

1. Survey Summary

Address of Transmitter Site Surveyed:	Ballymurragh, Co. Limerick
Survey Date:	15/05/2020
Measured Emission:	FM Radio, TETRA, PMR, DVB-T, LTE, GSM, UMTS FDD, WiFi

Measurement Location: (at point of maximum non-ionising radiation near site)	At entrance to farm lane, close to transmitter location.
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Measurement Location Coordinates:	LAT	<i>deg</i>	<i>min</i>	<i>sec</i>	LONG	<i>deg</i>	<i>min</i>	<i>sec</i>
	N	52	24	36.8	W	9	7	17.9

Purpose and Conduct of Survey:

The purpose of this survey was to assess compliance with the limits for general public exposure to non-ionising radiation (**NIR**) set by the International Commission on Non-Ionising Radiation Protection (**ICNIRP**) ("**ICNIRP Public Exposure Limits**").

Compliance with the ICNIRP Public Exposure Limits is a condition of a General Authorisation for an electronic communications network/service as well as of various Wireless Telegraphy licences issued by the Commission for Communications Regulation (**ComReg**).

The survey was conducted by:

- measuring the overall electromagnetic field (**EMF**) present at the point of highest exposure in a public area associated with the designated transmitter site;
- identifying the frequency of the principal emissions contributing to the EMF; and
- measuring the intensity (or level) of same.

Overall Conclusions of the Survey

Frequency Selective Measurements: (Individual emissions measured at specific frequencies)	Below ICNIRP Public Exposure Limits [Compliant]
Total Exposure Quotient: (Assessment of cumulative emissions from multiple transmitters)	Below ICNIRP Public Exposure Limits [Compliant]

2. Surveyors

Survey conducted for ComReg by:	Compliance Engineering Ireland Ltd.	
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Survey Engineer(s):	Report Writer:	Report Reviewer:
Michael Reilly, BEng	Michael Reilly, BEng	John McAuley, MEng

3. Survey Location Details

Designated Transmitter Site Photo



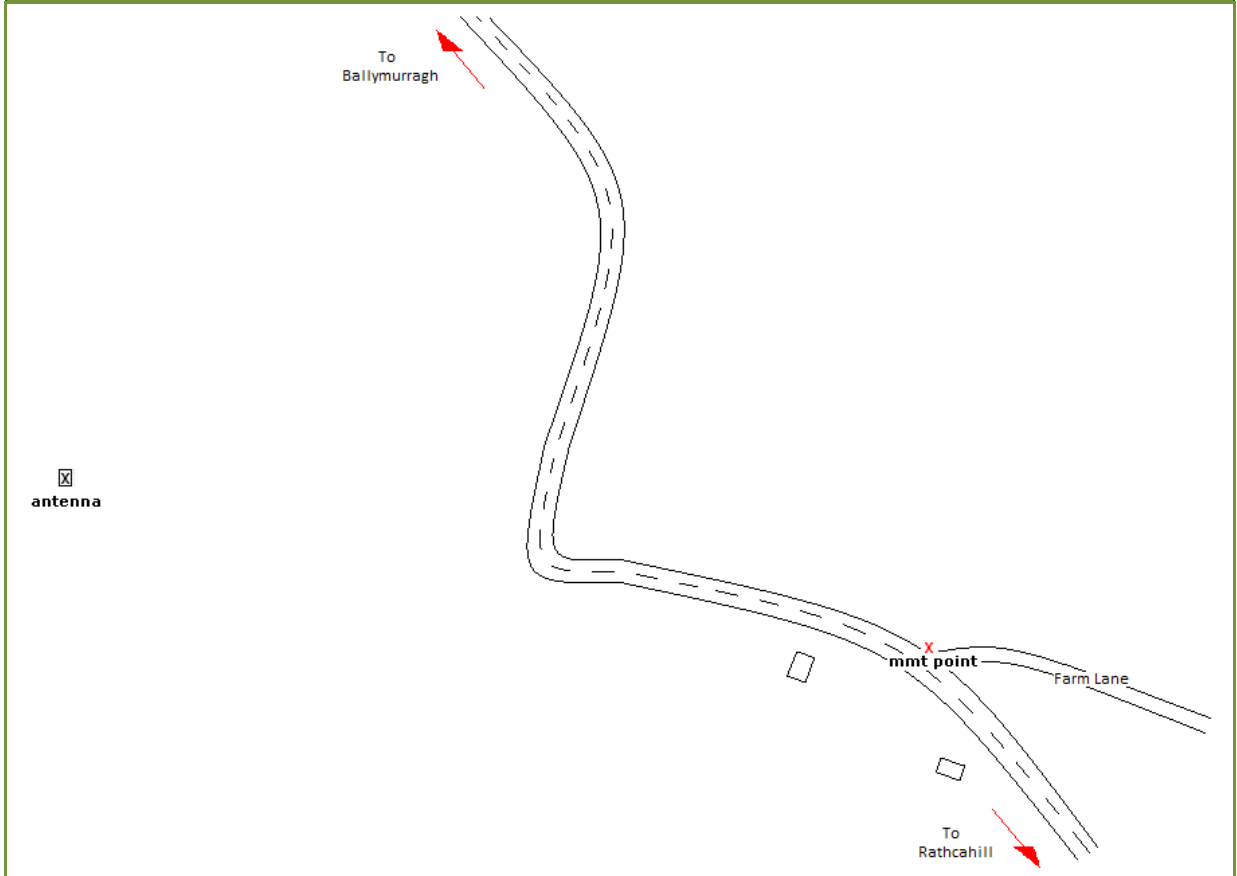
Survey Weather

Sky: Light Cloud

Temperature:
13° C

Relative Humidity:
47 %

Map of Designated Transmitter Site and Measurement Location



4. Introductory Note

Purpose of Survey

The survey of the designated transmitter site (“**Designated Site**”) was commissioned by ComReg as part of its Programme of Measurement of Non-Ionising Radiation. The purpose of the survey was to assess whether NIR (occurring within the radio frequency part of the electromagnetic spectrum) from the Designated Site complied with the limits for general public exposure specified in the guidelines published by ICNIRP (“**ICNIRP Public Exposure Limits**”).¹ Compliance with the ICNIRP Public Exposure Limits is a condition of a General Authorisation for the provision of an electronic communications network/service (e.g. mobile phone and broadcasting networks) as well as of various Wireless Telegraphy licences (in respect of transmitting stations) issued by ComReg.

Survey Methodology

Measurements of the NIR from the Designated Site were conducted in accordance with the methodology outlined in ComReg Document 08/51R3². Once standardised, these methodologies are to be incorporated. Methodologies used in conducting this site reports are listed below;

- European Electronic Communications Committee (**ECC**) Recommendation (02)04³;
- European Committee for Electrotechnical Standardisation (**CENELEC**) measurement standard EN 50492:2008⁴, and
- Measurement techniques developed by the Institut für Mobil- und Satellitenfunktechnik (**IMST**) and the EM-Institut on behalf of the German Federal Office for Radiation Protection.⁵

Additional methodologies to be used in conducting this site report are listed below;

- Measurement techniques as published by Dr. Helmut Keller on behalf of Narda Safety Test Solutions.⁶

Note re this Report Version

If you have downloaded this report from ComReg’s Siteviewer⁷ or from www.comreg.ie, you are reading an abbreviated version. The full technical version of this report also contains a comprehensive technical record of the measurements and any calculations performed, a list of equipment used, and a technical appendix. A copy of the full report is available upon request from ComReg.

¹ Current ICNIRP guidelines:

- “Guidelines for Limiting Exposure to Electromagnetic Fields (100 kHz to 300 GHz)”, ICNIRP, published in ‘Health Physics’, March 2020, Volume 118, No. 5: <https://www.icnirp.org/cms/upload/publications/ICNIRPrfgdl2020.pdf>
- “Guidelines for Limiting Exposure to Time-Varying Electric and Magnetic Fields (1 Hz to 100 kHz)”, ICNIRP, published in ‘Health Physics’, December 2010, Volume 99, No. 6: <https://www.icnirp.org/cms/upload/publications/ICNIRPLFgdl.pdf>

² <https://www.comreg.ie/publication-download/programme-of-measurement-of-non-ionising-radiation-emissions-methodology-for-the-conduct-of-surveys-to-measure-non-ionising-electromagnetic-radiation-from-transmitter-sites-2>

³ ECC RECOMMENDATION (02)04, “Measuring Non-Ionising Electromagnetic Radiation (9 kHz – 300 GHz)”, ECC, (revised Bratislava 2003, Helsinki 2007): <http://www.erodocdb.dk/Docs/doc98/official/pdf/REC0204.PDF>

⁴ EN 50492:2008, “Basic standard for the in-situ measurement of electromagnetic field strength related to human exposure in the vicinity of base stations”, CENELEC, November 2008: <http://www.cenelec.eu>

⁵ See: <http://www.bfs.de>.

⁶ “On the Assessment of Human Exposure to Electromagnetic Fields Transmitted by 5G NR Base Stations”, published in ‘Health Physics’, November 2019, Volume 117, No.5: https://journals.lww.com/health-physics/fulltext/2019/11000/on_the_assessment_of_human_exposure_to.7.aspx

⁷ <https://siteviewer.comreg.ie/>

5. Survey Overview

Survey Stages

In accordance with the methodology outlined in ComReg Document 08/51R4, this survey was conducted in three stages:

- 1 Initial Site Survey
- 2 Full Survey – Broadband Measurements
- 3 Full Survey – Frequency Selective Measurements

An outline of each stage, along with the results and conclusions of the measurements, are presented in the following three sections.

Measurement of Electromagnetic Fields

Electromagnetic fields (EMFs) can be sub-divided into two components:

- Electric field (**E-field**) (measured in volts per metre or “V/m”); and
- Magnetic field (**H-field**) (measured in amperes per metre or “A/m”).

The E-field and the H-field are mathematically interdependent⁸ in the **radiating near-field**⁹ and the **far-field**¹⁰, which are located before and beyond a distance of at least the wavelength of the radiated EMF respectively. 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 gives examples of wavelengths for some 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 (2G mobile base station)	925 MHz	0.32 m
LTE 1800 (4G mobile base station)	1805 MHz	0.17 m
UMTS (3G mobile base station)	2110 MHz	0.14 m
5G NR (5G Mobile base station)	3500 MHz	0.09 m

In the radiating near-field and far-field, only one component needs to be measured, as the other component can be readily derived from it. Normally, it is the E-field which is measured.

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**¹¹ region. In this region, located within a distance of at least the wavelength of the radiated EMF, the relationship between E and H becomes very complex and there is no direct correlation between both components of the EMF.

⁸ $E \approx H \times Z_0$ (Radiating Near Field) and $E = H \times Z_0$ (Far Field), where Z_0 (characteristic impedance of free space) $\approx 377 \Omega$

⁹ Beyond a distance of $\max(\lambda, D, D^2/4\lambda)$, where λ is the wavelength and D is the antenna's largest dimension


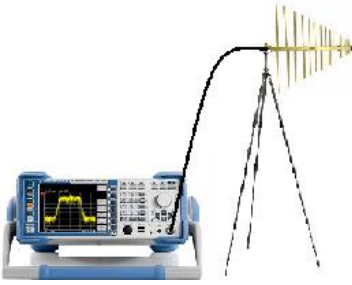

¹⁰ Beyond a distance of $\max(5\lambda, 5D, 0.6D^2/\lambda)$

¹¹ Within a distance of $\max(\lambda, D, D^2/4\lambda)$

Measurement Equipment

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

The table below shows examples of equipment typically used to measure EMFs in NIR surveys.

Initial Site Survey and Broadband Measurements	Frequency Selective Measurements	
 <p data-bbox="354 719 481 770">ISOTROPIC PROBE</p> <p data-bbox="370 969 497 1043">FIELD STRENGTH METER</p> <p data-bbox="220 1126 579 1301">Used to measure the overall electric or magnetic field present over a range of frequencies (e.g. 100kHz to 3GHz).</p>	<p data-bbox="603 577 970 629">SPECTRUM ANALYSER WITH TRIPOD MOUNTED ANTENNA CONNECTED</p> 	<p data-bbox="1040 577 1375 658">PORTABLE SPECTRUM ANALYSER WITH ANTENNA DIRECTLY CONNECTED</p>  <p data-bbox="603 1126 1441 1335">Spectrum analysers are used to measure individual emissions at specific frequencies. Individual emissions contribute to the overall EMF. 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 EMF at a particular location.</p>

6. Initial Site Survey

An initial survey was carried out in the area around the Designated Site in order to determine the point of maximum NIR. This is the location at which the overall E-field strength level measured was somewhat higher than that measured in other areas around the site and represents the highest level of exposure to which a member of the general public might be subjected in the vicinity of the transmitter.

For this initial survey a calibrated field strength meter fitted with a **3 GHz isotropic probe** was used. The meter and probe were used to measure the sum of all electrical fields present at **all frequencies from 100 kHz up to 3 GHz**.

Once the point of maximum NIR was determined, broadband and frequency-selective measurements were conducted at that location (see following two sections). For the duration of those measurements, the various instruments, antennas and probes used were mounted on non-metallic supports.

7. Full Survey – Broadband Measurements

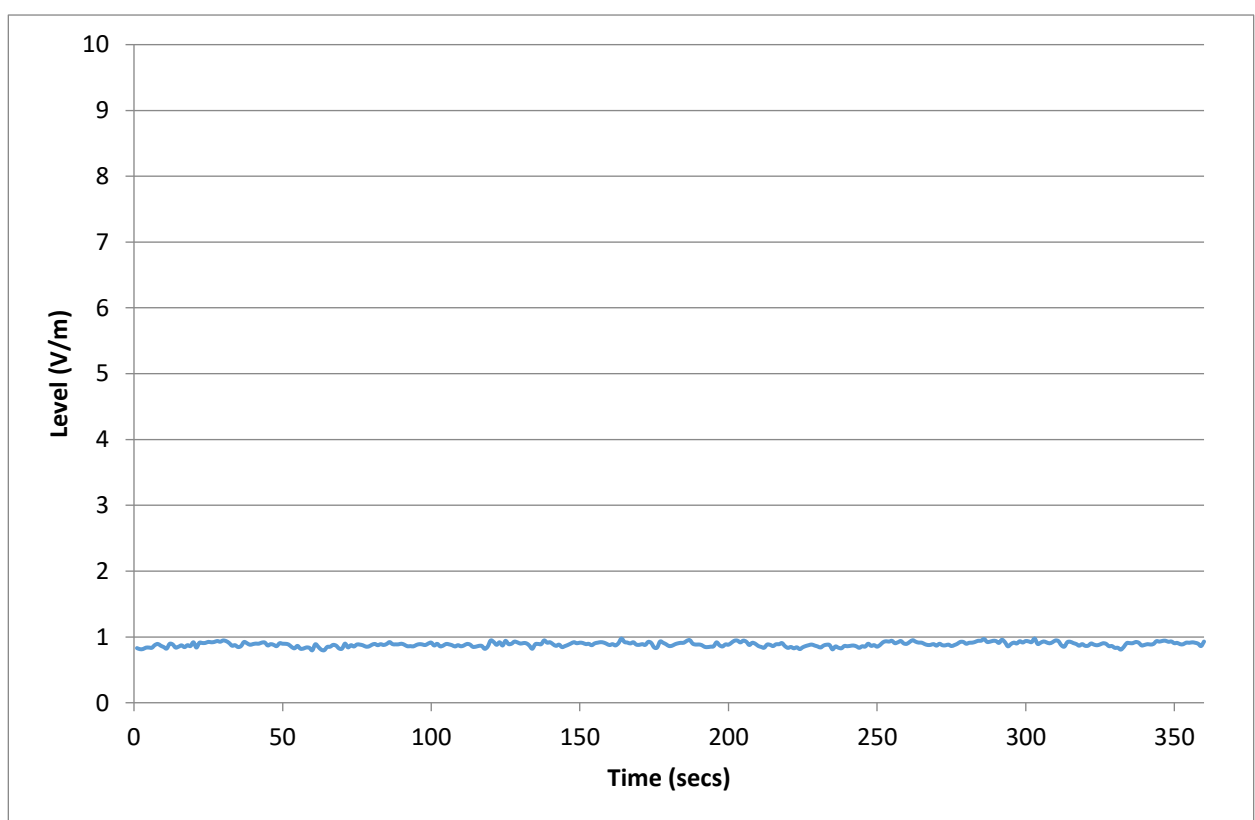
The purpose of these measurements was to get an overview of the intensity of the EMF present at the point of maximum NIR near the Designated Site.

There, the field strength meter (which was mounted on a tripod and fitted with a **3 GHz isotropic probe**), was set to record, over a six-minute period, simultaneous measurements of the sum of all received signals within the frequency range of the probe. This measurement was then repeated using a **40 GHz isotropic probe**.

The broadband measurement results presented below show the levels in volts per metre (V/m) recorded during the six-minute period. The average and maximum levels can be compared to the lowest maximum ICNIRP Public Exposure Limits which is 27.7 V/m.

If a broadband measurement is higher than 27.7 V/m, it does not necessarily follow that the ICNIRP Public Exposure Limits have been exceeded because the limits are frequency dependent. A more detailed investigation involving frequency selective measurement is necessary to assess compliance with the ICNIRP Public Exposure Limits (see following section).

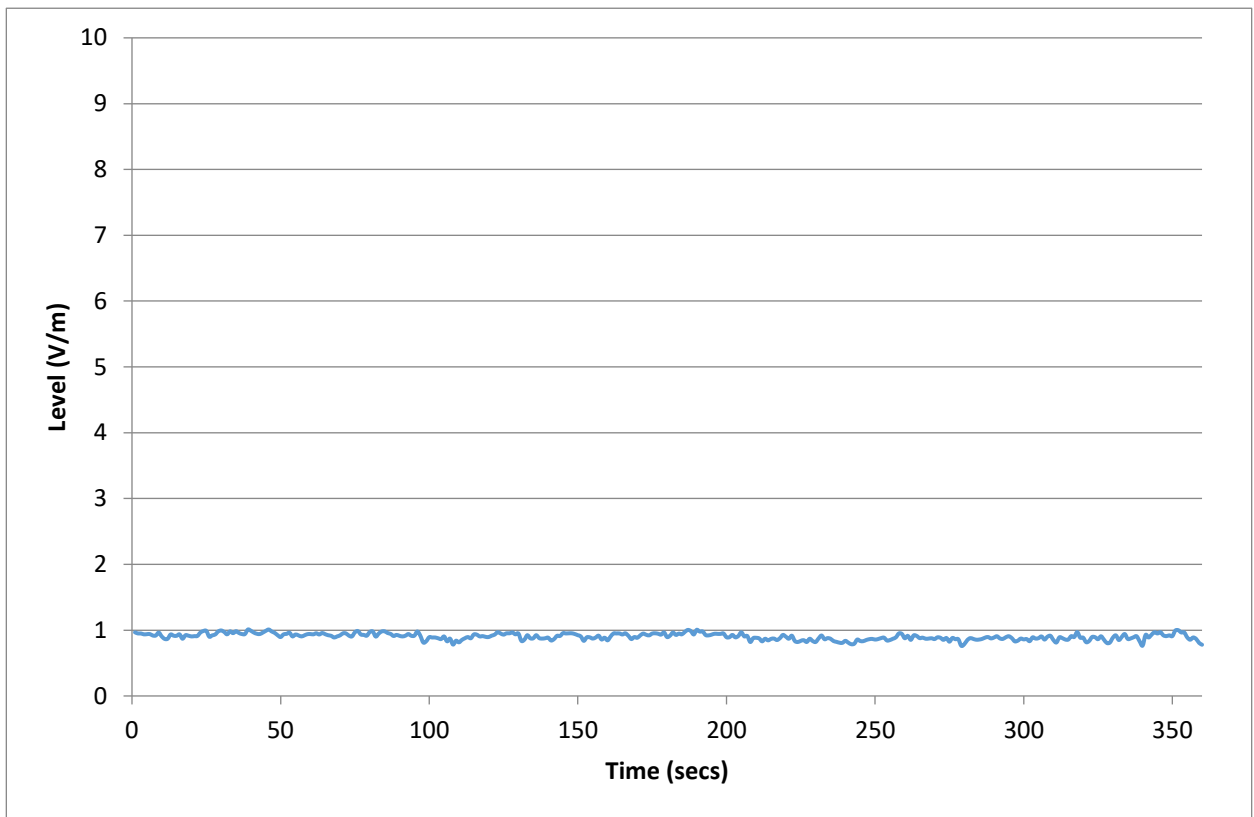
Electric field strengths recorded over 6 minute period using 3 GHz probe at point of maximum NIR



Acquisition Mode: 1 Sec. Sampling

Mean Measurement V/m:	0.89 V/m	Peak Measurement V/m:	0.98 V/m
Date:	15/05/2020	Start Time:	18:13
Meter:	NBM-550	Probe:	EF3091
Frequency Range:	100 kHz – 3 GHz		

Electric field strengths recorded over 6 min period using 40 GHz probe at point of maximum NIR



Acquisition Mode: 1 Sec. Sampling

Mean Measurement V/m:	0.90 V/m	Peak Measurement V/m:	1.01 V/m
Date:	15/05/2020	Start Time:	18:20
Meter:	NBM-550	Probe:	EF 4091
Frequency Range:	27 MHz – 40 GHz		

Conclusion of the Broadband Measurements

The mean and peak measurements were below the lowest ICNIRP guideline limit of 27.7 V/m.

8. Full Survey – Frequency Selective Measurements

Basic Measurement Procedure

A more detailed survey was performed at the point of maximum NIR near the Designated Site to identify the individual transmit frequencies and field strengths of each type of emission - e.g. mobile (GSM, UMTS, LTE and 5G NR), wireless broadband (BWA), television (DVB-T), FM radio - and their contribution to the total EMF.

The measurements were performed using spectrum analyser equipment and a range of antennas to match the frequency bands in which emissions were measured.

Table of Measurement Results

A list of the measurements made is presented in the table on the following page. For each emission measured, the table shows:

- **Emission Type** (e.g. GSM, UMTS, LTE, 5G NR, DVB-T etc);
- Transmission **frequency** of the signal;
- **Measured Level** (in volts per metre (V/m));
- **Adjusted Level** (if applicable to account for the characteristics of certain signal types or to compensate for limitations of measurement equipment or to estimate emissions for maximum call or data traffic); and
- **ICNIRP Public Limit**.

Further details of Adjusted Level/s and ICNIRP Public Exposure Limits are in the explanatory notes which follow the table of measurement results.

Assessment of ICNIRP Compliance of Individual Emissions

The levels for each measured emission (as adjusted where necessary) are compared to the relevant ICNIRP Public Exposure Limit which applies for the particular frequency of the emission. It should be again noted that the ICNIRP Public Exposure Limit varies according to frequency - the limits for the different measurements presented in the tables will vary as the measurements have been performed at different frequencies.

Assessment of ICNIRP Compliance of Cumulative Emissions

The levels measured for individual emissions are used to calculate **Total Exposure Quotients** to assess the cumulative effect of individual emissions from multiple transmitters. Further details of these quotients are in the explanatory notes which follow the table of measurement results.

The calculated values of the Total Exposure Quotients must be ≤ 1 in order for the aggregate of multiple measurements to satisfy the criteria of the ICNIRP Public Exposure Limit.

Table of Frequency Selective Measurement Results

Emission Type	Frequency (MHz)	Measured Level (V/m)	Adjusted Level (V/m)	ICNIRP Exposure Limit (V/m)	Times below Limit [adjusted Values]
FM Radio	95.260	0.02809	0.02809	27.7	986.116
FM Radio	98.390	0.01677	0.01677	27.7	1651.759
FM Radio	90.980	0.01671	0.01671	27.7	1657.690
FM Radio	100.590	0.01368	0.01368	27.7	2024.854
FM Radio	88.790	0.01358	0.01358	27.7	2039.764
FM Radio	93.180	0.01333	0.01333	27.7	2078.020
FM Radio	107.590	0.01020	0.01020	27.7	2715.686
FM Radio	96.380	0.01001	0.01001	27.7	2767.233
FM Radio	104.580	0.00859	0.00859	27.7	3226.558
FM Radio	104.200	0.00804	0.00804	27.7	3445.702
FM Radio	102.760	0.00745	0.00745	27.7	3717.123
FM Radio	91.560	0.00674	0.00674	27.7	4112.233
FM Radio	101.180	0.00662	0.00662	27.7	4185.555
FM Radio	89.400	0.00651	0.00651	27.7	4258.263
FM Radio	106.990	0.00650	0.00650	27.7	4258.918
FM Radio	93.780	0.00576	0.00576	27.7	4805.690
FM Radio	95.960	0.00519	0.00519	27.7	5334.104
FM Radio	98.980	0.00510	0.00510	27.7	5433.503
TETRA	REDACTED	0.08235	0.14263	27.7	194.203
TETRA	REDACTED	0.01830	0.03170	27.7	873.913
TETRA	REDACTED	0.01742	0.03017	27.7	918.060
TETRA	REDACTED	0.00797	0.01380	27.7	2007.860
TETRA	REDACTED	0.00675	0.01168	27.7	2370.679
TETRA	REDACTED	0.00605	0.01048	27.7	2643.405
TETRA	REDACTED	0.00498	0.00863	27.7	3210.721
TETRA	REDACTED	0.00432	0.00749	27.7	3700.278
TETRA	REDACTED	0.00337	0.00583	27.7	4748.397
TETRA	REDACTED	0.00284	0.00491	27.7	5641.130
TETRA	REDACTED	0.00244	0.00423	27.7	6554.345
TETRA	REDACTED	0.00234	0.00405	27.7	6831.526
TETRA	REDACTED	0.00203	0.00351	27.7	7897.581
TETRA	REDACTED	0.00188	0.00326	27.7	8497.663
TETRA	REDACTED	0.00156	0.00270	27.7	10258.244
TETRA	REDACTED	0.00146	0.00253	27.7	10938.853
TETRA	REDACTED	0.00141	0.00243	27.7	11382.635
TETRA	REDACTED	0.00138	0.00238	27.7	11622.531
TETRA	REDACTED	0.00135	0.00234	27.7	11837.604
TETRA	REDACTED	0.00119	0.00205	27.7	13495.867
TETRA	REDACTED	0.00118	0.00205	27.7	13541.577
TETRA	REDACTED	0.00111	0.00193	27.7	14381.837
TETRA	REDACTED	0.00103	0.00179	27.7	15466.734
PMR	REDACTED	REDACTED	REDACTED	REDACTED	29806.389

DVB-T	689.890	0.03141	0.03706	36.1	974.412
DVB-T	674.310	0.02478	0.02924	35.7	1221.094
DVB-T	657.320	0.01033	0.01219	35.3	2892.070
DVB-T	682.500	0.00874	0.01031	35.9	3483.456
LTE	759.476	0.00099	0.00284	37.9	13352.136
LTE	796.000	0.00640	0.01830	38.8	2119.401
LTE	806.000	0.13930	0.39840	39.0	97.984
LTE	816.000	0.05910	0.16903	39.3	232.378
GSM	955.255	0.23420	0.46840	42.5	90.729
GSM	927.813	0.21520	0.43040	41.9	97.311
GSM	945.438	0.11720	0.23440	42.3	180.369
UMTS FDD	943.000	0.18420	0.68786	42.2	61.384
UMTS FDD	953.500	0.15500	0.57882	42.5	73.353
UMTS FDD	937.000	0.15110	0.56426	42.1	74.593
UMTS FDD	932.500	0.01636	0.06109	42.0	687.277
GSM	1841.000	0.00209	0.00418	59.0	14114.104
LTE	1815.000	0.00280	0.00981	58.6	5971.899
LTE	1830.000	0.12000	0.48542	58.8	121.173
LTE	1855.000	0.06770	0.27386	59.2	216.245
LTE	1875.000	0.01100	0.03854	59.5	1545.041
UMTS FDD	2127.500	0.09986	0.31579	61.0	193.168
UMTS FDD	2132.500	0.08624	0.27272	61.0	223.675
UMTS FDD	2117.500	0.04556	0.14407	61.0	423.392
UMTS FDD	2122.500	0.04478	0.14161	61.0	430.767
UMTS FDD	2112.500	0.03967	0.12545	61.0	486.256
UMTS FDD	2137.500	0.03221	0.10186	61.0	598.875
UMTS FDD	2142.500	0.00765	0.02418	61.0	2523.186
LTE	3572.190	0.02101	0.08949	61.0	681.676
LTE	3588.905	0.03884	0.16547	61.0	368.640
LTE	3609.333	0.04663	0.19863	61.0	307.104
WiFi	5280.476	0.00233	0.00994	61.0	6139.327
WiFi	5300.794	0.00242	0.01030	61.0	5920.281

Total Exposure Quotients [calculated from Adjusted Levels]

Quotient	Frequency Range	Calculated Quotient Value	Limit
Electrical Stimulation Effects (as per ICNIRP 2010)	1 Hz to 10 MHz	n/a	1
Thermal Effects etc. (as per ICNIRP 2020)	100 kHz and above	0.001224	1

Overall Conclusions of the Survey

Frequency Selective Measurements: (Individual emissions measured at specific frequencies)	Below ICNIRP Public Exposure Limits (Compliant)
Total Exposure Quotient: (Assessment of cumulative emissions from multiple transmitters)	Below ICNIRP Public Exposure Limits (Compliant)

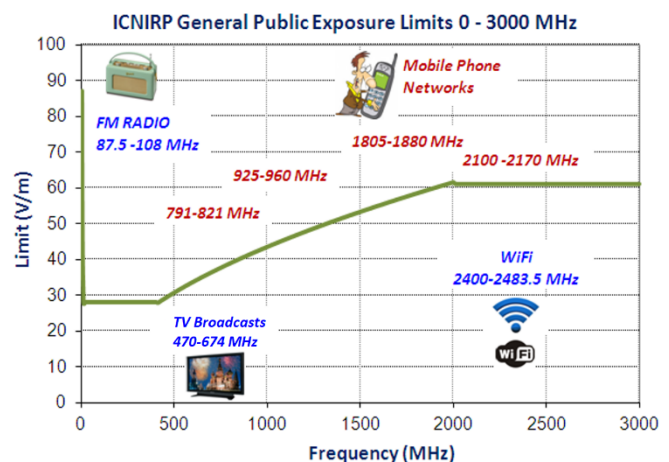
Adjusted Levels

For some emissions, an adjusted level may be required to be derived from the measured level:

- (1) **to compensate for the limited measurement resolution of the spectrum analyser.** For example, a measurement of a DVB-T (digital TV) signal performed with a resolution of 5 MHz needs to be adjusted upwards using a correction factor to account for the energy present within the full 7.61 MHz bandwidth of the signal; and/or
- (2) **to extrapolate to an estimate of the level under maximum traffic or duty cycle from the transmitter.** For example, the base stations of mobile phone networks produce emissions which vary according to the changing volume of calls or data traffic over the course of the day.

ICNIRP Public Exposure Limits

These are set out in the ICNIRP Guidelines as reference levels for the practical assessment of exposure to electric and magnetic fields, as experienced by the general public (excluding occupational exposure and exposure during medical procedures). The limits vary according to the frequency of the emissions as illustrated in the adjacent diagram. For example, the limits for Wi-Fi in the 2400-2483.5 MHz frequency band are higher than those for FM Radio transmissions in the much lower 87.5-108 MHz frequency band.



Total Exposure Quotients

The Total Exposure Quotients (which must be ≤ 1) are calculated in accordance with mathematical formulas specified in the ICNIRP Guidelines to 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 to account for total potential public exposure under maximum traffic conditions.

The two quotients are as follows:

(1) 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). This essentially involves summing the ratios (measured field strength/applicable limit) for each emission.

(2) Quotient for Thermal Effects etc. (100 kHz and above)

The measurements of any emissions above 100 kHz are used to calculate a quotient to assess any thermal (heat) and other effects as per ICNIRP 2020. This essentially involves summing the squares of the ratios (measured field strength/applicable limit) for each emission.