Phased-Array Doppler Velocity Log User Manual

Model: DVL-600K
Version: A1
Document Type: User Manual

1. Introduction

This manual serves as the product user guide for the DVL-600 Doppler Velocity Log (hereinafter referred to as the DVL). It provides a comprehensive introduction to the system composition, performance specifications, installation, commissioning, operation, maintenance, and troubleshooting methodologies of the DVL.

1.1 Main Applications and Scope

This user manual is intended to guide personnel in the installation, operation, and routine maintenance of the Doppler Velocity Log.

1.2 Operating Conditions

(1) Power Supply: 24±4 VDC; Peak current ≤ 4.0 A @ 24 V; Average power ≤ 15 W.

(2) Operating Temperature: -10 ℃ ~ +50 ℃.

Applicable Range and Accuracy Conditions:

(1) The equipment operates stably under vessel speeds ranging from -10 kn to +15 kn with a roll angle of less than 10°.

(2) The acoustic Bottom Track (velocity over ground) mode functions normally in environments where the seabed slope is less than 15° and the altitude/depth below the vehicle is ⩽80 m.

(3) The acoustic Water Track (velocity through water) mode functions normally when the altitude/depth below the vehicle exceeds 80 m.

1.3 Safety Requirements

⚠ WARNING: HIGH VOLTAGE HAZARD

(1) Hazardous Voltage: The electronics enclosure of the DVL contains lethal high voltages exceeding 200V during operation. Upon powering down, this residual voltage takes approximately 10 seconds to discharge to 0V. Non-authorized or non-professional personnel must NEVER open the electronics enclosure.

(2) Operational Restrictions: It is strictly prohibited to open the enclosure cover while the equipment is energized or running. If opening the enclosure for authorized

maintenance is required, you MUST disconnect the external power supply and wait for at least 1 minute to ensure absolute safety.

(3) Power Cycling Constraints: Rapid power cycling (turning the device on immediately after turning it off) is strictly prohibited. After powering down, a minimum cooling/discharge period of 1 minute must be observed before re-energizing the system.

2. System Composition of the Doppler Velocity Log

The Doppler Velocity Log consists of two parts: the electronics chassis and the transducer, adopting a split structure, as shown in Figure 1. The transducer completes the sensing of speed-sensitive acoustic signals, and the electronics chassis part completes the signal pre-processing, acoustic signal analysis, velocity measurement, and acoustic signal transmission functions.

The connecting cables include the cable between the transducer array and the electronics chassis (5 meters, comes with the product transducer). The electronics chassis is installed inside the submersible body, and the transducer array is installed outside the submersible body, adopting a pressure-resistant structure form.

Figure 1. Electronics Unit and Transducer

The acoustic signal pre-processing unit is shown in Figure 2. The signals output from the transducer are amplified, and then form four beams after beamforming. The four beam signals are sent to the A/D input terminals after bandpass filtering and post-stage amplification. The center frequency of the signals is 600 kHz.

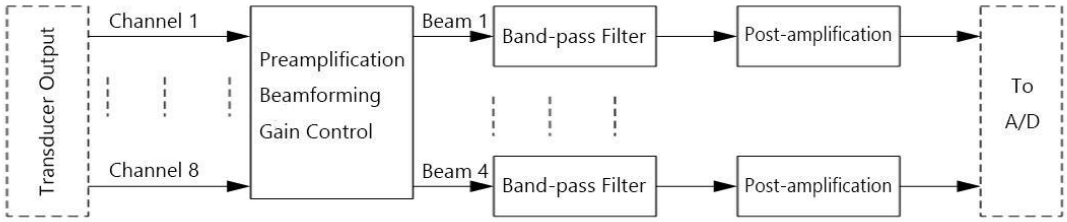

Figure 2. Block Diagram of the Receiver

The acoustic signal transmission unit is shown in Figure 3. The transmission excitation signals from the signal processor are power-amplified, and then applied to the transducer through the network matching circuit to complete the transmission.

Figure 3. Block Diagram of the Transmitter

The signal processor is the signal processing and control center of the Doppler Velocity Log, which is mainly composed of a DSP. It is responsible for the control of the processing system, such as signal transmission, upload of measurement results, velocity correction, and measurement of Doppler frequencies, which are further converted into one-dimensional velocity information. The entire system operates under the timing control of a CPLD.

The software processing workflow of the acoustic signal processing unit is shown in Figure 4. After the acoustic signal processing unit is powered on, it first executes the self-test module to check whether the functions of the signal processing board, transmission board, and reception board of the information processing device are normal, and then uploads and outputs the results. If the self-test operates normally, it enters the working state. Under the control of the internal periodic synchronization clock, it completes functions such as data acquisition, signal detection, frequency and velocity computation, and upload of velocity measurement results, thereby completing one velocity measurement operation, and waits for the arrival of the next synchronization clock.

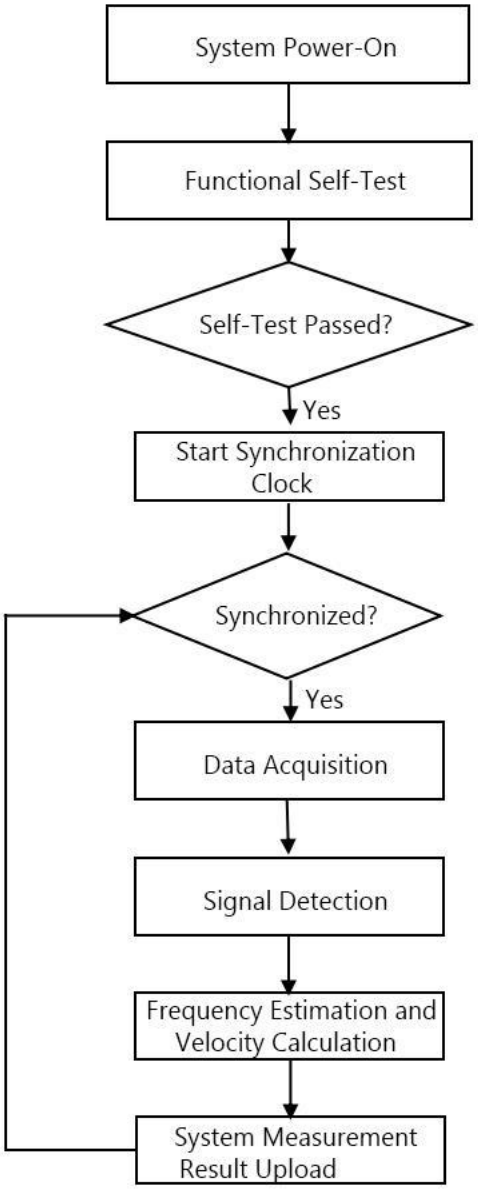

Figure 4. Software Processing Flow of Acoustic Signal Unit

3. System Specifications

3.1 Technical Specifications

(1) Operating Modes: Capable of operating in Bottom Track mode and Water Track (current layer tracking) mode, with automatic switching between the two operating modes.

(2) Velocity Accuracy (Bottom Track Accuracy): ≤2‰ ±2 mm/s (over a flat, sandy/muddy bottom in wide open waters).

(3) Velocity Range: -10 kn ~ +15 kn.

(4) Minimum Bottom Detection Depth: 1 m.

(5) Bottom Track Depth: >80 m (typical seabed).

(6) Power Supply: 24±4 VDC

3.2 Physical Specifications

(1) Electronics Chassis Dimensions: 125×100×100 mm.

(2) Electronics Chassis Weight: ≤1 kg (in air).

(3) Transducer Dimensions: Φ82.5×H36 mm (excluding cable).

(4) Transducer Weight: ≤0.6 kg (in air, excluding cable).

3.3 Mechanical Interfaces and Installation

3.3.1 Equipment Dimensions

The equipment dimensions are shown in Figure 1.

3.3.2 Installation Dimensions

The structural dimensions for installation are shown in Figure 5. When installing the Doppler Velocity Log transducer, the heading alignment mark (indicated by the red line) must point toward the vessel's bow.

- A positive output velocity on the Y-axis indicates the vessel is moving ahead (forward); a negative velocity indicates astern (reverse).
- A positive output velocity on the X-axis indicates the vessel is moving starboard (rightward); a negative velocity indicates port (leftward).
- The velocity coordinate system is a right-handed coordinate system.

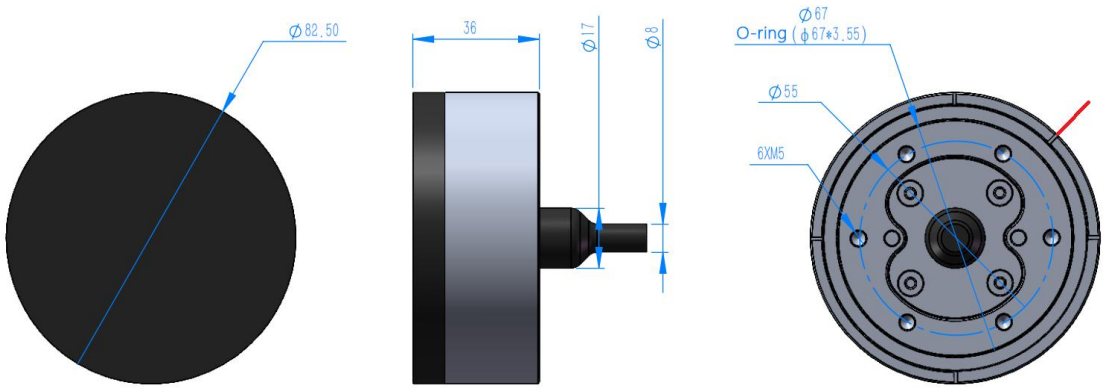

Figure 5. Transducer Installation Orientation

3.4 Interface Description

The DVL electronics chassis is equipped with a total of two interfaces: one is the transducer interface, and the other is the external communication interface (including the 24V power input). The relevant connectors and cables for the transducer interface are delivered with the product.

The external communication interface utilizes a J30-15ZKP socket, and a mating plug (including a 20cm pigtail cable) is separately provided with the product for user connection. Communication with external user equipment is conducted via an RS-422 serial port with a baud rate of 38400. The specific pin definitions are listed in the table below (unlisted pins are not connected)

Signal Name	J30-15ZKP Pin	Remarks
Tx+(Transmit Positive)	5	RS-422 external communication control serial port. Baud rate: 115200
Tx-(Transmit Negative)	6	
+24V	1、2	24V Power input
0V (24V)	3、4	24V Power ground(GND)

4. System Operation Instructions

4.1 Preparations and Pre-Use Checks

Before starting the Doppler Velocity Log (DVL), inspect all equipment interconnecting cables for any signs of loosening or poor contact. Verify that the power supply to the DVL is normal. Use a cloth moistened with soapy water to wipe away any oil or grease from the acoustic transducer.

4.2 Data Interface Format

The DVL transmits data to the control computer in the vehicle's instrument bay via an RS-422 asynchronous serial port.

- **Communication Protocol**: Baud rate: 38400 bps; Word format: 8-N-1.
- **Synchronization**: System operation is synchronized with the external trigger cycle; the system will not operate if there is no external trigger signal or if the trigger requirements are not met.

The DVL output data complies with the **PD6 format**. In Bottom Track mode, the DVL transmits only **BI** and **BD** frames. In Water Track (current layer tracking) mode, the DVL transmits only **WI** and **WD** frames. The data format is ASCII.

Frame :BI

Format: :BI, ±XXXXX, ±YYYYY, ±ZZZZZ, ±EEEEE, S<CR><LF>

A total of 35 characters (where Carriage Return <CR> and Line Feed <LF> count as two characters). Insufficient data bits are padded with spaces. This frame is used to upload real-time velocity and other information in Bottom Track mode.

- ±XXXXX = X-axis velocity, unit: mm/s. (e.g., uploading " +53", 6 characters in total)
- ±YYYYY = Y-axisvelocity, unit: mm/s. (e.g., uploading " +62", 6 characters in total)
- ±ZZZZZ = Z-axis velocity, unit: mm/s. (e.g., uploading " +12", 6 characters in total)
- ±EEEEE = Temporarily unused. (e.g., uploading " +11", 6 characters in total)
- S = Status validity flag (A = Valid, V = Invalid)

Example: :BI, +53, +62, +12, +11, A

Frame :BD

Format: :BD, ±EEEEEEEE.EE, ±NNNNNNNN.NN, ±UUUUUUUU.UU, DDDD.DD, TTT.TT<CR><LF>

A total of 59 characters (where Carriage Return <CR> and Line Feed <LF> count as two characters). Insufficient data bits are padded with spaces. This frame is used to upload self-test information, real-time altitude, and other information in Bottom Track mode.

- ±EEEEEEEE.EE = DVL Type Flag (" +1.00" for Shallow Water DVL; " +2.00" for Deep Water DVL)
- ±NNNNNNNN.NN = Self-test Flag, temporarily unused.
- +UUUUUUUU.UU = Transducer Array Immersion Depth, unit: meters. Temporarily unused, uploading " +0.00" (12 characters in total).
- DDDD.DD = Vertical distance from the acoustic array to the seabed (i.e., Altitude), unit: meters. (e.g., " 47.50", 7 characters in total).
- TTT.TT = Elapsed time since the last valid data, unit: seconds. Temporarily unused, uploading " 0.00" (6 characters in total).

Example: :BD, 1, 1, +0.00, 47.50, 0.00

Frame :WI

Format: :WI, ±XXXXX, ±YYYYY, ±ZZZZZ, ±EEEEE, S<CR><LF>

A total of 35 characters (where Carriage Return <CR> and Line Feed <LF> count as two characters). Insufficient data bits are padded with spaces. This frame is used to upload real-time velocity information in Water Track mode.

- ±XXXXX = X-axis velocity, unit: mm/s. (e.g., uploading " +53", 6 characters in total)
- ±YYYYY = Y-axis velocity, unit: mm/s. (e.g., uploading " +62", 6 characters in total)
- ±ZZZZZ = Z-axis velocity, unit: mm/s. (e.g., uploading " +12", 6 characters in total)
- ±EEEEE = Temporarily unused. (e.g., uploading " +11", 6 characters in total)
- S = Status validity flag (A = Valid, V = Invalid). Currently, the status uploaded in Water Track mode is always "A" (Valid).

Example: :WI, +53, +62, +12, +11, A

Frame :WD

Format: :WD, ±EEEEEEEE.EE, ±NNNNNNNN.NN, ±UUUUUUUU.UU, DDDD.DD, TTT.TT<CR><LF>

A total of 59 characters (where Carriage Return <CR> and Line Feed <LF> count as two characters). Insufficient data bits are padded with spaces. This frame is used to upload self-test information and other parameters in Water Track mode.

- ±EEEEEEEE.EE = Temporarily unused. (e.g., uploading " +0.00", 12 characters in total)
- ±NNNNNNNN.NN = Temporarily unused. (e.g., uploading " +0.00", 12 characters in total)
- +UUUUUUUU.UU = Temporarily unused. (e.g., uploading " +0.00", 12 characters in total)
- DDDD.DD = Temporarily unused. (e.g., uploading " 47.50", 7 characters in total)
- TTT.TT = Temporarily unused. (e.g., uploading " 0.00", 6 characters in total)

Example: :WD, 1, 1, +0.00, 47.50, 0.00

4.3 Shutdown Procedure and Precautions

Disconnect the power supply to de-energize the instrument and shut down the equipment.

5. General Troubleshooting and Fault Isolation

The Doppler Velocity Log (DVL) extensively incorporates large-scale integrated circuits; therefore, the instrument will operate reliably as long as the primary Printed Circuit Board Assemblies (PCBAs) function properly. If the DVL fails to output data normally, first verify that the aviation connectors are securely mated and the power supply is normal. Simultaneously, ensure that the RS-422 wiring and serial port baud rate configurations are correct.

6. Safety Protection Measures and Fault Handling

6.1 Protection Measures and Precautions

The input voltage fluctuations must remain within the limits specified in the technical specifications. Otherwise, the normal operation of the instrument may be compromised, or permanent damage may occur.

6.2 Fault Handling Procedures and Methods

(1) In the event of a fault, first verify whether the voltage is normal—specifically the 24V power supply, which is the baseline requirement for DVL operation. If the voltage is abnormal, replace the fuse or the power supply unit.

(2) Inspect for mechanical faults, such as loose cable connections or damaged wiring, and rectify them accordingly.

7. Maintenance and Servicing

7.1 Routine Maintenance and Schedule

(1) Inspect all interconnecting cables of the instrument for any signs of loosening.

(2) Clean and remove internal dust from all components of the instrument.

7.2 Maintenance During Long-Term Storage

(1) Retrieve the transducer and clean off any marine biofouling accumulated on its surface.

(2) Remove dust from all components of the instrument.

(3) Inspect the electrical contact reliability of all PCB plug-ins and interconnecting cables.

7.3 Maintenance Cycle

The standard maintenance cycle is typically every three months.

7.4 Operational Precautions

(1) DO NOT power on the instrument after the transducer is removed from the water (dry-firing in the air is strictly prohibited), as this may cause permanent damage to the transducer elements.

(2) During equipment utilization, ensure all cables are securely connected according to the wiring schematics before applying power. Hot-swapping (plugging or unplugging cables while energized) is strictly prohibited.

(3) The transducer array must maintain a rigid connection with the vessel hull during installation. The alignment mark on the array must be substantially aligned with the vessel's bow (heading direction).

(4) The radiating face of the transducer array should be kept as horizontal as possible relative to the vessel.

(5) The immersion depth of the transducer array must exceed 1 meter, and there must be no acoustic obstructions around the perimeter of the transducer's radiating face.

(6) The power supply voltage must strictly remain within the required specification range.

(7) The watertight connectors of the equipment are fitted with internal O-rings (water-tight rubber seals). Please ensure that the O-rings are properly seated and intact when mating or unmating cables.

(8) If a power cycle is required after shutdown, wait for at least 1 minute before re-energizing the system.