RECOMMENDATION ITU-R SM.182-5

Automatic monitoring of occupancy of the radio-frequency spectrum

(Question ITU-R 29/1)

(1956-1966-1982-1986-1992-2007)

Scope

This Recommendation sets the requirements for conducting occupancy measurements of the radio-frequency spectrum and specifies relevant parameters.

The ITU Radiocommunication Assembly,

considering

a) that the increasing demand of radio services requires the most efficient use of the radio-frequency spectrum;

b) that the most efficient use of the spectrum can be arranged only when the distribution in time, magnitude and direction of the signals occupying it is known;

c) that automatic monitoring equipment is now in use by administrations and that further development in automatic observation is foreseen, including methods for the analysis of records;

d) that, by the use of automatic monitoring equipment, a number of parameters can be evaluated which are of considerable value in enabling more efficient utilization of the spectrum;

e) that digital computing techniques and equipment offer a number of advantages and opportunities over analogue techniques in the implementation of automatic monitoring systems and in the processing of information gathered by these systems;

f) that in designing an automated system to gather occupancy data for use in spectrum management, one must determine what parameters are to be measured and how often measurements have to be taken to ensure the data are statistically significant,

recommends

1 that although automatic monitoring equipment will not completely replace manual observations, it is a valuable aid. Administrations should be encouraged to undertake the use and further development of such equipment;

2 that the ITU-R Handbook Spectrum Monitoring be used as a guidance for the automatic monitoring occupancy of the radio on-frequency spectrum;

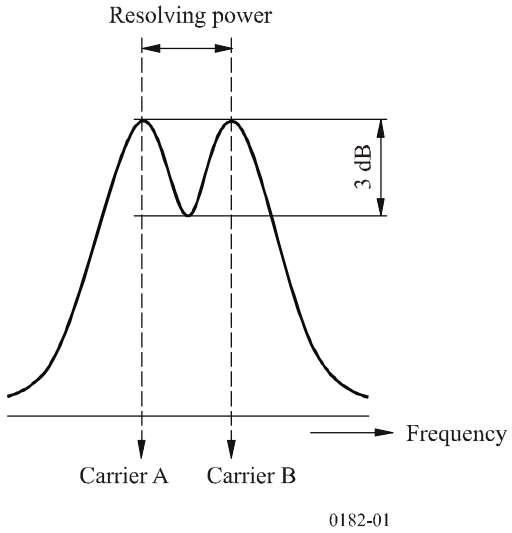
3 that, although further study is needed to enable administrations and frequency-planning authorities to derive the greatest benefit from the records produced, it is desirable that equipment should possess the following principal characteristics:

– total frequency range: minimum 2 MHz to 3 GHz: desirable on all the VLF/HF/VHF/UHF/SHF bands (9 kHz to 30 GHz or more)

–	swept frequency range:	variable from minimum to maximum tuneable frequencies of receivers
–	number of sweeps per minute:	variable; dependant on the swept frequency range used; manual stop on the required frequency
–	maximum rate of sweeping:	variable; dependent on the desired frequency resolution for the band being swept and the class or classes of emission being recorded
–	sensitivity:	highly dependant on the antenna: applicable to the frequency range up to 3 GHz
–	resolution bandwidth:	variable; approximately 10 Hz to 100 kHz; applicable to the frequency range up to 3 GHz.

NOTE 1 – Frequency resolution is the smallest frequency difference between two stable carriers of the same level which can be distinguished. For equipment using spectrum display, this resolution is the limit to which two stable carriers of the same level can be observed separately with a difference of 3 dB between the peak levels of the emissions and the minimum level between those peaks (see Fig. 1);

FIGURE 1



4 that it is desirable that the records should also contain, if possible, the following information:

Type of record: digital format

a) name and location of monitoring station

b) date and period of recording

c) frequency band

d) noise level

e) signal characteristic recorded:

- carrier frequency
- bandwidth
- field strength
- duration of occupancy

– identification of the emission recorded, as appropriate
– class of emission, as appropriate
– direction of signal;

5 that in designing a spectrum occupancy measurement programme, administrations consider the statistical implications of demanding high accuracy and confidence levels, since the measurement times needed to obtain these values quickly become prohibitively long as shown in Table 1. The table compares independent sampling, i.e. assumed instantaneous measurements having no relation to each other and dependent sampling, i.e. sampling of finite messages with fixed sampling time intervals. Although of interest, independent sampling is not applicable to actual monitoring since messages have finite lengths and the rate of sampling can be variable. The values in the table for dependent sampling were developed using a first order Markov chain;

TABLE 1

Number of dependent and independent samples required to achieve 10% relative accuracy and a 95% confidence level at various occupancy percentages (assumes a 45 s sampling period)

Occupancy (%)	Number of required independent samples	Number of required dependent samples	Required hours of sampling
6.67	5 850	18 166	20.18
10	3 900	12 120	13.47
15	2 600	8 080	8.98
20	1 950	6 060	6.73
30	1 300	4 040	4.49
40	975	3 030	3.37
50	780	2 424	2.69
60	650	2 020	2.24
70	557	1 731	1.92
80	488	1 515	1.68
90	433	1 346	1.49
100	390	1 212	1.35

6 that, in determining the accuracy of field-strength measurements made by automatic devices, the polarization and directivity of the antennas must be considered. In the 3 to 30 MHz range, where signals received over sky-wave paths contain both horizontally and vertically polarized components to a significant extent, a decision must be made as to the component to be measured. Since the vertical angle of arrival is most commonly less than 45°, less error will usually be introduced by measuring the vertically-polarized component rather than the horizontally-polarized component. Where greater accuracy is required, an appropriate correction may be applied, based upon a computed value for the vertical angle of arrival of the wave front;

7 that modern measurement equipments are able to measure signals with a large dynamic range of amplitude, in a wideband frequency domain, and computerized calculation allows determination of technical characteristics of complex emission with a great precision.