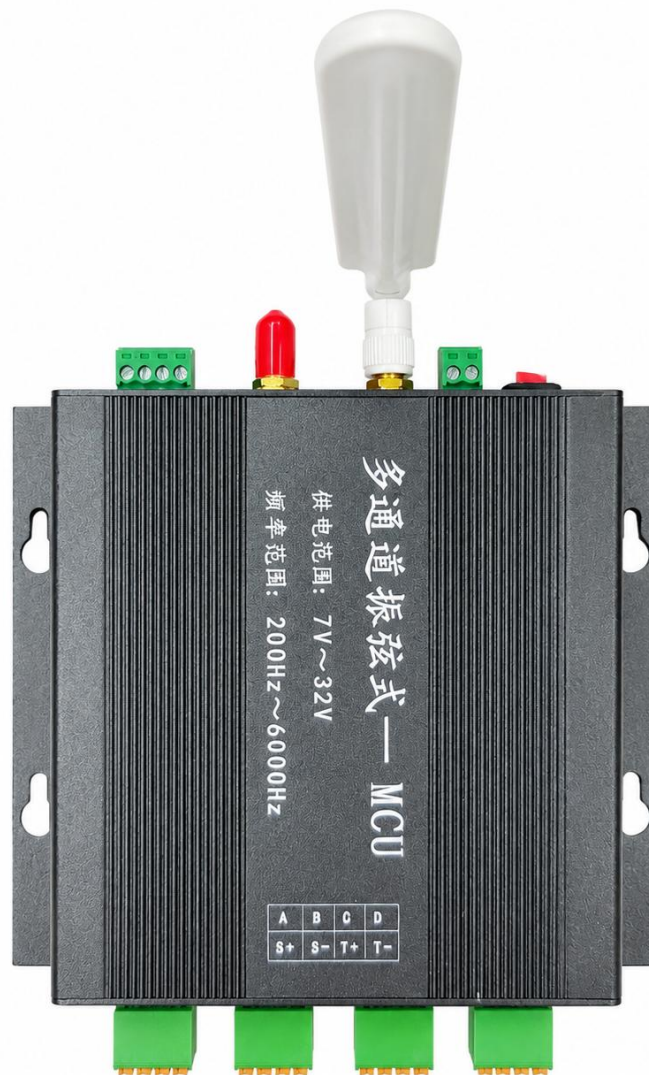


VW-4/8/16-4G Multi-channel Vibrating Wire Hybrid Data Acquisition RTU User Manual

V1.3.0

VW-402-4G (Applicable to VW- 802/ VW-1602)



Note: Accessories and interfaces may vary depending on the model; please refer to the actual product.

Shenzhen Hu Entropy Tech Co., Ltd

Email: hu@huentropy.com

WhatsApp: +86 183 1943 1978

I. Product Overview

This series of Vibrating Wire Remote Terminal Units (RTUs) represents a new generation of intelligent monitoring devices integrating data acquisition, edge computing, local storage, logic control, alarm management, and remote communication functions. The device integrates a multi-channel high-precision vibrating wire Acquisition Module. Its core algorithm employs **Fast Fourier Transform (FFT)** combined with **phase-difference spectrum analysis** technology to effectively filter out environmental noise interference, achieving accurate calculation of the resonant frequency of vibrating wire sensors.

Designed based on the vibrating wire frequency measurement principle, this device is designed for monitoring fundamental physical parameters in geotechnical and structural applications. Its working mechanism involves precisely measuring variations in the resonant frequency of a tensioned steel wire inside vibrating wire sensors. It provides excellent long-term stability and high measurement accuracy.

In terms of communication and integration, the terminal is equipped with a rich set of industrial-grade protocol stacks, natively supporting SL651 Hydrological Monitoring Data Communication Protocol, HJ212 Environmental Protection Data Transmission Protocol, Universal IoT Protocol (MQTT), and customized private protocols, enabling seamless access to various industry supervision platforms. Furthermore, the device possesses robust multi-source data fusion capabilities. While vibrating wire acquisition is its primary function, it can also expand connectivity via an RS485 interface to various Modbus sensors (such as flow meters, level gauges, rain gauges, water level meters, etc.), enabling a hybrid data acquisition architecture. This multi-purpose design significantly simplifies on-site network architecture and reduces deployment costs, making it an ideal edge computing terminal for scenarios like geotechnical engineering, smart water conservancy, and structural health monitoring.

The hardware utilizes a high-performance industrial-grade 32-bit communication processor and an industrial-grade 4G communication module, running an embedded real-time operating system, ensuring high reliability and stability in harsh industrial environments.

Flexible Interfaces and Configurations: This series offers flexible hardware configuration options, covering multiple channel versions like VW-402, VW-802, and VW-1602, allowing users to choose precisely based on measurement point scale and monitoring requirements. In terms of interface resources, the terminal standardly includes 1 controlled power output interface for programmable power management of external sensors, effectively optimizing system power consumption. It also integrates 1 standard RS485 interface (baud rate configurable from 1200 to 115200), supporting external expansion based on protocols like Modbus, enabling seamless integration with various 485-type transmitters (e.g., water level meters, rain gauges, temperature/humidity sensors). This further strengthens the device's multi-source data acquisition capability and on-site integration advantages.

Communication Integration: integrates 2G/3G/4G communication methods to establish a round-the-clock data transmission channel.

Protocol Compatibility: Fully supports Hydrological, Environmental Protection, MQTT, and standard Modbus protocols, enabling seamless connection with heterogeneous systems.

Convenient Operation & Maintenance: Supports remote parameter configuration and local visual debugging, significantly reducing on-site implementation and maintenance costs.

Application Scenarios: Widely used in smart water conservancy, irrigation district informatization, smart water utilities, smart cities, and geological disaster monitoring and early warning.

II. Technical Specifications

2.1 Basic Parameters

Name	Parameter
Operating Voltage	7~32 VDC (built-in reverse polarity protection)
Operating Current	≤30 mA (at 12 VDC)
Sleep Current	≤100μA
Main Controller	Industrial-grade 32-bit high-performance processor, M233 core
Data Storage	16M
Communication Module 4G	Frequency Band Support: FDD-LTE, TD-LTE, CDMA2000 1xEV-DO, WCDMA, TD-SCDMA, CDMA1X, GPRS/EDGE Theoretical Bandwidth: FDD-LTE: Downlink 100Mbps, Uplink 50Mbps TD-LTE: Downlink 61Mbps, Uplink 18Mbps WCDMA: Downlink 42Mbps, Uplink 5.76 Mbps TD-SCDMA: Downlink 4.2Mbps, Uplink 2.2Mbps CDMA2000 1xEV-DO Rev. A: Downlink 3.1Mbps, Uplink 1.8Mbps GPRS/EDGE: 171.2kbps/384kbps
Peripheral Interfaces	Data Acquisition Interface: 1 independent RS485 interface (built-in 15KV ESD protection) Power Control Output: 1 controllable power output interface

2.2 Interface Parameters

1. VW-402 (Interface Parameters)

No.	Interface Name	Description
Channel 1	Vibrating Wire (+)	Connect to vibrating wire sensor positive (+)
	Vibrating Wire (-)	Connect to vibrating wire sensor negative (-)
	Temperature (+)	Connect to vibrating wire temperature positive (+)
	Temperature (-)	Connect to vibrating wire temperature negative (-)
Channel 2	Vibrating Wire (+)	Connect to vibrating wire sensor positive (+)
	Vibrating Wire (-)	Connect to vibrating wire sensor negative (-)
	Temperature (+)	Connect to vibrating wire temperature positive (+)
	Temperature (-)	Connect to vibrating wire temperature negative (-)
Channel 3	Vibrating Wire (+)	Connect to vibrating wire sensor positive (+)
	Vibrating Wire (-)	Connect to vibrating wire sensor negative (-)
	Temperature (+)	Connect to vibrating wire temperature positive (+)
	Temperature (-)	Connect to vibrating wire temperature negative (-)
Channel 4	Vibrating Wire (+)	Connect to vibrating wire sensor positive (+)
	Vibrating Wire (-)	Connect to vibrating wire sensor negative (-)
	Temperature (+)	Connect to vibrating wire temperature positive (+)
	Temperature (-)	Connect to vibrating wire temperature negative (-)
RS485 Interface	VOUT	Controllable power output (Output voltage equals input voltage)
	A	RS485-A
	B	RS485-B
	GND	Power ground / Signal reference ground

2. VW-802 (Interface Parameters)

No.	Interface Name	Description
-----	----------------	-------------

No.	Interface Name	Description
Channel 1-8	Vibrating Wire (+)	Connect to vibrating wire sensor positive (+)
	Vibrating Wire (-)	Connect to vibrating wire sensor negative (-)
	Temperature (+)	Connect to vibrating wire temperature positive (+)
	Temperature (-)	Connect to vibrating wire temperature negative (-)
RS485 Interface	VOUT	Controllable power output (Output voltage equals input voltage)
	A	RS485-A
	B	RS485-B
	GND	Power ground / Signal reference ground (Ground)

3. VW-1602 (Interface Parameters)

No.	Interface Name	Description
Channel 1-16	Vibrating Wire (+)	Connect to vibrating wire sensor positive (+)
	Vibrating Wire (-)	Connect to vibrating wire sensor negative (-)
	Temperature (+)	Connect to vibrating wire temperature positive (+)
	Temperature (-)	Connect to vibrating wire temperature negative (-)
RS485 Interface	VOUT	Controllable power output (Output voltage equals input voltage)
	A	RS485-A
	B	RS485-B
	GND	Power ground / Signal reference ground (Ground)

2.3 Protocol Support

- HJ212 Protocol:** (Full name "Data Transmission Standard for Pollutant Online Monitoring (Surveillance) Systems") is a national industry standard issued by the Ministry of Ecology and Environment of China. It is primarily used to standardize the data transmission "language" between pollution source monitoring equipment (such as CEMS flue gas, water quality online

monitors) and environmental protection supervision platforms. Supporting this protocol means the device can directly act as a "data acquisition instrument" role, packaging collected sensor data into a format recognizable by environmental protection platforms for reporting.

2. **MQTT (Message Queuing Telemetry Transport)** is a lightweight publish/subscribe pattern messaging protocol based on TCP/IP. Proposed by IBM in 1999, it is now an ISO/IEC 20922 standard and one of the most mainstream communication protocols in the Internet of Things (IoT) industry.

3. **SL651 Protocol** (Full name "Communication Protocol for Hydrological Monitoring Data", Standard No. SL 651-2014) is an industry standard issued by the Ministry of Water Resources of China and serves as the "common language" in the water conservancy and hydrology field. It mainly standardizes the data transmission format and interaction rules between telemetry terminals (RTU/Telemetry Station) and central stations (Water Resources Platforms) in hydrological monitoring systems. Supporting SL651 means the device can directly interface with hydrological monitoring and early warning platforms of various water resources bureaus, commonly used in scenarios like flash flood disaster monitoring and reservoir water level/rainfall reporting.

4. **Private Protocol Mode:** A communication protocol customized by the manufacturer, specifically designed for efficient remote operation/maintenance and visualized data display. While ensuring basic acquisition, storage, and reporting functions, this mode opens a powerful RS485 data transparent transmission channel. The platform can both actively send transparent transmission instructions to the terminal's 485 interface and read real-time data from external sensors at any time, achieving millisecond-level control over on-site conditions.

Through this mechanism, managers can not only perform local parameter configuration and remote maintenance of the acquisition instrument but also directly "remote control" the 485 sensors connected to the terminal across the network (e.g., start/stop measurements, switch working modes). This enables two-way communication between the cloud platform and field sensors, reducing maintenance requirements for distributed monitoring sites. It effectively solves the pain points of "difficult sensor maintenance" and "difficult data traceability" in distributed monitoring sites, significantly reducing the cost and difficulty of manual on-site maintenance.

5. **DTU Mode** (Data Terminal Unit mode, often called "Transparent Transmission Mode" or "Serial to Network" mode); In this mode, the RTU no longer (or rarely) actively performs internal logic operations, I/O scanning, or protocol packaging. Instead, it acts as a transparent data channel, forwarding raw data received from the serial port (RS485) directly to the network platform without modification.

6. **MODBUS Mode:** In this operating state, the device participates in communication as a MODBUS node (usually a Slave/from-device). This means the RTU is no longer just a transparent transmission "pipeline" (DTU mode) nor only uses private packaging methods, but organizes data and responds to requests according to the MODBUS protocol standard.

III. Key Features

This series of Vibrating Wire RTUs possesses excellent protocol compatibility and platform adaptation capabilities. It integrates Hydrological (SL651), Environmental Protection (HJ212), MQTT IoT protocols, and manufacturer private protocols, and supports flexible switching of working modes—capable of being configured as a pure transparent DTU mode or mapped as a standard MODBUS master/slave station. The device supports simultaneous data distribution to four centers, combined with diverse reporting strategies (scheduled reporting, threshold triggering, event-based additional reporting, etc.), enabling flexible connection to supervision platforms at various levels and third-party systems.

In terms of data acquisition mechanisms, the terminal supports a "multiple acquisitions, centralized reporting" buffer mode to reduce communication power consumption, while also being compatible with the "acquire and send simultaneously" real-time response mode to meet the timeliness requirements of different monitoring scenarios.

The product adopts industrial-grade ultra-low power design, with current consumption in sleep mode as low as the microampere level. Coupled with an innovative peripheral power intelligent management strategy, the system can power on external sensors instantly during acquisition and immediately cut off power after acquisition is complete, completely eliminating standby leakage issues. This mechanism enables the device to maintain stable operation for several years even when powered by only a small-capacity battery under stringent conditions, greatly reducing maintenance pressure in field scenarios without mains electricity.

Edge Computing: This series terminals feature a built-in professional conversion engine at the edge, integrating real-time pressure and water level calculation functions. When users connect vibrating wire sensors like piezometers or water level gauges, they only need to input the sensor's base frequency and calibration coefficient (K-value) via the configuration tool. The device then automatically performs the conversion from raw frequency to Engineering Parameter (pressure/water level) locally. This mechanism allows the device to report intuitive engineering physical values (such as water level elevation, seepage pressure) directly to the platform, instead of raw frequency data (Hz), in water conservancy and hydropower scenarios like reservoir dams, embankments, and tailings ponds. Offloading the calculation pressure to the edge significantly reduces the data parsing and computational load on cloud servers and substantially improves the real-time data display and interactive experience, achieving a lightweight IoT architecture with real-time acquisition, calculation, and visualization.

Multi-channel Programmable: This series of Vibrating Wire RTUs features 32 independent programmable logic channels, offering various hardware versions like VW-402, VW-802, and VW-1602 for users to choose based on their needs. The vibrating wire acquisition channels are highly flexible, supporting free mapping of sensors to any logic channel. The channels incorporate

an edge computing engine, supporting not only arithmetic operations (addition, subtraction, multiplication, division) on collected data but also enabling seepage conversion functions to convert raw frequencies into pressure or water level values directly at the edge, fully freeing up cloud computing resources. The device also integrates 1 standard RS485 acquisition interface, fully compatible with various smart sensors on the market based on the Modbus protocol (such as rain gauges, temperature/humidity sensors, multi-parameter water quality sensors, etc.), enabling hybrid acquisition of vibrating wire and digital quantities. In terms of data transmission, the terminal can encapsulate data into standard protocols like Hydrological (SL651), Environmental Protection (HJ212), MQTT for reporting, and also supports outputting internal register values directly via Modbus instructions, granting third-party systems high data reading flexibility. This truly realizes a closed-loop integration of "acquisition-calculation-transmission".

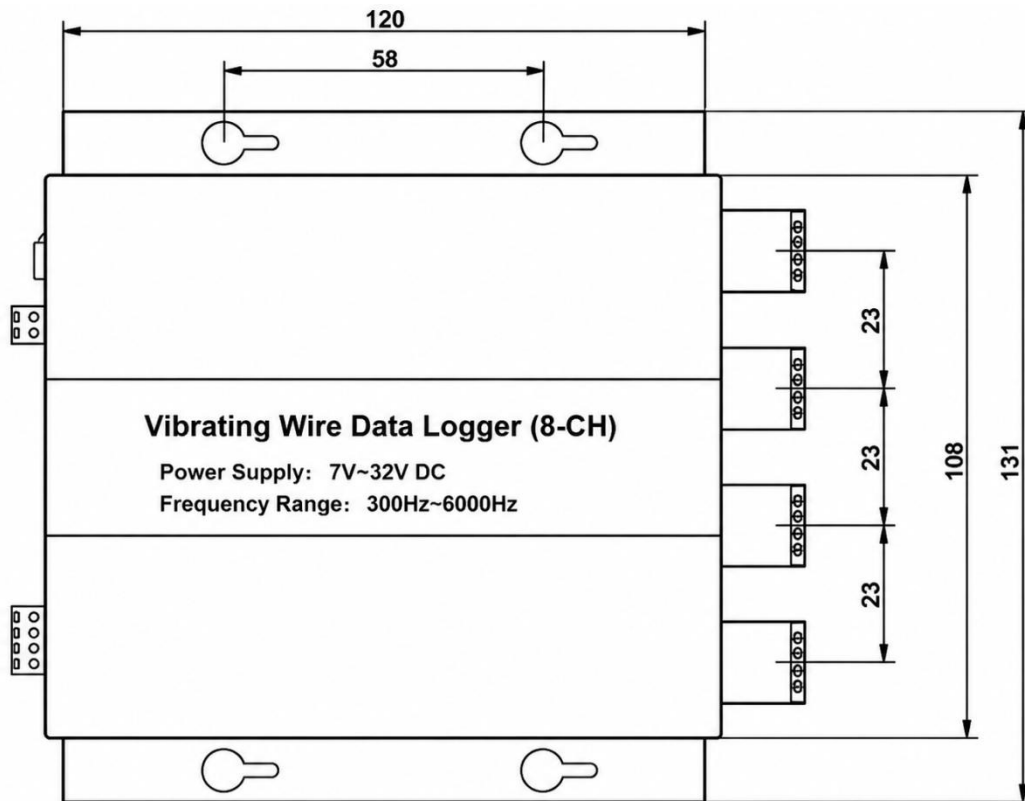
Multi-Monitoring Center Data Transmission: The system supports parallel data reporting to 4 independent centers. It offers high flexibility in communication protocols, allowing selection based on business needs, including the water conservancy industry standard SL651, the environmental protection industry standard HJ212, the general-purpose MQTT, and customized private protocols.

Alarm Triggering Function: All channels feature independent threshold monitoring. The system supports setting individual alarm thresholds for each acquisition channel (e.g., sudden water level changes, stress exceeding limits). When any channel's measured value triggers the preset condition, the device immediately interrupts the regular reporting cycle, automatically switches to high-priority alarm reporting mode, and uploads the anomaly data packet to the platform immediately. This mechanism effectively eliminates the "waiting for data sending" time window under traditional scheduled reporting modes, ensuring the platform can capture on-site mutation information more quickly. It provides accurate decision-making bases for time-sensitive scenarios like geological disaster early warning and reservoir flood control scheduling, significantly enhancing the real-time response capability and risk early warning level of the remote monitoring system.

Offline Retransmission: Offline retransmission (often called "store-and-forward" or "data backfill") refers to the capability where, if the RTU is temporarily unable to communicate with the central platform due to network failures, signal blind spots, or arrears, it stores the collected data in local memory. Once communication is restored, it automatically uploads the historical data from the missing time period to the center in order, ensuring data continuity and integrity in the database records.

Historical Logging: The historical logging function refers to the RTU's ability to automatically collect and store process variables (such as temperature, pressure, flow, switch states, etc.) into internal non-volatile memory according to preset time intervals or trigger conditions. Its core purpose is to independently "keep records" locally without relying on real-time communication, facilitating subsequent querying, exporting, or retransmission.

IV. Installation Guide



Product Dimensions

4.1 Installation Steps

1. Place the device flat and mark screw hole positions on the wall or cabinet using the hole spacing of the bottom mounting ears as a reference.
2. Drill mounting holes using a 3 mm diameter drill bit, approximately 25mm deep.
3. Ensure power is off before wiring.
4. Connect input power: Confirm the voltage range is 7-32V DC and connect positive and negative correctly.
5. It is recommended to install an external surge protector in areas prone to lightning.
6. Connect external devices: Connect vibrating wire sensors and 485 devices according to the interface definitions.
7. After checking that all wiring is correct, turn on the power. The device's indicator lights should turn on normally, indicating successful startup.

Note: Please strictly follow the terminal diagram on the device housing or in the manual for wiring. Ensure connections are not reversed or incorrect.

V. Indicator Lights Description



DATA (Green): Acquisition or transmission indicator; flashes once during data acquisition from vibrating wire/485 sensors; flashes once during TCP data transmission.

ACT (Red): Stays lit when the device is in active (wake-up) working state; turns off after the system enters sleep mode.

Note: The DATA indicator includes a built-in magnetic wake-up function. Users can simply use a magnet close to the sensing area to instantly wake up the device and trigger an active data acquisition and report. This function not only allows for immediate data verification after on-site installation without waiting for the scheduled acquisition cycle but also supports one-key wake-up to put the device into configuration mode, greatly improving the efficiency of on-site parameter maintenance and debugging.

VI. Parameter Configuration



The device supports protocol parameter settings via the configuration tool or AT commands. The specific steps are as follows:

1. Connect the Device: Use a Type-C data cable to connect the RTU's debug port to the computer's USB port.
2. Driver Check: Confirm that the computer has correctly recognized the device (it should display the corresponding COM port in Device Manager). If not recognized, please first install the included USB-to-serial driver.
3. Software Setup: Open the official configuration tool and select the correct COM port.
4. Parameter Configuration: Set the serial communication parameters to 115200 / No Parity (None) / Data Bits 8 / Stop Bits 1 (115200,N,8,1). Click "Connect" to enter the configuration interface.
5. Set Device Information: Configure basic device information such as serial port parameters, channel parameters, center parameters, etc.
6. Write Configuration and Restart: Write the configuration and restart the device for the parameters to take effect.

Note: For detailed configuration instructions, please refer to the accompanying "Parameter Configuration Manual".

VII. Troubleshooting

Fault Symptom	Possible Cause	Solution
No Power	Power supply issue or	Check if the power supply (battery or adapter) has

Fault Symptom	Possible Cause	Solution
Indicator Light (ACT)	device in sleep mode	voltage output (measure with a multimeter). Wake the device by using a magnet near the DATA indicator.
Cannot Connect to Config Software	Driver installation error or wrong COM port	Open your computer's "Device Manager" -> Check if a new COM port appears (e.g., COM3, COM4). If not, reinstall the PL2303GL serial driver.
Unable to Connect to Network / No 4G Signal	SIM card issue or weak signal	Remove the SIM card and insert it into a phone to check if it has data service, is not overdue, and has data functionality enabled.
Abnormal Data Acquisition	Incorrect baud rate or wiring error	Confirm A is connected to A, B is connected to B (cannot be reversed), and all devices share a common ground (GND connected together).
No Output from Sensor Power Supply Output	Incorrect configuration for the control interface	Check the configuration of the power control interface. Set the power-on and power-off times to 0. The device will then provide continuous power output.

VIII. Precautions

The device operating temperature range is $-40^{\circ}\text{C} \sim +85^{\circ}\text{C}$. Avoid installation in environments beyond the specified operating conditions.

Ensure the device is well grounded during installation to prevent electromagnetic interference.

If using a solar power system, ensure the battery voltage matches the device's input voltage range.

Do not plug or unplug interfaces while powered on to avoid damaging the device.

All wiring operations must be performed with the power completely disconnected.

Antennas (4G/LoRa/GPS) must be screwed in securely to ensure good contact.

Antenna feeder cables should be kept away from high-power cables and avoid parallel routing. Suction-cup antennas should be attached to a metal surface or placed facing upwards to ensure unobstructed signal transmission/reception.

The device must be installed inside a waterproof distribution box to avoid direct rain splashes and prolonged sun exposure.

Regularly check if connections are loose to ensure stable system operation.