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Crikey – It's PXI Down Under

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Category:
Communications

Products Used:
PXI-1000B Chassis
PXI-8176 RT controller
PXI-4472 DSA card(s)
PXI-6052E I/O card
LabVIEW RT Development System V6.1

The Challenge: To develop a cost effective system for measuring underwater radiated noise.

The Solution: A custom data acquisition system based on PXI hardware and LabVIEW software offered the optimum combination of input signal resolution and integrity, compact and robust form factor for seabed installation, and full PC programmability plus network support.

Abstract
This paper describes an Underwater Radiated Noise Measurement System with application in naval operations and the oil and gas industry. The system consists of an array of hydrophones connected to a Data Acquisition Pod that sits up to 150 m deep on the seabed. The Pod contains a Real-Time PXI Chassis with 24-bit, 96 kHz hydrophone inputs, and various analog and digital I/O that manage the transducer interface and monitor the Pod environment. The Pod is connected via Ethernet to a PC Master Station and a PC Operator Station on a surface vessel up to 2 km away. All acoustic data is logged to local disk in the Pod, and transferred via ftp to the Master Station for processing and archiving at the completion of a run. The operator can select any one of the acoustic channels to be relayed to the surface vessel to provide direct audio feedback on the status of the run.

Introduction
The monitoring of underwater radiated noise has application in naval operations and the oil and gas industry, for the characterisation and tracking of underwater vehicles such as submarines, ROVs, etc. In a broader sense it is a subset of a much larger range of marine applications for high-resolution multi-channel data acquisition systems capable of continuous logging at sample rates up to 200 kHz. Dynamic range is particularly important in the marine environment where signals are acquired in a complex background that ranges from very large amplitude, low frequency swell events, to low amplitude high frequency transients, both natural and man-made.

There are no standard "off-the-shelf" systems that encompass all requirements in the field. Almost all applications require at least some degree of customising of the system design and physical installation. PXI offered the optimum combination of technical characteristics to suit the task, together with tight coupling between the hardware and LabVIEW software which ensured that the custom integration could be completed in a timely and cost-effective manner.

Submerged PXI
Figure 1 shows a conceptual representation of the Underwater Radiated Noise Measurement System. The system consists of a hydrophone array which floats suspended above a Data Acquisition Pod that sits up to 150 m deep on the ocean floor. The Pod is a watertight steel cylinder that contains a Real-Time PXI data acquisition unit comprising a PXI-1000B chassis, PXI-8176 RT 1.26 GHz Embedded Controller, PXI-4472 dynamic signal acquisition card(s), and a PXI-6052E Multi-Function I/O card. The Pod is tethered to a monitoring vessel on the surface by up to 2 km of cable incorporating an Ethernet link.

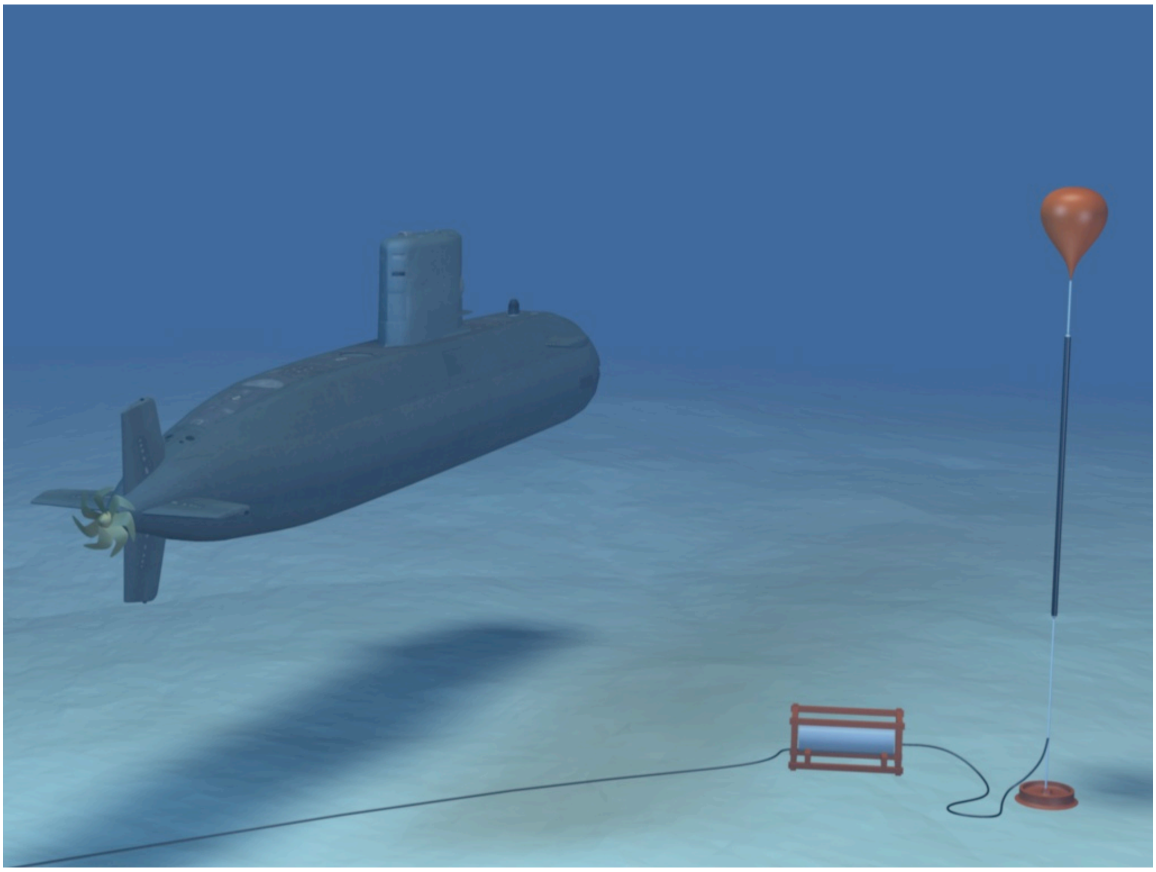

Fig. 1 – The Underwater Radiated Noise Measurement System (artist's rendition)

In typical operation the data acquisition system would be exposed to the noise source for a period ranging from a few to several tens of minutes, depending upon the nature of the source. During the exposure all hydrophone inputs would be sampled and logged continuously to the local PXI disk in the Pod at 24-bit resolution and 96 kSa/s sample rate. Any one of the inputs can be selected from the monitoring vessel and re-transmitted as audio over the Ethernet link to provide direct feedback to the operator. The re-transmission is implemented via a link from LabVIEW to Microsoft's DirectX audio-streaming technology. At the end of the exposure period the binary data file is transferred via ftp from the Pod to the master server on the monitoring vessel for long-term archiving and analysis. The binary data file is typically 100 MB in size. The cycle then repeats as required.

The LabVIEW software is a client–server architecture, shown schematically in Figure 2. The Pod client and Remote Control Station log into the DAS Server automatically. In addition to its main task of acquiring and logging the hydrophone data, the Pod client is also responsible for monitoring the Pod environment and controlling the hydrophone transducer interface. During an acquisition run the Pod client streams audio packets to the DAS Server, and environment and status packets to the Remote Control Station. The Remote Control Station provides the operator interface to the DAS Server and Pod client. It sends control packets to the Pod, and initiates the ftp data transfer from the Pod to the DAS Server once the run is complete.

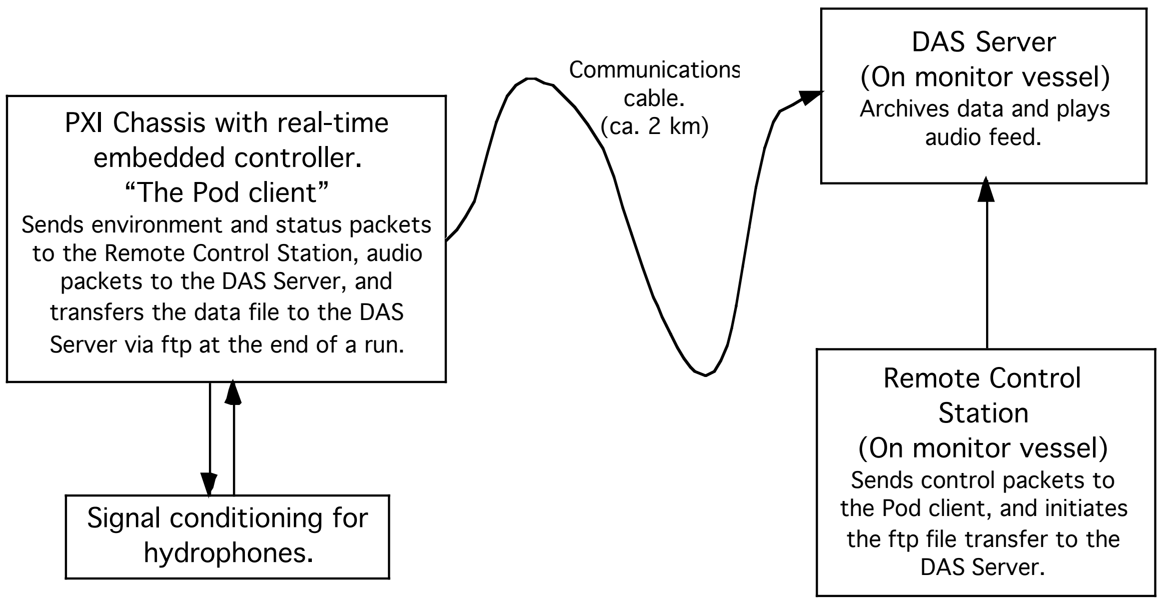

Fig. 2 – Schematic of the software client-server architecture

A Great Solution To A Generic Problem

In the introduction it was pointed out that measuring underwater radiated noise was a specific application of the more general problem of high-resolution, multi-channel data acquisition in the marine environment. Resolution is a particular issue given that signals are being acquired within a complex background that ranges from high amplitude swell effects at frequencies of several Hz, to a multitude of low amplitude natural and man-made signals at kHz and higher frequencies.

The client identified the PXI platform as offering the optimum mix of capabilities to address the requirements of the task. In general terms PXI offered a robust, compact form factor with modest power requirements, that made it suitable for encapsulation within the submerged Pod, without compromising data acquisition speed and computer processing power. The PXI-4472 24-bit Dynamic Signal Acquisition board in particular offers a combination of dynamic range, channel density, and sample rate that make it ideally suited to many underwater data acquisition tasks. Each PXI-4472 includes eight simultaneously-sampled channels, so the existing system could be upgraded to 56 input channels without significantly affecting the Pod architecture.

Using LabVIEW RT meant that the Pod client could take advantage of the additional robustness offered by running under a fully deterministic, embedded real-time operating system, without compromising programming power. This was very important, given that retrieval of the Pod from the seabed to address any computer-related issues was a major logistical task. The client and server applications running in the less demanding environment of the monitoring vessel were Windows based, enabling them to take maximum advantage of the many industry-standard productivity tools available for the Windows desktop.

While the ability of each hardware and software component to meet the requirements of the task was critical, the tight level of integration between the National Instruments hardware and LabVIEW RT software was equally important in the choice of platform architecture. The close coupling of hardware and software gave the client a very high degree of confidence that the custom system could be designed, built, and deployed in a cost-effective and timely manner.