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# CONSIDERATIONS IN THE DESIGN, INSTALLATION AND OPERATION OF A COMPLETE SOUNDING SYSTEM

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## ABSTRACT

This paper is concerned with the various parameters which are critical in order to achieve an optimal echo sounding system for a specific application. A number of practical examples are explained.

Echo sounding systems have a tendency to be so general, that it is important the user understands how to select the right type of echo sounding system for his application.

The paper only deals with the acoustic and analog signal handling, whereas the digital handling, which is mainly a software problem, is not discussed here.

Special attention is given to the right choice of transducer for a specific job and its installation.


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## Background

In this paper special emphasis is placed on a rather neglected part of an echo sounding system — the transducer.

The transducer itself costs generally less than 10 % of the total cost of an echo sounding system. An improvement in transducer performance can dramatically improve the complete echo sounding system, and for this reason it is good value for money to look into this area.

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**What is important to the operator ?**

A good echo sounder system should give a good strong echo signal, which yields a good recording and stable digitized echo information. However, in practice, this is not always the case. What are the possible reasons for this ? Before answering the question, let us look at the different links in the chain, which together form an echo sounding system (see fig. 1).

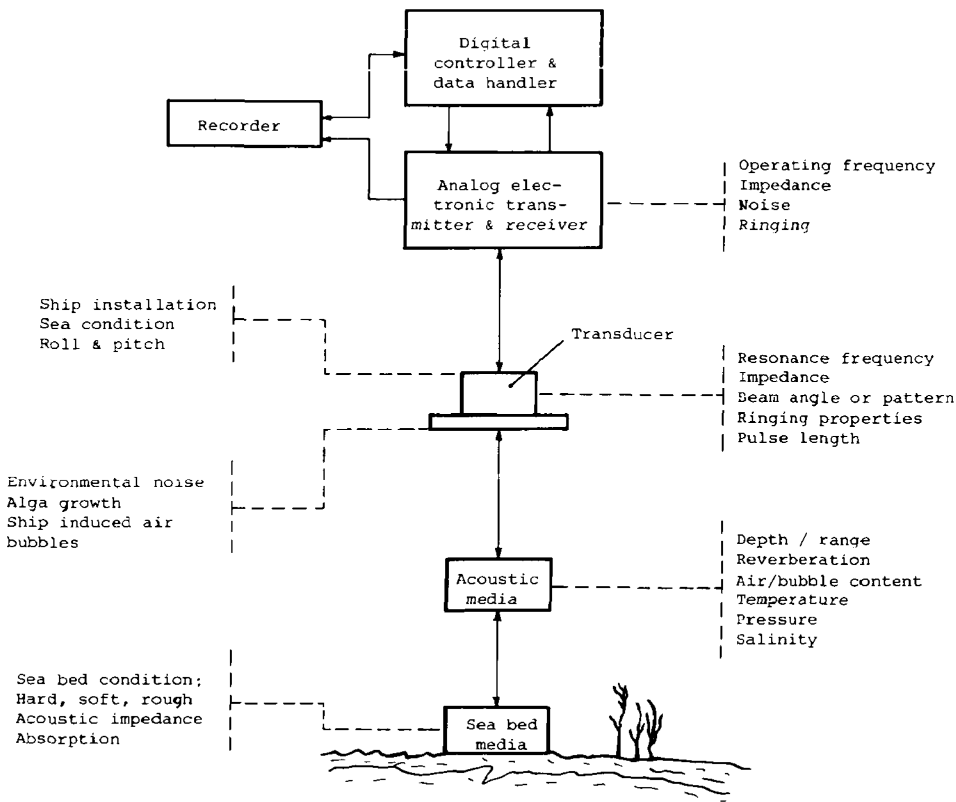


FIG. 1

Let us begin with the transducer :

It is essential that the transducer is situated and mounted correctly, to obtain the best possible performance.

(a) The transducer should be placed in the middle or up to the first third of the ship to avoid the noisiest part of the ship (see fig. 2).

(b) To obtain the best possible water contact, the transducer surface should point slightly forward ($1^{\circ}$ to $2^{\circ}$) to the bow direction, so the water builds a positive static pressure on the transducer surface. The transducer should preferably be a

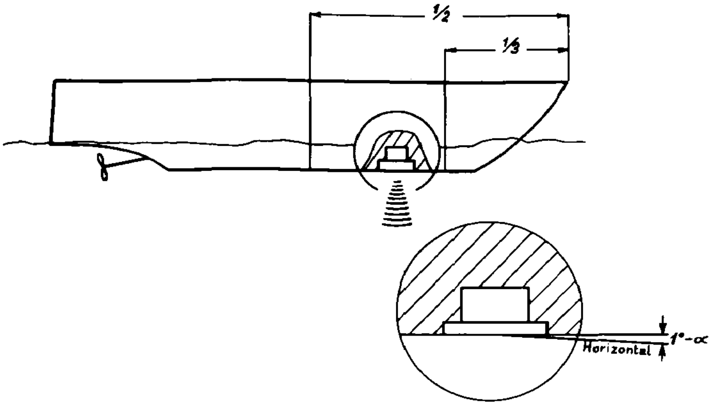


FIG. 2

little (1 to 1.5 mm) above flush mounting. If the transducer is below flush mounting, air bubbles might be caught on the transducer surface (see fig. 3).

(c) It is also essential that the transducer is mounted in a place where no air bubbles, or as few as possible, are carried under the ship hull and across the transducer surface. A slight amount of air or small bubbles can seriously obstruct transducer operation.

(d) If the transducer is not stabilized, which is normally the case, the smallest beam angle should always be chosen from the point of view of normal sea conditions, roll and pitch movements of the boat.

*Transducer operation*

(e) It is important that the operating frequency and the output impedance of the transceiver are carefully matched with the resonance frequency and the electrical input impedance of the transducer. This seems to be quite obvious; however, a mismatch is very often the case, resulting in poor performance. The

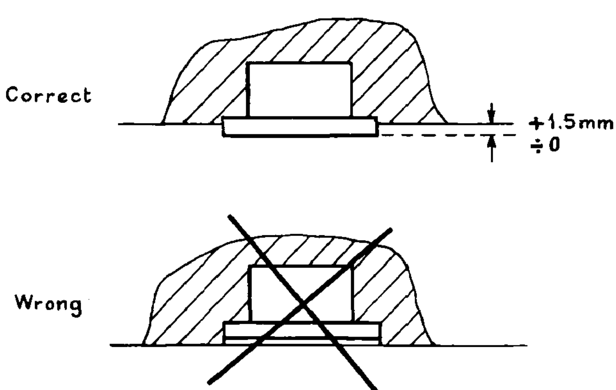


FIG. 3

reasons are square laws and exponential laws affecting the deviation from ideally matched impedance and resonance frequency. This means a 10 % deviation can easily affect the total performance by 20 to 30 dB — which can be crucial on longer ranges.

(f) Transducer ringing should normally be kept low, in order to get stable echo sounder operation in shallow water. However, it should be observed that ringing normally occurs as ringing in the transducer as well as in the transceiver or, worse, even as self-induced ringing in the transceiver. This can occur because the transducer together with the transceiver can act as a complex oscillating circuitry.

(g) As little noise as possible should be introduced into the receiver. This design parameter is just as important as the transducer performance, in improving the total echo sounder performance. In an echo sounder transceiver, the transmitting power level and the receiver gain (amplification) are normally automatically controlled. However, as an example, by increasing the transmitting power level by 10 times, it only increases the received signal by 10 dB, and the result may even be a damaged transducer. As a result of this, it is a much better idea to improve the receiver performance by fighting the noise introduced by the transducer and especially the noise introduced in the receiver. By using a carefully designed receiver, integrated with the transducer, the signal-to-noise ratio can be improved by 30 to 40 dB compared with the best of today's commercially available echo sounder systems.

As mentioned at the outset, the introduction of improved transducer characteristics will only very slightly increase the total system price, but will have a very big effect on its overall performance.

When a big, stable and conditioned echo signal is available from the receiver, it is pretty straightforward to digitize the signal for further data handling. Design aspects, on the digital part, are not within the scope of this paper.

*How to choose the right transducer for a specific echo sounder application*

Naturally, the answer depends very much on the type of application, and it is not easy to present a single answer.

However, there are some basic aspects which should be observed : *a system can be designed for maximum range based on a desired resolution.*

In choosing the right transducer, the suggested resolution, pulse length, operating frequency, beam angle, noise level, and power level, respectively, should be compared with the range, expected transmission loss and thereby the frequency, because the pulse is expected to contain at least 20 cycles (empirical value). The expected range can then be calculated from the well known sonar equation. But the data of the receiver also play an important role, referring to earlier discussions. Therefore, the sonar equation can only be used for determining physical limits on the range, and the supplier should furnish data on the actually expected range.

*In shallow water a system is normally designed to detect a specific type of target*

In this situation the transducer frequency and beam angle are specified in order to obtain a reliable echo from the target at small range.

As an example, it could be detecting possible obstacles around a harbour, like poles, stones and other objects. The echo sounding system will normally look on the first arriving echo, so it is only a question of whether the frequency is high enough to get an echo from the pole with the smallest projected dimension, e.g. diameter. To get a reliable echo from the pole, the wavelength should be at least less than the diameter of the pole. The beam angle of the transducer should be kept small, so the projected diameter on the sea bed does not exceed 10 times the pole diameter (pole reflection 40 dB down compared to the sea bed reflection).

Another application could be detecting holes in the sea bed.

In this case the beam angle of the transducer becomes critical because the surrounding sea bed will return the first echo if the beam angle is not so small that the projected sound can be contained in the hole. The projected diameter should be at least 2 to 3 times smaller than the hole diameter. However, this type of application can be very difficult to implement, because the trig criteria in a receiver can make this type of application impossible. These are just a couple of examples. Other applications require very accurate distance measurements, and here the frequency and beam angle are the most important parameters.

## CONCLUSION

From a user's point of view, echo sounding operation can be considerably improved if the installation is optimized in terms of correct installation of the transducer, selected transducer specifications for a specific application and a noise optimized transceiver.

However, the user should always consult experts in the field in order to obtain the best results.

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