A 16-Element Autonomous Receiving Array

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***Abstract* - An autonomous receiving array system has been designed, fabricated, and deployed at-sea for the collection of broadband underwater acoustic data. The system consists of a 16-element hydrophone array, a pressure case containing the data acquisition and disk storage hardware, and a mooring which includes floats for buoyancy, a RF-beacon and flasher, deep-sea batteries, and an acoustic release. The array cable consists of 16 twisted-pairs with a polyurethane outer jacket and a Kevlar strength member. In the current configuration, the array cable is 75 m in aperture with take-outs spaced every 5 m. Hydrophone-preamplifier packages (HTI-94-SSQ) are attached at each take-out and essentially have a flat frequency response from 20 Hz through 20 kHz. The multi-channel data acquisition system consists of a compact PCI chassis with CPU, signal conditioning electronics, and A/D. The data is recorded on four IDE, 60 GB, 2.5" disk drives. All data acquisition functions are carried out in LabVIEW. The CPU includes a 100BaseT Ethernet interface which is made available through a bulkhead connector on the pressure case. Thus, high-speed access to the data on the internal disks is available without the need to open the pressure case. Power is supplied externally by two 24 volt, Deep Sea Power & Light batteries which provide approximately 48 hours of underwater data collection. An alternative mooring configuration currently being developed will enable power and Ethernet connectivity to be provided by a surface buoy which then can facilitate access to the data over a RF-telemetry link from shore or a nearby ship (e.g. an 802.11b wireless LAN).**

I. INTRODUCTION

Two autonomous broadband receiving array systems have been designed, fabricated, and deployed at-sea during the Office of Naval Research ASIAEX East China Sea experiment (May-June 2001) [1-2]. Each system consists of a 16-element hydrophone array, a pressure case containing the data acquisition and disk storage hardware needed for sampling the hydrophone time series and operating the system for 48 hours, and a mooring which includes floats for buoyancy, a RF-beacon and flasher, deep-sea batteries, and an acoustic release.

II. HARDWARE DESCRIPTION

The hardware components of the autonomous broadband receiving array systems are described below. First, the specifications of the array cable and transducers are given. Next, an overview of the data acquisition system is provided. Lastly, the array mooring is described.

A. Array Cable and Transducers

The array cable consists of 16 twisted-pairs of #24 AWG wire with a polyurethane outer jacket and a Kevlar strength member at the center. The array cable has a working load of 1000 lbs and breaking strength of 5000 lbs. Take-outs are spaced every 5 m along the cable (75 m total aperture) and provide an Impulse IE2MF style connector for attaching a hydrophone.

The transducers are HTI-94-SSQ hydrophones with –198 dB re 1 Volt/μPa sensitivity and an 18 dB current loop preamplifier. The current mode preamplifiers are used because they essentially eliminate channel-to-channel crosstalk in the array cable. The hydrophone-preamplifier combination approximately is flat in response from 20 Hz to 20 kHz with high pass corner frequencies at 0.5 and 20 Hz. The preamplifier self-noise characteristics are as follows: (1) 54 dB re 1 $\mu Pa^2/Hz$ at 10 Hz, (2) 40 dB re 1 $\mu Pa^2/Hz$ at 100 Hz, and (3) 38 dB re 1 $\mu Pa^2/Hz$ at 1000 Hz and above.

The array cable terminates in a connector which plugs into its mating bulkhead connector on the pressure case.

B. Data Acquisition System

The multi-channel data acquisition system consists of a compact PCI (peripheral control interconnect) chassis with a Pentium-III 600 MHz CPU and 64 MB memory running Windows NT, a National Instruments A/D, and a custom electronics board providing signal conditioning prior to the A/D (see Fig. 1). The data is recorded as 16-bit integers and storage is provided by four IDE, 60 GB, 2.5” disk

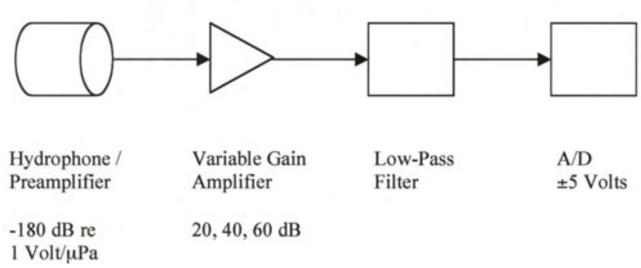

Fig. 1. Data acquisition system block diagram for the autonomous receiving array. All 16 channels are identical. Two sampling rate configurations have been implemented: f_s = 20.480 kHz and f_s = 50 kHz.

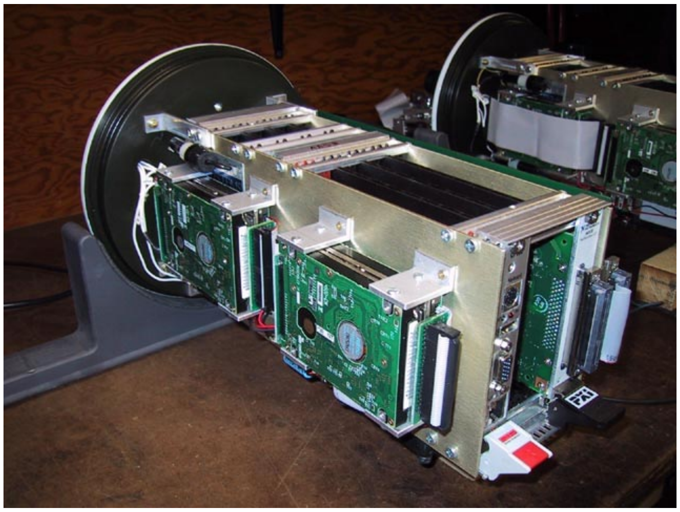

Fig. 2. Data acquisition system showing the four IDE, 60 GB, 2.5” disk drives. Immediately adjacent to the disks is the CPU in the 4-slot compact PCI card cage. Two slots remain free for future expansion.

drives (see Fig. 2). All data acquisition functions are carried out in LabVIEW 6i.

The signal conditioning for each channel (see Fig. 3) consists of a variable gain, split-resistor amplifier (jumper-selectable 20, 40, and 60 dB) and a low-pass filter (Maxim MAX274 with 0 dB insertion loss). The split-resistor amplifier design provides differential rejection of common mode noise sources inside the acquisition package (mostly digital and power supply noise). In addition to the variable gain amplifier, the A/D provides additional programmable gain over the range 0-40 dB.

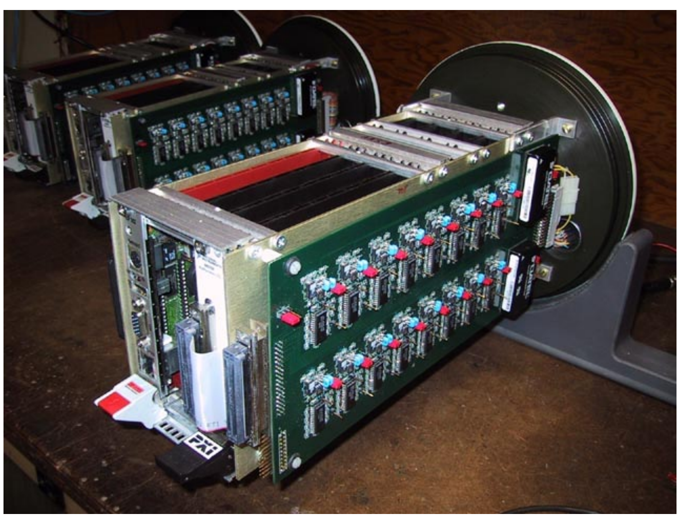

Fig. 3. Data acquisition system showing the custom electronics board which provides signal conditioning. Immediately adjacent to the signal conditioning board is the A/D.

Two sampling rate configurations have been implemented. For the ASIAEX East China Sea experiment, a National Instruments PXI-6052E 16-bit A/D (maximum throughput 333 kSamples/s) was used with each channel being sampled at f_S = 20.480 kHz. Here, an 8-pole Chebyshev low-pass filter was implemented with corner frequency at 10 kHz. As an alternative configuration, a National Instruments PXI-6070E 12-bit A/D (maximum throughput 1.25 MSamples/s) also has been assembled with each channel being sampled at f_S = 50 kHz. In this case, an 8-pole Butterworth low-pass filter has been implemented with corner frequency at 25 kHz. The Butterworth filter design was used in the second configuration of the signal conditioning board to reduce the electronics self-noise to that of the HTI preamplifier for all gain settings.

The CPU includes a 100BaseT Ethernet interface which is made available through a bulkhead connector on the pressure case (see Fig. 4). Thus, the desktop of the data acquisition system is made available remotely over the Ethernet for set-up of system parameters and modification of the LabVIEW VI (Virtual Instrument) if necessary. Furthermore, high-speed access to the data on the internal disks is available via a FTP server without the need to open the pressure case. It requires approximately 8 hours to FTP data from the internal disks (~240 GB) to an external FireWire disk attached to a laptop.

In addition to providing an Ethernet connection to through the pressure case, power also can be supplied through this connector for underwater or on-deck operation when it is desired to have direct access to the system. For autonomous operation, battery power (24 volts DC) is supplied externally through another bulkhead connector on the pressure case (see Fig. 4). A DC-to-DC converter (18-36 volts input) provides the voltages required by the data acquisition system (3.3, 5, and 12 volts). In order to protect the batteries, a power controller will latch off when the battery voltage drops below 18 volts (essentially, full discharge for the batteries). It requires approximately 8 hours to recharge the batteries from full discharge.

The data acquisition system draws a total of 43 watts while digitizing and archiving data to disk and 33 watts when idle.

C. Mooring

The mooring includes 12, 14” trawl floats for buoyancy above the array (38 lbs buoyancy/float) and another 4 floats on the seafloor end of the array to compensate for the weight of the batteries and acoustic release.

The pressure case, 24 volt batteries, RF-beacon, flasher, and flotation are mounted on a fiberglass box frame structure near the seafloor (see Fig. 5). The batteries are Deep Sea Power & Light SB-24/42 (24 volts DC, 42 AH) which provide approximately 48 hours of underwater data collection.

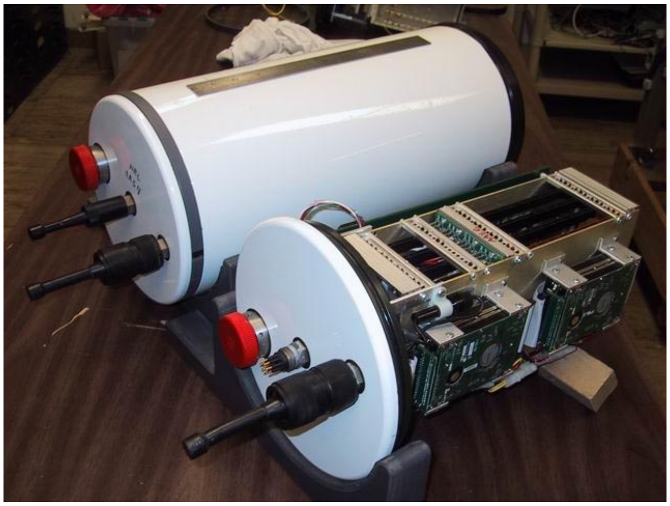

Fig. 4. Pressure case showing bulkhead connectors (left-to-right): (1) array, (2) 100BaseT and external power supply, and (3) battery power.

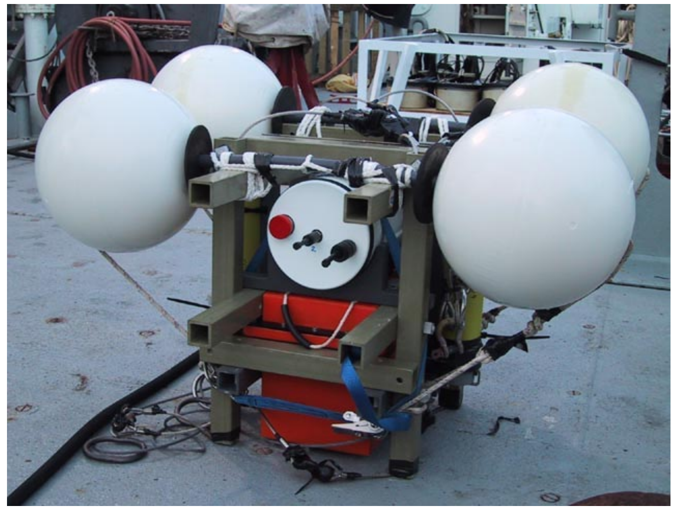

Fig. 5. Pressure case, 24 volt batteries, and flotation mounted on a fiberglass box frame structure.

A dual acoustic release (using EdgeTech AM200 releases) is configured underneath the box frame structure and is interrogated by a deck box (EdgeTech AMD200) (see Fig. 6). A sacrificial weight (~850 lbs) is attached below the dual release.

Fig. 6. Dual acoustic release.

III. SUMMARY

An autonomous, broadband receiving array system has been described. The system consists of a 16-element hydrophone array, a pressure case containing the data acquisition and disk storage hardware needed for sampling the hydrophone time series and operating the system for 48 hours, and a mooring which includes floats for buoyancy, a RF-beacon and flasher, deep-sea batteries, and an acoustic release. The hardware was deployed and successfully collected data during the ONR ASIAEX East China Sea Experiment [2] (see Fig. 7). An alternative mooring system currently being developed will enable power and Ethernet connectivity to be provided by a surface buoy which then can facilitate access to the data over a RF-telemetry link from shore or a nearby ship (e.g. an 802.11b wireless LAN [3]).

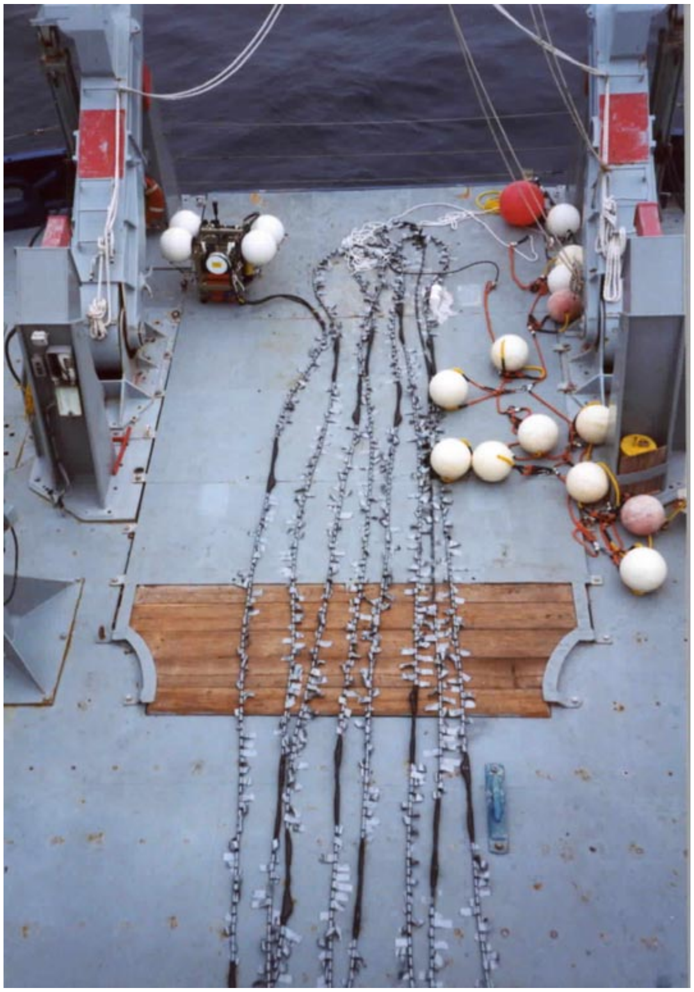

Fig. 7. Autonomous receiving array being prepared for deployment off the R/V Melville in June 2001 during the ONR ASIAEX East China Sea experiment.

ACKNOWLEDGMENTS

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