Case Study Underwater Lab

Sound waves studied in a simulated ocean with high-precision PCIe measurement cards

The Acoustics Research Group at the Department of Physics and Astronomy, Brigham Young University, Utah, USA has chosen Spectrum Instrumentation's leading-edge digitizers and signal generators to form the heart of its new underwater acoustics laboratory. The new lab is a big step forward in research on sound waves travelling through water as it effectively provides a miniaturized version of the ocean. Experiments are possible on sound wave's behavior in different water layers and their reflections from the ocean's most diverse ground materials such as rocks, sand or mud. The miniaturization means that the highest precision is needed from the measurement equipment as the experimental results are scaled up afterwards to indicate what would happen in the real world.

The new laboratory water tank is rectangular and measures 3.6 m long by 1.2 m wide with a maximum water depth of 0.91 m. The research involves using a hydrophone for the signals or chirps which are generated by an Arbitrary Waveform Generator (AWG), the Spectrum model M2p.6546-x4. This PC-card generates signals with 24 V output swings that are then amplified before being broadcasted by the hydrophones. After travelling through the tank, the signals are detected by another hydrophone and processed by a Spectrum M2p.5932-x4 digitizer card. The transmitter and receiver are each held by a robotic arm that positions and orientates them within the water so that source and receiver can be positioned as required.

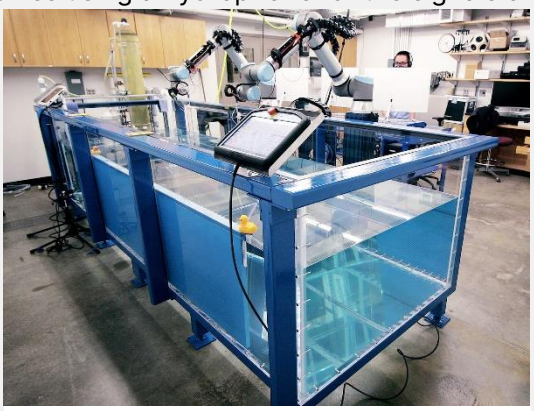

Figure 1: The water tank with the two robotic arms to position the transmitter and receiver

The tank enables experiments to be done on how the surface of the ocean floor affects sound waves bouncing off it. A pure rock bottom will have a different effect compared to sand or mud or layers of different materials. "It is even more complicated," explained Dr. Traci Neilsen, the professor in charge of the project, "because water is not homogeneous. Changing salinity or temperatures bend the waves travelling to and from the ocean bottom in a similar way to how mirages happen. By modelling these situations in the tank, we can more accurately understand signals as they travel through the ocean. It's a much more repeatable methodology than detonating explosives in the ocean and studying the resulting

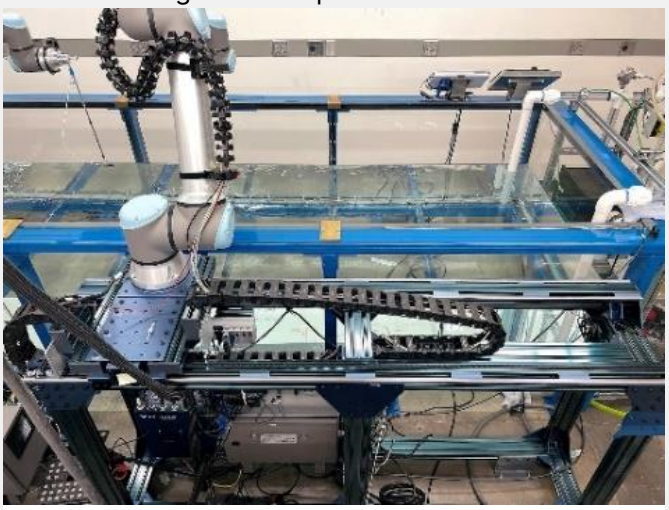

Figure 2: Mechanics of one robotic arm

© Spectrum Instrumentation GmbH, Germany

echoes and signals."

Adam Kingsley, the PhD student responsible for the acquisition software, said: "We chose Spectrum products because they have proved to be able to deliver the extremely high level of precision and synchronization that we require. Because this tank is effectively a miniaturization of a huge body of water, timing precision is vital for the results to be meaningful when scaled up."

Figure 3: The control console with the two grey PCIe chassis in the middle

The pair of Spectrum PCIe-cards are housed in an external PCIe chassis in the main control console and accurately synchronized together using a Star-Hub module by Spectrum. The setup has a second identical pair of cards in a second chassis that can be triggered into operation by the Star-Hub. The digitizers and AWG cards have a high resolution of 16-bit and a sampling rate of 40 MS/s that deliver the high precision required for the experiments. This scaled down experiment requires much higher frequencies than would be used in the ocean, which are in the kilohertz region. The AWGs generate the frequencies in the megahertz range needed for the experiment with

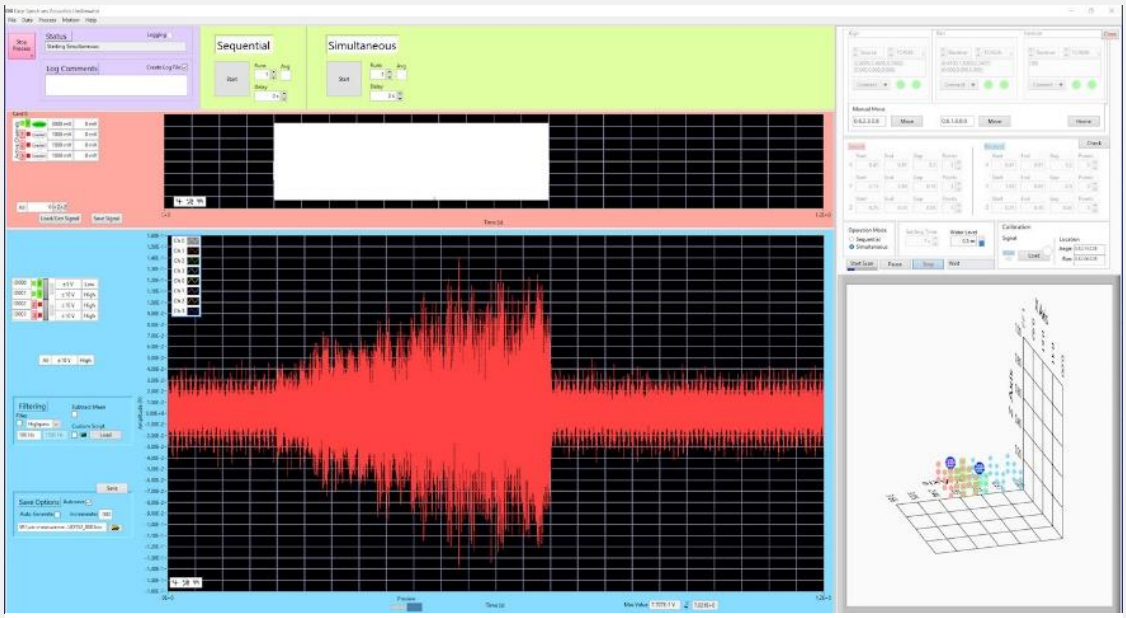

Figure 4: The ESAU software facilitates user communication with the Spectrum cards and the robotic arms

a channel skew of less than 100 pico-seconds. The two robot arms, along with the signal generation and the data acquisition, are all controlled by a custom LabVIEW software program that was created by Adam Kingsley himself and referred to as "Easy Spectrum Acoustics Underwater" (ESAU).

Case Study Underwater Lab

Figure 5: Digitizer card M2p.5932-x4 and generator card M2p.6546-x4 by Spectrum

A key part of the experimental set up is to model the open ocean, so special anechoic panels on the sides of the tank absorb stray reflections. A significant challenge was to design a filtration and circulation pump to keep the water clean without creating bubbles in the tank, which are a significant source of noise. With all these preparations in place, impulse responses could be measured, making it easier to eliminate noise from readings when an experiment is being done. The precision of the Spectrum PC-cards with a Signal to Noise Ratio (SNR) of more than 71 dB ensures that the impulse response elimination gives accurate experimental results.

Dr. Neilsen added: “This new lab was built to enable research students to design and run their own experiments as part of their university studies. It was therefore important that all the equipment used is robust and easy to use as this set up will be in operation intensively for many years. Like many other laboratories, we value the unique five-year warranty that Spectrum Instrumentation provides as it means we can rely on their products for years.”

© Spectrum Instrumentation GmbH, Germany