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The oceans, covering about 70% of the Earth's surface, are home to extensive ecosystems which the scientific community has only just begun to understand. Environmental conditions in the oceans greatly affect not only these ecosystems, but also the prevailing weather patterns on land and at sea. Accurate monitoring of these conditions – most often carried out by data buoys – is essential to a variety of applications. For example, the U.S. National Oceanic and Atmospheric Administration collects environmental data on coral reefs in their Coral Reef Early Warning System program. Many of the data buoys used in this program are supplied by Sound Ocean Systems, Inc., which uses the Vaisala Ultrasonic Wind Sensor WS425 for wind measurement on the ocean.

PHOTO COURTESY: NOAA PACIFIC ISLANDS FISHERIES SCIENCE CENTER, CORAL REEF ECOSYSTEM DIVISION

Figure 1. A data buoy built by Sound Ocean Systems, Inc., uses the Vaisala Ultrasonic Wind Sensor WS425 to measure hourly average wind speed and direction.

Ultrasonic Wind Sensors for Marine Data Buoys

Figure 2. The maintenance-free WS425 offers continuous data availability.

Data buoys can be outfitted with a variety of sensors to measure humidity, pressure, sea surface temperature, salinity, UV radiation and wind, to name but a few. The Coral Reef Early Warning System (CREWS) of the National Oceanic and Atmospheric Administration (NOAA) uses buoys to monitor various parameters of the world's coral reefs. Its primary function is to determine (and ideally also to predict) the environmental factors that are conducive to "bleaching" in which coral becomes white from lack of nutrients, a condition that has led to mass mortality in reefs throughout the world. Among the necessary data collected are wind speed and direction.

Founded in 1978, Sound Ocean Systems, Inc. (SOSI) of Redmond, Washington (USA) is a manufacturer of instrumented marine systems and equipment. They developed their first data buoy in 2001 (see figure 1) when awarded a contract by the NOAA for their Coral Reef Early Warning System. Sound Ocean Systems uses the Vaisala Ultrasonic Wind Sensor WS425 to outfit their buoys.

In designing buoys for the CREWS program, Sound Ocean Systems had many concerns. Because of the remote locations, most buoys would need to be deployed for up to 2 years at a time with no maintenance. The selected equipment would need to withstand the harsh marine environment with no adverse effects on performance. Finally, as the buoys are powered by only a cluster of alkaline batteries, the power consumption of the sensors would need to be minimal. "The WS425 not only met all of our design requirements, but was also highly accurate and reliable," says Ted Brockett, founder and President of Sound Ocean Systems. "Moreover, it offered digital outputs that could be easily integrated with SOSI's onboard data logger." ➤

Figure 3. Sound Ocean crew with ultrasonic wind sensors, from left: Ted Brockett (President), Larry Robinson (Electrical Engineer), Roland Armstrong (Electronic Technician), Mike Begley (Project Manager) and John Moore (Vice President).

Maintenance-free wind sensor

The Vaisala Ultrasonic Wind Sensor WS425 is completely solid state and has no moving parts that can seize up, wear or break. During each one-second period, it measures the transit time of ultrasound as it travels between transducers along three separate paths (see figure 3). The transit time will either increase or decrease, depending on wind velocity along each ultrasonic path. Using this data, the sensor plots the three vector components of speed and direction, then uses two of the vectors (called a "basis set") to calculate the resultant measurements. Because of the unique 3-headed design of the WS425, data from the measurement path most affected by turbulence is left out of the basis set for each instantaneous measurement. This results in the highest accuracy at all wind angles, which is important for rotating buoys.

Wind measurement principle

On the CREWS buoys provided by SOSI, the WS425 takes 40 concurrent wind speed and direction measurements, reporting the polar (X and Y) components to the on-board data logger, which computes the polar averages. The data is digitally transmitted to the logger using the SDI-12 serial protocol. By using SDI-12 submode A commands, the sensor can be put into the "sleep" mode when not taking measurements, which saves battery power. Polling occurs three times an hour, and these three data sets are averaged to produce the hourly average wind speed and direction. Once a day, the data is uploaded to the NOAA through an Argos satellite transmitter.

Because of the constant motion, a compass was installed directly under the wind sensor, which reports the buoy's heading to the data logger during each measurement. A true vector average is computed for every sample by combining the compass data with the WS425 data in the logger. Another factor affecting the 2-D wind data is the frequent off-axis rocking of the floating buoys. Unlike "cup and vane" type wind sensors, the ultrasonic sensor has a fairly predictable off-axis response, which is constant in all tilt directions. The long averaging interval (1 hour) allows for any off-axis measurements to be absorbed into the data set, with minimal overall effect.

Vaisala Ultrasonic Wind Sensor widens scope

Based on the success of their first program, Sound Ocean Systems has included the WS425 into their standard data buoy template, and has begun providing units to new customers. According to Ted Brockett, as they expand their operation, adding features like Iridium telemetry and new sensor types, "the ultrasonic wind sensor has remained our number one choice for accurate, dependable wind measurement." ●

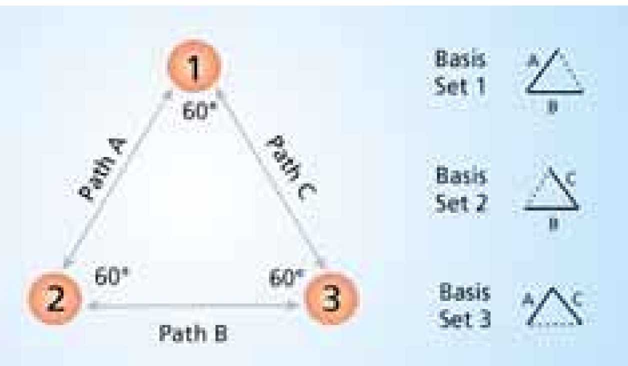

Figure 4. The WS425 measures the transit time of ultrasound along 3 component paths, then uses the most accurate basis set to calculate the resultant wind speed and direction.

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About one half of the electricity in the United States and one third of the electricity in the world is generated by the combustion of coal. Although the use of coal is economically beneficial, it is of concern due to the formation and release of various pollutants during combustion such as sulfur dioxide (SO_2), nitrogen oxides (NO_x), mercury and particulate matter. The release of carbon dioxide is also a concern, but it is not considered a pollutant because of its natural presence in the environment. These compounds adversely affect air quality, public health and the environment. Some of the environmental issues resulting from the release of these pollutants include acid rain, smog, haze and the warming of the atmosphere.

Regulations to ensure clean air

The U.S. Environmental Protection Agency (EPA) administers several regulatory programs under the Clean Air Act designed to address some of these environmental issues. The Acid Rain Program, one of the best known, is designed to improve air quality through the reduction of emissions of SO_2 and NO_x. It is estimated that, when the program is fully implemented by 2010, its public health benefits will amount to USD 50 billion annually, due to decreased mortality, hospital admissions and emergency room visits. Although mercury emissions from coal-fired plants are currently unregulated, the EPA will propose emission regulations for mercury in December 2003 and issue final regulations in December 2004. Concerning emissions of carbon dioxide, EPA regulations have not yet been defined, but public pressure is gaining momentum to establish new limits.

Meeting the regulations

In order to comply with environmental regulations, pollution