RD Instruments
Acoustic Doppler Solutions

9855 Businesspark Av
San Diego, CA 92131, USA
PH: 01.858.693.1178
www.adcp.com

Subject: RDI's Pulse-to-Pulse Coherent Mode 11

For Measuring Very Slow Flow, Very Low-Noise Data, or High Resolution Velocity Profiles

RDI's ADCPs are configured automatically at power-on to support a wide range of current profiling situations. This allows many users to acquire high quality results without altering the ADCP's robust default setup. At the same time, some users seek more control of the ADCP's performance or have to operate in more demanding environments. RDI's ADCP design anticipated these occasional, more specialized needs. In addition to standard operation, users with particular requirements can turn to operating modes optimized for specific conditions. This arrangement is similar to gears in an automobile or bicycle where the operator can, for the most part, cruise with standard operation yet select a specific gear for demanding situations (e.g. starting on an icy surface). This flexibility enables the same ADCP to work in both deep water and shallow water. In this note, we consider RDI's Pulse-to-Pulse Coherent Mode 11 that permits measuring (1) very slow flow, (2) very low noise data, and (3) very high-resolution velocity profiles.

Nomenclature note: This mode requires phase coherence between the two time series of echoes returned by a pair of successive acoustic pulses, leading to the name of pulse-to-pulse coherent mode. In RDI-speak, this is Mode 11 that now replaces its antecedent Mode 5.

What is Mode 11?

RDI's BroadBand™ signaling transmits sets of acoustic pulse pairs with pair members separated by a brief, known time lag. The pulses are narrow and therefore contain a broad frequency bandwidth. The default setup for the ADCP includes hundreds of these narrow pulse pairs in each depth cell with each pair effectively making a velocity measurement. Averaging these hundreds of measurements provides a more precise velocity measurement, lowering velocity data variance by 50 times compared with competing methods.

Another way to control the precision of the velocity measurement --independently of averaging-- is by increasing the time lag between members of each pulse pair. This precision control strategy is similar to that used when you compute velocity by differencing position fixes; fixes with greater time separation permit more precise velocity estimates. Widely separated pulses (in a pair) characterize Mode 11 (and its antecedent Mode 5).

Advantages of Mode 11

Mode 11 uses much longer delays in the acoustic pulse pair than RDI's default (power-on) operating mode (Mode 1). The fundamental advantage of this choice is ultra-precise velocity data in each sample (i.e., very low random noise) at 4Hz rate.

Two ways to take capitalize on this advantage are to collect

- ✓ *Very low-noise data* (standard deviation of 1 cm/s for 7 cm resolution at 4 Hz rate) or
- ✓ Velocity profiles with *very fine vertical resolution* (1 cm for 1200 kHz, 2 cm for 600 kHz).

There are, however, measurement constraints imposed by this Mode 11 choice: (1) limited profiling range (4 m for 1200 kHz, 8 m for 600 kHz) and (2) limited maximum velocity (1 m/s).

Applications of Mode 11

Mode 11 enables the high-resolution velocity profiles (small depth cell sizes) required for measuring accurately

- ✓ Slow, shallow flows (as shallow as 25 cm) (in river, estuary, and near-bottom applications)
- ✓ Near-boundary velocity profiles that have strong shear (in bottom boundary, sediment transport, and turbulence applications)

RDI's ADCPs have been measuring profiles in shallow water with the Pulse-to-Pulse Coherent Mode 5 since the early 1990's. The new Mode 11 provides finer resolution, faster sampling rates, and continues to function in depths too shallow for Mode 5.

Operating Envelope

As a *rule of thumb*, Mode 11 works best when the product of the profiling range and mean water velocity are less than 1 m^2/s (e.g., profiling range is 2 m, velocity<0.5 m/s). If conditions exceed this bound, you can switch to RDI's Mode 12 (see Mode 12 Tip).

Mode 11 Features		
Minimum Cell Size	1cm	2 cm
Number of Depth Cells	255	255
Scope of Profiling Ranges	25cm - 4m	50cm - 8m
Limit of Apparent* Velocity	<1m/s	<1m/s

*Apparent velocity is water velocity relative to ADCP (e.g., measure faster flows by moving ADCP downstream)