MICRORAD SOLUTION FOR THE MEASUREMENT OF 5G SIGNALS

Introduction to 5G

5G NR (New Radio) is the new standard for cellular mobile phone networks, and constitutes the evolution of the previous 4G LTE, from which it takes many features, such as **OFDM** (Orthogonal Frequency Division Multiplexing) digital modulations, the subdivision of uplink and downlink channels via FDD or TDD (Frequency and Time Division Duplex), the possibility of dynamically merging multiple channels (carrier aggregation) to increase performance, the use of multiple antennas (MIMO) to optimize the quality of communication.

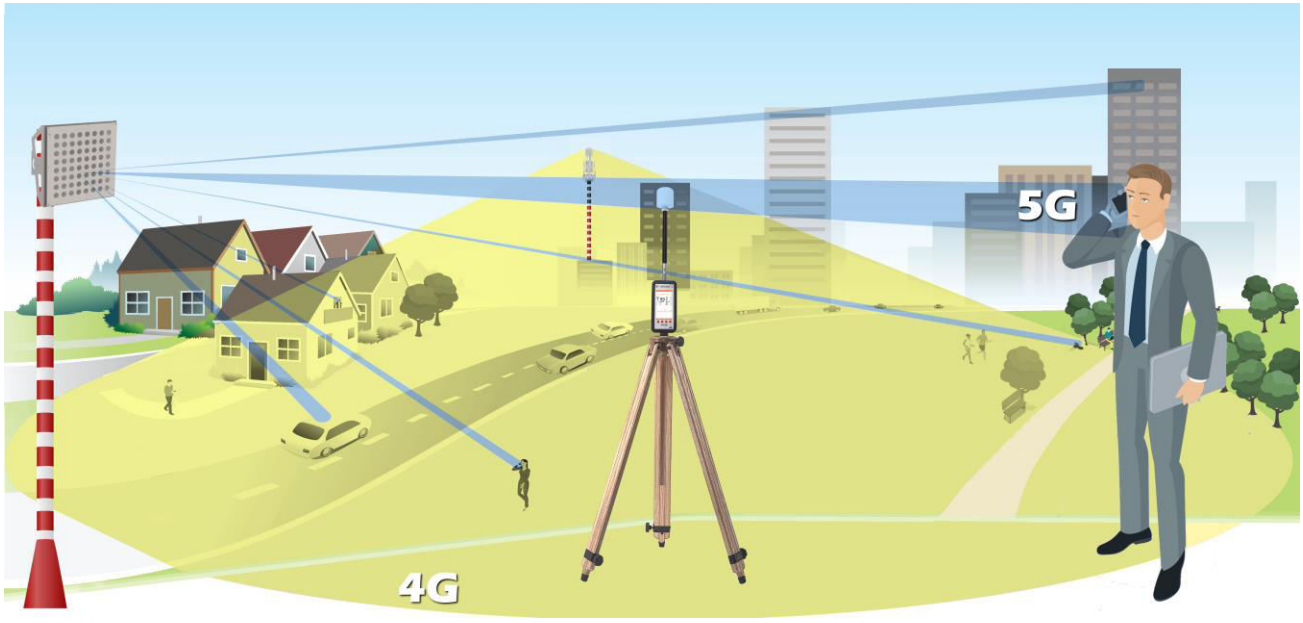
The frequencies used by 5G NR are located in the FR1 range (frequencies below 6 GHz), adjacent to those already in use for mobile telephony and other services (e.g. Wi-Fi, Bluetooth, DVB-T) and in the FR2 range (higher frequencies at 24 GHz) of millimeter waves, for short range applications.

The channel bandwidths have been extended, compared to the previous standards, and can reach 100 MHz in FR1 and 400 MHz in FR2.

The wide use of the **beamforming** technique (already foreseen also in the previous standards, but now more mature and performing) allows 5G to dynamically direct the transmission power in the space only in the areas where it is necessary for communication.

The implementation of a very dense network consisting of small cells and an extreme variety of configuration parameters allow optimization of the network and adaptation to the different operating conditions.

All this has advantages in terms of speed in data transfer, latency times, number of connections, consumption, and will allow the development of applications far beyond those typical of mobile telephony, such as home automation, telemedicine, car-to-car communications, Internet Of Thing.



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5G Emissions

The electromagnetic emissions generated by 5G radio equipment, as well as those relating to previous mobile phone standards, can be very variable, depending on the transmission apparatus, the number of users, the type of services provided, the distance between the base station and the users.

The beamforming technique introduces a further unknown factor in the evaluation, since the power is no longer delivered uniformly in the cell coverage area, but it is concentrated where the user is present. This involves a lowering of the average value of the electromagnetic field compared to previous technologies, but also a wide and rapid variability of emissions in space and time, which can generate high peak values even if of short duration, a phenomenon typical of signals with digital modulations.

In Italy, the use of 3 frequency bands is foreseen for 5G NR:

- 700 MHz band (694-790 MHz) not used yet
- 3700 MHz band (3600-3800 MHz) already in operation with the main commercial operators
- 26 GHz band (26.5-27.5 GHz) not in operation yet except for experimental applications

Currently, frequencies between 3300 and 3800 MHz are the most used, for 5G, in the world.

Normative requirements

Icnirp is the international non-governmental organization that provides guidelines derived from scientific evidence for health and safety with respect to the problem of exposure to electromagnetic fields. Therefore it is taken as a reference by the legislators all over the world.

From a protectionist point of view, the Icnirp 1998 guidelines indicate that it is necessary to evaluate the thermal effects of electric and magnetic field emissions with frequencies between 100 kHz and 300 GHz, considering the root mean square values (RMS) over a 6-minute interval for frequencies up to 10 GHz, or lower ranges for frequencies above 10 GHz, and comparing the average value obtained with the reference level specified for the emission frequency for both the population and the occupational fields.
The space average of the measured values is also calculated in order to evaluate the exposure in several points of the volume occupied by the human body.

When simultaneous emissions at multiple frequencies are present, calculation formulas are suggested for the thermal exposure index, consisting of quadratic sums weighed according to the values of the reference levels, whose result must be less than 1.

In the case of measurement carried out in far-field regions, a typical condition for emissions in the gigahertz range, it is sufficient to check only the electric field or the magnetic field.

In addition to the evaluation of the average values of the electric and magnetic fields, there is also a requirement on the peak values of emissions, which must be less than 32 times the values of the reference levels.

The recent Icnirp guidelines of 2020 increase the complexity of the evaluation cases, specifying exactly which quantities to evaluate based on the frequencies involved and the type of

electromagnetic zone (reactive near field, radiative near field, far field), prescribing the evaluation with an average of 30 minutes over the whole body, with an average of 6 minutes over smaller regions (4 cm^2 or less), with even shorter averages for pulse signals, or by directly evaluating the instantaneous peak values, and reporting for each type of measure the respective table of reference levels.

In Europe, the Recommendation of the European Council of 12 July 1999 (1999/519/EC) deals with the protection of the population from exposure to electromagnetic fields from 0 Hz to 300 GHz. In practice, it incorporates the reference levels and methods indicated in the ICNIRP 1998 guidelines.

In Italy, emissions are regulated, for the population, by the Prime Minister's Decree of 8/7/2003 and by article 14 of Legislative Decree 179 of 2012, with much more restrictive levels than the European recommendation.

As far as safety in the workplace is concerned, the requirements indicated in the European directive 2013/35/EU are in force.

Measurement with Microrad instruments

Microrad **NHT310FR** and **NHT3DLR** measuring instruments, combined with **01E**, **03E**, **04E** radiofrequency probes, allow carrying out electric field measurements relating to telecommunications signals in the spectrum range from 100 kHz to 40 GHz, including emissions related to the 5G NR standard.

The presence of digital modulations, characterized by high crest factors, as well as the rapid variations of the signal due to beamforming, are well traced by the Microrad probes, thanks to their fast response times, in the order of microseconds, and to a fast sampling of the signal, which allows a good reconstruction of the graph over time of the RMS electric field and the detection of peak values.

No special procedures are therefore necessary for the measurement in a 5G scenario, compared for example to 3G or 4G emissions measurements.

The evaluation of the sole electric field, omitting the magnetic components, can be considered sufficient in far-field conditions, a usual situation with frequencies of the order of gigahertz.

The aforementioned electrical probes are broadband, i.e. they do not distinguish the frequencies that contribute to the measured field value, and therefore do not allow an analysis of the contribution of different sources to the overall measured value.
Anyway, for protectionist purposes, all international standards require taking into account the sum of all fields sources.

Furthermore, the measurement is often carried out near a site whose type is known, and whose contribution will be preponderant compared to other more distant sources.
If several sources are present for which the emissions can be considered comparable, it is necessary to compare the result of the measurement with the more restrictive value of the reference levels among the present frequencies.

For example, in Italy the DPCM 2003 provides for an exposure limit of 20 V/m between 3 MHz and 3 GHz, and of 40 V/m above 3 GHz. Close to a 5G system at 3700 MHz, just check the last value. If there are sources below 3 GHz, the conservative level of 20 V/m shall be considered. The DPCM 2003 also provides for the verification of the attention value of 6 V/m over 24 hours, which is independent from the frequency, and therefore does not require any analysis on the sources involved.

Directives 1999/519/EC and 2013/35/EU provide for a constant reference level for frequencies above 2 GHz (61 V/m for the population and 137 V/m for the occupational), while below 2 GHz this decrease up to 400MHz.

Also in this case, therefore, considering the measurement of the same 5G system at 3700 MHz, it will be sufficient to check a single reference level if there are no other sources with frequencies below 2 GHz. Otherwise if, for example, there is a 4G system operating at 1800 MHz, it will be necessary to consider the reference level, more restrictive, at this frequency.

The NHT 310FR and NHT3DLR instruments measure the instantaneous value (RMS average over 250 ms) and peak value (RMS average over the probe integration time) thanks to three orthogonal sensors, ensuring the invariance of the measurement regardless of the probe orientation.

5G Trigger

The **Trigger** function allows you to identify and evaluate the emission peaks of the systems under observation. Microrad instruments are equipped with the trigger function, through which it is possible to set a threshold value above which the peak of a variable signal such as 5G is captured.

The instruments are also able to calculate the average between various points acquired in space and to carry out temporal averages on programmable intervals from 1 second up to 24 hours and beyond.

Furthermore, the continuous recording function (“monitoring”) allows you to store the measured field values at short intervals, up to 250 ms, and for long durations, beyond **24 hours**.

This is also thanks to the long operating life of the batteries supplied; the autonomy can also be further extended thanks to the possibility of receiving power from an external Power Bank, with which, for example, it is possible to monitor several days.

Information subject to change without notice
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