UNDERWATER ACOUSTICS

TECHNICAL GUIDANCE NOTE

National Physical Laboratory

Electrical loading corrections

The sensitivity of a hydrophone is often specified as the end-of-cable open-circuit sensitivity. This is the sensitivity of the hydrophone at the end of its cable when not connected to an electrical load. When a specific electrical load, such as an oscilloscope, an amplifier or extra cable is used at the output of the hydrophone, the end-of-cable loaded sensitivity of the hydrophone may be related to the open-circuit sensitivity in the following way.

Corrections using complex impedance

Consider the general case in which the hydrophone is considered as a two-terminal network of complex impedance Z_H connected to an electrical load of complex impedance Z_L. The end-of-cable loaded sensitivity of the hydrophone, M_L, when connected to the specified load is related to the end-of-cable open-circuit sensitivity, M_O, by

$$M_L = M_O \sqrt{\frac{\mathrm{Re}(Z_\mathrm{L})^2 + \mathrm{Im}(Z_\mathrm{L})^2}{[\mathrm{Re}(Z_\mathrm{L}) + \mathrm{Re}(Z_\mathrm{H})]^2 + [\mathrm{Im}(Z_\mathrm{L}) + \mathrm{Im}(Z_\mathrm{H})]^2}}$$

where Re and Im denote the real and imaginary parts of the relevant complex impedance.

Often, the electrical load can be assumed to be a parallel combination of a resistance R_L and capacitance C_L. In this case, $\mathrm{Re}(Z_L)$ and $\mathrm{Im}(Z_L)$ are given by

$$\mathrm{Re}(Z_L) = \frac{R_L}{1+\omega^2 C_L^2 R_L^2}$$

and

$$\mathrm{Im}(Z_L) = \frac{-\omega C_L R_L^2}{1+\omega^2 C_L^2 R_L^2}$$

where ω is the angular frequency.

Corrections using only capacitance values

A further simplification is possible if the impedances of both the hydrophone and the load can be assumed to be purely capacitive. This is often a valid assumption for a hydrophone at frequencies much less than the resonance frequency and for loads such as extension cables. In this case, if C_H is the end-of-cable capacitance of the hydrophone *including* any integral cable and connector, the above equation reduces to:

$$M_L = M_O\left[\frac{C_H}{C_H + C_L}\right] \quad \textbf{(1)}$$

For further information, contact:

Stephen Robinson
Centre for Mechanical and Acoustical Metrology
National Physical Laboratory
Hampton Road
Teddington
Middlesex TW11 0LW
United Kingdom
Tel: 020 8943 7152
Fax: 020 8943 6217
Email: stephen.robinson@npl.co.uk

Or, why not visit the NPL Acoustics web pages at: http://www.npl.co.uk/acoustics