UNIVERSITY OF NIŠ
The scientific journal **FACTA UNIVERSITATIS**
Series: **Working and Living Environmental Protection** Vol. 1, No 4, 1999, pp. 51 - 54
Editor of series: Ljiljana Rašković, e-mail: ral@junis.ni.ac.yu
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SPECIFIC FEATURES OF USING PIEZOCERAMIC TRANSDUCERS FOR UNDERWATER NOISE MEASUREMENTS

UDC 534.873

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Abstract. *Most sonar listening systems operate od a lw frequency range. Piezoceramic transducers often are chosen for their antenna grids, since they can be made relatively simply, to fulfill requirements of ruggendess and efficiency and because they can be used to cover a wide frequency band. The highest sensitivity and efficiency and the smallest size of the transducer is obtained when its active element excites bending modes. In the presented paper three types of transducers are investigated - bimorph, trimoph and cymbal type. Their fundamental features are described.*

Key words: *piezoceramic transducer, sonar system, underwater noise*

1. INTRODUCTION

The major research trends in sonar-related underwater acoustic signal processing from the earlier 1980-s to the present have been the increased interest in wide band transducers and lower frequencies for both passive and active sonar.

Piezoelectric transducers (and especially piezoceramic ones) often are chosen, since they can be used to cover the wide frequency range [1,2].

Another advantage is that piezoceramic transducer is fully revwersible so that it can be used both as a projector and a receiver. Three types low frequency range transducers are used widely - bimorph, trimorph and cymbal type.

Because of their ruggedness, sensitivity and simplicity, they are built in passive antennas of the data acquisition buoys (DAB-s). In this case the fact that these types of transudecers provide the highest sensitivity along with the smallest size (their active elements excite bending modes), is of the first importance.

Received July 26, 1999

2. PERSPECTIVE LOW FREQUENCY PIEZOELECTERIC TRANSDUCERS

Many construction of the passive acoustic antennas are based on a bimorph active element [3,4]. It is composed of two piezoceramic plates (generally disks), pasted each other with conductive glue. Depending on the direction of the polarization vector of the disks, two variants of electrical connection between them are possible. For mechanical strength one of them can be substituted for passive - from alloyed steel, titanium and others. This type of bimorph sometimes is named "half-passive".

The "sound cell" is composed of one or two bimorph elements. The symmetric construction, shown schematically in Fig. 1, is a typical one.

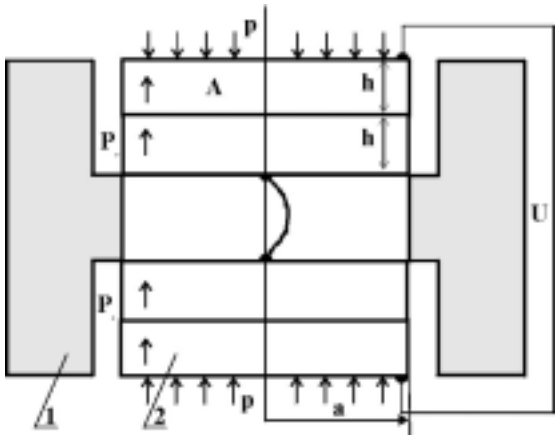

Fig. 1. Sound cell
1 - support; 2 - bimorph; p - sound pressure; P_0 - polarization vector.

Because the velocities of vibration of the opposite active surfaces are equal in value and opposite in sign, the transducer is classified like a pulsing one. This fact allows the problem of the obtaining the acoustic field to be substituted for the equivalent problem of the obtaining the field of the same transducer, installed in absolutely rigid acoustic baffe.

The "trimorph" element possesses essential advantages in comparison with bimorph. It consists of three plates - two of them are piezoelectric (active), and medium is passive - Fig. 2.

A "Cymbal - type" transducer is discussed in [15]. It has been developed by capping a poled piezoceramic disk - Fig. 3.

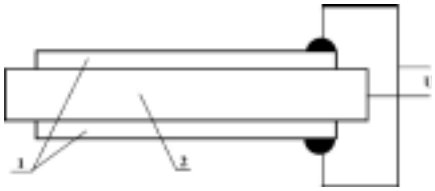

Fig. 2.
1-inner passive plate; 2-outer active plates.

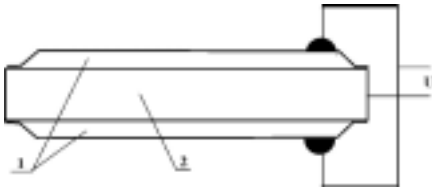

Fig 3.
1-piezoceramic disk;
2-caps from Al, Ti, Mo, Steel, Brass etc.

The commutation of the electrodes of the outer plates have to provide initation of opposite bending strain. The basic advantage of this element is that the outer plates can be very thin (0,1÷0,2 mm) and thus its resistance can be smaller than the bimorph one.

It is intended for use in the frequency range between 10 and 50 kHz. The two resonance frequencies can be manipulated by selecting appropriate materials or geometry. Proper placement of the resonance frequencies may allow for the broadening of the operational bandwidth as well as the generation of difference frequencies It can be seen that in a sense the cymbal-type construction is inverse of the trimorph one.

3. DATA AQUISITION BY CABLE COMMUNICATION LINES

The most frequently piezotransducers receive analogye signal. In many cases cable communication lines are used for this purpose (for example the cable between the underwater antenna, submerged in depth and DAB on the ocean surface).

Two ways are actual in organization of data aquisition in this case: the analog signal is directly transmitted or it is tranformed in digital. When piezotransducers are used for dataaquisition, conditioning preamplifiers are built in almost compulsory. The problems are analogous in ocean noise investigation by piezoelectric hydrophones as well as in using of piezoelectric accelerometers for vibration meassurements and control in the power electric station. Two types of conditioning preamplifiers are used: charge preamplifiers and preamplifiers with high input impedance [16,7].

Charge preamplifier possesses very good linearity, good frequency response, and, the most significant, the capacitance of connecting cable has not influence on its work. Deviation of the resonant frequency of the transducer is its disadvantage. Except this a special low noise cable for the signal must be used. It must have high insulated resistance and low electrization.

The high input impedance preamplifier doesn't load the transducer and possesses a high amplification facrot. The connecting cable influences its work strongli however. Therefore if the charge preamplifier can be coupled in the ened of the connecting cable, the high input impedance preamplifier must be near the transducer compulsory, i.e. near the submerged antenna of the DAB.

4. DATA AQUISITION CONDITIONING PREAMPLIFIER

The preamplifier is designated for use in the frequency range until 100 kHz - Fig. 4.

Its important feature is the use of two-wire line where the supply wire is united with the signal one. The other wire ins't connected to ghe ground but to the input of the next stage with input resistance R_1.

As it can be seen, the signal source (piezoelectric transducer) is floating. Because of this it can be used not only a coaxial cable with normalized resistance, but a skew-wire line with considerable deviation of the impedance parameters. The amplification factor of the preamplifier can reach 40 dB in the range mentioned above. Voltage noise in the 1 kHz band (10 kHz central frequency) is 2 μV, consumption current - no more 5 mA.

The preamplifier, in combination with a hydrophone sound cell type, was used for measurements and data acquisition, in the hydroacoustic tank and in situ in depth 100 m.

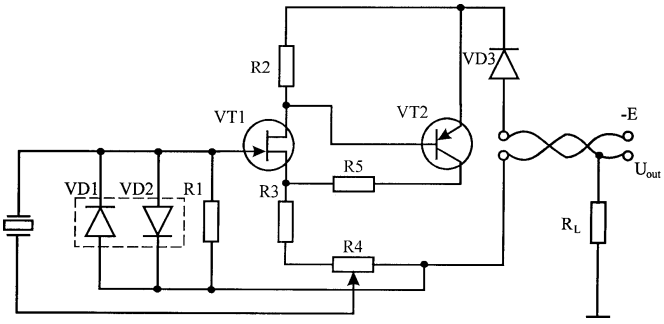

Fig. 4. High input resistance conditioning preamplifier

5. CONCLUSION

In designing and testing sonar systems, the specific features of the piezoelectric transducers must be taken into consideration. The most perspective in the low frequencies are bimorph, trimorph and cymbal types. The electronic system have to contain a conditioning preamplifer, which converts the hihg transducers impedance. It can be charge preamplifier or preamplifier with a high input impedance. A simple low - cost conditioning preamplifier can be arranged by using the couple JFE - BJ trannsistors.

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SPECIFIČNE KARAKTERISTIKE KORIŠĆENJA PIEZOKERAMIČKIH PRETVARAČA ZA MERENJE ŠUMA POD VODOM

Tihomir Trifonov

Veliki broj prislušnih sistema radi na niskim frekvencijama. Piezokeramički pretvarači se često koriste za njihove antenske rešetke, jer se mogu relativno prosto napraviti da ispune zahteve efikasnosti i jer mogu da pokriju širi frekvencijski opseg. Najveća osetljivost i efikasnost i najmanja veličina pretvarača dobija se kada njihov aktivni element pobuđuje bending modove. U prezentiranom radu istraživana su tri tipa pretvarača - bimorfni, trimorfni i cimbalni tip. Opisane su njihove osnovne osobine.