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MODEL OF PARAMETRIC HYDROLOCATION FOR STATISTICALLY INHOMOGENEOUS MEDIUM

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Consideration of parametric arrays in the structure of hydroacoustical complexes for the purposes of distant sounding of water medium is necessary to provide taking into account the probable characteristics of hydroacoustical signals. In this case the modeling of processes acquires especially importance, because of the providing of experiments in natural conditions is not always possible. Hydrolocation system is combination of hydrolocation means with medium of sound propagation. In linear case medium is considered by distortions, inserting to signal, reverberation noises, ets. In the case of parametric hydrolocation medium plays the additional very important function of formation of parametric array at all. The scheme and operator model of process were constructed. On transition from operator description to probable model one may use different models of hydroacoustical signals: canonical and parametric - for the case of inhomogeneous medium of propagation; additive-multiplicative - in conditions of wave-scattering and moving of locating objects; complex form - for overall analysis.

Analysis of operation of parametric arrays in structure of hydroacoustical complexes for the purposes of distant sounding of water medium is necessary to provide considering the probable characteristics of hydroacoustical signals. In this case the modeling of processes of sound propagation is of especial importance , because of the providing of experiments in natural conditions has definite restrictions. In the same time the Department of electrohydroacoustics and medical technique of Taganrog State University of Radioengineering repeatedly has been the participant of different ocean expeditions, that results in accumulation of numerous experimental material, that may be used for verifying of adequacy of models [1].

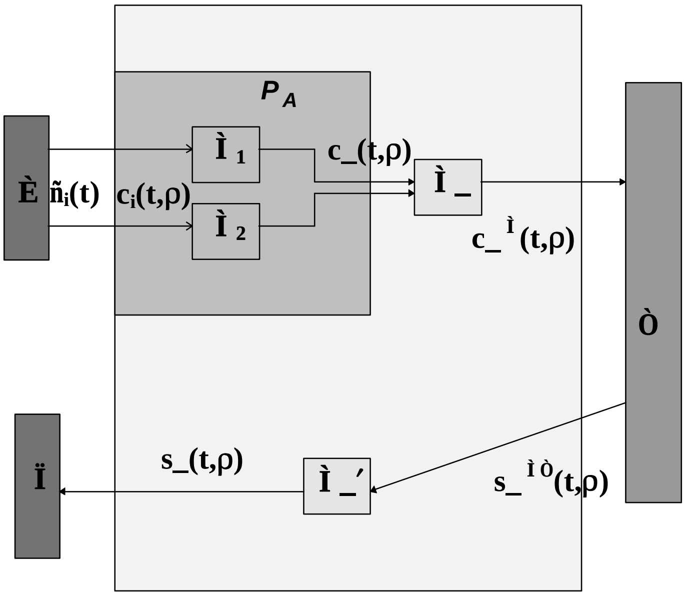

Fig. 1.

Hydrolocation system is combination of hydrolocation means and medium of sound propagation. In linear case the medium is considered by distortions, inserting to signal, reverberation noises, ets. In the case of parametric hydrolocation medium plays the additional very important function of formation of parametric array at all. Scheme of parametric hydrolocation may be represented, as shown on fig. 1.

Here *ñ*$_i$*(t, r)=Àñ*$_i$*(t)* - signal, radiating to medium; *È* - transmitter operator; $c_i(t)$ - electric signal, applying to hydroacoustical transducer; $r=r(x, y, z)$ - variable density.

Let $Ð_À$ - operator of non-linear interaction. Then

$$Ð_À=[ñ_1(t,r)ˣc_2^*(t,r)]=c\_(t,r)$$

- model of two-frequency interaction; $ñ\_(t,r)$ - difference frequency signal.

Considering the distortion of signals on the way of propagation we obtain

$$Ð_À[M_1c_1(t,r)M_2c_2^*(t,r)]=M\_c\_(t,r)=c\_^M(t,r),$$

where M_1, M_2, $M\_$ - operators, taking into account the distortion of signals on the way of propagation.

The object of location causes the reflection and scattering of signal $c\_^M(t,r)$, so the echo-signal $s^M(t,r)$ near object is $s^{M,T}(t,r)=Tc\_^M(t,r),$

where T - operator of object properties.

Receiving signal $s\_(t,r)$ with distortions on back way will be determined as

$$s\_(t,r)=M¢\_s^{M,T}(t,r)=M¢\_Tc\_^M(t,r)=M¢\_TM\_c\_(t,r).$$

For simplification in some cases we may consider that $M¢\_=M\_$. However for far location it is necessary to account space-time variability of medium. Because of that in general case $M¢\_¹M\_$.

In the example described above we consider the case when object is situated in farfield, so the operating signal is of difference frequency.

Scheme is considerably complicated, when the object of location is situated in the nearfield, so echo-signal consists of superposition of reflected primary signals, reflected signal of difference frequency and the result of interaction of reflected primary signals (fig. 2).

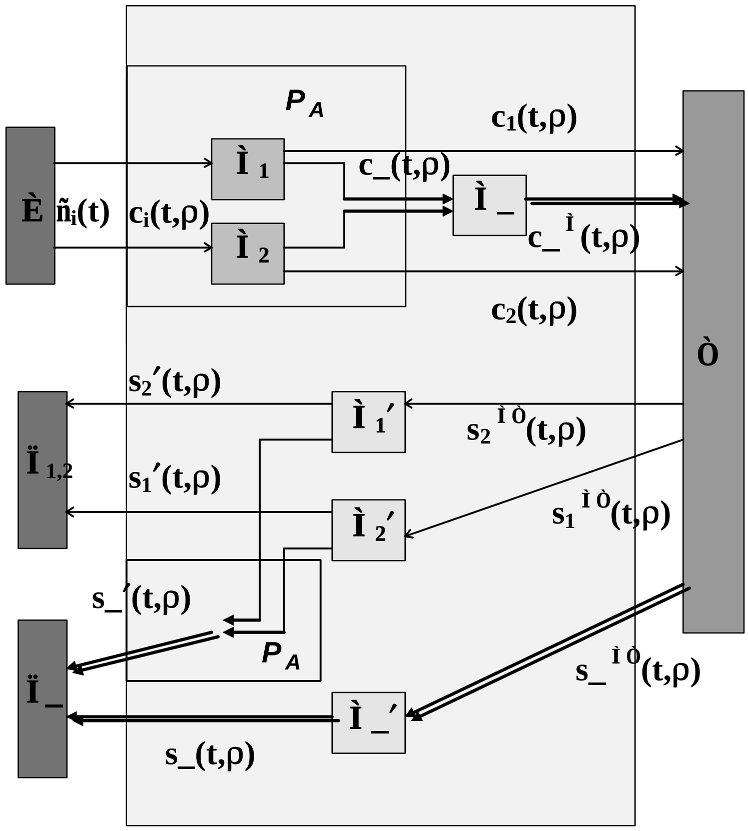

Fig. 2.

On nearfield location as signals of difference frequency $ñ\_^Ì(t,r)$, as primary frequencies $ñ_1^Ì(t,r)$ and $ñ_2^Ì(t,r)$, are applied to object $Ò$.

$$ñ_1^Ì(t,r)=Ì_1ñ_1(t,r);$$

$$ñ_2^Ì(t,r)=Ì_2ñ_2(t,r).$$

The set of signals: echo-signal of difference frequency $s\_^Ì(t,r)$ and echo-signals of primary frequencies, that are determined as shown below

$$s_1^{ÌÒ}(t,r)=Ò\,ñ_1^Ì(t,r);$$

$$s_2^{ÌÒ}(t,r)=Ò\,ñ_2^Ì(t,r),$$

will occur beyond the object *Ò* after reflection and scattering.

Primary signals $s_1{}^{ÌÒ}(t,r)$ and $s_2{}^{ÌÒ}(t,r)$ interacting between each other form the difference frequency signal. $s\_¢(t,r)$. Considering signal's distortions $Ì_1¢$ and $Ì_2¢$ and operator of non-linear interaction P_A, we may consequently y obtain

$$s_1(t,r)=M_1¢s_1{}^{MT}(t,r)= M_1¢Tñ_1{}^{Ì}(t,r)=M_1¢TM_1ñ_1(t,r);$$

$$s_2(t,r)=M_2¢s_2{}^{MT}(t,r)=M_2¢Tñ_2{}^{Ì}(t,r)=M_2¢TM_2ñ_2(t,r);$$

$$s\_¢(t,r)=P_A[s_1(t,r)\ s^*{}_2(t,r)]=P_A[M_1¢TM_1ñ_1(t,r)\ M_2¢TM_2ñ_2(t,r)]=T^2M\_¢M\_c\_(t,r)= =T^2\ M\_¢c\_{}^M(t,r),$$

where $s_1(t,r)$ and $s_2(t,r)$ - echo-signals of primary frequencies with distortion,
$s\_¢(t,r)$ - result of interaction of signals $s_1(t,r)$ and $s_2(t,r)$.

Resulting signal on receiver *Ï _* may be determined as

$$s_S(t,r)=s\_(t,r)+s\_¢(t,r)=TM¢\_c\_{}^M(t,r)+ T^2\ M\_¢c\_{}^M(t,r)=TM¢\_c\_{}^M(t,r)[1+T]= =s\_(t,r)[1+T]$$

On transition from operator description to probable model one may use different models of hydroacoustical signals: canonical and parametric - for the case of inhomogeneous medium of propagation; additive-multiplicative - in conditions of wave-scattering and moving of locating objects; complex form - for overall analysis.

There exists two ways of solving the problem: wave and phenomenological. Wave approach is based on decision of wave equation of limited beams in non-linear medium - equation of Khokhlov-Zabolotskaya-Kuznetsov. As primary data we use hydrophysical characteristics of medium, boundary conditions and characteristics of primary sources. Wave model has distinct physical interpretation, the usage of modern computing methods allows to provide enough full numeric analysis. Phenomenological approach is reduced to designing of simplificated in physical sense probable models, constructing of which often has heuristic character. The procedure contains the determination of operator with the help of which the representations of real hydroacoustical signals are obtained from simple-type processes.

R E F E R E N C E S

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