RECOMMENDATION ITU-R SM.1793

Measuring frequency channel occupancy using the technique used for frequency band measurement

(2007)

Scope

Frequency channel occupancy measurements should have a certain level of accuracy. In some cases the possibility exists to reach this level of accuracy by using the technique of frequency band measurements if certain requirements are met. By using this method a more efficient use of existing equipment is possible.

The ITU Radiocommunication Assembly,

considering

a) that some administrations assign the same frequency to more than one user for shared use;

b) that it is desirable to compare measurement results from different countries in border areas or for instance in aeronautical or maritime mobile services bands;

c) that spectrum management only can satisfactorily proceed if the monitoring service provides the radio spectrum planners with adequate high-quality information about the actual usage of the spectrum;

d) that information obtained from frequency assignment databases does not reveal the degree of loading on each frequency channel;

e) that results of frequency channel occupancy measurements would provide important inputs into:

– frequency allotments and assignments;

– verification of complaints concerning channel blocking;

– establishment of the degree of efficiency of spectrum usage;

f) that measurement procedures and techniques should be harmonized to facilitate the exchange of measurement results between various countries;

g) that several new communication systems, requiring advanced measuring techniques, are and will be put in place in the near future;

h) that harmonized frequency band registrations according to Recommendation ITU-R SM.1809 can be considered as frequency channel occupancy measurements, in case the relation between frequency step and channel separation is correct (e.g. frequency channel separation = 25 kHz the frequency step should be 25 kHz or 12.5 kHz), a gain of up to 800% in the number of channels is desired and a little decrease in accuracy is acceptable,

recognizing

a) that various principles and methods of frequency channel occupancy measurements are in use in the different countries;

b) that high-accuracy frequency channel occupancy are described in Recommendation ITU-R SM.1536;

c) that in case frequency band registrations are used to provide channel occupancy information, very simple equipment is needed,

recommends

1 that the measurement procedures and techniques specified in Annex 1 should be used for frequency channel occupancy measurements;

2 that frequency channel occupancy measurements should be repeated at regular intervals to enable achieving trends from historical data;

3 that the following Notes are part of this Recommendation.

NOTE 1 – More relevant information on frequency channel occupancy measurements can be found in the Handbook on Spectrum Monitoring.

NOTE 2 – Channel occupancy measurements may not be the appropriate mechanism to evaluate the need for a specific assignment or the efficiency of spectrum usage for some operators (i.e. emergency communications).

Annex 1

1 Introduction

This Annex describes frequency channel occupancy measurements performed with a receiver or spectrum analyser. The signal strength of each frequency step is stored. By means of post-processing the percentage of time that the signal is above a certain threshold level is determined. Different users of a channel often produce different field-strength values at the receiver. This makes its possible to calculate and present the occupancy caused by different users.

2 Requirements

2.1 Equipment

A suitable system capable of making frequency channel occupancy measurements by using frequency band registrations will consist of a PC/controller, suitable software with interface adaptor, radio receiver or spectrum analyser, appropriate antenna, calibrated cable, possibly a communications modem and appropriate post-processing software.

2.2 Site considerations

Various factors should be taken into consideration when selecting a site for frequency channel occupancy measurements. Measurement results should therefore be accompanied by a report of a site survey stating measurement antenna-type, antenna position, geographical coordinates, objects interfering with the measurements, etc.

2.3 Relationship between several parameters

2.3.1 There is a strong relationship between observation time, number of channels, average transmission length and the duration of monitoring.

2.3.2 The *revisit time* is directly dependent on the observation time and the number of channels. Also the processing time (data transfer between receiver and controller) influences the revisit time and should be kept as short as possible.

$$Revisit\ time = (Observation\ time \times Number\ of\ channels) + Processing\ time$$

2.3.3 The *observation time per channel* depends on the scanning speed of the monitoring equipment. In order to maintain a reasonably short revisit time with relatively slow equipment, the number of channels to be measured must be reduced.

2.4 Transmission lengths

2.4.1 The monitoring system needs to scan at an acceptable speed in order to detect individual short transmissions.

2.4.2 The optimum revisit time is equal to half of the minimum expected transmission length based on the Nyquist criterion and can only be achieved in case Recommendation ITU-R SM.1536 applies.

2.5 Duration of monitoring

2.5.1 The *duration of monitoring* is a combination of the revisit time, typical transmission lengths expected, number of frequencies to be scanned and the wanted accuracy of the results.

2.5.2 The duration of monitoring should be at least 24 h or multiples of 24 h. One week of monitoring gives the difference in occupancy over the various days of the week and occupancy during the week end. Seven periods of 24 h spread of a longer period of time (e.g. one year) gives more reliable occupancy information.

2.6 Time resolution of measurements

The monitoring software should be capable of producing occupancy information with a choice of time resolutions. The default time resolution of the measurements should be 15 min but should include the option to provide data in other resolutions.

2.7 Accuracy and statistical confidence level

2.7.1 There is no linear relationship between accuracy and revisit time.

In the case of measuring 100 channels with a revisit time of 1 s, which is a practical value, the number of channels can be increased to 1 000 with a revisit time of 10 channels without affecting the confidence level/accuracy too much.

2.7.2 There is a linear relationship between the occupancy and the number of samples required. The lower the occupancy, the more samples will be needed to achieve a desired confidence level. (see Table 1, § 4 of Recommendation ITU-R SM.182).

2.8 Limitations on monitoring

2.8.1 Simple automatic monitoring is not able to discriminate between wanted and unwanted emissions. Both types of emissions, if they are above the chosen threshold value, are treated as channel occupancy. Using modern post-processing software enables discrimination between different users because of different field-strength values at the receiver.

2.8.2 If more than one user is active on a frequency within the coverage area of the monitoring system, the occupancy recorded will be a combination of the radio traffic from each user. Modern software stores the field-strength value for every frequency step and enables by means of

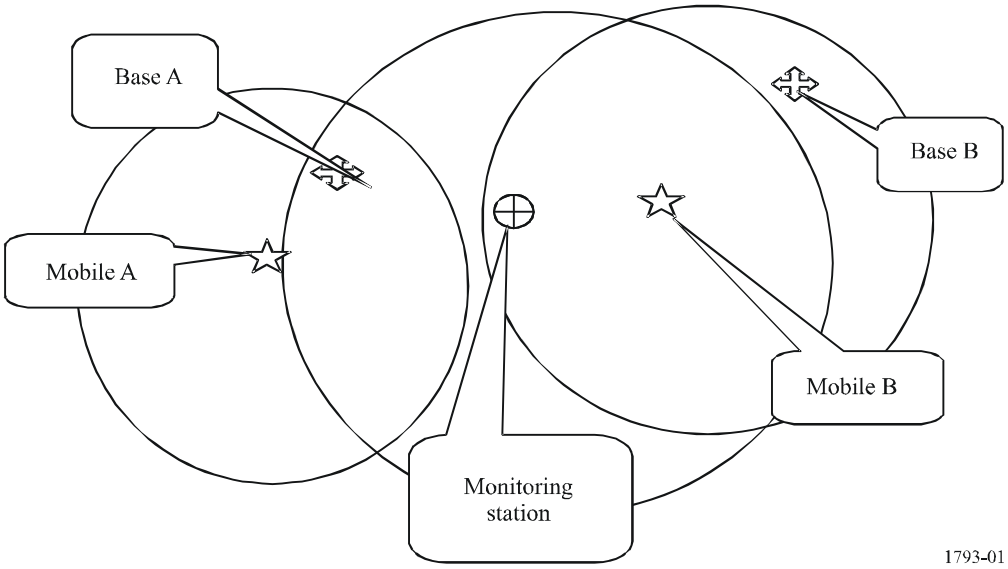
post-processing to discriminate between the different users of the radio channel and present the occupancy caused by the different users.

2.8.3 Monitoring mobile transmissions (see Fig. 1)

2.8.3.1 It is possible that a wanted mobile unit (Mobile A) will be located significantly further from the monitoring site than the user's own base site (Base A). Therefore the received signal strength may be less than the monitoring threshold value set, although strong enough at the intended base site to be useable.

FIGURE 1

Monitoring mobile transmissions



2.8.3.2 Conversely, a mobile unit from an out-of-area co-channel user (Mobile B) may be received at the monitoring site but not heard at the main user's base site.

2.8.3.3 Either of the above situations would lead to uncertainty in the information being recorded. It is for this reason that occupancy results recorded on mobile emissions must be treated with caution.

2.8.4 Propagation

Propagation conditions should also be considered when setting receiver threshold levels or propagation should be monitored during the measurement period.

2.9 Presentation and analysis of collected data

2.9.1 After the desired information is extracted from the sampled data, the sampled data can be discarded. The results can be stored every 5, 15, 30 or 60 min as required. From this data it is possible to generate presentations based on tables, textual graphs, line/bar graphs and maps.

2.9.2 The presentation system should, as a minimum, contain the location of the monitoring site, date and period of measurement, frequency, type of user(s), threshold level used, occupancy in the busy hour and revisit period.

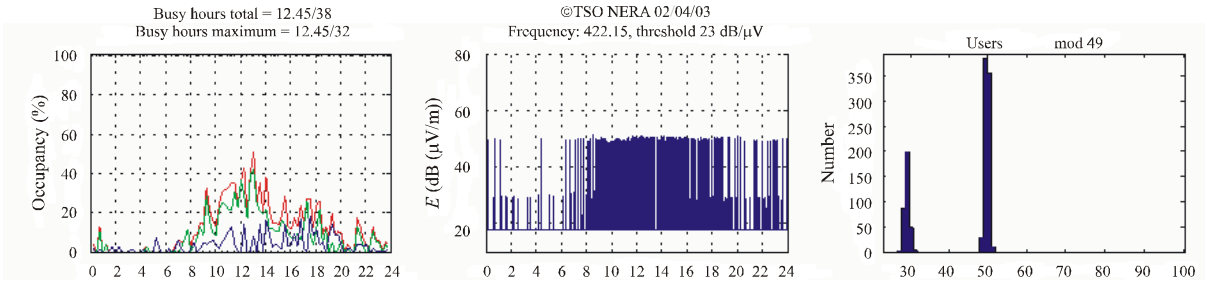
2.9.2.1 Field strength used to discriminate between different users

If field strength is recorded, additional information can be extracted from the measurement.

The left plot in Fig. 2 is a commonly used way to present the occupancy with a resolution of 15 min, normally with only one curve. The red curve in the left plot represents the total occupancy caused by all users on that channel. The green curve is the occupancy caused by the station received with about 49 dB(μV/m) (see middle and right side plot) and the blue curve is the occupancy caused by all the other users, in this case the second user received with about 29 dB(μV/m).

FIGURE 2

Enhanced processing of occupancy data



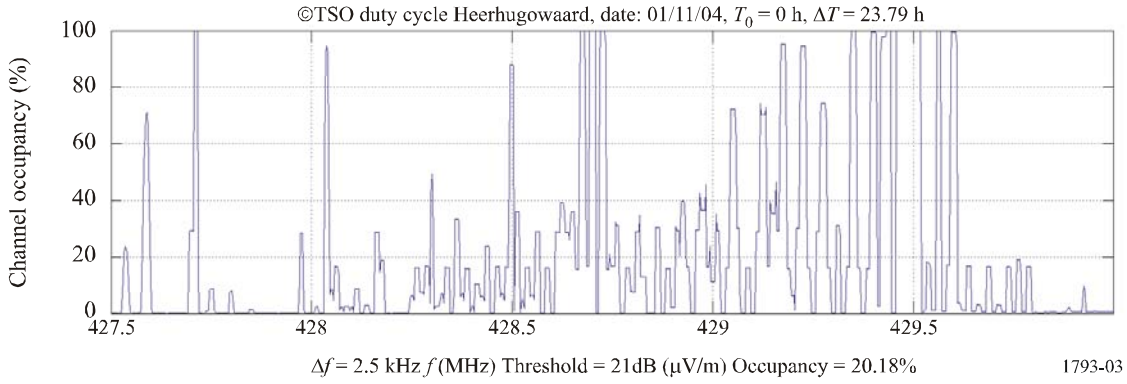
2.9.2.2 Frequency band occupancy

Instead of presenting the occupancy from every single channel, the occupancy of the whole measured frequency band should also be presented.

Figure 3 shows the average occupancy over 24 h from every single frequency step.

FIGURE 3

Average occupancy over 24 h



(In practical situations a frequency band can be measured in 1 000 steps in 10 s. From every step > 8 600 field-strength values are available. If, in that case, 4 300 times the threshold level on a channel/step is exceeded the occupancy will show 50%.) In this plot there is no time information left. In case an occupancy on certain channels is 50% there is no indication when this occupancy is caused.

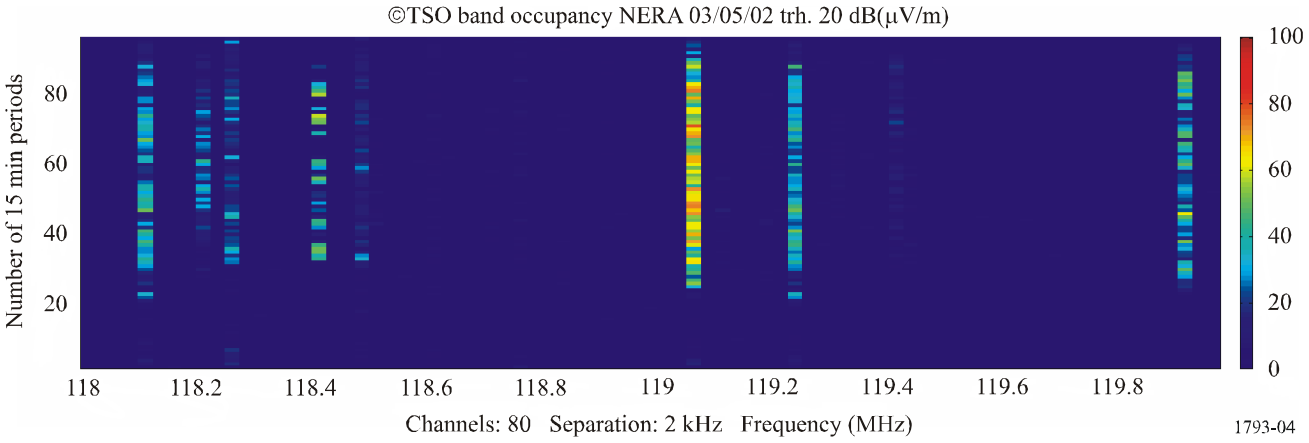
2.9.2.3 Frequency band occupancy using colours

To get a quick overview the occupancy can also be expressed by presenting a colour per channel per chosen resolution in time (normally 15 min). An example is given in Fig. 4.

In this presentation the time information is still available (96 values/24 h). The colour bar is presenting the occupancy (and not the field strength). The left Y-axis gives time, not in hours but in 96 periods of 15 min.

FIGURE 4

Frequency band occupation using colours (spectrogram)



2.10 Exchange of data

2.10.1 Data format

A common data format, which can be read by any database and/or spreadsheet program used in most countries is comma-delimited ASCII (CSV), and is described in Recommendation ITU-R SM.1809.

TABLE 1

Definition of terms used in this Annex

Frequency channel occupancy measurements	Measurements of channels, not necessarily separated by the same channel distance, and possibly spread over several different frequency bands to determine whether the channel is occupied or not. The goal is to measure as many channels as possible in a time as short as possible
Revisit time	The time taken to visit all the channels to be measured (whether or not occupied) and return to the first channel
Observation time	The time needed by the system to perform the necessary measurements on one channel. This includes any processing overheads such as storing the results to memory/disk
Maximum number of channels	The maximum number of channels which can be visited in the revisit time
Transmission length	The average length of individual radio transmission duration
Duration of monitoring	The total time during which the occupancy measurements are carried out

TABLE 1 (*end*)

Erlang	The unit of traffic intensity. The maximum traffic a single frequency can carry is 1 E
Preset threshold level for measurement	If a signal is received with a strength above the threshold level, the channel is considered to be occupied
Busy hour	The highest level of occupancy of a channel in a 60-min period