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OPTIMIZATION OF SPEECH MULTI-SUBSCRIBERS COMMUNICATION
IN THE SHALLOW SEA

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The problems of underwater communication in the shallow sea, also the model of computation and parameters analysis of electromagnetic channel of links in border less marine environment are considered in the paper. An example of engineering and experimental testing of intercommunication speech appliance for divers is offered using electromagnetic channel of communication.

Development of the ocean shelf zone exploitation demands more and more hi-tech and hi-fi reliable apparatus. One of the methods to supply aptitude for realization of undersea technical works is voiced underwater communication. At present a lot of systems for communication of different types and destination are being applied, including systems of hydroacoustical communication for shot distance.

Presented at the moment SHAC BD have the analog way of information transmission; amplitude-modulated, frequency-modulated (or their variants) types of carrier frequency; size and weight which are congruous with possibilities of users (diver, manned vehicle). However, all these systems have inherent draw backs. Such as in illegible speech during conversation and absence of criteria for creation of systems with high quality sounds of speech even at the stage of engineering. This happens because SHAC SD operate generally on the bottom or on the surface of water that resulted in appearance of the specific disturbances that look like multi-rays spread of the signal. Action of mylti-ray disturbance generals attenuation of signal at the reception part of SHAC BD or in the rarer cases as the distorted frequency of received signal. The complexity surmount such disturbances action conditioned by high degree of its correlation with irradiated signals. Therefore the existent SHAC BD possess low legibility of speech that achieves 70 % in some devices what is extremely scarce to provide quality and safe operations in the undersea technical works [1].

Thus, increase in illegibility of speech in SHAC SD while operating in the "shallow sea", also in bottom or surface layers is the actually important trend in underwater explorations and in engineering design of communication apparatus. However, it should be born in mind, that during recent technical management the new engineering of communication systems and tele-operation control based on digital methods of information transfer began to be applied, where partly aforementioned problems were success fully eliminated.

Employed electromagnetic channels under the engineering of voiced underwater communication systems admitted to decide arrow of listed questions. If a couple of electrodes placed in some basic distance between each other would be put into water giving them certain voltage, then electrical current runs between them. The electrical field created by spread currents will arise in the surrounding space. If in thus field another (receiving) couple of electrodes would be situated, then the acting potentials difference will be created around them. This phenomena is wide-known, although rarely used one, it could be applied at performing telegraph or telephone wireless underwater link modulating forced voltage with sound frequency.

Propagation of electromagnetic fields in endless homogeneous environment takes place in that case, when the distance between a transmitter and receiver significantly less, than summed up depth of submersible devices plus distance till the bottom (fig. 1), i. e.

$$r \ll (h_1 + h_2), \quad (1)$$

$$r \ll [2z - (h_1 + h_2)], \quad (2)$$

under such conditions the last is less strictly determined magnitude due to the bottom being weak conductive medium.

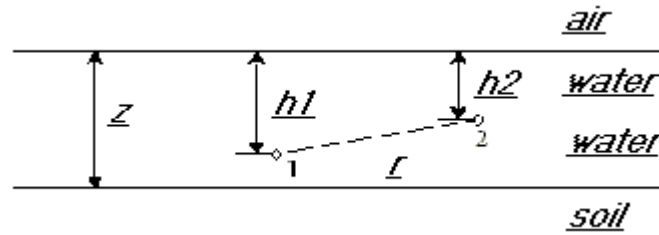


Fig. 1. Placement of sonar (1) and receiver (2) relatively boundaries of media separation.

There should be mentioned the case of propagation of electromagnetic field in half-endless conductive medium, when $r \gg |h_1 + h_2|$, i.e. in subsurface water layer, the energy follows in parallel on the string propagation way, also on the path “vertical up-along surface- vertical down”, and exponentially attenuates only on the vertical portions of way, but the way along surface the vertical portions of way, but the way along surface in the air it runs in practice without loss. The same situation, evidently, occurs while the electromagnetic field is spreading in the near-bottom interface being discriminated from the attenuation at propagation of the field energy in ground that is determine electro-conductivity of the bottom rock.

Under operation of systems of underwater communication the heaviest of electromagnetic field spread is the case of limitless environment, i.e. summarized depth of submergence of a receiver and a transmitter and as well as their total sum of distances from bottom to them are both much more then a magnitude of fade-layer in conductive medium δ . Therefore while designing systems of linkage it should be taken into account, that if the apparatus is fitted for the link in endless marine environment, then, in such case the hi-fi quality of communication is magnified in the near-bottom or subsurface layers because the signals that penetrated through air or ground with lessened loss are added to the right signals.

Created field basing on short (comparing to wave length) electrical dipole of l length and current in dipole being equaled to $I = I_0 \cdot e^{j\omega t}$ in endless homogeneous isotropic medium with specific electro conductivity σ , dielectric permeably ε , magnetic permeably μ under arbitrary frequency and arbitrary distance from the source is described by wide-known equations of Zommerfeld [2].

$$E_r = \frac{I \cdot l}{2\pi(\sigma + j\omega\varepsilon)} \cdot \frac{\cos\theta}{r^3} \cdot (1 + \gamma r) \cdot e^{-\gamma r}, \quad (3)$$

$$E_\theta = \frac{I \cdot l}{4\pi(\sigma + j\omega\varepsilon)} \cdot \frac{\sin\theta}{r^3} \cdot (1 + \gamma r + \gamma^2 r^2) \cdot e^{-\gamma r}, \quad (4)$$

$$H_\phi = \frac{I \cdot l}{4\pi} \cdot \frac{\sin\theta}{r^2} \cdot (1 + \gamma r) \cdot e^{-\gamma r}, \quad (5)$$

where constant magnitude of propagation γ , equals:

$$\gamma = \sqrt{-\varepsilon\mu\omega^2 + j\omega\mu\sigma}, \quad (6)$$

where $\omega = 2\pi f$ is angular frequency; $j = \sqrt{-1}$ is imaginable unit.

Expressions (3 ÷ 5) are adequate for every medium including conductive ones ($\omega\varepsilon \ll \sigma$) and every dielectric ($\omega\varepsilon \gg \sigma$).

On the basis of above-mentioned expressions the model of parameters estimation of electromagnetic link channel in the marine environment [3,4] was developed, which in its turn was fundamental to design underwater voiced appliance for divers and produced the experimental set of gauges by the specialists from Far Eastern Branch of Science Production Association for Commercial Fishery and Far Eastern State Technical University under consultative participation of the specialists from Institute of Problems of Ecology and Evolution of RAS.

Advantage of the voiced communication based on conductivity currents against the acoustical links is better eligibility of speech, absence of reverberation, penetration of sounds through seaweeds and preservation of link in case of obstacles like underwater rocks, aerated layers of water, also, little dependence on orientation in medium were surveyed in all tests and experiments.

The system of underwater radio-telephone communication intended for simplex link between the divers and operating ship, where the principle of electrical current field modulation is involved, consists of two half-sets. Underwater station includes in itself electronic module with seeding in box, microphone mounted in mask and the headphones of done conductivity (sink of car is opened for breath) as well the electrodes of dipole antenna that must be placed on shank and wrist of a diver. Above-water station has 30 m long antenna that can be longer depending on chosen distance of links. Modulation takes place in 300-5000 Hz band of sound frequency. Range of communications is 70-80 m (in the mode of "diver to diver") in the shallow water (till 20 m depth) it is equal to more than 100 m. The linkage distance between the shore (ship) and a diver is more then 150 m. The constituent parts of device for voiced communication are assembled as depicted in fig. 2.



Fig. 2. Underwater voiced device for communication of divers.

While making design of the systems of voiced communication through conductivity current in marine environment (for example, between divers and ship) that is supporting operations in all experiments and tests at the distance till 30 km, there was not observed any dependence on reciprocal orientation of users. Under enlargement of area for communication some factors at the different rate began to force, such as depth of the place, depth of submergence, orientation, etc.

Around the Reineke Island aquatic area the unilateral voiced communication was established to comply with the base of 2 m reception dipole over 2 km radius provided with the linear irradiating antenna of 300 m length, (wires to carry current with metal plates on the ends) which efficiency was strengthened for account of usage of the environment features. Beaming power of a coastal transmitter did not exceed 5 w under this experiment.

Over the aquatic area of Patrocl Bay (Bay 1) and Sobol Bay (Bay 2) testing experiment of the system for sound underwater communication using conductivity current in marine medium were performed. The scheme of experiment arrangement is depicted in fig. 3. Two superficial station were engaged in the test. In above water Patrocl Bay the unilateral voiced connection "shore-concrete mooring pier" was performed operation till 300 m distance. In such experiment the antenna dipole of reception station № 2 was situated at the rear part of the pier (for hydroacoustical link such conditions are insuperable because the concrete pier is an obstacle for acoustic waves). Emitting power of transmitting antenna did not exceed 5 w.

The unilateral voiced communication was established from the shore of Patrocl Bay till the station № 2, for that the electrodes of dipole were dug in the ground at 60-70 km distance from the station № 1 (connection of the "water-ground" type) when the dipole base of station № 2 antenna was

equal to 10 km. In this case the summarized signal was registered through the channels “water-ground” and “water-air-ground”.

The chance of presentation of link through the channel “water-ground” in telegraph mode applying a pulse generator was tested. There was estimated telegraph link of “water-ground” type. Communication in the mode of telephone or telegraph being directed from “ground-water” was not successful.

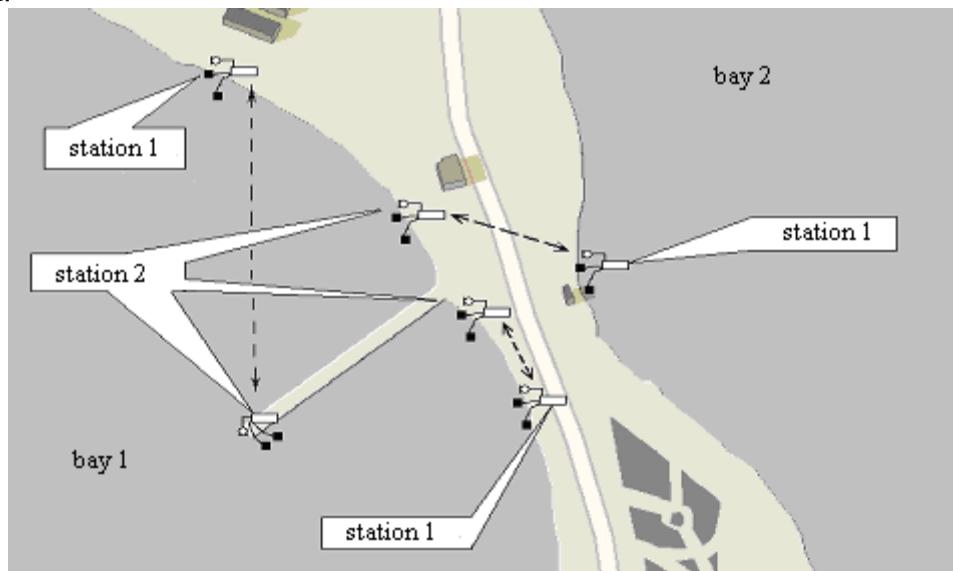


Fig. 3. The scheme of experiment arrangement

Beyond these there was established steady bilateral connection between Bay 2 and Bay 1 through ground isthmus at the distance of 100 m between communicating points. In this case the summarized signal was registered along the channels of “water-ground-water” and “water-air-water” types.

Experimental testing of the devices for talking was run by the specialists from Sakhalinsky DalmorNIIprogt, Preobrazhensky BRP of Primorriybprom, EMB “Glazkovka” of Primorriybprom, by underwater archeological expedition “Energy”, EMB “Posyet” and Far Eastern branch of SPA for Commercial Fishery in various conditions of real underwater technical operations.

In experimental testing the device for talking was employed under the exploration and ship repairing operations in the open sea and for film-shooting in sub sea archeological expedition, also for service in the mariculture farms for cultivation, and so on.

The sub sea archeological expedition “Energy” applied the device for talking when it run underwater operations in the Black Sea and in the Karskoye Sea. Testing experiment of the gauge was being fulfilled on the aquatic area of the Pacific ocean’s seas.

It should be noticed that especially important is underwater communication which is reliable and of hi-fi quality under the operations performing in the shallow sea and bays also successfully to employ appliances working on electromagnetic fields. All these could be involved in the building of oil terminals and pipe line construction, as well in search of natural resources in the shelf zone.

REFERENCES

1. Shabaev E.V. Exploration and construction of hydroacoustic systems of communication for short distance. Autoreferat on Candidate degree dissertation. Vladivostok: FESTU, 1998. (In Russian).
2. Olshansky V.M. Bionical modeling of the electrical organs in electrically charged fishes – Moscow: Nauka, 1990.-112 p. (In Russian).
3. Rublev V.P., Korochentsev V.I. Approximate model of parameters calculation of telemetric electromagnetic channel in marin medium. // Material of reports at the International scientific technical conference “Technical problems in developmental management of the World ocean”. Vladivostok: Dalnauka, 2005.- 207-210 pp. (In Russian).
4. Rublev V.P. Model of parameters calculation of electromagnetic channel in marine medium. // Materials of 48th Russian Inter-Institutional Scientific Technical conference. Vladivostok: TOVVM, 2005. (In Russian).