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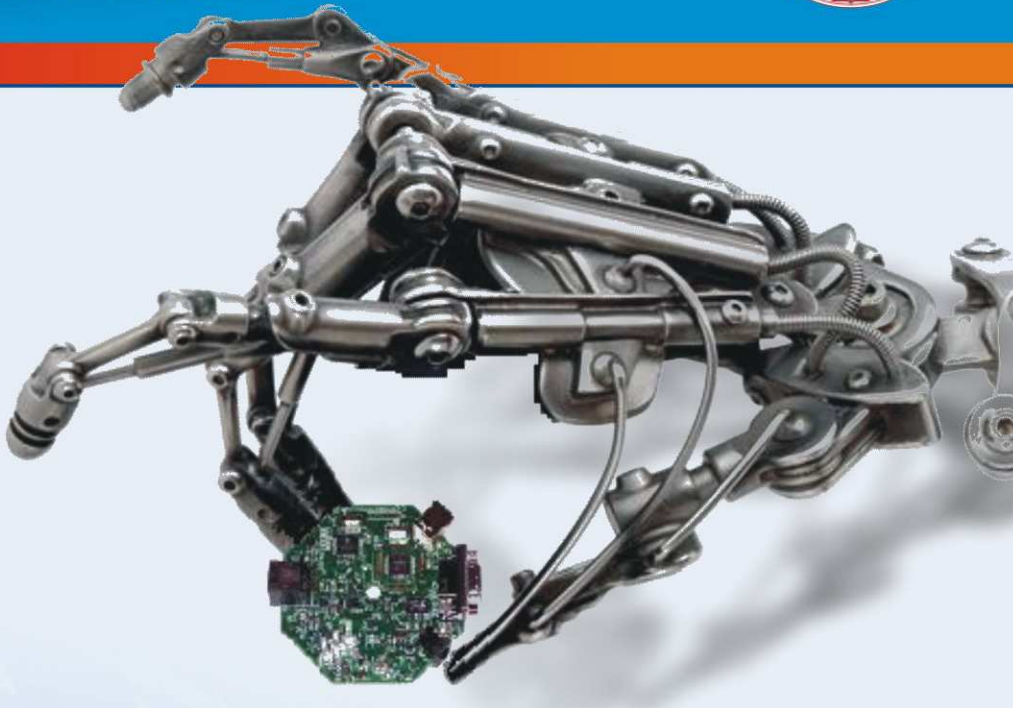

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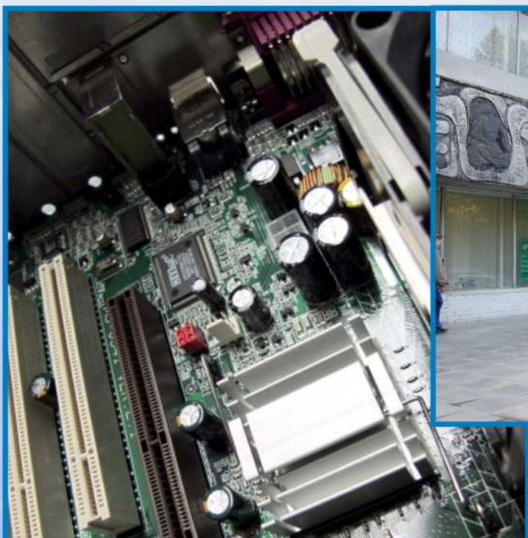

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Analysis of the Design Method of Robust Regulator by Means of Double Iterative Parallel Numerical Optimization

V. Zhmud, A. Zavorin, A. Polishchuk, O. Yadrishnikov

***Abstract*: The paper resolves the task of the regulator design for object with delay, which changes its model paremters approximately in three times. The way of the resolving of the task is the following: minimization of the functional quality kriterium, determinztion of undesirable set of the parameters values and repeated optimization of complect of systems, including objects with revealed undesirable sets of parameters. The method is illustrated with the example from practical task.**

***Key words*: regulator design, robust control, numerical optimization, optimization criterii**

1. INTRODUCTION

Control of dynaic objects in locked loop is very difficult if the object parameters are known with not sufficient accuracy or if they are changing under some uncontrolled factors even if they changing restricter by the known interval. It is necessary in this case the using of robust controlling methods. They provide successful object control with every possible variants of its paramters. Nowadays the following robust controlling metrhds are well-known: H_∞-design; H_2-design; *LQG*-design; *LQR*-design [1–4].

One of the robust control methods is optimization during modeling of the group of systems with the identical regulators but with different object models. These models correspond to the most characteristic variants from the total amount of the possible models of this object. The main idea of this approach is the providing of the stability and proper quality of the systems not with only nominal object model, but also with the chosen samples of models with the same regulator model. If for the numerical optimization of the regulator for single object the integral quality criterium can be used, then for the numerical optimization of the regulator for the croup of objects sum of these criterii should be used.

System of automatic control (SAC) of steam temperature in thermo-power plant can be an example of such system [5]. It is SAC of the live steam (temperature of steam at the output from the power boiler) and SAC of the intermediate overheating of the steam (temperature of the steam at the output from the cylinder of high pressure of turbin). The steam temperature controlling is one of the most important taske of automation of thermo-power process, because its resolving provides longer более долгий term of the effective operation of the equipment and increases efficiency of thermo-power plant Nowasays the tuning of such regulators is big technical problem. The resolving of the stated task on the base of the numerical optimization methods is perspective. In this paper the iteration loop of SAC of steam temperature with changing during working object farameters is inverstigated. These changing depend on the regimes of working of thermo-power plant.

2. THE TASK STATEMENT

The object of control has known model in the kind of transfer function $W_0(s)$, for example [5]:

$$W_0(s) = \frac{k}{(T_1 s + 1)(T_2 s + 1)} e^{-sT_d} . \quad (1)$$

Parameters of this transfer function change inside wide limits. It is necessary to calculate regulator, which would provide stable and accurate controlling of object with not only nominal value of transfer function, but also with all its possible changings. The desiner estimates the regulator quality by formal criteria, such as: overshooting, transfer process duration until the achievement of prescribed small error, integral from the error module or square of the error *etc*.

3. METHOD OF THE STETED TASK RESOLVING

To provide the demanded quality of the system with different values of parameters we propose the using of the many objects, having transfer function (1) with different parameters values, as *Figure* 1 shows. For each of such object the optimizing program simulates the identical regulator. It calculates regulator parameters by means of the optimization with the criterion containing errors of the all systems. The regulator structure we propose in the following form:

$$W_R(s) = k_P + \frac{k_I}{s} + k_D s , \quad (2)$$

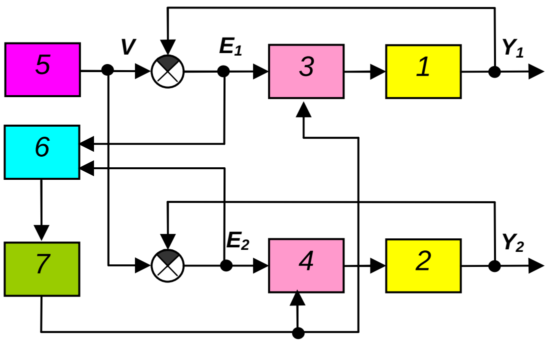

Figure 1. Model structure for the regulator optimization: 1 and 2 – models of the object with different parameters values; 3 and 4 – identical regulators models; 5 – test action former; 6 – system quality analiser; 7 – optimizer of the regulator parameters

One of the known programs [5–7] can calculate the reculator (2) parameters with fixed transfer function (1) parameters. To get robust controlling, we should optimize its coefficients with simultaneouse using of it in several systems with objects having different parameters of model. In this case, the similar regulator model works in each system, and the criterion of the quality is sum of ones for the every system.

Let $e_1(s)$ is the error of the control of nominal object; $e_2(s)$ is this of the disturbed object. The program makes numerical optimization of the regulator (2) coeffitients on the base of integral criterium depending on transient process after step or other input action, for example to the system input. In this case, for the task resolving, we should predict the goal (cost) function depending on the control error. Then we propose the functions of the quality estimate in the following forms:

1. Integral from the sum of the error modules:

$$\Psi_1 = \int_0^T \left[\left| e_1(t) \right| + \left| e_2(t) \right| \right] dt \,, \qquad (3)$$

2. Integral from the sum of the error modules multiplied to the time from the stert of the process:

$$\Psi_2 = \int_0^T \left[\left| e_1(t) \right| + \left| e_2(t) \right| \right] t dt \,, \qquad (4)$$

3. Integrsl from the sum of the function depending on the error and on the overshooting:

$$\Psi_3 = \int_0^T \left[\left| r_1(t) \right| + \left| r_2(t) \right| \right] t dt \,, \qquad (5)$$

where r_1 and r_2 are forming accordingly to the equations:

$$r_i = | e_i(t) | + 100 \max\{0, [y_i(t) - C]\} \,. \qquad (6)$$

We predict the overshooting value with the help constant value C: *a*) $C = 1.0001$; *b*) $C = 1.05$; c) $C = 1.1$; d) $C = 1.2$. In common case, $C = 1 + \delta$, where δ is masimal allowed overshooting.

4. SOFTWARE CHOICE

For the comparing, we used two different programs of regulators optimization: *MATLAB* and *VisSim* [9]. In the program *MATLAB* 7.11.0 unit Signal Constraint accomplishes the optimization. It works on the base of the Monte-Carlo method (method **DO**) [9]. In this unit, the designer gives the demands to the type of the transient process, and these demandings are the base for the numerical optimization (1).

Figure 2 shows the initial modeling structure of the discussed system in the program *VisSim* 6.0. The simulation duration is 250 *s* (it is not less then sum of the time contents multiplied to three).

5. THE OPTIMIZATION RESULTS WITH THE TWO PARALLEL SYSTEMS WITH CHANGING PARAMETERS

Lets fix values $T_1 = T_2 = 24$ *s* and $C = 1.0001$. We accomplished the optimization of the regulators for the two extreme values of the object parameters: with the least values of the gain and time constants ($k = 3{,}5$; $T_d = 3$); and with the biggest ones ($k = 9$; $T_d = 9$). Further, we determine the value of the quality of the transient process with the chosed criteria. The simulation duration is 200 *s*.

Figures 3–5 show the transient processes with the different regulators calculated with program *VisSim* 6.0. *Figures* 6–8 show the same with the regulators calculated with program *MATLAB* 7.11.0. The following designations are used at these figures: x: $k = 3.5$, $T_d = 3$; x_1: $k = 9$, $T_d = 9$; x_2: $k = 3.5$, $T_d = 9$; x_3: $k = 9$, $T_d = 3$; x_4: $k = 6$, $T_d = 6$, where x_i is the according system output signal.

It is obviouse from the *Figure* 3–8, that the systems remain stable in the all cases. Nevertheless, we have reseaches not all the variants of the parameter values.

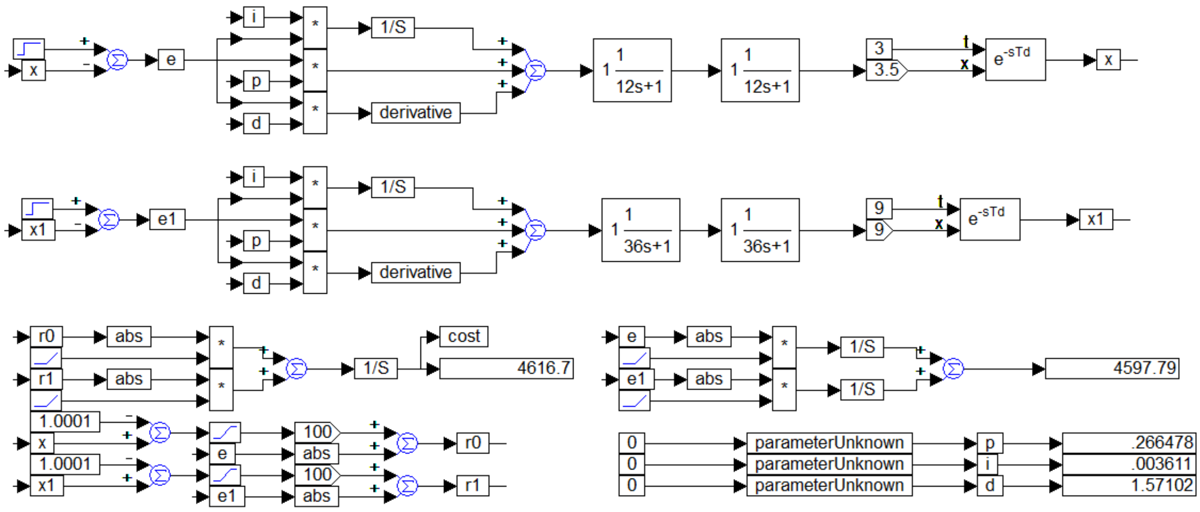

Figure 2. The modeling structure in program *VisSim* 6.0

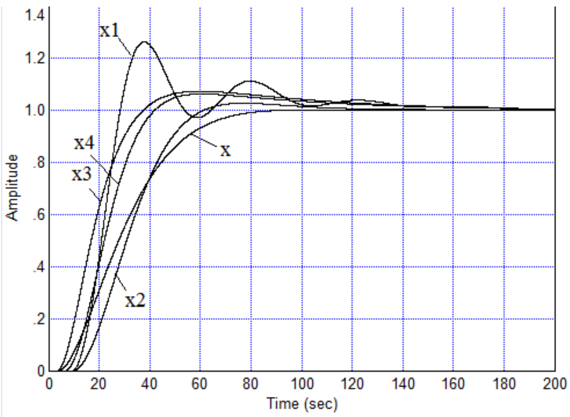

Figure 3. Transient process of the object (1) with the regulator on the quality criterion Ψ_1

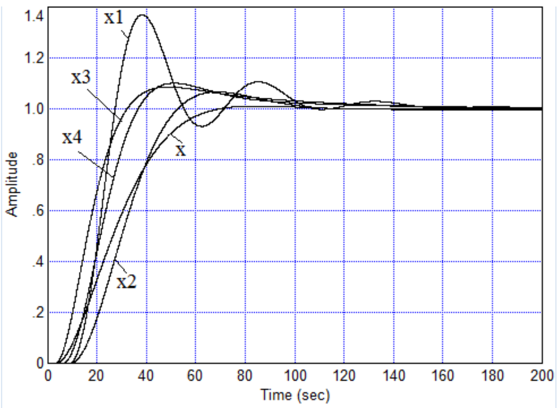

Figure 4. Transient process of the object (1) with the regulator on the quality criterion Ψ_2

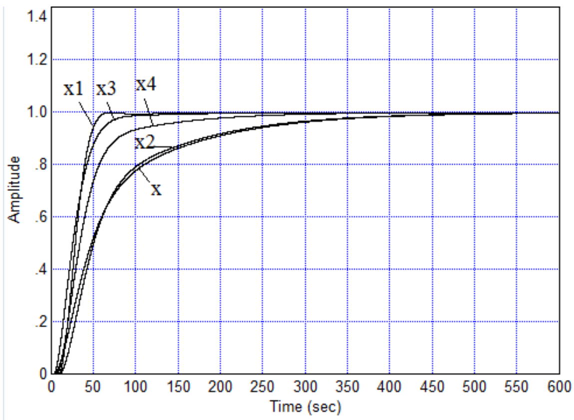

Figure 5. Transient process of the object (1) with the regulator on the quality criterion Ψ_3

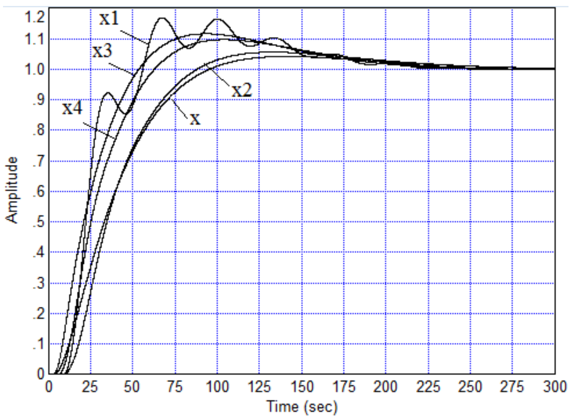

Figure 6. Transient process of the object (1) with the regulator on the method **DO-I**

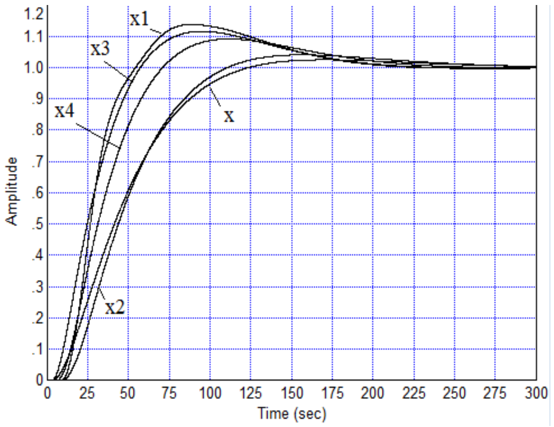

Figure 7. Transient process of the object (1) with the regulator on the method **DO-II**

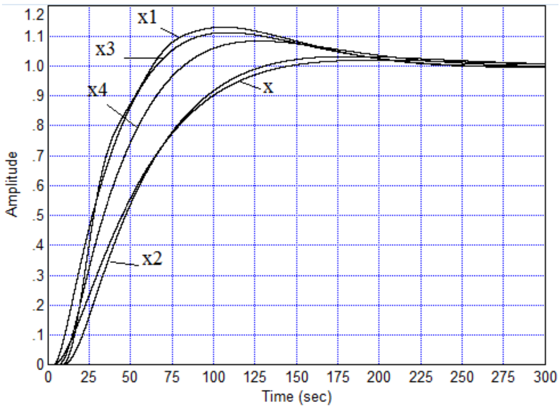

Figure 8. Transient process of the object (1) with the regulator on the method **DO-III**

With the unfavorable paramters combination, the transient responces can become unstable. Therefore, we should better to study all possible combinations. Since it is impossible, we should study the extreme meanings of them from the region of the allowable values, and their mean values.

6. THE BROADENING OF THE VARIANTS OF THE PARAMETERS COMBINATIONS

Let us consider all extreme variants of the object parameters, which are shown at *Table* 1. For the starting optimization we used parameters represented with variants x and x_1. In addition, it is useful to consider variants of the meaning of constant value C, corresponding to the overshooting from 0 to 20 %.

Simultaneous optimization of regulator for all possible combinations of object parameters is too time-consuming. Therefore, we propose at the first stage accomplishing of the optimization for the small amount of the extreme parameters values combination. After this, we choose the combinations, which most sensitively change its stability and the transient responces quality depending on the regulator tuning. We will use these combinations for the further iterative joint system regulator optimization.

Table 1. Variants of the combinations of object parameters

	x	x_1	y_{11}	y_{12}	y_{13}	y_{21}	y_{22}	y_{23}	y_{31}	y_{32}	y_{33}	y_{34}	y_4
k	3.5	9	3.5	3.5	9	9	9	3.5	3.5	3.5	9	9	6
T_d	3	9	3	9	3	9	3	9	3	9	9	3	6
T_1	12	36	12	12	12	12	36	36	36	12	12	12	24
T_2	12	36	36	12	12	36	36	36	36	36	12	36	24

Table 2 presents the results of PID-regulators optimization. *Figures* 3–6 present transient responces in objects with parameters combination x and x_1 from *Table* 1 and the resulting regulators calculated with the optimization in program *VisSim* 6.0.

Figures 9–14 show transient responces with different regulator calculated in the program *VisSim* 6.0. The following designations are used here: x: $k = 3.5$, $T_d = 3$, $T_1 = T_2 = 12$; x_1: $k = 9$, $T_d = 9$, $T_1 = T_2 = 36$, where x_i is the output signal of the system with varying parameters.

It is clear from *Figures* 9–14 that the system is stable withb extreme varying parameters. However, for the study of the robustness of the system, it is necessary to research its conduct with the peremeters deviations accordingly with the above said method. It is necessary to know the demands to the system for the choice of the best regulator on the base of the view of the transient process, which *Figures* 9–14 show.

Table 2. Regulator parameters

Cost function	PID-regulator parameters		
	K_p	K_I	K_D
Ψ_1	1.2098	0.0156	7.8468
Ψ_2	1.0273	0.0157	6.0002
Ψ_3(a)	0.2807	0.0025	1.9542
Ψ_3(b)	0.8876	0.0043	10.8686
Ψ_3(c)	1.0632	0.007	8.552
Ψ_3(d)	0.9104	0.0126	7.0024
Ψ_3(d, 6)	0.293	0.0044	1.563

In the case of the using of cost functions Ψ_1 and Ψ_2 the high speed of the system will be provised (transient process duration remains less then 180 *s*), but the overshooting achieves the value of 40 %. In the result of the use of cost function Ψ_3(a) the overshooting remains neglatively small, but the transient process duration achieves the value of 700 *s*. The cost functions Ψ_3(b) and Ψ_3(c) did not improved the result essencially, so the thrnsient response duration become 600 *s* and 400 *s*, respectively. The use of the cost function Ψ_3(d) allowed shortening of the transient responces to the velue of 200 *s* with the overshooting 20 %. Let the system with the parameters according to the cost function Ψ_3(d) satisfy the demads. Then the additional research is necessary to determine its robust features. *Figures* 15–18 shew transient responces of the system with the regulator according the cost function Ψ_3(d) with the deviated parameters.

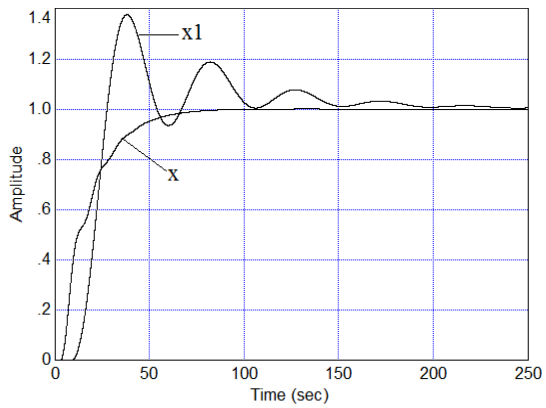

Figure 9. Transient responces of the system with the regulator according to cost function Ψ_1

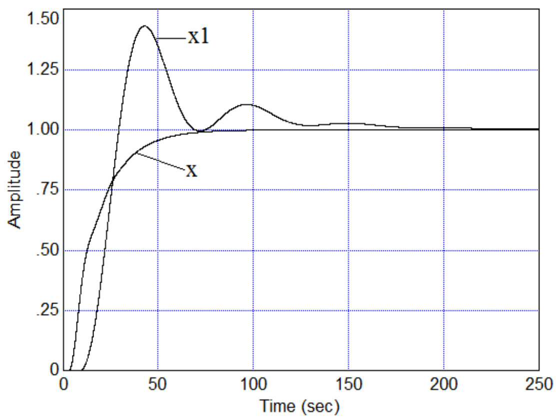

Figure 10. Transient responces of the system with the regulator according to cost function Ψ_2

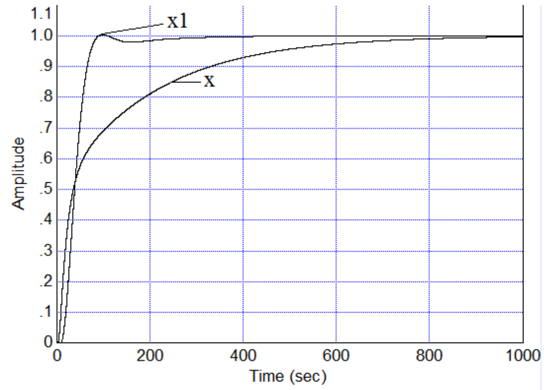

Figure 11. Transient responces of the system with the regulator according to cost function Ψ_3(a)

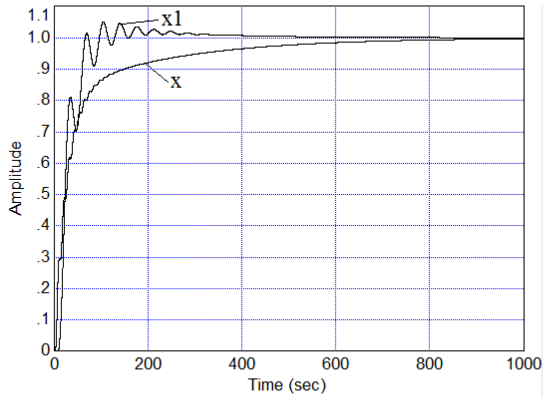

Figure 12. Transient responces of the system with the regulator according to cost function Ψ_3(b)

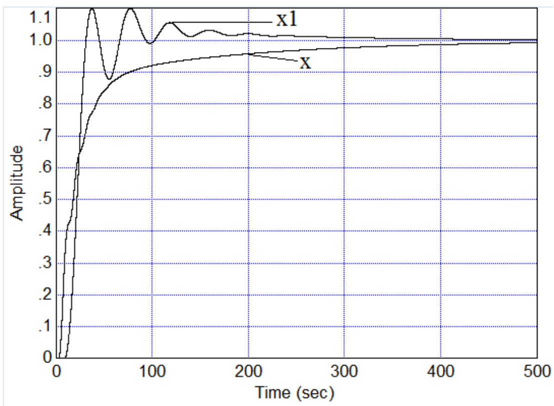

Figure 13. Transient responces of the system with the regulator according to cost function Ψ_3(c)

It is clear from *Figures* 15–17, that the system becomes unstable for the combinations of the parameters y_{12}, y_{13}, y_{21} and y_{33}. Hence given regulator is not robust, therefore object combination should be extanded with parameter combinations which distroyed the system stability.

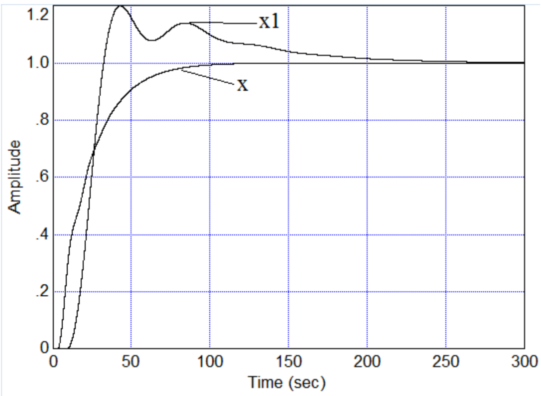

Figure 14. Transient responces of the system with the regulator according to cost function Ψ_3(r)

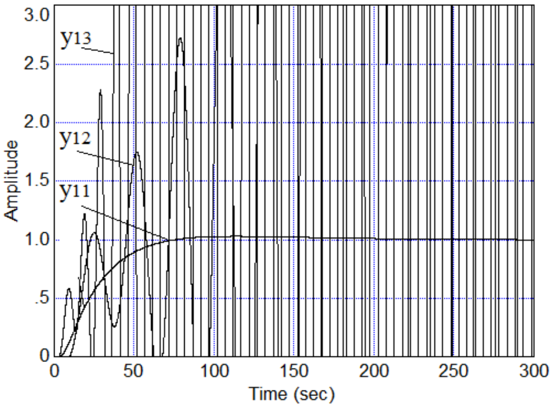

Figure 15. Transient responces of the system with the regulator according to cost function Ψ_3(d)

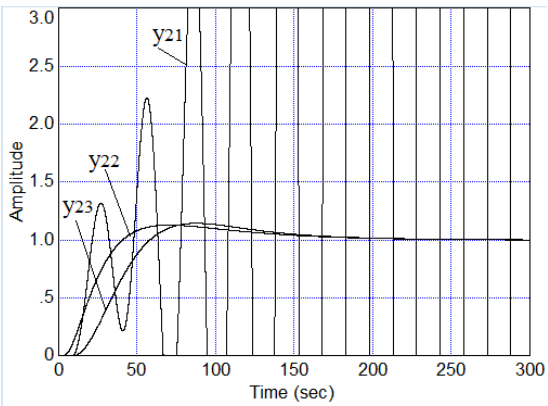

Figure 16. Transient responces of the system with the regulator according to cost function Ψ_3(d)

Then we add to the modeling structure systems with the objects having these critical combinations of the parameters. We will use cost function Ψ_3(d, 6), i. e. Citerion with the allowed overshooting 20% and with simultaneouse modelling of 6 systems with 6 parameters combinations. We have gotten the new regulator optimization result (see the last line in the *Table* 2).

We have gotten the six combinations of object parameters with the addition of four revealed problem combinations to the initial two combinations. *Figure* 18 shows graphs of the thransient esponces with the calculated regulator.

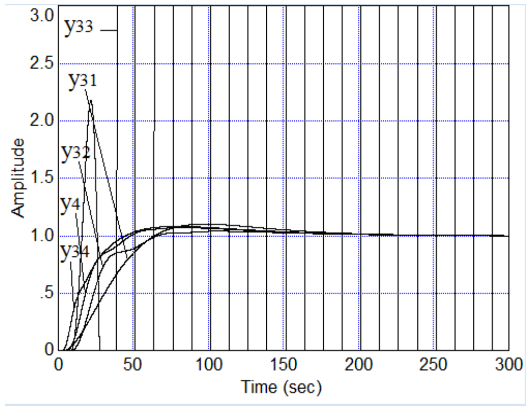

Figure 17. Transient responces of the system with the regulator according to cost function Ψ_3(d)

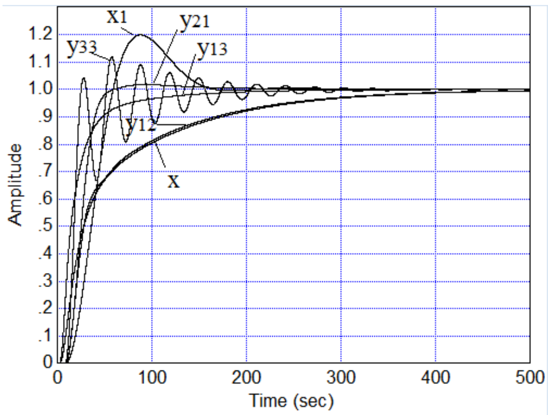

Figure 18. Transient responces of the system with the regulator according to cost function Ψ_3(d), specified by the six parallel models of the object, i.e. bu the cost function Ψ_3(d, 6)

7. FURTHER RESEARCH AND FURTHER OPTIMIZATION

Figure 18 shows transient responces with only five variants of object parameters combinations. Really there are more such combinations. *Table* 1 gives 13 variants, where the last one is combination of mean values of each parameter, and the first 12 variants are the combinations of the edge values.

It is useful to resolve the question about the representativity of the presented set regarding that the amount of the possible combinations is unlimited.

It is reasonable that the conrete values of the time constants of minimally-phase part of object model are not such important as their sum is. That is instead the taking into account of the each values T_1 and T_2 it is possible to use only their sum. This assumption demands its testing. As well it is usable to clarify whether the overshooting can be decreased.

We propose the follosing method of the stated tasks resolving.

1. Modeling of the systems with all variants of the combinations of the edge values of the parameters. The combinations of the parameters are presented in the *Table* 3.

2. Then we will add to these variant the combination containing mean values of all time constants (see coloumn PB in *Table* 3) and compare this result with the result of the modeling with the the same value of their sum, when one of these values is maximal, and the other on is minimal (coloumn DB).

3. For the representativity we combine the four curves in figures, the numbers of the corresponding figures are given in the line marked *"Fig"* in *Table* 3, the correspondence of the colour and parameters combination is indicated in the colouns of the *Table* 3 (R – red, DB – dark blue, PB – pale blue, B – black).

4. The results of the modeling are shown at *Figures* 19–23.

Table 3. Parameters of the objects to *Figures* 19–26

	R	DB	PB	B	R	DB	PB	B
k	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
T_d	3	3	3	3	9	9	9	9
T_1	12	12	24	36	12	12	24	36
T_2	12	36	24	36	12	36	24	36
Fig.	19, 23				20, 24			
k	9	9	9	9	9	9	9	9
T_d	3	3	3	3	9	9	9	9
T_1	12	12	24	36	12	12	24	36
T_2	12	36	24	36	12	36	24	36
Fig.	21, 25				22, 26			

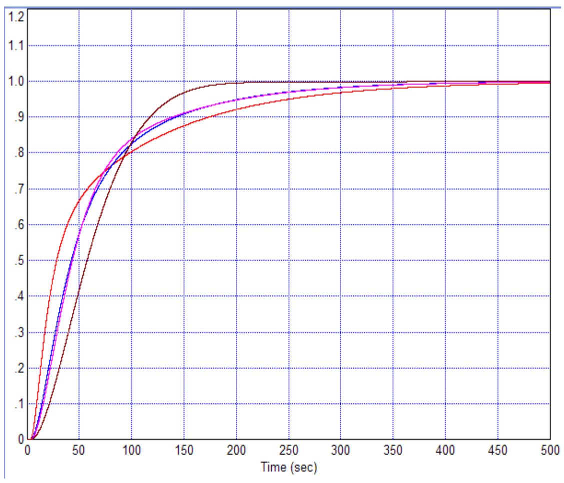

Figure 19. Transient responces of the object with regulator Ψ_3(d, 6) and parameters from *Table* 3

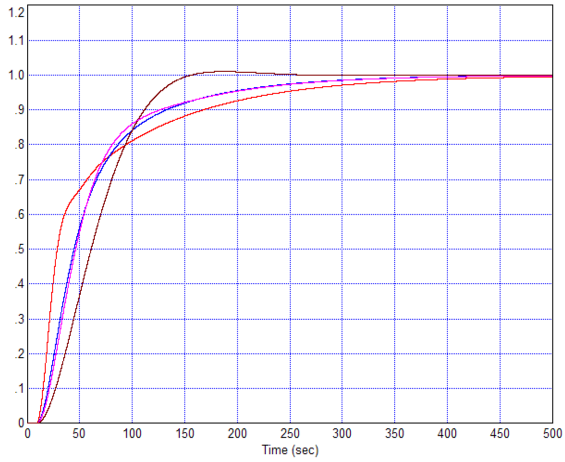

Figure 20. Transient responces of the object with regulator Ψ_3(d, 6) and parameters from *Table* 3

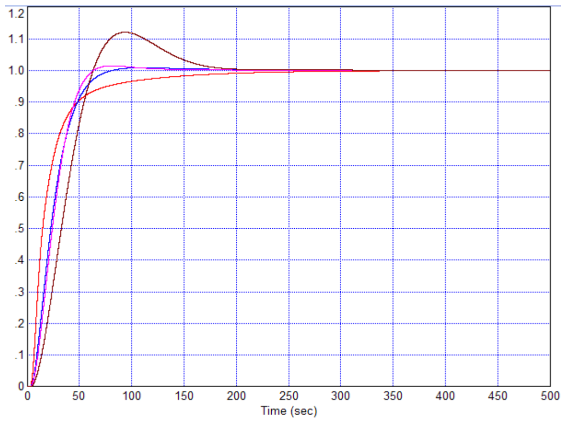

Figure 21. Transient responces of the object with regulator Ψ_3(d, 6) and parameters from *Table* 3

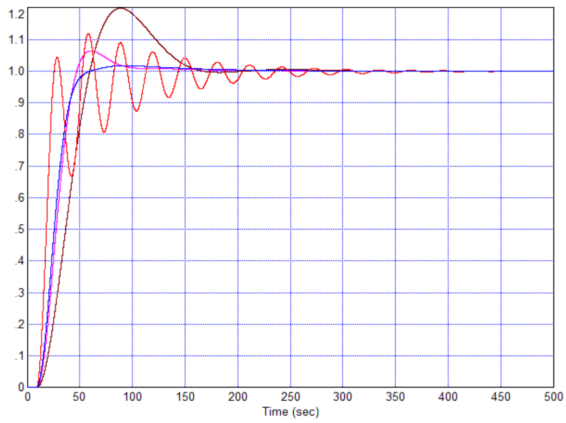

Figure 22. Transient responces of the object with regulator Ψ_3(d, 6) and parameters from *Table* 3

From the analisys of the *Figure* 19–22 we can make the following summary:

1. The assumption that the sum of time constants T_1 and T_2 is most important was confirmed; the according curves join together almost everywhere exept *Figure* 22, where pale blue curve has overshooting about 5%, and dark blue curve had overshooting less then 1%.

2. The most dangerous from the point of view of the stability loss are parameter combinations

shown at *Figure* 22 with black and red curves. These parameters combinations are charecterised with maximal delay and gain and extreme sum of time constants of minimally-phased parts of the object model. In the only case the overshooting achieves the value about 20% (*Figure* 22).

3. The less speed is with the less gain of object (*Figures* 19–20).

At these foundations it can be proposed decreasing of the overshooting, for example, to the value 5–15 %. At that for the final regulators desigh it is usable the following actions:

1. To prescribe into critarion (6) according value of constant C = 1.05 or C = 1.15.

2. To use only most unfovarable combination of the object parameters, namely: maximal gain and delay and edge values of the sum of T_1 and T_2.

3. To provide searching of the coefficients in the restricted field (and to prevent the fatal error caused by excessive increasing of some coefficient) it is usable to introduce to the cost function the additional term, which becomes big in the case of impossible big regulator coeffitient. With this aim we use non linear units as "dead band" with border values ± 20, sequenctly affiliated rectifier ans accumulator with big gain (100); the result is added under the integral, calculater function (5). In thes case we get the new functiuon:

$$\Psi_4 = \int_0^T \left[|r_1(t)|t + |r_2(t)|t + q \right] dt \quad , (7)$$

$$q = R(k_P) + R(k_I) + R(k_D) \quad , (8)$$

$$R(k_N) = 100 \max\{|k_N| - 100, 0\} \quad . (9)$$

The structure of optimization in program *VisSim* is shown at *Figure* 23. The result of final optimization of the regulator is shown at *Table* 4. Transien processes are shown at *Figures* 24–27.

Table 4. Final parameters of the regulator

Cost function	PID-regulator parameters		
	K_p	K_I	K_D
Ψ_4	0.275	0.00374	1.461

On the base of the results it can be made the following summary:

1. The decrease of the overshooting less then 15 % is provided for all combinations of the edge values of object parameters with the use of regulator from *Table* 4.

2. The using of only two models of objects (after the revealing of the most critical combination of parameters) turned out sufficient for the getting of the sure result.

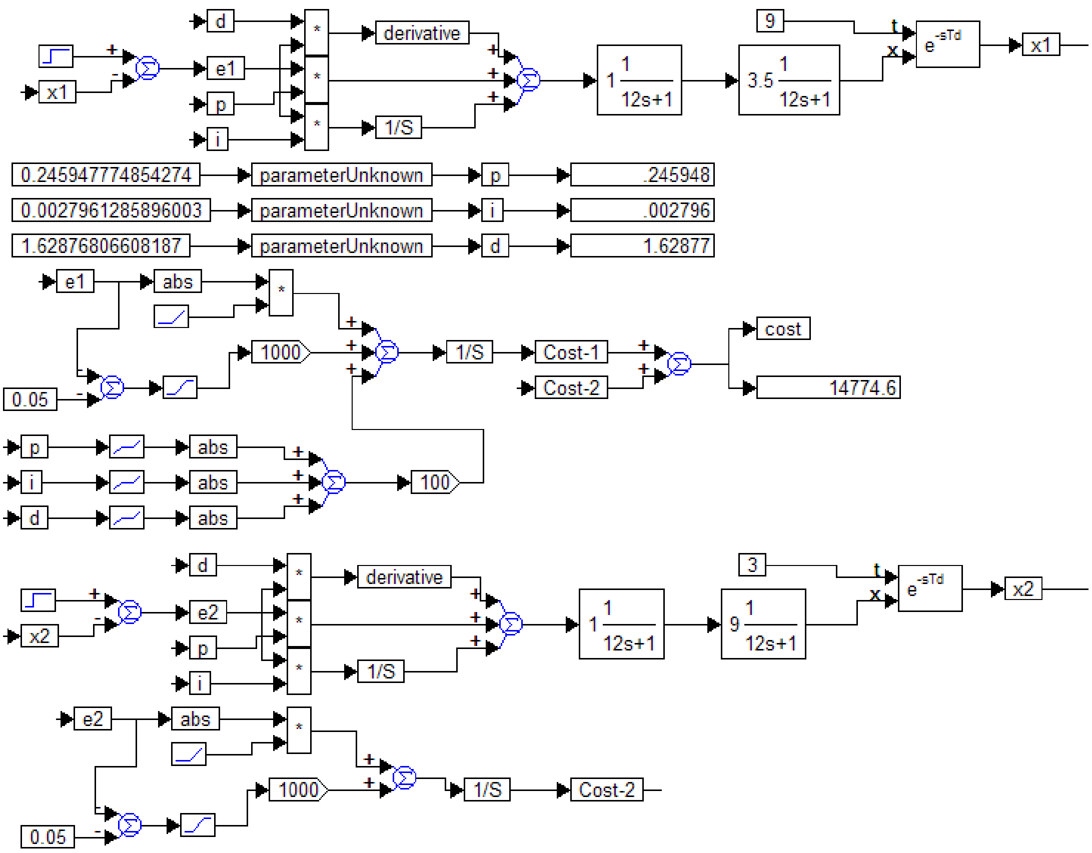

Figure 23. The structure of the numerical regulator optimization with the cost function Ψ_4

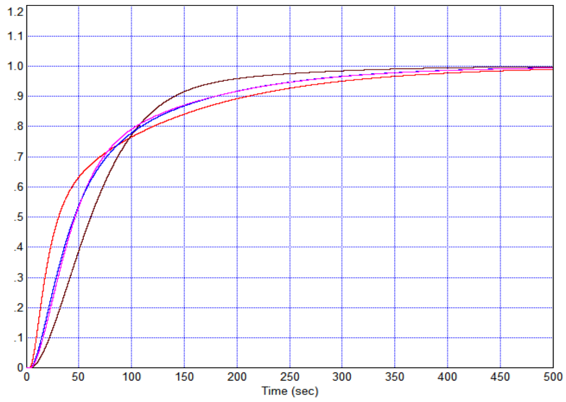

Figure 24. Transient responses of the object with parameters fron *Table* 3 and regulator Ψ_4 (*Table* 4)

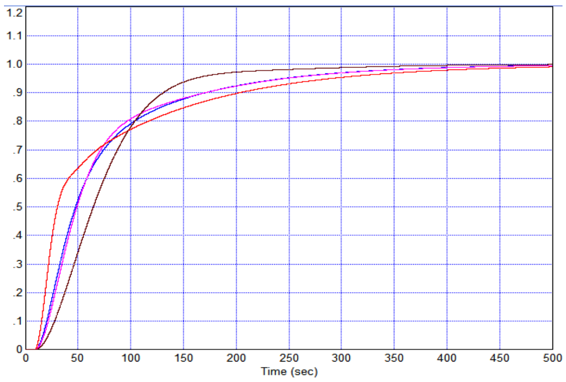

Figure 25. Transient responses of the object with parameters fron *Table* 3 and regulator Ψ_3(d, 6)

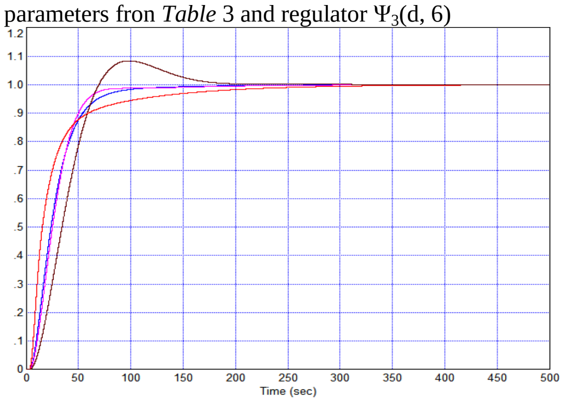

Figure 26. Transient responses of the object with parameters fron *Table* 3 and regulator Ψ_3(d, 6)

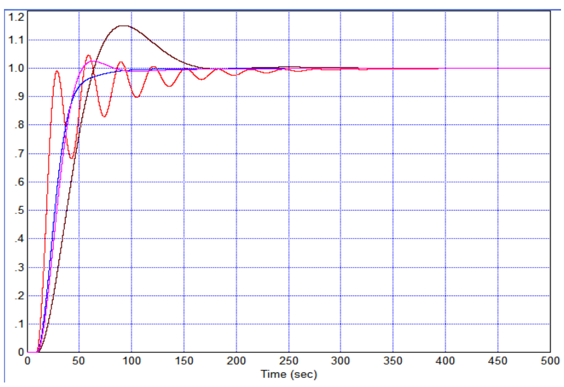

Figure 27. Transient responses of the object with parameters fron *Table* 3 and regulator Ψ_3(d, 6)

CONCLUSION

Finding of the critical combination of the object parameters with the including them to the ensemble of objects, used for the optimizationof the common regulator, gives the method of numerical optimization for the calculation of robust regulator, providing astatic control with overshooting more then 15 % and minimal duration of transient process under these conditions (400 *s*).

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Radio Frequency Method for the Measuring of Supersmall Displacements and Vibrations

V. Zhmud, D. Tereshkin, A. Liapidevskiy, A. Zakharov

***Abstract*: The paper discribes the measuring device which can be used in geodesy, building and systems of control of the state of complex engeneering structures, such as: hydroelectric power stations, dams, bridges and others for the high-presision non-invasive measurings.**

***Key words*: displacements measuring, vibrations measuring.**

INTRODUCTION

Methods based on the known velocity of the optical waves or radiofrequency waves are used for the non-invasive measurings of small displacements and vibrations. Optical devices, laser ones as a rule, has the highest accuracy. But they demand straight visibility of the object and the absence of optical disturbances, including overfalls of humidity or pressure, creating diffractive heterogeneities. Radiofrequency measurers as a rule have the worse accuracy, but have bigger measuring distance. They also have higher sensibility to the reflective features of the object and to its shape. They accuracy more strongly depend on the conductivity of the surrounding things. The accomplished analisys showed the significant advantage of the radiofrequency measurers for the goals of contonuouse monitoring of small displacements and vibrations in natural conditions. But the experiments with the first models of such devices allowed achieving the desired accuracy of measurings. In this connection the paper proposes and analyses the improved methods and devices for the measurements of super small displacements and vibrations with radiofrequency way out-of-doors at the distances more then 1 *km*.

1. THE ANALOGES AND PROTOTYPES DISCUSS

Measuring devices transforms the measuring linear displacement into time intervals of delay of the reflected signal, which is further measured with electronic means – measurers of time durations or phase differences. Disadvantage of optical measuring devices when used out-of-doors is the strong dependence of the accuracy on the meteorological conditions, having influence upon the optical waves spread in the air. Another disadvantage is the necessity of straight optical visibility between the radiation source and receiver. The disadvantage of optical measuring devices is the complexity of the constructing of the source of narrow-directed radiation sources and reflectors and the complexity of the tuning of such devices. Another disadvantage is the accruing of disturbances from the exterior objects which in some cases can't be eliminated.

The resolving of the task of continuous monitoring of the state of complex engeneering structures, such as dams, can be acheved with simultaneouse using of the all types of measurers. At that the optical measurer can be used for the control along the optical paths, provided with initial projecting and laid inside the construction.

The dependence of the measuring result on the athmosphere stste was seldom discussed in literature, but this disadvantage is essensial for the otpical measurers. Let consider the optical linear displacement measurer which structure is shown at *Figure* 1 [1]. In this measurer the radiation from the source goes through the transmitting optical system to the radiation spreading medium, where it spreads to the object and backward to the optical system. The photo detector transfloms the optical signal to the electrical one, which goes to the processing mean. There the relations of the phasesm frequencies or other parameters of the resieved signal are determined. On this base the calculating mean determines the distance from the measurer to the object. The optical radiation spends some time to pass the distance in the medium in the straight and back direction due to the restricted velocity of the light spread in the medium. The measuring of this delay allows measuring of the distance to the object. For the measuring of this delay the comparing with the signal, which arrived the same or additional receiver escaping the moving to the object and backward, can be used. Otherwise, the signal spreading from the object and backward can contain several modulation frequencies. The same delay in the signald on the different frequencies produces different phase shifts in the received signals, which allows calculation of the delay time. The processing mean accomplishes this calculation, and the calculation mean transforms it to the signals in the form convenient for the perception by the human of registering device.

Disadvantage of this measurer is dependence of the measuring result on the meteorological state, sich as pressure and temterature, changing the light velocity in the mediun as an air, which decreases the measuring accuracy. Another disadvantage is the necessity of the straight optical visibility on the all measuring length between transmissing and receaving systems.

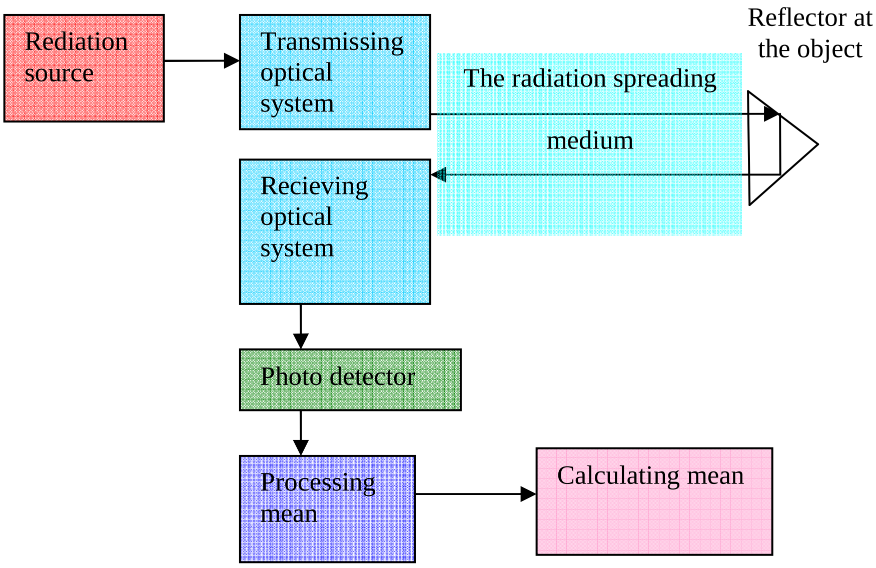

Figure 1. Generalized structure of optical displacement and vibrations measurer [1]

Radiofrequency measurer ideally can be fastened to the controlled parts of the construction and used without further tuning in the twenty-four-hour regime. Such device will find wide application provided measuring accuracy 1 *mm* at the distances more then 1 *km*. In this case it will surpass the optical devices with technical characteristics and the serviceability.

Let consider, for example, linear displacements measurer, which structure is shown at *Figure* 2 [2].

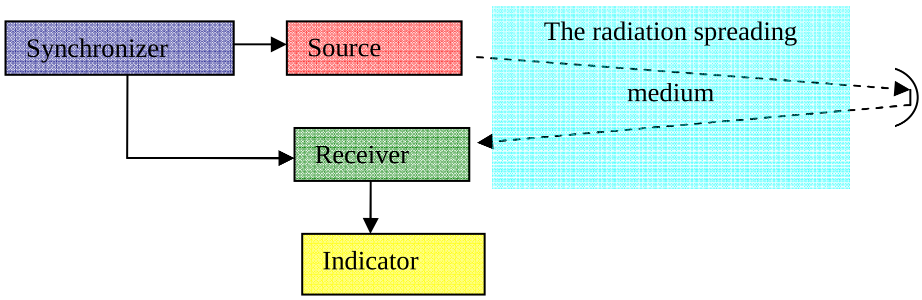

Figure 2. Generalized structure of radiofrequency displacement measurer [2]

The working of this linear displacements measurer is the following. Synchronizer forms synchronized signals to the inputs of the source and receiver of the electromagnetic waves. The source initiated with signal of synchronizer sends from its antenna signal which part is reflected by object and goes to the receiver antenna. The time of the arrival of this signal to the receiver is compared with the time of the arrival of signal of synchronizer. The displacement to the object is determined on the base of delay of the reflected signal relatively synchronizer signal ΔT, it is equal to the product of spreading velocity of the location signal V to the delay ΔT. The result of the measuring is represented at the indicator. In that way the distance between the device and the object is determined.

The disadvantage of this device is low accuracy of measuring resulting from using of radiofrequency signal reflected from the complex form object, which produces the disturbansies of the reflectrd signal form. The using of the special reflector is very complicated and not sufficiently effective because of the antipathy of the demands of narrow-directed action and low phase disturbansies.

Figure 3 demonstrates the structure of other radiofrequency displacements measurer, developed and recearched by us, which is the prototype of the proposed in this paper device [3]. Further at all figures the medium is not shown, because it is clear thet is present.

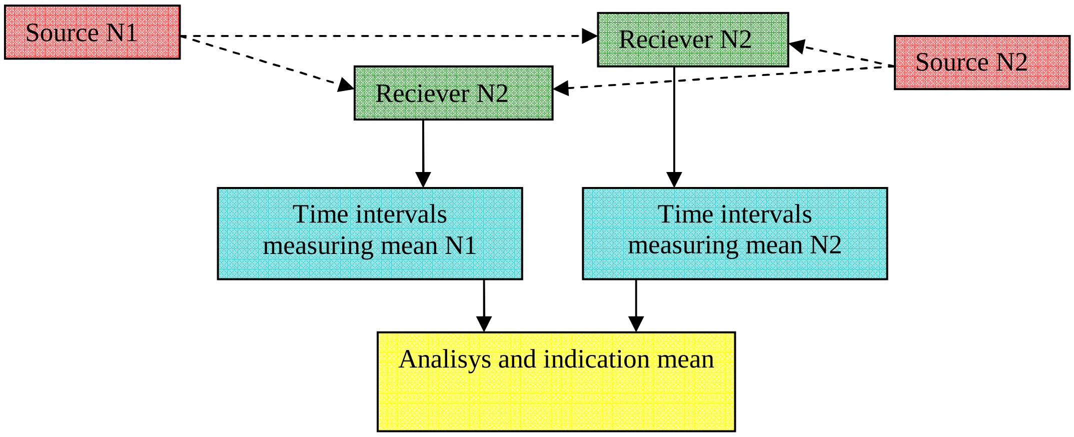

Figure 3. Radiofrequency displacement measurer [3]

The working of this linear displacements measurer is the following. The sources emmit readio signals, which can be easily distinguished from each other. At that each signal contains periodically incipient time indicator, or phase sign of the inner oscillator of tome standard. Each receiver perceives each source signal, distinguishing them by their typical features. Conceivably, such feature is leading frequency. The received signals together with their time indicators go to the time intervals measuring means. Each of these means determines the diference between the moments of these indicators. Let denote the time of the time indicator in the signal from the source with the number *N* at receiver with number *M* as t_{NM}. If the sources and receivers are pleced along the straight line from the first source to the second one, then the diference of the time moments of the time indicators $\Delta t = (t_{11} - t_{21}) - (t_{21} - t_{22})$ is proportional the displacement between the receivers.

This defference depends only on the required displacement between the receivers and on the wave velocity in medium. It allows calculating the value of the required diaplacement without using of signal reflectors.

In this way, the device allows measuring between the antennas of the two receivers. As long as the device does not use the reflector of the electromagnetic waves in radiofrequency range, it simplifies its construction, decreases its price and removes the dependence of the measuring result on the reflector quality. It allows increasing of the measuring accuracy. In the result the simplification of the device and its accuracy increasing is achieved.

The second source is transponderof the first cource signal, working on the different leading frequency. In this case the time indicator in each signal can be any mark in the similar envelope signal. At that the both receivers contain two selector channels, two demodulators and differential phasemeter as a time interval measuring mean.

The disadvantage of the above prototype is not sufficient accuracy due to the different contribution of the different recieving channels, because each receiver accipmlishes the signals reception at the twodifferent leading frequencies. Therefore for the receiving of the signals from the different sources the different electronic channes are used. They contain selectory channels, narrow-band filters, amplifiers and other units, tuned to the different frequencies. The delays of signals in these units can eccentially differ, and these differences change during time and dependently on the temperature and other outer factors.

Figure 4 shows the example of the radio receiving channel of the displacements measurer. As a rule, heterodyne oscillator is used in such channel, whose frequency is tuned to the received signal leading frequency. It allows increase the system sensivity. At that the phase of the processed signal depends not only on the phase of the received signal, but also on the phase of the heterodyne oscillator. Since in each receiving channel at the different leading frequencies the different heterodyne oscillators are used, then their phases are not equal. It introduces the additional error to the result of the measurings. Thus the further accuracy increasing demands the rejecting of this error source.

2. THE PROPOSED DEVICE AND THE PRONCIPLE OF ITS ACTION

Cardinal decision of the given problem can be achieved only in the case, if for the receiving of the two signals from the two sources the same receiving channel is used, which is possible only in the case of using of the same leading frequency. But in this case the distinguishing of the signals from the different sources is difficult. For the decision of this problem we propose to realize such modulation which keeps its time indicators even when two different signals are mixed.

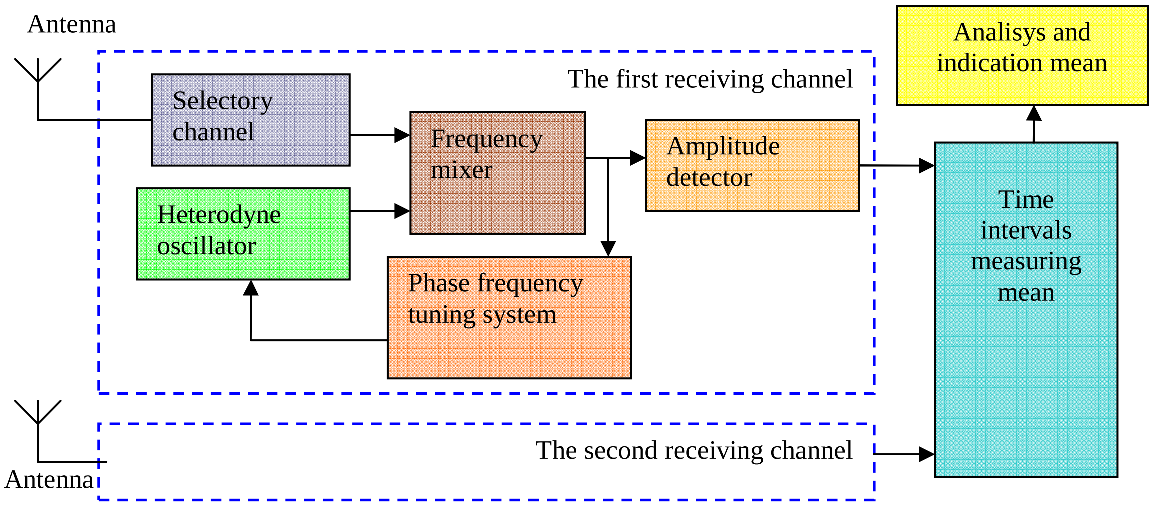

Figure 4. The example of the radio receiving channel of the displacements measurer [3]

The structure of proposed measurer is shown at *Figure* 5. The stated task is resolved with the using of the same frequency at the both sources, and the possibility of the distinguishing of the received signals is provided with the using of unique modulatory functions in each of the two sources.

The working of the proposed linear displacements measurer is the following. The sources radiate signals at the same leading frequency, but with the different modulatory functions. Each from the two modulatory functions (MF) is formed as time function at the output of each according generator. Each MF contains periodically arising time indicators (TI) from builted or outer generator of time standard. These generators acts to the inputs of the radiation sources causing the different but easily distinguishing modulation of the radiating signals, whos leading frequency is the same. These signals cam be received with detectors only together as a sum with the coefficients and delays depending on the distance between the sources and the receivers. In the received mixture of these signals it is necessary to distinguish the specific time indicators from each other. For this effect special methods are necessary realized with the specialized devices containing in each processing channel in the output of the receivers. Preliminary accepted by receiver signal is converted to the digital consistency of its values with the helps of analog-digital converter (ADC). Since the receiving of the mixture is accomplished with the same channel in each receiver then the including delays are the same for the both signals in the each one of the receivers. Therefore no changing of the delay in these channels including delays in ADC will make include to the difference between the characteric time indicators from the difference sources. Further processing of the signals is accomplished by digital way; therefore each included during the signal processing delay can be accurately defined and considered in the calculation of the final result of the difference between the times of the reception of the time indicators from the first and the second sources.

For this goal the time indicator distinguishing means are used shown at *Figure* 6. These time indicator distinguishing means средства discover separately time indicators of the two components. Their work is the following. There is generator in each channel, which forms output signal, changin during the time, which is the accurate copy of the corresponding modulatory function. But the time of the biginning of this signal can be controle by the outer signal.

Output signal from this generator arrives at the first input of the correlator, and signal from the time indicator distinguishing mean arrives at the secont input of it. The extreme tuning mean analyses output signal of the correlator. On the base of this analisys it changes the time of the start of generator to maximalize the correlator output signal. In the result of the action of this extreme tuning mean the oscillator becomes sinchronousely tuned to the component with the same form, which is contained in the input signal of the time indicator distinguishing mean. Therefore the gerenator outpus signal can be used as the source of the signal containing time indicator in the best way tuned to the corresponding component in the received signal. The time indicator distinguishing mean can has one or two outputs. It it has on output, then some given sign of the output signal, for example the forward front of the pulse, marks the moment of the appearance of the time indicator in the signal from the first source. And some another sign of the output signal, for example the faling adge of the pulse, marks the moment of the appearance of the time indicator in the signal from the second source.

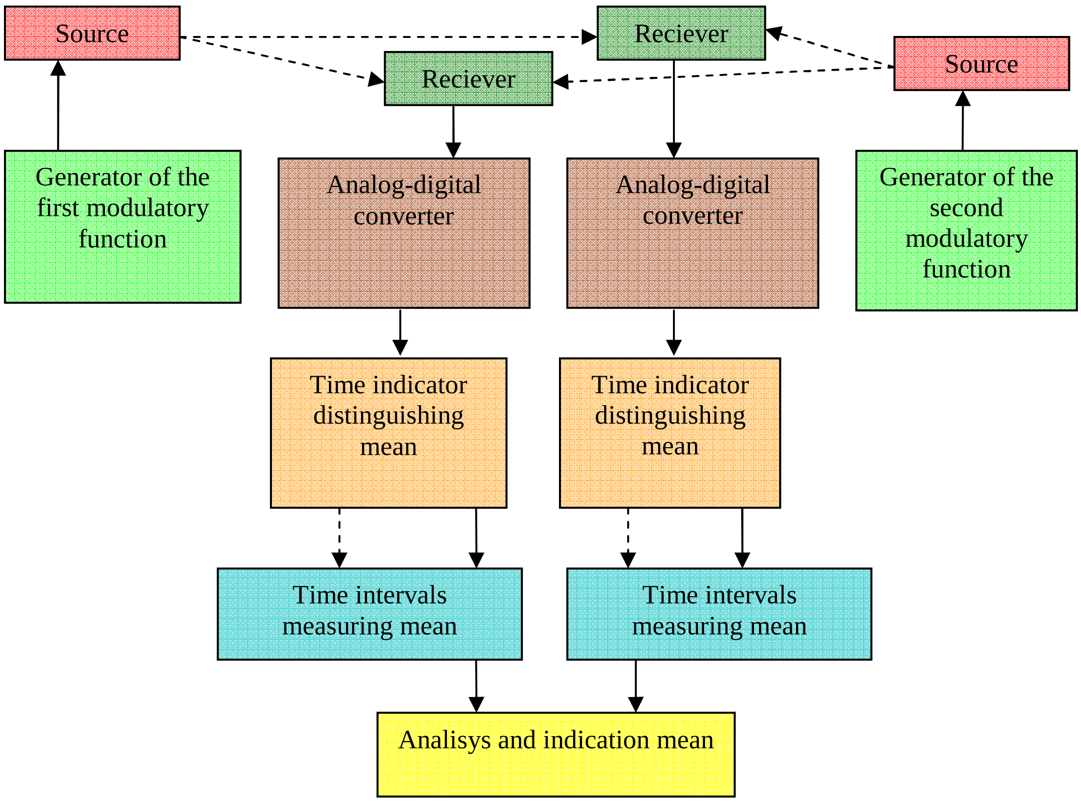

Figure 5. The structure of the proposed displacements measurer

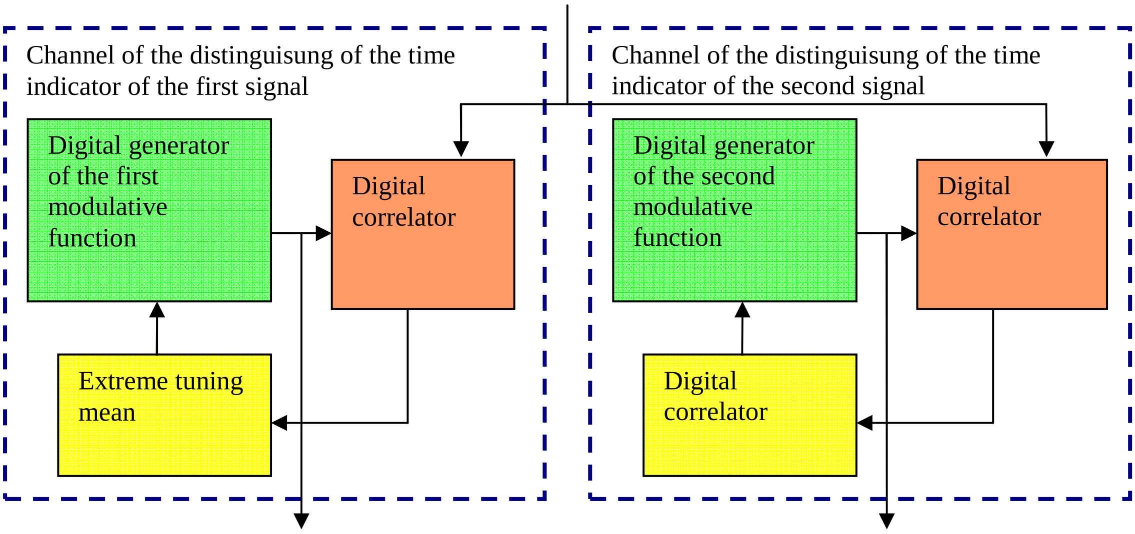

Figure 6. The structure of the proposed time indicator distinguishing mean

As well the time indicator distinguishing mean can have two outputs. In this case at the first output the defined sign, for example, the front of the pulse, marks the moment of the appearance of the time indicator in the signal from the first source, and the similar sign at the second output marks the moment of the appearance of the time indicator in the signal from the second source.

The practical realization of this device can be made on the base of the fast microprocessor with the corresponding program or on the base of specialized digital calculating device on based on the PLA. Phase meters or time counters can be used as the time interval measuring means, as in the prototype under the stipulation that, they provide the demanded accuracy. Personal computer provided with the corresponding communication means and program for the signal processing can be used as the analisys and indication mean. The signal sources can be made as traditional radio transmitters using amplitude, phase or other modulation. At that any or each source can contain channel of the automatic tuning of leading frequency to the outher frequency or its divisible part by means of the traditional phase feedback controling loop. It allows providing of the precise equality of the leading frequencies, which provide the precise equality of the time delays introduced by the all analog elements of the recievers. Generators of each modulative function can be made as sequentely switched former of fixed digital succession and digital-analog converter.

Thus, owing to the unicity of the channel of nalog signal processing (from antenna of the resiever to the input of digital-analog converter) and the using of digital processing by the time indicator distinguishing mean, the error produced in the prototype due to the inequality of the delays in the different analog processing channels is excluded. In the result the accuracy of the measuring increases.

3. PRACTICAL REALIZATION OF THE PROPOSED DEVICE

Figure 7 shows the functional structure of each receiver of the radio signals with the following channel of the processing of the signal mixture. Serial receiver, which contains antenna with the amplifier, quadrature-balance demodulator, heterodyne oscillator, forming coherent and quadrature components, ADC and heterodyne frequency controlling loop, can be used for the realization of this device. The original firmware is only signals processing mean, containing two time indicator distinguishing means and digital phase meter.

The Method of the qualitatively different envelopes. *Figure* 8 shows the example of the two kinds of amplitude modulations of the sighals. Each modulation provides the moduladed signal with the time indicator. The upper signal has modulation with triangular pulces, the the bottom signal has rectangular pulced modulation. The durations of the modulation periods are related as prime or even irrational number, the leasing frequency is the same. Together with the using of the correlator or instead of it other methods of the signal processing can be used. For example, the moment of the achievement of the maximum and minimum by the signal with the triangular modulation can be determined with the maximum-likelihood method. The same situation is with the determination of the moments of the front and faling adge of the envelope of the signal with the rectangular modulation.

Figure 9 shows the result of summing of signals, shown at *Figure* 8, and also results of the detecting of this signal separately with the coherent and quadrature heterodyne oscillators, which are shown with the different colours. The result of the summing of the two bottom signals is shown at *Figure* 10. The time indicators of the both initial signals can be distinguished separately in this signal. The moment of the sharp amplitude changing corresponds to the front or faling adge of the modulative rectangular signal (i.e. it contains the time indicators of the signal from the secont source) the moment of the envelope break contains the time indicators of the signal from the first source. This method can be named as Method of the qualitatively different envelopes.

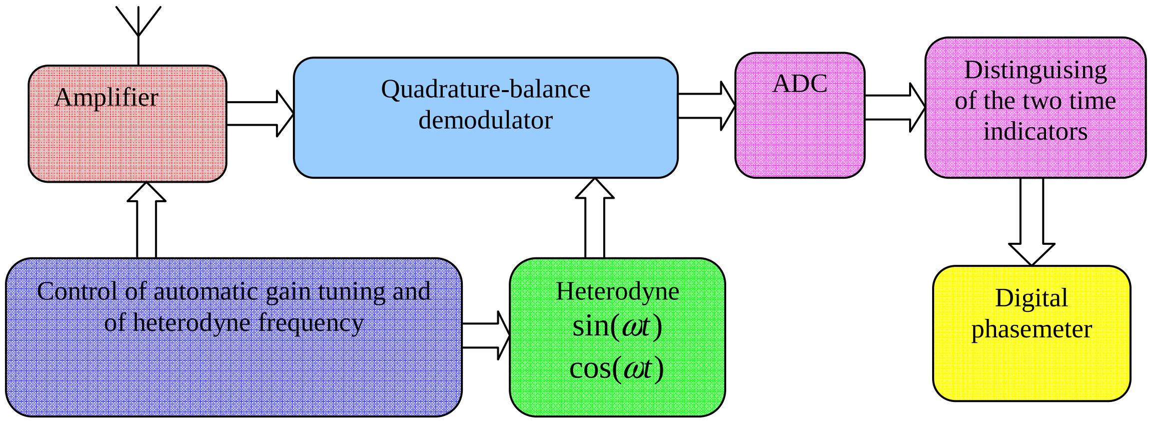

Рис 7. Functional structure of the receiver of the radio signals mixture

The Method of alternating silence. *Figure* 11 shows the couple of signals formed under the method, which can be names as alternating silence method. In this case the transmitting periods are taken turns with the silence periods. At thet the transmitting and silence periods of the different sources are such, that with any phase shifts between these signals there are surely intervals at which only first cource signal is present, and also there are intervals, where only signals from the second source are present. It is provided with the choice of the repeating periods, which are related as aliquant ratio, and with the choice of the signals durations. The irrational relation, for example number "π" or "e", allows providing the accuracy encreasing owing to the averaging tima increasing and to the accumulating of the statistical detecting signal.

Figure 12 shows the signals, obtained in the result of the coherent and quadrature demoidulation of the sum of the signals shown at *Figure* 11. It is seen that in the obtained signals there can be pointed up the intervals duiring which the both signals are absent, and the intervals on which at least on signal exixts. It is obviouse, that, as a rule, in the bigining only on of the signals appears, further the interval with the both signals follows, and at the following interval only the second singal exists. Even if such order become broken from time to time, the situation can be easily distinguished owing to the typical preliminary known form and aliquant duration of the first and the second signals.

Method of periodical phase inversion. Instead of the periodical silence the periodical phase inversion of the signal can be used. *Figure* 13 shows according signals of the transmitter. The period of the inversion is the typical indicator of the given transmitter. The inversion periods has relation as irrational numbers. The phase meter determines the phase of the received signal. At that the measured phase difference is changed with the jumps in the different time moments corresponding to the phase changing times at the first and at the second transmitters. On the base of the typical period of the each jump during the secondary signal processing it is possible to determine the indicators of the first or of the second transmitter. It can serve as uindicator of time (and indicator of the delay) from each transmitter separately.

The Method of the combination of the modulation types. The essence of this method is the complex simultaneous using of several modulation methods for more sure revelation of its indicators. For example, for the signals accordingly the metod of qualitatively different envelopes it can be proposed the additional step amplitude and (or) phase modulation for the first and (or) the second signal. For example, signal with the triangular envelope can change the phase of the leading frequency to 180 grades at the moment of the achievement of the sero level by the envelope. At thet the signal with the rectangular envelope after the silent period can change the leading frequency phase to the velue of 90 grades. Also the phase modulation can be used for only one of these two signals.

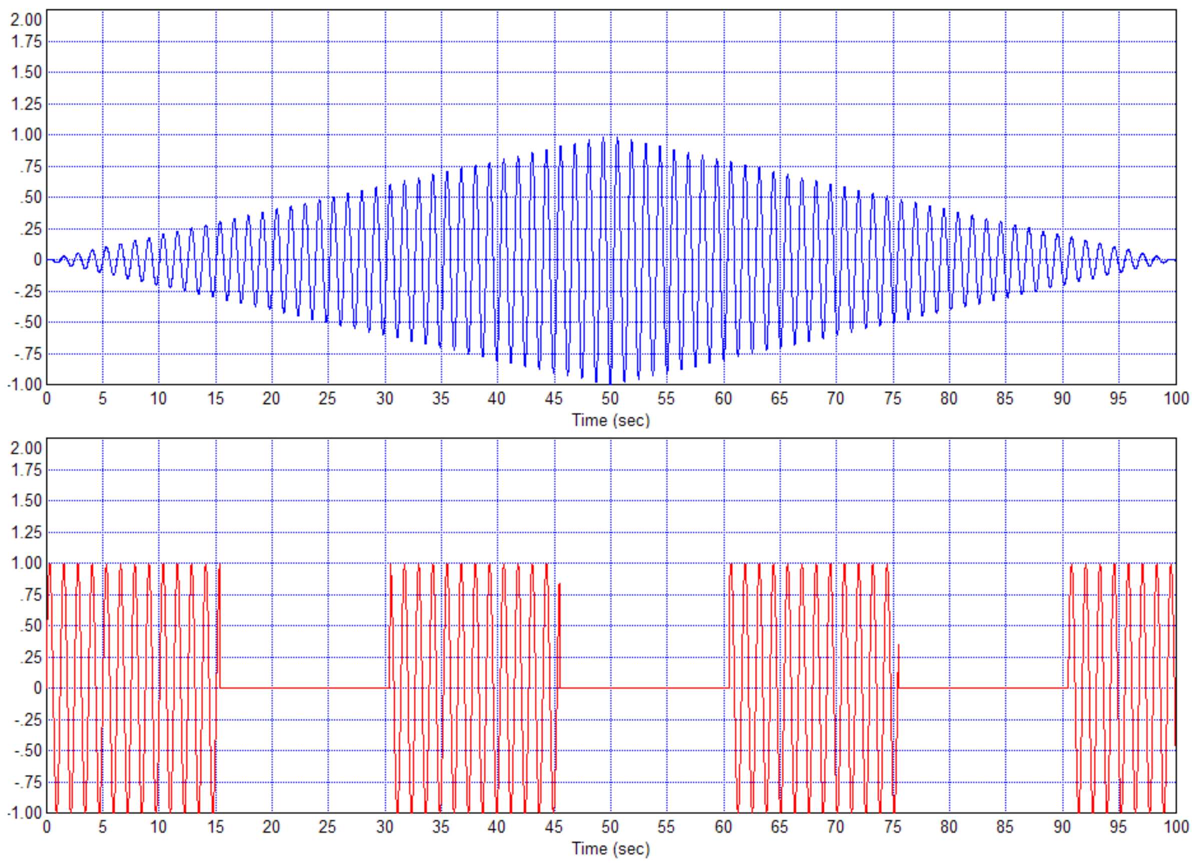

Figure 8. The example of the two types of the modulation providing the time indicators

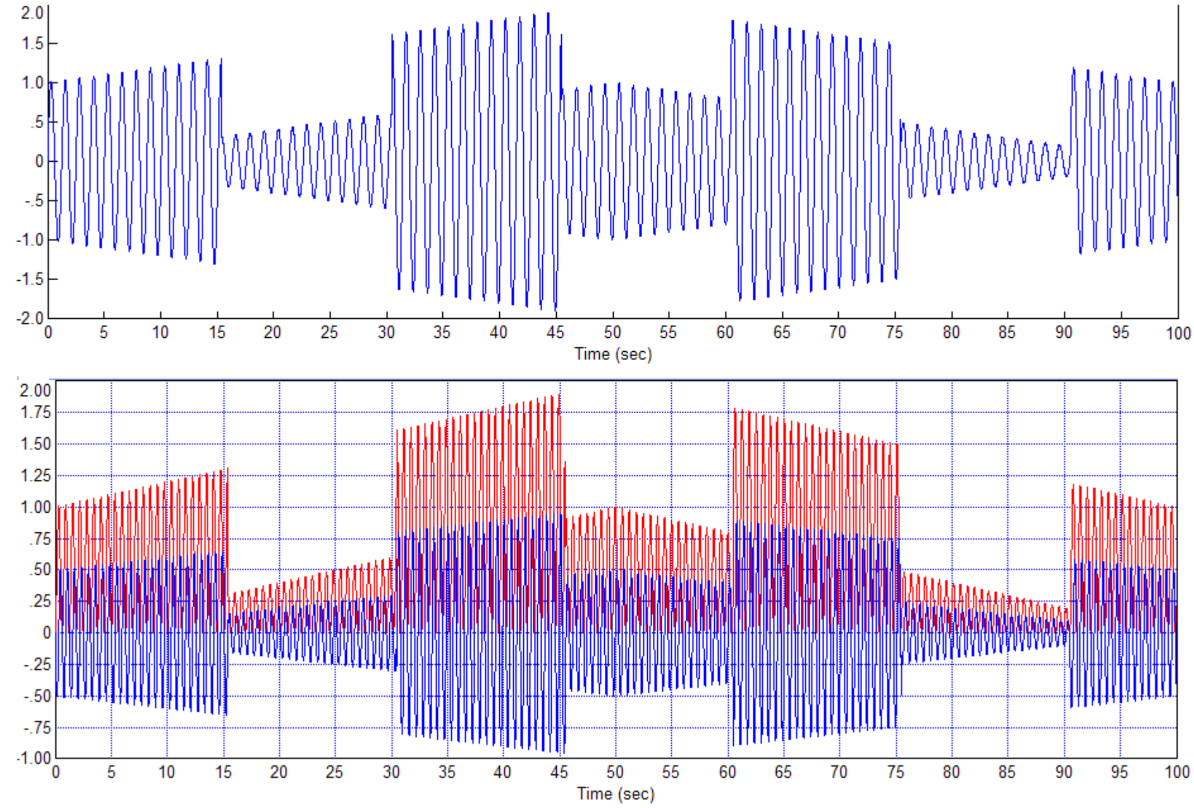

Figure 9. The sum of the signals from *Figure* 8 and the result of the detecting of this signal

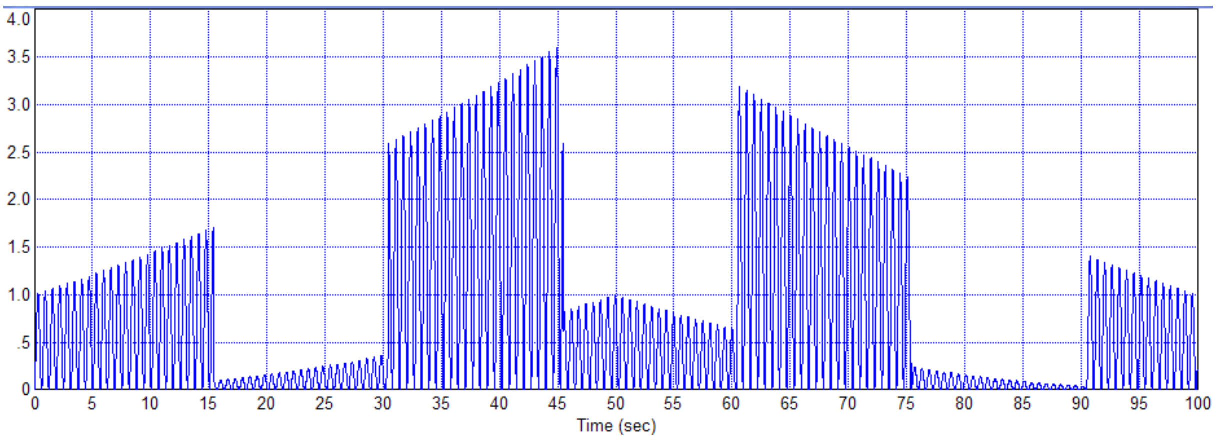

Figure 10. Sum of the blue and red bottom signals from *Figure* 9

The result of the all discussed technical decisions is the fact that the mixture of the signals from the two different sources workin on the same leading frequency can be received with the same antenna and with the same analog channek of the initial processing. In this case all kinds of the dalays, from antenna to the processing channel, including random deviations of the filters parameters and heterodyne oscillator phase, are the same for the both signals.

The derivable phase differences or the differences of the moments of the time indicators in the group signal can be identified and related to the concrete sources. At that the difference of the times of these time indicators arriving contains the infodmation about the difference of the distance of these sources relatively to the receiving antennas.

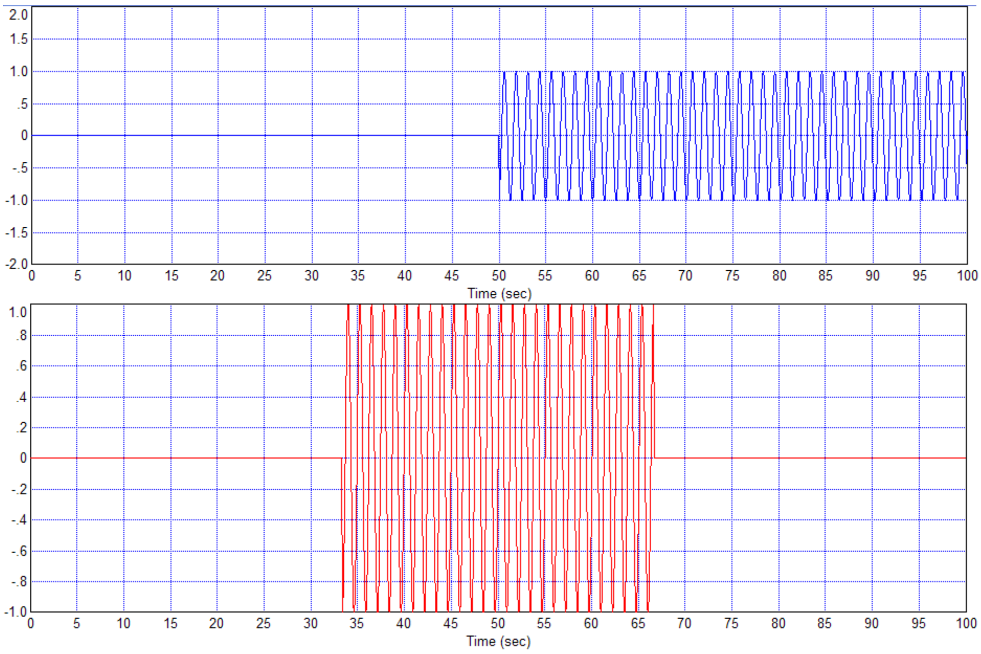

Figure 11. Signals according to the Method of alternating silence

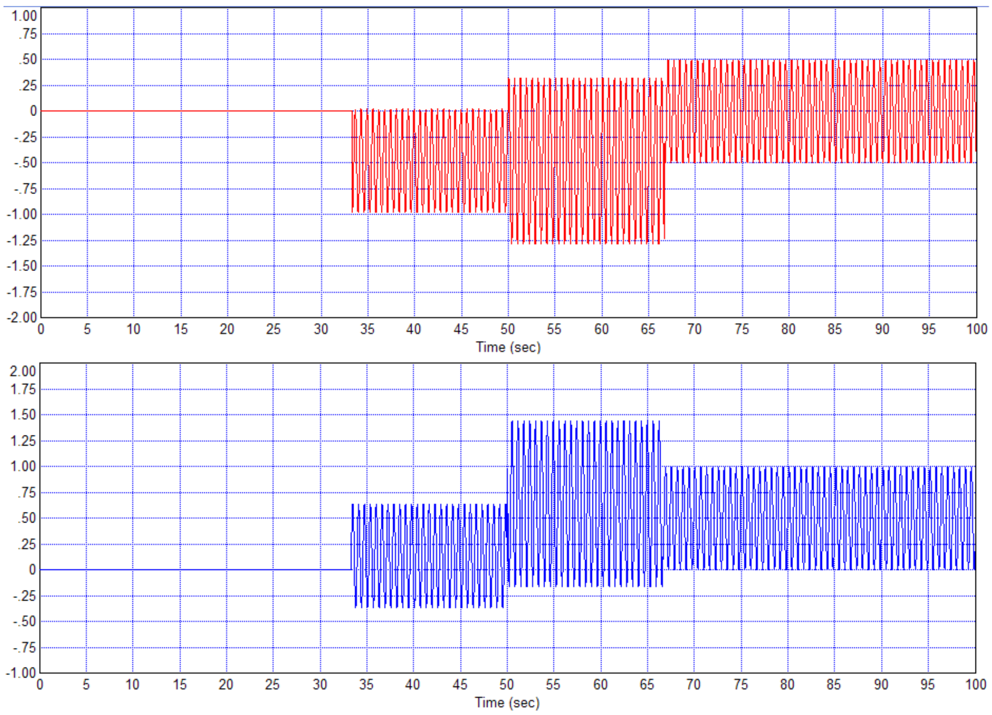

Figure 12. Signal components after the detecting (coherent and quadrature ones)

4. THE PROVIDING OF THE EFFECTIVENESS OF THE WORKING OF THE EXTREME TUNING MEAN

The choice of the modulation method influences to the effectiveness of the working of extreme tuning mesn. One of the reasones of the insufficient accuracy can be in the high error of the definition of precise moment of the time indicator.

The time indicator can be contained in the evident or in implicit form in the shape of the envelope signal function, transmitted by each of the sources. The evident time indicator can be, for example, pulse front or the moment of the transmitted signal phase inversion. The implicit indicator can be, for example, the accurate value of the harmonical envelope function slowly changing relatively the leading frequency. The difficulty of definitionof the evident time indicator consists in the following. First, it is the one of kinds of the fast signal changing, and hence the spectrum of the signal containing this indicator is very wide. Some part of the initial spectrum of the signal does not pass the radio frequency channel, which has as arule not too wide band.

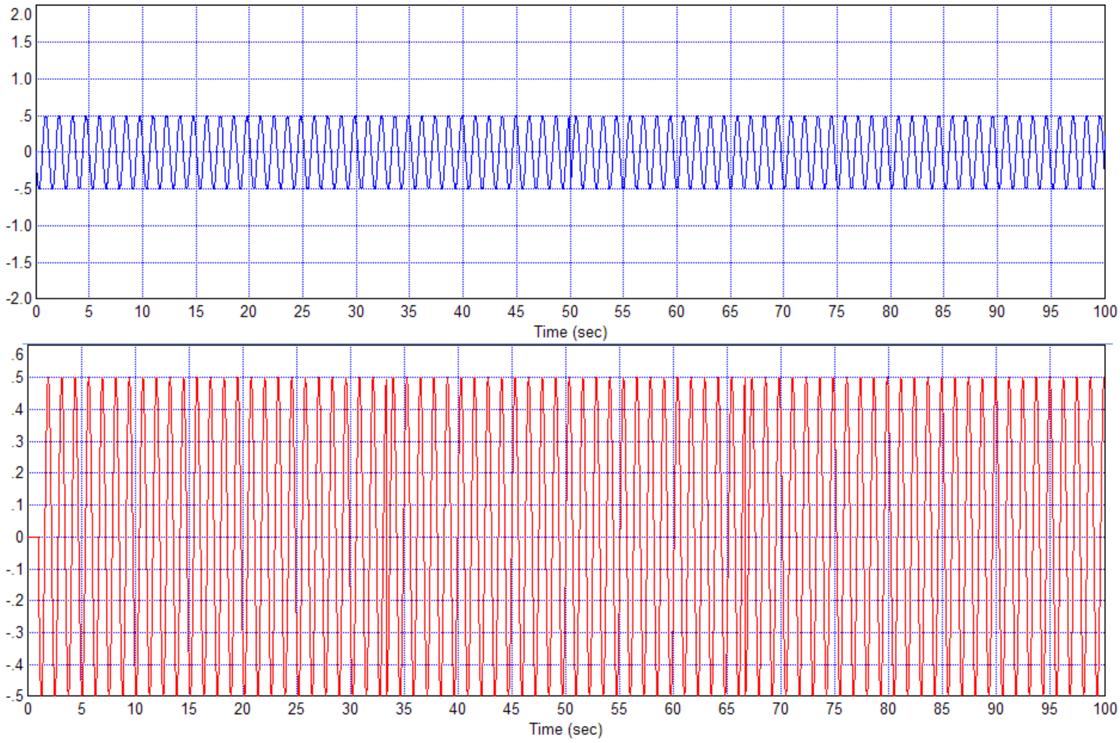

Figure 13. Transmitter signals according to the Method of the periodical phase inversion

Residuary signal obtains the distortions, which produces changing of the accurate moment of the definition of typical time indicator, and the moment of the phase switching became smoothed with the according transient process. Second, with the using of the correlation method, for example, for the seachning of time indicator, then the algorithm of the realization of this method becomes extremely sophisticated, since the dependence of the correlation function on the correlation tuning error is essentially not smoothed, hence the derivative of this function on the error many times changes its sign. It cases the possibility of the mistaken tunings to the local extremums of the correlation function. The difficulty of the accurate definition of implicit indicator is connected with the insignificant changing of tuning error signal with small error, i.e. with the small sensivity of the method.

The proposed technical decision is directed to the increasing of the measurer accuracy.

The stated task is resolved with the simultaneouse using of the two time indicators, one of them is implicit and it serves for the robust (approximate) searching of the time indicator and for tuning to it, and the second one is evident, and it serves for the accurate definition of the of the time indicator, for example, by the way of the tuning of the phase of the own (heterodyne) oscillator to this tine indicator. With this aim generators of the smoothed modulation and generators of the time indicator are introduced into each source. Also each receiver contains two channel of the signal distinguishing; in the each of them it contains two mean of the time indicator distinguishing.

The structure of this measurer is shown at *Figure* 14.

The sources of the radiosignals are supplied with two generators for the modulation of the transmitted signals: generator of the smothed modulation function and generator of the time ndicators. For the possibility of the distinguishing of the signals by the recievers all the said generators forms signals, deffering with many features. Thus, each of the sources radiates signals with the individual indicators. Each of the two transmitted signals has two types of modulation. Each modulation is carried out with signals from the output of the according generators. The smoothed modulation generator forms signal accomplishing smoothed modulation.

This modulation contains implicit time indicators; it is used for the approximate (preliminary) tuning of the signal processing channels. The time indicators generator forms signals, containing evident time indicators. These signals serve for the modulation which is used for the accurate determination of the moments of the time indicators arriving. Diferent types of the modulation can be introduced by means of their summing or by any other way. For example, one modulation can be amplitude, and the other modulation can be frequency one. Each of the receivers gets signal from each of the sources in the form of their mixture (sum with coefficients).

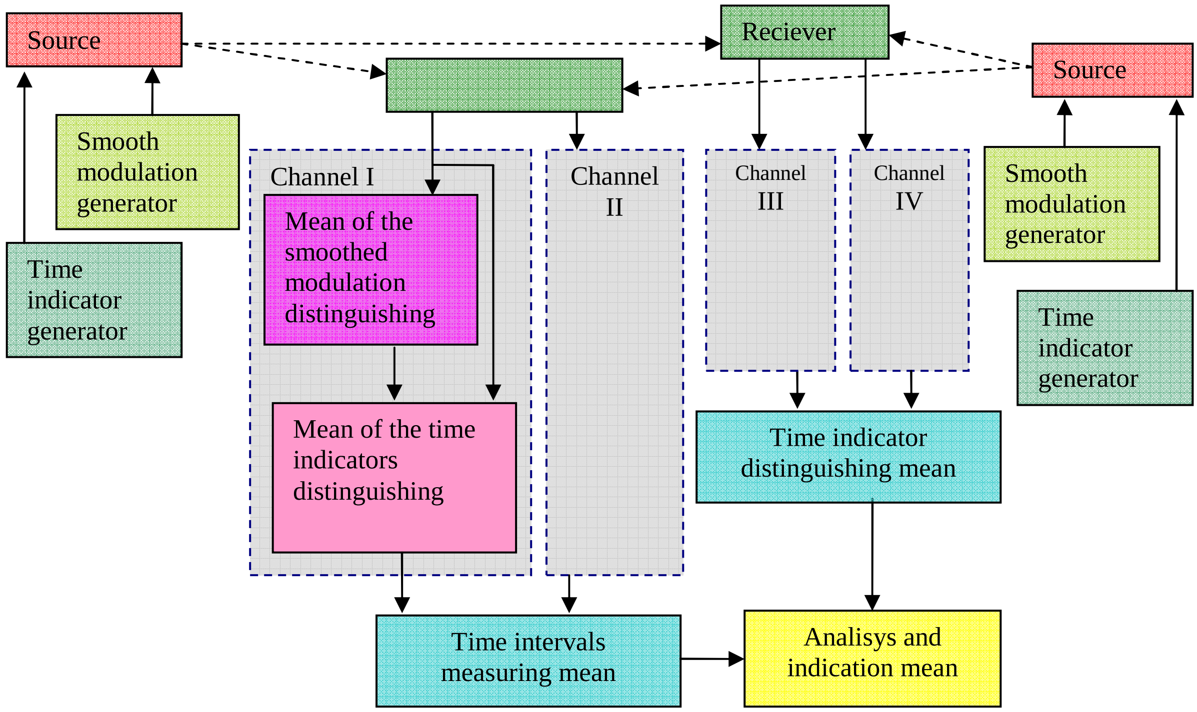

Figure 14. Structure of the device with the using of the two kinds of the modulation

The received signals from each source are supplied to the two individual channels of the processing. Each of the processing channels at first determines the moments of the receiving of the implicit time indicators containing in the smoothed modulation by means of the distinguishing of the smoothed modulationfor the approximate preliminary tuning. After that by the way of the distinguishing of the time indicators it determines more precisely the moments of the receiving of the evident time indicators introduced to the transmitted signals by the time indicator generators. The result of the action of signal processing channels is the presise definition of the moments of the receiving of the evident time indicators. Signals marking these moments go to the inputs of the time intervals measuring means, which determine the difference of the time of the evident time indicators receiving from the different siurces. The results of the measurements go to the analisys and indication mean. This mean calculates the difference of these results which is proportional to the distance between the receivers as it is said earlier.

The presence of the smoothed modulation in the received signals allows easy preliminary approximate tuning which excludes the tuning to local extremums and increases the reliability and speed of the system. The precence in the received signals of the evident time indicators allows accomplishing of more precise final tuning, which increases the accuracy of the measurement.

Each of the signal processing channels can be executed, for example, accordingly with the structure shown at *Figure* 15.

Each channel contains smooth modulation distinguishing mean and time indicators distinguishing mean. At that the input signal of each channel goes to each of these means. The additional signal of the approximate tuning is supplied to the additional input of the time indicators distinguishing mean. This signal allows more successfull (quick and sure) determination of the approximate velue of the moments of the time indicators arriving.

For example, smooth modulation distinguishing mean can contain connected in loop smooth modulation generator, correlator and extremal tuning mean. The smooth modulation generator is fully identical to according that connected to only one of the sources. The correlator compares signal from the output of the smooth modulation generator with the signal from the output of the receiving unit. The output signal of the correlation has smoothed dependence on the tuning error; the error derivative of this signal smoothely changes its value and seldom changes its sign. It allows to the extreme tuning mean sure and correct tuning of the phase of the smooth modulation generator, providing close equality of this phase to the phase of the received signal. Feedback tuning signal from the output of the extreme tuning mean is used by the time indicators distinguishing mean for the preliminary tuning. The time indicators distinguishing mean can work on the base of the same principle and has similar ctructure. Hence it can contain time indicators generator, identical to that in the source, correlator and extremal tuning mean. This extremal tuning mean uses information from the output of the smooth modulation distinguishing mean for the preliminary tuning of the time indicators generator. This accelerates the process of the tuning of the time indicators generator, excludes the tuning to the local extremum and hence increases the accuracy of the determination of the moment of receiving of the time indicators.

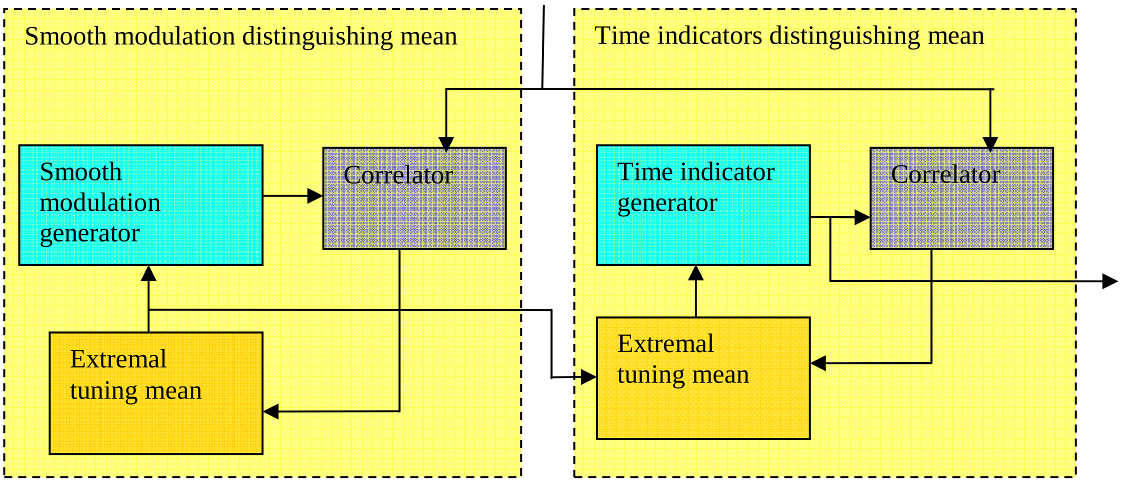

Figure 15. Structure of the signal processing channel

5. MODELLING TESTING OF THE PROPOSED METHOD

The effectiveness of the proposed method has been inverstigated with modeling in program *VisSim*. The results of the modeling are shown at *Figures* 16–20. The output signal of the correlator is simulated with the construction containing signal multiplier and low frequency filter at its output. The delay element allows getting arbitrary phase shift between the multiplied signals for the recearching of the influence of this shift to the output signal of the correlator. When harmohical signal is used, as *Figure* 16 shows, the dependence of the steady level of the output signal smoothely depends on the relative phase shift between the multiplied signals. It allows relatively easily organizing of the searching procedure for finding with numerical methods of optimal tuning, which corresponds to maximal value of the output signal of the correlator. Together with this advantage such signal has significant disadvantage consisting in too small changing of the correlator output signal prodused with small changing of delay value.

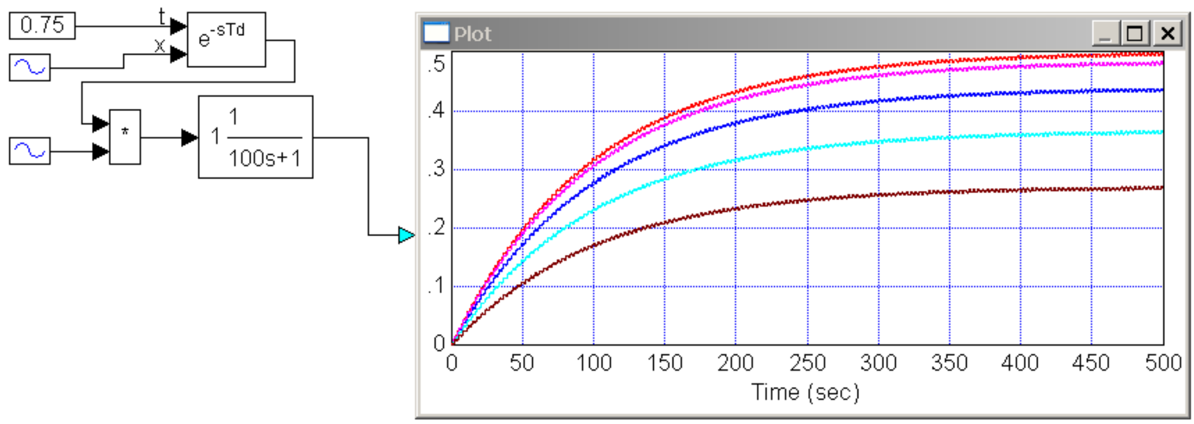

Figure 16. Monotonous dependence of the correlator output signal on the delay value

Figure 17 shows an example of using of pseudorandom signal with the same goal as the harmonical signal was used earlier. As it is seen from *Figure* 17, the accurate equality of the phase of multiplied signals produces sharp increasing of the correlator output signal. *Figure* 18 shows in large scale signals with different values of the delay, i.e. with the different value of the error of phase tuning. On the base of these signals it is difficult to do correct conclusion about value and/or sign of the phase error since the evident dependence between the phas error sign and correlator output signal sign.

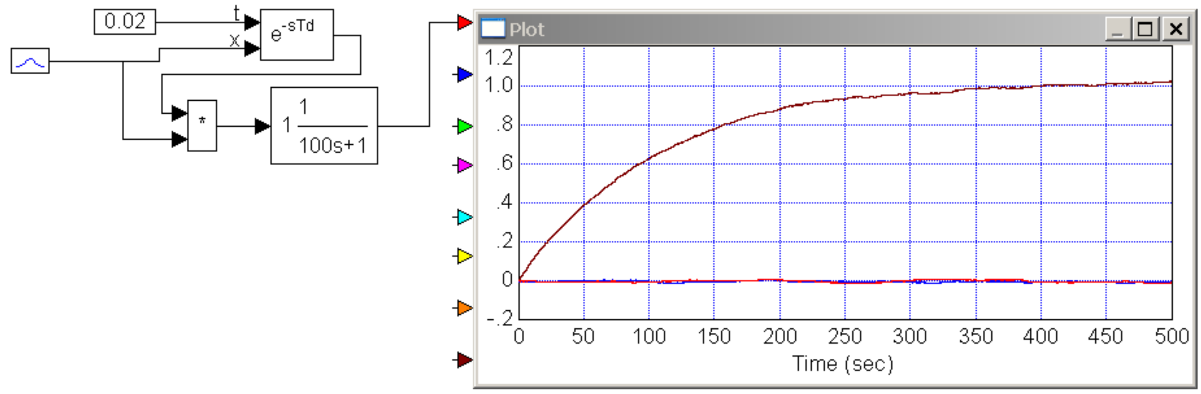

Figure 17. Non-monotonous dependence of the correlator output signal on the delay value

Figure 19 shows an example of the result of summing of the two signals, one of whish is pseudorandom, and the second one is harmonical. The result combines the both advantages and is free from the both disadvantages. Namely: the deependance of the correlator output signal on the error is cmoothed with extremum in the point of the higher accuracy of the tuning; at that the extremum is visible very distinctly, output signal increases into three times relatively to the signal with not accurate tuning (with the error equal to the integrating step stated in the modeling program).

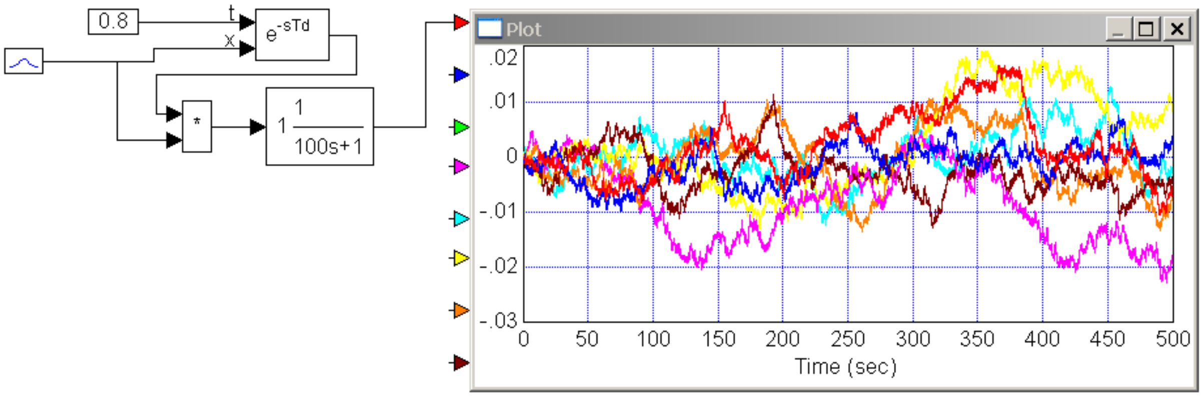

Figure 18. The same picture as in *Figure* 17 in larger scale

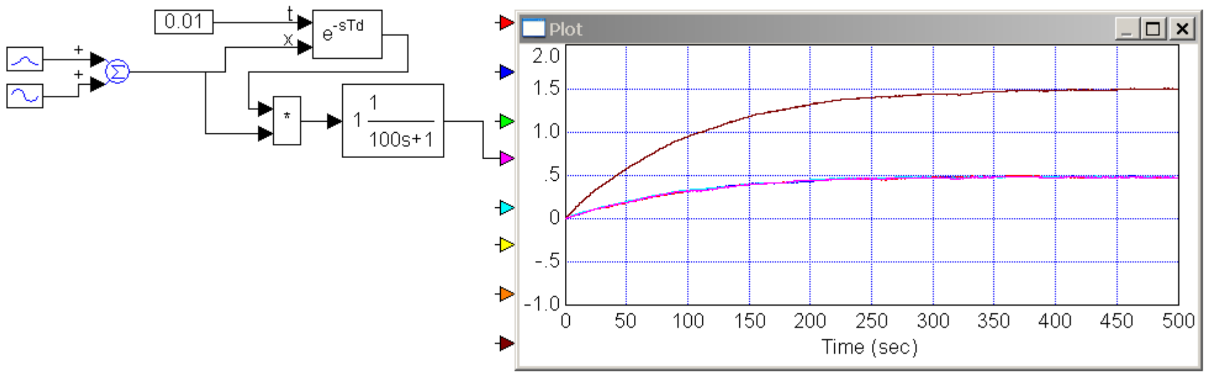

Figure 19. The monotonouse dependence on the delae with sharp peak when phase are equal achieved with summing of harmonical and pseudorandom signals (modeling of the correlator output signal)

Figure 20 shows the result of the using of of the two pseudorandom signals and harmonical one. The result is similar. *Figure* 21 shows the typical kind of such dependence in the axes: phas error (axis *X*, zero error corresponds to the value 8) – the correlator output signal (axis *Y*).

The device distinctive pecularities are the following. All known radiofrequency measurers act on the base of the principle of the reflection or dispersion of the radio signal from the object. Disadvantage of such measurer is complexity of creating of narrow directed radiation source and reflector, and also the complexity of the tuning such devices and origing of the disturbers from exterior objects which can not be removed.

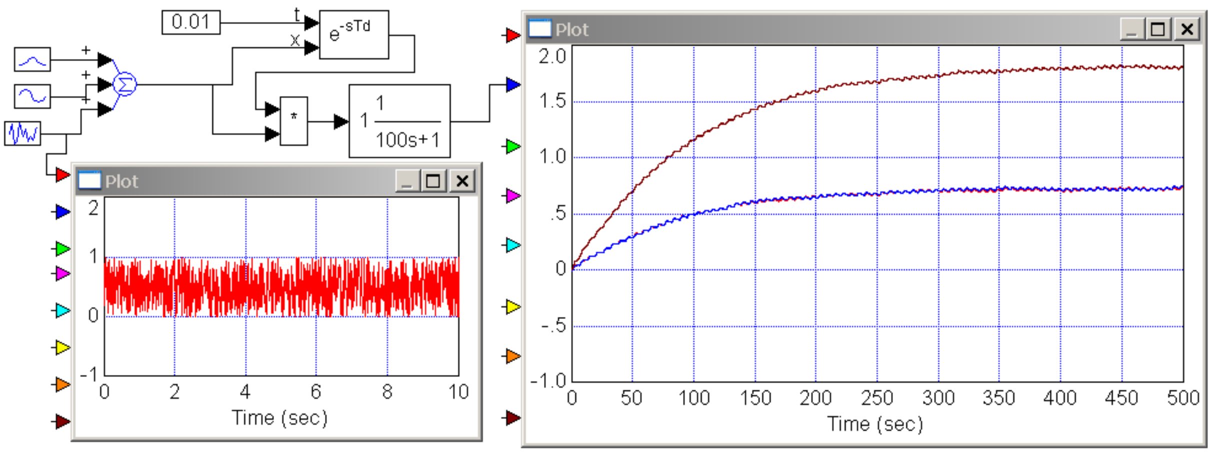

Figure 20. The using of the two pseudorandom signals and harmonical one

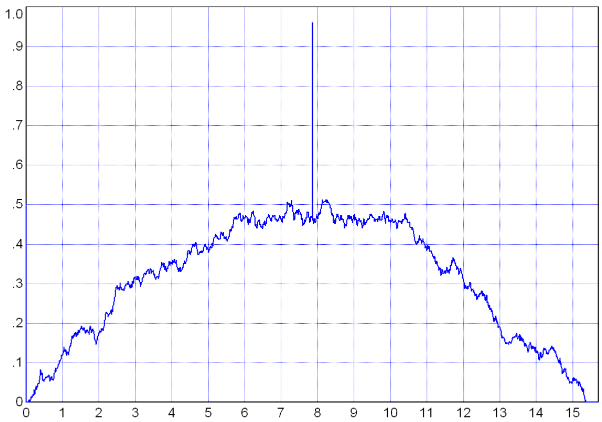

Figure 21. The dependence of the correlator output signal on the phase tuning (relative units)

In the proposed system the following advantages are achieved:

1. Stright visibility of the sources and receivers is not demanded.

2. The reflectance of dispersion of the signals is not demanded.

3. The dependence of the accuracy on the weather changing of athmosphere condition is decreased relatively the optic devices.

Let estimate the potential merits of the proposed method comparatively to the alternative radiofrequency structures from the position of the accuracy. To these alternative systems space systems such as GPS and GLONASS (Global Navigation System) must be refered to. The diagram of the arrangement of the main elements of the measuring system with the using of reflectance of dispersion is shown at *Figure* 22. The main problem of such structure is practical complexity of creating flat wave front by the method of reflectance of dispersion. The diagram of the using of the proposed measurer is shown at *Figure* 23, and *Figure* 24 shows the diagram of the using of the space systems.

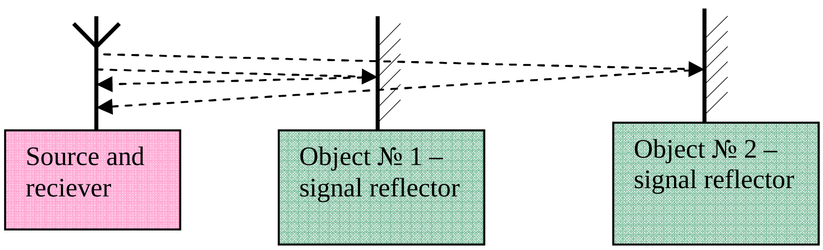

Figure 22. The diagram of the arrangement of the main elements of the measuring system with the using of reflectance of dispersion

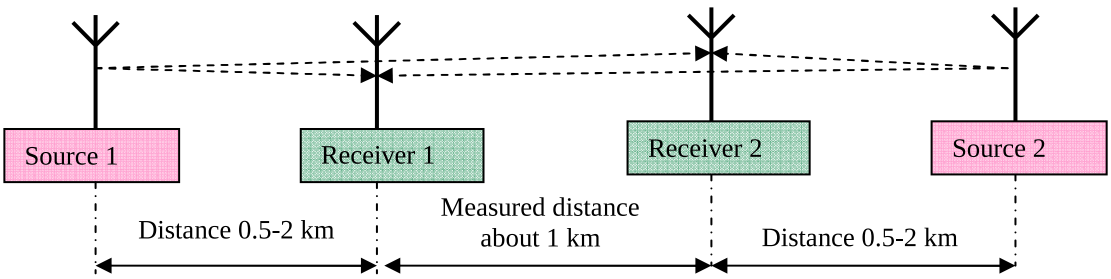

Figure 23. The diagram of the using of the proposed measurer

The radiofrequency method on the base of the space systems has the error fundamentally greater into 30 times relatively the ground-based one. However the ground-based experiments with the proposed systems can be the base of the development of the measuring methods with the helps of the space systems.

Actually, if the ground-based systems measure displacements with on the basis of 1 *km*, then the absolute error equal to 1 *mm* corresponds to the relative error 10^{-6}. If the measurements are accomplished with the space systems, then, for example, at the height 20 *km*, the distance to the satellite under angle 45° is approximately 30 *km*, hence with the same absolute error it is necessary to provide the relative error into 30 times less, i.e. $0{,}33 \cdot 10^{-7}$.

Thus, the basis of the possibility of using of this method is in the following: the concrete measurer is system consisting from two receivers and signal processing means. The same signals from the sources can be used for the unlimited number of the measurers. System does nod demand of the contacts with the sources. Satellite does not must reply to query of each measuring system. Sending of standardized unique signald is sufficient. Such system theoretically can be introduced to the space.

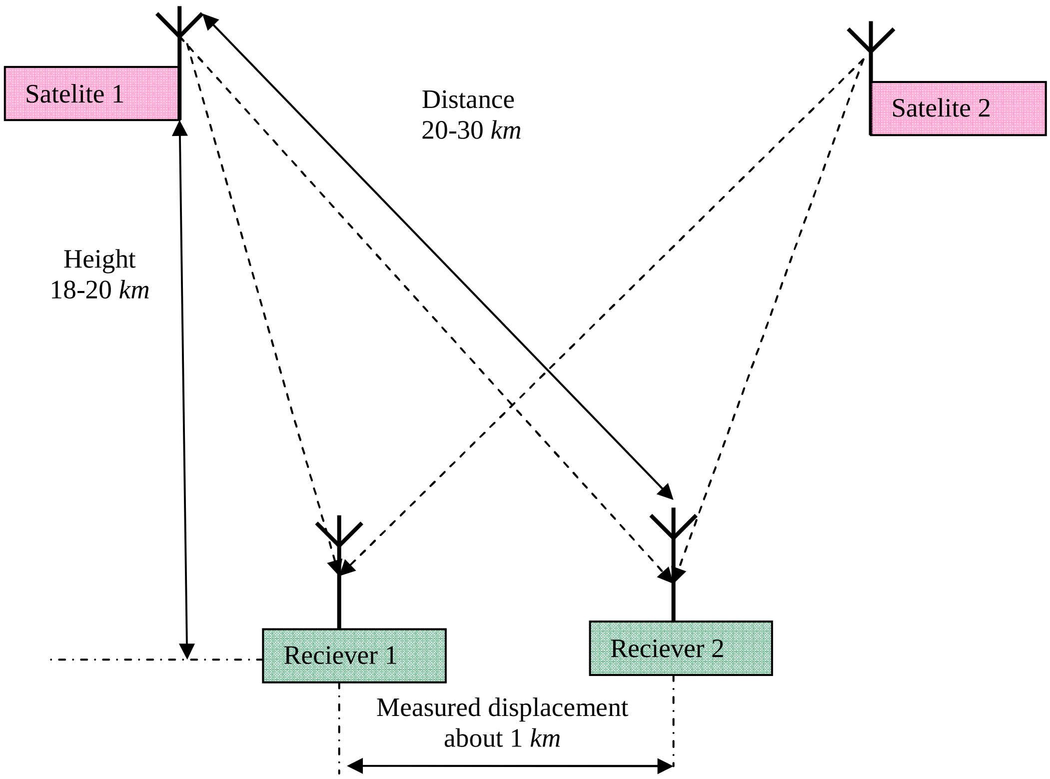

Figure 24. The diagram of the using of the space systems

Therefore the developed measuring method can be extended to the system GLONASS if it will demonstrate the higher accuracy. Under the condition of the conservation of the relative error such extend will increase the absolute error into 20–30 times. Similarly if the methodics available in the system GLONASS will be extended to the ground-based systems, the absolute error will be decreased into 20–30 times. When it is considered that in the space system there is essential heterogeneity (thickness and temperature) of the athmosphere for the space of the measuring track then the difference can increase from the said theoretical increasings of the error into additional several times.

The main task of the future researches is in the further increasing of the accuracy of the measurements with rediotechnical method.

In such a way the proposed method effectively resolves the task of the providing of sure working of the extremal tuning mean, since it provides simultaneously smoothed dependence of the correlator output signal on the tuning error and the sharp increasing of this signal with the high accuracy.

CONCLUSION

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ABSTRACTS

The following paper will be translated and published later.

Recearch of Optoelectronic Method and Development of Devices for Liquid Media Controlling and Monitoring

E. Yu. Kutenkova, B.N. Rakhimov, T.V. Larina, Sh. I. Madumarov

Abstract: **The paper gives the analisys of existing means of the liquid media monitoring. New construction of multifunctional optoelectronic photocolorimeter for the automatic control has been proposed. It is characterized with stationary situated cavity which is agglutinate from the two halfs cylinder with central hole for pouring of liquids. The presence of *n*+1 optron pairs allows controlling of the presence and content of *n* components in the composition of liquids.**

Key words: **light diode, photodetector, optron pair, quartz cavity, semi-transparent liquids, summer, photoelectrical signal processing unit, measuring device, optoelectronic system.**

Optoelectronic Method of the Control of Physical and Chemical Parameters of Hard Metals Surfaces

T.V. Larina, E. Yu. Kutenkova, V.A. Zhmud, D.D. Alijanov

Abstract: **The paper discusses the optoelectronic non-invasive method of control of the metal construction fatigue. Also the paper proposes the optoelectronic system containing of sensor and electronic unit. One of the variant of the sensor is presented which is made in the form of simi-tube basis or empty cilinder into which three pairs of *Y*-shaped and three common bringing and six deferent fibers are introduced.**

***Key words*:** **Light sensors and detectors, opticaal fiber, optoelectronic system, grain, roughness of the surface, defectiveness, chromaticity.**

Justification of the Choice of Software for Robotics

A. Kolker, D. Livenets, A. Kosheleva

***Abstract*: The paper gives the survey of the main software for the grafical programing in the aim of the robotics task resolving.**

Key words*: Software, robotics, *MatLab, Octave, Macsyma, Mathcad, Scilab, LabVIEW.

Development of Control Systems of Stand for Learning of the Transient Process in the High Vacuum Switch

A. Kolker, D. Livenets, A. Kosheleva

***Abstract*: The paper discribes the results of the development of system of control of training stand for the researching of transient responces in vacuul high-voltage switcher *EX-BB* 6-20/1000 У3-1.**

***Key words*: Software, vacuum swithcer.**

The Development of the Unit for the Robot Controlling System with the using of Engineering Sowtware SciLab

A. Kolker, D. Livenets, A. Kosheleva, V. Zhmud

***Abstract*: The paper discusses the result of the development of the Robot Controlling System on the base of free software SciLab.**

***Key words*: Robot, Controlling Systems, SciLab, Software**

The Researching of the Variants for the Creation of Intellectual Robotic Systems on the Base of Single-Plate Computers and Free Operation Systems

A. Kolker, D. Livenets, A. Kosheleva, V. Zhmud

***Abstract*: The paper discussed the variants of the creating of the simpliest robots on the base of the LEGO and single-plate computers with the using of free and open свободного software. The paper gives the example of the resolving of the said task.**

***Key words*: Robotics, Free software**

The Advantages of the Free Software for the Strategy Technologies

V. Zhmud, A. Liapidevsliy, A. Podolets

***Abstract*: The paper discussed the advantages of the using of free and opeen software for strategical technologies on the example of the tasks of robotics and controling of the organization.**

***Key words*: Free software, open software, centre of competence, automatics, robotics, strategy technologies**

Apology of the Theory of Automatic Control

V. Zhmud

***Abstract*: The paper is addressed to the students and university entrants and also to each person interested in the theory of automatic control outside of the frames of the basic speciality.**

***Key words*: Theory of automatic control, cibernetics.**

Future of the Double Diploma Program on Automatics: the Collaboration with Universities of Russia, Ukraine, Bolgaria, Chech, France

V. Zhmud

***Abstract*: The paper discusses the prospects of the closing of the education program in direction of the field of automation, robotics and mechatronics in Russian, Ukraine, Bulgarian and Chech universities for the Double Diploma Program (DDP) realization.**

***Key words*: automatics, mechatronics, robotics, higher professional education, DDP**.

Content