

RECOMMENDATION ITU-R SM.443-4

Bandwidth measurement at monitoring stations

(Question ITU-R 26/1)

(1966-1978-1995-2005-2007)

Scope

This Recommendation recommends methods for determining occupied bandwidth at monitoring stations for different classes of emission.

The ITU Radiocommunication Assembly,

considering

- a) the need for the measurement of bandwidths of emissions at monitoring stations to promote efficient use of the radio-frequency spectrum;
- b) the need for uniform, easy-to-perform and reliable results of bandwidth measurement at monitoring stations, to enable a comparison of the results obtained by different monitoring stations;
- c) the definitions of different bandwidths in the Radio Regulations (RR) and Recommendation ITU-R SM.328, especially the definitions of occupied bandwidth and x dB bandwidth;
- d) the increasing availability of equipment able to directly measure the occupied bandwidth, including equipment employing digital signal processing and fast Fourier transform (FFT) techniques;
- e) Chapter 4.5, on bandwidth measurement, of the ITU-R Spectrum Monitoring Handbook, (Edition 2002),

recommends

- 1 that the direct “ $\beta\%$ method” specified in Annex 1 should be used at monitoring stations when measuring the occupied bandwidth;
- 2 that the “ x dB method” specified in Annex 2 should be used at monitoring stations when measuring the x dB bandwidth;
- 3 that the occupied bandwidth can be estimated from the x dB bandwidth using the procedure described in Annex 3 when the conditions for accurate measurement of occupied bandwidth are not met, or in the absence of equipments capable of performing $\beta\%$ measurement.

Annex 1

Measurement method of occupied bandwidth ($\beta\%$ method)

1 Introduction

RR No. 1.153 and Recommendation ITU-R SM.328 define the term occupied bandwidth as follows:

“Occupied bandwidth: The width of a frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are each equal to a specified percentage $\beta/2$ of the total mean power of a given emission.

Unless otherwise specified in an ITU-R Recommendation for the appropriate class of emission, the value of $\beta/2$ should be taken as 0.5%.”

In line with § 2 of Recommendation ITU-R SM.328 on an emission of a transmitter, the optimum from the standpoint of spectrum efficiency is reached when the occupied bandwidth is equal to the necessary bandwidth of the relevant class of emission, given by Recommendation ITU-R SM.1138, which is incorporated into the RR by reference.

According to the definition above, the occupied bandwidth can be measured using either digital swept spectrum analysers or digital monitoring receiver allowing to store the recorded traces in memory for later graphical processing, or with analysers employing FFT techniques.

2 General conditions for bandwidth measurement

General conditions for bandwidth measurements are the following:

- The line-of-sight (LoS) with Fresnel curve between the transmitting and receiving antenna must be secured to ensure the high degree of discrimination of source of emission.
- A directional antenna with high directivity and high front-back ratio should be used to minimize the influence on multipath fading effects.
- Any suitable spectrum analyser or digital monitoring receiver can be used.
- Impulse interferences should not occur (for example, interference from an ignition source).

3 Measurement procedure

The spectrum analyser or digital monitoring receiver is adjusted with the following settings:

- Frequency: estimated centre frequency of the emission
- Span: 1.5 to 2 times the estimated bandwidth of the emission
- Resolution bandwidth (RBW): less than 3% of the span
- Video bandwidth (VBW): 3 times RBW or more
- Level/Attenuation: adjusted so that the S/N ratio is more than 30 dB
- Detector: peak or sample
- Sweep time or acquisition time: auto (for pulsed emissions long enough so that one pulse is recorded for every pixel on the screen)
- Trace: MaxHold (for analogue modulation), ClearWrite (for digital modulation).

In most digital systems, the occupied bandwidth is constant over time, because normally a data stream is transmitted with a constant symbol rate. In these cases, the momentary value of the calculated bandwidth will be relatively constant for each recorded trace. To smooth the results of

different subsequent measurements, a longer sweep time can be set. This will make the reading of the result easier.

In analogue systems, especially when audio signals are transmitted (F3E, A3E, J3E), the momentary occupied bandwidth changes rapidly with the modulation. In these cases, monitoring stations are only interested in the maximum occupied bandwidth within a certain observation time (e.g. one hour). To get this result, the “MaxHold” function has to be applied.

After the trace has been recorded, the displayed spectrum is mathematically analysed to calculate the occupied bandwidth as follows:

The spectral power (or level) of each frequency line of the stored trace is added throughout the adjusted span to give the 100% reference power. In a second calculation, starting from the lowest frequency recorded, the spectral power of each frequency line is again added up until the sum reaches 0.5% of the predetermined total power. At this point, a marker is set. The same calculation is then performed starting from the highest frequency recorded (the right edge of the display) until again 0.5% of the total power is reached and a second marker is set. The occupied bandwidth is the frequency difference between the two markers.

4 Measurement conditions and accuracy

The relative accuracy depends on:

- *The spectral shape of the signal*
When the signal raises and falls steeply towards the edges of the used channel, the accuracy is higher.
- *The resolution bandwidth*
Smaller RBW result in higher accuracy, because the bandwidth calculation is based on the graphical shape of the displayed trace which is always widened by the measurement filter.
- *The frequency span*
If the frequency span is too wide, more and more noise will be included in the calculation process which results in less accuracy. However, the span has to be wide enough to include at least some spectral components below the 0.5% (or –26 dB) points.
- *The noise and interference level*
Since noise and interference outside the used channel is included in the calculation process, a high difference between useful signal and interference will increase the accuracy. Therefore a minimum adjacent channel power ratio (ACPR) or minimum difference of the peak level and level of outmost frequencies of 30 dB is recommended to ensure a measurement error of less than 10% (see Fig. 1 and Fig. 2).
- *Measurement trials*
The fluctuation of digital signal due to the non-constant modulation signal can lead uncertainty on the measurement result. Therefore the measurement trials of at least 400 times are recommended to obtain the average occupied bandwidth.

Care should be taken that no interfering signal can be seen inside the recorded span because this would be treated as part of the wanted signal which may result in a high measurement error.