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New Generation of Instrumentation for Navis Profiling Floats

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ABSTRACT

Profiling floats most commonly report temperature and salinity averaged into pressure bins. The performance of Iridium communications now allows the number of pressure bins to increase and provides an opportunity for additional sensors to be included in the data stream. This currently is achieved through hardware and software add-ons to the float; the additional sensor data are collected asynchronously and integrated into the CTD data stream during post-processing.

A new pressure, temperature, and conductivity instrument centralizes the data from an arbitrary suite of up to 6 add-on serial sensors. Navis floats currently deployed include combinations of optical dissolved oxygen sensors, fluorometers, transmissometers, and multispectral radiometers, in addition to CTD. Tight integration of these sensors with the CTD allows the additional parameters to be collected and placed in pressure bins along with temperature and salinity profile data.

METHOD

This new profiling-float-specific instrument, the SBE 41N, extends the core hardware and features of the original SBE 41/41CP to collect new combinations of sensor data from more sources and tightly link them to the core CTD measurement. It features:

- compatible float controller interface, with the physical dimensions, CTD transducer conditioning circuits, and energy consumption of the original SBE 41/41CP
- external port that removes the necessity of a float controller gateway to perform configuration
- 6 serial interfaces and greatly expanded data storage
- expansion board facility for surface salinity, SBE 43 DO sensor, or other sensor expansion

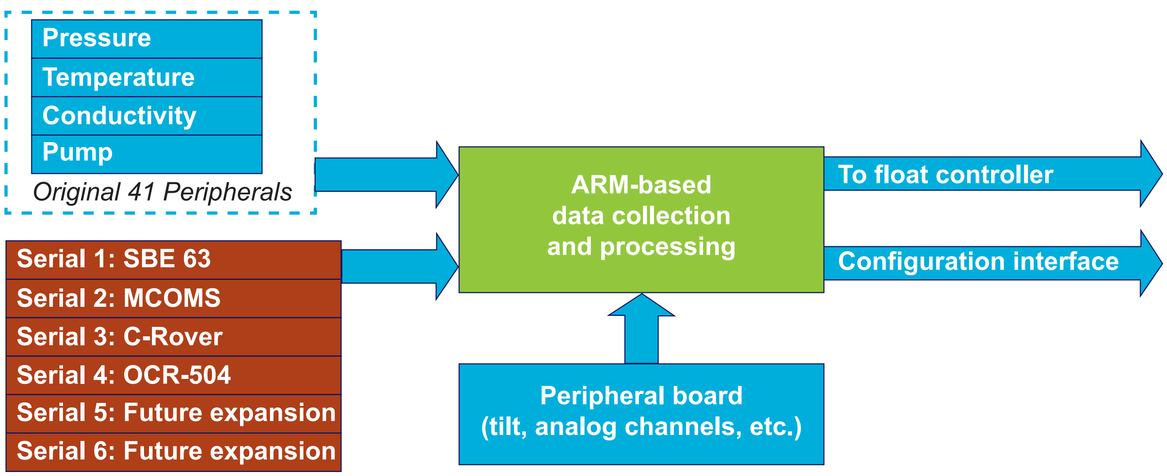

Figure 1. High-level block diagram of SBE 41N showing typical peripherals to ARM-based data collection and processing core. Serial ports are delineated with default function (SBE 63, MCOMS, etc.), but ports are generic (nothing locks a peripheral type to a given port). Peripheral board interfaces directly to microcontroller via high-speed serial bus, allowing significant flexibility in instrument expansion. SBE 41N can communicate and be configured over float controller interfaces or a separate configuration interface.

Using the serial ports, Sea-Bird Scientific integrated combinations of the SBE 63, WET Labs MCOMS and C-Rover, and Satlantic OCR-504, each powered and sampled independently. The SBE 41N retains the capability for surface salinity and an SBE 43, and adds a high-speed serial bus directly to the processor from the peripheral board. On recent deployments, the expansion board hosted a 3-axis accelerometer, which measured tilt and azimuth of the float throughout the profile as a data quality check for the C-Rover peripheral. Data from all these sources is stored with the pressure, temperature, and conductivity data, and subsequently converted and binned for transmission.

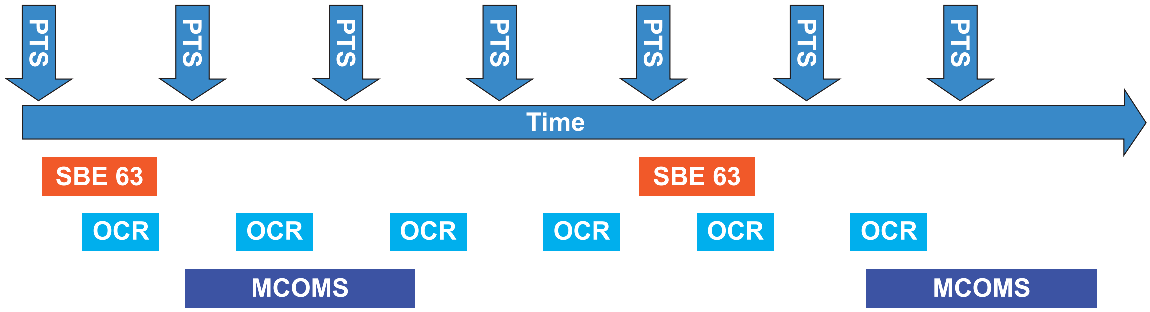

Figure 2. Pressure, temperature, and conductivity are measured at 1 Hz, while serial instruments can have independent update rates up to 1 Hz and be mixed and matched. Each instrument can have its own inquiry mode: queried for a sample or free running with continuous output. In this example, SBE 63 is continuously powered, queried for a value, and put to sleep between each measurement. MCOMS is powered, output is recorded, and power is removed at desired update rate. OCR-504 is running at 1 Hz, remains powered continuously, and samples each scan. Sampling technique for each instrument can be tuned to optimize data density for power expended.

The software controlling the serial ports is instrument agnostic and the hardware is designed for a broad variety of electrical interfaces. The ports feature:

- variable sample intervals from 1 to 120 sec, and power that can be turned on and off between scheduled measurements
- activation in a specific pressure band that includes penetrating the surface
- non-overlapping activation for instruments that have the potential for mutual interference
- configurable 5-18VDC output voltage with a protective current limit of 1A per port
- software switchable between conventional RS-232 levels and logic level
- interface baud rates of 600 to 38400

The only point where the peripheral identity is a factor is after the data is returned and ready to be parsed and stored. The software module performs error checking to ensure only properly formatted and physically consistent data is stored and forwarded.

RESULTS AND DISCUSSION

By centralizing data from all the sensors and integrating it into the CTD data stream, synchronizing all the data to one pressure series is possible. Through this, bin averaging is extended to the other instruments, improving their link to the physical oceanography while not imposing the telemetry burden of redundant sensor data. At a rise rate of 0.1 dbar/sec and bin size of 2 dbar, approximately 20 PTS samples are averaged into a single pressure-binned data point together with the samples from the external sensors. Although this algorithm results in smoothing, the SBE 41N's large storage space supports small bins for good data fidelity even in gradient regions. A disadvantage of this technique is that very low sample rates on peripheral measurements may not be perfectly aligned with faster rate sources in the same pressure bin. In typical measurement configurations, the external sample interval is short, with a resultant increase in data density and minimal shift relative to temperature, salinity, and other peripherals reported within the bin.

Float	MCOMS FLBBCD	MCOMS FLBB2	SBE 63 optical Oxygen	C-Rover Transmissometer	SUNA Nitrate sensor	OCR-504 Irradiance	Orientation
F0034	x		x	x			x
F0339		x	x			x	
F0032	x		x				
F0037	x		x		x		

Table 1. Float combinations deployed around Hawaii over past year with in-water duration of 2 to 4 weeks. Float lifetime of approximately 225 profiles is expected, dependent on deployed sensors, their operation, and float operation.

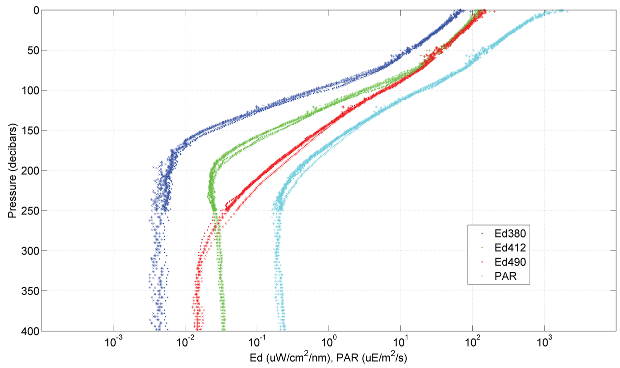

Figure 3. F0339 (Hawaii, 10/16-10/28/2013) sampling OCR-504 Irradiance sensor at 1 Hz, with data placed in 8-dbar pressure bins up to 250 dbars and 1-dbar pressure bins from there through surface. Plot shows 4 channels of OCR-504 collected on 4 profiles on 4 successive days.

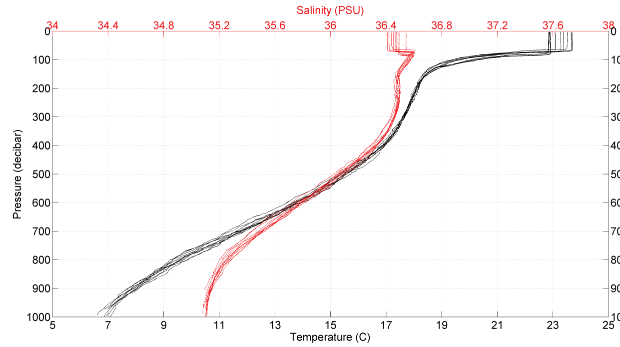

Figure 4. F0033 (Bermuda, 11/19/2013-12/1/2014) temperature and salinity sampled at 1 Hz and placed in 2 dbar pressure bins. SBE 41N uses same transducer conditioning circuitry, sampling methodology, and data processing as SBE 41/41CP to maintain consistency with existing fleet. External instruments and expandability of SBE 41N are an independent superset of those functions. (Thanks to Meg Estapa for providing this data. See her talk at Session 085).

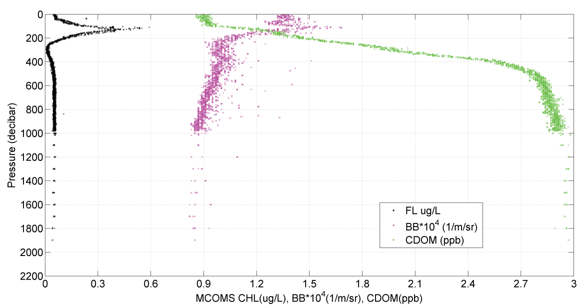

Figure 5. F0037 (Hawaii, 9/23-10/8/2013) sampling MCOMS. From 1000 dbars to measurement cutoff at 2 dbars, sensor is sampling at 5-sec intervals, with data placed in dbar bins. Below 1000 dbars, sensor is spot-sampled every 100 dbars, based on a pressure table. Plot shows 3 channels of MCOMS FLBBCD collected on 3 profiles on 3 successive days.

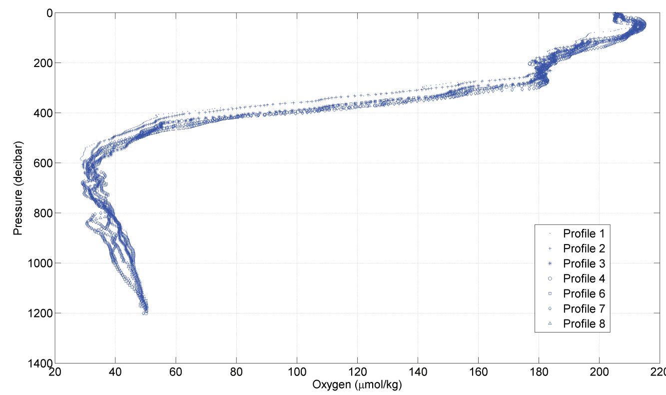

Figure 6. F0033 (Hawaii, 5/8-5/21/2013) sampling SBE 63 oxygen sensor every 5 sec, with data placed in 2-dbar bins. SBE 41N bins and returns raw SBE 63 data for calibration coefficients to be subsequently applied. For maximum power savings, SBE 63 enters very-low-power state between measurements and is queried for each data point. SBE 63 is in pumped flow path of CTD, physically protecting sensor film, tightly coupling water measured for temperature and conductivity to oxygen. Plot shows oxygen measurements across 7 profiles in 8 days. Profile 5 lost due to telemetry error.

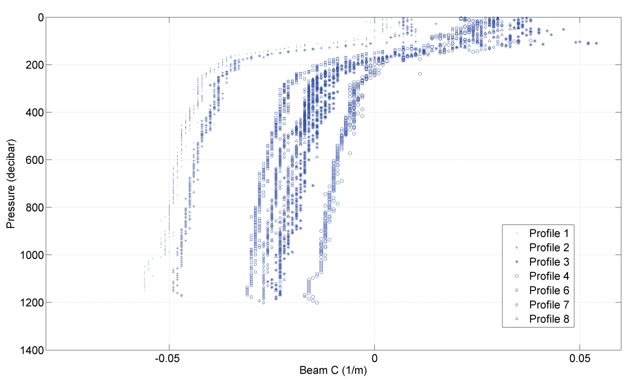

Figure 7. Float 0033 (Hawaii, 5/8-5/21/2013) sampling C-Rover Transmissometer every 10 sec and placing data in 2-dbar bins. With a rise rate of 0.1 dbars/sec, this resulted in 2 to 3 C-Rover measurements per bin. Plot shows beam c measurements across 7 profiles in 8 days (profile 5 lost due to telemetry error).

CONCLUSIONS

Sea-Bird Scientific developed a new instrument that centralizes both CTD and peripheral data from serial sensors. The independent serial interfaces are versatile in both data collection method and hardware interface to handle the broadest combination of deployments and sensors. Data from each of these sources is checked, stored, and converted in the same location and at the same time for the best integration. By placing all the sensors under a single controller, multi-instrument integration such as synchronized sampling or blanking periods for mutually interfering sensors are readily implemented.

Once the data is placed into pressure bins, the CTD and peripheral data are part of the same profile for ease in analysis and improved resolution. This correlates data from external sensors to the temperature-salinity profile and also ties the peripheral sensor data together. As an added benefit, the float system is made more modular compared to intermixing float controller and data collection functions.

The SBE 41N shows itself to be a versatile and adaptable data collection platform, while maintaining the measurement capabilities of the SBE 41/41CP.