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THE APERIODIC TRANSDUCER OUTPUT SIGNAL PROCESSING MULTIPURPOSE TASK SOLUTION ANALYTICAL ALGORITHMS

Let us consider, to be certain, that the transducers output signals are multiplied or divided each other.

The problem to discriminate useful signal – multiplicative interference is difficult enough to be soluted analytically, especially under simultaneous uncertainty of input signal transducer drift, as well as some physical process into interference transducer drift. The task becomes more complicated under additional uncertainty of input signal parameter, which is applied simultaneously to both transducers inputs. This way one is to discriminate useful signal – interference, facing three unknown parameters.

But this triple uncertainty is to be complicated by necessity to diminish the transient process dynamical error. It means that we would like to exactly know the output signal value at the very end of transient process just immediately after the transient process beginning.

So, the complete problem is to be formulated like follows.

One may observe the signal which is the result of either multiplication or division of the useful signal by interference under the set of circumstances, characterized above.

So we are to analytically and simultaneously solute the following tasks.

1. To find out the value of unknown input signal to both aperiodic transducers.
2. To find out the unknown drifts of both aperiodic transducers.
3. To discriminate useful signal–interference.
4. To minimize the useful signal transient process dynamical error, e.g., to calculate the value of the useful signal at the very end of transient process taking into account the same process values at the very beginning of it.
5. The useful signal time dependence.

To analytically solute the five tasks, mentioned above let us consider the system block diagram, plotted in fig. 1.

Here the jump–kind input signal U_0 in a synchronous way comes to the input of aperiodic transducer 1, which drift τ_1 value is unknown, as well as to the input of transducer 2, which drift value τ_2 is also unknown. The $U_1(t)$ signal is considered useful, $U_2(t)$ – interference.

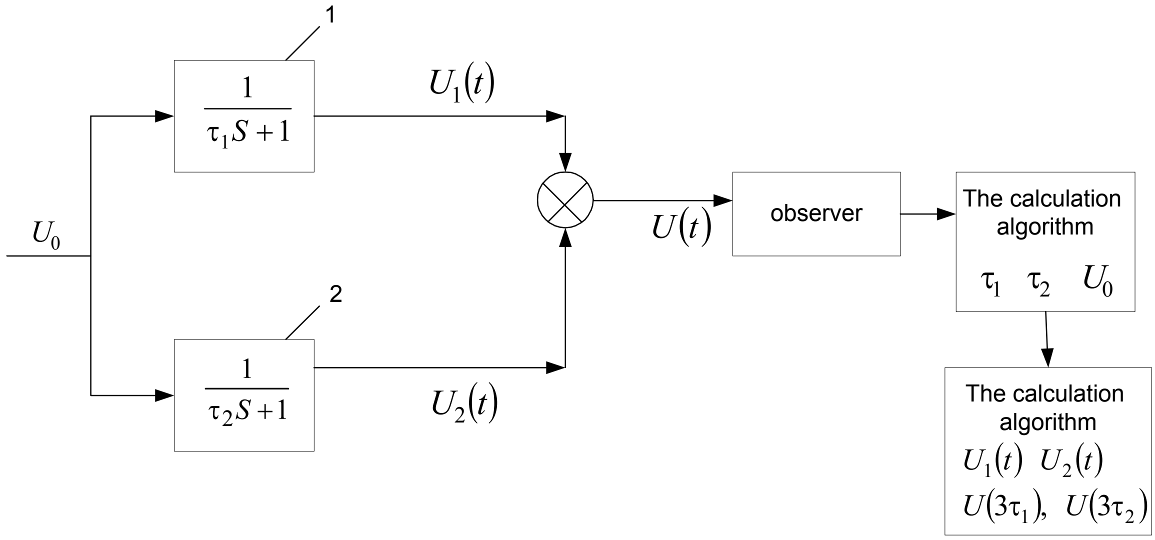

Fig. 1. Block diagram of input signal transforming and processing system

It is permitted to observe the only signal $U(t)$ of the kind of either

$$U(t)=U_1(t)\cdot U_2(t),$$

or

$$U(t)=U_1(t)\cdot U_2^{-1}(t).$$

To get the answers to the above–mentioned questions 1–5 it's necessary to firstly find out values of U_0, τ_1, τ_2. That's why we are forced to compose three metering equations, each of which is not consequence of any other.

It's reasonable to solute the task in the time area. Let the time be independent variable parameter.

$$U(t)=U_0\left(1-e^{-\frac{t}{\tau_1}}\right)\cdot U_0\left(1-e^{-\frac{t}{\tau_2}}\right). \tag{1}$$

By use notations

$$e^{-\frac{t_1}{\tau_1}}=p; \quad e^{-\frac{t_1}{\tau_2}}=g, \tag{2}$$

taking three discretes of the signal $U(t)$ at equally distanced moments of time $t_2=2t_1$, $t_3=3t_1$, we get three metering equation

$$U(t_1)=U_0^2(1-p)(1-g), \tag{3}$$

$$U(t_2)=U_0^2(1-p^2)(1-g^2)=U^2(1-p)(1+p)(1-g)(1+g), \tag{4}$$

$$U(t_3)=U_0^2(1-p^3)(1-g^3)=(1-p)(1+p+p^2)(1-g)(1+g+g^2). \tag{5}$$

By division equation (4) by equation (3), and equation (5) by equation (4), to extinguish unknown parameter U_0, one gets

$$\frac{U(t_2)}{U(t_1)} = C_{21} = (1+p)\,(1+g) = 1 + p + g + pg, \tag{6}$$

$$\frac{U(t_3)}{U(t_1)} = C_{32} = \frac{(1+p+p^2)(1+g+g^2)}{(1+p)(1+g)}. \tag{7}$$

It's possible to express p from equation (6)

$$p = \frac{C_{21} - g - 1}{g+1}. \tag{8}$$

The equation (8) may be transformed into algebraic equation (9)

$$(1+p+p^2)g^2 + [p^2 + (1 - C_{32})(p+1)]g + (p^2 + C_{32}p + p) + (1 - C_{32}) = 0. \tag{9}$$

By direct substitution p from term (8) to expression (9) one may obtain a homogenous algebraic equation of fourth power relatively the parameter g. This equation solution may produce some routs. By choosing the tolerant rout g from all possible routs one may immediately obtain the interference transducer drift τ_2 value

$$\tau_2 = -\frac{t_1}{\ln g}. \tag{10}$$

After that it becomes possible to obtain the parameter τ_1 value

$$\tau_1 = -\frac{t_1}{\ln p}. \tag{11}$$

That's why the process of U_0 value obtaining looks very simple

$$U_0 = \pm\sqrt{\frac{U(t_1)}{(1-p)(1-g)}}. \tag{12}$$

The U_0 sign uncertainty is easily removable by taking into account the sign of $U(t_1)$.

Now it's absolutely evident, that we have gotten possibility to bring the transient process error to practically zero just after taking the third discrete [$U(t_3)$] of output signal, long before the transient process finish.

It looks reasonable to analyze the option, when equation (1) is transformed into (13)

$$U(t) = \frac{U_0(1-e^{-\frac{t}{\tau_1}})}{U_0(1-e^{-\frac{t}{\tau_2}})}. \tag{13}$$

Two metering equations, necessary to help the task solution, look like follows

$$U(t_1) = \frac{1-p}{1-g} = m, \tag{14}$$

$$U(t_2) = \frac{1-p^2}{1-g^2} = \text{n}, \tag{15}$$

By expressing p from (14)

$$p = 1 - m\,(1 - g\,), \tag{16}$$

and substitution p into (15) one may obtain algebraic square equation relatively g, which tolerant root immediately brings the values of τ_1 and τ_2 according to equation (10) and (11), as well as U_0 from the equation

$$U_0 = \frac{U(t_1)}{1-\frac{t_1}{\tau_1}}. \tag{17}$$

By division the function

$$U(t) = U_0^2(1-e^{-\frac{t}{\tau_1}})\cdot(1-e^{-\frac{t}{\tau_2}}) \tag{18}$$

ordinates by the function $U_0\,(1-e^{-\frac{t}{\tau_2}})$ ordinates, which are now easily calculatable, one solutes the problem of useful signal – multiplicative interference discrimination in the shortest manner.

Following the complete analogy, by multiplying the function

$$U(t) = (1-e^{-\frac{t}{\tau_1}})(1-e^{-\frac{t}{\tau_2}})^{-1}$$

ordinates by the function $(1-e^{-\frac{t}{\tau_2}})$ ordinates, which now are easily calculatable, one easily solutes the task of useful signal–interference discrimination.

It worth’s special attention that the algorithms proposed have brought principally new possibility: it goes of bringing to practically zero the transient process of the useful signal, cleaned preliminarily from interference.

Conclusion: The approach used is applicable to other kinds of input signal, for instance, to the signals, which are changed in a linear manner.

The problem of discrimination useful signal–multiplicative interference has been analytically soluted applicably to jump–kind input signal.

Literature

1. *G. Corn, T. Corn* Mathematics reference for researches and engineers. – M.: Science, 1974. – 831 p.