The automated synthesis of microminiature multiresonator sensors of signals structure frequency analysis in Sim One circuit designer system

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Abstract. For synthesis system of signals processing devices "Sim-One Circuit Designer" it is developed builder band linear processing devices of signals with oblique interval an amplitude-frequency characteristic (AFC). The oblique section of AFC is formed N serially-connected resonators that allows to provide high slope characteristics of frequency conversion to voltage at small deviations from the linear law. In a basis builder the method of the automated synthesis of processing devices of signals with the frequency characteristics not having the analytical decision is supposed. Novelty of synthesis method consists in creation of computer-aided design (CAD) structure a considered class of the devices, an including database in the normalized range of the frequencies containing particular case the decisions of the task of approximation for the discrete values frequency overlap factor, approximation errors etc., searching modules the most close decision to the technical project on device calculation, algorithms of specification of the decision of the task of approximation.

1. Introduction
The task of the analysis to intraimpulse frequency and equivalent it on significance of phase structure of signals takes on special significance in the modern conditions. It is applied in different range of use as at the decision of tasks of the initial level which is including an estimation of parameters of signals, and at the decision most complex task - image identifications of objects. Signal processing in interests of an estimation of parameters and image identifications in many respects dares now successfully, the large-sized equipment of the technical analysis however will thus be involved.

Thus, the information on a wireless signal (hydroaudible tone) should be delivered immediately in some equipment with functional part the analysis of signals that in some cases it is inconvenient, and frequently - it is impossible. So, for example, there are tasks of remote recognition and control of sources of the signals which execution can be successfully solved with usage unmanned devices of air [1], terrestrial, surface or underwater basing. Necessity of remote measurement of parameters
(recognition of objects) it is in turn caused large by controllable territories, inaccessibility of objects of control, zones of emergency situations (danger of application piloted crafts). In this case, as a rule, for signal reception onboard sensors unmanned devices are used, and then execute data transfer of onboard measurements in point of information processing or is produced decryption monitoring after resetting of the pilotless device. Data transfer from a board essentially is at a loss load of radio-frequency and acoustic ranges, and data handling after arrival conducts to the big inertness of systems of engineering control.

The modern progress led to intellectualization radio-controlled tools that led to evolution of the terminology. The modern progress led to intellectualization radio-controlled tools that led to evolution of the terminology. The modern progress led to intellectualization radio-controlled tools that led to evolution of the terminology. The term «the is distant-piloted device» was initially used. Now even more often in the use the word "remotely" is eliminated and sounds UAV (unmanned aerial vehicle), and the functional of terrestrial points of remote control was in many respects reduced to monitoring of independent actions UAVs, including group [2]. Actually it also is initial display of intellectualization of the pilotless aircrafts, consisting in the extension of possibilities of information processing immediately onboard UAV. The modern possibilities of electronic basis allow to create miniature computer complexes, applicable on UAV small range (SR), essentially restricted on mass useful load and to the sizes. Thus, it is equal as the task of the remote analysis of signals with usage of pilotless machines, actually robots, and a tendency to their self-sufficiency at execution missions, the extension of possibilities on information processing immediately onboard pilotless tools demand. The key moment in this question is efficiency of sensors of signal processing, including the analysis of intrainpulse frequency (phase) structure of signals for which improving in studies [3] the methodology providing synthesis of the linear multiresonator structures of the functional nodes of the analysis of signals, including a method of creation of multiresonant converter units of a type of modulation, the synthesis algorithms of the frequency characteristics different from known according to simultaneous support high discrimination on frequency and a small level of nonlinearity, simplicity of implementation, upgrade Remez algorithm by switching-on of additional criterion integral precision displays is offered, developed. Let's consider its essence and implementation at the decision of the task of image identification of sources of a radio frequency radiation.

Variant of implementation onboard detector (recognition devices) an interesting signal is the generalized circuit presented on fig. 1, including: the amplifier with automatic gain control (AGC), wideband the frequency detector (WBFD), the multi-channel correlator, a database of images of sources of radio frequency radiations (RFRS).

![Diagram](image)

**Figure 1.** The generalized circuit of the device of recognition RFRS

The key device signal detector is WBFD with which usage it is formed time-frequency matrix (TFM) RFRS on the basis of conversion law of frequency variation in the law amplitude variation. Inherently WBFD represents sequentially connected modulation converter units (MCU): from the frequency modulation (FM) in the amplitude-frequency (AFM) and the envelope detector. WBFD "frequency-pressure" is characterized, first of all, slope characteristics of the converter unit.
where \( \Delta U = U_{\text{max}} - U_{\text{min}} \) – a difference of the maximum and minimum values of output voltage, 
\( \Delta \Omega = \Omega_\text{e} - \Omega_\text{wb} \) – operation frequency band WBFD in values of the normalized angular frequencies, where \( \Omega_\text{e} = \frac{\omega}{\omega_\text{e}} \) also \( \Omega_\text{wb} = \frac{\omega}{\omega_{\text{wb}}} \) boundary normalized angular frequencies, thus \( \omega \) – angular frequency \( \omega_{\text{e}} \), \( \omega_{\text{wb}} \) – boundary not normalized angular frequencies.

Value (1) is defined the linear section slope of an amplitude-frequency characteristic (AFC) MCU WBFD. For classical circuitry implementations [4] it is especially difficult to receive high value slope the linear section AFC slope for a detection case in broad range of frequencies, therefore the amplitude of the transformed signal in such circuits appears a smaller half of input amplitude. It is caused by that increment of steepnesses of slope MCU AFC in a type separately taken filter circuit leads increment deviations from a straight-line characteristic of frequency conversion to voltage that conduces to lowering of accuracy of frequency conversion to voltage. Therefore in papers [3] the method of creation of conversion detectors in voltage with high slope the linear section of the amplitude-frequency characteristic, founded on the cascade connection of filters of the upper (lower) frequencies of the second order and minimization of a deviation of a resultant amplitude-frequency characteristic from the linear law (figure 2) is offered and developed.

![Figure 2. The generalized principle of implementation MCU WBFD](image)

Actually, this serial connection resonance sensors [5], leading to more effective signal processing. Such method of creation of converter units allows to increase considerably slope detection characteristics with augment the circuit order in comparison with periodic circuits at saving linearity processing.

Practical implementation WBFD is complicated by that synthesis multiresonator MCU upon is accessible only narrow specialist while one of pressing questions is time minimization design nodes of radio-electronic equipment (REE).

Among other, that WBFD for minimization of overall dimensions REE, can be fulfilled as analog input circuits of sensors while design engineer REE frequently, reluctantly undertake alteration of
analog units is important also. It is caused by that involves frequently cardinal conversions REE as a whole while, for example, the numeral part will be reprogrammed rather operatively and without essential material inputs.

Thus, the contradiction in WBFD designing on a basis multiresonator MCU is watched: fast rate of obtaining of ready decisions on the one hand is required, essential temporal expenses for implementation effective, as a rule nonclassical, including the analog, circuitry decisions, demanding knowledge of narrow experts on the other hand are required. By resolution of the given contradiction designing automation can appear.

Quick designing processing devices and formation of signals it is provided with application of packets of mathematical, imitative and circuitry modeling. Mathematical modeling system, most significant of which MATLAB, Mathcad, Maple etc., allow to solve effectively tasks of creation and optimization of mathematical models of characteristics signal generation and processing devises. At the same time it is necessary to mark that known operations [6], [7] which algorithms are taken as a principle mathematical modeling system, in some cases, for example, at obtaining Chebyshev characteristic, are directed on improving of initial approach and do not guarantee the optimal decision. Imitative (behavioral) modeling system at level of skeleton diagrams, such as Simulink (MATLAB extension), SystemView, Visual System Simulator etc. allow to check up quickly skeleton diagram functional capabilities in dynamics and to eliminate certainly unsuccessful development of schematic circuit. Circuitry modeling is provided with programs of automation of designing of electronic devices (EDA - Electronic Design Automation, ECAD - Electronic Computer-Aided Design) which history of development totals some tens years and began with development Spice of models. Now leaders in this sector are programs Synopsis HSPICE, Cadence Spectre and PSPICE, Mentor ELDO, National Instruments MultiSim, Micro-Cap, etc. It is necessary to mark also and the Russian developers, firm Eremex which has developed and permanently improving product SimOne. Besides, developers of GSI as analog, and digital, offer the software solutions developed immediately under specific series of chips leaders among which are production associations of Altera and Xilinx and Anadigm.

Despite huge potential of the existing software solutions, the existing task of development effective signal generation and processing devises with the characteristics which do not have analytical decision, in short terms cannot be solved. It is caused, first of all, by that technical decisions and their information support in existing modeling system are not present.

Summing up on the functional composition of systems of computer-aided design, it is possible to draw an output that the existing and developed nonclassical decisions directed on development effective signal generation and processing devises, in them practically miss, therefore creation of technology of computer-aided design of multiresonant sensors of the analysis of the frequency structure of signals became the purpose of researches.

2 Practical implementation of the designer of the linear devices with oblique section AFC in plug-in SimOne Circuit Designer

For support synthesis stable algorithm, in sense of obtaining of optimal decisions, in papers [8] on the basis of generalization of results [3] the technology of creation of a CAD of devices with the characteristics which do not have analytical rated ratios for determination of parameters has been developed. The technology includes three interacting components: the analysis module of the input data, control module of the current decision, calculations module of current approach. The technology is implemented in plug-in SimOne Circuit Designer [9] which is included in turn by the designer of devices with the oblique section AFC which main window is presented on figure 3.
Figure 3. The builder window of devices with oblique interval AFC

In the left part (figure 3 see.) possibility to set parameters of calculated characteristic MCU is given to the developer. In the right part of a window possibilities of operative control of the received characteristic are given. By this time there is a possibility of implementation of three types of devices with oblique interval AFC: with increasing interval AFC, with decreasing interval AFC, with symmetric transfer-function coefficient on voltage concerning ground potential. Oblique AFC are implemented in two element bases: ARC-element base (service band to 1 kHz), LC-element base (operating range in SMD execution to 80 MHz). The choice of this or that MCU implementation variant depends from frecuency operating range and logicians of operation of metering equipment. At the same time, it is installed that for unipolar converter units, most the steepness of the characteristic of frequency conversion to voltage is reached at small coefficients of overlapping on frequency at formation of increasing section AFC, at decreasing - at coefficients more than 30 [3]. As a whole it is proved that the highest slope the symmetric circuits of frequency conversion to voltage possess.

Besides, in considered builder, as well as in a case with dispersing delay line, is available possibility of control of parameters of the developed circuit with usage test linear-frequency modulation signal (figure 4) and its passages through the device that inherently and there is an analysis of time-and-frequency structure of signals.
Figure 4. Chirp pulse advancing through a circuit with oblique interval AFC

After setting of demanded characteristics and monitoring of results of handling in a print preview window, the user launches automatic creation of the developed circuit which process of generation is presented on figure 5 on an example of the automated development of the passive converter unit of a type of modulation with symmetric AFC.

Figure 5. Verification MCU AFC with the symmetric voltage transfer coefficient

On figure 6 the result of automatic generation of the circuit with symmetric AFC [8] is presented.
Figure 6. Automatic generation of the circuit with symmetric AFC

3 Conclusions
The led review of existing systems of mathematical, functional and circuitry modeling, showed that methods of synthesis of processing devices of signals with the nonclassical frequency characteristics, providing steady synthesis of multiresonator sensors with oblique interval AFC, in them miss.

Theoretical the backlog on synthesis of multiresonator sensors of the analysis of signals is finished to practical implementation of sensors of a sound range of frequencies and intermediate frequencies of the radio-receiving devices inclusively to 80 MHz.

The technology of implementation of system of the automated synthesis of processing devices of signals with the frequency characteristics not having the analytical decision, different from characteristics of physically implementable devices known for steady search, and including databases of initial approximations in the normalized range of frequencies, units of a program choice of the most close decision to the technical project on device calculation, algorithms of specification of the decision of the task of approximation is developed.

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