RD Instruments
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Subject: RDI's Phased Array Technology

RDI's patented 2-d Phased Array technology expands the scope of ADCP and DVL performance and widens our range of configurations. While still making four different measurements simultaneously-- two from an acoustic pulse profiling the water column (velocity profile, echo intensity profile), and two from a bottom-tracking (BT) pulse (velocity over bottom, altitude above bottom)-- the Phased Array technology has pushed back the practical, mechanical limits for transducer size and frequency *at both ends of the size continuum*. In this note, we consider new measurement capabilities derived from RDI's 2-d Phased Array technology.

- ✓ For ADCPs, Phased Array technology permits longer range profiling (800-1000 m) at lower frequency (38 kHz). This enables detailed spatial surveys of *deep-water currents* that can reveal patterns of circulation, impossible to observe any other way.
- ✓ For DVLs, Phased Array technology permits increased performance in smaller configurations. This makes highly accurate, precise, and robust navigation available to even miniature underwater vehicles.

RDI's 2-d Phased Array (PA) Transducer

A Phased Array transducer is composed of many elements, arranged in a fixed pattern, that emit acoustic energy simultaneously. The phase lag of the signal transmitted by each element, however, is specific to that element. Particular patterns across the array are specified for the phase lags. These patterns cause the propagating acoustic signals to interfere with each other in an organized manner that results in forming one or more acoustic beams in specific directions. To create beams angled 30 degrees off vertical, the phase lags assigned to adjacent elements in a horizontal array differ by 90 degrees.

This arrangement contrasts with a piston (array) transducer where all elements fire with the same phase lag to form a beam that is directed perpendicular to the transducer face. In this case, having a beam point in a specific off-vertical direction requires the piston to be installed at an angle to the horizontal.

RD Instruments has a patent for its method of forming a 4-beam Janus configuration from a phased array transducer. Achieving this configuration had formerly required using two separate phased-array transducers arranged to be perpendicular to each other.

Phased Array's Mechanical Advantages

The fundamental mechanical advantage enabled by RDI's 2-d Phased Array technology is smaller size. This five–fold reduction in area results from the four, slanted, orthogonal acoustic beams being emitted by a single transducer ceramic (cf. four ceramics in a traditional piston array). This size reduction is achieved while maintaining the same accuracy in the velocity measurements; data variance is slightly higher (see below).

Associated with smaller size is another mechanical advantage—less weight. Together these advantages make for easier handling and installation.

Phased Array's Profiling Advantages

At lower frequencies, PA's smaller-sized transducers enable

- ✓ 38kHz for high precision current profiling to 800-1000 m and bottom tracking to 1500 m while retaining a practical, mechanical size
- ✓ 75 kHz to replace a 150 kHz piston ADCP. This doubles the current profiling range while using the same sea chest—a tremendous savings in installation costs

At higher frequencies, smaller-sized transducers enable a new generation of high-performance, compact, and portable DVLs and ADCPs.

Advantages of a Flat-Faced Transducer

Because the phased array can emit beams slanted to the transducer face, the array can be mounted flat enabling several advantages relative to a piston transducer assembly.

- ✓ The accuracy of velocities (derived from the Doppler shift in returning echoes) is not affected by speed of sound changes in front of the transducer (or through the water column)
- ✓ Reduced flow disturbance by the transducer assembly
- ✓ Reduced flow noise contaminating the velocity data

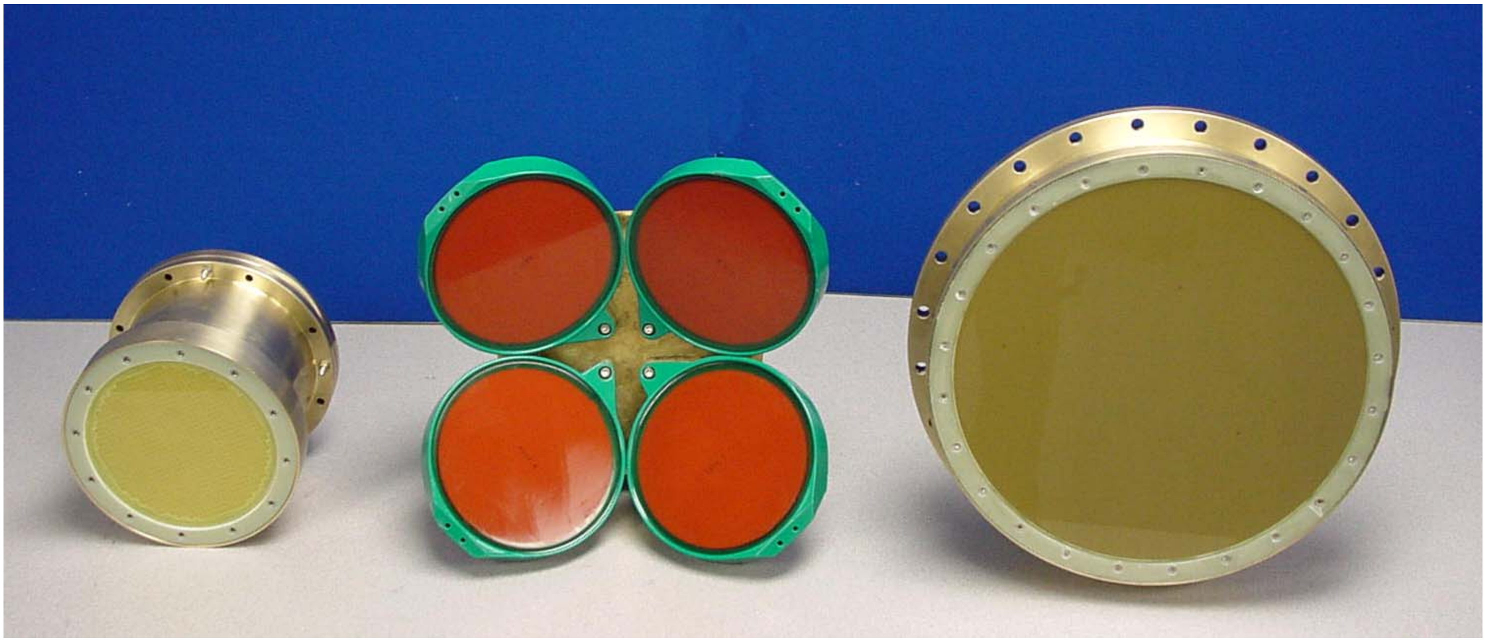
Phased Array's Data Precision

The pointing angle for PA beams varies with frequency. With this in mind, RDI limits the bandwidth of the transmitted signals to 6% of the carrier frequency. Bandwidth determines the number of samples per ping in each depth cell. So the variance of the velocity data varies inversely with bandwidth. Velocity variance also varies inversely with $\sin^2$(beam angle) so that 30-degree (off-vertical) beams output "quieter" data.

Compared with a 4-piston WorkHorse ADCP transmitting RDI's 25% bandwidth BroadBandTM signals along beams angled 20 degrees off-vertical, the velocity data of a Phased Array ADCP has standard deviation increased by 1.3 times.

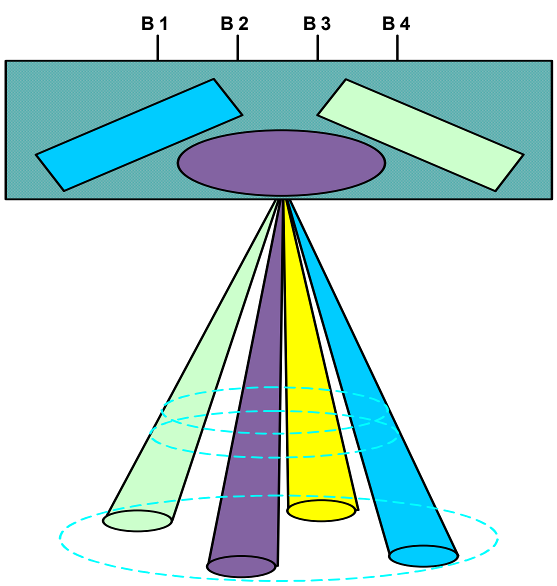
Comparison of a multi-piston and a 2-dimensional phased array transducers

150 kHz Phased Array | 150 kHz 4-Piston Array | 75 kHz Phased Array



1. MULTI-PISTON ARRAY

Height = 3
Face area = 5
Volume = 10



2. PHASED ARRAY

Height = 1
Face area = 1
Volume = 1