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Response to James McNames, Portland State University by Tom Mortensen PLM Sensors RESON Group, Nov 12, 2009.

1. Own noise of a hydrophone:

The equivalent spectral noise pressure curve on a hydrophone datasheet is the own noise of the hydrophone. In popular terms the electrical output from the hydrophone if it was isolated completely from its surroundings. The spectral noise curve is the magnitude of the spectrum normalized to a 1Hz bandwidth and units are dB re 1µPa/√Hz.
Below on Figure 1 is shown the equivalent noise spectrum for TC4032 operating in single ended mode (looking the positive signal only).

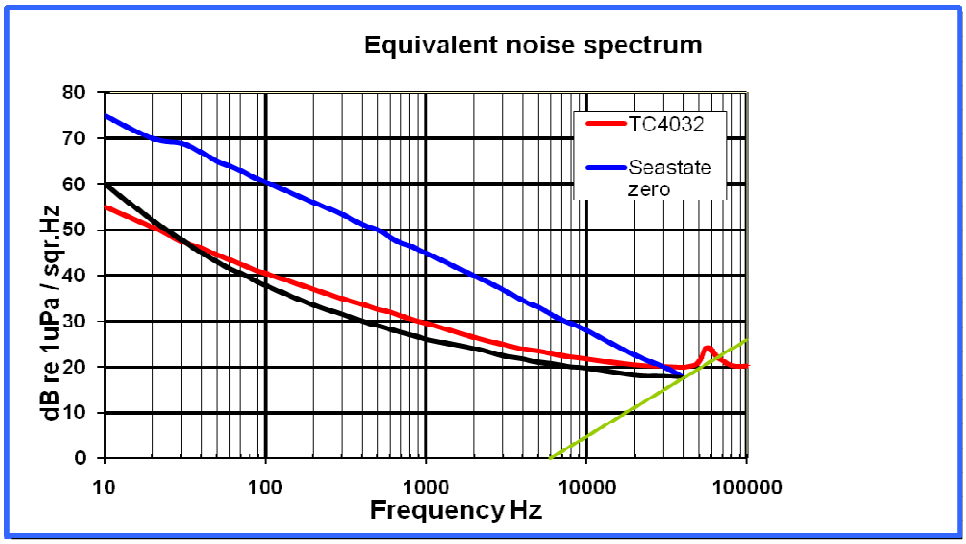

Figure 1: Equivalent noise spectrum for TC4032.

In order to measure own noise of a hydrophone first of all you need to isolate the hydrophone from the environment - this means that all acoustical noise sources need to be eliminated and the same goes for all electrical noise sources. This is easier said than done – and the following will show how it is possible to make a setup that is getting close to what is required.

1.1. Acoustic noise:

The hydrophone need to be placed in a sound dead chamber. The best decoupling you get in air or possibly with vacuum in the chamber. Notice that down at the low frequency range air couples equally well than water to the hydrophone sensor element. This is utilized in a piston-phone calibration that typically is done at 200 or 250Hz. See also tech note on piston-phone calibration. Placing the hydrophone in water will lead to much higher pickup of real acoustic noise from the environment. Noise will couple through the ground to the water and also via the water/air surface. Real acoustic noise is sound that really should and will be picked up by the hydrophone and therefore needs to be eliminated so it doesn't add to the measured "own" noise.
A sketch of the setup used by RESON for own noise measurement is shown on Figure 2.

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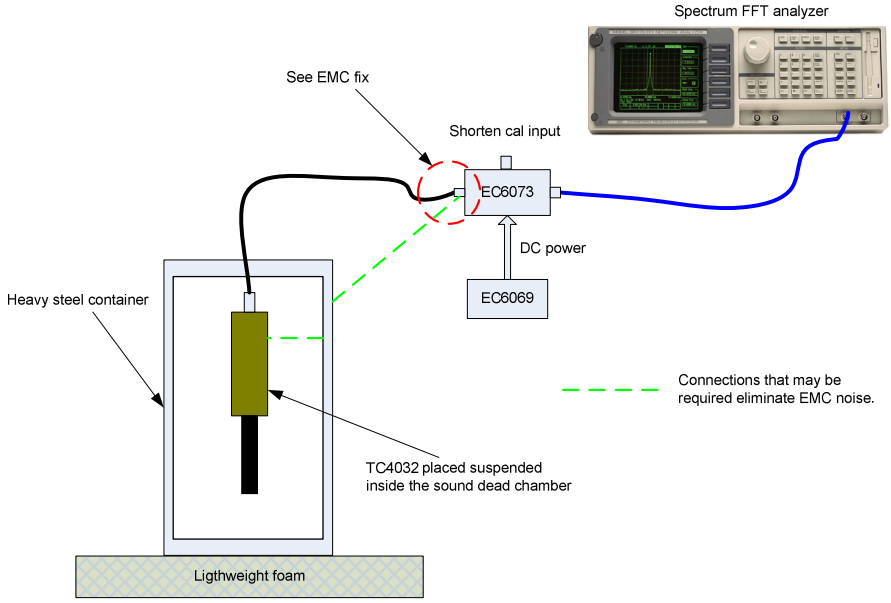

Figure 2: Sketch of the setup used by RESON.

The best way to make a sound dead chamber is to use a large and heavy steel container with a small opening that allows feed the cable through. The sound chamber needs to be isolated from the external environment – typically it will be standing on a floor or on a table. Isolation can be done by placing the chamber on a thick layer of lightweight foam material.
A positive side effect of using a steel container is that it also acts as a Faraday cage meaning a shield against external electromagnetic noise – a point that will be addressed later on.

Notice also that a typical hydrophone will work as an accelerometer so mechanical vibrations from the environment will feed/couple through the cable and the way the hydrophone is suspended inside the steel container and down to the sensor element where vibrations will transform into output voltage that will be amplified by the preamp and send up via the output lead.

Figure 3: Example of a suitable steel container. The container needs to be decoupled properly from the floor and still be placed in a very quiet place this means no heavy traffic outside the building – no doors slamming – no people talking etc….

1.2. Electromagnetic noise sources

All possible electromagnetic noise sources need to be eliminated from the measurement setup. The easiest setup is obtained by using an EC6073 input module and EC6068 rechargeable battery or EC6069 dry cell based. A DC lab supply

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may be ok - but could also induce electrical noise - noise that will feed to the preamp inside the TC4032 hydrophone and get back amplified via the signal wire.

Notice that the EC6073 input module only handles the positive output signal from the differential TC4032. The negative signal that combined with the positive signal gives the differential output is not utilized of the EC6073 input module is used. For your info a new version of the input module that handles both single ended and differential signals is on the way but is not released/for sale yet.

The EC6073 is build with proper EMC shielding. The BNC caltone input connector needs to be shortened via a 50 Ohm resistor. If not cal tone input will act as an antenna and pick up electrical noise that will be amplified.

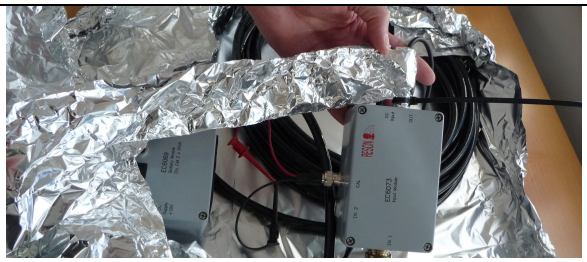
The output from EC6073 is on a BNC connector and coax cable is used to connect to a spectrum analyzer.

If a pigtail cable is used from the hydrophone to the signal acquisition setup point, the cal wire need to be shortened to ground. Secondly a proper Faraday cage needs to be built around the end of the cable and the Faraday cage need to be connected to ground. If not the open wire ends will act as an antennas and pickup electrical noise from the environment noise that will feed down via the cable to the preamp and become amplified.

The 21Hz hum signal certainly indicates electrical noise pickup and is not generated inside the hydrophone. Adding a high pass filter doesn't help – the source need to be found and eliminated.

A Faraday cage can be made out of tinfoil - just be sure not to shorten anything that shouldn't be shortened. In an environment with lot of electromagnetic noise it may be necessary to put everything inside a Faraday cage as shown below Figure 4. The only output from the Faraday cage is the coax cable with the hydrophone signal. This will also be the proper way in case a pigtail cable is used between hydrophone and signal acquisition electronics. The Faraday cage doesn't have to look nice.

The hydrophone wrapped in tinfoil



Battery box + EC6073 input module inside tinfoil wrapping. Notice the tinfoil tail on the BNC output to make sure that signal ground is properly connected to the cage.

The TL8058 cable that goes between hydrophone and the input module is placed inside the tinfoil wrapping.

During the experiment the tinfoil wrapping needs to be kept nicely together – not like on the picture above.

Figure 4: Example of a tinfoil based Faraday cage.

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1.3. Measurement done in Open office space and no precautions taken

The purpose of the following plot it to show difference between an own noise measurement done in proper lab environment and a measurement done in an open office environment - the red curve compared to the light blue. Notice that the output voltage level of the TC4032 at 1000Hz when placed in the setup on Figure 6 equals only $2 \cdot 10^{-7}$Volt. We are talking very tiny signal levels and even the slightest amount of acoustic or electromagnetic noise will spoil an own noise measurement.

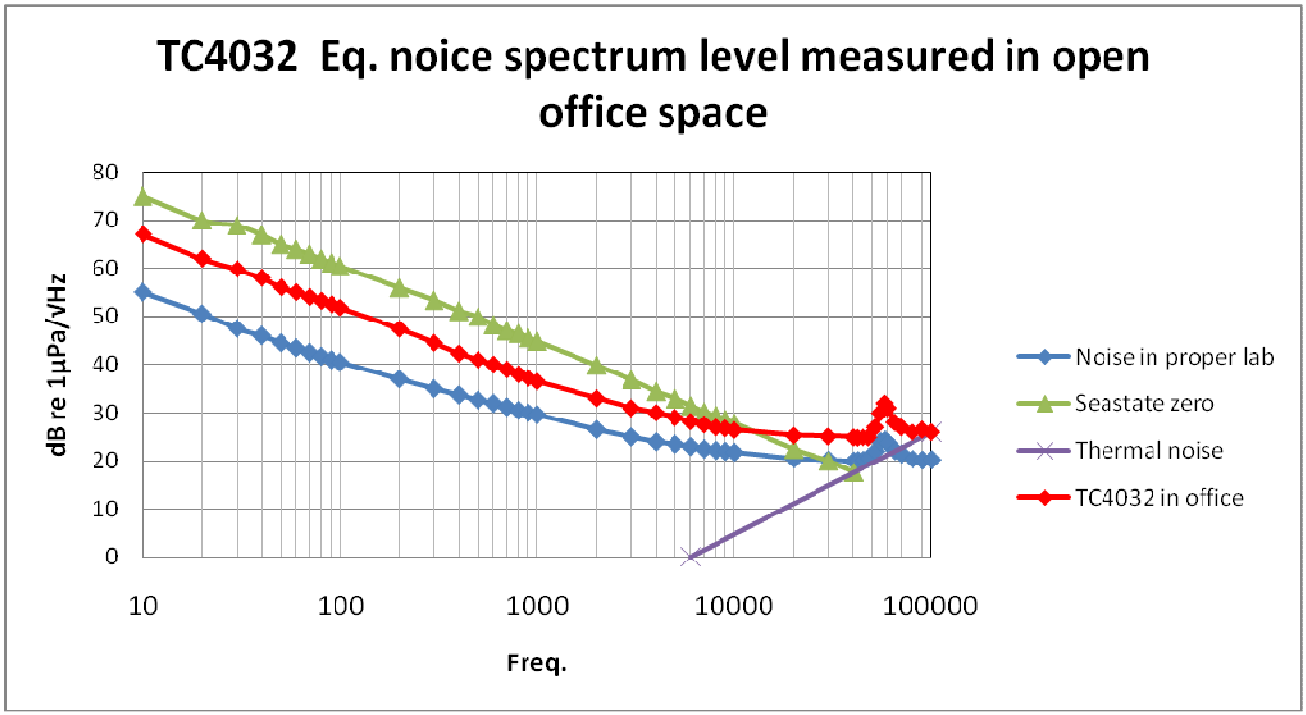

Figure 5: Comparison of own noise measurement done in a proper test lab and in an open office environment.

Figure 6: The open office setup – no shielding, 10meter cable between hydrophone and input module. A setup like that is simply not good enough for a proper own noise measurement.