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An Approach to Optimize the Setting Process of Radar Components at Repair

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Key Words: *Optimal control; constrained optimization; optimization model; global optimization; adaptive parameter.*

Abstract. *In this case study the object of the research is the electronic components of the radiolocation system (RLS) for measuring the distance to marine objects. It is proposed an approach for automatic determination of operating parameters of the respective facilities and with optimization procedures to determine these parameters. The complexity and flexibility requirements of modern repairs of radiolocation components require to search for both local and global optimization [2,3], which is related to the specifics of the particular repair and the selected methods of formalization. The aim is to create a system for determination the optimal operating parameters of the radar components during the repair process. The optimization of impulse parameters means the choice of such values of the components parameters which complete the restrictions by value, imposed on them so that the parameters fall within the specified tolerance ranges according to the respective technical conditions. In any cases, the following relations should be observed: 1) Circuit function (Dependence of the output impulse parameters of radar components on the variation of the parameters of the electrical elements (R, L, C); 2) Optimality criterion; 3) Matching methods. The formalization approach of the setting process of RLS helps to optimize the individual operations and stages. The optimization could be executed in real or pseudo-real time by an automatic or automated system as well. In the process of experimental research, the range of possible values of the output parameters of the selected elements due for setting is clarified on the basis of the data obtained. It is achieved a simple and reliable algorithm enough to link the circuit function to the setting area of the existing components parameters.*

1. Introduction

Optimization of impulse parameters means the choice of such values of the selected elements (R, L, C) of electrical circuit whereby the impulse parameters fall within the tolerance ranges specified under the technical conditions (TC) and the limitations by value imposed on them are executed in order to ensure reliable work [1,4].

In any cases, the following relations should be observed:

1. Circuit function (dependence of the output impulse parameters of radar components on the variation of the parameters of the electrical elements (R, L, C).
2. Optimality criterion.
3. Matching methods.

The formalization approach of the setting process of RLS helps to optimize the individual operations and stages. The optimization could be executed in real or pseudo-real time by an automatic or automated system as well.

In this case, a two-step optimization approach is proposed.

The aim is to be achieved within the meaning of points 1 and 2 during repair of electronic components of the product, whereby the following requirements are met [1 – page 19]:

1. Taking into account the accepted optimality criterion to be ensured that optimum values of the impulse parameters specified for setting are determined using the circuit function of the system.
2. To be provided task solution for obtaining optimal values of the impulse parameters at reliable operation of the electronic circuit.

2. Essence of the Research Approach Used

Circuit function

It is sought the dependence of the output impulse parameters of the electronic circuit from RLS on the variation of the electrical parameters of the elements (R, L, C).

Choice of optimality criterion

An approximation criterion based on a quantification of the difference between the true value of the system's characterization and its assessment is used.

The following criterion is considered:

(1) J = max $|\delta_i|$,
i=l,...,m.

When evaluating these points according to above criterion, the point with the smallest maximum deviation δ_i will be the best.

The target function corresponding to the criterion whose extreme value indicates a point that best suits the equation

(2) $\Phi(x_1,...,x_n) = \max|\Phi_i(x_1,...,x_n) - A_i|$, $i=1,...,m$.

The search for a variation of the radar scheme optimized by this criterion is to search for such a set of numerical values of the variables, where the function reaches an extreme value

(3) $\Phi(x_1,...,x_n)$ = min.

The FIRST stage of the optimization task, defining the range of the allowable values of the circuit elements parameters, is to ensure the condition for reliable operation

(4) SUP $P\sum(t)$, at $U \epsilon G$,

where $P(t)$ – probability of falling within the range of allowable parameter values of the elements;

U – impulse parameter, required for setting;

G – range of allowable parameter values of the impulse specified under certain technical conditions.

The task here is to determine the limit search for optimal values of the selection elements at reliable operation of the component from RLS. (No distortion of the output impulses for adjustment). It is introduced an electrical circuit output model in the form of a circuit function, which is an algebraic equation linking the output parameter of the impulse to the parameters of its components

$$(5)\quad \begin{array}{l} |U_1=F_1\,(\Pi_1,\Pi_2,\ldots,\Pi_n\,)| \\ |\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots|, \\ |U_k=F_k\,(\Pi_1,\Pi_2,\ldots,\Pi_n\,)| \end{array}$$

where $\Pi_1,\ldots,\Pi_n$ – parameters of the electrical components shown for selection in the setup manual (SM).

Limitations of the output impulse parameters specified for adjustment according to technical conditions (TC) of RLS are as follows:

$$(6)\quad \begin{array}{l} |U_1'<U_1\,(\bullet)<U_1\,''| \\ |\ldots\ldots\ldots\ldots\ldots\ldots\ldots| \\ |U_k'<U_k\,(\bullet)<U_k\,''| \end{array}$$

Parameter limitations of the elements appointed for selection in SM, determined by the possibilities for their physical realization, should be defined

$$(7)\quad \begin{array}{l} |\Pi_1'<'\Pi_1<\Pi_1\,''| \\ |\ldots\ldots\ldots\ldots\ldots\ldots|. \\ |\Pi_n'<'\Pi_n<\Pi_n\,''| \end{array}$$

The conduct of the research is possible to be specified with the following algorithm – *figure 1*.

At this stage, the minimum and maximum permissible level of the main output impulse parameter given for adjustment according to SM, is set

$$(8)\quad U_{i\,min}<U_i<U_{i\,max}.$$

Parameters limitation of all pre-defined elements specified for TC selection is determined

$$(9)\quad \Pi_{i\,min}<\Pi_i<\Pi_{i\,max}.$$

The limit values of the selected elements are determined based on the analysis of the magnitude of influence of the change in the value of each element specified for TC selection from the circuit on the output parameters of the signals and the relative rate of change of the parameters – the area for the reliable work.

The SECOND stage is the choice of the optimal values of the elements. Here we study the circuit of $U_{min} – U_{max}$, which allows to limit the area of optimal permissible solution and to determine the sampling number – k.

The optimization process of radiolocation impulses consists of:

1. Step determination procedure.

It always starts with rough step and the subsequent course of the process depends on its effect on the impulse parameter.

2. Determination (measuring) procedure for radiolocation parameter using an Automatic Control System (ACS).

From the measured values of the radiolocation impulse parameters will be decided to change the step or if the target is achieved – to stop the process.

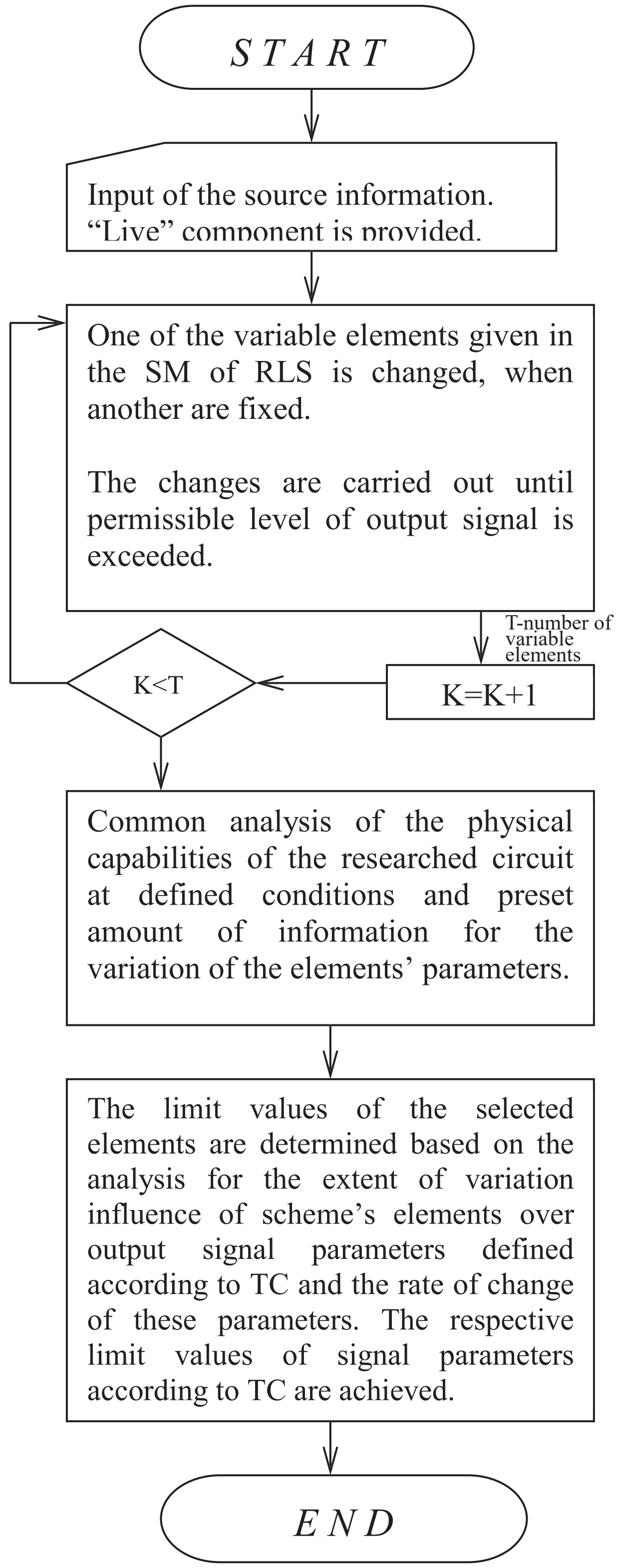

Figure 1. Block scheme of the algorithm

Point 1 and point 2 follow upon another until the parameter of the radiolocation signal reaches the tolerance ranges defined by the technical conditions (TC).

3. Research Scheme

For each impulse, at initial working capacity (efficiency) of the step, the following applies:

1. It is first determined which of the control elements (defined by the technical conditions for selection) have the highest relative rate of change of the impulse parameters (defined by TC) under the specified conditions.

2. The allowable range (limits) of values variation of each element (R, C) is determined for rational optimal selection.

3. The values of rough and exact step are determined as well as the magnitude of influence of the change in the values of elements on the output parameters of the impulse.

4. The optimization of impulse parameters of complicated circuits without feedback is achieved on steps starting with the first step. If there is a feedback between the steps of the circuit, the optimization is carried out initially by progressive stages without feedback, then with feedback by refining the results.

5. This method contains the basic idea of consistent step-by-step search.

An incomplete step is applied, aiming at achieving a better radiolocation impulse value (closer to the optimum value).

6. It is applied to optimize the impulse parameters of steps with simultaneous or sequential variation of several element parameters. Pre-accumulated information about the relative rate of change of elements parameters is used, which facilitates the practical realization of the task.

7. The optimization of the impulse parameters of the circuit is carried out after providing the initial operational capability lively component (no incorrectly installed components). The required output signal parameters are measured. Then, a certain step change in the parameters of the selected elements is ensured until the requirement of the optimality criterion is met (the impulse parameter falls within the tolerance limits imposed by the technical conditions TC).

8. In the step search, the size of the selected step for changing each parameter is rough and accurate.

The value of the accurate step (which is considered)

(10) $\Delta\gamma_1=0.01\text{-}0.02[g_{max} - g_i]$,

where g_i – current parameter value;

g_{max} – maximum permissible value of the selected element parameter.

The value of the rough step (which is considered)

(11) $\Delta\gamma_2=0.01\text{-}0.02[g_{max} - g_i]$,

where g_{max} is determined by consecutively variation of each parameter of selected element to a value at which one of the accepted impulse constraints occurs.

The values of the rough and accurate step can vary according to the degree of closeness to the optimum.

9. The process of searching for the rational sequence of variation of element parameters is carried out according to the degree of influence on the output parameter of the impulse.

10. The examined search approach is used to determine the optimal values of elements (R, C).

4. Experimental Results

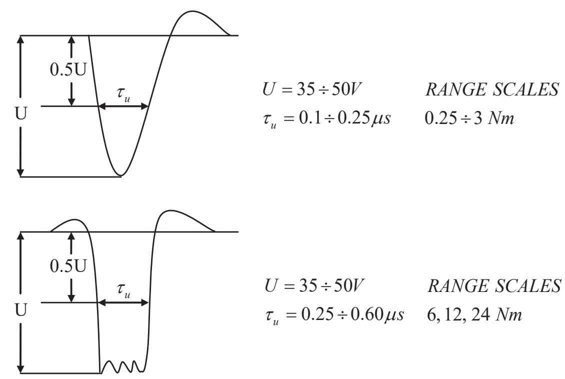

Figure 2. Impulse of control

Circuit function

a) $U=f(C^*_{24}, R^*_{17})$;

b) $\tau_n=f(R^*_{24}, R^*_{15})$.

• **For a)** There is a direct proportional dependence on the change of $R^*_{17}(R^*_{17}\uparrow\rightarrow U\uparrow)$ and inverse proportional dependence on the change of $C^*_{24}(C^*_{24}\uparrow\rightarrow U\downarrow)$.

In determining the area of variation of the element values, it was found out

$R^*_{17}=82\div100\Omega$ for reliable operation of the circuit (element);

$C^*_{24}=150\div330pF$ for reliable operation of the circuit (element);

$C^*_{24}\approx220pF$ for optimum value of the impulse of control.

• **For b)** There is a direct proportional dependence on the change of elements parameters R^*_{24} and R^*_{15} inverse proportional dependence on the change of $C^*_{24}(C^*_{24}\uparrow\rightarrow U\downarrow)$

R^*_{24} – potentiometer.

It must be in the middle position for reliable operation of the step (element).

$R^*_{24}\approx2,2k\Omega$ for optimum value of the impulse.

R^*_{15} – potentiometer.

It must be in the middle position for reliable operation of the step (element).

$R^*_{15}\approx220\Omega$ for optimum value of the impulse.

5. Conclusions

1. In the process of experimental research, the range of possible values of the output parameters of the selected elements due for setting is clarified on the basis of the data obtained.

2. The obtained data allows us to qualitatively assess the reliability of the controlled step (element) taking into

account the requirements for the output parameters of the signals.

3. It is achieved a simple and reliable algorithm enough to link the circuit function to the setting area of the existing components parameters.

4. The magnitude of influence of the individual selected elements on the set impulse parameter is practically determined, as well as the order of change of radio elements (R, C), which facilitates the realization.

5. An attempt is made to introduce standardization (unification) of the applied algorithms – only with change of input data to be feasible in another radiolocation system, which is very convenient in practical repair conditions.

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