037	0.08074	42.48	526.15
GSM 900	939.82	0.02667	0.05334	42.15	790.26
GSM 900	947.40	0.02208	0.04416	42.32	958.39
GSM 1800	1835.75	2.26800	4.53600	58.91	12.99
GSM 1800	1840.00	0.48100	0.96200	58.98	61.31
GSM 1800	1863.25	0.05102	0.10204	59.35	581.66
UMTS	2111.5	0.08303	0.53693	61.00	113.61
UMTS	2128.0	0.03161	0.20441	61.00	298.42
UMTS	2146.6	2.55000	16.49008	61.00	3.70
UMTS	2166.7	0.03463	0.22394	61.00	272.39
UMTS	2139.4	0.07083	0.45804	61.00	133.18
UMTS	2157.4	0.10640	0.68806	61.00	88.66

Total Exposure Quotients (calculated from Adjusted Levels)

Quotient	Frequency Range	Calculated Quotient Value	Limit
Electrical Stimulation Effects	1 Hz to 10 MHz	n/a	1
Thermal Effects	100 kHz and above	0.07957073	1

3.1.9 Kildare: Celbridge - Dublin Road

Measurements

Signal Type	Frequency (MHz)	Measured Level (V/m)	Adjusted Level (V/m)	ICNIRP Limit (V/m)	Times below limit (of Adjusted Level)
GSM 900	940.05	0.01634	0.03268	42.16	1290.02
GSM 900	948.80	0.03653	0.07306	42.35	579.71
GSM 1800	1832.00	0.03867	0.07734	58.85	760.96
GSM 1800	1839.00	0.45260	0.90520	58.96	65.14
GSM 1800	1845.00	0.19290	0.38580	59.06	153.09
UMTS	2113.4	0.93110	6.02114	61.00	10.13
UMTS	2146.4	0.52090	3.36850	61.00	18.11
UMTS	2167.4	0.43540	2.81560	61.00	21.67

Total Exposure Quotients (calculated from Adjusted Levels)

Quotient	Frequency Range	Calculated Quotient Value	Limit
Electrical Stimulation Effects	1 Hz to 10 MHz	n/a	1
Thermal Effects	100 kHz and above	0.01520667	1

3.1.10 Meath: Clonee - Bracetown Business Park

Measurements

Signal Type	Frequency (MHz)	Measured Level (V/m)	Adjusted Level (V/m)	ICNIRP Limit (V/m)	Times below limit (of Adjusted Level)
GSM 900	951.25	0.01744	0.03488	42.41	1215.83
GSM 900	937.95	0.01019	0.02038	42.11	2066.28
GSM 900	950.55	0.00828	0.01655	42.39	2561.49
GSM 1800	1836	0.02337	0.04674	58.92	1260.52
GSM 1800	1843.5	0.1735	0.347	59.04	170.14
UMTS	2112.2	0.03839	0.24826	61	245.71
UMTS	2146.8	0.2342	1.5145	61	40.28

Total Exposure Quotients (calculated from Adjusted Levels)

Quotient	Frequency Range	Calculated Quotient Value	Limit
Electrical Stimulation Effects	1 Hz to 10 MHz	n/a	1
Thermal Effects	100 kHz and above	0.000669	1

4. Conclusion

The conclusion of this report is that at all 10 licensed transmitter sites surveyed by ComReg in April 2008:

(1) Measurements undertaken of non-ionising radiation emission levels on individual frequencies were found to fall below the international ICNIRP reference levels for general public exposure.

(2) The levels measured were not found to cause the aggregate of non-ionising radiation emissions to exceed the criteria for simultaneous exposure to multiple frequency fields specified in the guidelines published by ICNIRP.

Annex 1 - NIR and Emissions Standards

Definition

Non-ionising radiation (NIR) is that part of the electromagnetic spectrum below 3000 million MHz (3 x 10^{15} Hz). Non-ionising radiation includes all radiations and fields of the electromagnetic spectrum that do not normally have sufficient energy to produce ionisation in matter and is characterised by energy per photon of less than about 12 eV and wavelengths greater than 100 nm. Radio waves, infrared radiation and visible light are examples of NIR. Electromagnetic waves at frequencies above 3000 million MHz are known as ionising radiation and this includes X-rays and Gamma rays as well as some Ultraviolet radiation.

Standards for limiting exposure to non-ionising radiation

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) is an independent, scientific organisation established in 1992. The ICNIRP was established for the purpose of advancing Non-Ionising Radiation Protection and in particular to provide guidance and recommendations on protection from NIR exposure. ICNIRP operates in co-operation with the Environmental Health Division of the World Health Organisation and the United Nations Environment Programme.

In 1998 ICNIRP published guidelines[10] for limiting exposure to NIR (up to 300 GHz). Many countries have adopted the 1998 ICNIRP document as the reference for setting emissions limits. It should be noted that in 1999 the Council of the European Union issued a recommendation[11] to limit exposure of the general public to electromagnetic fields 0Hz - 300GHz

[10] "Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz)", Health Physics, vol 74, no. 4, April 1998

Available on the Web at www.icnirp.de.

[11] Recommendation of the European Council 1999/519/EC of July 12, 1999

based on a set of basic restrictions and reference levels developed internationally under the advice of the International Commission on Non-Ionizing Radiation Protection. In relation to emissions within the radio spectrum, these limits are equivalent to the ICNIRP guideline limits. An outline of the ICNIRP Guidelines is presented in Annex 2.

Non-ionising radiation licence conditions

It is a condition of various licences[12] issued by ComReg pursuant to the Wireless Telegraphy Act, 1926 (No. 45 of 1926) that licensees must ensure that NIR emissions from each radio installation operated thereunder must be within the limits specified in the guidelines published by ICNIRP.

[12] e.g. GSM, 3G Mobile, Radio and TV Broadcasting, MMDS, FWA (Wireless Broadband), among others.

Annex 2 – The ICNIRP Guidelines

SUMMARY OF THE ICNIRP GUIDELINES FOR LIMITING EXPOSURE TO TIME-VARYING ELECTRIC, MAGNETIC, AND ELECTROMAGNETIC FIELDS (UP TO 300 GHz)

In 1974, the International Radiation Protection Association (IRPA) formed a working group on non-ionising radiation (NIR), which examined the problems arising in the field of protection against the various types of NIR. In 1977, this working group became the International Non-Ionizing Radiation Committee (INIRC).

In cooperation with the Environmental Health Division of the World Health Organization (WHO), the IRPA/INIRC developed a number of health criteria documents on NIR as part of WHO's Environmental Health Criteria Program, sponsored by the United Nations Environment Program (UNEP). Each document includes an overview of the physical characteristics, measurement and instrumentation, sources, and applications of NIR, a thorough review of the literature on biological effects, and an evaluation of the health risks of exposure to NIR. These health criteria have provided the scientific database for the subsequent development of exposure limits and codes of practice relating to NIR.

At the Eighth International Congress of the IRPA, a new, independent scientific organization—the International Commission on Non-Ionizing Radiation Protection (ICNIRP)—was established as a successor to the IRPA/INIRC. The functions of the Commission are to investigate the hazards that may be associated with the different forms of NIR, develop international guidelines on NIR exposure limits, and deal with all aspects of NIR protection.

ICNIRP has defined two guideline exposure limits, one for members of the general public and one for people classified as occupational (e.g. telecommunication engineers). The occupationally exposed population consists of adults who are generally exposed under known conditions and are trained to be aware of potential risk and to take appropriate precautions. By contrast, the general public comprises individuals of all ages and of varying health status, and may include particularly susceptible groups or individuals. In many cases, members of the public are unaware of their exposure to EMF. Moreover, individual members of the public cannot reasonably be expected to take precautions to minimize or avoid exposure. It is these considerations that underlie the adoption of more stringent exposure restrictions for the public than for the occupationally exposed population.

ICNIRP has defined basic restrictions and reference levels. Depending on frequency, the physical quantities used to specify the basic restrictions on exposure to electromagnetic fields (EMF) are current density, specific absorption rate (SAR), and power density. SAR is not easily measurable in living people therefore reference levels have been obtained from the basic restrictions by mathematical modelling and by extrapolation from the results of laboratory investigations at specific frequencies.

The reference levels are provided for comparison with measured values of physical quantities; compliance with all reference levels given in these guidelines will ensure

compliance with basic restrictions. If measured values are higher than reference levels, it does not necessarily follow that the basic restrictions have been exceeded, but a more detailed analysis is necessary to assess compliance with the basic restrictions.

Frequency Range	E – Field Strength (Vm^{-1})	H – Field (Am^{-1})	B – Field (μT)	Equivalent plane wave power S (Wm^{-2})
up to 1 Hz	-	1.63×10^5	2×10^5	-
1 – 8 Hz	20,000	$1.63 \times 10^5/f^2$	$2.5 \times 10^5/f^2$	-
8 – 25 Hz	20,000	$1.63 \times 10^5/f$	$2.5 \times 10^4/f$	-
0.025 – 0.82 kHz	$500/f$	$20/f$	$25/f$	-
0.82 – 65 kHz	610	24.4	30.7	-
0.065 – 1 MHz	610	$1.6/f$	$2.0/f$	-
1 – 10 MHz	$610/f$	$1.6/f$	$2.0/f$	-
10 – 400 MHz	61	0.16	0.2	10
400 – 2000 MHz	$3f^{1/2}$	$0.008f^{1/2}$	$0.01f^{1/2}$	$f/40$
2 – 300 GHz	137	0.36	0.45	50

Table 1: Reference levels for occupational exposure to time-varying electric and magnetic fields (unperturbed rms values). f in units as indicated in the Frequency Range column.

Frequency Range	E – Field Strength (Vm^{-1})	H – Field (Am^{-1})	B – Field (μT)	Equivalent plane wave power S (Wm^{-2})
up to 1 Hz	-	3.2×10^4	4×10^4	-
1 – 8 Hz	10,000	$3.2 \times 10^4/f^2$	$4 \times 104/f^2$	-
8 – 25 Hz	10,000	$4{,}000/f$	$5000/f$	-
0.025 – 0.8 kHz	$250/f$	$4/f$	$5/f$	-
0.8 – 3 kHz	$250/f$	5	6.25	-
3 – 150 kHz	87	5	6.25	-
0.15 - 1 MHz	87	$0.73/f$	$0.092/f$	
1 – 10 MHz	$87/f^2$	$0.73/f$	$0.092/f$	-
10 – 400 MHz	28	0.16	0.092	2
400 – 2000 MHz	$1.375f^{1/2}$	$0.0037f^{1/2}$	$0.0046f^{1/2}$	$f/200$
2 – 300 GHz	61	0.16	0.20	10

Table 2: Reference levels for general public exposure to time-varying electric and magnetic fields (unperturbed rms values). f in units as indicated in the Frequency Range column.

Simultaneous Exposure to Multiple Frequency Fields (Total Exposure Quotients)

ICNIRP has specified a means of assessing additivity of exposures in situations of simultaneous exposure to fields of different frequencies. Additivity is examined separately for the effects of electrical and thermal stimulation, and ICNIRP has set out basic restrictions which should be met for both considerations.

For practical application of the basic restrictions, ICNIRP has advised that the following criteria[13] regarding reference levels of field strengths should be applied:

Induced Current Density and Electrical Stimulation

For induced current density and electrical stimulation effects, relevant up to 10 MHz, the following two requirements should be applied to the field levels:

$$\sum_{i=1\ \mathrm{Hz}}^{1\ \mathrm{MHz}} \frac{E_i}{E_{L,i}} + \sum_{i>1\ \mathrm{MHz}}^{10\ \mathrm{MHz}} \frac{E_i}{a} \leq 1,$$

and

$$\sum_{j=1\ \mathrm{Hz}}^{65\ \mathrm{kHz}} \frac{H_j}{H_{L,j}} + \sum_{j>65\ \mathrm{kHz}}^{10\ \mathrm{MHz}} \frac{H_j}{b} \leq 1,$$

where

E_i = the electric field strength at frequency i;

$E_{L,i}$ = the electric field reference level from Tables 1 and 2;

Hj = the magnetic field strength at frequency j;

$H_{L,j}$ = the magnetic field reference level from Tables 1 and 2;

a = 610 V m^{-1} for occupational exposure and 87 V m^{-1} for general public exposure; and

b = 24.4 A m^{-1} (30.7 μT) for occupational exposure and 5 A m^{-1} (6.25 μT) for general public exposure.

[13] The calculated values are referred to as '**Total Exposure Quotients**' elsewhere in this report.

Thermal Considerations

For thermal considerations, relevant above 100 kHz, the following two requirements should be applied to the field levels:

$$\sum_{i=100\ \mathrm{kHz}}^{1\ \mathrm{MHz}} \left(\frac{E_i}{c}\right)^2 + \sum_{i>1\ \mathrm{MHz}}^{300\ \mathrm{GHz}} \left(\frac{E_i}{E_{L,i}}\right)^2 \leq 1,$$

and

$$\sum_{j=100\ \mathrm{kHz}}^{1\ \mathrm{MHz}} \left(\frac{H_j}{d}\right)^2 + \sum_{j>1\ \mathrm{MHz}}^{300\ \mathrm{GHz}} \left(\frac{H_j}{H_{L,j}}\right)^2 \leq 1,$$

where

E_i = the electric field strength at frequency i;

$E_{L,i}$ = the electric field reference level from Tables 1 and 2;

Hj = the magnetic field strength at frequency j;

$H_{L,j}$ = the magnetic field reference level from Tables 1 and 2;

C = $610/f$ V m^{-1} (f in MHz) for occupational exposure and $87/f^{1/2}$ V m^{-1} for general public exposure; and

d = $1.6/f$ A m^{-1} (f in MHz) for occupational exposure and $0.73/f$ for general public exposure.

Annex 3 – Survey Methodology

The purpose of the surveys was to quantify the electromagnetic field (EMF) present at each area and to identify the frequency and intensity (or level) of the principal emissions contributing to the field. The locations of the survey were chosen by ComReg.

Some of the typical emission types encountered when measuring EMF are AM and FM broadcast radio, broadcast television signals, wireless CCTV, mobile radio, emergency services radios, pager base station radios, taxi base station radios, mobile phone base station signals and wireless broadband signals.

Measurements were carried out broadly in accordance with ECC Recommendation (02)04[14]. Some departure from this prescribed methodology was taken, but only in order to take into account the particular signal characteristics of certain emission types (e.g. UMTS and GSM signals having different bandwidths require different measurement bandwidths to be employed in each case)[15]. This is in order to provide a more accurate picture of the level of emissions present.

Surveys were, in most cases, conducted in three stages as follows:

1 Initial Site Survey

At all sites surveyed, initial investigations were carried out using a field strength meter and a broadband probe to find the position of the maximum field strength. The probe used for the initial investigation measured and summed all emissions present in a broad frequency range (typically 100 kHz to 3 GHz).

[14] ECC REC (02)04 (revised Bratislava 2003, Helsinki 2007), "MEASURING NON-IONISING ELECTROMAGNETIC RADIATION (9 kHz – 300 GHz)", published by the European Communications Committee on www.ero.dk

[15] ***For example:*** ECC REC (02)04 recommends a measurement bandwidth of 100 kHz for both GSM and UMTS. However, measurement bandwidths more appropriate to the actual signal bandwidths of 200 kHz and 5 MHz respectively have been employed.

2 Broadband Measurements

Once the location was identified, the field strength meter and broadband probe were mounted on a non-conductive tripod and the aggregate field strength in Volts per meter was recorded over a period exceeding six minutes.

3 Frequency Selective Measurements

Measurements of emissions at specific frequencies were then carried out at the same location using a spectrum analyser and a range of antennas matched to the frequencies being measured. The spectrum analyser was set to sweep a frequency range continuously for a period of up to six minutes and the results were stored in the spectrum analyser.

This procedure was repeated at different frequency ranges until the electromagnetic fields at all relevant frequencies were recorded. The results were later transferred to a computer for analysis and comparison with the ICNIRP general public guideline levels.

Annex 4 – Measurement of Electromagnetic Fields

Electromagnetic fields can be sub-divided into two components:

(1) Electric field **E** [measured in Volts per metre or V/m]

(2) Magnetic field **H** [measured in Amperes per metre or A/m]

The E-field and the H-field are mathematically interdependent[16] in the **far-field** which is the region[17] where the distance from the radiating antenna exceeds the wavelength of the radiated electromagnetic field. The measurement locations for most transmitter installations lie well within the far-field, as the wavelengths of the transmitted signals are relatively short and the antennas are typically located many metres from any public area. The following table shows wavelengths for commonly transmitted signals:

Transmitter Type	Frequency	Wavelength
PMR Low Band VHF	68 MHz	4.41 m
UHF TV	470 MHz	0.64 m
GSM 900 (mobile phone base)	925 MHz	0.32 m
GSM 1800 (mobile phone base)	1805 MHz	0.17 m
UMTS (mobile phone base)	2110 MHz	0.14 m

In the far-field only one component needs to be measured, as the other component can be easily derived from it. Normally it is only the electric field which is measured in this region.

In the case of transmitters of very long wavelength signals, such as long wave radio (1.19 km wavelength), the H-field and E-field must be measured separately as the point of measurement will most likely lie within the **reactive near-field** region. This is the region located less than one wavelength from the radiating antenna. Here, the

[16] $E = H \times Z_0$ where Z_0 (characteristic impedance of free space) $\approx 377\ \Omega$

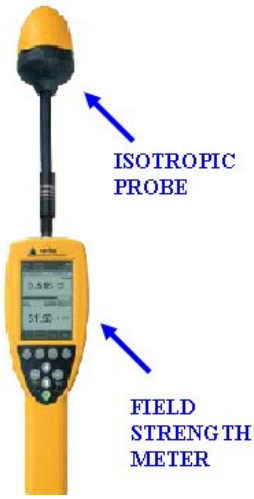
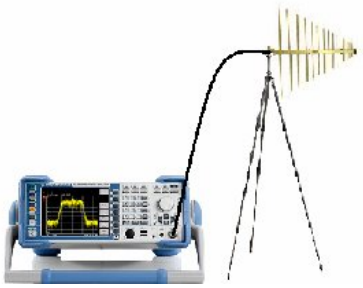
[17] Beyond a distance of $\lambda + 2D^2/\lambda$ where λ is the wavelength and D is the antenna's largest dimension

relationship between E and H becomes very complex and there is no direct correlation between both components of the electromagnetic field.

Measurement Equipment

The measurement of electromagnetic fields is a complex process which involves the use of various meters, spectrum analysers, probes and antennas, which are appropriate to the frequencies of the emissions being measured.

The table below shows examples of equipment typically used to measure electromagnetic fields in non-ionising radiation surveys.

<table>
<tr><th>Initial Site Survey and Broadband Measurements</th><th colspan="2">Frequency Selective Measurements</th></tr>
<tr><td> 
</td><td>SPECTRUM ANALYSER WITH TRIPOD MOUNTED ANTENNA CONNECTED
  </td><td>PORTABLE SPECTRUM ANALYSER WITH ANTENNA DIRECTLY CONNECTED
  </td></tr>
<tr><td>Used to measure the overall electric or magnetic field present over a range of frequencies. (e.g. 100kHz to 3GHz)</td><td colspan="2">Spectrum analysers are used to measure individual emissions at specific frequencies. The individual emissions contribute to the overall electromagnetic field. Examples of individual emissions are a TV signal and a mobile phone signal for a particular mobile operator. There may be a number of emissions from different transmitters contributing to the overall electromagnetic field at a particular location.</td></tr>
</table>

Annex 5 – Derivation of Adjusted Levels

In the case of some services an adjusted level is calculated from the measured electric field level and is presented in the relevant frequency selective measurement table for comparison with the applicable emission limit. For a particular measurement, the adjustment may be performed for any or all of the following reasons

(1) to compensate for the limited measurement resolution of the spectrum analyser used;

(2) to extrapolate to an estimate of the level of emissions from a transmitter under maximum traffic conditions (e.g. when a mobile phone base station is serving its maximum number of calls and data clients);

(3) to account for the characteristics of certain signal types.

Compensating for the limited measurement resolution of the spectrum analyser.

In many cases it is necessary to compensate for the limited measurement resolution of the spectrum analyser, as the bandwidth of the signal measured may be greater than the resolution bandwidth (RBW) of the analyser. For example, a measurement of a digital television signal performed with at an RBW setting of 5 MHz needs to be adjusted upwards by multiplying it by a correction factor in order to account for the energy present within the full 7.6 MHz bandwidth of the signal.

The correction factor is derived as follows:

Correction Factor: $K = 10 \times \log_{10} (B_{Signal} / B_N)$

(for a Gaussian Filter: $B_N = 1.1 \times B_{3dB}$)

Example:

IF

$B_{Signal} = 4.6$ MHz

RBW (i.e. B_{3dB}) = 1 MHz

THEN

$B_N = 1.1 \times 1$

AND

$K = 10 \times \log_{10} (4.6 / 1.1) = 6.2$ dB

Extrapolation to Max Traffic Signal Level

In the case of some networks it is necessary to extrapolate to an estimate of the level under maximum traffic from the transmitter. For example, the base stations of mobile telephone networks produce emissions which vary according to the changing volume of calls or data traffic over the course of the day.

In the cases of GSM, TETRA and UMTS (3G), the estimated electric field levels for maximum traffic conditions are extrapolated from the constant pilot channels (BCCH for GSM and TETRA and P-CPICH for UMTS) as follows:

GSM and TETRA:

V/m Calculation	dB Calculation
$\mathbf{E_{MAX}}$ = Signal Level (BCCH) x sqrt (no. channels per sector*)	$\mathbf{E_{MAX}}$ = Signal Level (BCCH) + 10Log(no. channels per sector*)
* number of channels per sector, if not known, is taken as: 4 for GSM 3 for TETRA (Emergency) 2 for TETRA (Civil)	

UMTS:

V/m Calculation	dB Calculation
$\mathbf{E_{MAX}}$ = Signal Level (P-CPICH) x Extrapolation Factor (=3.1623)	$\mathbf{E_{MAX}}$ = Signal Level (C-PCICH estimate) + Extrapolation Factor (=10 dB)
The P-CPICH transmits with a constant power typically 10 dB below P_{MAX}. The signal level measured is taken as an estimate of the P-CPICH level if the measurement receiver is unable to identify and measure any P-CPICH channels present.	

If necessary, as in the case of GSM and TETRA, the frequencies of the pilot channels present have been identified prior to recording the standard frequency selective scan of the band.

Accounting for characteristics of certain signal types:

In the case of some signals with a complex structure, such as analogue PAL television, it is necessary to apply a correction factor for reasons such as the following:

- to take into account characteristics of the signal shape, which make it difficult to measure an RMS level directly, which is indicative of worst case exposure.

- to derive a level more indicative of the aggregate of emissions attributable to the individual signal components.

Analogue PAL TV

- The peak field strength caused by the synch pulses of the picture carrier is measured.

- The field strength from the picture signal is at its highest when a black picture is being transmitted.

- It is assumed that 100% black picture is transmitted permanently for worst case exposure evaluation.

- The mean (RMS) level is then calculated from the synch pulse level by applying a correction factor.

- The value of this **correction factor** is **-2.3 dB**.

- The small contributions of the FM and NICAM sound signals have already been taken into consideration in this factor.

Annex 6 – Glossary

Antenna: - A conductive structure specifically designed to couple or to radiate electromagnetic energy.

BCCH: - Broadcast control channel. BCCH is a constant carrier on GSM base stations. Essentially it is the 'always on' pilot channel. The constant signal level of the BCCH allows for extrapolation to a maximum traffic signal level for a base station.

Broadband Measurement: - A measurement carried out using a meter and probe combination that simultaneously measures and sums all received signals within the frequency range of the probe. Generally this meter and probe combination is not as sensitive as the equipment used for narrowband measurements but is useful for getting an overall picture of the level of electromagnetic fields present at a site.

ComReg: - The Commission for Communications Regulation. ComReg is the statutory body responsible for the regulation of the electronic communications sector (telecommunications, radiocommunications and broadcasting transmission) and the postal sector in Ireland.

Electric Field Strength: - Electric field strength is a quantitative expression of the intensity of an electric field at a particular location. The standard unit is the Volt per meter (V/m). A field strength of 1 V/m represents a potential difference of one volt between points separated by one meter.

Electromagnetic Field (EMF): - Combined electric and magnetic fields, in this case radiating from an antenna.

Electromagnetic Spectrum: - The complete range of the wavelengths of electromagnetic radiation, beginning with the radio waves and extending through microwaves and visible light (a very small part of the spectrum) all the way to the extremely short gamma rays that are a product of radioactive atoms. The electromagnetic spectrum contains both non-ionizing and ionizing radiation

Frequency: - The number of cycles completed in one second by an electromagnetic wave. It is expressed in Hertz (Hz) or a multiple of Hertz, e.g. kHz (kilohertz, 1,000 Hertz), MHz (MegaHertz, 1,000,000 Hertz) and GHz (GigaHertz, 1,000,000,000 Hertz).

Frequency Range: - A group of frequencies between a selected start and stop frequency. E.g. the frequency range of the FM broadcast band includes all frequencies between 88 and 108 MHz.

Frequency Selective Measurement: - A measurement carried out using a receiver and an antenna which measures the received signal strength at specific frequencies. A spectrum analyser is usually used as the receiver, and a range of antennas is used which are suitable for reception of all the frequencies to be measured.

ICNIRP: - The International Commission on Non-Ionizing Radiation Protection.

Ionising radiation: - Ionising radiation, also called radioactivity, is electromagnetic (EM) radiation whose waves contain energy sufficient to overcome the binding energy of electrons in atoms or molecules, thus creating ions. It occurs at frequencies higher than ultraviolet light and includes x-rays and gamma rays. The sources of electromagnetic fields measured in this survey do not produce any ionising radiation.

Isotropic probe: Receives electromagnetic signals regardless of polarisation or direction of travel. An isotropic probe is designed to give the same reading, no matter which way it is pointed.

Non-ionising radiation (NIR): - Includes all radiations and fields of the electromagnetic spectrum that do not normally have sufficient energy to produce ionization in matter; characterized by energy per photon less than approximately 12 electron Volts, wavelengths greater than 100 nm, and frequencies lower than 3×10^{15} Hz.

Occupational Exposure: - All exposure to EMF experienced by individuals who are exposed under known conditions in the course of performing their work and who are trained to be aware of potential risk and to take appropriate precautions.

Public Exposure: - All exposure to EMF experienced by members of the general public, excluding occupational exposure and exposure during medical procedures.

P-CPICH: - Primary Common Pilot channel. P-CPICH is a downlink channel broadcast by UMTS Node-Bs (i.e. 3G base stations) with constant power. It allows extrapolation to a maximum traffic signal level for a UMTS channel.

Radiofrequency (RF): - For this survey any radio signals between the frequencies 100 kHz to 40 GHz.

Spectrum analyser: - An instrument that displays signal amplitude (strength) as it varies by signal frequency. The frequency appears on the horizontal axis, and the amplitude is displayed on the vertical axis. It can be set to sweep a frequency band where the amplitude of the received signals show up as spikes on the recorded trace.