

RECOMMENDATION ITU-R SM.1681

Measuring of low-level emissions from space stations at monitoring earth stations using noise reduction techniques

(Question ITU-R 202/1)

(2004)

Scope

In view to protect passive services, and in particular the radio astronomy service (RAS) from interference, the measuring of low-level emissions from space stations of monitoring stations, earth stations, using noise floor reduction techniques is very important. Further to monitoring requirements, the Recommendation gives the concept to reduce the noise floor by means of digital signal processing.

The ITU Radiocommunication Assembly,

considering

- a) that there is a need to protect the radio astronomy service (RAS) from interference;
- b) that the objects in space observed on frequencies used by the RAS in principle are of extremely low pfd levels when arriving on the Earth's surface;
- c) that for such observations receive techniques have been developed the sensitivity of which allows to recognize signals far below the noise floor;
- d) that it is one of the tasks of monitoring earth stations to monitor levels of unwanted emissions of space stations as specified in the Radio Regulations;
- e) that there may be a need for the exchange of the measurement results to other parties,

recommends

- 1 that monitoring earth stations should measure unwanted satellite emissions according to:
 - 1.1 the monitoring requirements in Annex 1;
 - 1.2 the concept to reduce the noise floor by means of digital signal processing as described in Annex 2;
- 2 that the results should be recorded as in Annex 3.

Annex 1**Monitoring requirements****1 Introduction**

To measure low-level spurious and out-of-band emissions for the protection of the RAS a space monitoring facility should be aware of the following requirements.

2 Monitoring pre-requisites

- 2.1** An understanding of the pfd levels of the RAS to be protected.
- 2.2** The technical capacity to perform the monitoring of low-level emissions.
- 2.3** Order of magnitude of noise floor reduction as compared to the normal space monitoring criteria for the monitoring of space communication fixed and broadcasting services.

3 Parameters to be monitored

- 3.1** The normal space monitoring values of parameters to characterize the sources of emission, i.e. frequency, orbital position, or elements, time, power density, polarization, bandwidth, modulation, spectral characteristics, access method, and continuous wave/burst transmission.
- 3.2** The power density of emission should be recorded as pfd and spectral pfd.

4 Monitoring procedure (see also ITU-R Handbook – Spectrum Monitoring)

- 4.1** Acquisition of interfering source.
- 4.2** Measurement of frequency.
- 4.3** Determination of polarization.
- 4.4** Measurement of bandwidth.
- 4.5** Measurement of pfd using noise reduction method described in Annex 2.

5 Confirmation of measurement results

Where possible the results should be confirmed by another monitoring earth station in the ITU List of international monitoring stations.

Annex 2

Concept to reduce the noise floor by means of digital signal processing

1 Introduction

In order to protect the RAS there are pfd limits specified that are below the noise floor for usual monitoring facilities. To reduce the noise floor different possibilities may exist. This concept here defines a method using digital signal processing.

2 Technical principle

The RF signal to be monitored is received by a directive antenna, and is then down converted to the IF level. The analogue IF signal is converted to digital signal samples. This digitized signal is then converted to the digital baseband. After that the conversion from the time domain into the frequency domain is achieved by means of the fast Fourier transformation (FFT). This measurement is repeated typically 10 000 times in order to acquire 10 000 recorded spectra.

This whole previous procedure is repeated to record comparison signals. For non-geostationary satellites this is done across the sky along the same track of the now absent satellite. For geostationary satellites the monitoring antenna needs to depart slightly from the orbit position. In both cases the comparison signals are recorded in the same environment including the noise of the station itself, however, without the wanted satellite. These 10 000 spectra for comparison contain the noise but no satellite signal.

At this point additional processing may take place, e.g. to eliminate Doppler shift where applicable.

Then the spectra of both wanted and comparison signals are averaged, and the linear values thereof subtracted. The result is a pfd spectrum of the relevant satellite emission with the noise suppressed in the order of typically 10 to 20 dB.

This method makes use of the fact that the wanted signal contributes with each of the large number of spectra to its appearance, whereas the noise in the large number of spectra cancels itself out due to its statistical properties.

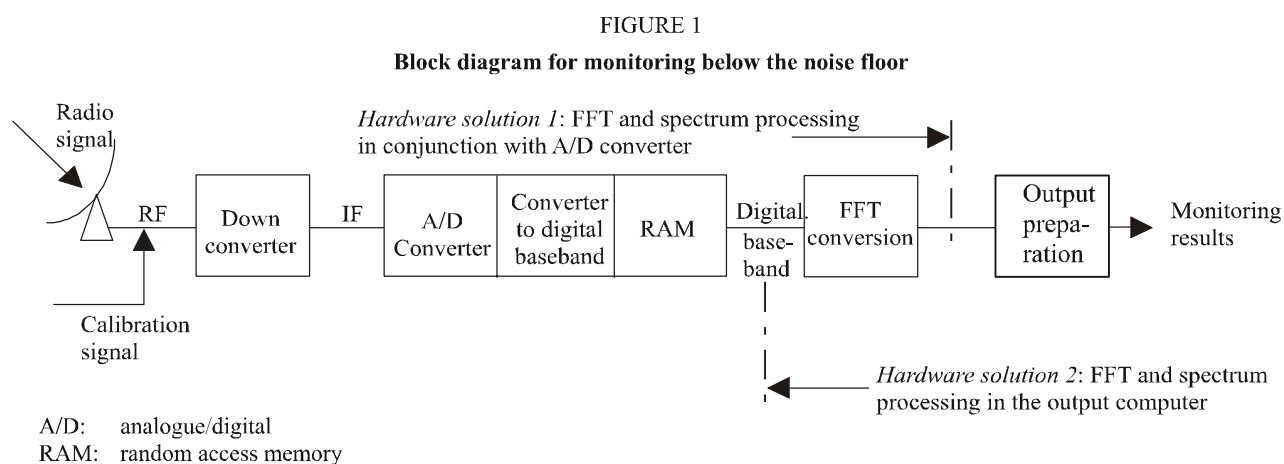
The subtraction of the comparison spectra from the satellite spectra is for eliminating also interference sources recorded with the noise in both series of spectra.

A true correlative method could improve the suppression of the noise level even more.

3 Concept of hardware and software

The block diagram for monitoring below the noise floor is shown in Fig. 1.

3.1 Hardware



The difference between the two hardware solutions shown in Fig. 1 lays in the equipment separation, i.e. the connection between different locations is done in solution 1 after the FFT conversion; in solution 2 the connection is accomplished before the FFT conversion. Therefore the type of connection between locations may be one criterion for one or the other solution. Other criteria may be the commercial availability of equipment component blocks and the maximum frequency band to be monitored.