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DIGITAL METHOD OF MEASUREMENT OF UNWANTED SIGNALS IN COMMUNICATION RECEIVERS

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Abstract − The software way of the estimation of the quantities the unwanted signals, on the basis of the digital data, at a communication receiver output has been presented. Advantages of the presented digital method in comparison with these recommended by the standard methods have been given. Thanks to the use of the separating operation of random and determined components in the digital stored measuring signal, the very low measurement errors of the estimated parameters have been achieved.

Keywords: virtual instrument, noise and interference measurements, communication receiver

1. INTRODUCTION

Low frequency signal at the communication receiver output includes, except an usable signal, its own noise components derived from a receiver equipment, the conducted from a supply network unwanted signals (50 Hz and its harmonics), an unwanted signal occurred as a result of the nonlinear distortion including these at the output stages of the receiver and the intermodulation distortion occurring at its input stages.

In the ship condition, with regard to big accumulation of the different equipments, the levels of the unwanted signals at the receiver output may be significantly high.

Communication receiving equipment, in respect to the noise, is usually described with the help of the noise factor F and its sensitivity E_s [1-3]. From the consideration presented by the authors in [2, 5], it results that for the calculation of the sensitivity value E_s, the noise factor F and the noise passband Δf should be determined. Both parameters can be measured by the worked out by the authors virtual instrument.

Communication receiver proprieties , in respect to nonlinear distortion, are described with the help of the distortion factor (for the distortion mainly occurs in the output stages) and the intermodulation parameters, dissimilar to different nonlinear phenomena that occur in receiver input stages [3]. There is no parameter in recommended standards which describes the influence of the means on a low frequency output signal of the receiver. The essential parameters determining the unwanted signals at the receiver output describe, as a rule, only its chosen unwanted proprieties. Whereas, in the observed signal at the output of the receiver, usually both usable and unwanted signals occur at the same time. Hence, very often to determine the numerical value of the suitable parameters, the errors are committed as a result of the applied ways determining these quantities. It is the consequence of the assumption that in the measuring signal there is only a component described in the definition of the given parameter.

In the presented digital method of measurement, thanks to the use of the separating operation of the random and determined components of the measured signal, which is made by a software (with the use of PC), much lower measuring inaccuracy of the determining parameters has been achieved [4].

2. THE WAY OF DETERMINING QUANTITIES DESCRIBING UNWANTED SIGNALS

In the measuring system the source of the receiver input signal depends on the measuring parameter and it is a standard noise generator or a standard signal generator (e.g. when the intermodulation parameters are measured, two standard signal generators should be used) (Fig. 1).

Quantities determine the unwanted signals at the output of the receiver can be determined by storing data in the measuring system, in which depending on a tasked parameter, the measuring conditions are changed only and the appriopriate parameters are calculated using algorithms in the virtual digital measuring signal processing set in *off line* mode (Fig. 2).

The signal taken from a receiver output is preliminarily conditioned (amplified and filtered) and then passed to a/d converter in the hardware part of the measuring instrument (using *National Instruments* components). The analysis of the sampled signal is made by the virtual instruments working in the LabVIEW software environment (Fig. 2).

In the digital measuring signal the two components are separated: the periodic and the random. The author's procedure of separating both the components in the input waveform consists in adding coherently the voltage time sections of the length corresponding to the overall multiple of the periodic component period [4]. Distinguishing between the periodic and random components of the signal in virtual instrument requires entering following input data:

- sampling frequency f_s,
- basic frequency of periodic interference f_1,

- multiple of adding the sets of samples,
- number of samples in the set.

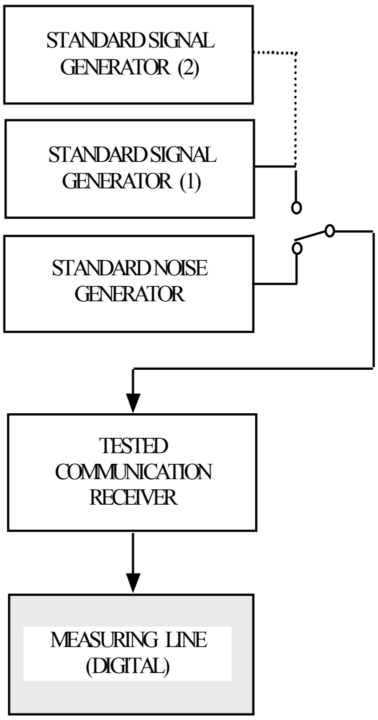

Fig.1. Block diagram of digital system determining of unwanted signals of communication receiver

These parameters influence the accuracy of the obtained results, the resolution of a further spectral analysis as well as the inaccuracy of the estimation of the values connected, for example, with the mean square value (effective), the spectrum density of the power of the examined course.

Next a further analysis is carried out, separately for random (Fig. 2-I) and periodic (Fig. 2-II) component of the measured signal. Giving the signal from the standard noise generator at the input of the communication receiver, on the basis of random component (Fig. 2-I) the noise factor of the receiver equipment and the energy passband for chosen type of modulation are determined [2]. The quantity characterising periodic component of the measured signal at the output of the receiver is mean power of the signal (Fig. 2-II).

The component of unwanted periodic signals at the low frequency receiver output coming from the supply network voltage is most effectively measured when there is no usable signal at the receiver input and there is considerable gain of the receiver equipment. Unwanted signals resulting from intermodulation phenomena at the input stages of the receiver should be measured by giving at its input the two appropriately frequency adjusted signals of the same level. While measuring nonlinear distortions occurring at the output stages of the receiver, it is necessary to gain considerably the input usable signal in low frequency receiver stages. Giving the usable signal from the standard signal generator at the receiver input, it is possible to determine on the basis of the analysis of periodic and random components of the measured signal the ratio of the usable signal power and unwanted signal power at the receiver output [3].

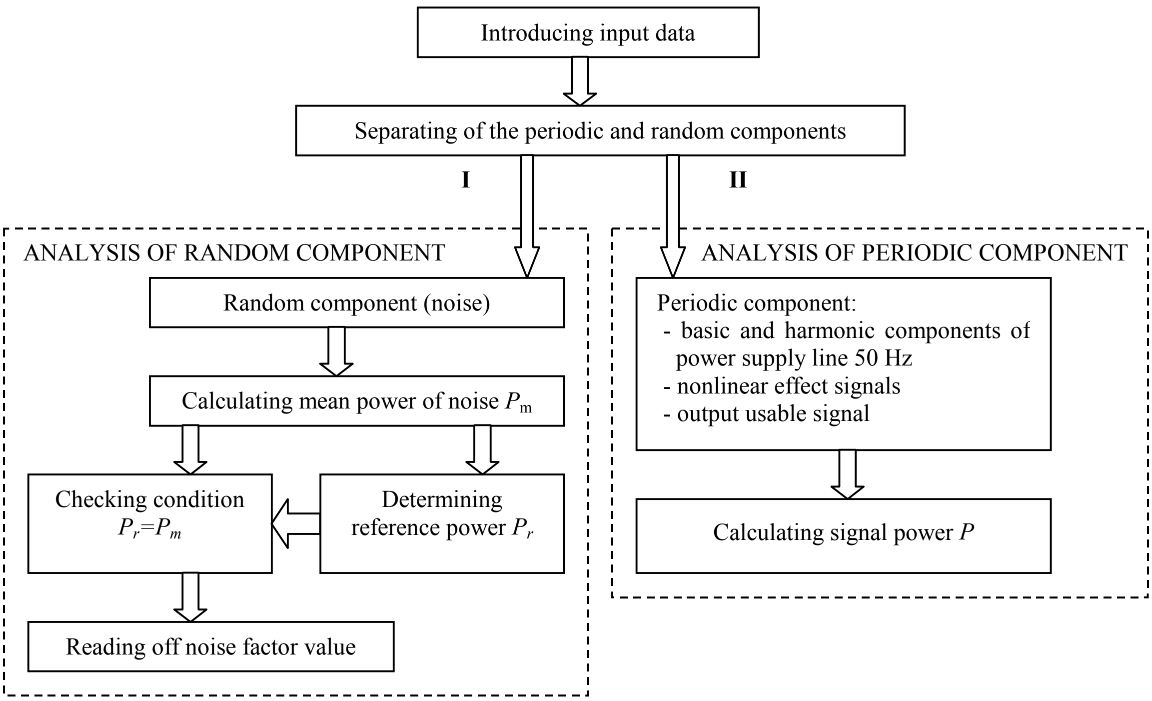

Fig. 2. Algorithm determining quantities characterising random and periodic components of output receiver signal in the virtual instruments

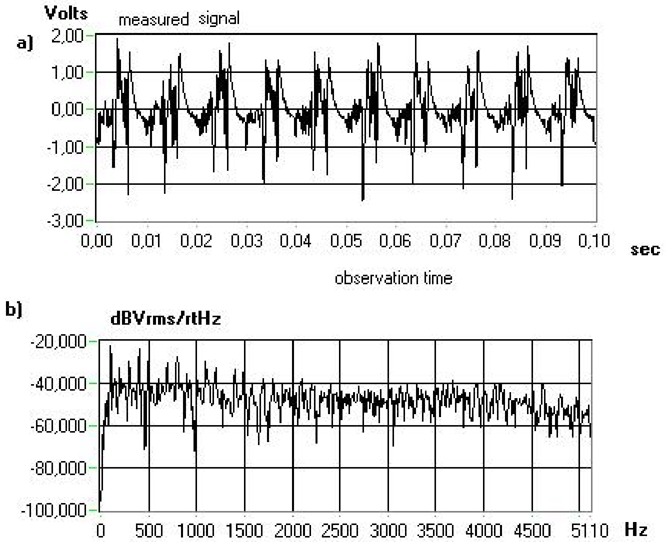

Fig. 3. Time waveform (a) and the power spectral density (b) of output receiver signal, while there is no input usable signal; f_s equal 10240 Hz [*virtual instrument panel*]

3. RESULTS OF EXPERIMENTAL RESEARCH

The presented algorithm has been used to analise the output signal of a typical communication receiver. It enables with regard to the conditions of the receiver work to measure usable signal, the component from own noise of receiver equipment, unwanted signal from the supply network (and its harmonics), unwanted signals resulting from nonlinear distortions including these occurring in the output stages of the receiver and intermodulation products resulting in its input stages.

The most essential measurement results of the periodic and random components of the output signal of marine communication receiver RA 1776 made by RACAL have been presented.

In the first of the presented results (Fig. 3) the measurement was made when there was no signal at the receiver input (the antenna input shorted by 50 Ω resistance) and there was receiver gain ensuring standard output signal power (100 mW). In the above conditions of the receiver work its output signal contains the random component from the receiver's own noise and the periodic component from the conducted unwanted signals of the supply network (50 Hz and its harmonics).

In the signal stored at the receiver output together with the noise, harmonics signals of the supply network with the dominant second harmonic 100 Hz (Fig. 3b) have been observed. As the result of the separation of periodic and random components a considerable contribution of the periodic component has been noticed (Fig. 4) in the measured signal at the output of the receiver equipment (periodic component voltage amplitude constitutes 25 % of maximum quantity of instantaneous measured voltage).

For the other presented result (Fig. 5) at the receiver input the SSB (Single Side-Band) signal has been given which has the level equal to its usable sensitivity (gain of the receiver ensuring the standard output power and the assumed output ratio of the signal power and the noise power equal 20 dB. In such working conditions of the receiver its output signal contains the dominant periodic component of the usable signal of frequency 1 kHz and random component coming from the receiver's own noise and the distorted wanted signal.

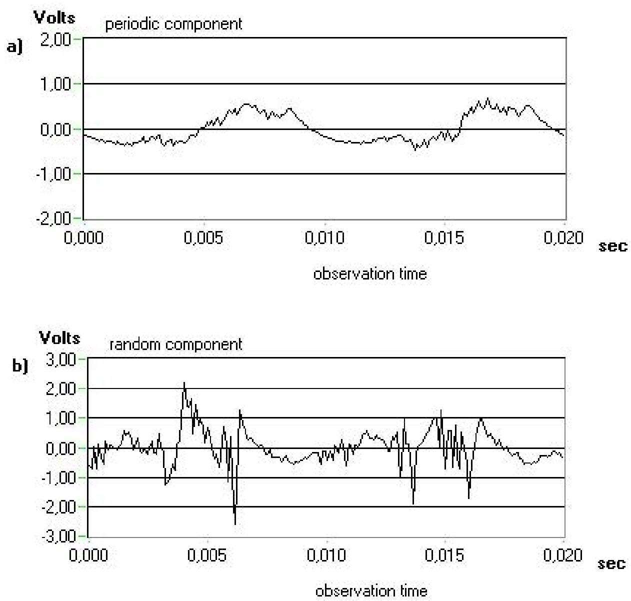

Fig. 4. Time waveforms of periodic (a) and random (b) component of output receiver signal, while there is no input usable signal; the averages number equal 50 [*virtual instrument panel*]

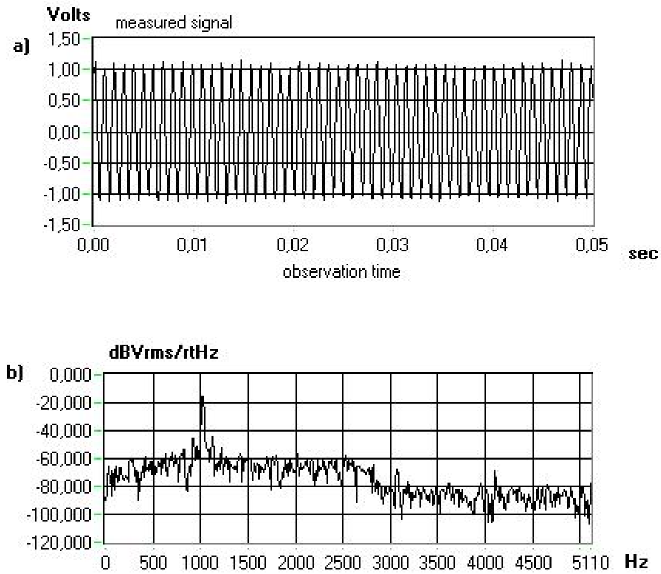

Fig. 5. Time waveform (a) and the power spectral density (b) of output receiver signal, while input usable signal is equal receiver sensitivity; f_s equal 10240 Hz [*virtual instrument panel*]

Thanks to the use of the procedure separating periodic and random components of the measured signal it was observed that in the receiver output signal except the usable periodic component (Fig. 6a) there exists the unwanted

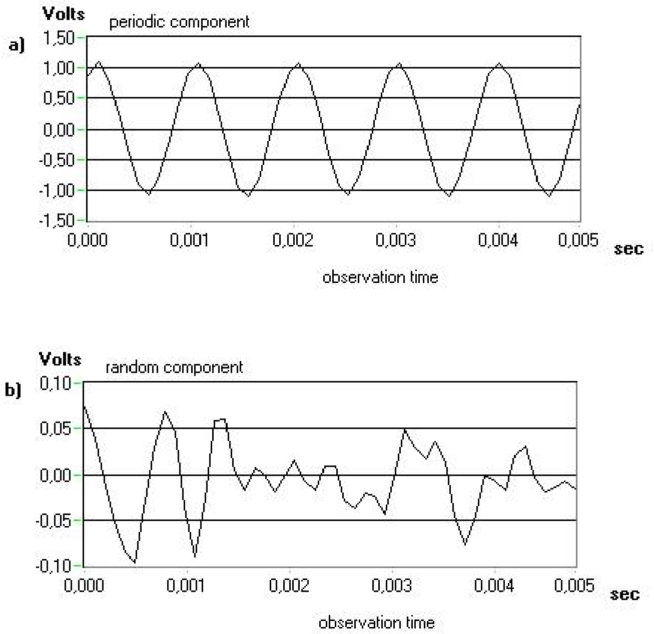

Fig. 6. Time waveforms of periodic (a) and random (b) component of output receiver signal, while input usable signal is equal receiver sensitivity; the averages number equal 50 [*virtual instrument panel*]

random component containing not only the receiver's own noise having the constant power spectral density but unwanted noise of power spectral density of the type $1/f^{\alpha}$ as well (Fig. 6b).

4. CONCLUSIONS

The way of the digital determining quantities presented by the authors describing unwanted signals at the communication receiver output, allows to achieve much lower errors of the measuring parameters in comparison with these recommended by the standard methods. It follows from the fact that in algorithms software calculating numeric values of determining parameters, exclusively these components of the measured signal which result from the definition of the given parameter are taken into consideration.

The proposed measuring method is much simpler and at the same time more universal in comparison with the methods so far used and in addition it allows fuller description of the analysed signals at the communication receiver output.

The advantage of the presented method is also a considerable shortening of the total estimation time of the parameters and characteristics describing the unwanted signals of the communication receiver, in consequence of a modification of the calculating procedures in *off line* mode.

After a slight modification of the presented method, including in particular the used procedure for the software determination of the receiver parameter, the internal noise of the tested receiver can be used [2], and the number of parameters and characteristics describing the communication receiver operation can be also enhanced, i.e. in the range of the parameters describing the electromagnetic compatibility of the communication receiving system in the conditions appearing on the ship.

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