CEPT/ERC RECOMMENDATION 01-10 E (Naples 2000)

FREQUENCY CHANNEL OCCUPANCY MEASUREMENTS

Recommendation adopted by the Working Group "Frequency Management" (FM):

"The European Conference of Postal and Telecommunications Administrations,

considering

a)   that there is increasing use of the radio frequency spectrum and demand for frequencies.

b)   that efficient Spectrum Management only can satisfactorily proceed if the Monitoring Service provides the radio spectrum planners with adequate reliable information about the actual usage of the spectrum.

c)   that information about licensed users retrieved from Frequency Management databases only indicates that the use of the frequency is authorised. The number of assignments on a frequency does not give any information about the actual use of that particular frequency therefore frequency channel occupancy measurements should be carried out.

d)   that results of Frequency Channel Occupancy Measurements will give information about the current use of frequencies which is essential:
   - to serve customers applying for a new frequency
   - to verify complaints concerning channel blocking from co-channel users
   - to establish that the spectrum is being used efficiently.

e)   that most countries assign the same frequency to more than one user for shared use.

f)   that there is a need to compare measurement results from different countries in border areas for instance in aeronautical bands, maritime bands and in Private Mobile Radio co-channel assignments.

g)   that in order to assist in the spectrum management process, the measurement principles in different countries should be harmonised to allow administrations to directly compare their measurement results.

h)   that frequency channel occupancy measurements should be repeated at regular intervals in order to obtain information relating to usage trends.

recommends

1)   that the measurement methods as specified in the ANNEX should be used in order to harmonise the collection and representation of data obtained from frequency channel occupancy measurements."

Annex

DEFINITION OF TERMS USED IN THIS ANNEX

Frequency Channel Occupancy Measurements	Determine whether channels are occupied or not. Measurements of channels, not necessarily separated by the same channel distance, and possibly spread over several different frequency bands.
Busy Hour	The Busy Hour is a continuous 60-minute period of time in which the highest occupancy level occurs on a channel. It is aligned to the start of an occupancy summary period.
Duration of monitoring	The duration of monitoring is the amount of time that a monitoring system operates from a location.
Number of channels	The number of channels which can be visited in the re-visit time.
Observation time	The average time needed by the system to perform the necessary measurements on one channel to determine whether it is occupied or not before moving on to the next channel. This includes any processing overheads such as storing the results to memory/disk.
Occupancy summary period	The time period over which occupancy data for each channel is summarised and recorded.
Occupied channel	A signal received with a level above the chosen threshold level means that the channel is considered to be occupied.
Re-visit time	The time taken to visit all the channels to be measured (whether or not occupied) and return to the first channel.
Threshold level	The value of field strength at which a signal has to exceed for the channel to be considered as occupied
Transmission length	The average length of individual radio transmissions.

1. Introduction

1.1 This document describes frequency channel occupancy measurements normally performed with a receiver. The result is the percentage of time that signals are above a certain threshold level over a specified time interval.

2. Equipment

2.1 A suitable system capable of making Frequency Channel Occupancy Measurements will consist of a PC/controller, measuring receiver, appropriate antenna, connecting cable, and possibly interfaces for remote control.

2.2 Modern receivers may make use of digital signal processing techniques where most processing is performed in software allowing some future improvements without necessarily replacing the hardware.

3. Site considerations

3.1 Various factors should be taken into consideration when selecting a site for Frequency Channel Occupancy Measurements such as being remote from strong radio transmissions and/or structures and buildings which could cause excessive reflections or shading.

3.2 The measuring site should be centred in the area of interest to achieve a result from the customer's point of view. In certain cases it may be more appropriate to measure from a perimeter position using directional antennas.

4. Relationship between several parameters

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

4.2 The *re-visit time* is directly dependent on the observation time and the number of channels

re-visit time = observation time per channel x number of channels

4.3 The *observation time per channel* depends on the scanning speed of the monitoring equipment.
Note: some measuring receivers dwell longer on a channel if a signal is detected.

4.4 In order to maintain a reasonably short re-visit time with relatively slow equipment, the number of channels to be measured must be kept to a minimum.

4.5 The monitoring system needs to scan at an acceptable speed in order to increase the probability of detecting individual short transmissions.

4.6 In order to capture varying usage throughout different days of the week, the minimum *duration of monitoring* should be 7 consecutive days. Ideally a further 7 days should be monitored in order to determine that the information collected is 'typical' for that location.

4.7 In exceptional cases where the general pattern of usage is known in advance (such as users who do not work at weekends), it may be possible to reduce the duration of monitoring below the 7-day minimum period.

5.   Resolution of measurement results

5.1   The monitoring software should be capable of producing occupancy information with a choice of resolutions. The occupancy should be capable of being summarised in 15 minutes periods. It should include the option to provide data in other resolutions e.g. 5 minute or 60 minute periods.

6.   Accuracy

6.1   *Statistical confidence level*

6.1.1   To achieve a certain accuracy with a specific confidence level a given number of samples are required.

6.1.2   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 the desired confidence level at the relative accuracy.

6.1.3   The relationship between the number of samples required, the relative accuracy and the confidence level is detailed in Recommendation ITU-R SM.182.4, with table 1 reproduced below for reference purposes.

Table 1: Number of dependent and independent samples required to achieve +/- 10% relative accuracy and a 95% confidence level at various occupancy percentages. The table assumes a 4-second re-visit time.

Occupancy (%)	No. of required Independent samples	No. of required Dependent samples	Required Hours of Dependent sampling
6.67	5850	18166	20.18
10	3900	12120	13.47
15	2600	8080	8.98
20	1950	6060	6.73
30	1300	4040	4.49
40	975	3030	3.37
50	780	2424	2.69
60	650	2020	2.24
70	557	1731	1.92
80	488	1515	1.68
90	433	1346	1.49
100	390	1212	1.35

Table 1

6.2   *Total occupancy*

6.2.1   The occupancy measurement method discussed in this document compares detected field strength against a threshold level.

6.2.2   The monitoring system should automatically apply the antenna factor and thus record the field strength in dBμV/m.

6.2.3   In addition to monitoring the wanted emissions, the results may also include any unwanted emissions such as intermodulation products, spurious emissions, co-channel users from distant locations during periods of enhanced propagation etc.

6.3   *Other factors*

6.3.1   The accuracy of the results also depends on other factors such as the choice of location, height of monitoring antenna, threshold value used etc.

7.   Analysis of results

7.1   *Propagation considerations*

7.1.1   Propagation changes continuously and influences the measured results.

7.1.2   The knowledge of propagation on the observed frequency band during the duration of monitoring is important when examining the Frequency Channel Occupancy Measurement results.

8.   Presentation of collected data

8.1   The presentation system should, as a minimum, contain the location of monitoring site, date and period of measurement, frequency, threshold level used, occupancy in the busy hour and re-visit time.

8.1   It is also desirable to include additional information such as the antenna type, direction (if a directional antenna is used) and height above ground level if these details are available.

8.3   From the collection of raw data it is possible to generate presentations based on tables, textual graphs, line/bar graphs and maps.

9.   Exchange of data

9.1   Ultimately, the success of data exchange between systems lies with the ability for the receiving software to successfully read the processed data written by the occupancy monitoring system.

9.2   *File Format*

9.2.1   The final output should be in comma-delimited ASCII (comma separated value - CSV) format which can be read by common database and spreadsheet programs used in most countries.

9.3 *Choice of data*

9.3.1 The basic data fields which should be exchanged between countries, including their format, are:
Header information
- Location   (Text: 40 characters max)
- Occupancy summary period in minutes   (Numeric: integer)
- Re-visit time in seconds   (Numeric: real)

Data
- Date   (Date format: see below)
- Frequency in MHz   (Numeric: real)
- Threshold level used in dBμV/m   (Numeric: signed integer)
- Percentage occupancy values e.g. 96 x 15 minutes or 288 x 5 minutes (Numeric: unsigned integer 0-100).

9.3.2 To avoid confusion with the format of the date, it should be stored in YYYY-MM-DD format e.g. 2000-01-08 for 8th of January 2000.

9.4 *Transfer file*

9.4.1 There follows an example file containing the basic fields necessary to exchange data between countries:

9.4.2 Note that each line of data should contain the same number of fields delimited by commas. If a frequency is not monitored during a period then no occupancy value should be recorded however the commas must still be included. The period from 0100-0300 on 3rd October 1999 in the following example illustrates this point.

9.4.3 Example file:

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"Location details contained in this header",15,1.2
1999-10-02,163.2125,18,11,4,3,8,4,0,0,0,15,4,23,0,0,13,49,49,48,47,48,etc
1999-10-03,163.2125,18,17,31,0,0,,,,,,,,,0,2,0,0,0,0,0,etc
1999-10-04,163.2125,18,41,41,36,39,20,17,2,0,2,4,0,0,0,0,0,0,16,3,12,etc
1999-10-02,163.2250,18,34,14,0,27,10,24,0,4,49,30,0,0,0,1,0,0,0,0,0,etc
1999-10-03,163.2250,18,22,6,0,0,,,,,,,,,35,0,0,0,0,0,0,etc
1999-10-04,163.2250,18,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,etc
1999-10-02,163.2375,18,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,etc
1999-10-03,163.2375,18,0,0,0,0,,,,,,,,,0,0,0,0,0,0,0,etc
1999-10-04,163.2375,18,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,etc
etc.
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10. Further information on Frequency Channel Occupancy Measurements can be found in the Spectrum Monitoring Handbook