ENAMS spectra measurement

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Abstract: The ENAMS system is a measurement system for the noise level in the frequency range from 0.06 to 30 MHz, which was inititated by the German Amateur Radio Club, DARC. This paper decribes some aspects of the measurment procedure and storing the measured data.

1. Measurement of spectra using ENAMS

The measurements to be made with the ENAMS measurement system shall be performed permanently in order to enable long-term comparison (years) and thus document the development of noise interference in the range from 0.06 to 30 MHz.

International standards are obligatory for the measurement of spectra. The measurement standard CISPR 16-1-1 (DIN EN 55016-1-1) specifies that the quasi-peak values shall be measured for at least one second each in a frequency band of 9 kilohertz. As a result, for a conventional measurement up to 30 MHz without considering the settling time of the filters, about 3300 consecutive measurements have to be performed, which corresponds to a measurement time of about 55 minutes.

2. Description of the Advanced Measurement Method

The measurement system proposed here is based on an advanced CISPR 16-1-1 of 3/2015. According to this standard it is allowed to perform a measurement over the prescribed one second in a wide frequency range and to transform this by Fourier transformation to the parallel subranges of 9 kHz bandwidth.

This also allows a complete measurement from 0 to 30 MHz to be acquired in wide subranges.

The acquisition with e.g. a bandwidth of 1.25 MHz can sweep the entire range 0 to 30 MHz by approx. 30 repetitions with different center frequencies { e.g.: f_m = 0.6; 1.8; 3.0; ... MHz}.

The recorded band ranges are currently transferred into the frequency range with a Short-Term FFT (STFFT) using the Welch method with approximately overlapping 620 time sections selected here. For further processing the center frequency range (approximately 1.04 MHz) ist used. With the 30 repetitions, these sections are combined to an overall frequency pattern. This finally allows an overview from 60 kHz to 30 MHz with a detailed resolution of the momentary selected 305 Hz.

This method compiles the information about the 9 kHz wide frequency bands from the recorded 30 time ranges with 1.25 megasamples. Since the available memory of the used Red Pitaya only covers 256 MByte, a processing and acquisition strategy is necessary which partially preprocesses this amount of data.

From the acquisition of

$$T=30\cdot 1.25\,MSamp/s\cdot 1\,s=37{,}5\,MSamp\cdot(2\cdot 4\,Byte)=300\,MByte$$

about 110,000 frequency points are formed,of each 305 Hz bin width by frequency transformation. A measurement of the entire spectrum with an amplitude resolution of 0.01 dB after processing takes up about 220 to 250 kByte of memory space with all additional information.

Since the measurements are now stored with a bandwidth of 305 Hz, larger bandwidths can be obtained by convolution, e.g. with a rectangular window of the desired bandwidth. For example, the bandwidth of 9.15 kHz is formed with a 30 bins window of 305 Hz width, other bandwidths more or less.

After saving the frequency transformations, the recorded time sequences must be deleted simultaneously. The detection defined by the standards for the bandwidth of 9 kHz with the modes Peak, RMS, Average or Quasipeak can only be evaluated on the basis of the time intervals.

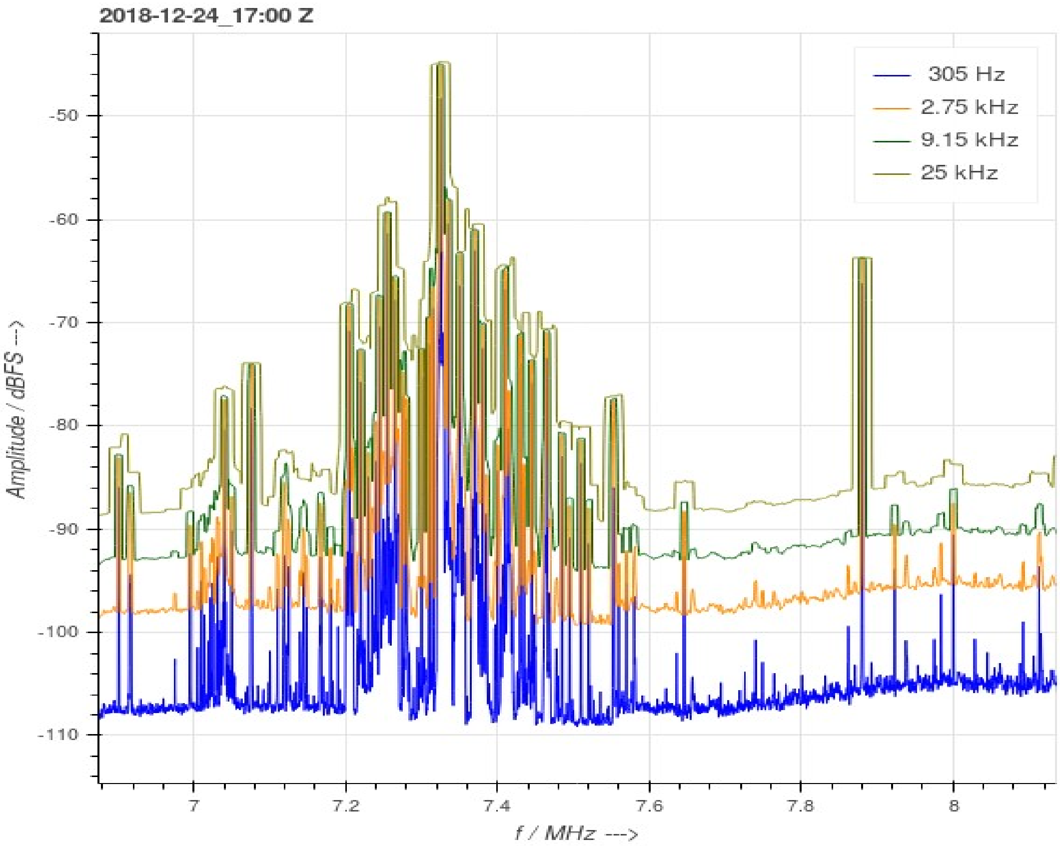
It is therefore necessary to perform and store such an evaluation in the various detection modes during the measurement. The storage of the spectrum with a bandwidth of about 9 kHz requires about 3000 storage points for the spectrum from 0 to 30 MHz.

3. Exemplary measurement on 24.12.2018

An arbitrary time segment was selected. The representation in figure 1 is a section of the whole spectrum from 0.06 to 30 MHz. The shown amplitdes 6.9 to 8.2 MHz are displayed in parallel with several bandwidths {0.3; 2.7; 9.2 and 25 kHz}.

The amplitude offset results from the different noise bandwidths. Only when the amplitude of a single carrier stands out "very far" from the noise level of the largest bandwidth do all bandwidths display practically the same amplitude - see at 7.88 MHz. This behavior corresponds to observation with a "tuned through" receiver with different bandwidths.

The mean amplitude of the noise level is obtained by statistical methods in frequency segments.



Fugure 1: Amplitude graph of the frequency range 7 to 8 MHz with different bandwidths

4. Storage of the measurement

4.1 Aims and objectives

The time measurement performed must be processed and stored as frequency transformations.

Additional data is required in order to be able to classify the measurement coherently.

4.2 Data record structure

The information stored in a data record can be divided into

1. system data
2. parameter of the database
3. parameters of the measurement and their representation
4. measurement results
5. parameters of the evaluation
6. evaluation results