PCC.II/REC. 44 (XXII1-14) [1]

GUIDELINES FOR THE HARMONIZATION OF MEASUREMENT PROCEDURES FOR THE TECHNICAL VERIFICATION OF SPECTRUM USE FOR COORDINATION IN BORDER AREAS

The XXIII Meeting of the Permanent Consultative Committee II: Radiocommunication (PCC.II),

CONSIDERING:

a) That the establishment of harmonized technical procedures for the verification of the spectrum use by administrations would be beneficial for identifying problems of interference in border areas, leading to a solution for said interferences;

b) That in order to carry out the radio electrical spectrum monitoring and control function in a more efficient manner, it its advisable that the administrations develop harmonized procedures to verify the technical parameters of the spectrum according to the band or service subject of study;

c) That it is beneficial to harmonize criteria in the region with regards to the way of presenting the results of the interference measurements carried out in border regions, to facilitate understanding of the information exchanged among the administrations in order to a rapid interpretation without difficulties;

d) That although the methods used to technically verify the spectrum vary according to the services, frequency bands, and the responsible personnel, it is important to establish general guidelines for measuring equipment, configuration and/or operation thereof;

e) That technological changes favors development of new services and modalities thereof, resulting in the need to doing revisions and updates eventually of the procedures for spectrum monitoring;

f) That although the region does not suffer from interference events caused by the illegal use of the radio electrical spectrum in border areas, it could be necessary for administrations to establish agreements that allow for solving any potential interference caused by said illegal emissions,

RECOMMENDS:

1. That administrations sharing common borders include procedures to identify interference issues as part to their coordination processes.

2. That Annex be used as guidance for carrying out the measurement procedure.

3. That the procedures described in Annex 1 to this Recommendation, be updated and improved, as necessary, based on contributions of the administrations, considering their experiences and needs both individual and common.

[1] CCP.II-RADIO/doc. 3580/14 rev.1

ANNEX TO RECOMMENDATION PCC.II/REC. 44 (XXII1-14)

GUIDELINES FOR THE HARMONIZATION OF MEASUREMENT PROCEDURES FOR THE TECHNICAL VERIFICATION OF SPECTRUM USE FOR COORDINATION IN BORDER AREAS

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1. General Considerations

The International Telecommunication Union (ITU) Handbook on Spectrum Monitoring contains typical specifications on technical verification receivers and stations, and describes, in a general manner, some of the parameters' configurations it requires to carry out the spectral analysis. However, it is necessary to detail and standardize the minimum configuration and operation conditions for such systems according to the radiocommunication services and the frequency bands to be monitored, as well as, define the procedures to be followed upon verifying occupancy and the technical parameters of the fixed stations that use spectrum in border areas, considering the use of superheterodyne spectrum analyzers.

The above is important, considering, this document seeks to facilitate criteria unification at a regional level for each nation's administrators to adopt common positions and similar procedures that allow for execution of an appropriate technical verification of the spectrum, and in the cases required, facilitate joint study to achieve harmonizing use of the radio electrical spectrum in border areas, thus guaranteeing an efficient solution for interferences in such areas.

2. Terms and definitions

2.1 Antenna

A part of the broadcasting and receiving system designed to broadcast or receive electromagnetic waves. [2]

2.2 HPBW (Half Power Beam Width)

In a radiation pattern the area that has a lobe's maximum, the angle between the two directions in which the radiation intensity is half the maximum value. [3]

2.3 BWFN (Beam Width Between First Nulls)

Taken from its name in English width of the beam between first nulls. The width of the beam between first nulls is approximately half the power beam width. [4]

2.4 Antenna Gain

Ratio, generally expressed in decibels, that must exist between the power required at a reference loss – less antenna's entry point and the power supplied at the entry point of such antenna, so that the two antennas produce the same field power intensity, or the same power flow density, in a single direction at the same distance. Unless otherwise indicated, gain means the antenna's maximum radiation direction. Gain for a specified polarization might eventually be taken into account.

Depending on the selected reference antenna it is possible to differentiate among:

a) Isotropic or absolute gain (Gi) if the reference antenna is an isotropic antenna isolated in the space;
b) Gain in relation to a half wave dipole (Gd) if the reference antenna is half wave dipole isolated in space and whose equatorial plane has a given address;
c) Gain in relation to a short vertical antenna (Gv) if the reference antenna is a rectilinear conductor a lot shorter than a quarter of a wavelength and perpendicular to a perfectly conducting plane containing the given address. [5]

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[2] IEEE Standard Definitions of Terms for Antennas, IEEE STD 145-1993.
[3] IEEE Standard Definitions of Terms for Antennas, IEEE STD 145-1993.
[4] J. D. Krauss, ANTENNAS, 2da edición p.p. 27 de Mc Graw Hill.
[5] Recommendation ITU-R V.573-5 Radio communication Vocabulary.

2.5 Resolution of an antenna

t is defined as the BWFN/2, that is, as the equivalent to half the beam width between first nulls. [6]

2.6 Antenna radiation pattern

Spatial distribution of an amount characterizing the electromagnetic field generated by an antenna.[7]

2.7 Superheterodyne Spectrum Analyzer

2.7.1 RBW (Resolution Band Width)

From its English name the resolution filter's bandwidth, expressed in kHz. (1000, 100, 30, 10, 1). The lower its value the better defined the signals appearing at the entrance of the Spectrum Analyzer are, similarly the lower its value the better the noise floor of the measurement instrument is.

2.7.2 VBW (Video Band Width)

From its English name Video filter bandwidth, the lower its value the cleaner the width trace can be seen.

2.7.3 SPAN

It defines the range of the spectrum recorded by the spectrum Analyzer.

2.7.4 SWEEP TIME

Sweep trace speed, it depends on the SPAN, RBW and VBW

2.8 Low noise amplifier (LNA)

2.8.1 NOISE FIGURE

Ratio between the Signal Power Ratio vs. Noise Power at the input, compared to the Signal Power Ratio vs. Noise Power at the Output. [8]

2.9 Sensitivity

The sensitivity of a technical spectrum verification receiver is defined as the minimum signal (µV) voltage at the input of the technical verification receiver that allows demodulation and audible listening of the received signal.[9]

An audible signal´s minimum level may be determined by measurement the signal/interference ratio including noise and distortion (SINAD).

2.10 Analyzer's Noise Floor

It refers to the level given in dBm showing the spectrum analyzer once it has been configured for measurement and before connecting the antenna.

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[6] J. D. Krauss, ANTENNAS, 2da edición p.p. 27 de Mc Graw Hill.
[7] IEEE Standard Definitions of Terms for Antennas, IEEE STD 145-1993.
[8]HaraldFriis (Friis, H.T. Noise Figures of Radio Receivers, Proceeding of the IRE, Julio, 1944, pages. 419-422.
[9] Report ITU-R SM.2125-1, Parameters and measuring procedures on the stations and receivers for technical verification on decametric / metric / decimetric wave bands.

2.11 Geo - Referencing

Correlating the measurement point with the geographical coordinates of the site, it is important to consider the DATUM the coordinates are recorded with.

2.12 Intervisibility

Intervisibility is the ability to observe in a direct visual line (without obstructions) from a position on the surface of the earth to another, taking into account the land and the obstacles between them. For the case of technical verification is a type of line of sight with a measurement point and that also has to take into account the height at which the measurement system antenna is located.

3. Planning and Pre Engineering for Technical Verification of Spectrum Use

3.1 Preferred parameters of the Basic Measurement Systems

In order to establish the minimum specifications that basic measurement systems should have in order to comply with this Recommendation, the following minimum requirements are provided below:

- System sensitivity between -90 and -130 dBm isotropic depending on the type of service to be evaluated.
    - To improve sensitivity in the systems, it is recommended to have a characterized pre – amplifier (LNA), that has a noise figure less than or equal to 3 dB, with a minimum gain of 20dB.
- Frequency operating range according to the operation band of the service to be evaluated.
- Equipment calibrated according to a manufacturer's recommendation.
- Characterized antennas with answer charts in Frequency vs. Gain or antenna factor
- Characterized (LNA) Pre – amplifier, of low noise level (a noise figure lower than 4 dB) of 20 to 40 dB gain according to the sensitivity of the systems to be implemented in the band of interest, typically for broadcasting measurements a preamplifier is not necessary. Low - loss interconnection wires between the antenna and the analyzer, which has been characterized according to the frequency.
- 5 to 60 degree resolution according to the BWFN of the test antenna. It does not apply when using an omnidirectional antenna.
- Signal characterization as per the Recommendations given by the ITU and the Frequency Allocation Chart.

The configuration Recommendation an operator of the basic measurement system has to take into account in order to perform the technical verification of the radio electrical spectrum is shown below:

From 510 kHz to 1800 kHz, Sound Broadcasting Service in Amplitude Modulation (AM)
RBW_{Max}: 300 Hz
VBW_{Max}: Automatic depending on the RBW (preferably 1 to 3 ratio)[10]
Sweep Time: Automatic depending of the RBW and VBW
Span: 40 kHz
Trace: 10 on Average

[10]Recommendation ITU-R-SM-443-4

The previous definition was made based on the use of a laboratory that observed the behavior of an amplitude modulation signal in the band 810 kHz, using standard spectrum analyzers from brands generally used in the region, such as: Rohde&Schwarz, Anritsu, Hewlett Packard and Agilent.

VHF and UHF Analogue and Digital Television Broadcasting Service
From 54 MHz to 88 MHz, 174 MHz to 216 MHz, 470 MHz to 806 MHz

RBW_{Max}: 3 kHz
VBW_{Max}: Automatic depending on the RBW (preferably 1 to 3 ratio)
Sweep Time: Automatic depending on the RBW and VBW
Span: Minimum value in Megahertz as observed in the channeling of the standard adopted by each administration.
Trace: 10 on Average

Sound Broadcasting Service in Frequency Modulation FM
From 88 MHz to 108 MHz,

RBW_{Max}: 3 kHz
VBW_{Max}: Automatic depending on the RBW (preferably 1 to 3 ratio)
Sweep Time: Automatic depending on the RBW and VBW
Span: 500 kHz
Trace: 10 on Average

Point-to-point digital and analogue radio electric relays service in SHF microwave bands
From 3,6 to 4,2 GHz, 4,4 to 5,0 GHz, 5,725 to 6,425 GHz, 5,725 to 7,1 GHz, 7,1 to 7,750 GHz, 7,725 to 8,5 GHz, 10,5 to 10,68 GHz, 10,7 to 11,7 GHz, 12,75 to 13,25 GHz, 14,4 to 15,35 GHz, 17,7 to 19,7 GHz and 21,2 to 23,6 GHz

RBW_{Max}: 30kHz
VBW_{Max}: 30kHz
SPAN: Minimum value in Megahertz as observed in the channeling adopted in the frequency band attribution chart of each administration.
Trace: 4 on Average

3.2 Types of measurement to be performed

As a general rule, the types of measurements to be performed may be classified as follows:

Azimuth: Measurements that have been programmed to determine the degree of occupancy in a range of interest of the radio electrical spectrum, by characterizing the results in the interest band at a 360 degree interval. It is recommended that the degree spacing be less than half the center of the BWFN of the test antenna, although it is possible to define other spacing according to the testing scenario and the additional requirements of the measurement; this type of measurements is widely used for point to point links since it allows for frequency reuse analysis in case the band has great occupancy; verification is always performed on vertical and horizontal polarity. Using the antenna position engine with a remote control is OPTIONAL.

Time: Measurements programmed to determine the degree of occupancy in a range of interest of the radio electrical spectrum and characterize measurements in the band of interest. Measurements can be programmed in time intervals, which can be minutes, hours or days; this type of measurement is very useful when evaluating signals whose presence is not constant in time; for example the PTT (*Push to talk*) systems, typically use non – directive test antennas with omnidirectional radiation patterns.

Azimuth – Time: Measurements programmed to characterize directive measurements and which are permanent in time, for example, *Spread spectrum* and *frequency hopping* Systems.

Technical parameter infraction: Verifying several carriers during a time interval defined by the user, using easy to define reference masks that evaluate the bandwidth and power characteristics of the measurements of interest, whenever any of the boundaries that have been set up is exceeded the signals are recorded in an alarm file and sent through various means to the party interested.

3.3 Configuration of the basic measurement system

Receiving system configuration must allow for maximum resolution of the signals as well as an appropriate noise floor according to the type of signal being measured with the instrument. If a spectrum analyzer is used it has to conform to Recommendations ITU-R SM.377-4 and ITU-R SM. 378-7, which refer to minimum accuracy both in frequency and in measurement the field intensity.

Practically speaking, for a spectrum analyzer, of the super heterodyne type, measurement in real time parameters RBW, VBW and SPAN which are the ones impacting the noise floor and signal resolution should not be greater than the following values: RBW ≤30 kHz. ; VBW ≤100 kHz, SPAN ≤300 MHz The important thing is to comply with global sensitivity of the system and keep the SIN Spectrum Analyzer calibrated at all times (a message reading “UNCAL” or any other equivalent indication should not appear in the screen).

4. Technical Verification of Spectrum Use

A measurement plan is scheduled and geo – location of the measurement point is defined as a preliminary stage based on the pre – engineering information. To do this, it is necessary to pinpoint the geographical location of the site on a map and as much as possible, an intervisibility analysis.

Upon arriving at each site, the leading technician who is responsible for the monitoring unit needs to identify the most appropriate point to perform the measurement and, depending on the band to be studied, the technician needs to decide whether it is necessary to climb the tower or not, in case said tower does exist.

Once the measurement point has been defined, it needs to be documented in a geo – referenced manner (by recording the reference geodetic datum used to collect the coordinates) and by making note of the stations visible in the line of sight from the chosen point. If there are a large number of these stations, they have to be documented by grouping them in blocks and identifying them in some intelligible manner (for example by using letters from A to Z or clockwise from north). For each site a log containing the relevant data for the record analysis must be made.

Once the monitoring system has been deployed, the scheduled measurement plans must be performed. If the analysis includes FBAC (Frequency Band Attribution Chart) full-scale bands which typically correspond to ≥ 500 MHz bandwidths, spectrum samples must be sequentially in order to maintain an appropriate resolution of the signals and the sensitivity required, and preferably, by computerized means, consolidate the sequenced samples in just one graph that allows for observing full – scale bands of the spectrum.

4.1 Defining measurement procedures

Measurement procedures are a fundamental element for good practices standardization and accreditation in the spectrum's technical validation, the measurement standards will be very useful since they will allow for improvement and optimization of resources in the following technical tasks:

- Occupation measurements
- Technical parameters validation
- Validation of availability of spectrum's bands
- Interferences problems resolution
- Measurement of Electromagnetic Radiations RNI

Each of the indicated technical tasks must include detailed guidelines on the best practices to undertake each one of the measurements, which must include people in charge, incoming documents, outgoing documents, among others, pursuant to the quality recommendations stated for that purpose.

4.2 Management and analysis of the spectrum's technical verification results

When several spectrum measurements are performed, a homogeneous configuration of the equipment is recommended, as well as it is recommended to store records in the database.

The database must record each one of the measurements per site, which can be queried through filters such as site, frequencies or dates for a quick frequencies availability analysis, using channeling from the National Frequency Allocation Table adopted by the country where the measurement is performed.

A recommendation regarding the content of the technical report that an administration needs to take into account is provided below so it can be easily understood by other administrations.

5. Submission of Results

The recommended structure a spectrum's administration's agency should take into account to make a technical report which submits measurements made in the field, so that it can be easily understood by other administrations is as follows:

1. Introduction
   - Indicates why the measurement is being made and who participates in the measurement
   - Purpose of the measurement
   - Date of field measurements and names of those who participated in the measurement, in the results analysis and signature of the engineer who approved the study. The engineer who approves the study must be able to prove that his/her title is recognized in the country in which the study is approved; for instance, through a professional registration number from the engineer agency or association from his/her country or with an apostille of the degree if the degree is from a country different from the country where the report is approved.
2. Description of the measurement site: Documentation as mentioned in section 3.2, including complementary, relevant information such as photographic record and details of possible obstacles regarding the intervisibility of the measurement point.
3. Submission of monitoring plan.
   - o Indicate bands, type of measurement (azimuth, time, etc.) and configuration of the verification system.
4. Special considerations
5. Graphical information of records of measurement results.
6. Analysis of the results, band per band
7. Conclusions

8. Recommendations
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9.1. Appendix I; Valid Calibration Certificates of the Spectrum Analyzer.
9.2. Appendix II: Characterization of antennas, cables and LNA.