UDC 681.327.8: 681.3.08(045)

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THE METHODICS OF SIGNAL TYPE IDENTIFICATION ACCURACY WITH HARDWARE TOOLS

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Abstract. *The error fractions analysis of receiving tract devices that influence on the signal type identification accuracy is given in the article. To increase the signal type identification accuracy with hardware tools the error fractions of electronic devices are determined.*

Keywords: communication channel; receiving path components; signal type identification precision; spectral signal components.

1. Introduction

To evaluate the accuracy of signal type identification the set of electronic devices as composite structures and systems is used.

They are joined by common end use and form a communication channel that is optimal for interaction with the object and the operator.

Thereby, metrological maintenance of all communication channel parts is needed.

Modern methods of estimation accuracy significantly differ from classical, previously developed and provided metrological rules and state standard [1–5].

This difference is due to the new information technologies, which leads to the new functionality of designed devices, improvement of maintenance comfort level and the virtual place to display information.

At the same time, the new sources of errors, associated with the medium appear.

To interpret the accuracy evaluating methodic by means of the uncertainty identification makes a lot of problems associated with the recognition and subsequent error fractions liquidation or reducing to the non-significant level.

Due to the original measurement process, error fractions estimation for the whole series is unavailable.

These are errors determined to harmonic components imperfect identification that does not ensure subsequent liquidation of their influence on the information signal, unaccounted errors depending on the location of the controlled object in space and time, errors occurring in a particular physical environment in the receiving-transmitting process.

Due to this, the research direction of this article is relevant [6, 7].

2. The error fractions analysis in the signal type identification with hardware

Standard software applications (MultiSim, LabView or other special-purpose program packages) use virtual spectrographs.

During exploratory design phase they are rationally used to get error fraction analysis of electronic devices functioning in ideal conditions.

Such error fractions as: random error δ_r, noise error δ_n, specificity slot error δ_{ss}, electric characteristics drift error after calibration δ_{cc}, end instrument setting instability error δ_{si} can be revealed and discounted only in real-time use, e.g. during the particular device functionality test audit.

Industrial environment with engineer intuition and field experience permit hardware tools using, e.g. scanning receiver as SR2000 and spectrograph as GSP-7830.

Required metrological model of receiving tract devices can be provided during the error fraction graph amendment and known remedies or reduction to insignificant level.

To transmit information by dint of the communication channel the radiosignals are used.

They can be sized according to: frequency (frequency range), modulation format (manipulation), spectral width, modulating signal type (sound, video).

Receiving tract identifies radio signal type with scanning receiver, spectrograph and Master Control (MC) based on Personal Computer (PC) (Fig. 1).

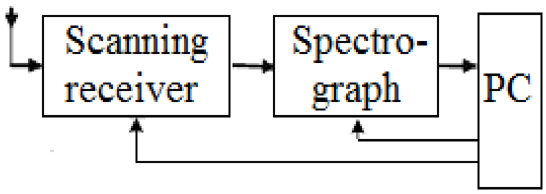

Fig. 1. Receiving tract of communication channel

The precision of radio signal type identification depends on precision of: receiver tunings, signal transmission through receiving-amplifying communication channel tract without distortions, spectrum signal measurement, signal type defining by expert system [9, 10].

Taking into account four previous items, we can define total error of signal type identification (Fig. 2):

$$\delta_{\Sigma} = \delta_{rt} + \delta_{trt} + \delta_{sm} + \delta_{es} \ldots,$$

where δ_{Σ} – total identification error;

δ_{rt} – receiver tuning error;

δ_{trt} – signal transmission through receiving-amplifying communication channel tract error;

δ_{sm} – spectrum signal measurement error;

δ_{es} – signal type defining by expert system error.

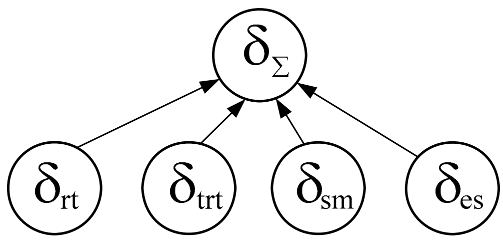

Fig. 2. The graph of signal type identification error

The possibility of errors fraction revealing with hardware tools to improve signal type identification includes:

1. The evaluation of scanning receiver spectrum error. To evaluate it the SR2000 receiver was used.

The faceplate of SR2000 is given on the Fig. 3.

The scanning receiver characteristics are: relative frequency instability ±1x10^{6}; frequency response ripple 3db; harmonic distortion coefficient 3 %

The digital frequency synthesizer is used to tuning on a frequency. It is controlled by the MC based on PC.

The relative frequency deviation of the receiver from the nominal value is determined by the reference generator instability.

The parameters given above, influence on the output waveform, and as a consequence, its spectral content.

The tuning error can lead to out-of-control pass bandwidth condition of signal spectrum.

The cutoff frequencies can be out of the pass, which would lack the frequency of the output spectrum.

This will make an effect on the signal identification. It can be misidentified or even doesn't identified.

This is a random error that can be discounted by means of mathematical statistics.

The Frequency Response Ripple (FRR) of receiving-amplifying tract disposes frequency distortions of the spectrum, which ultimately affect the output spectrum.

Unlike the tuning error, the FRR – characteristics that can be determined, interpolated with calculating the signal corrections, i.e. FRR can be discounted in spectrum construction.

The nonlinear distortion factor (harmonic distortion) – characteristic that shows a spectral composition change after signal passing through the receiving-amplifying tract.

This leads to the appearance in the output signal spectrum the new frequencies, absent in the input frequency spectrum, which is especially important for signal identification by spectrum, as new signal components change it.

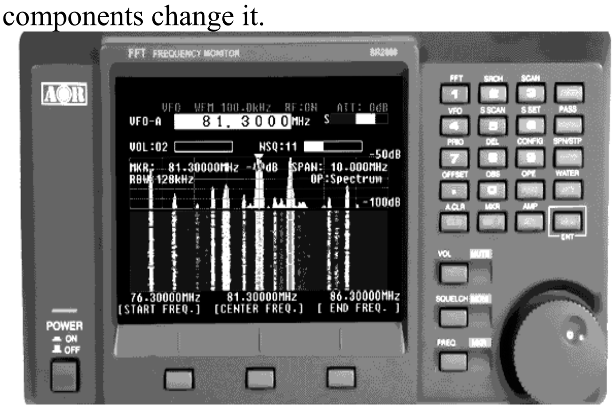

Fig. 3. Scanning receiver SR2000

If the coefficient of harmonic distortion is small, it will not effect on the signal type identification.

2. Evaluation of measurement error range of the spectrum analyzer (Fig. 4).

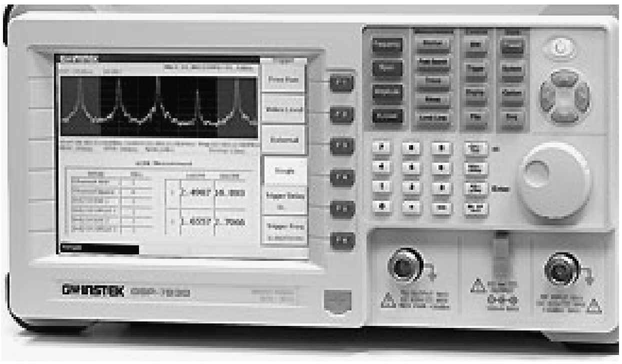

Fig. 4. Spectrum analyzer GSP-7830

The spectrum analyzer characteristics are:

– reference frequency source error $\pm 5x10^{-6}$;

– frequency response ripple ±1,5db;

– measurement error ±1,5db / 100 MHz.

The graph includes three components of the error spectrum measurement δ_{sm} (Fig. 5).

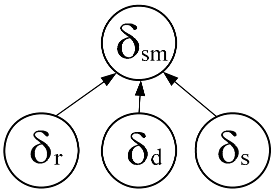

Fig. 5. The error spectrum components graph:

δ_r – random errors;

δ_d – drift errors;

δ_s – systematic errors

The random errors δ_r are irregular and can't be compensated by device calibration.

The graph on the Fig. 6 shows such random errors:

– noise error δ_n;

– specificity slot error δ_{ss};

– end instrument setting instability error δ_{isi}.

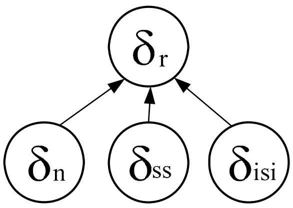

Fig. 6. The random error δ_r graph of spectrum measurement components

Noise errors are caused by electrical fluctuations in electronic components used in the measuring instrument.

To reduce these errors the signal power measured in the circuit device can be increased, the filter bandwidth can be reduced, the averaging mode can be switched.

The specificity slot error fluctuations caused by fluctuations of electrical slot characteristics due to wear.

This error can be reduced by replacement or a careful slot handling.

Drift error caused by changes in the device electrical characteristics, occurred after calibration (Fig. 7).

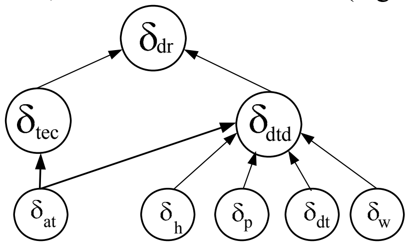

Fig. 7. The drift fraction error graph

The main reason for this drift – the thermal expansion of the connecting cables δ_{tec} because of the change in the ambient temperature δ_{at} and the electronic components temperature drift inside the device δ_{dtd} due to its warming up δ_w, humidity δ_h, pressure δ_p, and time of day δ_{dt}.

The warm-up time compliance before work and recalibration of device with changes in the factors mentioned above can reduce these errors.

The systematic errors are caused by not ideal electrical characteristics of devices, including connecting cables, slots and signal sorting circuit.

These errors are repeatable and their characteristics do not change with time.

The test verification can characterize the systematic errors. To compensate them the calibration and mathematical approach in measurement results are used (Fig. 8).

To estimate the characteristics of systematic errors the parameters of reference model circuits are measured.

The reference model circuits are the calibrating measures.

To calibrate the electronic devices the calibrating measures are: the short circuit measure and the idle stroke measure.

The spectrum analyzer uses two calibration methods: calibration of frequency transmission uneven and advanced calibration of frequency transmission uneven.

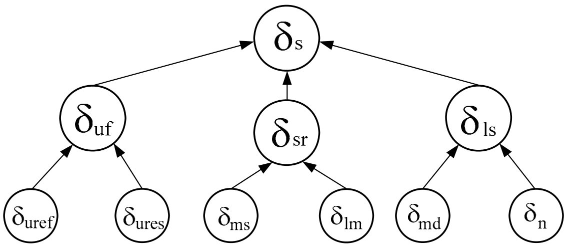

Fig. 8. The systematic error graph of spectrum measurement fraction δ_s :

δ_{uf} – error caused by uneven frequency device and test setup;

δ_{sr} – errors caused by signal reflections in the measuring system;

δ_{ls} – errors caused by leakage signal in measuring system;

δ_{uref} – frequency uneven of the reflection track;

δ_{ures} – frequency uneven of the receiving track;

δ_{ms} – matching error source;

δ_{lm} – load matching error;

δ_{md} – measurements directivity;

δ_n – noninteraction

The total error graph, including components of spectrum measurements error, showed on Fig. 9.

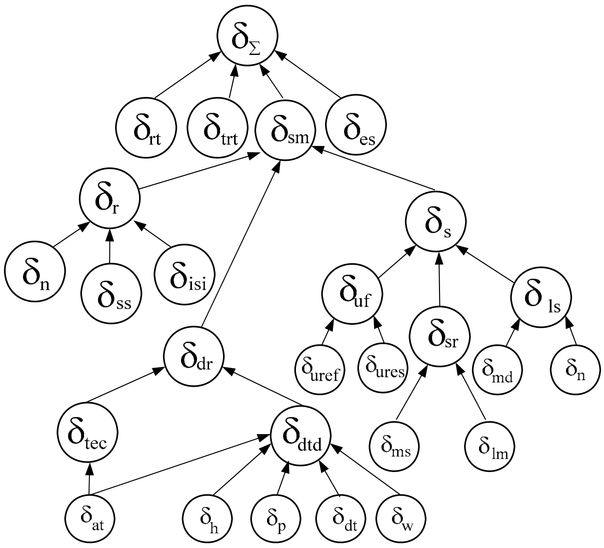

Fig. 9. The total error graph

The Expert System (ES) identifies signal.

ES models neural network tuned to certain types of signal spectrum.

The neural networks feature is data grouping.

Receiving the particular input vector, the network "recognizes" the signal.

If the input vector is near the band edge, dividing several groups, even small tuning (teaching) neural network errors can influence the outcome.

Therefore network should be trained under close to the edge conditions [8].

The tuning accuracy (training) of the neural network is determined by the condition: multiple input vectors of different groups, minimally different from each other, are correctly recognized and several vectors of the same group, the most different from each other, are correctly recognized.

3. Conclusions

1. The comparative analysis of the receiving tract errors fractions is given. It allows justifying the structures choice and principles of communication channel.
2. The accuracy of signal type identification will increase if error fractions identified and reduced to the level of insignificant or eliminated.
3. The reasonability of error fractions revealing with hardware tools for repeating the operating conditions and environmental variability of experimental studies is proved.
4. The methodic of signal type identification realized with total error graph of receiving track, increases its accuracy.

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Received 16 June 2014.

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Наведено аналіз складових похибок приладів приймального тракту каналу зв'язку, які впливають на точність ідентифікації типів сигналів. Розглянуто складові похибок електронних приладів для підвищення точності ідентифікації типів радіосигналів апаратними засобами, поєднаних загальним цільовим призначенням і утворюючих оптимальний для взаємодії з об'єктом і оператором канал зв'язку. Показано, що точність ідентифікації типу радіосигналу залежить від точності настроювання вимірювального приймача, передачі сигналу по приймально-підсилювальному тракту при відсутності спотворень, вимірювання спектру сигналу, визначення типу сигналу за допомогою експертної системи. З урахуванням указаних факторів визначено сумарну похибку ідентифікації типів сигналів, подану у вигляді повного графа складових похибок приймального тракту каналу зв'язку, який дозволяє оцінити переваги використання апаратних засобів перед програмними засобами і підвищити точність ідентифікації типів сигналів з їх допомогою.

Ключові слова: канал зв'язку; складові приймального тракту; спектральний склад сигналу; точність ідентифікації типів сигналів.

В.П. Харченко[1], В.Ю. Ларин[2], Я.А. Савицкая[3]. Методика прецизионной идентификации типа сигналов с помощью аппаратных средств

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Выполнен анализ составляющих погрешностей устройств приемного тракта канала связи, оказывающих влияние на точность идентификации типов сигналов. Рассмотрены составляющие погрешностей электронных устройств для повышения точности идентификации типов радиосигналов аппаратными средствами, объединенных общим целевым назначением и образующих оптимальный для взаимодействия с объектом и оператором канал связи. Показано, что точность идентификации типа радиосигнала зависит от точности настройки измерительного приемника, передачи сигнала по приемно-усилительному тракту при отсутствии искажений, измерения спектра сигнала, определения типа сигнала экспертной системой. С учетом указанных факторов определена суммарная погрешность идентификации типов сигналов, представленная в виде полного графа составляющих погрешностей приемного тракта канала связи, который позволяет оценить преимущества использования аппаратных средств перед программными пакетами и повысить точность идентификации типов сигналов с их помощью.

Ключевые слова: канал связи; составляющие приемного тракта; спектральный состав сигнала; точность идентификации типов сигналов.

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