
Electromagnetic Field (EMF) measurements near 5G mobile phone base stations

Summary of results

A [Welsh version of the Overview](#) is available

Technical Report

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Contents

Section

1. Overview	1
2. Background	3
3. High-level methodology	4
4. Summary of test results	6
5. Glossary	10

1. Overview

- 1.1 Ofcom has been carrying out radio frequency electromagnetic field (EMF) measurements near mobile phone base stations for many years.¹ These measurements have consistently shown that EMF emissions are well within the internationally agreed levels published in the Guidelines² from the International Commission on Non-Ionizing Radiation Protection (ICNIRP). The results of previous measurements are available on [our website](#).
- 1.2 While all the frequency bands now in use by mobile phone base stations have been used for various services for many years, our previous EMF measurements did not include the specific frequency bands now being rolled out by the mobile operators for 5G. The results reported here therefore concentrate on measurements near 5G-enabled mobile phone base stations.
- 1.3 In the UK, Public Health England (PHE) leads on public health matters associated with radiofrequency electromagnetic fields, or radio waves, and has a statutory duty to provide advice to Government on any health effects that may be caused by EMF emissions³. On 5G, PHE's view is that *'the overall exposure is expected to remain low relative to guidelines and, as such, there should be no consequences for public health'*.⁴

What we've found

To date, we have carried out EMF measurements at 16 locations in 10 cities across the UK, including Belfast, Cardiff, Edinburgh and London. We have targeted this first set of measurements in areas where there are likely to be high levels of mobile phone use, including in and around major transport hubs and shopping centres.

The results so far indicate that:

- In all cases, the measured EMF levels from 5G-enabled mobile phone base stations are at small fractions of the levels identified in the ICNIRP Guidelines (the highest level being approximately 1.5% of the relevant level); and
- The contribution of 5G to the total emissions level observed is currently low – the highest level we observed in the band used for 5G was just 0.039% of the reference level.

¹ Ofcom inherited a programme of EMF measurements started by its predecessor, the Radiocommunications Agency (one of the five regulators whose duties were subsumed by Ofcom when it was created).

² Guidelines for limiting EMF exposure that will provide protection against known adverse health effects are published by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). ICNIRP is formally recognised by the World Health Organization (WHO). The Guidelines are available on the [ICNIRP website](#).

³ The Scottish Government set out its position on 5G and public health in a [statement](#) published alongside its [5G strategy](#) in August 2019. This noted that "the advice provided by PHE is fully endorsed by the Chief Medical Officer for Scotland". Public Health Wales notes on its [website](#) that "specialist radiation protection information and advisory services are provided in Wales by Public Health England's Centre for Radiation, Chemical and Environmental Hazards (CRCE)".

⁴ See: <https://www.gov.uk/government/publications/mobile-phone-base-stations-radio-waves-and-health/mobile-phone-base-stations-radio-waves-and-health>

Electromagnetic Field (EMF) measurements near 5G mobile phone base stations

- 1.4 A detailed summary of results is presented in Section 4.
- 1.5 Clearly, the deployment of 5G networks and the take-up of 5G services is at an early stage. We will therefore continue to undertake EMF measurements to monitor the overall trends in the long term. This will include measurements in new areas and repeat measurements at a number of the locations which we have already visited. We will continue to publish these measurements on our website as they become available.

2. Background

- 2.1 In March 1999, the Chairman of the National Radiological Protection Board (NRPB, now part of Public Health England) was asked by the Minister for Public Health to set up an independent expert working group to assess the current state of research into possible health risks from mobile phones. The Independent Expert Group on Mobile Phones (IEGMP) was set up in April 1999 and was chaired by Sir William Stewart.
- 2.2 The IEGMP published its report in May 2000 (the Stewart Report), recommending the establishment of an independent audit of EMF emissions from mobile base stations.⁵ In response to this report, the Government commissioned the Radiocommunications Agency (RA) to implement a national measurement programme to ensure that emissions from mobile phone base stations did not exceed the levels identified in the ICNIRP Guidelines for general public exposure. Ofcom has continued this programme since its establishment in 2003.
- 2.3 In 2012, this activity switched from a proactive to a reactive programme. From this date onwards, Ofcom has continued to conduct EMF exposure measurements on request. This is provided as a free service to qualifying schools and hospitals (i.e. those that do not benefit financially from base stations installed on their property). Further information about Ofcom's EMF exposure measurement surveys are published in our information sheet [OfW80](#). The results of all measurements published to date are available on [our website](#).
- 2.4 In recent years, the number of requests for EMF exposure measurements has been declining. However, the introduction of 5G has seen a renewed interest in the potential impact of radio waves on health and Ofcom has received an increasing number of queries about the safety of 5G deployments.
- 2.5 This report presents the results of proactive EMF exposure measurements undertaken by Ofcom at locations near 5G-enabled mobile phone base stations.

⁵ IEGMP, [Mobile Phones and Health](#), 2000 (archived 10 September 2010)

3. High-level methodology

- 3.1 In this section we set out the high-level methodology we have used to measure general public exposure to EMF near 5G-enabled mobile base stations.
- 3.2 We have measured the EMF exposure level at selected test locations using a field strength analyser with an isotropic probe following a procedure based on the in-situ RF exposure measurement method set out in section B.3.1.2 of IEC 62232:2017⁶.
- 3.3 The power density reference levels from the ICNIRP Guidelines for general public exposure (applicable to mobile phone frequencies) are as follows:

<i>Frequency range</i>	<i>Power density (W m⁻²)</i>
400 – 2,000 MHz	$f/200$ *
2 – 300 GHz	10

* Where f is the frequency in MHz

- 3.4 The measurements were conducted over the individual frequency bands used for mobile base station (downlink) transmissions as well as across all other frequency bands between 420 MHz to 6 GHz (see below for more details).

Table 3.1: Frequency bands covered in this report

Frequency band	Frequency range	Technology ⁷
700 MHz	738-788 MHz	Not currently used. Spectrum award planned in 2020
800 MHz	791-821 MHz	4G
900 MHz	925-960 MHz	2G, 3G, 4G
1400 MHz	1452-1492 MHz	4G (Supplementary downlink)
1800 MHz	1805-1880 MHz	2G, 4G
1900 MHz	1900-1920 MHz	4G
2100 MHz	2110-2170 MHz	3G, 4G
2300 MHz	2350-2390 MHz	4G
2600 MHz	2570-2690 MHz	4G
3.4 GHz	3410-3680 MHz	5G, 4G
3.8 GHz	3680-4200 MHz	Various
Others ⁸		

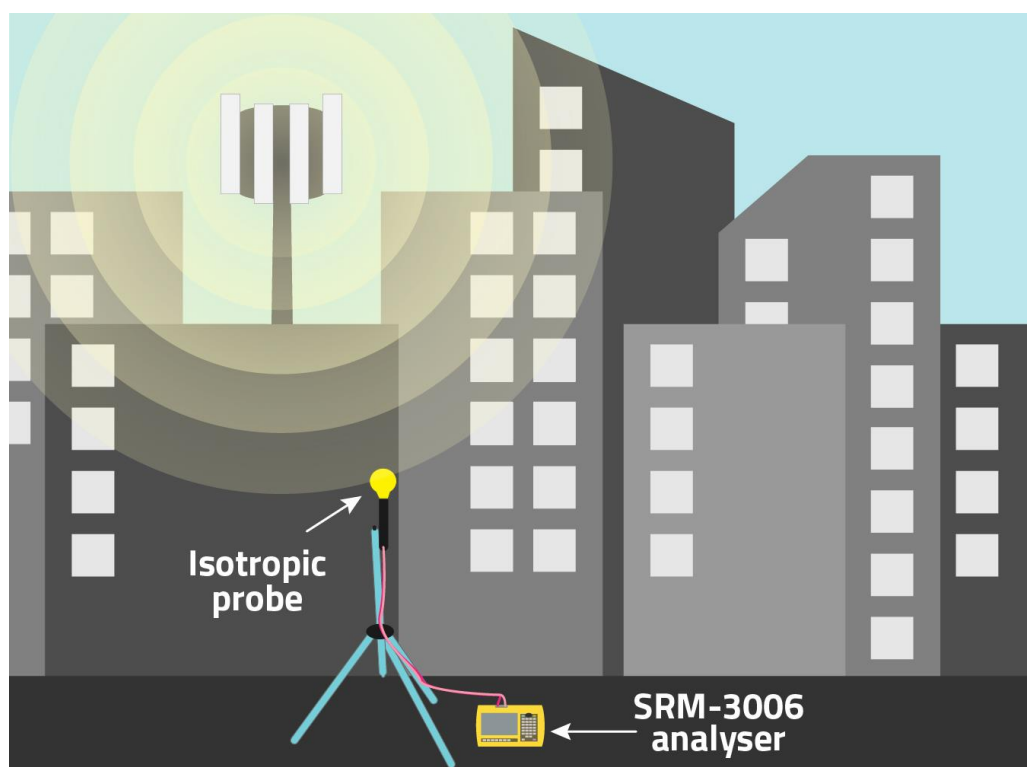
⁶ International Electrotechnical Commission, [IEC 62232:2017: Determination of RF field strength, power density and SAR in the vicinity of radiocommunication base stations for the purpose of evaluating human exposure](#), 23 August 2017

⁷ Note: this is an indication of the type of technologies typically deployed in these bands. Not all frequency bands and technologies will be in use in any one location.

⁸ All other frequencies between 420 MHz and 6 GHz

- 3.5 We used a field strength analyser (Narda SRM-3006),⁹ connected to an isotropic electric field (E-field) probe, to carry out the measurements. As illustrated in Figure 3.1 below, the probe is mounted on a tripod at a height of 1.5m above ground level. The use of an isotropic probe means that the measurement result is not affected by the direction of signal arrival and the polarisation of the measured field.

Figure 3.1: Narda SRM-3006 field strength analyser connected to an isotropic E-field probe mounted on a tripod 1.5m above ground level



- 3.6 The SRM-3006 analyser together with the probe has an overall operating frequency range from 420 MHz to 6 GHz. This is sufficient to cover all the frequency bands currently used for mobile phone base station transmissions.
- 3.7 For the measurements reported here, the SRM-3006 was set to its Safety Evaluation mode. In this mode, the analyser automatically adjusts its resolution bandwidth to 5 MHz and its frequency step size to 2.5 MHz and repeatedly sweeps across all frequencies from 420 MHz to 6 GHz at a rate of approximately 1 sweep per second. At each frequency step the analyser measures the root mean square (rms) field strength. As specified in the ICNIRP Guidelines, the measurements at each location are averaged over a six minute period.
- 3.8 The SRM-3006 reports the exposure level as a percentage of a selected safety standard limit (e.g. the levels from the ICNIRP Guidelines). Exposure levels are reported for each individual frequency band and the total EMF emission level across all bands measured (420 MHz – 6 GHz) is also reported.

⁹ <https://www.narda-sts.com/en/products/selective-emf/srm-3006-field-strength-analyzer/>

4. Summary of test results

- 4.1 At the time of publication, we have carried out measurements close to known 5G-enabled mobile phone base stations in 16 locations across England, Scotland, Wales and Northern Ireland. We have published individual measurement test reports for each location on [our website](#). This section provides a high-level summary of the results for all locations visited.
- 4.2 The map below shows the cities where we have conducted measurements to date.

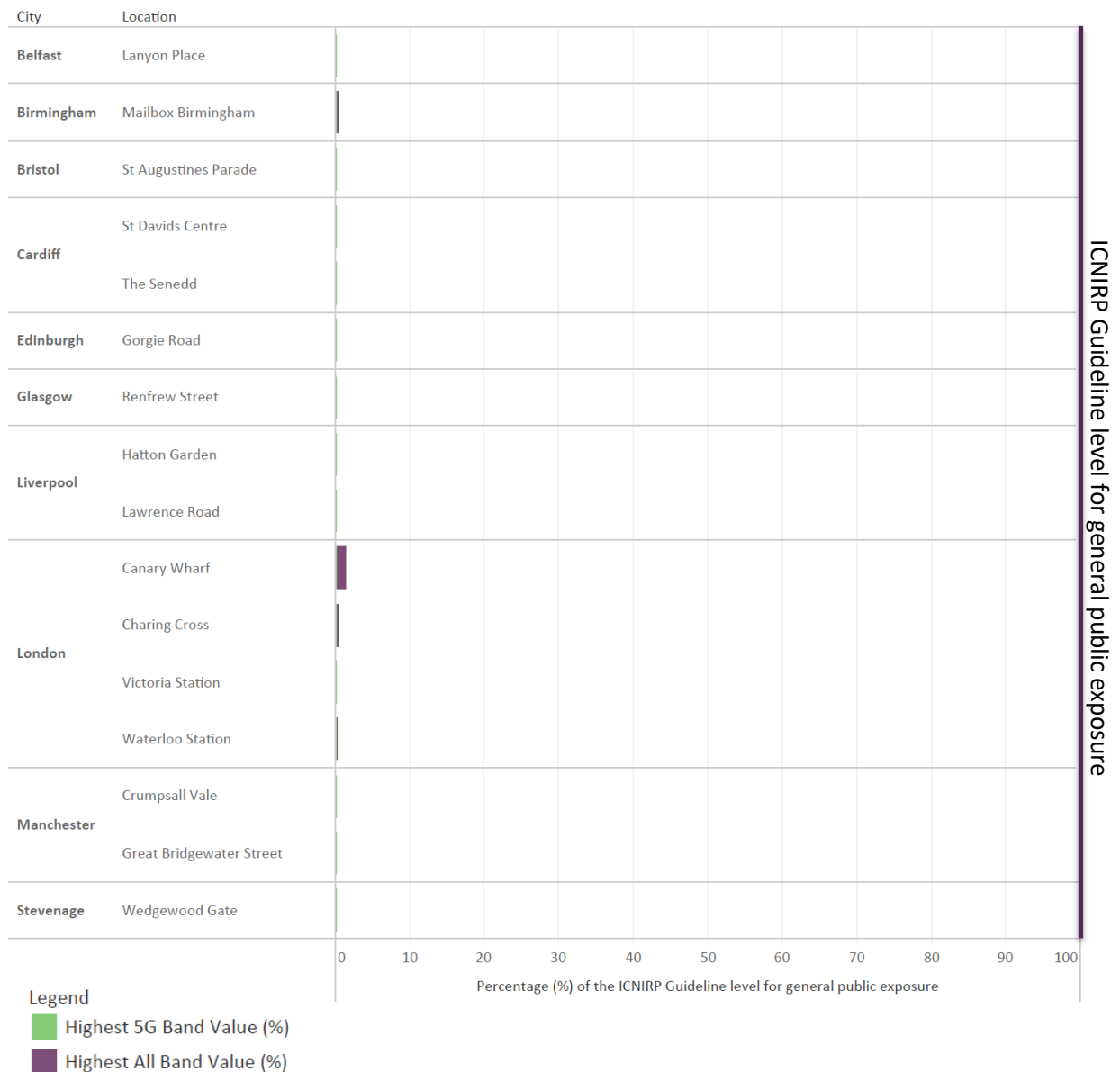
Figure 4.1: Cities where we have conducted measurements



4.3 Figure 4.2 below shows the highest average exposure level that we recorded at each location. Table 4.1 on the following page shows the same data in tabular form. The exposure levels are expressed as a percentage of the reference levels for general public exposure in the ICNIRP Guidelines¹⁰. The chart presents two measured levels:

- a) the exposure level measured across all mobile frequency bands; and
- b) the exposure level for the 5G frequency band (currently, 5G is deployed in the 3.4-3.6 GHz band).

Figure 4.2: Highest recorded average exposure levels at all 5G-enabled sites visited



Note: Some of the smallest bars in the chart are green in colour. This is not because the 5G band value is the same as or larger than the All band value. Rather, it is because both values are lower than can be effectively displayed within the resolution constraints of the chart. In all cases, as would be expected, the 5G band value is lower than the All band value. The detailed values are presented in Table 4.1

¹⁰ All figures below (or equal to) 100% are considered as being within the recommended exposure limits.

Table 4.1: Highest average exposure levels at all locations visited

City	Measurement location	Highest All Band value (% of ICNIRP level)	Highest 5G Band value (% of ICNIRP level)
Belfast	Lanyon Place	0.0807	0.0006
Birmingham	Mailbox Birmingham	0.4688	0.0386
Bristol	St Augustine's Parade	0.0460	0.0068
Cardiff	The Senedd	0.1195	0.0060
	St David's Centre	0.0823	0.0041
Edinburgh	Gorgie Road	0.1419	0.0004
Glasgow	Renfrew Street	0.1399	0.0044
Liverpool	Lawrence Road	0.1371	0.0069
	Hatton Garden	0.0894	0.0011
London	Canary Wharf	1.4960	0.0000
	Victoria Station	0.2483	0.0042
	Charing Cross	0.5970	0.0014
	Waterloo Station	0.3828	0.0065
Manchester	Crumpsall Vale	0.0736	0.0016
	Great Bridgewater Street	0.2460	0.0019
Stevenage	Wedgwood Gate	0.0654	0.0008

- 4.4 As can be seen from Figure 4.2 and Table 4.1 above, EMF emission levels from 5G-enabled mobile phone base stations remain at small fractions of the reference levels for general public exposure in the ICNIRP Guidelines, with the highest level recorded being approximately 1.5% of the reference level.
- 4.5 Our measurements also show that the contribution of 5G to the total emissions level observed is currently low – the highest level we observed in the band used for 5G was just 0.039% of the reference level.
- 4.6 We note that the measurement results presented in this report are not directly comparable with previous EMF measurement surveys for several reasons. For example, our current programme of measurements has been focused on areas where we can expect to see the highest levels of mobile phone use, whereas previous measurements were largely focused on schools, hospitals or residential areas. In addition, our latest measurements include a larger number of frequency bands, including frequencies recently made available for 5G.
- 4.7 The measurements show some variation between the exposure levels measured at each location. This is likely to be due, at least in part, to differences in the position of the measurement probe relative to the base station at each location. We took all measurements in publicly accessible areas, and these areas were at varying distances to

Electromagnetic Field (EMF) measurements near 5G mobile phone base stations

the mobile phone base station serving the area. In all cases however, we sought to take measurements at locations with the highest signal strength near the base station.

- 4.8 The deployment of 5G networks and the take-up of 5G services in the UK is still at an early stage. We will therefore continue to undertake EMF measurements to monitor the overall trends in the long term.
- 4.9 This will include repeat measurements at a number of the locations which we have already visited as well as measurements in new areas.
- 4.10 We will continue to publish the results of these measurements on our website as they become available.

5. Glossary

List of acronyms and units

5G	The fifth generation of mobile telecommunications technology
Base station	Radio transmitter infrastructure that controls and communicates to mobile phones
Downlink	In mobile communication, a downlink refers to the transmission link from the base stations to the mobile devices such as mobile phones or tablets.
E-field strength	Electric field strength
EMF	Electromagnetic fields
Far field	Regions where the distance from the measurement point to the source is greater than D^2/λ where D is the diameter of the source antenna and λ is the wavelength of the frequency.
GHz	Gigahertz (1 GHz is equivalent to 1000 MHz)
ICNIRP	The International Commission on Non-Ionizing Radiation Protection
IEC	The International Electrotechnical Commission
IEGMP	The Independent Expert Group on Mobile Phones
kHz	Kilohertz (1 kHz is equivalent to 1000 Hz)
MHz	Megahertz (1 MHz is equivalent to 1000 KHz)
NRPB	The National Radiological Protection Board, now part of Public Health England
Ofcom	The Office of Communications
RA	The Radiocommunications Agency
rms	The root mean square (rms) is defined as the square root of the arithmetic mean of the squares of a set of numbers
$W m^{-2}$	Watts per square metre, a measure of radiated power density.