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# ON POSSIBILITY OF SCHUMANN RESONANCE OBSERVATIONS WITHIN INDUSTRIAL AREA

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## ABSTRACT

Use of ADC with high resolution allowed us to embrace dynamic range both signal and powerful narrow-band interference and on this base to implement a compensative real-time algorithm for suppression of narrowband interference. The developed algorithm provides suppression of "wings" occurred due to incommensurability of a time interval of a signal that undergo to the spectral analysis and a period of a narrowband interference. Preliminary results of observations of extremely low frequency (ELF) natural electromagnetic background (Schumann resonance) performed within urban areas are presented in the paper. We demonstrate both possibilities of registration of average spectra of the Schumann resonance background signal and ELF-transients.

## INTRODUCTION

A phenomenon called Schumann Resonance (SR) is observed in spectra of the natural terrestrial radiation in the ELF range as a number of peaks at frequencies 8, 14, 20, 26 Hz. SR is excited by the worldwide lightning and represents natural oscillations of the Earth-ionosphere cavity. SR carries information both on electromagnetic properties of the lower ionosphere and ELF sources. SR measurements are used for inferring thunderstorm activity total level and its spatial distribution with the purpose of monitoring for global environmental changes [1,2]. In particular realization of idea of worldwide lightning tomography [2] will require creation of global network of the SR observatories. In this paper we consider possibility of SR observations within urban environment that would provide more regular and careful control on the receiving equipment and extending of the number of probable observation points.

As a rule the most powerful interferences are the power-line harmonics 50(60) Hz hitting into the studied frequency range. They essentially cut down the dynamic range of recorded signals. The use of traditional notch filters becomes sometimes not effective due to the suppression fails because of fluctuations of the power line frequency. Using synchronous notch filters with phase self-tuning of the rejection frequency [3] can solve the problem but relative complexity and complication in their tuning limits its using in portable systems. A data acquisition system with high resolution embracing dynamic range both signal and interference that permitted both to realize the signal filtration in a digital form and to reduce to the minimum using analogous components in the receiving system was used in the present work for the SR observations.

## METHOD FOR COMPENSATION THE NARROW-BAND INTERFERENCE

The monochromatic signal $s(t) = a\cos(\omega_0 t + \varphi)$ multiplied by the rectangular time window $[0..T]$ is used as a model of narrow-band interference. The spectrum of this signal includes two peaks with frequencies $\pm\omega_0$ with a width that is determined by the number of hitting, into the interval $[0..T]$, of periods of the high-frequency infill. The

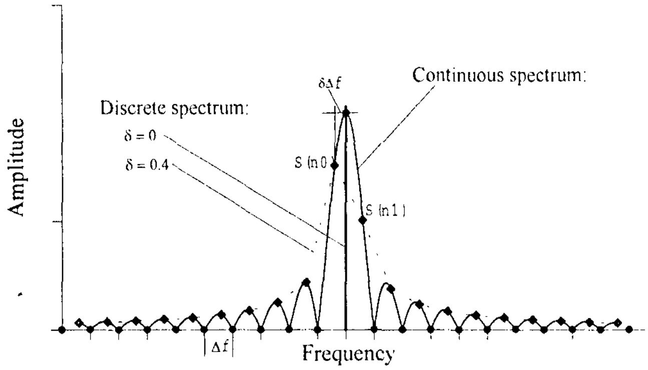


Fig.1. Formation of discrete spectrum of the bounded in time signal for fractional and integer ratios between duration of the analyzed signal and

width of these peaks will be up to the realization duration and the high-frequency infill period ratio when the transition to the discrete spectrum takes place. If the integer quantity of periods misses to $T$, then the infinitely narrow lines will result on the high-frequency infill frequencies in the spectrum (see Fig.1). The value of a fractional part δ is the result of the division the interval $T$ by the high-frequency infill period $t_0=2\pi/\omega_0$ and defines both the amplitude of peaks and appearance of "wings". These "wings" can essentially distort a spectrum at far enough frequency range.

Taking into account only positive frequencies after elementary transformations we got the next representation for the spectral density in discrete form:

$$S(n) \cong \frac{aT}{2} e^{i(\pi\delta+\varphi)} \frac{\sin\pi\delta}{\pi(n-n_0-\delta)}, \tag{1}$$

where $n$ is the current point in the spectrum, $n_0$ is the result of integer dividing $\omega_0$ by the value of $2\pi\Delta f$, where $\Delta f = 1/T$ is the frequency resolution of the discrete spectrum. To compensate the interference signal we need to determine exactly its frequency $\omega_0$, phase $\varphi$, and amplitude $a$, that is performed by finding of parameters of two points in the discrete spectrum around the narrowband signal frequency on the basis of eq.1:

$$\delta = \frac{S(n_1)}{S(n_0)+S(n_1)};$$
$$a = \frac{2}{T}\left[S(n_0)+S(n_1)\right]\cdot\frac{\pi\delta(1-\delta)}{\sin\pi\delta}; \quad \omega_0 = 2\pi\Delta f(n_0+\delta); \quad \varphi = \arg S(n_0) - \pi(\delta + n_0 + 1) \tag{2}$$

## SOME RESULTS OF THE SR OBSERVATIONS

The problem of SR measurements includes two parts that reflect spectral and time presentation of a signal. This is an accumulation of average spectra of background signal formed by overlapping pulses from the aggregate of lightning discharges occurred all over the Earth. Also this is a separation of ELF transients – signals generated by the distance powerful lightning discharges and exceeded the background amplitude in 3-10 times. One of the basic problems for measurements is a radiation of power lines harmonics with amplitude exceeding the level of natural signal on 40-70 dB.

"Wings" from the strong narrowband interference can essentially distort the spectrum of measured weak signals even when high resolution ADC is used. This situation is demonstrated in Fig.2 where spectra are represented both with use compensation and without this. The effect of using of compensation method for separating the impulse signal (ELF-transient) is demonstrated in Fig.3. The suppression effectiveness is high enough under condition if interference parameters are stable on the interval of analyzed time span. Sensitivity to sudden changes in both phase and amplitude of the narrowband interference can be reduced by fragmentation primary interval to shorter ones.

An advantage of the proposed compensation method of filtration is concluded both in absence of distortion of spectra due to its multiplying by the proper transmission characteristics when analog, digital-analog or digital filters are used and its applicability for signal separating both in time and in frequency domain.

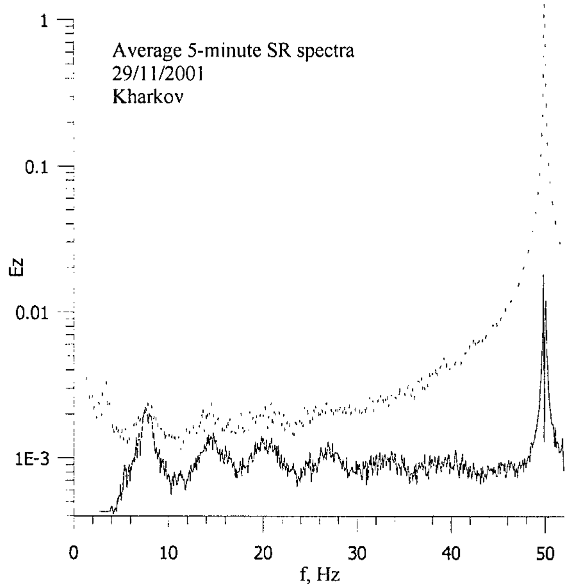


Fig.2. Average spectra of a SR background signal with compensation the power line interference and without this.

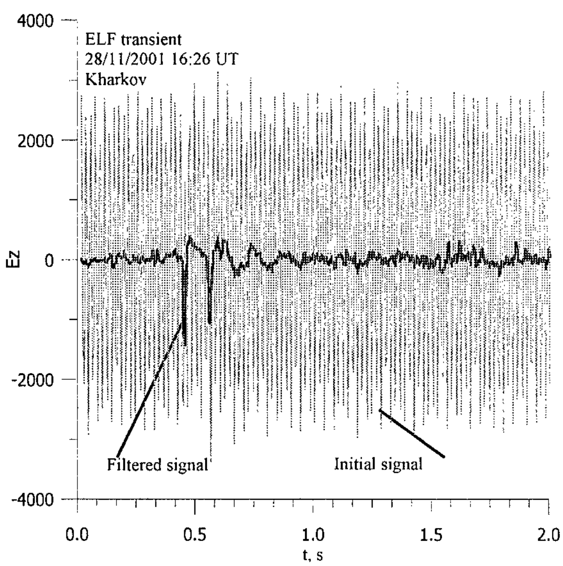


Fig.3. Revealing an ELF transient from a signal by using compensation of the 50 Hz power line interference.

## CONCLUSION

A compensation algorithm for narrowband interferences filtration is developed and realized that provides both to eliminate the influence of "wings" on the form of spectra of analyzed weak signals and to separate waveforms of impulse signals. Realization of the proposed algorithm for interference suppression is based on the using ADC with high-order resolution embracing dynamic range of signal and interference.

Results of Schumann resonance observations are demonstrated performed under condition of high level of industrial interferences within urban areas.

## REFERENCES

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