Inductive telemetry for UOP Ocean Reference Station Moorings

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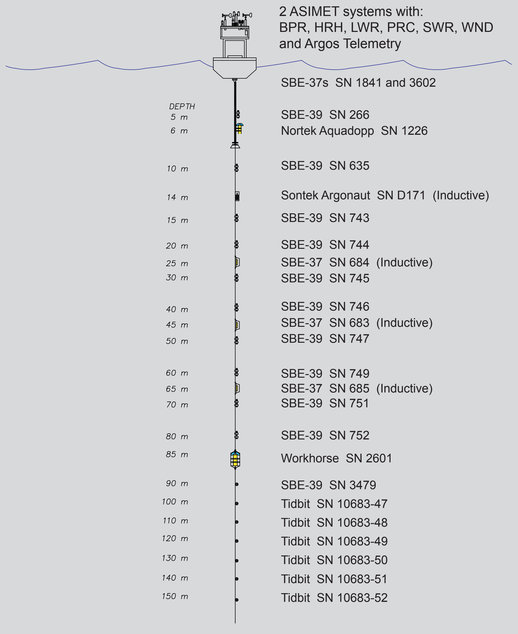
As part of an effort to make real-time upper-ocean temperature and velocity available from UOP Ocean Reference Stations (ORS), an inductive telemetry system was developed for use on the NTAS ORS mooring. An electro-mechanical (EM) interface was designed to reduce fatigue while providing an electrical connection from the surface buoy to jacketed wire rope on the mooring. Conductors from electronics in the buoy well are mated to a six-meter EM section which terminates at a wire coupling assembly. The NTAS-7 mooring was outfitted with 4 inductively-coupled sensors in the upper 65 m: 3 Seabird SBE-37s and a Sontek Argonaut current meter. A communications subsystem was developed to acquire and transmit data from the sensors. A low-power Inductive modem controller awakens a Seabird Inductive Modem (IM) every 5 minutes. The IM then awakens the modems of all attached instruments, and within about 20 seconds gets all the responses. Every 4 hours, an Iridium Communication Module (ICM) requests the most recent buffered data from the IM controller, creates four 1-hour averages of the data, formats the result and sends it to the Iridium modem. The modem initiates Short Burst Data transmissions which are received and processed on a workstation at WHOI. The processing system decodes the binary data and produce data listings and plots on the UOP web site within minutes of data being transmitted.

Background

As part of an effort to make real-time upper-ocean temperature, conductivity and velocity available from the UOP Ocean Reference Stations (ORS), an electro-mechanical (EM) interface developed by the WHOI Applied Ocean Physics and Engineering (AOPE) Department was adapted for use on an ORS mooring. One of the problems encountered when bringing data up conductors to a surface buoy is cyclic fatigue due to wave action. A robust, re-usable EM interface capable of accommodating both inductive and acoustic telemetry was desired.

The goal was to obtain near-surface currents along with temperature and salinity (T/S) data within the upper 100 m. The Northwest Tropical Atlantic Station (NTAS) mooring design (figure below) was modified to have a single section of jacketed wire rope between 8 and 80 m depth which could accommodate inductive sensors.



Schematic drawing of the upper 150 m of the NTAS-7 mooring with inductively coupled current meter at 14 m and inductive T/S sensors at 25, 45 and 65 m.

AOPE engineers have developed similar interfaces for previous projects. The Ice Tethered Profiler project (http://www.whoi.edu/arcticgroup) developed a wire-rope termination that preserves the electrical isolation of the wire from sea water. The Nootka project (Frye et al., 2005) developed an EM interface for acoustic telemetry. Elements of these designs were combined to produce an EM interface for ORS moorings capable of both inductive and acoustic data telemetry. The UOP group designed a buoy communicaitons controller to complete the system.

Methods and Results

Electro-Mechanical Components

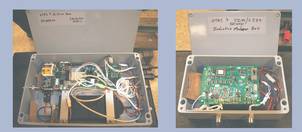
The mechanical components of the EM interface include a specially designed universal joint, a six-meter molded chain section, flanged spacers for managing electrical connections, and a wire coupling assembly with space for an acoustic modem to be mounted alongside (acoustic telemetry was not used for this deployement).

The molded chain section uses ¾" mooring chain as a strength member. The chain is passed through a close-fitting reinforced hose which is sealed at one end and filled with flexible polyurethane. An eight conductor, insulated "coil cord" is then wound over the chain/hose assembly, another reinforced hose is fed over this assembly, the chain is secured to flanges at each end, and the outer hose is filled with polyurethane. The result is a robust, yet compliant electro-mechanical section that brings protected conductors through the sea-surface interface.

A bell mouth and socket in the coupling assembly accept a specially terminated shot of 7/16" jacketed wire rope which completes the electrical connection from the base of the buoy to a mooring wire of arbitrary length below the coupling assembly.

Communications Subsystem

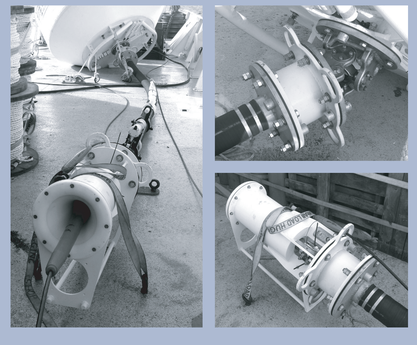
The inductive communications subsystem is built around an ASIMET C530 Inductive Modem (IM) controller connected to a Seabird IM and an Iridium Communication Module (ICM). The IM controller powers up the Seabird IM every 5 minutes to get new data from the instruments. The controller polls fixed addresses on the IM loop and places the responses in a buffer that holds up to 4 hours of data.



The ICM consists of an NAL 9522A Iridium modem, a Linux Single Board Computer (SBC), and a power control/regulator board. Every 4 hours, the SBC is turned on and requests the most recent buffered data from the IM controller. The SBC creates 4 one-hour averages of the 5-minute data, formats the result as a binary message, sends it to the Iridium modem and logs the averaged data to compact flash. The modem initiates a Short Burst Data (SBD) transmission and sends the data. The SBC is powered down after its message has been sent and the data recorded.

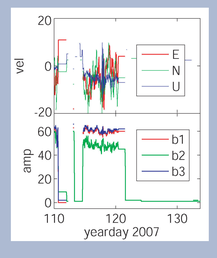
An automated system running on a workstation at WHOI receives the SBD messages as email attachments, extracts the data payloads and produce data listings and plots on the UOP web site within minutes of data being transmitted from the buoy.

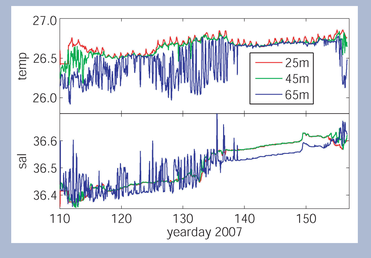
Assembly and Deployment



In preparation for deployment, components of the EM interface are laid out on deck, connected electrically, and tested by using a temporary, hard-wired connection to provide the ground from the base of the mooring wire to the coupling assembly. Once proper functioning of inductive communications is confirmed, the EM interface is assembled mechanically. During deployment, a portion of the mooring wire, with instruments attached, is run to the stern and the lower portion of the EM interface is lifted over the rail with a crane. The EM interface is then tied off until the buoy is ready to be lifted into the water.

Initial Results





For NTAS-7, the subsurface telemetry system was outfitted with three Seabird SBE-37s and a Sontek Argonaut current meter in the upper 65 m. The hourly data received via Iridium is a subset of the data returned from inductive polling.

Sontek telemetry failed after the first 10 days (left figure). Inspection by divers determined that this was due to failure of the wire connecting the inductive coupler to the instrument housing. Data from Seabird SBE-37s, which use a coupler integrated to the sensor housing, have been obtained reliably since deployment in April 2007 (right figure).

Summary

An electro-mechanical (EM) interface capable of accommodating both inductive and acoustic telemetry, and a telemetry controller for inductive telemetery, were developed for use on a WHOI ORS mooring. The system was deployed on the NTAS replacement mooring in April of 2007.

The mechanical components of the EM interface include a specially designed universal joint, a six-meter molded chain section iwth spiral-wrapped conductors, flanged spacers for managing electrical connections, and a wire coupling assembly for mechanical and electrical connection to the upper section of jacketd wire rope on the mooring. The telemetry controller consists of an inductive modem controller and an iridium communications module.

The inductive portion of the telemetry system was incorporated on the NTAS-7 ORS, outfitted with three Seabird SBE-37s and a Sontek Argonaut current meter in the upper 65 m. The telemetry controller was set up to obtain 5 min data via inductive modem link from the subsurface sensors and return hourly average data at four-hour intervals via Iridium satellite link.

Telemetry of currents was unsuccessful due to mechanical failure between the inductive coupler and the sensor. Telemetry of temperature and salinity was successful and data are available on the UOP website.

Further Information

Near real time subsurface telemetry data from NTAS-7 are available from the UOP website at http://uop.whoi.edu/projects/NTAS/ntasdata.htm.

Information about the ITP inductive telemetry interface can be found at http://www.whoi.edu/itp/technology.html

Information about the Nootka project can be found at http://www.whoi.edu/oceanus/viewArticle.do?id=9627 and in:

Ware et al., 2005. A solar powered ocean observatory using acoustic and Iridium links, Proc. Marine Tech. Soc. Meeting.

Frye et al., 2005. An acoustically-linked deep-ocean observatory, Proc. Oceans '05.

Technical information about the ASIMET buoy meteorology system is available at http://frodo.whoi.edu

Acknowledgments

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