AWAC™

with Acoustic Surface Tracking (AST)

- ✓ **Wave height**
- ✓ **Wave direction**
- ✓ **Full current profile**

...all with a single instrument

The Nortek AWAC is a revolutionary instrument that gives you both a current profiler and a wave directional system in one unit. You can measure the current speed and direction in 1-m thick layers from the bottom to the surface and you can measure long waves, storm waves, short wind waves, or transient waves generated by local ship traffic.

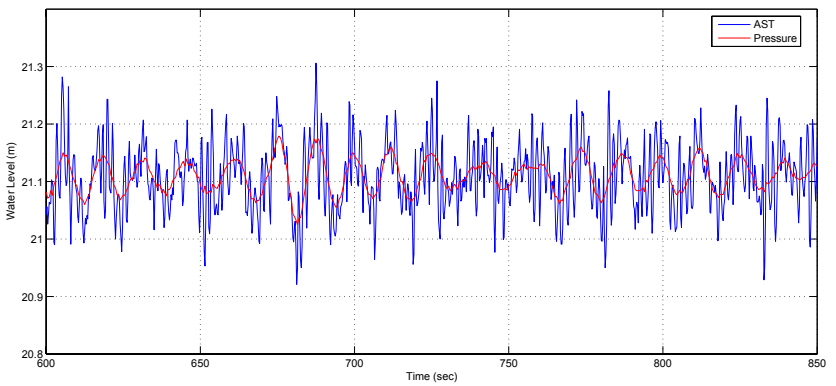
The AWAC is designed as a coastal monitoring system. It is small, rugged, and suitable for multi-year operation in tough environments. It can be operated online or in stand-alone mode with an internal recorder and batteries.

The sensor is usually mounted in a frame on the bottom, protected from the harsh weather and passing ship traffic.

The mechanical design is all plastic and titanium to avoid corrosion. Online systems can be delivered with protected cables, interface units on shore, acoustic modems and backup batteries. In stand-alone use, the raw data are stored to the recorder, and power comes from an external battery pack. A variety of options are available to achieve your required combination of deployment length and sampling interval.

The AWAC software is used to configure the instrument for deployment, retrieve the data and convert all data files to ASCII, and view all the measured current profiles and wave data. In order to calculate the wave parameters, the non-graphical "Quickwave" software will generate ASCII files with all the interesting wave parameters, "Storm" gives you several graphical views of the processed data, and "SeaState" provides online information.

As the plotted time series indicates, both the AWAC's pressure and AST time series capture the long waves. The notable difference is that the AST is capable of measuring the shorter waves superimposed on the longer waves. The AST advantage becomes more relevant and clear as the deployment depths become greater.



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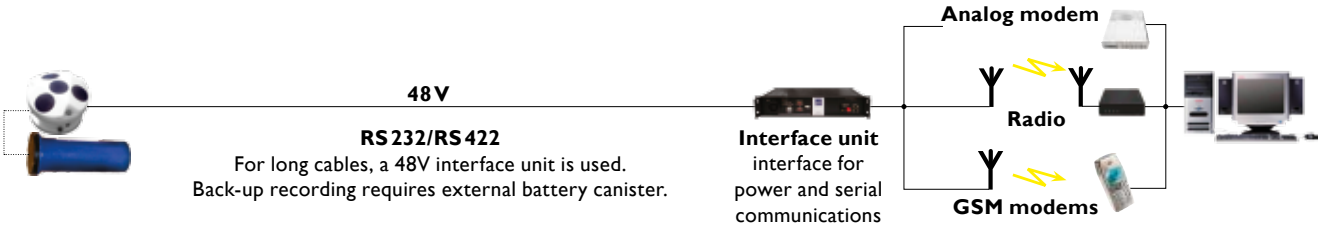
Online Solutions

AWACs can be deployed for long term monitoring of the local wave and current conditions.
Depending on the specific circumstances, Nortek can provide long cables, radio/telephone communication equipment, acoustic modems, etc., that can meet the requirements of your specific project.

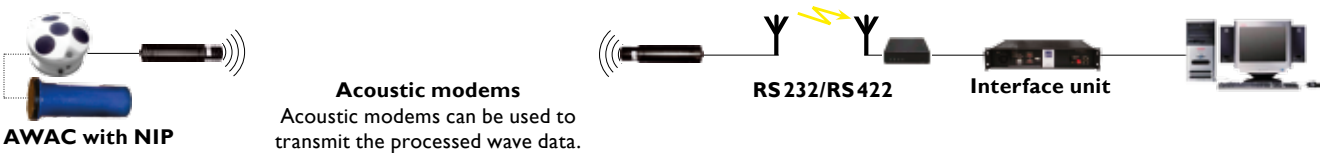
RS232/RS422

For cable lengths < 100 m, standard cable can be used. For lengths > 100 m and/or tough environments, offshore cable should be used. In RS422 configuration, cable communication can be achieved for distances up to 5 km.



RS232/RS422
For long cables, a 48V interface unit is used.
Back-up recording requires external battery canister.

Interface unit
interface for power and serial communications



AWAC with NIP

Acoustic modems
Acoustic modems can be used to transmit the processed wave data.

NIP- Nortek Internal Processor

The NIP is a micro computer that fits inside the AWAC. It processes the raw wave data to provide estimates of wave height, period, and direction. Reduction of wave data is valuable when considering low bandwidth communications (e.g. acoustic modems).

The NIP is easily configured with the NIPtalk software or the online software SeaState. Data output may be as detailed as full spectral information or simple as basic wave estimates; the output format is either binary or user defined ASCII strings.

NIP Specifications

Memory	25 Mb
Processor	320 MHz
Dimensions	54 X 110 mm

Power Consumption

Active state	600 mW
Low power state	110 mW
Sleep state	10 mW

Modes

Command
Transparent
Master (data streaming)
Polled (request data/measurement)

Data Products (binary or ASCII)

Current Profiles
Sensor data
Wave estimates (Height, Period, Direction)
Energy spectra
Directional spectra
Spreading spectra
Fourier coefficient spectra

Stand-alone Solution

The AWAC can collect data to the internal recorder if it is deployed with an external battery canister. The AWAC software is used to configure the data collection interval for both current profile and wave data.
Typical deployment duration is 1-6 months, depending on the recorder size, battery option and data collection strategy.

AWAC Wave Measurements

Optimized wave data collection measurements begins with a well designed instrument. The AWAC measures three different wave quantities that allow us to arrive the estimates of wave height and wave period. These quantities are pressure, wave orbital velocity, and surface position. The pressure is measured with a high resolution piezo-resistive element. The orbital velocity is measured by the Doppler shift along each beam. The surface position is measured with Acoustic Surface Tracking (AST), a special mode where the instrument acts as an inverted echo sounder.

The fact that waves are a random event requires that measurements are made over defined periods of time, or bursts. Typically these bursts are 512, 1024, or 2048 seconds in length and sampled at 1–4Hz.

The measurement cells and the AST window are adaptively configured during the current profile which immediately precedes the wave burst. The position and size of the velocity cell as well as the AST window are determined based on the minimum pressure. By adaptively configuring the burst measurements, the AWAC not only ensures a maximized signal level and data quality for widely varying wave conditions, but it also permits the AWAC to automatically account for extreme tidal variations.

Wave Processing

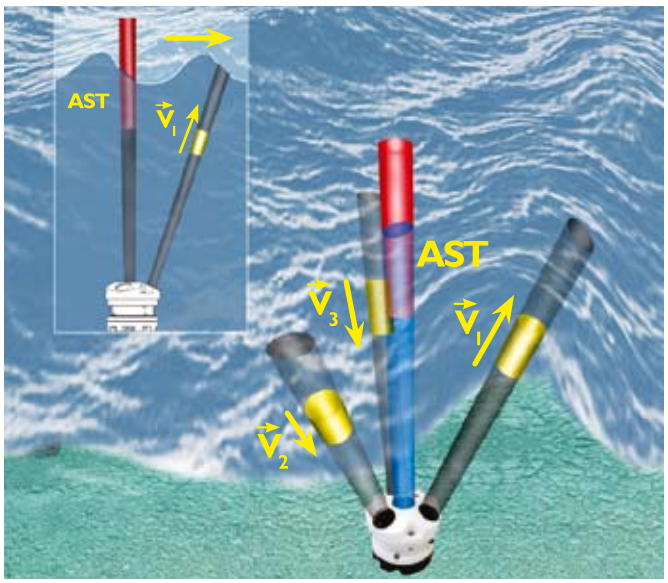
The non directional wave estimates are available from the three independent spectra: pressure, velocity, and AST. The frequency range of these estimates increases respectively: pressure, velocity, AST.

The determination of wave directional estimates is a little more complicated, and may be performed with either the Maximum Likelihood Method (MLM) or a special triplet solution known as the SUV method. The MLM exploits the time-lag between the array of the three spatially separated velocity and AST measurements to determine wave direction.

The solution attempts to determine the direction that provides the best agreement between all four of these measurements. This calculation is performed at discrete frequencies. The end result is a description of the energy distribution in both direction and frequency.

One distinct advantage of using array measurements, is that the method is capable of resolving waves at the same frequency coming from two different directions. One scenario would be identifying incident and reflected waves from a coastal structure.

The SUV approach differs from the MLM approach in the sense that it uses the measurements as a triplet (similar to a wave buoy or PUV instrument). The triplet is composed of the AST and the horizontal velocity estimates of U and V. The advantage of the SUV method is that the AWAC may be mounted on a subsurface buoy allowing it to rotate freely, which is not possible with array solutions like the MLM. The ability to mount the AWAC on a subsurface buoy comes from the fact that the tilt and heading sensors are sampled at a similar rate as the wave measurements, and as a result these estimates may be converted to an Earth frame of reference.



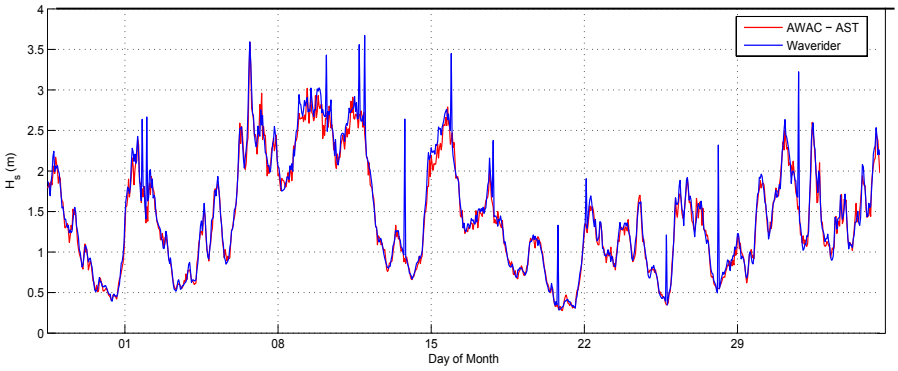
The AWAC measures three different wave quantities that allows us to arrive at the estimates of wave height and wave period. These quantities are pressure, wave orbital velocity, and surface position. The pressure is measured with a high resolution piezo-resistive element. The orbital velocity is measured by the doppler shift along eack beam. The surface position is measured with Acoustic Surface Tracking (AST), a special mode where the instrument acts as an inverted echo sounder.

AST defined

For AST it all lies in a dedicated vertical beam where a short acoustic pulse is transmitted by the center beam and the return is finely resolved such that a sub centimeter resolution is achieved.

The AST is not subjected to attenuation as the velocity and pressure signals, so it provides a direct measurement of the free surface. This means that the AWAC is not limited to measuring just the long waves, but all ocean waves. Resolvable wave periods can be as low as 0.5 seconds.

Apart from circumventing the limitations associated with measuring an attenuated quantity, the AST provides a time series of the free surface which allows for enriched data analysis. This includes identifying nonlinear waves, evaluating transient waves (ship wake), and important time series estimates such as H_{max}, H_{10}, T_{mean}, T_{max}, etc. These estimates are unique to AST and cannot be properly determined with just the velocity or pressure measurements. Furthermore, when the AST is included in the MLM solution, the directional estimates becomes much more accurate than without the AST.



Significant wave height estimates compared for the AWAC-AST (red) and the Waverider buoy (blue). Data shows both small and large wave measurement capabilities. Data was collected on the east coast of the UK in 32 meters depth.

Specifications

System

Acoustic frequency	1MHz or 600kHz
Acoustic beams	4 beams, one vertical, three slanted at 25°
Operational modes	Stand-alone or online monitoring

Current Profile

Maximum range	30m (1MHz), 50m (600kHz) (depends on local conditions)
Depth cell size	0.4 – 4.0m (1MHz) 0.5 – 8.0m (600kHz)
Number of cells	Typical 20–40, max. 128
Maximum output rate	1s

Velocity measurements

Velocity range	±10m/s horizontal, ±5m/s along beam
Accuracy	1% of measured value ±0.5cm/s

Doppler uncertainty

Waves	3.5cm/s at 1Hz for 2m cells
Current profile	1cm/s (typical)

Wave measurements

Maximum depth	40m (1MHz), 60m (600kHz)
Data types	Pressure, one velocity cell along each slanted beam, AST
Sampling rate (output)	1Hz/2Hz standard, 2Hz /4Hz AST (1MHz), 1Hz standard, 2Hz AST (600kHz)
No. of samples per burst	512, 1024, or 2048

Wave estimates

Range	-20 to +20m
Accuracy/resolution (Hs)	<1% of measured value/1cm
Accuracy/resolution (Dir)	2° / 0.1°
Period range	0.5-30sec

Depth (m)	cut-off period (Hs)	cut-off period (dir.)
5	0.5 sec	1.5 sec
20	0.9 sec	3.1 sec
60	1.5 sec	5.5 sec

Sensors

Temperature	Thermistor embedded in housing
Range	–4°C to 40°C
Accuracy/ Resolution	0.1°C/0.01°C
Time constant	<10 min
Compass	Flux-gate with liquid tilt
Accuracy/Resolution	2°/0.1° for tilt <20°
Tilt	Liquid level
Accuracy/Resolution	0.2°/0.1°
Up or down	Automatic detect
Maximum tilt	30°
Pressure	Piezoresistive
Range	0–50m (standard)
Accuracy/Resolution	0.5% of full scale/ Better than 0.005% of full scale per sample

Transducer configurations

Standard	3 beams 120° apart, one at 0°
Asymmetric	3 beams 90° apart, one at 5°

Data Recording

Capacity (standard)	2 MB, expandable to 26/82/154MB
Profile record	Ncells×9 + 120
Wave record	Nsamples×24 + 46

Data Communication

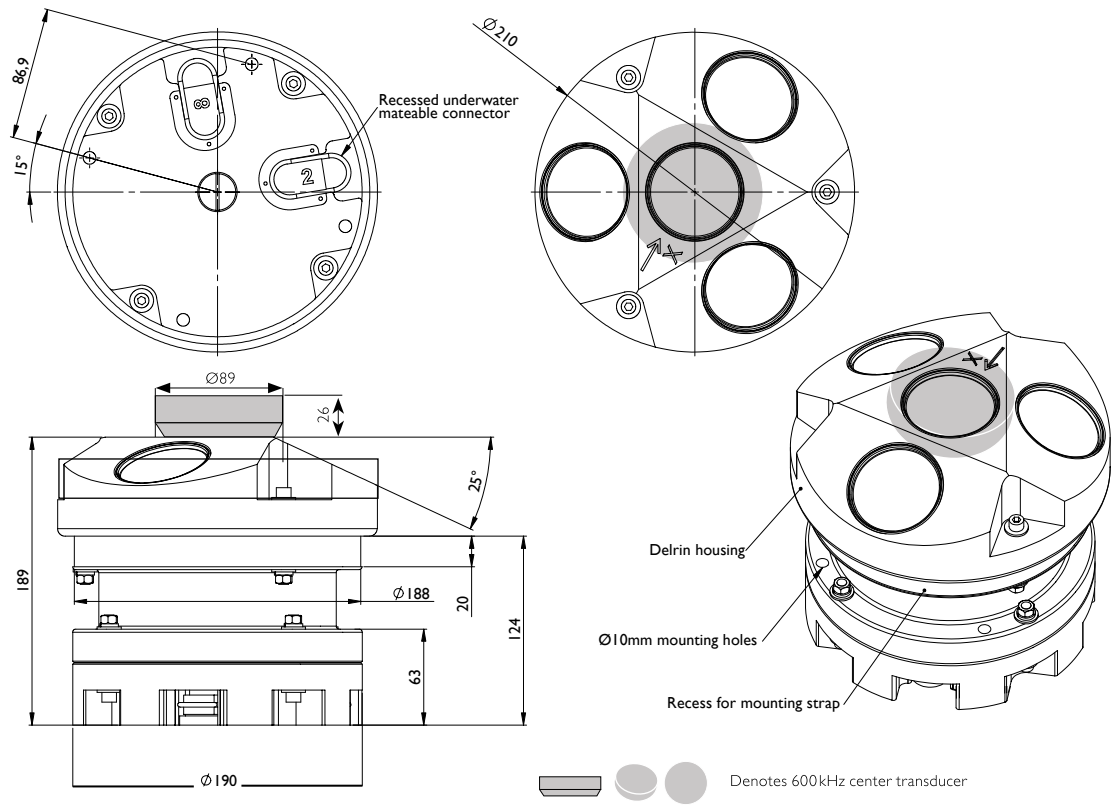
I/O	RS232 or RS422
Baud rate	300–115200, inquire for 1MBit
User control	Handled via "AWAC" software, NIPtalk or ActiveX® controls

Power

DC input	9–16VDC
Peak current	2A
Power consumption	see AWAC software

Offshore Cable

The Nortek offshore cable can, when properly deployed, withstand tough conditions in the coastal zone. In RS422 configuration, cable communication can be achieved for distances up to 5km.



11.2006

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